Nature	**COMPTE-RENDU DE REUNION**
Titre ***Title***	**Review Meeting ITER_GOT_PPE du 01/12/2011**
Auteur(s) *Author(s)*	L. Doceul, P. Messina
Catégorie *Category*	
Référence(s)	I0000545827

Résumé *Abstract*	Status of the PPE Program Work performed in the frame of WP2 Work performed in the frame of WP4 Work performed in the frame of WP5 Work performed in the frame of WP6 Descriprtion about the end of WP1 and WP3 Open discussion on PPE program
Destinataires *Addressees*	CEA : J. Bucalossi, L. Doceul, D. Keller, Ph. Magaud, P. Messina, S. Salasca. EFDA : C. Bachmann FZJ: O. Neubauer KIT: H. Neuberger, T. Scherer HAS: I. Tamas ITER : B. Levesy

EUROPEAN TRAINING NETWORK for ITER PORT-PLUG ENGINEERING

Association EURATOM-CEA

2011 review meeting EFDA ITER Goal Oriented Training Programme

Port Plug Engineering (PPE)

Participants

ITER-PPE training management board

EFDA: Bachmann Christian (remote)

CEA: Doceul Louis, Delphine Keller, Salasca Sophie

FZJ : Neubauer Olaf (remote)

KIT : Neuberger Heiko (remote) , Scherer Theo (remote)

HAS : Ilkei Tamas, Grunda Gabor (remote)

PPE euro-trainees

CEA: Julien Wagrez (remote)

FZJ : Romaric Voinchet (remote)

KIT : Gaetano Aiello (remote), Zeile Christian (remote)

HAS : Nemeth Joszef (remote)

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EUROPEAN TRAINING NETWORK for ITER PORT-PLUG ENGINEERING

Association EURATOM-CEA

Agenda

13h30 Status of the PPE program (L. Doceul)
13h40 Work performed in the frame of WP2 (J. Wagrez)
14h00 Work performed in the frame of WP4 (C. Zeile)
14h20 Work performed in the frame of WP5 (J. Németh)
14h40 Coffee break
15h Work performed in the frame of WP6 (R. Voinchet)
15h20 Short oral description about the end of WP1 and WP3 (S. Salasca, T. Scherer)
15h40 Open discussion on PPE program (sharing, conference, training session,….) (All participants)
16h30 End of the review meeting

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EUROPEAN TRAINING NETWORK for ITER PORT-PLUG ENGINEERING

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Status of the GOT PPE programme

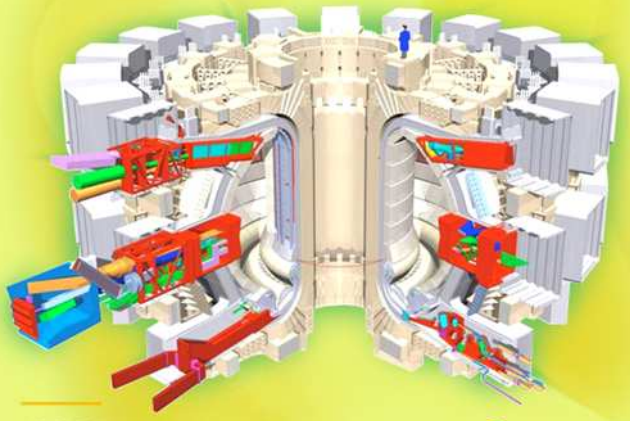
PLANNING

2011 EVENTS

2012 EVENTS

DELIVERABLE

CONCLUSION



HA1 CEA — HA2 KIT — HA3 HAS — PA4 FZJ

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PLANNING

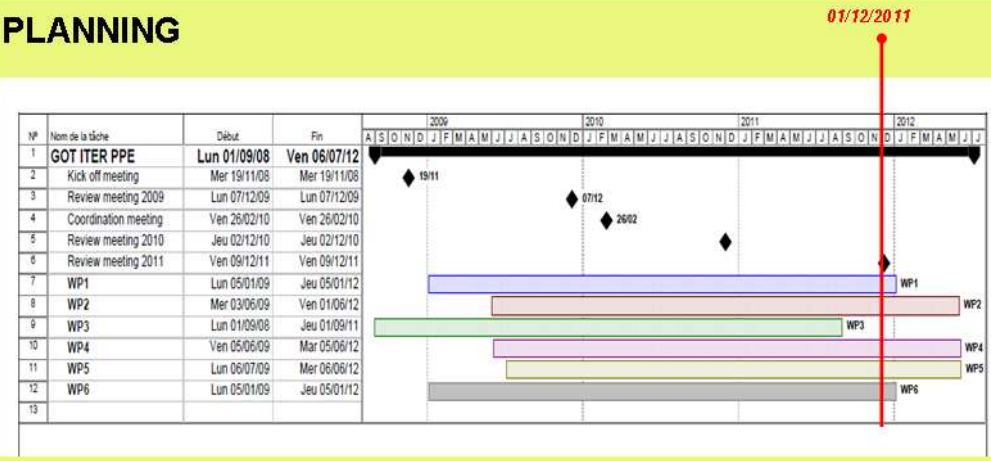
PLANNING

2011 EVENTS

2012 EVENTS

DELIVERABLE

CONCLUSION



Nº	Nom de la tâche	Début	Fin
1	GOT ITER PPE	Lun 01/09/08	Ven 06/07/12
2	Kick off meeting	Mer 19/11/08	Mer 19/11/08
3	Review meeting 2009	Lun 07/12/09	Lun 07/12/09
4	Coordination meeting	Ven 26/02/10	Ven 26/02/10
5	Review meeting 2010	Jeu 02/12/10	Jeu 02/12/10
6	Review meeting 2011	Ven 09/12/11	Ven 09/12/11
7	WP1	Lun 05/01/09	Jeu 05/01/12
8	WP2	Mer 03/06/09	Ven 01/06/12
9	WP3	Lun 01/09/08	Jeu 01/09/11
10	WP4	Ven 05/06/09	Mar 05/06/12
11	WP5	Lun 06/07/09	Mer 06/06/12
12	WP6	Lun 05/01/09	Jeu 05/01/12
13			

92% of the PPE programme accomplished

WP1 stopped in advance

WP3 finished in time

WP6 is almost finished

6 month remaining for WP2, WP4 and WP5

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2011 EVENTS
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Brief recall of the PPE Work Programme events in 2011:

- New EFDA responsible for the GOT PPE: Bachmann Christian
- End of WP1 and WP3: Miguel DAPENA hired by ITER
  Gaetano AIELLO new contract with KIT (3 years)
- New supervisor for WP5: Tamás ILKEI
- Sharing within the associations: 9 person.month in 2011
- Other Sharing : 5 person.month in 2011
- Training session organized by KIT (7-10/06/11) Introduction into Vacuum- and Cryo-Technology, Project Management with focus on inter-cultural aspects
- Review meeting GOTP PPE: 01 december 2011

L. Doceul - 01 december 2011 - Review meeting GOTP PPE

EUROPEAN TRAINING NETWORK for ITER PORT-PLUG ENGINEERING — Association EURATOM-CEA

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Work Programmes	Host WP1/CEA	Host WP2/CEA	Host WP3/KIT	Host WP4/KIT	Host WP5/HAS	Host WP6/FZJ
WP1/CEA						
WP2/CEA			3 weeks banana blanket concept November 2011	2 weeks RH TBM December 2011		
WP3/KIT						
WP4/KIT	3 months Design of the IR diagnostic in ITER EQPP1 May – July 2011					
WP5/HAS	1 months Design of the IR diagnostic in ITER EQPP1 January 2011		1,5 month Analyses EQPP ECRH November-December 2011	1,5 month Analyses UPPP TBM October-November 2011		
WP6/FZJ						

Sharing within the associations: 9 person.month in 2011

Work Programmes	Host CEA/LIST (robotics)	Host AREVA TA	Host AREVA NP	Host Cybernetix / CNIM	Host Mecachimie	Host Reueter	Host MAN Turbo	Host University Karlsruhe	Host University Budapest
WP1/CEA		X 2011							
WP2/CEA	May-July 2011	X 2011		X 2011	X 2011				
WP3/FZK						April 2011	January 2011		
WP4/FZK								X 2011	
WP5/HAS									X 2011
WP6/FZJ			X 2011						

Other sharing: 5 person.month in 2011

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Events to be organised for 2012
Course and training session :
Table to be discussed
To be consolidated at the end of the meeting
Trainee sharing:
Sharing between association
To be consolidated at the end of the meeting
Sharing with industrial partner
To be consolidated at the end of the meeting
L. Doceul - 01 december 2011 - Review meeting GOTP PPE

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Deliverable for 2011
3 documents required by work program
GOT – Financial Reporting
Nothing for the moment
GOT – Periodic Network Report
OK for WP3
GOT – Trainee Report
OK for WP1, WP2, WP3
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CONCLUSION
Conclusion
92% of the ITER Goal Oriented Training Programme on Port Plug Engineering is accomplished.
3 work programmes (WP2, WP4 and WP5) are still running untill mid 2012.
9 person.month in 2011 of trainee sharing between associations.
5 person.month in 2011 for other sharing.
Deliverables to be produce before end of 2011.
L. Doceul - 01 december 2011 - Review meeting GOTP PPE

energie atomique • energies alternatives

WP2 - PPE - GOT annual review

Julien Wagrez GIPM 01/12/2011

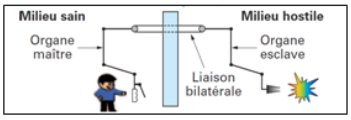
Remote Handling

- General overview about RH technologies
- RH tools integration in Virtual Reality room
- Application on Grant 026 (ICRH)

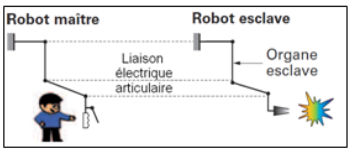
Remote Handling – Basics

- **Definition**
  - > Remote handling is the combination of technology and engineering systems to enable operators perform manipulation of items without being in personal contact with those items.
    Man in the loop strategy ≠ industrial robotic strategy (détails)

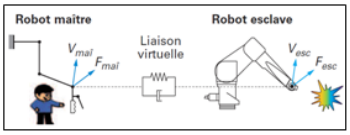
- **Technologies**
  - > Master-Slave Manipulator (MSM)
    - Mechanical connection
    - Iso-kinematics (joint coupling) (détails)



  - > Electrical Manipulator (EMSM)
    - Electrical connection
    - Iso-kinematics (joint coupling)(détails)



  - > Computer Aided Remote Handling (CARH)
    - Electrical connection
    - Generic kinematics (Cartesian coupling)



Julien Wagrez GIPM 01/12/2011 3

Remote Handling – Basics

MSM
A100 use in KIT

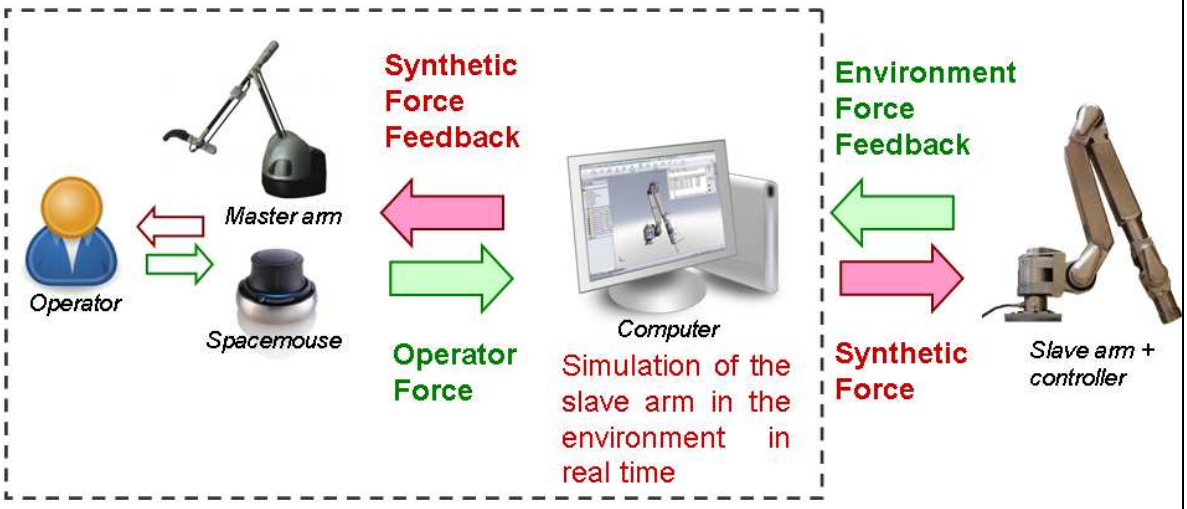
EMSM
used at JET

CARH
used in

Julien Wagrez GIPM 01/12/2011 4

Remote Handling – CARH

- **CARH Architecture**



Currently in the IRFM virtual room

Remote Handling

- General overview about RH technologies
- **RH tools integration in Virtual Reality room**
- Application on Grant 026 (ICRH)

RH tools integration in Virtual Reality room

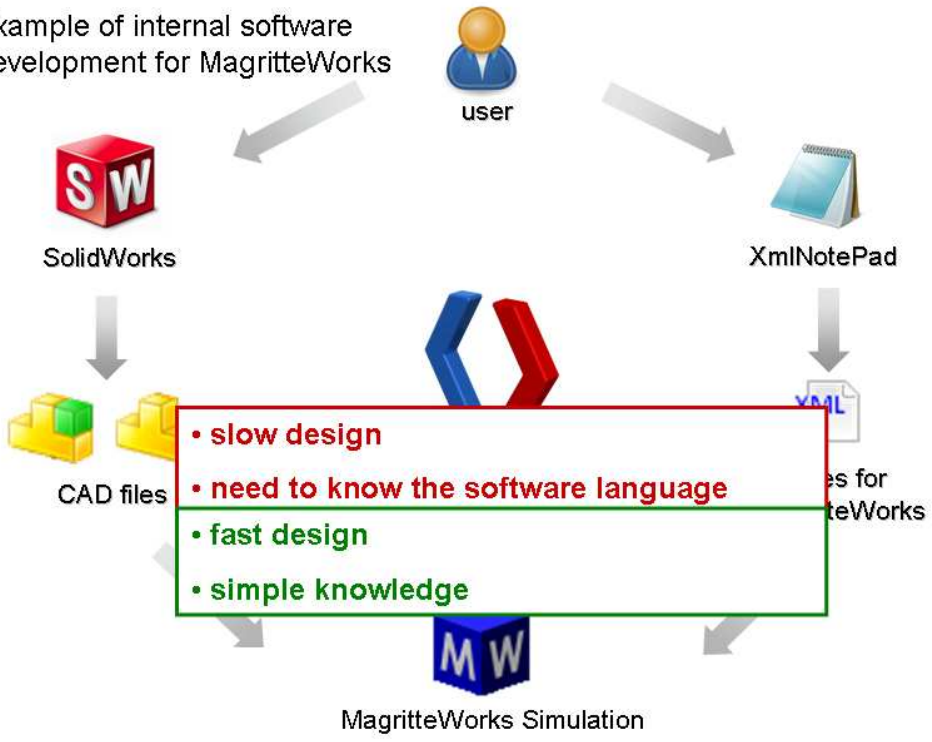
- **CARH software : MagritteWorks**

> Created by CEA – LIST Fontenay-aux-Roses
> R&D software ≠ industrial software

Advantage	Drawback
• Performance	• Not user friendly • Need to integrate new developments

RH tools integration in Virtual Reality room

Example of internal software development for MagritteWorks

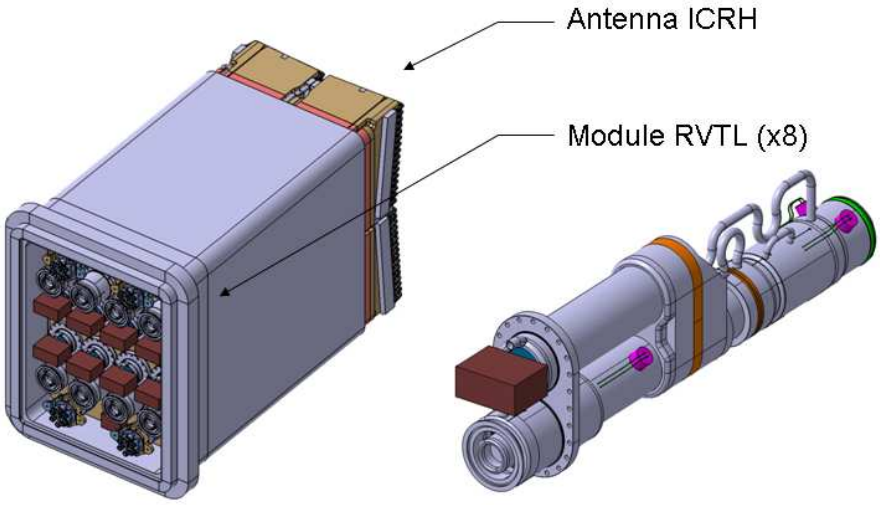


Remote Handling

- General overview about RH technologies
- RH tools integration in Virtual Reality room
- **Application on Grant 026 (ICRH)**

Remote Handling – Application on ICRH task

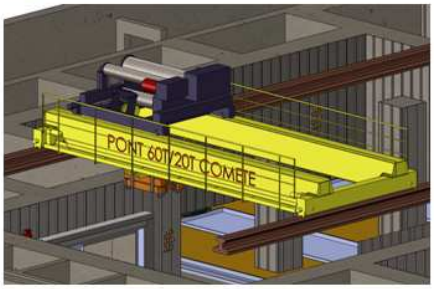
- **In the frame of the GRANT 026 ICRH, the CEA has to study the maintenance of the ICRH antenna through RH tools.**



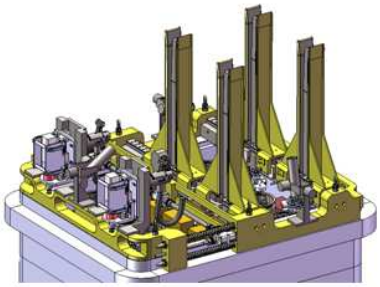
Designed by CCFE

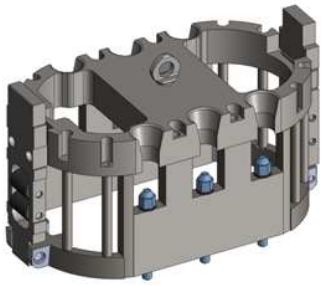
Remote Handling – Application on ICRH task

- **A vertical removing by the hot cell crane**
  - > Hot cell crane



  - > Tools : Guidance + RVTL interface



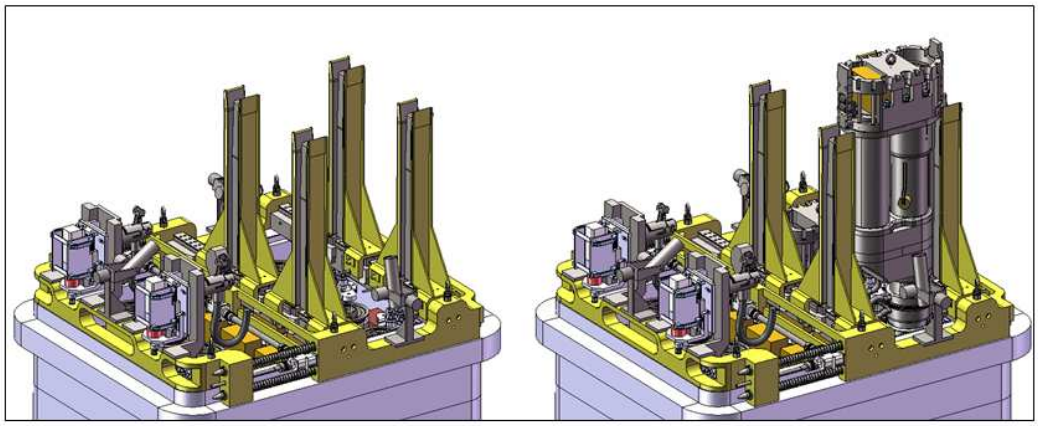


Designed by CEA C.Dechelle

Julien Wagrez GIPM 01/12/2011 11

Remote Handling – Application on ICRH task

- **Maintenance steps**
  1. Unbolting of RVTL
  2. Positioning of guidance
  3. Screwing RVTL interface
  4. Vertical removing



Designed by CEA C.Dechelle

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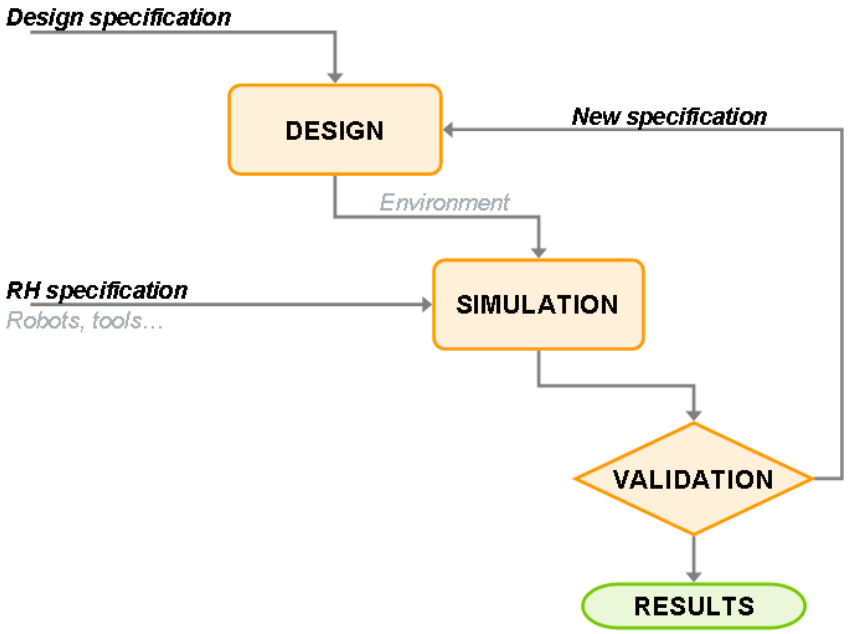
Remote Handling – Application on ICRH task



Remote Handling – conclusion

- Integrate as soon as possible the RH constraints in the design
- Validation of RH concept through Virtual Prototyping
- Streamline real prototyping
- Cost reduction

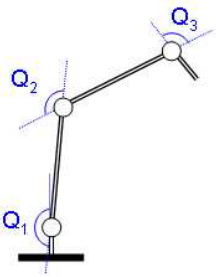
Man in the loop strategy ≠ industrial robotic strategy

- **Remote Handling**
  - > Objective
    - Operator protection
  - > Characteristics
    - Diversified tasks
    - Immersive system
    - Extremely low failure level*

- **Industrial Robotics**
  - > Objective
    - High level of productivity
    - Lower cost
  - > Characteristics
    - Repetitive tasks
    - Well-Known Environment
    - Heavy calibration phase
    - Low failure level acceptable

*specific to nuclear field

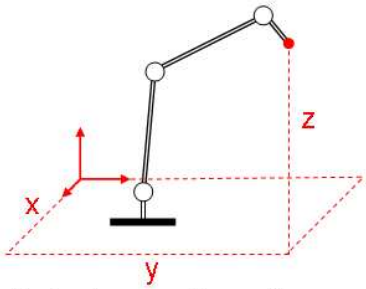
Coupling Mode



Joint configuration
{Q_1 ; Q_2 ; Q_3}

DGM

IGM



Cartesian configuration
{x ; y ; z}

Joint conf.

Cart. conf.

Controller

Joint conf.

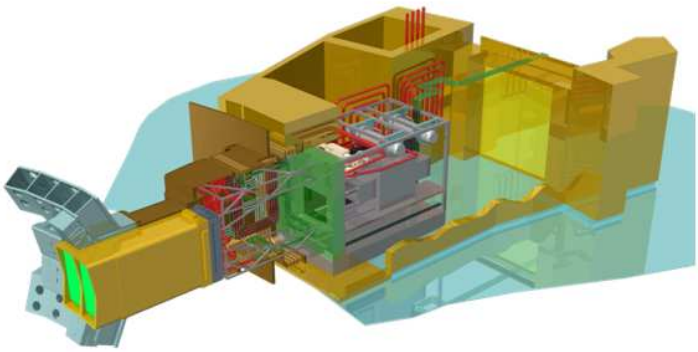
Robot

Karlsruhe Institute of Technology

EFDA

ITER GOT PPE Review Meeting 2011

WP4 – Design, manufacturing and integration of ITER relevant structural components



Christian Zeile

Supervisor: Heiko Neuberger

Institute for Neutron Physics and Reactor Technology (INR)

KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

Outline

Karlsruhe Institute of Technology

- Training Courses 2011
- Technical Work
  - Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)
  - Design and Analysis of the attachment system (KIT)
- Outlook / Future Work

Training Courses / Conferences 2011

- Project relevant introduction
  - Vacuum / Cryo- Technology
- Complementary training
  - Project Management with inter-cultural aspects
- Project relevant meetings and conferences
  - ISFNT 2011 in Portland
  - Several technical meetings with Industrial suppliers

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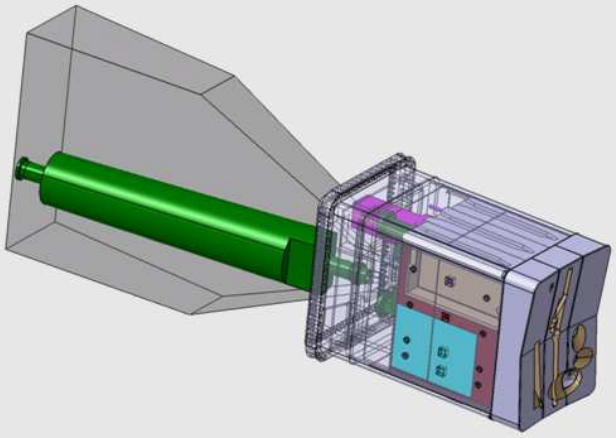
Technical Work

Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)

- Work performed during 3 month stay at CEA Cadarache (May-July 2011)
- Involvement in the work on F4E Grant 24: Equatorial port plug diagnostic integration analysis
- Thermal and Structural Analyses of the shieldings in Port Plug 1 under different operating conditions



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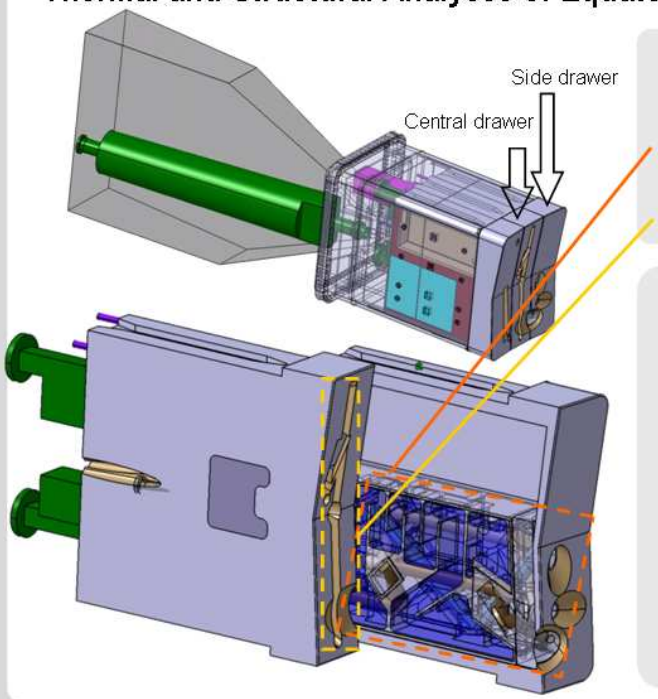
Technical Work

Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)



The EPP 1 contains 9 diagnostics:

Two of them are lead diagnostics:

-Equatorial Visible/Infrared Wide Angle Viewing System (Vis/IR WAVS)

-Radial Neutron Camera (RNC)

The measurements acquired by lead diagnostics belong to category 1a:

-essential for ITER operation

-used to protect important machine components

-available for all ITER pulses

⇩

Absolute reliability required

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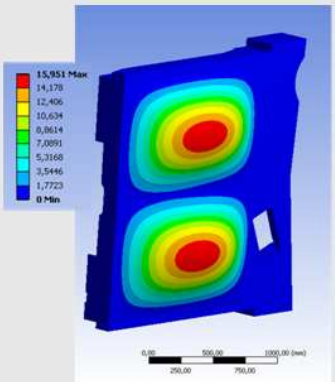
Technical Work

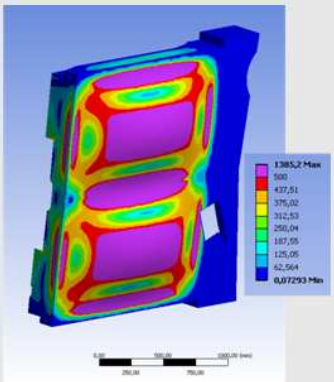
Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)

Central drawer: Baking operation (1)

Cooling water at a temperature of 240 °C and pressure of 4.4 MPa for 100 h



Deformation in mm



Stresses in MPa

High stresses due to inflation of the structure

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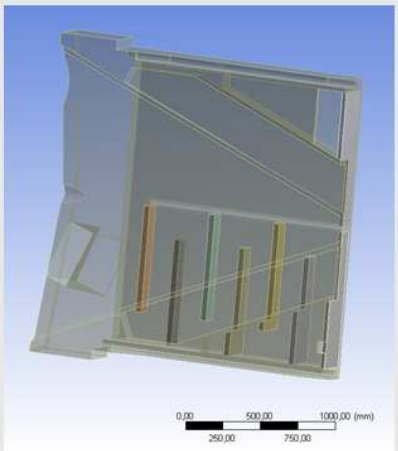
Technical Work

Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)

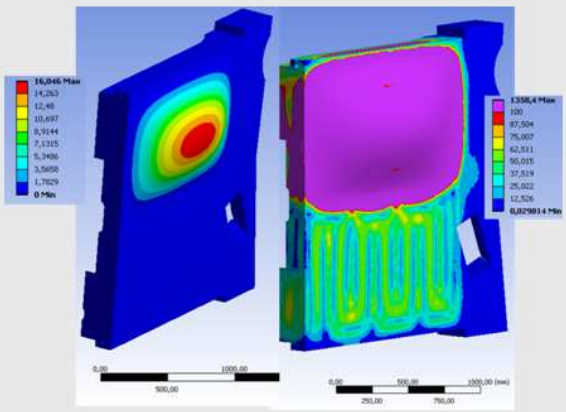
Central drawer: Baking operation (2): Improved design



Introduction of stiffening ribs with two functions:

-Reinforcement of the structure

-Guidance of the water flow



Deformation in mm Stresses in MPa

-Stresses are below 100 MPa

-Acceptable stress level according to design codes

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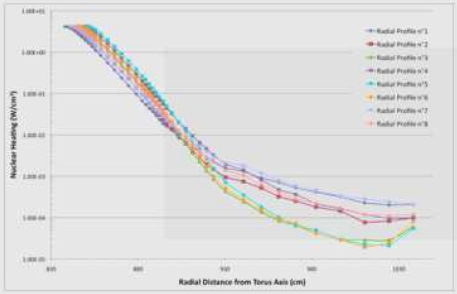
Technical Work

Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)

Cooling of the drawer at normal operation: Boundary conditions

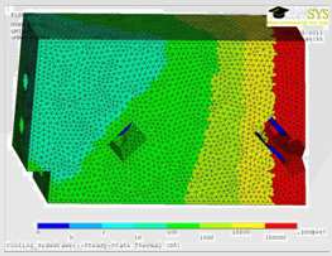
Internal nuclear heating due to neutron irradiation

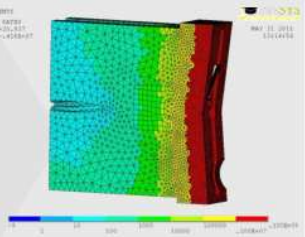


Nuclear heating profiles

Neutronic calculations done by ENEA in the frame of Grant 24

Central drawer





Side drawer (Shielding)

Cooling water:

Temperature: 70 °C

Mass flow: 6.55 kg/s (Central drawer),
3.93 kg/s (Side drawer)

Calculation of heat transfer in cooling channels

Calculation of heat transfer coefficient (HTC) in the cooling channels is difficult due to complex shaped cooling channels

Very rough calculation and parameter study:

HTC: 500 – 2400 $\frac{W}{m^2 °C}$

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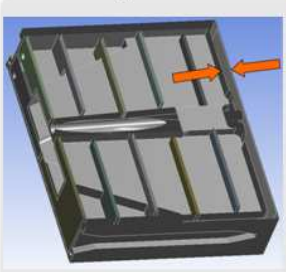
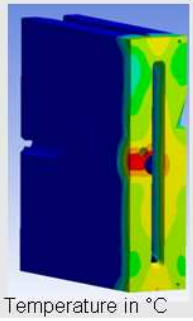
Technical Work

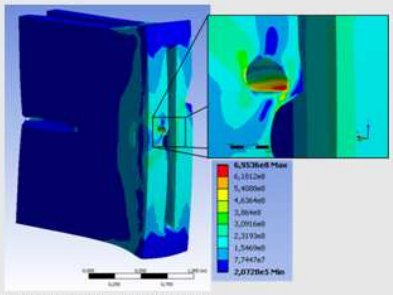
Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)

Cooling of the drawer at normal operation: Central drawer





Temperature in °C

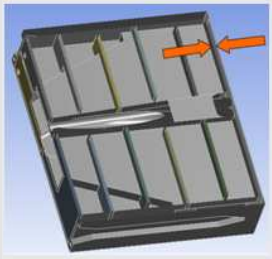


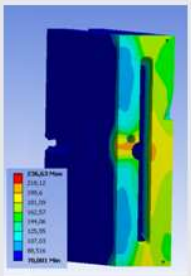
Von Mises stresses in Pa

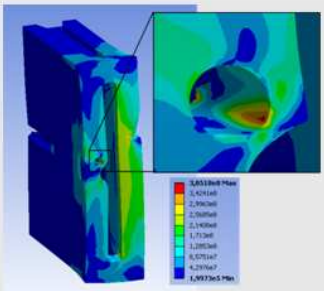
Reference design:

-High temperature gradient around the circular line of sight

-High stress at the inner wall of the cylindrical tube







Reduced thickness of the left front wall:

-Significant decrease of the temperature at the left front face

-Maximum stress is reduced from 695 MPa to 385 MPa

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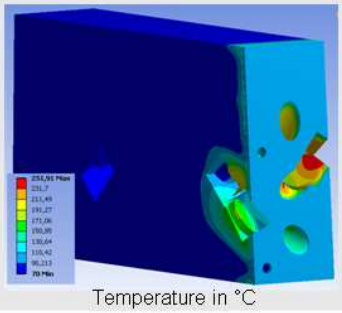
Technical Work

Thermal and Structural Analyses of Equatorial Port Plug 1 components (CEA)

Cooling of the drawer at normal operation: Side drawer

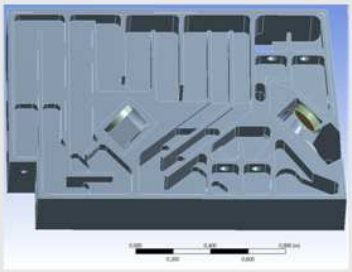


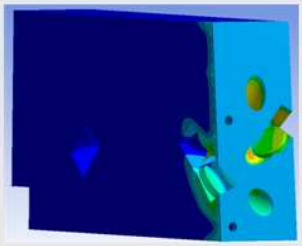
Temperature in °C

Reference design:

- Big distance between cooling channel and mirror

-High temperature on the mirror due to poor heat transfer





Reduction of the distance between mirror and cooling channel:

-Significant decrease of the temperature on the mirrors

-Still high temperature gradient on the mirrors which will have to be addressed in a next step

-Active cooling necessary

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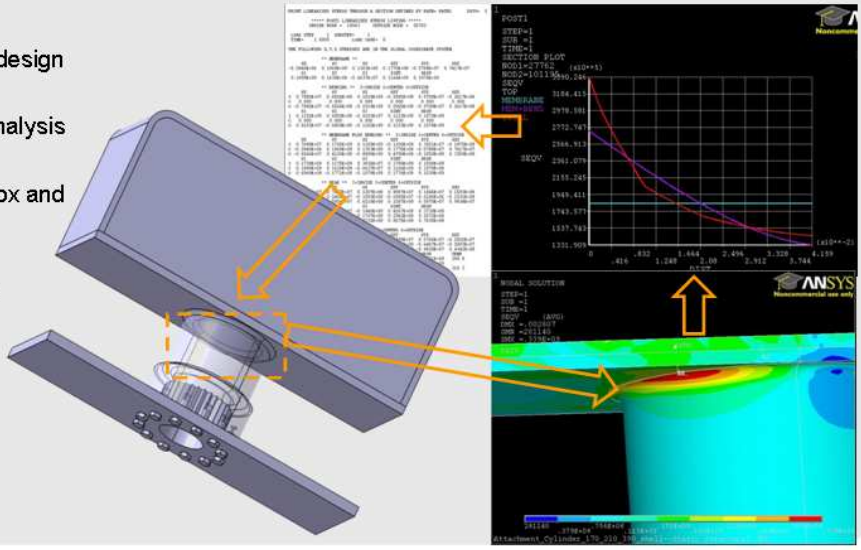
Technical Work

Design and Analysis of the attachment system (KIT)

- Development of new design
- Transient structural analysis
- Connection to TBM box and shield
- Strain sensor system



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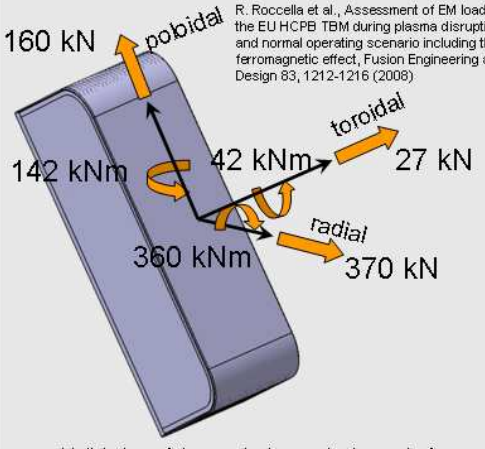
Technical Work

Design and Analysis of the attachment system (KIT)

Boundary conditions – Steady State

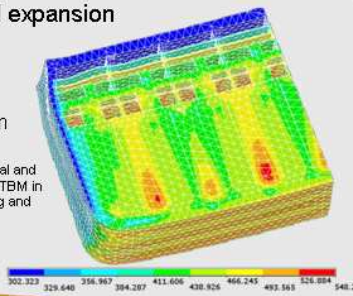
Maximum EM loads during fast VDE type II



R. Roccella et al., Assessment of EM loads on the EU HCPB TBM during plasma disruption and normal operating scenario including the ferromagnetic effect, Fusion Engineering and Design 83, 1212-1216 (2008)

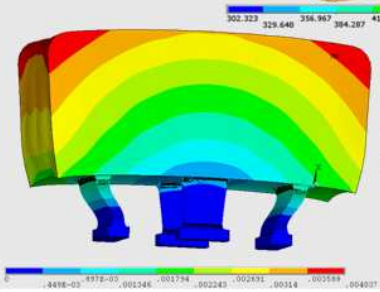
Validation of the analysis results is goal of the EM-campaign

Thermal expansion



Temperature distribution on quarter model

F. Cismondi et al., Design update, thermal and fluid dynamic analyses of the EU-HCPB TBM in vertical arrangement, Fusion Engineering and Design 84, 607-612 (2009)



Deformation due to thermal expansion

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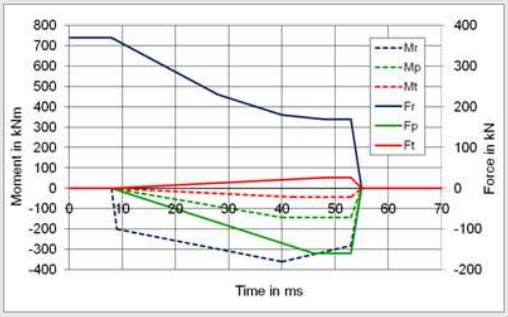
Technical Work

Design and Analysis of the attachment system (KIT)

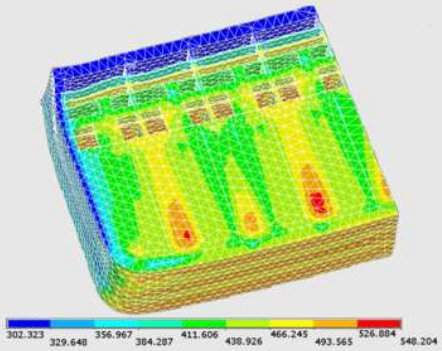
Boundary conditions – Transient

Transient EM loads during fast VDE type II



- First 8 ms are steady state conditions during normal pulse
- No damping is considered (conservative)

Thermal expansion



- Temperature distribution considered as constant due to short duration of plasma disruption

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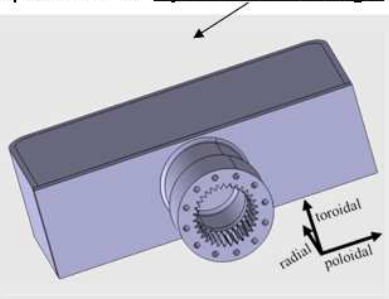
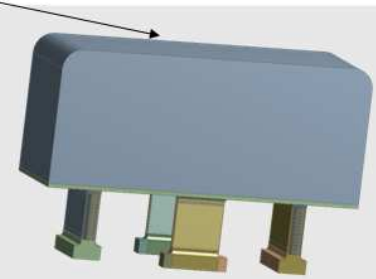
Technical Work

Design and Analysis of the attachment system (KIT)

Comparison of cylindrical design and lamella design





- Flexibility is less important due to central position
- Easy assembly as only one part has to be aligned

- Difficult trade off between flexibility and stiffness
- More space for piping

Stress evaluation - Static	Cylinder	Lamella	Limit	Margin Cylinder	Margin Lamella
Immediate plastic collapse	68	140	191	181 %	36 %
Immediate plastic instability	117	166	268	129 %	61 %
Immediate plastic flow localization	184	237	265	44 %	12 %
Immediate local fracture due to exhaustion of ductility	339	599	593	75 %	-1 %
Progressive deformation (RCC-MR)	315	352	573	82 %	63 %

- Higher margins of cylindrical design with regard to the stress limits
- Cylindrical design is new reference design for transient analyses

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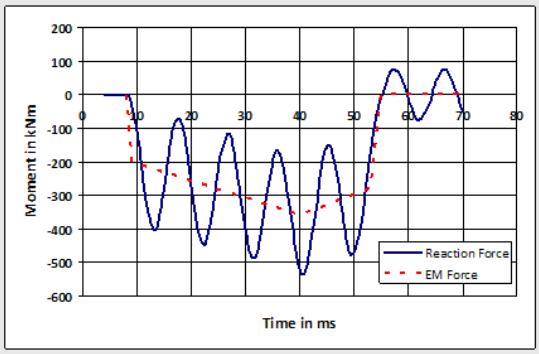
Technical Work

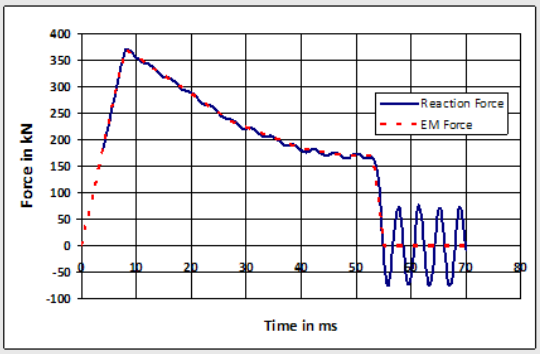
Design and Analysis of the attachment system (KIT)

Results of the transient analyses (1)

Radial Torque



Radial Force



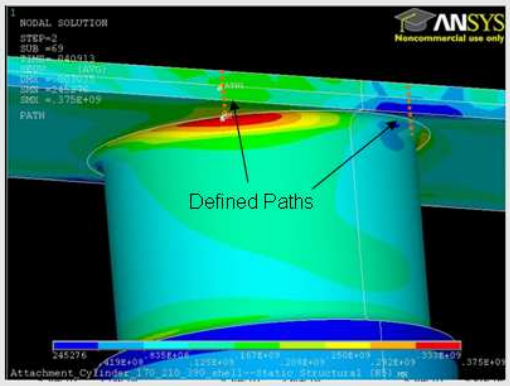
- Strong oscillations of the attachment system due to the fast rising of the radial torque component at the beginning of the VDE
- Significant oscillations at the end of the VDE

Technical Work

Design and Analysis of the attachment system (KIT)

Results of the transient analyses (2)

Stress state at 40.9 ms



Primary + Secondary stresses

Evaluation of the design according to SDC-IC and RCC-MR

	Stress in MPa	Limit in MPa
Immediate plastic collapse	93	191
Immediate plastic instability	154	268
Immediate plastic flow localization	204	265
Immediate local fracture due to exhaustion of ductility	375	593
Progressive deformation (RCC-MR)	345	573

The design complies with the requirements of the design codes:

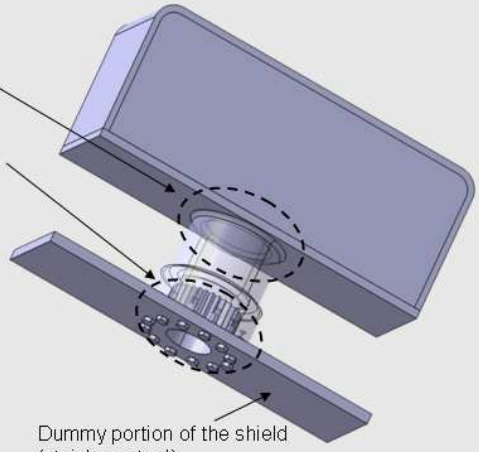
Stresses are within the limits at 300 °C

Technical Work

Design and Analysis of the attachment system (KIT)

Possible connection to shield and TBM

- Connection of TBM box and attachment system by welding
- Welding not preferable between shield and attachment system due to dissimilar materials:
  - Splined shaft to transfer high torque
  - Screws to restrict axial movement
- Routing of the pipes partially through cylinder



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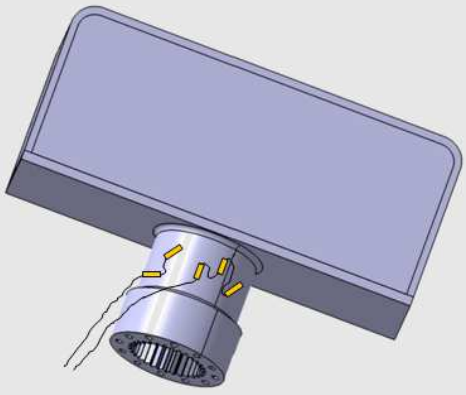
Technical Work

Design and Analysis of the attachment system (KIT)

Strain Sensor System

- Measurement of strains on the attachment system to validate design
- Optical fiber sensors could be used due to their electro magnetic immunity
- High temperature resistance of sensors has to be checked
- Concept for the fixation of the sensors on the cylinder and routing of the cables has to be developed
- Data acquisition system has be designed



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Outlook / Future Work

Technical Work 2012

- Final design of the connection of the attachment system to TBM box and shield
- Development of strain measurement system

Activities in the frame of Work Package 5

ITER GOT PPE review meeting
1th December 2011, Karlsruhe, Germany
József NÉMETH

Association EURATOM-HAS
KFKI Research Institute for Particle and Nuclear Physics

CONTENTS

- Retrospection
- Development of TATOP PI
- Secondment in KIT
- Next training steps

Activities in the frame of Work Package 5

Retrospection

Thermal analysis of ITER CXRS shutter actuator

Thermo mechanical analysis of ITER EQPP 1

Secondment in CEA

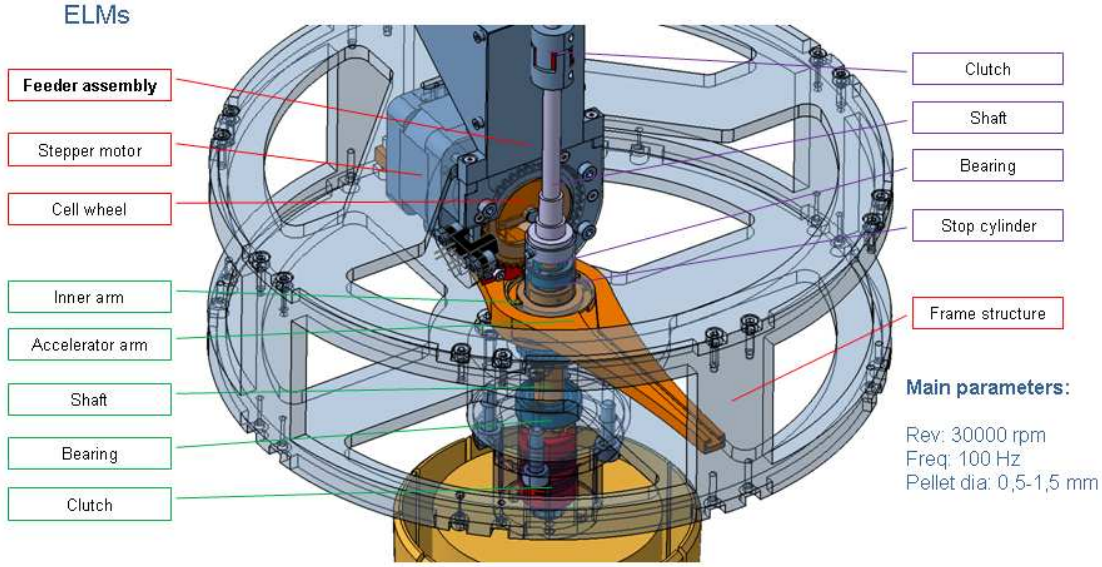
Integration of VisIR diagnostic

Activities in the frame of Work Package 5

Development of TATOP PI

Description of the appliance

The aim of the equipment: inject solid pellets into the plasma to examine the ELMs



Main parameters:

Rev: 30000 rpm
Freq: 100 Hz
Pellet dia: 0,5-1,5 mm

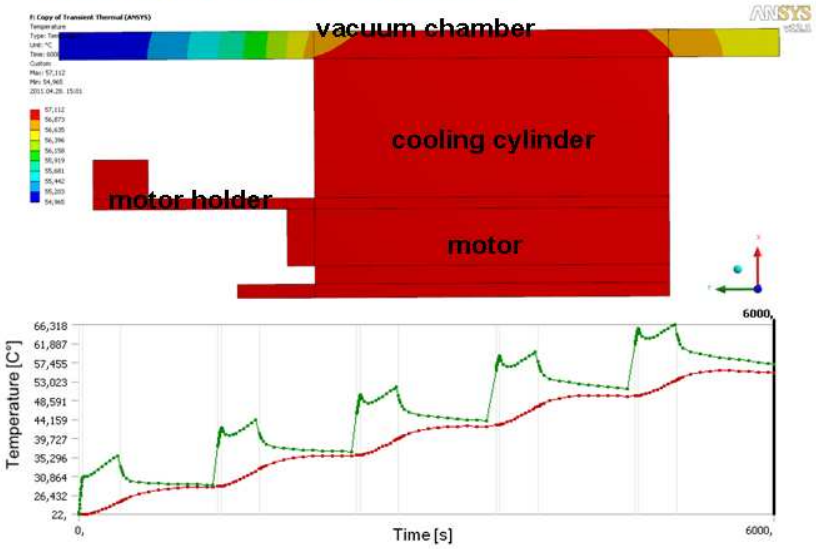
Activities in the frame of Work Package 5

Development of TATOP PI

Tasks to fulfill

Design

3D CAD modeling and 2D drawing
FEM analysis and analytical calculations



Activities in the frame of Work Package 5

Development of TATOP PI

Tasks to fulfill

Procurement

Standard parts and raw material
Manufacture tending

Table of suppliers and subcontractors

Company	
Kurt J. Lesker	Vacuum components
VG Scienta	Vacuum components
SKF	Bearings
TME Hungary Kft.	Electrical components
GordiuszINOX Kft.	Fasteners, bolts
Amari Hungaria	Raw materials
Italinox	Raw materials
Elemech Kft.	Manufacturing

Activities in the frame of Work Package 5

Development of TATOP PI

Tasks to fulfill

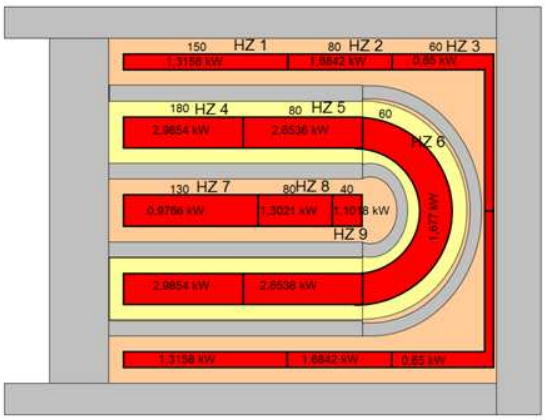
Testing

Activities in the frame of Work Package 5

Secondment in KIT

Secondment in INR – Thermal FEM analysis for HCPB-TBM Breeder Unit

The aim of this study was to define an adequate layout and power needs of the electrical heaters.



Used heaters

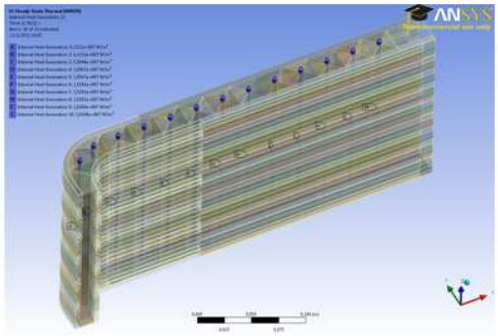
	THERMOCOAX SEI 10/200 wire	WATLOW 1/8" Firerod Cartridge
Diameter	Ø1 mm	Ø1/8 "
Max length	2000 mm	304 mm
Max power	750 W	744 W
Max temperature	1000 °C	760 °C
Material	Inconel	Inconel or 304 stainless steel
Area	Ceramics pebble bed volumetric heating	Beryllium pebble bed volumetric heating
Note	Minimum bending radius 3D	

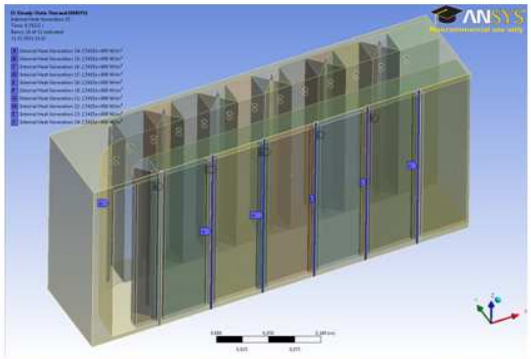
Activities in the frame of Work Package 5

Secondment in KIT

Description of the model

Because of symmetric reasons a half model has been examined, and hexa mesh has been applied.
The helium coolant has been represented by fluid elements.
The mass flows and the heat transfer coefficients in the cooling channels have been come from previous CFX simulations.
Temperature filed has been used on the boundary surfaces, which are the results of the reference simulation.



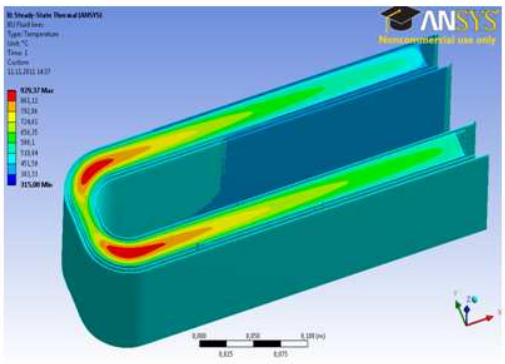


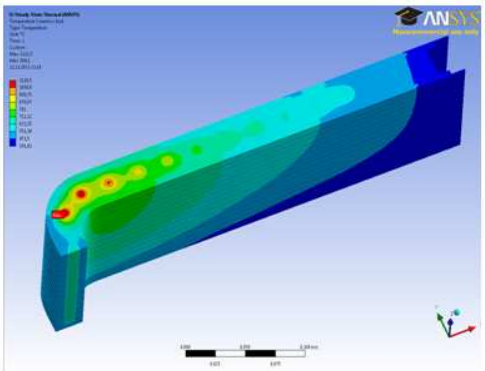
Activities in the frame of Work Package 5

Secondment in KIT

Results

The result shows, it is possible to reach similar average temperature in the structure with electrical heaters.
The temperatures show good conformity with the reference temperature field nevertheless some local temperature peaks are higher than the required.

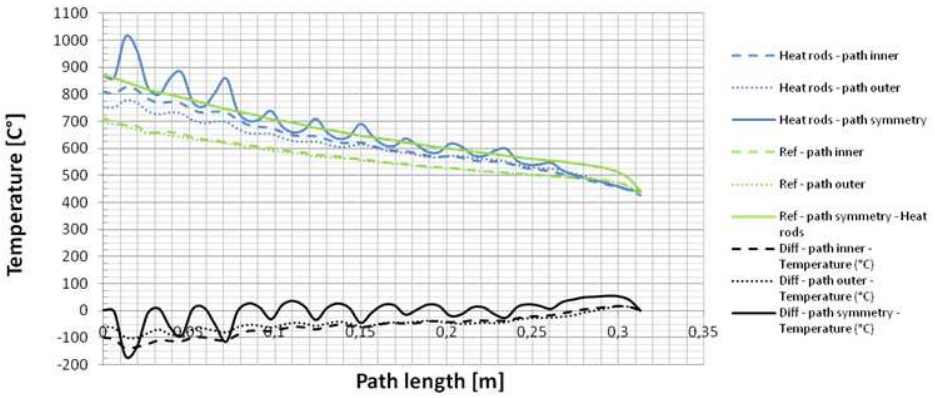




Activities in the frame of Work Package 5

Secondment in KIT

Conclusion



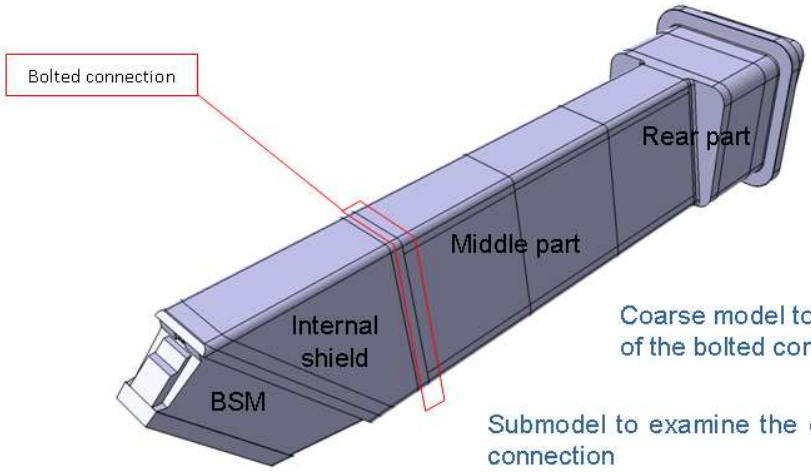
The line of the symmetry path is oscillating around the reference temperature, which means the average difference is very close to 0.
The neutronic heat generation has exponential shape what is not trivial to produce with one heating element.
We should use as dense heater division as possible, but the space requirements limit the number of the heaters.

Activities in the frame of Work Package 5

Secondment in KIT

Secondment in IAM – Structural FEM analysis for the bolted connection of the ECH UPP structure

The aim of this study is to examine the possibility of using bolts to attach the parts of the upper launcher.



Coarse model to detect the critical region of the bolted connection

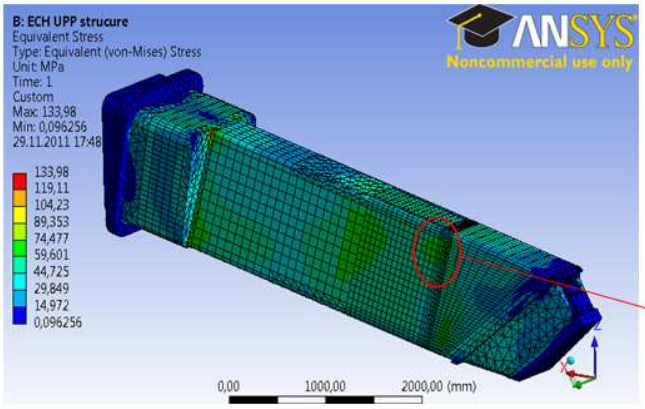
Submodel to examine the critical part of the bolted connection

Activities in the frame of Work Package 5

Secondment in KIT

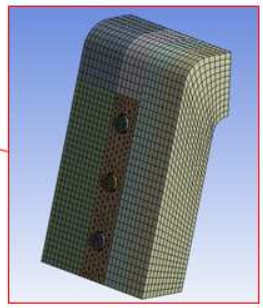
Description of the model

The loads are moments and forces, which come from electromagnetic loads.
The port plug was fixed at the back part of the structure.



Coarse model

Submodel



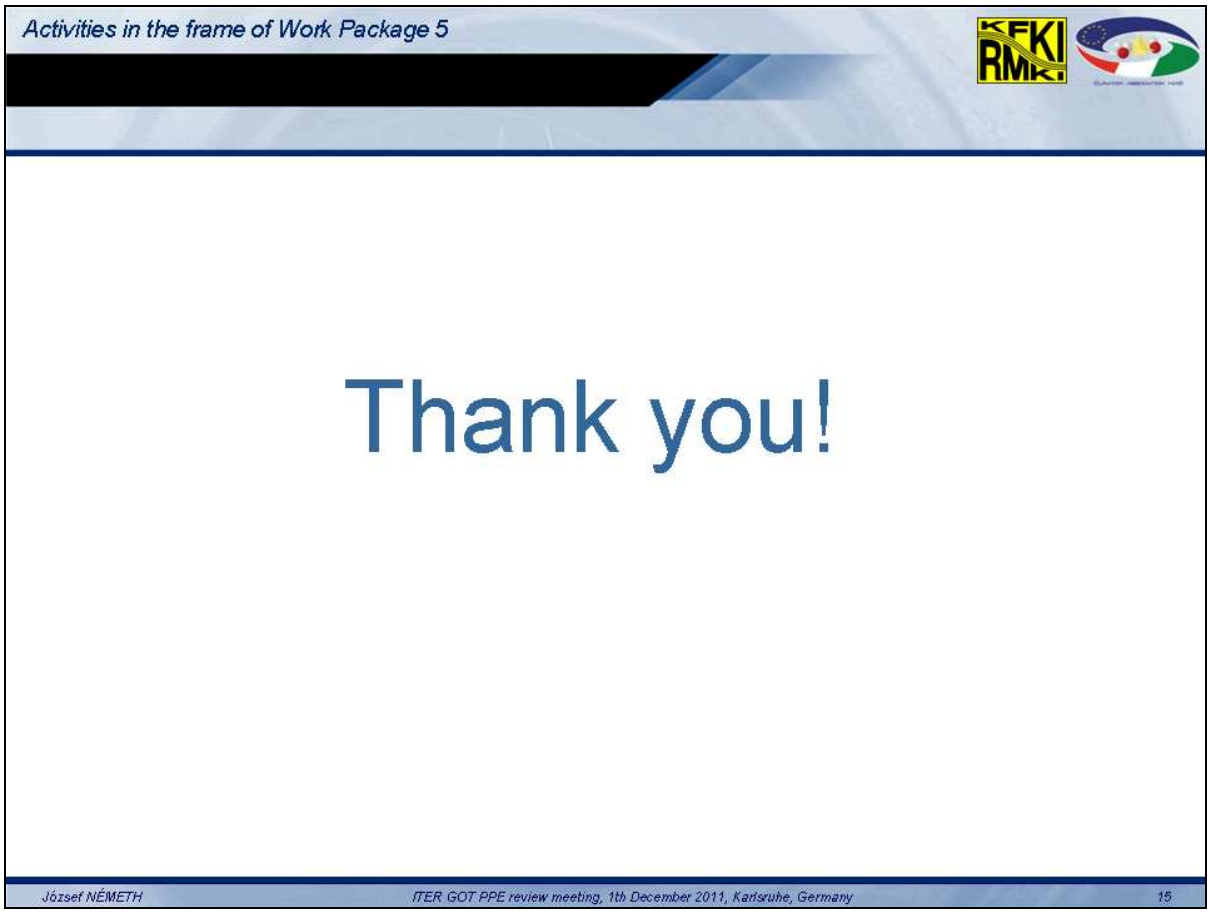
Activities in the frame of Work Package 5

Next steps in 2012

The work will be continued on TATOP PI.

Secondment in Jülich. Subject is not fixed yet.

Student supervising is foreseen during the summer.


Activities in the frame of Work Package 5
Thank you!
József NÉMETH
ITER GOT PPE review meeting, 1th December 2011, Karlsruhe, Germany
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Mitglied der Helmholtz-Gemeinschaft

JÜLICH FORSCHUNGSZENTRUM

WP6 – Activities

2. Dezember 2011 Romaric Voinchet

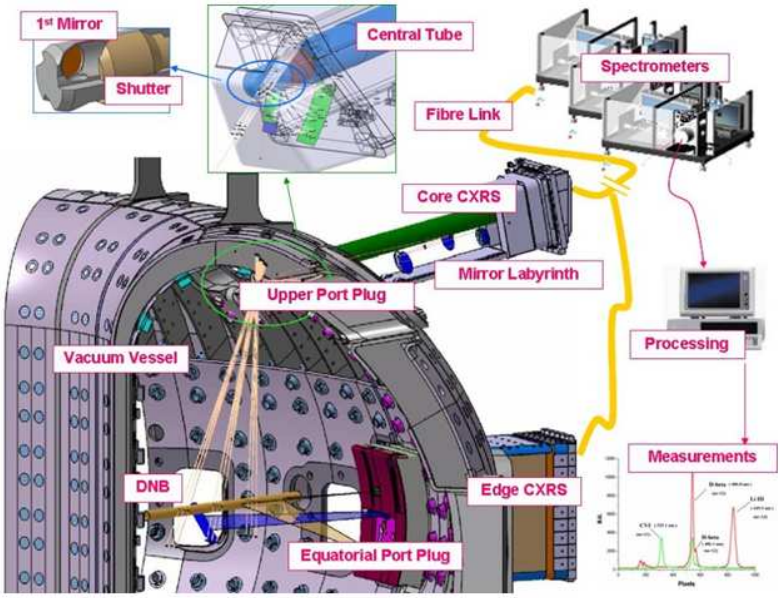
Overview

- Thermo-mechanical analysis of a concept of first mirror:
  - General assumptions;
  - First estimation: analysis of the mirror temperature and deformation with variation of the fluid parameters and cooling channel;
  - Second estimation: analysis of the mirror tilting during operation (α) as function of the contacts and cooling temperature of the support;
  - Third estimation: α and thermal analysis as function of the interfaces at hinges;
  - Fourth estimation: analysis of the chosen model;
- Analysis of a mirror cooling alternative with strips;
- Design of a concept of first mirror assembly
- Design of a test facility for analysis of castellation inclination in regard of particle deposition.

2. Dezember 2011 Folie 2

The cCXRS diagnostic – Reminder

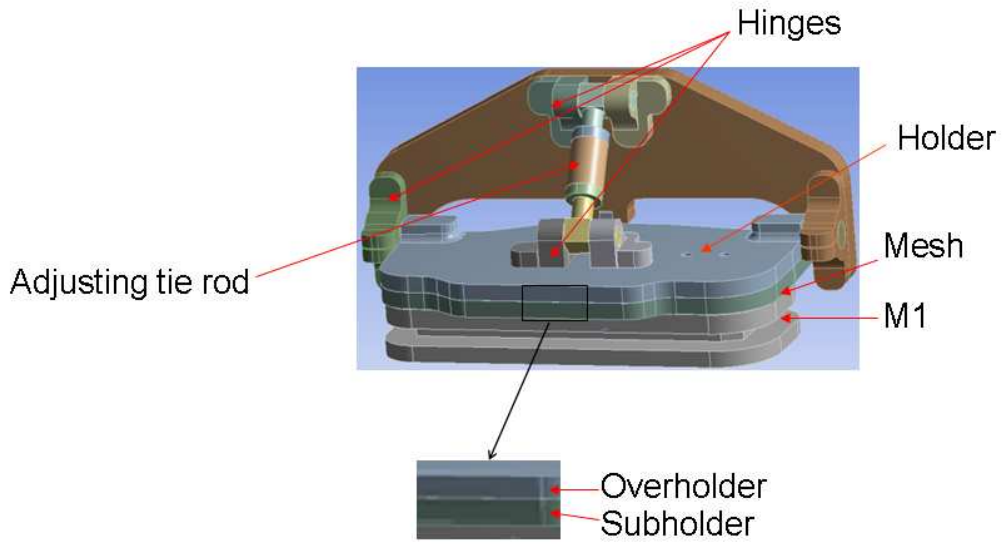
JÜLICH FORSCHUNGSZENTRUM



2. Dezember 2011 Folie 3

Thermo-mechanical analysis of a concept of first mirror - Model

JÜLICH FORSCHUNGSZENTRUM



2. Dezember 2011 Folie 4

Introduction

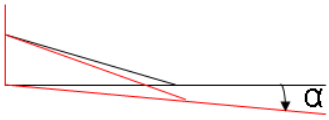
JÜLICH FORSCHUNGSZENTRUM

The thermo-mechanical analysis of the M1 assembly has been performed to:

- compare cooling channel options,
- analyze the thermal effect of the holder material, coolant pressure and velocity,
- analyze the M1 tilting during operation (α) as function of:
  - the contact conductance between components,
  - the cooling temperature of the DSM,
  - the interfaces hinges/holder,
- calculate the M1 local curvature radius, distortion and tilting (α and RT*/operation).

Conditioning phase (heating by fluid)

Operation phase (cooling by fluid)



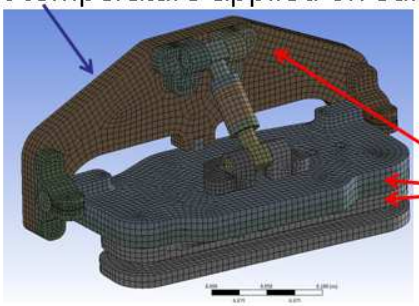
*RT: room temperature

2. Dezember 2011 Folie 5

General assumptions: thermal modeling details

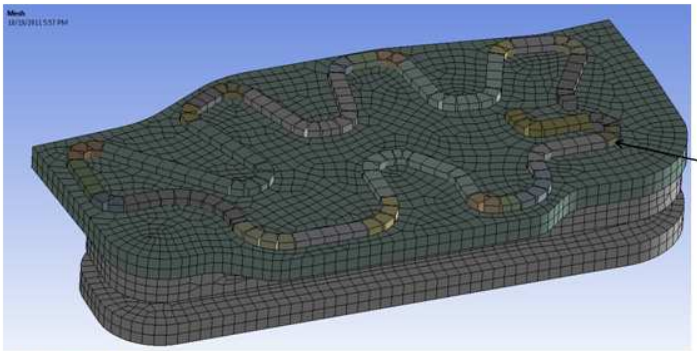
JÜLICH FORSCHUNGSZENTRUM

Support temperature applied on surface



Thermal elements: SOLID87/90

Neutron loads applied on volumes



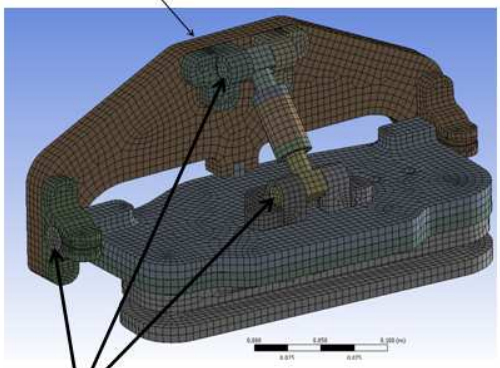
Fluid elements: FLUID116

2. Dezember 2011 Folie 6

General assumptions: structural modeling details

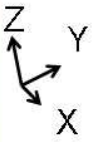
JÜLICH FORSCHUNGSZENTRUM

Support: fixed



Cylindrical support

Structural elements: SOLID186/187



α obtained by creation of 2 volumes from deformed nodes:
- 1 at conditioning
- 1 at operation

→ α = angle between the 2 volumes

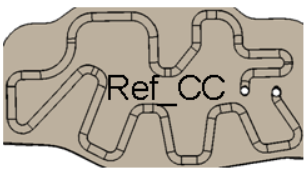
- Cylindrical contacts at hinges: no-separation type/pure penalty formulation (pivot links);
- All other contacts: bounded type/pure penalty formulation.

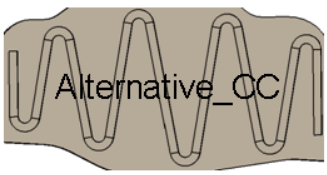
2. Dezember 2011 Folie 7

First estimation: analysis of the mirror temperature and deformation with variation of the fluid parameters and cooling channel

JÜLICH FORSCHUNGSZENTRUM

Model:
- Neutron loads: 0.3W/cm^3 for M1, 0.24W/cm^3 for the other parts
- Holder material: full SS and SS/CuCrZr;
- All hinges considered of SS;
- Fluid: Helium;
- Fluid pressure: 30 and 40bar, inlet temperature: 250°C;
- Fluid velocity: 8, 16 and 24m/s (503, 867 and 1192W/m².K, respectively);
- Temperature of the DSM coolant: 100°C;
- Cooling channel (reference (Ref_CC) and alternative (Alternative_CC)):

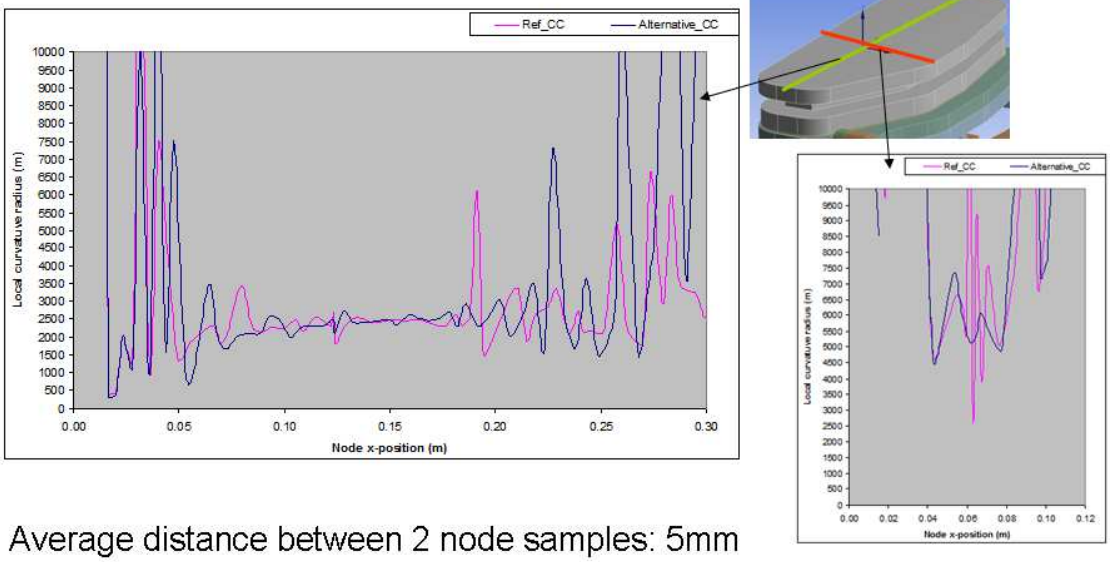




2. Dezember 2011 Folie 8

First estimation: cooling channel comparison - local curvature radius

JÜLICH FORSCHUNGSZENTRUM



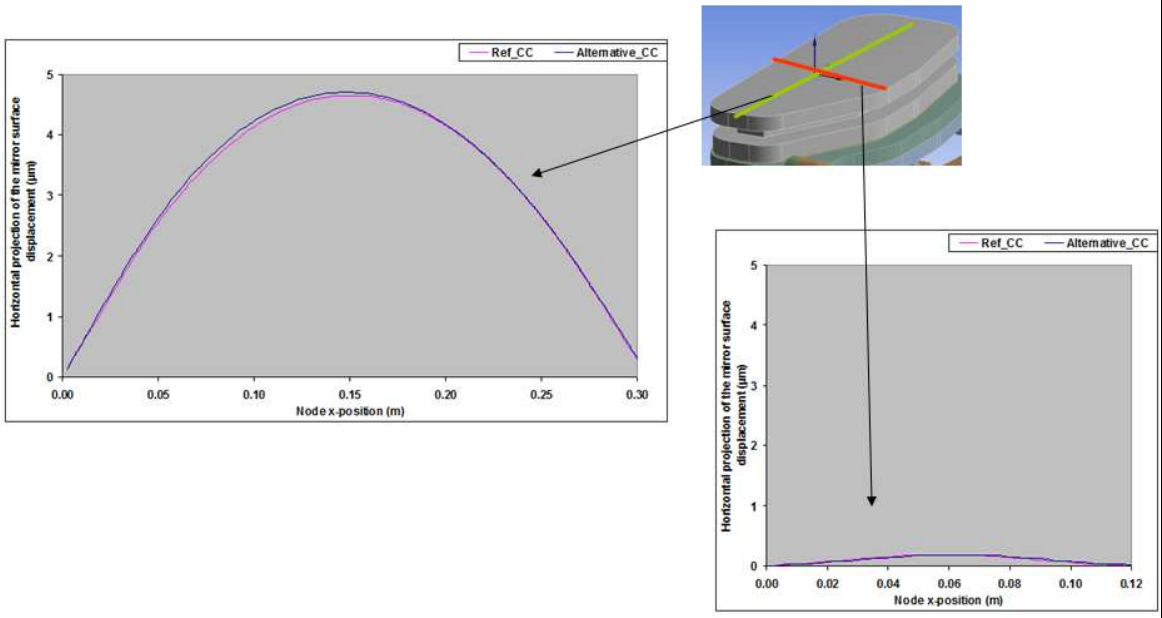
Average distance between 2 node samples: 5mm

Advantage for the reference cooling channel option: local curvature radius generally higher

2. Dezember 2011 Folie 9

First estimation: cooling channel comparison - distortion

JÜLICH FORSCHUNGSZENTRUM



Distortion comparable for both cooling channels

2. Dezember 2011 Folie 10

Second estimation: analysis of the M1 tilting during operation (α) as function of the contacts and cooling temperature of the DSM

JÜLICH FORSCHUNGSZENTRUM

Model:

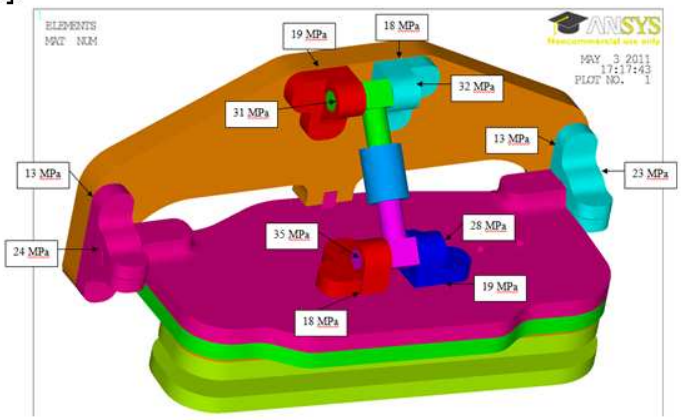
- Neutron loads: 0.3W/cm^3 for M1, 0.24W/cm^3 for the other parts
- Conductance*: "low", 500W/m².K, and "real", calculated from the contact pressure at links [7] considering:
  - cylindrical contact surfaces: Ra = 0.8µm,
  - flat contact surfaces: Ra = 1.6µm,
- Fluid: helium;
- Fluid pressure: 30bar, inlet temperature: 300°C;
- Fluid velocity: 24m/s (HTC of 1175W/m².K);
- Material:
  - SS for the holder and subholder,
  - inconel 718 for the adjusting tie-rod and hinges;
- Temperature of the DSM coolant: 100°C and 70°C;
- Cooling channel:

2. Dezember 2011 *For all contacts excepted those with mesh Folie 11

Second estimation: conductance from contact pressure

JÜLICH FORSCHUNGSZENTRUM

Contact pressures calculated from the M8 bolt preload of 400MPa [6]:



Tool created to calculate the contact conductance from the contact pressure [7]:

Material1/Material2	σ1: Roughness1 (m)	σ2: Roughness2 (m)	λ1: Conductivity1 (W/m.K)	λ2: Conductivity2 (W/m.K)	λ_{eq} (W/m.K)	P_c: Contact pressure (Pa)	σ_u: Ultimate strength of the softest material (Pa)	E1 (Pa)	E2 (Pa)	E (Pa)	Tc (°C)	Tmelt (°C)	K	Conductance (W/m².K)	Conductance with applied 52% error (W/m².K)
SS/Inc718	1.60E-06	1.60E-06	15.5	12.4	1.38E+01	1.30E+07	4.58E+08	1.93E+11	1.95E+11	1.94E+11	1.00E+02	1.26E+03	4.6875	4.92E+03	2.36E+03
SS/Inc718	1.60E-06	1.60E-06	15.5	12.4	1.38E+01	1.56E+07	4.58E+08	1.93E+11	1.95E+11	1.94E+11	1.00E+02	1.26E+03	4.6875	6.19E+03	2.97E+03
SS/Inc718	1.60E-06	1.60E-06	15.5	12.4	1.38E+01	1.80E+07	4.58E+08	1.93E+11	1.95E+11	1.94E+11	1.00E+02	1.26E+03	4.6875	5.99E+03	2.87E+03
SS/Inc718	8.00E-07	8.00E-07	19.24	16.65	1.79E+01	2.40E+07	4.07E+08	1.72E+11	1.83E+11	1.77E+11	3.50E+02	1.26E+03	9.375	1.75E+04	8.38E+03
SS/Inc718	8.00E-07	8.00E-07	19.24	16.65	1.79E+01	1.80E+07	4.07E+08	1.72E+11	1.83E+11	1.77E+11	3.50E+02	1.26E+03	9.375	1.47E+04	7.04E+03
SS/Inc718	8.00E-07	8.00E-07	19.24	16.65	1.79E+01	1.80E+07	4.07E+08	1.72E+11	1.83E+11	1.77E+11	3.50E+02	1.26E+03	9.375	1.47E+04	7.04E+03

2. Dezember 2011 Folie 12

Second estimation: analysis of cooling temperature at DSM

JÜLICH FORSCHUNGSZENTRUM

For plasma operation, the cooling temperature of the DSM would be reduced from 100°C to 70°C.

→ Impact of this reduction on the α angle:

Hinges	Contacts	Cooling temperature at DSM (°C)	α (mrad)
Inc. 718	Real	100	0.46
Inc. 718	Real	70	0.57

Impact negligible.

2. Dezember 2011 Folie 13

Second estimation: analysis of the contact conductance

JÜLICH FORSCHUNGSZENTRUM

The M1 tilting during operation (α angle) has been analyzed considering, at the hinge contacts, low conductance of 500W/m².K ("low") and calculated [7] from the contact pressure [6] taking into account the bolt preload of 400MPa ("real"):

Hinges	Contacts	Cooling temperature at DSM (°C)	α (mrad)
Inc. 718	Low	70	0.89
Inc. 718	Real	70	0.57

Relatively important impact

→ The contact conductance between part is a critical parameter for the α angle.

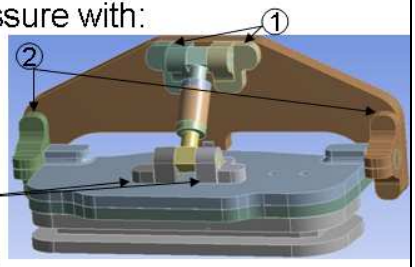
2. Dezember 2011 Folie 14

Third estimation: α and thermal analysis as function of the interfaces at hinges

JÜLICH FORSCHUNGSZENTRUM

Model:

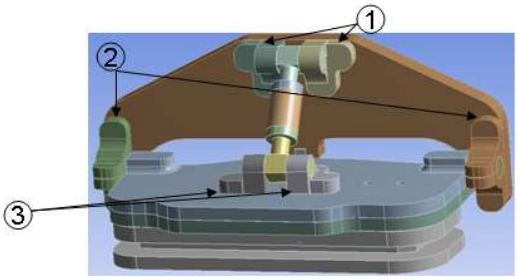
- Neutron loads: 0.3W/cm^3 for M1, 0.24W/cm^3 for the other parts
- Conductance at hinges considering contact pressure with:
  - contacts {1,2,3}: inc.718/SS (case 1),
  - contacts {1,2,3}: Cu/SS (case 2),
- Conductance at mesh: 10000W/m².K;
- Fluid: helium;
- Fluid pressure: 30bar, inlet temperature: 300°C;
- Fluid velocity: 24m/s (HTC of 1175W/m².K);
- Material:
  - SS for the holder and subholder,
  - inconel 718 for the adjusting tie-rod and hinges;
- Temperature of the DSM coolant: 70°C;
- Cooling channel:



2. Dezember 2011 Folie 15

Third estimation: analysis of the interfaces at hinges

JÜLICH FORSCHUNGSZENTRUM



Hinges	Contacts	Cooling temperature at DSM (°C)	α (mrad)
Inconel 718	{1,2,3}: Inc.718/SS	70	0.57
Inconel 718	{1,2,3}: Cu/SS	70	0.57

From thermal and α angle point of view, the copper interlayer at contacts {1,2,3} doesn't have interest, but may have from thermal stresses point of view.

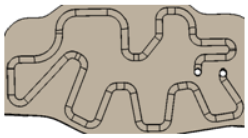
2. Dezember 2011 Folie 16

Fourth estimation: analysis of the chosen model

JÜLICH FORSCHUNGSZENTRUM

Model:

- Neutron loads: 0.3W/cm^3 for M1, 0.24W/cm^3 for the other parts
- Conductance at hinges considering contact pressure with Inc.718/SS interfaces (case 1 of the third analysis),
- Conductance at mesh: 10000 and 500W/m².K;
- Fluid: helium;
- Fluid pressure: 30bar, inlet temperature: 300°C and 260°C;
- Fluid velocity: 24m/s (HTC of 1175W/m².K);
- Material:
  - SS for the holder and subholder,
  - inconel 718 for the adjusting tie-rod and hinges;
- Temperature of the support coolant: 70°C;
- Cooling channel:

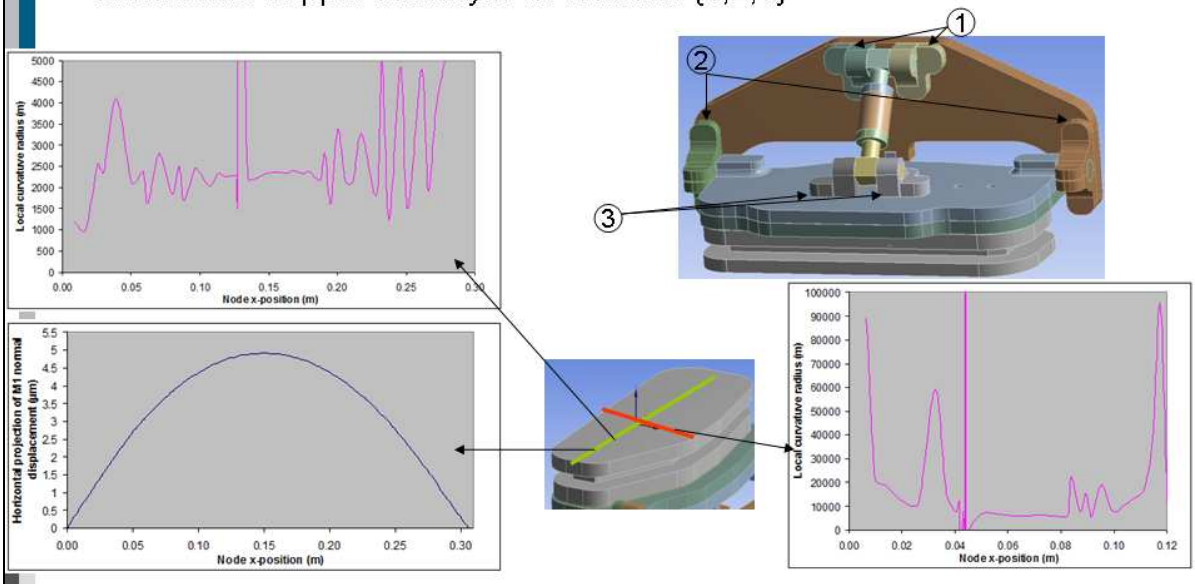


2. Dezember 2011 Folie 17

Fourth estimation: M1 local curvature radius, distortion and tilting

JÜLICH FORSCHUNGSZENTRUM

Model with copper interlayer at contacts {1,2,3}



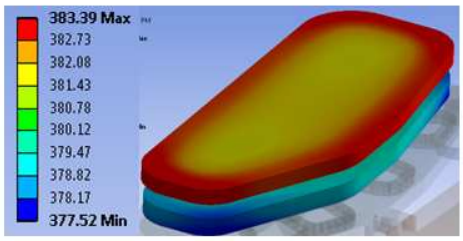
Minimum curvature radius: 900m, distortion: 5µm, M1 tilting (α): 0.57mrad, M1 tilting (RT/operation): 1.024mrad.

2. Dezember 2011 Folie 18

Fourth estimation: low conductance at mesh

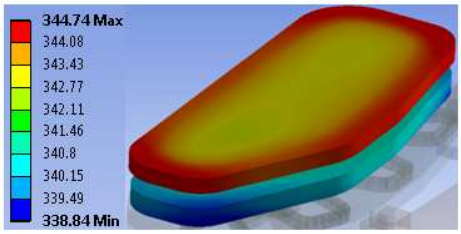
JÜLICH FORSCHUNGSZENTRUM

In case of low conductance at mesh (500W/m².K), the maximal temperature at mirror increases to 384°C. In this case the coolant inlet temperature has to be redefined.



Coolant inlet temperature to get 350°C as maximal M1 temperature: 260°C

Resulting temperature distribution:

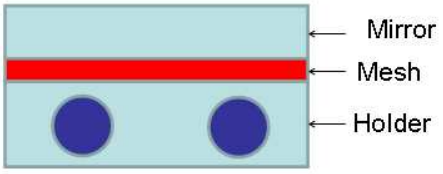


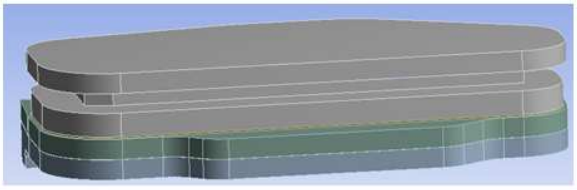
2. Dezember 2011 Folie 19

Analysis of a mirror cooling alternative with strips

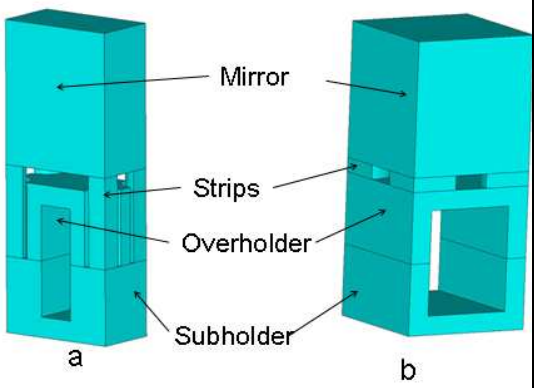
JÜLICH FORSCHUNGSZENTRUM

Aim: improve the heat transfer from the mirror to the holder (actively cooled)





Reference (contact with mesh)



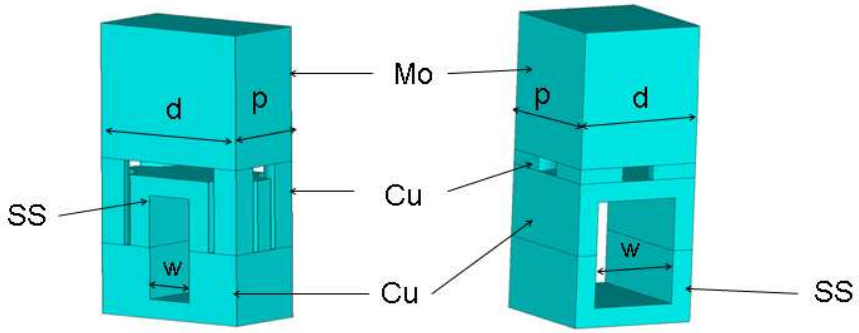
Alternative (contact with strips):
a: strips connected to the subholder
b: strips connected to the overholder

2. Dezember 2011 Folie 20

Model

JÜLICH FORSCHUNGSZENTRUM

- Neutron loads: 0.3W/cm^3 for M1, 0.24W/cm^3 for the other parts;
- Coolant temperature: 300°C;
- Contacts: ideal;
- Parameters:
  - d: distance between strip rows
  - p: strip pitch
  - w: cooling channel width
  - D: strip diameter



2. Dezember 2011 Folie 21

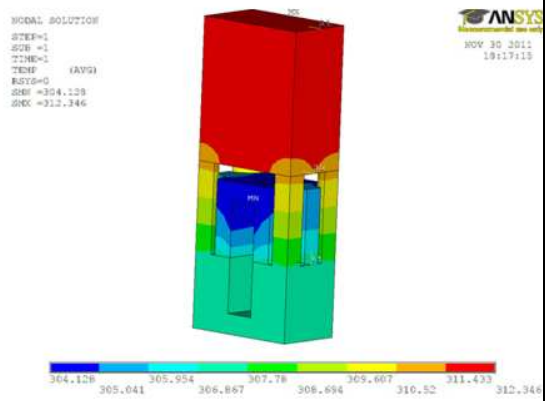
Results - alternative a (strips connected to the subholder)

JÜLICH FORSCHUNGSZENTRUM

1 – Variation of the strip pitch p, the strip diameter D and the cooling channel width w
→ optimal: p = 14 mm; D = 8 mm; w = 6 mm;

2 – Variation of the distance between strip rows d
→ optimal: d = 24 mm

Distance between strip rows d (mm)	Strip pitch p (mm)	Strip diameter D (mm)	Cooling channel width w (mm)	Max temperature at M1 (°C)	Max temperature gradient at M1 (°C)
24	14	8	6	312	1.5



2. Dezember 2011 Folie 22

Results - alternative b (strips connected to the overholder)

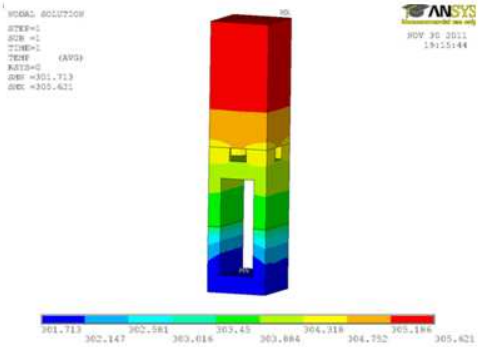
1 – For a strip diameter D, a strip pitch p and a distance between strip rows d :

variation of the cooling channel width

2 – Same procedure with another D, p and d

→ optimal: d = 14 mm; p = 14 mm; D = 10 mm and w = 8 mm

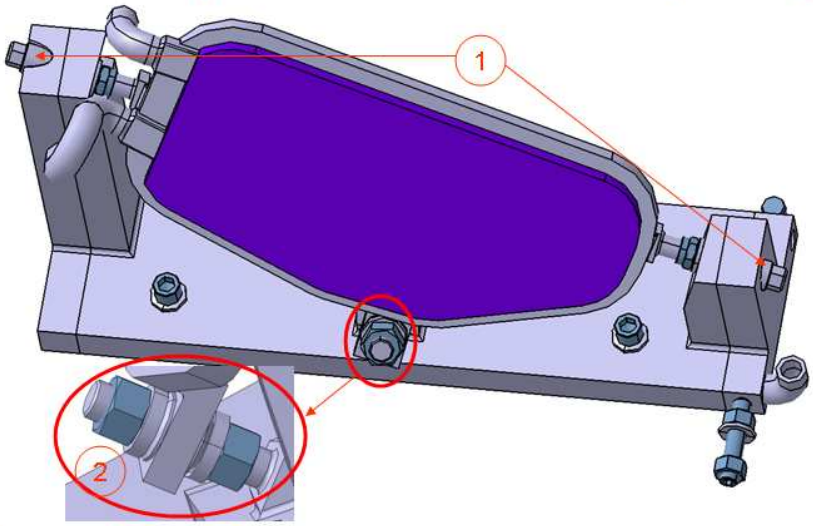
Distance between strip rows d (mm)	Strip pitch p (mm)	Strip diameter (mm)	Cooling channel width (mm)	Max temperature at M1 (°C)	Max temperature gradient at M1 (°C)
14	14	10	8	306	1



- The alternative b is preferable
- The optimal parameters found have to be adjusted to fit the concept of the mirror assembly

2. Dezember 2011 Folie 23

Design of a concept of first mirror assembly

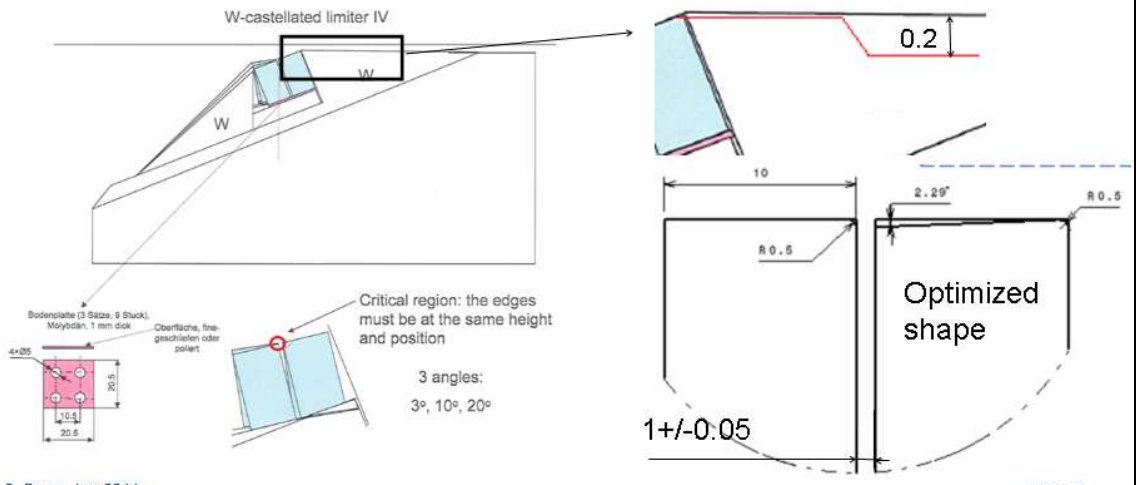


1. Screwing the cylindrical supports to the nuts at both holder ends with elastic washers (to allow symetric differential thermal expansion holder/adjustment system);
2. Adjustment by threaded rod in an oblong hole with 2 spherical washers + nuts.

2. Dezember 2011 Folie 24

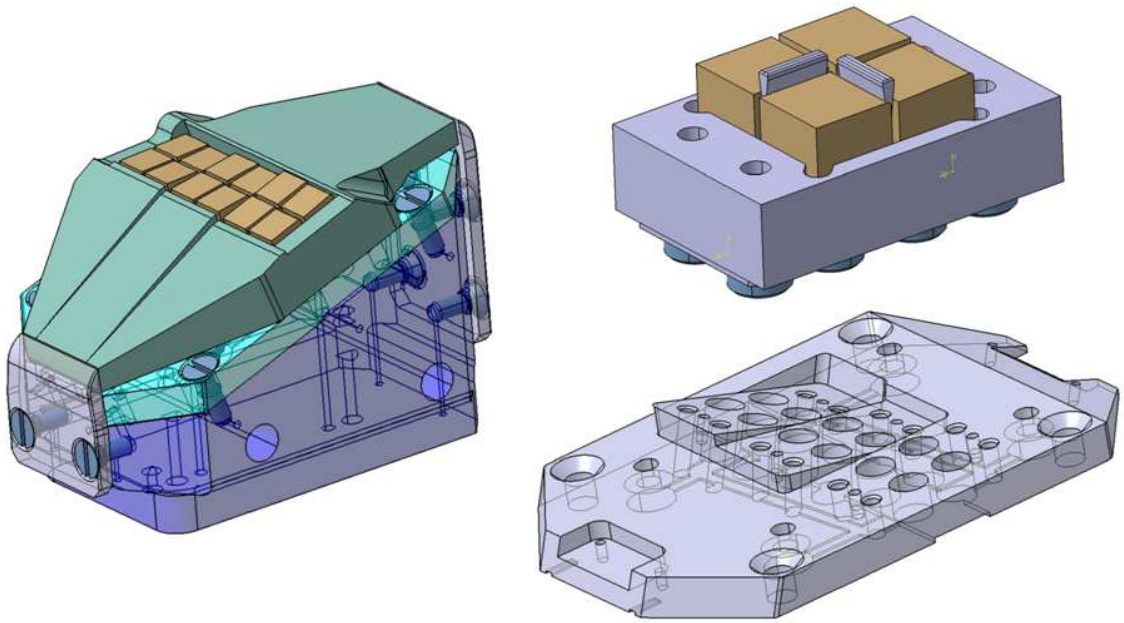
Design of a test facility for analysis of castellation inclination in regard of particle deposition

Aim: analyze the particle deposition from the plasma for different inclination of castellation
→Determine optimal inclination
→Check the advantage of optimized shape of castellation: create shadows from plasma (but decrease the exposed surface)



2. Dezember 2011 Folie 25

Design and manufacturing



- Manufacturing in progress

2. Dezember 2011 Folie 26

References

[1]: M. Lipa , Ph. Chappuis and A. Dufayet; Measurements of heat transfer coefficients at low contact pressures for actively cooled bolted armour concepts in Tore Supra; Fusion Engineering and Design 49–50 (2000) 243–248;

[2]: Korshunov I.G., Cherepaev V.I., Tarasov B.N.; Influence of media interface on thermophysical properties of bimetallic structures; Article n°10 275-276 (2002);

[3]: Thermal Contact Resistance; internet webpage (http://www.kxcad.net/SolidWorks/COSMOSWorks_online_help/analysis background/thermalanalysis/thermal_contact_resistance.htm);

[4]: Fernando H. Milanez et al.; Thermal Contact Conductance at Low Contact Pressures; JOURNAL OF THERMOPHYSICS AND HEAT TRANSFER Vol. 18, No. 1, January–March 2004;

[5]: AFCEN; RCC-MR 2007;

[6]: Anatoly Panin; determination of the bolt preloading considering the EM loads;

[7]: S.Y. Mesnyankin. A.G. Vikulov, D.G. Vikulov; Solid-solid thermal contact problems: current understanding; Physics-Uspekhi 52 (9) 891-914 (2009);

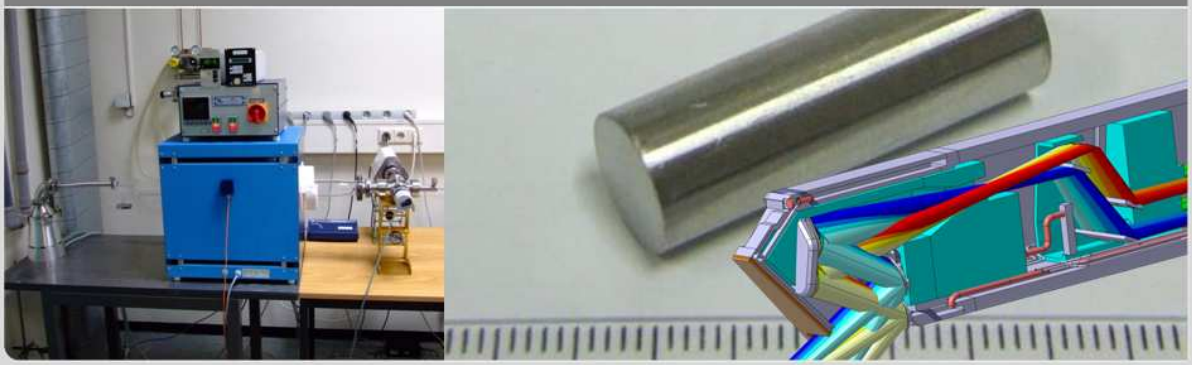
2. Dezember 2011 Folie 27

Karlsruhe Institute of Technology

ITER Port Plug Engineering: overview of the training activity performed in WP3

Trainee: Gaetano Aiello
Supervisor: Theo Scherer

Institute for Applied Materials

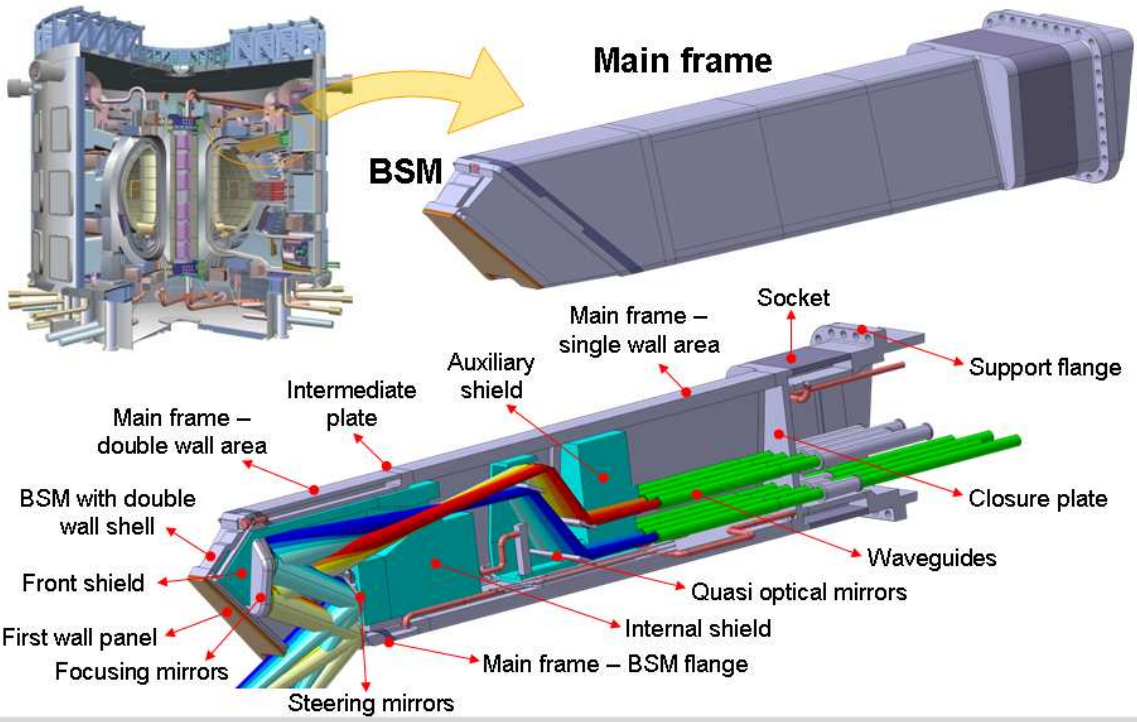


Work Package 3

Karlsruhe Institute of Technology

- Location: KIT, Institute for Applied Materials
- Start date: 01 September 2008
- End date: 31 August 2011
- Topic: materials, manufacturing and assembly of upper port plug structures, with particular application on ITER ECRH upper launcher
- Sharing among the associations: CEA/Cadarache, HAS

The ECRH upper launcher in ITER



Achieved objectives over three years

The trainee acquired experience and skills in:

- experimental outgassing measurements of SS-samples in vacuum and high temperature conditions,
- design of ECRH prototype components by CATIA,
- manufacturing and testing of ECRH prototype components,
- CFD and thermo-mechanical analyses of ECRH prototype components by ANSYS tools,
- project management,
- writing and preparing papers, posters and presentations for conferences and meetings.

Training courses

The trainee took part in training courses related to:

- fusion technologies,
- radioprotection and safety objectives of ITER,
- design and simulation tools (CATIA, ANSYS),
- RCC MR code,
- project management and effective negotiations,
- how to write scientific articles and reports in English and how to give high performance presentations.

5 01 December 2011 Overview of the training activity performed in WP3 Institute for Applied Materials

Secondments

The trainee carried out the following secondments:

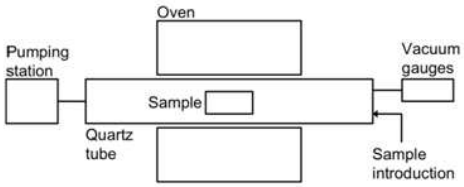
•CEA/IRFM institute in Cadarache, 02 May – 30 July 2010. He started developing a simplified neutronic CATIA model of the ITER diagnostic equatorial port plug 1.

•Company MAN in Deggendorf, 12 January – 2 February 2011. He worked in the prototype design of the double wall structure of the upper launcher main frame.

•Company REUTER in Alzenau, 02 – 21 April 2011. He experienced several welding techniques and milling, turning and grinding processes of components for vacuum chambers, etc.

6 01 December 2011 Overview of the training activity performed in WP3 Institute for Applied Materials

Example 1: outgassing measurements



An experimental setup was developed to investigate the partial outgassing rates *q* of HIPed SS-samples.

Results were presented at *SOFT 2010*.

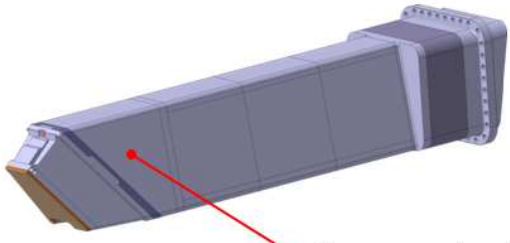
$$q = \frac{C(P_{sR} - P_{bR})}{A_r}$$

7 01 December 2011 Overview of the training activity performed in WP3 Institute for Applied Materials

Example 2: prototype design by CATIA

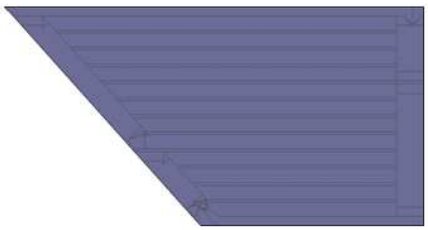
Objective: to identify the optimum manufacturing strategy for double wall components.

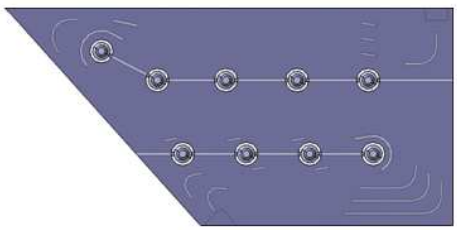
MAN DWE Apparatebau Deggendorf www.man-dwe.de



Nuclear heat loads up to 0.8 W cm^{-3}

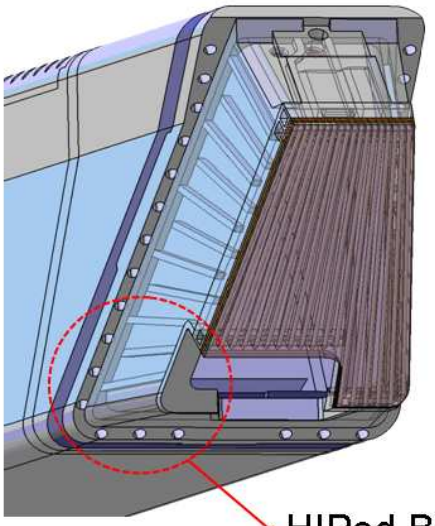
2 manufacturing options:





8 01 December 2011 Overview of the training activity performed in WP3 Institute for Applied Materials

Example 3: prototyping and testing of the BSM



HIPed BSM corner prototype

Thermo-hydraulic testing

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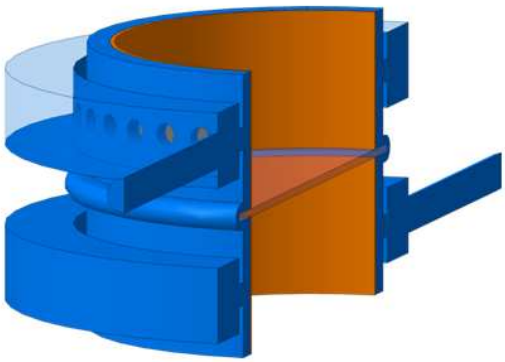
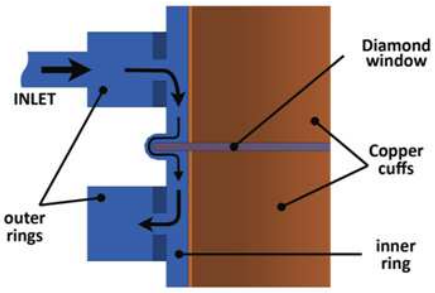
Example 4: CFD and thermo-mechanical analyses by ANSYS tools

CVD diamond window units are used for the microwave transmission as vacuum and tritium barriers towards the gyrotrons.





10 01 December 2011 Overview of the training activity performed in WP3 Institute for Applied Materials

Conclusions

- The trainee reached most of the objectives defined in the career developmet plan.
- Deviations from the plan: the trainee was involved in simulation work and did not perform the secondment at HAS.
- The trainee was hired till August 2014 by KIT to carry on his work in the team for the design and analysis of the ITER ECRH upper launcher.

Course and events

Topics	Date and Location	Duration	WP Interested	To be organise by	Comments	Status
General						
Introduction to fusion physic and technology	Sept 09 Karlsruhe	2 W	All	KIT	Karlsruhe fusion summer school	Done
Fusion materials	Spring 09/ Athena Greece	1W	All		KIT gives informations	Cancelled
Pulsma Physic and techno workshop	2010 / Hungary	2 days		HAS	Small conference	done
Training session at JET	08/06/09 = 12/06/09	1 W	All	UKAEA	Several topics around fusion technology	Done
Conference						
ISFNT, SOFE, ANIMMA, Other	2009		All		To be detailed WP1, WP2, WP3, WP4, WP5, WP6	Done see trainee presentation
SOFT 2010	2010		All		All WP present	Done
Infrared millimetre Conference	2011		WP3			Cancelled
Technical meeting on ECRH for large fusion device	2011					Cancelled
Engineering tools						
Catia V5 basic training	2009	1W	All		No common training	Done in associations
Catia V5 advanced training	2010	1W	All		No common training	Done in associations
Smarteam	2009	1W	All	KIT		Not yet organised, postponed in 2011 if required to be discussed with M. Lux Cancelled
ANSYS (classic including workbench)	2010	1W	All	HAS	Common training	Done
ITER						
Introduction to ITER design on PPE	2010		All	ITER/CEA	To be discussed with ITER DO,	Postpone in 2011 if required, waiting for A. Malaquias information, end of January. Cancelled
Introduction to ITER CAD tools	ITER DO 2009	1W	All	CEA	To be discussed with ITER DO	Postpone in 2011 if required waiting for A. Malaquias information, end of January. Cancelled
Port plug design manufacturing and QA (upper and equatorial)	2010		All	CEA/LJ		To be combine with ETN_QPM, postpone in 2011, waiting informations from A. Malaquias. Cancelled
Assembly and acceptance test procedure	2011		All	?		See RCC-MR courses
Nuclear						
Nuclear engineering	Cadarache 09 08/12/09 = 11/12/09	1 W	All	CEA	AREVA TA	Done
QA in nuclear engineering	Cadarache 10			CEA	AREVA TA ??	To be combine with ETN_QPM, postpone in 2011 Cancelled
Vacuum technology in nuclear environment	2011			KIT		Done Proposed by KIT with SMARTEAM (2days for vacuum, 3 days for SMARTEAM) Done in 2011
Vacuum technology	2011			KIT		Same that above Done in 2011
Nuclear Codes and standard (RCC-MR, ASME,..)	2010	1W	All	KIT	AREVA NP	Done
Neutronics and radiation protection (ALARA)	2009					Done included in Nuclear engineering
Remote handling and maintenance in nuclear plant	2010		All	CEA	CEA Marcoule	INSTN Marcoule D. Keller, postpone in 2011 Cancelled
Management						
Project management	2011	1 W	All	KIT	Common training? WP3	Done See FTU waiting for information of Theo Scherer
Procurement and risk management	2011				Common training? WP3	Done See Project management
Level 3 documents	2010		All	CEA		Cancelled
FTU offered training	2010/ KIT	1W	All	KIT	28/29 october	Postpone in 2011 if required Cancelled

Work Programmes	Host WP1/CEA	Host WP2/CEA	Host WP3/KIT	Host WP4/KIT	Host WP5/HAS	Host WP6/FZJ
WP1/CEA						**3 month manufacturing.** **Cancelled**
WP2/CEA						
WP3/KIT					**3 month diag assembly** **Cancelled**	
WP4/KIT		**3 months Design and Assembly simulation on equatorial port plug** **TBD in February**			**3 months Analysis** **TBD in February**	
WP5/HAS						**2 months** **Analyses UPPP CXRS** **Thermal-stress, structural and hydraulic analyzes of units of alternative CXRS.** **TBD**
WP6/FZJ						

	Ass1		Ass2		Ass3		Ass4		Total
	current year	cumul	current year	cumul	current year	cumul	current year	cumul	
Expenditures under additional support Personnel costs - training - mentoring Other costs									
total in k€									
in % of the global budget (1)									
mobility costs									

(1) please comment any deviation with the budget (forecasts of under/over expenditures)

EFDA GOAL ORIENTED TRAINING PROGRAMME

Template Proposal

"Periodic Network Report"

1. GENERAL PROGRESS OF THE PROJECT

a) The Project is running as originally planned b) Some minor modifications are needed c) Major modifications are needed	❑ ❑ ❑

2. IDENTIFICATION OF PROBLEMS ENCOUNTERED AND CORRECTIVE ACTION(S) TAKEN; ACTIVITIES ON CRITICAL PATH

If you answered b) or c) under 1.), please include a detailed description of the research problems encountered, deviations and/or modifications to the project during the reporting period.

3. ADMINISTRATIVE MATTERS OR ANY OTHER POINTS OF RELEVANCE

E.g., changes in TA positions (coordinator, scientist-in-charge) should be reported.

4. FINANCIAL MATTERS

	ASS 1 ..... ASS 2					ASS N		TOTAL	
	current year	cumul	current year	cumul		current year	cumul	current year	cumul
Expenditures under additional support Personnel costs - training - mentoring Other costs									
total in k€									
in % of the global budget (1)									
mobility costs									

(1) Please comment any deviation with the budget (forecasts of under/over expenditures)

5. TIME AND DURATION OF EACH INDIVIDUAL CONTRACT

Network Partner	**Name of the trainee**	**Start of training / employment contract**	**Duration of contract (months)**

6. IMPLEMENTATION STATUS

Rate of recruitment for each participant (trainee) and for the TA as a whole (ratio person-months filled/offered)

A	B	C	C/B
Network Partner	**Man-months training contractually foreseen at the end of the reporting period (cumul)**	**Man-months training performed at the end of reporting period (cumul)**	**Percentage of compliance**

Nature and justification for adjustments, if any, to the original overall number of person-months per trainee

7. ORGANISATION OF THE NETWORK MEETINGS (CAN BE REMOTE)

Place of TA meeting	Date and duration of TA meeting

8. PRESENTATIONS BY THE TRAINEES TO PEER GROUPS

Name of trainee	**Title of presentation**	**Date**	**Place**

Cumulative overview from the respective start of the training:

Name of trainee	Total No. of presentations to	No. of presentations to

	peer groups so far	peer groups expected by the end of the training

9. PAPERS SUBMITTED BY THE TRAINEES FOR PUBLICATION OR PRESENTED AT CONFERENCES

Name of trainee	**Title of paper**	**Lead Author Y/N**	**Authors**	**Name of the Journal**	**Name, date and place of conference**

Cumulative overview from the respective start of the training:

Name of trainee	Total No. of publications submitted so far	No. of publications expected by the end of the training

- More Categories like above, e.g., patents, can be included if considered useful in the particular context -

10. COURSE WORK COMPARED WITH THE TARGET AGREED

Indicate the overall target of course days.

Name of trainee	**Course title**	**Date**	**Place**	**Duration (days)**

Cumulative overview from the respective start of the training, including previous reporting:

Name of trainee	Total No. of course days attended so far	No. of course days to be attended by the end of the training:

11. REPORT ON TRAINING ACTIONS BY THE TRAINEES AND THE SCIENTISTS IN CHARGE

For each trainee, a **Trainee Report** for the reporting period produced by the trainee and confirmed by the supervisor for quality and progress against the planned work must be annexed to this Periodic Activity Report:

Trainee report of	**Annex number**

EFDA GOAL ORIENTED TRAINING SCHEME

TASK AGREEMENT
WP……. ……

Trainee Report - Template
Reporting Period: ……..

Entire Period of Research Training: ……

NAME OF TRAINEE:
EMPLOYING INSTITUTION / TA PARTNER:
REPORT ON TRAINING ACTIONS *Guidelines(to be deleted)* *Each trainee should report on his/her activities during the reporting period. This report should be confirmed by the supervisor. The report should address the following points:* • *Main training activities performed,* • *milestones reached,* • *status of deliverables,* • *general performance in comparison to the career development plan of the research training activities including any deviations from the original work plan.* *(Length of the report: up to 2 pages including a list of references; publications, reports, seminars, etc...)*

DATE:
NAME AND SIGNATURE OF TRAINEE:
NAME AND SIGNATURE OF SUPERVISOR / SCIENTIST-IN-CHARGE (HOME INSTITUTION):
SIGNATURE OF SUPERVISOR / SCIENTIST-IN-CHARGE (HOST INSTITUTION) if applicable**:**