T-Station Alignment Infrastructure at LHCb

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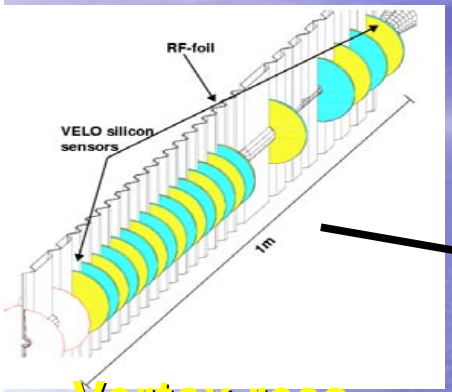
Outline

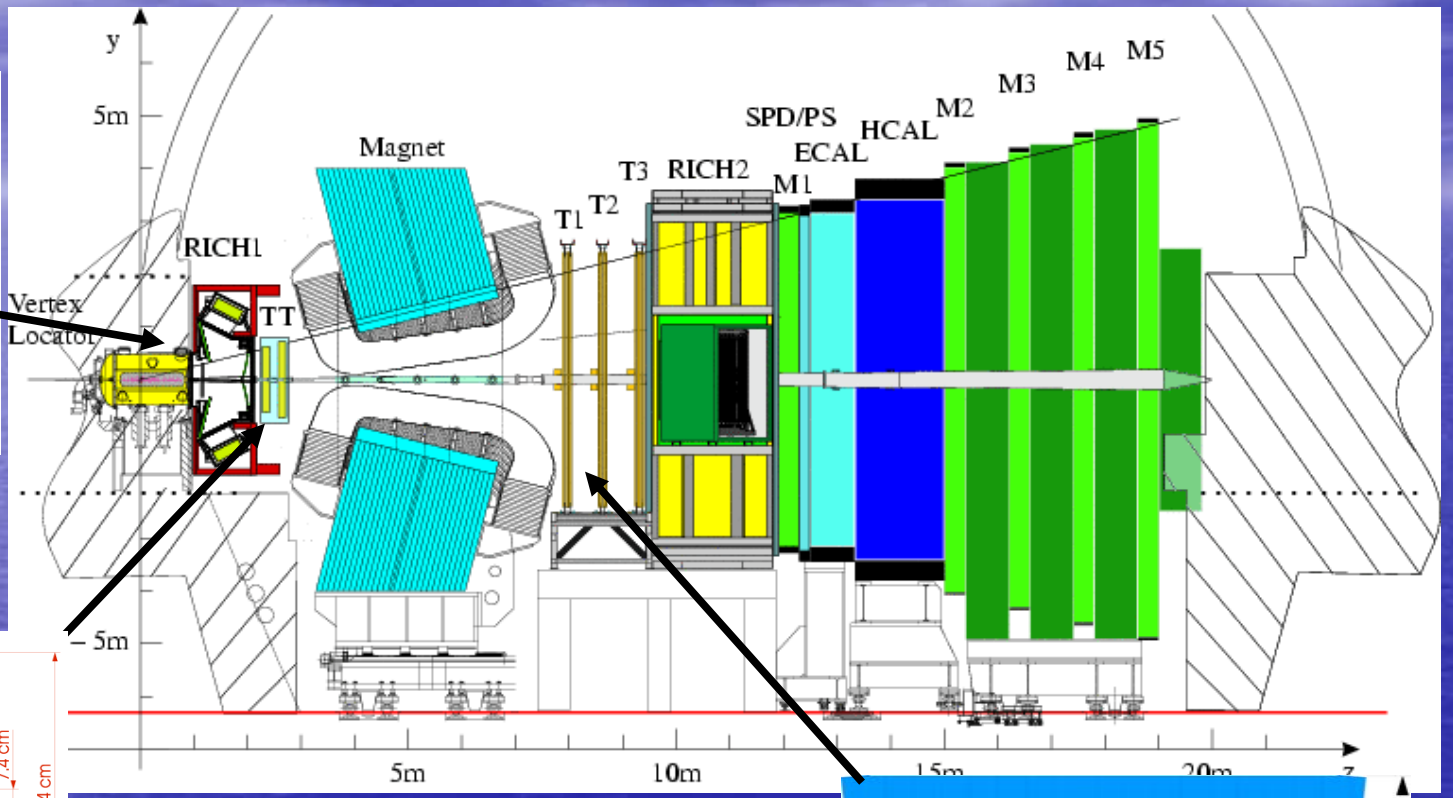
- Introduction
  - Vertexing and tracking subsystems
  - T stations
- Alignment framework: global view
- Geometry and alignable units
- Tracking model and tools
- Solving tools
- Conclusion and outlook

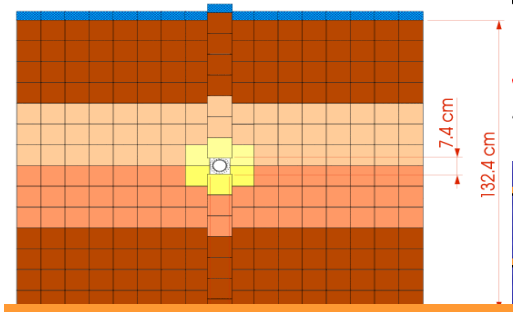
Vertexing and tracking in LHCb

VeLo



Vertex reco.

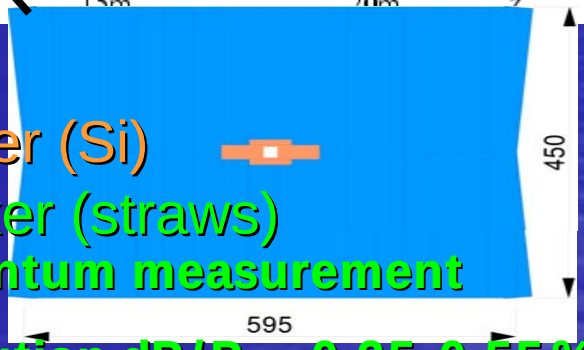




Trigger Tracker

In fringe field of magnet
Fast track momentum measurement for trigger
dP/P ~ 30% (PT=3GeV)
Offline reconstruction of long-lived and low momentum particles

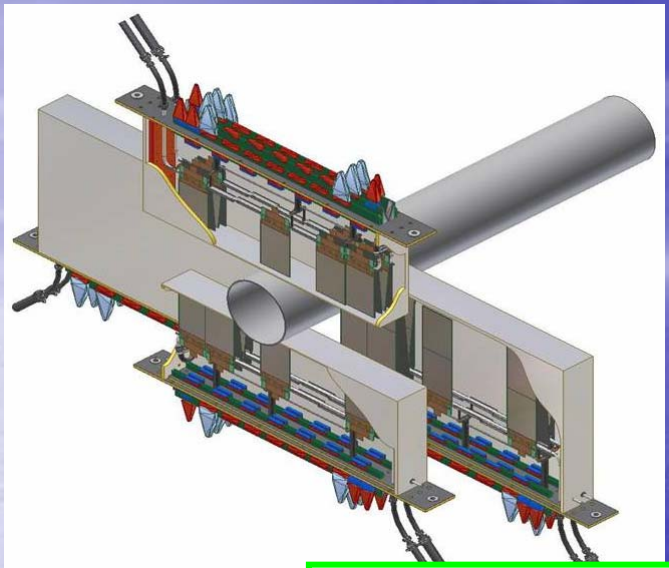
T Stations
Inner Tracker (Si)
Outer Tracker (straws)
"Full" momentum measurement



Target resolution dP/P ~ 0.35-0.55 %

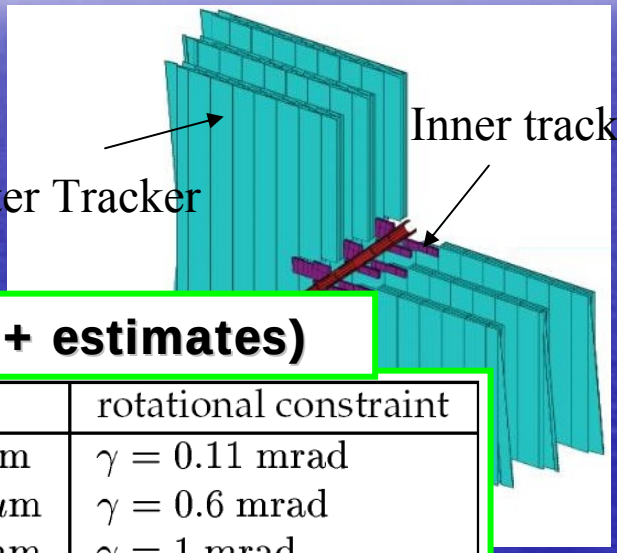
T stations

Inner Tracker



3 Stations with 4 layers, x type and stereo u,v type (0º, -5º, 5º, 0º)

Outer Tracker



- High tra
- Silicc
  - F
    5
  - 2
    tr
  - M

IT Initial positioning (meas. + estimates)

Object	tolerance	rotational constraint
sensors on ladder	$\Delta x, \Delta y = 10\ \mu$m	$\gamma = 0.11$ mrad
ladders on rod	$\Delta x, \Delta y = 100\ \mu$m	$\gamma = 0.6$ mrad
cooling rod to cooling rod	$\Delta x, \Delta y = 0.5$ mm	$\gamma = 1$ mrad
detector box	$\Delta x, \Delta y = 1$ mm	$\gamma = 1$ mrad

Degradation: for x misalign of 0.5 mm, although trk efficiency not much affected, $\Delta p/p$ ~ 10-15 %

(25 % for 1mm)

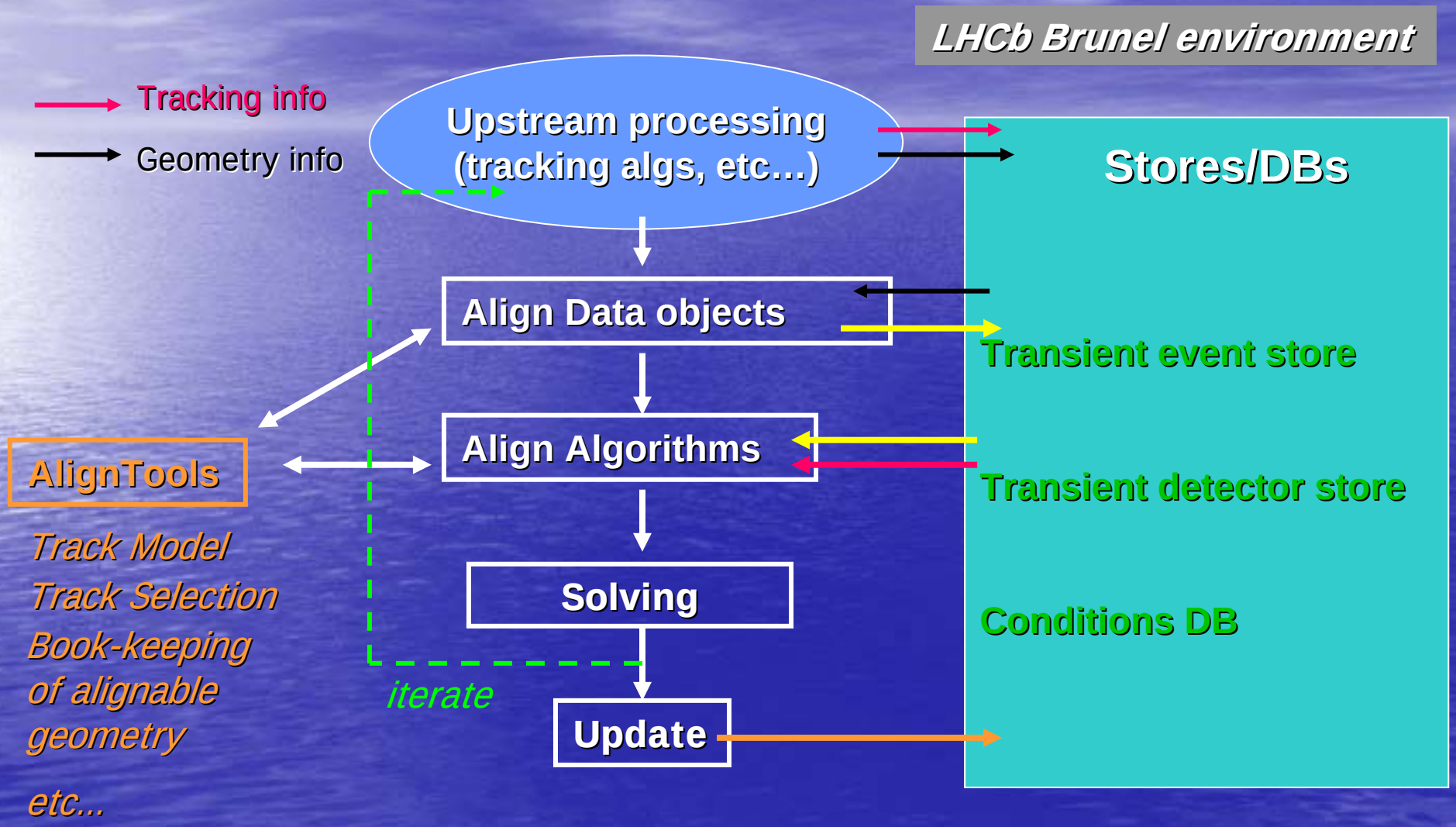
tubes

mixture

dules to

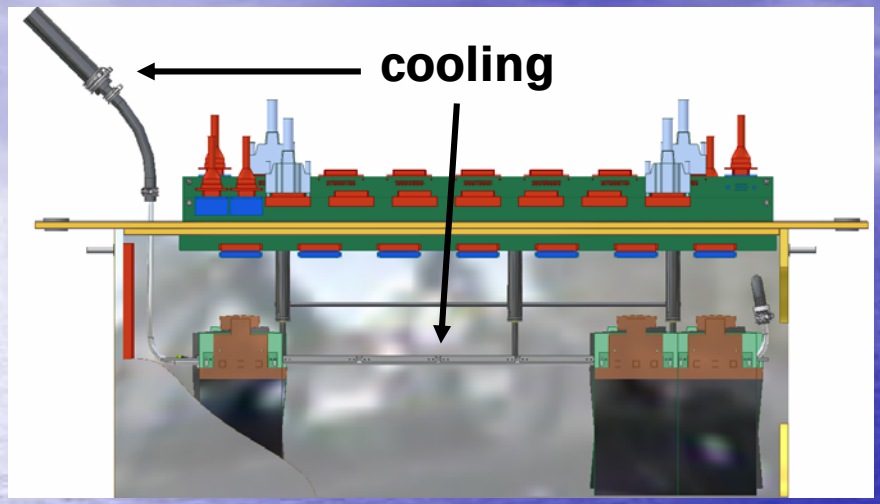
- Each station has four boxes
  - Total: 336 ladders to align

Alignment framework

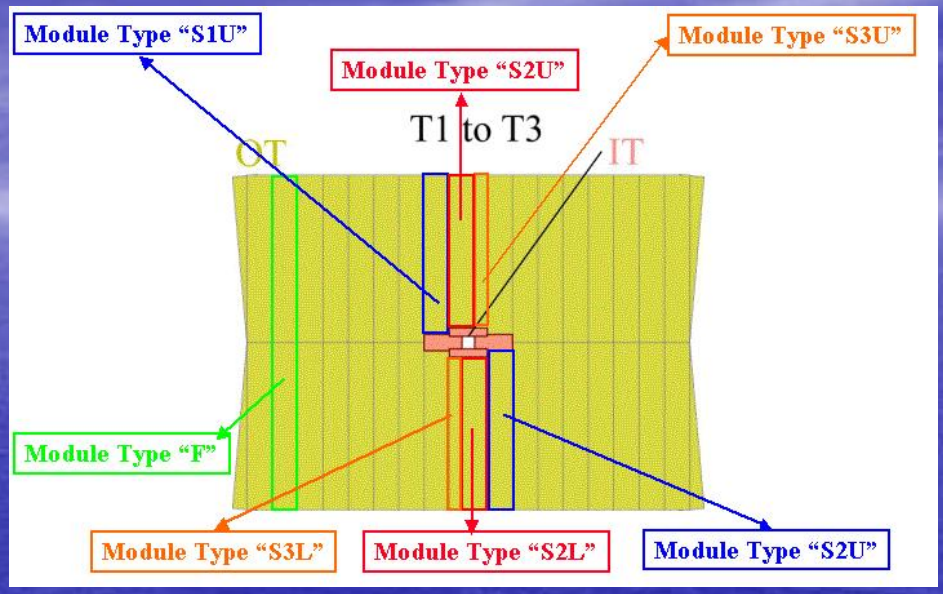


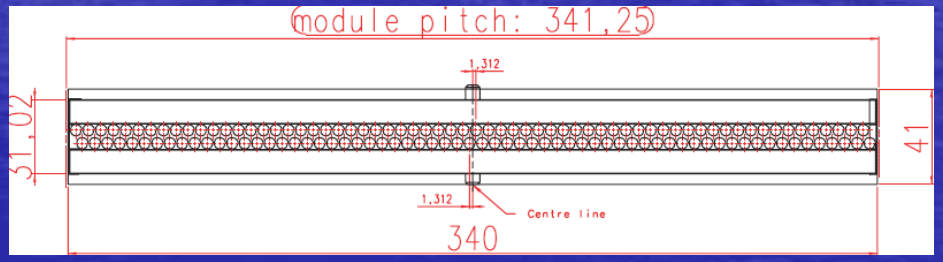
Geometry and granularity

IT



OT





Inside IT box:

4 ladder layers: 2 layers mounted on each cooling rod.

Overlaps:

IT ladders overlap across the strips

Overlaps between IT boxes

Small overlap between IT and OT

Straws grouped in double layered modules

4 module layers per station

Tracking model and tools

Velo tracks

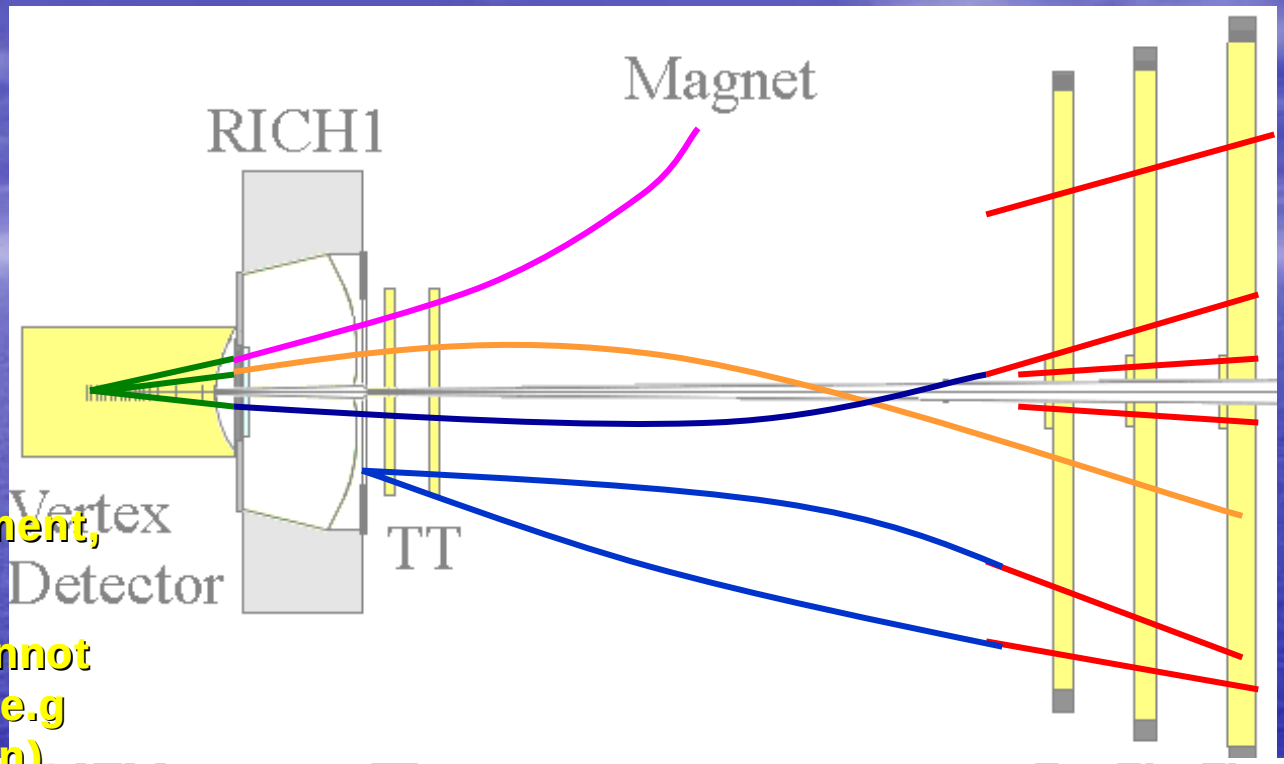
Forward tracks

Matched tracks

Seed tracks

VTT tracks

T → TT tracks

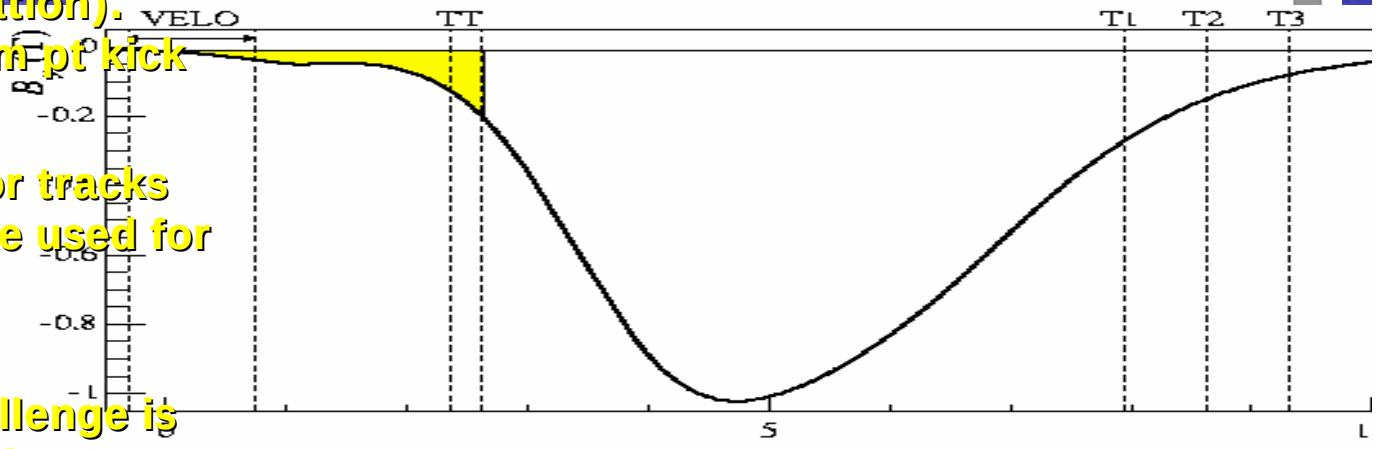


For T station internal alignment, use of T seeds

- Because of fringe field, cannot take a purely linear model (e.g polynomial parameterization). Momentum estimate from pt kick in the magnet

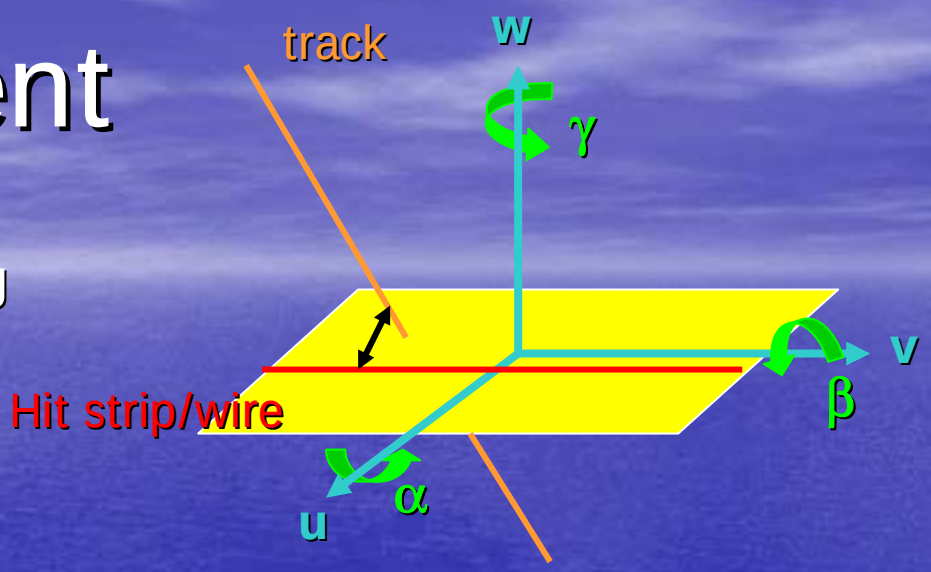
- Trajectory tool (both for tracks and measurements) to be used for derivatives, defining misalignments, etc...

- For selection, main challenge is to reject ghost tracks, select isolated tracks



Solving alignment

- Splitted between processing (i.e accumulate statistics) and solving
- IT ladders and OT modules treated in a similar way
- Processing part meant to run in different ways: direct use of Millepede, global minimization, etc…
- Final solving part separated from the processing part
  - On call methods implementing different approaches (singular-friendly inversion as embedded in Millepede, diagonalization, MINRES algorithm)
- Steps:
  - Align IT and OT internally
  - Use “hybrid” tracks and overlaps to align IT wrt OT



Measurement, ϕ stereo

u = x cos(ϕ) + y sin(ϕ)

$$\chi^2 = \sum_i \left(\frac{\vec{x}^{\,i}_{meas} - \vec{x}^{\,i}_{trk}}{\sigma^i_{meas}} \right)^2$$

Early studies

- *Note: the studies have been done with simplified set-ups, neglecting many effects (sensor thickness, multiple scattering, etc...)*
- Done only for two degrees of freedom (translations in the plane perpendicular to the beam axis) + straight tracks
  - Non linearities not taken into account
- With all the detector effects, the hope is to achieve:
  - IT: 10 μm precision for the coordinate across the strips (x) and about an order of magnitude worse in y
  - OT: ~ 50 μm precision across the straws (x)
- Currently:
  - Rotations and z translation being studied
  - Modeling of non-linearities under investigation
- Iterations machinery to be trained further

Conclusion and outlook

- T-Station Alignment strategy defined
  - Implementation of core software on-going
- Feasibility studies performed
  - Despite the naïve simulation, important items figured out already: treatment of non-linearities, handling iterations,...
- The plan is to have a complete SW framework by the end of the year
- Event samples for the algorithms
  - Simulated minimum bias and inclusive b events
  - Before “proper collision” data, beam-gas and beam-halo tracks to be considered (no cosmics like other experiments)

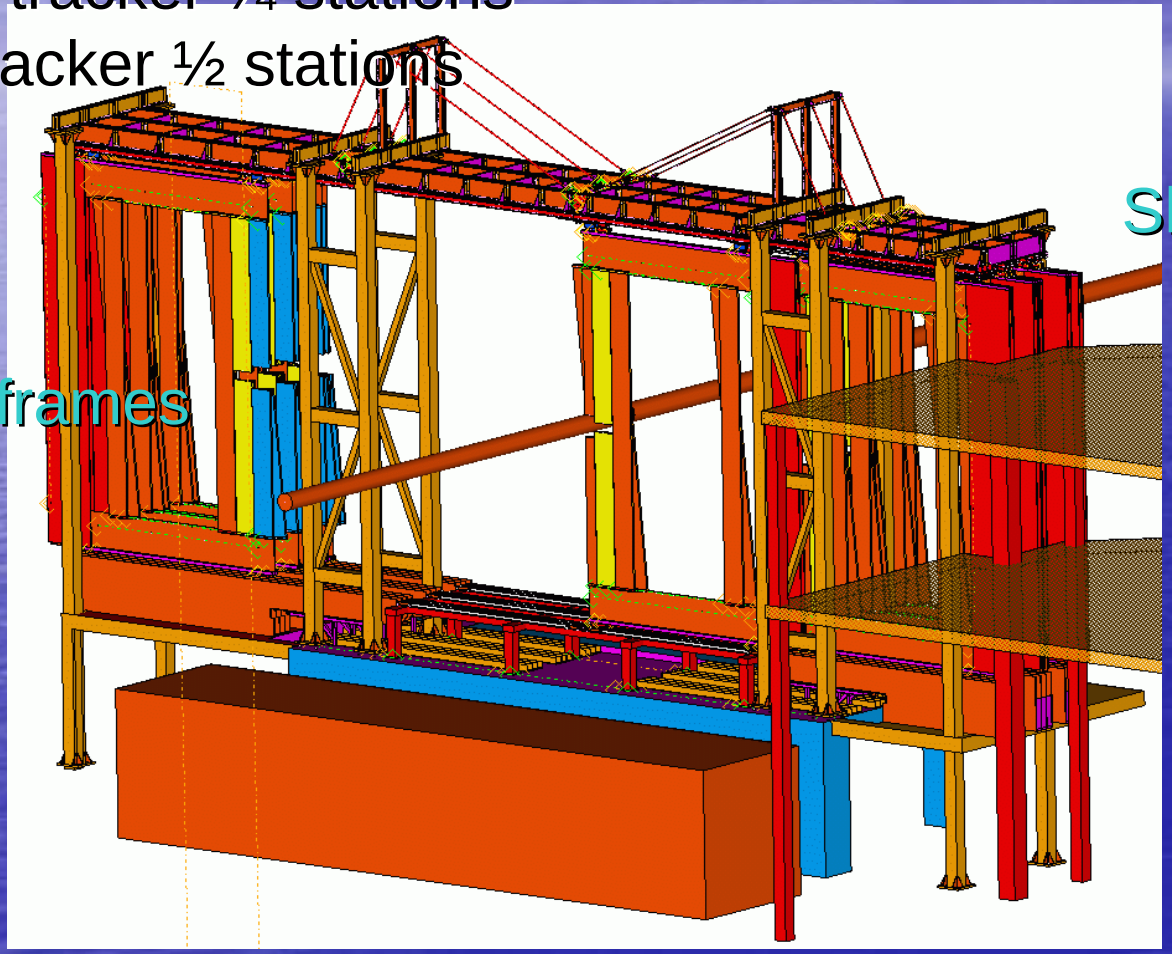
Back up

Bridge frame (stainless steel)

Supports:

12 Outer tracker ¼ stations

6 Inner tracker ½ stations



Shorter frames

Longer frames

Rail tolerances:

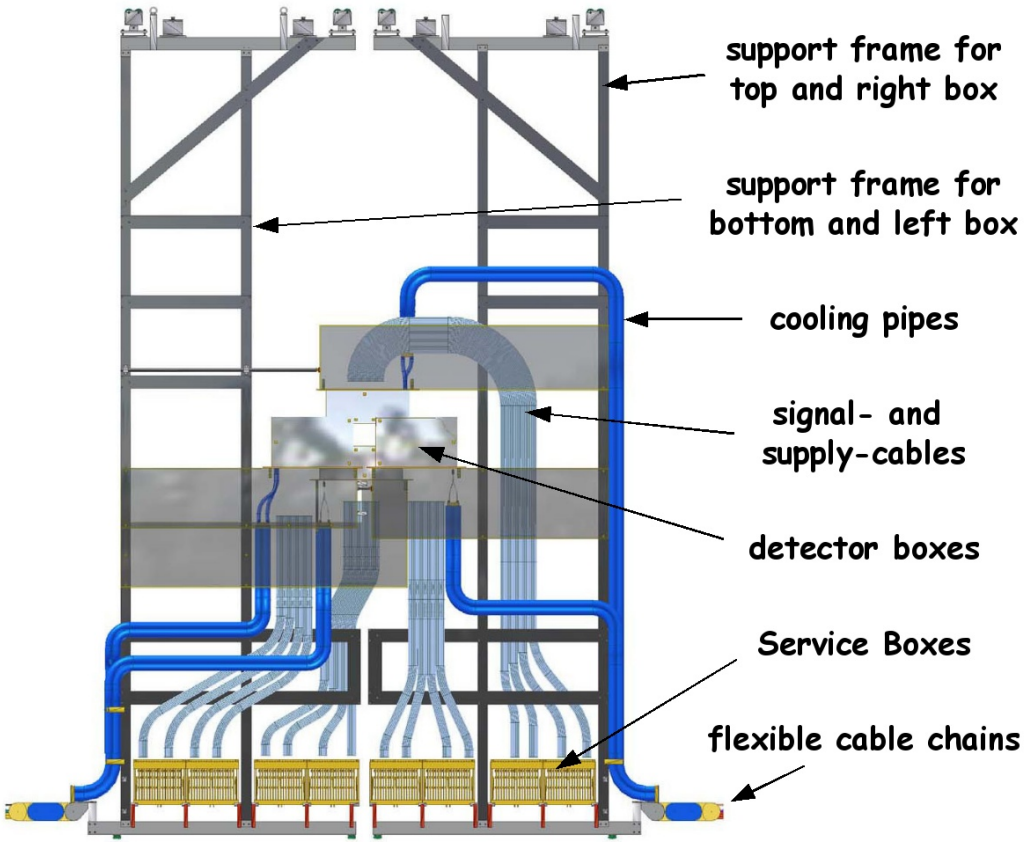
Flatness: 3 mm

Straightness: 2mm

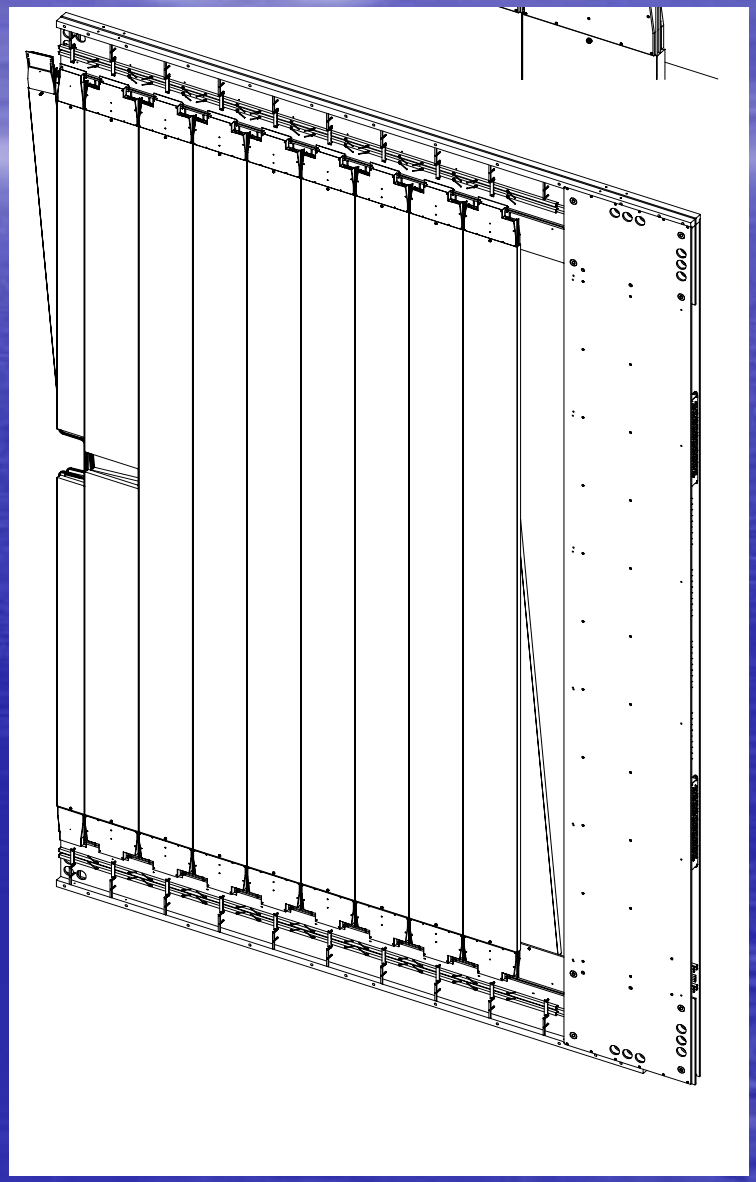
(over 6.55 m)

Support structures for the trackers

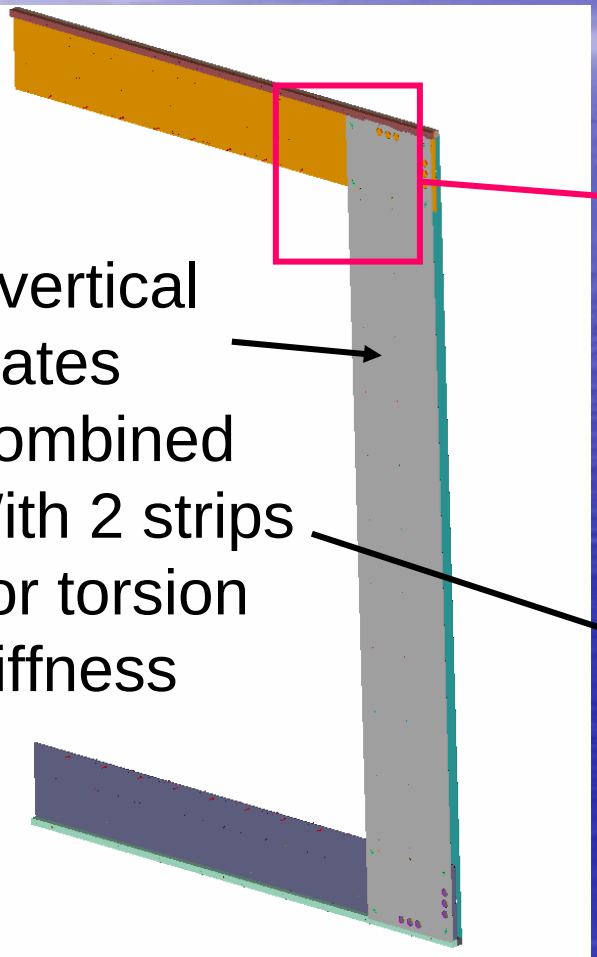
IT support frame



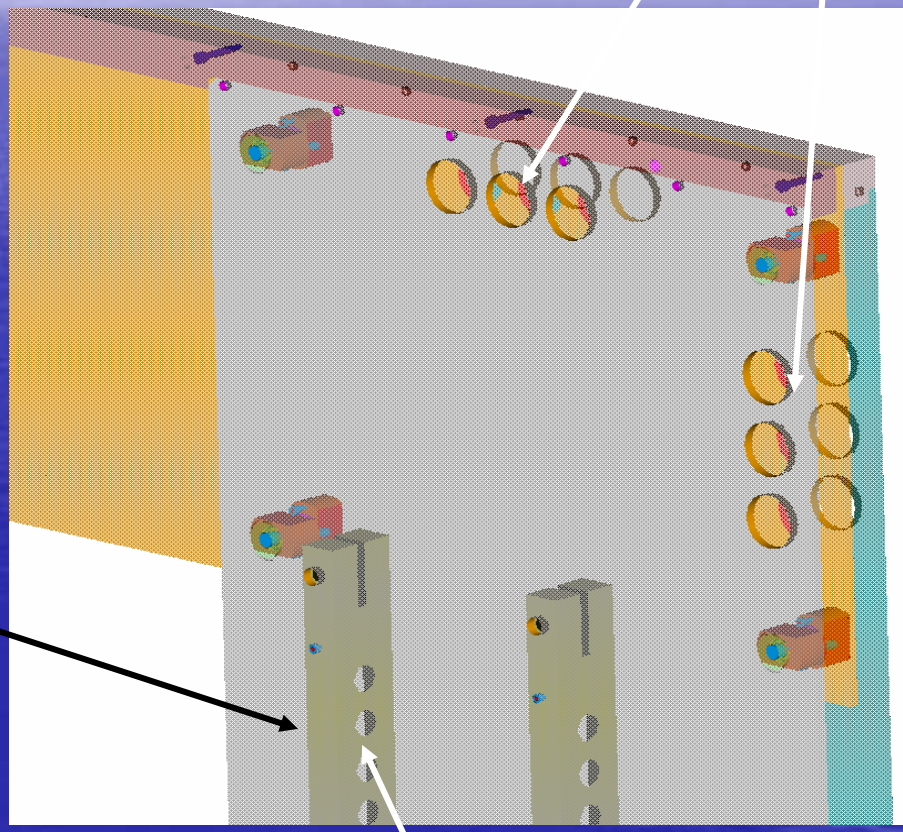
OT C-frame



C-frame details



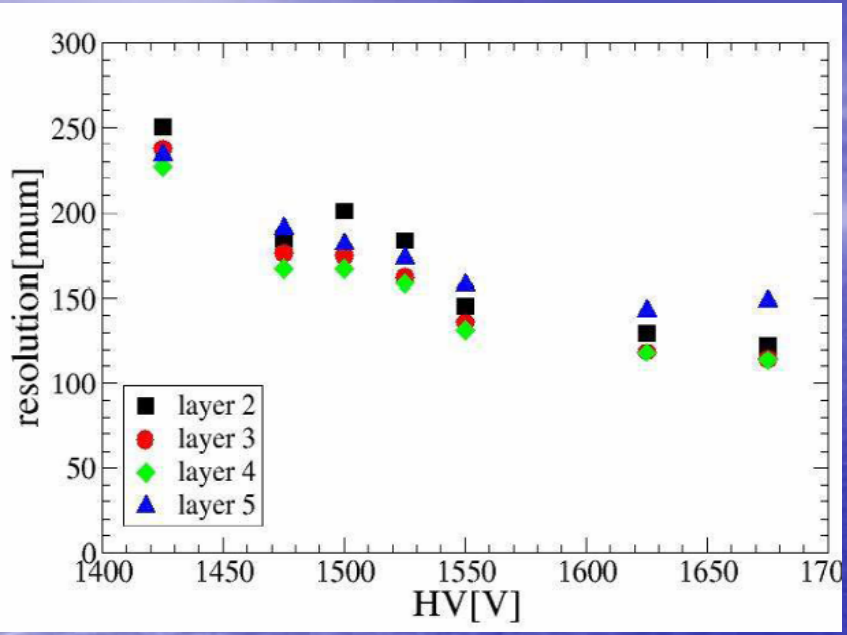
2 vertical
Plates
Combined
With 2 strips
For torsion
stiffness

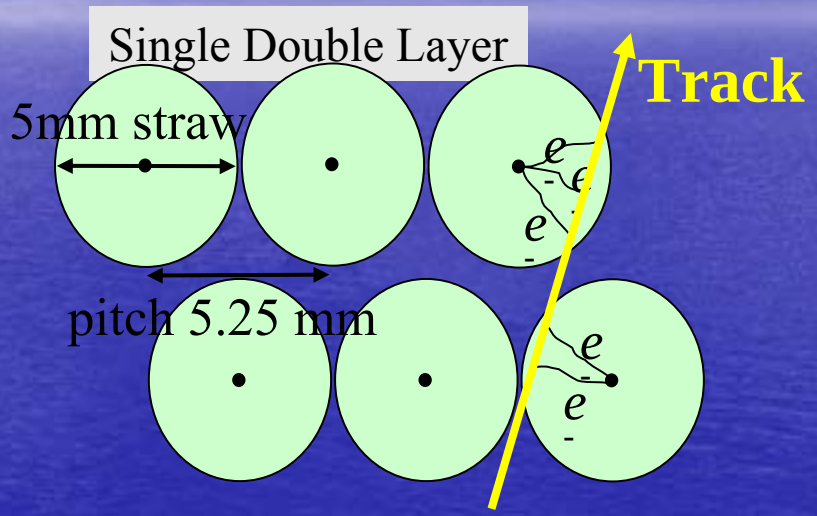


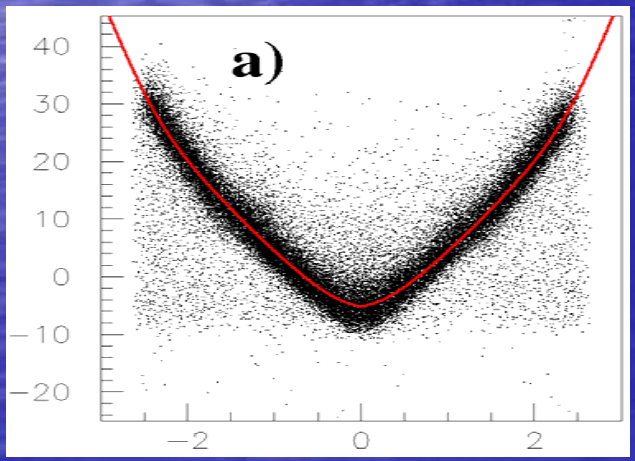
RASNIK alignment holes

Holes for services

More on OT



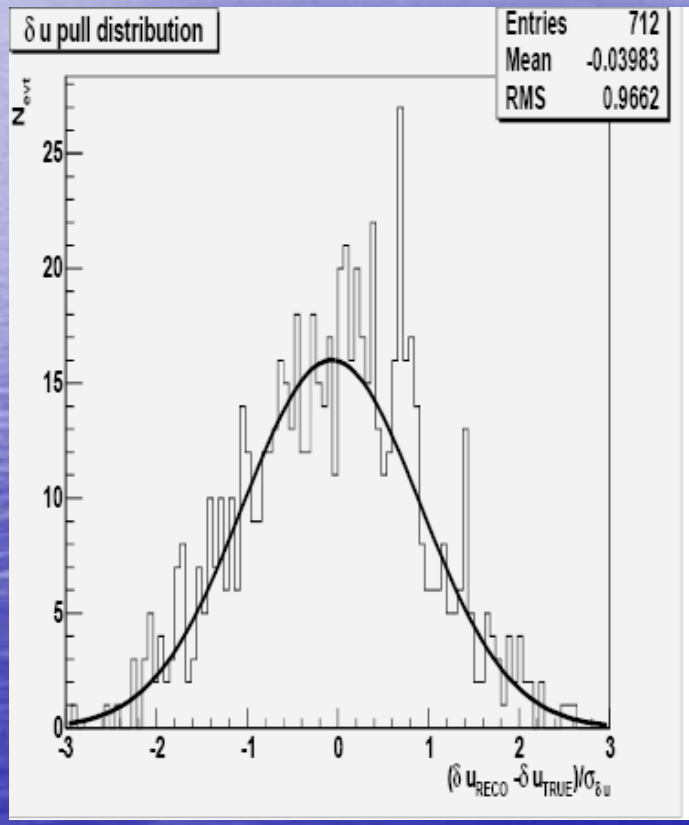


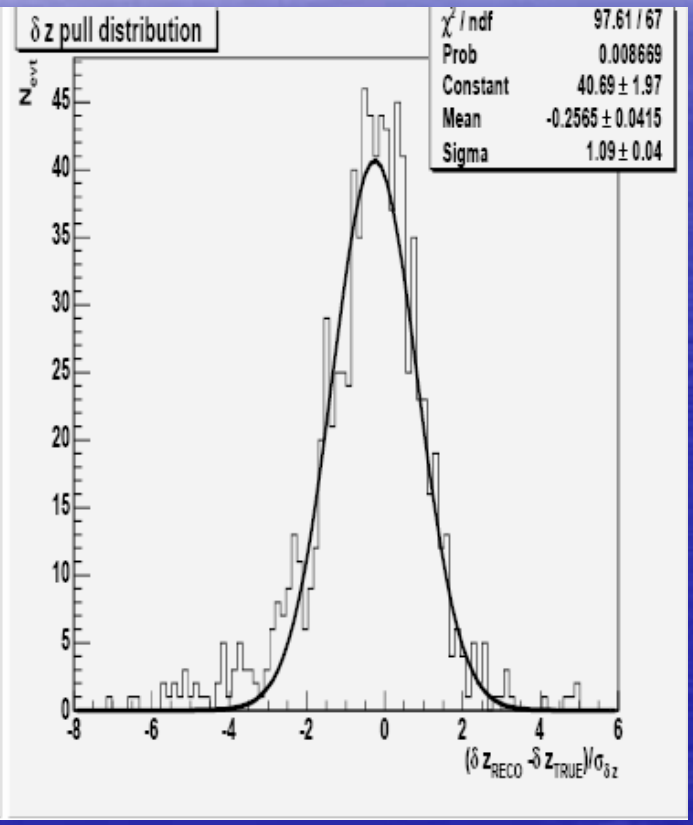


Drift time (ns)

r (mm)

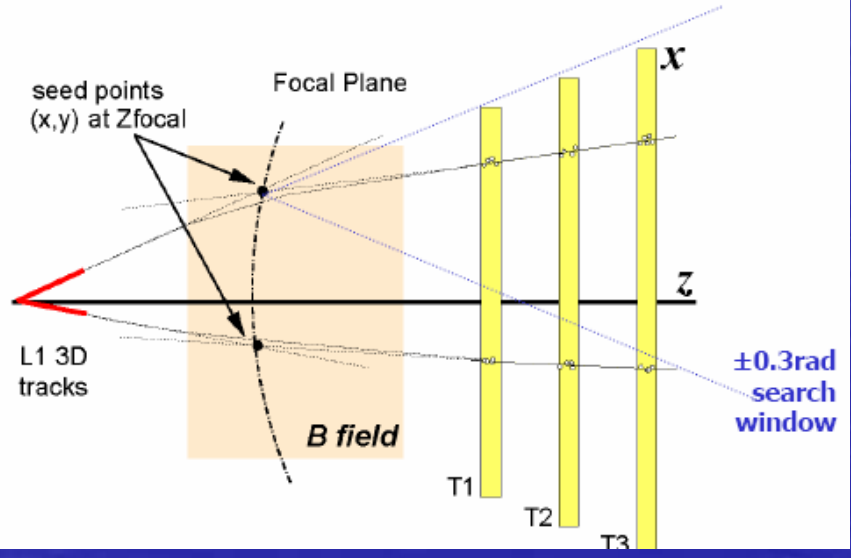
Pulls for IT align param x and z (toy MC study)





Pt derivation from Velo tracks

- Approximate B-field as thin lens ("p_t-kick method")
- Project VELO tracks to focal plane
- Search for IT / OT hits in search window of ±0.3rad (deflection<0.25rad for p>3GeV)



Slide from
J.Albrecht