A fast front-end readout design for NICA-MPD shashlik electromagnetic calorimeter

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General Backgrounds of NICA-MPD ECAL

☐ NICA Multi Purpose Detector (MPD)

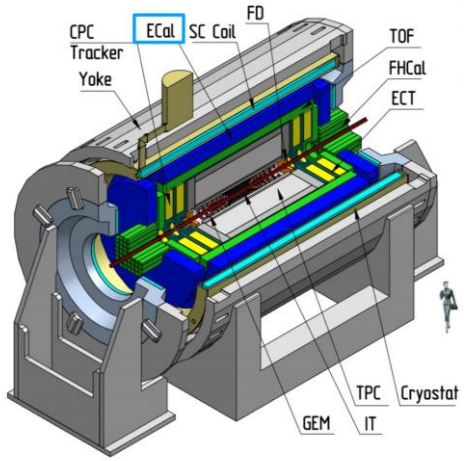
- A 4π spectrometer for heavy-ion collision detection at high luminosity
- Au+Au interactions at 6 kHz, with multiplicity: >1000 charged particles for central collisions at $\sqrt{s_{NN}} = 11\ GeV$

☐ The previous FEE for Electromagnetic Calorimeter (ECal)

- **Shashlik-type calorimeter**: bremsstrahlung photons collected through optical wavelength shifter (WLS) fibers, couped with SiPM detectors
- **FEE**: SiPM readout board (shaping and anti-alias filter), together with a 64-channel 14-bit, 62.5 MS/s commercial ADC board
- **Performance**: $\sigma_t \sim 1\ ns$, $\frac{\Delta E}{E} = 6\%$

☐ Timing requirement

- ~10 ns: background and pile-up cancellation to zero
- ~1 ns: suppress secondary background events down to negligible level
- Sub-ns: work in the ToF mode for auxiliary time measurements
  - ECal TDR: reach the level of 150 ps



General layout of MPD (central part)

1st stage

SC Coil – superconducting solenoid

IT – inner tracker

TPC – time-projection chamber

TOF – time-of-flight system

ECal – electromagnetic calorimeter

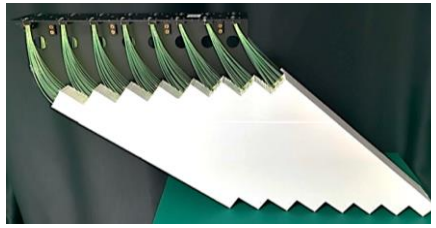
FD – fast forward detectors

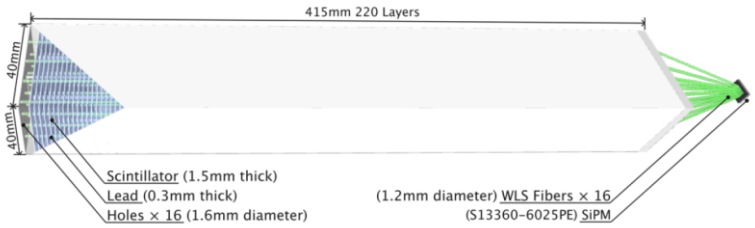
FHCal – forward hadron calorimeter

2nd stage

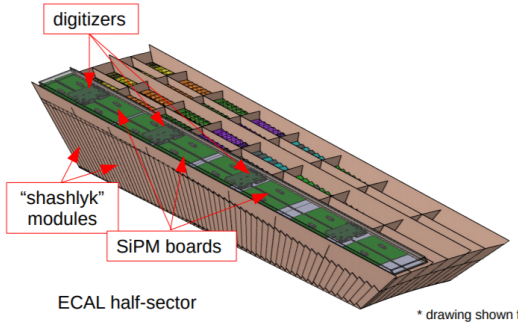
ECT – endcap tracker

CPC – cathode pad chambers





1/6 of the half-sector of the ECal (Zone 8) and single tower structure (Cited from: Y. Li et al 2022 JINST 17 T04005)



- 38,400 readout channels
- 14 bit, 62.5 MS/s digitizers
- 600 digitizer boards inside MPD magnet
- 38 data merger boards in electronics racks
- 10 kW dissipated power

Cited from: Ilia Slepnev, JINR CHEF 2019, Fukuoka, November 28.

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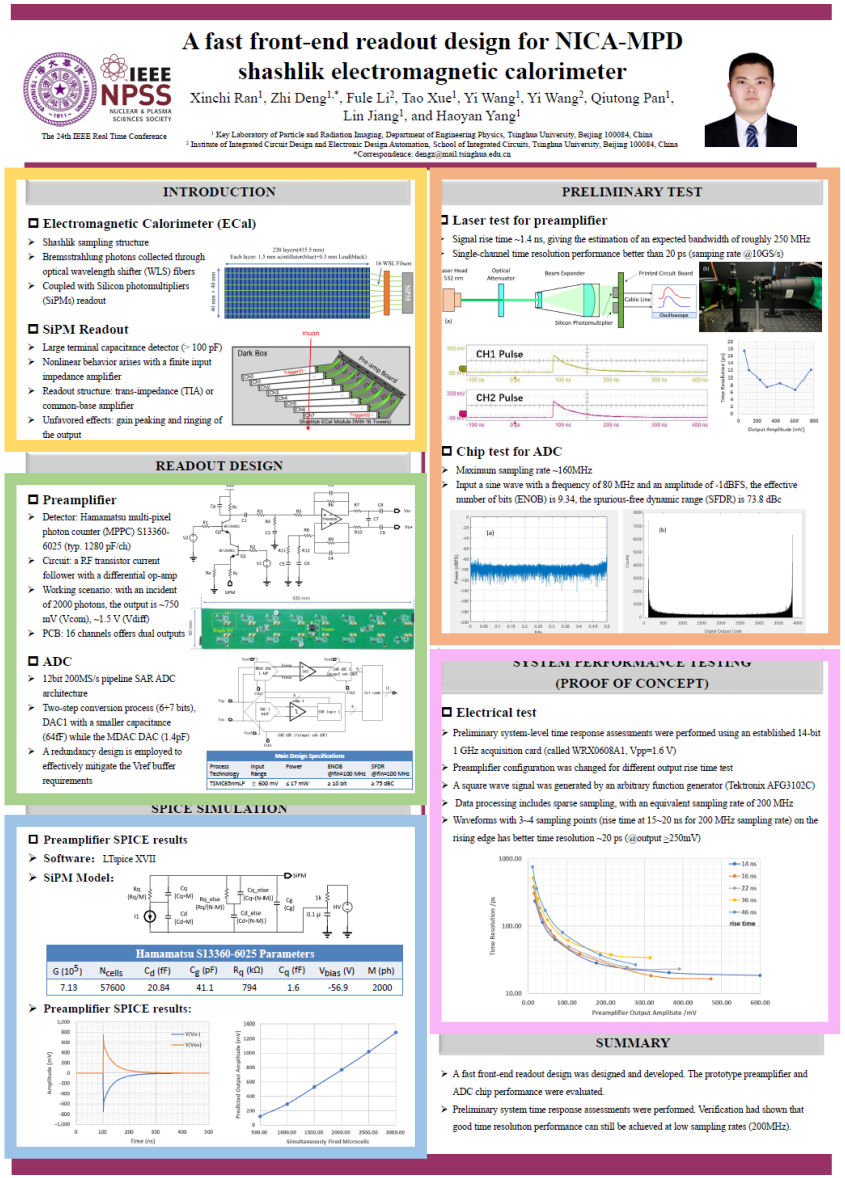
@ Poster B Section !!

Introduction and motivation

Readout Design Architecture

Pre-amp	a RF transistor current follower with a differential op-amp
ADC	12bit 200MS/s pipeline SAR ADC

SPICE simulation for pre-amp in working scenario



Preliminary Test Results

- **Pre-amp**: BW~250 MHz
  - Single-channel time resolution better than 20 ps
- **ADC**: ~160 MS/s (max.)
  - ENOB=9.34 bit, SFDR=73.8 dBc

System Performance

- **PROOF OF CONCEPT**
  - For 200MS/s sampling rate: proper configuration (3~4 sampling points on the rising edge) can achieve time resolution ~20 ps (@output ⩾250mV)