CMS Muon Trigger Studies for Phase 2

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for the CMS Collaboration

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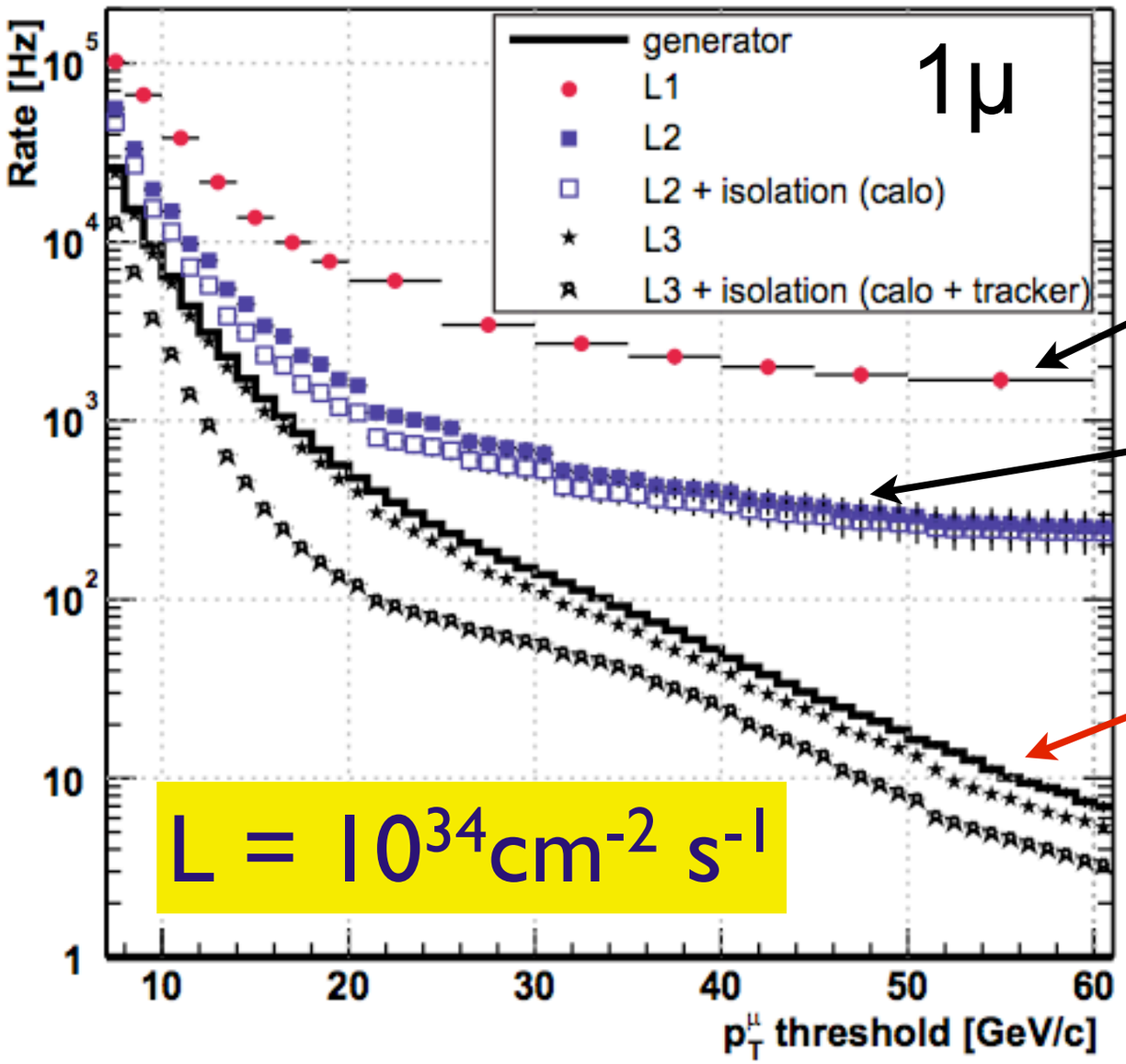
Caveat and Credits

- This talks will cover only some of the studies under way in the Muon community: in particular DT (Barrel) and CSC (Forward) studies
- Other studies on detector improvements for the forward region are going on
- Many thanks for providing the material to:

  Ivan Furic, Bobby Scurlock, Ignazio Lazzizera, Pierluigi Zotto, ...

LV1 Muon Rates at High Luminosity

- Multiple scattering limits p_T resolution in Muon system
  - Low momentum muon feedthrough to high p_T region

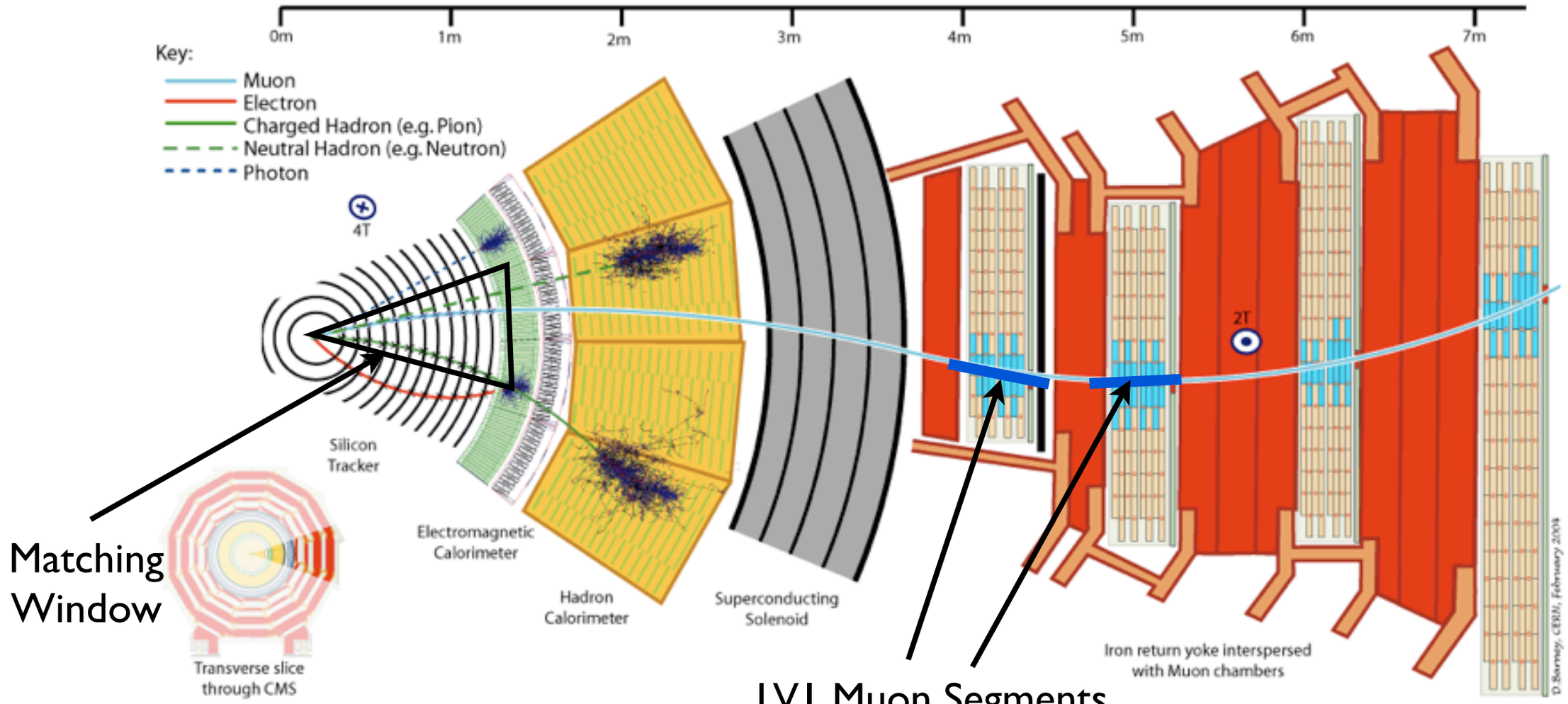


LV1 trigger:
increasing threshold
not very effective

High Level Trigger (software):
big improvement when
also Tracker is used

How to improve resolution

- Associate muon track with LV1 Track Trigger primitives provided by the upgraded Tracker:
  - stubs from Stacked Layers or Cluster Width or..anything else depending on what will be the Tracker architecture, see talk by Marcello Mannelli later this morning



Upgrade strategy towards Phase II

- Improve standalone Muon trigger for Phase I upgrade, see slides by Ivan Furic presented on Wednesday:
  - increase trigger primitive throughput from chambers to improved CSC Track Finder
  - no improvement possible on DT chamber local trigger (Minicrate) but relocate bottleneck peripheral electronics (Sector Collector) from cavern to counting room
- Project Phase I upgrade fully compatible with further improvements
- Study LV1 hardware oriented algorithms to integrate Track Trigger with Muon Trigger system for Phase II

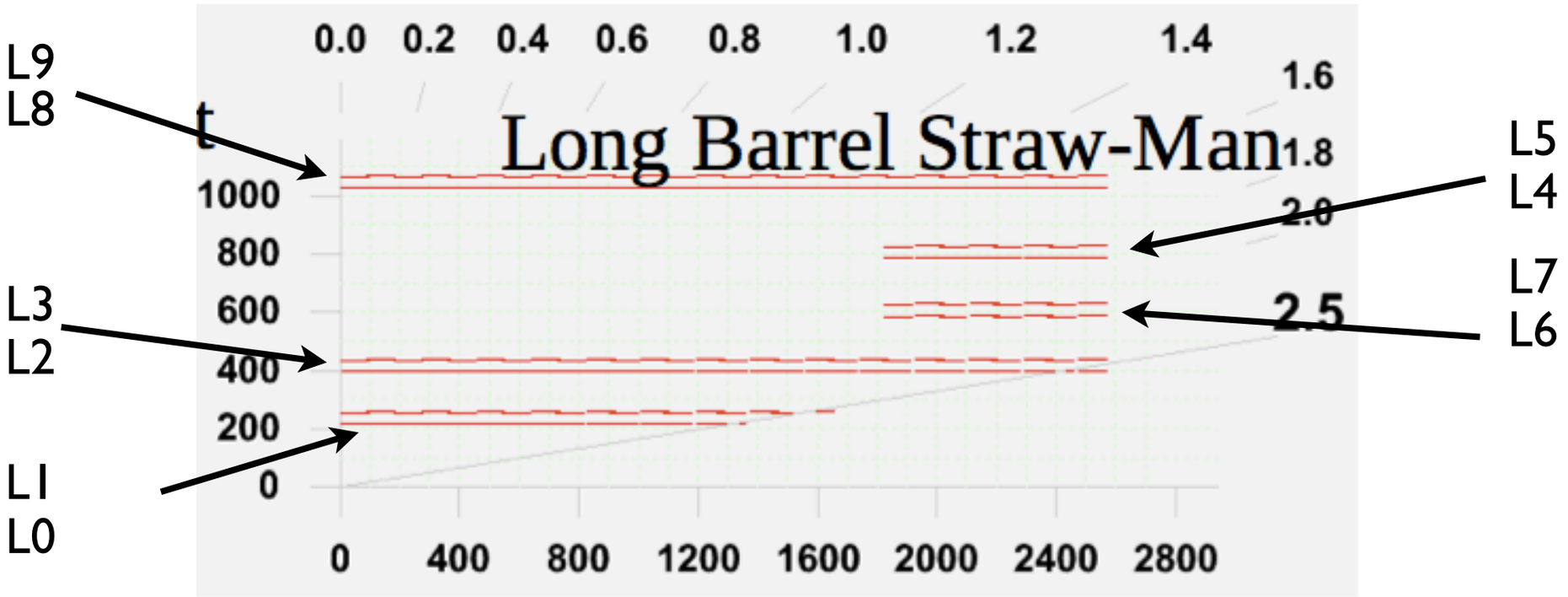
Muon-Tracker association studies

Barrel and Forward groups are working on a similar approach

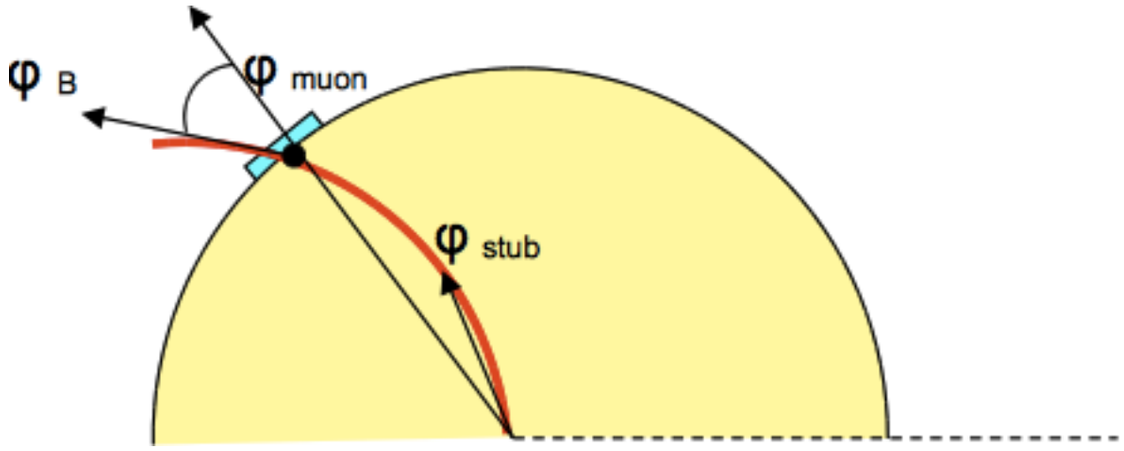
- Extrapolate Muon trigger primitives to the Tracker triggering layers:
  - linear extrapolation before track finding in Barrel
  - LUTs from CSC Track Finder
- Define the size of matching region on the basis of the muon primitive position and transverse momentum
- Match with stubs of Tracker triggering layers, that filter low momentum tracks:
  - ask for Muon trigger primitive confirmation
  - recompute momentum using muon points and/or stubs

Simulation tools

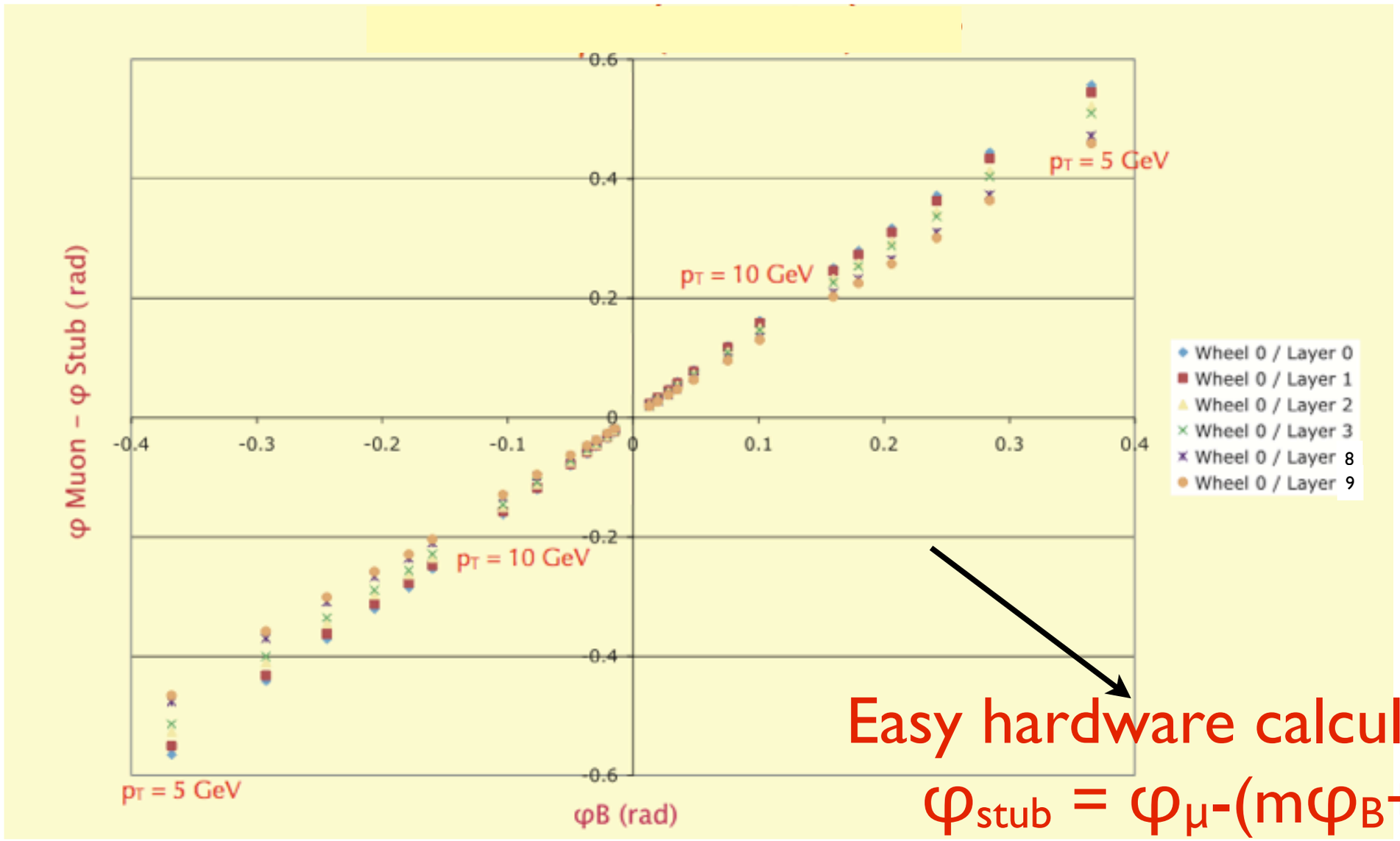
- Full detailed simulation of detector with Single Muons and Minimum Bias with 200 pile-up events
- Long Barrel geometry, that includes Track Trigger stubs reconstruction (p_T > ~2 GeV):
  - ..but our studies apply also to other designs under study



Barrel extrapolation to Tracker



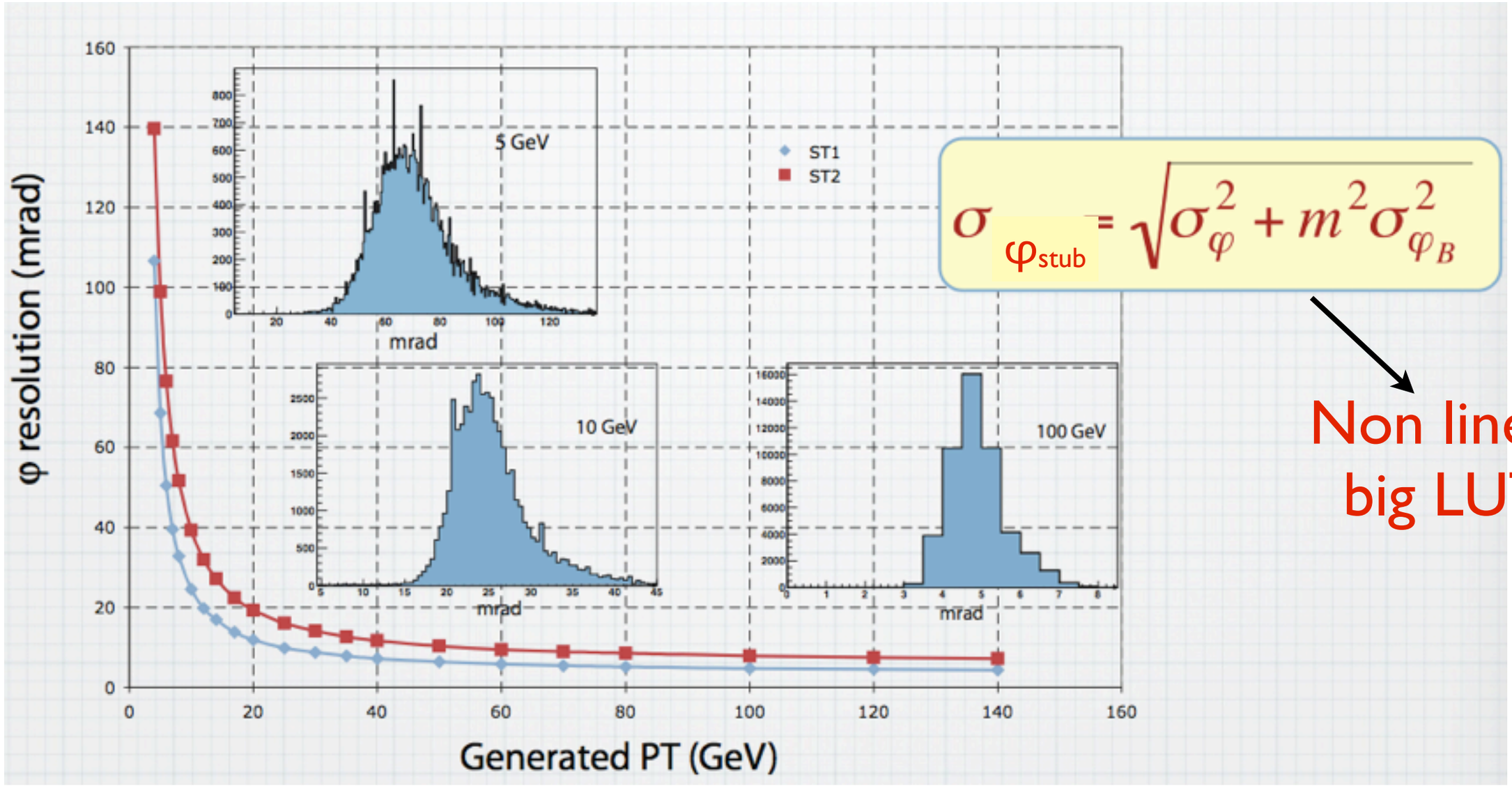
Exploit linear relationship between (φ_{muon} - φ_{stub}) and φ_B



Easy hardware calculation:

$\varphi_{stub} = \varphi_{\mu}-(m\varphi_B+q)$

Barrel windows



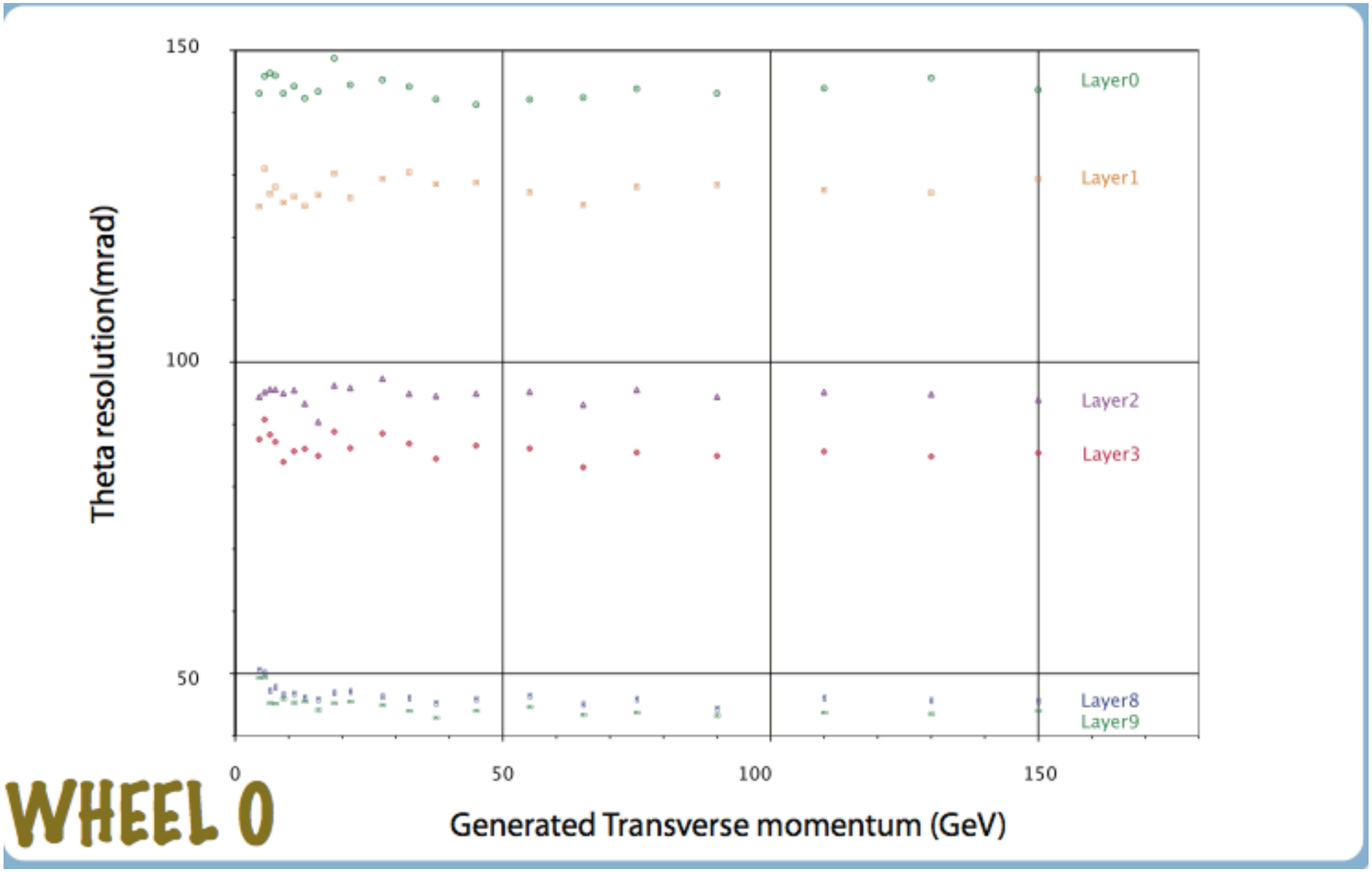
φ resolution is dominated by multiple scattering

φ windows (±3σ) are p_T dependent:

± 90 mrad at 10 GeV

± 15 mrad at 100 GeV

Barrel windows



θ resolution is dominated by beam spot spread

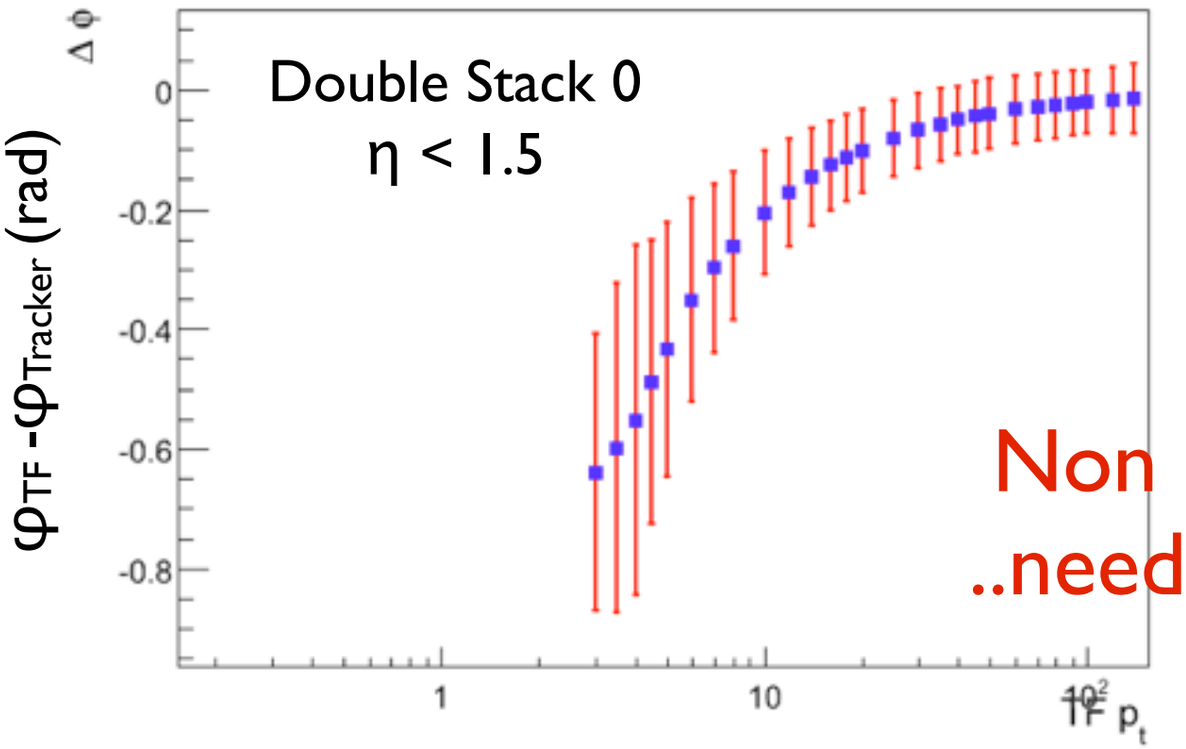
θ windows (±3σ) are dependent on the position of Tracker layer:

± 440 mrad at 35 cm from beam

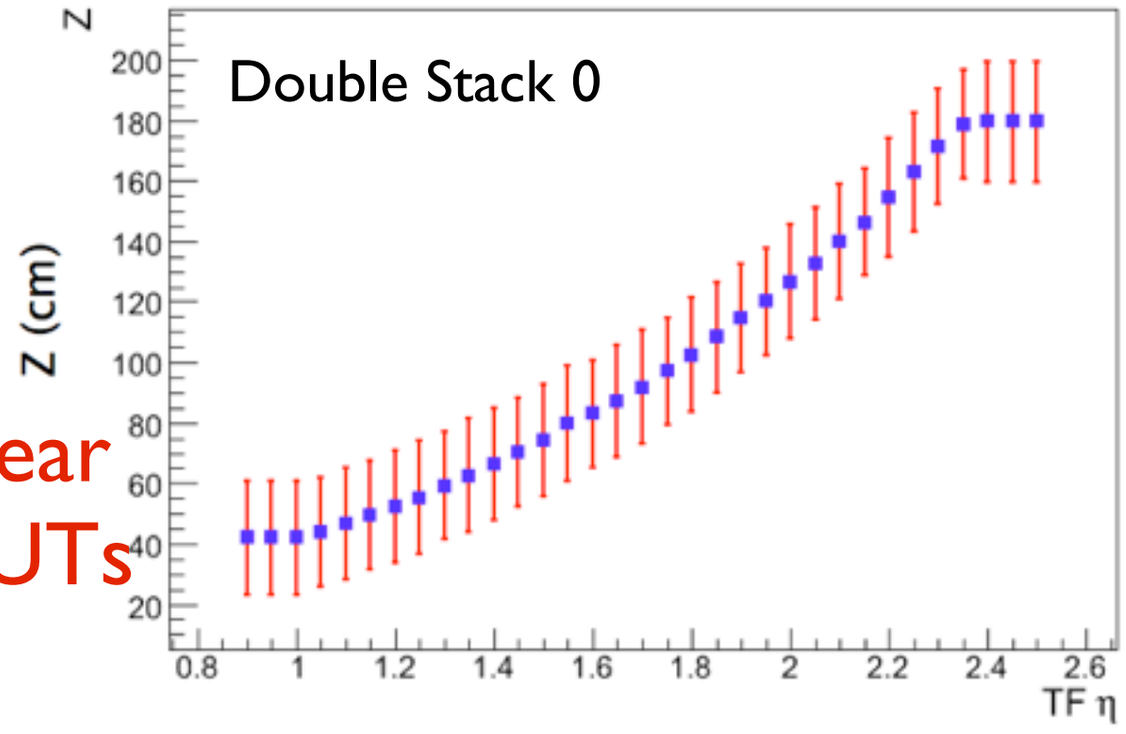
± 130 mrad at 100 cm

Forward windows

Matching $\varphi_{TF} \rightarrow \varphi_{Tracker}$ windows



Matching $Z_{TF} \rightarrow Z_{Tracker}$ windows



Non linear
..need LUTs

Residual σ ~ O(0.1) - O(0.01) rad, dominated by multiple scattering and p_T resolution

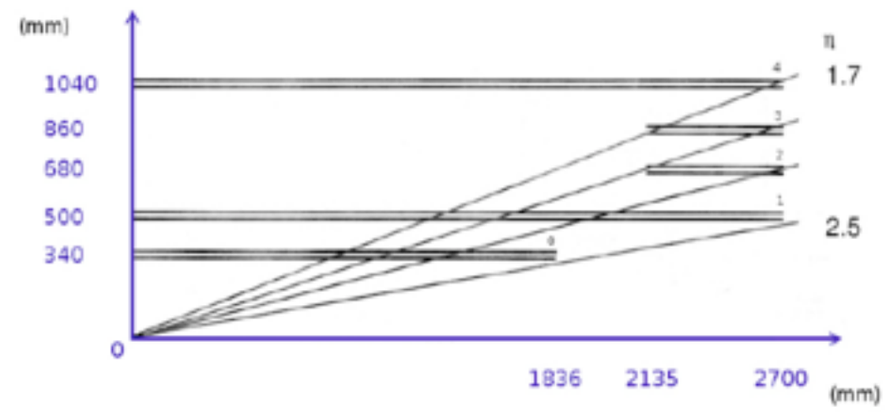
± 3 σ window:

±100 mrad at 10 GeV

± 50 mrad at 100 GeV

Residual σ ~ 6 cm, dominated by beam spot

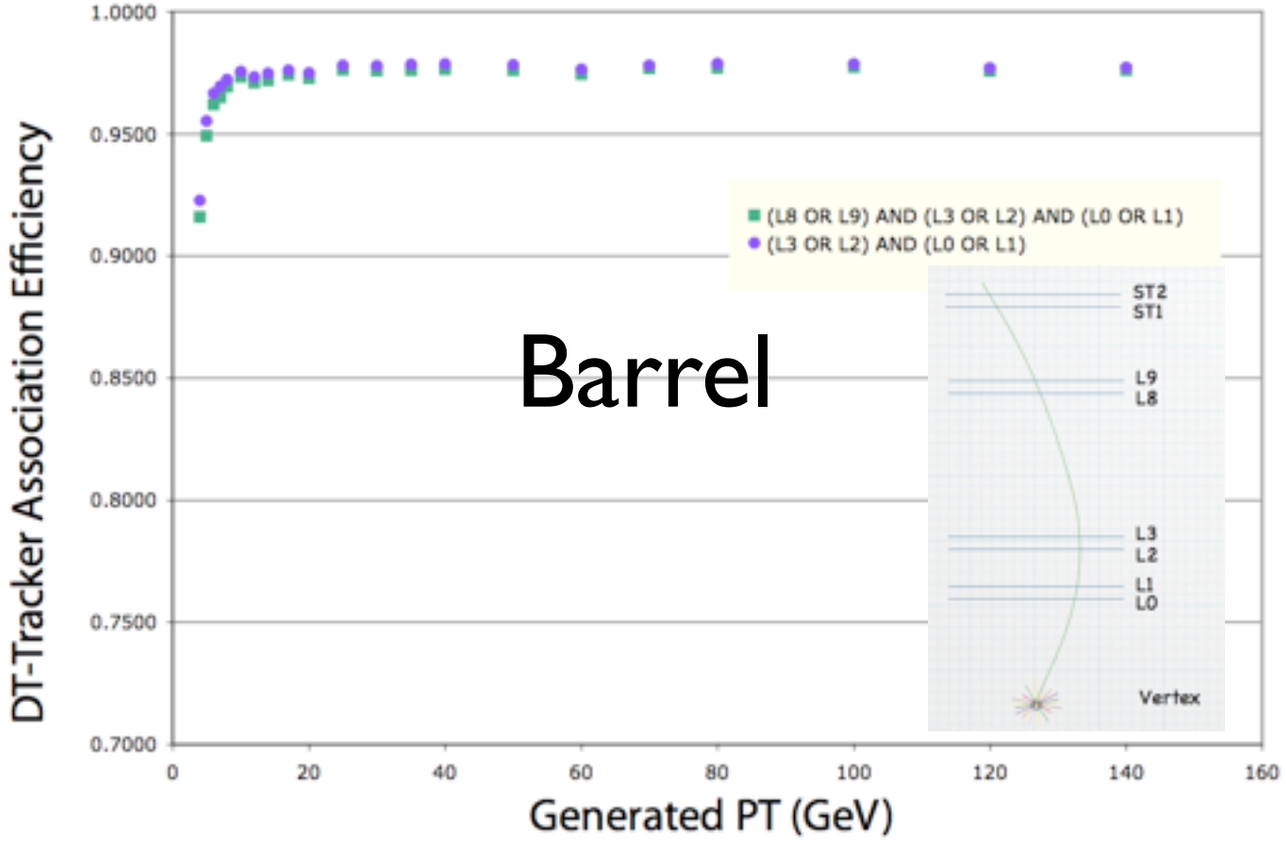
± 3 σ window: ± 18 cm wide

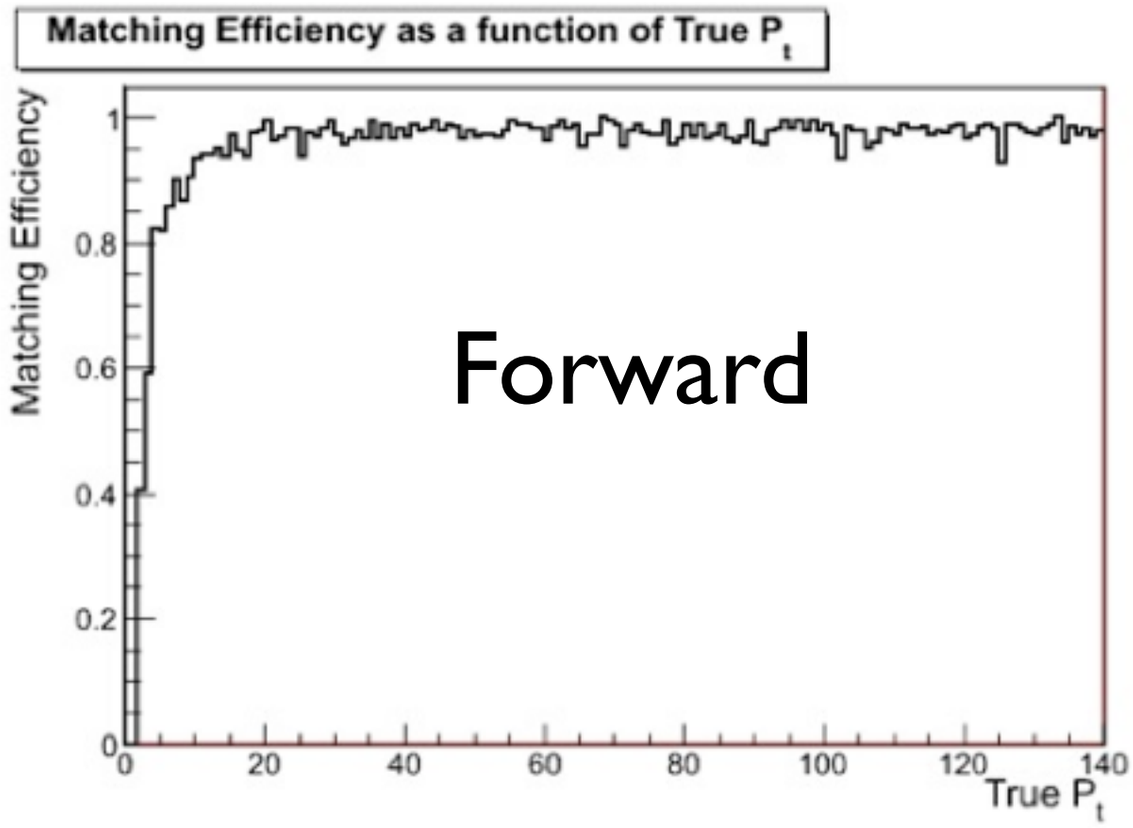


Muon-Tracker matching efficiencies

- Performance of matching algorithm tested with single muons
- Efficiency to find the stub inside the matching window:

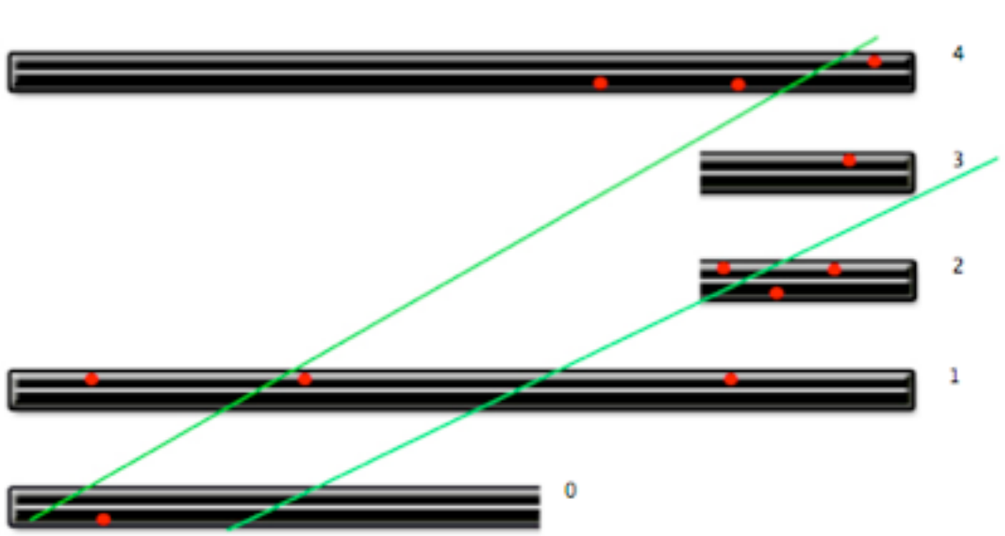
>95% for true p_T>10 GeV

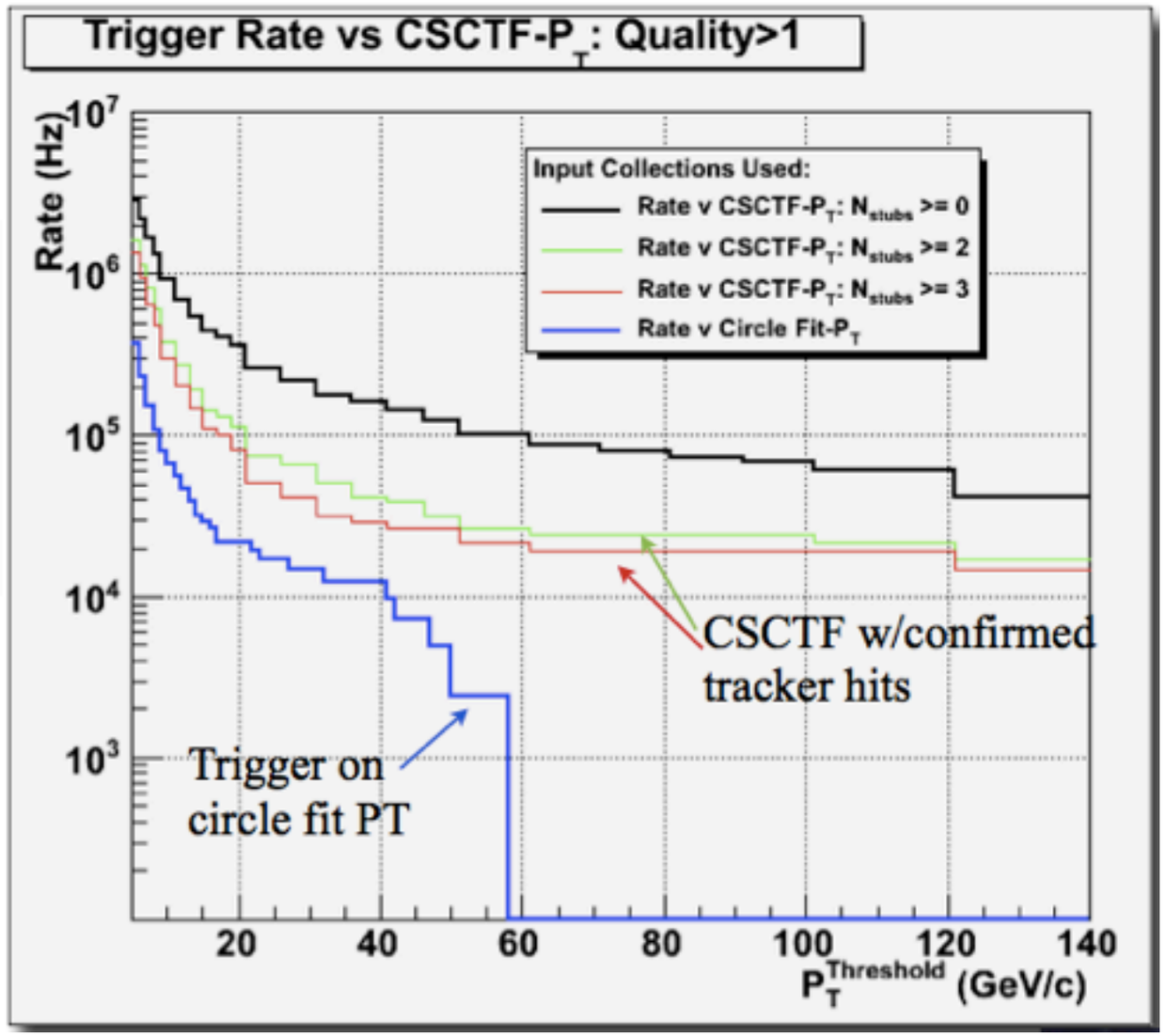




Rate reduction from stubs matching

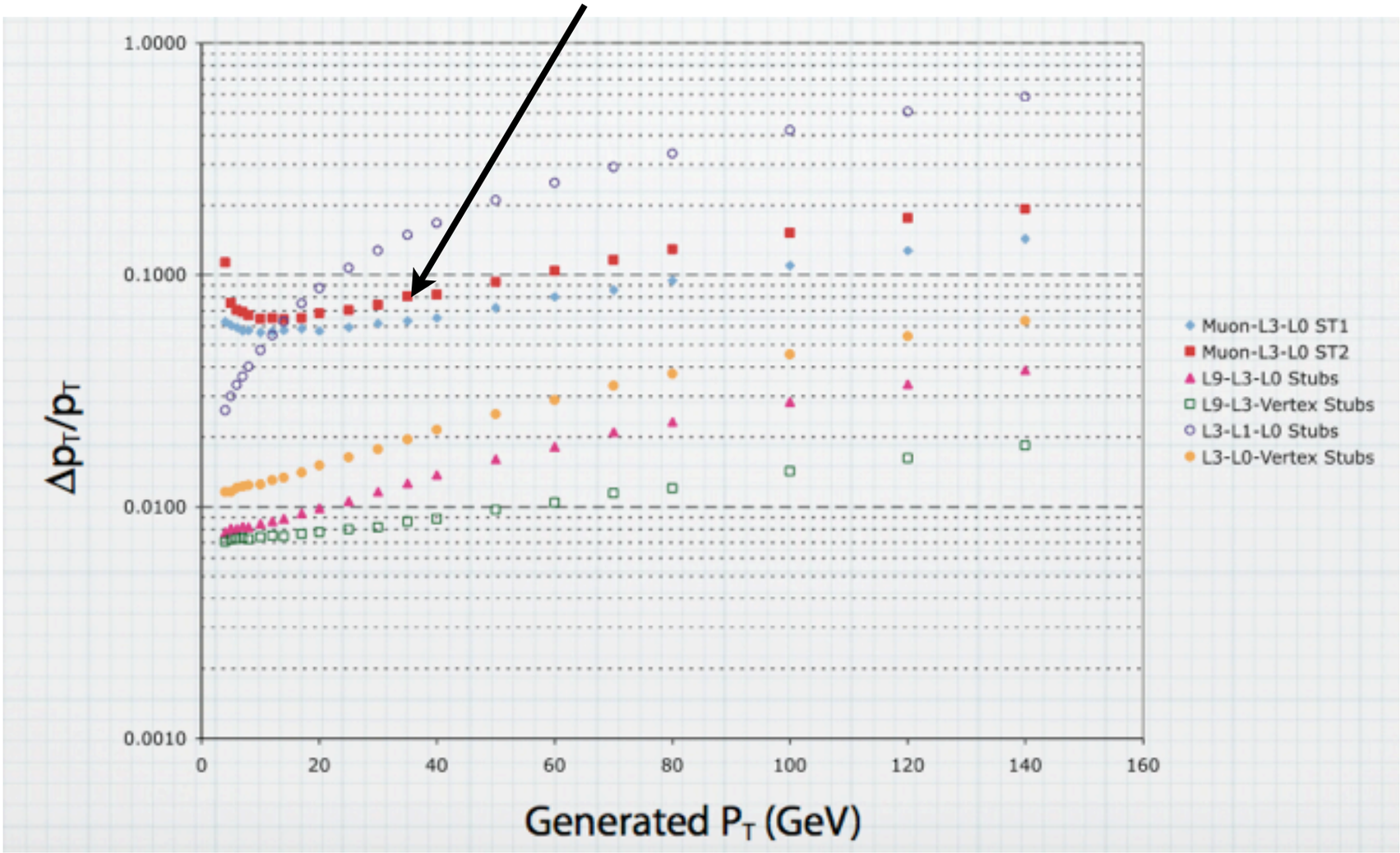
- Count Track trigger stubs in matching window extrapolated from Muon trigger: Forward case presented here
- Minimum Bias 200 pile-up events
- Muon trigger confirmed if Tracker stubs are found: strong rate reduction power..

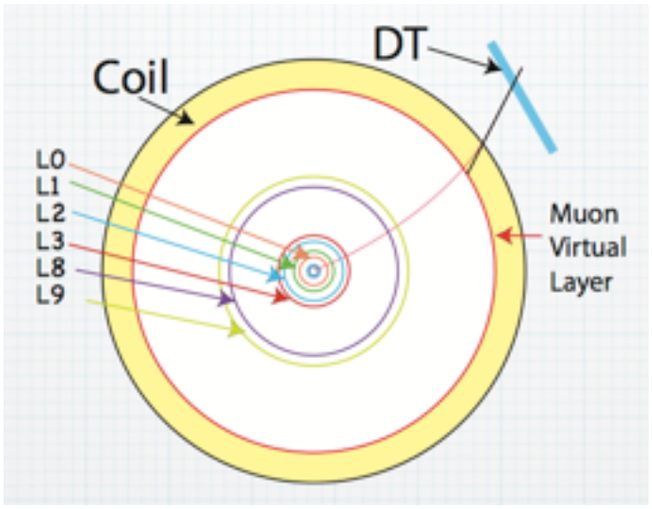




Transverse momentum estimation

- Circle fit through 3 points: Barrel case presented here
- Several combinations compared:
  - large dependence on lever arm
  - even 1 muon+2 internal stubs useful to improve resolution





Conclusions

- The strategy is to improve as much as possible muon trigger for Phase I in view of further improvements for Phase II
- All components of full algorithm flow for matching with Tracker Trigger have been developed for Barrel and Forward
- Enhanced p_T resolution allows big improvement in trigger rate control
- Hardware architecture will be dependent on what will be the choice and the performance of the Track Trigger...for sure significative processing power and big LUTs will be needed..