Inner silicon tracking in the LDC

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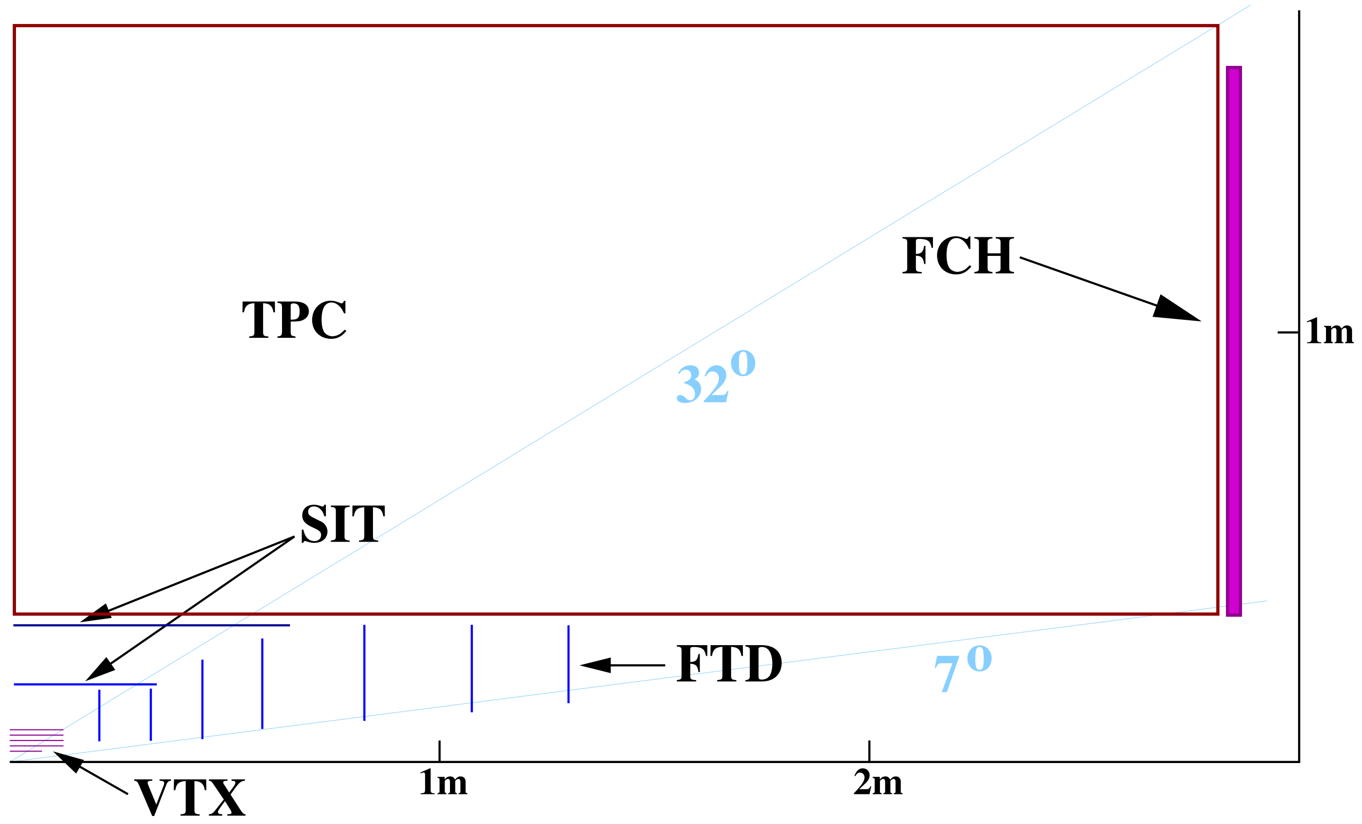
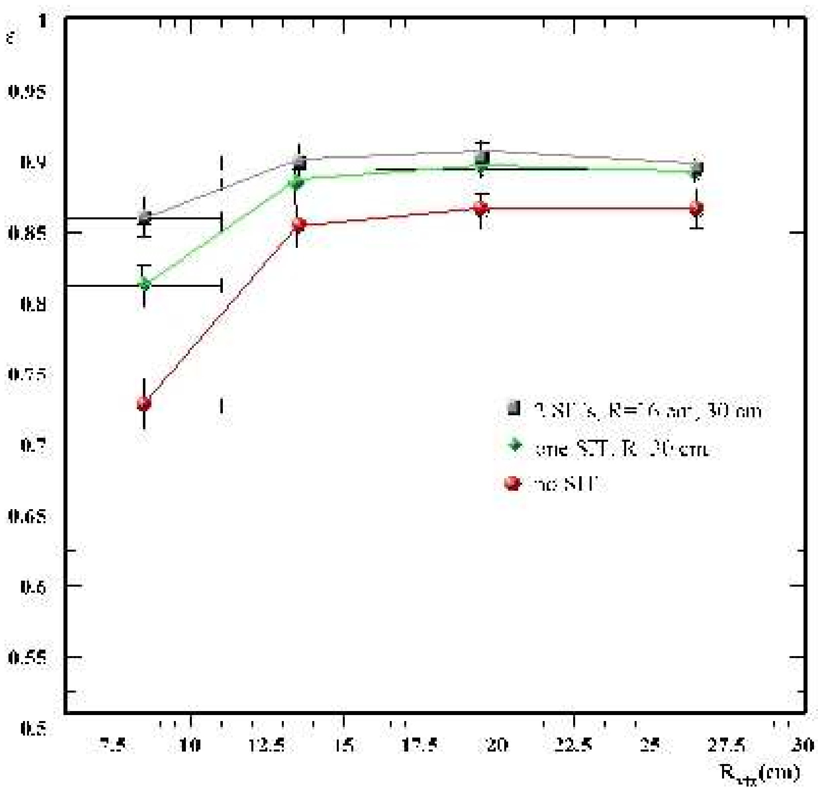
Inner silicon in the TDR

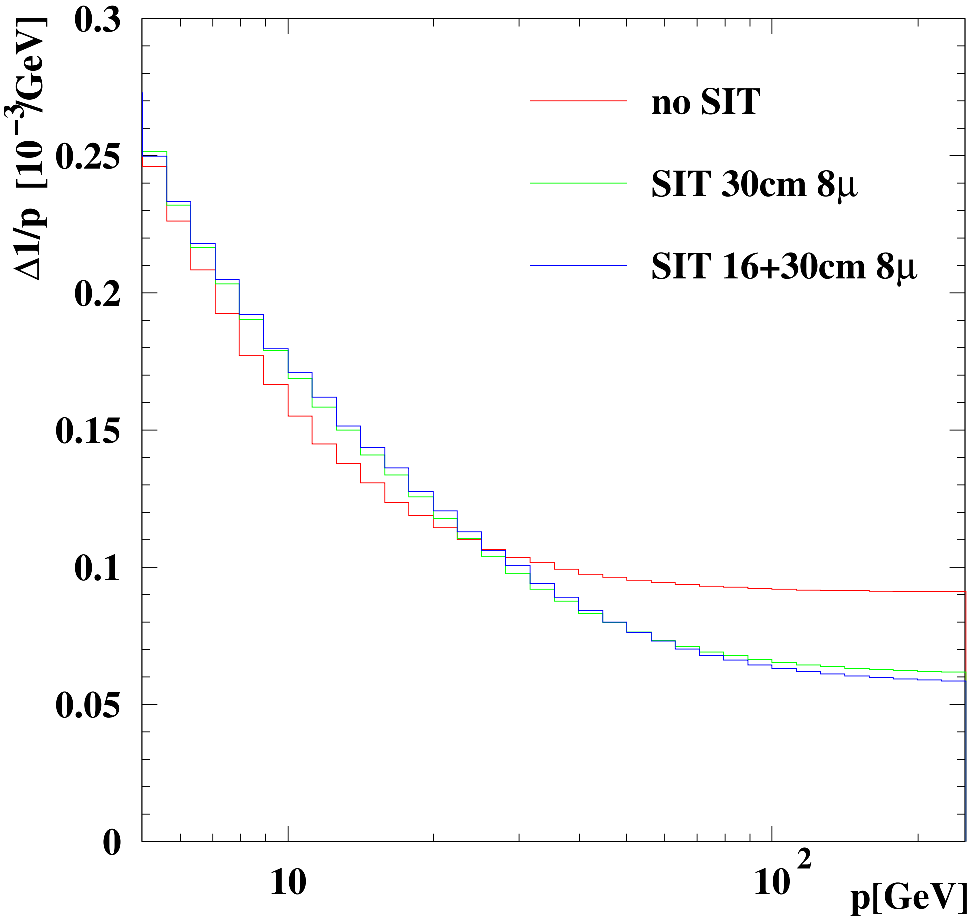
- Charged particle tracking above $\theta = 7^\circ$
- Main tracker: TPC (gradually getting weaker below $\theta = 32^\circ$)
- Silicon tracking between VTX and TPC (SIT, FTD)
- Forward chamber behind TPC endplate



Why barrel silicon?

- For high link-efficiency VTX-TPC need detector in between with intermediate resolution
- SIT improves momentum resolution by 30%



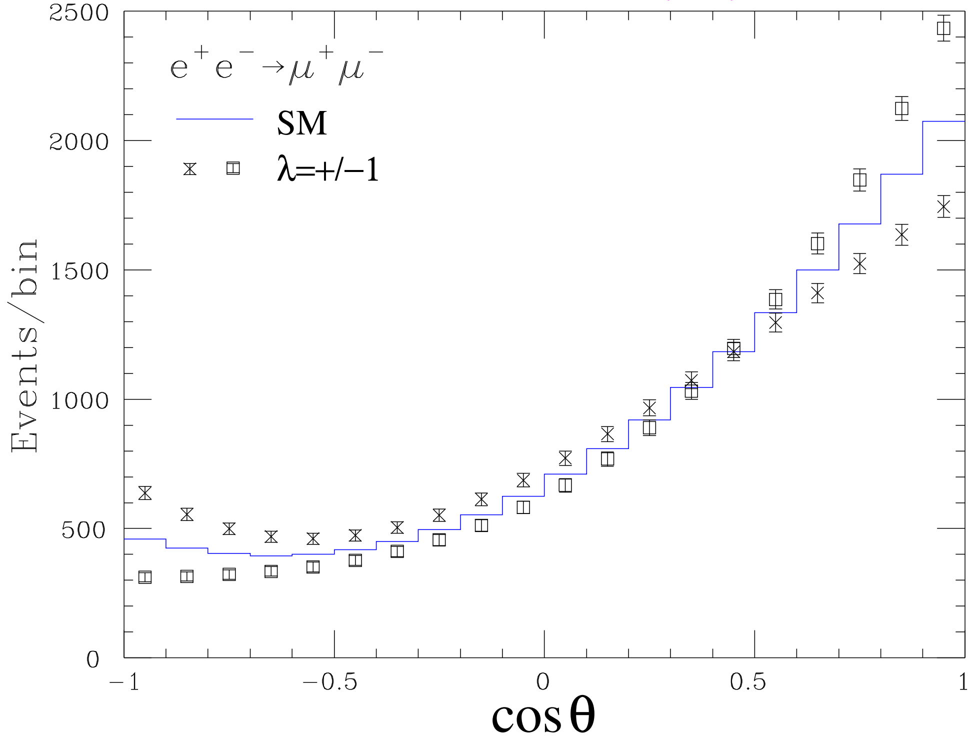


- K_s^0 reconstruction efficiency improves substantially due to SIT

Why forward tracking?

- Many processes at LC are peaked in the forward region like Bhabha scattering or W-pair production
- Fermion pair production has highest sensitivity to forward-backward asymmetry or to distinguish Z' effects from extra dimensions in the forward region

G^*-effects in $e^+e^- \rightarrow \mu^+\mu^-$



- W-pairs forward peaked with high momentum muons due to W-polarisation

➡ Good momentum resolution in the forward region is essential for charge determination and W suppression

Bhabha scattering

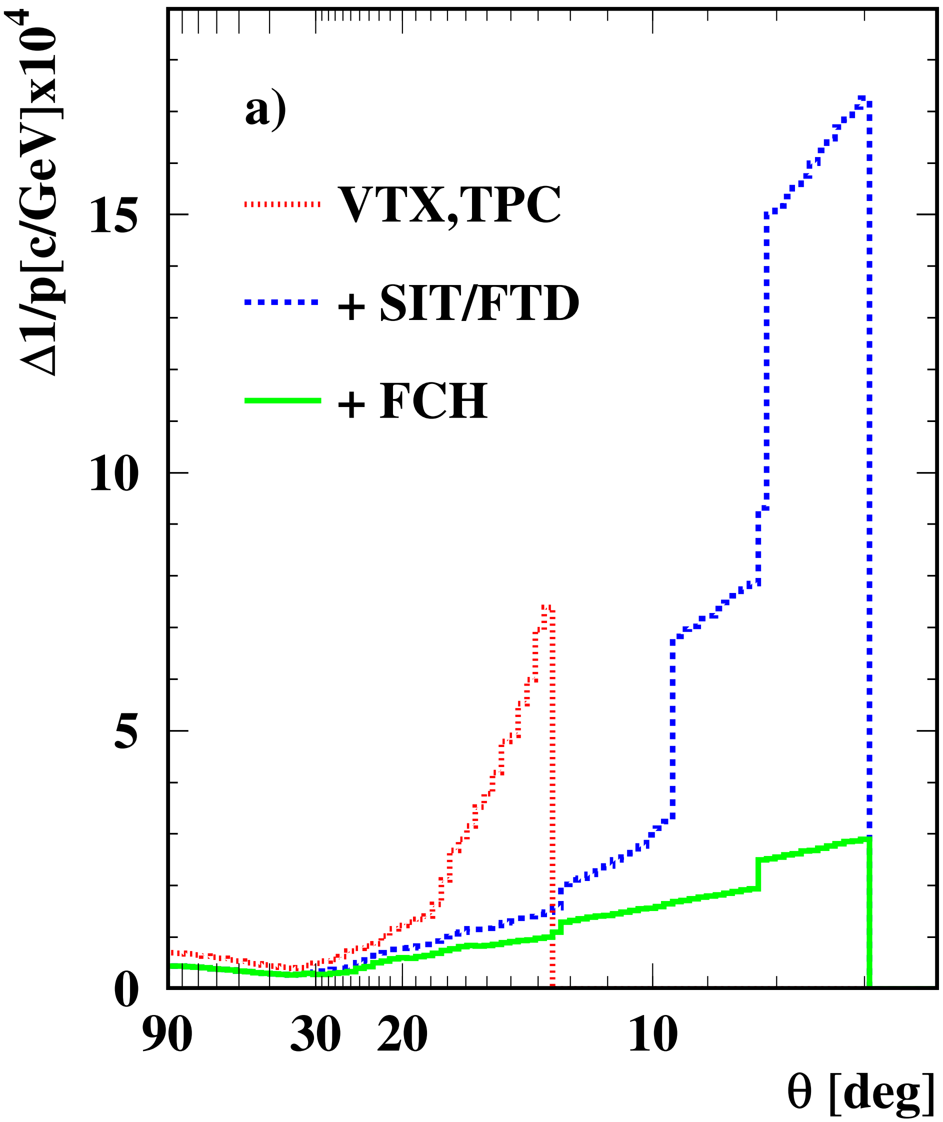
- Ideal calibration process for the beam spectrum
- Again strongly forward peaked ($d\sigma/d\theta \propto 1/\theta^3$)
- Reconstruct $\sqrt{s'}$ of e^+e^- system from polar angles assuming energy momentum conservation and only one radiated photon
- Want to measure beamstrahlung ($\mathcal{O}(10^{-2})$) and beam energy spread ($\mathcal{O}(10^{-3})$)
- $\sqrt{s'}$ error from angular reconstruction method: $\Delta\sqrt{s'}/\sqrt{s'} \approx \Delta\theta/\sin\theta$
  ➡ need $\Delta\theta < 10^{-4}$ in forward region
- Electrons radiate in material and cylinders (e.g. TPC field cage) are crossed with small angles
  ➡ better assure angular resolution close to the IP

➡ Good angular resolution close to the IP is key point for Bhabha

Momentum resolution in the forward region

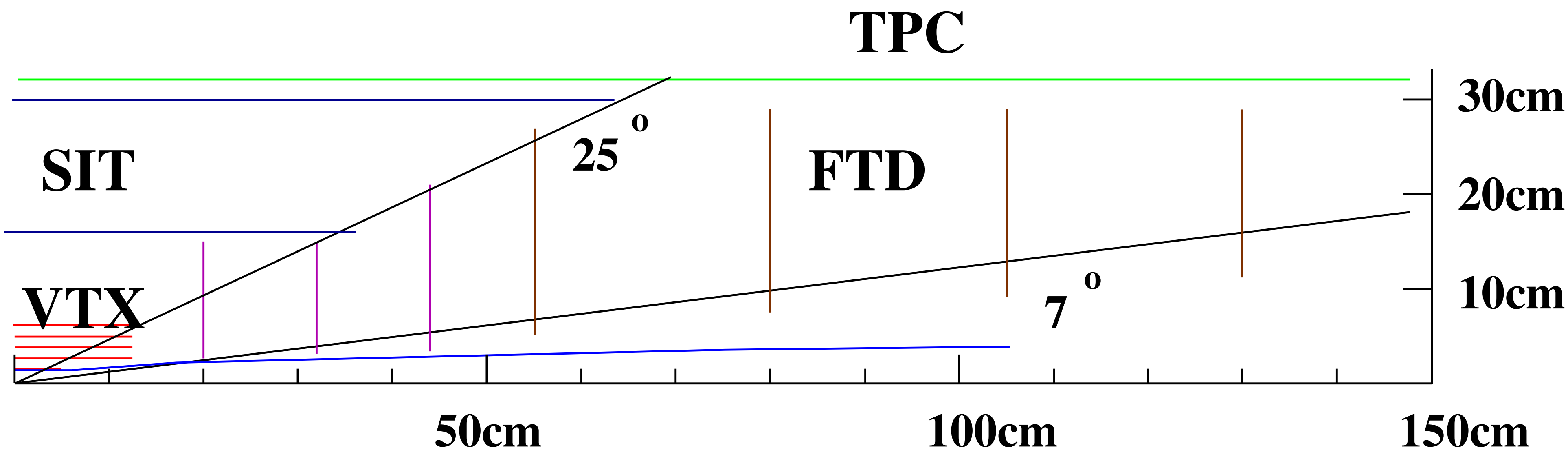
- Without specialised forward tracking resolution gets weak around 20° and stops at 12°
  ➠ FTD mandatory for muons and hadrons
- FCH improves resolution for $\theta < 10°$
  ➠ useful for muons, for hadrons should be discussed
  ➠ Lee's talk

$1/p$ resolution for 200 GeV muons vs θ



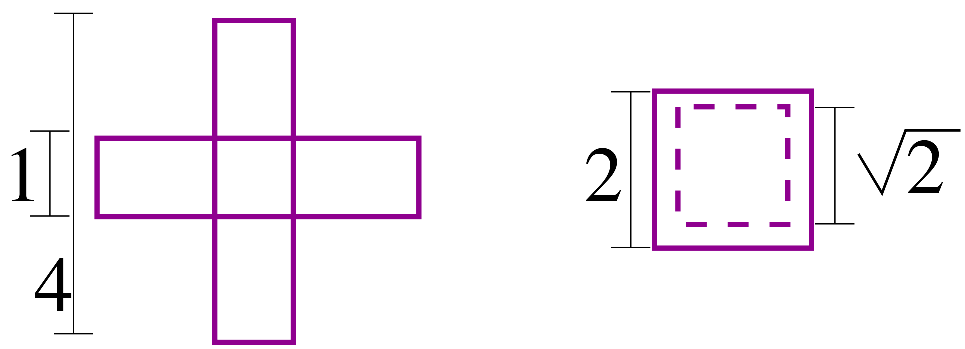
The SIT/FTD

- Two barrel layers, $r = 16, 30\,\text{cm}$, $\sigma = 8\mu\text{m}$
  resolution similar to LEP, but larger
- Optimised for the TESLA TDR ➠ should be updated
- Three pixel disks $d = 50 \times 200\mu\text{m}$ crossed basically a copy of ATLAS in 2001
- Four strip disks, $\sigma = 25\mu\text{m}$ ($90\mu\text{m}$ strip pitch, $270\mu\text{m}$ readout pitch)
  back-to-back or double sided

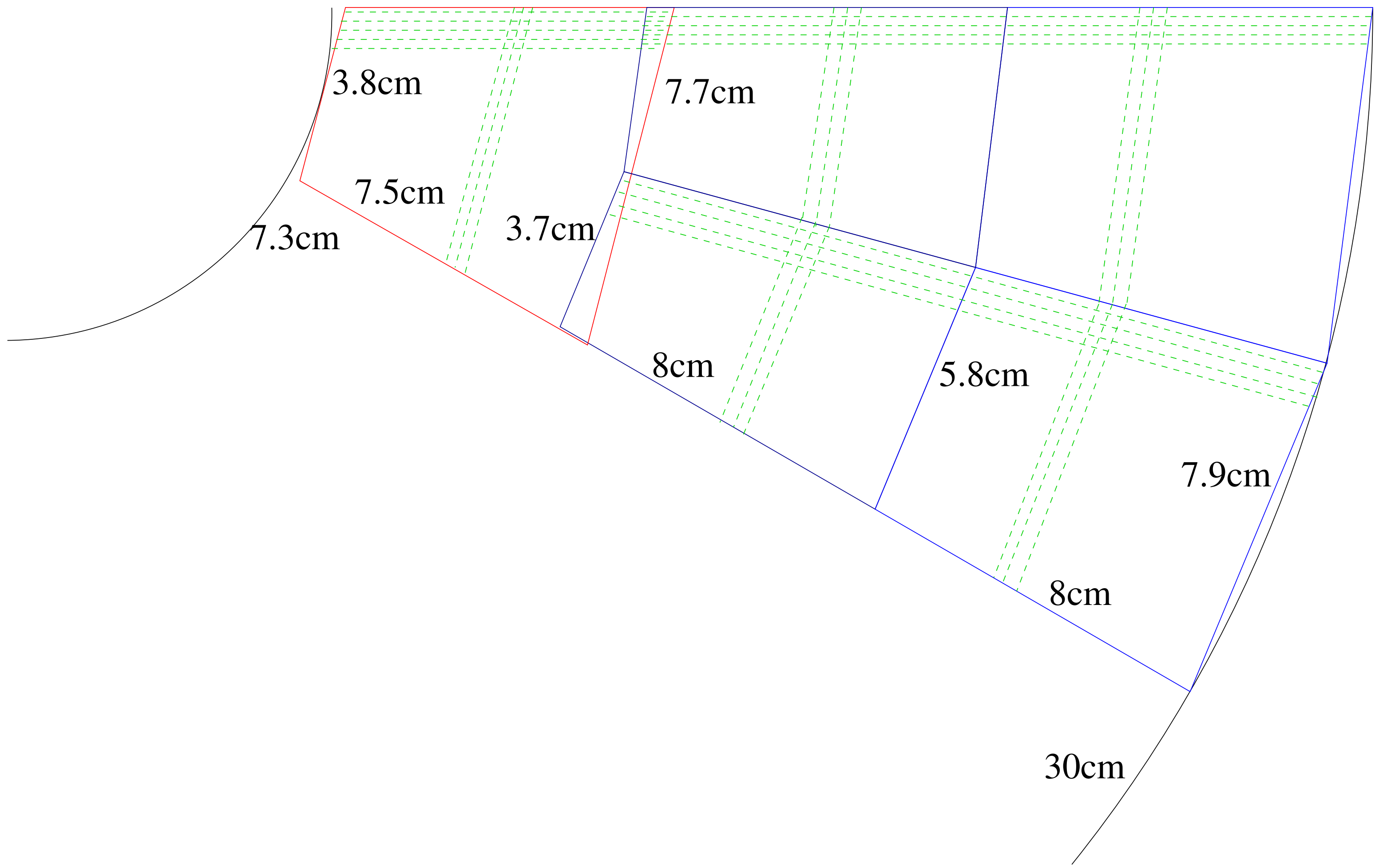


Some details

- Decision pixels/strips:
  - pixels are more expensive
  - pixels are less sensitive to background
  - pixels give less ambiguities in pattern recognition
  - strip resolution usually better
- For the pixels the very rectangular shape from ATLAS ($\sigma = 50 \times 200\mu$m) is taken
  ➠ if the narrow direction is alternated resolution is better than squares with same area



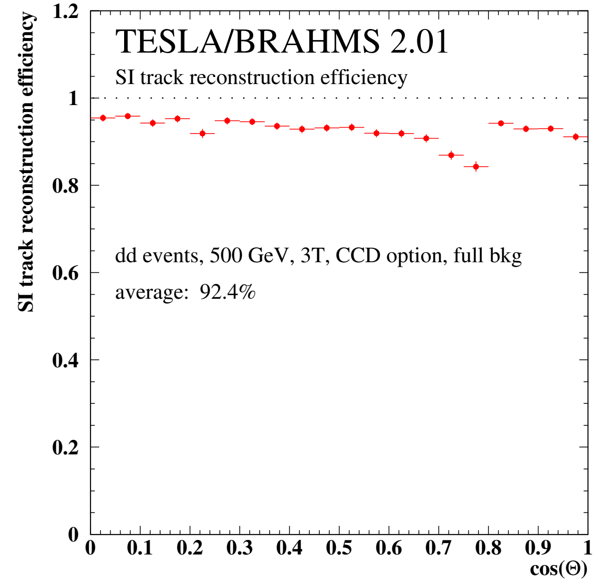
- How to avoid too many ambiguities in strips in hadronic events?
  - chose trapezoidal modules
  - strips parallel to one edge
  - ➡ flipping modules gives stereo angle with only one module type



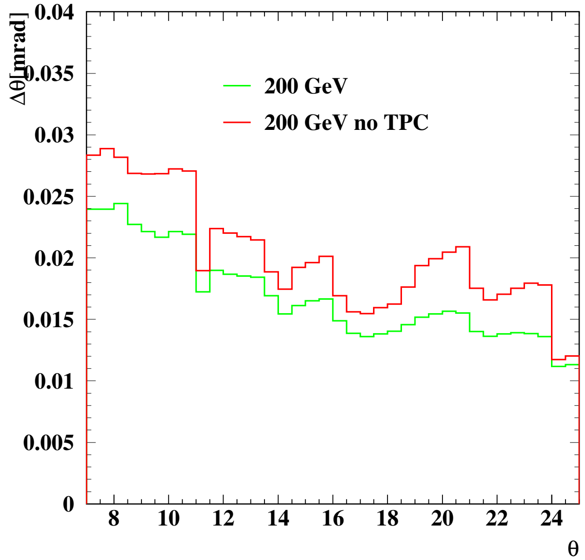
Performance of the TDR detector

- Momentum resolution: already shown
- Standalone reconstruction efficiency in jets: $\sim 90\%$
- Polar angle resolution sufficient for beam parameter measurements

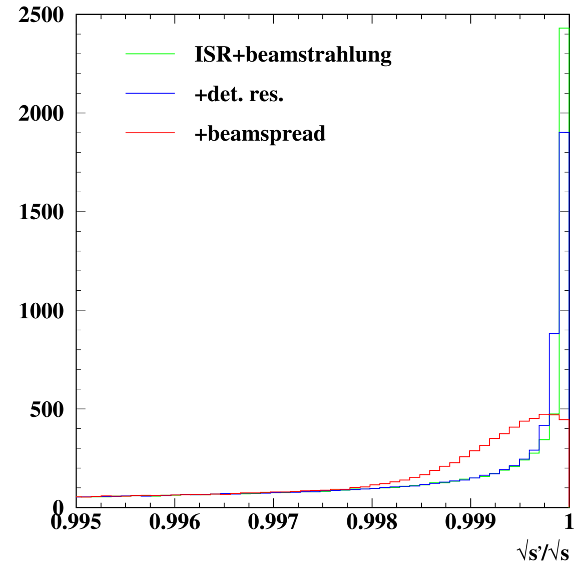
Efficiency vs $\cos\theta$ in FTD/SIT for hadrons



Polar angle resolution in forward region



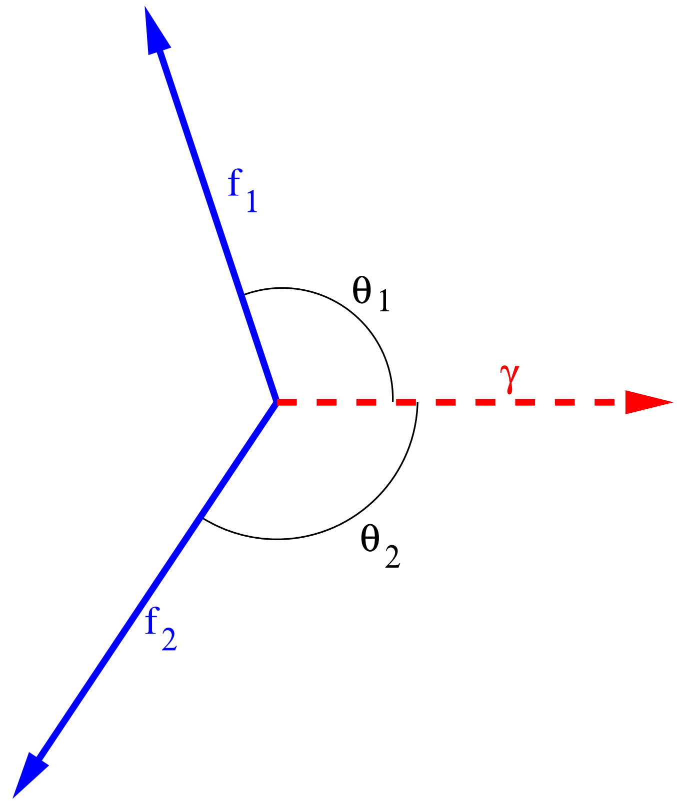
$\sqrt{s'}$ spectra from Bhabha acolinearity



New challenge: systematics

Example: beam energy with radiative return

- Beam energy can be measured from angles and Z-mass constraint
- $\sqrt{s} = m_{\mathrm{Z}} \sqrt{\frac{\sin\theta_1 + \sin\theta_2 - \sin(\theta_1+\theta_2)}{\sin\theta_1 + \sin\theta_2 + \sin(\theta_1+\theta_2)}}$
- Error from $100\,\mathrm{fb}^{-1}$ at $\sqrt{s} = 350\,\mathrm{GeV}$: $\Delta\sqrt{s} = 50\,\mathrm{MeV}$
- Detector uncertainty: Aspect ratio (R/L) error systematically shifts θ



$$\Delta\left(\frac{\delta R}{\delta L}\right) = \delta \tan\theta = 10^{-4} \Rightarrow \Delta\sqrt{s} = 30\,\mathrm{MeV}$$

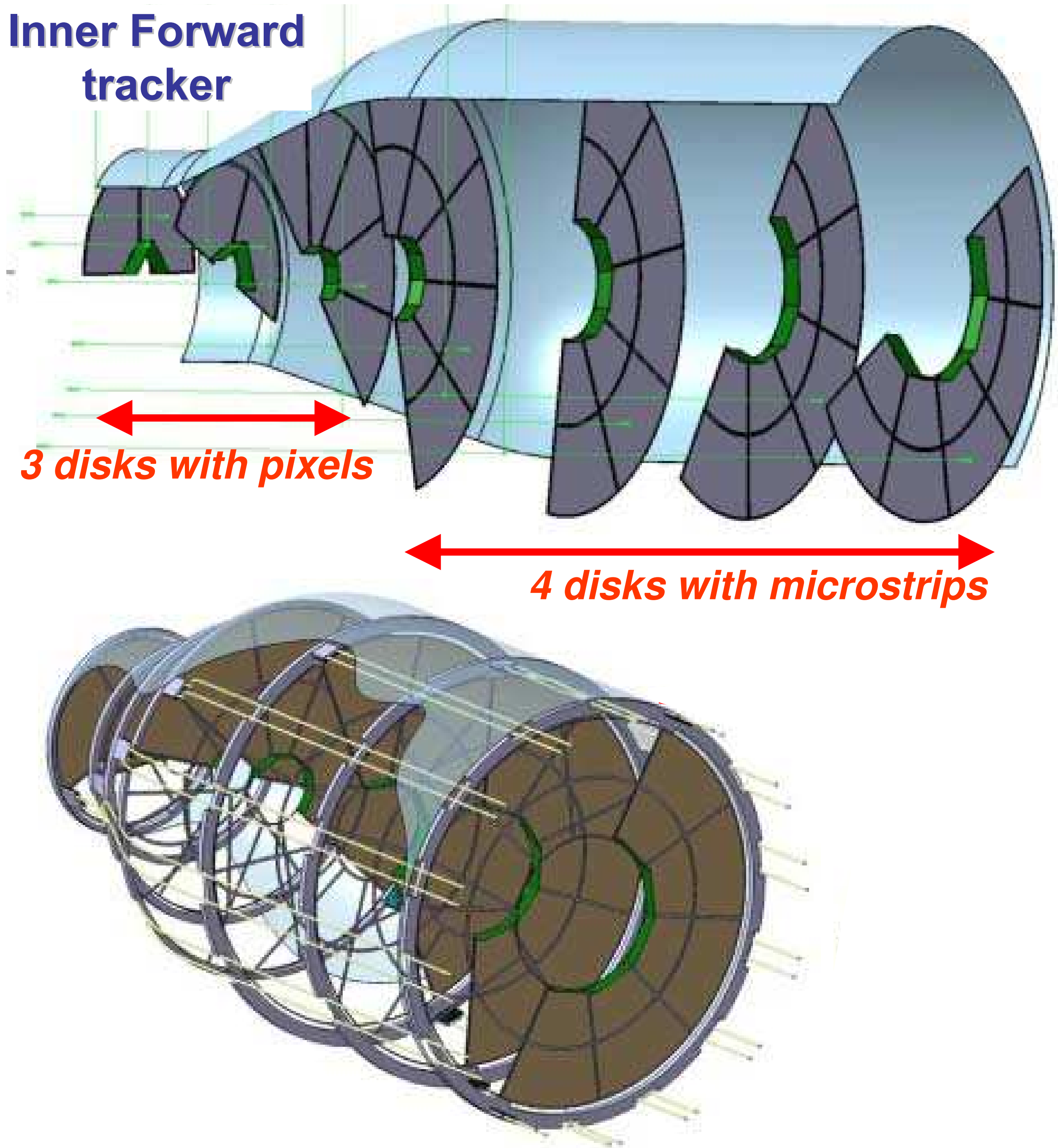
Need this precision in the detector aspect ratio

1st option:

One envelope for FTD

(A. Savooy-Navarro)

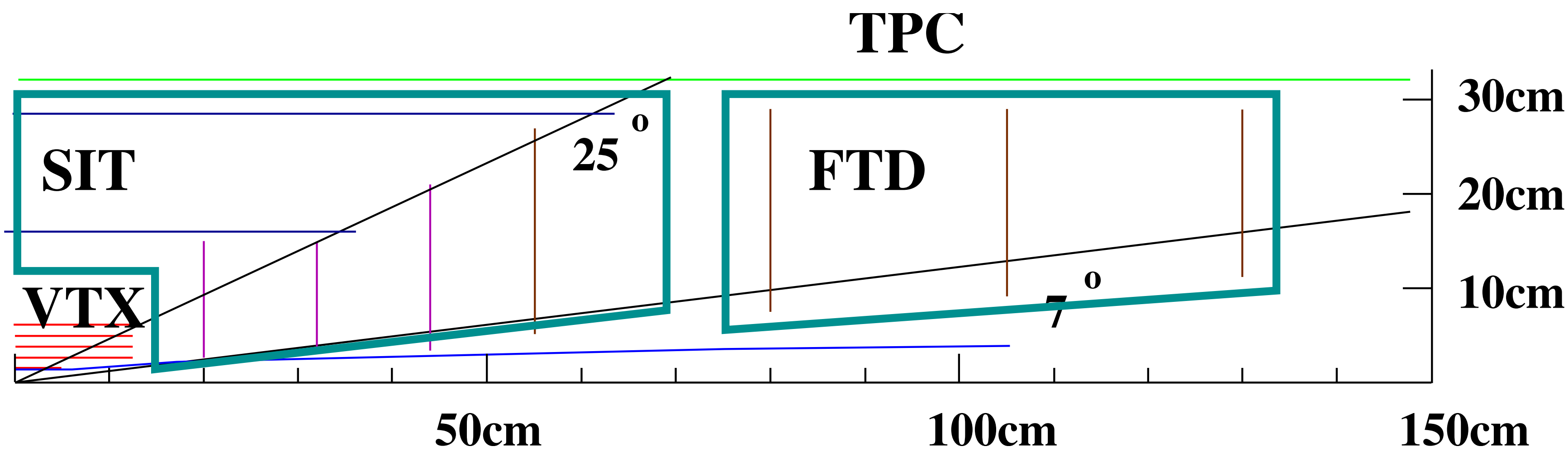
- Can survey FTD and SIT separately very well
- SIT-FTD relative has to be done via small overlaps or VTX



2nd option:

One envelope for SIT+inner FTD disks

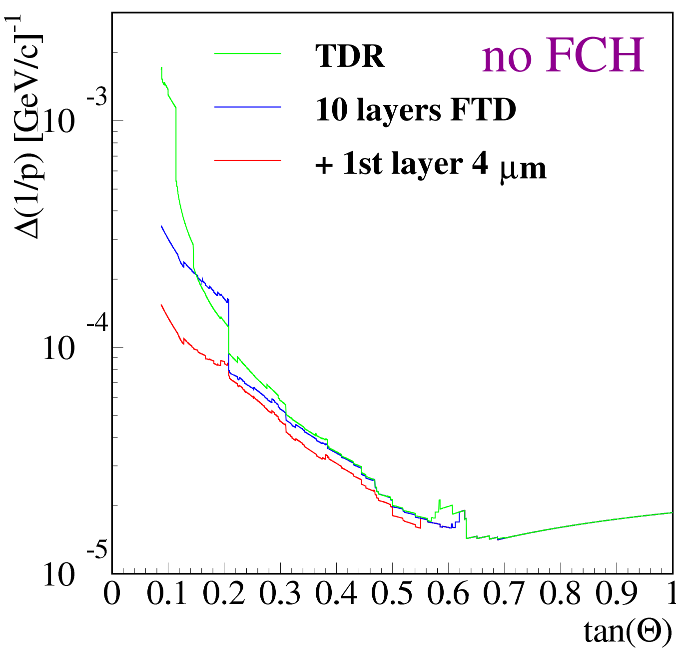
(A. Savooy-Navarro)

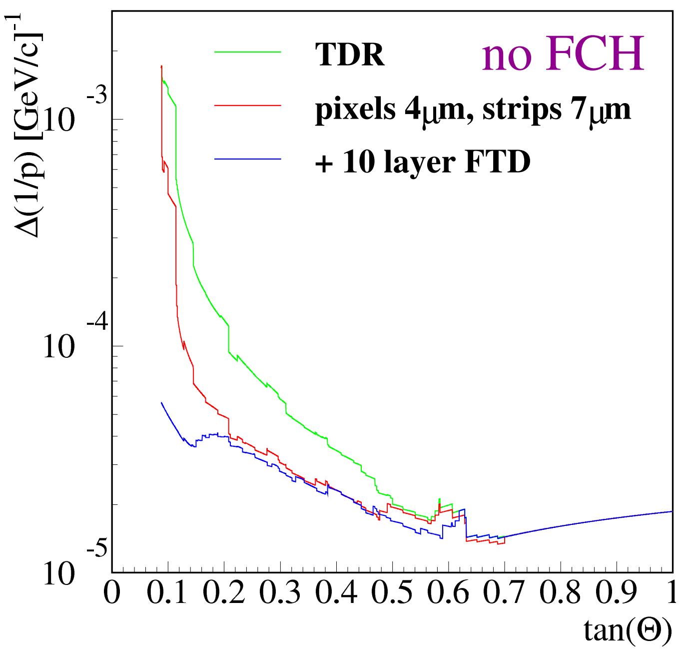


- SIT + inner disks can be surveyed
- Outer disks can be aligned with tracks
- No detailed design yet, but potentially preferable

Improved momentum resolution

- Can add disks up to TPC end (10 disks)
- Replace the 1st one by a VXD disk (4μm resolution)
- Can go even further with all pixels 4μm and strips 7μm resolution
- Does this technology still allow bunch tagging?





- What momentum resolution do we need?
- Bunch tagging of each plane is a must!

Towards the new baseline

- The TDR setup seems to perform well
- Anyway should redo studies with new TPC resolution
- Have to rediscuss the strip/pixel question in FTD:
  - pattern recognition in jets (under way)
  - machine related background with crossing angle
- For which detector length(s) shall we optimise?
- On which benchmarks do we optimise?
- Have to decide on a mechanics design that is stable and allows for a precise survey