# Spatial Resolution Studies with a GEM-TPC in High Magnetic Fields

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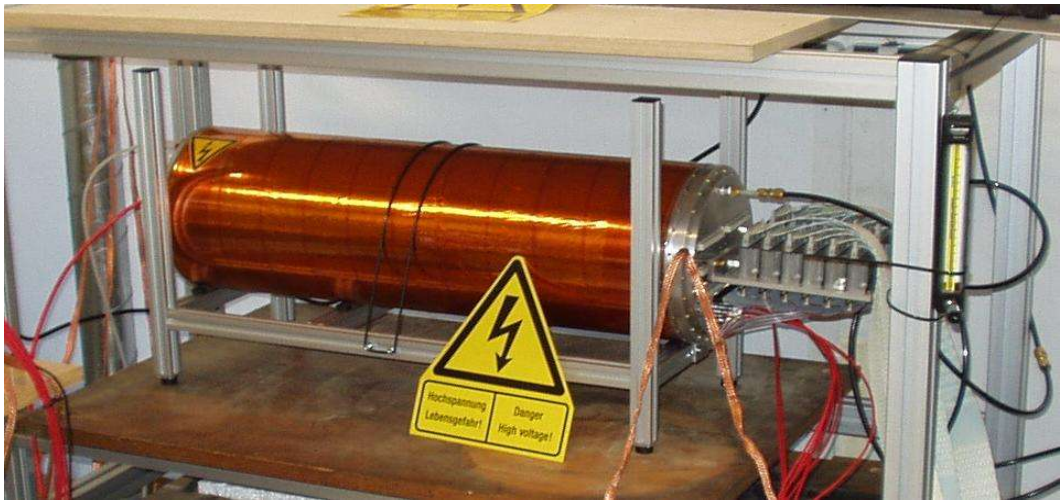
# Experimental Setup



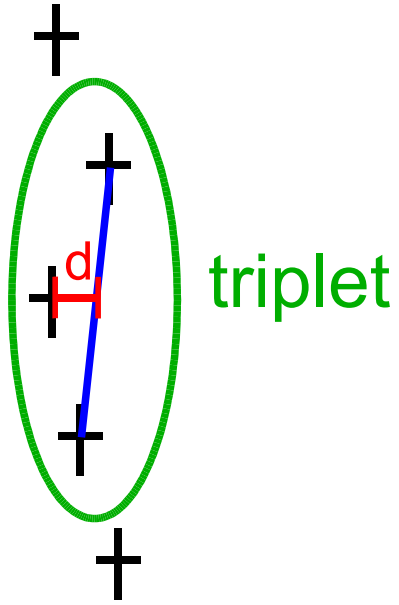

- length 80 cm, diameter 25 cm
- pad layout: 24 columns, 8 rows
  2.2 mm x 6.2 mm (pitch)
- sensitive volume:
  52.6 mm x 49.4 mm x 670 mm
- triple GEM gas amplification system

- cosmic rays
- sc 5 T magnet at DESY

# Triplet Method

Determine residual only from three adjacent pad rows:

- Draw straight line through outer hits
- Determine distance between straight line and central hit
- Resolution $\sigma$ assuming same uncertainty for all hits: $\sigma = \sigma_d \sqrt{(2/3)}$

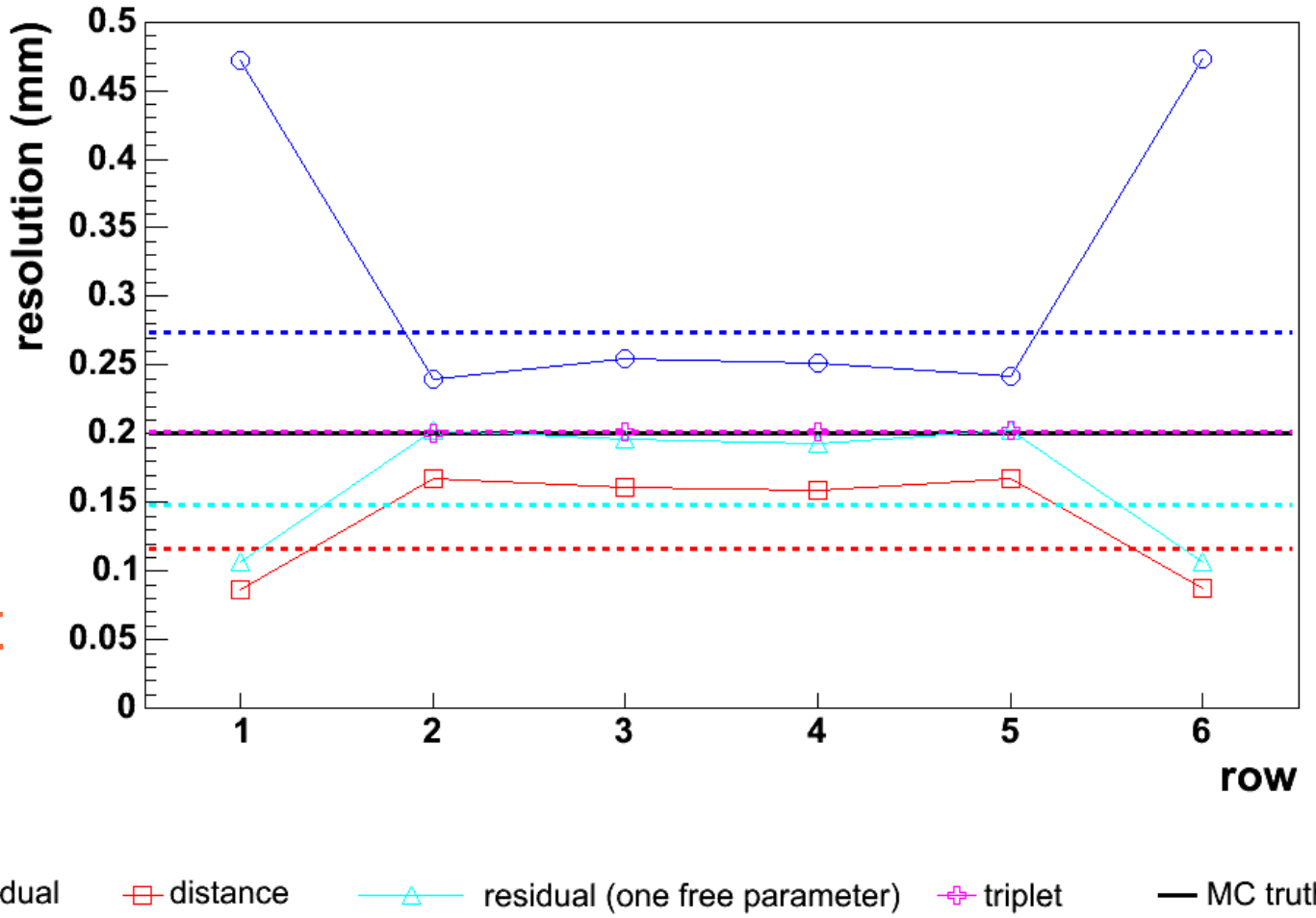



Advantages of triplet method:

- Very simple and robust
- No difference between straight and curved tracks
- Probably less sensitive to field inhomogeneities

# Comparision of Track Fit Methods

- MC tracks with 500 mm < R < 2000 mm
- 6 hits per track
- 200 μm spread




Triplet method is virtually unbiased (assuming perfect reconstruction of hit position)

# Cuts

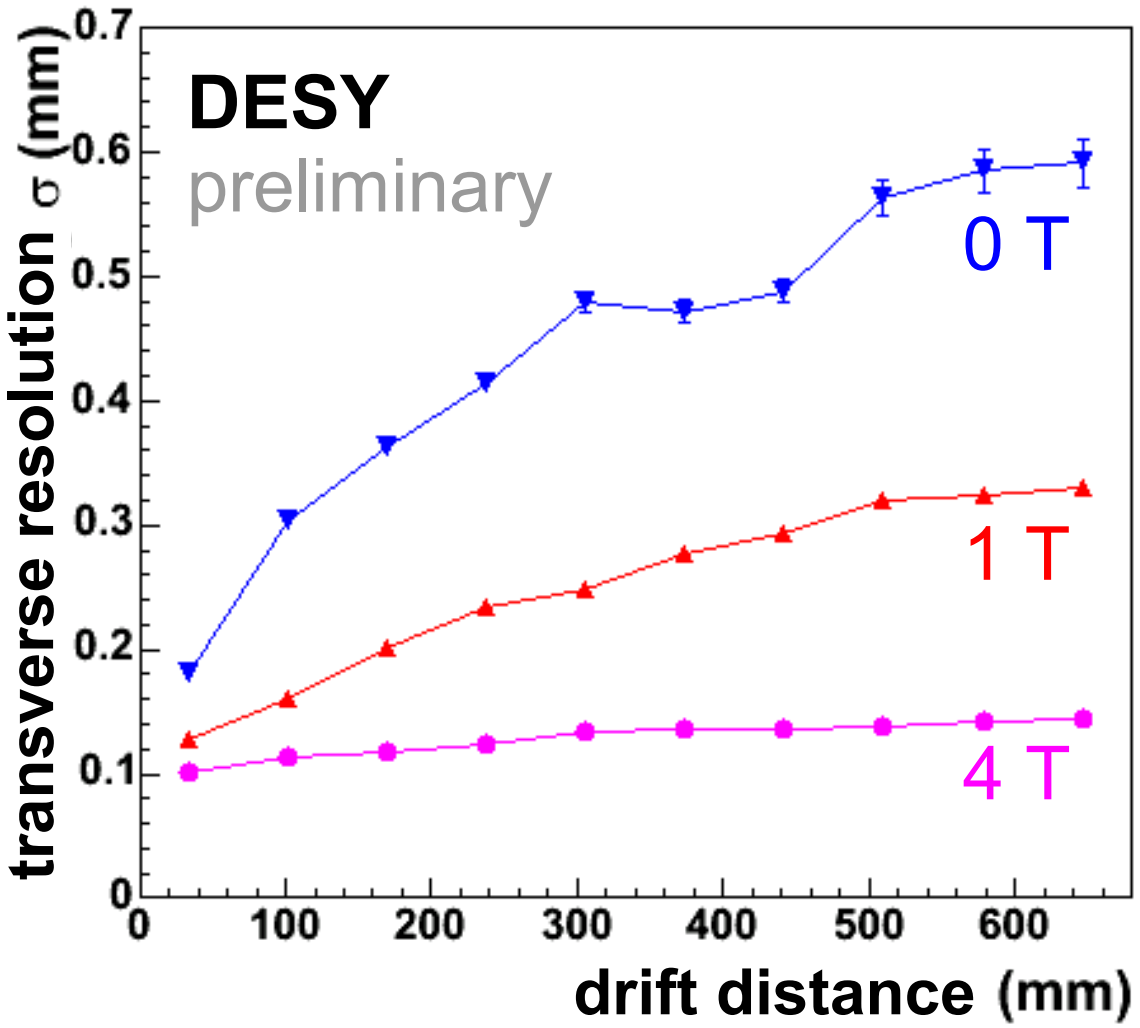
- only 6 central rows considered
- only 1 track events
- track requirements:
  - $|\phi| < 5°$
  - has 6 hits
- triplet requirements:
  - hit position 11.0 mm < x < 41.8 mm (fully recorded tracks)
  - no FADC overflow

example data set:

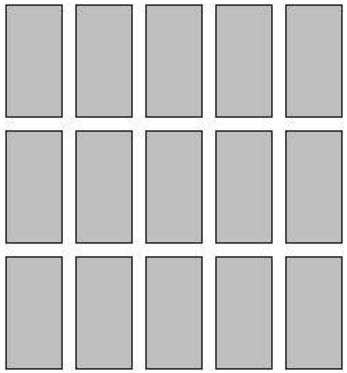
| | |
|---|---|
| # trigger | 111351 |
| all events | 22634 |
| 1 track evts. | 22450 |
| 6 hits | 20822 |
| $\|\phi\| < 5$ | 16696 |

| | |
|---|---|
| triplets | 66672 |
| x cut | 41909 |
| no overflow | 39121 |

# Resolution (Non-staggered Pads)




- **TESLA TDR gas** ($Ar:CH_4:CO_2$ 93:5:2)
- **Non-staggered pads** (2.2 x 6.2 mm²)

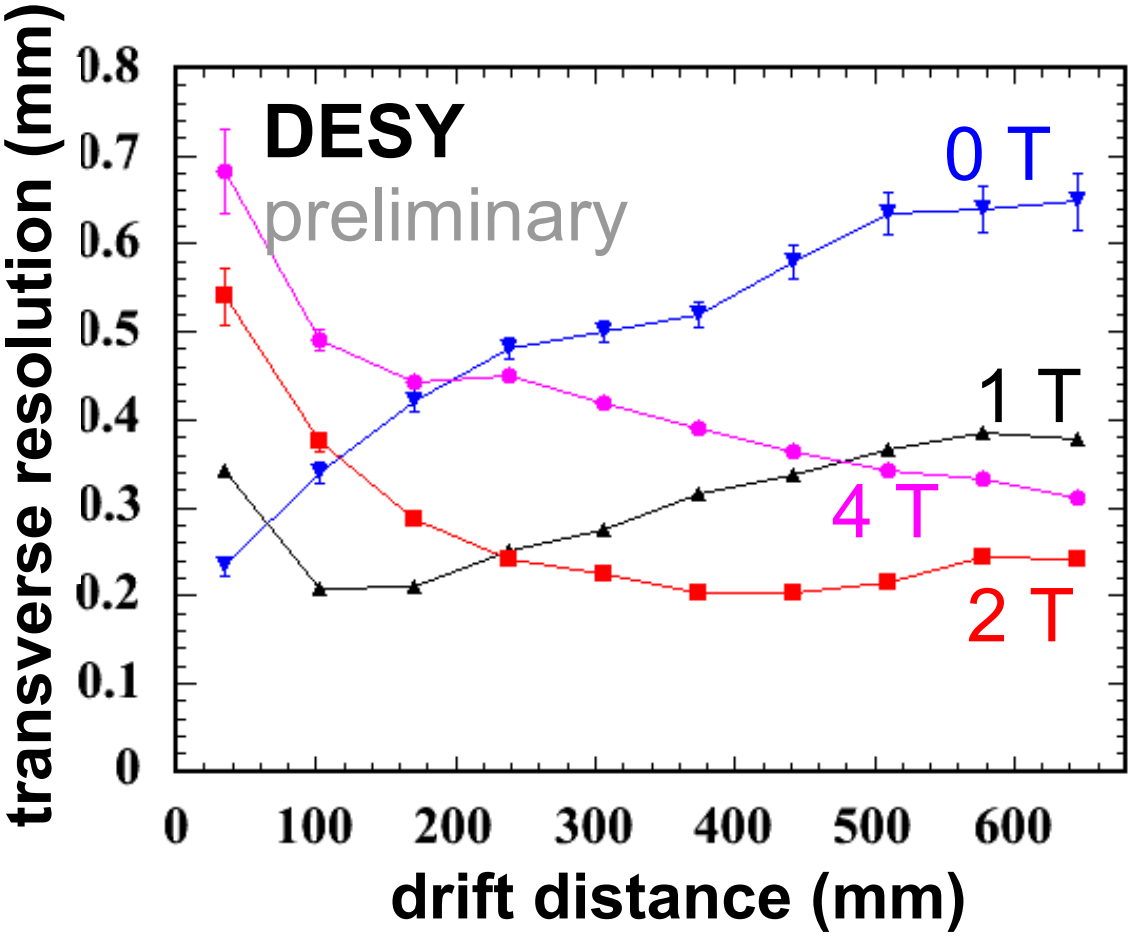


Resolution determined by:

- diffusion
- defocussing
- readout geometry

(relative contributions vary with B)

# Cross-check with Staggered Pads

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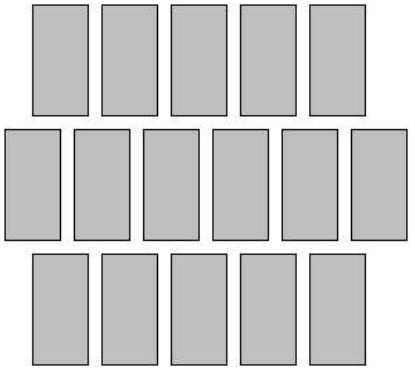
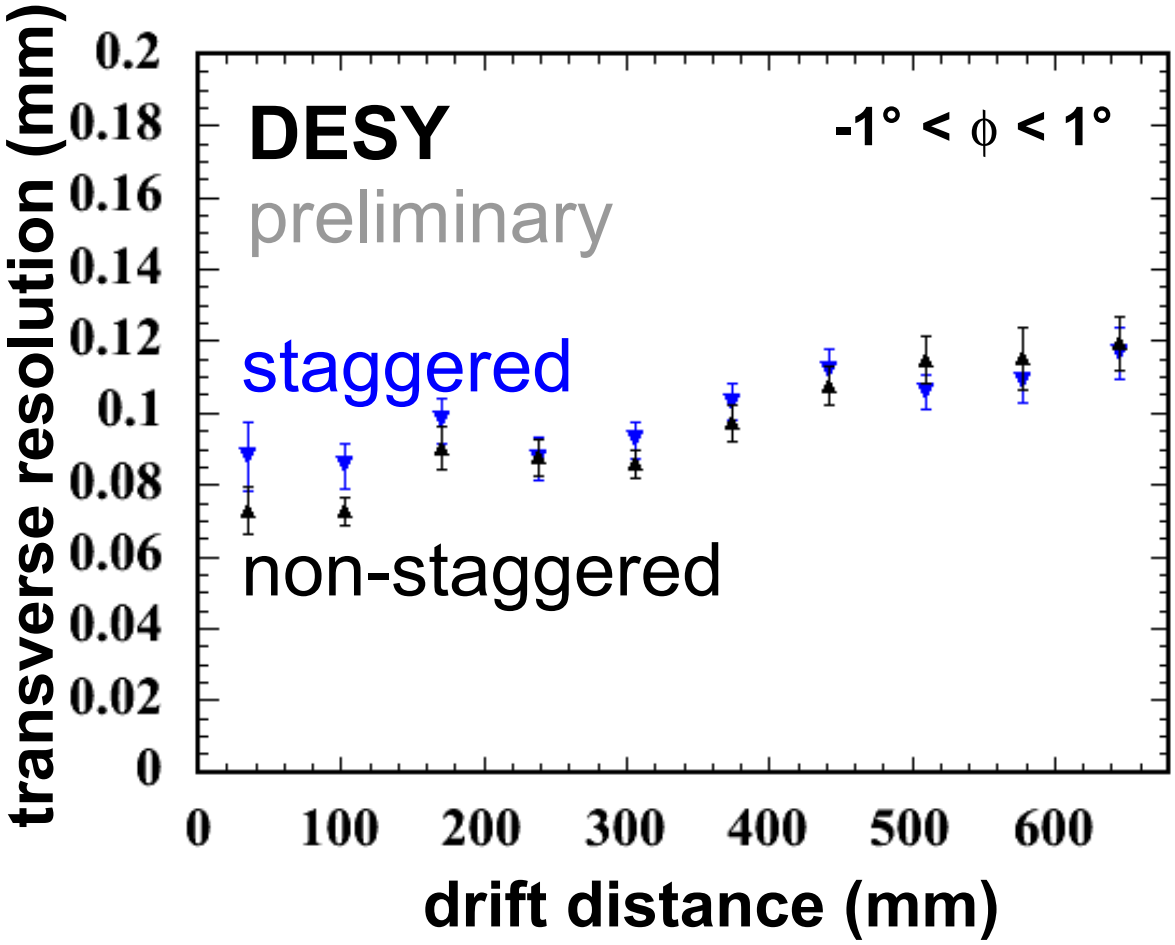
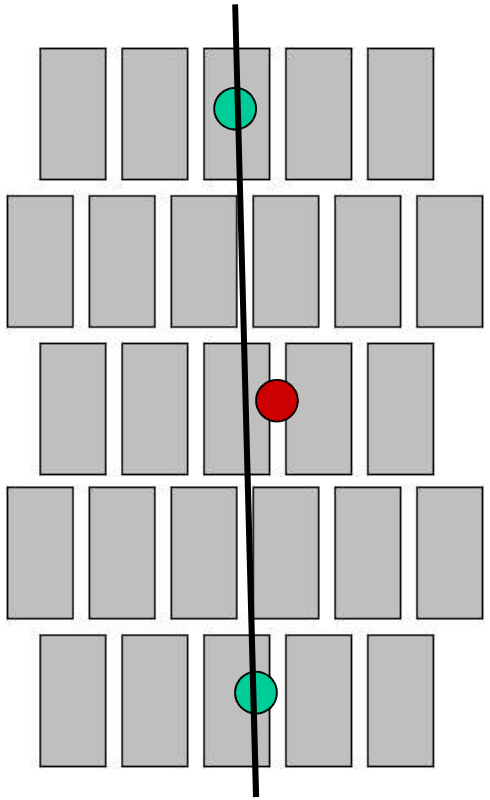


**What's the trouble?**

# Cross-check (2)

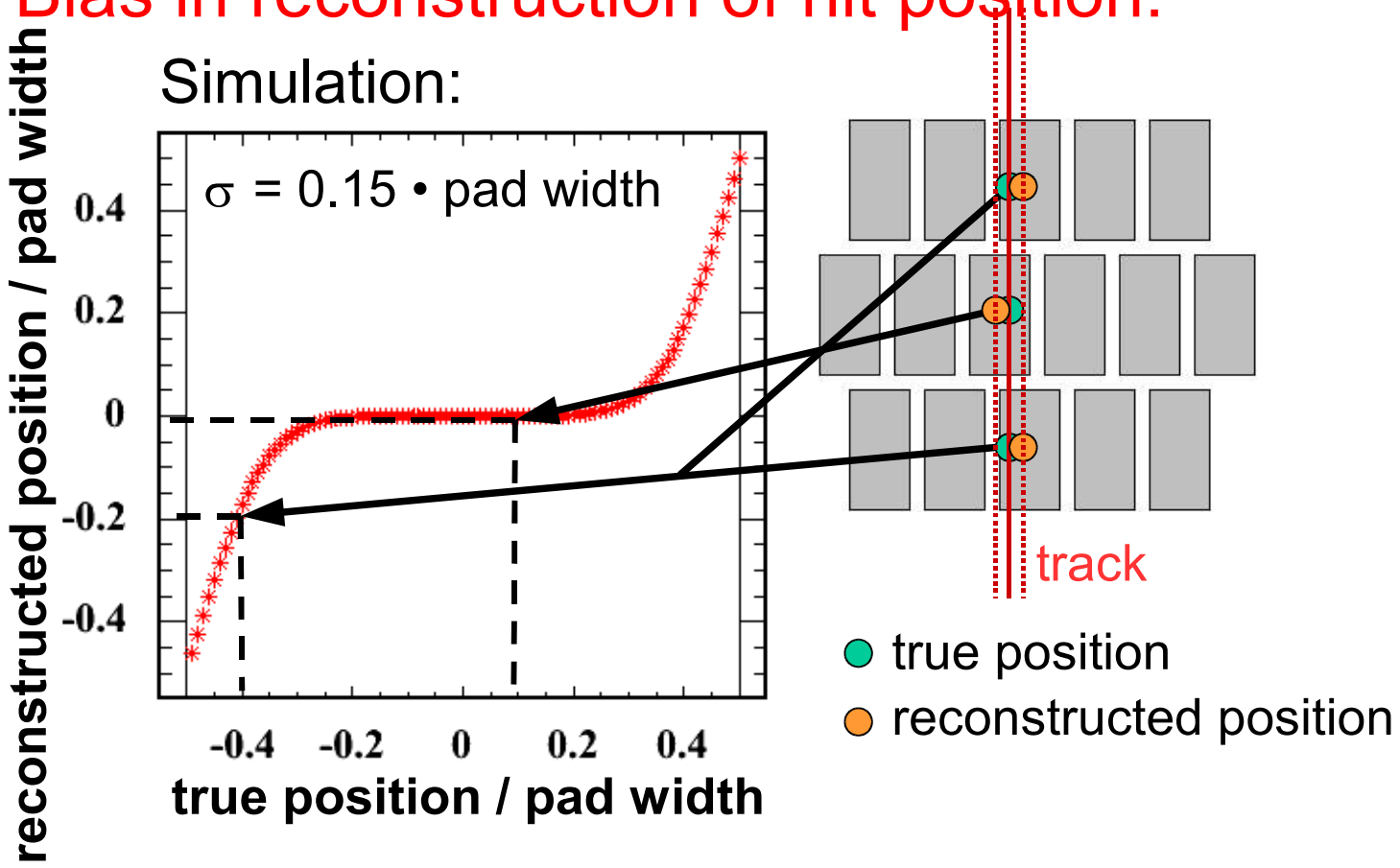
Resolution with triplet method using every second row



# Possible Explanation

Bias in reconstruction of hit position:



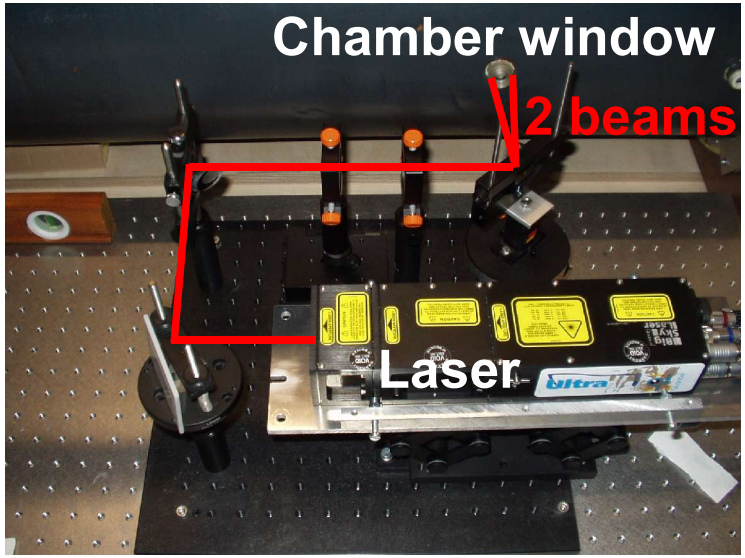

We either need

- a better hit reconstruction (problem: flat region)
- or narrower pads

# Laser Setup

Track production options:

- cosmics
- test beam
- UV laser




Advantage of laser:

Controllability and reproducibility of track parameters

Disadvantage:

Different ionization mechanism and finite beam diameter

Goal of laser studies:

Measurement of double track resolution in x and z

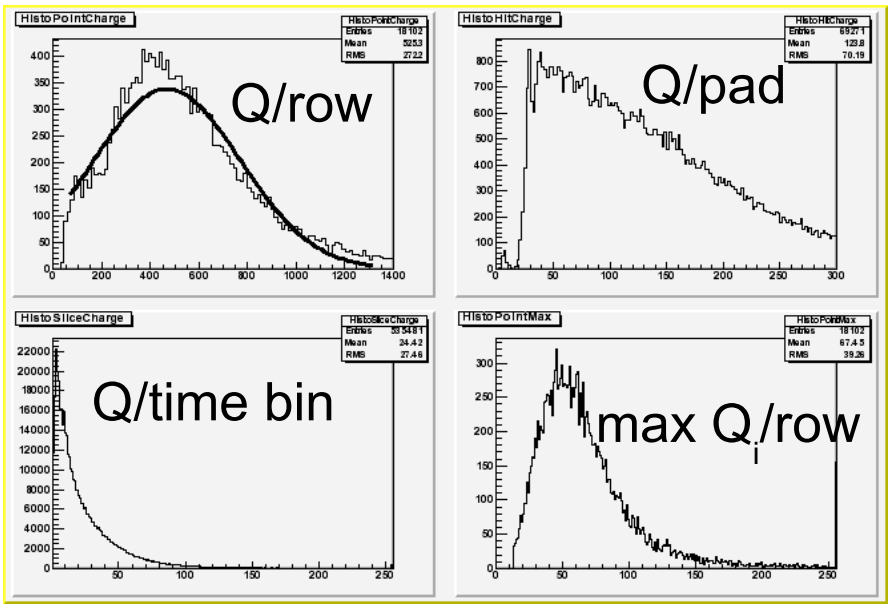
# Electron vs Laser Track

We are interested in performance of TPC for charged particles

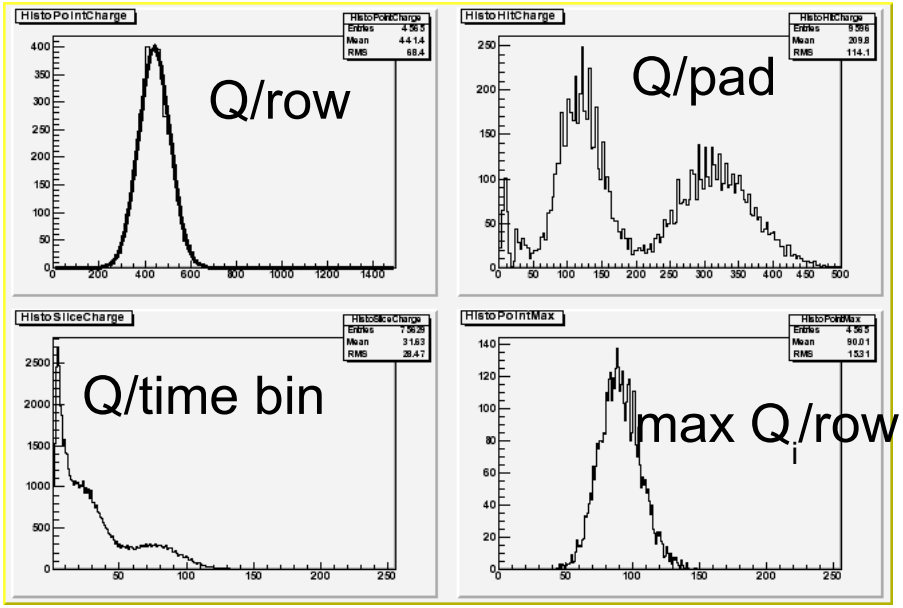
Is it possible to relate findings obtained with laser tracks to results for charged particles?

Answer requires precise understanding of charge production mechanisms and laser beam properties

3 GeV electrons from test beam

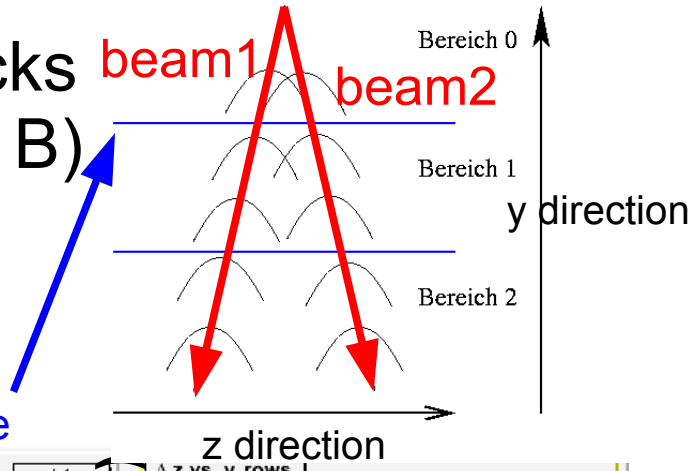



Laser track



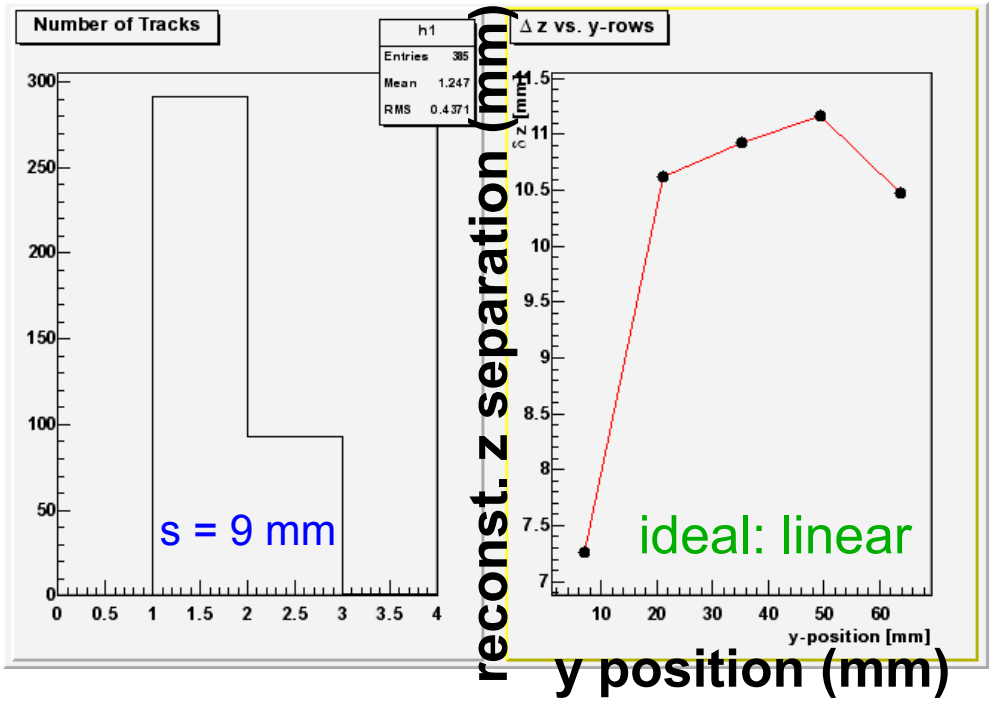
# Double Track Studies

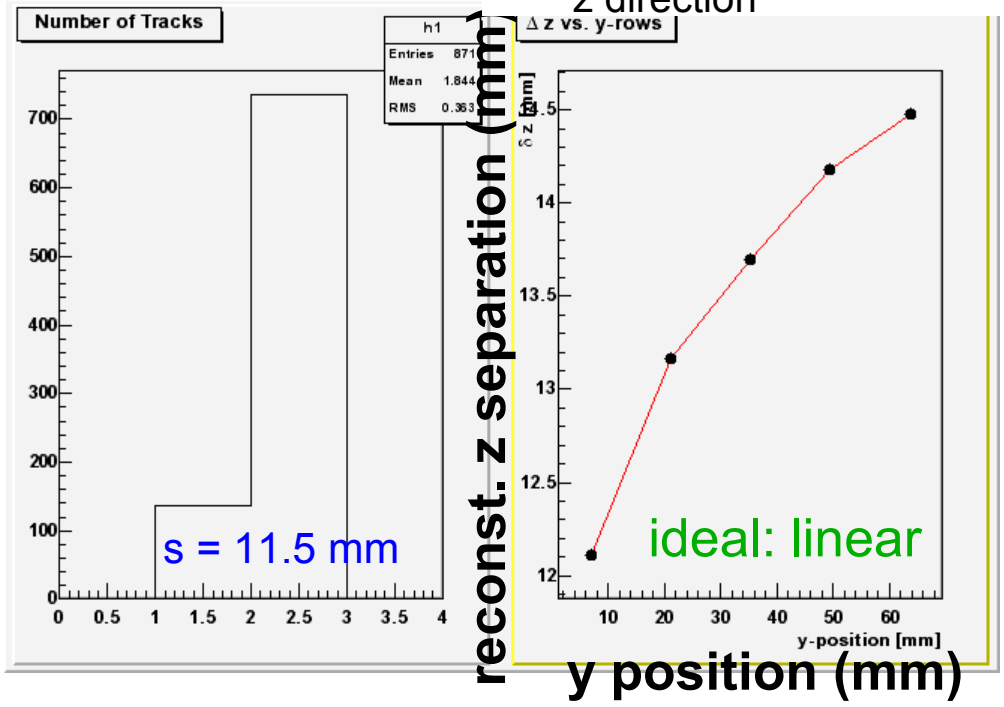
Double track resolution studies with two tracks separated in z (resolution independent from B)




Detailed understanding needs to be gained:
quantification, influence of ion backflow, impact of separation algorithm, etc.

s = separation of laser tracks at the beginning of sensitive volume




TESLA TDR goal (≤ 1 cm) seems to be achievable

# Summary

- Successful data taking: Collected huge cosmics data sets for magnetic fields up to 4 T.
- Detailed studies of systematic effects: significant bias for reconstructed hit positions found at 4 T. Investigations are ongoing...
- Double track resolution studies with UV laser started for longitudinal direction. First results suggest that TESLA TDR goal seems feasible. A lot of work is still to be done...
- Double track resolution in transverse direction will be investigated in 5 T magnet soon.