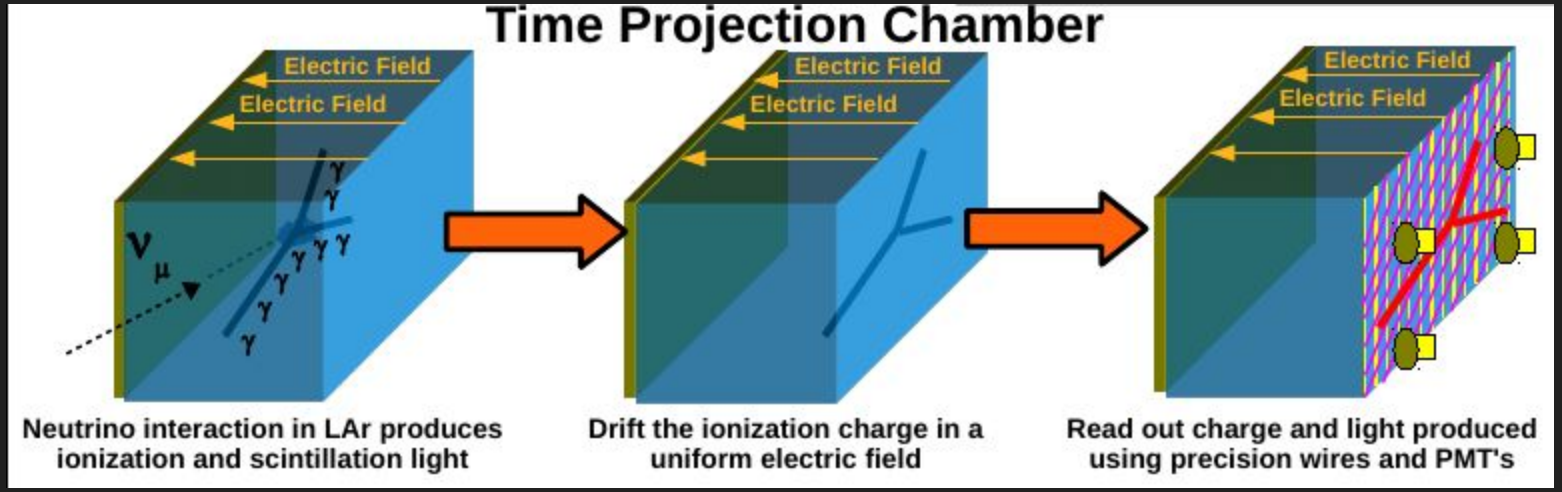
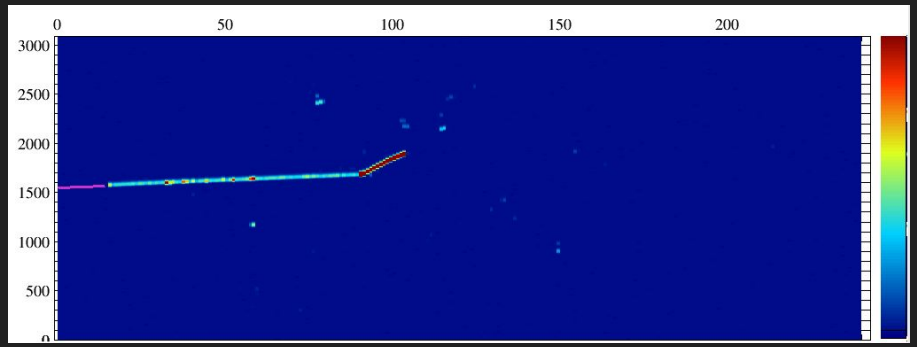
Neutrino - Latin America Workshop
April 27, 2016 - Fermilab

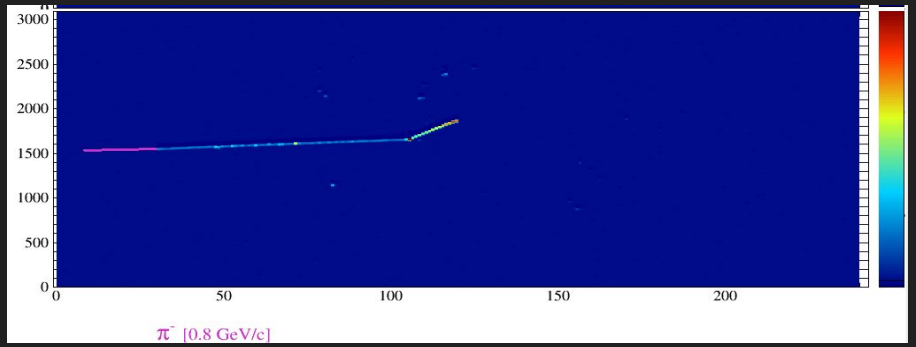
Latin American contributions to Liquid Argon detectors

Celio Moura (UFABC)

Institutions


Time Projection Chamber
Electric Field
Electric Field
Electric Field
Electric Field
Electric Field
Electric Field
ν
μ
γ
Neutrino interaction in LAr produces ionization and scintillation light
Drift the ionization charge in a uniform electric field
Read out charge and light produced using precision wires and PMT's


0
50
100
150
200
3000
2500
2000
1500
1000
500
0


3000
2500
2000
1500
1000
500
0
0
50
100
150
200
π⁻ [0.8 GeV/c]

Liquid Argon Time Projection Chamber - LArTPC

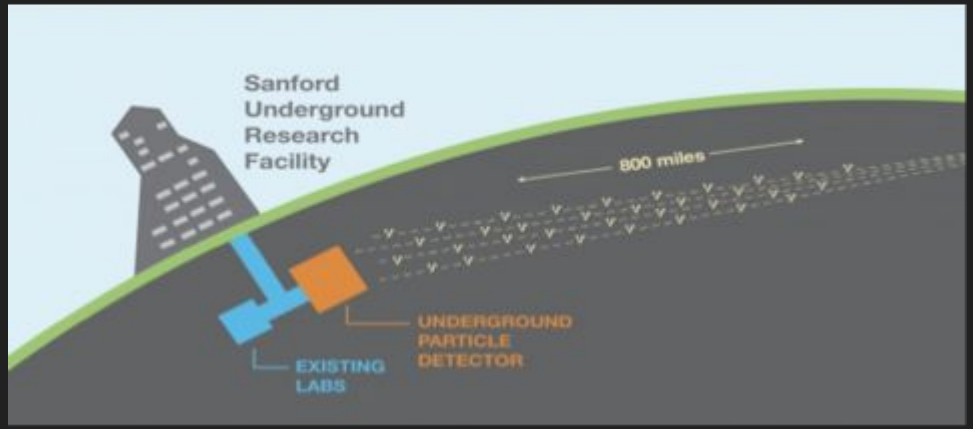
From many different perspectives
LAr is the best choice for a TPC

- Dense (40% more than water)
- Abundant (easily found in nature: 1% of the atmosphere)
- Highly ionizing
- High electron lifetime
- Produces copious scintillation light (transparent to light produced)

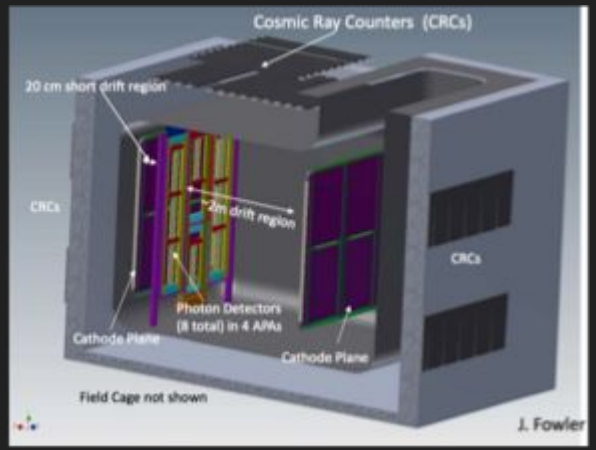
	He	Ne	Ar	Kr	Xe	Water
Boiling Point [K] @ 1atm	4.2	27.1	87.3	120.0	165.0	373
Density [g/cm^3]	0.125	1.2	1.4	2.4	3.0	1
Radiation Length [cm]	755.2	24.0	14.0	4.9	2.8	36.1
dE/dx [MeV/cm]	0.24	1.4	2.1	3.0	3.8	1.9
Scintillation [γ /MeV]	19,000	30,000	40,000	25,000	42,000	
Scintillation λ [nm]	80	78	128	150	175	

Table by Mitch Soderberg

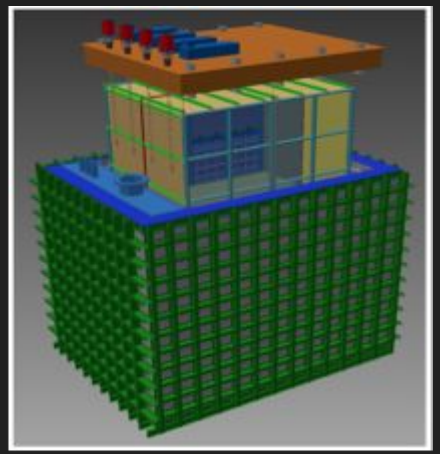
DUNE



35 ton

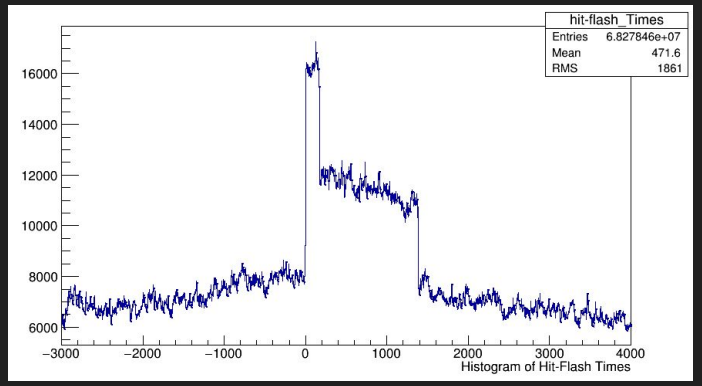


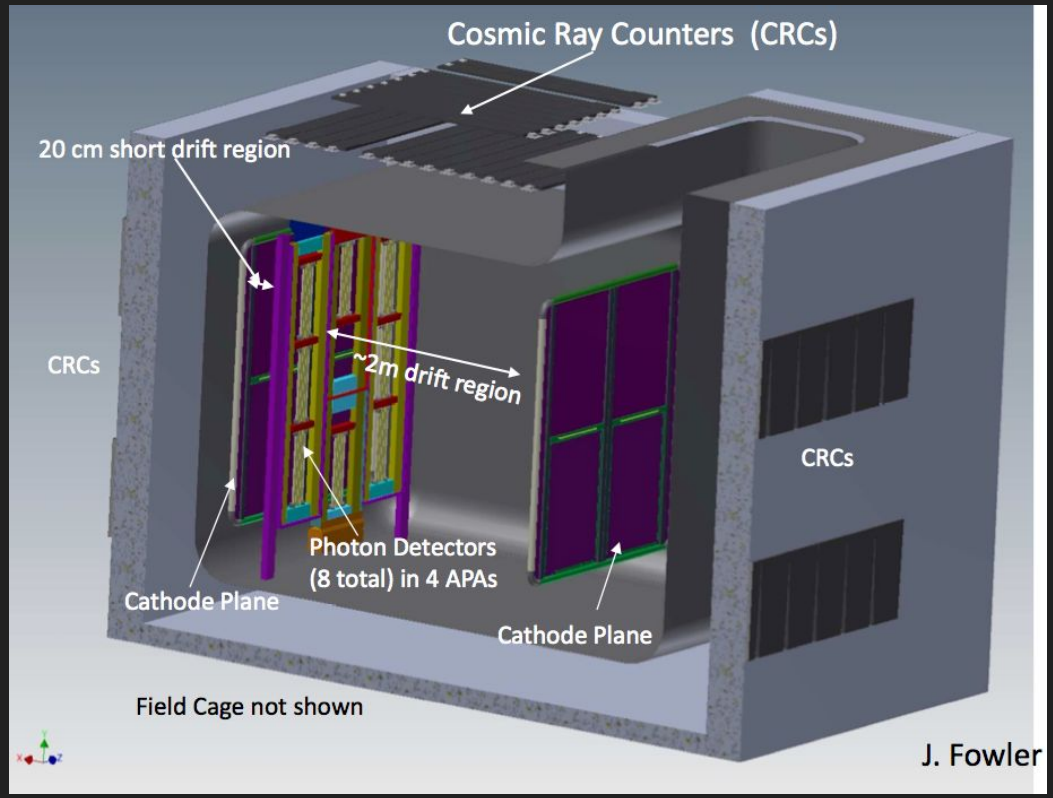
SBND



LArIAT

35ton prototype





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Universidade Federal do ABC

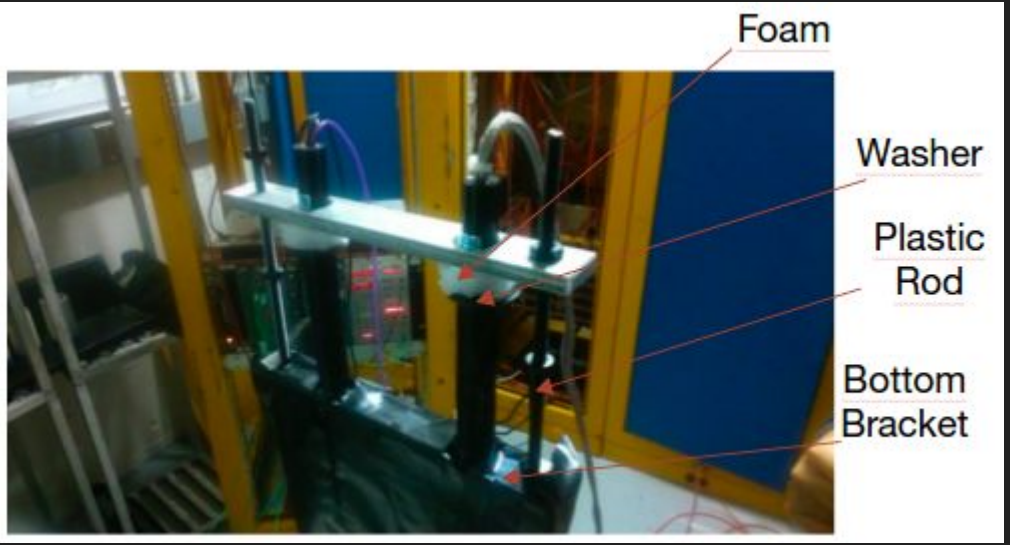
Cosmic Muon Veto Assembling, event simulations, dead channel mapping, Purity, PDS

Students: Monica, Thales, Ohana

LArIAT

Instrumentation work for the Muon Range Stack.

- co-incidence study for the small delicate Hamamatsu PMTs in the test setup at FTBF.
- new stable bracket design to hold the PMTs in MRS.



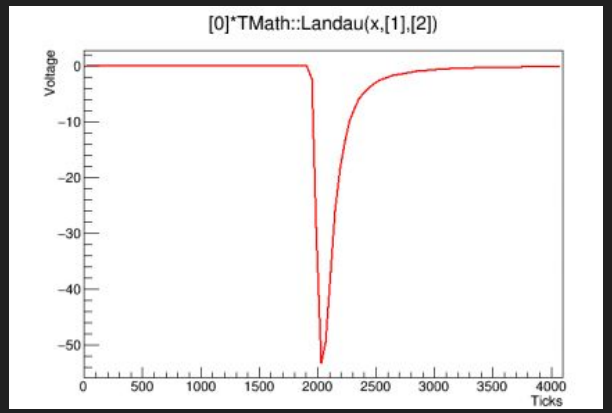
Developing the G4Beamline simulation code to simulate the signal response of several detectors (e.g. Wire Chambers, Aerogel etc.) in LArIATSoft framework.

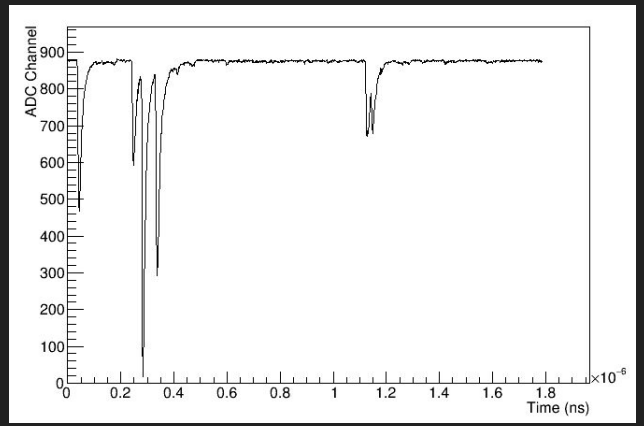
LArIAT

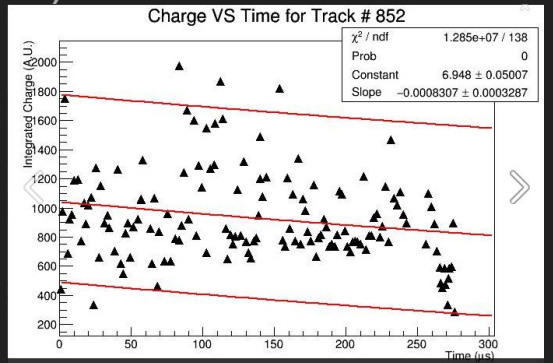
Remote shift setup: test and certification of remote shift procedures and viability

Liquid argon purity: studies using cosmic muon data (Monica)

Simulations: pulse shape parametrization from real data (Lucas)





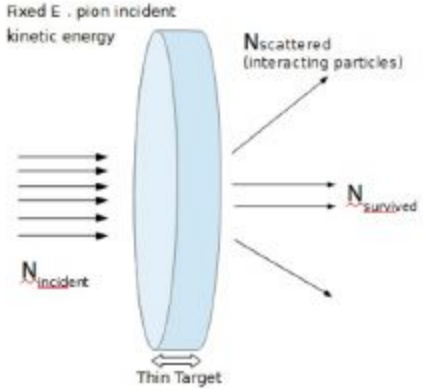


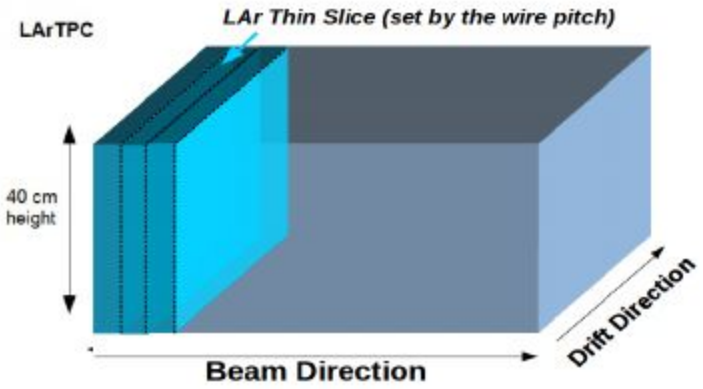
LArIAT - First Total π-Ar Cross Section Measurement

$$P_{\text{Interacting}} = 1 - (1 - \sigma n \delta z + \ldots)$$

$$\sigma(E) \approx \frac{1}{nz} P_{\text{Interacting}} = \frac{1}{nz} \frac{N_{\text{interacting}}}{N_{\text{Incident}}}$$

Where $n = \rho N_A / A$



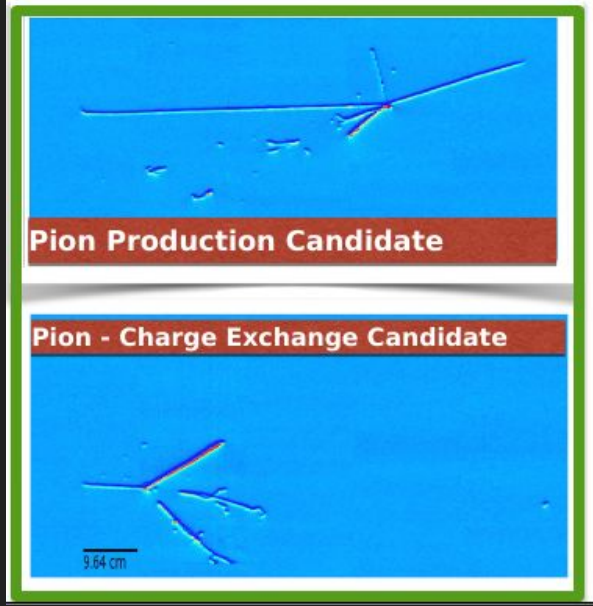


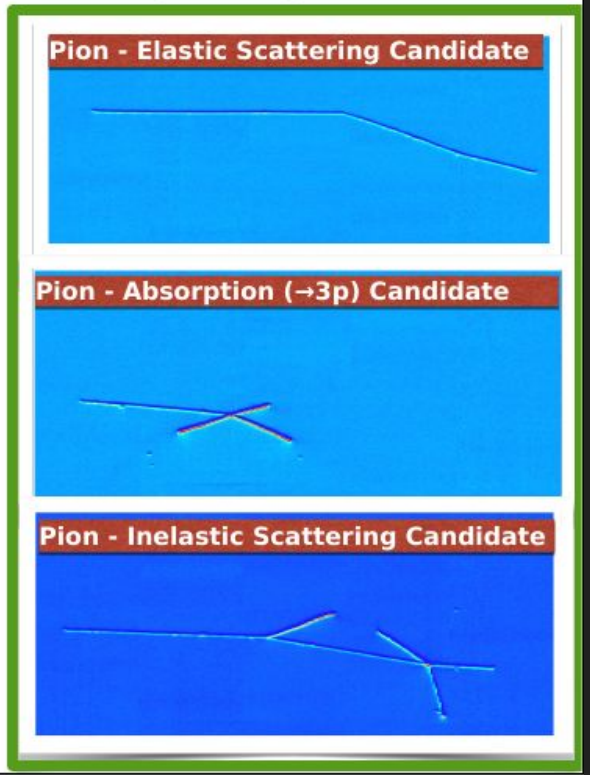
Universidade Federal do ABC

LArIAT - First Total π-Ar Cross Section Measurement

$$\sigma_{Total} = \sigma_{elastic} + \sigma_{inelastic} + \sigma_{ch\text{-}exch} + \sigma_{absorp.} + \sigma_{\pi\text{-}production}$$

- Our inclusive cross section definition currently includes the **traditional processes** as well as **background processes**

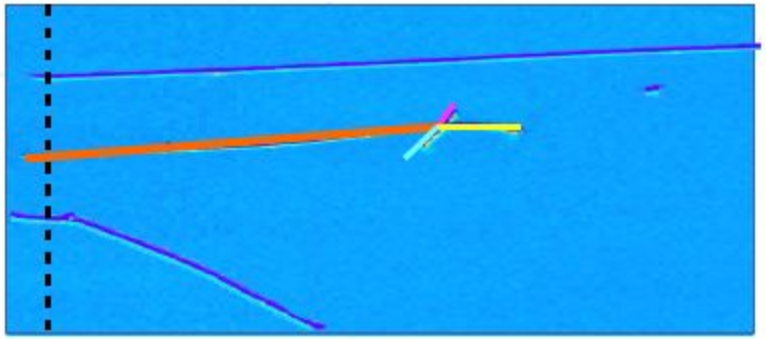


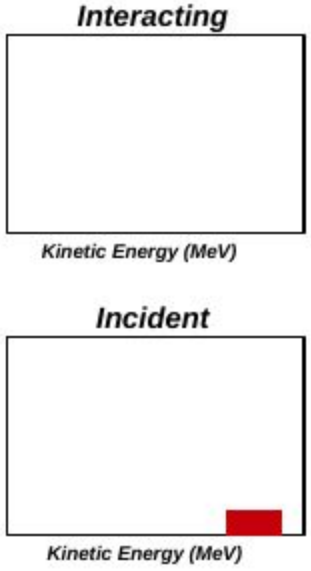


LArIAT - First Total π-Ar Cross Section Measurement

- For each slice we ask: “Is this the end of the track?”
  - **NO:** Calculate the kinetic energy at this point and put that in our “non-interacting” histogram

$$KE_{Interaction} = KE_i - \sum_{i=0}^{nSpts} dE/dX_i \times Pitch_i$$





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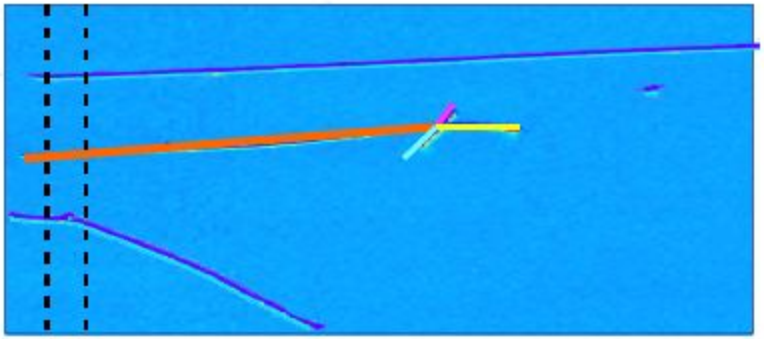

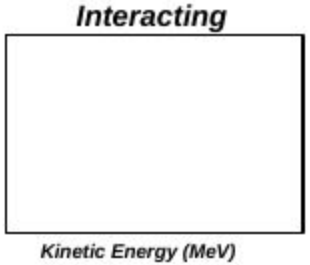

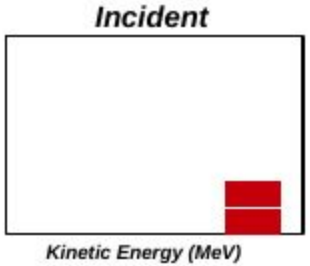

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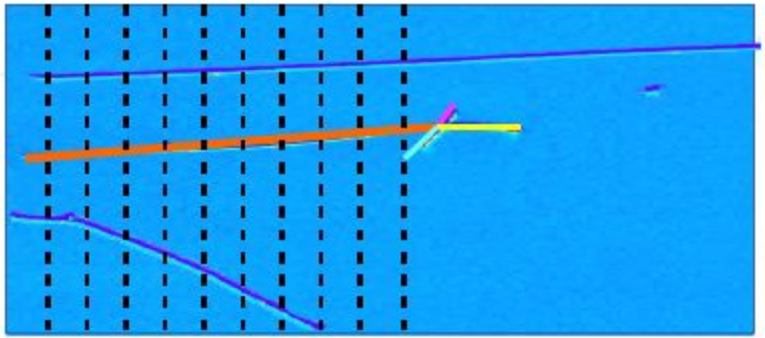

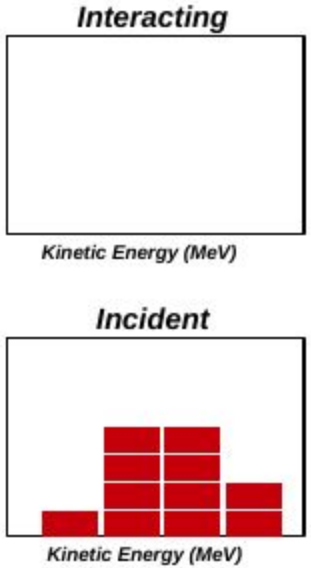

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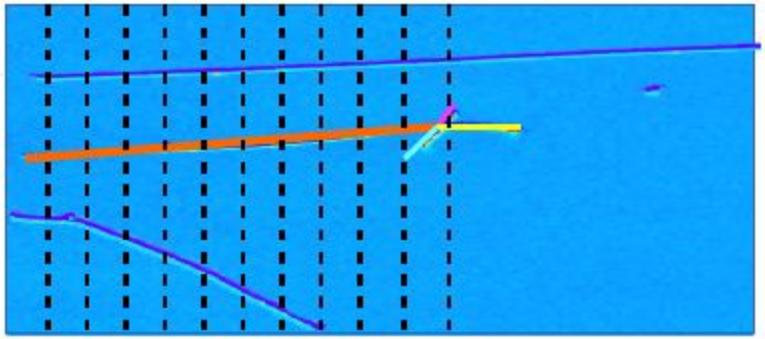
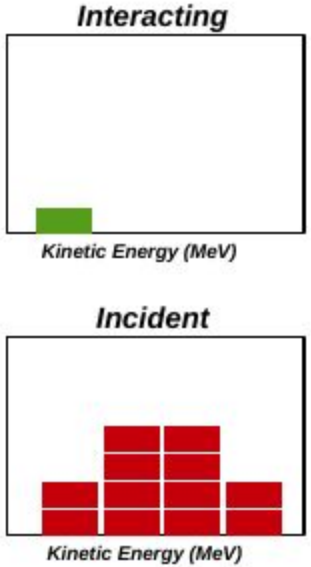
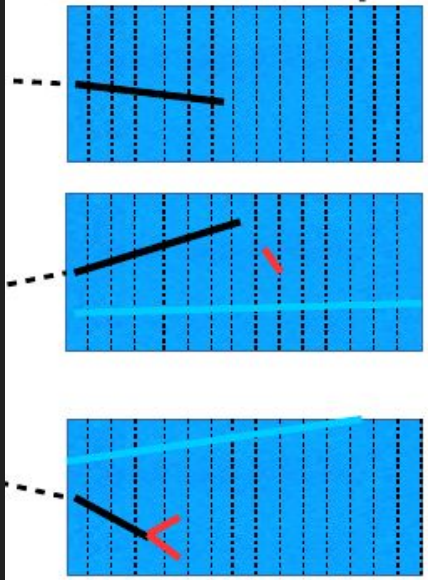
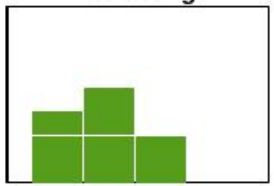


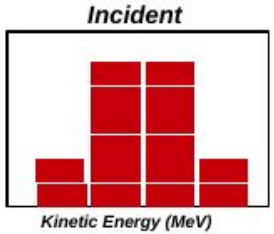


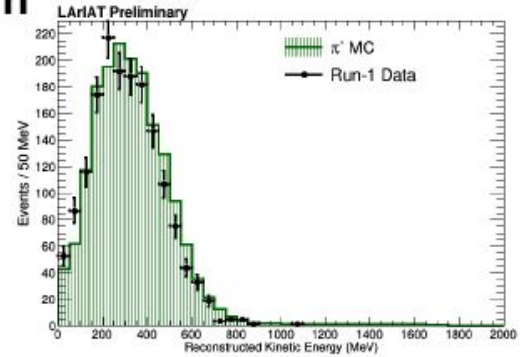
LArIAT - First Total π-Ar Cross Section Measurement

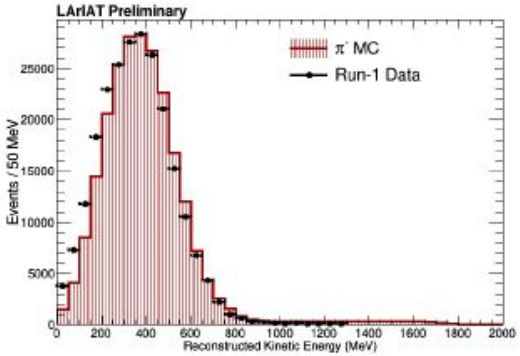
- **We repeat this process event-by-event until we have gone through our entire sample**





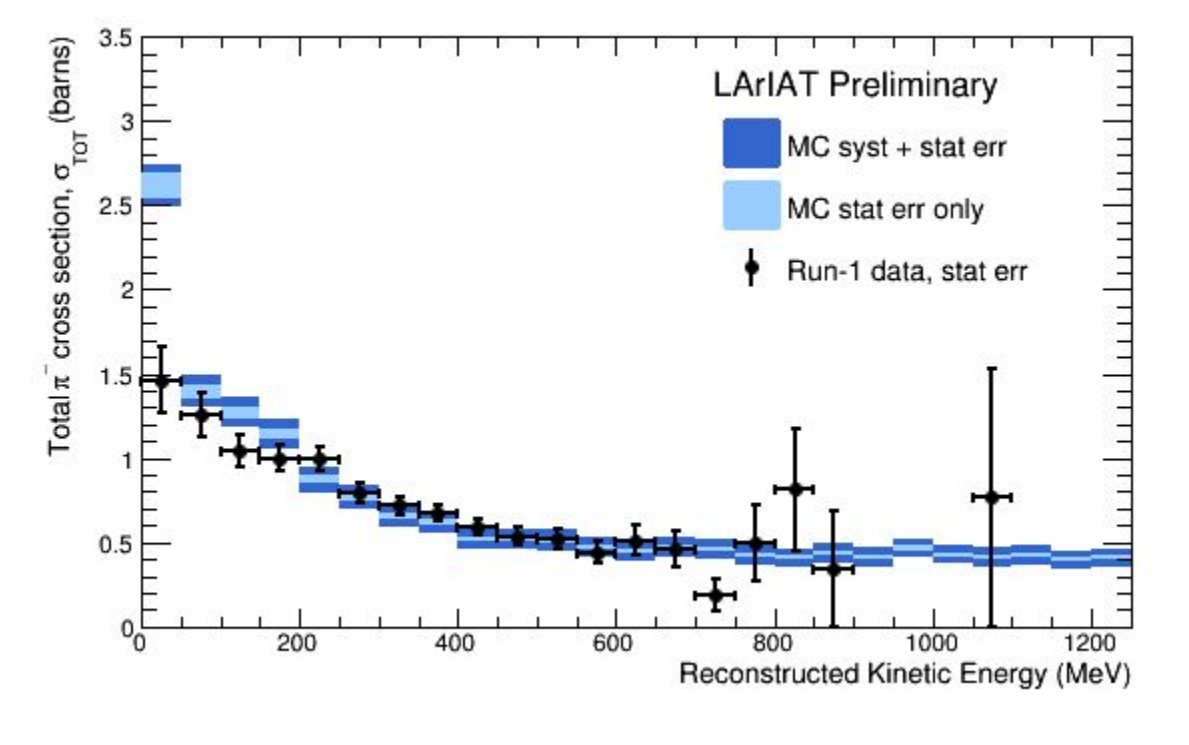




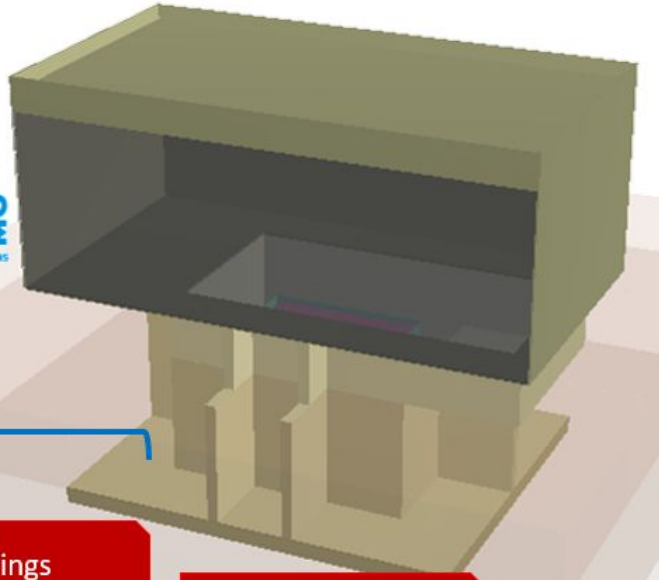


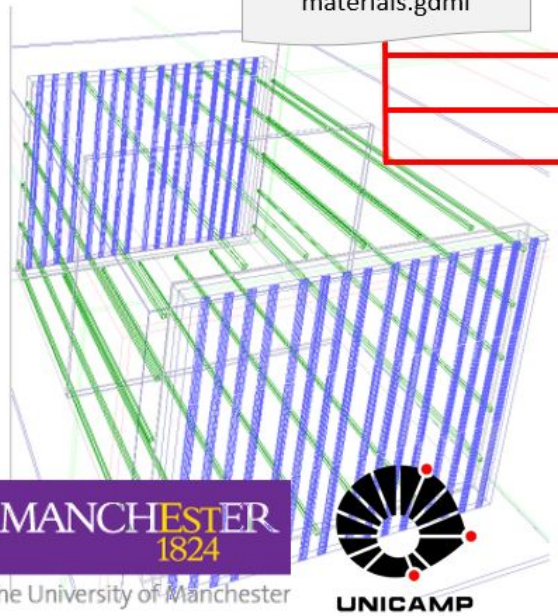
We ignore other tracks in the event not matched to the Wire Chamber Track

LArIAT - First Total π-Ar Cross Section Measurement



SBND's Geometry Tree Proposal





- Geometry
  - sbnd.gdml
  - definitions.gdml
  - materials.gdml
  - undergrounds
    - detectorhall.gdml
    - equipment.gdml
  - buildings
    - building.gdml
    - tanks.gdml
    - windows.gdml
  - detector
    - tpc.gdml
    - crt.gdml
    - pds.gdml

Surroundings

Each group with its own piece

Unifal MG
Universidade Federal de Alfenas

MANCHESTER 1824
The University of Manchester

UNICAMP

Photon Detection System - R&D

Fibers

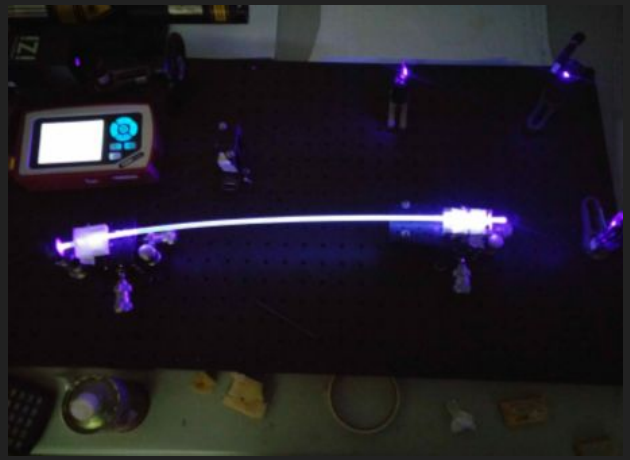
ARAPUCA

Near Infrared

Fibers

R&D for light guides: acrylic fibers doped with wavelength shifter (TPB)

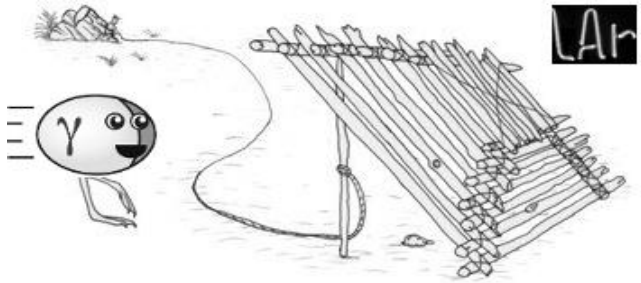
Extrusion tower



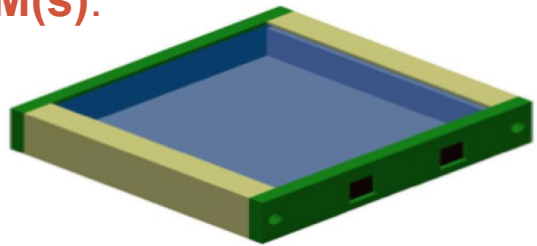
Attenuation length measurement

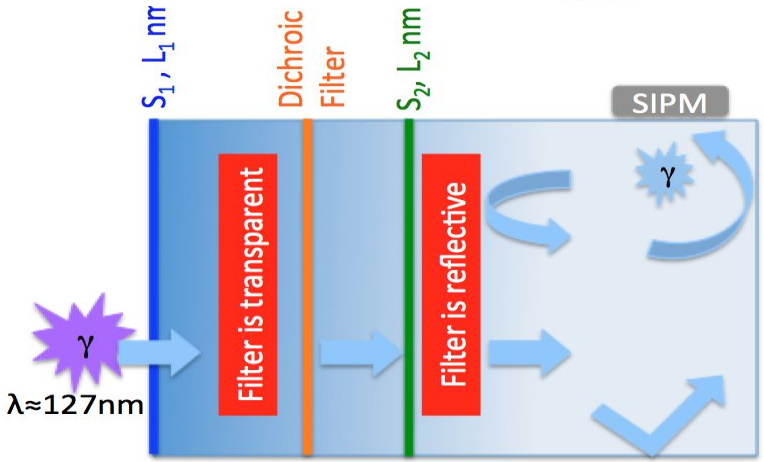
ARAPUCA - New concept for light detection in (LAr)

ARAPUCA in the language of *native Brazilian* means ***trap*** for birds



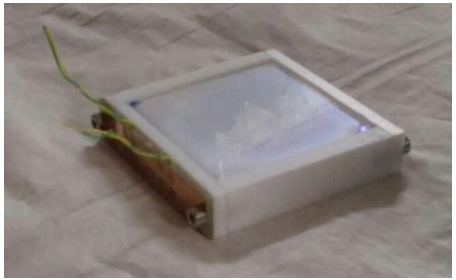
- The idea is to **trap photons** inside a box with highly reflective internal surfaces.
- This trap is made by a **dichroic filter** and two **wavelenght shifters**
- After few reflections these photons will be detected by the **SiPM(s)**.





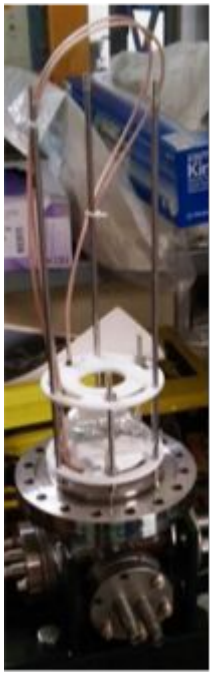
For more details see: *A.A.Machado and E.Segreto 2016 JINST 11C02004*

ARAPUCA testing …

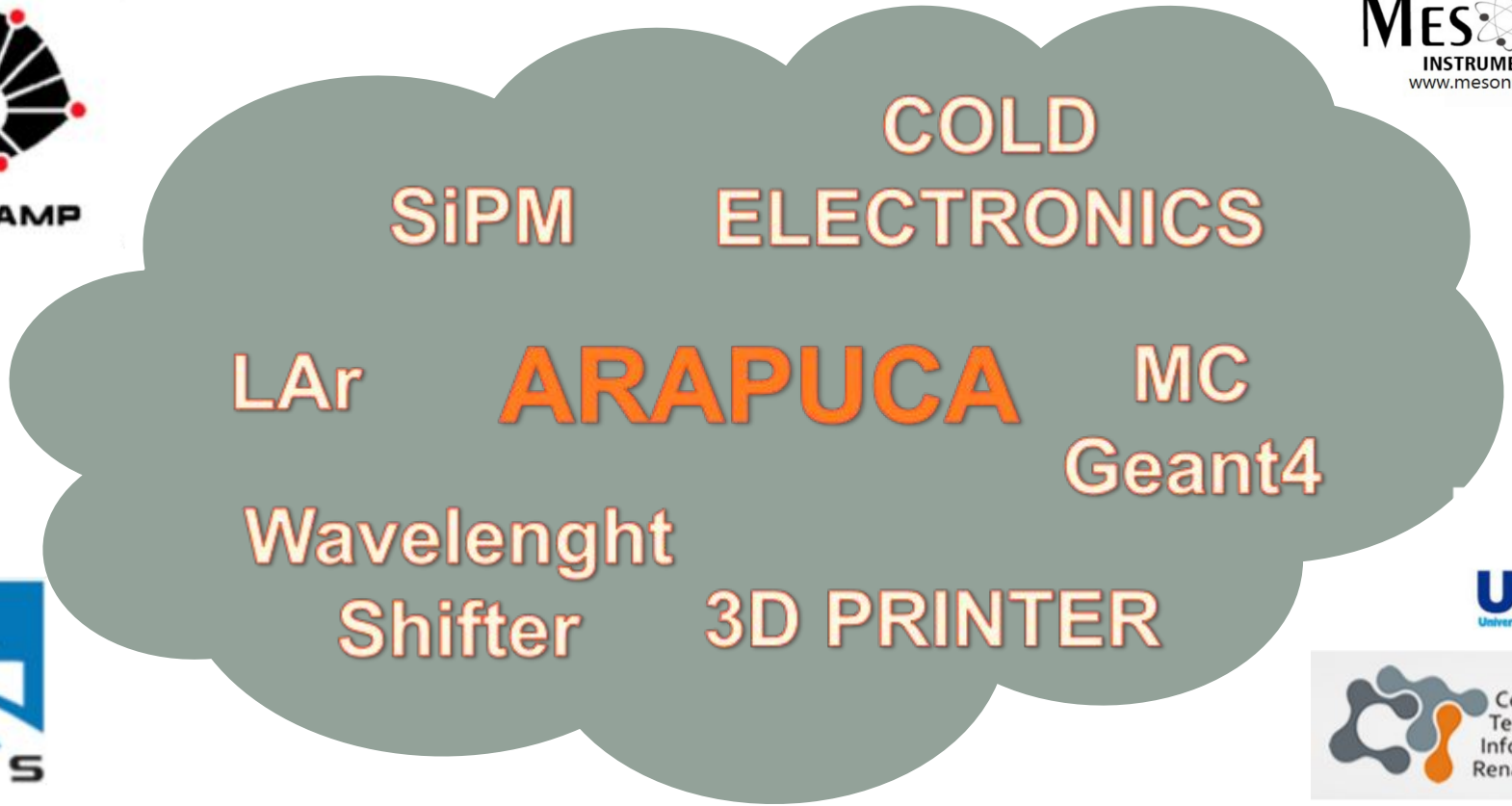


Few prototypes realized

- 1 tested at UNICAMP at room temperature that proved the trapping mechanism.
- 1 actually being tested in LAr at FERMILAB to measure efficiency



Technological innovation for Brazil



UNICAMP

MESONN INSTRUMENTS
www.mesonn.com

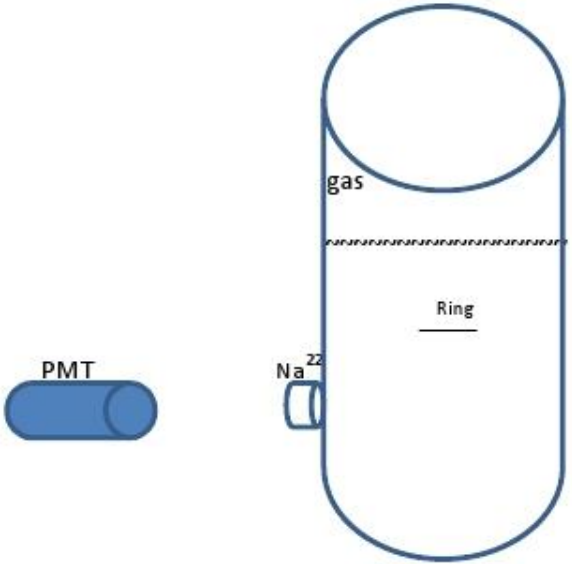
LNLS

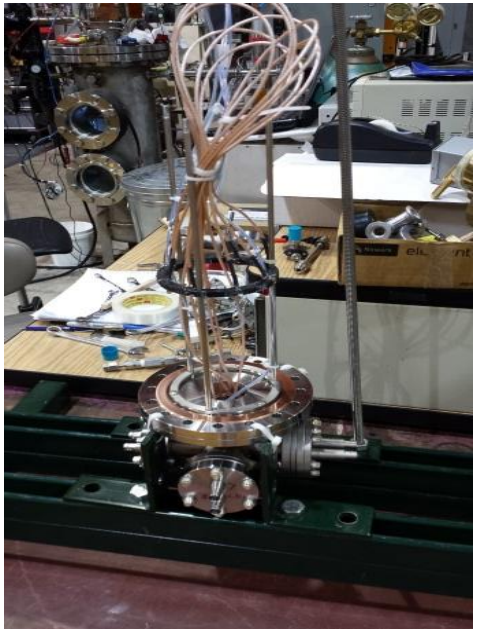
Unifal MG
Universidade Federal de Alfenas

Centro de Tecnologia da Informação Renato Archer

Near-Infrared Scintillation in Liquid Argon

Purpose: to investigate the NIR emission in Liquid Argon as a possible alternative for the light signal in LAr TPC's (t_0 , PID). Advantages: lack of Rayleigh scattering, reflectivity on any metal surface, possibility of doping LAr with TMG, improving charge collection.





Near-Infrared Scintillation in Liquid Argon

Encouraging preliminary results obtained with the Scene cryostat at PAB, Fermilab:
LAr excited by tagged gammas from Na22 source
PMT fires on Na22 gamma before SiPM receives the NIR photon emitted from the AR2 excited by the other gamma from the Na22 source.
Ref. JINST 11 C03010 (2016)
Work in progress at PAB with a more sophisticated instrument.

Conclusion

- A lot of work to be done and opportunities to collaborate;
- Very interesting physics program and possibly nice surprises due to the new technology.

Collaborators

UNICAMP - A.A.Machado, E.Segreto, E.Kemp, A.Fauth, C. Escobar, **UNIFAL-MG** - G.Valdiviesso, **CTI** - V.Pimentel, **LNLS** - W.Araujo, **UFG** - R.Gomes, T.Ghosh, **UFABC** - C.A. Moura