R&D for the International Linear Collider Damping Rings

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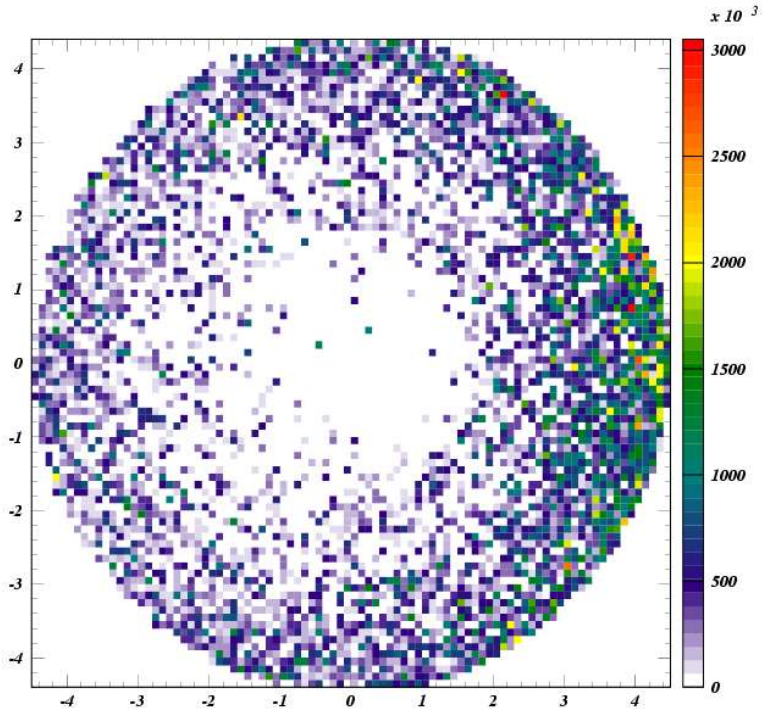
Cornell LEPP REU, summer 2008



Overview

- Two main projects in the ILC R&D effort
  - Low Emittance Tuning
  - Electron Clouds
- Emittance is a measure of beam size
- Electron clouds seen as the major obstacle to ultra low emittance operation of ILC damping rings
- Low Emittance tuning is the optimization of the accelerator to operate at ultra low emittance
- I worked within both efforts, but my main contribution was to the Low Emittance Tuning group

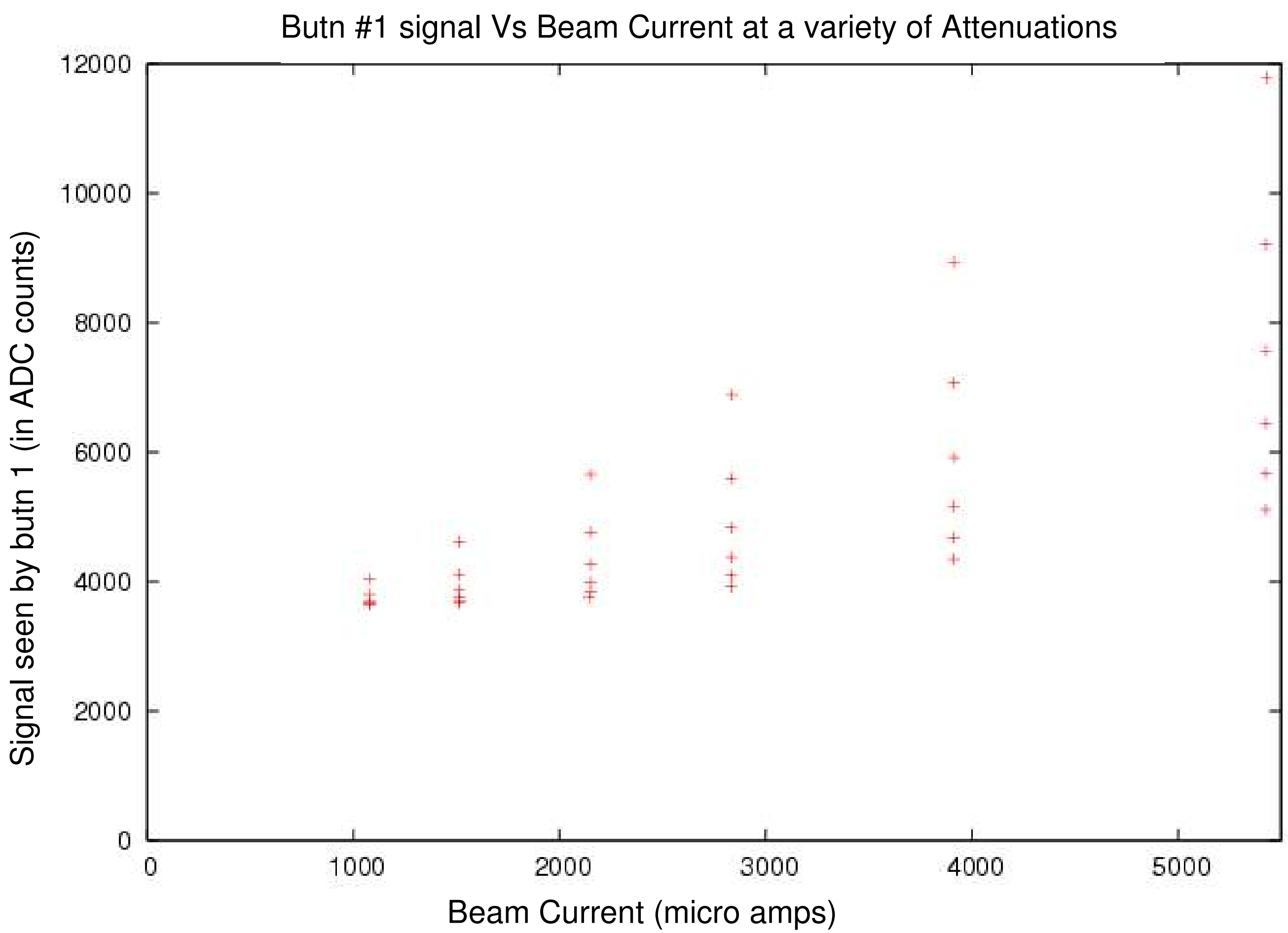
ILCDR08

- Week long workshop with international collaborators
- ~40 physicists from all over the world
- Workshop was divided into an electron cloud group and a Low Emittance Tuning group
- I spent most of my time with the electron cloud group
- The workshop was very educational, both from a scientific perspective and as an introduction to large international collaborations

Dispersion Anomaly Overview

- The Dispersion function is the relation between energy spread and its contribution to position spread in the beam, has units of length/%
- The design energy spread is 0.1%, so an uncertainty in the dispersion of 10cm corresponds to a beam size uncertainty of 100 microns
- Measure by taking the difference of two orbits at different energies
- Since 2006, dispersion measurements have differed from the design dispersion in one localized region. During the course of months of investigation, this phenomenon took on the name 'horizontal dispersion anomaly.'
- Dispersion Anomaly could be due to survey problems, control problems, or data acquisition problems.
- However, it's stable enough that we can correct via calibration constants
- Data was taken giving orbits at many beam currents and various attenuations
- Python script was developed to analyze the orbit files
- The results of the analysis were used to prepare a calibration, and a script to apply the calibration directly to the data

Initial Investigation



- Typical BPM from Trouble Region
- Mostly linear response, but signal offset of about 2000 adc counts
- some non-linearity at low intensity/high attenuation

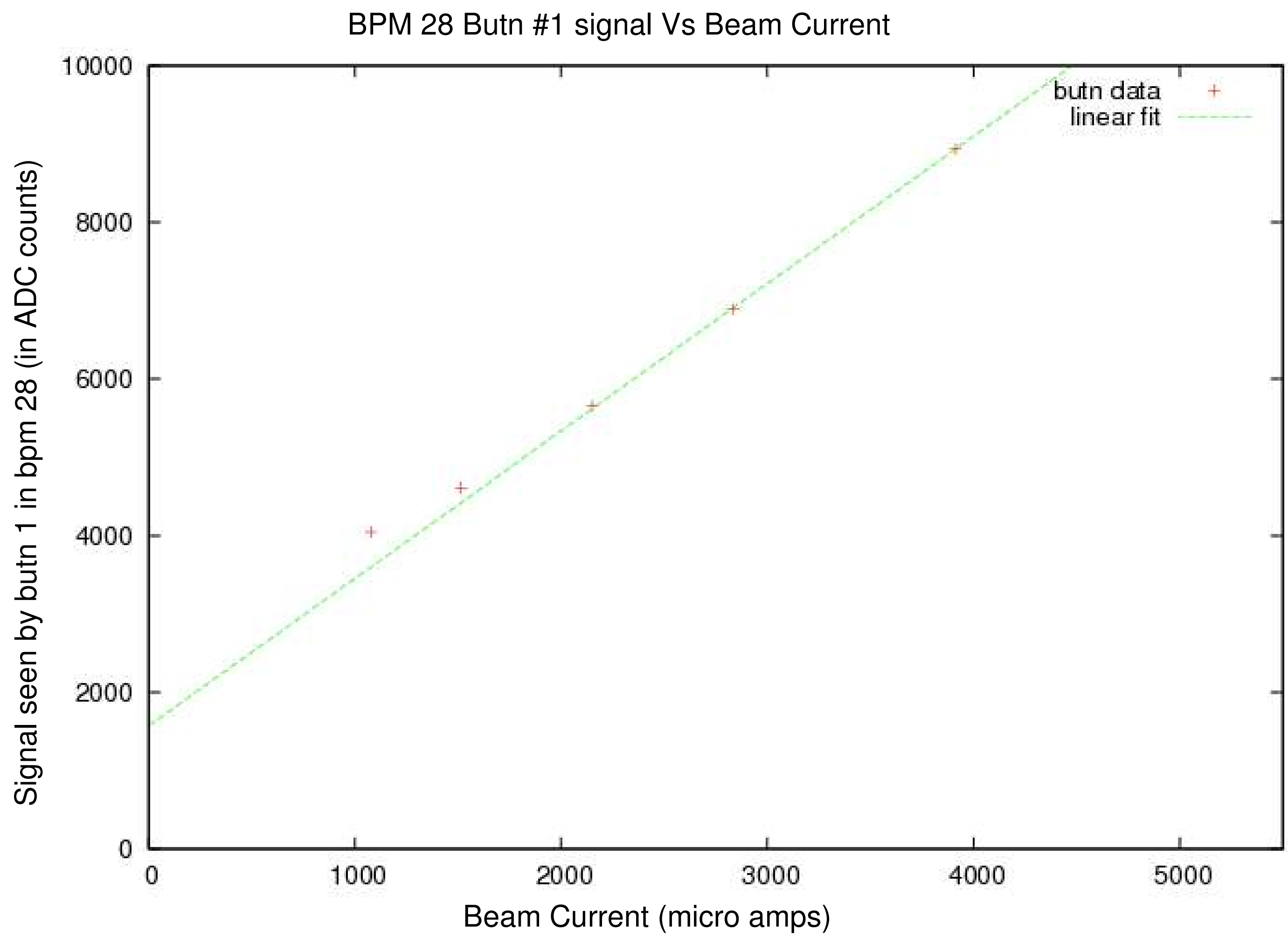
Why is vertical offset a problem?

The formula we use for determining beam position is:

$$x = \frac{(b_2 + b_4) - (b_1 + b_3)}{\sum (b_i + \Delta S)}$$

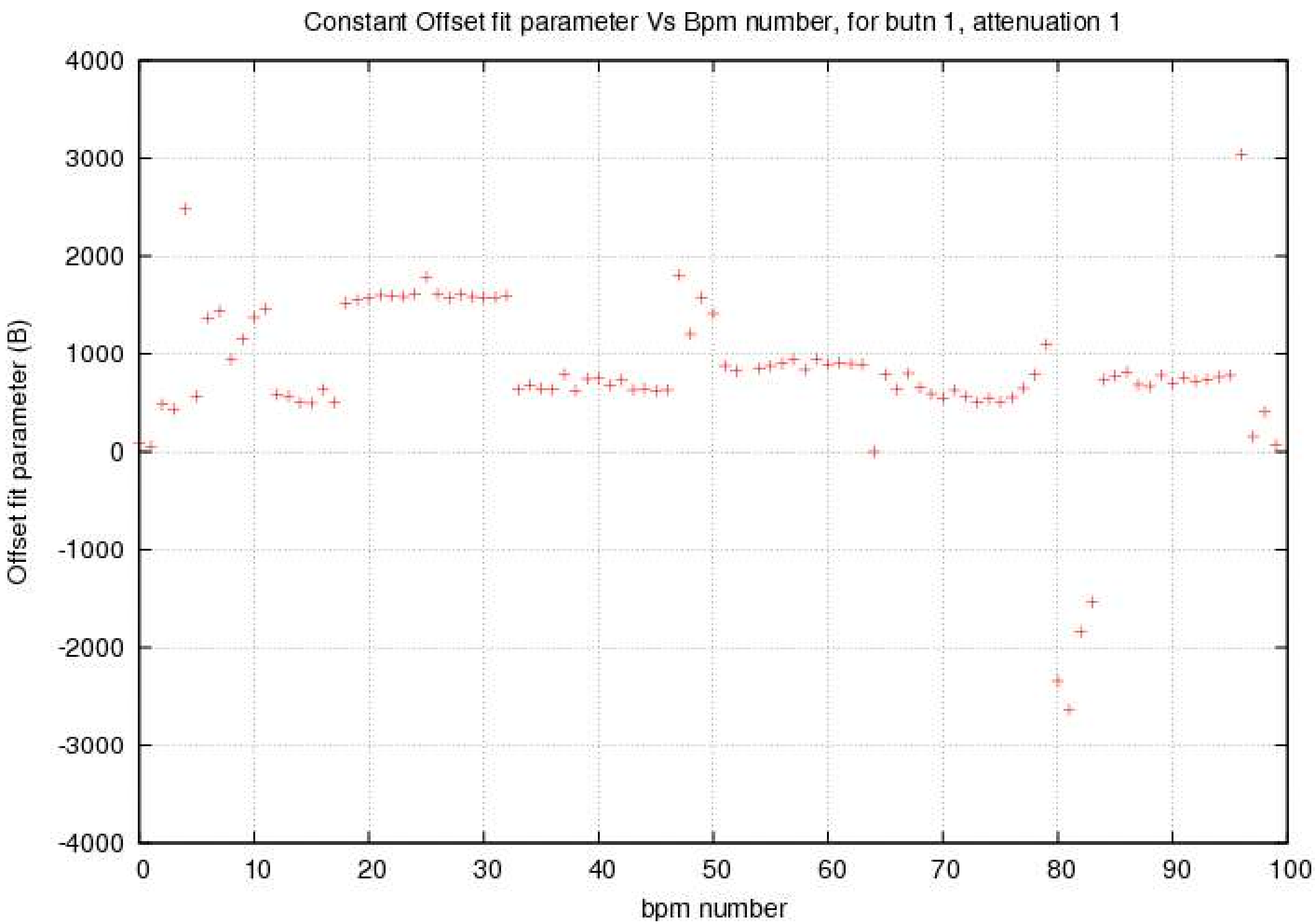
where ΔS is the signal offset. If $\Delta S = 0$, then all is well offset is important!

Initial Analysis



- consider the slope of the top two points, lowest attenuation, butn #1
- As you can see, there is a considerable signal offset

Plotting Fit Parameters

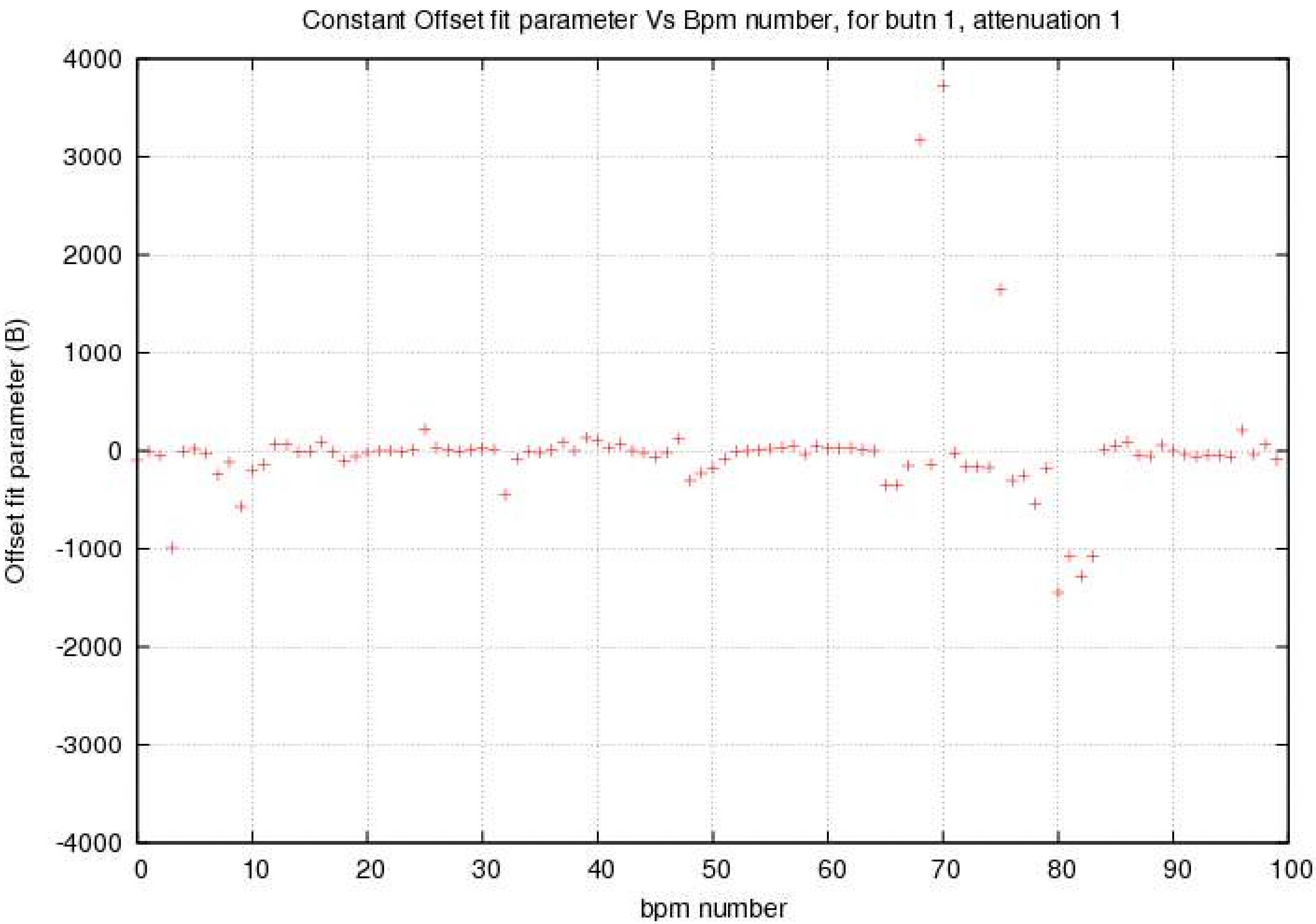


Plot of the offset, for butn #1

Note the large jump between bpms 19-33! These BPMs are all on the same processor. Looks like a data acquisition hardware problem

A similar localized effect is present for all bpm buttons

Doing a Correction

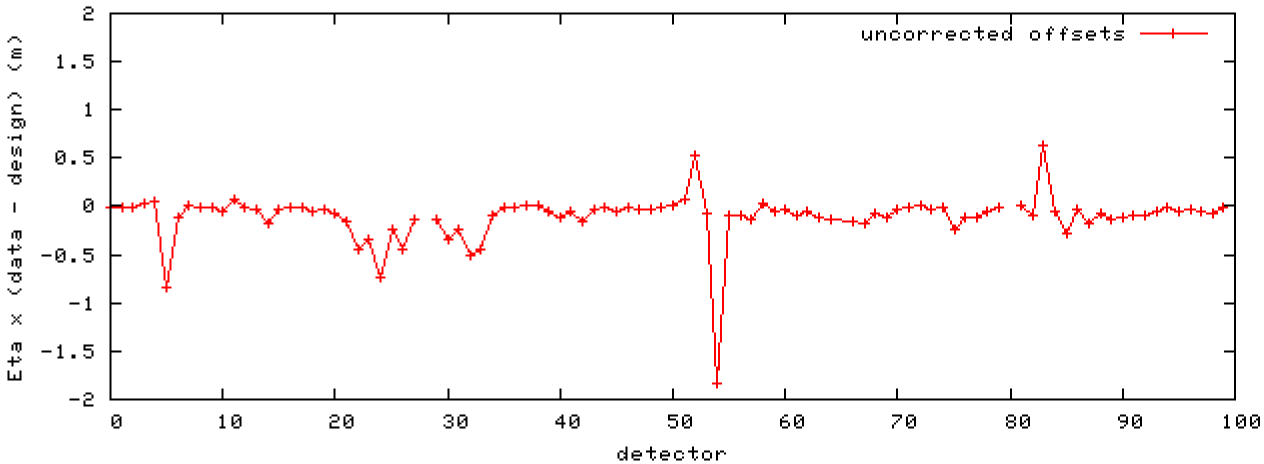


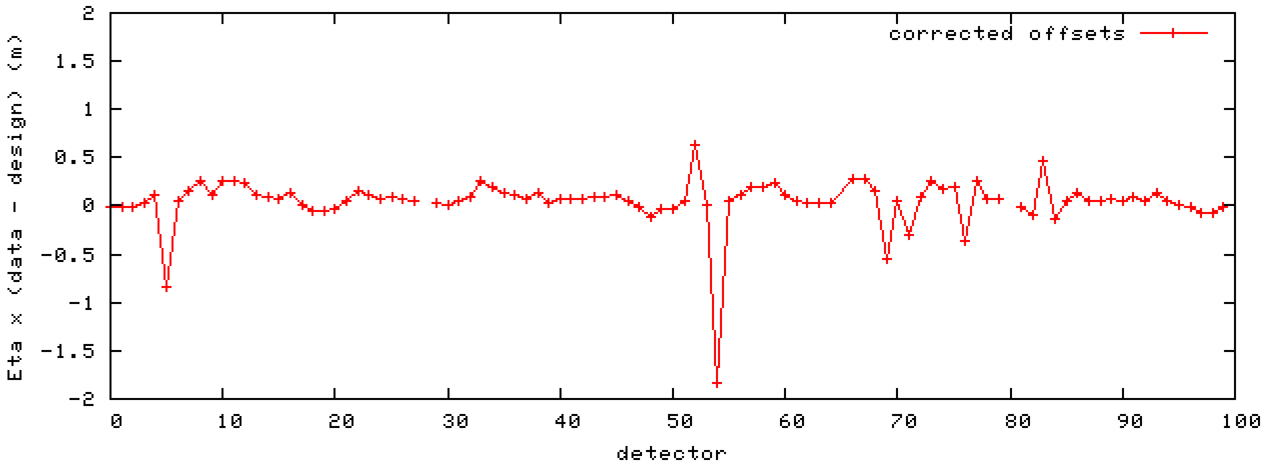
Plot of the offset

Averaged across the lowest two attenuations, and all four butns

Capability exists in code to correct butns individually

Effects on Dispersion





Horizontal Dispersion

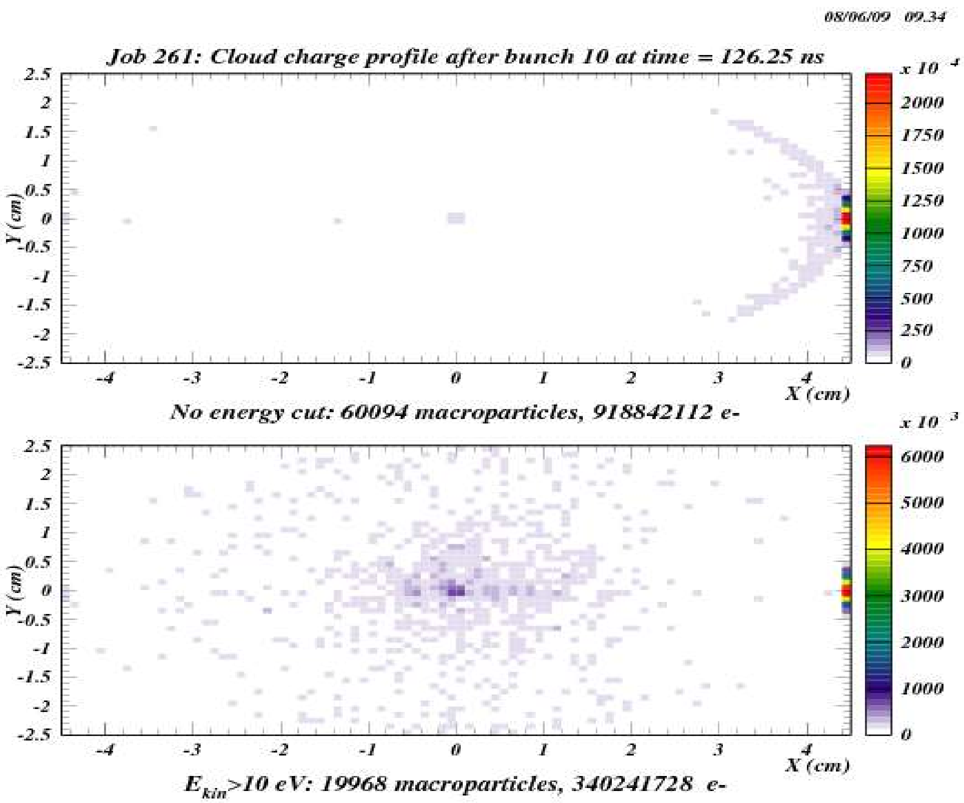
Measured dispersion, before and after correction

Note that the region between 19 and 33 is corrected to below the level vital for the success of the CesrTA project (<5cm dispersion)

Electron Clouds

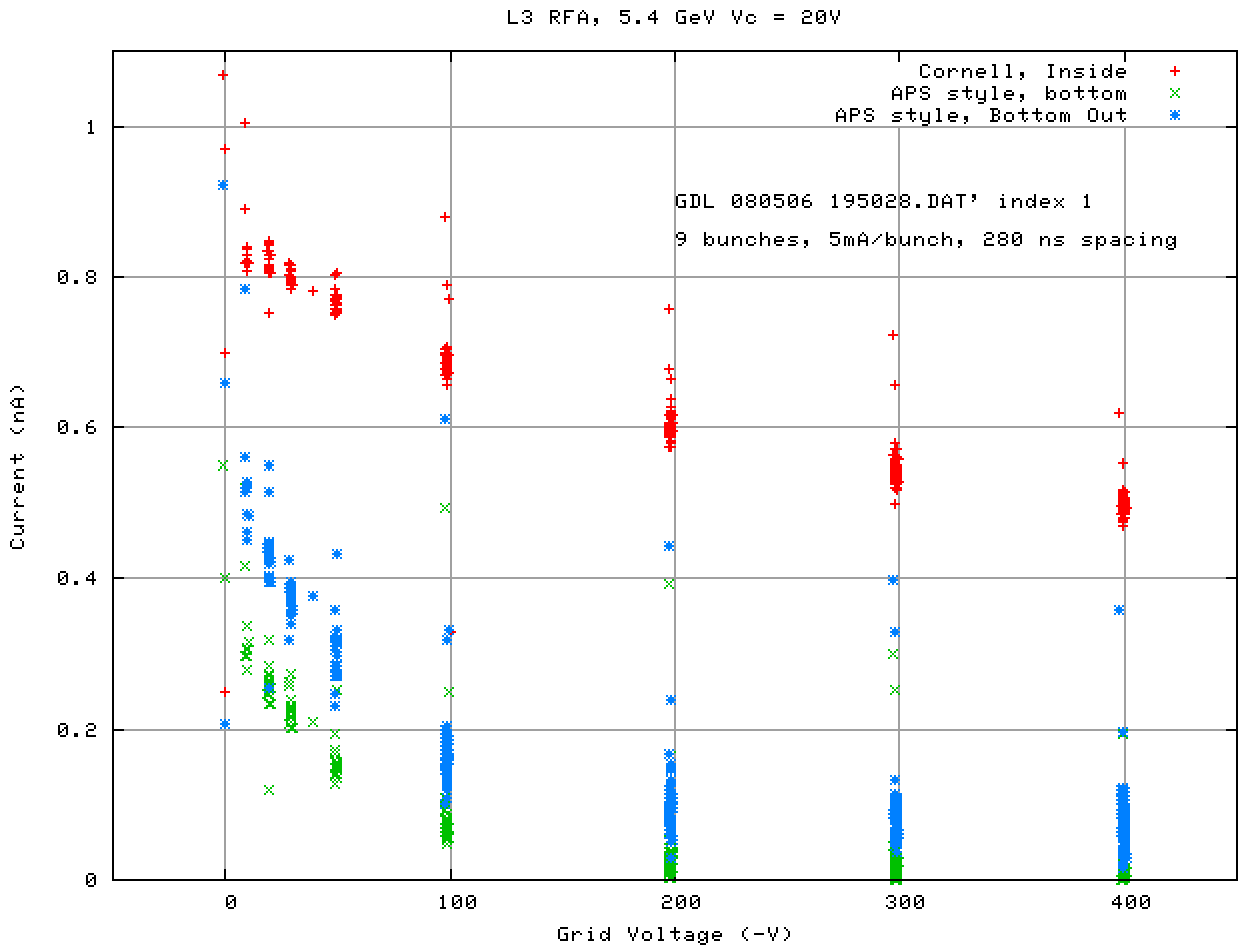
Electron Clouds are the major source of emittance growth in the ILC

- Primary Source: Synchrotron Light
- Charges accelerated by beam passage
- Secondary Electrons generated from high-velocity electrons impacting the beam pipe wall
- We are using ECLOUD V3.2 to model 2d electron cloud dynamics
- Sample ECLOUD output:
- Showing the cloud density around the beampipe.
- Rather than using individual Electrons, model using macro-particles with constant charge/mass ratio



Retarding Field Analyzers

- Consists of a retarding grid and a collector grid.
  – Retarding grid carries negative voltage to repel low-energy electrons, serves as energy cutoff
  – collector grid carries positive charge, measures current of incident electrons
- Used to measure Electron Cloud build up and energy profile



Displays current on collector plate as a function of retarding grid voltage. This gives us an integrated energy spectrum of the electrons

Questions and Acknowledgements

Questions?

Thanks to Jim Crittenden

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