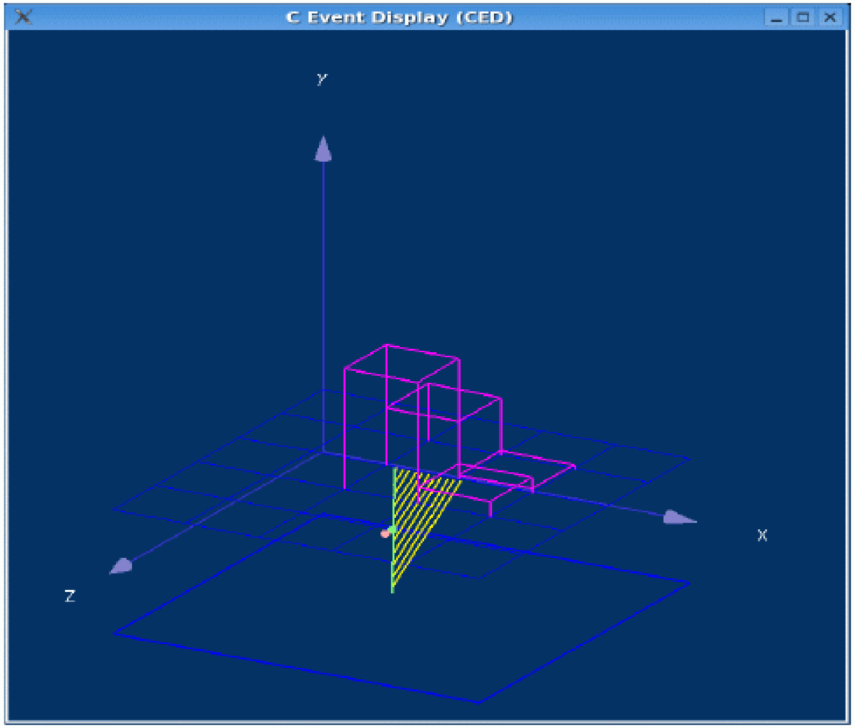
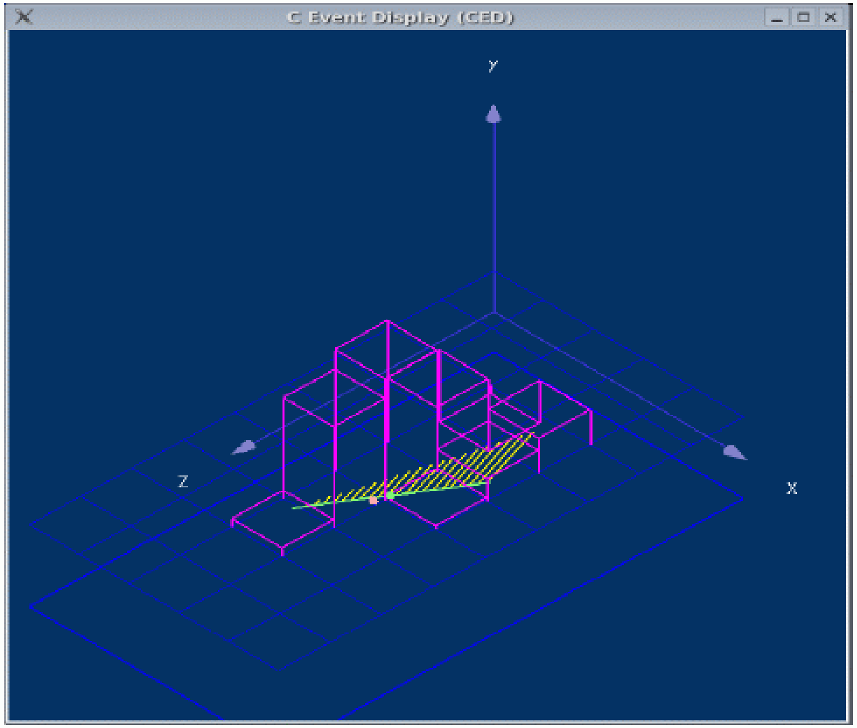
Simulation Studies of DEPFET VTX for SiD





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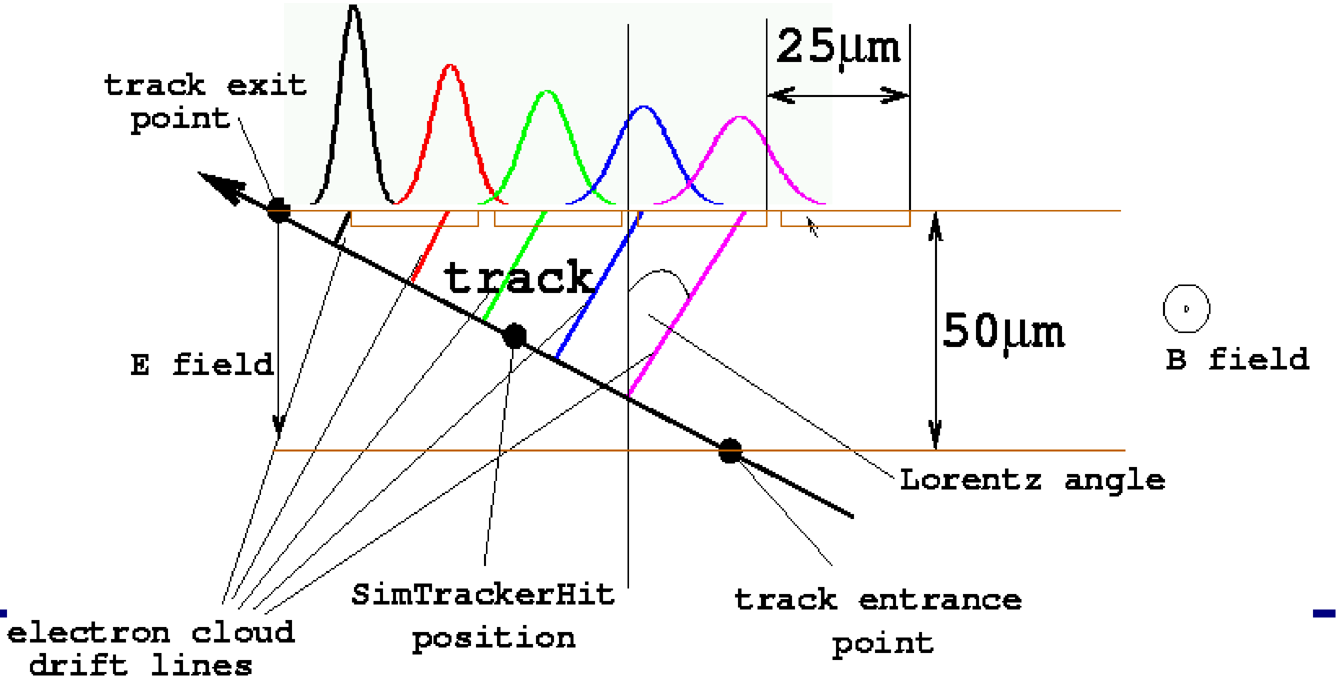
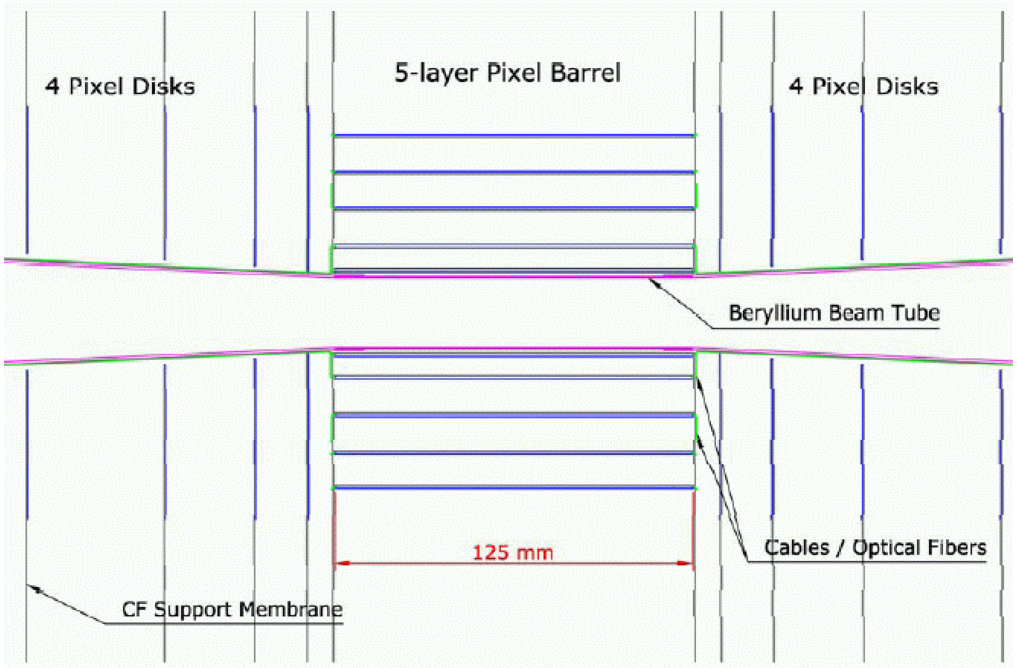
SiD Meeting, 14/04/2008

Simulation Procedures

- Modelling of VTX in Mokka (G4 based program for LDC)
  - Detailed geometry description (support frames, electronics etc...)
  - Particle gun for studies with single particles
  - PYTHIA ⇒ tt→6jet events for pattern recognition studies
  - GUINEA-PIG files for beam backgound studies
- Simulation of DEPFET sensor response (Digitization)
  - Energy loss fluctuations;
  - Electron cloud diffusion;
  - Electronic noise;
  - Lorentz shift (B-field);
  - SimTrackerHit ⇒ list of fired cells



Implementation of VXD Geometry in Mokka



Central beam tube

Radius, mm	Length, mm	Thickness, mm
12	60	0.4

Barrel

Layer	# ladders	Radius, mm	Length, mm
1	8	14	125
2	8	22	125
3	12	35	125
4	16	48	125
5	20	60	125

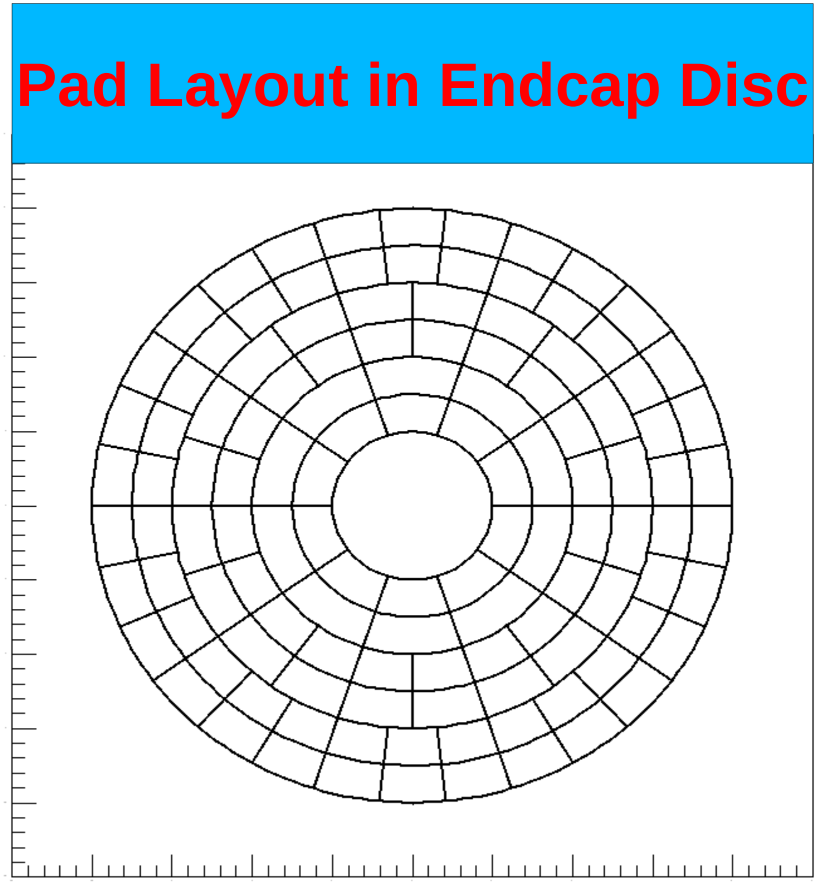
Depfet specific parameters

- Sensitive layer thickness 50 μm
- Sensitive layer length 120 mm (barrel)

Endcap

Disc	Rin, mm	Rout, mm	Z, mm
1	14	71	72.3
2	16	71	92.1
3	18	71	123.4
4	20	71	171.7

Pad Layout Geometry

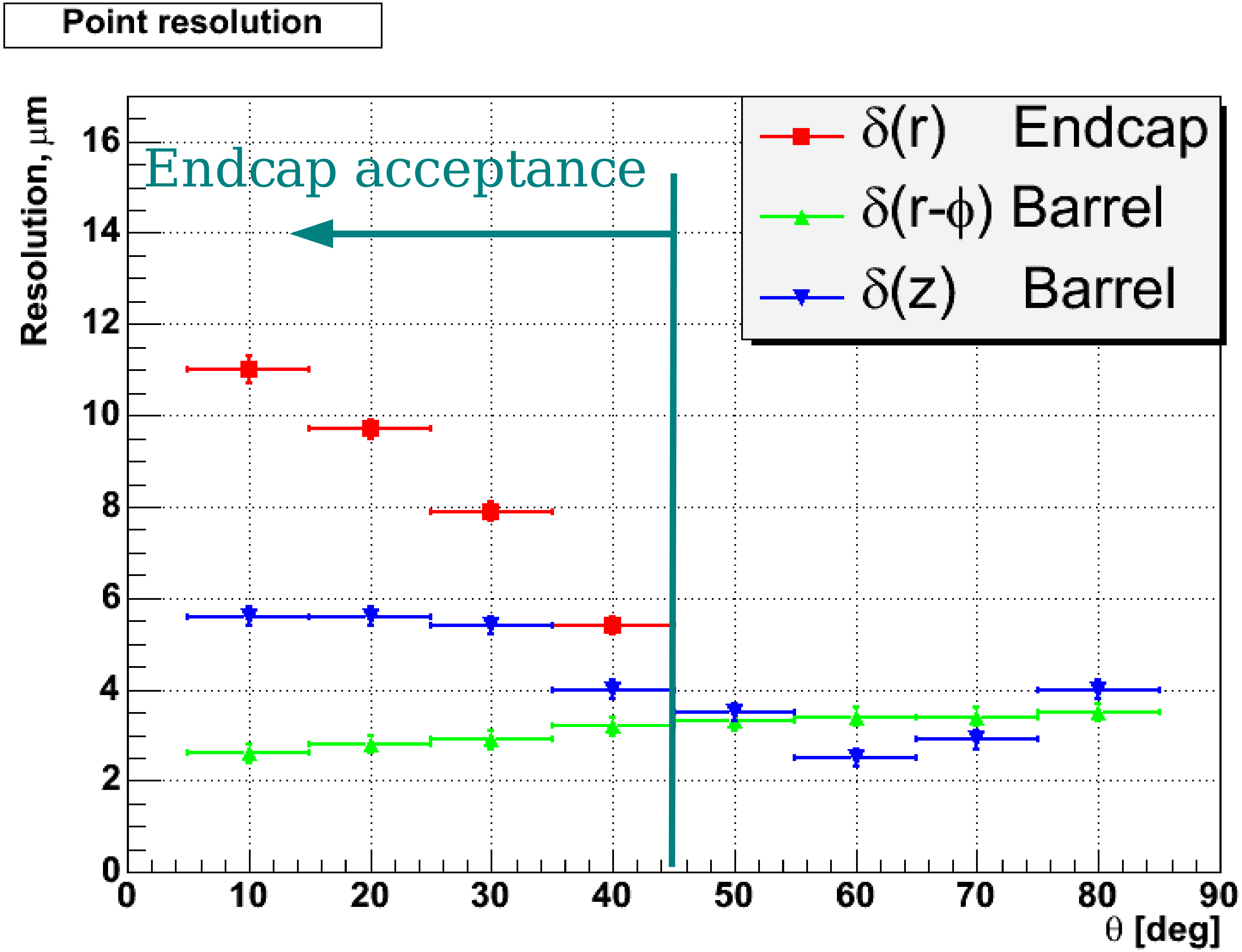


- Barrel ladders : square pads $25\times25\ \mu m^2$
- Endcap discs : pad rings
- Ring is divided in subrings & sectors : $[r,\phi]$-division
- Pad width varies with radial coordinate
- Transition : $r=n\cdot R_{min}$
  $\Rightarrow$ number of sectors inscreases
  pad width is sets to its minimal value
- Pad height is constant : default value $= 50\ \mu m$
- Default value of pad width = $[50,100]\ \mu m$

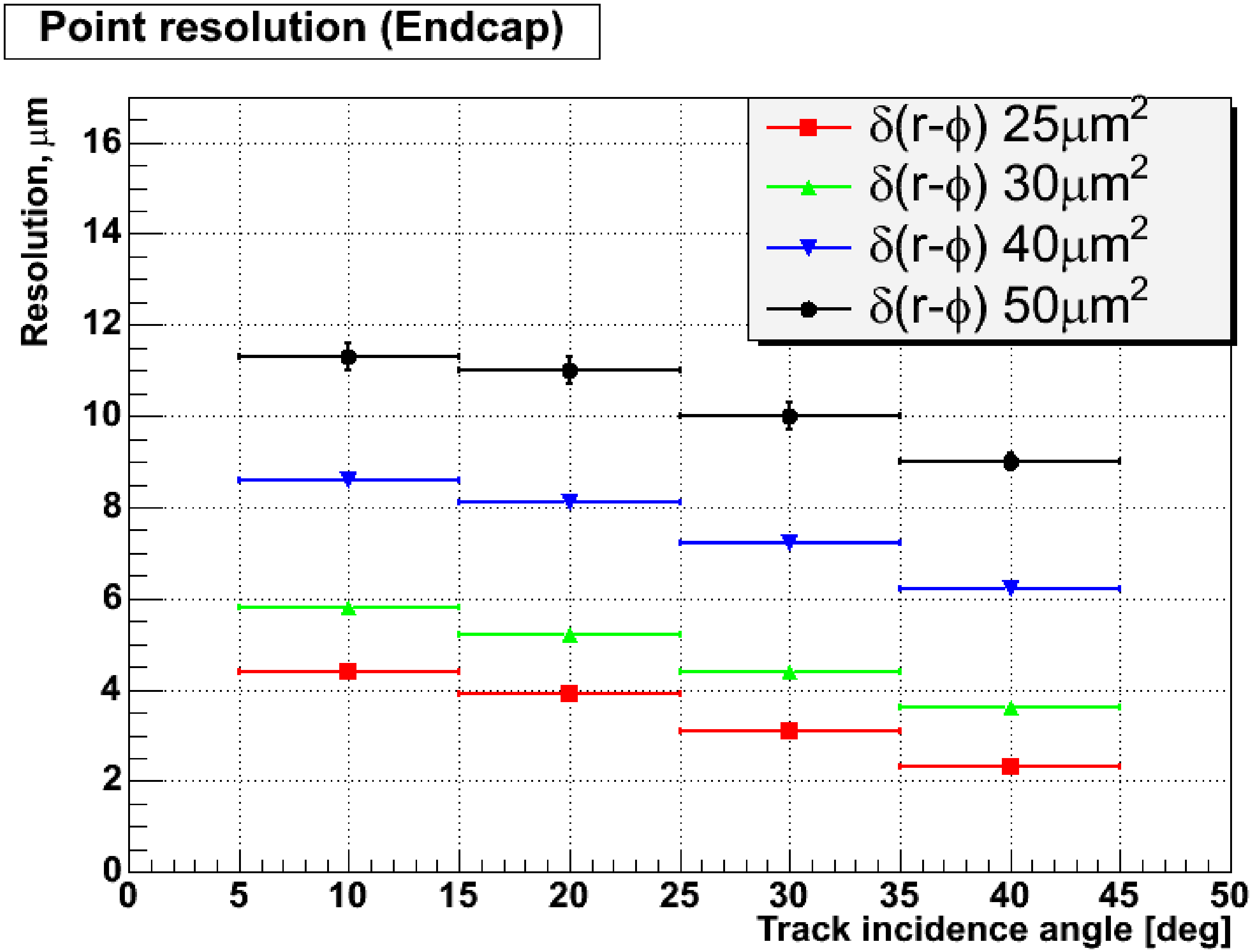
Study of Spatial Point Resolution

- **Single muon events are used, momentum = 10 GeV/c**
- **θ range [10 , 80]^o in 10^o step $\pm$5 deg smearing in θ**
- **Uniform distribution in ϕ**
- **Seed-based NN clustering of fired pads $\Rightarrow$ reconstructed cluster**
- **Position reconstruction from the cluster hits :**
  - **cut of 200e on hit amplitude (assumed elec. noise = 100e)**
  - **center-of-gravity method for r-ϕ in barrel**
  - **η-algorithm (z in barrel ; r-ϕ , r in endcap)**
- **Spatial point resolution is studied as a function of**
  - **θ for z and r-ϕ in barrel ladders and in r in endcap discs**
  - **pad width/height for r-ϕ and z in endcap**

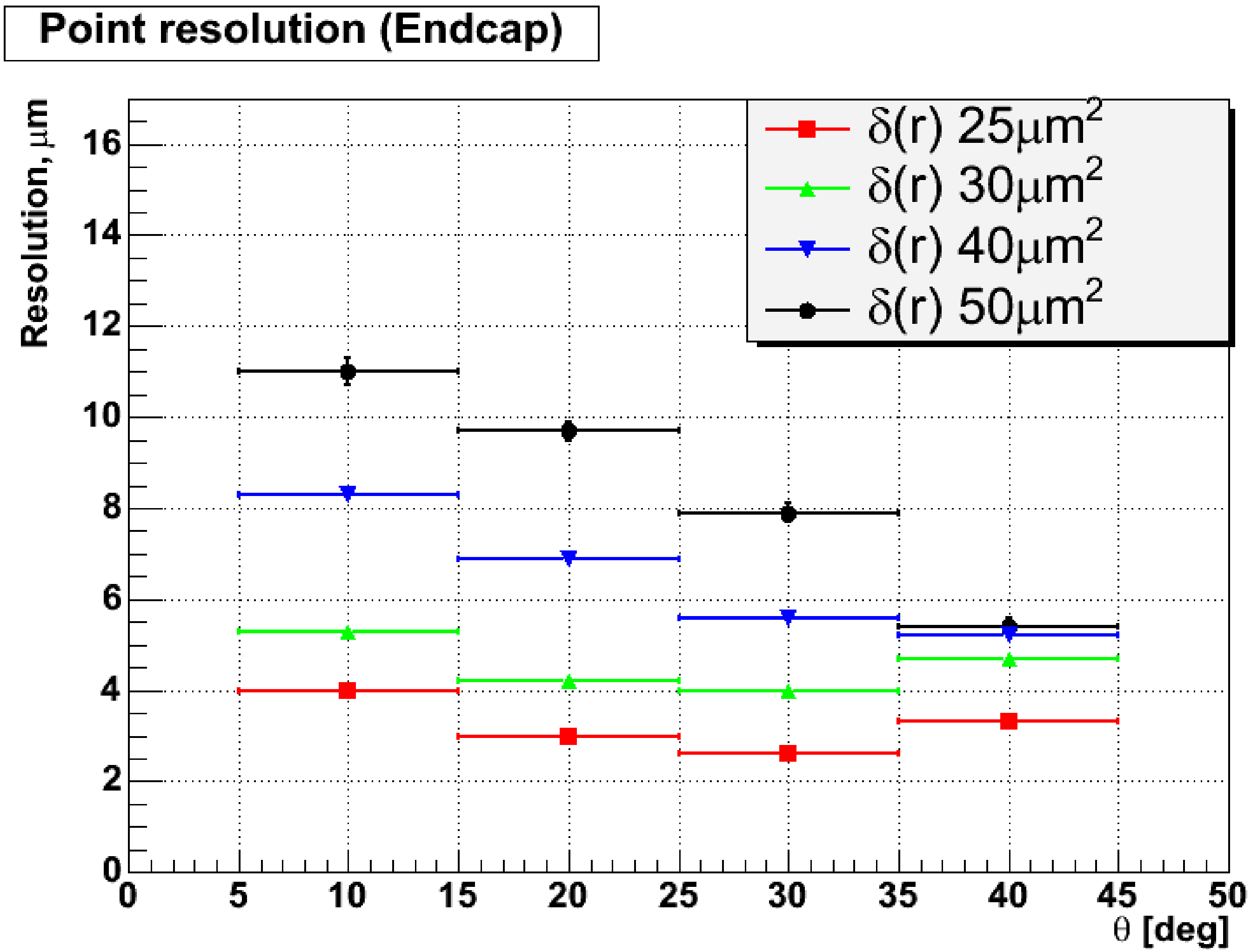
Spatial Point Resolution



Spatial Point Resolution (*r*-ϕ) in Endcap vs. Pad Width



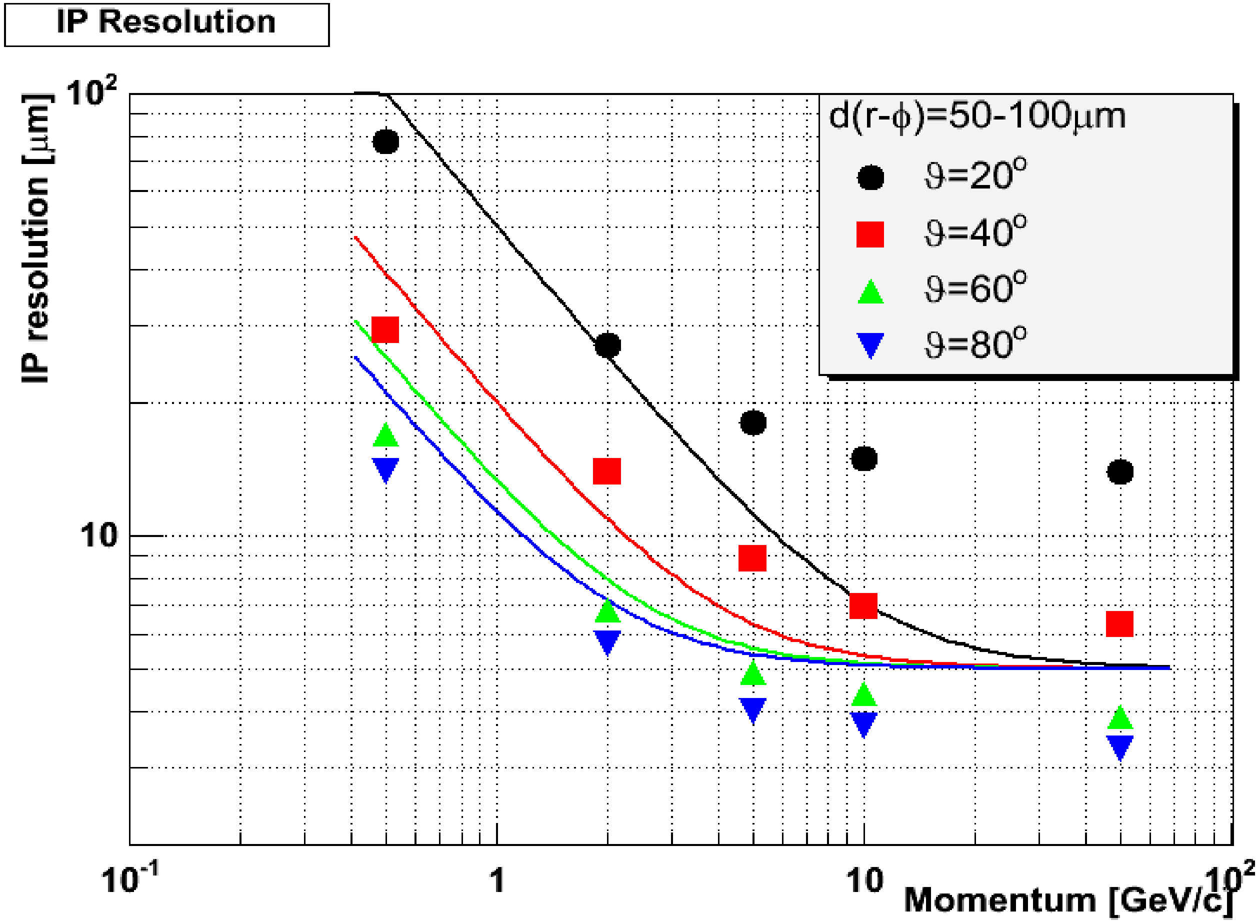
Spatial Point Resolution (*r*) in Endcap vs. Pad Height



Impact Parameter Resolution and Pattern Recognition

- Digitized hits are subject of the dedicated pattern recognition procedure in VTX detector
- Reconstructed tracks are fitted with the Kalman filter $\Rightarrow$ track parameters in LC convention
- IP resolution studies with single muons,
  - E= 0.5, 2, 5, 10, 50 GeV
  - θ=20, 40, 60, 80° , $\pm$10° uniform smearing at each θ point
- Pattern recognition performance with $\mathbf{t\bar{t}\rightarrow 6jet}$ events
  - **<u>still in the absence of beam induced backgrounds</u>**
  - performance quantified in terms of track finding efficiency & fake track rate

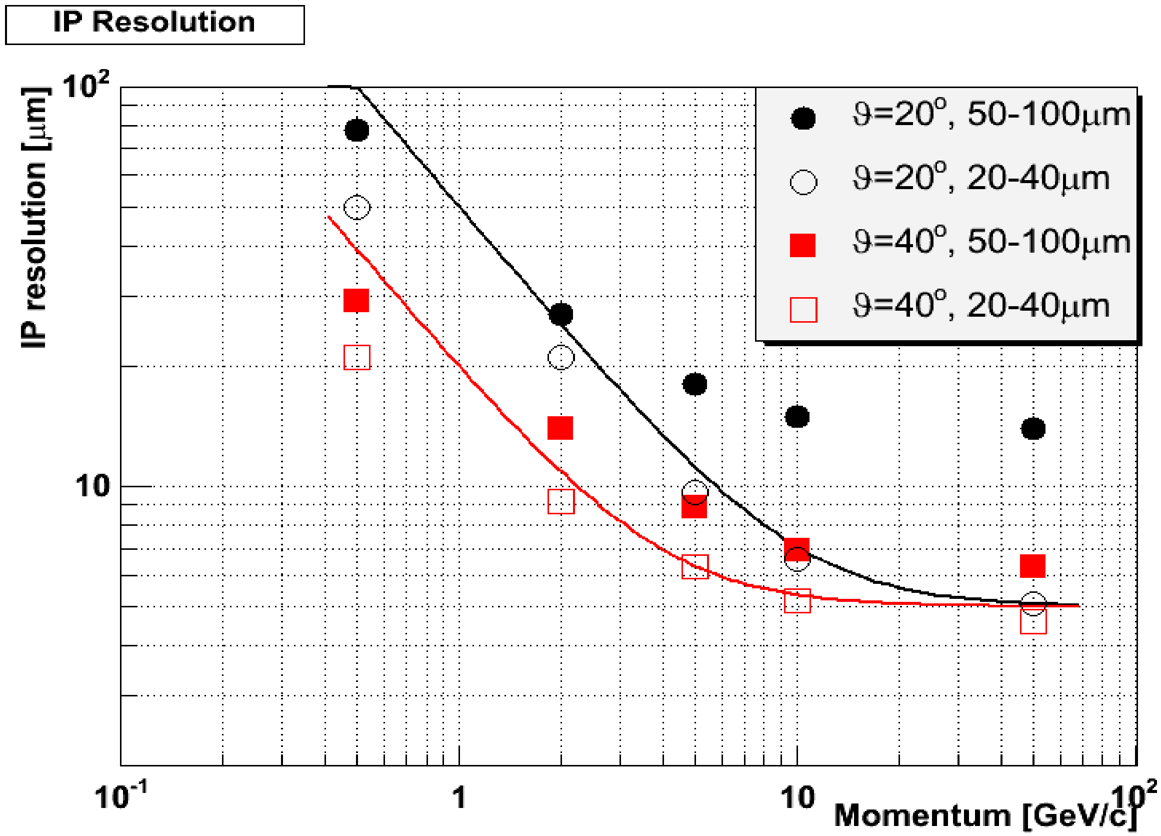
Impact Parameter Resolution



Lines indicate ILC requirement

$$\sigma(IP)=5\mu m \oplus 10\mu m / p \cdot \sin^{3/2}\theta$$

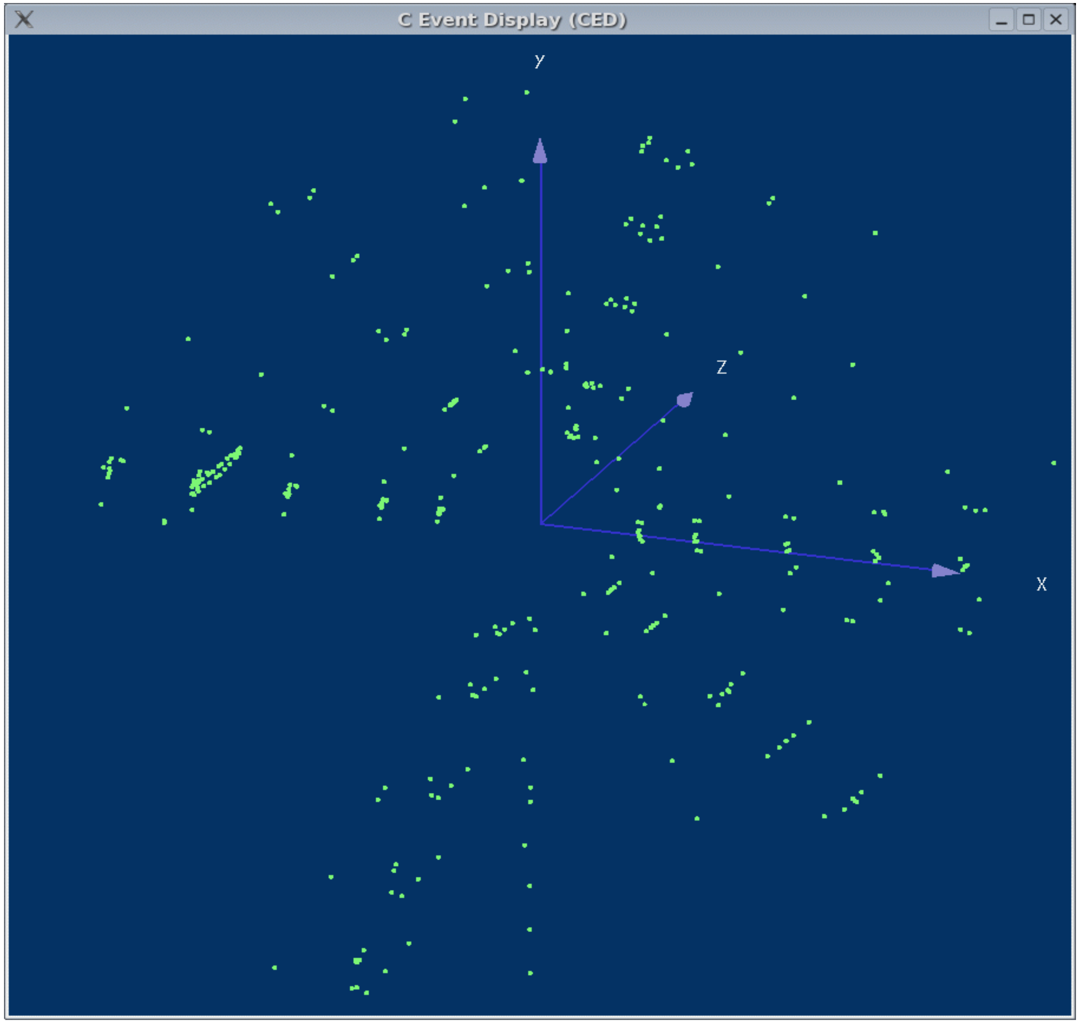
IP Resolution. Requirement on Pad Width in Endcap Discs



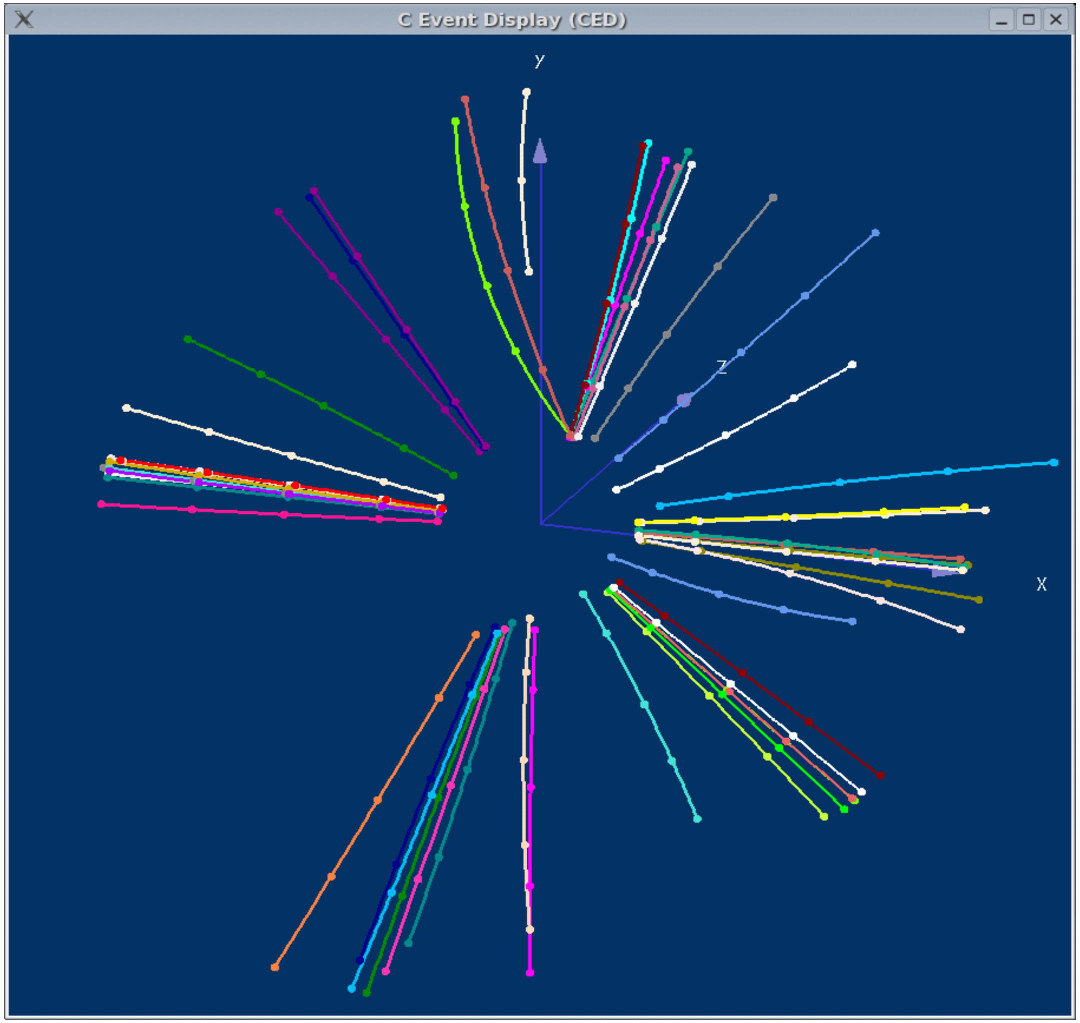
To achieve ILC goal for IP resolution, pad width in the endcap disc should be [20,40] μm

tt→6jet @ 500 GeV

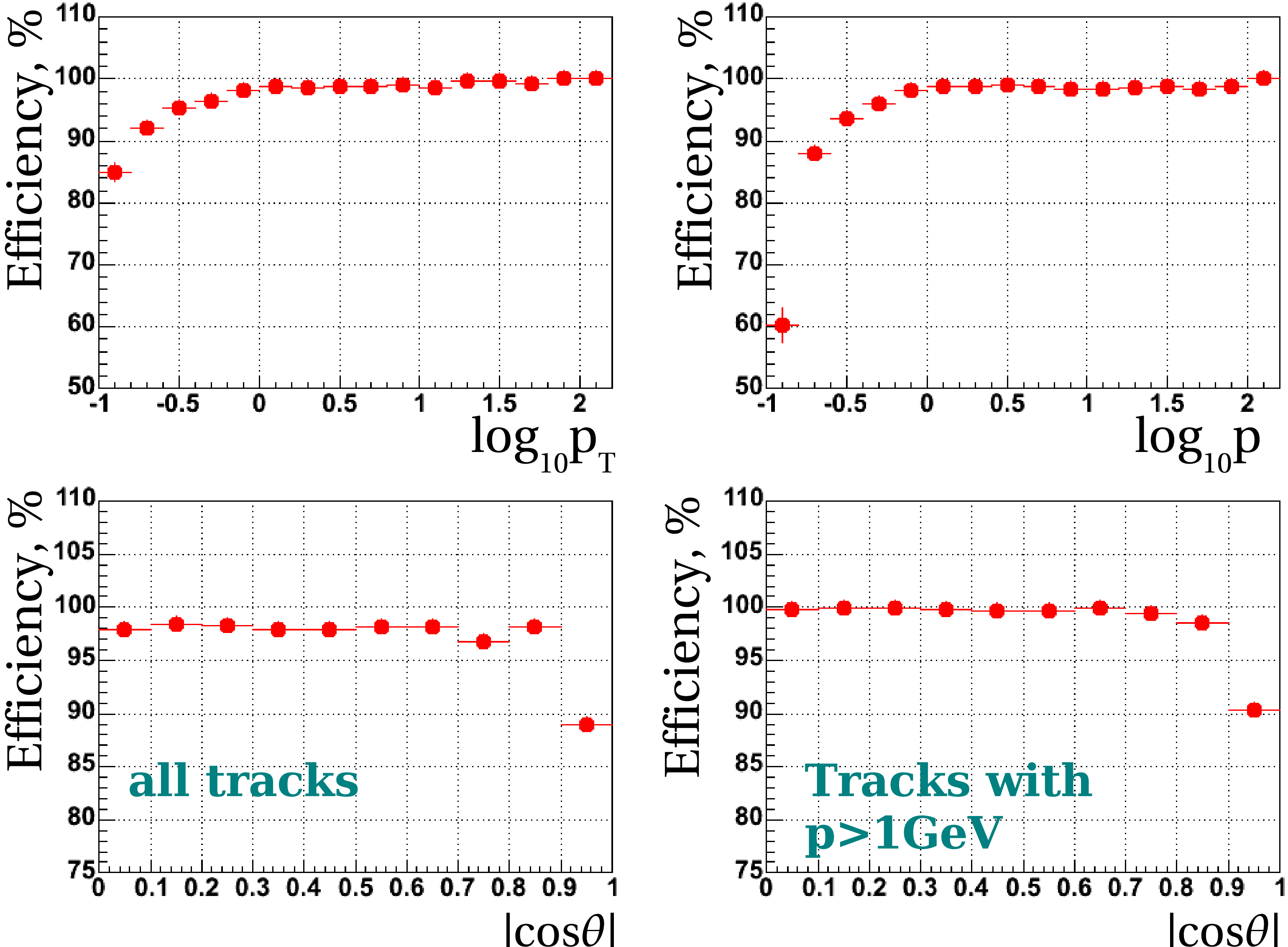
Hit Pattern in VXD



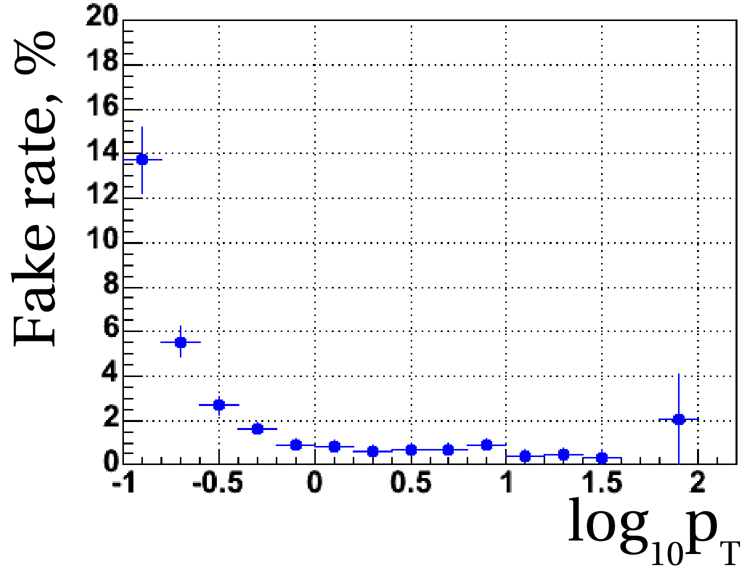
tt→6jet @ 500 GeV
Reconstructed Tracks in VXD

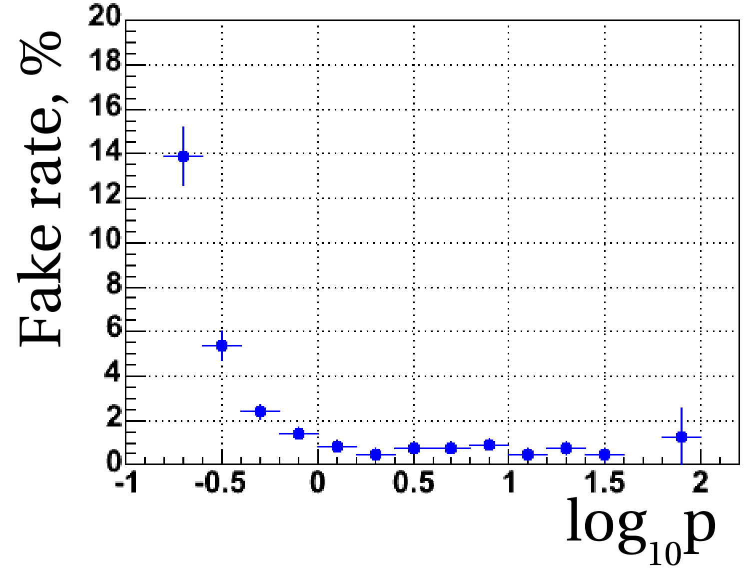


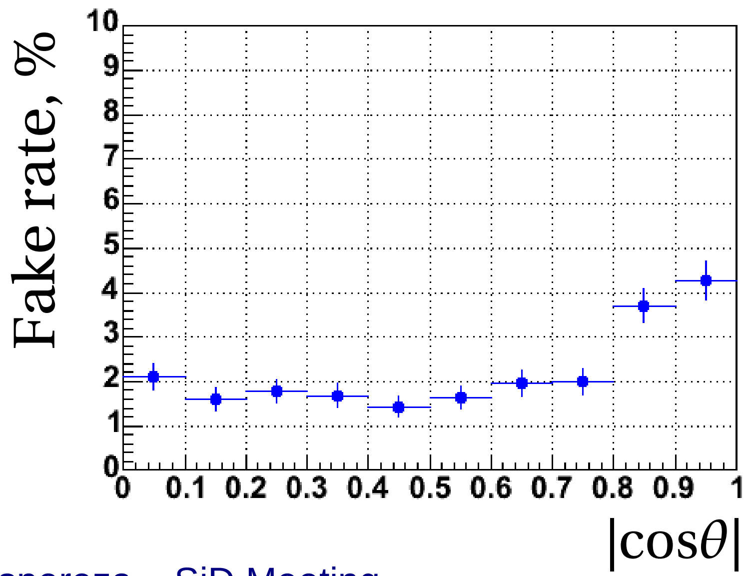
Tracking Efficiency (tt→6jet @ 500GeV)



Fake Rate (tt→6jet @ 500GeV)







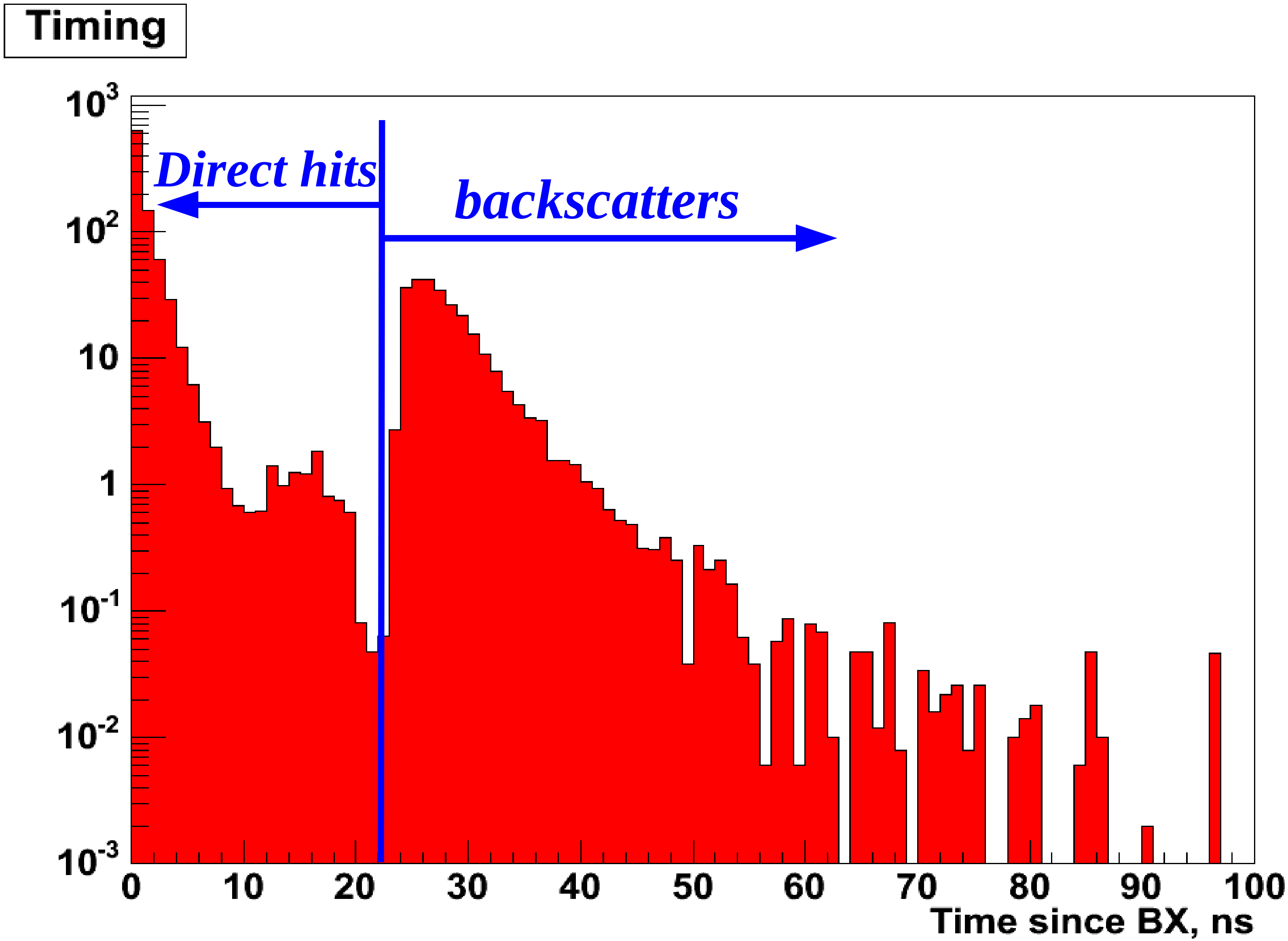
Beam Induced Backgrounds

- e^+e^- pairs are generated with GUINEA-PIG and passed through Mokka and digitization program
- „TESLA-500" accelerator parameters (2 mrad x-angle, no (a)-DiD)
- Forward region instrumentation *a-la* LDC
- Both direct hits and backscatters are considered
- Integration time ~ L/pad_size, L – *readout row length*

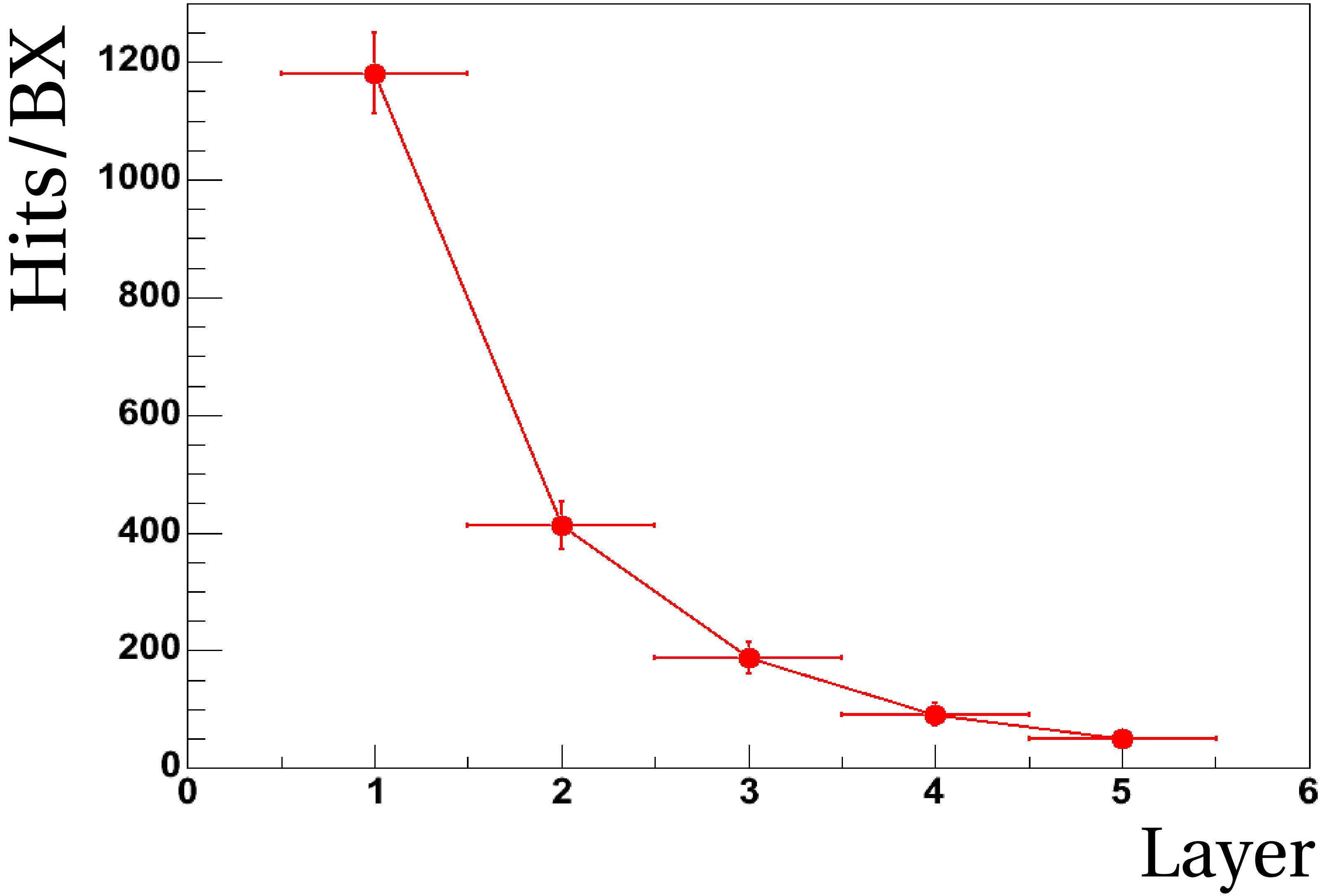
⇒ barrel : 75BX (*pad_size=25μm*) ; endcap : 32 BX (*pad_size=50μm*)

- Beam induced backgrounds are estimated in terms of parasitic hits and pad occupancy
  - Overall occupancy = number of fired cells / total number of cells;
  - Local occupancy = ρ^*/ρ, ρ^* - local density of fired pads,
    ρ - local density of pads

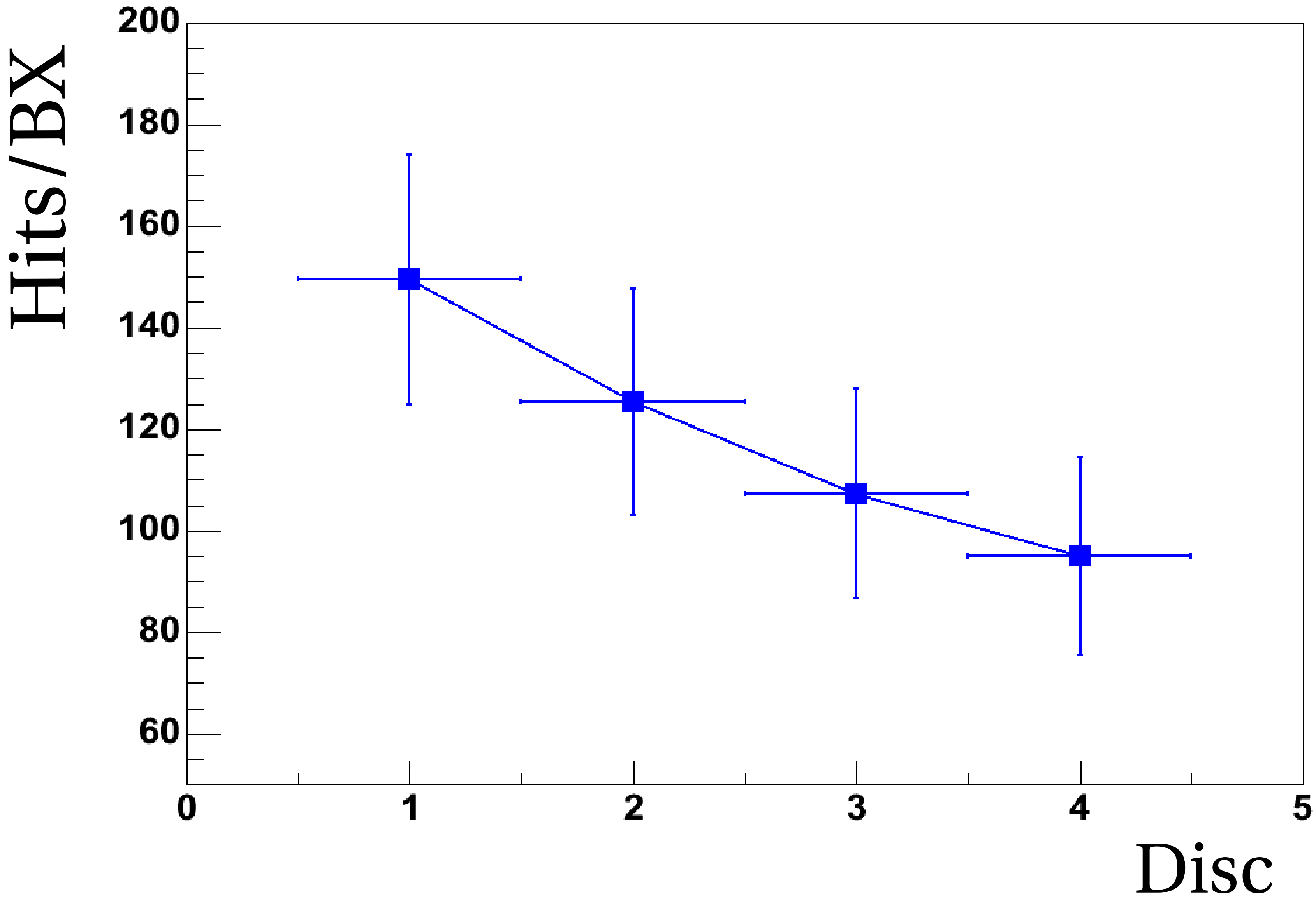
Timing Structure of Background Hits



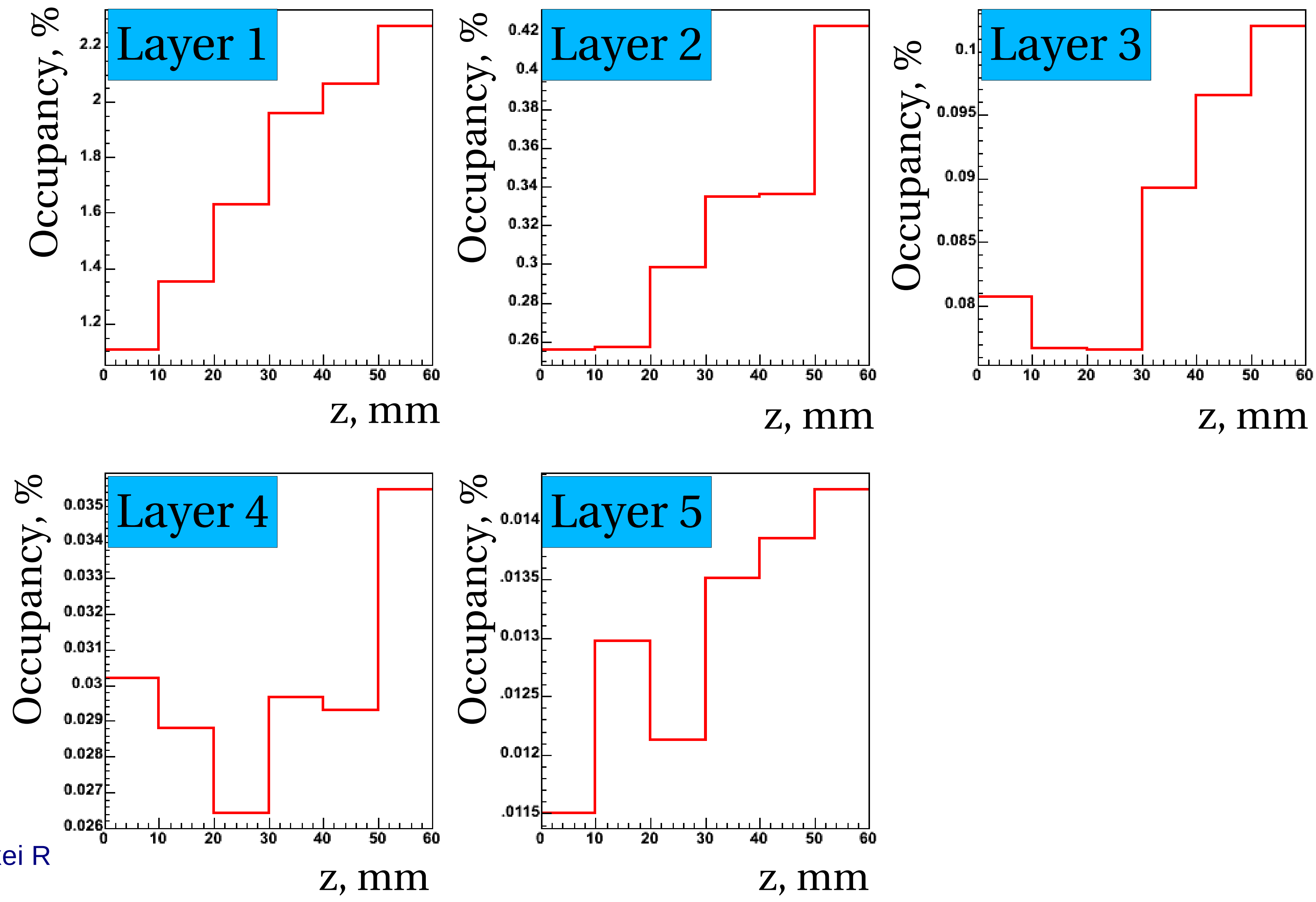
Background Hits in Barrel Layers



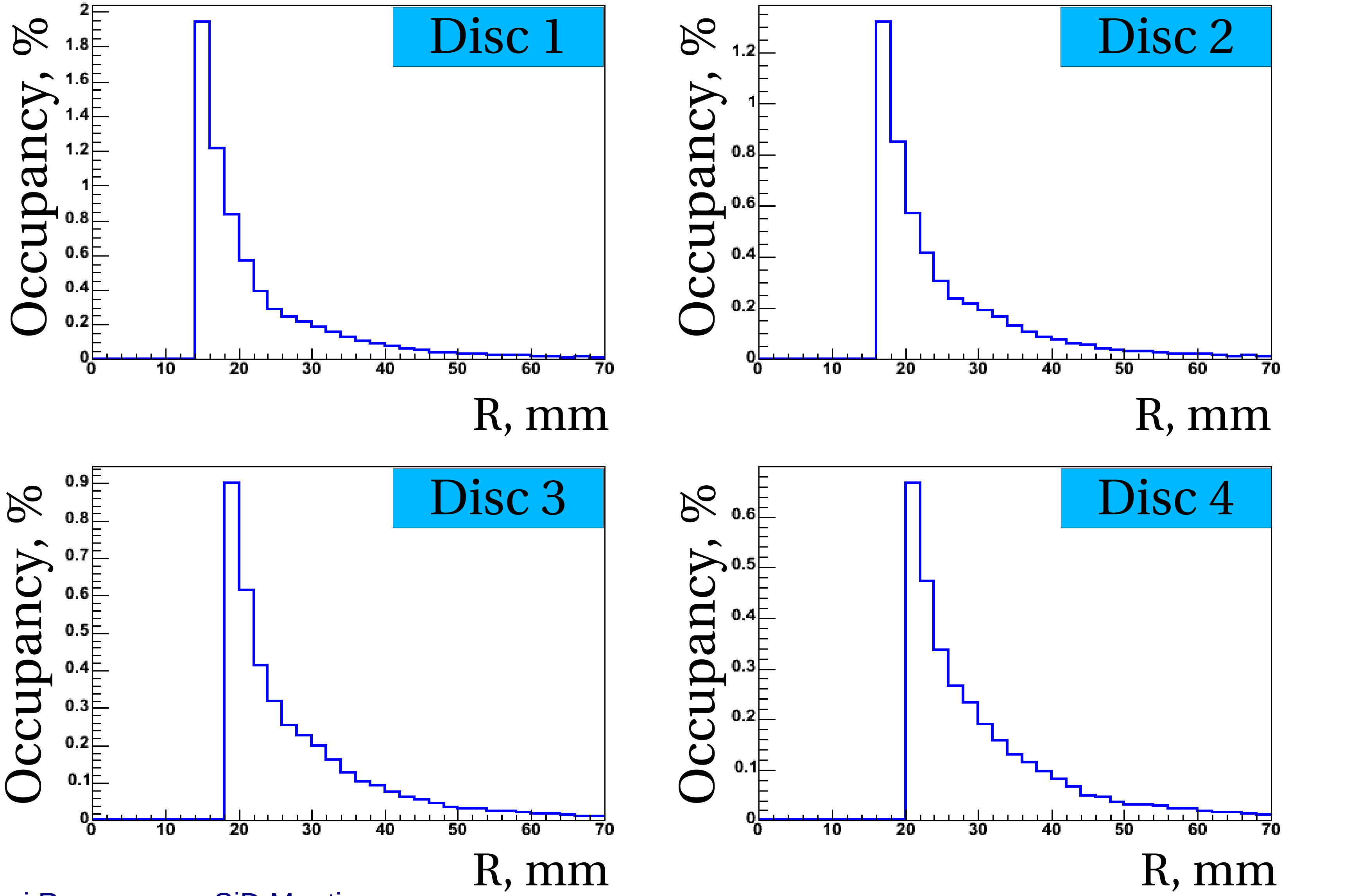
Background Hits in Endcap Discs



Pad Occupancy vs. Z in Barrel Layers



Pad Occupancy vs. R in Endcap Discs



Summary and Outlook

- Initial simulation studies of DEPFET VTX performed
- Spatial point and impact parameter resolution are estimated as a function of pad size
  - pad size 25×25 μm in barrel ladders ensures required IP resolution
    $$\sigma(IP)=5\mu m \oplus 10\mu m/p \cdot \sin^{3/2}\theta$$
  - pad width in endcap discs must be [20,40] μm to meet ILC requirement on IP resolution
- Pad occupancy in the presence of beam background is estimated to range from per-mill to percent level
- Further studies are planned
  - evaluation of effect of beam backgrounds on pattern recognition