APEX
Target System

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on behalf of the APEX Collaboration

Outline

- Physics considerations on the APEX target
- Target design
- Performance studies
- Alignment and Optics Calibration
- Outlook

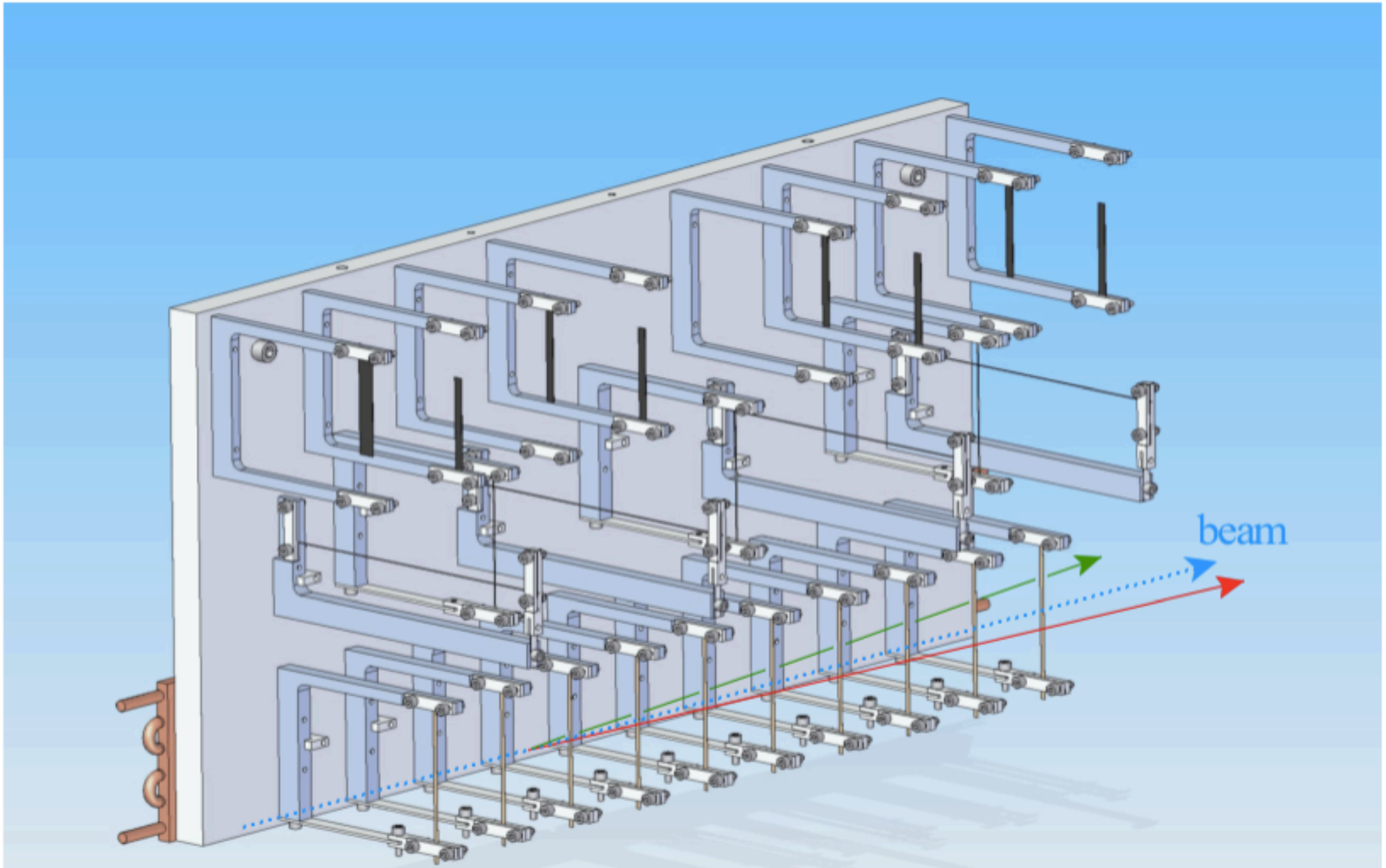
Physics Considerations

- Best possible mass resolution
  - minimize multiple scattering of electron/positron in target
  - need sufficient material to get rate
- Maximize rate
- Wide and uniform mass range coverage
  - use a target elongated along the beam line
- Optics calibration along the length of the target
- Use a high Z target to maximize the electron to pion ratio
- Minimize accidental coincidence backgrounds
  - separate target components along beam line

Design Considerations

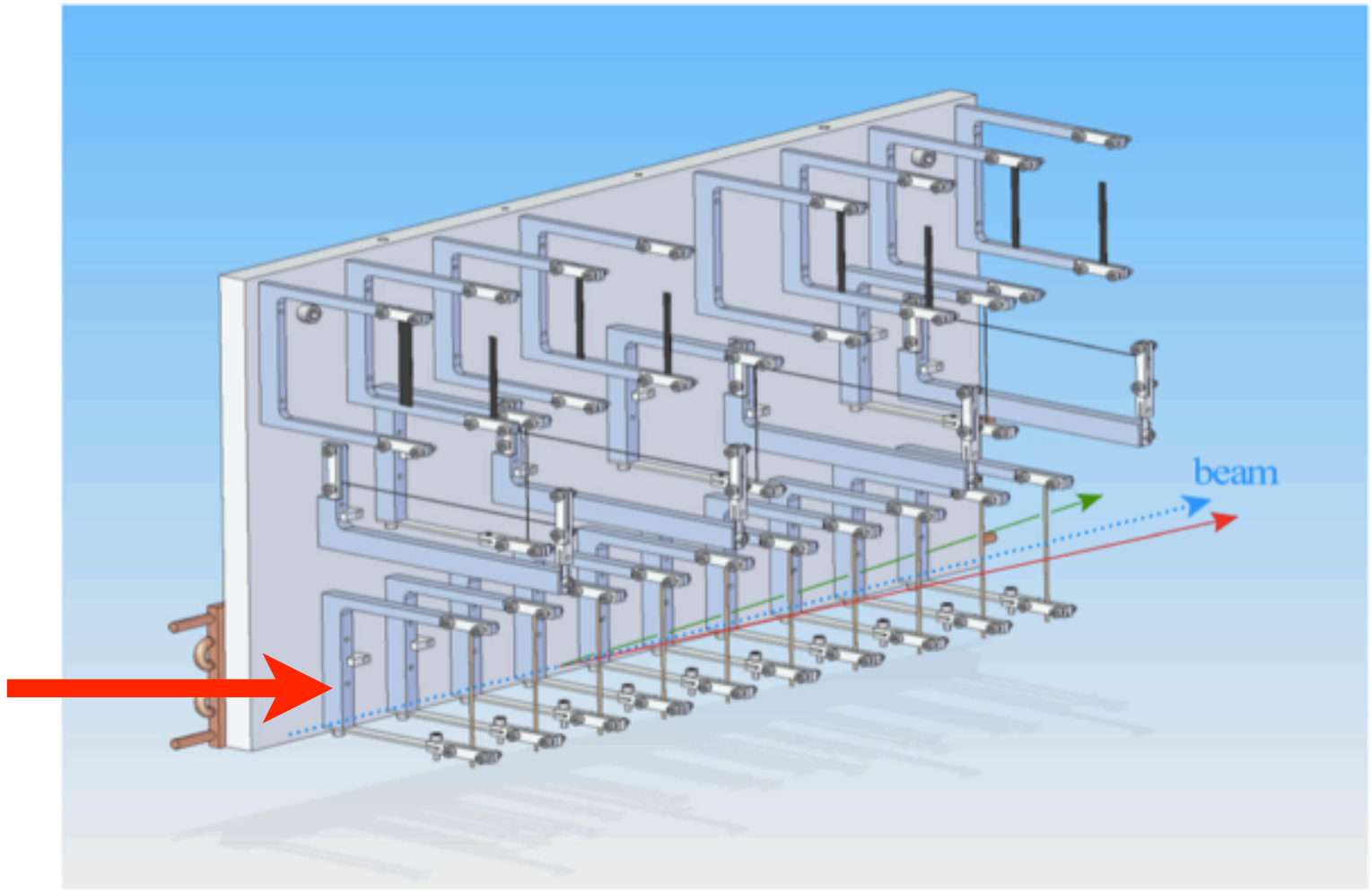
- Target material stability at high temperatures
- Target system is in vacuum → frame cooling
- Alignment of the components
- Survey of the target system
- Ease of repair and changing target components
- Mounting to the “water-fall” lifter
- Cost

Target Design



Designed and built largely by the SLAC group for 2-pass APEX test run conditions

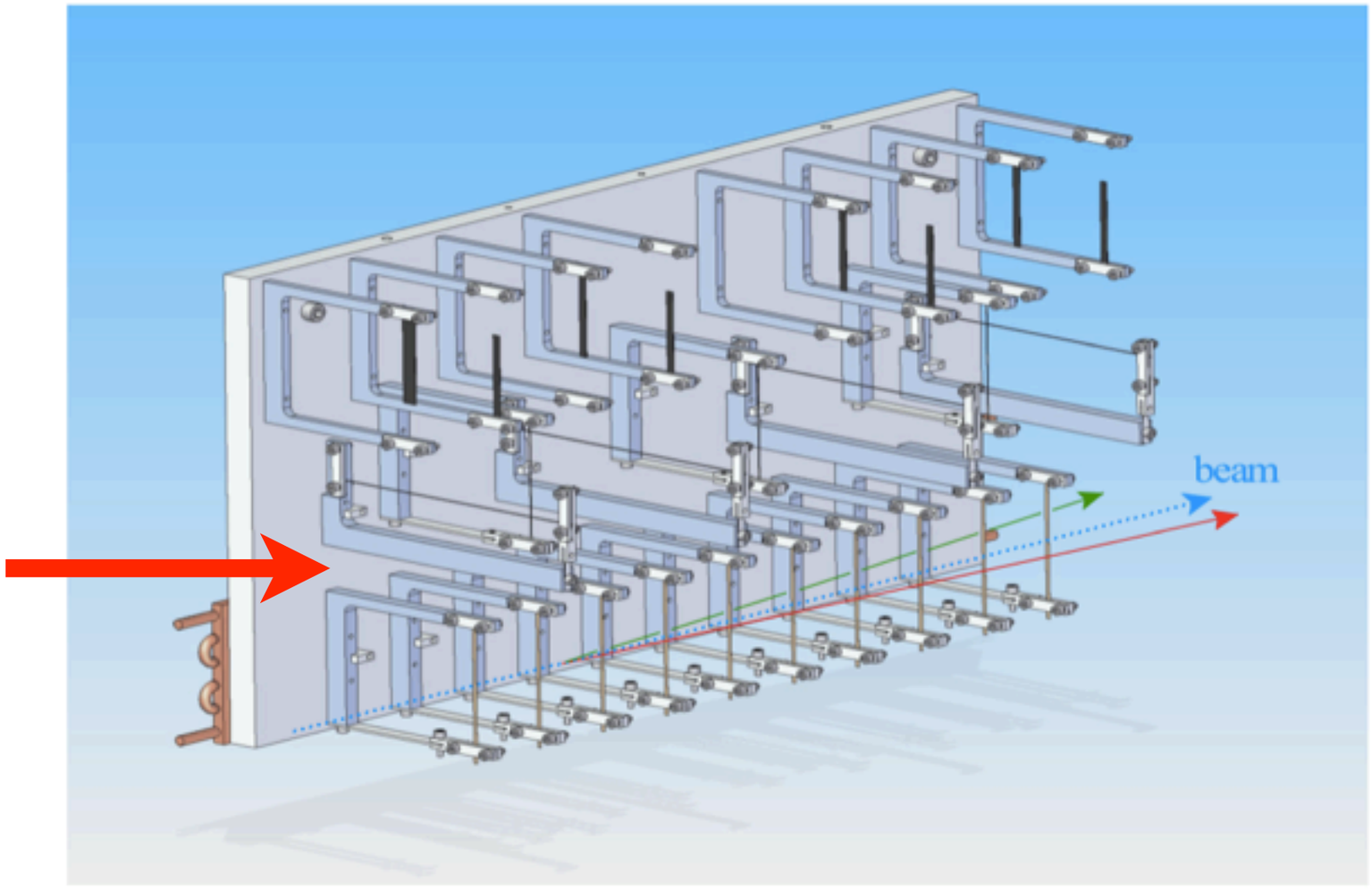
Target Design - Production, Alignment, and Optics



Production Section:

- 10 ribbons of 15 micron tungsten (4.3% rad. lengths)
- 2.5 mm wide ribbon (to accommodate raster of beam)
- 5.5 cm spacing along the beam line
- easy to swap in/out ribbon holder → flexible configuration

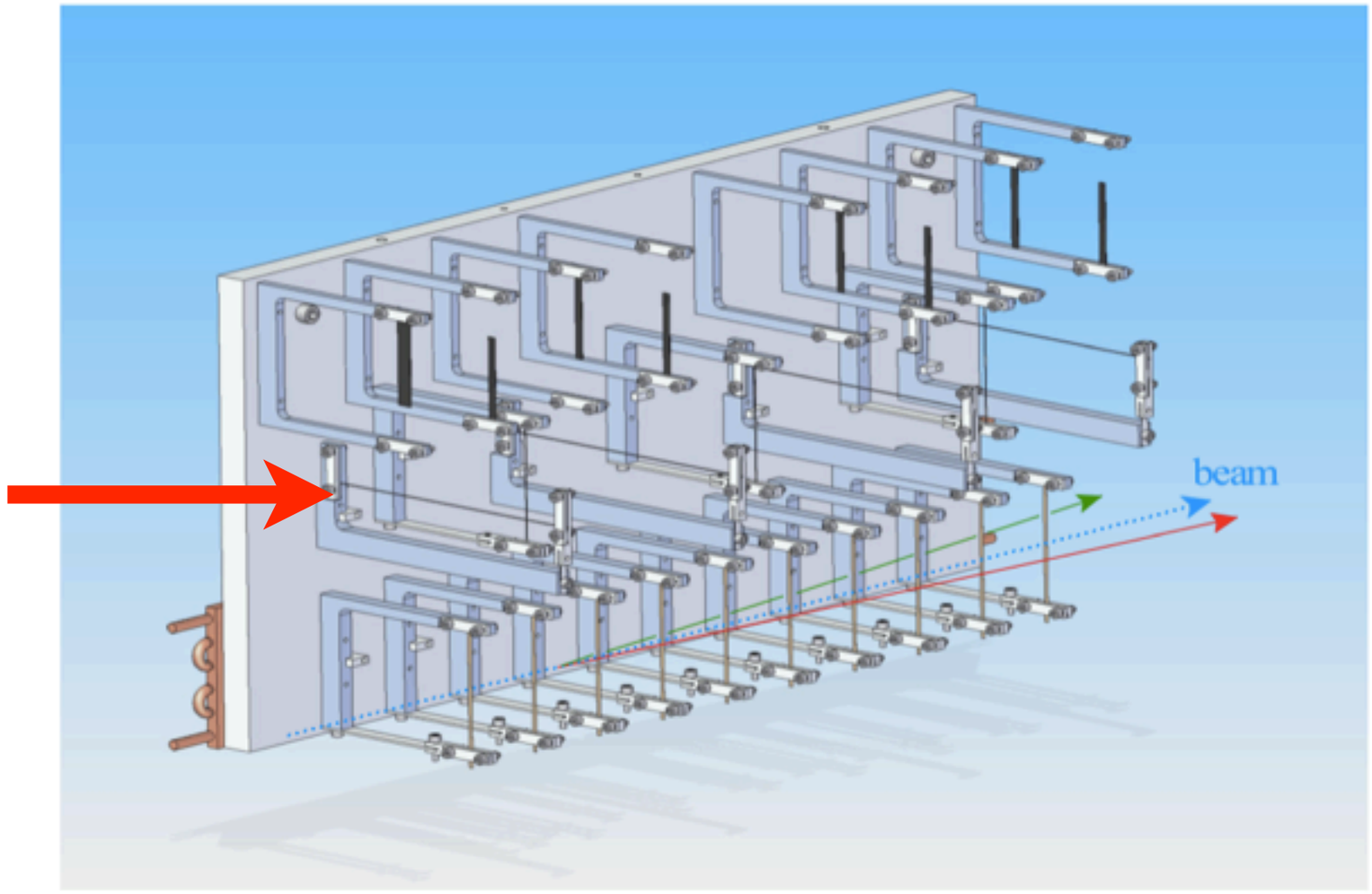
Target Design - Production, Alignment, and Optics



Empty Section:

- required for beam tuning

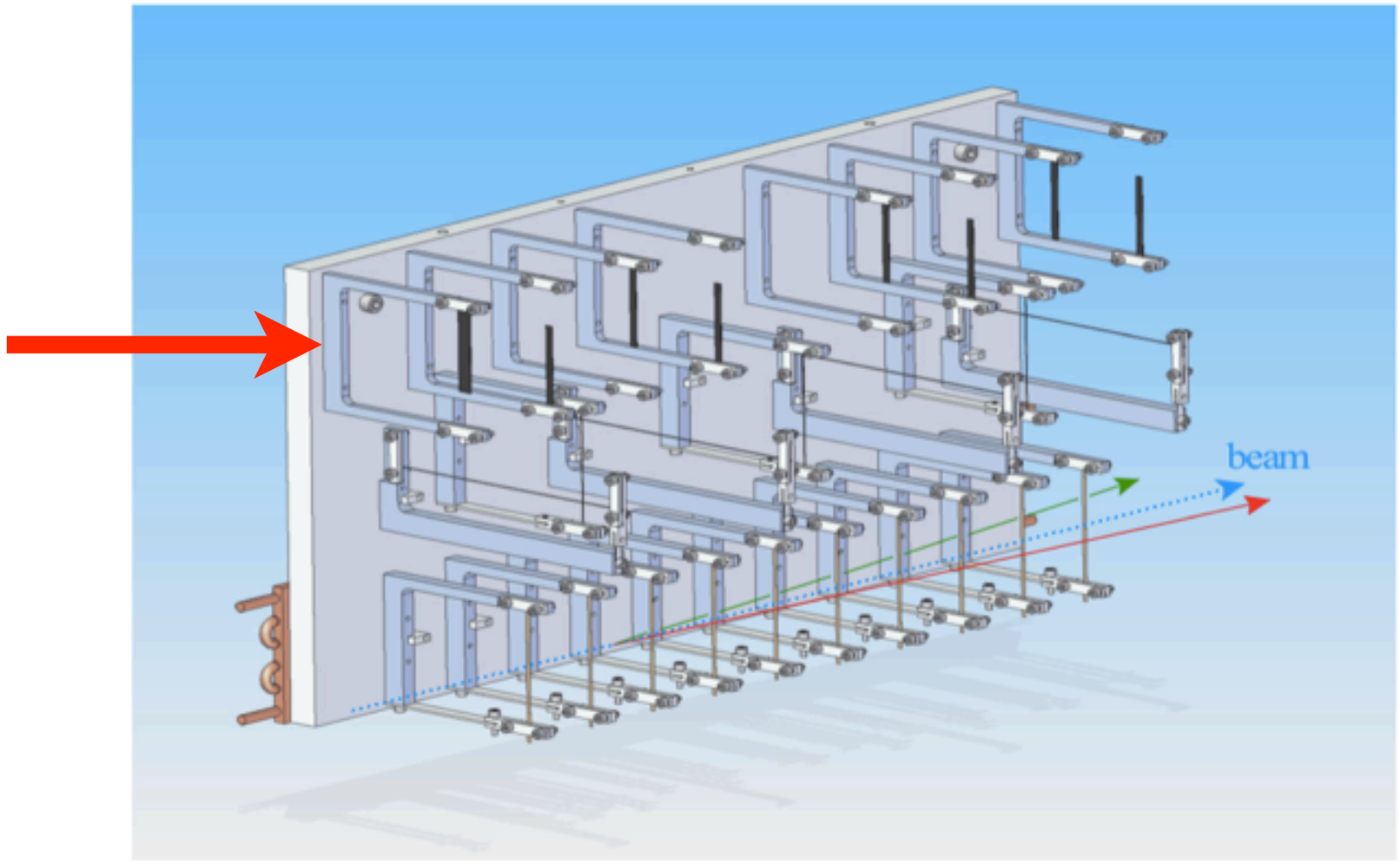
Target Design - Production, Alignment, and Optics



Beam-Target Alignment Section:

- Tungsten wires of diameter 100 microns
- 4 horizontal wires, in 5mm vertical steps, at -25, -10, 10, and 25 cm along z
- 3 vertical wires, in 2.5 mm horizontal steps, at -20, 0, and 20 cm along z
- use wires to measure target orientation to sub-mrad accuracy

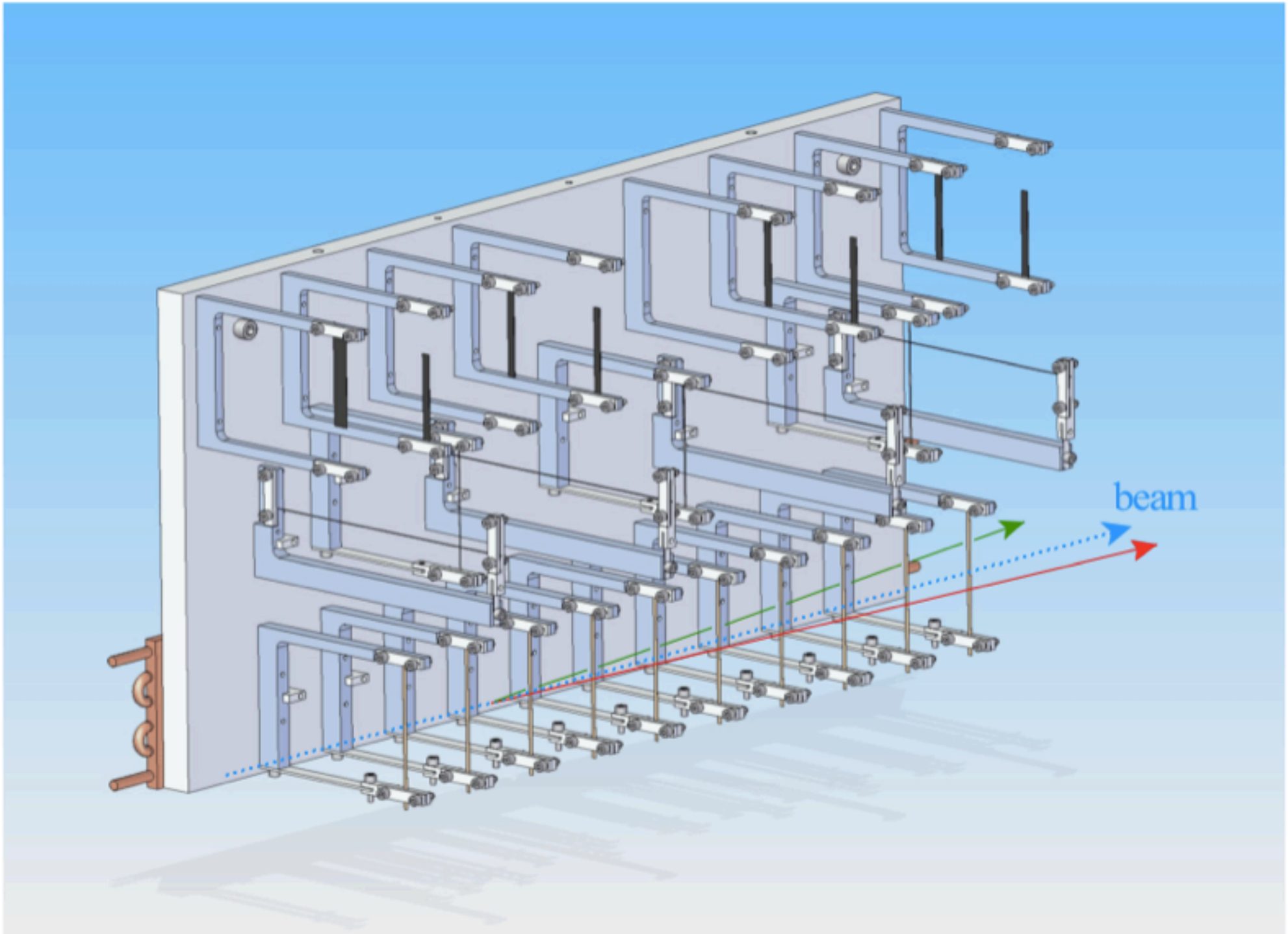
Target Design - Production, Alignment, and Optics



Optics Section: (See Jin Huang's talk)

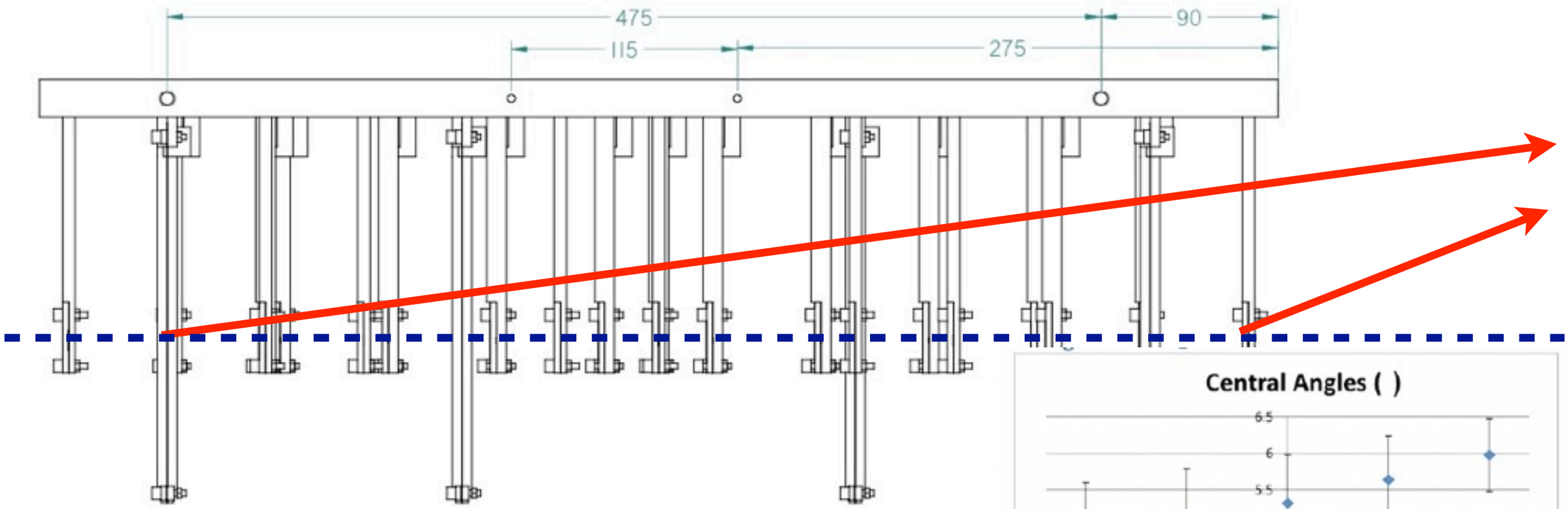
- 8 carbon foils providing calibration points
- BeO viewer for the front foil
- beam can pass through top 4, bottom 4, or all 8 foils in center position
- spacing of 14 cm (top and bottom) or 7 cm (center) between foils

Minimizing Multiple Scattering

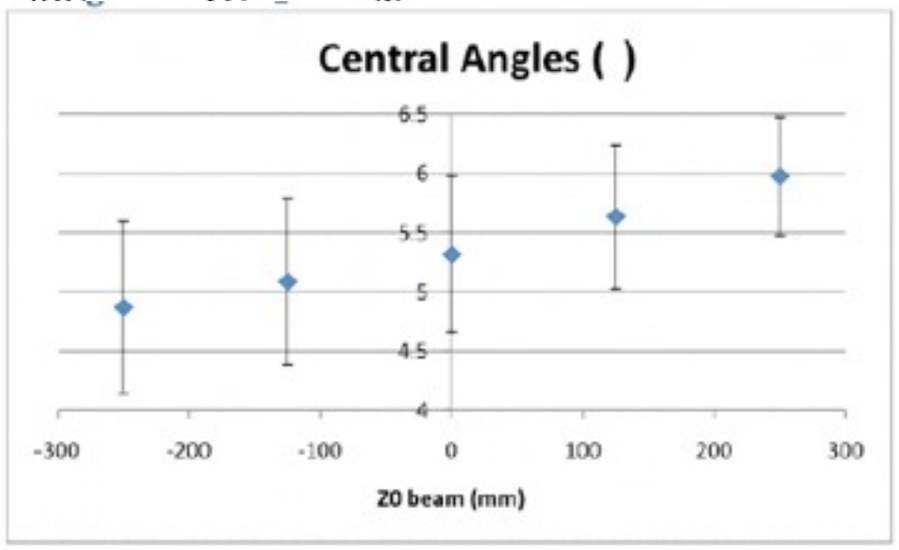


Outgoing electron/positron pairs in the spectrometer acceptance miss downstream material. Only one ribbon contributes to multiple-scattering in the target!

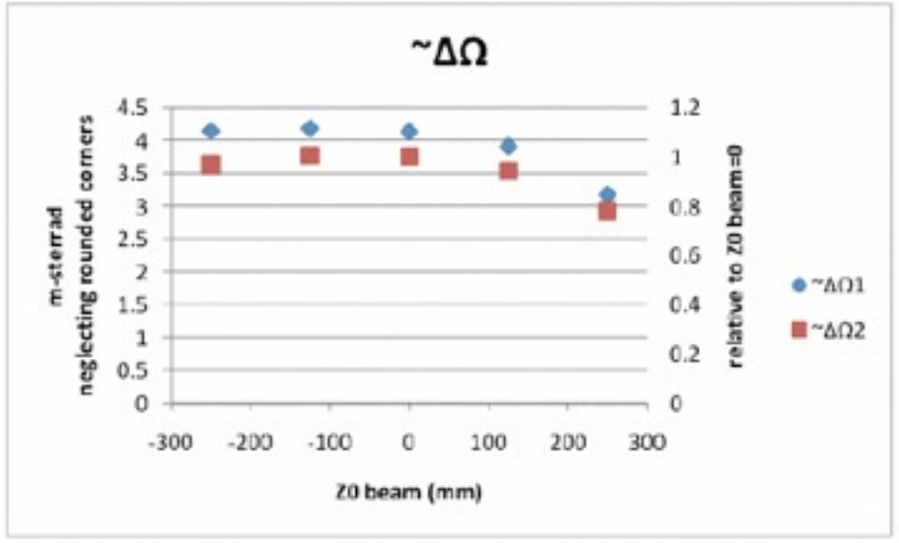
Extended Mass Range Coverage



- 11 degree (horizontal) maximum angular clearance
- Variation of 1 degree over the extent of the target
- 50% increase in mass coverage per setting



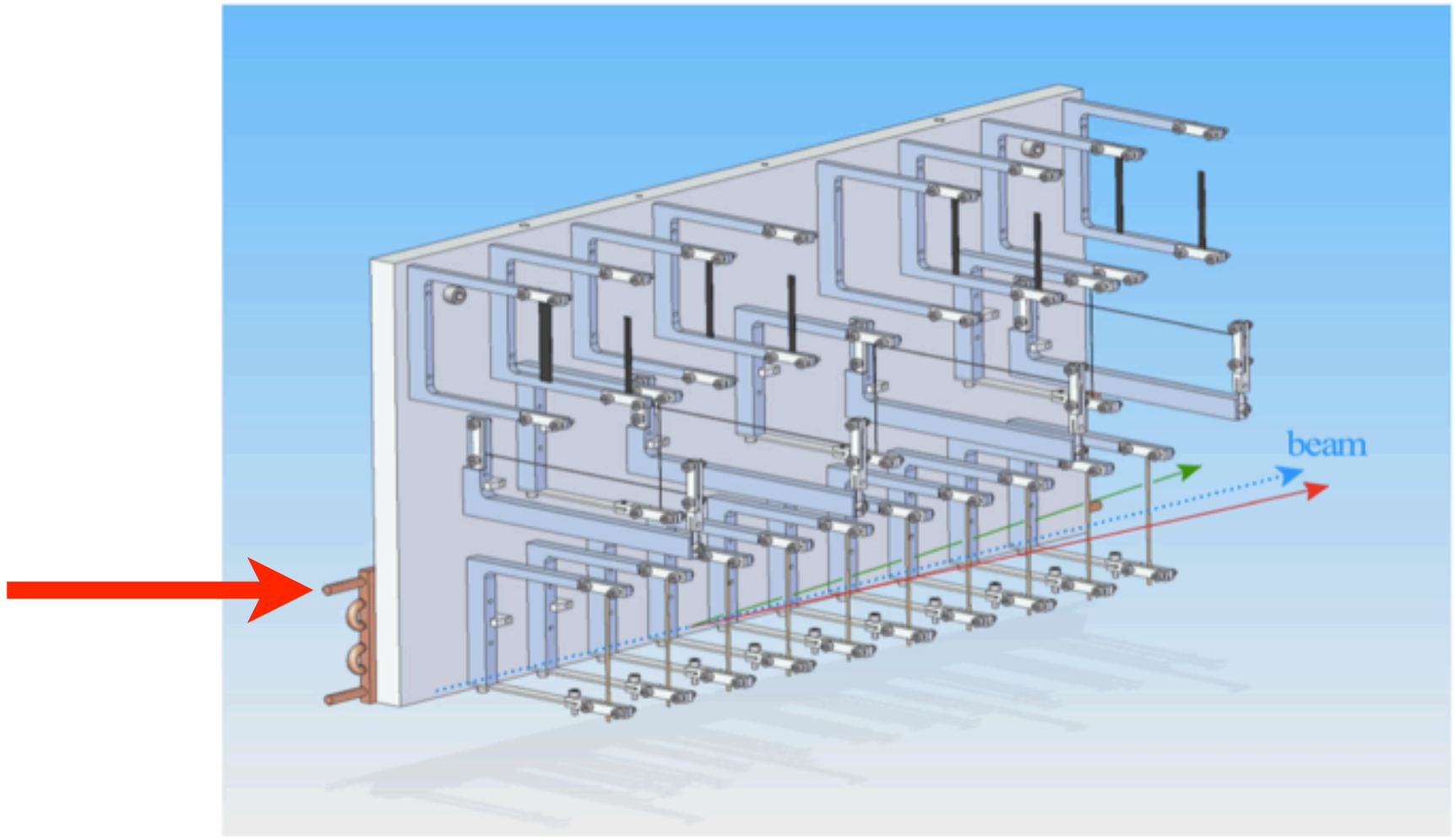
Z0 beam is position along the beamline



Reducing Accidental Coincidence Backgrounds

- See Jin Huang's talk on optics calibration and optics from the E06010 experiment for illustration
- Transverse position resolution of 1 mm expected → 1 cm resolution along the beam line
- By requiring electron/positron pair to come from the same vertex, we can reduce accidental backgrounds
- Even with 5 cm resolution, we obtain a factor of 4 rejection (assumed in proposal), but we expect to do better.

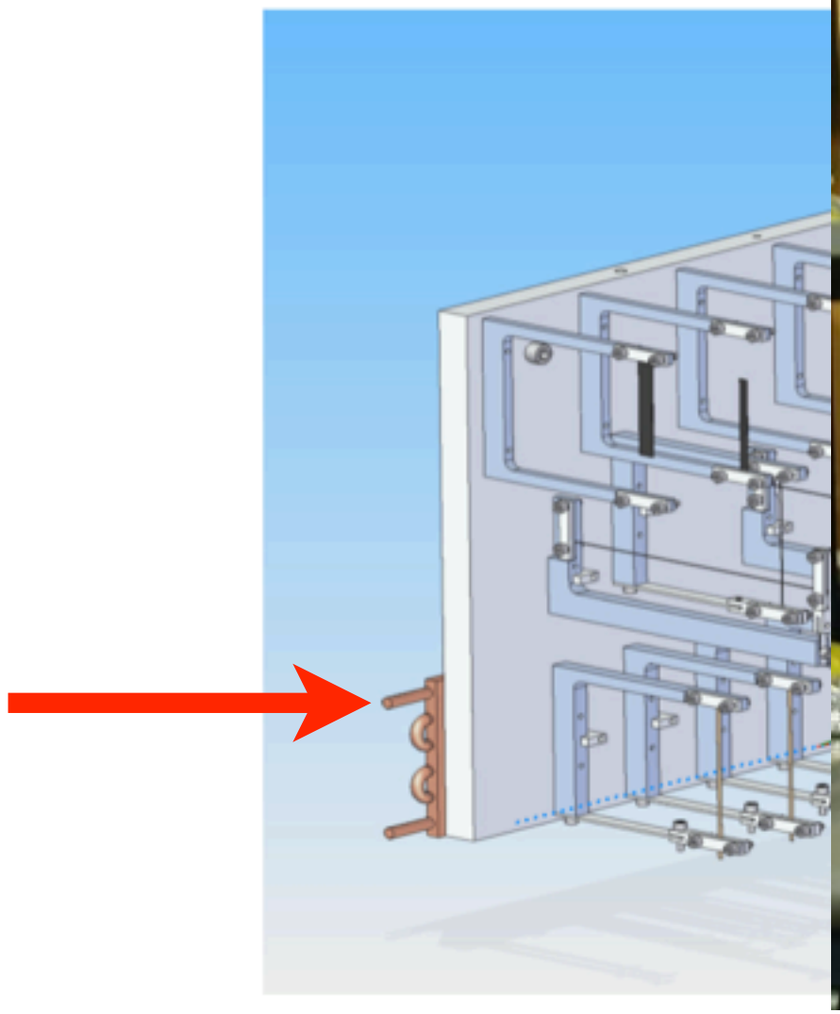
Target Design - Production, Alignment, and Optics



Cooling:

- Up to 4 Lytron CP15 cold plates
- cooling supplied by nitrogen gas (in series or parallel)
- heat removal of 25 - 200 Watts may be necessary

Target Design - Production, Alignment, and Optics



Cooling:

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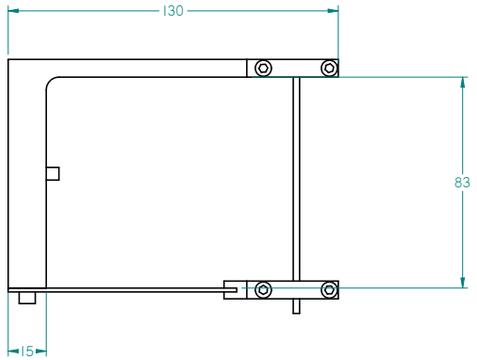
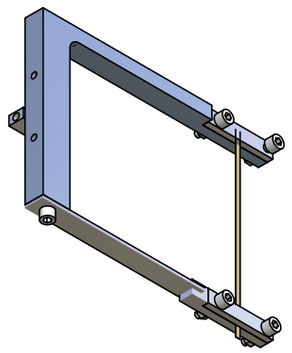
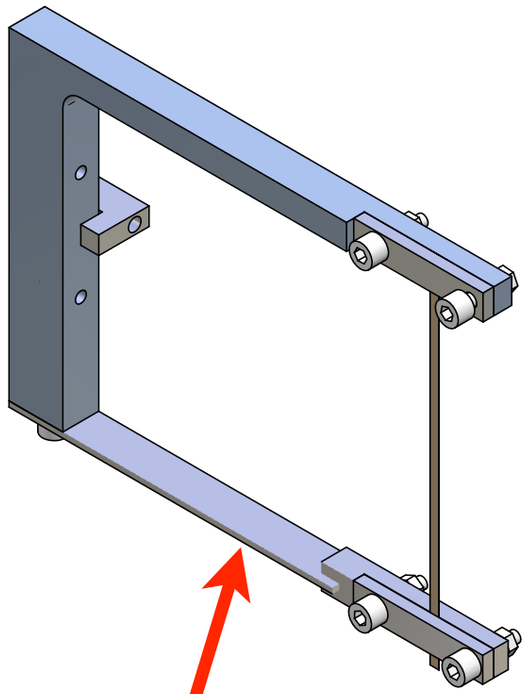
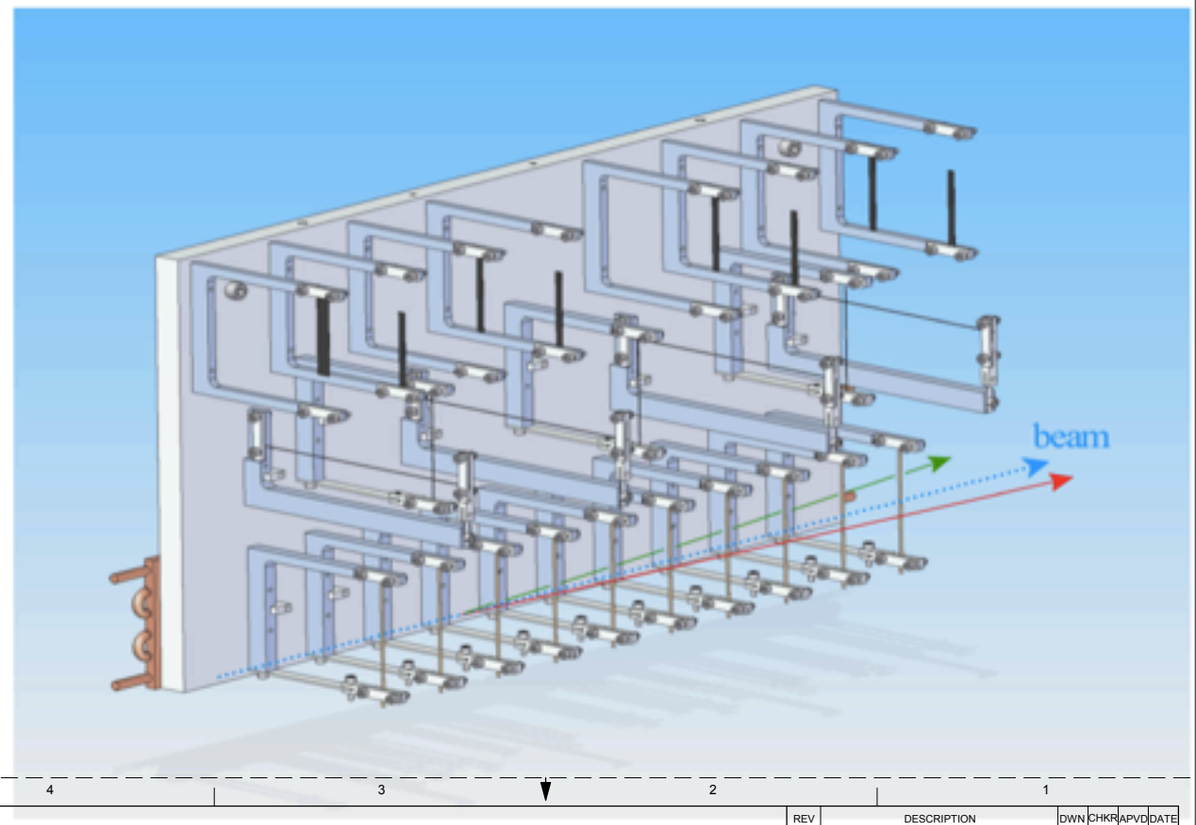
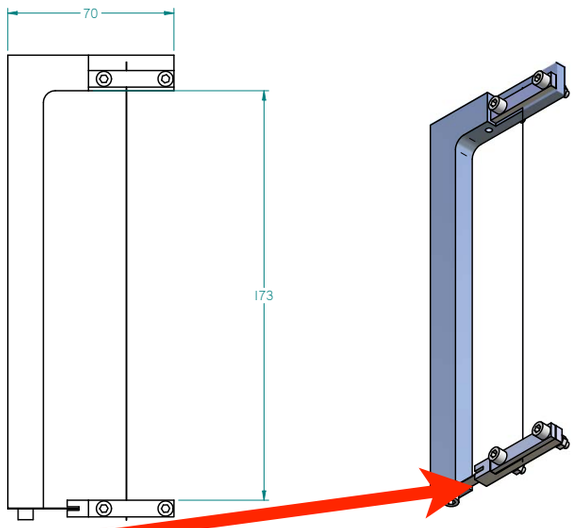
Target Design - Tensioned Holders

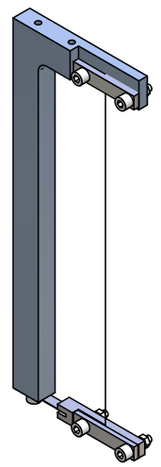










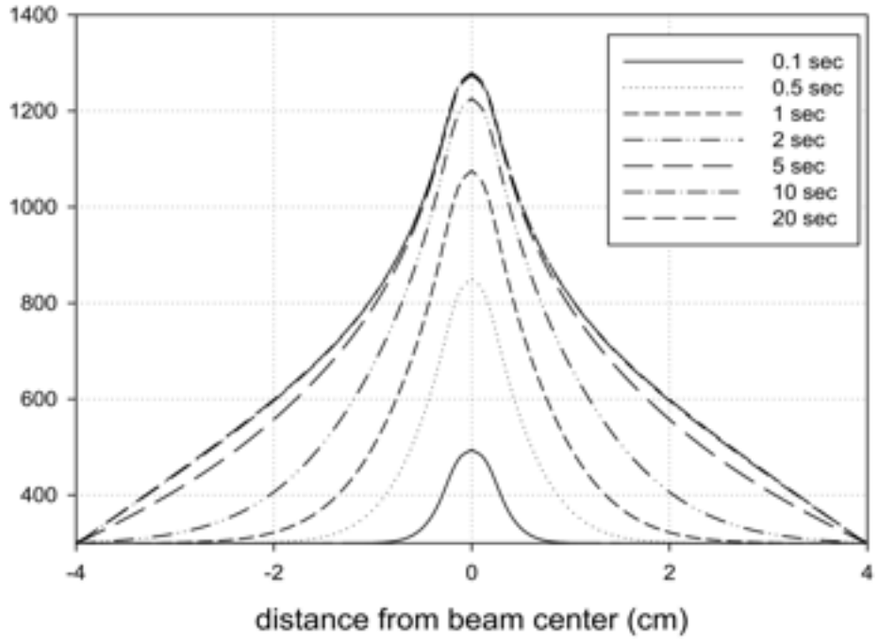


Tensioning beam keeps ribbons/wires straight as temperatures increase

Performance Studies - Production Target

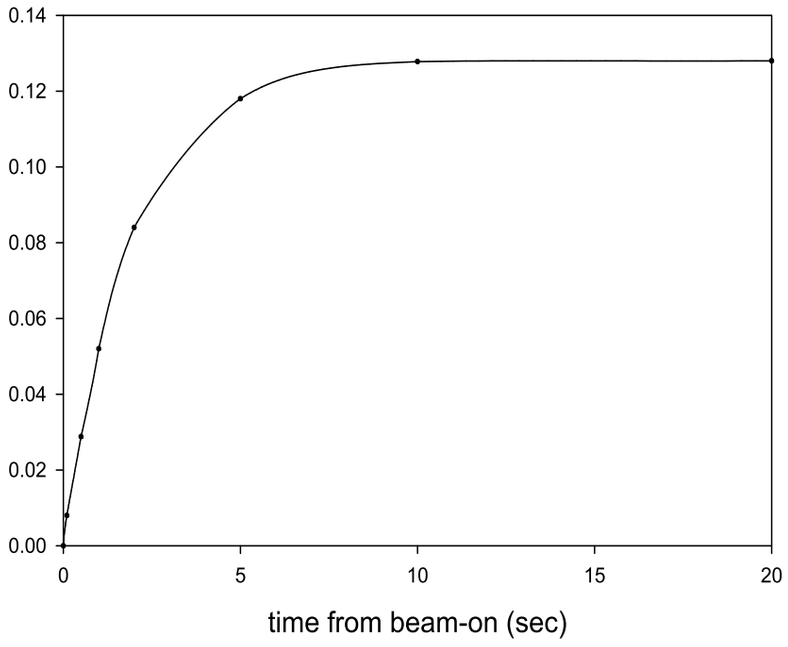
from Clive Field

Tungsten foil, 15 microns thick ± 4 cm tall.
Beam 40 μA, dither ± 2.5 mm high, beam sigma 0.4 mm,
beam just fills 2.5 mm wide ribbon

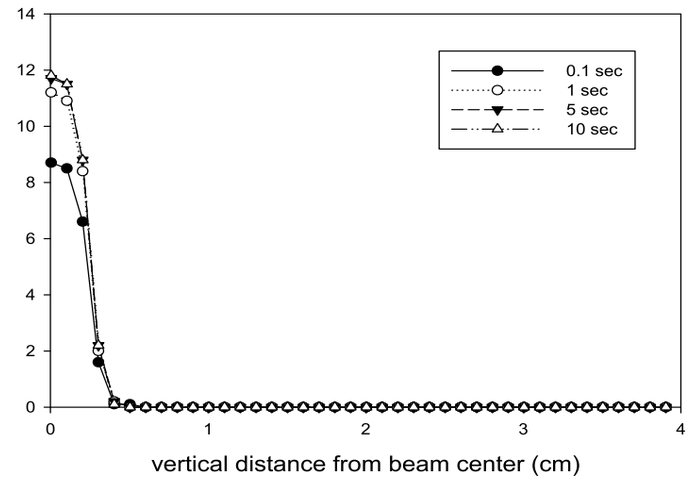


- heating of production ribbons is not overly severe
- elongation of hot ribbons is much smaller than range of tensioning beam
- horizontal temperature profile on ribbons is uniform so that transverse stresses are not severe

Thermal expansion after beam turn on
of 80 mm long tungsten ribbon, 15 μm thick.
Beam 40 μA, 5 mm vertical dither, sigma 400 μm.



Temp difference(K) between inner 0.25 mm strip and
outer 0.25 mm of 2.5 mm wide ribbon,
vs. distance up from beam center, after various beam times.
15 μm tungsten; 40 μA beam, 5 mm vertical dither,
1.5 mm horiz dither, 0.4 mm RMS spot size



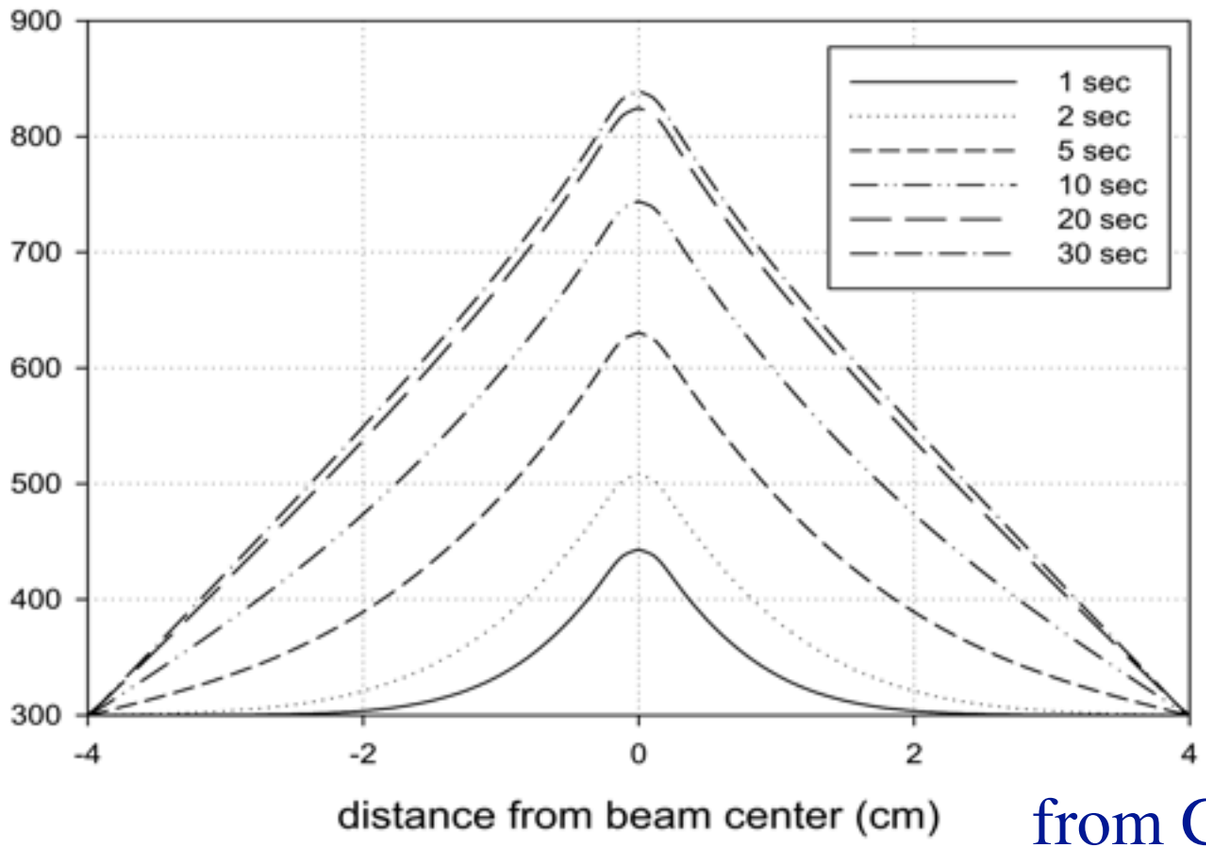
Beam-Target Alignment

- Optical survey target mounts are on the back side of aluminum mounting frame
- Wires in alignment section are surveyed relative to the optical survey targets (and frame)
- Can check alignment relative to beam with sub-mrad accuracy.

Tungsten wire 100 μm diam, ± 4 cm tall.
Beam 5 μA, dither 2 mm X & Y:
beam sigma 0.4 mm. Various times after beam on.

100 micron wires can get hot, but this should be ok.

150 g tensioning is expected to keep the wires straight.



Peak temp 900 K

from Clive Field

Summary of APEX Target System

The target system was constructed by SLAC and is currently at JLab.

Additional Studies

Target system in this talk was designed for the 2-pass beam test run → additional studies required to plan for use in full experiment

We were unable to test the target system during the test run
Did learn: Ta was not evaporated at 150 uA in PREX setup, beam-target alignment can be achieved using a hole, we developed detailed installation plan and preliminary alignment procedure

- For 1-, 3-, and 4-pass configuration, swap in different target holders (easy to do)
  - Less material (~x8) for 1-pass
  - More material (~x2) for 3- and 4-pass
  - Purchase additional ribbon material (need 30 micron thickness) - extra ~$1000
- Additional study of ribbon temperature and cooling for 3- and 4-pass running needed

Summary of APEX Target System

Target system has been constructed to meet the physics and design demands for 2-pass running

We expect that this system can be adapted for use in all running configurations of the full experiment