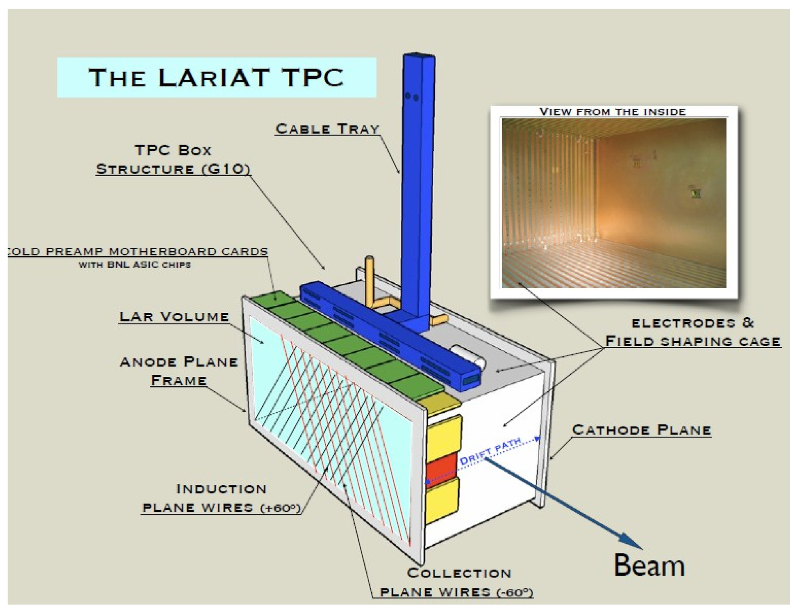
Study of charged pion interactions in Liquid Argon through ionization free charge and scintillation light in LArIAT

Irene Nutini, Università degli Studi di Firenze – irene.nutini@stud.unifi.it

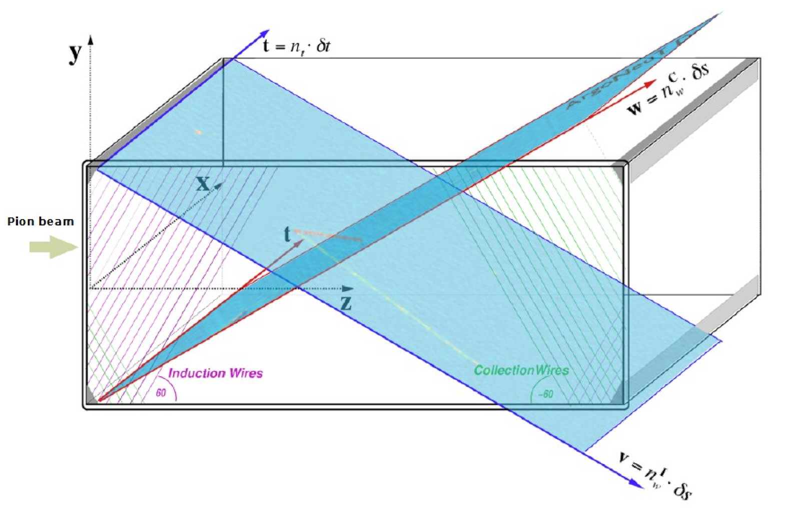
LArIAT stands for **Liquid Argon Time Projection Chamber In A Testbeam**. This program supports the LArTPC neutrino experiments at Fermilab. LArTPC detectors offer full 3D imaging, good particle identification and precise calorimetric reconstruction. A good characterization of LArTPC performance is considered of great interest for the development of the Intensity Frontier Program in the US, especially for the SBN and LBN programs for precise neutrino oscillation physics and proton decay searches.

The LArIAT program consists of a **calibration of a Liquid Argon TPC in a dedicated beam line**. The work is focused on the study of all the particles that could emerge from neutrino interactions with Argon nuclei (mainly pions, muons, protons, kaons and electrons). The TPC detector is placed on a beam of charged particles of known type and momentum, in an energy range of 0.2 to 2.0 GeV. The aim is to characterize the signal from different particles in the LArTPC and to find criteria to discriminate among them.

LArIAT cryostat hosting the TPC placed in the beamline at FTBF - MCenter

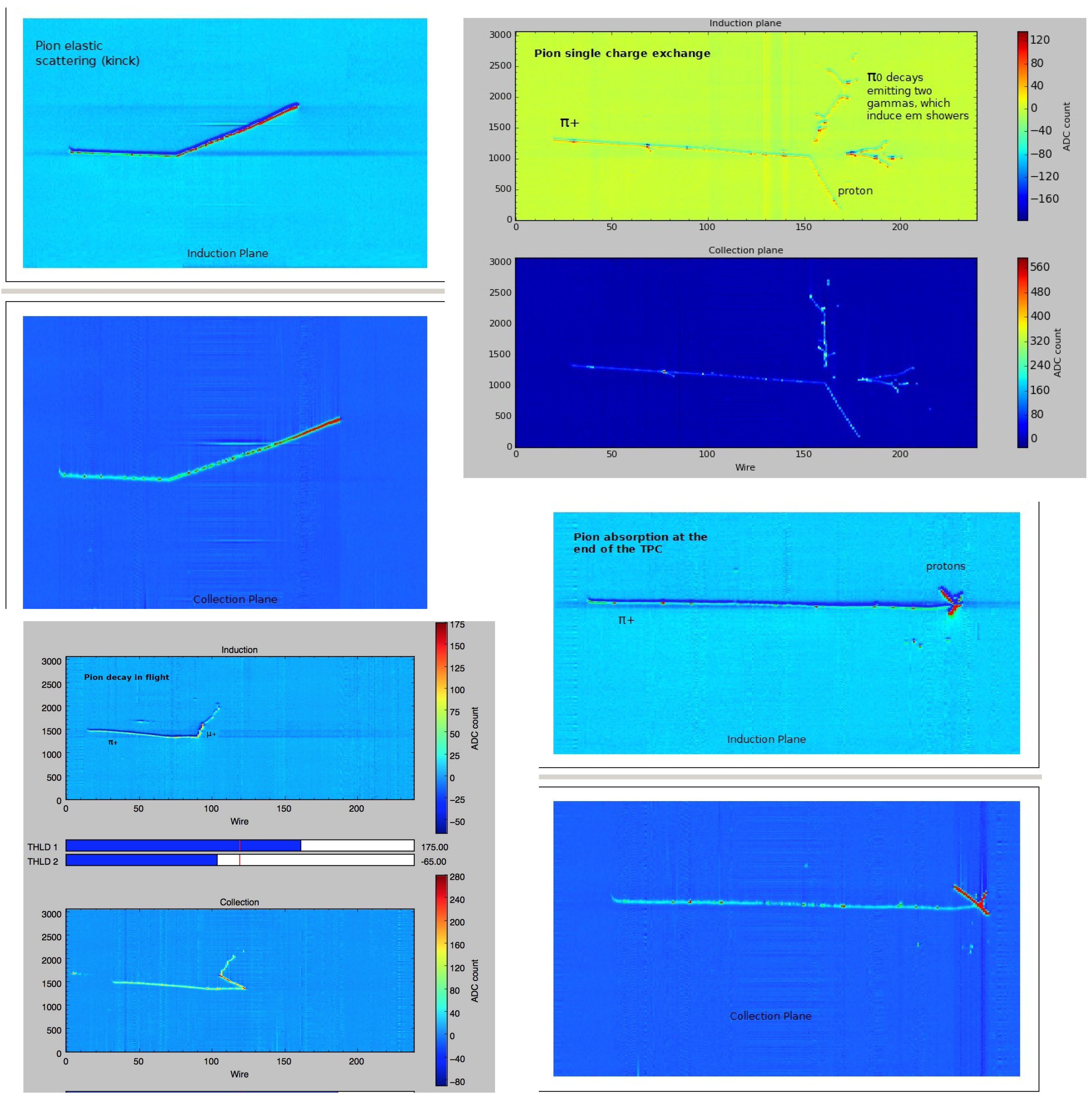


The TPC active volume is 47 cm (width) x 40 cm (height) x 90 cm (length – along beam axis), corresponding to a volume of 170 litres of Liquid Argon (90 K). There are three wire planes to see the drifting electrons inside the TPC. The anode wire spacing is 4 mm in all planes. Induction and collection planes wires are read with dedicated cold electronics (waveforms recorded by ASICS). Then the pulse signals are collected and analysed through LArSoft, a dedicated framework for Liquid Argon TPC tracks reconstruction. So it is possible to have the 2-D track reconstruction on the Induction and Collection plane, that is useful to study the topologies of the interactions of incoming particles with Argon nuclei. Eventually, the 3-D reconstruction of the event is obtained by matching the hits/clusters having the same drift time in the two views. Next step would be the analysis of single and multiple reconstructed tracks for calorimetry and cross section studies and for a complete characterization of the LArTPC response.



Schematic of the LArIAT TPC and the reference frames adopted for 2D and 3D imaging of the ionization events.

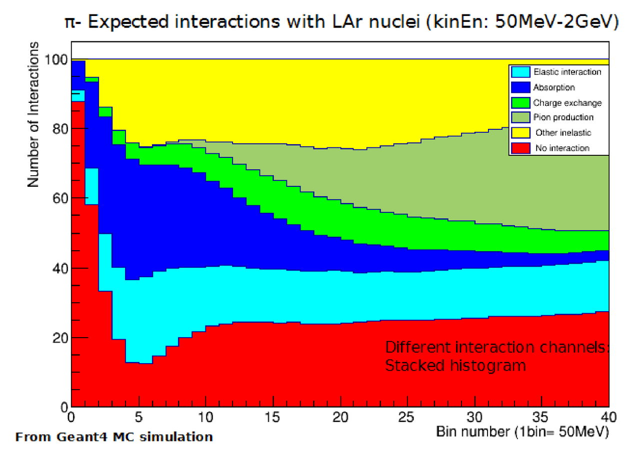
Pion interaction events in the TPC from the TestBeam runs (from May 2015):



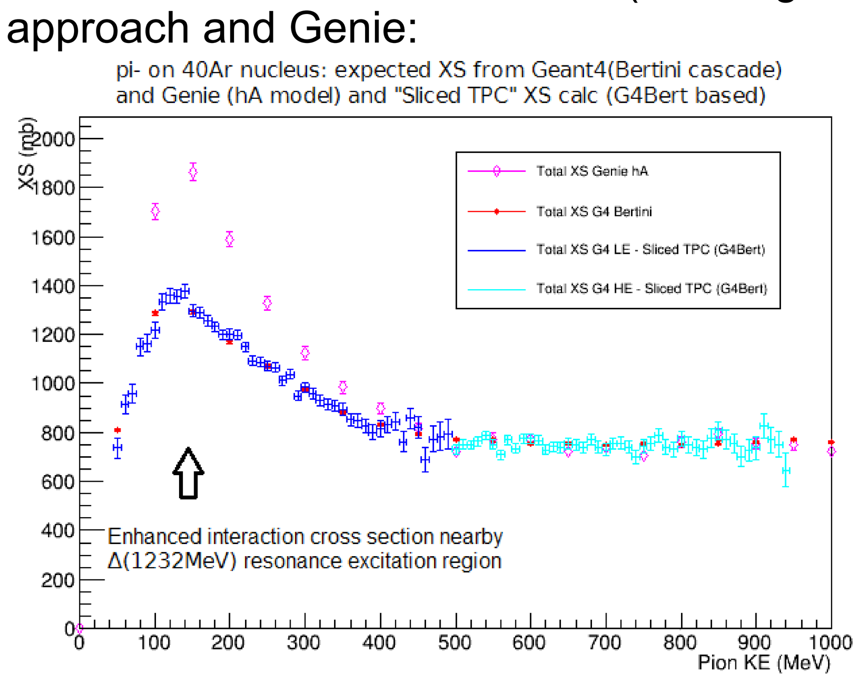
Pion interactions with nuclei have an important role for neutrino physics. One of the major sources of systematic uncertainty in precision neutrino oscillation measurements is the uncertainty on pion-nucleus interaction cross sections. Pions are frequently produced in neutrino interactions with nuclei for neutrino energy Eν in the GeV range and they have very large interaction cross sections with nuclei, especially nearby the Δ resonance region.

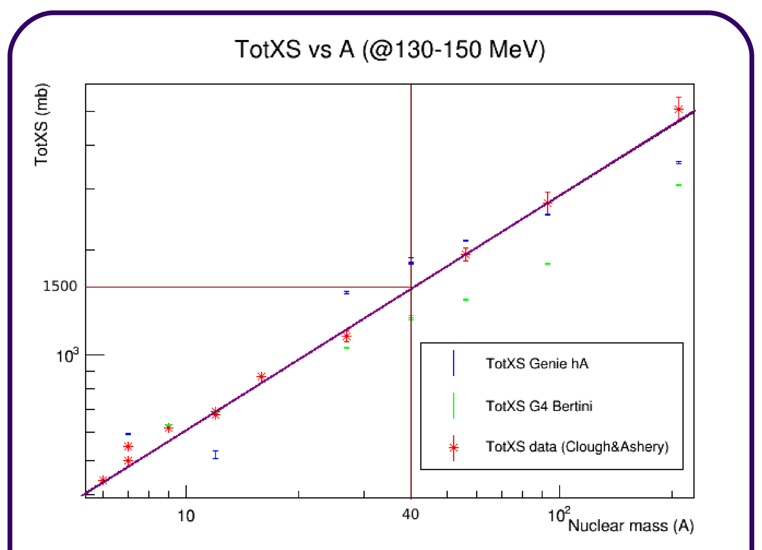
Charged pions interaction channels with nuclei:

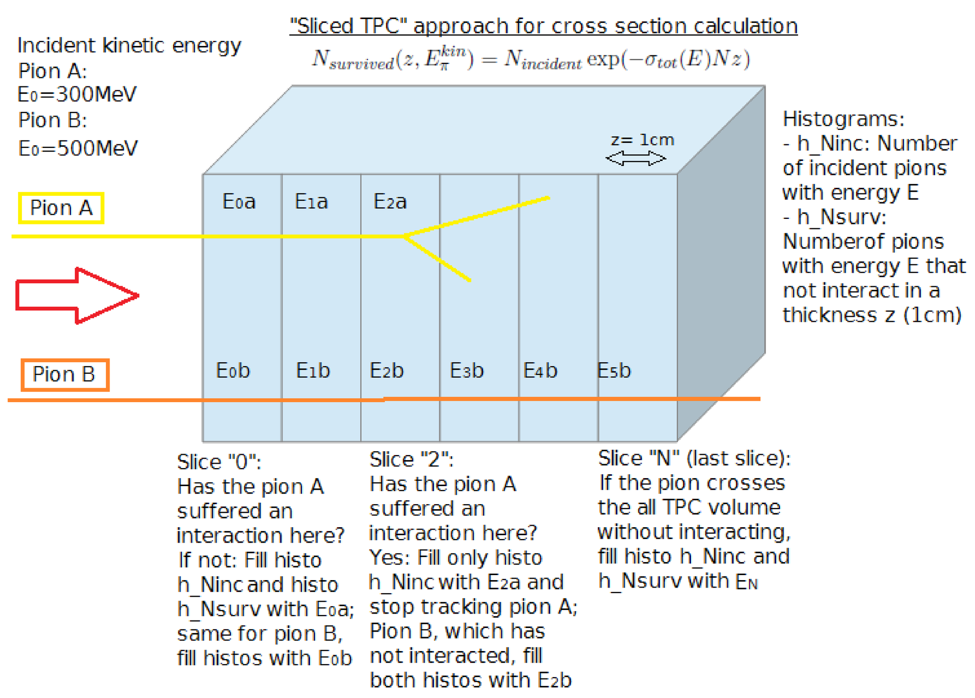
- Elastic scattering
- Inelastic scattering (Delta resonance excitation)
- Absorption (2-body, 3-body)
- Charge exchange (single, double)
- Pion production (>500 MeV, pion kinetic energy)

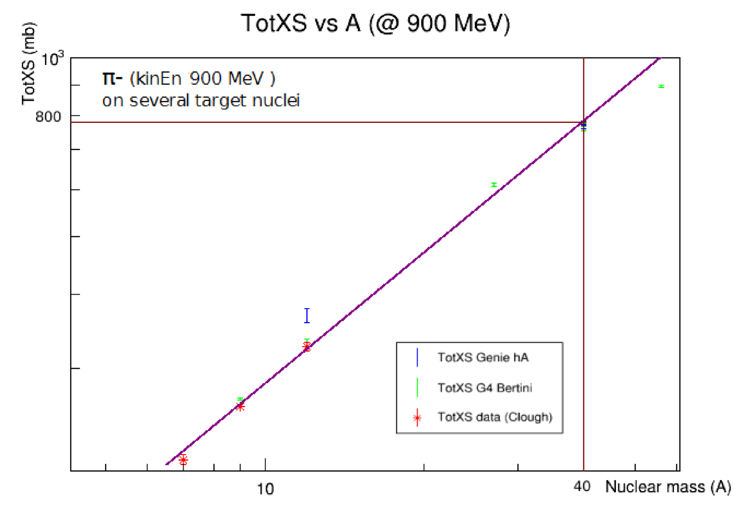


Expected pion – ^{40}Ar nucleus cross section dependence on pion kinetic energy from MC simulations in Geant4 (thin target and LArTPC target-"Sliced TPC" approach and Genie:



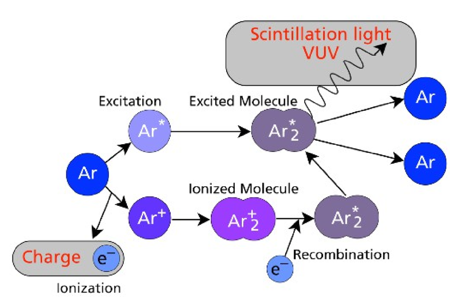




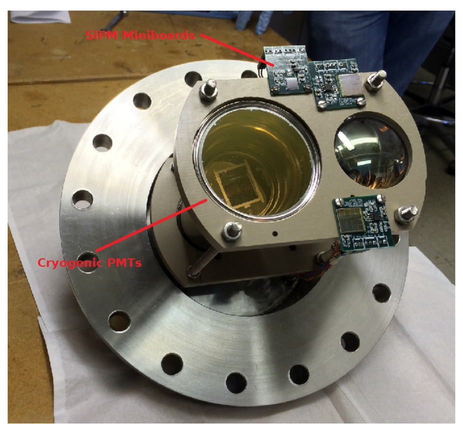


Next studies in LArSoft framework: Reconstruct pion tracks from data collected at the testbeam, apply the "Sliced TPC" cross section calculation to them and compare with MC simulations.

Light collection system:



While the LArTPC is used to collect and measure the ionization electrons generated by charged particles that pass through LAr, there is also an interest in studying the Argon atoms that are excited or ionized by the primary particles and then can pair with neutral argon atoms to form an excited molecule, which subsequently decays by emitting an ultraviolet 128 nm scintillation photon (τf = 5 ns, τs = 1260 ns).



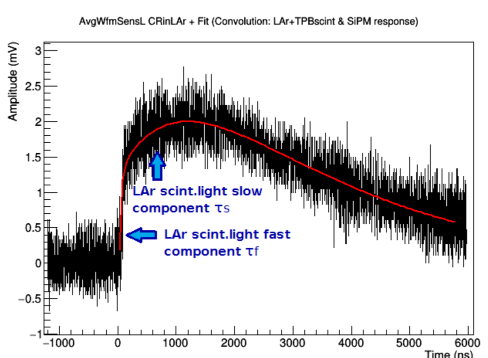
The light collection is performed with optical devices: two cryogenic PMTs and three SiPMs mounted inside the cryostat. The SiPM preamplifier boards were custom-designed for LArIAT.

The LAr scintillation UV photons are wavelength shifted into optical (428 nm) by covering the whole TPC with TPB (Tetraphenyl butadiene) evaporated reflective foils.

The scintillation light readout is now used only for triggering purposes and measure of ToF; the aim is to extend its use for calorimetric energy reconstruction.

Study and characterization of LAr scintillation signals collected by SiPMs:
Single channel SiPM SensL MicroFB 60035

- Sipm signal preamp, Npe count (wfm from a beam event) ???



48th Fermilab Users Meeting, New Perspectives 2015 June 8-9