The Current T2K Beam Window Design and Upgrade Potential

Oxford-Princeton Targetry Workshop

Princeton, Nov 2008

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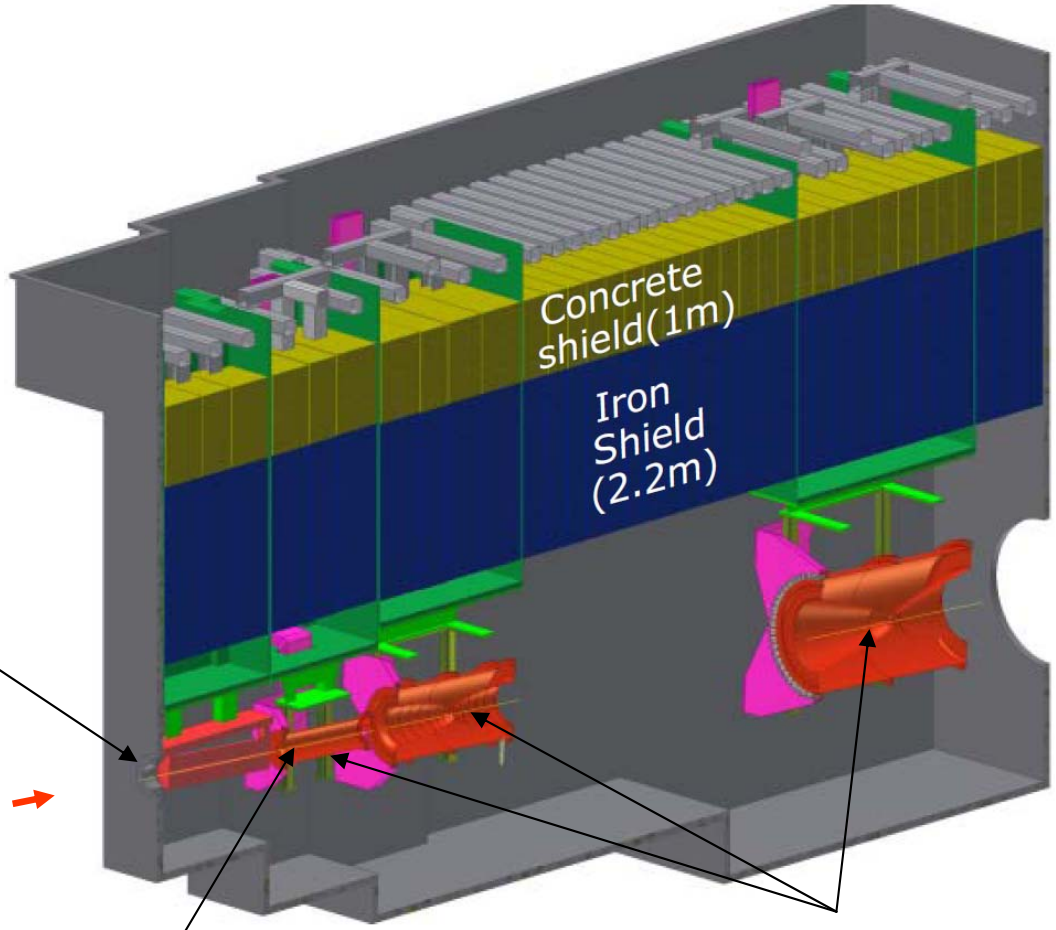
Science & Technology Facilities Council

T2K Target Station

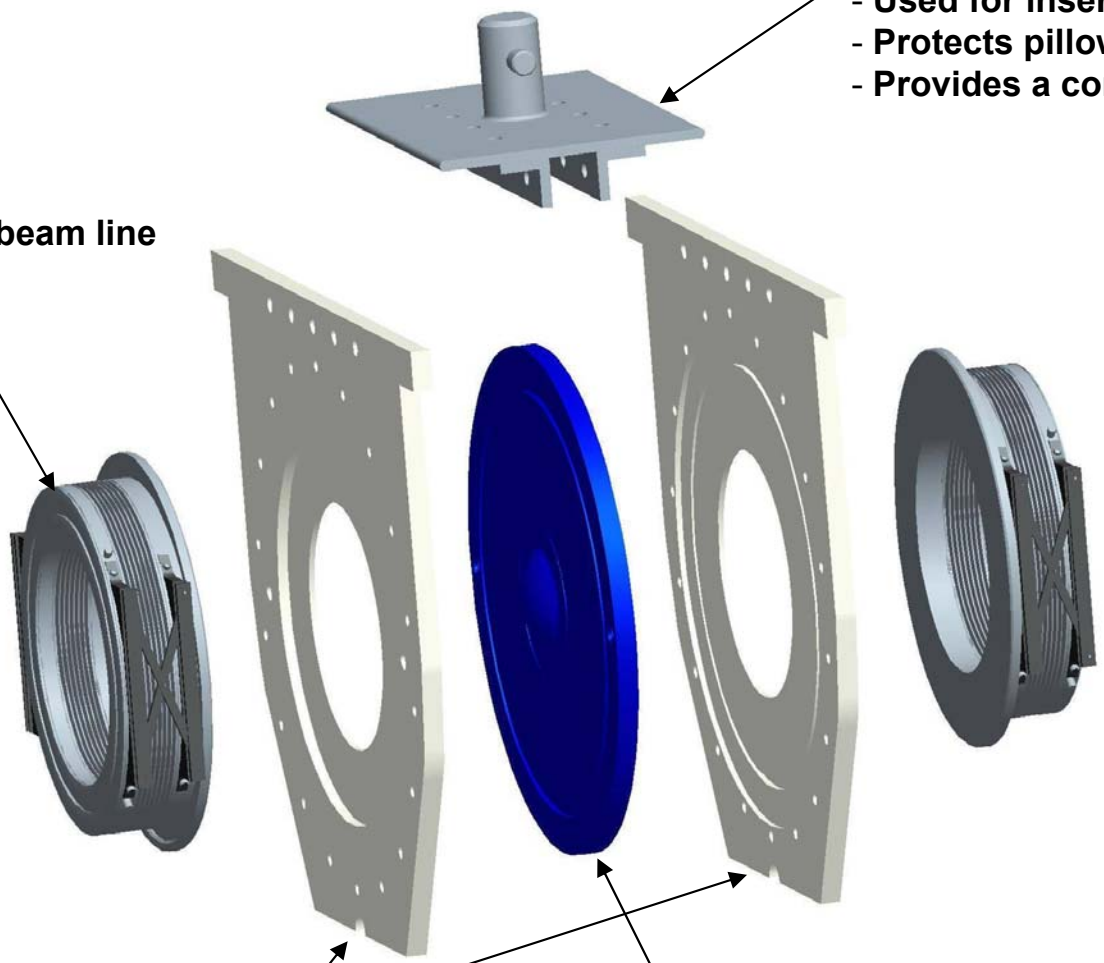


Beam window design overview

Exploded assembly view

Top plate
- Used for inserting and removing window
- Protects pillow seals and mating flanges
- Provides a connection point for services

Inflatable seals
-Seal helium vessel and beam line



Side plates
-Provide a firm support for the beam window and guidance during installation

Ti-6Al-4V beam window

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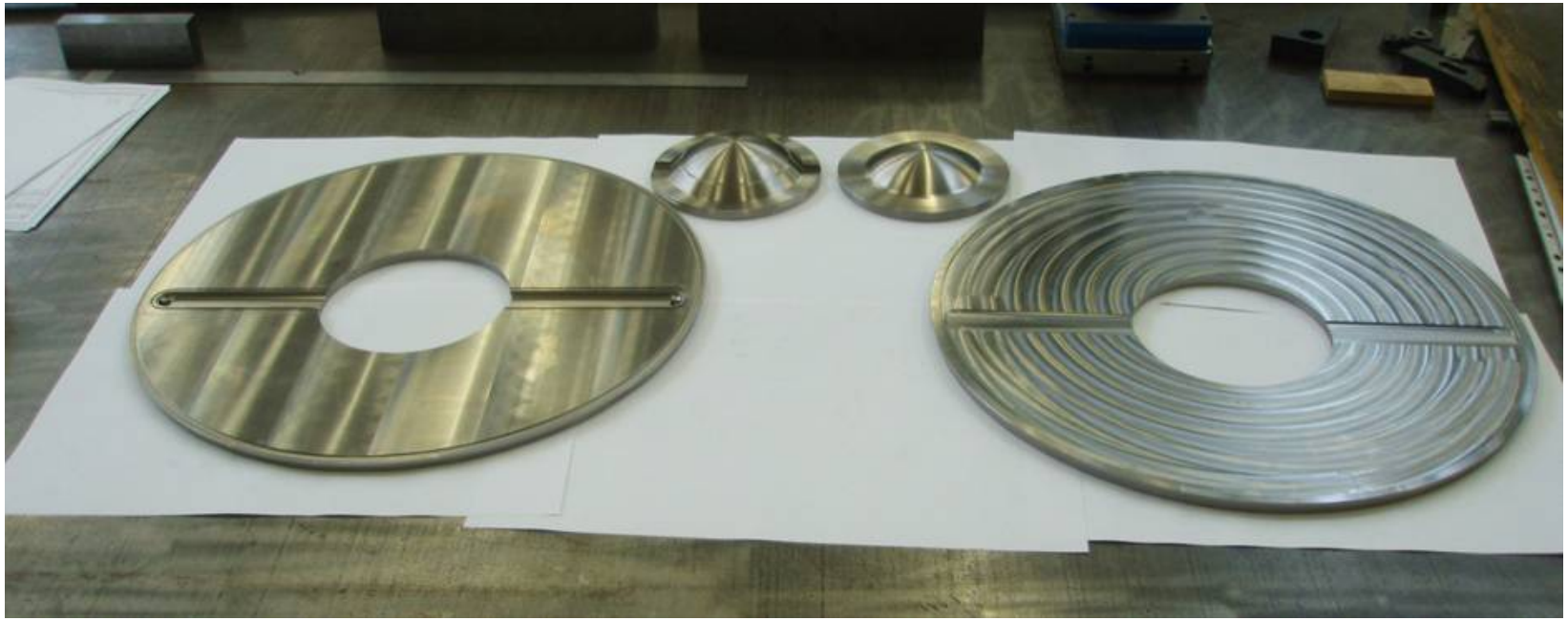
Ti-6Al-4V Beam window



- Some difficulties with post-machining and post-weld distortion – a common problem with Ti-6Al-4V.
- E-beam welding conducted by Culham UKAEA Special Techniques Group.

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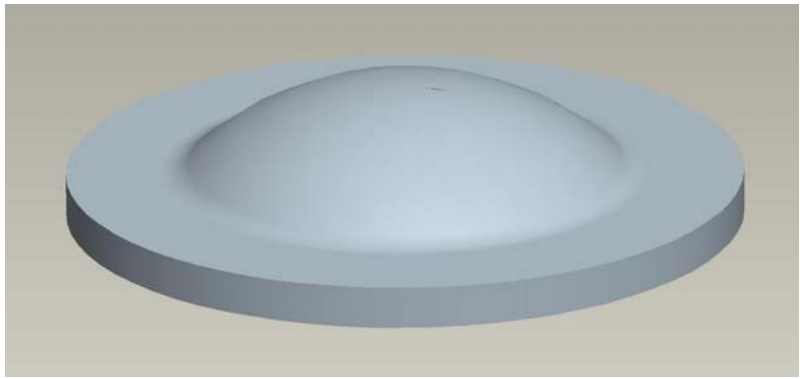
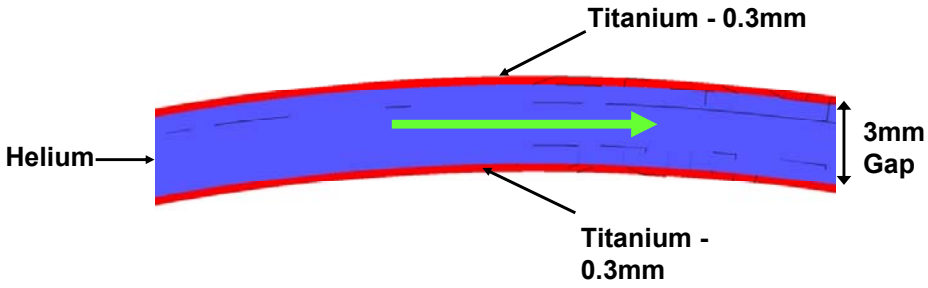
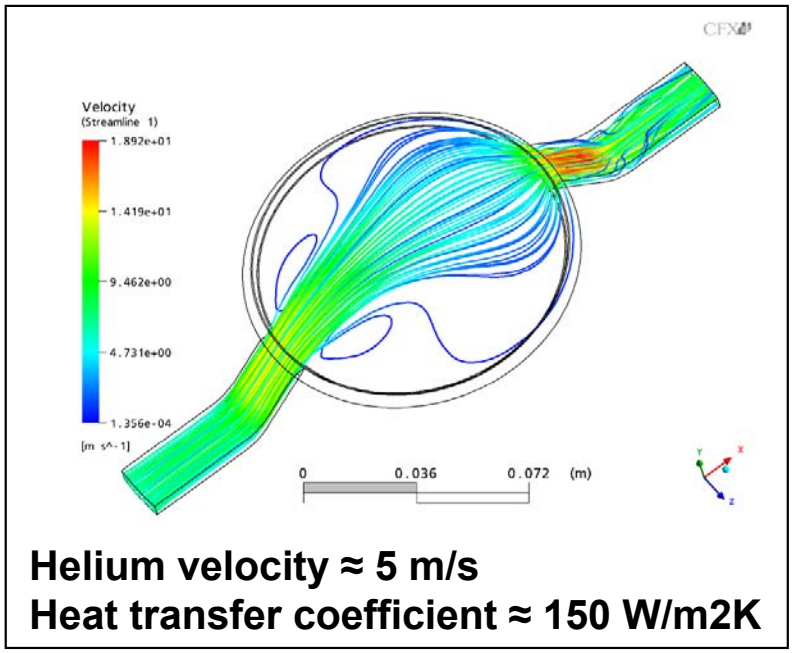
Helium cooling

Upstream



He gap

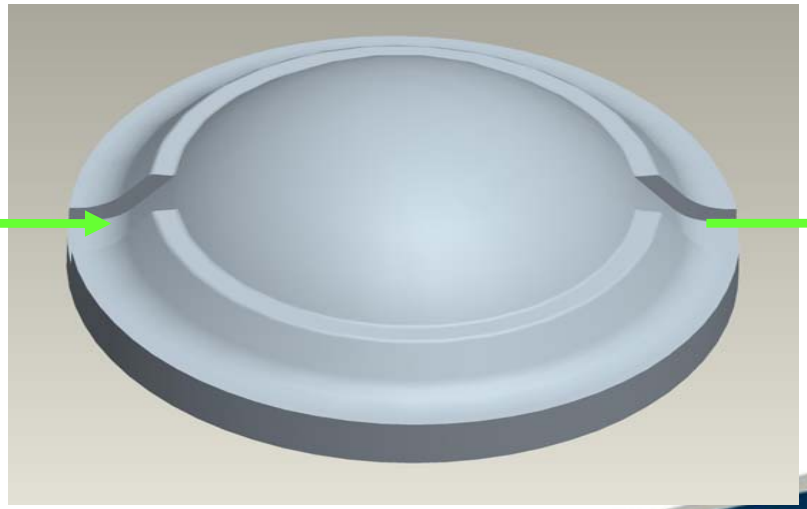




Helium velocity ≈ 5 m/s
Heat transfer coefficient ≈ 150 W/m2K

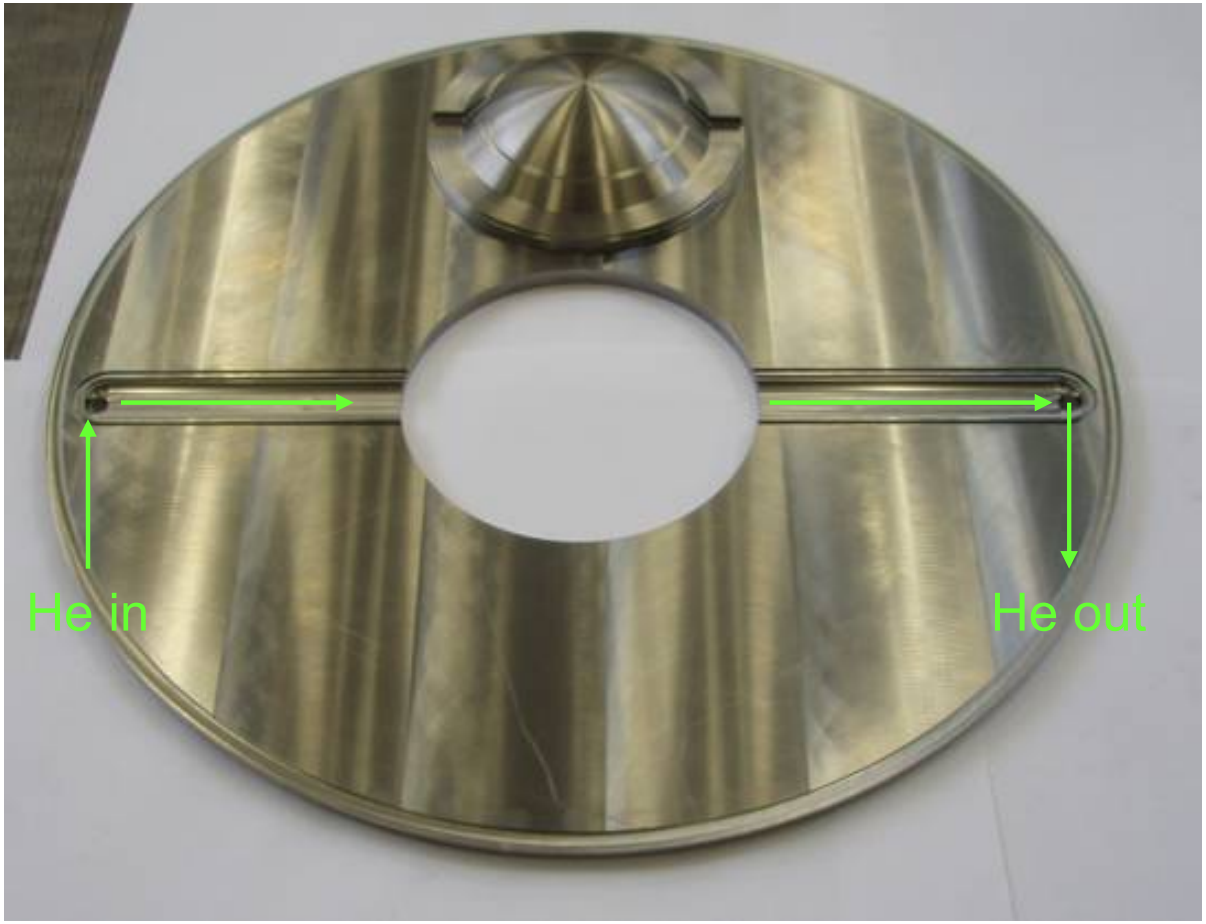
Downstream

He in



He out

Helium flow grooves



Inflatable seals

PSI

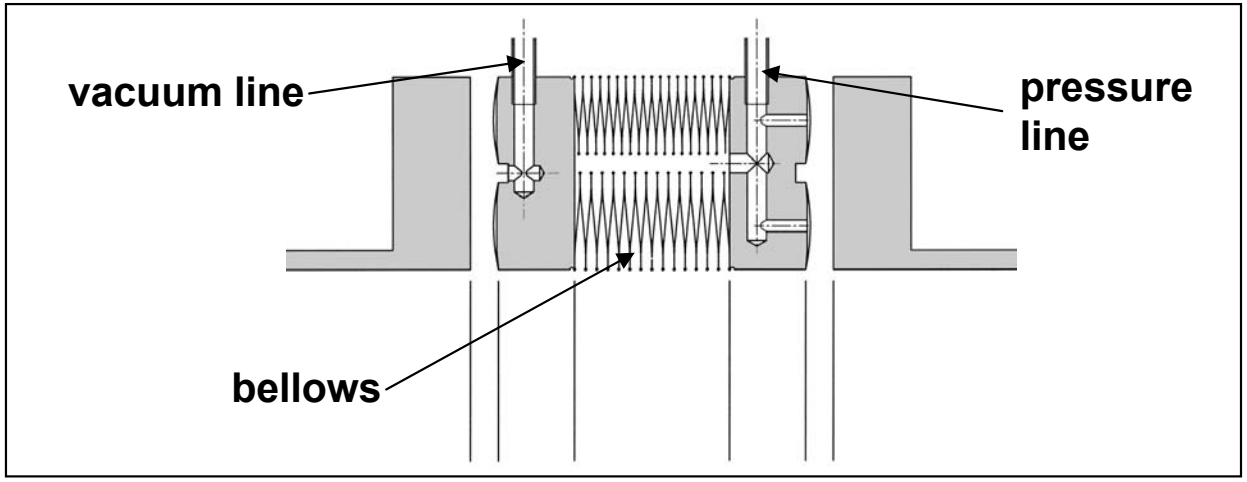
Picture courtesy of PSI

KEK Muon Group

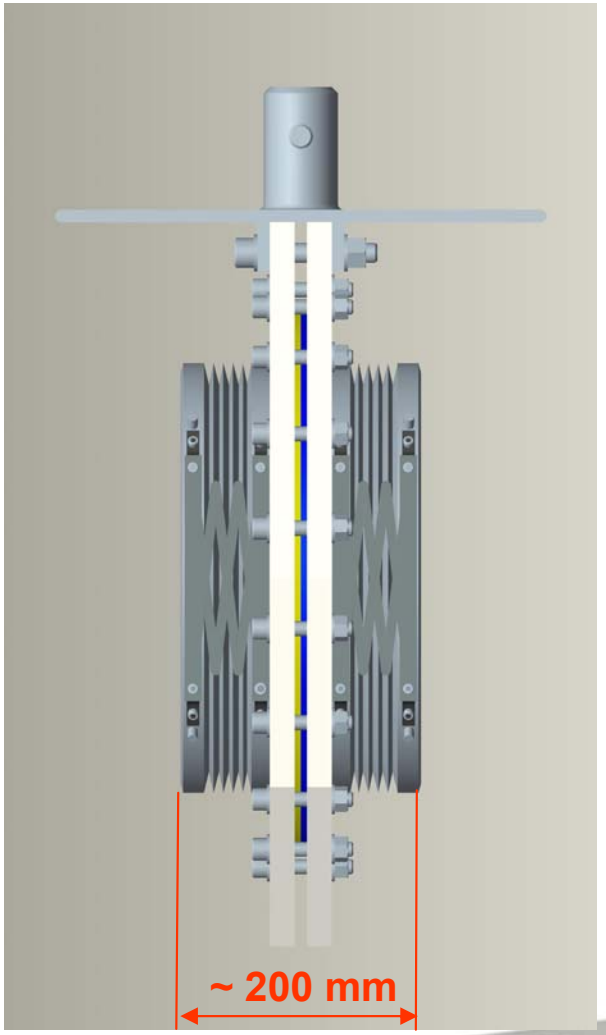
Picture courtesy of Y. Miyake and S. Makimura (KEK)

Pillow seals

Section view



Window – side view



KEK Muon Group pillow seal

Pictures courtesy of Y. Miyake (KEK)

Seal and mating flange

Seal foils (surface roughness, Ra = 0.004 μm, Rt = 0.030 μm)

Polished flange (surface roughness, Ra = 0.020 μm)

Seals manufactured by UHV Design in UK. Developed from similar design at KEK (via Oak Ridge via PSI).

Assembled Window

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Remote Handling

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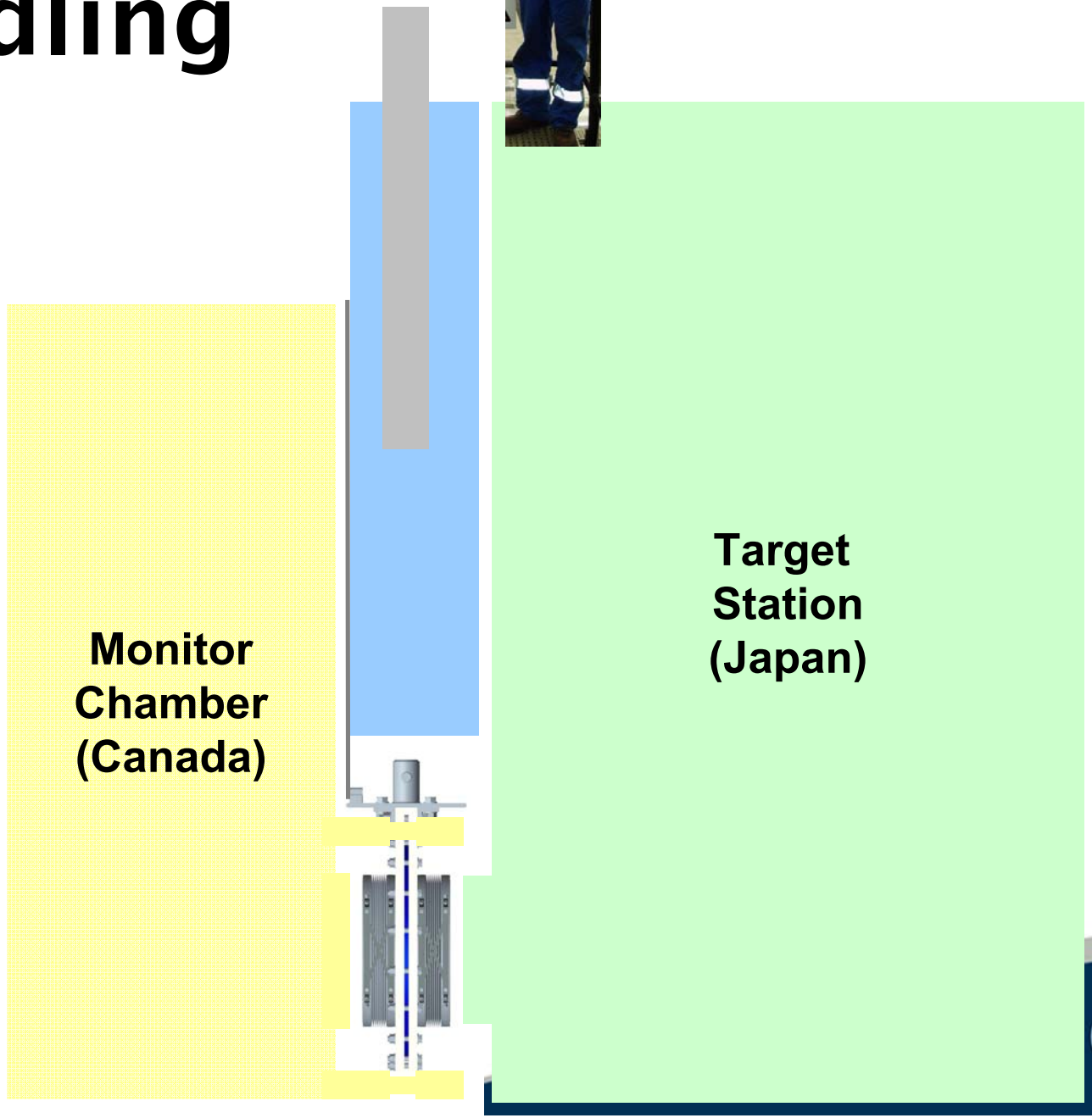
Remote handling



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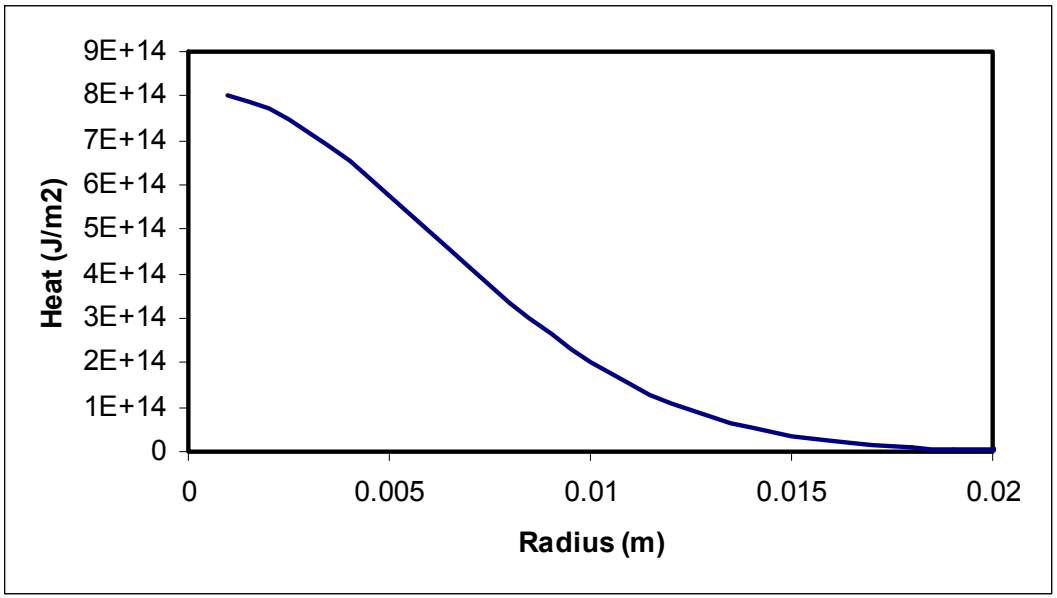
Remote installation

Stress analysis and upgrade potential

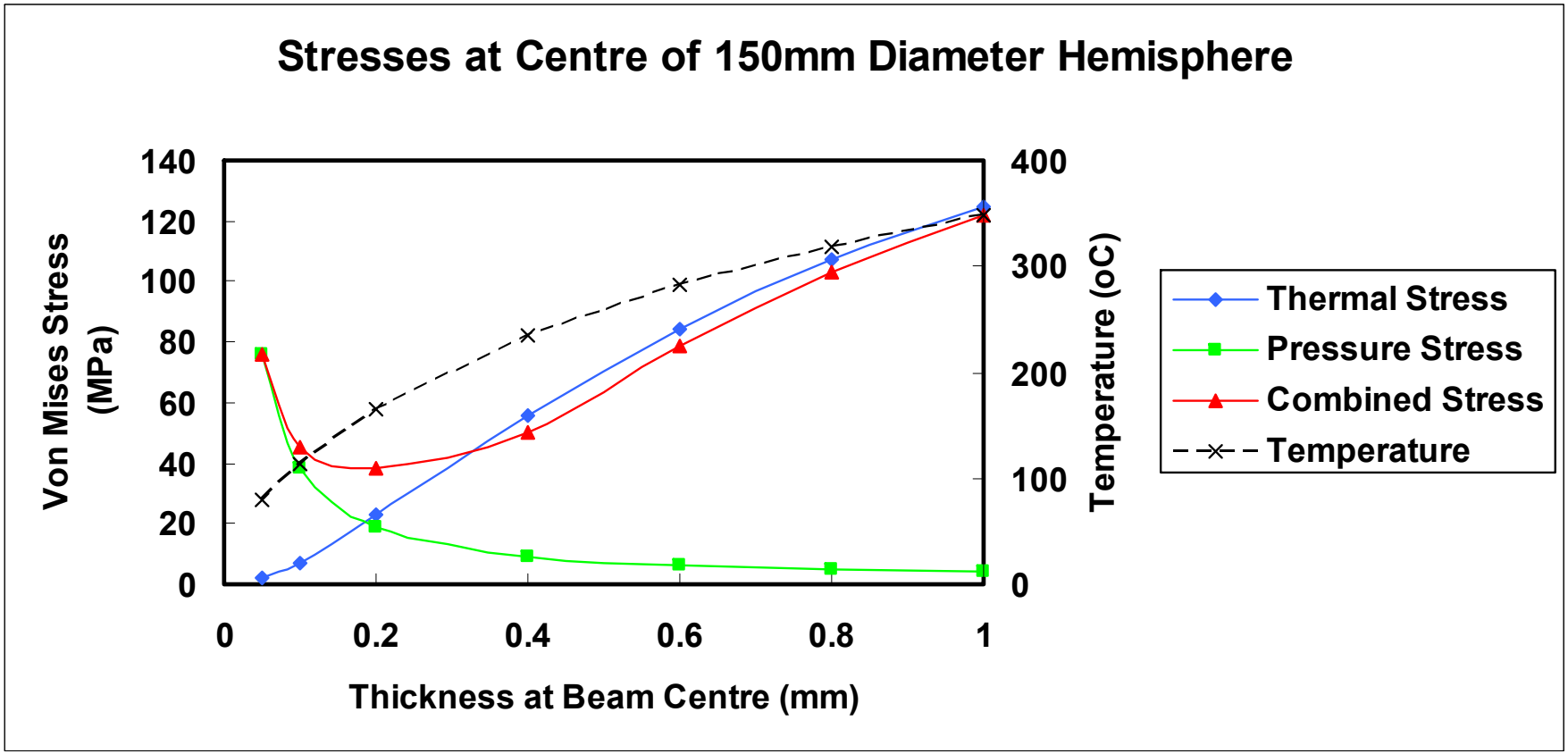
Beam properties

- **0.75 MW beam power**
- **3.3 x 10^{14} protons per pulse**
- **Gaussian profile with 4 mm rad rms beam spot**
- **5 μs pulse = 8 x 58ns bunches**
- **1 pulse every 2 seconds at 30 GeV**



Energy deposited in window with distance from beam centre

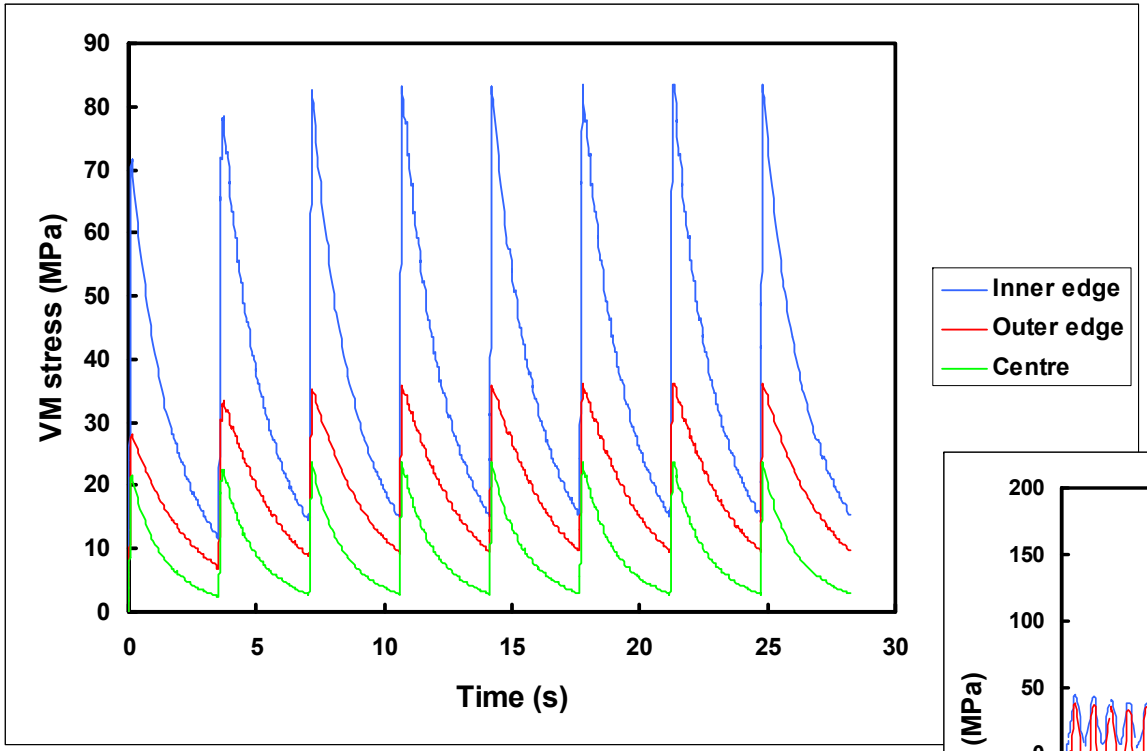
ANSYS Static Stress Results

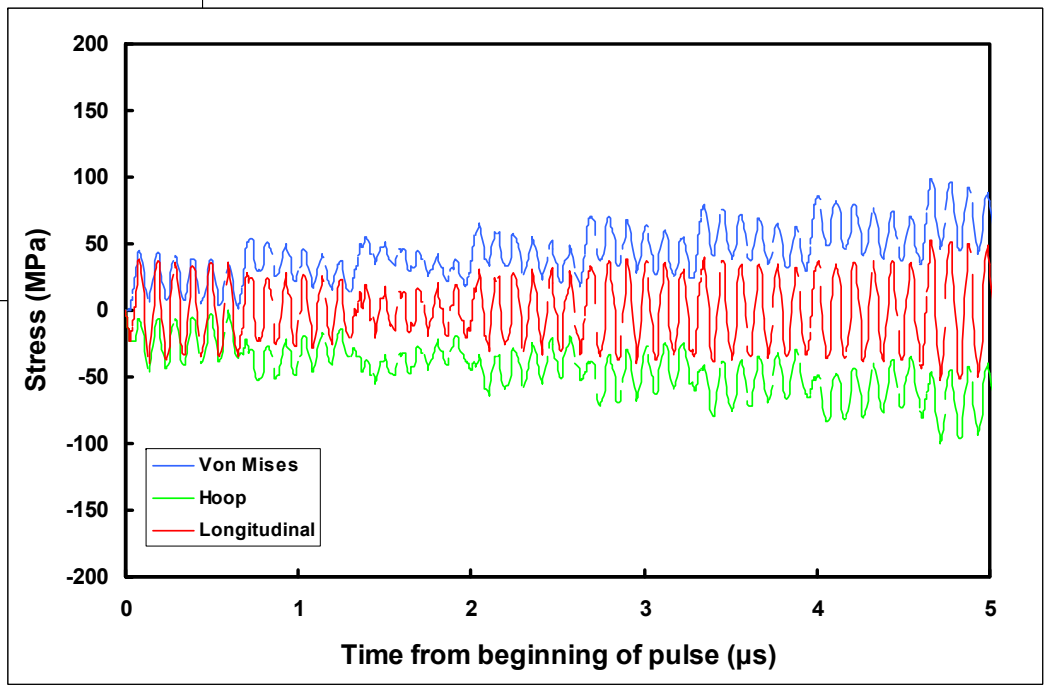


UTS Ti-6Al-4V ≈ 1GPa

NOTE: 100W/m^{2}K heat transfer coefficient applied to internal wall

Transient thermal stress over multiple pulses

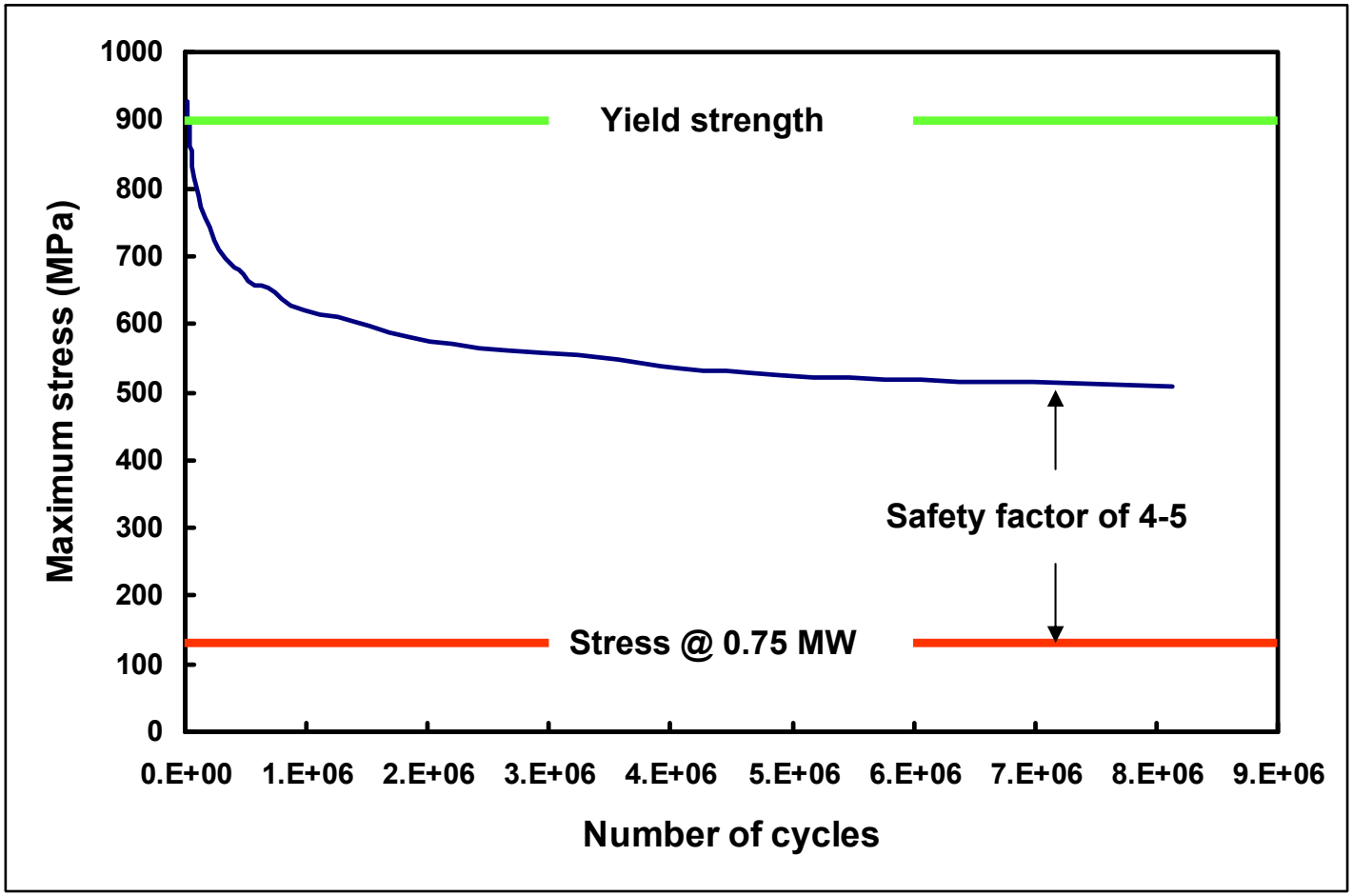




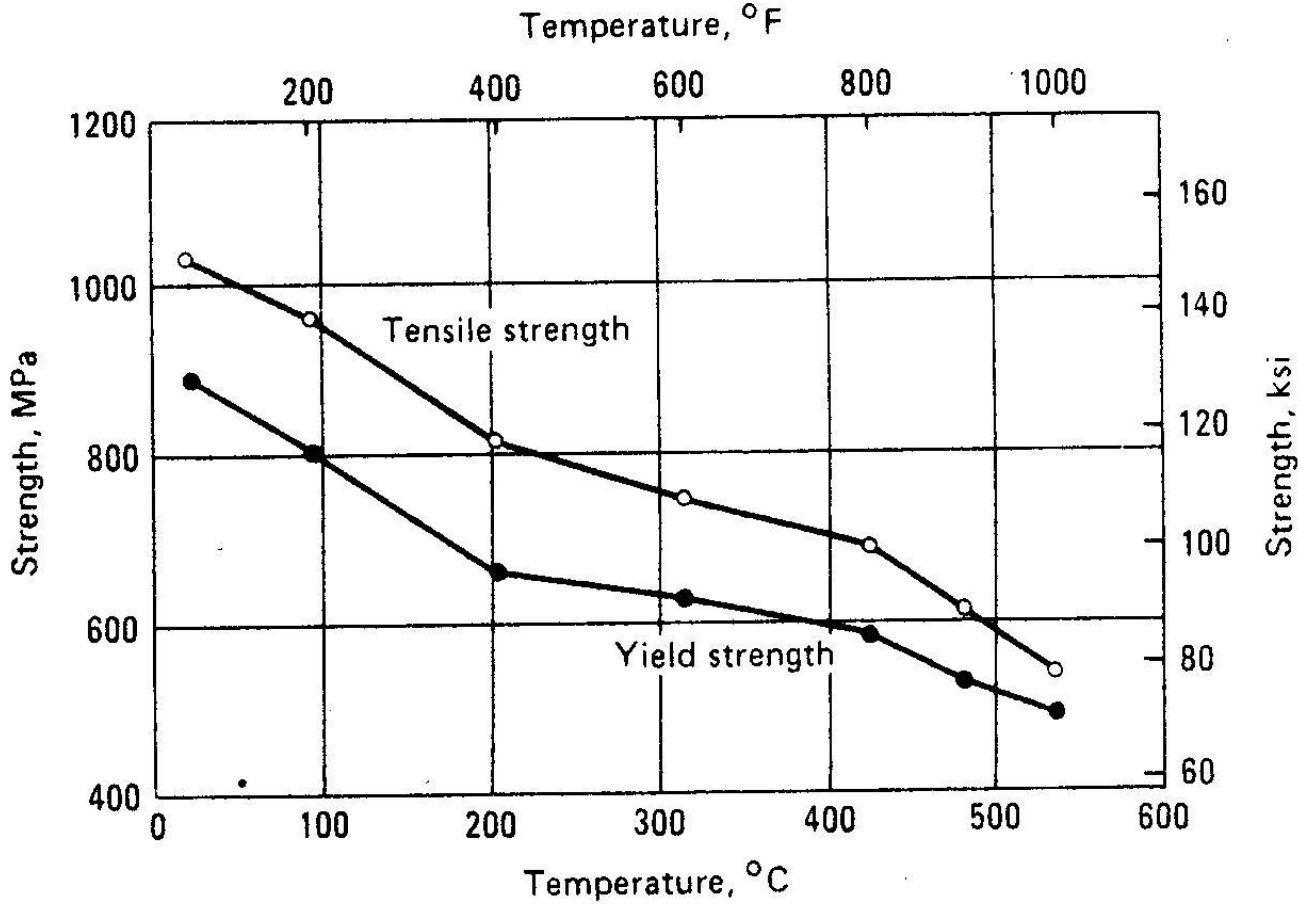
Stress waves developing over pulse

Ti-6Al-4V – the good news

Fatigue strength

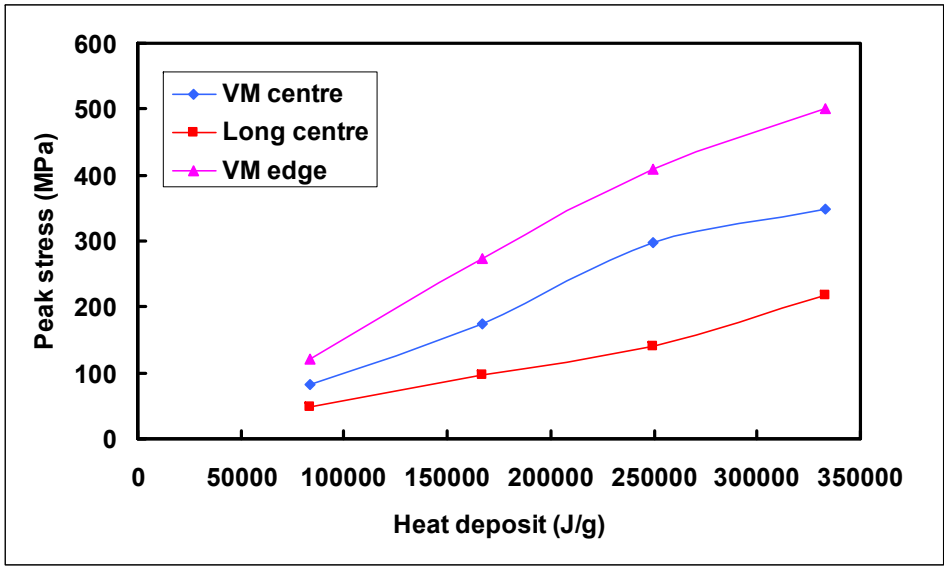


Ti-6Al-4V – the bad news



- reduction in strength at elevated temperatures

T2K beam window upgrade potential



Increased number of protons per pulse would push the limits of Ti-6Al-4V.

0.75 MW pulse ~ 100 MPa shock stress

3.0 MW pulse ~ 500 MPa shock stress

Room temp yield strength Ti-6Al-4V = 900 MPa.

But higher power could also be achieved through a higher beam frequency.

Stress Analysis Overview

- Long term survival of window looks likely for 0.75 MW beam.

- Beam upgrades with increased PPP would test the limits of the material.

- Potential for power upgrades more promising if number of pulses is increased.

- Radiation damage then becomes the dominant factor in determining live in service.

Fin

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