Studies toward an upgraded CSC + Tracker TF

D. Acosta, M. Fisher, I.K. Furić, J.Gartner,
D. Holmes, A. Madorsky

University of Florida

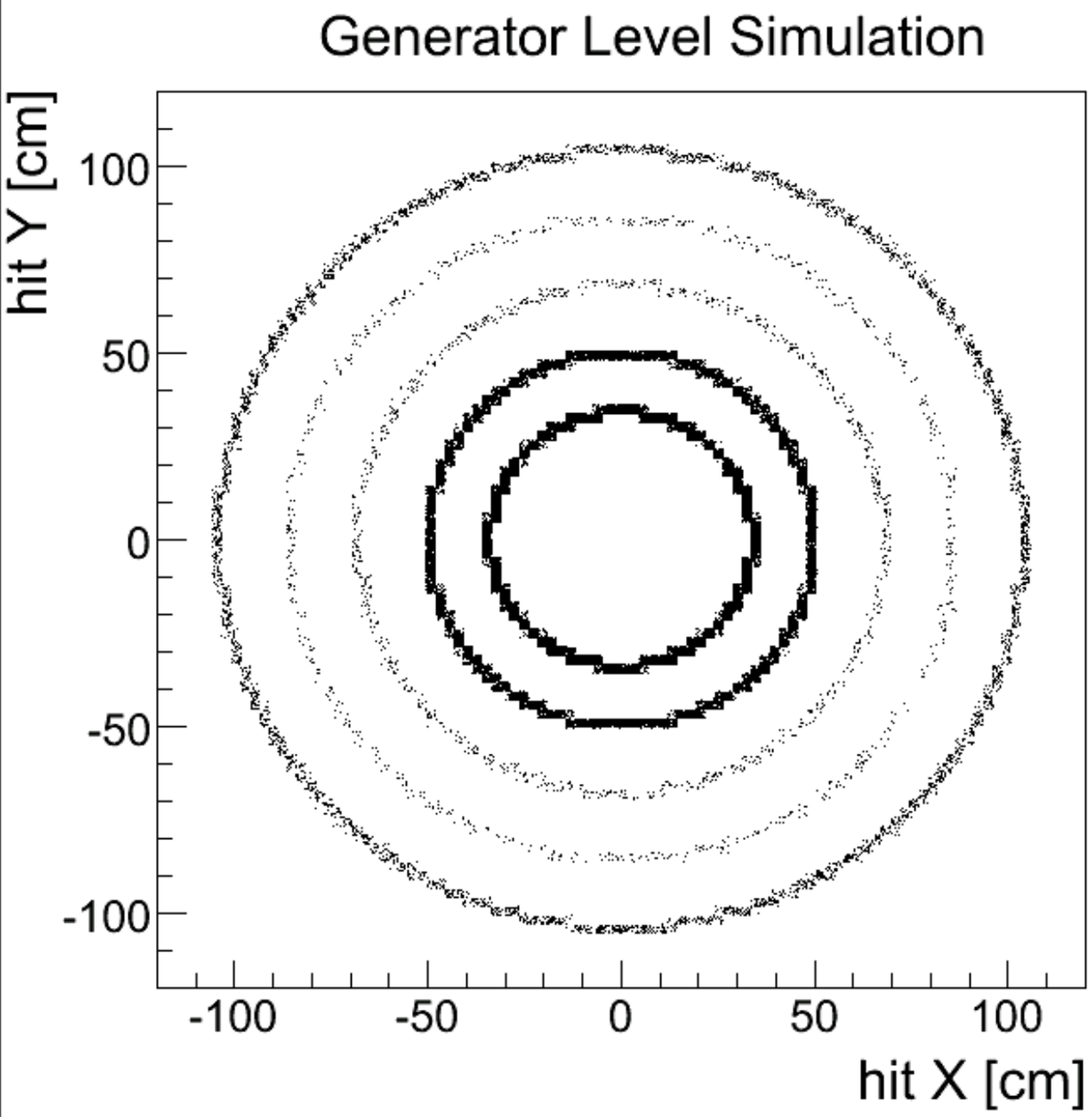
Introduction / Goal

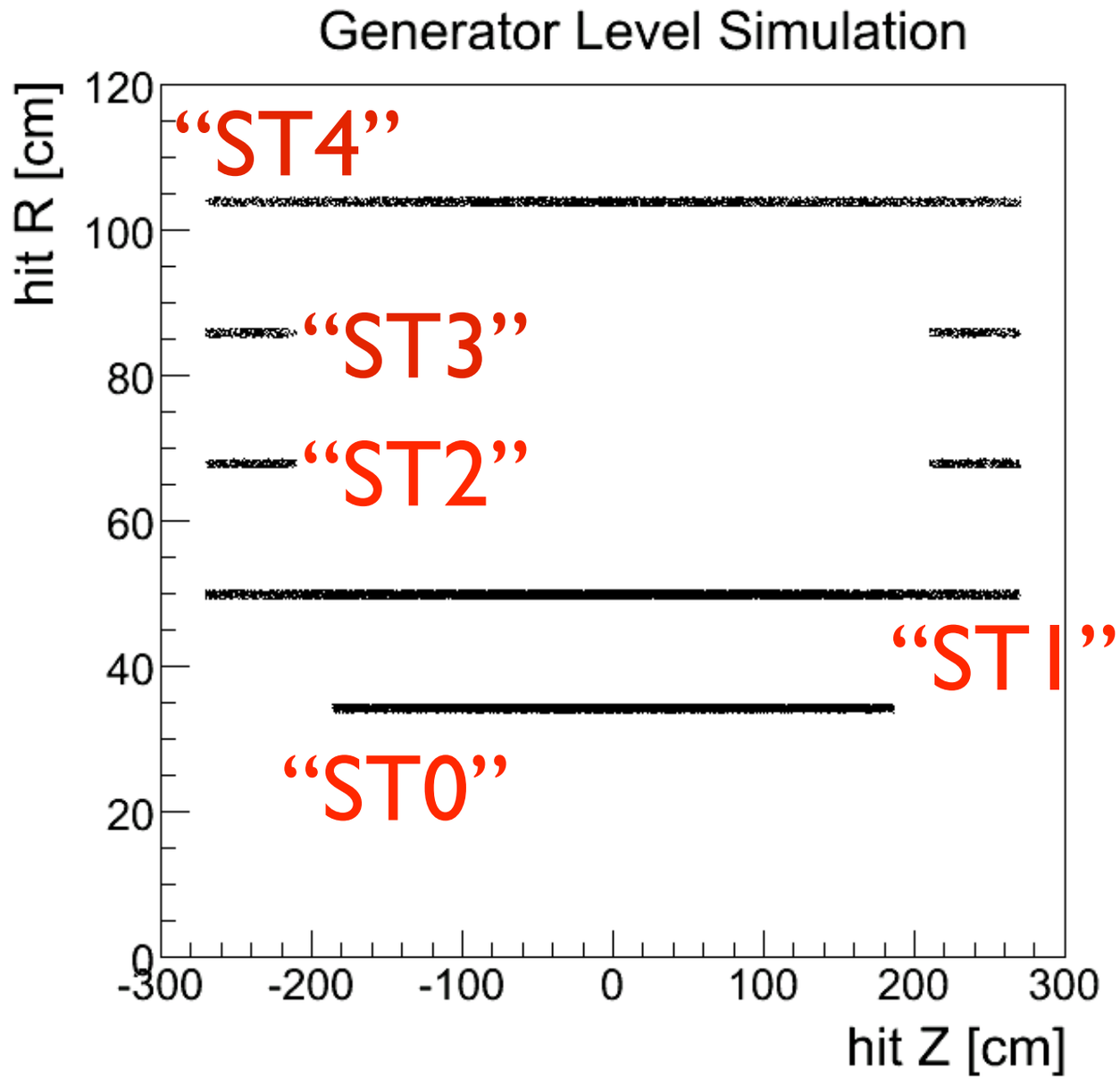
- Main Goal: develop a device for matching CSC TF tracks to Tracker Trigger tracks
- Intermediate Goal: Upgrade TF output to necessary resolution for useful track seeding / matching
- Boundary conditions for a trigger device:
  - data transfer volume and feasible rate
  - pattern recognition combinatorics
  - decision / output time
- Plan to study/develop design with increasing level of realism and complexity with time
- today: mostly generator level studies

CSCTF - TK Interface

- low occupancy in muon system → seed tracks
- "swim" CSCTF tracks into tracker, establish search windows for matching with stubs/tracklets
- either "pull" tracker information from TK system or combine TF+TK data as TK "pushes" information out

Tracker Simulation



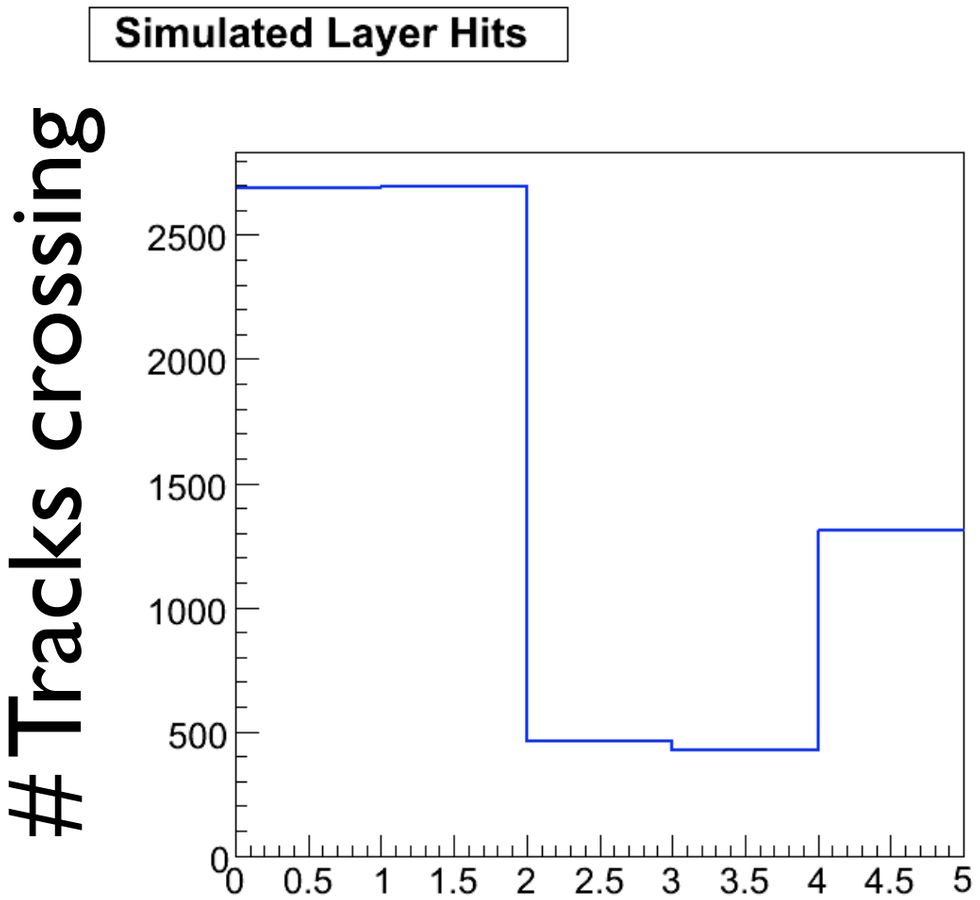


Based on Peter Sharpe's talk @FNAL, Nov 2008

Fiduciality-level studies only - no resolutions

TK Layers Contributing

- investigating forward region: $0.9 < \eta < 2.4$, $p_T > 2$ GeV/c
- expect hits in ST0, ST1 always (modulo construction cracks)
- ST2, ST3 hit ~ 20% of the time
- ST4 hit ~ 50% of the time
- due to construction, most of the tracks are 3-hitters (0,1,X)
- ~15% of tracks 2-hitters (0,1)
- 4hitters - mostly (0,1,3,4), ~3%

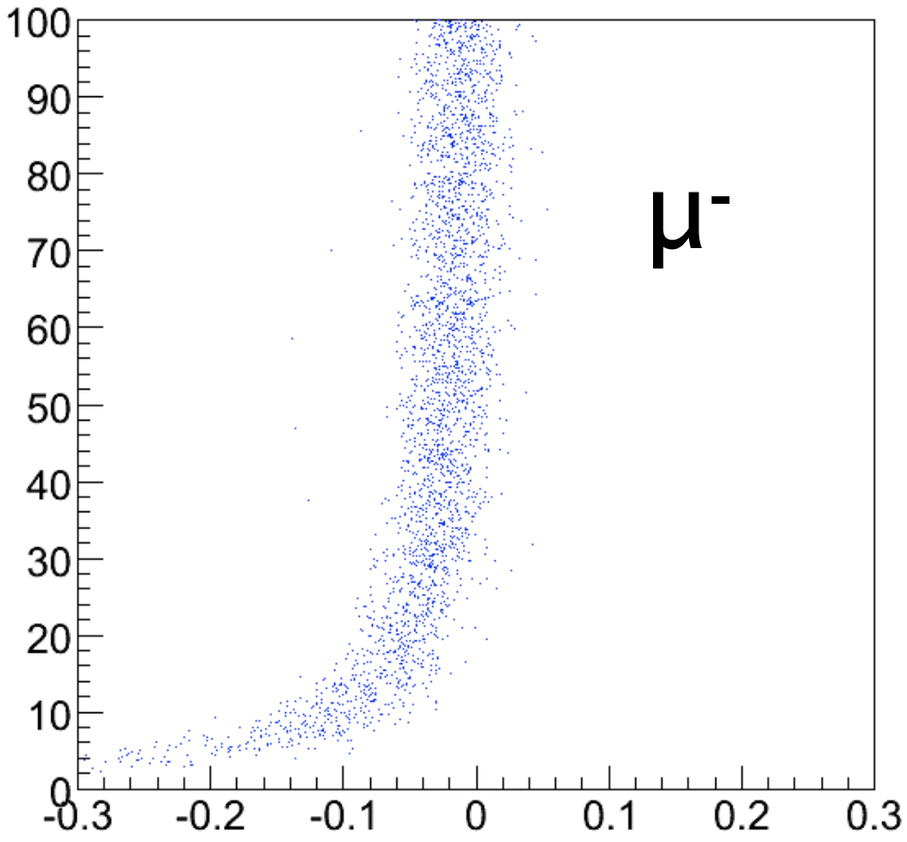


CSC TF Resolutions

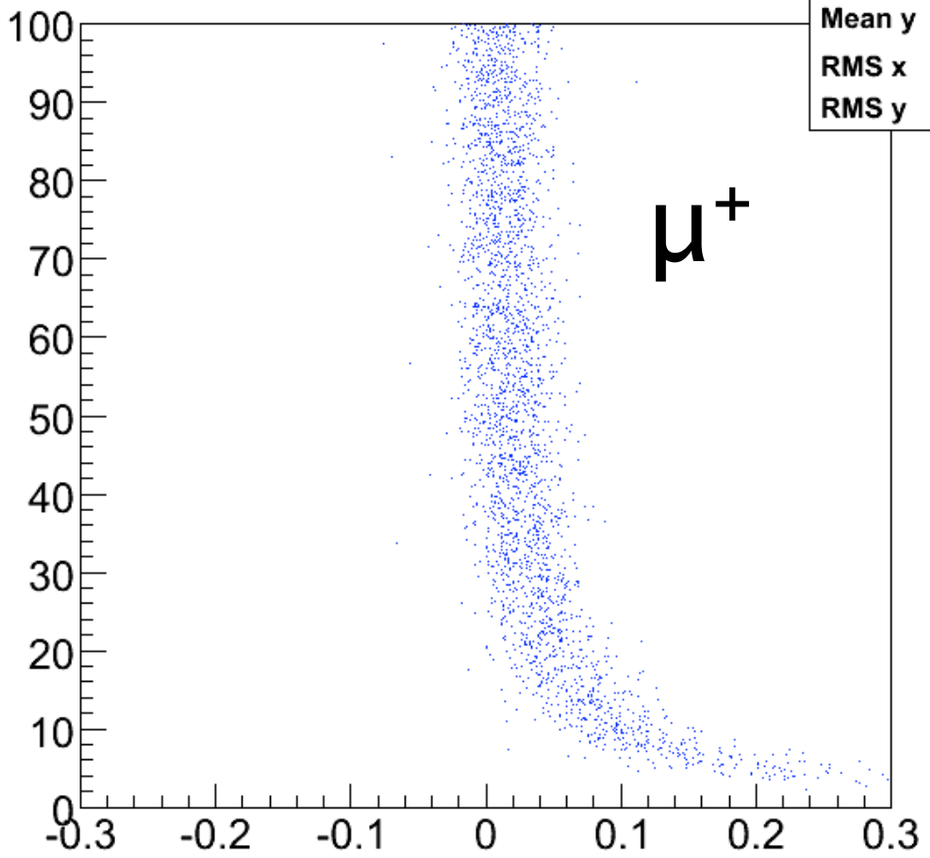
- not estimating combined CSCTF+TK resolutions
- depends on TK output, combination algorithm
- for matching to TK, CSCTF standalone important
- TF track used as seed - TF reports phi, eta at Station 2
- used uncorrected as seed at detector center
- both simulated and TF tracks swam through tracker volume
- compute distance between true track and TF track

CSC TF Δφ Windows

Station 0



Station 0

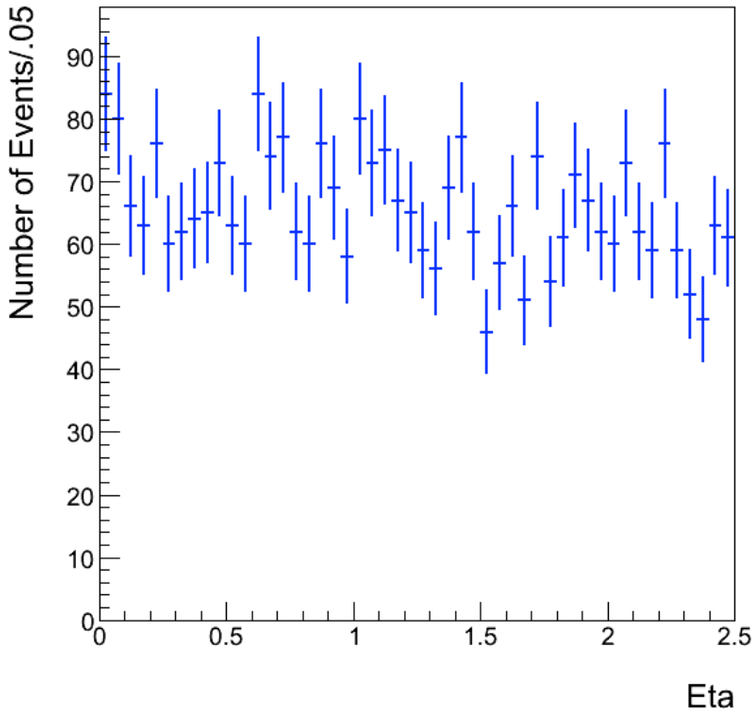


- will need to implement bending corrections for low momentum tracks
- some amount of correction already in plots
- crucial for "low" momentum triggering (<20 GeV)

High-PU Charged Particle Multiplicity

Eta < 2.5 and Pt > 5 GeV

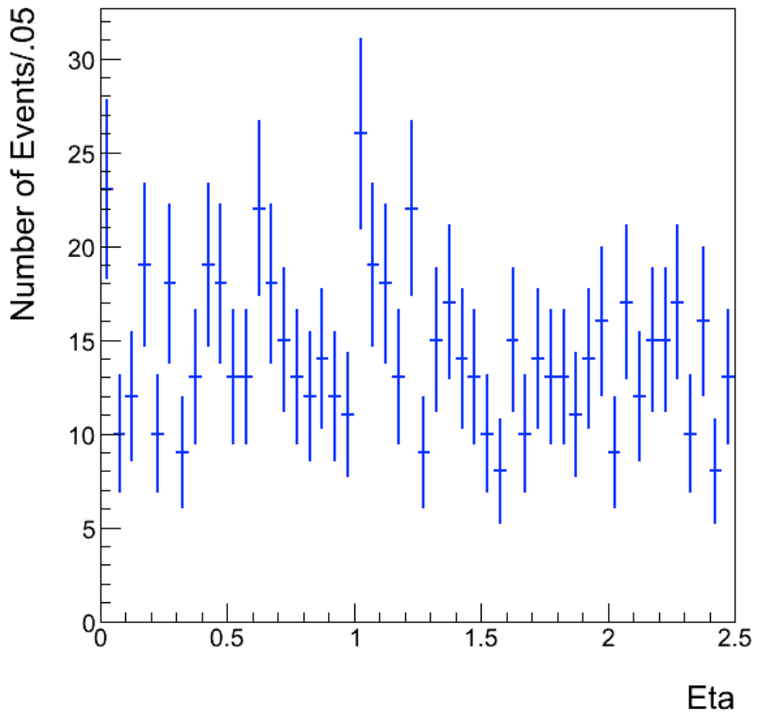
Eta < 2.5 and Pt > 1 GeV

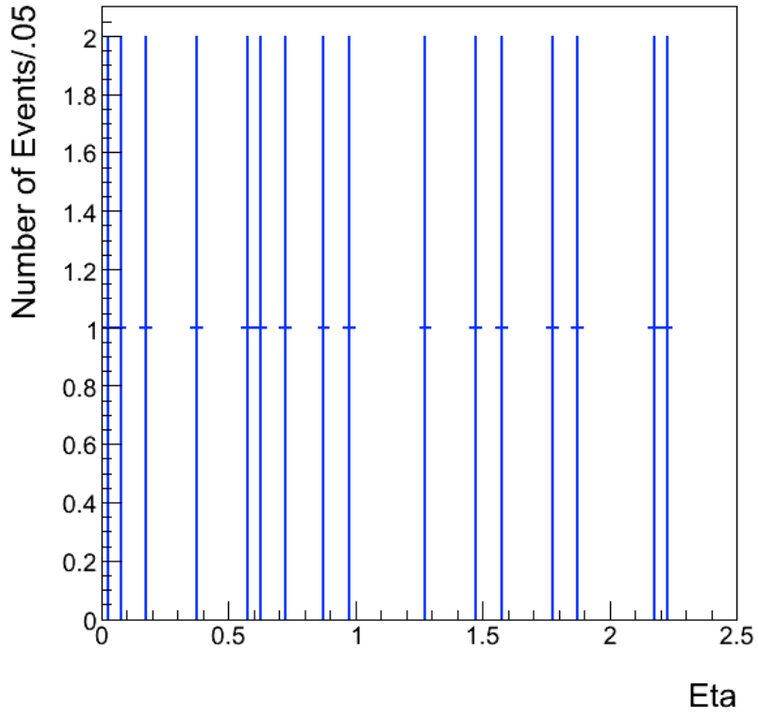


0.2 part/1η/1Φ/PU

0.04 part /1η/1Φ/PU

Eta < 2.5 and Pt > 2 GeV

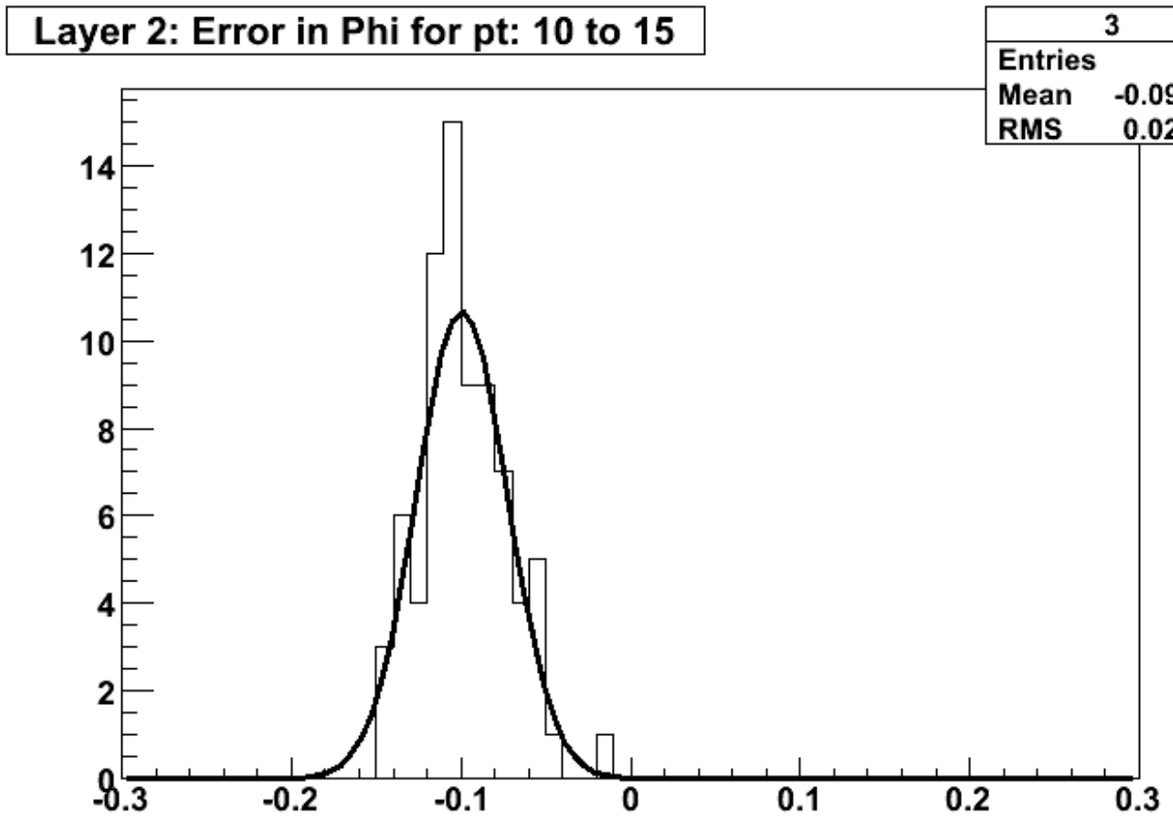


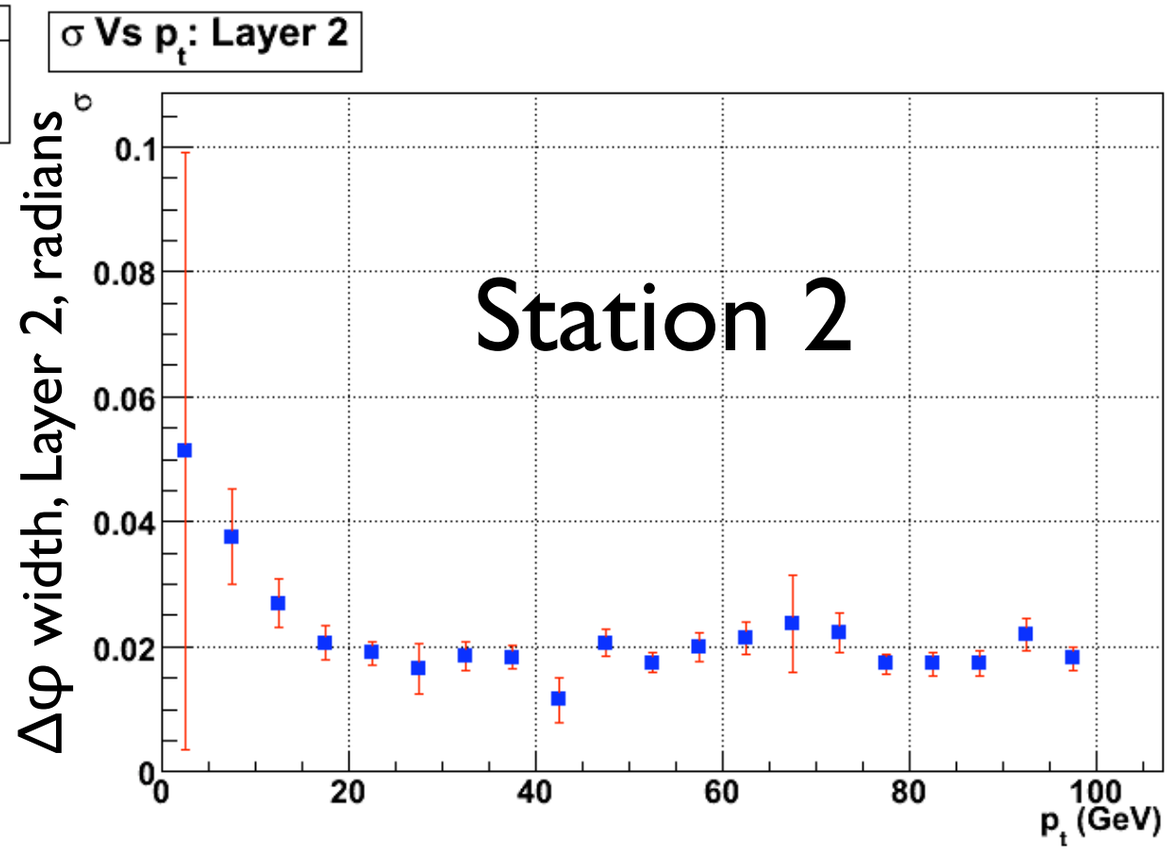


0.001 part/1η/1Φ/PU

- 0th order - looking at minbias sample track multiplicities at different momenta, 1000 single MB ev
- below 1 GeV: 1.04 particles / unit η/ unit Φ/ PU

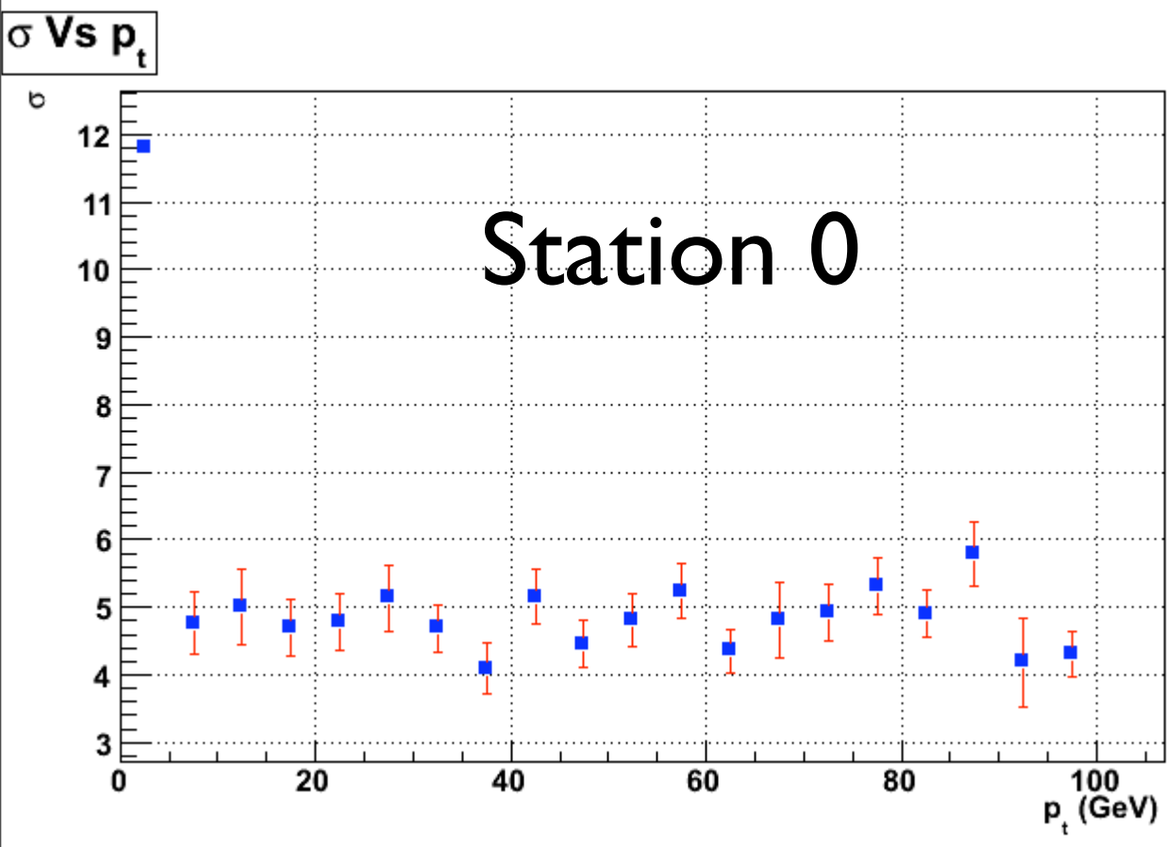
Search window sizes

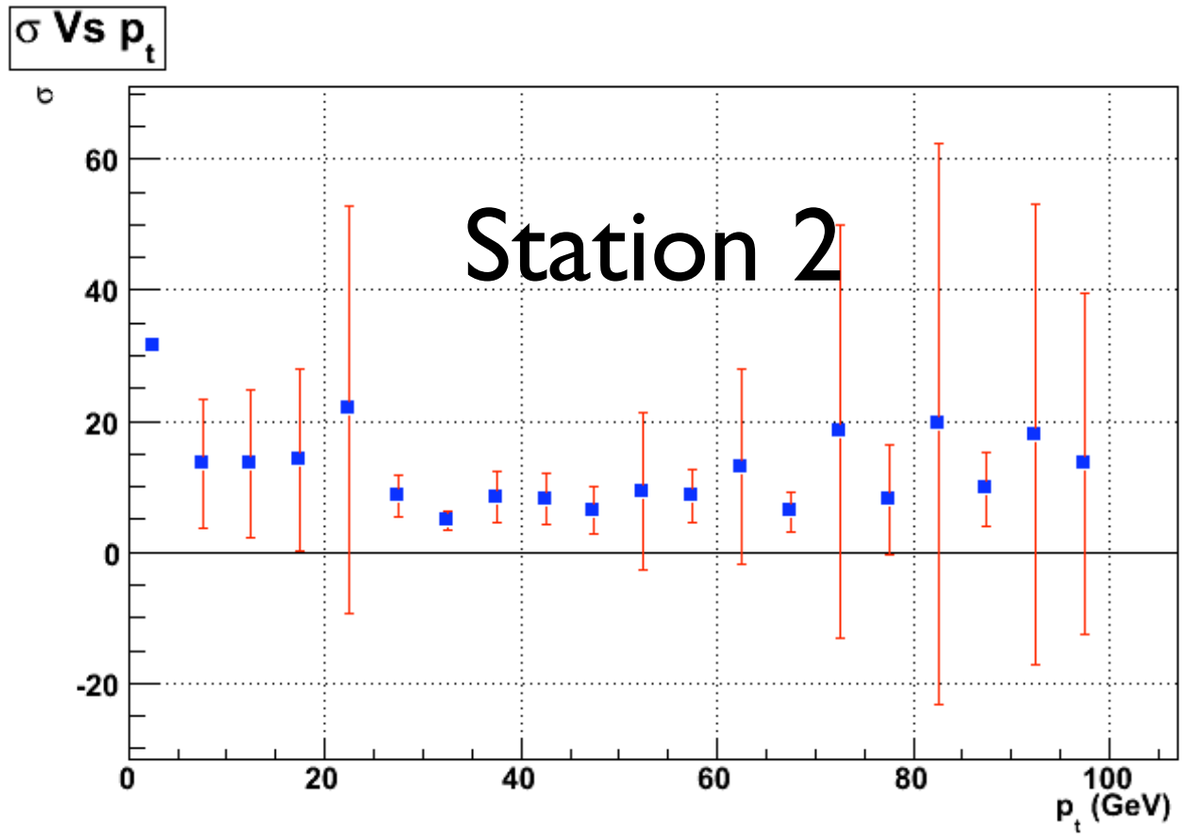




- distributions fairly Gaussian, can use 3σ to approximate 99.5% efficient search windows (~0.02 rad *2*3 = 0.12 rad)
- knowing initial search window sizes, can estimate expected occupancies in the high

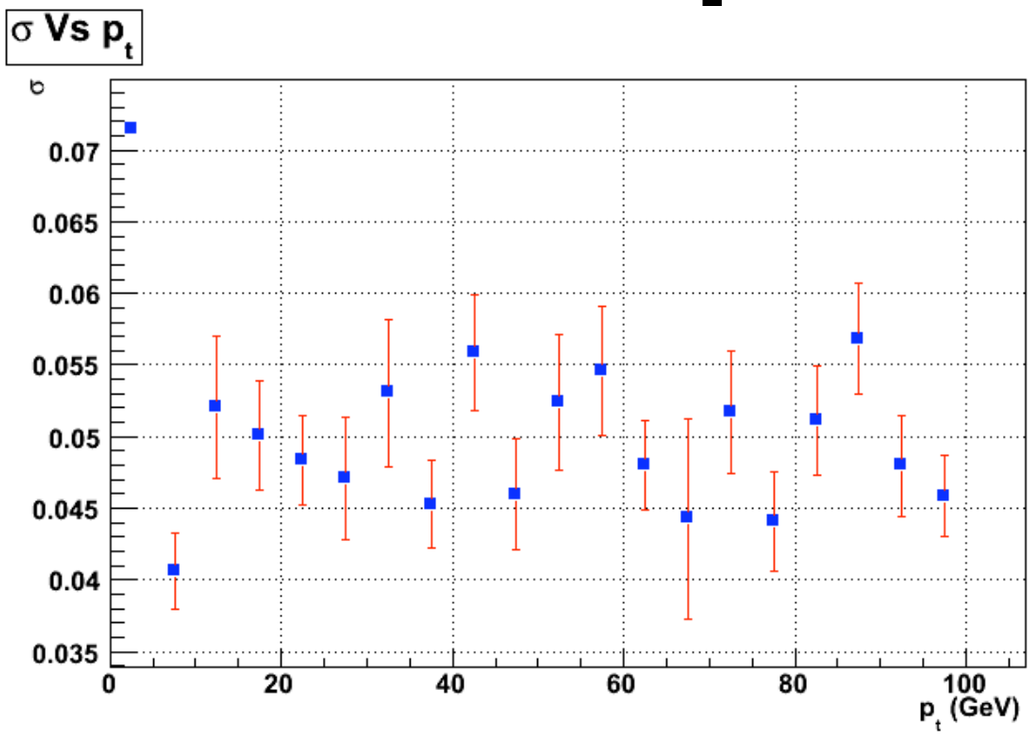
CSCTF Δz Windows

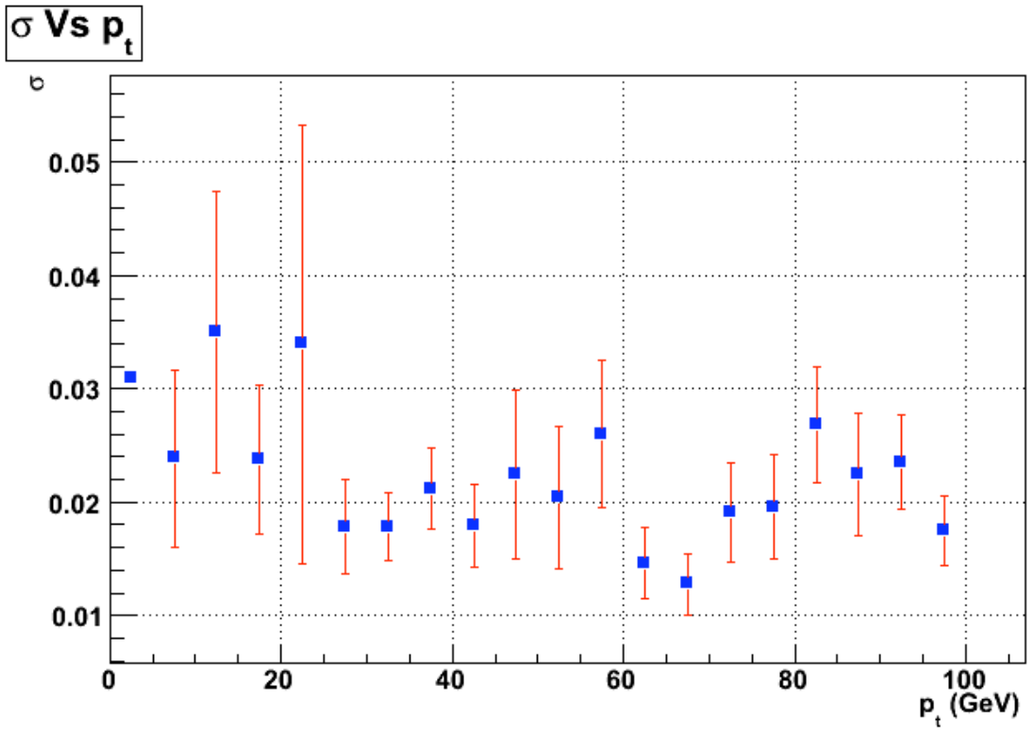




- z window size is driven by both beam spot size and pointing issues
- typical width ~ 5 cm @ST0, Gaussian → 30cm search window

Back of Envelope Occupancy Estimate





- matching window eta x phi footprint @ ST0: 0.036
- expect ~0.014 part, p_T > 5 GeV, ~0.58 part, p_T > 2 GeV
- matching window eta x phi footprint @ ST2: 0.0144
- expect ~0.0058 part, p_T > 5 GeV, ~0.23 part, p_T > 2 GeV

CSCTF4LHC Deliverables[12]

- The CSC Track-Finder identifies muons in the CSC system with a 60° azimuthal segmentation
- LHC:
  - 3 best muons each 60° sector, best 4 selected overall by Muon Sorter
  - PT reported with 20-30% precision on 5 bit scale, and charge
  - Coarse η and φ granularity reported to GMT (0.05 and 2.5°, respectively)
- Precision of CSC information intrinsically better

CSCTF4SLHC Deliverables[13]

- CSC-only tracks
  - Could allow more muons per sector if needed
  - PT and charge precision about the same, perhaps slightly better with larger LUTs
  - η and φ reported at full precision needed to match to Tracker stubs (e.g. 0.0125 in η, finer in φ)
- CSC-based search windows
  - propagated into relevant tracking volume
  - bending correction, charge specific
- CSC+TK tracks
  - different ways to combine CSC+TK information
  - depending on trigger time budget and needs

Conclusions / Plans

- after a bumpy start, we have secured dedicated manpower (graduate student Matt Fisher) for the CSCTF upgrade project
- Darin's and Ivan's previous experiences with trigger level pattern recognition involve different technologies (FPGA vs AM logic)
- for both approaches - initial / key question is the same - matching windows inside TK
- defines logic sizes, #combinations, AM input streams and pattern #
- presented studies very preliminary, updates will follow - plan to add levels of realism as they become

Manpower + Tasks

- System Design: Darin part time + Ivan part time
- Design Studies and Code: Matt
- Trigger Primitives to simulate:
  - Upgraded TF standalone output
  - TF+TK matching algorithm output
  - TF+TK combined tracks
- we have additional manpower (2 undergraduates) to help out with code development at higher level
- have temporary software engineering support from Dan Holmes (upgraded CSCTF standalone output)

Supporting Slides

Components Needed For Studies

- Target: first estimates of data volume and possible combinatorics
- CSCTF simulation
  - today: current design and simulation
- TK+TRG simulation
  - today: generator level simulation of proposed geometry
- Pileup
  - today: Summer '08 MinBias sample, pile up w/ Poisson average 100, 200, 400 MB by hand

CSC Track Finder Simulation

- Full CMSSW simulation, matches TF board output
- CMSSW 2_2_3
- sample: single muon gun, 2 GeV < p_T < 100 GeV
- 1.8 < | η | < 2.4
- no pileup - outputs are “ideal” resolutions etc.