Radiation and Beam Background Issues in the BABAR Calorimeter

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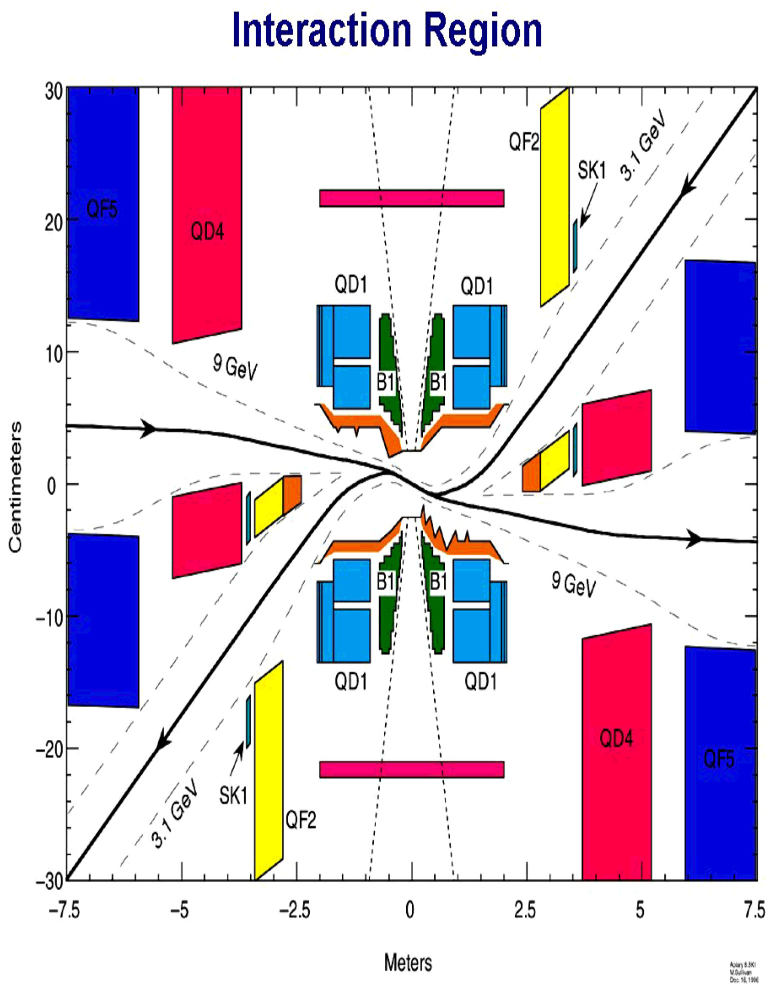
Beam backgrounds in *BABAR*

- **Beam background rates in the *BABAR* detector are mainly attributable to the presence of fixed dipole magnets close to the IP**
  - beams collide head-on but are separated 62 cm from the IP
  - B1 dipoles begin 20 cm from the IP

- **Magnets tend to sweep off-energy particles into the detector**

- **Expect no significant time structure in EMC backgrounds**
  - EMC shaping time >> bunch crossing time



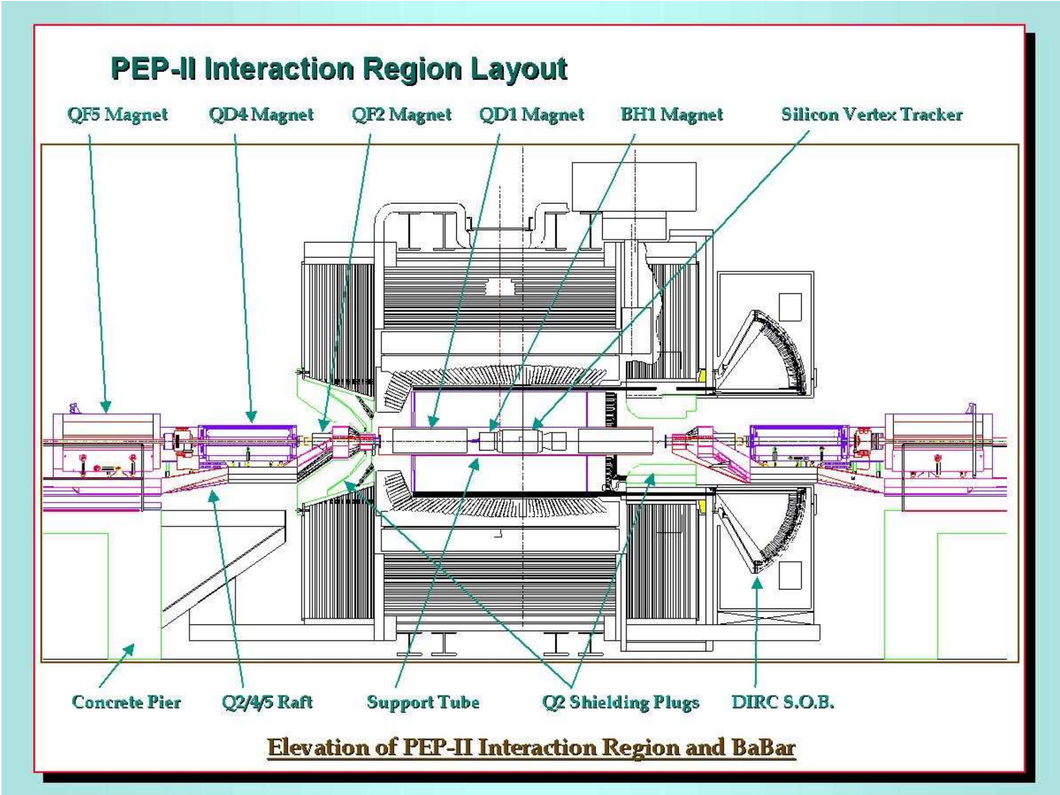
Calorimeter (EMC) backgrounds

- Observed backgrounds are mostly low energy photons from EM showers produced by lost primary beam particles which strike machine elements near the interaction point

- Main culprits are the Q2 septum chambers and (to some degree) the Q4&5 flanges

- Also a significant "luminosity" contribution due to small angle (radiative) Bhabhas which strike machine elements (B1-Q2)

- Characteristic HER and LER and luminosity background patterns and energy spectra



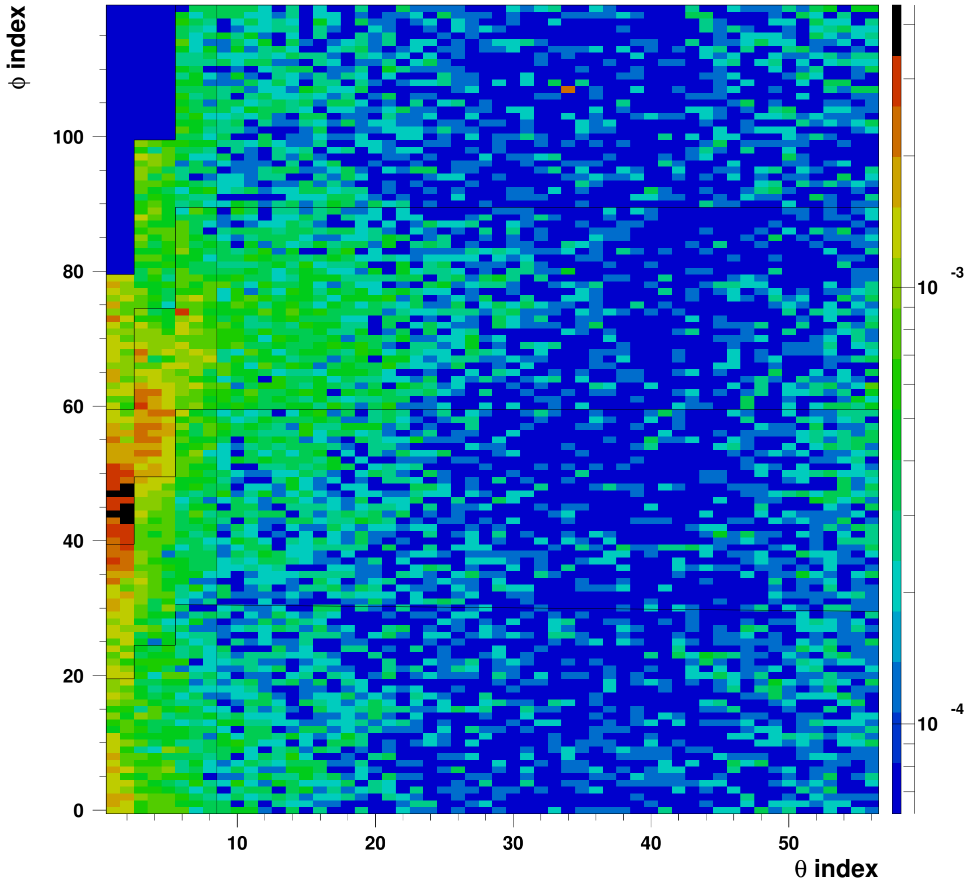
EMC backgrounds

Beam background rates are obtained using random (non-physics) triggers to provide a "snapshot" of detector conditions during normal data taking

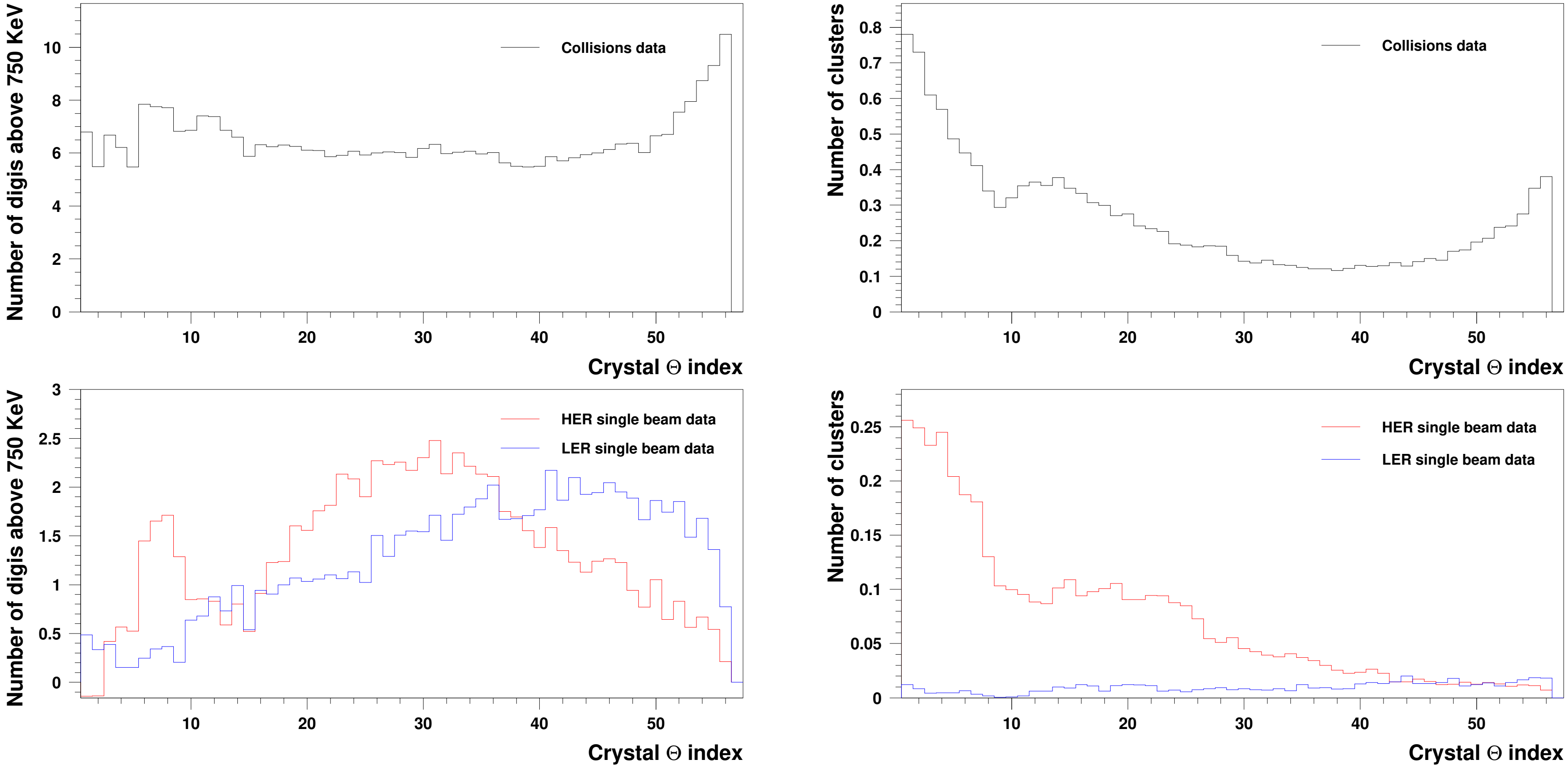
- HER(LER) single beam backgrounds preferentially produce occupancy in the forward(backward) direction in the horizontal plane, towards the inside(outside) of the PEP-II ring

- Luminosity produces more uniform EMC occupancy

- Different regions of the detector see significantly different rates of high or low energy photons

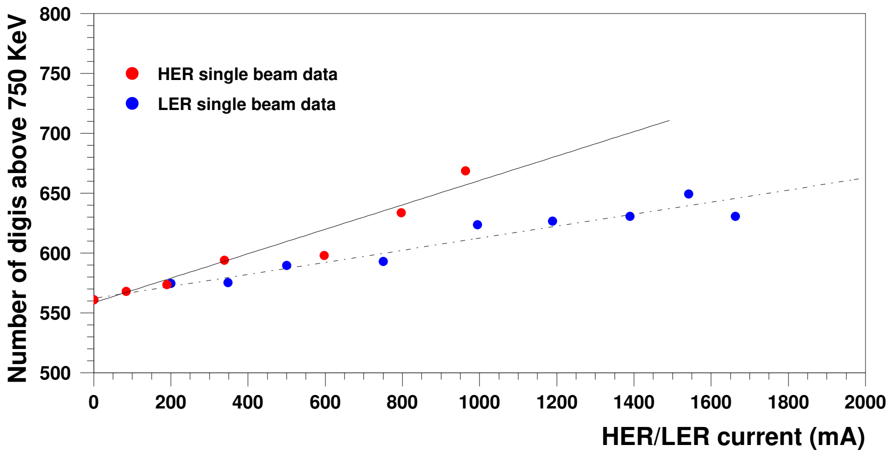


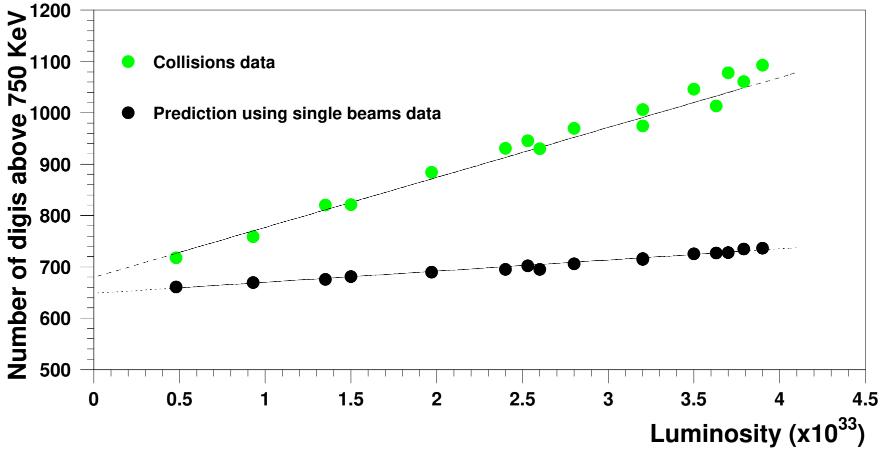
Angular distributions



⇒ Energy scale of interest dictates size of the beam background problem

Parameterization of rates

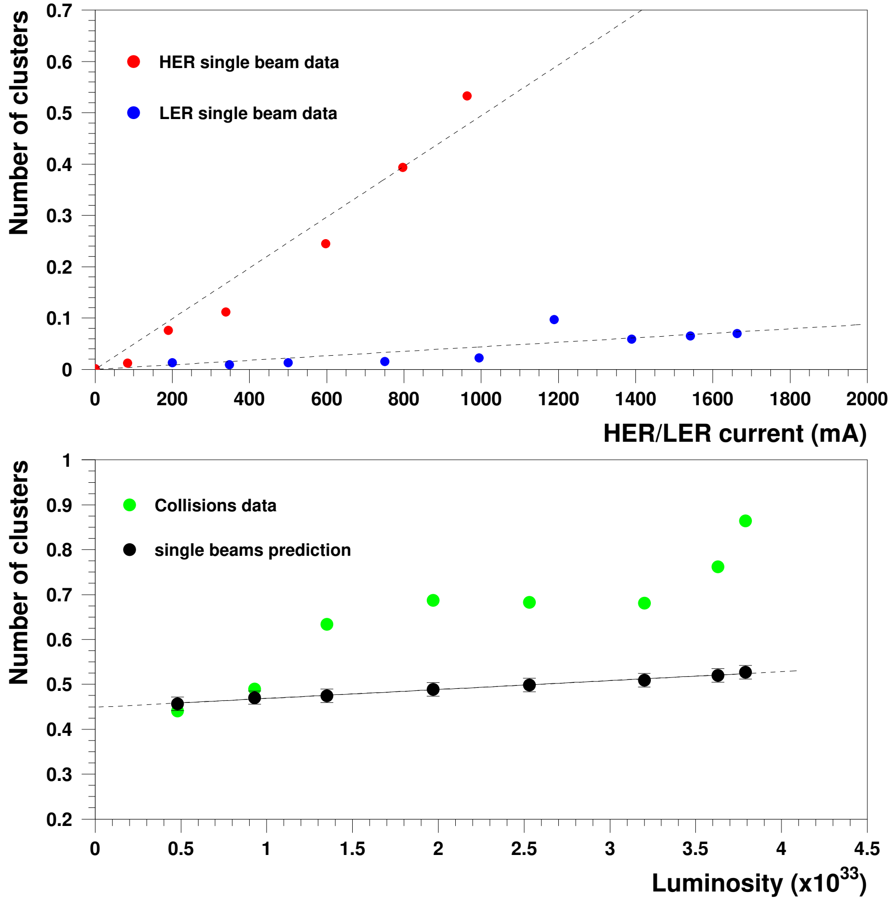




- HER/LER/Lumi contributions obtained (very) recently from single and colliding beam runs under tightly controlled conditions
- Last done in June 2001: Many changes!
  - Digital filtering of waveforms
  - Lower crystal energy threshold (1 MeV $\longrightarrow$ 0.75 MeV)
  - Vacuum improvements in the vicinity of the IR
- Electronics noise contribution obtained from "no-beam" runs
- Figures of merit are:
  - Number of crystals with signal (digis) above the 0.75 MeV threshold
  - Number of reconstructed clusters ($E_{clus} > 20$ MeV)

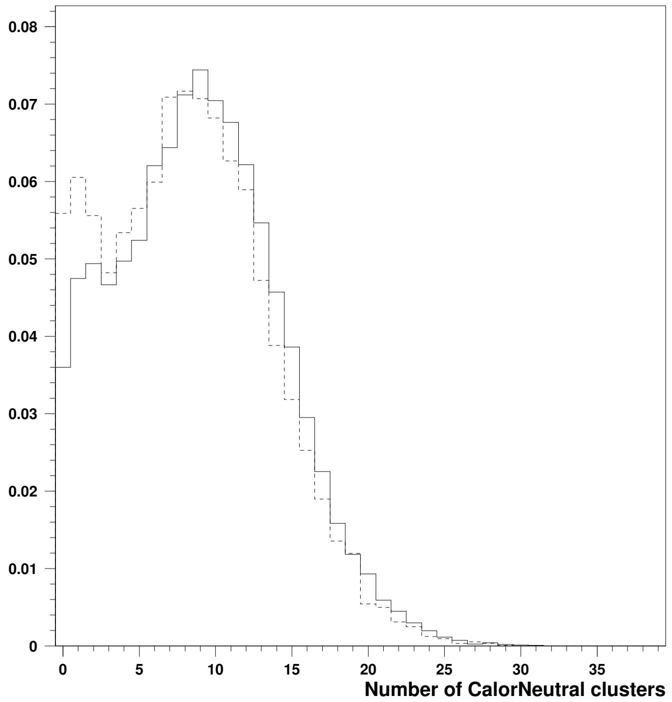
Cluster reconstruction

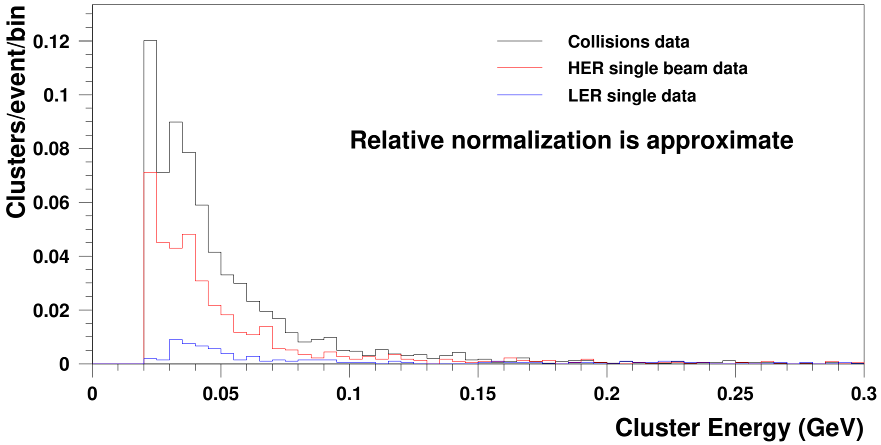
- Raw digis ($E > 750$ keV) must pass a "sparsification" algorithm
- Cluster formation requires a "seed" digi of $E > 10$ MeV
- Digis are added to the cluster using a nearest-neighbour algorithm
- Final cluster must have energy $E_{clus} > 20$ MeV
- Loose (tight) cluster candidates at analysis level generally require $E_{clus} > 30$ (100) MeV



Background clusters

Number of reconstructed clusters in "multihadron" events in low (dashed) and high (solid) luminosity data:





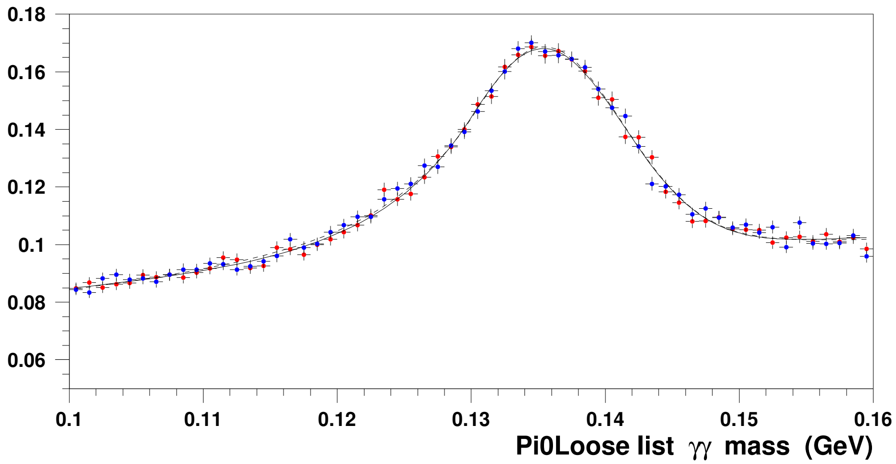
- Typically see one cluster per event from backgrounds ($E_{clus} > 20$ MeV)
- HER and Luminosity backgrounds dominate cluster production

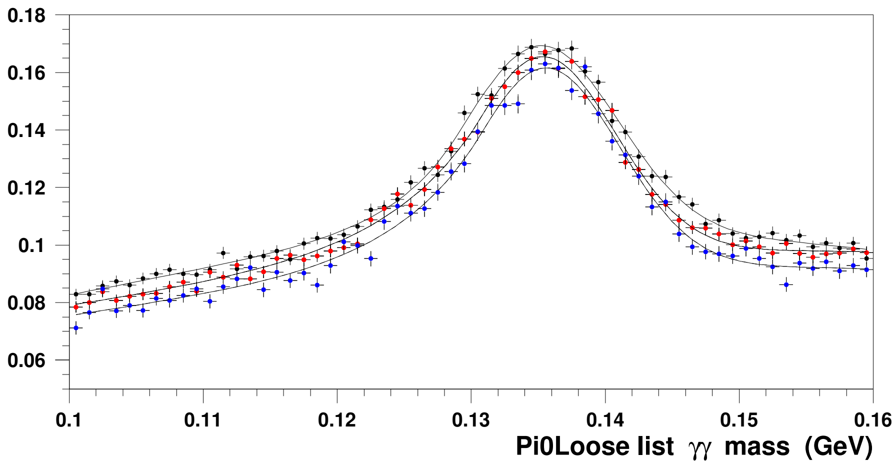
π^0 reconstruction

At very high luminosity:

- Random photons from beam background can either produce their own clusters, or overlap with clusters from "interesting" physics events
- Expect increased combinatorics under π^0 peak
- Expect (eventually) a degradation of the π^0 width, and an upwards shift in the central value of the mass

Compare data from high and low luminosity runs...

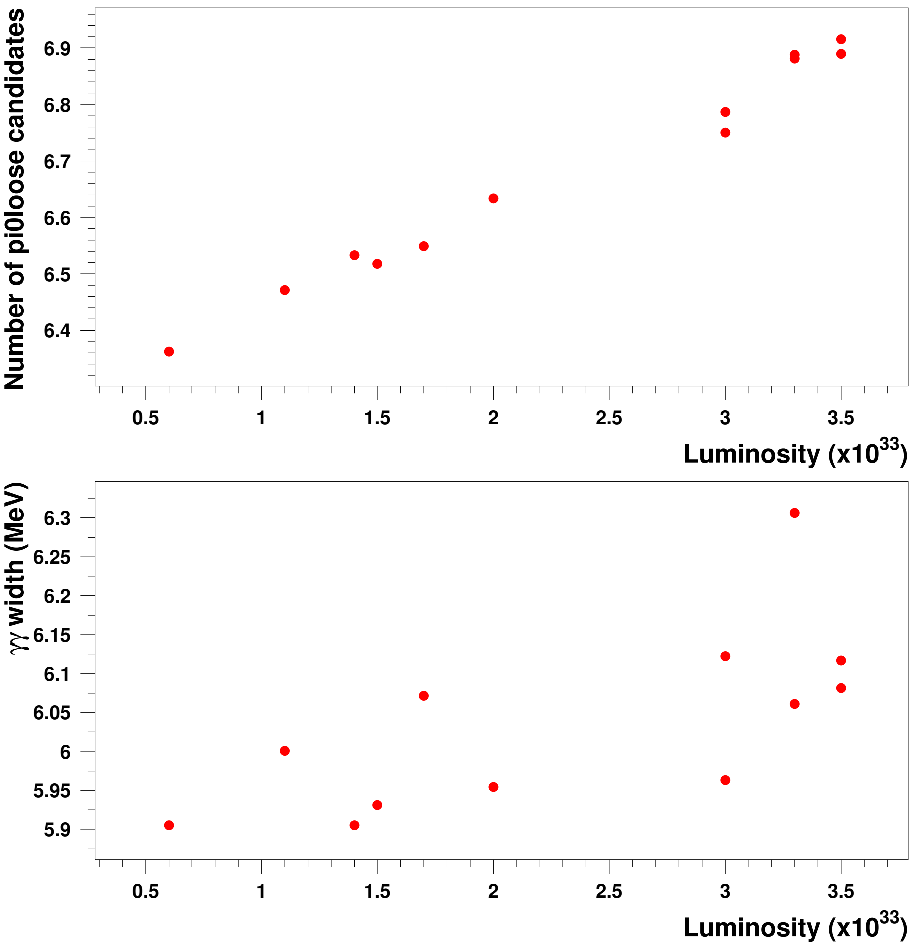




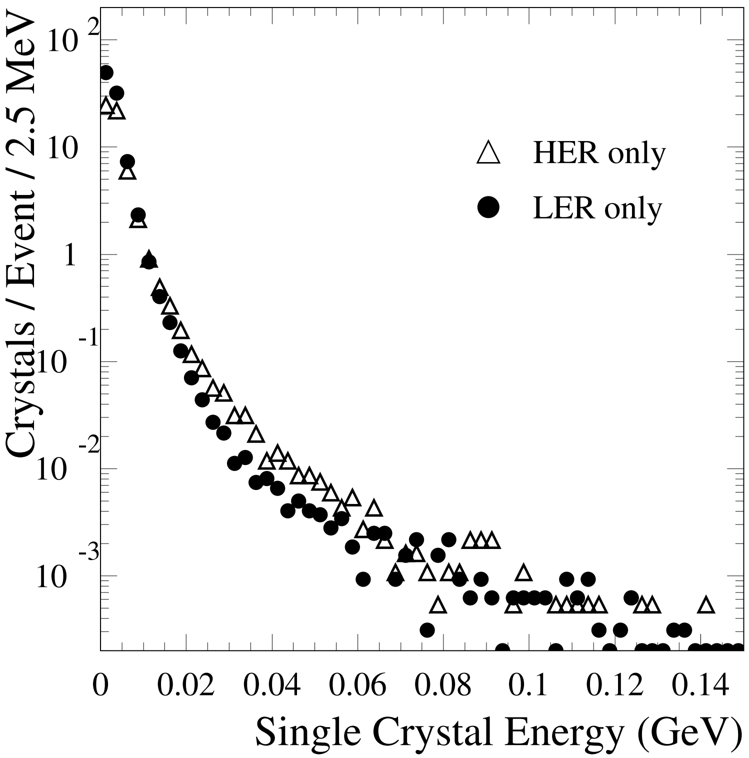
π^0 reconstruction

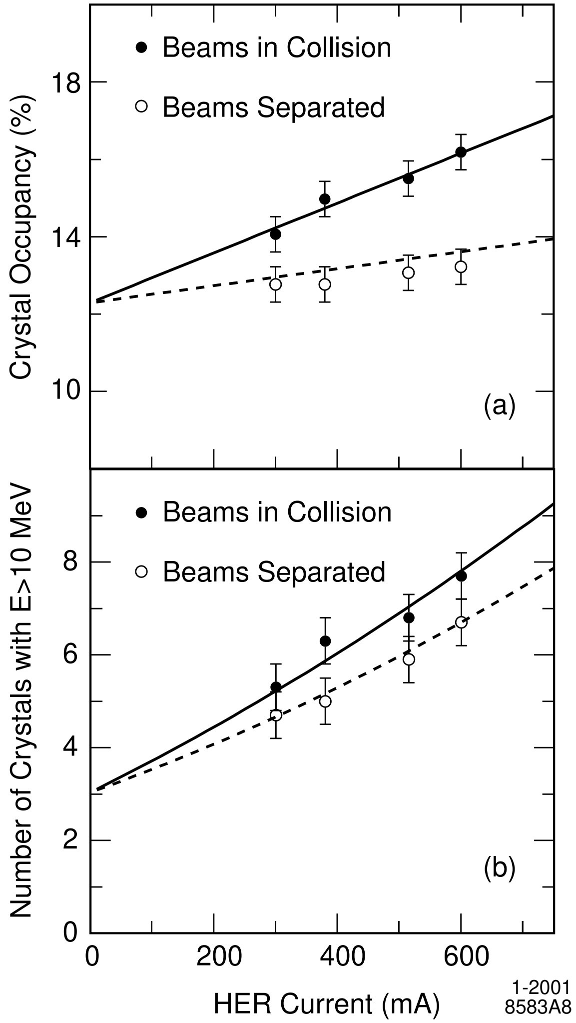
VERY preliminary results from recent backgrounds experiments indicate:

- Clear evidence of increased combinatorics from background clusters...
- ...but no convincing evidence (so far) of a degradation of the width, or any shift in the mean



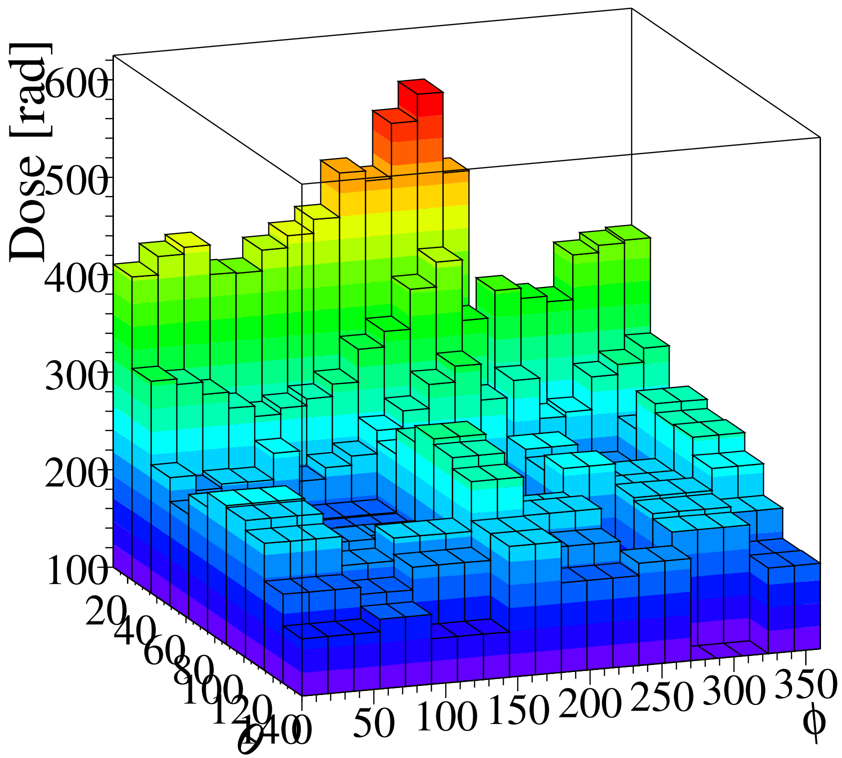
Backgrounds in 2001





Radiation monitoring

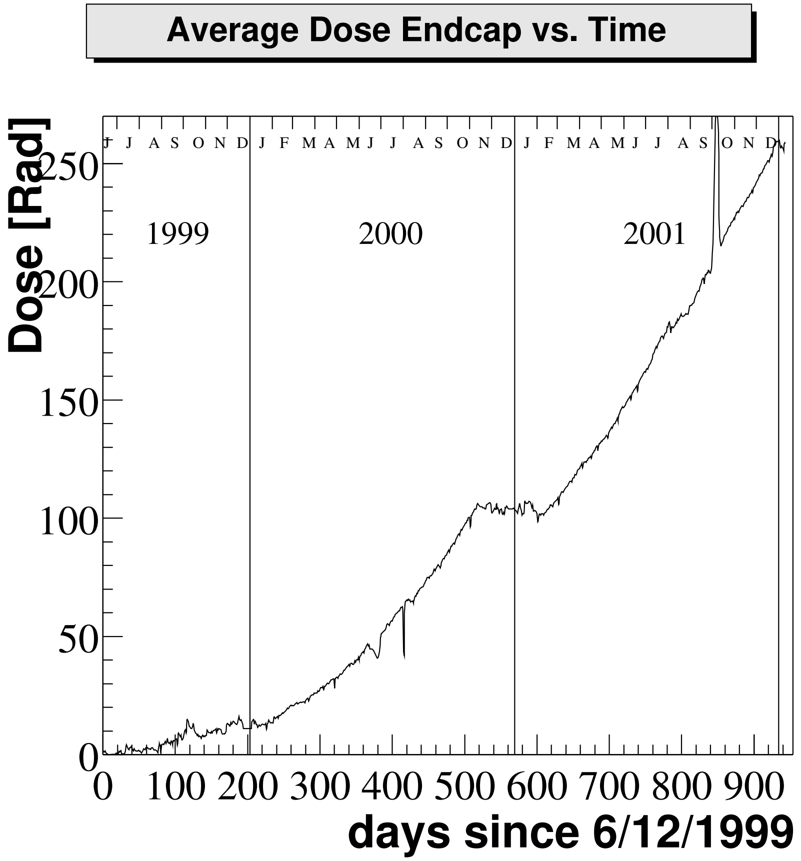
- Radiation damage in CsI(Tl) results in a reduction of light yield and crystal uniformity through the formation of color centres in the crystal
- Dose budget is 10 kRad over *BABAR* lifetime
- Radiation is predominantly from lost-particle backgrounds and very low angle radiative Bhabha events
- Array of 116 RadFETs distributed over front face of EMC crystals
- Dose map reproduces observed pattern from beam backgrounds

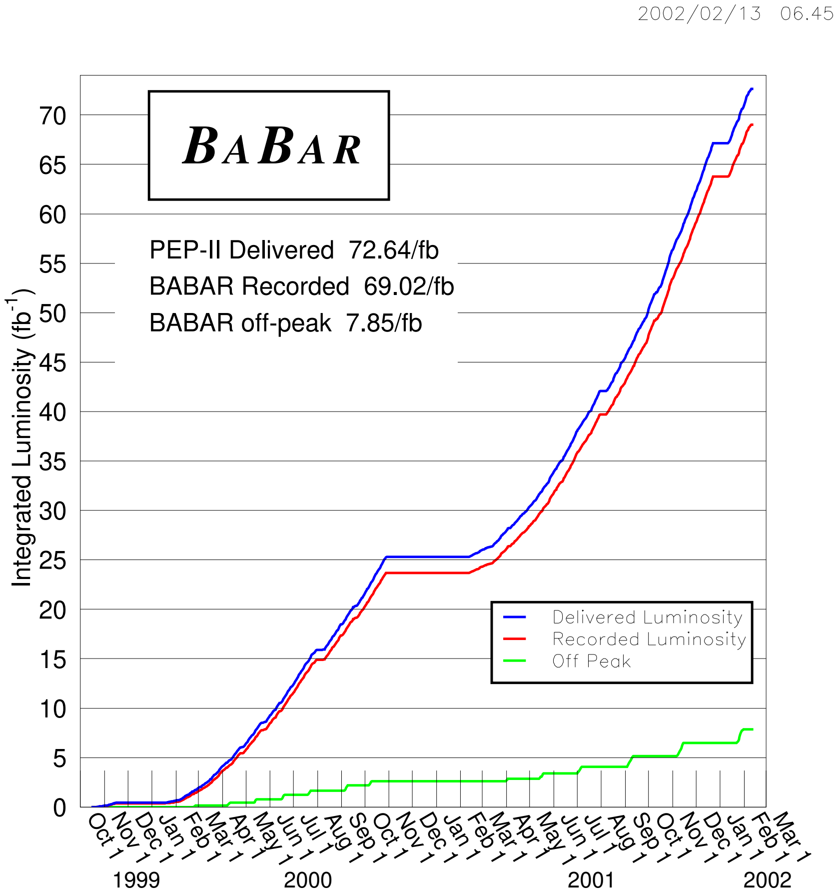


(plots by Joerg Stelzer)

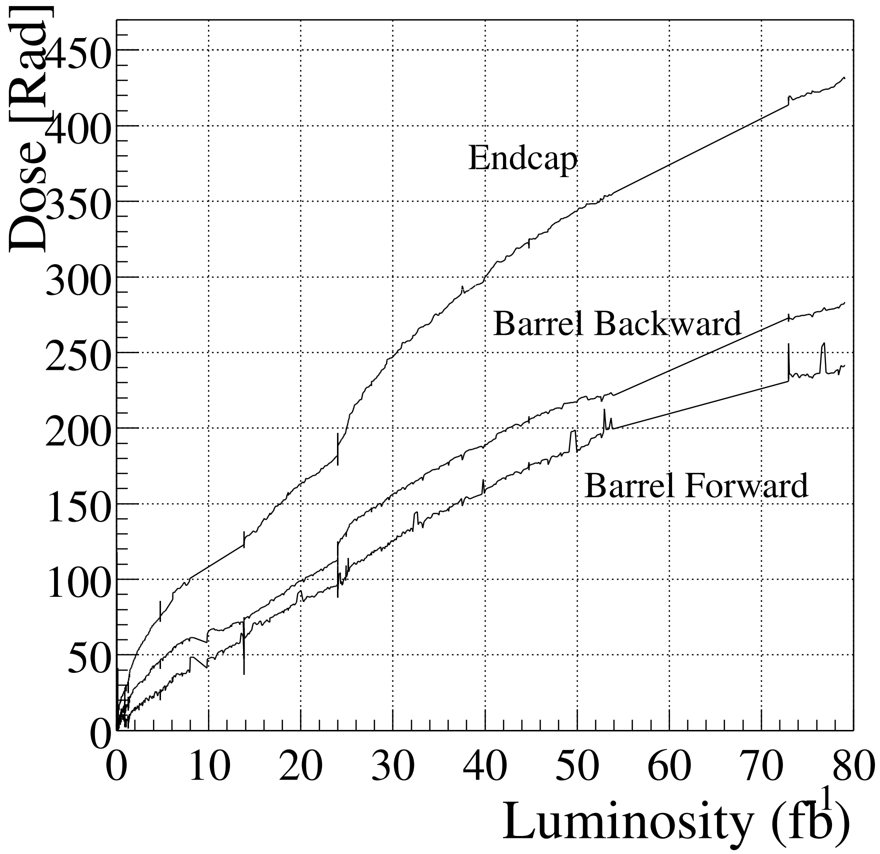
Integrated dose

Integrated dose also tracks the integrated luminosity:



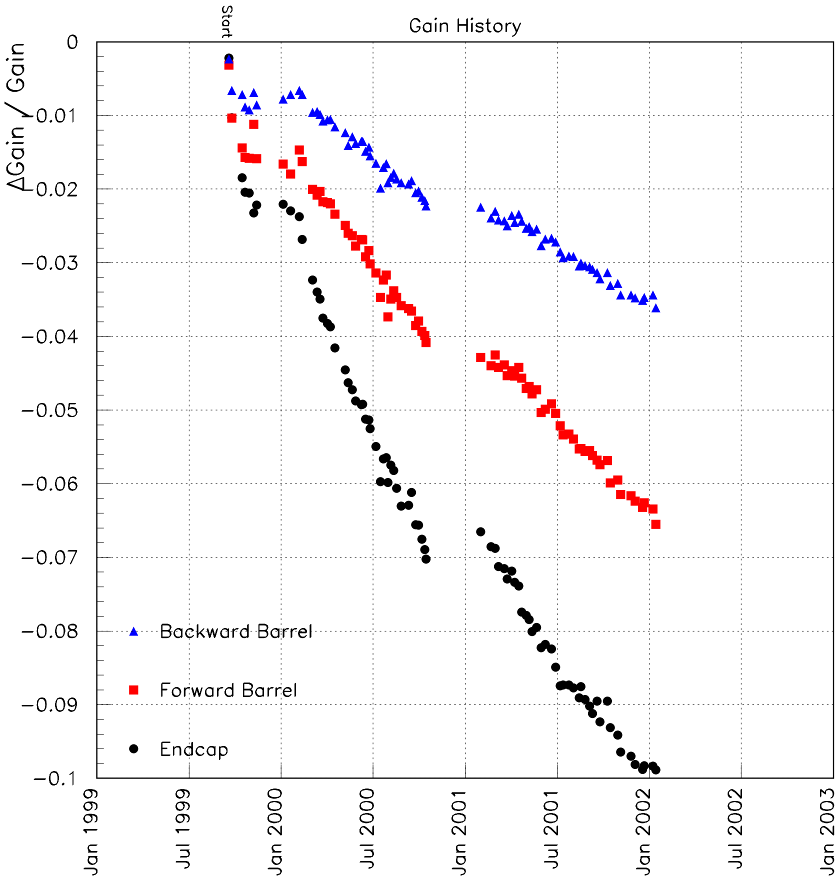


Radiation monitoring

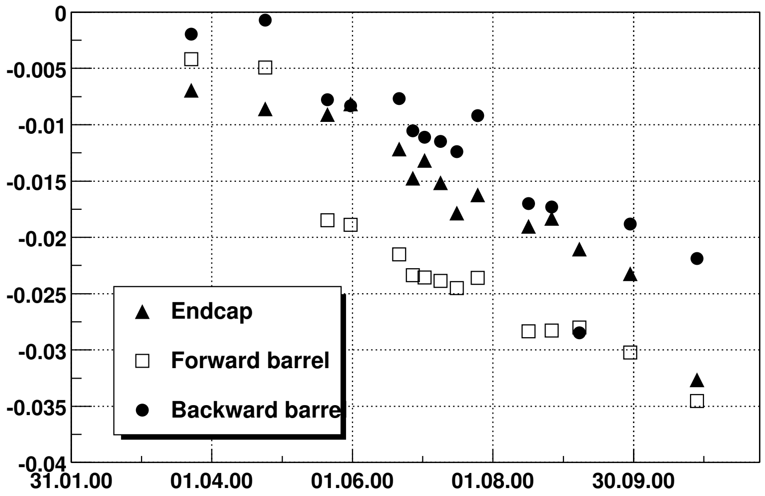


- Dose accumulation so far has a rate of $(4-12)$ Rad/fb^{-1}
- Assuming scaling holds, EMC should be ok until ~2007

Crystal light yield

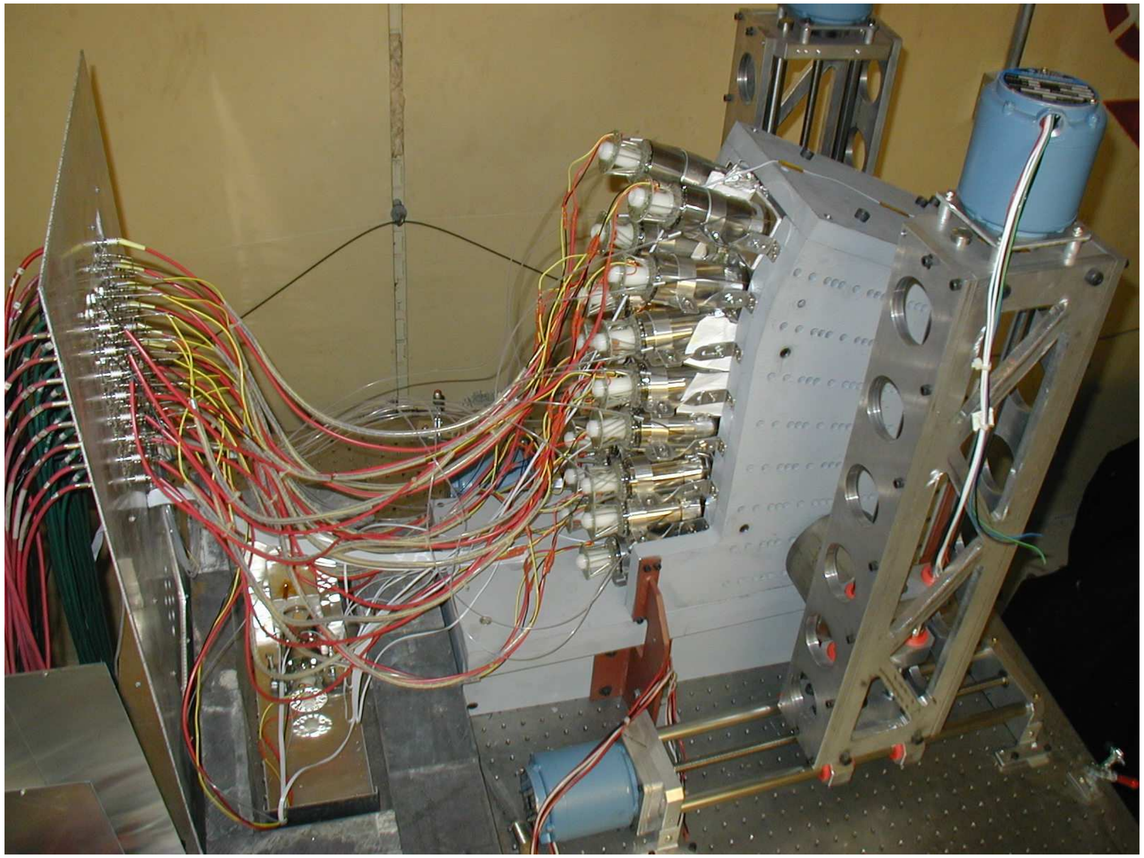


Relative gain obtained using the radioactive source (6 MeV) and Bhabha calibrations suggest that the crystals are not being uniformly irradiated:



CsI(Tl) radiation damage studies

- Experiment in progress [a] at SLAC to study the effect of radiation damage on *BABAR* CsI(Tl) crystals
- Test setup permits precise measurement of light loss along the length of the crystals after irradiation with a calibrated source



[a] T. Hryn'ova, P. Kim, M. Perl, H. Rogers, R. Schindler, W. Wisniewski

Outlook

- **Present background rates seem to be managable:**
  - Effective background reduction through digital filtering, sparsification and cluster reconstruction
  - Typically ~ 1 low-energy cluster per event attributable to backgrounds
  - Small effect on π^0 combinatorics and no visible effect on the width
- **Extrapolation of rates (+simulation) suggests that physics impact should be tolerable for at least the next few years**
- **Effect of radiation damage is clearly visible, but not yet problematic**
- **Radiation dose closely tracks integrated luminosity and is within budget**