Calibration Software Needs
For CAL BFEM

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What changes are needed to BF CAL recon?

- Energy measurement was poorer than it should have been because
  1. The charge-injection calibration didn't cover bottom and top of each range well enough.
     - Muon peak set the gain scale, but it wasn't well covered by chg-inj.
  2. My quadratic-quadratic gain model wasn't good enough.
     - Some channels just had a different shape.
  3. People used calibrations for time periods for which they weren't valid.
     - Gain calib was not valid for January proton runs, but we used it anyway.
     - Led to false impression that CAL wasn't calibrated.

- So we need new energy scale fcns in BF recon.
  - New chg calibration covers full range.
    - I ran pre-ship, will continue to run pre flight.
  - New gain model (piecewise linear).
    - AI: create new ADC_to_fC fcn (Chekhtman)
    - AI: create new fC_to_MeV tables (Grove, Chekhtman)
Operational needs

Ground calibration of CAL

- Test and checkout plan, instrument operations
- During BF payload integration and pre-flight checkout
  - Periodic overnight muon runs
    - To set absolute energy scale
  - Periodic electronic calibrations
    - To set gain scale, linearity
  - One big, long muon run
    - To map all crystals

See my details for CAL in Eduardo’s session
What changes are needed to BF CAL recon?

- BF will have random mix of photons and particles
  - All subsystems need to work on photon-hadron/nucleus discrimination
  - CAL recon will otherwise merrily try profile fitting on C nuclei!
- BF gives opportunity to put recon in context of Richard’s “From Space to Photons” flow chart.

- BF GCRs are useful for developing CAL calibration algorithms.
  - Need photon-nucleus discrimination.
    - Use ACD ULD for first pass.
  - Need TKR recon for trajectories.
  - Need good ground calib of CAL.
GCR rates for Palestine balloon flight

- Require passage through uppermost full Si layer and bottom of CsI
- Used CREME96 for 35km above Palestine in 2001, from H to Ni

Assuming 8 hrs at float
- ~4000 CNO
- ~900 Ne, Mg, and Si
- ~250 Fe
to play with.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total rate (per hr)</th>
<th>Non-fragmenting rate (per hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>220</td>
<td>63</td>
</tr>
<tr>
<td>N</td>
<td>58</td>
<td>15</td>
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<tr>
<td>O</td>
<td>220</td>
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<tr>
<td>Fe</td>
<td>29</td>
<td>4</td>
</tr>
</tbody>
</table>
Also Ground s/w, but beyond scope of this review

- **CAL ground support equipment (CalGSE)**
  - Command generation & control (in use, complete)
  - Command state verification (prototype for balloon flight?)
  - Health & Safety Monitoring (prototype for balloon flight?)
  - Data logging (in use, complete)
  - CAL simulator

- **CAL bench-checkout**
  - Low-level analysis, “recon” (in use, extensive suite)

**[Balloon flight is an opportunity to put recon in context of flight data flow, Richard’s “From Space to Photons.”]**
Functional requirements (top level)

- **Electronic calibration**: eCalib shall generate pedestal and integral linearity model for each gain range for each PIN diode.
  - Required accuracy is TBD; goal is 3%.
  - Data source is Charge-Injection Calibration Mode.

- **Absolute light yield**: GCRCalib shall calculate the absolute light yield at the center of each log for each PIN diode.
  - Required accuracy is TBD; goal is 3%.
  - Data source is GCR Calibration Mode.

- **Light asymmetry model**: GCRCalib shall produce maps of light asymmetry (i.e. light collection efficiency as a fcn of longitudinal position) of each log end and the sum of ends for each log.
  - Required accuracy is 10%; goal is 1%.
  - Data source is GCR Calibration Mode.
The various calibration processes produce a number of parameters describing the response of the CsI logs.

- All are time-dependent (TBR).
- Time scale is likely to be ~ weeks to months (TBR).

Calibration Parameter Database is a service of Software Central.

1. **Pedestals**
   - Accumulated on board
     - Telemetered: pedestal, pedestal width, diagnostic histogram
     - Optional diagnostic mode telemeters full CAL data set, i.e. not zero-suppressed.
       - 2 bytes x 2 parameters x 4 ranges x 2 ends x 1536 logs = 48 kB

2. **Differential linearity correction**
   - Make the CDB smooth.
     - Worth thinking about some more. Consider 1 byte per ADC bin per range.
       - 1 byte x 4096 channels x 4 ranges x 2 ends x 1536 logs = 50 MB
3. **Integral linearity correction (ADC to fC)**
   - **Electronic calibration**
     - Internal charge-injection circuit; used during in-flight diagnostic mode
       - 4 bytes x 10 parameters x 4 ranges x 2 ends x 1536 logs = 480 kB
   - **GCR calibration**
     - Might uncover additional non-linearities. Might not; thus these might not be used.
       - 4 bytes x 5 parameters x 4 ranges x 2 ends x 1536 logs = 240 kB

4. **Gain (optical conversion efficiency: fC to MeV[center of log])**
   - Accounts for light collection: electrons at preamp per MeV deposited
   - Calculated from GCR Calibration data. Updates ground calibration.
     - 4 bytes x 4 ranges x 2 ends x 1536 logs = 48 kB

5. **Light attenuation model (MeV[center] to MeV[position])**
   - Accounts for variation of light collection along each log.
   - Calculated from GCR Calibration data. Updates ground calibration.
   - Small and large PINs have same light attenuation, so each log has 3 models:
     - Individual ends
       - 4 bytes x 5 parameters x 2 ends x 1536 logs = 60 kB
     - Sum of ends
       - 4 bytes x 5 parameters x 1536 logs = 30 kB