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

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Introduction

Analyzing 7 TeV Data with CRAB

- *crab_2_7_2* has arrived yesterday
- start with a clean server shell, then

need this UI –
ini glite won't work for me

```
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/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

7 TeV Data

Software, Samples, Selection

- CMSSW_3_5_6
- DATA: /MinimumBias/Commissioning10-PromptReco-v8/RECO, GR10_P_V4
- Runs: 133336 - 133512, 2111 'good' lumi sections
- 'monster event' filter used, trigger bits: 0 & (40 or 41) & NOT (36 – 39)
- 110 out of 125 CRAB job used, others not done yet

  → *4.0 M events*
- **at least one track**: track p_T > 2 GeV/c, at least 10 dE/dx measurements/track, |dz| < 10 cm

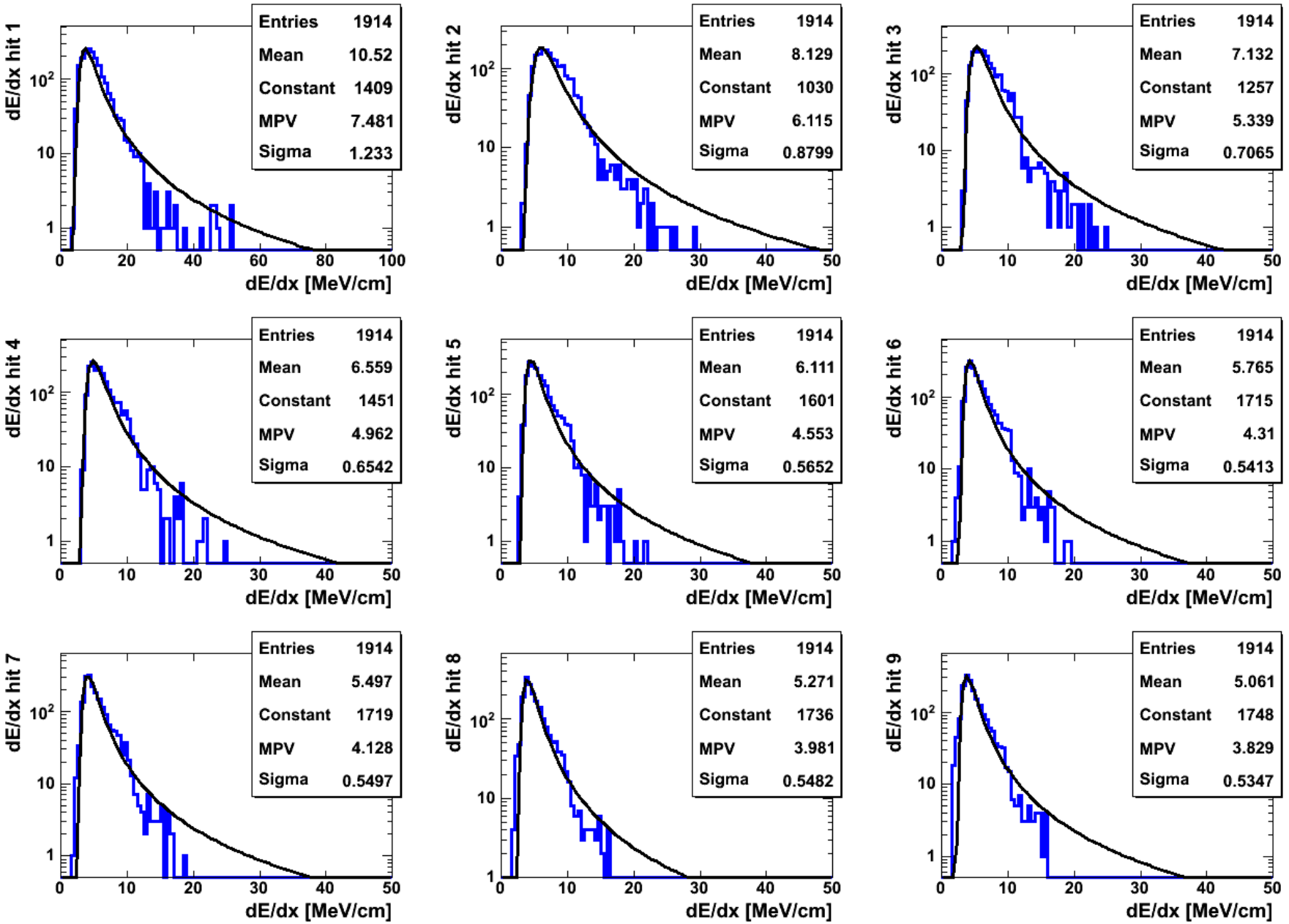
  → ***1.22 M tracks***
- MinBias MC: /MinBias/Spring10-START3X_V26A_356ReReco-v1/GEN-SIM-RECO

  1 M events → 520 k events→ ***450 k tracks***
- signal MC: /EXO_HSCP_STAU308_356_START3X_V26_GEN_SIM_RECO

  1000 events → ***1914 tracks***
- caveat: no particle gain calibration for strip modules in global tag (to be included in next reprocessing with 3_5_8)

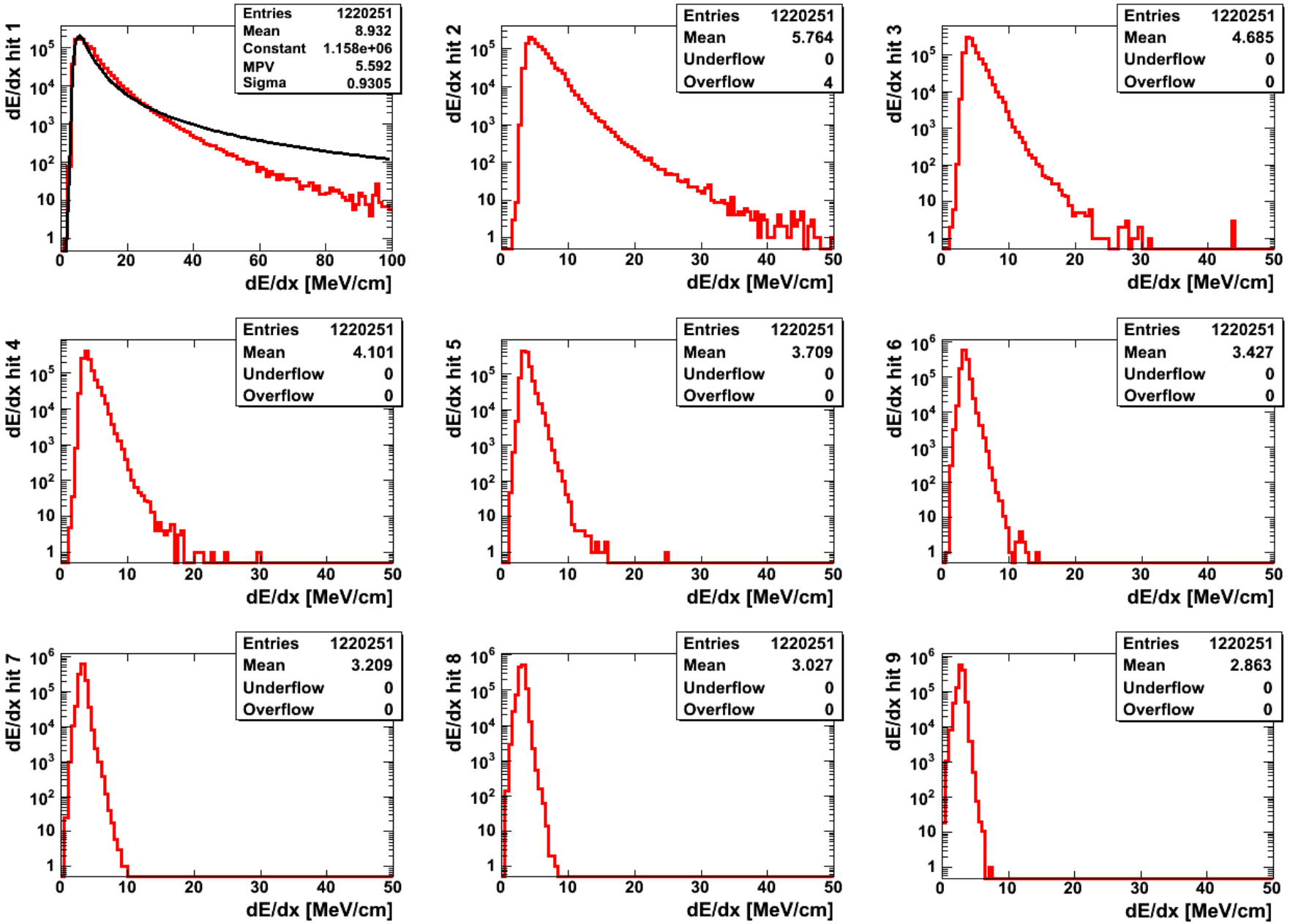
Hit dE/dx Values - MPVs

HSCP stau MC (m = 308 GeV): truth matched (dR < 0.05) ***stau tracks***



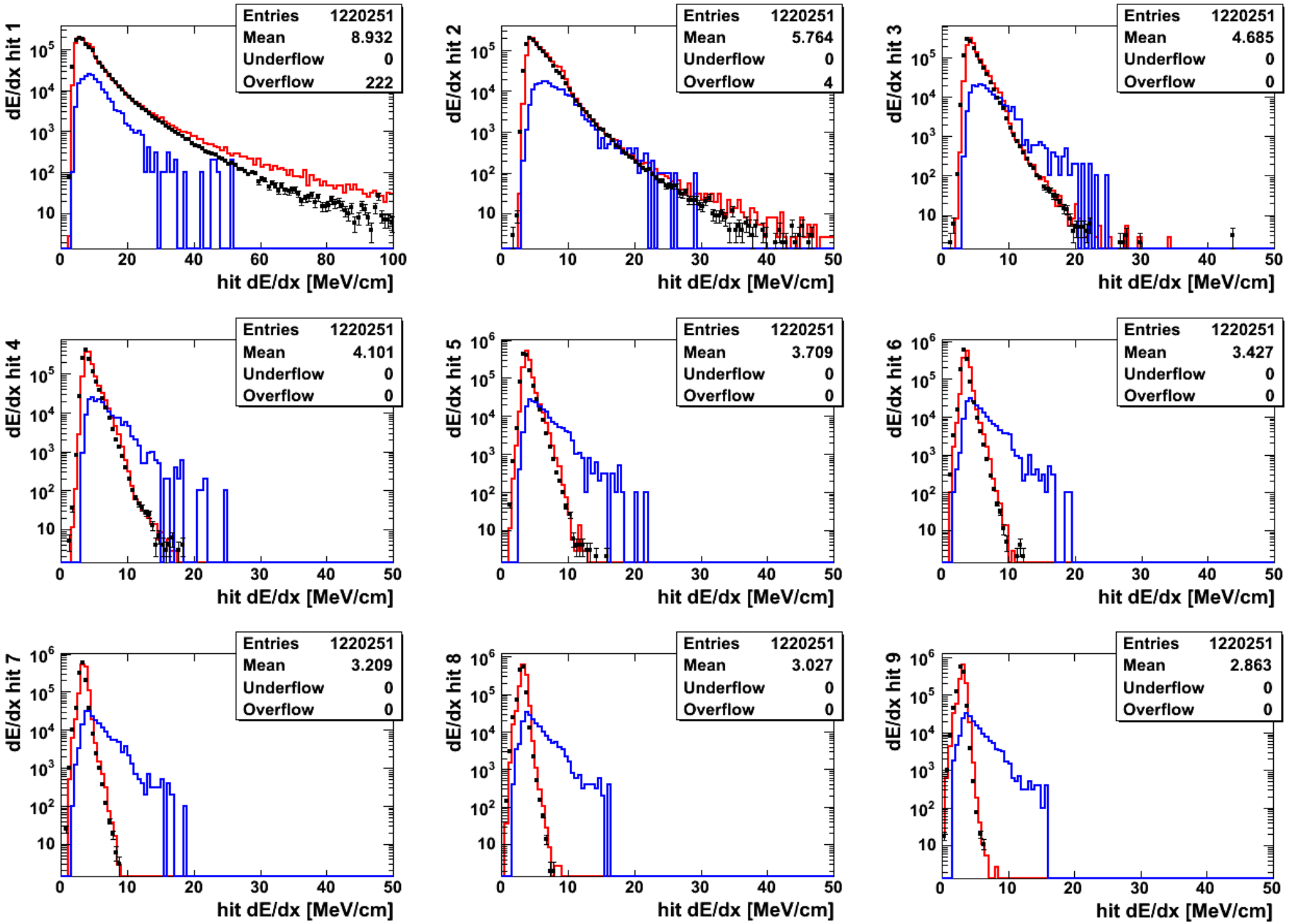
Hit dE/dx Values - MPVs

Data - Landau tails recede quickly



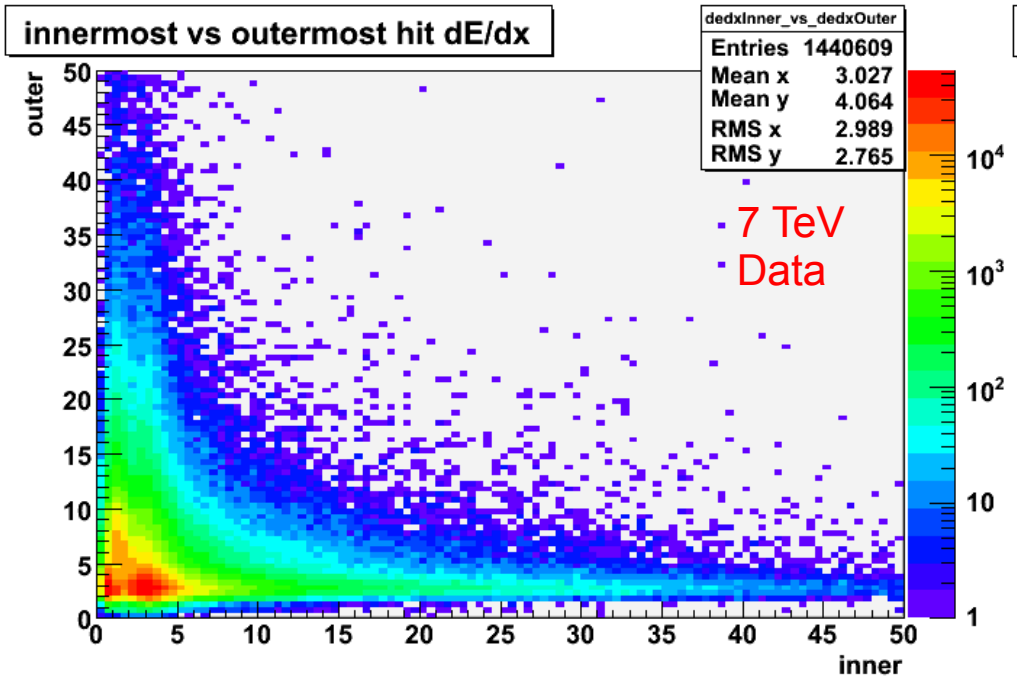
Hit dE/dx Values

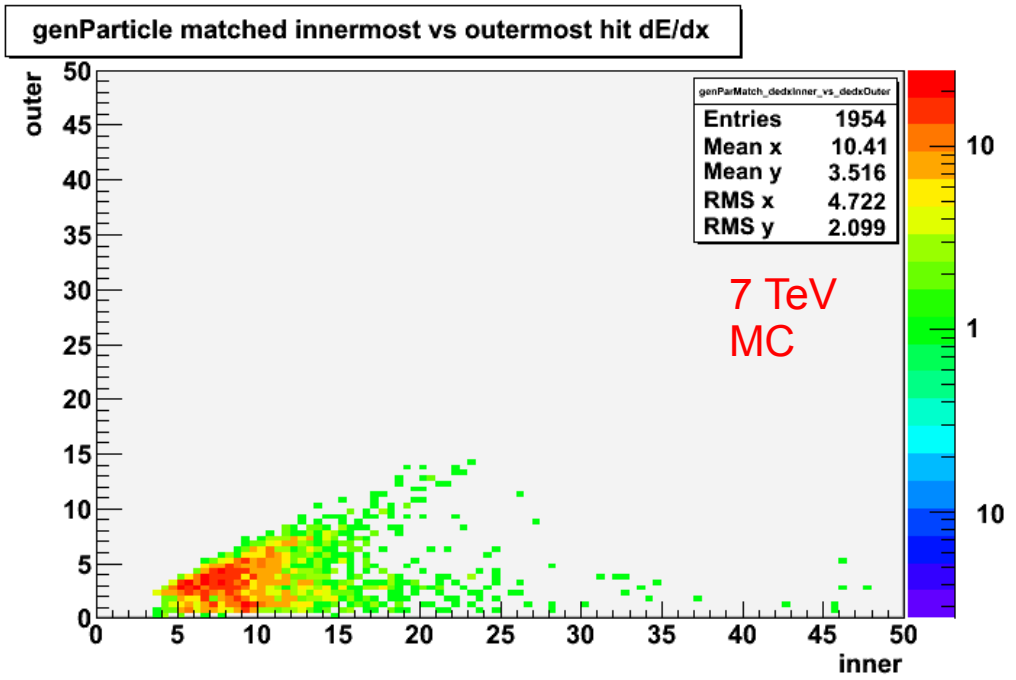
Data, **MinBias MC** (normalized to data), **signal MC** (factor 100)



7 TeV Data - Plots

Comparison with GMSB stau MC sample (m = 308 GeV)





- only 4 dE/dx hits/track required!
- many high dE/dx hits with low 'partner' hits, even outside in

→ plot hit dE/dx vs module radius

→ select longer tracks (e.g. > 9 hits)

- only 4 dE/dx hits/track required!
- NO outer hit values higher than corresponding inner hit!

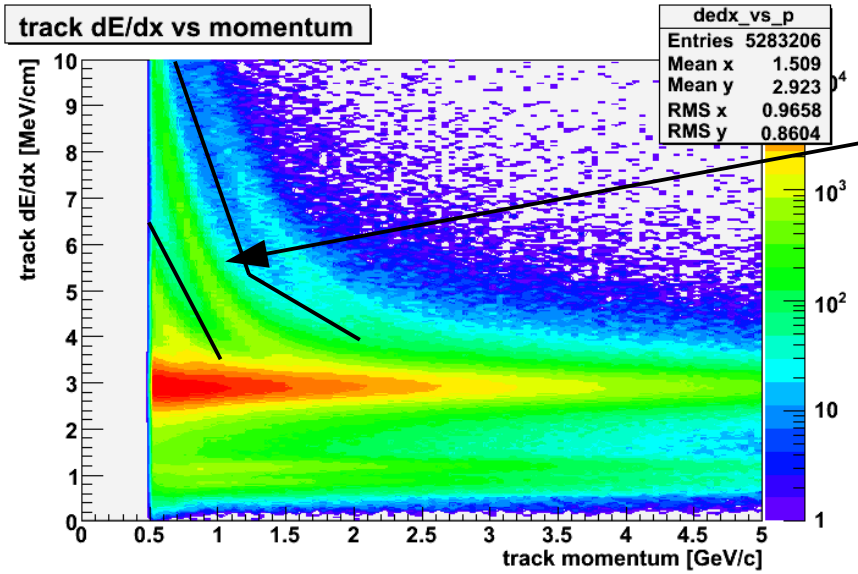
Detecting HSCPs

Measurement of β

- Tracker: estimate dE/dx of tracks → **1/β = sqrt(K dE/dx)**

K: calibration factor obtained from data

(low-momentum protons)



- Drift Tubes: time-of-flight measurement → **1/β = c Δx / d(layer) v(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 -> 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 ($\mathbf{p = \beta\gamma c\, M}$)
- lepton-like HSCPs behave like muons
- R-hadrons may interact hadronically (via light partons), switching charge but “surviving”