Electron Identification without the Pixel Detector

First Progress Report

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Outline for this talk

- Project outline and goals (part of the project was to define it)
- Pixel algorithm and why $e^{\pm}$-finding is harder without a pixel detector
- The importance of realistic Monte Carlo
- Implementing a placeholder in CMSSW
- Next steps

Project Outline and Goals (we welcome corrections)

Goal: identify electrons (HLT and offline) and reject background by matching ECAL SuperClusters to Si-strip tracker hits

A well-studied algorithm exists which matches SuperClusters to pixel hits

Early data will be taken without a complete pixel detector, so our algorithm is a fallback

Strictly Level 2.5: input is reconstructed SC and tracker hits, output is

- a list of electron candidate objects *for HLT filter to save event if non-empty*
- track parameters *to seed a track in Level 3*
- possibly other quality objects (list of hits, not for seeding)

Project Goals (continued)

fast: $\lesssim$100 ms per SuperCluster on a 1 GHz PC
scale as a low power of background hits: $\mathcal{O}(\text{hits}^{\,p})$ where $p \lesssim 2$

robust: electron-finding efficiency independent of tracker misalignments of $\sim$500 μm,
independent of tracker-ECAL misalignments of $\sim$1 mm, and
independent of number of background hits
($\rightarrow$ this will make electron efficiency easier to understand)

flexible: provide parameters to tune efficiency versus rejection, and/or versus speed

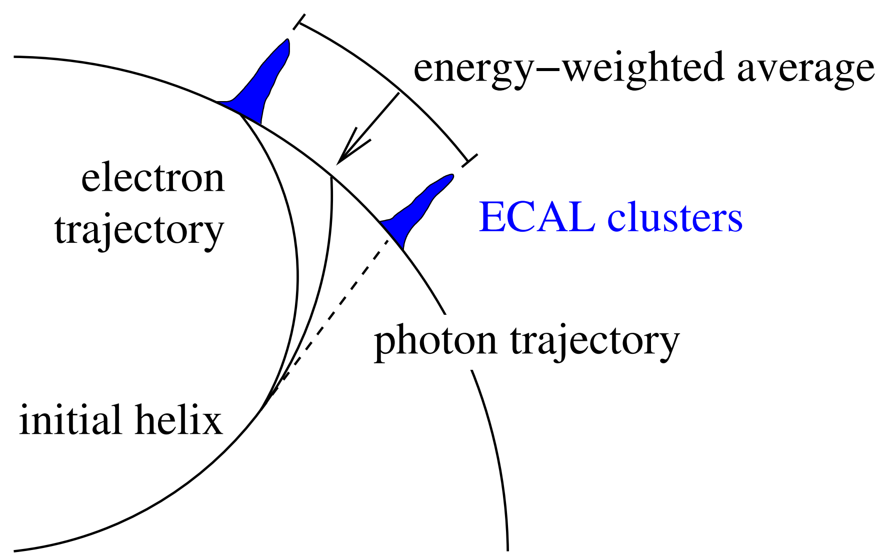
Pixel Algorithm

1. Project helix from ECAL position to origin (curvature from SC energy) for each of two charge hypotheses
2. Wide window in first pixel layer; identified hit narrows search window on subsequent layers

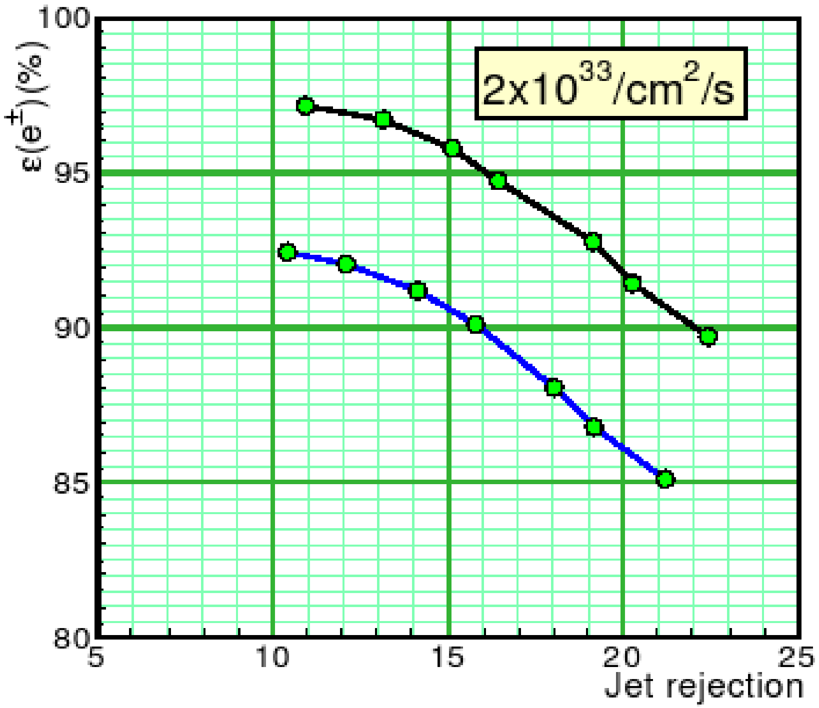
Electrons radiate in tracker material and often intersect ECAL far from initial helix. *Why does a helix projection work?*

Theorem: if all bremsstrahlung photons are included in a SC, energy-weighted position is on the initial helix

Lesson: inner hits point more reliably to SC position



Pixel algorithm performance
(something to aim for without being too expectant)



Pixel's advantage: Z precision
ΔZ cut window $= 1$ mm

Tracker has 4 stereo layers with 1 mm resolution

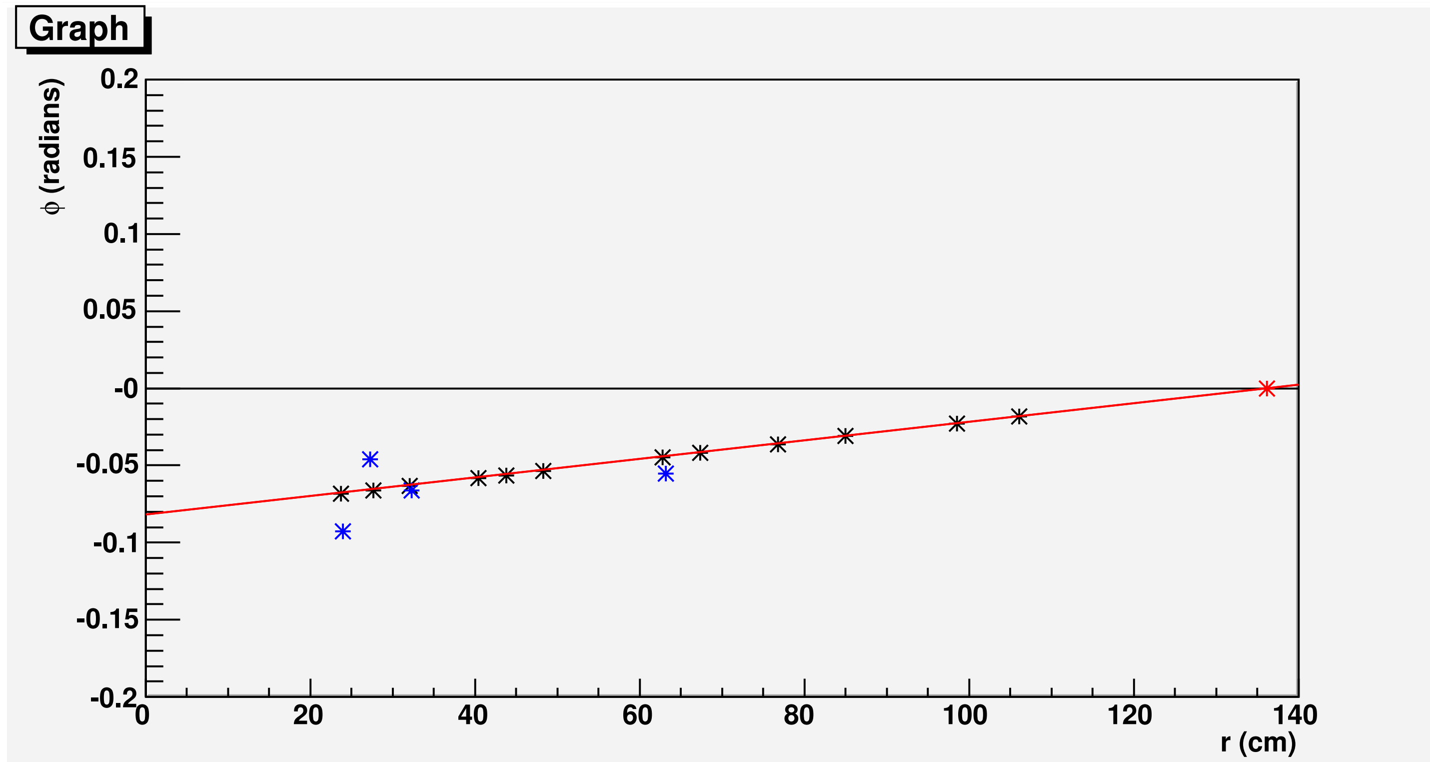
but most layers have only 10–20 cm segmentation in Z

Try to regain lost signal/noise by looking for more than 3 hits

(We'd like to make the equivalent plot, but need the same MC samples)

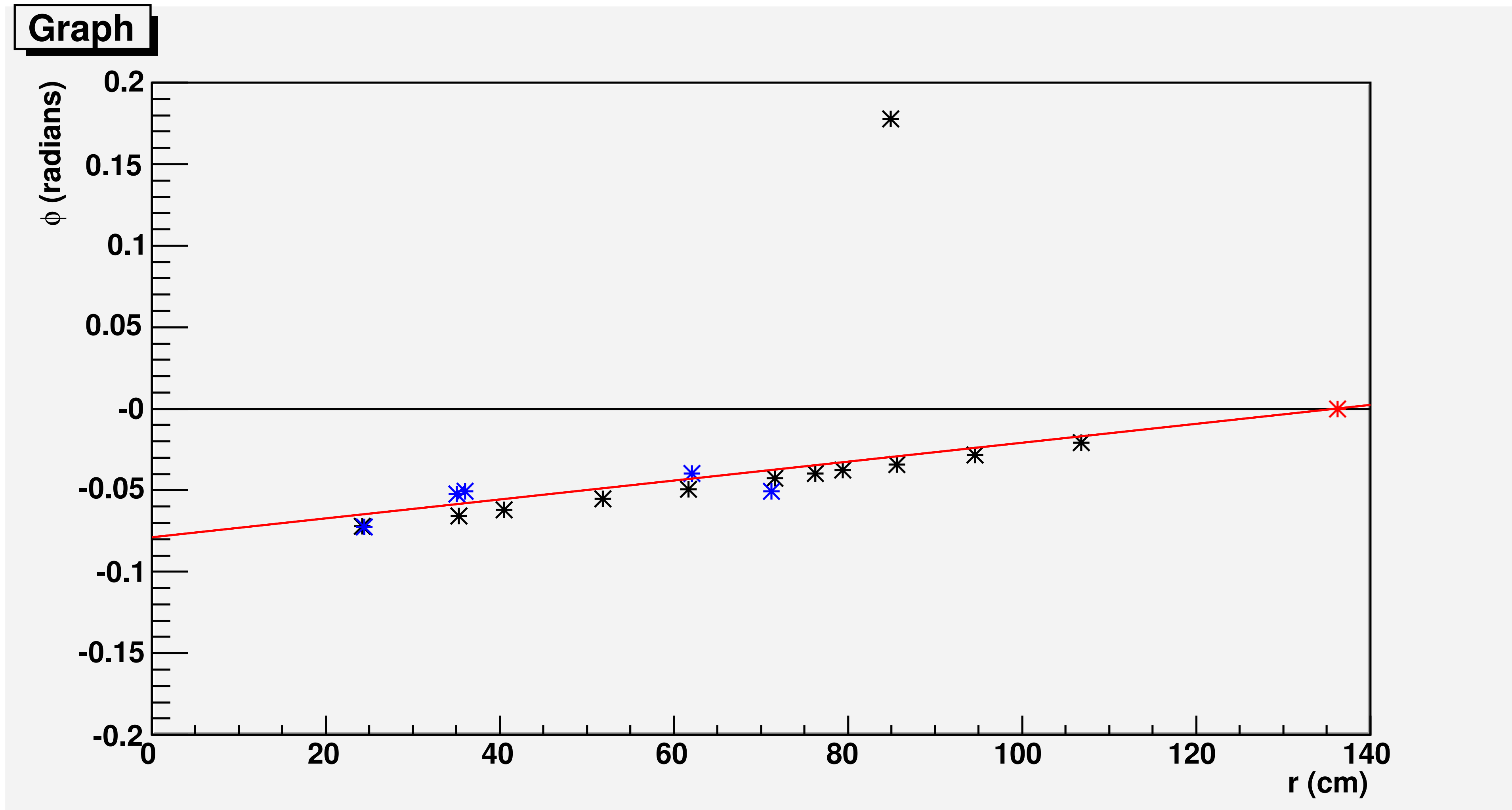
“Event Displays”

vertical axis is ϕ position of each hit with SuperCluster’s ϕ as zero
horizontal axis is cylindrical radius of each hit

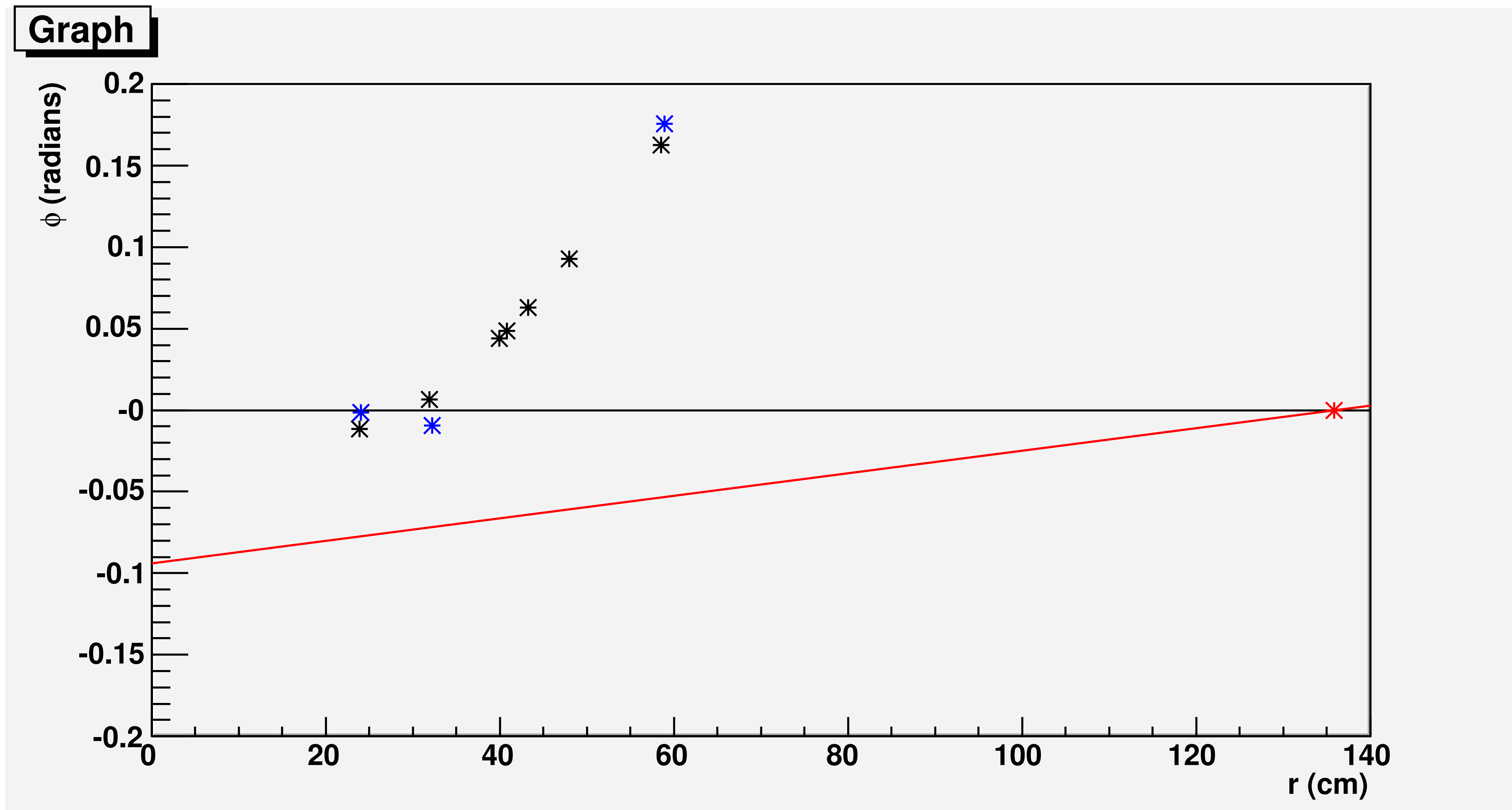


helical track projects an arcsin curve, but even at 10 GeV, this is linear (helix is approximated by a parabola)

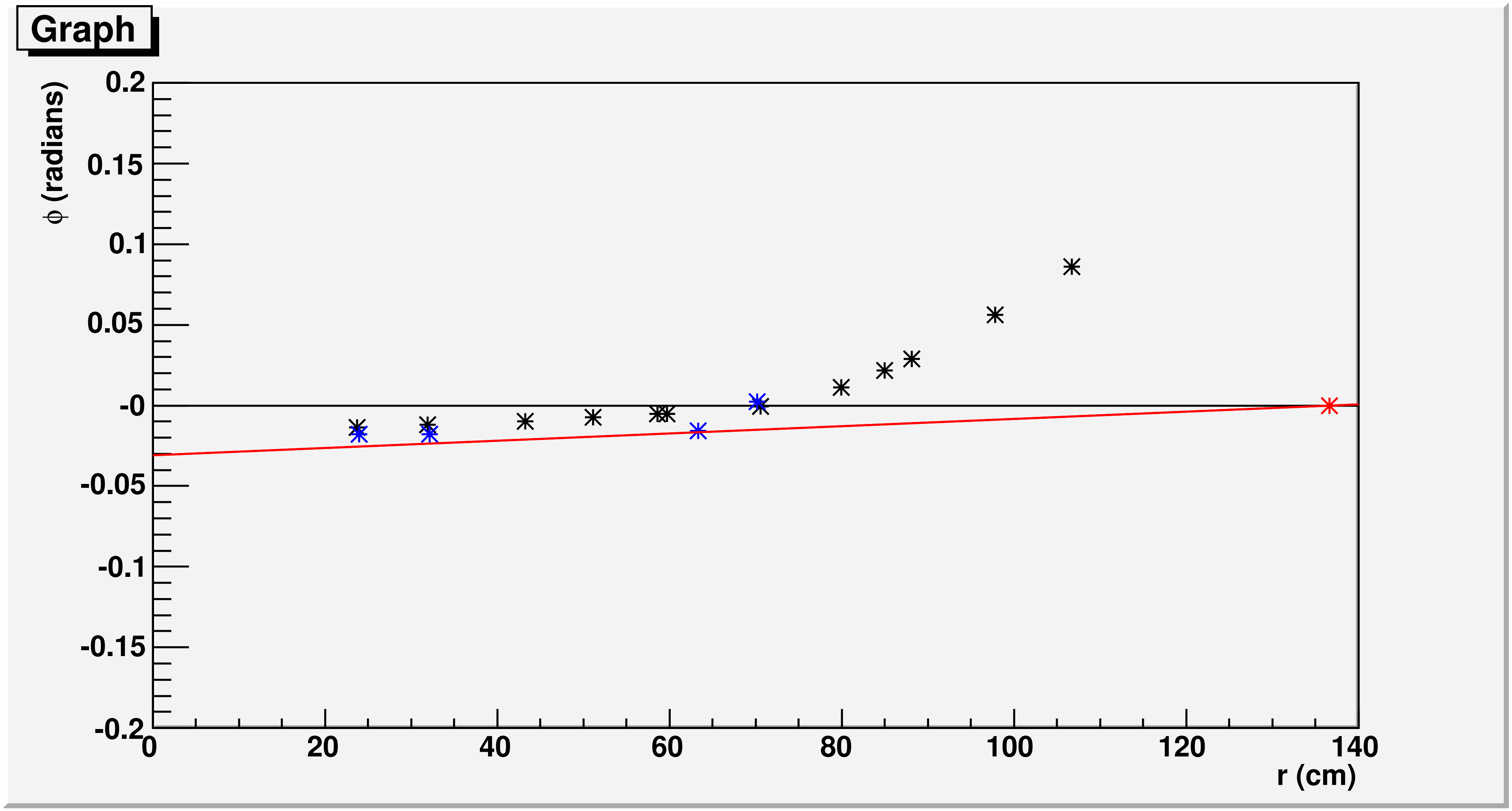
A typical electron



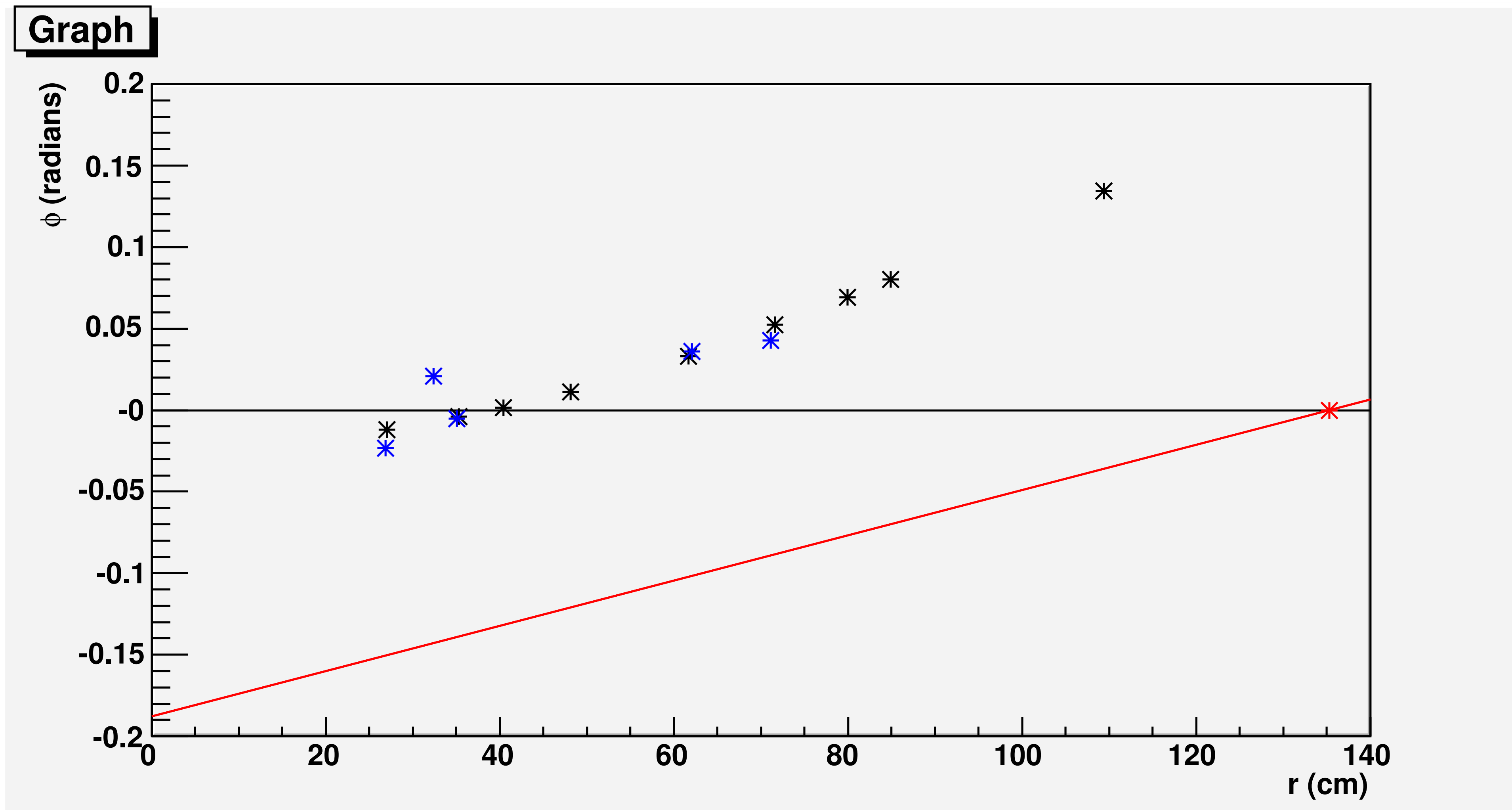
Electron with early scatter or bremsstrahlung (*not* in pixel material!)



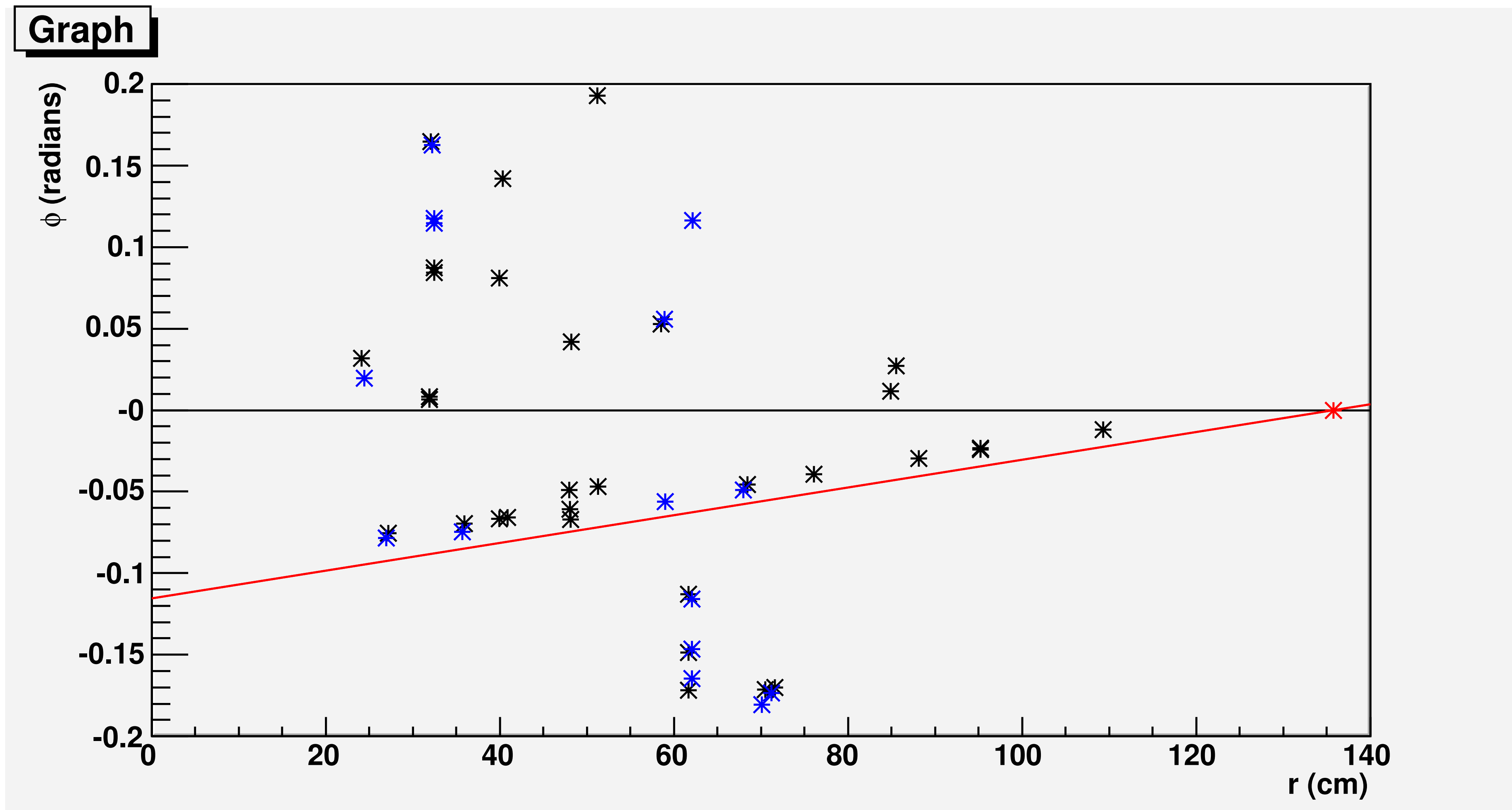
Electron with scatter in strip tracker



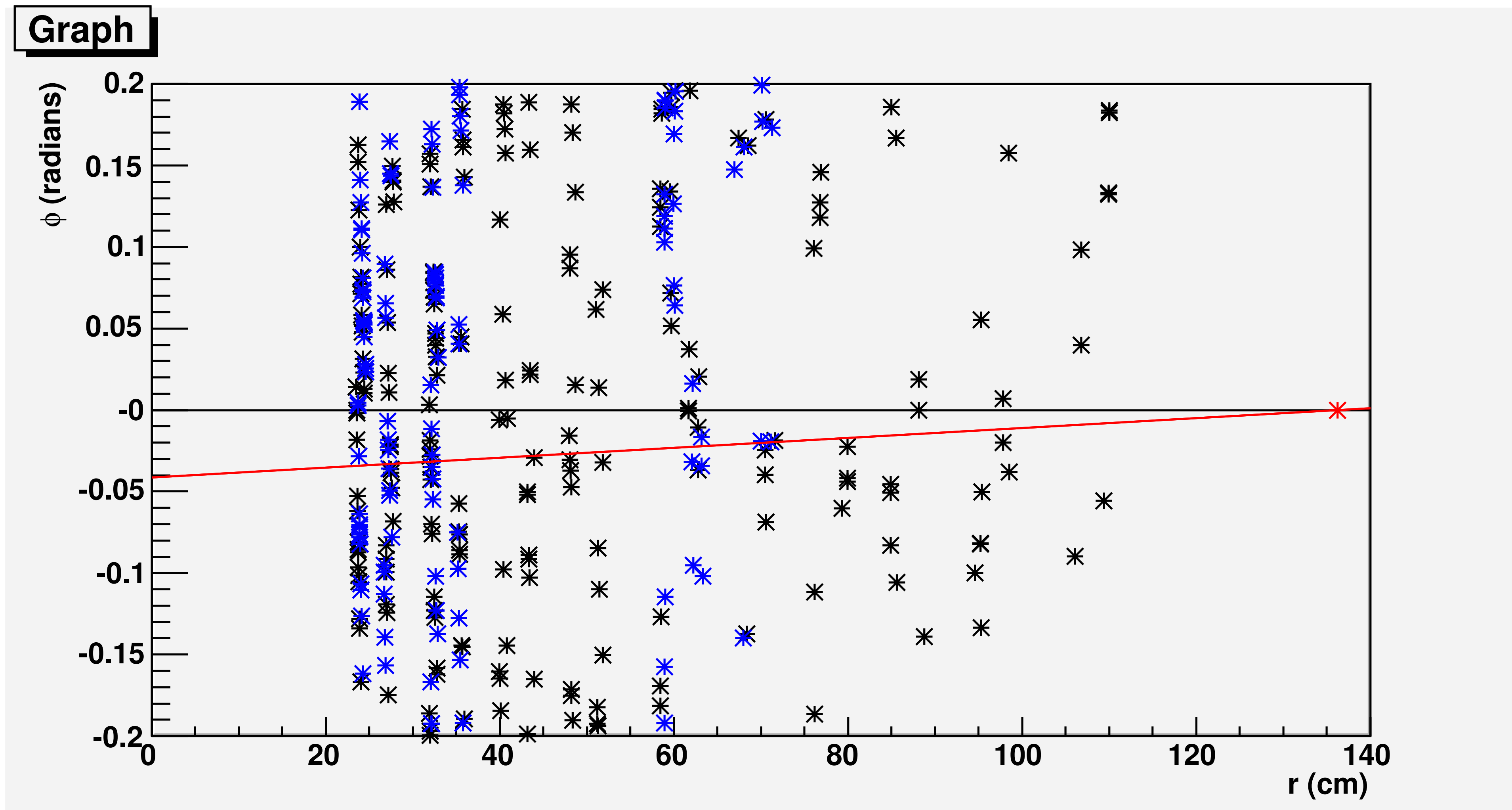
Electron with wrong SuperCluster position (lost a photon?)



A typical electron superimposed on minbias (to simulate underlying event)

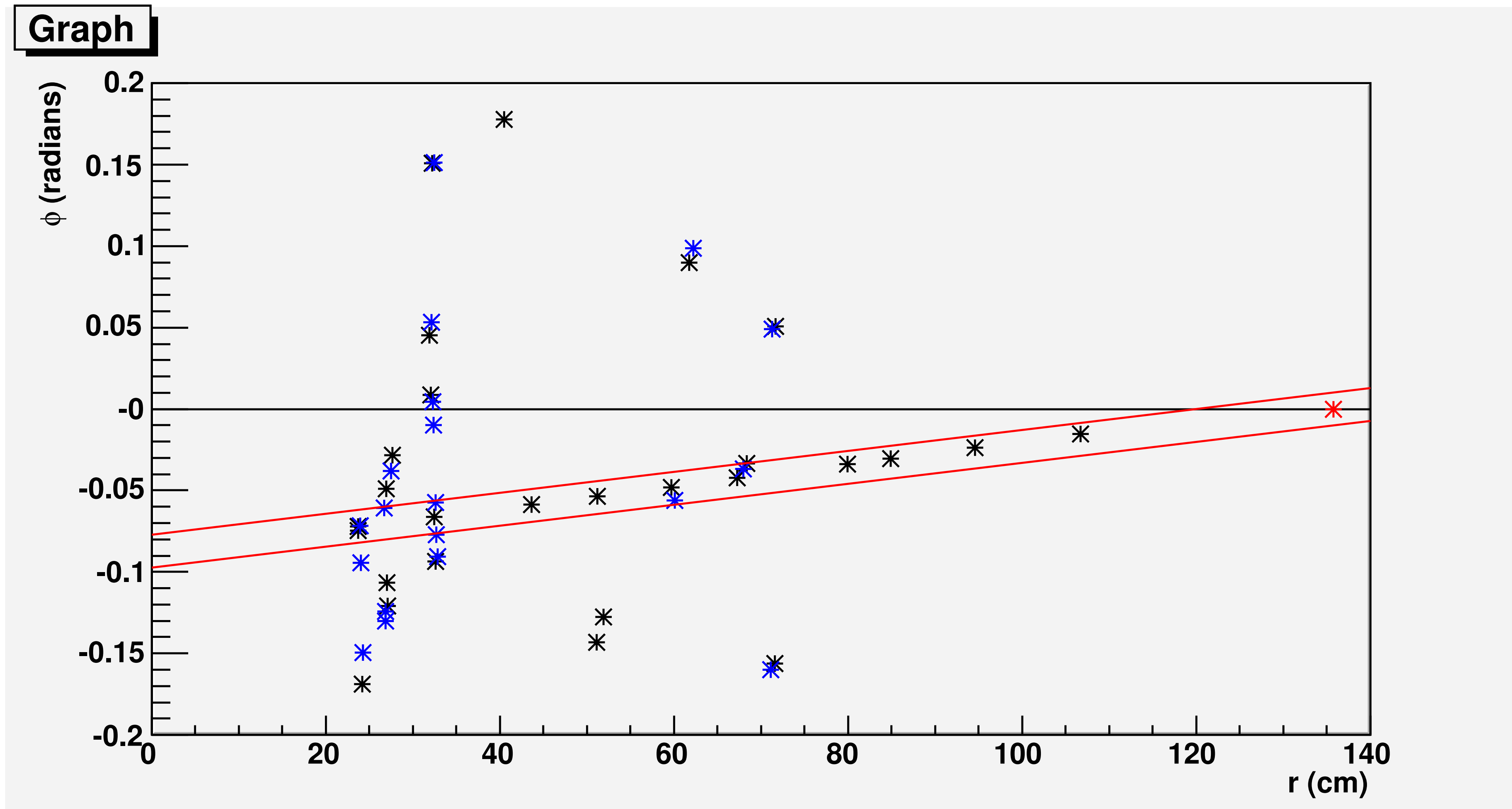


Background: minbias event with a 17 GeV SuperCluster

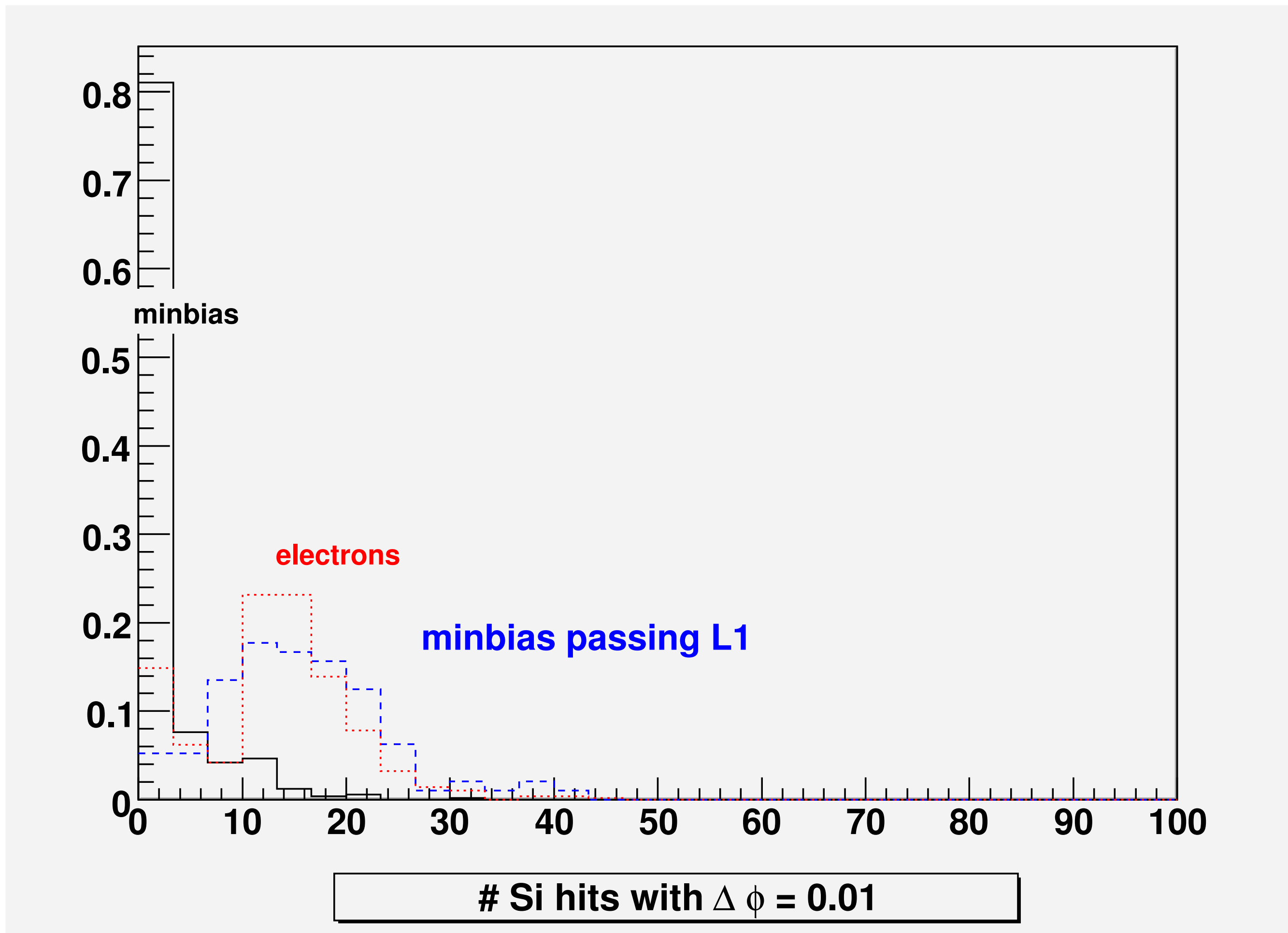


Here's a simple algorithm:

Define a 10 mrad $\Delta\phi$ band around hypothesis, count hits within that band

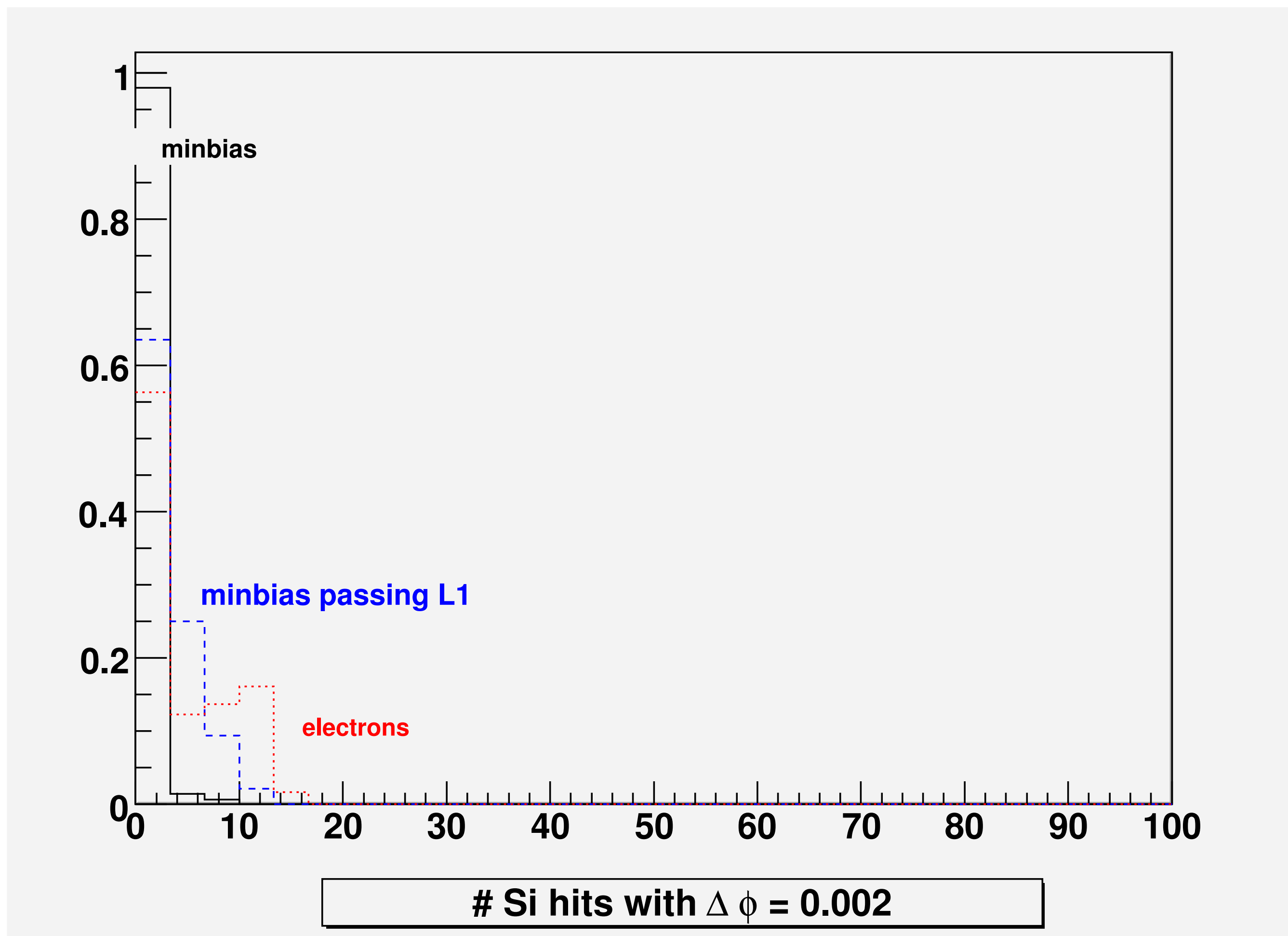


Where to set minimum number of hits cut?



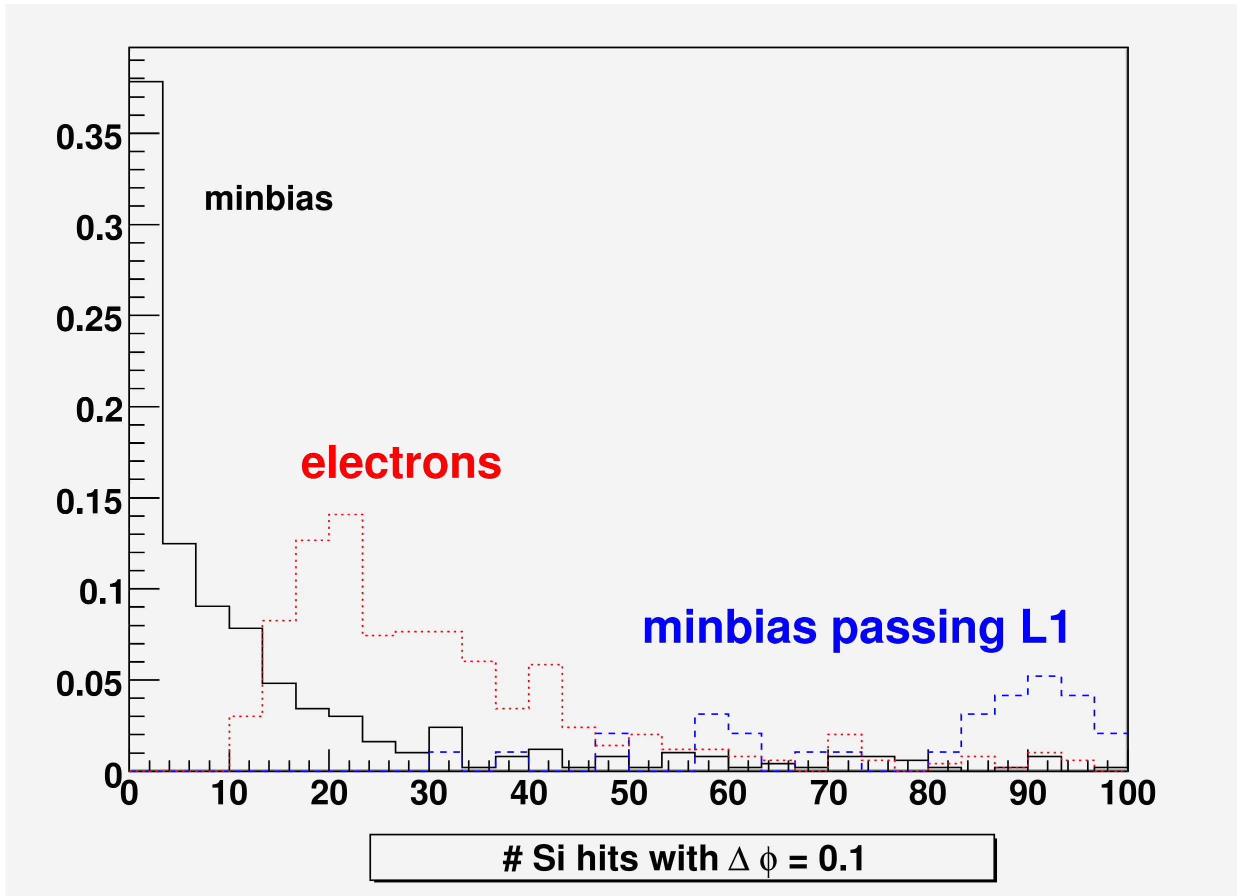
minbias passing L1 ($\geq$ 17 GeV SC) is staring into a jet for most events

Narrow $\Delta\phi$ to 2 mrad?



Not narrow enough to distinguish electrons from background, and too narrow for robustness goals

Widen $\Delta\phi$ to 100 mrad and cut on *maximum* number of hits?



That would be a track isolation cut, not track-cluster matching!
Can we afford to isolate electons? Need to see physics electrons.

MC studies drive algorithm development

Nevertheless, we will implement a placeholder in CMSSW.

Proposal:

- add `SiStripElectronCandidate` to `EgammaCandidates`

  as a subclass of `ElectronCandidate`

  (sibling of `PixelElectronCandidate`?)

- add `SiStripElectronProducer` to `RecoEcal`

- add `ElectronCandidateAnalyzer` to `RecoEcal`

Algorithm will be trivial (no background rejection) until we get more information from physics studies

Next steps:

- Check approved subclass, producer, and analyzer into CVS (today)
- Obtain realistic Monte Carlo

  signal: physics electrons (how often do they overlap jets?)

  underlying event and multiple interactions at generator level

  (how often do U.L. and M.I. interfere with stereo matching?)

  remove pixel material (done)

  background: large minbias sample which has passed Level 2

  (we quickly generated our sample by requiring generator-level $p_T > 50$ GeV)

  This should be communal, right? Does it exist?
- Study event properties (in CMSSW/FWLite)

  $\uparrow \quad \downarrow$
- Improve algorithm (in CMSSW)