INTT G4 modification

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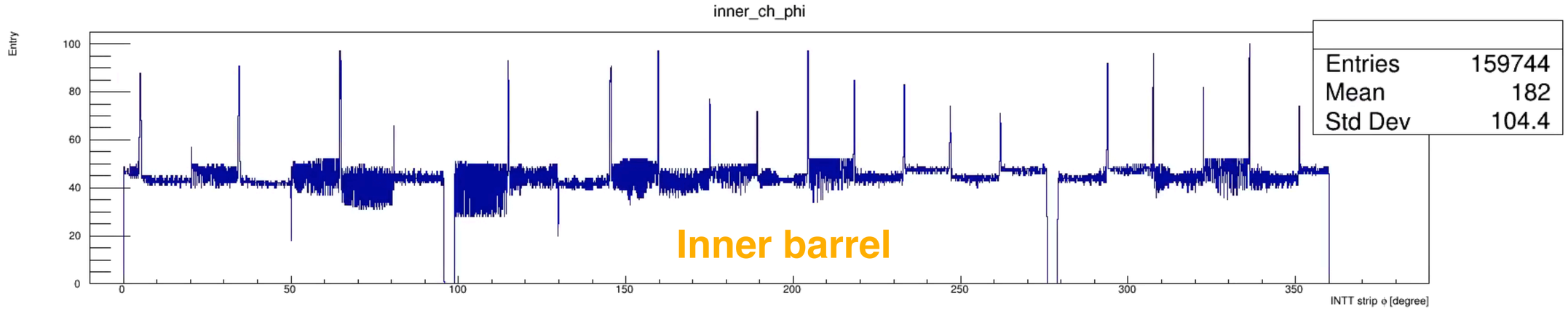
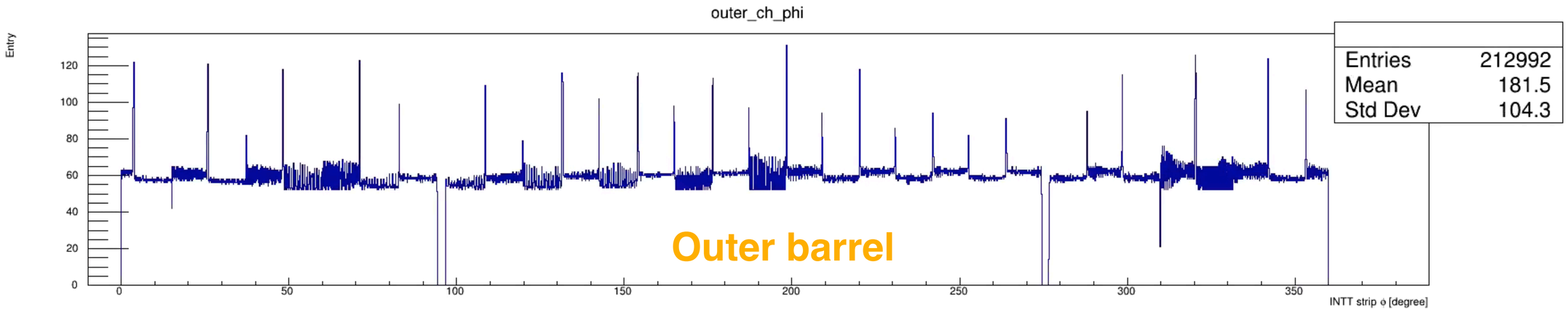
XXX meeting

sPHENIX INTT sPHENIX

Purpose of modifying the INTT G4

Full survey data with 3.32 mm correction in radius included
No MC or data included, the ϕ positions of all the **INTT channels** were filled in the histogram
Bin width : 0.1 degree

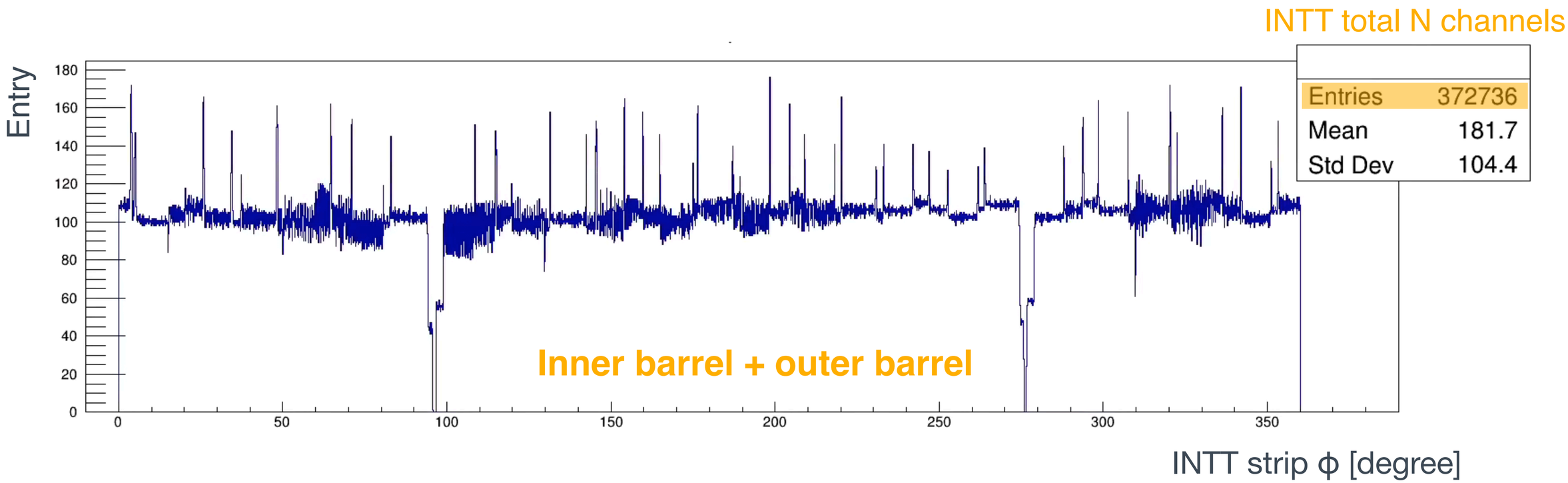




Purpose of modifying the INTT G4

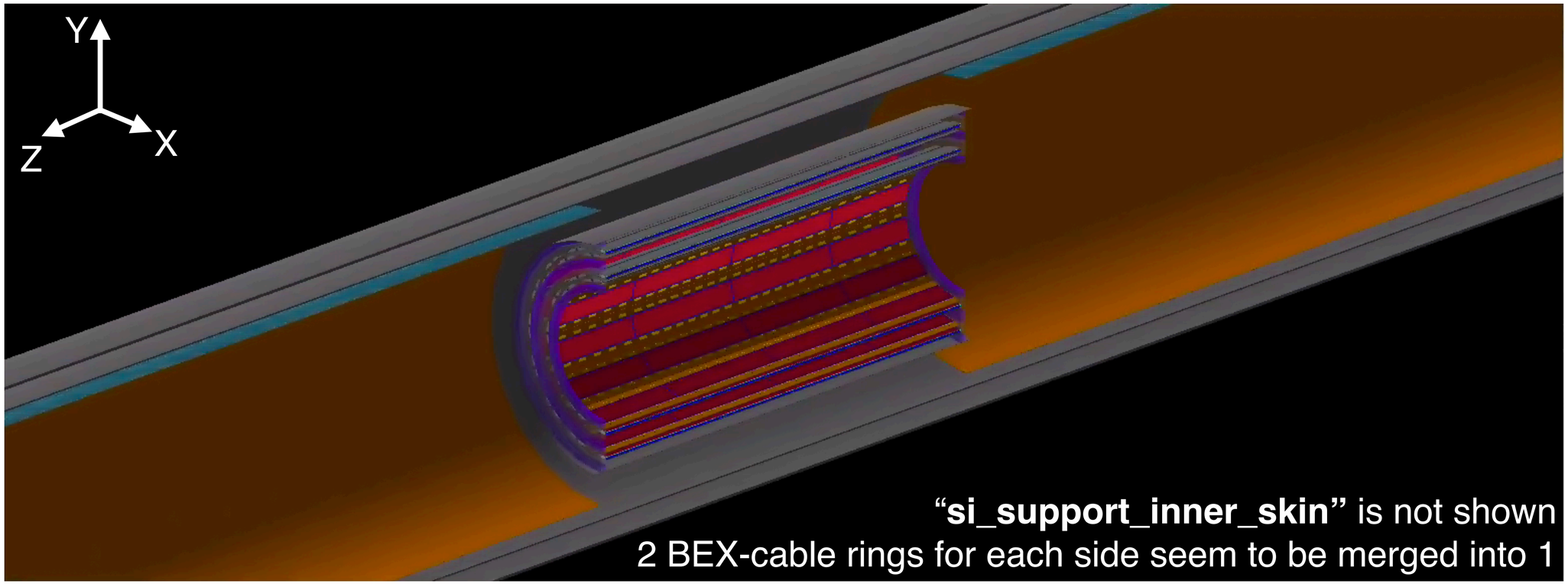
- Goal: to reproduce the open region we saw with the survey data in Geant4 simulation

Full survey data with 3.32 mm correction in radius included
No MC or data included, the ϕ positions of all the **INTT channels** were filled in the histogram
Bin width : 0.1 degree



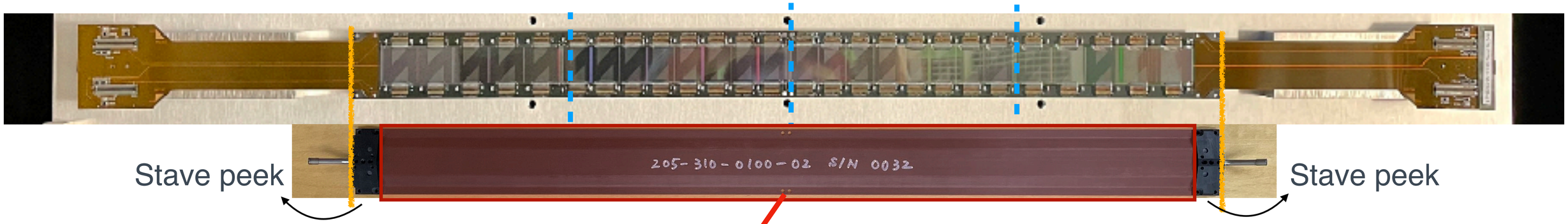
INTT Geant4 original status

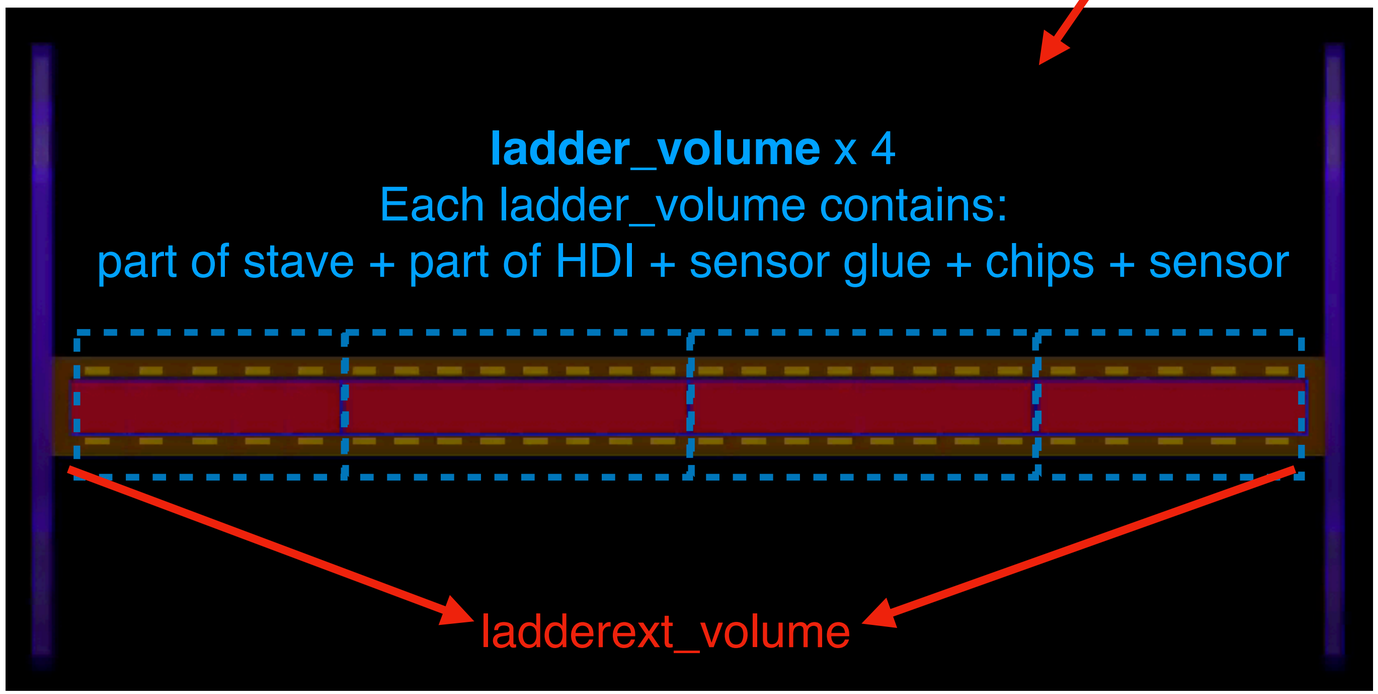
- Overall speaking, it's well made and lots of work has been done. Beautiful structure!
- Geometry: more and less **ideal geometry**
  - Some numbers are not "that" correct (sensor radius and z position), but should be minor
- No half-barrel structure introduced. All the components are independent and have the same center reference, the **trackerenvelope**

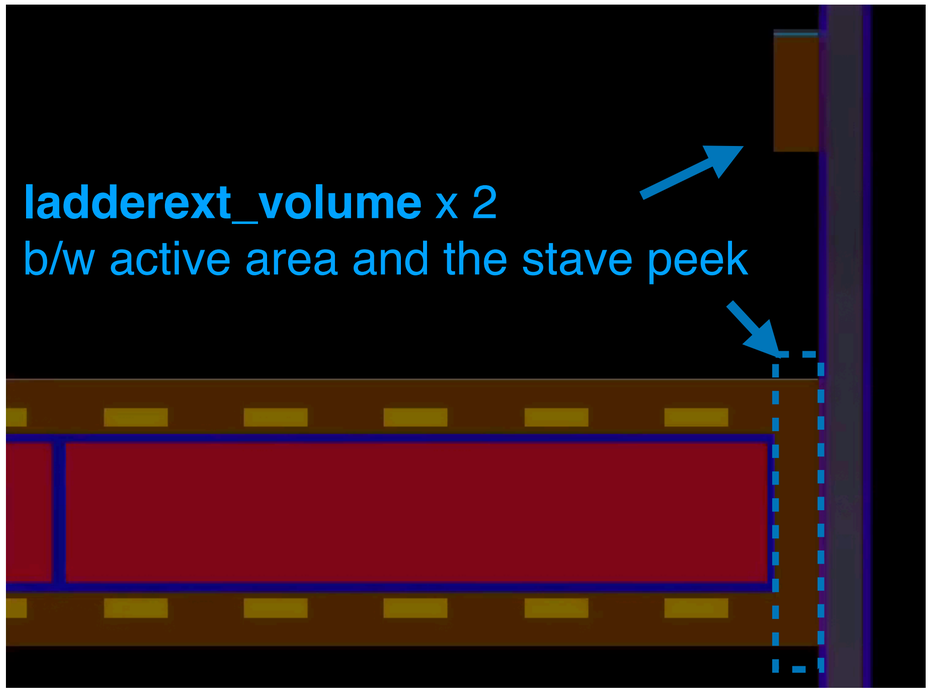


INTT Geant4 original status - ladder within peek

- Ladder **within** the peek is composed of 4 **ladder_volume** + 2 **ladderext_volume**







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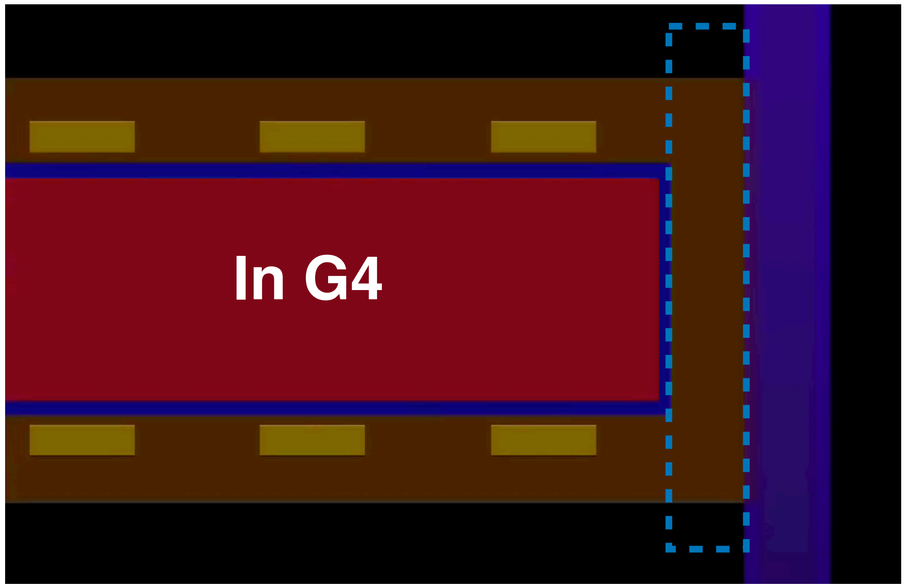
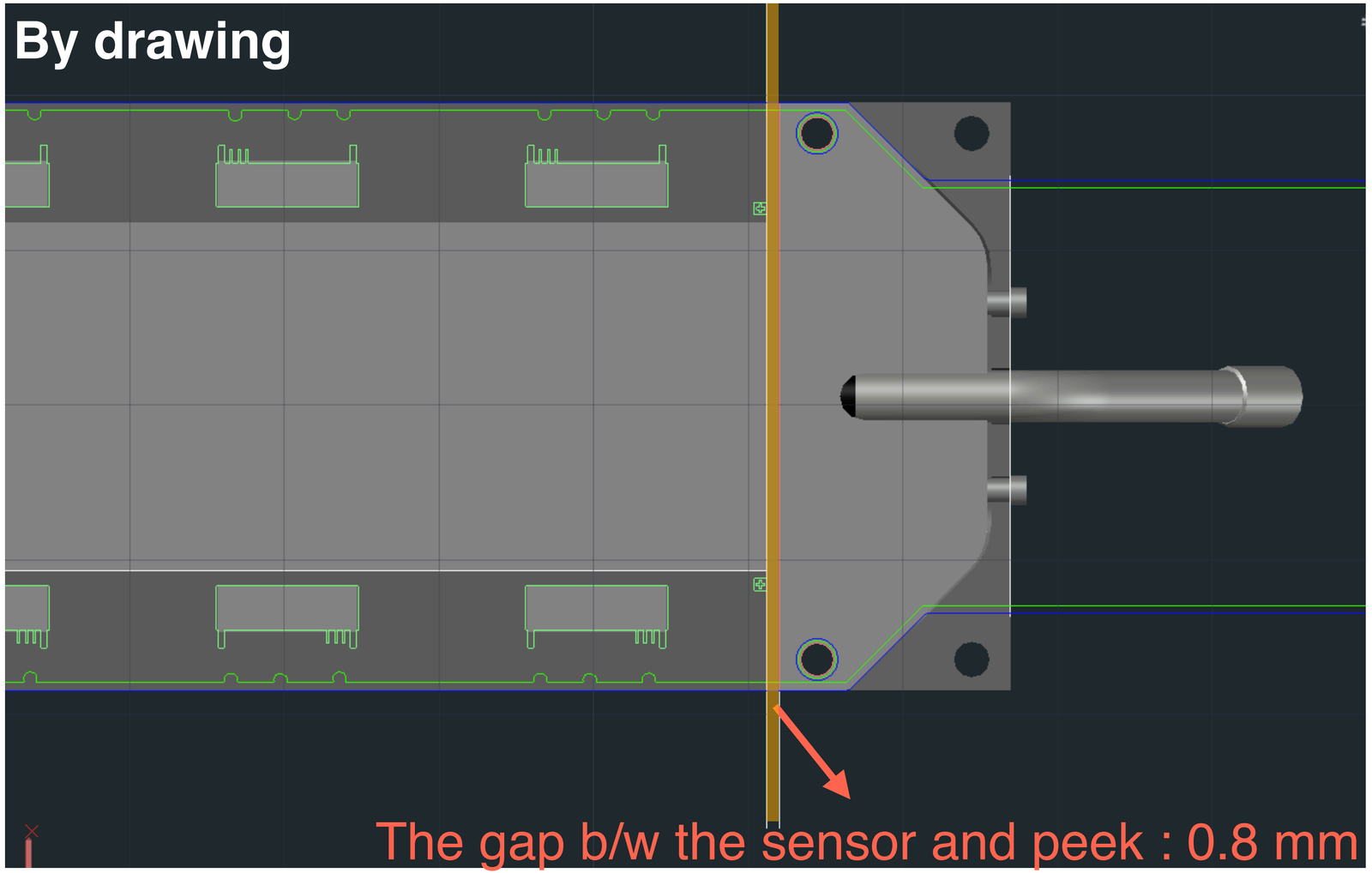
ladderext_volume
b/w active area and the stave peek
length: 7.622 mm

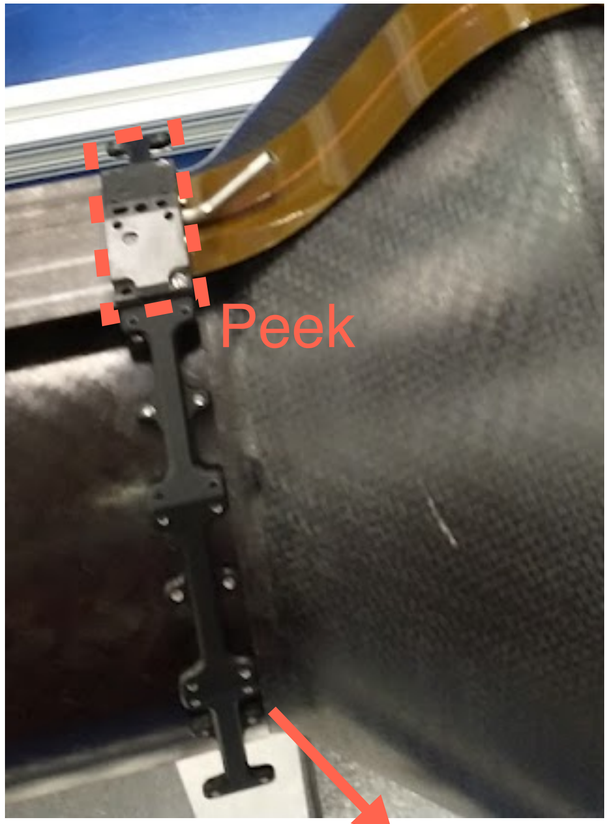


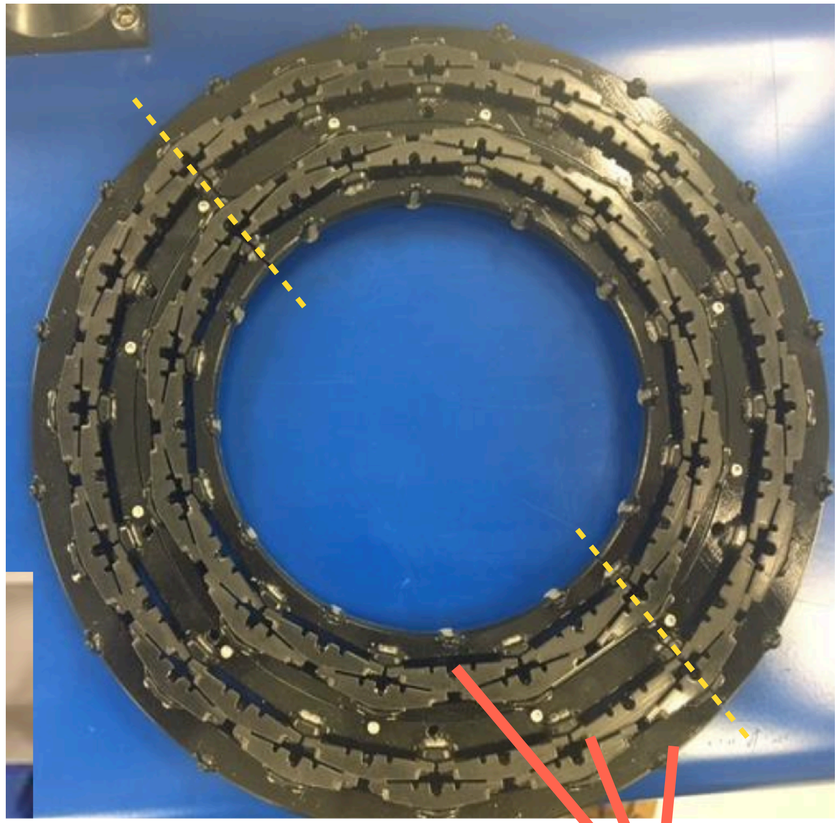


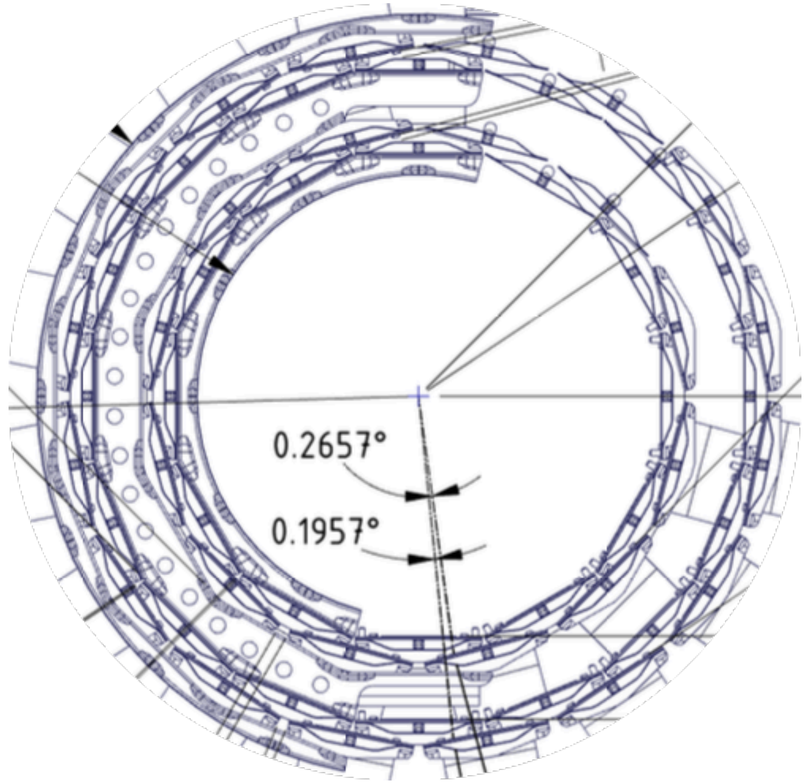
The length of **ladderext_volume** is overestimated (possibly mimicked to the peek region when designed)

INTT Geant4 original status - peek region

- Peek region: stack with stave peeks and metal support rings
- Geant4 approach: introduce the rings with different materials to mimic the reality
  - **Metal ring** for support structure & **CF (peek) ring** for stave peeks







Purple: metal

Grey: carbon fiber to mimic the stave peek

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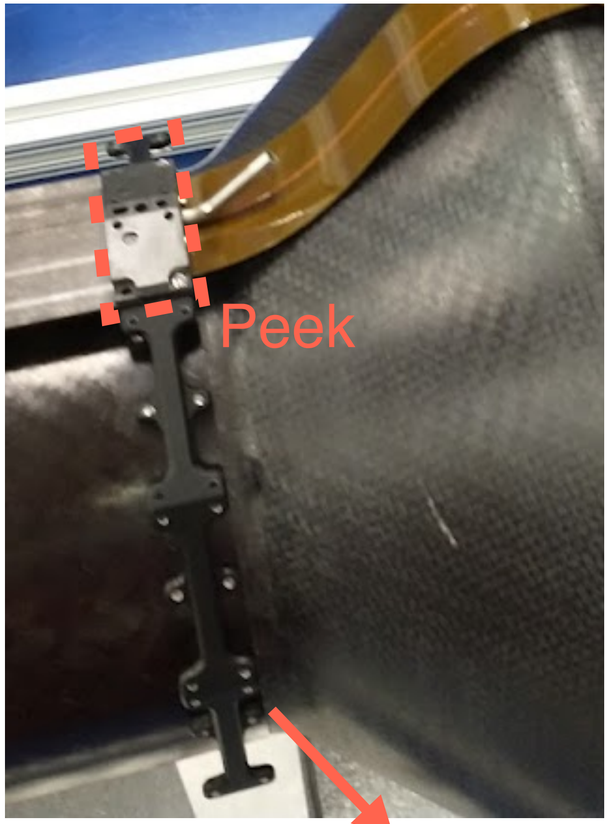

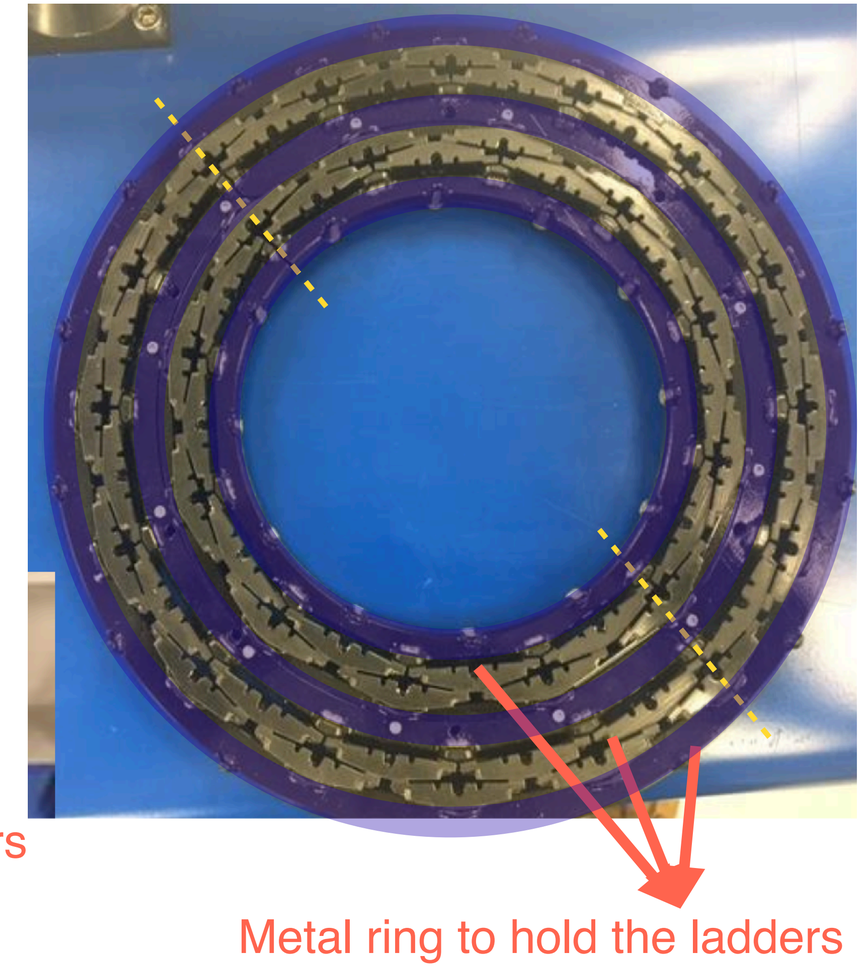

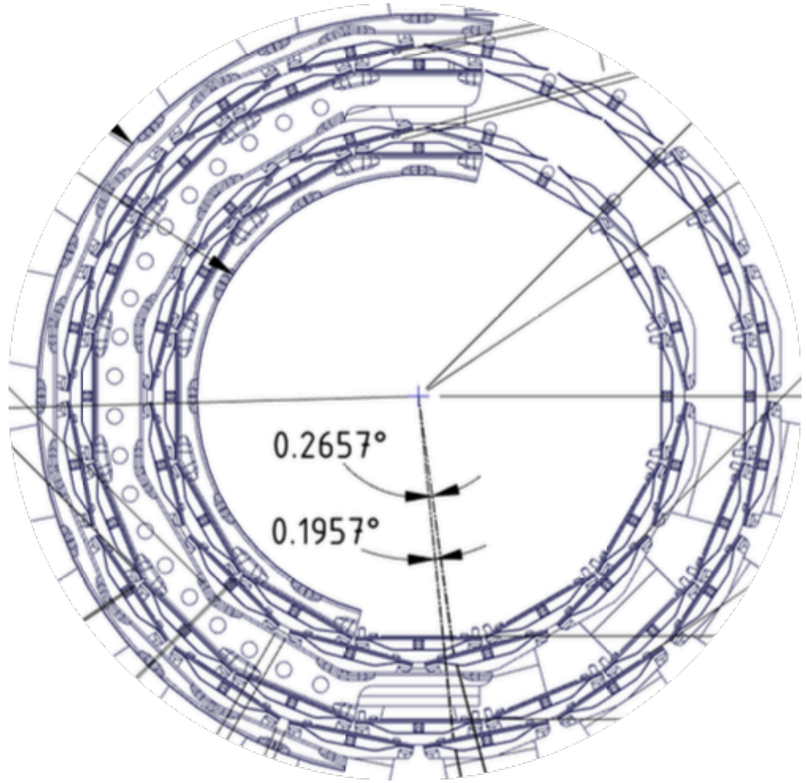

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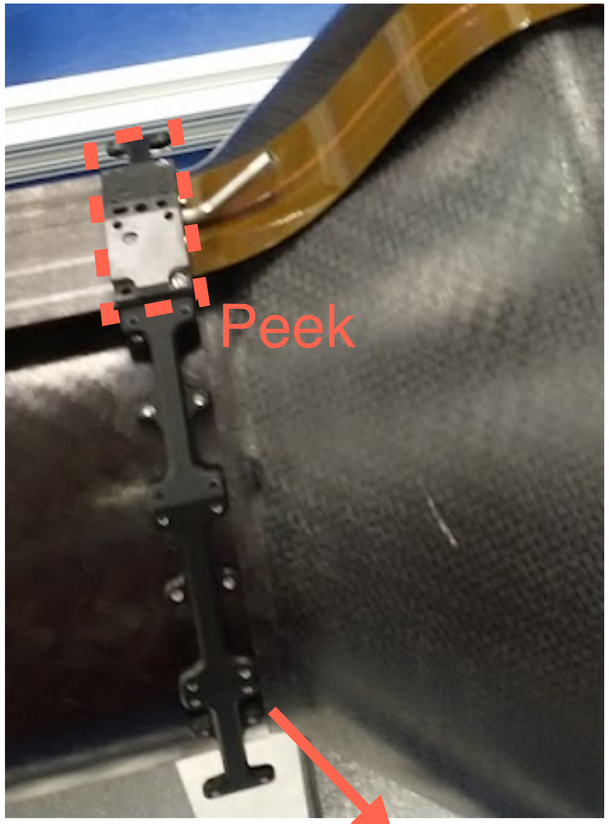

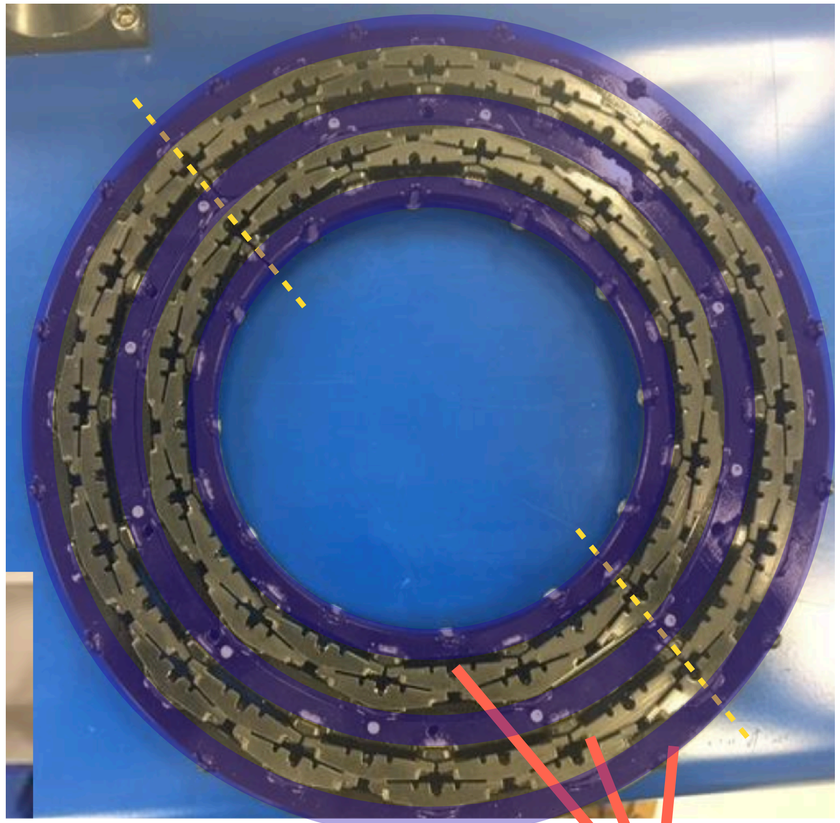

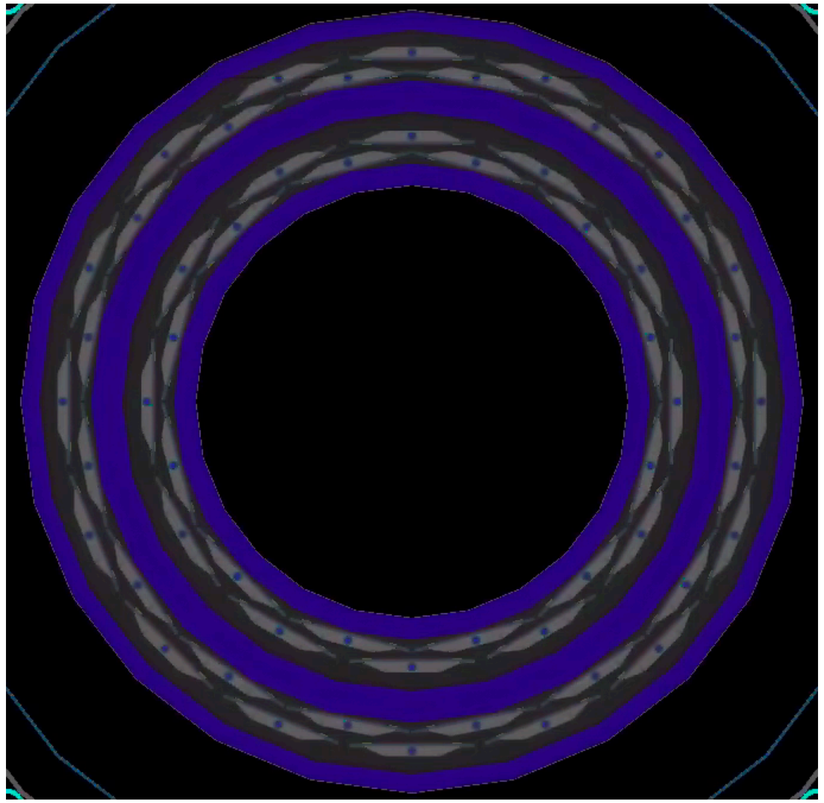

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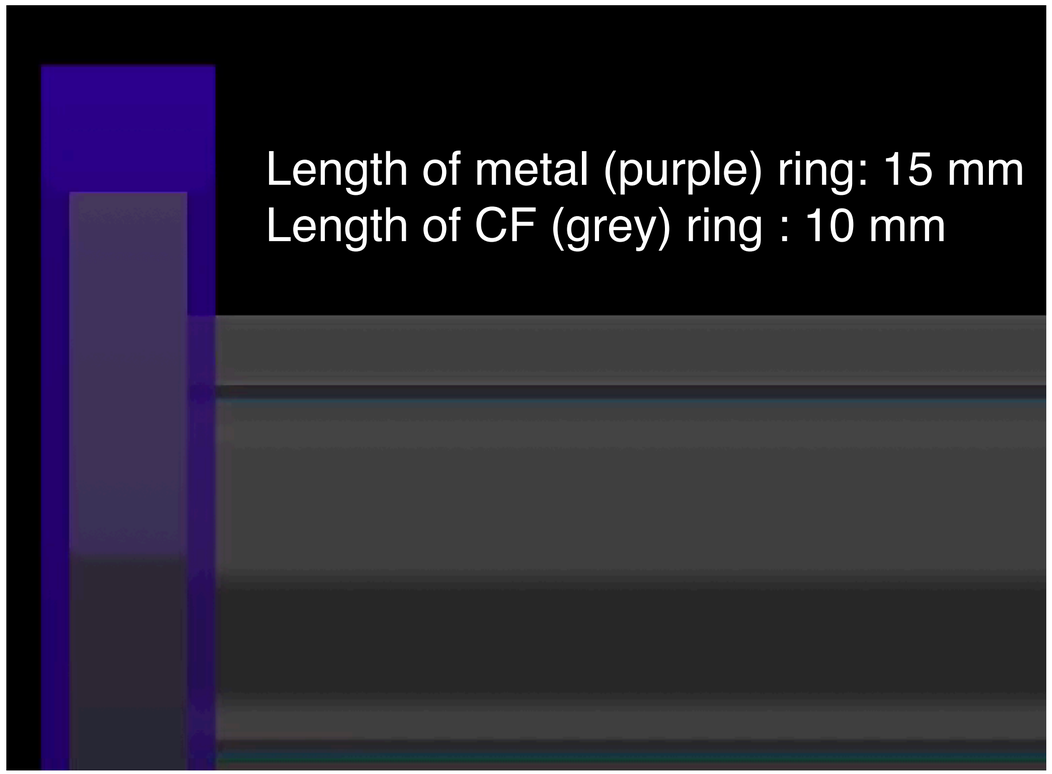


Ideal geo., ladders have no overlap with metal ring

Ladders may overlap with metal ring if the radius were changed

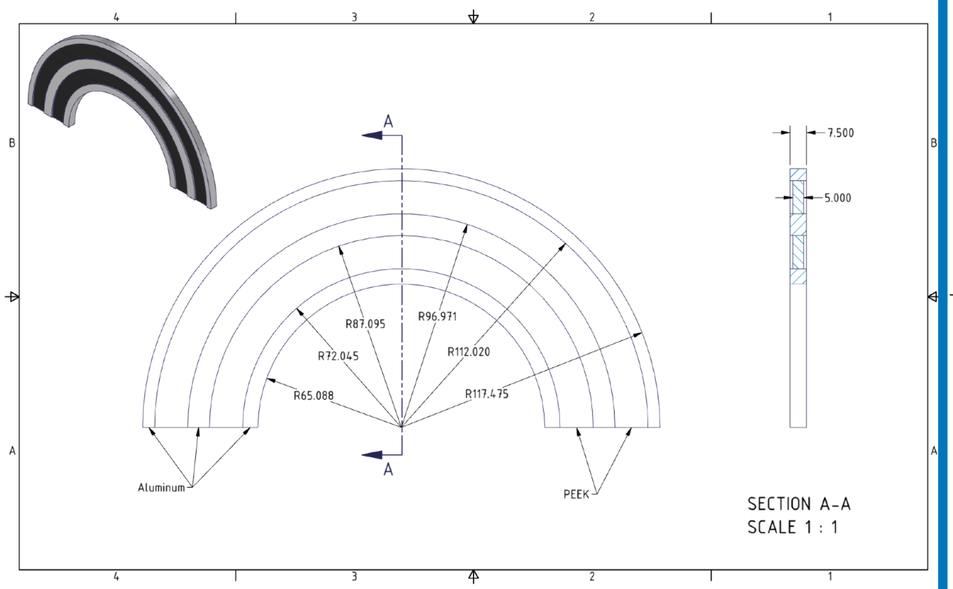
The simple-ring structure has to be optimized to cooperate with the survey geometry

More about the end ring

- Perfectly implementing the geometry of the peek region is not trivial
- The alternative is to take the total volume of metal/CF components into account, and mimic that region by the tube structure with the identical volume

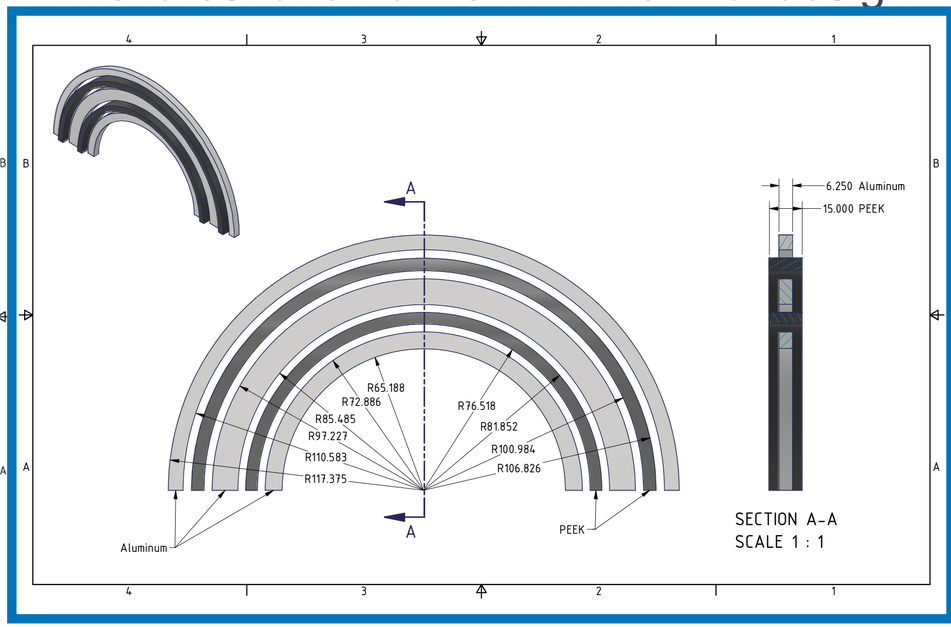
In the reality

The request 3 years ago



The length of metal ring is longer than CF ring

The latest alternative with the final design



The new structure in G4

Same material budget as the design

All designs made by Dan Cacace

The survey data

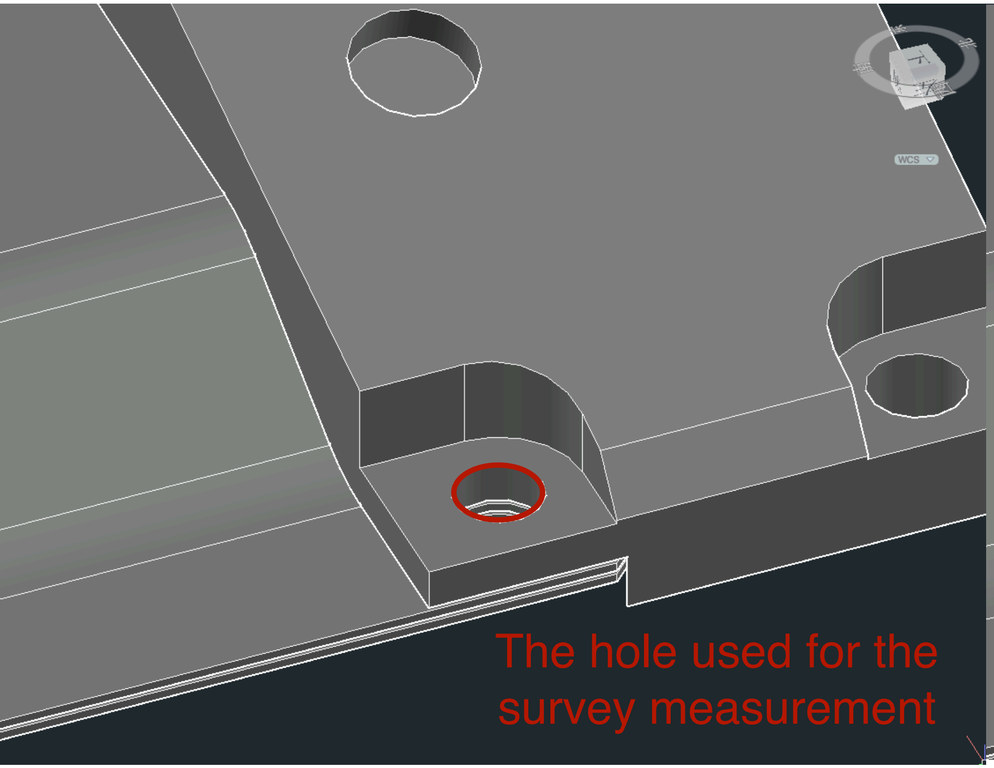
- The files provided by the survey group
  1. 4 sensor positions w.r.t. stave center for each ladder (measured by OGP in lab, 510)
  2. Ladder positions w.r.t. INTT half-barrel (measured by machine arm in lab, 510)
  3. Half-barrel positions w.r.t. sPHENIX coordinate (measured in IR, 1008)

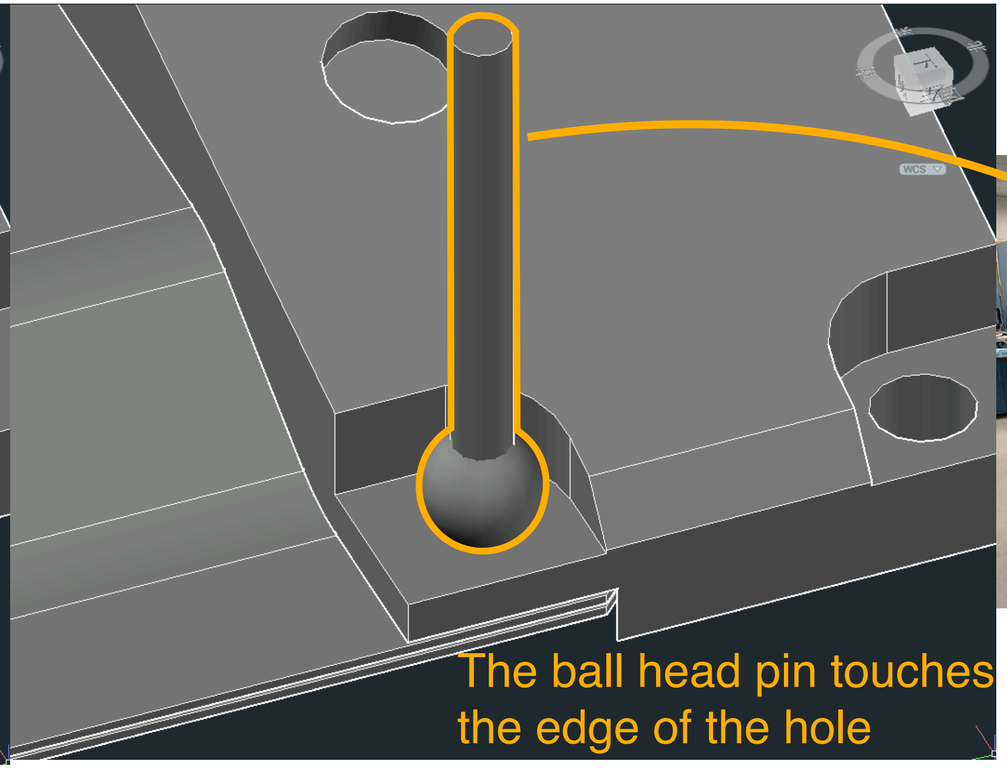
- Survey provided by Joseph can provide
  - Sensor position w.r.t. sPHENIX coordinate (224 sensors x 6 DoF, file 1+2+3)
  - Ladder position w.r.t. sPHENIX coordinate (56 ladders x 6 DoF, file 2+3)
    - Goal: reproduce the opening

- The modification of the survey data is necessary
  - The reference position can be different

How did people do the survey

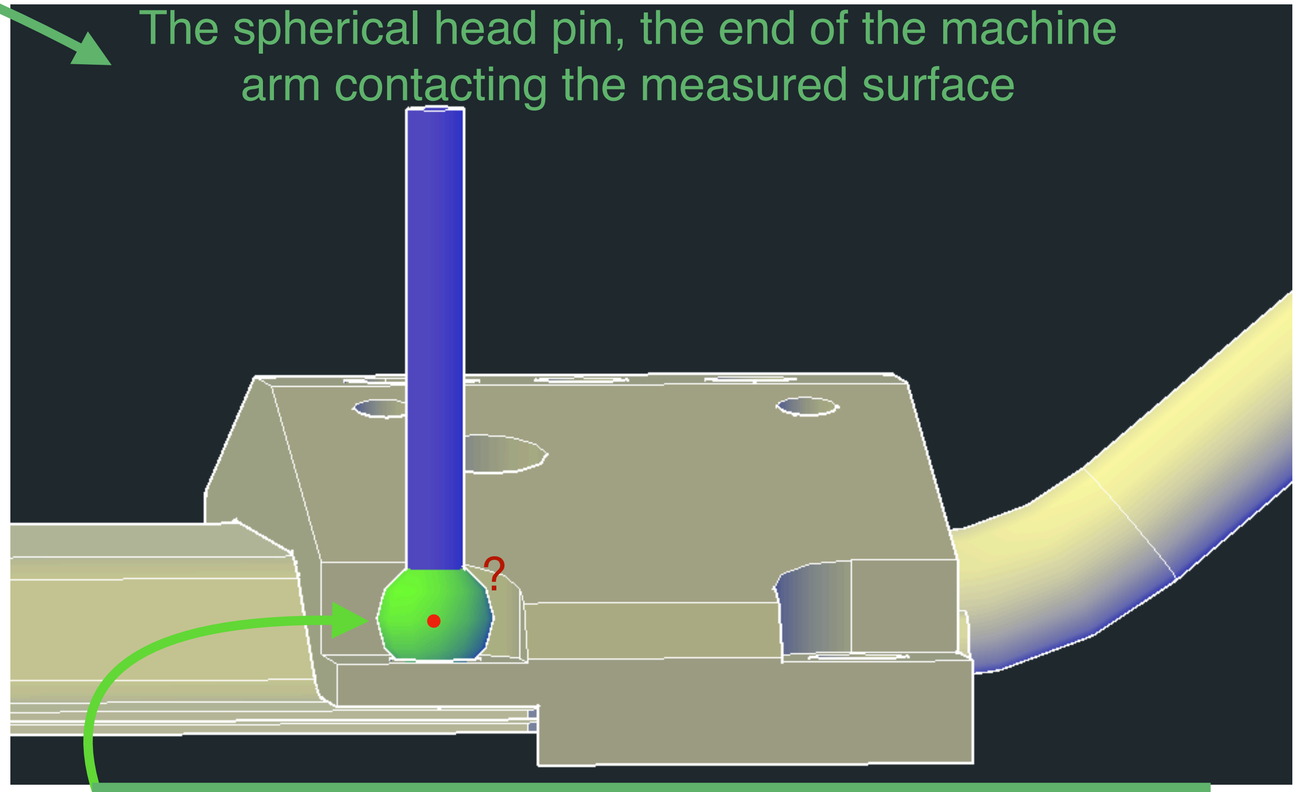
- For the survey measurements after putting the ladders on the INTT barrel supporting structure, survey group touched the hole of the stave peek by the **sphere head pin** of the machine arm

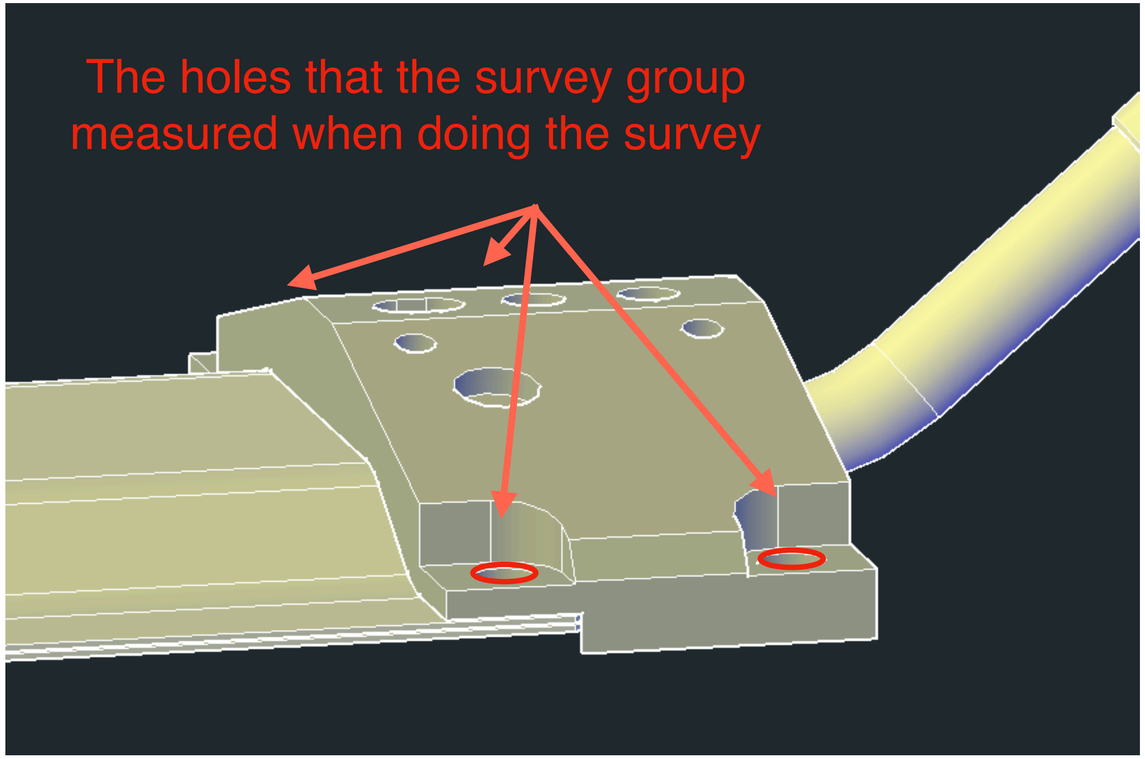




The machine arm

Questions to Rachid, waiting for reply



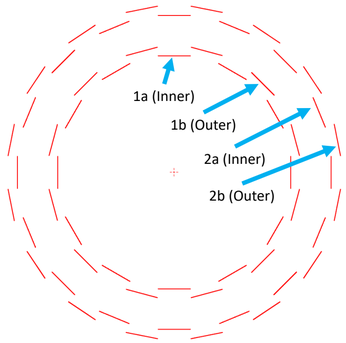


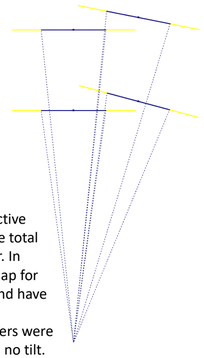
Q1 : What is the size of the sphere?
Q2 : Are the positions provided by the survey group the center of the spherical head?

Mail has been sent to Rachid → Rachid is not sure

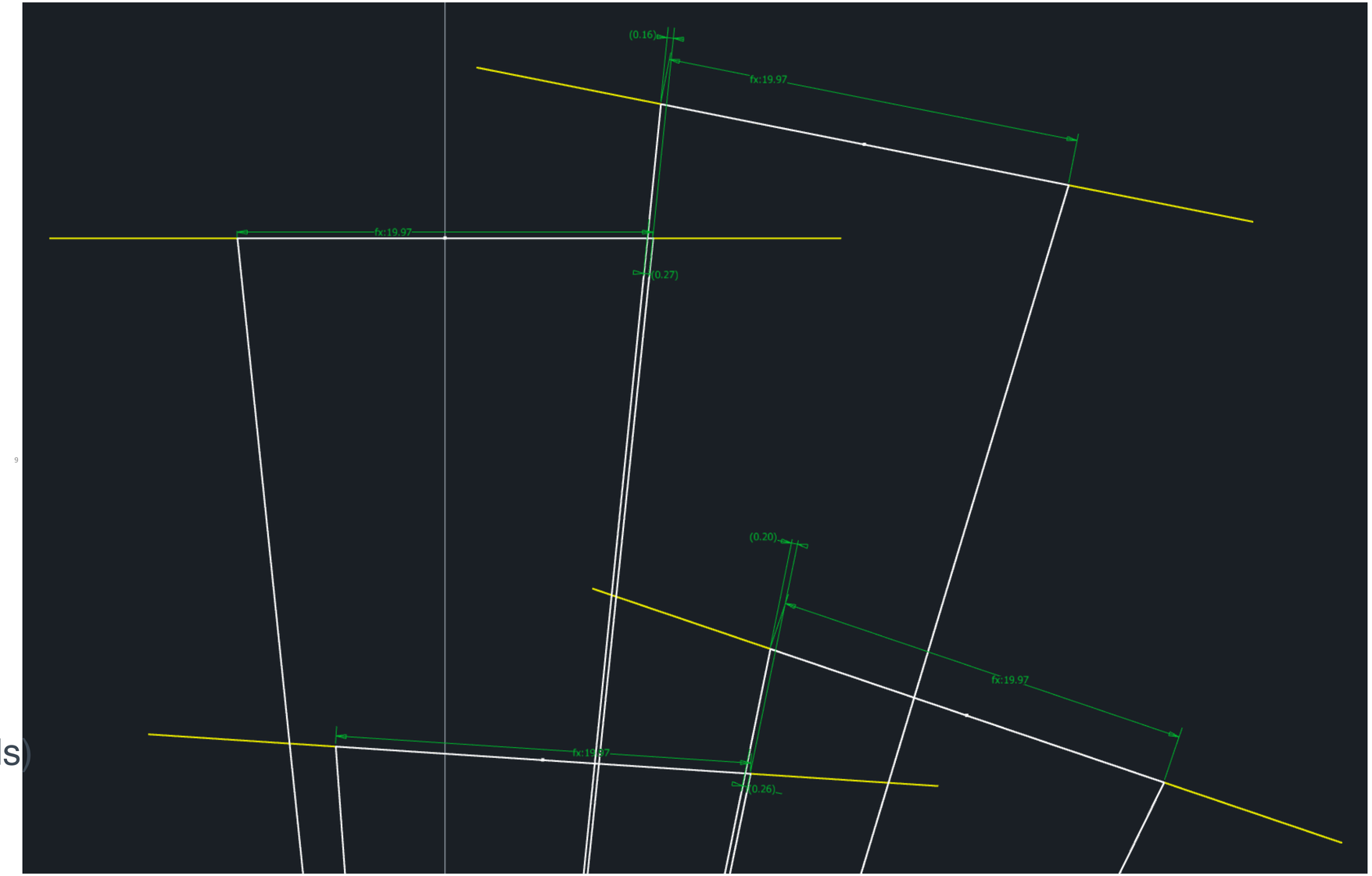
The following slides: assuming the position of contact planes are given

The area of overlap b/w ladders





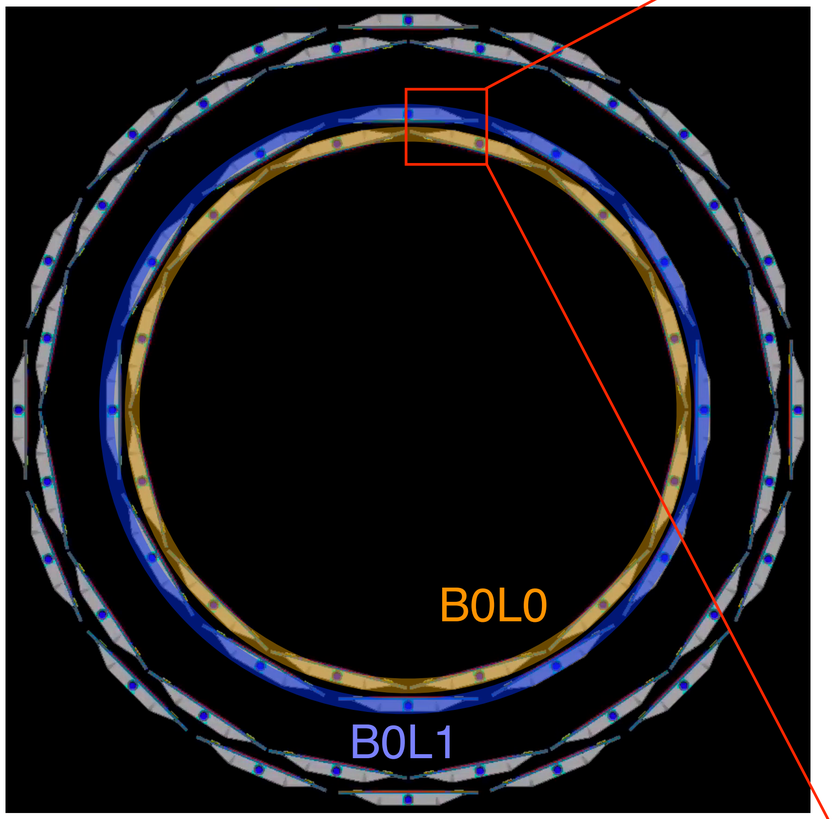
The width of the active area is 52.6% of the total width of the ladder. In order to have overlap for full PHI coverage and have a reasonable stave thickness, the ladders were stager radially with no tilt.

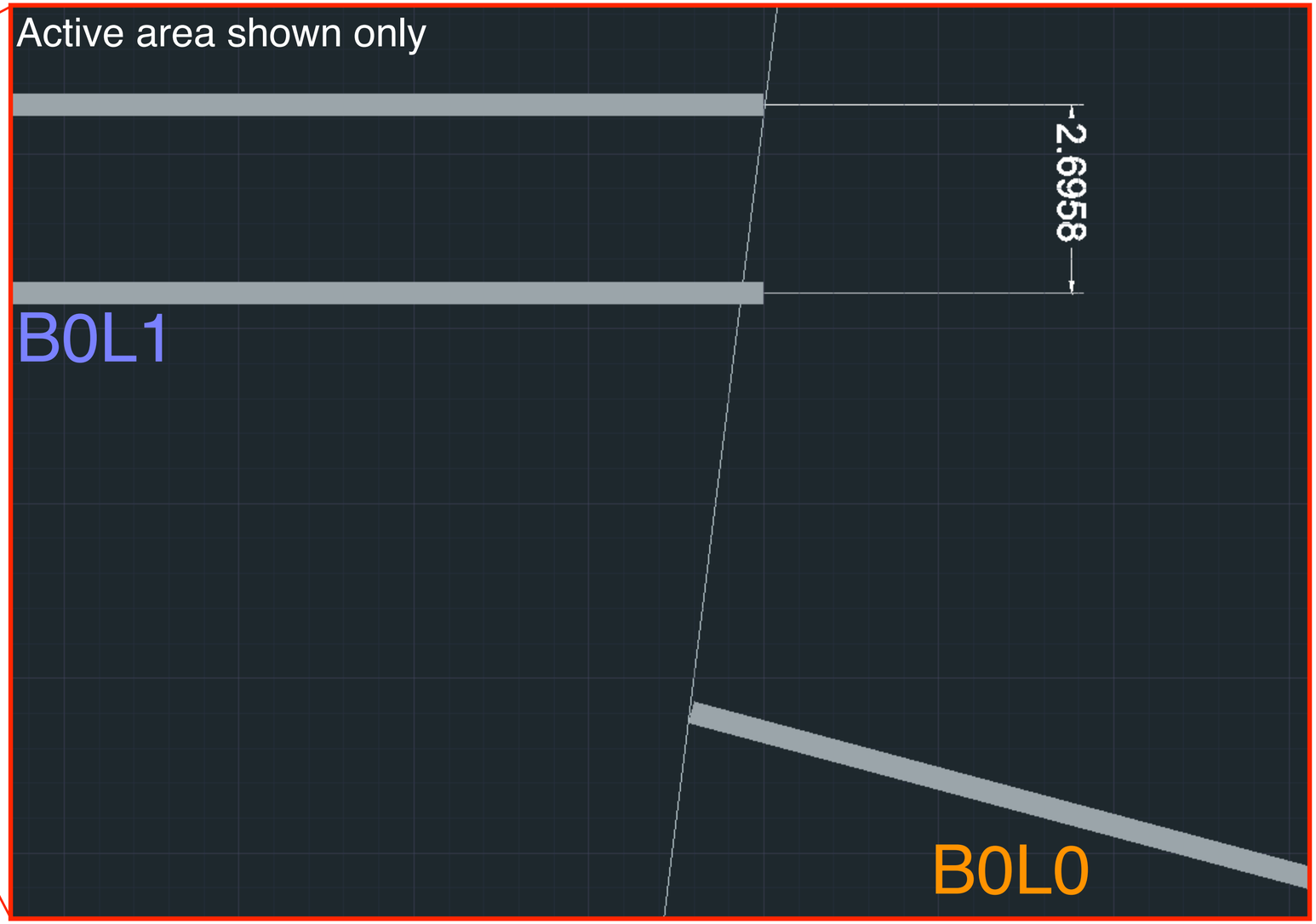


Overlaps:
about 0.20 degree in ϕ (inner barrel)
about 0.16 degree in ϕ (outer barrel)
(an overlap of 0.25 mm for both barrels)

The correction may have to be treated carefully as the overlap between is small

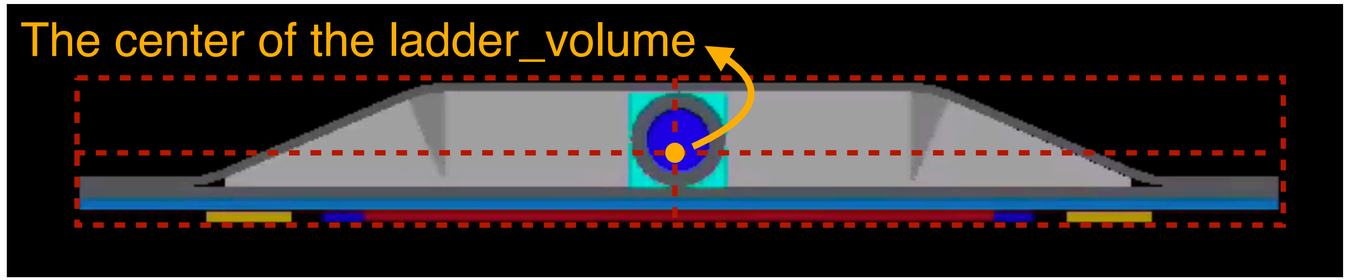
The tolerance of correction inaccuracy ?





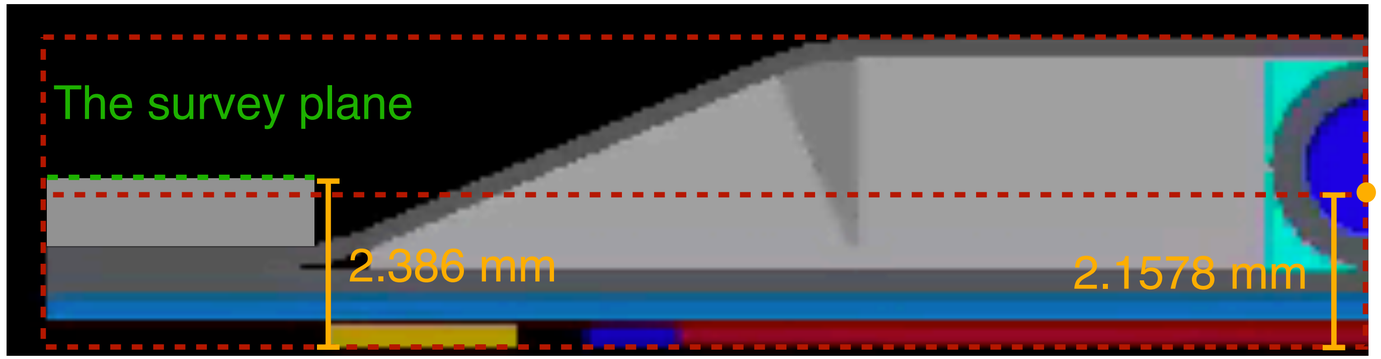
The overlap b/w ladders can be preserved if the correction doesn't over/under-correct the radius more than ~ 2 mm

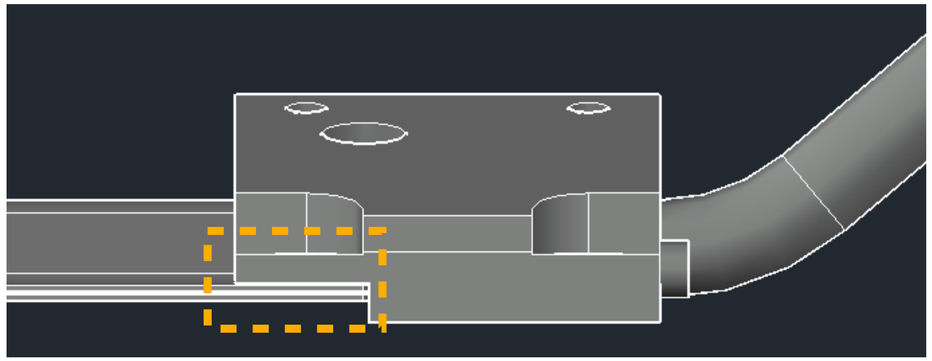
New correction in radius (ladder to sPHENIX coord.)



The expected ladder_volume
- the sensor surface and the surface of the backside of stave are attaching to the ladder_volume box

- In G4, sensor center position in the ladder_volume: 1.9978 mm
- Half of sensor thickness: 0.32 / 2 = 0.16
- Thickness of ladder_volume: (1.9978 + 0.16) x 2 = 4.3156 mm
- Distance b/w the survey plane and the sensor surface: 1.62 + 0.432 + 0.014 + 0.32 mm = 2.386 mm
  → **Correction in radius : 2.1578 - 2.386 = -0.2282 mm**



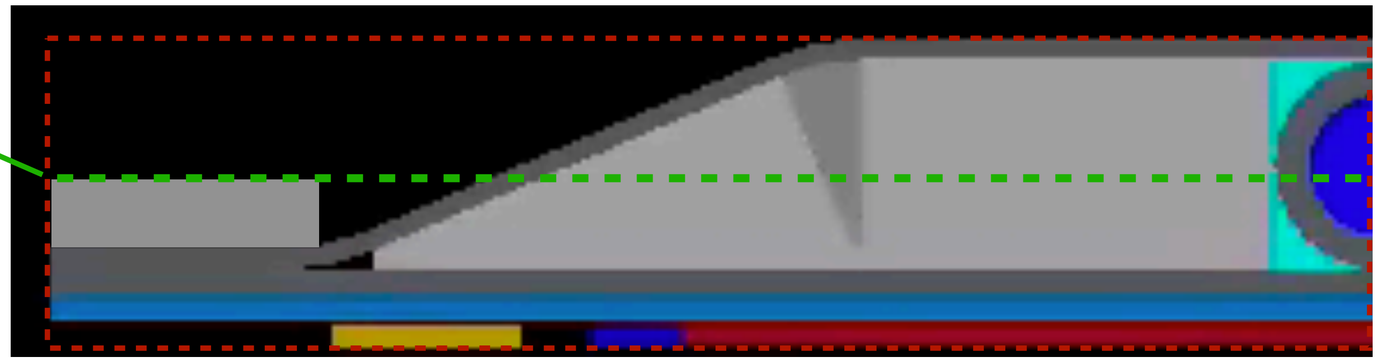


This is the correction for implementing the survey data (ladder pos. w.r.t. sPHENIX coordinate) in the Geant4 only
For the cases of implement the survey data (sensor pos. w.r.t. sPHENIC coord.) and data local to global coord. transformation, that would be different story

Direction of the correction

ONLY for the case of implementing the survey data (ladder to sPHENIX coordinate) to Geant4

The position provided by survey



If we place the ladders by the positions given by the survey data, the ladders will have larger radius than expected
Therefore, the correction should be **0.2282 mm inward**

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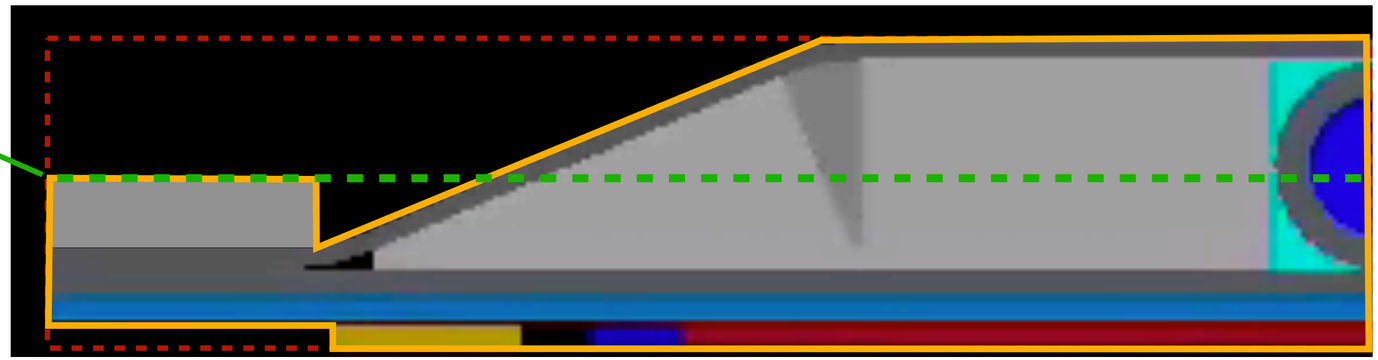

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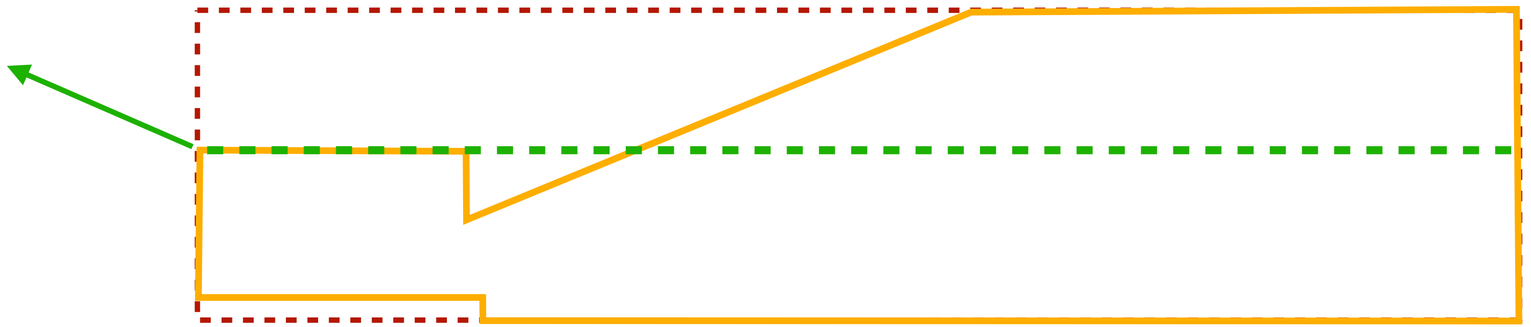

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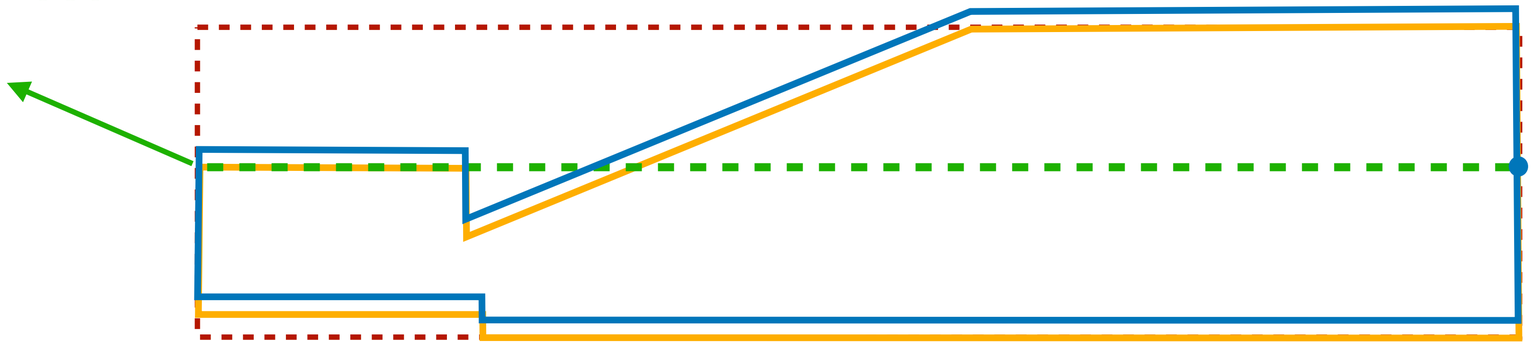

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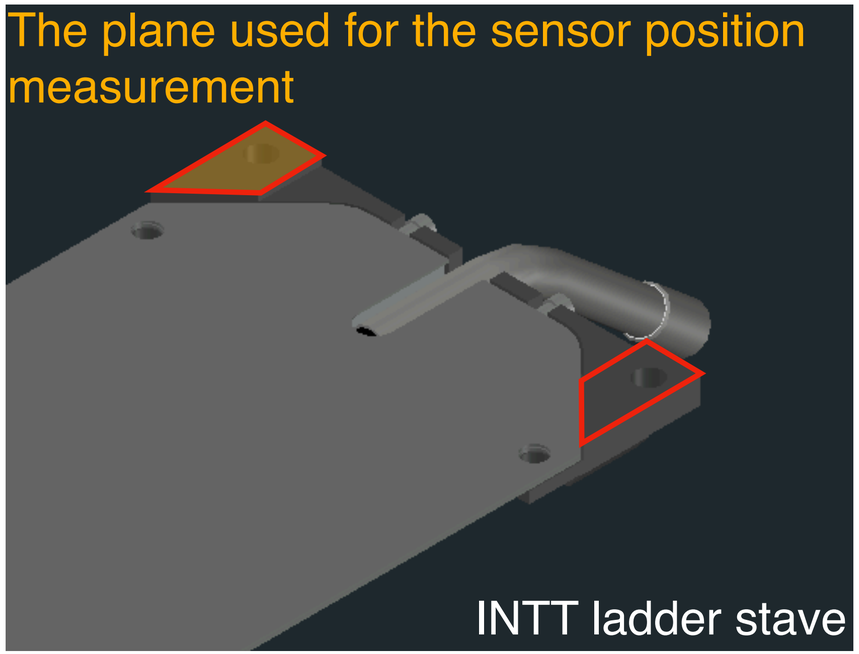
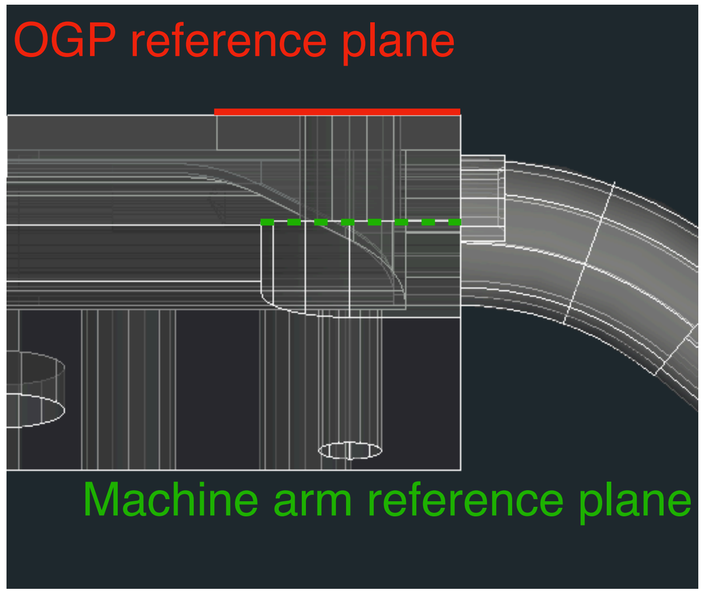
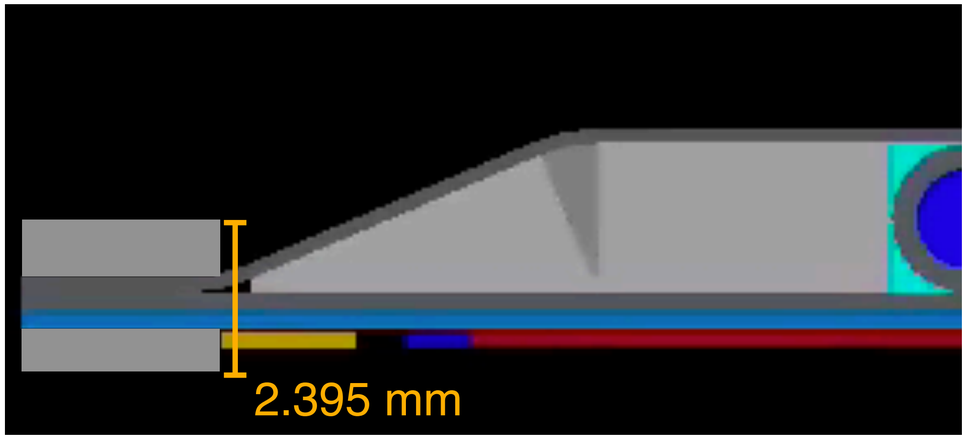
Another correction

- The correction for full survey data (sensor to sPHENIX coord.) used in “data” clustering (local to global transformation)
- The correction : 2.395 mm inward

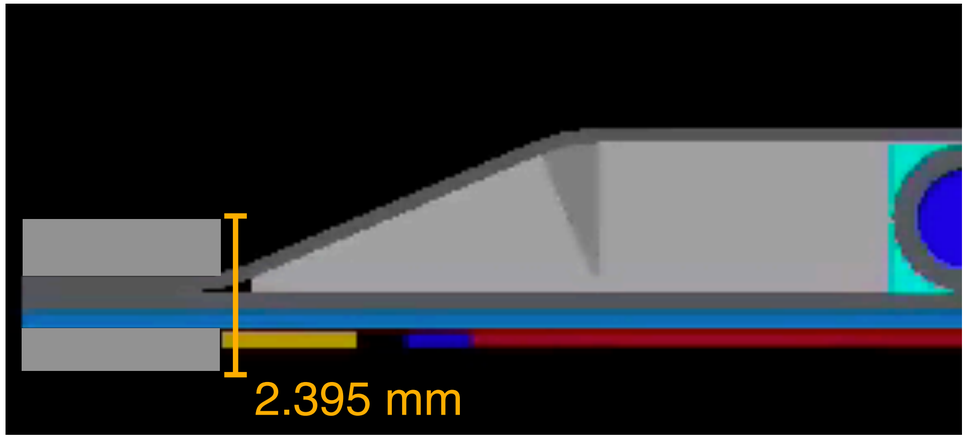






The direction of another correction

- The correction for full survey data (sensor to sPHENIX coord.) used in “data” clustering (local to global transformation)
- The sensor radius will be larger if we apply the sensor-position survey on the ladder-position survey
- The correction : 2.395 mm inward



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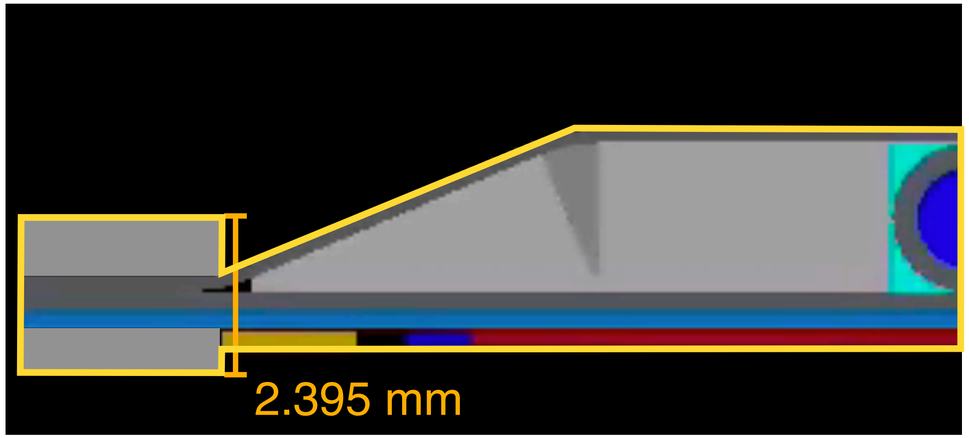

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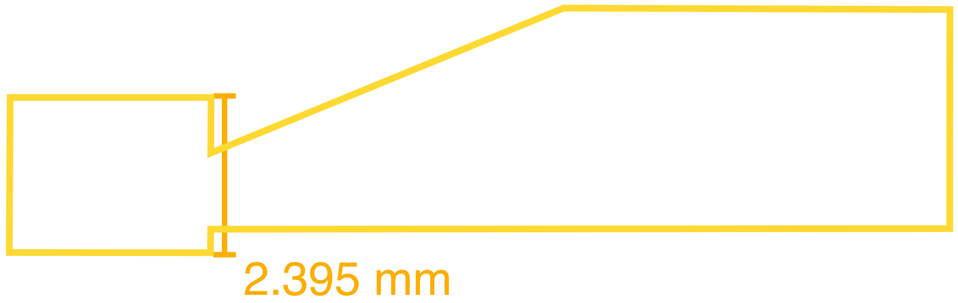

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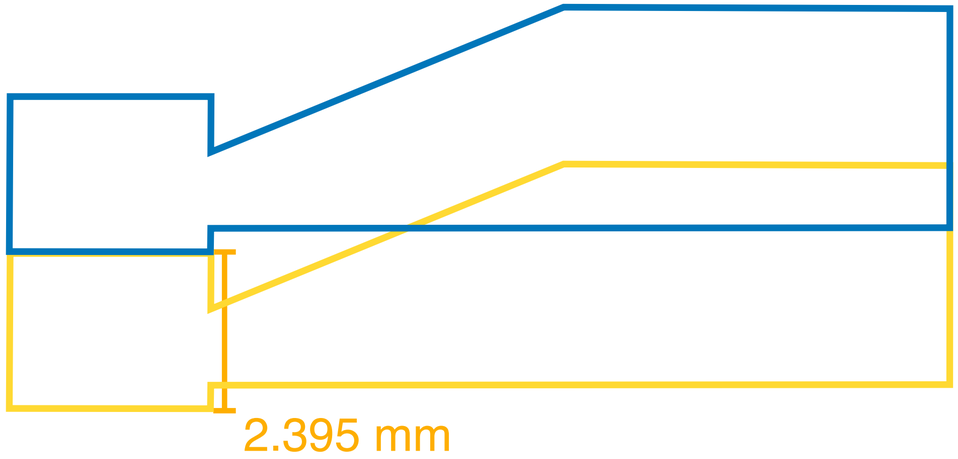
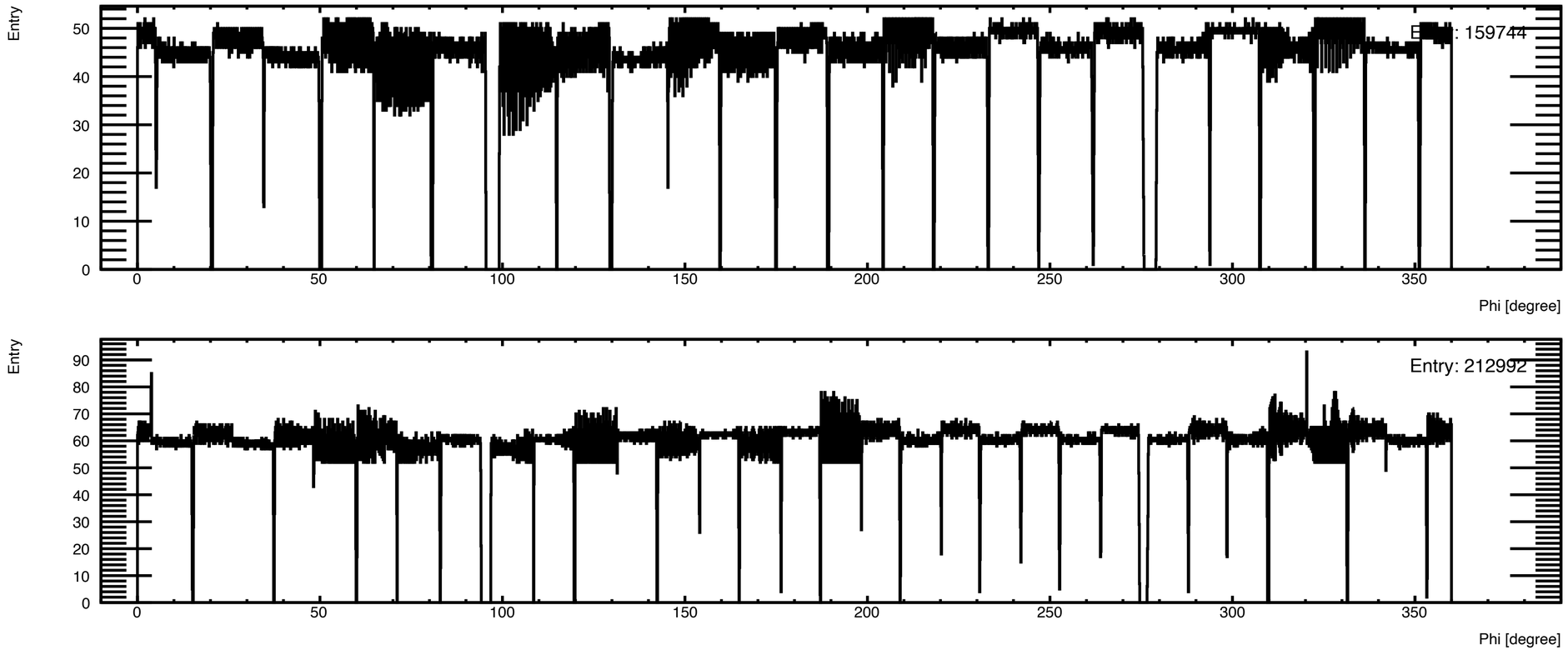


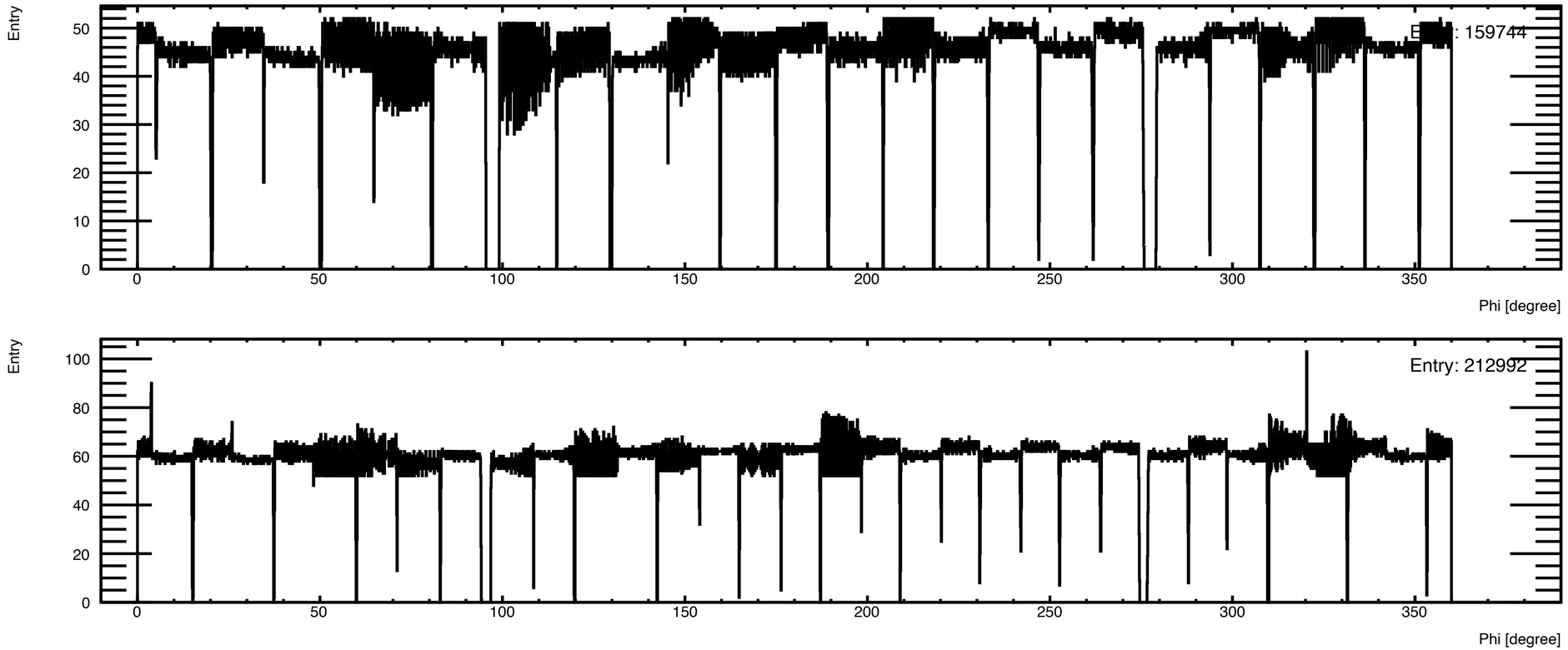
Study the survey data - zero correction

- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of all the INTT channels were filled



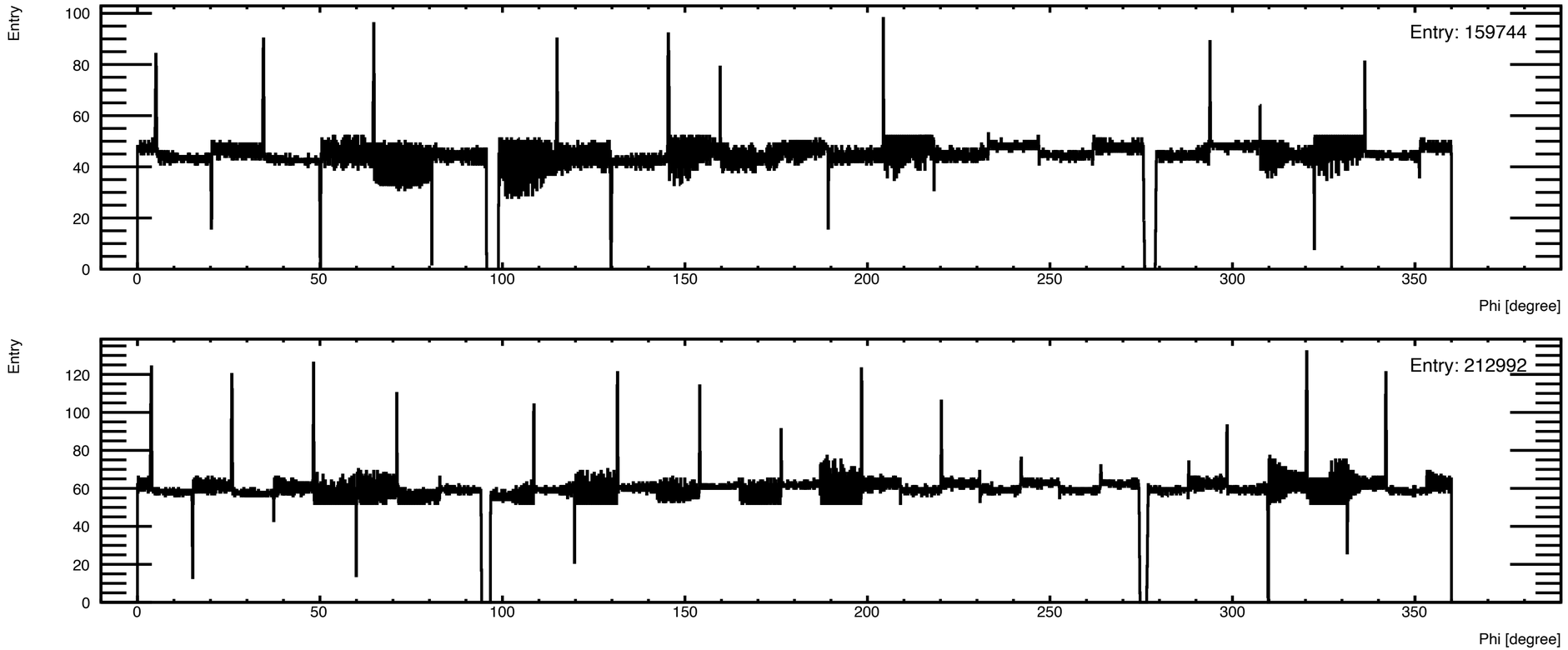
Study the survey data - 0.2282 mm inward

- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of all the INTT channels were filled
- Correction for implementing the survey ladder position in Geant4



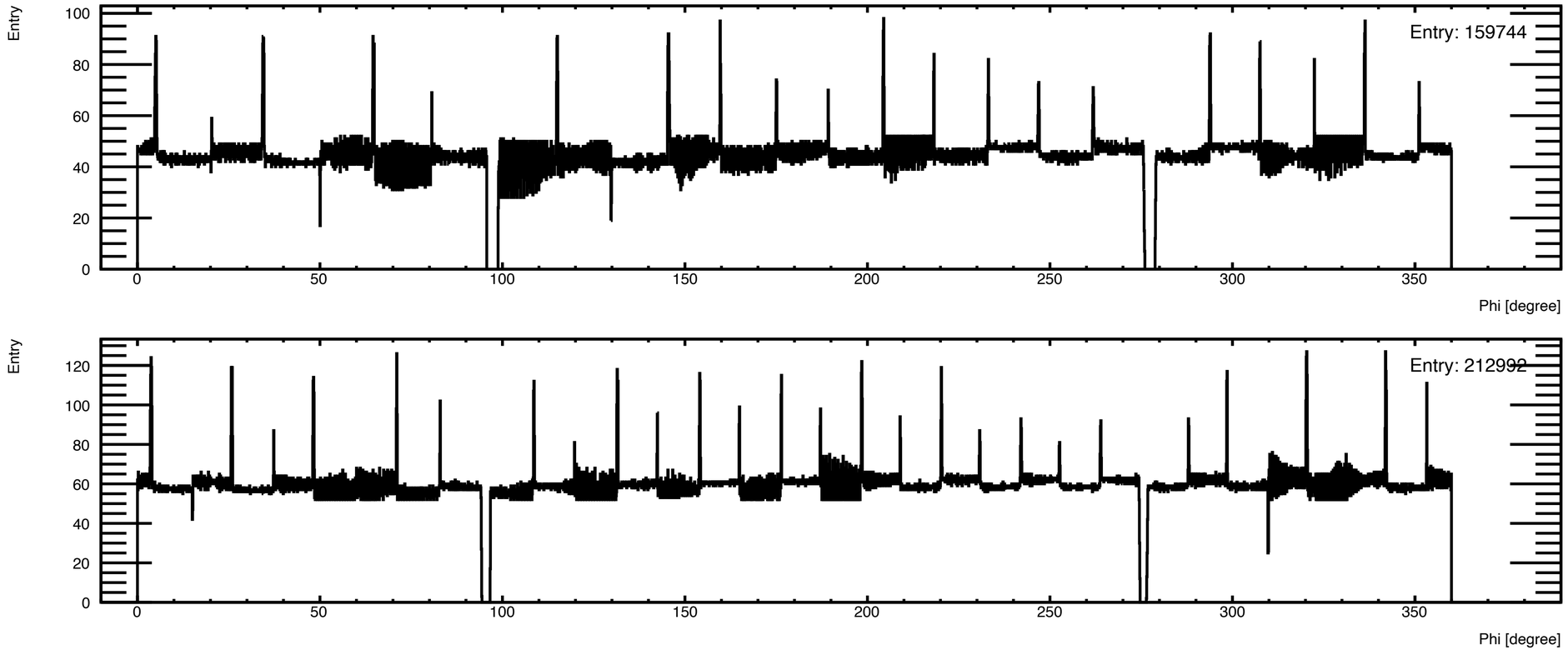
Study the survey data - 2.395 mm inward

- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of all the INTT channels were filled
- Correction for **data** clustering (local to global coordinate transformation), correction based on the peek thickness



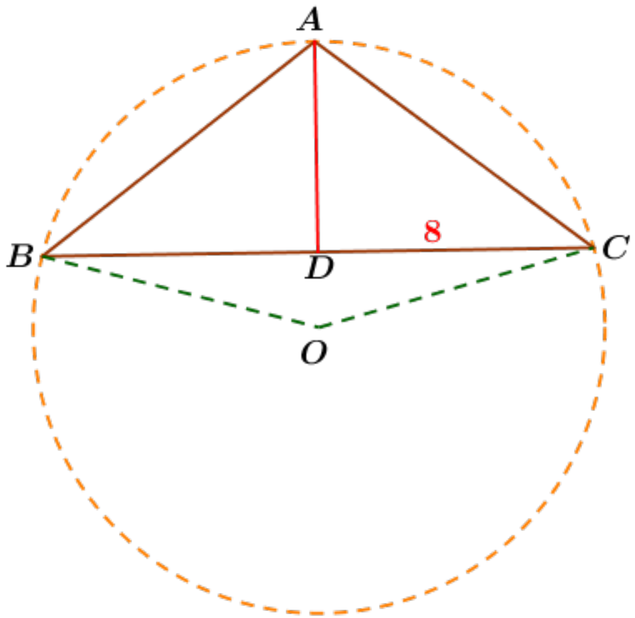
Study the survey data - 3.32 mm inward

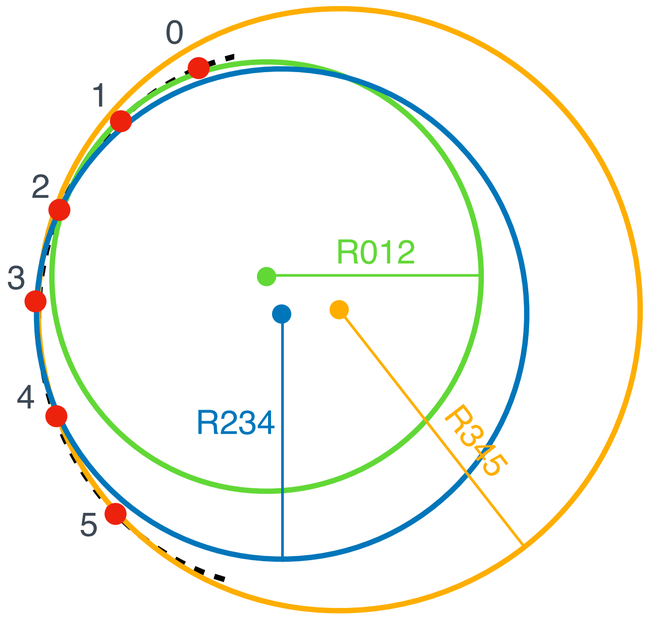
- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of all the INTT channels were filled
- Correction for **data** clustering (local to global coordinate transformation), correction forces the survey to align the ideal sensor radii



Survey data check

- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- Survey ladder radii check: diagnostic tool
- ΔABC by Heron's formula ($\sqrt{s(s-a)(s-b)(s-c)}$, $s = (a+b+c)/2$)
- Circle radius = (a * b * c) / (4 * ΔABC)
- Each three-ladder pair tells one radius → $C_3^6 = 20$ and $C_3^8 = 56$

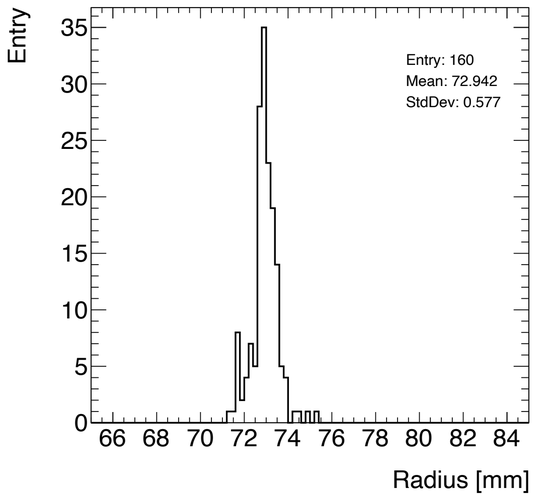


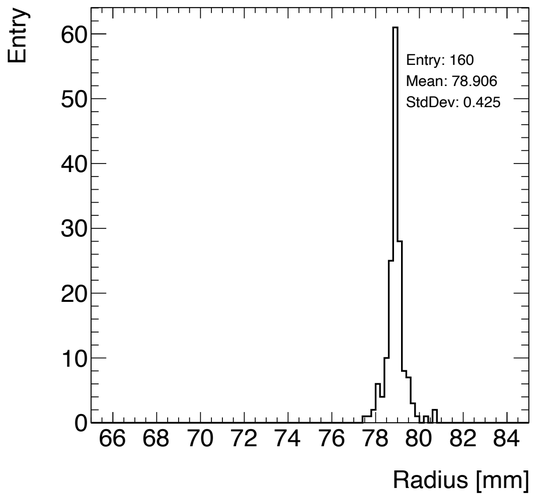


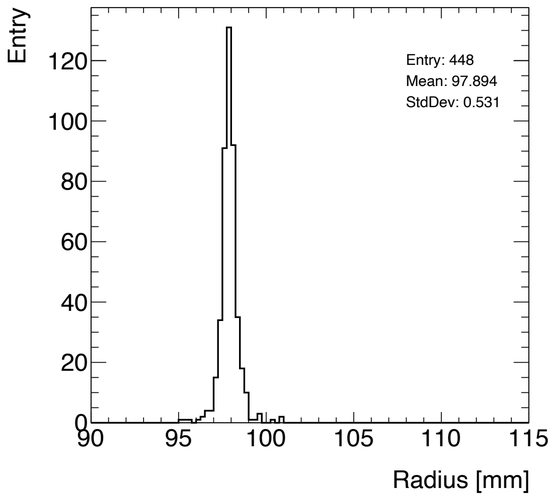
Assume an elliptic shape of INTT semi sublayer

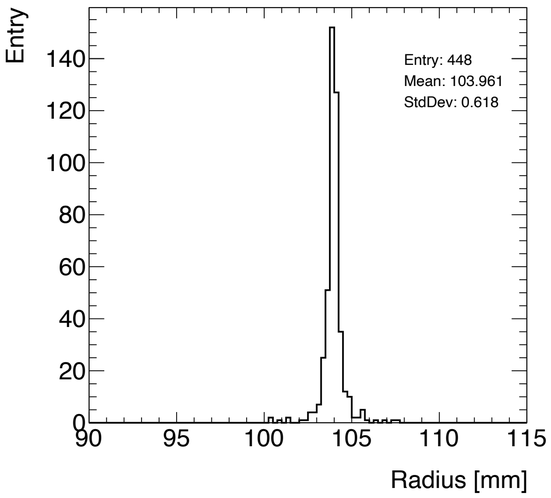
Study the survey data - 2.395 mm inward

- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of **sensors** were used in the radius calculation
- Correction for **data** clustering (local to global coordinate transformation), correction based on the peek thickness





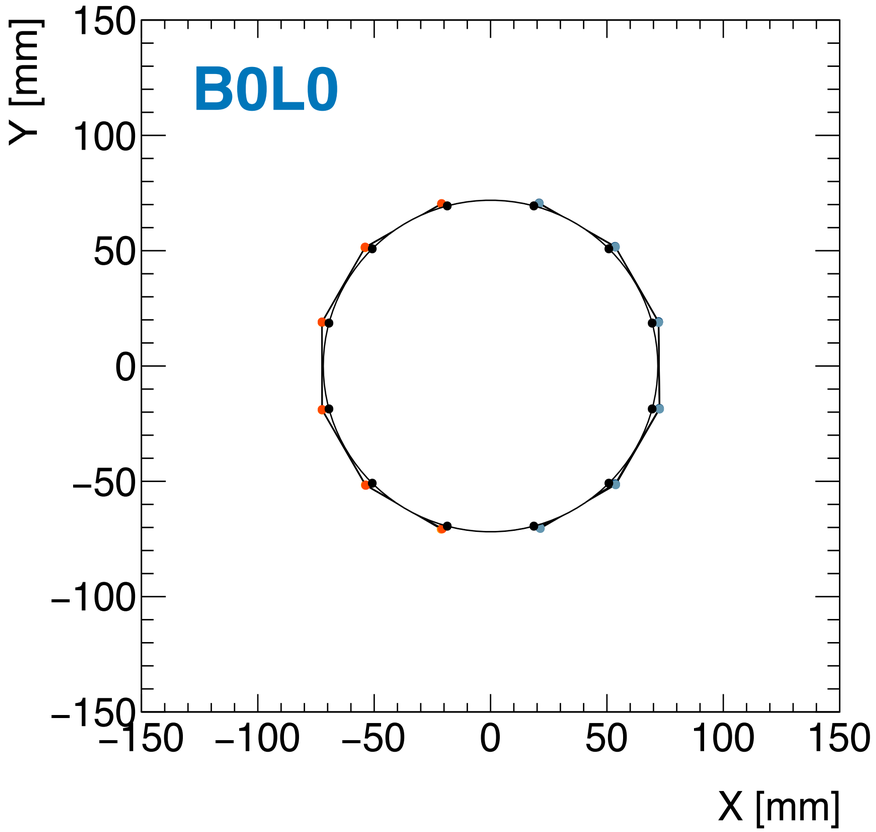


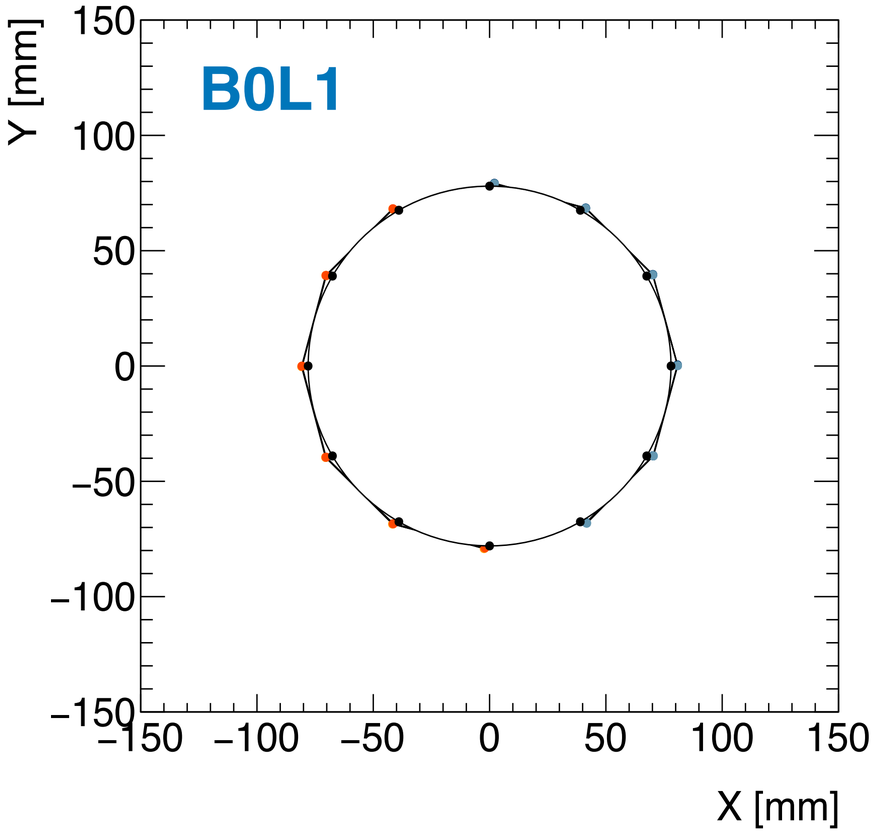


~ 1 mm larger than the ideal geometry

Study the survey data - 2.395 mm inward

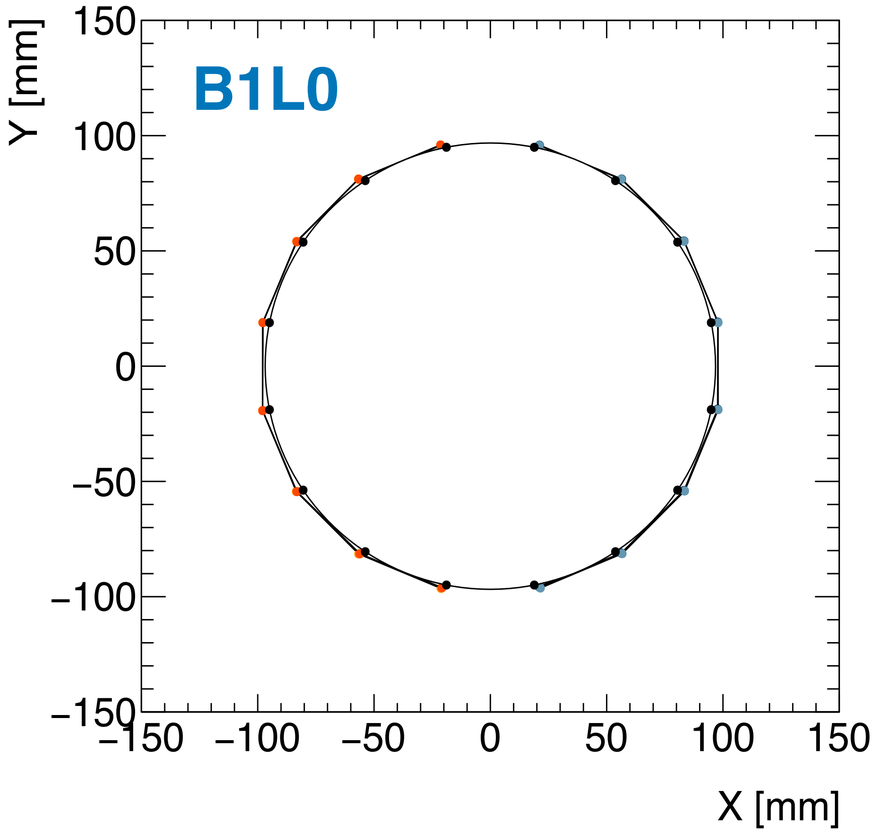
- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of **sensors** were shown
- The circles : sensor positions of ideal geometry

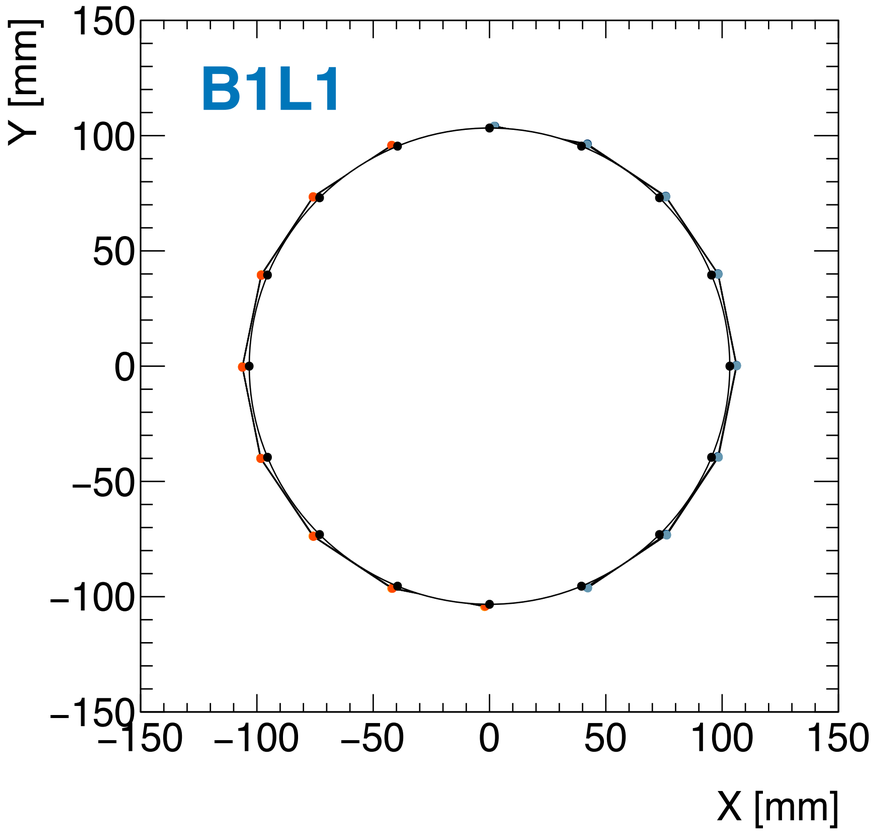




Study the survey data - 2.395 mm inward

- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of **sensors** were shown
- The circles : sensor positions of ideal geometry

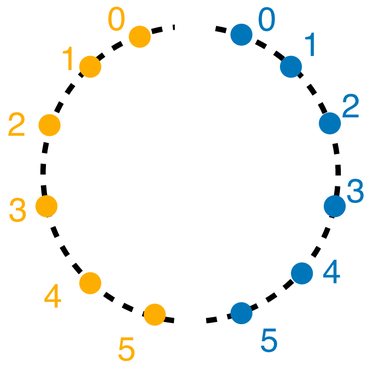




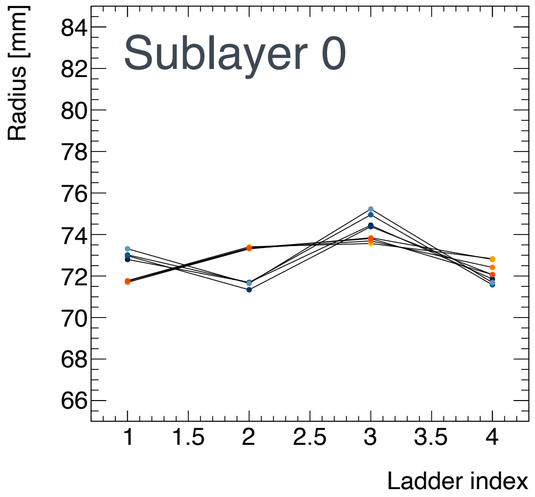
Study the survey data - 2.395 mm inward

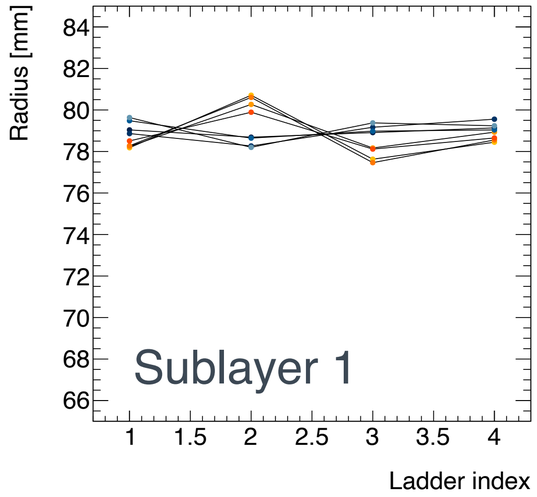
- Ideal sensor radii: 71.88, 78.00, 96.80 and 103.30 mm (given by Dan Cacace)
- The positions of **sensors** were used in the radius calculation
- Correction for **data** clustering (local to global coordinate transformation), correction based on the peek thickness

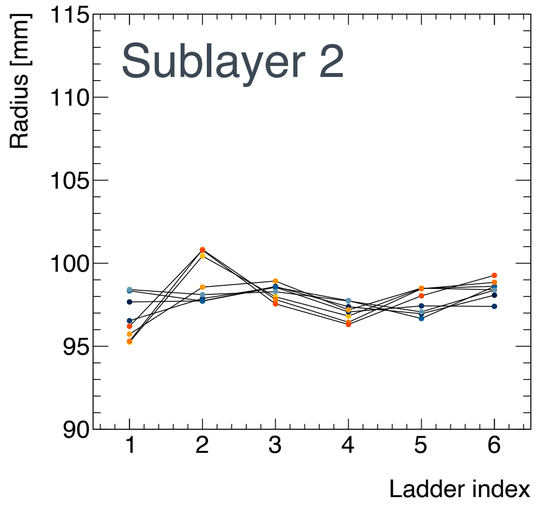
Question: are the INTT half sublayers still a round shape or elliptic shape ?

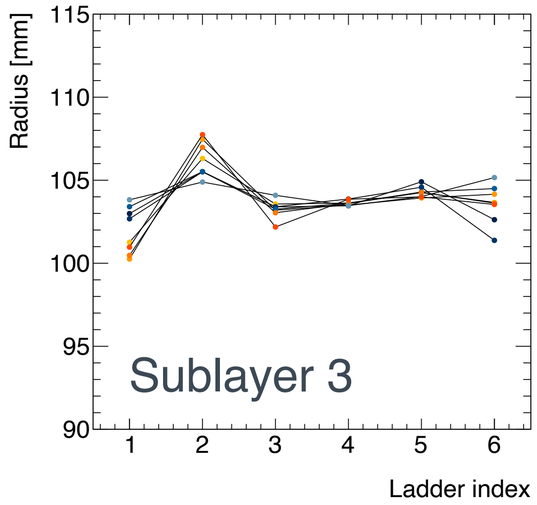


Ladder index 1 = R012
Ladder index 2 = R123
Ladder index 3 = R234







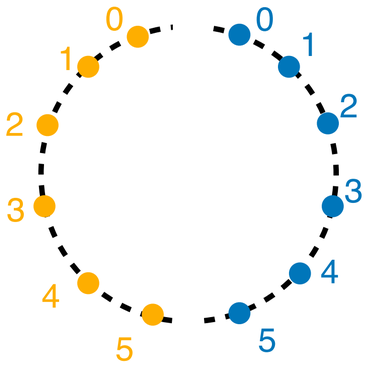


The half-barrels more and less seem to be round shapes

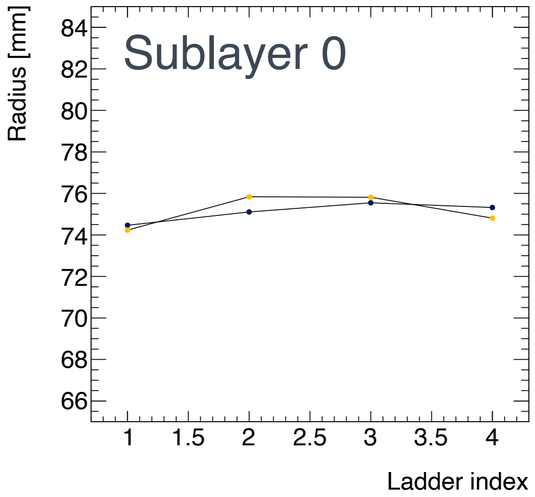
Study the survey data - 0.2282 mm inward

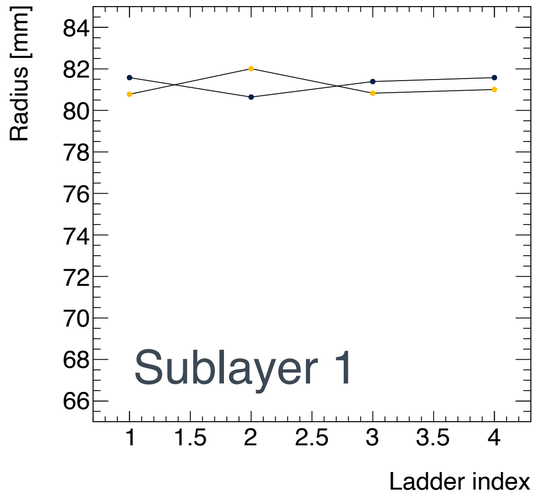
- The positions of **ladders** were used in the radius calculation
- Just want to see the relation, should have similar dependency with the sensor one

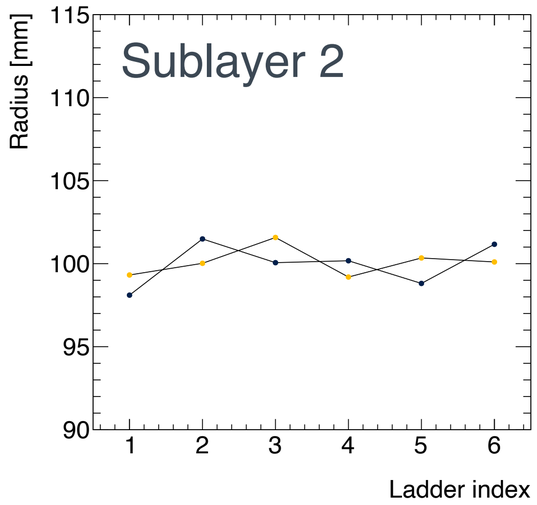
Question: are the INTT half sublayers still a round shape or elliptic shape ?

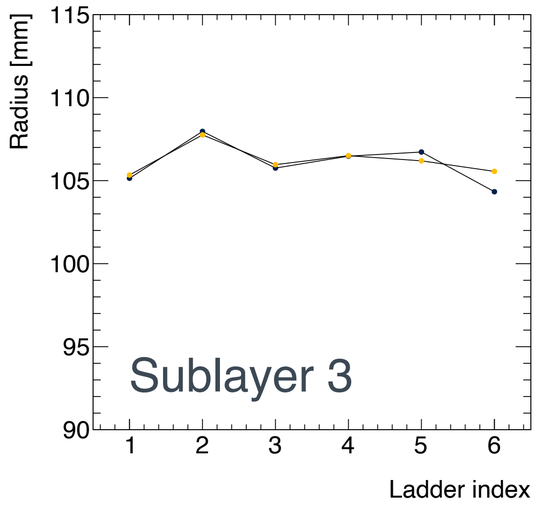


Ladder index 1 = R012
Ladder index 2 = R123
Ladder index 3 = R234





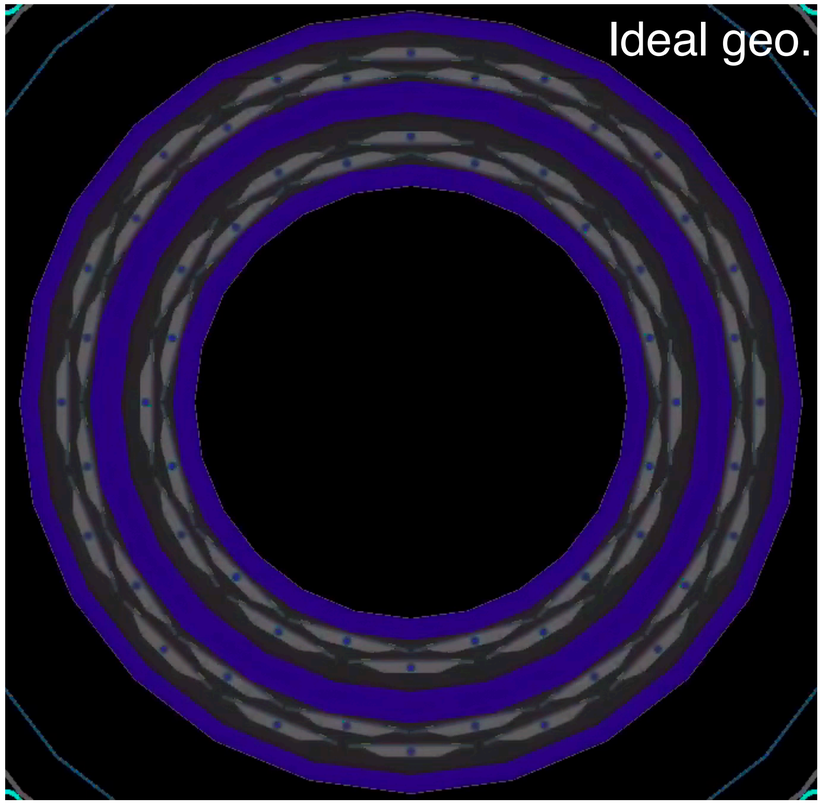


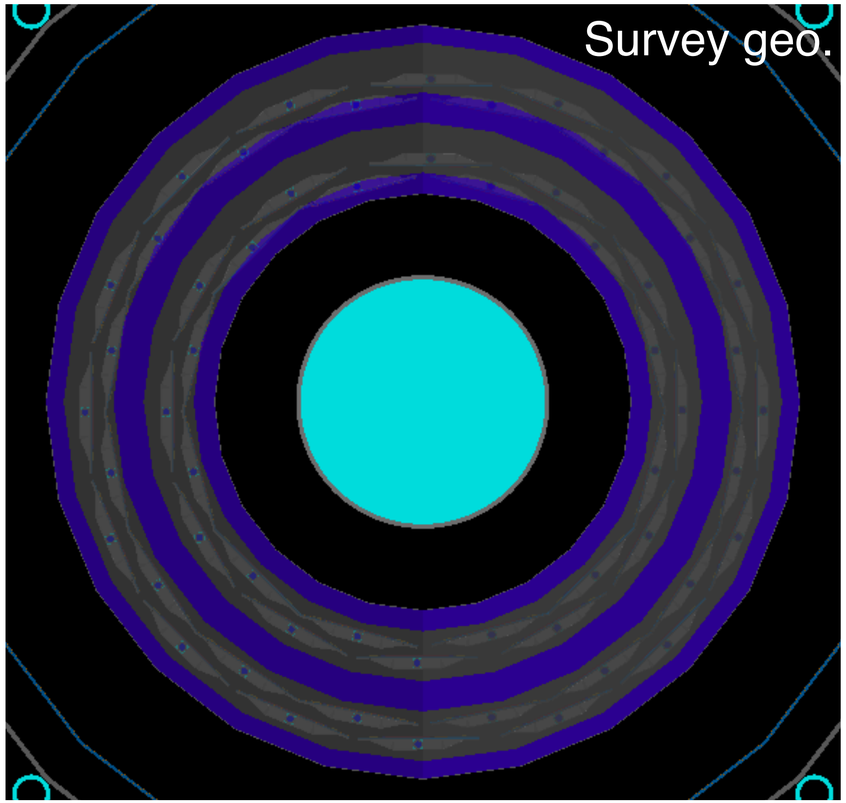


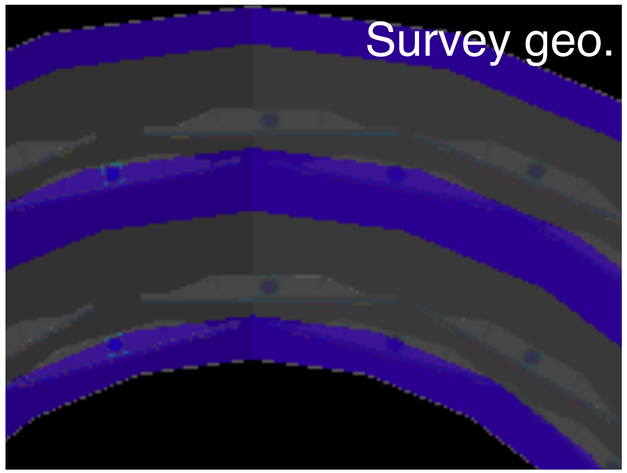
The half-barrels more and less seem to be round shapes

Position XY offset

In G4, the pos. XY of **end ring**, **CF ladder skin**, **BEX tube** and **outer CF support** are used to be at (0, 0)
It looks like the whole ladder barrel is shifted downward a little bit





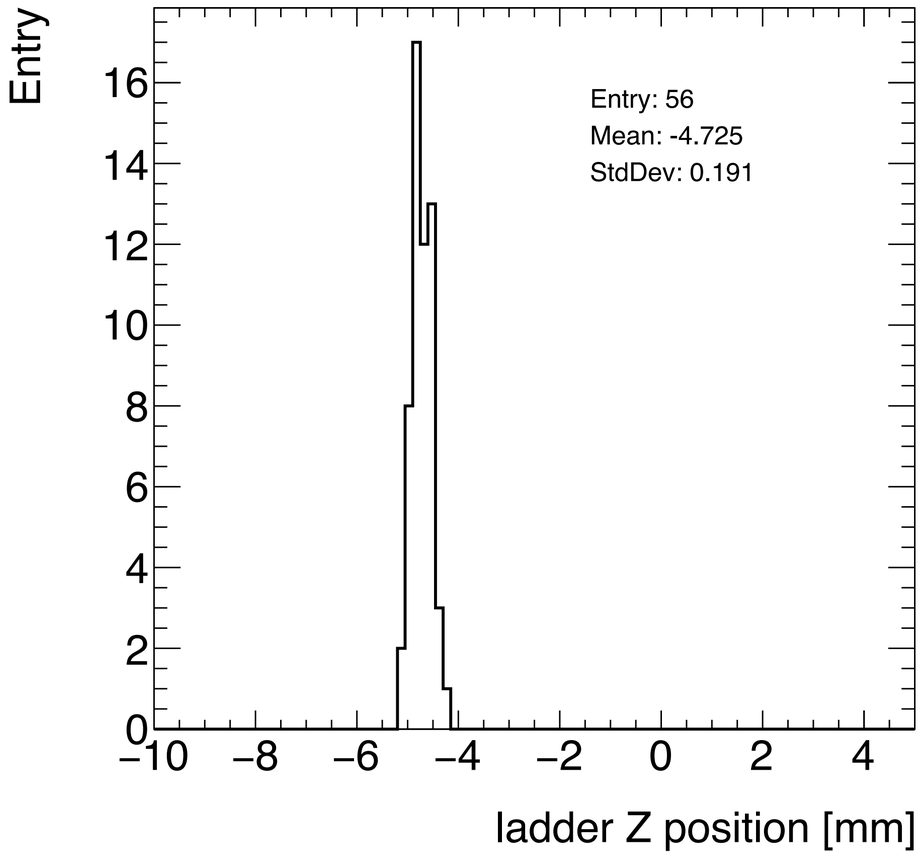


The position XY for the INTT infrastructure has to be modified accordingly

For the survey with 0.2282 mm inward correction, barrel shift in XY :
(0.402536 mm, -2.88624, mm)

Survey data, barrel shift in Z axis

- According to the survey data, the ladders have the systematic shift around 5 mm toward South side
- The variation is small. Therefore, apply the average shift to the **INTT infrastructure** and **INTT ladders** accordingly



Barrel shift in Z : -4.72449 mm

Suggestion from tracking group

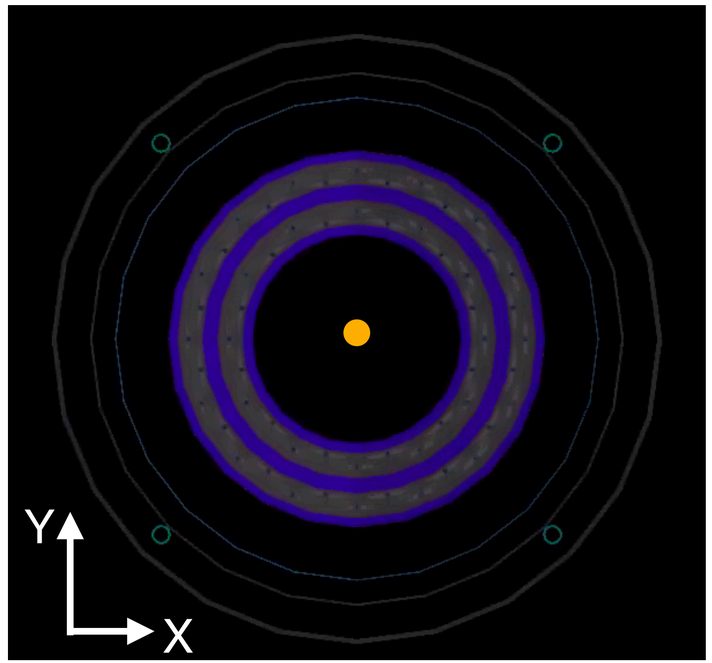
- Introduce the “half-barrel” structure
  - Put everything in a new introduced **half_barrel_volume**
  - Introduce the systematic offset of the two barrels
  - Pros: no additional overlap errors because of the barrel displacement
  - Cons:
    - Content of half_barrel_volume should have:
      - 28 ladders, **half** CF ring, **half** metal ring and **half** CF support skin, etc.
    - Have to perform a **major surgery** to change almost the whole structure of the code

Suggestion from tracking group

Original setup

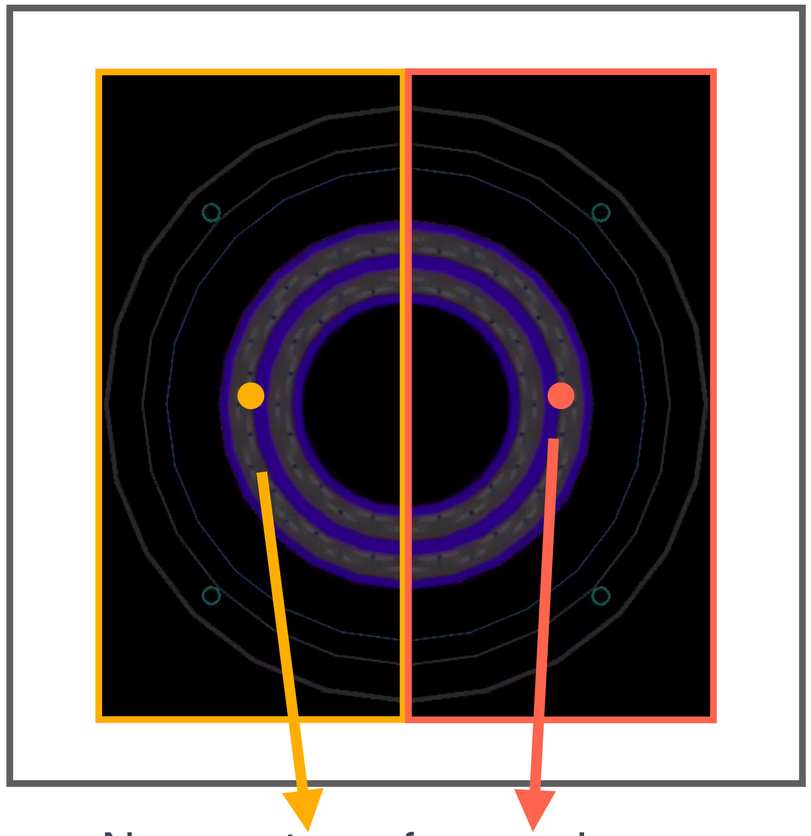
Tracking group suggestion:
half-barrel introduction, and change the half-barrel position afterwards

trackerenvelop volume



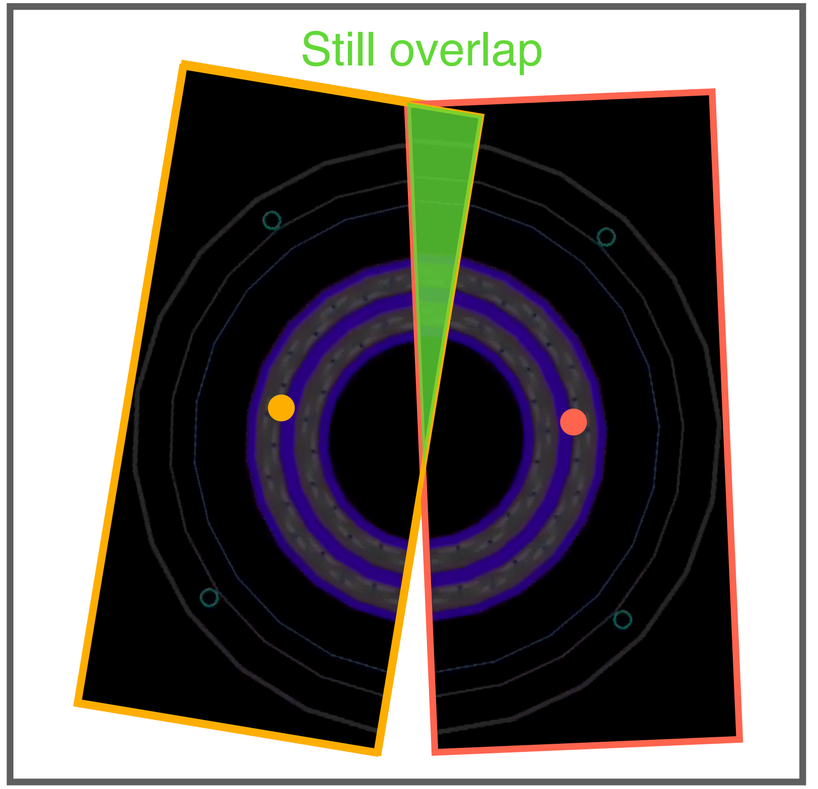
Components share the same center with mother_volume

trackerenvelop volume



New centers of new volumes

trackerenvelop volume



Possibly doable, won't be too accurate and time consuming

Direction of survey implementation

- For survey data
  - Request new survey geometry with new correction in radius from Joseph

- In Geant4
  1. Correct the length and position of **ladderext_volume**, 7.622 mm → 0.8 mm
  2. Update the end ring structure with the new design, so as their center positions
  3. Assign the position XY to INTT infrastructure based on the average survey ladder pos.
  4. Assign the Z shift to INTT infrastructure and INTT ladders based on the avg. survey ladder pos.
  5. Modify the position XY and rotation about z axis of all **ladder_volume** and **ladderext_volume** by the survey data

Direction of survey implementation

- survey file : /sphenix/u/jbertaux/sphnx_software/INTT/general_codes/josephb/codes/intt_alignment/dat/intt_survey_cdbttree_p00_2282mm.root
  - **Shift A** = systematic shift in XY, (0.402536 mm, -2.88624 mm)
  - **Shift B** = systematic shift in Z, -4.72449 mm
  - **INTT ladders** = ladder_volume + ladderext_volume
  - **INTT infrastructure** = si_support_inner_skin + si_support_outer_skin_cfcin + Al ring + CF ring

1. Correct the length and position of **ladderext_volume**, 7.622 mm → 0.8 mm
2. Update the end ring (Al ring and CF ring) structure with the new design, so as their center positions in Z axis
3. Assign the position XY to **INTT infrastructure** based **Shift A**.
4. Assign the Z shift to **INTT infrastructure** and **INTT ladders** based on **Shift B**.
5. Modify the position XY and rotation about z axis of all **INTT ladders** by the survey data

ideal / survey switch

- One switch will be implemented, in order to switch the geometry between the ideal one and the survey geometry
- Expected to be in the Fun4All INTT level → no need to re-compile if changes

Status

- Plots to be included

Summary for the G4 survey implementation

- The current method seems to be most efficient way to achieve to **goal**
- It may not and shouldn't be the final version for the diverse sPHENIX analyses
  - The sensor translation and rotation were not yet included
  - The objects with the **G4Tube** structure may have to be modified

- The survey may need study, more, but it's not in the scope for the time being.

- Eventually we may have to perform the major surgery to the code, to make sure the code can be compatible with any displacements and rotations of sensors given by the survey.
  - It's out of the scope of the dN/dη ana. team. I think I can succeed to the work afterward if needed.

Back up

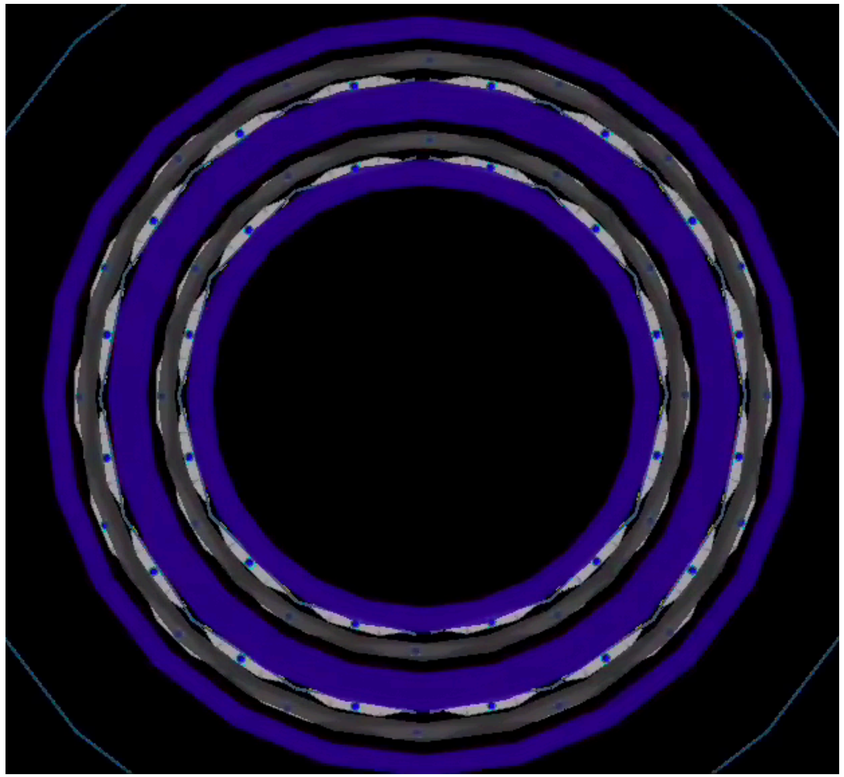
INTT Geant4 check

- Ideal sensor radii: 7.188, 7.800, 9.680 and 10.330 cm (given by Dan Cacace)
- (sensor?) radii in G4: 7.1844, 7.7284, 9.6764 and 10.2584 cm
  - Ladder volume radii: 73.8418, 79.2818, 98.7618 and 104.582 mm
  - Difference in radius : 1.9978 mm

- Sensor center position in a given ladder_volume : 1.9978 mm
  - The positions of ladder_volume make the sensors to be at correct positions

- Center in survey data ?

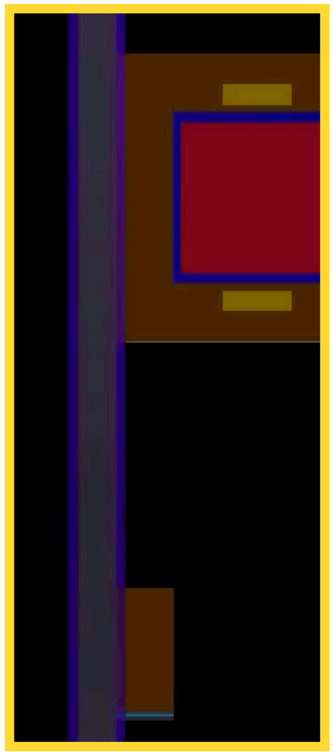
Status



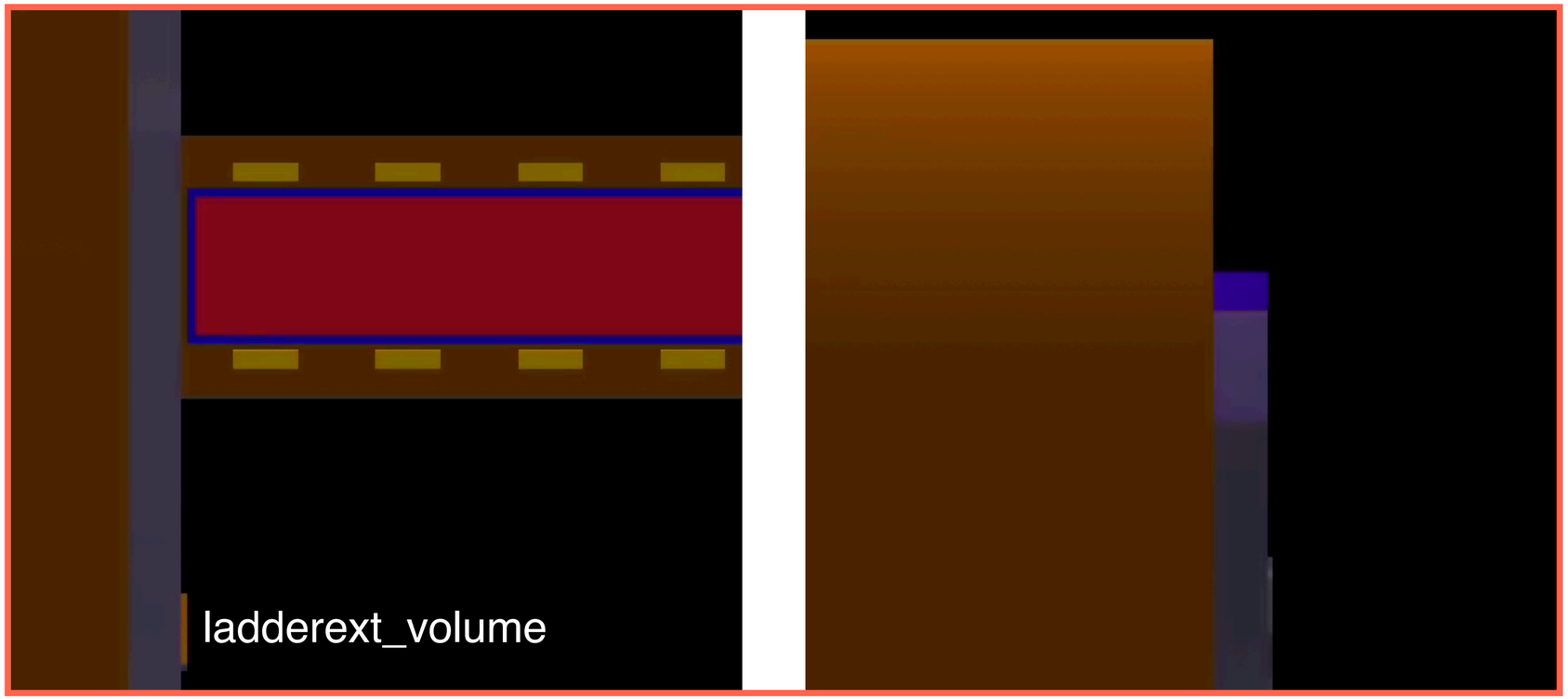
Current status

- ladderext_volume correction done
- End (metal and CF) ring correction done
- Able to load the survey geometry and change the ladder XY position and rotation about z

Orignal

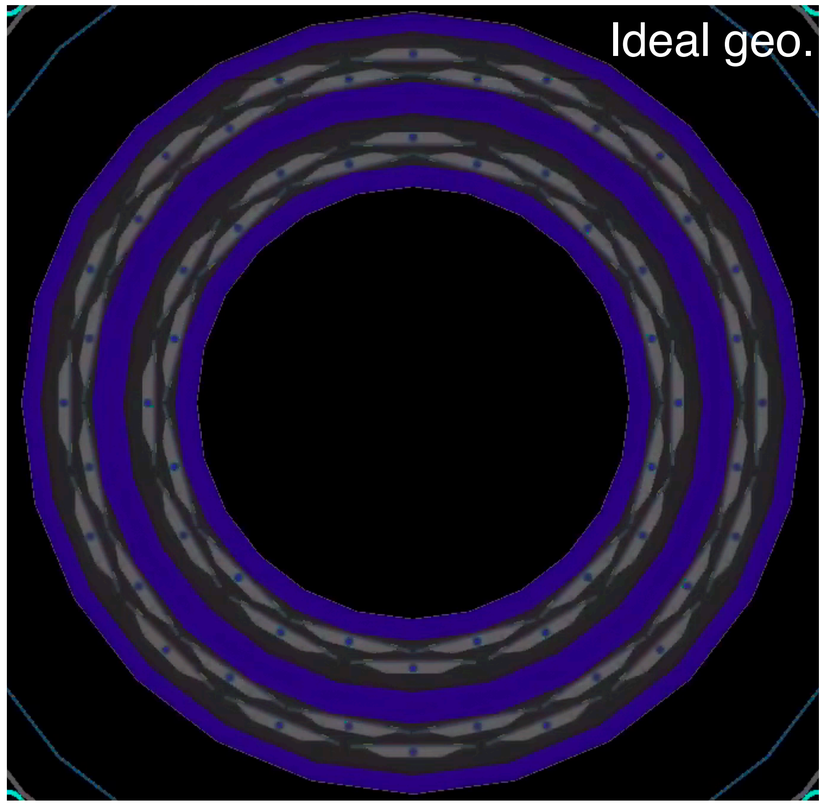


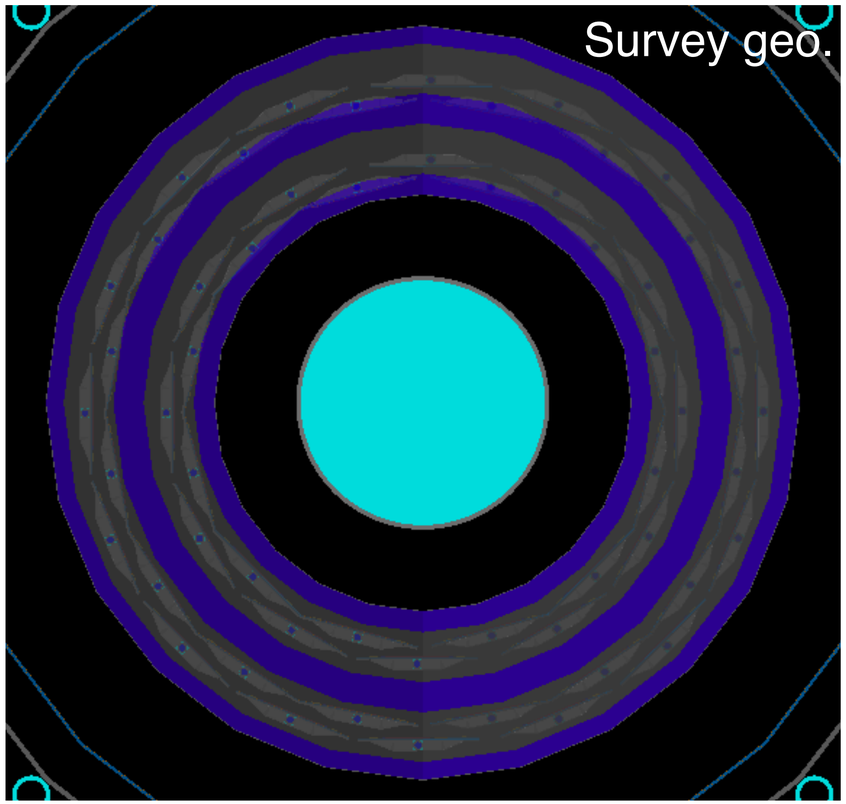
Post correction

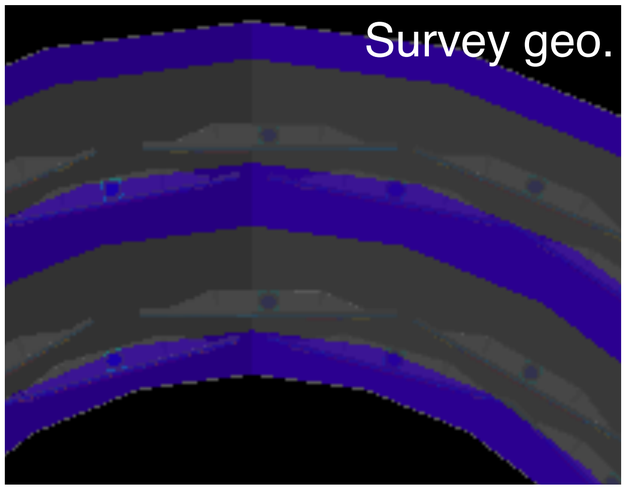


Current status

- ladderext_volume correction done
- End (metal and CF) ring correction done
- Able to load the survey geometry and change the ladder XY position and rotation about z
- Have the overlap errors b/w ladders



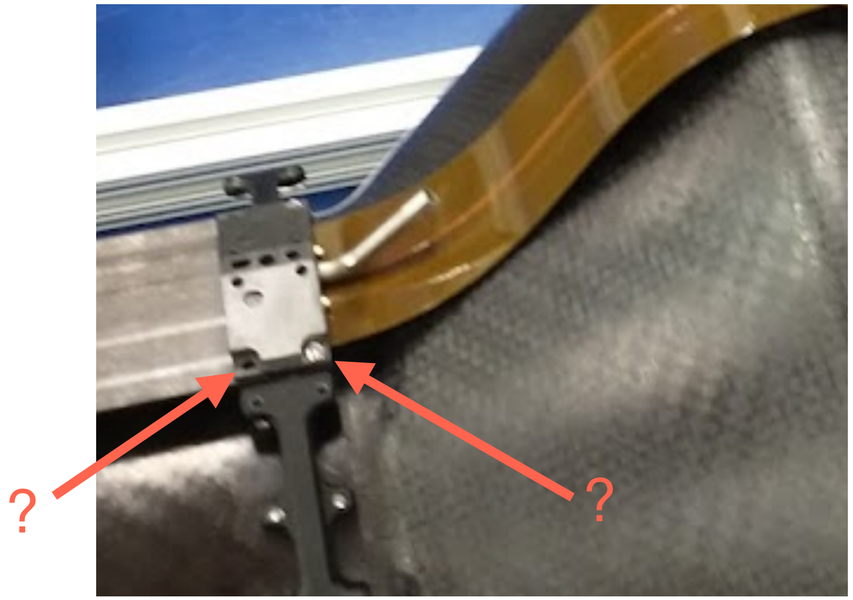




No more overlap errors b/w ladderext_volume and end rings

More about the survey

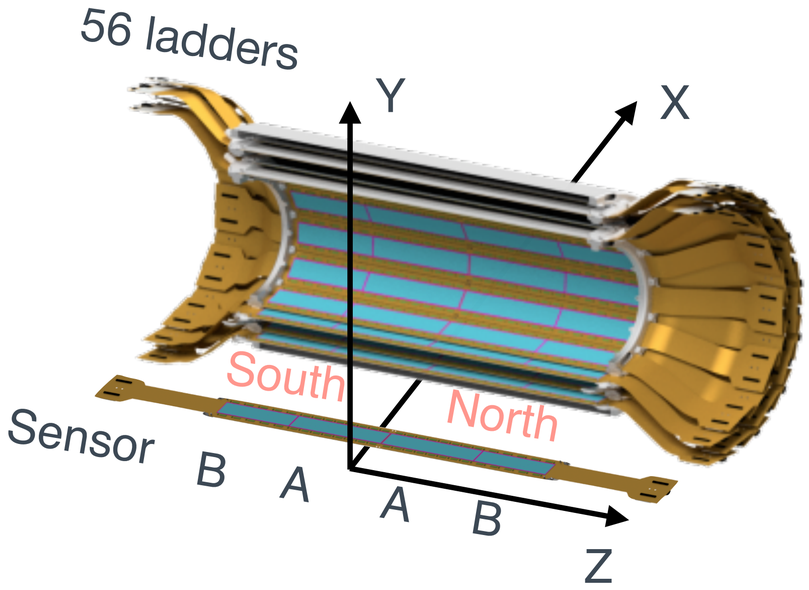
- Where did the survey group touch ?
  - The hole of the stave peek or the head of the screw fasten in the stave peek hole?
- Should be the “hole of the stave peek” according to Dan Cacace
- Might be better if a photo can prove it. Has sent the mail to Rachid, wait for reply



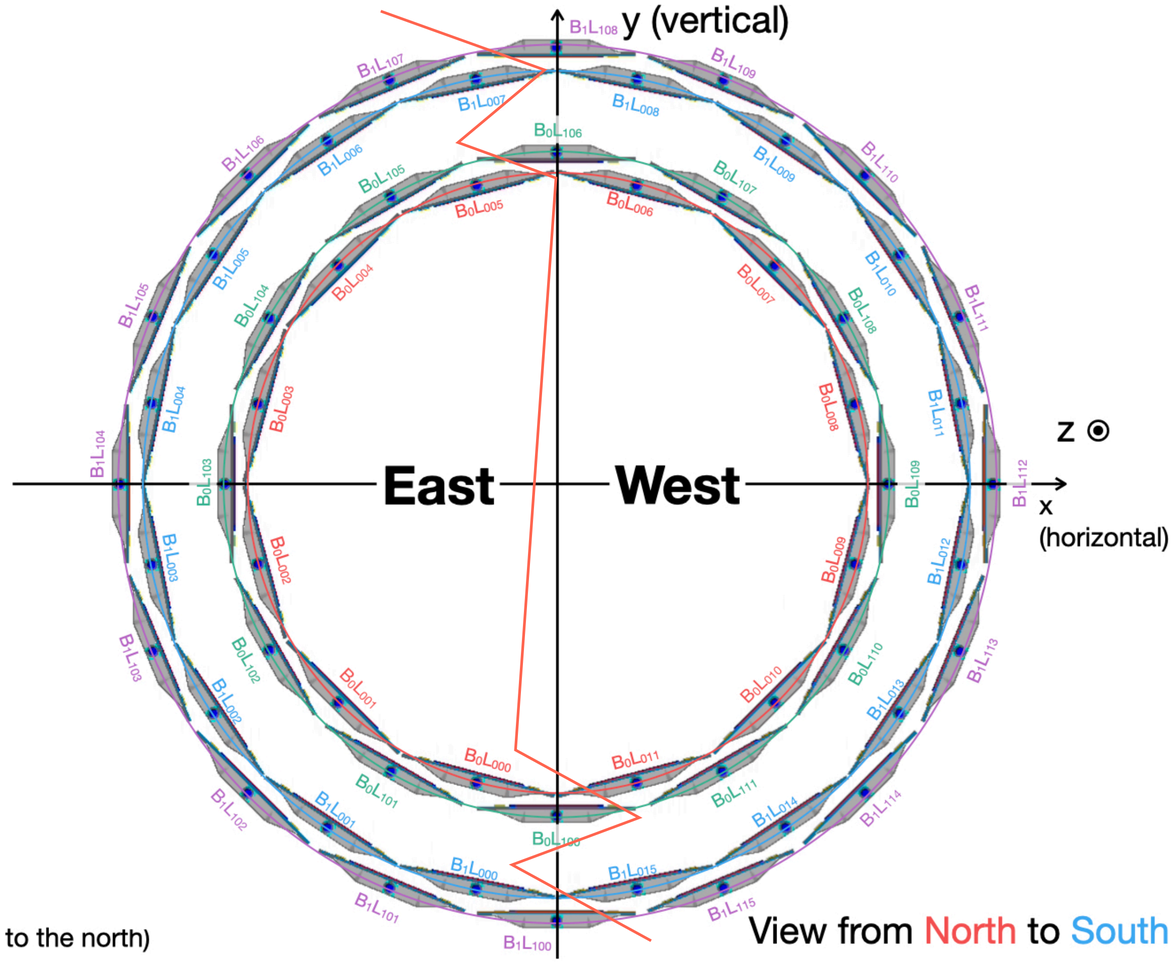
Did the survey group touch the hole or the head of the screw?

INTT geometry

INTT: 2 sensors X 2 sides of half-ladders X 56 ladders = 224 sensors



Notation: B_xL_{yzz}
- x: Barrel ID (0 for inner or 1 for outer)
- y: Layer ID (0 for inner or 1 for outer)
- zz: Ladder ID (from 0 to 15)



Axis (Right-haded coordinate)
- x-axis: $\vec{y} \times \vec{z}$
- y-axis: Vertically upward direction
- z-axis: The blue beam direction (pointing to the north)

View from North to South