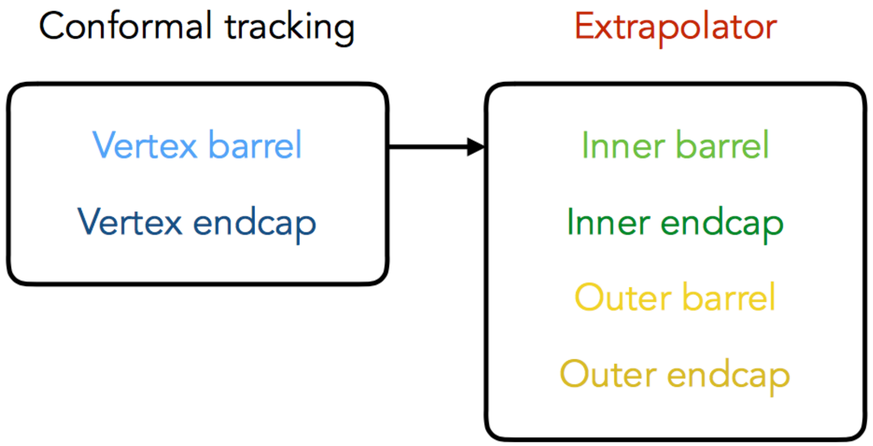
Current status of the tracking software and detector validation

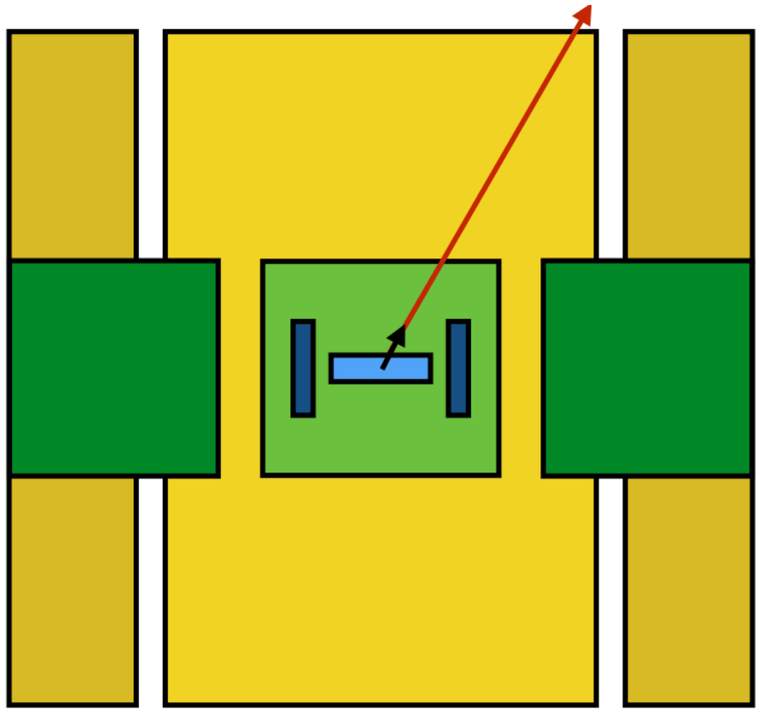
Emilia Leogrande, Daniel Hynds

CLICdp detector optimization and validation meeting

CERN – 1st Aug 2017

From last meeting





Overview - intention

Conformal tracking

Build tracks	Vertex barrel	Standard cuts
Extend tracks	Vertex endcap	Standard cuts
Build tracks	Vertex B+E	Standard cuts
Build tracks	Vertex B+E	Looser cuts
Extend tracks	Tracker collections	Standard cuts
Extend tracks	Tracker collections	Looser cuts
Build tracks	All collections	Displaced cuts

Outline of this talk

- Software validation and detector model optimization proceed closely intertwined

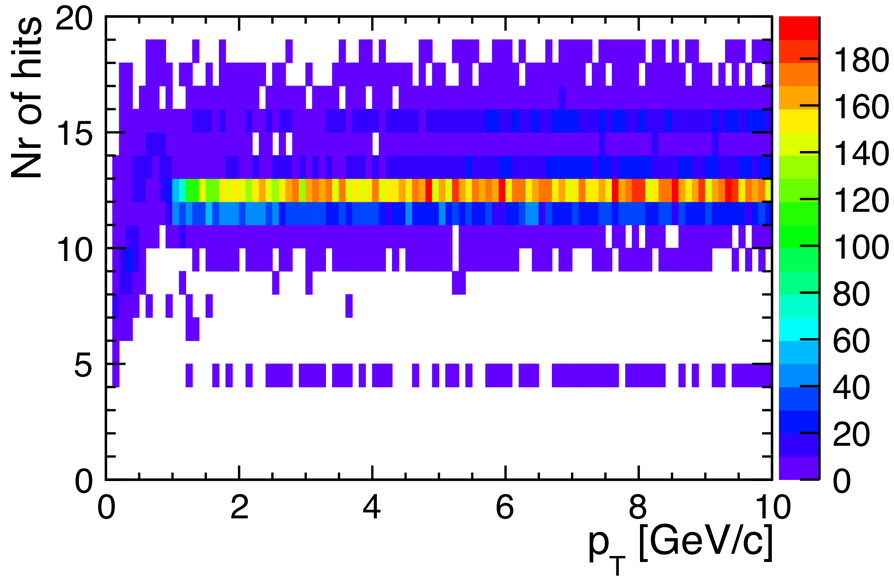
- The performances of the latest CLIC detector model (CLIC_o3_v11) have been studied with the latest iLCSoft release (2017-07-27) comparing 3 different tracking algorithms:
  - Truth tracking ('cheating' pattern recognition that assigns hits to the tracks based on MC information)
  - Conformal tracking + Extrapolator (hits from the vertex barrel and endcaps are transformed in conformal space and fitted with a straight line; tracks are then extrapolated through inner and outer tracker)
  - Conformal tracking full (hits from the full tracking system, i.e. vertex and tracker, are transformed in conformal space and fitted with a straight line to make the tracks)

  - Single mu, Z=>uds and ttbar events are simulated and reconstructed to test:
    - pattern recognition in terms of number of hits per track
    - tracking efficiency
    - momentum resolution
    - first look at displaced tracks

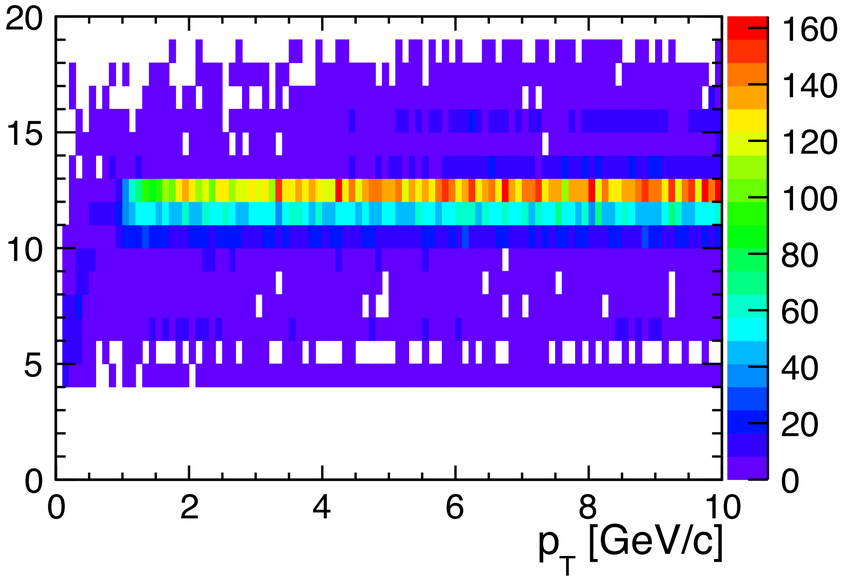
Testing pattern recognition algorithms

- 2M single muon events
  - isotropic angular distribution, linear energy distribution 0-500GeV
- Hits per track distribution as a function of p_T, θ and φ

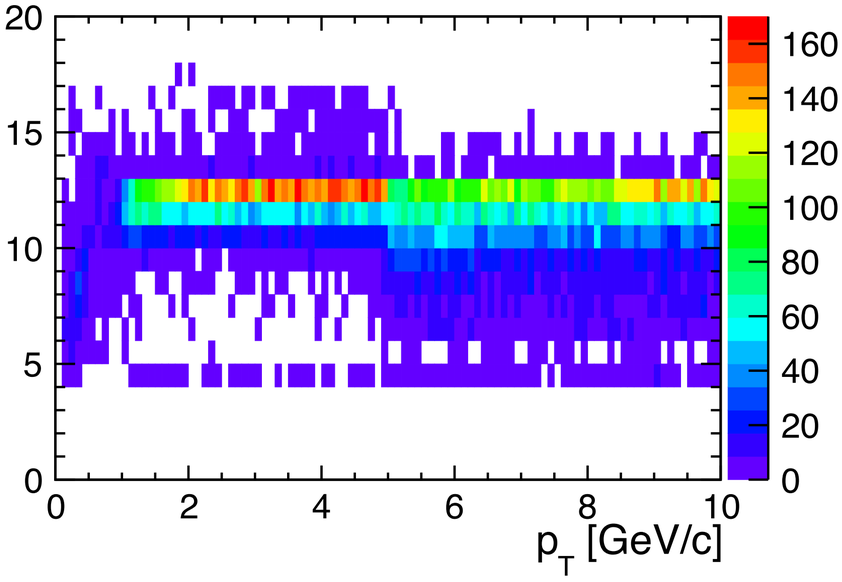
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



Conformal Tracking (FULL)



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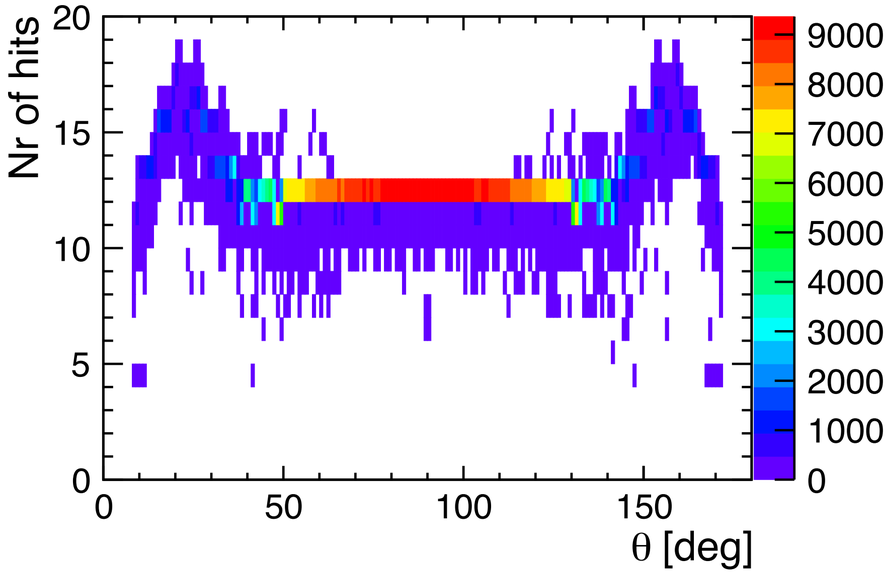

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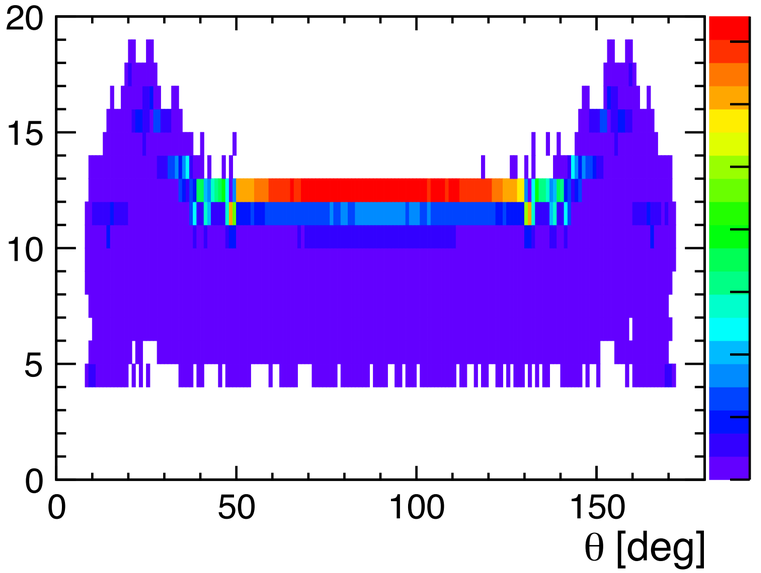

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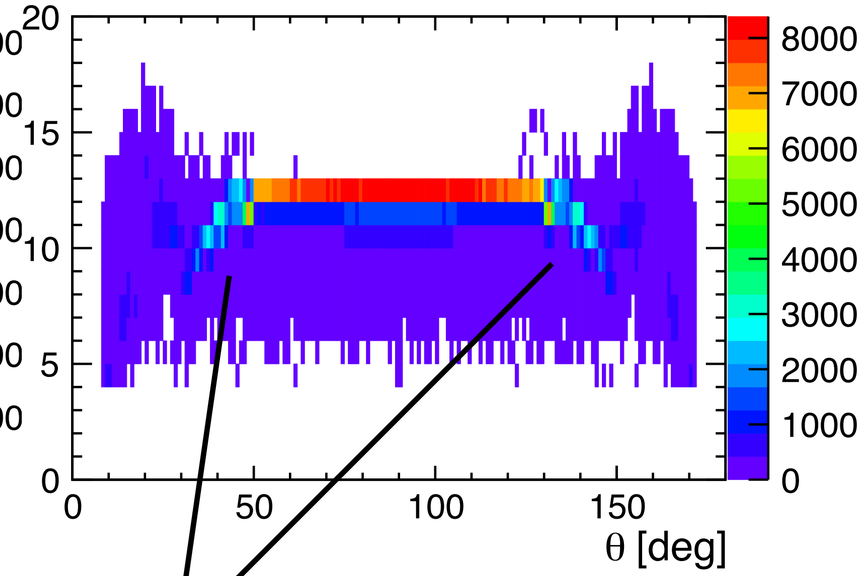

- What happens: hits are discarded due to high $\Delta\chi^2$ per hit during fit in the z-s plane. Fix is ongoing

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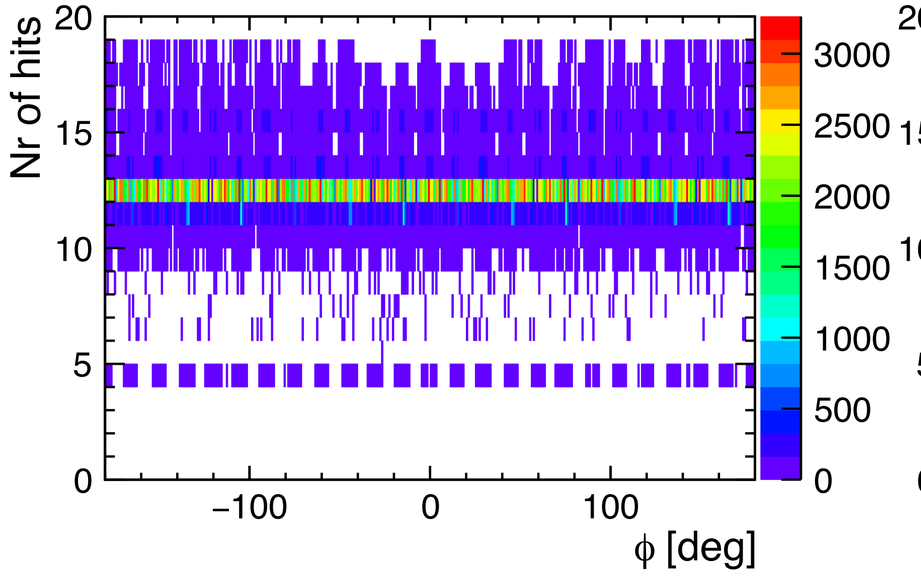

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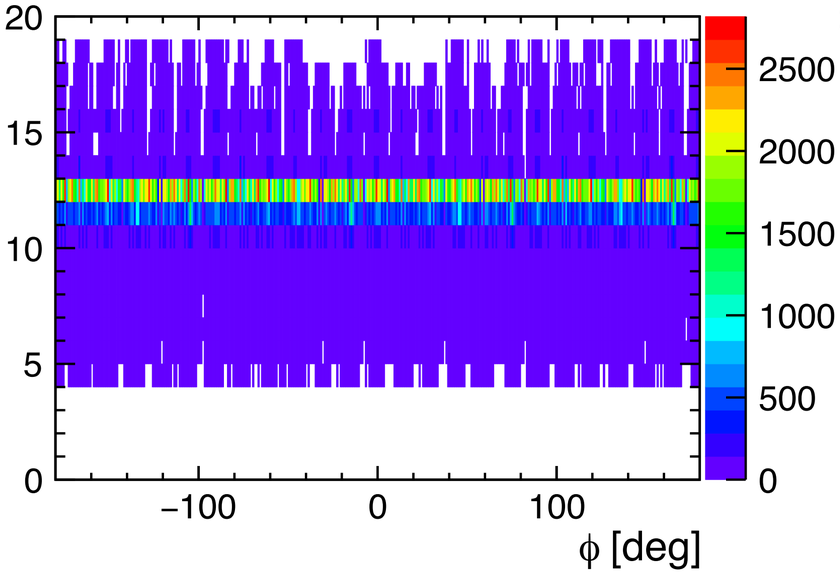

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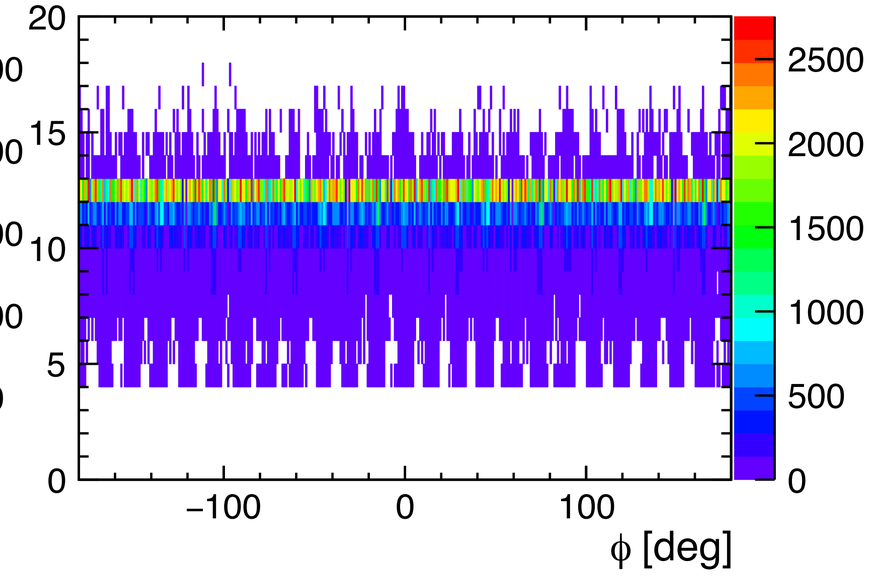


Tracking efficiency

$$\text{Tracking efficiency} = \frac{\text{Nr of reconstructed tracks}}{\text{Nr of reconstructable particles}}$$

Nr of reconstructable particles:

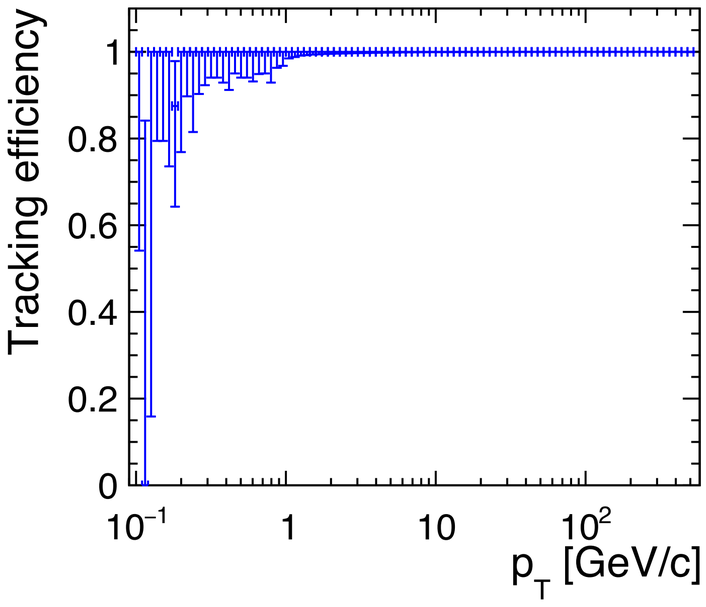
- ☆ PDG = 13 (muons) ***
- ☆ vertex = 0
- ☆ Nr hits >= 4
- ☆ $|\cos(\theta)| < 0.99$, i.e. $8^\circ < \theta < 172^\circ$
- ☆ $p_T > 100$ MeV/c
- ☆ is not a loop, i.e. no more than one hit on the same layer of the same sub detector

*** this requirement will not be used for complex events (Z=>uds, ttbar)

Tracking efficiency

- 2M single muon events
  - isotropic angular distribution, linear energy distribution 0-500GeV
- Tracking efficiency as a function of p_T, θ and φ

Truth Tracking



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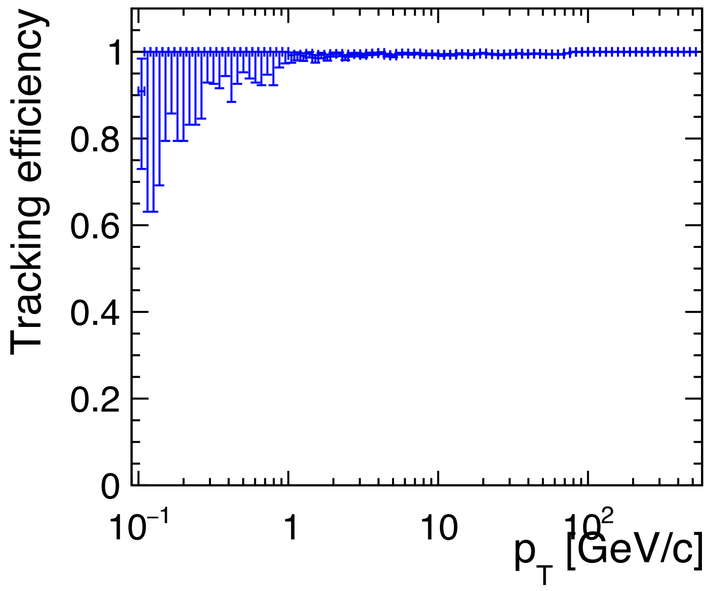

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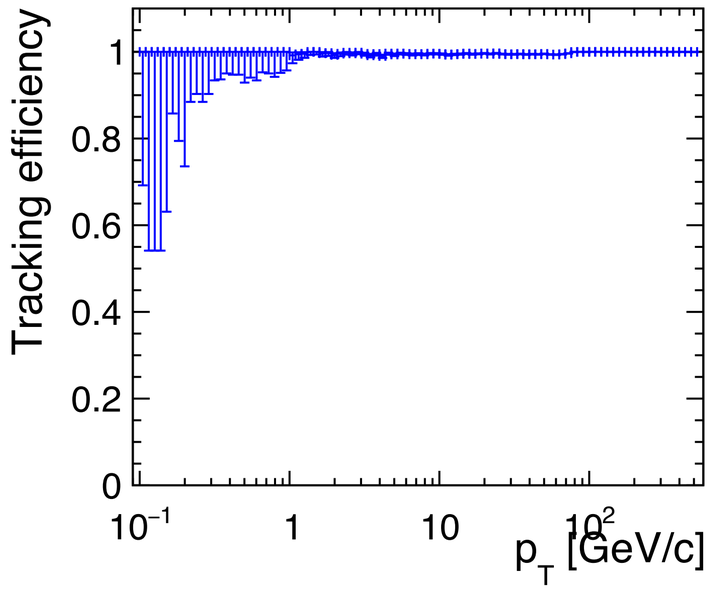

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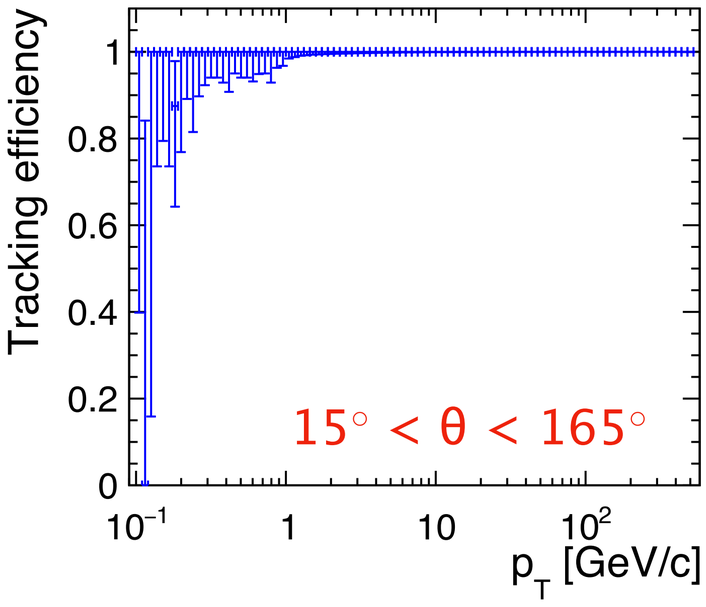

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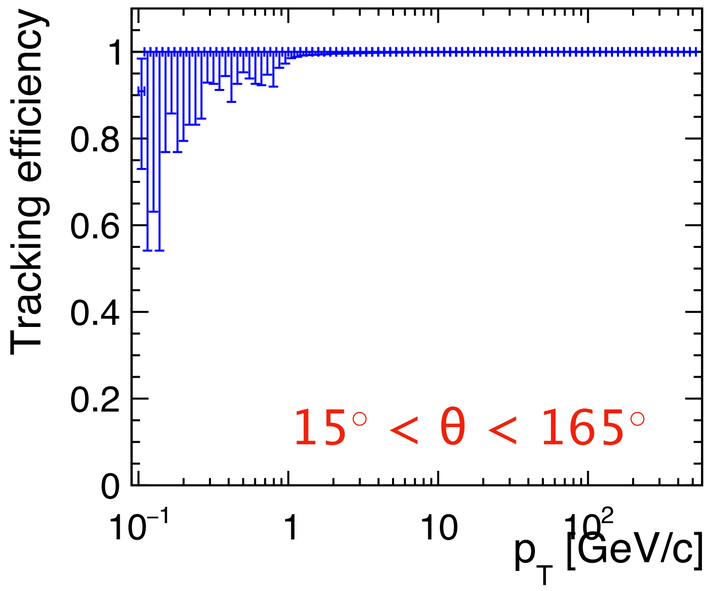

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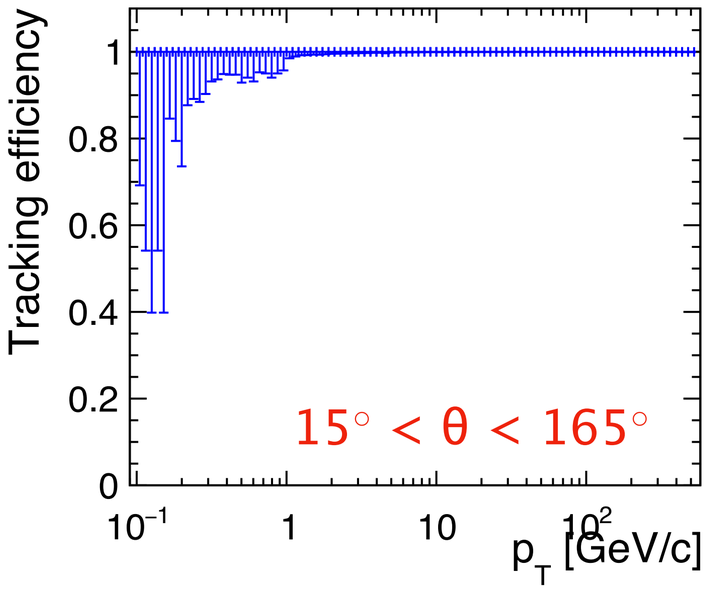

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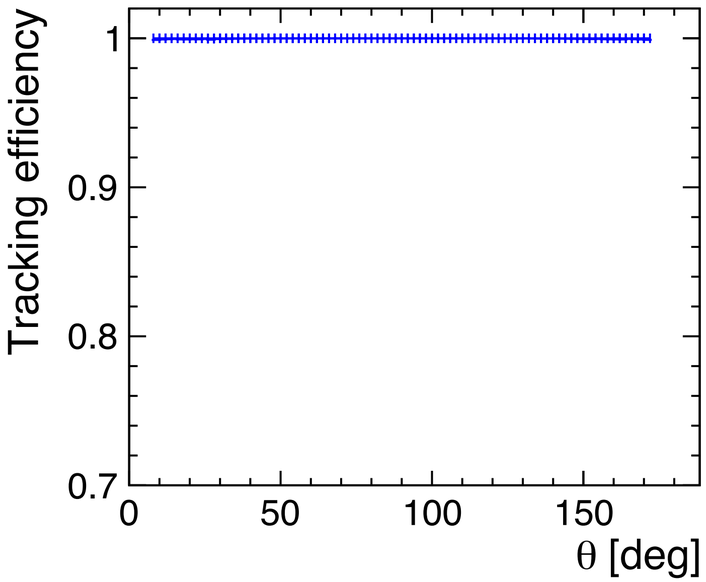

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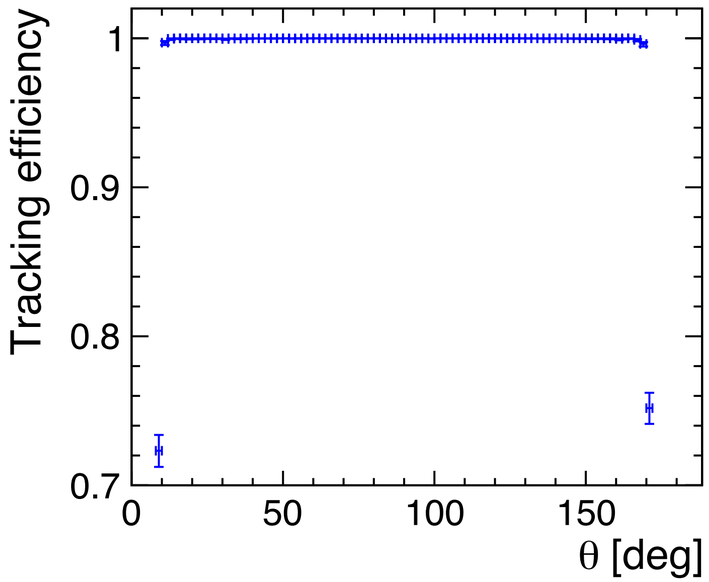

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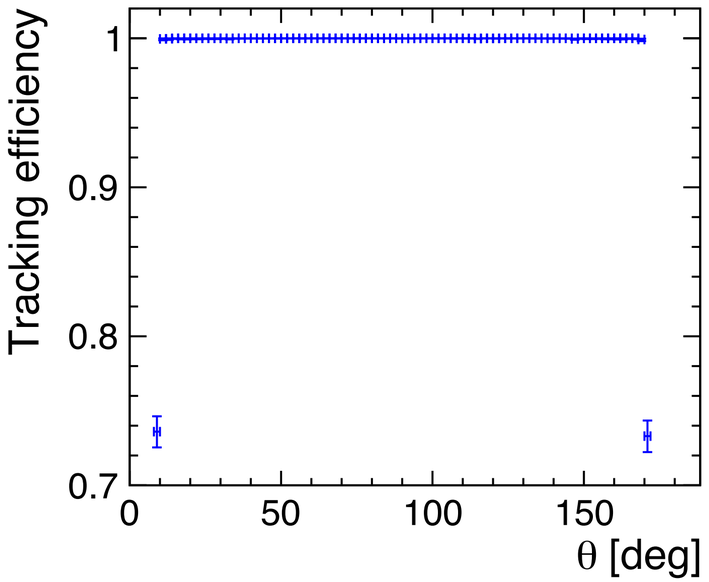

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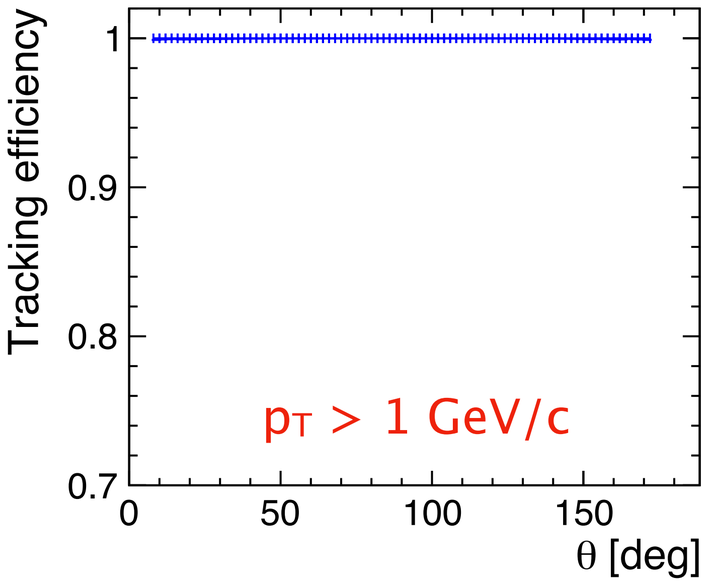

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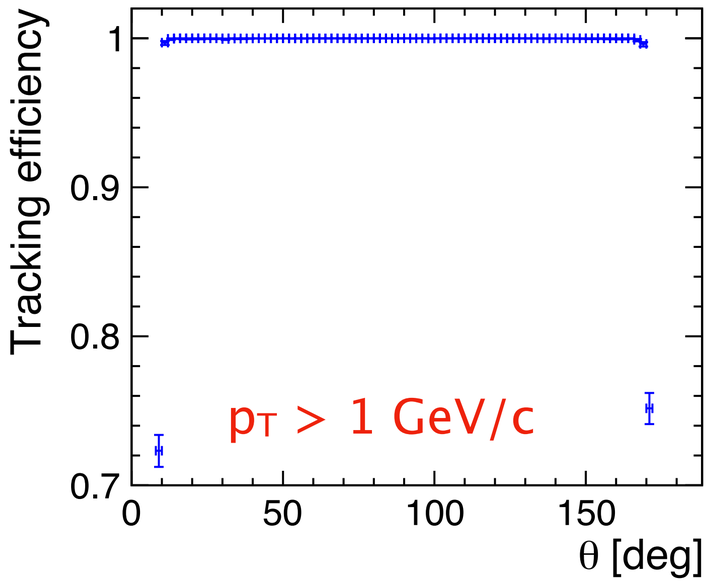

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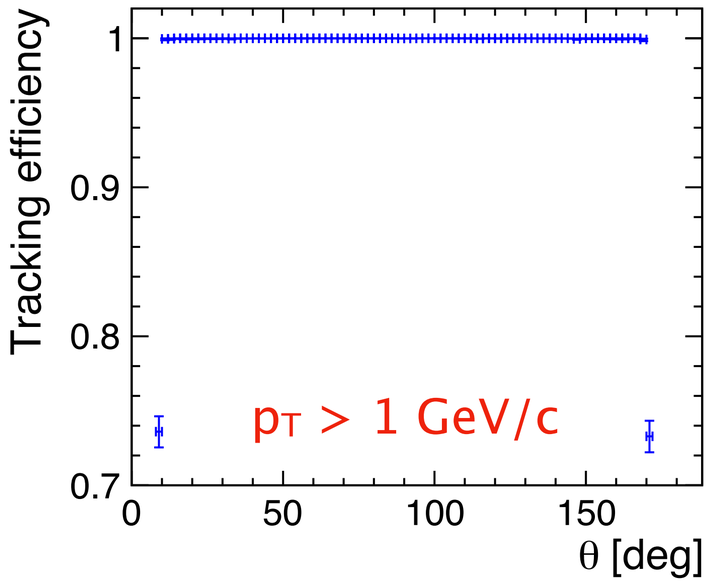

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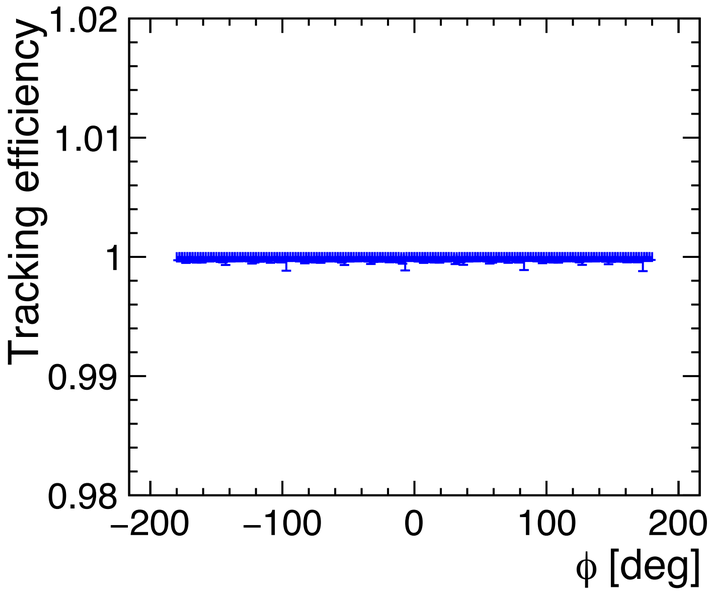

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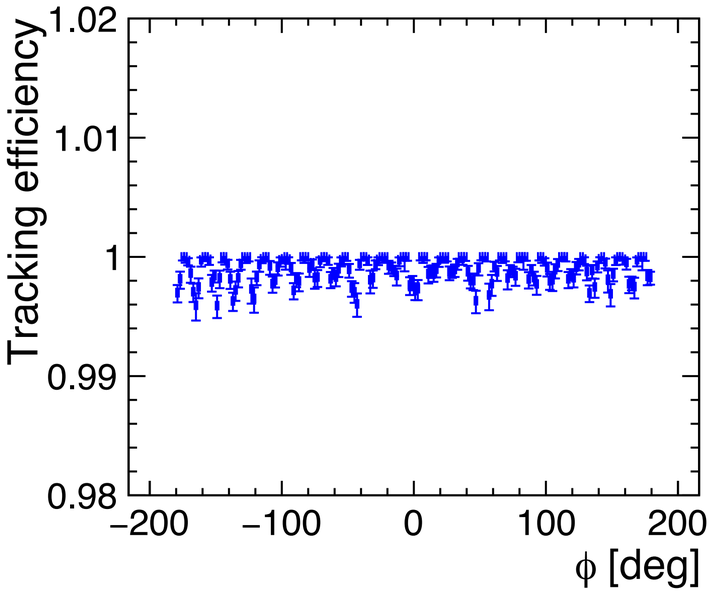

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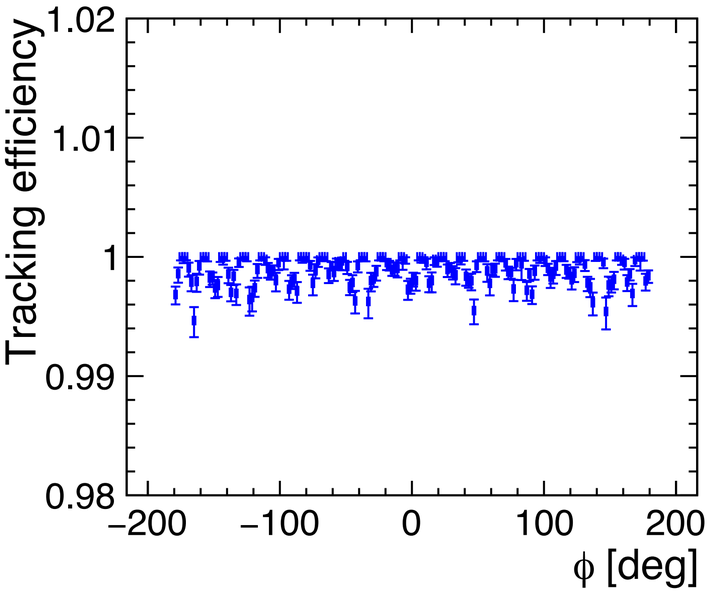

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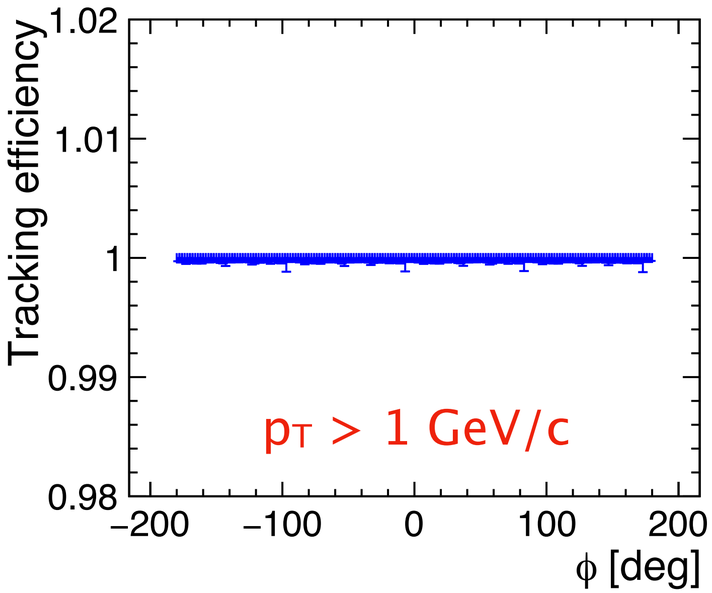

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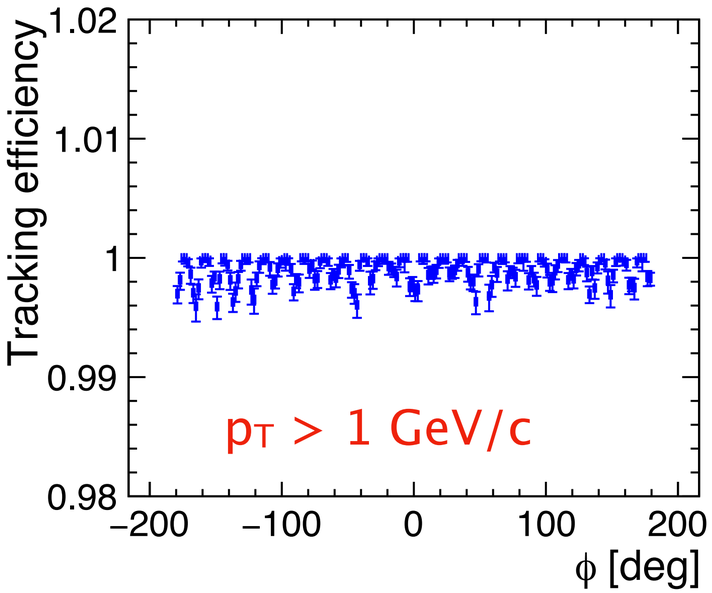

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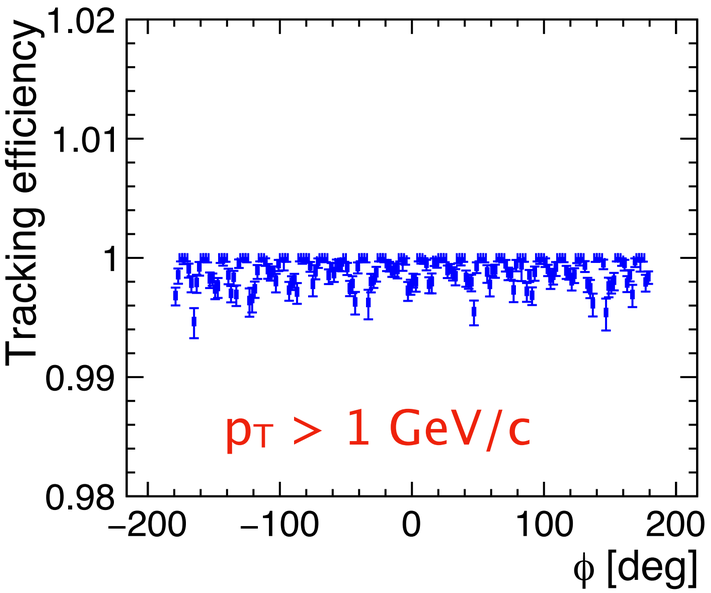
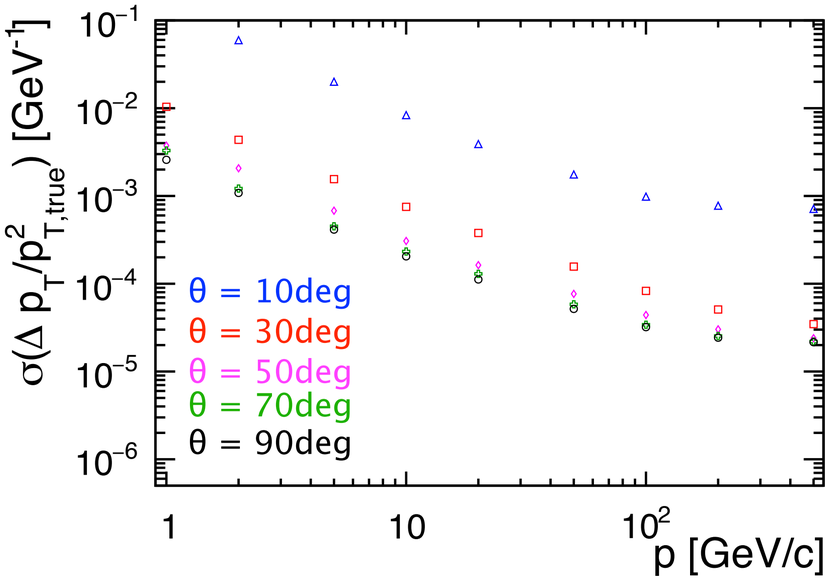


Momentum resolution

- 10k muons guns
  - fixed energy = GeV {1,2,5,10,20,50,100,200,500}
  - fixed theta = deg {10,30,50,70,89}
- Resolution = σ of the Gaussian fit of the distribution $(p_{T,reco} - p_{T,\,true}) \,/\, p_{T,true}^2$

Truth Tracking



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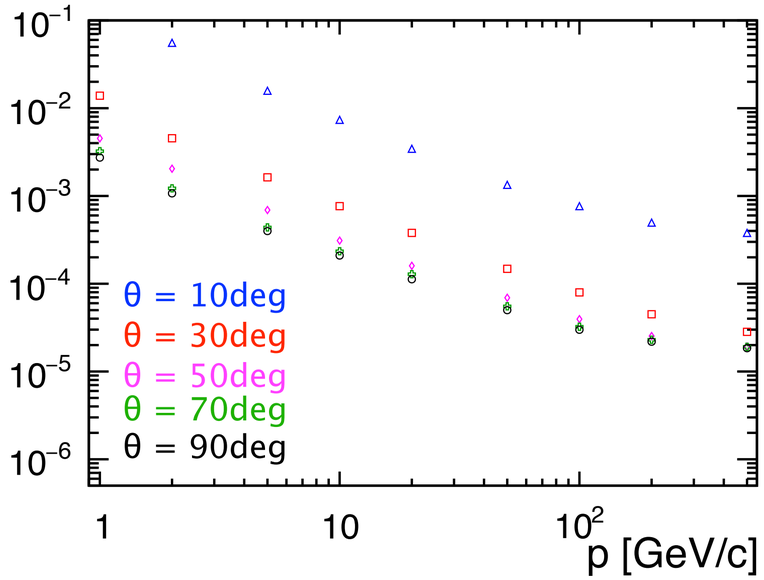

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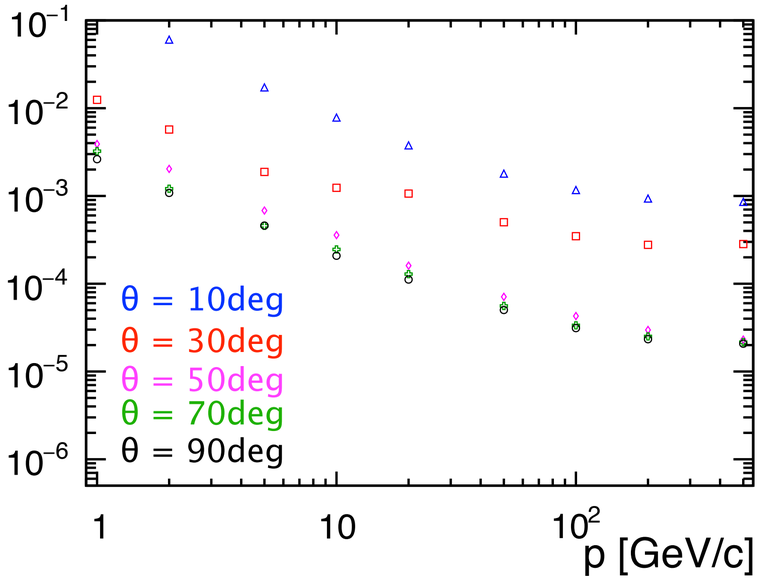


✓ Single muons are reconstructed with an efficiency of 100% down to 100MeV/c and in the full phase space down to 10 (170) deg

✓ Momentum resolution achieved: 2×10^{-5} for high energy (500GeV) muons in the central barrel

✓ Conformal Tracking shows almost no differences with Truth Tracking

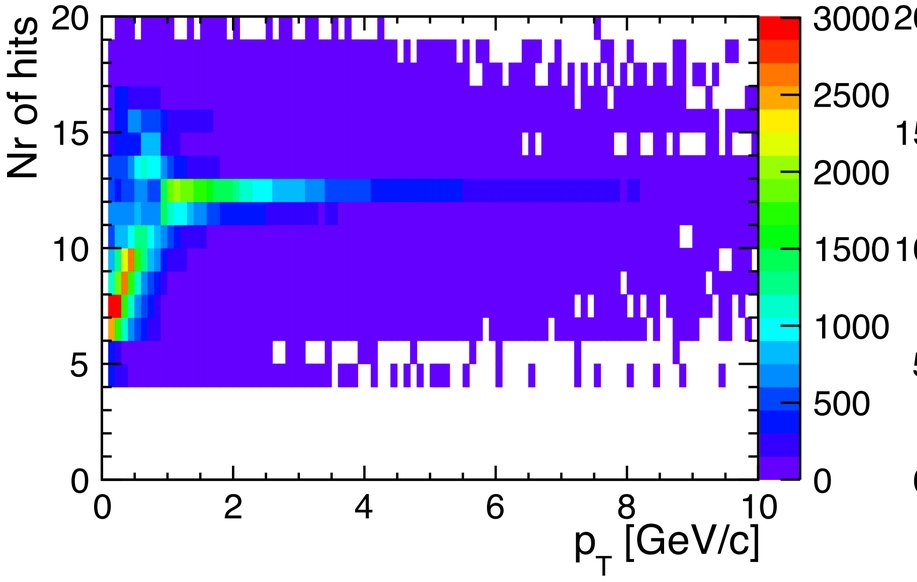
✎ Conformal Tracking Full rejects hits in the transition region barrel-endcap (30-50deg). Issue is understood and fix is ongoing

NEXT: Z => uds @ 91 GeV

Testing pattern recognition algorithms

- 10k Z=>uds events
- Hits per track distribution as a function of p_T, θ and φ

Truth Tracking



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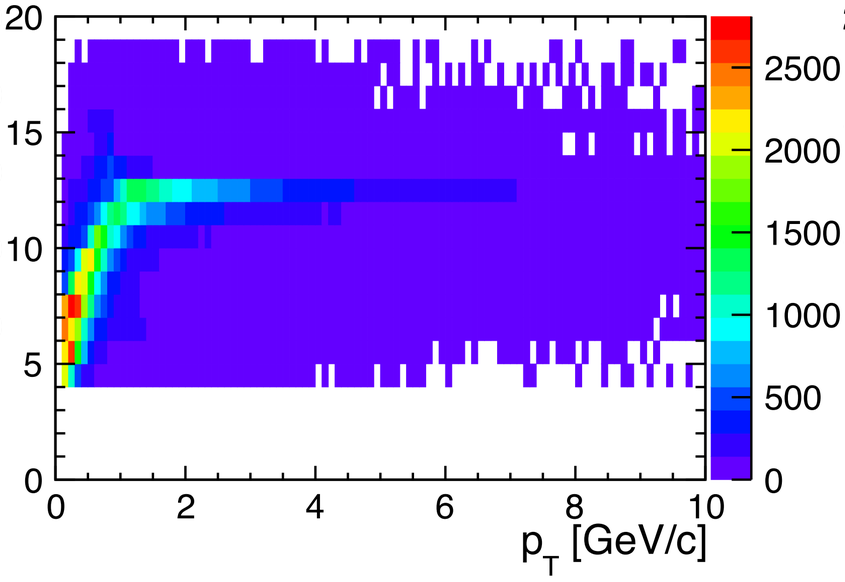

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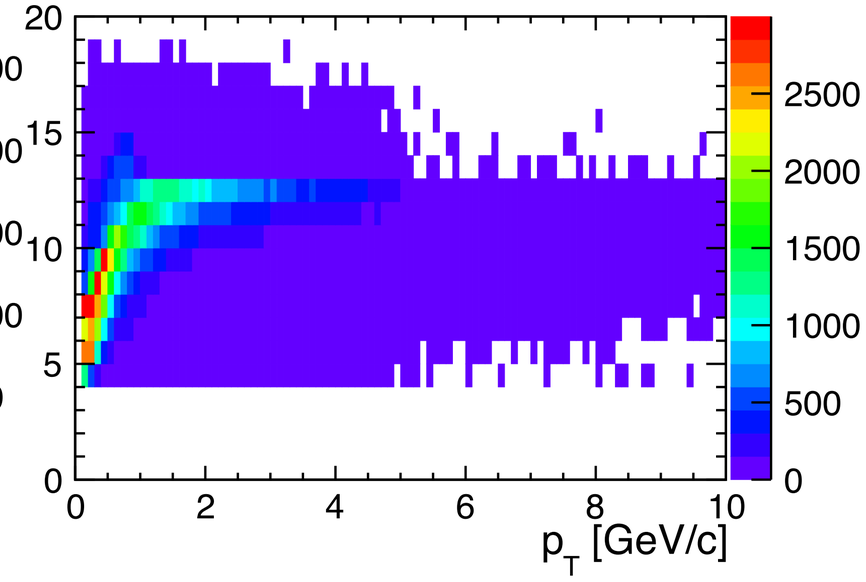

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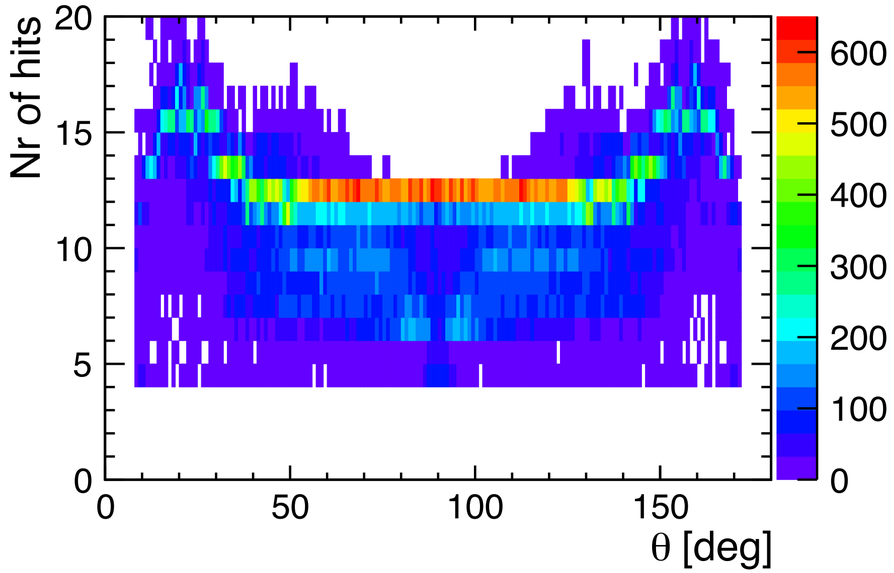

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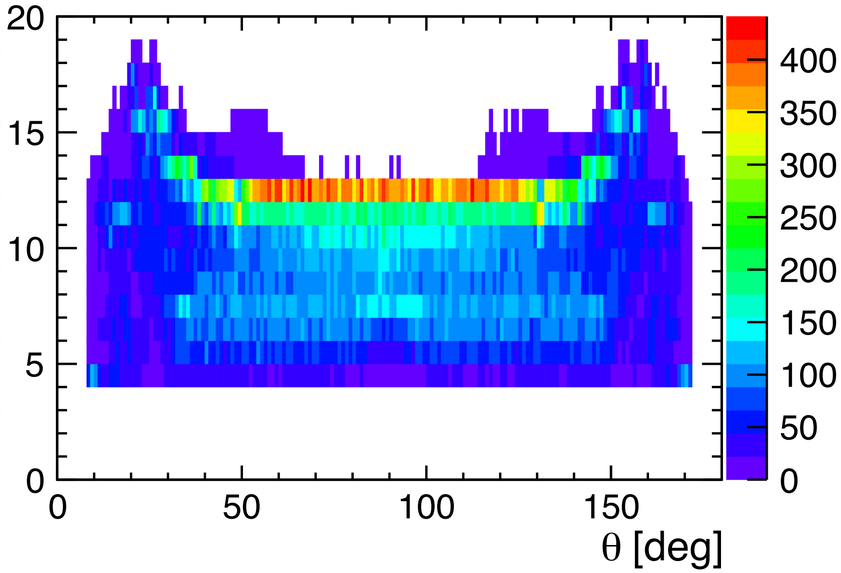

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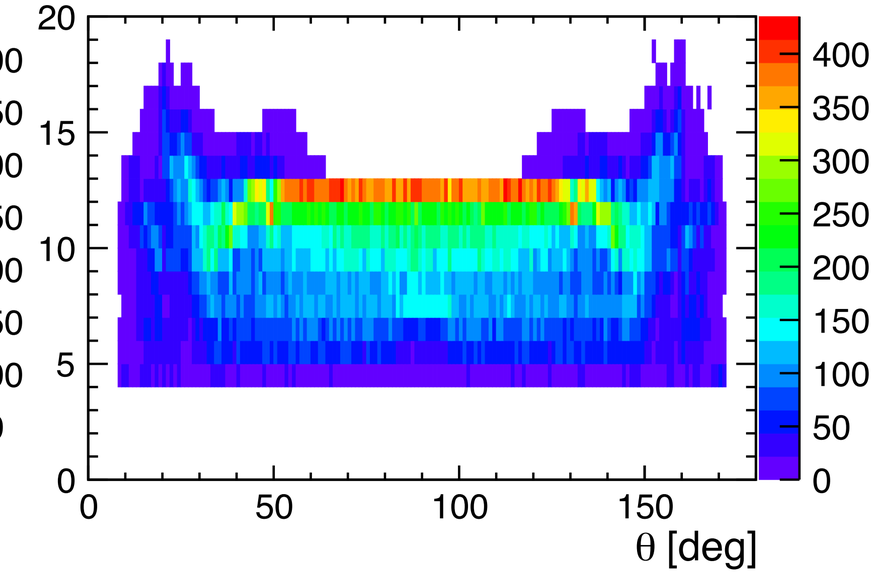

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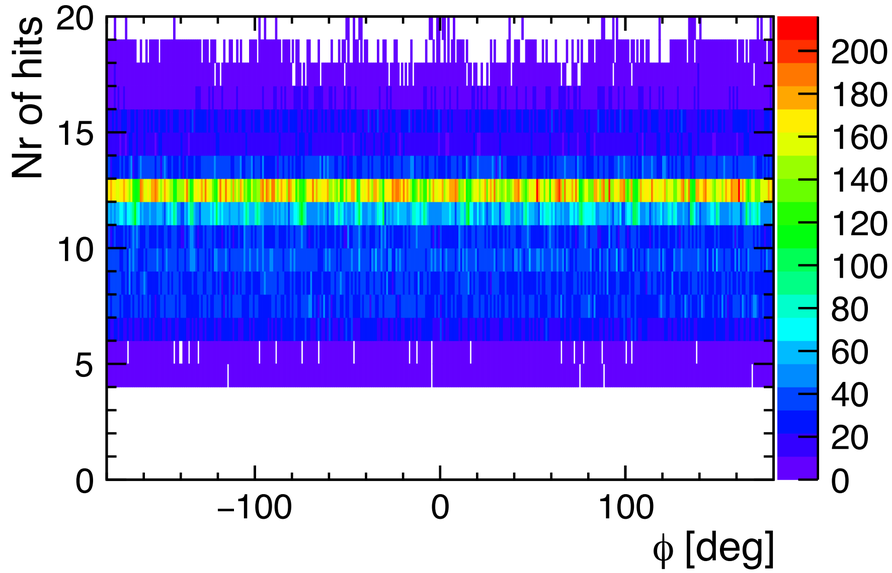

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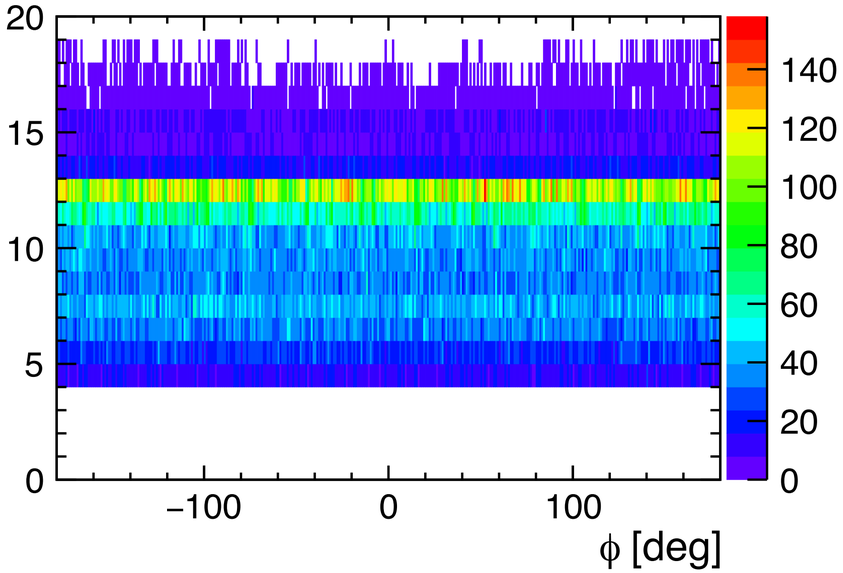

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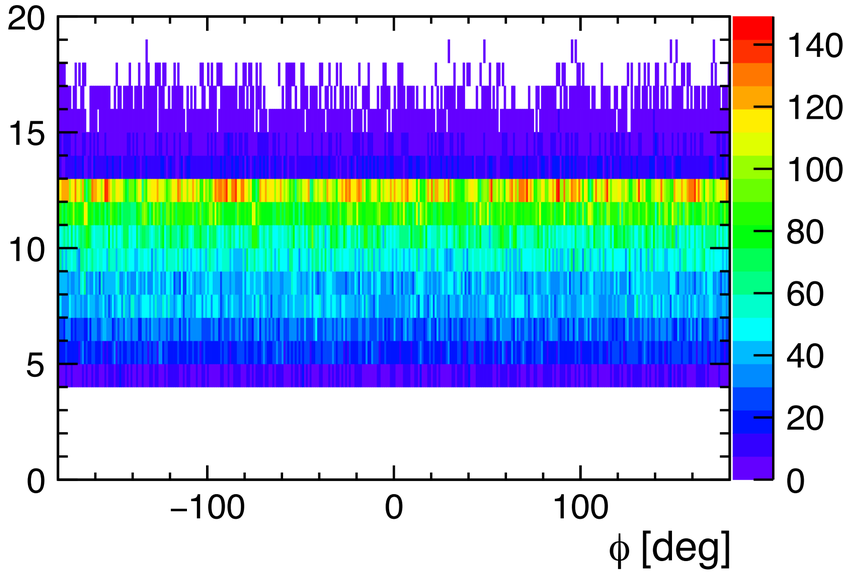

Tracking efficiency

- 10k Z=>uds events
- Tracking efficiency as a function of p_T, θ and φ

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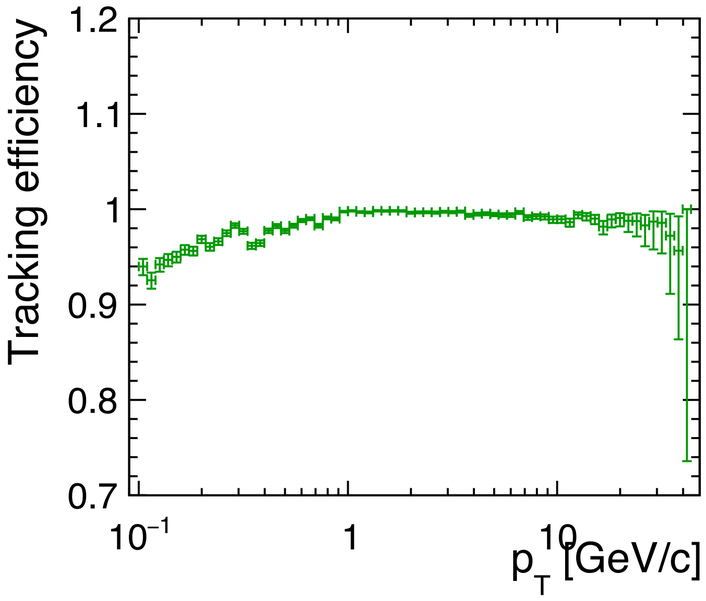

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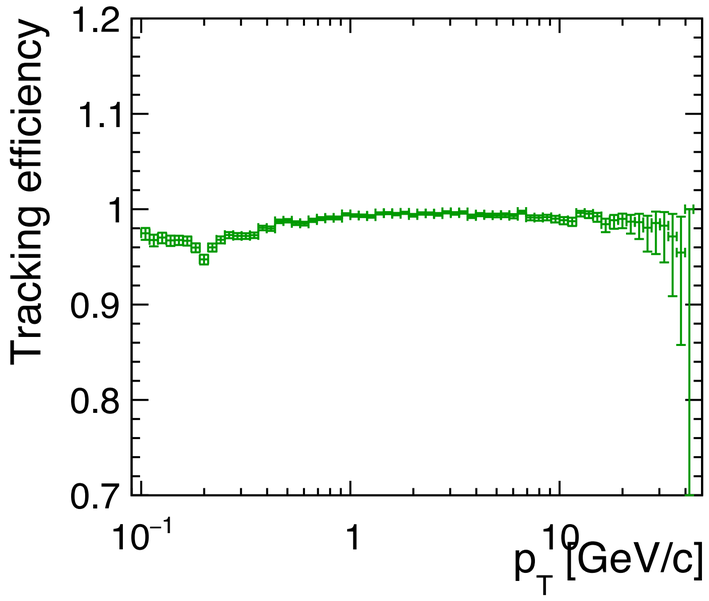

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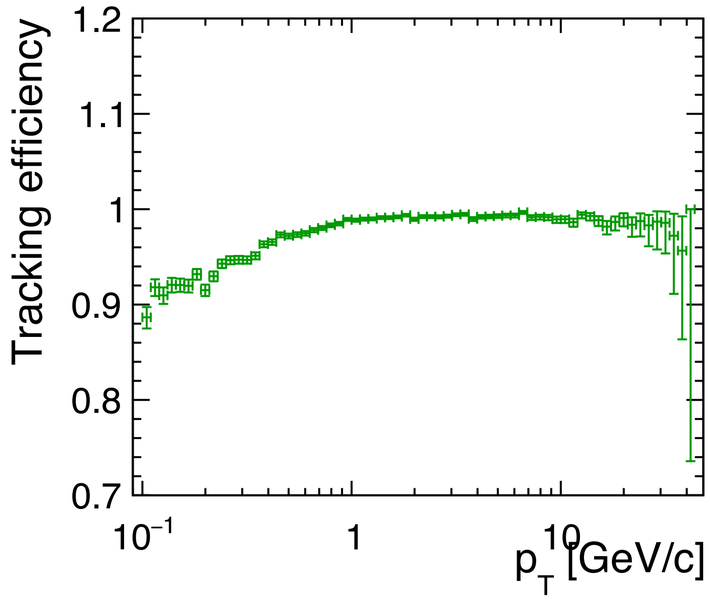

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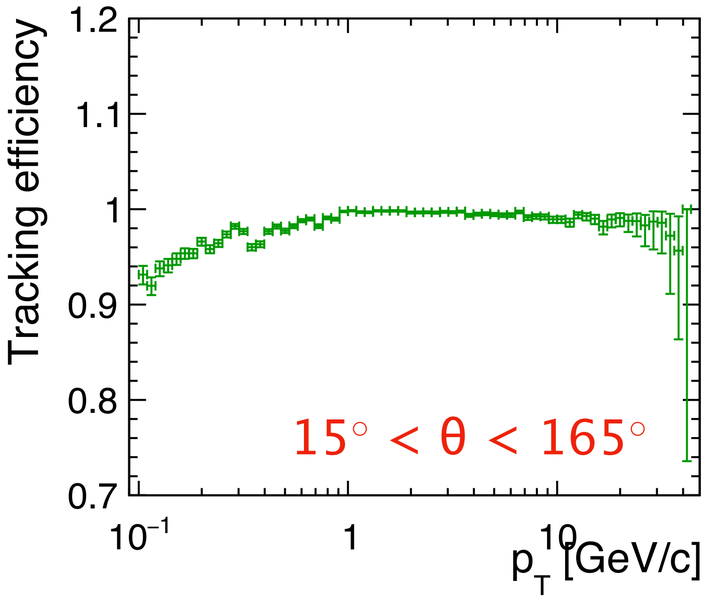

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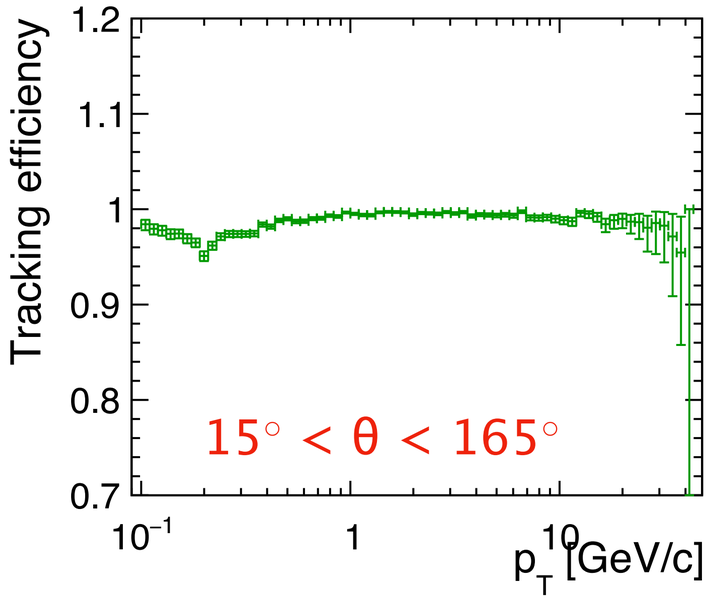

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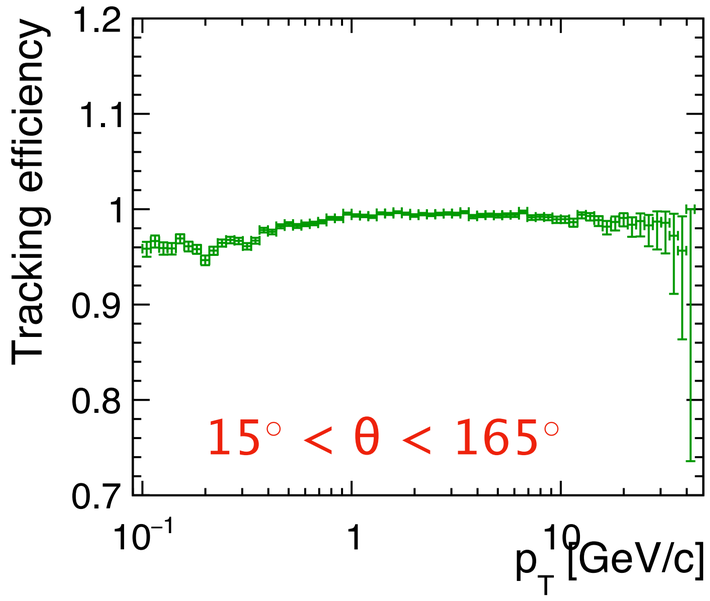

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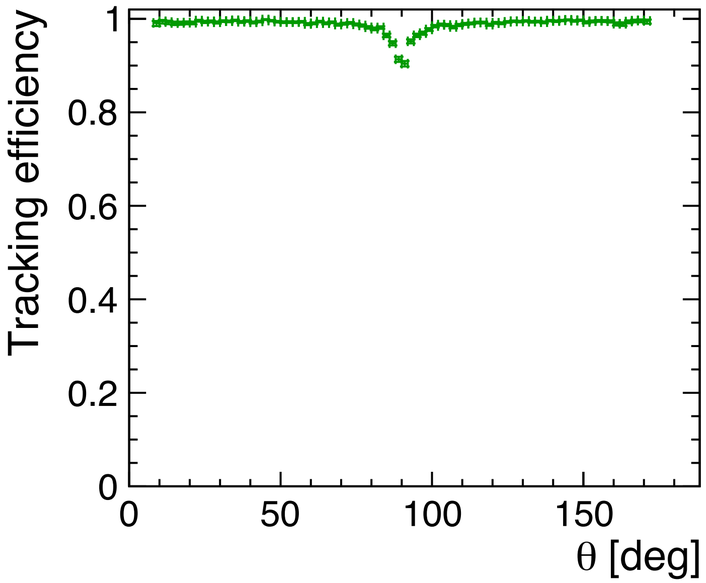
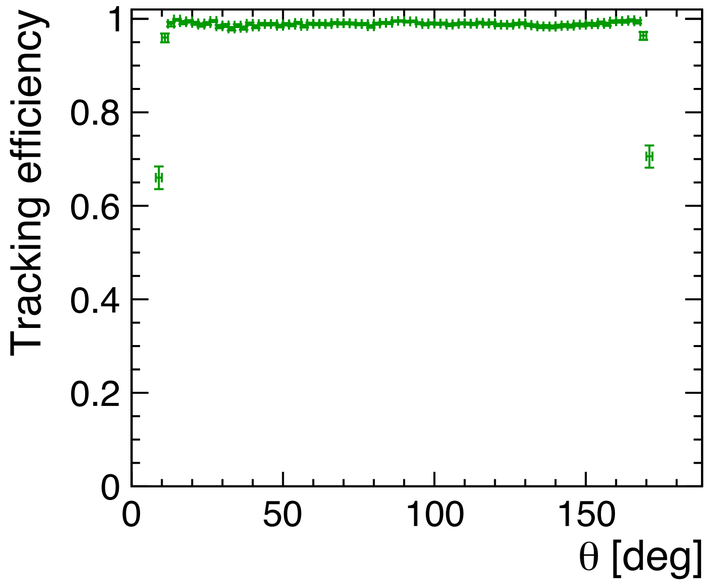
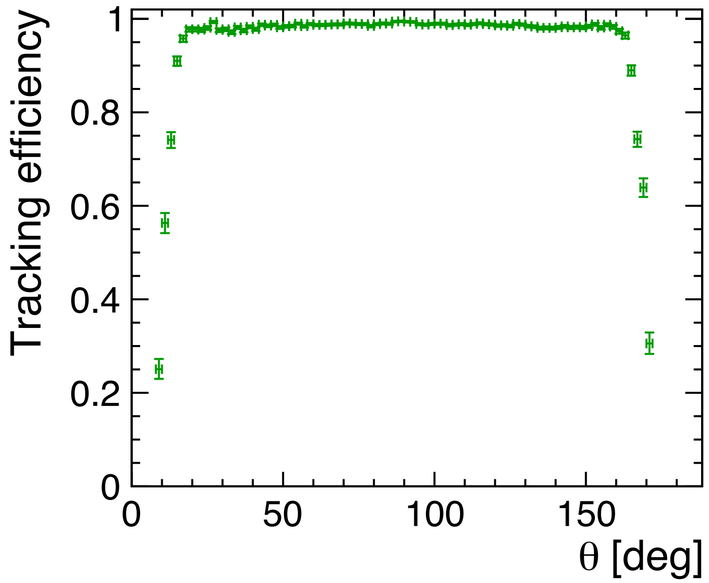


Conformal Tracking (VTX) + Extrapolator



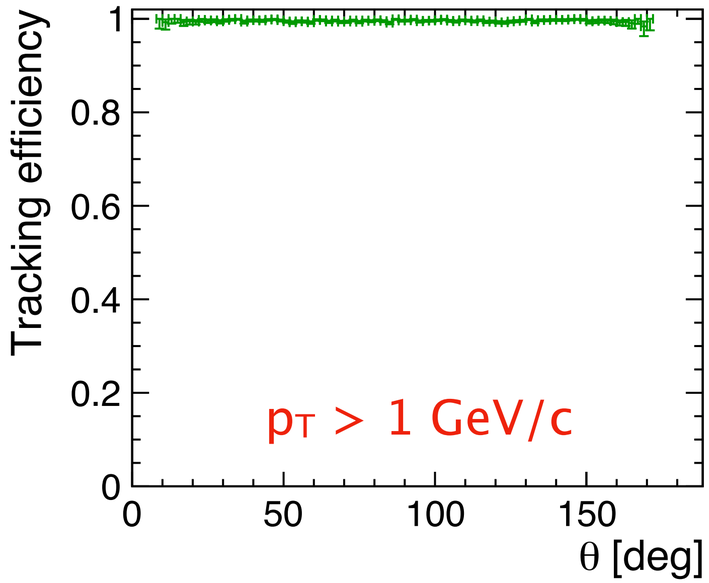
Conformal Tracking (FULL)



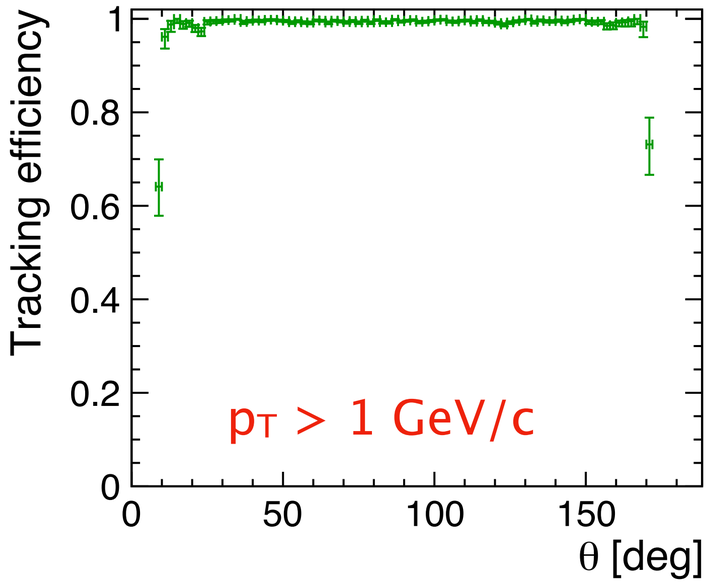
Tracking efficiency

- 10k Z=>uds events
- Tracking efficiency as a function of p_T, θ and φ

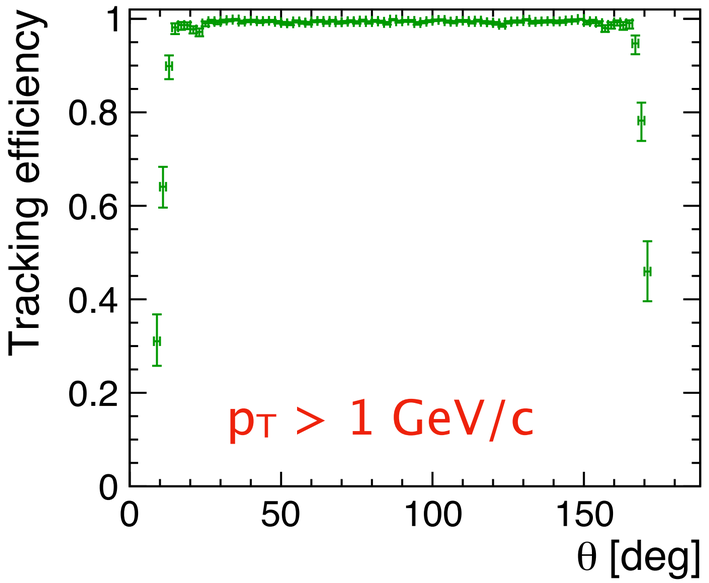
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



Conformal Tracking (FULL)

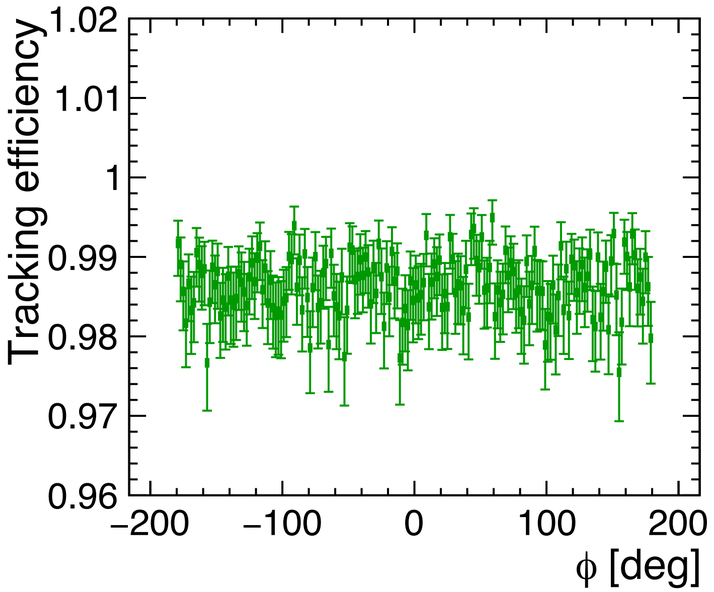


- Differences in the drop-off in very forward region

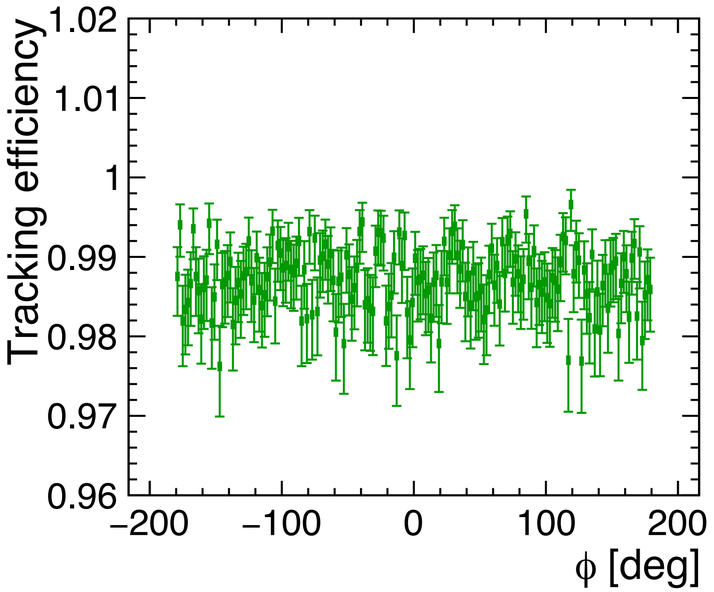
Tracking efficiency

- 10k Z=>uds events
- Tracking efficiency as a function of p_T, θ and φ

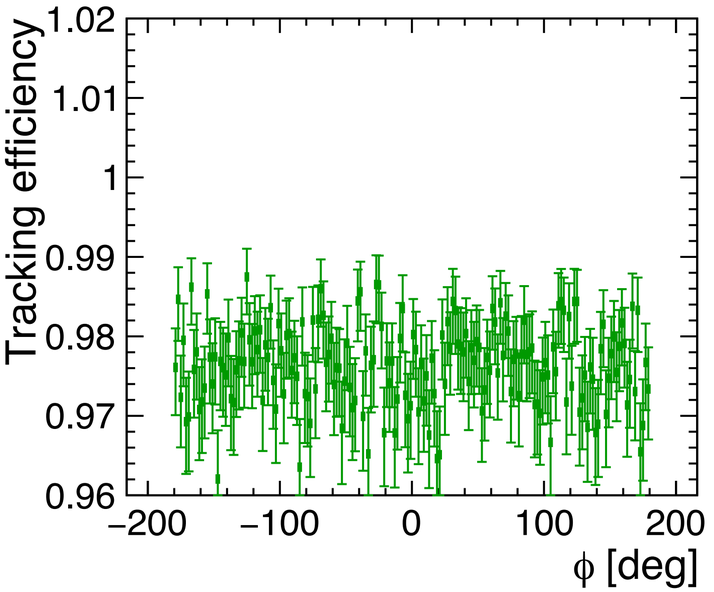
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



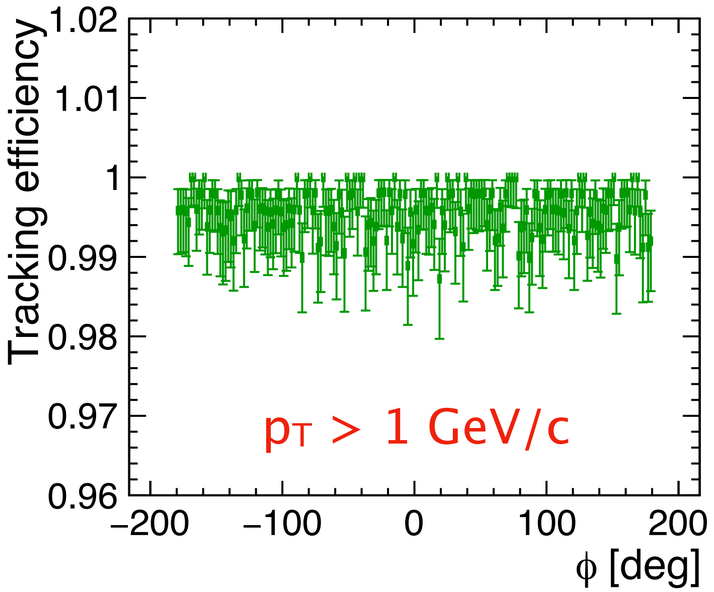
Conformal Tracking (FULL)



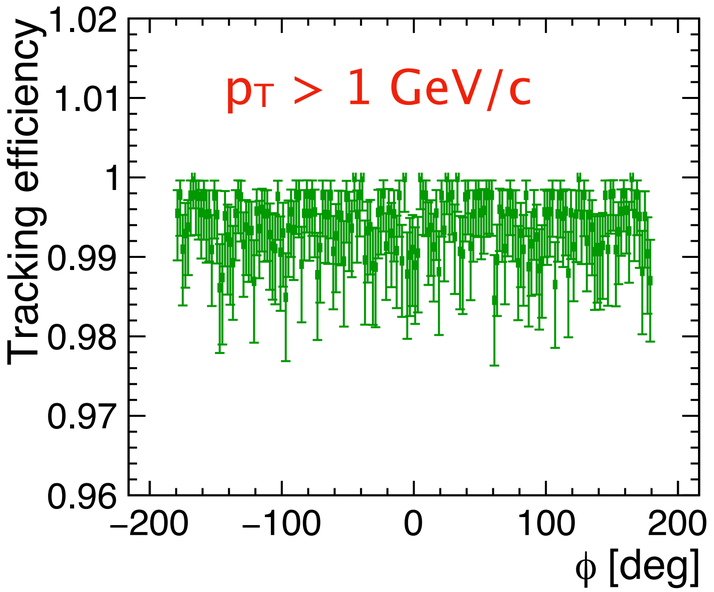
Tracking efficiency

- 10k Z=>uds events
- Tracking efficiency as a function of p_T, θ and φ

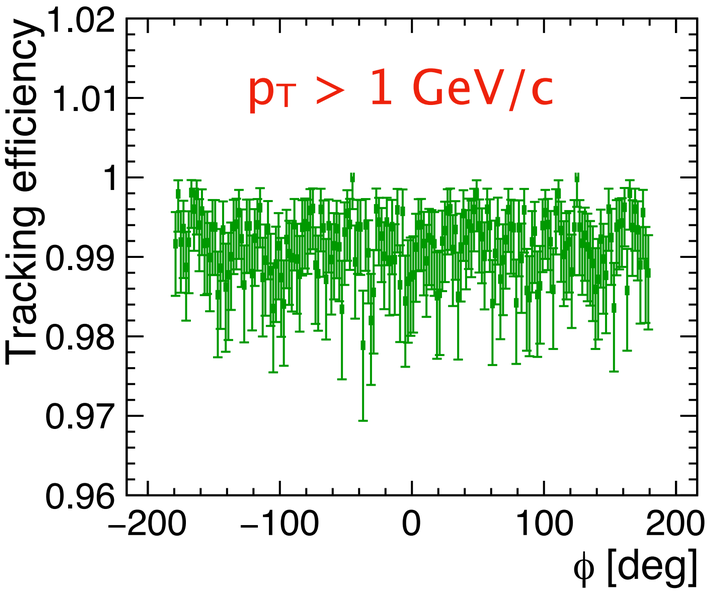
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



Conformal Tracking (FULL)



✓Z=>uds events at 91GeV are reconstructed with a tracking efficiency larger than 90% (and around 99% above 1GeV/c)

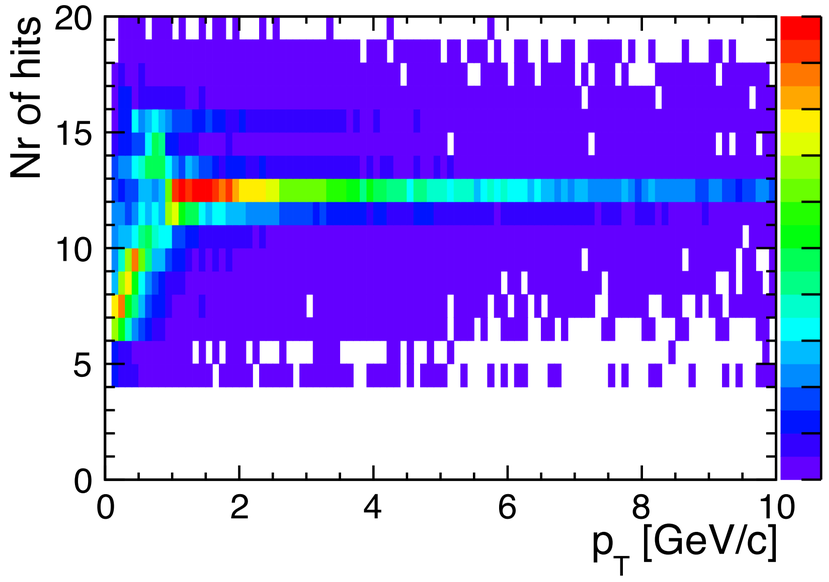
✎ Conformal Tracking Full shows a deeper drop-off at very forward region

NEXT: ttbar @ 3 TeV

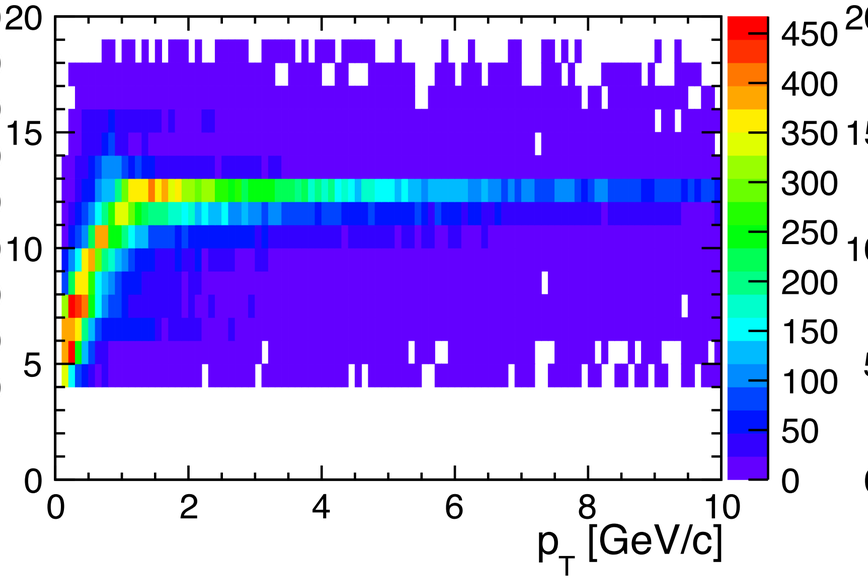
Testing pattern recognition algorithms

- 1k ttbar events
- Hits per track distribution as a function of p_T, θ and φ

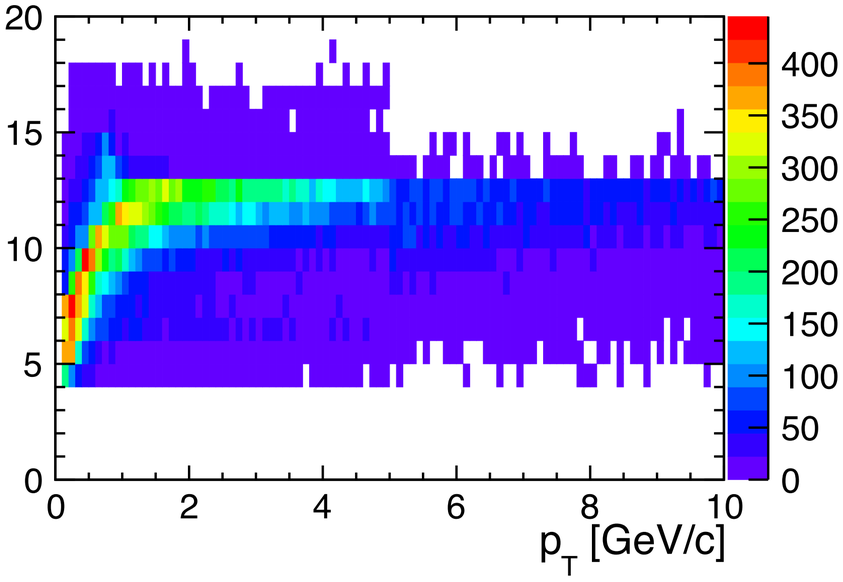
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



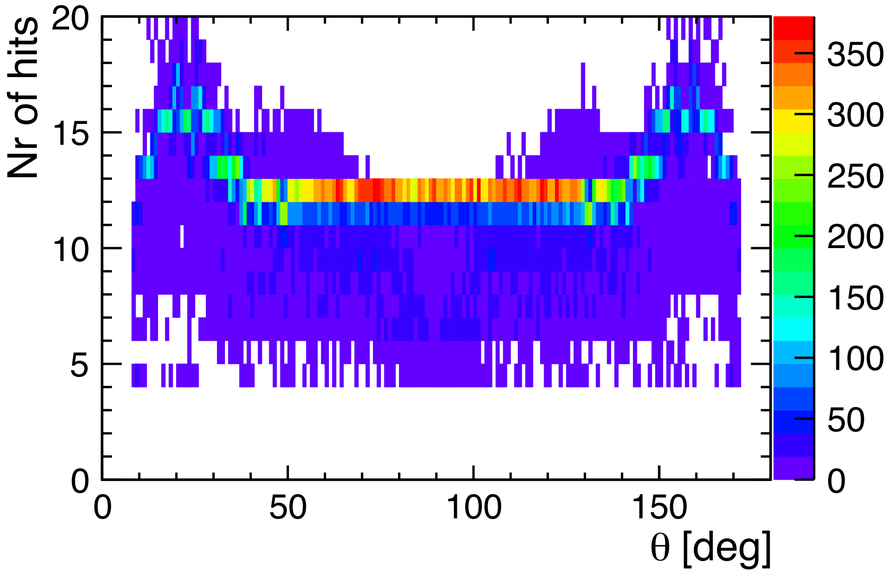
Conformal Tracking (FULL)



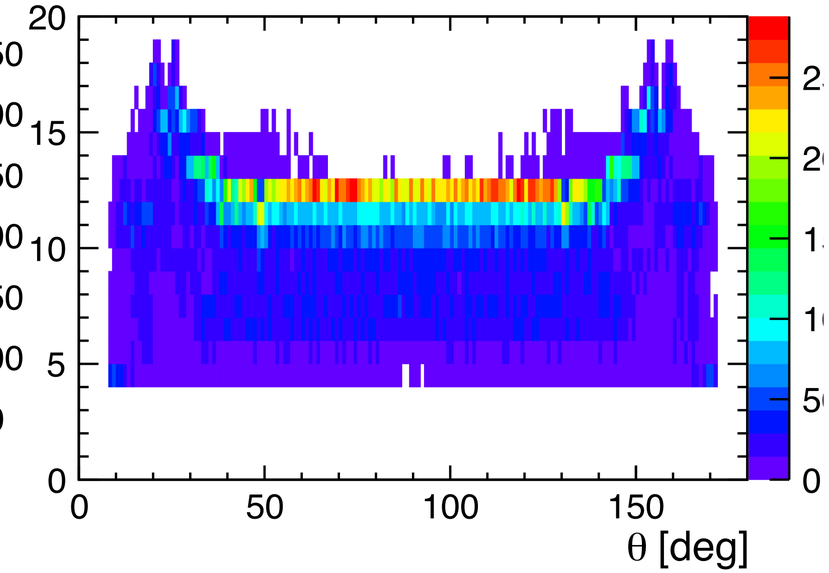
Testing pattern recognition algorithms

- 1k ttbar events
- Hits per track distribution as a function of p_T, θ and φ

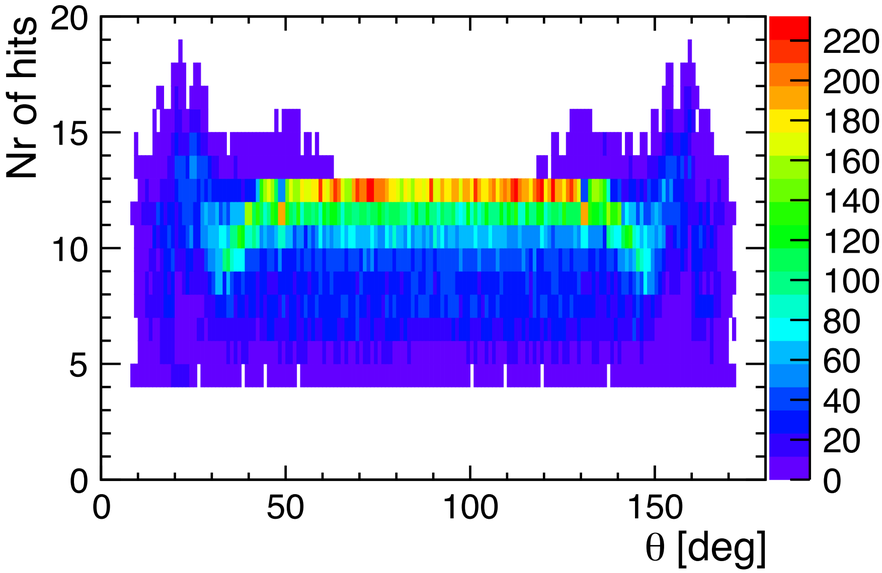
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



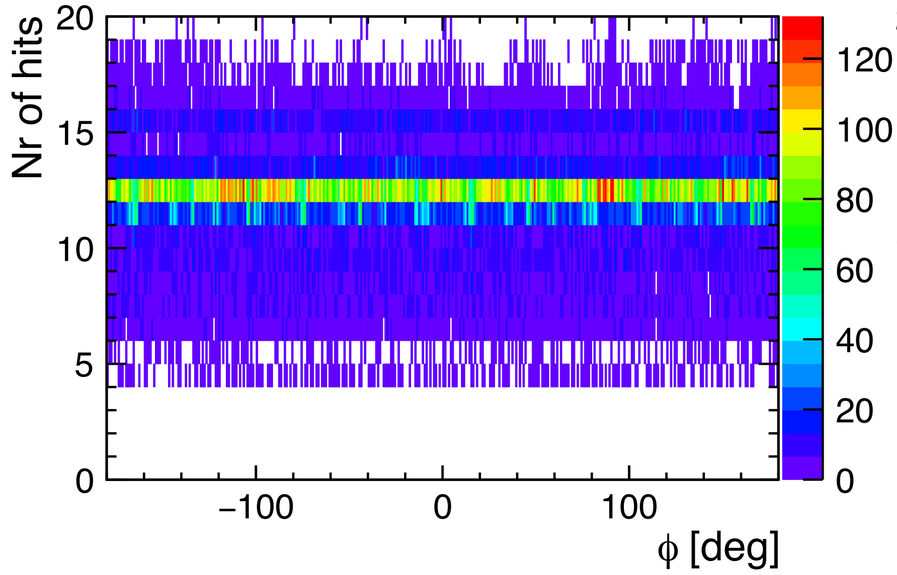
Conformal Tracking (FULL)



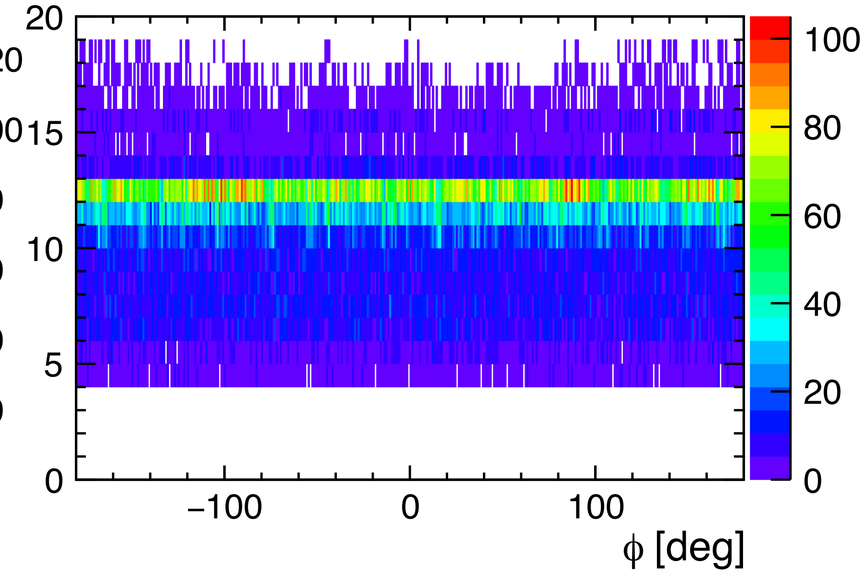
Testing pattern recognition algorithms

- 1k ttbar events
- Hits per track distribution as a function of p_T, θ and φ

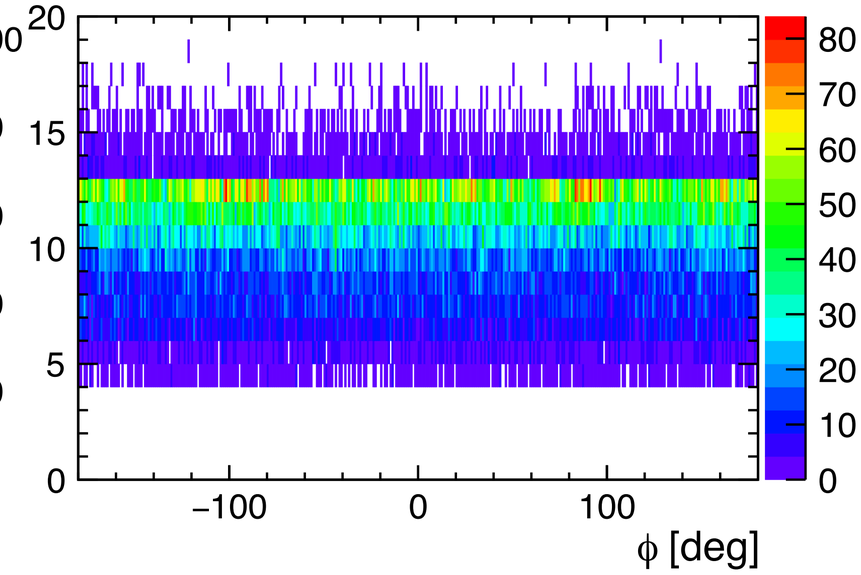
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



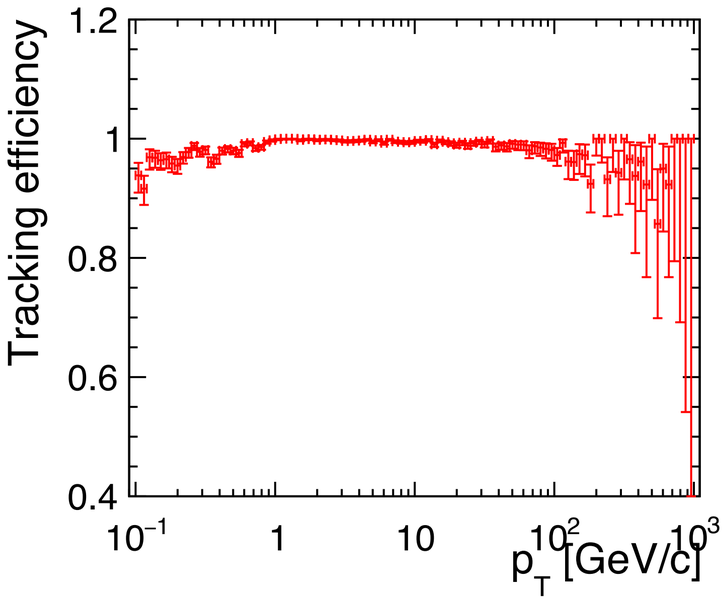
Conformal Tracking (FULL)



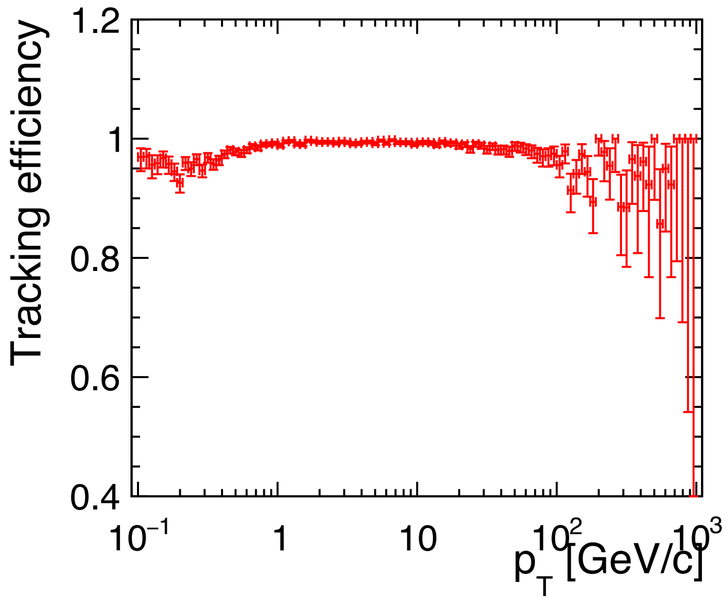
Tracking efficiency

- 1k ttbar events
- Tracking efficiency as a function of p_T, θ and φ

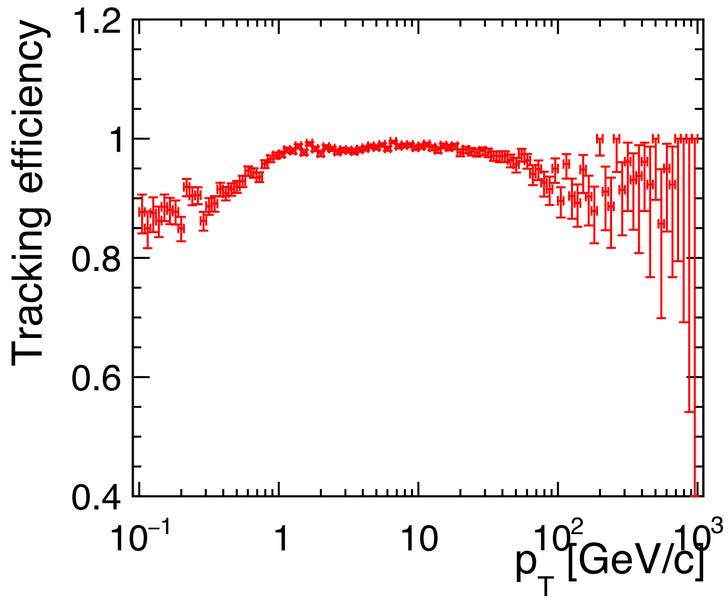
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



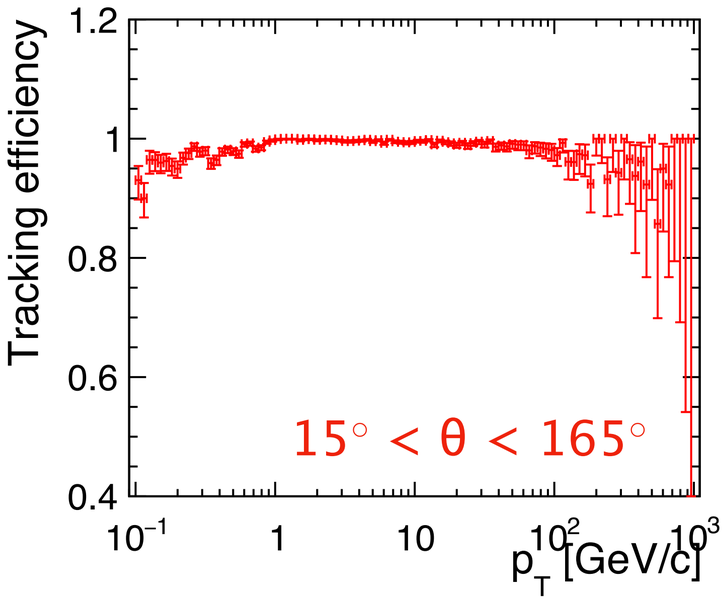
Conformal Tracking (FULL)



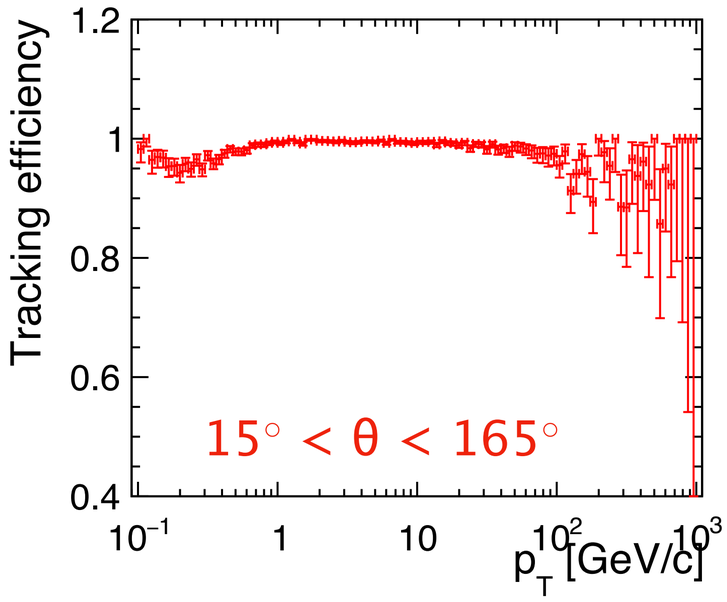
Tracking efficiency

- 1k ttbar events
- Tracking efficiency as a function of p_T, θ and φ

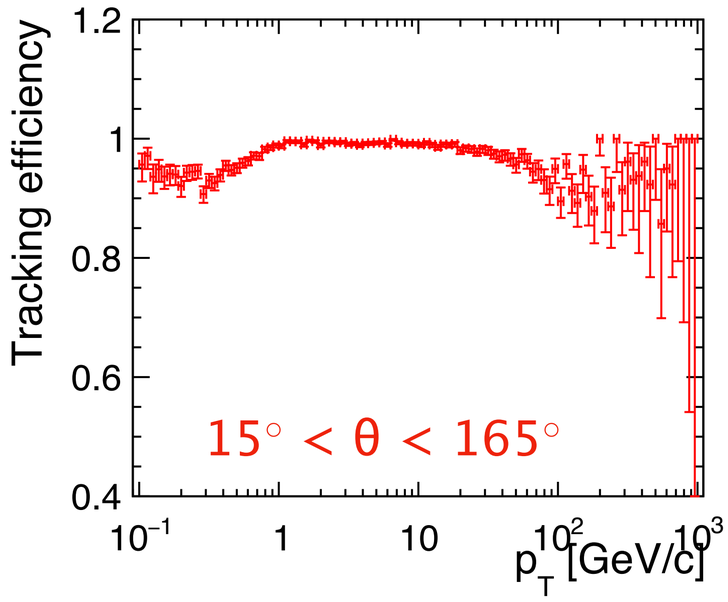
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



Conformal Tracking (FULL)

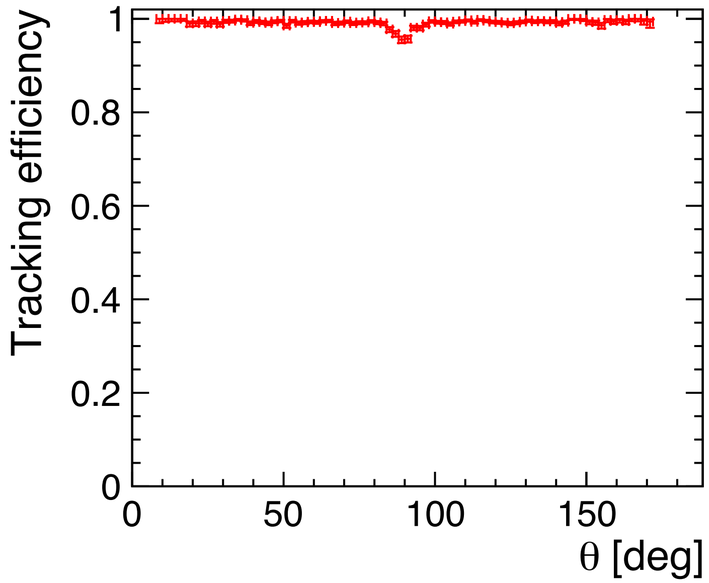


- Slight efficiency loss above 100GeV/c

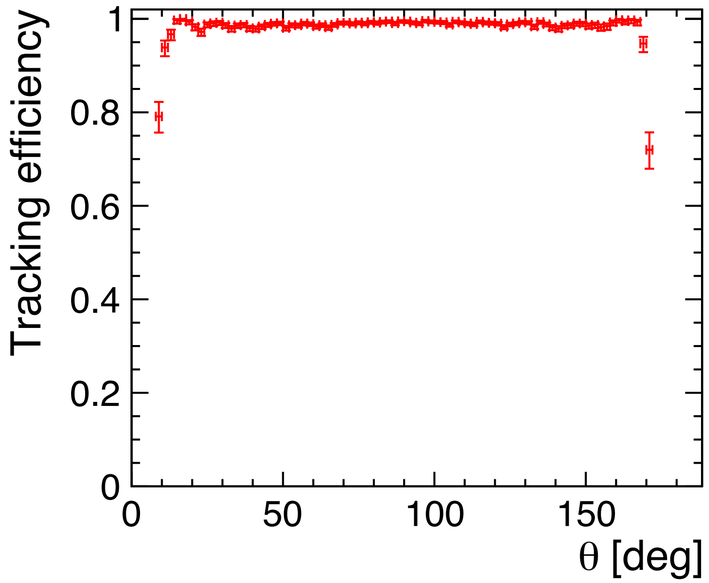
Tracking efficiency

- 1k ttbar events
- Tracking efficiency as a function of p_T, θ and φ

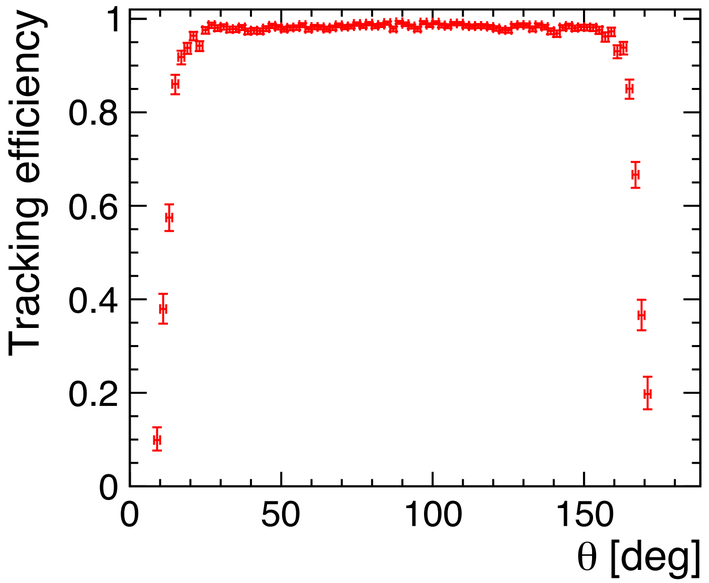
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



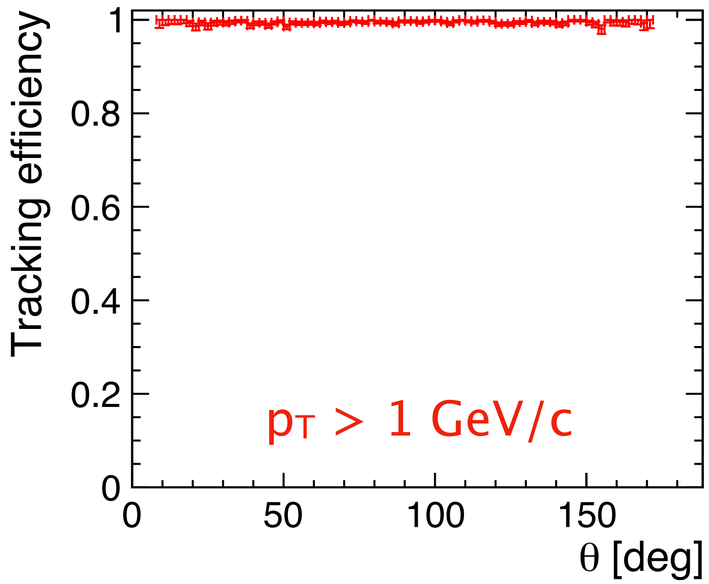
Conformal Tracking (FULL)



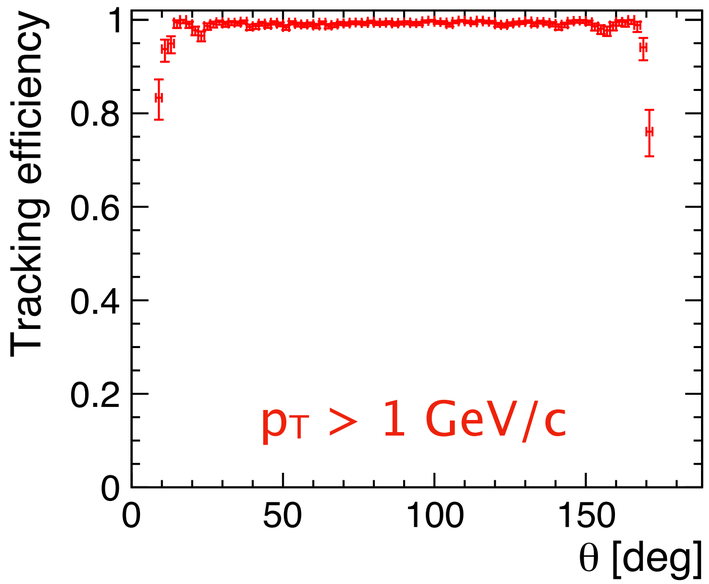
Tracking efficiency

- 1k ttbar events
- Tracking efficiency as a function of p_T, θ and φ

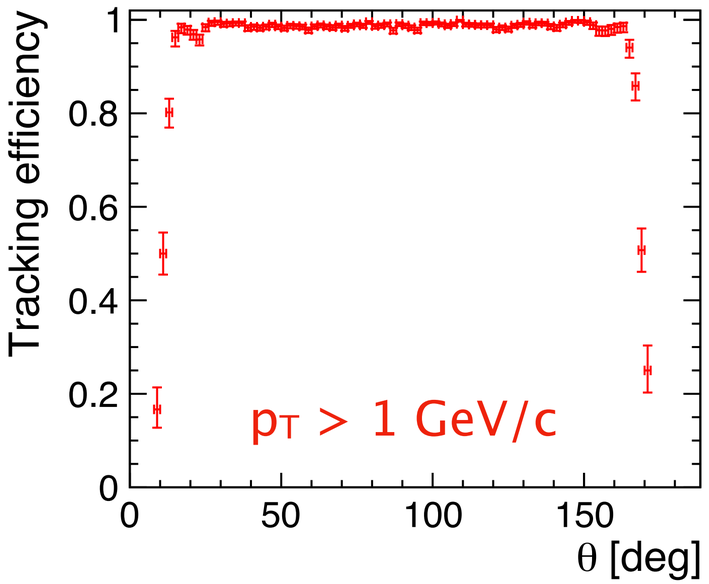
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



Conformal Tracking (FULL)

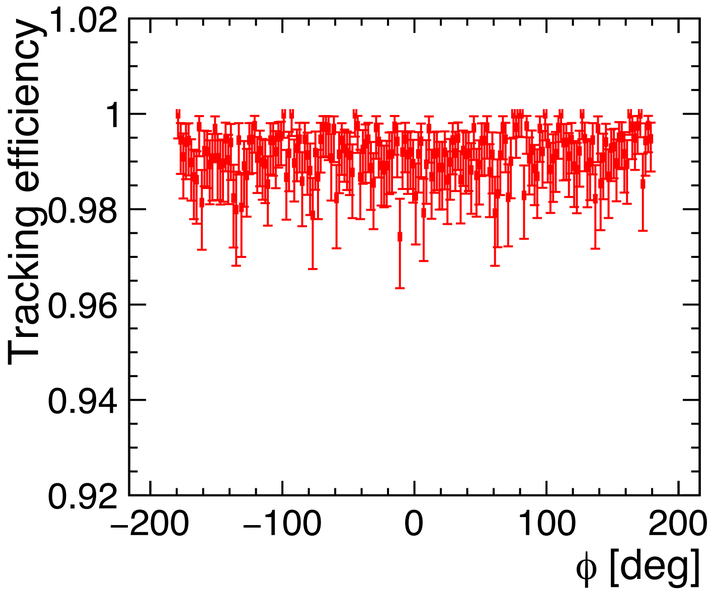


- Differences in the drop-off in very forward region

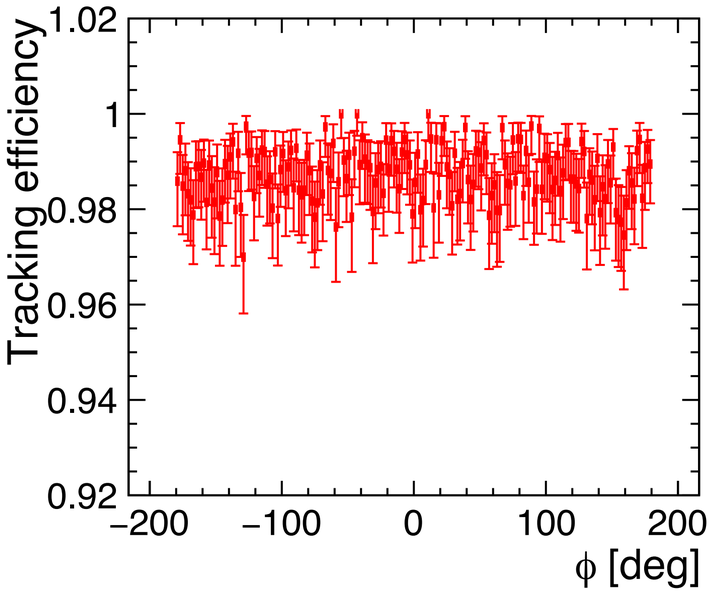
Tracking efficiency

- 1k ttbar events
- Tracking efficiency as a function of p_T, θ and φ

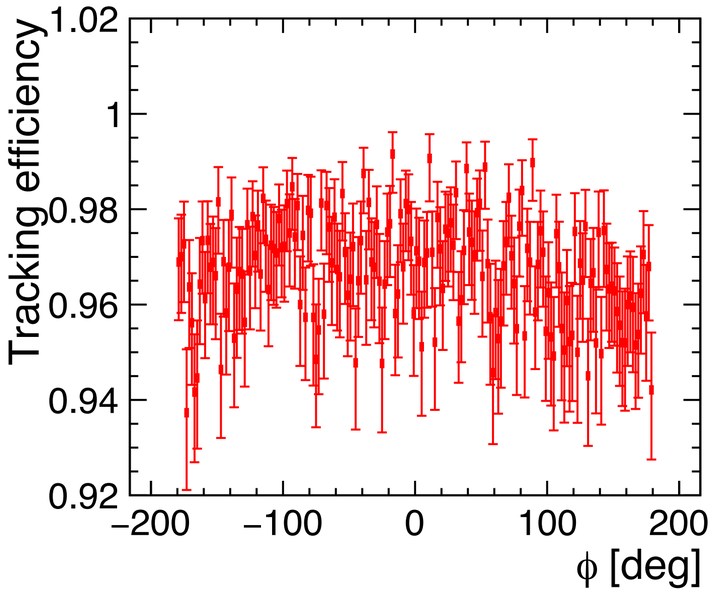
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



Conformal Tracking (FULL)



Tracking efficiency

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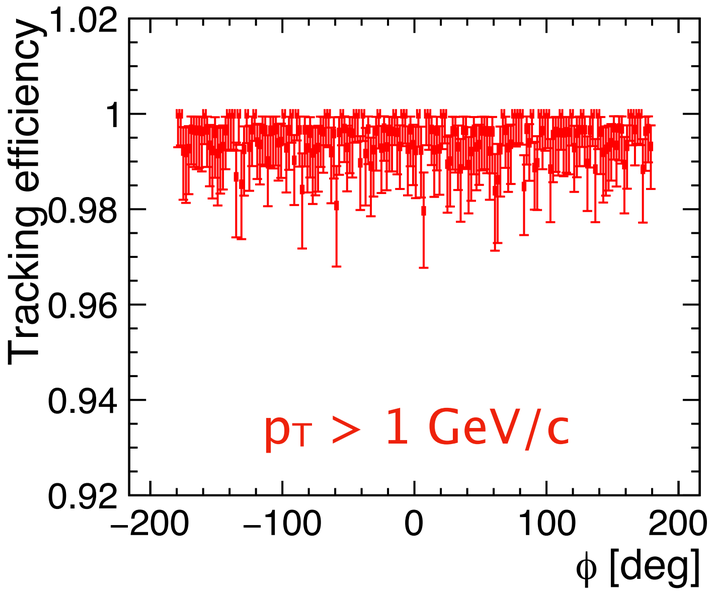
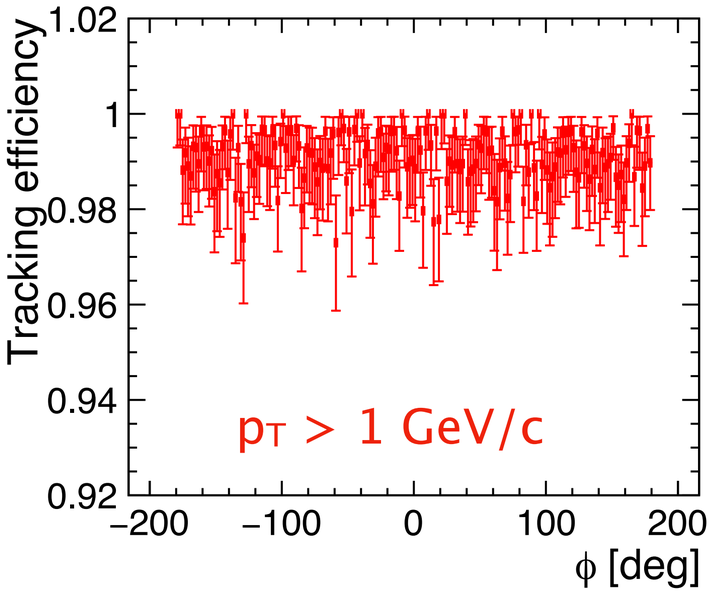
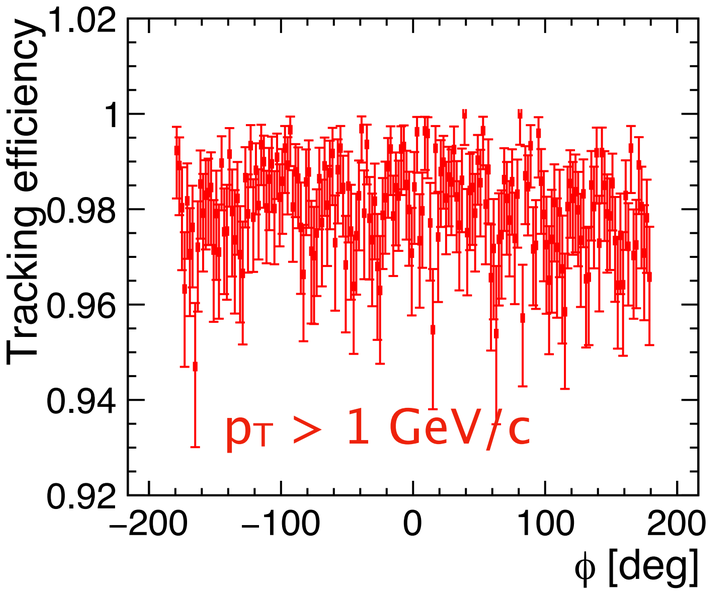
Truth Tracking



Conformal Tracking (VTX) + Extrapolator



Conformal Tracking (FULL)



✓ ttbar events @ 3TeV are reconstructed with a tracking efficiency larger than 90% (and around 99% between 1 and 100GeV/c)

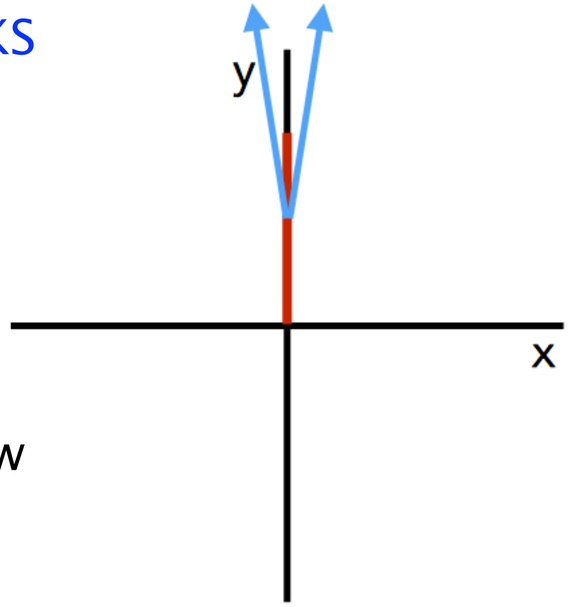
✎ Conformal Tracking Full shows a deeper drop-off at very forward region

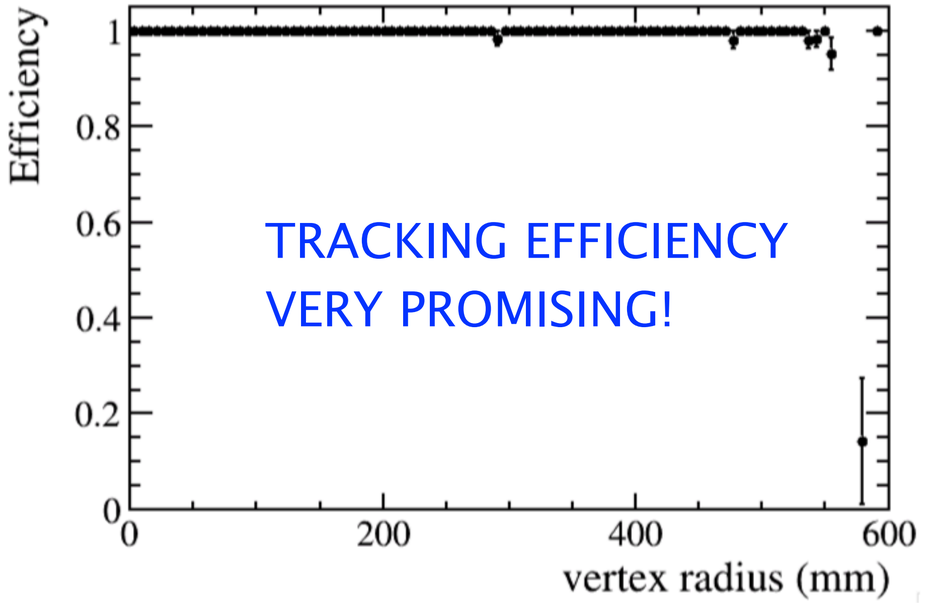
Summary and news

- ✓ Single muons are reconstructed with an efficiency of 100% down to 100MeV/c and in the full phase space down to 10 (170) deg
- ✓ Momentum resolution achieved: 2×10^{-5} for high energy (500GeV) muons in the central barrel
- ✓ Z=>uds events at 91GeV are reconstructed with a tracking efficiency larger than 90% (and around 99% above 1GeV/c)
- ✓ ttbar events @ 3TeV are reconstructed with a tracking efficiency larger than 90% (and around 99% between 1 and 100GeV/c)

FIRST LOOK AT DISPLACED TRACKS

- ☆ 100GeV displaced muons generated in $0 < y < 1$m
- ☆ $80^\circ < \theta, \varphi < 100^\circ$ to point away from IP
- ☆ cuts tuning optimized to reduce execution timing (now 20s/evt)





BACKUP

Vertex barrel layout