Status of DATCON
-
Simulation

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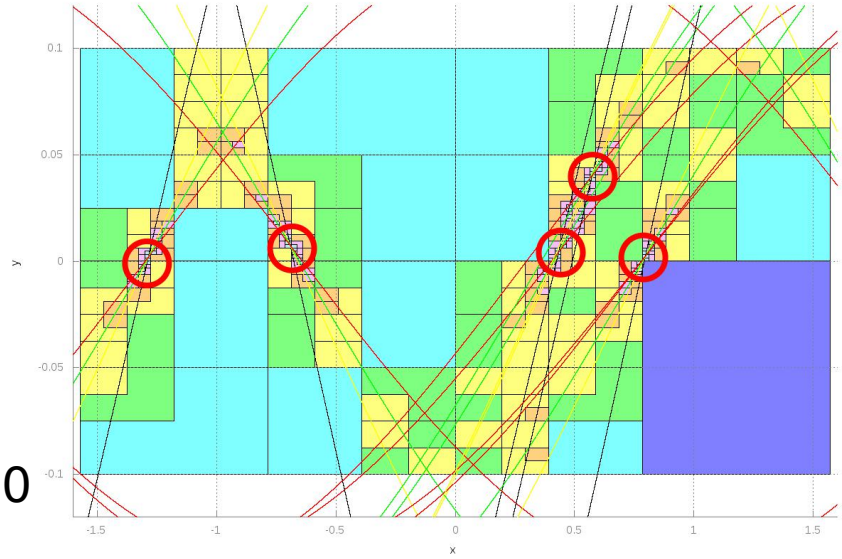
Recap

- Tracking was performed with fast "Divide & Conquer" Hough Trafo also in simulation with BASF2
  - By dividing the Hough Space (HS) in half, the number of sectors for horizontal and vertical direction in the HS was the same
  - >95% track reconstruction efficiency
  - >95% ROI finding efficiency with DRF ≥ 10
  - especially limited in the low p_T region due to multiple scattering and energy loss of low-energy particles (as expected)



DATCON Simulation

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- Implementation and testing of HT without D&C but with checking every (predefined) sector (as on the FPGA)

  → all combinations of sector numbers possible, not only powers of 2

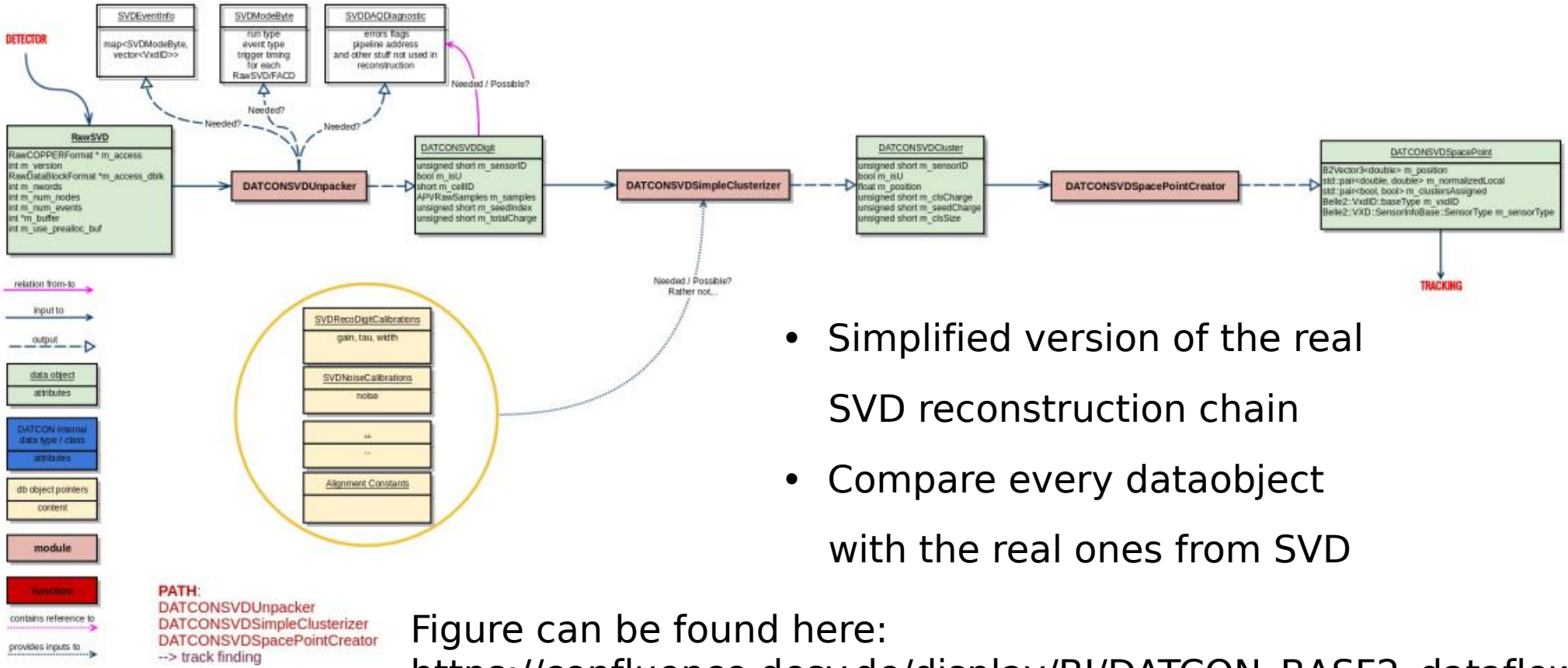
  → decreased number of fakes (less active sectors)

  → increased computation time on PC

- New approach for clustering of HS, not used as default
- Bachelor student helped with MVA to find maximum in performance
  - Used set of 6 parameters of the DATCON algorithm
  - Optimum ROI size (u x v) 110 x 120 pixel fixed size
  - Simulations with variable ROI size were performed, but not yet analyzed with the MVA
  - Future plan: use the MVA with all (O(20)) free paramers

DATCON Simulation

- Working on the SVD R/O / reconstruction chain
- Already implemented in hardware already has this implemented, but simulation still uses SimHits of BASF2

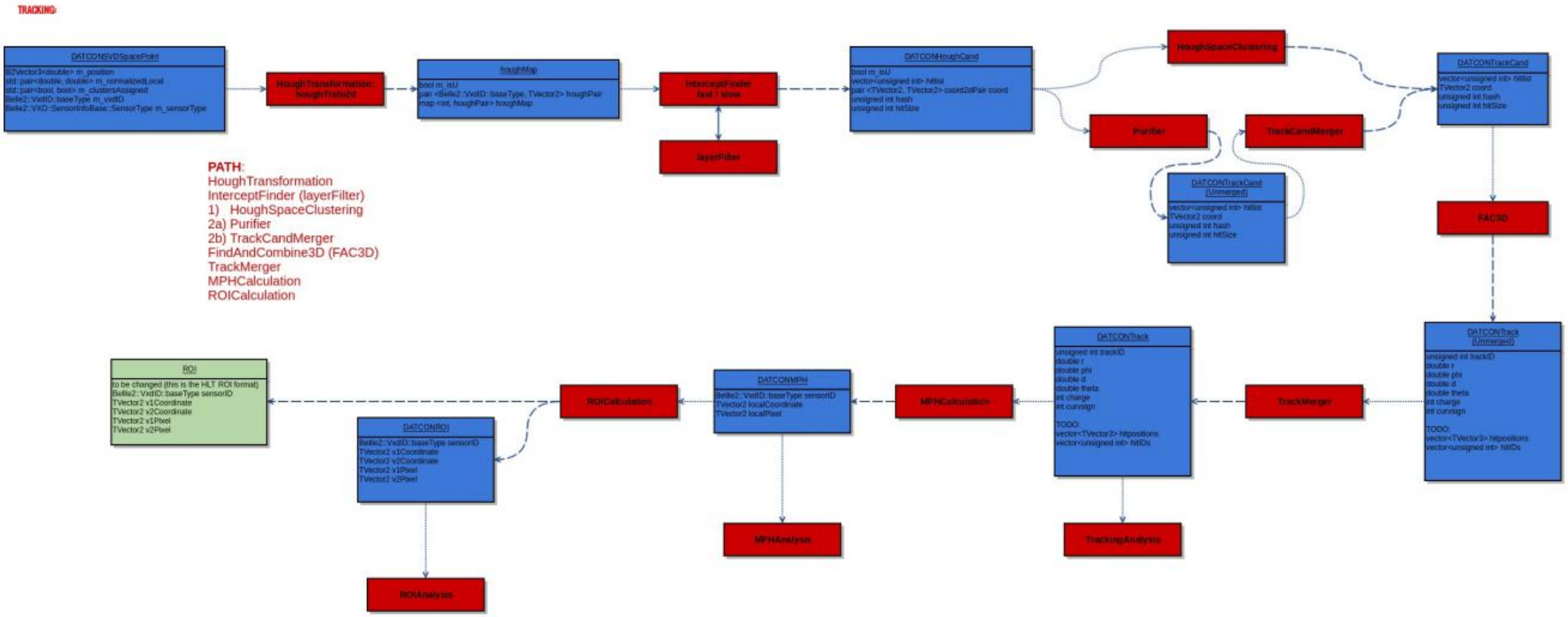


- Simplified version of the real SVD reconstruction chain
- Compare every dataobject with the real ones from SVD

Figure can be found here:
https://confluence.desy.de/display/BI/DATCON_BASF2_dataflow

DATCON Simulation

- Workflow inside the DATCON simulation



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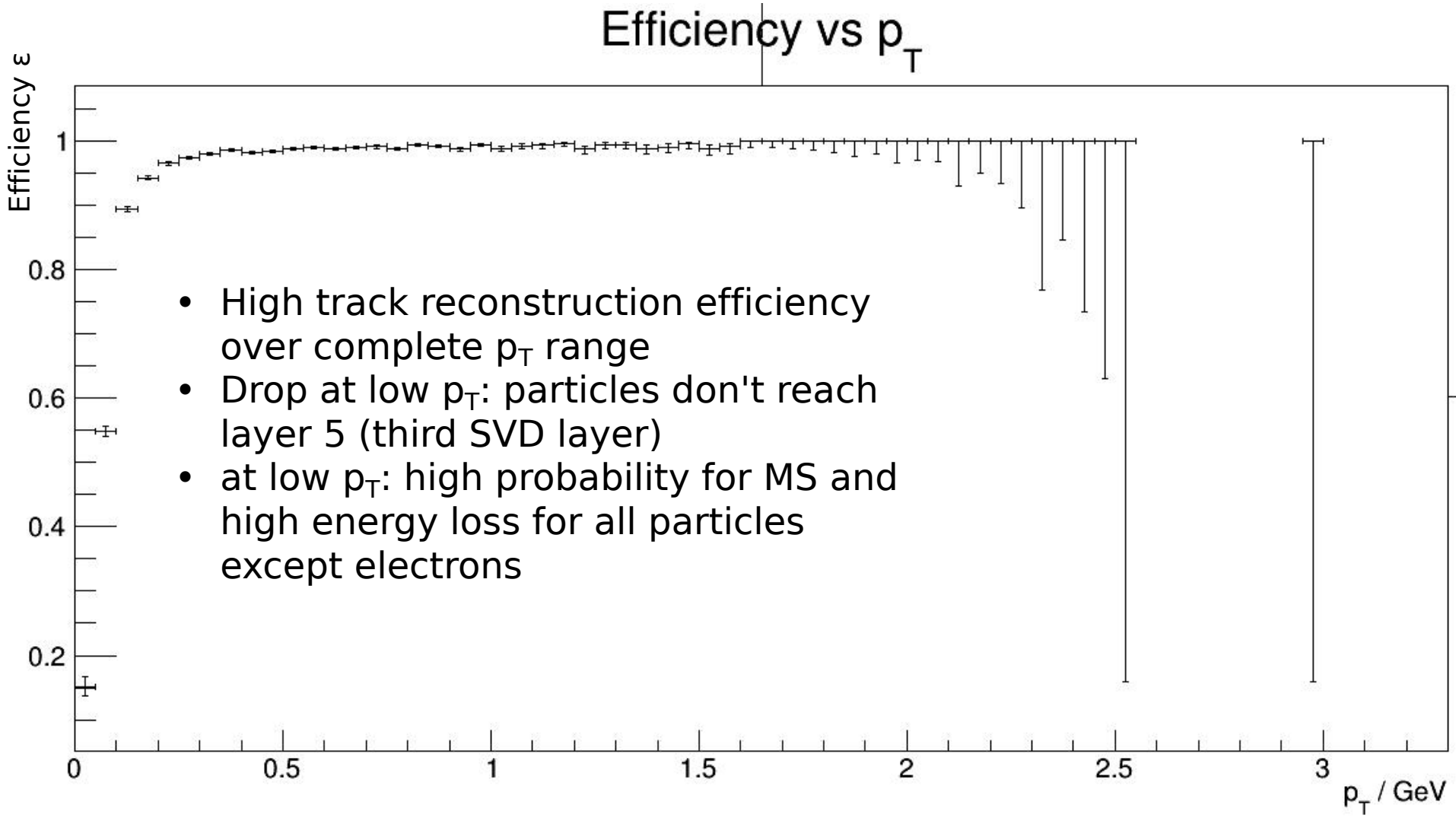
Tracking - Results

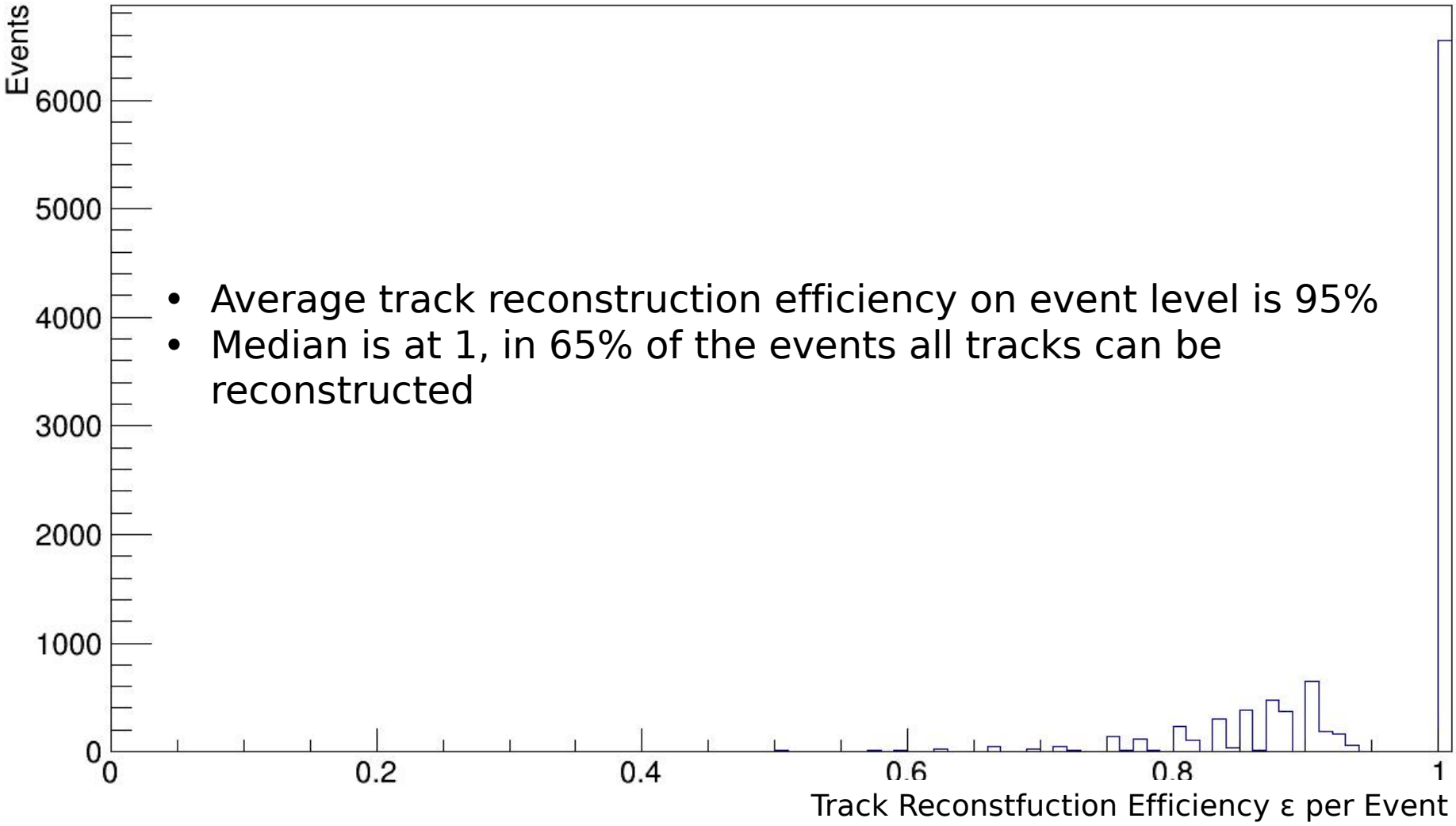
Simulation with generic Y(4S) events using full background of campaign 15



- High track reconstruction efficiency over complete p_T range
- Drop at low p_T: particles don't reach layer 5 (third SVD layer)
- at low p_T: high probability for MS and high energy loss for all particles except electrons

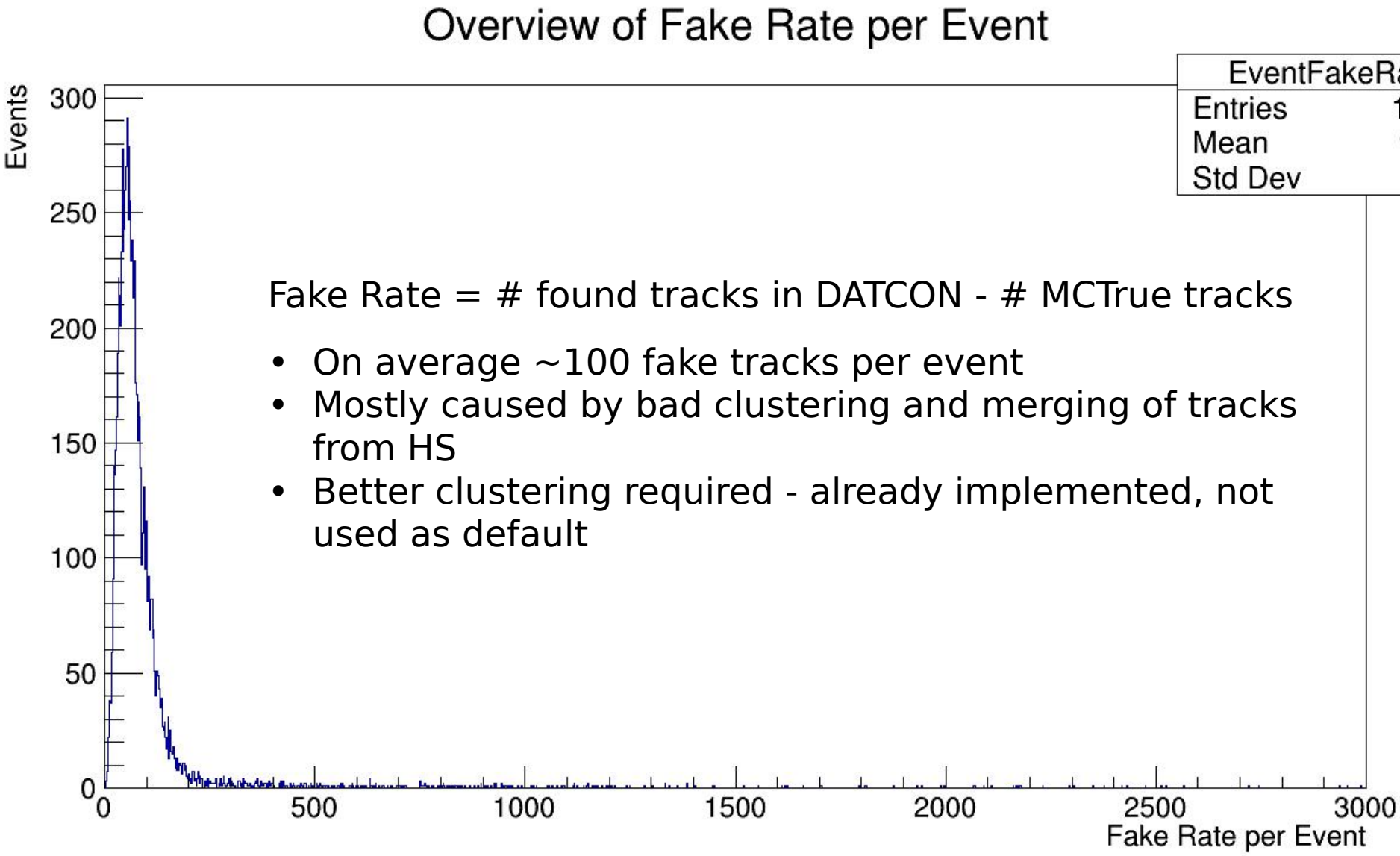
Tracking - Results

Overview of Track Reconstfuction Efficiency per Event



- Average track reconstruction efficiency on event level is 95%
- Median is at 1, in 65% of the events all tracks can be reconstructed

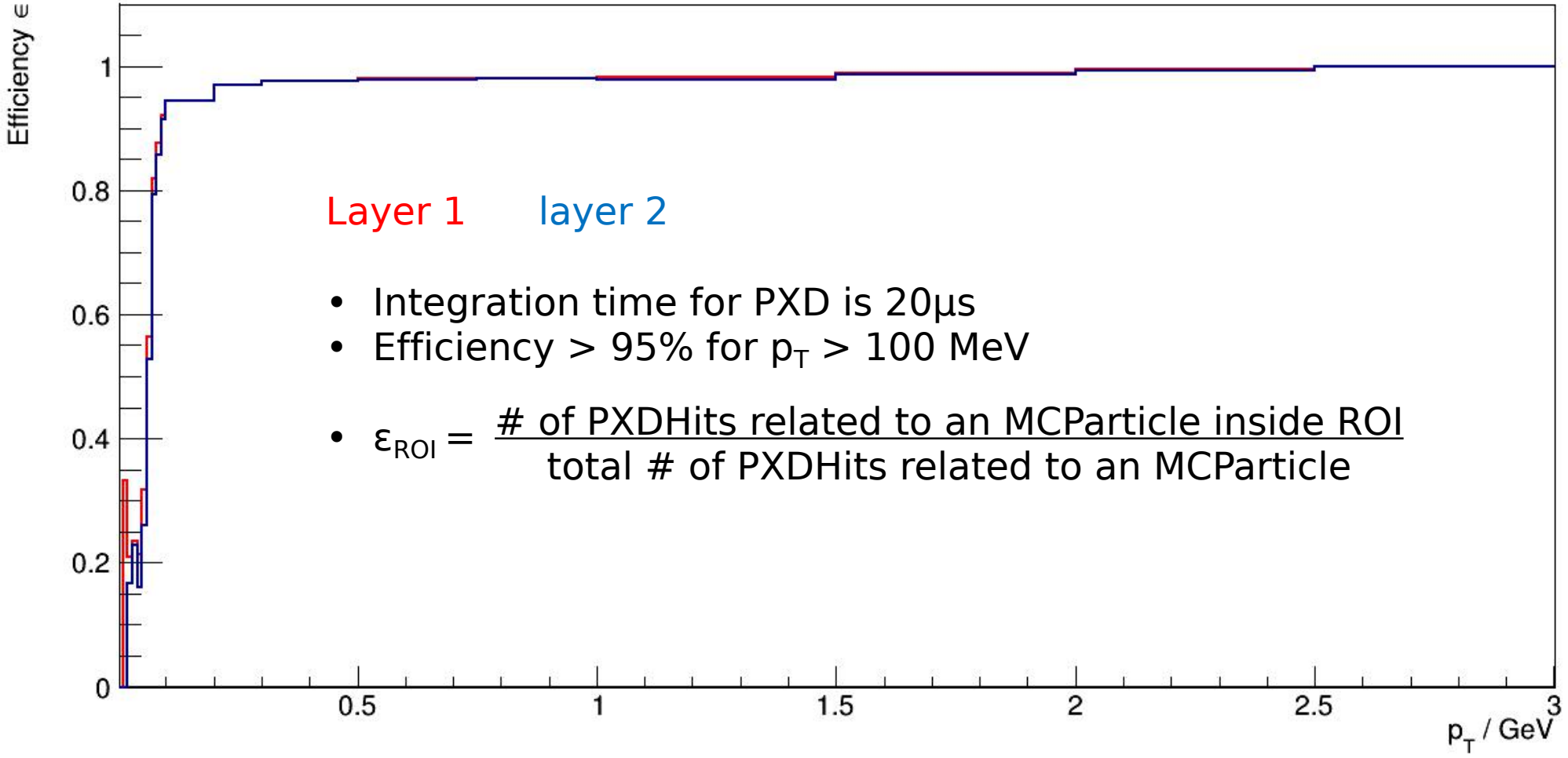
Tracking - Results



Fake Rate = # found tracks in DATCON - # MCTrue tracks

- On average ~100 fake tracks per event
- Mostly caused by bad clustering and merging of tracks from HS
- Better clustering required - already implemented, not used as default

ROI Finding - Results

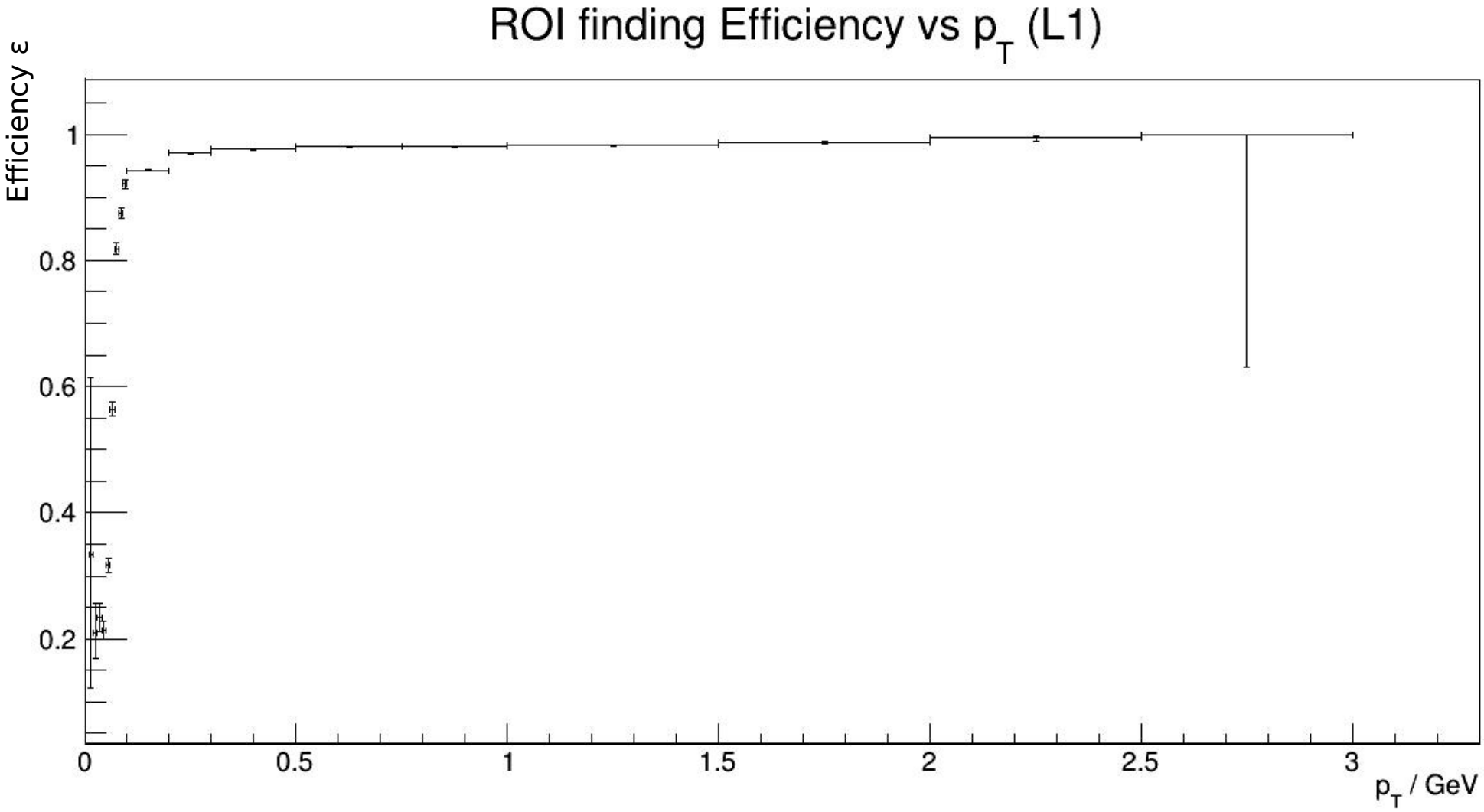


Layer 1 layer 2

- Integration time for PXD is 20µs
- Efficiency > 95% for p_T > 100 MeV
- $\varepsilon_{ROI} = \frac{\text{\# of PXDHits related to an MCParticle inside ROI}}{\text{total \# of PXDHits related to an MCParticle}}$

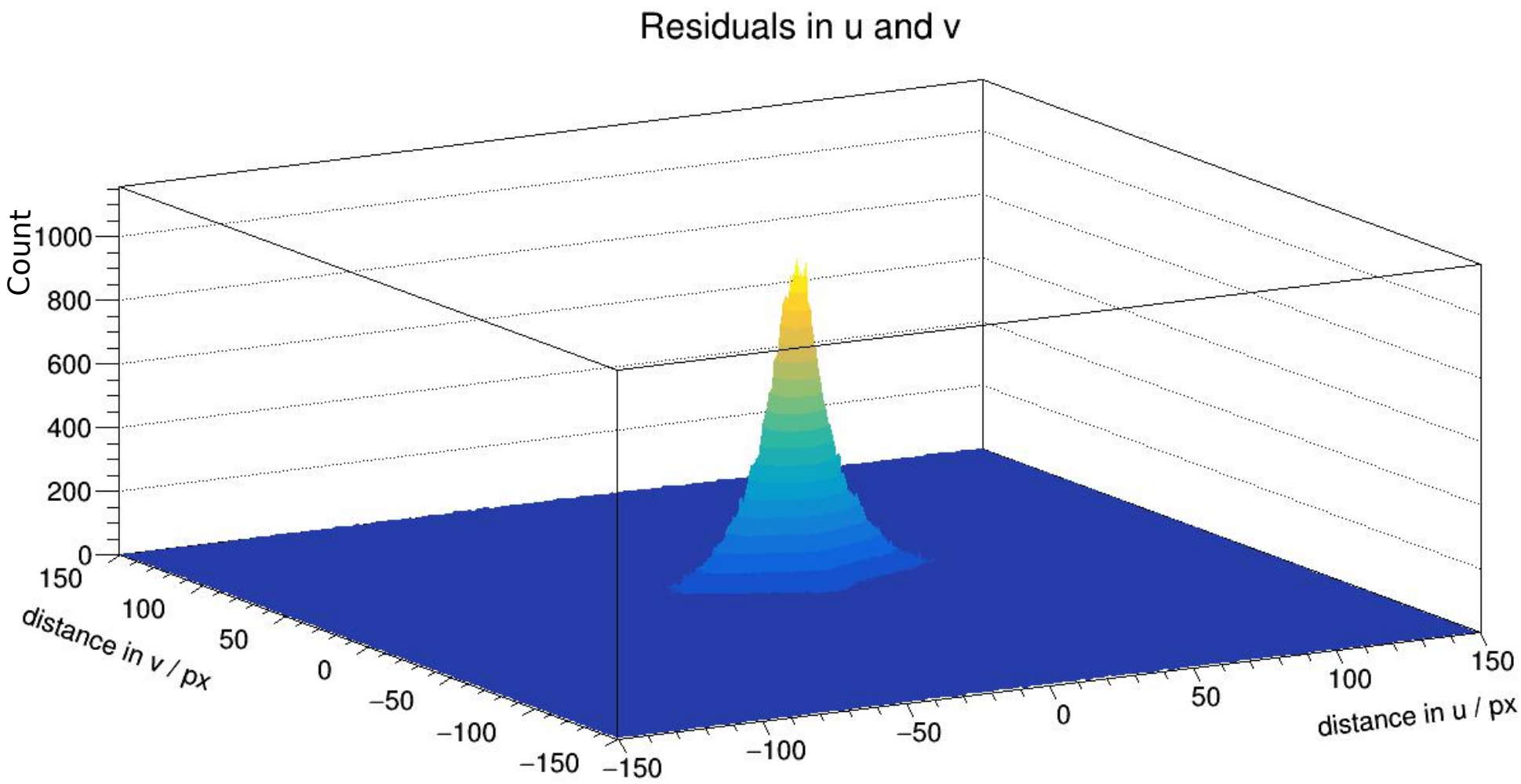
ROI Finding - Results

Same data for L1 as on last slide, but with (small) error bars

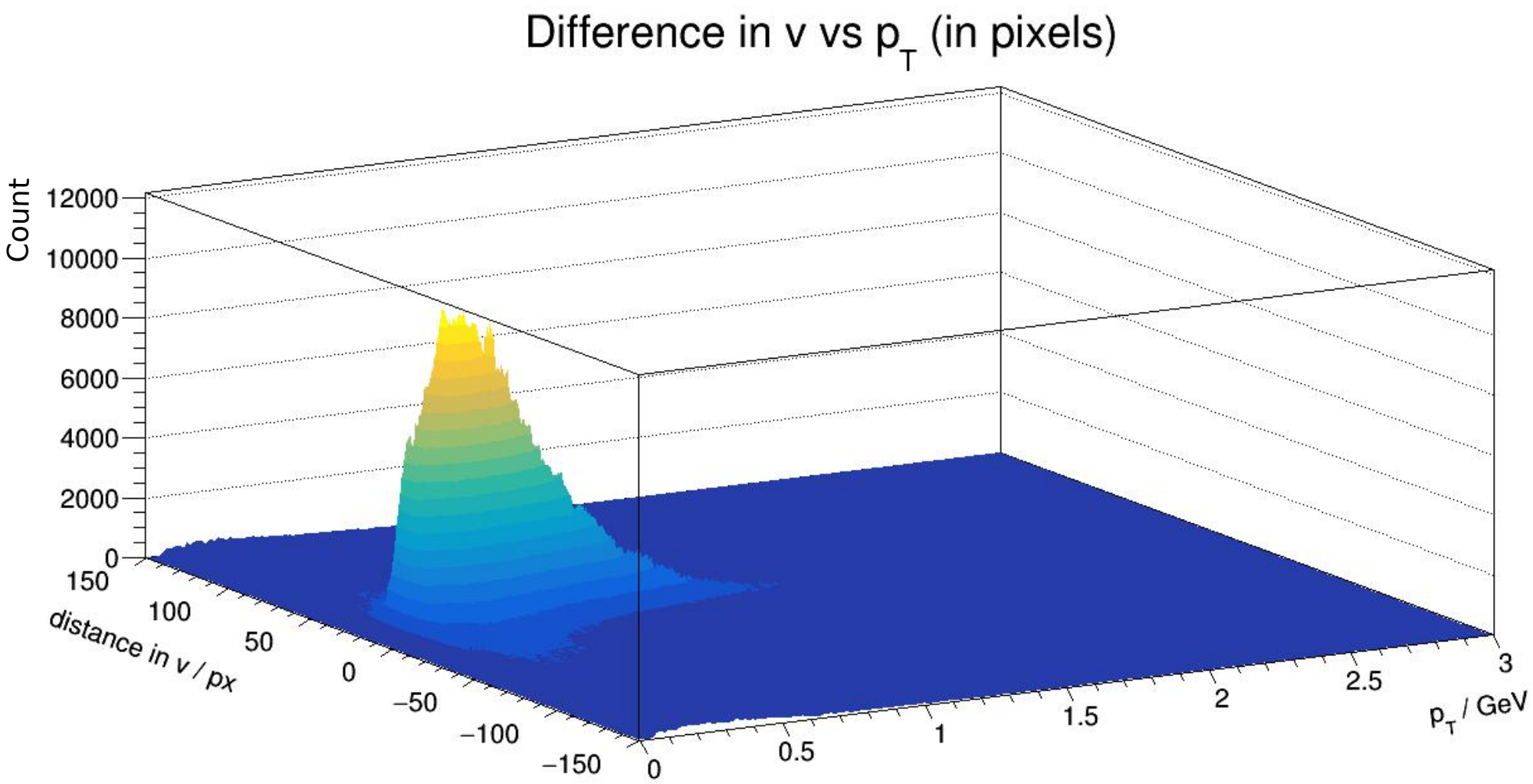


ROI Finding - Results

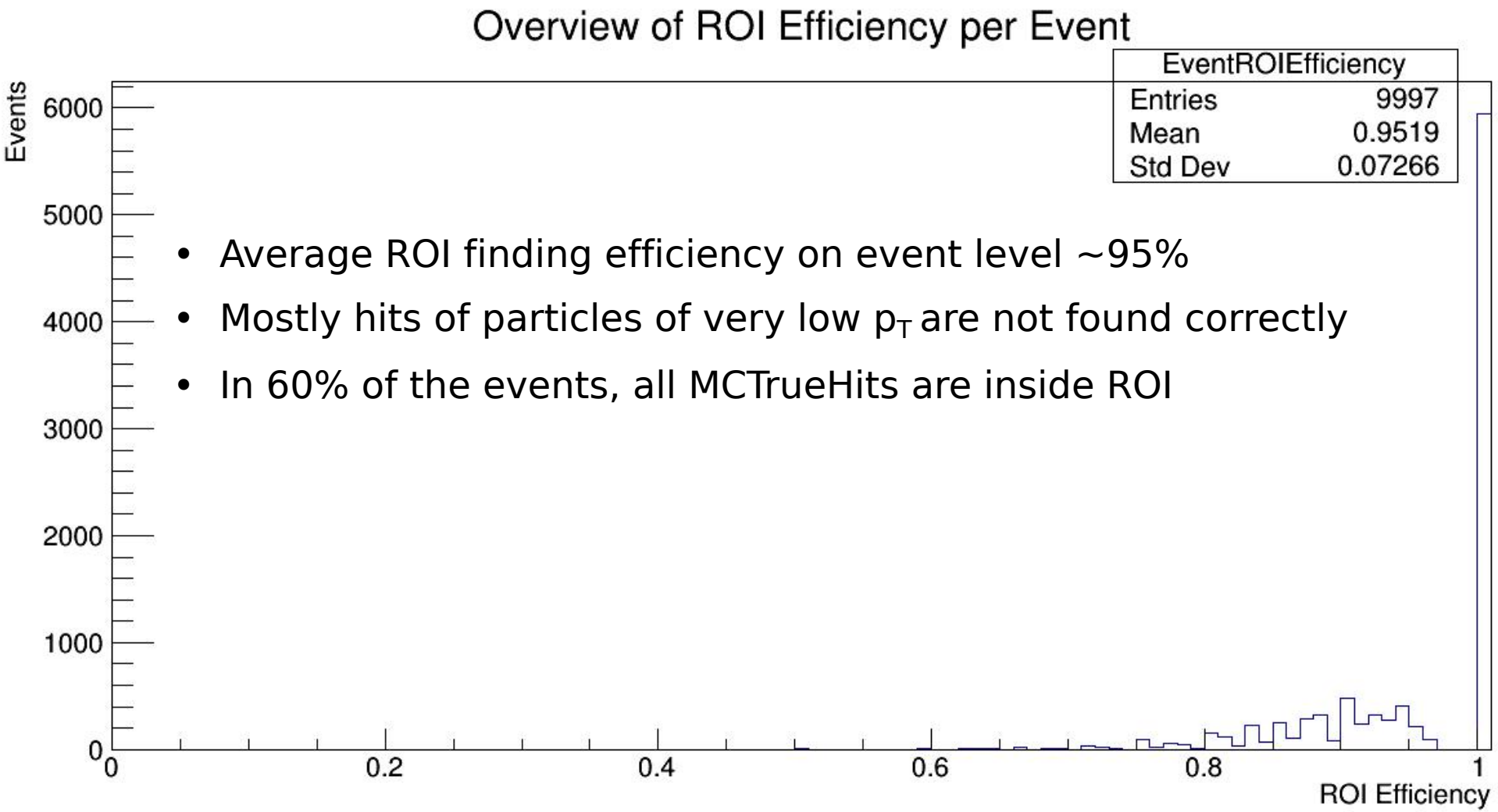
Residual: extrapolated (u/v) - true MC (u/v) position



ROI Finding - Results

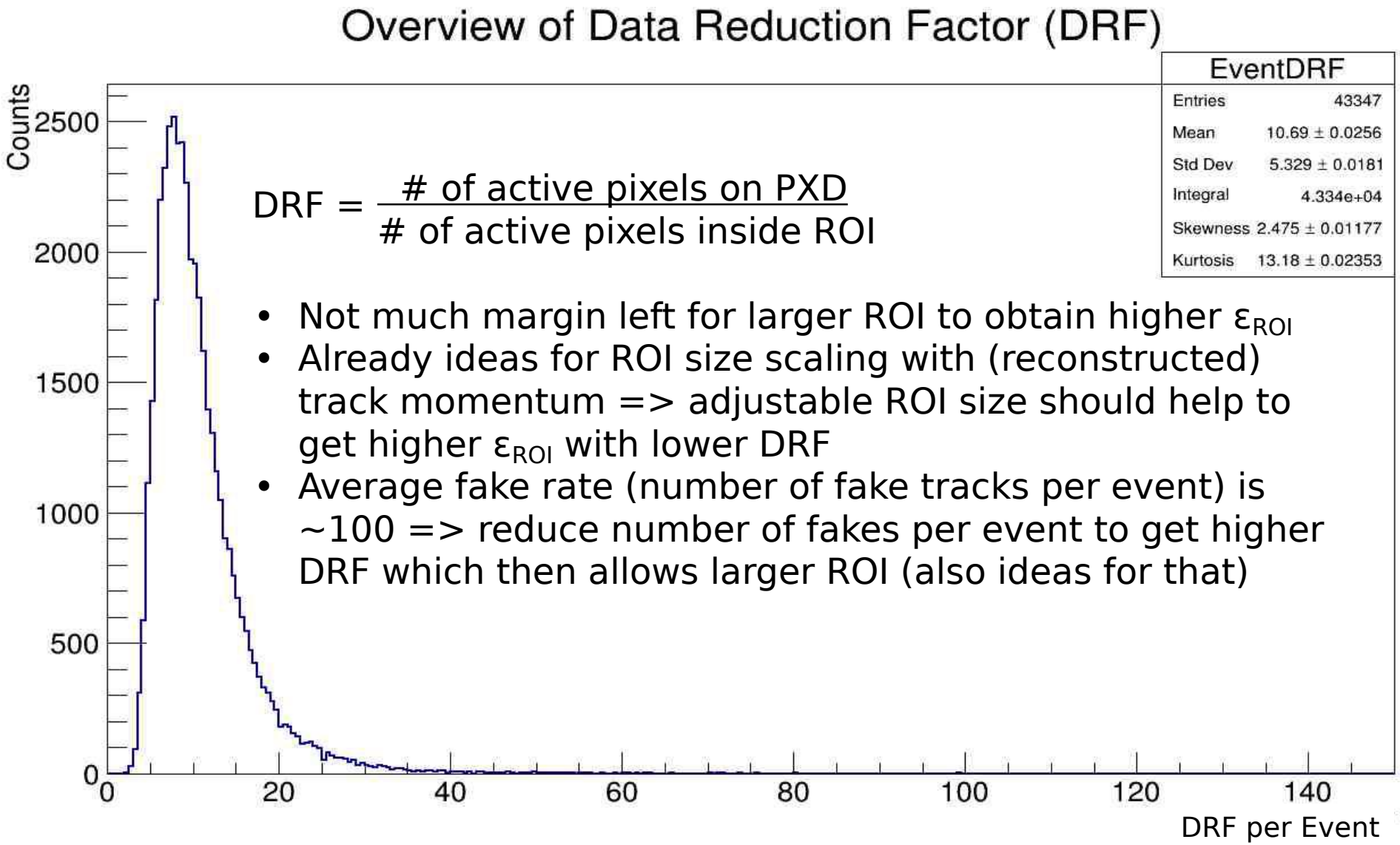


ROI Finding - Results



- Average ROI finding efficiency on event level ~95%
- Mostly hits of particles of very low p_T are not found correctly
- In 60% of the events, all MCTrueHits are inside ROI

Simulation Results - ROI Performance



$$DRF = \frac{\#\text{ of active pixels on PXD}}{\#\text{ of active pixels inside ROI}}$$

- Not much margin left for larger ROI to obtain higher ε_{ROI}
- Already ideas for ROI size scaling with (reconstructed) track momentum => adjustable ROI size should help to get higher ε_{ROI} with lower DRF
- Average fake rate (number of fake tracks per event) is ~100 => reduce number of fakes per event to get higher DRF which then allows larger ROI (also ideas for that)

Conclusions

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- Very good tracking performance of BASF2 DATCON algorithm (> 97%) for generic Y(4S) events with background of campaign 15, but
  - Quite high number of fake tracks → crucial for data reduction factor
- Good ROI finding efficiency of >96% (complete p_T range) and DRF ≈ 10
- O(20) parameters to tune for optimisation of tracking and ROI calculation
- DRF can be increased by using ROI of variable size instead of fixed size
  - $\propto 1/p_T$ or $\propto -p_T$ (first test proved the potential of this)
- Still need for optimisation of ROI finding performance for (very) low p_T tracks (p_T < 100 MeV) → maybe via variable ROI sizes

Outlook

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- Implementation and test of complete SVD-like data chain
  - DATCON only receives SVDDigits and strip ID, not SVDClusters or space points → create these ourselves
  - trying to be as close as possible to BASF2 / real SVD data chain, considering what is possible to do on FPGA
- Change BASF2 implementation of DATCON to be very close to hardware implementation
- Simplify and refactor the DATCON BASF2 implementation
- Optimisation of parameters for HT, TrackMerger, ROI sizes (variable or fixed size), ...

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Thank you

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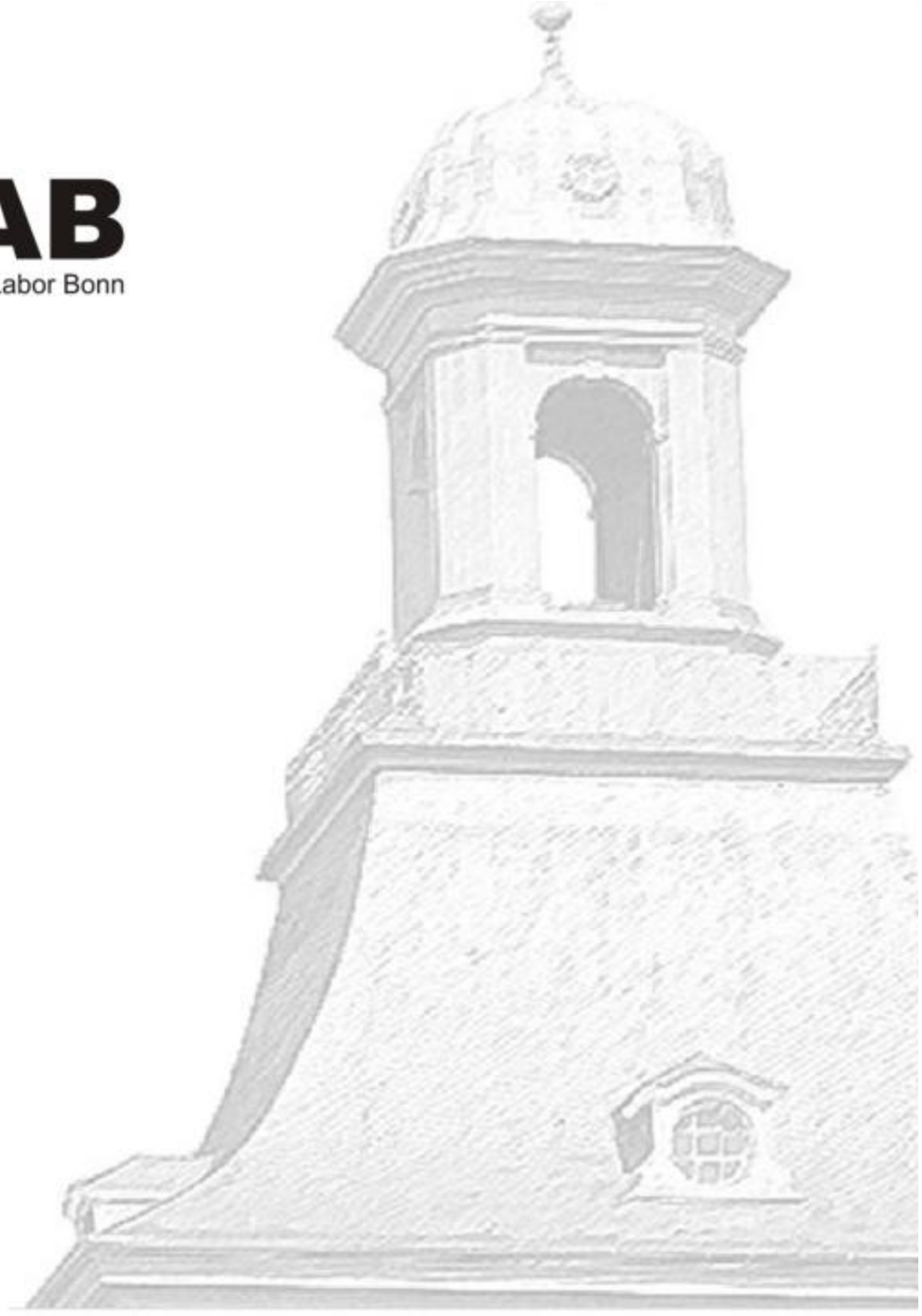

Backup

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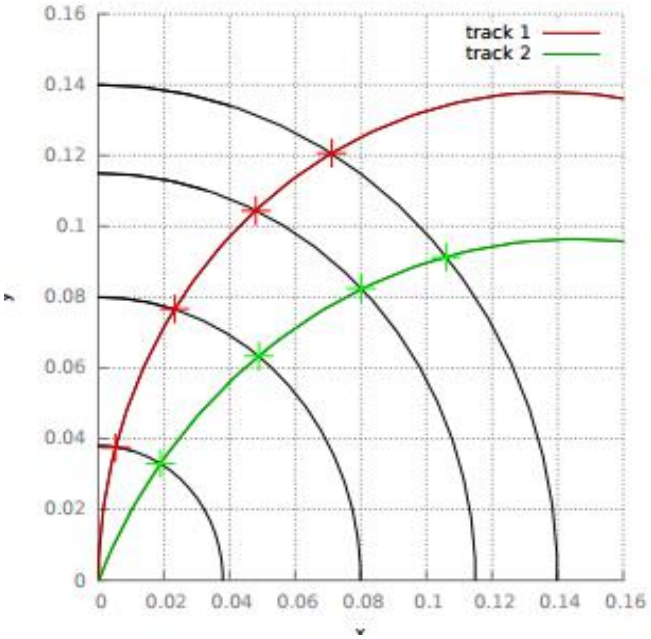
SVD Track Reconstruction

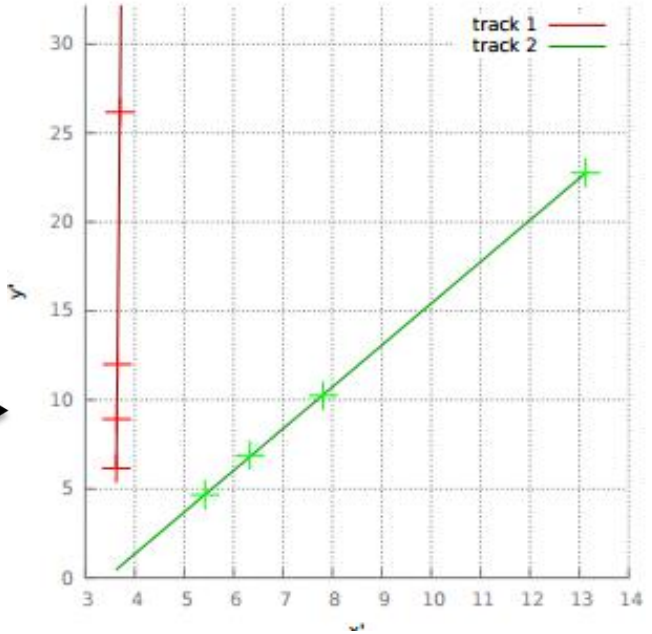
- Use of the Hough transformation:

$$d = x \cdot \cos\alpha + y \cdot \sin\alpha$$

- Drawack: Can only be applied for straight line (as previously implemented on FPGA)
- For circular track a conformal transformation is needed



$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \frac{1}{r^2} \cdot \begin{pmatrix} x \\ y \end{pmatrix}$$



Extrapolation

- Simulations with Y(4S) events are performed
  ⟶ results look promising, but further improvements necessary

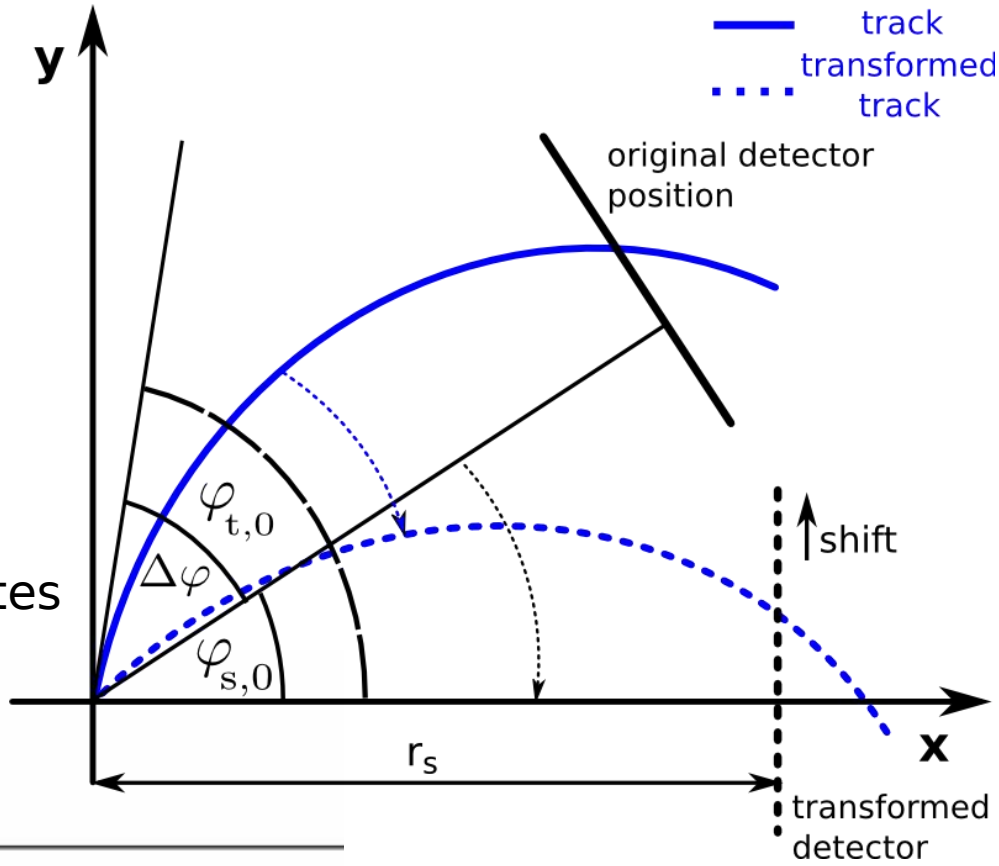
- Also new extrapolation method implemented:
  intersection of circle (= track) with straight line (= detector plane)

- Afterwards: multiplication of (x,y) with rotation matrix to obtain 3d MPH (most probable hit) coordinates

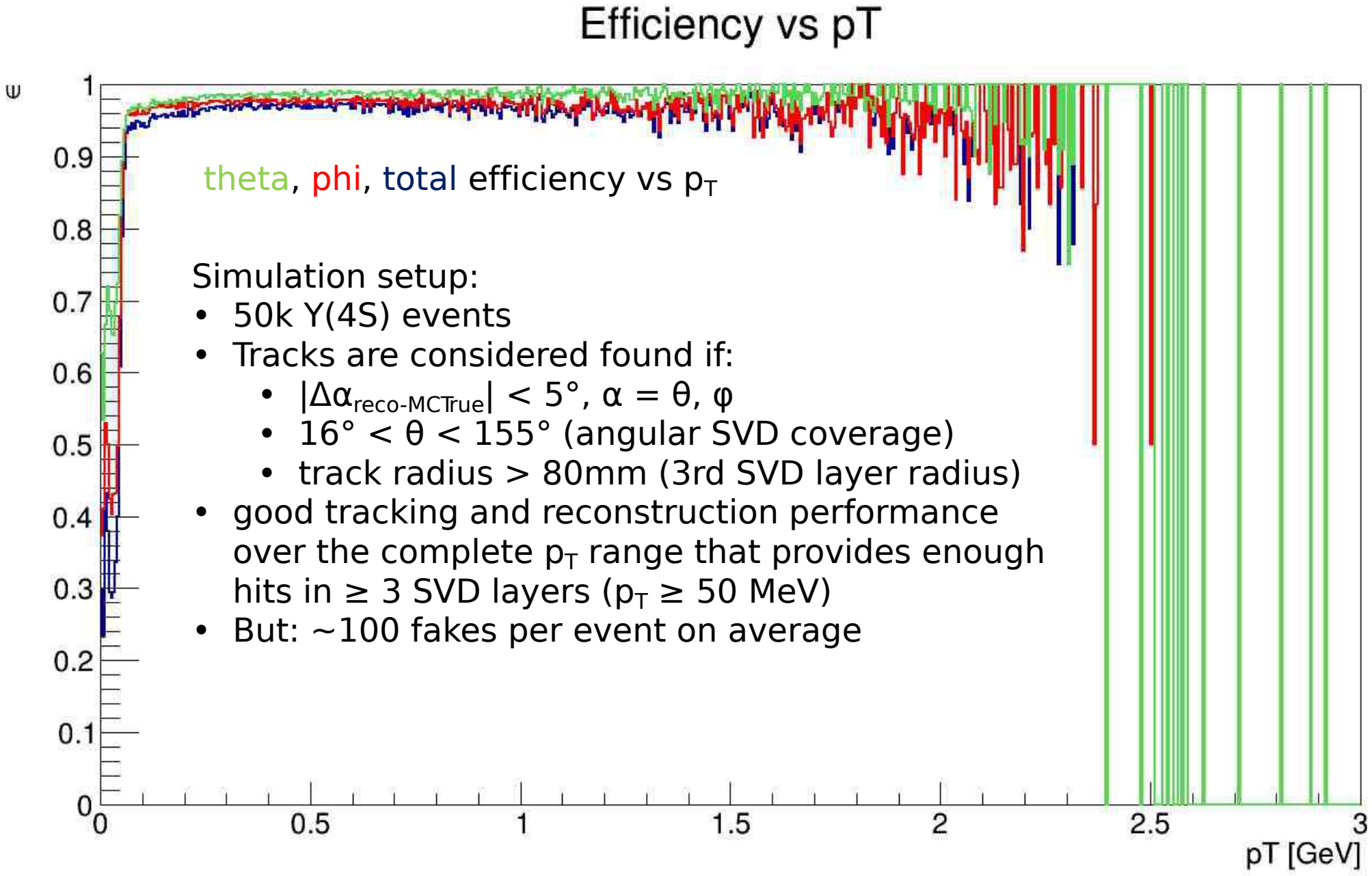
$$\Delta\varphi = \varphi_\mathrm{t} - \varphi_\mathrm{s}$$

$$x = r_\mathrm{s}$$

$$y = r_\mathrm{t} \cdot \cos\Delta\varphi + \sqrt{r_\mathrm{t}^2 - (r_\mathrm{s} - r_\mathrm{t} \cdot \sin\Delta\varphi)^2}$$



Simulation Results - Tracking Performance

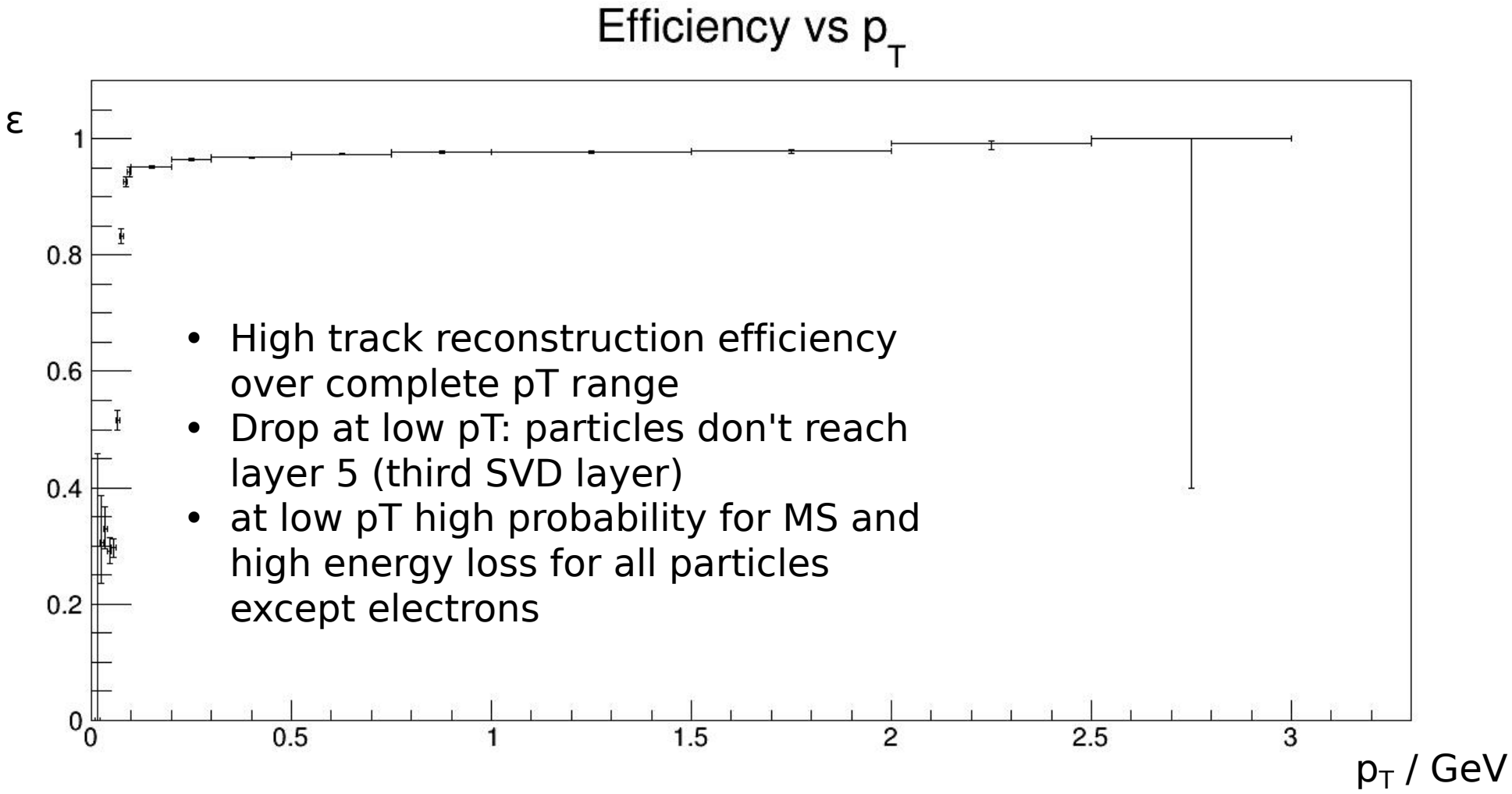


theta, phi, total efficiency vs p_T

Simulation setup:

- 50k Y(4S) events
- Tracks are considered found if:
  - $|\Delta\alpha_{\text{reco-MCTrue}}| < 5°$, $\alpha = \theta, \varphi$
  - $16° < \theta < 155°$ (angular SVD coverage)
  - track radius > 80mm (3rd SVD layer radius)
- good tracking and reconstruction performance over the complete p_T range that provides enough hits in ≥ 3 SVD layers ($p_T \geq 50$ MeV)
- But: ~100 fakes per event on average

Tracking - Results



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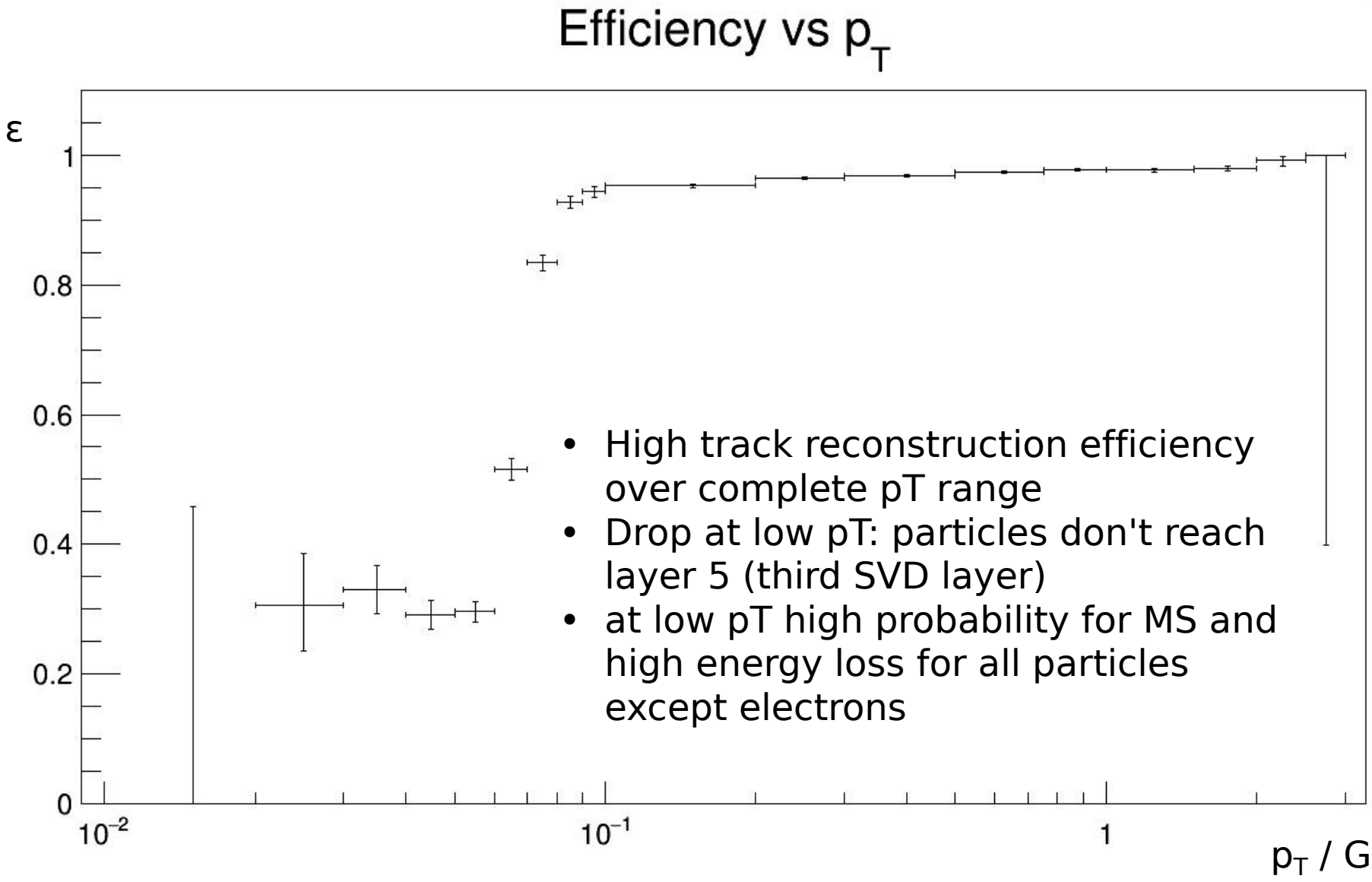
Tracking - Results



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