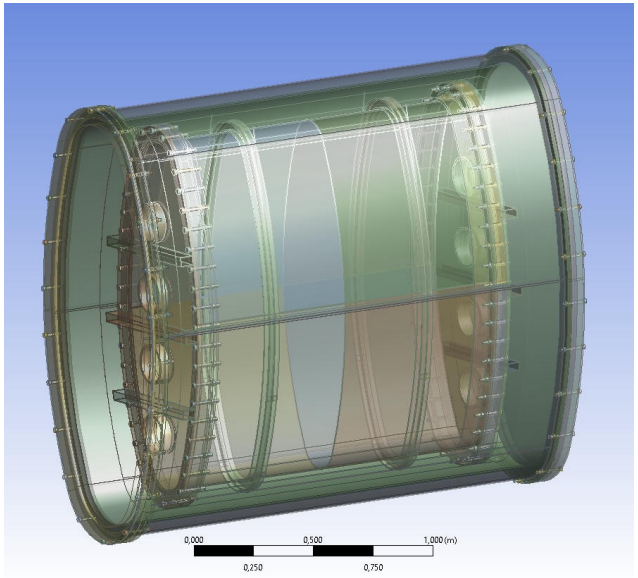
GRAIN: Status & progress of GRAIN Working group

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

SAND technical meeting
Jun, 27th 2023

GRAIN: Mechanics



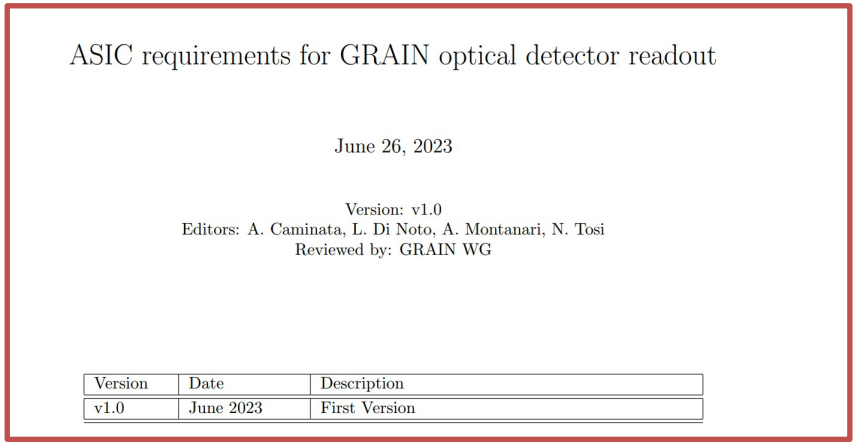
- Inner vessel:
  - Finite element simulations committed to an external company
- Outer vessel:
  - Different companies were contacted
  - Some critical points have to be discussed and checked with tests
- Outer vessel for tests in Legnaro:
  - Drawing completed → purchase procedure in progress

The current dimensions should be considered for future SAND simulations and analysis

GRAIN: Electronics

- Torino group (Angelo Rivetti, M. Da Rocha Rolo…) started to work to design of a new ASIC for the detector readout

- a first document for describing the ASIC requirements was circulated in GRAIN WG



ASIC requirements for GRAIN optical detector readout

June 26, 2023

Version: v1.0
Editors: A. Caminata, L. Di Noto, A. Montanari, N. Tosi
Reviewed by: GRAIN WG

Version	Date	Description
v1.0	June 2023	First Version

  - Authors: A. Caminata, L. Di Noto, A. Montanari, N. Tosi
  - Goal of the document:
    - explain physic context
    - list the requirements for ASIC (inspired by ALCOR)
    - first draft of the GRAIN framework (to be integrated in SAND)

ASIC requirements for GRAIN

Contents

Interactions in GRAIN and photon distribution on SiPM

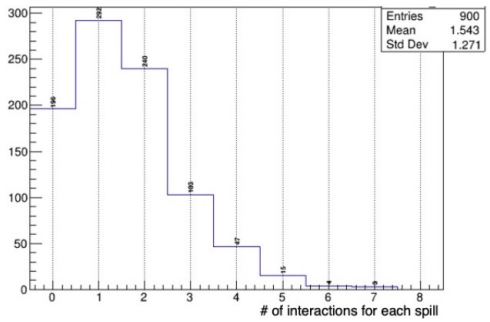


Figure 2: Number of neutrino interactions for each spill, whose tracks are detectable in GRAIN. A track is considered detectable if more than 6 MeV are deposited in the liquid Argon volume.

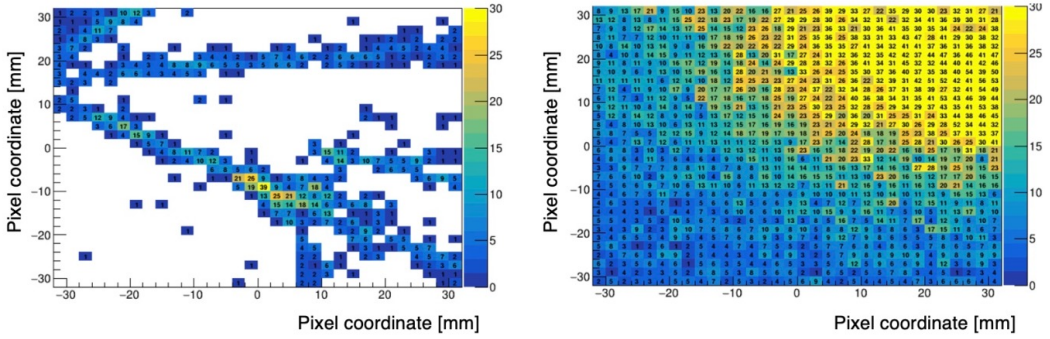
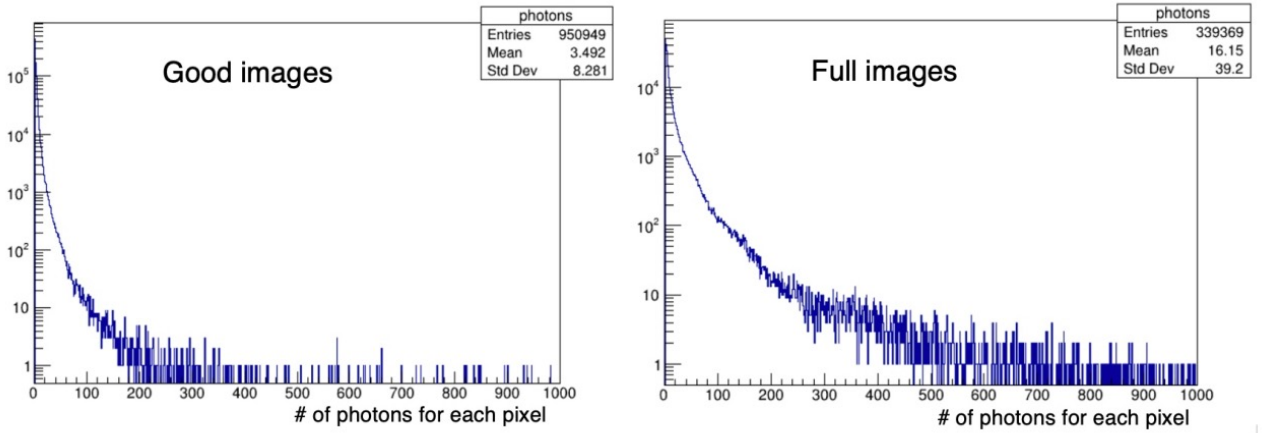


Figure 7: Example of images acquired by lens based detector. At left: a typical "good image" where vertex and tracks are clearly visible. At right: typical "full image" where 60% of pixels have collected photons.



Photon distributions on SiPM

both Argon or Xenon option has to be considered

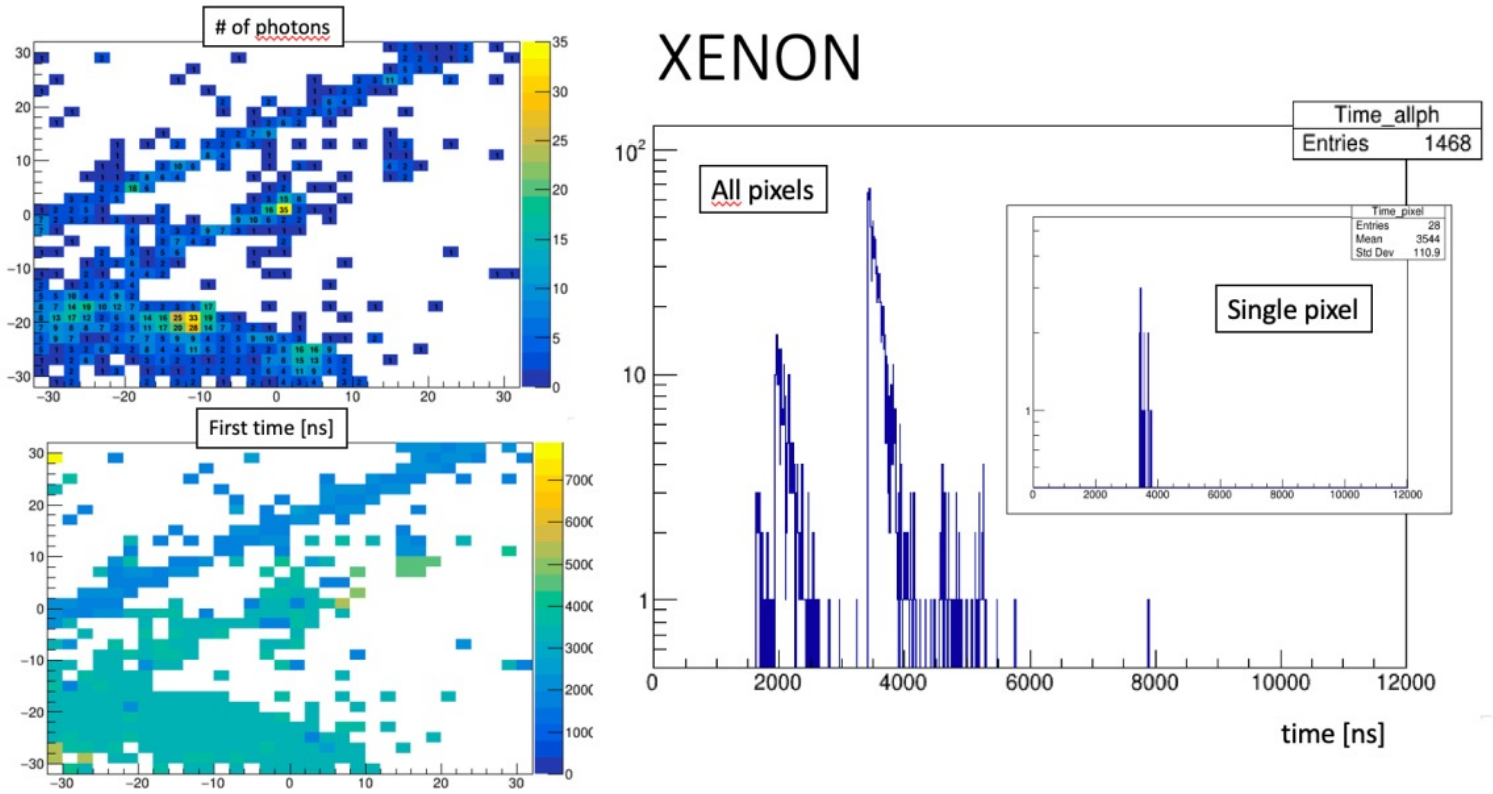


Figure 10: Spill event simulation where tracks coming from 5 different interactions were detected by the same camera, when Xenon doped Argon was considered. Top left: image obtained by integrating all the photons arriving in the pixel during the entire spill. Bottom left: time of the first photon impinging in each pixel. Right: distribution of the time arrival of photons in all the sensor pixels (in the big plot) and in the most populated pixel (in the inset).

ASIC requirements

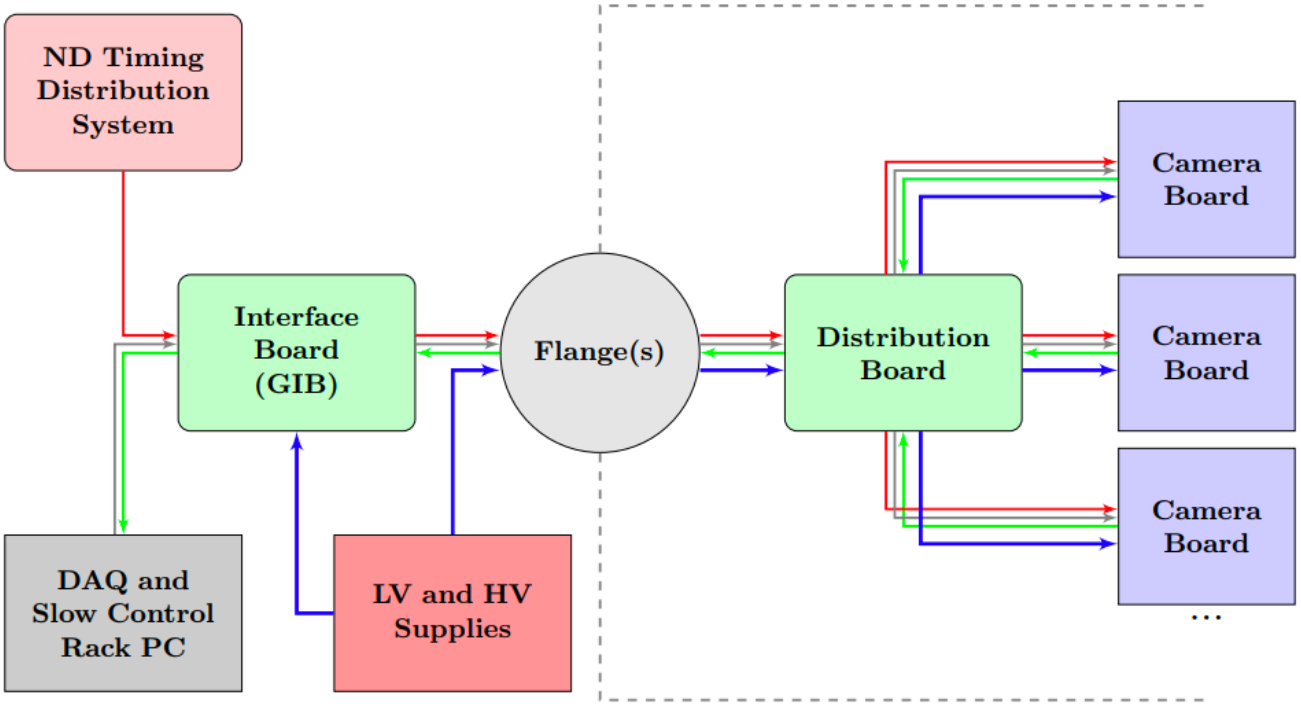
- 1024 channels
- For SiPM matrices ranging from 1x1 mm^2 → 4 x4 mm^2
  - Baseline (2x2 mm^2 for lens and 3x3 mm^2 for mask)
- Signal shaping and architecture optimized for achieving:
  - Good infor about # of photons in each pixel
  - Precise O(100 ps) time information on the first photons in each pixel

- **Test pulse signal**: The ASIC has to react to a specific signal, firing a pulse through the amplification and digitization chain

- **Reset signal**: The ASIC has to be reset by a dedicated signal input synchronous to the ASIC clock for synchronization

- Optimized **power consumption** (power gating during off-beam time)

Preliminary GRAIN framework

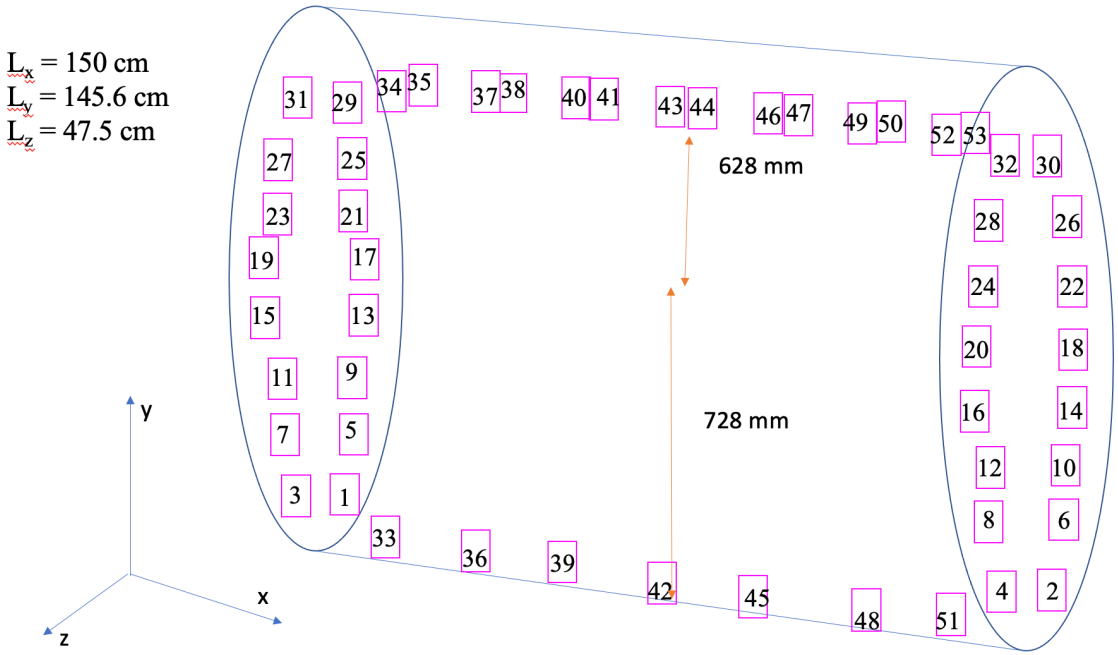


This is just a starting point:

- Dedicated discussion with DAQ & SlowControl WG will be organized

Sim & Reconstruction

- New geometry for lens-based optical detector



- 16 sensors in the lateral walls
- 7 sensors at the bottom
- 14 sensors at the top

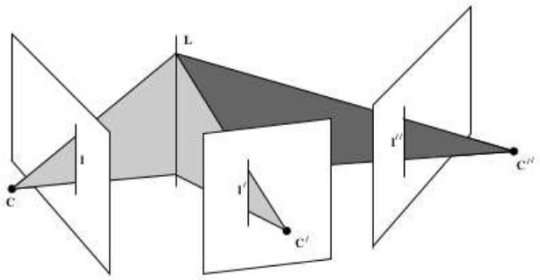
TOTAL: 53 sensors

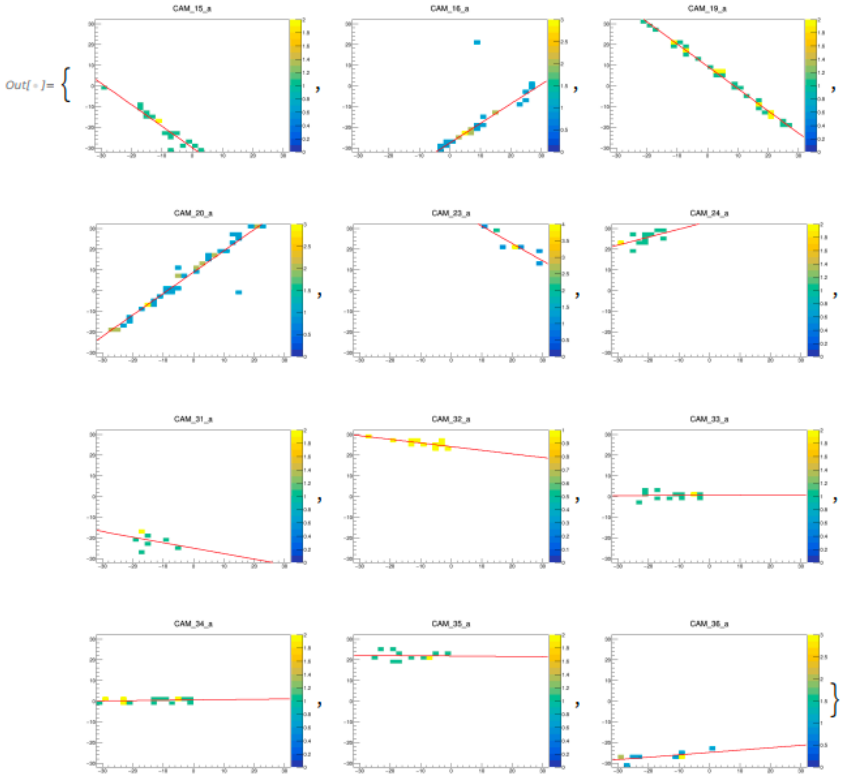
for a better inner volume coverage

by considering the current inner vessel dimensions

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))

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

i, j camera indices

- Analysis of intercepts of the M reconstructions

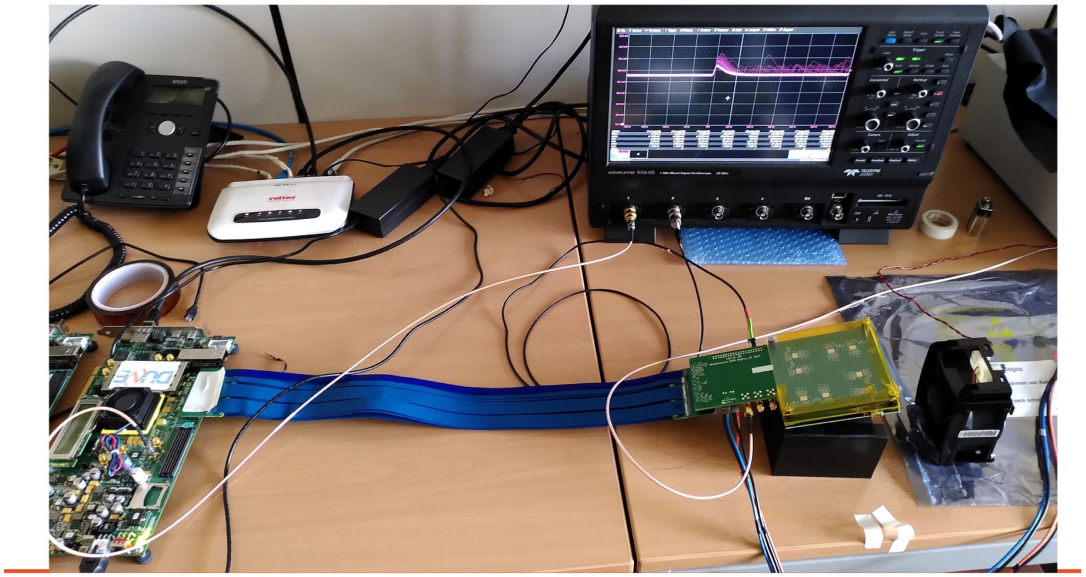
- Single track: tested
- Test with 2 tracks from neutrino interaction: in progress

Tests of prototypes in ARTIC

- Mechanics completed

Tests of prototypes in ARTIC

- Sensor readout in progress
  - FPGA configuration completed
  - ALCOR configuration and SiPM parameter setting and optimization in progress

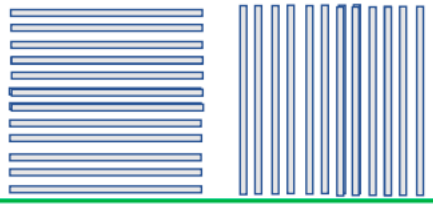


- Sensor installation and tests in July-September

CRT tagger for ARTIC

Trigger : fourfold coincidence

TOP: 48 cm x 48 cm



d = 4 cm 12 bars x 2 planes = 24 bars x 2 chs ?

Or:

d_1 = 4 cm 8 bars x 2 planes = 16 bars x 2 chs ?

+

d_2 = 2 cm 8 bars x 2 planes = 16 bars x 2 chs ?

BOTTOM: 32 cm x 32 cm (or 34 cm x 34 cm)

d = 4 cm 8 bars x 2 planes = 16 bars x 2 chs ?

Or:

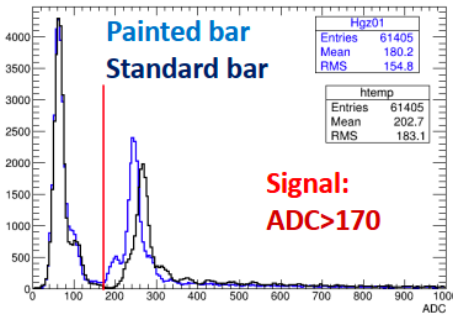
d_1 = 4 cm 5 bars x 2 planes = 10 bars x 2 chs ?

+

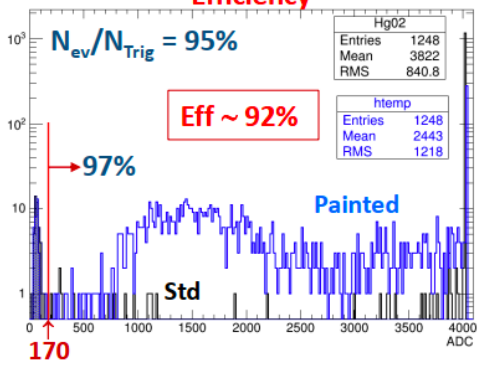
d_2 = 2 cm 7 bars x 2 planes = 14 bars x 2 chs ?

Trigger: (Ch1.or.Ch3)

ADC spectra



Efficiency



Conclusions

- Mechanics: in progress
- Electronics: activity started → deeper studies and discussions are planned
- Tests of prototype: very close to the first installation

Photon distributions on SiPM

both Argon or Xenon option has to be considered

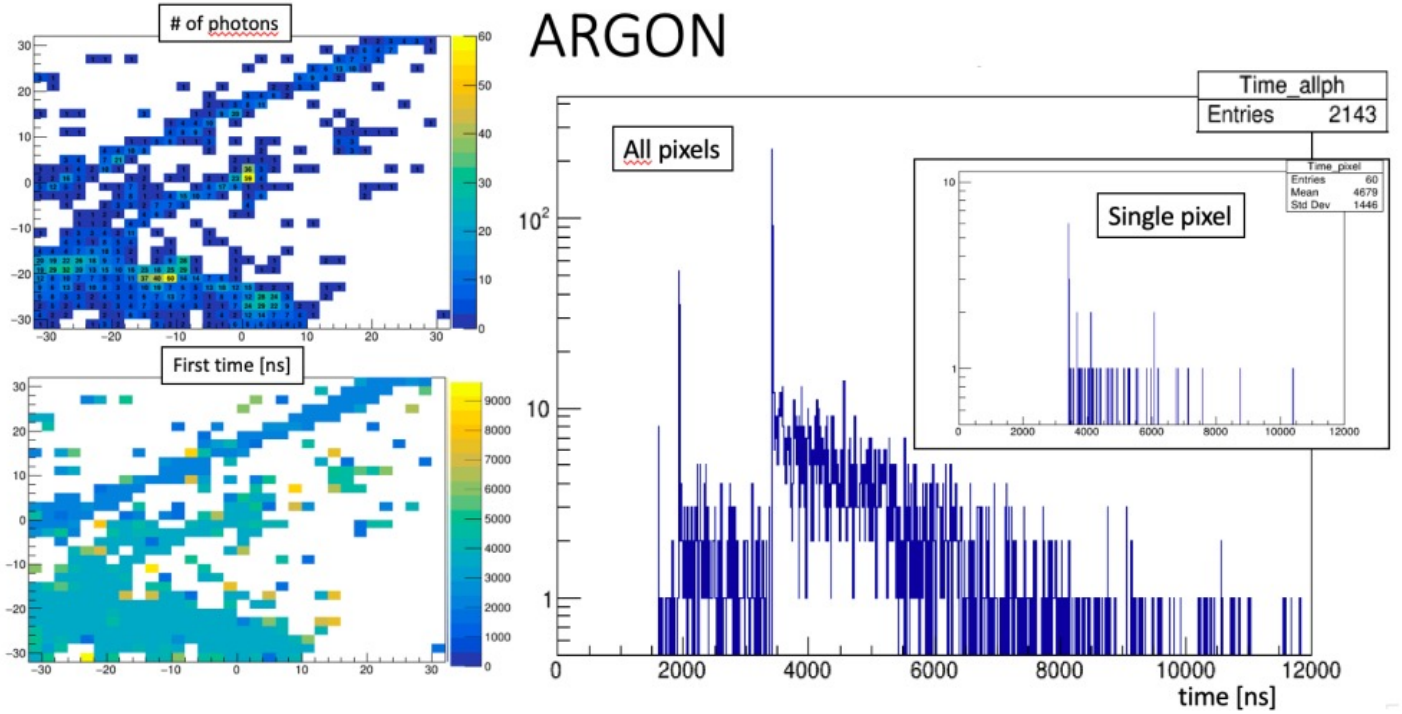
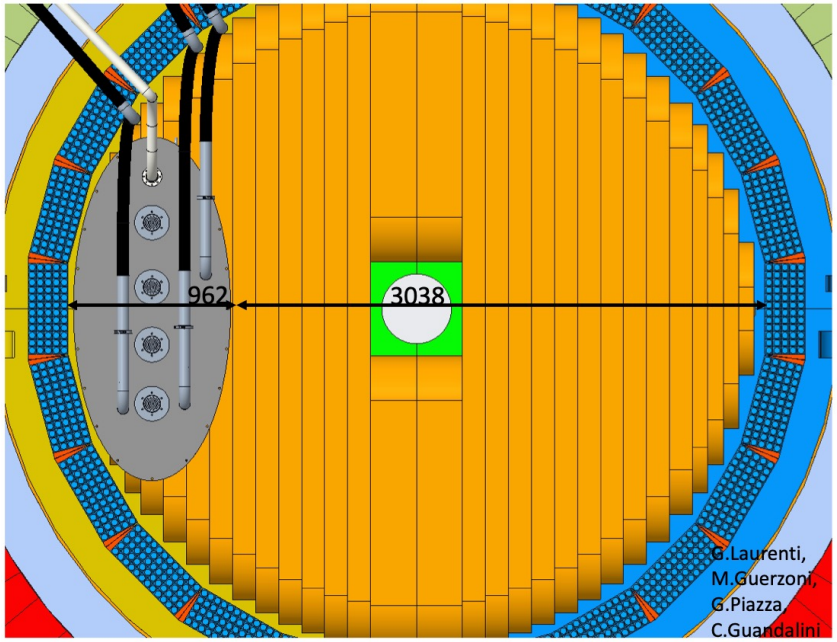


Figure 9: Spill event simulation where tracks coming from 5 different interactions were detected by the same camera, when pure Argon was considered. Top left: image obtained by integrating all the photons arriving in each pixel during the entire spill. Bottom left: time of the first photon impinging in each pixel. Right: distribution of the time arrival of photons in all the sensor pixels (in the big plot) and in the most populated pixel (in the inset).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M.Guerzoni,
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