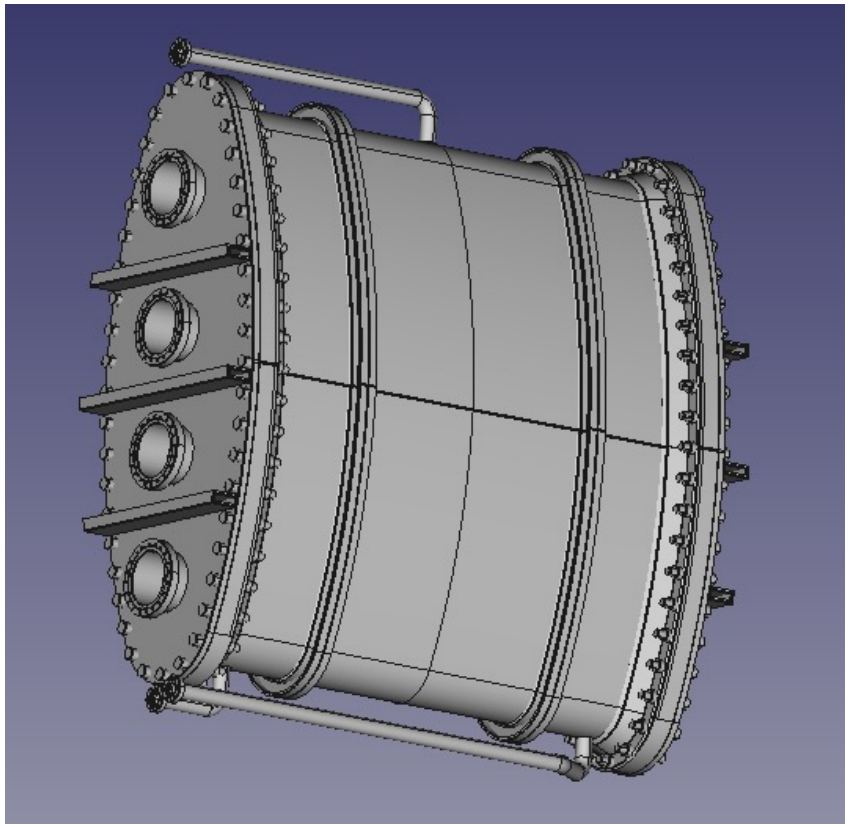
GRAIN: Status & progress of GRAIN Working group

Conveners: Lea Di Noto – Univ. and INFN Genova
Alessandro Montanari- INFN Bologna

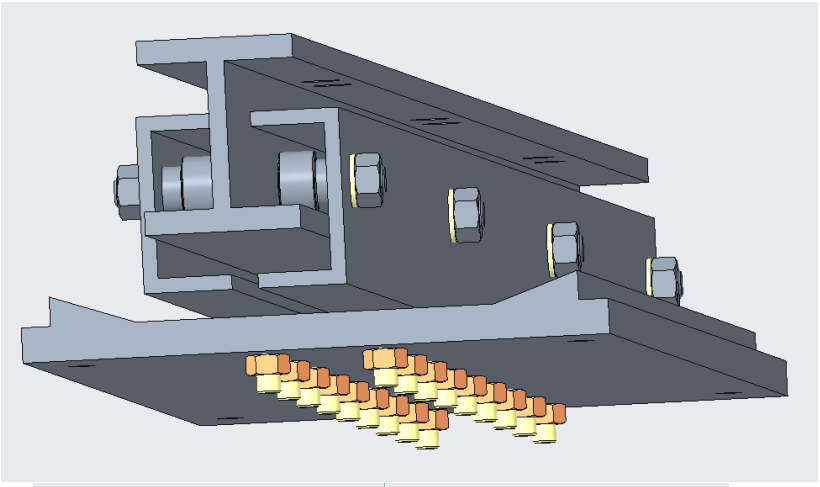
SAND General meeting,
May, 14th 2024

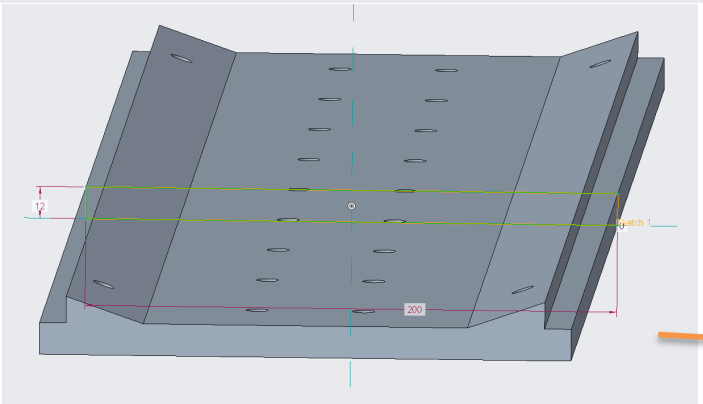
Inner Vessel Design

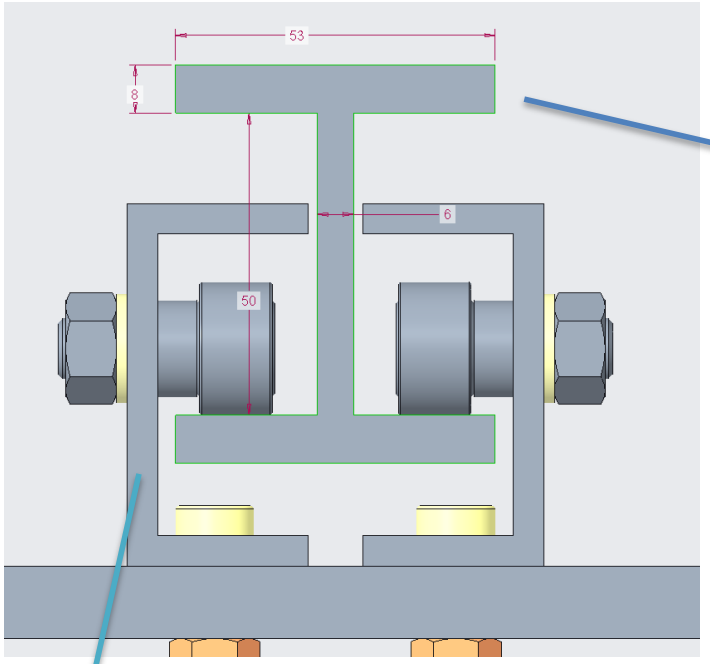
- Material:
  - Stainless Steal 316L seems adeguate for our application
- Covers:
  - 30 mm thickness
- Simulation of Helicoflex sealing under way



Sliding System







IPE beam like:

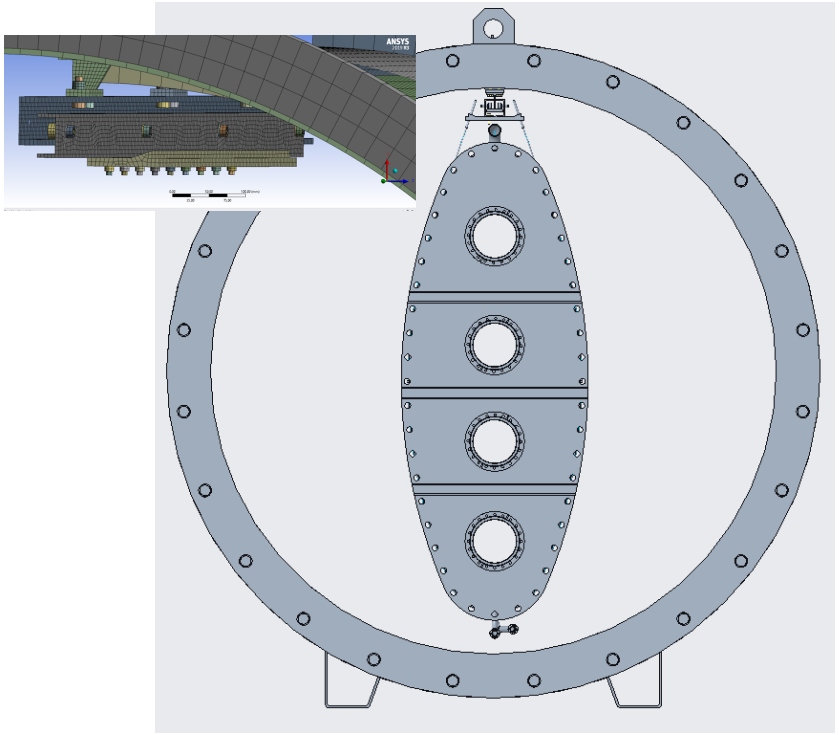
h=66 mm
b=53 mm
tf=8 mm
tw=6 mm
L=1800 mm

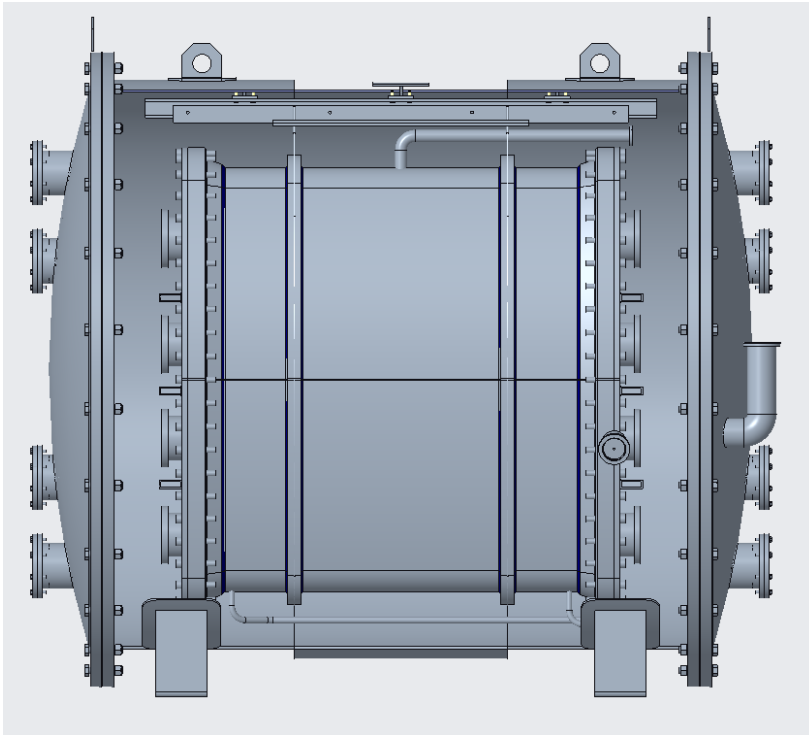
Montanstahl can produce laser welded customised profiles in 316L
1500 € for 3000 mm ca

C beam IPA hot rolled, dimensions:
60x30x5 mm, 1600 mm long

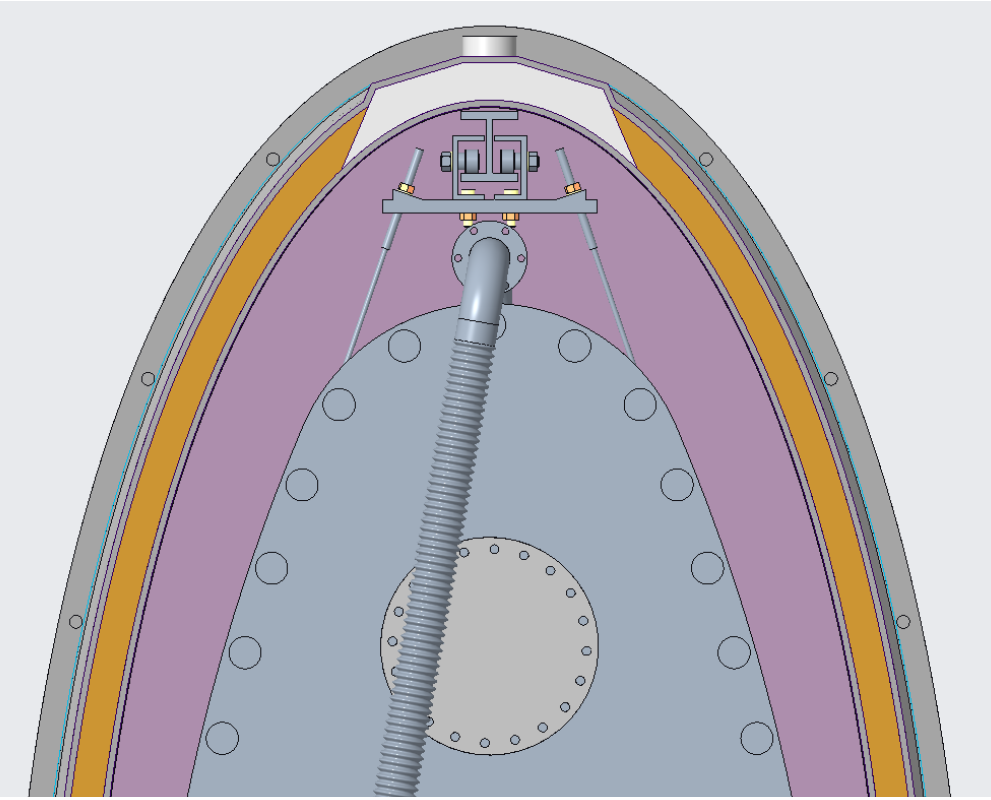
Plate 200x12x900 mm

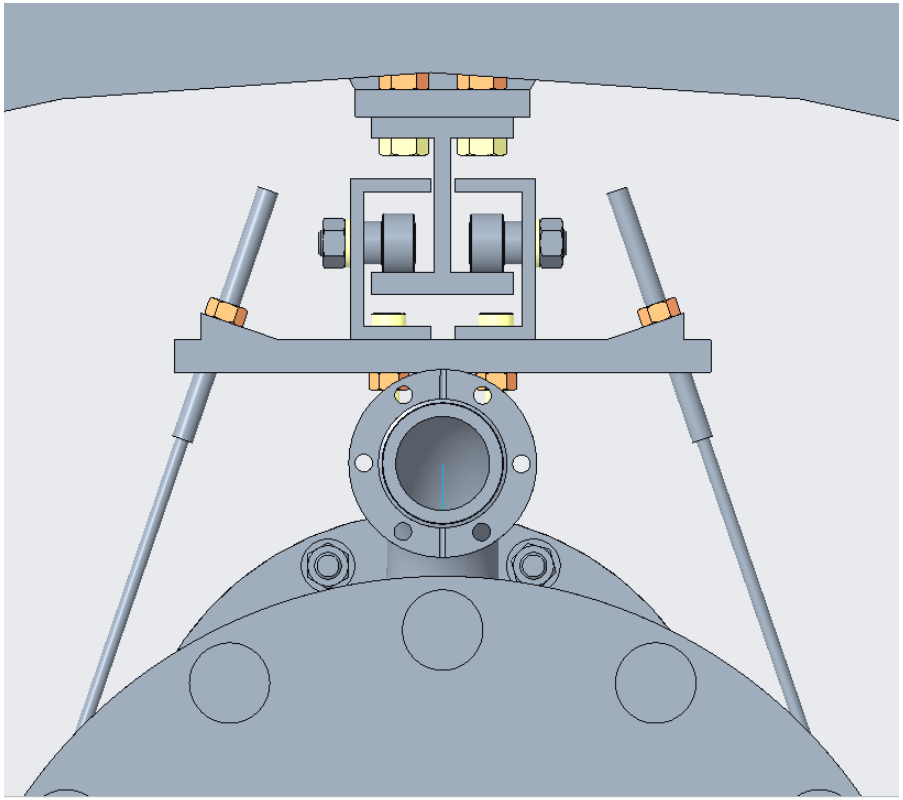
Sliding inside Vacuum Tank in Legnaro





Sliding inside final External Vessel





Test Facility in Legnaro

- Refurbishment of old lines is under way

- Components of Control System have been delivered. Assembly must be done by an electrician

- Cryogenic complete scheme is preliminary designed:
  - Identify a unique company that will produce and certify the whole system
  - Only one tender with delivery split into different batches

- Meeting on 28 May at 14:00 with new LNL Director

  (R.Pengo, M.Pallavicini, S.Bertolucci,L.Patrizii, A.Montanari, L.Di Noto, G. Piazza, A.Mengarelli).

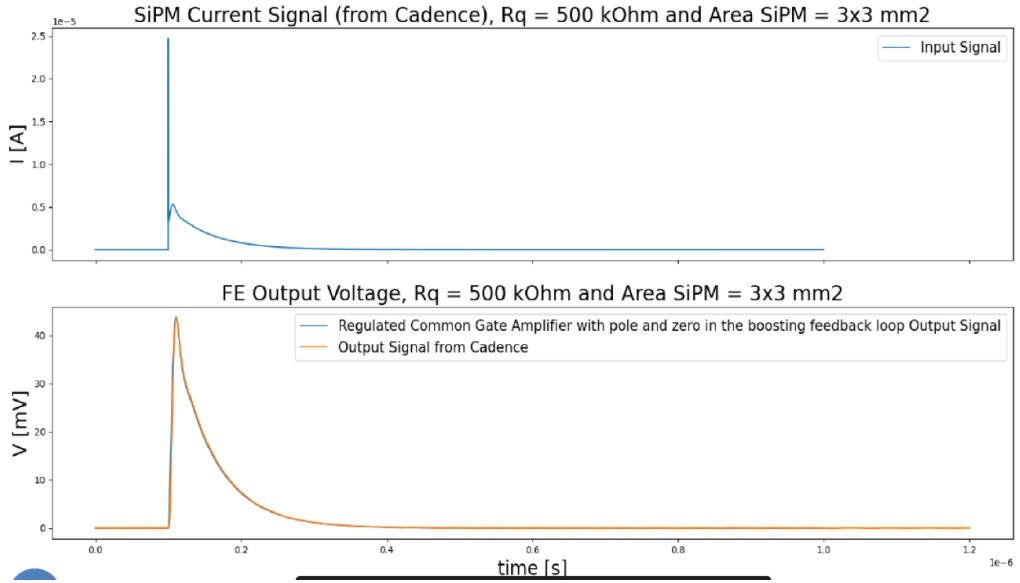
Electronics

- Torino group has started to design a dedicated ASIC for GRAIN
  - A. Rivetti, M. Da Rocha Rolo, S. Durando (Post-doc), S. Blua (PhD), V. Pagliarino (master student)

Torino group is producing a reliable simulation of the signal shaping and digital processing from SiPM signal to the readout data

Front End simulation

(using Alcor Transfer function)



Current studies for electronics design

Architecture with few integrators for each pixel for each spill

- For each integrator we record:
  - Time with O(100 ps) resolution for rising edge on a 0.5 pe threshold,
  - Time with O(2 ns) resolution for falling edge
  - number of photons during the integration window

- Parameters under study for the ASIC design:
  - Number of integrators for each channel
  - Dynamic range for each channel (maximum number of photons)
  - SiPM parameters (quenching resistor, SiPM size, ..)

Genova and Bologna groups are studying the GRAIN performance with coded mask or lens for:

- tracking reconstruction
- calorimetric reconstruction
- multiple event identification

Number of capacitors

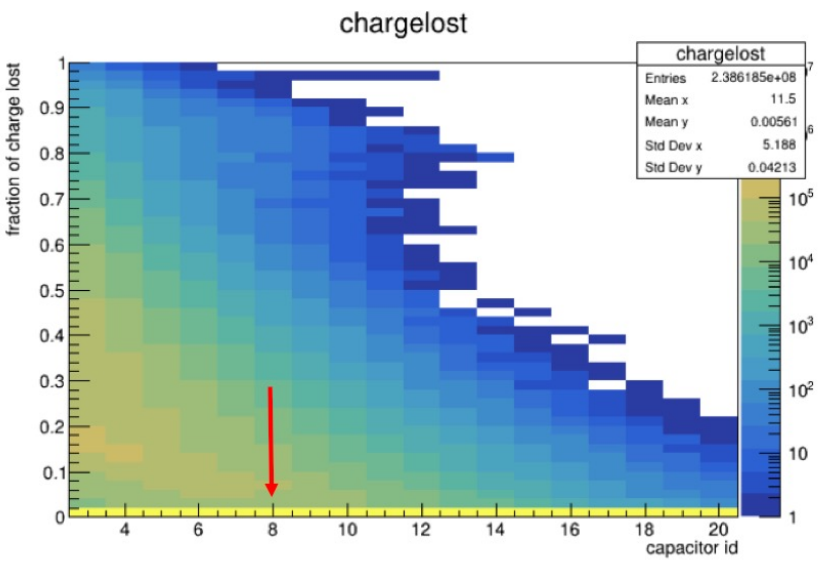
from spill simulations with coded masks

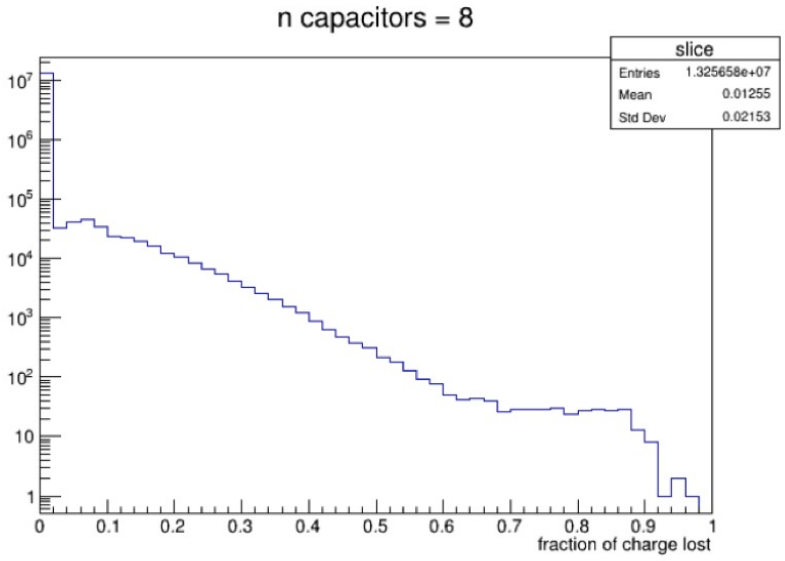
Fraction of lost charge per number of capacitors

Rq = 2000 kOhm

$$Q_{lost} = \frac{\sum_{c>n} (\text{n integrated photons})_c}{\text{total integrated photons}}$$

ALL cameras

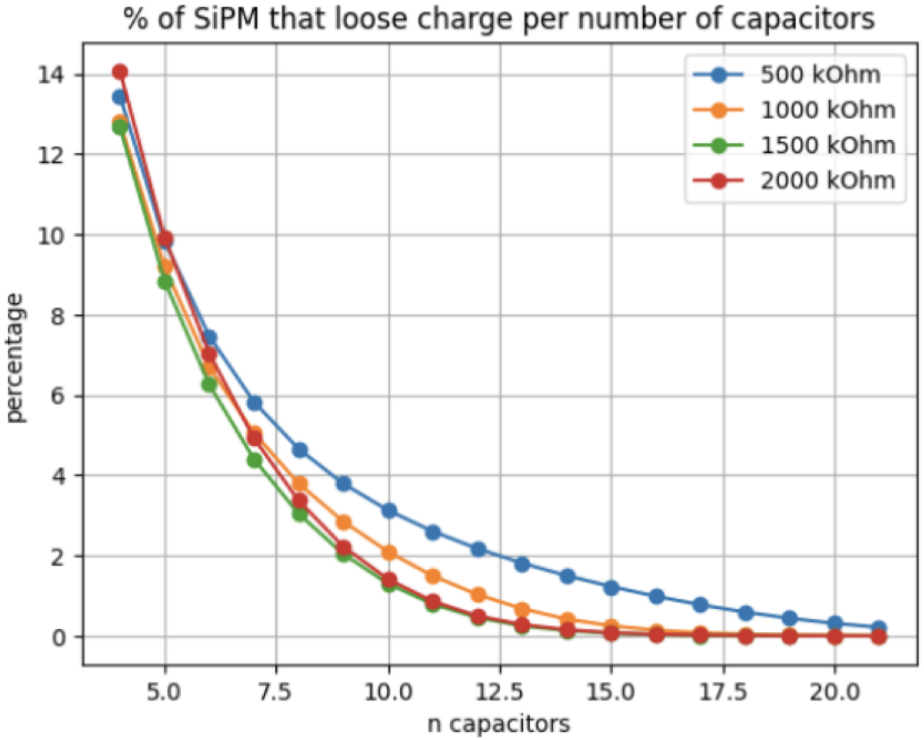


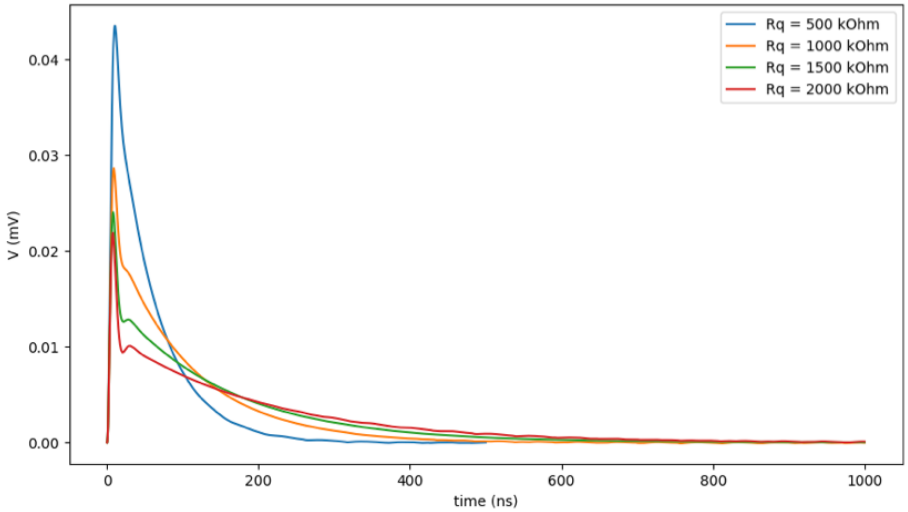


Number of capacitors

from spill simulations with coded masks

Considering different quenching resistors → different signal time constant

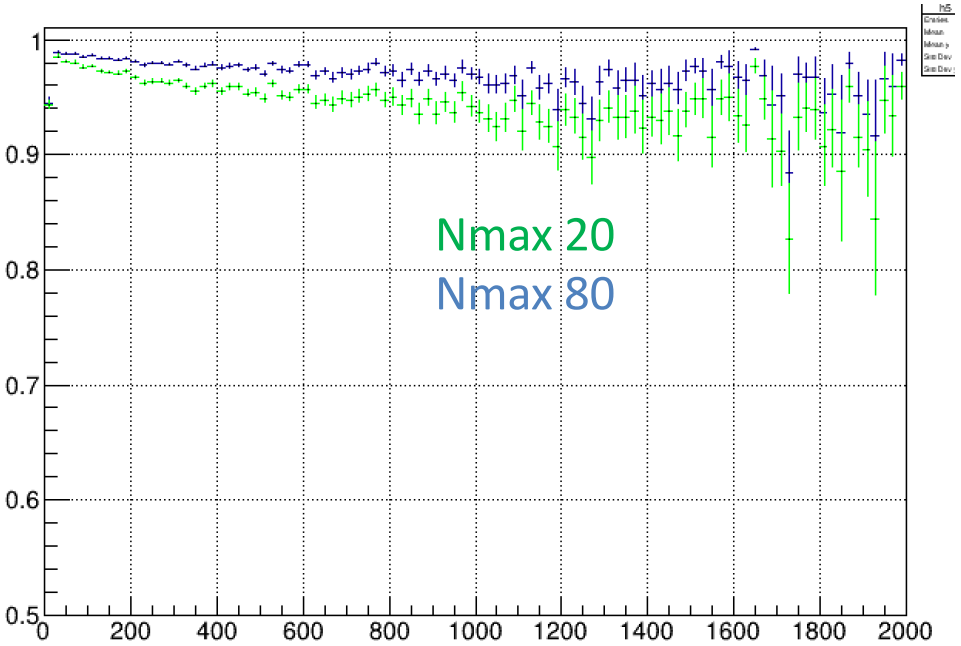




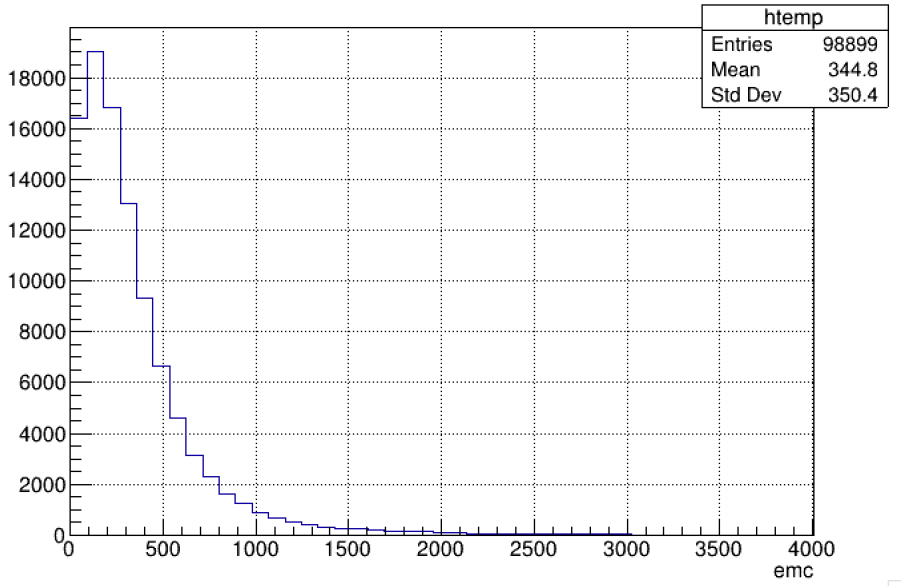
Dynamic range optimization

from single interaction simulations with lenses

Neutrino interaction vertex in the the biggest fiducial volume
(0 cm from lens surfaces)



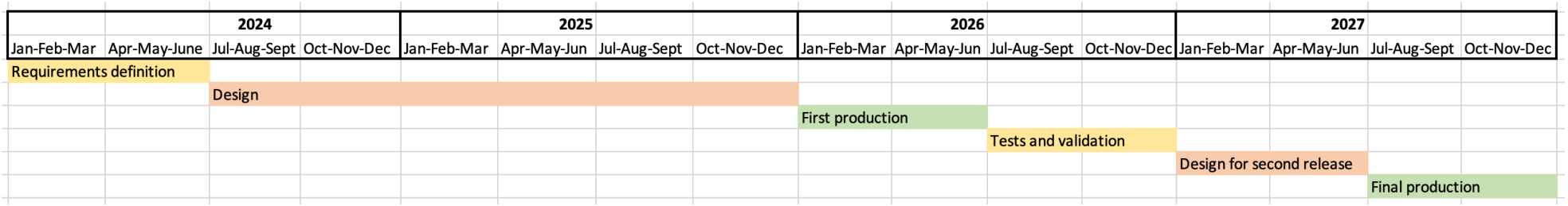
Energy deposit [MeV]



Energy deposit [MeV]

Timeline for ASIC

- Timeline was agreed with Torino group during the last meeting (9th May)



- 2 runs are foreseen

- by 1 month the requirements must be completed and integrated in the ASIC requirement document (GE-BO)

- The first phase: ASIC design (TO) → about 18 months (not more!)
  - Intermediate milestones to be agreed in the next meeting

Reconstruction algorithm

- **For coded mask:**
  - algorithm running on GPU, for a 3D reconstruction by using all the images
    - Algorithms was improved
  - quantitative evaluation of reconstruction performance is in progress

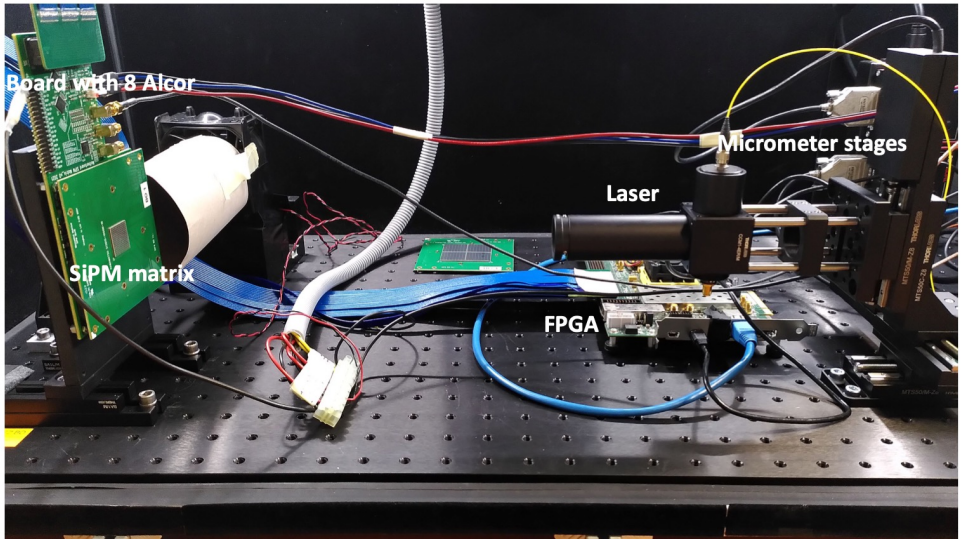
- **For lens based detector**:
  - ***Simple reconstruction*** based on fit on images available
    - MC info for matching tracks from different cameras still necessary
  - Evaluation of reconstruction performance with the latest geometry is in progress

  - Dedicated algorithm based on ***multiple-view projective geometry***
    is under development
    - it was tested on point like or single tracks
    - current study on neutrino interaction events with 2 tracks

Detector prototypes

- We can test detector prototypes with a 16x16 SiPM matrix acquired by 8 Alcor chips

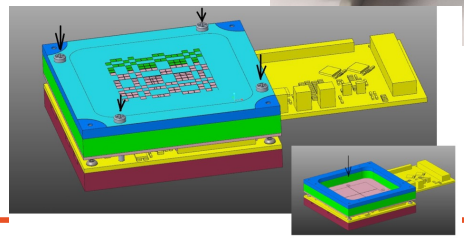
- Since December 2023 we have 2 Front End boards (at Bo and Ge)



- DAQ with a Xilinx FPGA board is working (many improvements in the last period)

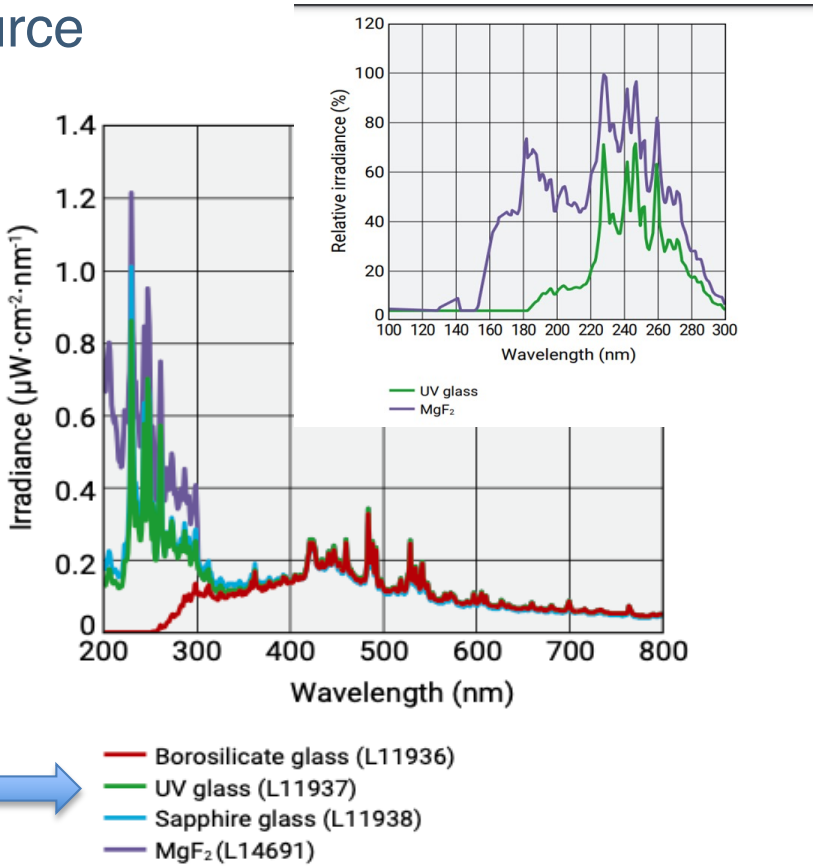
- First test with SiPM matrices already performed

- Tests with lenses or coded masks in ARTIC in the next weeks



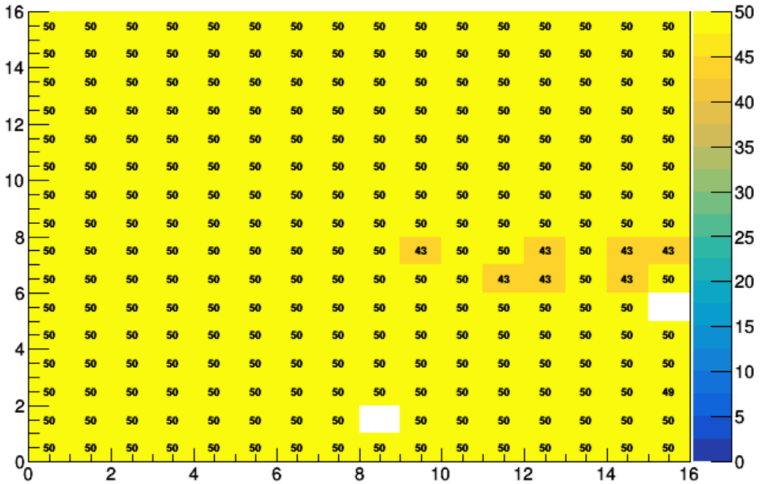
First tests in Genova

- First test with 256 channels SiPM matrix with TPB deposition
  - At room temperature or at liquid nitrogen temperature
  - with a pulsed 230 nm Xenon light source



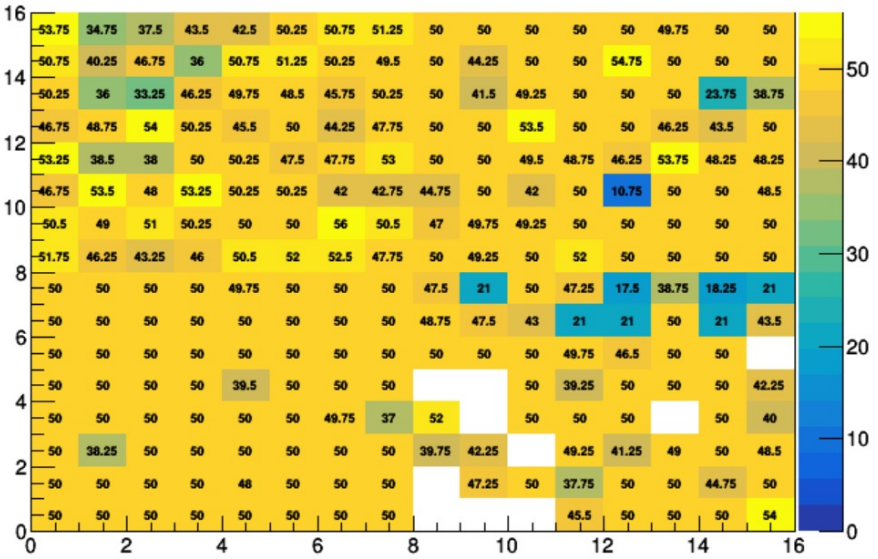
First tests

- TDC calibration signal



- Front End calibration signal

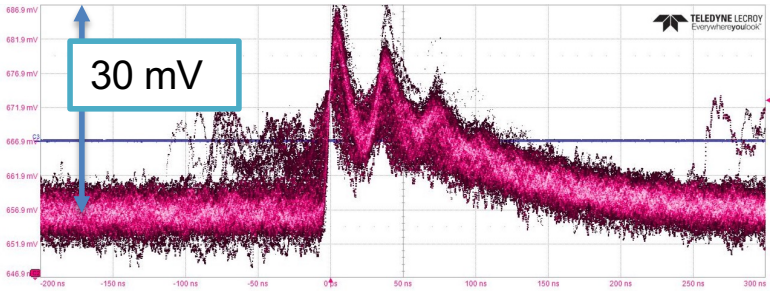
  it depends on thresholds

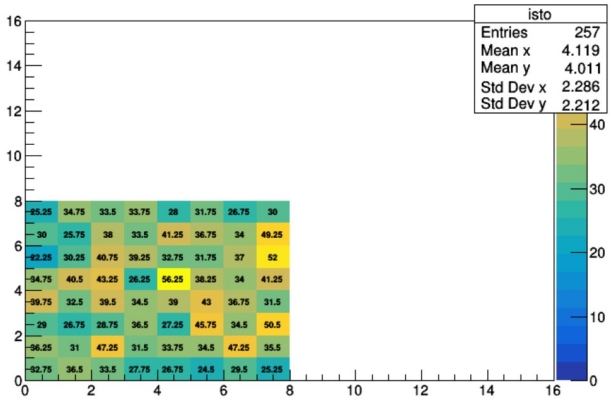


50 counts were expected in each channel

First tests

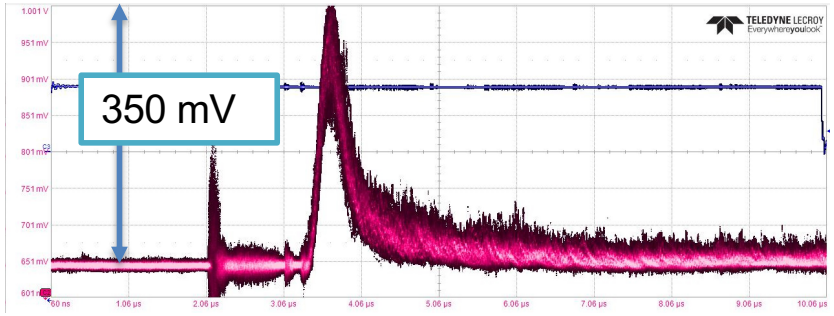
- Dark counts at room temperature

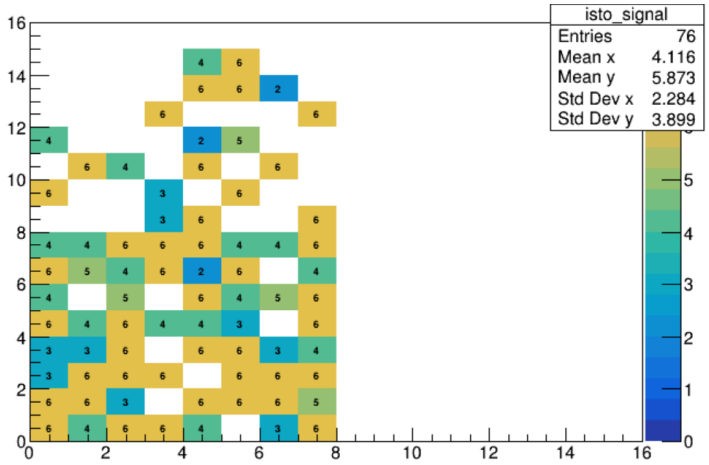




- Only 2 chips (64 channels) were acquired here
- 45 counts are expected for each channels

- Pulsed light signal



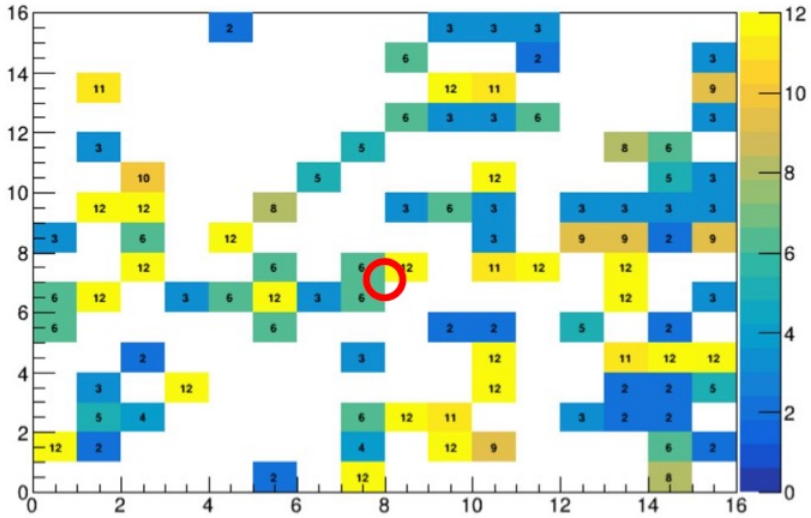


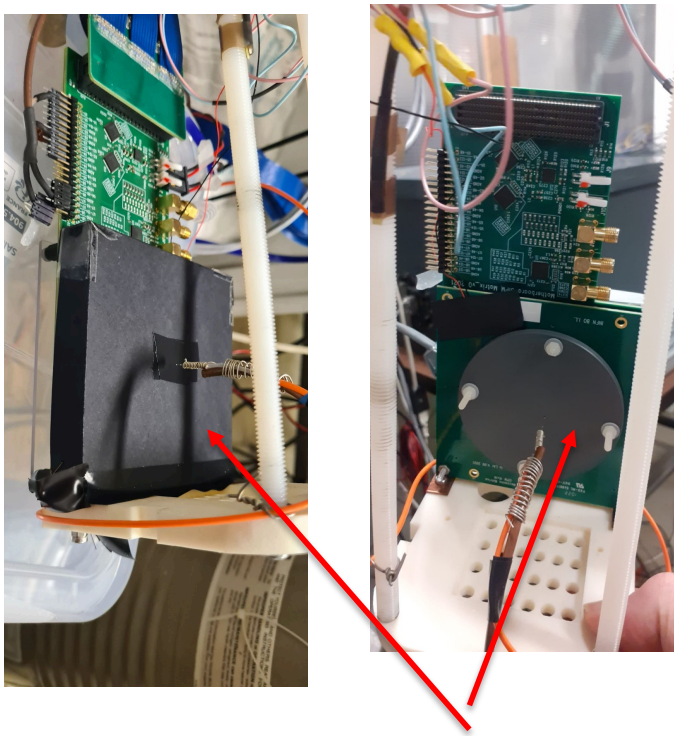
- Only 3 chips (96 channels) were acquired here
- 6 counts are expected for each channels

A problem with the TPB deposition

If we point the light on a single SiPM

the light is detected everywhere





There is a very small hole

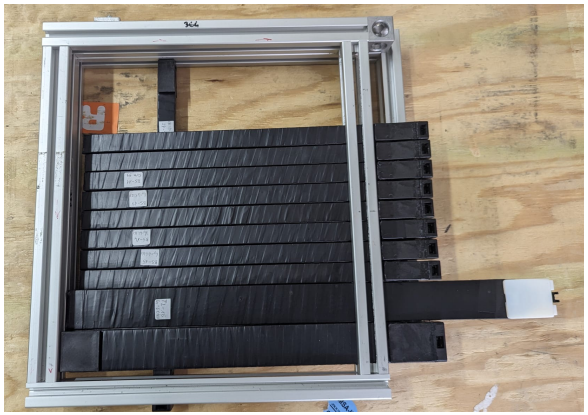
- If we acquire the analog signal, the light signal is visible everywhere..
- This is due to TPB deposition

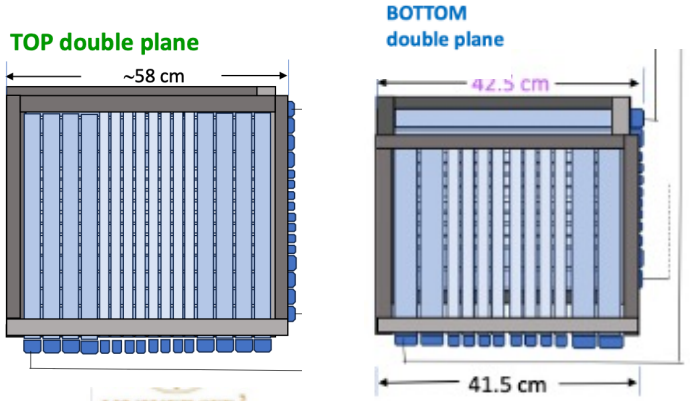
  → we are design a proper grid for a new deposition

  → we will continue to test prototypes with visible light and matrix without TPB

CRT for ARTIC

- Detector design completed
- Detector assembly and test: in progress





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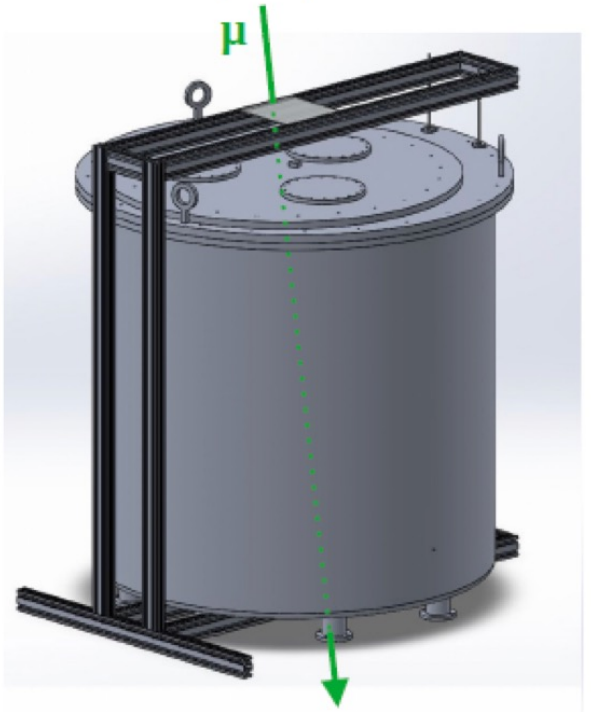
CRT GOALS:

- Trigger for the LAr acquisition (fourfold coincidence)
- Two-view tracking to help the LAr event reconstruction



Trigger condition: Fourfold coincidence

To-do list

- Mechanics design and realization (C-structure, scintillator-frames, trays, lifts, anchorings, ..) COMPLETED
- Wrapping of scintillator bars COMPLETED
- Mounting of single bars (SiPM, End-caps, PCB, connector, …)
- Test of single bars COMPLETED
- Assembling of CRT planes and Installation on the mechanical structure
- Overall test and DAQ with cosmic rays

Conclusions

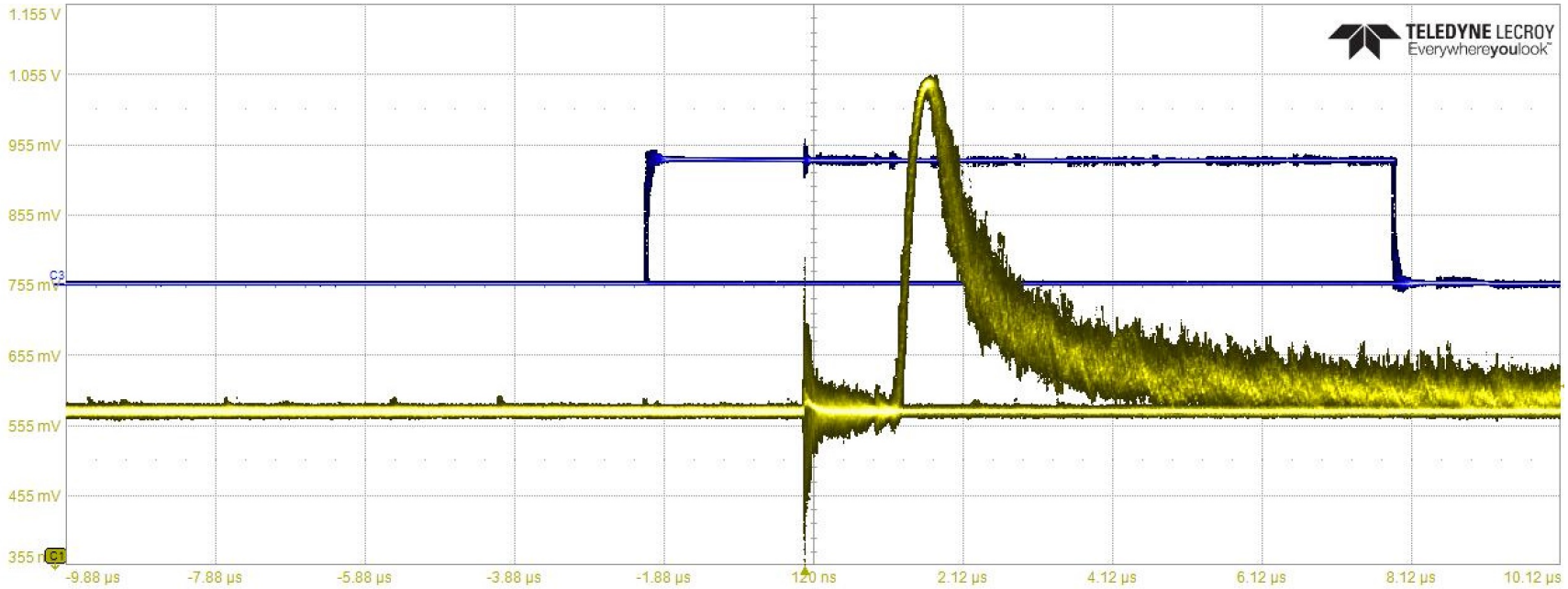
Many important activities are in progress :

- refurbishing in Legnaro
- Mechanical design for vessels and integration

- Reconstruction performance of neutrino interactions in GRAIN for TDR

- ASIC design with Torino group
  → a schedule was defined
- Test with prototypes
  → finally started, new results in the next future

Analog signal from Xenon lamp



Interactions in GRAIN and photon distribution on SiPM

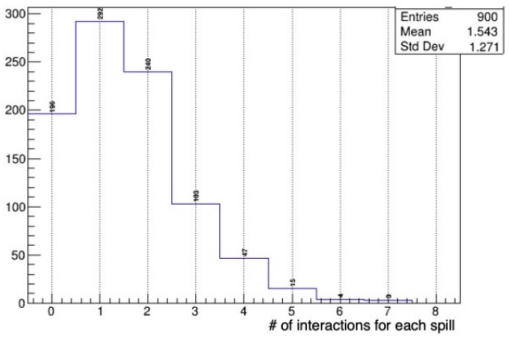


Figure 2: Number of neutrino interactions for each spill, whose tracks are detectable in GRAIN. A track is considered detectable if more than 6 MeV are deposited in the liquid Argon volume.

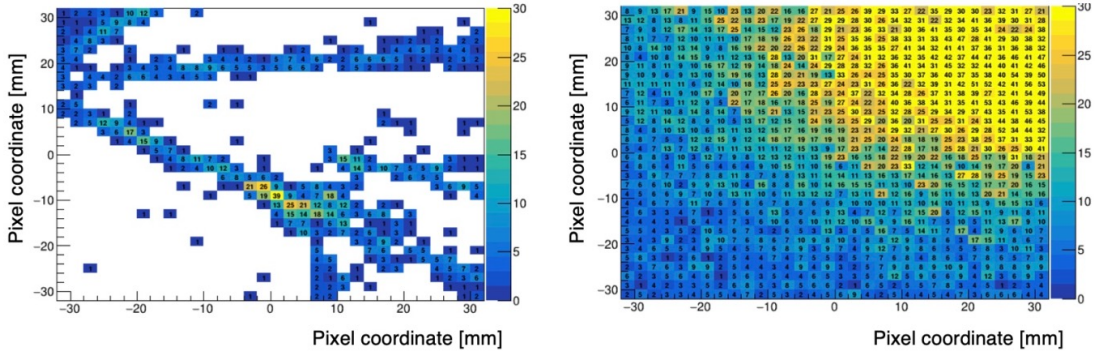
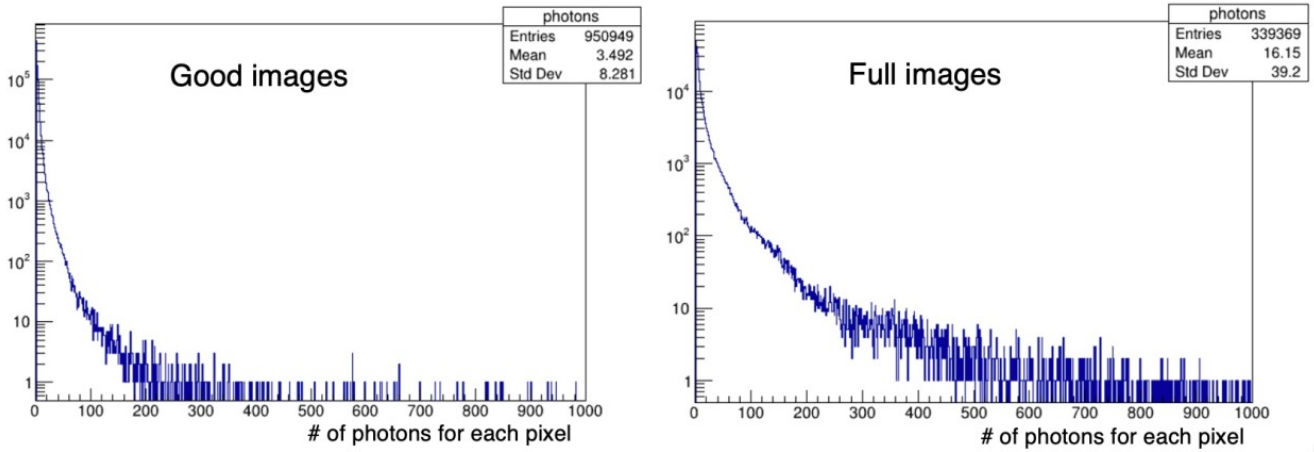
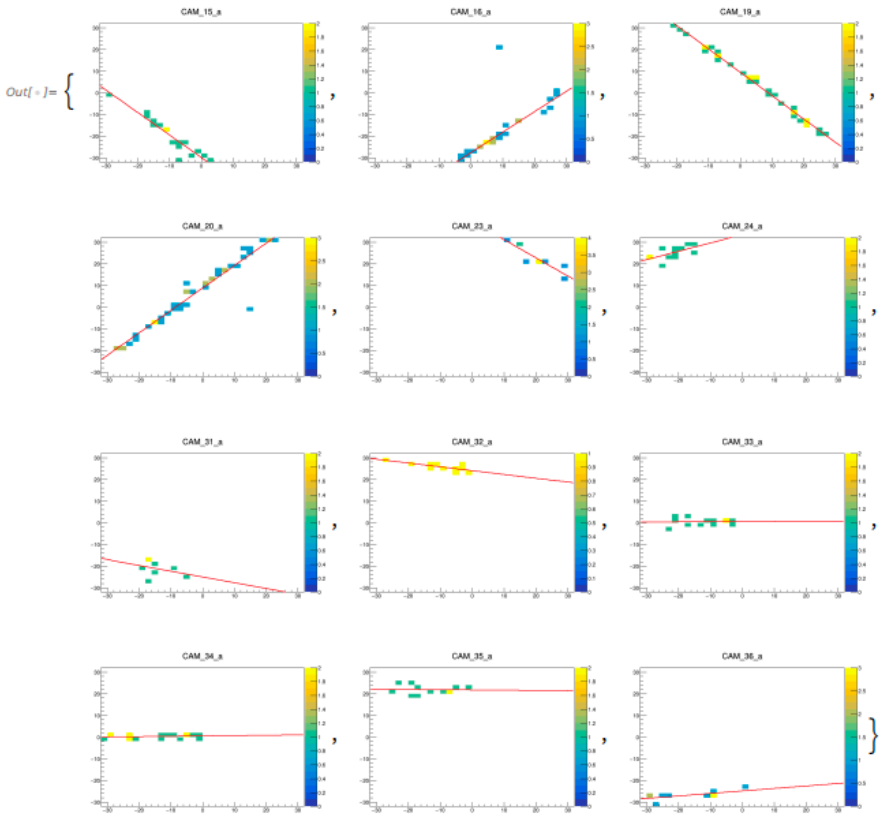


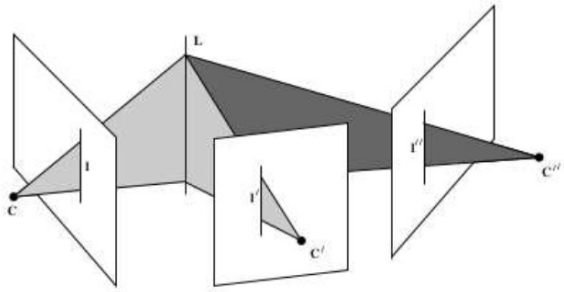
Figure 7: Example of images acquired by lens based detector. At left: a typical "good image" where vertex and tracks are clearly visible. At right: typical "full image" where 60% of pixels have collected photons.



Sim & Reconstruction

- Algorithm for track reconstruction under development by Lecce group





Global Multiple View Reconstruction of a Track

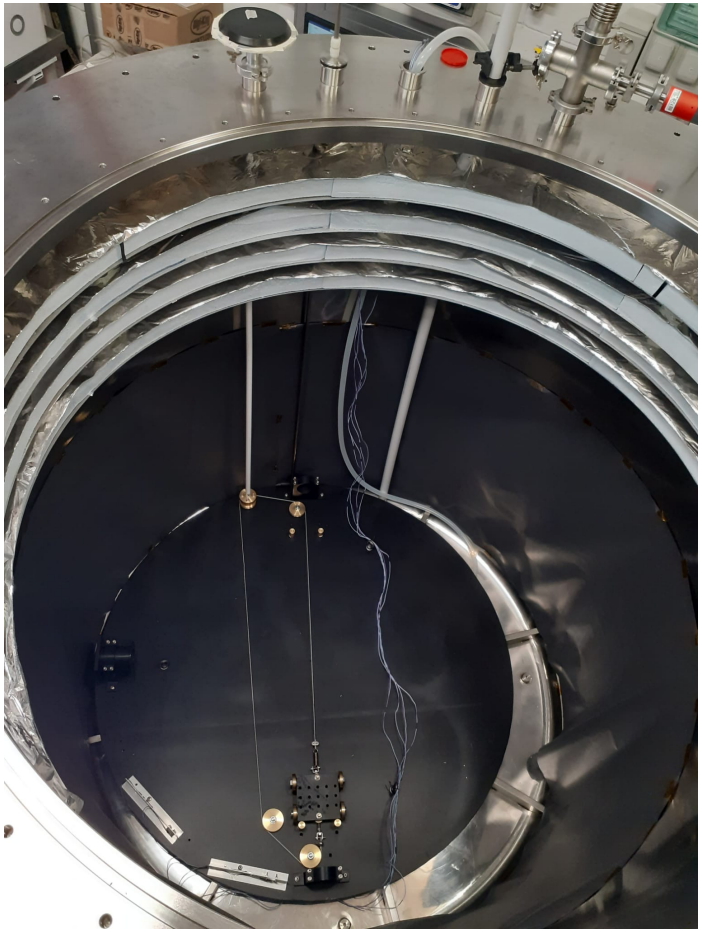
- The track is detected/seen by N cameras
- There are $M = \frac{N!}{2!(N-2)!}$ possible double-view reconstructions for the track
- We perform M reconstructions
- We take the mean value of the M possible reconstructions for each line parameter (director cosines (l, m, n))

$$l = \frac{\sum_{i<j}^{N} l_{ij}}{M} \qquad m = \frac{\sum_{i<j}^{N} m_{ij}}{M} \qquad n = \frac{\sum_{i<j}^{N} n_{ij}}{M} \tag{21}$$

i, j camera indices

- Analysis of intercepts of the M reconstructions

- Single track: tested
- Test with 2 tracks from neutrino interaction: in progress

Tests of prototypes in ARTIC

- Mechanics completed