Integration of the TPC Test-Chamber in PANDAroot: A Glance at Simulations and Data

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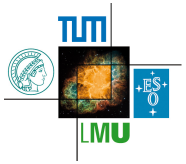
Germany

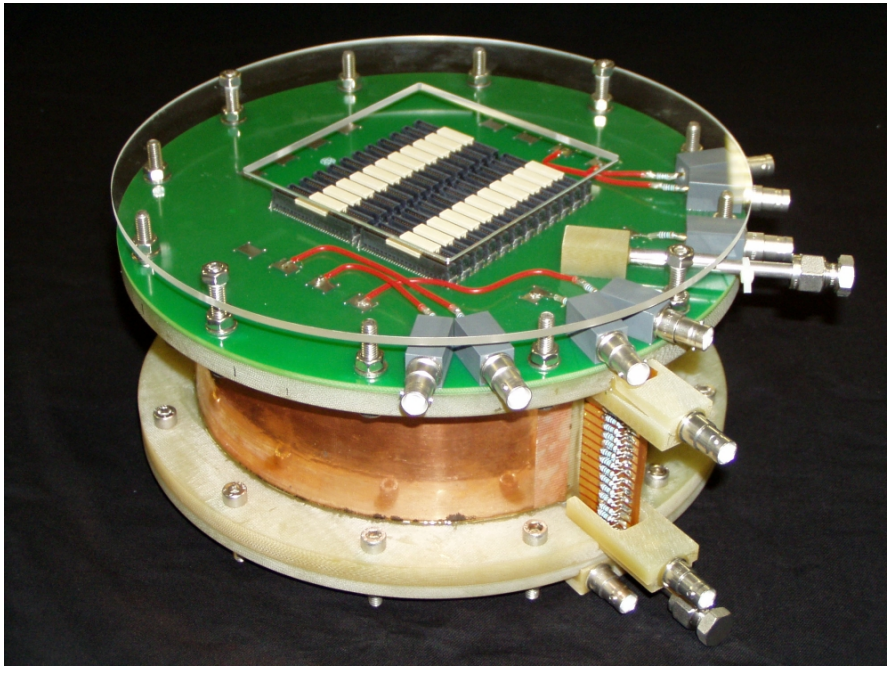
PANDA collaboration meeting at GSI, Darmstadt
March 2010



The TPC Test Chamber - Hardware

Hardware:

- $10 \times 10\,\mathrm{cm}^2$ active area
- Gem stack as gas amplification
- 8 cm drift length
- 1500 hexagonal pads:
  - 1.5 mm outer radius
  - 1.25 mm outer radius



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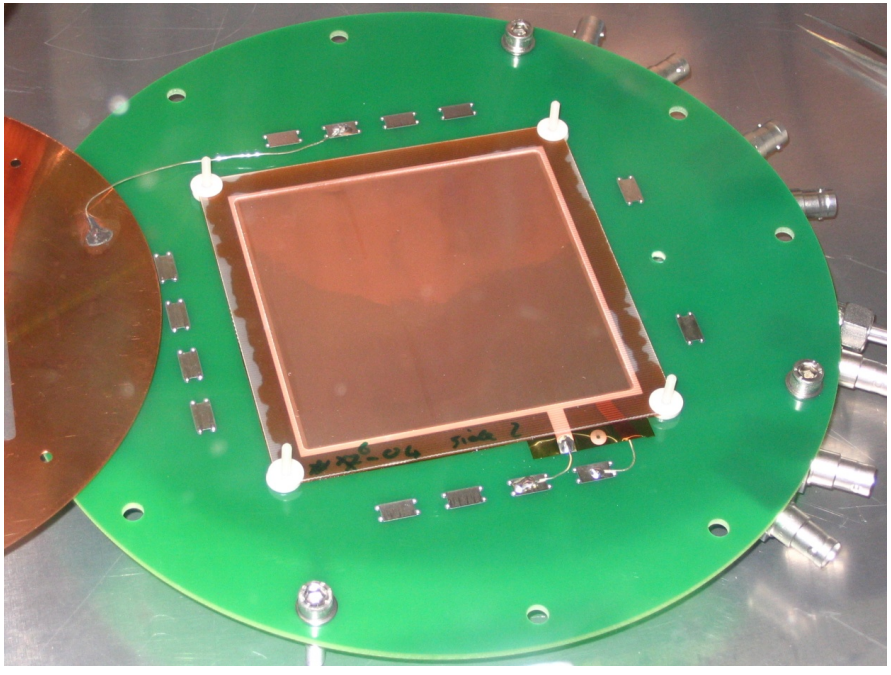

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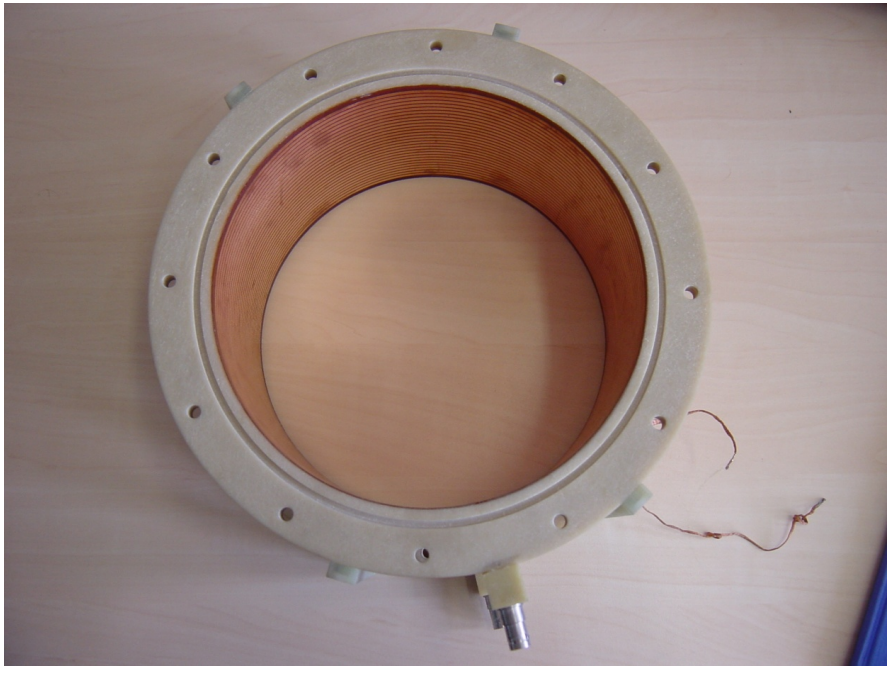

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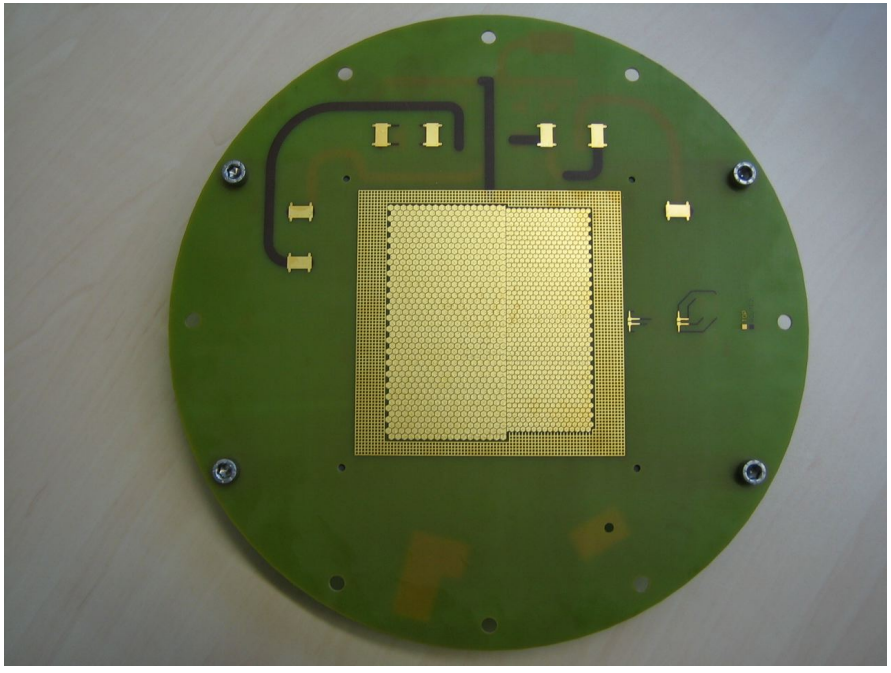
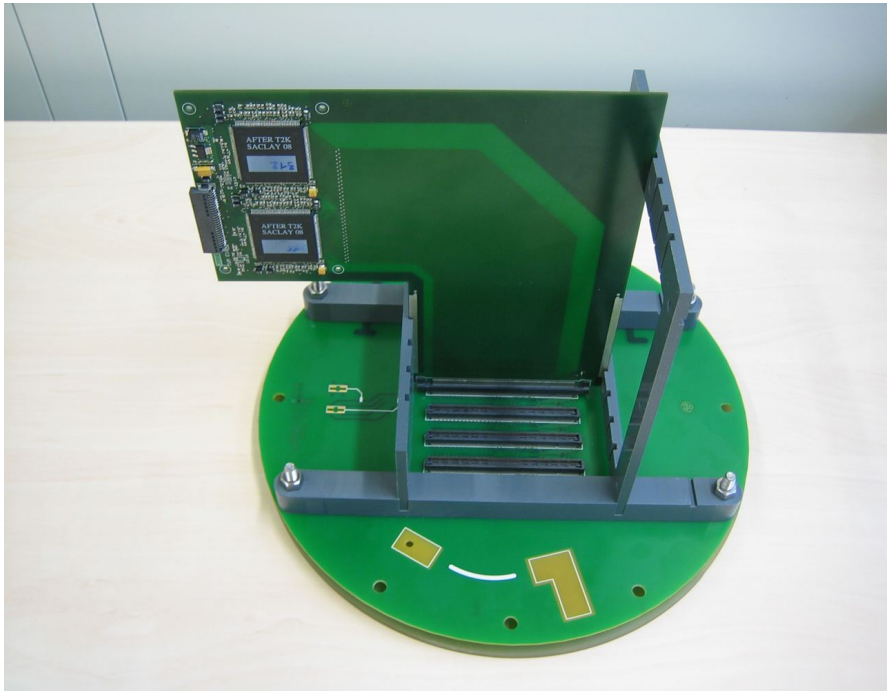


The TPC Test Chamber - Electronics

Electronics:

- T2K AFTER chip (Saclay)
- 4 chips $\times$ 64 channels per FE card
- Noise: $< 1000\, e^-$
- Up to 16 chips per ADC module



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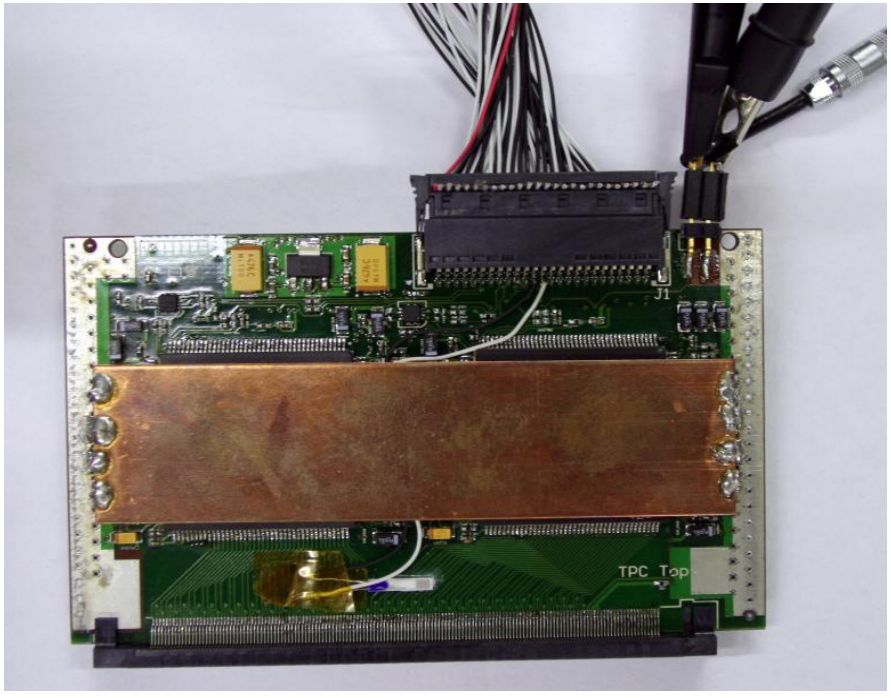

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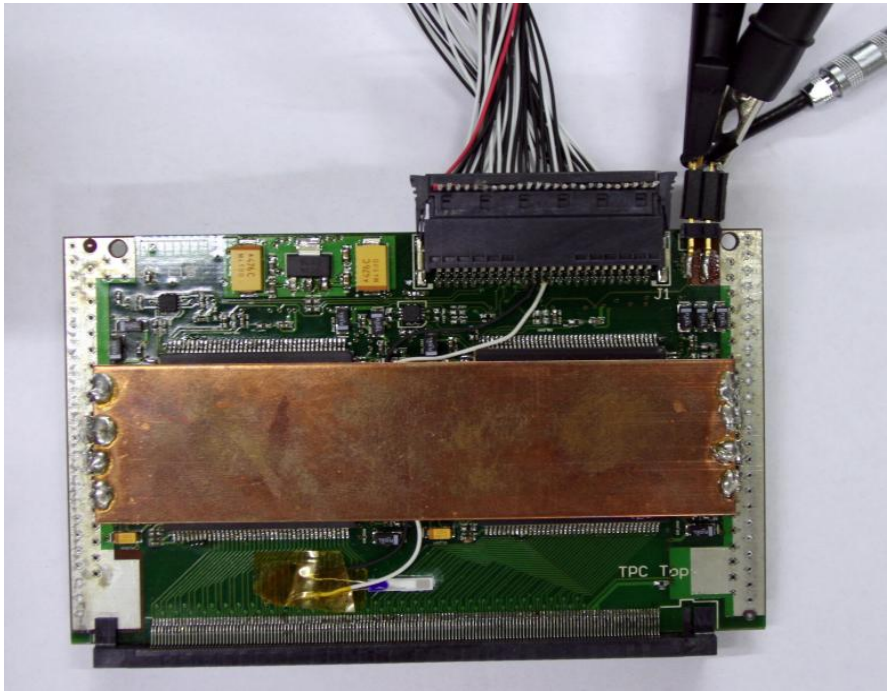

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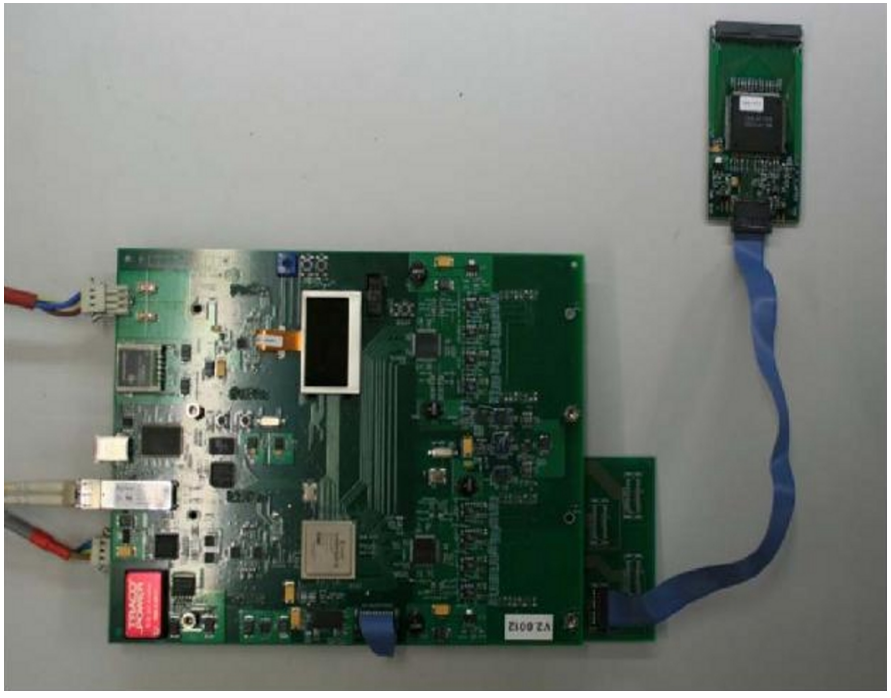


Modifications and Adjustments

- Different drift gas: Ne / CO_2 [90 / 10] $\longrightarrow$ Ar / CO_2 [70 / 30]
- Geometry (not yet modeled the whole setup)

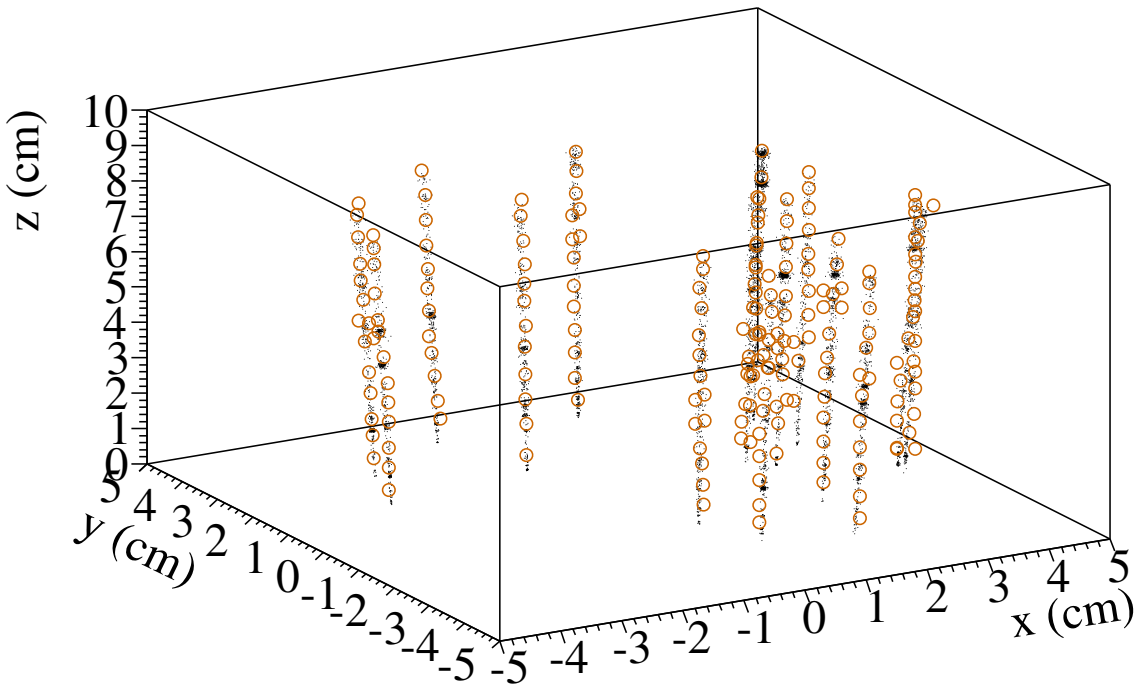
- **Tracking (no magnetic field!):**
  - Fast Hough-Transform pattern recognition was already there (GPU talk last fall!)
  - Geane disappointing (over 90 % of all fits fail)
  - Wanted to make use of genfit

New track representation: **RKTrackRep** (more in summer)

- Improved Pulse Shape Analysis
- Added tasks for data I/O, noise/cross-talk suppression, ...
- The rest was pretty much there!

Simulation in $\overline{\text{P}}$ANDAroot

- BoxGenerator (e^- @ 500 MeV/c) at -100 cm
- Opening angle chosen to illuminate the active area



- Simulated TestChamber tracks (drifted electrons) and obtained clusters (circles)

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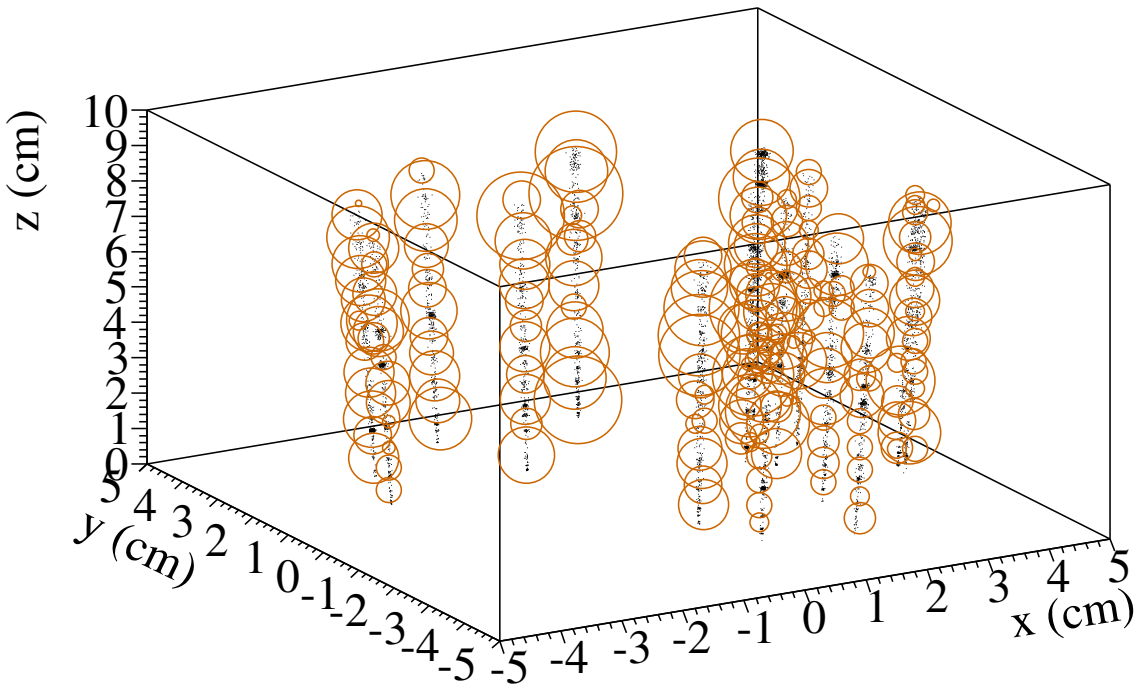

- Symbolical cluster sizes (**not to scale!**)

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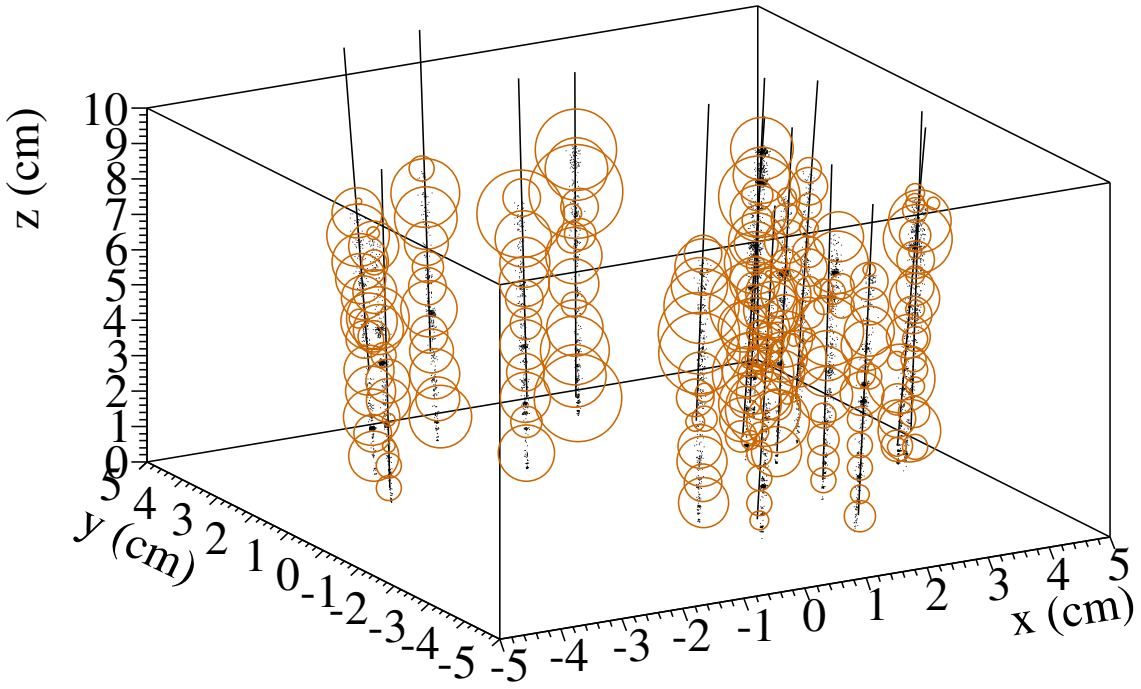
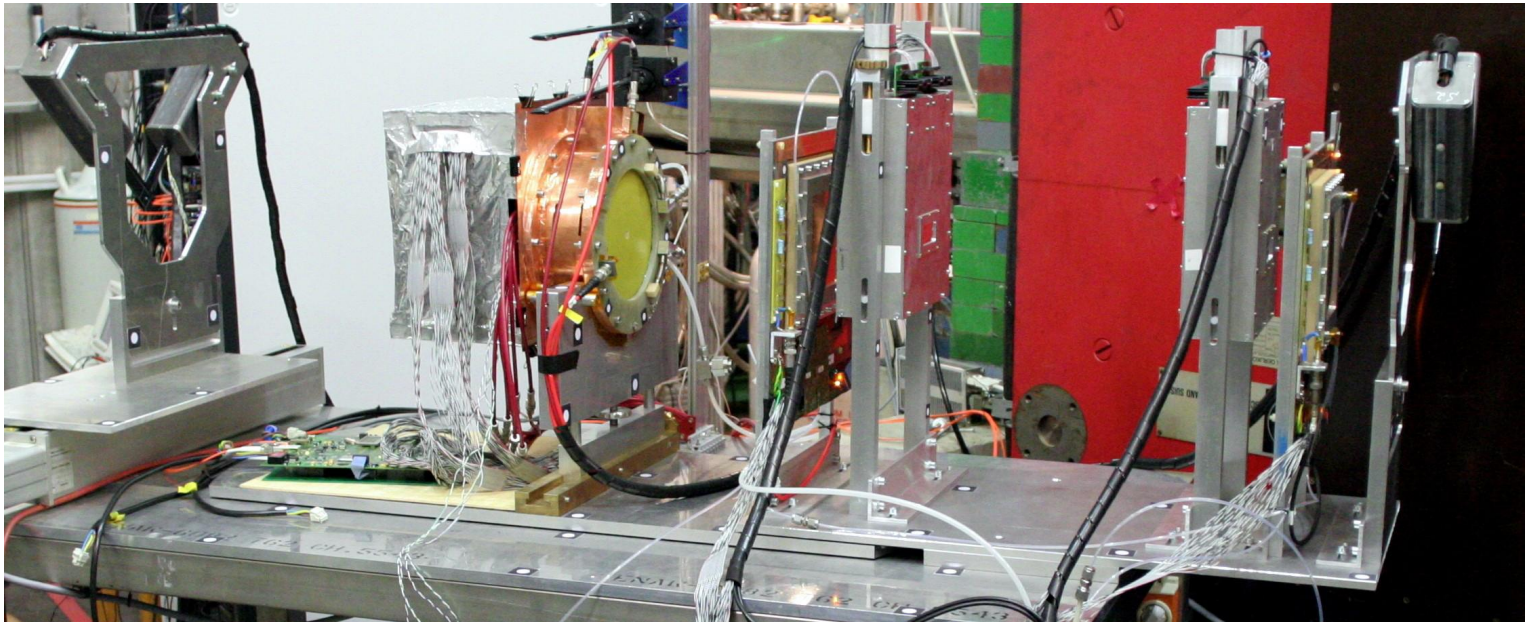


- With genfit fit (*"RKTrackRep"*)

Setup at the ELSA Electron Beam

- 500 MeV/c electron beam



- TPC Test Chamber
- Scintillator trigger system
- Two 10 $\times$ 10 cm^2 GEM detectors
- Four silicon plane detectors

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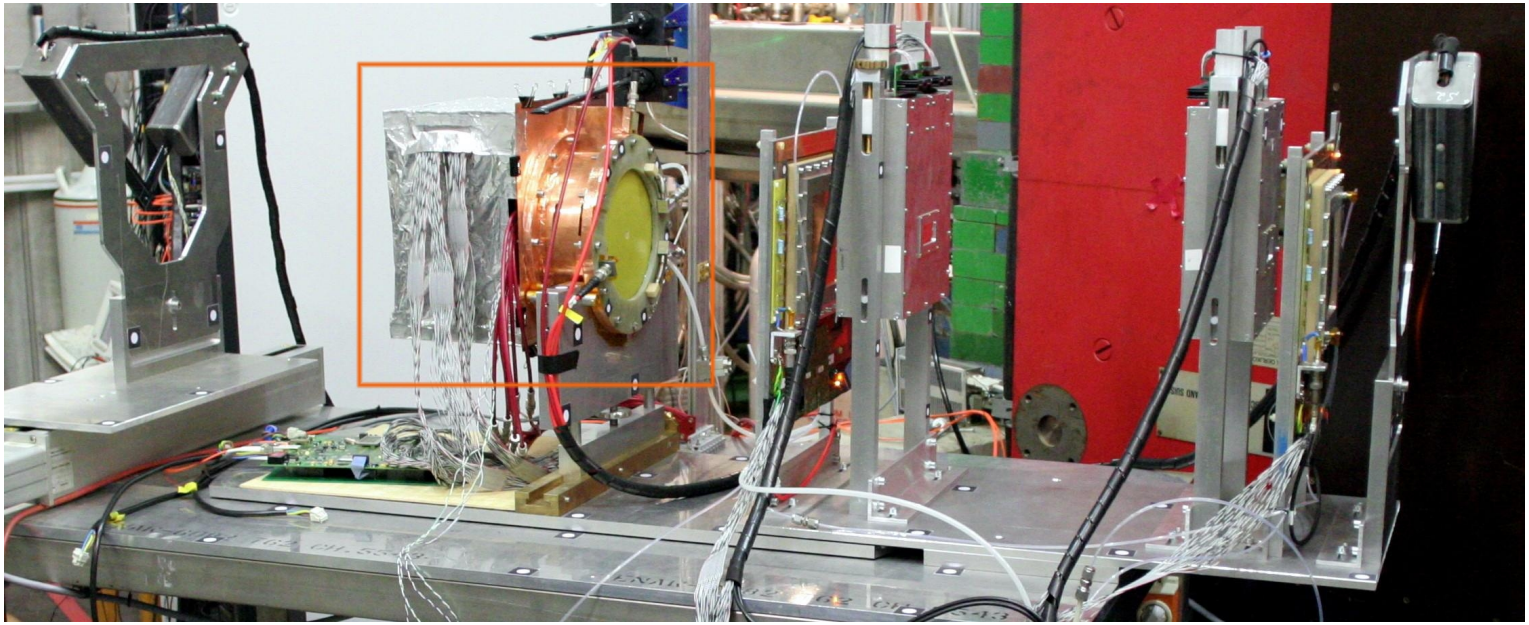

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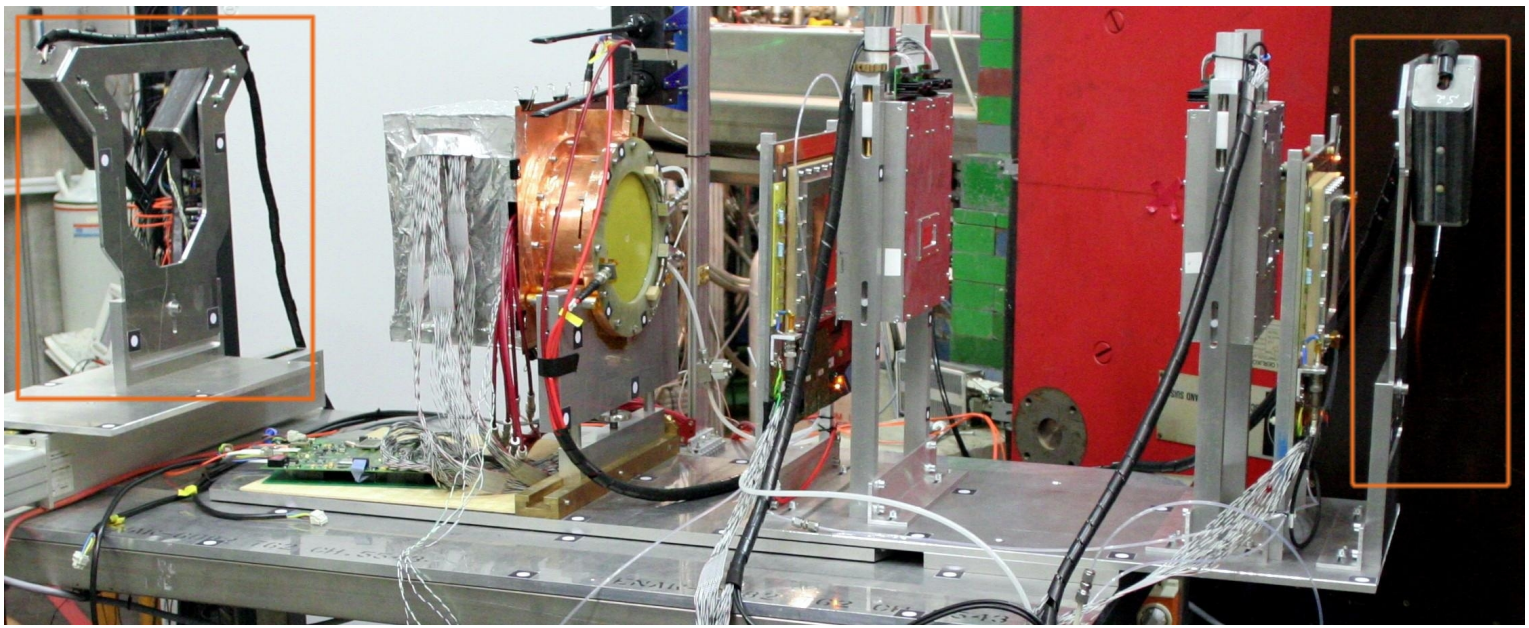

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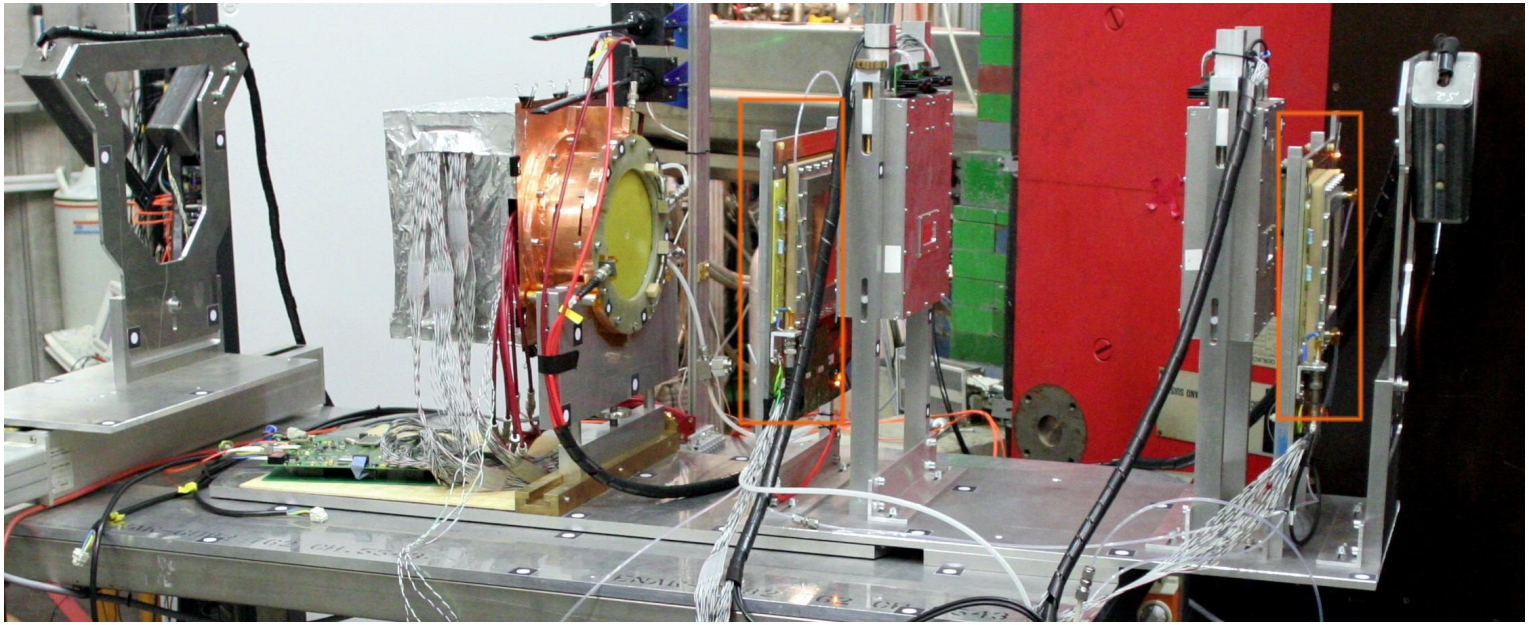

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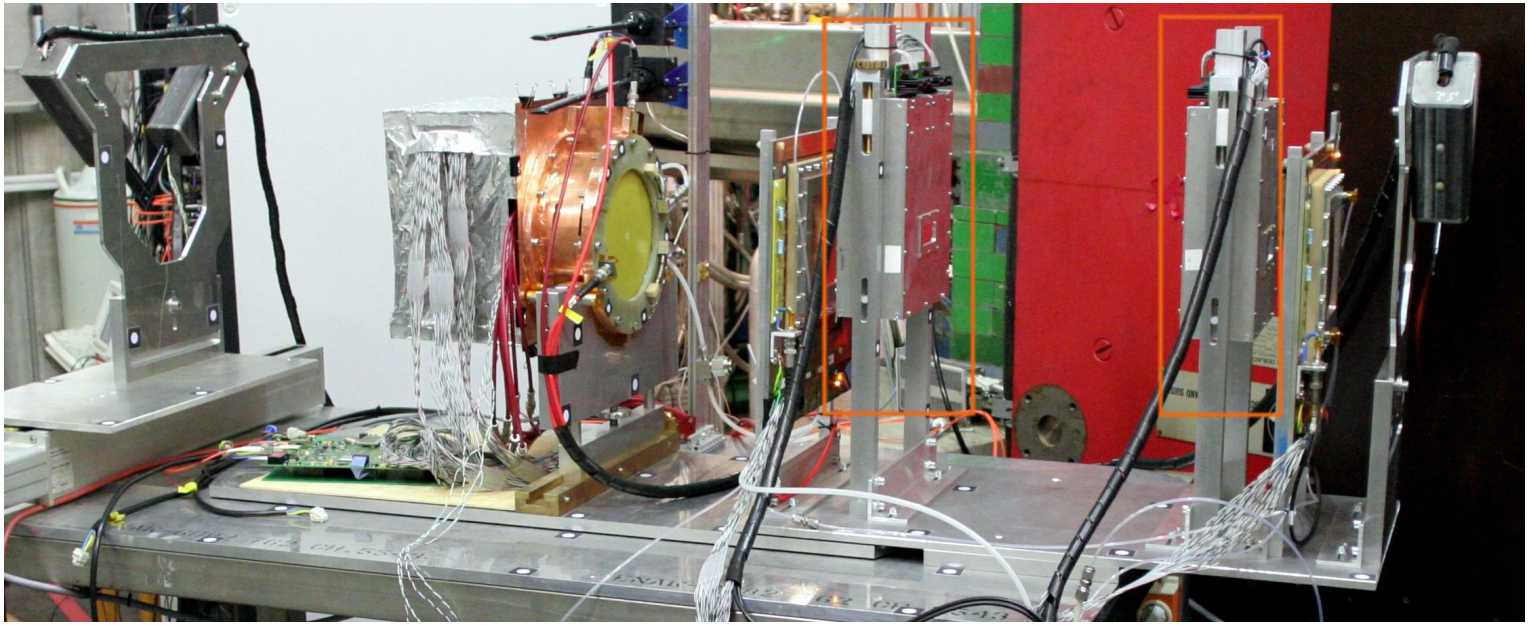

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Event Reconstruction

Bridge to framework:

- `DataReaderTask`: Conversion of decoded detector data (`PndTpcEvent`) into `PndTpcSamples` inside PANDAroot

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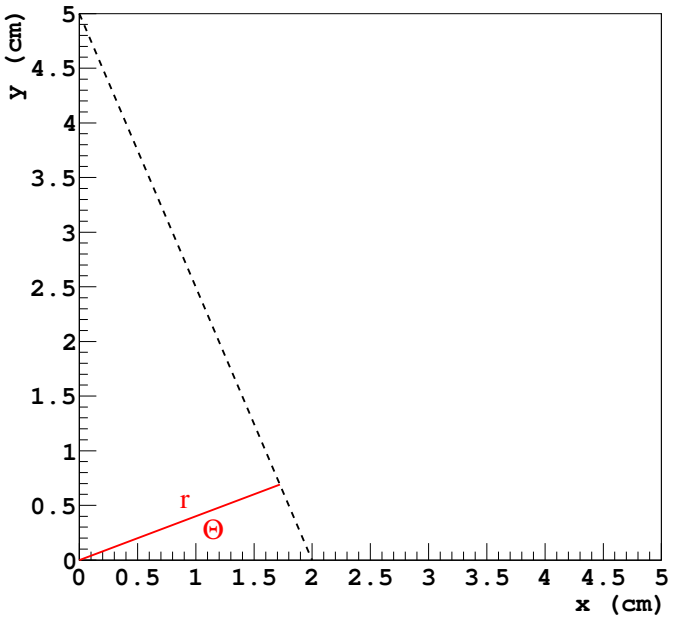
Usual routine:

- `PSATask`: Pulse shape analysis extracts `PndTpcDigis` (talk of Maxence Vandenbroucke)
- `ClusterFinderTask`
- **Pattern Recognition:** Straight line pattern recognition is done using a *Fast Hough Transform* in two dimensions (see my talk from fall '09)
- **Fitting** using genfit and a new track representation

Pattern Recognition: Hough Transform

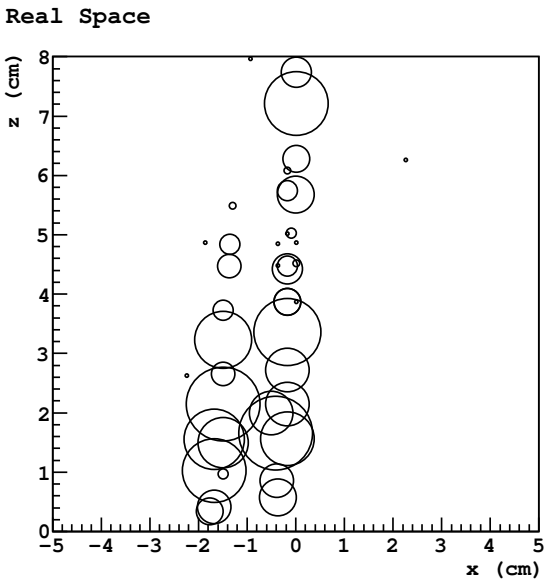


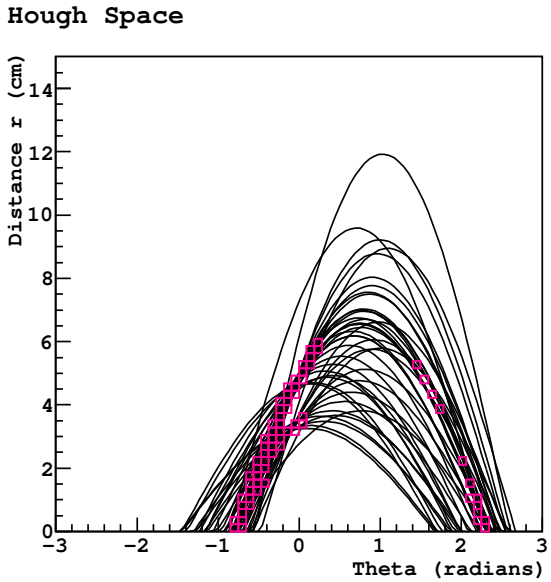
- Parametrize line through closest distance to origin r and "polar" angle Θ.
- Transform each measured point $\mathbf{X_i}$ to *Hough Space* $\{\Theta, r\}$:

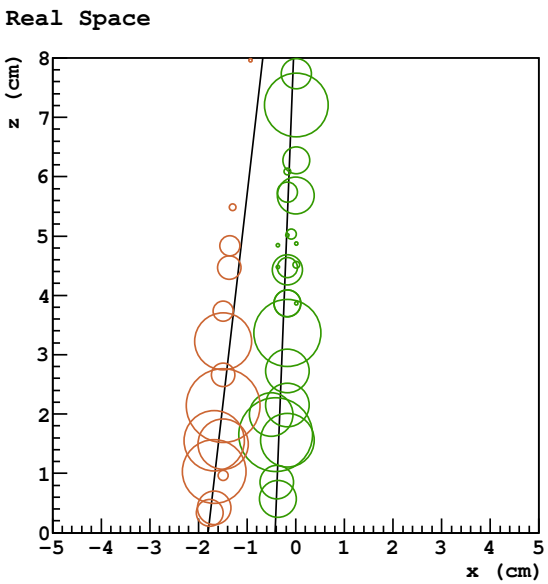
$$r(\Theta) = x \cdot \cos(\Theta) + y \cdot \sin(\Theta)$$

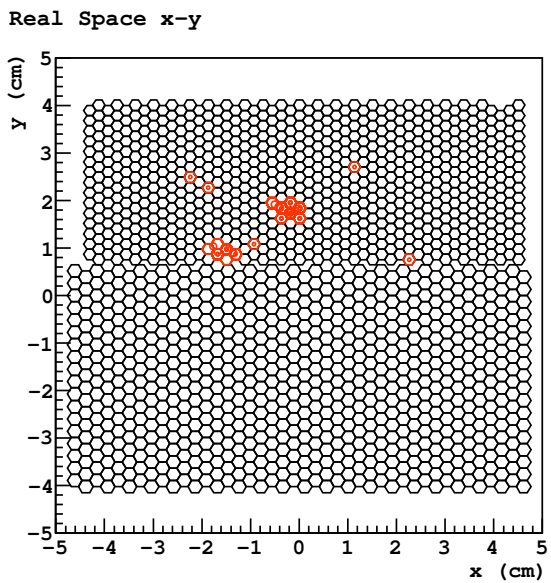
- If points lie on a straight line $\longrightarrow$ **Maximum in the Hough Space**
- Maximum detection using a tree search (*"Fast Hough Transform"*, see talk of 9/09 about GPU implementation)

Example Events









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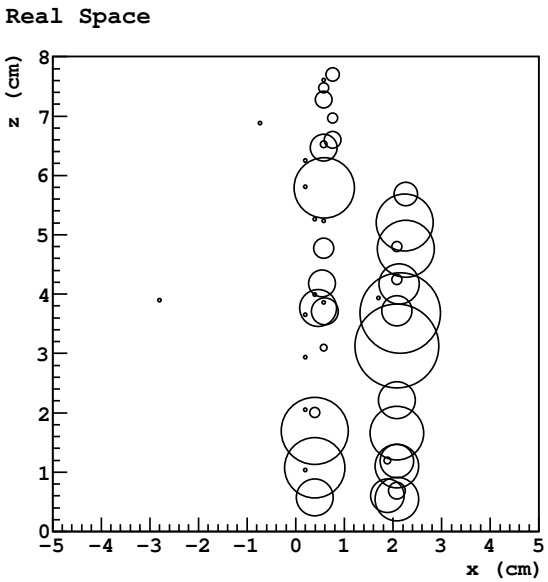

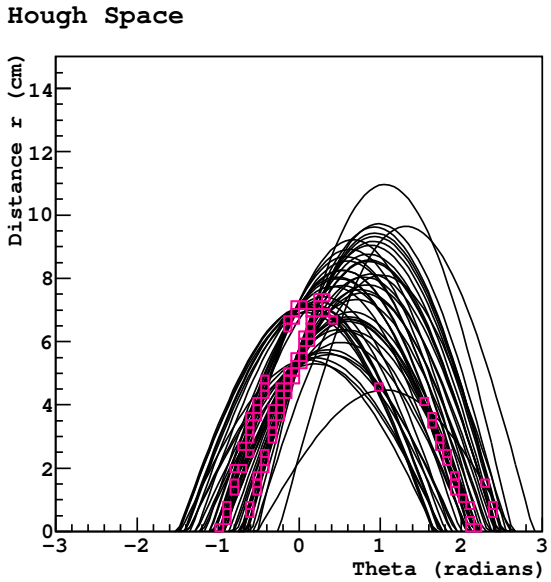

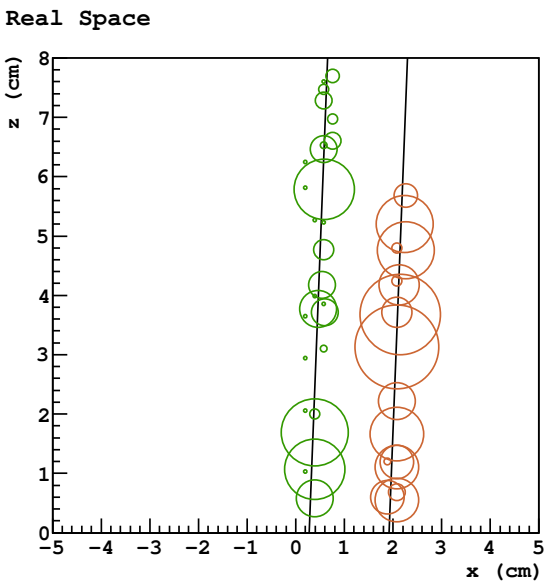

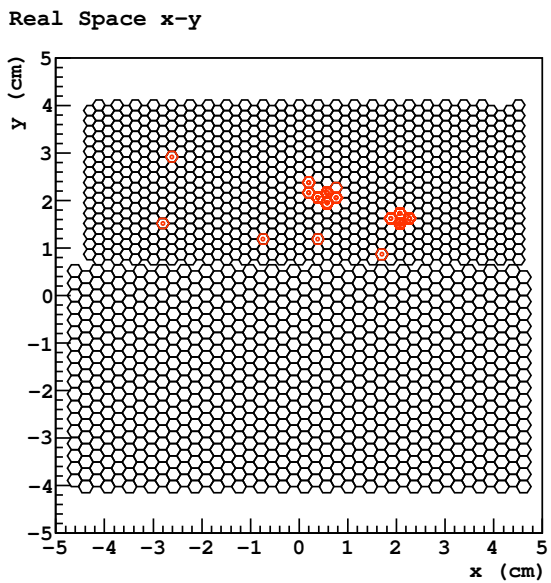

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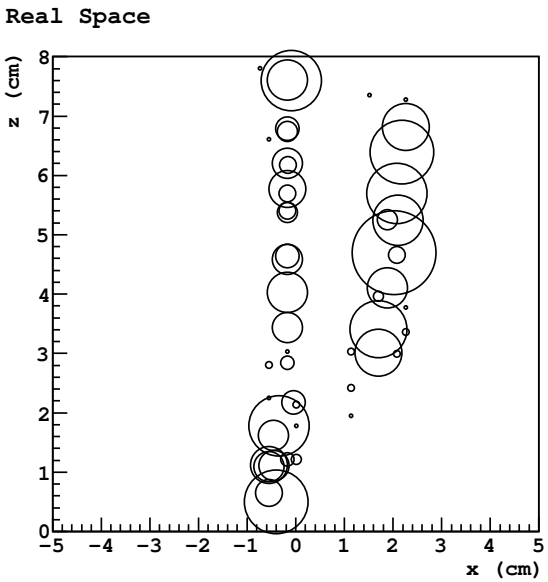

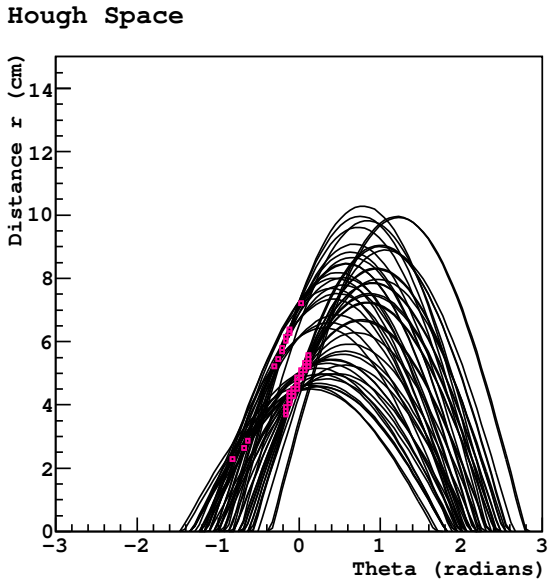

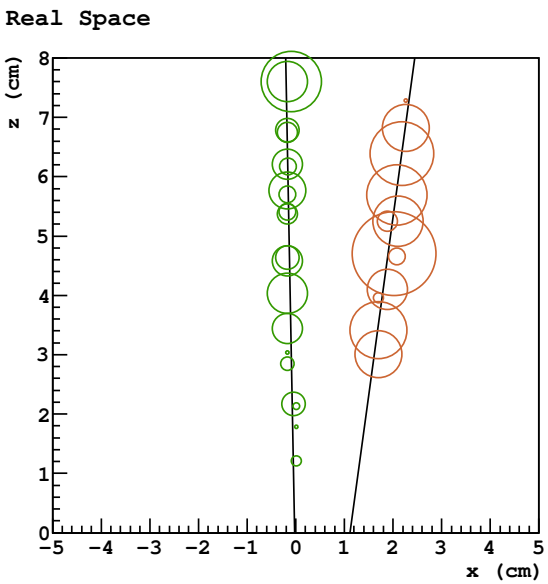

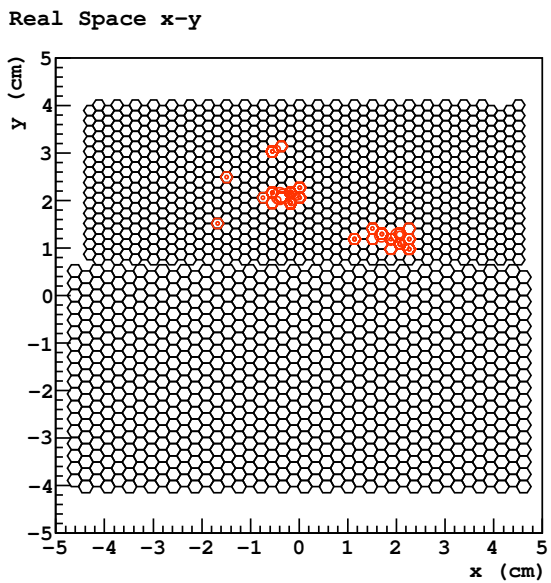

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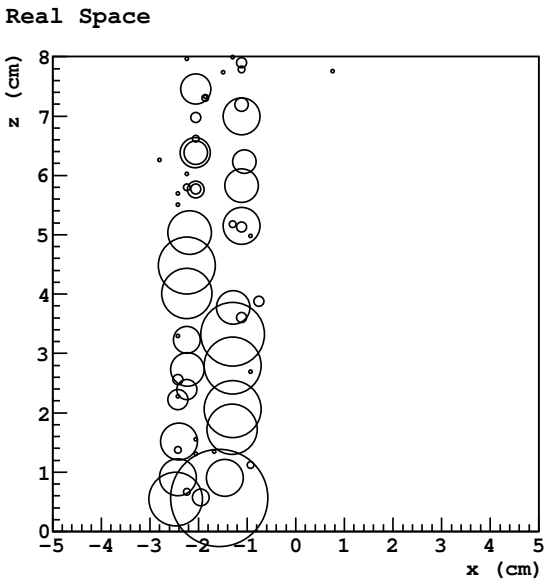

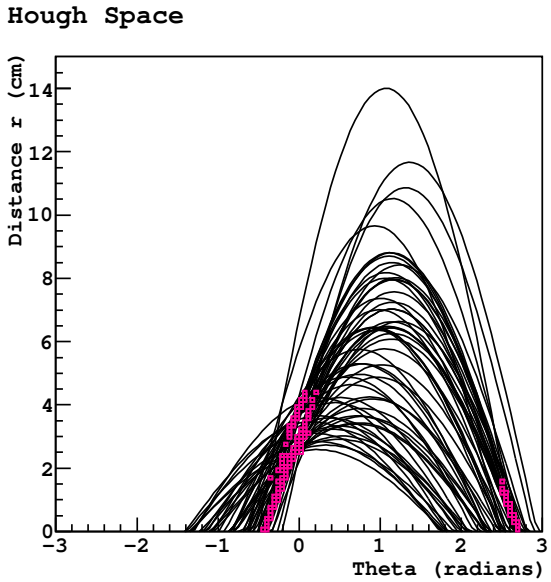

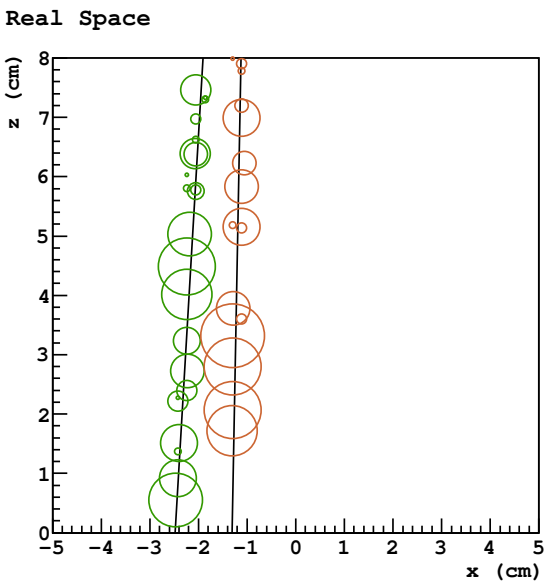

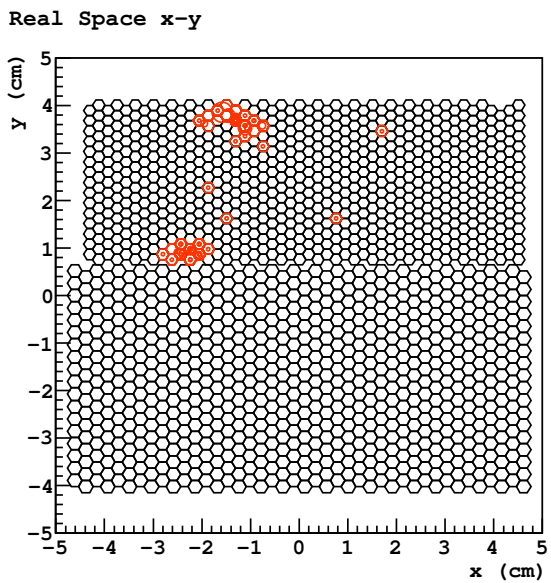

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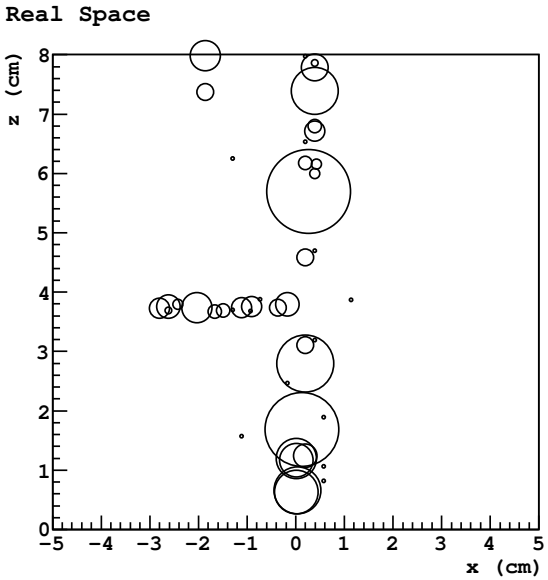

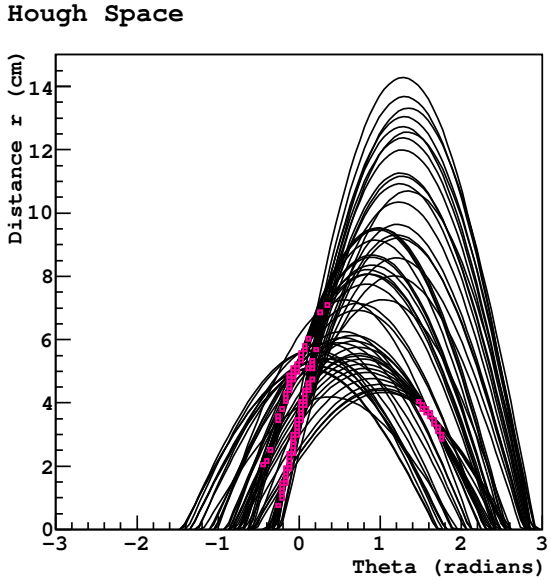

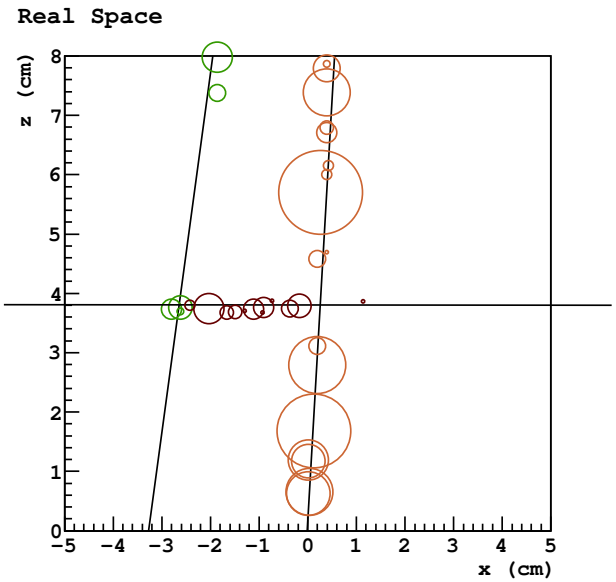

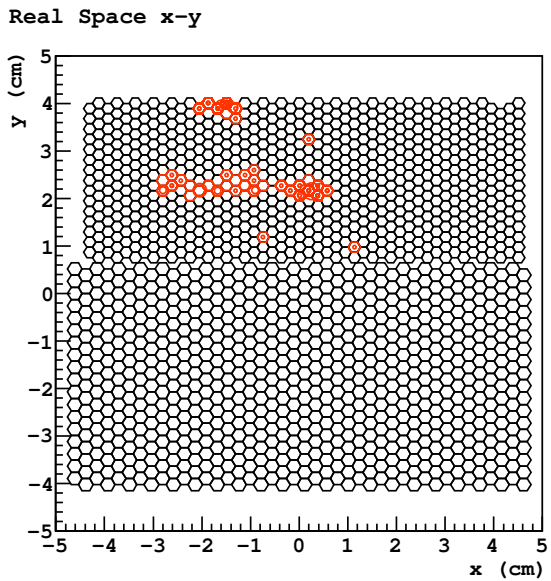

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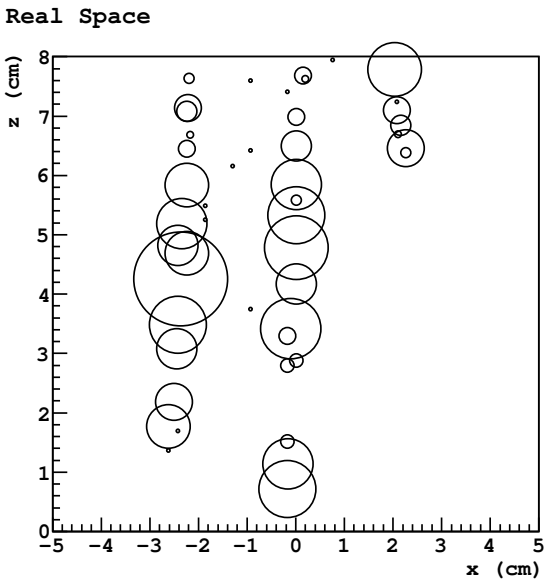

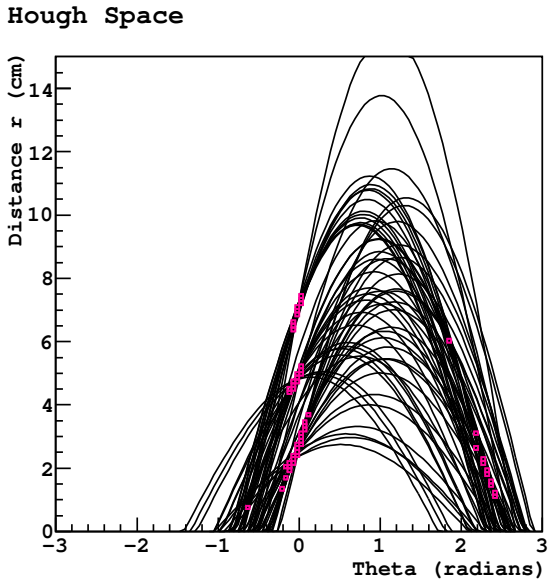

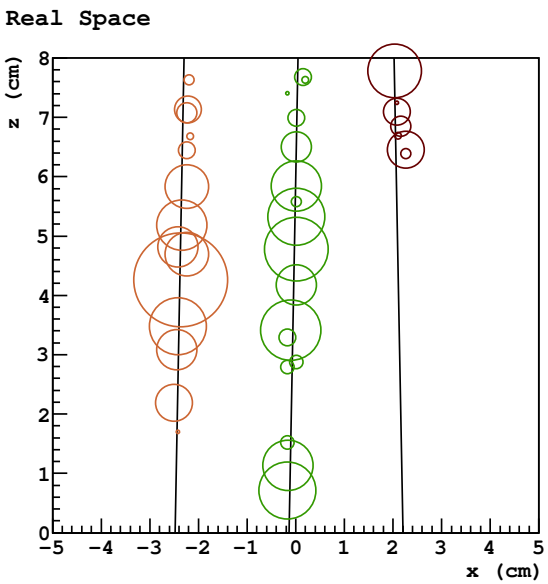

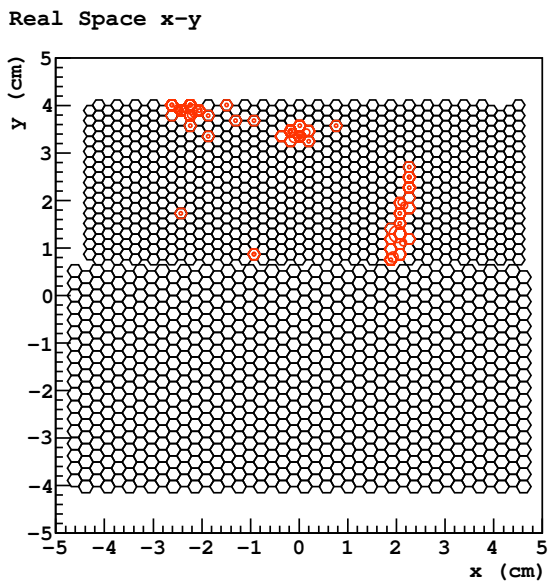

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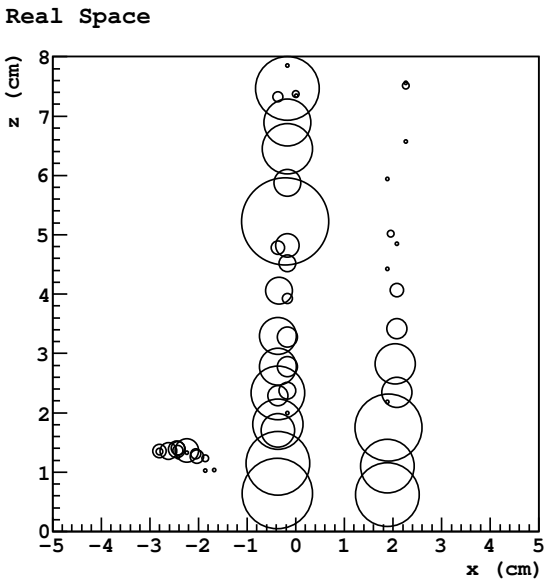
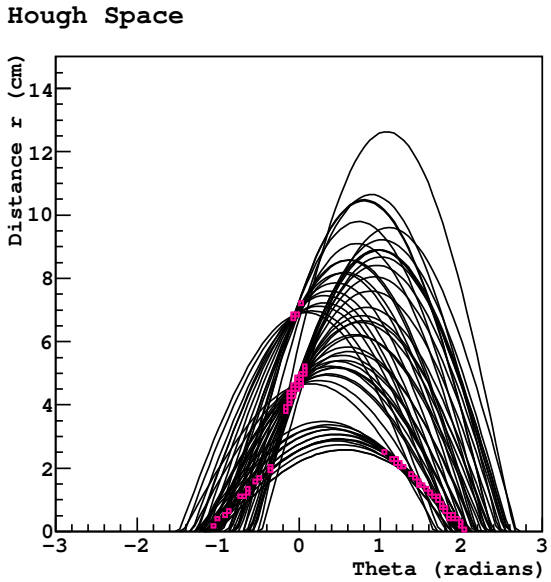
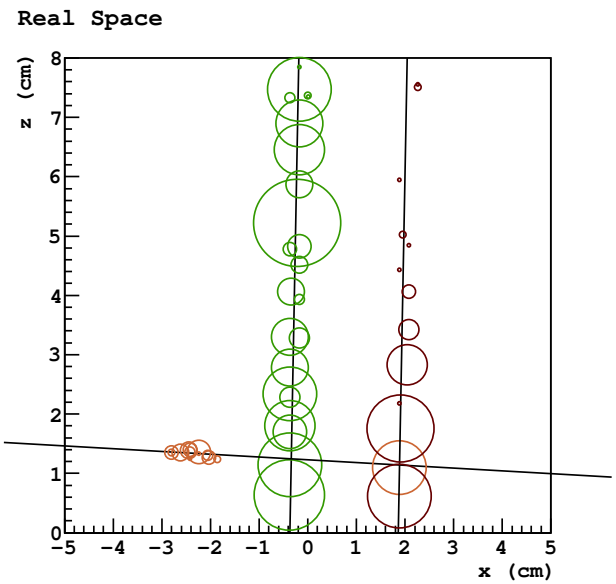
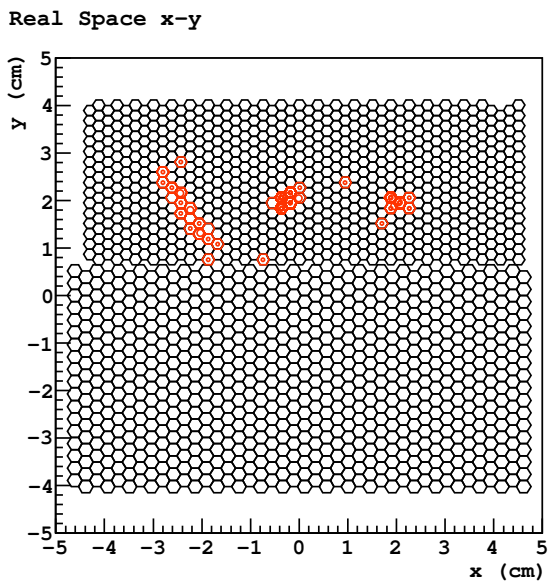


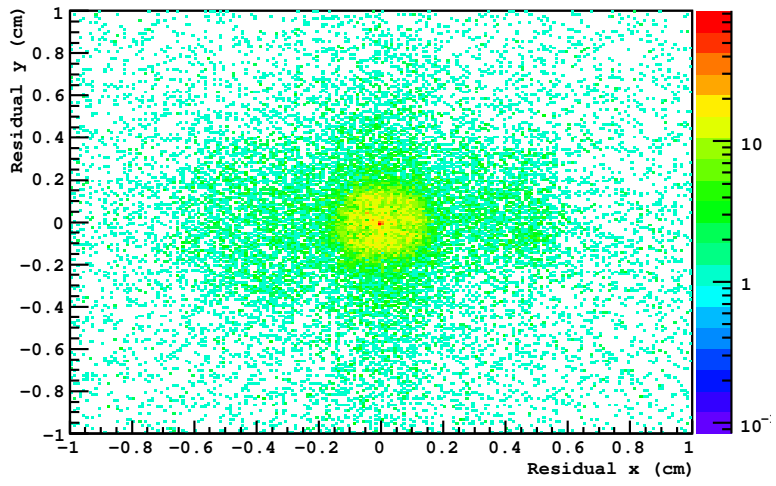




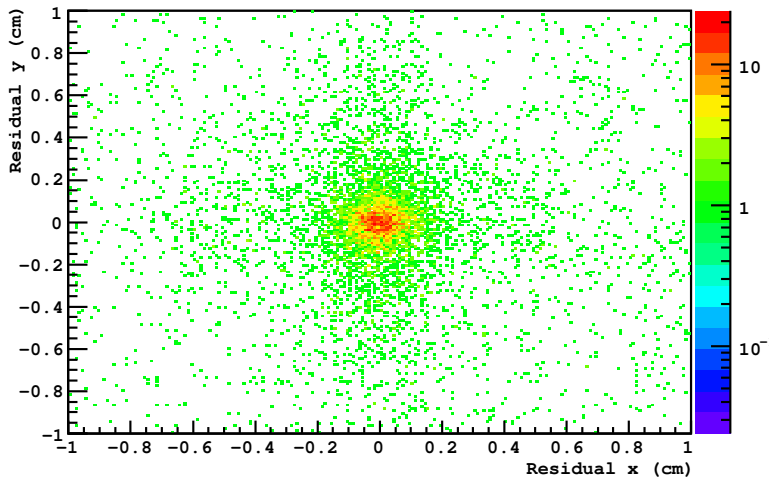


Residuals (biased)

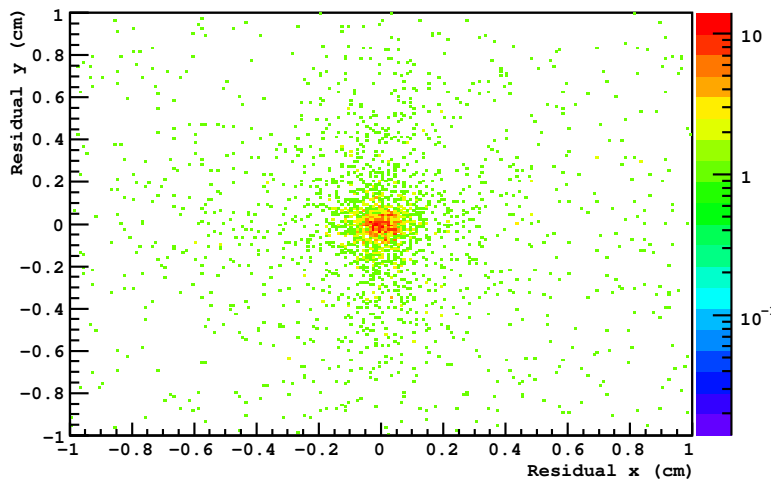
ClusterSize1



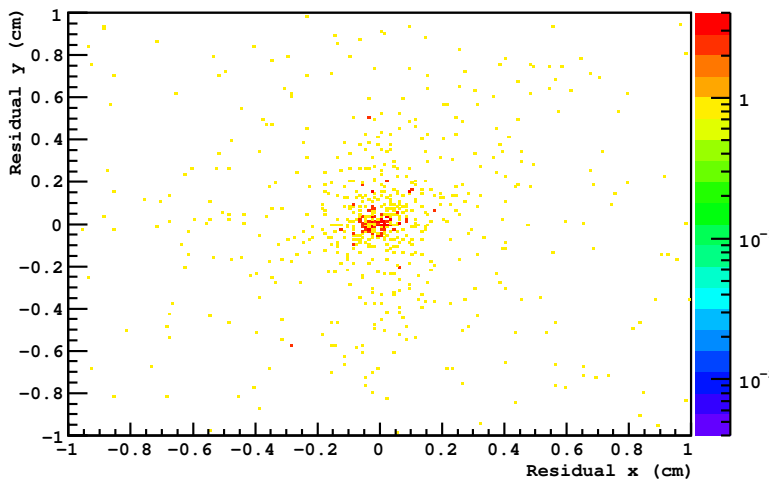
ClusterSize2



ClusterSize3

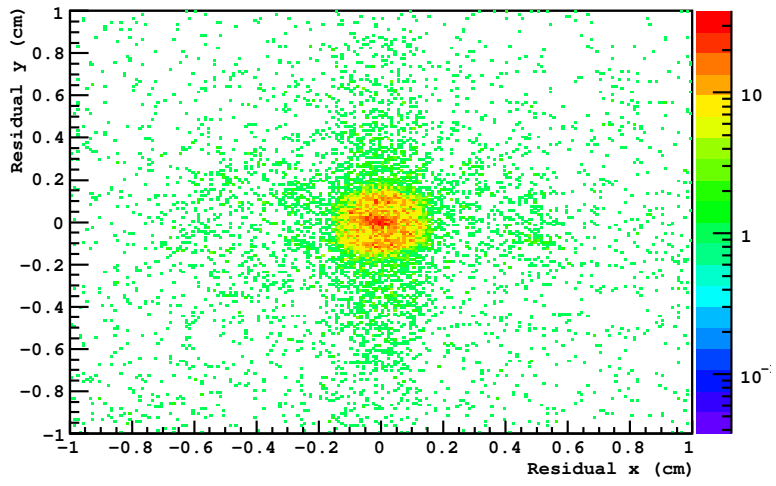


ClusterSize4

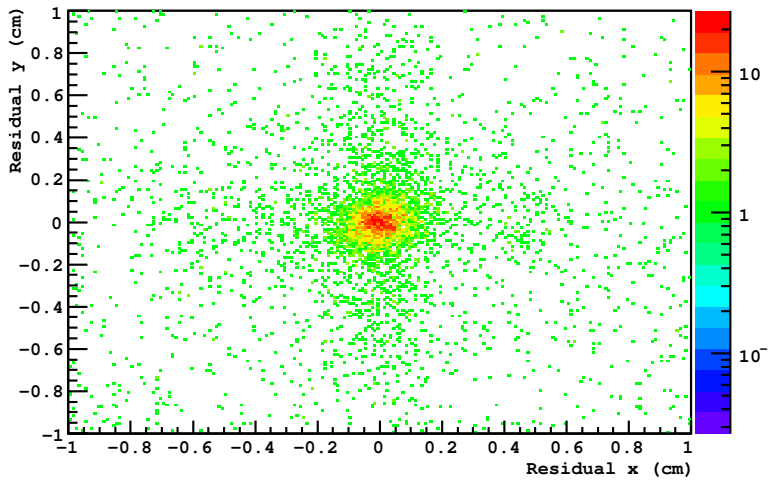


Residuals - Crosstalk-corrected

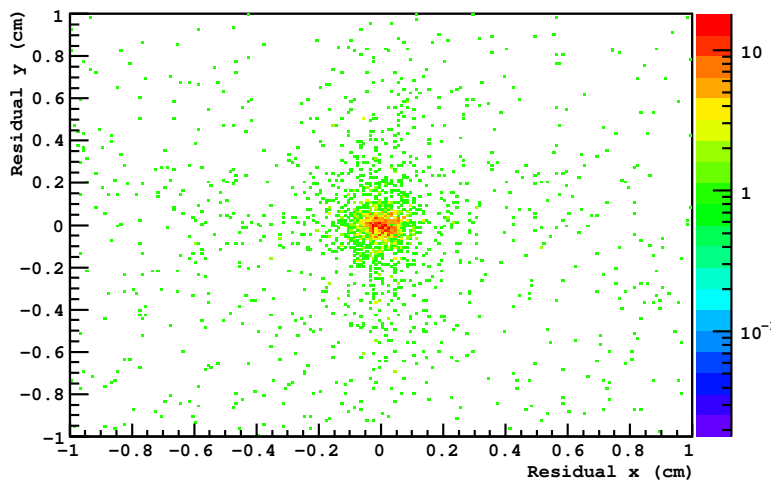
ClusterSize1



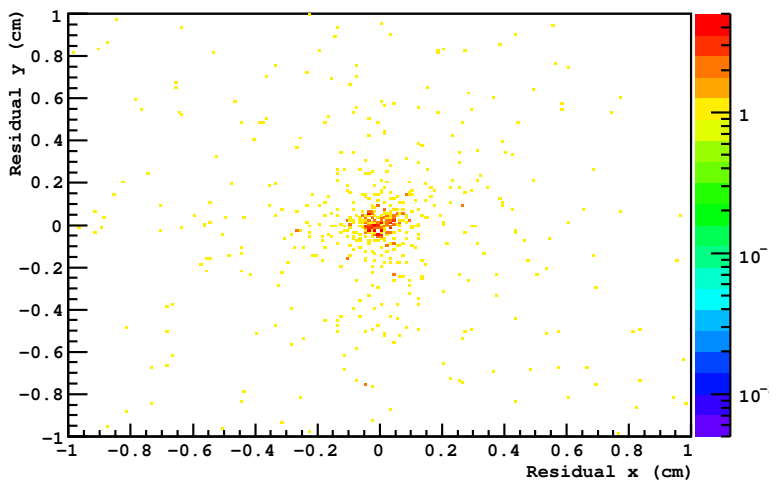
ClusterSize2



ClusterSize3

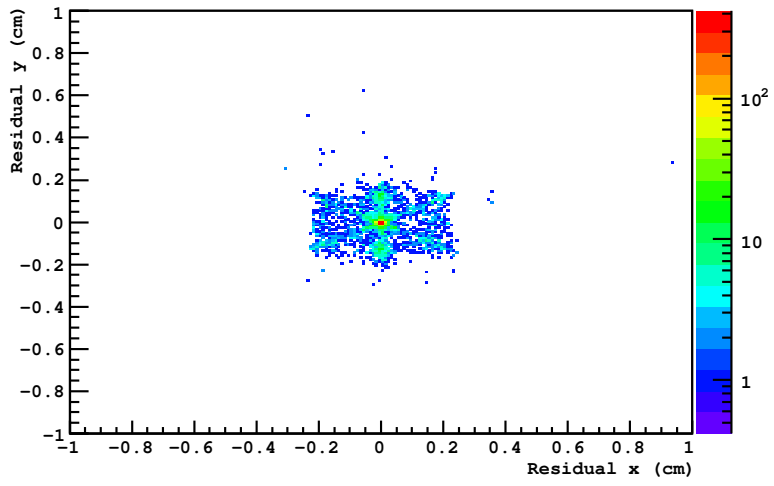


ClusterSize4

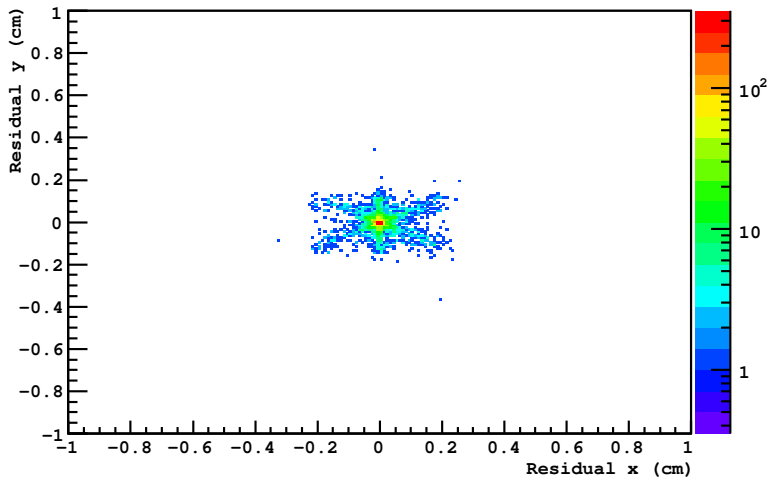


Residuals - Simulation

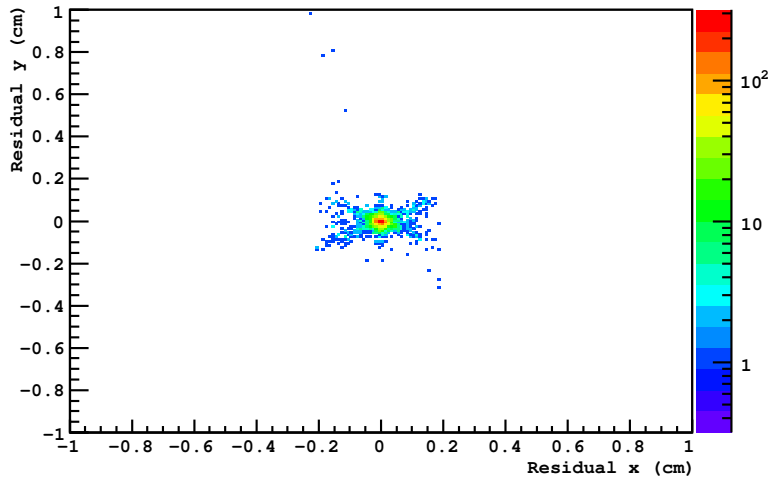
ClusterSize1



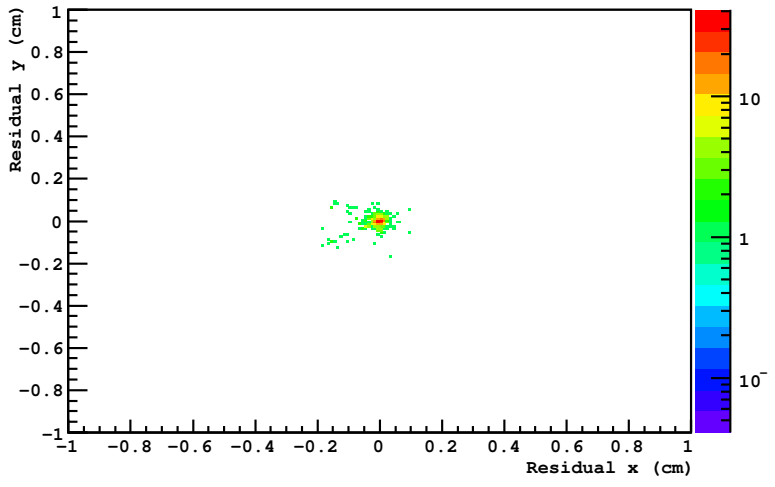
ClusterSize2



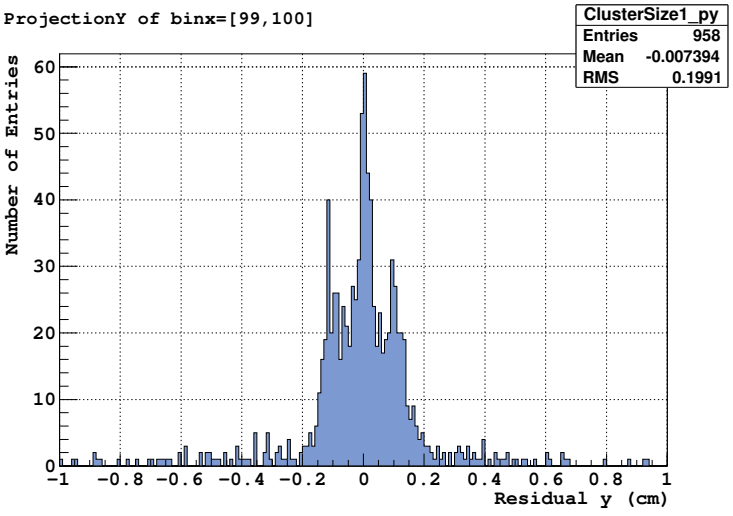
ClusterSize3

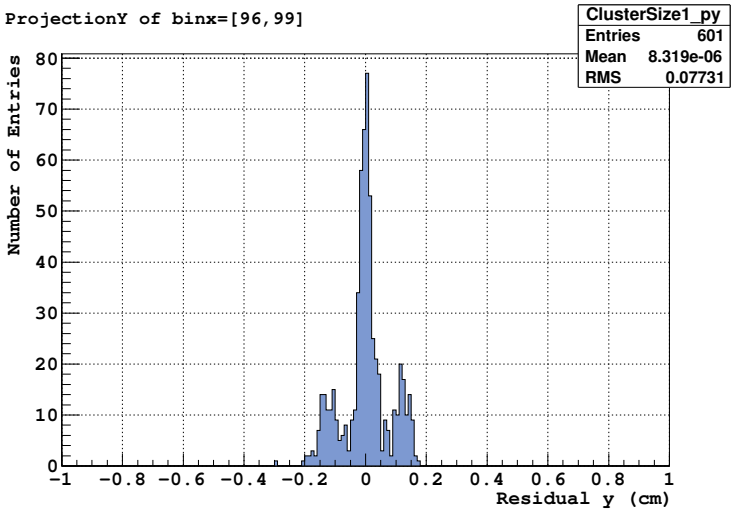


ClusterSize4



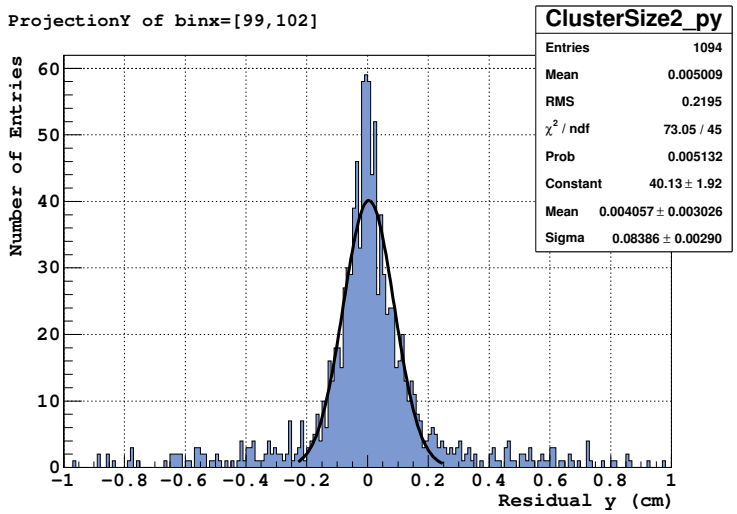
Residuals - ClusterSize 1

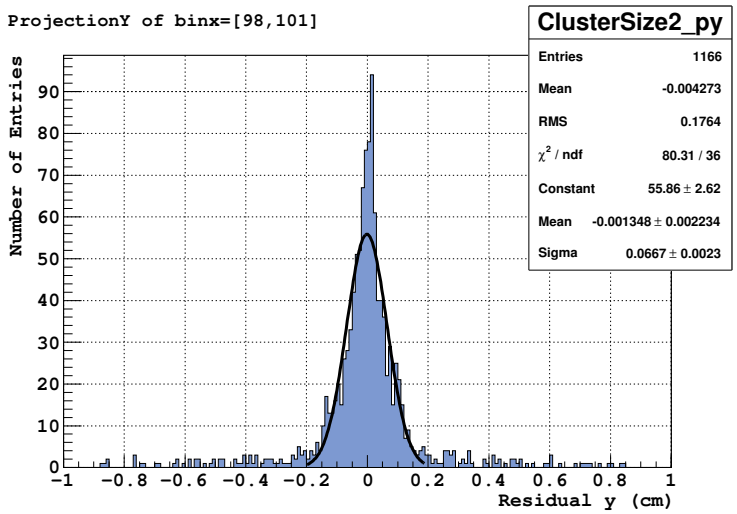




- "Triple-peak" in both data and simulation
- Reason: cluster-position is identical to pad-position for clustersize 1
- **Tracks perpendicular to the readout are the worst case**

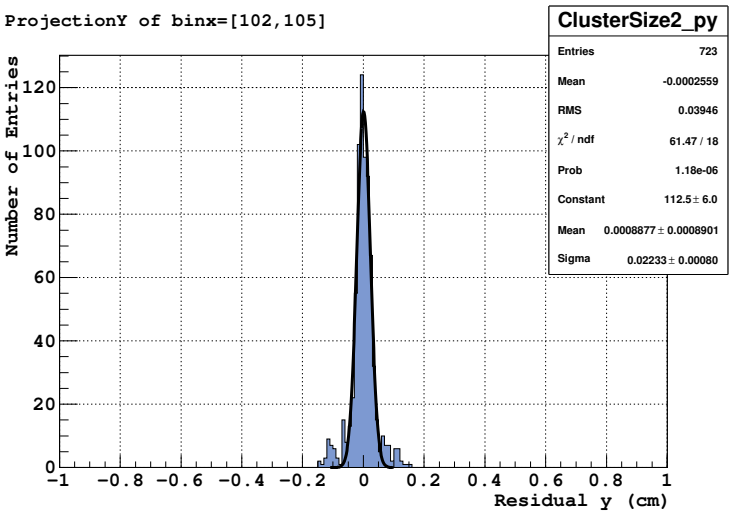
Residuals - ClusterSize 2

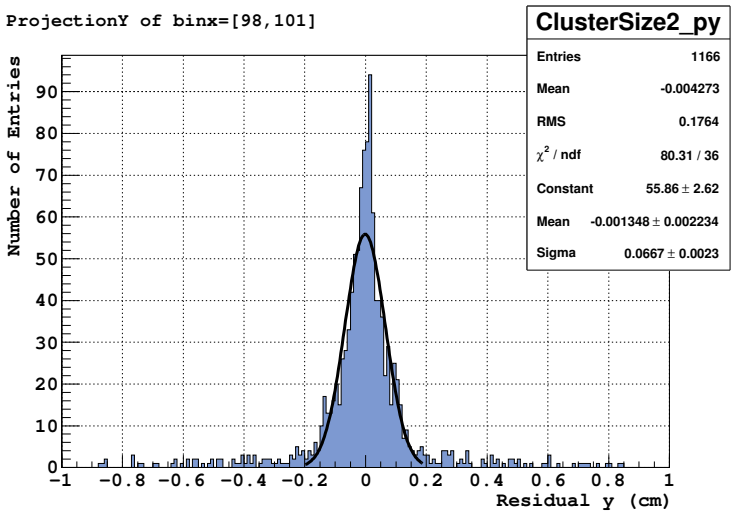




- Crosstalk correction helps to improve resolution
- Correction improves measured resolution to $\sim 600\,\mu\text{m}$
- Simulated data shows resolutions of a factor 3 better
- Reason: Problems during the run at ELSA (pedestals, high signal threshold, ...)

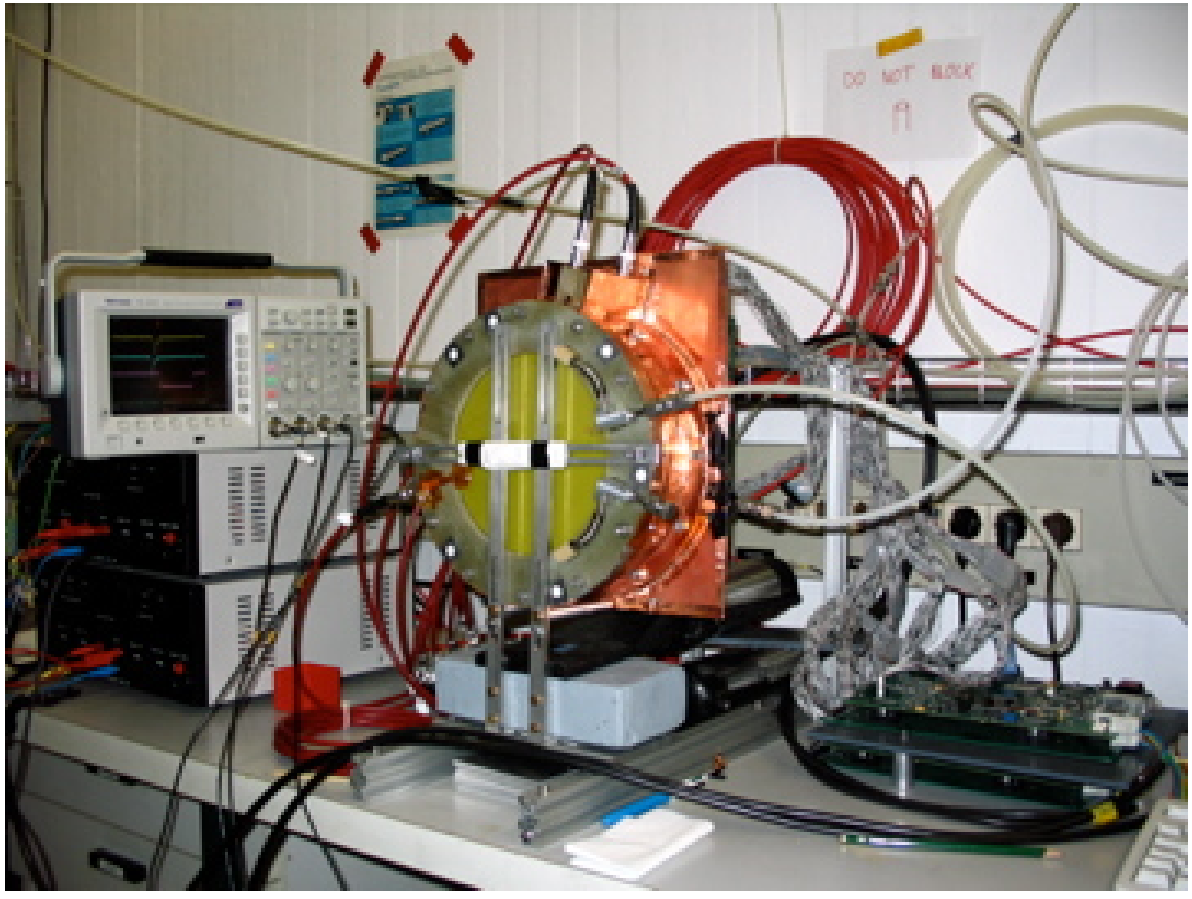
Residuals - ClusterSize 2





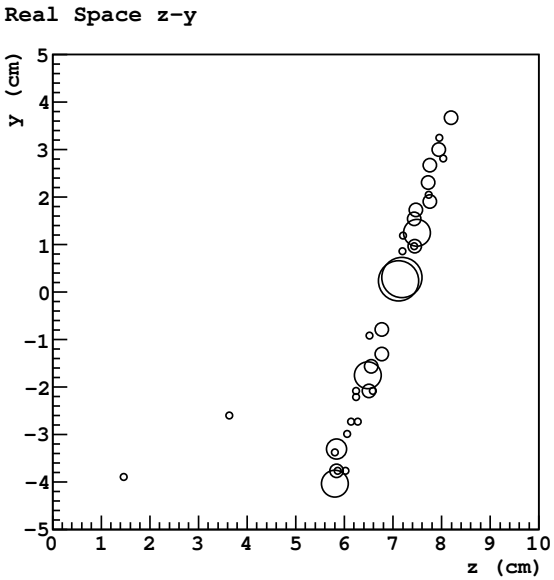
- Crosstalk correction helps to improve resolution
- Correction improves measured resolution to $\sim 600\,\mu m$
- Simulated data shows resolutions of a factor 3 better
- Reason: Problems during the run at ELSA (pedestals, high signal threshold, ...)

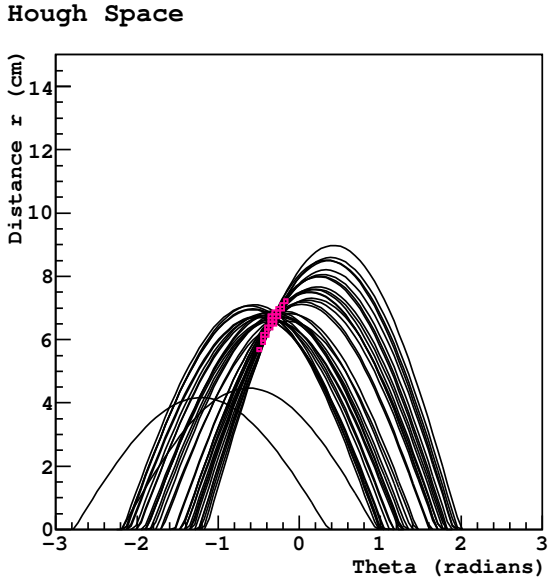
Cosmic Setup @ E18

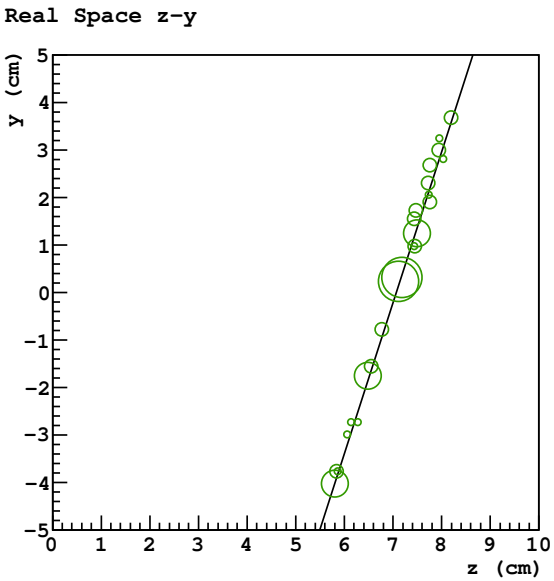


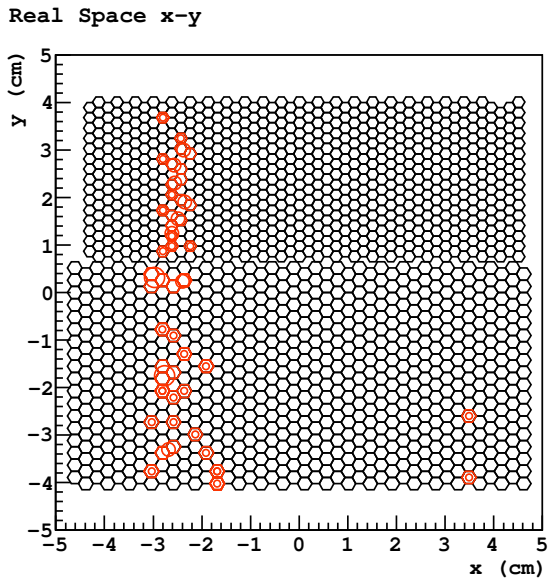
- Scintillator trigger system
- Tracks **parallel** to the readout

Example Events

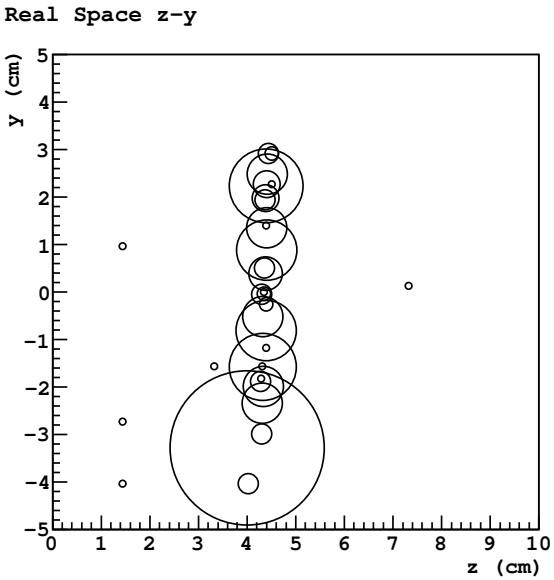


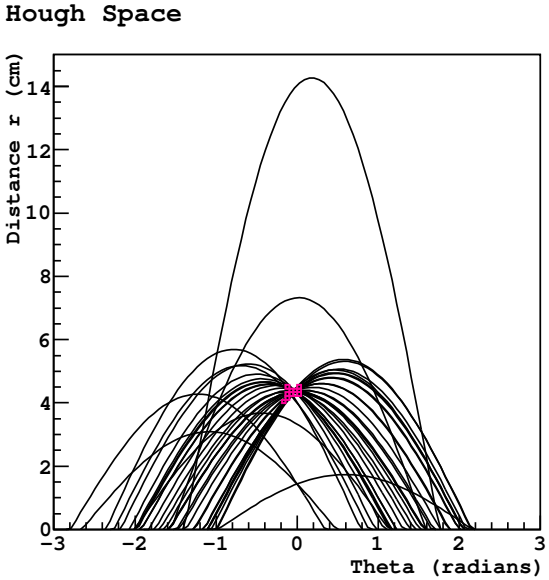


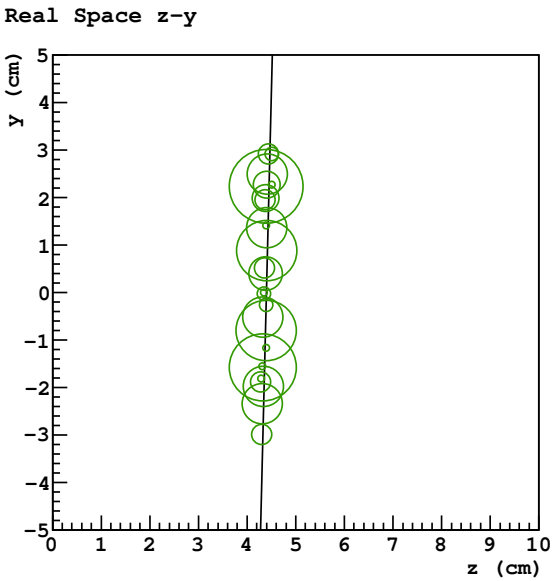


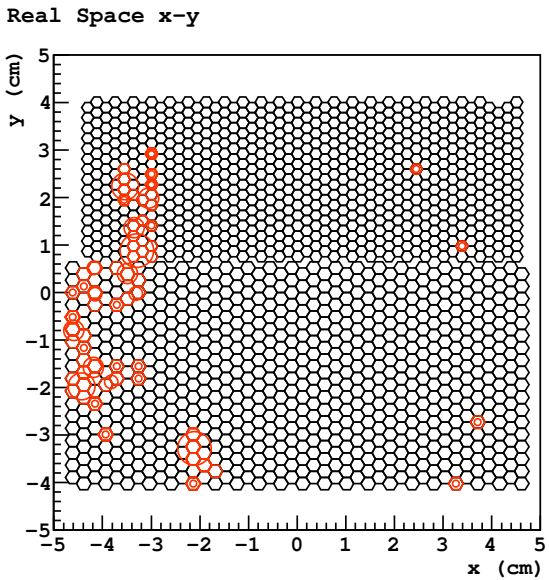


Example Events

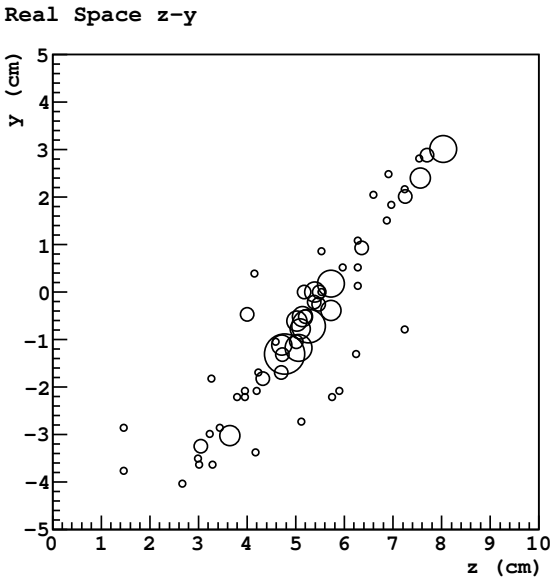


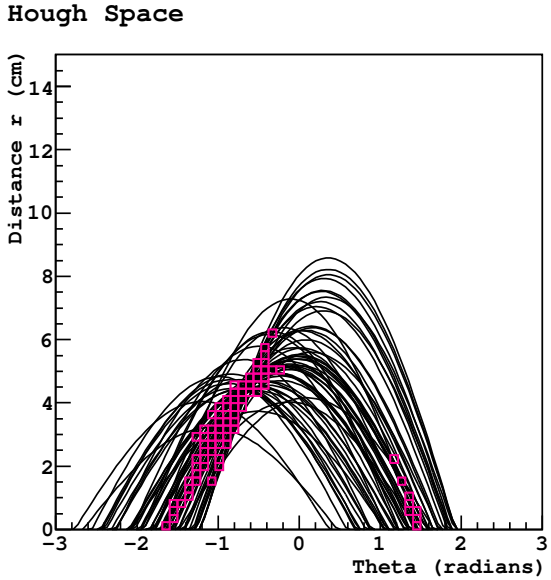


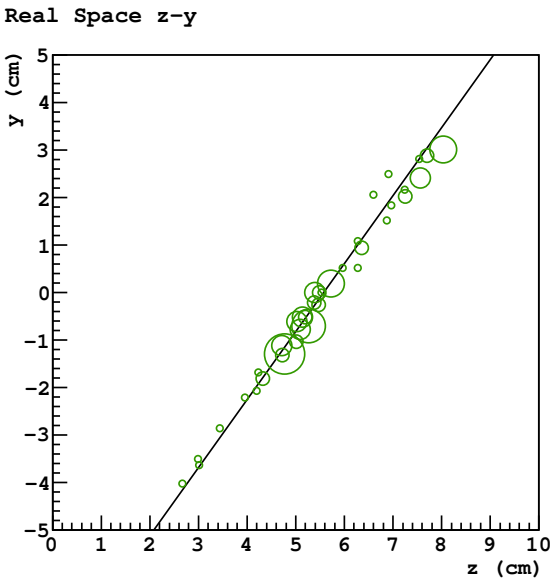


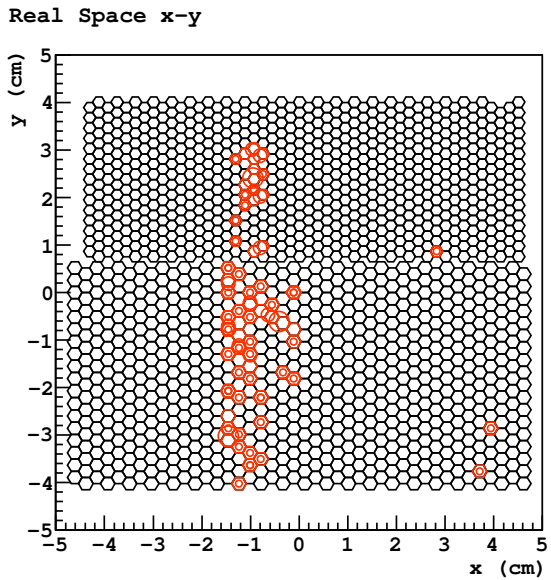


Example Events

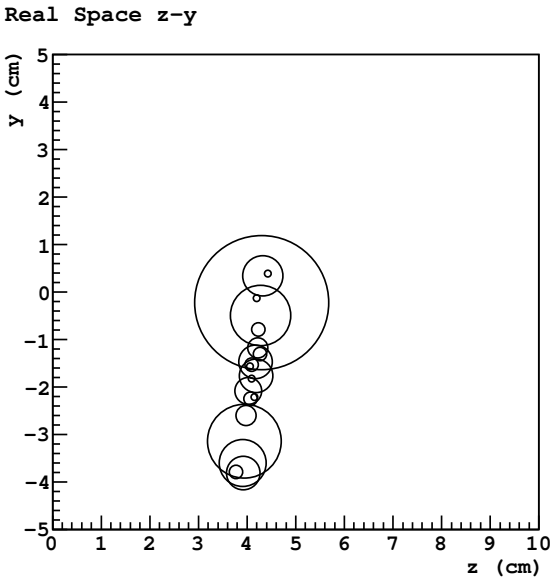


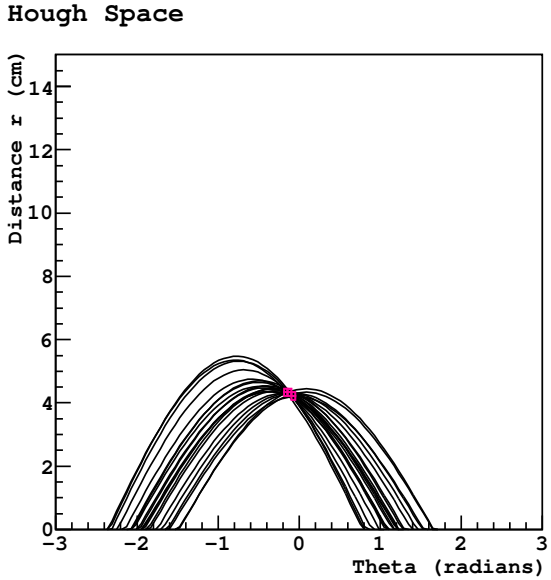


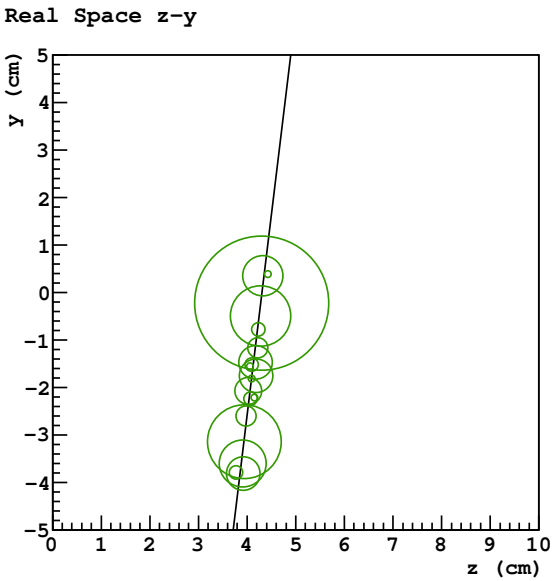


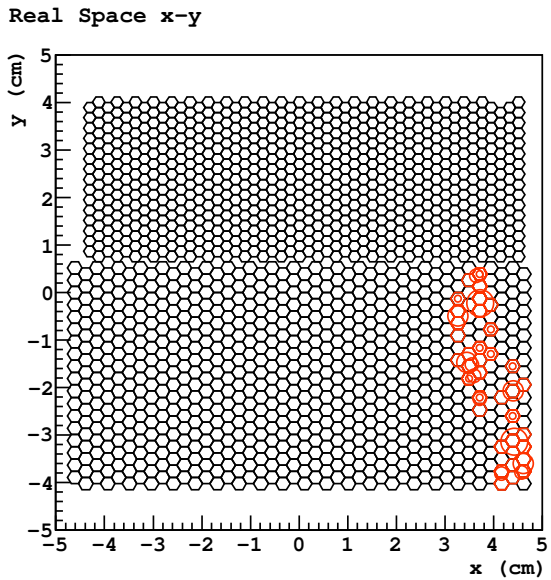


Example Events

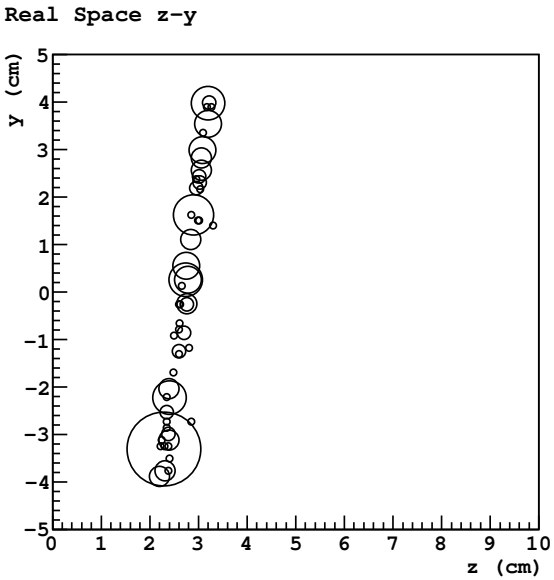


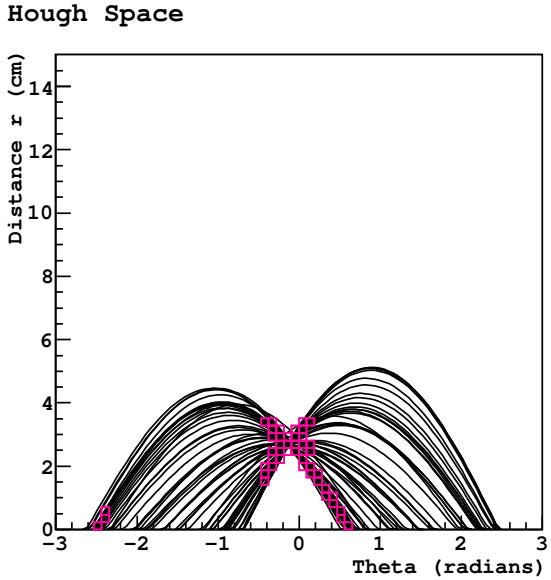


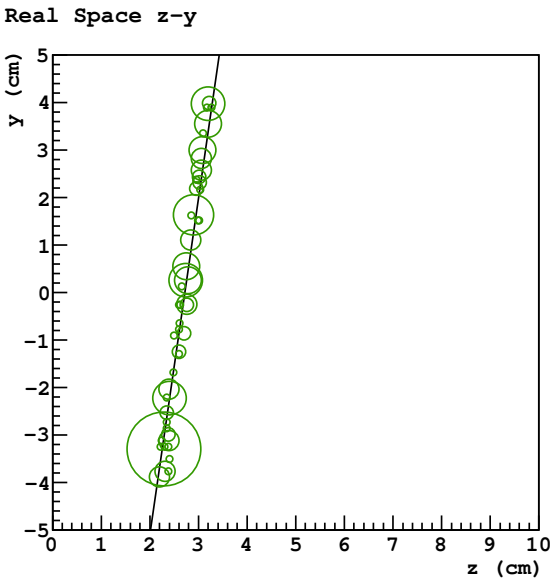


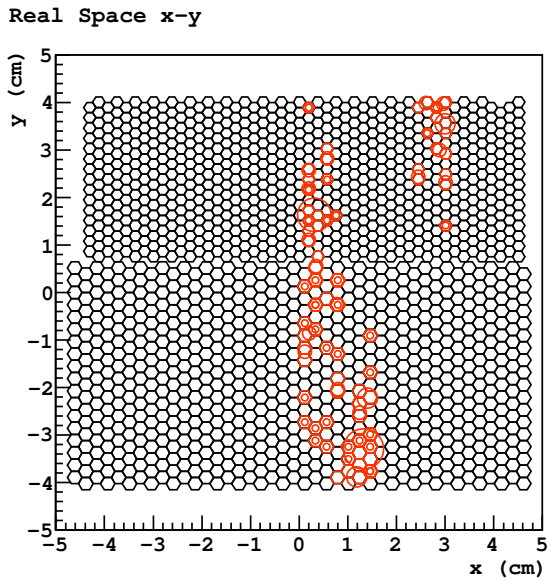


Example Events

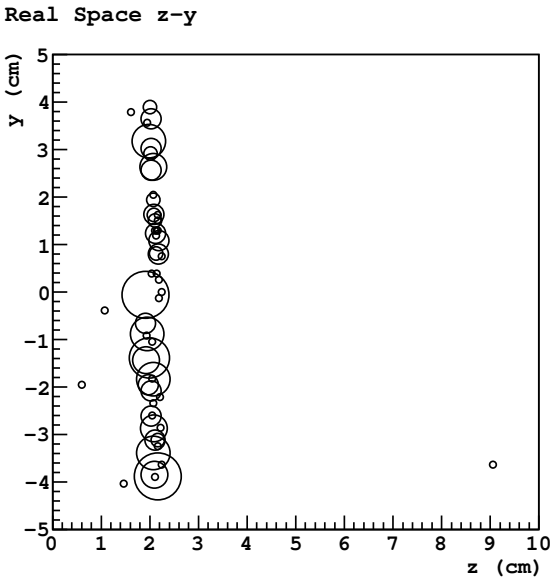


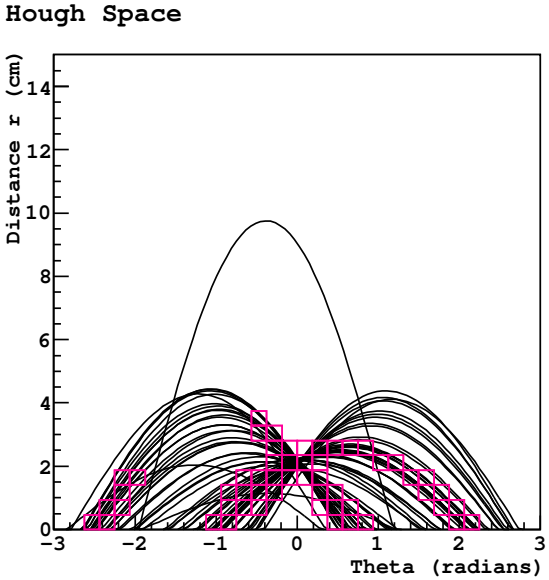


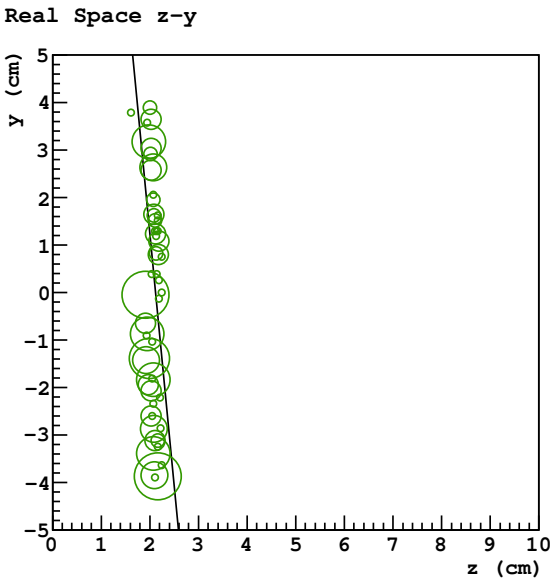


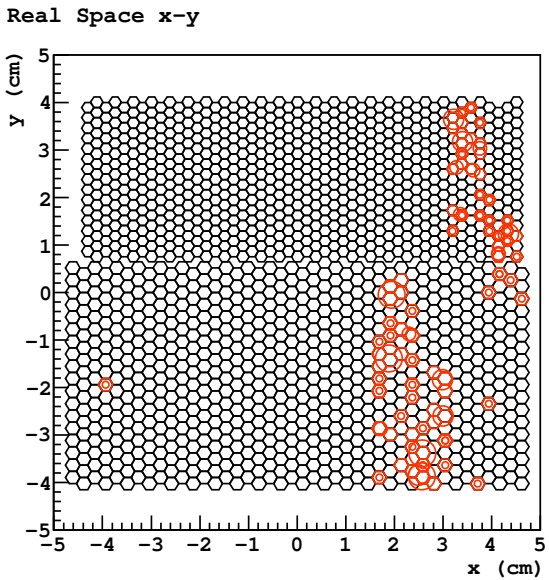


Example Events









Conclusion & Outlook

Summary:

- **TPC test detector readout fully intergrated in $\overline{\text{PANDA}}$root**
- Full portability to other prototypes / large prototype!
- Started analysis of data of the small TestChamber
- Pattern recognition (2D Hough, TrackEater) and tracking (genfit, GEANE/RK - TrackRep) fully functional ($>$ 90 % eff.)
- Currently experiencing mapping problems in the data decoding software $\rightarrow$ re-design going on
- Data at ELSA was taken with too high signal threshold due to faulty pedestal calculation $\rightarrow$ reduced detector performance

Outlook:

- Upgrade to new FE cards will lead to reduction of crosstalk
- For more hardware news please see the talks of S. Dørheim and M. Vandenbroucke on Tuesday
- **We are now able to efficiently tune our simulations to real data.**