Startup with MB

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+ MB definition
+ startup conditions
+ MB kinematics
+ possible measurements
+ detector commissioning
+ physics

Minimum Bias measurement

A minimum bias event is:

everything collected by a completely inclusive trigger

It means:

+ generic single proton-proton collision
+ elastic+inelastic, diffractive and not

MB interactions are:

+ $<N_{int}> = L_{inst} * \sigma$
+ low transverse energy
+ low multiplicity
+ huge cross section

Minimum Bias measurement

Our ability to perform this measurement, from the earliest stage of data taking, relies on:

+ physiscs model understanding

+ **detector understanding (and commissioning)**

$$\sigma_{tot} = \sigma_{Elastic} + \sigma_{SingleDiffractive} + \sigma_{DoubleDiffractive} + \sigma_{HardCore}$$

(14 TeV) ~20 mb ~15 mb ~10 mb ~55 mb

$$\sigma_{tot} = \sigma_{Elastic} + \sigma_{SingleDiffractive} + \sigma_{DoubleDiffractive} + \sigma_{HardCore}$$

(900 GeV) ~15 mb ~12 mb ~6 mb ~35 mb

MB is defined by the trigger used -> CMS doesn't have a dedicated one (for now?)

MB (and UE) understanding is critical for modeling pile up and physics process at higher energies

...and could be useful for the tracker commissioning...

LHC at Startup – Pilot Run

November 2007

(far from nominal condition)

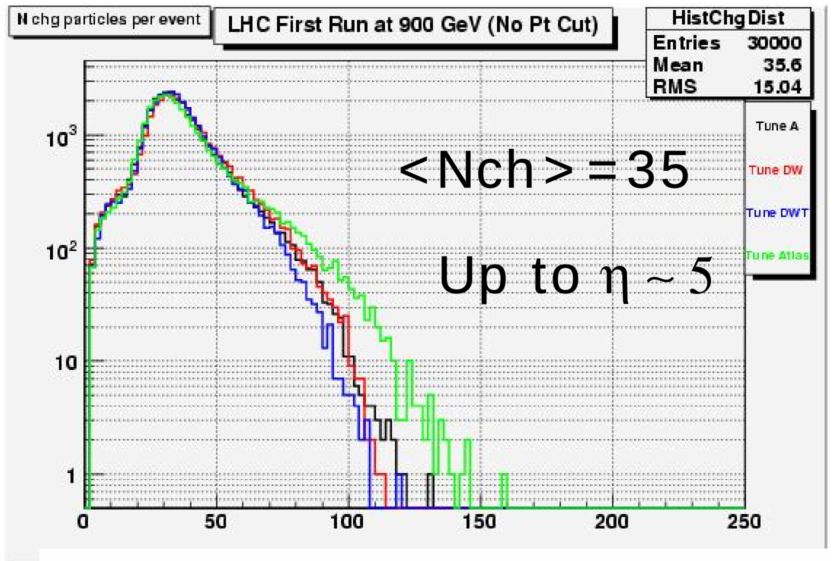
+ 900 GeV CME
+ 75 ns
+ 1 -> 156 bunches/beam (?)
+ 10^{10} -> $4*10^{10}$ proton/bunch
+ β: 18 -> 2 m
+ Luminosity 10^{27} -> $2*10^{31}$
+ <1 ev/bunch-crossing

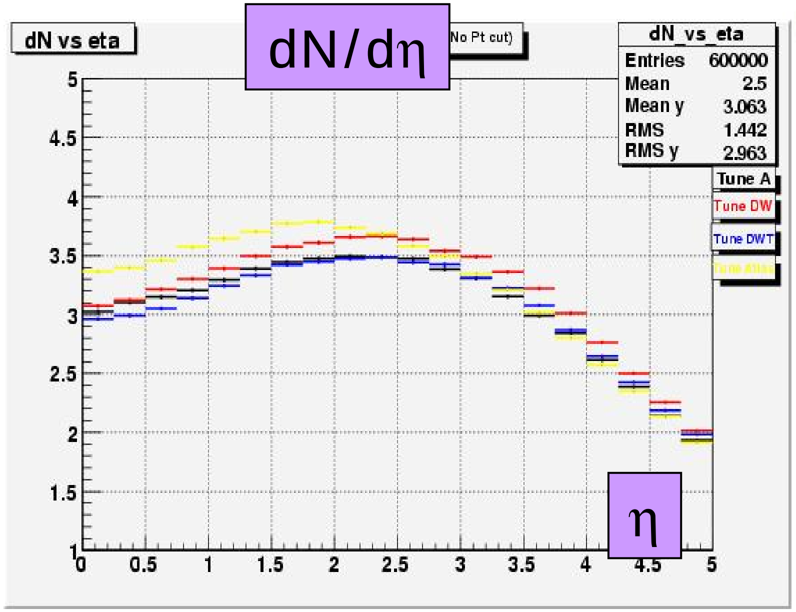
+ Expected Integrated Luminosity 10 pb^{-1} (?)

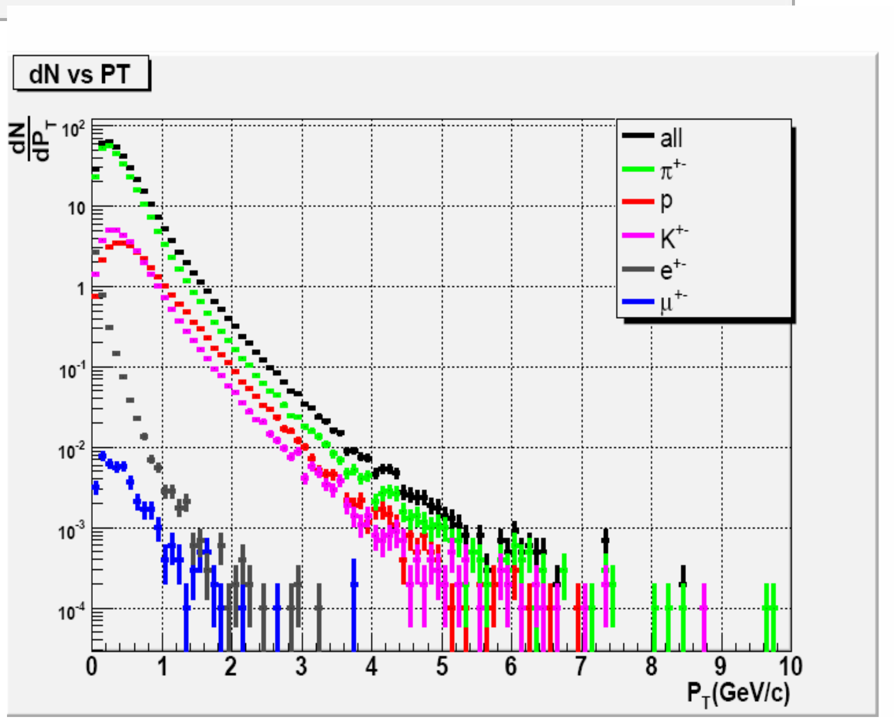
LHC at Startup – expected event rate

	σ x BR	Events in 2 pb^{-1}
W $\rightarrow \mu\nu$ (no Pt cut)	**8 nb x 10%**	**1'600**
Z $\rightarrow \mu\mu$ (no Pt cut)	**2 nb x 3%**	**120**
J/Psi $\rightarrow \mu\mu$ ($p^{J/psi}_T$>5 GeV)	**10 nb**	**20'000**
bb $\rightarrow \mu$ X (PT>10 GeV bbbar generation)	**400 nb x 20%**	**160'000**
bb $\rightarrow \mu\,\mu$ X (PT>10 GeV bbbar generation)	**400 nb x 2%**	**16'000**
Minimum Bias	**40-50 mb**	**10^{11}**

LHC at Startup – Minimum Bias - kinematics



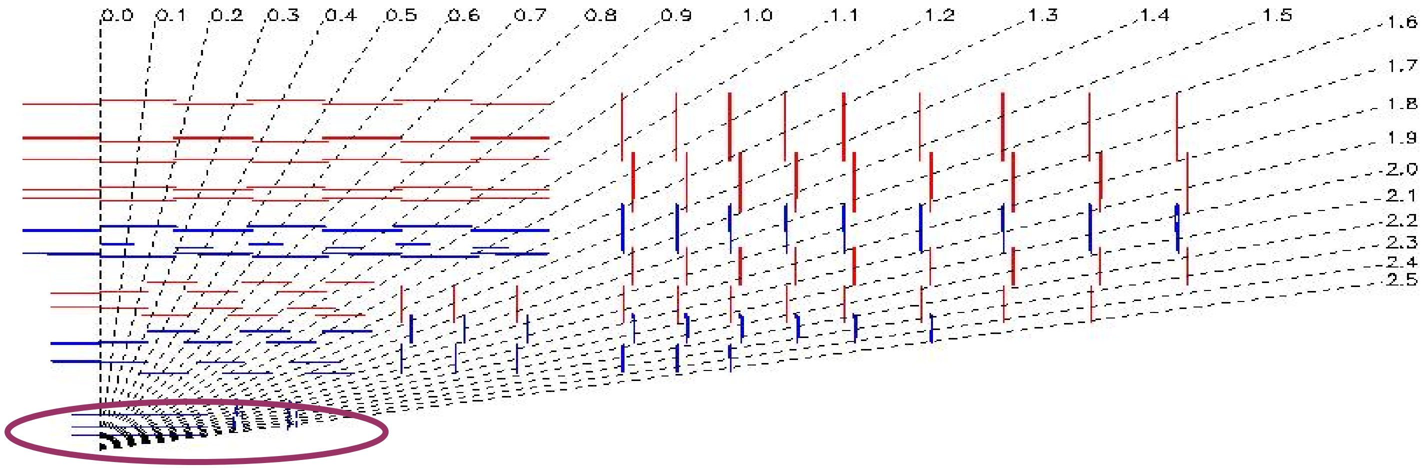




there are ~ 15 tracks/ev in the Tracker acceptance region with an average momentum of ~ 350 MeV

About 2-3% of the tracks with a momentum larger than 2 GeV

CMS Tracker at Startup



Critical points:

+ pixel -> 3 blades in the FW (30 degrees)
2 half ladders in the barrel ← readable

+ Mis-alignment (expected up to 500 μm)

We should setup:

+ ad hoc production with expected geometry? Is it critical?
alternative: switch off pixels just for reconstruction,
but the material is still there (Ok)

+ estimate track reconstruction performances in this scenario:
- **different seeds**
- **hard dis-alignment**

CMS at Startup – MB trigger

How do we plan to trigger on Minimum Bias event?

Several ideas and methods:

dedicated trigger -> triggers on π0, crossing triggers, tirggers on calo towers, forward triggers, TOTEM(??)...

from other streams -> using pile up interactions (all of them / event)

Not for startup

We need to define a strategy soon

Hypothesis (conservative):

L1 -> there will be only one 12.5 KHz slice

Suppose we could trigger at L1 using a trigger with about 100 Hz (given the small size of the events)

2 tracks/sec (PT>2GeV)-> with 10 hours running by day:

70'000 tracks/day, or in 10 days

~700'000 tracks in 10 days with PT>2 GeV/c

~ 3.5*10^6 tracks in 10 days with PT>1 GeV/c

LHC

L=10^{28}

CMS at Startup - Track reconstruction

While MB is mainly composed by soft tracks, tracking performances have to be carefully investigated

Starting from an ideal tracker, we should consider loss due to seeding without pixel and mis-aligned tracker

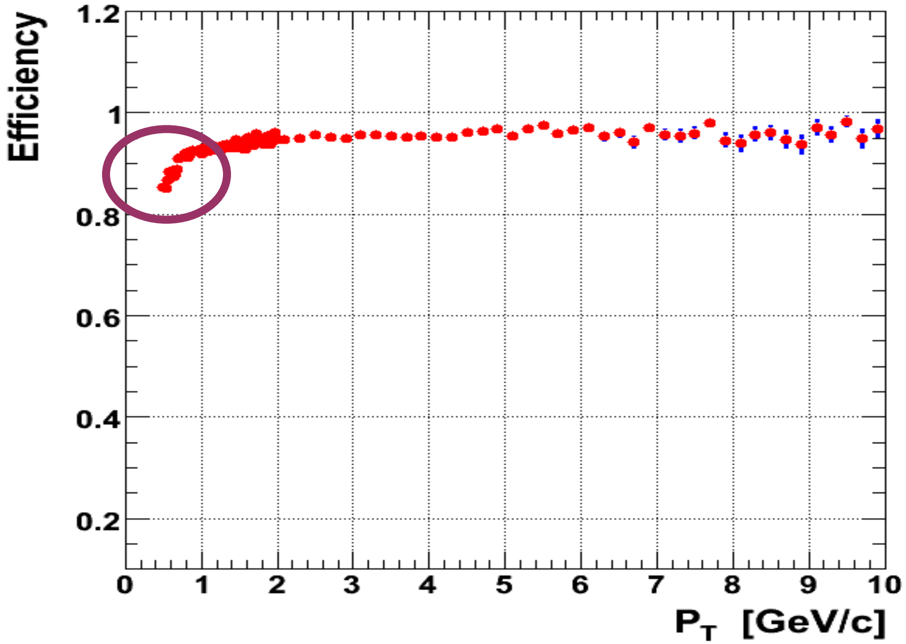
How low in PT can we reconstruct tracks?

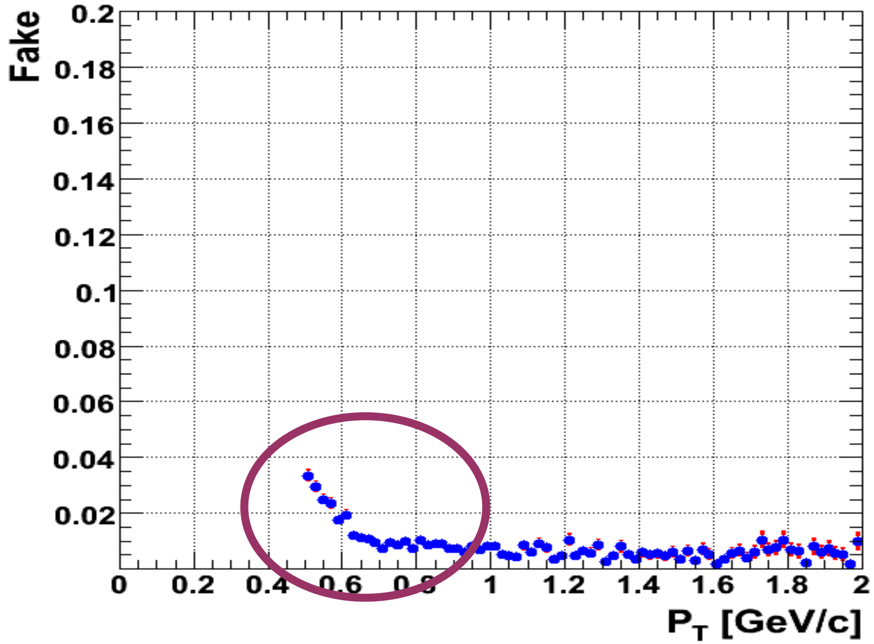
lower threshold is limited by the absence of pixels

(we cannot use inner triplets to make tracks)

CMS - Track reconstruction – nominal performances

Tracks in jets – **Nominal Condition** (aligned detector, pixel seeding)





PT_seed>0.5

PT_track reco >0.5

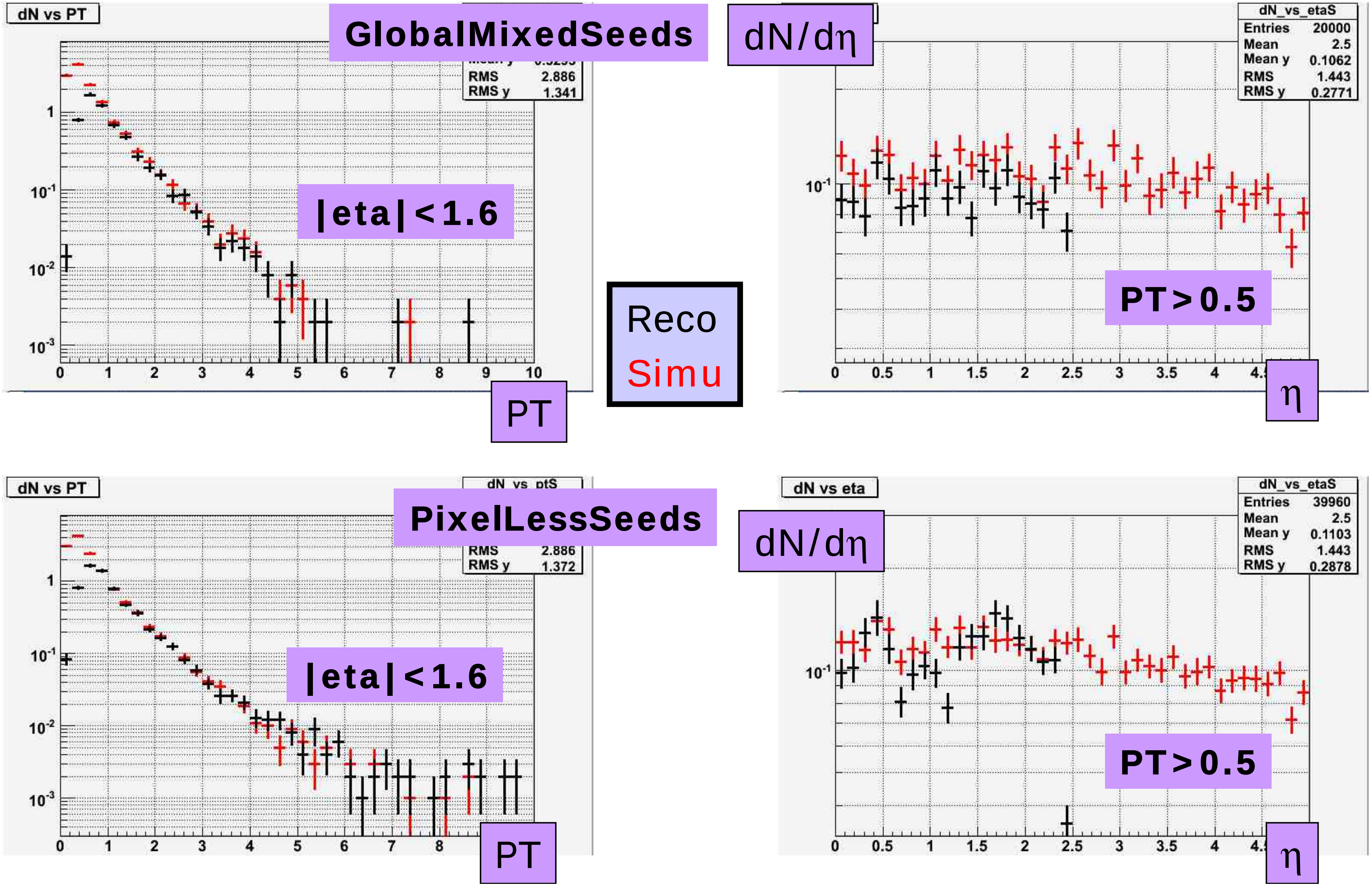
High reconstruction efficiency with fake under control down to 500 MeV/c

To estimate efficiencies and fake we use as association criteria the number of hits shared between reconstructed and simulated tracks (at least 50%)

OLD STUDY with ORCA

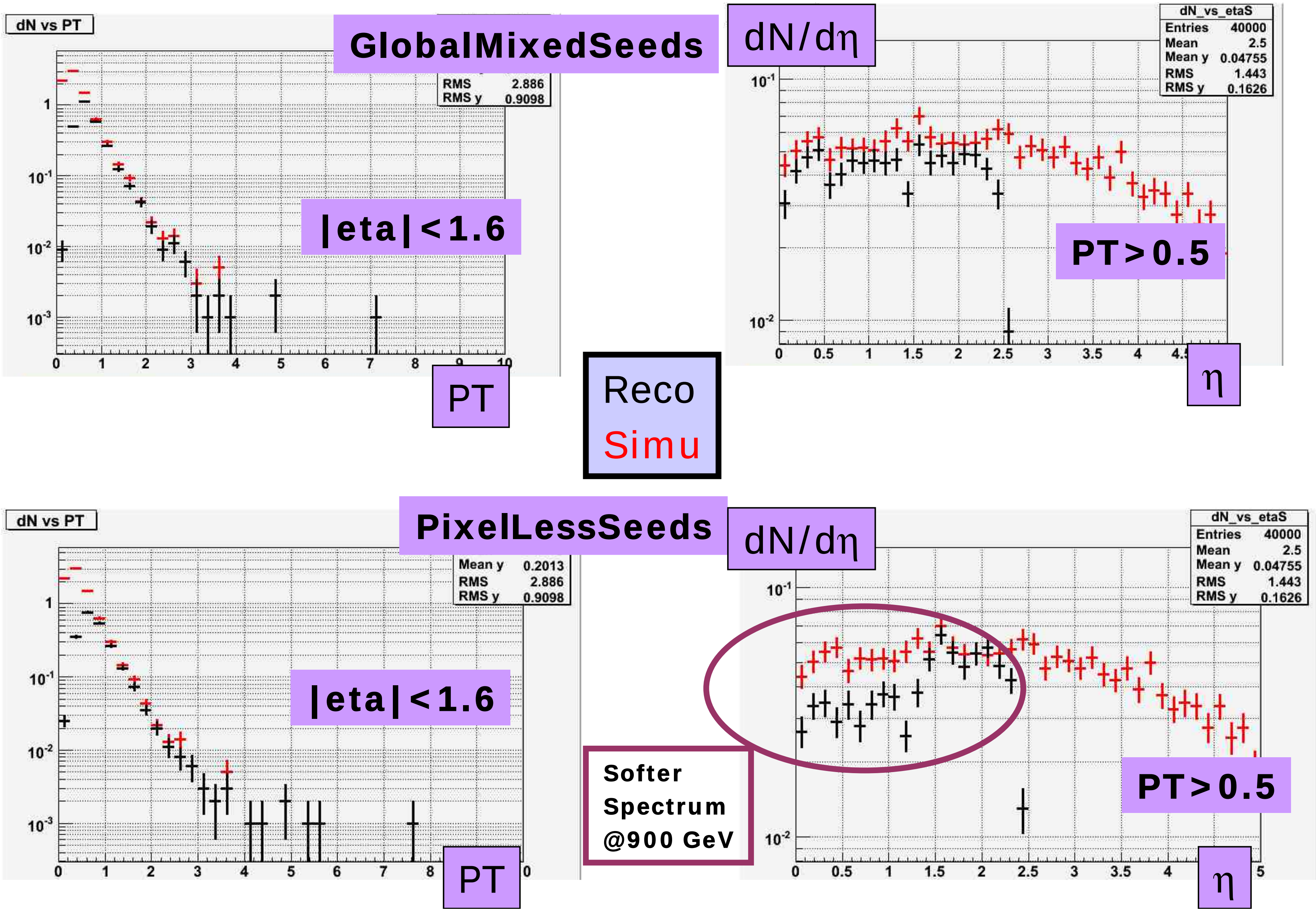
CMS at 14 TeV - Track reconstruction - PRELIMINARY

CMSSW – GlobalMixedSeeds / PixelLessSeeds



CMS at 900 GeV - Track reconstruction - PRELIMINARY

CMSSW – GlobalMixedSeeds / PixelLessSeeds



CMS at 900 GeV - Track reconstruction - PRELIMINARY

CMSSW – Global Seeding / PixelLess Seeding

Startup:

preliminary overview on track reconstruction performances
seeding without pixel

good reco performances for track PT > 1 GeV (preliminary)

Critical point:

low <PT> @ 900 GeV (~350 MeV)
lower reconstruction efficiency,
especially for seeding without pixels

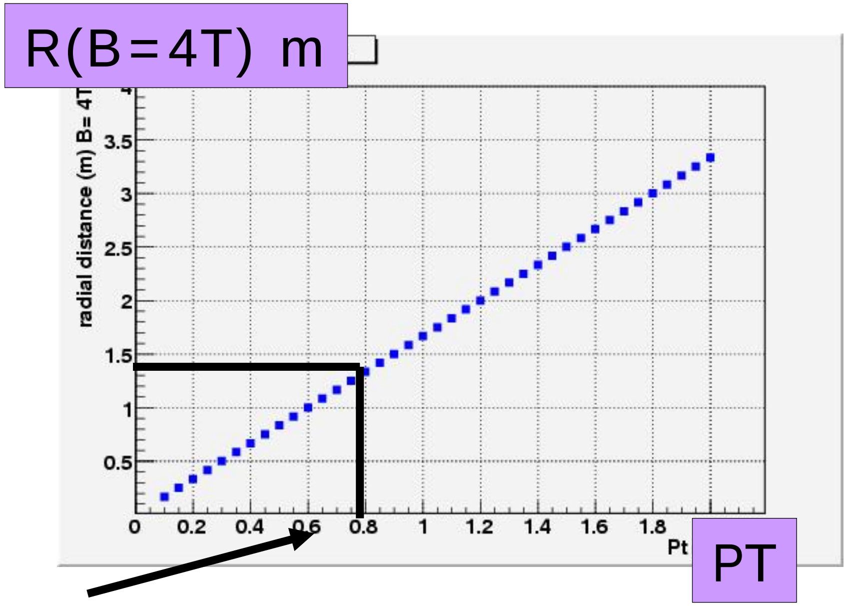
Still to understand:

lower reconstruction efficiency in the central region
(at 900 GeV for pixelLess seeding)

more systematic analysis in terms of efficiency and fake rate
(an associator is needed…work is ongoing)
and increasing the eta region up to 2.4

effect of a misaligned detector

LHC at Startup – Playing with B

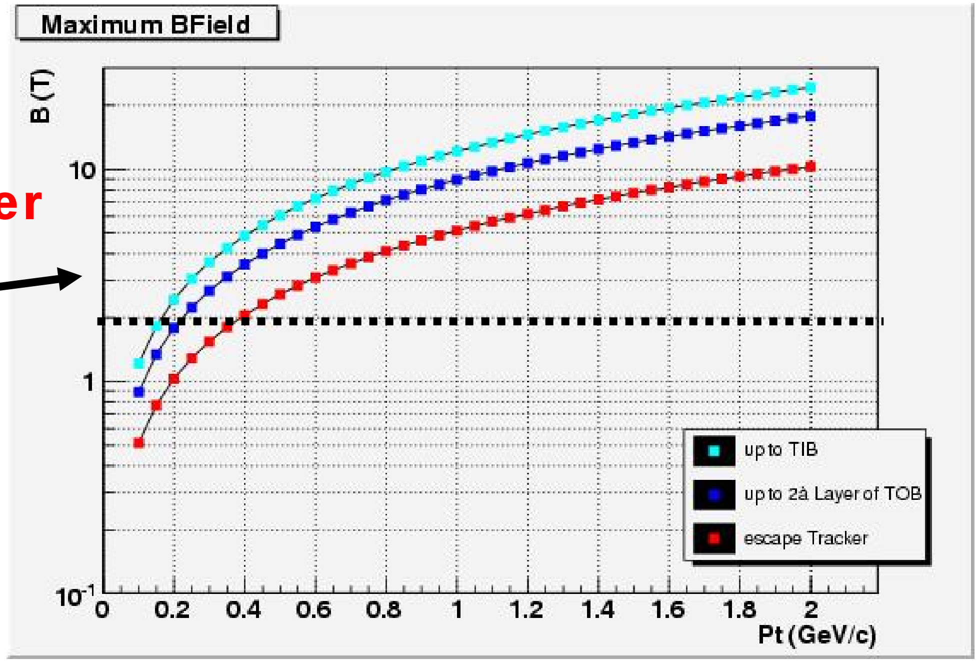


Can we take data with reduced B field?

(Field mapped at 0, 2, 3.8 and 4 T)

If yes (2T), the number of "useful" tracks can increase by a factor 10

800 MeV to reach the calorimeter at 4 Tesla



2 Tesla:

400 MeV -> EM calorimeter

200 MeV -> 2nd TOB layer

150 MeV to cross the TIB

Less than 150-200 MeV:

track reconstruction will be very difficult because of the Multiple Scattering contribution

CMS at Startup - some commissioning idea with MB

On which data we can trust during the pilot run?

- **cosmic rays (PT> 10 GeV, 60 Hz rate in the tracker)**
- **isolated muons from J/psi or b decay (still to evaluate)**
- **Millions minimum bias tracks**

Detector Understanding:

- **channels mapping and calibration**
- **hit resolution studies**
- **material budget measurement**
  (photon conversion and nuclear interactions)
- **magnetic field mapping and**
- **lorentz angle measurements**
- **Feed back to simulation**
- **tracking/vertexing**

Alignment:

- **pre-alignment with cosmic**
- **using tracks from beam halo (single bunch operation)**
- **using tracks**

Something more sophisticated:

- **tracker/muon system matching**
- **track/calorimetric deposit matching**

CMS at Startup - some commissioning idea with MB

+ cosmic rays
(PT> 10 GeV, 60 Hz rate)

+ isolated muons from J/psi or b decay

Low statistics, but more energetic particles:
Subdetector-level pre-alignment
Tracker alignment wrt other detectors

MB: high statistics with softer spectrum
3.5*10^6 (PT>1 GeV) in the tracker acceptance
considering 10 days and 10 hours/day at L=10^28

~500 tracks/module in TIB+TOB:
+ probably enough to perform module-level alignment and other commissioning studies

+ probably not-enough for a complete channel mapping and gain calibration

Any way the starting hypothesis is very conservative,
we can expect to increase the statistics by more then a factor 10:
+ reconstruct track with PT < 1 GeV/c
+ L > 10^28
+ B < 4T

CMS at Startup - some measurement idea from MB

Which kind of physics we will be able to measure with a basically unknown and mis-aligned detector with an uncomissioned accelerator and with few hours of data taking?

Probably nothing.

In the best scenario we will be able to commission the tracker, reconstruct tracks and test several tools.

But if we're lucky, collected data will be enough, we can start to cross check collected data with SppS and start to understand the tuning of MC for LHC:

+ Minimum Bias activity and

+ very preliminary Underlying Event estimation

(strictly dependant on the possibility to collect "hard" activity

900 GeV CME -> ~1% of events with a Jet with PT>10 GeV it means ~10^{6} events)

MB&UE at CMS group

Plans

What we need to be prepared ?

+ simulated MB events at 900 GeV CME (ongoing)

+ special samples (100K) with different B-Field (down to 1T)

+ simulated 0-activity events (“geantino”) to understand beam-halo interaction (it can be an important background)

Low priority

+ understand contribution from bb inclusive production (ongoing)

+ re-estimate tracking performances with CMSSW FW considering (ongoing) :

pixel-less seeding

mis-aligned detector

+ estimate how much time/data is/are needed to (ongoing):

align the detector down to ~ 50 μm

BackUp

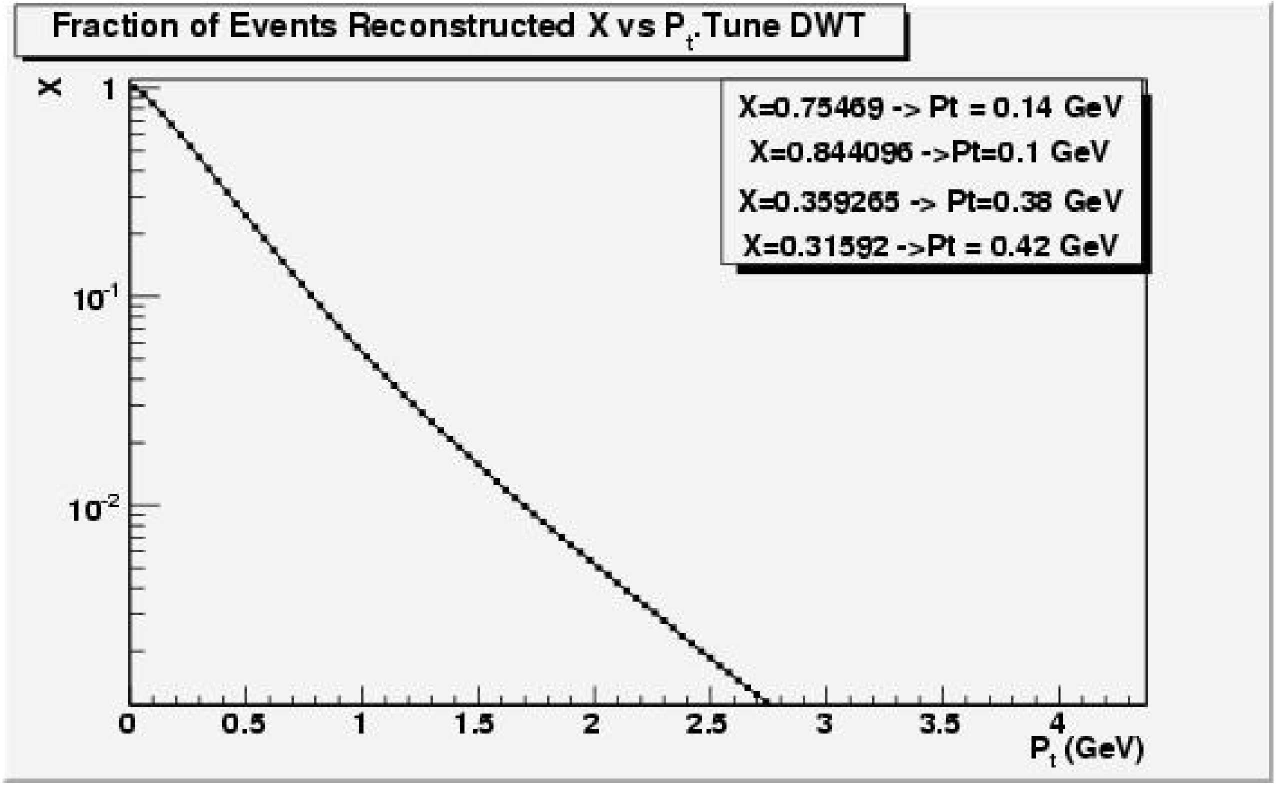

Fraction of Events Reconstructed X vs Pt.Tune DWT
X=0.75469 -> Pt = 0.14 GeV
X=0.844096 ->Pt=0.1 GeV
X=0.359265 -> Pt=0.38 GeV
X=0.31592 ->Pt = 0.42 GeV
X
1
10-1
10-2
0
0.5
1
1.5
2
2.5
3
3.5
4
Pt (GeV)

Table 4: Cross sections (in μb) for $b \to \mu + X$ production, with a muon, or both, satisfying appropriate cuts. Only muons coming directly from B decays are included here. The calculation was performed using the CTQ4M parton densities. The upper number are the maximum, and the lower number the minimum of the values obtained by varying the scales in the usual way. The corresponding total cross sectios are 165 to 864 μb The $B \to \mu$ branching fraction was taken equal to 10.5%. Different values for the ϵ parameter of the Peterson fragmentation function are assumed. The last two column show the impact of a rather large intrinsic transverse momentum of the incoming partons.

ϵ	0	0.002	0.006	0.002	0.006
$\langle k_T \rangle$ (GeV)	0	0	0	4	4
A: $b\bar{b} \to \mu(\lvert\eta\rvert < 2.4,\ p_T \geq 6)$	3.3 1.06	2.41 0.81	2.12 0.72	3.4 1.06	2.91 0.94
B: $b\bar{b} \to \mu(p_T > 6)\ \mu(p_T > 3)$	0.76 0.304	0.52 0.219	0.45 0.19	0.67 0.252	0.54 0.214
C: $b\bar{b} \to \mu(p_T > 6)\ e(p_T > 2)$	1.18 0.43	0.83 0.32	0.71 0.277	1.1 0.38	0.92 0.33
D: $b\bar{b} \to \mu(p_T > 7,\ \lvert\eta\rvert < 2.4)$	2.26 0.78	1.62 0.58	1.41 0.5	2.23 0.73	1.9 0.63
E: $b\bar{b} \to \mu(p_T > 7,\ \lvert\eta\rvert < 2.4)$ $\mu(p_T > 4.5,\ \ 0 < \lvert\eta\rvert < 1.5)$	0.0304 0.0146	0.0203 0.0102	0.0174 0.0087	0.0232 0.0105	0.0188 0.009
F: $b\bar{b} \to \mu(p_T > 7,\ \lvert\eta\rvert < 2.4)$ $\mu(p_T > 3.6,\ 1.5 < \lvert\eta\rvert < 2)$	0.0101 0.0045	0.0075 0.0032	0.0068 0.0026	0.0096 0.0035	0.0076 0.00281
G: $b\bar{b} \to \mu(p_T > 7,\ \lvert\eta\rvert < 2.4)$ $\mu(p_T > 2.6,\ 2 < \lvert\eta\rvert < 2.4)$	0.0105 0.0038	0.0073 0.00263	0.0053 0.00219	0.0082 0.00251	0.0062 0.0024
H: $b\bar{b} \to \mu(p_T > 1,\ 2 < \lvert\eta\rvert < 6)$	19.3 5.4	18.8 5.3	18.6 5.2	19.1 5.4	18.9 5.3
I: $b\bar{b} \to \mu(p_T > 2,\ 2 < \lvert\eta\rvert < 6)$	10.2 2.94	9.1 2.65	8.6 2.51	10.6 3.11	10. 2.96

Composition from bb, considering just qq->bb, gg->bb production (no flavor excitation and gluon splitting)