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X-ray Beam Position Monitors

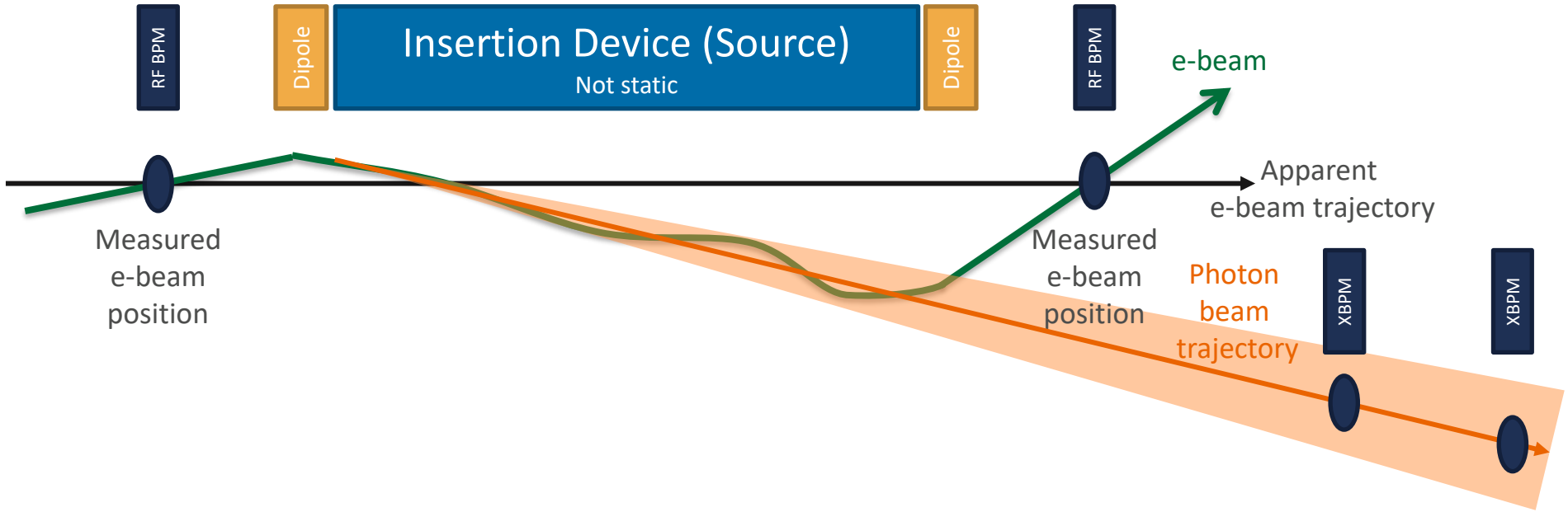
Developments at the Australian Synchrotron

Becky Lin, Sina Porsa, Jonathan McKinlay, Eugene Tan

Science. Ingenuity. Sustainability.

Purpose / Why

- Photon beam position monitors before the beamlines.
- Some difference between photon and electron beam trajectories.



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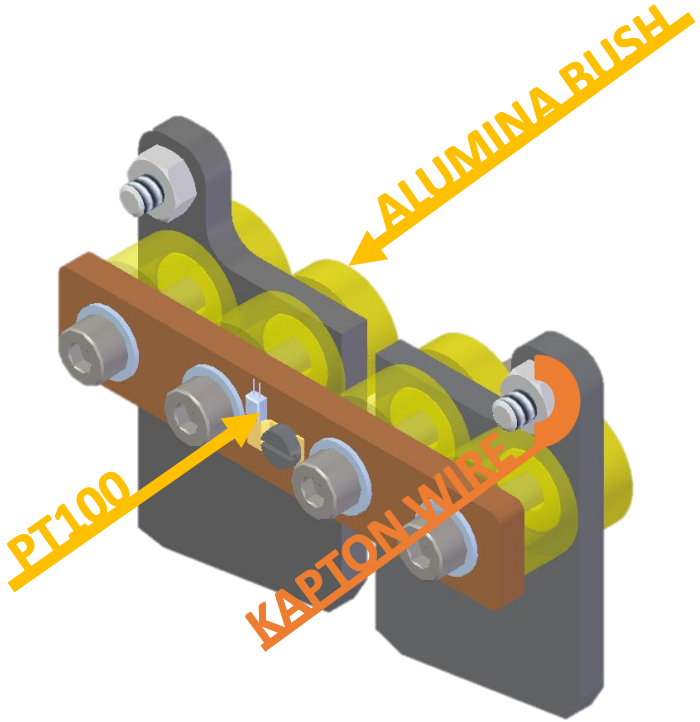
Challenges

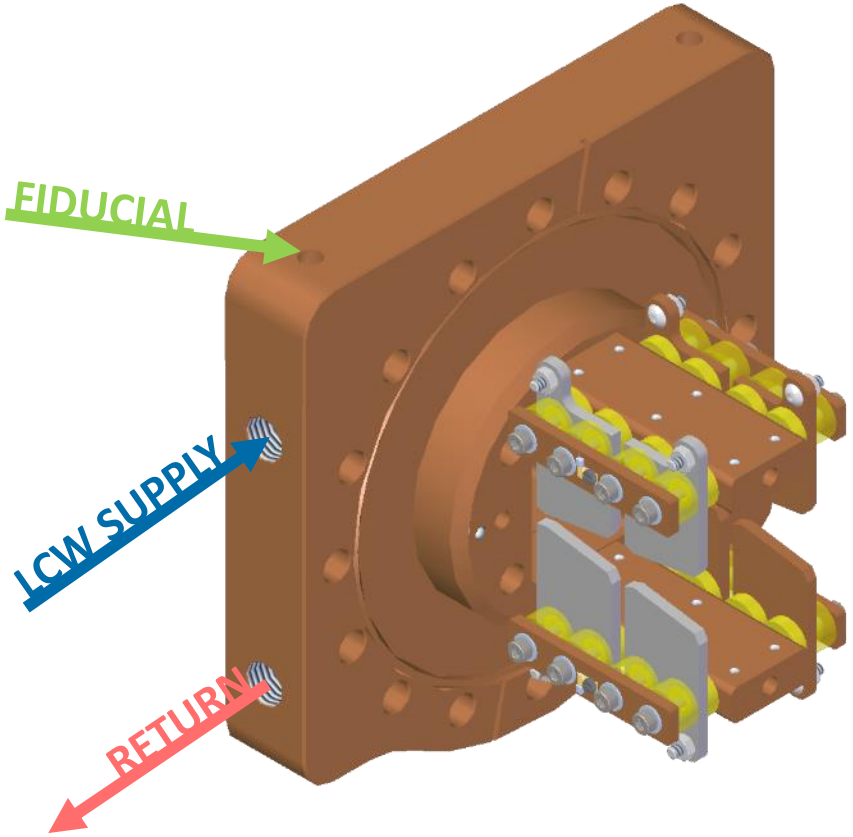
- Non-intercepting
- Resolution ~100 nanometre
- White beam → High power density (thermal challenges)
- Photon spectrum and distribution can change
- Types of XBPMs:
  - Photoelectric – measure drain current from metallic probes
  - Photoconductive – generally intercepting, not for white beam
  - Ionisation chambers – slow, low resolution

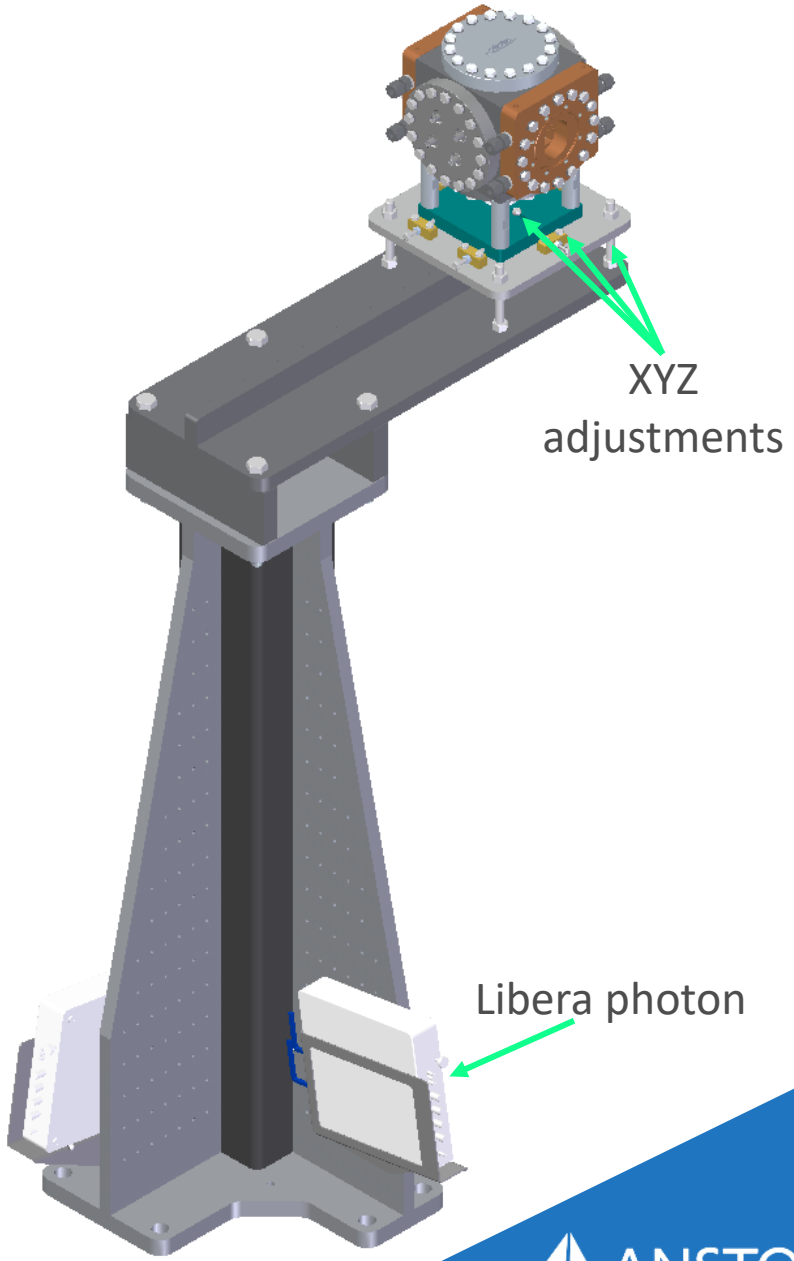
Prototype XBPM

- XBPM for a Dipole radiation source:
  - Only vertical distribution
  - Low power densities, static photon spectrum and distribution.
- Goals:
  - Difference in white beam response between W and Cu.
  - Increased number of sensors/blades used from 2 → 4.
  - Possibility of using pinhole masks to improve sampling of the photon distribution.
  - Simplified manufacturing: no brazing (Fe/Cu)

Prototype XBPM







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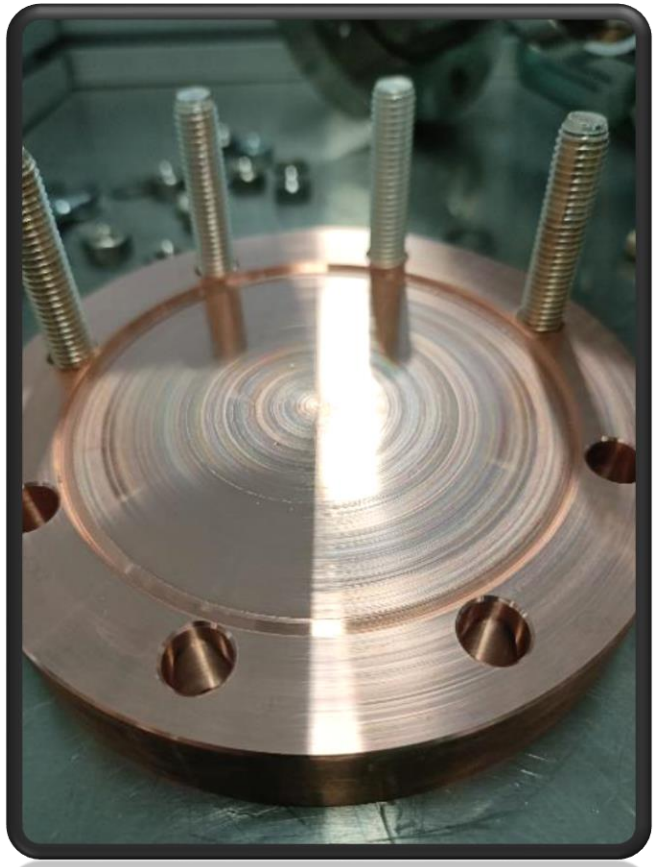
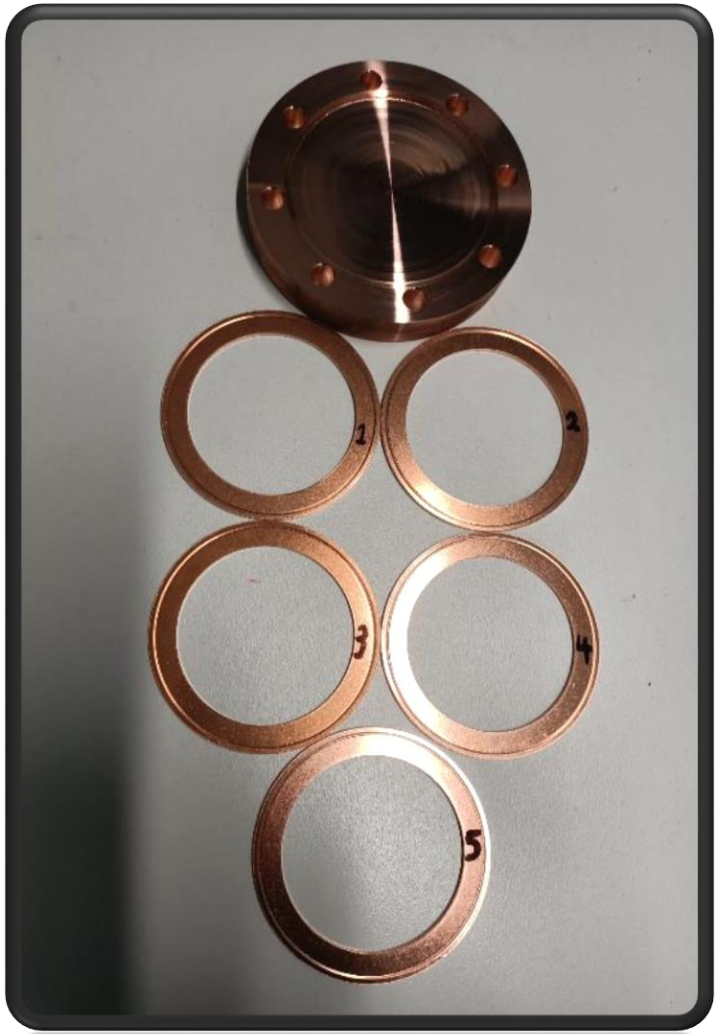
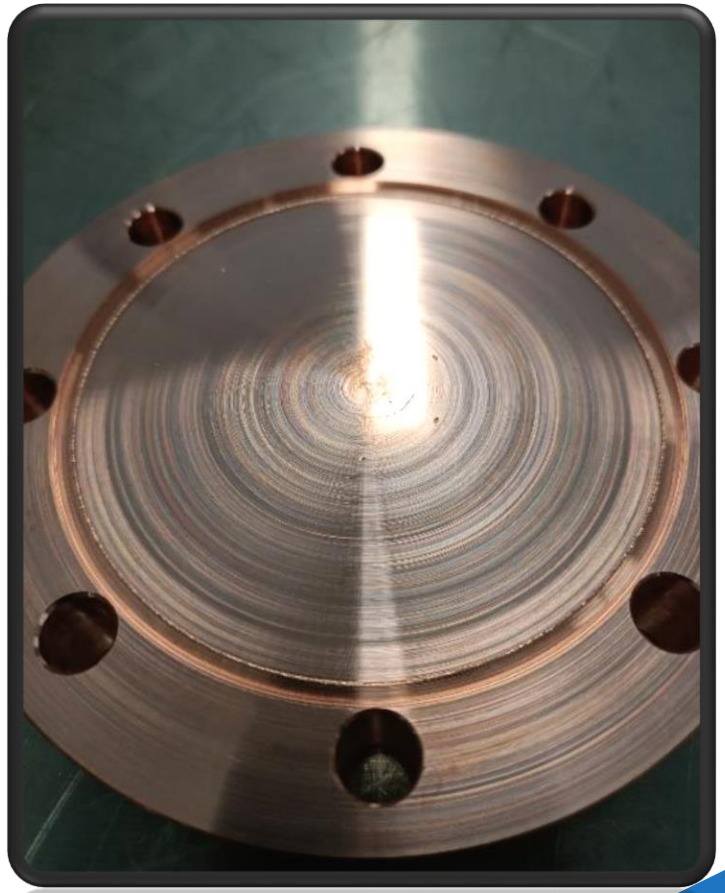
Experiments







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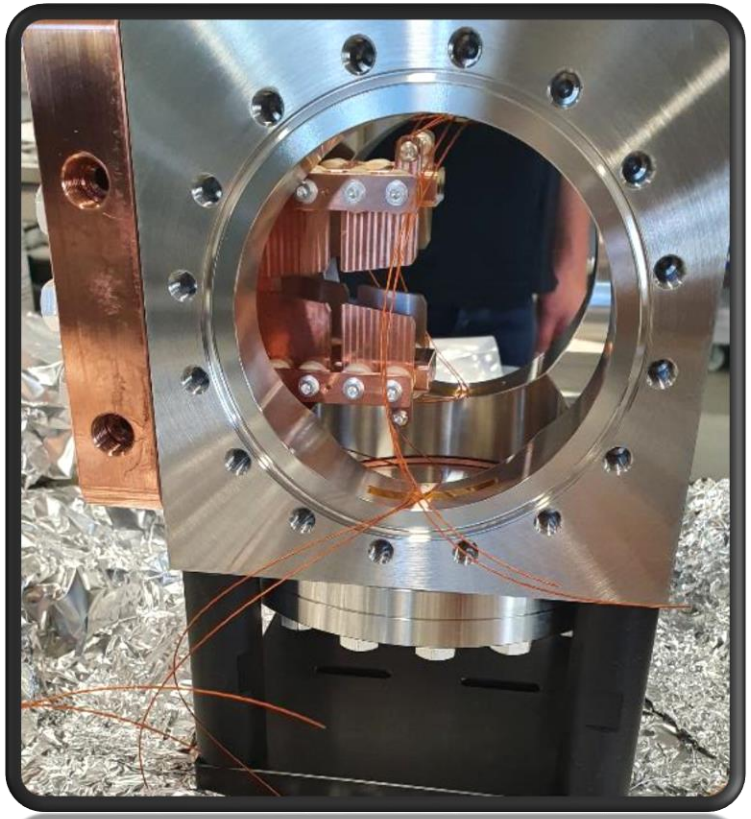
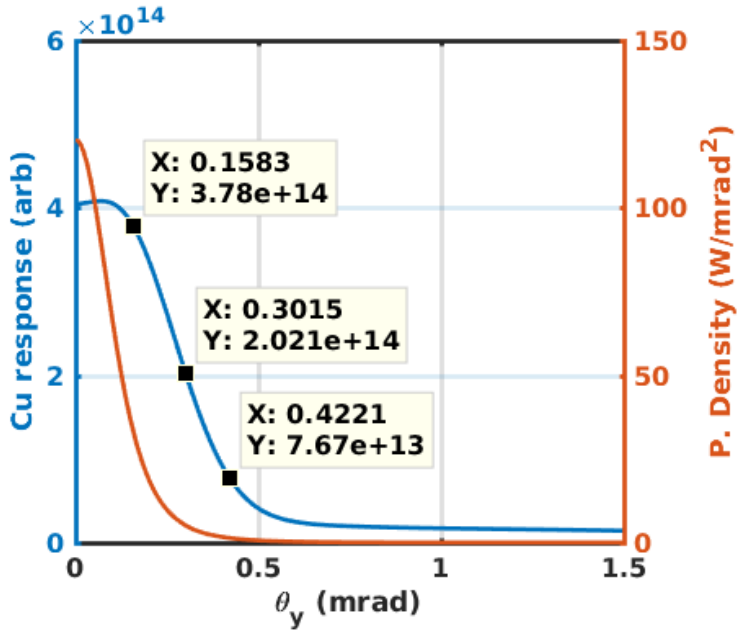
Experiments





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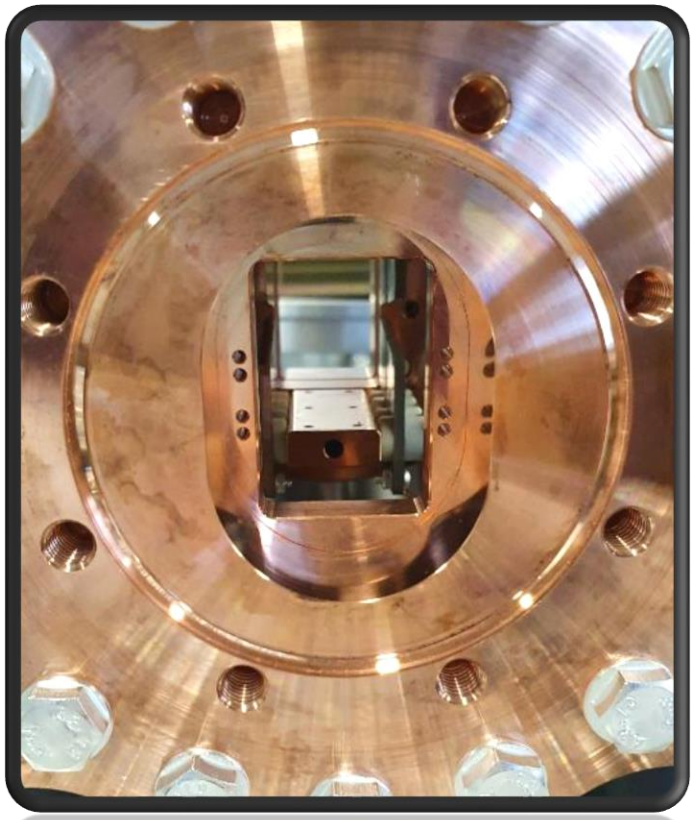
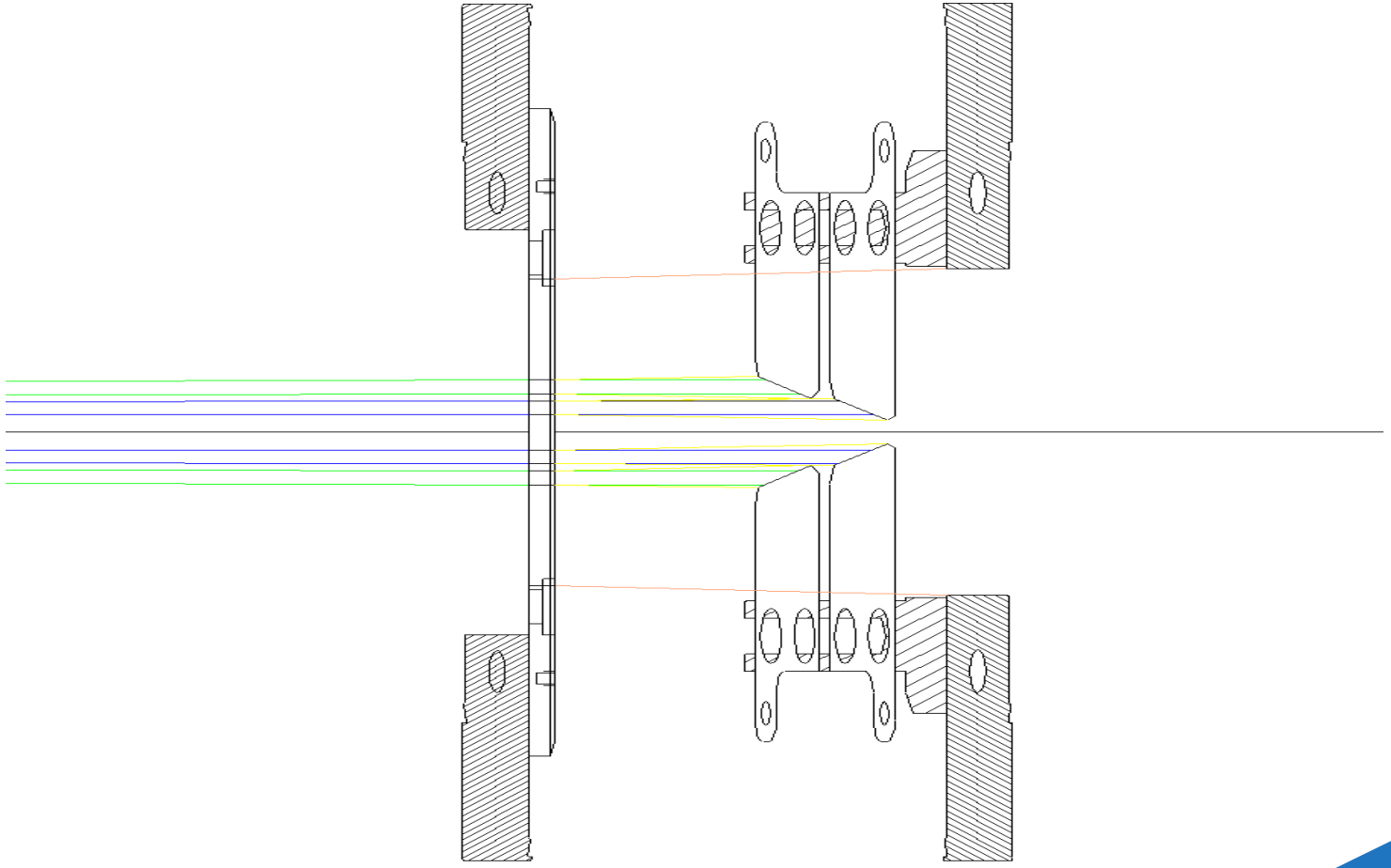
Experiments





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Prototype XBPM – Installed

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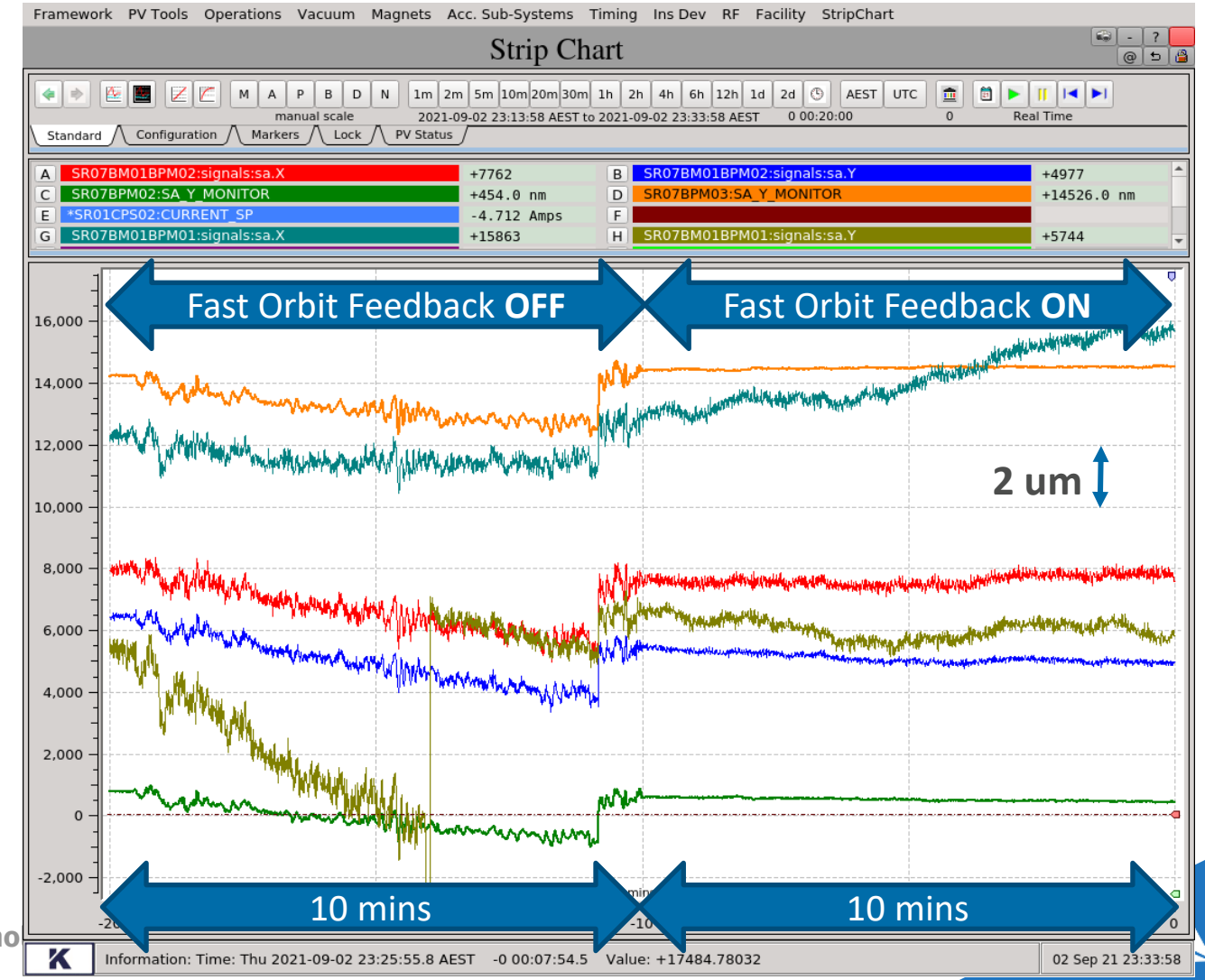
Prototype XBPM – Results/Learnings

- Resolution < 200 nm.
- Very sensitive to cooling water temperature.
- Unexplained:
  - Horizontal position sensitivity
  - Factor 10 difference between similar blades.
  - Bursts of outgassing
  - Calibration gain changes over time



Cu Inner
RF BPM

W Inner
Cu Outer
W Outer

RF BPM

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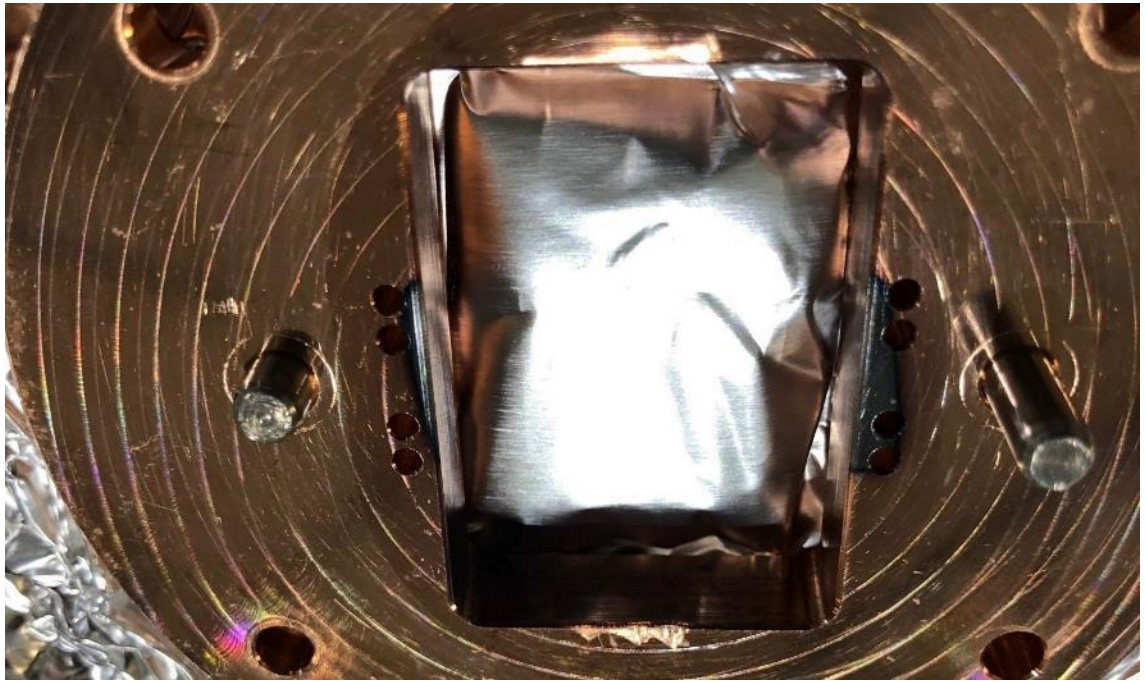
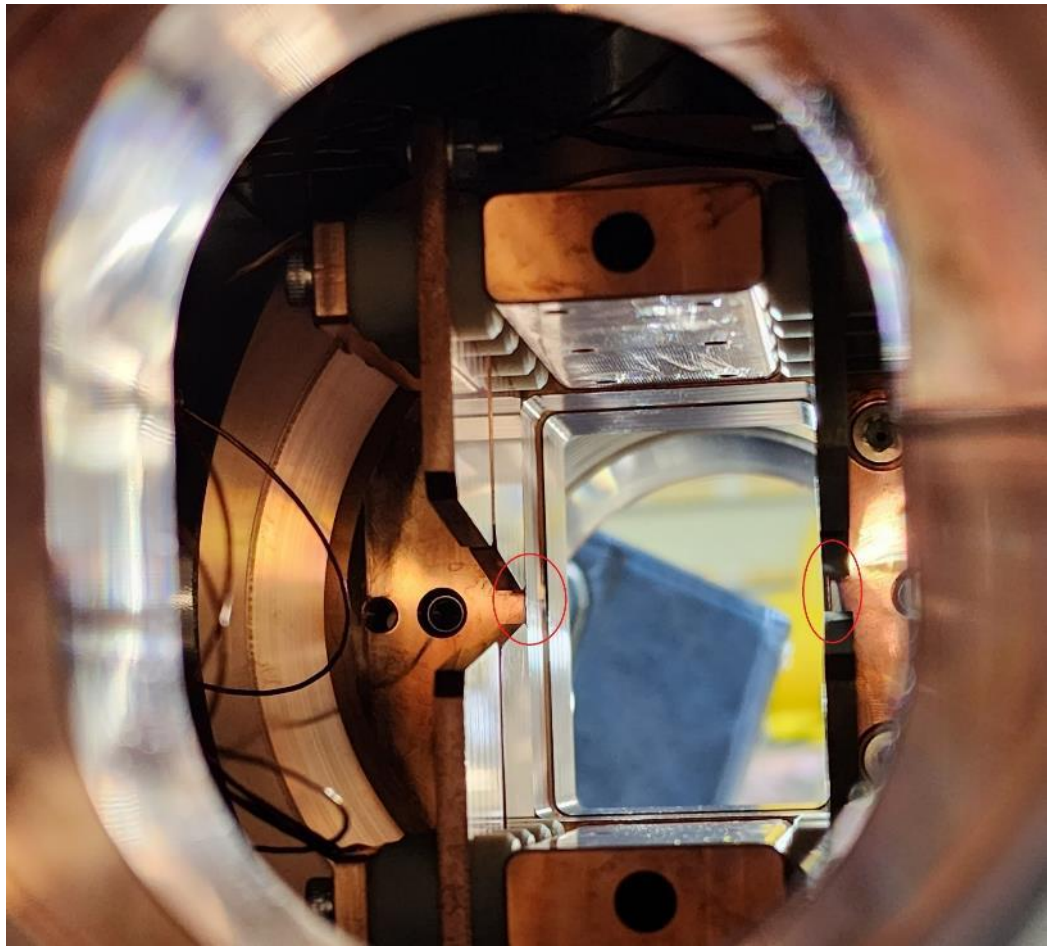
Prototype XBPM – Removed





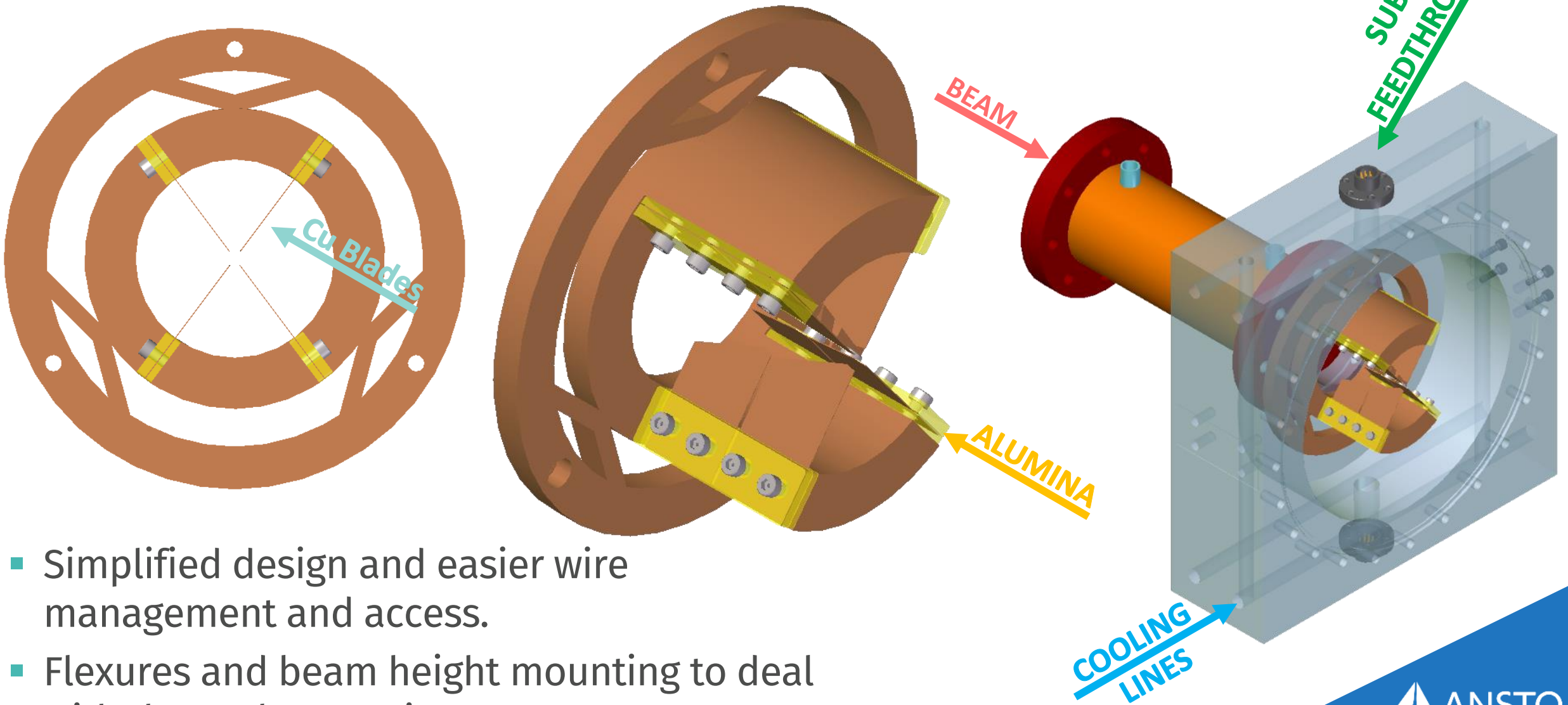
Discovered that the photon beam was 5 mm narrower than expected and at an odd angle due to the first mask in the main chamber. Explains:

- ✓ Explains the strange horizontal position sensitivity
- ✓ Factor 10 in signal for similar blades

Prototype XBPM – 2nd Iteration

- Photo electron re-capture:
  - Permanent voltage bias source.
  - Angle blades to flat surfaces don't face each other
- Narrower blade positioning and re-instate mask.
- Lab tests to find source of "bursts" of outgassing.

MX3 Beamline XBPM



- Simplified design and easier wire management and access.
- Flexures and beam height mounting to deal with thermal expansion

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SURFACE COATED BLADES

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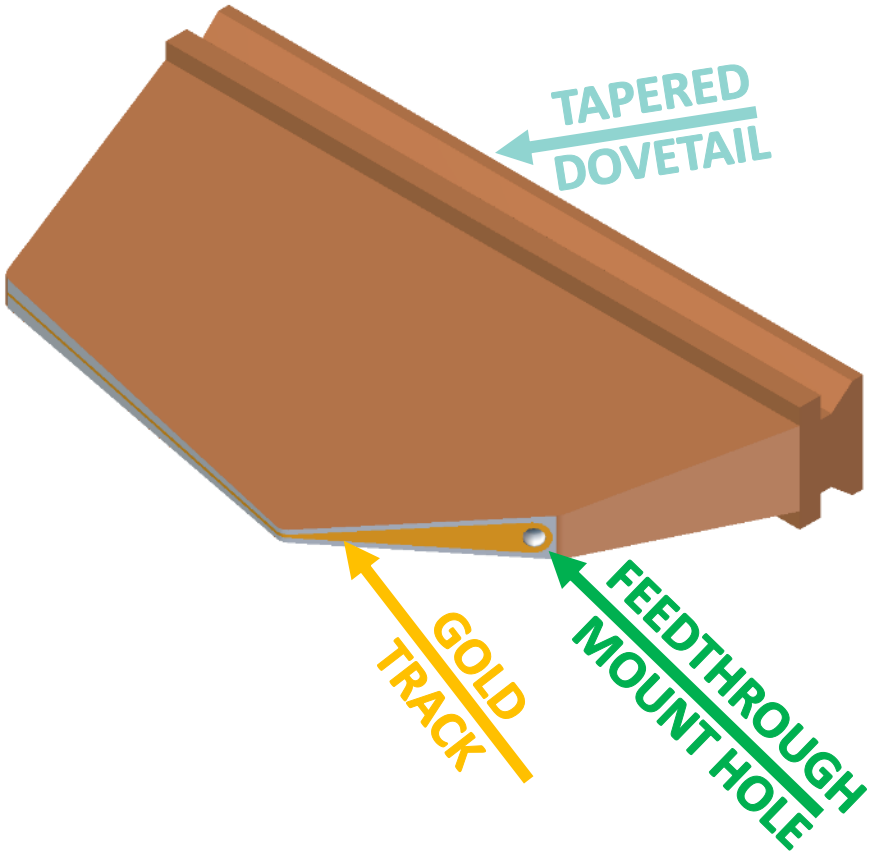
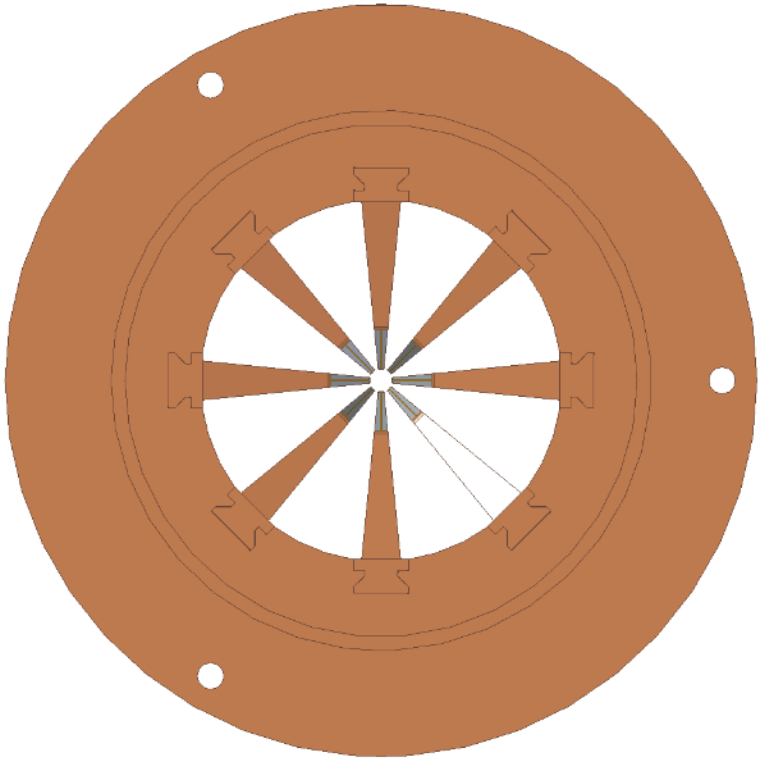
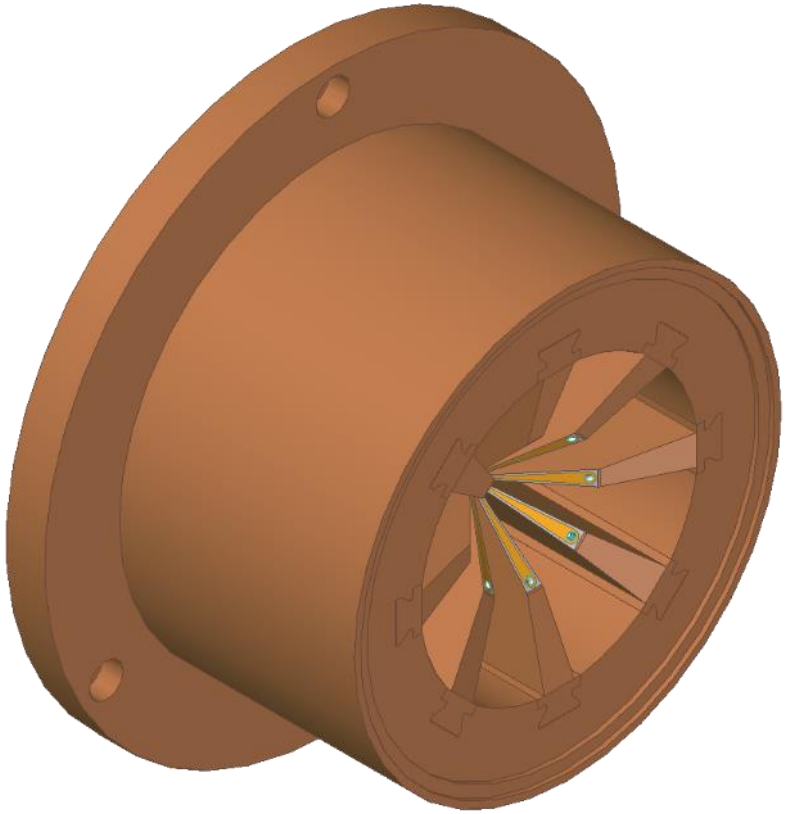
Coating Blade Design



FRONT VIEW



BACK ISOMETRIC VIEW



- Significant reduction in complexity
- Improved thermal distribution.
- Improved photon beam sampling

- Challenges: Suitable materials for robustness of insulation layer and tracks

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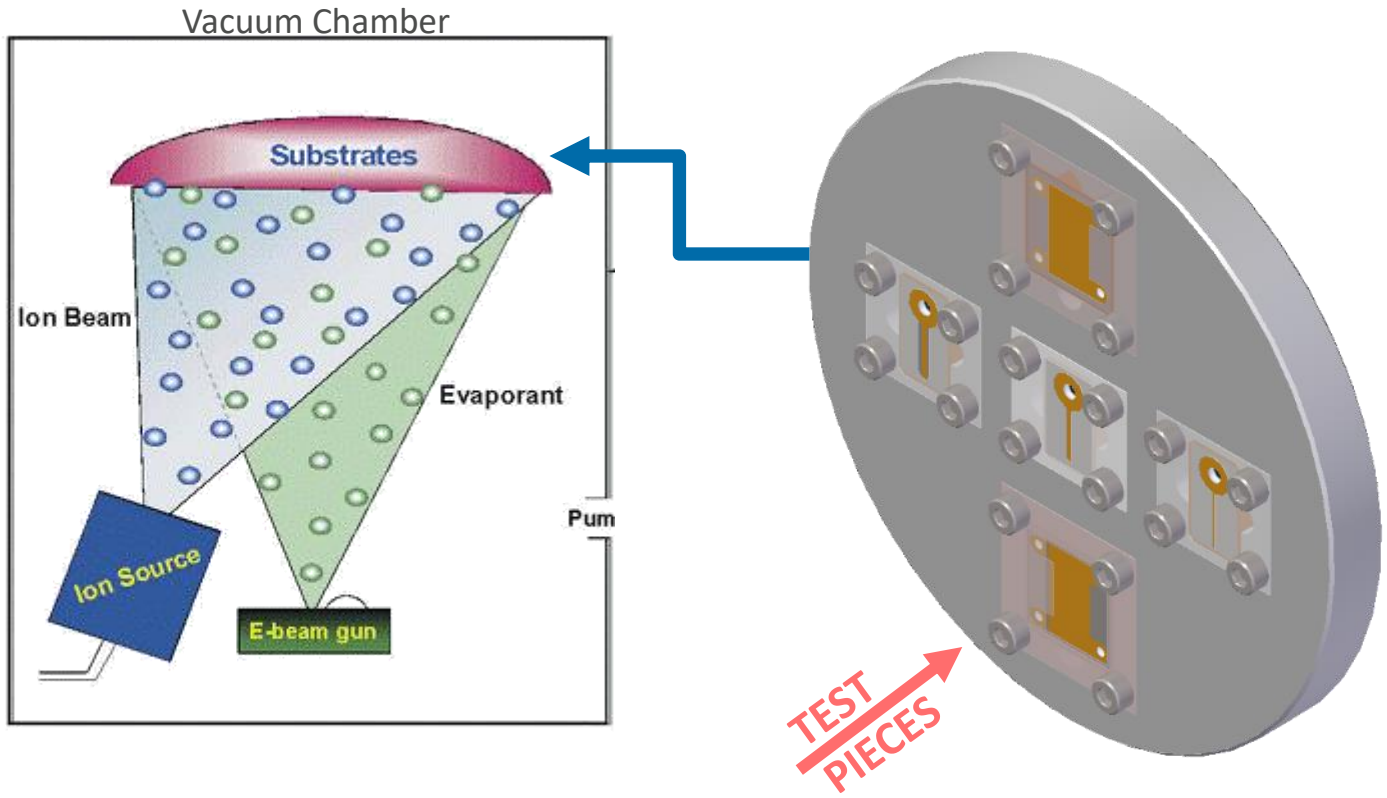
Evaporative Beam Deposition Test



- Insulation: SiO_2 500nm
- Signal Path: Au 100nm

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THERMOMECHANICAL BPM (TBPM)

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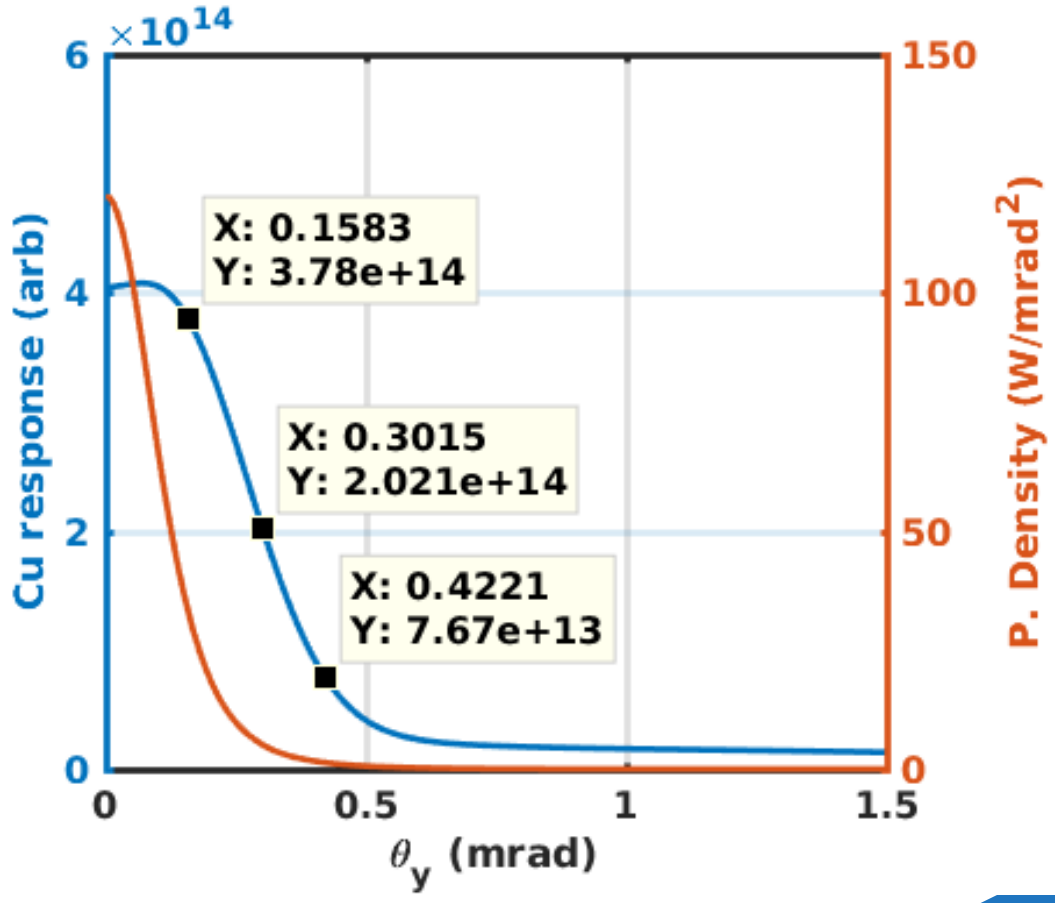
Thermomechanical BPM (TBPM)

- Problems with photoemission
  - Signal depends on material surface properties and photon spectrum.
  - Photon spectrum and distribution changes as beamlines request different energies.
  - Free electron recapture
- Potential solution: use the power density
  - Not applicable for all beamlines



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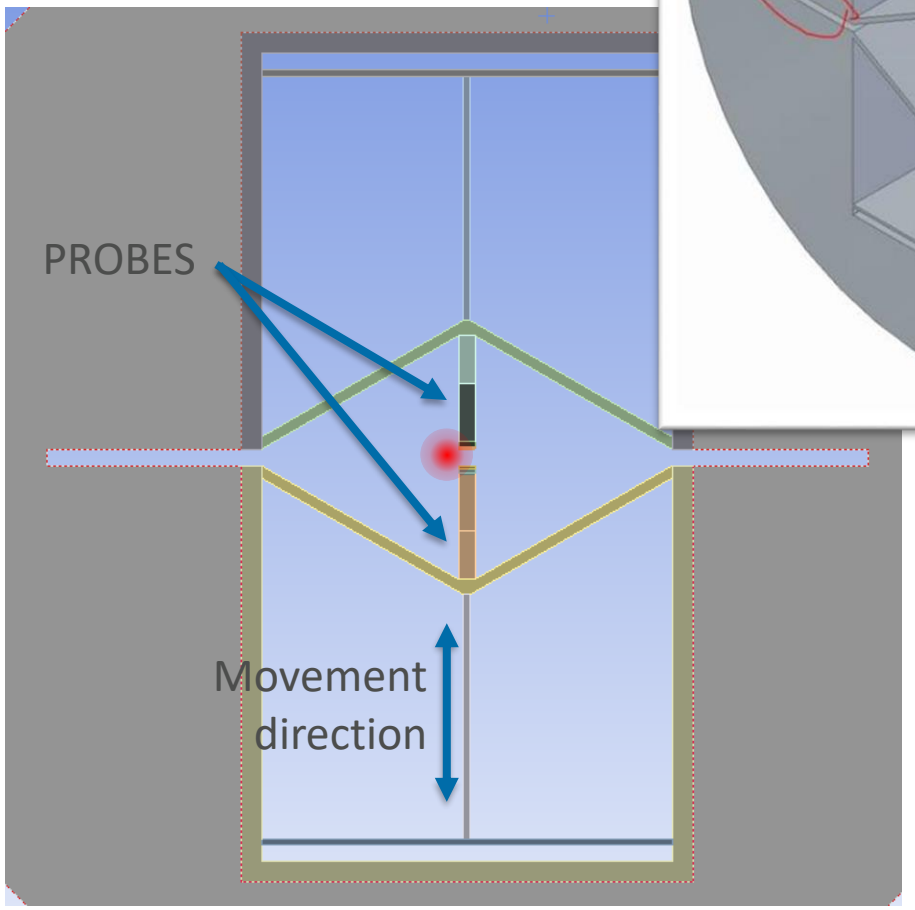
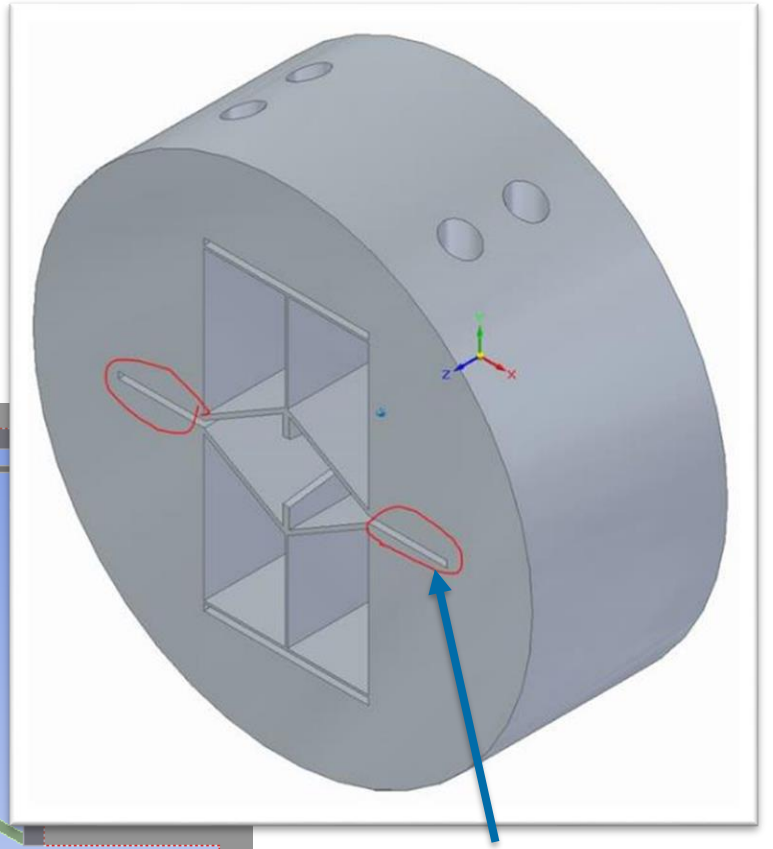
TBPM Design

- No feedthroughs
- Single water-cooled Cu block
- Temperature changes to the probes causes the flexure to move vertically.
- Differential measurement to measure shift in the beam centroid.





Cuts to increase thermal gradient.

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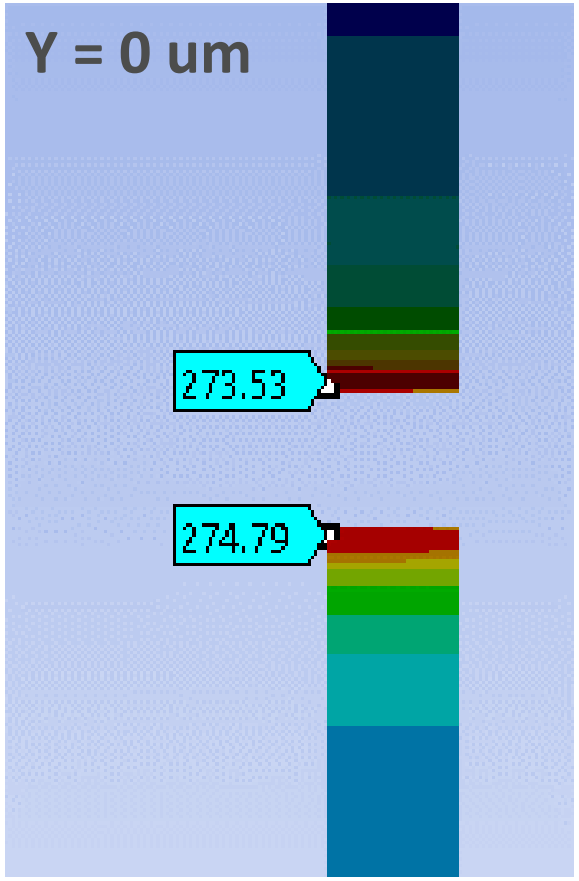
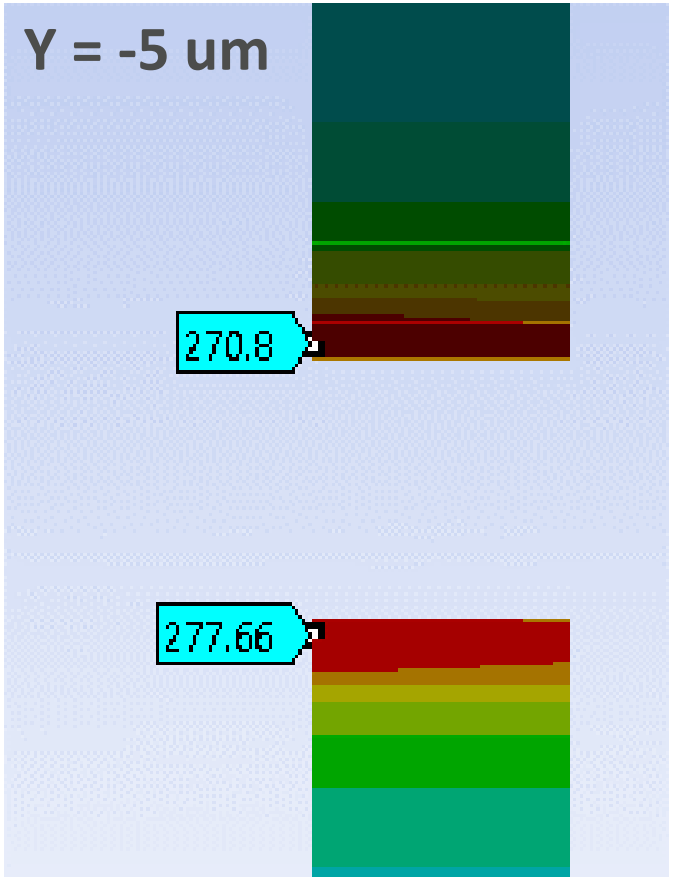
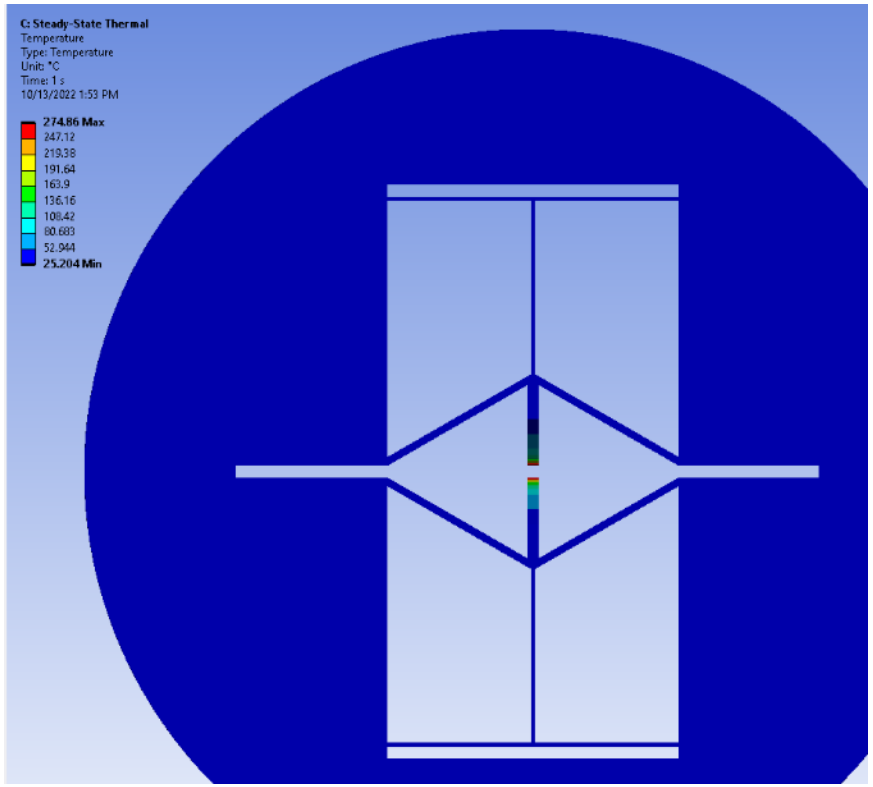
TBPM – FEA Studies







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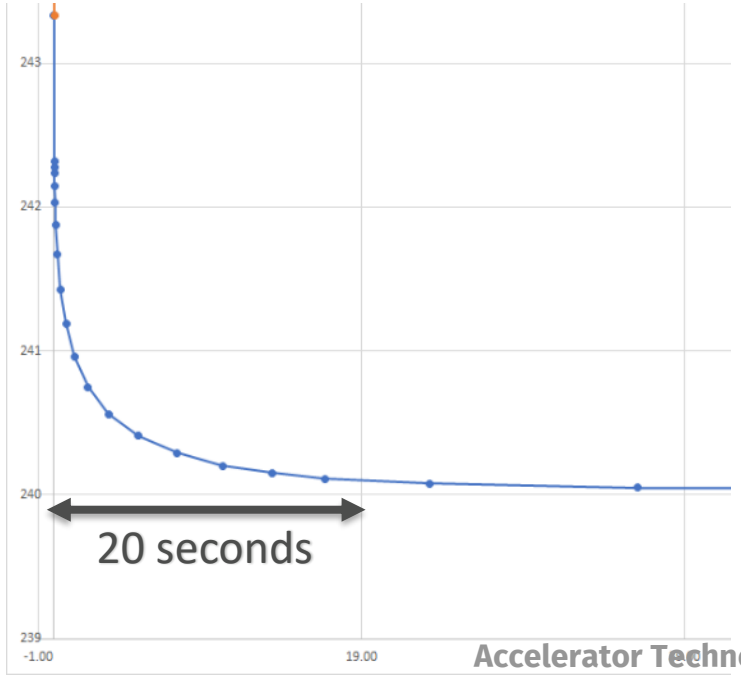
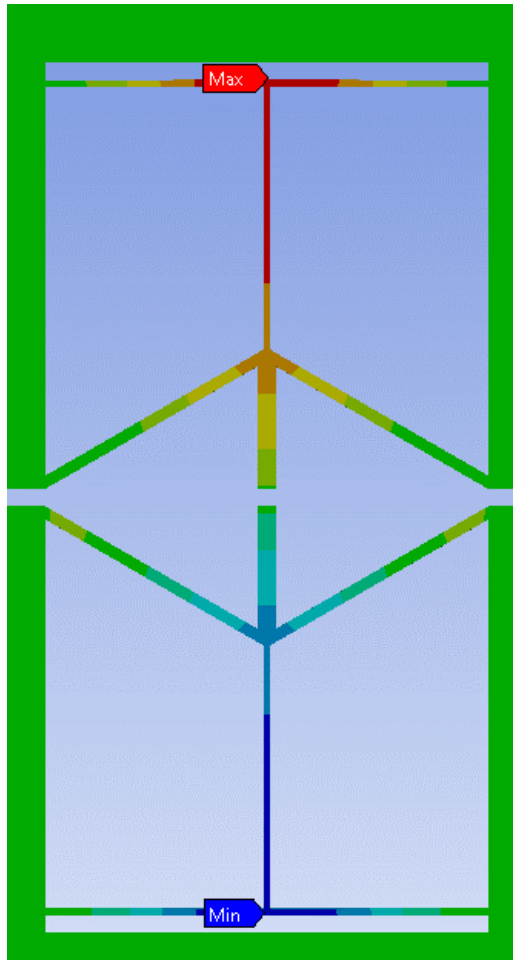
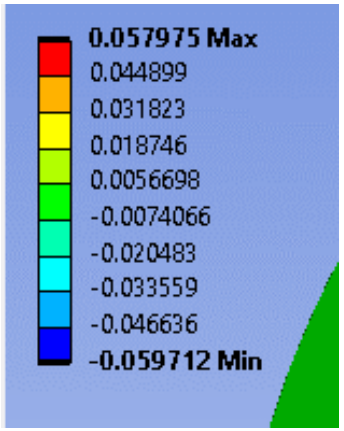
TBPM – FEA Studies

- Y = -5 um beam shift → 1.8um difference in flexure position.
- Response time ~10 s.







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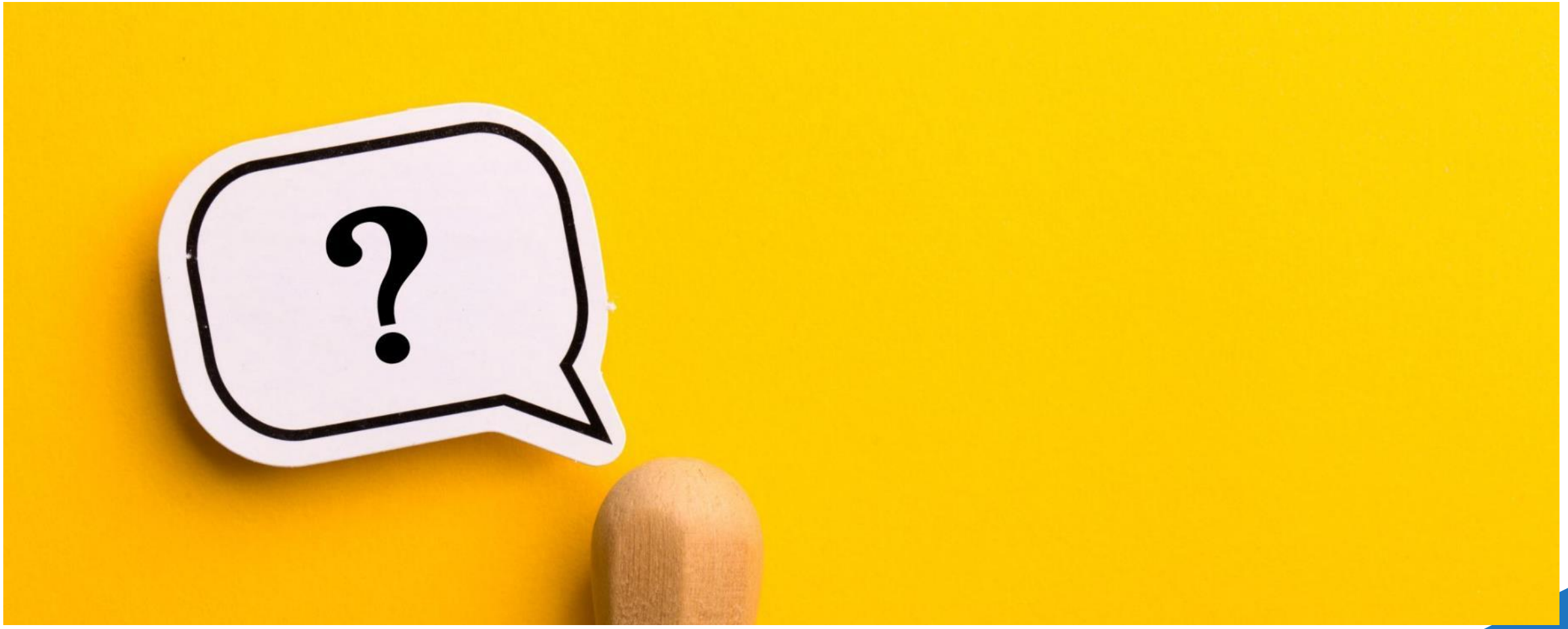
Questions and Feedback



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Thank You

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