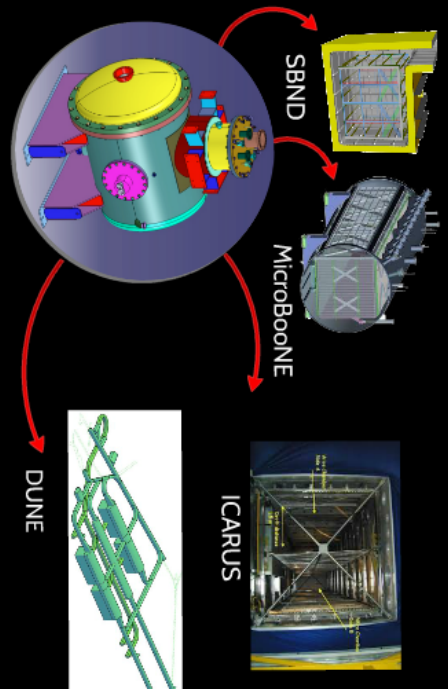
LArIAT: Liquid Argon In A Testbeam

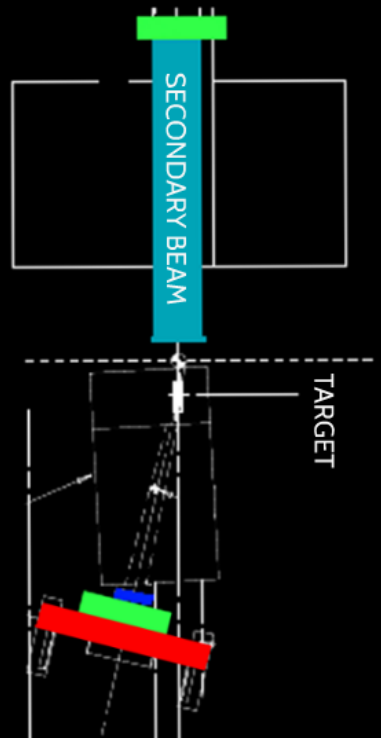
Elena Gramellini, Yale University
on behalf of the LArIAT Collaboration at Fermilab

WHY LArIAT?

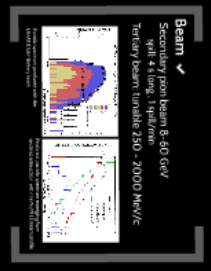
PHYSICS: Study interactions in LAr relevant to the intensity frontier (SBN + underground physics) in a controlled environment: Tertiary Beam at FTBF

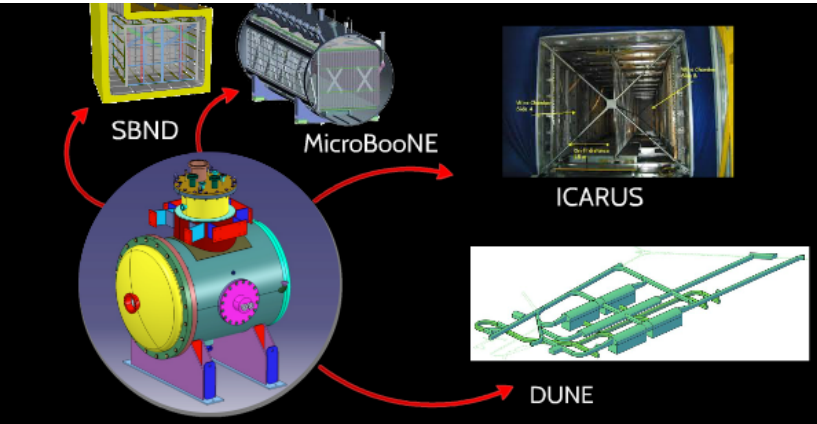
R&D: Development of LArTPC technology
- e/γ/μ reconstruction
- dE/dx resolution
- LAr Scintillation Light Collection

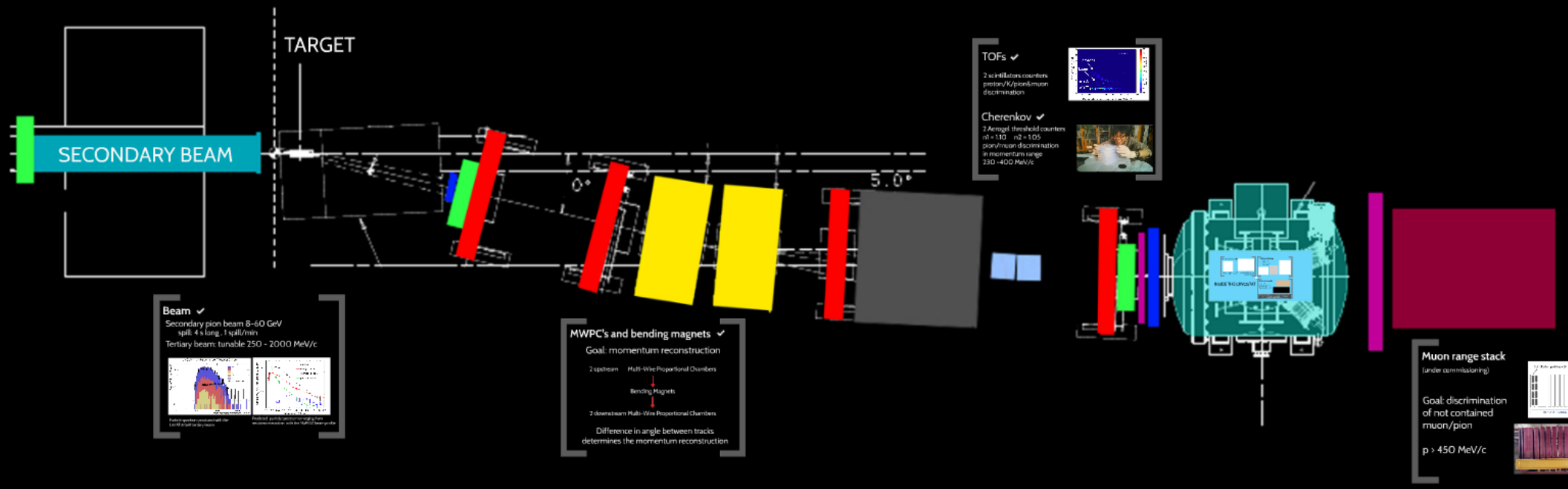


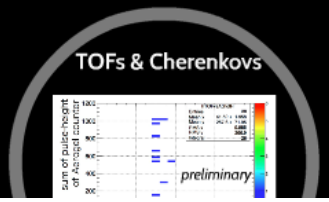


Beam ✓
Secondary pion beam 8 - 60 GeV
spill 4 s long, 1 spill/min
Tertiary beam tunable 250 - 2000 MeV/c




SBND
MicroBooNE
ICARUS
DUNE


TARGET
SECONDARY BEAM
0°
5.0°
Beam ✔
Secondary pion beam 8–60 GeV
spill: 4 s long, 1 spill/min
Tertiary beam: tunable 250 - 2000 MeV/c
MWPC's and bending magnets ✔
Goal: momentum reconstruction
2 upstream Multi-Wire Proportional Chambers
Bending Magnets
2 downstream Multi-Wire Proportional Chambers
Difference in angle between tracks
determines the momentum reconstruction
TOFs ✔
2 scintillators counters
proton/K/pion&muon
discrimination
Cherenkov ✔
2 Aerogel threshold counters
n1 = 1.10 n2 = 1.05
pion/muon discrimination
in momentum range
230 -400 MeV/c
Muon range stack
(under commissioning)
Goal: discrimination
of not contained
muon/pion
p > 450 MeV/c


TOFs & Cherenkovs
preliminary

Light Collection

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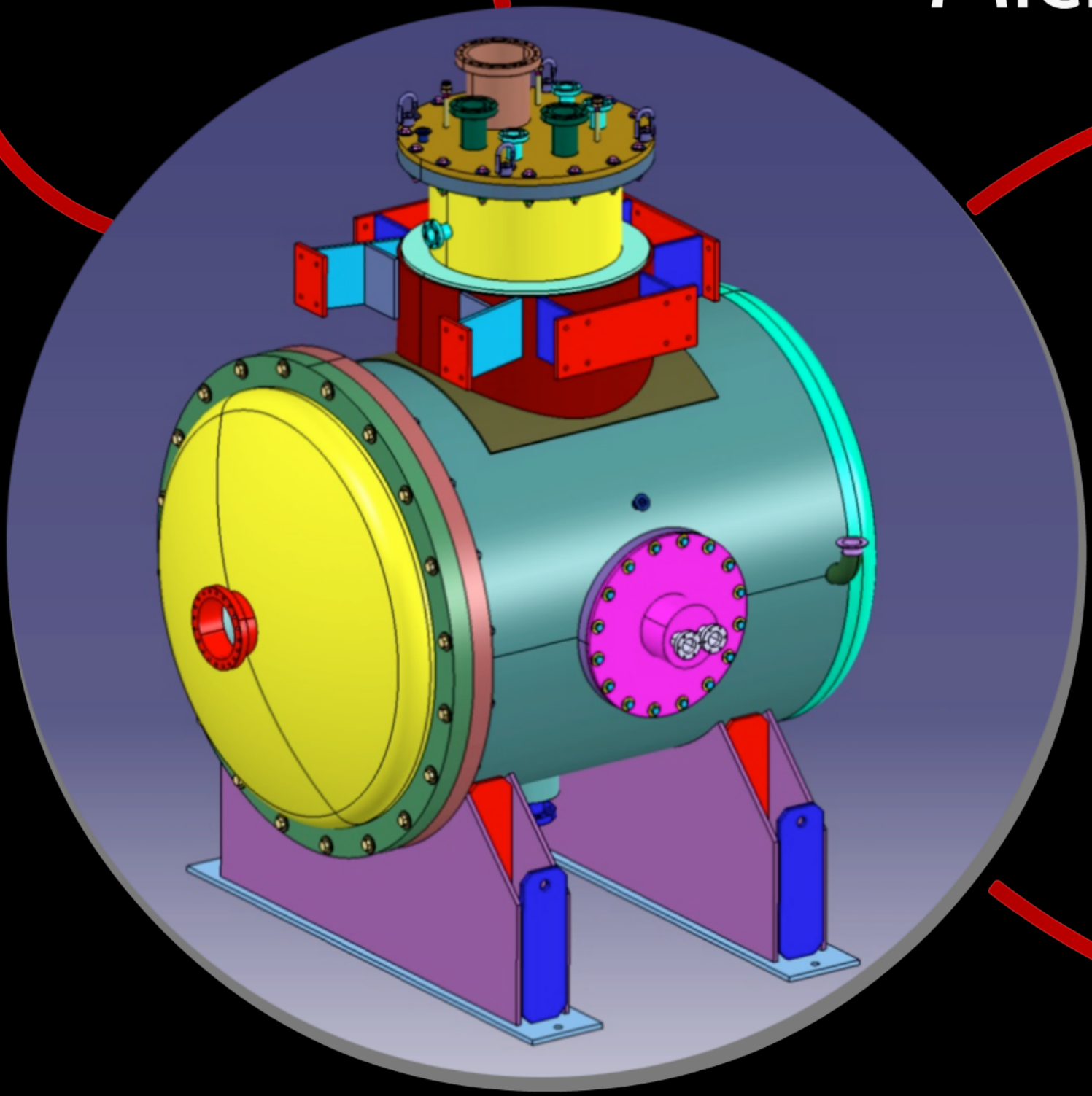
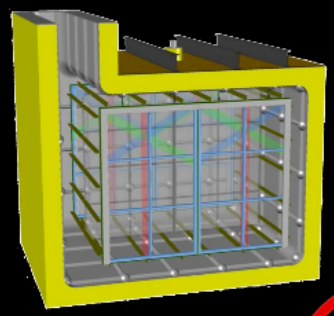
- LAr Scintillation Light Collection

MicroBoo





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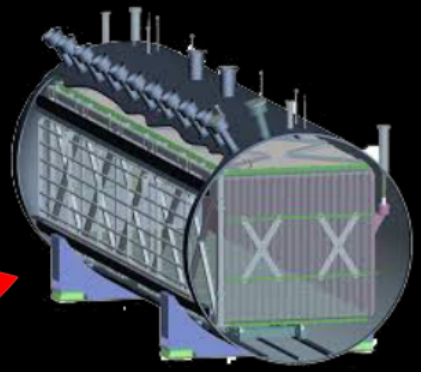
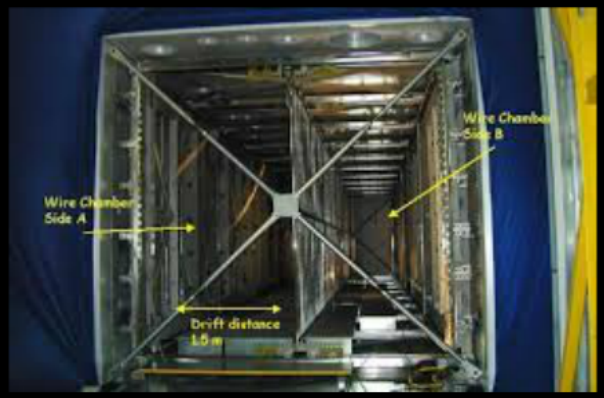
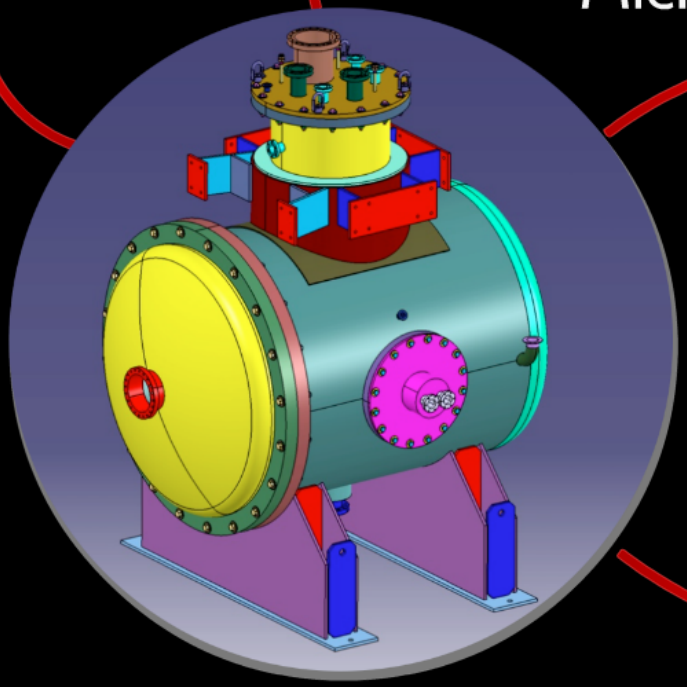
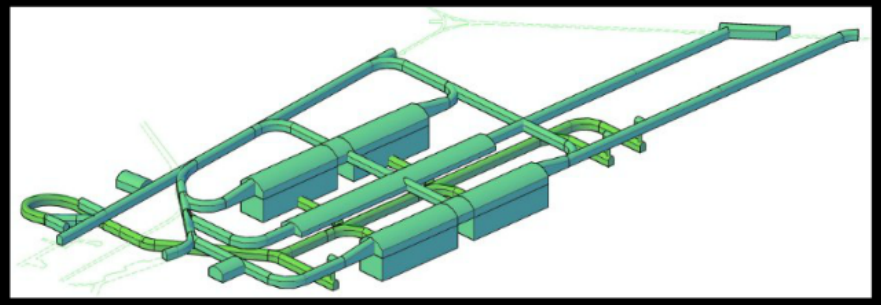


MicroBooNE

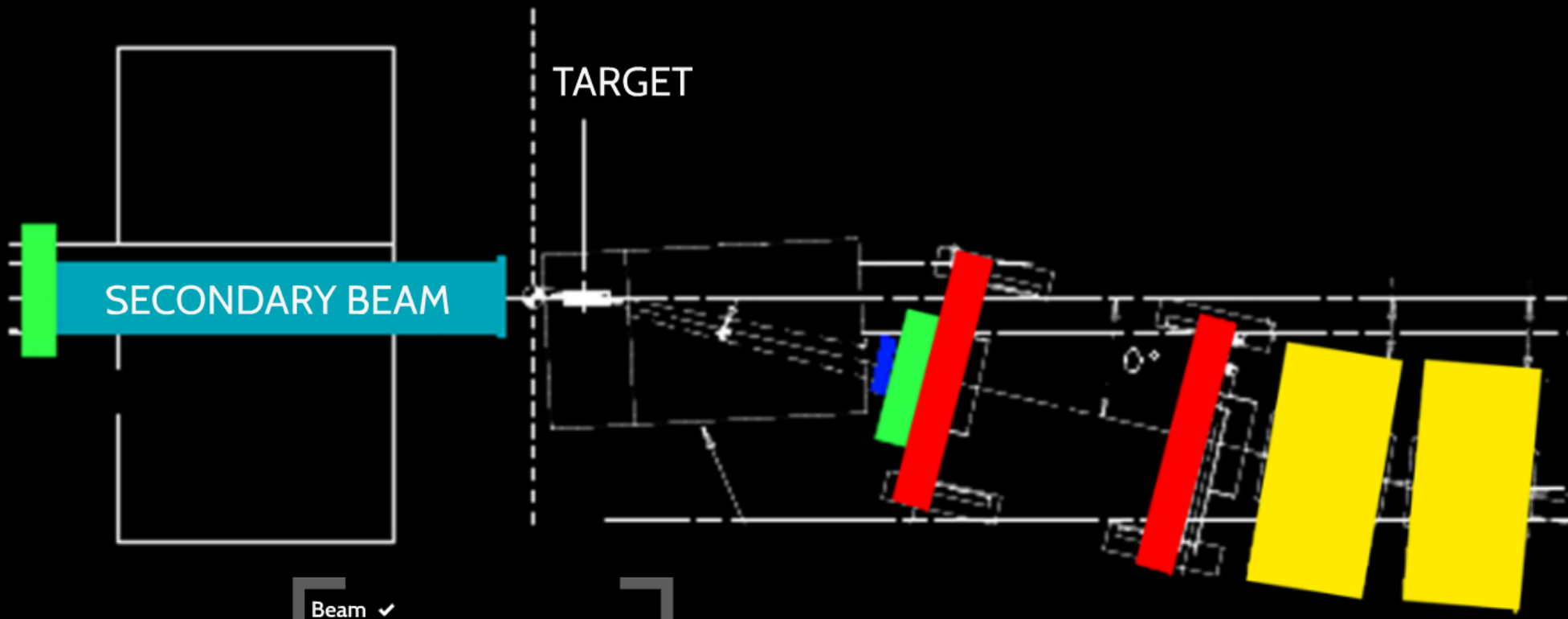


ICARUS





DUNE



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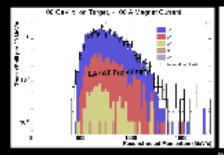
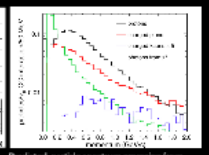


Particle spectrum produced with the LAriAT 8 GeV tertiary beam



Predicted particle spectrum emerging from neutrino interaction with the NuMI LE beam profile

MWPC's and bending magnets ✔

Goal: momentum reconstruction

2 upstream Multi-Wire Proportional Chambers

↓

Bending Magnets

↓

2 downstream Multi-Wire Proportional Chambers

Difference in angle between tracks determines the momentum reconstruction

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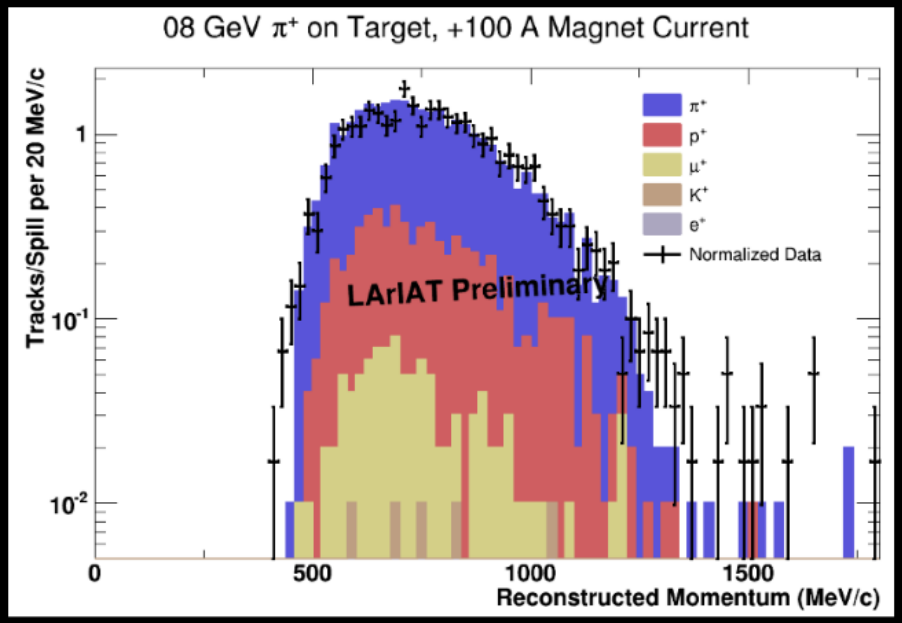

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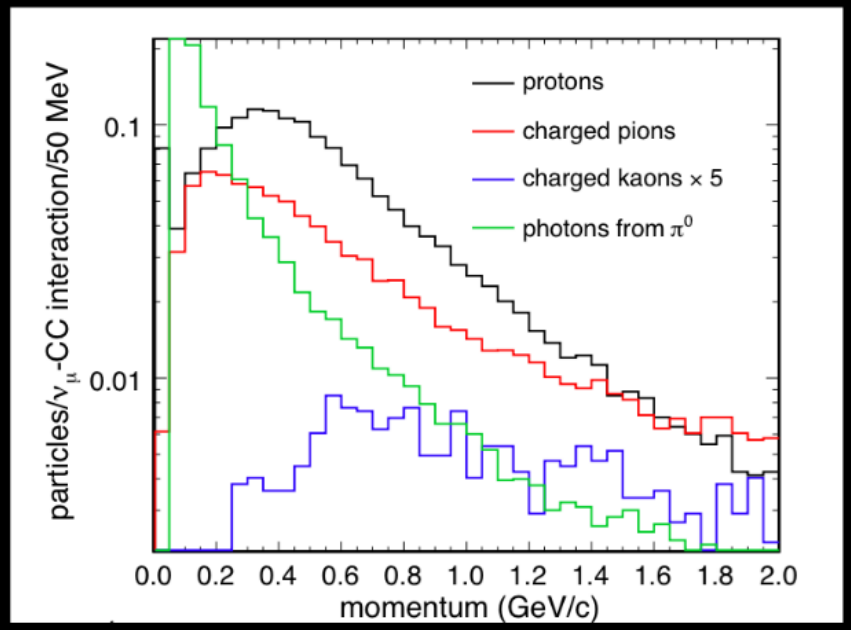

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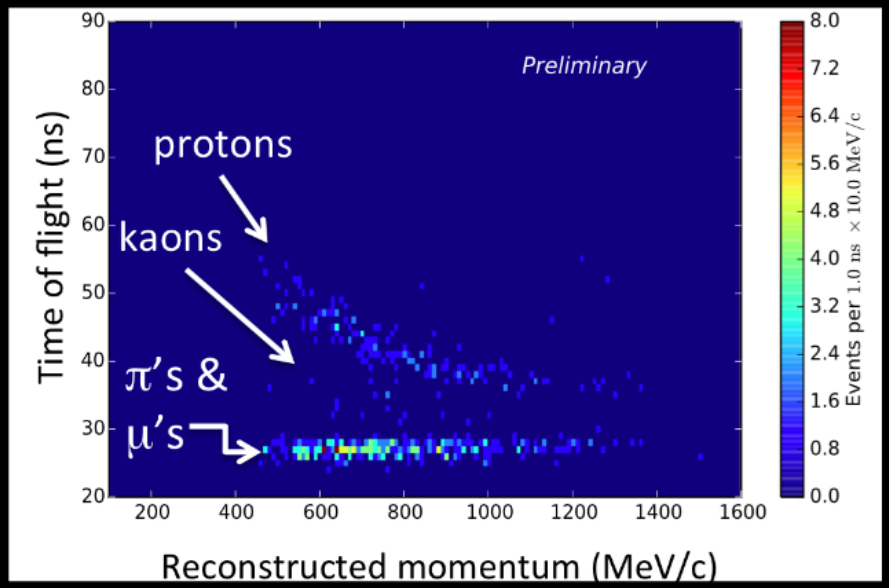
2 scintillators counters
proton/K/pion&muon
discrimination



Cherenkov ✔

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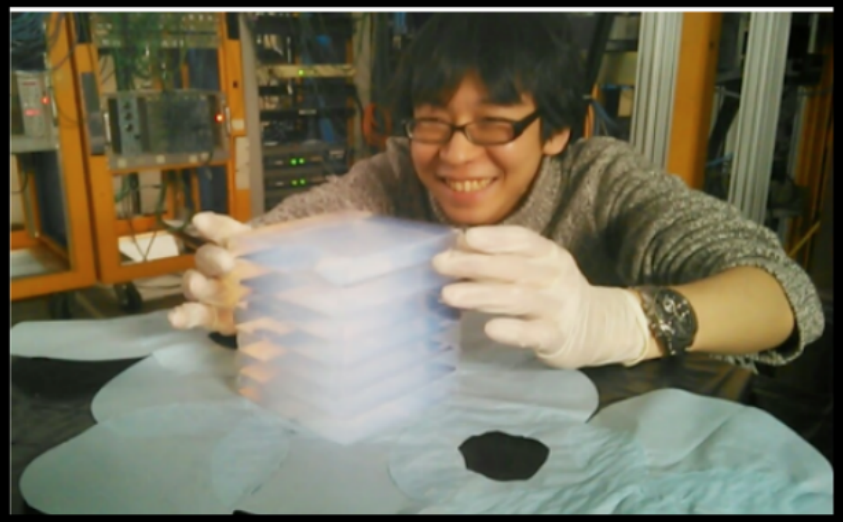
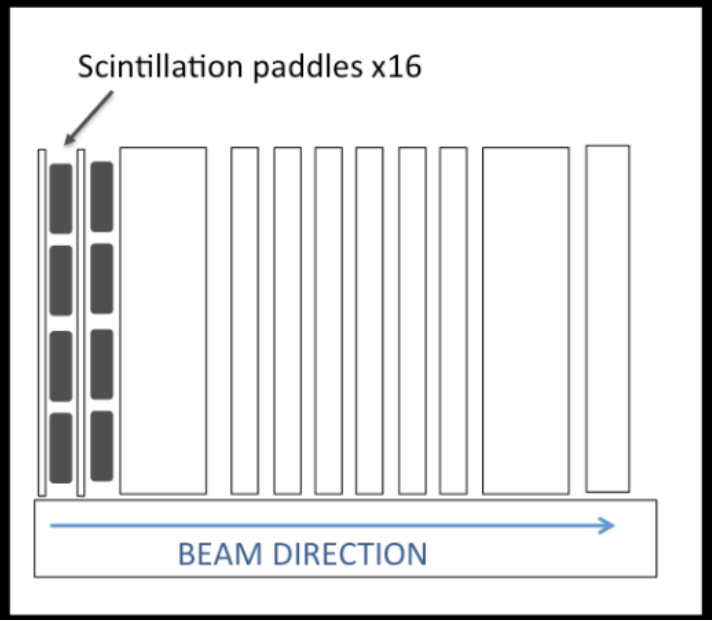
pion/muon discrimination
in momentum range
230 -400 MeV/c



Muon range stack

(under commissioning)



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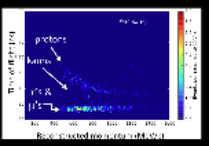
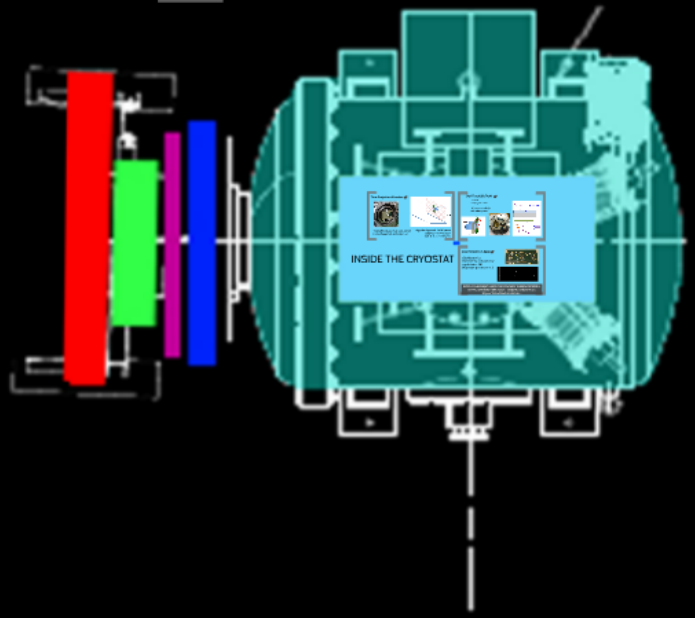
p > 450 MeV/c





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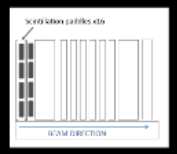
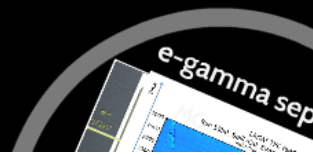
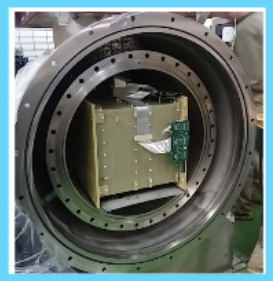


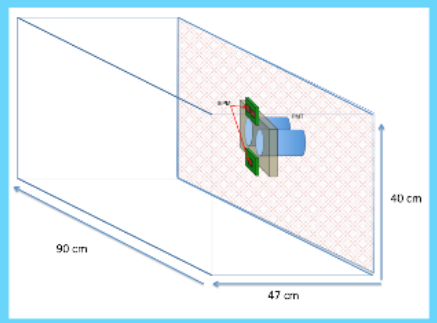


INSIDE THE CRYOSTAT

Time Projection Chamber ✓



Filled with ultrapure LAr 2015-04-29
Worked beautifully at first turn-on

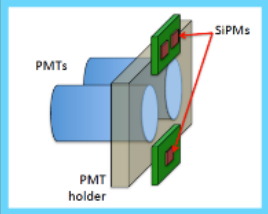


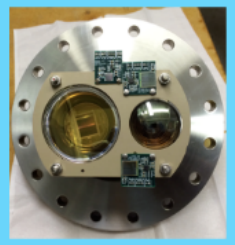
Upgraded ArgoNeuT TPC/Cryostat
3 planes, 240 wires each
Drift E-field: ~0.5 kV/cm

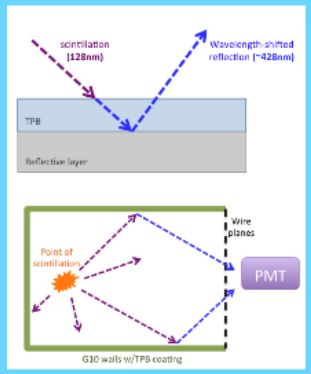
LIGHT COLLECTION ✓

3 SiPMs
2 cryogenic PMTs

Reflector based light collection system

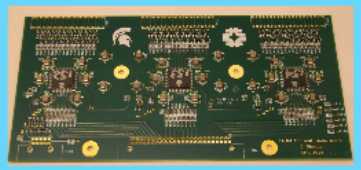


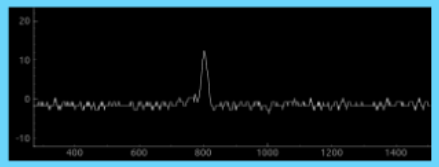




ELECTRONICS & DAQ ✓

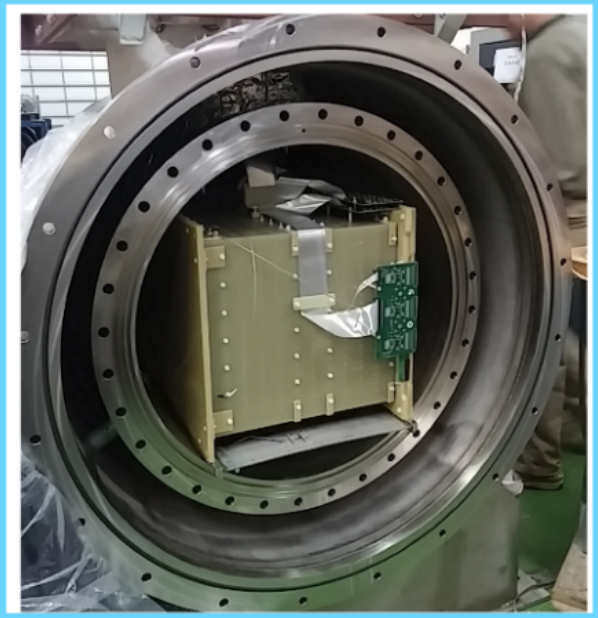
Cold electronics
to reduce the ambient noise
signal/noise > 50
(Argoneut signal/noise~ 15)

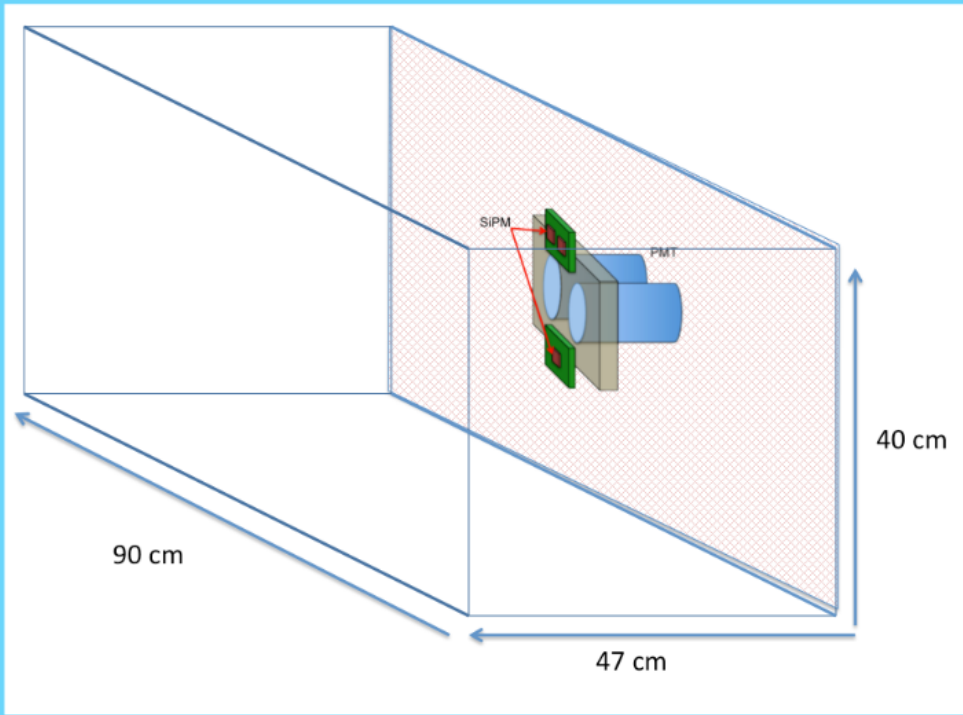




EVERY COMPONENT INSIDE THE CRYOSTAT WORKS PROPERLY.
LArTPC, scintillation light system, cryogenics and purity are all good immediately at start-up ...

Time Projection Chamber ✓





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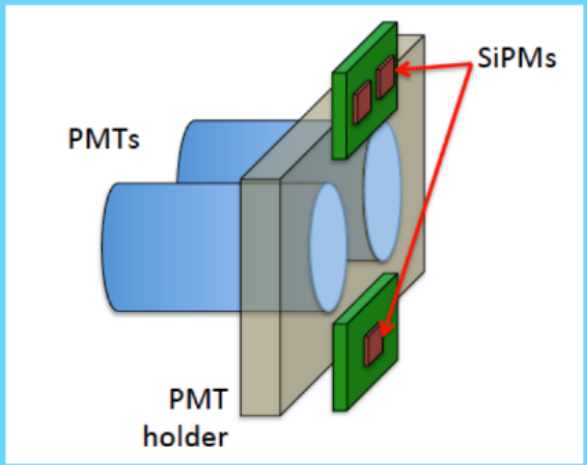

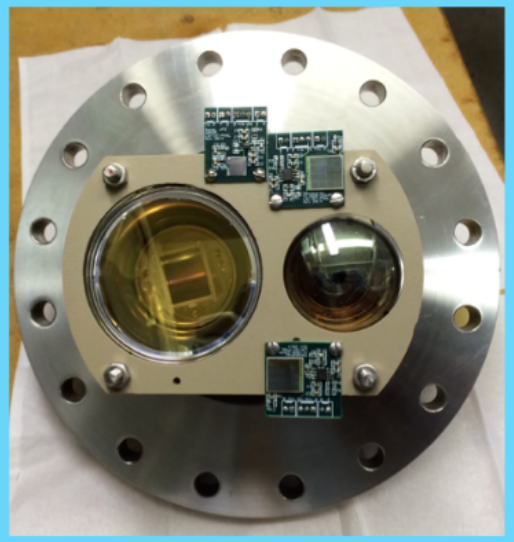

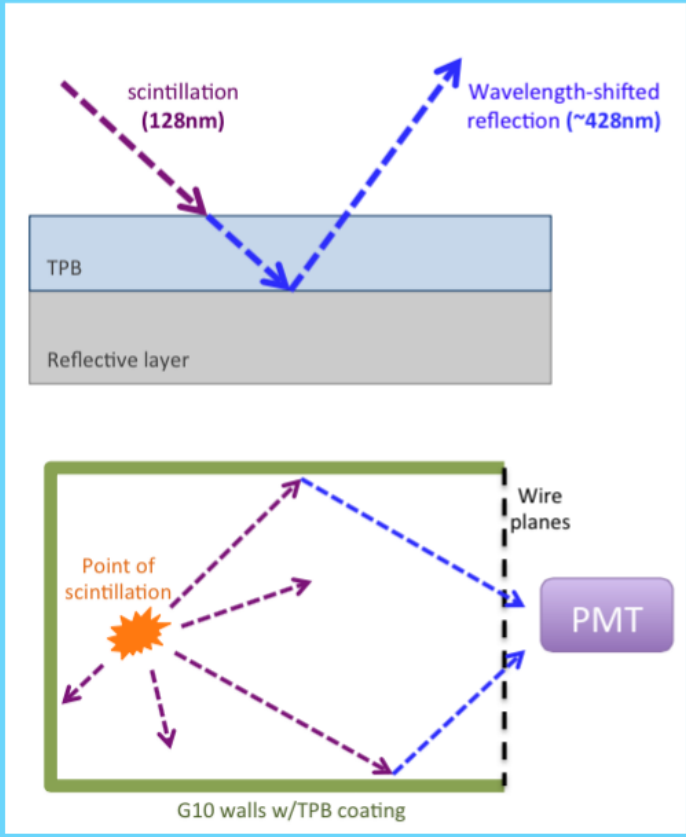

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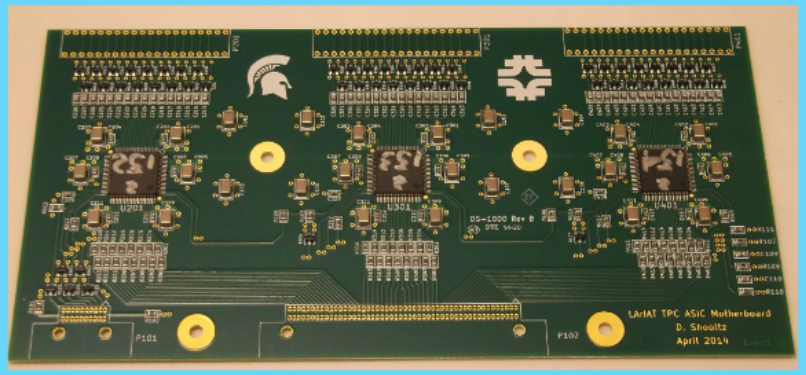

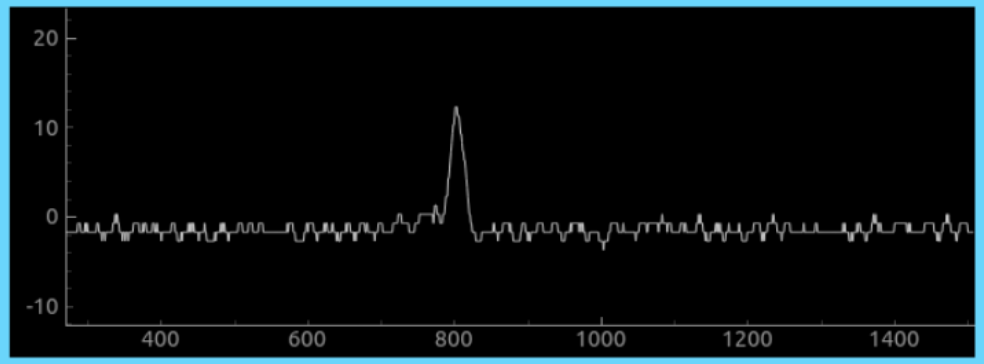

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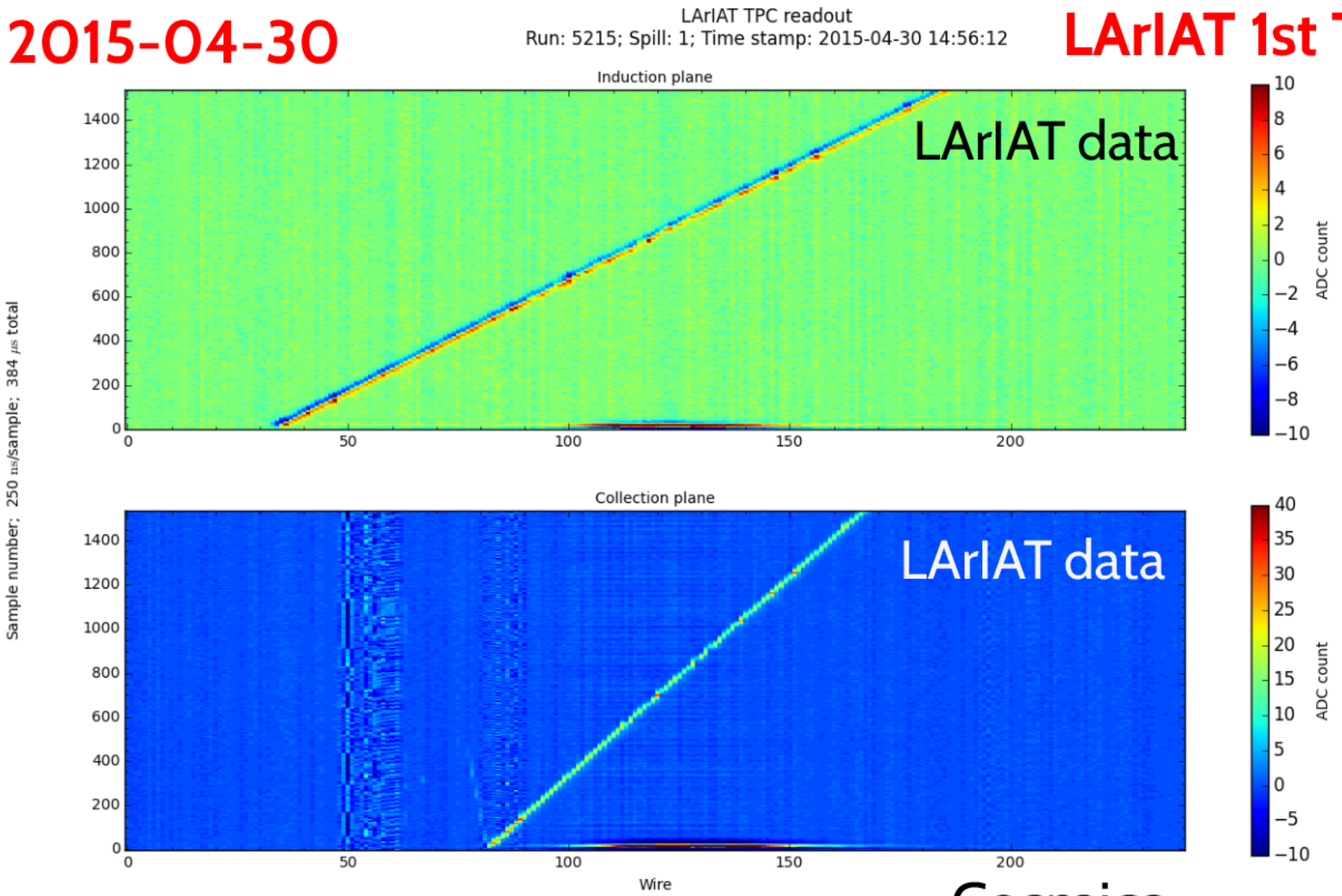
2015-04-30

LArIAT 1st TRACK



Cosmics

Ongoing Analysis

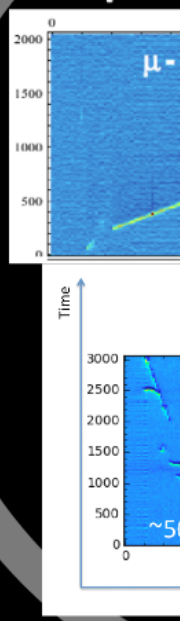
R&D.

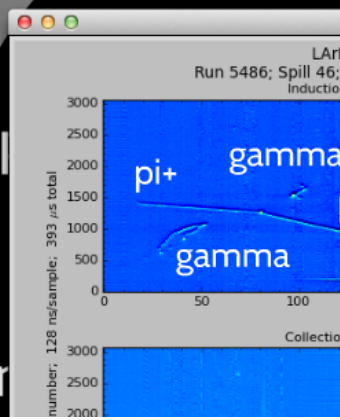
electron/gamma separation

PHYSICS.

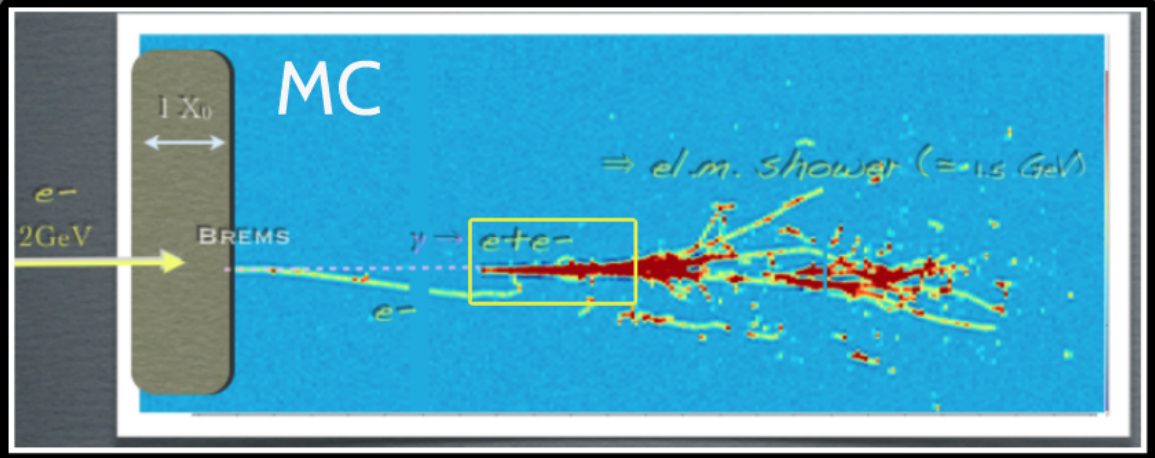
muon sign determination in absence of magnetic field

hadronic cross sections





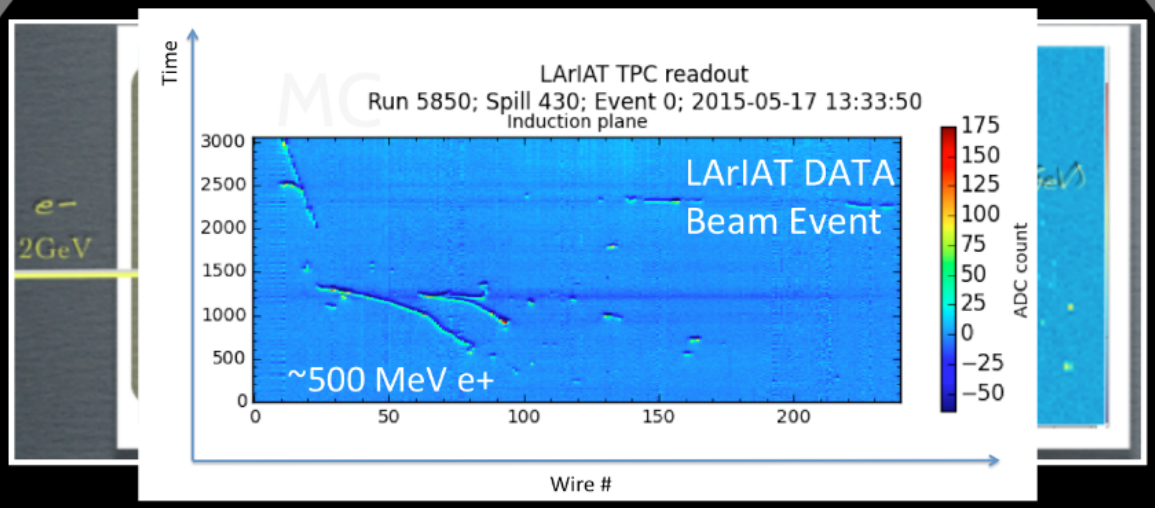
e-gamma separation



Measure separation efficiency and sample purity for em showers from electrons and from photons

Key feature for all LArTPC

e-gamma separation



Measure separation efficiency and sample purity for em showers from electrons and from photons

Key feature for all LArTPC

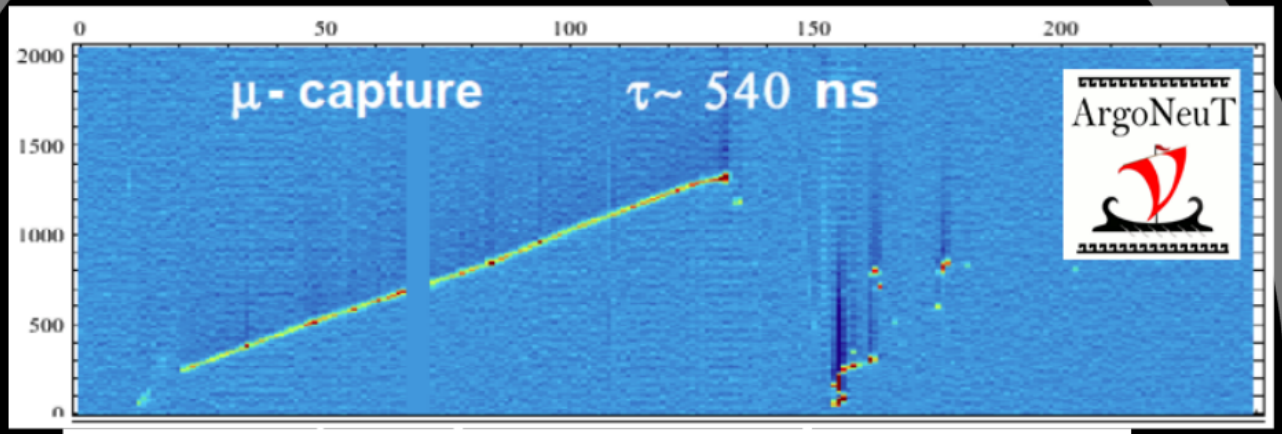
μ sign determination

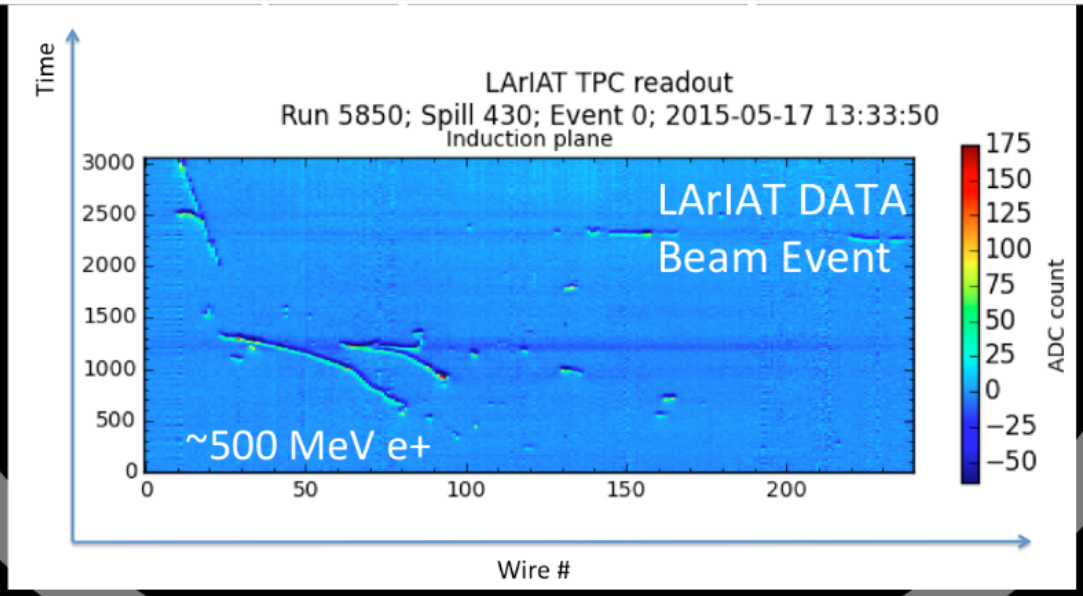
Topological search +
scintillation light analysis

μ^+ decay only

μ^- ~76% capture
~24% decay

μ sign determination





Pi and K cross sections

Pions: main component of the Tertiary beam
Pion charge exchange is a major systematics for neutrino experiment
K: not many... possible dedicated run

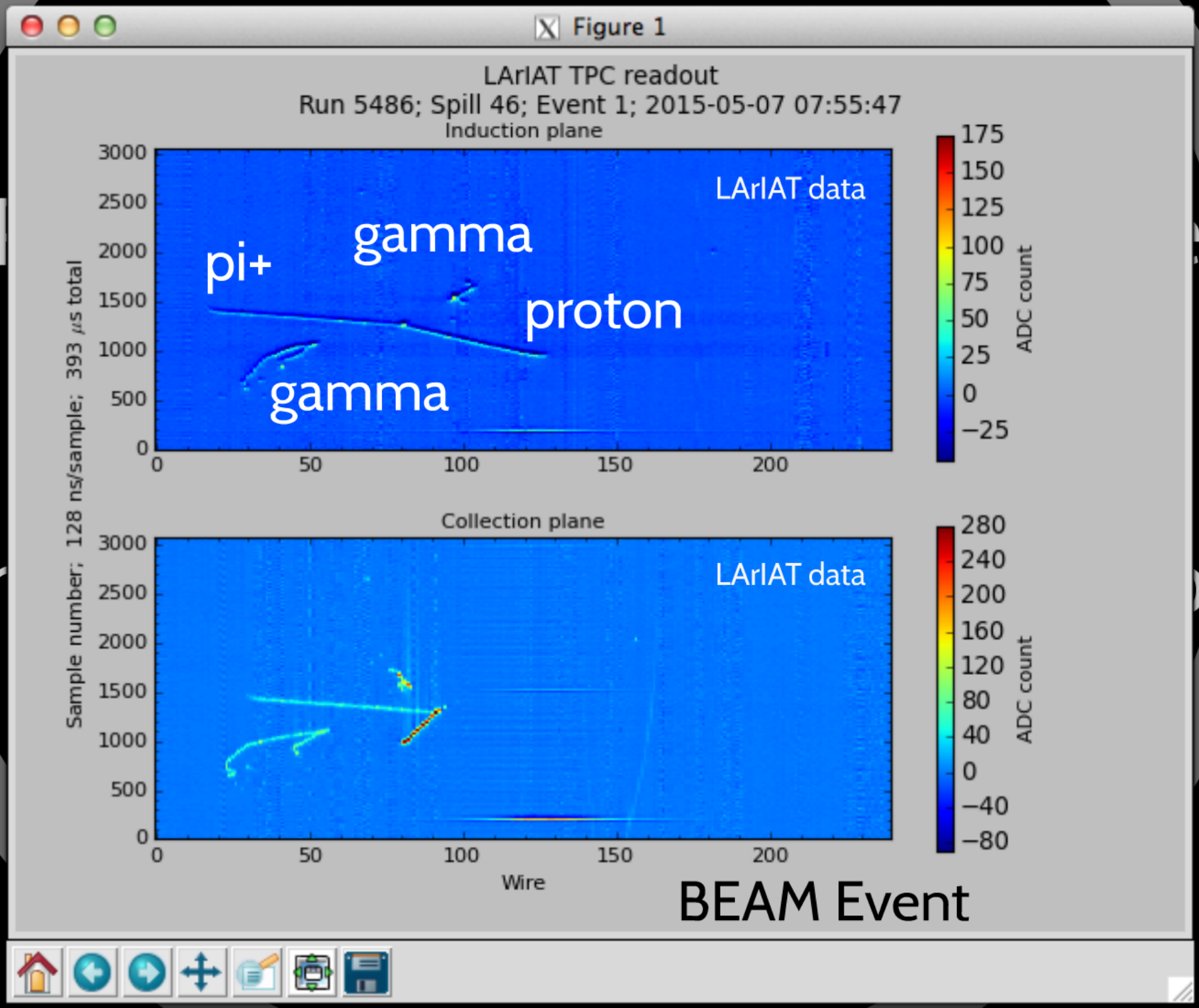
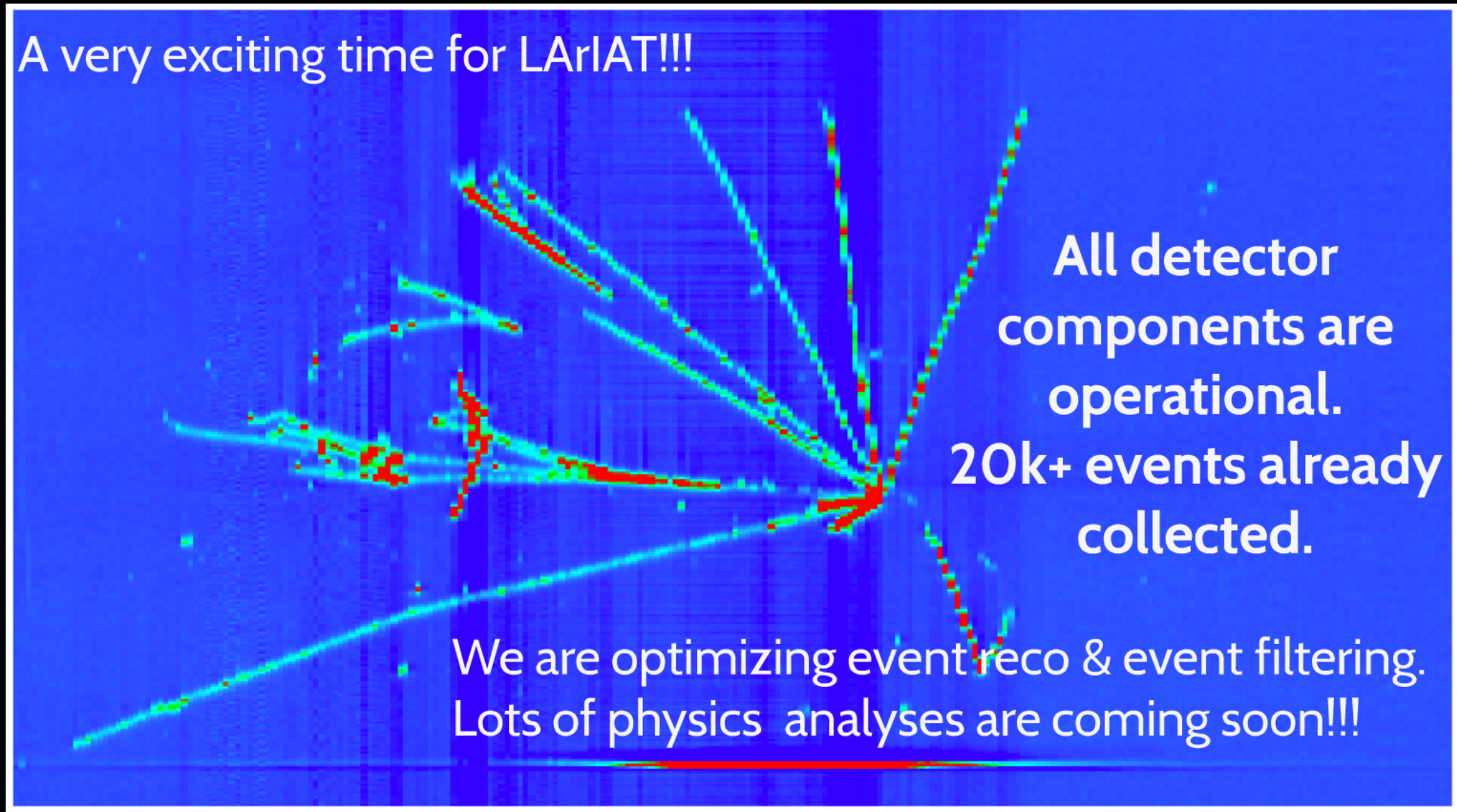


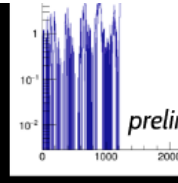
Figure 1
LArIAT TPC readout
Run 5486; Spill 46; Event 1; 2015-05-07 07:55:47
Induction plane
LArIAT data
pi+
gamma
proton
gamma
Sample number; 128 ns/sample; 393 μs total
ADC count
Collection plane
LArIAT data
Wire
ADC count
BEAM Event


A very exciting time for LArIAT!!!
All detector components are operational.
20k+ events already collected.
We are optimizing event reco & event filtering.
Lots of physics analyses are coming soon!!!

Thanks!

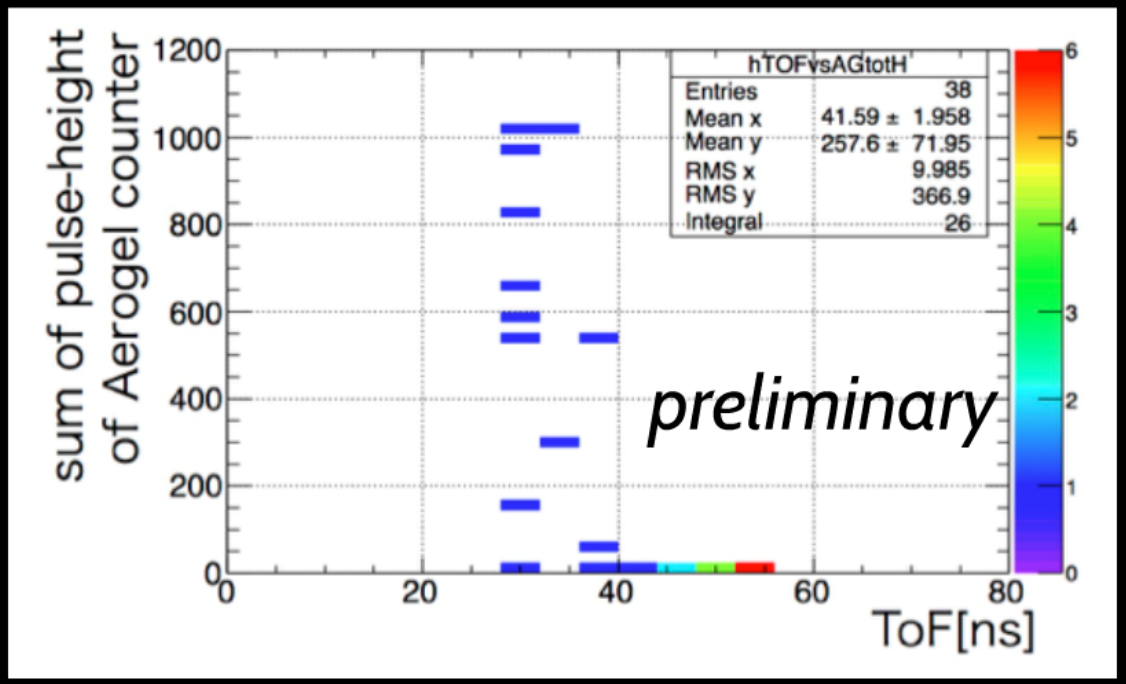
- **Argonne** Jon Paley
- **Boston U.** Flor de Maria Blaszczyk, Dan Gastler, Ryan Linehan, Ed Kearns
- **Caltech** Ryan Patterson
- **U. Chicago** Will Foreman, Johnny Ho, Dave Schmitz
- **U. Cincinnati** Randy Johnson, Jason St. John
- **Fermilab** Roberto Acciarri, Michael Backfish, William Badgett, Bruce Baller, Flavio Cavanna† (also INFN, Italy), Eric Church, Alan Hahn, Doug Jensen, Hans Jostlein, Mike Kirby, Tom Kobilarcik, Pawel Kryczynski, Sarah Lockwitz, Alberto Marchionni, Irene Nutini, Ornella Palamara (also INFN, Italy), Jennifer Raaf†, Brian Rebel‡, Michelle Stancari, Sam Zeller
- **Istituto Nazionale di Fisica Nucleare, Italy** Flavio Cavanna (also Fermilab), Ornella Palamara (also Fermilab)
- **Imperial College London** Morgan Wascko
- **KEK** Eito Iwai, Takasumi Maruyama
- **LANL** Christopher Mauger
- **Louisiana State University** William Metcalf, Andrew Olivier, Martin Tzanov
- **U. Manchester** Justin Evans, Pawel Guzowski
- **Michigan State University** Carl Bromberg, Dan Edmunds, Dean Shooltz
- **U. Minnesota, Duluth** Rik Gran, Alec Habig, Karl Kaess
- **U. Pittsburgh** Steve Dytman
- **Syracuse University** Jonathan Asaadi, Jessica Esquivel, Mitch Soderberg
- **U. Texas, Arlington** Amir Farbin, Seongtae Park, Timothy Watson, Andy White, Jae Yu
- **U. Texas, Austin** Will Flanagan, Junting Huang, Karol Lang
- **University College London** Anna Holin, Ryan Nichol
- **William & Mary** Mike Kordosky‡, Matthew Stephens, Patricia Vahle
- **Yale University** Bonnie Fleming, Elena Gramellini, Andrzej Szelc

scintillation light
from cryo PMT



BACKUP SLIDES

TOFs & Cherenkovs



S
c
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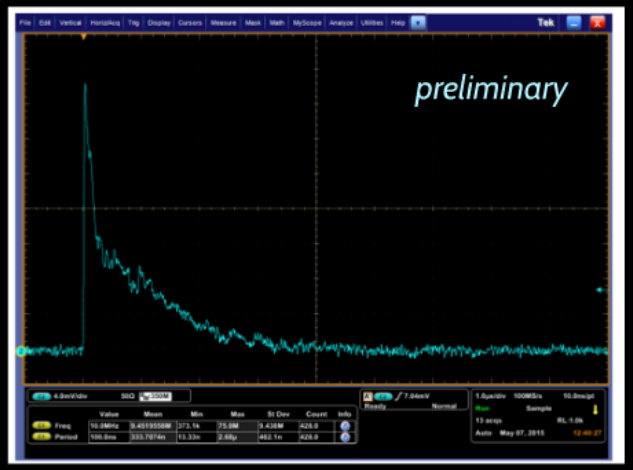
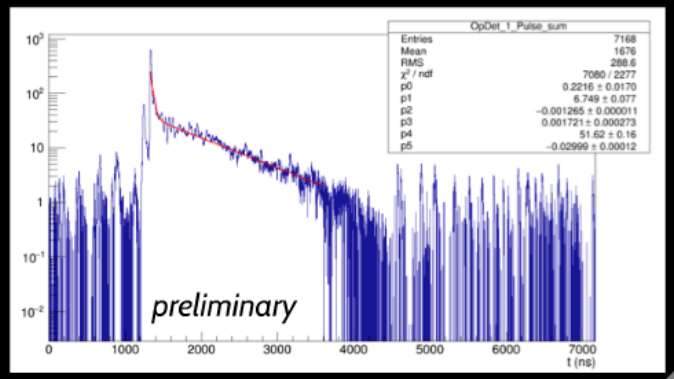
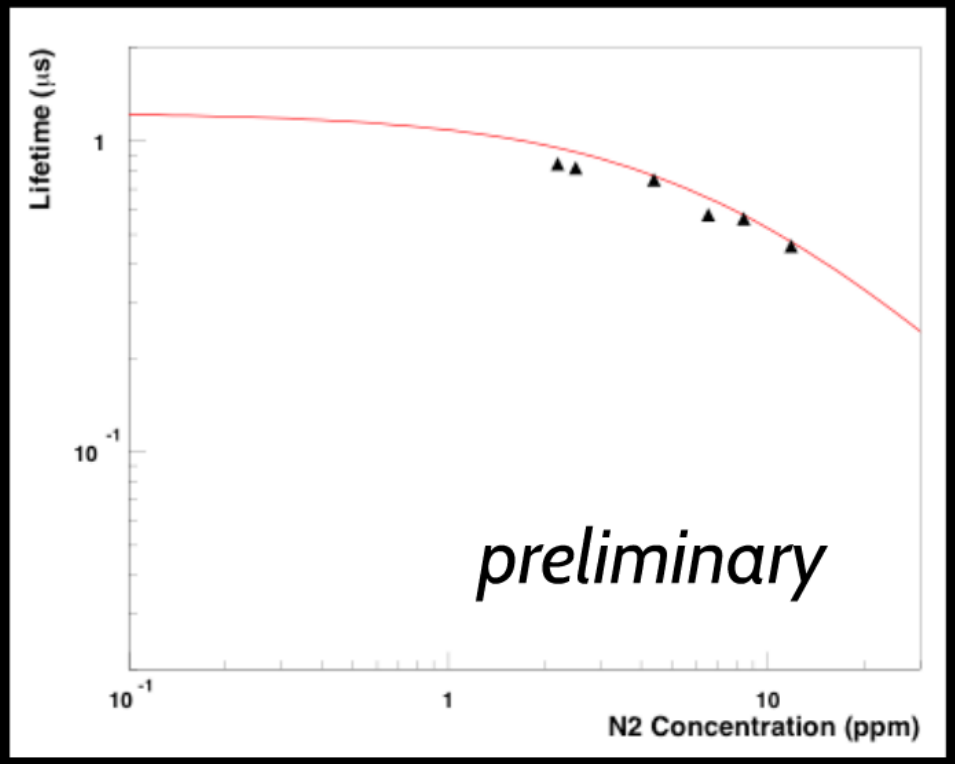
Light Collection



Signal on SiPM from single crossing muon

Study of slow component scintillation light from cryo PMT



Ar purity