BaBar Backgrounds

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B-Factory Operations Review

April 24, 2006

Topics

- Background Model / Characterization
- Past Year Performance
- Future Projections

Background sources in PEP-II

- **Synchrotron radiation** *(this bkg negligible in PEP-II)*

- **Beam-gas (bremsstrahlung + Coulomb)**
  - **HEB only:** $B_{Hbg} \sim I_H * (p_H^0 + P_H^{Dyn} * I_H)$ ***Note: $p^0 = f(T)$!***
  - **LEB only:** $B_{Lbg} \sim I_L * (p_L^0 + P_L^{Dyn} * I_L)$ ***Note: $p^0 = f(T)$!***
  - **beam-gas x- term:** $B_{LHbg} \sim c_{LH} * I_L * I_H$ *(LEB+HEB, out of collision) (?)*

- **Luminosity (radiative-Bhabha debris) – *major concern as L ↑***
  - $B_P \sim d_P * L$ *(strictly linear with L)*

- **Beam-beam tails**
  - **from LER tails:** $B_{L,\,bb} \sim I_L * f_L(\xi_{L,H}^{+/-})$
  - **from HER tails:** $B_{H,\,bb} \sim I_H * f_H(\xi_{L,H}^{+/-})$

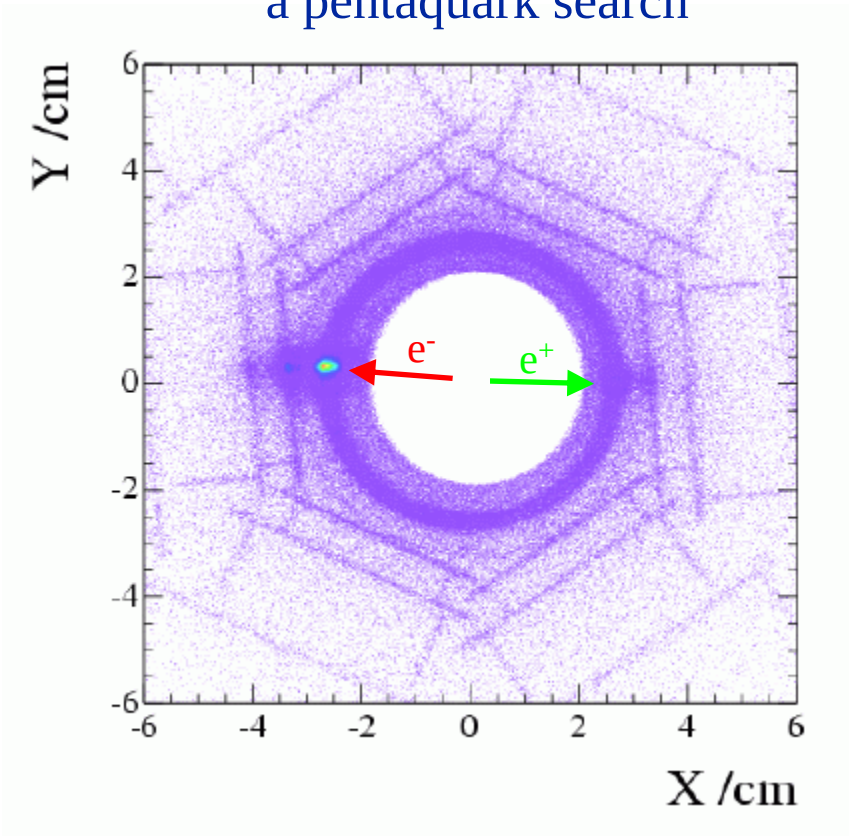
- **Trickle background:** B_{Li} **,** B_{Hi} *(injected-beam quality/orbit + beam-beam)*

- **Touschek:** B_{LT} *(signature somewhat similar to bremsstrahlung; so far small)*

Beam Gas Background Illustration

Beam-gas bremsstrahlung reduces the energy of the incoming electrons and positrons. The separating dipoles bend some of these into the detector along the horizontal plane.

$K_S p$ production vertices from a pentaquark search



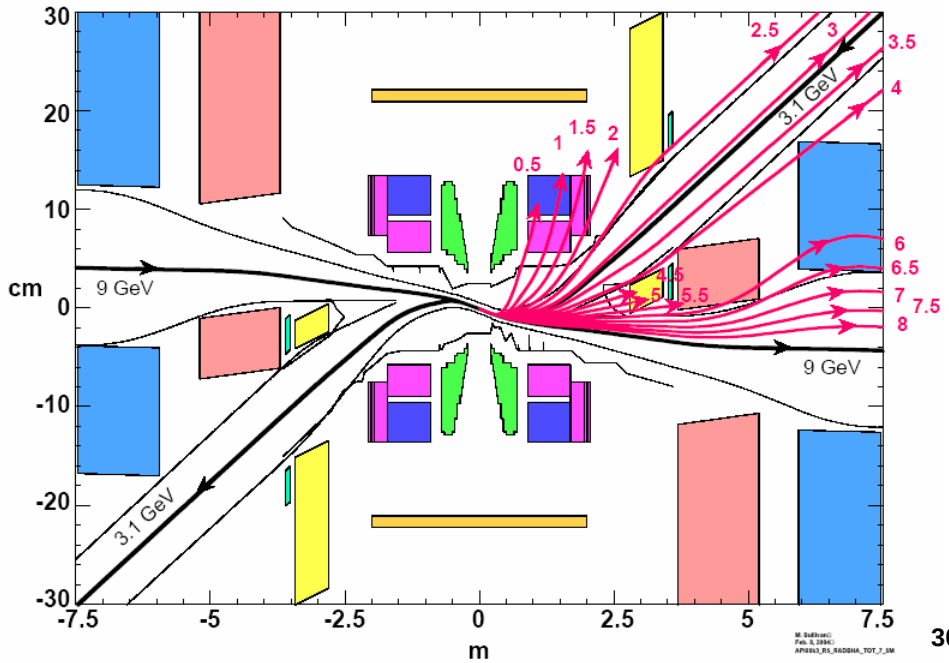
J.Coleman and W.Dunwoodie

Luminosity background

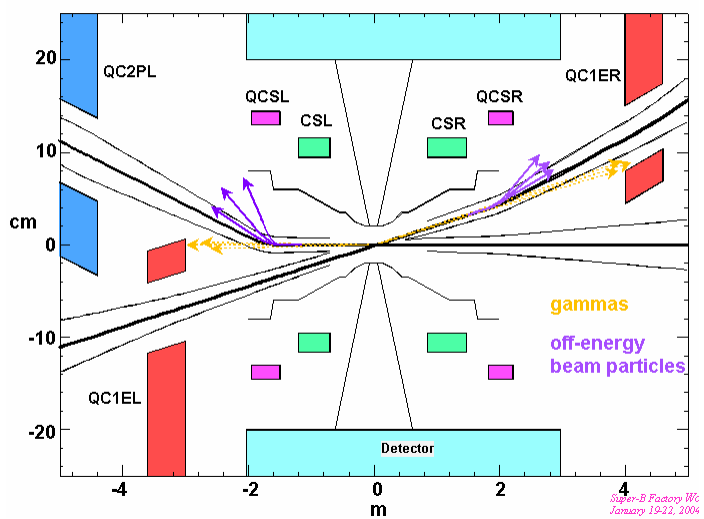
$e^+ e^- \rightarrow e^+ e^- \gamma$

- elm shower debris
- neutrons!
  - no contribution from coasting HEB or LEB
  - *may* dominate DCH, DIRC rate

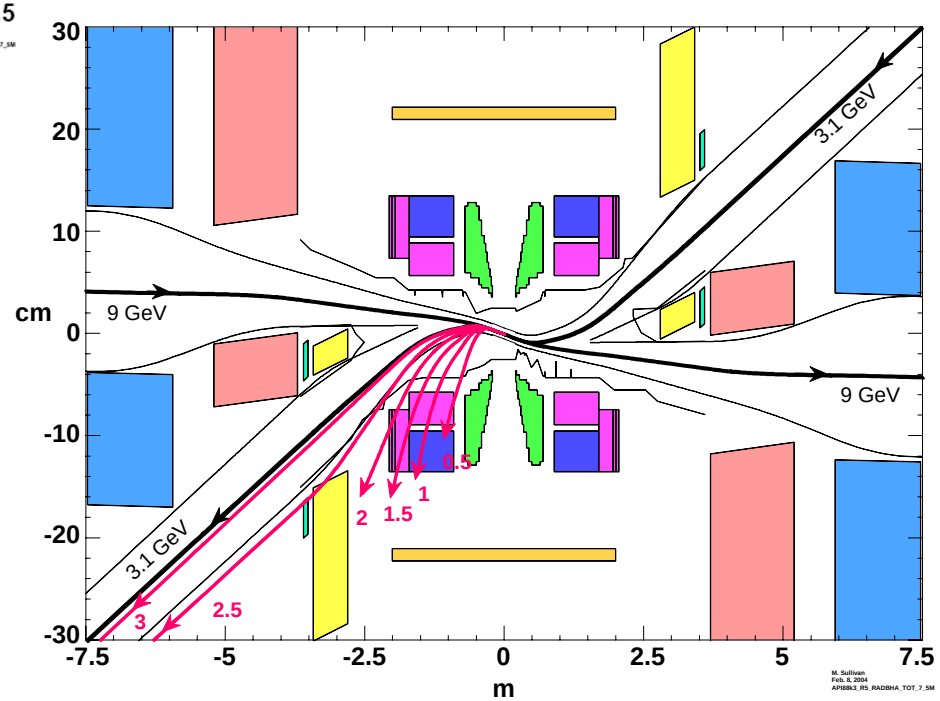
HER Radiative Bhabhas



KEK Interaction Region

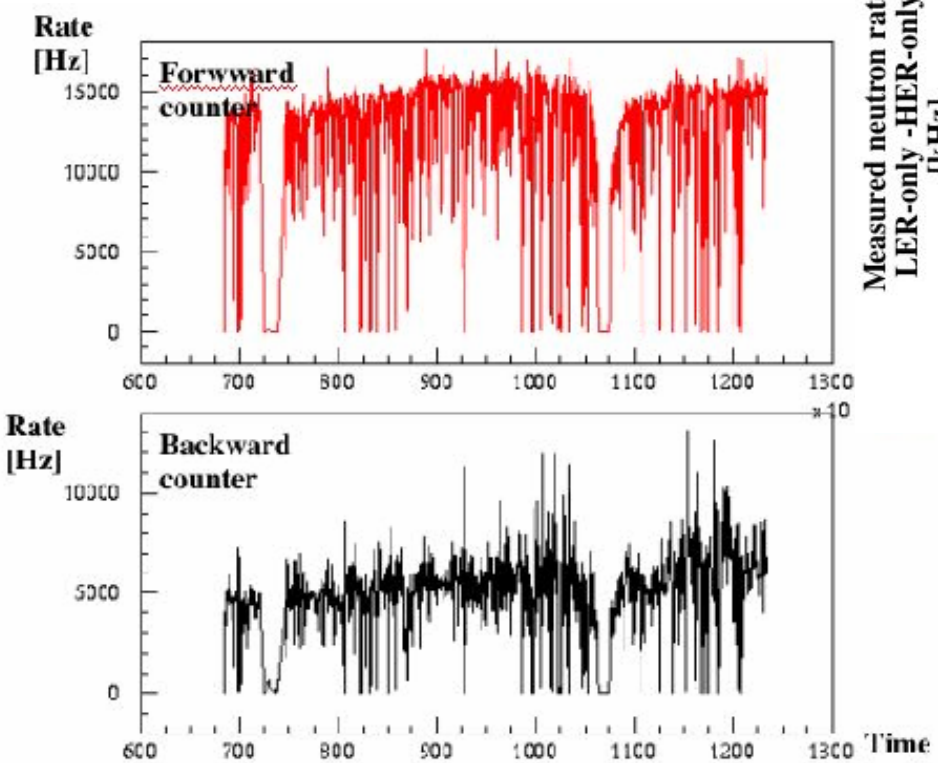


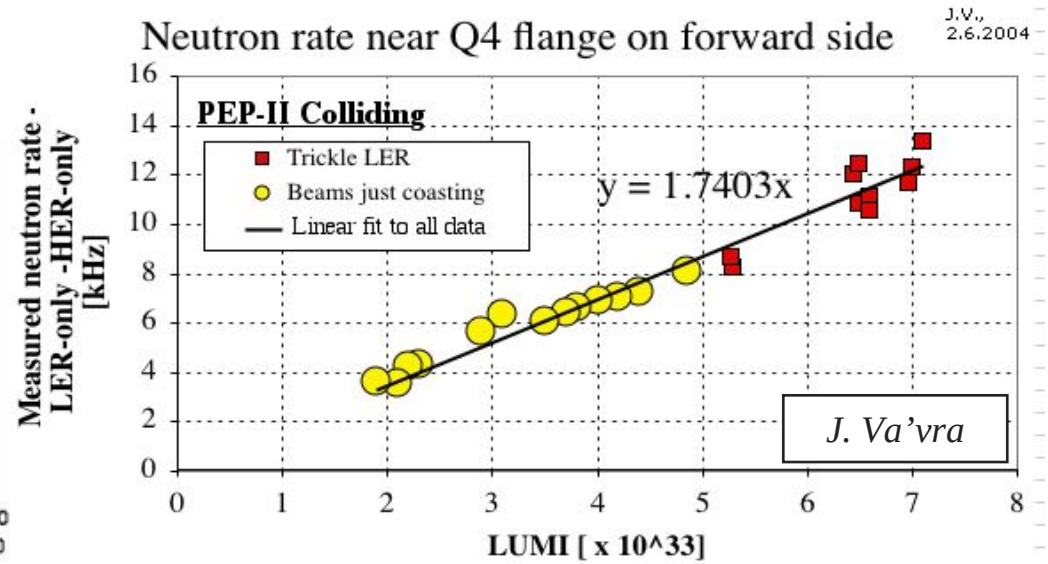
LER Radiative Bhabhas



More Luminosity Background

Neutrons

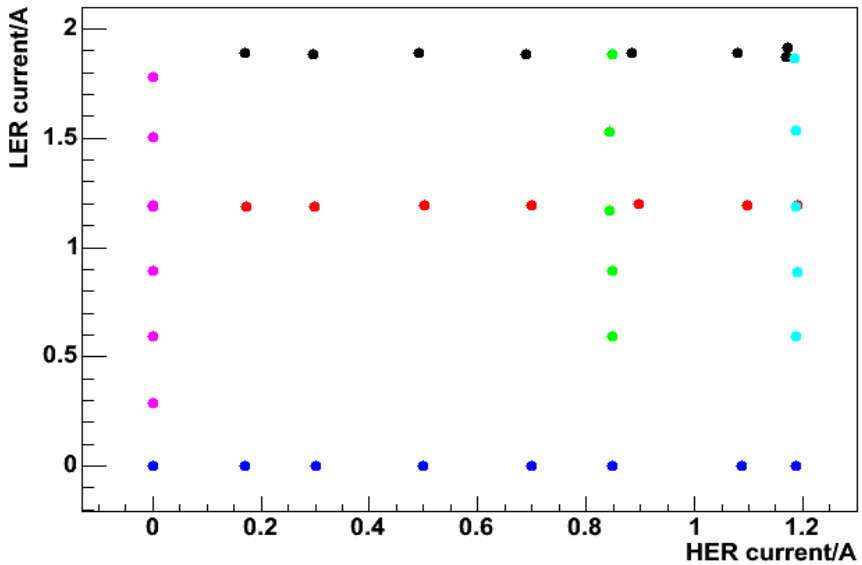




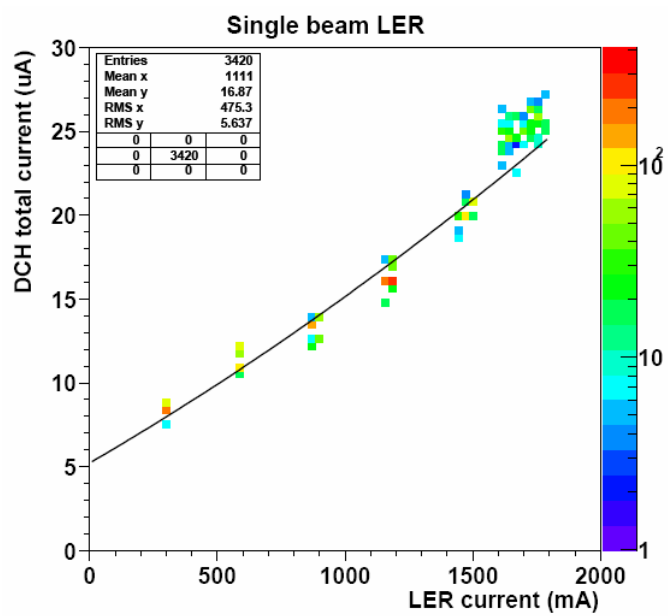
A high rate of neutrons is generated from radiative Bhabha interactions. These neutrons are believed responsible for DCH electronics radiation upsets at a rate of 2/hour. A small fraction of these alter the electronics behavior, and data acquisition must be paused to re-configure the electronics.

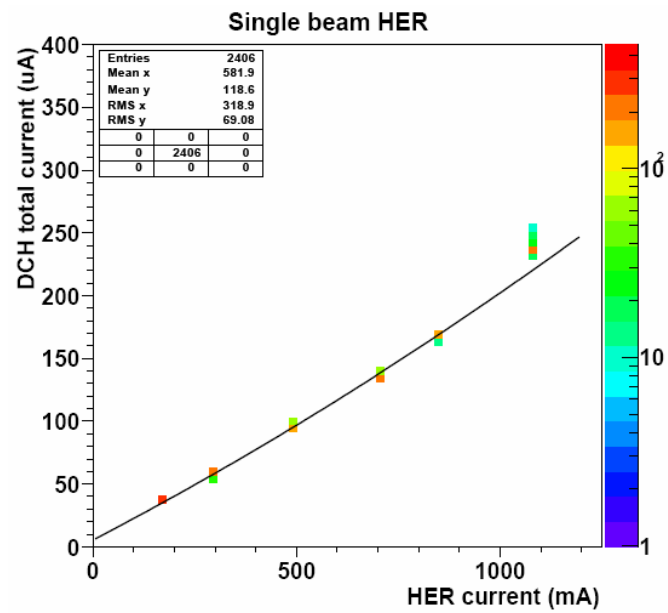
Background characterization measurements

Data: Jan 04

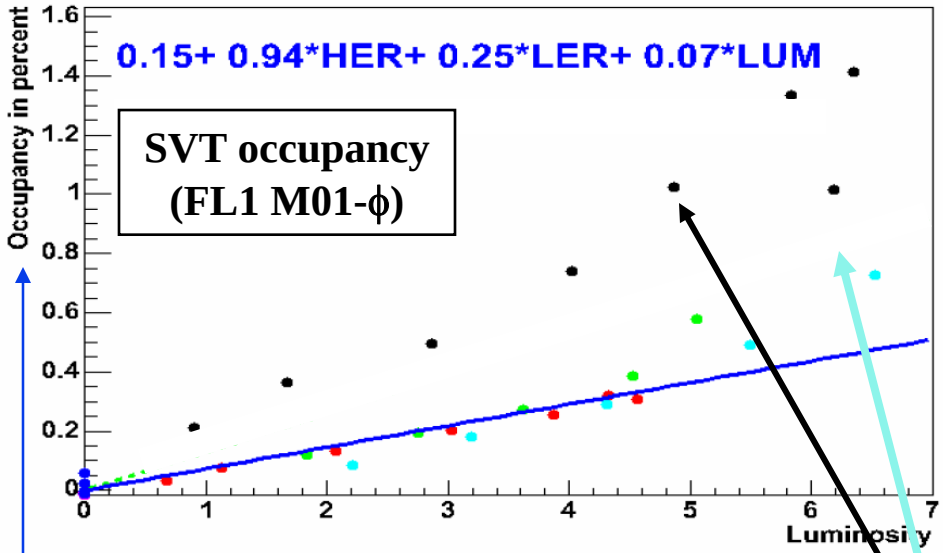


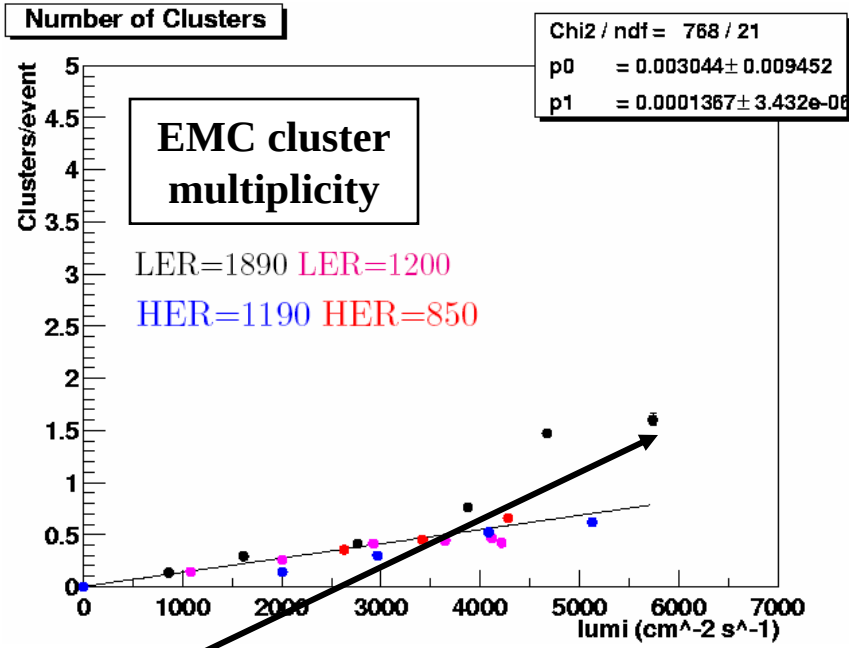
Step 1:
Beam-current scans
→ single-beam terms





Step 2: L & beam-beam terms





Total occupancy

-HER single beam

- LER single beam

Beam-beam term

- **present in all subdetectors**
- **fluctuations, short - & long-term**
- **➔ parametrization optimistic ?**

Step 3: Background Parametrizations

- DCH example: total current & occupancies

$$I_{DCH} = 5 + 9\, I_{LER} + 1\, I_{LER}^2 + 170\, I_{HER} + 28\, I_{HER}^2 + 60\, L$$
$$+10\, I_{LER} + 30\, I_{HER} \quad (\text{beam} - \text{beam})$$

Step 4: Background Extrapolations

Given PEP projections for HER, LER currents and luminosity, estimate detector impact (occupancies, dose) and data acquisition required performance.

Predictions are valid in the absence of abnormal vacuum activity.

Should repeat characterization when PEP-II reach is extended.

Background Monitoring

SVTRAD diodes + diamonds	dose rates, dose / injection abort fast history
DCH high voltage	current
DRC PMTs	scaler rates
IFR high voltage	current
Fast Control & Timing	deadtime, L1 rates, time wrt injection, assoc to bunch in train
Level 3 Trigger	subdetector occupancies
Neutron counters	scaler rates
CsI IP detectors	(logarithmic response)

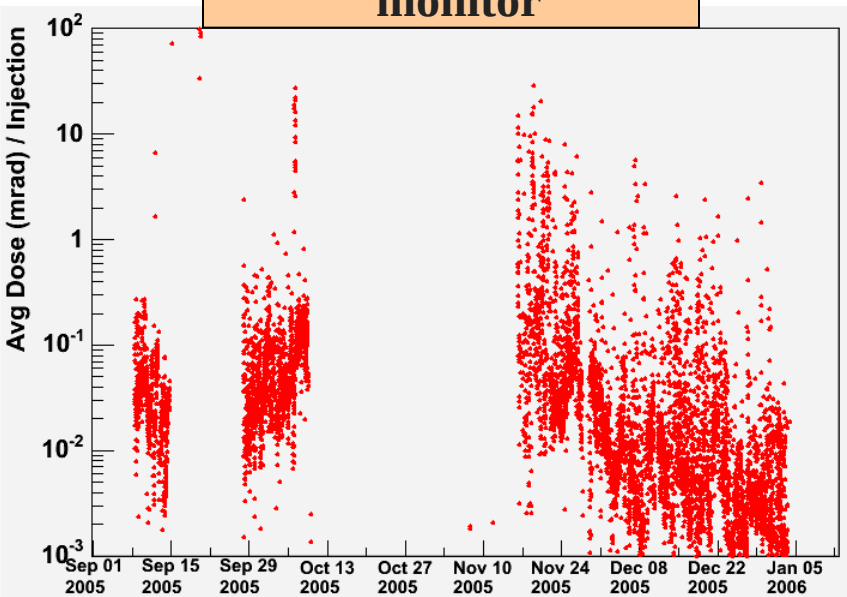
- All update in small intervals (1-5 seconds)
- Reviewed weekly with PEP/BaBar management versus expectations

Injection- & trickle- background history

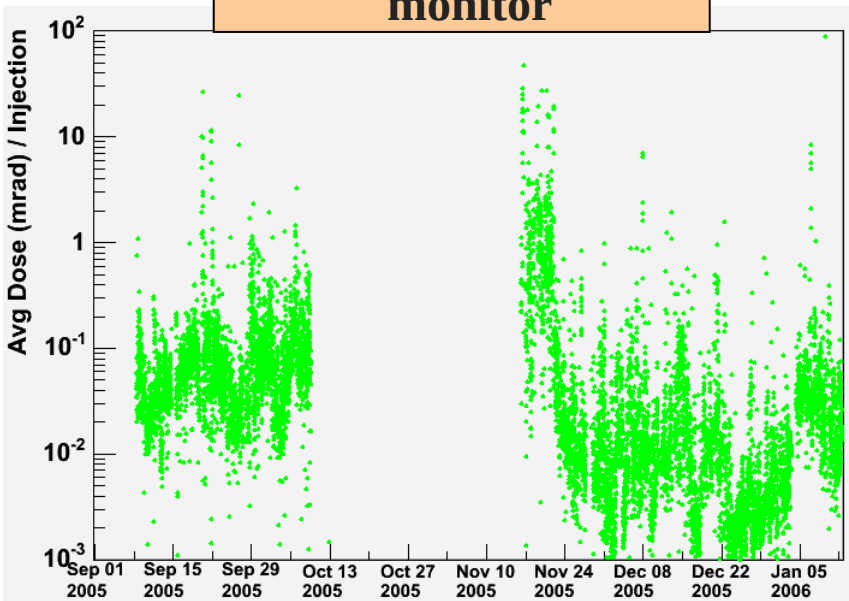
Monitor by integrating SVTRAD diode signals over 12 ms after each injection

SVT electronics are sometimes "upset" by exposures greater than 50 mrad / injection.

HER injection-quality monitor



LER injection-quality monitor

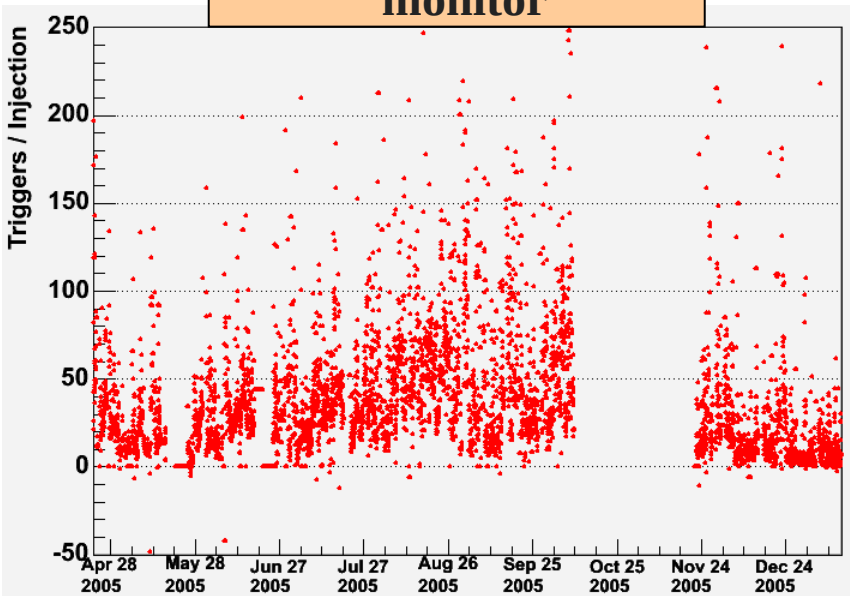


Injection- & trickle- background history

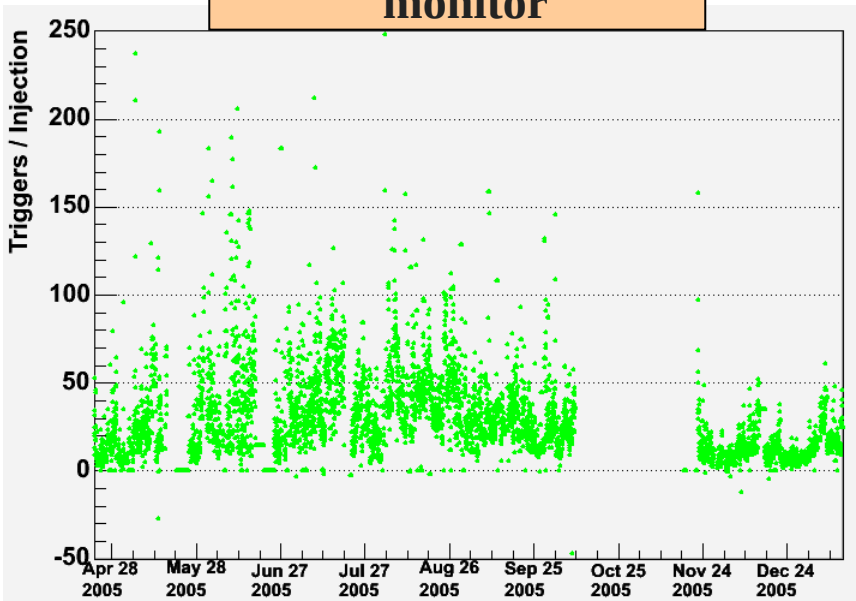
Monitor using triggers gated around the passing of the injected bunch (1 μs x 15 ms)

Injection contaminates the BaBar physics data sample if backgrounds endure too long

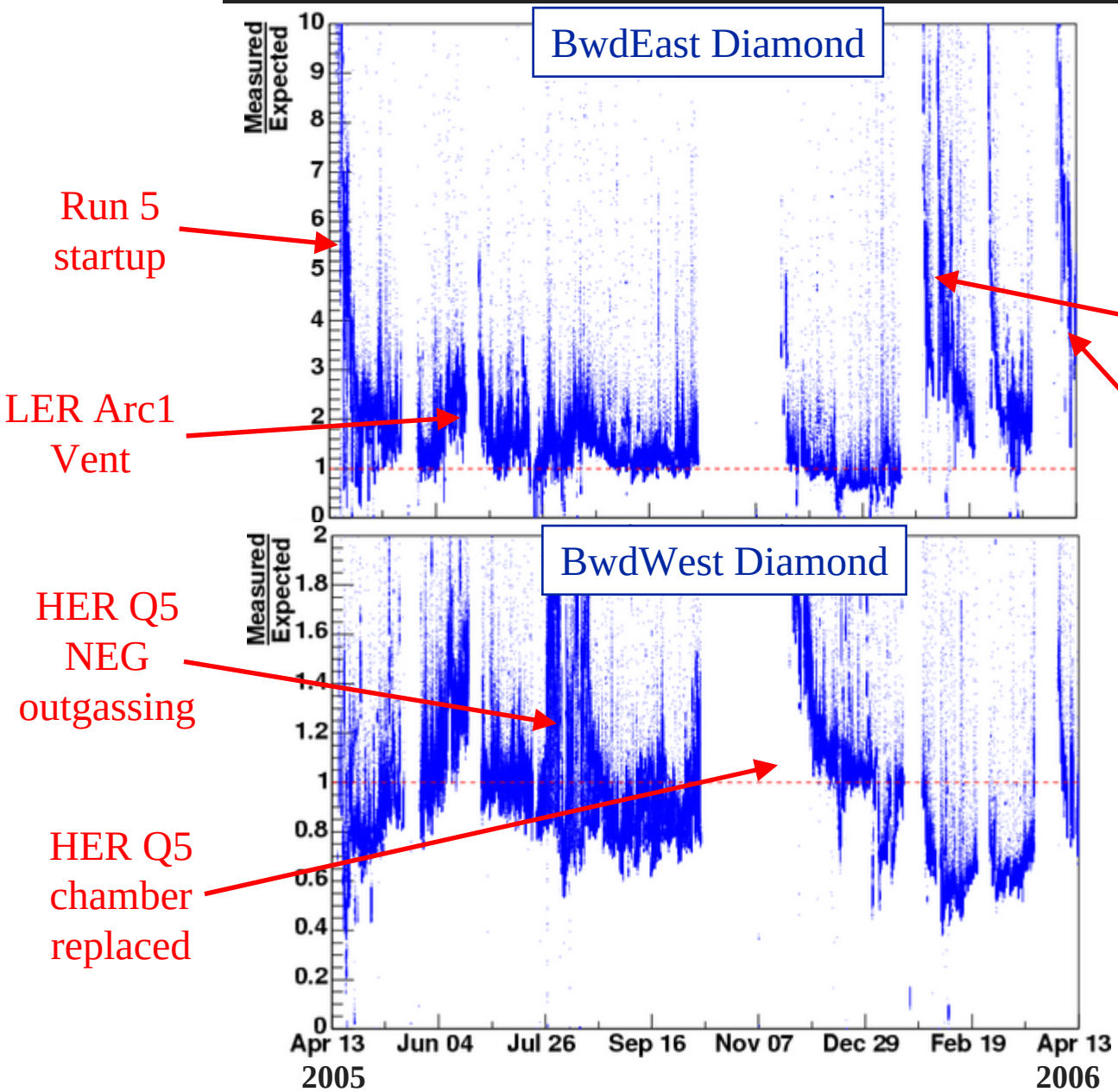
HER injection-quality monitor



LER injection-quality monitor



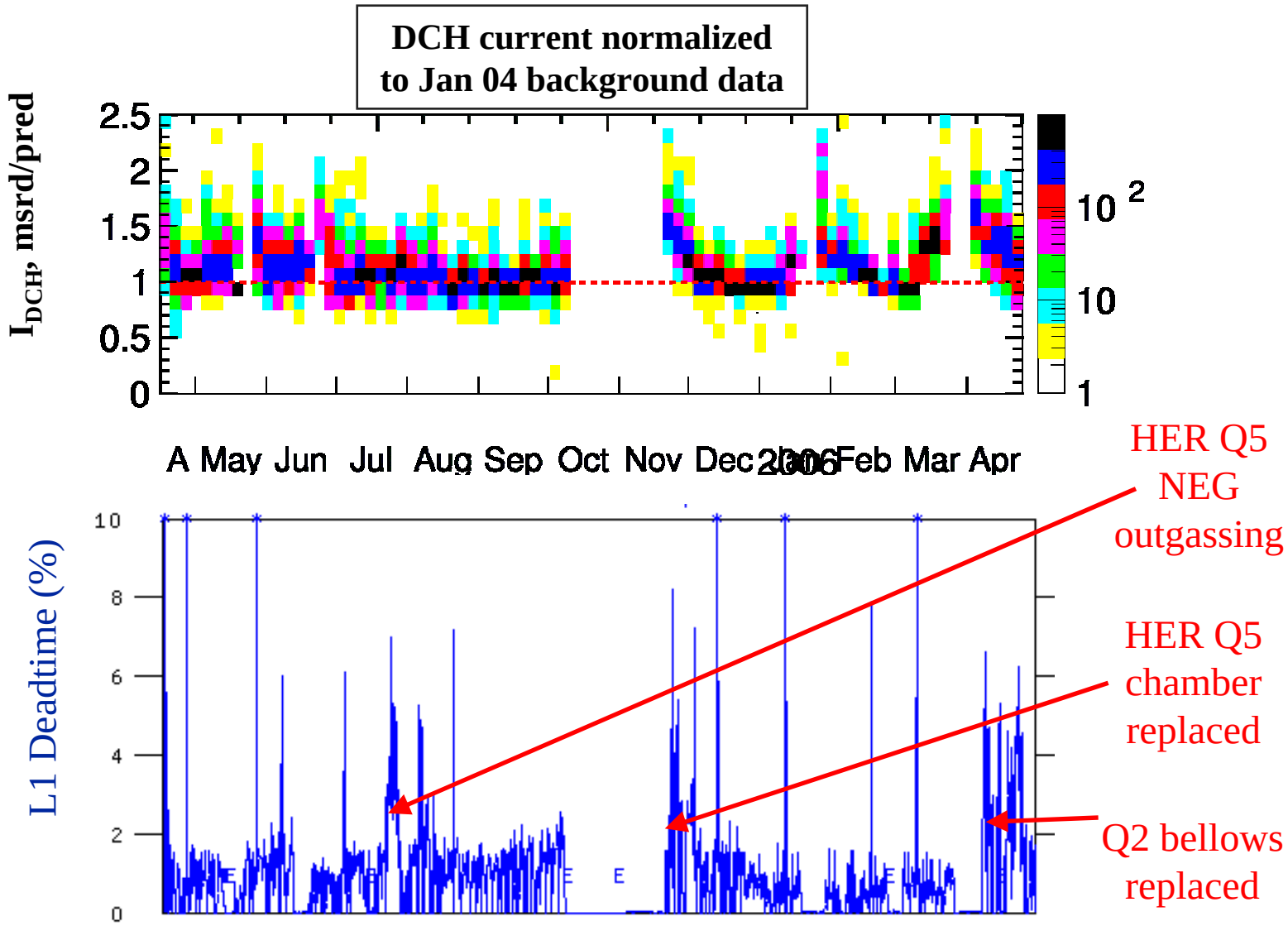
Stored beam background history – SVTRAD sensors



Normalized to prediction from Jan 04 characterization data

SVTRAD sensors are most sensitive to vacuum problems

Stored-beam background history

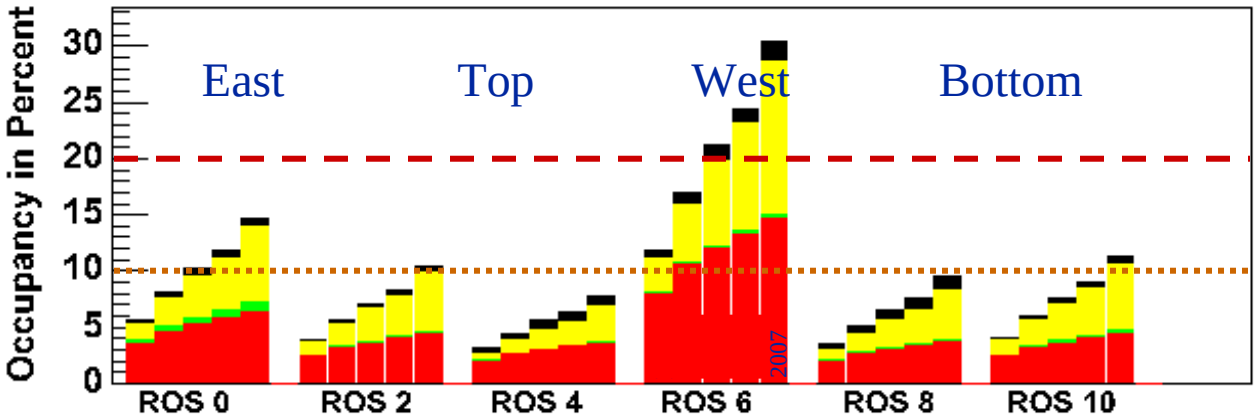


Future Projections

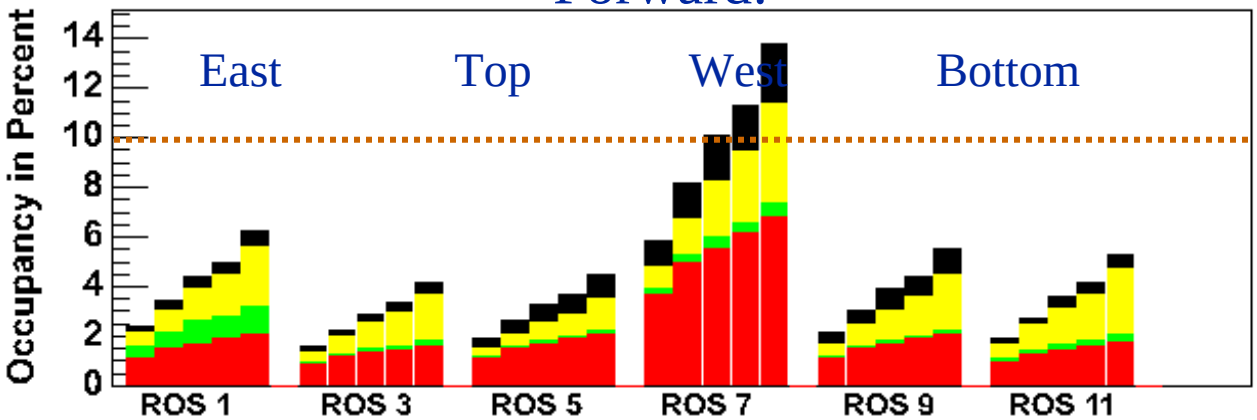
SVT

Integrated dose will be more than 1 Mrad/year in 2007

Backward:



Forward:



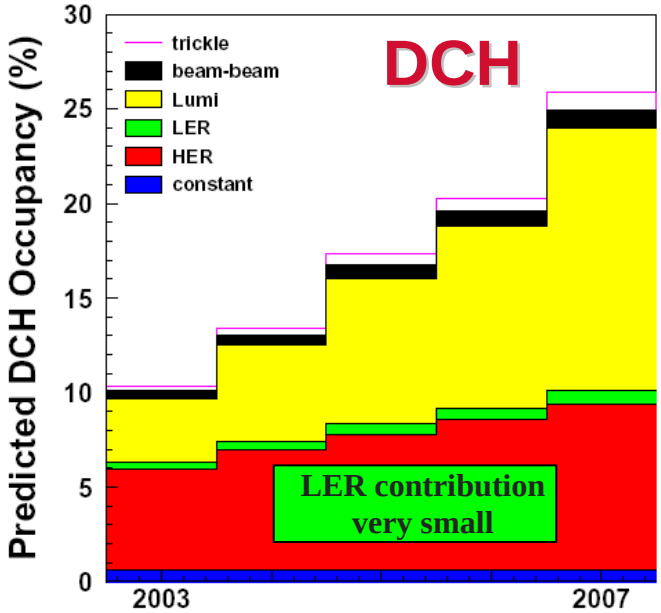
In 2007, background will be **50% HER, 50% L**

Background strongly ϕ - dependent

By **2007** predict **80%** chip occupancy right in **MID-plane**

In **layer 1**, 10% will be **above 20% occupancy**

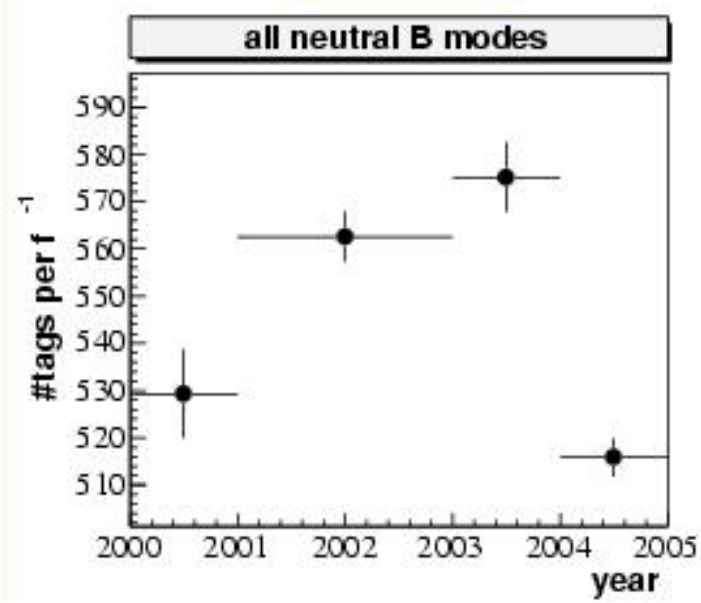
Impact on tracking

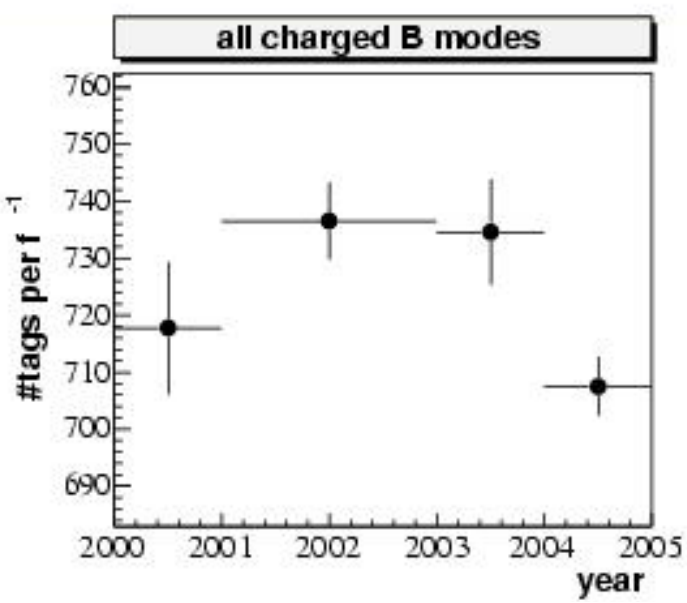


Tracking efficiency expected to drop by roughly 1% per 3% occupancy

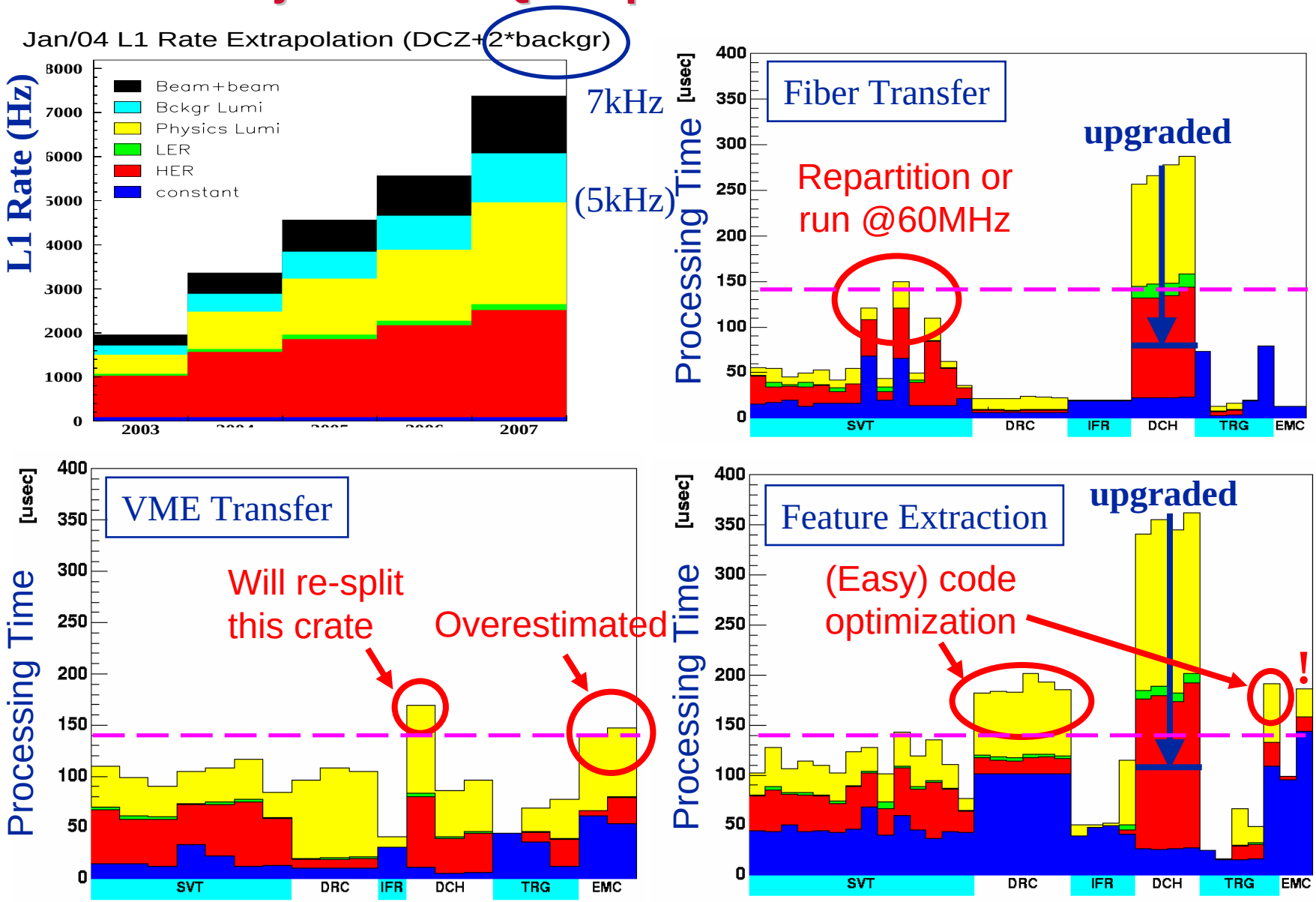
Observed significant drop in yields for run4 data.

Validation review is underway to investigate run4 yields and correlate with background and other factors





Projected DAQ Requirements/Performance



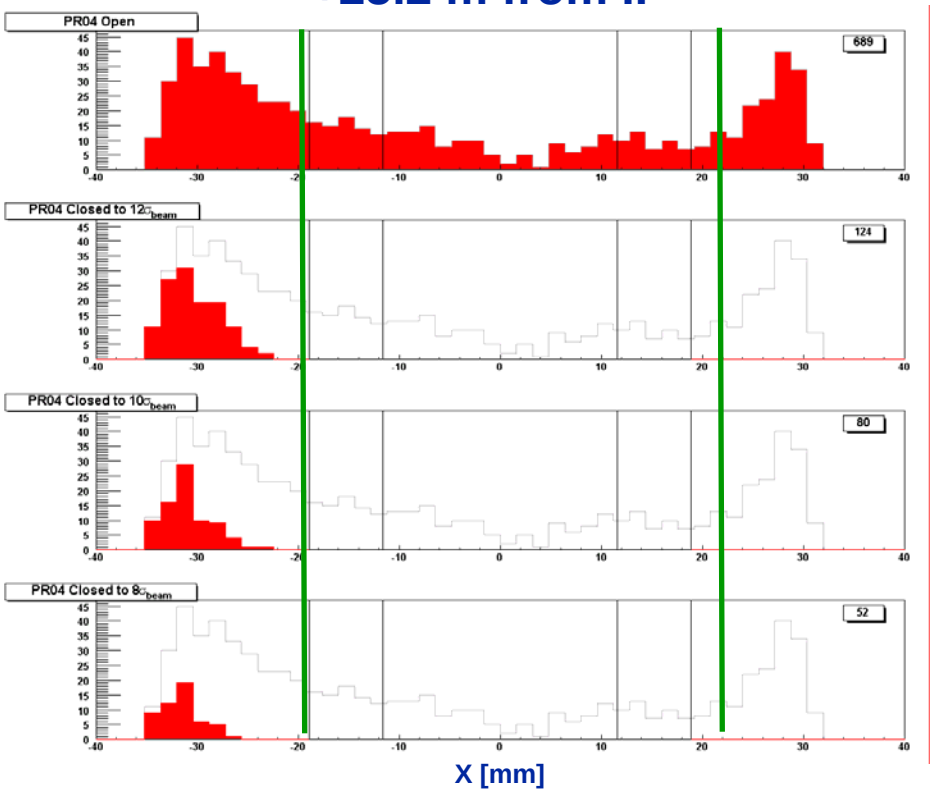
BaBar Efforts to Improve Backgrounds

- We continue to develop background monitors that are useful to the operators (low latency, fast updates) for tuning the accelerator { injection dose, occupancies }
- Background simulation efforts target possible improvements { beam-beam collimation, sensitive vacuum regions }
- Analysis of events which disrupt PEP operation { aborts, vacuum bursts }

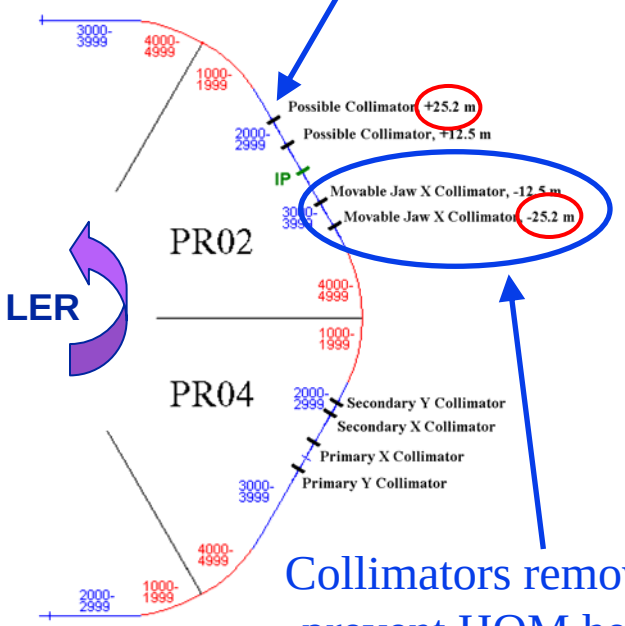
Beam-beam background collimation

Turtle simulation of LER scattered particles striking near IP

+25.2 m from IP



Collimator added to Mitigate LER beam-beam background



Collimators removed to prevent HOM heating

S.Majewksi, W.Kozanecki

Pressure Shape Analysis

The fast fall-time can be understood as a pumping effect

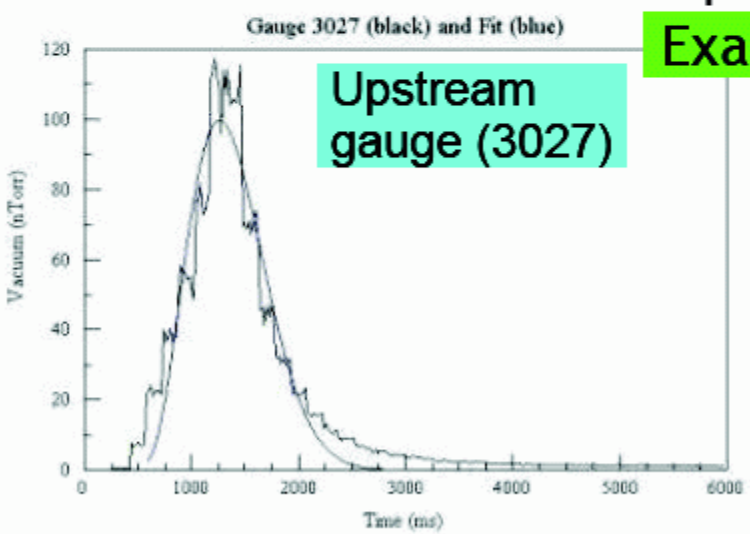
Introduce velocity cut-off by modifying time: $t' = t \, \mathrm{Exp}[\, (t / t_c)^p \,]$

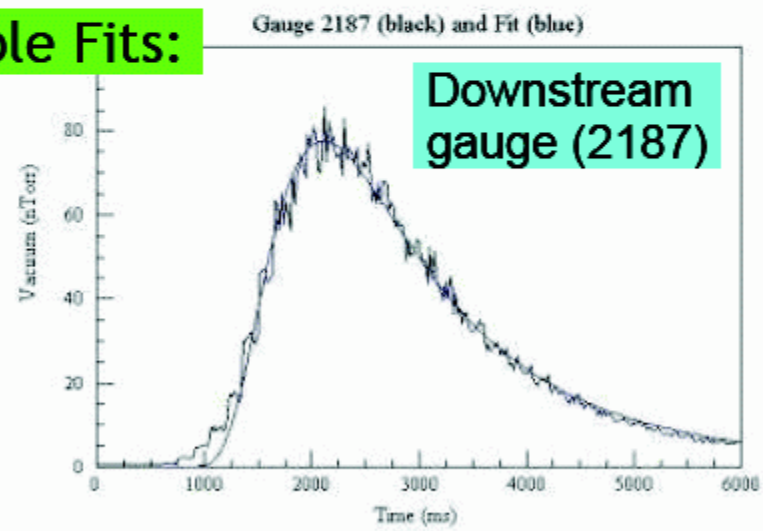
The actual function used to fit the data was:

$$f(t) = A \, (M/T)^{1.5} \, (d / t')^2 \, \mathrm{Exp} \, [- 0.060 \, (M/T) \, (d / t')^2 \,]$$

Effective temperature

Example Fits:





d = 1.94 m

d = 7.30 m

Distance between gauges: 10.7 m

H.Nicholson

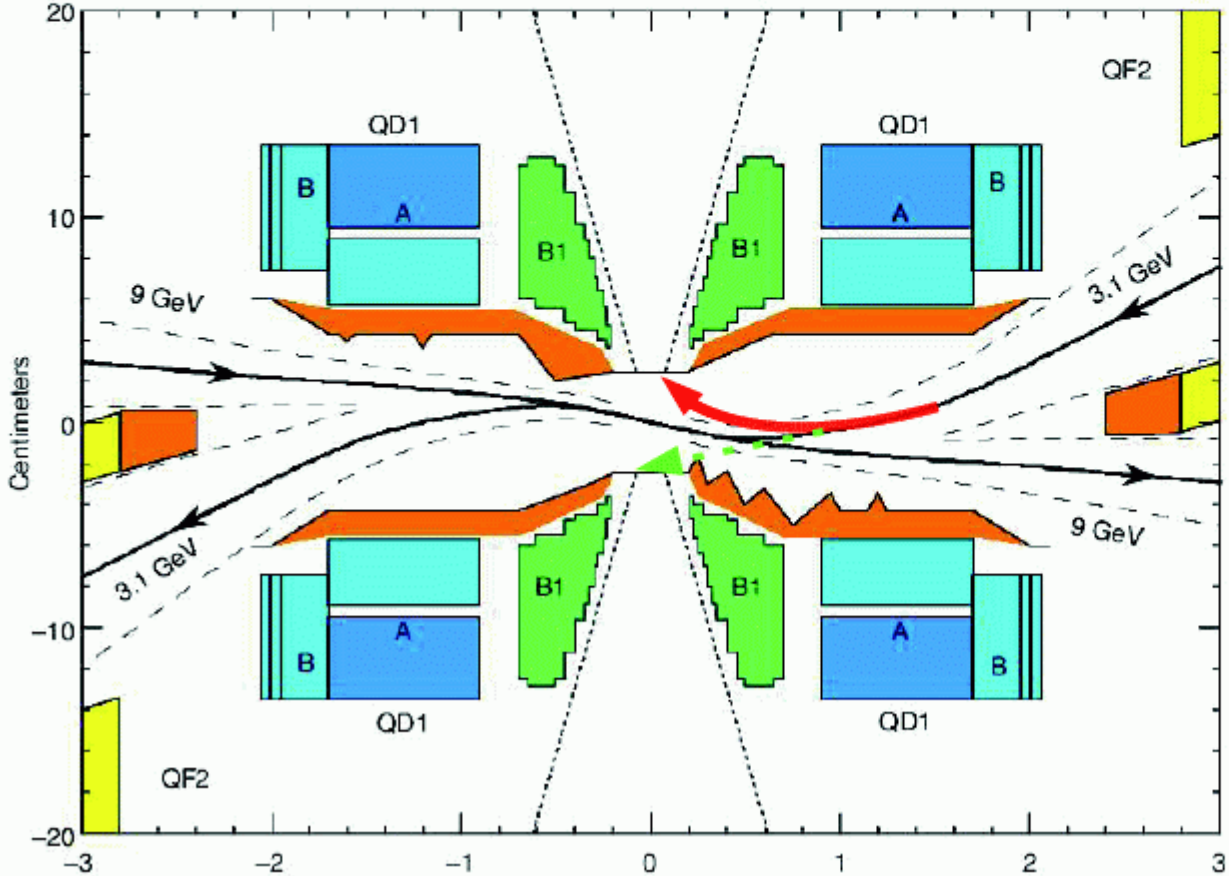
LER Vacuum Burst Studies

B.Petersen

SvtRad PIN-diode Study

SvtRad PIN-diodes are sensitive to bremsstrahlung near IR

Interaction Region



brems-e^+ from z=9.5m to z=0.5m hit east midplane diodes

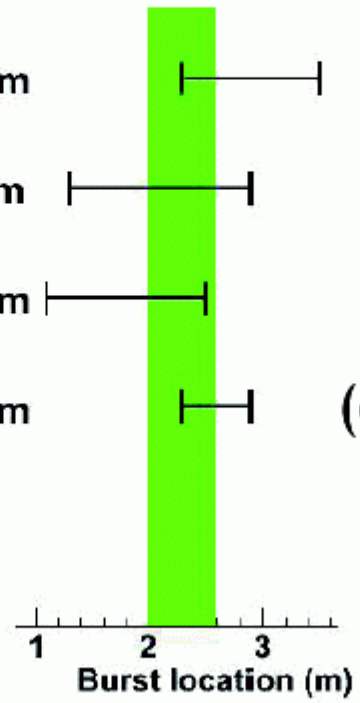
brems-γ from z=1.2m to z=1.6m hit west midplane diodes

West diodes also sees fraction of brems-e^+

Summary

Vacuum data has been analyzed in several different ways
All analyses are within 1m of each other:

Fit Shape, HN	2.9±0.6m
Leading Edge, HN, MK	2.1±0.8m
Leading Edge, HN, AC	1.8±0.7m
Diode Analysis, BP	2.6±0.3m
"Average"	2.3m



(or z<0.8m)

Best guess: source is in Q1/Q2 bellows

Summary

- Vacuum problems and consequent incursions have impacted PEP performance and background levels.
- Characterization experiments allow understanding of background sources and enable us to predict impact of future conditions. A new set of experiments is planned.
- Future expected trigger rates of 5 kHz are nearing the edge of data acquisition performance and have no allowance for worsened conditions (would like to have 7 kHz performance). Historicly, we've seen thermal outgassing episodes that push background beyond expectatations.
- We need to continue working with PEP experts to monitor and control background levels.