CLIC_SiD Tracking

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DESY

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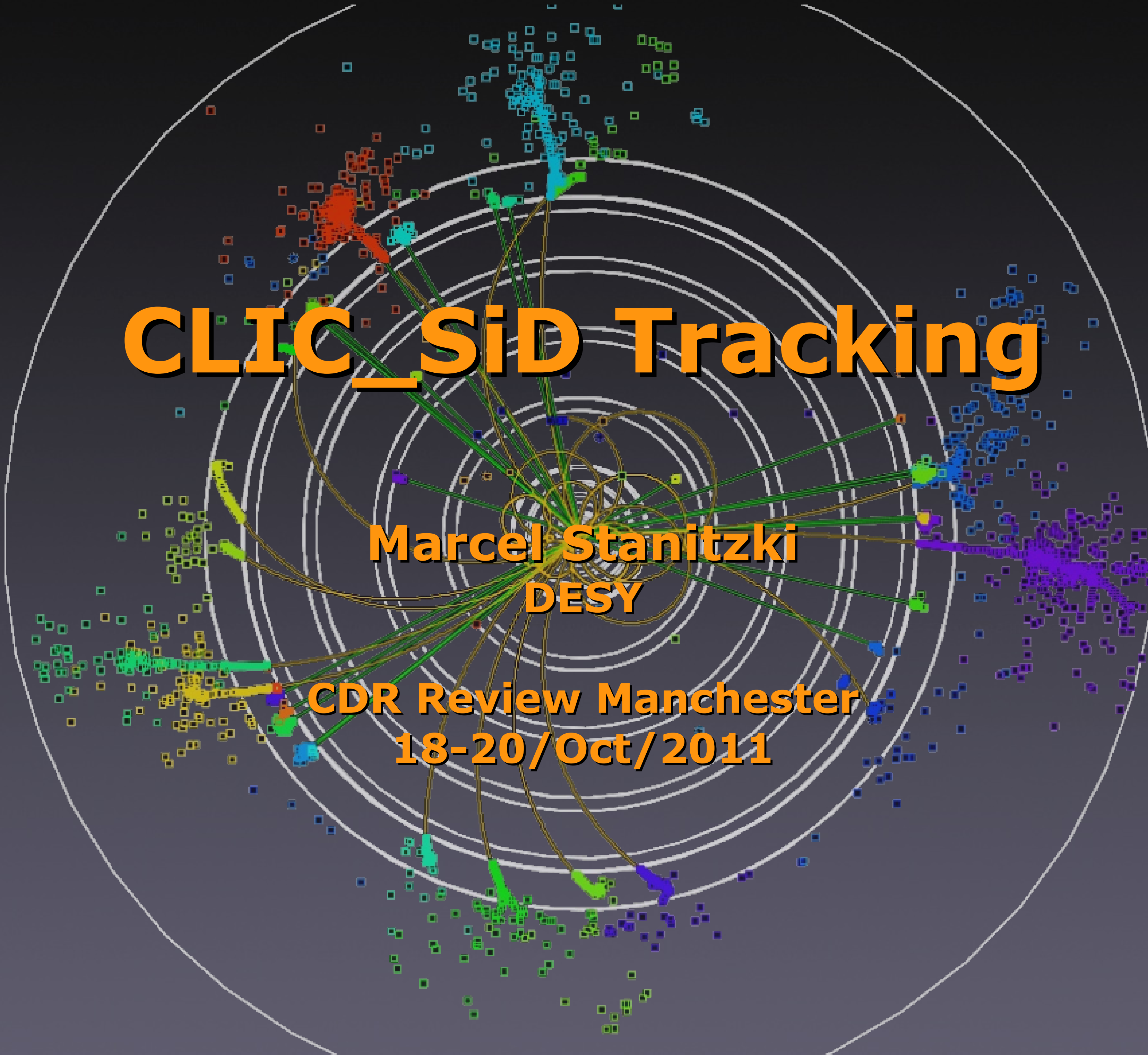
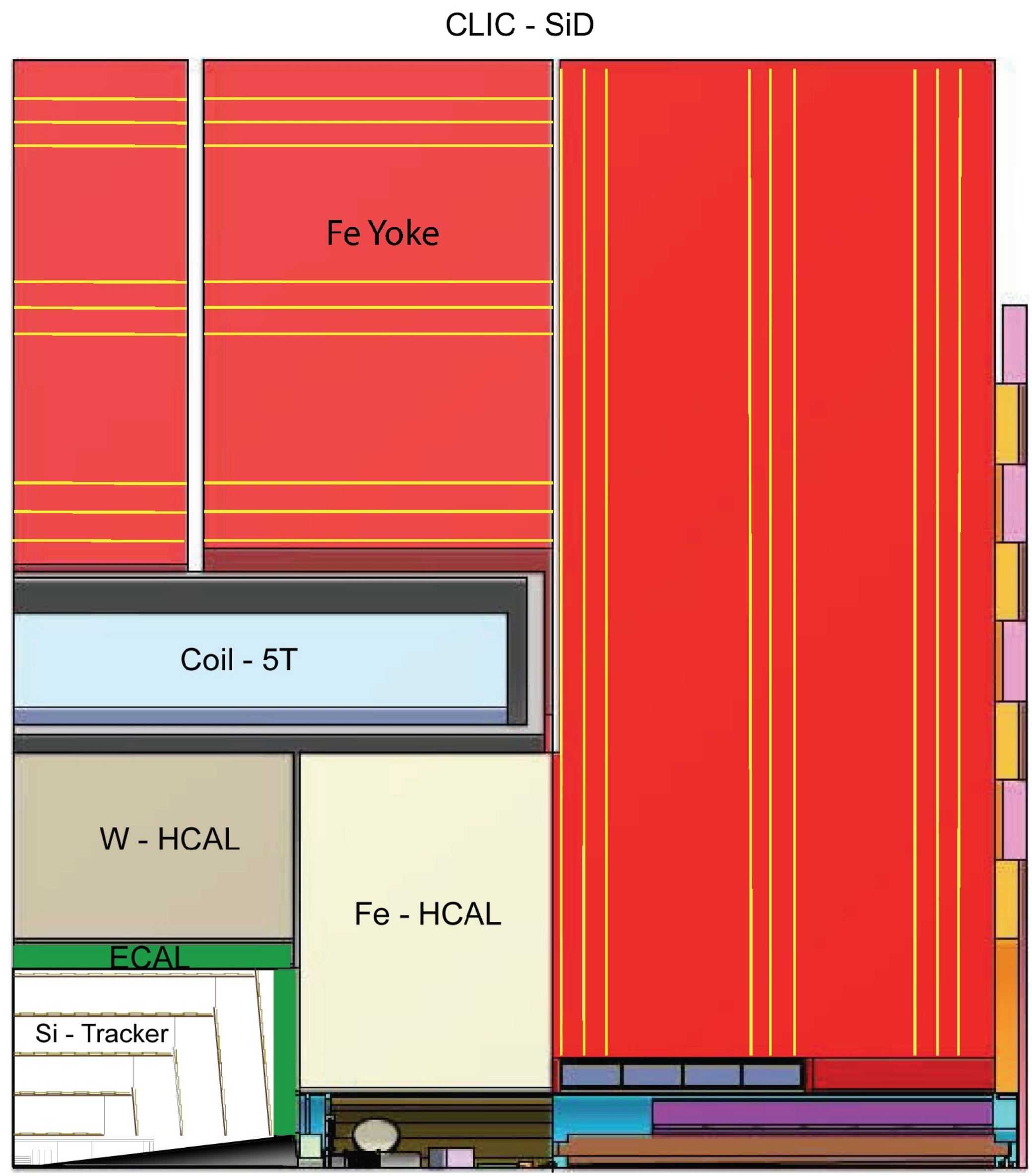


Tracking Overview

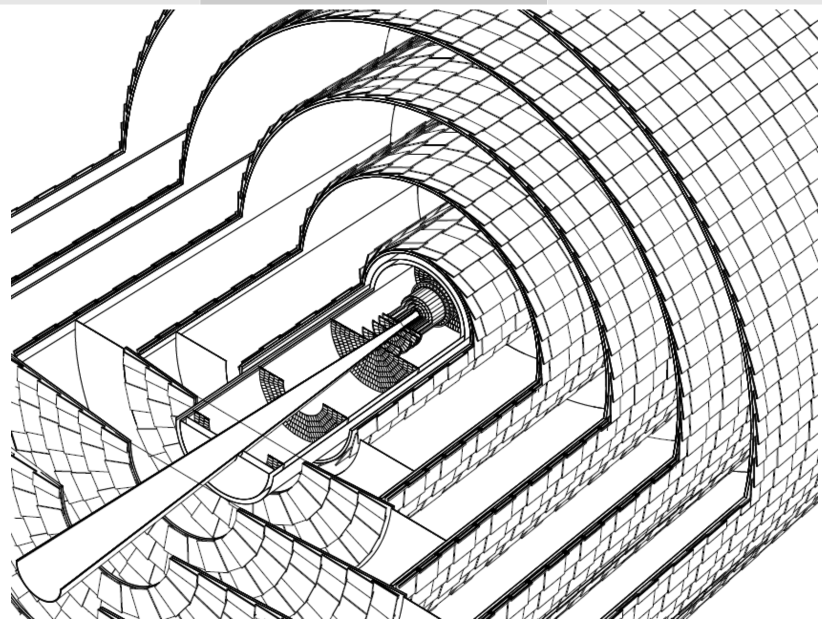
- Compact All-silicon system
  - Precise hit resolution
  - Fast charge-collection
  - time-stamping
- Integrated approach
  - Vertex detector and Tracker viewed as **one** system
  - Combined Seeding and Tracking
- CLIC_SiD and SiD main tracker are identical



Tracker at a glance

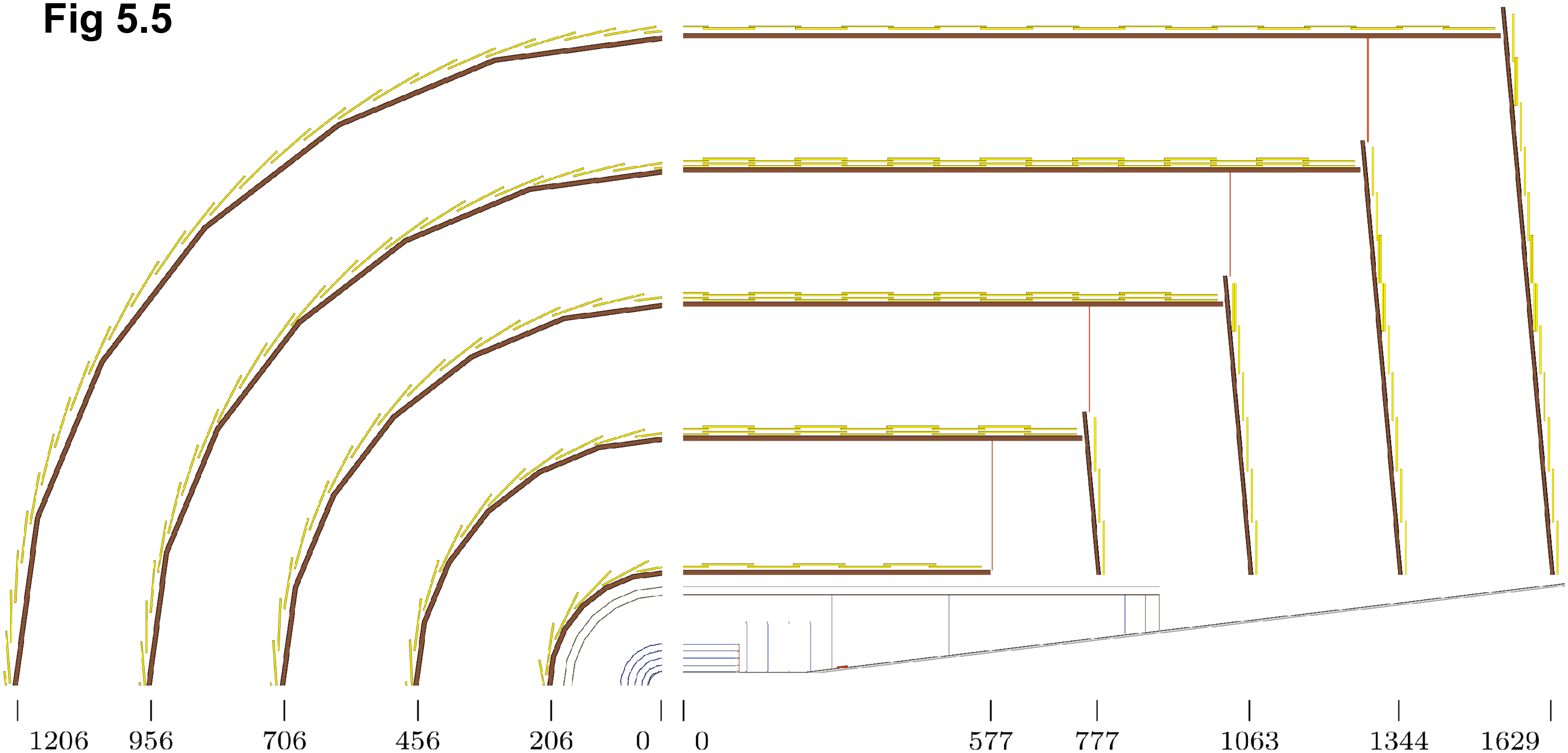
- Strip sensors
  - 25 µm strip pitch
  - 50 µm readout pitch
  - 300 µm sensitive thickness
- Modules
  - 97.8 x 97.8 mm (barrel)
  - Trapezoids (endcap)
  - 2 KPIX chips with 1024 channels each
- Mechanics
  - Mounted on carbon-fiber structure

Barrel	**Inner radius**	230 mm
	Outer radius	1239 mm
	Max Z	578 -1536 mm
	Hits	5 (rφ)
Endcap	**Inner radius**	207 -1162 mm
	Outer radius	1252 mm
	Max Z	1556 mm
	Hits	4 (SAS)



Tracker layout

Fig 5.5



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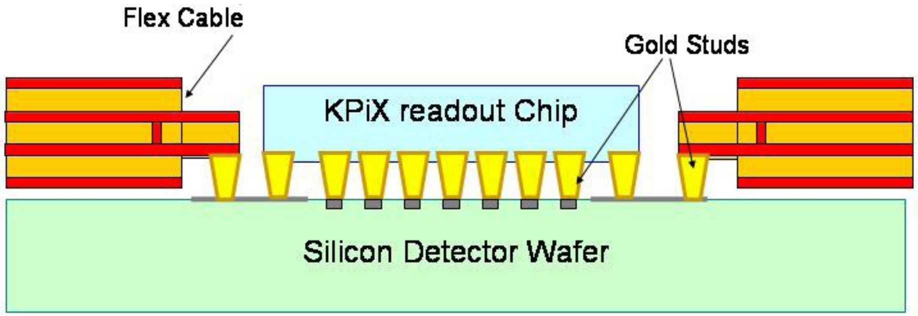
Tracker Modules

- Design using 3 components (no hybrid):
- Silicon Sensor
  - Routing of signals through 2nd metal layer
  - Power and clock signals also routed over the sensor
- KPiX readout
  - Two KPiX chips bump-bonded to the sensor
- Flexible readout cable
  - 2-layer 50 μm Kapton



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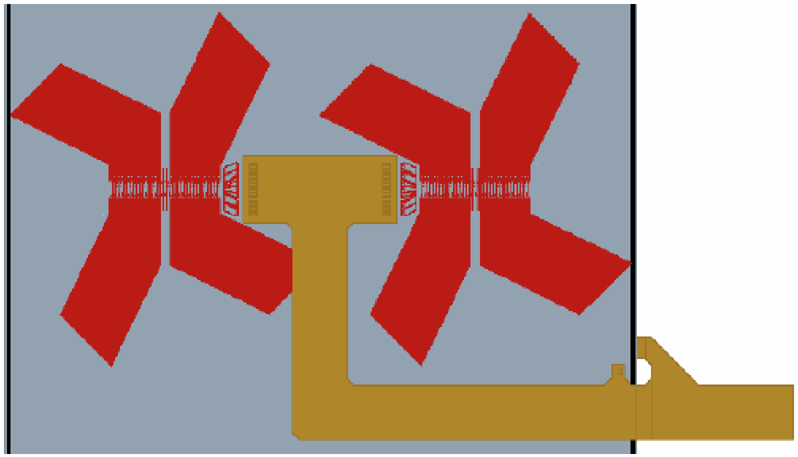
Tracker Cabling

- Low-mass readout cables
  - connect tracker modules to the concentrator boards mounted at the ends of each barrel.
- Cable has 2 components:
  - Pigtail, a short cable glued to the module
  - Extension, a long cable connecting the Pigtail to the concentrator



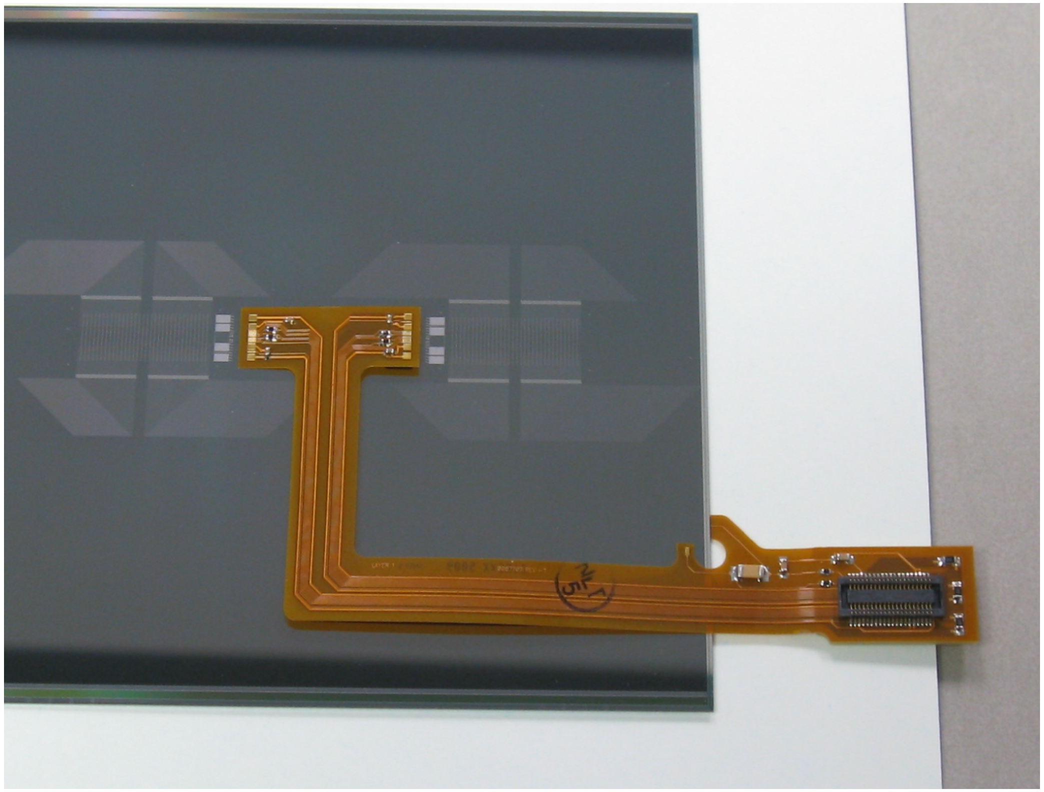
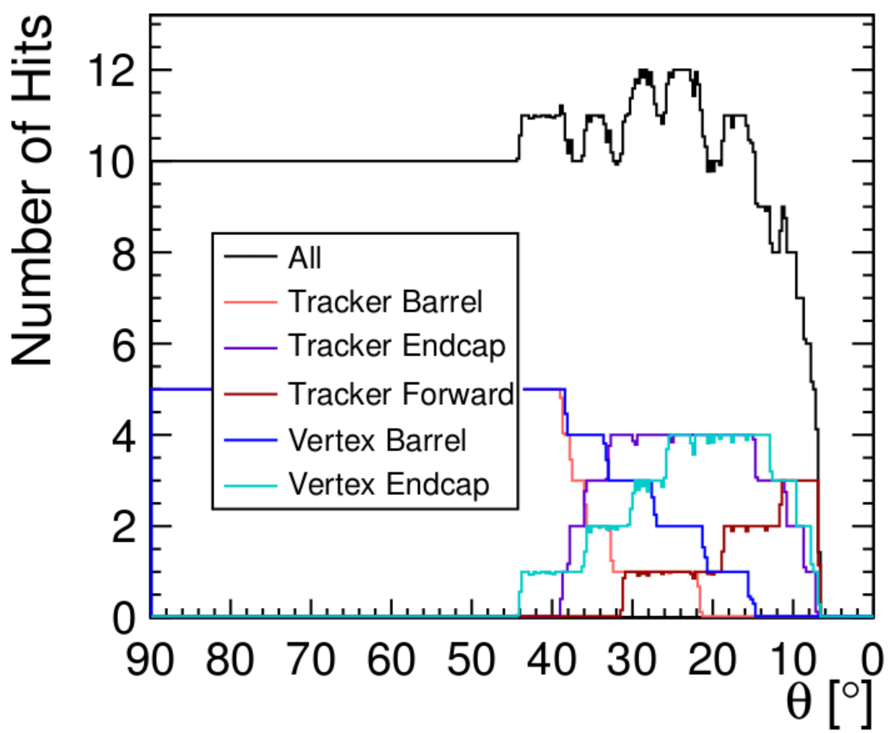
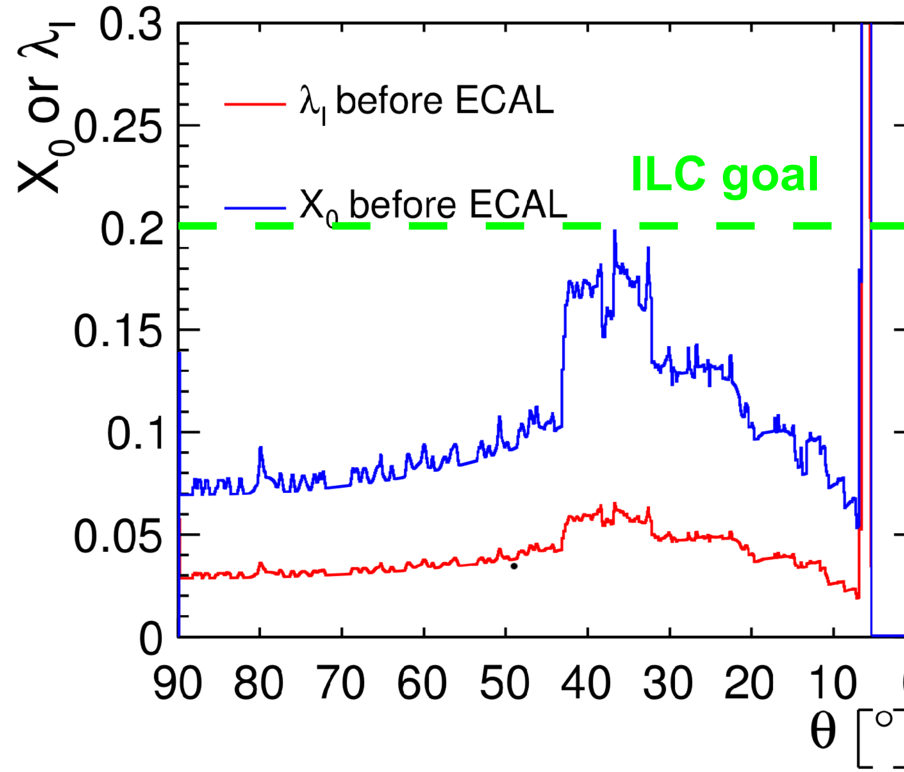


Fig 5.6



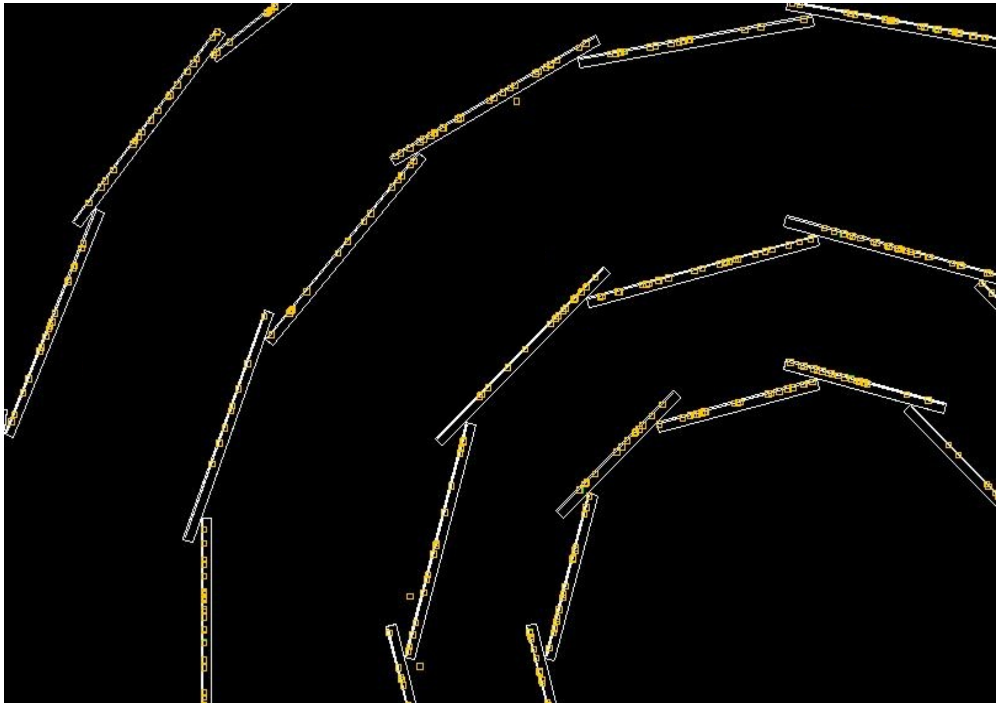
10 hits down to 15 degrees
6 hits down to 8 degrees



Material budget < 0.2 X_0

Tracking strategies

- Tracking studies use
  - Planar sensor geometry
  - Realistic charge deposition and digitization/clustering
- Time-stamping of 20 BX
  - Background reduction
- Strategy builder to optimize tracking performance
  - At least 7 hits required



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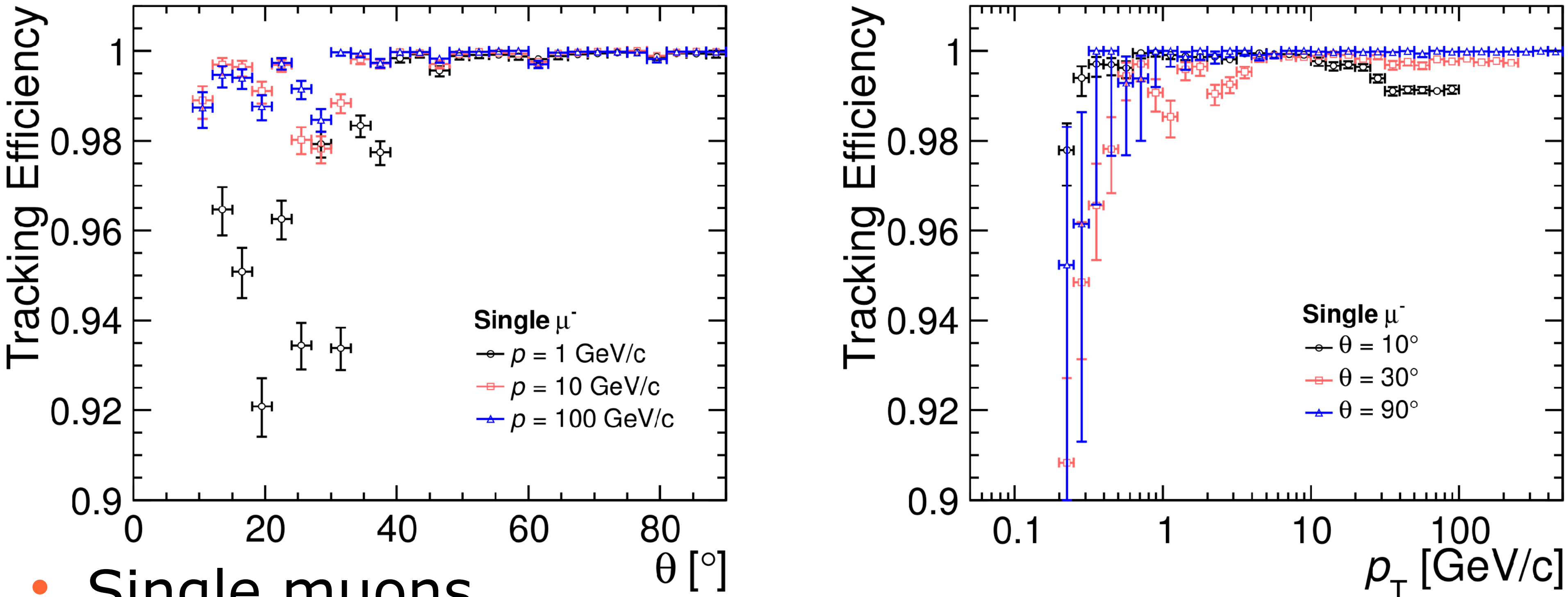
SeedTracker algorithm

- SeedTracker algorithm in org.lcsim
- Finding track seeds in seed layers
  - looking for combinations of at least three hits that fulfill a helix fit
- Track seeds extension
  - successively adding more hits
- Vertex constraint to reduce number of possible combinations
  - $\pm$ 5 mm in rϕ, $\pm$ 10 mm in z (loose enough to find tracks from displaced vertices)
- Select final tracks according to strategy

Single Muon Performance

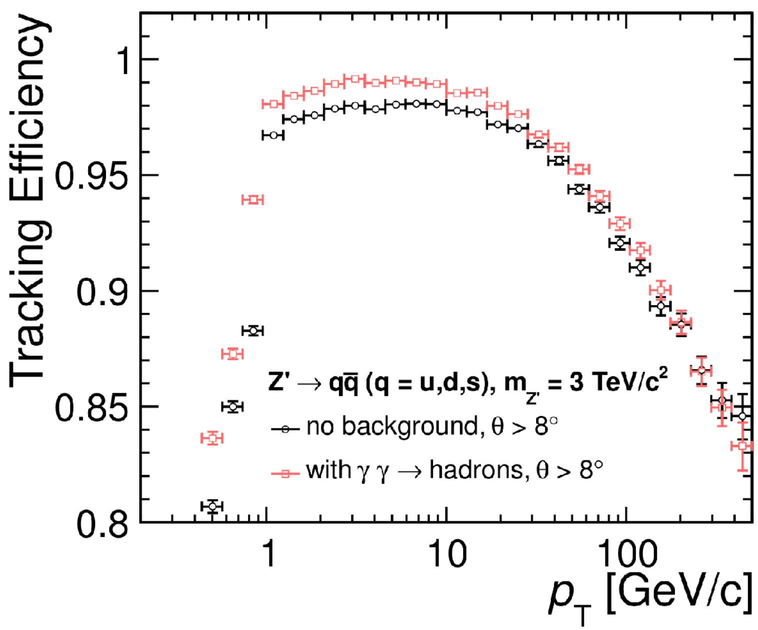
Fig 5.15

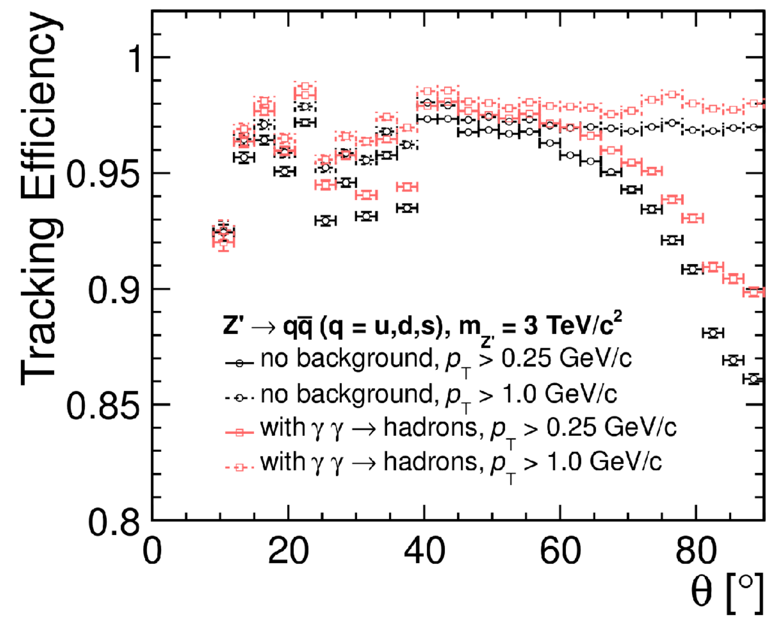


- Single muons
  - Good efficiency down to 8 degrees (7 hit cut-off)
- Low momentum performance
  - Affected by material budget at low angles

Di-jet performance

Fig 5.16

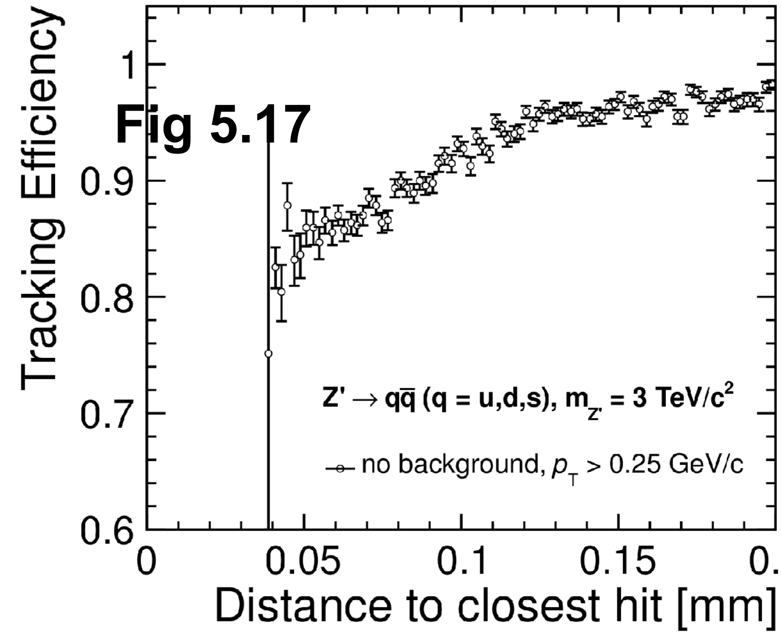


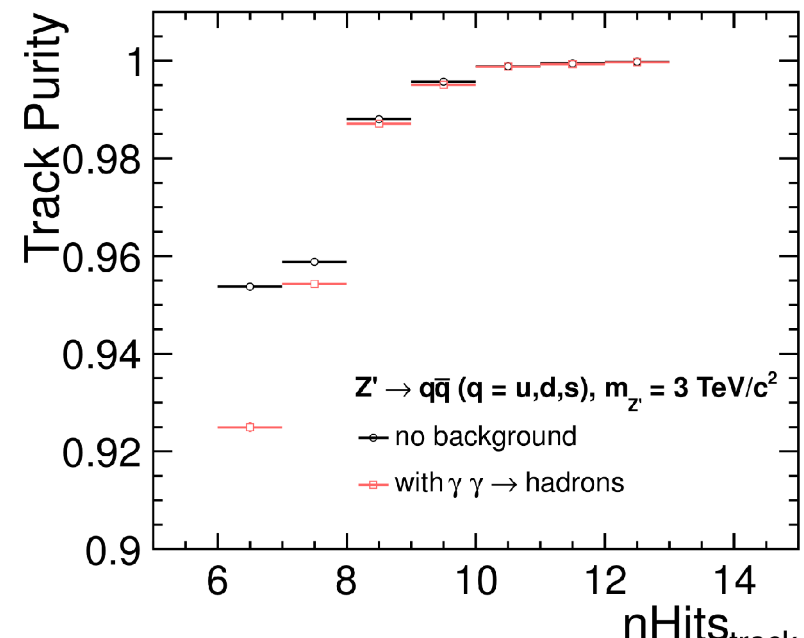


- Using a Z' to uds decays
  - Jets with high energy, very collimated
- Tracking efficiency remains high
  - Robust against $\gamma\gamma \rightarrow$hadrons background

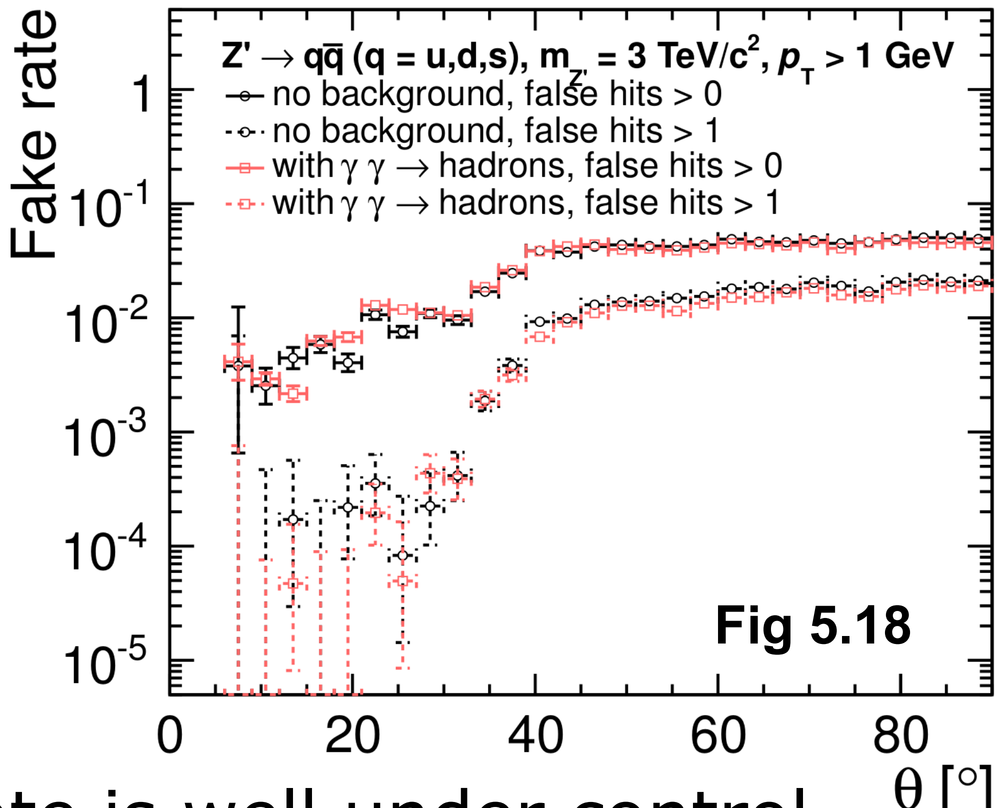
A few more details

- Tracks (p_T< 1 GeV/c)
  - Loop in the barrel
  - Not enough hits to form a track
- High momentum Tracks
  - Center of the jets
  - Merging Hits leads to efficiency drop
- Adding background
  - Does sometimes "improve" performance
  - With 1 fake hit track passes quality cut





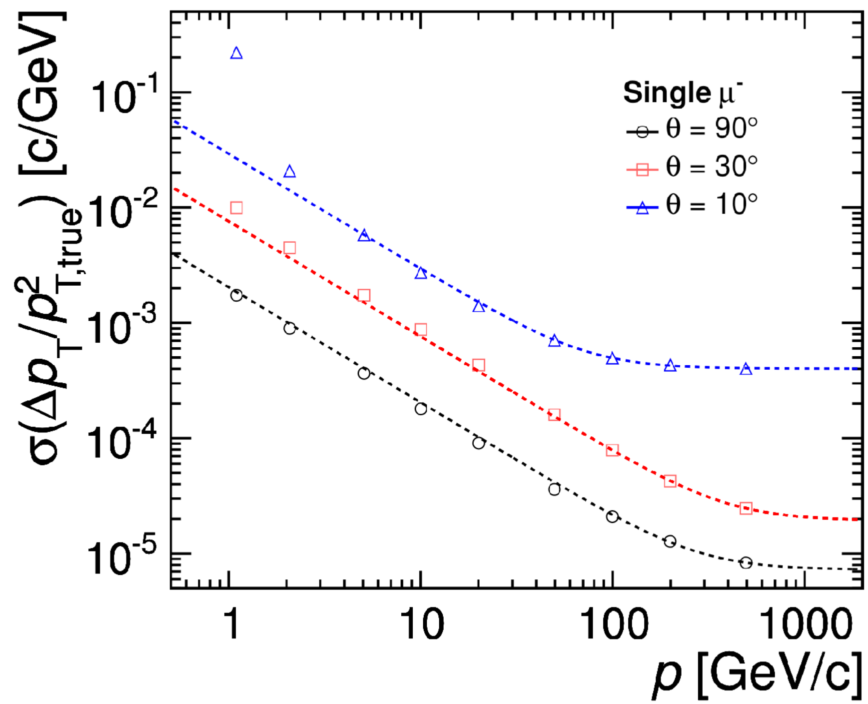
Fake rate



- Fake rate is well under control
  - 95 % of tracks have no fake hit attached
  - Robust against background
  - Forward region has lower rate due to smaller segmentation

Performance & outlook

- Tracking performance reaches CLIC goal
  - < 2 x 10^{-5} down to 30°
- Robust against backgrounds
- Still room for improvements
  - Better track fitter
  - Improved strategies
  - Loop recovery

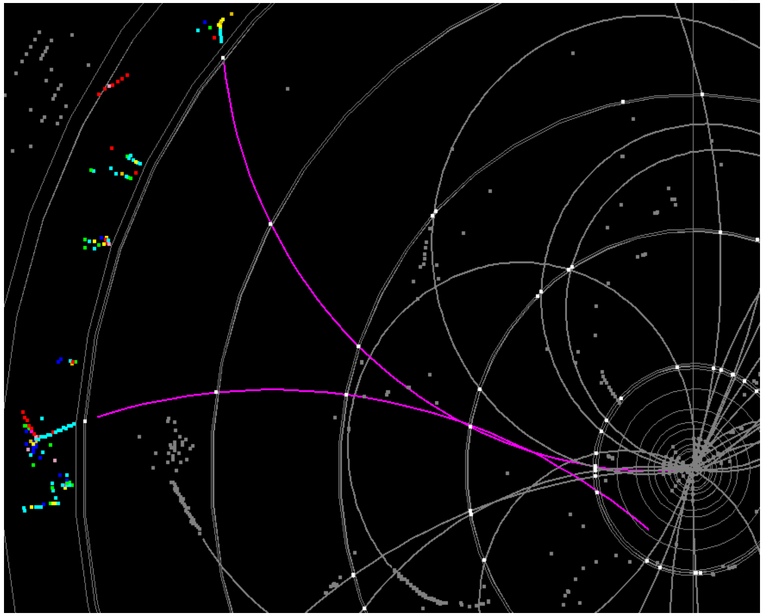


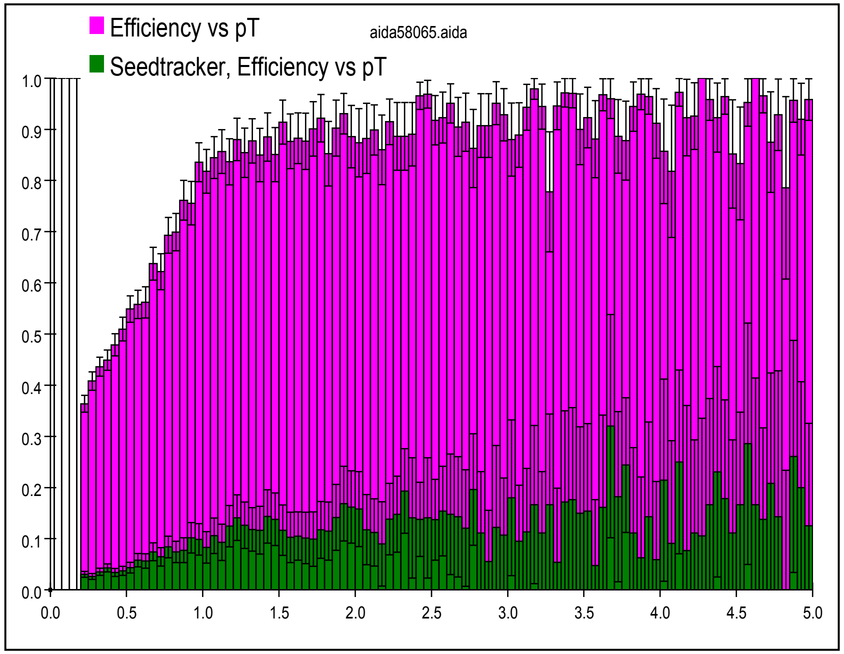
$$\sigma\left(\Delta p_T/p_T^2\right) = a \oplus \frac{b}{p_T} = a \oplus \frac{b}{p \sin\theta}$$

θ [°]	a [GeV^{-1}]	b
90	$7.3 \cdot 10^{-6}$	$2.0 \cdot 10^{-3}$
30	$1.9 \cdot 10^{-5}$	$3.8 \cdot 10^{-3}$
10	$4.0 \cdot 10^{-4}$	$5.3 \cdot 10^{-3}$

Non-prompt tracks

- Calorimetry Aided Tracking
  - Uses finely-segmented ECAL for track stubs
  - proof-of-principle code exists
  - Hasn't been used for the CDR
- Will be further explored
  - In the post-CDR phase





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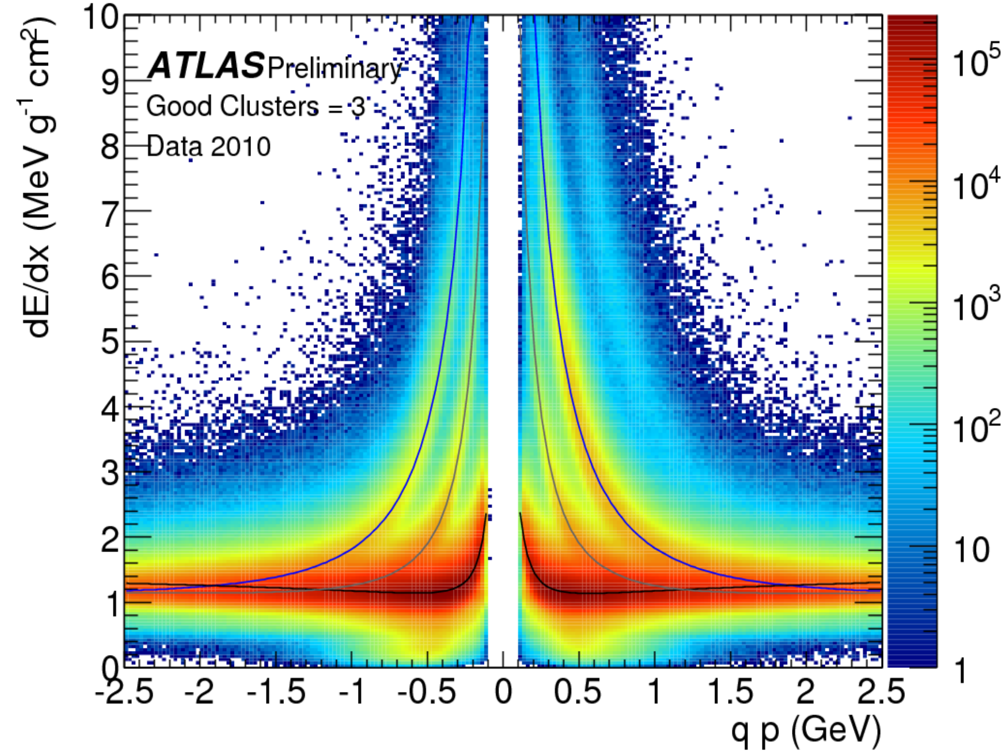
dE/dx

- This hasn't been really explored yet
- But there are other tracking doing dE/dx in silicon
  - CDF
  - ATLAS
  - CMS
  - ...
- No reason not to implement this later on



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Conclusions

- CLIC_SiD tracking
  - Robust tracking in the CLIC environment
  - Achieves performance goal
- Background robustness demonstrated
- Hardware developments on their way
- Room for improvements
  - Track finding and fitting
  - Non-prompt tracks
  - dE/dX