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

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Data

Software, Samples, Selection

- CMSSW_3_6_1
- Collision data:

  /MinimumBias/Commissioning10-May6thPDSkim_GOODCOLL-v1/RAW-RECO

  → L ~ 1/nb
- Signal MC:

  /EXO_HSCP_***STAU100***_356_START3X_V26_GEN_SIM_RECO

  - Gauge Mediated Susy Breaking: Drell-Yan stau pair-production (m_{stau} = 100 GeV, σ = 1.3 pb)

  - 1000 events → 2000 stau tracks (ΔR-matched)
- Cuts*:*

  - track p > 5 GeV/c

  - > 9 dE/dx measurements per track,

  - |dz| < 10 cm, |dxy| < 1 cm,

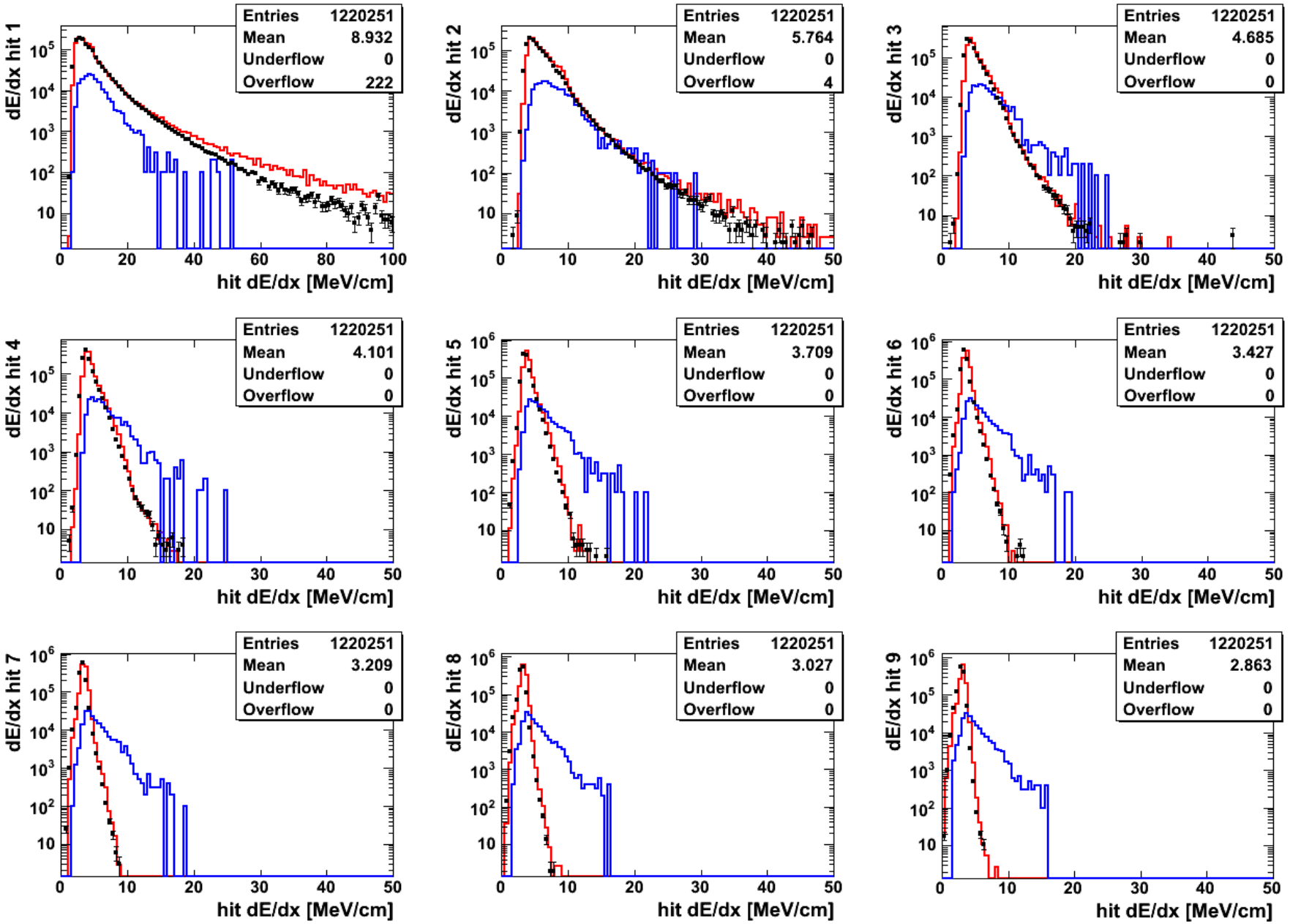
  - p_T resolution < 0.2
- Selected Tracks:

  - Collisions 7.24 M,

  - stau100: 1833

Hit dE/dx Values

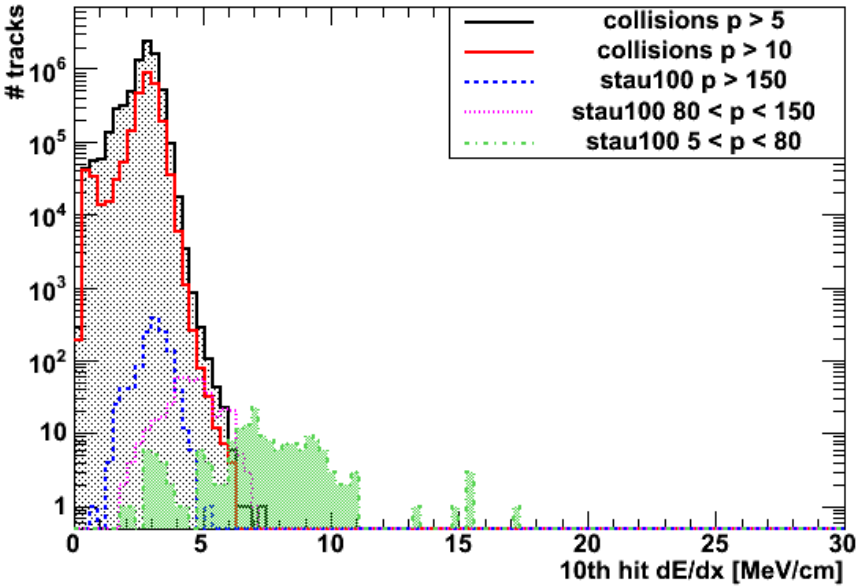
Data, **MinBias MC** (normalized to data), **signal MC** (unnormalized – *WAY too high*)

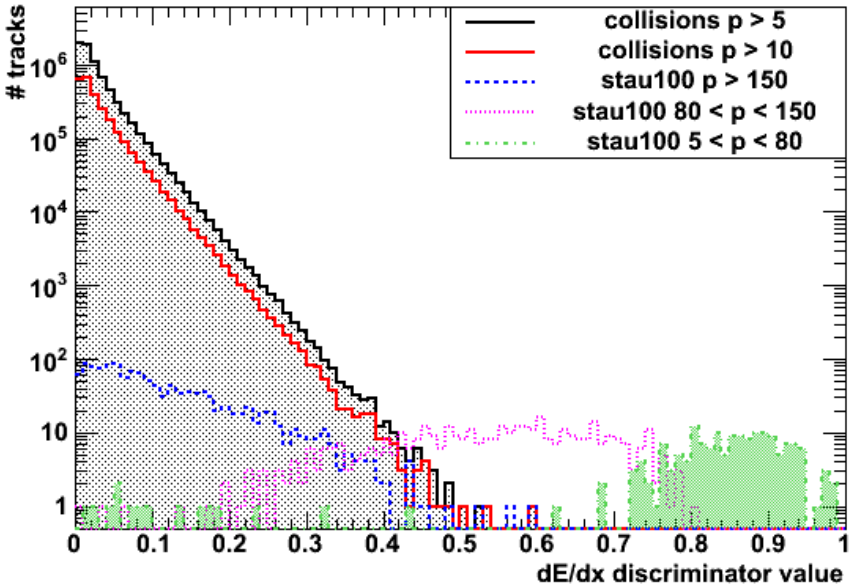


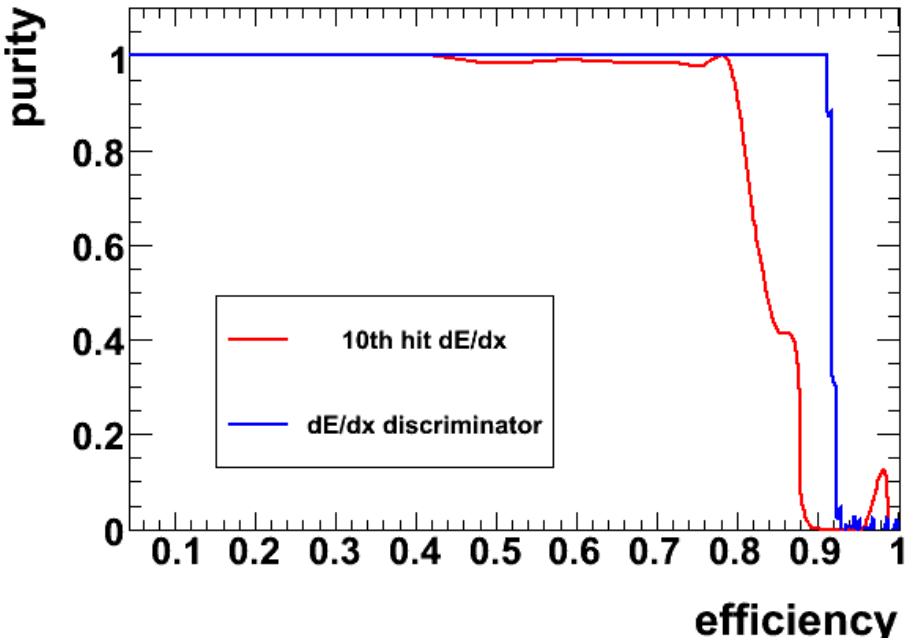
shown last meeting - outdated!

Signal-to-Data Separation

10th hit dE/dx vs. track dE/dx discriminator







- Signal MC is unnormalized for visibility!
- Stau tracks (ΔR-matched) split by momentum
- Lower momentum → higher ionization
- dE/dx Discriminator:

uses MIP template (muons) to determine probability that a given track ionizes less than a MIP

- Discriminator performs better, further investigation pending

Outlook

- Some further investigation into Discriminator vs. Nth dE/dx hit to be done

- Analysis: Which way to proceed?
  - inclusive track search (CMS approach)
  - SUSY approach: require jets + MET, then look for tracks
  - use calorimeter information
    (HSCPs deposit more than muons but less than e, gamma, pions, etc.)
  - start with muons, then look for high dE/dx tracks (CMS approach)
  - ...

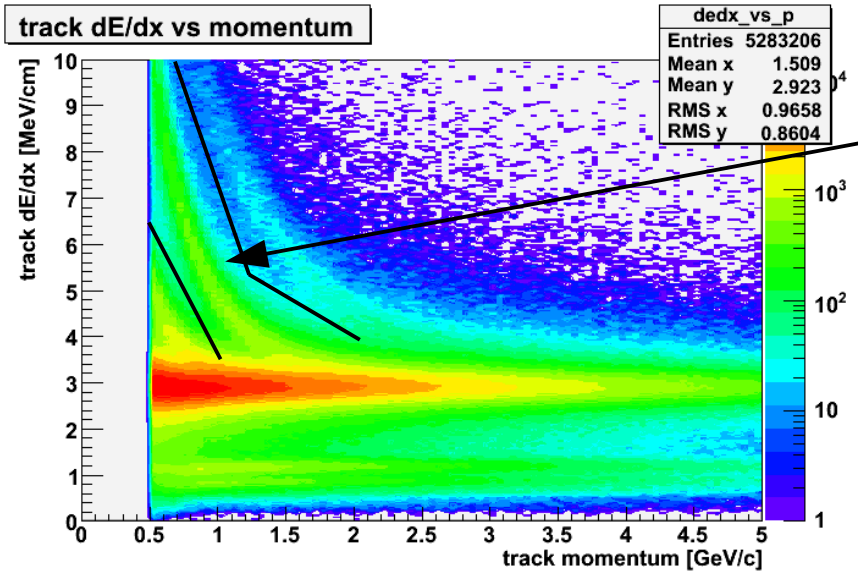
Detecting HSCPs

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”