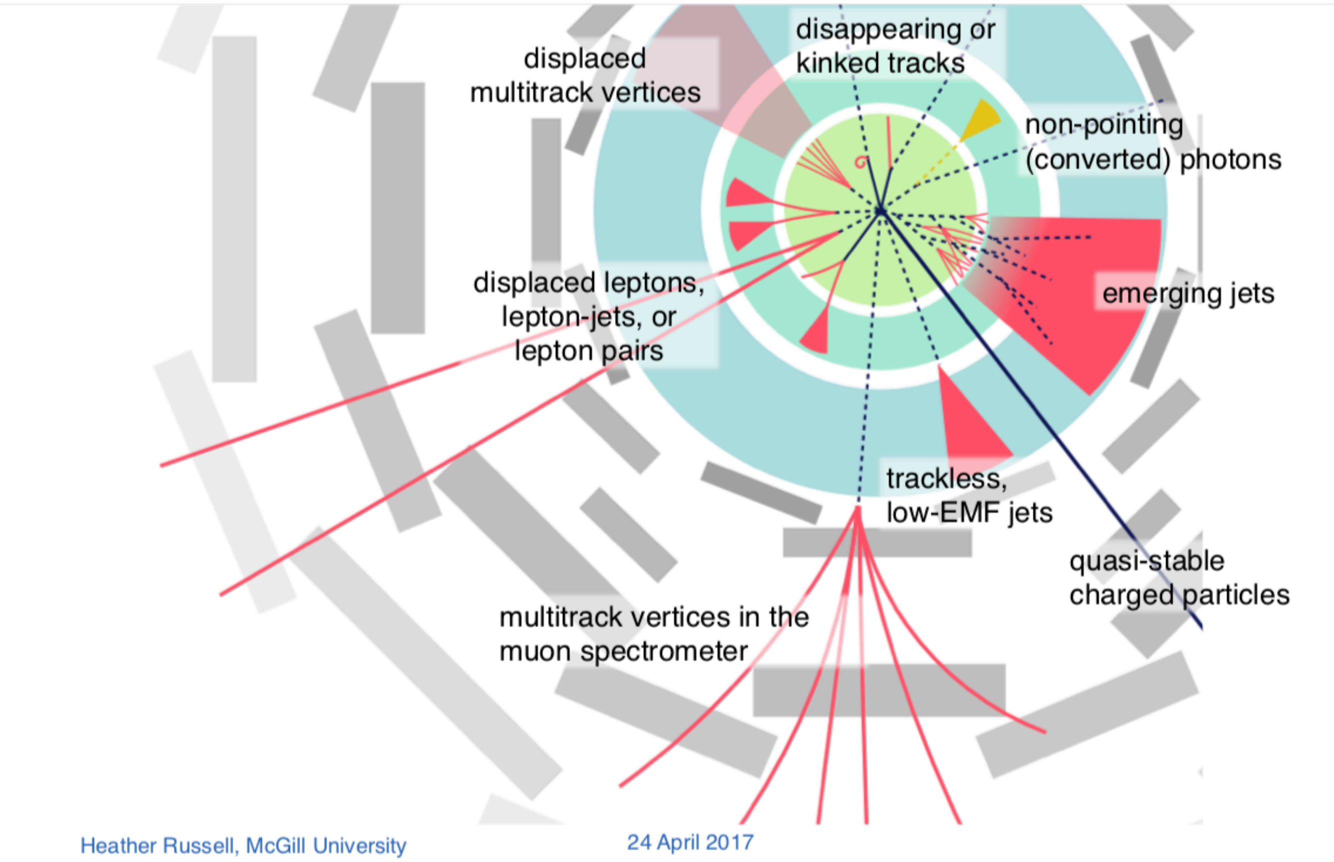
“Stub” track reconstruction at CLICdet

Emilia Leogrande (CERN)

Analysis Meeting
18 March 2019

Introduction



from Roberto's talk at CLIC workshop 2019

- signatures of new physics may be very diverse
- detectors at future colliders should be able to assess the broadest spectrum possible

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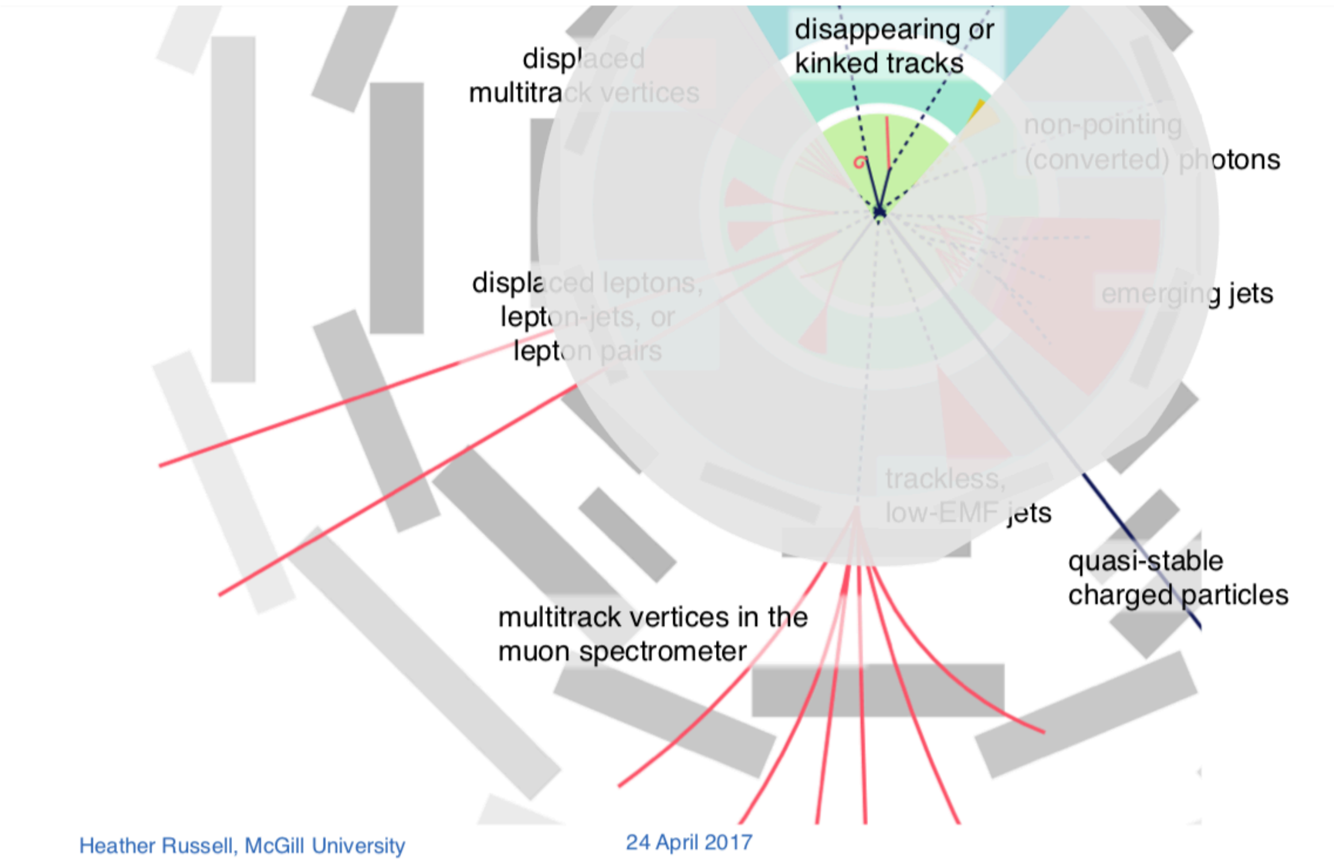

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- this preliminary study focuses on CLICdet capability of reconstructing disappearing tracks, a.k.a. 'stub' tracks

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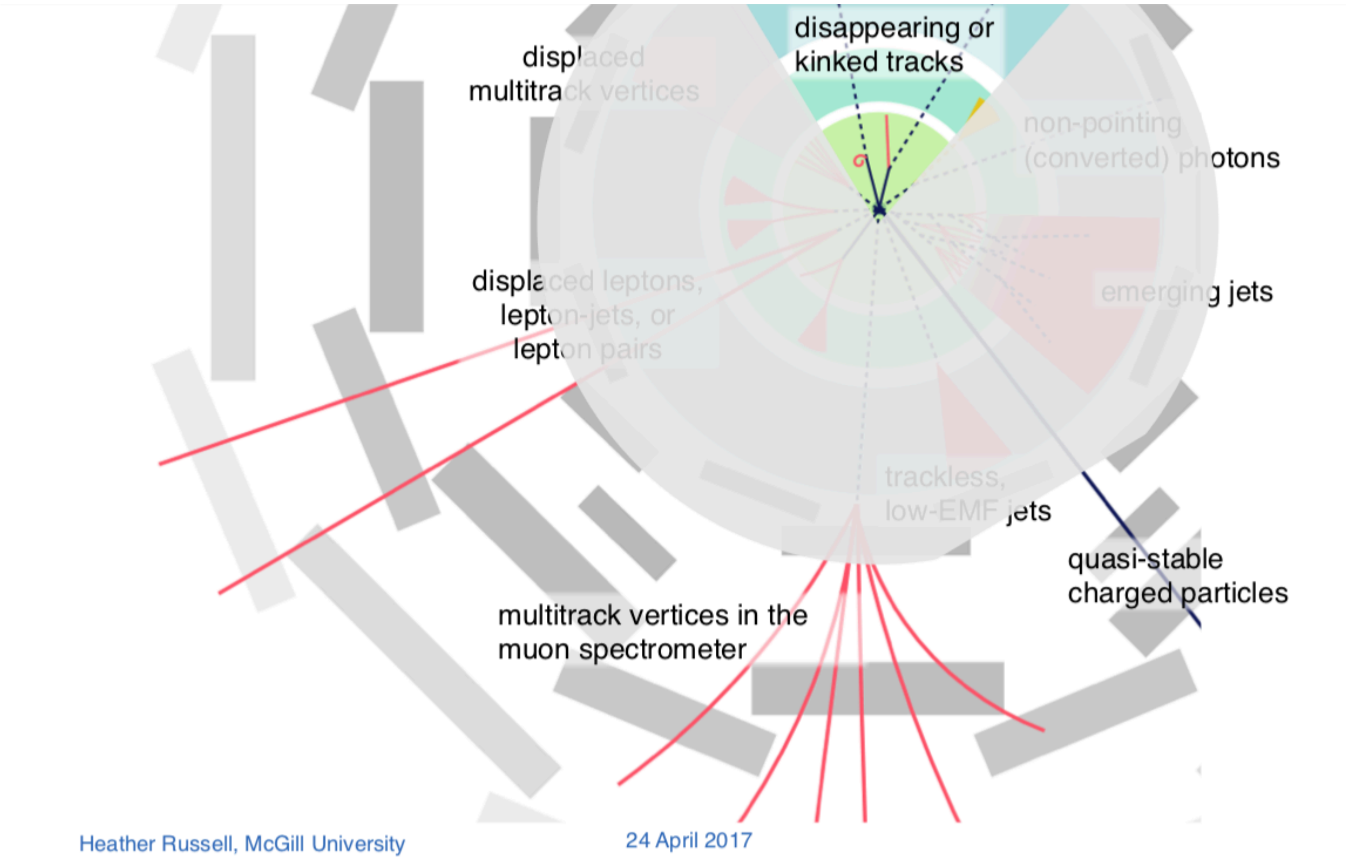

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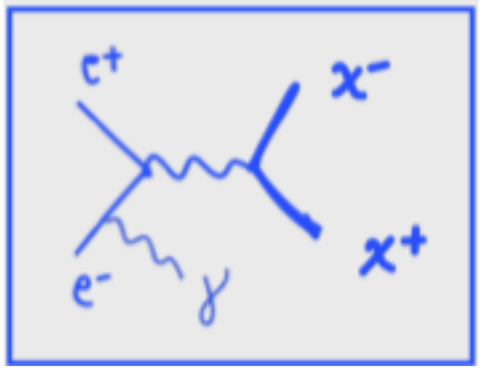
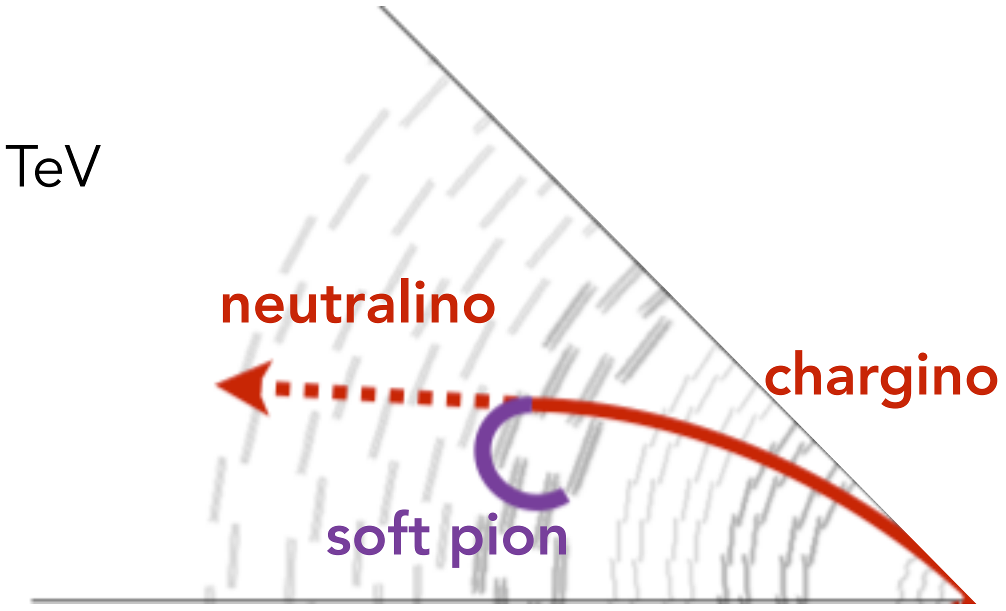
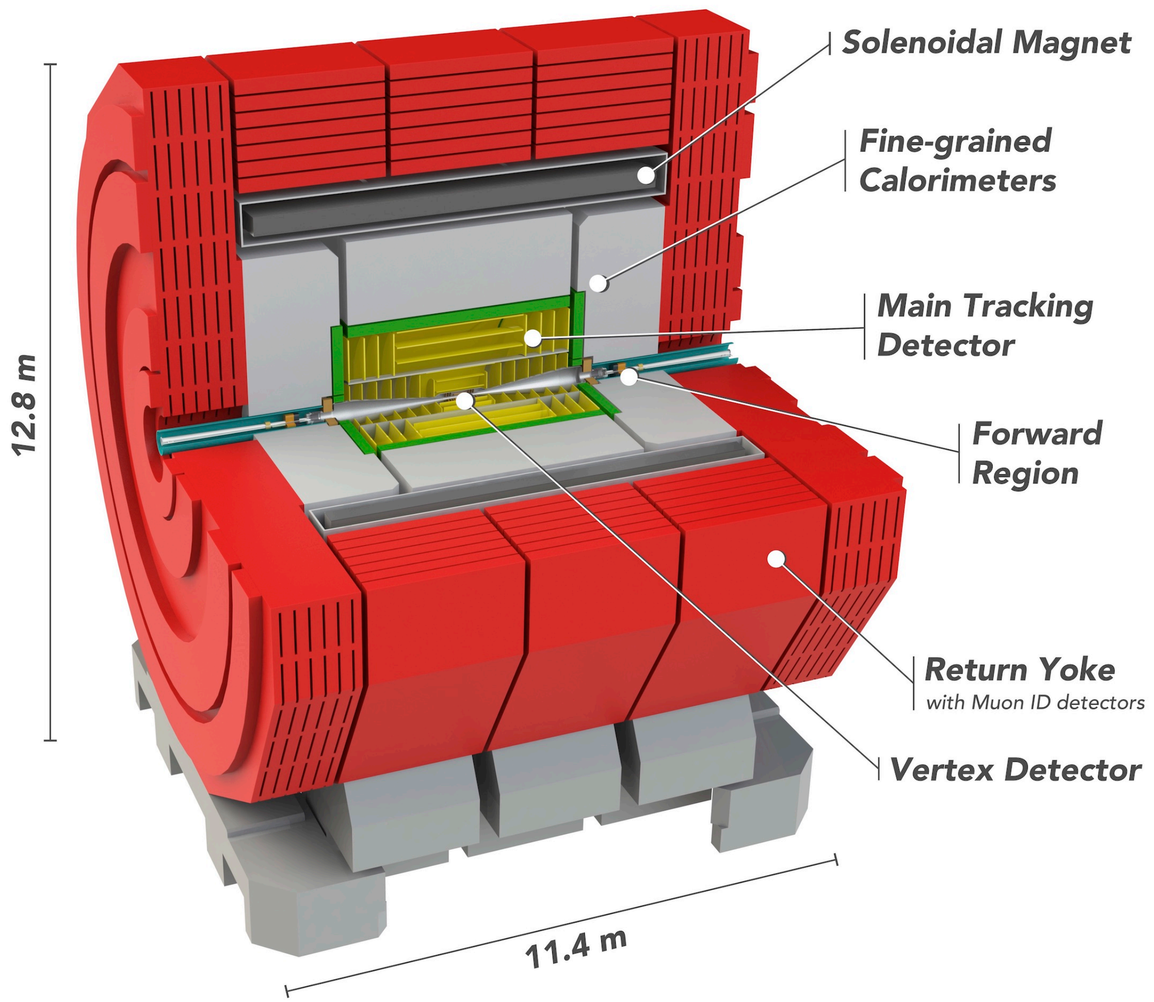


- e+e- @3 TeV => chargino E ~ 1.5 TeV
- chargino m = 1.05 TeV
- $p^2 = E^2 - m^2 = 1.07$ TeV
- => very straight and short tracks



Stubs in CLICdet



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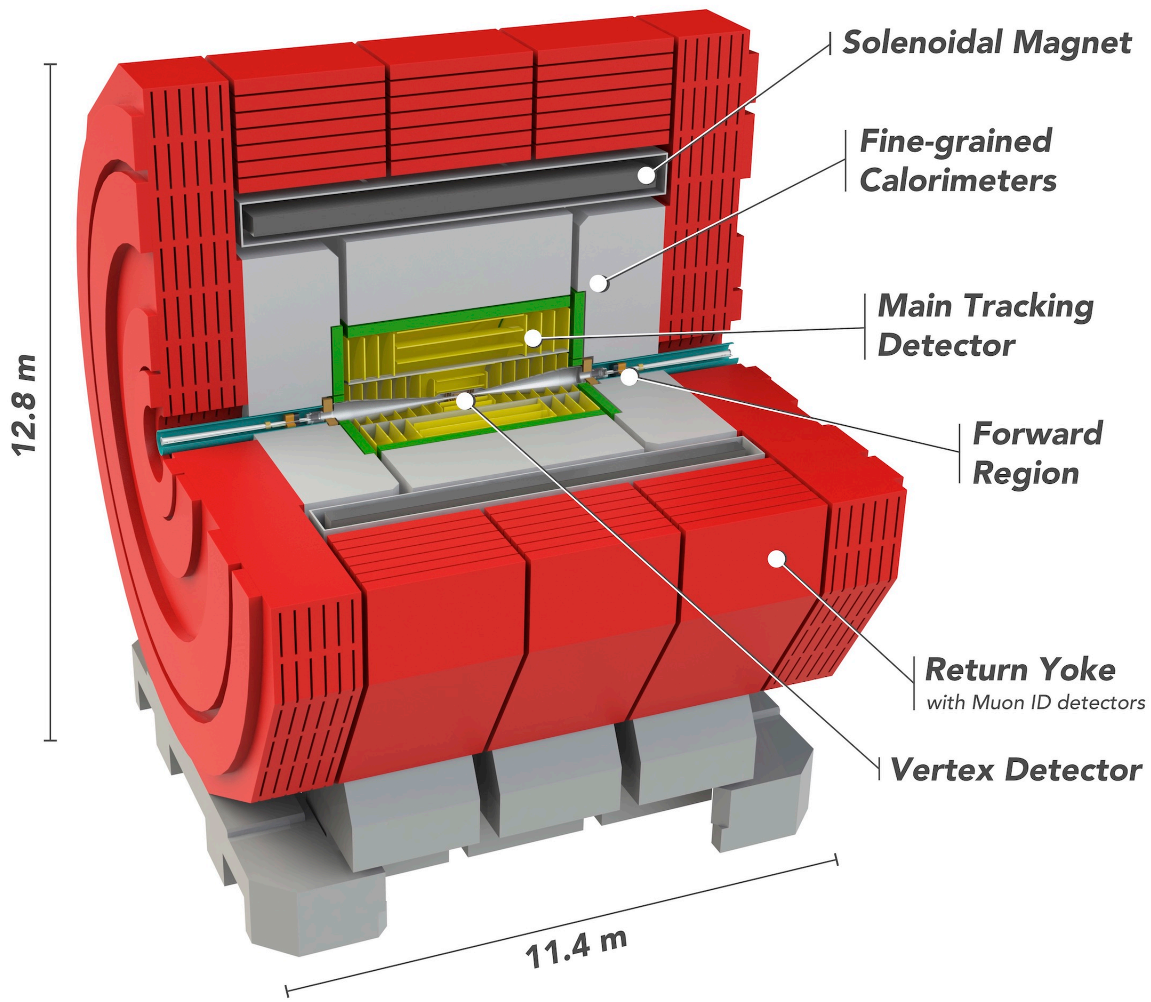
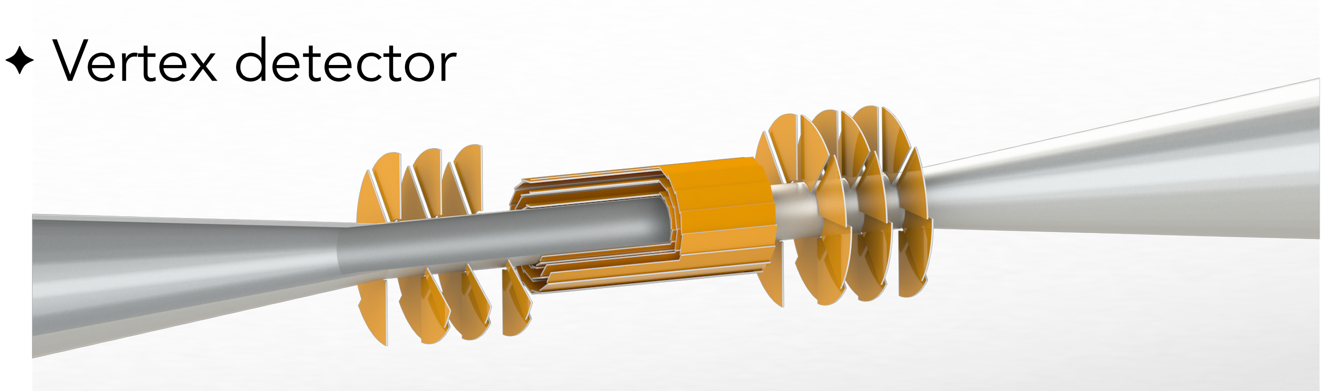
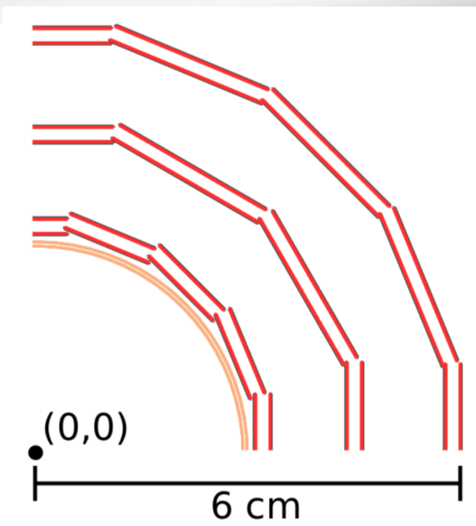


✦ Vertex detector

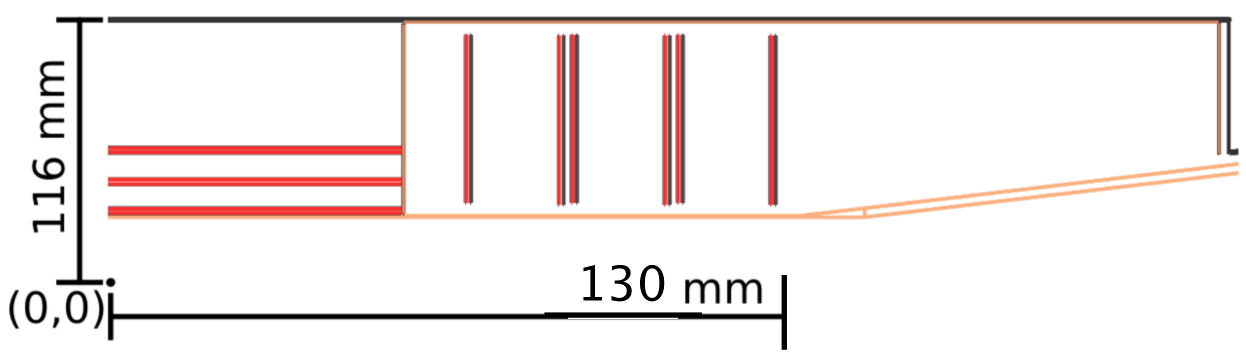


✦ single point resolution = 3 μm x 3 μm

barrel layers	radii [cm]
1 - 2	3.1 - 3.3
3 - 4	4.4 - 4.6
5 - 6	5.8 - 6.0



endcap layers	z [cm]
1 - 6	3.5 - 13.0



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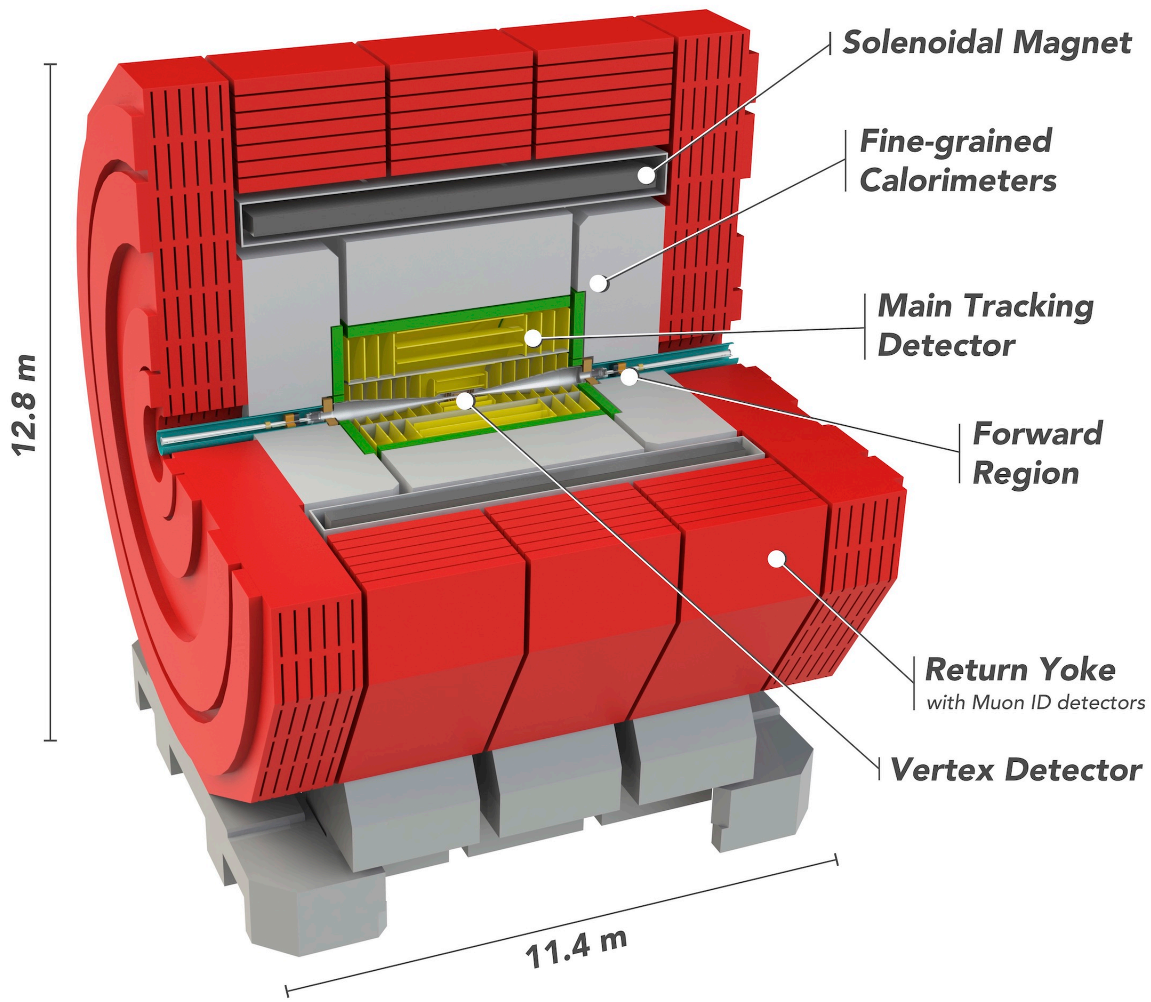

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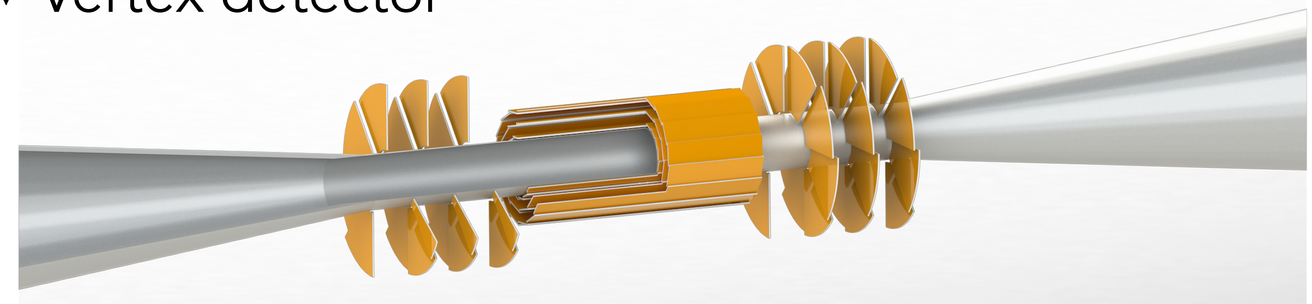

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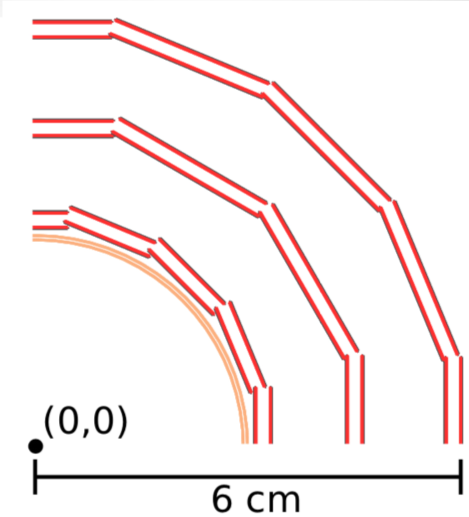

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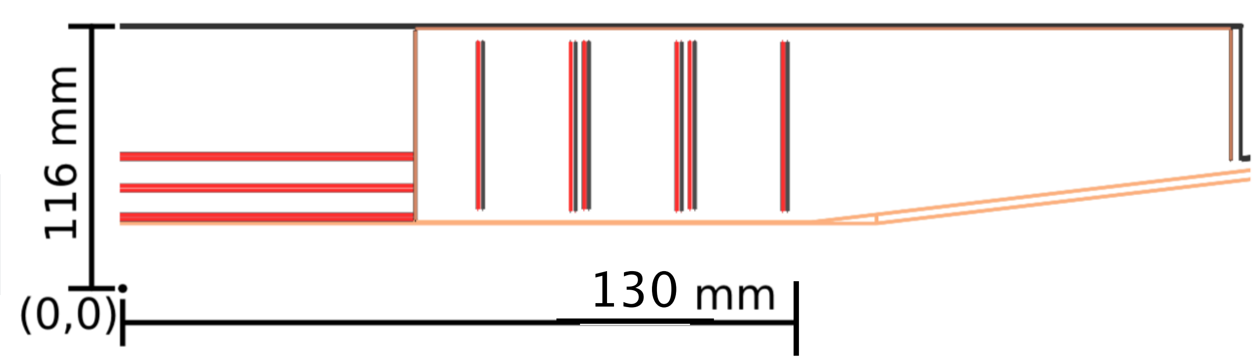
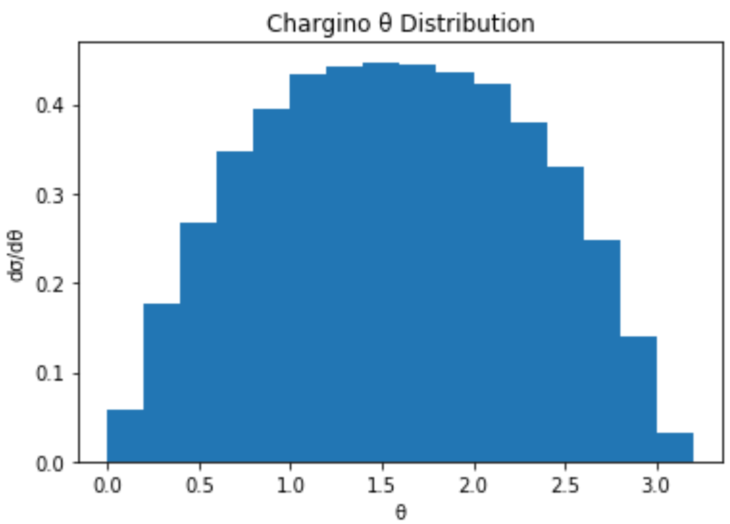


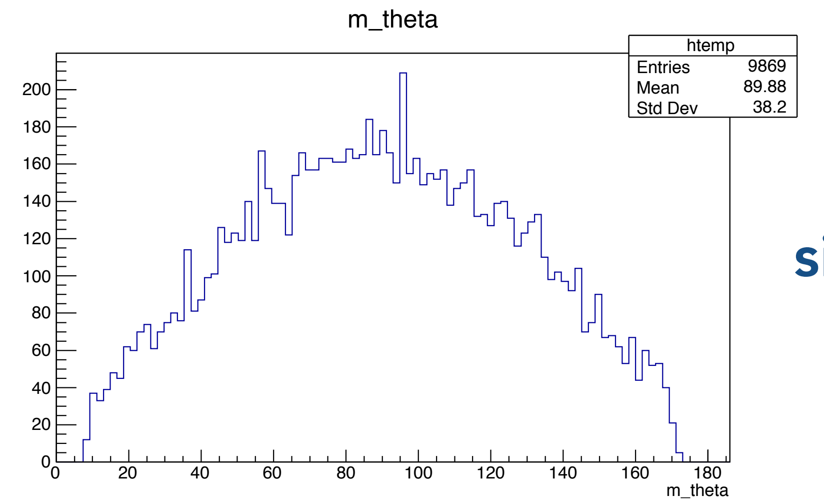
- Stub length O(cm) => in this study, the CLICdet has been **reduced to the vertex detector only**
- => workaround to make **artificially short** tracks

Simulation and reconstruction settings

- **Simulation (DDSim)**
  - [particle type] no MC samples available (yet) with realistic signal => easiest particle type: muons
  - [momentum] p = 1.0 TeV
  - [angular distribution] cos(theta)

theory



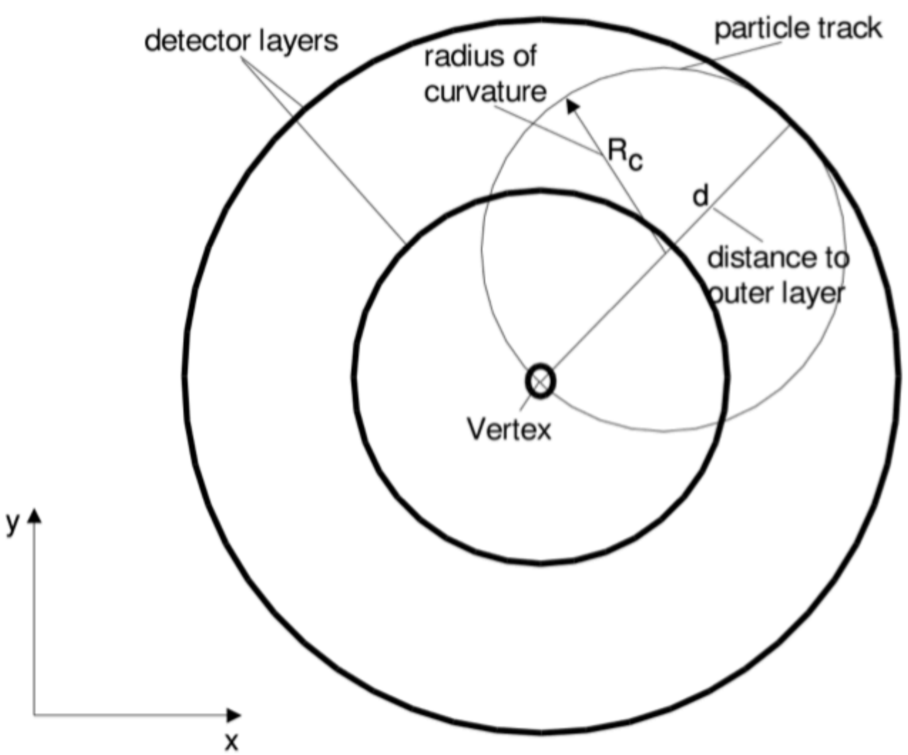


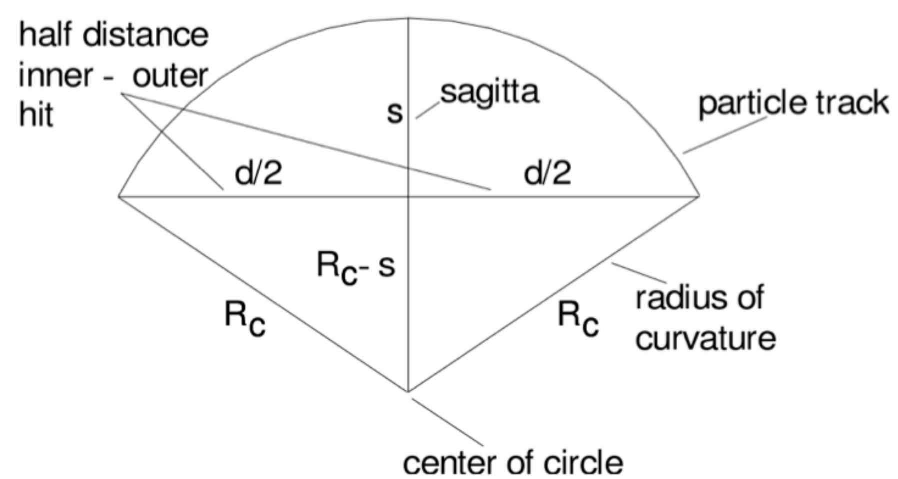
simulation

- **Reconstruction (Marlin)**
  - [software release] iLCSoft_2019-01-16
  - [tracking algorithm] conformal tracking
  - [relevant cut for prompt tracks] <u>min number of hits = 4</u>
    - N.B: interaction point not included in the pattern recognition, only used to constrain the fit

Analytical calculation: max reco p_T

- The sensitivity to the curvature of a particle in a given magnetic field depends on the **length of the track** (d) and on the **sagitta** (s)





$$\left(\frac{d}{2}\right)^2 + (R_c - s)^2 = R_c^2$$

(1)

$$=> R_c = \frac{\left(\frac{d}{2}\right)^2 + s^2}{2s}$$

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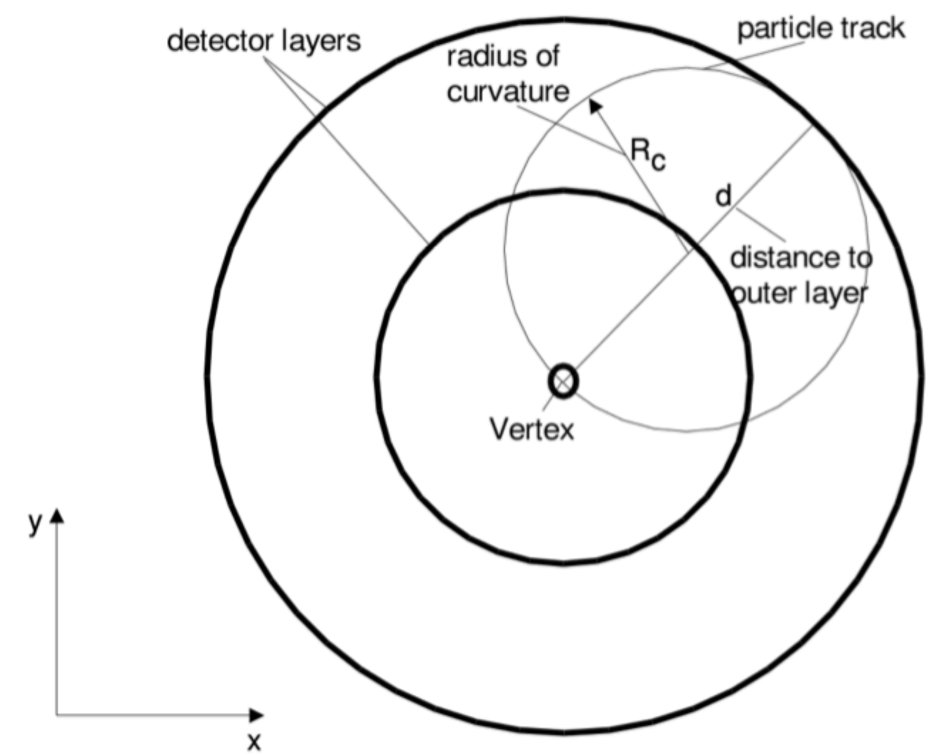

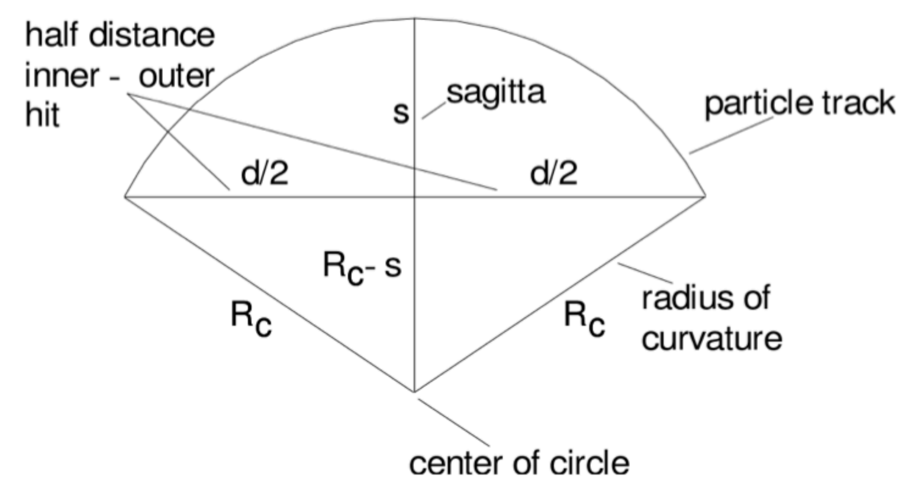

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(2) $$p_T = 0.3BR_c$$ p_T [GeV/c], B[T], R_c[m]

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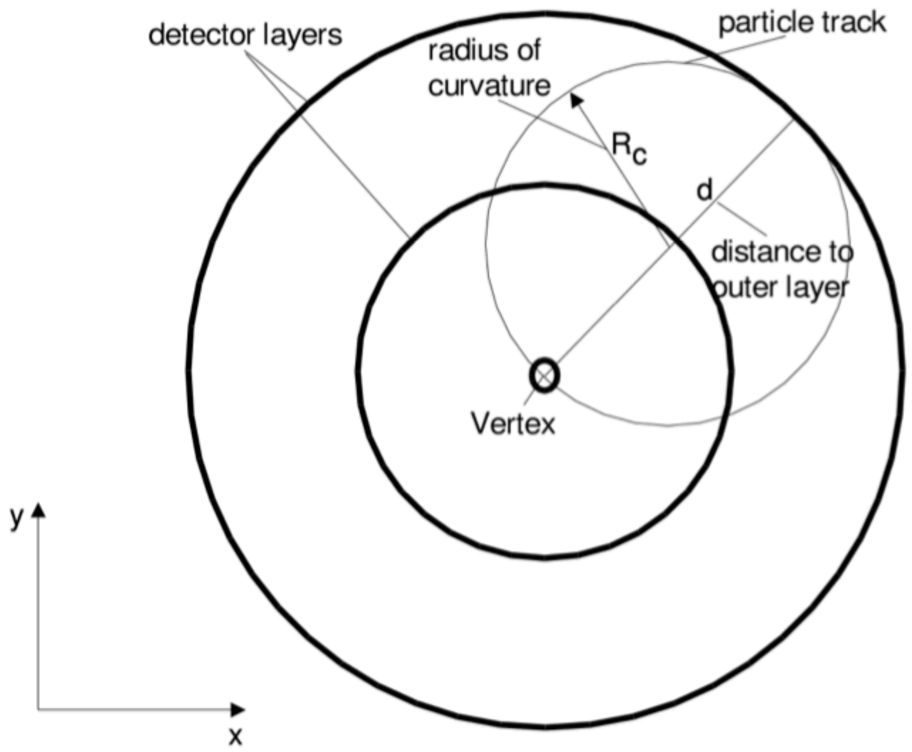

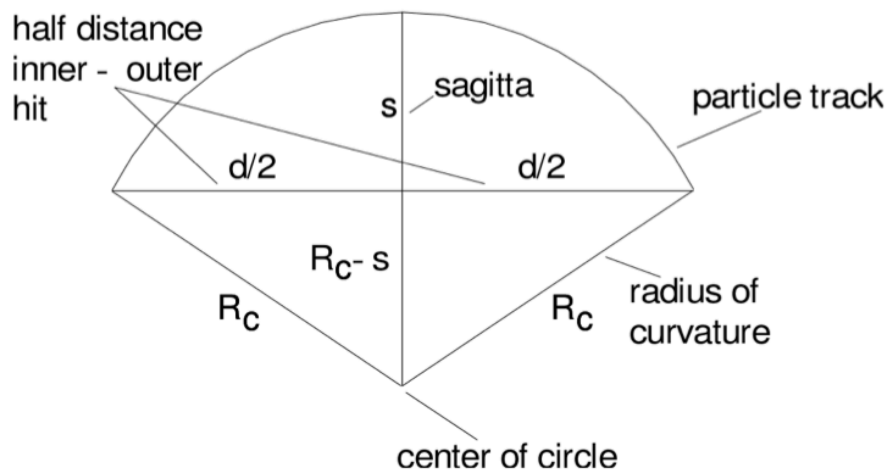

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- Combining (1) and (2):

$$p_\mathrm{T} = 0.3B\frac{\left(\frac{d}{2}\right)^2 + s^2}{2s}$$

Analytical calculation applied to CLICdet

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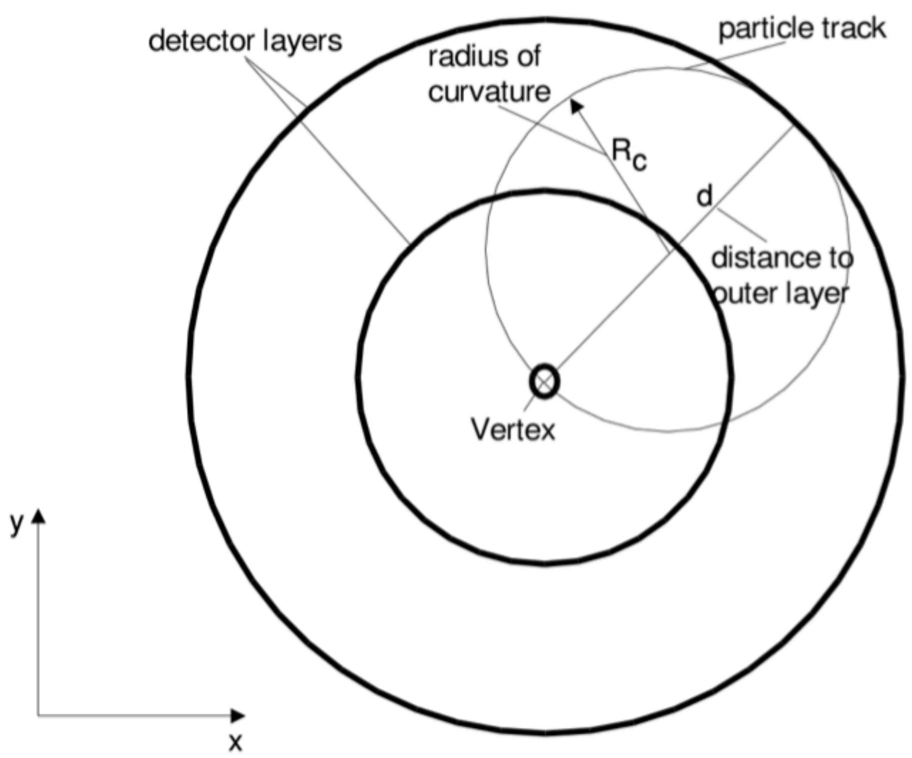

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- [**length (d)**] given that the IP is not a measurements (i.e. a hit on the track), the track length has to be calculated as the **difference between the outermost and innermost hit radii**
- [**sagitta (s)**] should correspond to the error on the intermediate hit position (single point resolution). Since we have double layers, the single point resolution corresponds to as **3μm/sqrt(2)**

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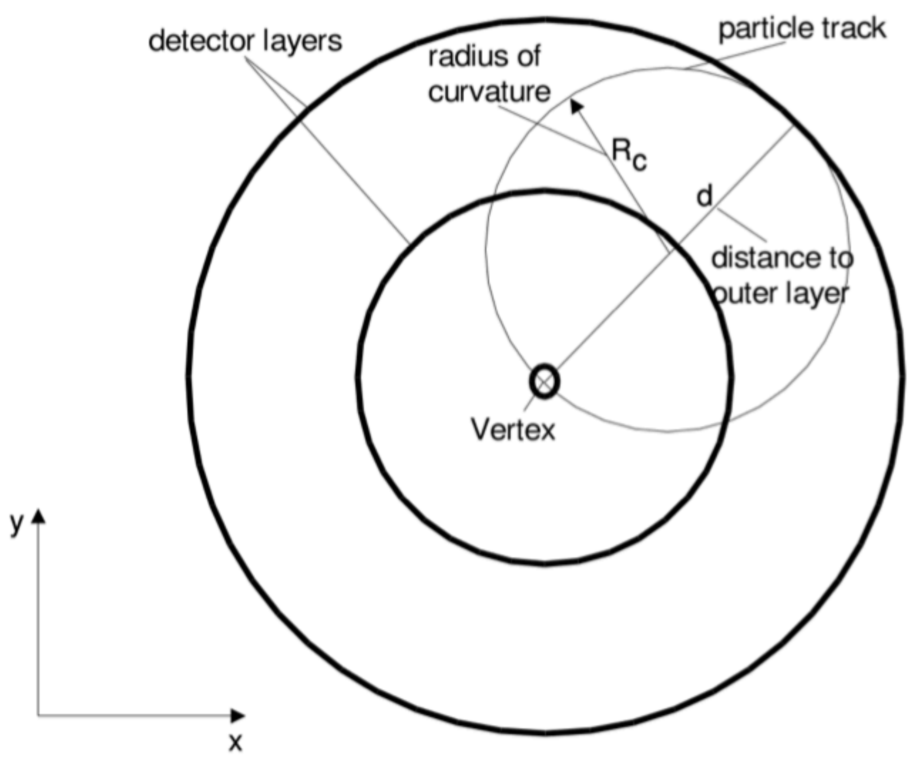

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- Polar angle distribution central-peaked => let's focus on the barrel
- [max hits = 6] d = r_{max} - r_{min} = 2.9 cm => p_T ~ 60 GeV/c
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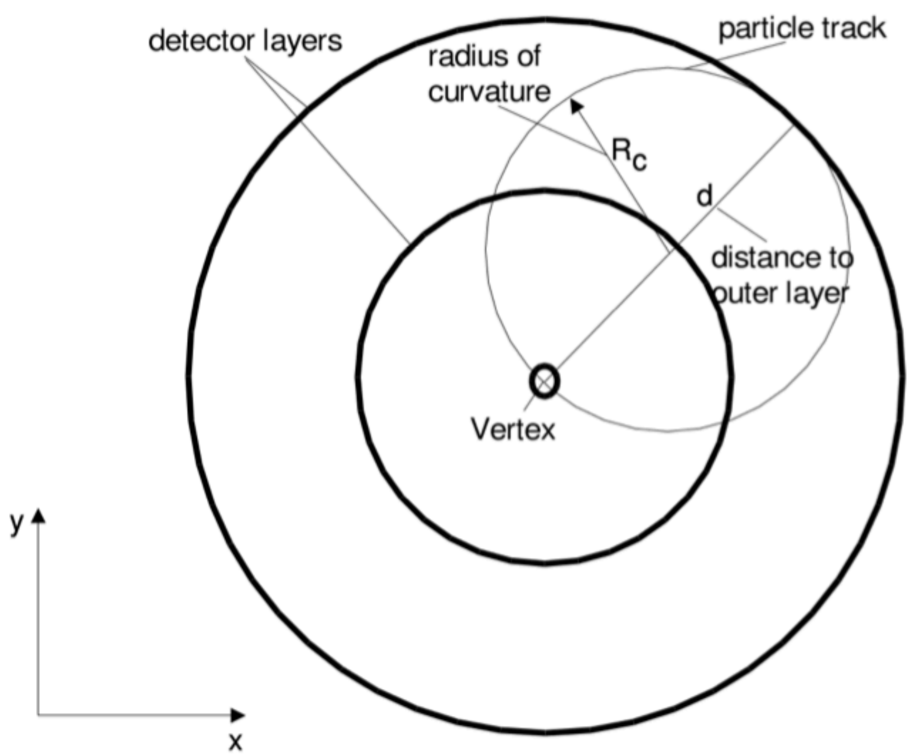

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- If IP would be included in the track:
  - d = 6.0 cm => p_T ~ 254 GeV/c
  - d = 4.6 cm => p_T ~ 150 GeV/c

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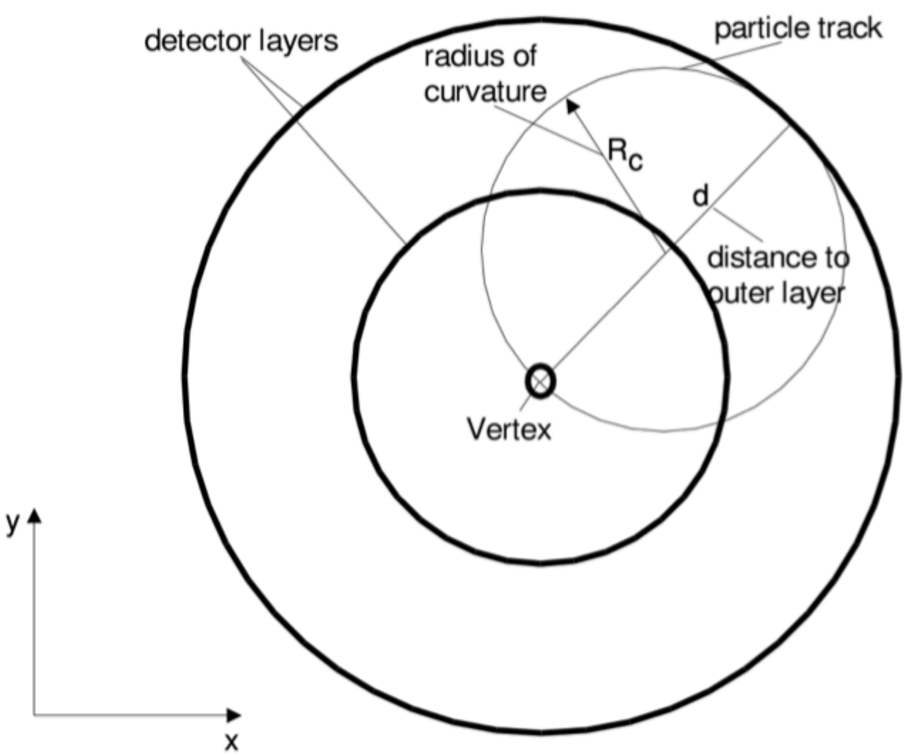

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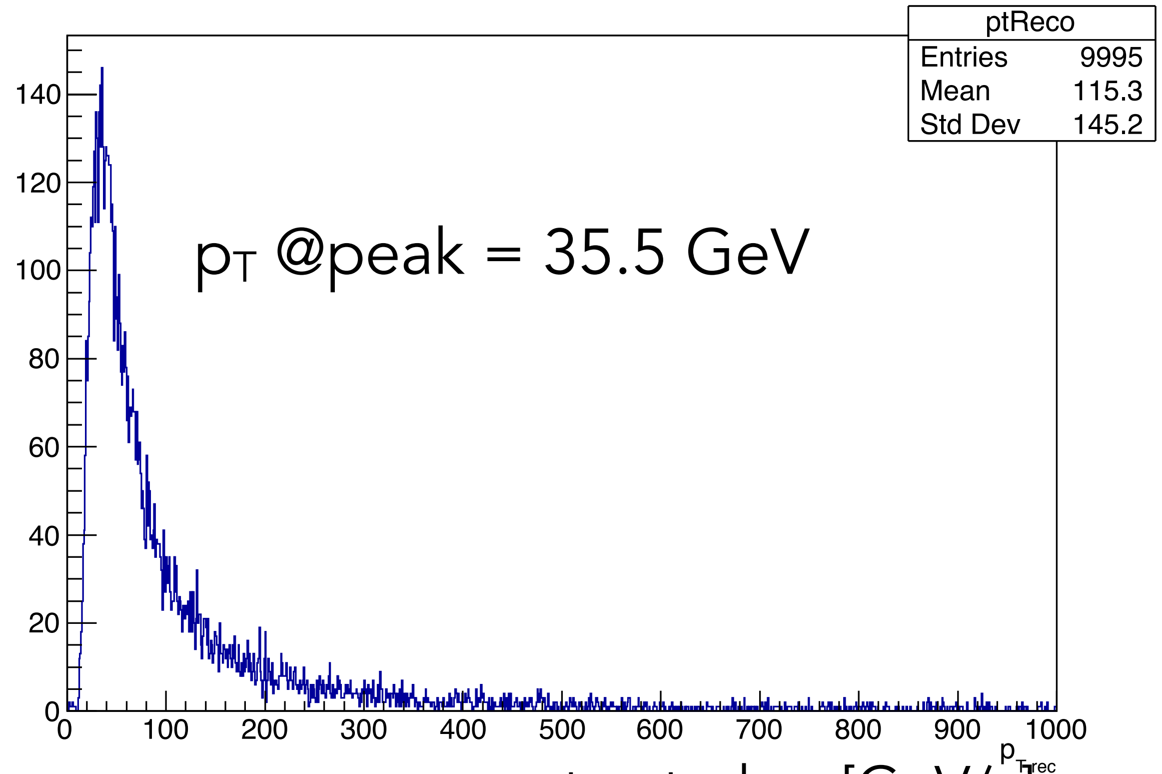
- *N.B: this estimation is just an approximation, since no error on the hit measurements (innermost, outermost) is included*

Results for reconstructed p_T

✦ Muons p = 1 TeV, θ = 89 deg (simplified case)
[max hits = 6] d = 2.9 cm => p_T ~ 60 GeV/c



p_T @peak = 35.5 GeV

reconstructed p_T [GeV/c]

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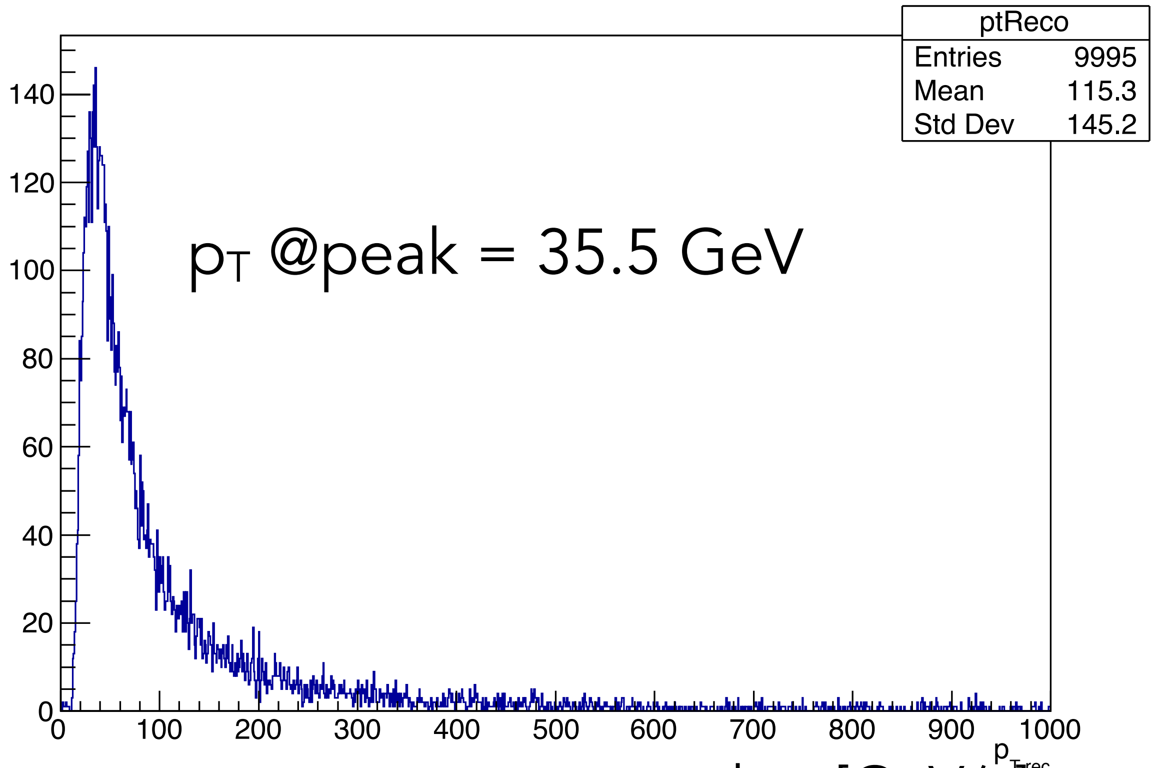

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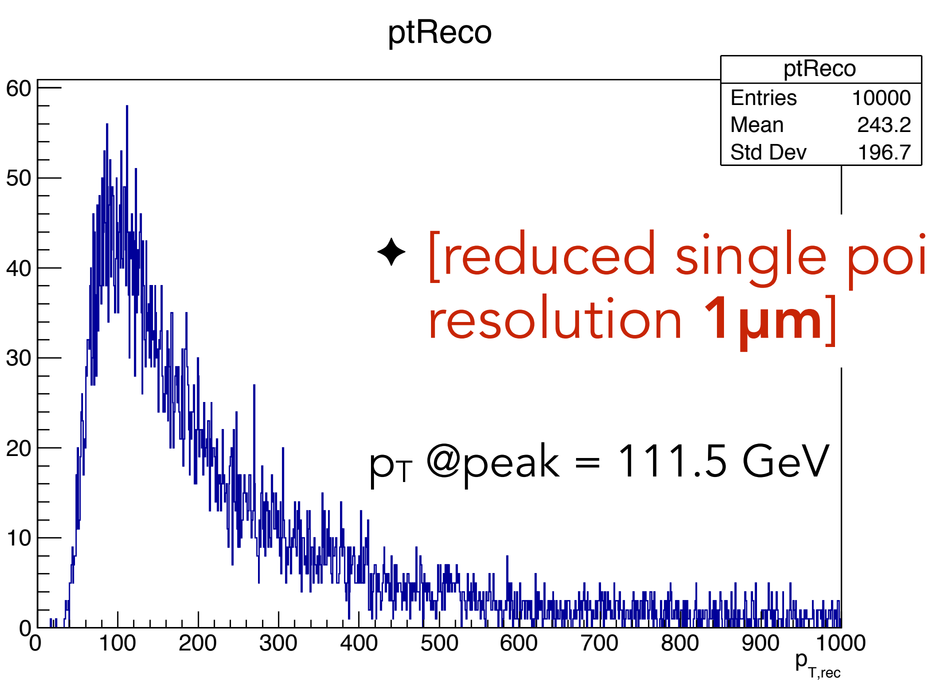

- [reduced single point resolution **1µm**]

p_T @peak = 111.5 GeV

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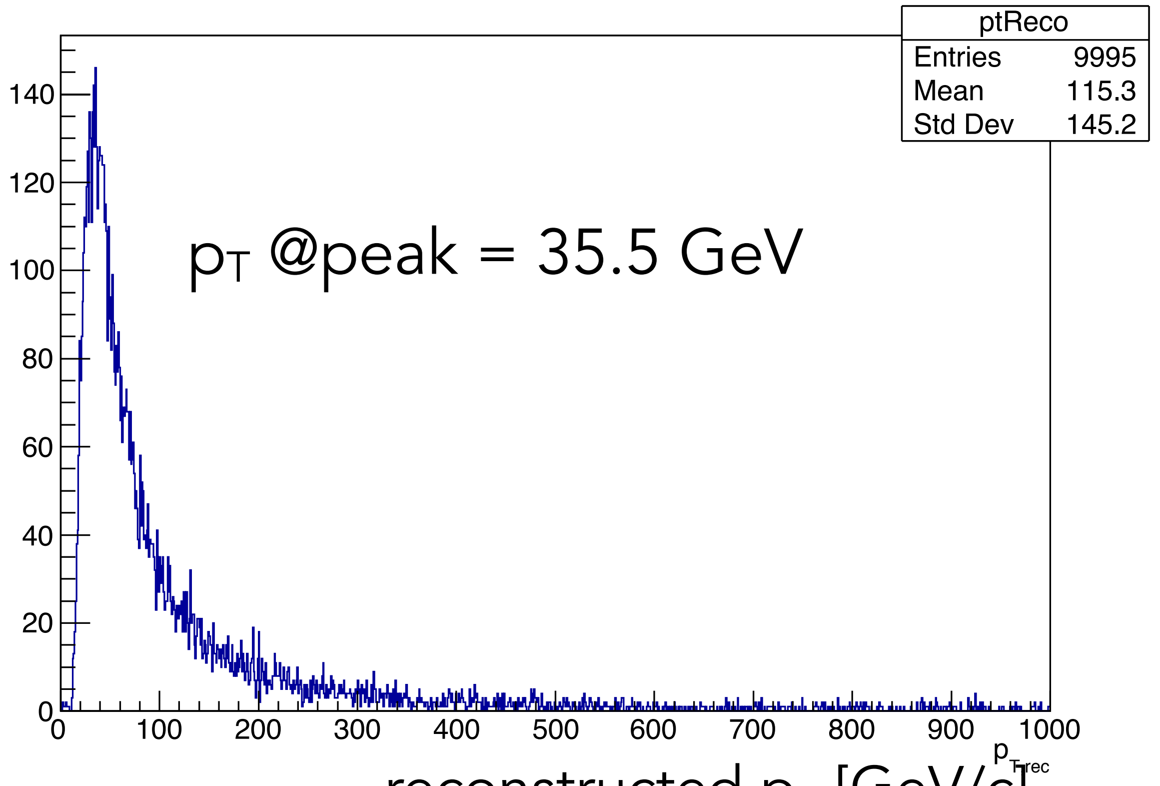

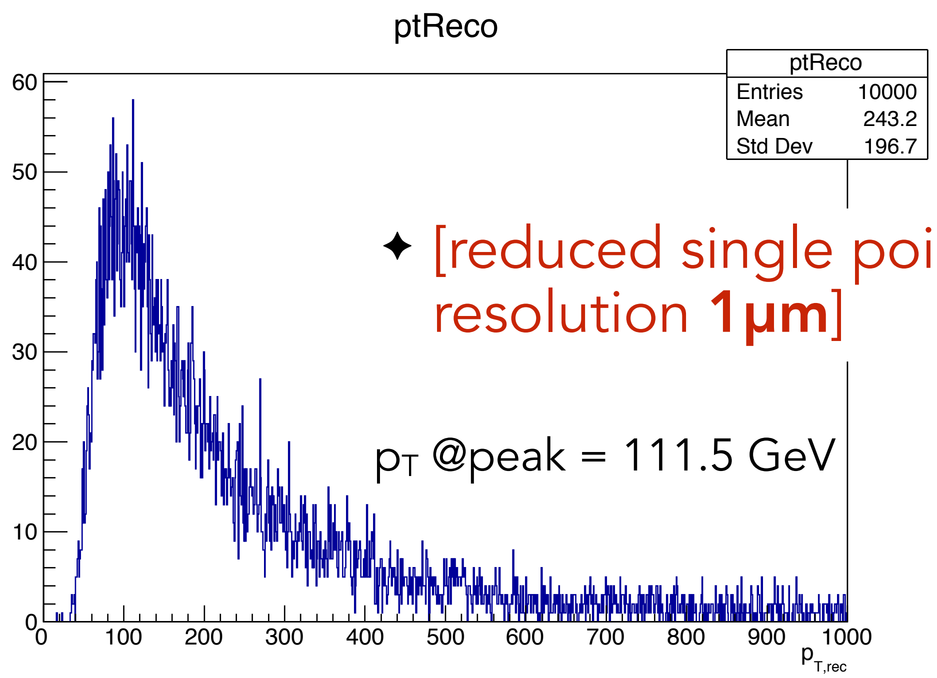

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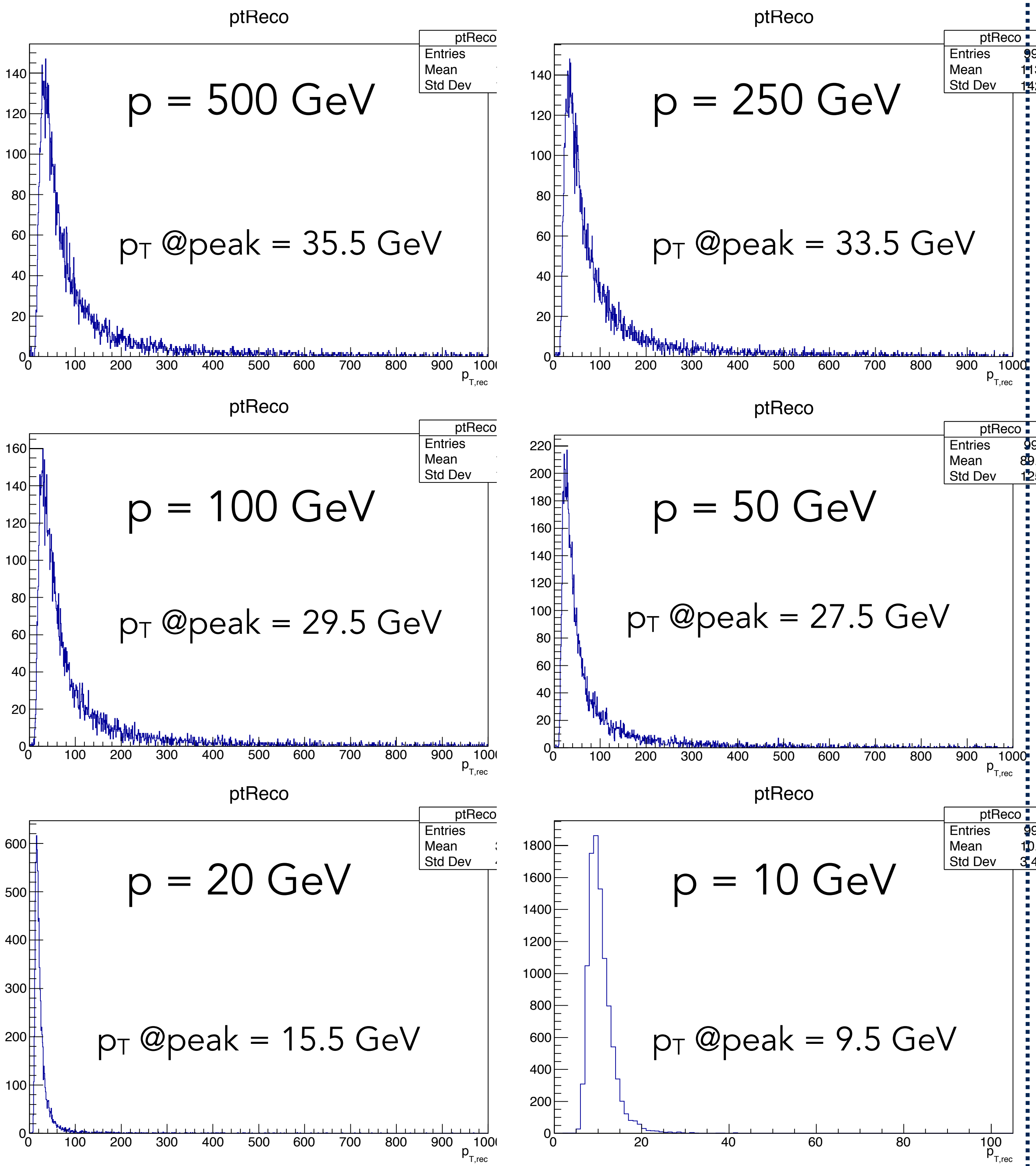
✦ Momentum scan



Conclusions on stub p_T reconstruction

- The hard limit on the maximum reconstructed p_T is given by a combination of magnetic field, stub track length and single point resolution

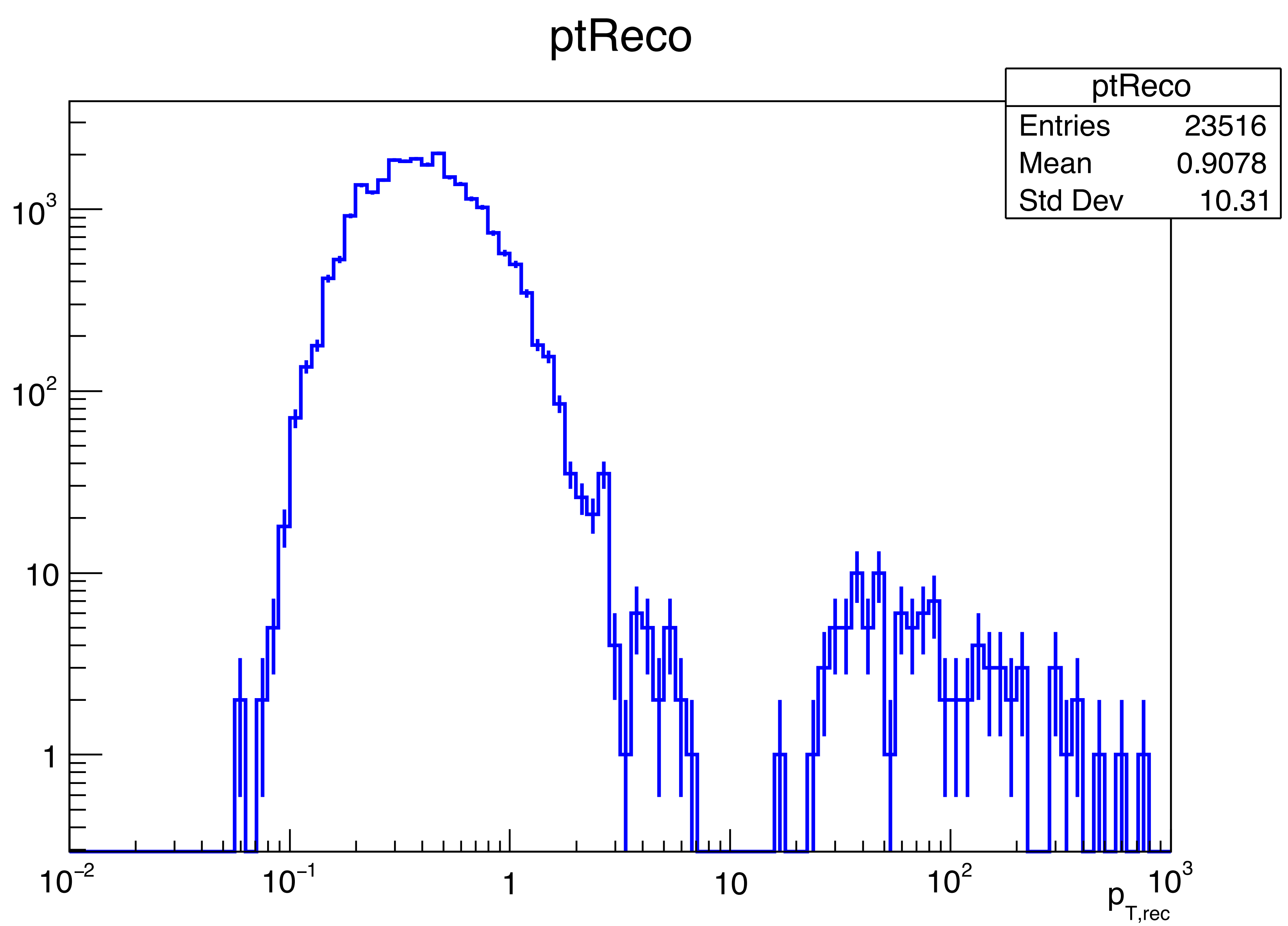
- For stub tracks of p = 1 TeV in the barrel (θ = 89 deg) and length d
  - From analytical estimate:
    - [max hits = 6] d = r_{max} - r_{min} = 2.9 cm => p_T ~ 60 GeV/c
    - [min hits = 4] d = r_{max} - r_{min} = 1.5 cm => p_T ~ 16 GeV/c
  - From analytical estimate and IP included as innermost hit on track:
    - [max hits = 6] d = 6.0 cm => p_T ~ 254 GeV/c
    - [min hits = 4] d = 4.6 cm => p_T ~ 150 GeV/c
  - From full simulation results [# hits = max hits = 6]:
    - [single point resolution 3μm (default)] mode of the reco p_T distribution ~ 35 GeV/c
    - [single point resolution 1μm] mode ~ 110 GeV/c

$$p_{\mathrm{T}} = 0.3B\frac{\left(\frac{d}{2}\right)^2 + s^2}{2s}$$

- To be able to reconstruct properly the p_T of a 1 TeV track in the barrel
  - [single point resolution 3μm] stub length should be at least 12 cm
  - [single point resolution 1μm] stub length should be at least 7 cm

Stub tracks with γγ—>hadron overlay

- ✦ 100 physics events: "short" muons with p = 1 TeV, θ = 89 deg
- ✦ Overlay of 30BX (10BX before the physics event, 20BX after)



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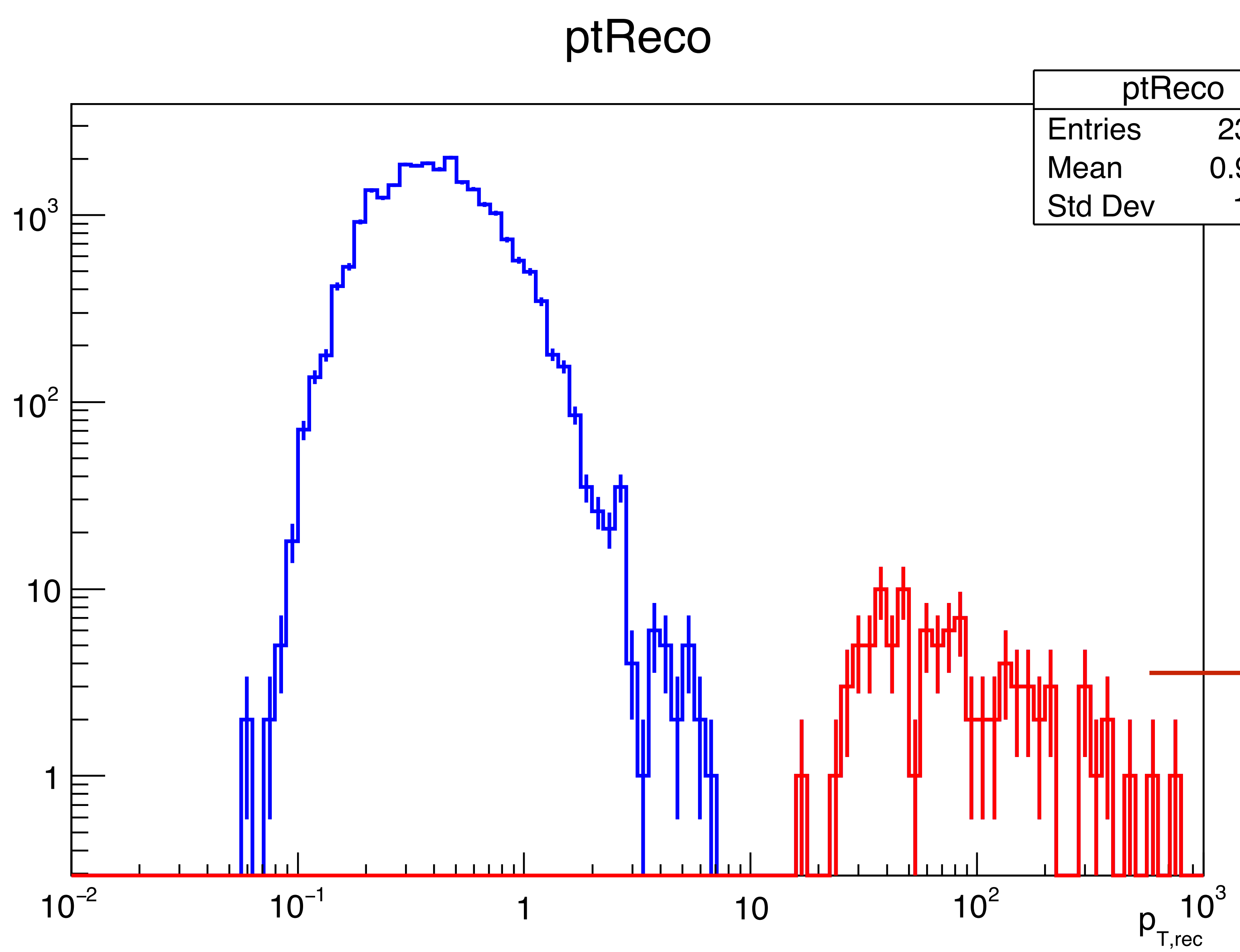

✦ the signal!

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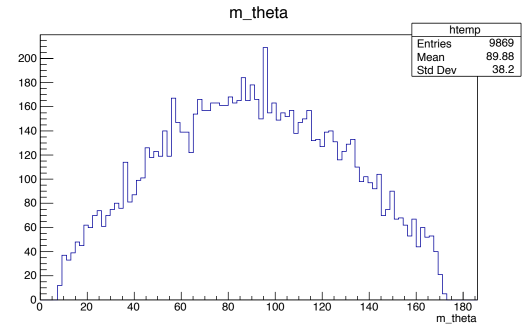

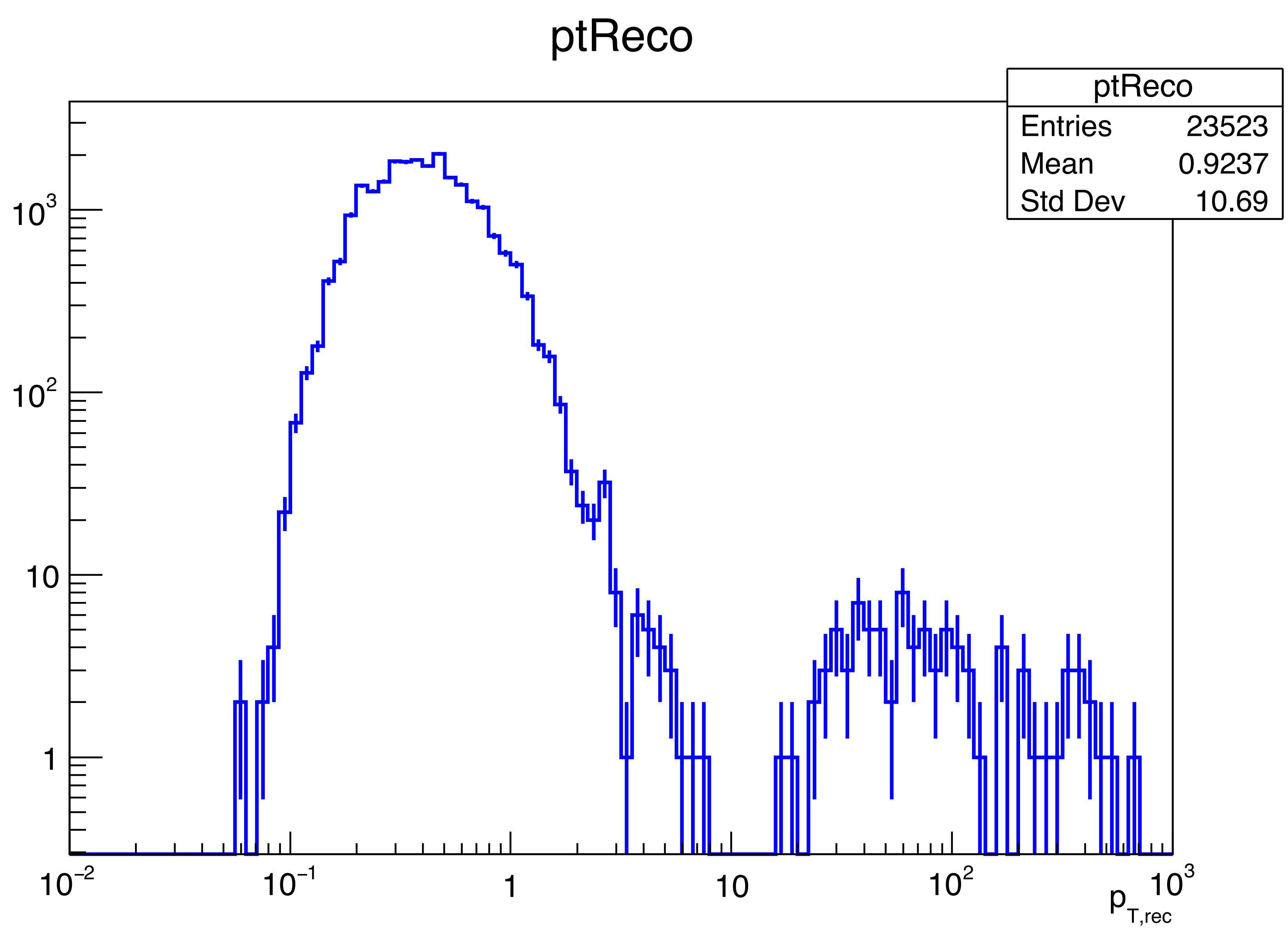

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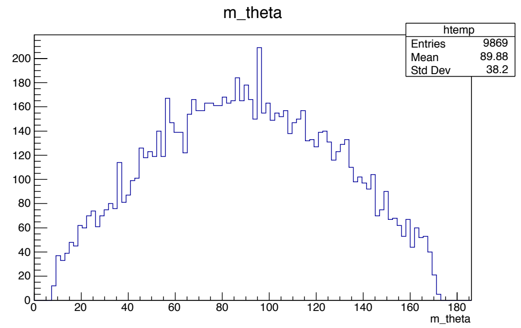
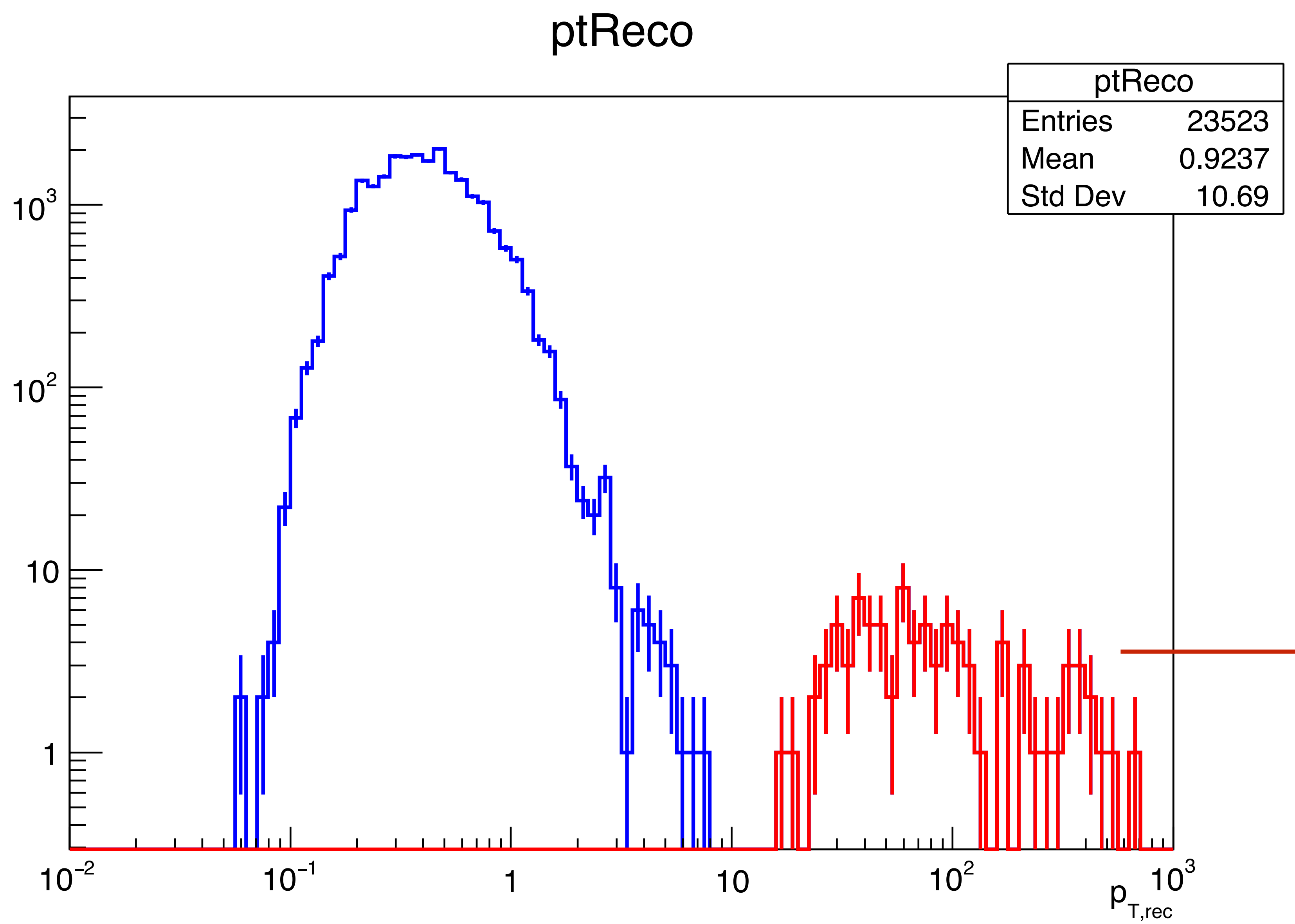
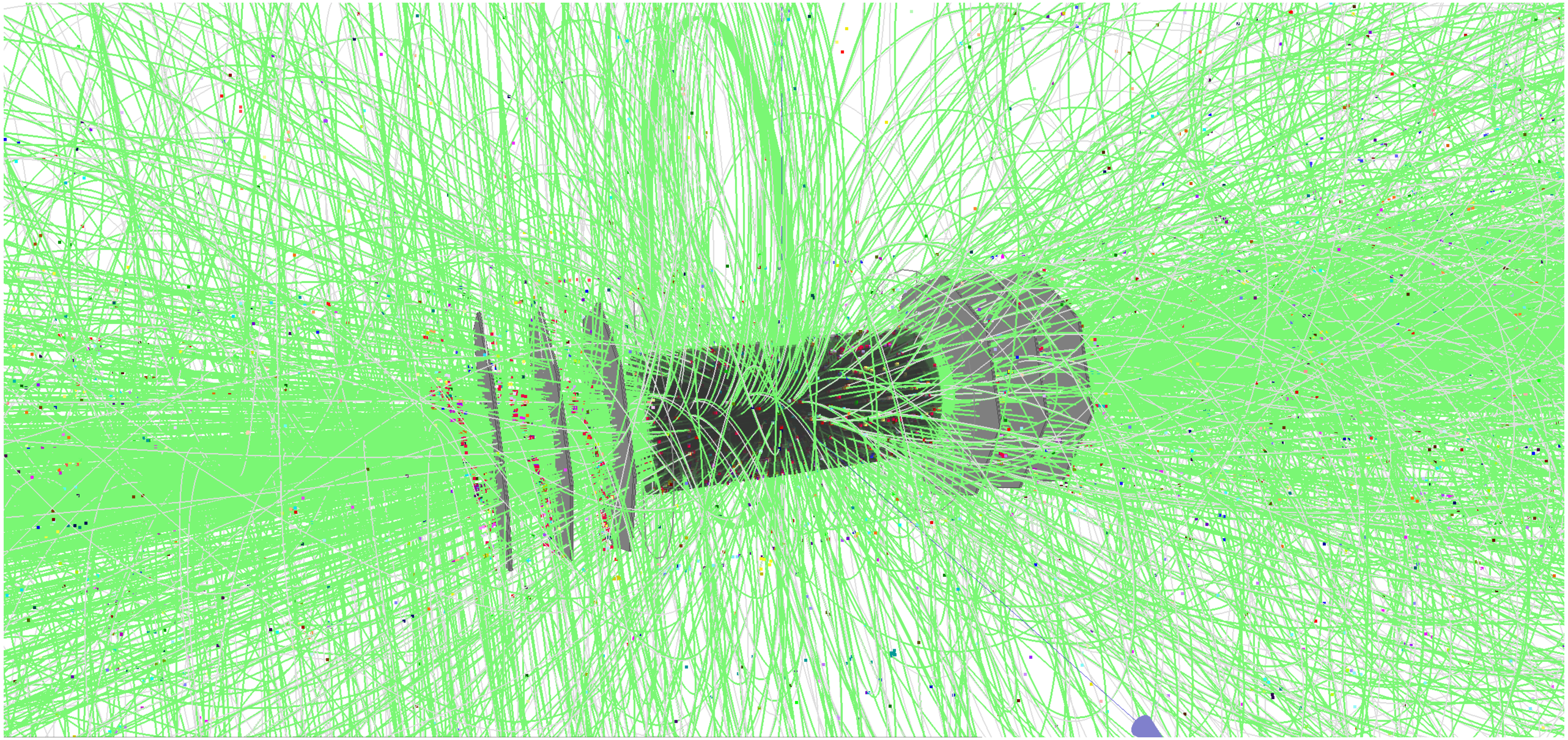




✦ the signal!

Stub tracks with γγ—>hadron overlay

✦ …this is how it looks like



✦ The high energy of the stub tracks is problematic in terms of p_T resolution, but it is an advantage in terms of background subtraction

✦ More dedicated studies will follow to assess the reconstruction efficiency of realistic chargino samples [Ulrike, Erica, CLICdp Summer Student 2019]