Calibration Concepts

- Calibration system description
- Online calibration modes
- Online infrastructure
- Subsystem utilities and interface
- Detailed example for DIRC

Introduction and Scope

- Calibration is (formally) a new part of online
  - First formal discussion during online review last week
  - Only a conceptual overview today
- I am not an online expert
  - Primary responsibility is to the DIRC subsystem
  - 'concerned collaborator' on calibration
- Aspects of the infrastructure are uncertain
  - Database is underdeveloped
    - No working 'input' models
    - No interactive access tools
  - ROM performance is unknown
- Goals for today:
  - Introduce the existing plan
  - Get feedback!
  - Start to address the 'Calibration Luminosity Budget'

Calibration System

- Roles
  - Provide constants to link raw measurement values (ADC, TDC, ...) with reconstruction primitives (charge, time, ...)
    - Feature extraction
    - Trigger
    - Reconstruction
  - Quality Assurance and performance monitoring
  - Commissioning and debugging

} Measure response to a known, prepared input

- Scope
  - Dedicated online running
  - Prompt Reconstruction calibration stream
- Participants
  - Online
    - provide infrastructure
    - provide templates
  - OEP and Prompt Reconstruction
    - same
  - Computing
    - database tools
  - Subsystems
    - Algorithms
    - Implementation
    - Manpower

Calibration Modes

- 'Fast' calibration
  - 'Calibration run mode' (DRQ)
  - Single detector partitions
    - Specialized hardware
    - Specialized trigger sequences and timing
  - Raw data access limited to the ROM
    - Exploit parallel processing power
    - Minimize dataflow overhead (no transfer of single L1 accept data)
  - Performed during machine top-off (~1 minute, once/hour)
    - Test subsystems for correct functioning (10% level test)
    - Renew 'pedestals'
  - Performed once/day or once/shift (~5 minutes)
    - more precise correct functioning tests
    - Renew 'liinear' constants
  - Minor, Major, and Meta nested loops (see next slide)
- 'Slow' calibration
  - 'Data taking run mode' (DRQ)
  - Special purpose and infrequent calibration
    - Cross talk studies
    - Diagnostic and commissioning runs
  - Performed during machine down time
  - Trigger rate limited to < 2kHz
  - Multi-detector partitions possible (Interference tests)
  - Single layer looping
  - OEP performs calibration analysis (replaces L3 trigger)

Online Infrastructure

- Loop support for Fast Calibration
  - 'Minor cycle' loop over L1 triggers
    - 1 Complete loop $\leftrightarrow$ 1 event to dataflow
    - Special segment builder operation
      - Loop instantiation and bookkeeping
      - Access hooks to each L1 trigger, beginning and end of loops
      - Buffer forwarding
    - Data accumulation in 'static' buffers
      - Histograms
      - Average + RMS
  - 'Major cycle' loop over conditions (DAC values, ...)
    - Threshold scans, response curves, etc.
    - Minor loop is repeated for each setting
  - 'Meta cycle' sequence of algorithms (pedestal, gain, ...)
    - Corresponds to a run
    - Combines all algorithms necessary for constants renewal
      - Efficiency
      - Results may be stored in a single database object
- Calibration validation
  - Necessary before constants become visible (flagging)
  - Normally performed offline during physics running
    - Start physics run immediately after calib data taking
    - Use previous constants
  - Physics runs can be forced to wait for new constants
    - Previous calibration run failure
    - Old constants are stale

Subsystem Interface

- Event access
  - Privileged consumer
  - OEP and Workstation
- Database
  - Standard tools for inspection, histogramming, and QA
  - Flags for validation, precedence, cleanup, ...
- Templates
  - Meta,Major,Minor cycles (from dataflow)
  - Calibration data buffers
    - Histograms
    - Average + RMS
    - Derived buffers (major cycle fits)
- Code migration mechanism (OEP$\rightarrow$ROM)
  - Standard tools for converting UNIX code to ROM code

Example: DIRC

The DIRC data consists of TDC hits. Hits are defined by a (fixed) threshold. Channel gains are adjustable. Sparse ADC (charge) output is available for diagnostics. Calibration inputs are provided by on-board charge injection, light injection through a fast, uniform LED, and physics data.

(Partial) List of DIRC Calibration Items:

Quantity	Measurement	Use
Channel Gain	ADC gain "Threshold" scan	Front-end
T0 (integer)	LED	Feature Extraction
T0 (floating)	Ring T0	Reconstruction
TDC time/count	LED time scan	Reconstruction
Hit Efficiency	LED Ring Efficiency	Reconstruction
Noise Rate	LED Ring stray hits	Reconstruction Feature extraction
Cross-talk	Slow Calib	Reconstruction?

DIRC Database Objects

- "Channel-by-channel information should be grouped to improve database efficiency and reduce overhead." (DRQ)
  - Group channels 'geographically'
  - Group types according to update frequency, use, and origin
- DIRC Objects (preliminary)
  - Group channels by sector
    - 12 sectors, ~1K channels each, = 1 ROM
    - 'Tag' objects by their sector number
  - Topoff Fast Calibration Object (~10^3 pulses)
    - Channel gain
    - T0 (integer)
    - Efficiency
  - Once/Shift Fast Calibration Object (~10^5 pulses)
    - TDC time/count
    - ADC charge/count
  - Once/week Fast Calibration Object (~10^7 pulses)
    - Precise channel gain
  - Slow Calibration Object
    - cross talk
  - Offline (data stream) calibration Object
    - T0 (floating)
    - Efficiency

DIRC Online Buffers

- 1-D Histograms
  - X-axis = channel # (~1K bins)
  - Items
    - Efficiency
    - Noise Rate
- 2-D Histograms
  - X-axis = channel #
  - Y-axis = 'value' (~1K X 50 bins)
  - Items
    - T0 (TDC)
    - Charge Pedestal gain (ADC)
    - Light gain (ADC)
    - Electronics charge gain (ADC)
- Average and RMS (HBOOK profile plot)
  - X-axis = channel #
  - Y-axis = major loop counter (2-D), or none (1-D)
  - Channel contents = 'value' average and RMS
  - Items
    - TDC time/count
    - ADC charge/count
    - "Threshold" efficiency scan
    - "Threshold" noise scan

DIRC Calibration Processing

- Simple counting
  - Efficiency
  - Noise Rate
- Simple Gaussian fit
  - ADC pedestal
  - ADC electronics gain
- Sophisticated Gaussian fit
  - Light gain
  - T0
- "Linear" fit
  - TDC time/count
  - ADC charge/count
- Non-linear fit
  - "Threshold" scan efficiency

DIRC Calibration QA

- Full calibration output stored in the database
  - Derived quantities plus raw data (histograms)
  - Raw data kept in a separate database 'Source'
  - Complete short-term history of all objects (~2 weeks)
  - Sparse long-term history of all objects (~1/100 saved)
  - Complete history of all derived quantities flagged for use (online or offline)
- Database contains a 'reference set' of objects
  - 1 reference set at a time (complete)
  - Concatenate several run, or a single high-statistics run
- QA compares current run with reference set
  - Automatic statistical comparison (note: must save errors)
  - Automatic 'fixed window' comparison
  - Automatic histogram comparison
  - Graphical (interactive) comparison
- Calibration output is 'flagged'
  - Ignore this calibration (good run, no significant change)
  - Use this calibration (good run, significant change)
    - start a new reference set ASAP
  - Failed calibration
  - Expiration data

Conclusions

- A conceptual outline of the BaBar calibration system exists
  - Dataflow interface
  - Database interface
  - Subsystem interface
- Crucial steps are still ahead
  - Evaluation of sub-system needs
  - Prototypes
  - Estimation of the calibration 'luminosity budget'
- A partnership with sub-system DAQ representatives is essential
  - Insufficient resources in the online group to provide the entire infrastructure
  - Sub-systems are the best experts on their own needs