Status of T2K Target

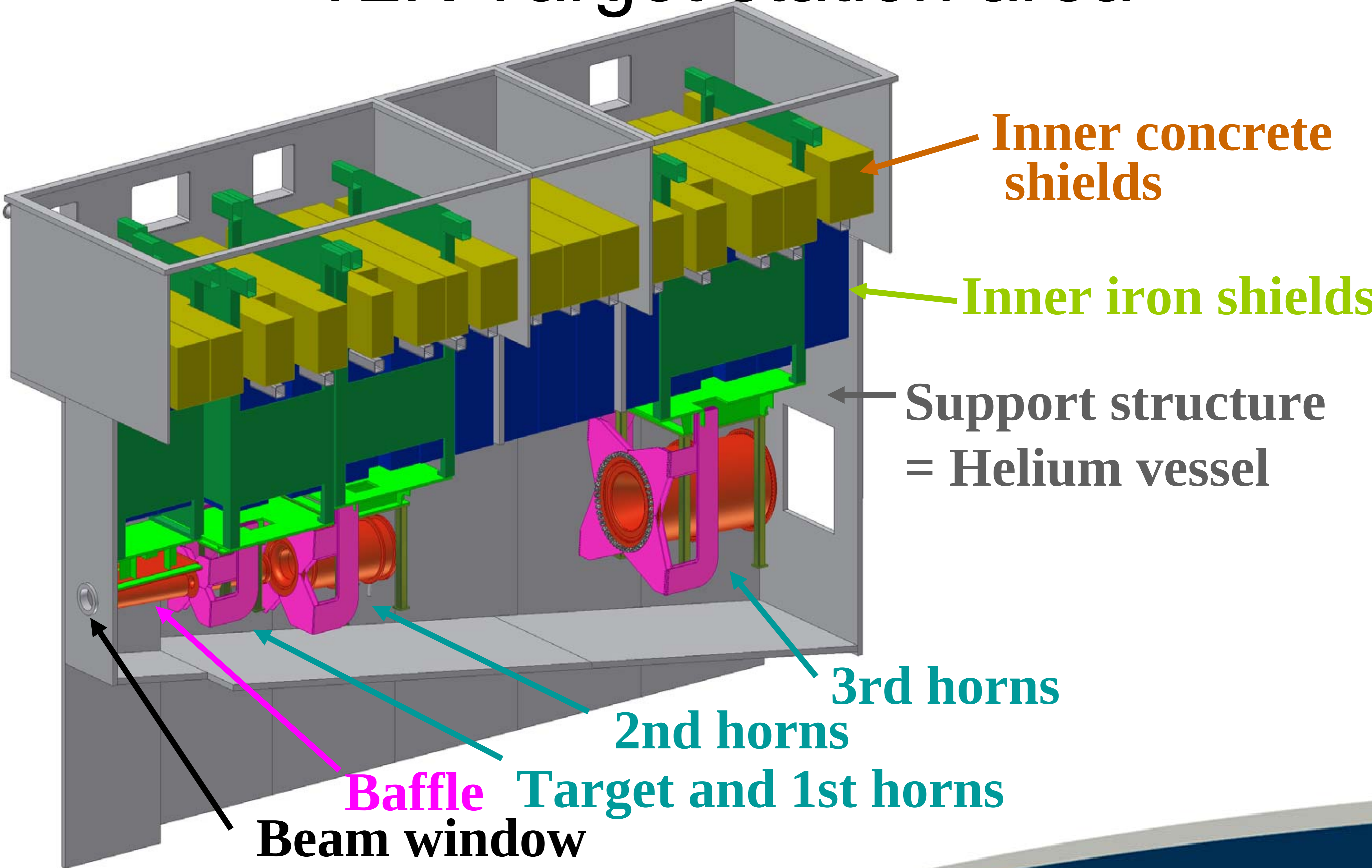
2nd Oxford-Princeton High-Power Target Workshop
6-7th November 2008

Mike Fitton
RAL

Contents of Talk

- T2K target station
- Aims of target design
- Current target design
- CFD analysis
- Remote target exchange concept
- Future upgrade plans

T2K Target station area

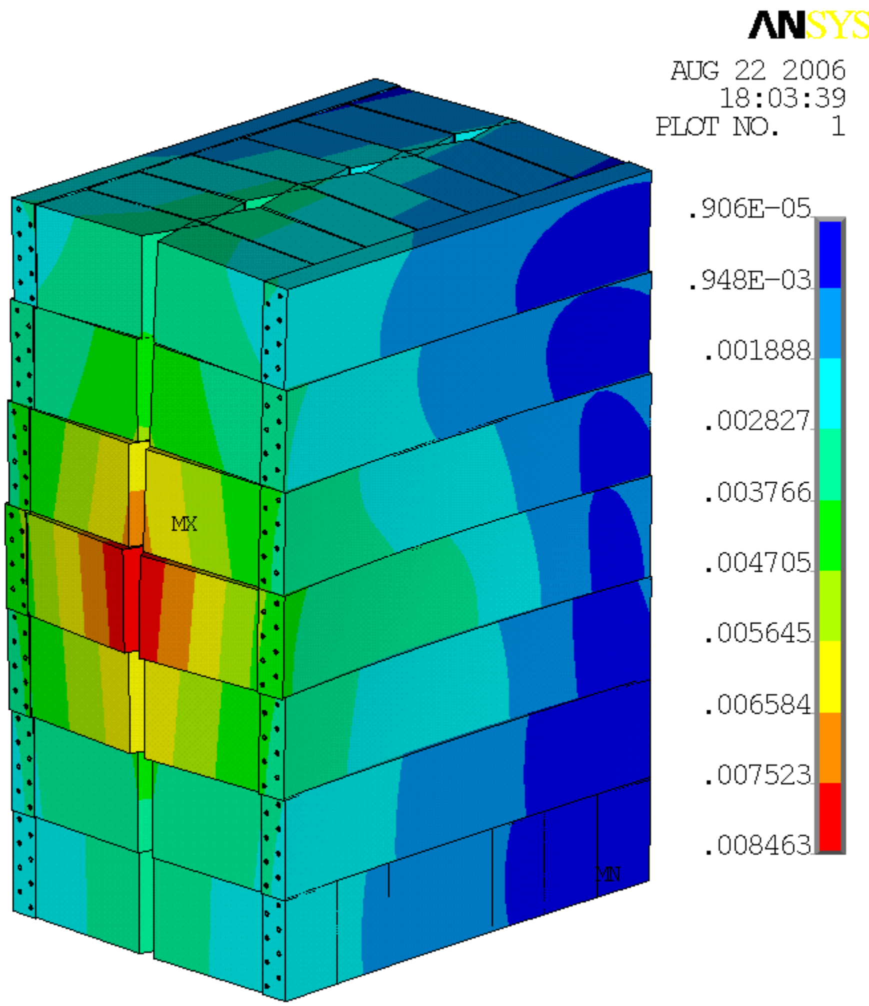


Baffle / Collimator

High power target group, RAL

Test install into Target station October 2008

4MW Hadron Absorber

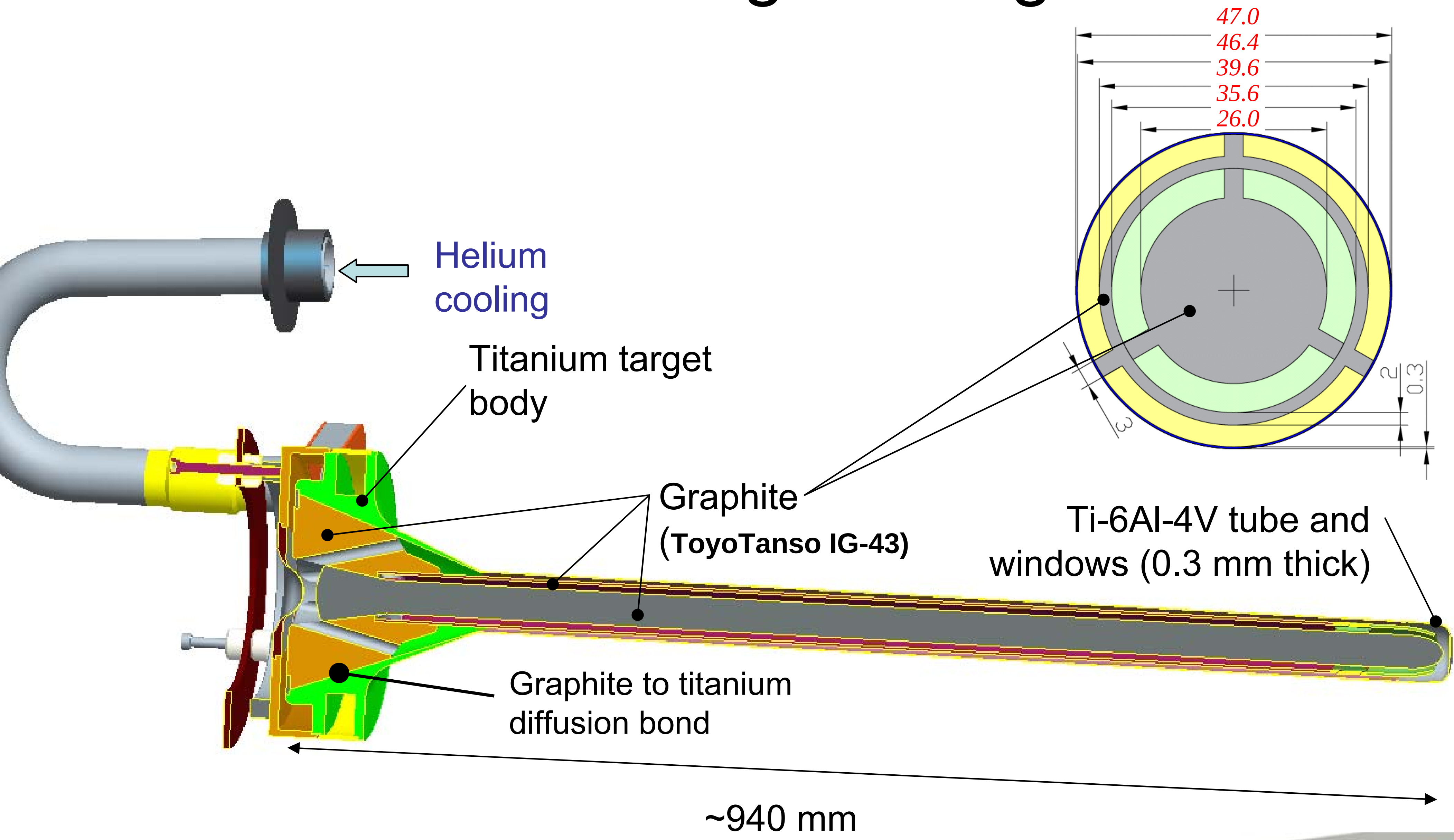


T. Ishida, KEK & C. Densham, RAL

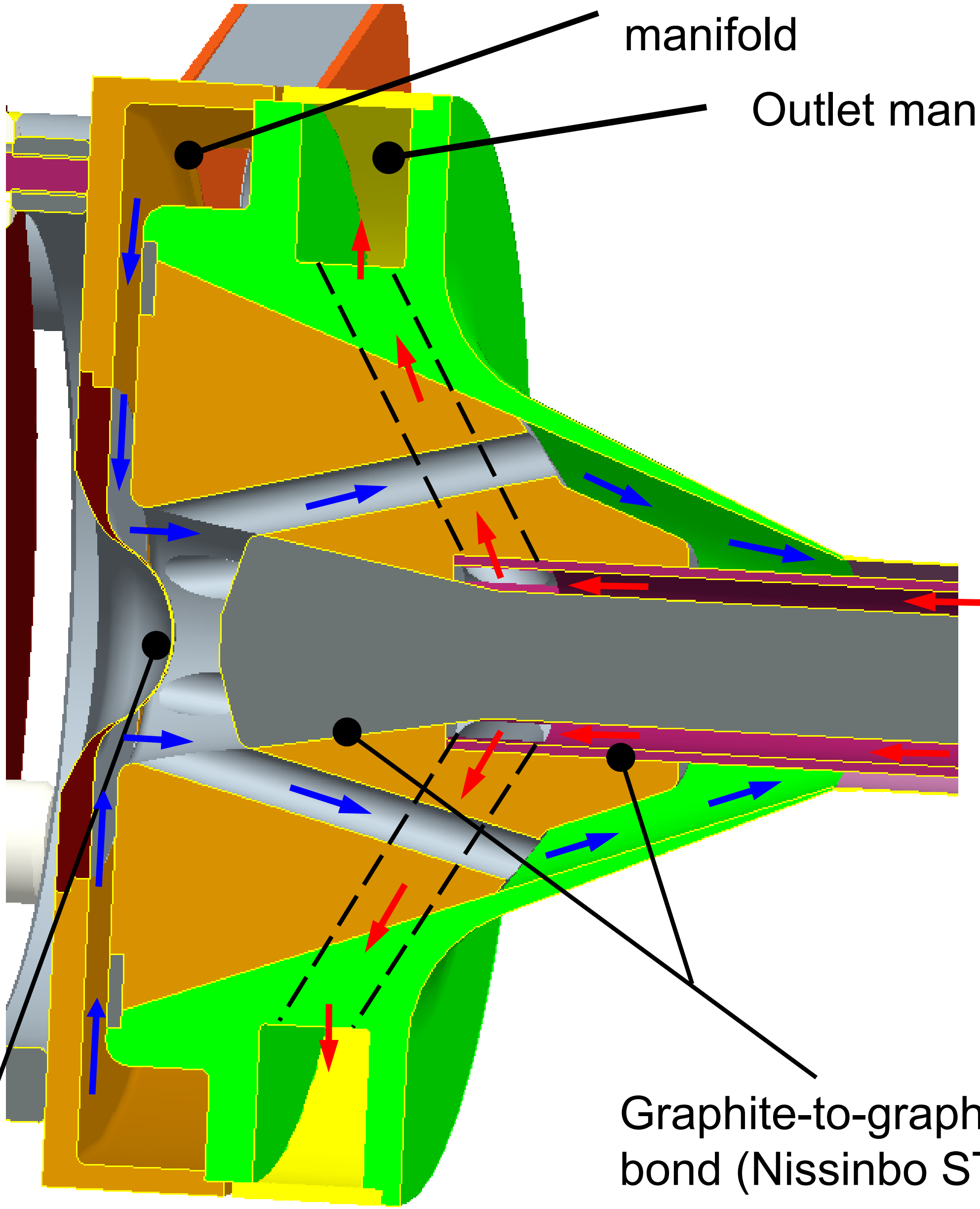
Aims of Target Design

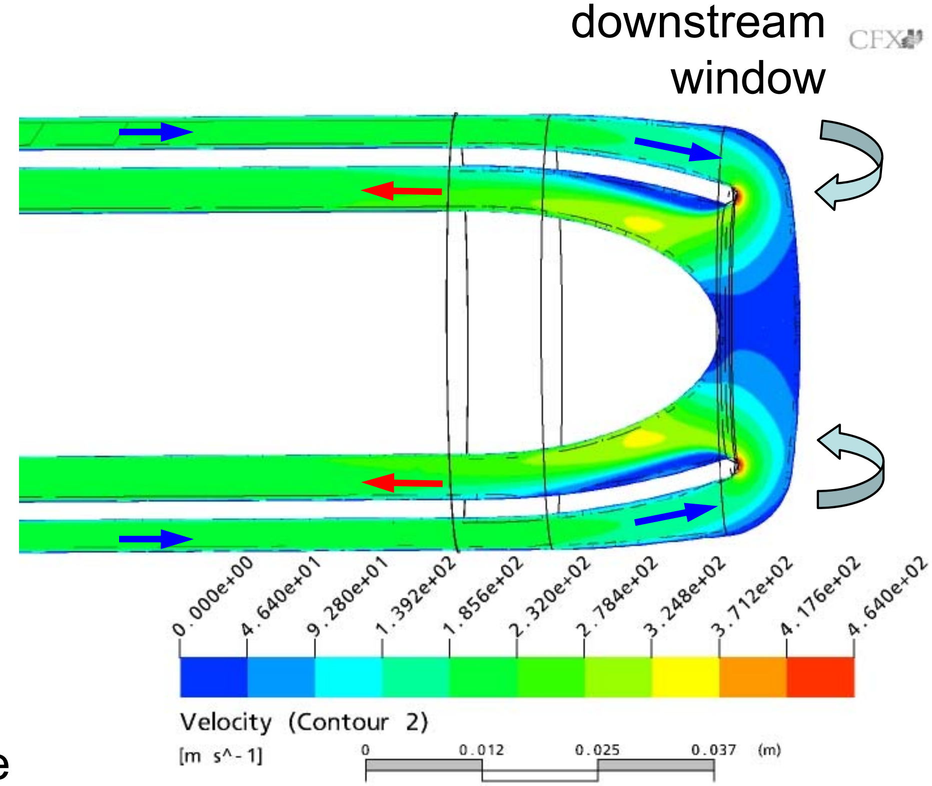
- Target is graphite rod, 900mm long and 26mm diameter
- Target should be Helium cooled to allow higher operating temperature and to avoid shock waves from liquid coolants
- Target rod to be completely encased in titanium and cooled using high purity helium to prevent oxidation of the graphite
- The Helium should cool both upstream and downstream titanium window first, before cooling the target due to material limits
- Pressure drop in the system should be kept to a minimum due to high flow rate required (max. 0.8 bar available for target at required flow rate of 32 g/s (30% safety margin))
- Target rod to be uniformly cooled, but kept above 400°C to reduce radiation damage effects
- It should be possible to remotely change the target in the first horn

Current Target Design

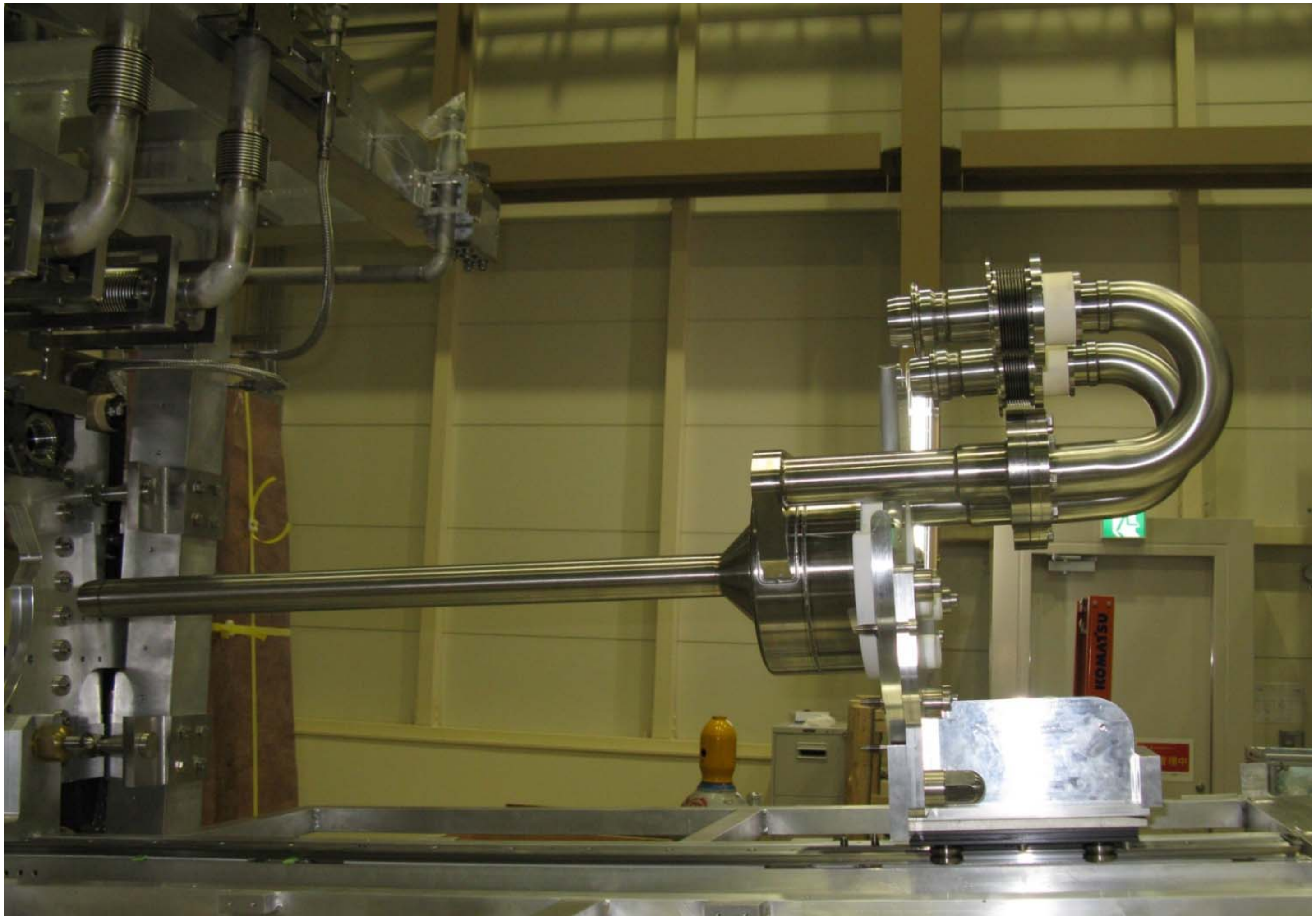


Target Design: Helium cooling path





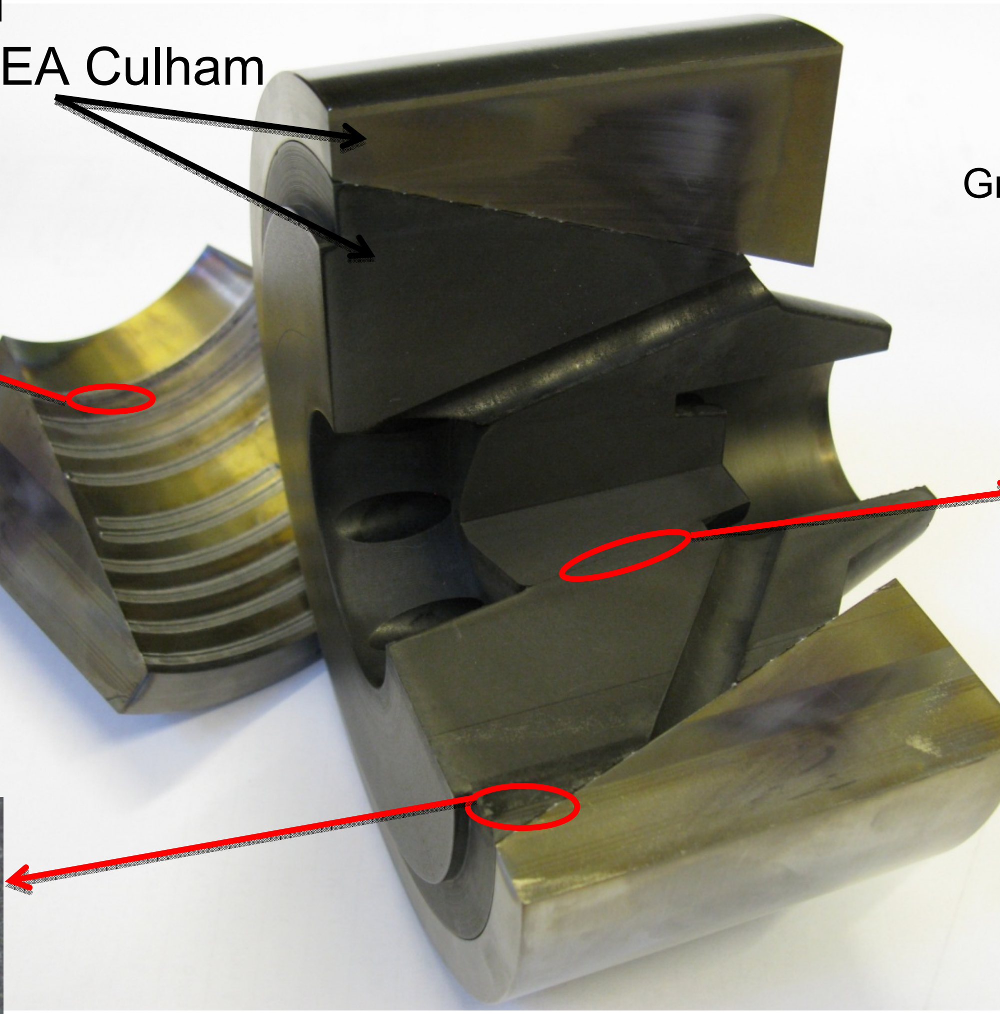
Target v.0 – September 2008

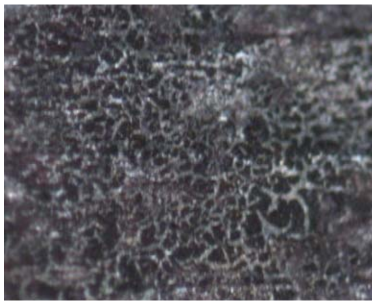


Target manufactured by Toshiba, Japan
Pipes, Isolators, remote connectors and remote handling/alignment systems by RAL

Diffusion Bond + Graphite-Graphite bonding test

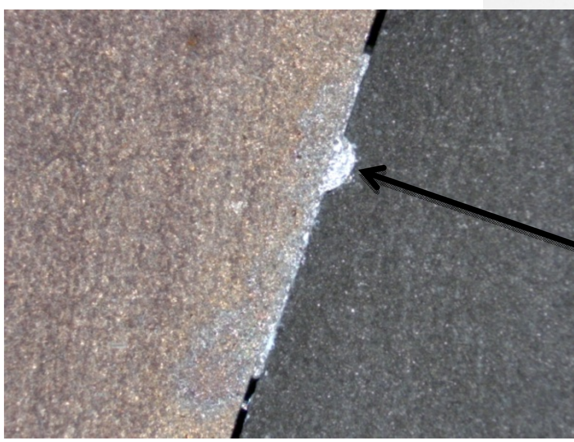
IG43 Graphite diffusion bonded into Ti-6Al-4V titanium, Special Techniques Group at UKAEA Culham





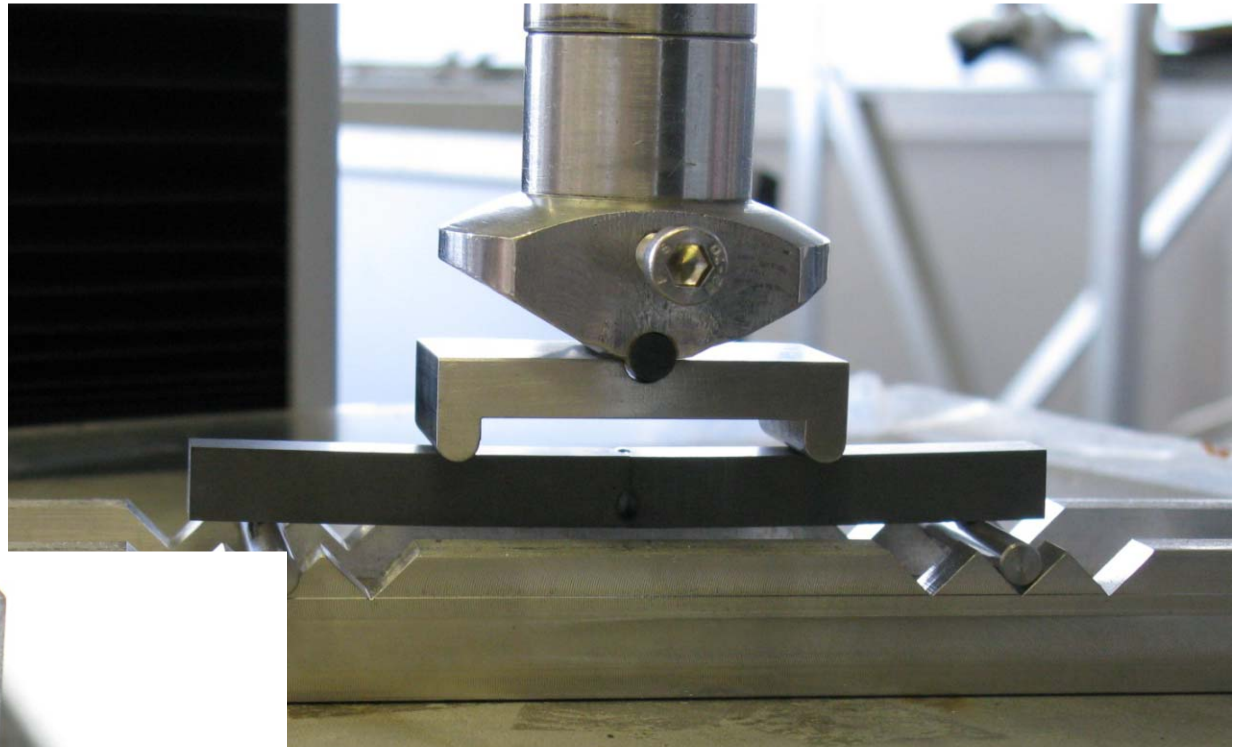
Graphite transfer to Aluminium

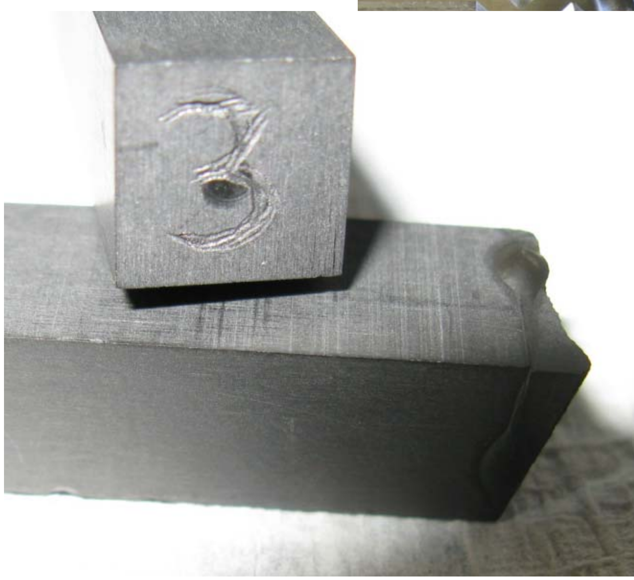
Graphite-Graphite bonding



Aluminium intermediate layer, bonding temperature 550ºC
Soft aluminium layer reduces residual thermal stresses in the graphite

Testing of graphite bonding





Adhesive cured and fired to 1000°C
Fracture strength ~40MPa
Failure through substrate, not bondline

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CFD Analysis outline

Required flow rate

Boundary conditions

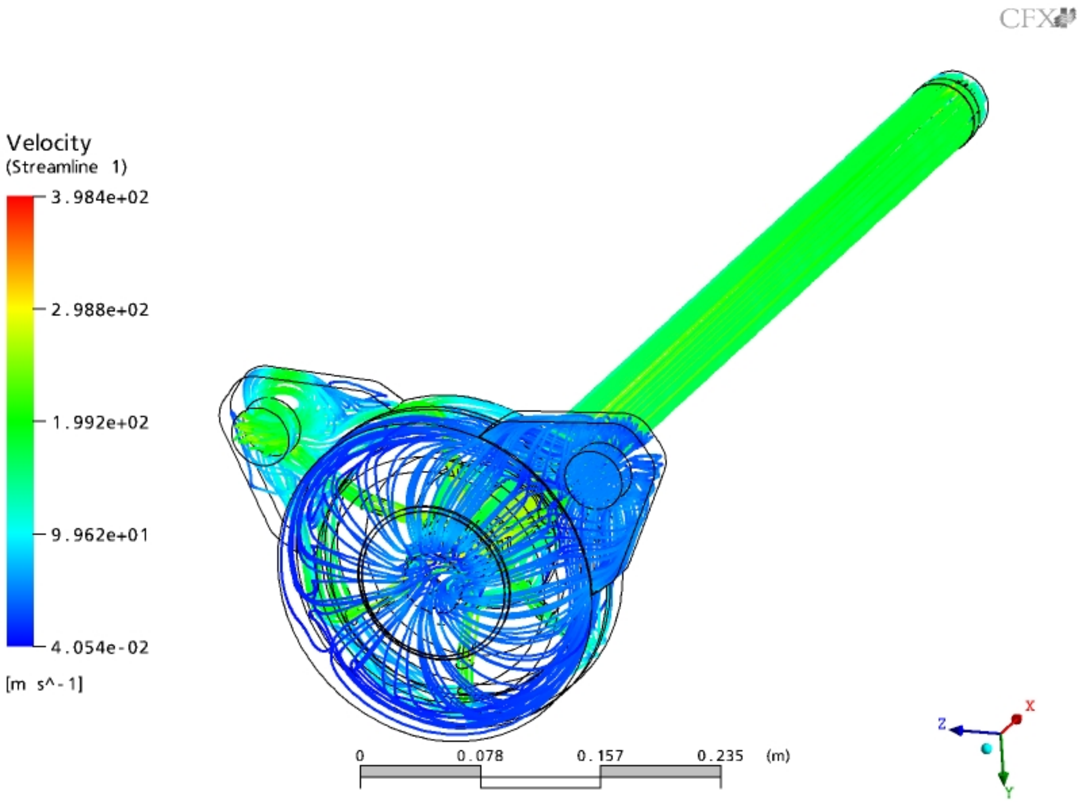
- *Inlet Mass flow rate = 25g/s and 32g/s*
- *Helium Inlet temperature = 300K*
- *Outlet Pressure = 0.9 bar (gauge)*

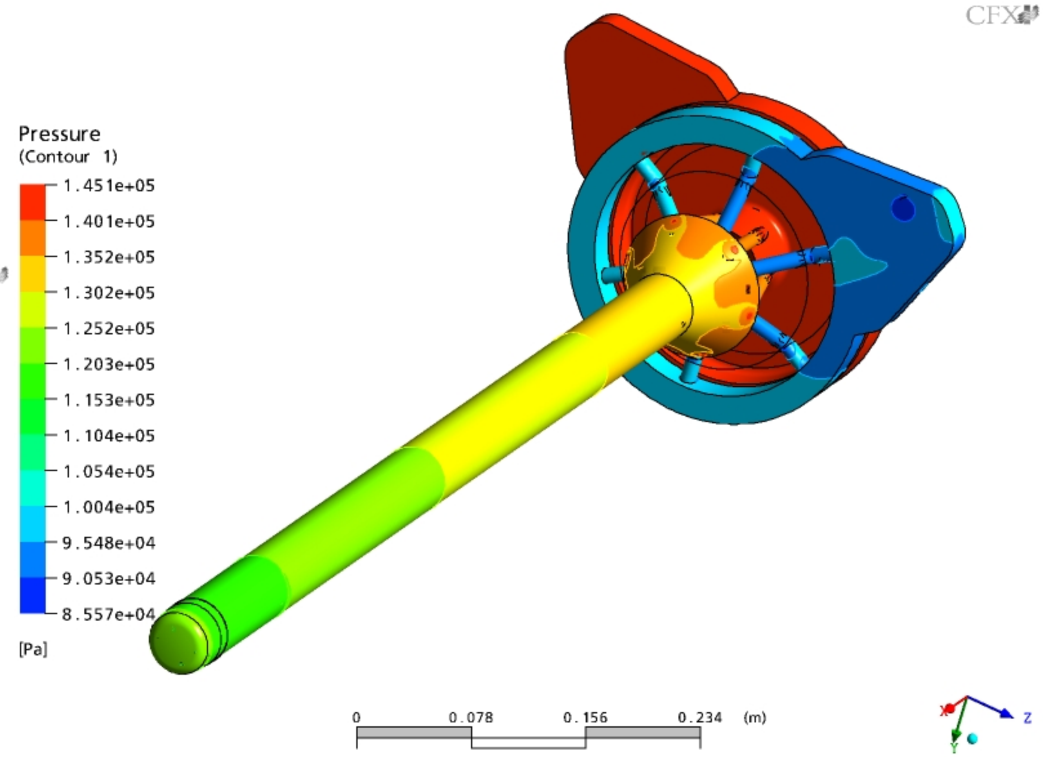
Heat deposition from MARS simulation

- *On target as a function in r and z*
- *On upstream and downstream window as radial function*
- *On Inner graphite tube as a function of z*
- *On Outer tube as a total source*
- **TOTAL HEAT LOAD = 22kW**

Velocity streamlines & Pressure drop

Maximum velocity = 476 m/s @ 32g/s
Maximum velocity = 398 m/s @ 25g/s





Pressure drop = 0.545 bar @ 25g/s
Pressure drop = 0.792 bar @ 32g/s

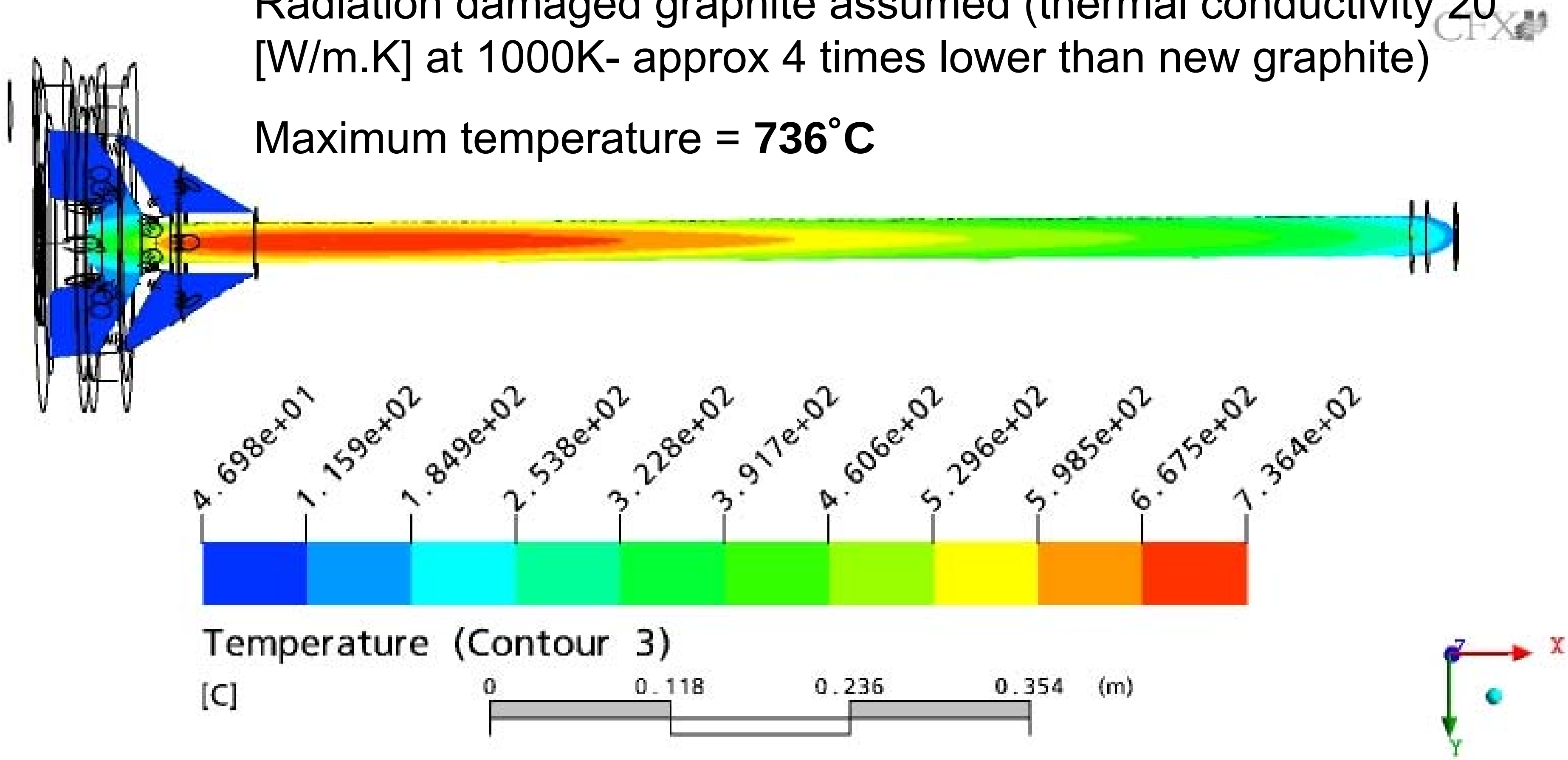
Steady state target temperature

30 GeV, 0.4735Hz, 750 kW beam

Helium mass flow rate = 32g/s

Radiation damaged graphite assumed (thermal conductivity 20 [W/m.K] at 1000K- approx 4 times lower than new graphite)

Maximum temperature = **736˚C**



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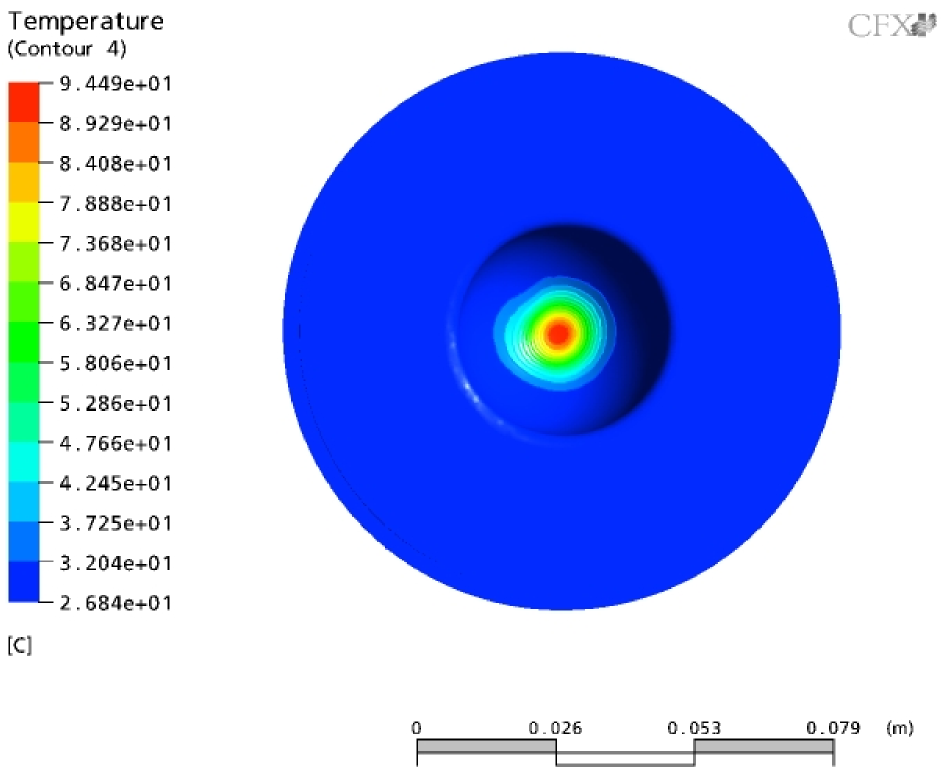
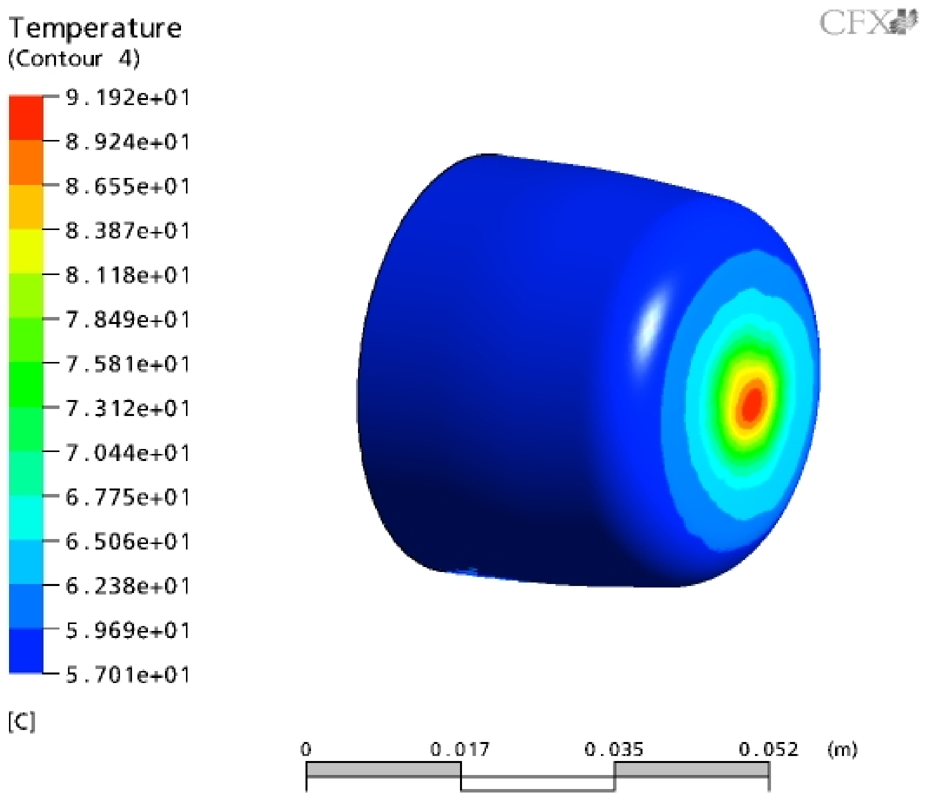
Target window temperatures

Upstream Window



Max Steady State Temperature = 95°C

Downstream Window



Max Steady State Temperature = 92°C

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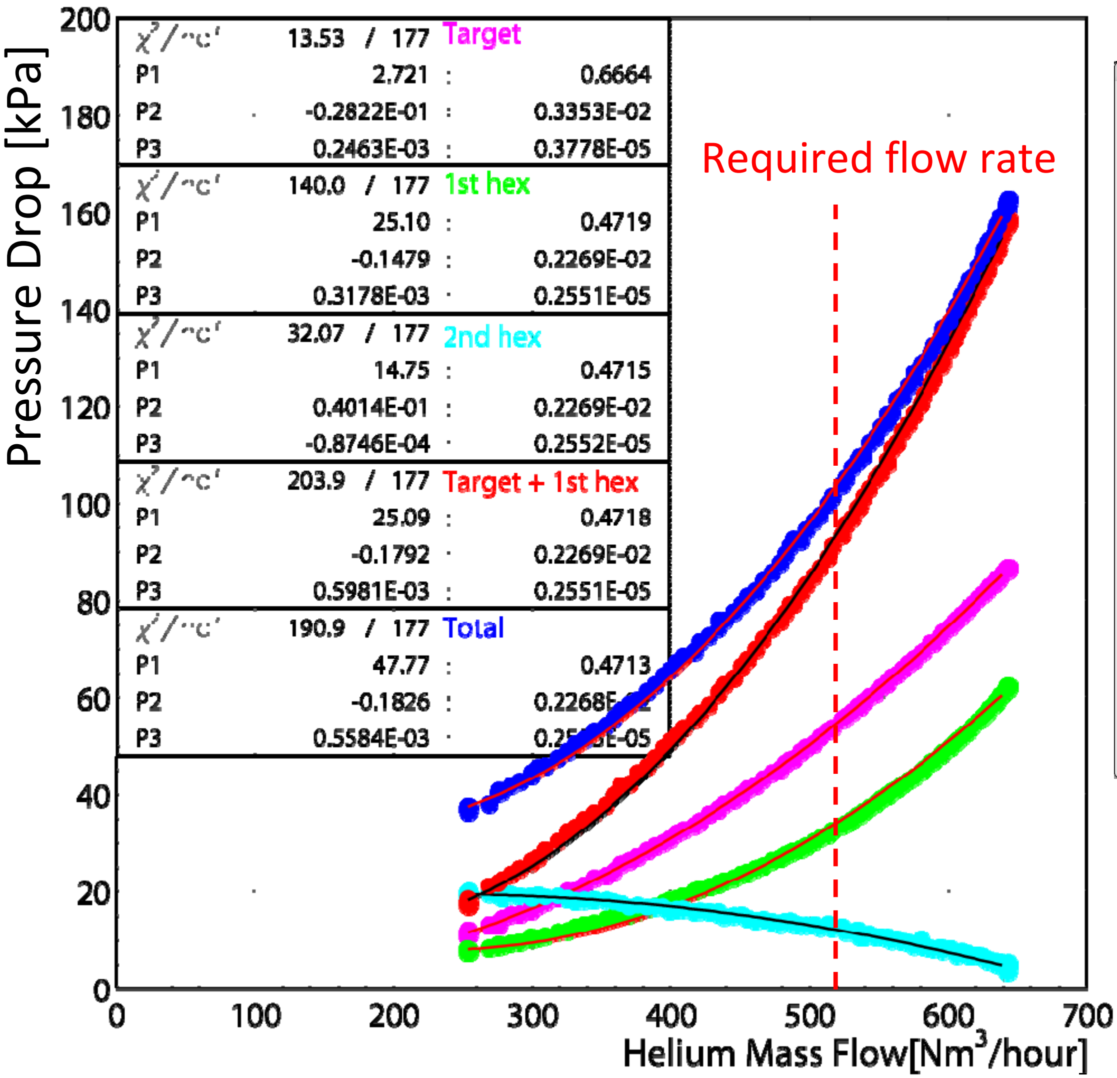
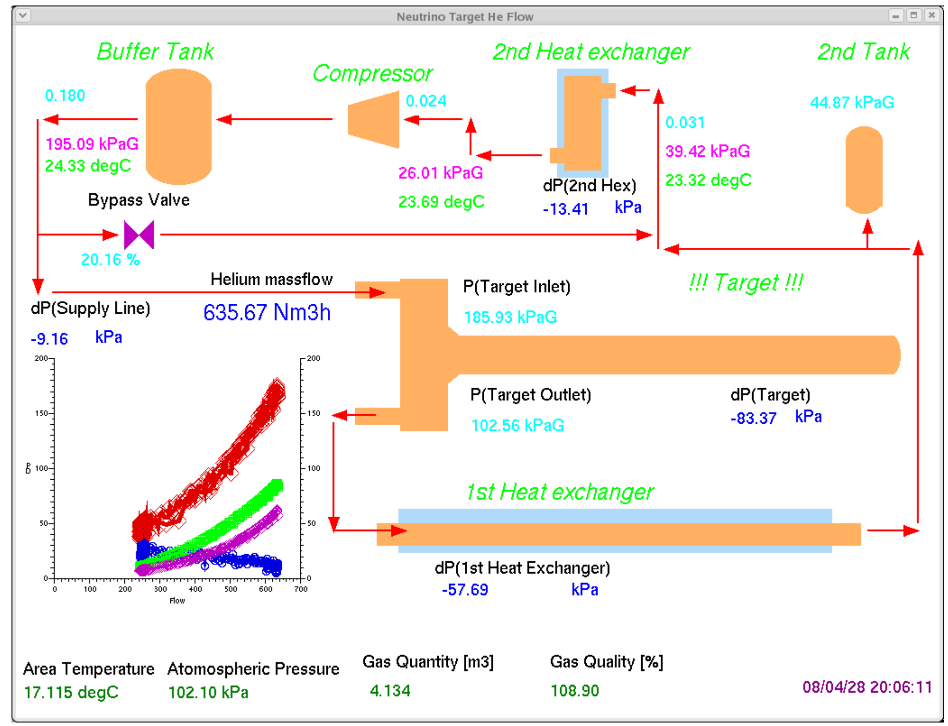
He flow test with actual target



Status monitor display (EPICS/EDM)



Pressure drop is consistent with the Expectation by CFD simulation by M. Fitton.

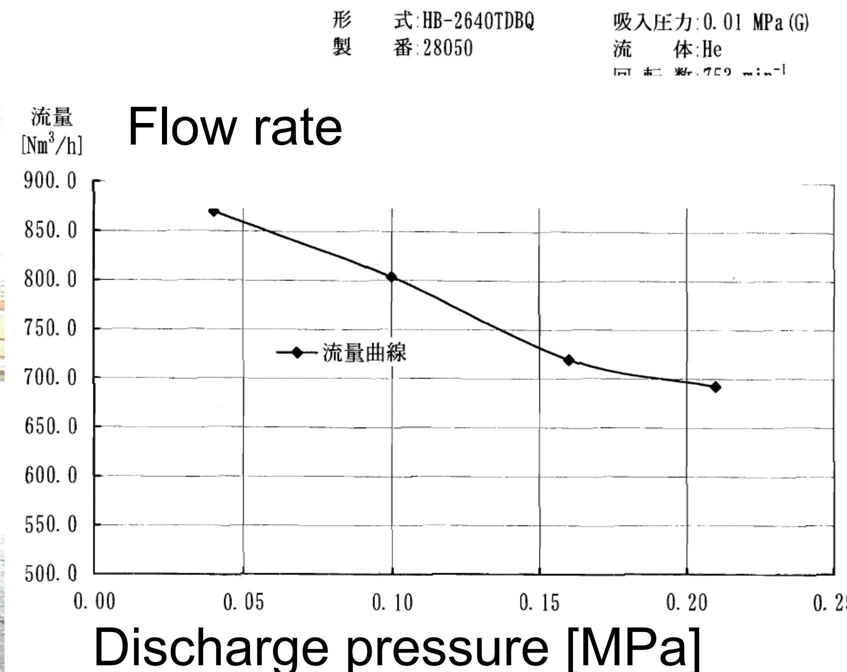
T. Nakadaira, KEK

Achieved mass flow is 650 [Nm^3/h] … requirement + 27%

(Requirement for 750kW beam = 510 [Nm^3/h])

Target helium compressor

- *Power consumption: 34kW*
- *Helium gas leak rate < 1.1×10^{-5}[Pa·m/s]*



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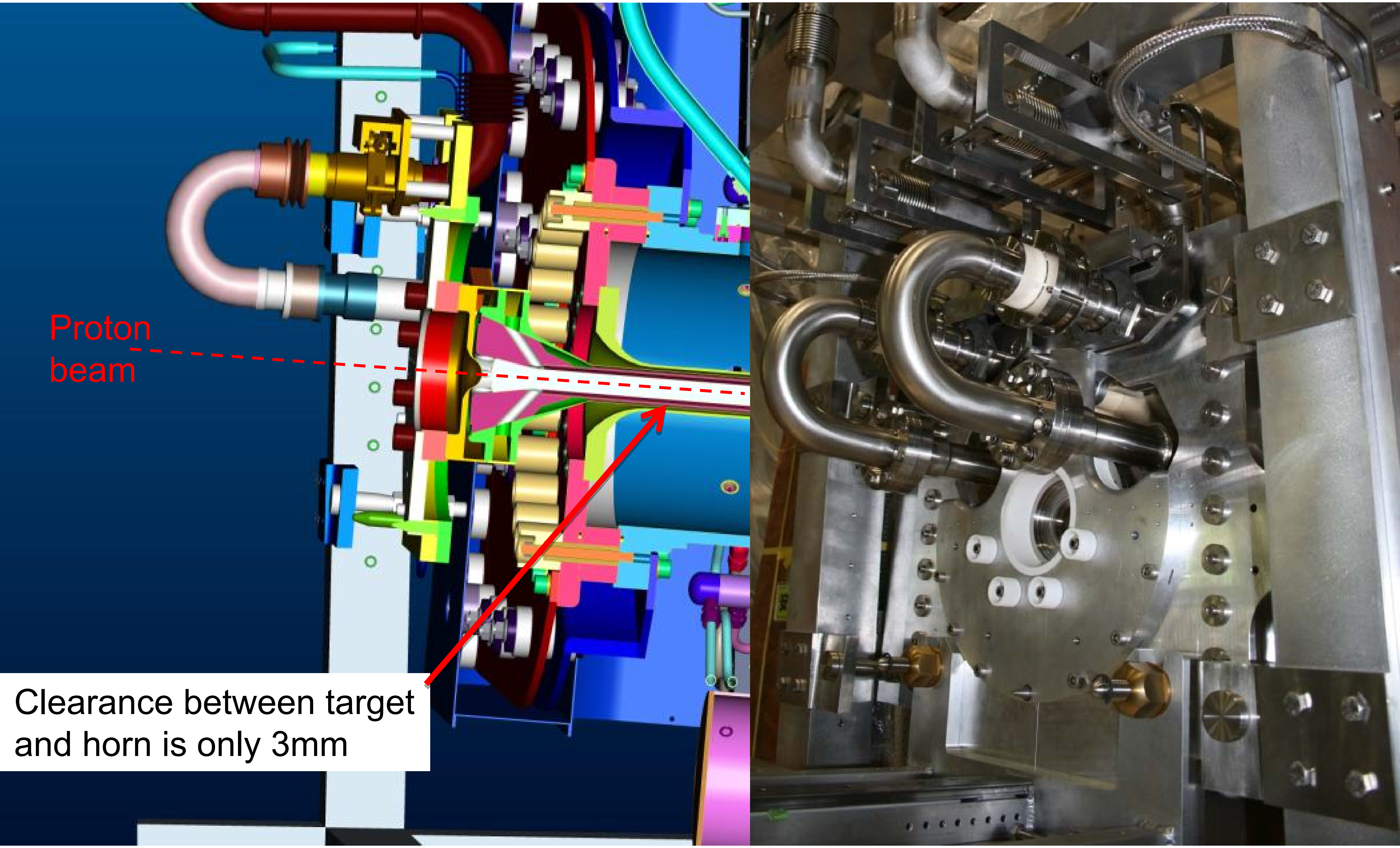
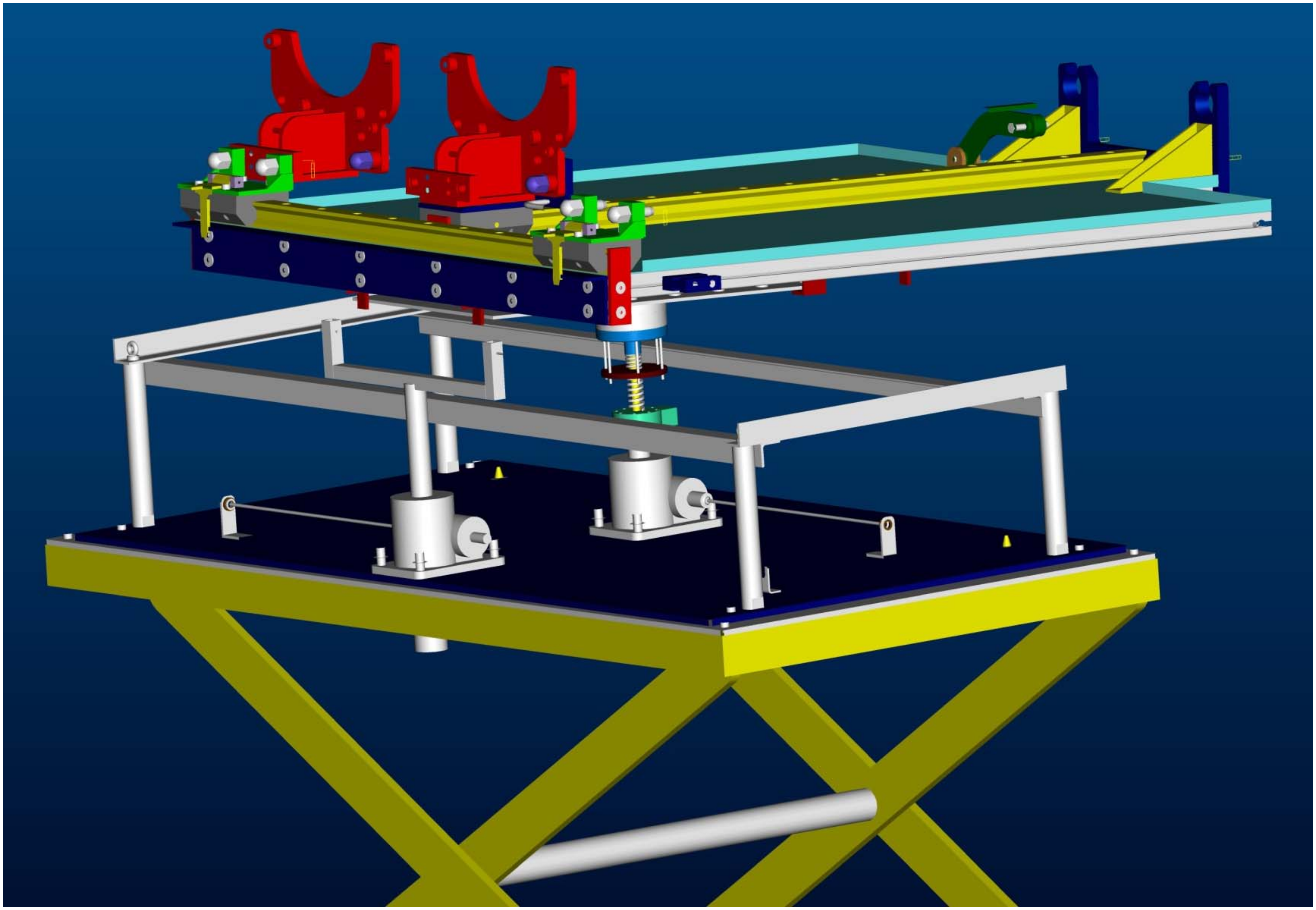
Target installed within 1st magnetic horn



Prototype Target remote exchange system

Target remote exchange system



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Future upgrade plans

1st April 2009 – Start operation

2010 – Power to 750kW

2014 – Power to 1.66MW

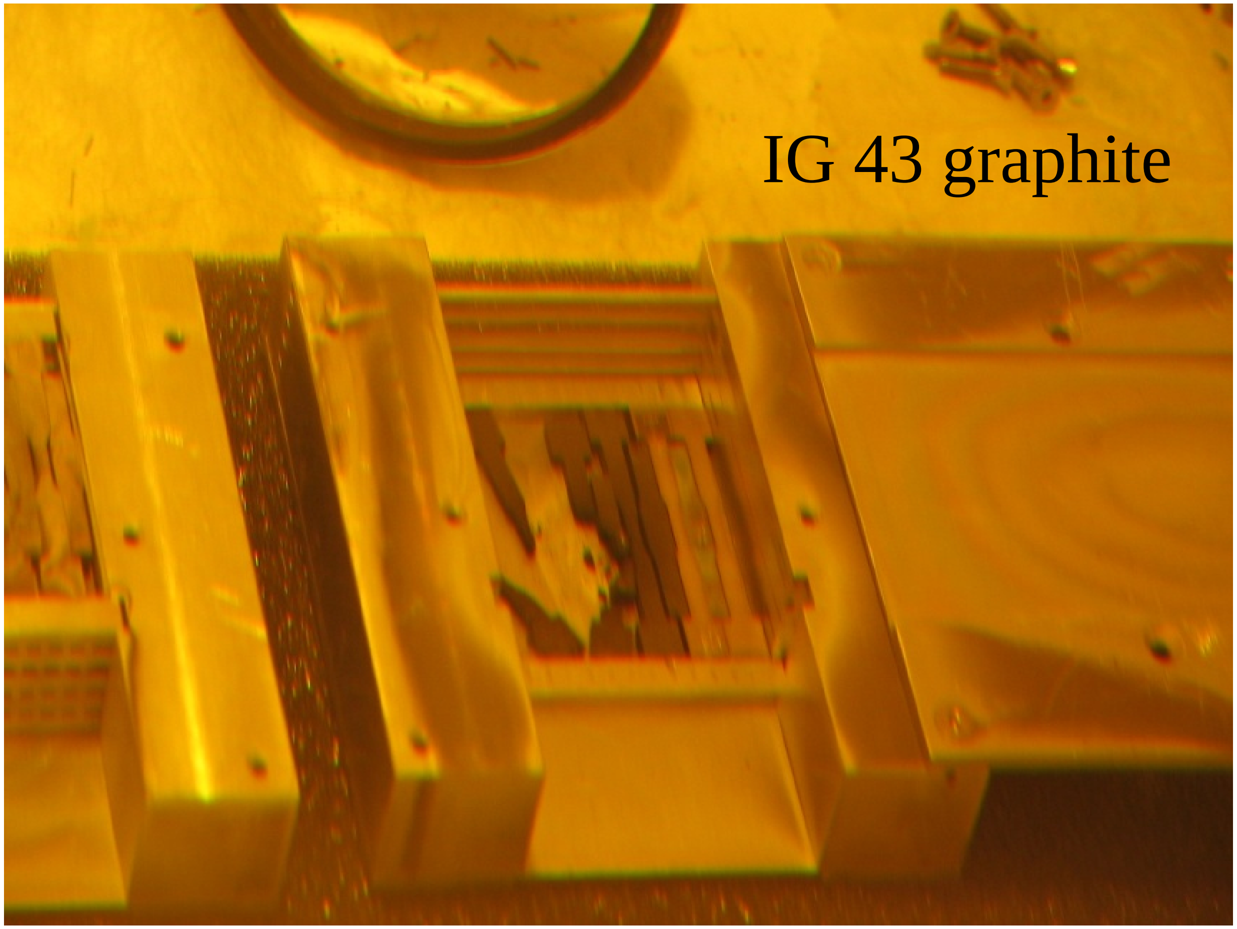
20? ? – Power to 3-4MW

Only Hadron absorber and DV currently designed for this power

Only approximately 50kW deposited in target, however

- With current setup helium ΔT too high (350°C)
- Need to increase flow rate → Higher pressure
  - May need to modify target and HX to lower ΔP

Radiation damage likely to be limiting factor for target life



200 MeV proton fluence

~10^21 p/cm2

c. 1 year operation in T2K

Water cooled

Nick Simos, BNL

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Irradiation effects on Graphite

Expected radiation damage of the target

- *The approximation formula used by NuMI target group : 0.25dpa/year*
- *MARS simulation: 0.15~0.20 dpa/year*

Dimension change : shrinkage by ~5mm in length in 5 years at maximum.
~75μm in radius

Degradation of thermal conductivity … decreased by 97% @ 200 °C
70~80% @400°C

Magnitude of the damage strongly depends on the irradiation temperature.

- *It is better to keep the temperature of target around 400 ~ 800 °C*