BaBar Backgrounds

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B-Factory Operations Review
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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: $B_{Hbg} \sim I_H \ast (p_H^0 + P_H^{Dyn} \ast I_H)$
  - LEB only: $B_{Lbg} \sim I_L \ast (p_L^0 + P_L^{Dyn} \ast I_L)$
  - beam-gas x-term: $B_{LHbg} \sim c_{LH} \ast I_L \ast I_H$ *(LEB+HEB, out of collision)*

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

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

- **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 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_{sp} 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

**LER Radiative Bhabhas**
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 reconfigure the electronics.
Background characterization measurements

Data: Jan 04

Step 1:
Beam-current scans → single-beam terms
Step 2: L & beam-beam terms

SVT occupancy (FL1 M01-φ)

0.15 + 0.94*HER + 0.25*LER + 0.07*LUM

Total occupancy
- HER single beam
- LER single beam

Beam-beam term
- present in all subdetectors
- fluctuations, short - & long-term
- \( \Rightarrow \) parametrization optimistic?

EMC cluster multiplicity
LER=1890  LER=1200
HER=1190  HER=850

Chi2 / ndf = 766 / 21
p0 = 0.003944 \pm 0.009452
p1 = 0.0001367 \pm 3.432e-06
Step 3: Background Parametrizations

DCH example: total current & occupancies

\[ I_{DCH} = 5 + 9 I_{LER} + 1 I_{LER}^2 + 170 I_{HER} + 28 I_{HER}^2 + 60 L + 10 I_{LER} + 30 I_{HER} \text{ (beam – beam)} \]

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

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

**Injection- & trickle- background history**

**HER injection-quality monitor**

**LER injection-quality monitor**
Stored beam background history – SVTRAD sensors

Normalized to prediction from Jan 04 characterization data

LER Q4 chamber replaced

Q2 bellows replaced

SVTRAD sensors are most sensitive to vacuum problems

Run 5 startup

LER Arc1 Vent

HER Q5 NEG outgassing

HER Q5 chamber replaced

Normalized to prediction from Jan 04 characterization data

LER Q4 chamber replaced

Q2 bellows replaced

SVTRAD sensors are most sensitive to vacuum problems
Stored-beam background history

DCH current normalized to Jan 04 background data

$I_{DCH}^{msrd/pred}$

A May Jun Jul Aug Sep Oct Nov Dec 2005 Feb Mar Apr

L1 Deadtime (%)

HER Q5 NEG outgassing
HER Q5 chamber replaced
Q2 bellows replaced
In 2007, background will be 50% HER, 50% L

Background strongly $\phi$ - dependent

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

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

Jan/04 L1 Rate Extrapolation (DCZ+2*backgr)

- **L1 Rate (Hz)**
  - 0
  - 1000
  - 2000
  - 3000
  - 4000
  - 5000
  - 6000
  - 7000
  - 8000

- **Processing Time**
  - Overestimated
  - Will re-split this crate
  - Overestimated

- **Fiber Transfer**
  - Repartition or run @60MHz

- **Feature Extraction**
  - Upgraded
  - (Easy) code optimization

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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 }
Turtle simulation of LER scattered particles striking near IP

Collimator added to Mitigate LER beam-beam background

Collimators removed to prevent HOM heating
LER Vacuum Burst Studies

Pressure Shape Analysis

The fast fall-time can be understood as a pumping effect. Introduce velocity cut-off by modifying time: \( t' = t \exp\left(\frac{t}{t_c}\right)^p \)

The actual function used to fit the data was:

\[
f(t) = A \left(\frac{M/T}{1.5}\right)^2 \left(\frac{d}{t'}\right)^2 \exp \left[-0.060 \left(\frac{M/T}{d'/t'}\right)^2\right]
\]

Effective temperature

Example Fits:

- Upstream gauge (3027) - \( d = 1.94 \text{ m} \)
- Downstream gauge (2187) - \( d = 7.30 \text{ m} \)

Distance between gauges: \( 10.7 \text{ m} \)
LER Vacuum Burst Studies

**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
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). Historically, we’ve seen thermal outgassing episodes that push background beyond expectations.

We need to continue working with PEP experts to monitor and control background levels.