Calorimeter Electronics

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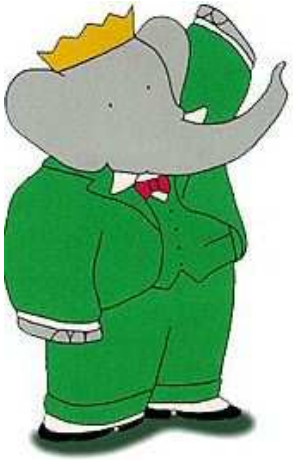
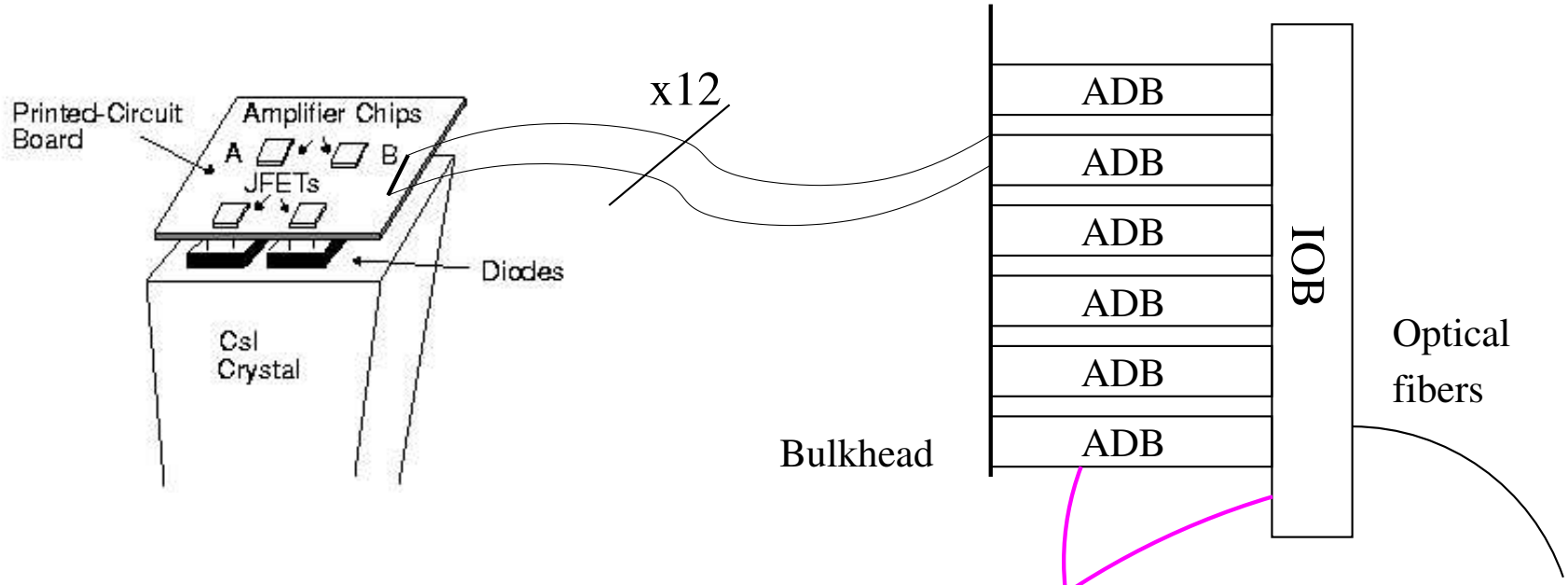
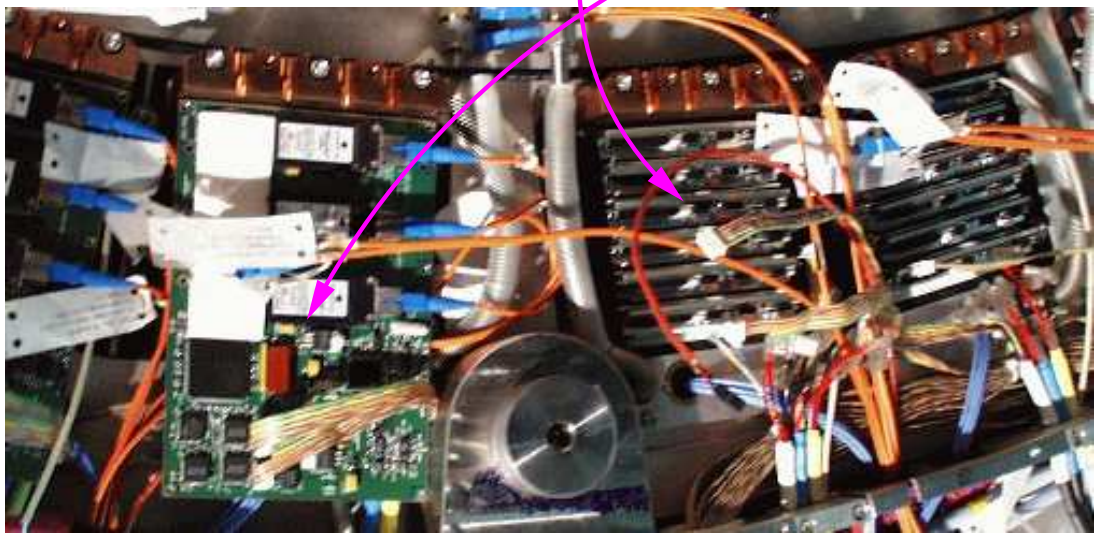


– Status of present barrel FE electronics
– Calibration systems
– Endcap FE electronics

Present Barrel Readout



72 channels per FE crate



Preamps

- 5760 preamps in total.
- Forward preamps (21 rings) have lower gain (x1.6).
- Shaping is done on the preamp, peaking time is about 1 μs.
- 30 phi rows have a longer shaping time (production variation in ASIC).
- 3 channels are completely masked.
- 61 channels have 1 diode masked.
- Some of the masked channels are grouped together which suggests problems on the bulkhead board rather than on the preamp.
- In some cases the pins on the bulkhead board are broken.
- There is channel cross-talk which is believed to come from the bundling of the flat cables inside the detector.

ADBs

- 480 ADBs in total, 12 crystals per ADB.
- Very poor reliability. It usually takes about a month or two until another board breaks.
- Connection with IOB requires perfect alignment. Changes in temperature during power cycling can lead to a disconnect. Installing the heavy copper heat sink can lead to a disconnect.
- Connection to the bulkhead board is problematic because the pins are on the bulkhead board side. If a pin breaks it cannot be replaced. If it is bent it is very difficult to realign it.
- Channels cannot be masked individually for charge injection. This makes cross-talk measurements difficult. Electronics calibration has to be performed with either all channels or half the channels simultaneously which means large cross-talk during calibration.
- Create a lot of heat.
- 4 gain ranges in the CARE chip are a lot. Large lever arm in electronics calibration between x1 and x256. Range switching effects must be calibrated out.

IOBs

- Some reliability issues, but not as bad as ADBs.
- Had to replace a number of Finisar transmitters.
- Practically no spares (< 5).

Bias Voltage

- Minicrate 4-9 has a fluctuating bias current which trips the power supply sometimes.
- The source of the problem is on the inside of the detector.
- Bias voltage connectors are extremely difficult to access.
- There are lots of bent pins on the bias voltage connectors on the bulkhead.

Hardware Conclusions (1)

- **Preamps:** In good shape.
  - Single bad preamps could be replaced.
  - Replacing all preamps would be a large project. Possible improvements would be a uniform, adjusted shaping time, charge injection decay constants that match CsI(Tl), less non-linearity at x32 saturation point.
- **Bulkheads and cabling:** Improvements are possible.
  - One could try to redo the cable routing inside the detector to reduce channel cross-talk.
  - The bulkhead connectors would ideally be replaced with connectors that don't have pins.
  - Bias voltage connectors should be placed on the bulkhead in an accessible way. Connectors without pins should be used.
  - The split FWD/BWD readout for modules B4 leads to high noise in those modules. Ideally complete modules should be read out to the same bulkhead.

Hardware Conclusions (2)

- **ADBs:** Need to be replaced.
  - New ADBs have to be more reliable.
  - A new connection scheme between ADBs and IOBs is needed that is more robust against alignment imperfections and temperature changes.
  - The new ADBs should have the capability of masking any combination of channels for charge injection.
  - 3 gain ranges would be more solid than 4. Depends on source calibration (see below).
  - **IOBs:** Need to be replaced.
  - Connection scheme with ADBs has to be changed.
  - If the feature extraction could be done on the IOB it would save bandwidth and computing power downstream. It would, however, be difficult to implement things like sparsification that require communication between front end crates. Also SEUs are an issue.

Source Calibration

- **Advantages:**
  - Instant calibration constants as opposed to the Bhabha calibration which needs to accumulate data over several days at least.
  - The system exists. A new neutron generator was purchased recently.
- **Disadvantages:**
  - Requires running non-standard DAQ that would have to be ported to the new DAQ system.
  - Neutron generators are expensive and not very durable (we used 3 for Babar).
  - Requires high gain (x256) on the ADB. Without the source calibration one could probably get away with 3 gain ranges instead of 4.
  - The source calibration constants are derived from very low energy photons (6 MeV).

Source Calibration

In principle one could do calibration with the Bhabha constants alone à la Belle.

Lightpulser

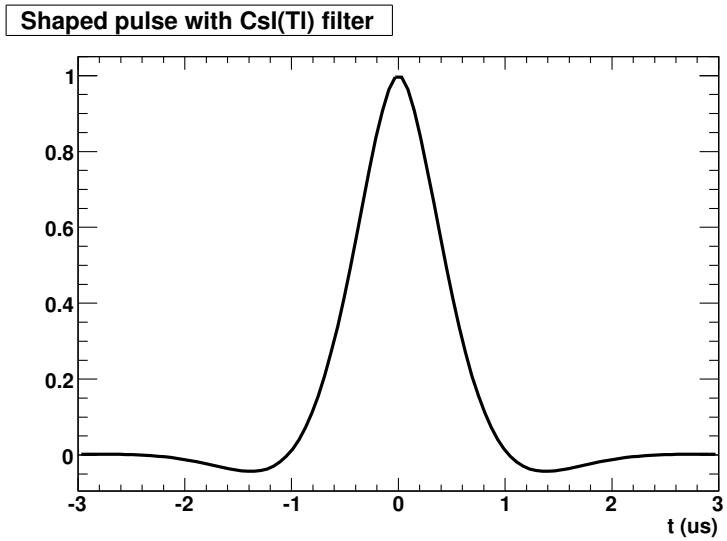
- The lightpulser is used as a quick functional test (not for calibration).
- The collaborators who built the LP want to take parts (attenuators, reference systems) back.
- The forward endcap would need new module bundles.
- The backward endcap would need both primary fibers and module bundles.
- R&D would be needed.
- Fiber installation is labor intensive.

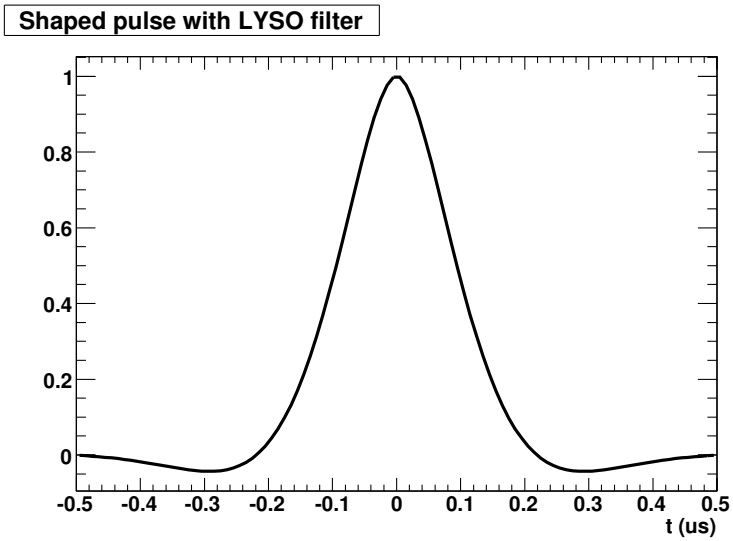
Endcap Readout

- LYSO crystals + APDs yield 25 times the signal of the present CsI(Tl) + PIN.
- APD capacitance is the same order of magnitude as in PIN diodes.
- APDs have significantly better S/N.
- In principle one could use the same preamps as in the barrel with an adjusted gain.
- EXO uses the non-ASIC version of the Babar preamp for APD readout.
- This would not be optimal because the filters in the Babar preamp are tuned for a 1 μs crystal decay time.
- The decay time for LYSO is 40 ns.

Endcap Readout (2)

- Did an estimate of the filtering for LYSO signal following Walt Innes' Babar note 327.
- Replaced the decay constant for CsI by the one for LYSO in the filter calculation which only assumes beam background but no electronics background.
- Plot shows shaped pulses for optimal filter for CsI(Tl) and LYSO.
- The rise time decreases from 1 μs to ca. 200 ns.





Endcap Readout (3)

- The calculated noise only decreases by a factor of 2 from 1930e to 885e for nominal TDR background because ENC $\propto \sqrt[4]{\tau_s}$.
  (1 MeV is 6000e)
- The cutoff frequency increases from 500 kHz to 2.3 MHz.
- A more realistic background rate should be derived from actual Babar cyclic triggers.
- In principle the filtering for the endcap could be done purely digitally with no shaping in the preamps but Dieter Freytag says it's not practical.
- The discrete Babar preamps could be used to do testing with LYSO crystals because the shaping constants as well as the gain can be adjusted by replacing capacitors and resistors.
- In the end a new ASIC would have to be designed.

Sampling Frequency

- At present the sampling frequency is 3.7 MHz.
- For the preamp shaping in the barrel this is adequate albeit a bit on the low side.
- With significantly shorter peaking times in the endcap the sampling rate would have to be increased by the same ratio as the peaking time decreases (e.g. for 200 ns peaking time instead of 1000 ns the sampling rate should be 18.5 MHz).
- If the trigger jitter was the same as before the number of samples that cover the same trigger window would also increase (e.g. 40 samples instead of 8).
- Can the endcap readout run at a different rate than the barrel?

Conclusions

- The barrel preamps could be reused for the Super-B.
- The rest of the electronics should be redesigned.
- The source calibration system could be reused with little effort.
- The lightpulser system would need some retrofitting and upgrading.
- Endcap readout needs preamps with lower gain.
- A lower shaping time would be appropriate for LYSO.
- This would require a higher sampling rate.