SuperB Trigger Introduction & Status

S. Luitz, SuperB General Meeting, Elba, June 2010

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Outline

- Rate Estimates
- Trigger Architecture
- L1 Trigger
- L3 / HLT Trigger
- Beyond the baseline
- Next Steps / R&D

SuperB Trigger Architecture

- Baseline: Re-implement BaBar trigger with some improvements
- "Hardware" L1 Trigger
  - Synchronous, fixed latency, fully pipelined
  - DCT, EMT, GLT
  - Optional: Bhabha Veto, SVT trigger
- Software L3/High Level Trigger
  - Runs on Trigger Farm, decision based on fast specialized reconstruction of complete events
  - 10ms / event (?)
- No L2 trigger
  - Placeholder for a filter in the data path that would act on partial event information

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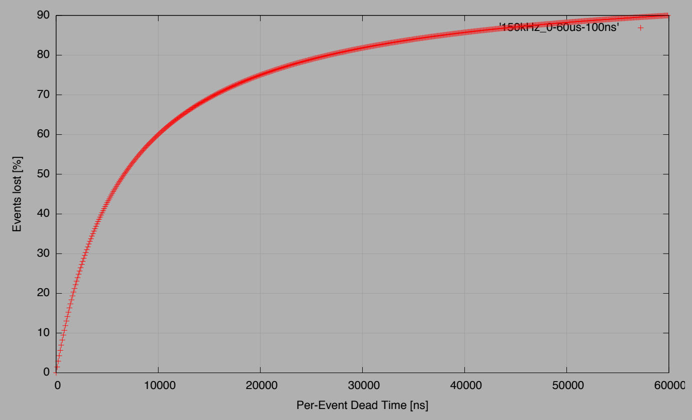
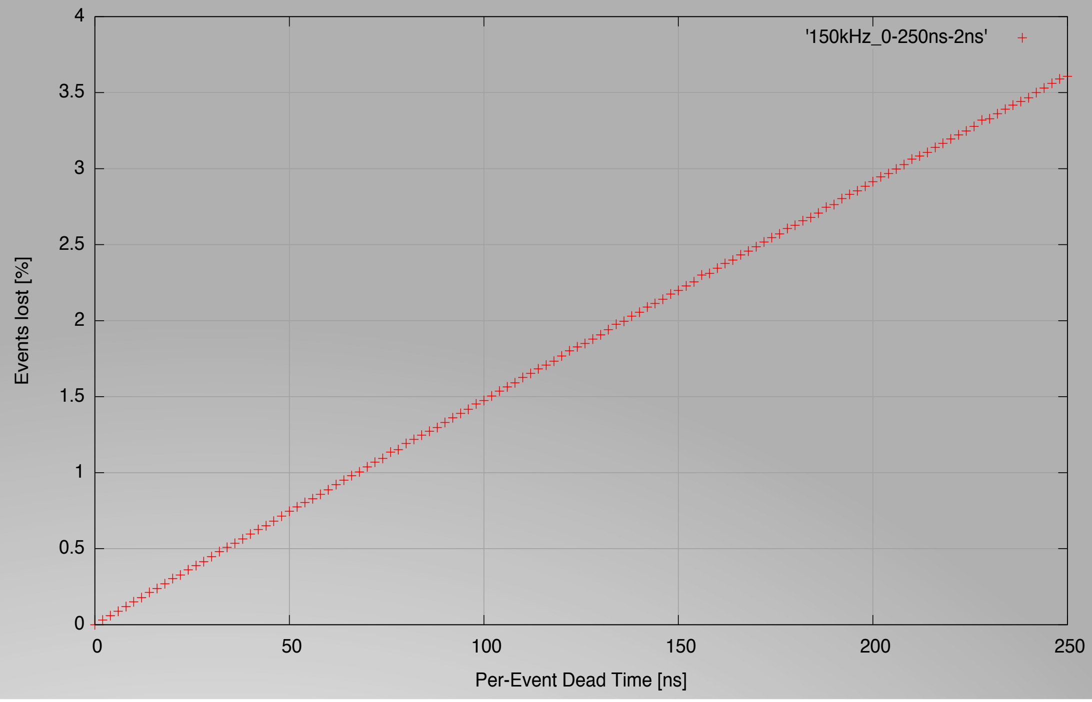
Trigger Rate Extrapolations

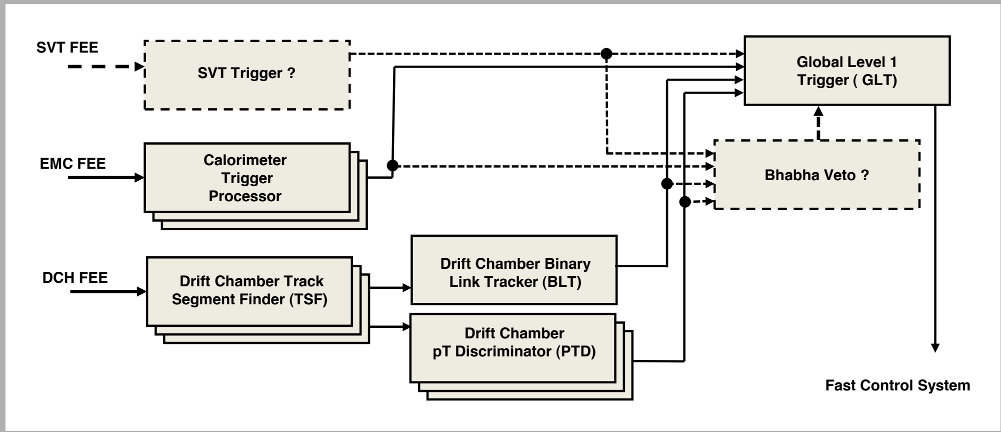
- Estimates extrapolated from BaBar for a detector with BaBar-like acceptance
- Bunch crossing instantaneous rate: 476MHz
  - At 10^{36} the average rate about half that (only half the RF buckets are filled)
- Level-1 trigger rates (scaled from BaBar)
  - At 10^{36}: 50kHz Bhabhas, 25kHz beam backgrounds, 25kHz "irreducible" (physics + backgrounds)
  - → 75kHz with a Bhabha veto at L1 rejecting 50%
  - → 100kHz without Bhabha veto
  - 50% headroom desirable (from BaBar experience)
- → baseline: 150kHz rate capability
- HLT output rate
  - Expect do be able to achieve 25nb logging cross section with a safe real-time HLT
  - Could be improved by maybe 5-10nb with a more aggressive filter (storage & processing cost vs. risk)
- → Have to log 25kHz of 75kByte events

Dead Time

- Target: ~1% event loss
- Assume exponential pdf of event interarrival time.
- Assume continuous beams (2.1ns between bunch crossings)
- No simulation of derandomizer buffers yet
- 1% event loss due to dead corresponds to 1/150kHz -- ca. 70ns maximum per-event dead time.
- Places hard constraints on trigger output and FCTS command length!







- Fully pipelined
- input running at 7MHz
  - continuous reduced-data streams from sub-detectors over fixed-latency links
    - EMC crystal sums (in the FEE)
    - DCH hit patterns (in the FEE)
- output maybe 14 MHz (fine time fit)
- Total latency goal: 4us
  - Includes trigger readout, FCTS, propagation
  - leaves about 1-2 us for the trigger itself

Level-1 Trigger

"BaBar-like L1 Trigger"

- Calorimeter Trigger
  - cluster counts and energy thresholds
- Drift chamber Trigger
  - Track counts, p_T, z-origin of tracks
- Highly efficient, orthogonal

To be studied:

- SVT trigger
  - # tracks, # tracks not from IP, # back-to-back tracks in phi
- Bhabha veto
  - → HLT?

- **Drift Chamber Trigger (DCT)**
  - Track Segment Finder (TSF) performs lookup table driven hit pattern recognition inoverlapping 8-wire supercells
  - Binary Link Tracker (BLT) combines track segments in 5 to 10 superlayers to short / long tracks (B and A tracks)
  - PT Discriminator (PTD) applies mininum transverse momentum requirement using
  - track segments (A'tracks)
- **Calorimeter Trigger (EMT)**
  - Combines EMC crystals to towers in 40 phi bins
  - Applies three different energy thresholds (M, G, E clusters)
- **IFR (instrumented flux return) Trigger**
  - Encodes hit topologies of penetrating particles
- **Global Level 1 Trigger (GLT)**
  - Combines, matches and counts inputs from the above objects to Level 1 primitives

BaBar Level-1 Trigger Components

(subsequent slides contain info from a talk by R. Bartoldus in 1999) – note tat this is pr-DCZ

BaBar GLT Input

- The GLT receives input signals from DCT, EMT and IFT as 9 different trigger objects.
  - **DCT objects**
    - A track (a long track passing all 10 superlayers)
    - B track (a short track reaching superlayer 5)
    - A'track (an A track satisfying a mininum pt > 800 MeV)
  - **EMT objects (with different energy thresholds)**
    - M cluster (minimum ionizing cluster > 100 MeV)
    - G cluster (intermediate energy cluster > 300 MeV)
    - E cluster (high energy electron/gamma > 800 MeV)
    - X cluster (MIP in the forward endcap > 100 MeV)
    - Y cluster (electron in the backward barrel > 1 GeV)
  - **IFT objects (3-bit pattern)**
    - U (e.g. U=3 encoding two back-to-back sextants in either the barrel or the endcap)

BaBar GLT and GLT Output

- The GLT delays and combines these objects into a total of 17 object counts:
  - **Back-to-back objects**
    - A*, B* (back-to-back short/long tracks)
    - M*, G* (back-to-back M/G clusters)
    - EM (E vs M clusters back-to-back)
  - **DCT + EMT match object**
    - AM (A track and M cluster phi match < 72 deg)
    - BM (B track and M cluster phi match < 72 deg)
    - A’M(A’trackandMclusterphimatch<36deg)
    - BMX (M cluster object vetoed by X without BX phi match)
- **Outputs**
    - GLT outputs 24 trigger lines to the Fast Control and Timing system (FCT)
    - Each line is specified by one or more cuts in terms of the 17 object counts
    - A cut is defined by an operation code (>=, = , <) and a cut value (0-7), e.g., (nB >= 2 and nA >= 1)

BaBar L3 (HL) Trigger (1)

- Receives events at L1-accept rate from network event builder
- Performs specialized fast DCH & EMC reconstruction using L1 information as seed
  - Track segments
  - EMC clusters
- High efficiency (typ. >99% for physics processes)
- CPU usage ~1ms/event/core on modern CPUs

- Uses offline framework
  - Construct trigger objects using “tools”
  - Apply “filters” based on objects
  - Construct “paths” from tools and filters
- Event classification in terms of track and cluster topologies
  - Identification of physics processes for monitoring and performance studies
  - Exception: Bhabha events
    - Lumi measurement
    - Veto: clean Bhabas are downscaled

BaBar L3(HL) Trigger (2)

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BaBar L3(HL) Trigger Tools

- Tracking
  - Combine Track Segment Finder (TSF) segments from the drift chamber trigger (lookup table driven pattern recognition)
  - Find event t0 from TSF hits (to better than 10ns)
  - Perform fast 3D track finding and fitting using TSF + DCHhits (down to Pt ~ 250 Mev)
- Clustering
  - Perform fast 1D clustering based on EMT phi strips
  - Use EMT clusters as seed to perform fast 2D clustering onEMC crystals (used for Bhabha identification)
- Combined
  - Track - cluster matching
  - Track extrapolation to calorimeter intercept

BaBar L3(HL) Trigger Filters

- DCH Filters
  - IP Track Filter (requires tracks close to the interaction point)
    - 1 track with: |d0|<1.0cm, |z0|<10cm, Pt>600MeV
    - Or 2 tracks with: |d0|<1.5cm, |z0|<7cm, Pt>250MeV
- EMC Filters
  - High Energy Filter and High Multiplicity Filter
    - 4 EMT clusters with Etot > 1.5 GeV and within 45 degrees back-to-back
    - 2 EMT clusters with Etot > 2.0 GeV and within 45 degrees back-to-back
- Combined Filters
  - Bhabha Veto (very high purity, 1-prong and 2-prong)
  - Online Luminosity (Bhabhas, well known efficiency)
  - Bhabha Accept (high efficiency, for offline luminosity)
  - Radiative Bhabha (for calibration)
  - Prescaled (unbiased) *L1Accept*
- Logic can be applied to the filters
  - OR, VETO
  - Prescale
- Histograms are filled with L3 quantities for monitoring

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Baseline SuperB Level-1 Trigger

- Overall
  - Reduce latency (faster FPGAs, more parallelism)
  - Goal: 4us total latency (to be validated)
- DCH Trigger
  - Double sampling frequency
  - Integrate Z-Trigger (from BaBar upgrade)
    - Requires stereo layers
- EMC Trigger
  - Projective (1d) trigger view -> 2d map (overlapping postage stamps)
  - Cluster finding in 2d map
- GLT
  - Process 2d EMC map info
    - For back-to-back info
    - for track – cluster matching
- GLT to be read out as a subdetector (as in BaBar)
  - Track and cluster seeds (per-event)
  - Monitoring and debug information (per-event)

SuperB EMC 2d Map

- Cell Sums in FEE
  - 3x4 in Barrel (12+4 bit full resolution of sum)
  - 5x5 in Endcap (12+5 bit full resolution of sum)
    - Chop off LSB and transmit 16bits?
- 2d map in trigger processor
  - Overlapping postage stamps from cell sums
    - 6x8 for barrel
    - 10x10 for endcap

SuperB L1 Beyond the Baseline

- Bhabha Veto at L1
  - Can be done (was in principle possible with BaBar)
  - Is it safe for physics – to be studied
- SVT Trigger
  - # of tracks
  - # of back-to-back tracks
  - To be studied

- Assume 10ms / event / core
- 1500 cores for 150kHz
- 10x the time used by BaBar L3
- Improvements
  - Better tracking
- Should there be a "L4" trigger?
  - BaBar used a filter stage at the input of Reco
  - Should this be moved to the HLT to reduce the amount of permanently recorded data?
    - Safe for physics?
    - Filter was changed a few times through the lifetime of BaBar
    - Risk vs. benefits

SuperB HLT

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Next Steps

- Validate the L1 baseline for SuperB
  - Are efficiencies acceptable for SuperB physics
  - Are our rate estimates correct
    - Needs background studies
  - What of the BaBar L1 implementation (VHDL) can be reused / adapted – how?
- Study the beyond-the-baseline options
- Work with DCH and EMC on details of trigger primitives
- Organize trigger workshop (later this year?)
  - Invite BaBar expert(s) for brain-dump ☺