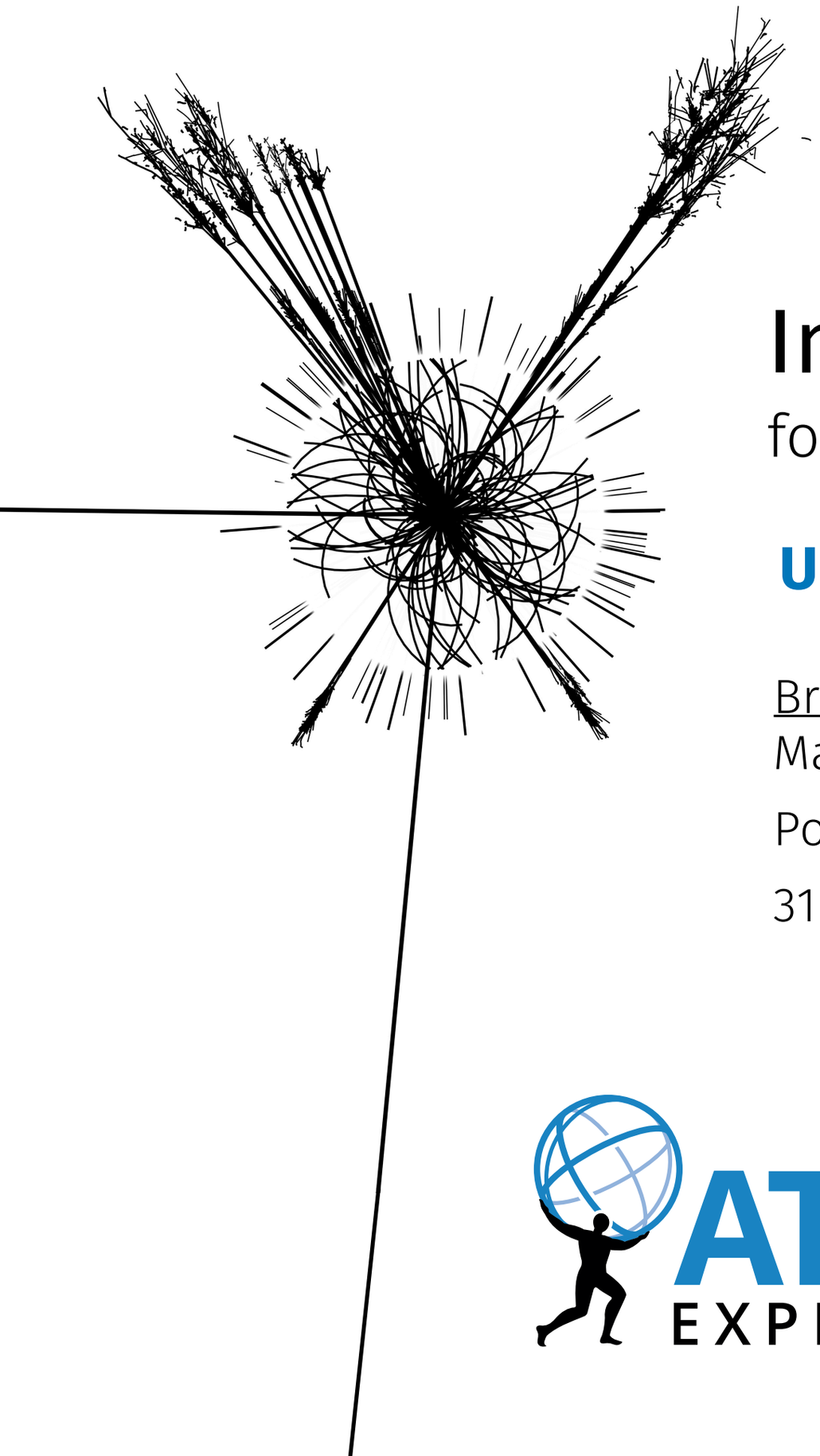


Inner Rim Measurements

for the ITK endcap

Updates

Brian Moser, Martijn van Overbeek, Johan van den Berg, Marcel Vreeswijk

Post-{Nikhef ITK Weekly}

31/05/2019

ATLAS EXPERIMENT

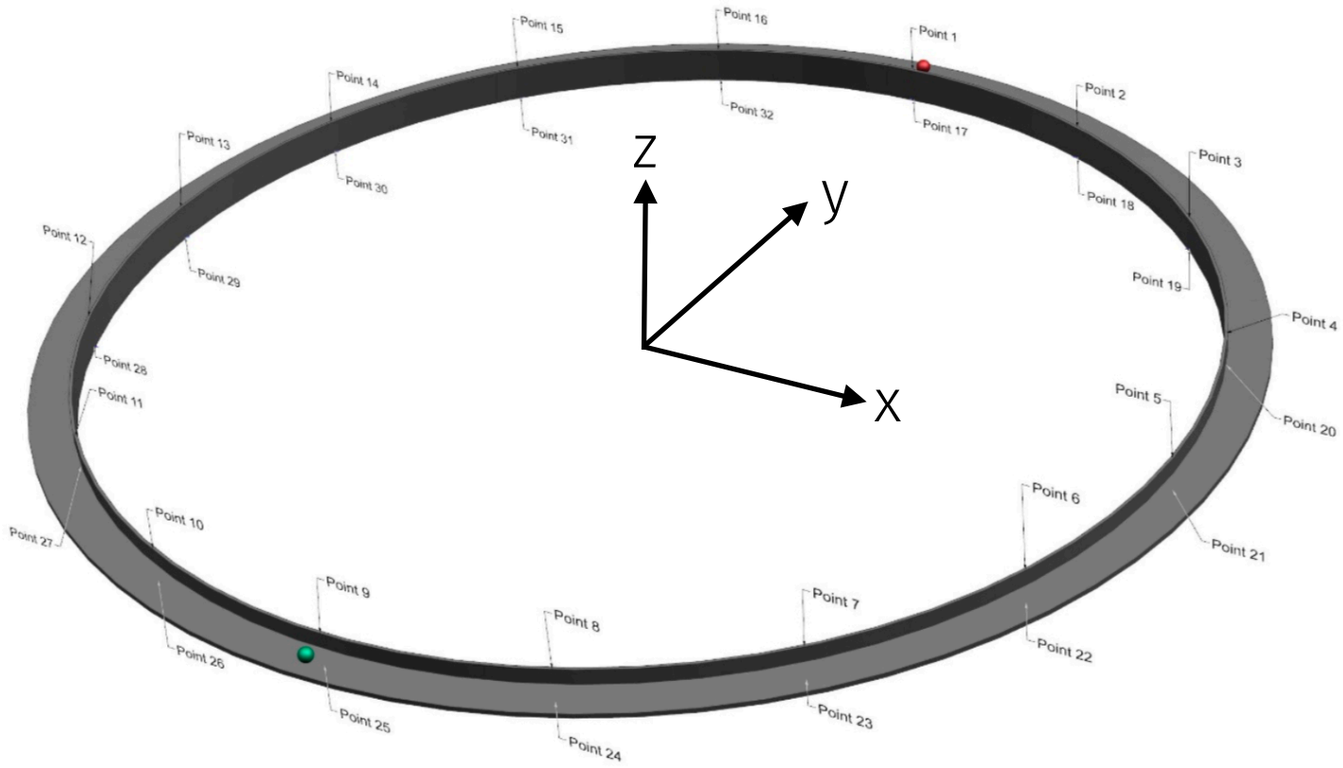
Nikhef

Open points from last time

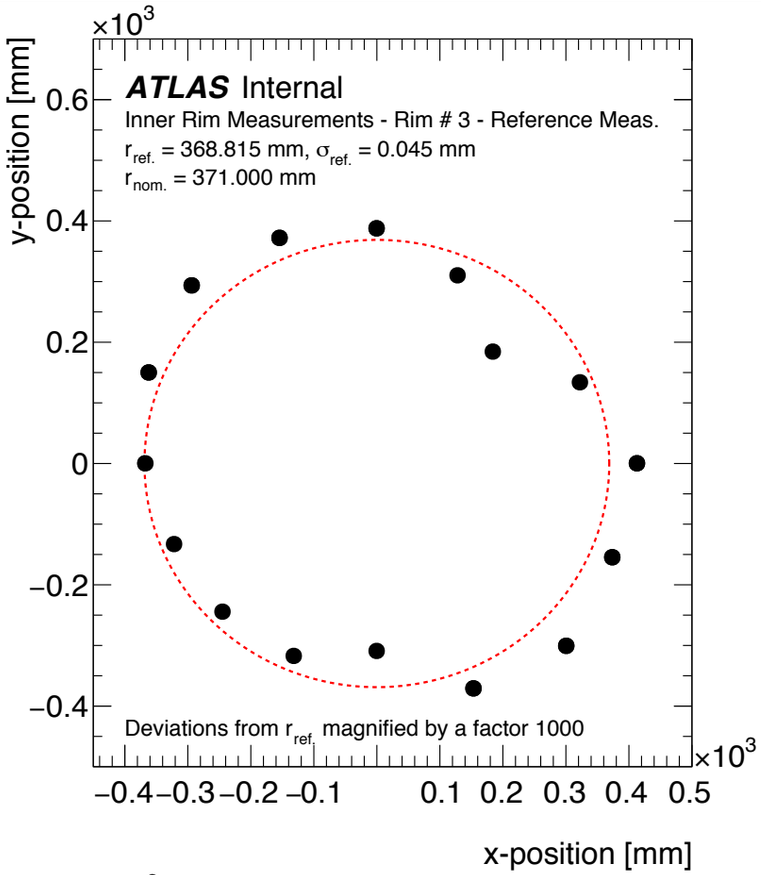
- Follow-up on presentation shown on 27.05.2019 [here]

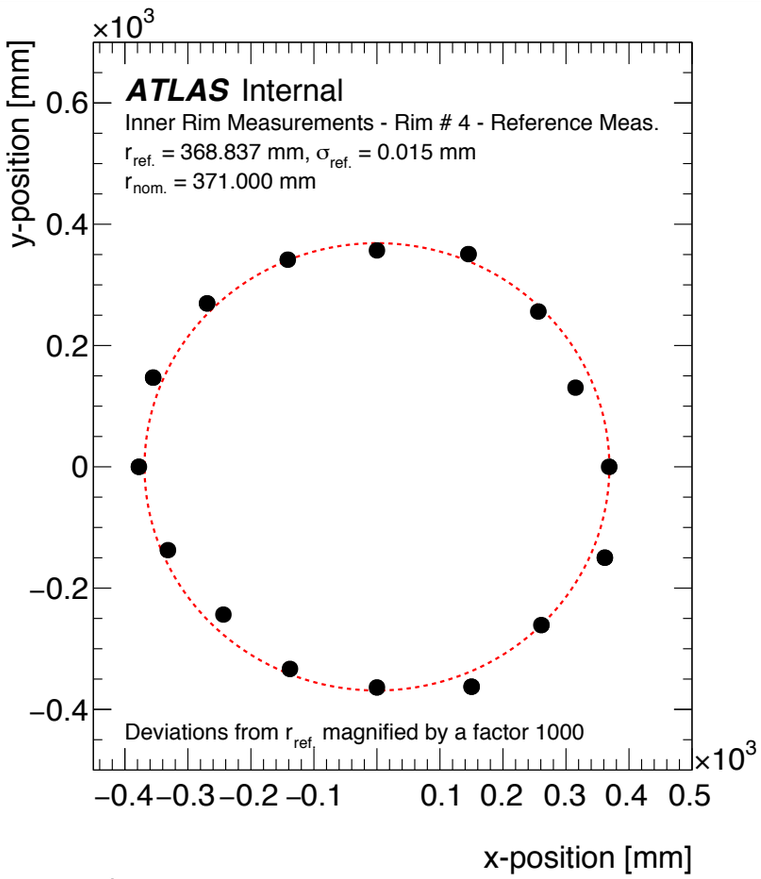
The shape of the rings:

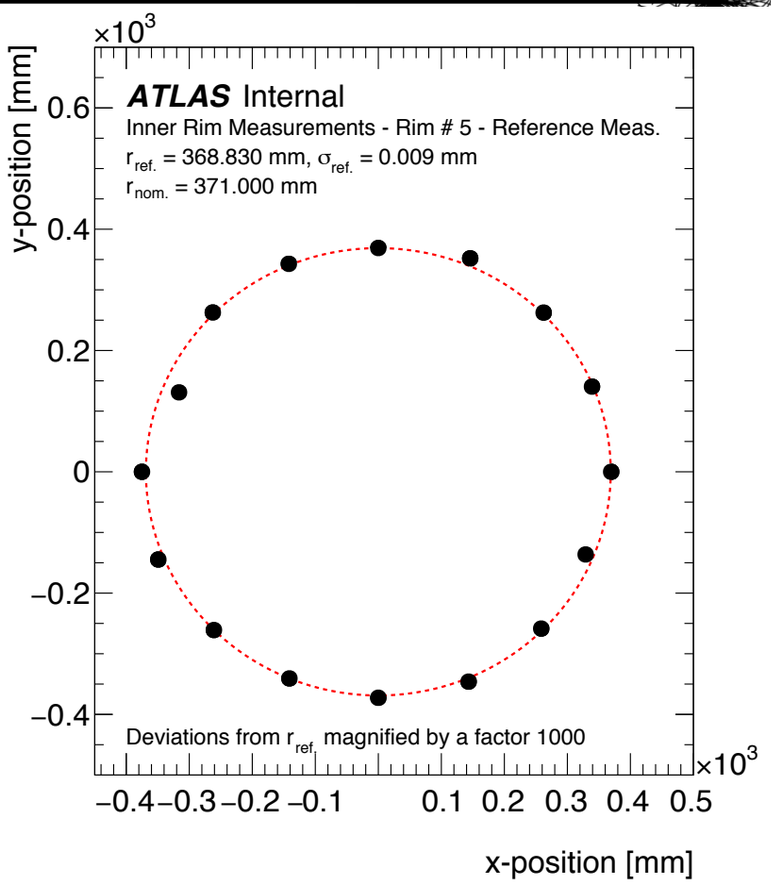
- Extracted the x-y coordinates of the 16 measurement points along the inner part of the ring
- Fitted the measurement points with a circle
- Compared the fit radius with the nominal radius and calculated the sample variance (σ) from the fitted radius
- The deviations from the fitted radius are magnified in the following slides by 1000

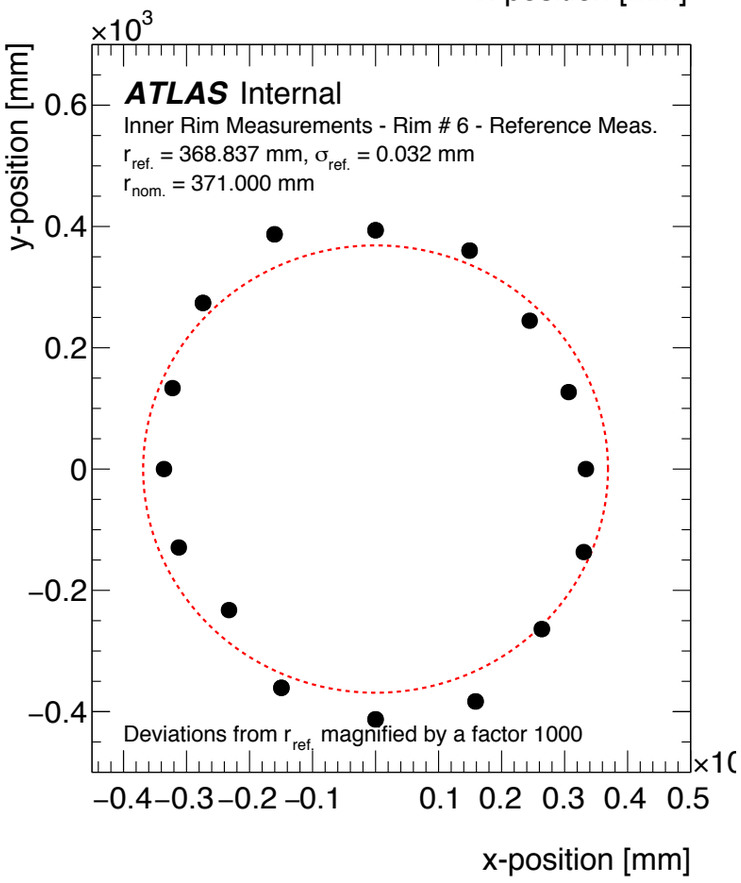


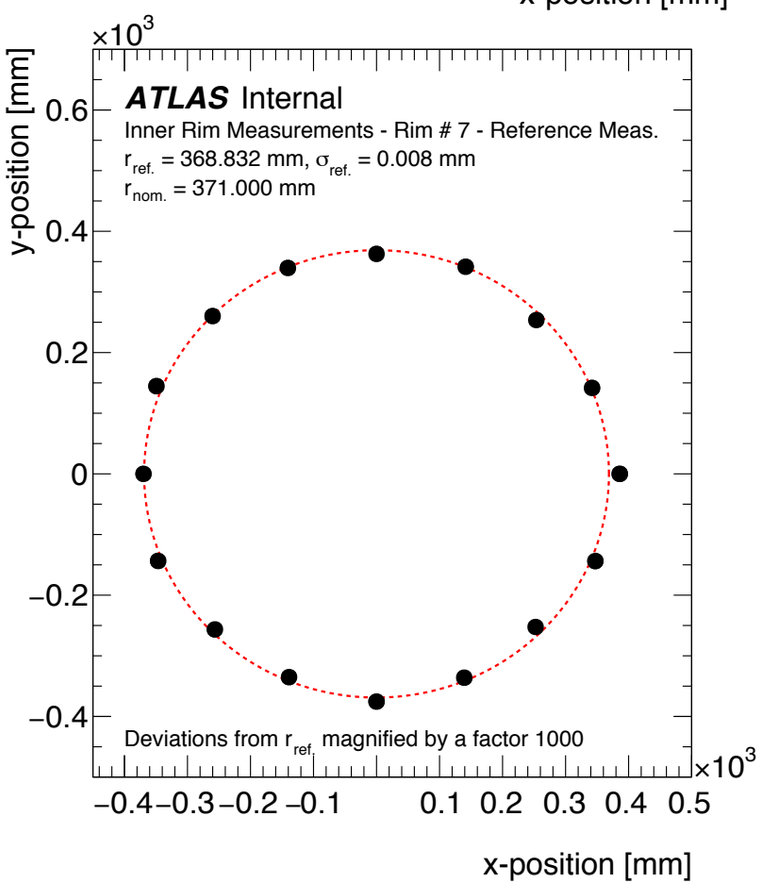
Radial measurements - Reference (before cool.)





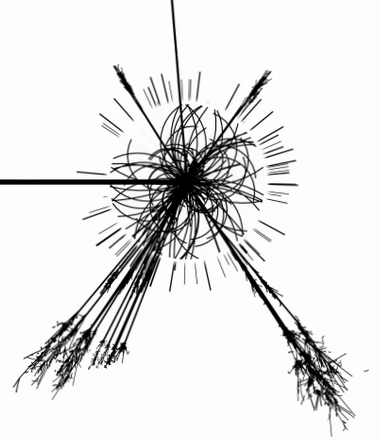






- Rings systematically smaller than what's stated
- Low spread in fitted r_{ref} between the rings (good)
- **Ring 7** looks the best (~ 8μm spread from being a perfect ring)

Radial measurements - Reference (before cool.)



- Design inner radius: 371.000 mm
- ~ 2.1 mm smaller fitted radius (more or less consistent for all rings)

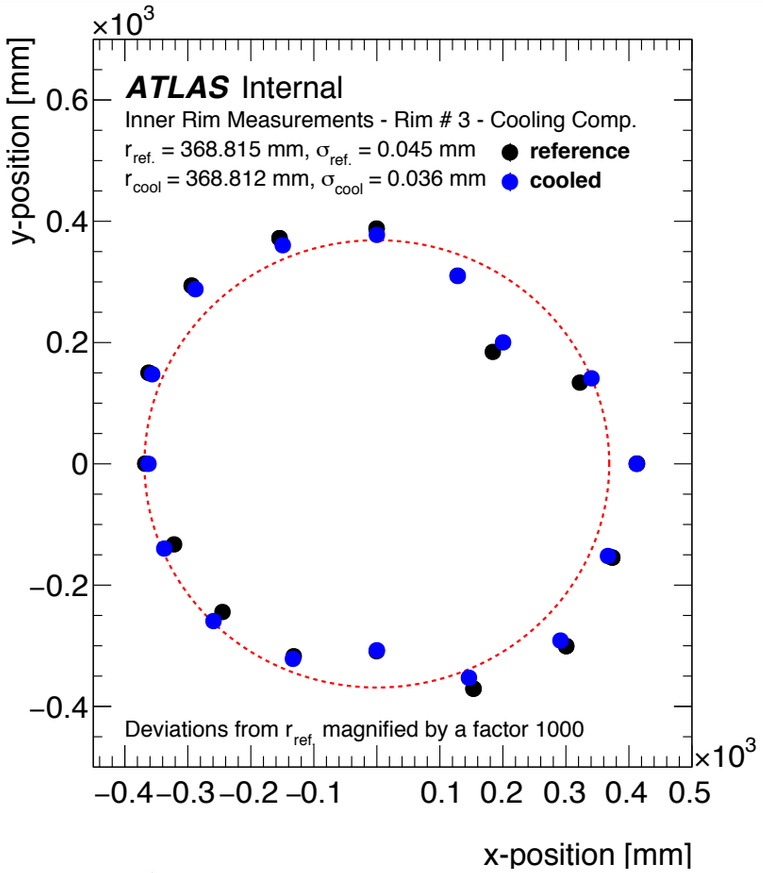
Ring	Fitted Radius [mm]
3	368.815
4	368.837
5	368.830
6	368.837
7	368.832

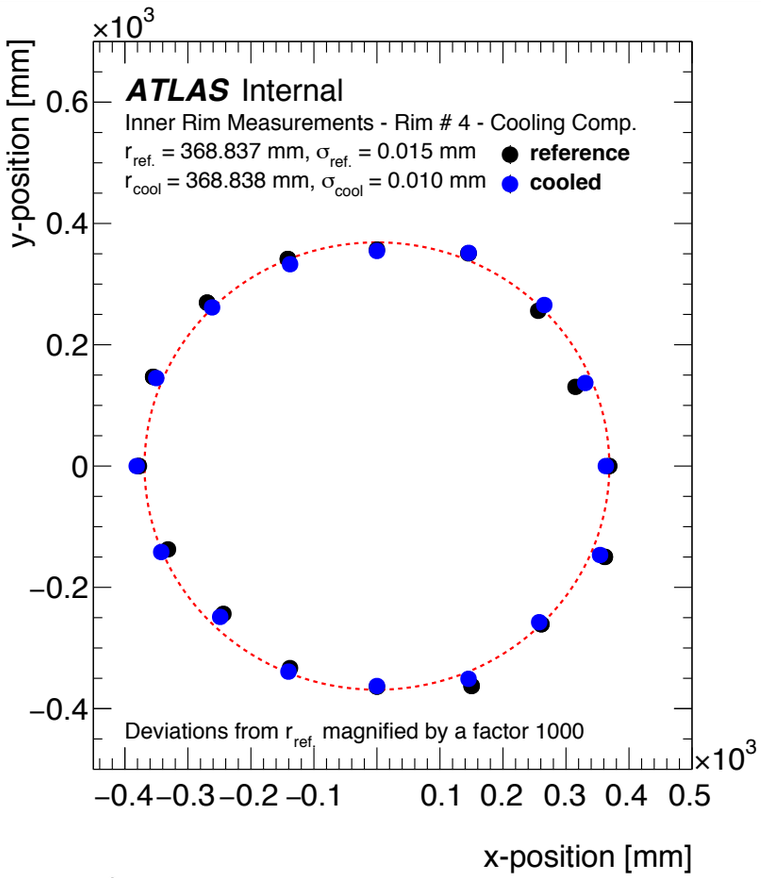
(nominal machine precision on single measurements: ~4µm)

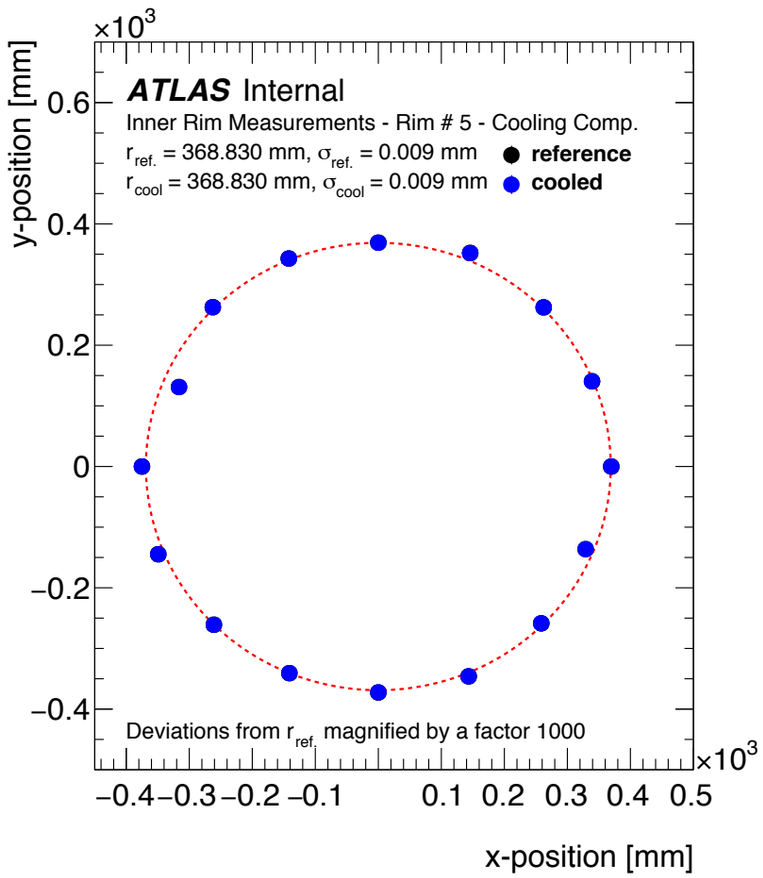
Explanation:

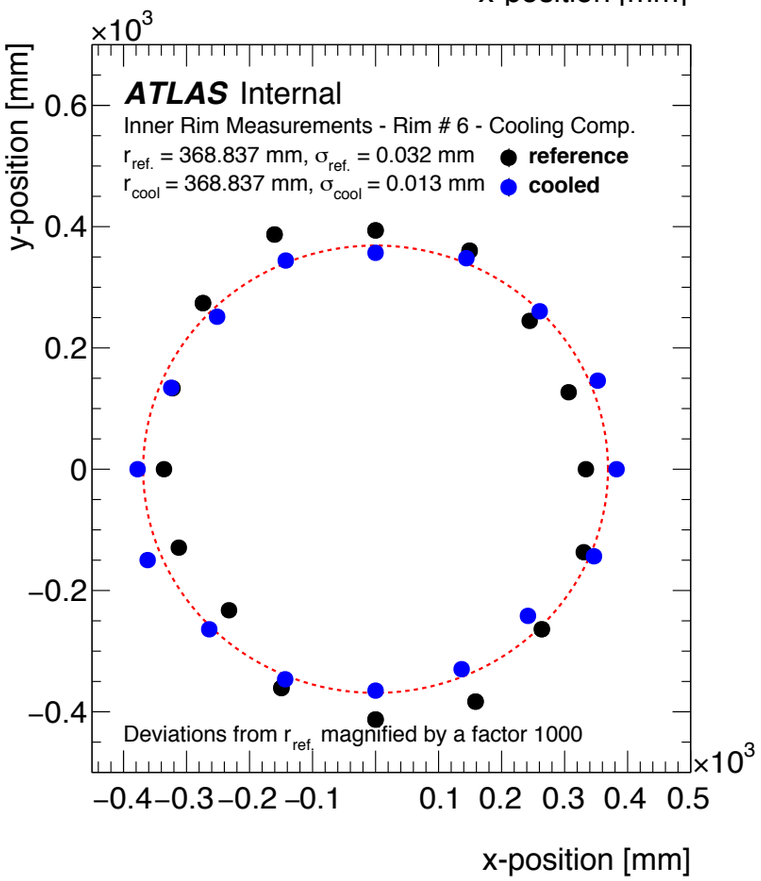
- The probe used to measure the ring has a diameter of 4.32 mm
- Probably the measured points are the center of the probe

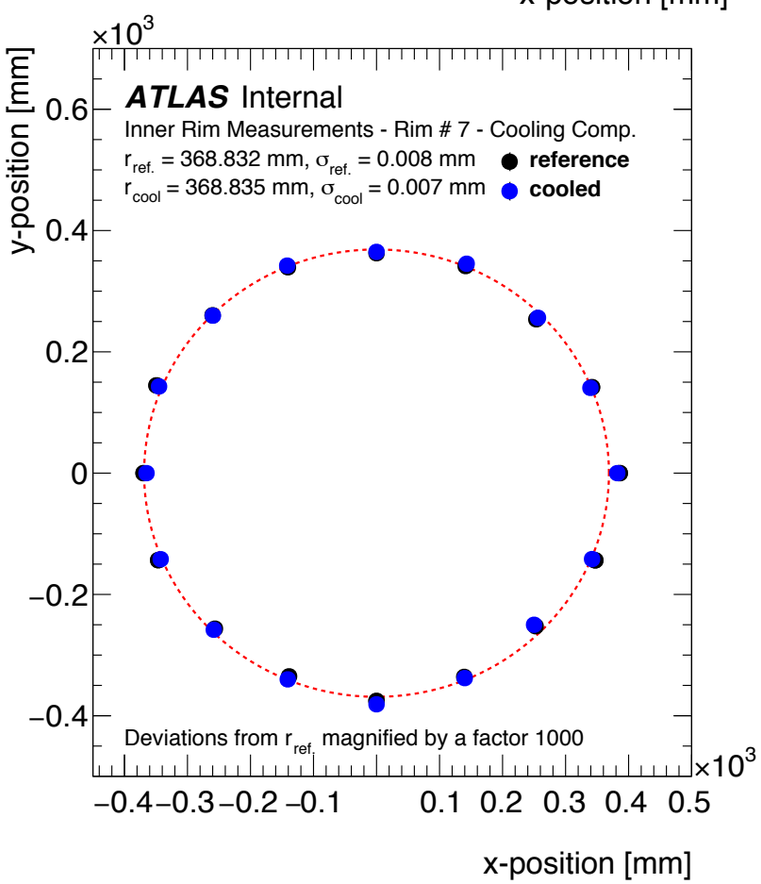
Radial measurements - Reference (before cool.)





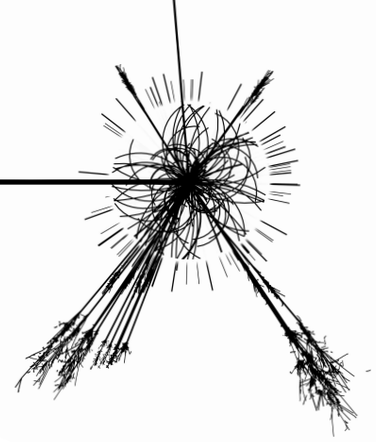




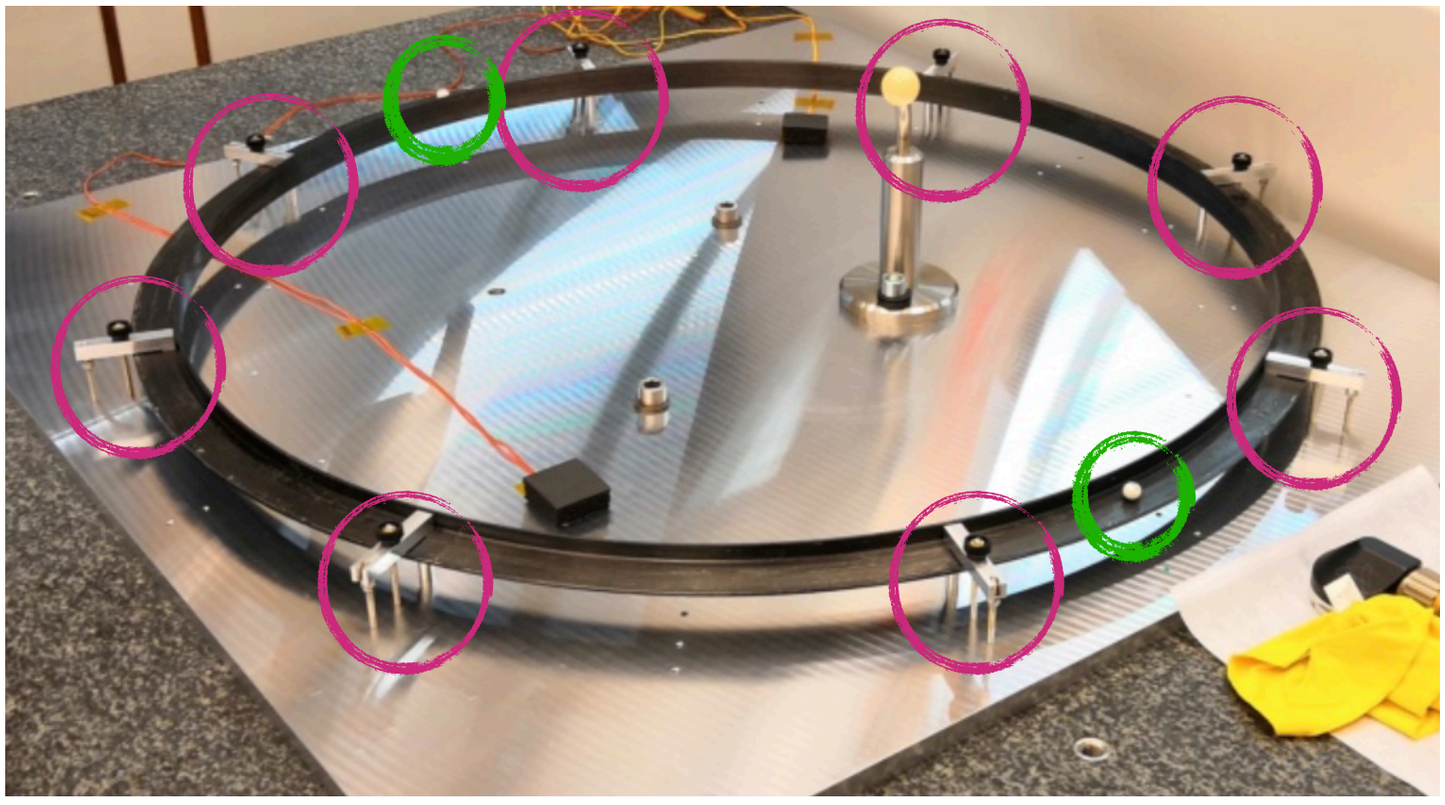


- The already very much deformed rings change also quite a lot after the temperature cycle
- **I don't believe we're measuring a temperature effect** (see next slide)
- **Ring 7** looks the best

Are we really measuring temperature effects?

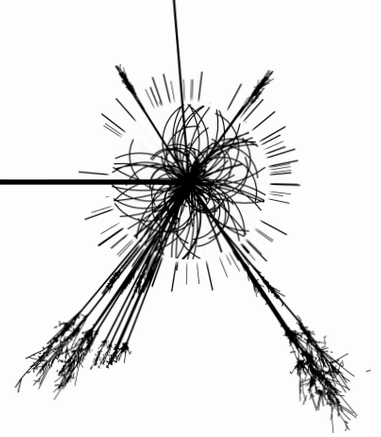


- When fixing the ring in the 3D measuring machine, we use **8 clamps**
- If the ring itself is deformed, the clamps will press it into a certain shape (we're measuring this, i.e. ring-form with clamps)
- There is currently no good way of putting the ring back at **exactly** the same place (we use the **two small spheres** as reference by eye)
- The measurement itself is always done at exactly the same points (because the machine does an alignment procedure using the spheres)
- **Claim:** The dominant effect on the shape difference is the different positions of the clamps and not the temperature cycle

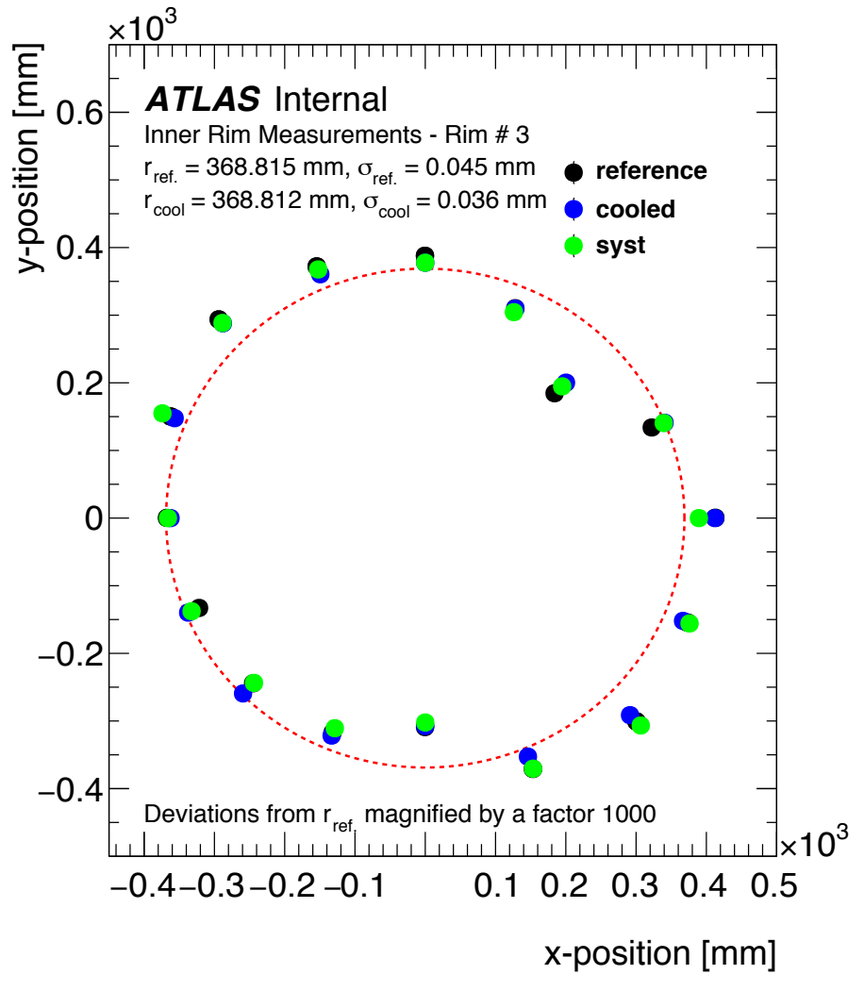


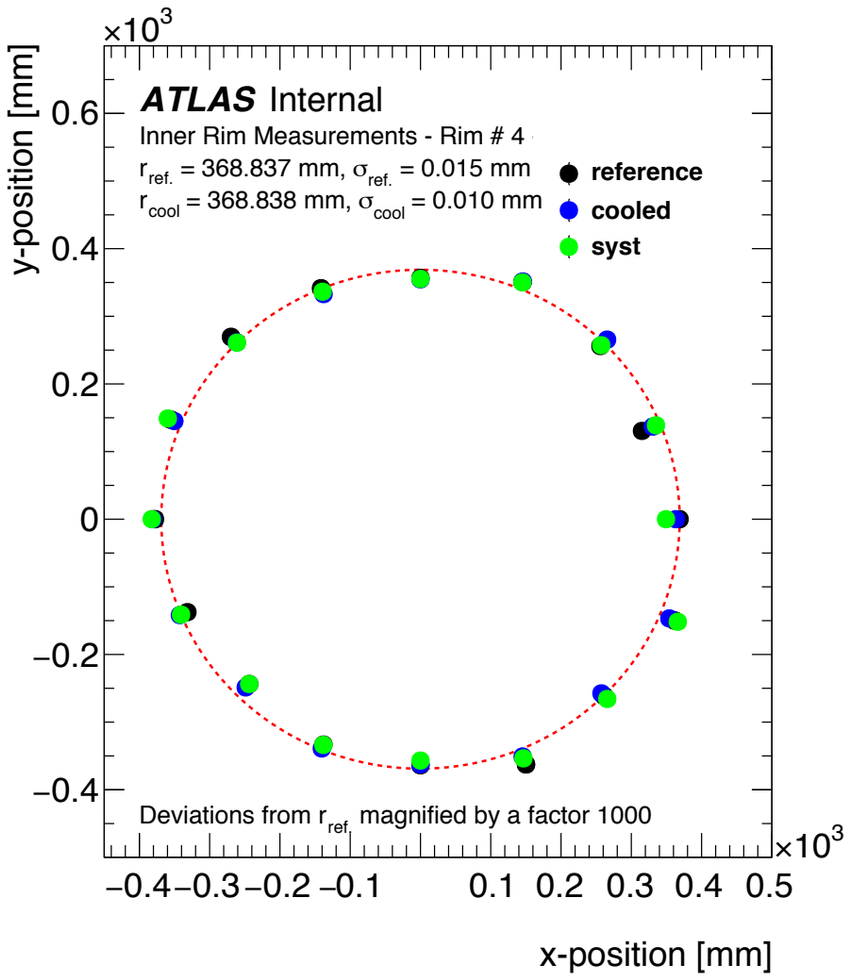
- Test this by measuring the same ring twice and taking it out and putting it in the machine between the two measurements
- Use this as a systematic uncertainty

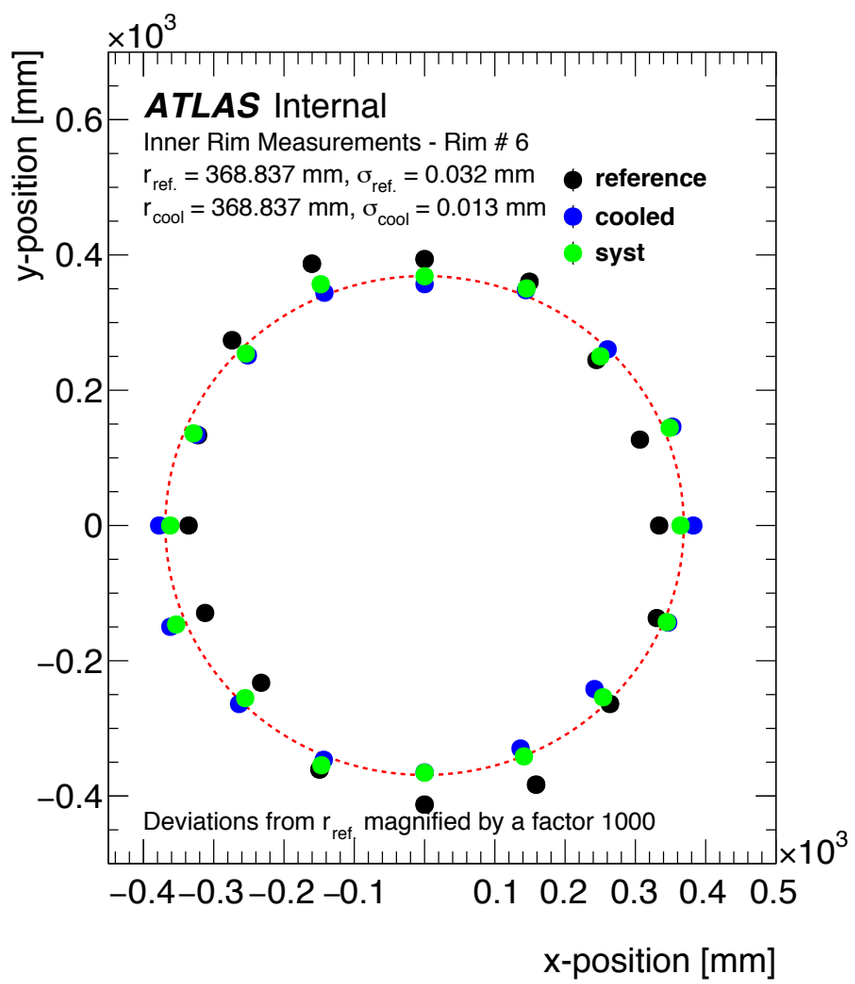
Systematic measurements: **Radius**



- Done with the already temperature-cycled rings (but should not matter)
- Visually compare for the rings with the most deviation (3,4, and 6)

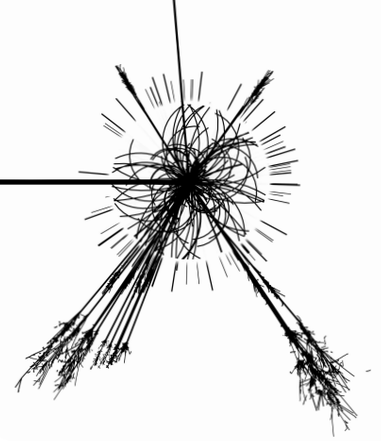


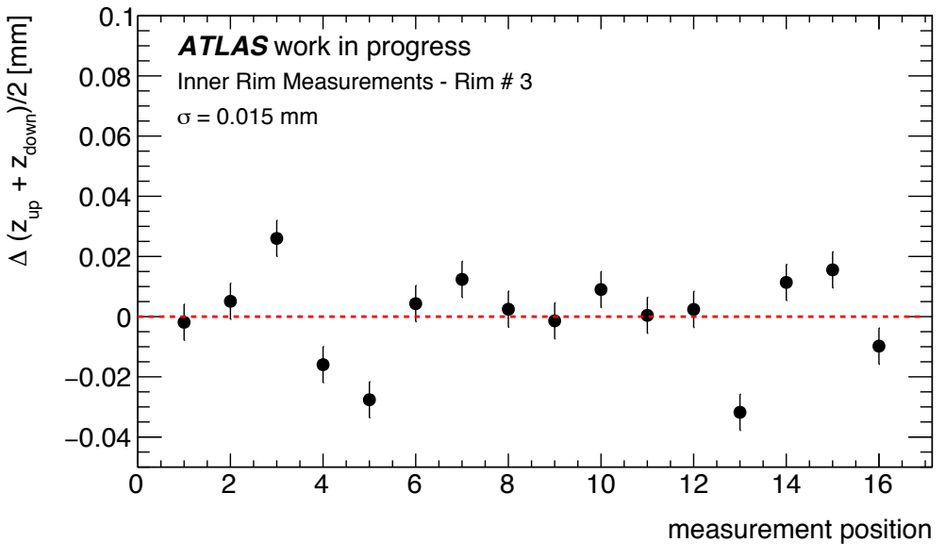


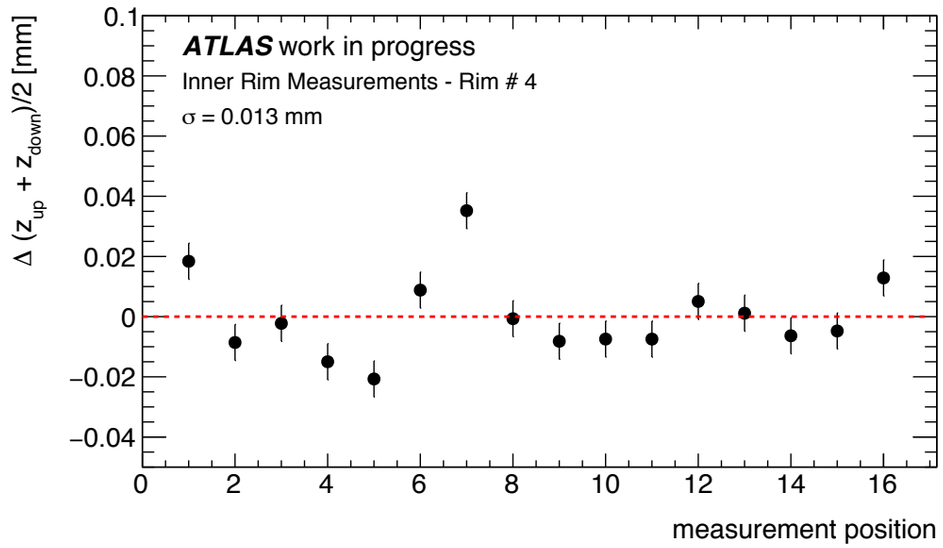


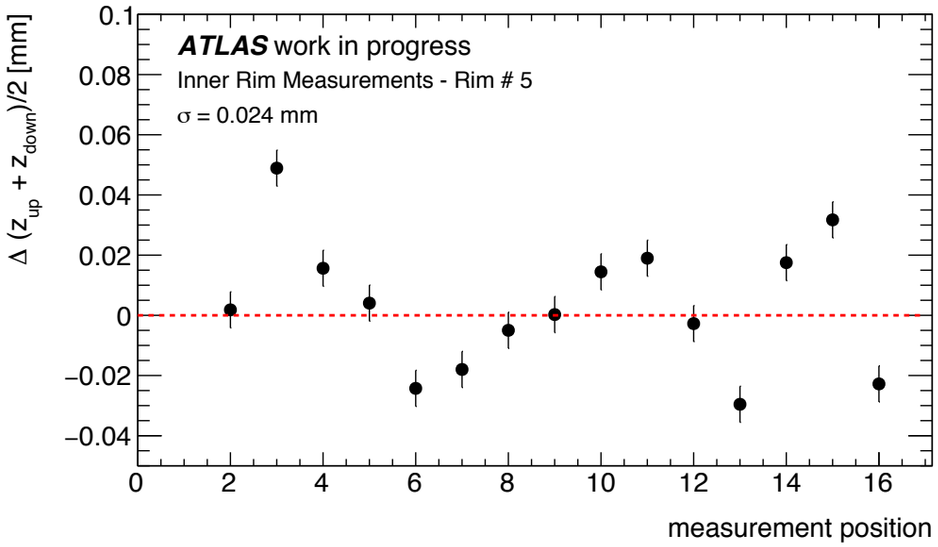
- The difference for between **cooled** and the **systematic** measurement is ~ of the order of magnitude as the difference between **cooled** and the **reference**
- **This is a bottleneck for our measurements (i.e. the comparison is meaningless)**

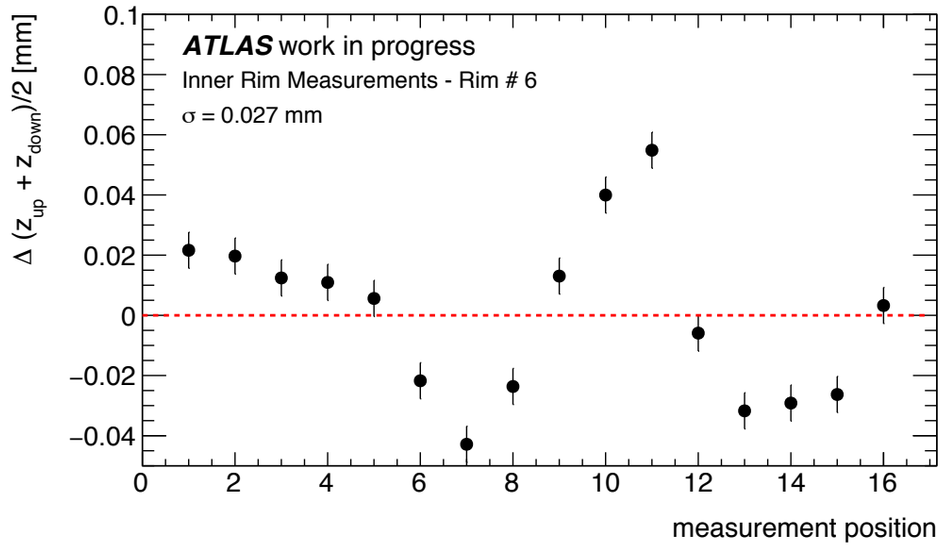
Reminder: the bending measurements

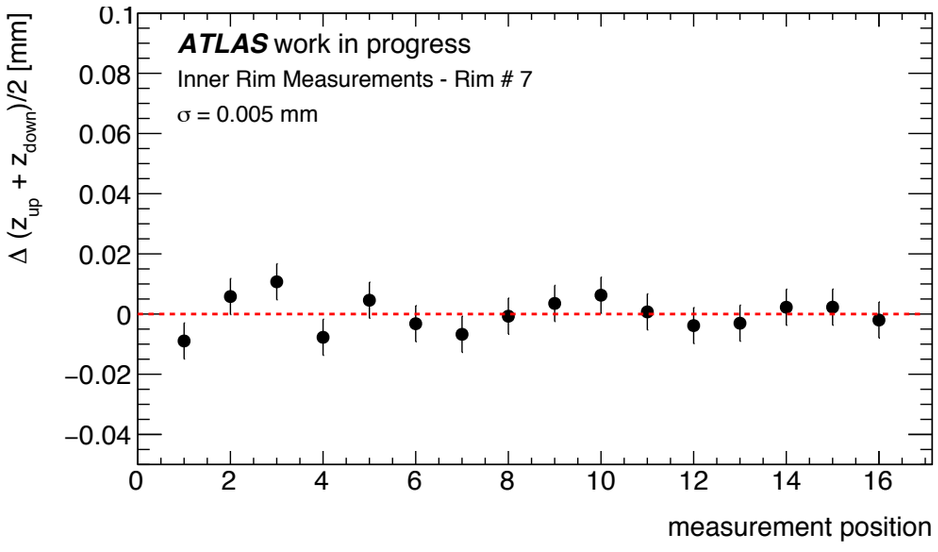










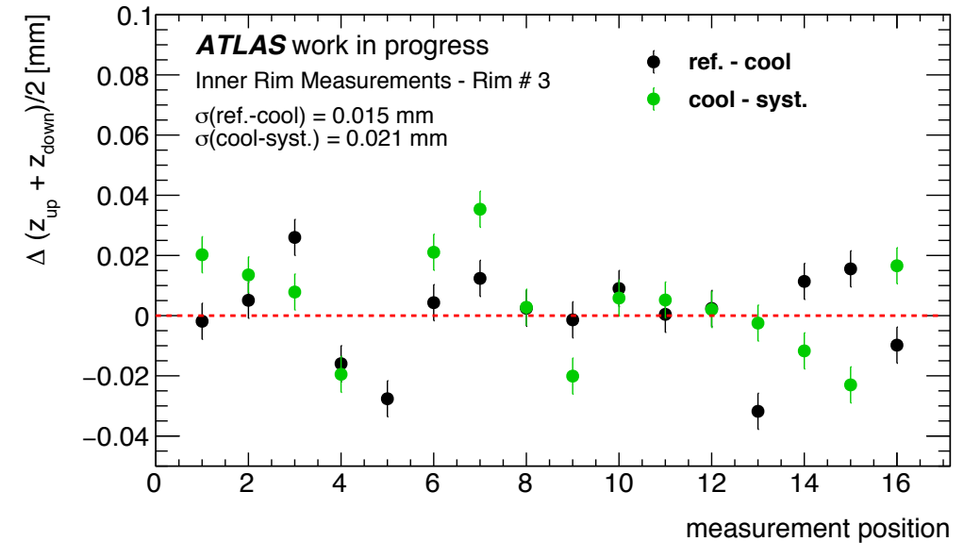


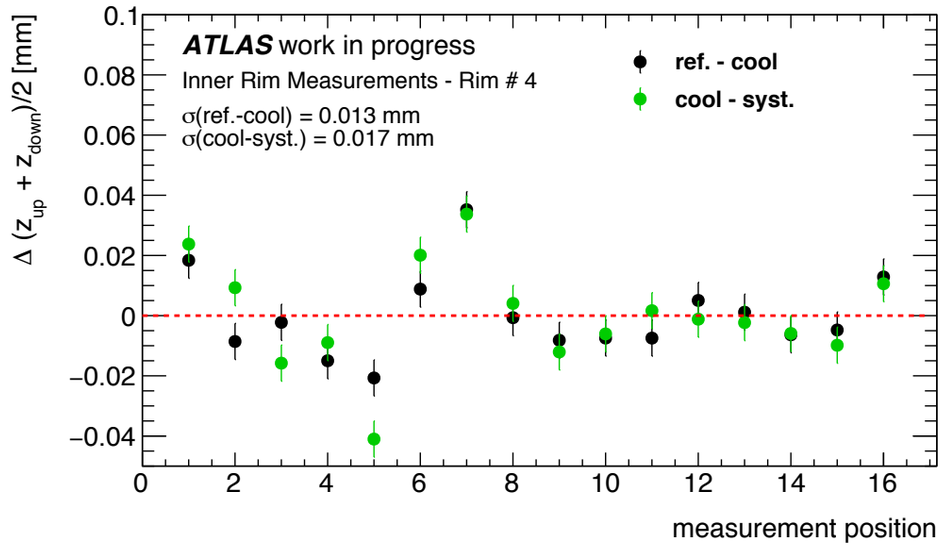
- Bending defined as:

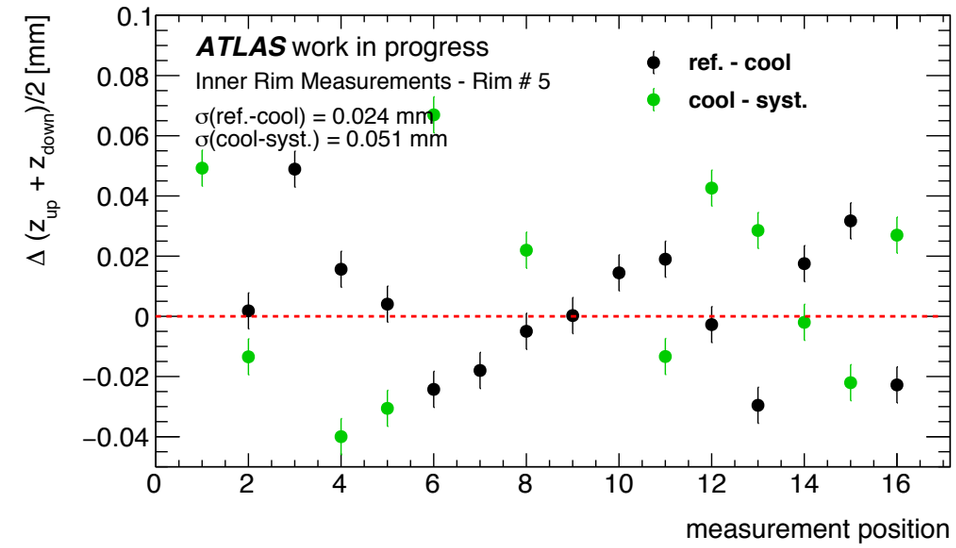
$$\left(\frac{z_{\text{up}} + z_{\text{down}}}{2}\right)_{\text{measured}} - \left(\frac{z_{\text{up}} + z_{\text{down}}}{2}\right)_{\text{expected}}$$

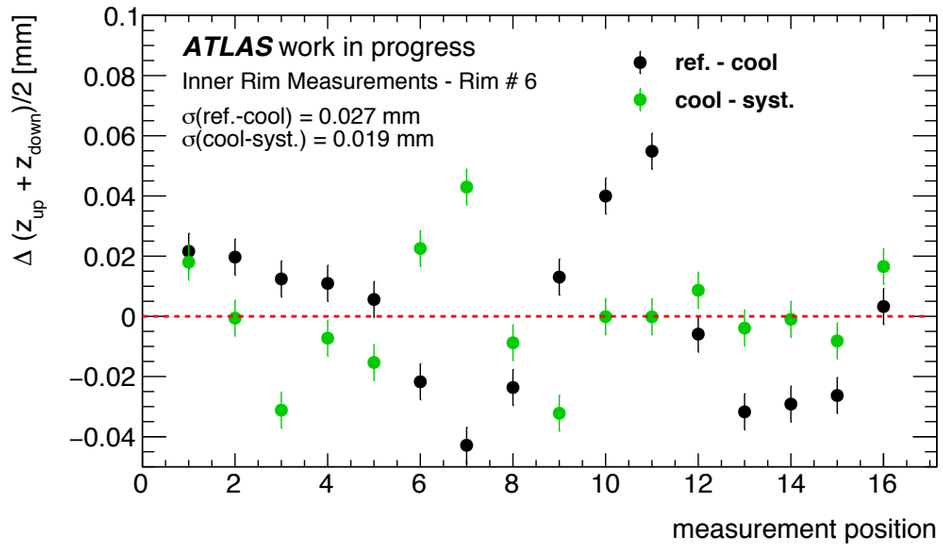
- Shown: Reference - Cooled

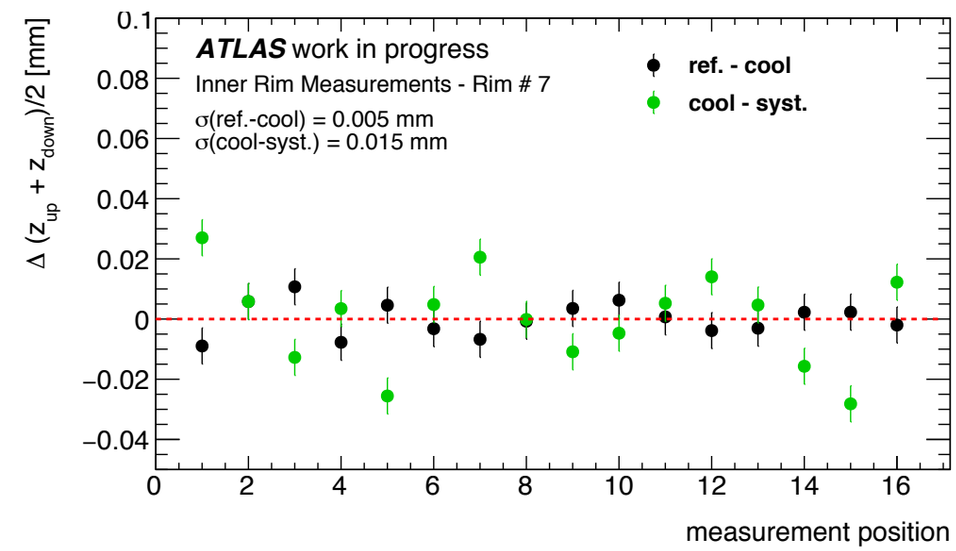
Systematic measurements: **Bending**





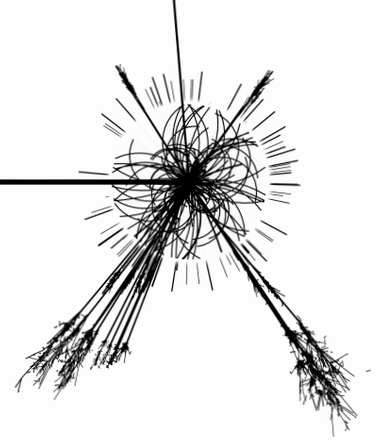






- **We're not sensitive to potential permanent deformations due to the temperature cycling**
- **The measured bending is solely defined by the position of the clamps**

Summary and closing remarks

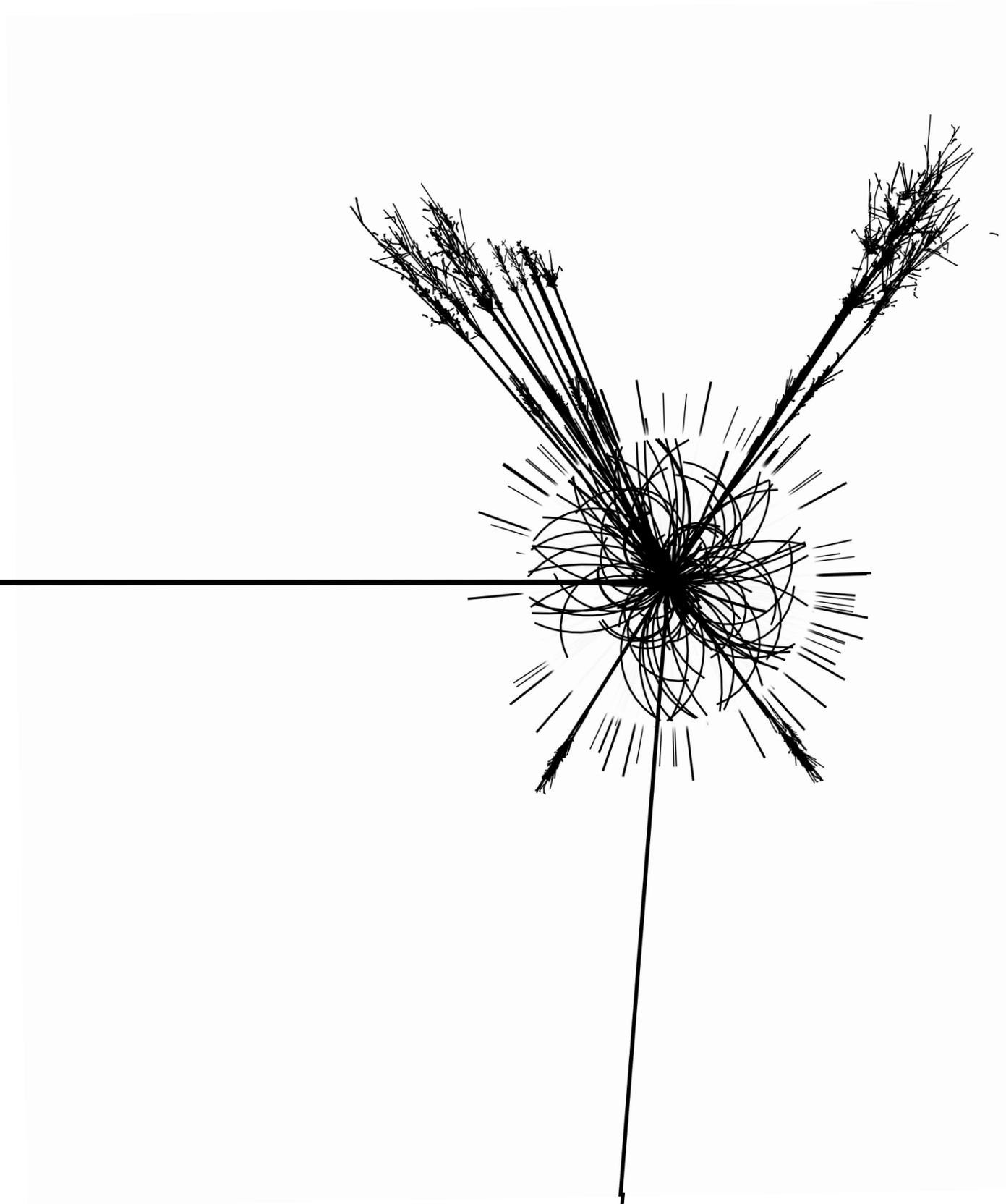


Intermediate conclusions:

- **Ring 7** is closest to the „ideal“ ring in terms of deformations
- For each ring, the flange is not a perfect blank but thinner on the inner part and thicker on the outer part
  - The difference in width between the inner and the outer part is O(400 µm)
  - Johan thinks it’s caused by the anti-glue put between the mould and the epoxyvs
- Our current method of measuring is limited by the precision of putting the ring back in to the machine at exactly the same points (due to the bending caused by the clamps)
- Possible permanent temperature deformations are well below this systematic uncertainty

Comments/suggestions and questions very welcome

Backup.



Measurement # vs. production

- There is a mismatch between the measurement numbers and the production number of the rims
- The plots show the measurement number
- The following table contains the correct mapping (to check the ring production parameters)

measurement #	3	4	5	6	7
production #	3 or 4	6	7	3 or 4	5

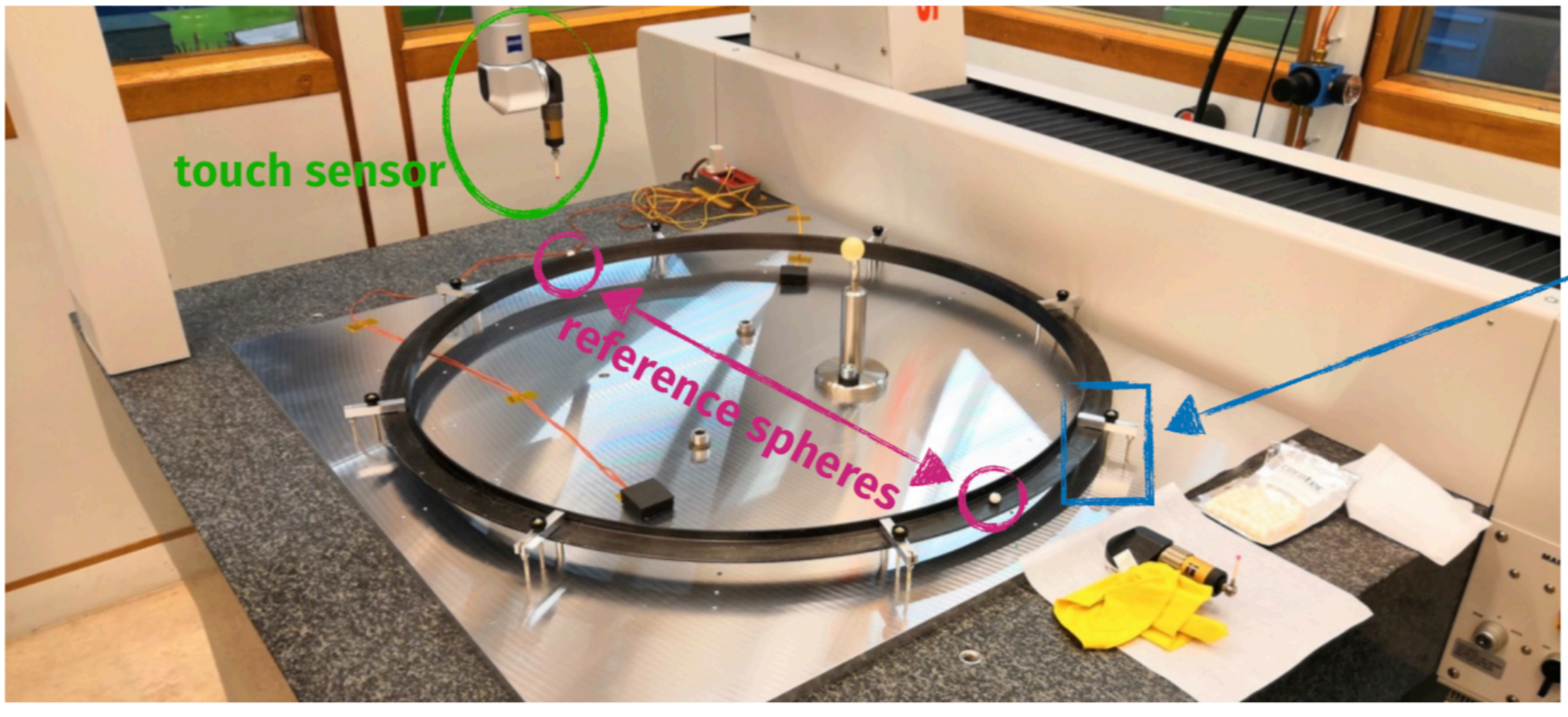
Motivation: What, why and how?

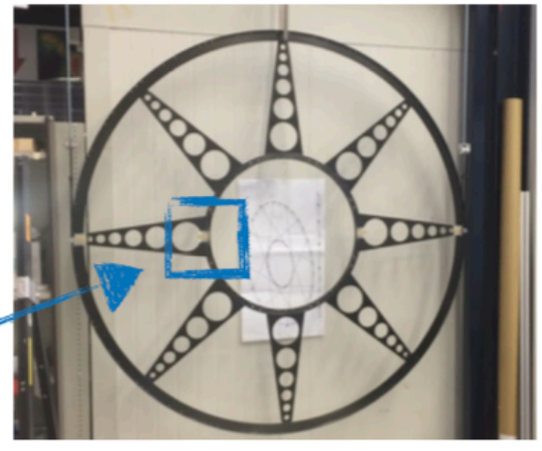
- **Goal:** Understanding the thermal behavior of the ITK inner rim
- 5 inner rims available to test, produced with different settings (amount of epoxy, ...)
- **Measurement plan:** (reference) measurement → thermal cycle → measurement

  results shown today

Measurement setup:

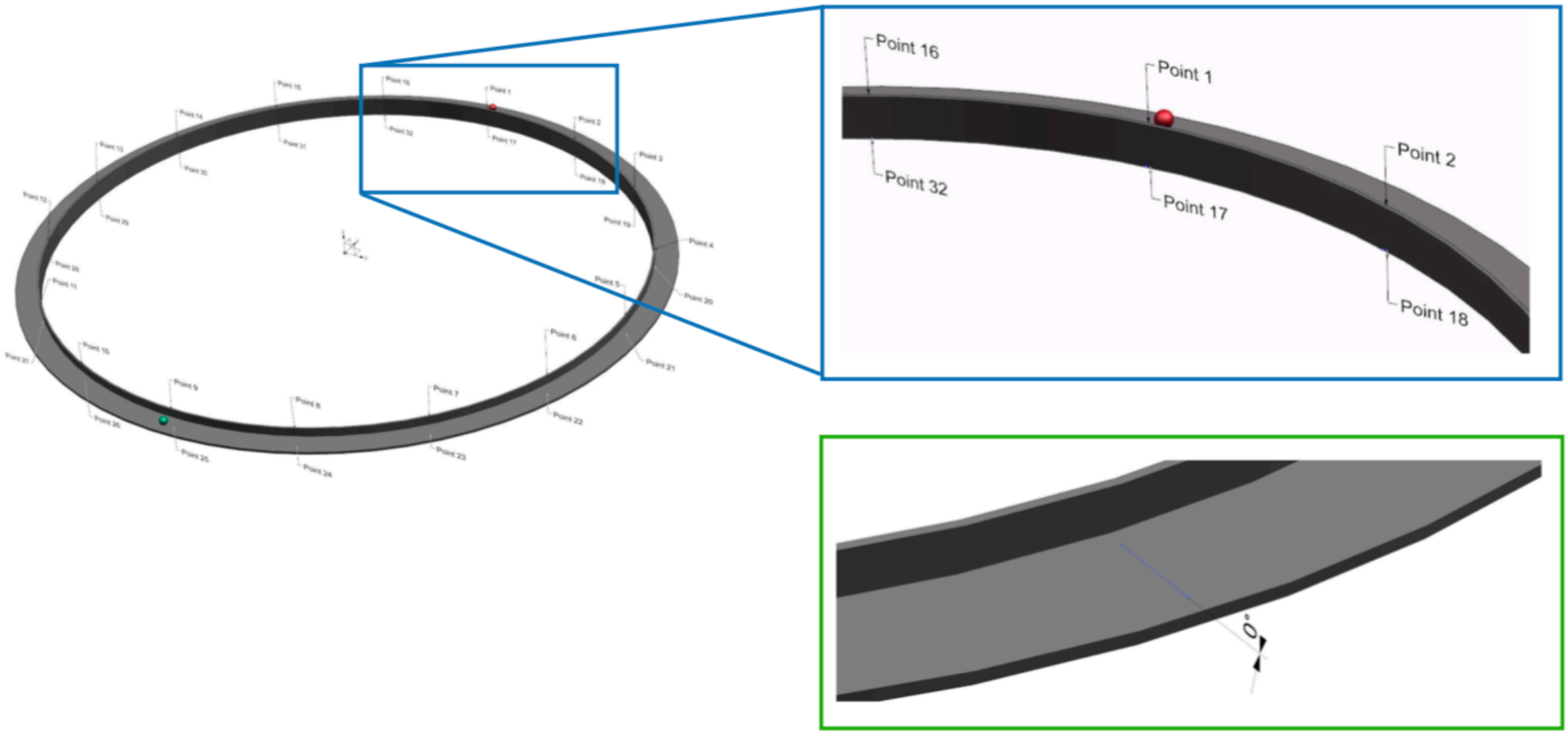
- 3D measuring machine used to scan the ring
- Fixation points needed for measurement but also mimic in a way the final setup
- Aligned machine yields a precision of ~ 4 µm





What is measured, exactly?

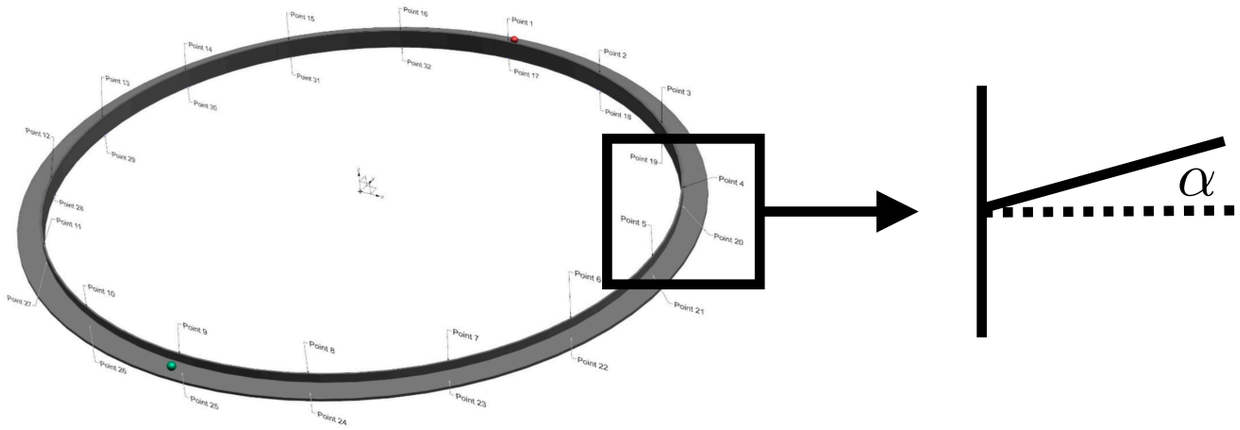
- Two types: position of points on cylinder section and inclination angle of the flange
  - 16 points on top of the cylinder, 16 points on the bottom (> distance between)
  - 16 lines on the flange (2-points) to measure the angle
- Point and angle measurement positions shifted by ~ 6°
- Reference spheres on the ring allow to redo the measurements **at exactly the same points**



Open points from last time

- Follow-up on presentation shown on 20.05.2019 [here]

The shape of the rim:



- Measurement of the inclination angle of the flange lead to positive angles of ~ + 8 mrad for all the rings
- Should not happen since rings are put into the machine with random orientation

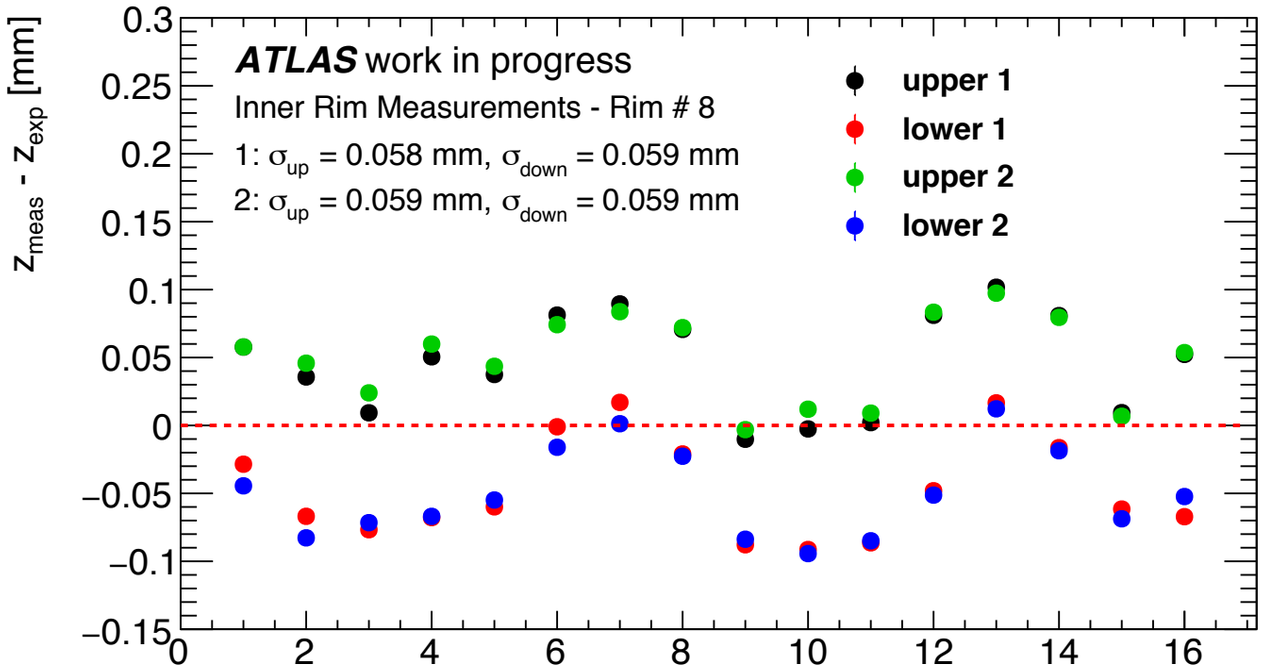
What's causing this?

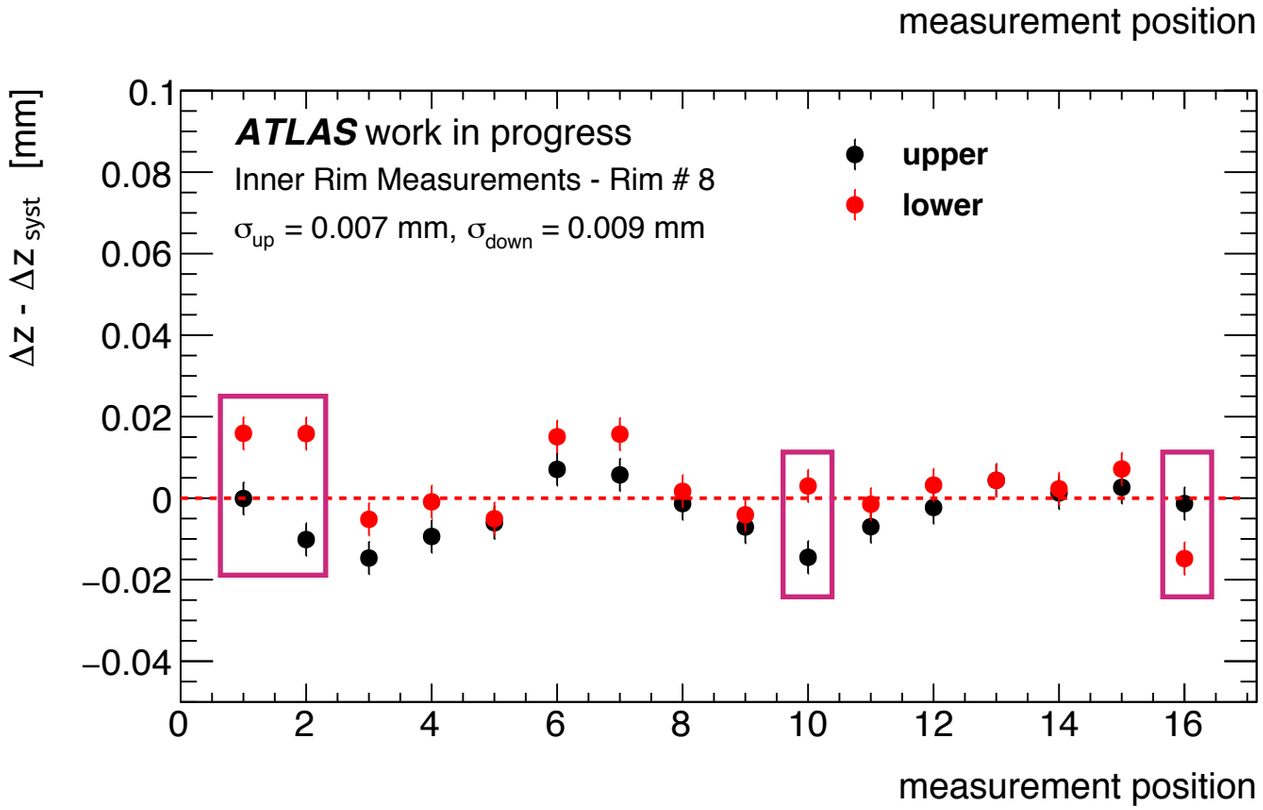
- The flange is not a perfect blank but thinner on the inner part and thicker on the outer part

- The difference in width between the inner and the outer part is O(500 μm)
- Johan thinks it's caused by the anti-glue put between the mould and the epoxy

Systematics measurement

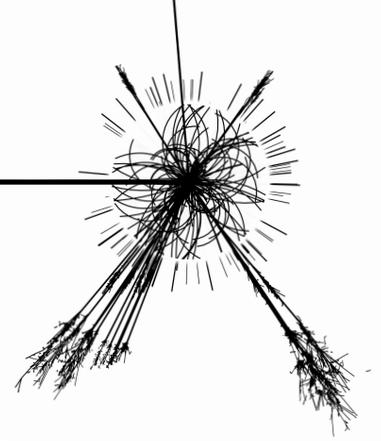
- Measure one ring twice to get a feeling for systematic uncertainties

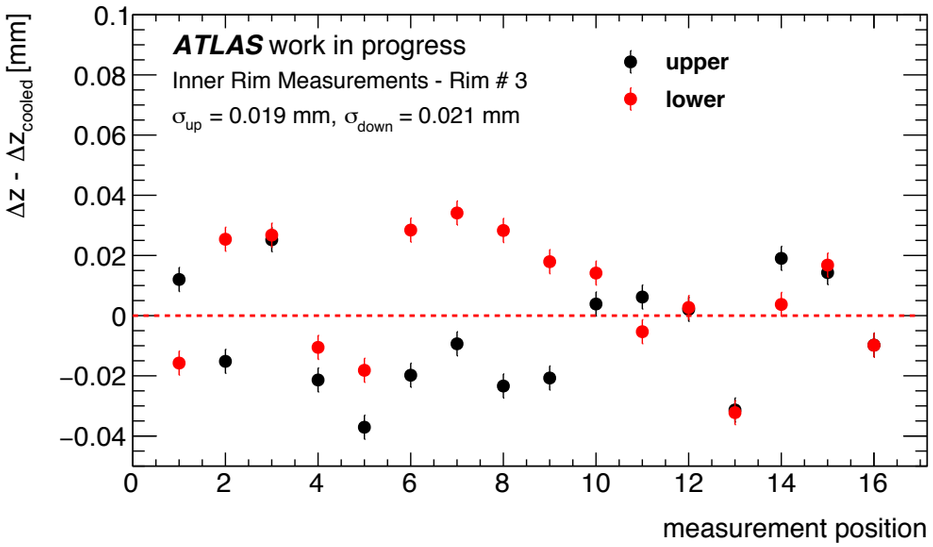


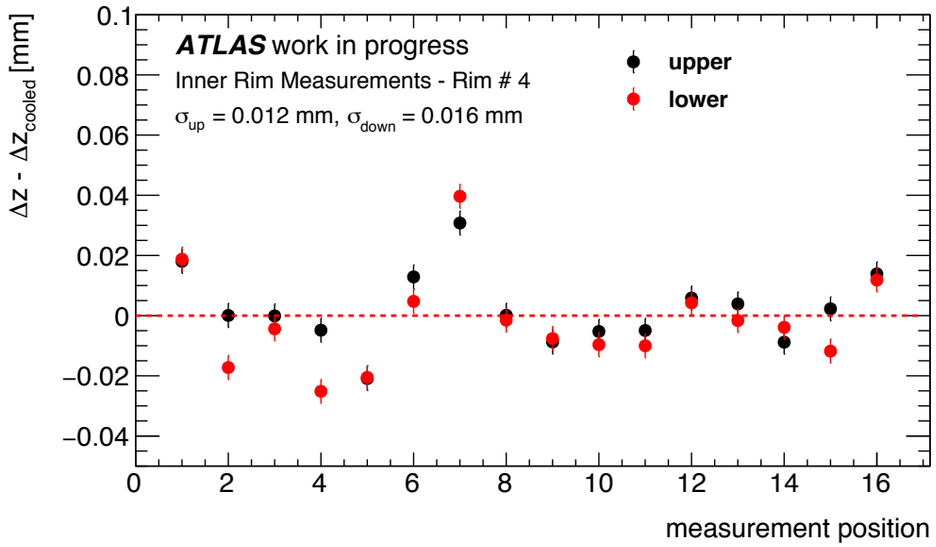


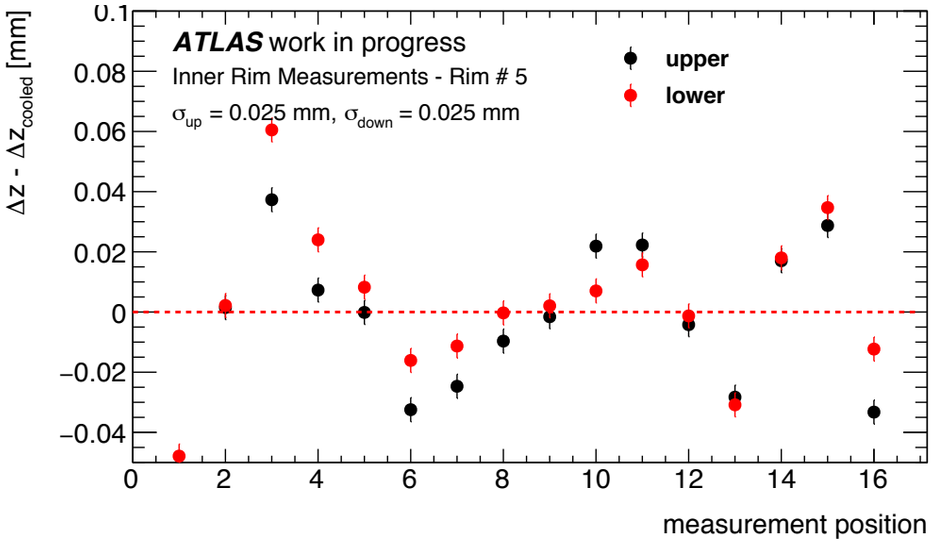
- Overall the „trend" remains the same
- Sinoidal behavior in the differences (not everywhere)
- The clamps provide fix points and bend the ring differently depending on where they are put
- With the current setup it's impossible to put them back at exactly the same position
- Are we ok with this drawback?
- How do we want to quantify this „uncertainty"? Add a σ_{syst} to the measurement points?

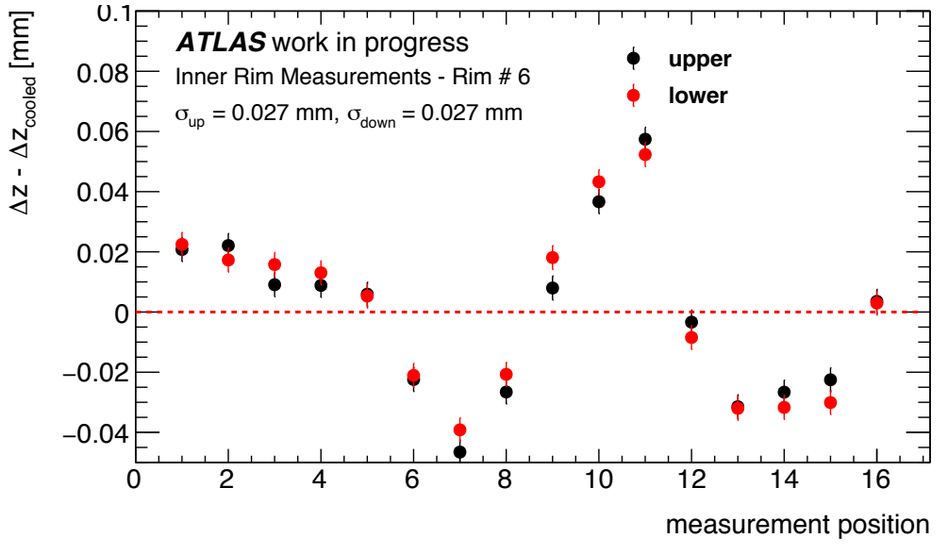
The permanent impact of the cooling - z Pos.

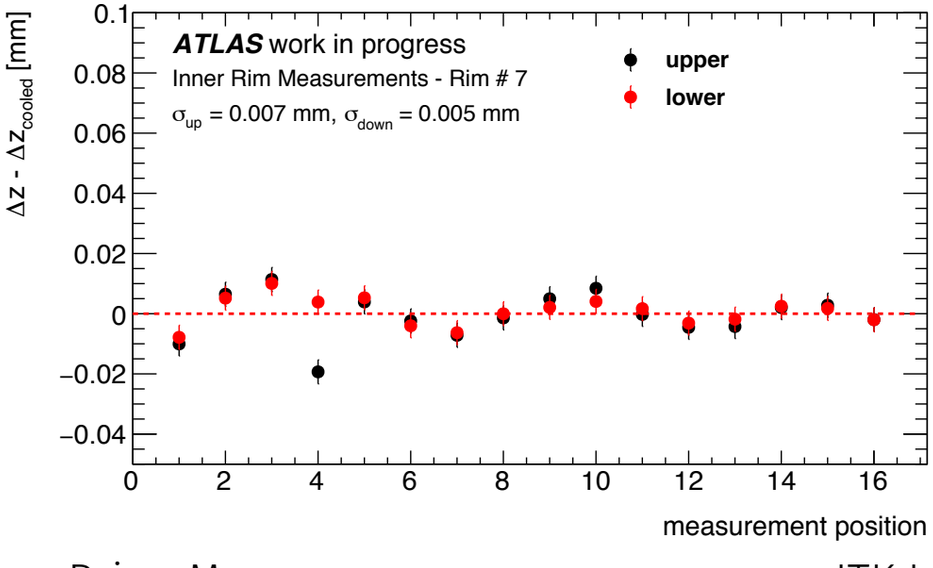






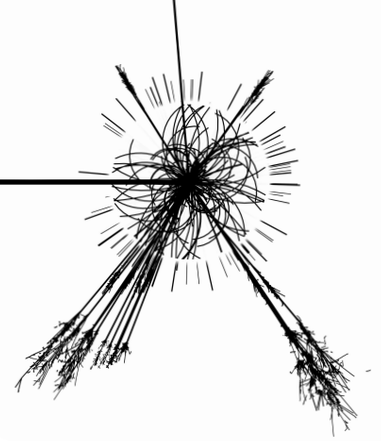


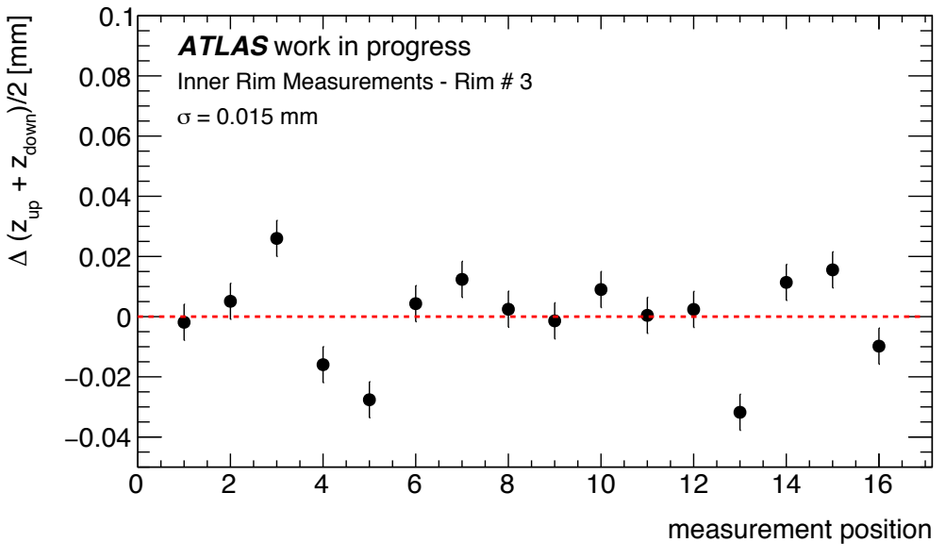


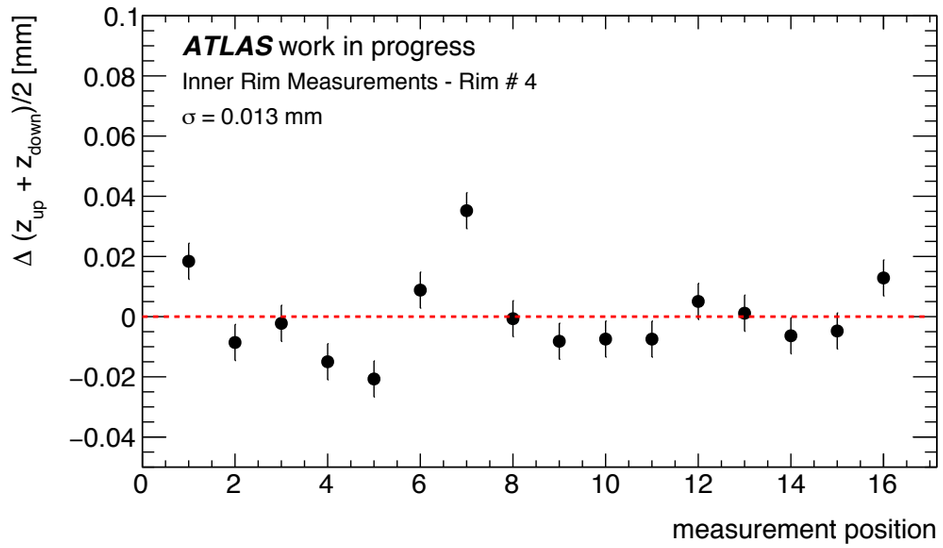


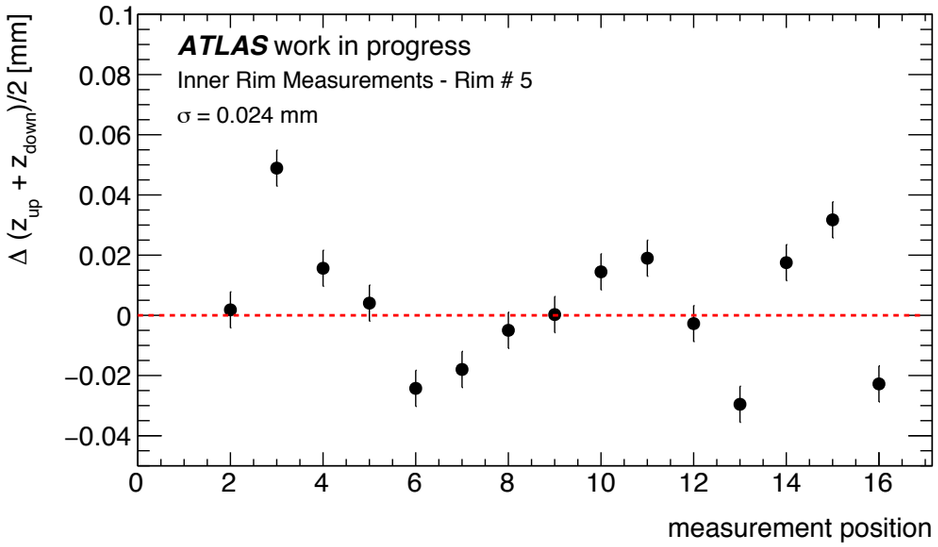
- Shown: Reference - Cooled
  (deviations from the expected z-position)

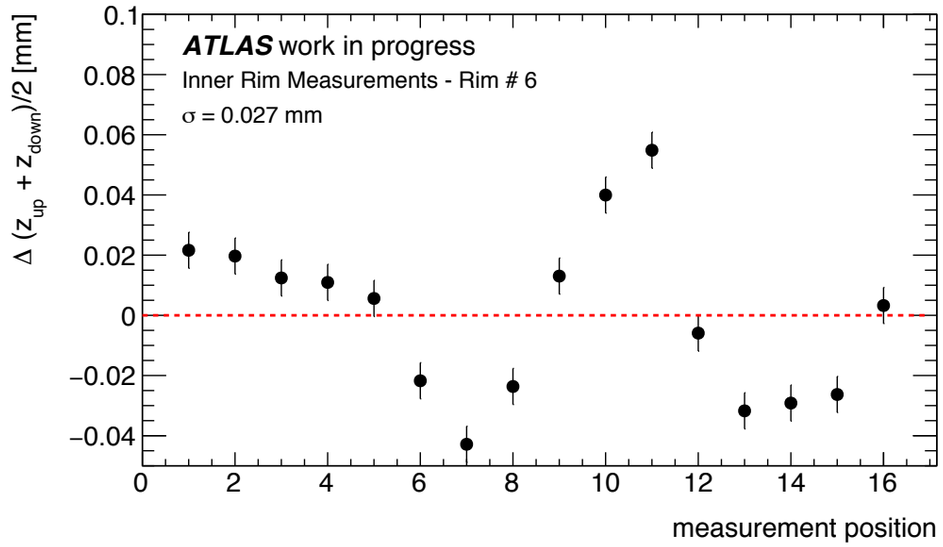
The permanent impact of the cooling: Bending

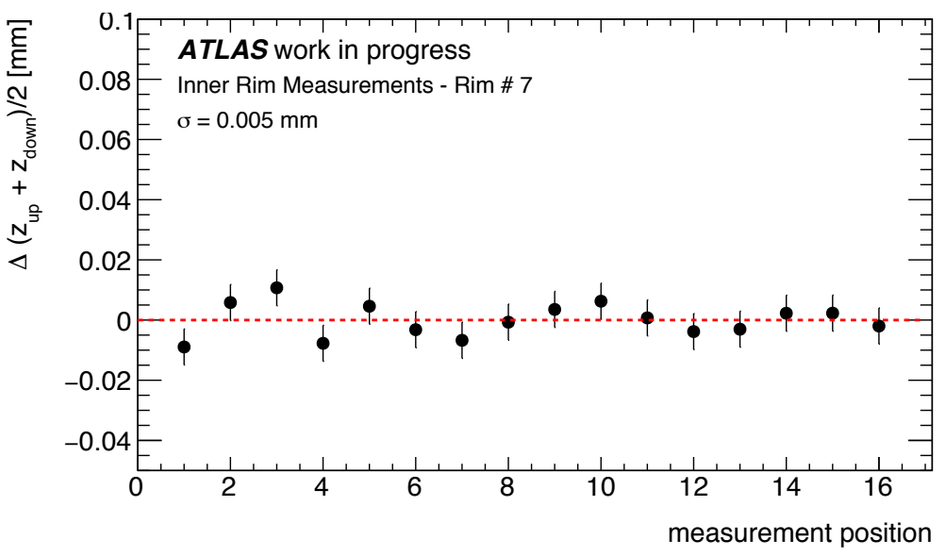










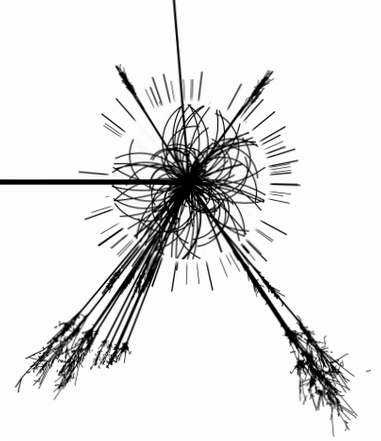


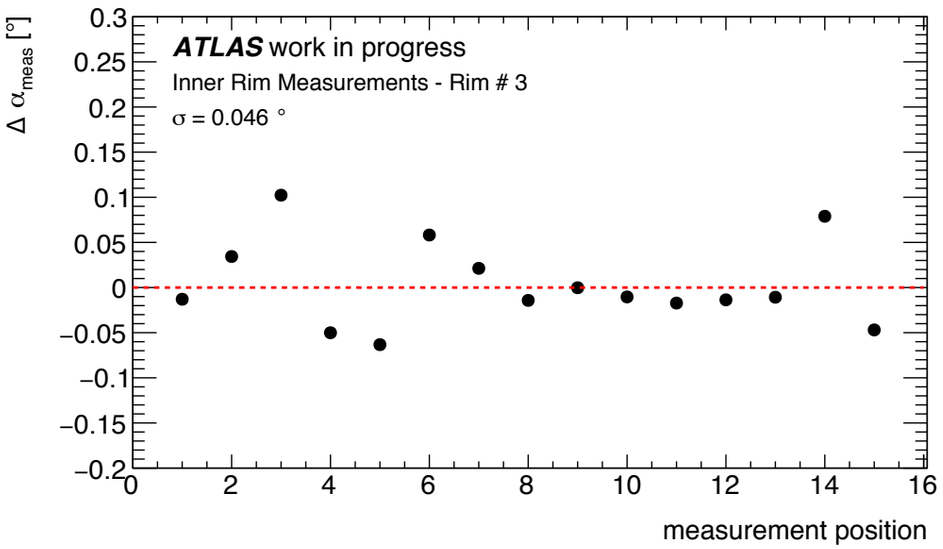
- Bending defined as:

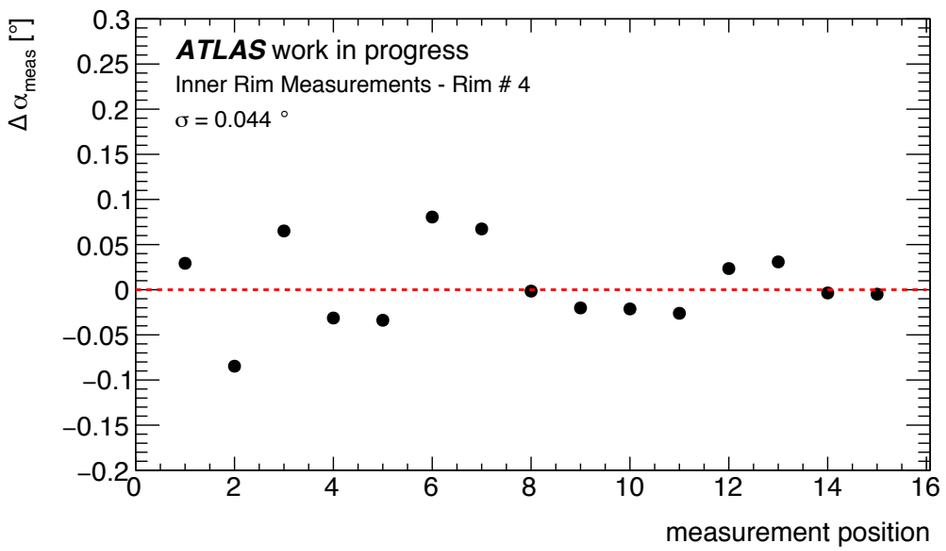
$$\left(\frac{z_{\text{up}} + z_{\text{down}}}{2}\right)_{\text{measured}} - \left(\frac{z_{\text{up}} + z_{\text{down}}}{2}\right)_{\text{expected}}$$

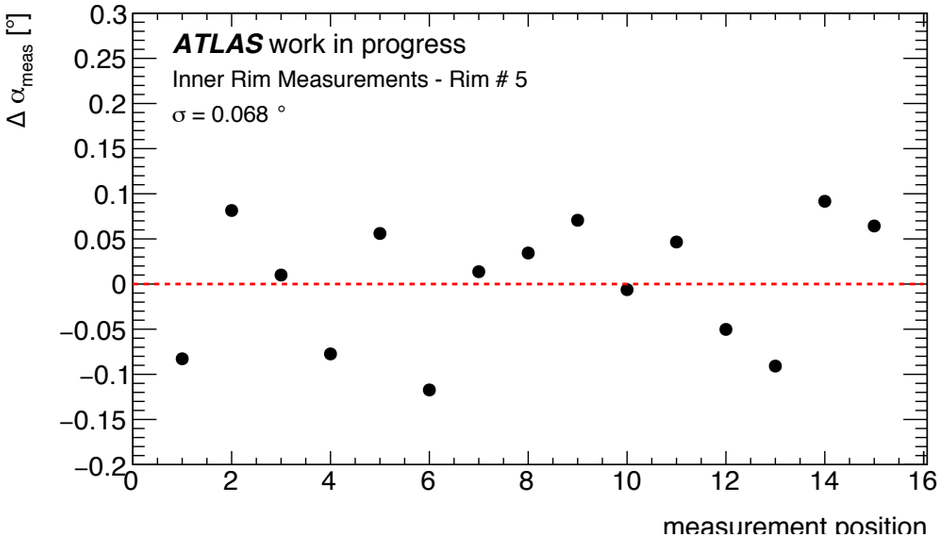
- Shown: Reference - Cooled

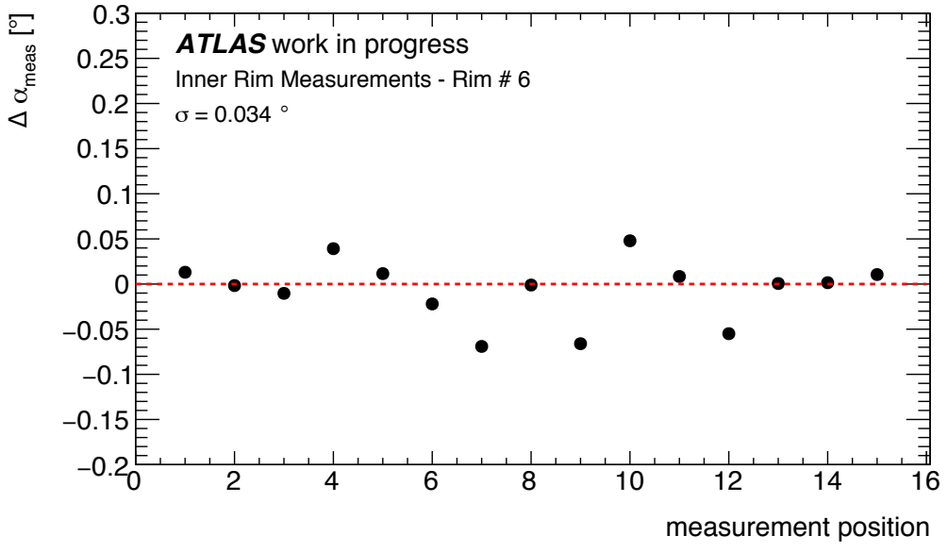
The permanent impact of the cooling: Angle

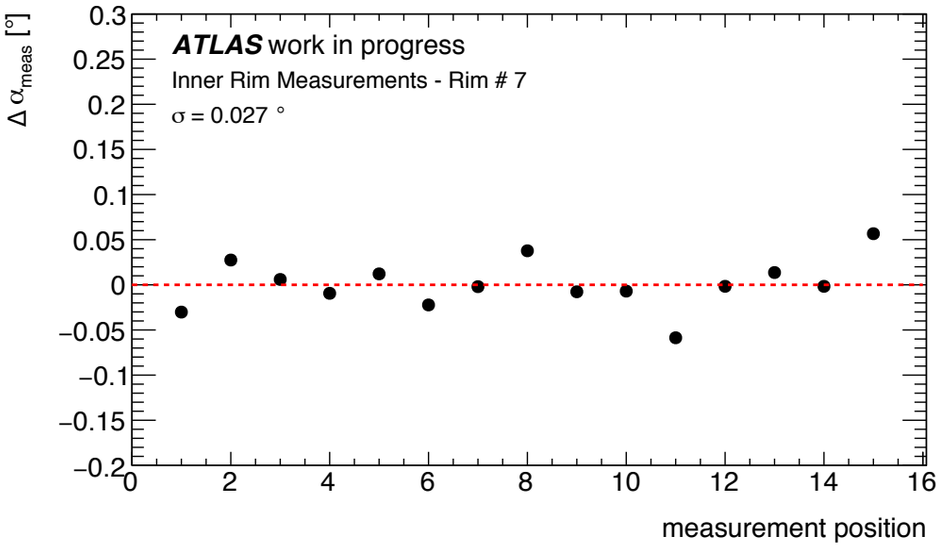












- Shown: Reference - Cooled

The permanent impact of the cooling: Angle