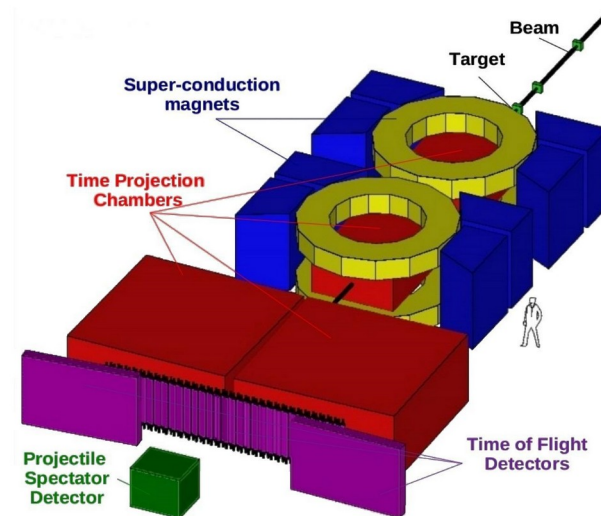


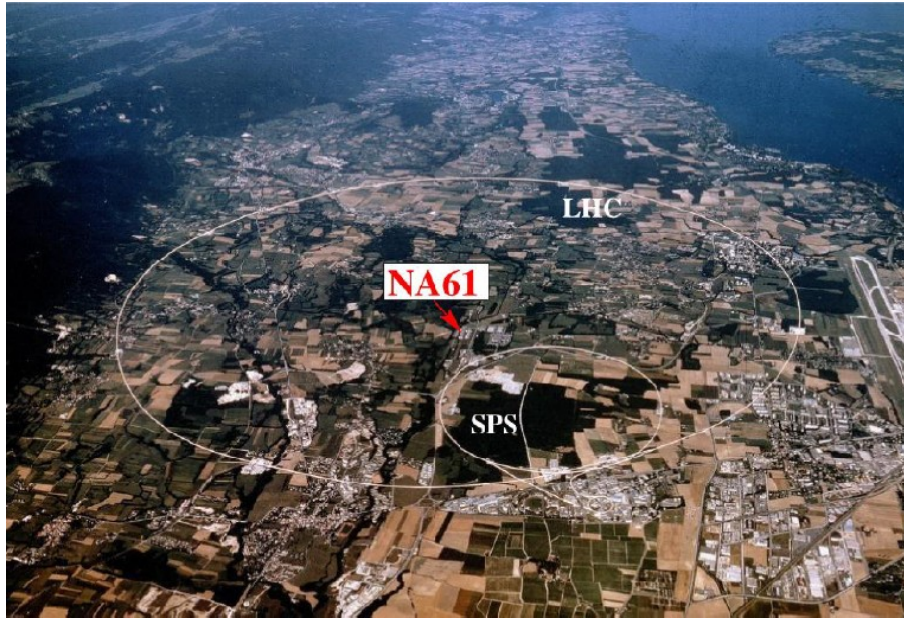
Forward hadron calorimeter (PSD) upgrade for the NA61/SHINE experiment

Sergey Morozov on behalf of INR RAS, Moscow

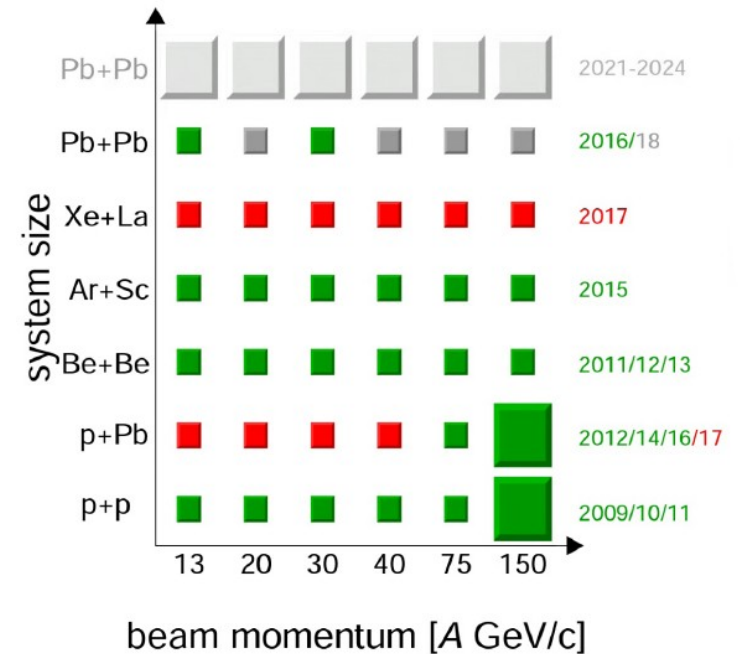


Forward calorimeter (PSD) upgrade for the NA61/SHINE

NA61/SHINE experiment at CERN SPS



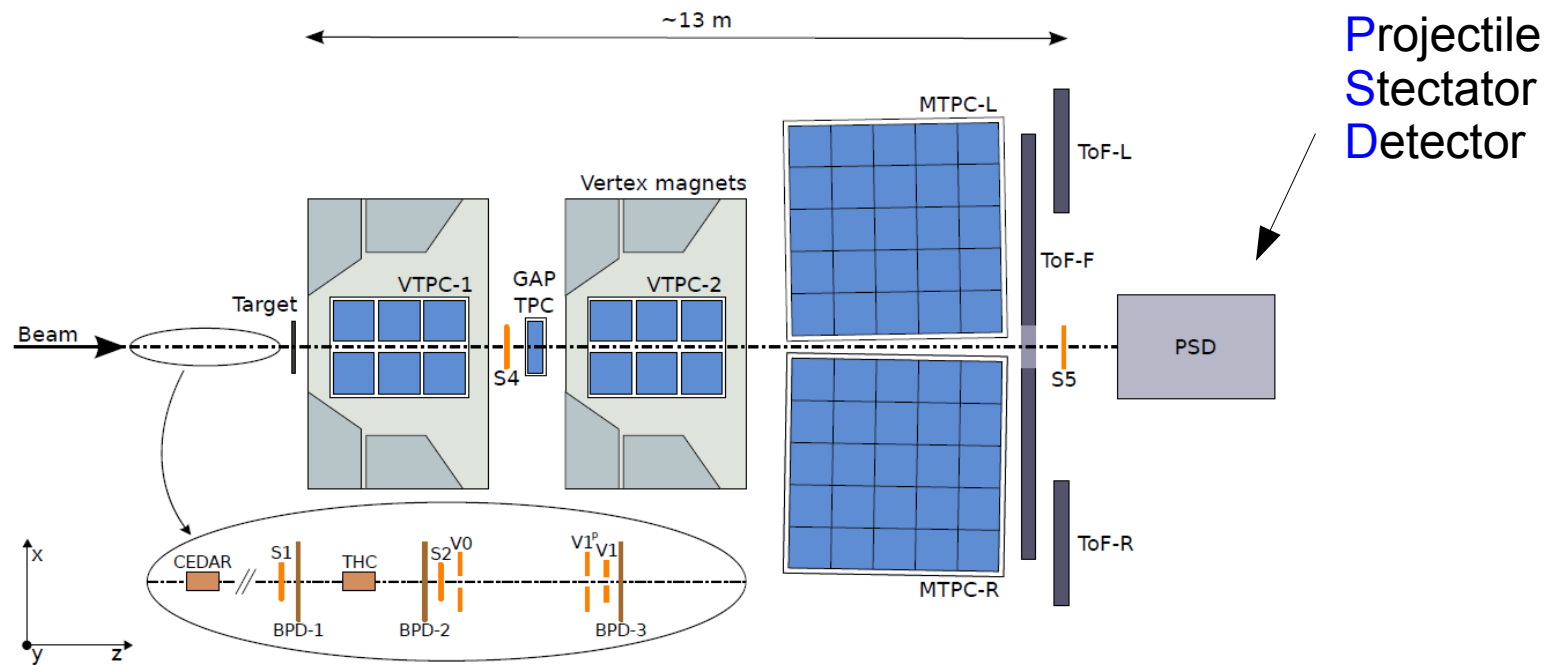
Physics program at NA61



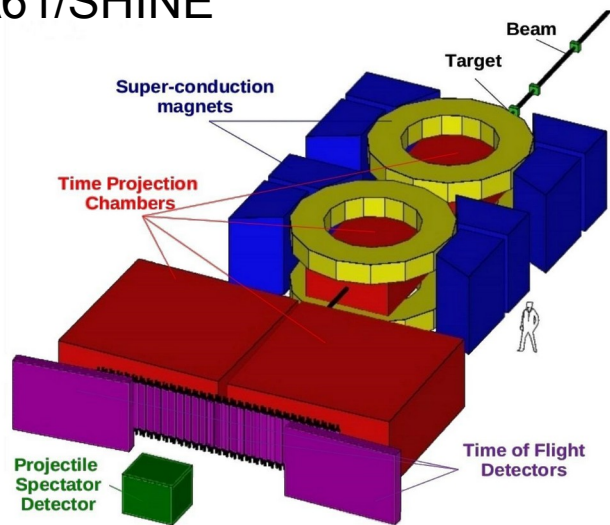
NA61/SHINE facility:

- accelerator chain, beam line and detectors
- hadron production spectrometer for h+p, h+A, A+A
- energies: 13 – 150 AGeV/c (400)
- precise measurements of produced particles (charge, mass, momentum)

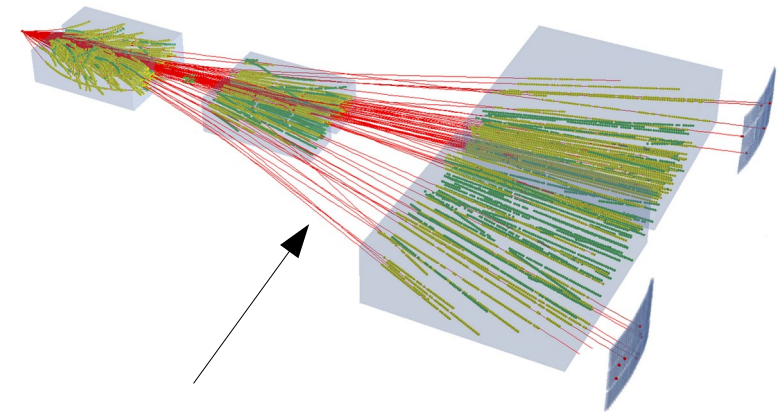
Forward calorimeter (PSD) upgrade for the NA61/SHINE



NA61/SHINE



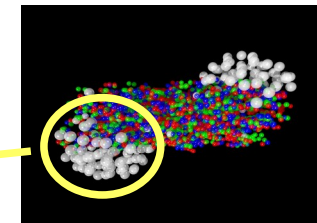
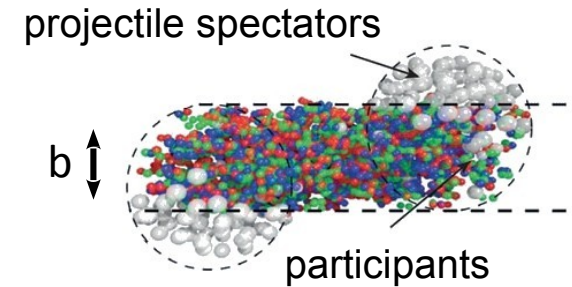
Ar + Sc @ 150 AGeV/c



tracks reconstructed

Forward calorimeter (PSD) upgrade for the NA61/SHINE

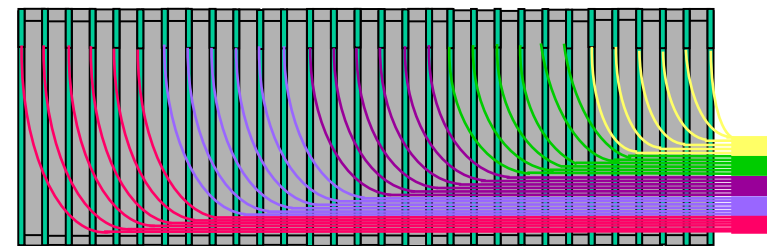
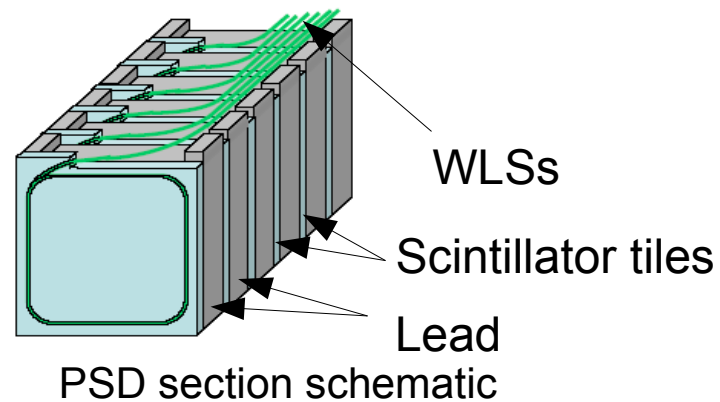
Hadron calorimeter PSD at NA61/SHINE



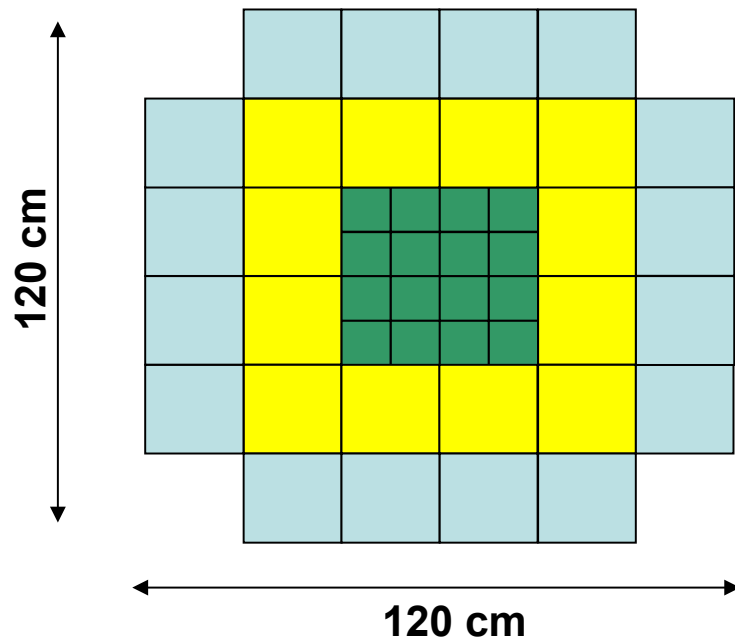
Main goals of PSD:

- event selection with collision centrality classes
- event plane reconstruction (with transverse granularity)

Forward calorimeter (PSD) upgrade for the NA61/SHINE



Module schematic



44 modules + 1:

16 small: 10cm x 10cm size

28 large: 20cm x 20 cm size

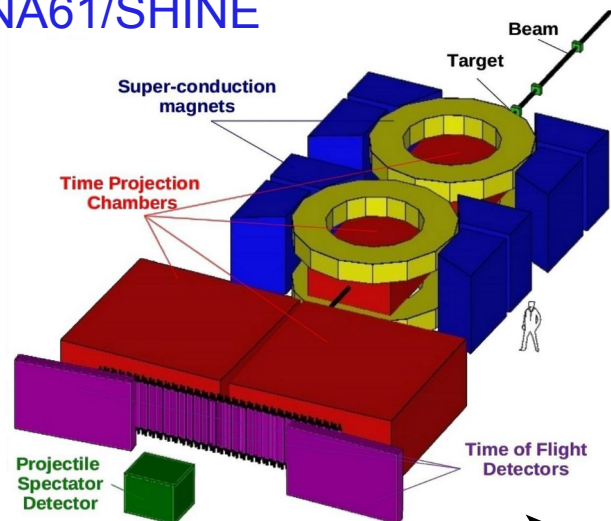
(10 sections in 1 module) => ~5.6 int. length

1 short module of 2 sections

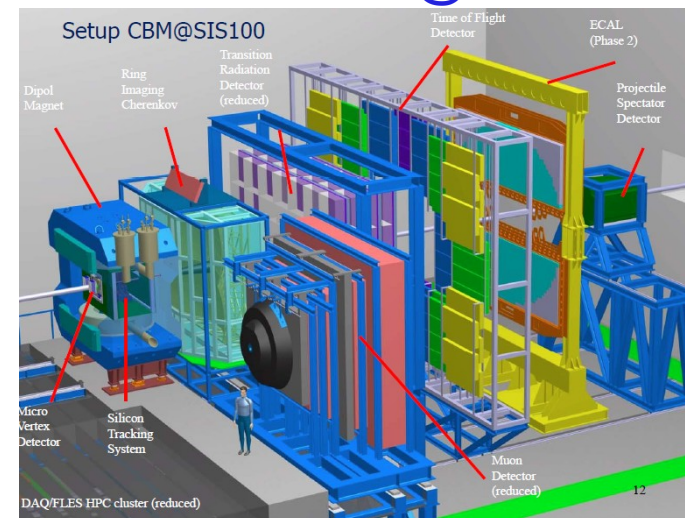
450 channels to read-out

Forward calorimeter (PSD) upgrade for the NA61/SHINE

NA61/SHINE

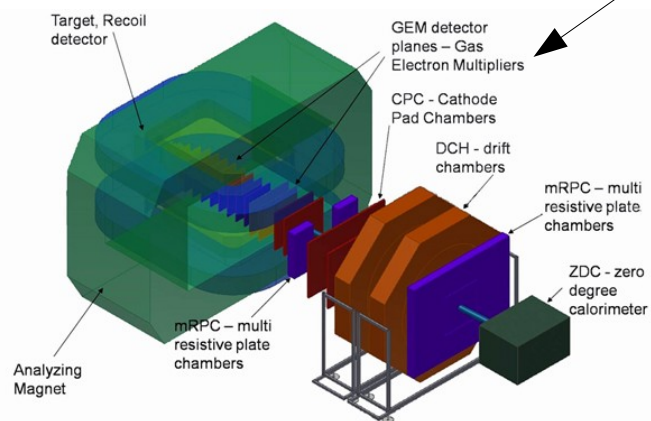


CBM @ FAIR

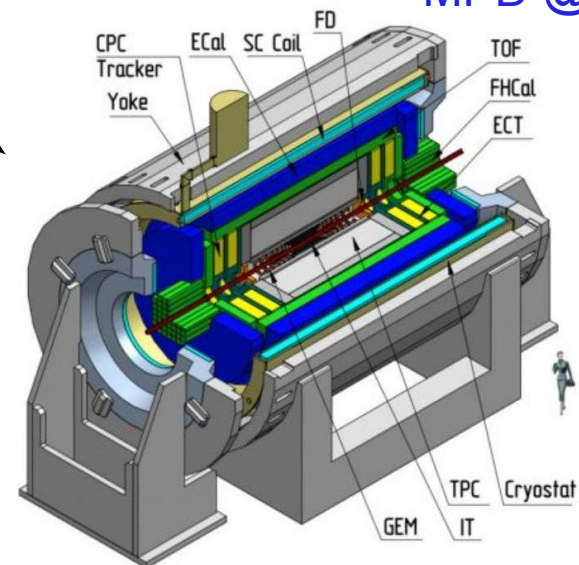


Forward Hadron Calorimeters

BM @ Nuclotron

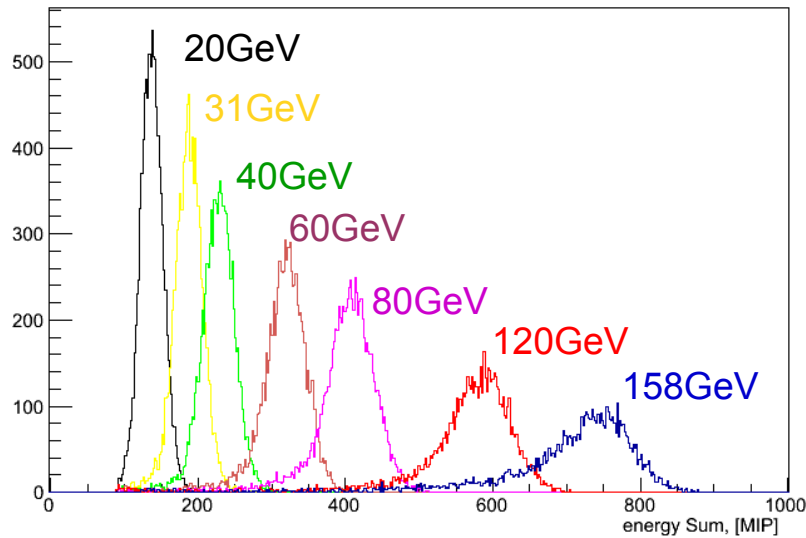


MPD @ NICA

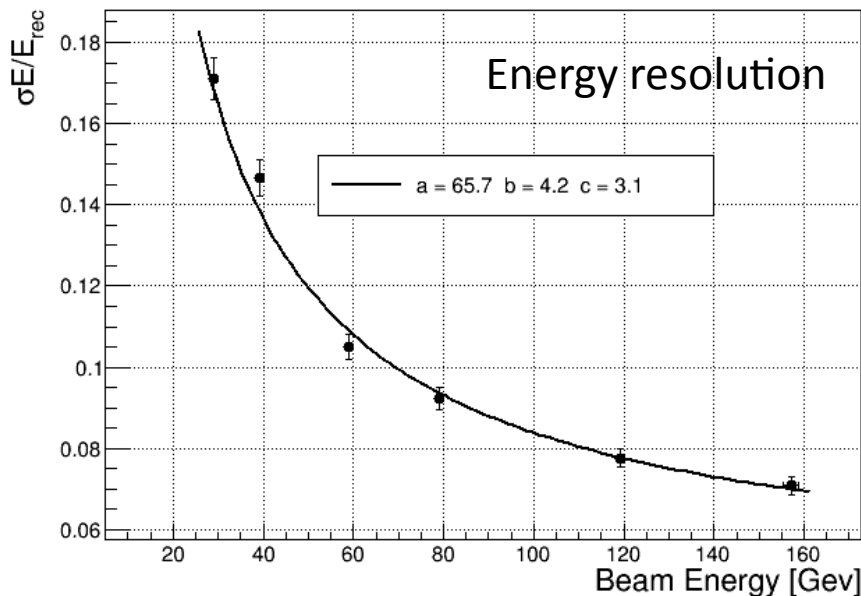
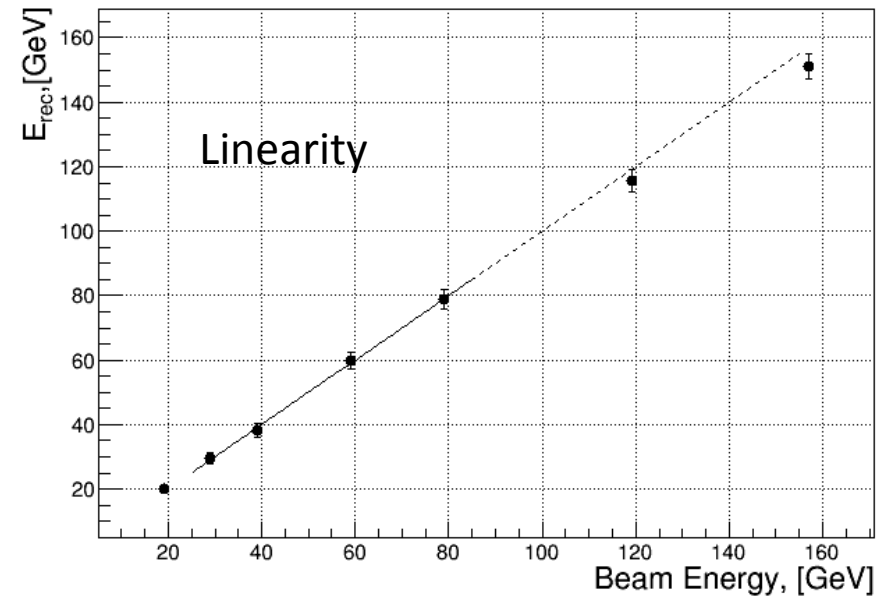


Forward calorimeter (PSD) upgrade for the NA61/SHINE

PSD energy in MIPs



NA61 PSD Calibrations



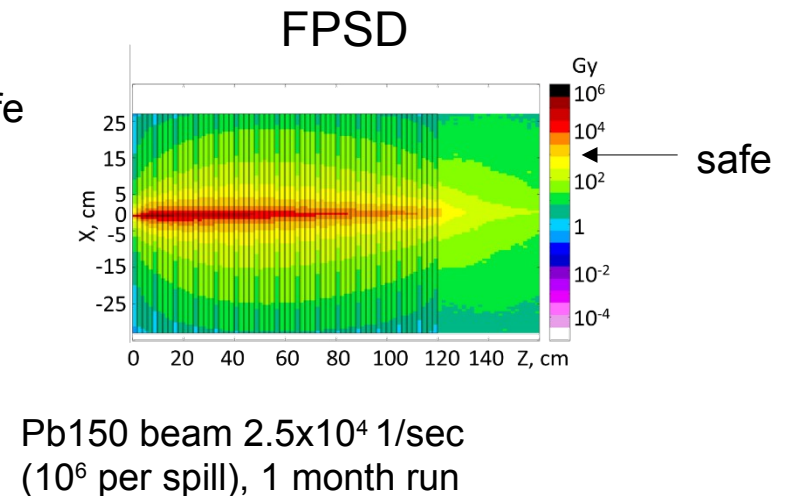
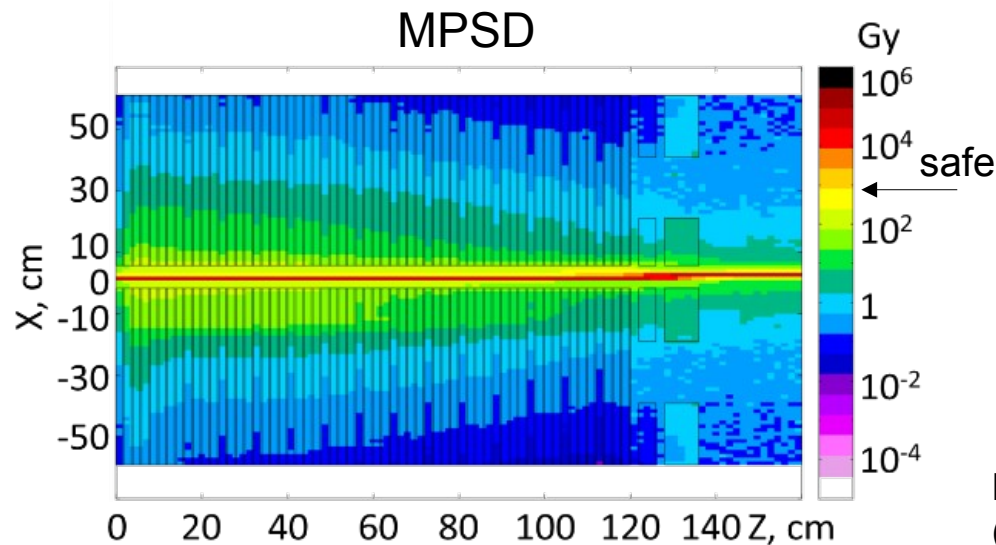
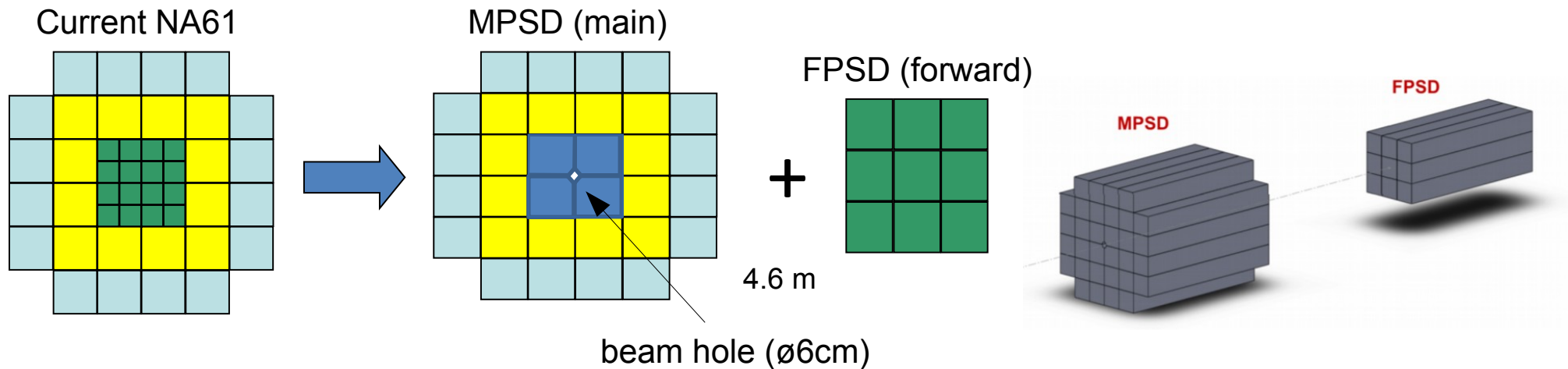
Forward hadron calorimeter at NA61/SHINE:

- good linearity with slight longitudinal shower leakage effect starting from 120GeV
- good energy resolution with about 65% stochastic term

Forward calorimeter (PSD) upgrade for the NA61/SHINE

PSD upgrade motivations:

- radiation damage of central modules of PSD with expected high beam intensity
- decouple the detection of single spectators and heavy fragments
- problems with radiation alarm (PSD is now an active beam dump!)



Forward calorimeter (PSD) upgrade for the NA61/SHINE

MPSD and FPSD has been assembled:



- 13 new modules in MPSD (borrowed at CBM experiment)
- 1 new (central) FPSD module with 4 cm hole in scintillators to avoid degradation of response with time due to high radiation doses

Forward calorimeter (PSD) upgrade for the NA61/SHINE

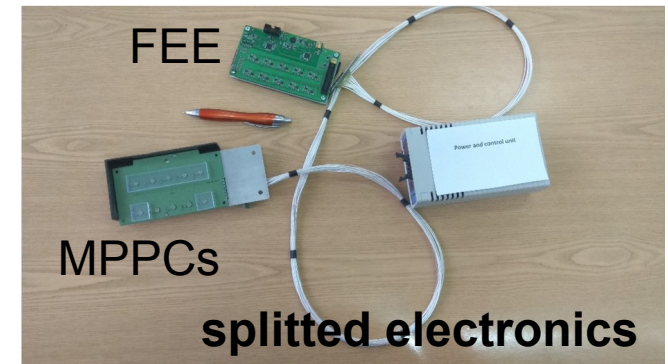
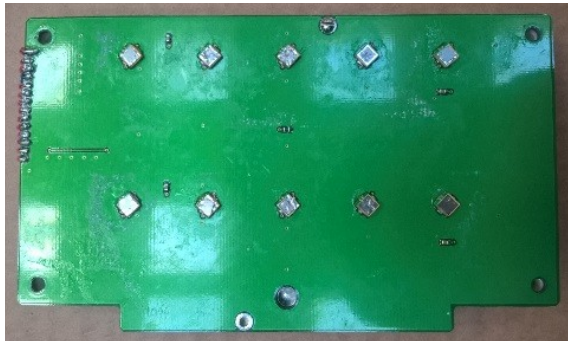
MPSD upgrade status:

- new fast Hamamatsu MPPCs in all modules – no more saturation effect due to long pixel recovery time

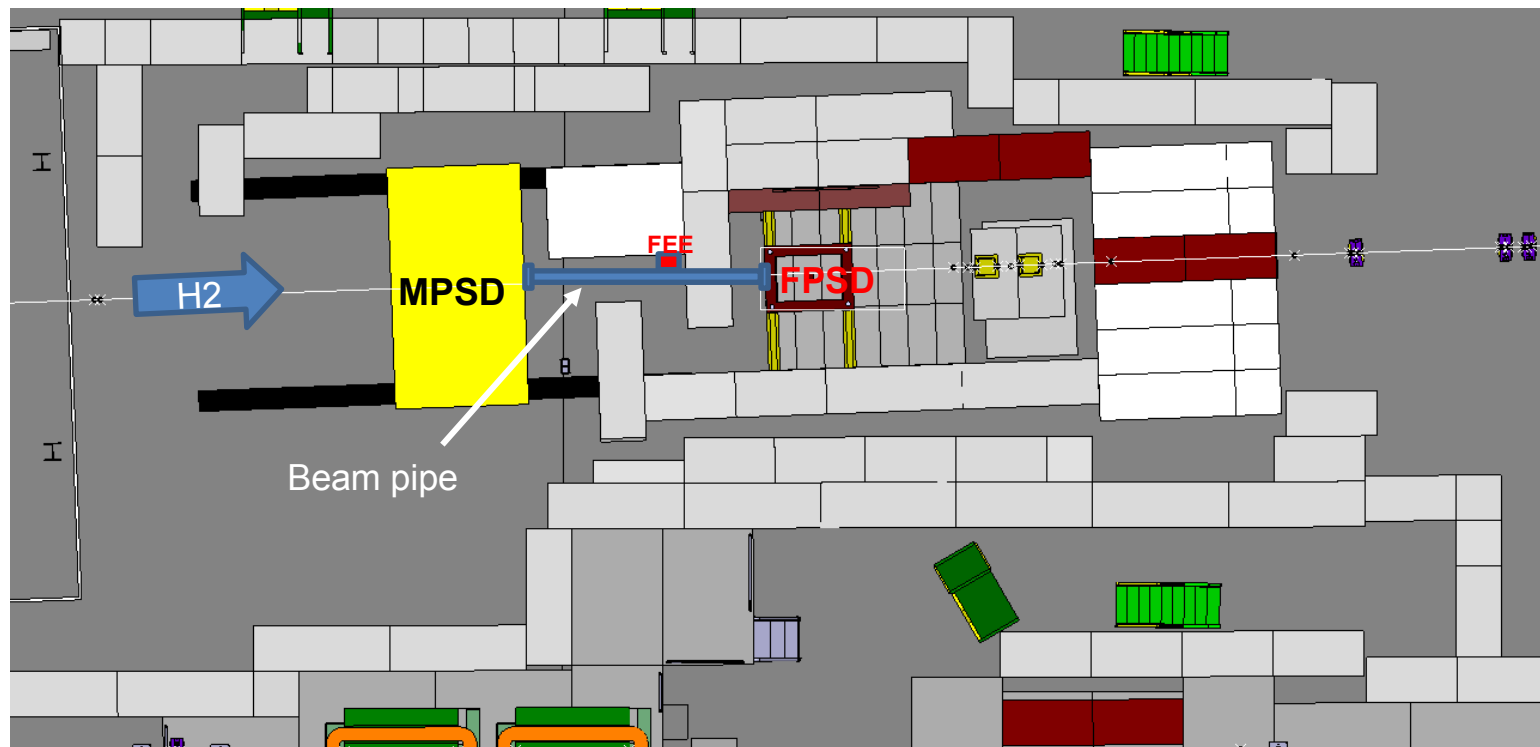


Forward calorimeter (PSD) upgrade for the NA61/SHINE

FEE for FPSD (based on developments for CBM experiment)



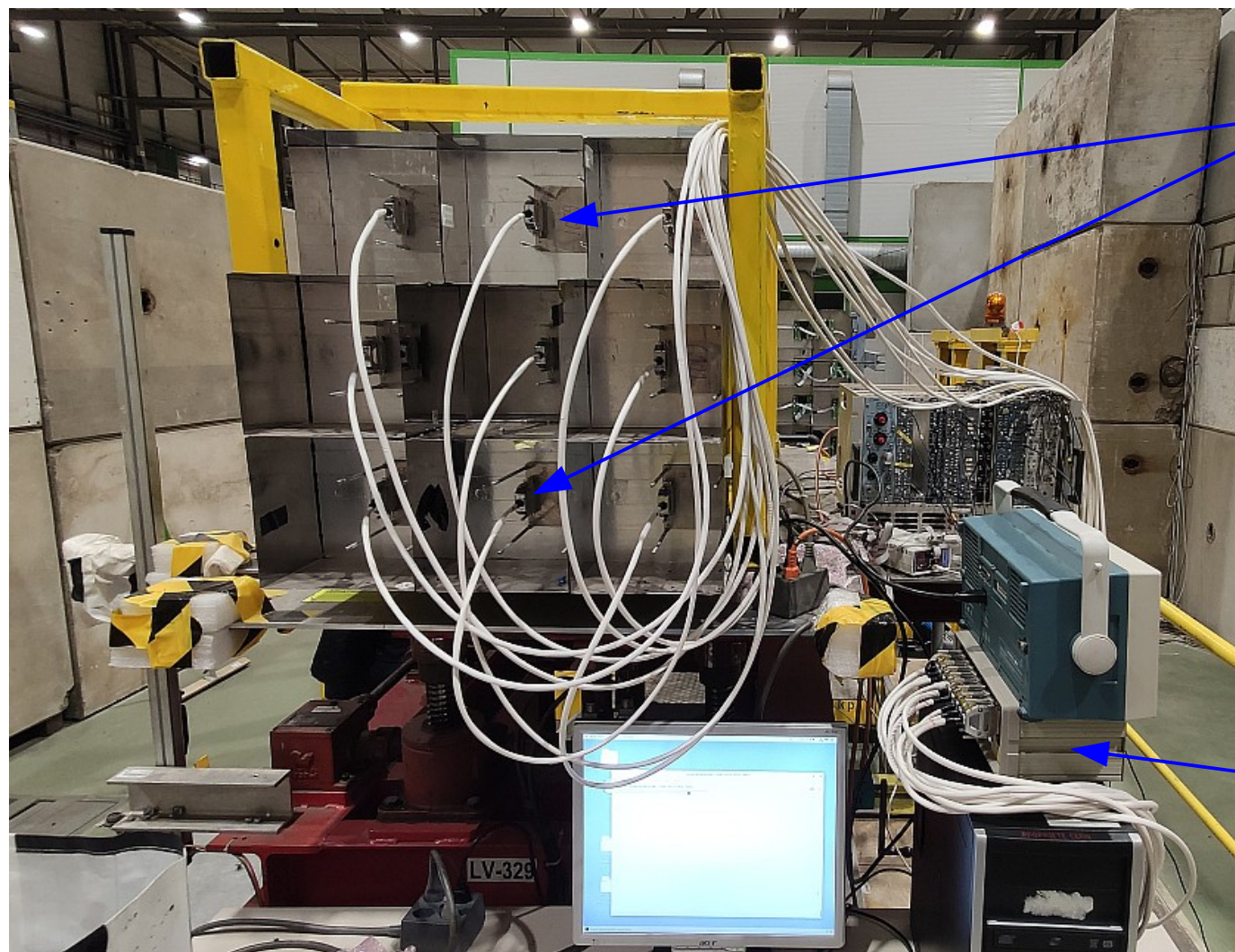
FPSD shielding structure



..to be constructed

Forward calorimeter (PSD) upgrade for the NA61/SHINE

FPSD FEE and slow control has been installed



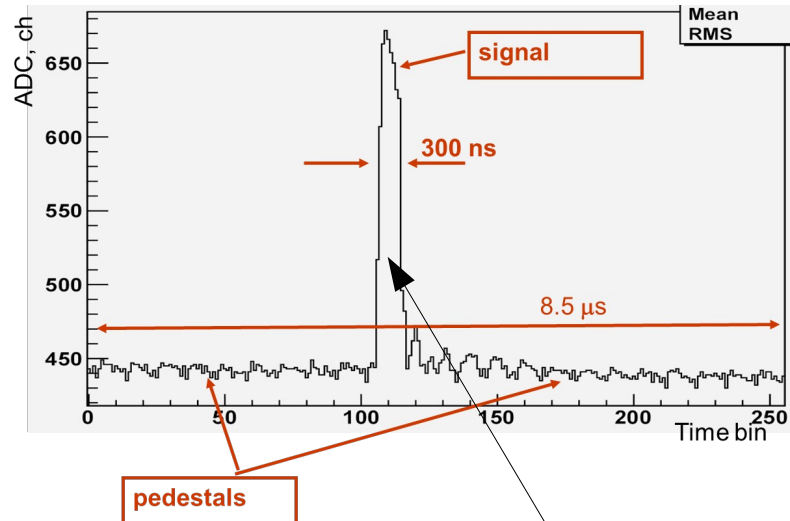
PCB with MPPCs

HV control box
with 9 boards

Forward calorimeter (PSD) upgrade for the NA61/SHINE

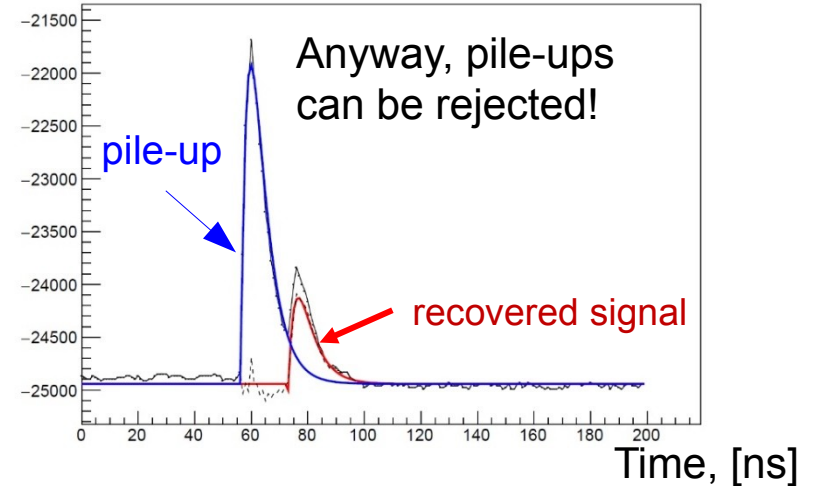
New DRS4 read-out system for MPD + FPSD

Old PSD: shape of digitized signal (after integrator).



possible pile-ups are inside

DRS4 signal is ~ order shorter.
No problem with pile-ups!

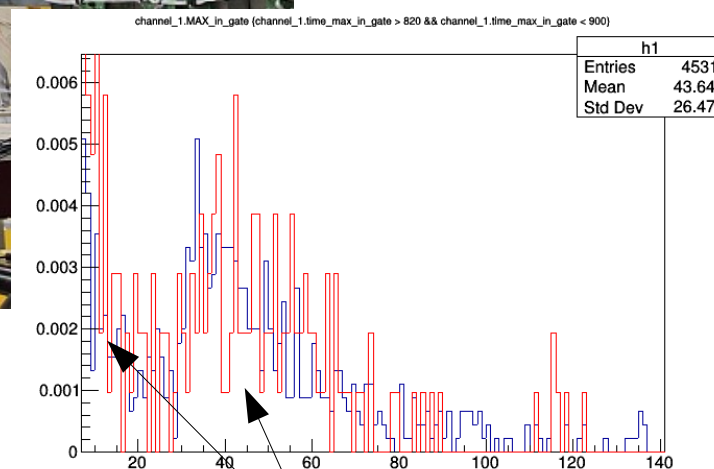
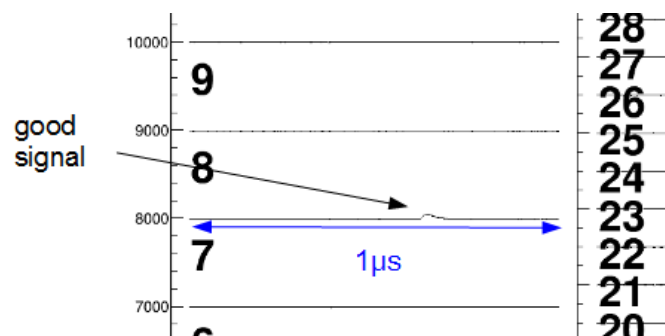


DRS4 board time window:

~200 ns, ~500ns or ~1000ns
(with clock set)

Forward calorimeter (PSD) upgrade for the NA61/SHINE

FPSP with DRS4 boards at cosmic tests in November 2019

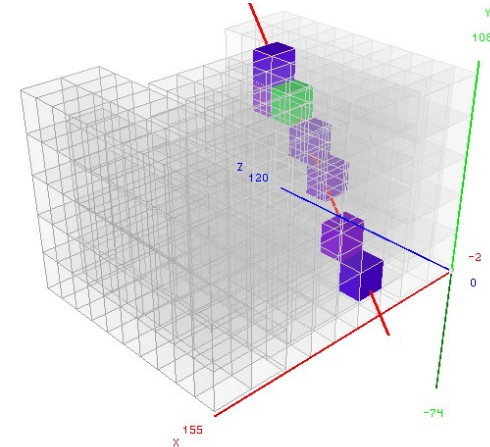
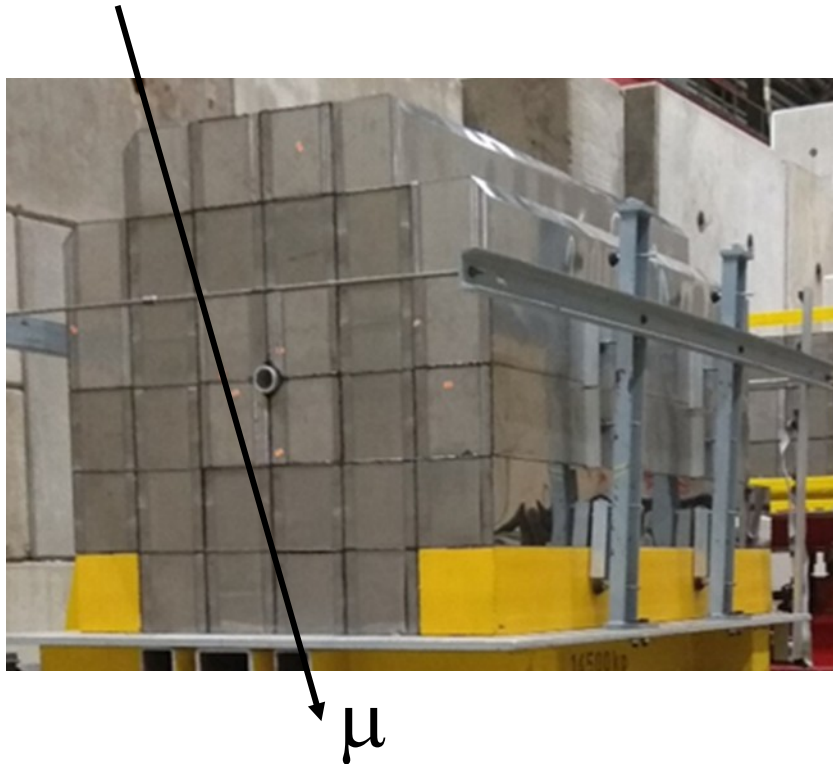


good signal/noise ratio

..first (cosmic) data on upgraded PSD has been taken

Forward calorimeter (PSD) upgrade for the NA61/SHINE

New approach for PSD calibration with cosmic muons



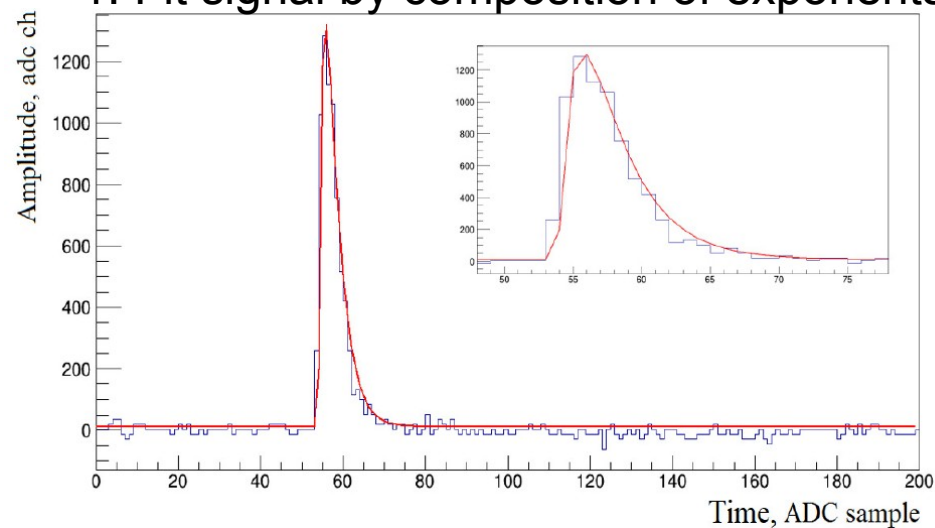
example of 3D muon track reconstruction

- Amplitudes of muon signals are comparable with electronic noise.
- The procedure of muon signal evaluation has been developed.
- The correction for pass length in scintillators is applied.

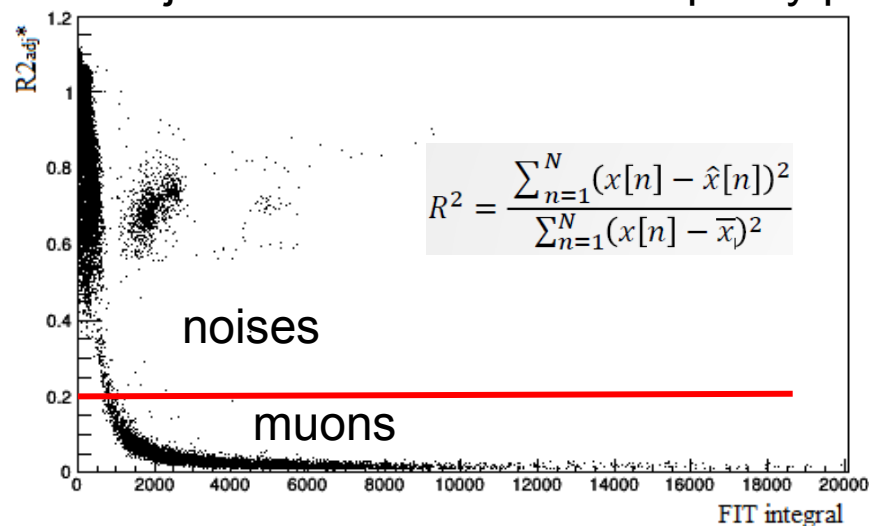
Forward calorimeter (PSD) upgrade for the NA61/SHINE

New approach for PSD calibration with cosmic muons

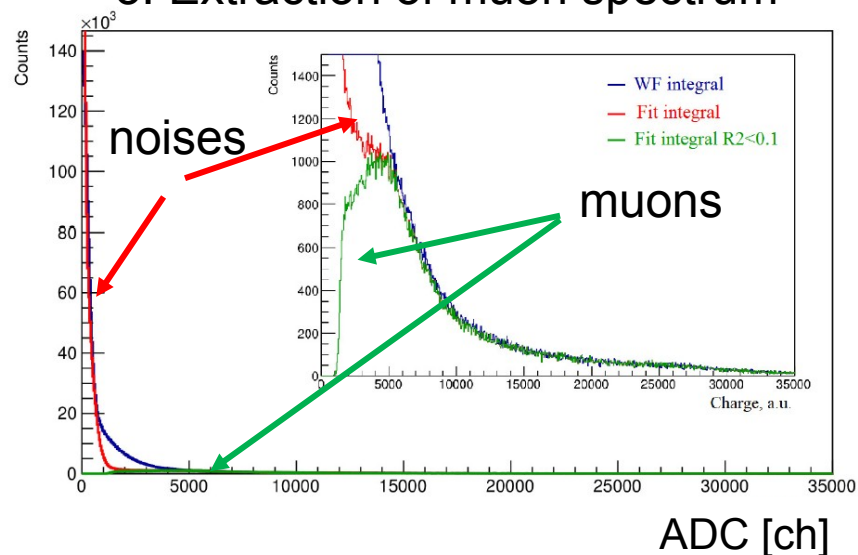
1. Fit signal by composition of exponents.



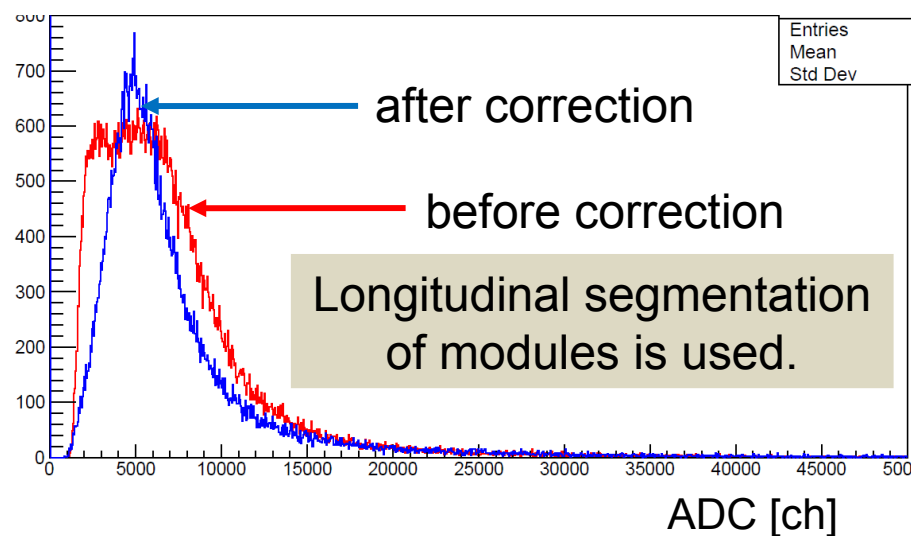
2. Rejection of noises with fit quality par.



3. Extraction of muon spectrum



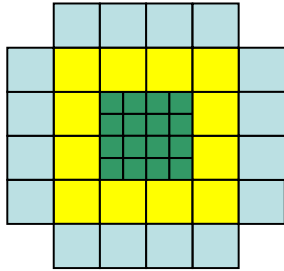
4. Correction for pass length in scintillators.



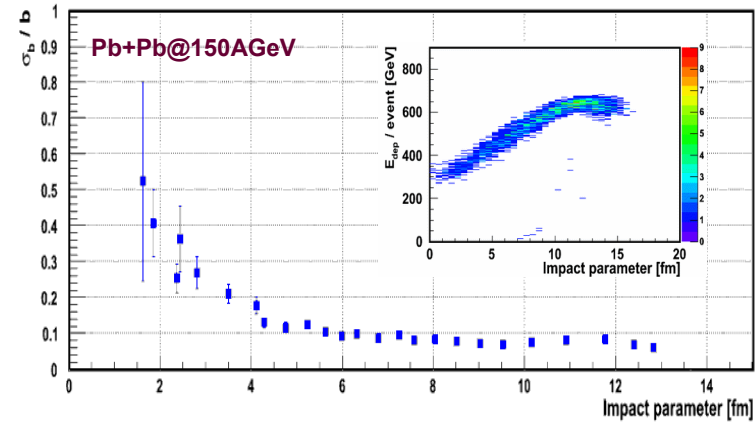
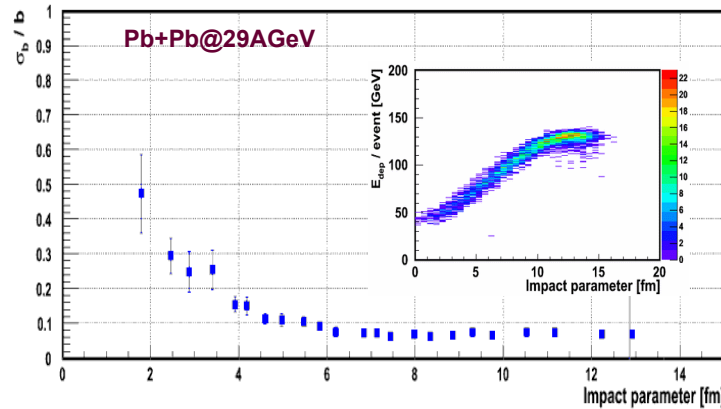
Forward calorimeter (PSD) upgrade for the NA61/SHINE

Centrality determination with PSD schematics:

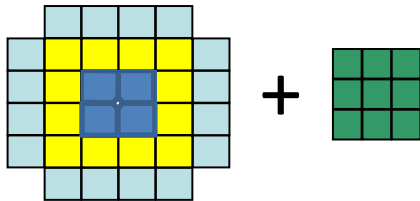
old NA61/SHINE PSD



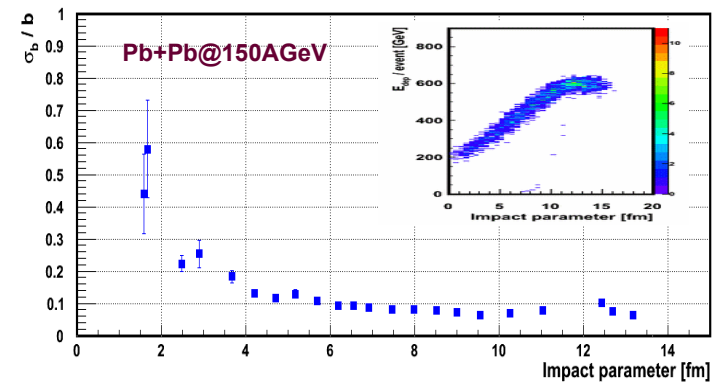
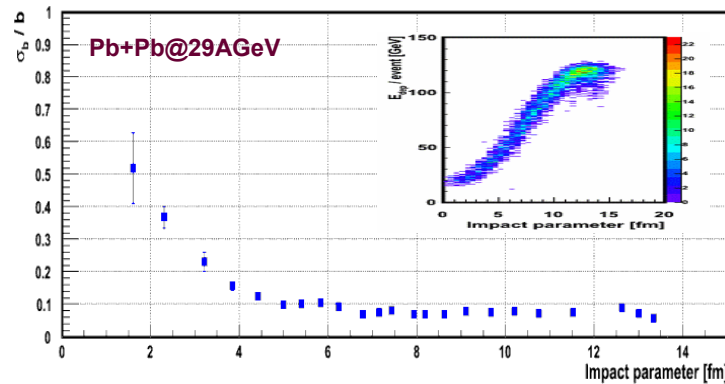
simulated impact parameter resolution



New MPSPD+FPSD

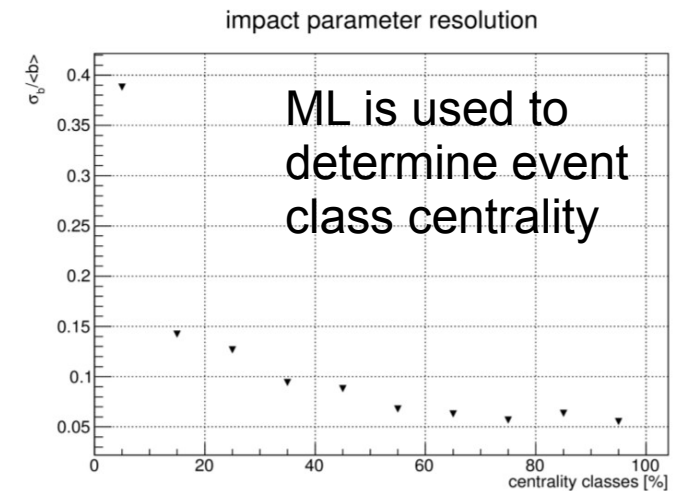
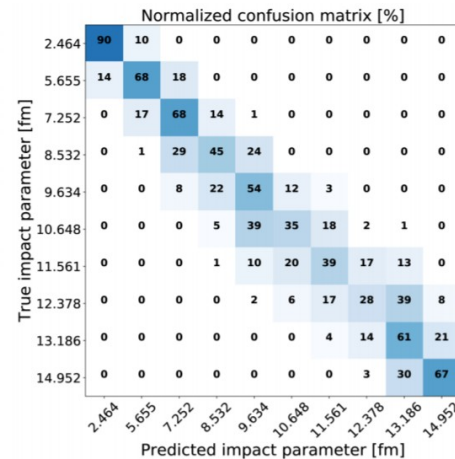
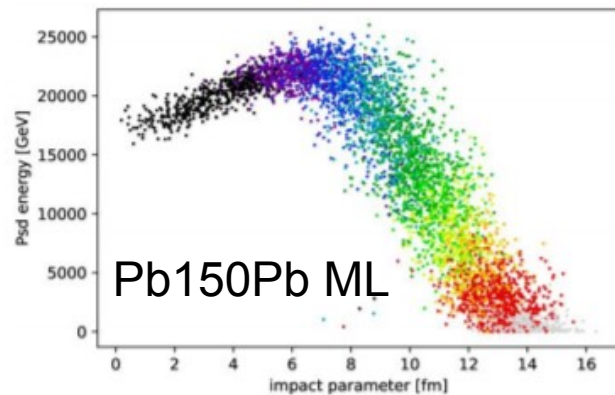


simulated impact parameter resolution



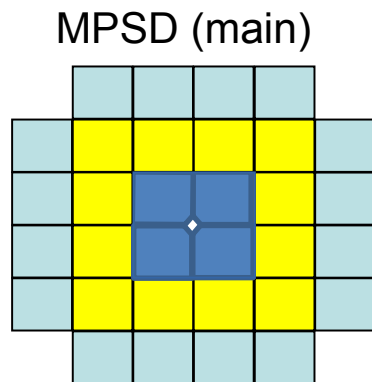
Forward calorimeter (PSD) upgrade for the NA61/SHINE

New approach with Machine Learning technique for event selection with MPSPD only



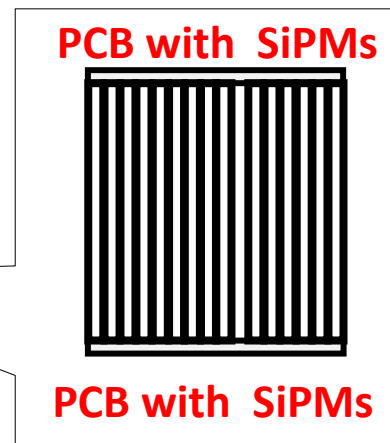
(see Friday talk by Nikolay Karpushkin for details)

..and an alternative to the FPSD to help with event centrality estimation



+

quartz forward hodoscope



Quartz forward hodoscope is under development at INR (planned to be used with BM@N and CBM calorimeters)

Conclusions:

- forward hadron calorimeters (PSD) are widely used in many heavy ion experiments
- new challenging conditions (high beam rate) will require PSD upgrade
- NA61/SHINE PSD detector has been updated with MPSD+FPSD calorimeter system
- new approaches for event centrality estimation are under development
- cosmic muon calibration procedure has been developed for current and future segmented hadron calorimeters

Thank you for your attention!