DE LA RECHERCHE À L'INDUSTRIE

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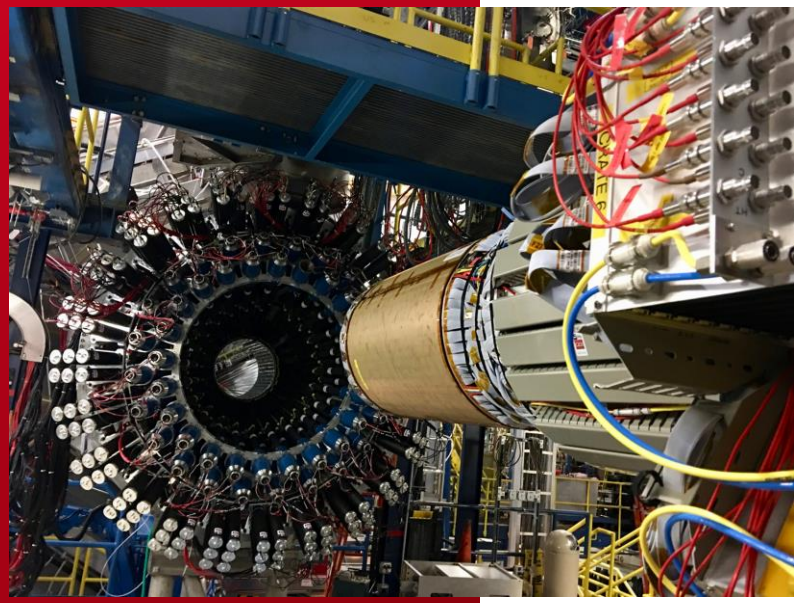
Maxime DEFURNE presents:

Alignment status for the **C**entral **V**ertex **T**racker For CLAS12



On behalf of the CVT team:

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- Yuri Gotra

- Jerry Gilfoyle

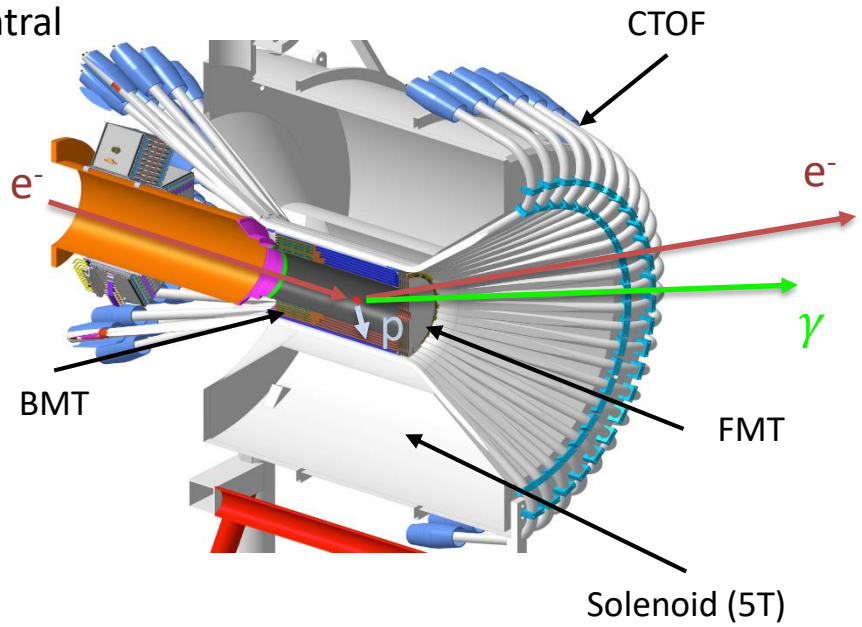
- Veronique Ziegler

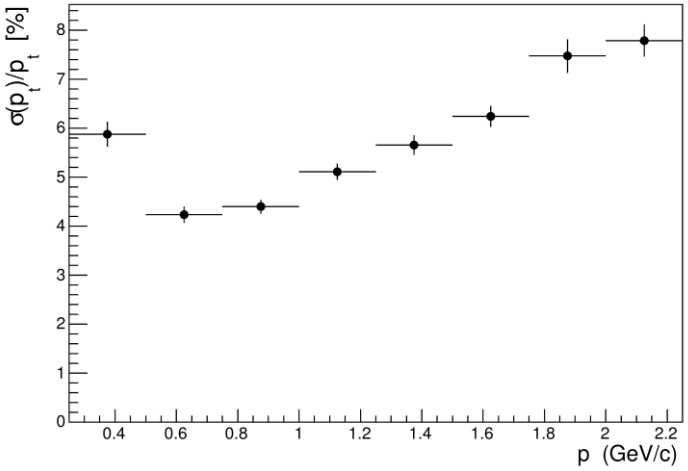
A central vertex tracker for CLAS12

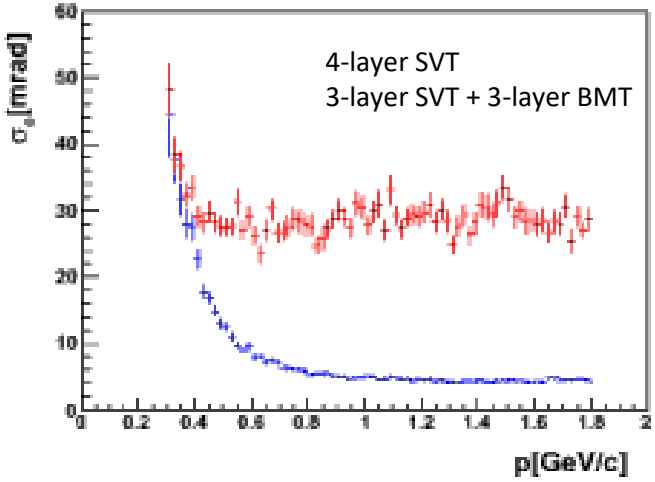
- In the 5T magnetc field of the solenoid, there is a central vertex tracker made of Micromegas and Silicon dectectors.

- The central vertex tracker must ensure:
  - 5% resolution on momentum.
  - 5 mrad in azimuthal angle.
  - 5 mrad in polar angle.
  - vx and vy resolution at 500 um.

- A central Time-of-flight completes the tracker for particle identification.

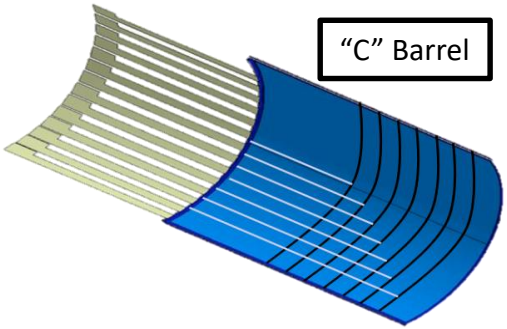


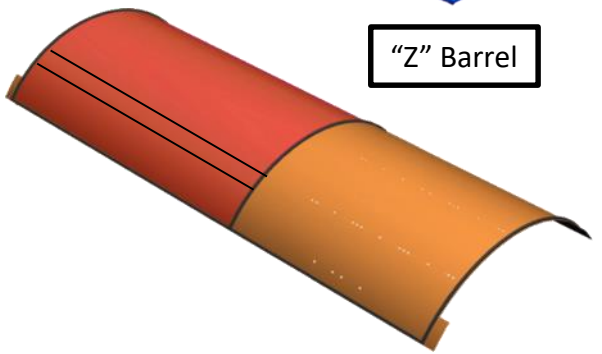




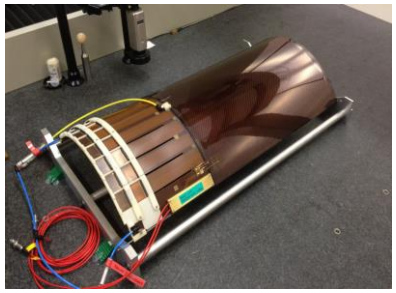
CVT description

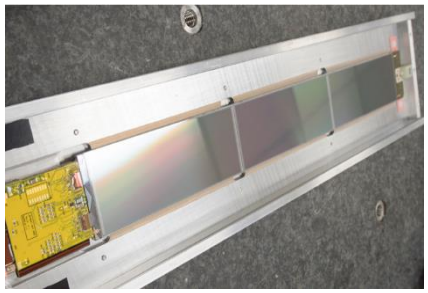
- Barrel Micromegas tracker is made of 6 layers with **radii from 140 mm to 225 mm**.
- Each layer is made of 3 tiles covering approximately 120 degrees.
- There are two kind of tiles for the **azimuthal ("Z") and polar ("C") angle**.
- **Z-tiles** have a constant pitch of about **500 um**.
  C-tiles have a varying **pitch from 330 to 600um**.
- The Silicon Vertex Tracker is made of **three double layers**.
- Four regions were made but three are currently used in CVT.
- Strips on bottom and top bottom have a **stereo angle**.
- Spatial resolution is expected to be **50um.**
  (although current GEMC simulation gives 30um)

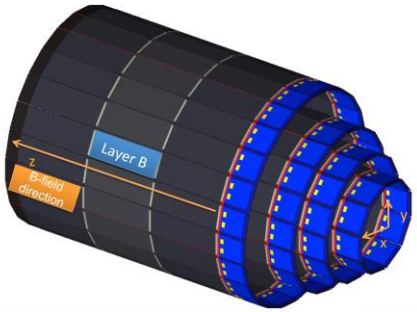


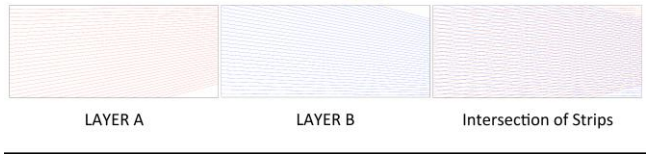


CVT = A TOTAL OF 92 ELEMENTS with 3 different geometries







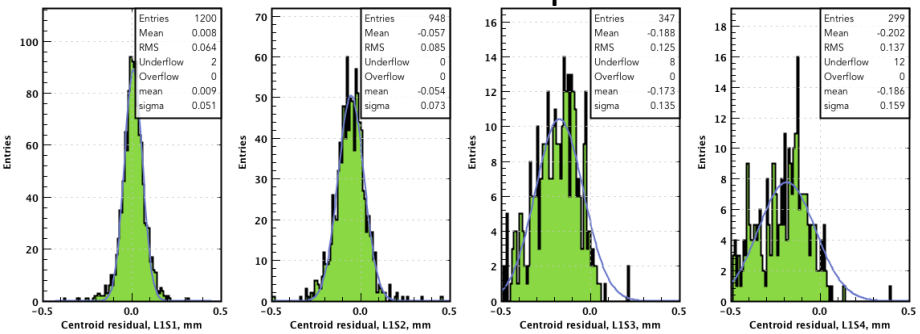


Prerequisites

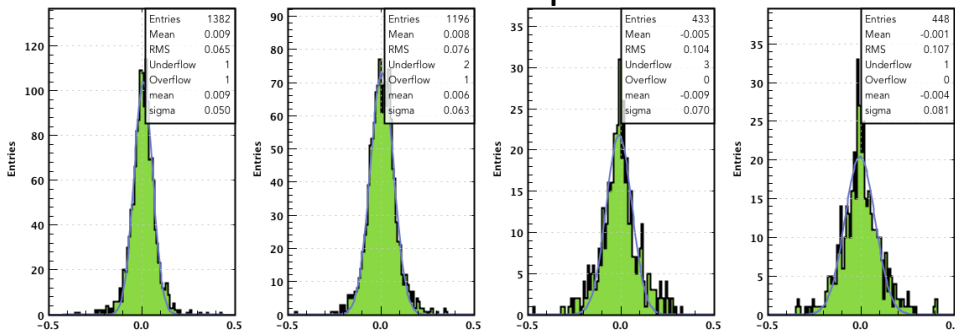
- To do a good alignment, you need:
  - a validated code for the geometry of the detectors,
  - a validated tracking code (You do not want your tracking to be biased)

- Most of the times dedicated to validate both codes… we even found that gemc could be optimized.

1-mm step size



30-um step size



- There are two codes under the form of runnable jar files.
  - Tracker.jar: Do straightline fitting with different options such as SVT-standalone, MVT-standalone, excluding a given detector. It produced a hipo file exactly as regular reconstruction.

  - Alignator.jar: Based on a reconstructed files, it aligns a module or tile. The translations and rotations are written in a text file which can be loaded by Tracker.jar and Alignator.jar itself.

- The source codes are accessible on github. As being developed, the best was done to make it readable. (but I am physicist, so it is not an example for programming)

- Documentation will be written when procedure well established.

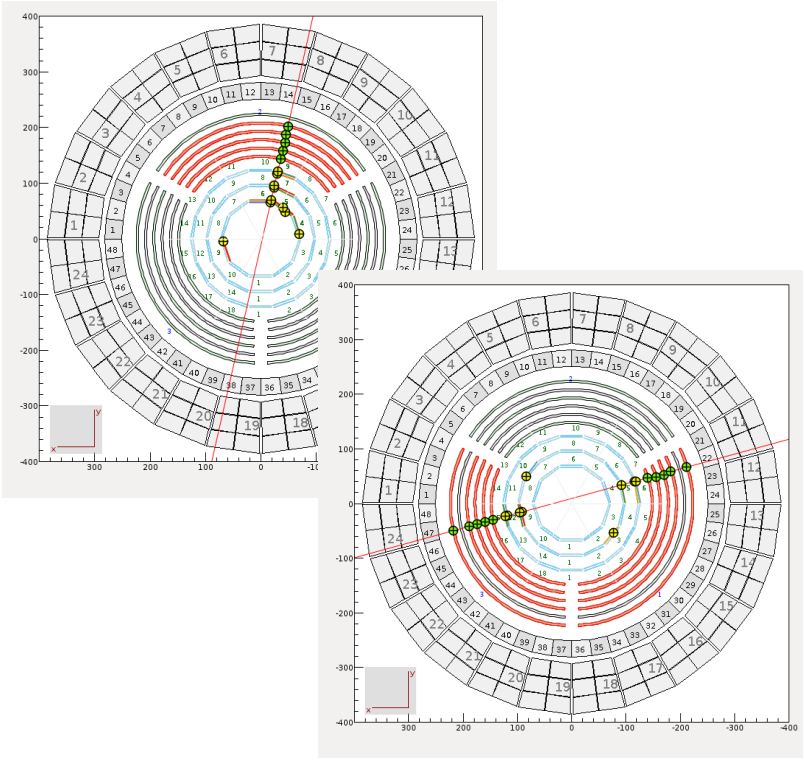
Alignment and definitions

- In this alignment study, all Tile/Module are attached to a frame in which you know absolutely the position of the detector. The frame is chosen to be the ideal x-y-z lab frame.
  In ideal situation,

- MVT frame: Frame in which all the tiles should be aligned with each other.

- SVT frame: Frame in which all modules are aligned with each other.

- In ideal, SVT frame = MVT frame.
  In reality, misalignment between both.
  => Main misalignments due to MVT versus SVT position.



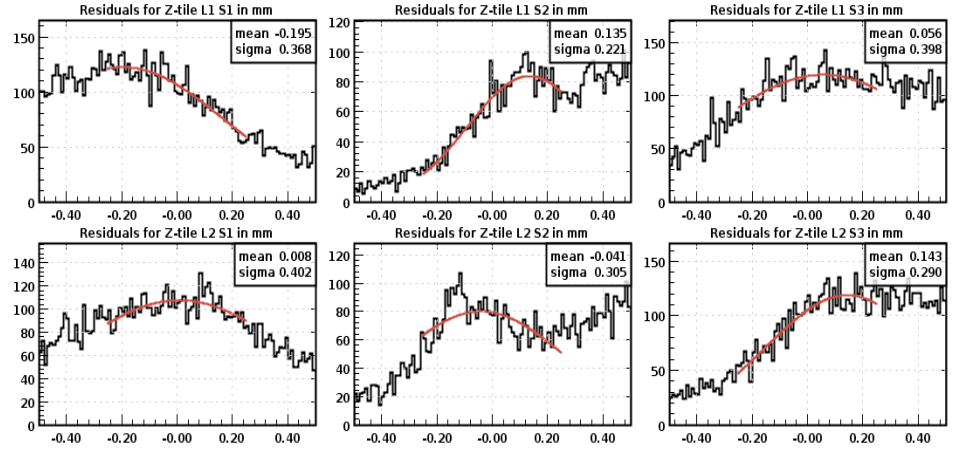
- Beam rays are tracks collected during an alignment run at field B=0,

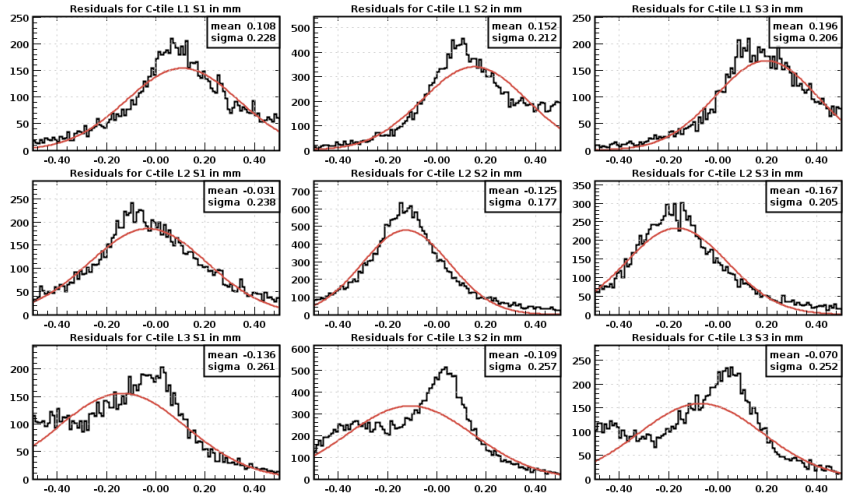
- Cosmic rays were also collected. They provide correlations between the sectors of CVT, whereas beam rays are going only through one sector.

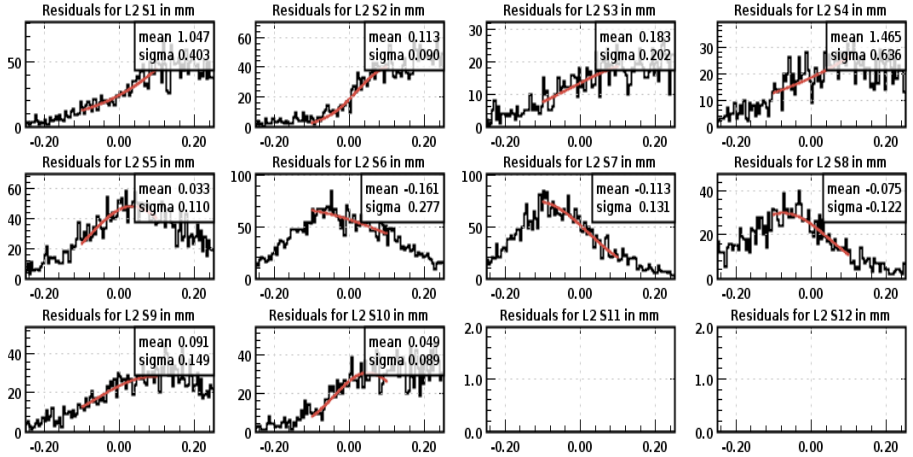
- For this reason, the code must run on cosmic and beam rays simultaneously.

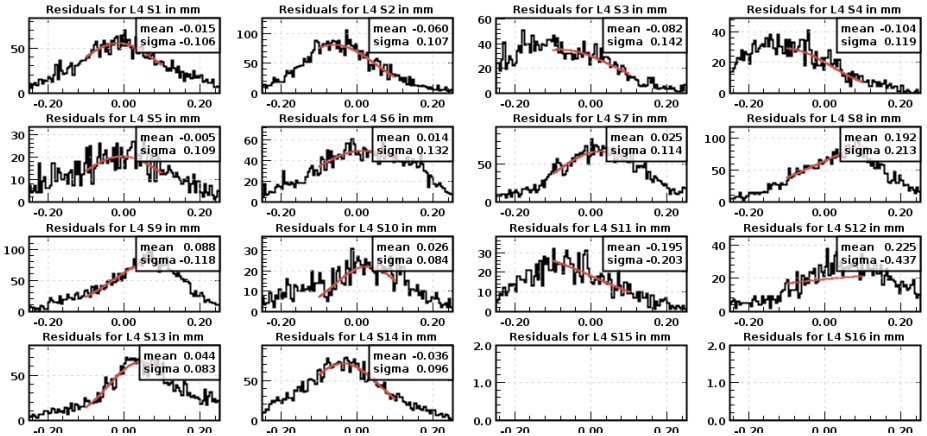
Is it necessary?

- It seems complicated… Is it really necessary? Cosmic data collected in April 2018.









- We are far from residuals centered a 0 with a 50um resolution for SVT, not even mentioning the weird shapes of MVT residuals.

Procedure for alignment

- Step 1: Find Tx, Ty, Tz and Rx, Ry, Rz (6 parameters) to align MVT frame and SVT frame.
  => Correct for major misalignments expected between the two subsystems… Speed up convergence.

- Step 2: Exclude 1 tile or 1 module from the tracking.
  Then try to find rotations and translations to decrease residuals of the excluded elements.
  This step should be iterated until rotations and translations don't change anymore.

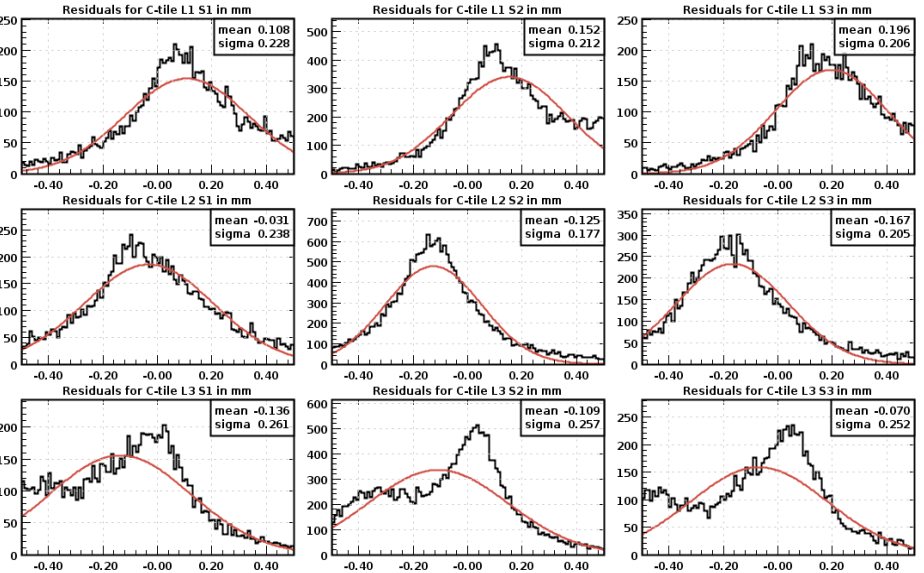
  To align one detector, you take into account the results of the detectors previously aligned.

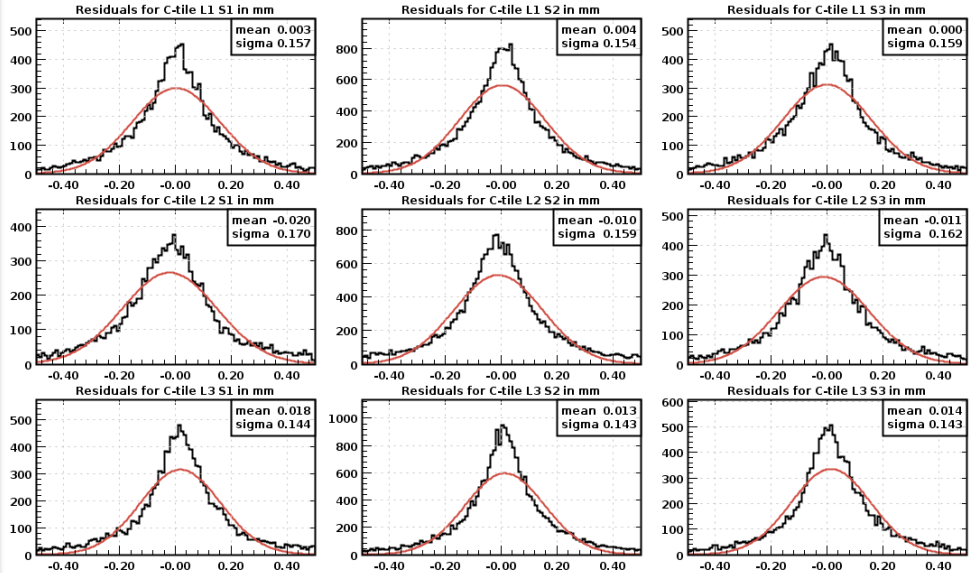
- Step 3: In step 2, both layers of a SVT module are moved together. But top and bottom layers can be misaligned.
  Try to find one translation to align both layers.
  A second iteration might be required.

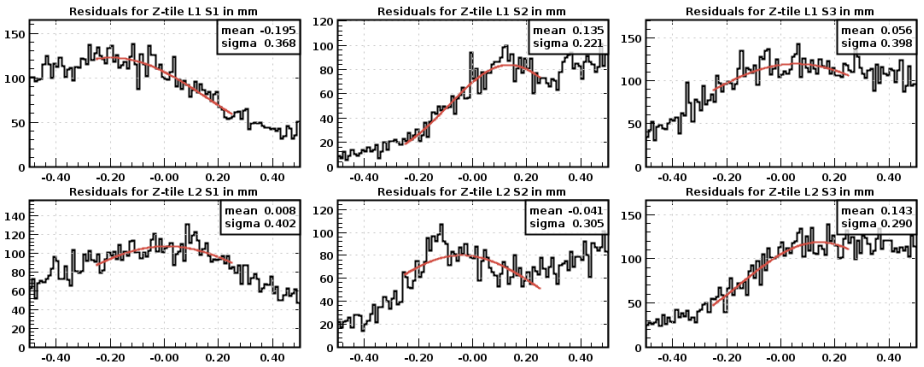
- Results shown later in this talk are still preliminary. A few translations/rotations are still **forbidden**
  -BMT-Z tile: The **translation along the z-axis** is forbidden because in the direction of the strips.
  -BMT-C tile: The **rotation along the beam axis** is forbidden for same reasons.
  -SVT module: The translation along the z-axis is forbidden as well (but we will come back later on this point).

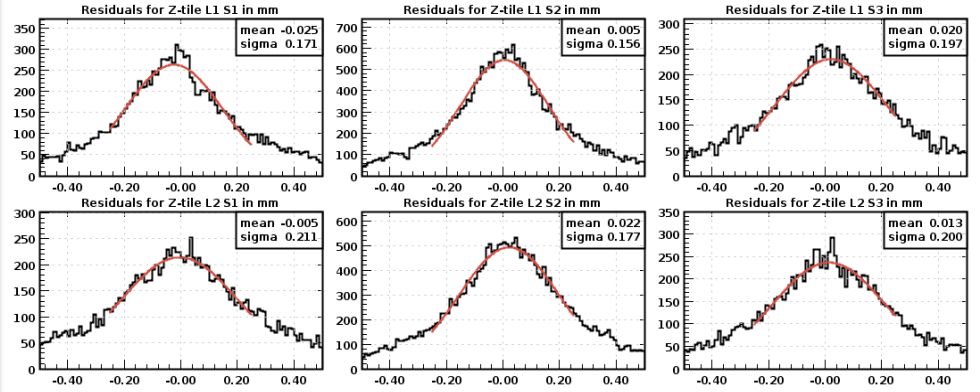
- Advantage: Easy to implement.
  Drawback: Time needed for convergence depends on the sequence in aligning the detectors.

Result BMT with cosmics

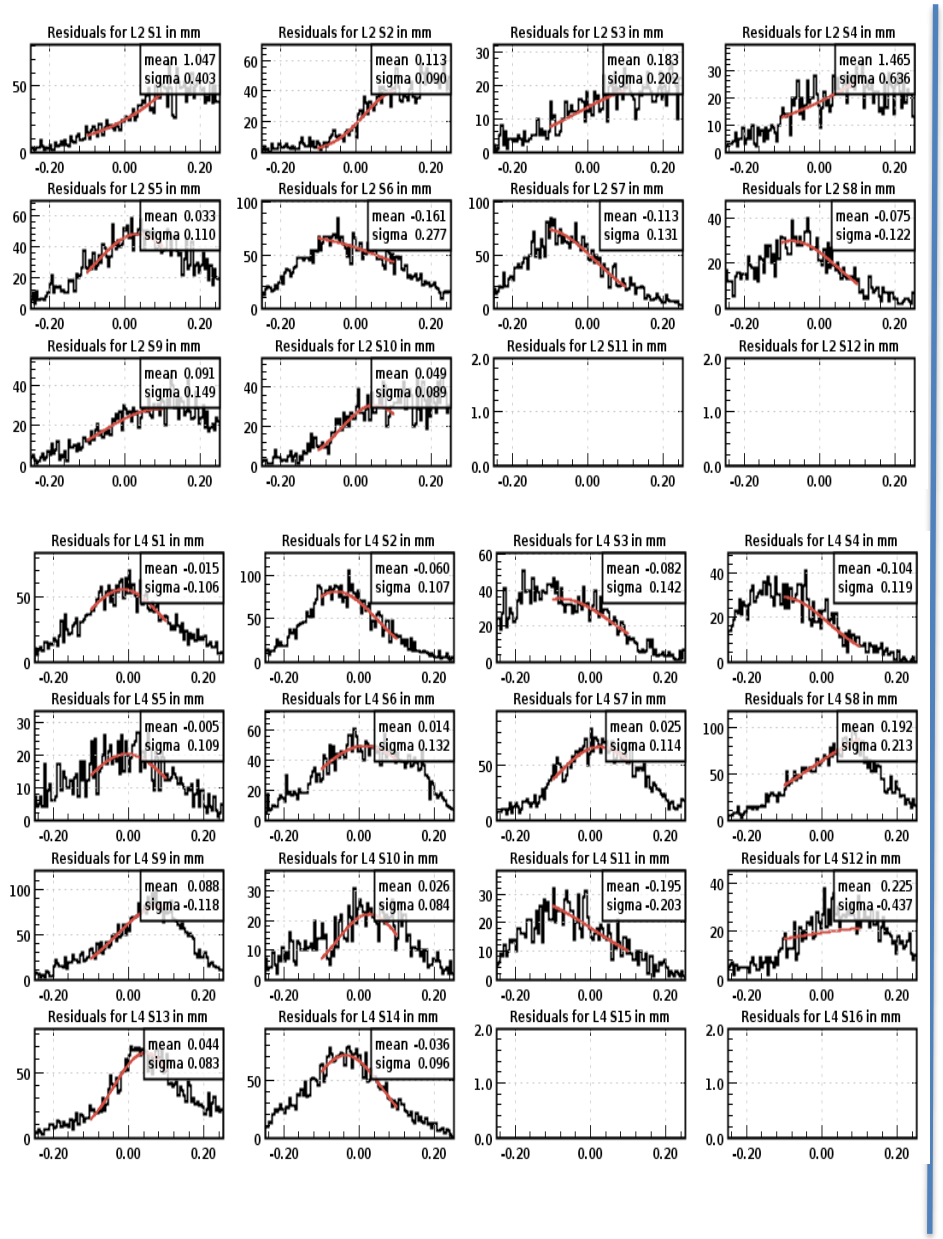


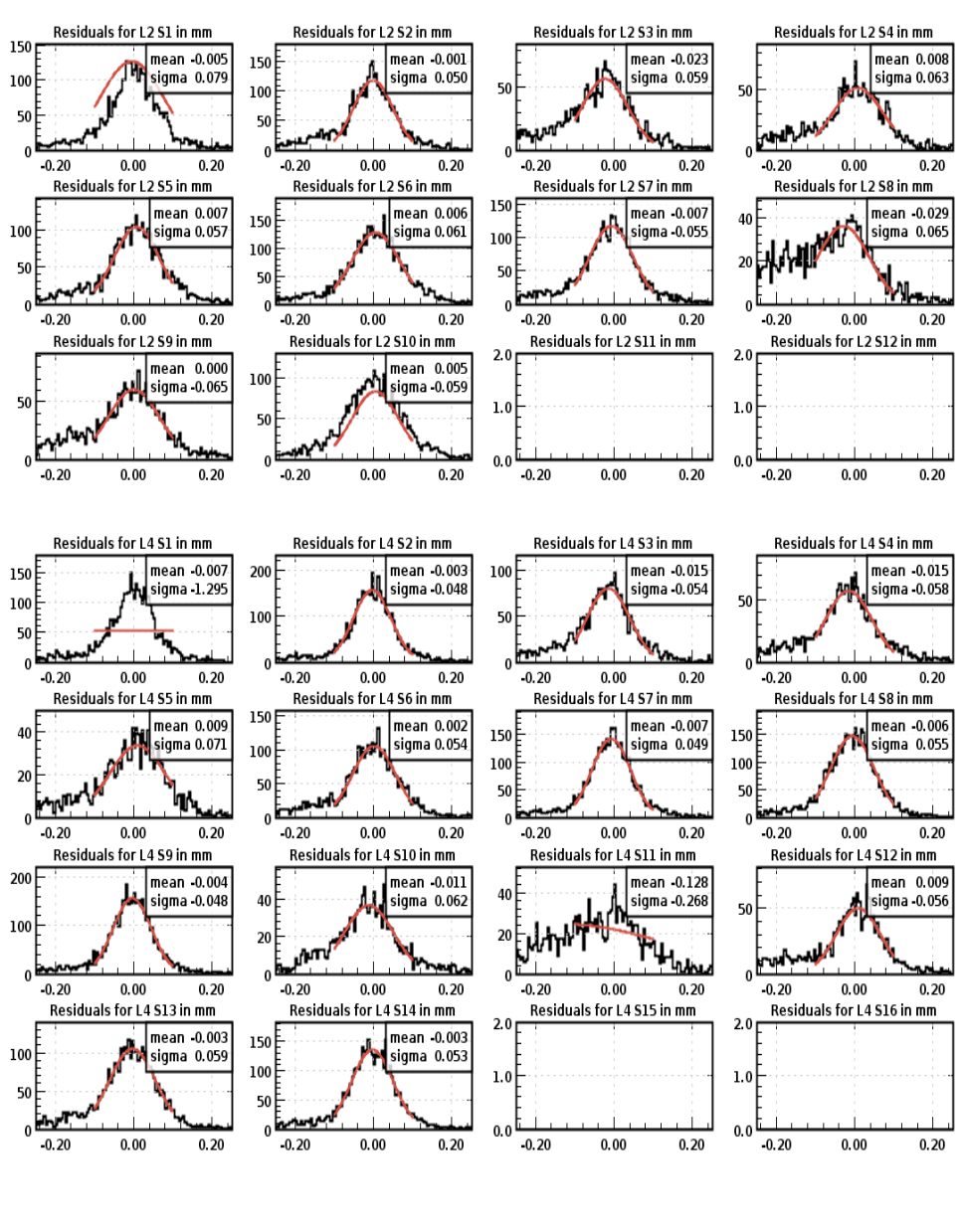






Result SVT with cosmics

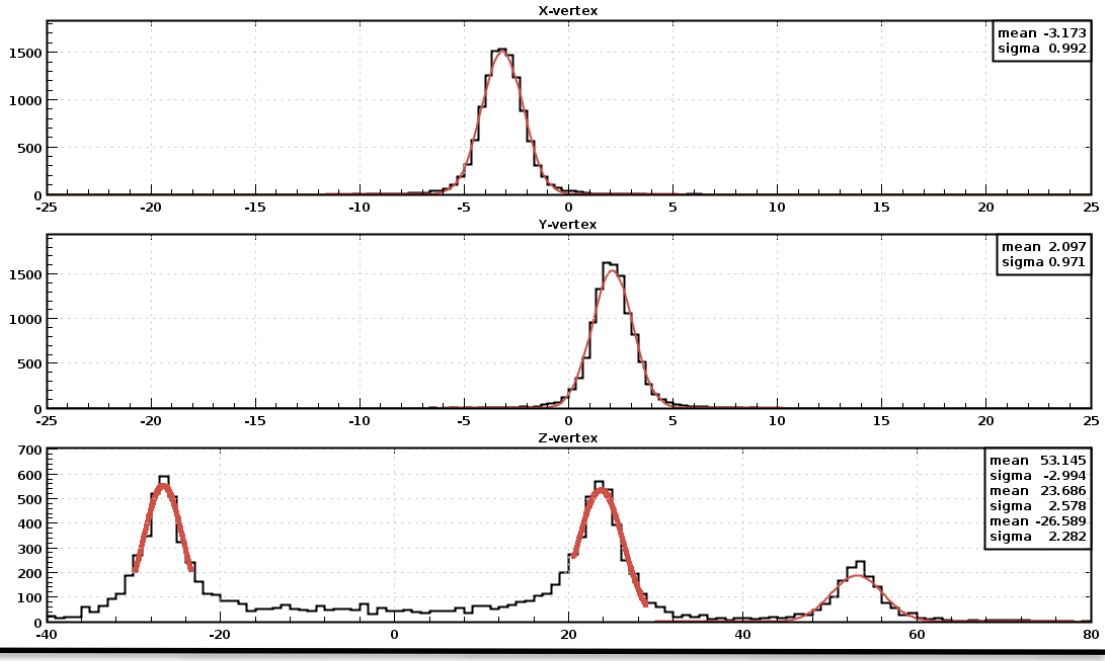




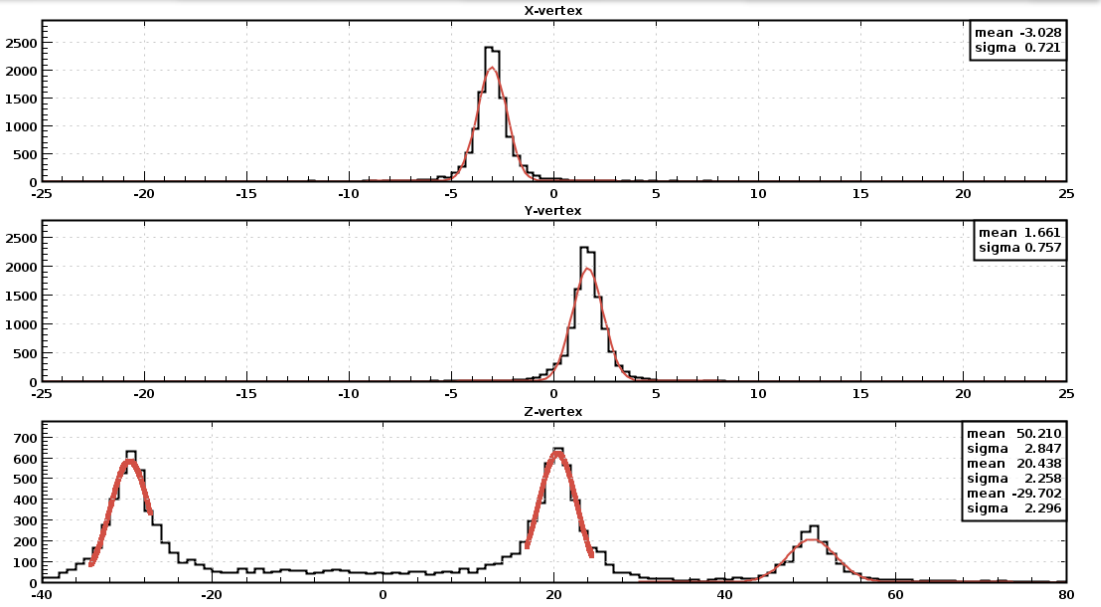
Vertexing improved as well

Beam position in CVT frame
Not the lab frame.

Before Alignment	
X-position	-3.173 +/- 0.992
Y-position	2.097 +/- 0.971
Upstream-z	-26.589 +/- 2.282
Downstream-z	23.686 +/- 2.578



After alignment	
X-position	-3.028 +/- 0.721
Y-position	1.661 +/- 0.757
Upstream-z	-29.702 +/- 2.296
Downstream-z	20.438 +/- 2.258



Target position quite sensitive to misalignment.

Conclusion and Perspectives

- Conclusion 1: CVT alignment is definitely needed!
- Conclusion 2: Although fairly simple algorithm, it shows major improvement on all residuals… very close to specifications.
- Conclusion 3: I have only use 1% of the alignment run and cosmic data collected. I expect a much better improvement by increasing the statistics.
- Conclusion 4: Might be sensitive to track quality (L4S11) and ratio cosmic/beam data. It will be the fine tuning of the procedure.
- Perspective 1: Improve the sequence to align the detector
  For SVT, modules facing space between MVT tiles are complicated to align. They should be aligned at the very end, once all other detectors are aligned => Like playing rubik's cube
- Perspective 2: I have forbidden z-translation for SVT because I tried to align both sides of a module independently. But aligning modules, I have a constrained information about the Z-position of the module (stereo angle), that I did not have by considering all layer independent.
- Perspective 3: Currently working on the implementation of misalignments for end of January in official reconstruction. Seems easy to do… but need to update geometry before and validate it! As well as the tracking!
- Perspective 4: Try to use Millepede to do simultaneous alignment… but not a priority for the moment.