Muon Detectors scaled from DØ to VLHC

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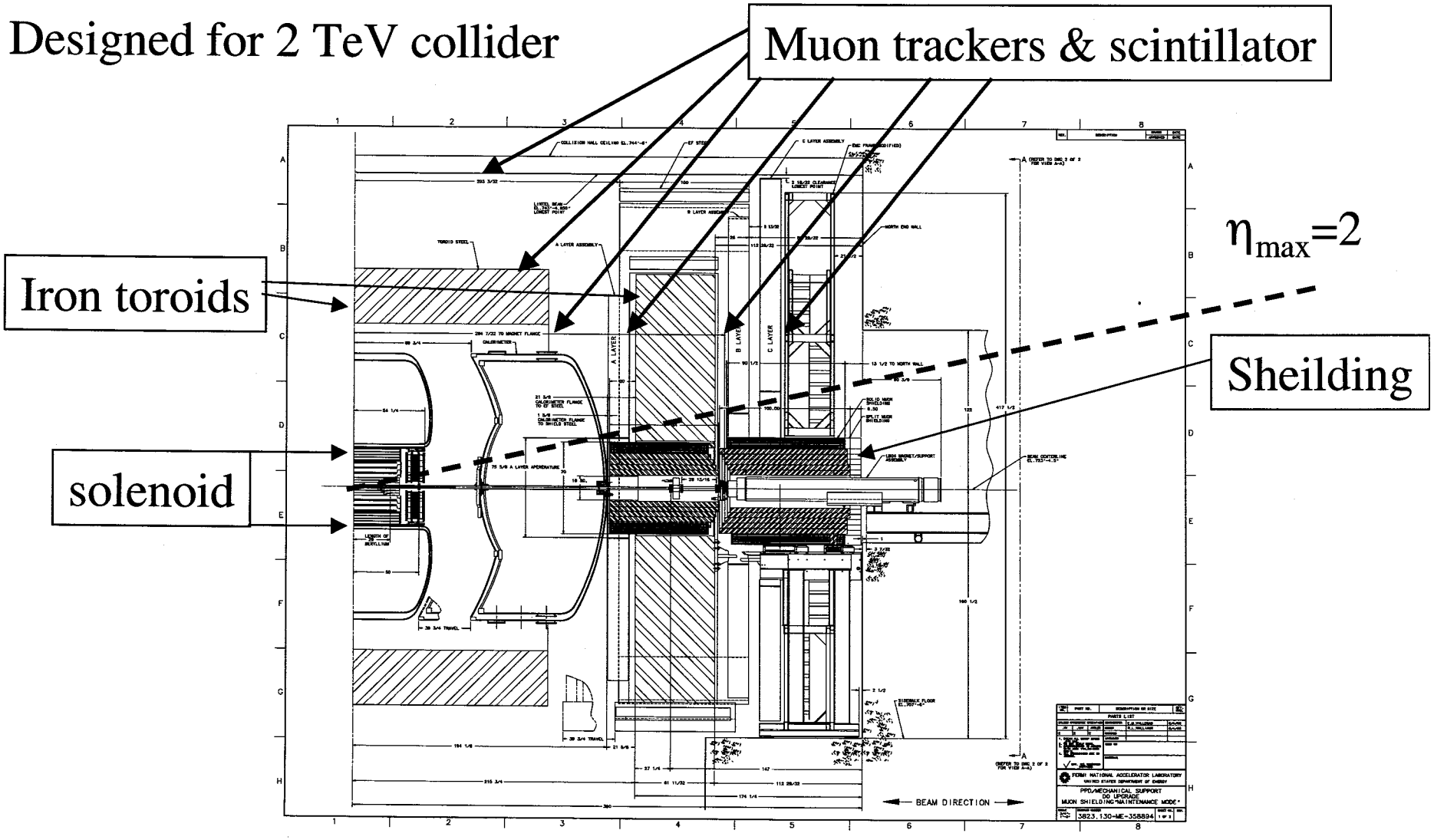
Disclaimers

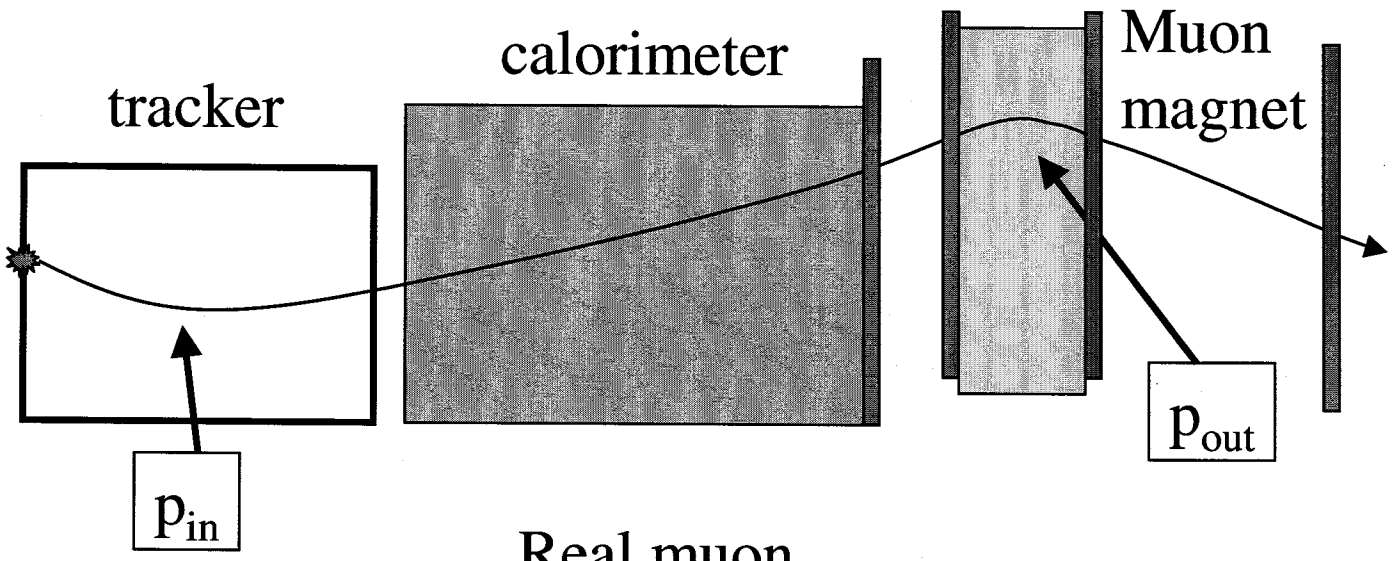
- Asked to give this talk a few days ago…not prepared before Snowmass
- Not an author SSC, LHC, or VLHC studies (should be experts in the audience)
- References:
  - Design Study for a Staged VLHC (Fermilab-TM-2149)
  - "Muon Identification at a Very Large Hadron Collider", T. LeCompte, et al., VLHC detector workshop 1997
  - PDG Review of Particle Properties, ch. 23
  - CMS muon system TDR
  - Also ATLAS, SDC, GEM, …
- Goal: stimulate useful discussion

DØ Muon System

Designed for 2 TeV collider



Signal

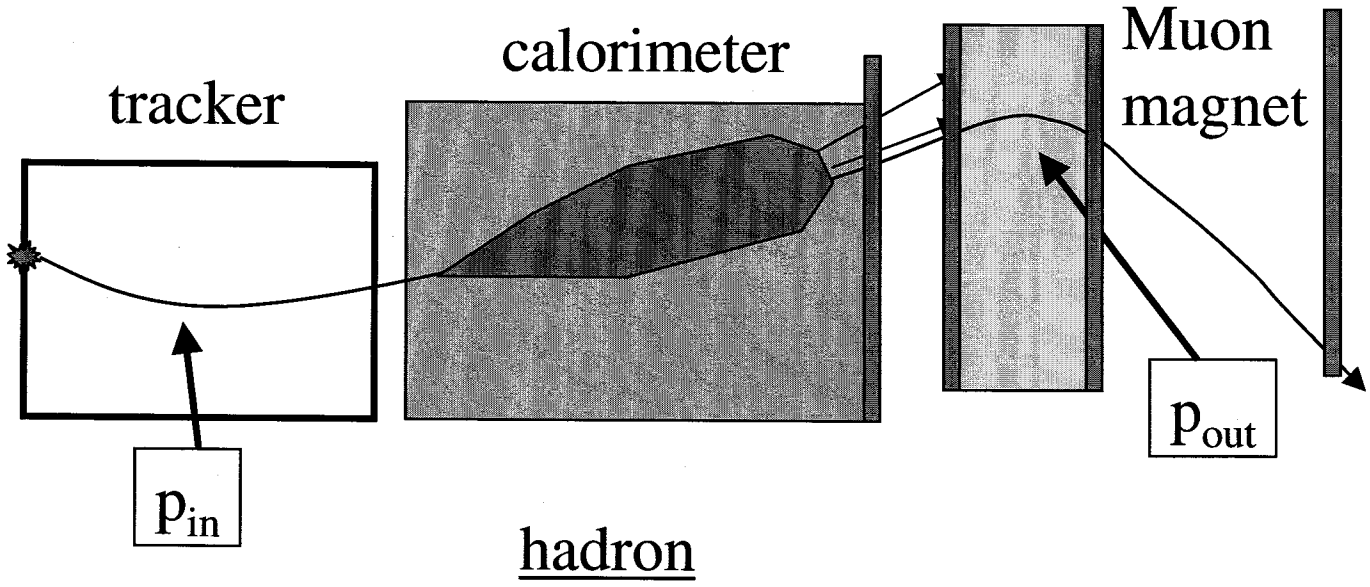


Real muon

$p_{in} \approx p_{out} + E_{loss}$ (muon ID tool)

Better resolution comes from tracker; p_{out} dominated by multiple scattering (or showering)

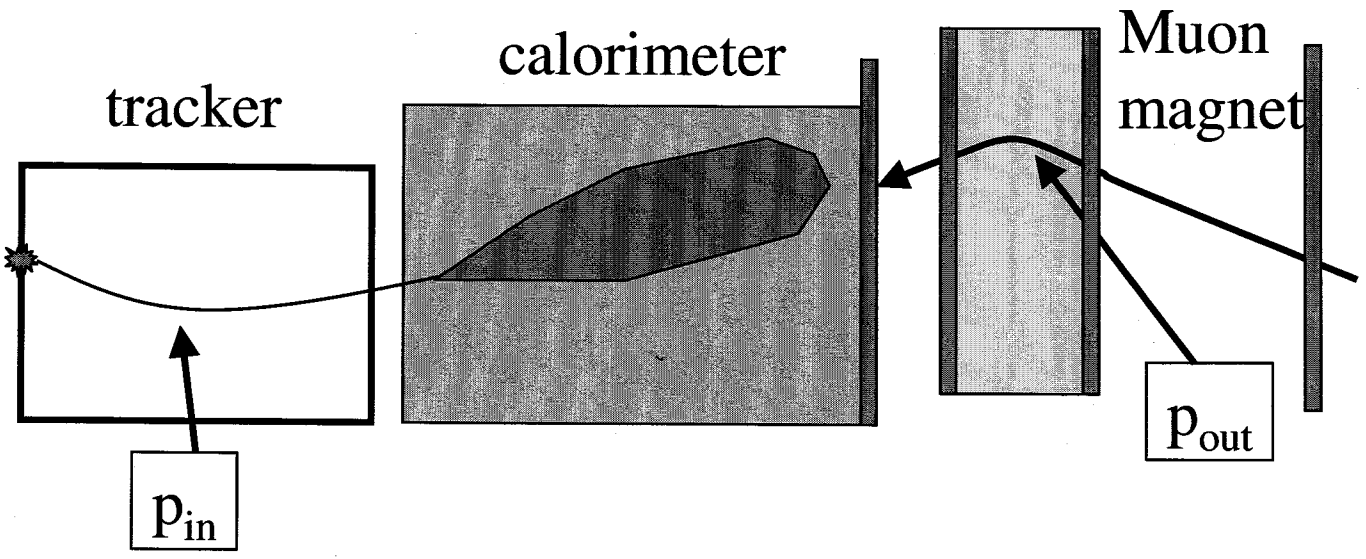
Background 1: punchthrough/decay



$p_{in} >> p_{out} + E_{loss}$

Outer decay/p.t. track points back to parent hadron, but momenta do not match.

Background 2: halo/backscatter

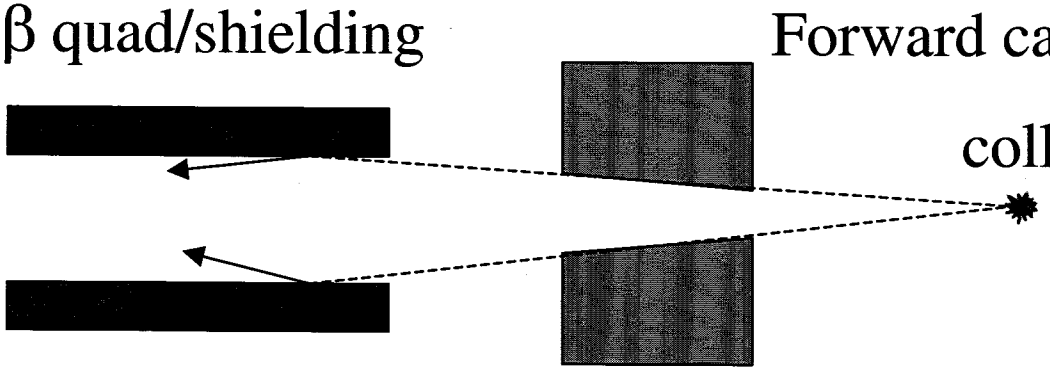


p_{in} ? $p_{out}+E_{loss}$

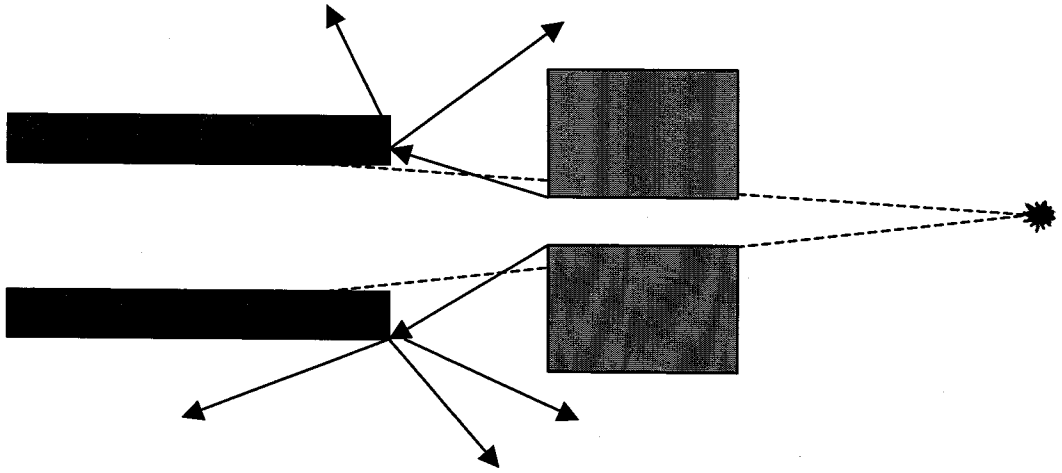
Good timing (scintillator) can get rid of most of these

Backscatter background

- Reduce source: conical beam pipe/calorimeter:



Or else…



- shield around quads
- reject remaing backscatter with timing

Naïve scaling: rapidity coverage

- $y_{max} \approx \ln(\sqrt{s}/M)$
  - $2.0 \rightarrow 5.0$ (40 TeV), 6.6 (200 TeV)
- Rapidity coverage probably depends on what physics we want to do:

	2 TeV	40 TeV	200 TeV
W (M=.08 TeV)	3.2	6.2	7.8
Ttbar (M=0.35 TeV)	1.7	4.7	6.3
Zprime (M=2 TeV)	0	3.0	4.6

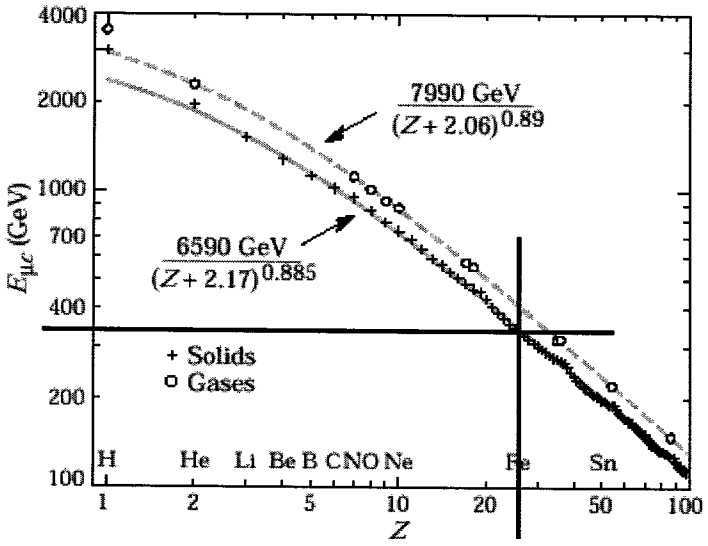
Caution: this is real rapidity (y) of the parent system, not the pseudorapidity of the daughter muon

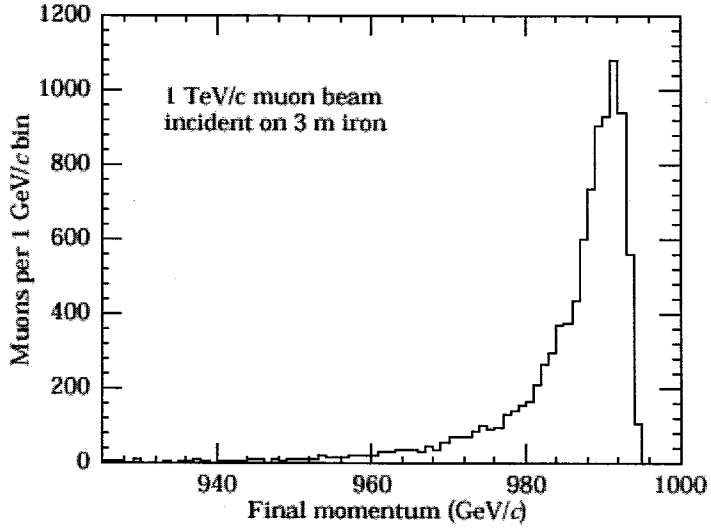
Naïve scaling: sagitta measurement

- DØ: Bdl=2 T*m, with 10 points measured with about 1mm precision.
  - Multiple scattering and sagitta errors equal at 60 GeV (muon stand-alone measurement)
  - Loose sign determination at 300 GeV
- Assume similar geometry at VLHC
  - Sign determination up to 10 TeV requires
    - 30 micron precison or
    - eBdl=60 T*m or
    - More lever arm or
    - More points measured or
    - Combination
- Even possible to do given showering effects?

Scaling violations

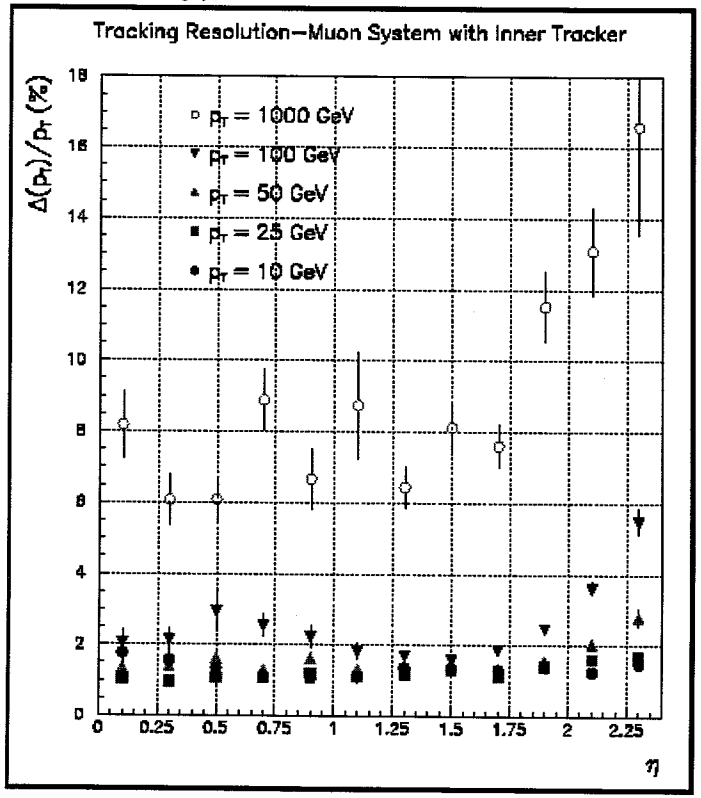
- Very high energy muons start to shower like electrons. Critical energy = place where showering losses = dE/dx





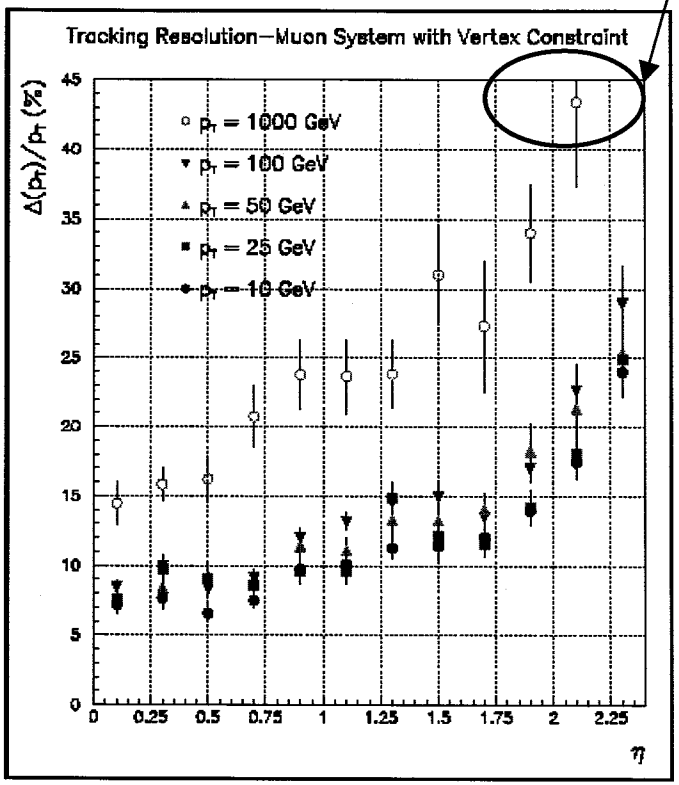
CMS Muon Resolution (MC)

- Stable up to 100 GeV
- Degradation at 1 TeV due to both sagitta resolution and showering.



With central tracking

p = 4 TeV



Without central tracking

Discussion points

- $\sqrt{s}$=40 TeV: What can be learned from SDC and GEM designs?
- $\sqrt{s}$=200 TeV: What to do about muon showering?
  - Muon calorimetry
  - Transition radiation
- Triggering?