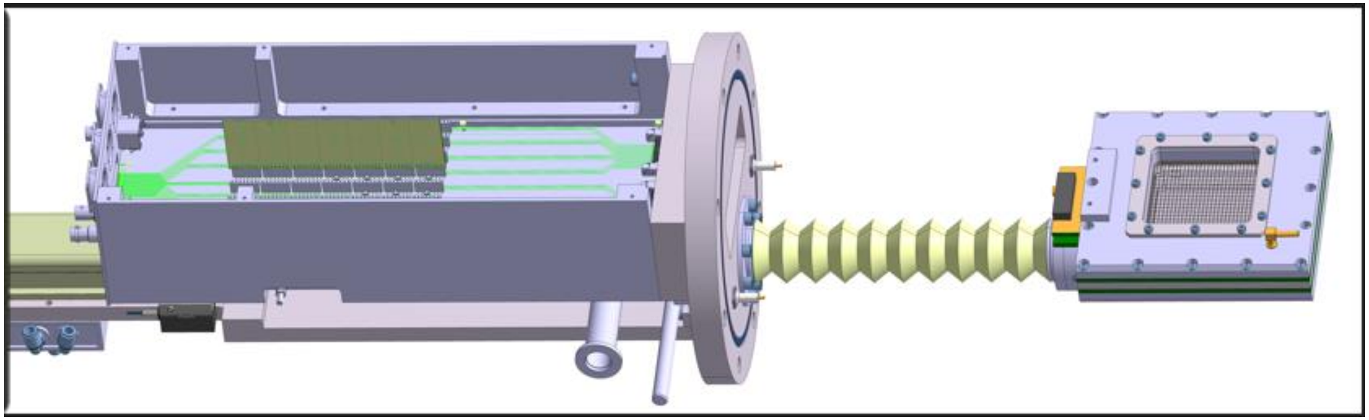
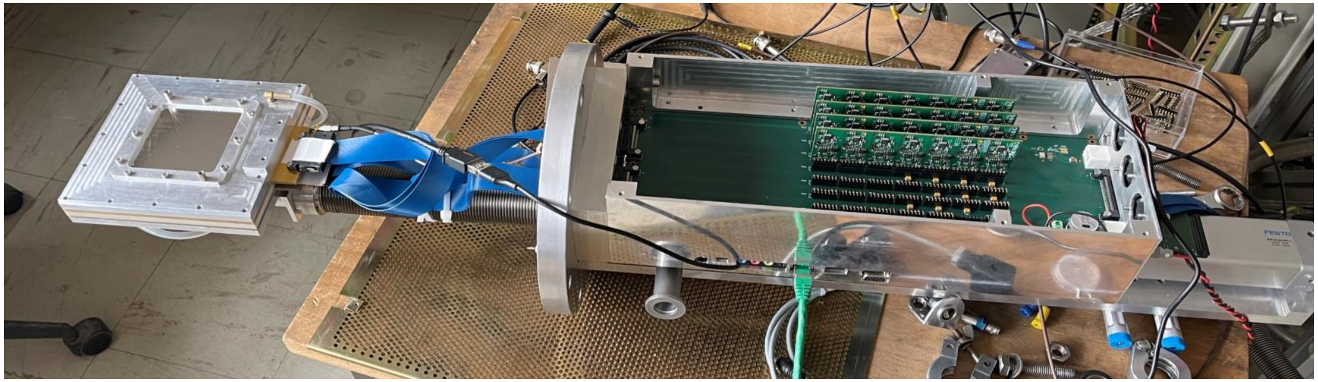
CAT'S UP GANIL/CENBG

TRACKER FOR GANIL EXPERIMENT





Summary

- What is CATS and why an upgrade?
  - Detector
  - Electronic and DAQ system
  - Current use and result
- Detector Upgrade
- Electronics Upgrade (Renocats)
  - History
  - New Front-end
  - SAM backend
- Status and raodmap

What is CATS

CATS is a *Low presure multiwire proportionnal chamber for secondary beam tracking*

S.Ottini-Hustache et al, CATS…,NIMA431(1999).

Goal:

- *Providing event by event particle tracking until 5.10^5 pps*
- *Time of flight measurement (accuracy between 440ps to 1,2ns)*
- *Position of ion (spatial resolution 400-700µm)*
- *Efficiency close to 100% with ion from He up to Ni at 40-50 MeV/u*

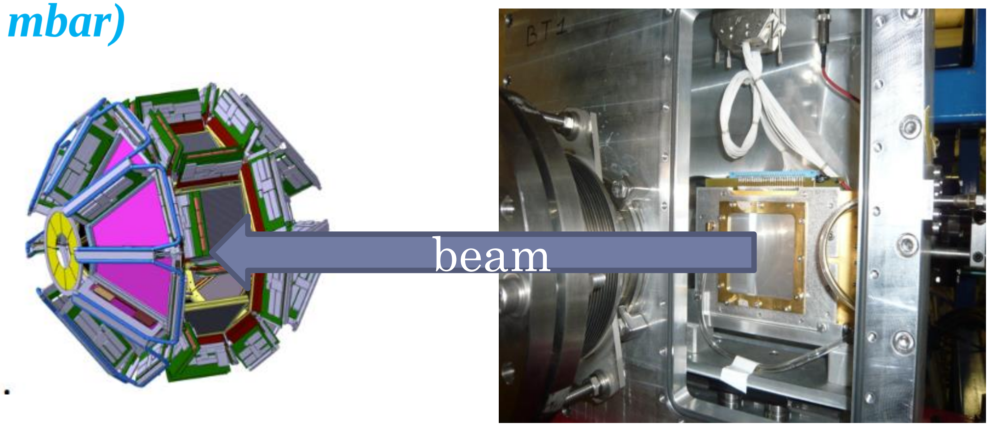
Particularity:

- *Very transparent detector (4,4µm of Mylar foil)*
- *Fast response to accept high flux*
- *Aluminium strips for low budget material*
- *Low pressure gas (6-8 mbar)*

Two detectors CATS
Separated by around
50cm

Typical use:

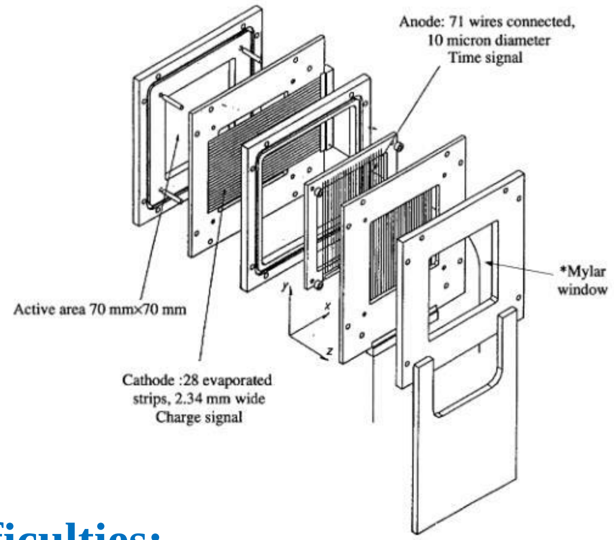
Silicon detectors
And/or Gamma detector around
the target

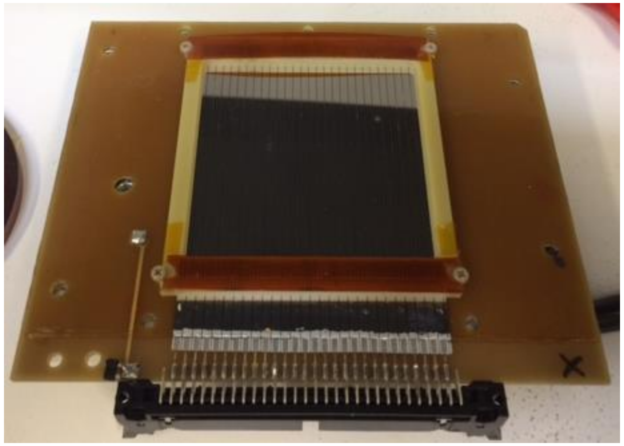


The detector

Design

- *One wire anode (70 wires of 20µm every 1mm)*
- *Two cathodes aluminium strip X and Y (28 strips/pitch 2,54mm, 0,9µm thick Mylar foil with 200nm Aluminium strips evaporated on Mylar)*
- *Area of 70*70mm^2 and 6,4mm gap*





Difficulties:

- *Very transparent and fragile detector (4,4µm of Mylar foil)*
- *Fast response to accept high flux*
- *Aluminium strips for low budget material*
- *Low pressure gas: 6/8 mbar*

Cathode fragile need regular, difficult maintenance

The electronic

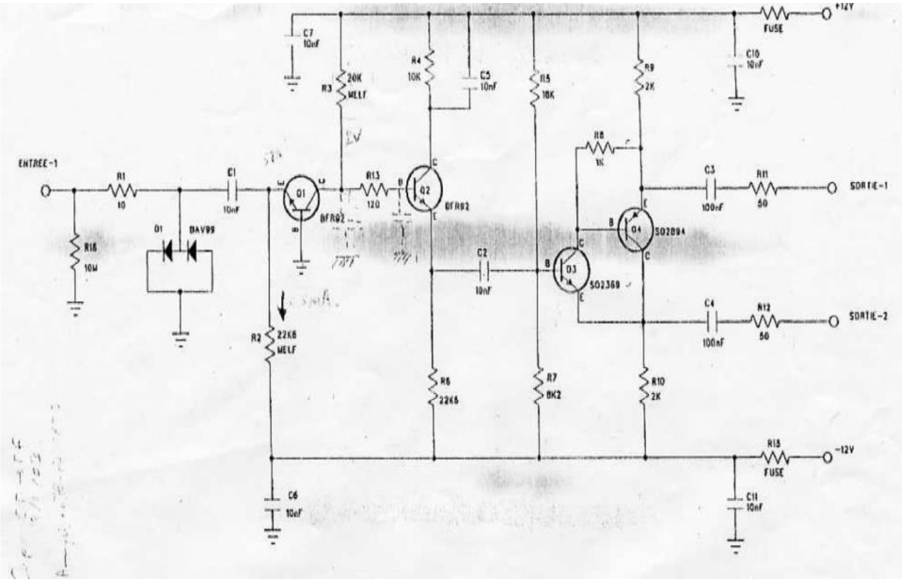
Front-end

- *CPLear: Differential integrator with very low capacitance*
- *Mainly electron signal over 40ns (ion currents last about 1.5 μs)*
- *Very low dead time*

Very hard to manage precision on low capacitance

Back end

- *Delay line 500ns (500m cables) by channel for coupling with master detector*
- *Digitization by QDC on VXI system*
- *Acquisition coupling with new system (VME//Numexo/µTca) by centrum module*



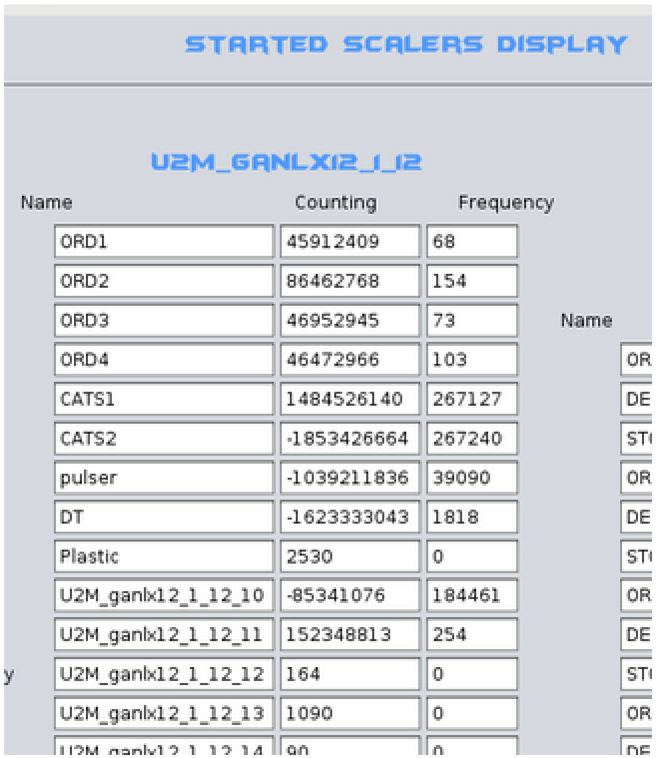
Cplear design

Obsolete system / No more production and difficulties to couple DAQ with the others system

Actual result

Used currently on Mugast Campaign at Lise

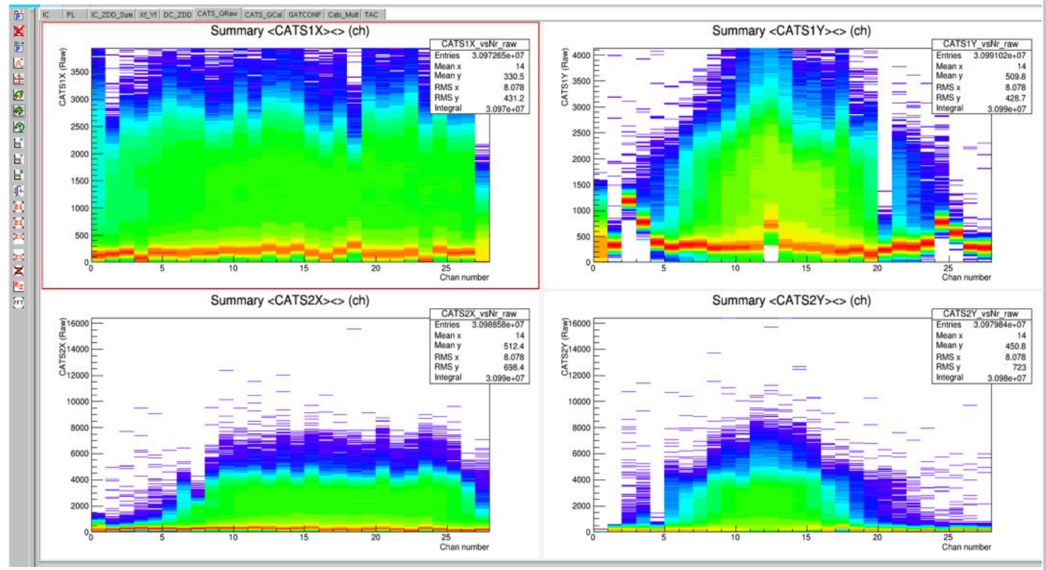
- *3.10^5pps during 300 hours with no or one detectors changing*
- *Normalization on beam intensity, checking beam purity*
- *Incidence ion on target for reconstruction*

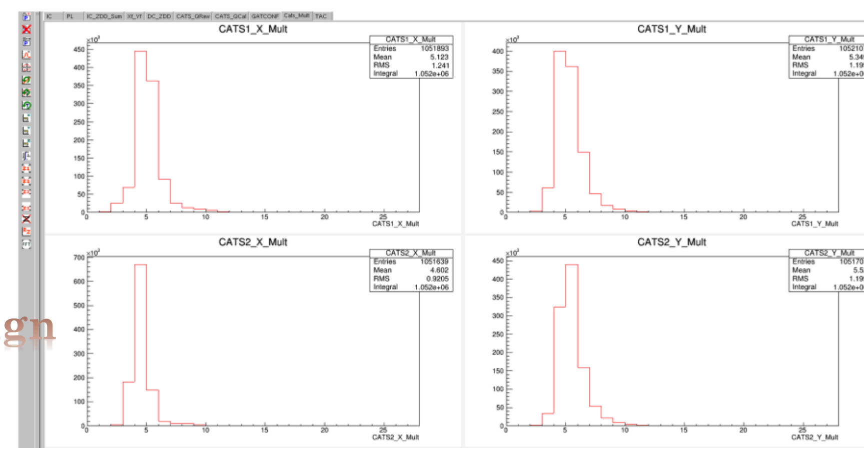


STARTED SCALERS DISPLAY

U2M_GANLX12_1_12

Name	Counting	Frequency
ORD1	45912409	68
ORD2	86462768	154
ORD3	46952945	73
ORD4	46472966	103
CATS1	1484526140	267127
CATS2	-1853426664	267240
pulser	-1039211836	39090
DT	-1623333043	1818
Plastic	2530	0
U2M_ganlx12_1_12_10	-85341076	184461
U2M_ganlx12_1_12_11	152348813	254
U2M_ganlx12_1_12_12	164	0
U2M_ganlx12_1_12_13	1090	0
U2M_ganlx12_1_12_14	90	0



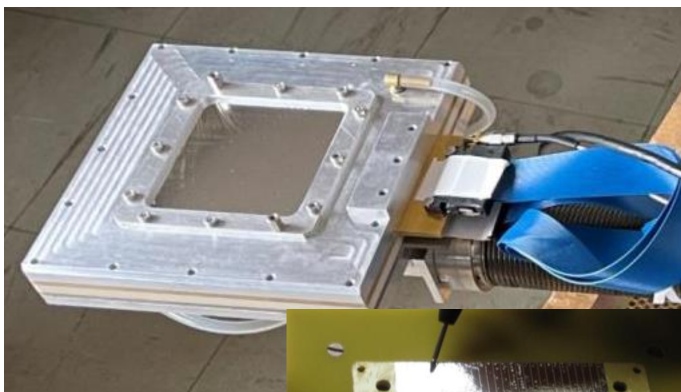


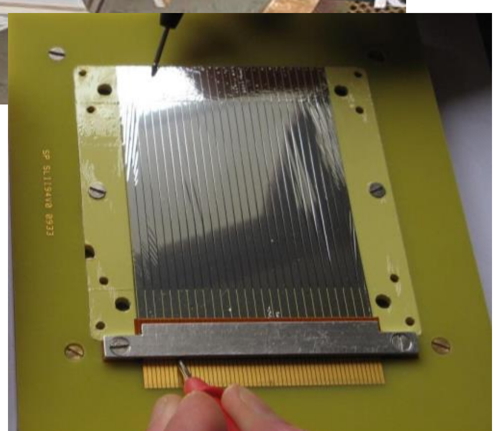
Multiplicity around 5 channel
Picture from Lise Mugast campaign 2023

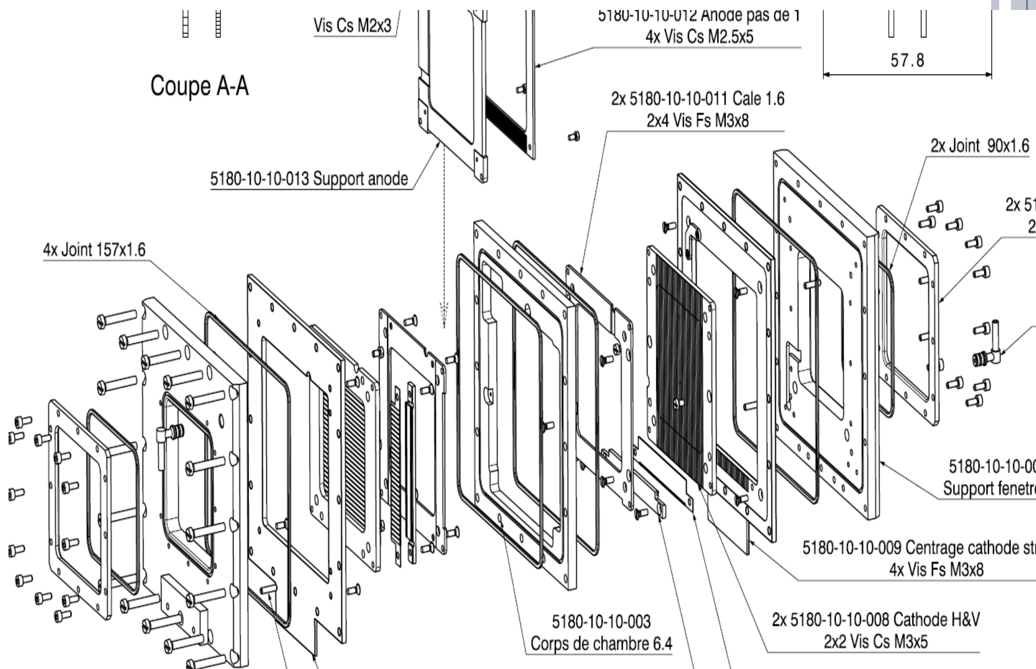
Detector Upgrade

Easier maintenance detector

- ✓ Independence of striped mylar cathode from PCB signal reading
- ✓ Same pieces for X and Y plane and possibility to put wires plan in X or Y position.
- ✓ Mechanical Connection stripped without silver paste
- ✓ Mechanical connection for High tension on the anode (no soldering wire)
- ✓ Modification of wire plan for capacitance isolation of strips planes from HT line in calibration mode







New design: M.Riallot (IRFU) followed by P.Gangant (Ganil)

Electronic Upgrade

laboratoire commun CEA/DSM CNRS/IN2P3

History

- *Upgrade idea: Use current preamplifier for fast response signal*
- *KBTD: first design at IRFU on 2008: Pb of noise, project stopped*
- *Review on 2013 by University of Sevilla KBTD for SED tracker without changing DAQ system*
- *Prototype and publication made but no finalization of the project and loss of the details studies and simulation.*
- *Opening Cat's up project on 2018 at Ganil with CENBG collaboration to review the SEDA design and coupled it with SAM acquisition system (Get system like)*

Design and Measurements of a Preamplifier for Particles Tracking in Secondary Electrons Detectors

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***Abstract*— This paper presents a preamplifier design and experimental characterisation to be used in the Front-End Electronic (FEE) required for spatial resolution measurements in low-pressure gaseous Secondary Electrons Detectors (Se⁻D). The circuit – implemented in a Printed Circuit Board (PCB) as a probe of concept – achieves a transimpedance of 80dB, a DC-gain of 18dB, a Signal-to-Noise Ratio (SNR) of 36dB and a shaping time of 140-170ns. These characteristics allow us to minimise the overlapping probability in tracking detection for Radioactive Ion Beams (RIB) with a counting rate higher than 10^6 particles per second.**

Keywords: Preamplifier; Transimpedance Amplifier; Shaper; Line Driver; Particle Tracking; Secondary Electrons Detectors; Spatial Resolution; Radioactive Ions Beams.

I. INTRODUCTION

New generation of particle accelerators such as "Système de Production d'Ions RAdioactifs en Ligne de 2ème génération" [1] and "Facility for Anti-proton and Ion Research" [2], will provide low-energy RIB (<10MeV/n) with higher counting rates than the ones currently available, in the order of 10^6 particles per second (pps). The nuclear structure and reactions mechanisms of new isotopes will be studied thanks to these beams. Ions track reconstruction (spatial and time detection) before target impact, are required to identify initial conditions of particles which produce a nuclear reaction.

In this scenario, the work in this paper contributes to this topic by presenting the design and performance of a 4-channel preamplifier named "Secondary Electrons Detector preAmplifier" (SEDA) [3]. The circuit is intended for spatial resolution measurements in a low-pressure gaseous detector [4] known as "Mini Secondary electrons Detector" (Mini-Se⁻D) [5, 6].

SEDA is based on a transimpedance amplifier (TIA) and a shaper to achieve fast preamplification and minimise the probability of overlapping signals from detected particles at high counting rates in beam tracking detectors. This configuration has been chosen due to previous studies. In 2008, CEA-Saclay developed "K Beam Tracking Detector" (KBTD) preamplifier [3] with the same configuration, TIA and shaper, as base of the circuit design. The problem was that SNR of KBTD was worse than SNR of previous preamplifier developed for "CP-violation of kaon particles at Low Energy Antiproton Ring" (CPLEAR) experiment [7].

Therefore, experimental results obtained with the designed preamplifier (SEDA) have been compared with previously reported state-of-the-art preamplifiers, and particularly with CPLEAR. The latter is a charge amplifier which output voltage amplitude depends on the input charge coming from the detector as well as its integration time and the integration capacitor value. However, the output amplitude of TIA based preamplifiers, like the proposed one, only depends on the input charge. So that, we expected TIA concept to be better than charge amplifier since it is independent of an integration time.

A systematic top-down methodology was followed from system-level simulations to layout and physical implementation on PCB. In order to check the experimental performance of the circuit, the preamplifier was tested in different experiments performed with particles detectors, using CEA-Saclay laboratory facilities.

II. PREAMPLIFIER DESCRIPTION

Fig. 1 presents the spatial detection system for Mini-Se⁻D. The use of Charge-to-Digital Converters (QDC), or similar digitisers, allows us to obtain the charge value at the output of the detector cathodes. The charge distribution around X and Y axis cathodes, will indicate the two-dimensional spatial coordinates associated to a detected particle (valid event). In addition, an electronic trigger system indicates when events happen. This way, a QDC integrates a valid current signal from each channel of the preamplifier only when a particle is detected. As shown in Fig. 1, an analogue signal from a silicon detector and the anode output from the Mini-Se⁻D are amplified and compared with a threshold higher than noise level to avoid triggering false events owing to noise. Therefore, when a particle is detected by both detectors, an active pulse known as "integration gate" is generated to trigger the QDC and set the integration time.

A.Garzon Camacho et al, SEDA electronics (2012).

Electronic Upgrade

Front end design by current preamplifier

- *Response signal is independent of integration time and just proportional to the charge.*
- *Wide bandwith : so very high sensibility to noise and impedance variation*

Characteristic

- *Spark protection*
- *TIA: AD8015 IC*
  - *80dB/10KΩ*
  - *240MHz BW*
  - *3pA/√Hz noise*
- *Shaper block :LMH 6733*
  - *Rise and fall time adjustment*
  - *HPF and LPF cut-off biquad*
  - *40dB/decade reduction noise*

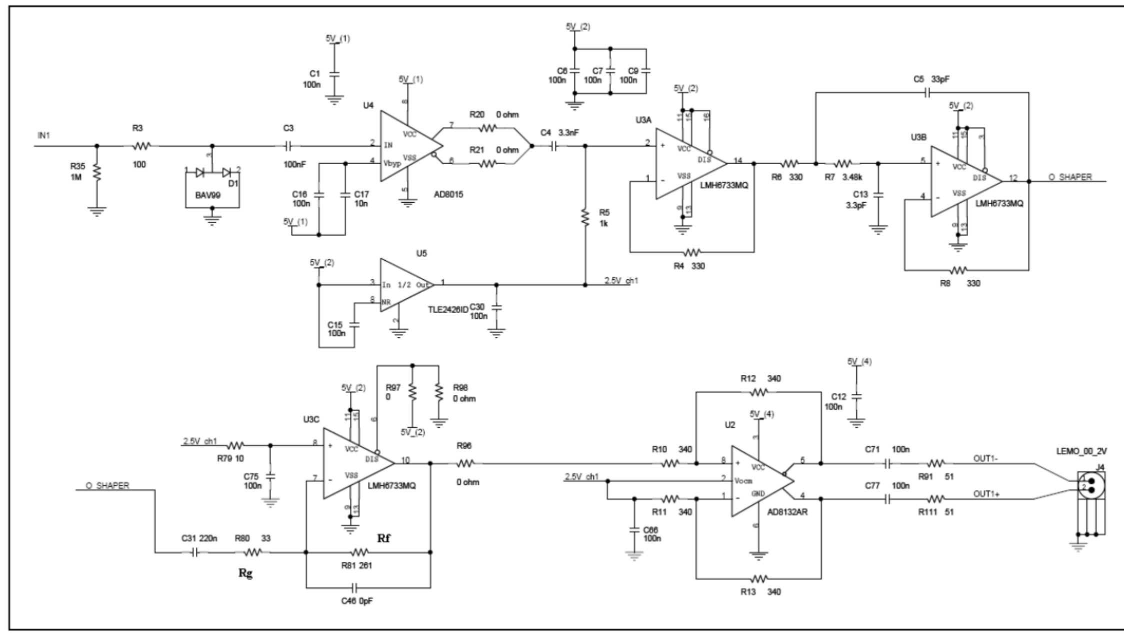


Figure 2. One channel schematic of SEDA.

SEDA design:
Transimpedance wideband amplifier and triple amplifier/shaper

Goal:
dynamic: 20fC to 400fC

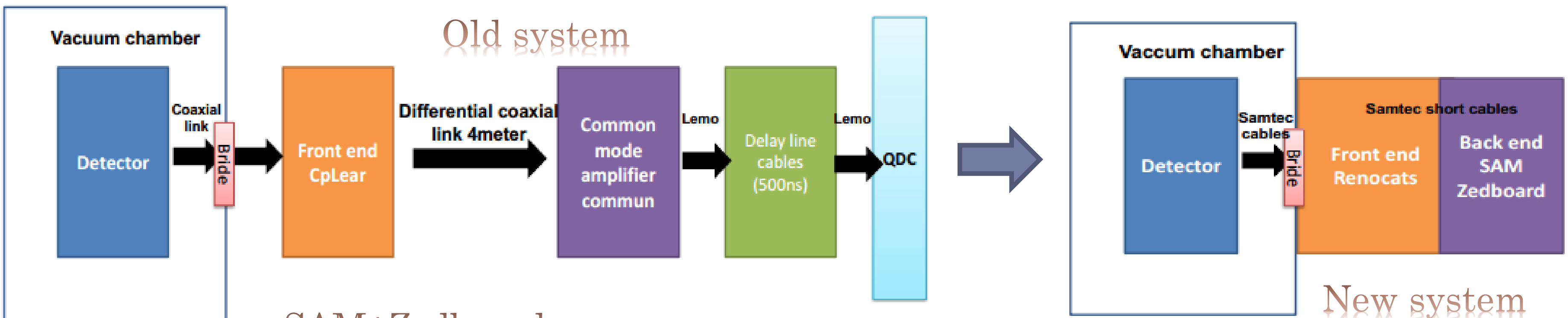
Note: BW and noise decrease with input capacitance

Electronic Upgrade

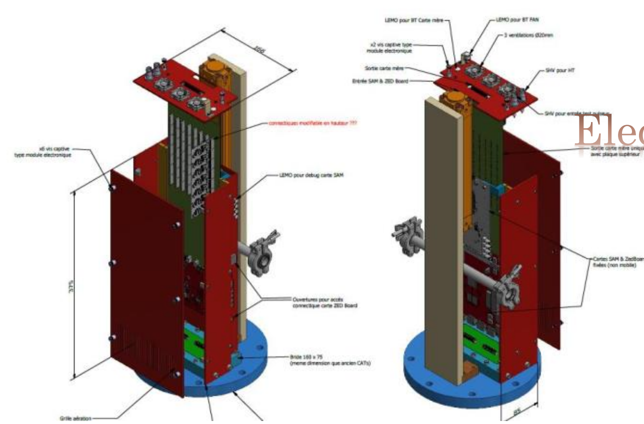
Back end system

- *SAM design from CENBG (Get light system)*
  - *Squeeze Get premaplifier.*
  - *Use shapping Get (Sallen-Key Filter)*
  - *Digitization with one GET chip (64-channels)*
  - *Acquisition by Zedboard (Commercial card): No CoBo Card*
  - *Coupling with dedicated card (collaboration with GTA Ganil)*

Very Compact design
Delay adjustable to 5 µs

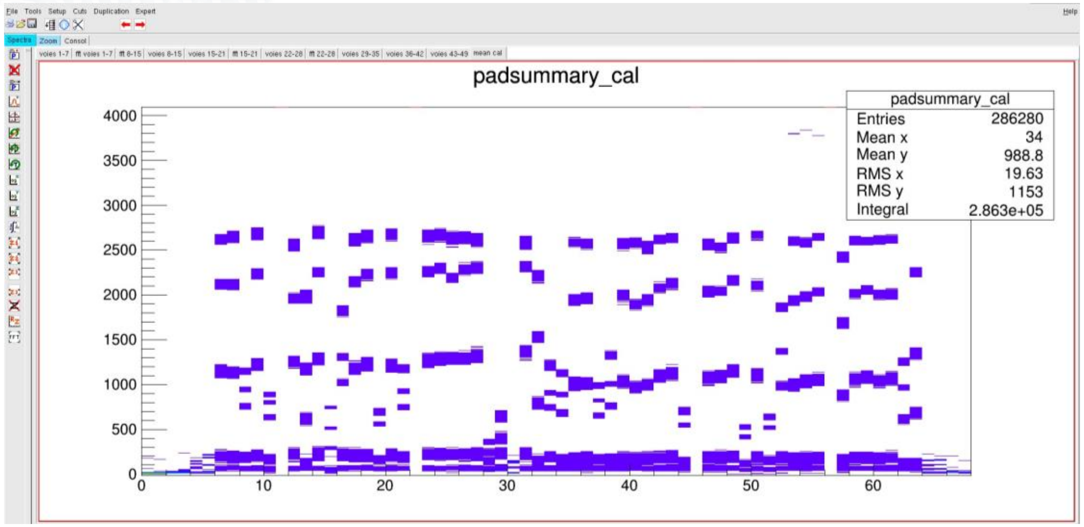


SAM+Zedboard

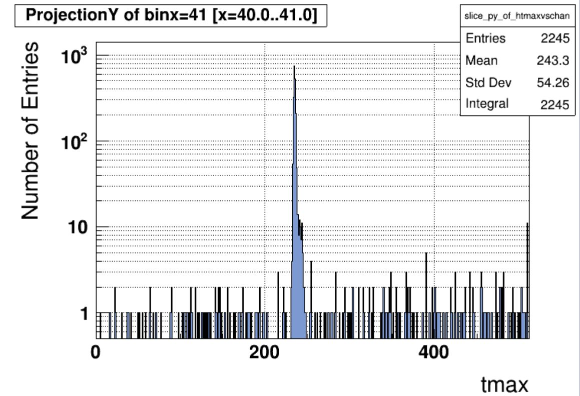


Electronic integration

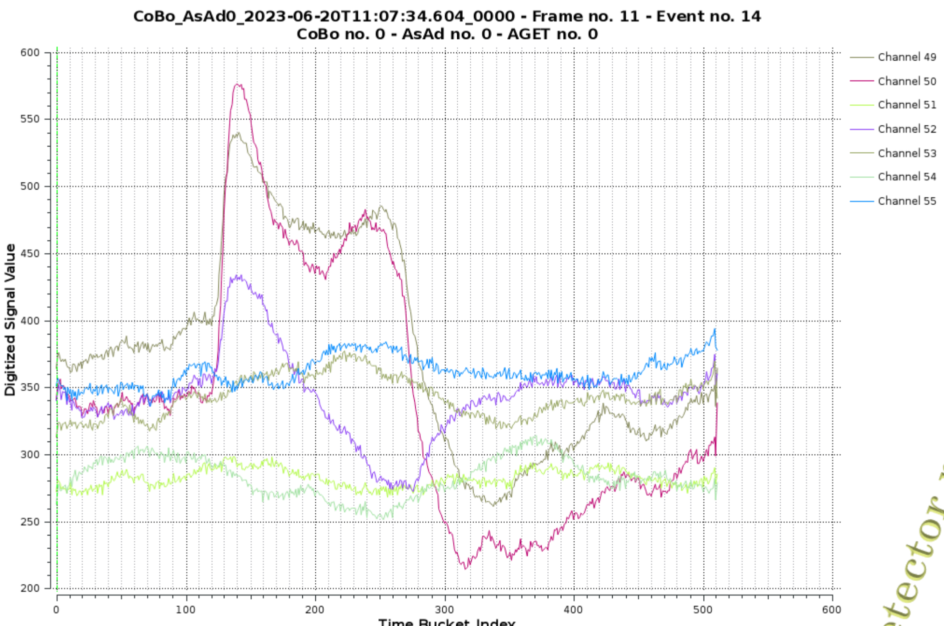
Results



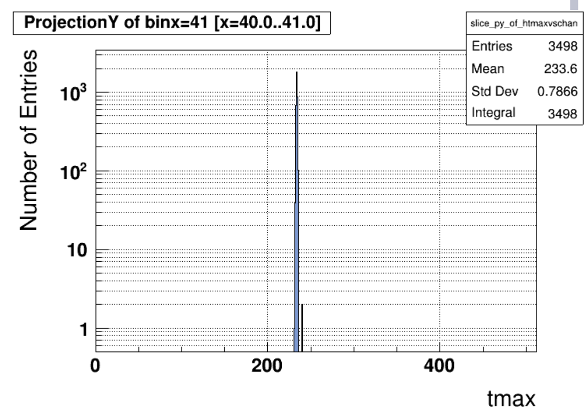
Global response to 3 différents signal input



pulse 25mV



Detector response alpha source



Pulse 50mV

Status and roadmap

laboratoire commun CEA/DSM CNRS/IN2P3

Detector Upgrade

- *Prototype validated*
- *Production made (4 detectors)*
- *Need final tests with definitive electronic and beam commissioning expected in 2025*

Electronics Upgrade

- *Prototype characterized and lot of behaviours understood*
- *New design and production of mother front end board to be tested for S/N improvement by :*
  - *Reduction of strips length before preamplifier*
  - *Stripped embedeed into PCB (more parasitic capacitance but less CEM sensibility)*
- *Actual test and optimization of centrum card adaptation for zedboard*
- *Mechanical electronics integration design to be adjusted*

Thanks for your attention

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