SLEPTON MASS RECONSTRUCTION AND DETECTOR RESOLUTION

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Special Recognition: Troy Lau, UCSC senior thesis student (now at University of Michigan)

Motivation for Study

- Is there information on Slepton masses in the forward region?
- Can we detect it above backgrounds?
- Are our detectors up to the task?

In doing the study, we also found that questions can be raised about the central region.

THE UCSC SUSY GROUP

Past

Sharon Gerbode (now at Cornell)
Heath Holguin (now a UCSC grad student)
Troy Lau (Now at Michigan)
Paul Mooser (Software engineer)
Adam Pearlstein (now at Colorado State)
Joe Rose

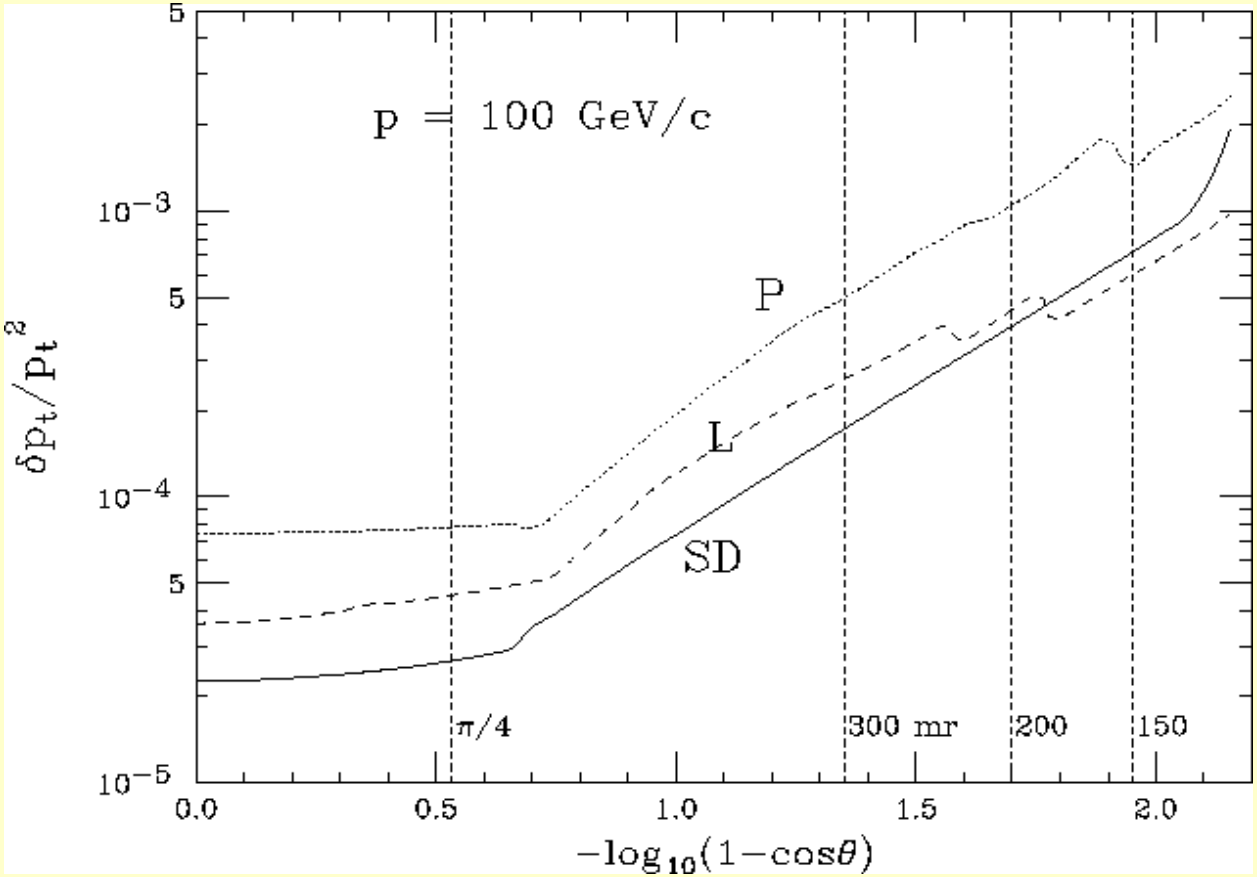
Present

Ayelet Lorberbaum
Eric Wallace
Matthew vegas

Work accomplished by exploiting UCSC's senior thesis requirement…

Motivation

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

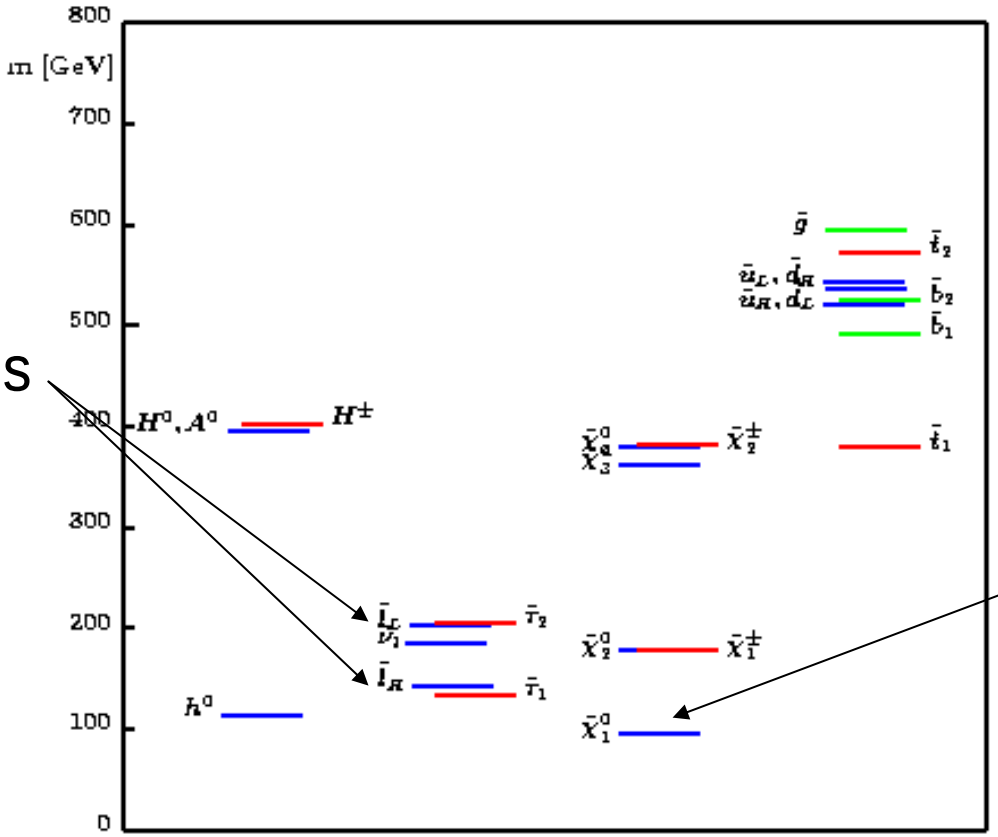
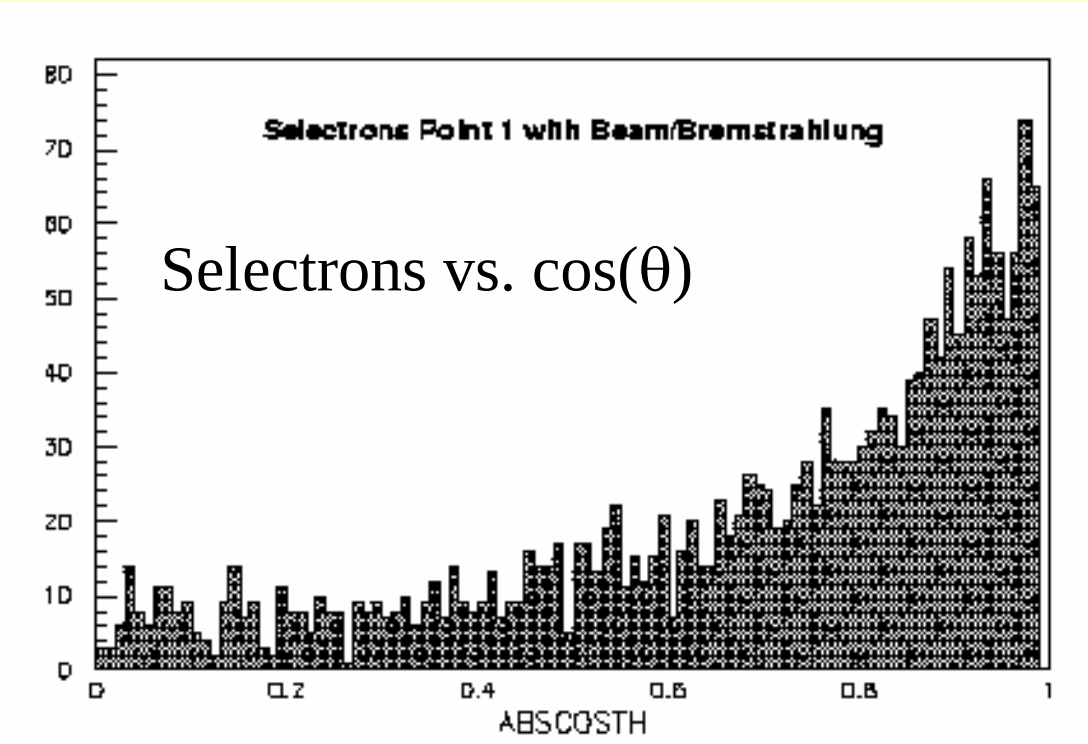


Figure 1: SPS 1 mass spectrum of ISAJET

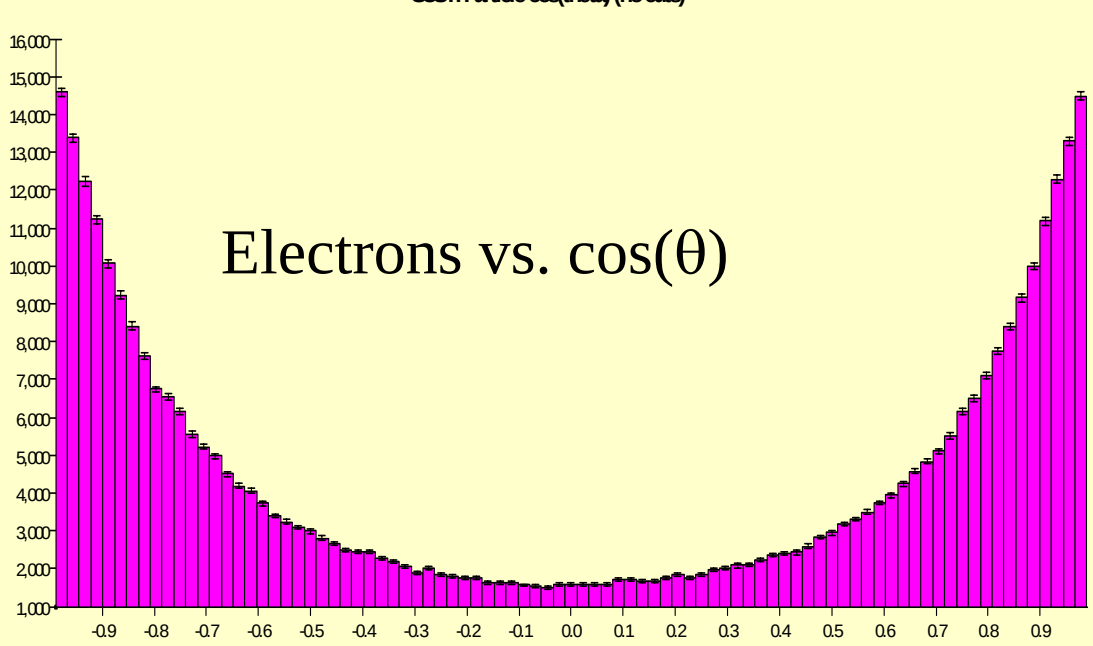
selectrons

LSP



SPS1A at 1 TeV

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



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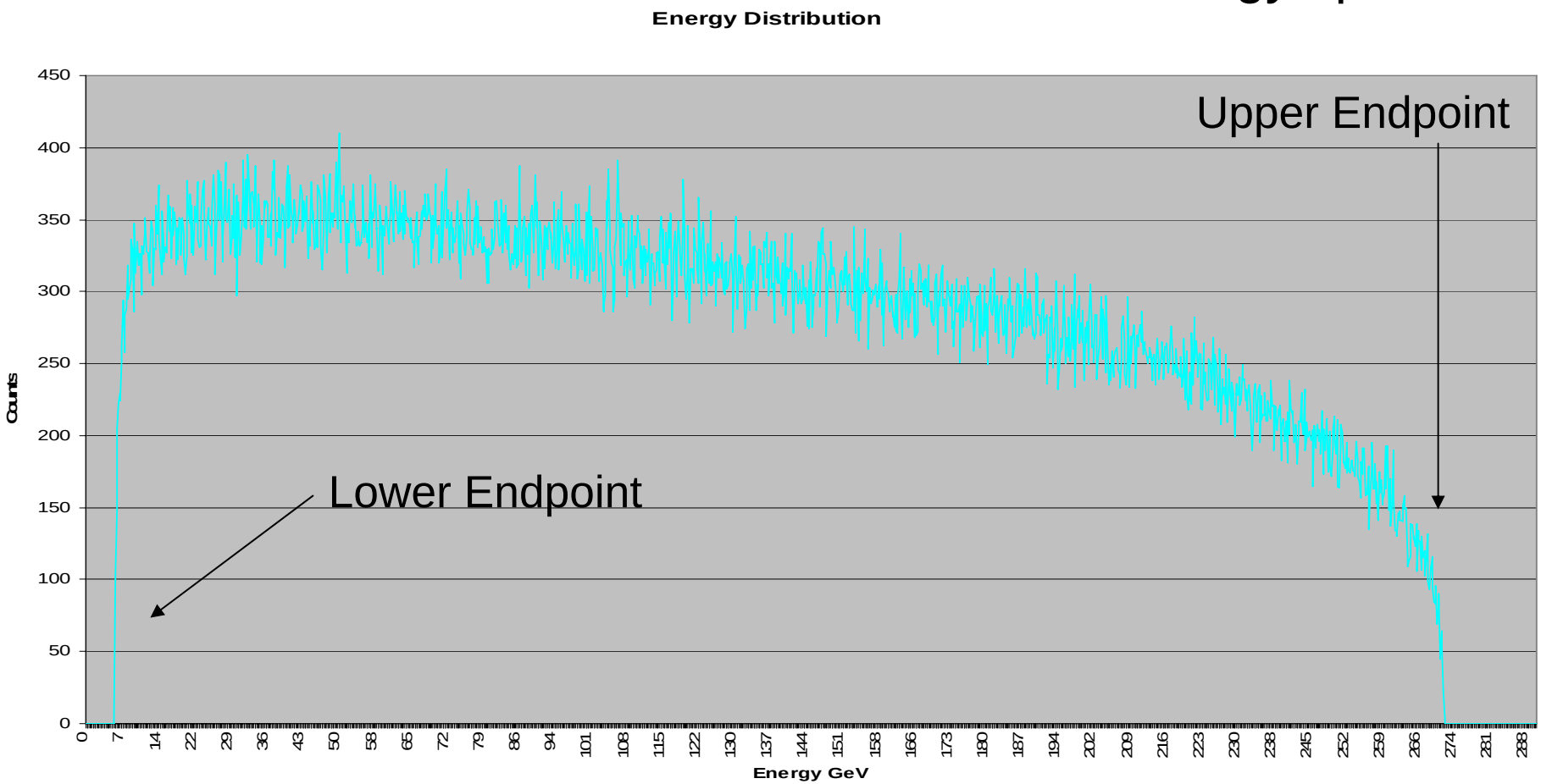
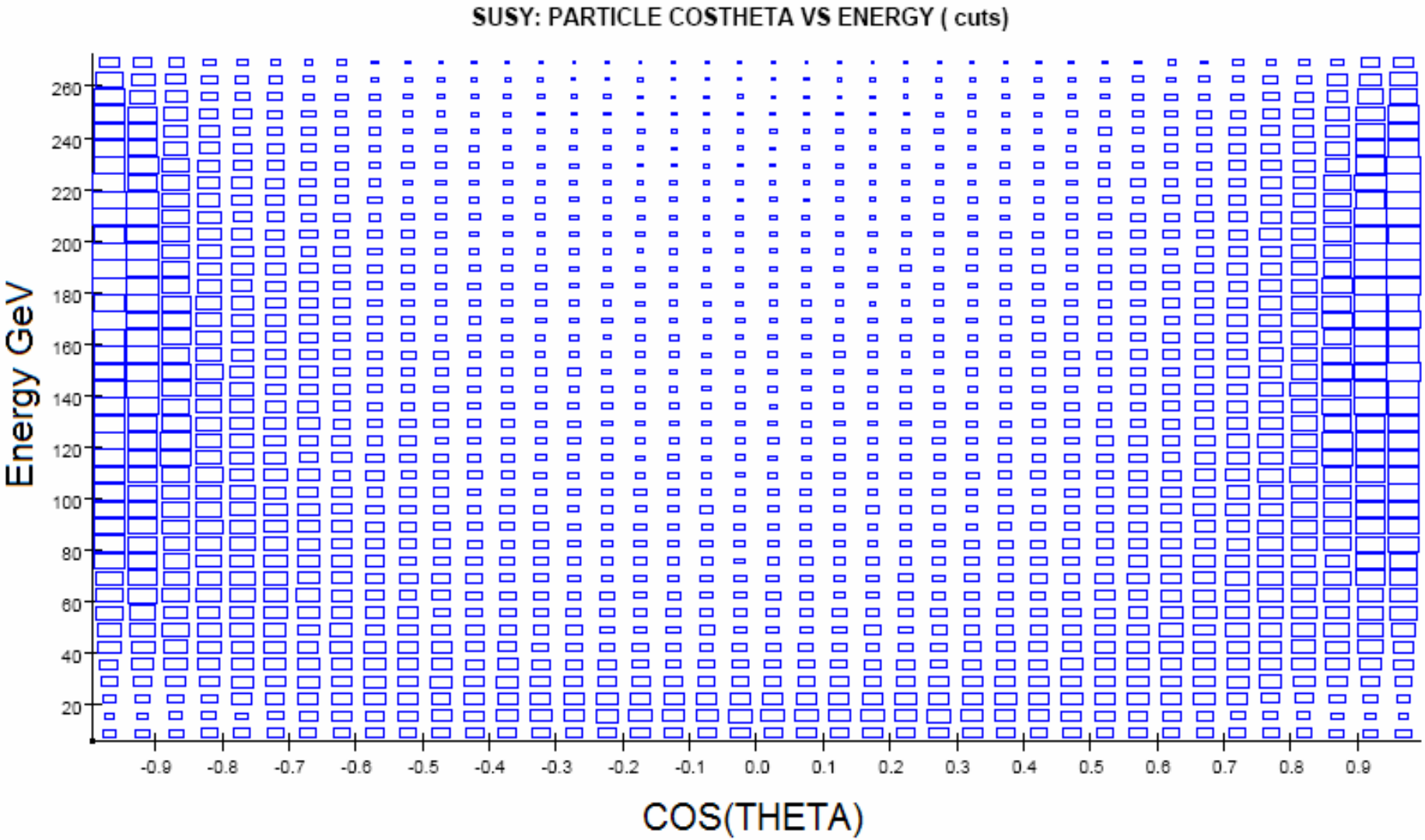
International Linear Collider

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.

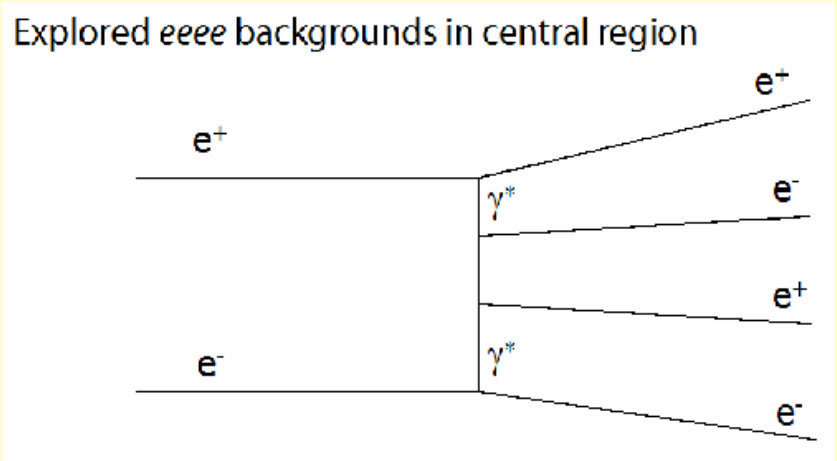


Previous work:

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 $|\cos(\theta)|$ 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 $20\text{mrad} < \theta < 110\text{mrad}$)

• **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

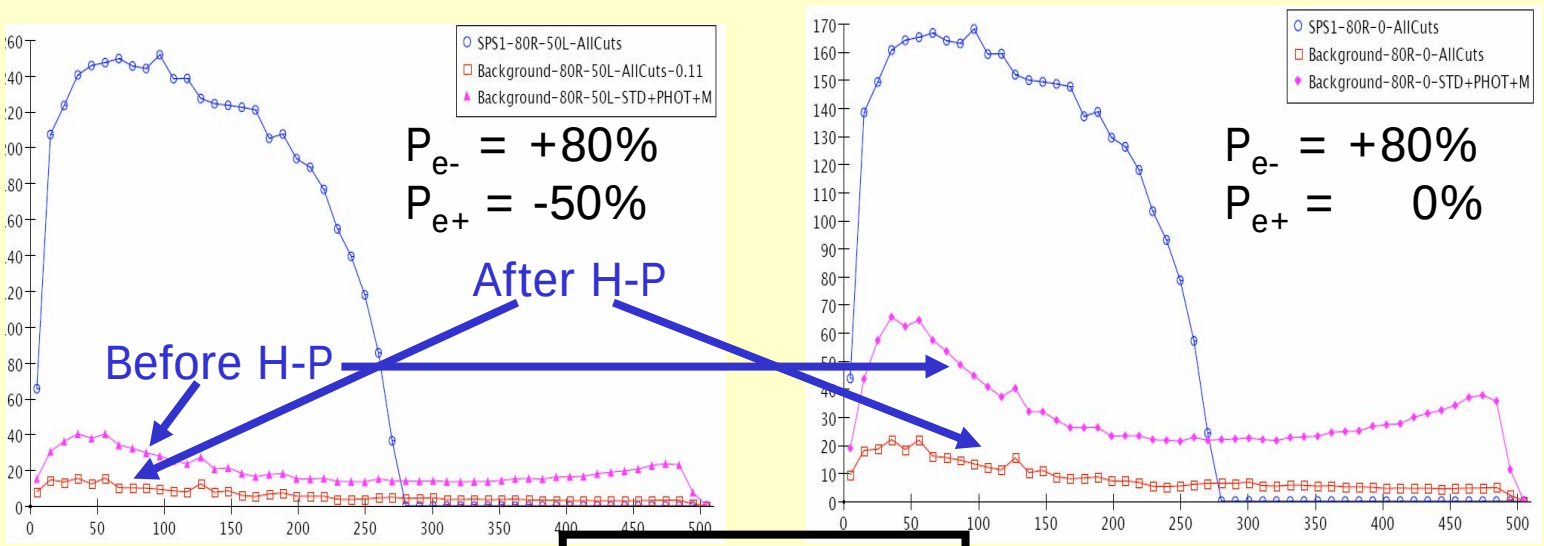
• **Photon Cut:** TM cut eliminates four-electron background except for radiative events. Remove remaining radiative events by looking for radiated photon; i.e., if there is a photon in the tagging region with energy of 20GeV or more.

• **HP Cut:** Removes low-mass, t-channel-dominated $ee\nu\nu$ 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.

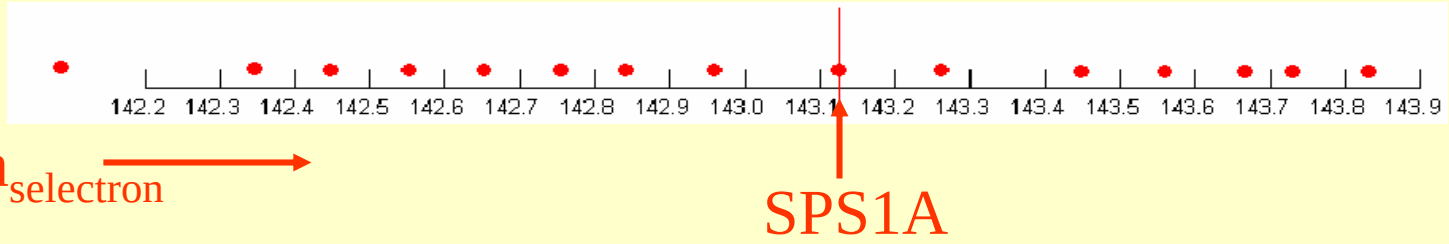


$|\cos\theta| < 0.994$

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.

Selectron Mass Study Scenarios

12 scenarios were considered:

Detector Resolution

Perfect (no smearing) and SDMAR01

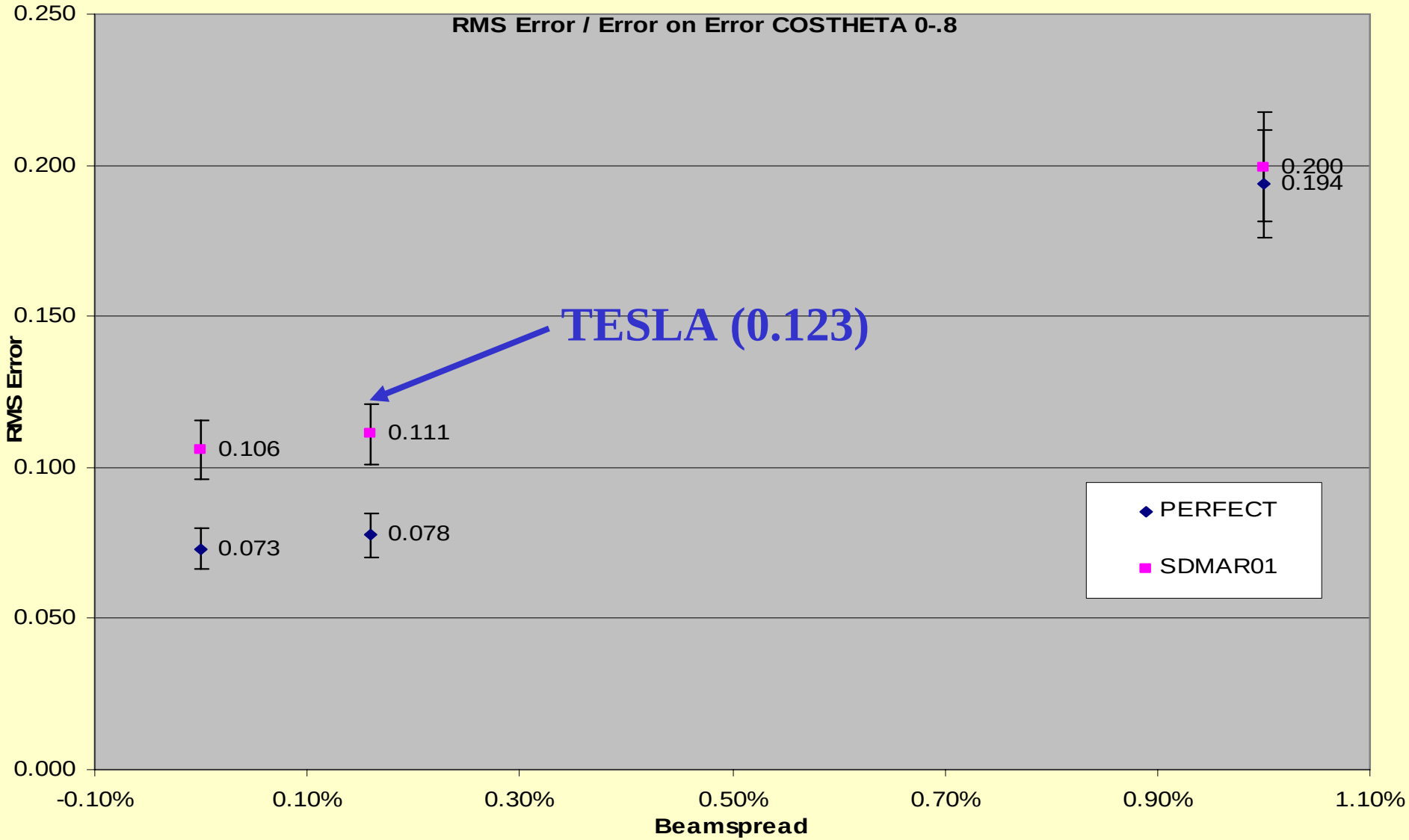
Detector Coverage

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

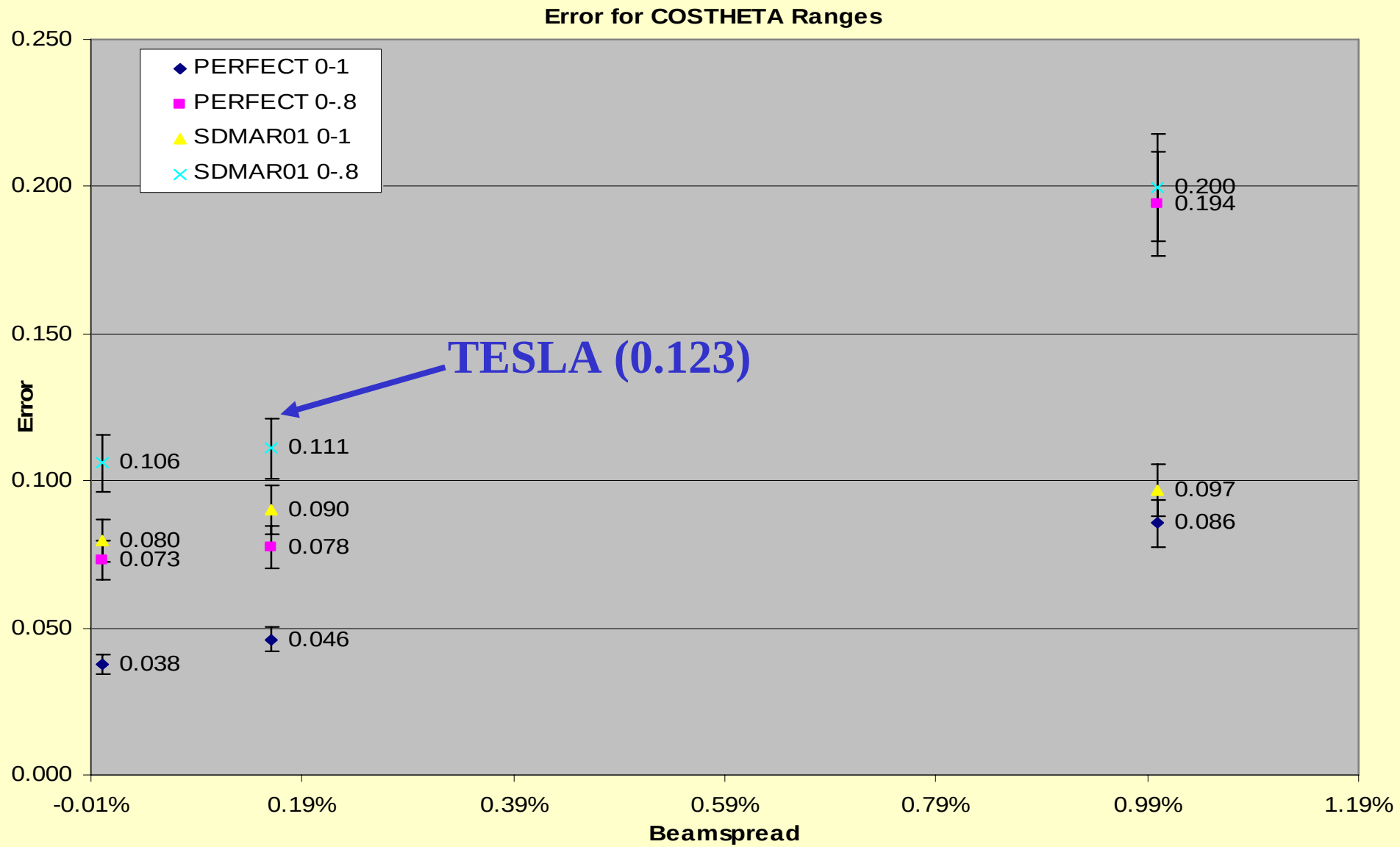
Beam Spread

0%, 0.16%, and 1.0%

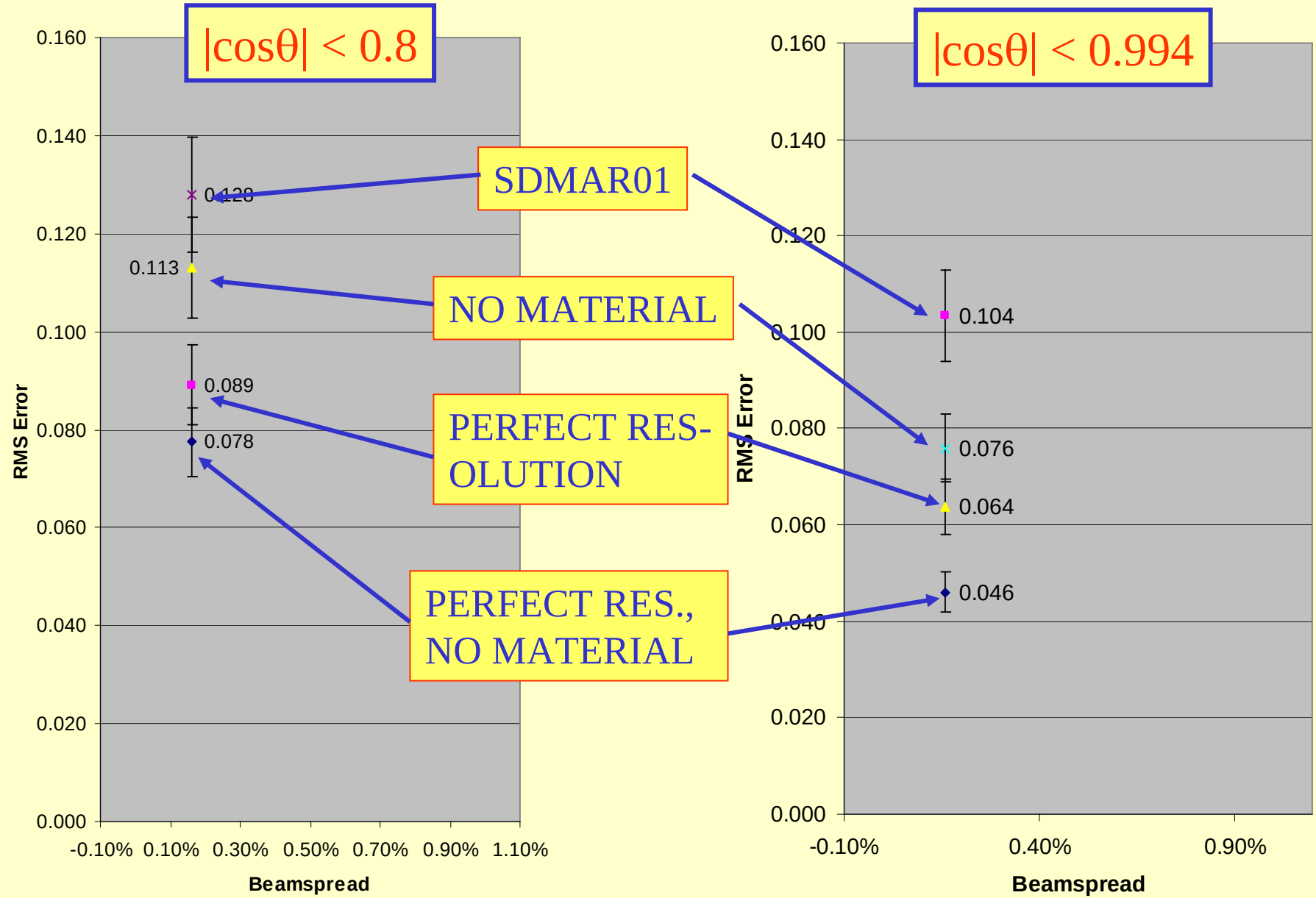
First, just look in the central region (|cosθ| < 0.8)



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



Is it the point resolution, or the material?



Tentative Conclusions to Draw

1. Due to the stiffening of the spectrum in the forward region, there is a surprising amount of information there. **For this scenario, most of the information on slepton masses lies in the forward ($|\cos\theta| > 0.8$) region.**
2. For cold-technology beamspread (0.14%), SDMAR01 resolution has not reached the point of diminishing returns. The physics seems to be limited by detector resolution. Point resolution is the dominant issue.
3. Any gains that can be made in $p_\perp$ resolution in the forward region would reap large rewards for light sleptons.