# S-T RELATIONS

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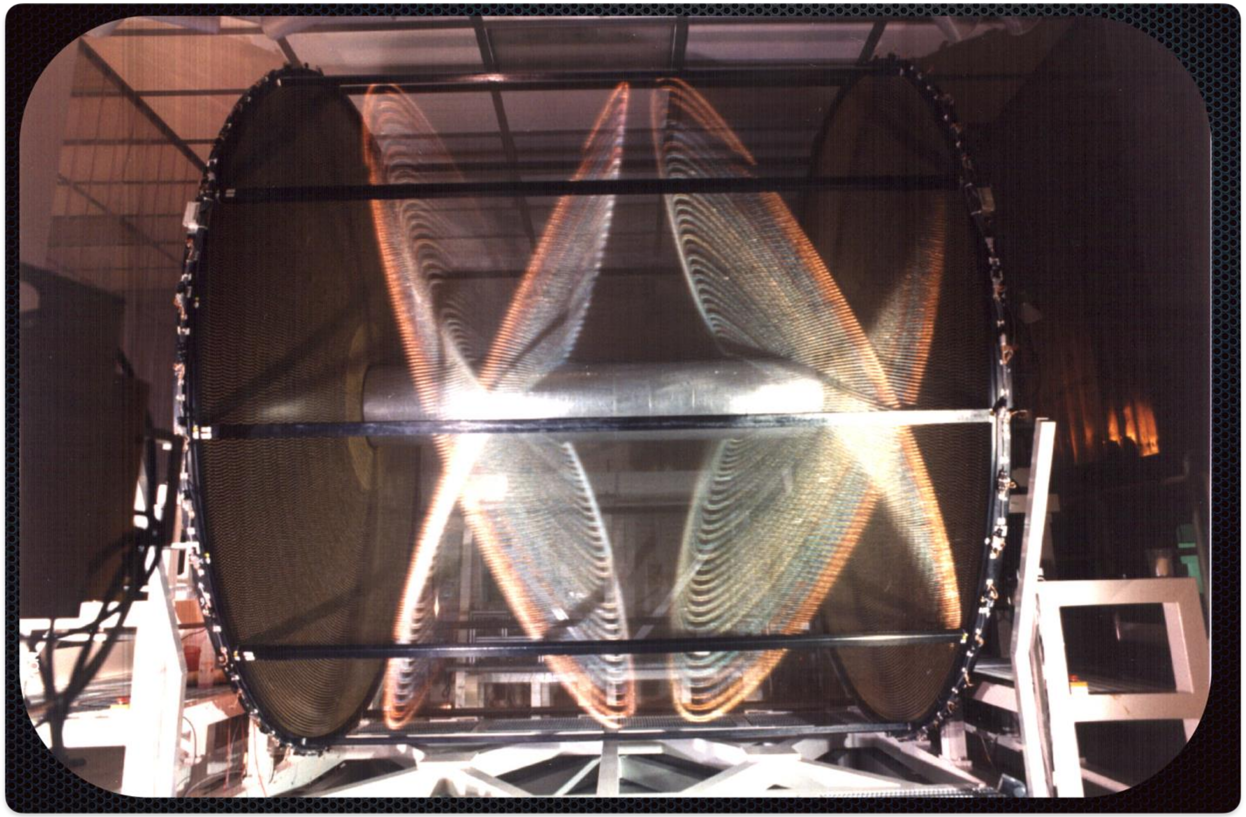
# UPDATE

- ❑ Dsts available to resume working on MC data comparisons and investigation into tracks
- ❑ KLOEsoft up and running (thank you Fedor and Niels)
- ❑ prod2root files made for 3pi for a subset of the dsts
- ❑ Stentu framework also working on gamma (thank you Fedor)
- ❑ Have begun making 3pi stentu files

- ❑ Data comparison plots being made using prod2root files and stentu files
- ❑ Investigating the track quality cuts that are used for stentu
- ❑ Replotting positive and negative track variables.

This presentation is an introductory overview of s-t relations.

# KLOE DRIFT CHAMBER



KLOE drift chamber is cylindrical

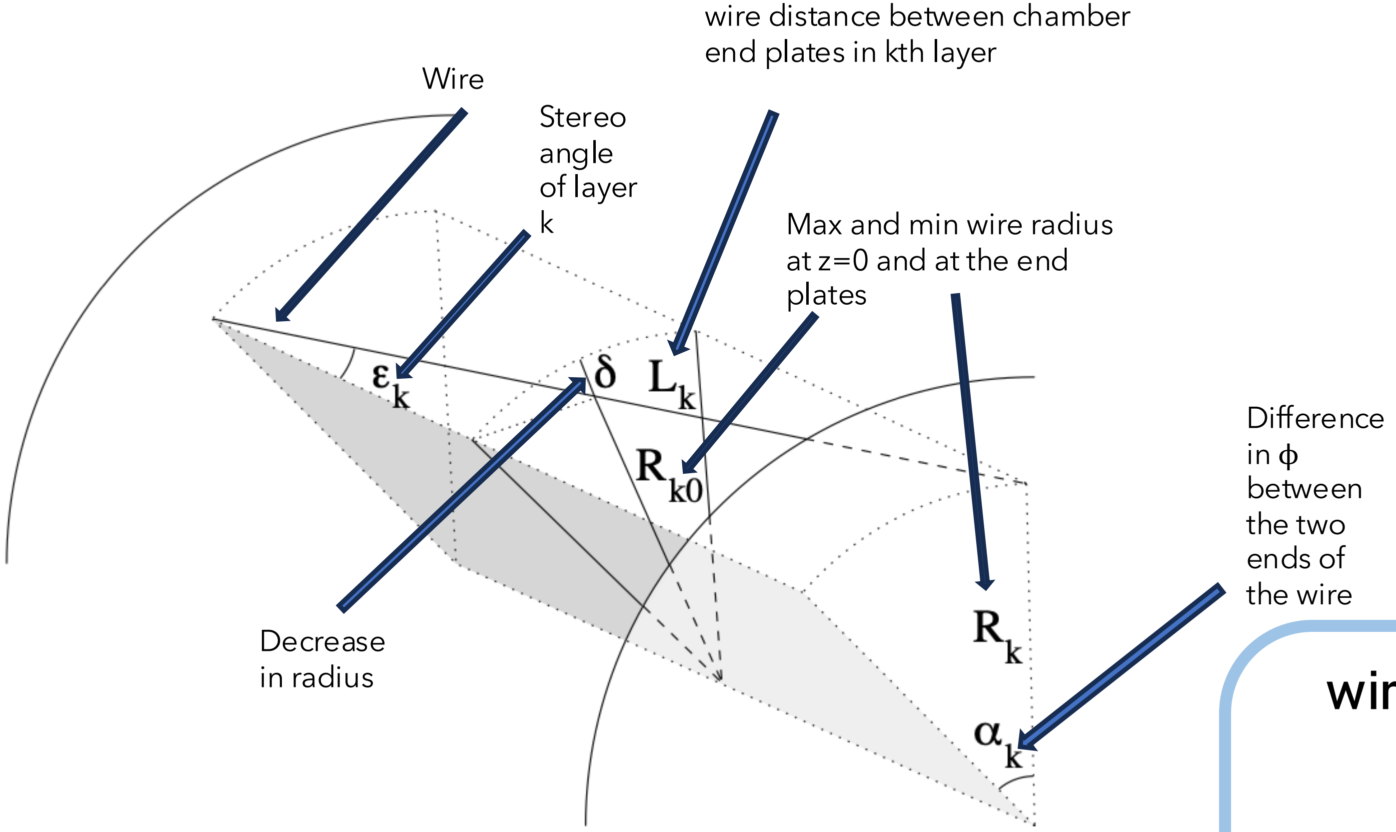
Radius of 2.0m and a length of 3.3m.

It is surrounded by a calorimeter and then a 0.6 T axial magnetic field.

The beam pipe has a radius of 10cm

It has a track resolution of $\sim 200\ \mu m$ and a vertex resolution of $\sim 1mm$

# DRIFT CHAMBER WIRE ARRANGEMENT

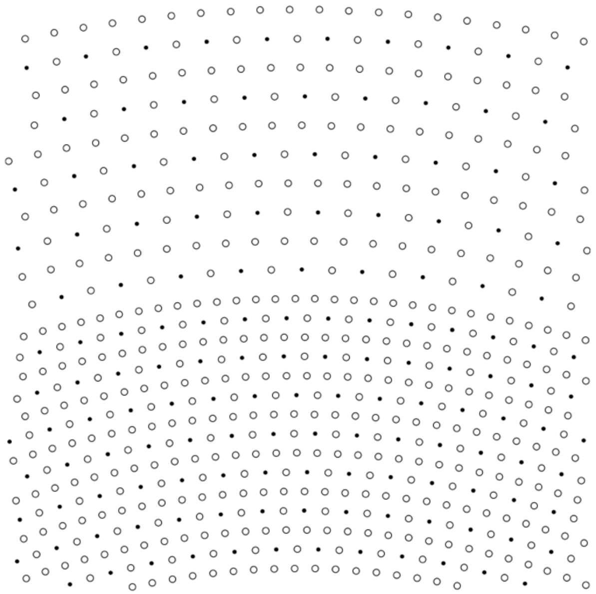



**wire radius from the chamber axis varies with z. It is maximum at the end plates and minimum at the centre.**

**Resolution requirement in z:** $\sigma_z = \sigma_{r\phi}/tan\epsilon$

$$\tan \varepsilon_k = \pm \frac{2\delta}{L_k}\sqrt{\frac{2R_{k_0}}{\delta} - 1}$$

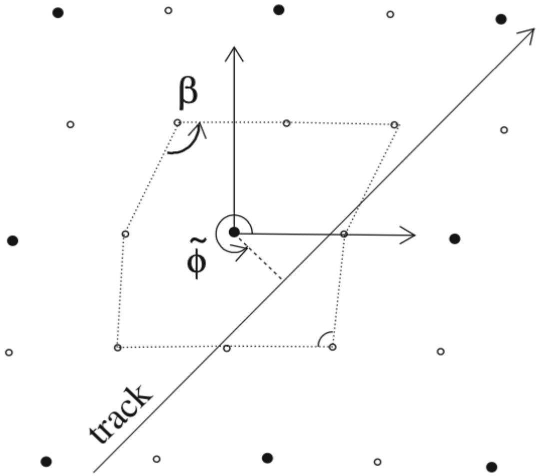
# DRIFT CELLS



Design goal is to have 3-D track reconstruction with uniform efficiency throughout

Drift cells are the basic units of a drift chamber formed by the arrangement of wires.

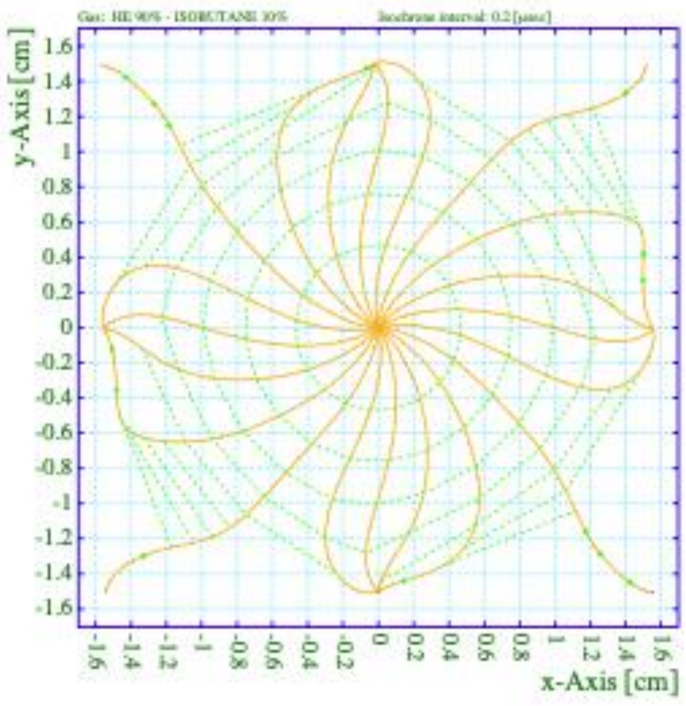
A drift cell is defined by sense wires • (signal wires which collect charge) and field wires ° (shape the electric field).

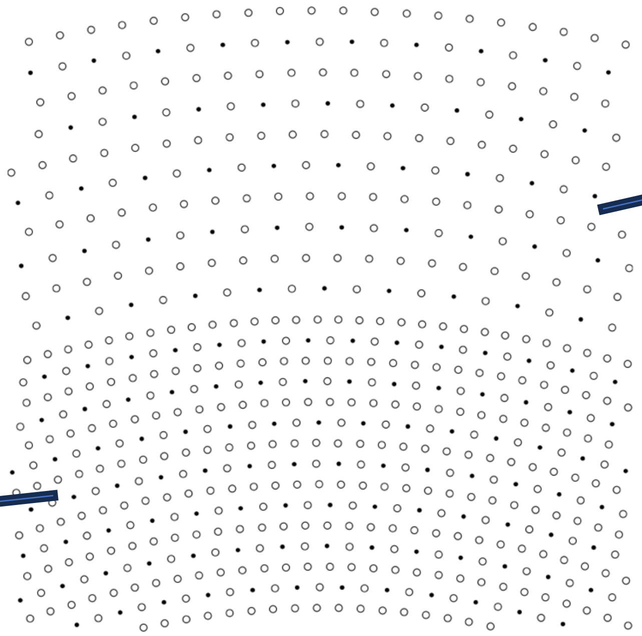


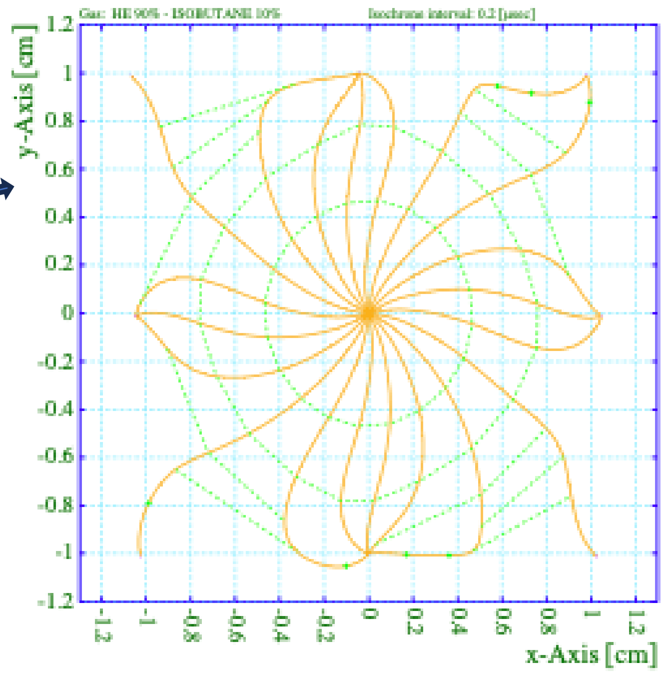

KLOE drift cells are almost square in shape and are arranged in concentric layers around the beam pipe and have alternating stereo angles.

12582 single sense wire cells are arranged in 58 circular layers.

# DRIFT CELLS






Drift line configurations for small and big drift cells are a result of the following choices:

- Helium based gas mixture
- Drift cell geometry
- Voltage
- Wire diameter

# PATTERN RECOGNITION

Track reconstruction algorithms is made up of 3 steps: Pattern recognition → Track fit → Vertex fit

**Step 1 :**
**Pattern recognition**

hit is the presence of a wire signal and relevant information.

1. Hit association per stereo view.
2. Drift distances and their errors from s-t relations are used as input to form track segments and trajectory information
3. Track segments are searched first in x-y plane then z-coordinates are found.

1. From the outermost layer hits close to each other are matched to form **hit chains**.
2. When **n≥3 hits** are associated, hit n+1 is added if the resulting track curvature is consistent.
3. More hits are added keeping only the combination with the **lowest** $\chi^2$
4. A track candidate requires at least **4 hits**
5. Tracks are refit and parameters computed. Track candidates from the **two stereo views** are combined in pairs by curvature and geometry
6. **Z coordinate** is found here by a 3-D fit to all associated hits.

# TRACK FIT

Track reconstruction algorithms is made up of 3 steps: Pattern recognition → Track fit → Vertex fit

**Step 2 :**
**Track fit**

Track fitting is an iterative procedure where $\chi^2$ is minimised. Drift distances are used to fit the track and residuals from the fit which is used to compute $\chi^2$

1. Use tracing relations to determine the track incident angle and hit positions from "raw" space-time relations.
2. Drift distances are corrected using "fine" s-t relations.
3. Residuals are used for subsequent corrections to the fine s-t relations.

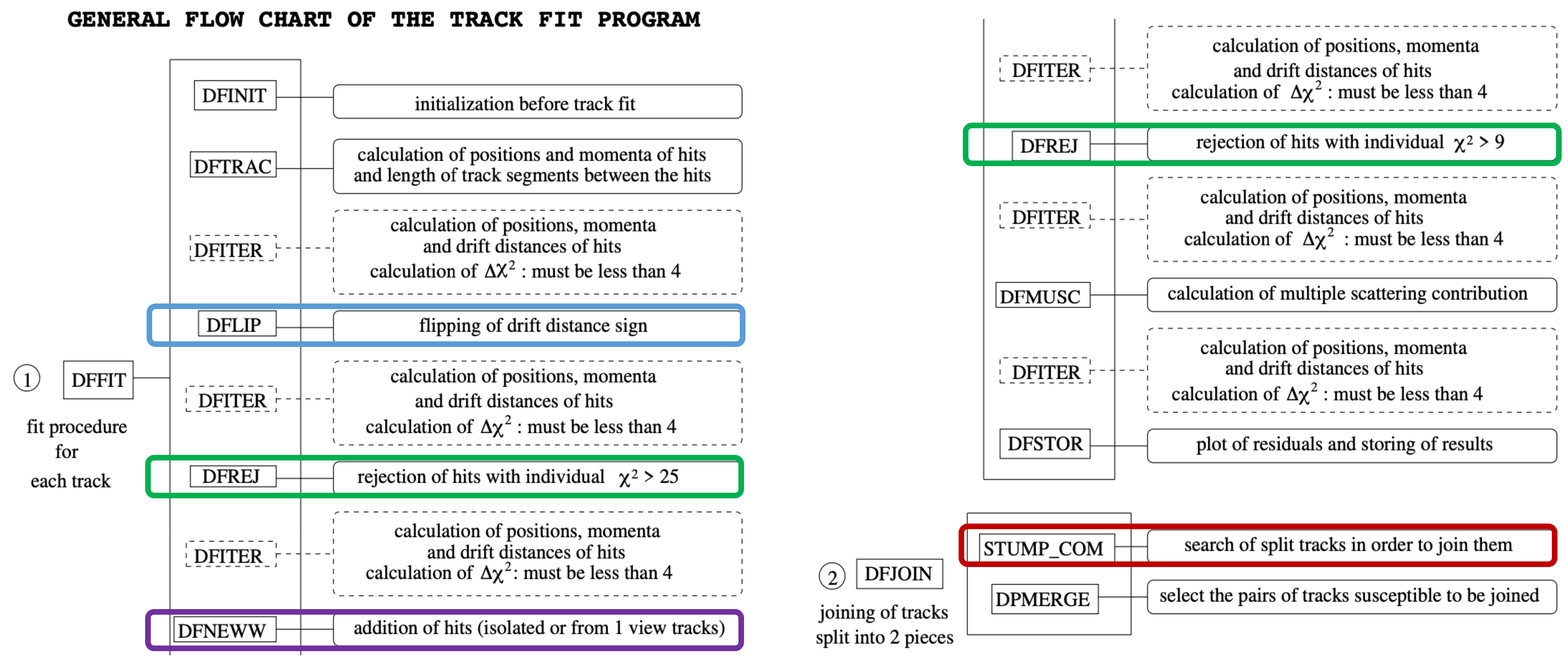
To improve the track fit:

1. Check the sign of the drift distance hit by hit.
2. Add missed hits from pattern recognition to the track
3. Reject wrongly associated hits.
4. Identify split tracks and join them

$$\chi^2 = \sum_i \left( \frac{d_i^{\text{fit}} - d_i(C_k^0)}{\sigma(d_i)} \right)^2$$

# TRACK RECONSTRUCTION

**Step 2 :**
**Track fit**



# TRACK RECONSTRUCTION

**Step 2 :**
**Track fit**

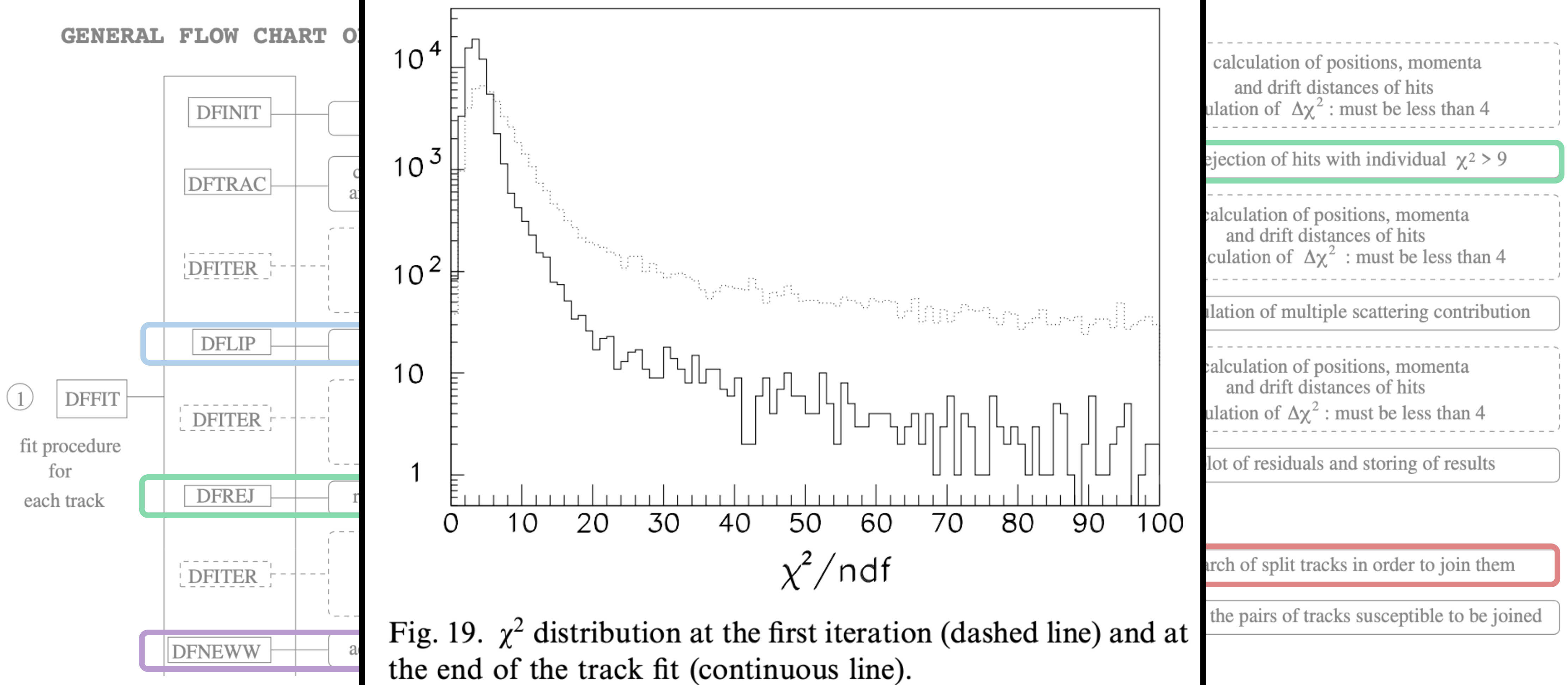
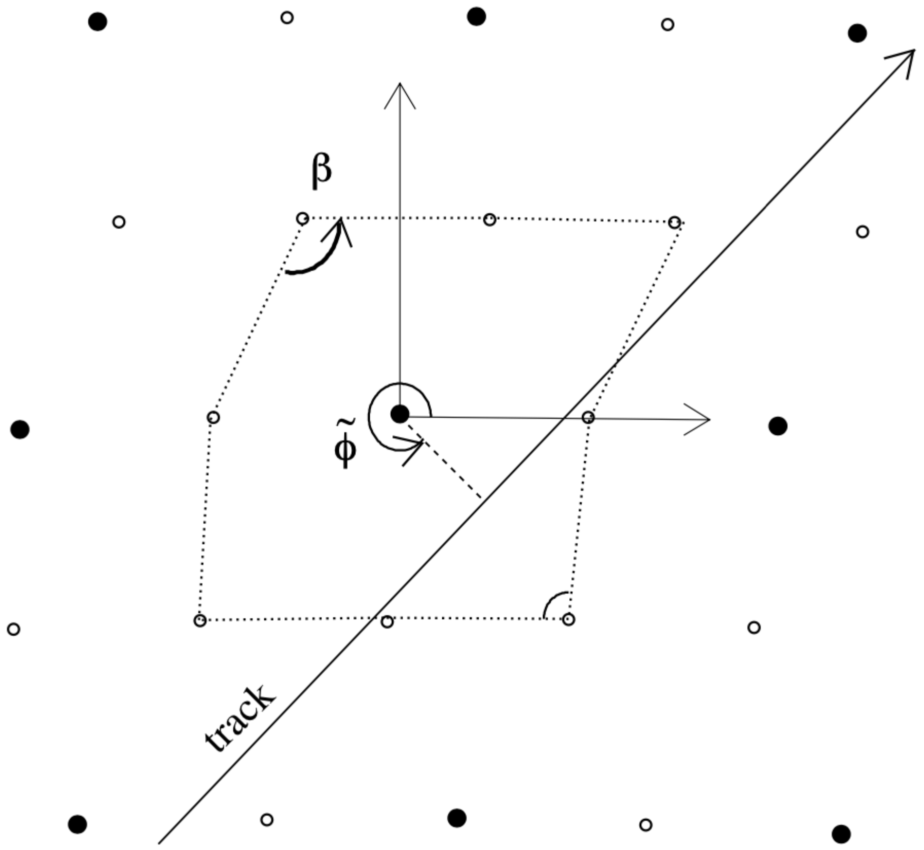



Fig. 19. $\chi^2$ distribution at the first iteration (dashed line) and at the end of the track fit (continuous line).

# SPACE-TIME RELATIONS




Space-time relations: dependence of the drift time on the distance from the wire.

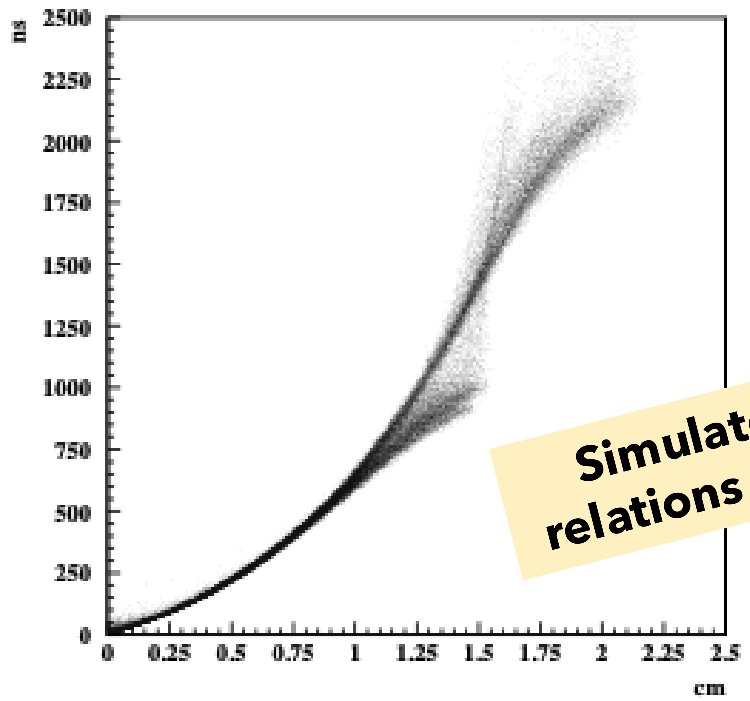
Drift velocity varies as a function of the electric field along the wire.

s-t relations change with track orientation and position along the wire.

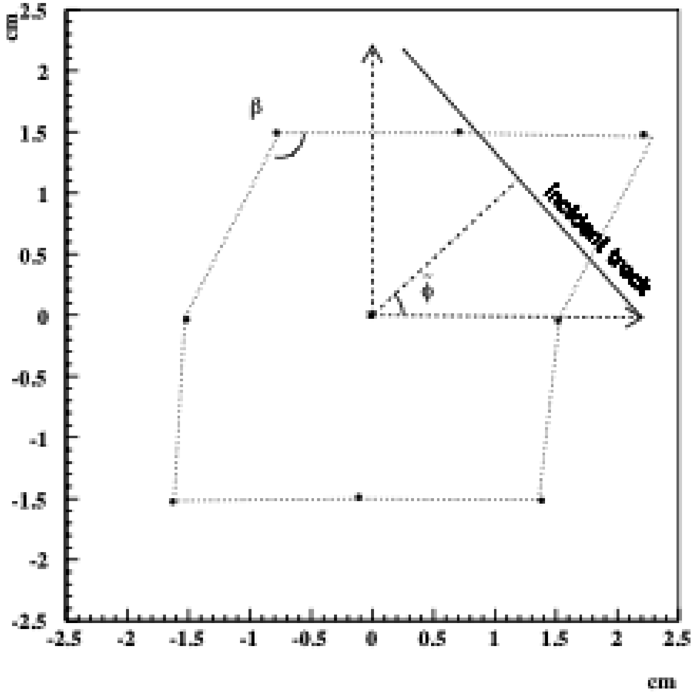
You can parametrise the s-t relations in terms of $\beta$ and $\tilde{\phi}$

S-t relations are parameterised using cosmic rays and 6 reference cells of different shapes

# SPACE-TIME RELATIONS




Simulated s-t relations for cells




The distortions of the electric field strongly affect the s-t relation at big impact parameters. To parametrize the cell response over the greatest area, we need to correct for the azimuth $\tilde{\phi}$ of the incident tracks.

# RAW VS FINE

**Raw s-t relations**

The trajectory of the particle is unknown at the level of pattern recognition so there is no information about the values of $\beta$ and $\tilde{\phi}$.

The cell response is described at this level by only one s-t relation which is the average over all of the track orientations and drift cell shapes

**Fine s-t relations**

*Using the raw s-t relations the pattern recognition algorithm finds the track candidates for each event allowing for an estimate of $\beta$ and $\tilde{\phi}$.*

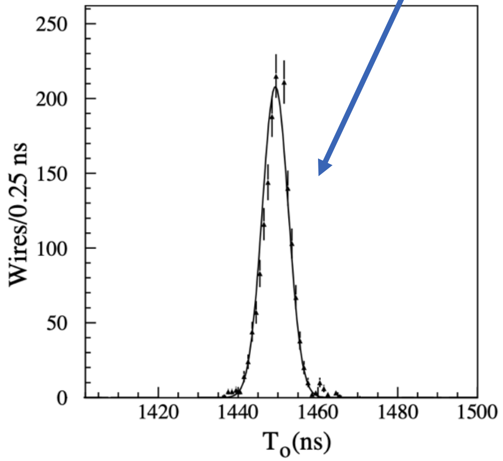
The drift distances are parameterized using a fifth order Chebychev polynomial, $d(C_k, t - T_0)$ . Coefficients $C_k^i$ of the polynomial k= 1….232 and i=0…5 define the fine s-t relations which account for the cell type (big or small) track angle ($\tilde{\phi}$) and cell deformation parameter **($\beta$).**

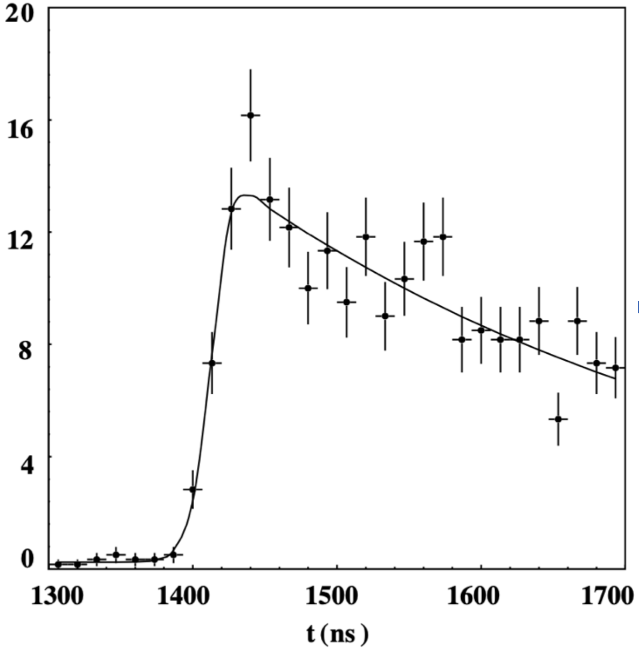
The track fit procedure computes the impact parameters for each hit of a track by inverting the Chebychev polynomial.

# TIME

Determined event by event from trigger and calorimeter. Track is approximated as a straight line

Rms is 2.9 ns and is the part of the time resolution that is due to jitter of the wire signals and trigger




$$t = T_{tof} + T_{wire} + T_{drift} + T_0$$

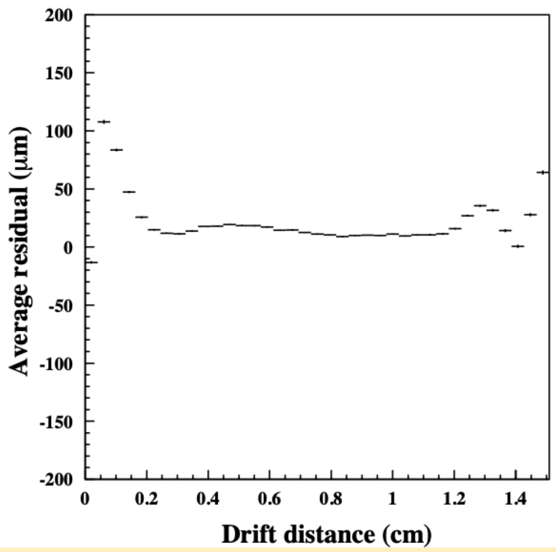
- $T_{tof}$ : particle time of flight between the calorimeter and the wire.
- $T_{wire}$: propagation time of the signal along the wire.

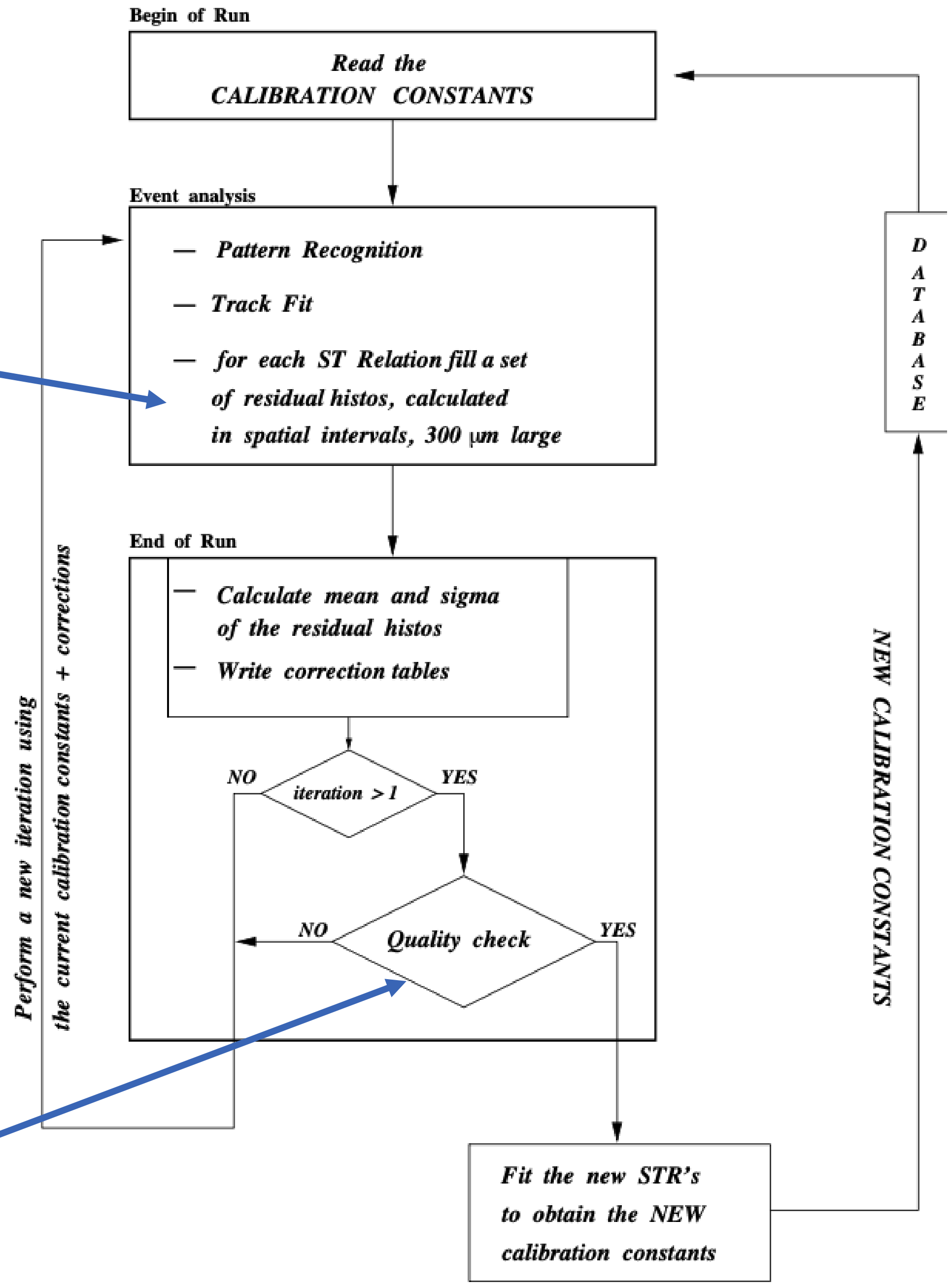
- $T_{drift}$: drift time
- $T_0$: time offset.
  - Defined by the maximum of the first derivative of the $T_{drift} + T_0$ distribution. This distribution is fit with the above function.

$$a + b\,\frac{e^{-d(t-T_1)}}{1 + e^{-(t-T_0)/c}}$$

# CALIBRATION

The values of $t_i$, $d_i(C_k)$, $d_i^{fit}$ are stored in a bank according to the values of $\beta$ and $\tilde{\phi}$ defined by the track fit. The 232 residual distributions are then binned in intervals of drift distance of $300\ \mu m$ width and fitted with Gaussians.




Determine the mean value of the residuals and the variance in each bin. Mean value of the residual distribution $|<r(C_k)>|$ is smaller than $100\ \mu m$

# FINE S-T RELATIONS

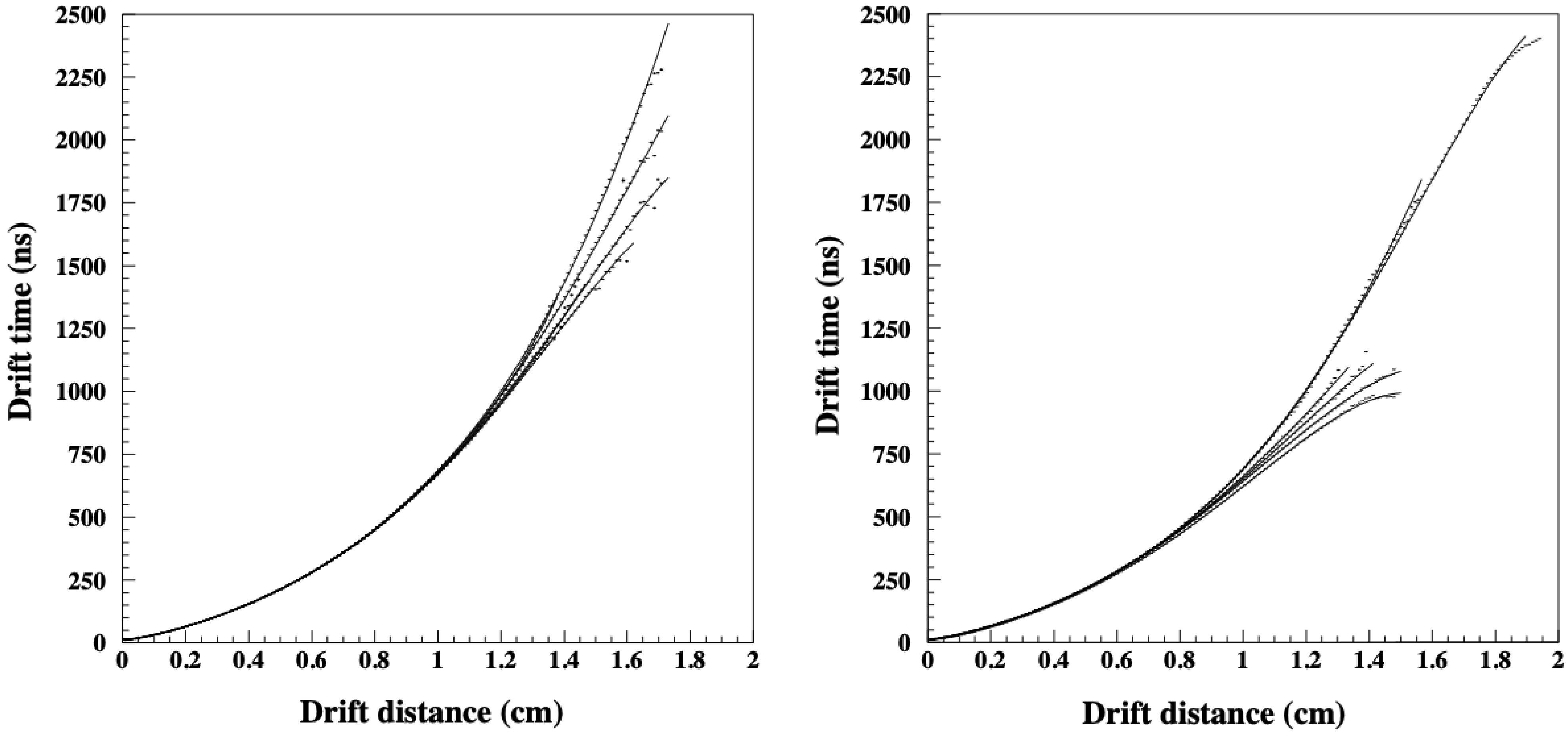



Fig. 24. Time to space relations for the different values of the shape parameter $\beta$ (left) and for different incidence angles $\tilde{\phi}$ (right).

# TAKEAWAYS

# TRACK RECONSTRUCTION

Track reconstruction algorithms is made up of 3 steps: Pattern recognition → Track fit → Vertex fit

**Step 3 :**
**Vertex fit**

Track parameters from track fit are used to search for primary and secondary vertices

1. Tracks are extrapolated to the beam crossing in the transverse plane.
2. Primary vertices are searched for using tracks with an impact parameter smaller than 10% of the radius of curvature
3. Secondary vertices are searched for by excluding tracks associated to another vertex.
4. For each track pair a vertices position is determined by minimising $\chi^2$ function evaluated from the distance of closest approach and the extrapolation errors.