PRIN 2022KJZSYB Kickoff Meeting | *Bologna*

Nicolò Tosi | 9-10-23

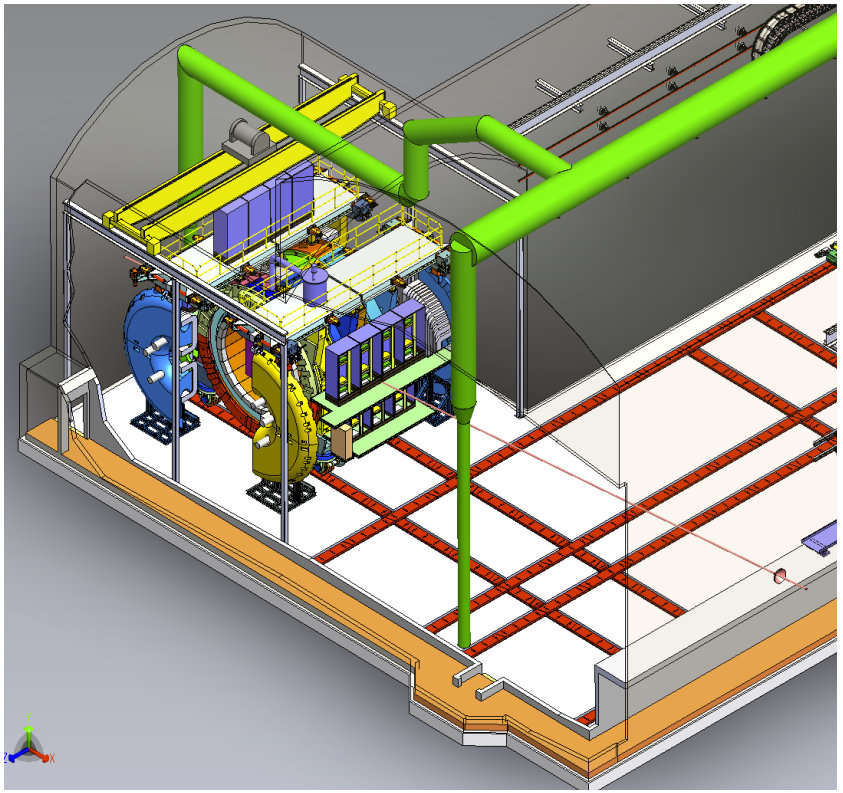
First and most crucial Issue

We need a name better than 2022KJZSYB, suggestions?

What is this all about?

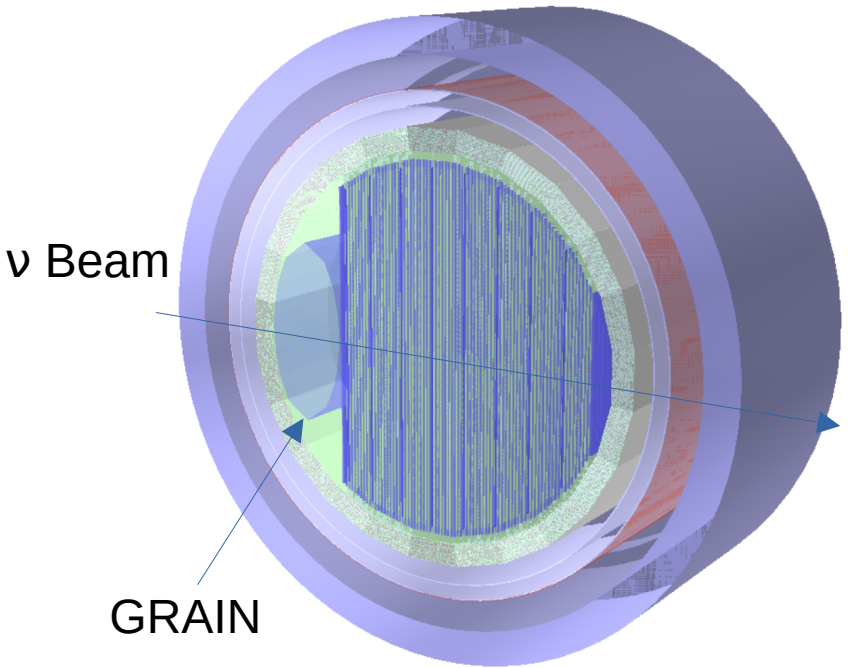
- The main reason for this proposal is to support the effort of developing GRAIN
- We also want to explore other applications of Coded Aperture Imaging with SiPMs:
  - PET (both crystals and LAr)
  - Calorimetry

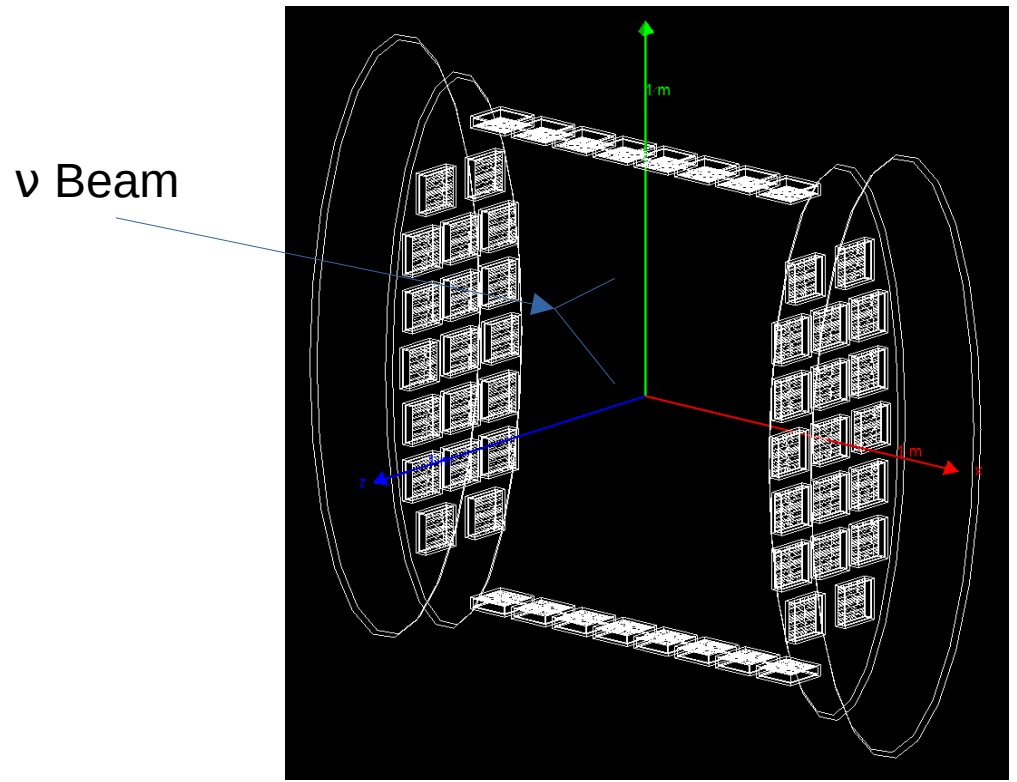
SAND



- SAND is one of the 3 DUNE Near Detectors
- SAND contains
  - Gas based Tracker
  - Pb-SciFi ECAL
  - a small LAr target: GRAIN
- GRAIN is not the usual TPC, but a scintillation imaging detector

GRAIN IN SAND

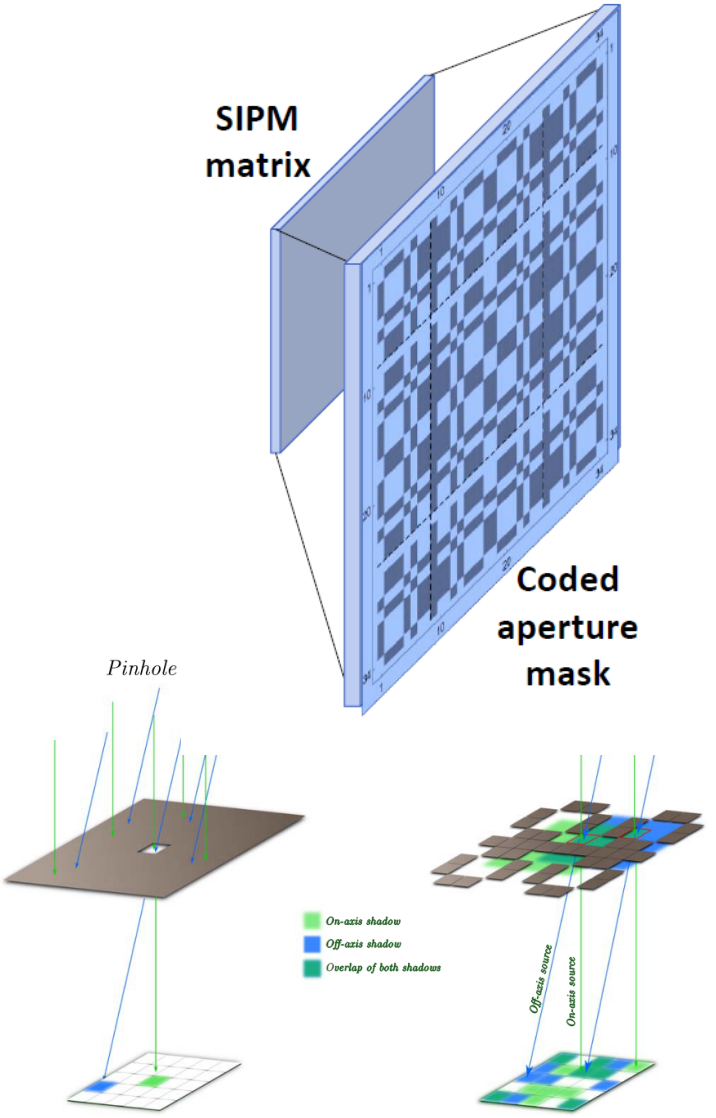




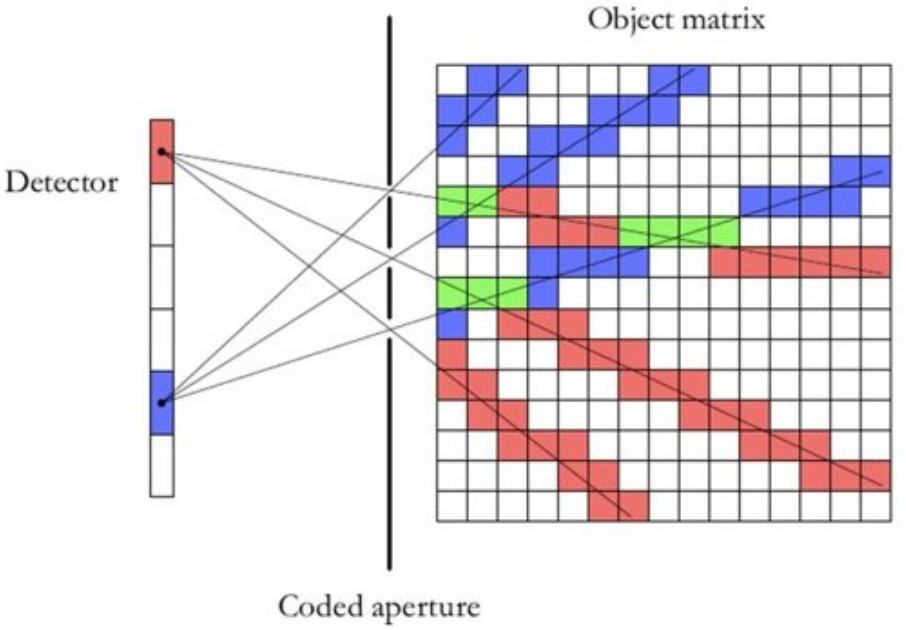
GRAIN

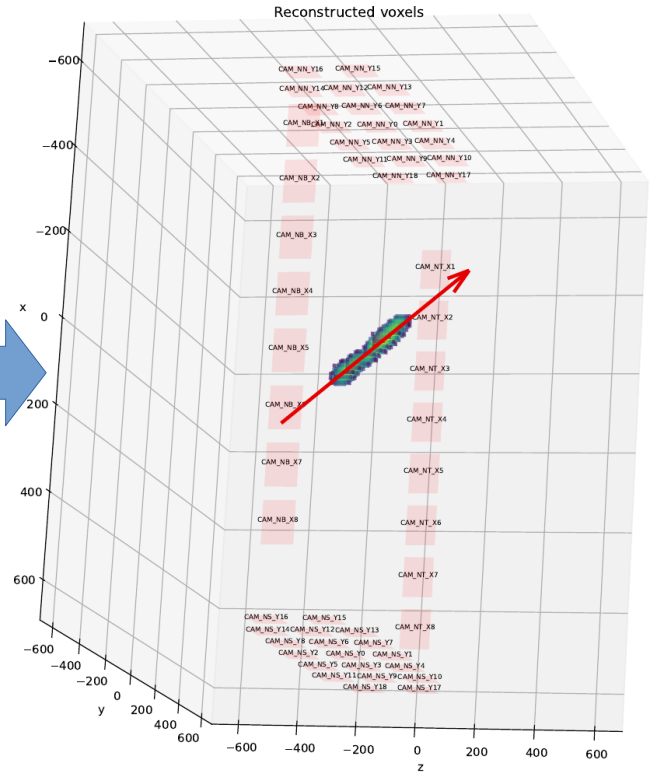
- We want to *take a picture* of tracks
- Liquid Argon scintillates at 128 nm
- Difficult to build conventional optics

- Coded Aperture Masks
  - (used in X-ray imaging, etc…)
  - Complex reconstruction



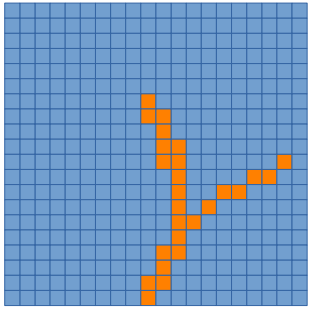
GRAIN reconstruction

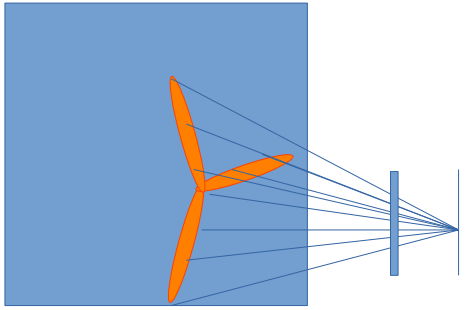




Why Imaging?

- Imaging achieves spatial resolution in 3D without segmentation of the sensitive volume





- Our channels scale with **area** instead of **volume**
- We are trading some rate capability for channel count

An example for PET

3DPi Overview

A Total-body (TB), Time of Flight (TOF) PET scanner

- Xenon-doped Liquid Argon instead of Crystal scintillators
- Using Silicon Photomultipliers (SiPM)
- Double sided SiPM on scintillation
- Multiple detection layers

Geometry:

- 9 annulus detection layers
- Each layer has the scintillator sandwiched between two layers of SiPMs
- Each detection layer has ~18 mm LAr thickness
- PTFE supporting structure
- 2 m in length
- Geant4 simulations

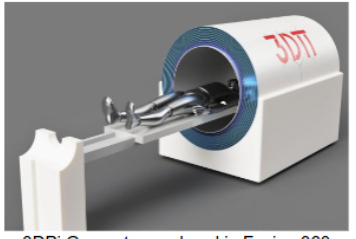
Two configurations:

*LAr+Xe

*LAr+TPB (TetraPhenylButadiene: an organic WLS)

Geant4 Geometry Parameters

Parameter	Value
Inner radius (cm)	45
Outer radius (cm)	64
Length/AFOV (cm)	200
LAr thickness (cm)	16.2
Number of LAr layers	9
SiPM size (mm x mm)	10 x 10
Number of SiPMs	~1 x 10^6
Cryostat Thickness (mm)	6



3DPi Geometry rendered in Fusion 360

XeSAT 2023 - Nantes

Azam Zabihi, ASTROCENT/CAMK-PAN, Warsaw, Poland, 3Dπ TB-TOF-PET Collaboration

This project foresees **100 square meters (!!) of SiPMs** and a million channels* for 3D segmentation of just 1.6 tons of LAr

Can we do better with imaging?

(and with SiPMs/ WLS coatings?)

* Guess what ASIC they use...

Our Official Timeline

- Phase 1 - Conceptual design:
  - Development of general-purpose analytical reconstruction algorithms - Y1Q1 to Y2Q2
  - Development of mathematical framework for analytical reconstruction - Y1Q1 to Y1Q4
  - Development of general-purpose numerical reconstruction algorithms - Y1Q1 to Y2Q2
  - Development of mathematical framework for numerical reconstruction - Y1Q3 to Y2Q2
- Phase 2 - Optimization and prototyping for specific applications:
  - Optimization for Neutrino detectors - Y1Q4 to Y2Q4
  - Optimization for HEP calorimetry - Y1Q4 to Y2Q4
  - Optimization for small crystal applications - Y1Q3 to Y2Q2
  - Design and construction of small-scale crystal-based prototypes - Y2Q2 to Y2Q3
  - Test of small-scale crystal-based prototypes - Y2Q3 to Y2Q4

A change in the UniBO unit

- A change of co-PI was made necessary by a formal requirement imposed by MUR
- The new co-PI brings a lot of expertise on a different subject
- We decided to shift part of the UniBO unit work to a related development of Perovskite based Wavelength shifting coating (to improve upon TPB)

Plans

- Today we try to decide what to focus on

- By end of the year we need to recruit:
  - 1 yr AdR for the INFN unit (sim/reco/DAQ)
  - 1 yr AdR for the UniBO unit (perovskite deposition)