TPC Status

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The TPC Prototypes

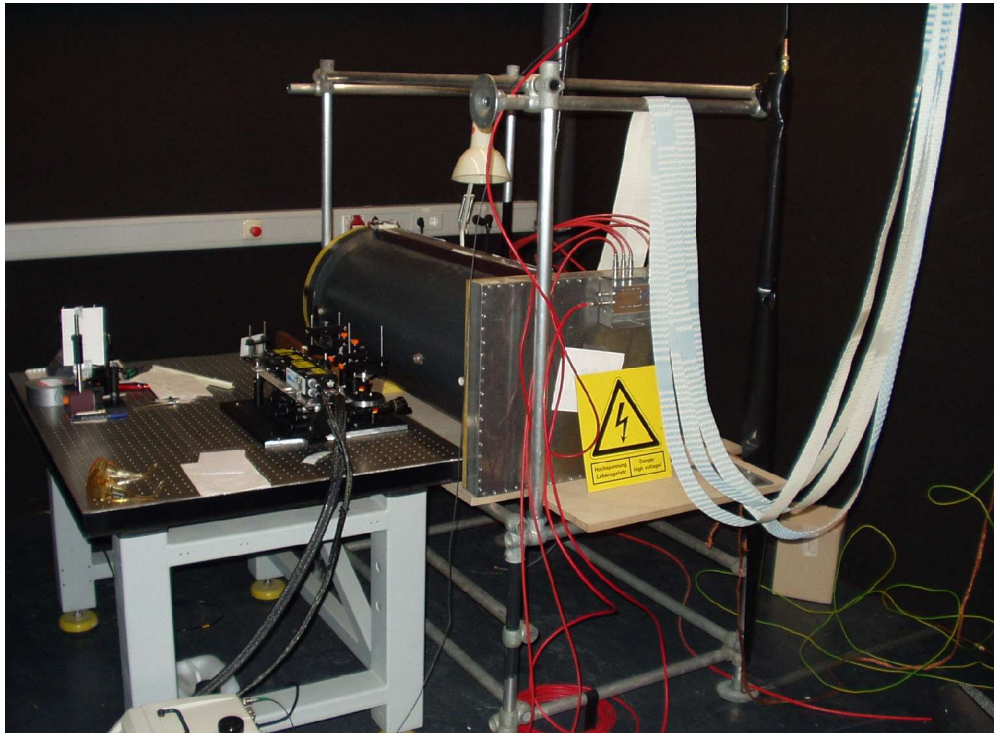
Main activities in the Hamburg/Rostock TPC group:

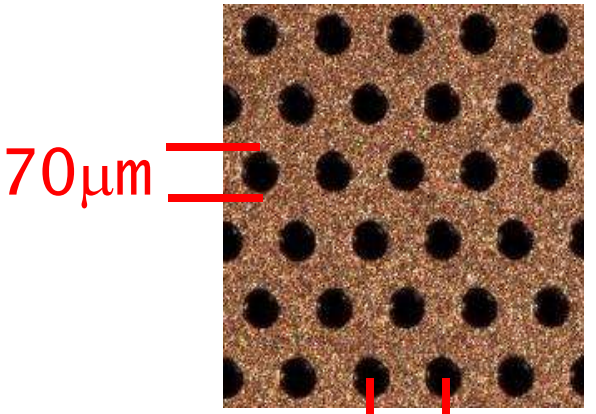
Study the behaviour of GEM TPC-prototypes

- Hardware: design and mechanical stability test field cage, implementation of slow control system, test of TDC readout electronic
- Analysis: studies of single point and two track resolution in high magnetic fields (deeper understanding of fit systematics, comparison of different fitting algorithms and techniques)
- Simulation: studies of neutron background in the TPC, reliable simulation of pad geometries

This talk focuses mainly on Analysis work. Especially the comparison of different fitting algorithms and techniques.

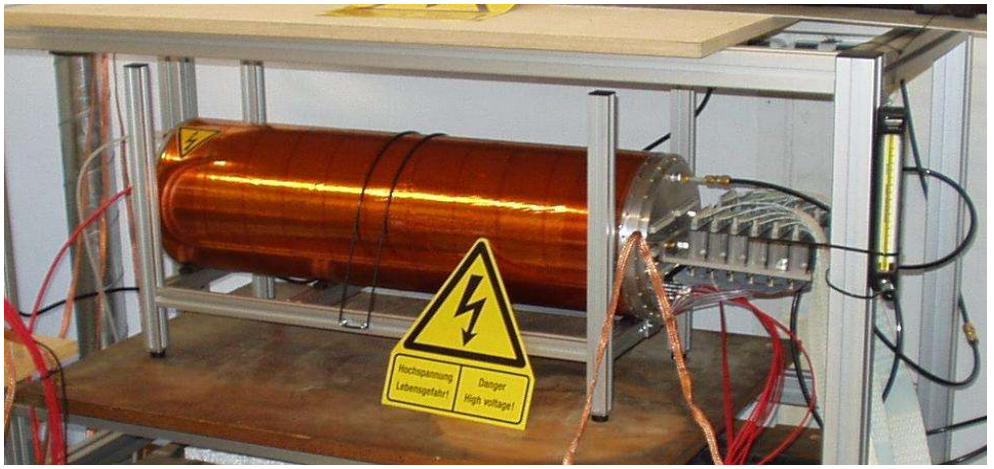
The TPC Prototypes@Hamburg

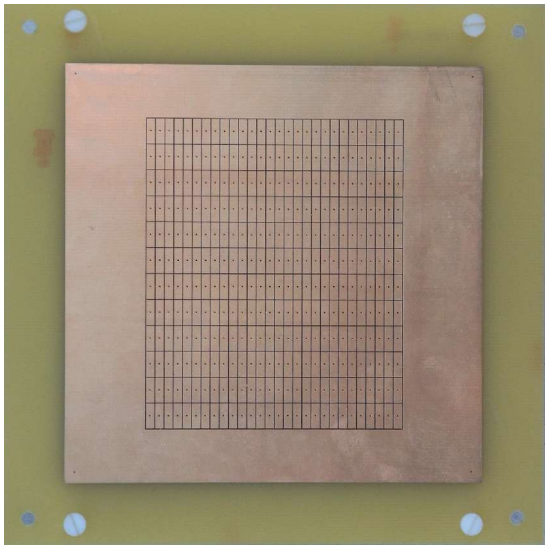




pad size:

2.2 x 6.2 mm^2, 8 rows, 24 columns





Needs for comparison of Results

Despite first interesting results from many groups, that have built TPC prototypes, numerous open questions remain.

Consistency Checks are needed:

- to gain deeper understanding on the detector, the analysis methods and the interpretation of results
- to save ressources, time and manpower by "not inventing the wheel twice"
- to have a common base for design decisions, but ...

Comparison between results of different groups are difficult:

- different pad geometries
- (partly) different gases
- different analysis methods
- different sets of cuts

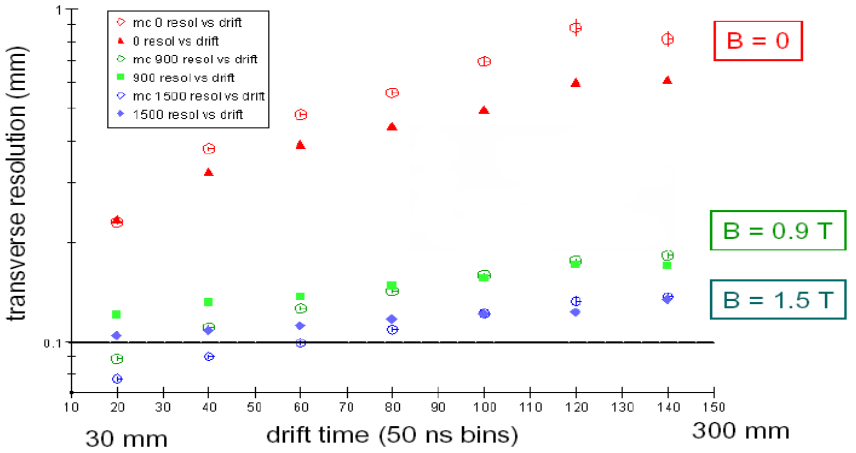
$\Rightarrow$ Too many differences to (easily) check consistency

Analysis Methods I

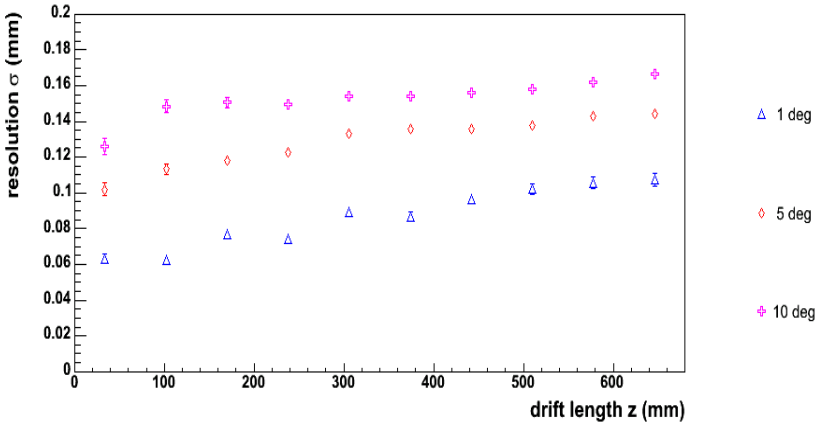
- modular reconstruction ↔ monolithic appproach
  hit finding, track finding, track fitting
- global track fit ↔ local triplet method
- different implementations → different ways of exception handling (FADC overflows, broken pads, numerical instabilities, ...)

⇒ different definitions of resolution

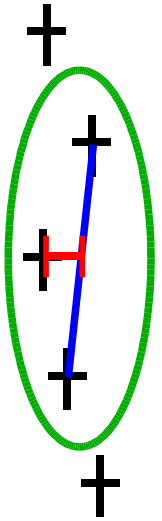
monolithic approach - JTPC



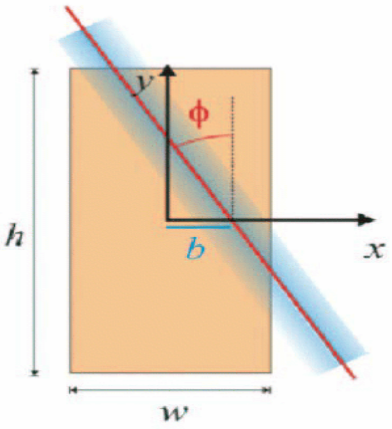
modular reconstruction - Multifit



Analysis Methods II



triplet



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

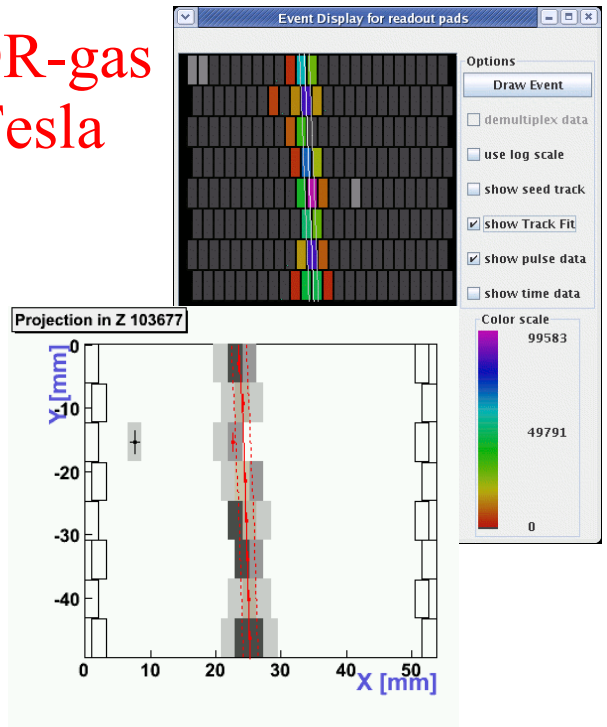
- x-y track fit uses a Gaussian model for the ionization
- Three/four parameter fit:
  x_0 (x at y=0), ϕ (azimuthal angle),
  σ (transverse size of the cloud), C (curvature)
- Maximize the likelihood of the observed charge fractions from each row

For Consistency check, monolithic approach has been implemented in Multifit.

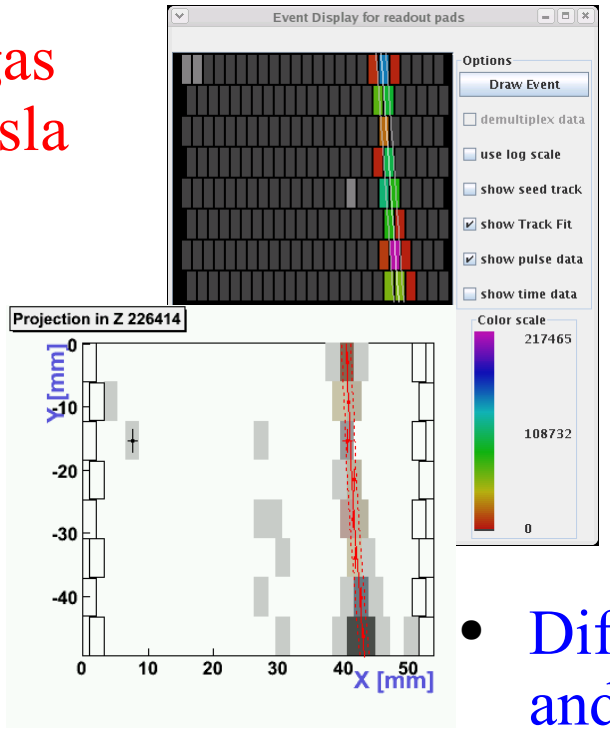
Comparison I

Comparison between both implementations: on event by event basis

TDR-gas
1 Tesla



P5-gas
4 Tesla



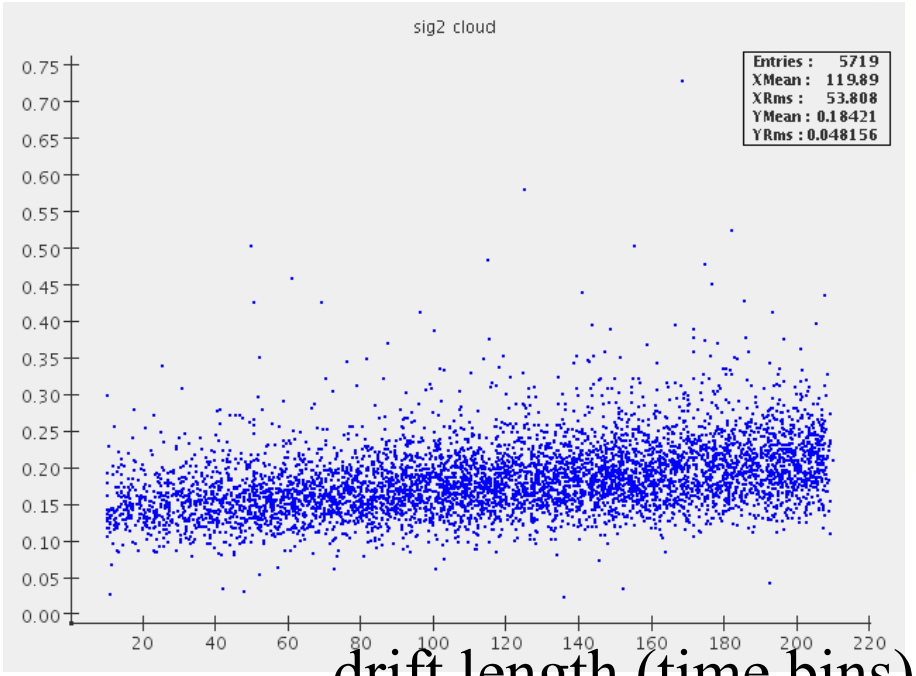
	TDR 1T		P5 4T	
	MultiFit	JTPC	MultiFit	JTPC
Intercept X / X0	23.52	-1.82	40.43	15.14
Slope X / Phi0	-0.050	0.040	-0.027	0.056
Sigma	1.140	0.947	0.695	0.395
Curvature / 1/r (10^-4)	6.00	1.40	1.20	0.99

- Differences in intercept and slope are due to the coordinate system which is used
- Differences in sigma seems to be systematic

Comparison II

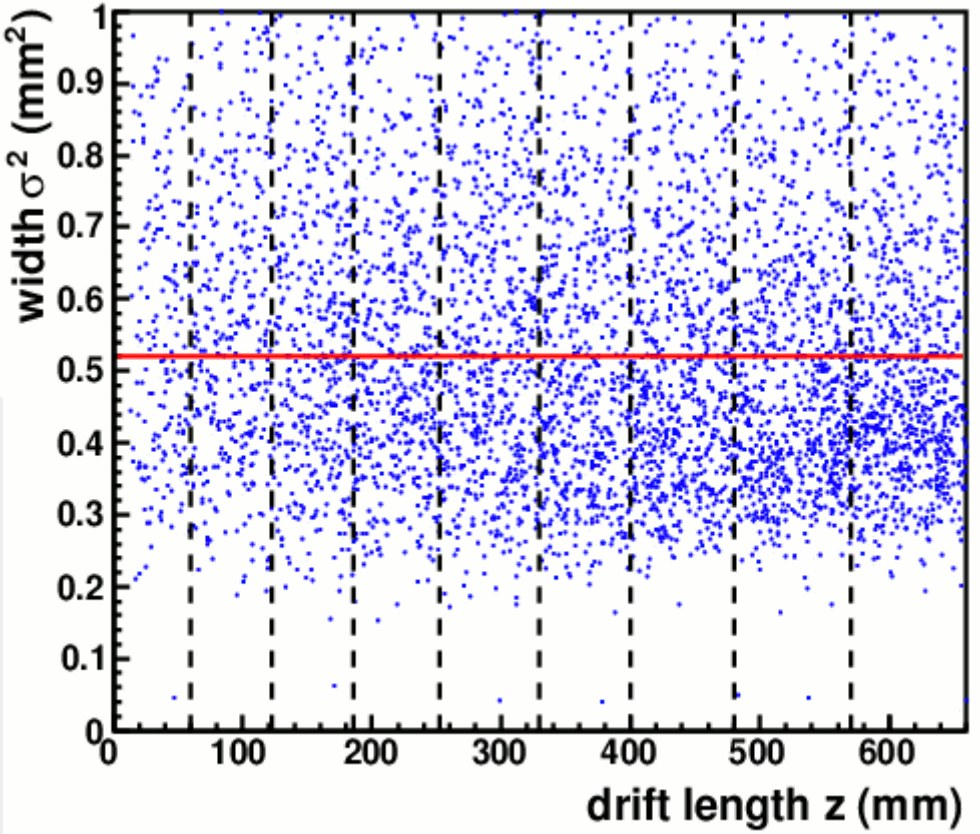
Comparison between both implementations: on diffusion

differences can be clearly seen for P5 gas at 4 Tesla



σ^2

drift length (time bins)



$$\sigma^2 = D^2 z + \sigma_0^2$$

Change in Multifit

$$L = \sum_{Pad} Q_{measured} \ln\left[\left(\frac{Q_{expected}}{\sum_{Row} Q_{expected}} + N \right) / (1 + N)\right]$$

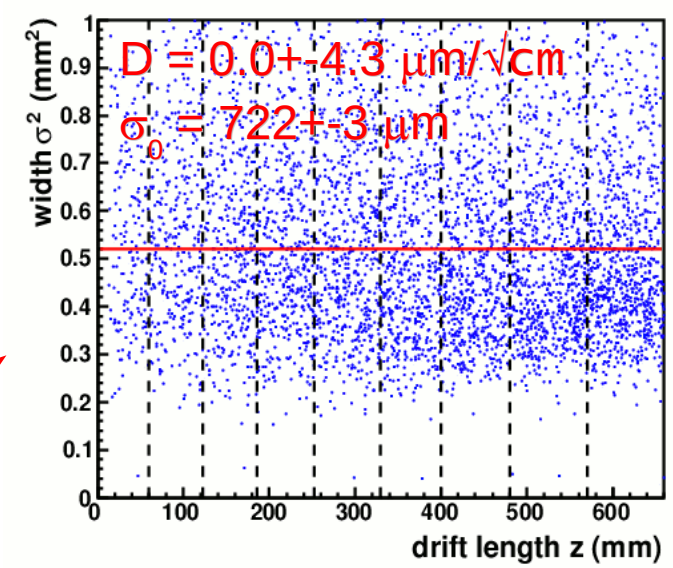
- implement a noise N
- And for calculation the charge of one pulse, integrating is expended to time bins before and after pulse over threshold: Also negative signal are taken into account

Diffusion before and after the change

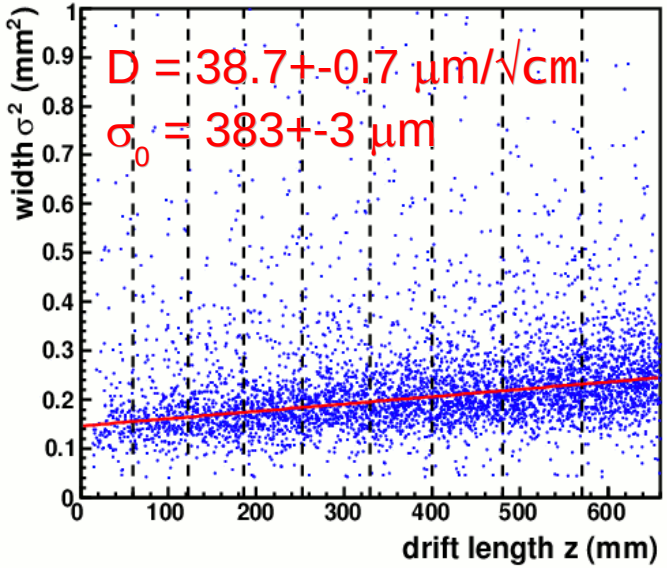
small changes in diffusion coefficient, but huge impact on defocusing constant σ_0

P5 4T

before

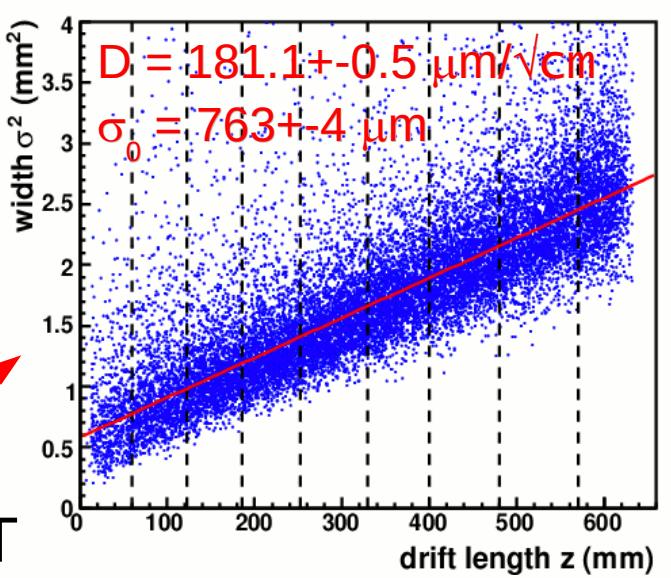


after

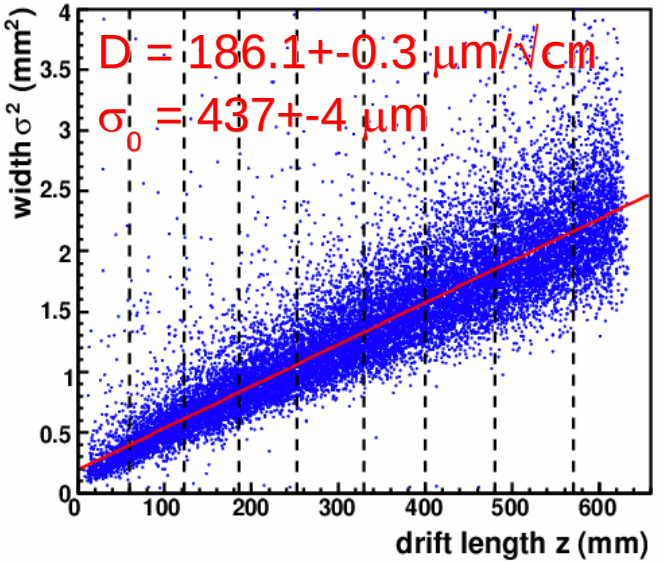


TDR 1T

before

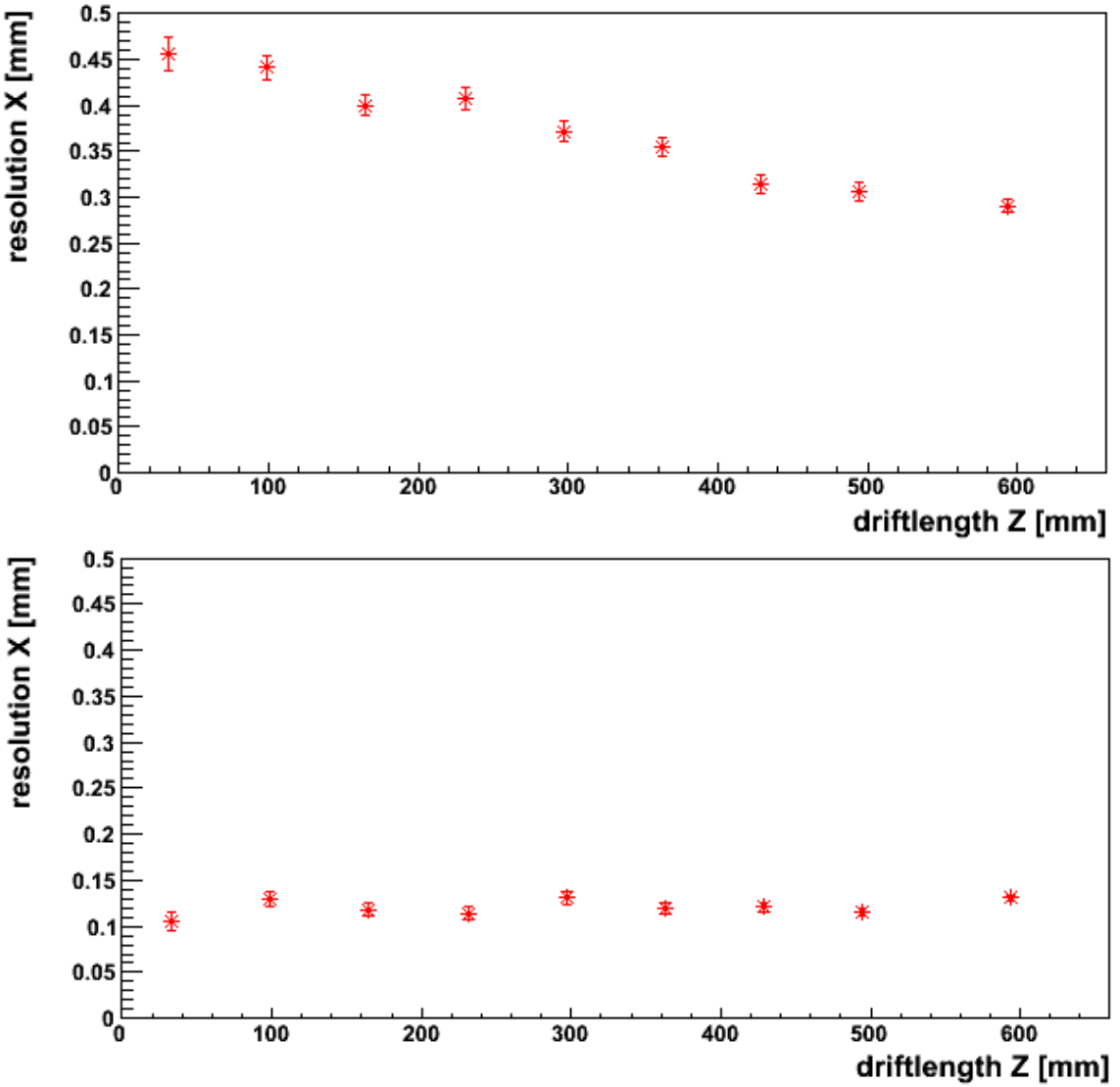


after



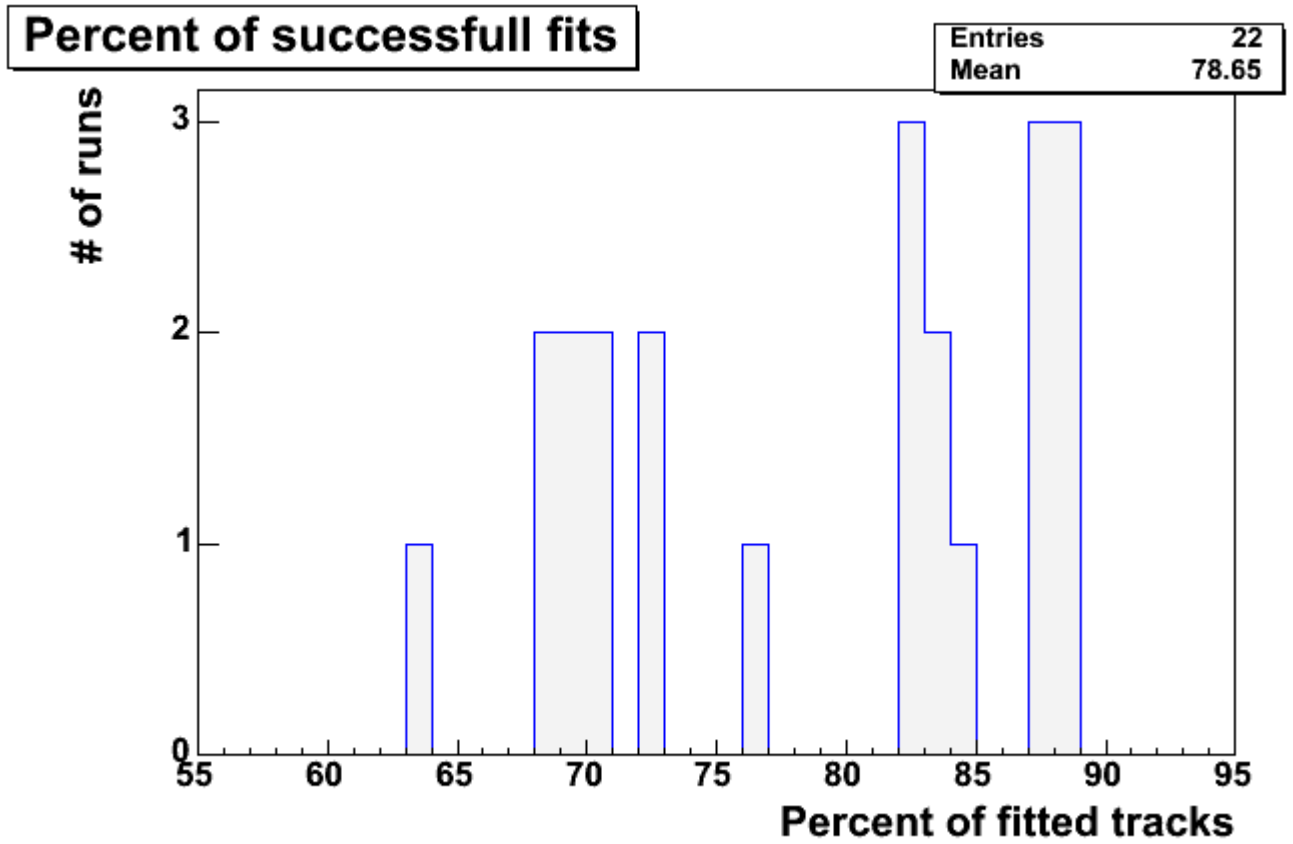
Resolution before and after the change

- improvement of resolution for P5 4T is amazing
- further studies are needed



Fitting efficiency of the algorithm

First look at the fitting efficiency of the algorithm gives a mean of about 0.78 %.

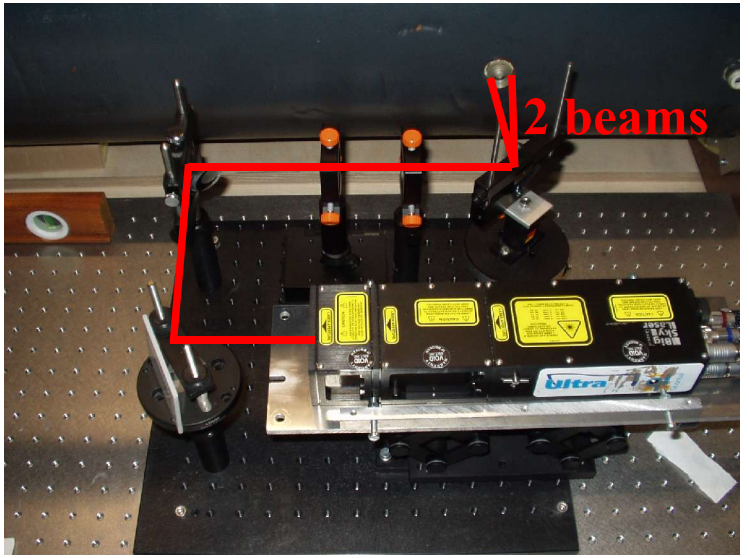


A problem is to fit only four parameter to 6 rows, but even this fitting efficiency can't explain the dramatic improvement in the resolution

Laser setup

Track production options:

- cosmics
- test beam
- UV laser



Advantage of laser:

Controllability and reproducibility of track parameters

Disadvantage:

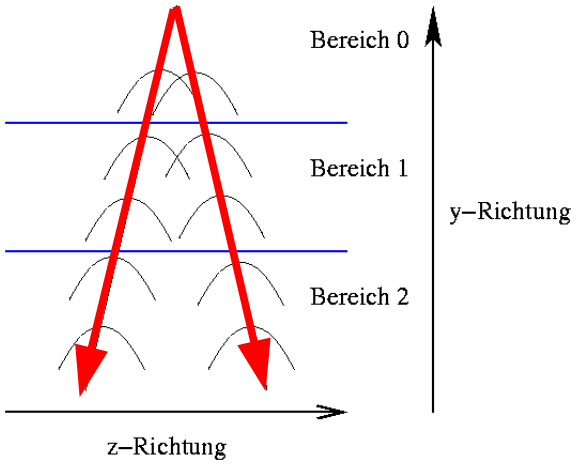
Different ionization mechanism and finite beam diameter

Goal of laser studies:

Comparison between MIP- and Laser-like single tracks

Measurement of double track resolution in x and z

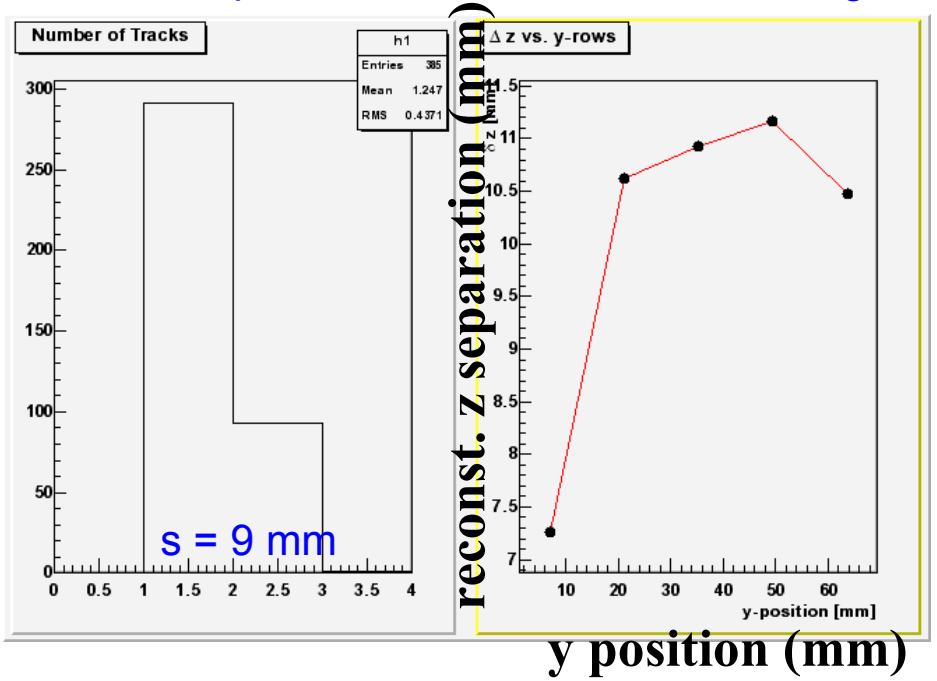
Double Track Studies

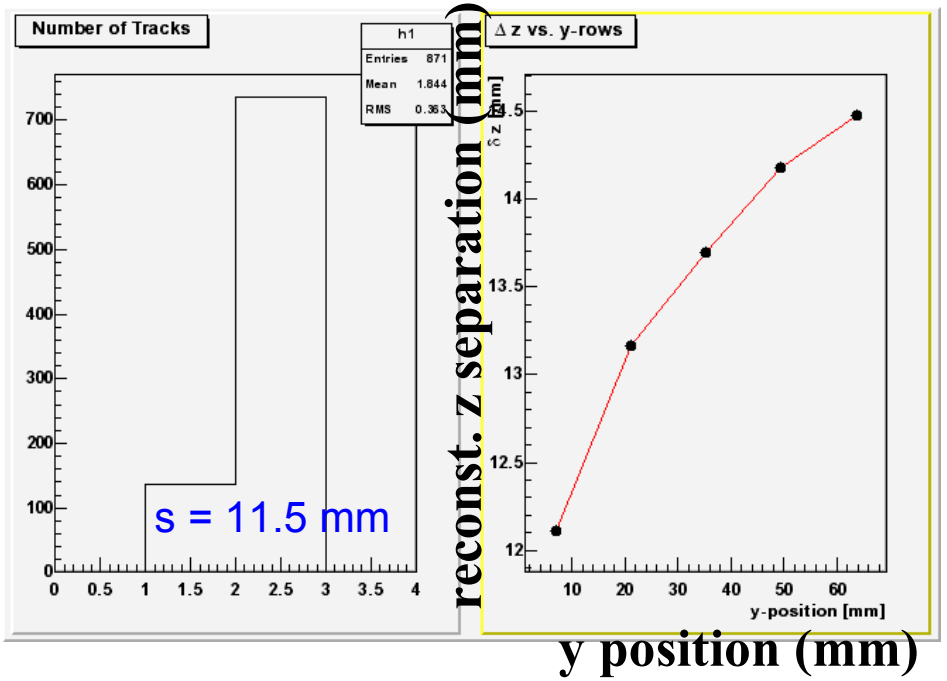


Double track resolution studies with two tracks separated in z (resolution independent from B)

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

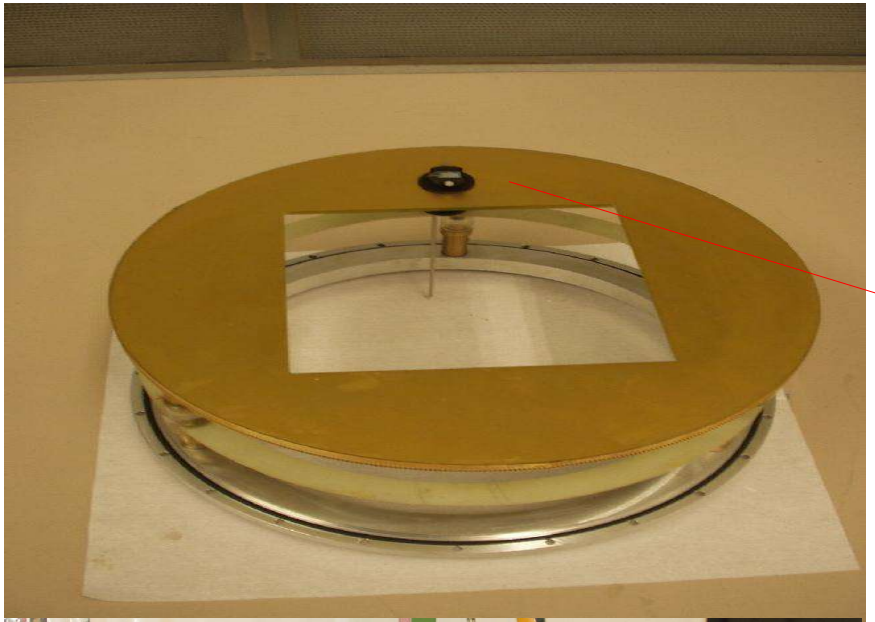
s = separation of laser tracks at the beginning of sensitive volume

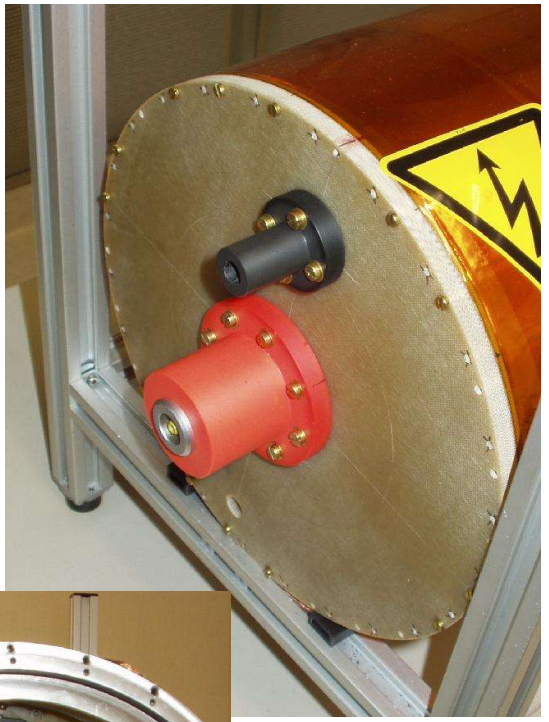


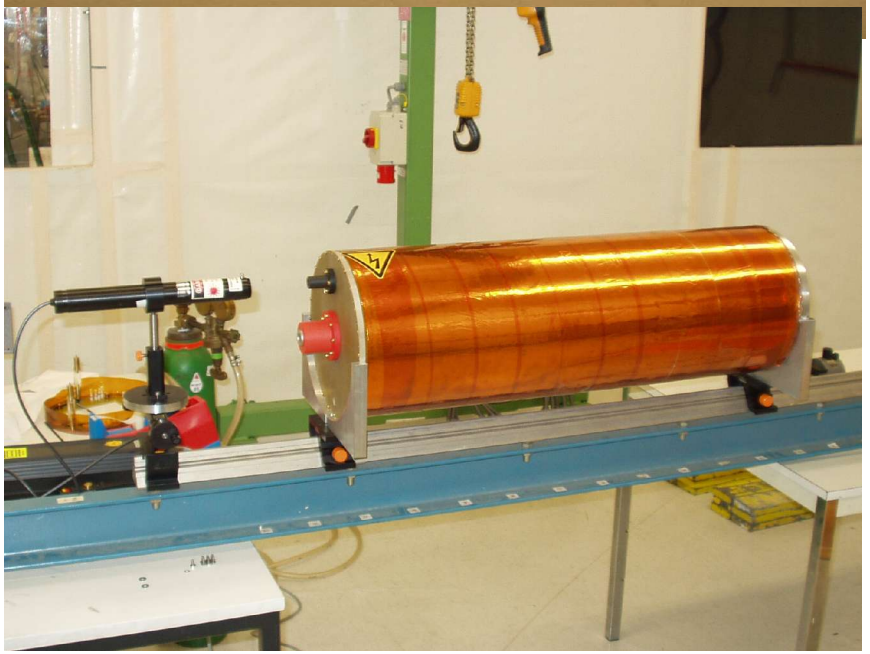


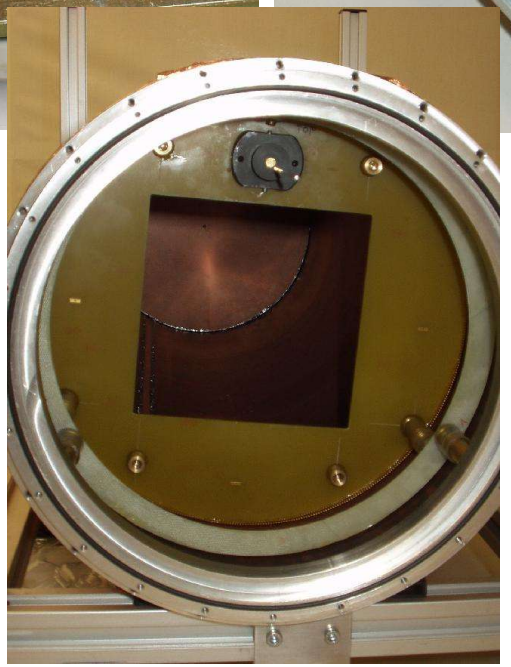
TESLA TDR goal (≤ 1 cm) seems to be achievable

Modification of the TPC





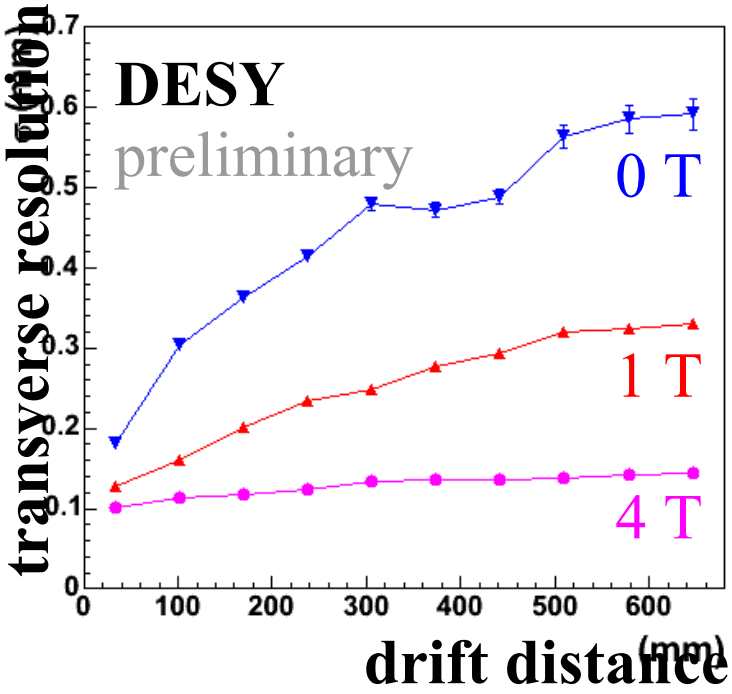


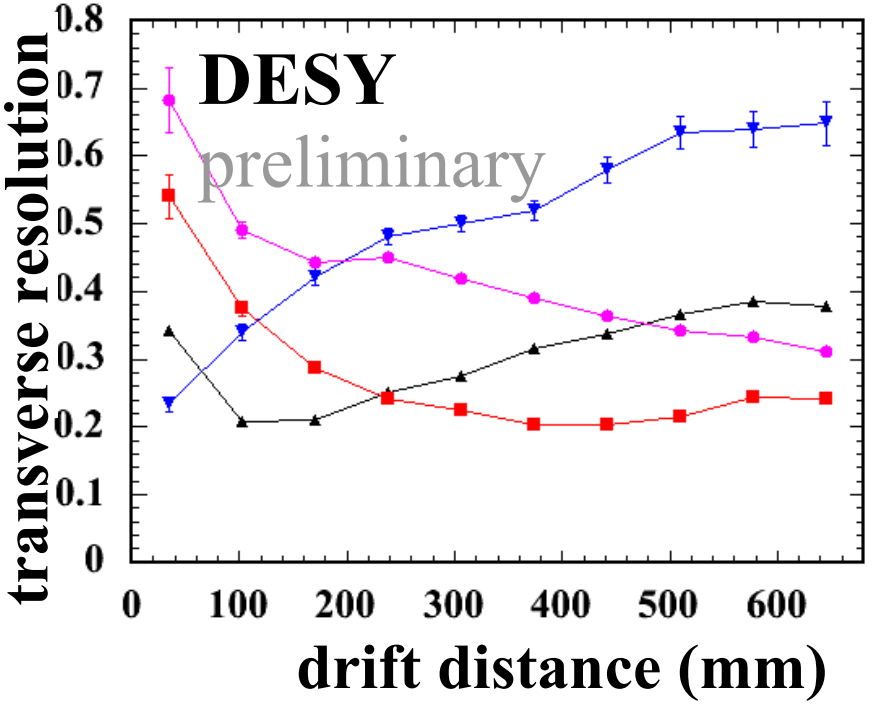


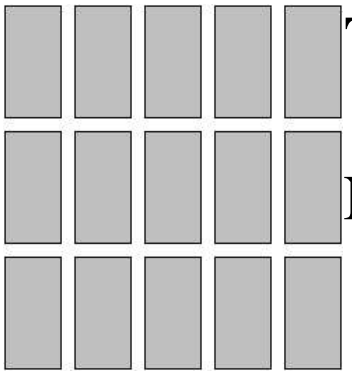
Summary

- First Consistency checks between different analysis methods
- Some efforts has been done to come to a common reconstruction software based on Marlin & LCIO
- First preliminary results of two track resolution in z from laser studies
- Modification of the TPC-Prototype for Laser studies in high magnetic field are ongoing

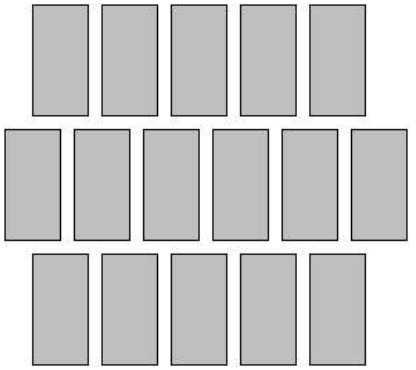
Cross Check between staggered and non-staggered pad geometries







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



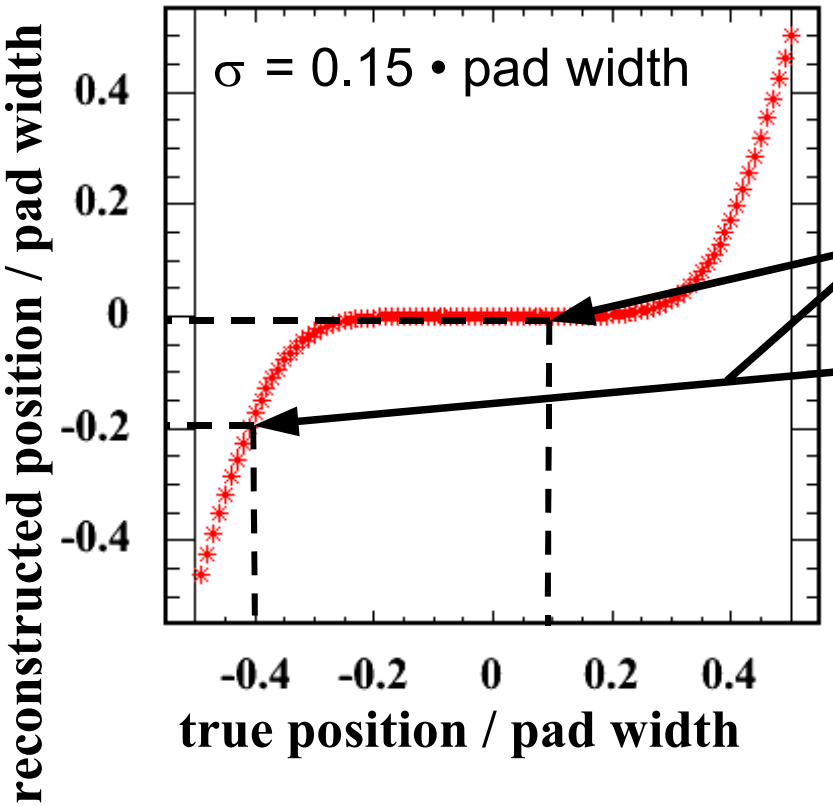
TESLA TDR gas
($Ar:CH_4:CO_2$ 93:5:2)
Staggered pads
(2.2 x 6.2 mm²)

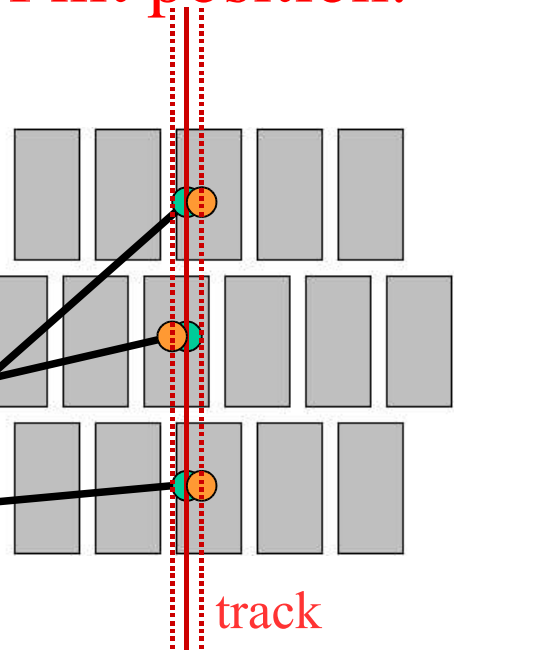
What's the trouble?

Possible Explanation

Bias in reconstruction of hit position:

Simulation:





true position

reconstructed position

We either need

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