Light Pulser Reference System

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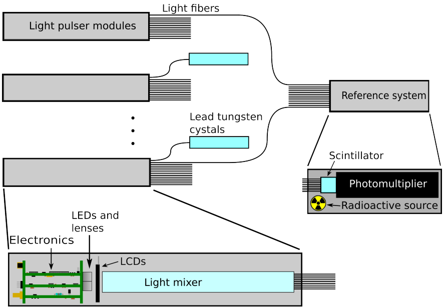
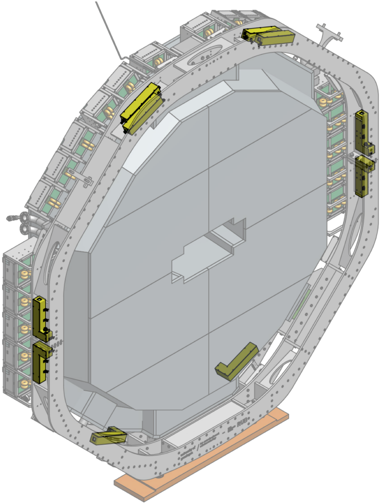
$\overline{\text{P}}$ANDA Collaboration Meeting 02/18
Stockholms Universitet, June 06th 2018

Reminder: The LED Pulser System for the $\overline{\text{P}}$ANDA EMC

- LED based system producing light pulses mimicking scintillation light pulses in PWO crystals
- Ten LP modules to be deployed in the forward endcap
- Light coupled into every PWO crystal via silica fibres





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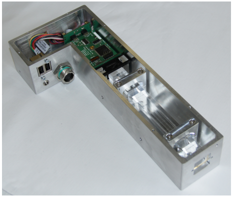
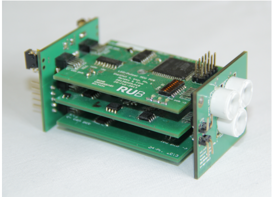
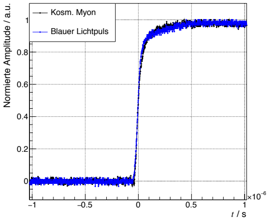


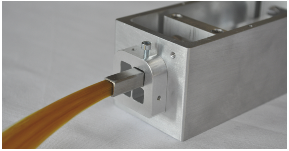


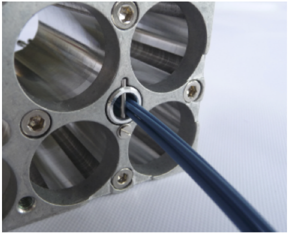


- Stack of interconnected PCBs
- System driven by AT90CAN128 microcontroller
- Three LEDs (high intensity blue, low intensity red & green)
- Plexi glass light mixing bar
- Light attenuation realized via two optical shutter LC displays
- Controlled via CAN / EPICS
- EM shielding: solid aluminum casing

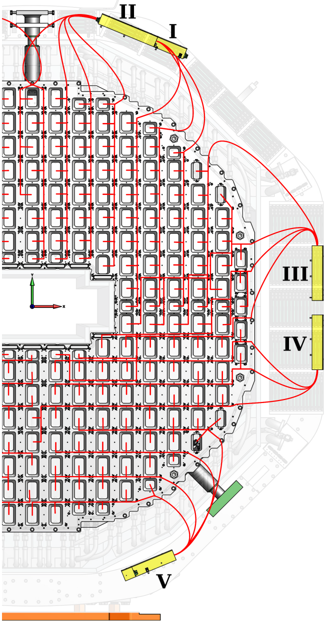
- Goal: System must generate light pulses mimicking crystal scintillation light over full dynamical range
- FOM: Pulse shape at preamplifier output

Light Distribution





- Fibre bundles with up to 544 single fibres connect to LP modules
- 4-crystal fibre plugs secured in mountplate
- Detailed routing scheme for light fibre bundles ready
- Maximum fibre length about 3 m



The LP Reference System

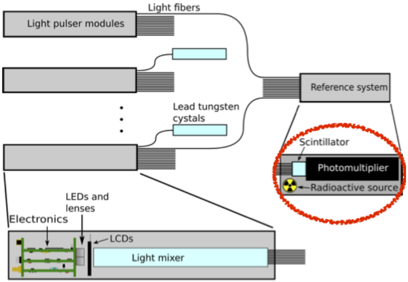
- Paper about LP system in preparation, one of the few missing items:

→ **Stability and referencing of the LP system**

- Challenge: Absolute stability of light pulser module intensity cannot be guaranteed due to aging of LED, temperature variations, ...

→ Necessity for a system providing stable reference measurement

→ Up to now only concept drawings available, started to build a prototype



The LP Reference System

- Challenge: Measure stable reference signal, e.g. from radioactive source together w/ LP signal using the same photo sensor over complete dynamic range
- Design concept:

→ Using one of our final VPTT + Basel-preamplifier

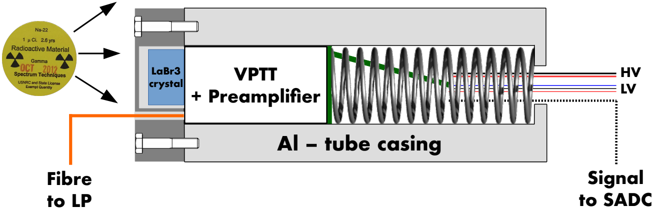
→ Benefits:

  - Insensitive to temperature variations
  - Can handle signals over complete dynamic range
  - Output signals can be processed by the same sampling ADC as rest of EMC

→ $LaBr_3$ scintillator + ^{22}Na source

→ Benefits:

  - Already bought and delivered!
  - Two distinct photo peaks (511 keV and 1275 keV) for calibration
  - Very high light yield of $LaBr_3$, while temperature dependence is negligible



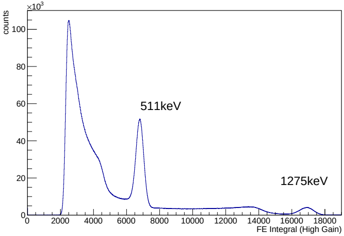
Signal Response of Reference System

- VPTT+Preamp delivering a 2.2 V signal at 12 GeV single crystal deposit (max.)
- ADC input stage designed to handle these signals
- ADC splitting: High Gain up to ≈ 750 MeV PWO equiv., low gain up to 12 GeV PWO equiv.

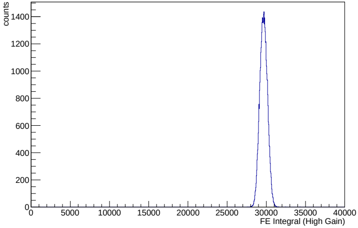
→ LP signals recorded by the Ref. system VPTT unit in the same way

- ^{22}Na spectrum comfortably visible in the high gain range due to high light yield of $LaBr_3$

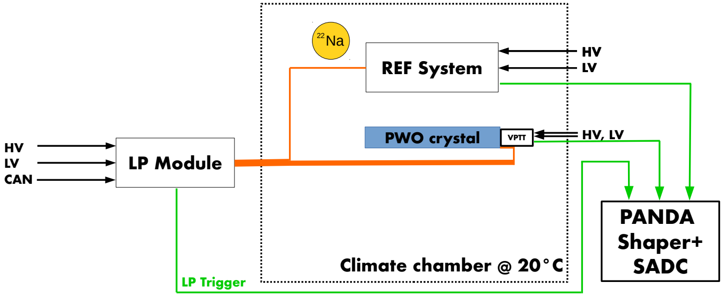
^{22}Na spectrum



LP spectrum



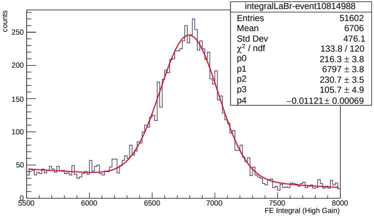
Measurement Setup



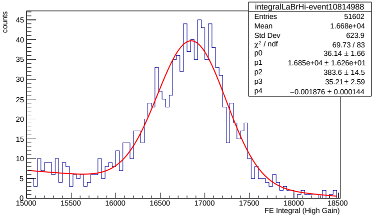
- Recording of LP trigger signal allows for offline separation of LP and ^{22}Na signals
- Additional final VPTT/Preamplifier/Crystal unit as detector to be referenced
- Procedure:
  - Collect ≈1200 events in 1275 keV region (about 20 min.)
  - Fit both photo peaks (use both peak positions as stable reference values)
  - Calculate reference amplitude (pulse-by-pulse):
    $E_{\text{ref}} = (E_{\text{ref,LP}} - E_{\text{ref,Na22 offset}})/E_{\text{ref,Na22 slope}}$

  → Calculate Pulse-by-pulse-referenced detector response:
    $E_{\text{Det,ref}} = E_{\text{Det}}/E_{\text{ref}}$

511 keV Peak



1275 keV Peak



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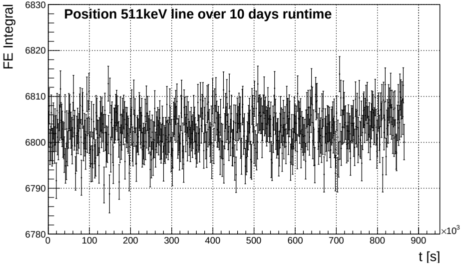
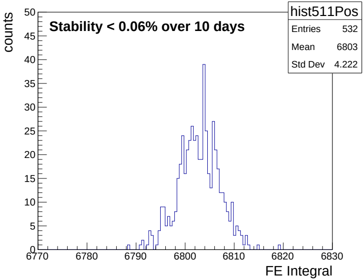
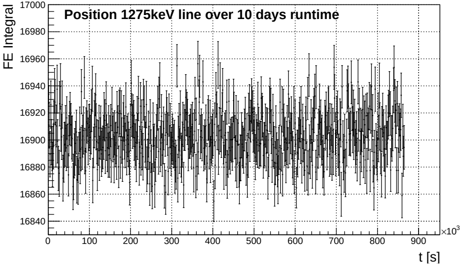
Stability over 10 days runtime

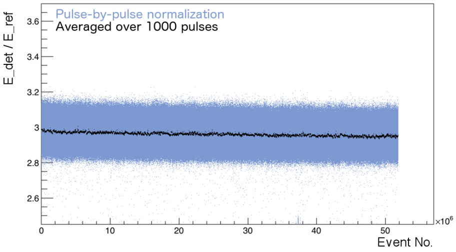


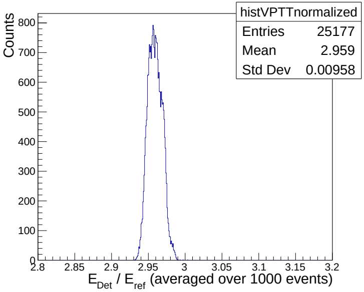




- ▶ Position of γ lines from ^{22}Na source are extremely stable
- → Proof-of-principle: Usage of $LaBr_3$ scintillator and $\overline{\text{P}}$ANDA VPTT unit seems adequate
- → Same signals as from regular endcap detector units, thus can be read out with $\overline{\text{P}}$ANDA FEMC Shaper+SADC without any adaption

Stability over 10 days Runtime





- Very time consuming measurements
- Achieved stability of referenced detector response to LP signals over 10 days: $\approx 0.3\%$
- Important observation:
  - Hamamatsu data sheet states: Keep VPTTs dark with HV applied for > 30 minutes to allow tube to recover
  - Observation shows, that this is true for the first $\approx 99\%$ of the signal recovery after application of daylight
  - Last percent will be recovered only after several days (exponential behavior)

  $\rightarrow$ Started shown measurement after 4 days in dark climate chamber

Conclusions

- Prototype for light pulser reference system built

→ Performance is acceptable

- Measurement still running, soon will have doubled the runtime

→ **Proposal:** Foresee reference system based on VPTT detector unit and $LaBr_3$ scintillator for installation

- Space for reference system module(s) must be reserved, incl. fibre routing out of the magnet
- We should keep in mind and further investigate recovery time for VPTT units