Forward detector proposal

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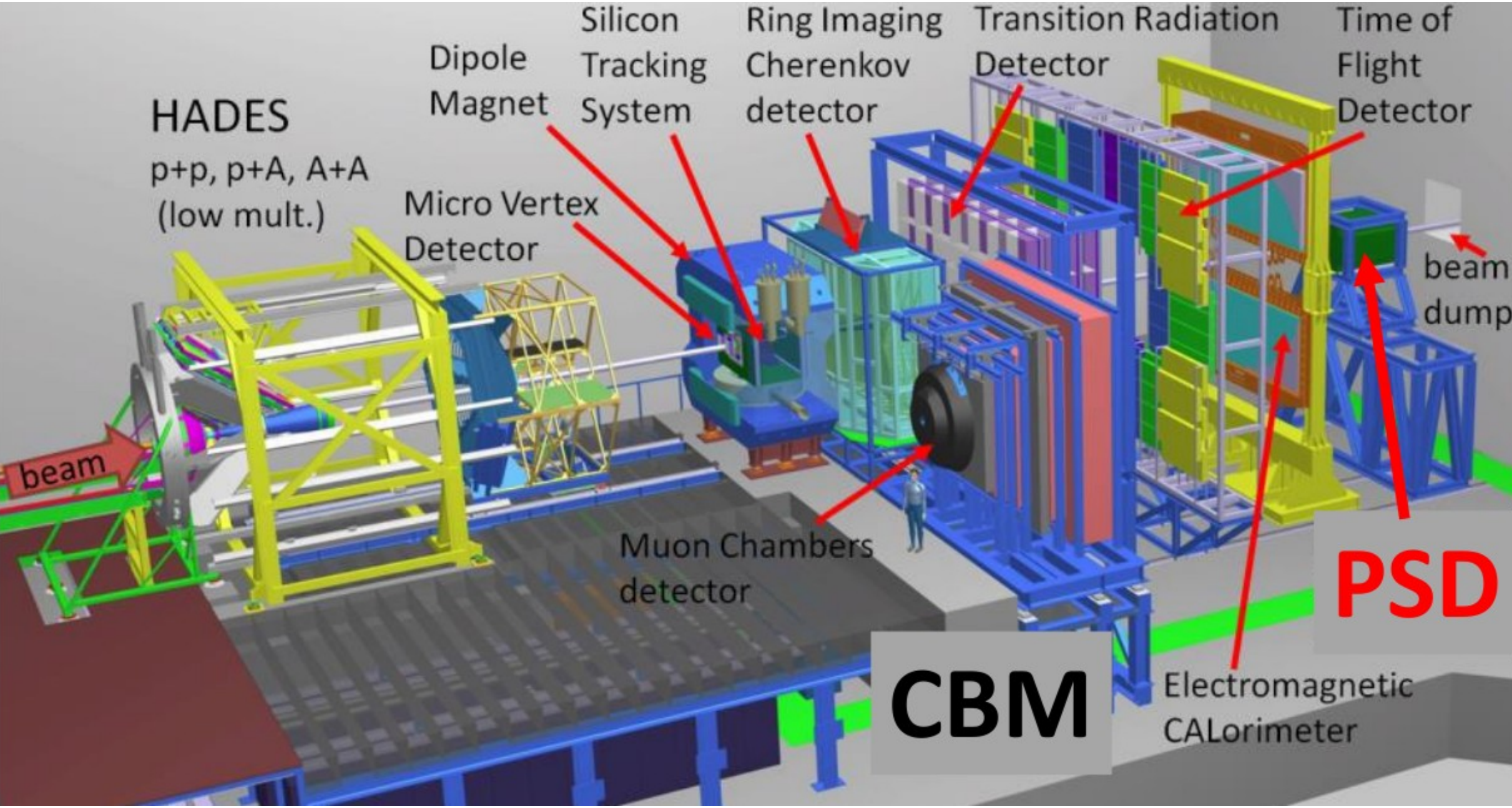
Proton Spectator Detector(PSD)



Proton Spectator Detector(PSD)

GOALS:

- spectators detection in the beam energy range of $E_b = 2 - 35$ AGeV.
- operation at beam intensities up to 10^9 Au ions per sec.
- reaction plane determination with an accuracy better than 40 degree.
- determination of collision centrality classes with an accuracy better than 10%

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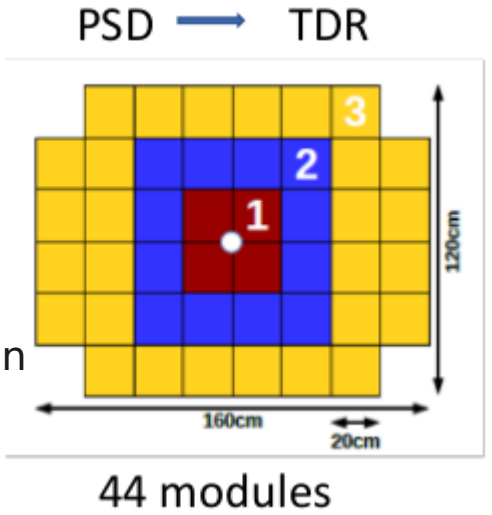
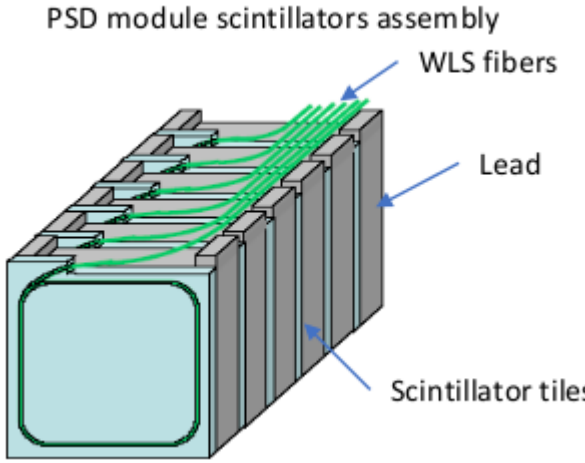


FEATURES:

- compensating sapling calorimeter (44 modules)
- Covers $0.21° < \Theta < 5.7°$
- 6.5 l, good energy resolution ~55%/√E
- light readout from a section through WLS fibers by photodiodes
- 20x20cm beam hole in the center - reducing radiation damage
- total 22 tons of weight on a platform movable in 3 dimensions



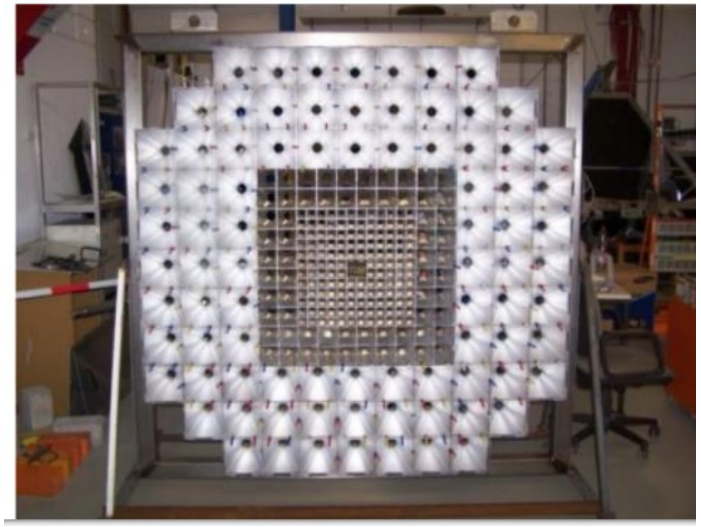
Similar calorimeter at NA61@CERN, and one prepared for BM@N at NICA.

- One module installed at mCBM

New forward detector for CBM

Proposing SCINTILLATOR HODOSCOPE:

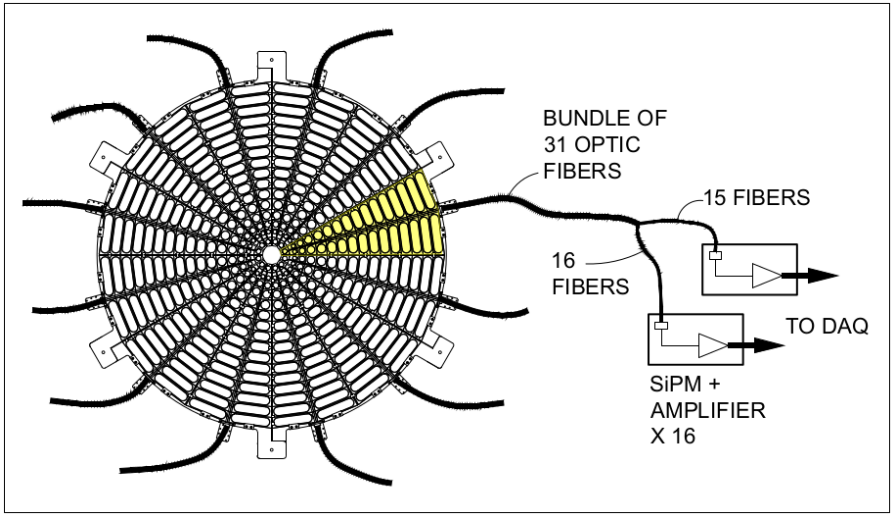
- analogous in function to HADES forward wall
  - Increasing granularity closer to the beam
  - Total charge used to determine centrality.
  - Fast readout by PMT – expensive
  - Plan to **use SiPM instead**



Plan to **use similar technology as STAR EPD**

- Readout by embedded wavelength shifter coupled to clear fibers
- SiPM readout away from radiation zone
- Scintillator can be thicker than EPD's 1.2cm

- **GOALS**:
- fast readout, radiation hardiness
- based on proven technology, reuse maxim knowledge gained from PSD
- reasonable budge



NIM A 00 (2020) 1–17

Mechanical design

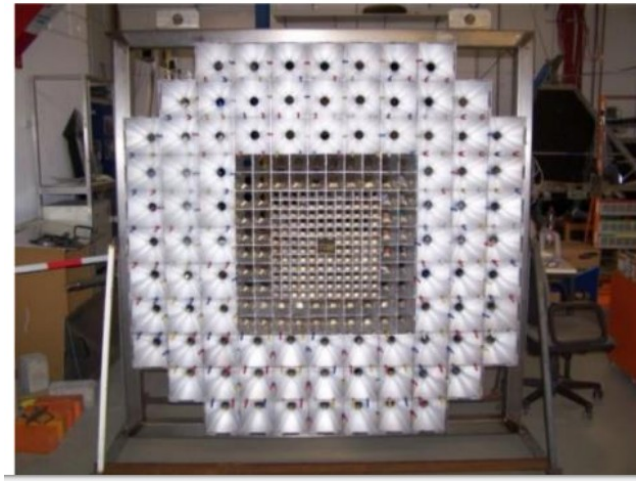
Did not do detailed studies to, but likely:

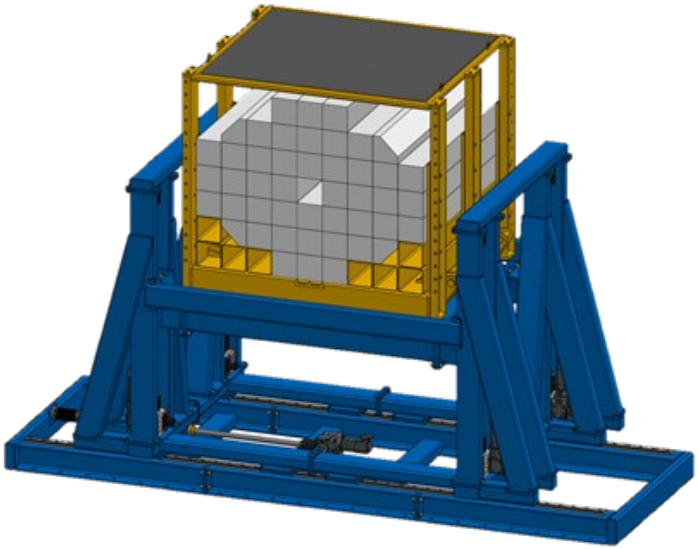
Composed of individual replaceable tiles

- Possible to remove radiation damaged center tile
  - How close can we get to the beam? (needs simulation)
- Likely HADES-like structure with tiles with varying tile sizes
  - Granularity will be optimized based on simulations

Reusing PSD platform

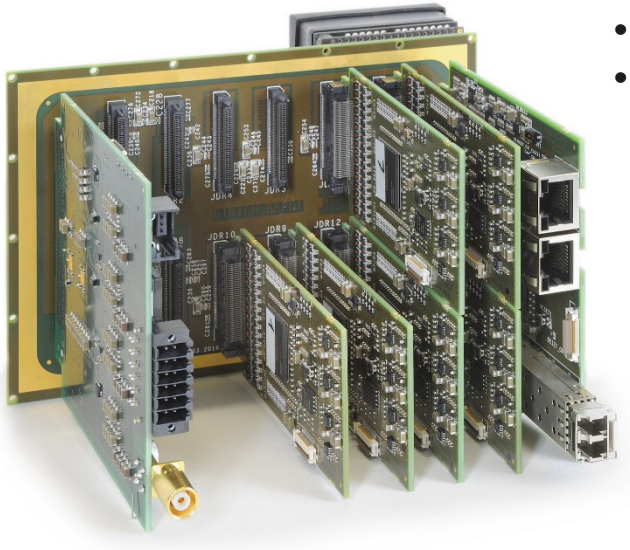
- Can support „any“ weight
  - Can have robust frame if needed
- Will it be possible to hang on the front?
  - Would still be able to add calorimeter in future





Read-out electronics

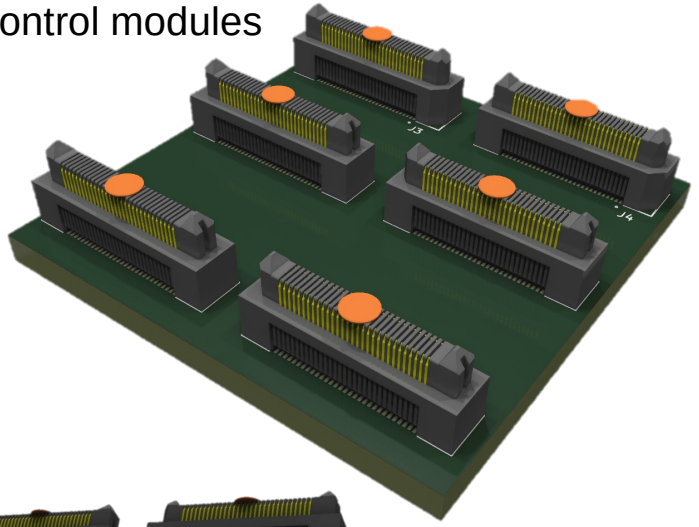
- In order to minimize the development and implementation effort and time in CBM very well known DiRICH electronics was chosen.

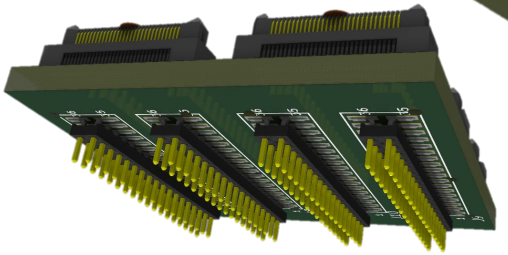


- Instead of the MAPMT, SiPMs are planned to be used
- Assembly of several boards will be used to mimic the MAPMT interface

Carrier board

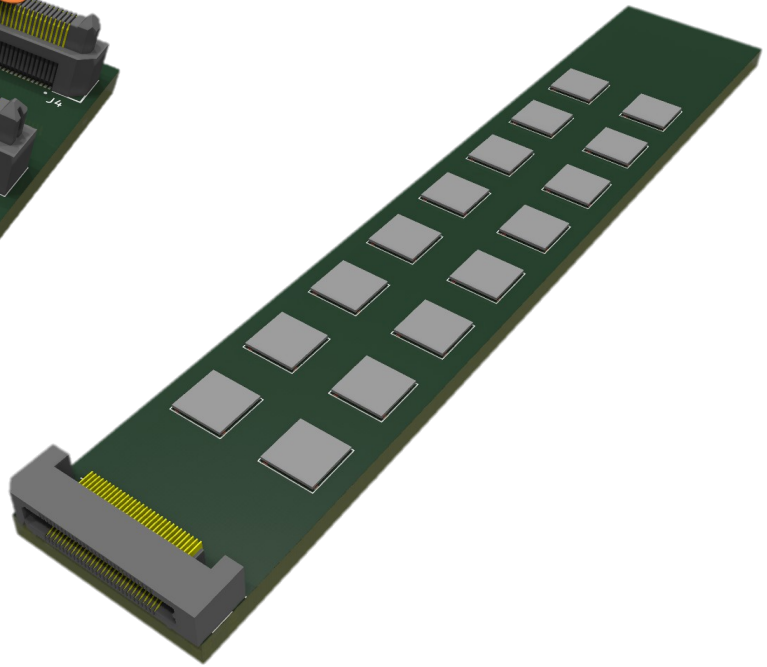
- transfers signals to DiRICH backplane
- holds SiPM blades and perhaps voltage control modules





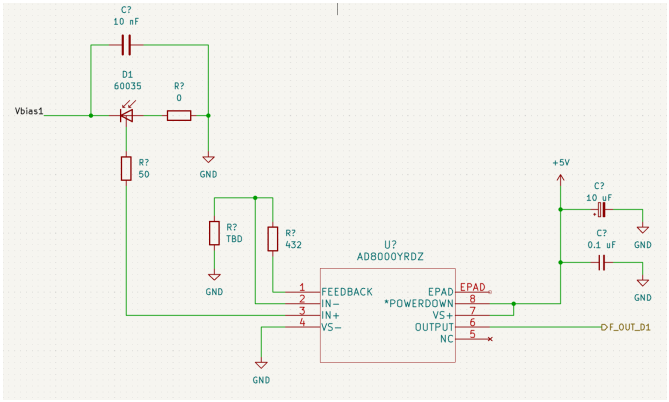
SiPM blade

- 16 SiPMs
- temperature sensing
- signal amplification/shaping
- Bias voltage control - TBD



Signal amplification

- First ideas are drawn and to be evaluated



Choice of SiPMs

Things to consider:

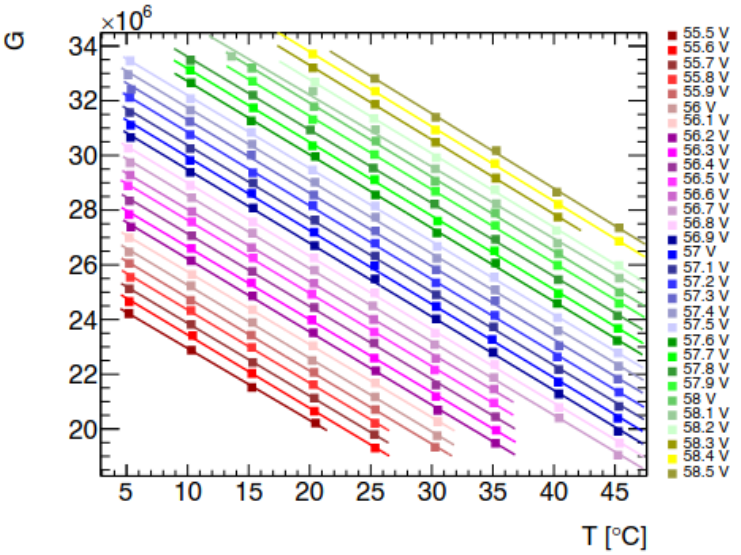
Radiation hardness – not crutial

All balanced against cross talk, gain, noise …

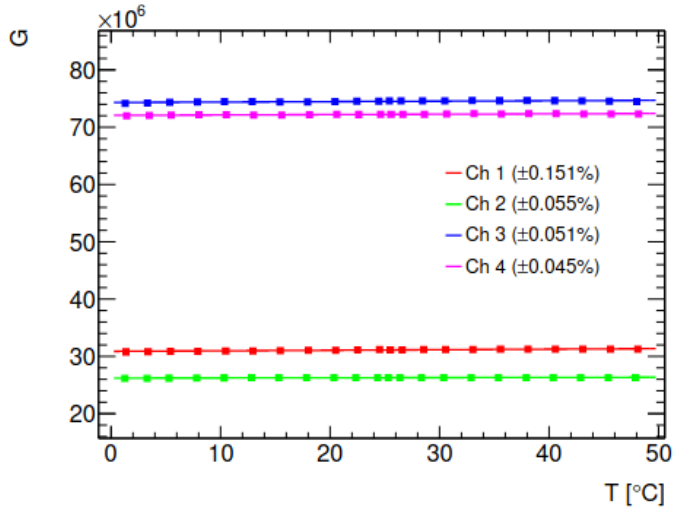
Overvoltage control and temperature stabilization

- Temperature monitoring on blade boards
- Temperature-controled readout box
- Possibly adaptive bias voltage regulator
  - discussing with CALICE experts

Hamamatsu MPPC S13360-1325b



G. Eigen et al 2019 JINST 14 P05006



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Calibration

- Based on on LED-pulser
- Ideally brought to both scintillators and SiPMs

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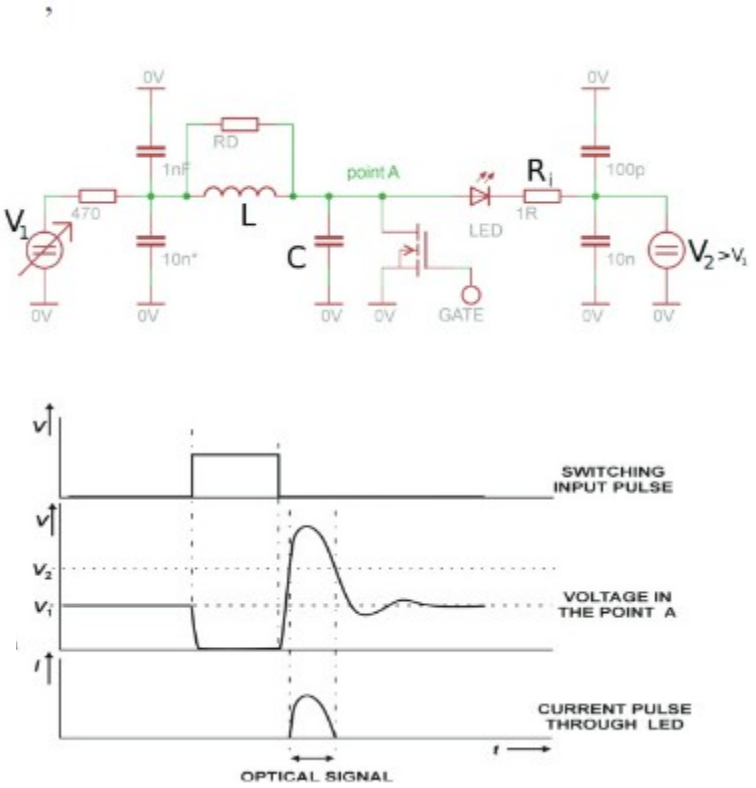

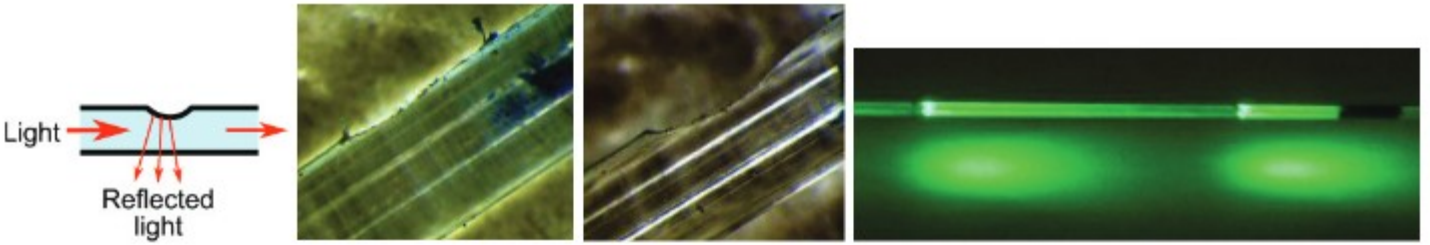

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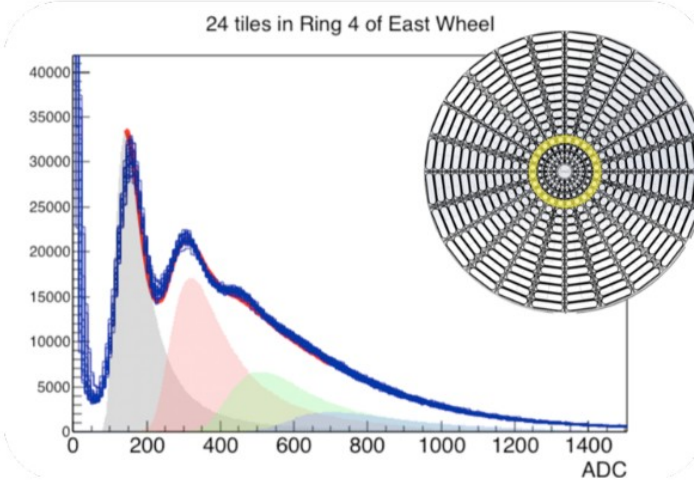
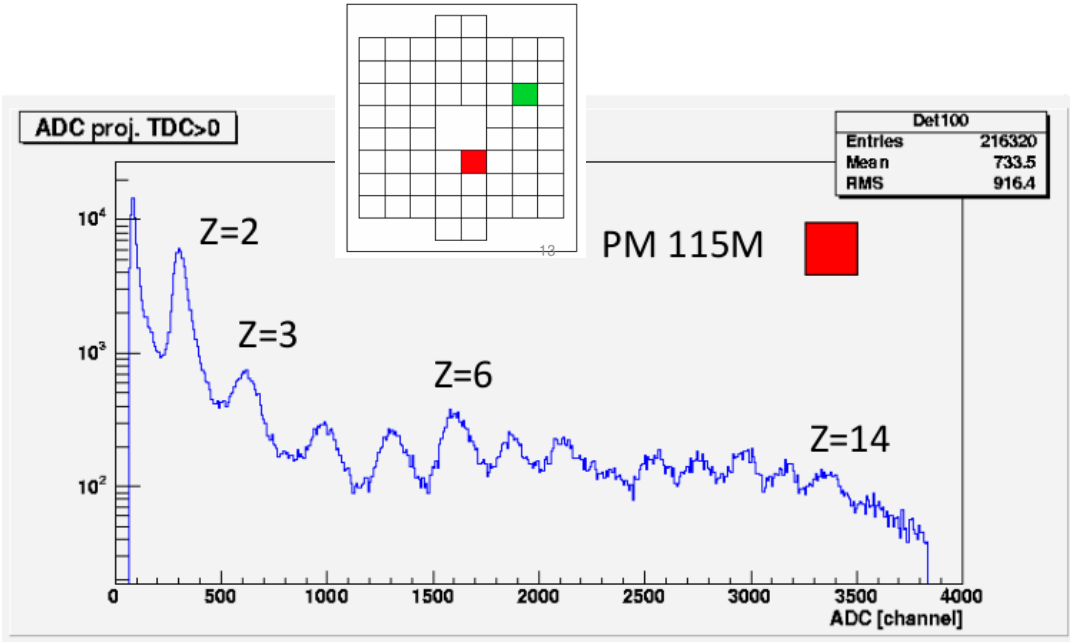
Dynamic range

- High charge fragments
- Possible non-linearity and saturation
  - Will need simulation
  - May add attenuated readout channel





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Time resolution

- Likely driven by tile size and WLS
- Considering Onsemi SiPM with fast output

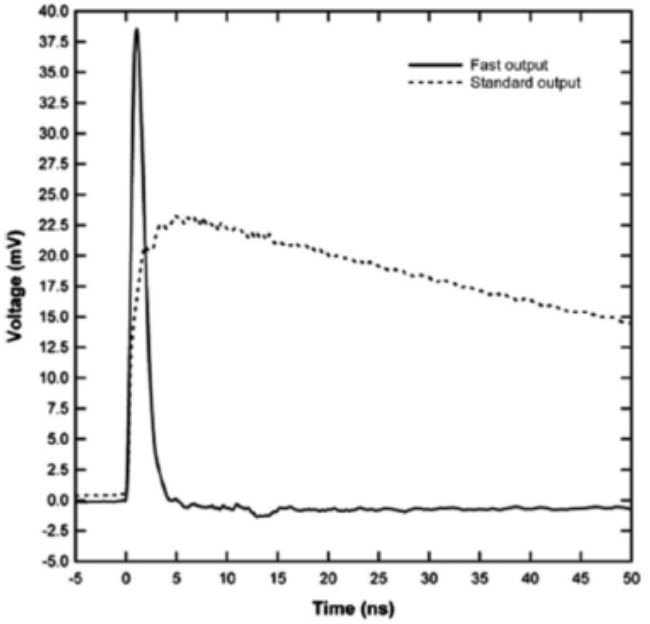


Figure 5. Example fast and standard output signals from an ON Semiconductor SIPM.

Simulation for physics perfomance

Many questions:

Event plane and centrality resolution

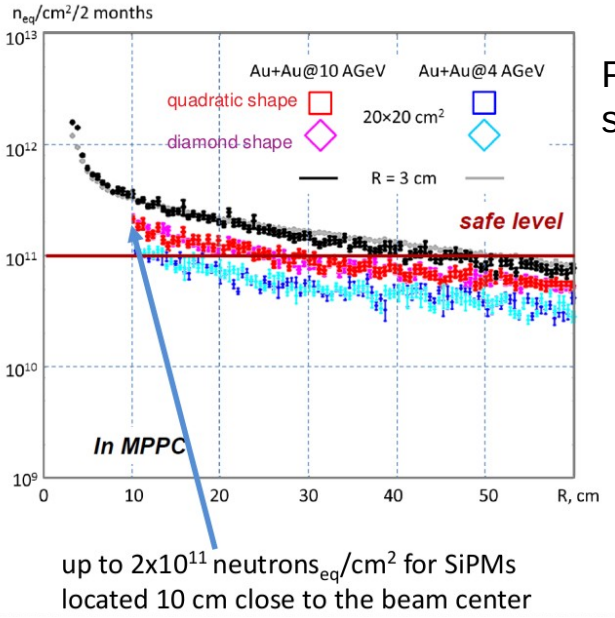
- Background effcest
- Effect of central hole

Optimization of tile depth

- Influence on charge-weighting
- Yield vs readout time
- Needed dynamics range

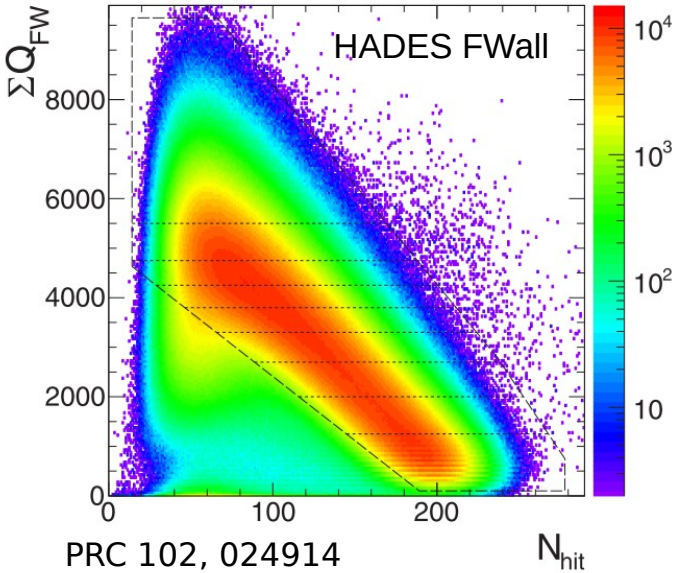
Expected radiation dose (FLUKA)

- Previously done with MCNP
- How close can we get to beam?



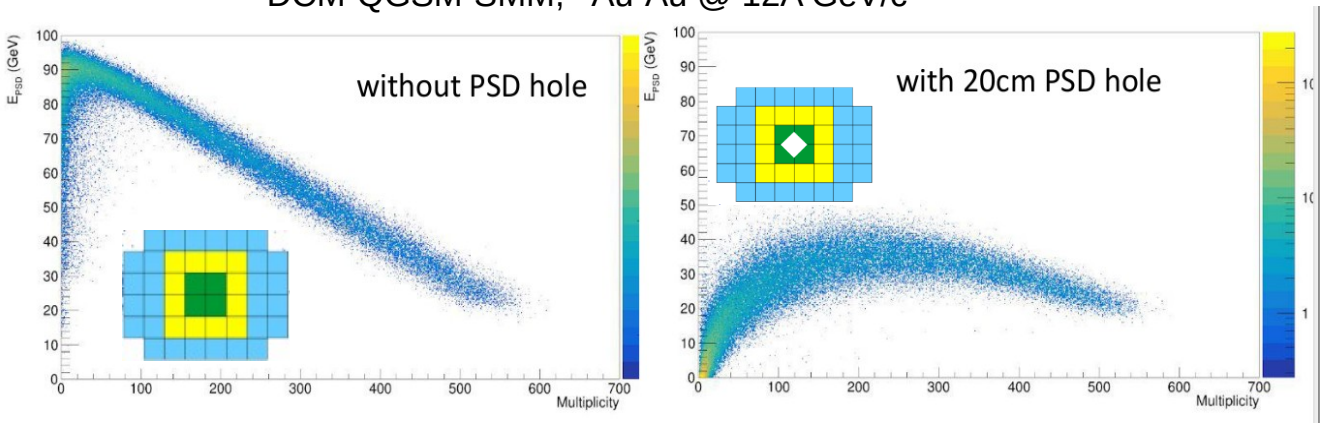
PSD radiatiion dose simulation

up to $2x10^{11}$ $neutrons_{eq}/cm^2$ for SiPMs located 10 cm close to the beam center



PRC 102, 024914

DCM-QGSM-SMM, Au-Au @ 12A GeV/c



D.Finogeev at 38th CBM Collaboration Meeting

Simulation for physics perfomance

Very first look (Lukas Chlad):

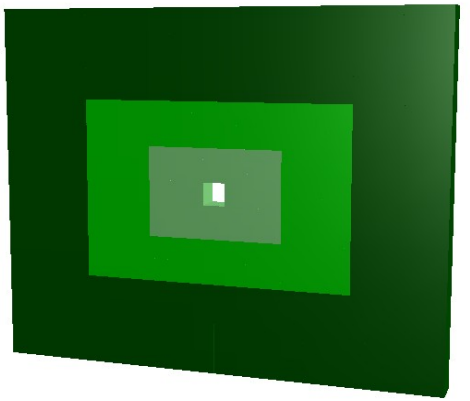
Geometry taken from HADES

- uRQMD
- Will try fine grained model and resuming

Planning to use other models

- Geant4 + DCM-QGSM seemed to do better for PSD
- Plan to use QnVector framework and compare to PSD performance simulations

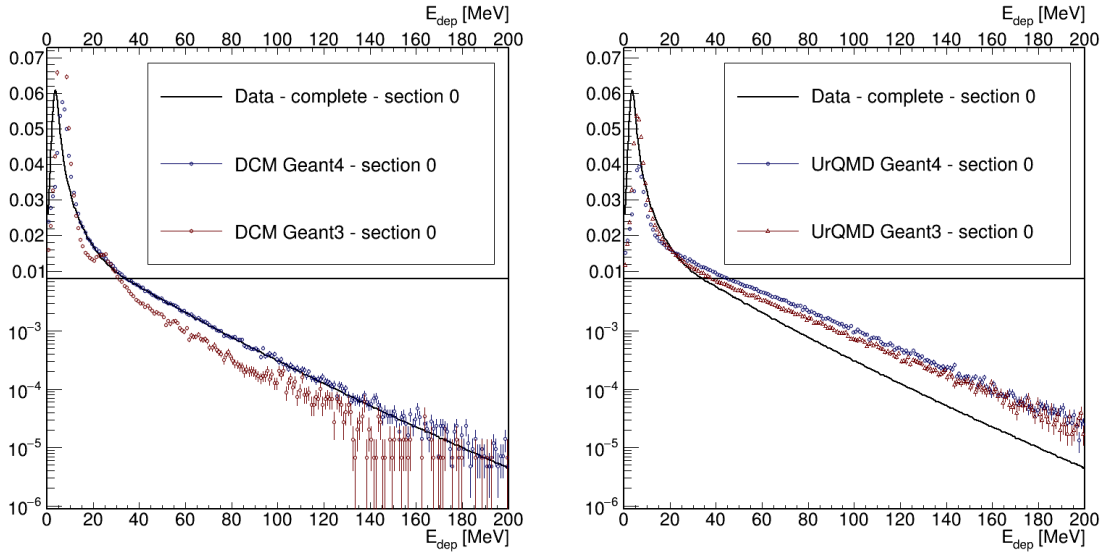
„FWall“ for CBM

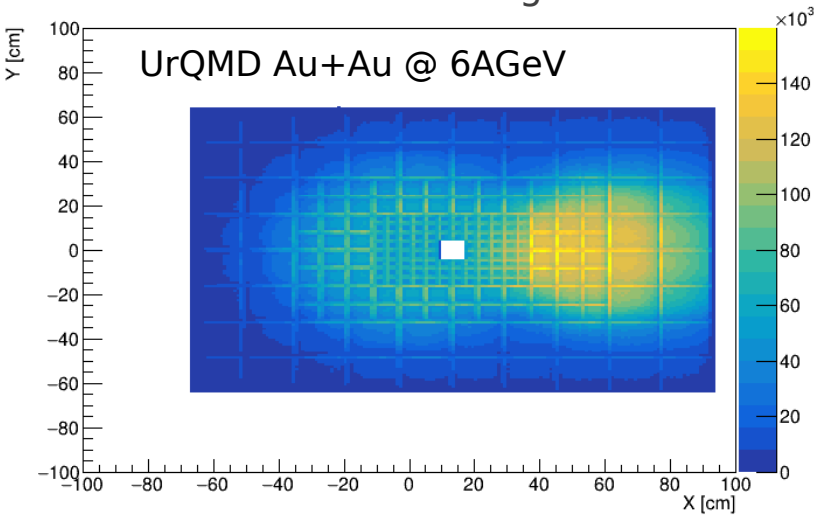


Detector size (cm):
160 x 128 x 10

Modules:
Small: 4x4 cm²
Medium: 8x8 cm²
Large: 16x16 cm²

Comparison of PSD simulation with mCBM real data (L. Chlad):

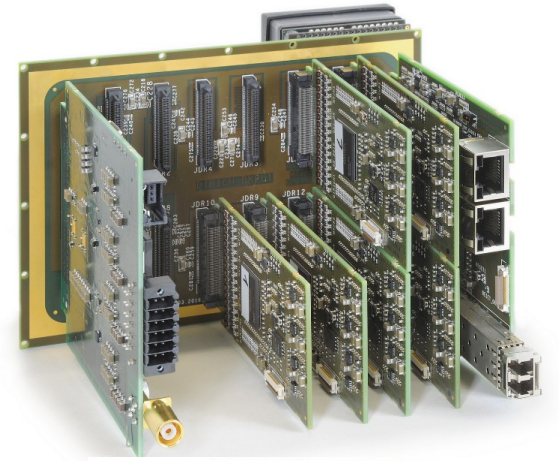




Where are we now

Testing setup TRB+DiRich+SiPM test board
(thanks to Michael Traxler)

- Designing add-on board for DiRich backplane
- Voltage regulation
- Temperature measurement



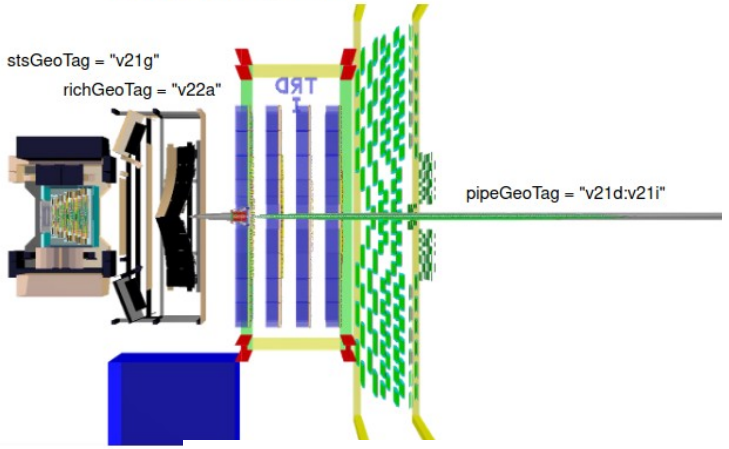
sis100_electron_OCT22

Initial ideas on calibrations and mechanical design

- ...those will likely change many times

Starting work on simulations

- Initial work with uRQMD
- Needs realistic backround + material (beampipe)
- Planning to use QnVector Corrections and Analysis framework



Many things not addressed yet

- mainly scintilllator and WLS material

Other things

- Make small setup for testing at mCBM
- Opportunistic complementation with calorimeter modules
- Involve other interested institutions/persons