

# TIK-4.3 Irradiation Module

In-Kind Partner Team: **Consiglio Nazionale delle Ricerche (CNR)**

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ESS Teams: Moderator and Reflector, Neutronics, Handling, Materials

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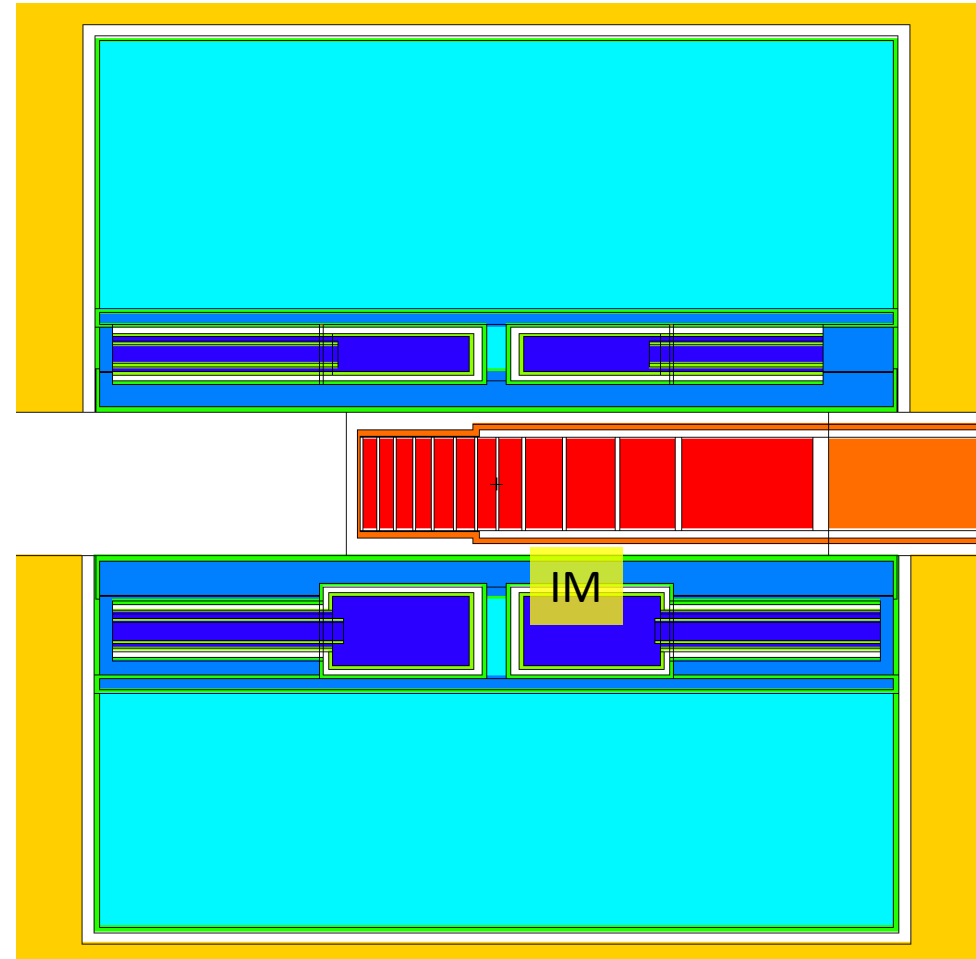
July 6th, 2016

# Outline

- Highlights
- Near-term plans
- Risks and issues
- Concluding remarks

# Highlights of work since last meeting

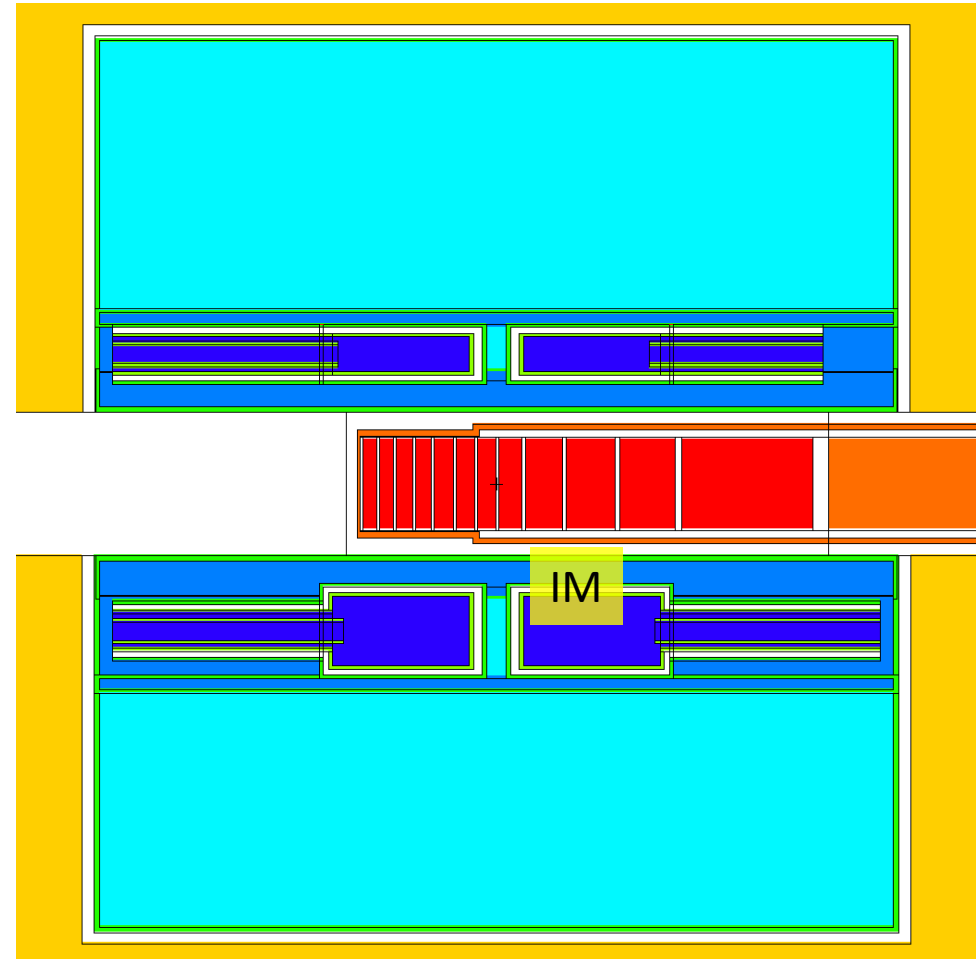
- Following the final choice of location for the module (Nov. 2015), the Irradiation Module work element has been put under the Moderator Reflector plug work unit.
- Scheduling has changed considerably due to Interfaces. Changes to the scheduling moved inward the final delivery on site to Nov 1 st 2016, with respect to previously scheduled date of July 31st 2017



# Highlights of work since last meeting

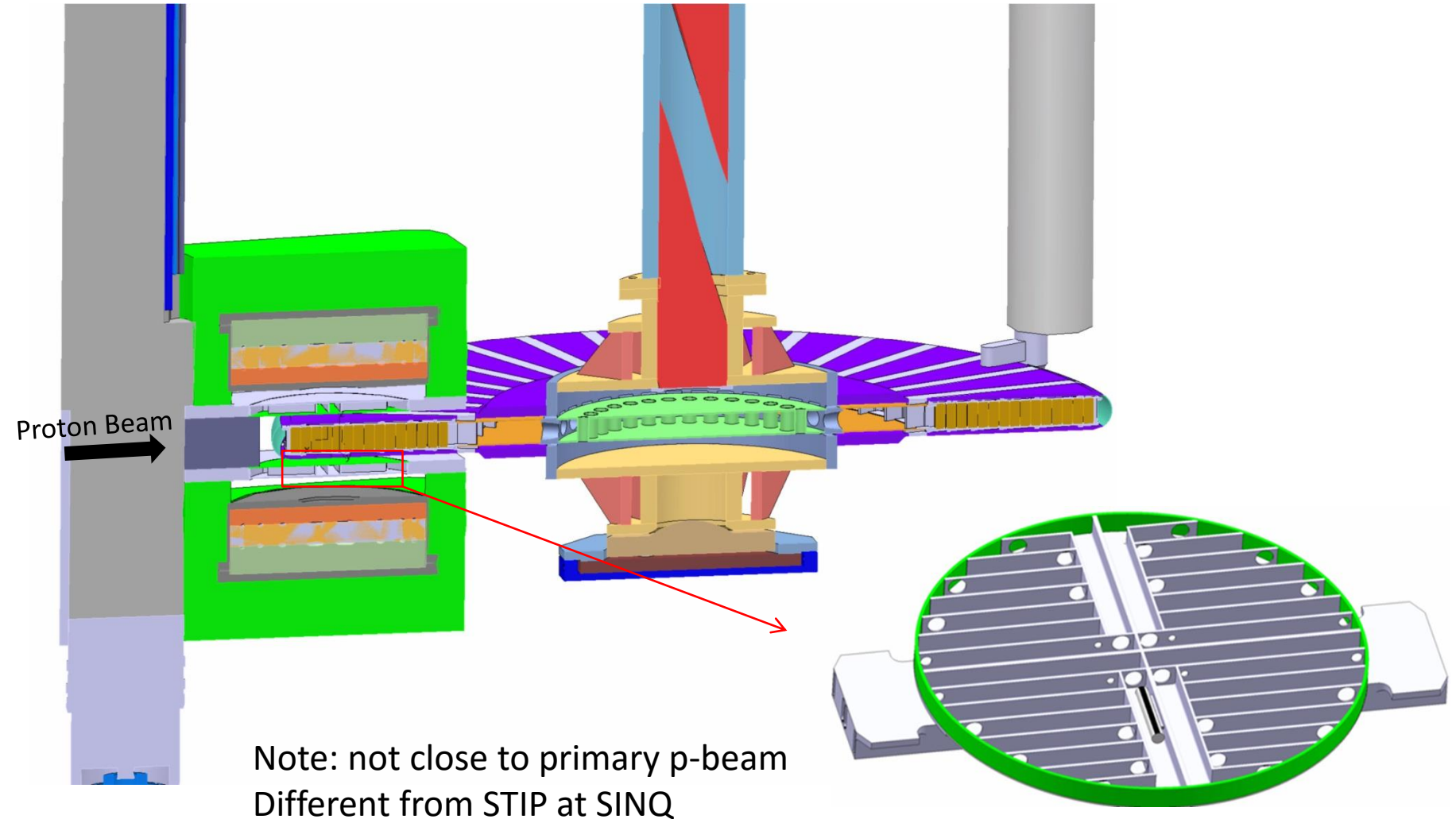
## •To this aim restructuring of the work plan includes:

- Manufacturability test and manufacture of the IM and samples to be carried out by Julich (MR plug in Kind partner)
- Compliance of the design with the intent of the design standards of RCC-MRx to be carried out by Julich (MR plug in Kind partner)
- Handling, defining the logistical and interface needs, concepts for extraction of the Irradiation Module after irradiation, to be carried out in collaboration between CNR, ESS, Julich



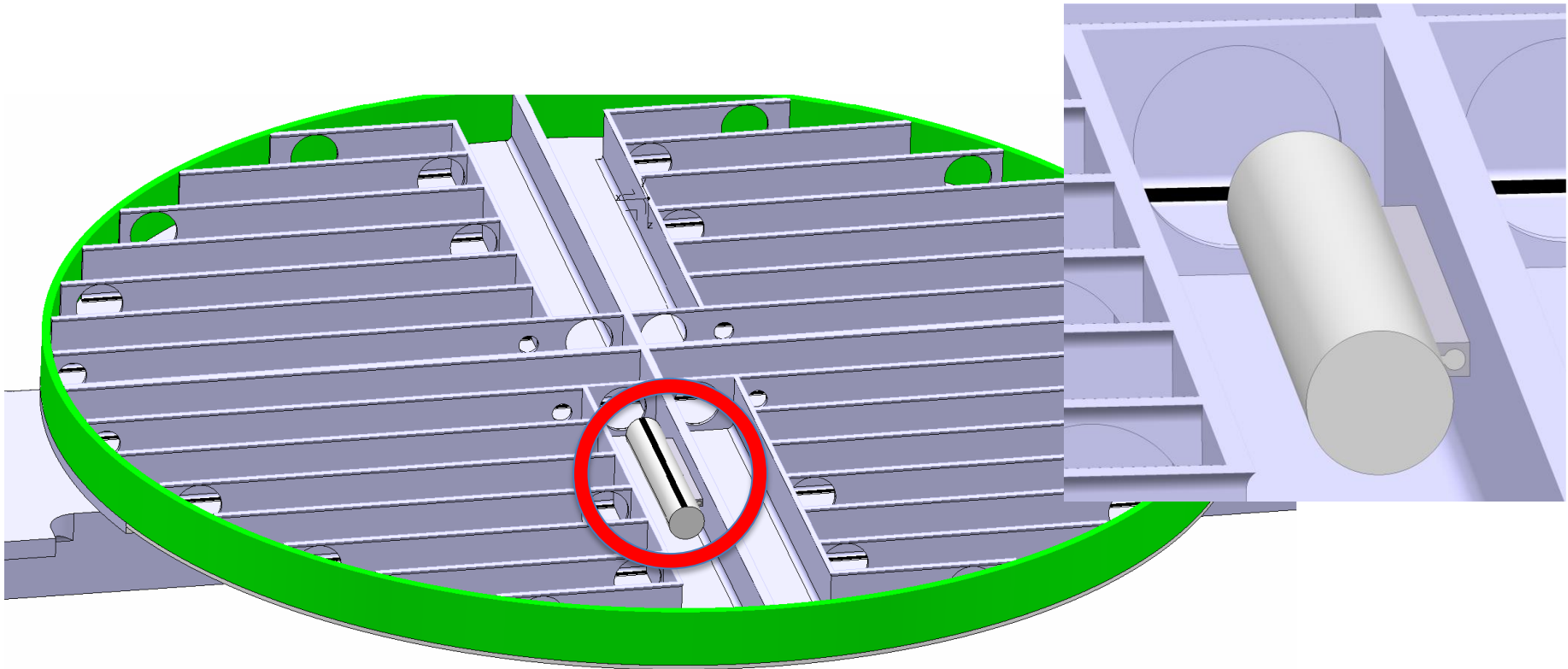
# Highlights of work since last meeting

## Updated concept



# Highlights of work since last meeting

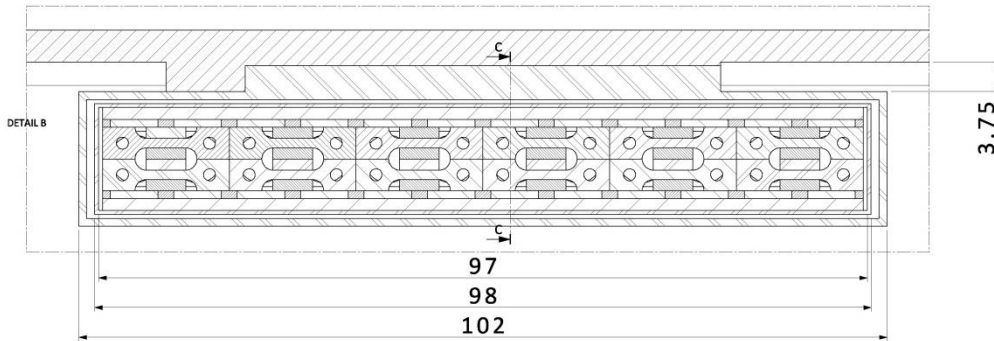
## Updated concept



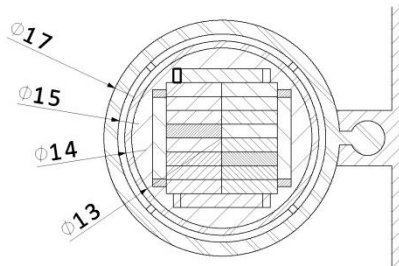
Sample specification description completed in June 2016, led by ESS Materials group

# Highlights of work since last meeting

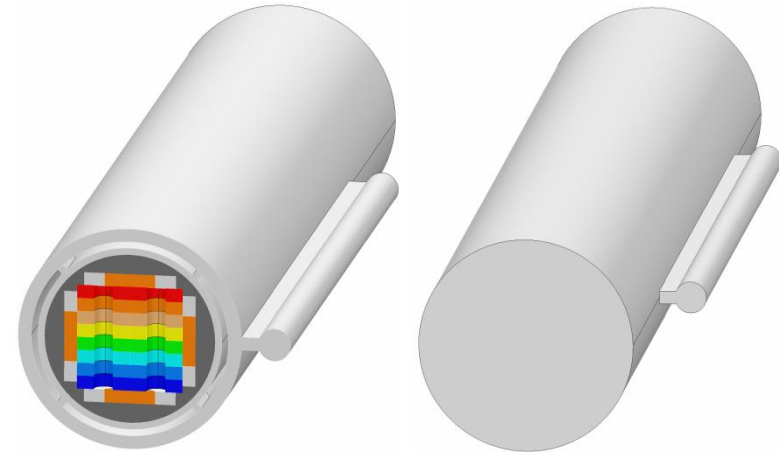
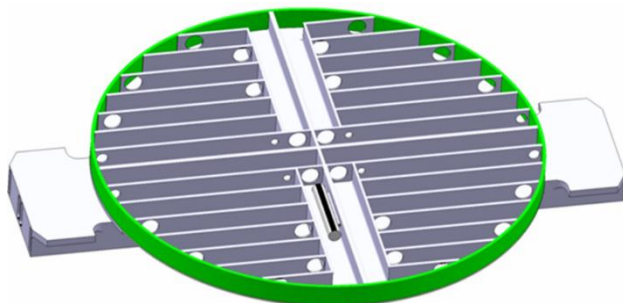
## Updated concept



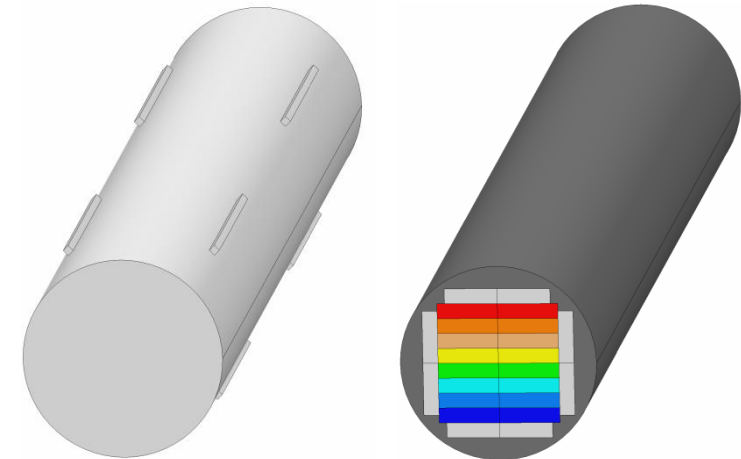
SECTION C-C (7:1)



<b>ASSY WEIGHT: 4g</b>		DRAWING TITLE: BIP-PLUG/START TITLE	
General Information	Revision	Imitation Module: main dimensions	ISSUANCE NUMBER
Form and Number: <b>ISO 2768-mK</b>	DESIGNED BY	DATE	<b>ESS-0062068</b>
Character: <b>ISO 2768-mK</b>	CHECKED BY	DATE	SPECIFICATION
Material: <b>Al 6061-T6</b>	APPROVED BY	DATE	REV. SHEET
Classification: <b>ISO 15015</b>	DATE	DATE	1/1
Dissemination protection as per <b>ISO 15015</b>	DATE	DATE	SCALE
ESS EUROPEAN SPALLATION SOURCE	DATE	DATE	A2 1:1
DATE	DATE	DATE	CATIA V6



Outer Vessel: Al 6061 –T6



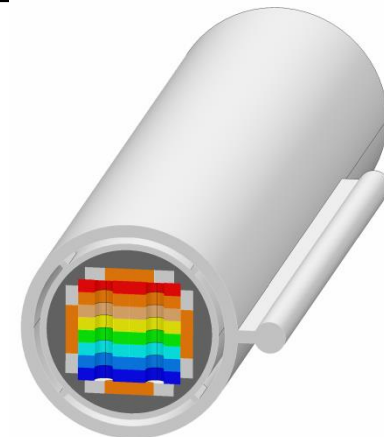
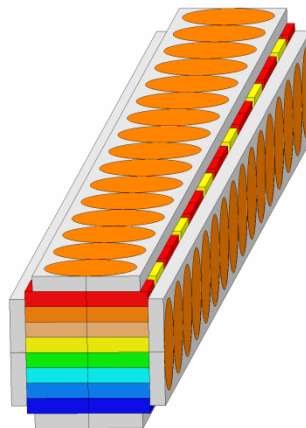
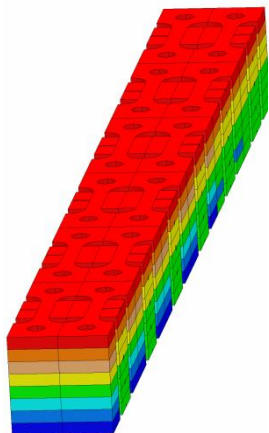
Inner Vessel: Zircaloy-2

Sample holder: Al 5754

# Samples specifications

Nonferrous Metal	Ferrous Metal
Al6061-T6	Invar
Al5754-NET-O	Stainless Steel 316L
Al6061-T6 with Al4047 filler	EUROFER97
Al6061-T6 and Al5754-O hybrid	F82H

Module Component	Geometric Description	Material
Sample Unit	See Table 3	See Table 3
Filler Unit	See Fig. 5 (left)	Al5754-O
Inner Vessel	0.5 mm thick closed pipe with 12.5 mm outer diameter	Zircaloy-2
Spacer	See Fig. 5 (middle)	Al5754-O
Outer Vessel	0.5 mm thick closed pipe with 14.5 mm outer diameter	Al6061-T6
Filling Gas		Helium
Welding Unit	See Fig. 5 (right)	Al6061-T6



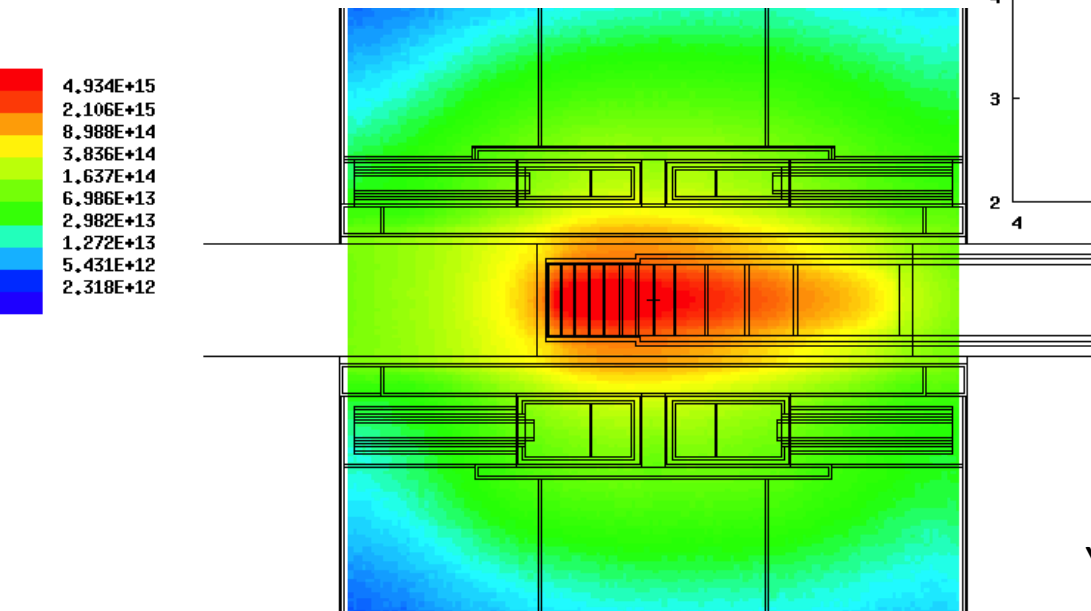
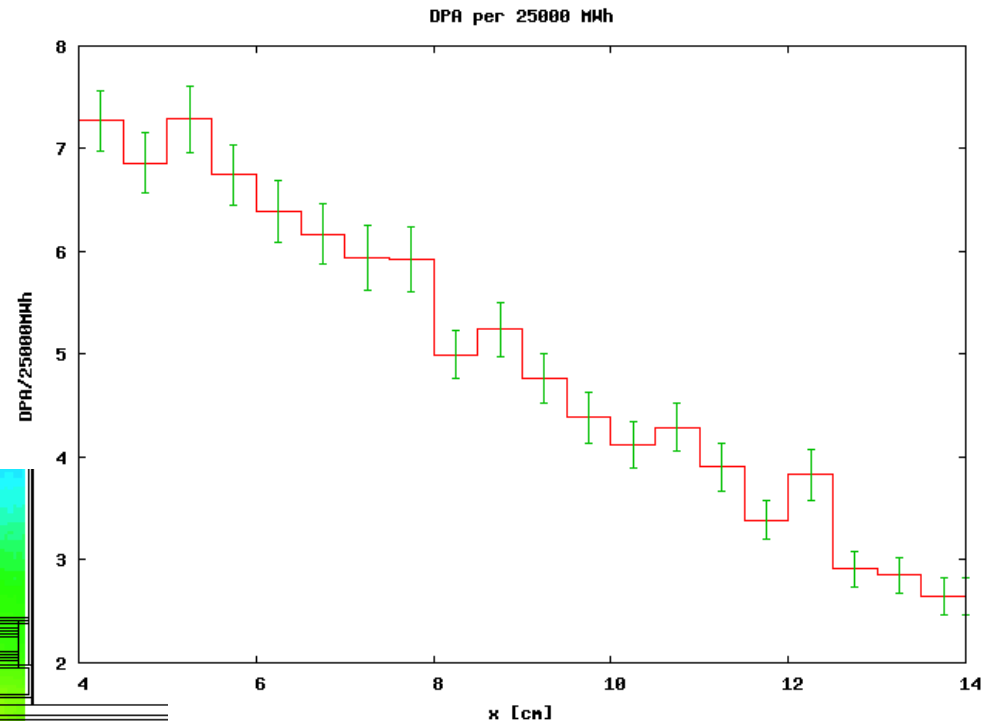


# Post Irradiation Examination Plan

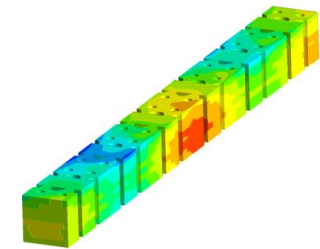
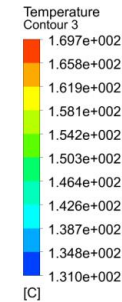
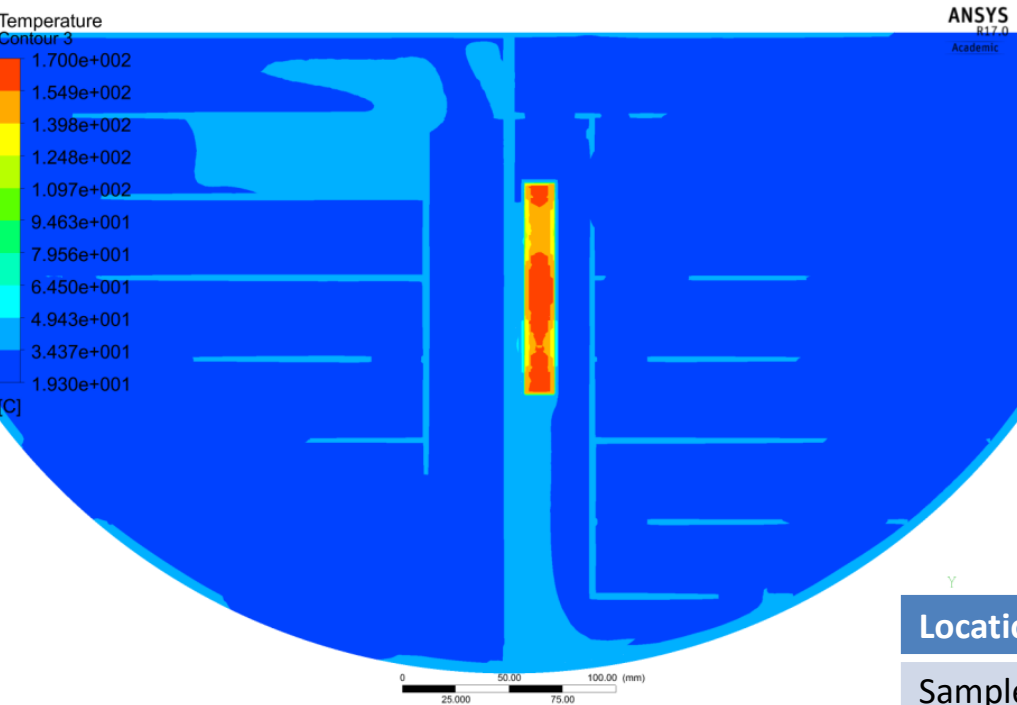
Required Tests	Material Property	Required Specimen
Tensile tests	Mechanical property	Tensile specimen
Bending tests	Mechanical property	Miniature bar without notch
Swelling measurement	Swelling property	Miniature bar without notch
CTE measurement	CTE	Miniature bar without notch
Charpy notch tests	Fracture toughness	Miniature bar with notch
EC meter	Electrical conductivity test	Miniature bar
SEM/EDX	Microstructure and elemental analysis	Tensile specimen and disc
TEM/EDX	Nanostructure and elemental analysis	Tensile specimen and disc
Gamma Spectroscopy	Isotope analysis	Tensile specimen and disc
LFA	Thermal diffusivity	Disc
DSC	Specific heat capacity	Disc

# Expected Damage and He-Production in SS 316L

- Damage Rate:
  - 7 dpa/25000 MWh
- Helium Production Rate:
  - 110 appm/25000 MWh
- He/DPA: 15



# Thermal analysis

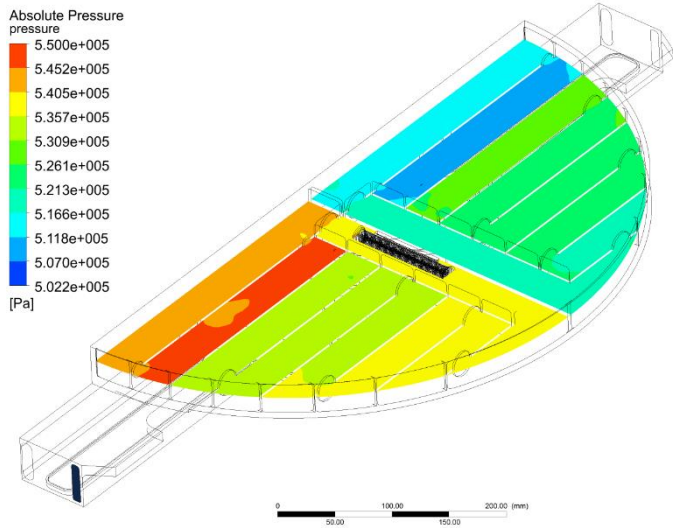


He gap thickness, length of spacers between inner and outer vessel influence  
Maximum temperature  
Largest temperature reached on Steel samples  
Parameters should be adjusted to  $T < 130$  C to avoid losing temper on T6 Al alloy samples

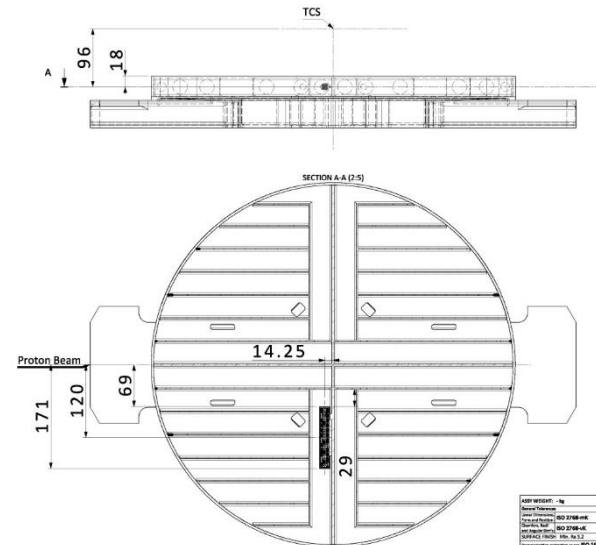
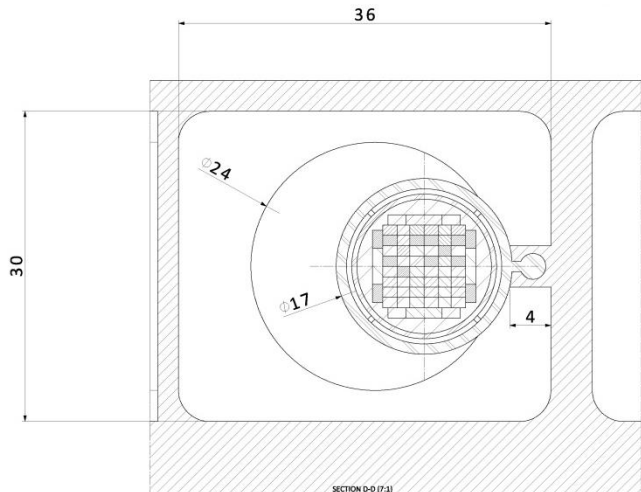
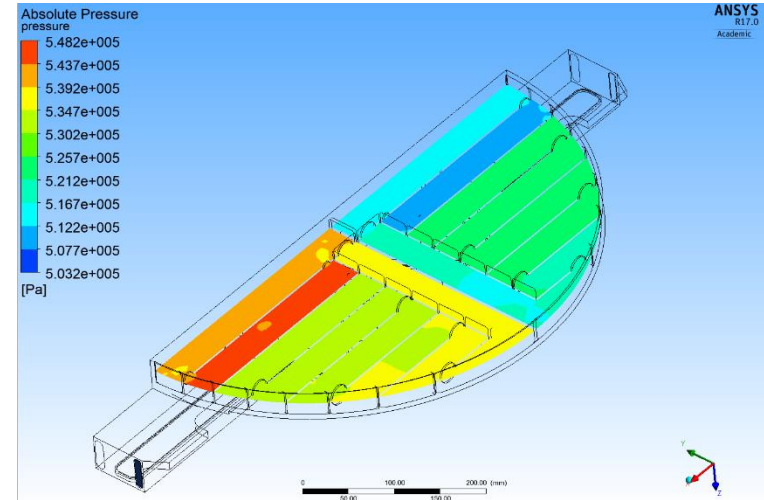
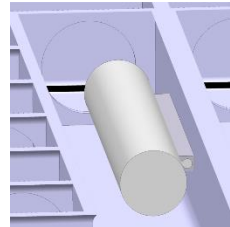
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Location	Highest Temperature (C°)
Samples	170
Holder	155
Inner Vessel	150
Helium	150
Outer Vessel	70
Water	50
Th. Moderator (interface)	50

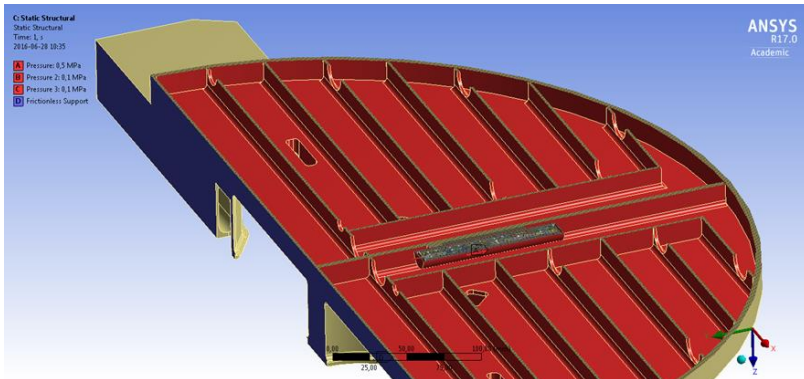
# Fluid dynamics analysis



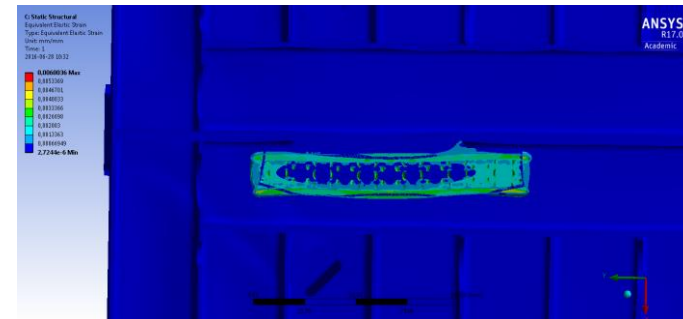
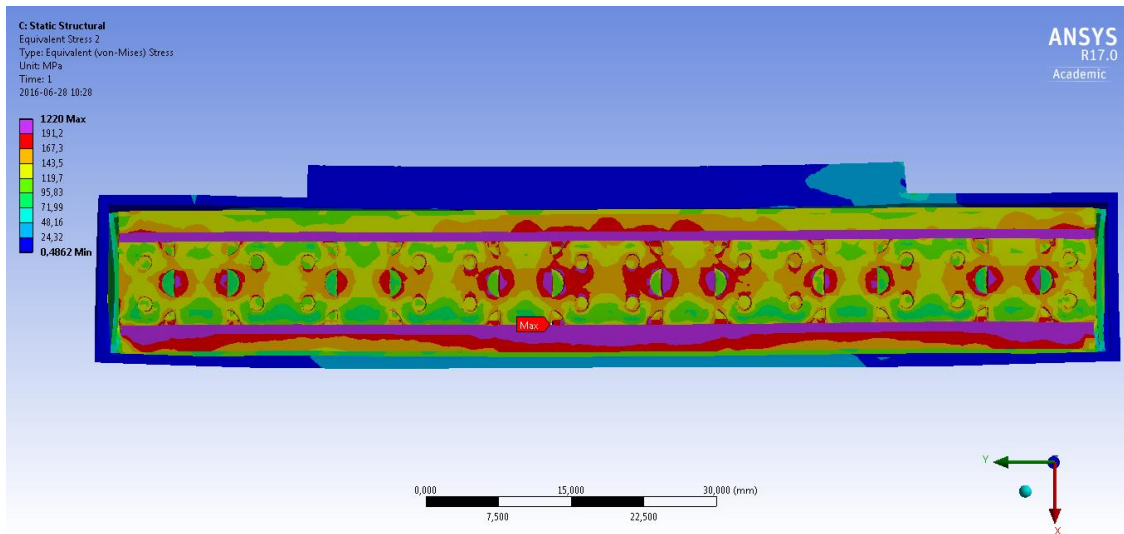
Negligible contribution to the pressure drop



# Structural analysis



Clearance between parts needed to mitigate stresses from thermal expansion

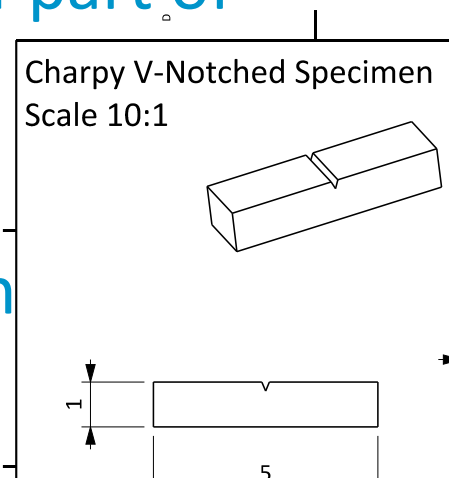


## *Highlights of work since last meeting*

- PDR carried out on July 1st 2016
- Recommendations report expected on July 15 th 2016
- Cost estimate for manufacturing received by Juelich, including strategies to incorporate IM into premoderator

# Near Term Plans

- Define paths and dates towards CDR
- Complete interface documentation to full setting of system requirements: Handling ; Waste.
- Final neutronic analysis and final design of part of samples (charpy samples), input from PSI
- Refine hazard analysis
- Update cost estimates and Post Irradiation Examination plans (outside In-Kind)



# Risks and Issues

- Project work load is very high- to critical
- Time to receive review/approval of documents is critical
- Prompt feedback/support from ESS Reflector & Moderator Systems
- *All partners are working towards a common goal and are helping each other to reach the milestones*



# Concluding remarks

- Refine scope: Post Irradiation Examination will be at the end of first generation MR- past the construction phase
- Case for Post Irradiation Examination programme on the longer term (see for example STIP-I, STIP-II,STIP-III,... at PSI)
- Opportunities towards non-ESS related activities
- *All partners are working towards a common goal and are helping each other to reach the milestones*