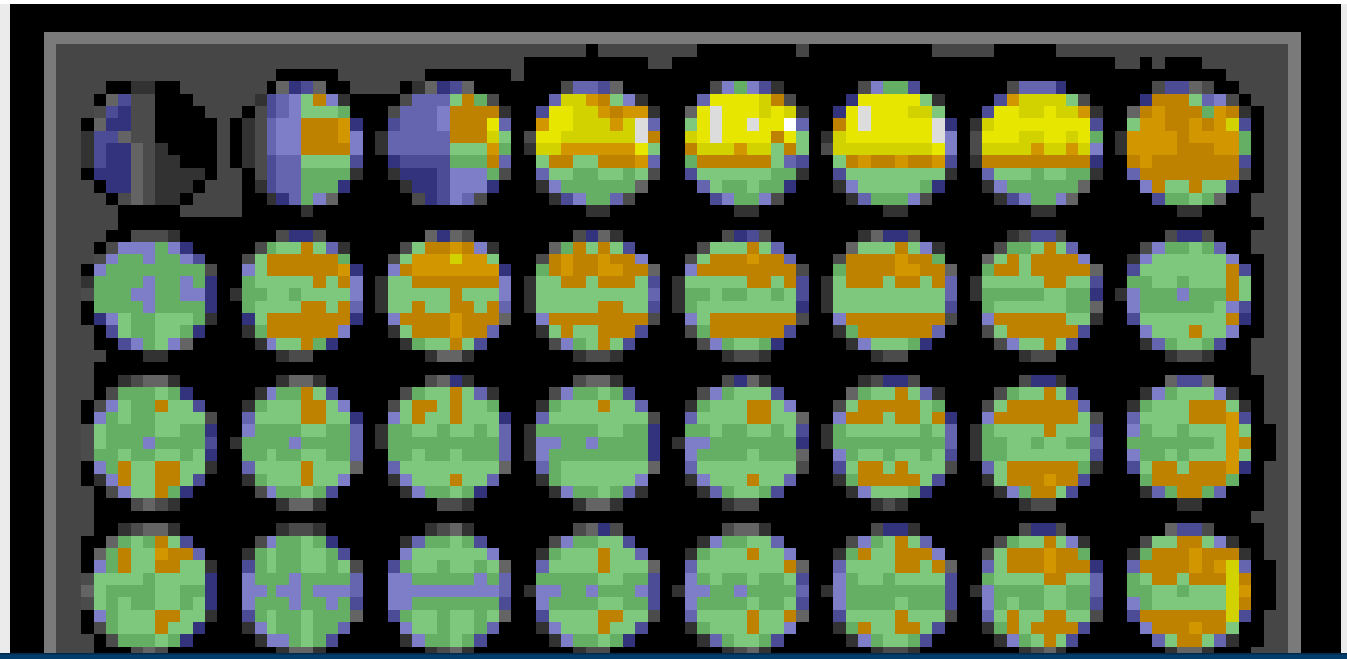
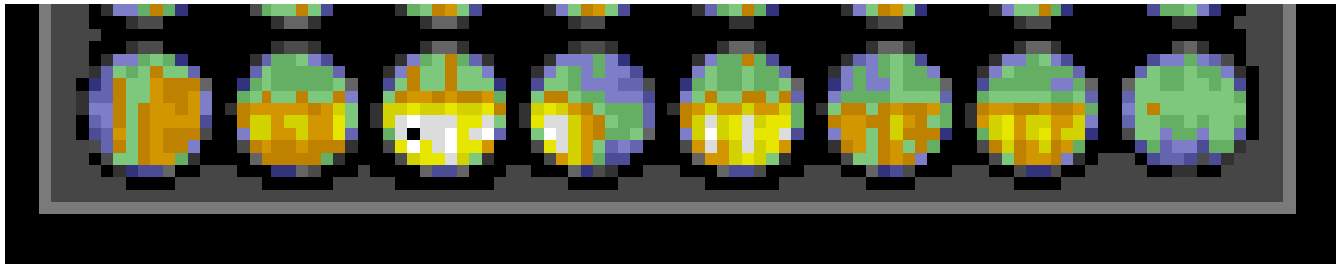


# REPORT ON DIRECT MAPMT READOUT

## SINE2020 Meeting Bilbao

MAY 28, 2019 I R. ENGELS



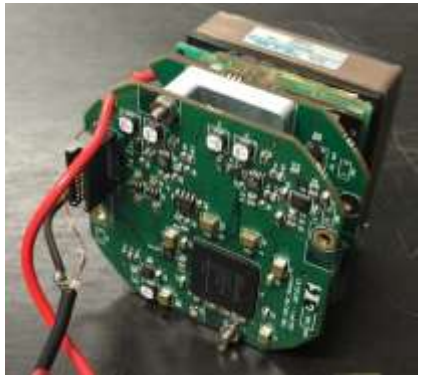
# HEADLINE

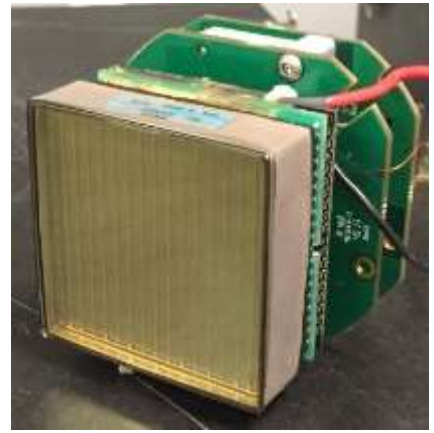
- Where were we coming from
- Used components
- Latest measurements
- Anger Camera‘s in use
- Summary

# READOUT ELECTRONICS EVALUATION SYSTEM

## History

- 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

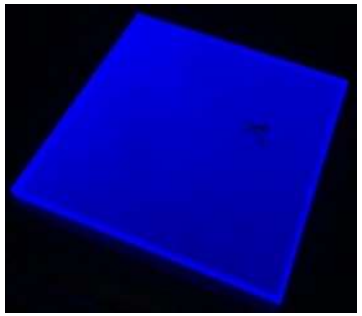




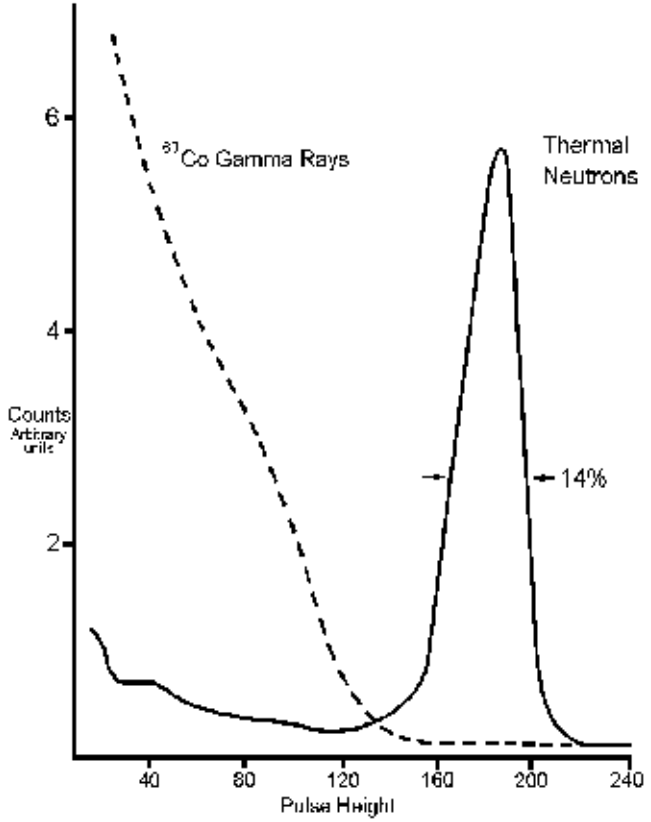
# STANDARD NEUTRON SCINTILLATOR

## GS20-$^{6}$Li-glass

- Usage of Li-glass scintillator and PMT for light detection
- Apply threshold on PMT signal height to select and register neutron peak
- Emission peak at ~390 nm (Ce doped)
- Light yield ~ 6000 photons/n (corresponds ~1.5 MeV gamma)
- Neutron Sensitivity
  - 65% @ 1 Å
  - 85% @ 2 Å



Scintillator with support glass



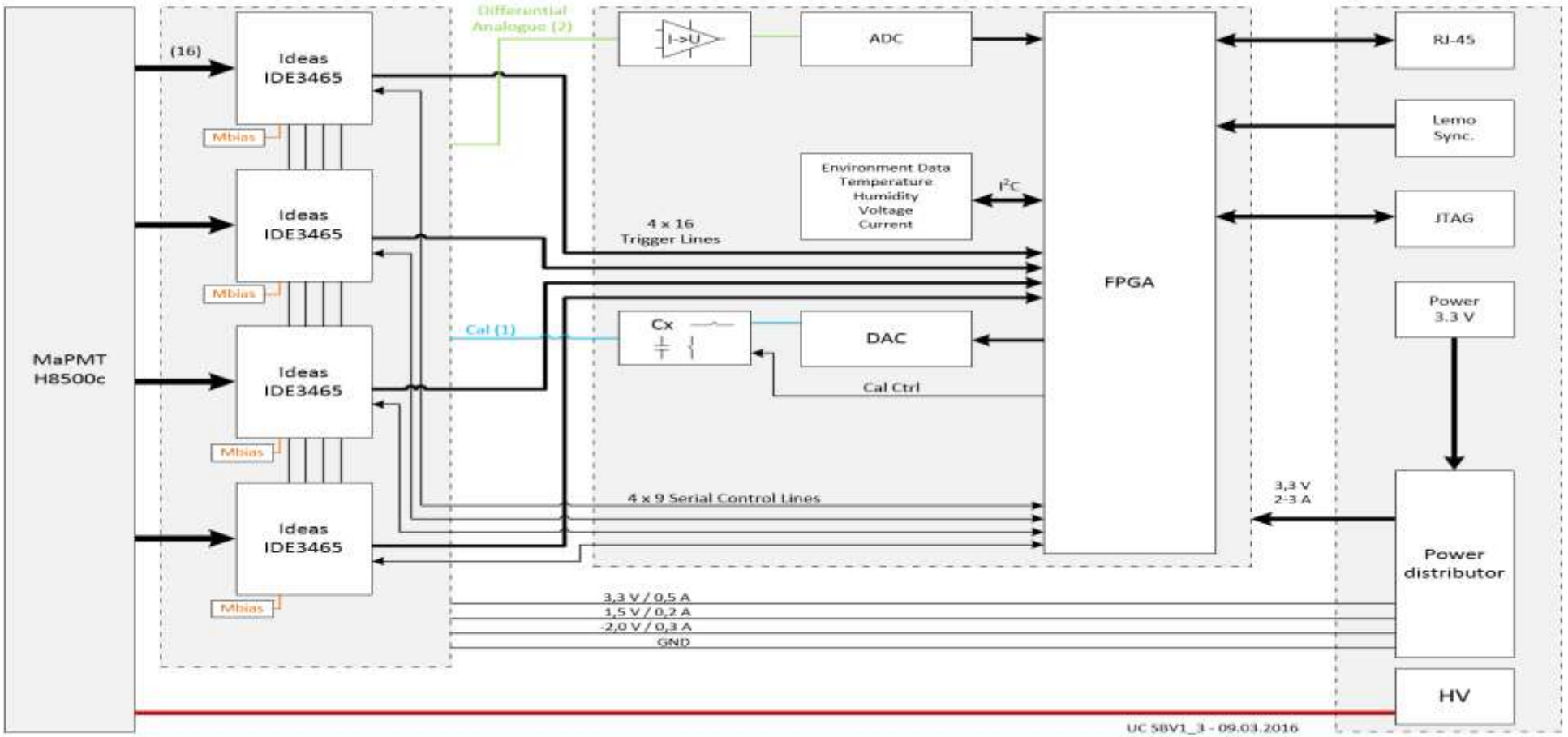
# MULTIANODE PHOTOMULTIPLIER (MAPMT)

- **Hamamatsu H8500 / <u>H12700</u> :**
  - dense array of PMT channels with small amount of dead space (~89 % active area)
  - possibility of modular and scalable design for large areas
  - High-Rate Mode (SoNDe):
    - count rate capability theoretically up to max. 1 MHz per MaPMT
  - also: High-Resolution Anger Mode
    - position resolution of ~0.6 - 0.7 mm

Figures from Hamamatsu

# SYSTEM OVERVIEW

## Current architecture



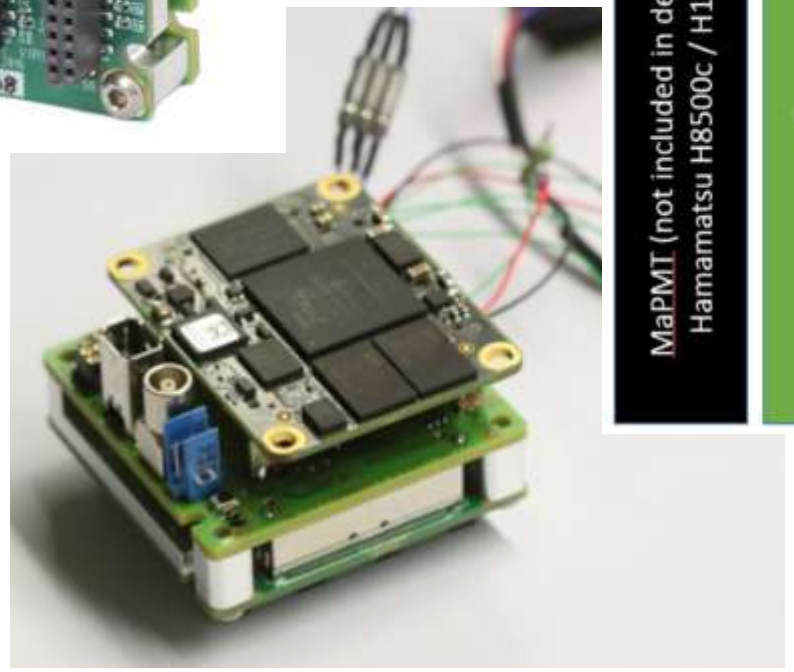
# TRENZ ELECTRONIC TE0720

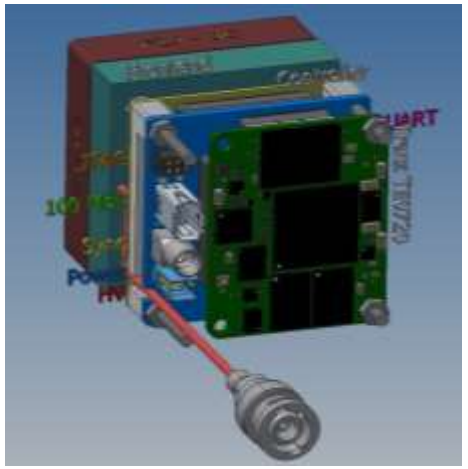
- Xilinx Zynq SoC micromodule
- ARM dual-core Cortex-A9 MPCore
- 10/100/1000 tri-speed Gigabit Ethernet transceiver (PHY), SGMII accessible on a board-to-board connector
- USB 2.0 high speed ULPI transceiver
- 32-bit-wide 1 GByte DDR3 SDRAM
- 32 MByte SPI Flash memory (for configuration and operation)
- 4 GByte e-NAND (up to 32 GByte)
- Plug-on module with 2 × 100-pin and 1 x 60-pin connector
- 152 FPGA I/O's (75 LVDS pairs possible) and 14 MIO's Valid MAC Address and 2K serial EEPROM
- SHA-256 authentication chip with unique serial number
- …..

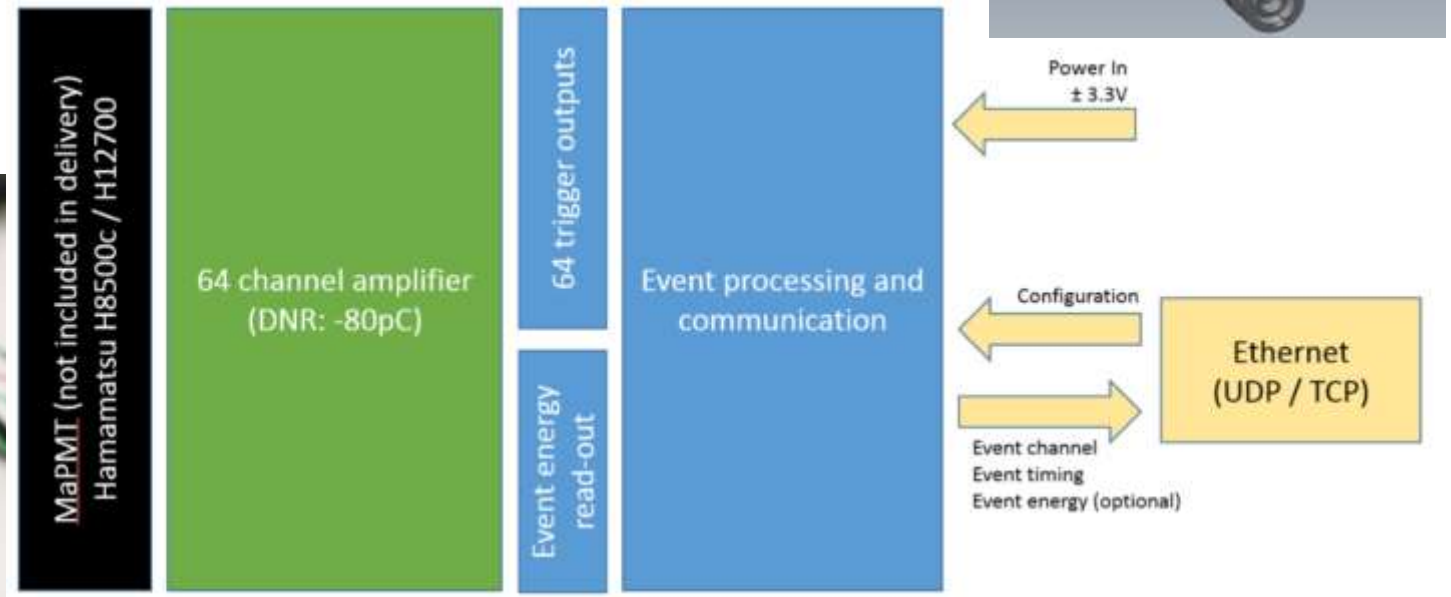
TE0720 Module

TE0720 L1IF (lower power consumption)

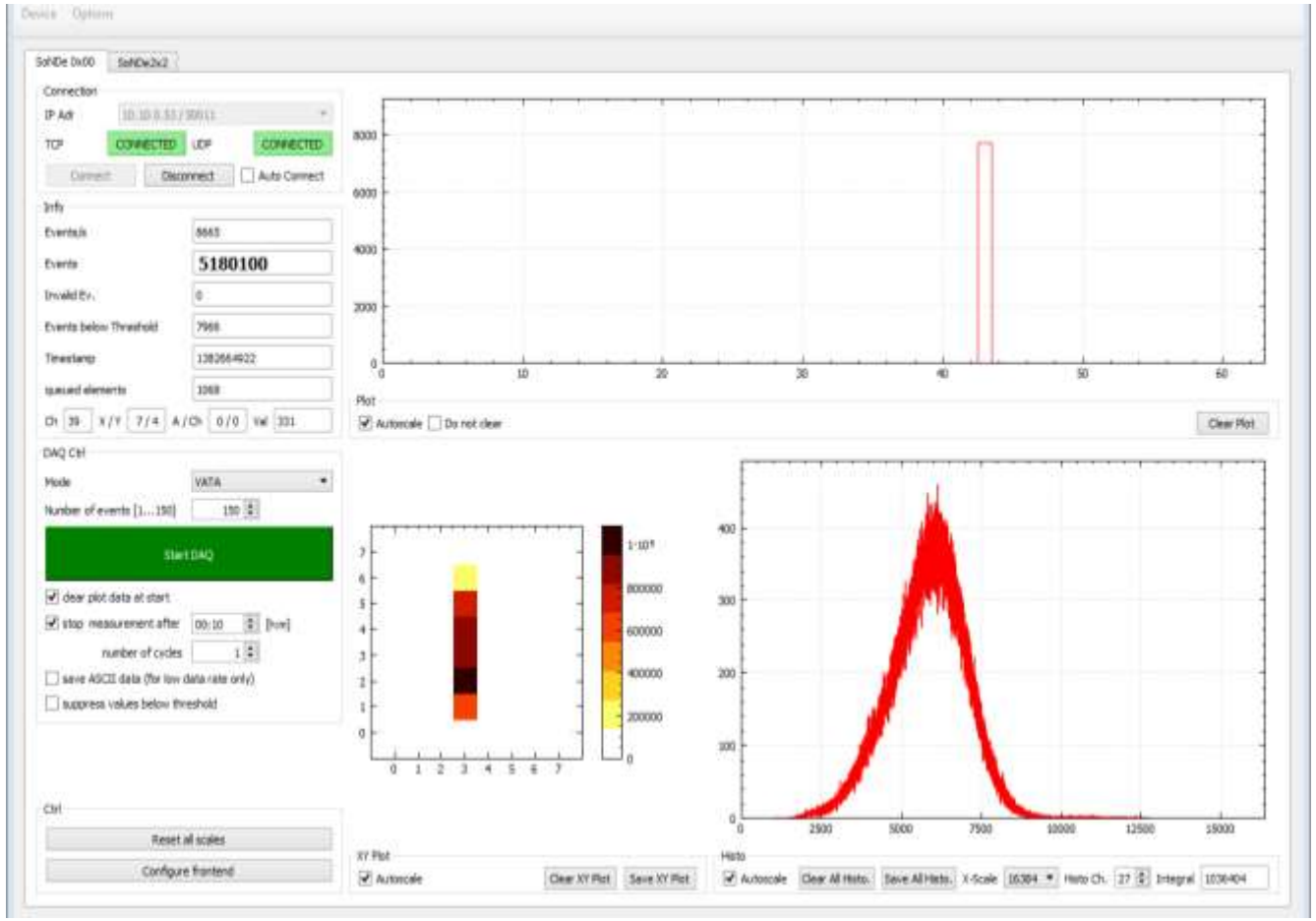
# DETECTOR READ-OUT MODULE





# TESTS WITH THE MODULE

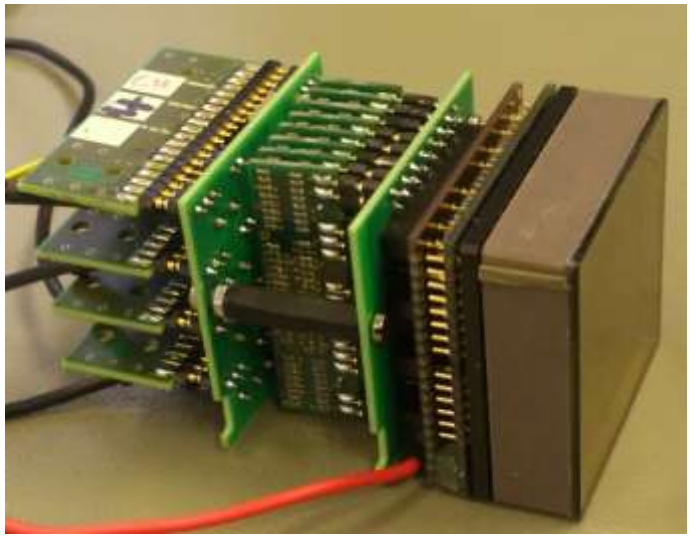



Measurements using a neutron beam in Munich.

# NEW HIGH-RESOLUTION ANGER-NEUTRON DETECTOR BASED ON H8500 MAPMT

- **Motivation**:
- Scalable design for larger detector size
- Higher resolution by smaller pitch size of neighboring light detectors
- Higher count rate by smaller detector units
- Replacement of Hamamatsu R3292 photomultiplier

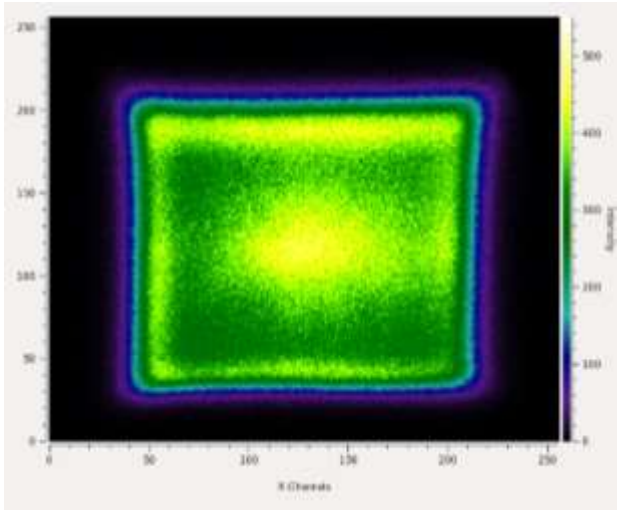
- → Usage of H8500 MaPMTs from Hamamatsu



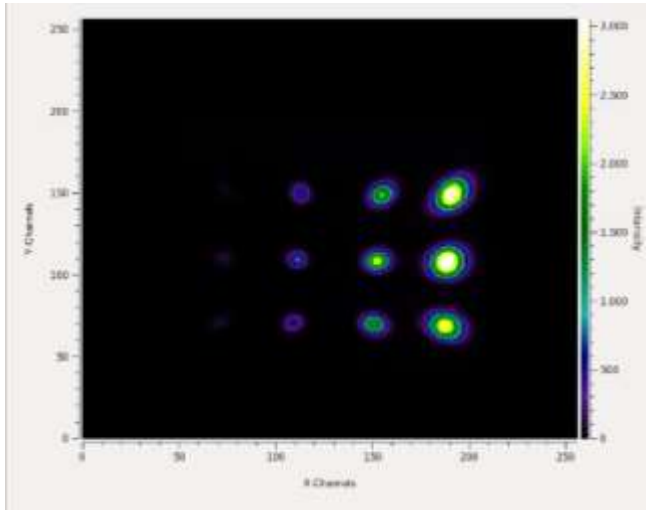
# NEUTRON MEASUREMENTS WITH VHR DETECTOR

## Pixelated MaPMT

- Single H8500 MaPMT with $^{6}$Li-glass scintillator and Anger readout electronics
- Measurements at TREFF and at KWS-3



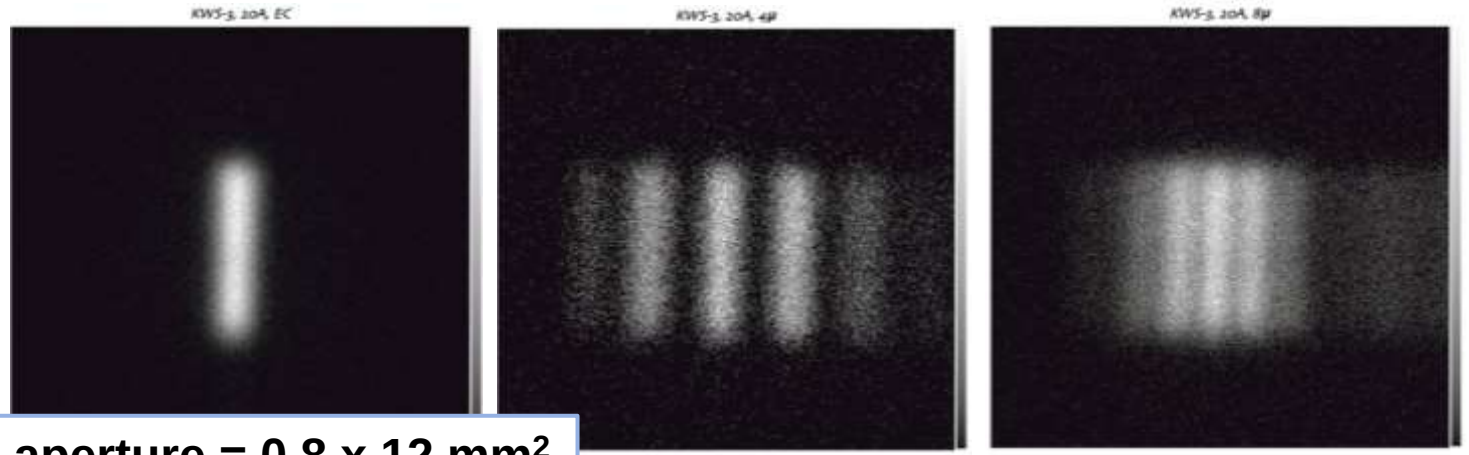
- Empty beam; no sample; open thresholds
- To be used for calibration and discrimination table



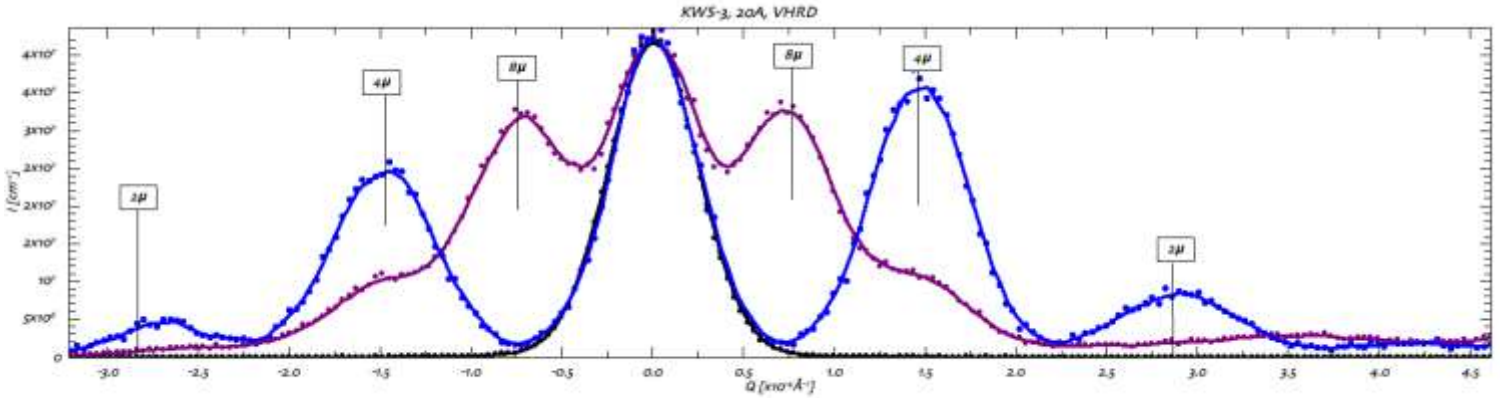
- Thin Cd and Boron Carbide Diaphragm in front of the detector
- Hole size 0.5; 1.0; 2.0 and 4 mm with 10 mm spacing
- => Spatial resolution < 0.7 mm FWHM

# “SMALL” DETECTOR (VHRD) :: RESOLUTION TEST

VHRD :: used size:3x3cm$^2$, pixel ≈0.12mm :: $Q_{min}$@20Å :: 0.00003Å$^{-1}$



**Entrance aperture = 0.8 x 12 mm$^2$**



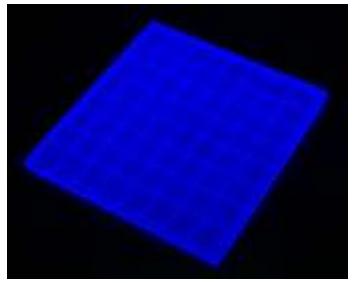

**Resolution Example:**
→ Gd gratings 4μm
→ Gd gratings 8μm

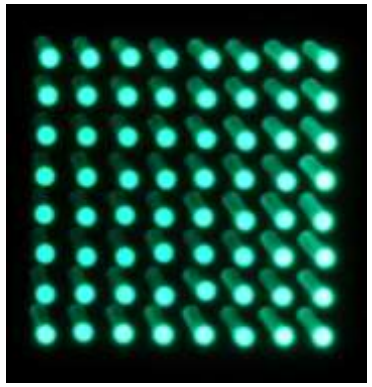
© V. Pipich

Largest measurable structure size: **20μm** (2π/0.00003)

# SUMMARY

- Backend Board was designed
- Adaption to the ASIC board was successfully
- Electronic Tests with one Module was shown
- Very good collaboration with IDEAS Team
- New High-Resolution Anger-Neutron



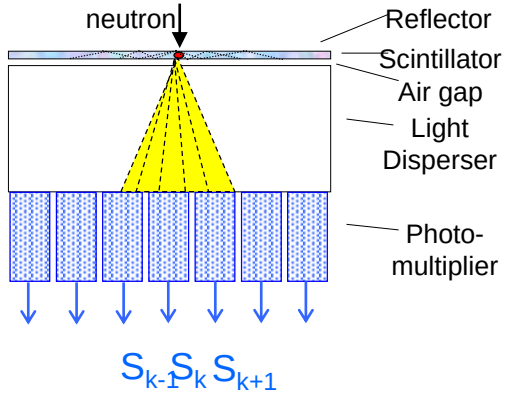


Thanks !

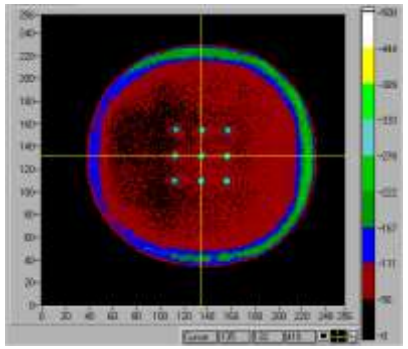
# HIGH RESOLUTION ANGER - MODE

## Position Sensitive Tube

- Anger-Principle:
  - Scintillator light spread over several PMTs
  - Determine position by PMT signals (R ~ 0.1 pitch size)
- KWS-2/3 & TREFF: Anger detector with position sensitive PMT
  - $^{6}$Li-Glas scintillator for neutron capture
  - Photomultiplier with Mesh-Dynode structure
  - Readout via resistor network
  - Position reconstruction via division method




**3 x 3 Diaphragm**
**with 2 mm holes and 10 mm spacing**



# DISTORTION CORRECTION

## Mask scan