Luminosity Determination with misaligned Detectors

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Software Alignment

What is it and do we need it?

Software alignment:

- Determine where components *are*
- Account for actual position in software
- Thereby increasing measurement quality

Can be done with:

- Cosmic muons
- Particle tracks

Wrong sensor position:

- Wrong angular distribution
- Wrong Luminosity

State of Software Alignment in PANDA

As of last month, the alignment Framework is integrated in FairRoot/dev and preliminary tests are promising!

However, not all interfaces are ready yet.

In general, these macros need to be aware of misalignment:

- SimBox / SimDPM
- Digitization
- Reconstruction

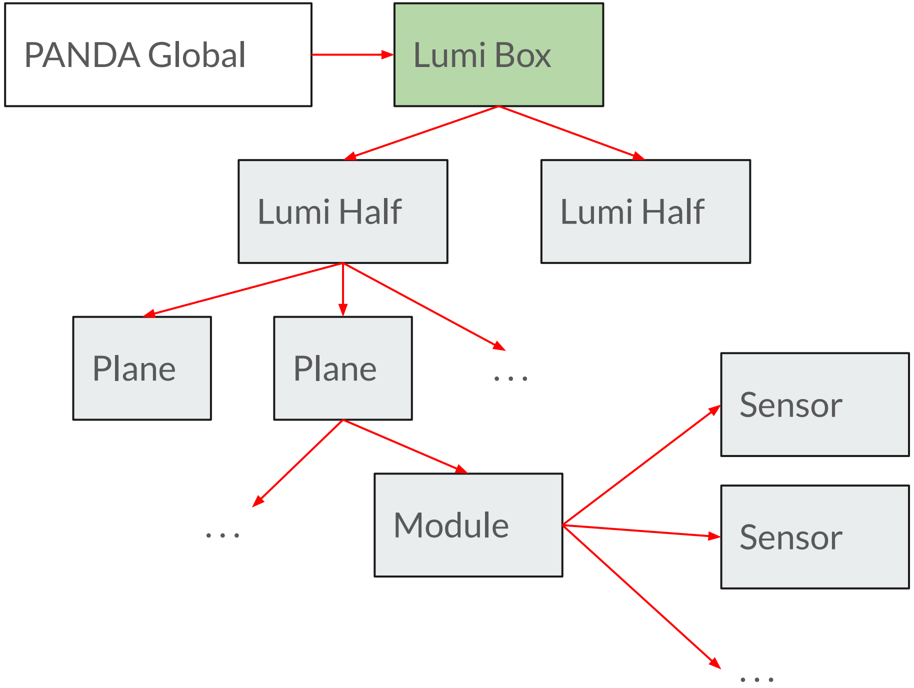
All other steps should be fine.

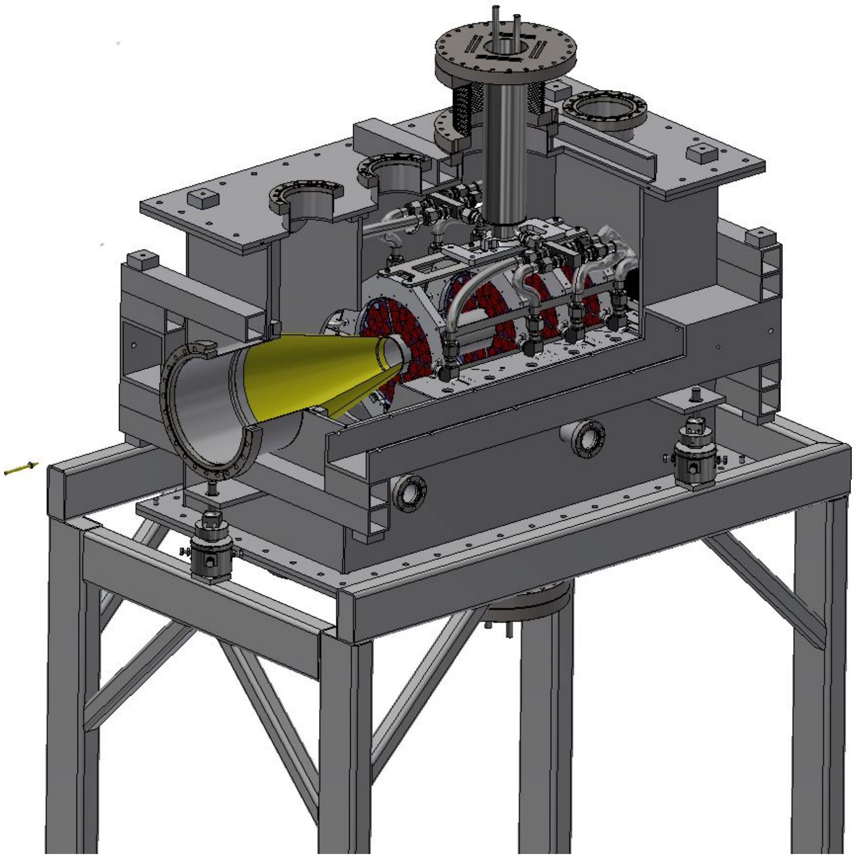
And as of last week, PANDARoot can be compiled against FairRoot/dev, which means the first major hurdle has been passed.

As before, examples of how to use misaligned geometry and correcting alignment matrices can be found in:

`Pandaroot/macro/detectors/lmd/runLumiPixel*`

Luminosity Detector | Box





Example: Misaligned Geometry and Luminosity

We're estimating the remaining uncertainty after component placement and initial survey, but without software alignment.

These estimations are **preliminary** and will likely change!

Uncertainty is simplified to three influences:

Contributor	σ (translation)	σ (rotation)
Box Position	50 μm	1 mrad
Module Position	100μm	0.1 mrad
Sensor Position	10μm	0.1 mrad

We'll call this uncertainty by a shorthand:

A misalignment factor of **1.0**.

We can now compare multiple misalignment factors to see how well we can measure the luminosity. A factor of 0 means aligned geometry.

Interim Result: Combi Misalignment Luminosity

Fitted Luminosity vs. Misalignment @1.5 and 15.0 Gev

Misalignment Scale	Lumi deviation [%] @1.5 GeV	Lumi deviation [%] @15.0 GeV
0	0.044	0.74
0.5	0.5	16.0
1.0	4.4	66.3
2.0	26.9	97.9

These are still without software alignment, so no interpretation will be given!

Interim Result: Individual Component Misalignment

We can misalign sets of components individually:

- **The Box**
- **Modules**
- **Sensors**

Similar to above, we can define a standard misalignment after survey and call it 1.0.

Detailed values are subject to change, we'll only use shorthand notation here.

Note: this is still without software alignment!

Component	Factor	Lumi Deviation [%] @ 1.5GeV
Box	0.5	0.2
Box	1.0	1.2
Box	2.0	11.2
Modules	0.5	1.8
Modules	1.0	8.4
Modules	2.0	-
Sensors	0.5	2.0
Sensors	1.0	9.9
Sensors	2.0	-

Improvement: Track filtering and Software Alignment

What steps can be taken to improve the alignment results and lumi fit results?

For Sensor Alignment: Pair Filters

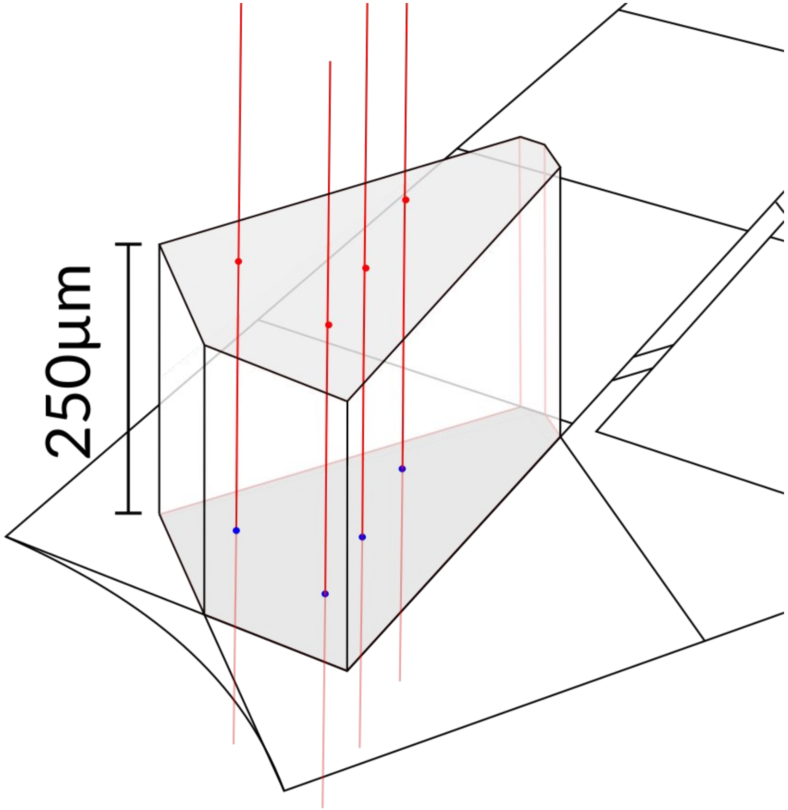
For Modules: Corridor Alignment

And of course lots of hardware survey!

Single Detector Module

- 10 Sensors per module
- Overlapping areas between sensors
- Treat hits on the front and back sensors as point clouds
- After filtering and selection, two clouds with N elements remain
- Each point in cloud A corresponds to a point in cloud B.

The more pairs, the more accurate the result!



Track selection for alignment

Checks for **HitPair:**

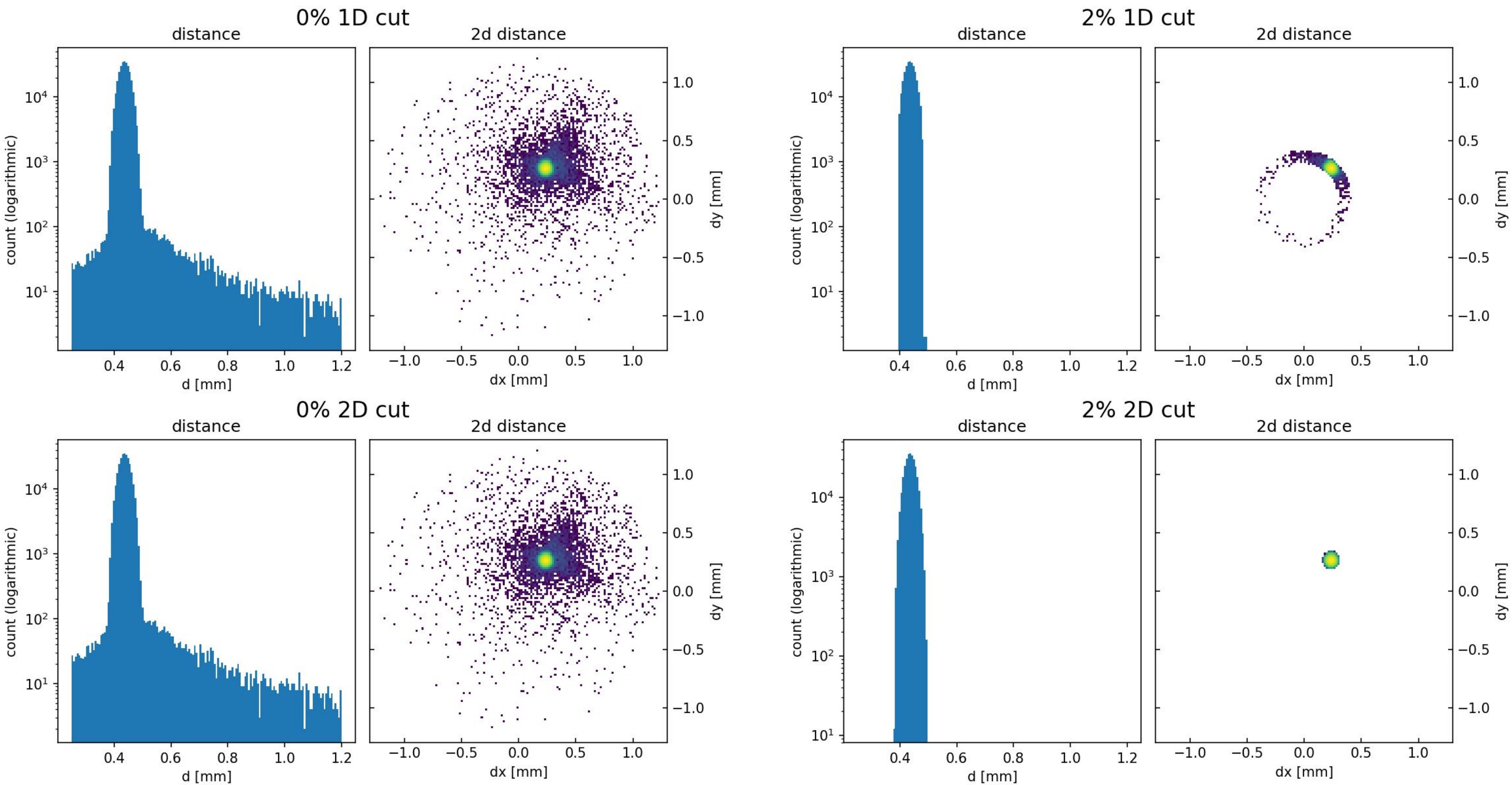
- Same module
- In overlapping area
- Pair Distance between hits < 1.2mm
- Correct interaction point reconstruction

But: every overlapping area is misaligned differently

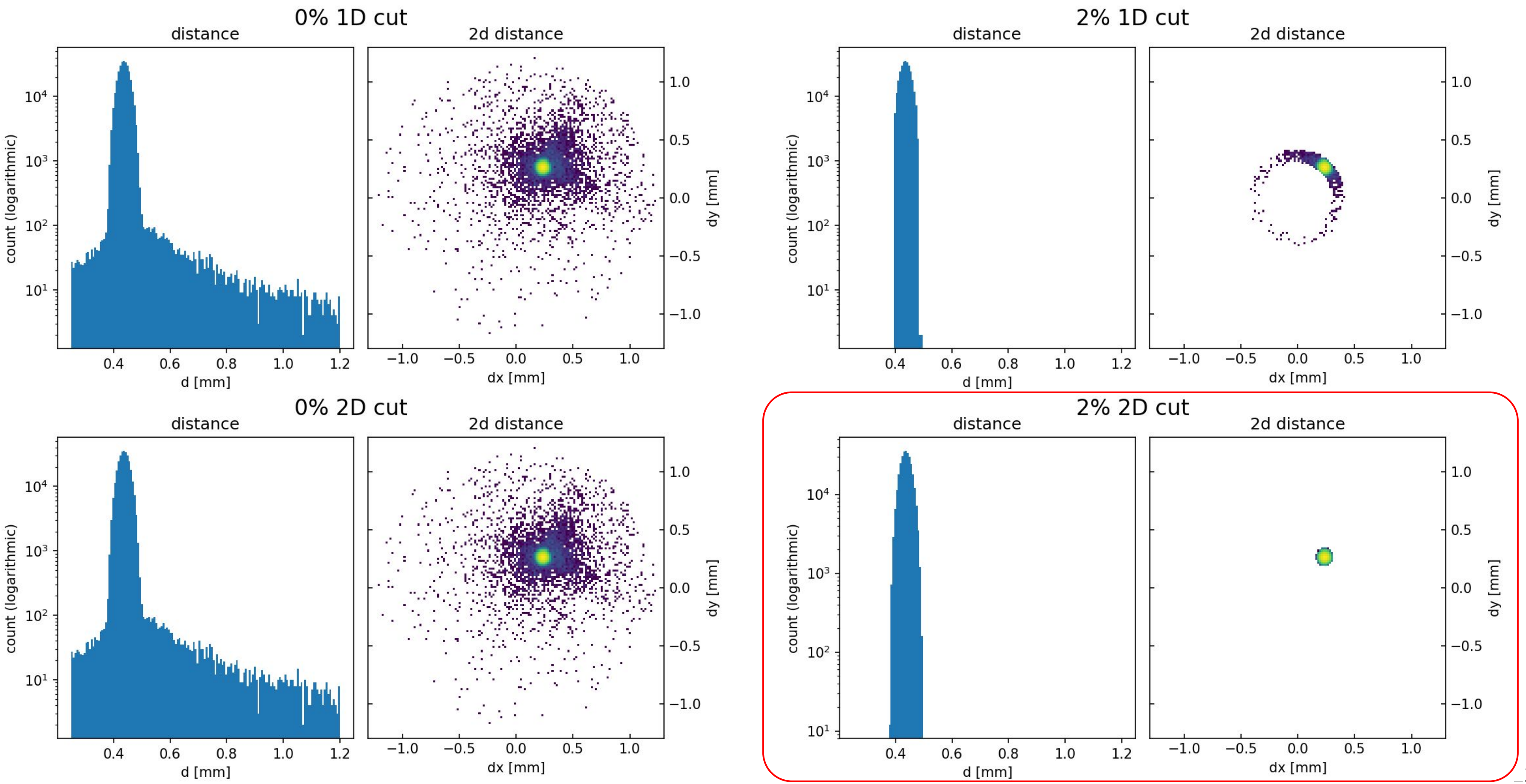
→ different distance check for every overlapping area!

Quality of transformation matrix depends on the validity of the HitPairs!

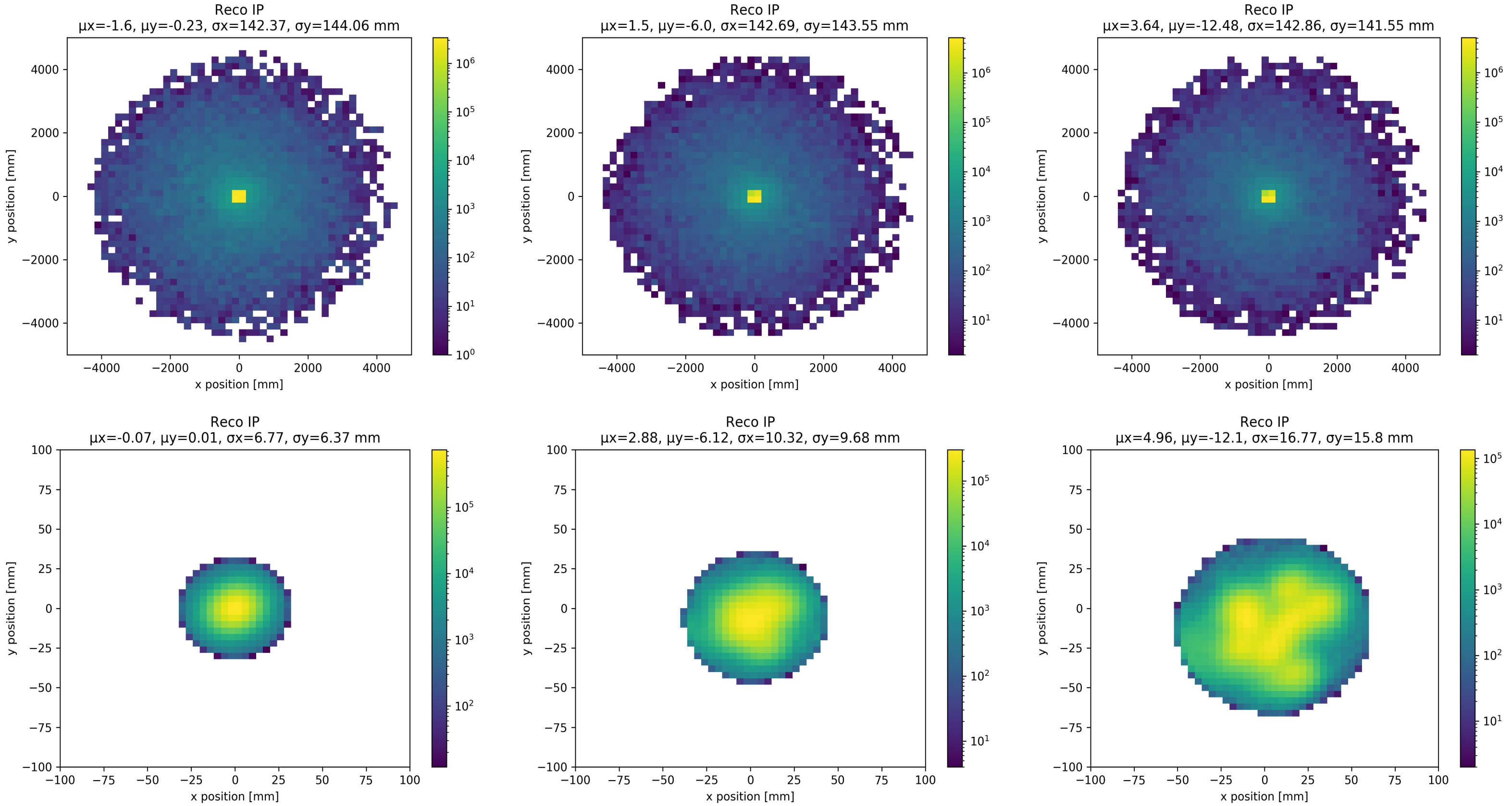
Pair Distance: Dynamic Cut, 1D and 2D



Pair Distance: Dynamic Cut, 1D and 2D



Interaction Point: Dynamic Cut 2%



Factor 0.0 | Factor 1.0 | Factor2.0

Conclusion

- Software alignment is still work-in-progress

- Misalignment must be known *precisely*!

- Luminosity determination with misaligned geometry is possible

- But results are very unreliable without further alignment!

Thank you for your attention!