

Search for Heavy Stable Charged Particles with dE/dx Measurements from the Tracker

Kolja Kaschube

April 28, 2010

Introduction

Analyzing 7 TeV Data with CRAB

✦ *crab_2_7_2_pre1* is needed, so:

✦ start with a clean server shell, then

```
source /afs/cern.ch/cms/LCG/LCG-2/UI/cms_ui_env_3_2.sh
```

```
cd your/cmssw/environment
```

```
cmsenv
```

```
source /afs/cern.ch/cms/ccs/wm/scripts/Crab/CRAB_2_7_2_pre1/crab.sh
```

✦ get a JSON file containing certified good runs/lumi sections from

<https://cms-service-dqm.web.cern.ch/cms-service-dqm/CAF/certification/>

✦ adjust your crab.cfg, see next slide

✦ submit your crab jobs

crab.cfg

[CRAB]

```
jobtype = cmssw  
scheduler = glite  
use_server = 1
```

necessary

[CMSSW]

```
datasetpath = /MinimumBias/Commissioning10-PromptReco-v8/RECO  
pset = your/cmssw/environment/your_cfg.py  
#total_number_of_events = -1  
number_of_jobs = 500  
#events_per_job = 50
```

```
lumi_mask = your_json.txt  
total_number_of_lumis = -1  
#lumis_per_job = 5
```

necessary

*2 out of 3 of these parameters
must be used/specified*



```
get_edm_output = 1
```

[USER]

```
return_data = 1  
copy_data = 0  
dontCheckSpaceLeft = 1
```

NB: It is currently ***not possible***
to select jobs by event number
when using JSON files with
CRAB

[GRID]

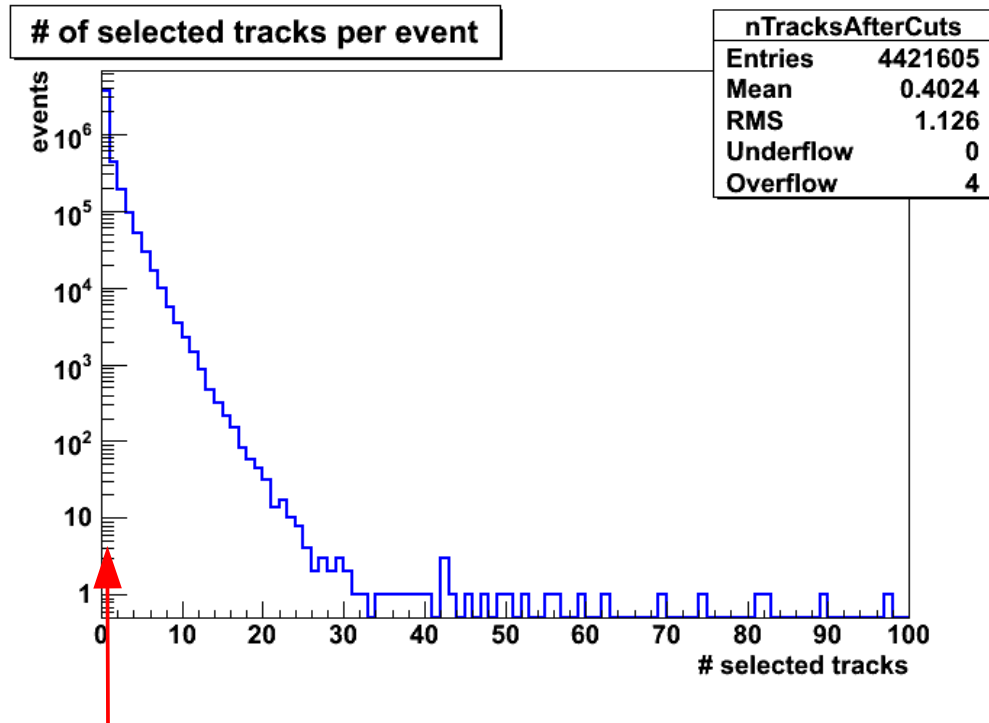
```
#se_white_list = T2_DE  
group = dcms
```

7 TeV Data

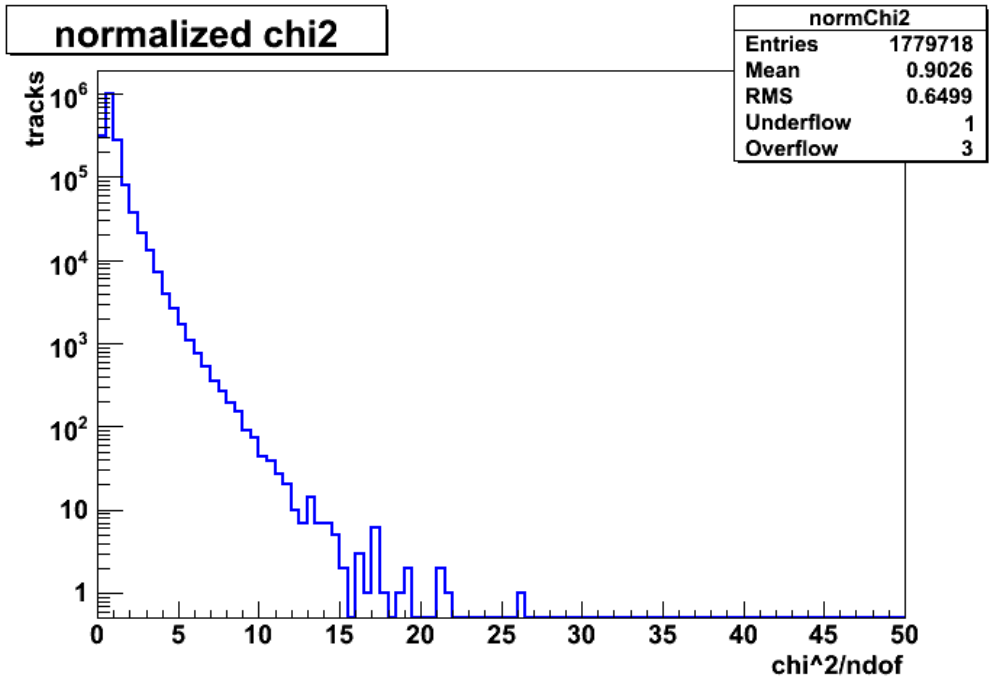
Software, Sample, Selection

- ◆ CMSSW_3_5_6, GR10_P_V4
- ◆ sample: /MinimumBias/Commissioning10-PromptReco-v8/RECO
 - **89 M events**
- ◆ Run range: 132440 – 133336, 6774 'good' lumi sections
- ◆ 'monster event' filter used
- ◆ trigger bits: 0 & (40 or 41) & NOT (36 – 39)
- ◆ 200 out of 374 CRAB job failed ('bad' server)
 - **4.4 M events**
- ◆ track $p_T > 2$ GeV/c, at least 4 dE/dx measurements/track, $|dz| < 10$ cm
 - **0.7 M events** → **1.78 M tracks**
- ◆ caveat: no particle gain calibration for strip modules in global tag (to be included in next reprocessing with 3_5_8)

7 TeV Data - Plots

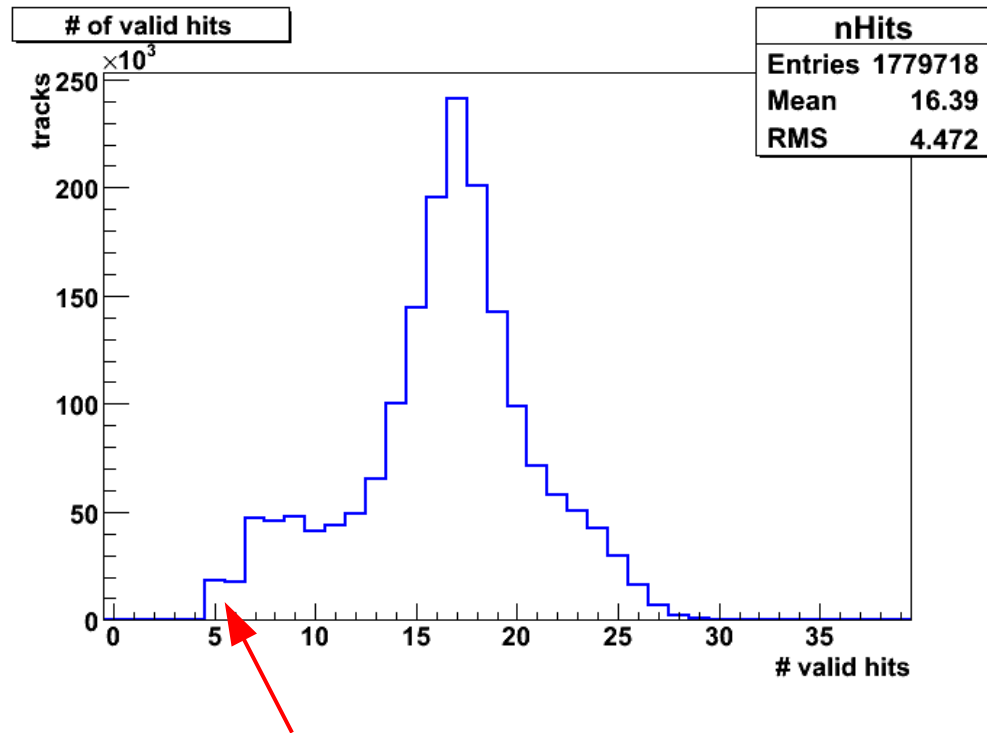


first bin (0 tracks) has about 3.7 M entries

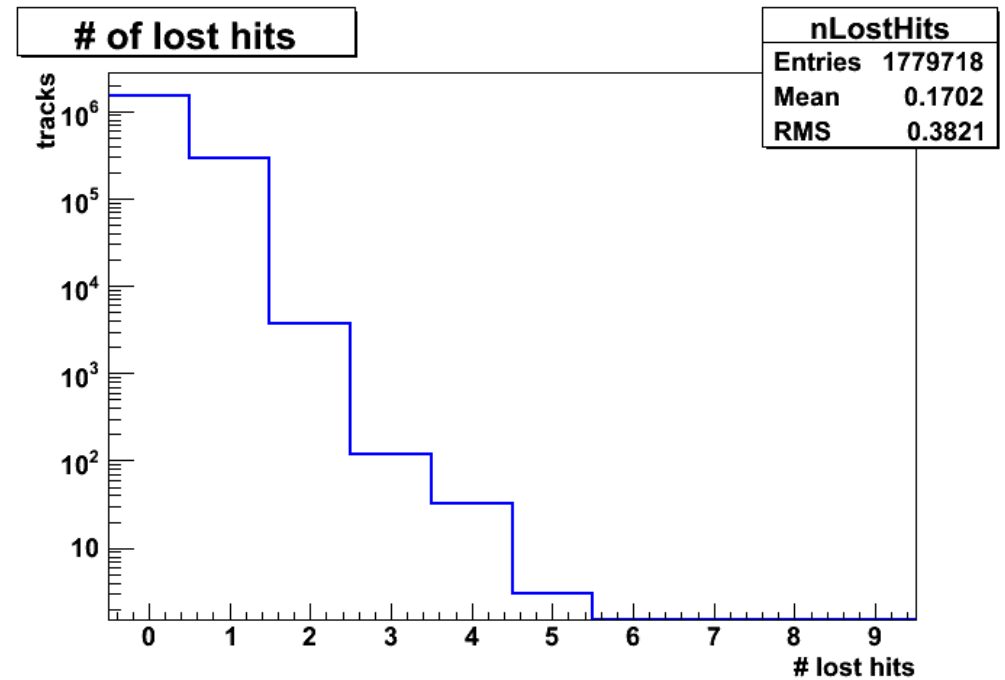


should cut on this (< 5 or 10)

7 TeV Data - Plots

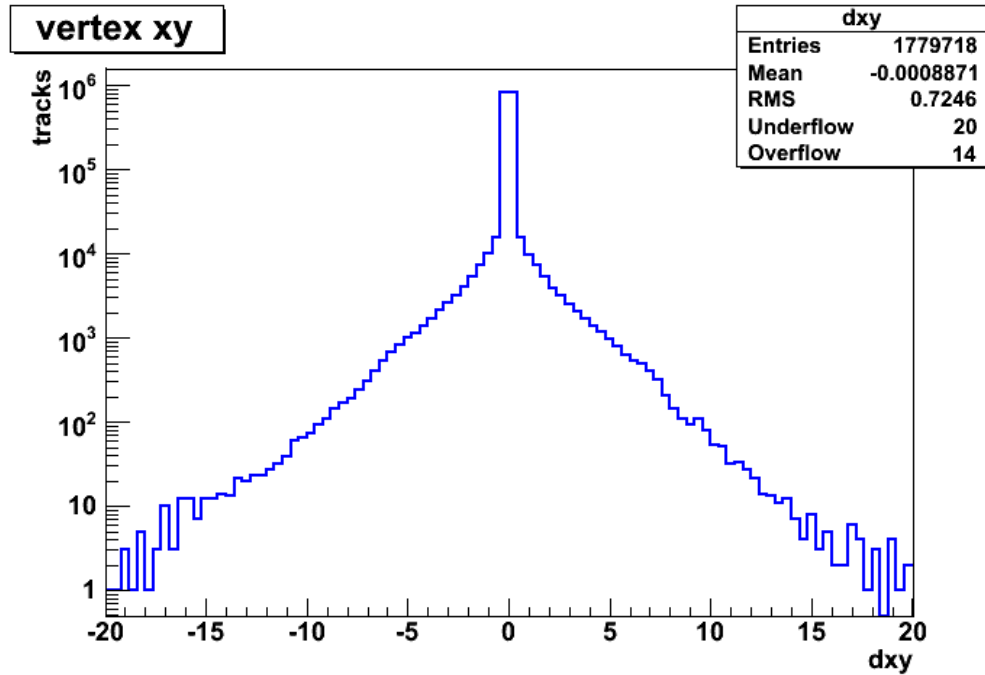


4 dE/dx measurements required,
a few tracks have only 1 or 2 pixel hits

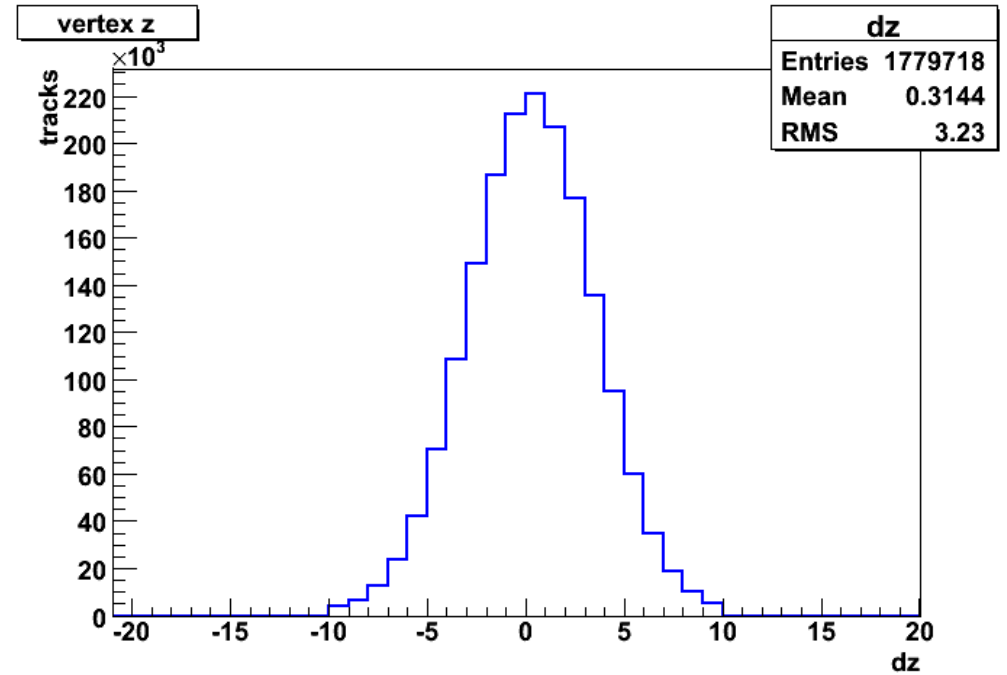


hits that the track reco algorithm
expects but doesn't find

7 TeV Data - Plots



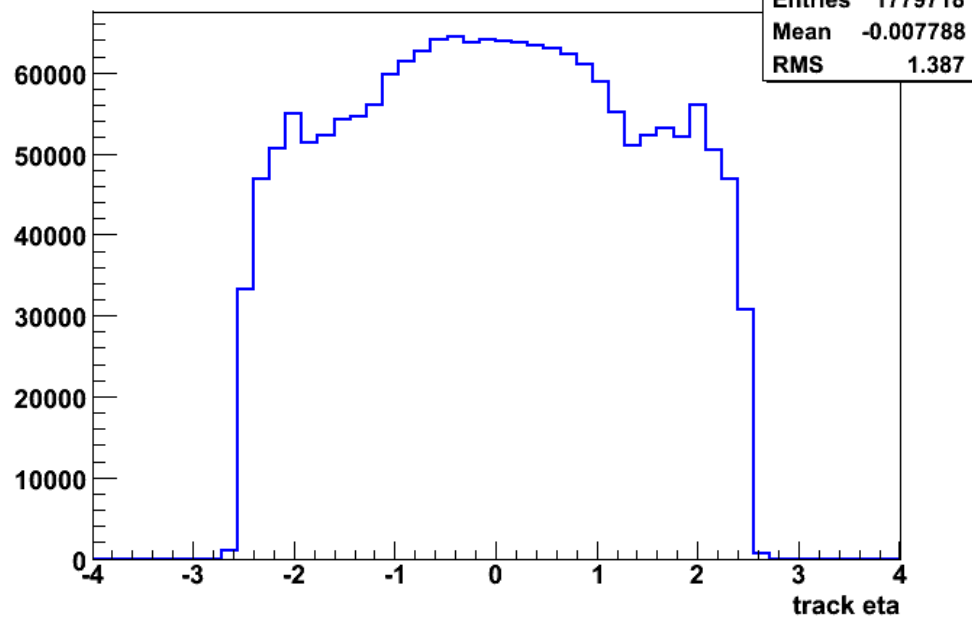
transverse impact parameter;
could cut here, too (< 2 or $3?$)



longitudinal impact parameter;
rejected: $> |10 \text{ cm}|$

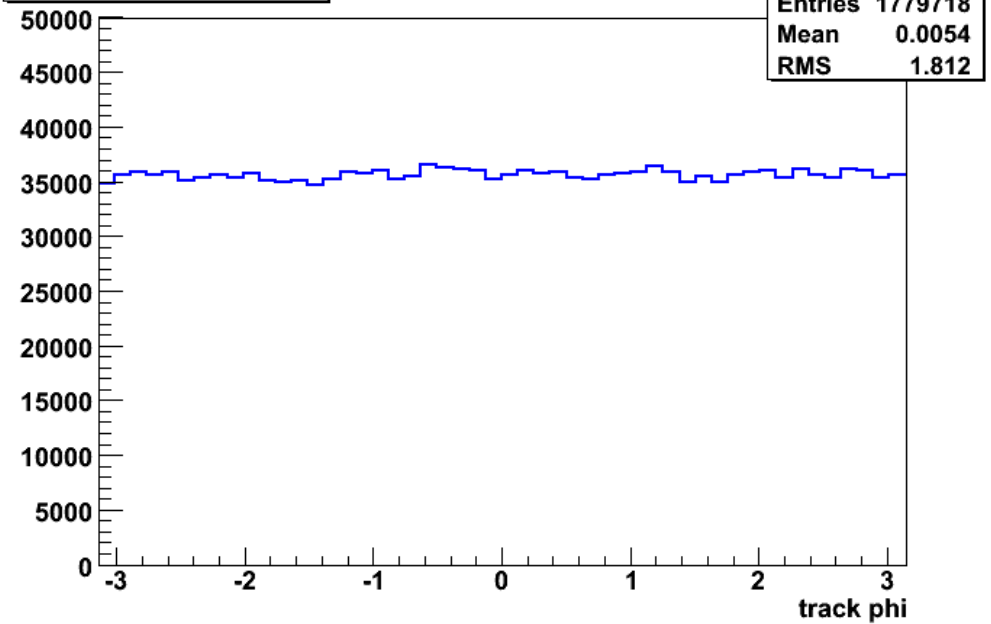
7 TeV Data - Plots

eta of reco tracks



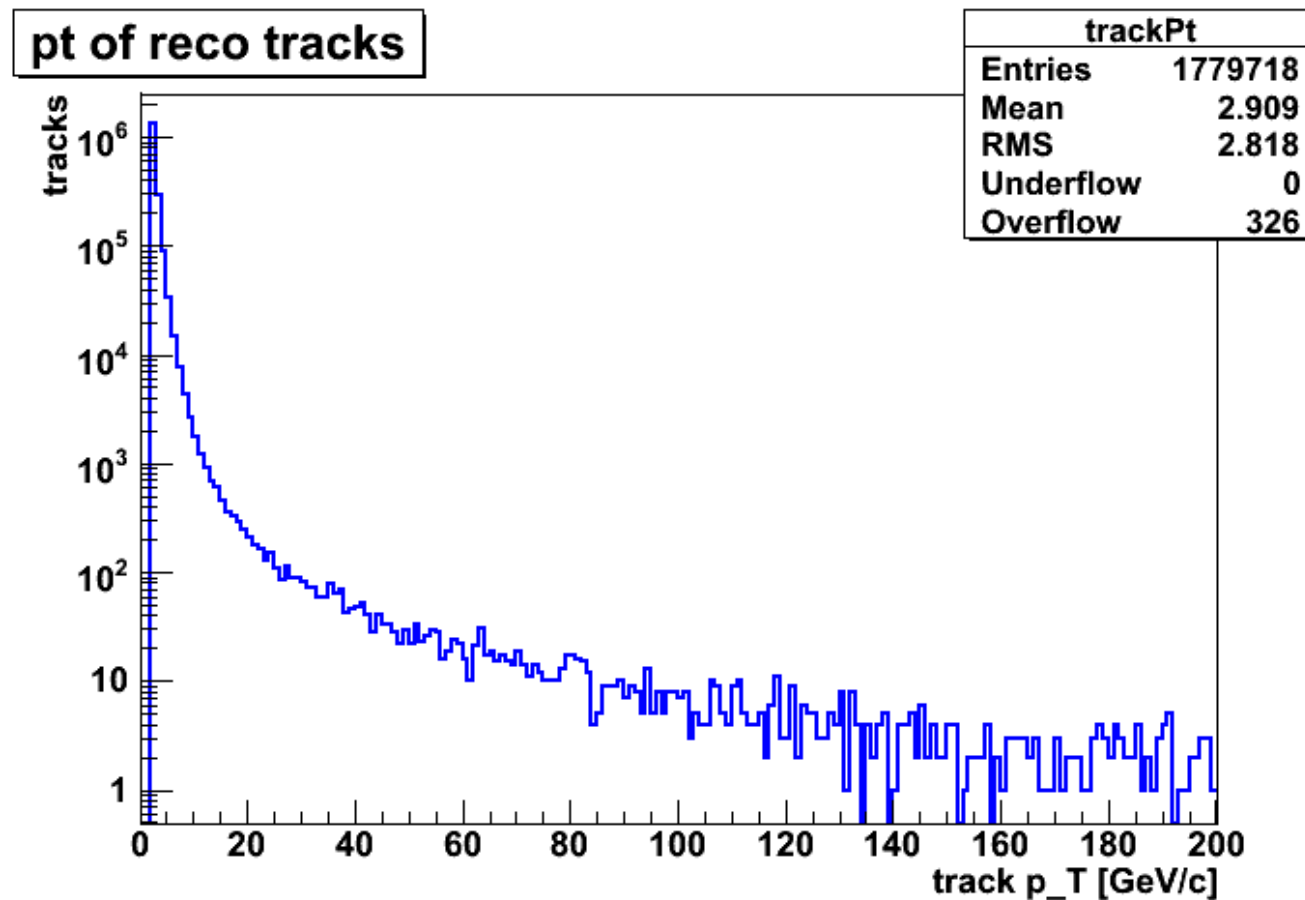
slightly more activity in the barrel
($|\eta| < 1.4$)

phi of reco tracks



flat, good

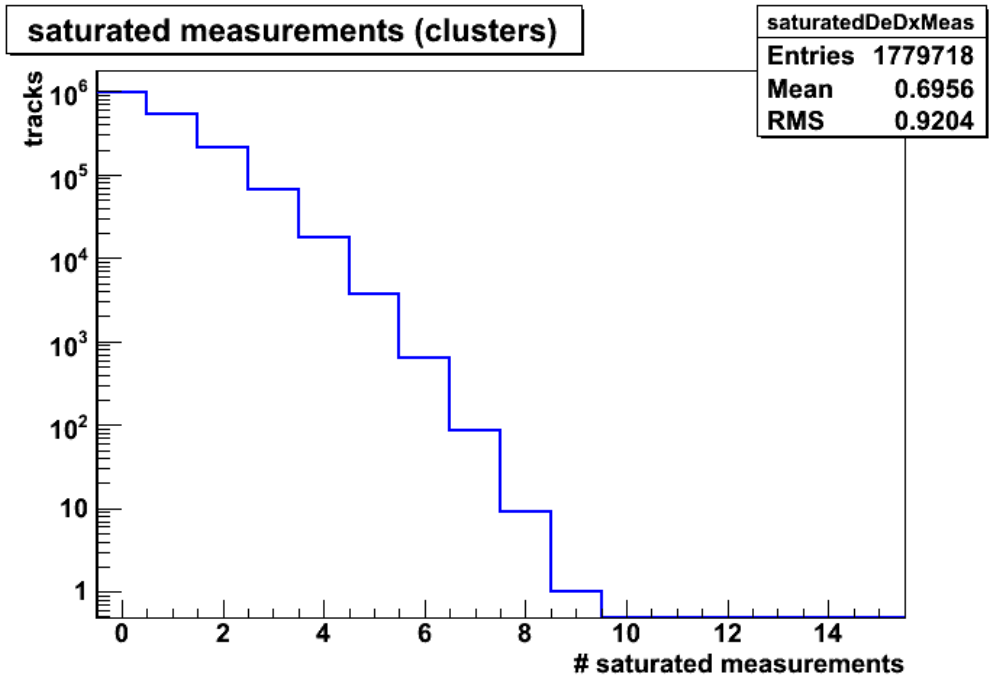
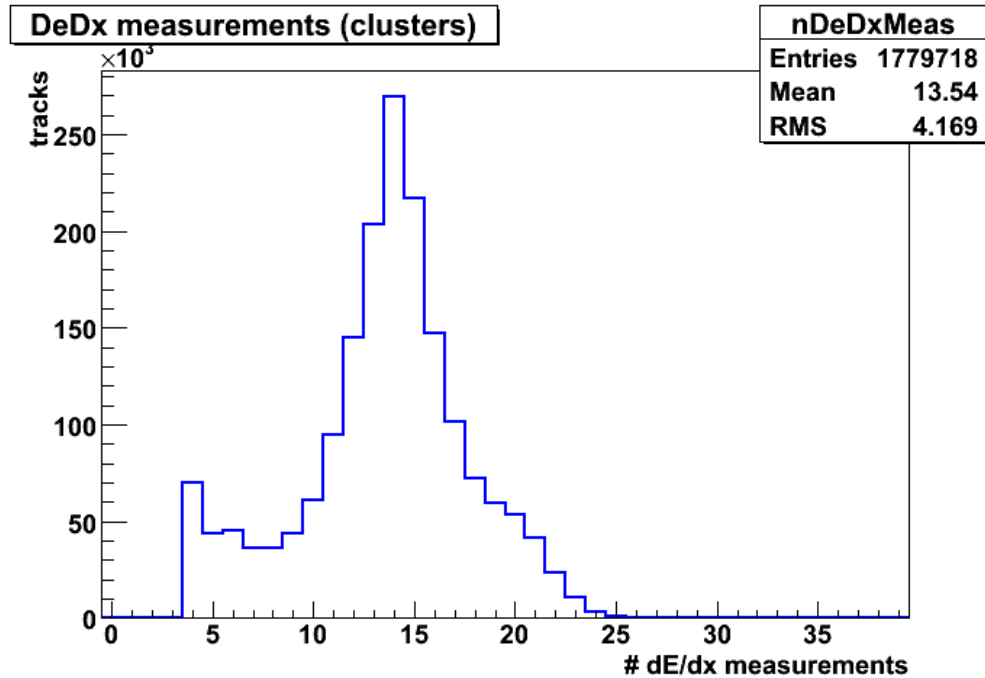
7 TeV Data - Plots



rejected: < 2 GeV/c

DATA – lots of studies to be done!

7 TeV Data - Plots



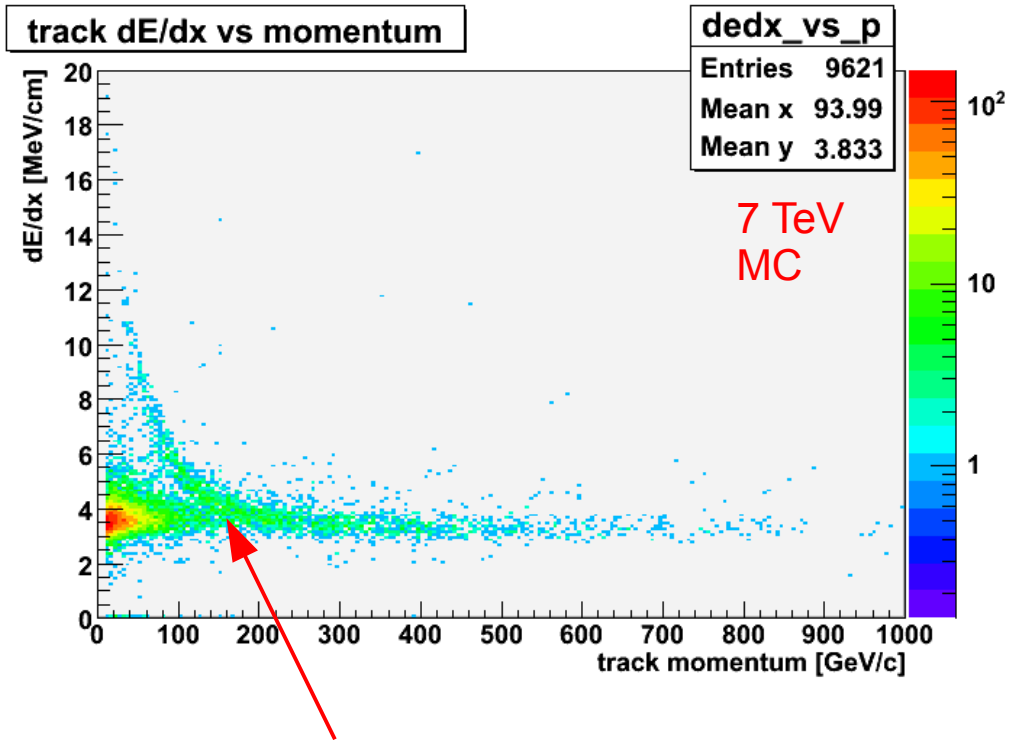
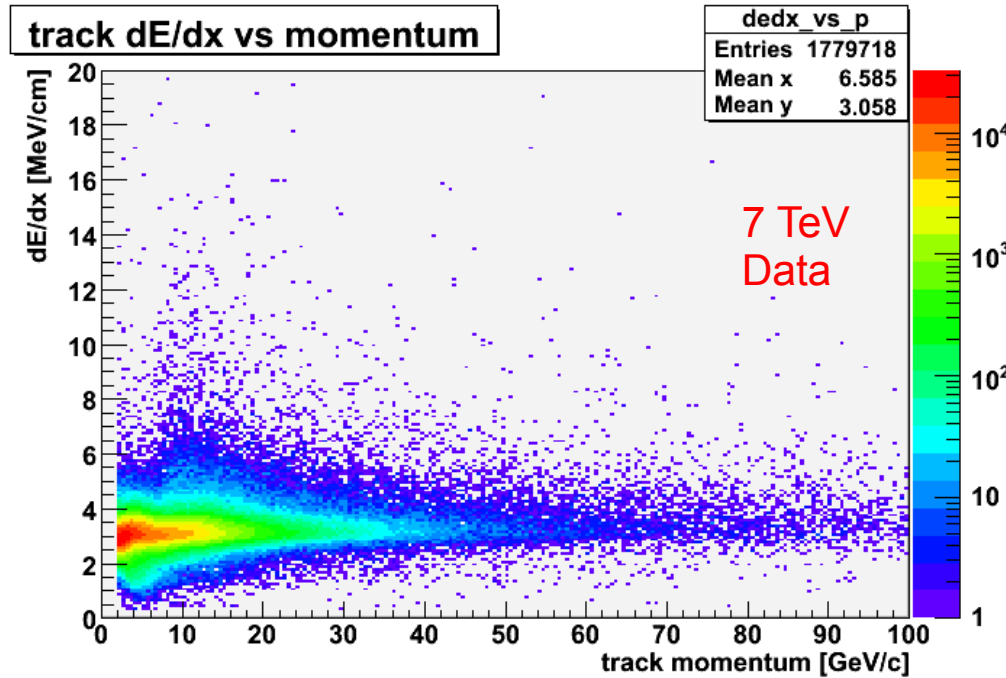
similar to # of *valid hits*, although
Mean is reduced by ~ 3
(no pixel dE/dx measurements used)

rejected: < 4

number of dE/dx measurements (hits)
with *at least* one saturated strip
(> 254 ADC counts)

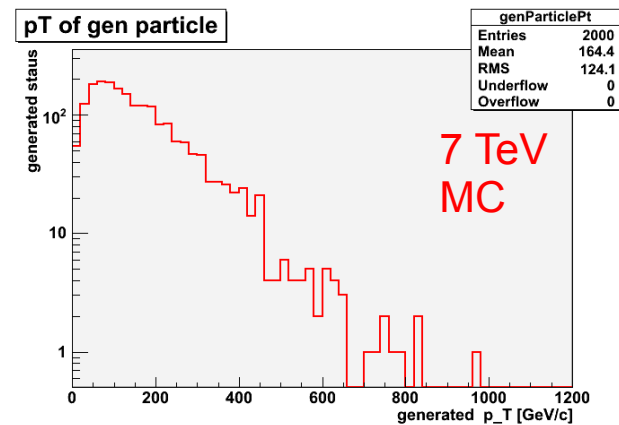
7 TeV Data - Plots

Comparison with GMSB stau MC sample ($m = 100$ GeV)



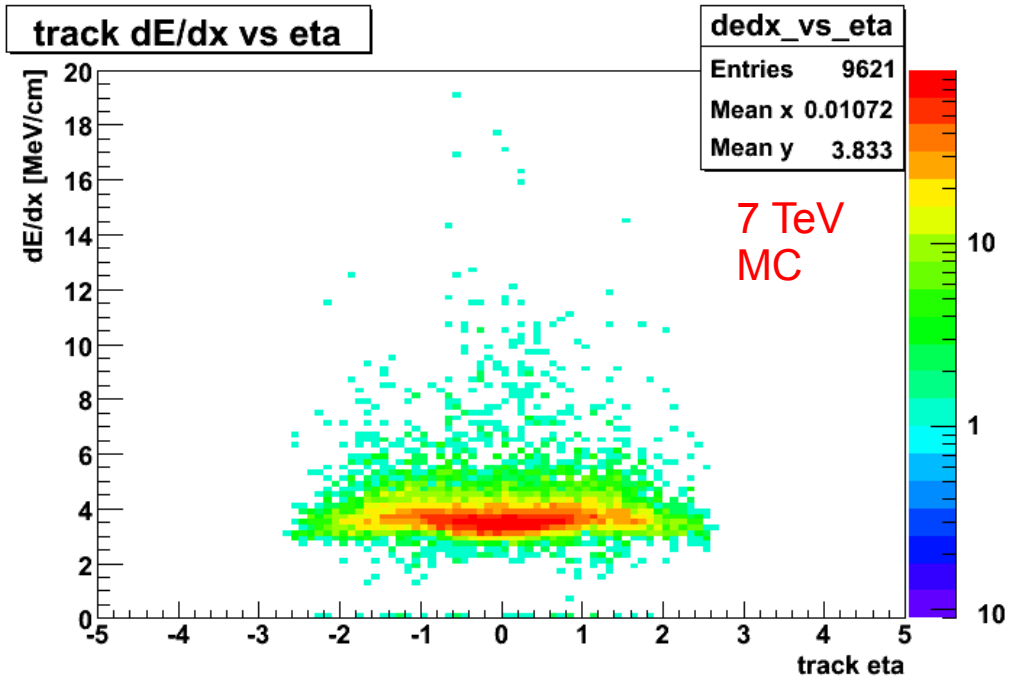
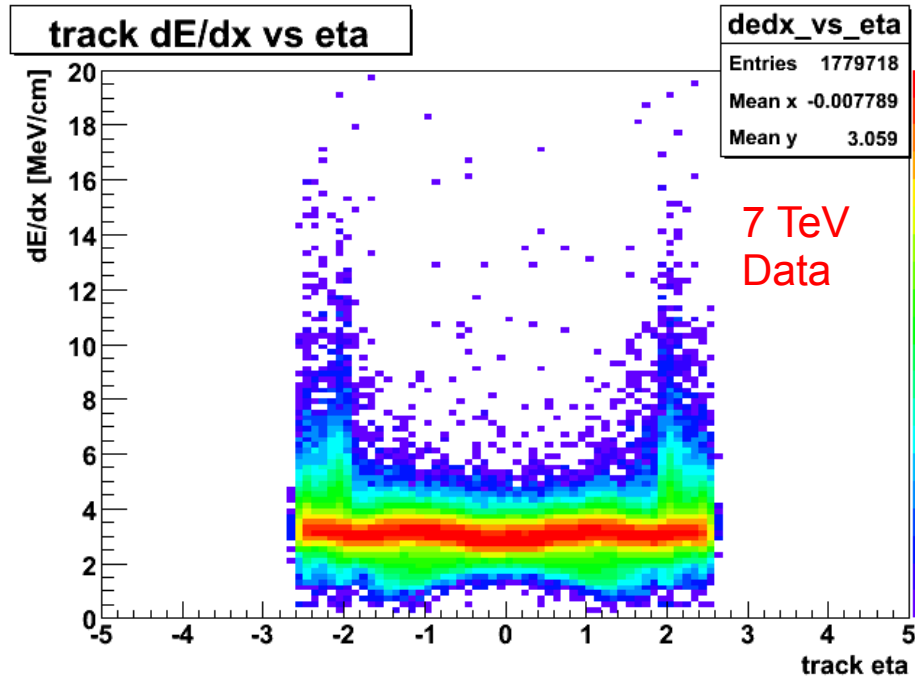
Minimally Ionizing Particles (MIPs) have $dE/dx \sim 3$ MeV/cm;
different momentum scale on the right-hand MC plot!

band branching off at $p \sim 150$ GeV/c
is stau distribution



7 TeV Data - Plots

Comparison with GMSB stau MC sample ($m = 100$ GeV)



- ◆ red band at 3 MeV/cm are MIPs;
- ◆ forward tracks have some higher values;
- ◆ Mean = 3.06

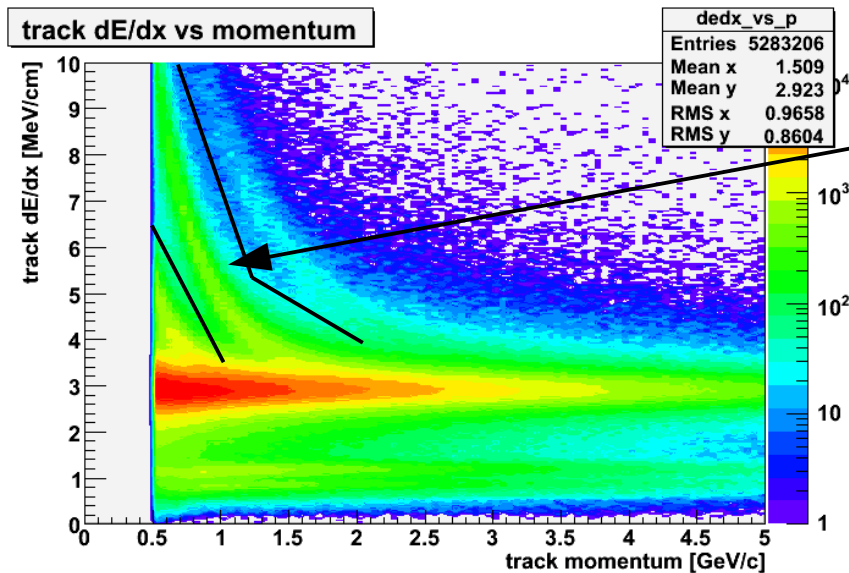
- ◆ 1000 events, 2000 staus, 10 000 tracks;
- ◆ more central distribution due to high transverse momentum spectrum of staus;
- ◆ higher Mean = 3.83

Detecting HSCPs

Measurement of β

- Tracker: estimate dE/dx of tracks $\rightarrow 1/\beta = \text{sqrt}(K \text{ dE/dx})$

K: calibration factor obtained from data
(low-momentum protons)



- Drift Tubes: time-of-flight measurement $\rightarrow 1/\beta = c \Delta x / d(\text{layer}) v(\text{drift}) + 1$

Δx : distance of reconstructed to actual hit position
due to delayed arrival of HSCP at DTs

Phenomenology

Heavy Stable Charged Particles (HSCPs) may emerge from several BSM theories

- GMSB: stau (NLSP)
- Split SUSY: long-lived gluino \rightarrow hadronizes to form R-hadrons
- Universal Extra Dimensions: Kaluza-Klein tau
- and a few others...

HSCP characteristics

- lepton-like (stau, KK-tau) or hadron-like (R-hadrons)
- cross entire CMS detector before decaying
- mass of order > 100 GeV
- highly ionizing, (very) little bremsstrahlung
- high momentum, often slow ($v < c$) due to high mass ($p = \beta \gamma c M$)
- lepton-like HSCPs behave like muons
- R-hadrons may interact hadronically (via light partons), switching charge but “surviving”