XBPM temperature interlocks for DLS-II

DEELS 07/07/2021

C Bloomer, C Houghton, L Bobb

Problem:

- Front end (white beam) XBPMs are the **first instrument** on the front end.
- Upgrades for DLS (new IDs) and for DLS-II (new machine) will **increase the flux and power**.
- Our current MPS interlock is a **PT100 temperature sensor**, located in the XBPM aperture.
- **Beam is dumped** if temperature goes above 50 degrees C.
- …but this interlock is unreliable. Easily possible to "**fail-unsafe**"!

Outline of talk

1. DLS-II power loads.
2. XBPM design.
3. FEA results to assess effectiveness of temperature sensor.
4. Machine day experiments to assess effectiveness of temperature sensor.
5. Conclusions and some potential solutions.

DLS-II power densities

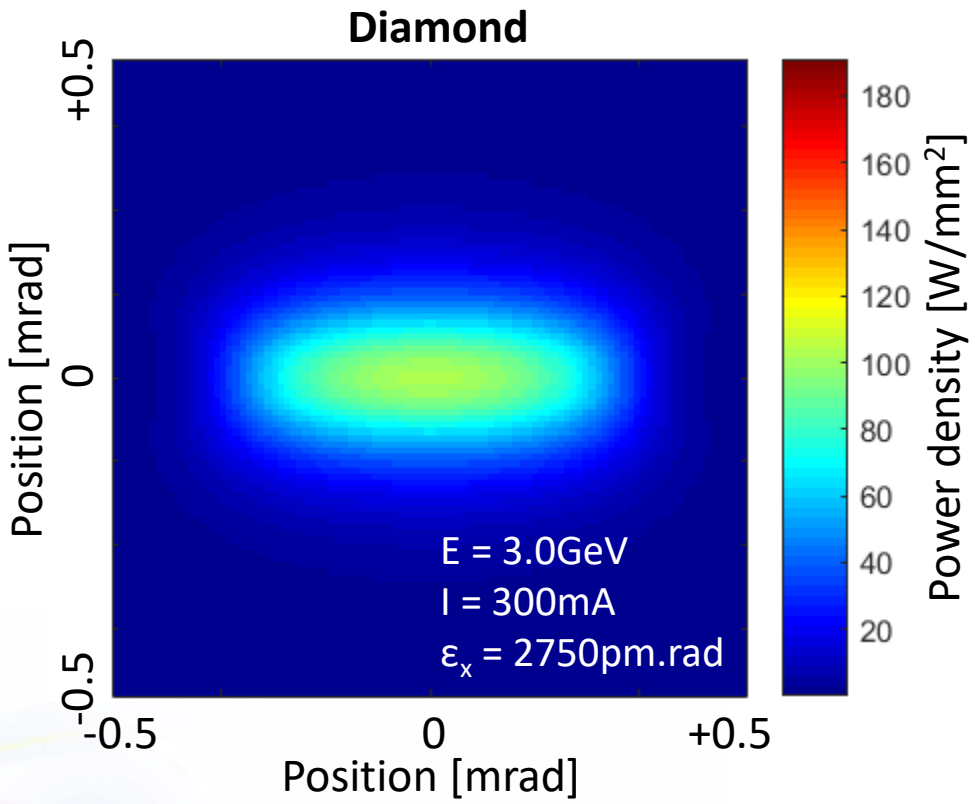
..assume a very simple ID:

22mm period

K_y = 2.0

2m long

*Taking a simulation plane at **15m** from the source point, the rough location of the XBPM.*



Just approximate, indicative results.
NOT FOR DESIGN PURPOSES!

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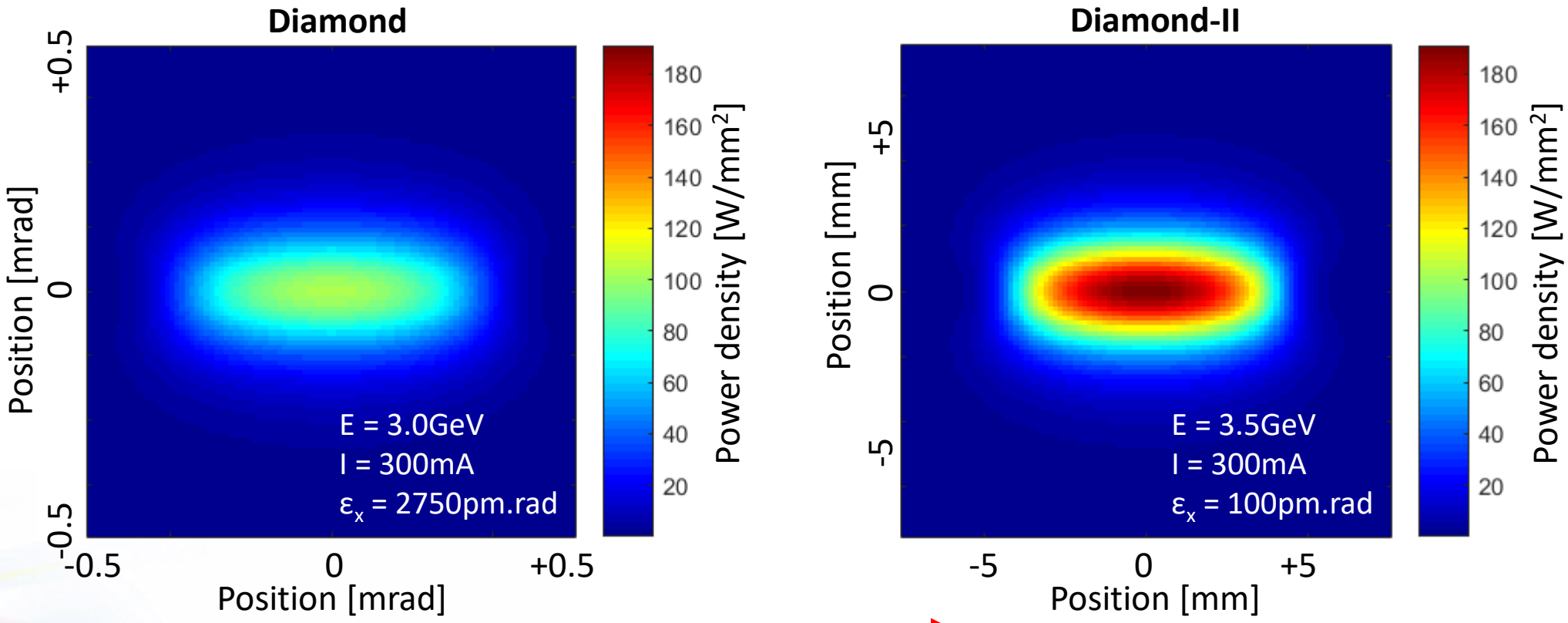

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~2x increase in power density..
~2x increase in total power..

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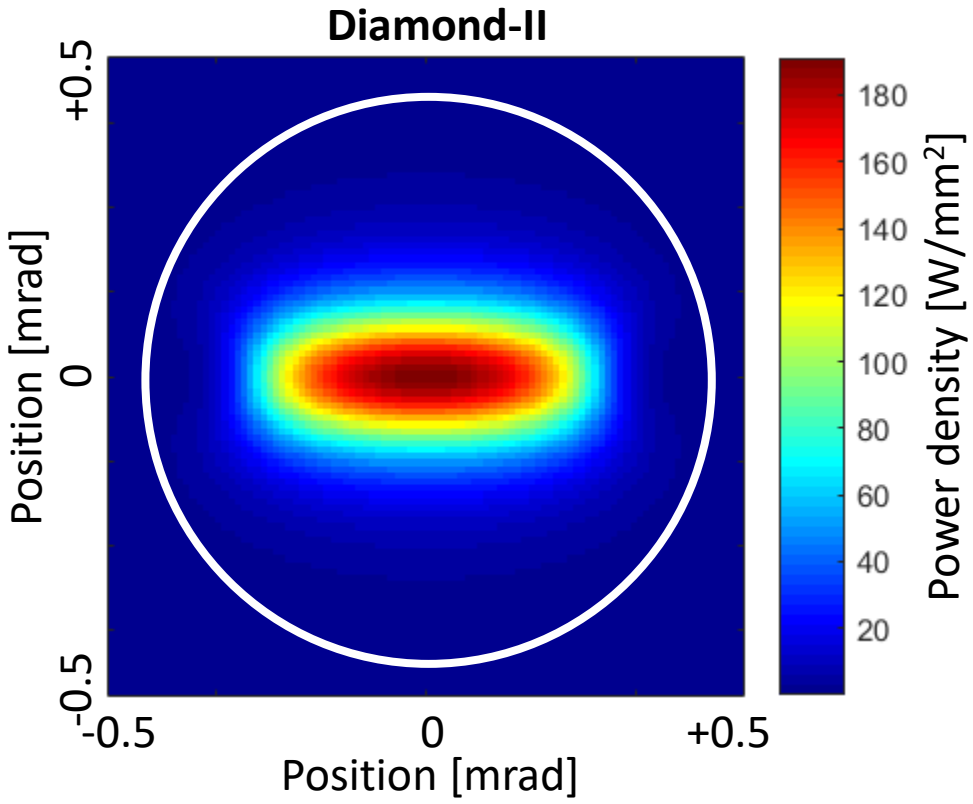

…**±0.5mm misalignment at EBPMs** will result in **~0.18mrad** beam missteer, power densities on aperture **up to ~100W/mm²**.

…including XBPM stage misalignment of **±1mm** and power densities reach ~**150W/mm²**.

Just approximate, indicative results.
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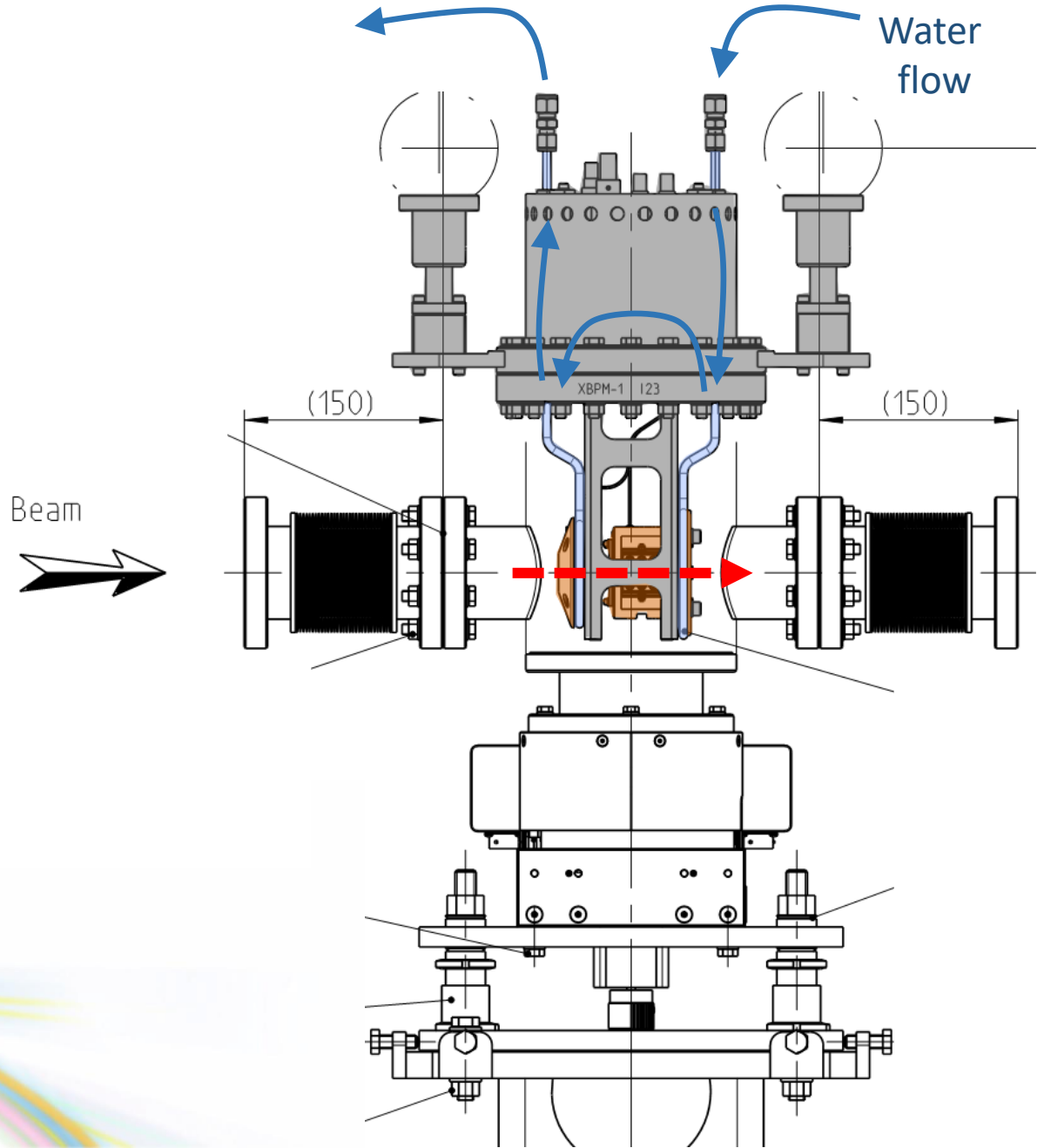
XBPM design

Shown here is the XBPM vacuum vessel insert.

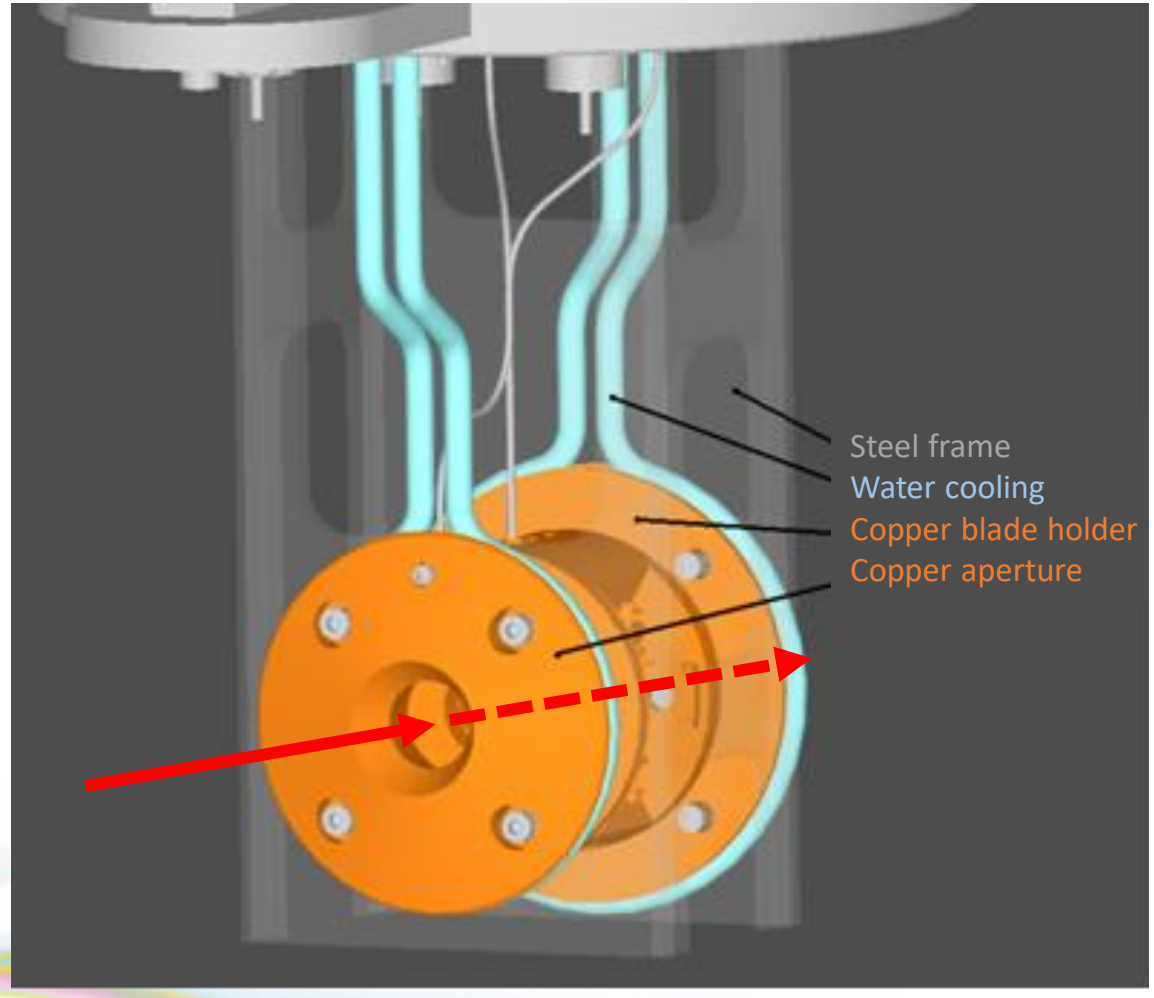
The beam passes through the instrument from left to right, shown in **red**.

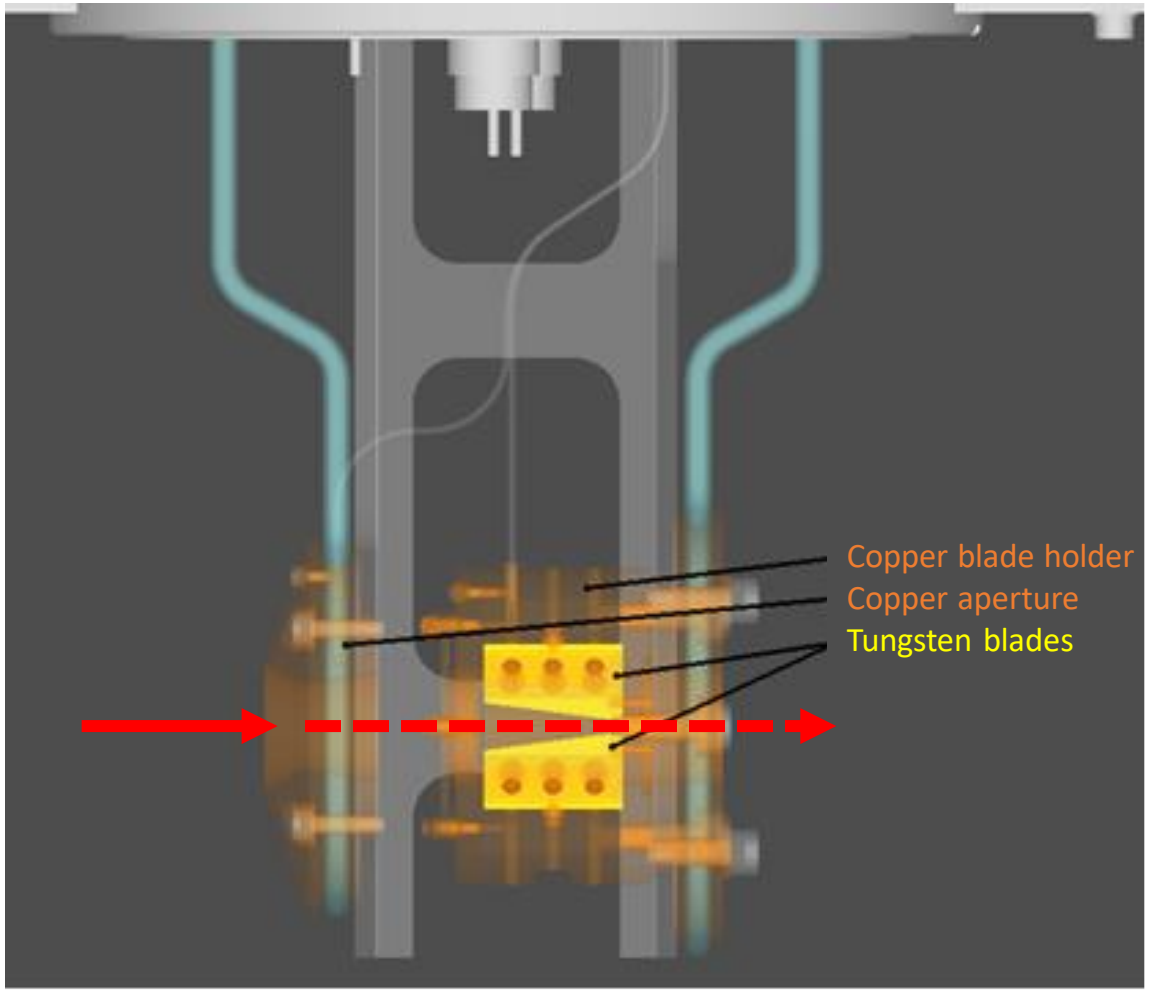
The water cooling is marked in **blue**.

The water-cooled copper aperture and copper blade holder components are marked in **orange**.



XBPM design

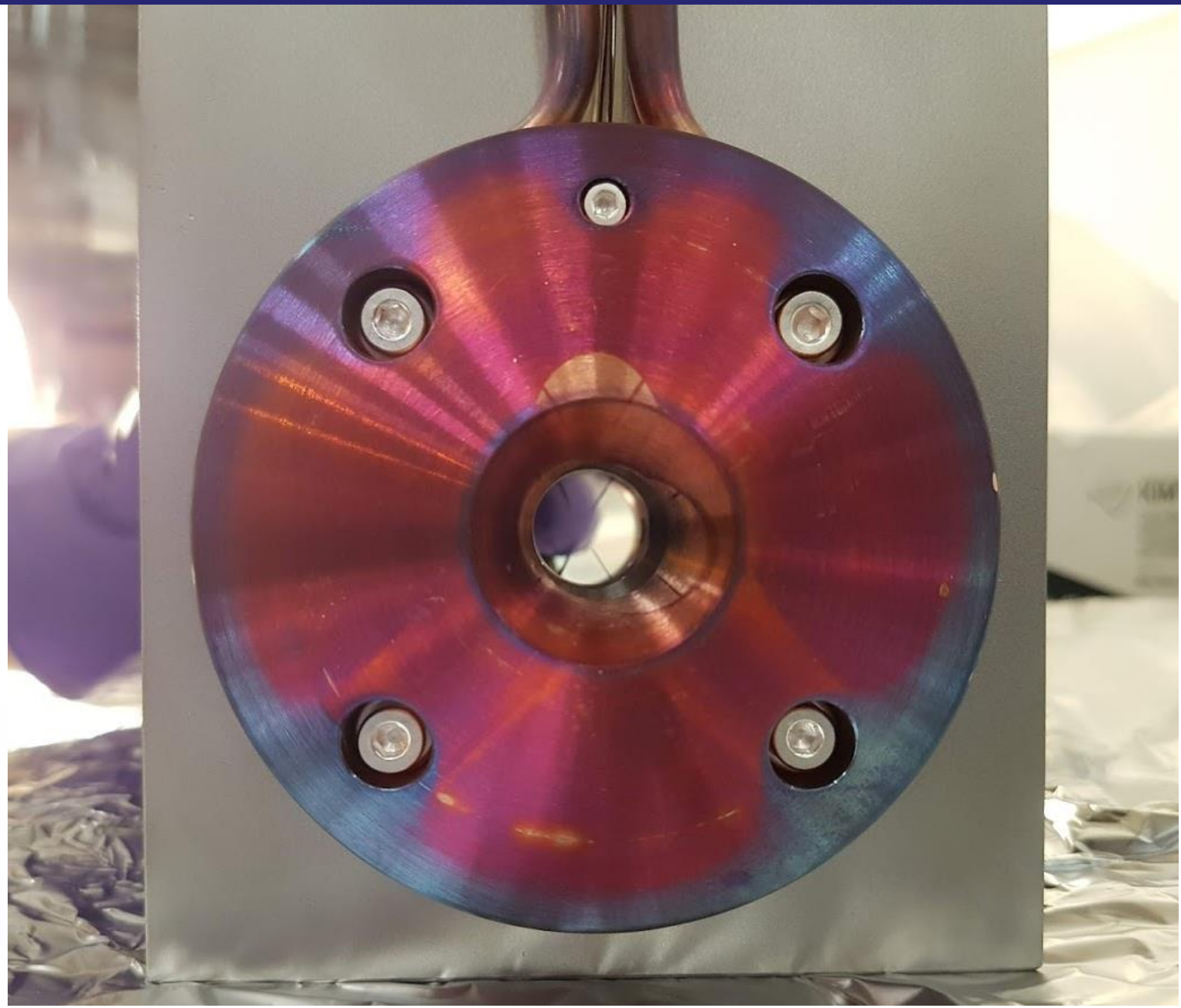

Steel frame
Water cooling
Copper blade holder
Copper aperture


Copper blade holder
Copper aperture
Tungsten blades

XBPM design

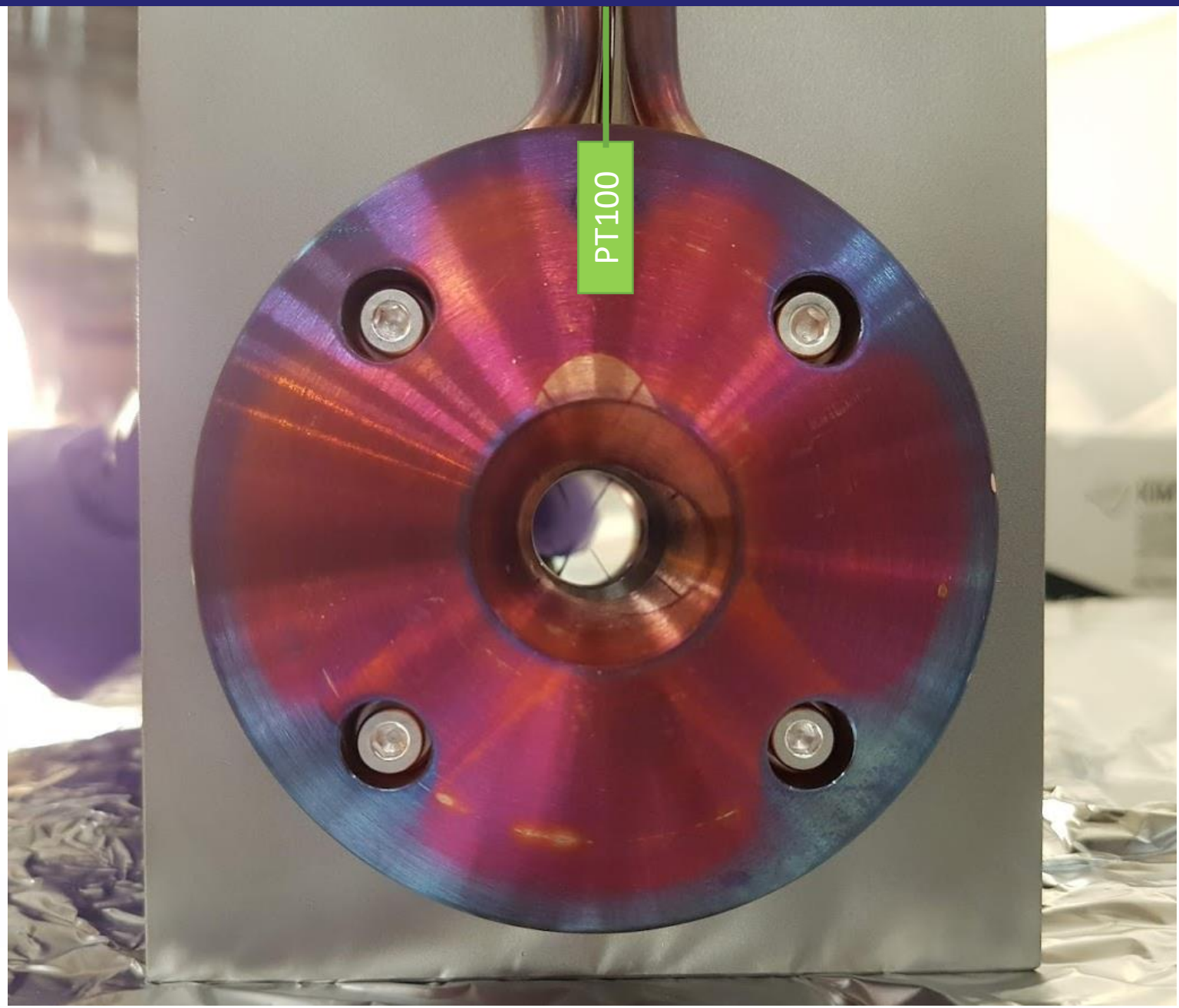
The XBPM's copper aperture protects blade holder in the event of a missteer.

The circular hole in the centre of the aperture is ~10mm diameter.



XBPM design

The PT100 temperature sensor (location indicated in **green**) is used for MPS. However, this only really gets warm if the beam hits the aperture near the sensor!

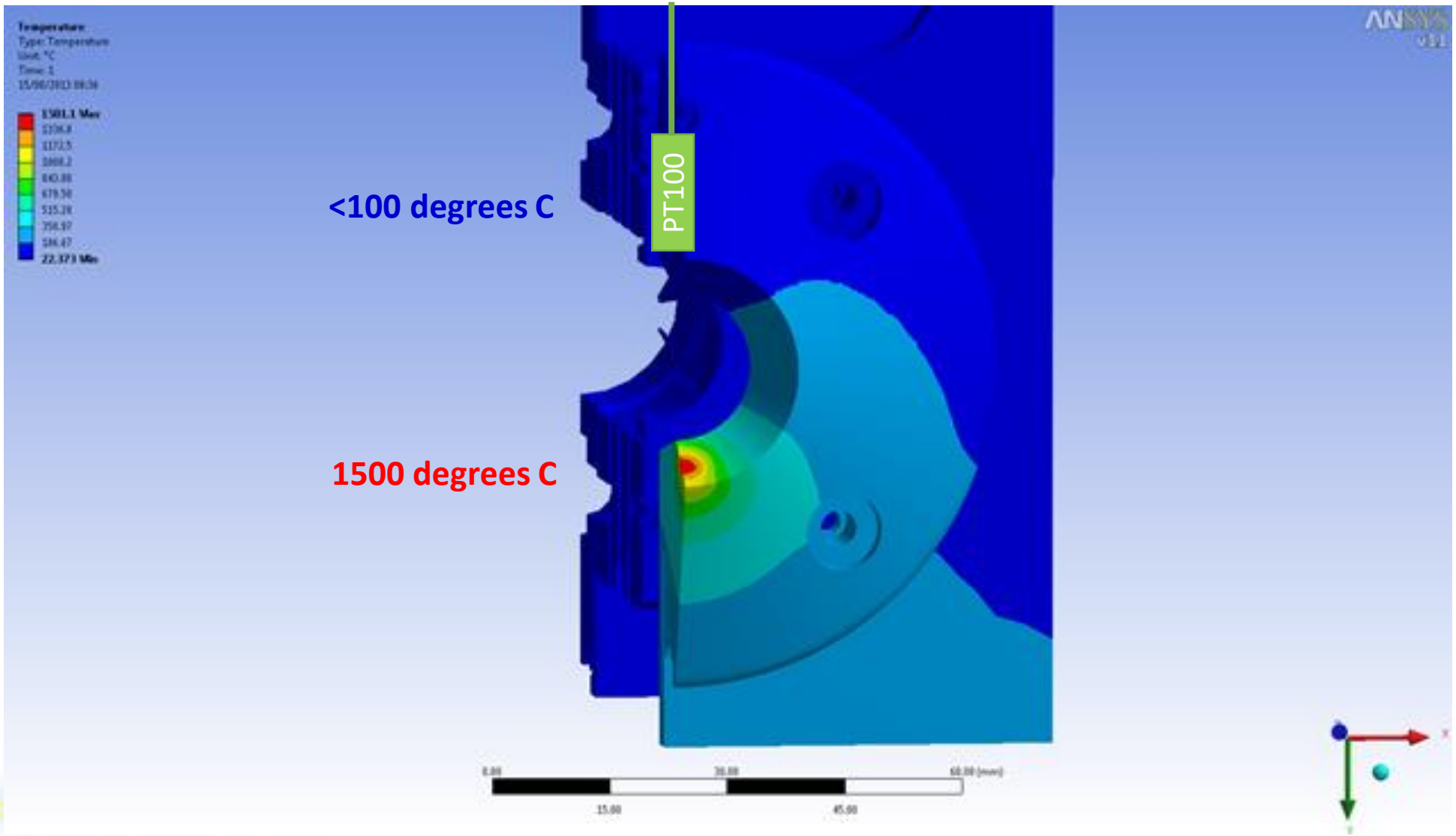


FEA results

Worst case scenario:

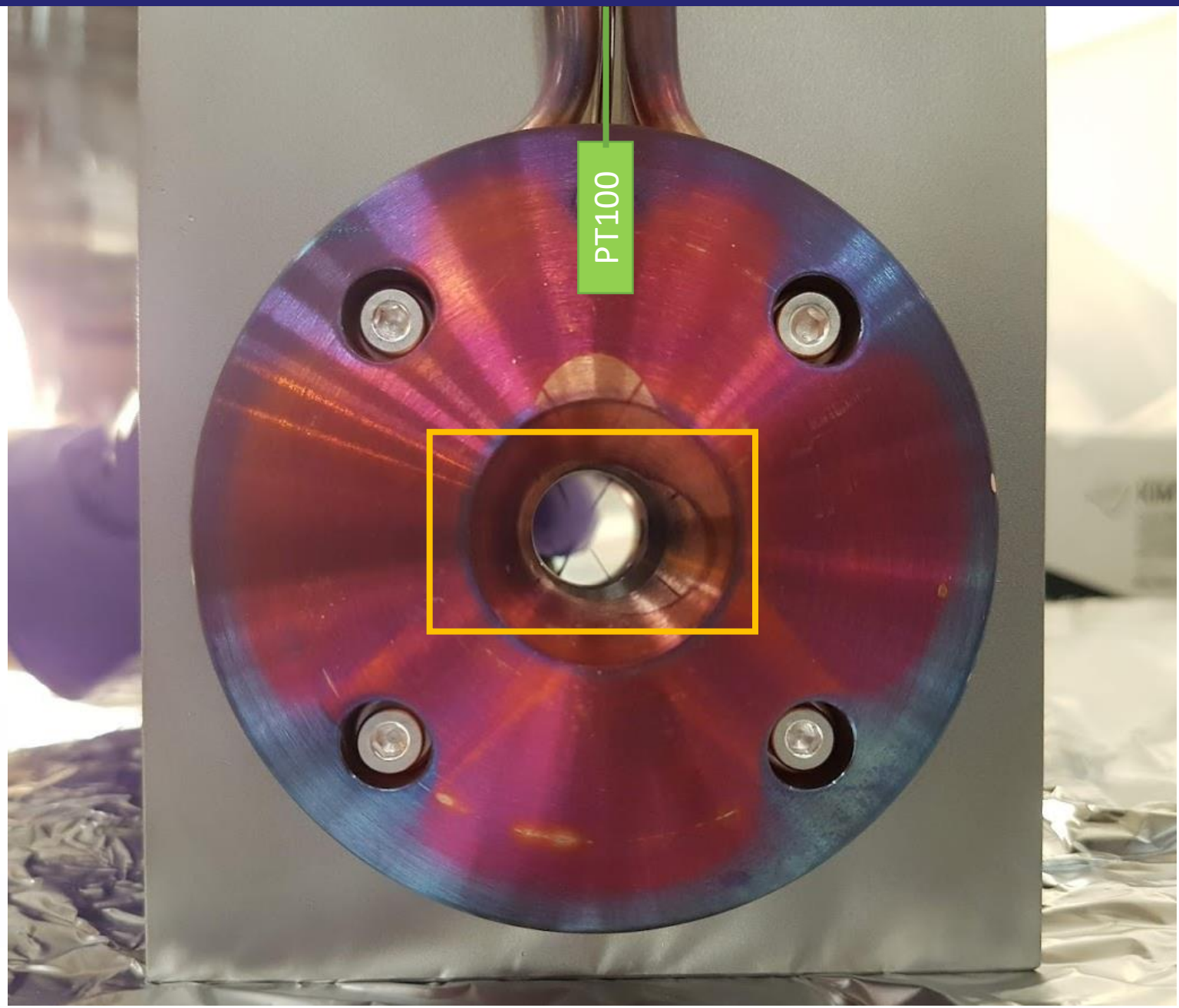
Severe missteer, on Diamond's most powerful in-vacuum ID, entire power deposited into aperture.

Beam hits "wrong" side of aperture, and PT100 barely sees temperature increase!



Upstream apertures

Upstream of the XBPM is a “mask” to protect downstream components from stray radiation. The approximate edge of the mask is shown (indicated by the **yellow** box).

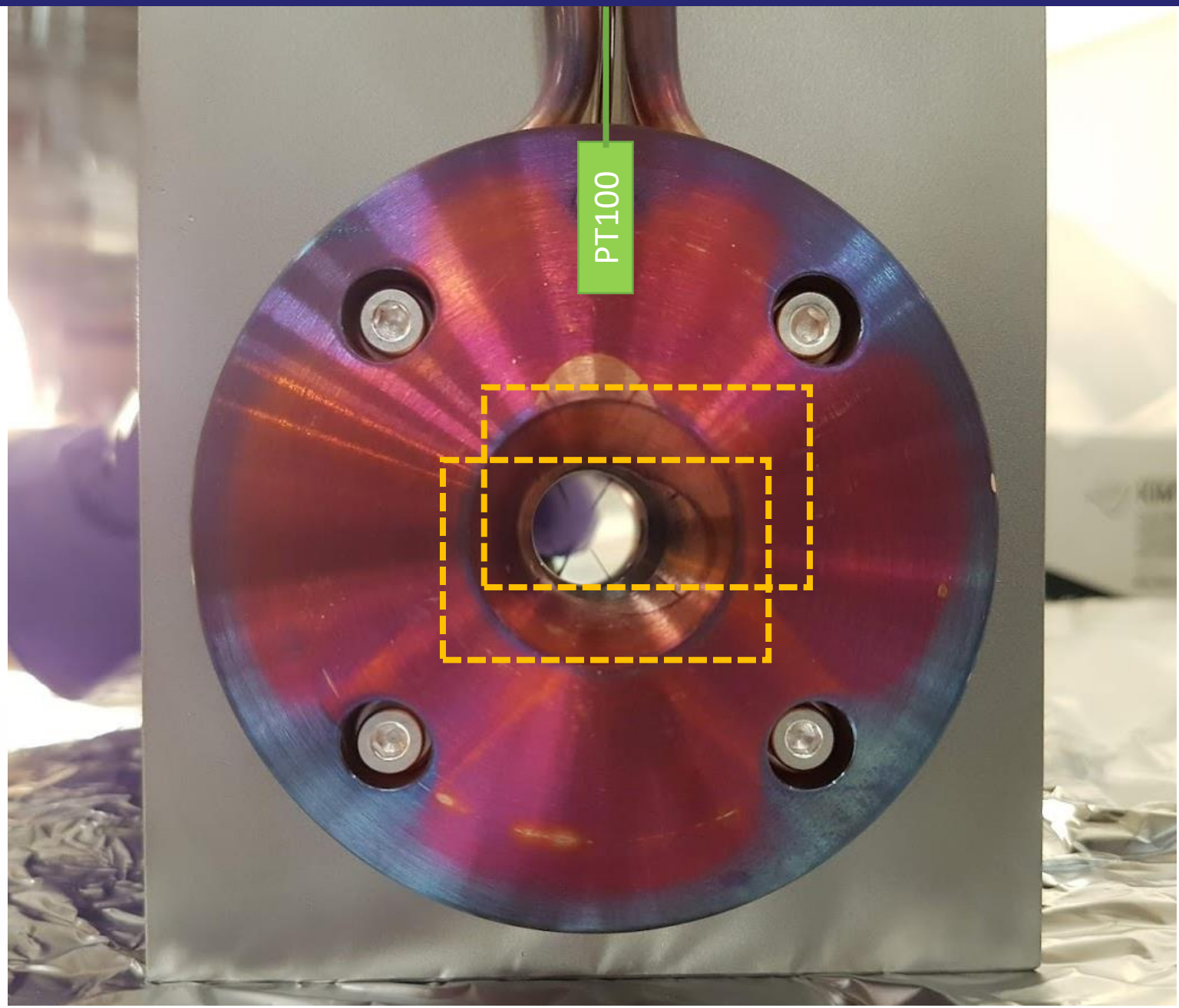


Upstream apertures

Upstream of the XBPM is a “mask” to protect downstream components from stray radiation. The approximate edge of the mask is shown (indicated by the **yellow** box).

Note: sometimes the “mask” is not very well aligned to the beam, and might be a few millimetres too high or too low!

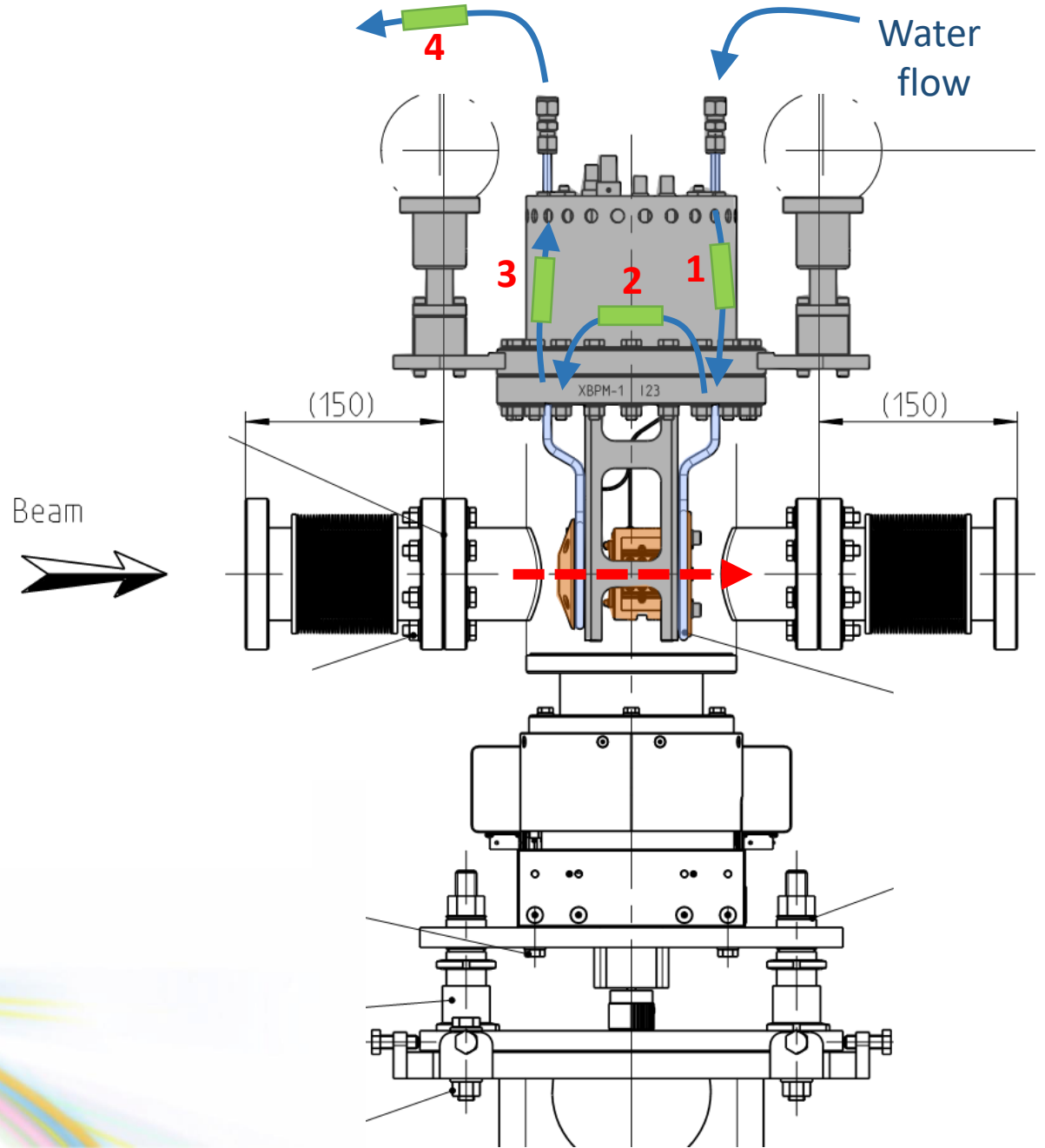
In fact, in some situations the mask almost completely stops any radiation reaching the aperture near the PT100!



Machine development tests

We wanted to try monitoring the water temperature, to see if this could be the basis of an interlock.

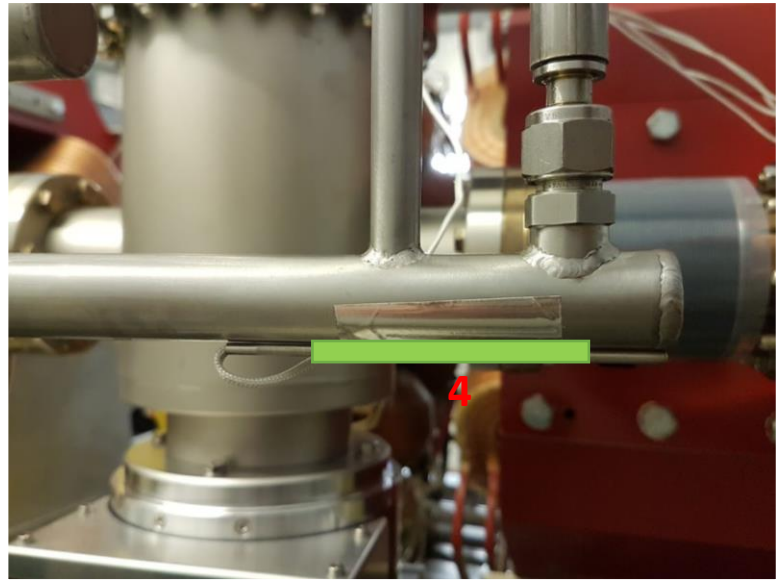
We applied temporary sensors to the cooling pipes, to see if there was anything measurable.



Machine development tests

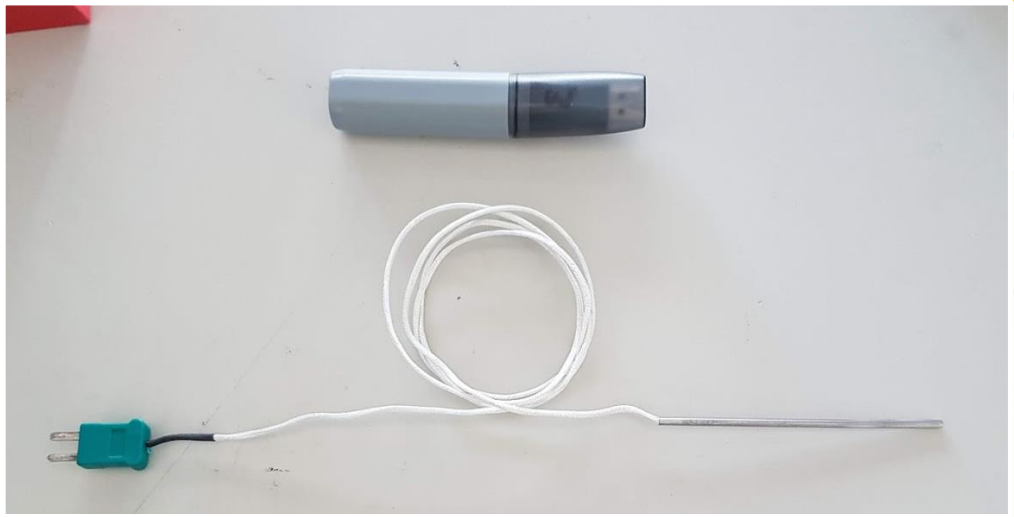
Additional sensors 1-3 placed monitoring water pipe temperatures, close as possible to XBPM.
Sensor 4 placed outside XBPM, downstream.

1: water inlet.
2: mid-point between blade holder and aperture.
3: water outlet.
4: 30cm downstream of outlet.

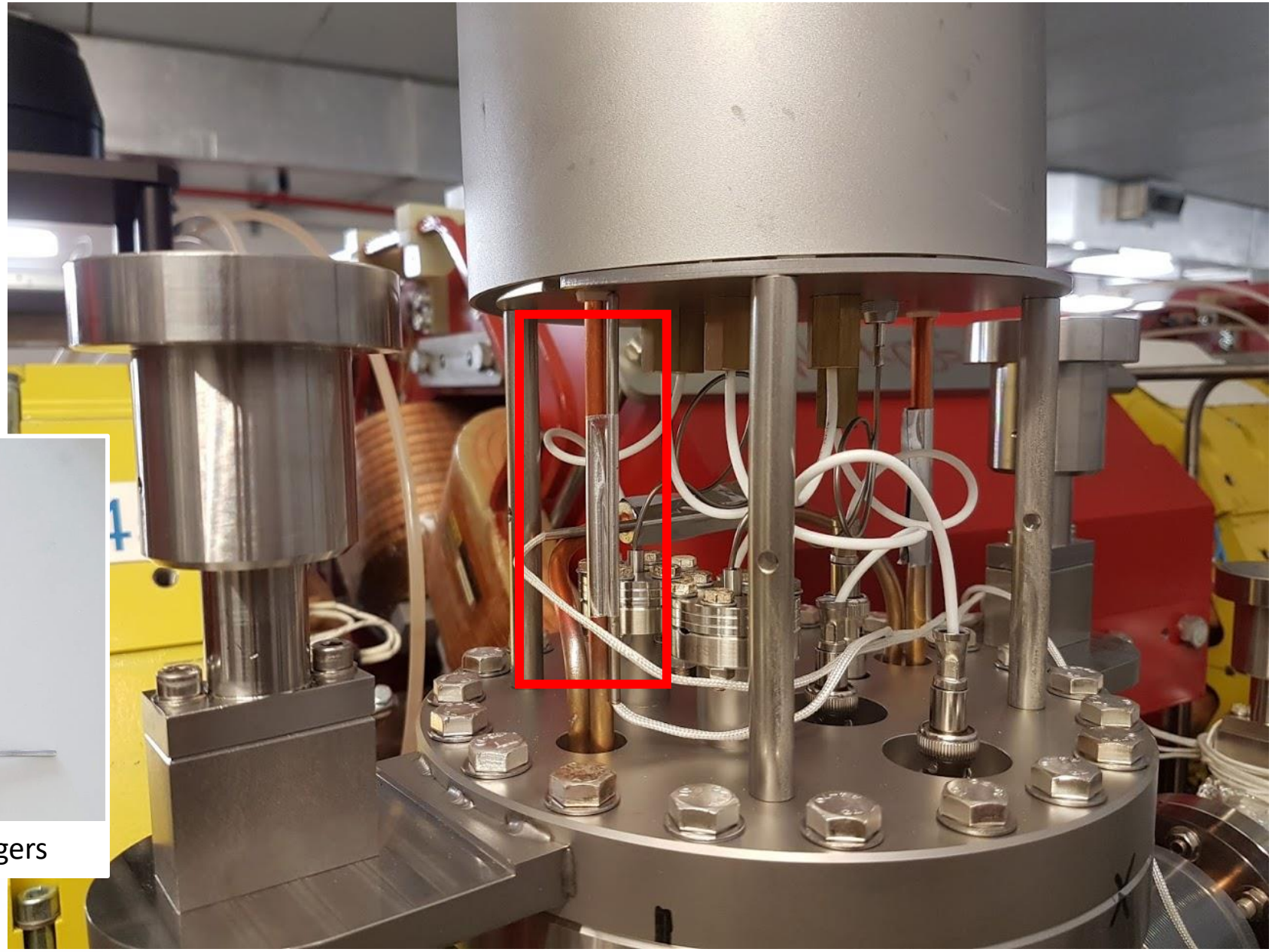


Machine development tests

Sensor probes fixed to pipe firmly using thermally conductive aluminium tape to try and ensure best temperature measurement.

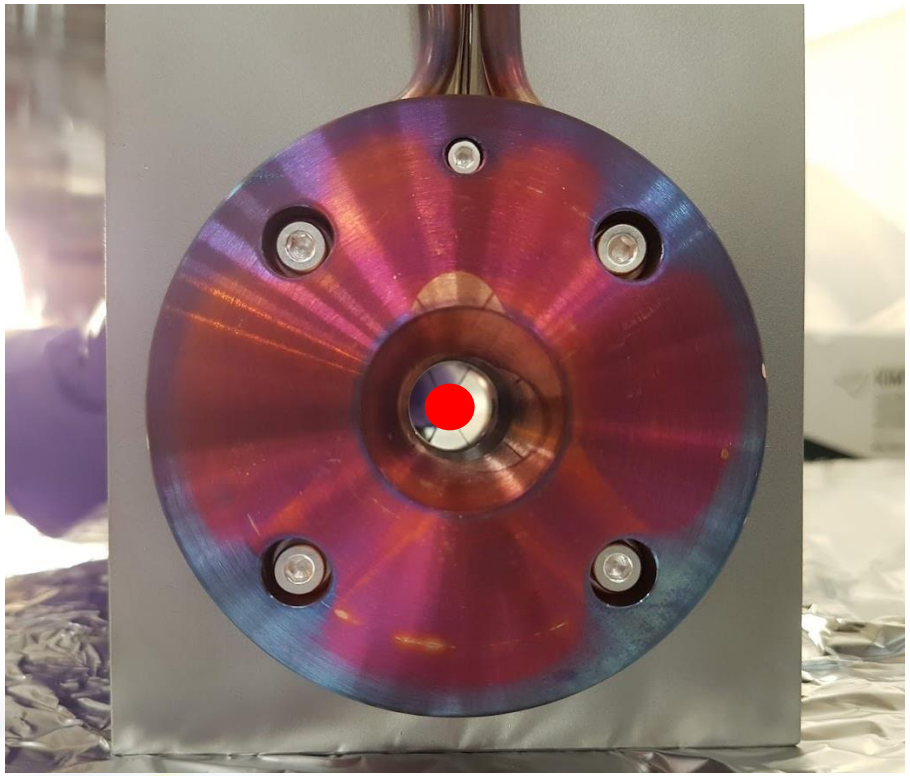


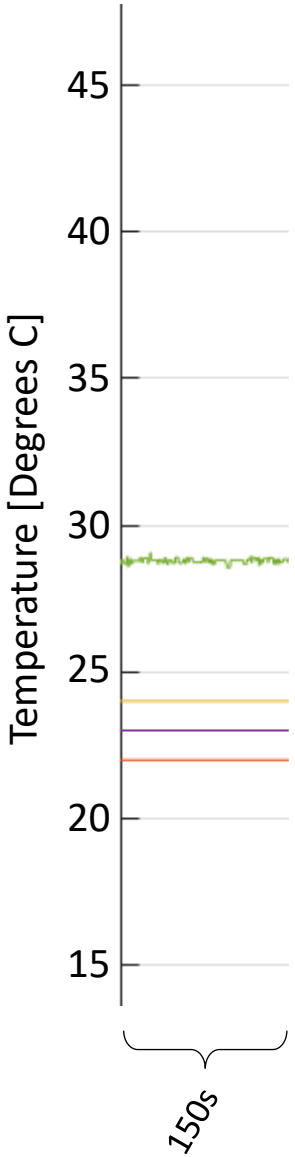
EL-USB-TC battery powered temperature loggers



Machine development tests

Beam centred on XBPM



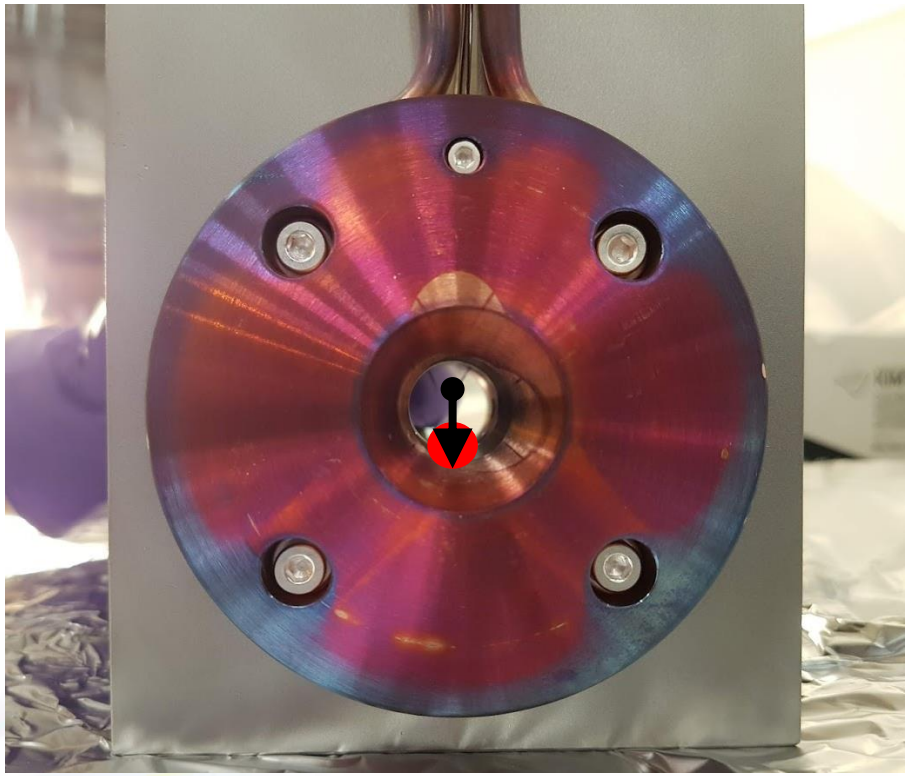


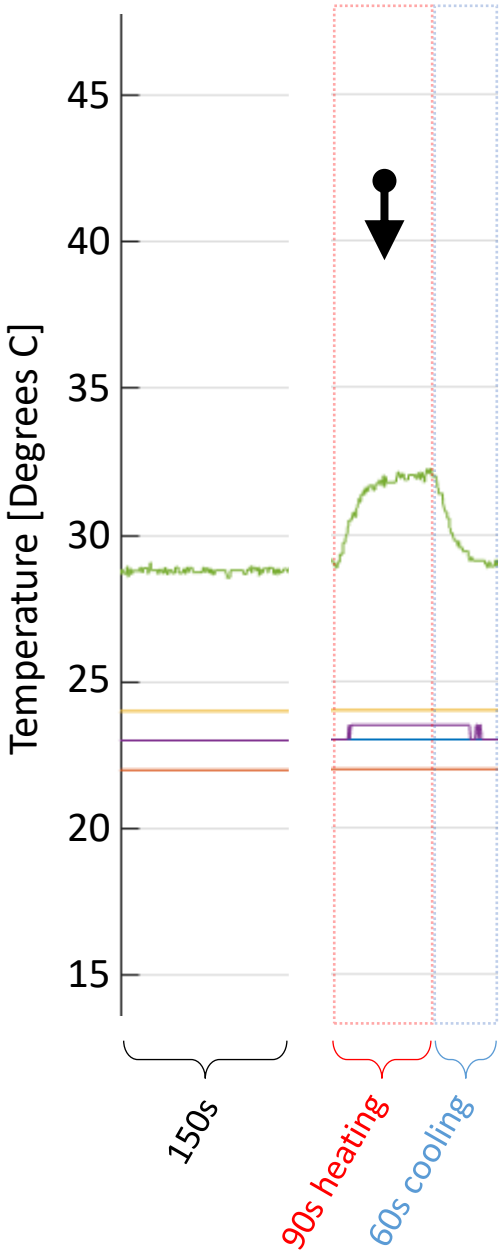
Aperture sits at ~28 degrees C

Water temperature is ~23 degrees C
(identical, within zero offset error of loggers)

Machine development tests

0.18mrad missteer
(approx. ±0.5mm at the EBPMs)





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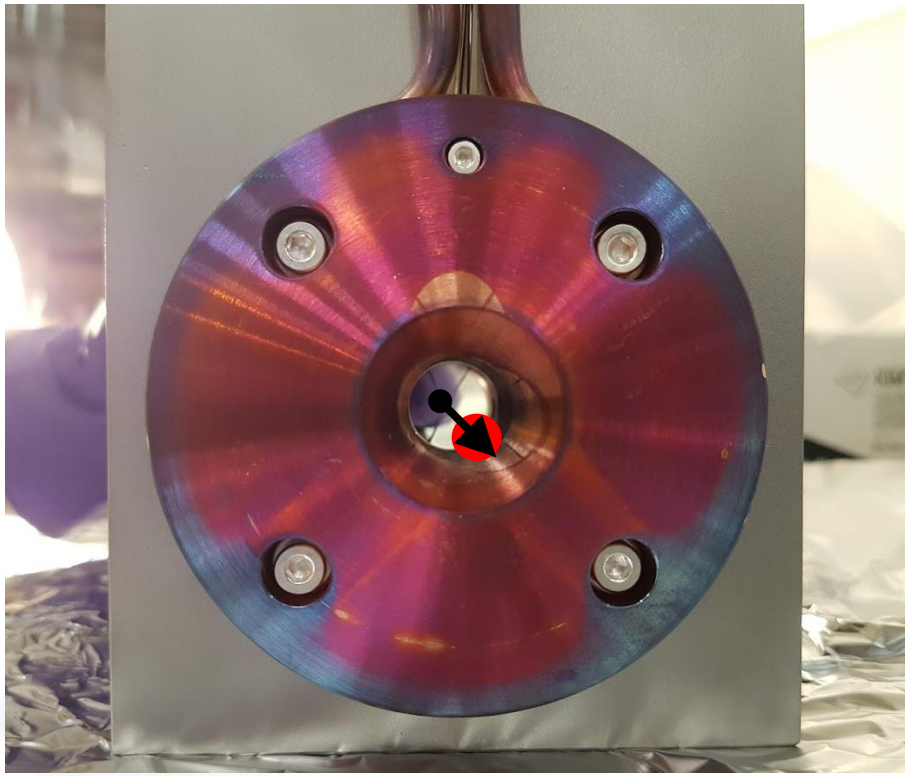

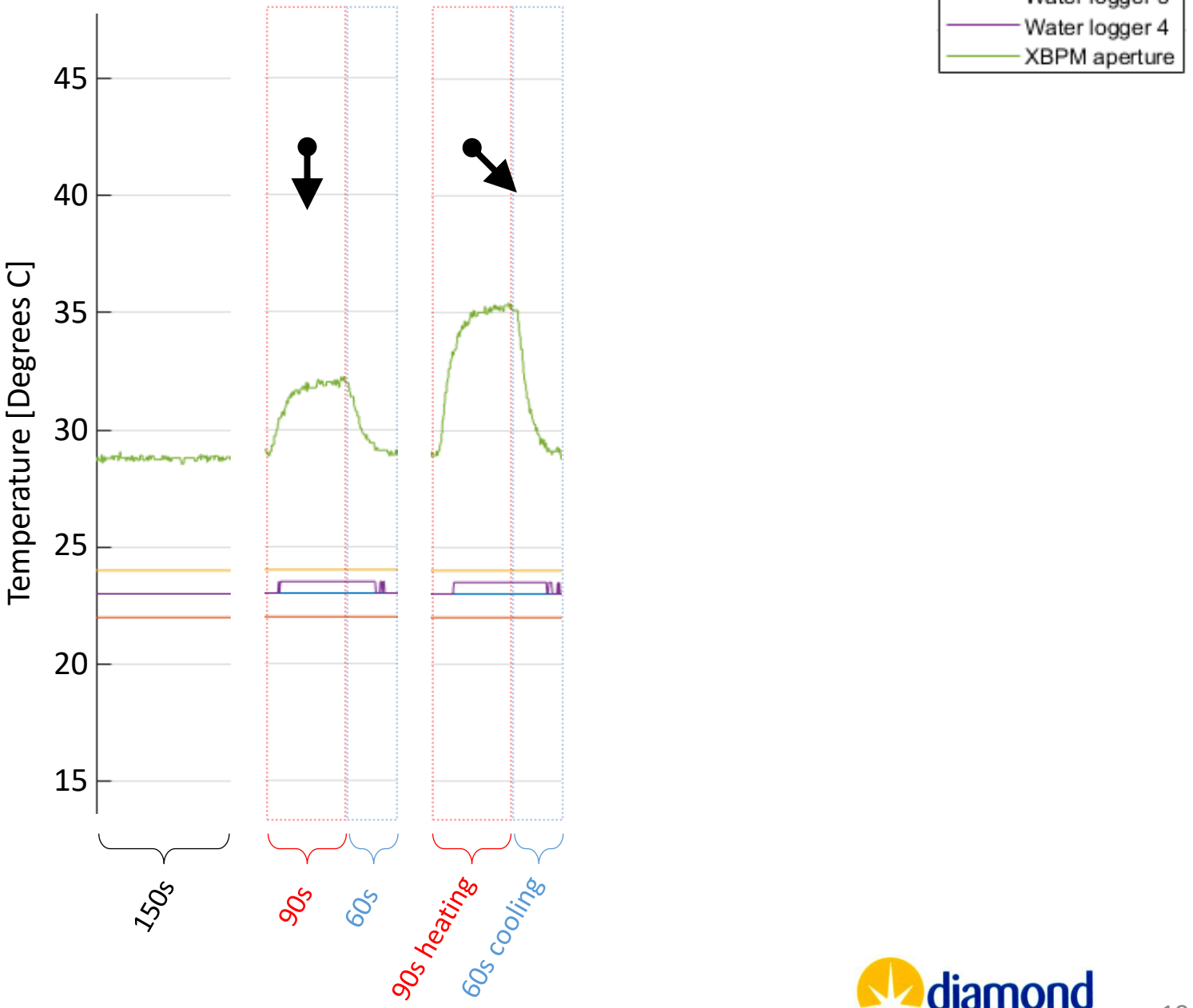

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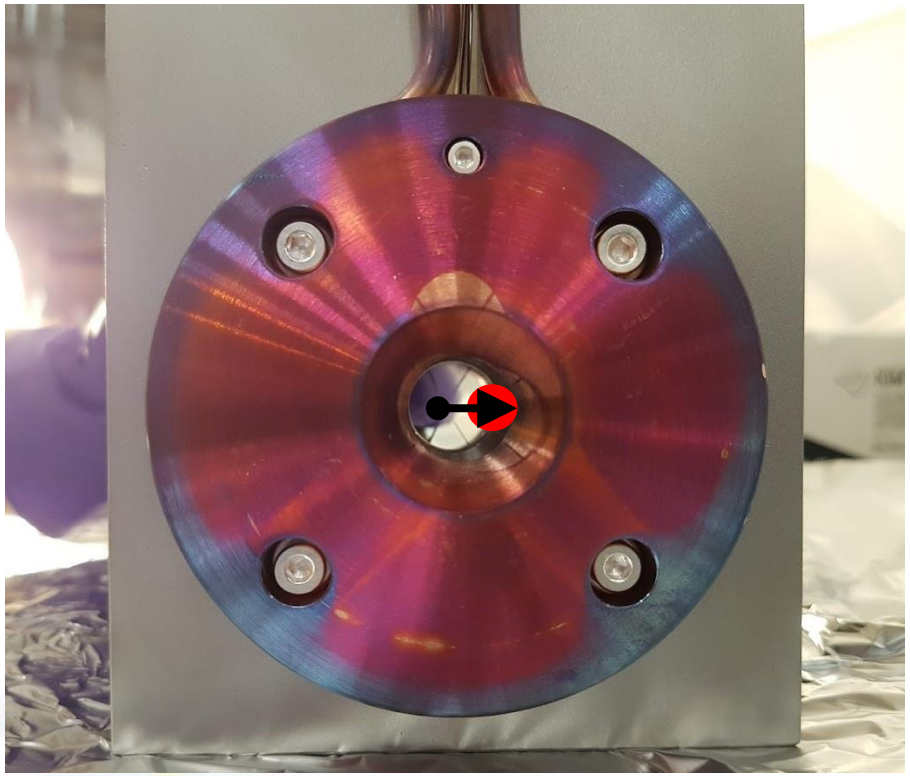

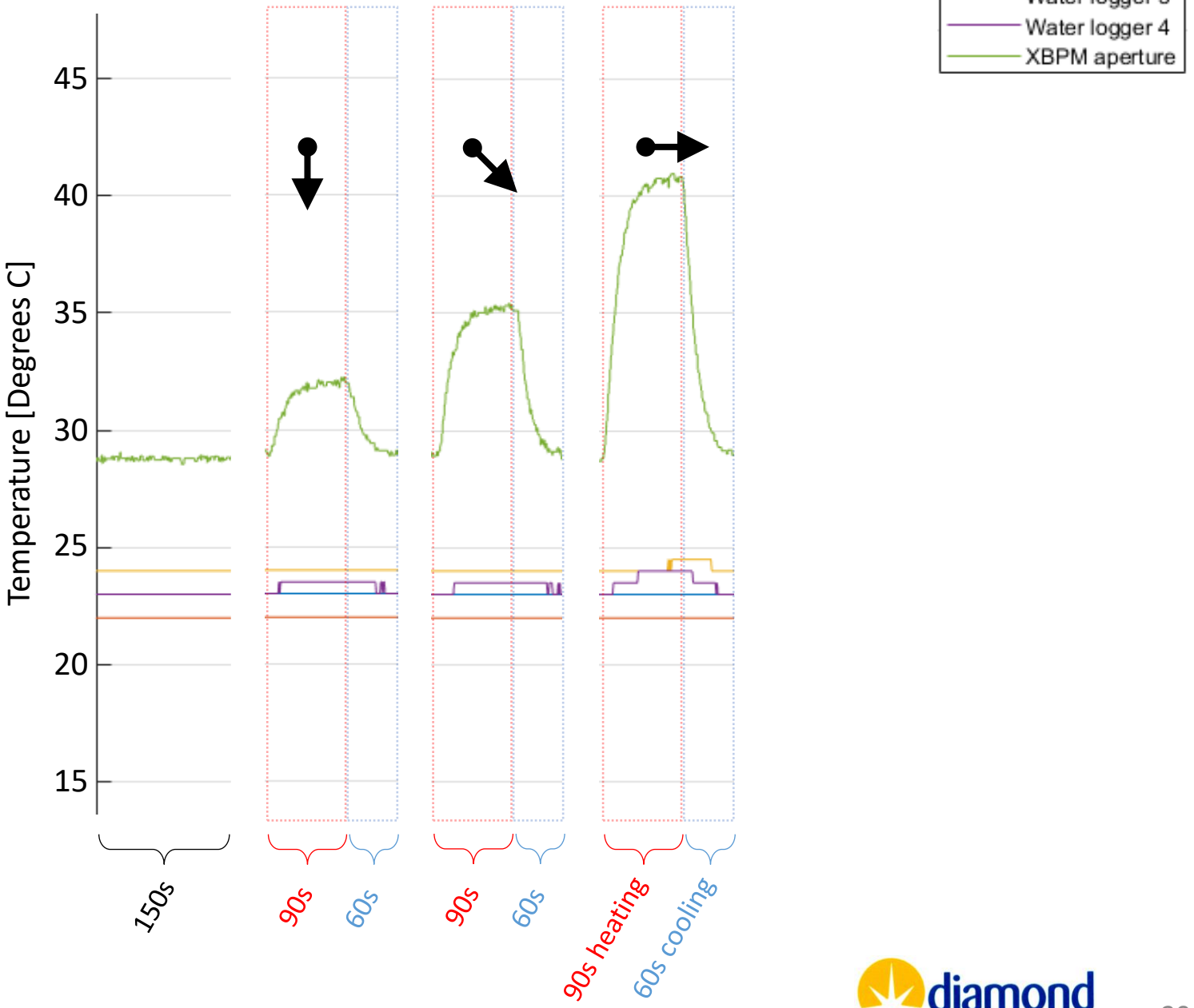

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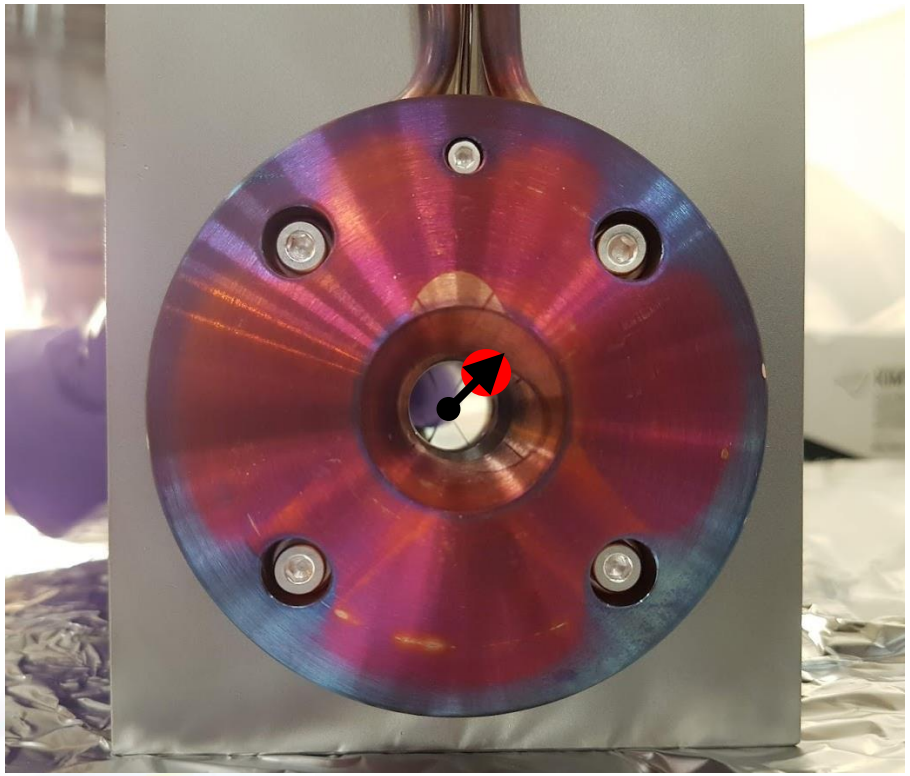

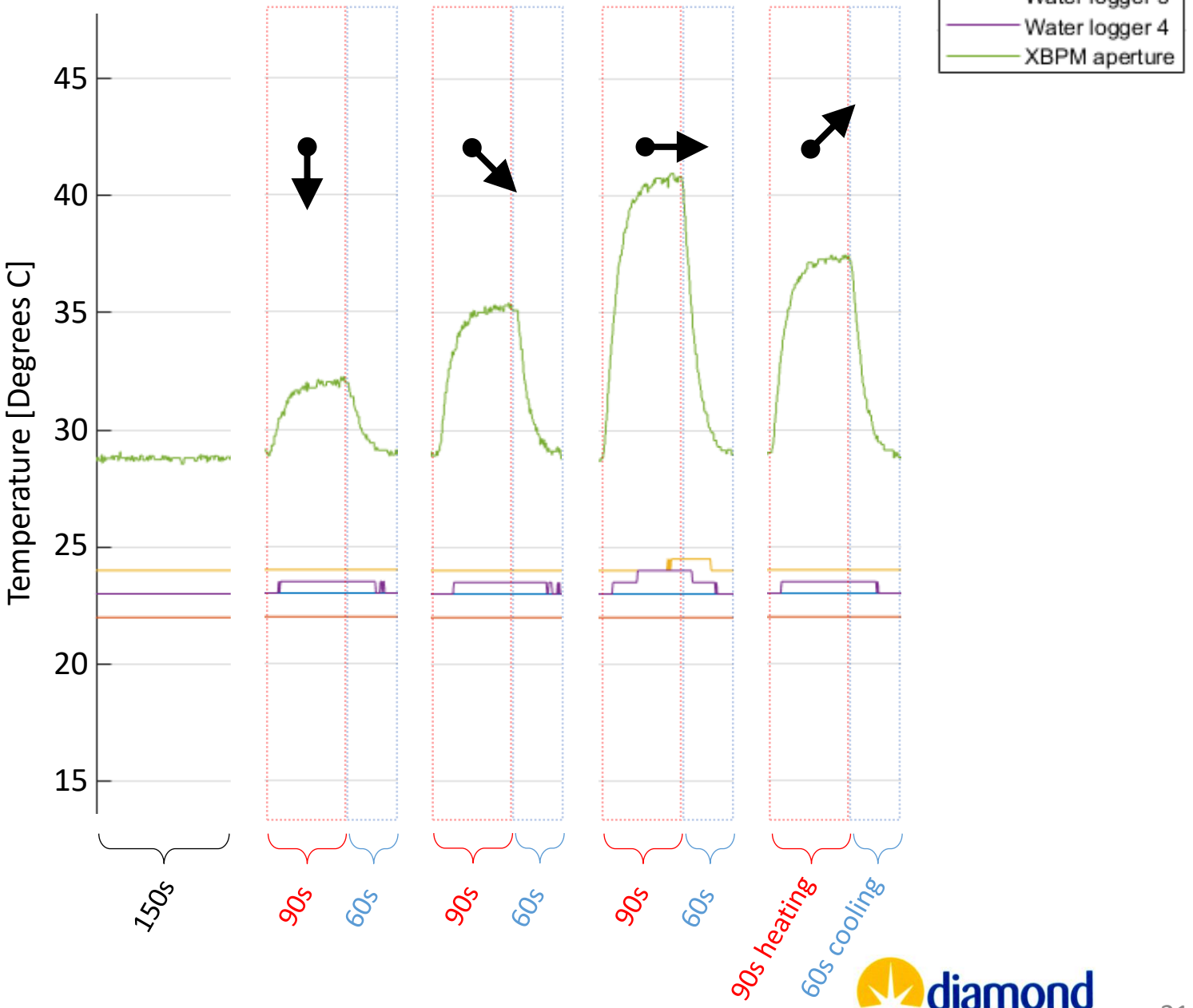

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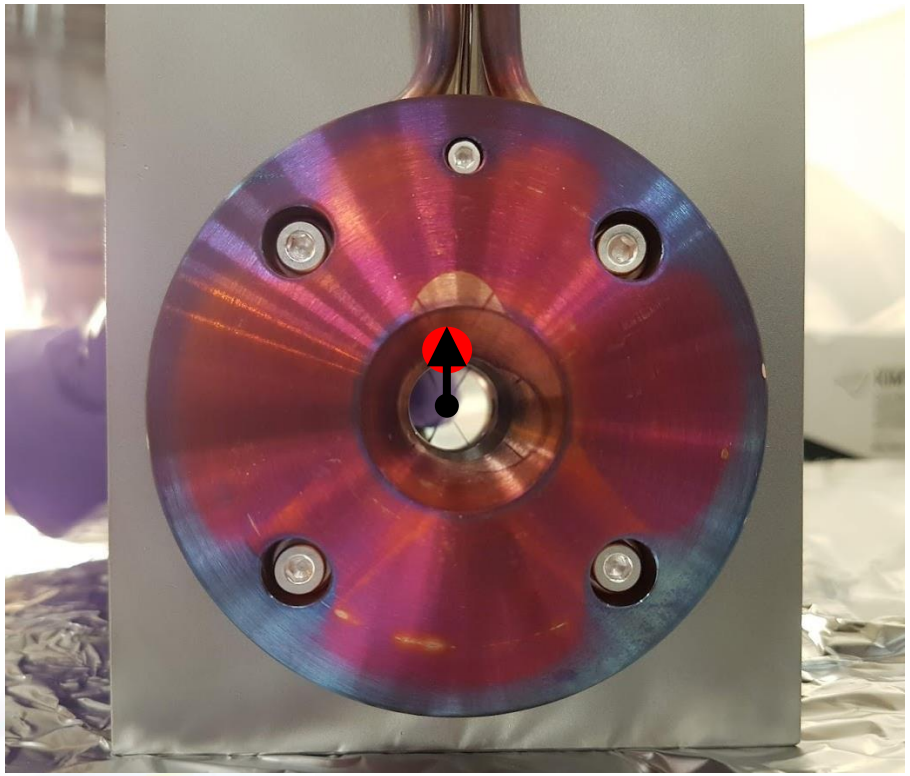

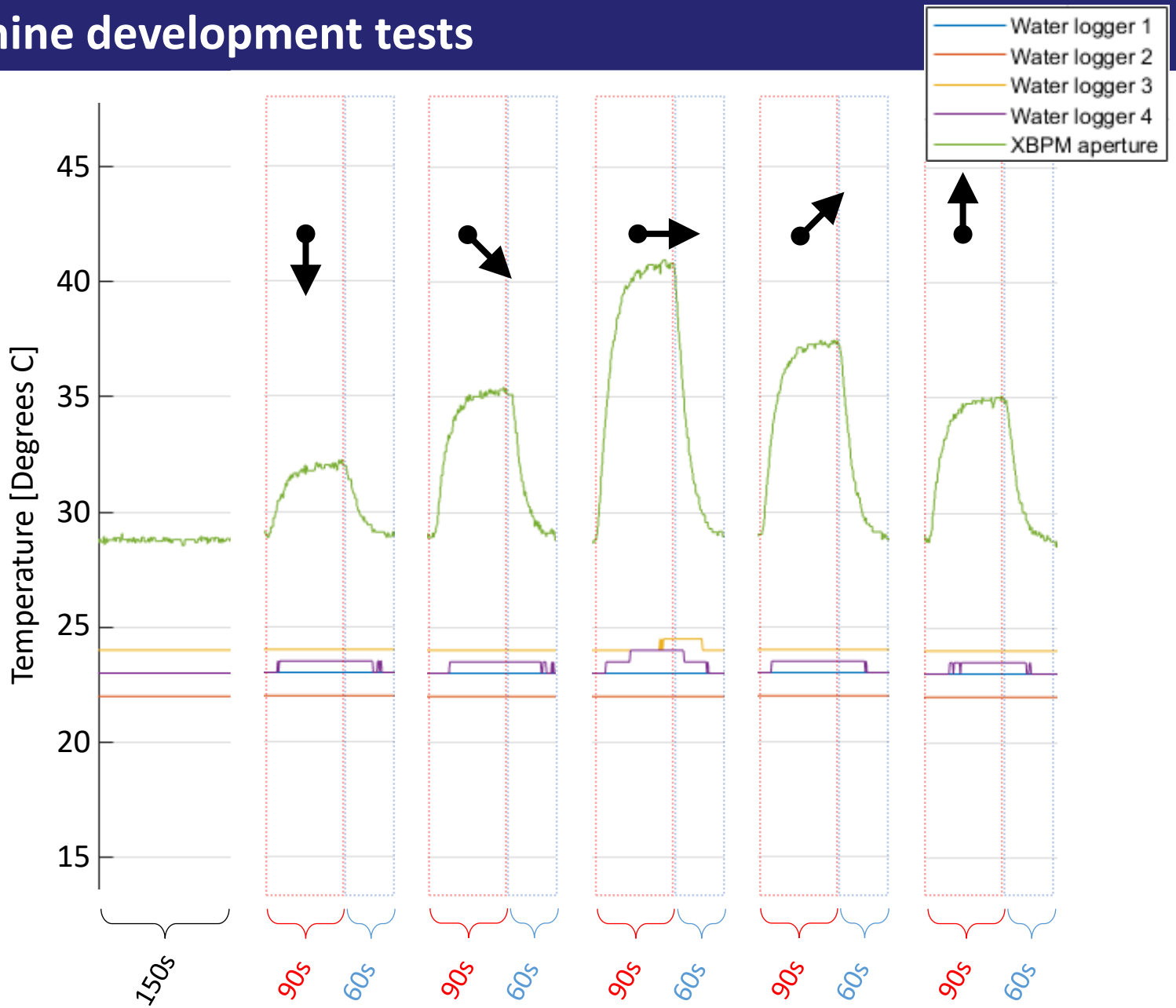

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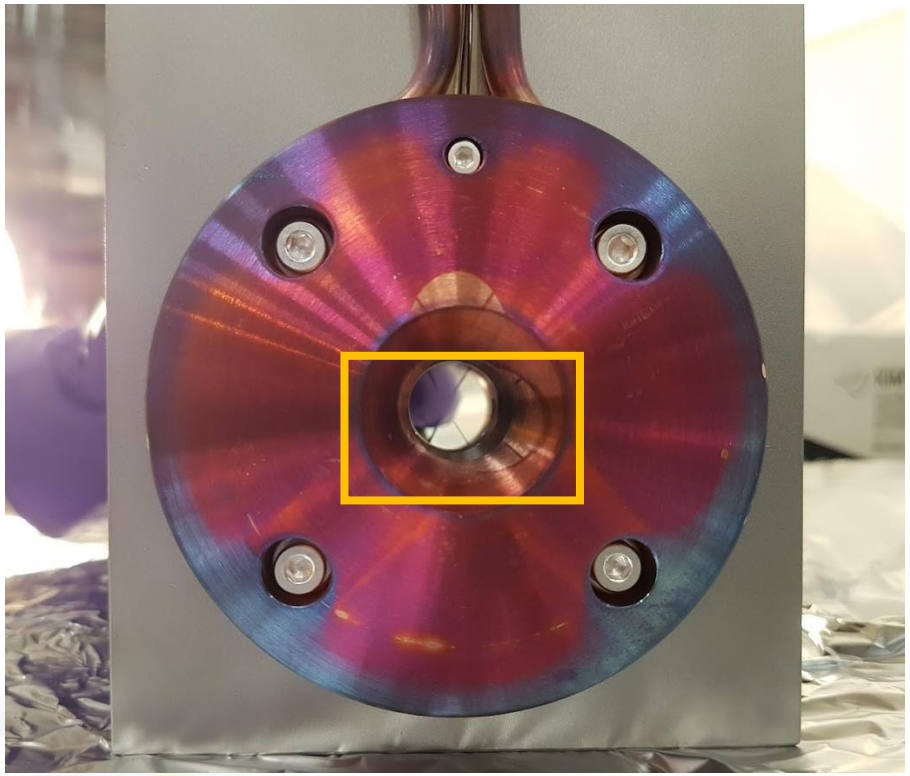

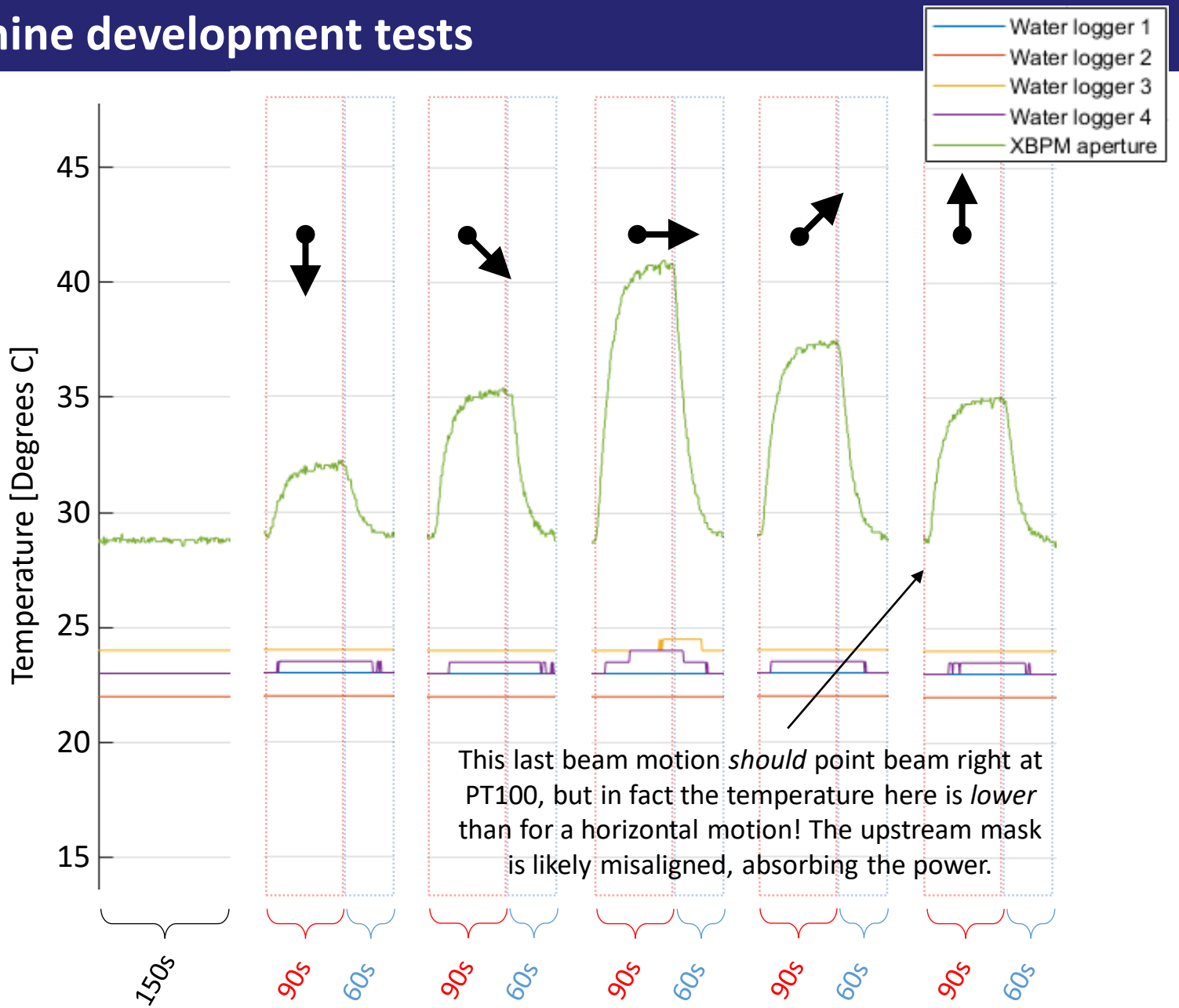

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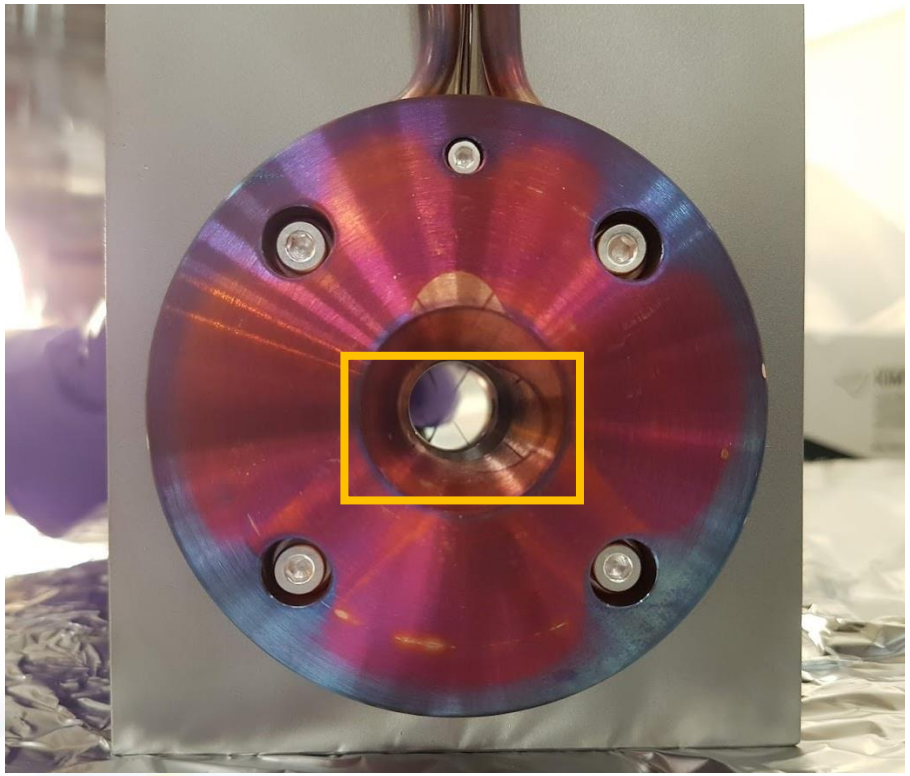

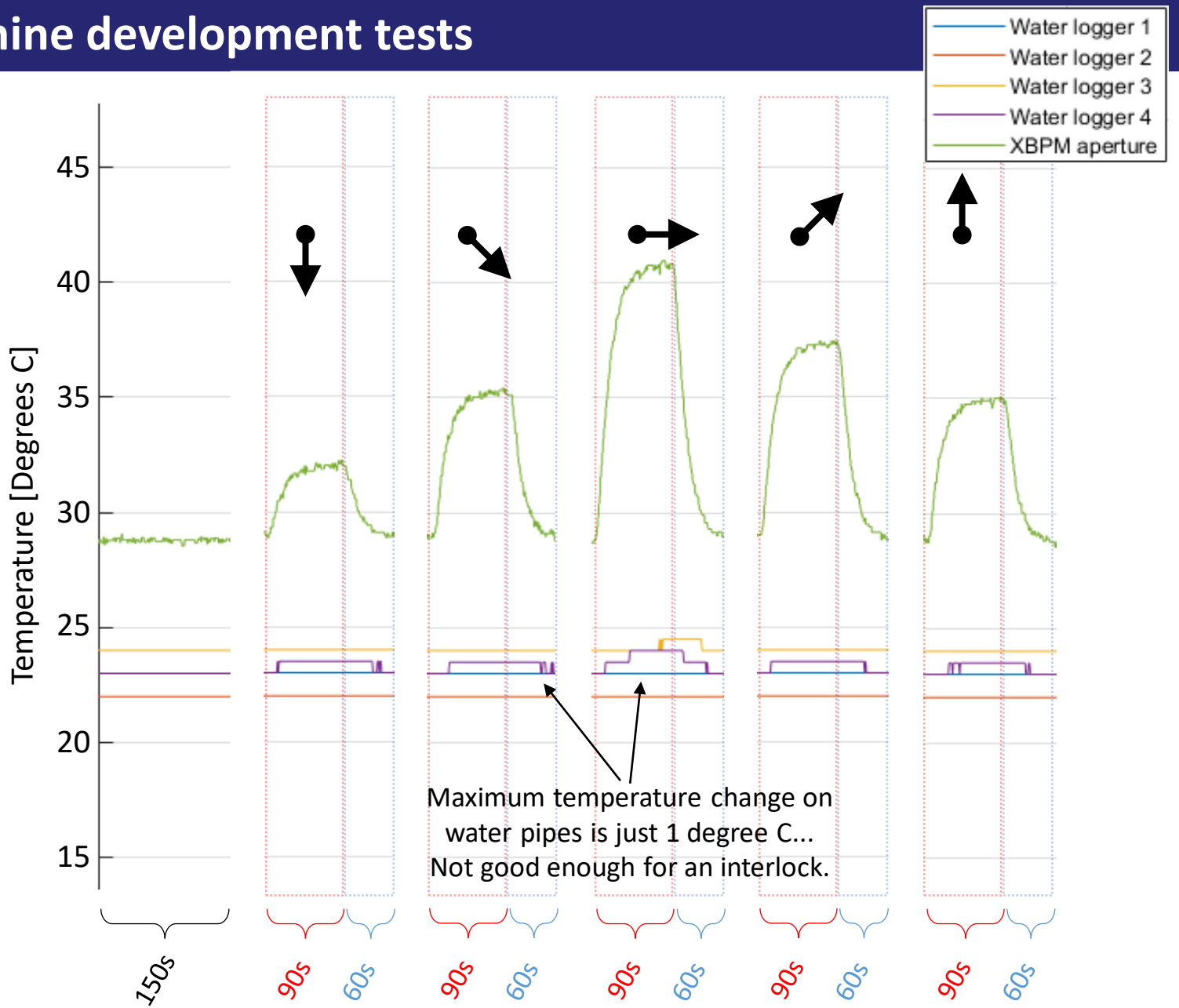

Conclusions and solutions….?

- Additional temperature sensors…?
  - Difficult, as we want to try and re-use our existing apertures.
  - Replacing apertures would be expensive!

- Monitor water pipe temperature…?
  - Not much cooling-pipe temperature change..

- Scattered radiation sensors…?
  - If beam is hitting aperture there will be backscattered photons.
  - Could a sensor detect this?
  - Could this be installed without expensive redesign of XBPM?

- Severe limits on (mis) alignment…?
  - Align XBPMs once, then unplug the motors?
  - Or set limit switches to ±0.5mm? A little tricky, but possible.

- “Blade current” interlocks…?
  - If blade current >1mA, dump beam.
  - Doesn’t protect the *aperture*, but we can protect the blades.

- Rely on water flow meters…?
  - Temperature only rises if water fails.
  - Anyone have any experience of testing XBPM temperatures without cooling?

- Dump beam? Or force open ID…?
  - We have no mechanism to force open ID at Diamond.

Acknowledgements

Thanks to colleagues for useful discussions
and posing excellent questions!

Marie Labat, SOLEIL

Karsten Holldack, BESSY

Juraj Krempasky and David Just, SLS

Jordi Ruzafa, ALBA

Thank you for listening.

Any questions?

..suggestions welcome!