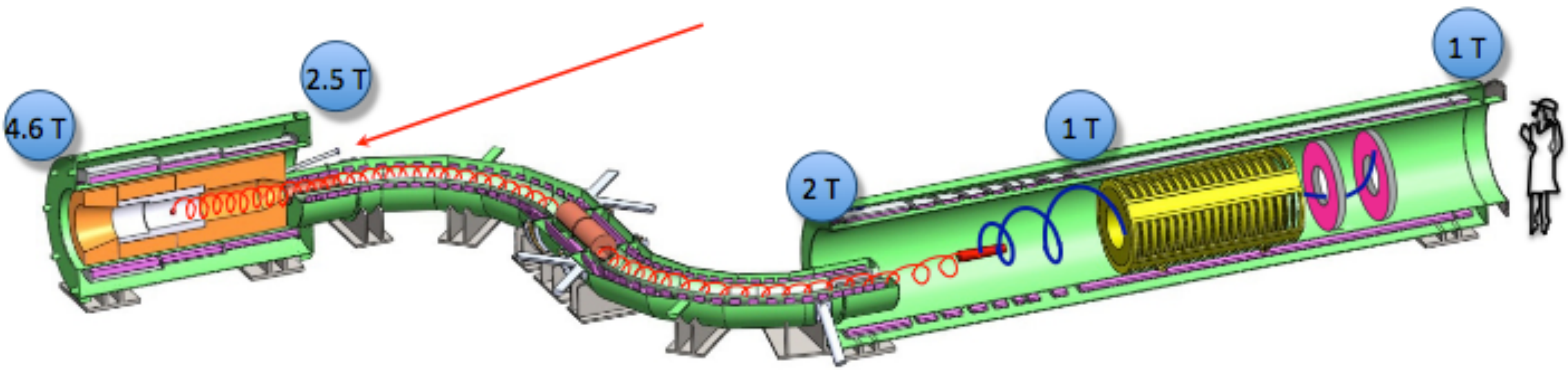
Target Hall Overview

Rick Coleman
L3 Manager Target Station
3/3/2015

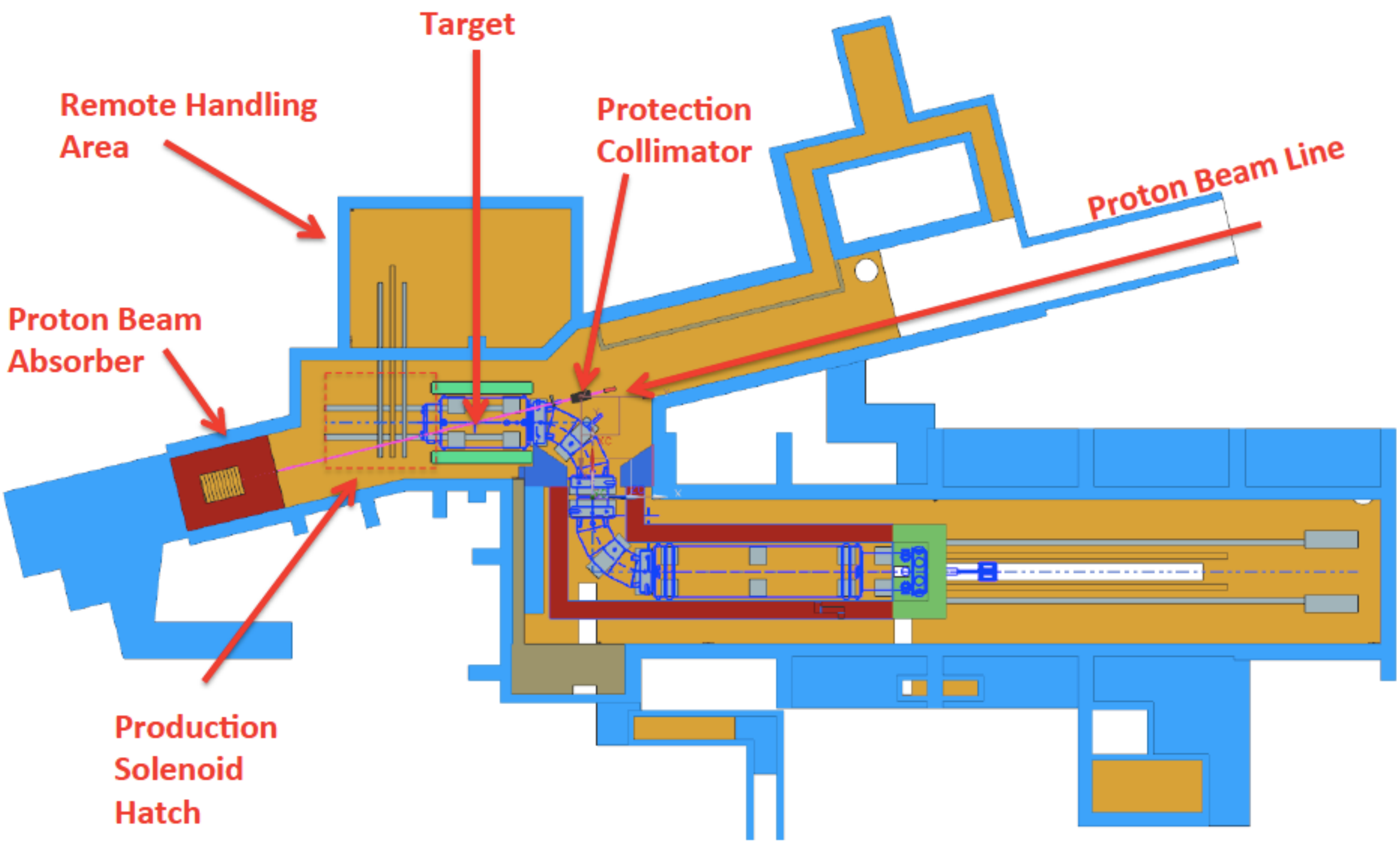
WBS 475.02.09 Target Station

- The Target Station
  - proton beam production target
  - heat and radiation shield (HRS)
  - target remote handling system
  - proton beam absorber
  - protection collimator

- There is a WBS task for each of above, plus one for simulations and one for technical documentation (& general support)



Overview of Layout



Requirements

- Mu2e Proton Beam (see Steve's talk)
- Production Target Requirements
  - Maximize number of stopped muons (high Z material, small radius target and minimize target support structure material to reduce pion reabsorption)
  - Target Lifetime > 1 year to minimize interruptions to experiment
  - Target-Beam Alignment < 0.5 mm transverse, < 10 mr angle
- Remote Handling Requirements
  - Control Radiation exposures
  - Preserve target alignment
  - Handle window replacements as well
  - Minimize Downtime- Replace target within time period of ~ one month (annual downtime expected)

Organizational Breakdown

WBS 475.02.09
Target Station
R. Coleman
R. Schultz (deputy)

- WBS 9.1 Simulations — R. Coleman, V. Pronskikh — AD/FNAL
- WBS 9.2 Fabricate Target — C. Densham — Rutherford Labs
- WBS 9.3 Remote Handling — M. Campbell — AD/FNAL
- WBS 9.4 HRS — L. Bartoszek — Bartoszek Engineering
- WBS 9.5 Proton Absorber — A. Stefanik — PPD/FNAL
- WBS 9.6 Protection Collimator — A. Stefanik — PPD/FNAL
- WBS 9.7 PS Hatch Blocks — R. Coleman — AD/FNAL
- WBS 9.8 Technical Doc. — R. Coleman — AD/FNAL

Target Station Team

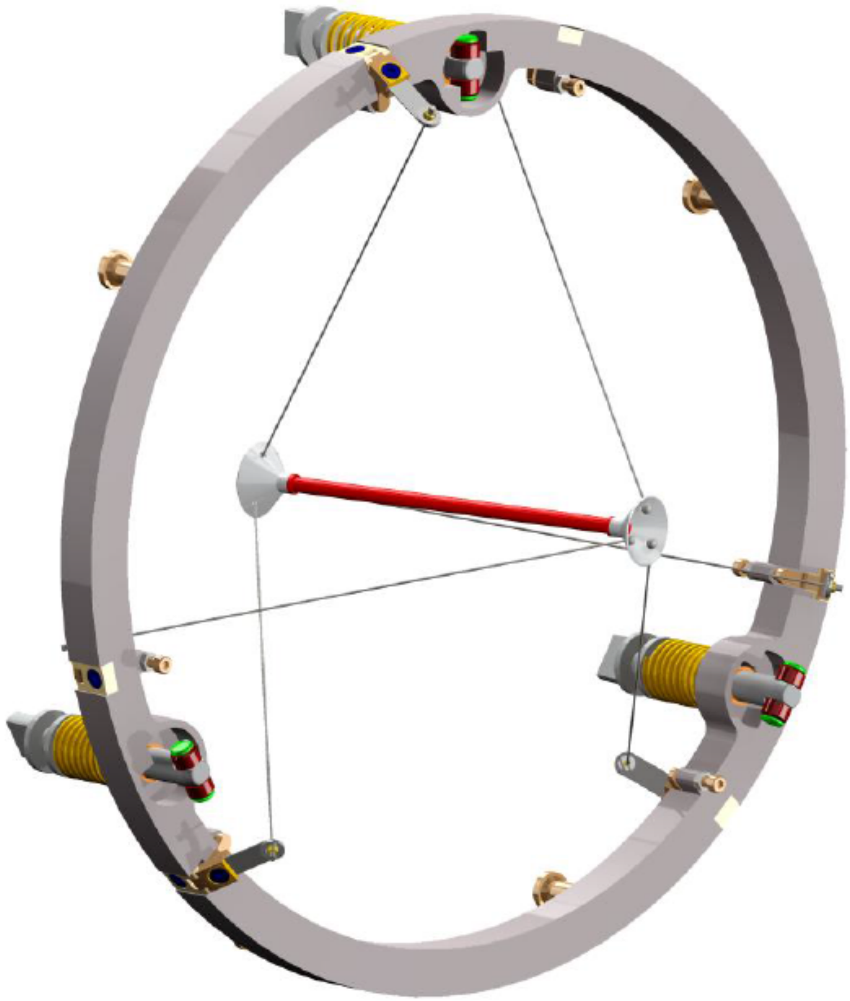
- Steve Werkema, Vladimir Nagaslaev, Mike Campbell
  - L2 Manager, Deputy and Engineer
- Rick Coleman, Ryan Schultz
  - L3 Manager, Deputy
- Target- Rutherford High Power Targetry Group- Chris Densham, Peter Loveridge, Joe O'Dell, Roger Bennett, Otto Caretta
- Remote Handling- Mike Campbell
- Heat and Radiation Shield- Bartoszek Engineering- Larry Bartoszek
- Proton Beam Absorber and Protection Collimator- Andy Stefanik
- Simulations- V. Pronskikh, N. Mokhov, Y. Eidelman
- Radiation Safety & ES&H – A. Leveling, M. Wolter, D. Hahn
- Project Mechanical Engineer (Integration) - K. Krempetz
- Muon Beamline L2 Manager- G. Ginther
- University Collaborators- J. Popp, K. Lynch
- Alignment- H. Friedsam

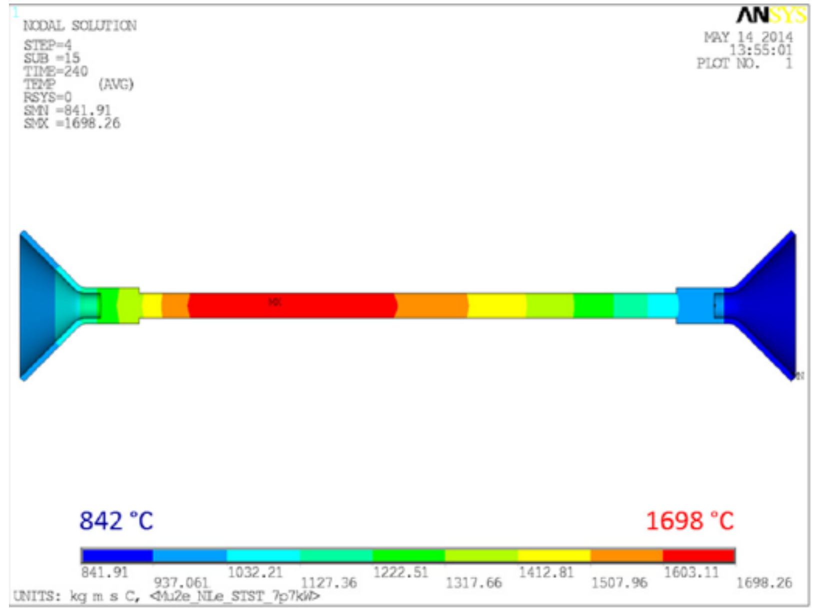
Target Design

Science & Technology Facilities Council
Rutherford Appleton Laboratory

Doc db 2406
68 pages,
August 2012

Tungsten Rod
L=16 cm r=3.2 mm



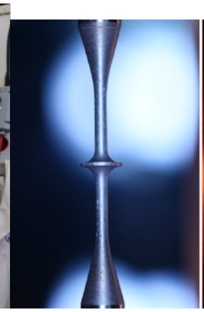
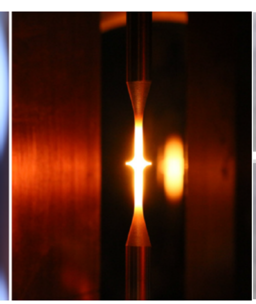
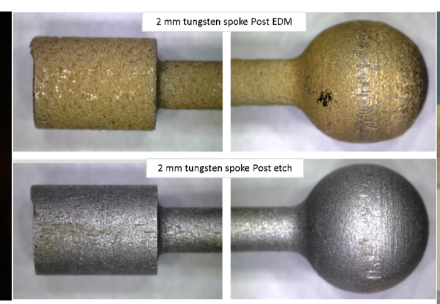


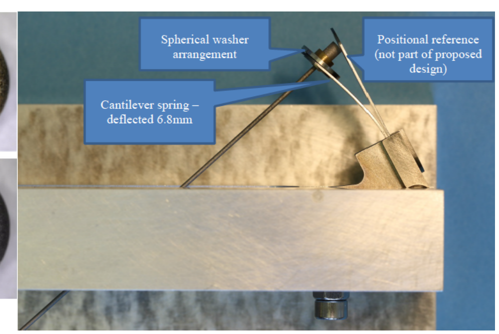
Target Design/R&D

STFC Rutherford Appleton Laboratory
High Power Targets group

June 2014 Report, 82 pages

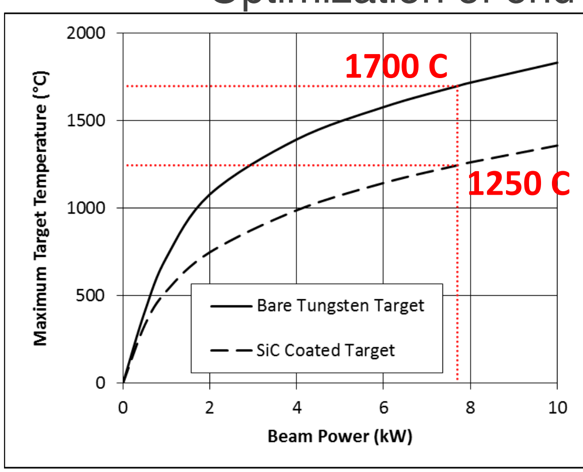
- Completed Design, Testing, and Prototype work
  - Design shown on previous page
    - spoke tensioner, support ring detailed work
  - Measurements
    - vacuum vessel and equipment setup for testing
    - emissivity measurements at high T (5% verification of literature)
    - lifetime pulsed heating tests (fatigue)- OK for 4 years equivalent
  - Study of Creep in the Target Support- 6 micron elongation OK
  - Spoke Prototyping (manufacturing, spring tests, adjustments)
  - Literature Study of Target Material Recession due to Oxidation
    - Literature =>1e-5 Torr OK, quick, crude measurement done at 1e-3 Torr showed not good enough

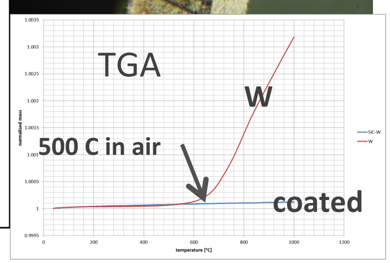





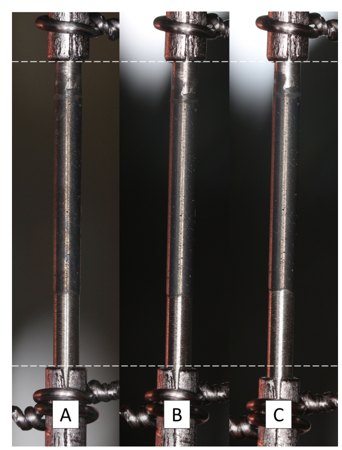


Target Design/R&D

- Work started Fall 2014
  - Tungsten tests in medium vacuum (10^{-4} to 10^{-5} Torr)
  - SiC coating/surface/oxidation/fatigue R&D, including:
    - Various surface treatment/coating R&D
    - Emissivity measurements of surface coatings
    - Medium vacuum (10^{-4} to 10^{-5} Torr) lifetime testing
    - Pulsed current fatigue testing for shaped test samples (horizontal test)
  - High temperature creep testing of spokes and spring tensioners
  - He cooling feasibility study and preliminary plant specification
  - Optimization of end joints







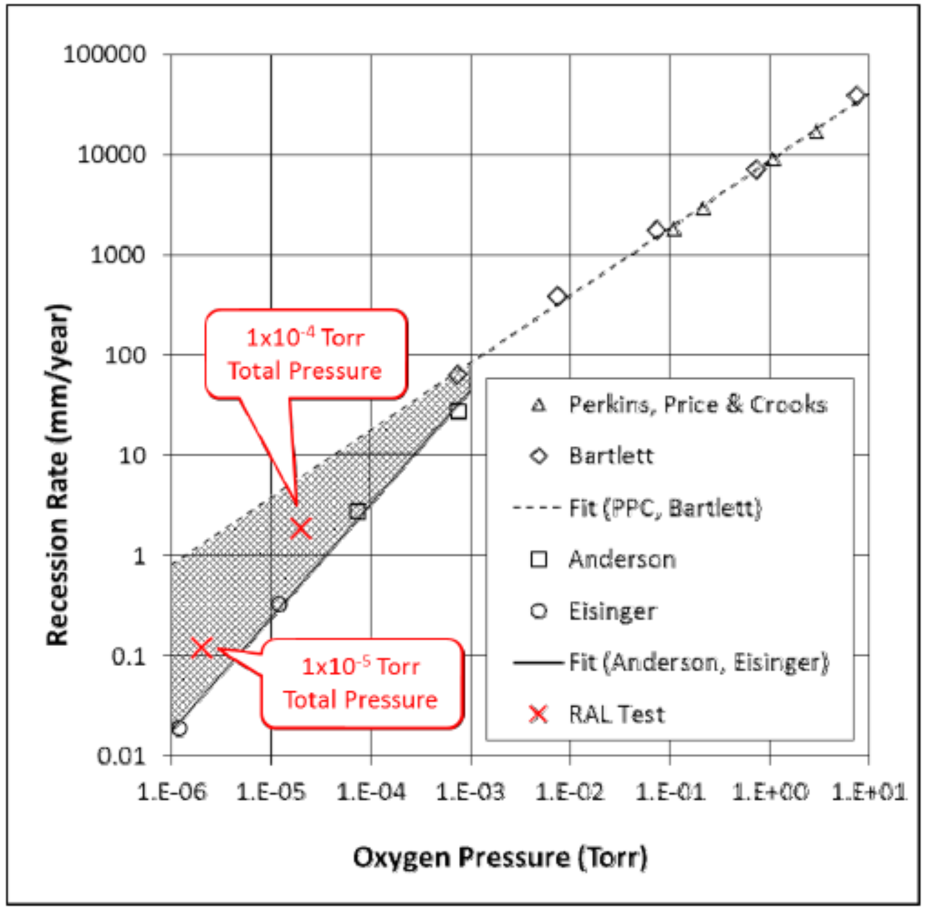
Thermal Cycles 1500 C

Baking 40 days

Target Design/R&D – Jan 26 test results

Summary: Bare Tungsten @ 1700°C

Total Pressure *(Torr)*	Recession Rate *(mm/year)*
1×10^{-4}	1.8
1×10^{-5}	0.12
1×10^{-6}	Few Microns



- At 10^{-5} Torr total pressure and 1700°C the erosion rate looks to be tolerable

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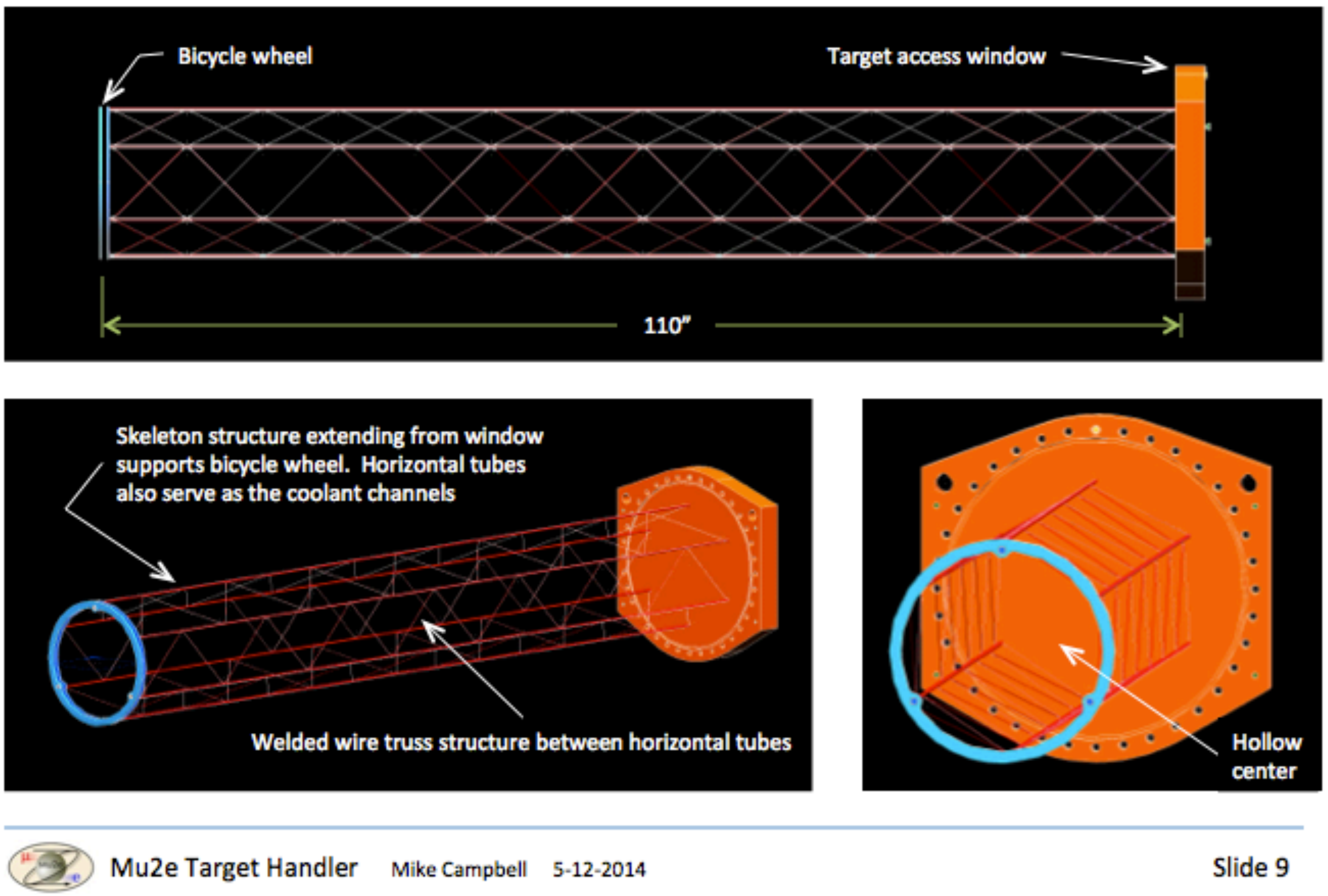
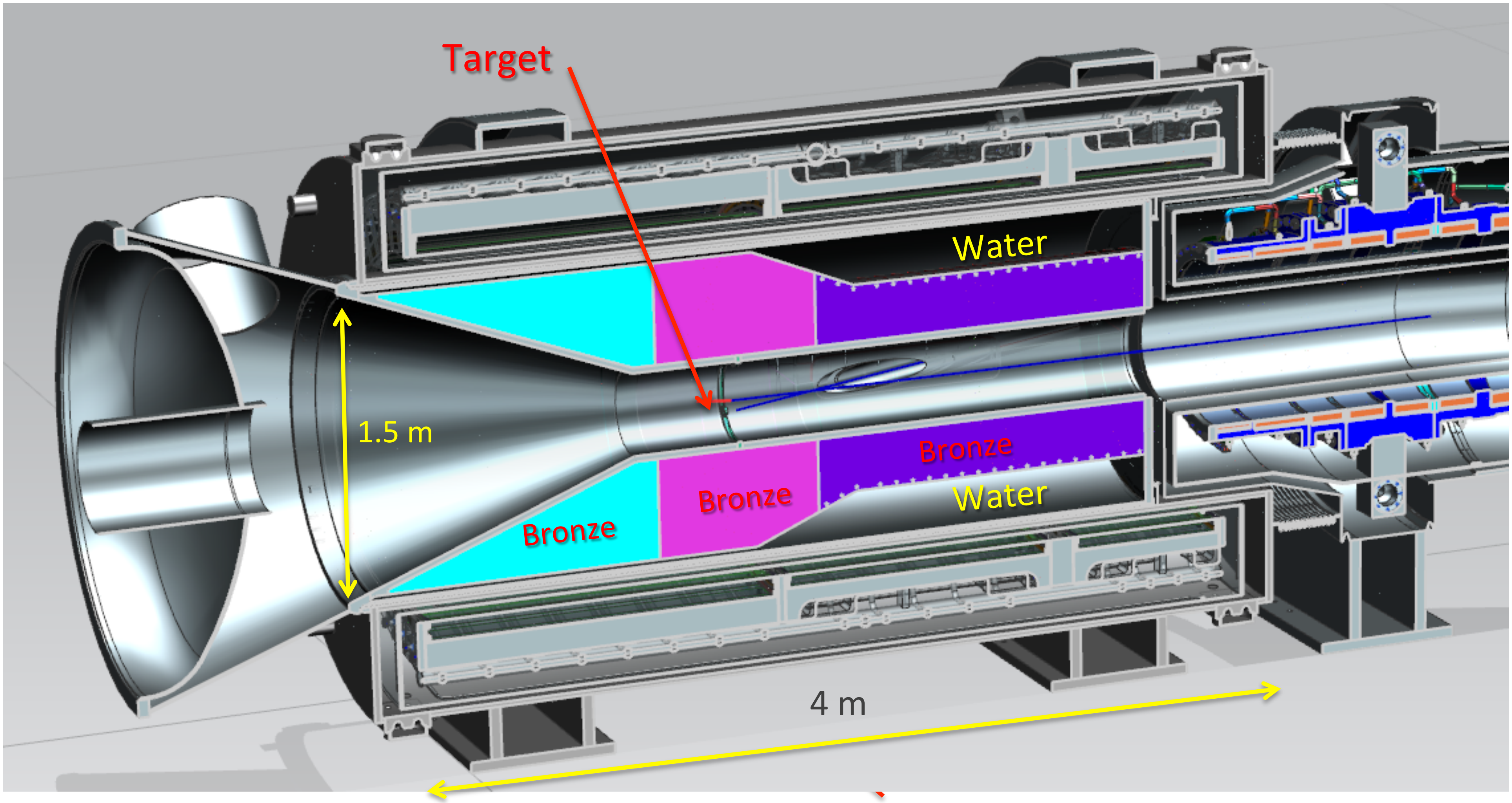
"So far so good" on Radiative Cooled Target but......

- Backup: He cooled Target as shown below, viable in vertical scheme only, more later

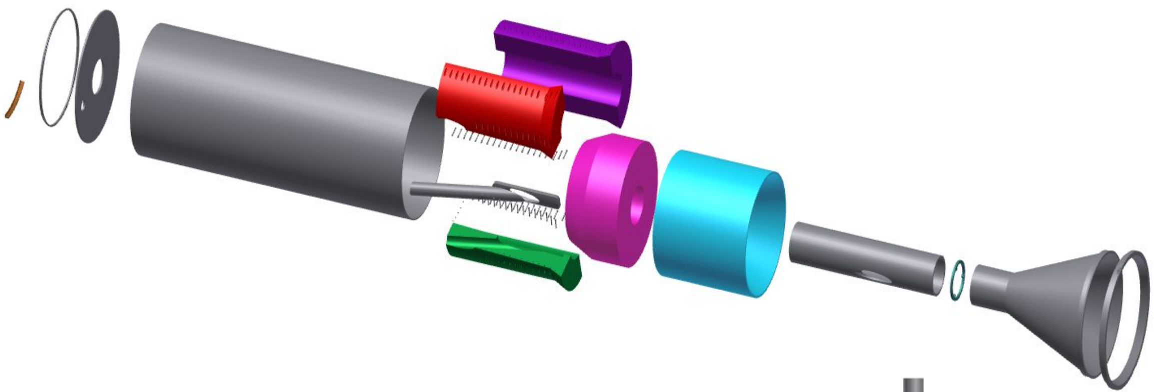


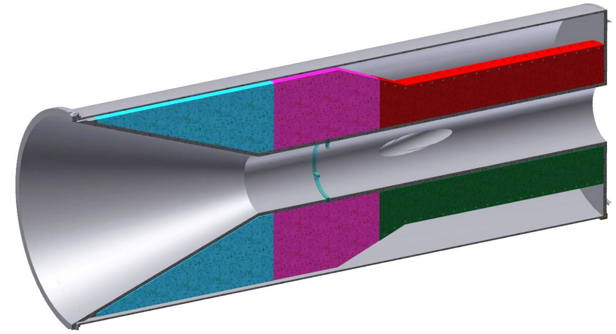
Heat & Radiation Shield (HRS)

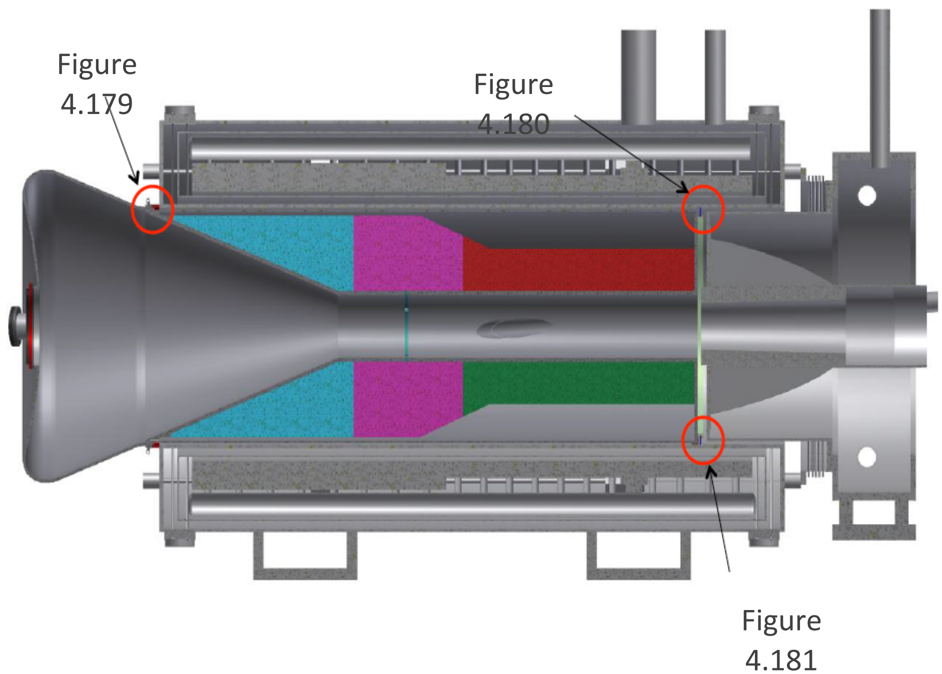
Bartoszek Engineering

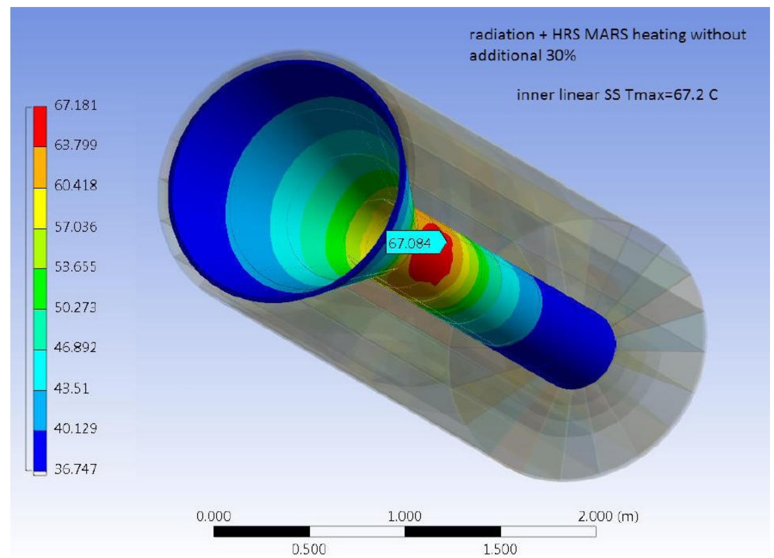


Heat & Radiation Shield (HRS) Details

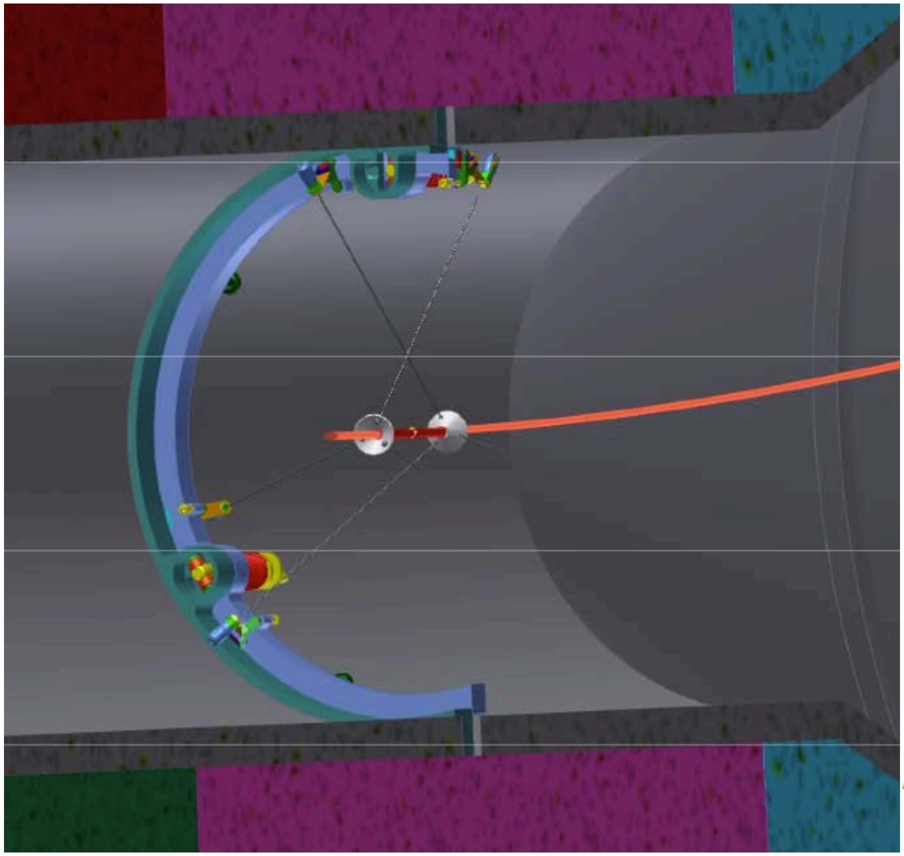


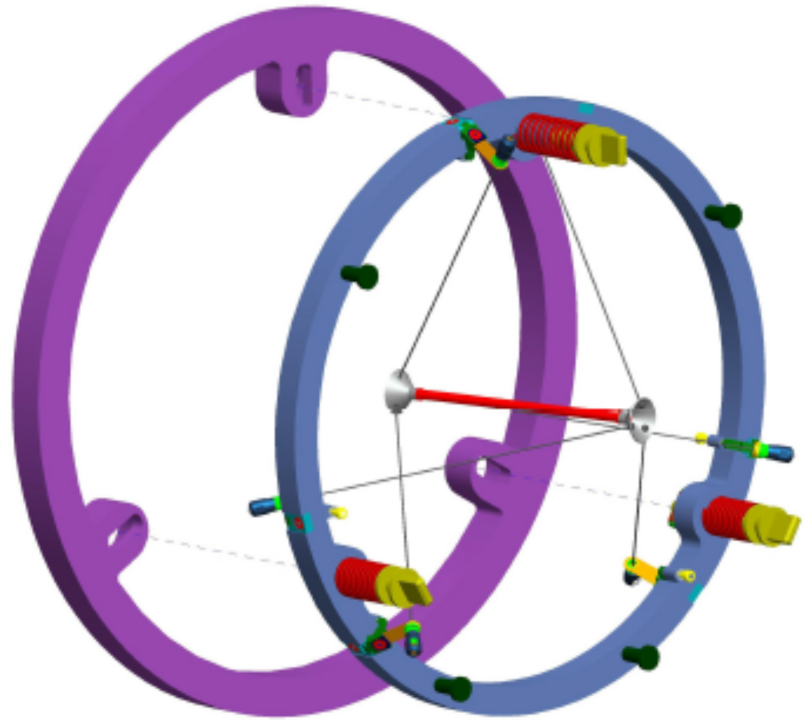






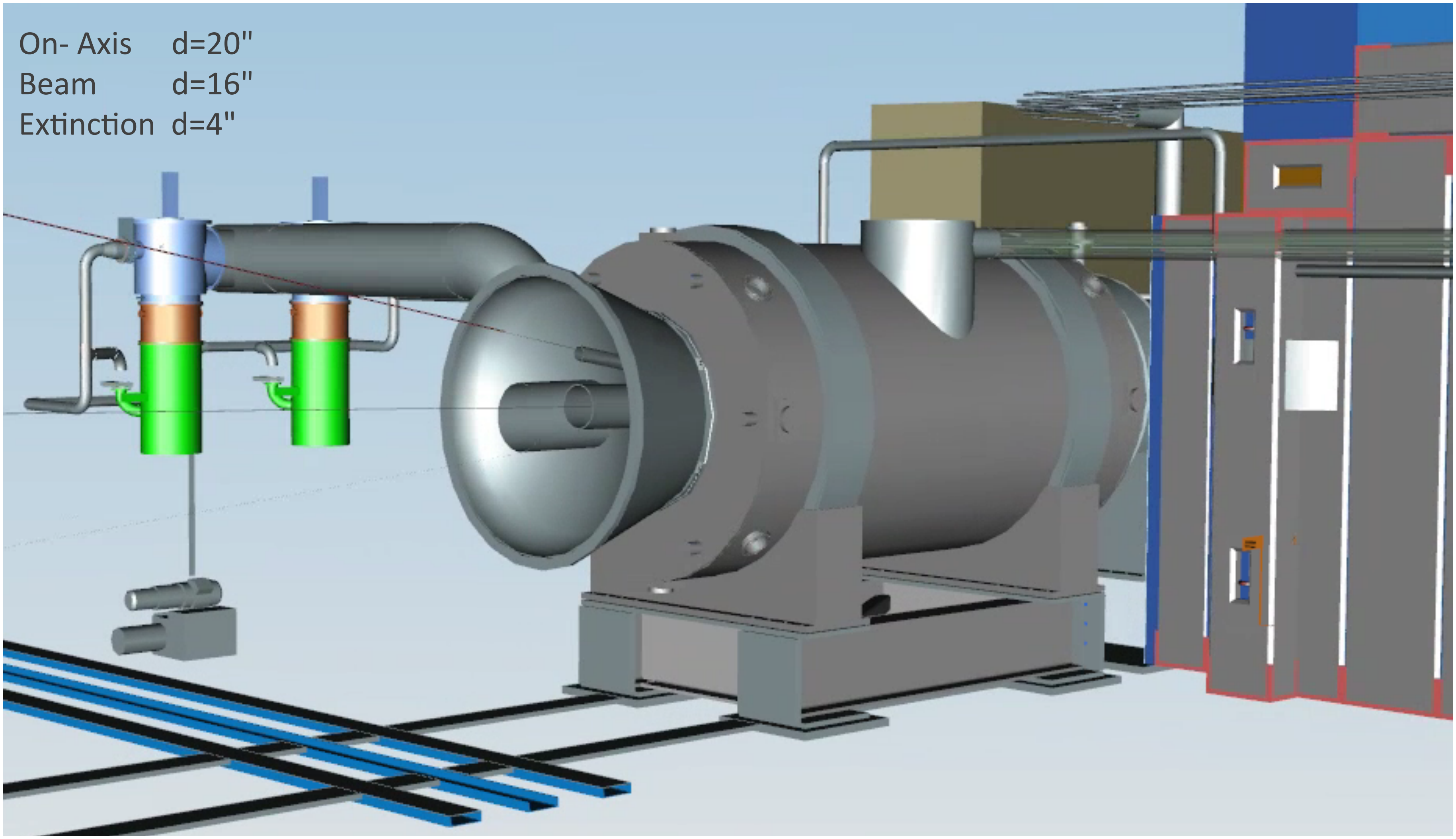
Target Mount Ring in HRS





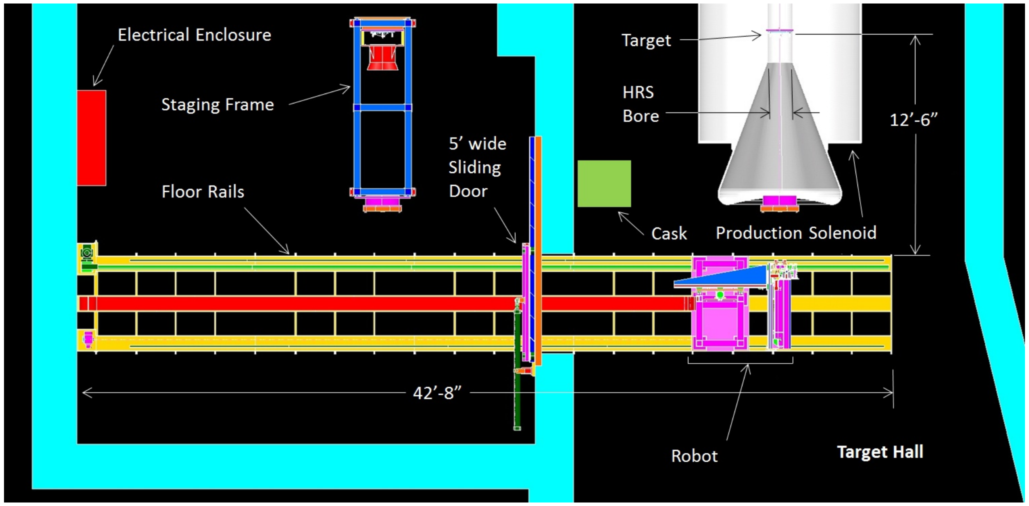
4.152. Target mount to HRS bore.

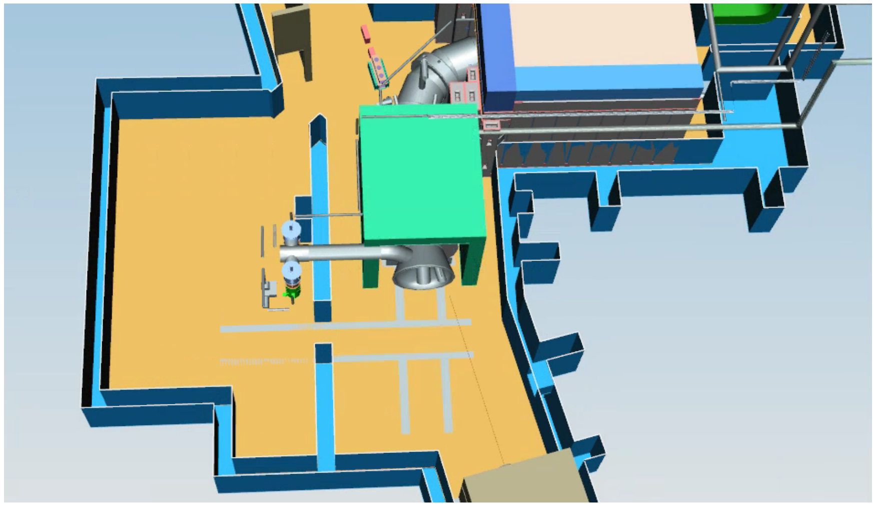
Exit Windows- On-Axis, Proton Beam, Extinction Monitor

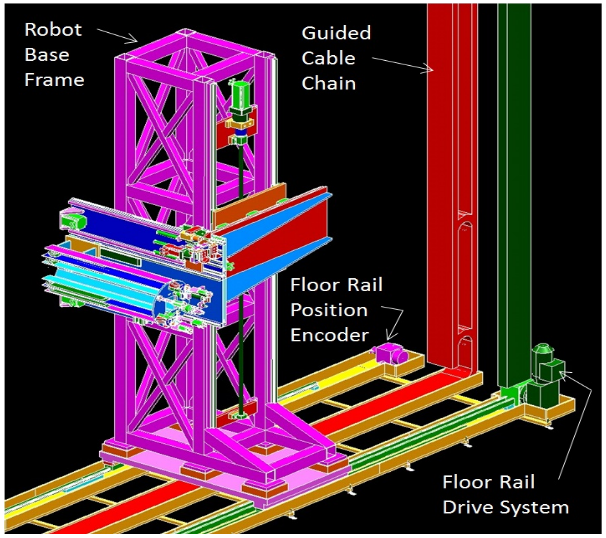


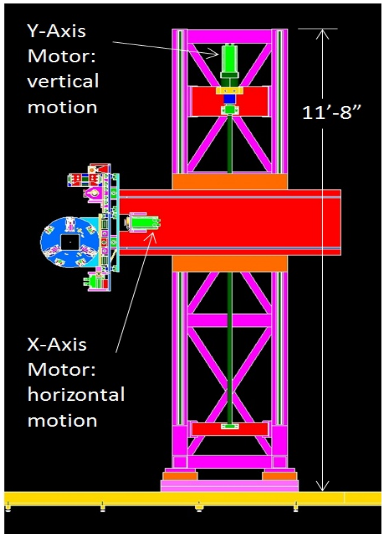
Target Remote Handling Design

see Mike Campbell's talk









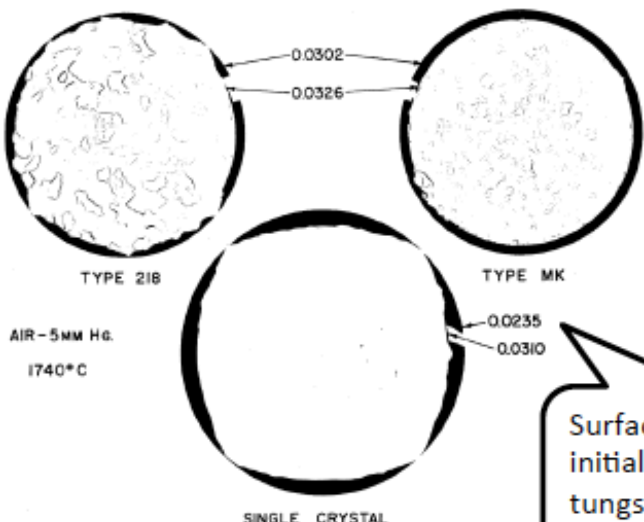
Summary from Fall 2014 CD-2/3b Review

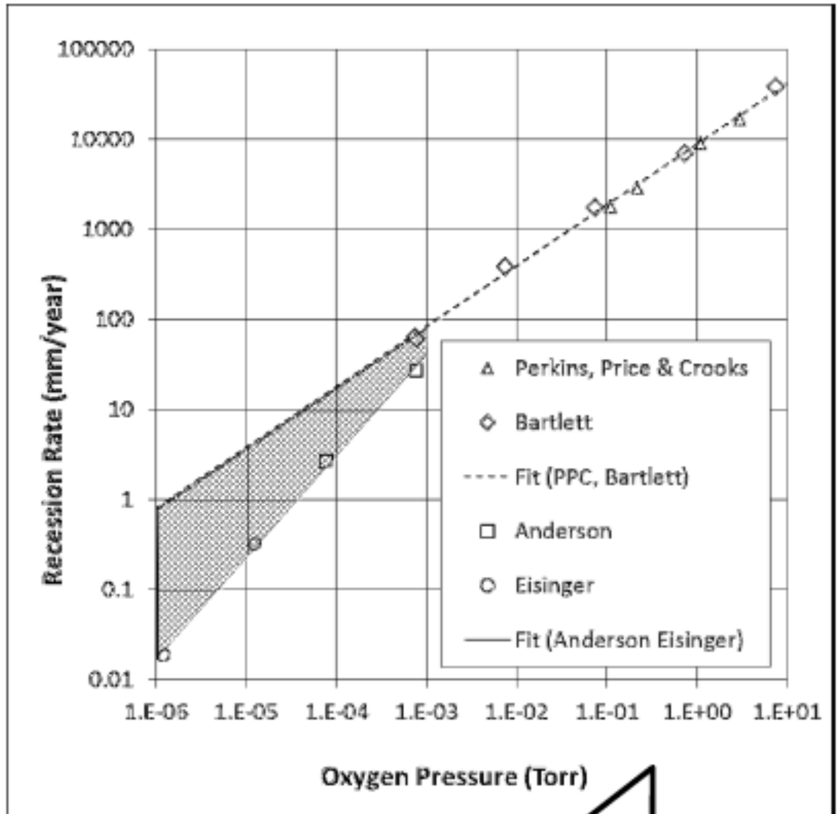
- The Target Station Design is well integrated with the Solenoids, Muon Beam line, Civil Construction, and Radiation Safety
- A preliminary design is complete
- **A review and choice is needed on the remote handling scheme**
- R & D is well underway to decide on target choice- radiative or convection cooled
- We are ready to baseline our schedule

Backup Slides

Motivation for Vacuum / Leak Test

At temperatures exceeding ~1300°C in vacuum, tungsten oxide will evaporate faster than it is formed. In this regime oxidation is realised as a surface recession, the rate of which depends strongly on temperature and oxygen pressure.





Surface recession of initially cylindrical tungsten rods heated in a low oxygen pressure

Literature data on recession rate as a function of oxygen pressure @ 1700°C

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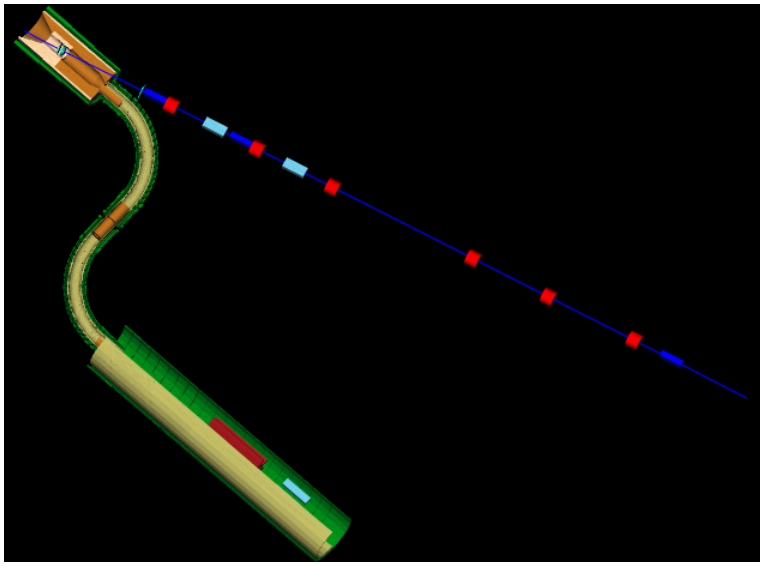
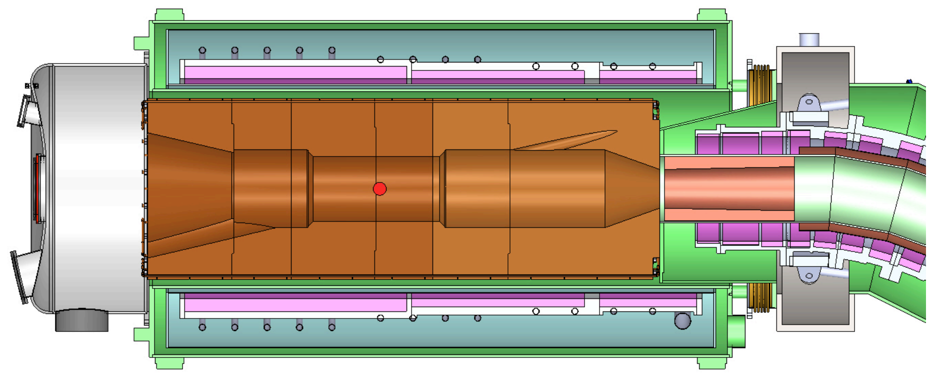
Cost Table

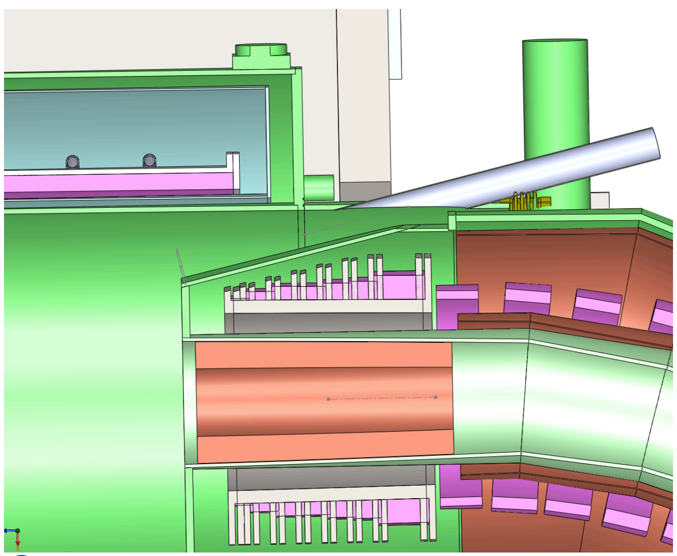
	Base Cost (AY K$)					
	M&S	Labor	Total	Estimate Uncertainty (on remaining budget)	% Contingency on (on remaining budget)	Total Cost
475.02.09.01 Simulations and Calculations	67	1,329	1,396	171	31%	1,567
475.02.09.02 Fabricate Target	1,863		1,863	497	41%	2,360
475.02.09.03 Target Handling	1,177	1,457	2,634	777	33%	3,410
475.02.09.04 Production Solenoid Heat & Radiation Shield	2,632	200	2,831	875	32%	3,706
475.02.09.05 Target Station Proton Beam Absorber		57	57	14	53%	71
475.02.09.06 Solenoid & HRS Protection Collimator	126	201	326	128	42%	454
475.02.09.07 Hatch Shielding Blocks					n/a	
475.02.09.08 Technical Documentation		1,240	1,240	245	22%	1,485
Grand Total	5,863	4,483	10,346	2,706	32%	13,053

Proton Beam Through Solenoids



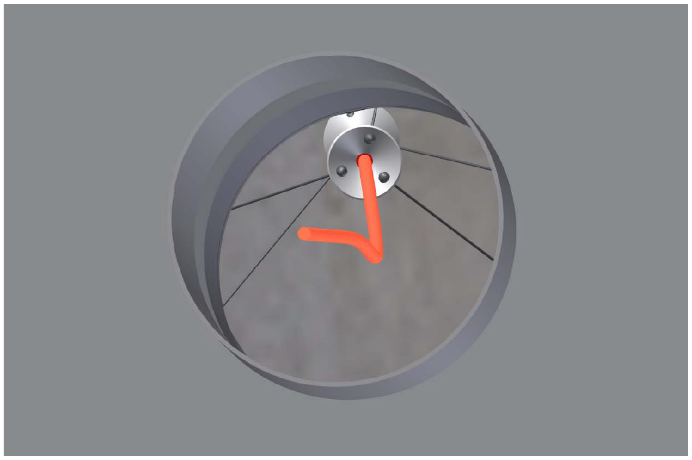
T. Page



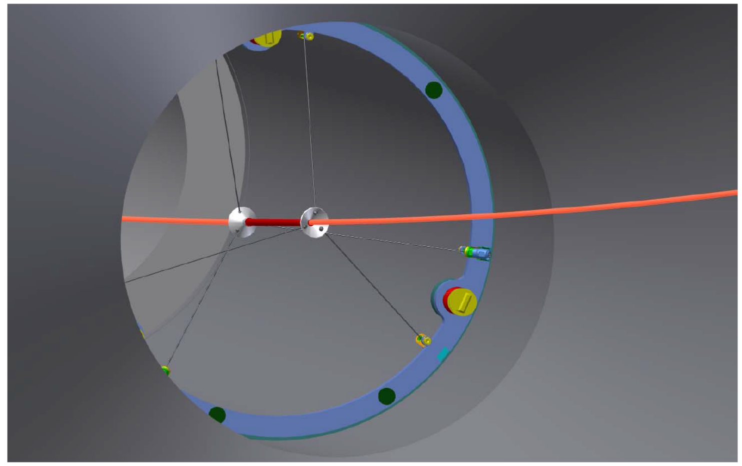


Proton Trajectory in Engineering Model

This view looks proton downstream through the holes in the TS and HRS

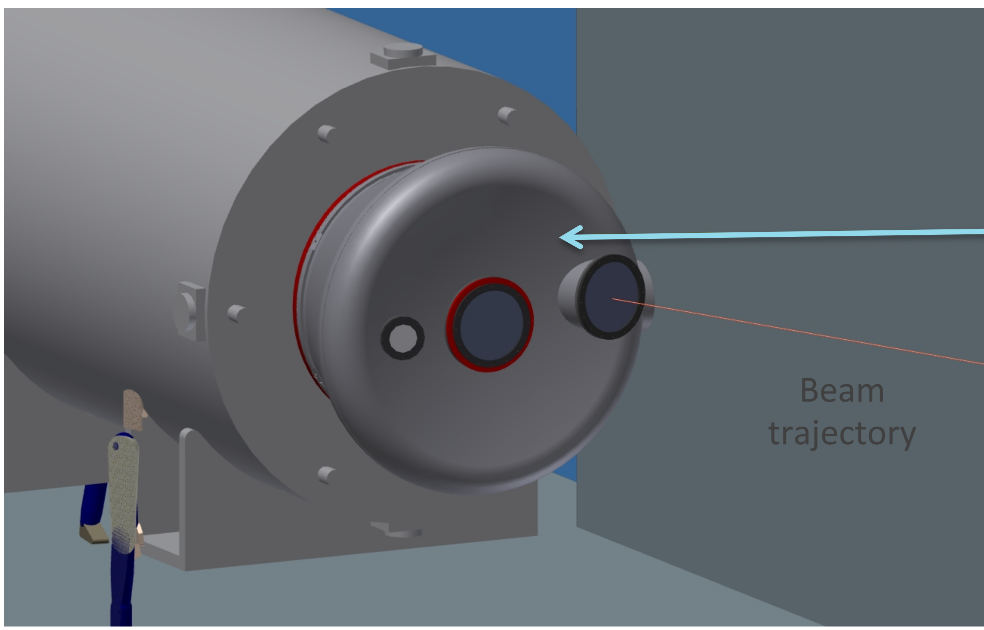


This view shows the proton beam exiting the target



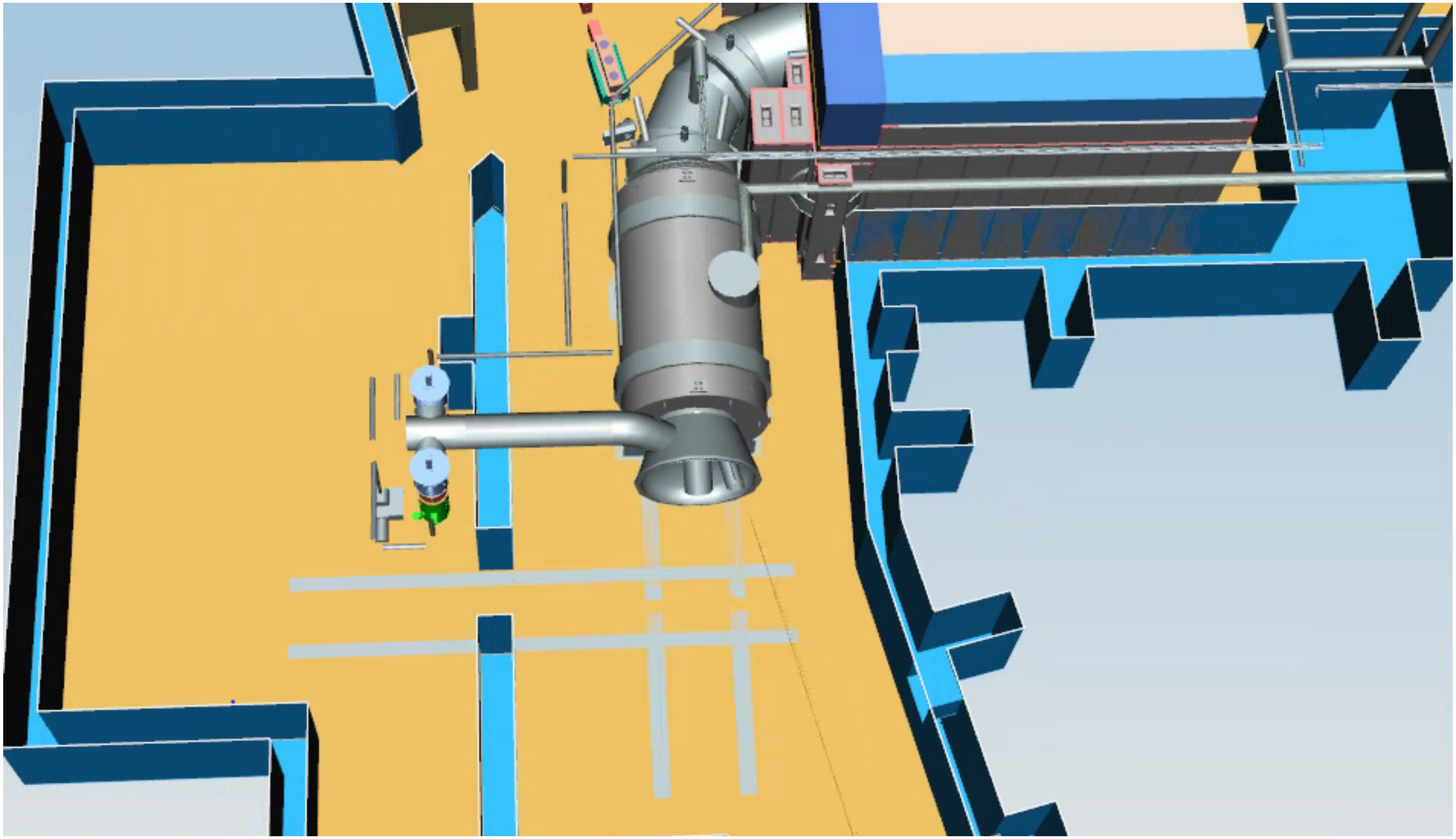
L. Bartoszek
Check of Trajectory

Other checks by:
A. Stefanik
T. Page
J. Brandt



PS endcap

PS without Concrete Shield



Target Alignment/Tolerances Summary

Target dimension tolerances

- Target Length = 16 cm ±2 mm
- Target Radius = 3 mm ±0.1 mm

Alignment of target with respect to PS/HRS

- Replacement target positioning repeatability: ±0.25 mm
- Transverse placement w/resp. to PS axis: ±5 mm
- Longitudinal placement along PS axis: ±10 mm

Alignment of target with respect to the proton beam:

- Transverse beam positioning requirement: ±0.5 mm
- Horizontal and vertical angle alignment: ±0.2°

Alignment Details

The alignment strategy to accomplish these requirements is:

- The target/supports/mounting must be quite stable and reproducible during target change relative to the PS. The tolerance on the manufactured target rod dimensions should be: length = +/- 2 mm and radius= +/- 0.1 mm. The target position relative to the PS must be stable to about ±0.25 mm during operation, taking into account distortions due to thermal cycling from ambient conditions when the beam is turned on. The target support structure and remote handling system must allow replacement targets to be placed within about ±0.25 mm of the first.

- The relative alignment of the target with respect to the PS axis is not as critical as the target-beam alignment. The muon yield is very insensitive to transverse [5] or motion along the z axis up to several cm. There is a potential background for ~100 MeV electrons, if the target source is more than 2 cm below the nominal elevation [6]. The relative alignment of the target to the PS axis should be +/- 5 mm transversely and +/- 1 cm along the PS axis.

- The PS axis must be aligned transversely to the proton beam to within: +/- 5 mm in position and +/- 0.2 degrees in angle. The angular requirement is set by the narrow channel available to the proton beam to pass through the transport solenoid entrance beam pipe which is 4.75" inner diameter about 3 m upstream of the target. Given the target z location, this pipe sets an angular acceptance of +/- 1 degree. The muon yield is much less sensitive to the angle [7].

The proton beamline has the ability to adjust the transverse position +/-1 cm and +/- 0.8 degrees at the target. If the alignment moves outside the range allowed by the beamline adjustment then the beam-PS alignment must be corrected.