SINE2020

WP9 Instrumentation: Detectors

Task 9.2.2 Scintillation Detectors with direct PMT readout

LIP Coimbra 07. September 2016 | Ralf Engels

Outline

- Detector Setup
- Coarse Concept
- Scintillator
- Readout Electronics
- First Tests
- Conclusions

Detector Setup

- **Envisaged Detector Principle**
  - usage of Li-glass scintillator and PMT for light detection
  - apply threshold on PMT signal to select and register neutron peak
- **Extend Principle by usage of Flat-Panel MaPMT**
  - simple neutron counter
  - dense array of PMTs with small amount of dead space
  - possibility of modular and scalable design for large areas
  - position resolution determined by pixel size of individual PMTs
  - count rate capability probably mainly limited by maximum current

Coarse Detector Concept

Envisaged Detector Principle

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➡ Simple neutron counter

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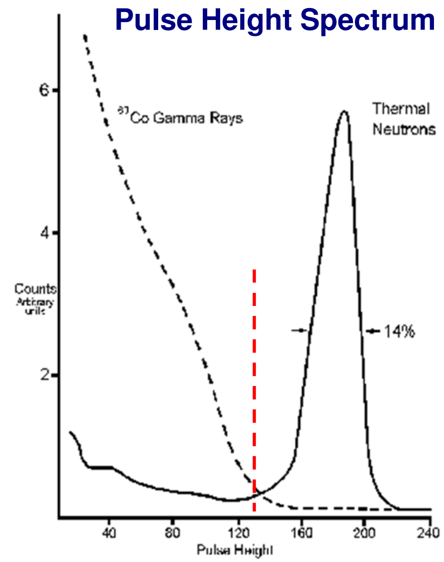
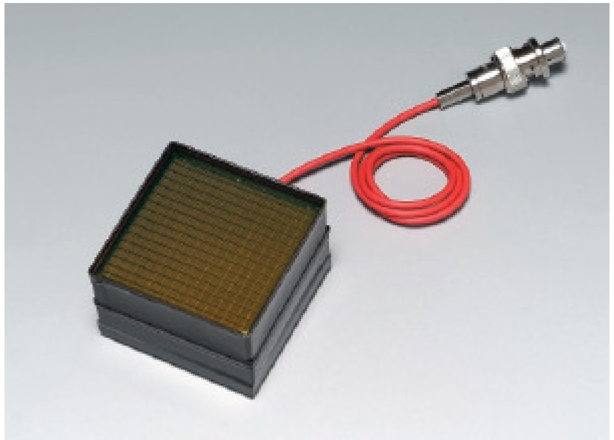




GS20-^{6}Li-glass scintillator

Neutron capture reaction:

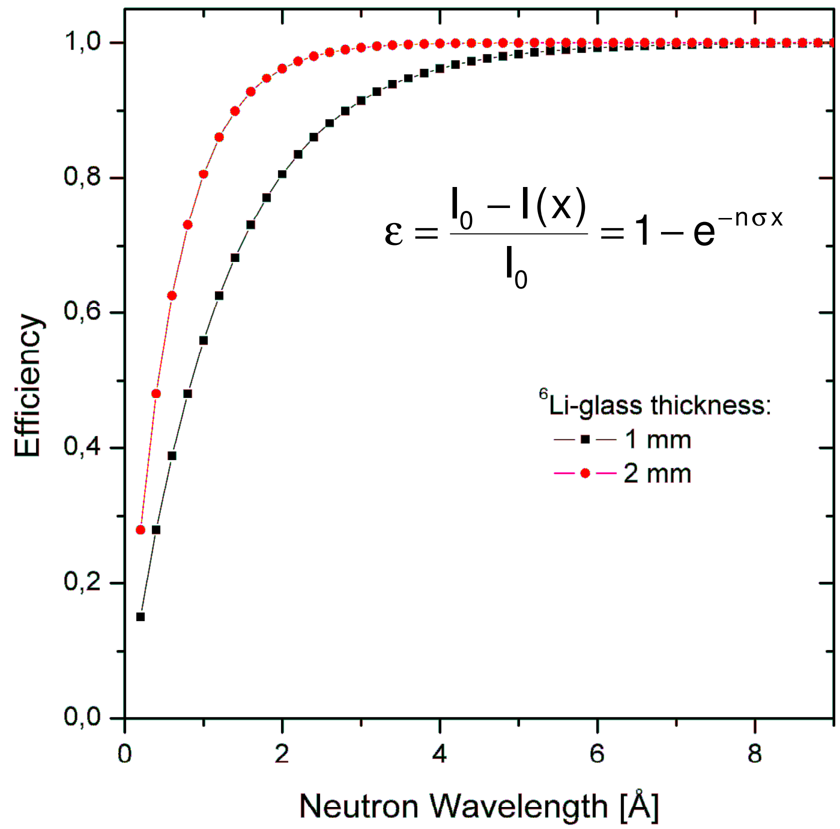
$$n + {}^6Li \rightarrow {}^4He + {}^3H + 4.79\,MeV$$

6.6 weight% Li, 95% ^{6}Li-enriched

Emission peak at ~390 nm (Ce doped)

Light yield ~ 6000 photons/n (corresponds ~1.5 MeV gamma)

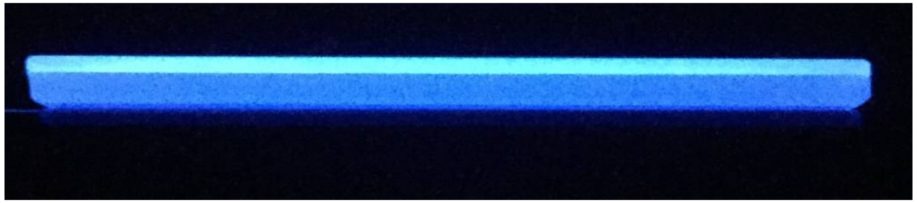
- avoid optical crosstalk by machining thin grooves corresponding to pixel edges and fill them with reflector
- insensitive outer edge of 1.5 mm of MaPMTs together with 200 µm insensitive grooves yield an active area of 84% for H8500
- 1mm Li-glass scintillator could be sufficient for detection efficiency of ~80% @ 5A

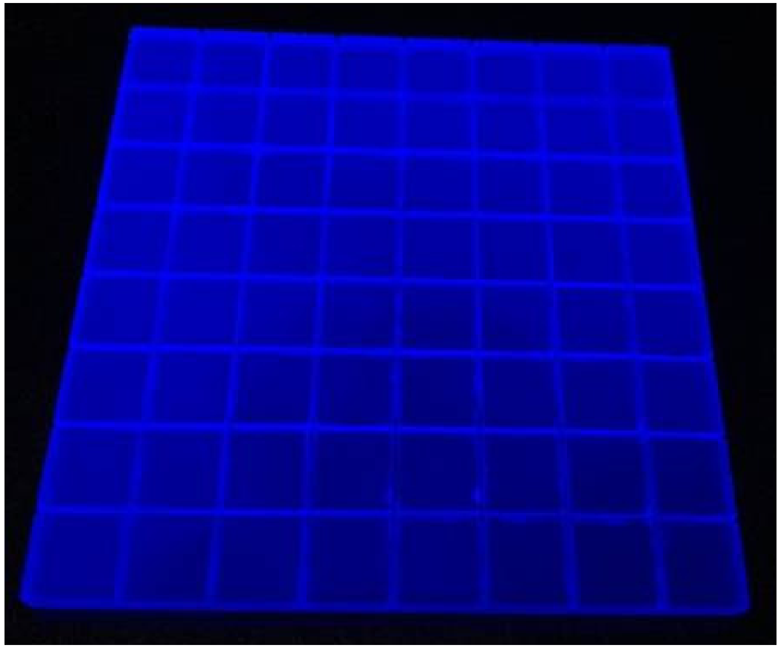


→ High Detection Efficiency

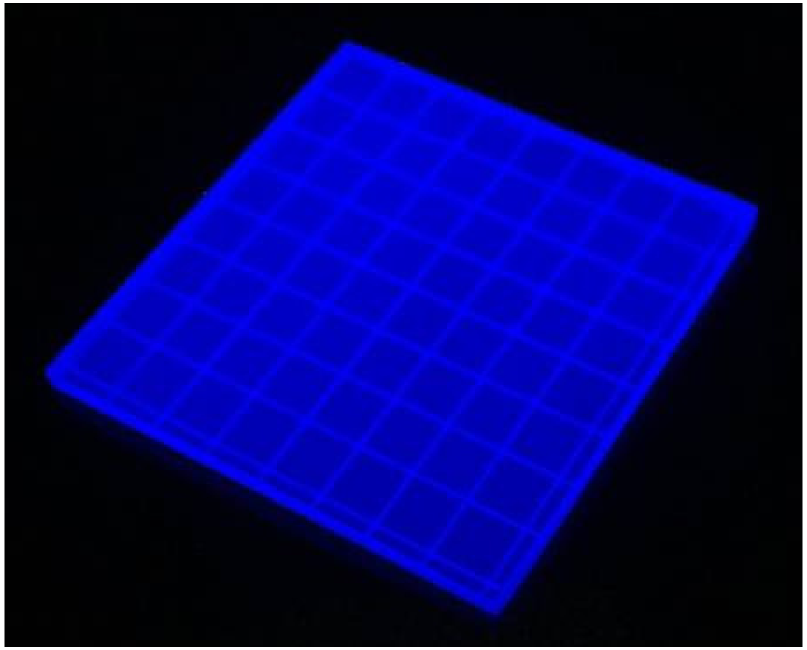
Scintillator Groove Tests

Scintillator glued on support glass
(1 mm scintillator, 2 mm glass)





Common glass saw



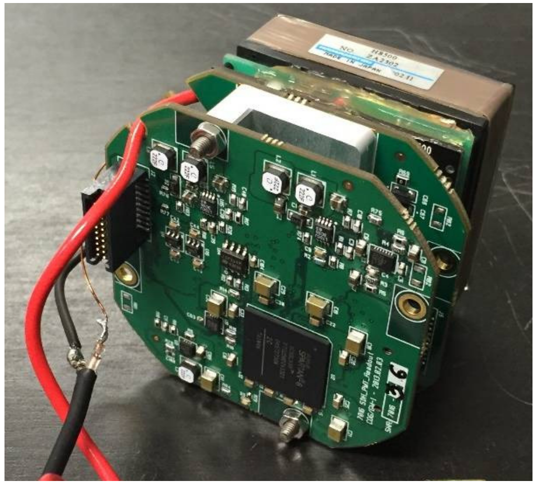
Wafer saw

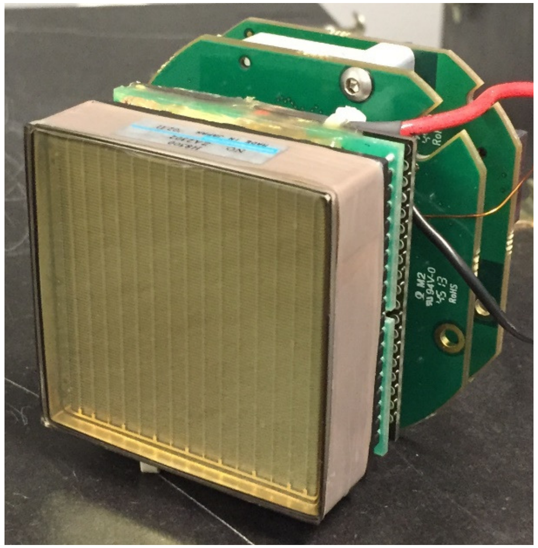
Coarse Readout Electronics Concept

- Pulse Processing and Neutron Recognition
  - amplification of PMT signals (e.g. variable gain amplifier)
  - measurements by registering signals above a given threshold applied by a discriminator
  - calibration by measurement of pulse height spectra and adjustment of discriminator thresholds relative to neutron peak
- Control and Readout Electronics
  - time stamping, coding and transport of neutron hits
  - control and readout interface for adjustment of pulse processing

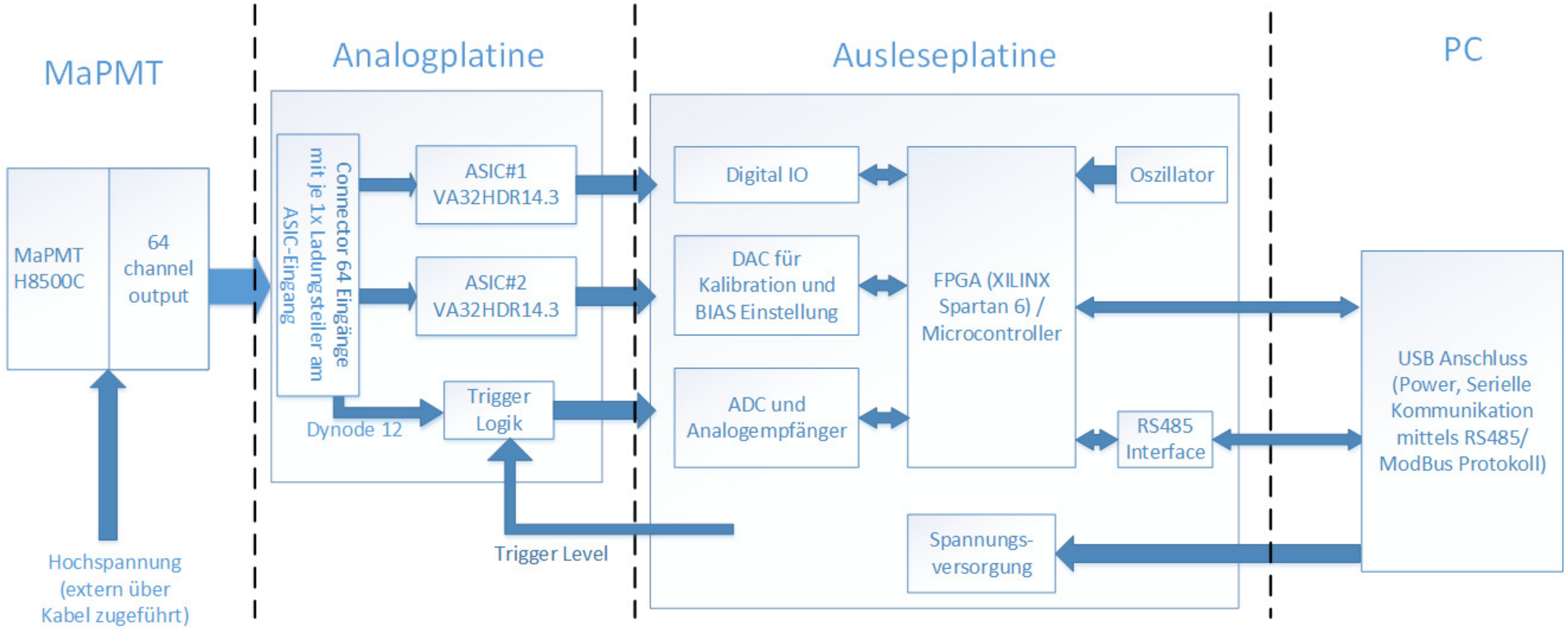
Readout Electronics Evaluation System

- Required parameter for pulse processing: charge per neutron
  - dependent on number of photons hitting photocathode, quantum efficiency, gain of MaPMT
  - difficult to predict (reflective effects)
  - adjustable to some degree by MaPMT gain
- ROSMAP readout system for evaluation
  - digitization and counting mode available, but only digitization mode used for tests
  - 2x VA32HDR14.3 ASICs for digitization of channels with 10:1 (changed to 3:1) charge splitter for measurement up to 200pC input charge
  - trigger derived from PMT dynode signal
  - 14 bit ADC, data values are delivered with 8 bit resolution via ModBus interface
  - read out rate of ~50 Hz achieved for digitization mode (with python interface)
  - external high voltage supply for MaPMT

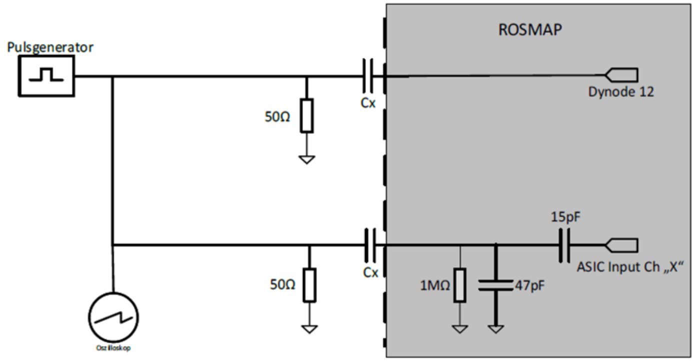




Blockdiagram of the ROSMAP System



Charge Measurements



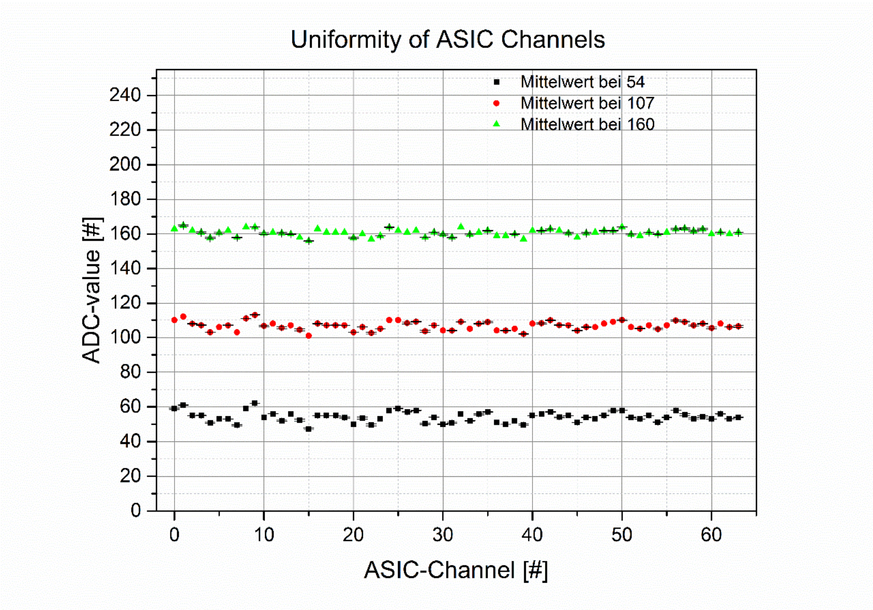
Blockdiagram of the test setup

- Homogeneity between the different ASIC Channels
  - Comparison of the gain with a constant charge injected into all 64 ASIC channels

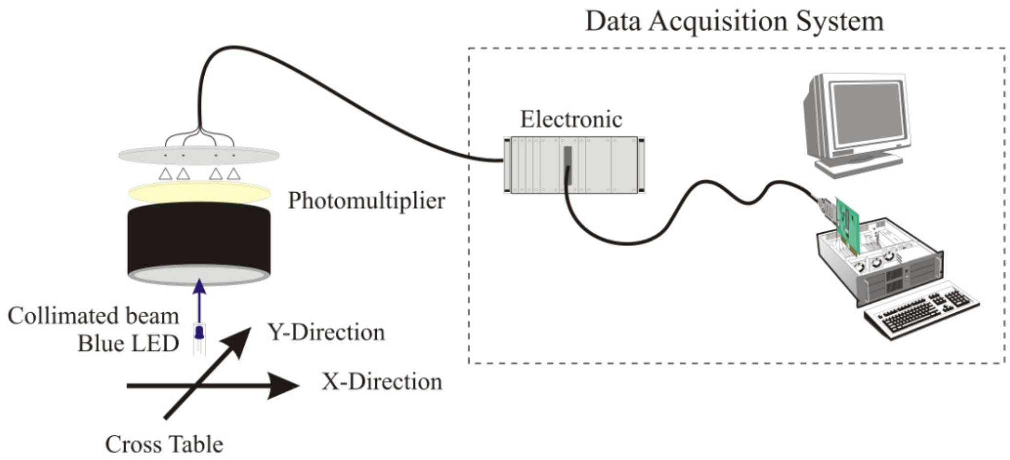
Δ Max / Min = 9

Δ Max / Min = 12

Δ Max / Min = 14,7



Setup of the test bench and cross talk measurement



- The test bench has an active scan range of 40cm x 40cm with a collimated 1mm (exchangeable) blue light source
- SPS controlled motion unit
- Position reconstruction is < ±15µm

- Test software allows different figures/scans to test the PMT

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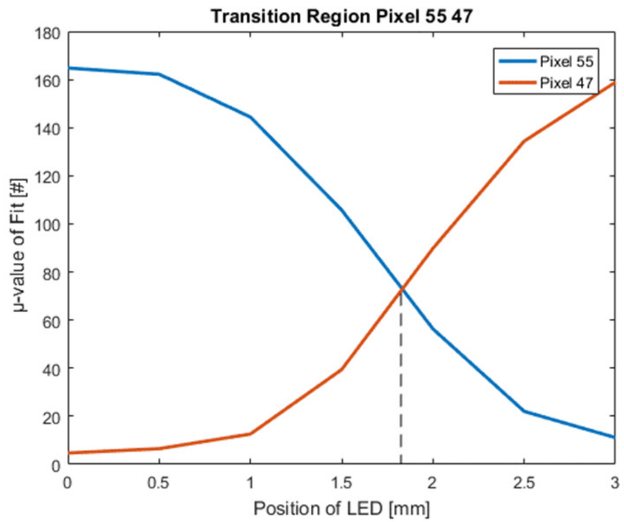
P55	P56

- Every parameter are stored in files for each scanned PMT like
  - scan area,
  - temperature in/out-site scan box,
  - pulse height spectra for each pixel and in total



Conclusion

- machining of the scintillator for grooves was successful, but still need to be further investigated
- ROSMAP system has been chosen for evaluation and initial operation with the system and a H8500 has been started
- modification of the ROSMAP LabVIEW software is needed
- first optical and electronic measurements were carried out
- low count rate expected with the ROSMAP System