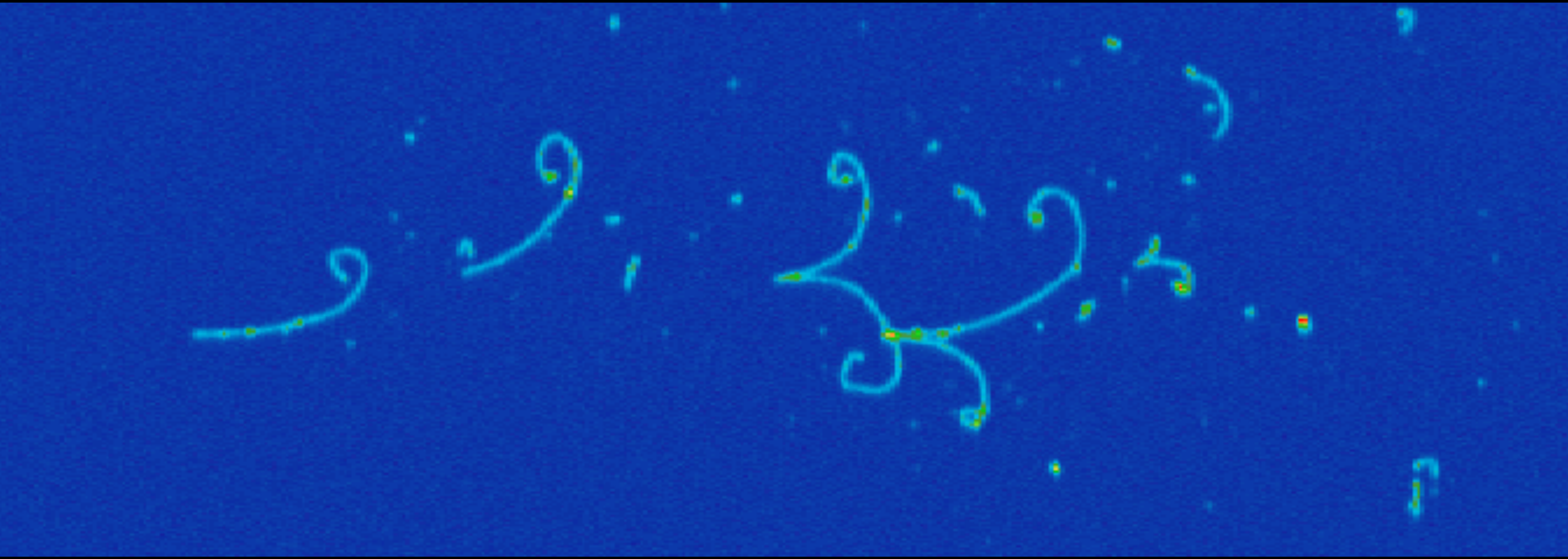
A Liquid Argon Time Projection Chamber in a Magnetic Field

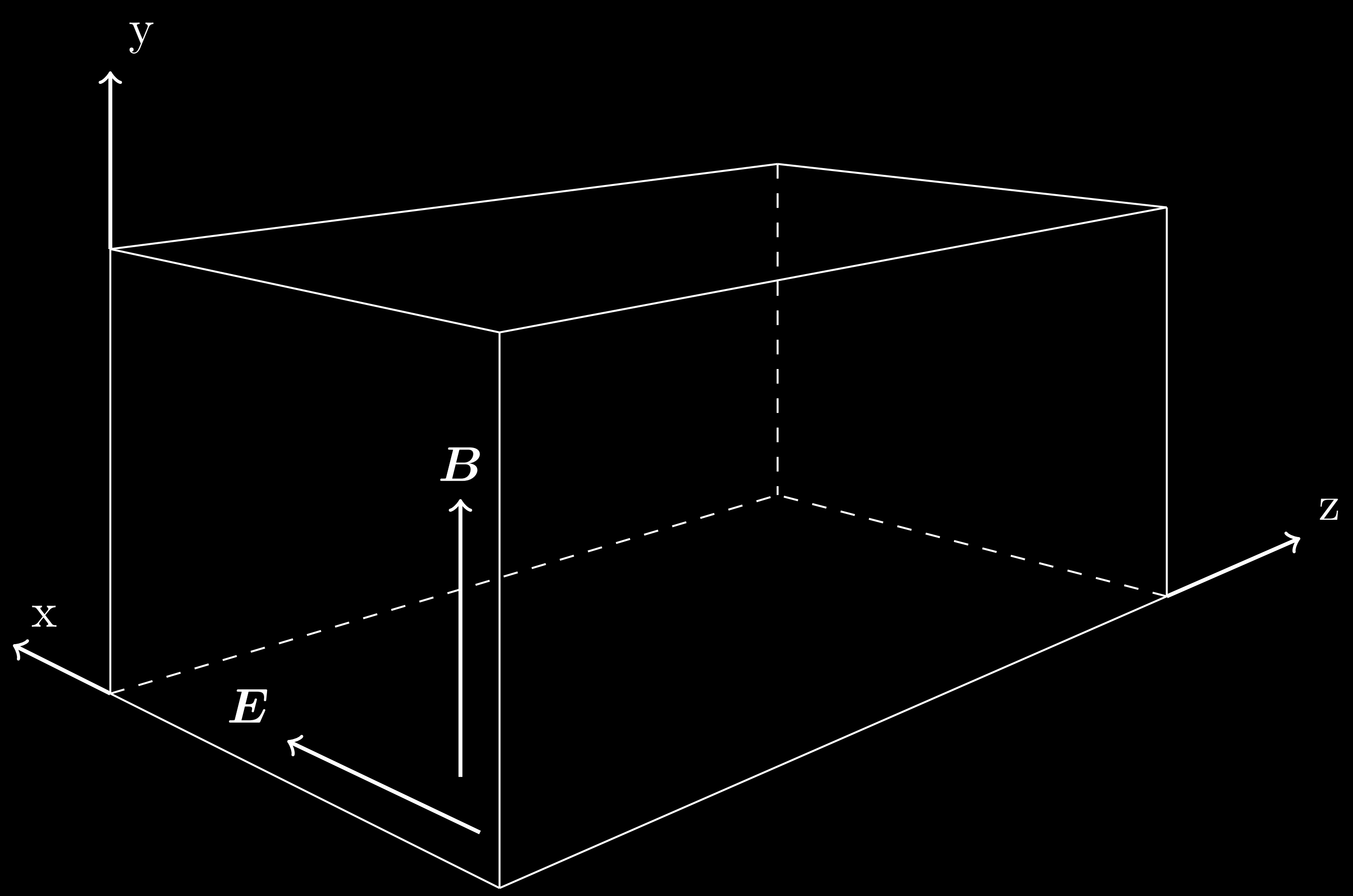


PI: Marco Del Tutto

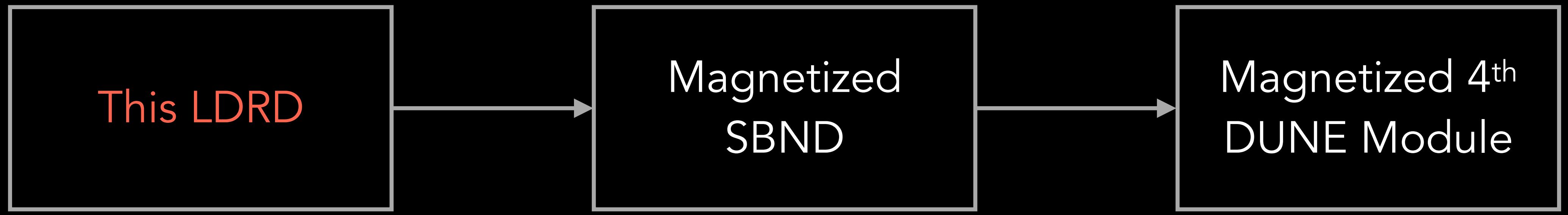
CO-I: Ornella Palamara, Claudio Montanari, Roberto Acciarri, Will Foreman, William Badgett, Angela Fava, Flavio Cavanna, and INFN Genova and University, Italy

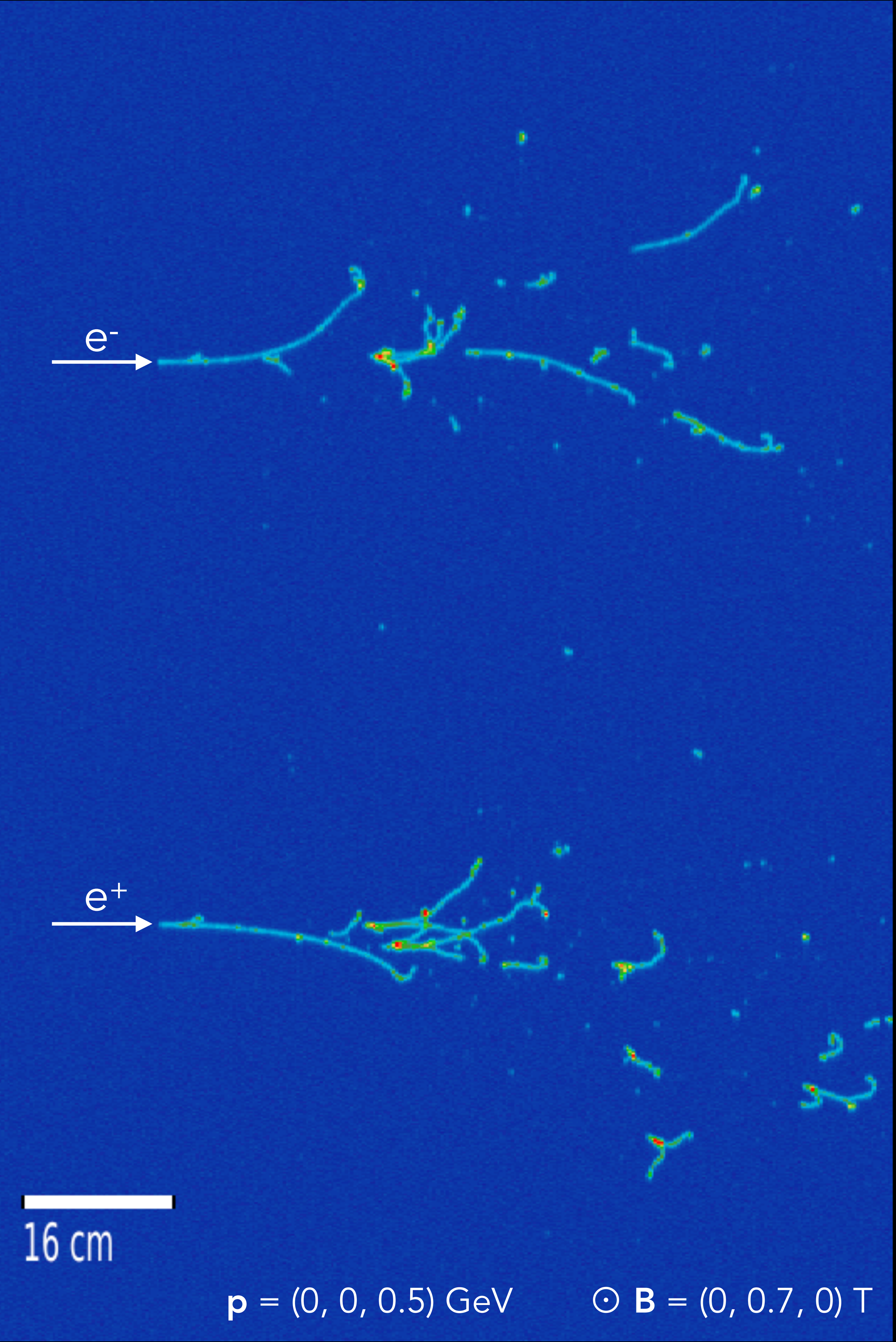
LDRD Oral Presentation, 1st December 2021

Project Description

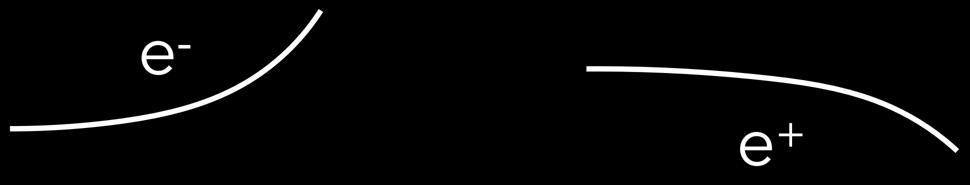


The scope of this project is to demonstrate that a **LArTPC** detector can operate in a **magnetic field** and establish the minimum field required to measure the sign of particles' charges and momenta.



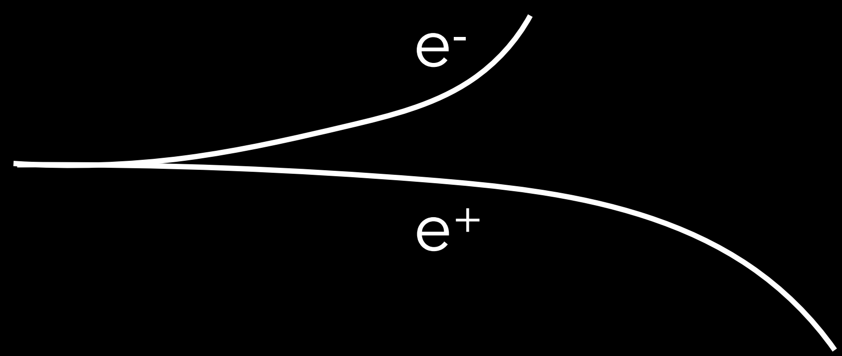


Electron/Positron Discrimination

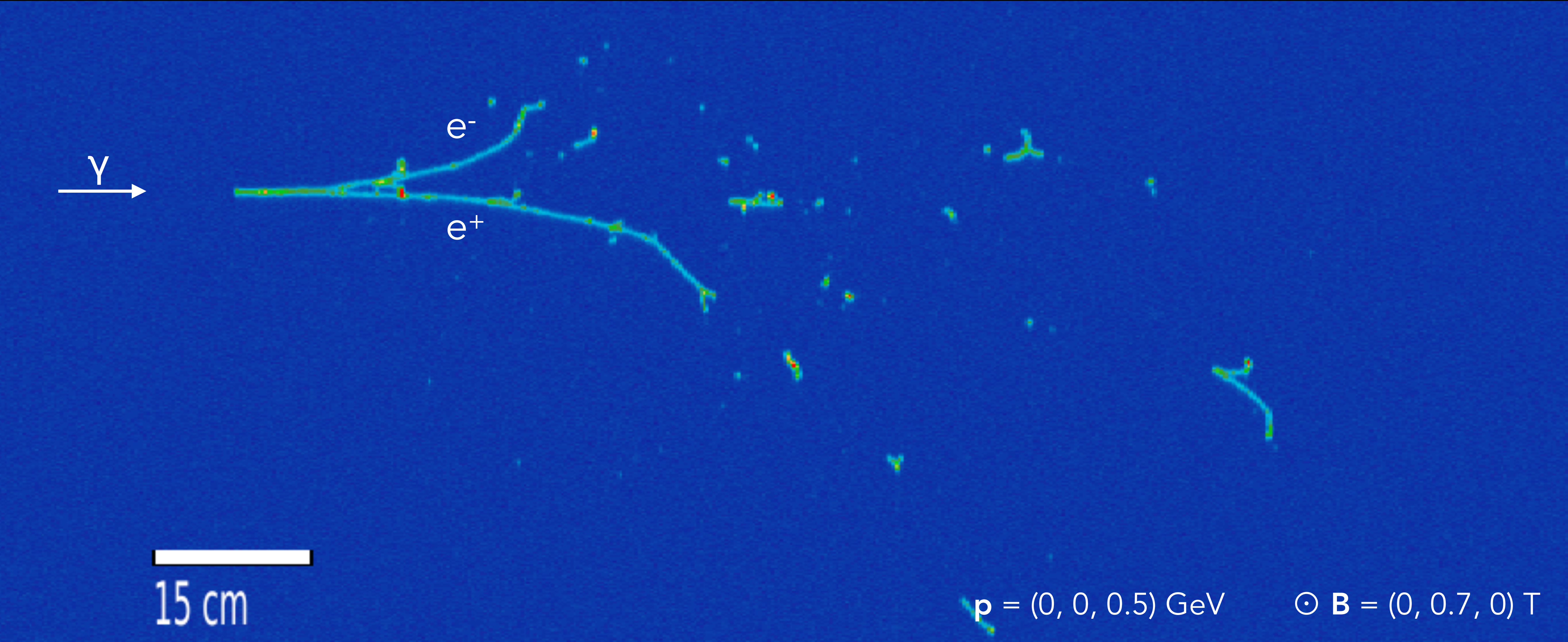


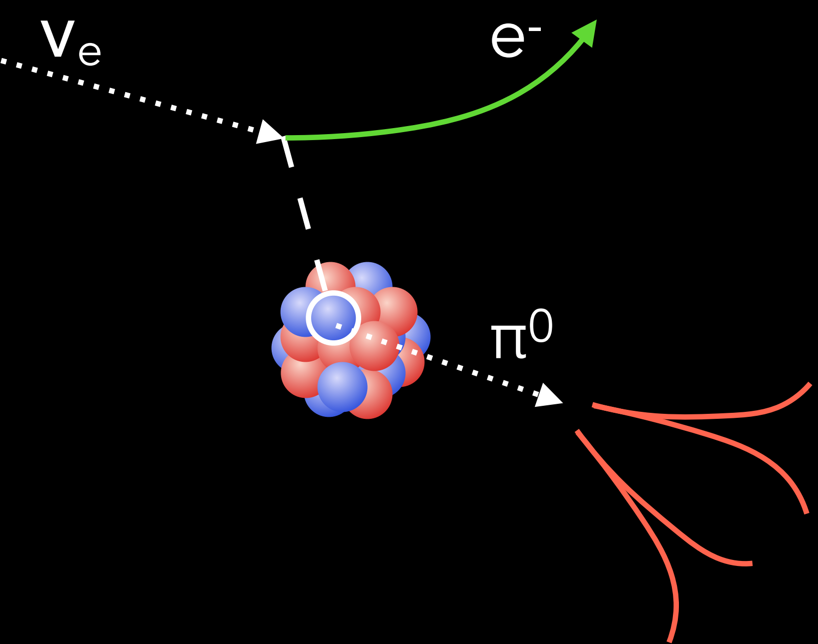
- The first part of the electromagnetic shower can be used to measure the curvature of the primary electron or positrons.
- Important to remove "wrong-sign" background contamination.

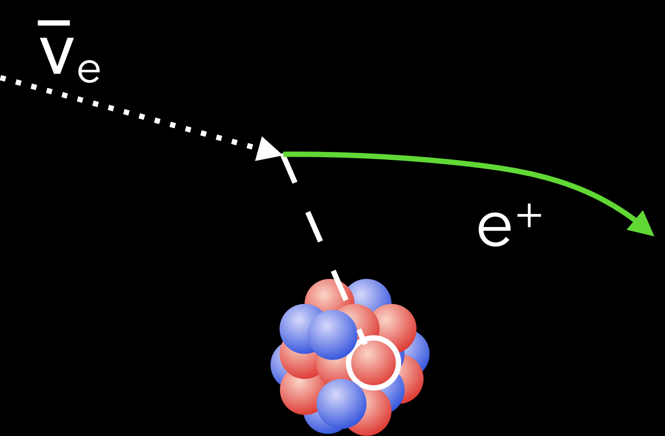
Electron/Photon Discrimination

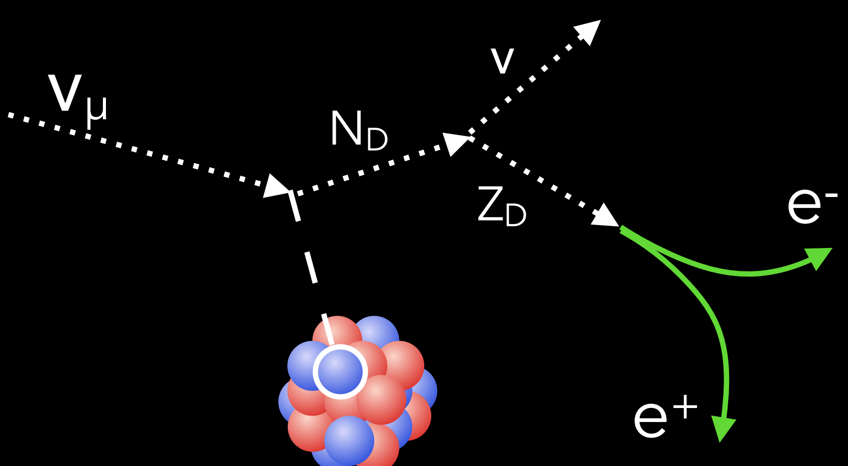


Photon-induced showers can be identified based on V-like signature, as the electron and positron are pulled apart by the magnetic field.

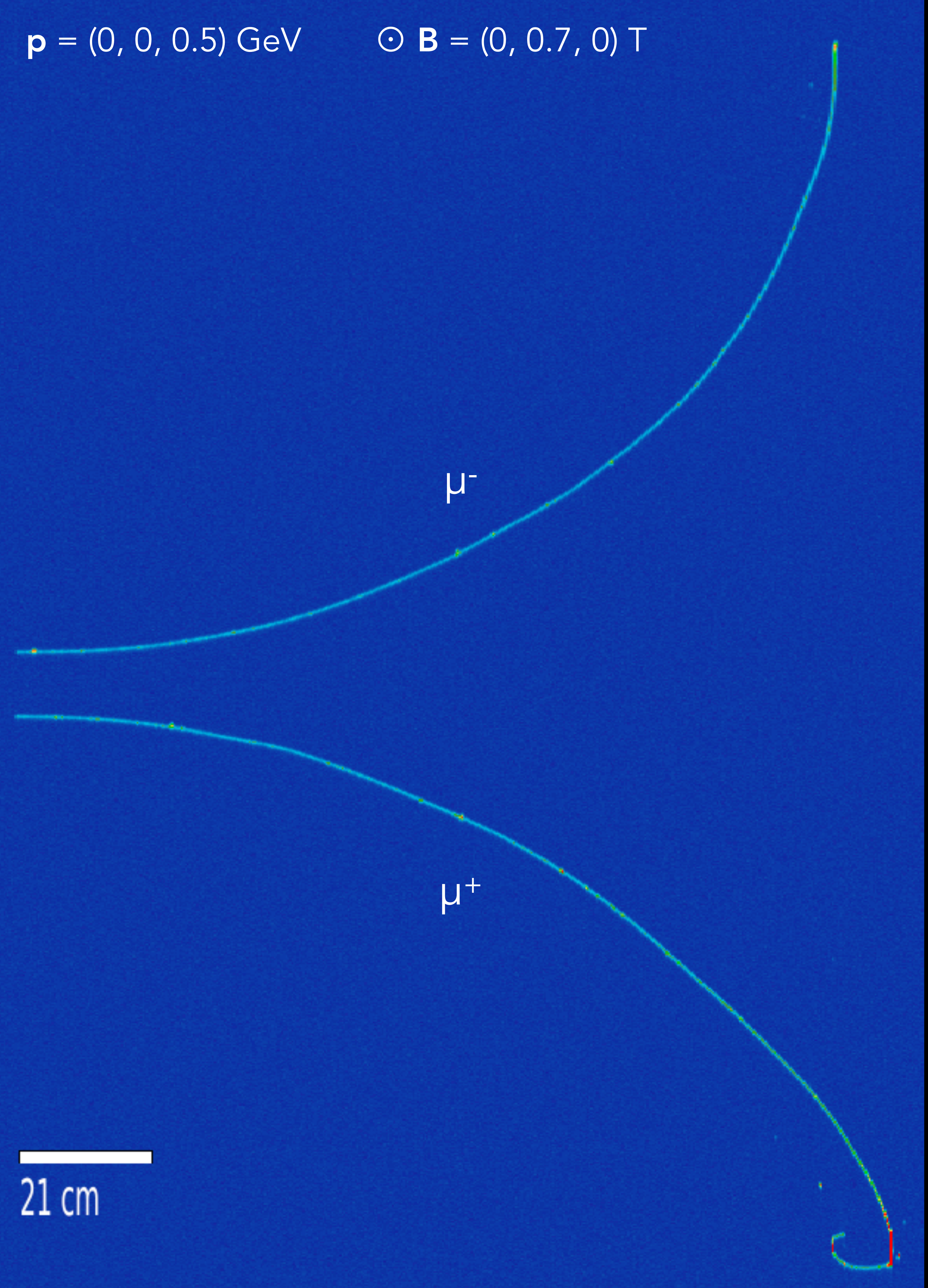








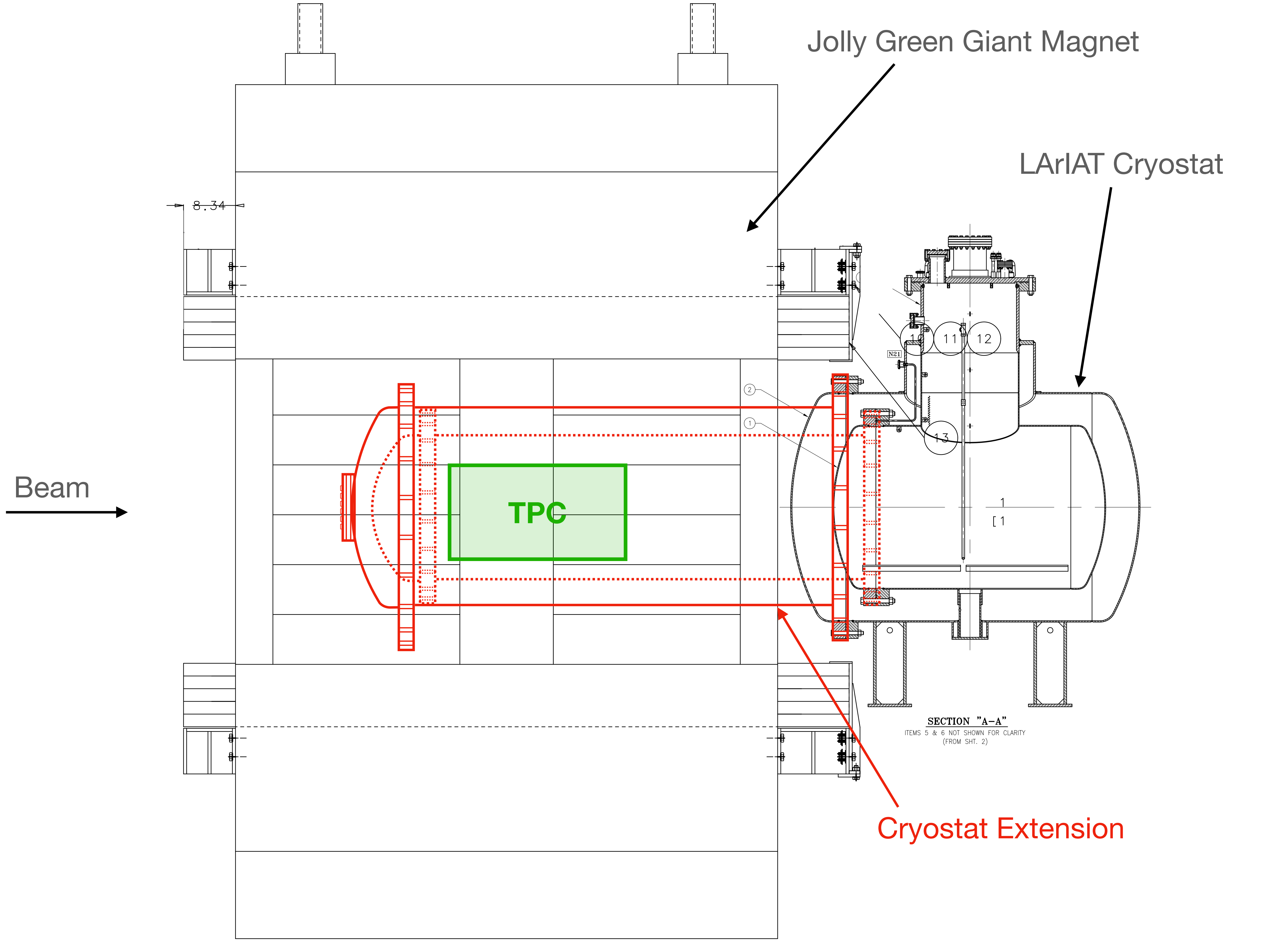
- Can measure neutrino and anti-neutrino **cross section** separately:
  - Extremely sensitive to the nucleon axial mass.
- **SBN Sterile Neutrinos**:
  - Electron/photon separation enables a further background reduction from π^0 or Δ production.
  - Magnetic field crucial if running in anti-neutrino mode.
- **Beyond Standard Model Physics**:
  - Charge ID crucial to identify $\mathbf{l^-/l^+}$ in the final state, typical of many BSM physics models
  - magnetization gives extra sensitivity when the pair is boosted and has a small opening angle
  - **Trident events**, can measure all channels $\mu^+\mu^-$, e^+e^-, μ^+e^-, and $e^+\mu^-$
- DUNE **CP-violation** sensitivity with atmospheric neutrinos increases by 50%.
- Background reduction for **tau neutrinos** increased by more than 20%.



Momentum Measurement

- Can use track curvature to measure momentum.
- Especially important for muons and pions exiting the detector.
- Momentum resolution:
  - 9% for a 5 m muon (SBND)
  - 4% for a 30 m muon (DUNE)

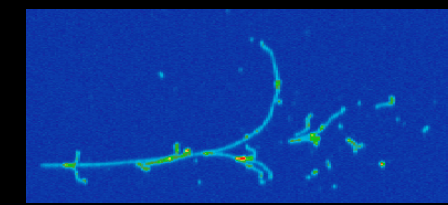
Jolly Green Giant Magnet



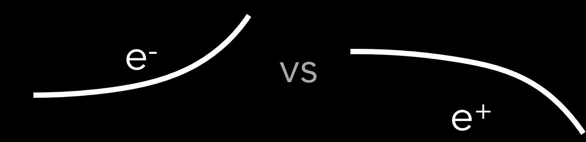
Jolly Green Giant Magnet
LArIAT Cryostat
8.34
Beam
TPC
Cryostat Extension
N21
10
11
12
13
1
2
SECTION "A-A"
ITEMS 5 & 6 NOT SHOWN FOR CLARITY
(FROM SHT. 2)

Objectives

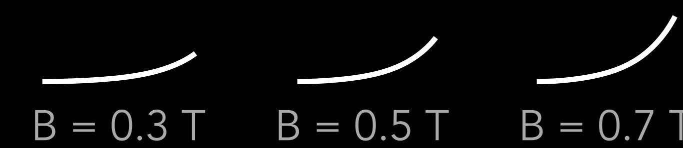
I. Verify that the TPC can operate in a magnetic field.



II. Verify that electron/positron separation is achievable in a 0.7 T field.

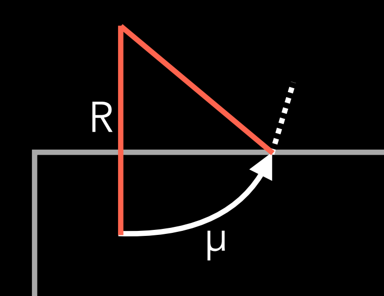


III. Establish minimum field required for electron/positron separation.

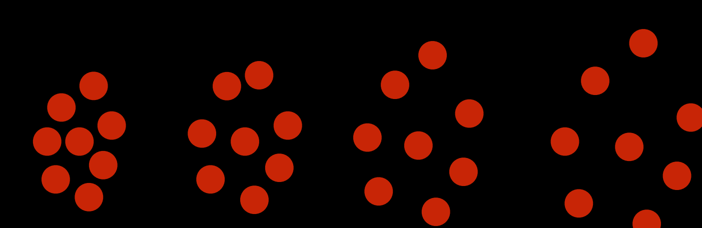


IV. Measure the efficiency in electron/photon shower separation.

V. Measure muon and pion momentum using their curvature.

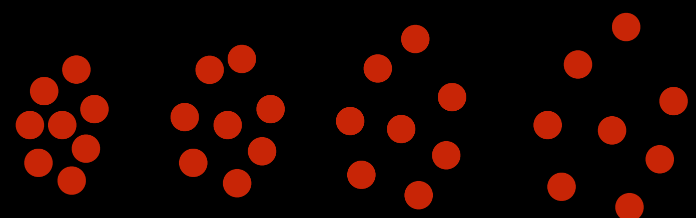


VI. Measure electron diffusion in the presence of a magnetic field.



Main Objectives

This LDRD will establish the minimum field required for electron/positron separation.
A pivotal input for all future magnetized LArTPCs.



This LDRD will assess how electron diffusion is affected by the magnetic field.
This is key to understating if the magnetized LArTPC technology is pursuable in the future.