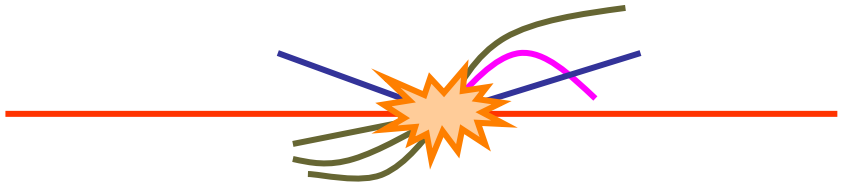
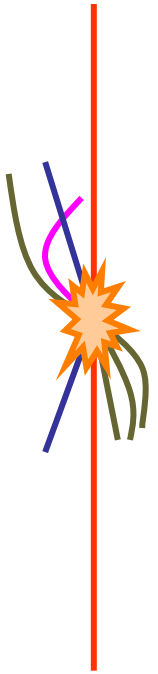
Minimum Bias



W. H. Bell
University of Glasgow

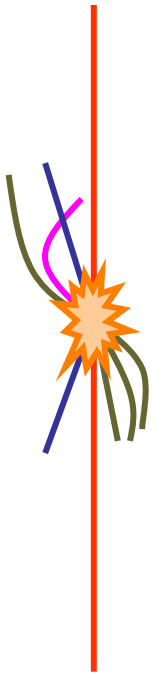
On behalf of the Minimum Bias working group

Overview



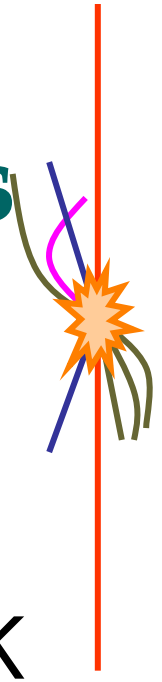
- Motivation
- Analysis Goals
- CSC studies
  - Generated Sample
  - Minbias Trigger
  - Low PT tracking and results
  - Tracking efficiency from data
- Outlook
- Conclusions

Minimum Bias Motivation



- Need to understand inelastic event characteristics at 14TeV.
- Minbias events provide a high statistics sample of uniform events for commissioning the detector.
- Overlap with studies of the underlying event in high-*pT* collisions.
- These interactions will be a significant background at higher luminosities $10^{33} cm^{-2} s^{-1}$

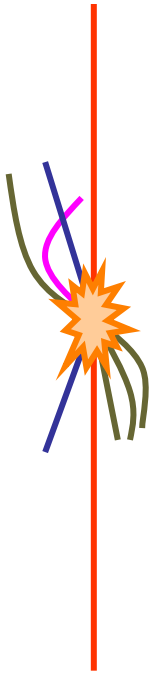
Minimum Bias Analysis Goals



Event estimates based on statistical errors

- Charged particle dN/dη > 10K
- Charged particle multiplicity (KNO) > 400K
- $\langle P_T \rangle$ vs N > 1M
- UE distributions > 10M
  - Probe jet E_T up to approx. 150GeV

CSC Note Studies



- A first analysis
- PHOJET not available, used PYTHIA
- Trigger tools in development
- Low P_T tracking in development
- Analysed data mainly from RDO

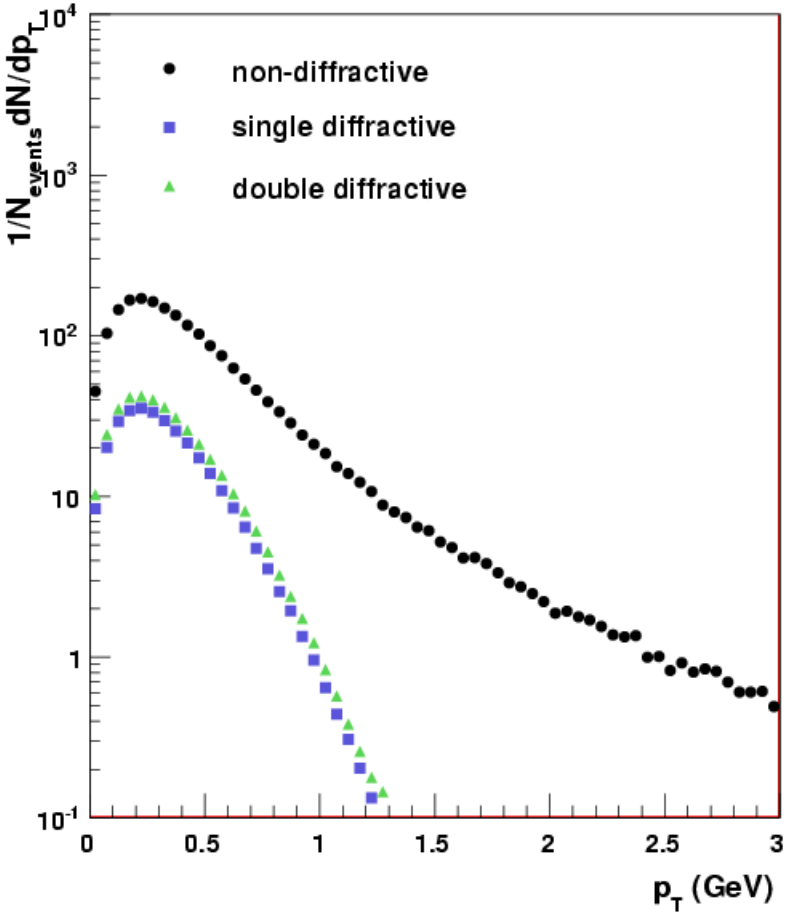
Production Cross Sections

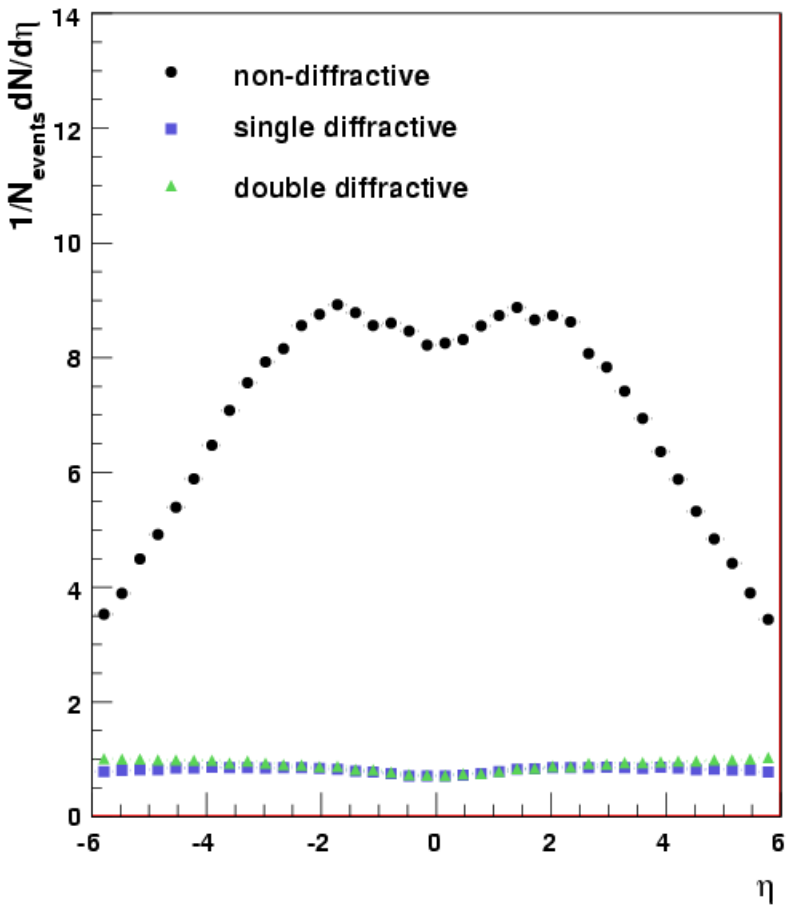
- Assuming the PYTHIA cross sections for 14TeV
- Using PYTHIA version 6.403

Non-diffractive	Double Diffractive	Single Diffractive (AB→AX and AB→XB)
54.7 mb	10.2 mb	14.3 mb

Generated Samples

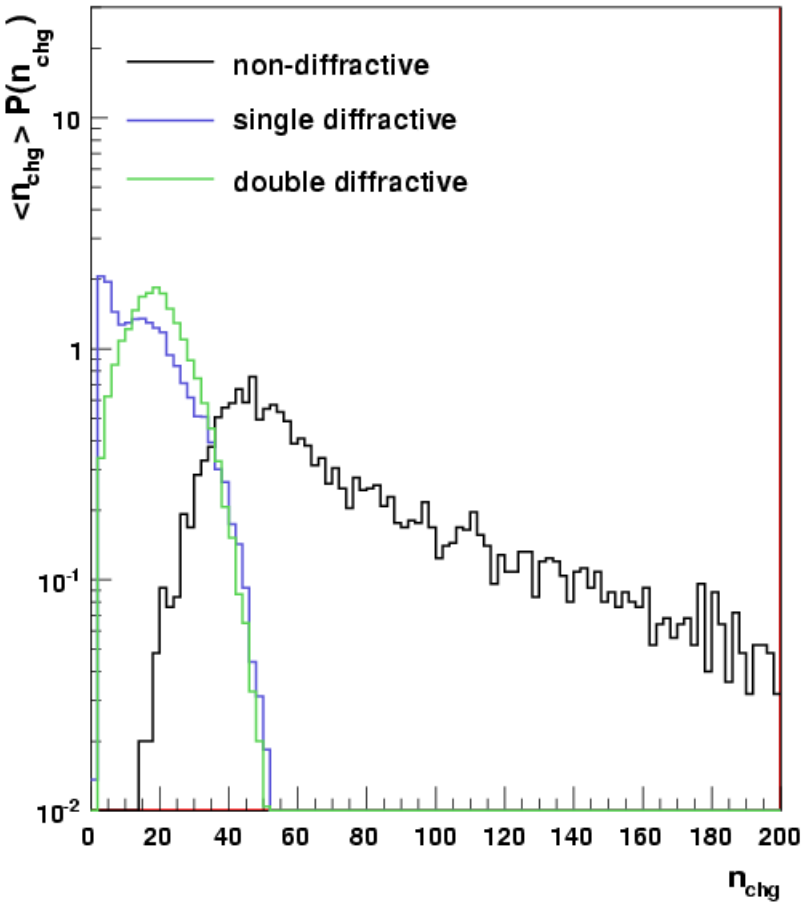
PYTHIA version 6.403



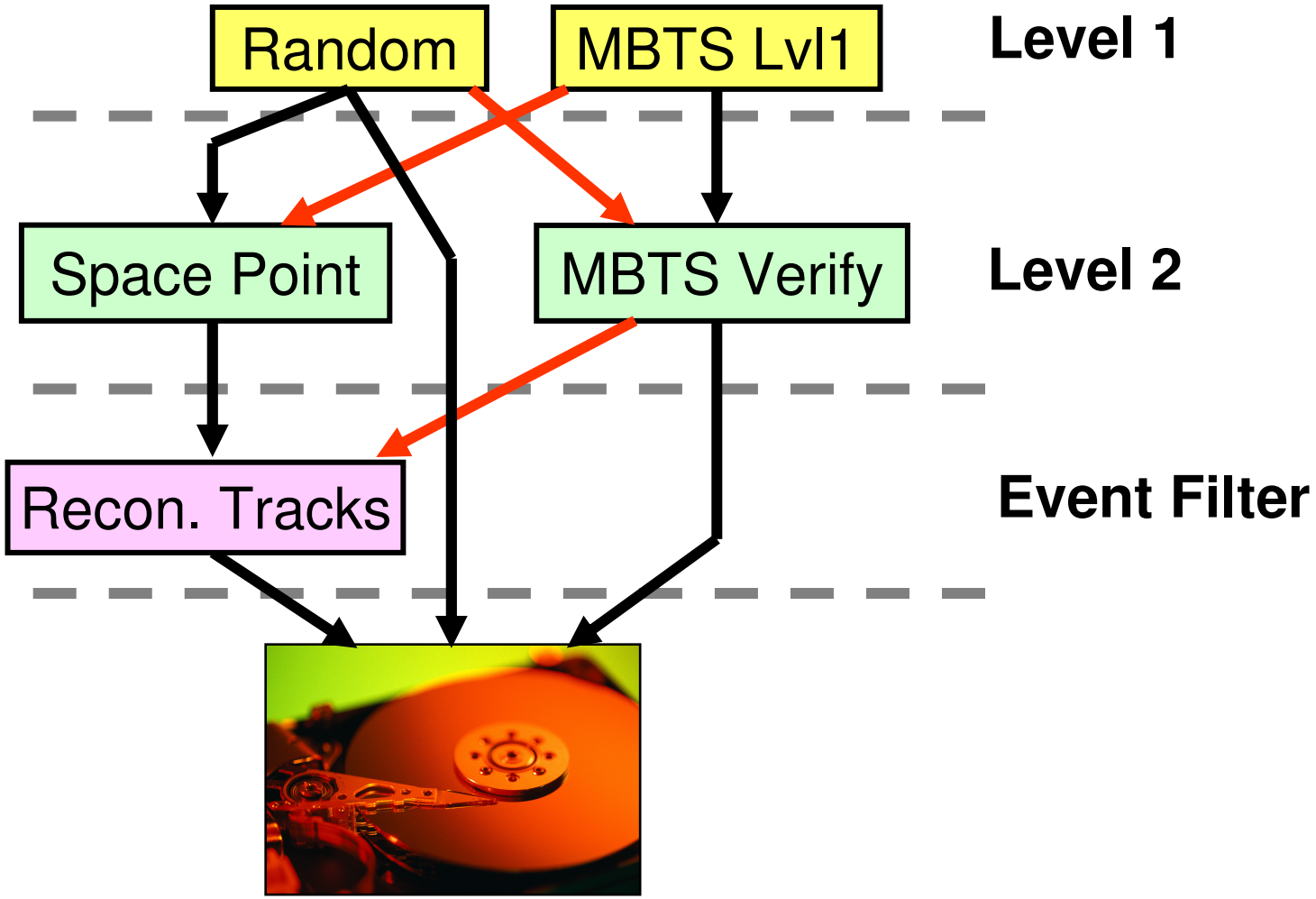


Generated Samples

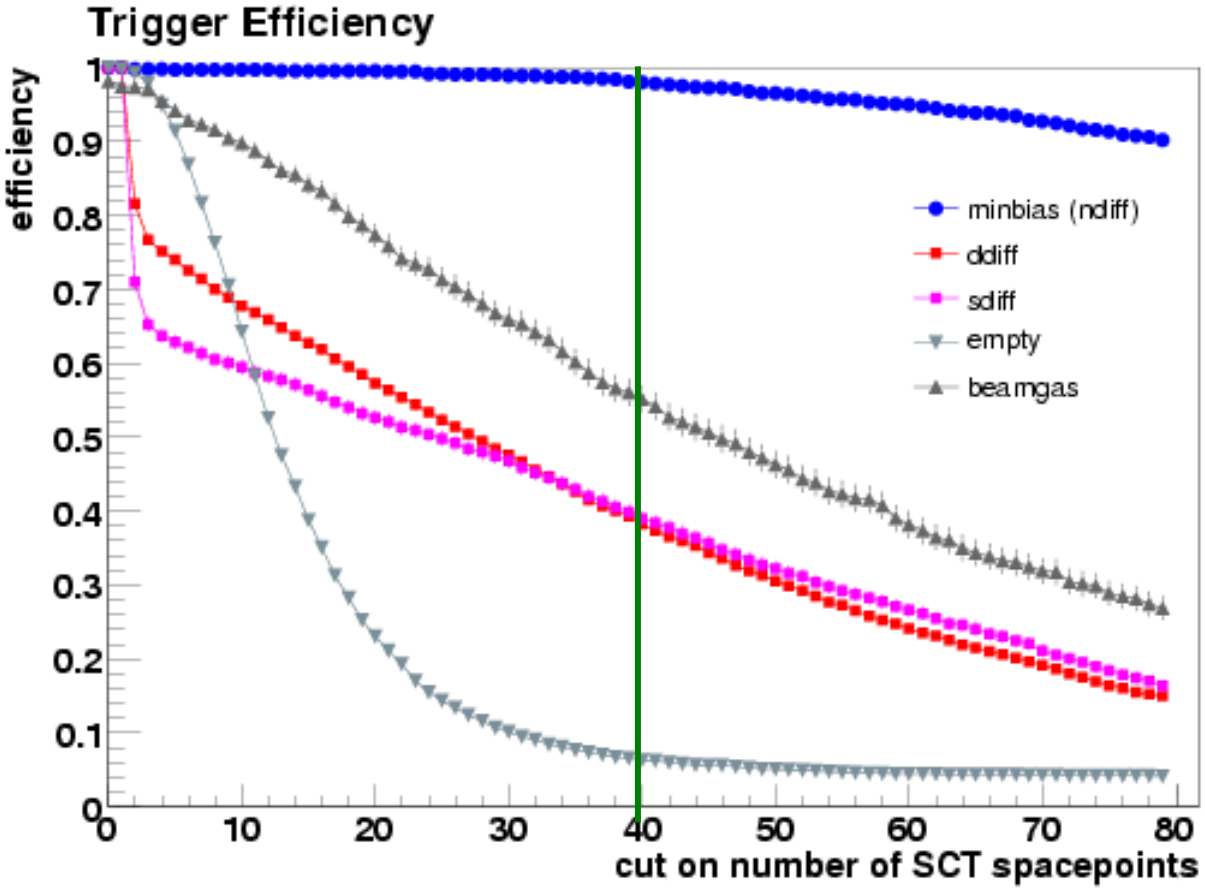
PYTHIA version 6.403



Minimum Bias Trigger Slice

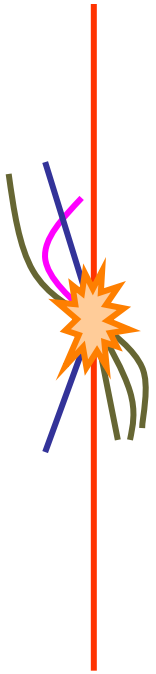


Space Point Algorithm



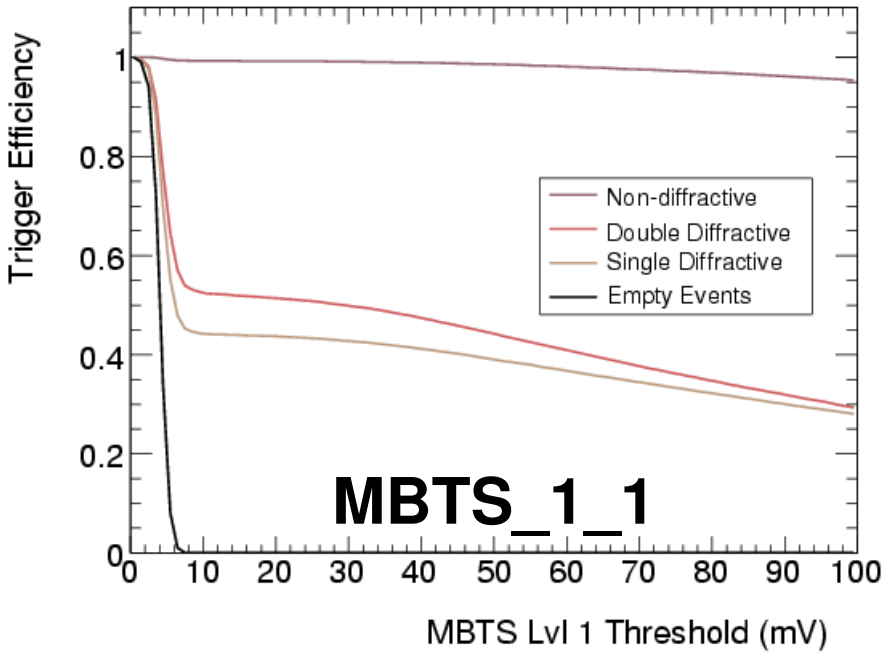
- Efficiencies: 0.98, 0.38, 0.39, 0.06 for ndiff, ddiff, sdiff and empty events.

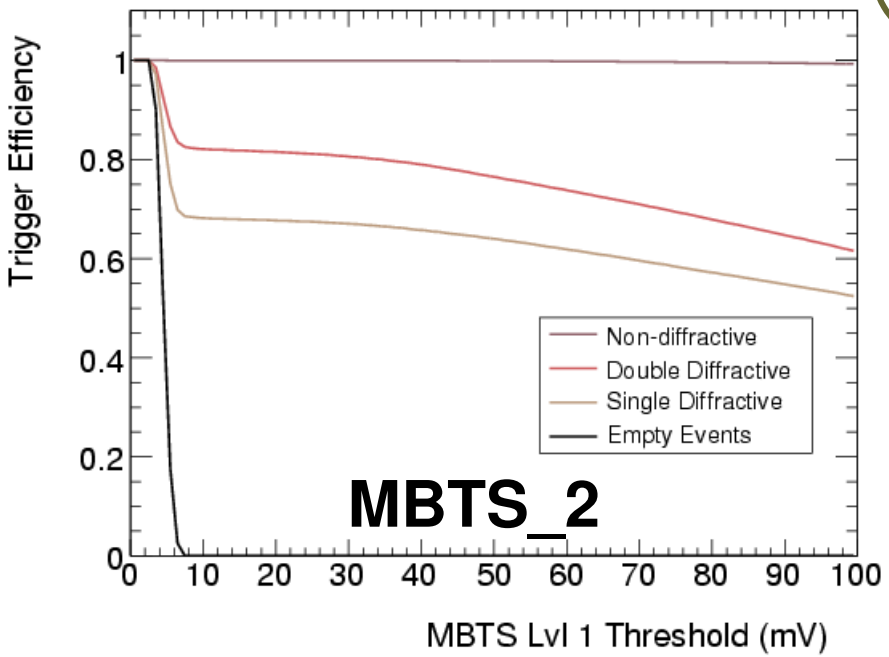
MBTS Triggers



- Of the 32 MBTS counters form three trigger decisions:
  - MBTS_1 – One or more counter above threshold.
  - MBTS_2 – Two or more counters above threshold.
  - MBTS_1_1 – At least one counter above threshold in both hemispheres.

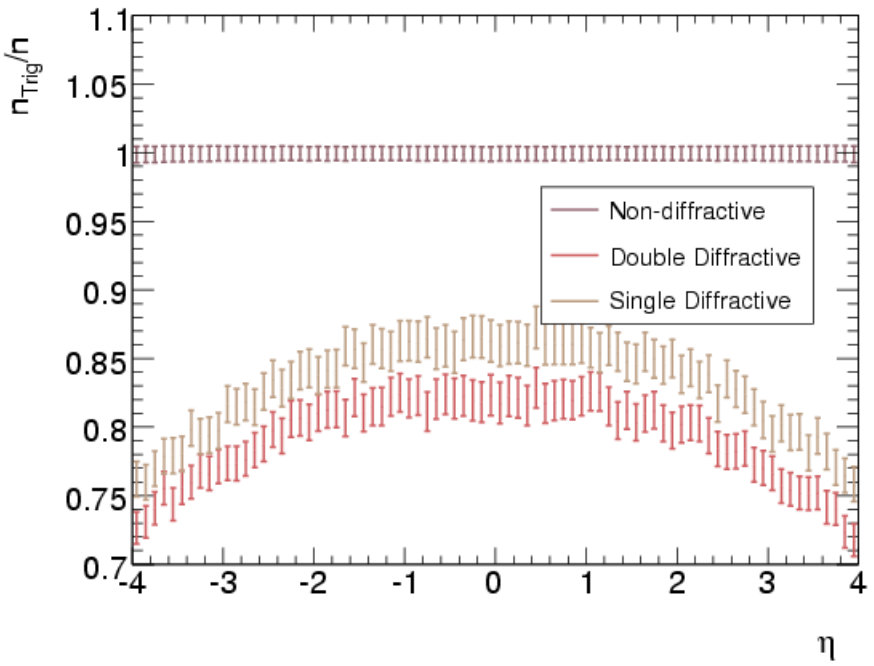
MBTS Lvl 1



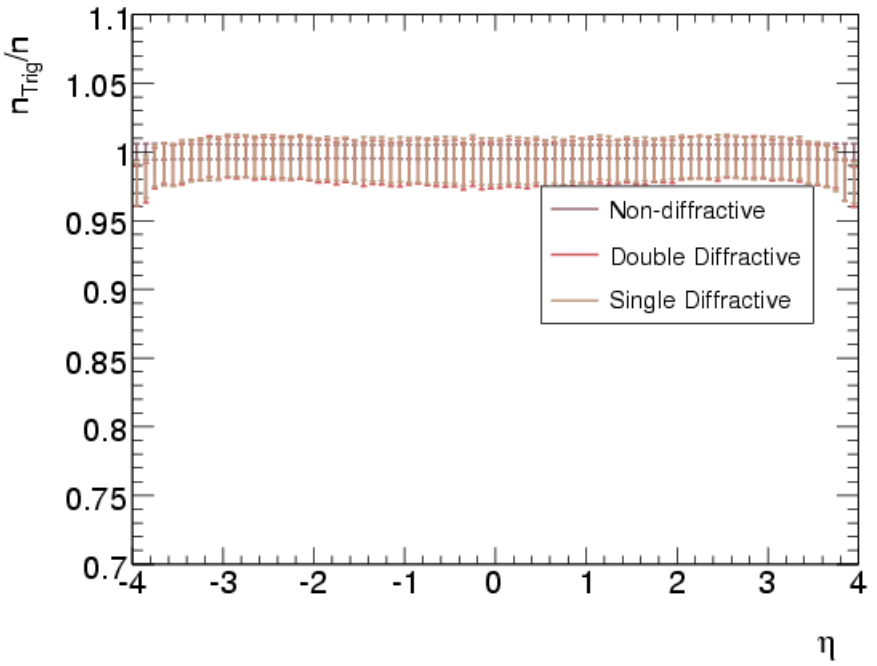


	ndiff	ddiff	sdiff	empty
MBTS_1_1 (@ 7.5mV)	0.99	0.54	0.45	0.0005
MBTS_2 (@ 7.76mV)	1.00	0.82	0.68	0.0005

MBTS Trigger Bias



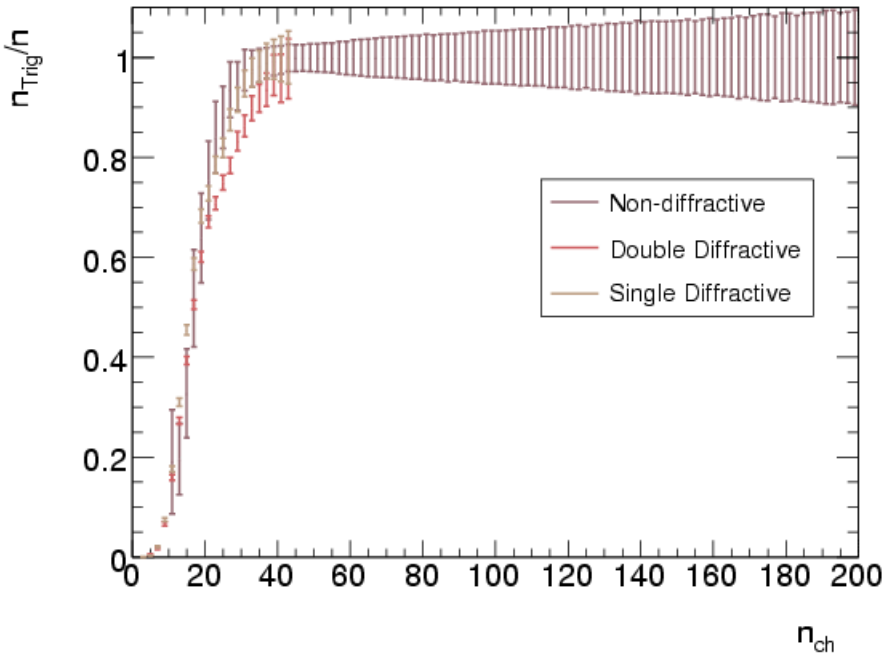
MBTS_1_1



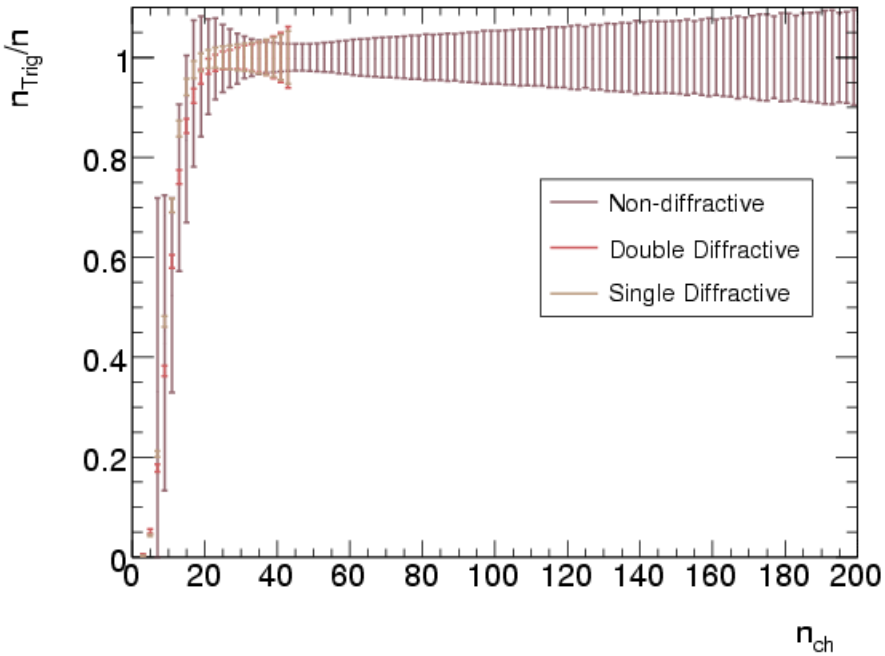
MBTS_2

- Trigger bias from truth.
- Need to repeat this with offline low P_T tracks

MBTS Trigger Bias



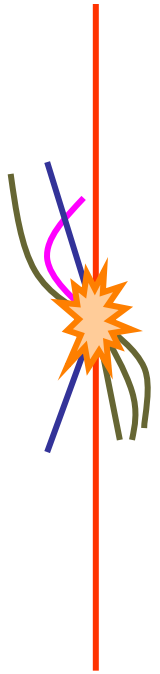
MBTS_1_1



MBTS_2

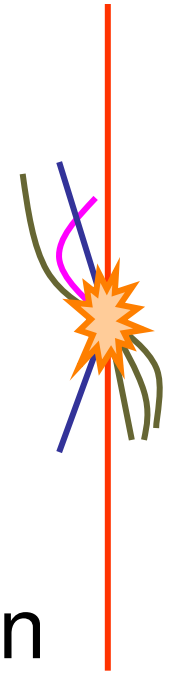
- Trigger bias from truth.
- Need to repeat this with offline low P_T tracks

Minbias Trigger Software Status



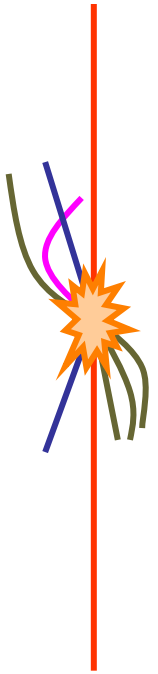
- Space Point algorithm – 13.0.40
- Random trigger – 13.0.40
- Level 1 MBTS trigger – 13.2.0 nightly
- Track trigger and Level 2 MBTS verification algorithms will follow.
- Target for this slice to be fully functional and validated: Feb rel. 14.

Low P_T Tracking



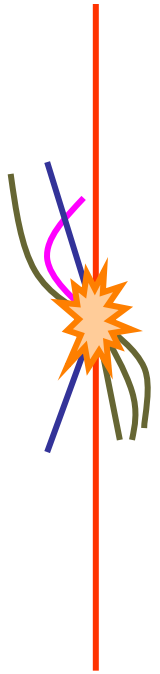
- Accepting a cut at 500MeV would introduce large systematic errors.
- In principle tracking can be extended down to 100MeV.
- Low P_T tracking requires non-standard constraints in tracking algorithms.

CSC Analysis



- 144,427 inelastic events where reconstructed with 13.0.20
  - PYTHIA ndiff, ddiff, sdiff
- The MBTS_1_1 trigger was used
- Tracking efficiency was calculated from Track-Truth match.
- Final reconstructed distributions were corrected using tracking efficiency and trigger efficiency.

Loose Track Quality Cuts



- Using loose track cuts to
  - Remove fake and secondary tracks
  - Select tracks with reasonable fits

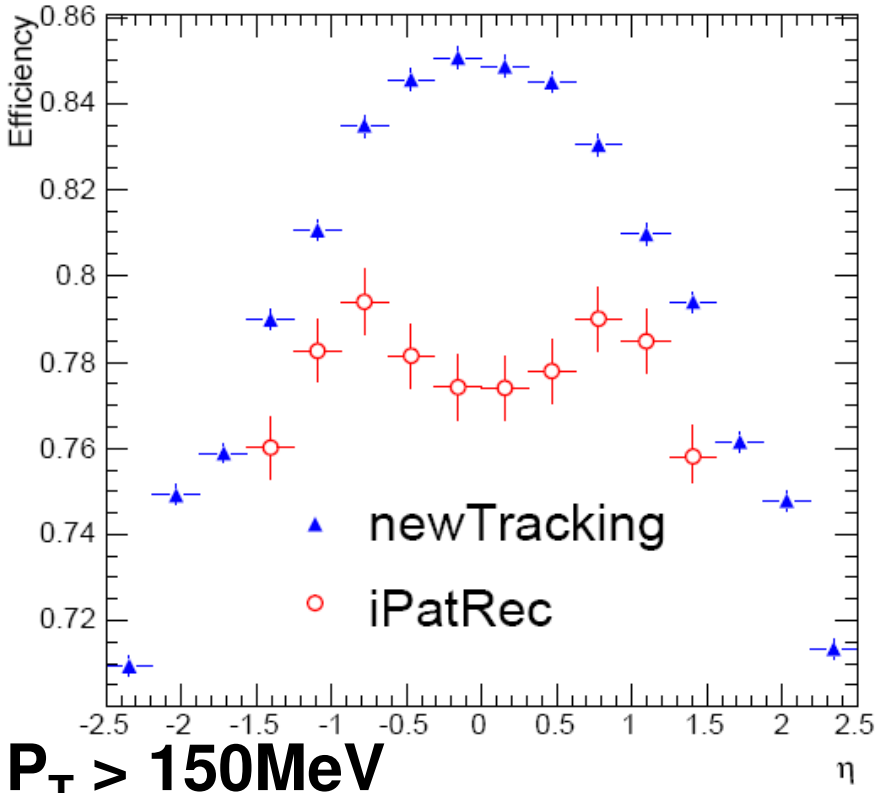
Quality cuts	No. of b-layer hits ≥ 1 No. of Silicon hits ≥ 5 $P(\chi^2) > 0.0$
Resolution cuts	$\lvert\sigma_{d_0}\rvert < 1.6$ mm $\lvert\sigma_{z_0}\rvert < 6.0$ mm $\lvert\sigma_{\phi}\rvert < 0.03$ $\lvert\sigma_{\theta}\rvert < 0.015$ $\lvert\sigma_{q/p_T}\rvert < 0.0003$ (GeV)$^{-1}$
Track-to-vertex cut	$N_{\sigma} < 3$

Using Gaussian fits to parameters, cuts are 3σ

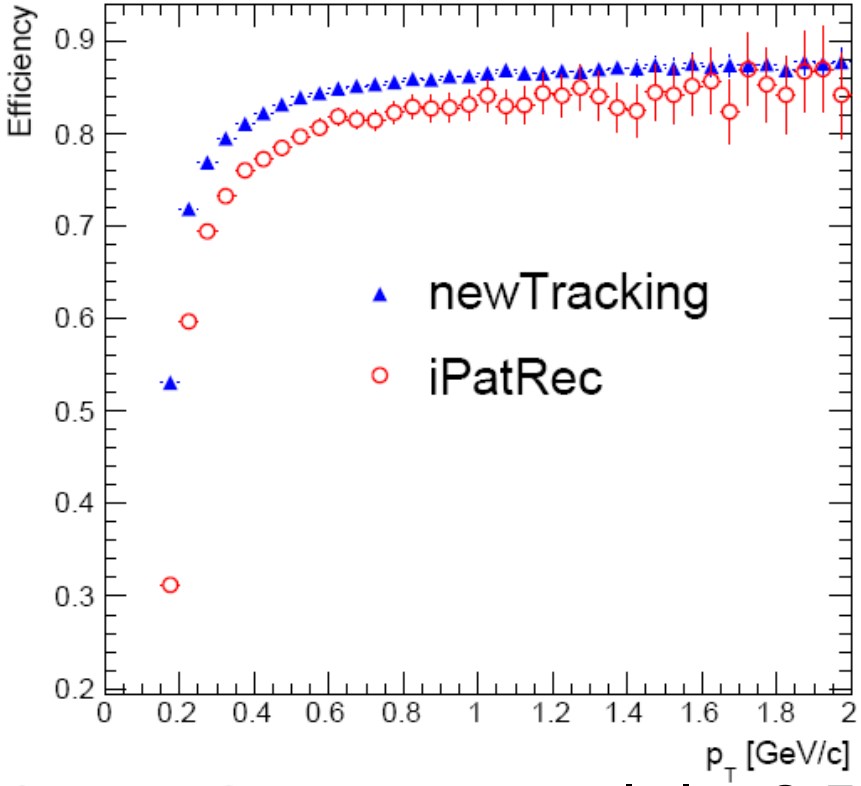
Tracking Efficiencies

$$\text{truth probability} \equiv \frac{\sum_{i=\text{subdetector}} w_i C_i}{\sum_{i=\text{subdetector}} w_i T_i}$$

Truth probability ≥ 50% => Matched



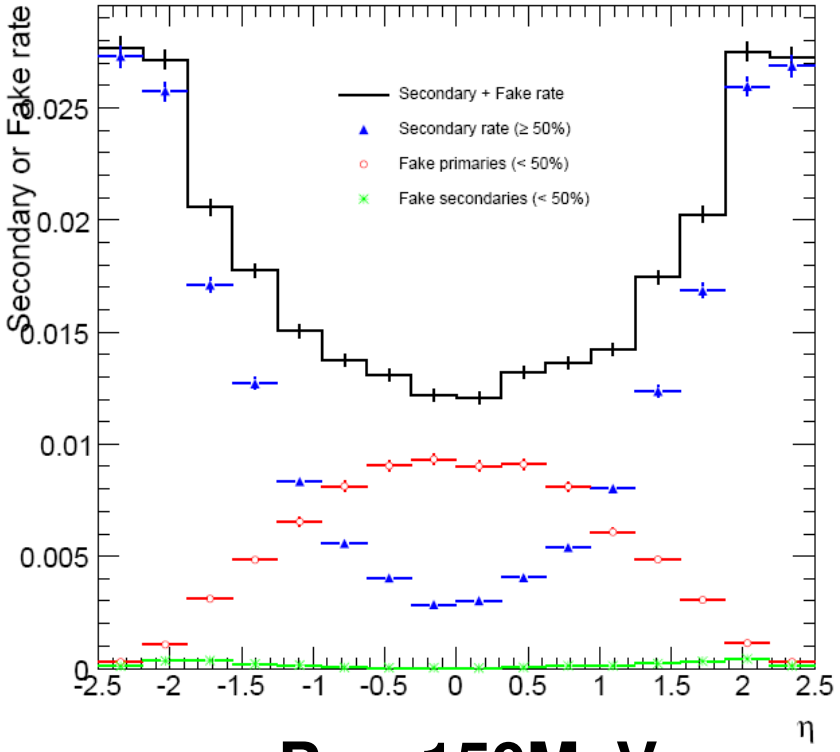
P_T > 150MeV



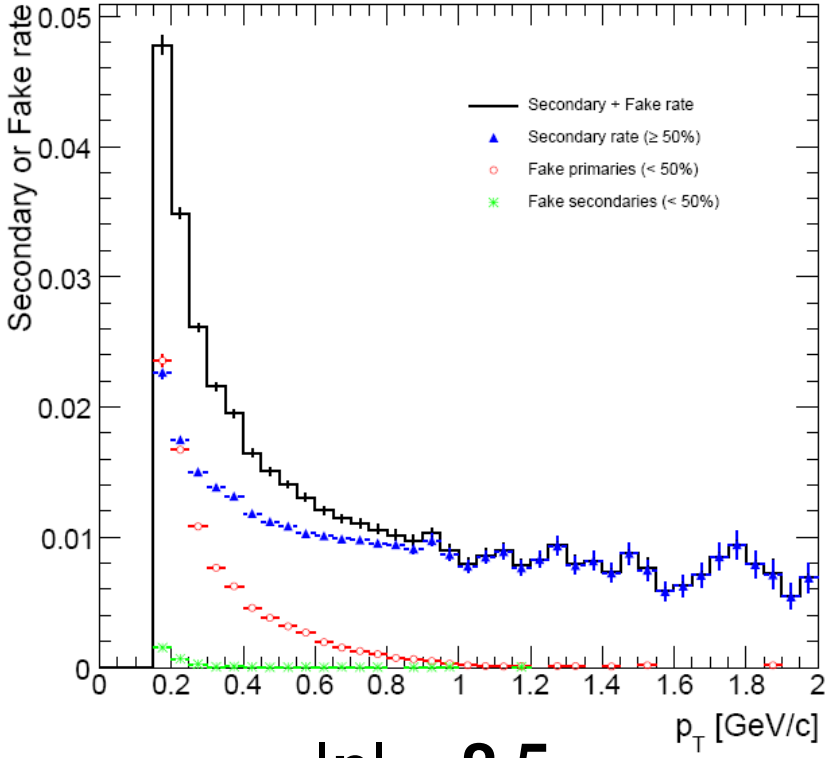
|η| < 2.5

$$\varepsilon_{tr} \equiv \frac{\text{No. of found generated primaries}}{\text{No. of generated primaries}}$$

Secondary and Fake Rates

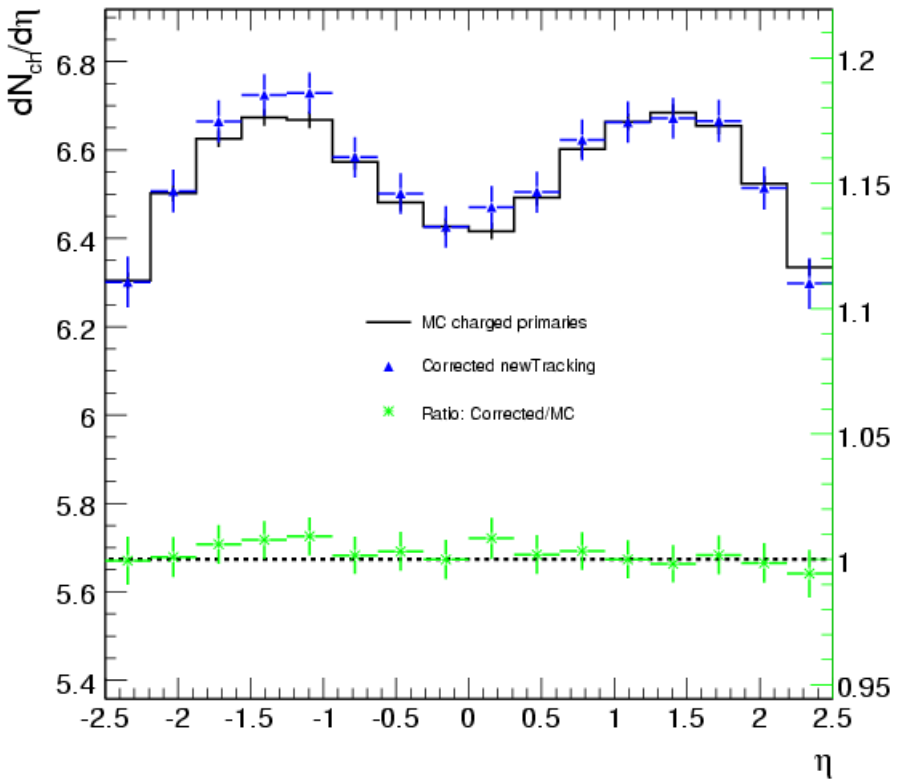


$P_T > 150MeV$

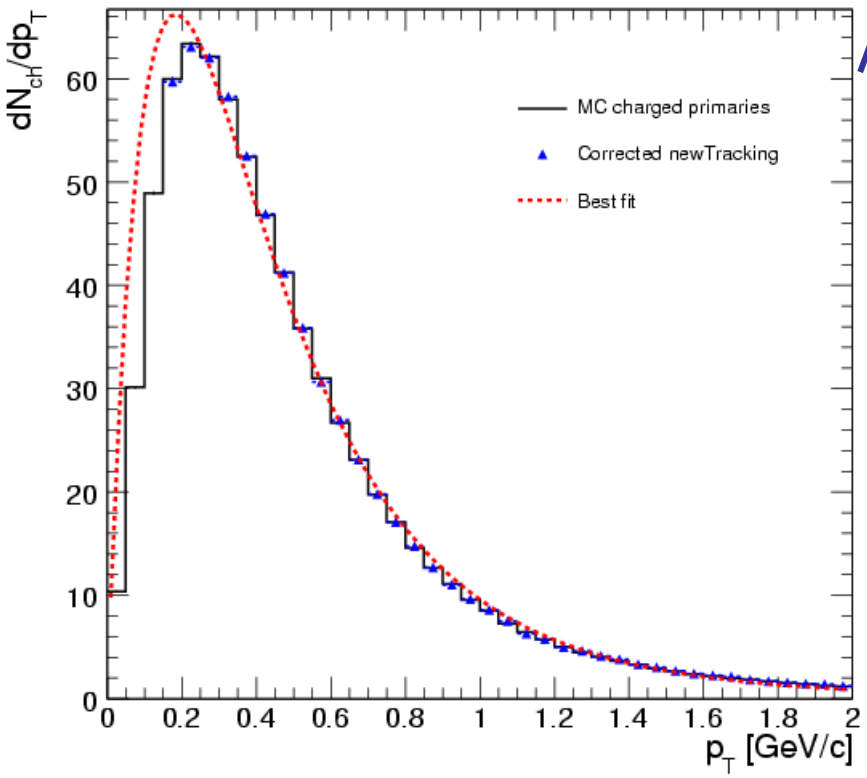


$|\eta| < 2.5$

Corrected Distributions

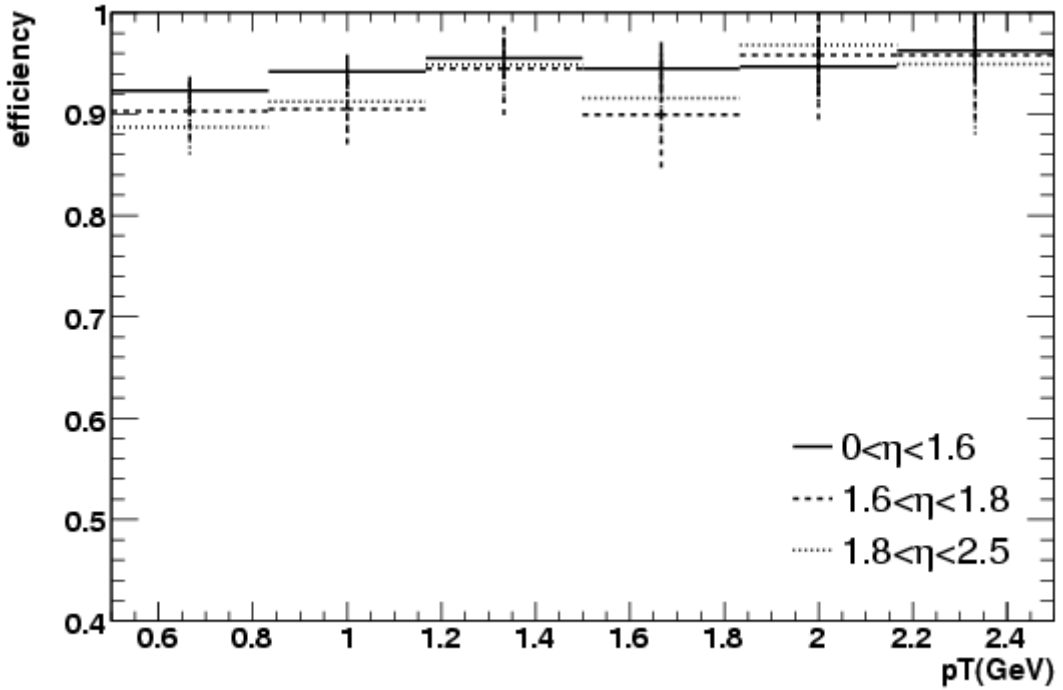


P_T > 150MeV



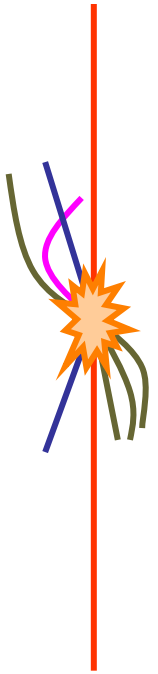
|η| < 2.5

Tracking Efficiencies from Data



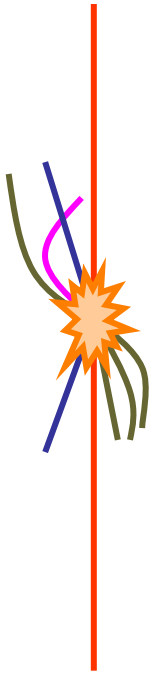
- First study with InDetOverlay and muons
  - Used patched 12.0.5 release
  - Used default 500MeV cut off to avoid crashes (now fixed)

Outlook



- Trigger bias studies
  - Repeat studies for MBTS
  - Study Space Point and Track Algorithms
- Simulation of beam gas and beam halo understudy
  - Gas rates expected to be low (a few Hz assuming 156 bunches)
- Low P_T tracking
  - Two pass track reconstruction
  - Low P_T vertexing
  - Performance studies need to be repeated

Conclusions



- Minbias CSC note was submitted last year.
- Trigger software and hardware nearing completion.
- Low P_T tracking is being integrated as a reconstruction option.

- We look forward to beam!
  - Single beam running – background studies
  - Colliding beams – the first LHC measurement