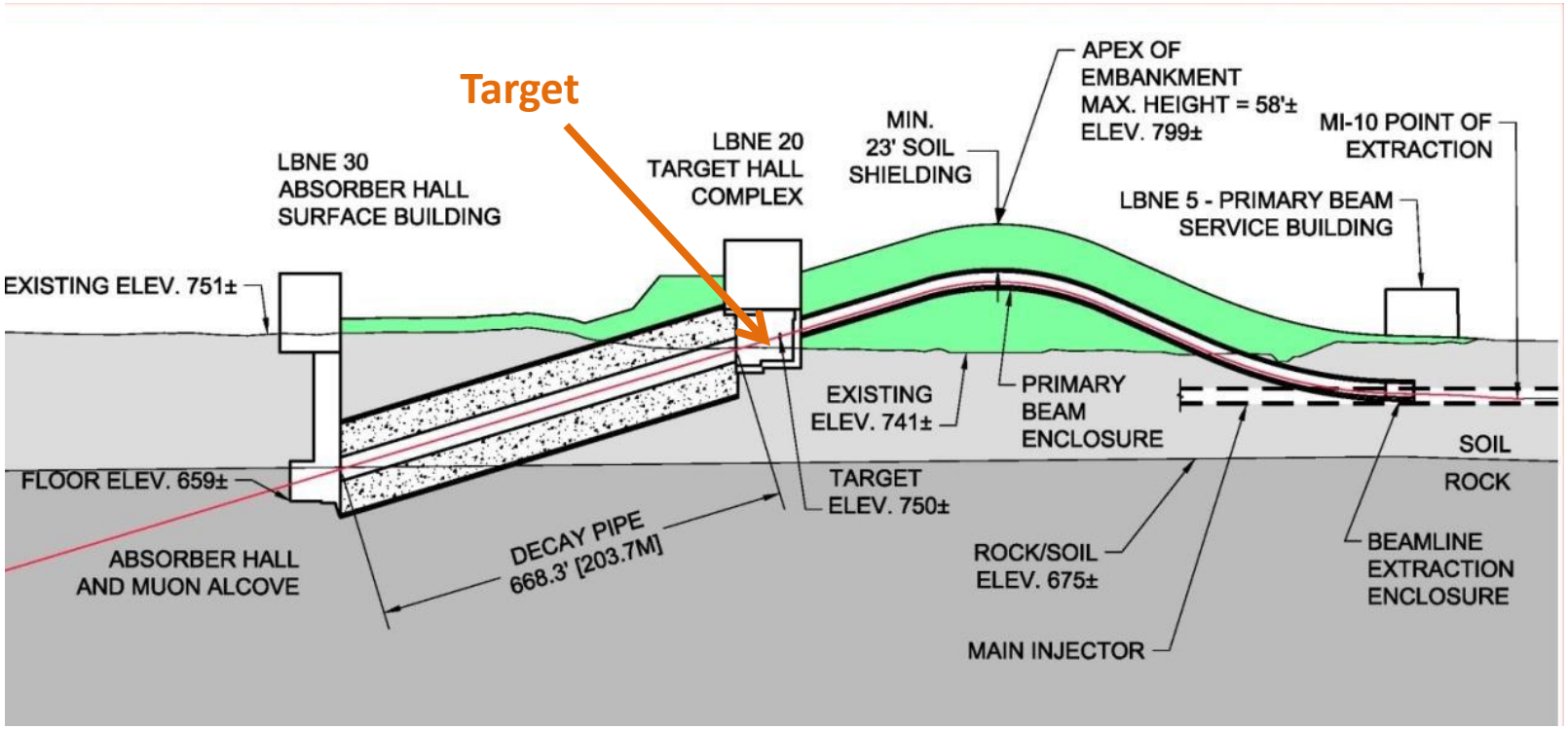
# LBNE 1.2MW Target

NBI 2014

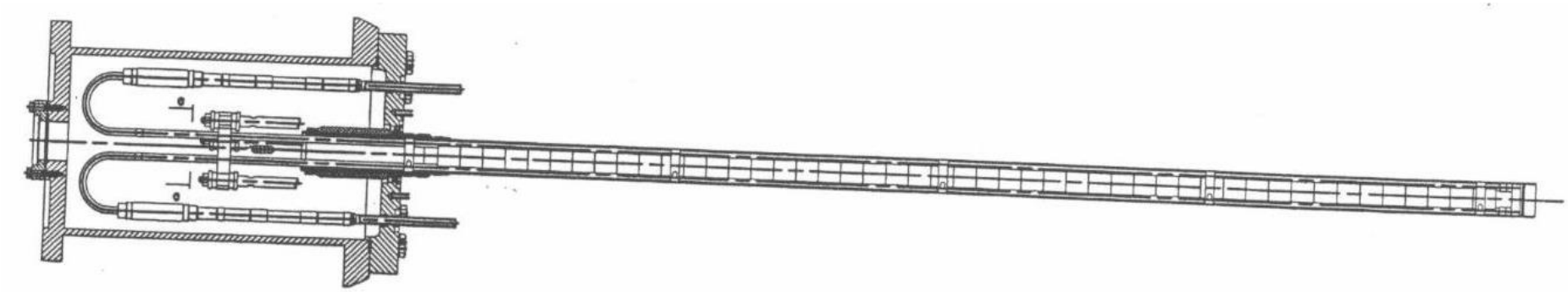
Presented by Brian Hartsell

# LBNE Target - Introduction

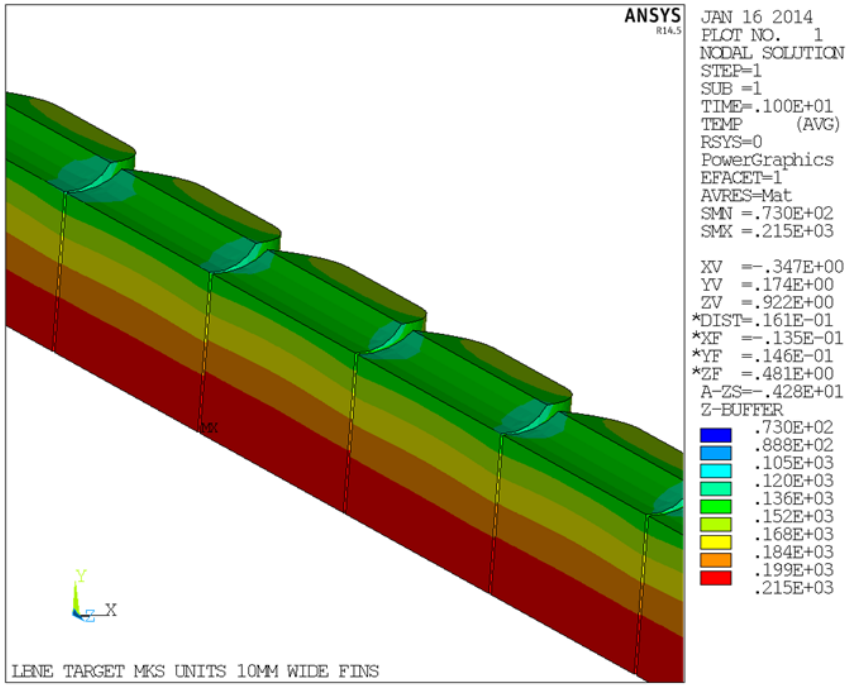



- Relevant parameters for 1.2MW target operation:
  - 120 GeV: 7.5e13 ppp, 1.2 sec cycle time
  - 80 GeV:  7.5e13 ppp, 0.8 sec cycle time

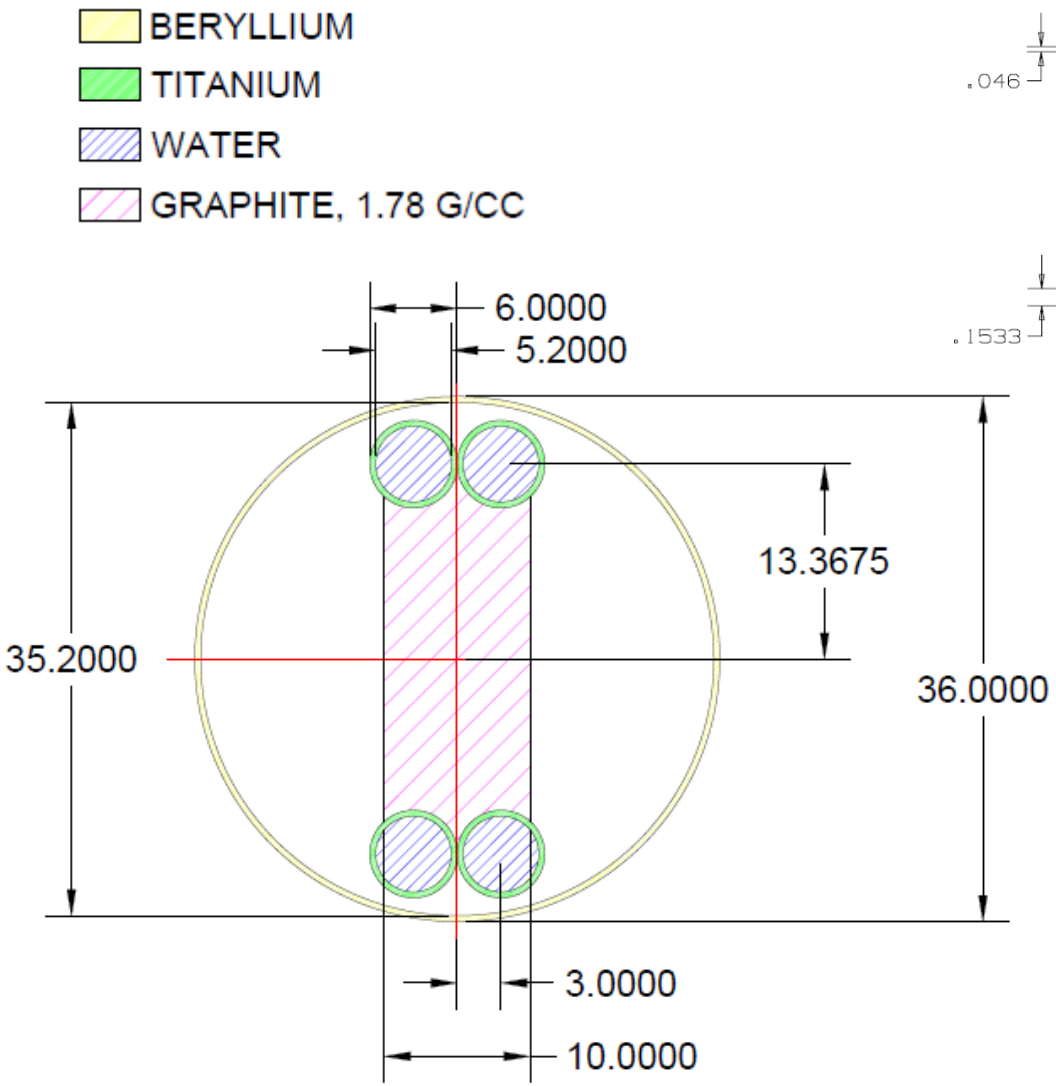
# First pass - scaling up the NuMI target

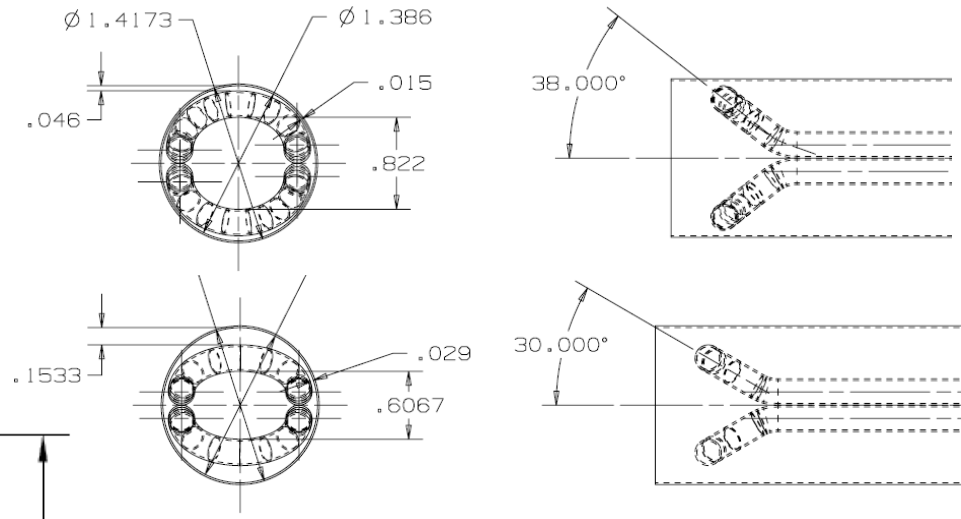


- Based on the original NuMI LE target design from IHEP.
- Increase the beam sigma from 1.3mm to 1.7mm to give the same peak proton flux (700kW NOvA to 1200kW LBNE)
- Simply scaling up the target results in temperatures at the water line interface that are too large (>150C)



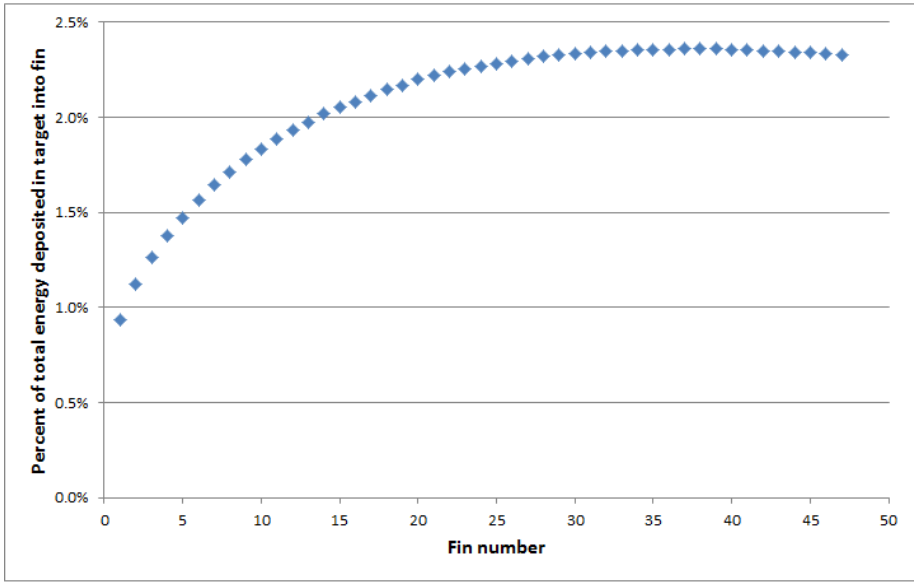
# LBNE Target - Geometry

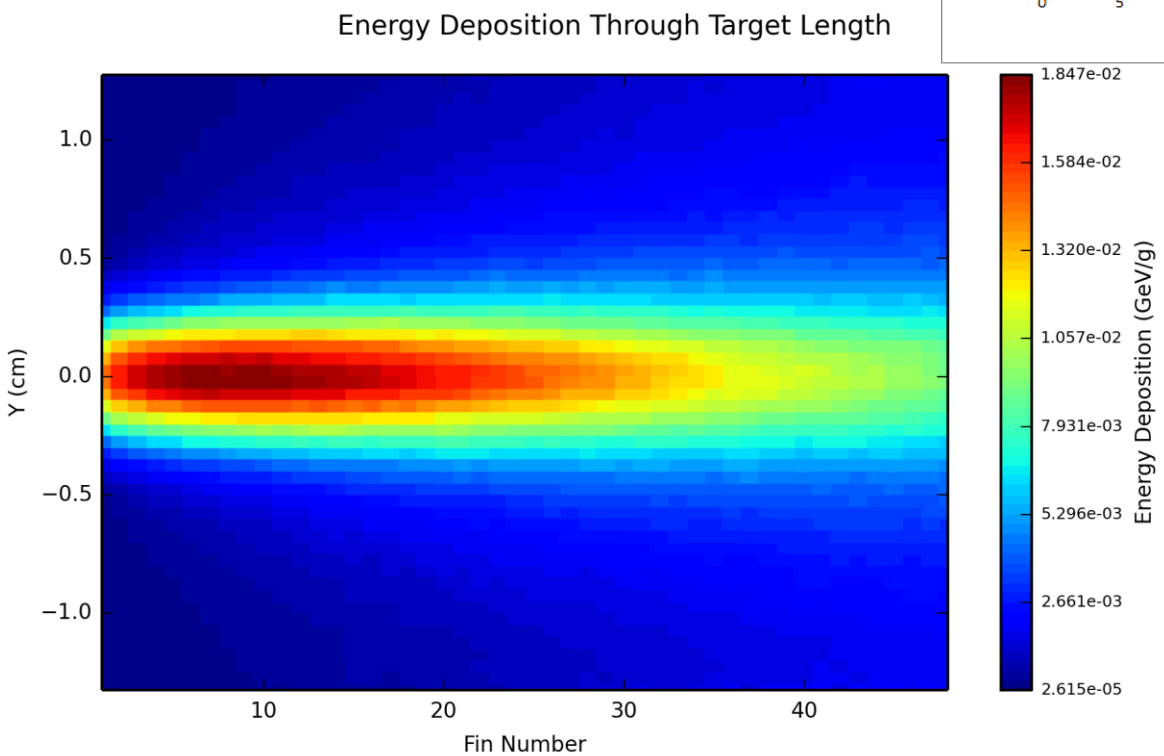


# Energy Deposition

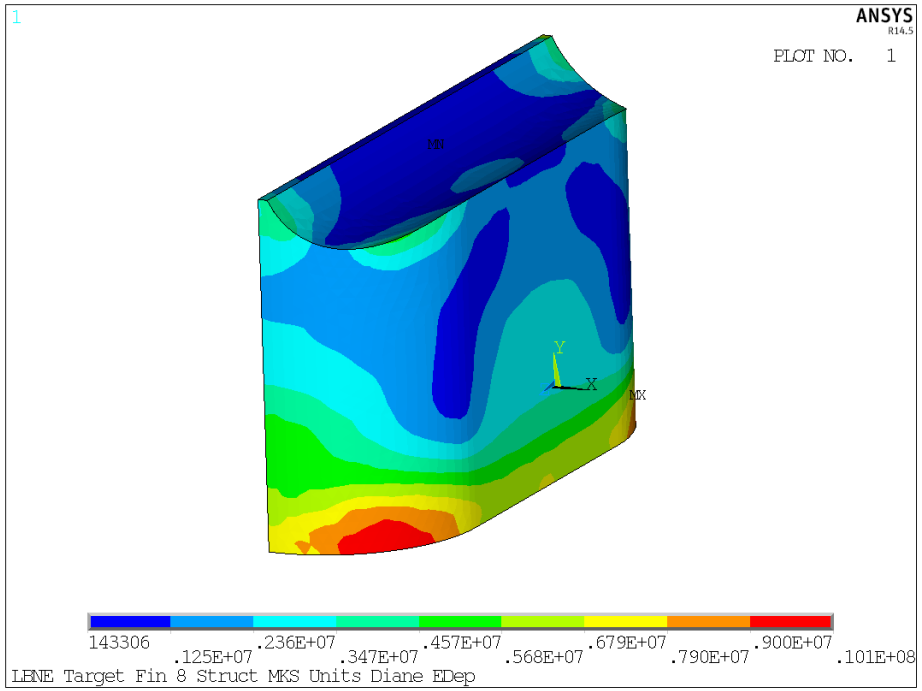
- Analysis provided by Diane Reitzner
- 1 & 3 sigma energy deposition peaks at fin 8
- Total heat load: 12kW
  - ~11kW to graphite, ~1kW to Ti/Water

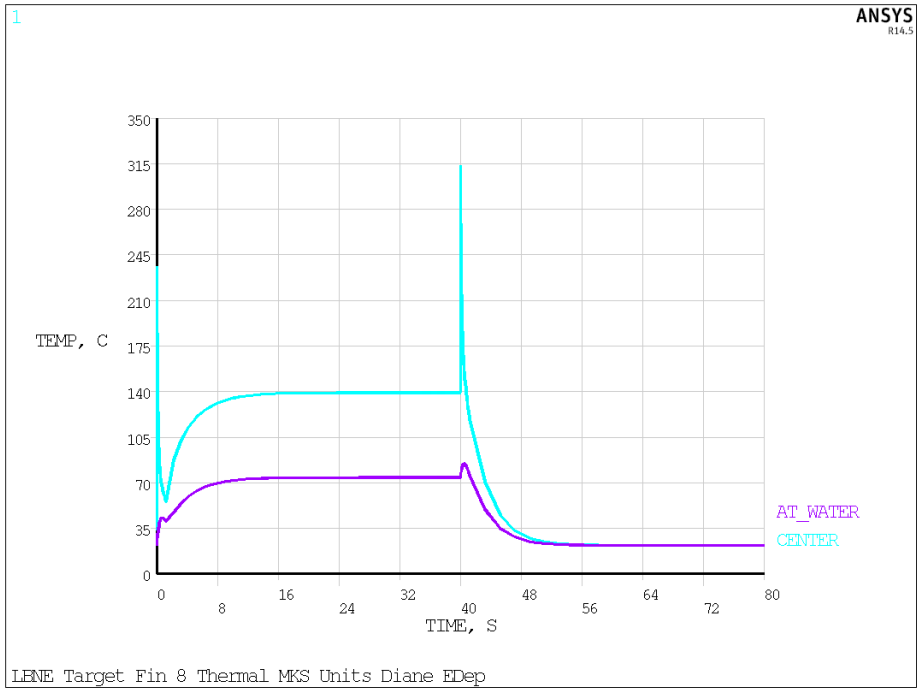


# Fin 8 Stress/Temperature

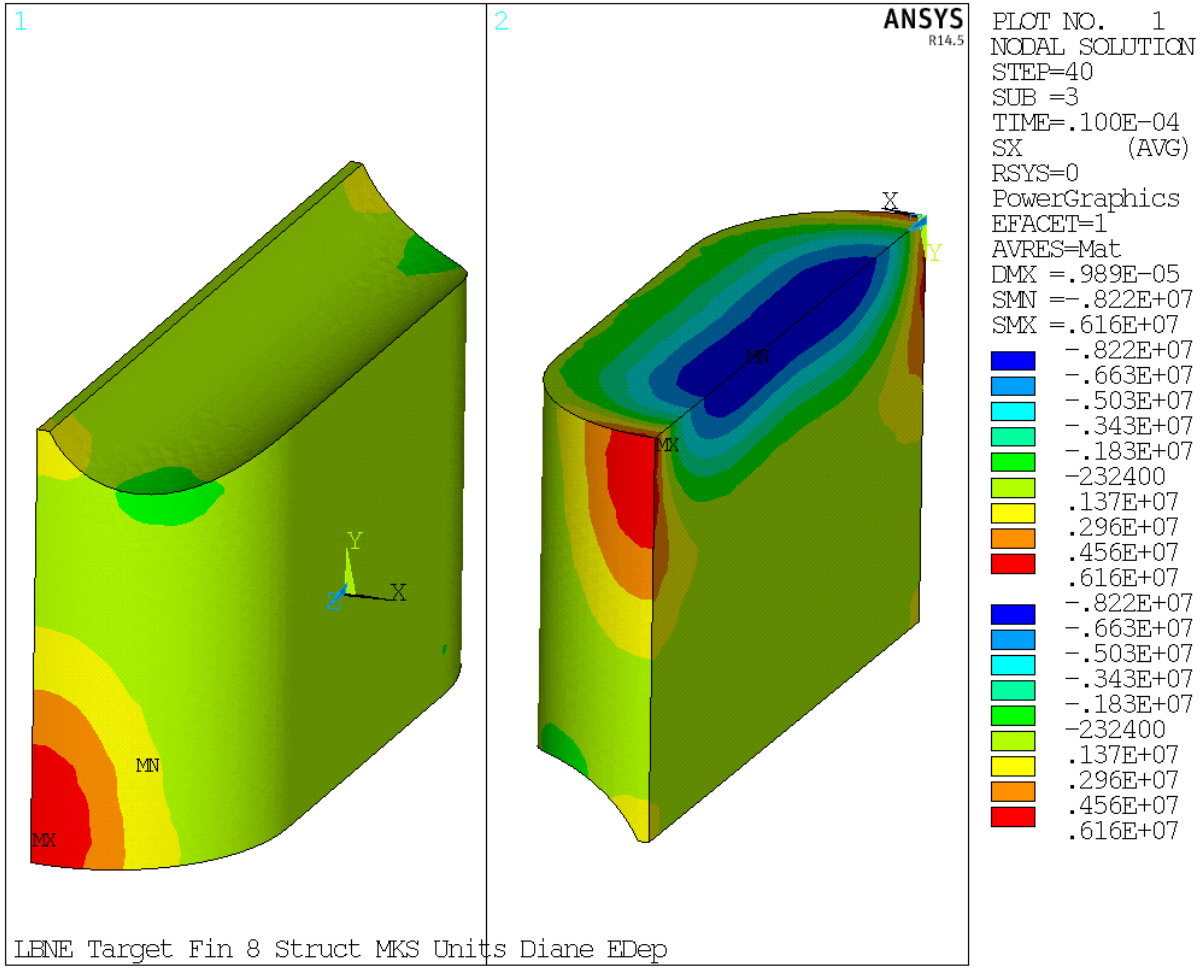
- Fin 8 chosen due to highest temperature and largest temperature gradient. Fairly simple model of one pulse at room temperature, warm to steady state, another pulse, and cooling to room temperature.
- Maximum Von-Mises stress is ~10MPa while yield is near 80 MPa.



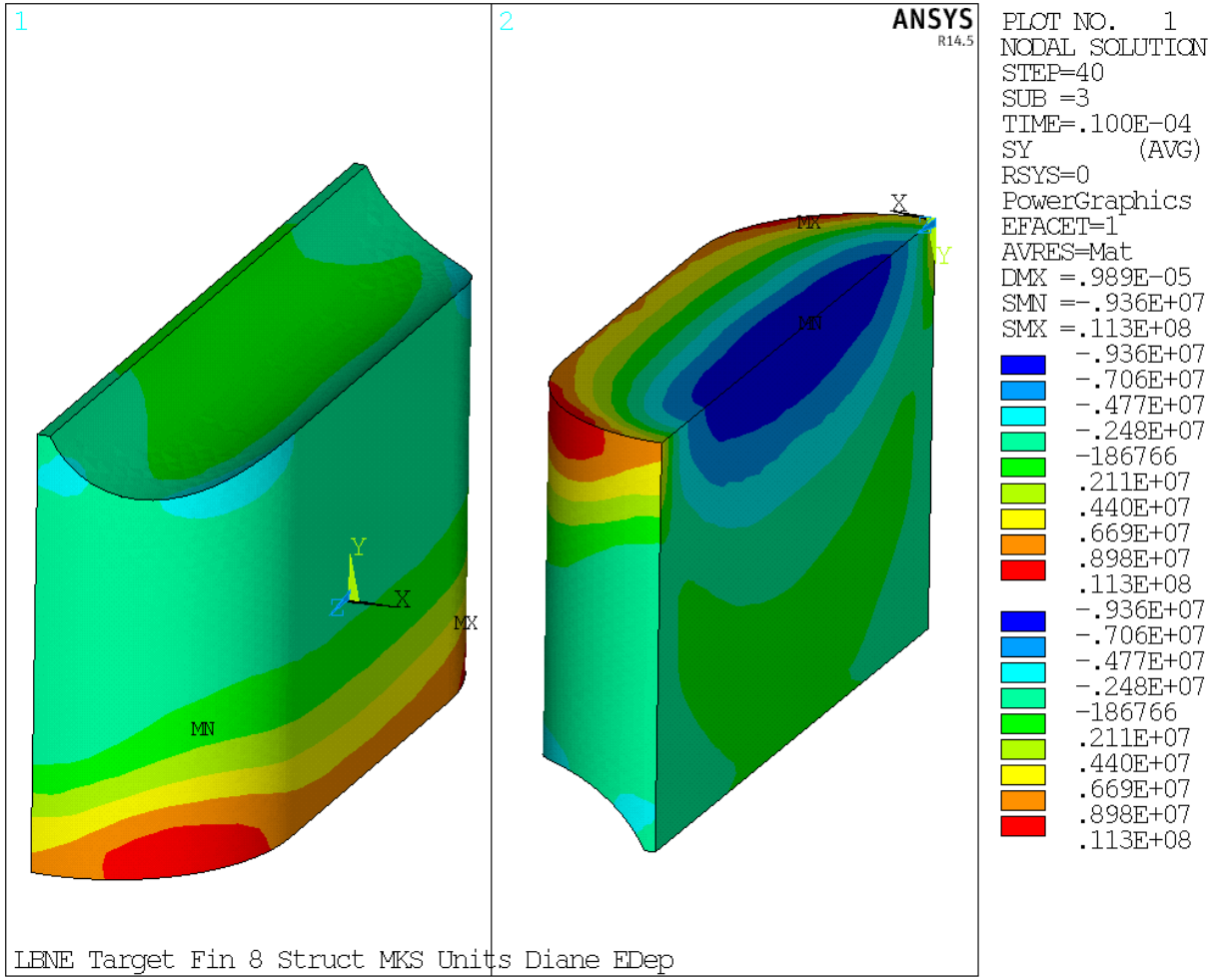
# Stress Components

- Generated these plots in response to the discussion yesterday afternoon.
- X component of stress



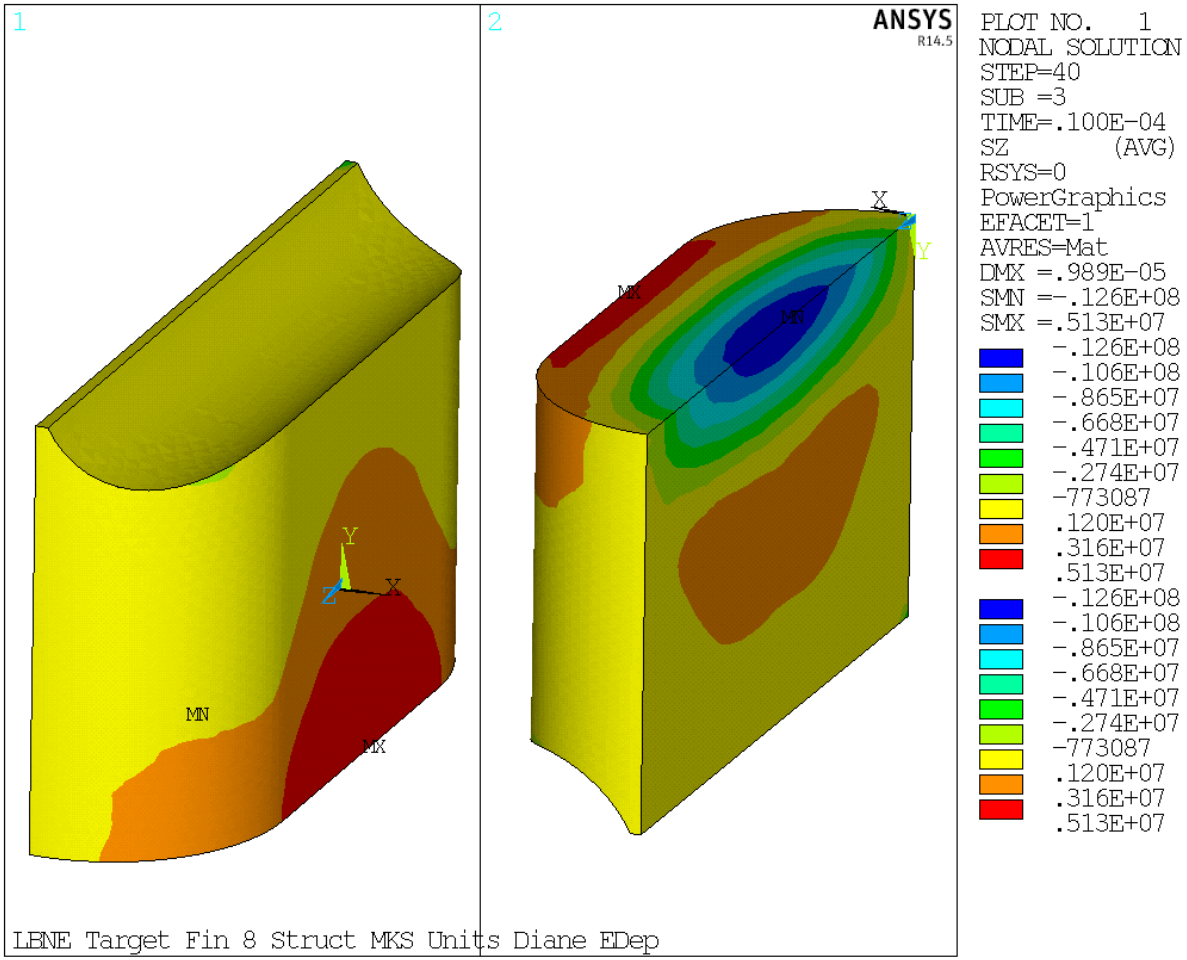
# Stress Components

- Y component of stress

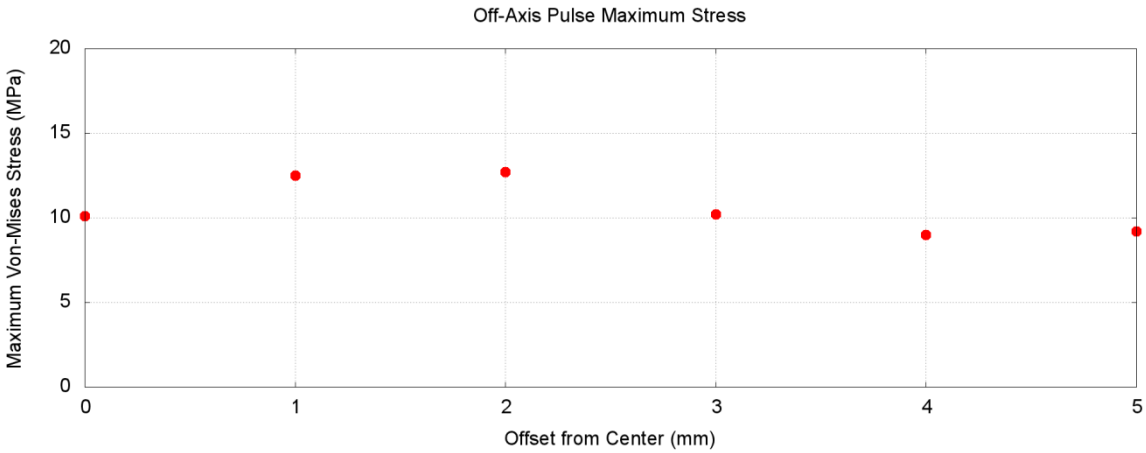


# Stress Components

- Z component of stress



# Off-Center Pulse Effects

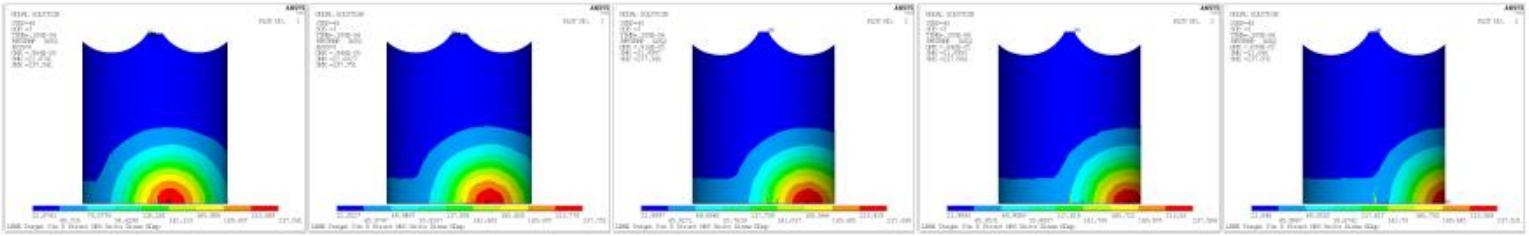



Find expected stress from a single pulse of an off-center beam in the X direction

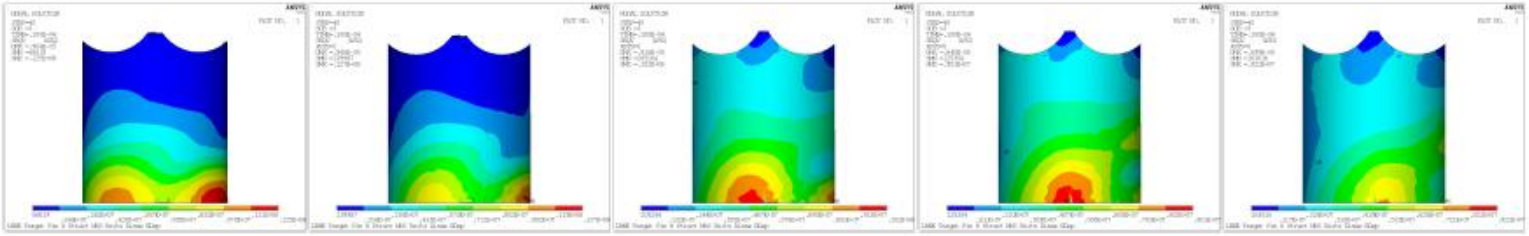
Beam Offset

1mm 2mm 3mm 4mm 5mm

Thermal



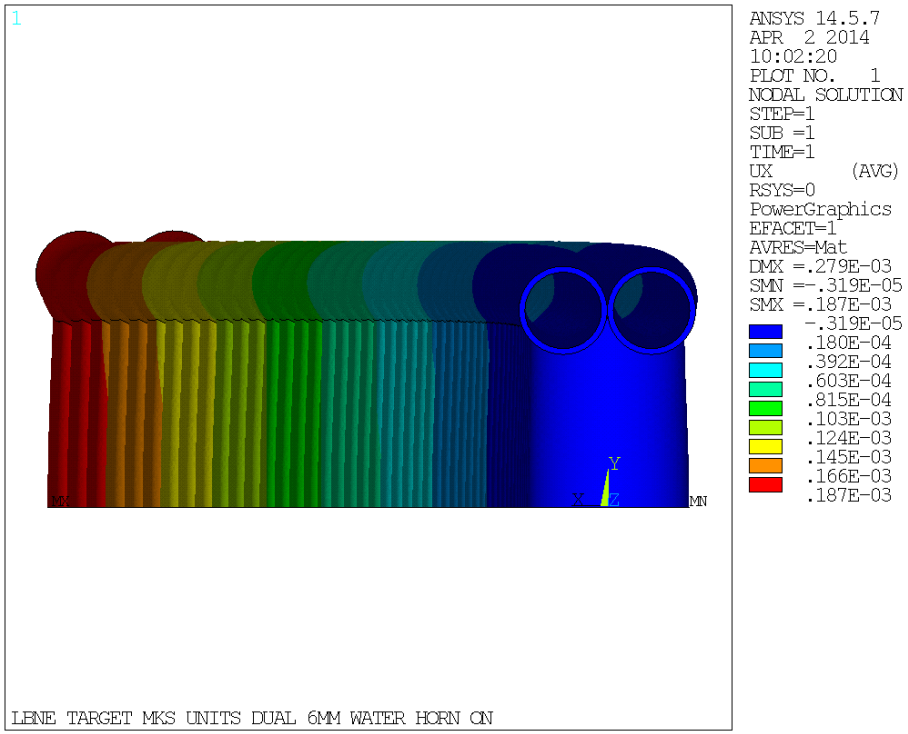
Structural VM Stress



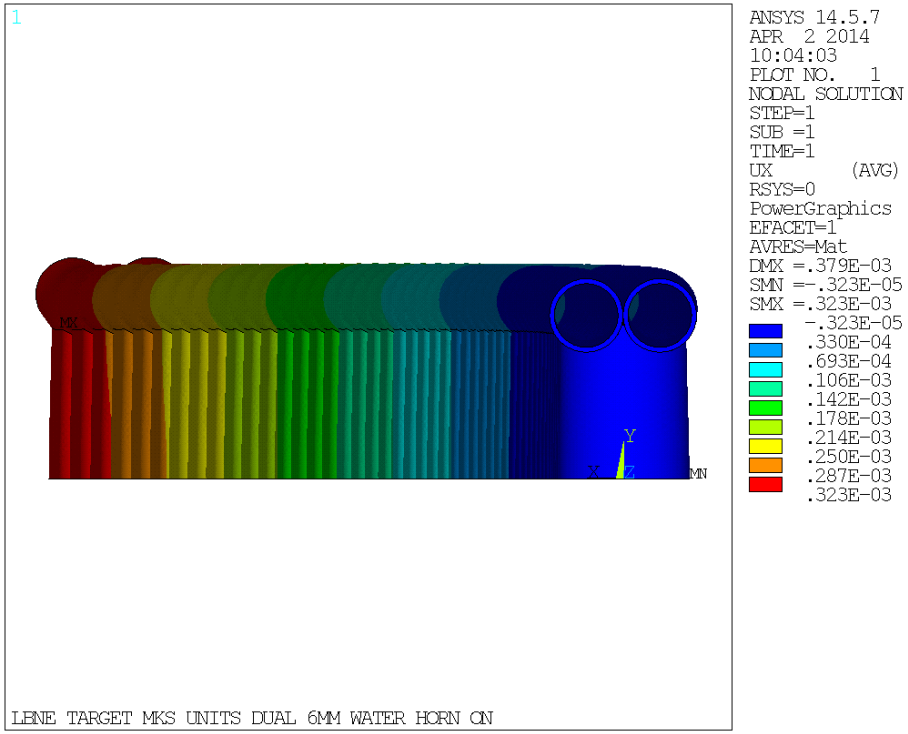
# Off-Center Pulse Effects

- Modeled the steady-state deformation of sustained off-center pulses.
- Deformations are exaggerated by a factor of 200 for visual effect.

1mm offset
0.19 mm deformation



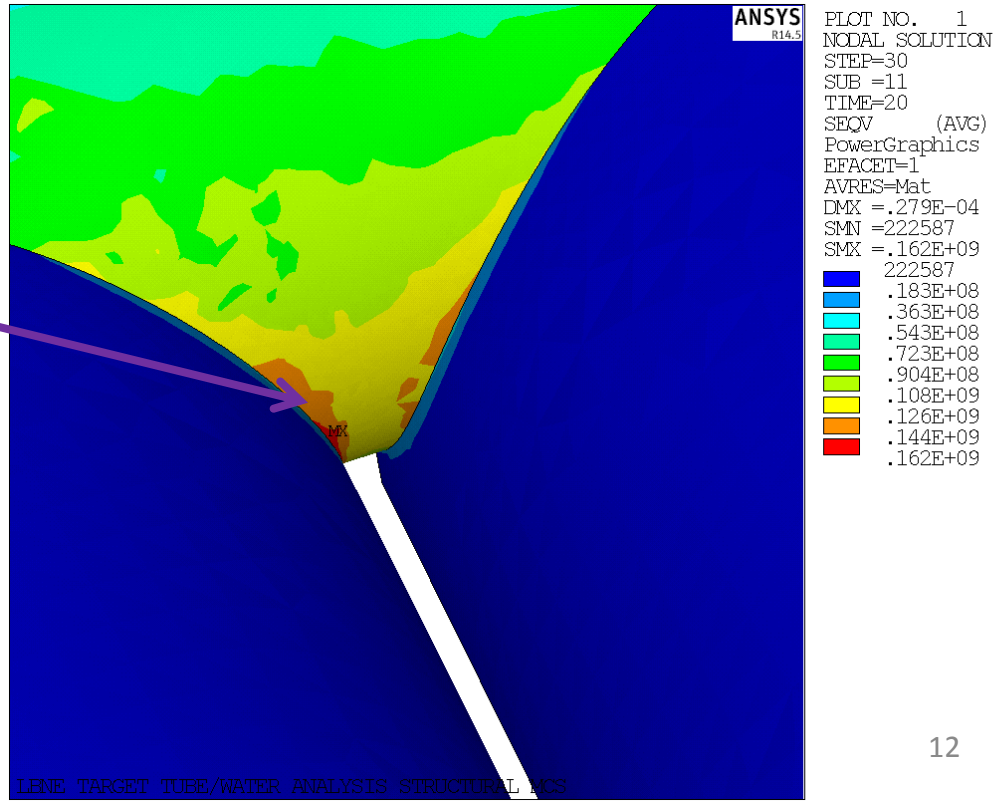

2mm offset
0.32 mm deformation



# Ti Water Lines

- Grade 2 Titanium water lines are chosen based on a report by the RAL group (O. Caretta, T. Davenne, C.J. Densham). Originally this model was intended to evaluate the water hammer effect from the beam impact.
- Most interesting part of this model wasn't the water hammer, but the stress between the fins.

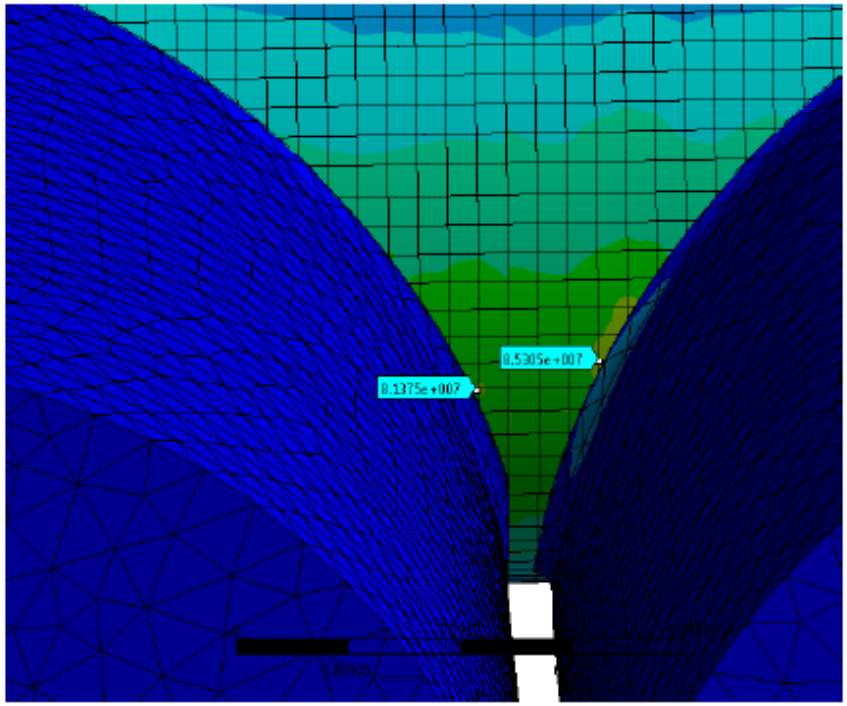
Stress concentration introduced by the sharp transition between fin and water line – safety factor of 2.4 to fatigue as modeled



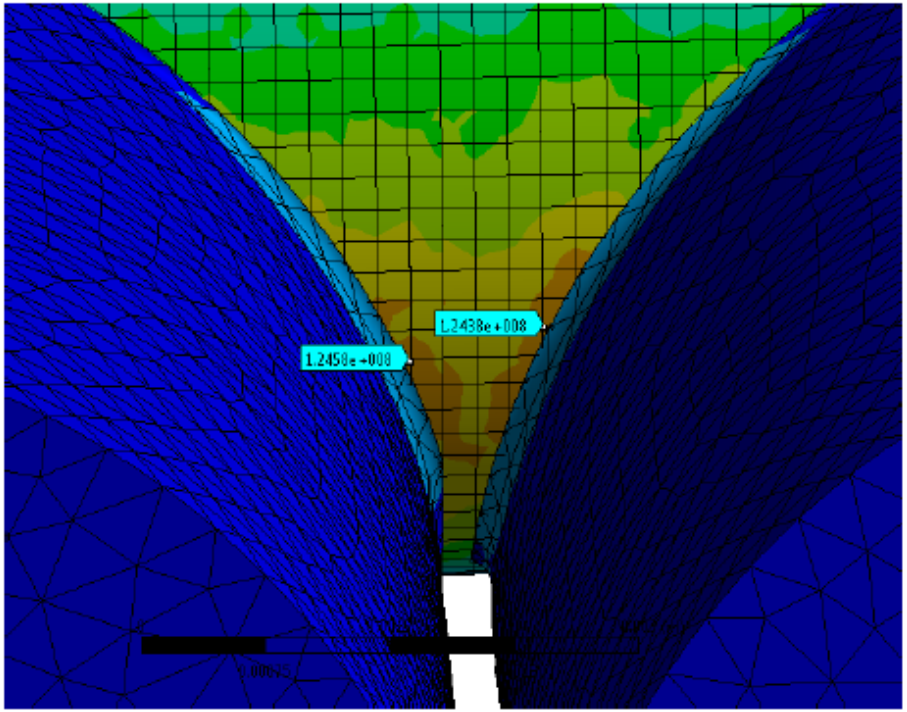
# Ti Water Lines

- Water line model was refined to include a 0.005” fillet introduced by the brazing process for a more realistic evaluation of the safety factor.
- Increased fatigue safety factor to 3.2.

VM stress before pulse

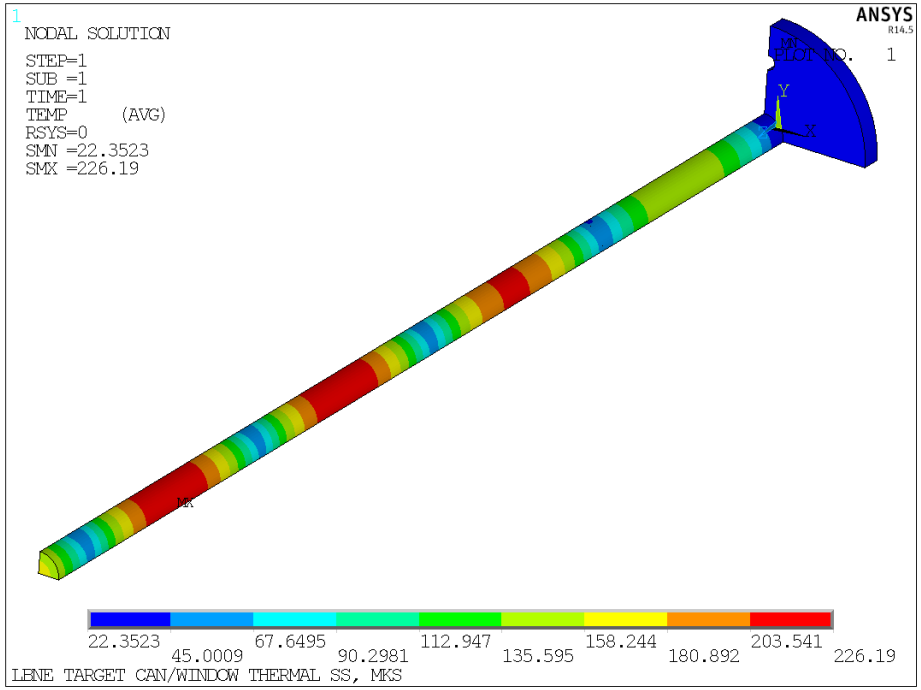


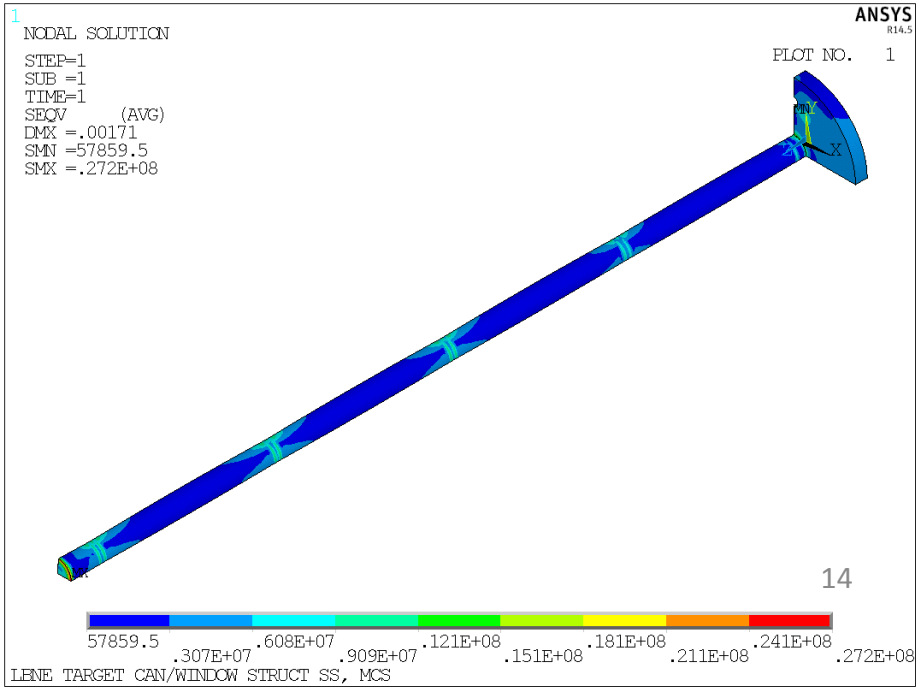

VM stress after pulse



# Target Canister

- The target canister and downstream window will be constructed from Beryllium for less heading due to the beam interactions.
- Look at temperatures and stresses in this canister.
- Cooling only provided by water loop on the target and the connection to the base.
- Resulting temperatures (~225C) and stresses (27 MPa) are low.



# Safety Factors Rollup

| Location | Material | Stress | Criteria | Safety Factor |
|---|---|---|---|---|
| Worst Case Fin | Graphite | 10.5 MPa | UTS - 80MPa | 7.6 |
| Fin, Off-Center Pulse | Graphite | 12.7 MPa | UTS - 80MPa | 6.3 |
| Water Line, Pulsed | Titanium Grade 2 | M-96MPa, Alt-23MPa | Goodman @ 90C (mean temp) | 3.2 |
| Can | Beryllium | 25.9 Mpa | Yield - 218 MPa @ 185C | 8.4 |
| Window | Beryllium | 27.2 MPa | Yield - 218 MPa @ 185C | 8.0 |

# Target DPA

120GeV

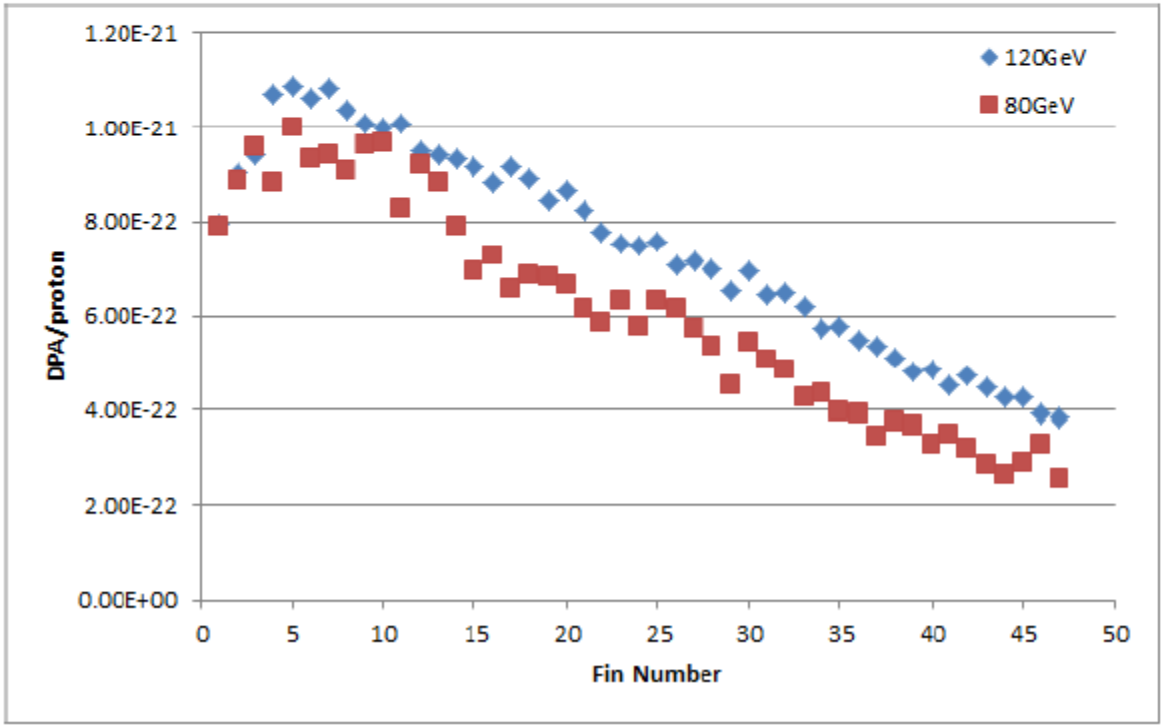
1.09e-21 DPA/proton in fin 5
6.25e13 protons/sec

6.8e-8 DPA/sec

80GeV

1.0e-21 DPA/p in fin 5
9.375e13 protons/sec

9.4e-8 DPA/sec



# Conclusions and To-Do

- A workable design has been presented with acceptable safety factors

- 80 GeV FEA work still to be done.