FORWARD SELECTRON PRODUCTION AND DETECTOR PERFORMANCE

Bruce Schumm

University of California at Santa Cruz

SLAC LCWS05

Special Recognition: Troy Lau, UCSC senior thesis student.

THE UCSC SUSY GROUP

Past

Sharon Gerbode (now at Cornell)
Heath Holguin (now a UCSC grad student)
Paul Mooser
Adam Pearlstein (now at Colorado State)

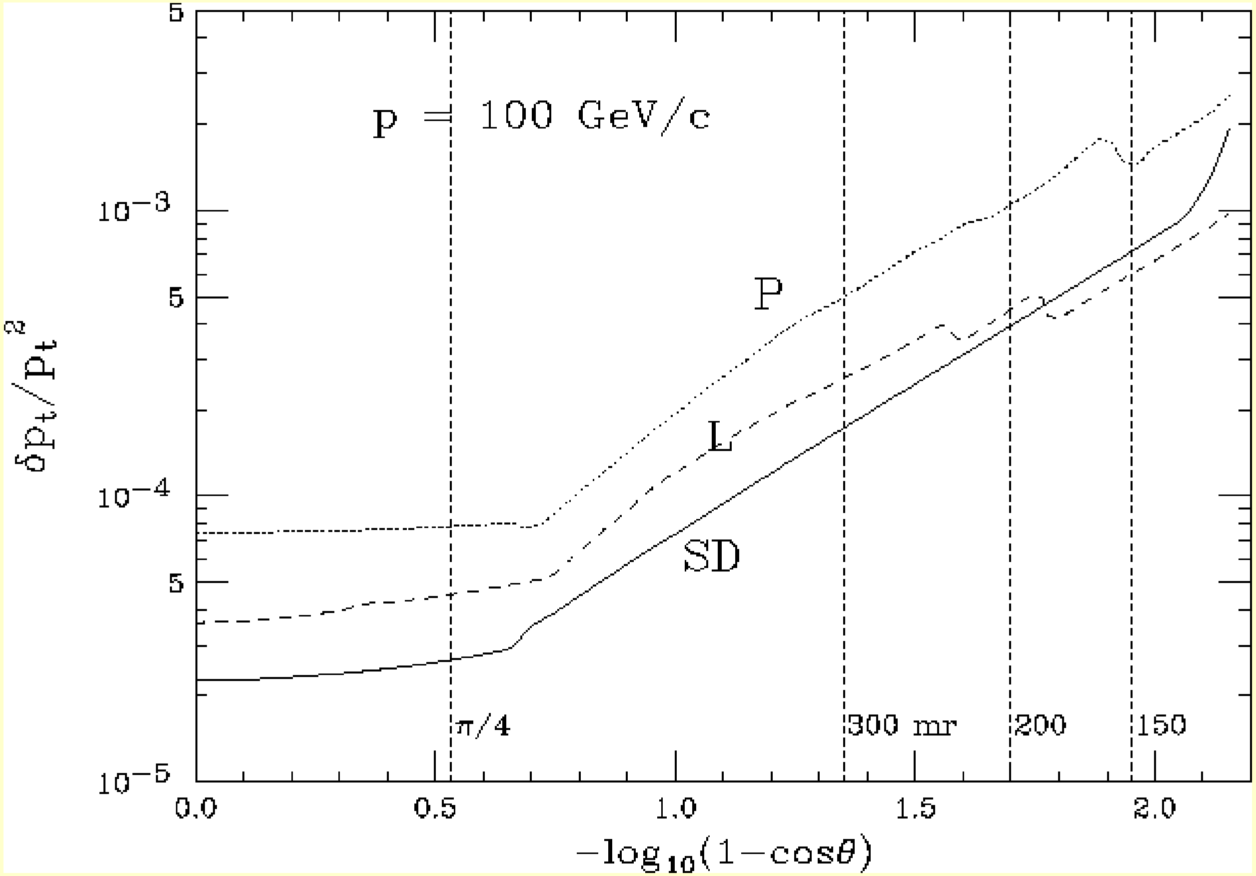
Present

Troy Lau (will be at ??)
Ayelet Lorberbaum
Joe Rose

Particular mention: **Troy Lau** has done an extraordinary job as an undergraduate senior thesis student. This presentation would not be possible without his work and creativity.

Motivation

To explore the effects of limited detector resolution on our ability to measure SUSY parameters in the **forward** (|cos(θ)| > .8) region.



SPS 1 Spectroscopy:

At E_{cm} = 1Tev, selectrons and neutralino are light.

Beam/Brehm:
$\sqrt{s}_{min}$=1
$\sqrt{s}_{max}$=1000
γ = .29
s_z = .11 (mm)

1 SPS 1 – mSUGRA scenario

m_0	100 GeV
$m_{1/2}$	250 GeV
A_0	−100 GeV
$\tan\beta$	10
sign μ	+

'typical' scenario
$m_0 = 0.4\, m_{1/2} = -A_0$

1.1 Spectrum & parameters of ISAJET 7.58

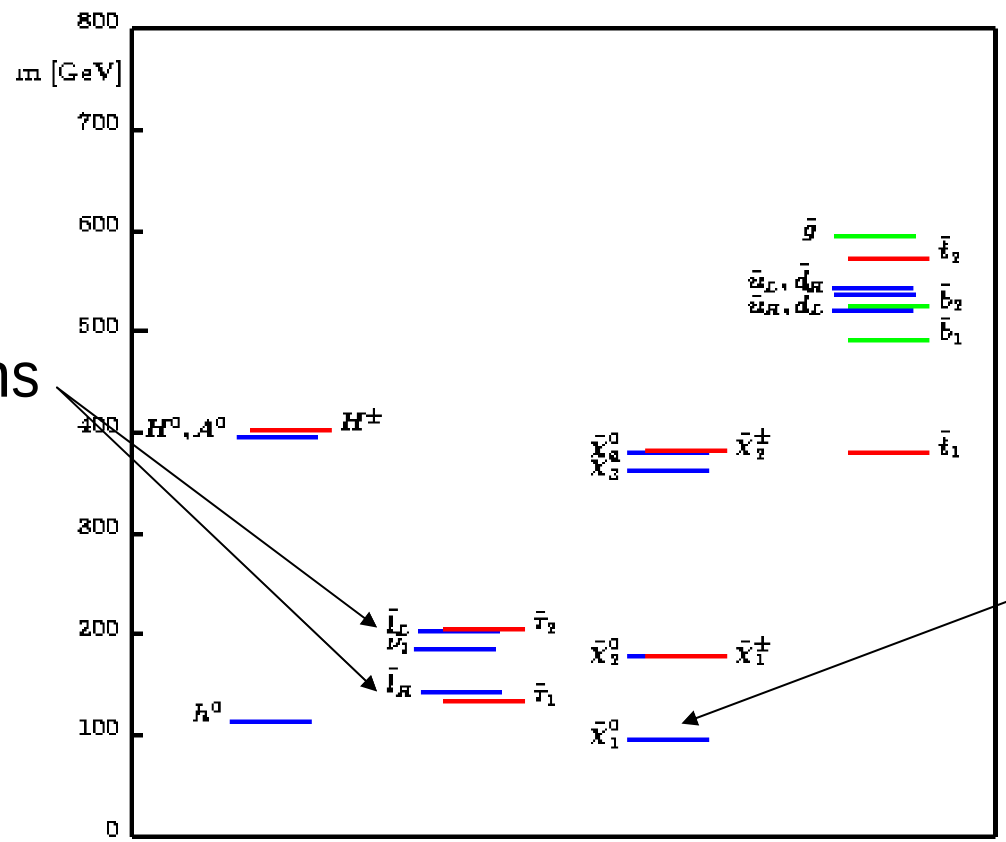
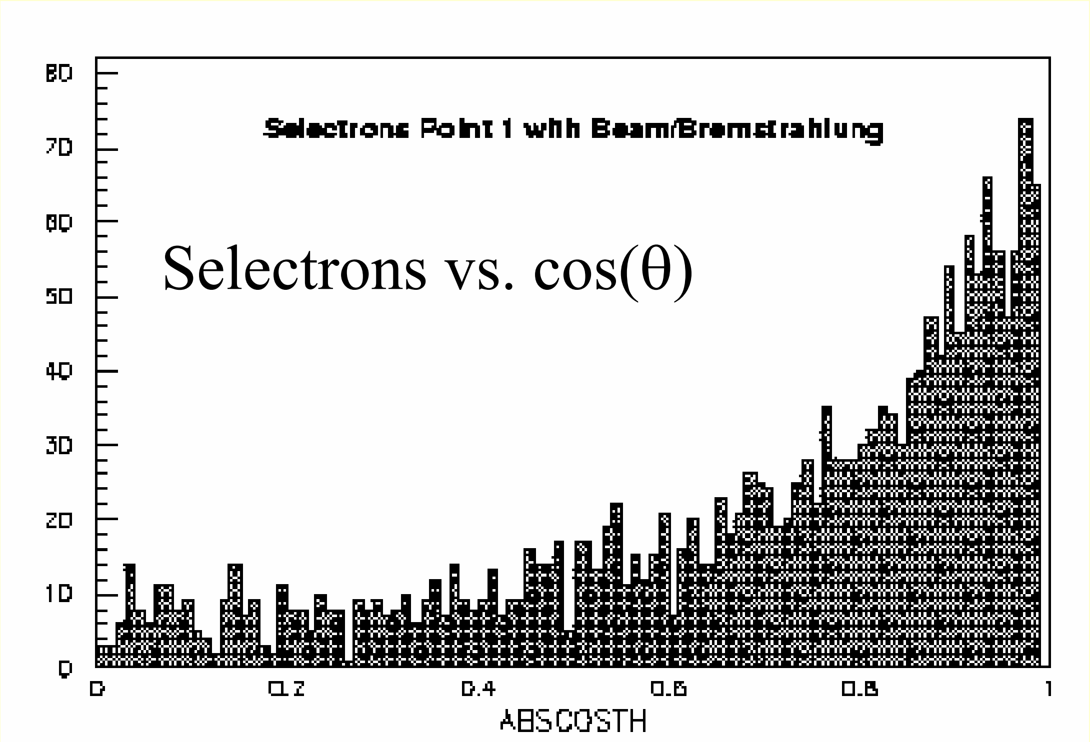
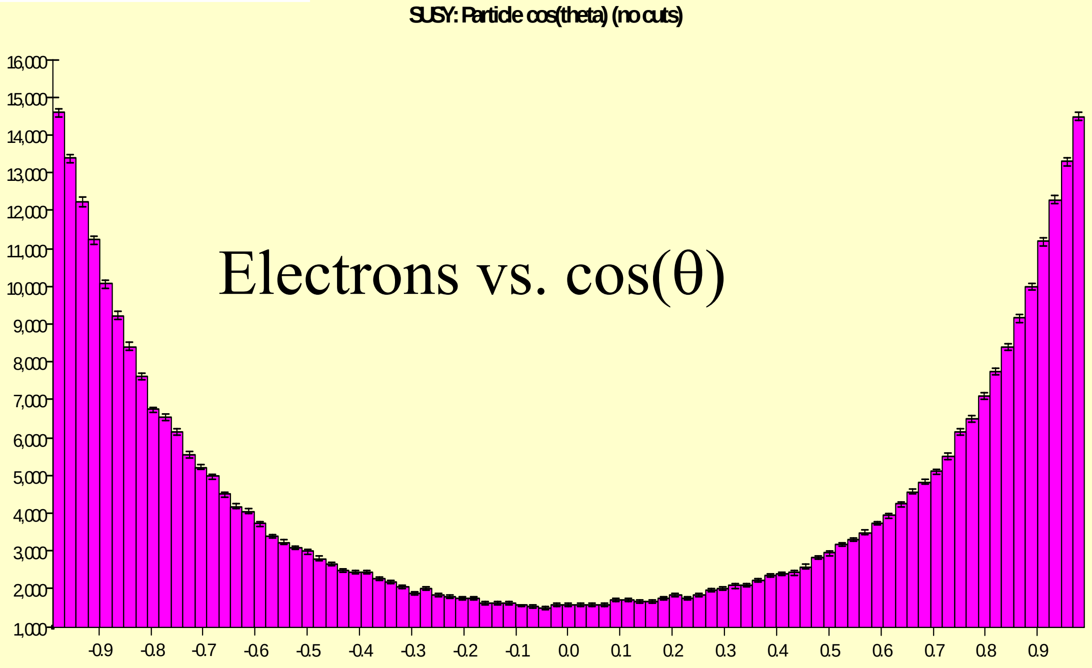


Figure 1: SPS 1 mass spectrum of ISAJET

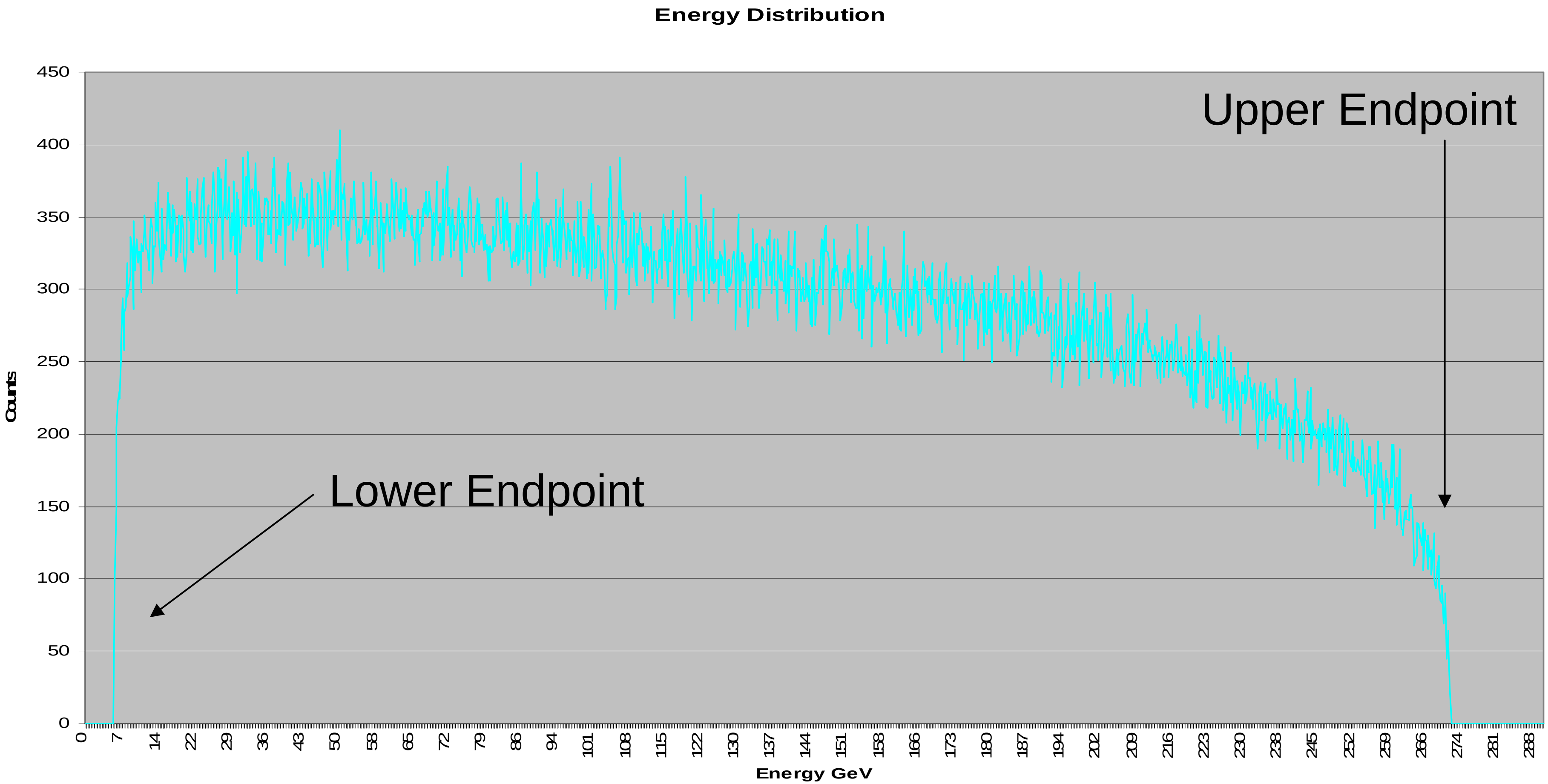


SPS1A at 1 TeV

Roughly ½ of statistics above |cos(θ)| of 0.8, **but**…

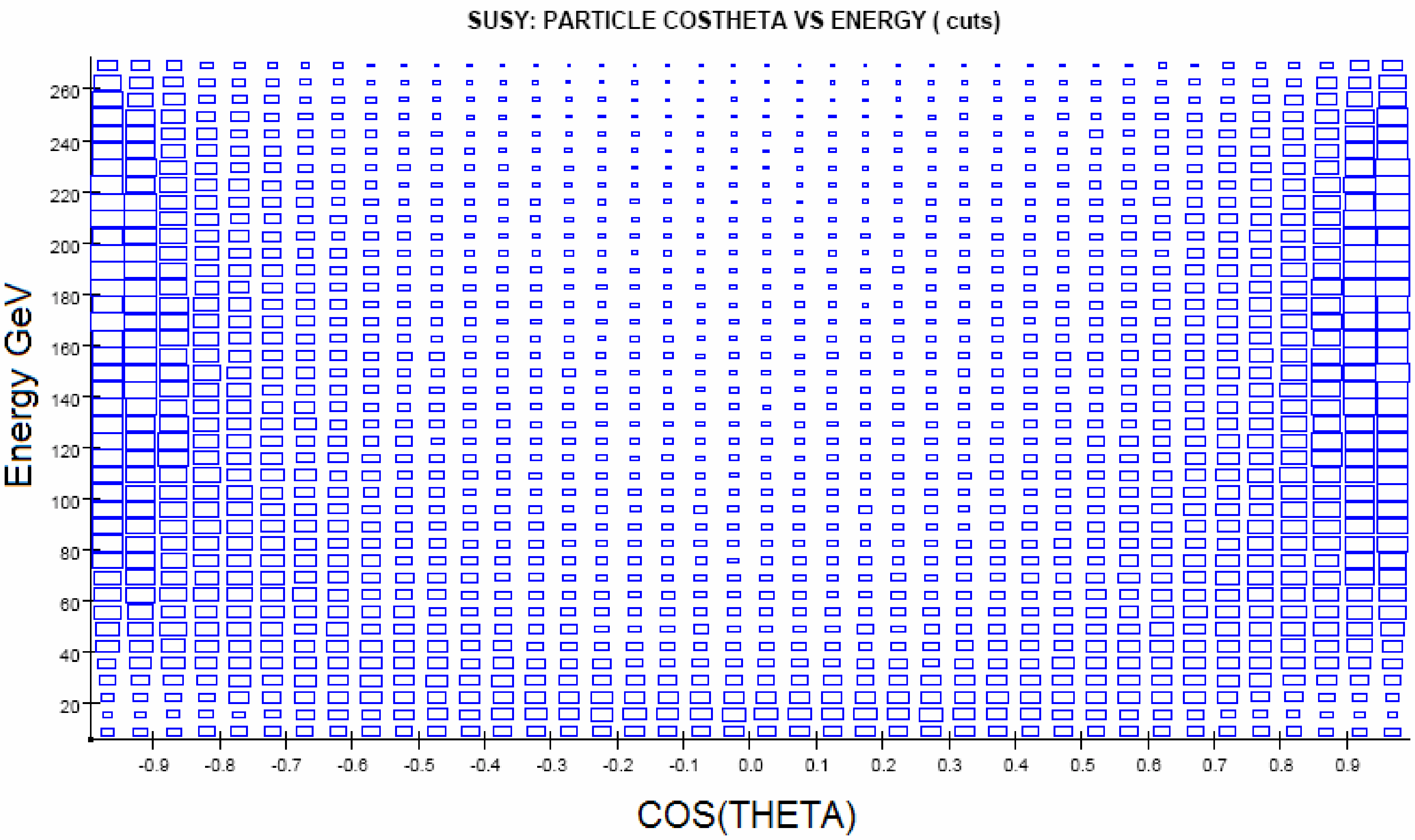


Electron energy distribution with beam/bremm/ISR (.16%). No detector effects or beam energy spread.



- sample electron energy distribution $M_{selectron}$ = 143.112 (SPS1A)

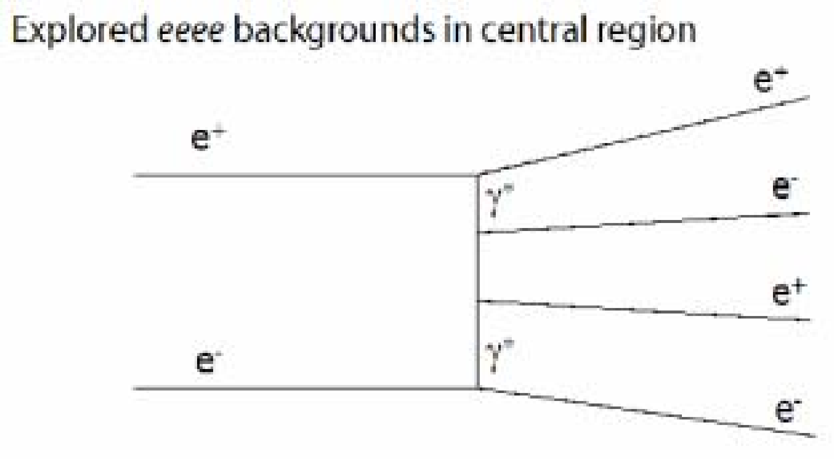
The spectrum is weighted towards higher energy at high |cos(θ)|, so there's more information in the forward region than one might expect.



Previous work:
Can one find the selectron signal for $|\cos(\theta)|>0.8$?

Dominant Backgrounds:

$e^+ e^- \rightarrow e^+ e^- e^+ e^-$



$e^+ e^- \rightarrow e^+ e^- \nu \nu$

‘STANDARD’ CUTS

• **Fiducial Cut:** Exactly one final-state positron and one final-state electron pair in |cos(θ)| region of interest, each with a transverse momentum of at least 5GeV. Otherwise the event is discarded.

• **Tagging Cut:** No observable electron or positron in low-angle `tagging’ calorimetry (with coverage of 20mrad < θ < 110mrad)

• **Transverse Momentum (TM) Cut:** Cuts events where vector sum of transverse momentum for e^+e^- pair is less than 2 * 250GeV * sin (20 mrads)

‘NEW’ CUTS

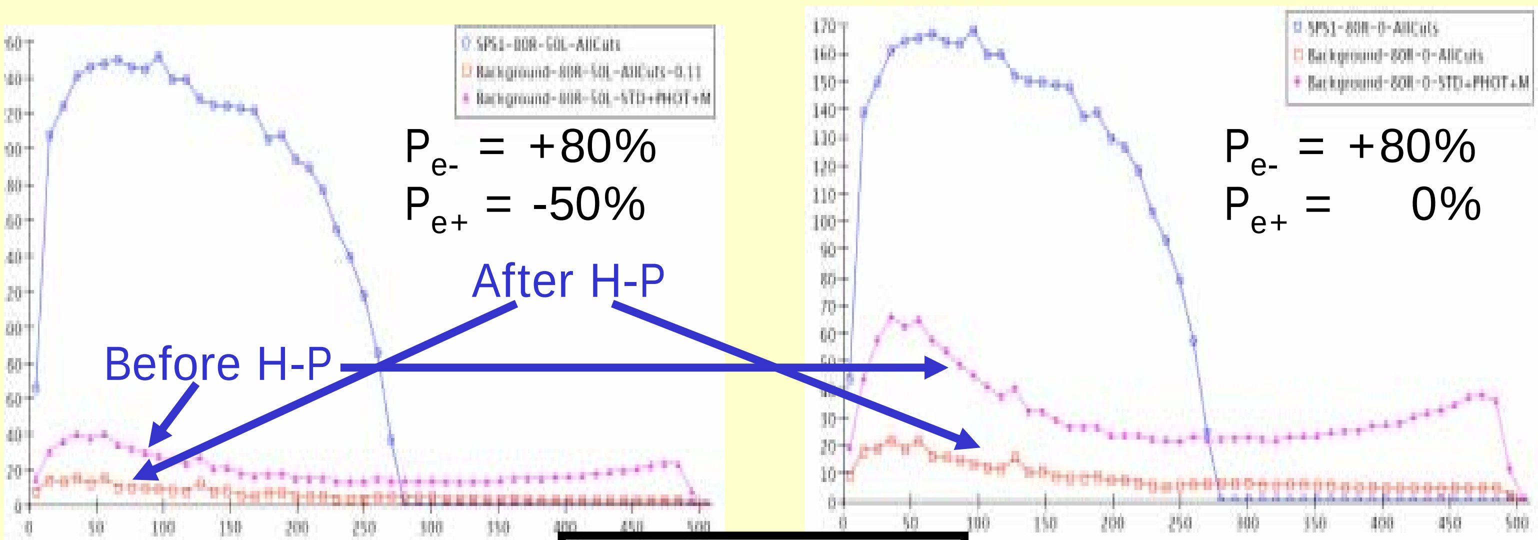
• **Photon Cut:** TM cut eliminates four-electron background except for radiative events. Remove remaining radiative events by looking for radiated photon; i.e., if there is a photon in the tagging region with energy of 20GeV or more.

• **HP Cut:** Removes low-mass, t-channel-dominated eeνν backgrounds while preserving high-mass SUSY signal

Standard Model Backgrounds

After 'photon cut', which eliminates the four-electron background, the dominant background is eeνν. Manipulation of the beam polarization, combined with application of the 'HP Cut' reduces background to minimal levels, even in forward region.

→ Ignore backgrounds in detector resolution studies.

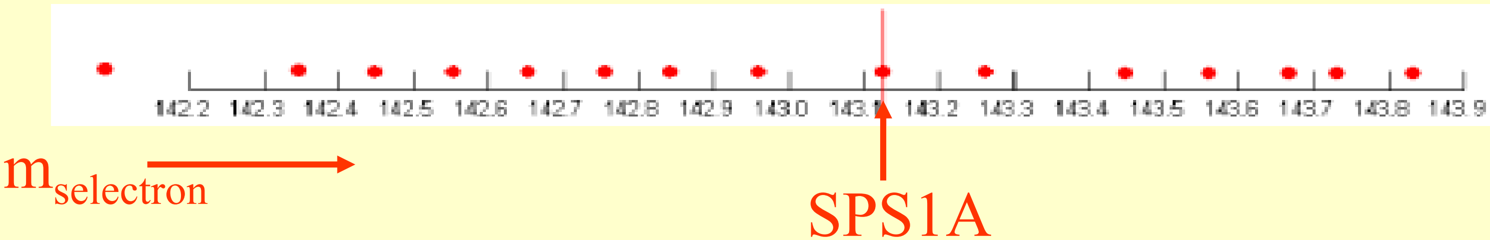


$|\cos\theta| < 0.994$

Fitting the Endpoints for the Selectron Mass

For now, we have done one-dimensional fits (assume χ^0 mass known)

Vary SUSY parameters minutely around SPS1A point so that selectron mass changes while χ^0 mass remains fixed.

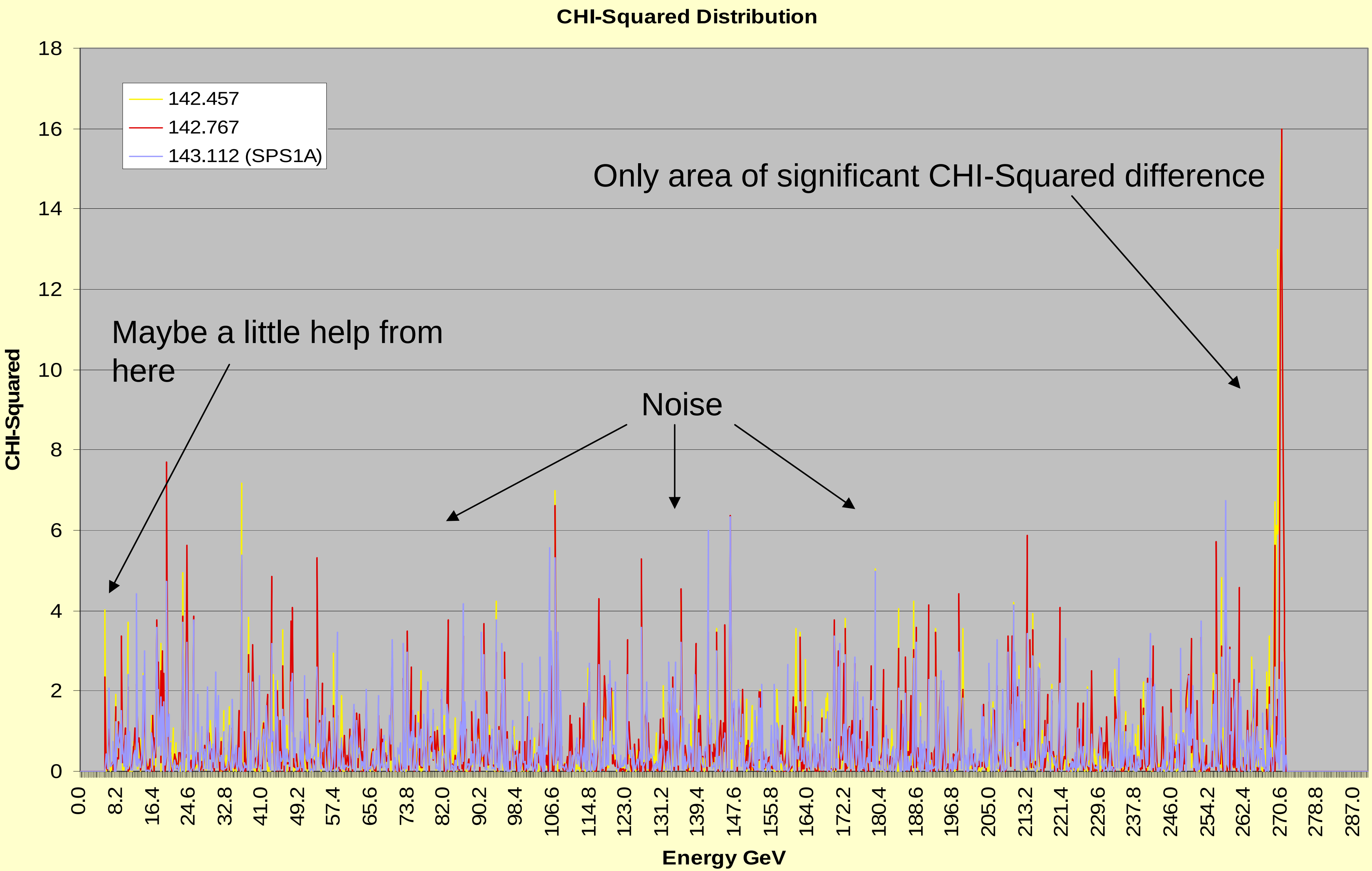


Generate 'infinite' (~1000 fb^{-1}) at each point to compare to 115 fb^{-1} data sample; minimize χ^2 vs. $m_{selectron}$ to find best-fit selectron mass.

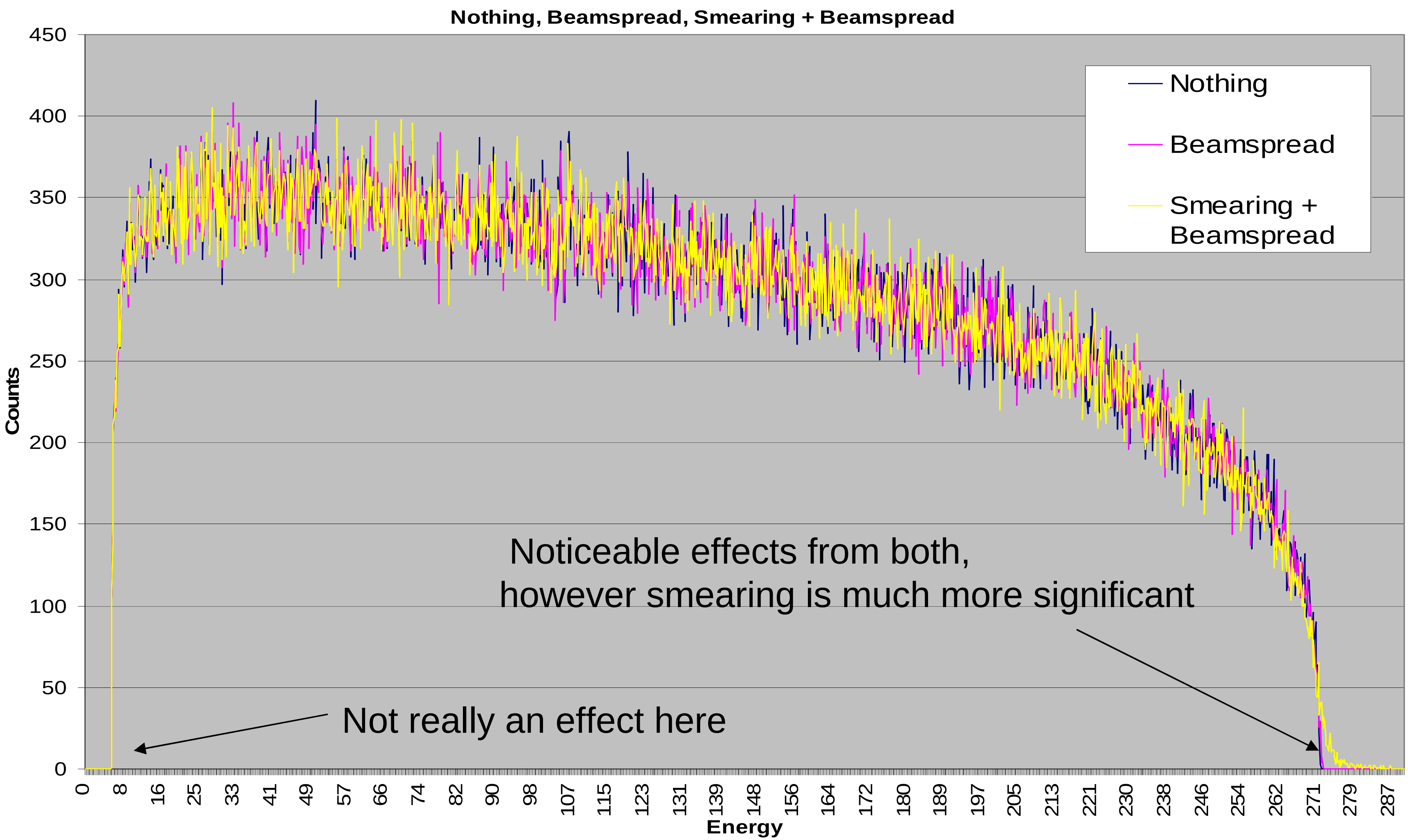
$$\text{CHI-Squared} = \sum \frac{(w * n_i - m_i / w)^2}{(n_i * w^2 + m_i)}$$

Repeat for 120 independent data samples; statistics from spread around mean rather than directly from χ^2 contour.

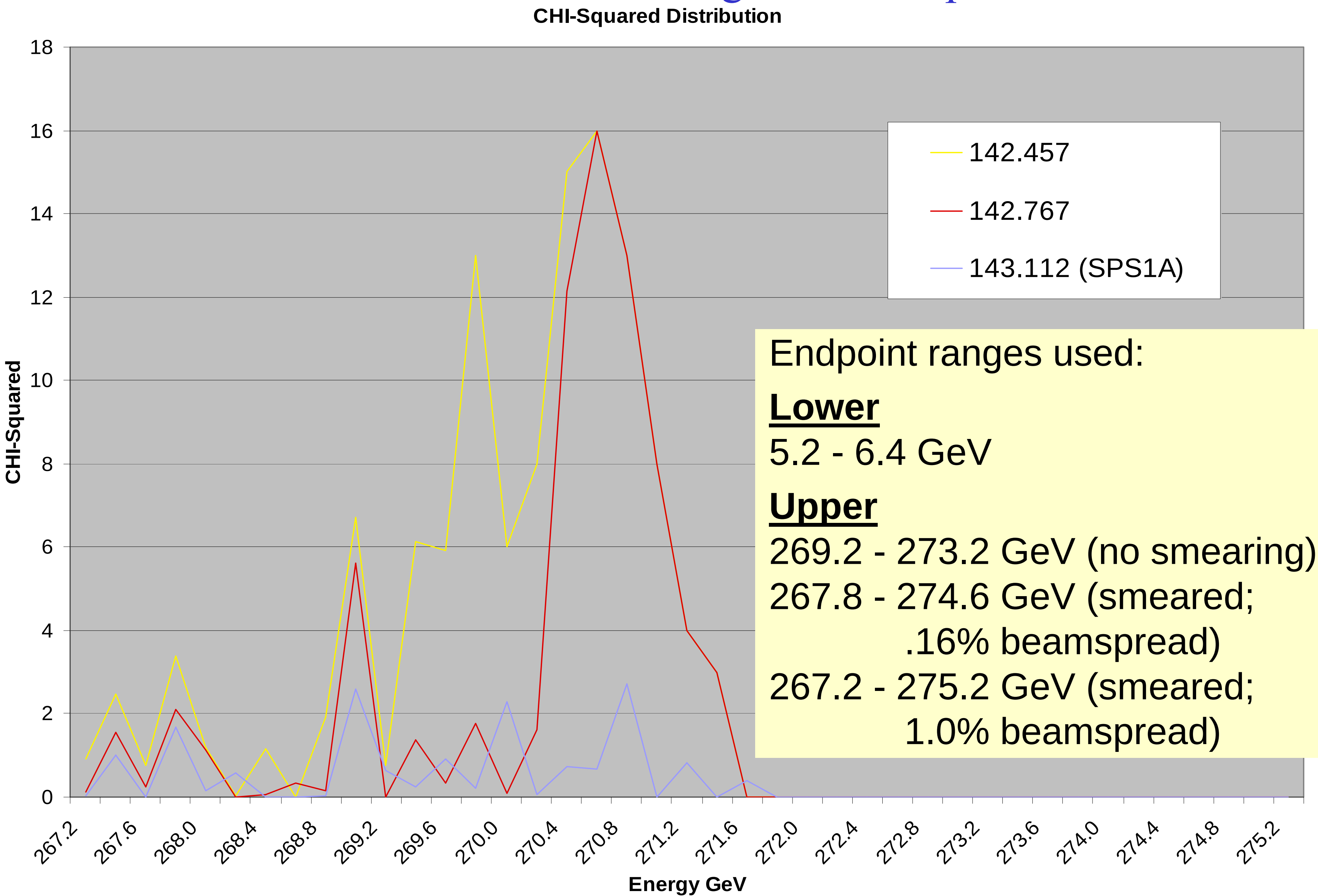
Defining the Fit Region



SPS1A template (high statistics) set
Mass of right selectron = 143.112
Beamspread = .16%



Choose fits region carefully (depending on smearing/beamspread) to avoid noise from flat region of the spectrum.



Endpoint ranges used:

Lower

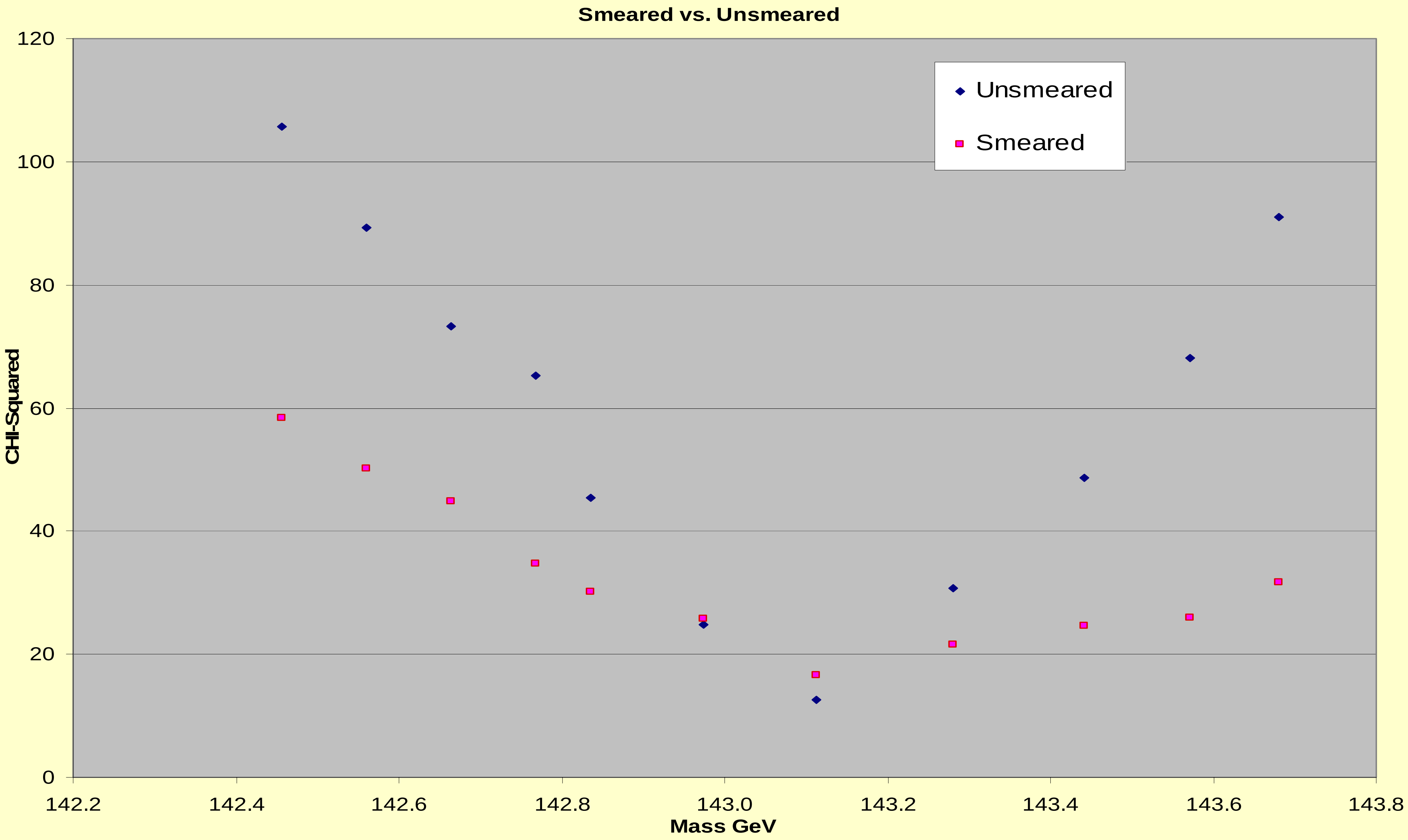
5.2 - 6.4 GeV

Upper

269.2 - 273.2 GeV (no smearing)

267.8 - 274.6 GeV (smeared; .16% beamspread)

267.2 - 275.2 GeV (smeared; 1.0% beamspread)



Detector smearing does make a difference; how much?

Selectron Mass Study Scenarios

12 scenarios were considered:

Detector Resolution

Perfect (no smearing) and SDMAR01

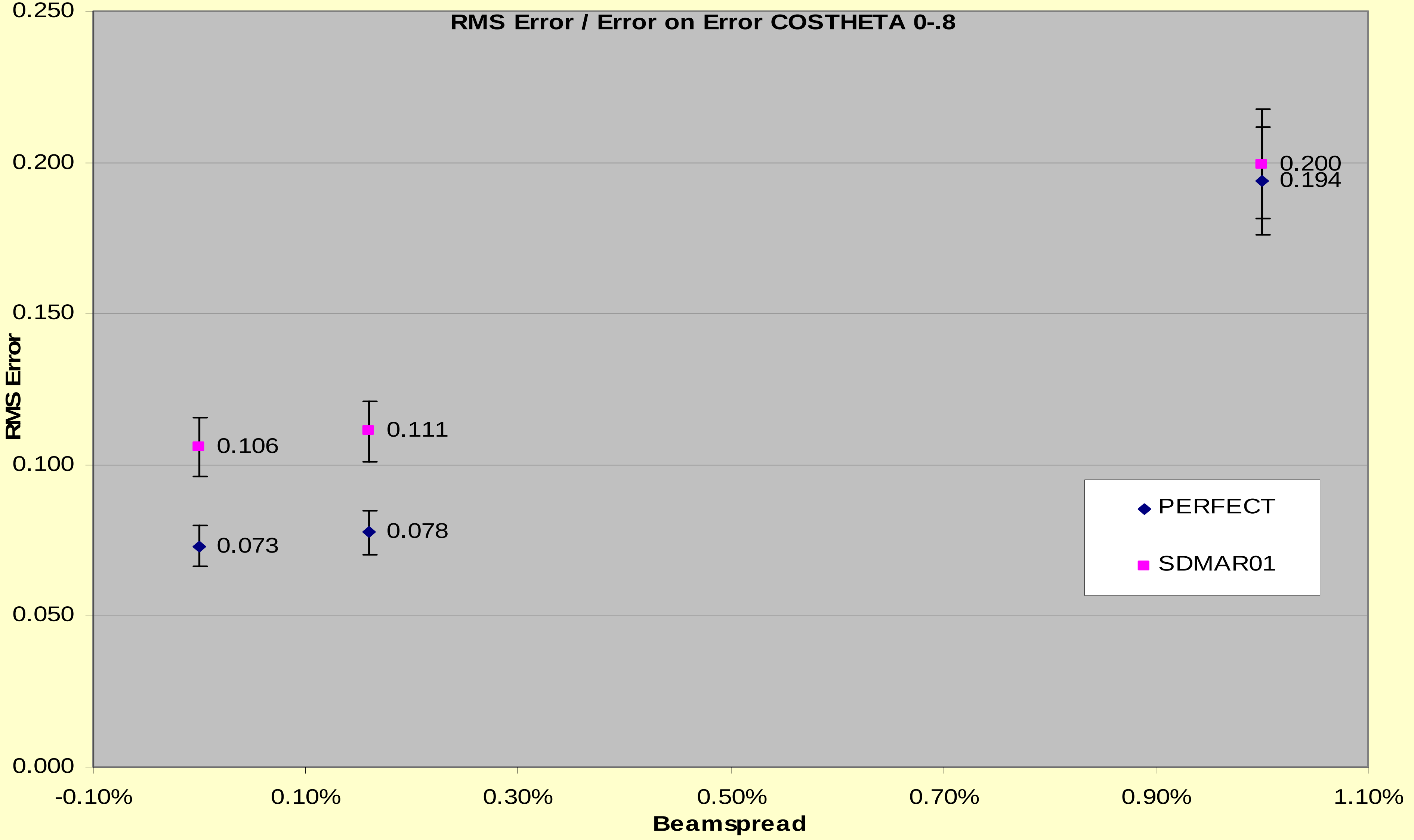
Detector Coverage

$|\cos\theta| < 0.8$ and $|\cos\theta| < 0.994$

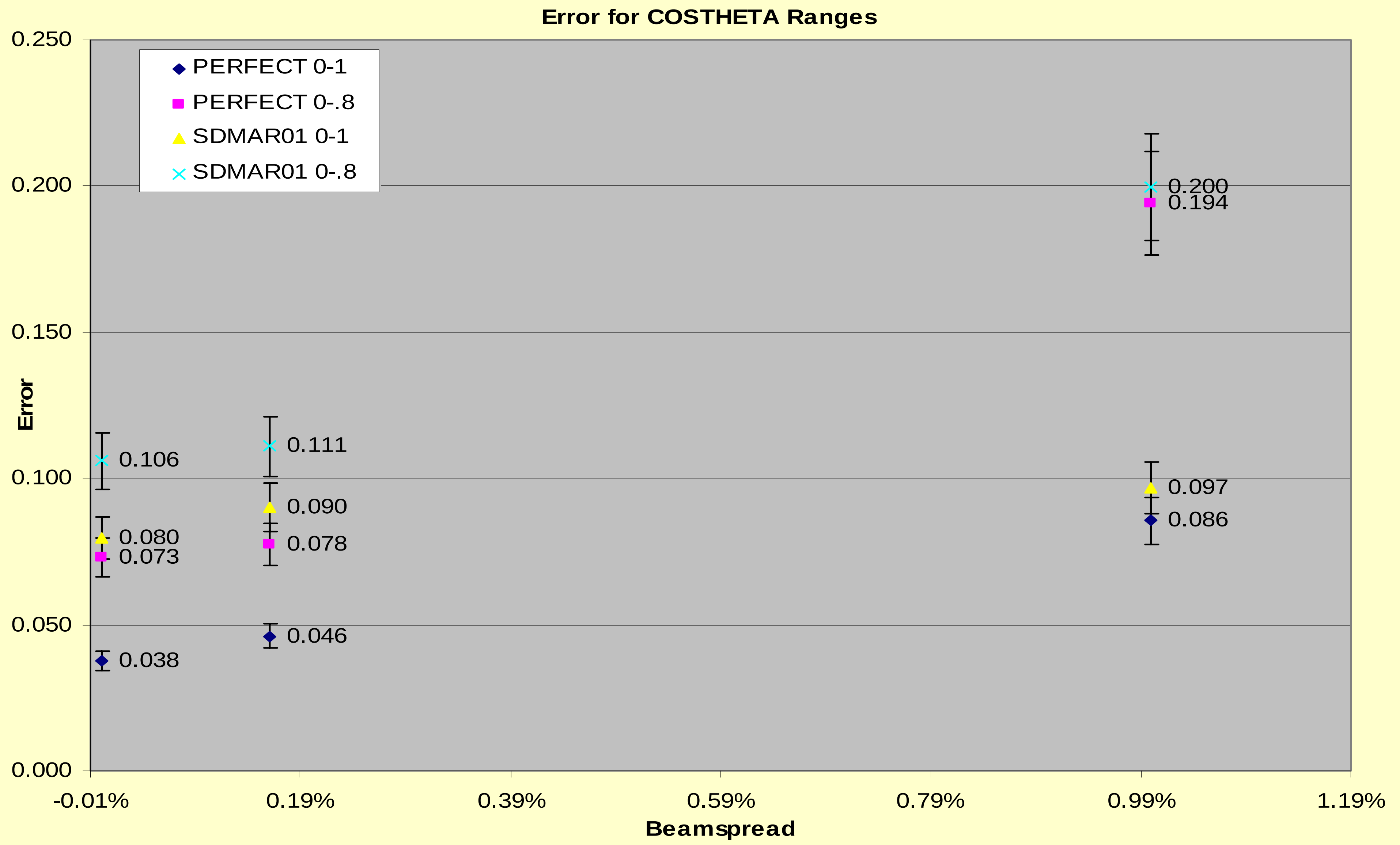
Beam Spread

0%, 0.16%, and 1.0%

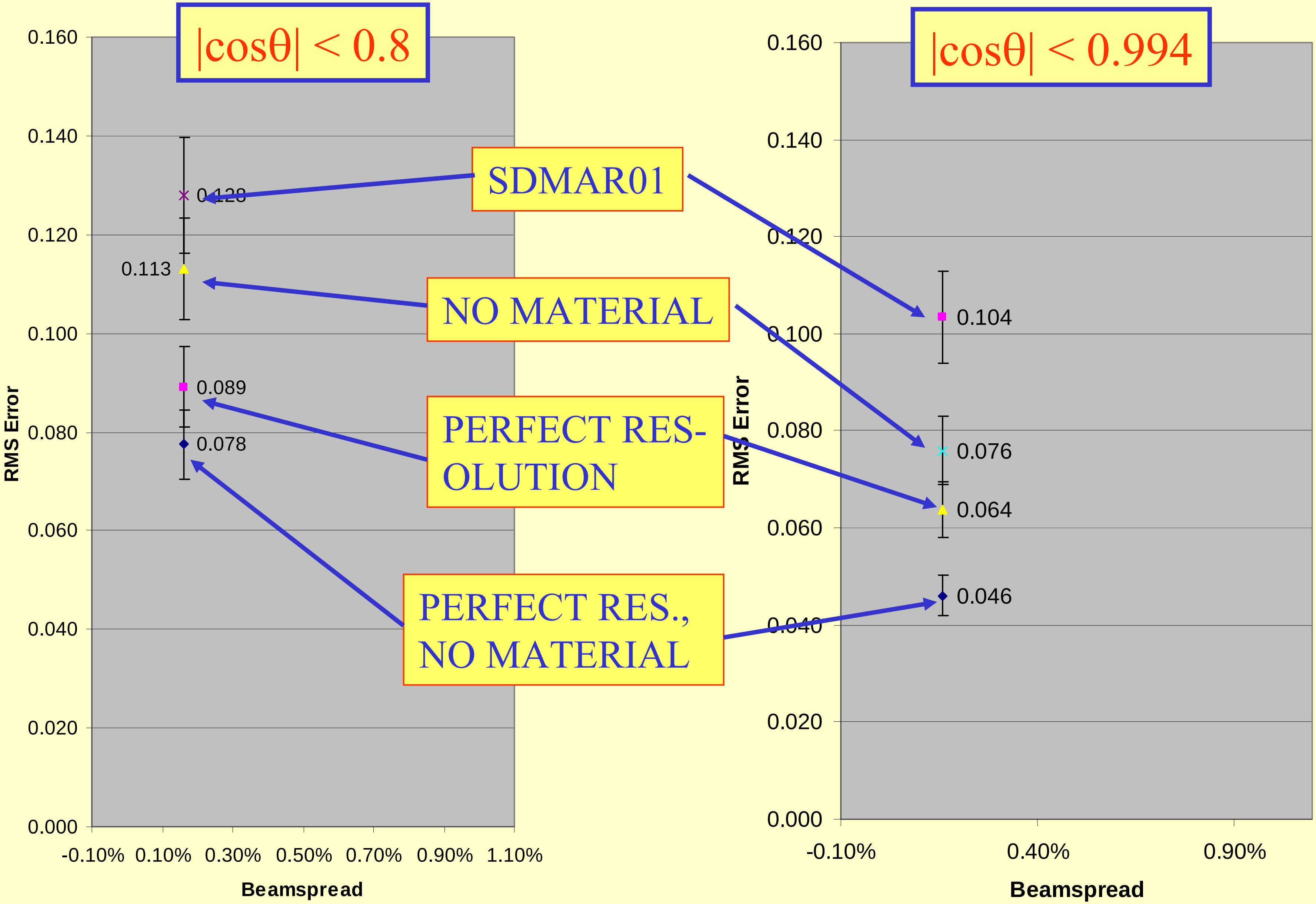
First, just look in the central region (|cosθ| < 0.8)



Now, include the full region (|cosθ| < 0.994)



Is it the point resolution, or the material?



Tentative Conclusions to Draw

1. For cold-technology beamspread (0.14%), SDMAR01 resolution has not reached the point of diminishing returns
2. Due to the stiffening of the spectrum in the forward region, there is a surprising amount of information there.
3. Detector resolution is even further from ideal in this region. If there is forward SUSY production to be measured, there is much to be gained by improving the detector
4. In the central region, point resolution is dominant. In the forward region, material may also comes into play.
5. Need to explore these conclusions further, and use studies to develop reasonable goals for forward tracking.