How to measure MB and UE in ATLAS – some issues

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Outline

- Why measure minimum bias events
- Detector elements
  - Triggering
  - Tracking
- Reconstructing underlying event

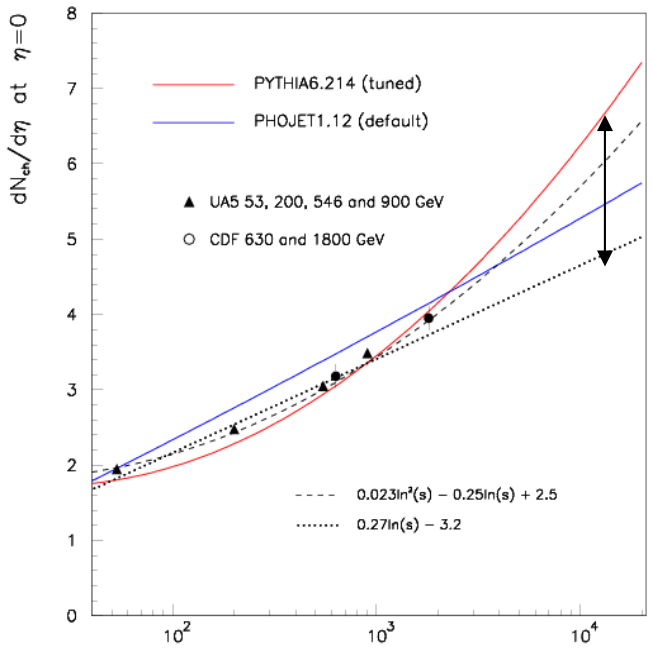
- Nothing on tuning
  - covered in Borut Kersevan's talk in Monday session

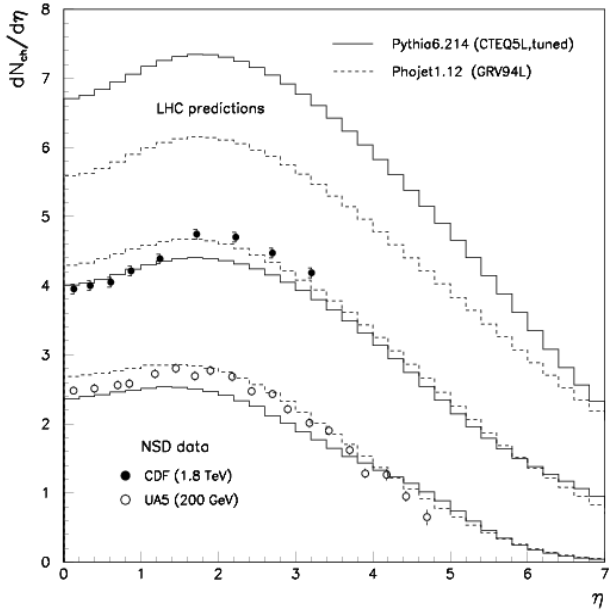
Why measure min bias?

Not exactly what the LHC was built for!

But…..

- Physics: measure dN/dη|η=0
  - Compare to NSD data from SppS and Tevatron
- MB samples for pile-up studies
  - Calorimeter
  - Physics analyses
- Overlap with underlying events
  - analyses eg VBF, Jets…
- Demonstrate that ATLAS is operational
- Inter-calibration of detector elements
  - Uniform events
- Alignment
- Baseline for heavy ions





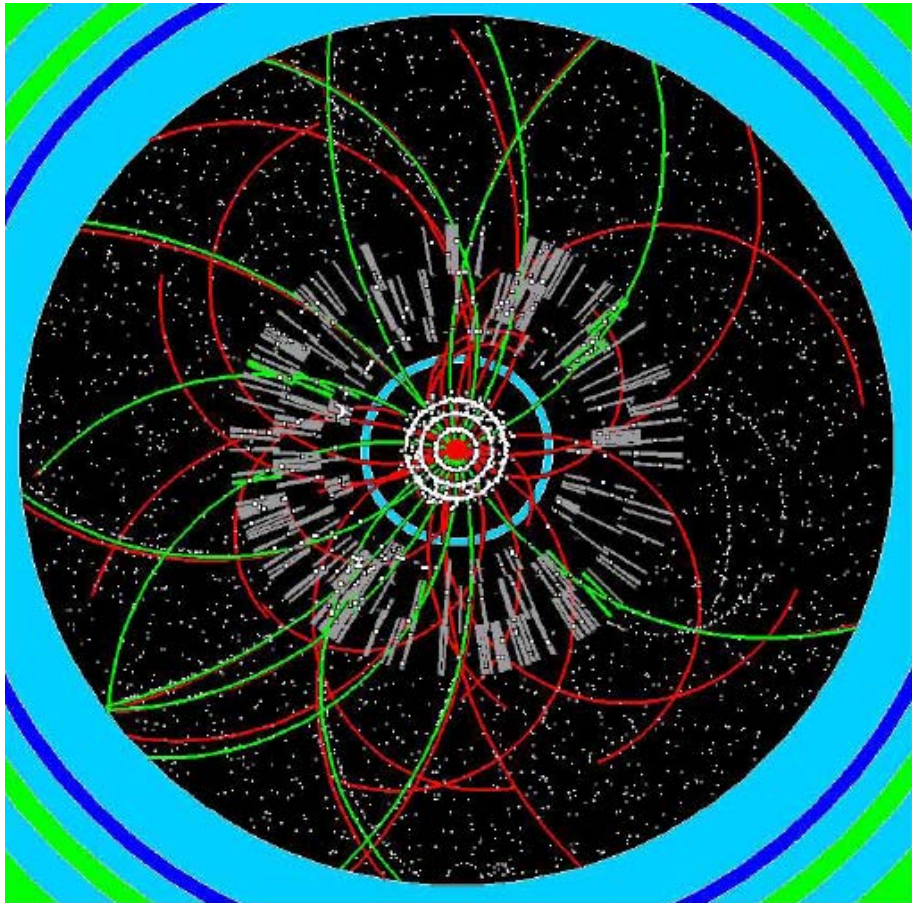
Detector elements required

- Tracking
  - Start with barrel ID and move forward
  - Full tracking
    - has p_T cut-off → bias of min bias and large extrapolation back to p_T=0 ~x2
  - Pixels
    - pixel tracklets have lower pt cut-off
    - requires pixels on day-zero or at least early running – feasible beam backgrounds?
    - What are pixel running conditions ?
- Triggers
  - L1: Minimum Bias Trigger Scintillators (MBTS) low gain, random
  - L2: RoI for MBTS high gain(?)
  - EF: Tracking and pixel tracklet reconstruction
- Calorimeters
  - Look at correlation of MB events in tracker and calorimeter
  - What trigger information can we use?

Event characteristics

- Event characteristics
  - Non-single diffractive~non-diffractive inelastic
  - Soft tracks p_T^{peak}~250MeV
  - Approx flat distribution in η to $|\eta|$~3 and in ϕ
  - N_{ch}~30; $|\eta|$<2.5
- Trigger rates

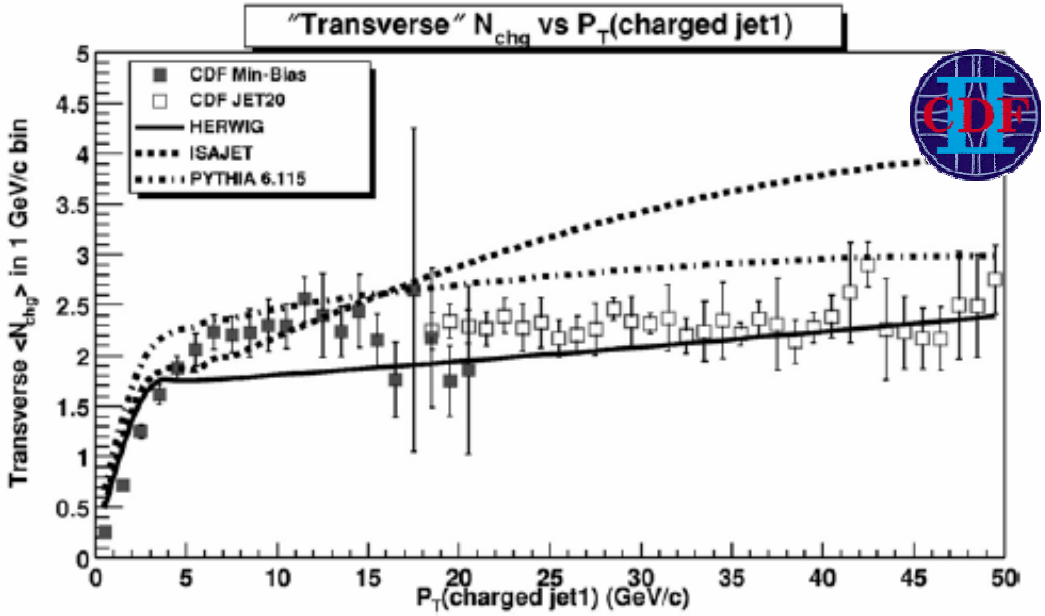
  σ~70mb (NSD!)
  - R~700kHz @ L=$10^{31}cm^{-2}s^{-1}$



M. Leyton

How many events do we want?

- For dN/dη require ~10k
- For UE need ~20M MB events to get some with leading jets P_T~30GeV
- Need to overlap with jet triggers
  - Prescaled P_T>25GeV
- CMS quote ~18M to intercalibrate their calorimeter with MB
- Commission tracker: 10 tracks/strip in SCT barrel → ~2.5M events



Low Luminosity Prescales

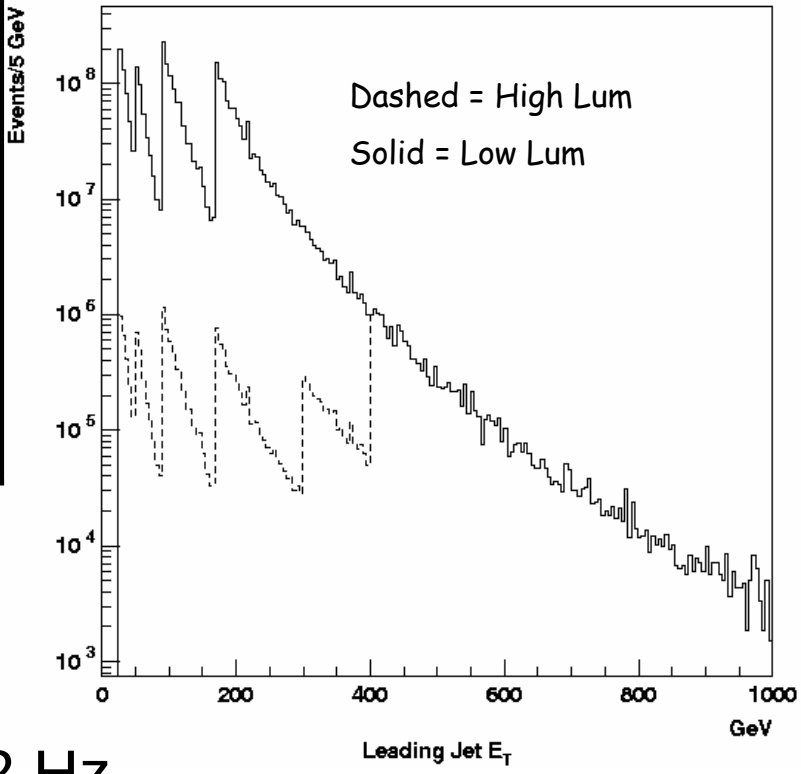
T.LeCompte

Threshold	Prescale
25 GeV	2,000,000
50 GeV	200,000
90 GeV	5,000
170 GeV	200
300 GeV	20
400 GeV	1

2 x 10^{33} Prescales

Threshold	Prescale
25 GeV	10,000
50 GeV	1,000
90 GeV	25
170 GeV	1
300 GeV	1
400 GeV	1

1 x 10^{31} Prescales

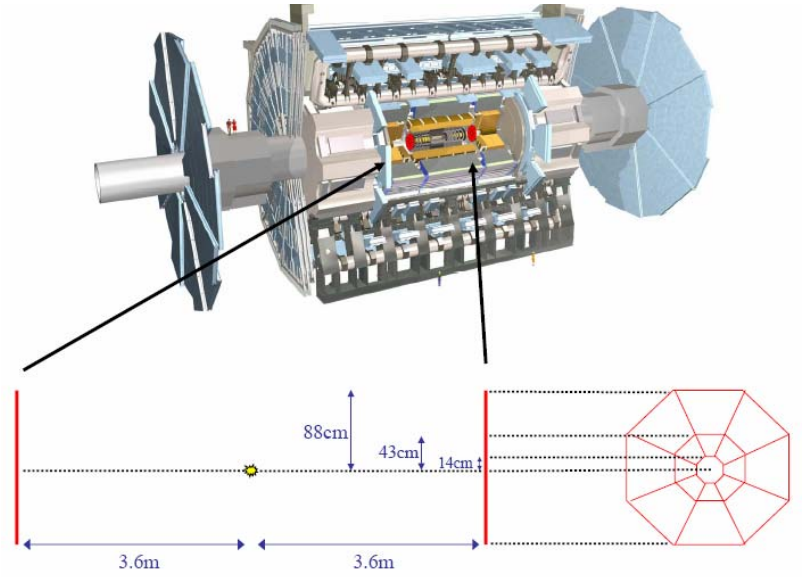


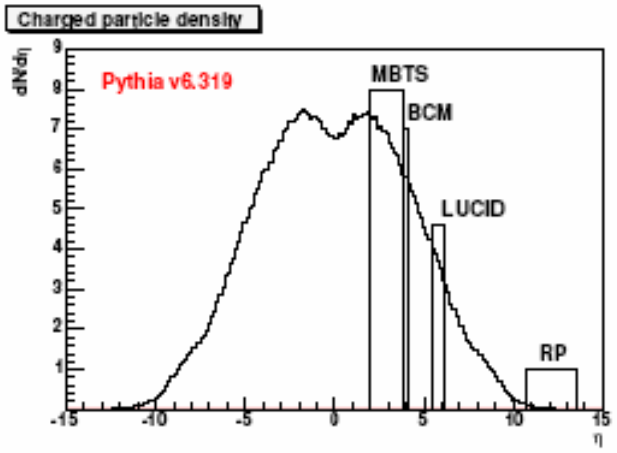
- This holds the rate constant at ~22 Hz
- Lowest threshold moves from ~400 GeV to ~ 170 GeV

MBTS

- Trigger scintillation counters mounted on end of LAr calorimeter covering same radii as ID
  - Cover 2<|η|<4
- At S/N at L1 is 'modest'
  - Now in simulation can be tuned to pit measurements in the summer
- Can do better at L2 with precision readou
  - Not clear how to implement this
- Trigger logic not defined
  - Likely to be coincidence between hits in forward and backward hemisphere
- Can check operation with random trigger?
  - Difficult for L <10^{31}
  - Use lepton trigger to at least get some check of operation at very low lumi
- Can be used for first data BUT!
  - Not rad-hard, lifetime not known

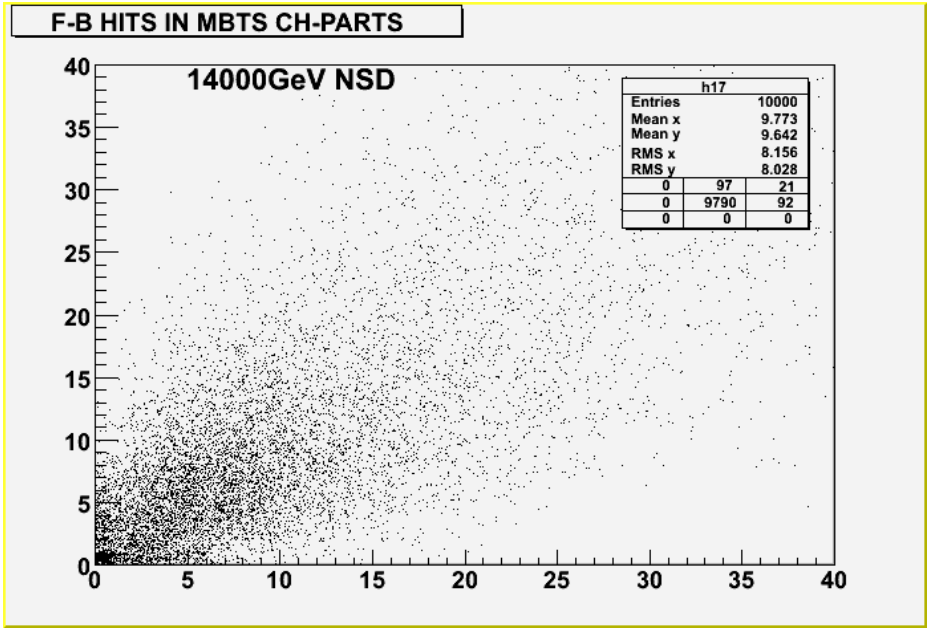
  → cannot use in 2008 running?





ure 1: The inelastic charged particle density as a function of pseudorapidity from Pythia v6.31 standard ATLAS settings.

Forward-backward trigger in ATLAS



	FB>=1	FB>=2	FB>=5
All	0.78	0.66	0.47
NSD	0.87	0.75	0.55
Nd-Inel	0.96	0.86	0.65
SD	0.36	0.18	0.04

How are we biassing our events?
Need good simulation of DD, SD and inelastic events

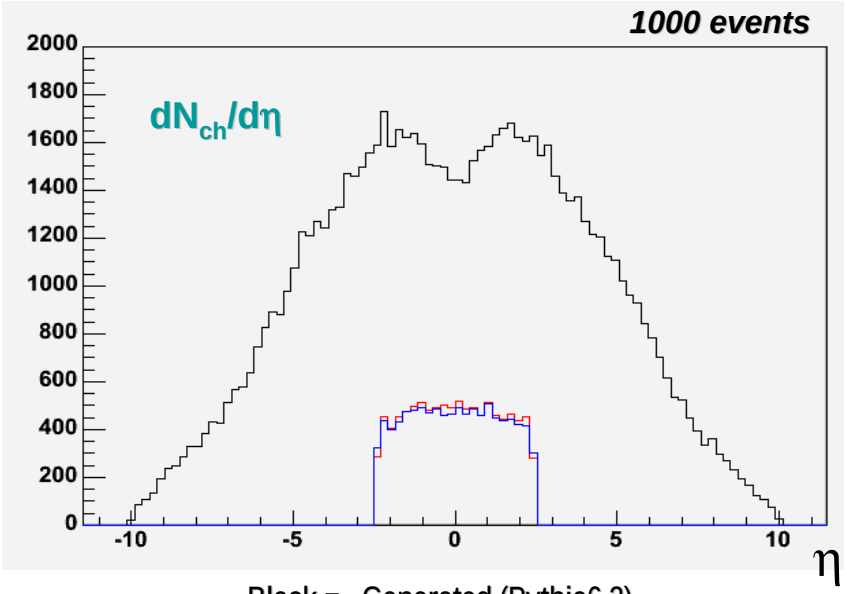
Generate two samples?

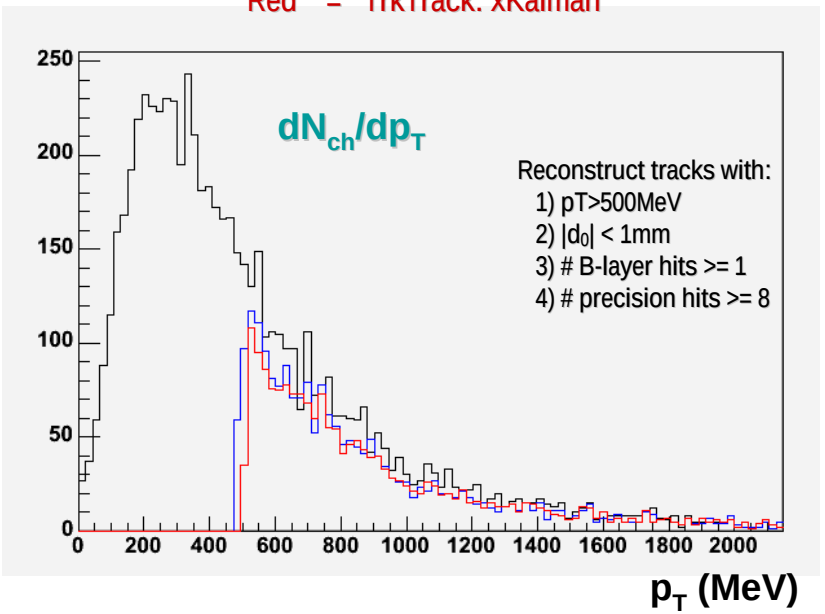
- Zero bias with random trigger (L~10^{31})
- NSD with MBTS

Tracking in MB events

- Acceptance limited in rapidity and pt
- Rapidity coverage
  - Tracking covers |η|<2.5
- p_T problem
  - Need to extrapolate by ~x2

  →Need to understand low pt charge track reconstruction



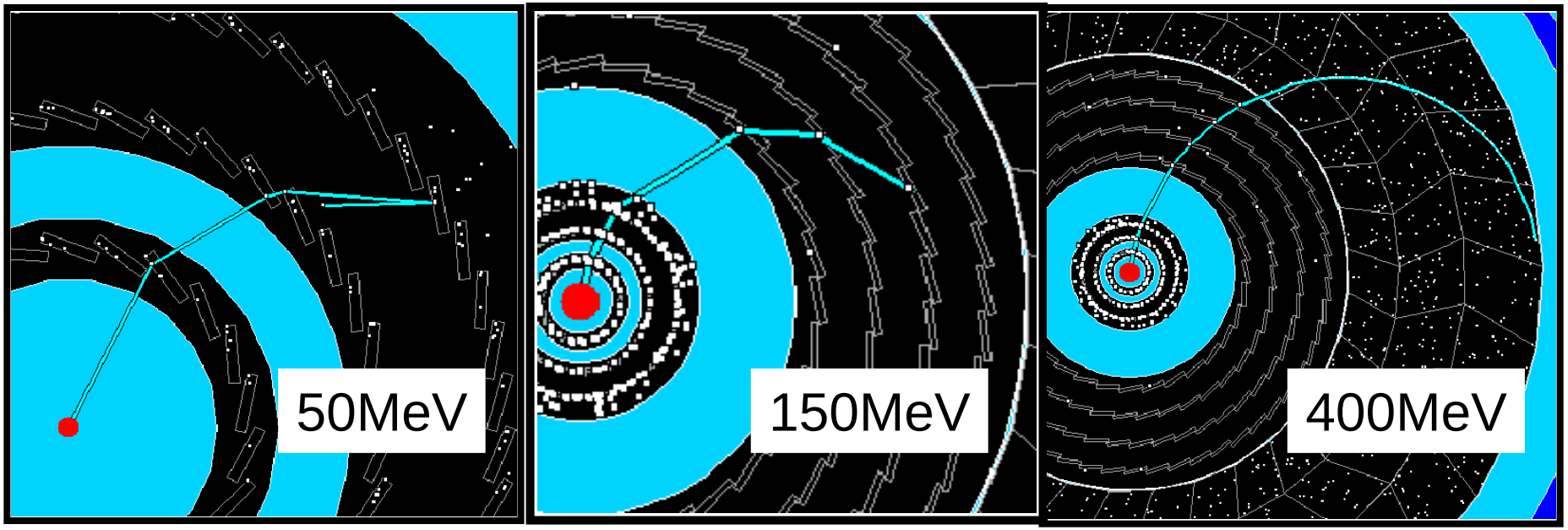


Where is the Momentum Limit ?

- Tracker is in principle sensitive to soft tracks
  - Pt = 400 MeV - tracks reach end of TRT
  - Pt = 150 MeV - tracks reach last SCT layer
  - Pt = 50 MeV - tracks reach all Pixel layers

  → Do not need to run with low field

Pixels | Pixels+SCT | ID=Pixels+SCT+TRT



Tracking Strategy for soft Particles

- Step 1: Primary track reconstruction (= current NewTracking)
  - Track candidates in Pixels+SCT - ambiguity solution - TRT extension

  similar in xKalman and iPatRec

- Step 2: Secondary track reconstruction (release 13)
  - TRT leftover segments - extension to SCT and Pixels - global ambiguity

- Step 3 (New): Soft particle reconstruction after primary vertexing
  - Select soft track candidates pointing directly to established primary vertex

  - this would mostly reuse reconstruction tools from the common tracking framework

  - dedicated search tuned specifically for very soft tracks (maybe even for pixel only tracks)

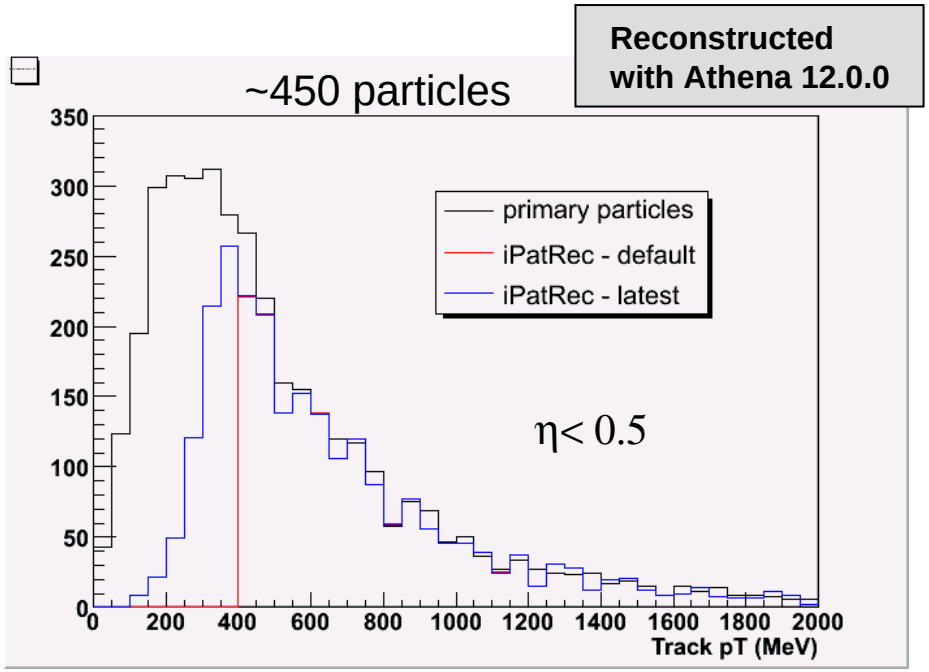
  - direct control of soft tracking, no interference with default reconstruction

  - Michael Leyton interested in this…

Low-pT track reconstruction

- Extending reconstruction to lower pT:
  - Not clear what limit is?
  - Need to investigate inefficiences and fake rates in this new pT regime – lots of testin

Progress so far

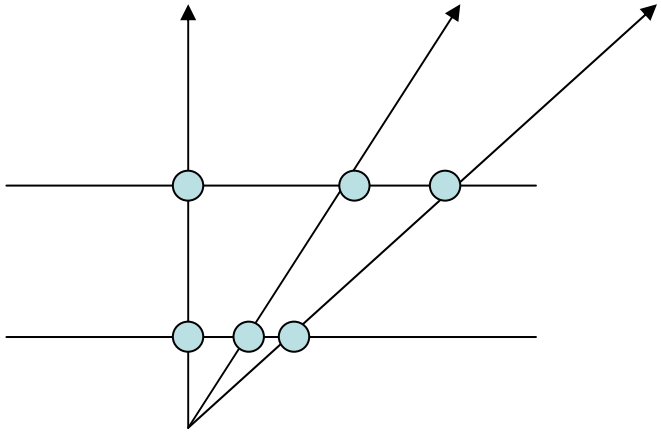


(CSC11.005001.pythia_minbias.digit.RDO.v11000401)

- Problem getting good efficiencies below pT ~ 300MeV – under investigation.

Pixel tracklets

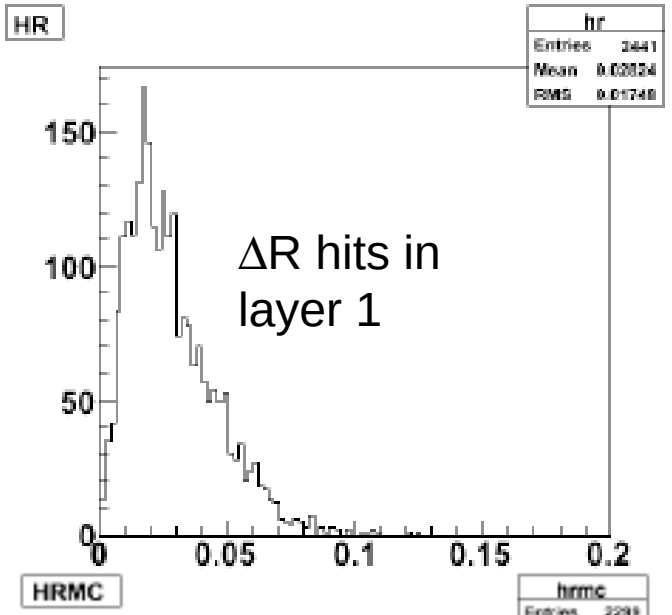
To avoid pt-cut-off use pixel layers 0 and 1

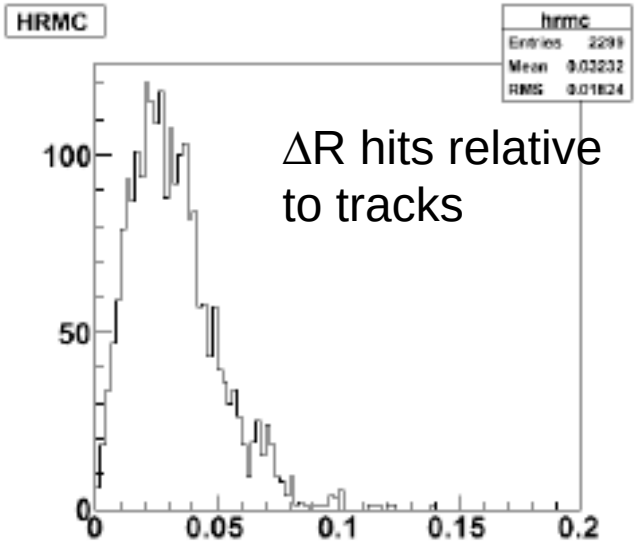


Minimise for layer 1 hits relative to layer 0

$$\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$$

How to get efficiencies?





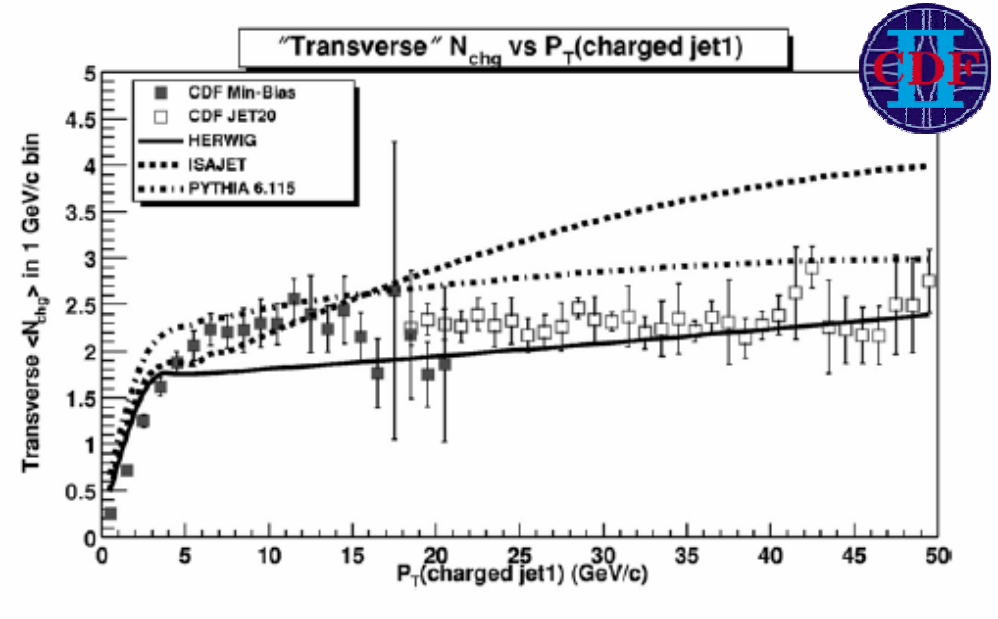
Reconstructing the underlying event

A.Moraes ATL-PUB-2005-015

How to trigger at low pt,
Overlap with jet trigger?

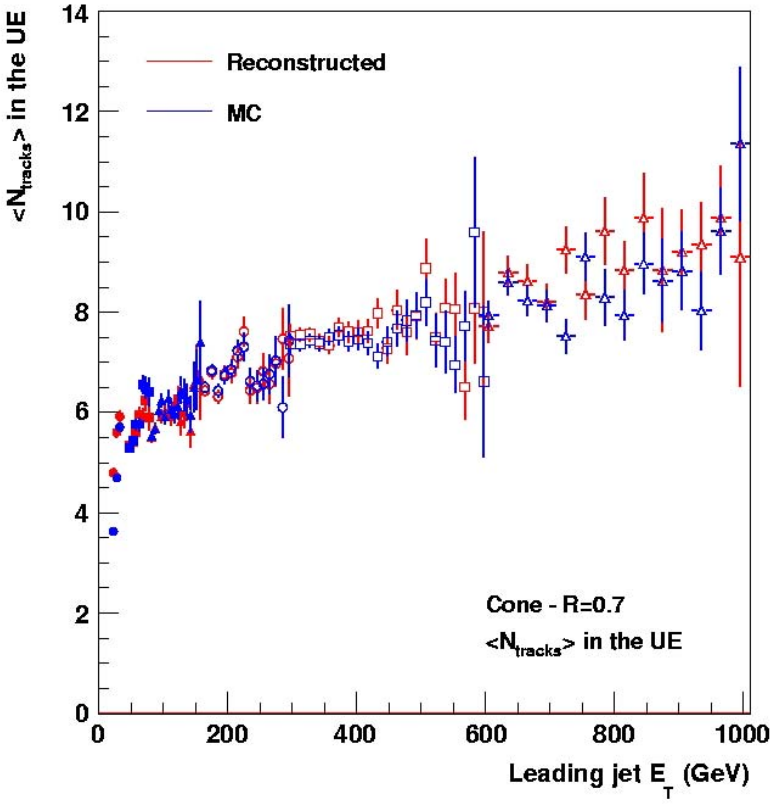
Njets > 1,
$|\eta jet|$ < 2.5,
ETjet >10 GeV,

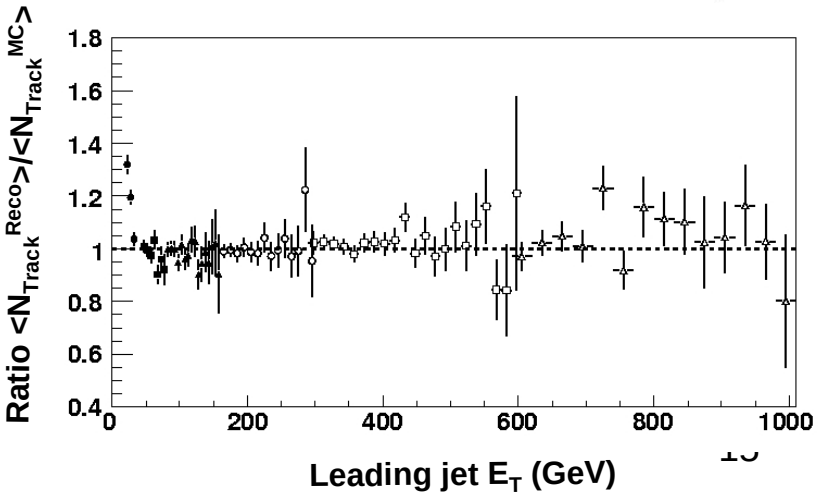
$|\eta track|$ < 2.5,
pTtrack > 1.0 GeV/c



CDF Run 1 underlying event analysis
Phys. Rev. D, **65** 092002 (2002)

ATLAS DC2 Simulated data

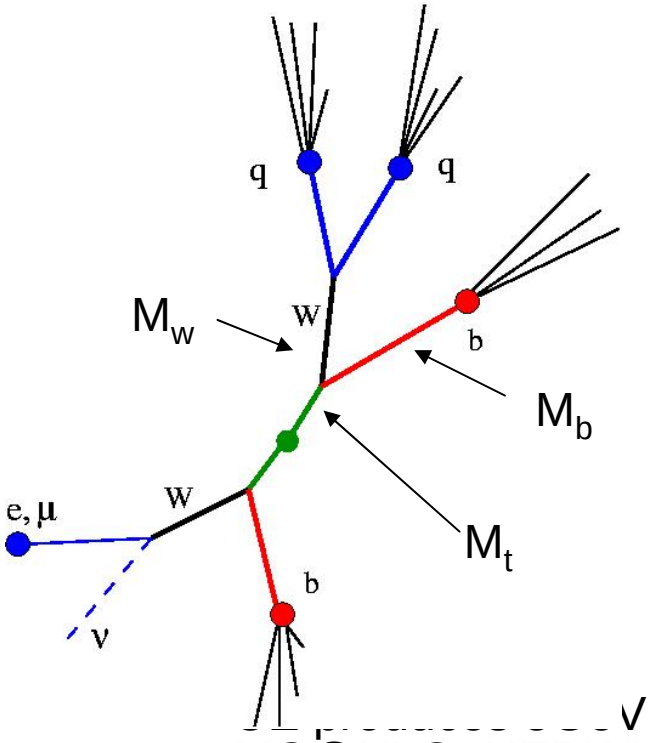




MC issues

- Need to understand NSD
  - Ie what is fraction of SD and DD?
- Current MCs
  - PYTHIA – non-diffractive inelastic scattering described by multi-parton model, also used for UE
    SD and DD described
  - PHOJET
  - One MC or mix ?
  - V.different xsect mix for diff and nd inel in PHOJET+PYTHIA
- How to compare to previous NSD data?
  - Use multiplicity distributions in data and MB
- How to tune triggers?

Underlying event

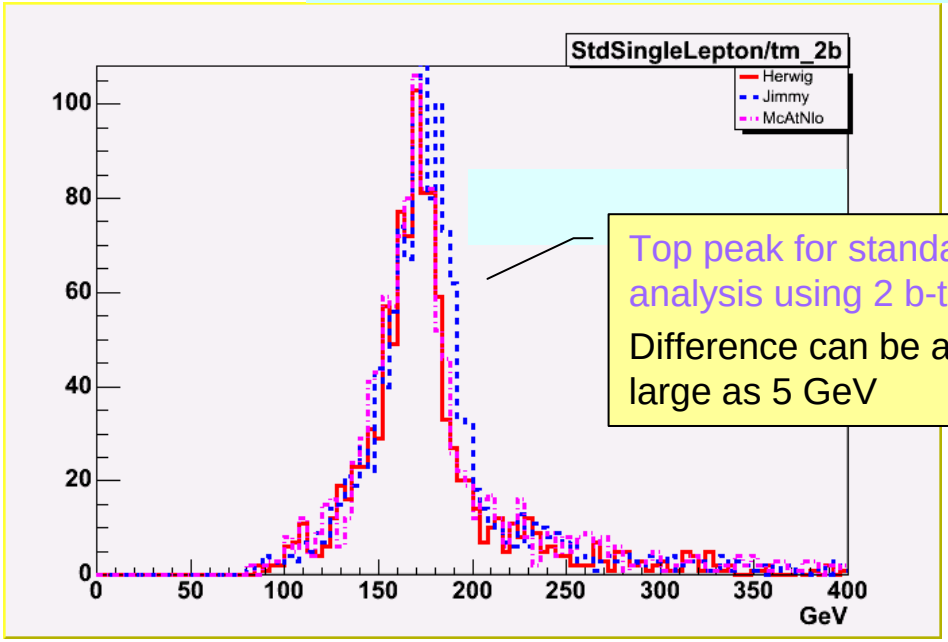


M_W

M_b

M_t

M_{top} for various UE models



Top peak for standard analysis using 2 b-tags

Difference can be as large as 5 GeV

V shift in Higgs mass using MC@NLO+HERWIG+JIMMY
old result but demonstrates range on uncertainty

- How to describe UE in complex process
  - Multipartons and radiation
  - M_t,m_W,m_b
- Can we extrapolate from ‘simple’ UE measurements in dijets to more complex states?

Summary

- A lot of work on tuning PYTHIA and JIMMY (see Borut Kersavan's talk for details)
- Main focus now: how to measure MB and UE
- MB studies in ATLAS
  - Triggering
  - Reconstructing low P_t tracks
  - Aim to get dN/dη and other event properties
- UE studies in ATLAS
  - Reconstructing UE a la CDF
  - How does it afffect jets properties?
  - Dependence of UE on process?

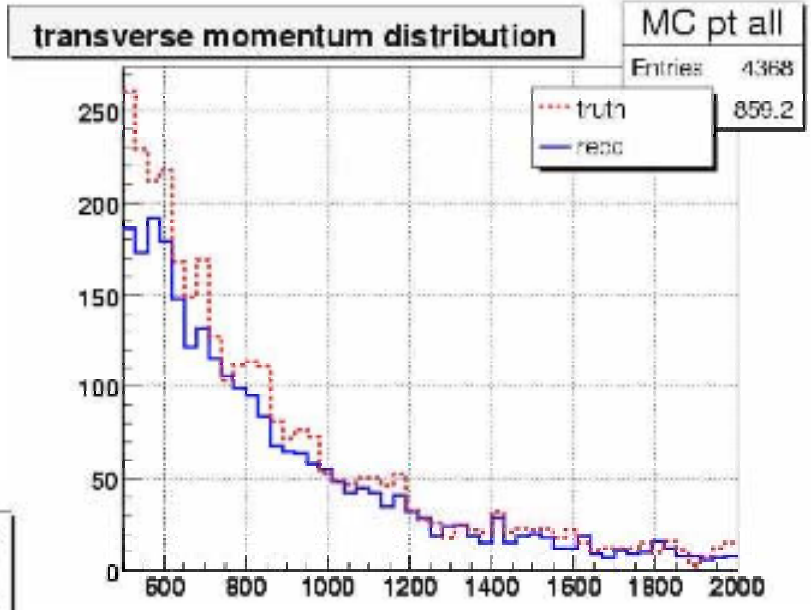
Extra slides

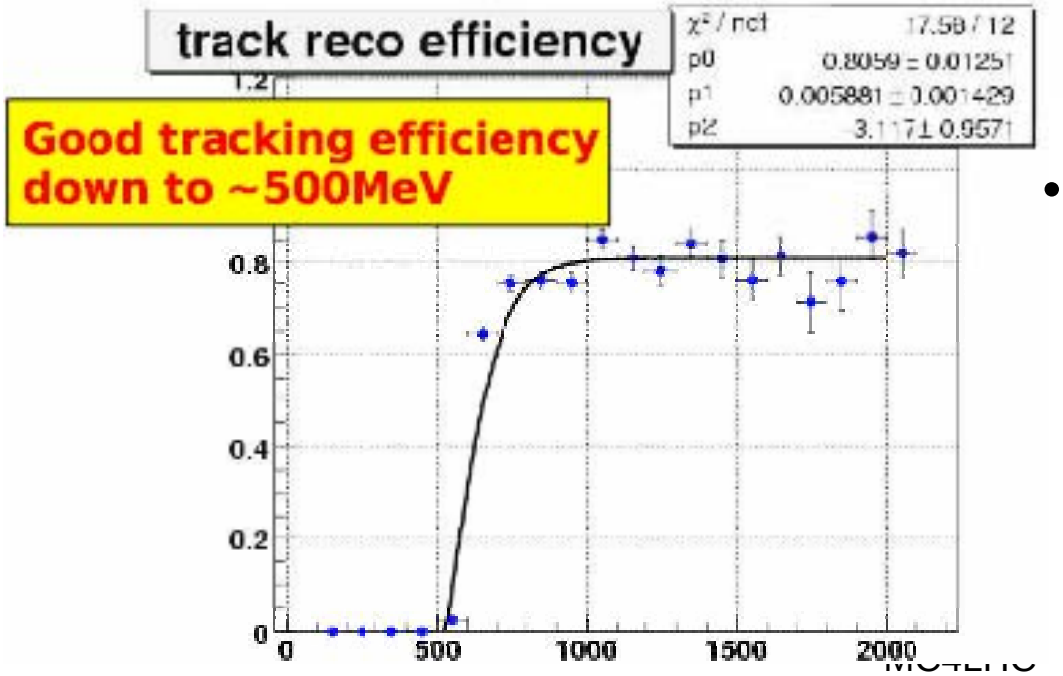
Random trigger

- 75ns @ $L=10^{31}cm^{-2}s^{-1}$ gives $<n_x>\sim 0.05$
  - → Probability of 1 event/xing =0.05
  - → Assume 1 month of running with eff=50%
  - → For 20M events to tape from HLT
  - → 1kHz L1 random trigger
  - → Process in EF to remove empty events
    - →eg track reconstruction
  - → 20Hz output from HLT
    - →Assumes 100% efficiency in identifying MB and rejecting backgrounds
    - → How to identify MB in EF ← Later
  - → Probably need x2 safety factors at L1 and EF
    - →There is a built in safety factor – empty events are small
  - → For lower luminosity ÷10 need to increase L1 random rate by x10 to maintain 20Hz HLT rate

Tracking: Startup-Initial Alignment

- Very first alignment will be based on:
  - Mechanical precision
  - Detailed survey data
  - Cosmics data (SR1/Pit)
  - Minimum bias events and inclusive bb

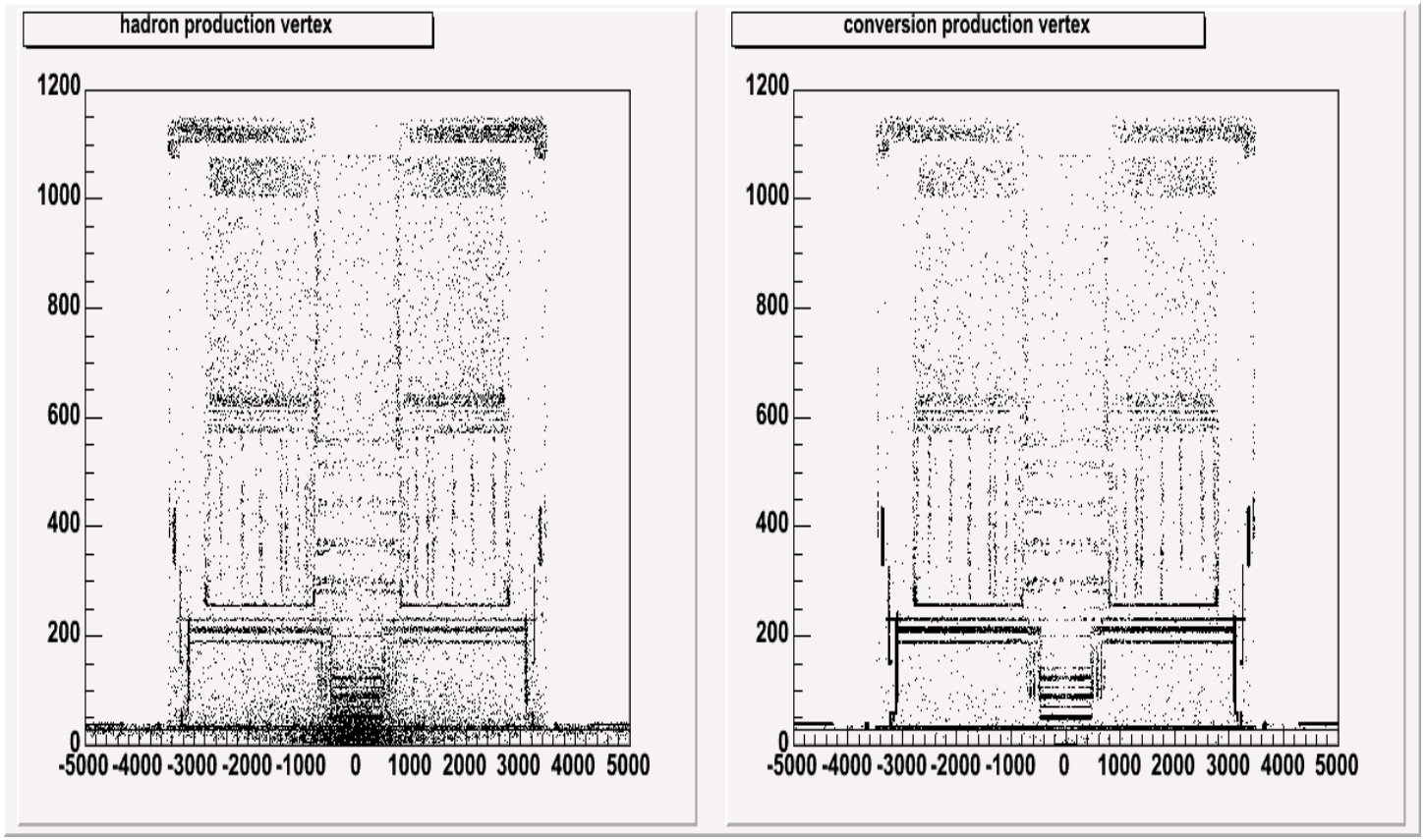




- Studies indicate good efficiencies after initial alignment
  - Example taken from T.Golling
  - Precision will need Zs and resonances to fix energy scales, constrain twists, etc…

M.Elsing Talk in SM meeting

- Interactions of minbias particles with inner detector material



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