NEWS*dm*

SHIELDING SIMULATION AND STUDIES ON CARBON ION SAMPLES

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Napoli group meeting
21/12/2018

Introduction

- Simulation results for 10 g mth and 10 Kg y experiments
  - Use OPERA emulsion films for the reduction of cosmic background
- Studies on Carbon ion samples
  - Track length threshold achieved with Elliptical shape and Plasmon analysis

SHIELD SIMULATION FOR
10 g mth
10 Kg y
experiments

V. Gentile

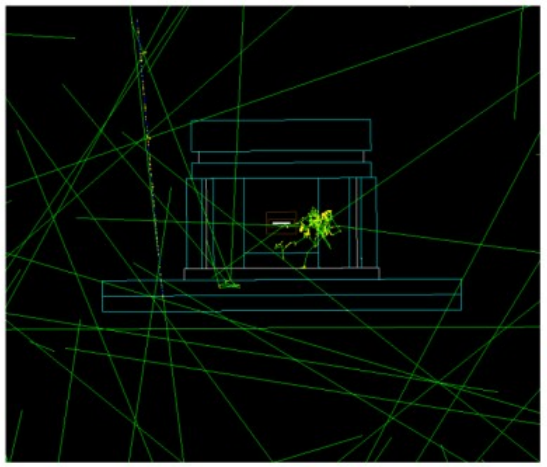
Physical background sources

	Source	Flux
External →	Environmental gammas	$0.35\ \mathrm{cm^{-2}\ s^{-1}}$
	Environmental neutrons	$8.7 \times 10^{-7}\ \mathrm{cm^{-2}\ s^{-1}}$
	Cosmogenic neutrons	$7.3 \times 10^{-10}\ \mathrm{cm^{-2}\ s^{-1}}$
	Cosmic Muons	$0.3 \times 10^{-7}\ \mathrm{cm^{-2}\ s^{-1}}$
Internal →	Radiogenic neutrons	$1.2\ \mathrm{Kg^{-1}\ y^{-1}}$
	Intinsic β-rays	$7.3 \times 10^{8}\ \mathrm{Kg^{-1}\ y^{-1}}$

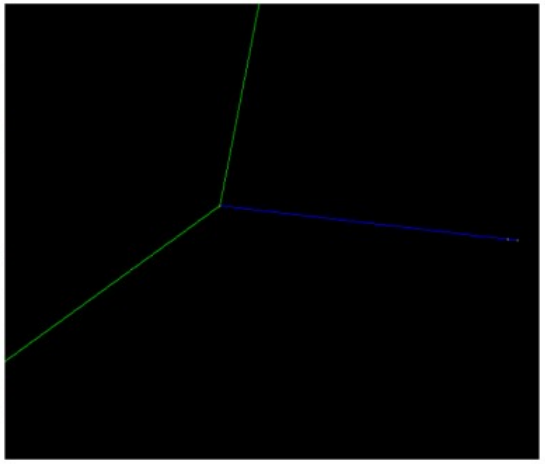
Physical background sources for NIT emulsion at LNGS

Geant4 simulation

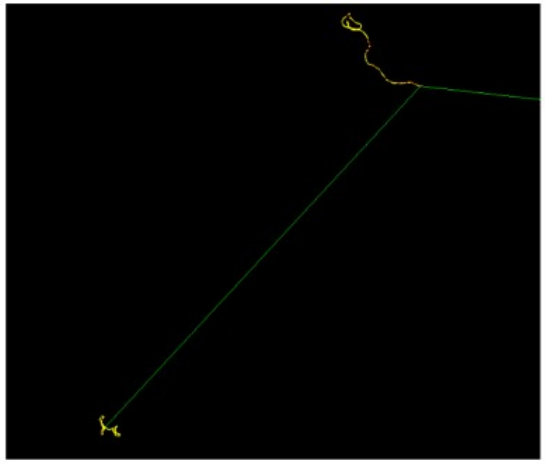
A Geant4 simulation has been performed to evaluate the event rate induced by each background source



Event display of multiple particles

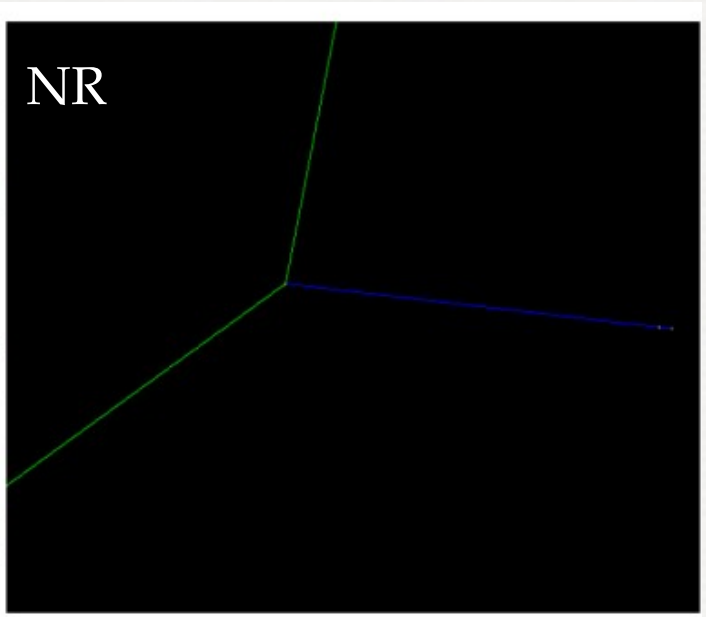


Nuclear recoil

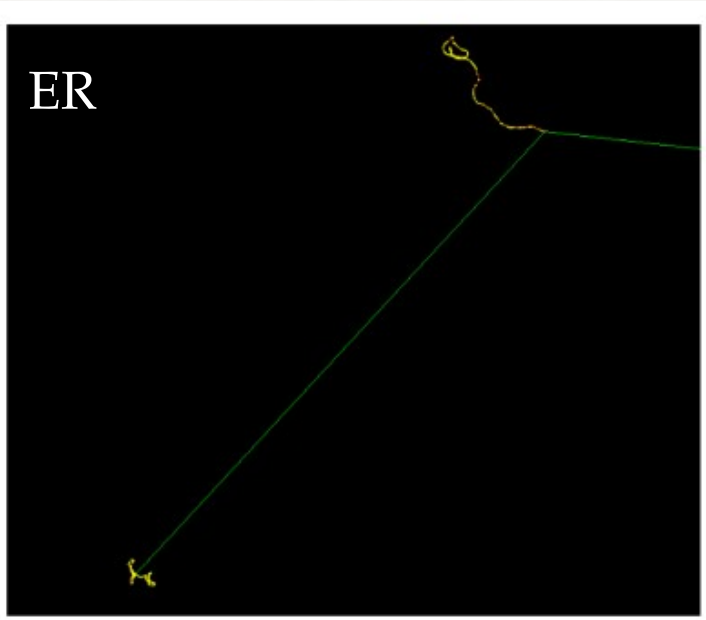


Electron recoils

Nuclear and electron recoils



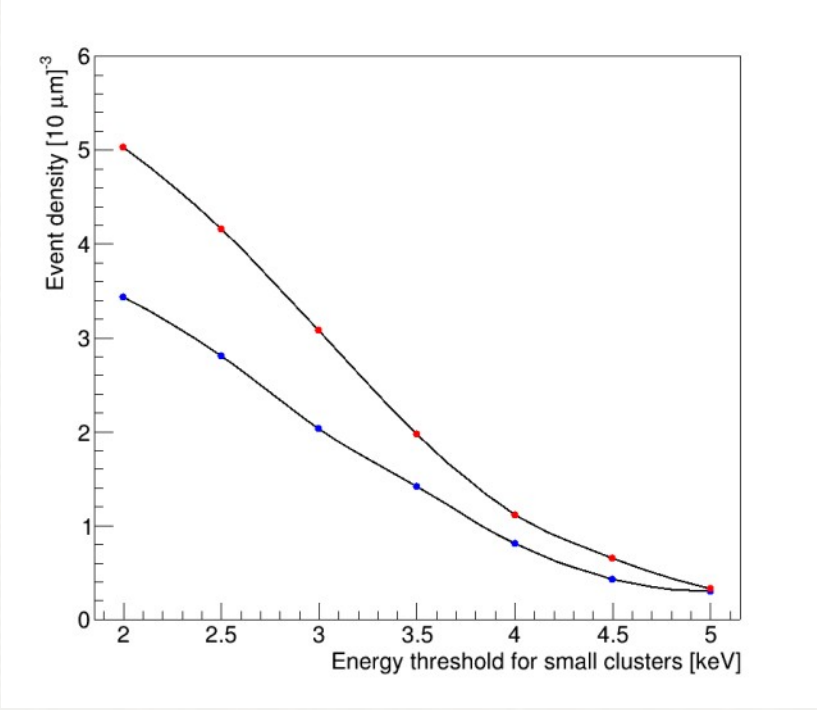
Track length is defined as the distance between the first and the last step



A clustering approach (DBSCAN) has been used to evaluate the number of grains sensitized

Electron recoils

Calibration performed with ^{241}Am (γ~60 MeV)



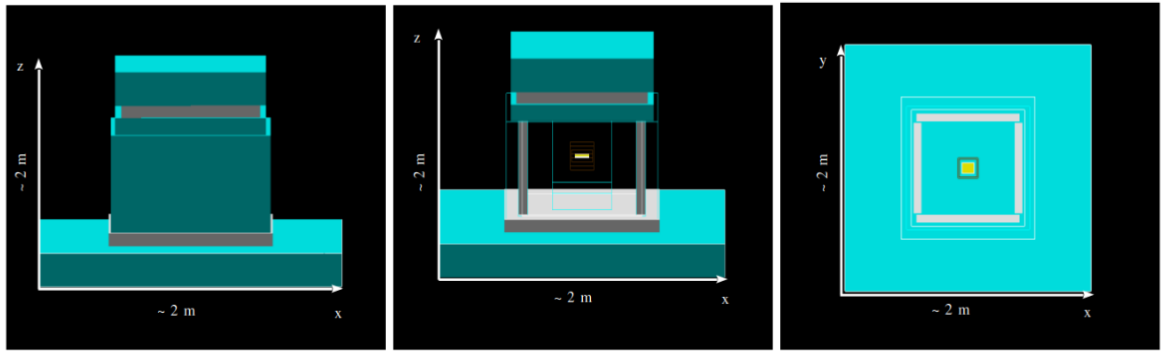
The minimum energy to sensitize a grain is assumed to be ~ 4 keV

Recently Fukuzawa in Nagoya studied other samples exposed to ^{60}Co, ^{137}Cs.

^{60}Co (γ~1 MeV)
^{137}Cs (γ~0.6 MeV)

Data have been shared and will be used to confirm the assumed threshold

10 g mth experiment



(A) (B) (C)

FIGURE 4.14: Shielding for 10g × mth: lateral view (A), axonometric view (B) and top view (C).

Source	Exposure $[10\,\mathrm{g\,mth}]^{-1}$	SR events	Rate $[10\,\mathrm{g\,mth}]^{-1}$
Environmental gammas	0.1	31	310 ± 56
Environmental neutrons	5	0	$< 4.7 \times 10^{-2}$ (90% C.L.)
Cosmogenic neutrons	883	6	$(6.8 \pm 2.8) \times 10^{-3}$
Cosmic Muons	3.1	0	$(1.7 \pm 1.0) \times 10^{-4}$ (90% C.L.)

TABLE 4.3: Estimation of the background rate, normalized to $[10\,\mathrm{g\,mth}]^{-1}$, induced by the external sources for the technical test.

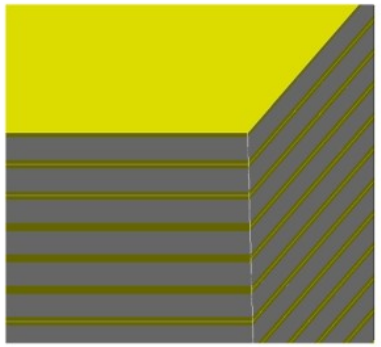
10 Kg y experiment

Aim: study of different material for the NEWSdm shielding

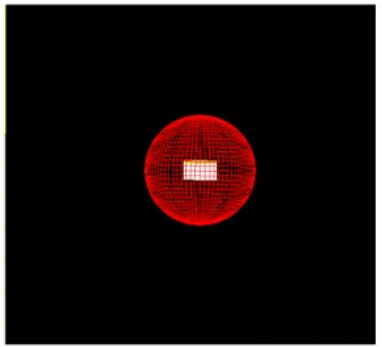
Goal: reach a background rate less than 1 event per 10 Kg per year

Technical details:

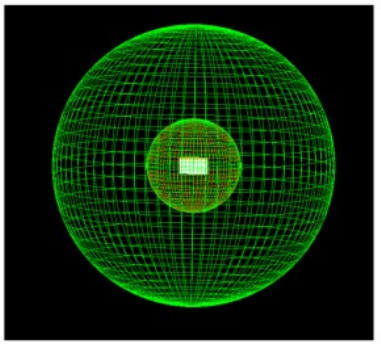
- NIT density = 3.43 g cm^{-3}
- Film thickness = 50 um
- Film surface = 36 x 30 cm^2
- Base thickness = 1 mm
- No. films for 10 kg = 540
- Height of the stack = 56.7 cm
- Radius of the inner shell = 50 cm

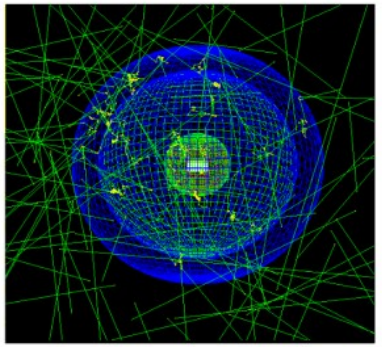


(A)

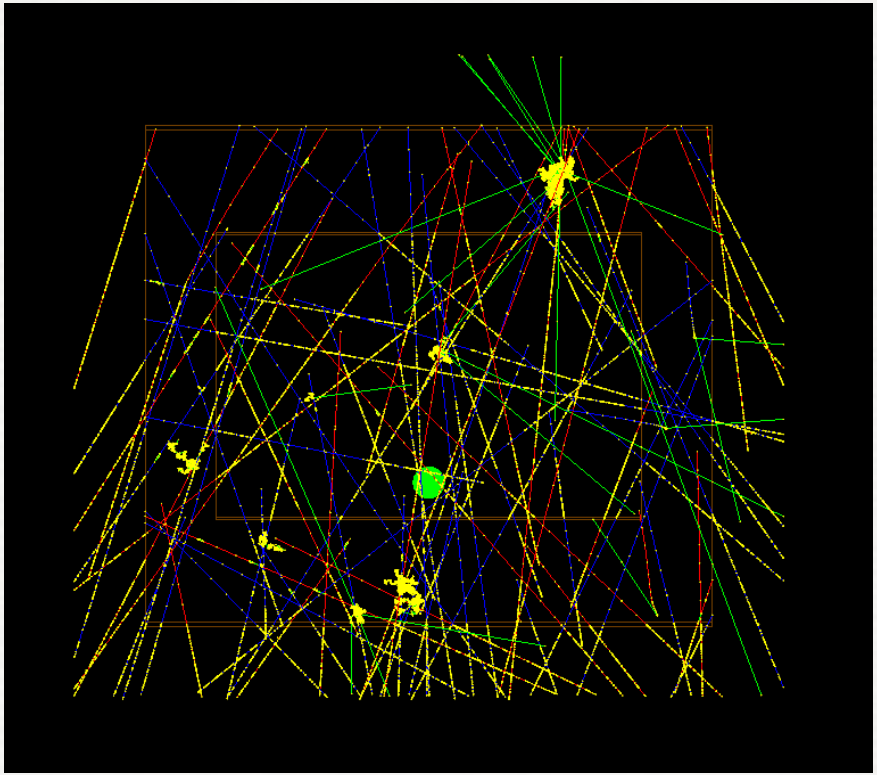


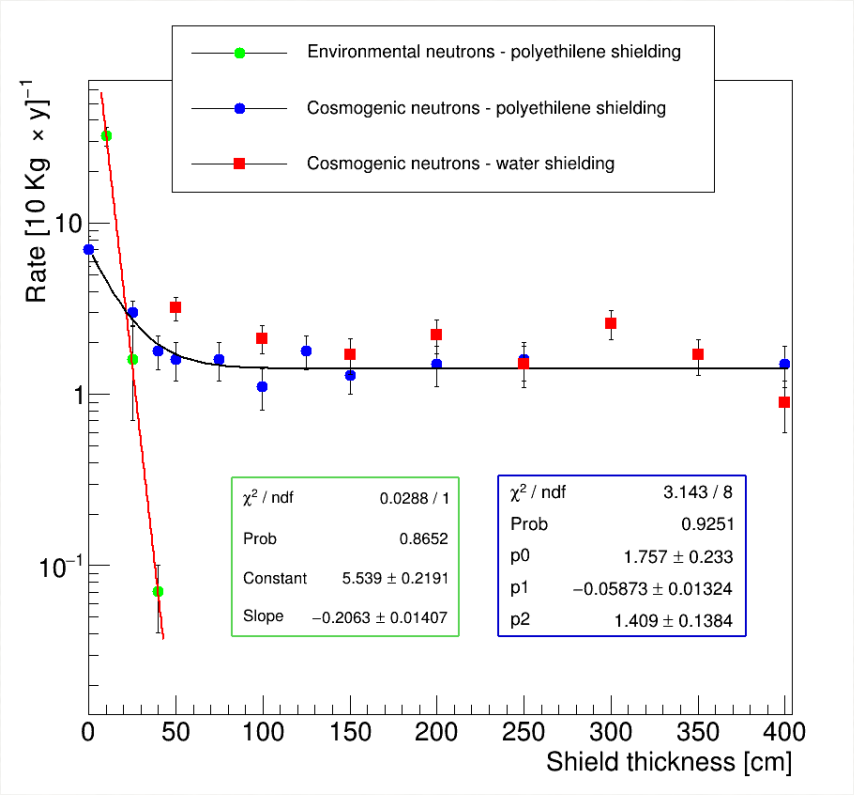
(B)





10 Kg y experiment

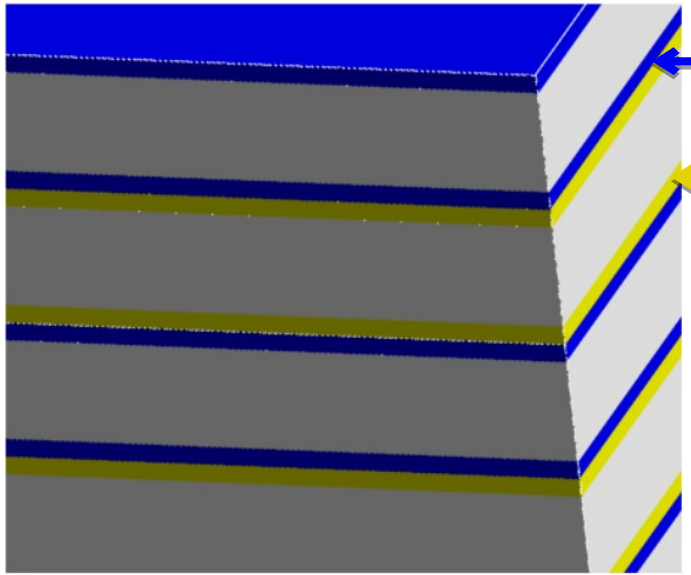




A shield made of 100cm of Polyethylene ensures a background rate of 1.4 Kg^{-1} y^{-1}

10 Kg y experiment

Only chance to reduce the rate of background events induced by muons is the use of **OPERA-like** emulsions

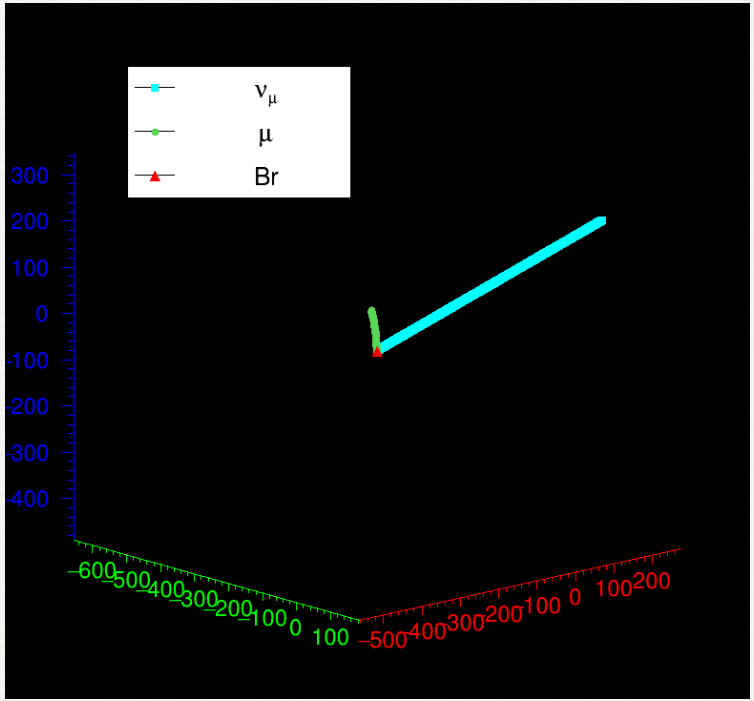


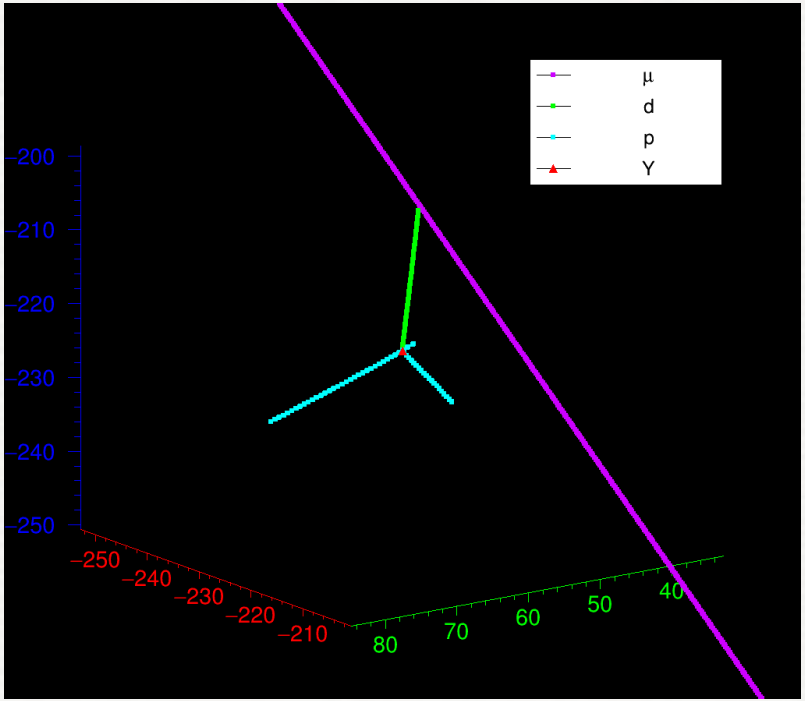
OPERA-like films added as a veto between consecutive NIT films

10 Kg y experiment

Preliminary analysis based on visual inspection of event displays used to evaluate background reduction

25% REDUCTION





SIMULATION AND ANALYSIS OF CARBON ION SAMPLES

V. Gentile

CARBON ION SAMPLE

Aim: study of plasmon analysis with carbon ion samples

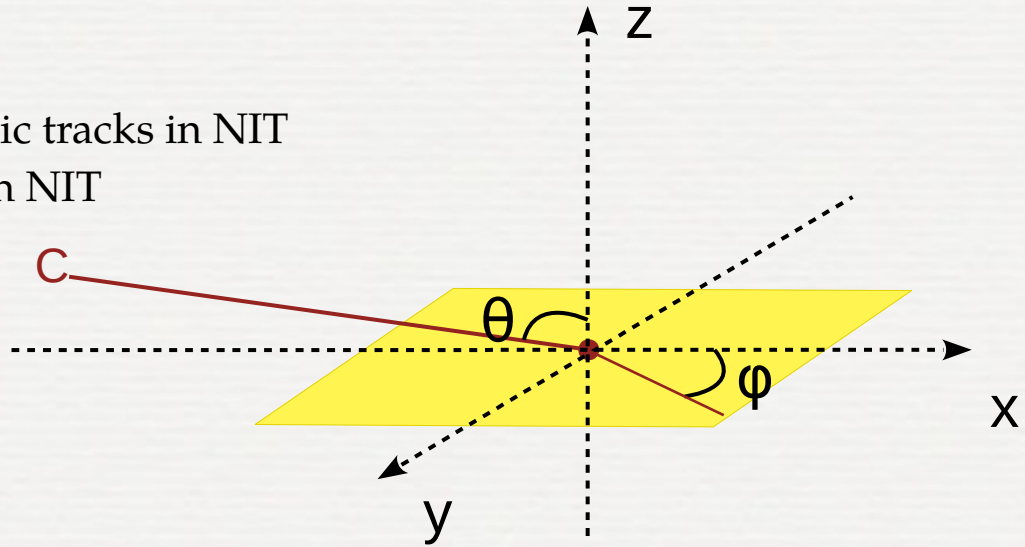
Goals:

- exploit resonance effect of polarized light to measure the direction of carbon tracks
- Evaluation of identification efficiency with plasmon analysis
- Estimation of track length threshold

Horizontal exposures to produce sub-micrometric tracks in NIT
Vertical exposure to produce at most one grain in NIT

Carbon ion implantation:

100keV	(Horizontal ~ 80°)	Signal-like
60keV	(Horizontal ~ 80°)	Signal-like
30keV	(Horizontal ~ 80°)	Signal-like
10keV	(Vertical ~ 10°)	Bkg-like

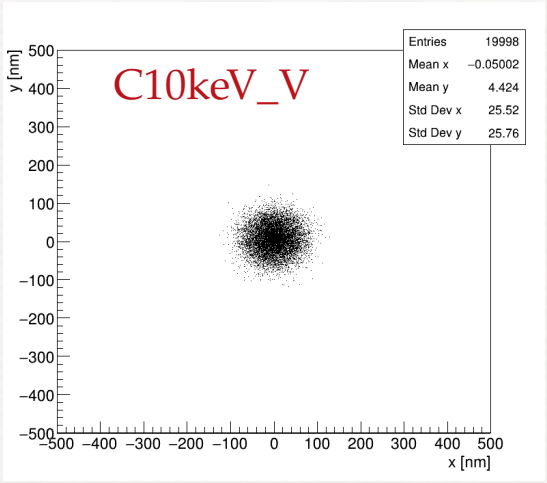


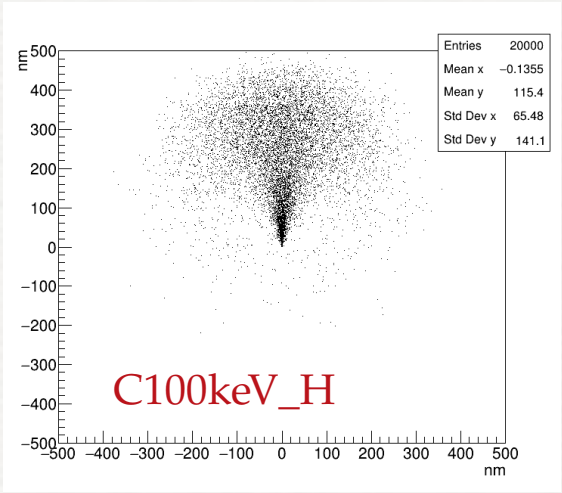
SRIM SIMULATION

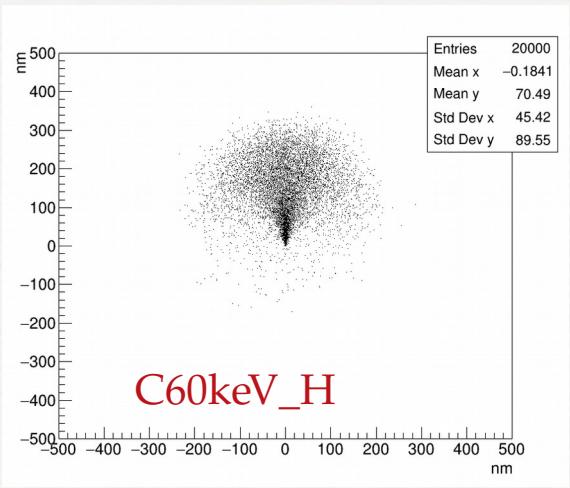
Simulation of carbon ions on NIT compound
3D position for all the hits of a track

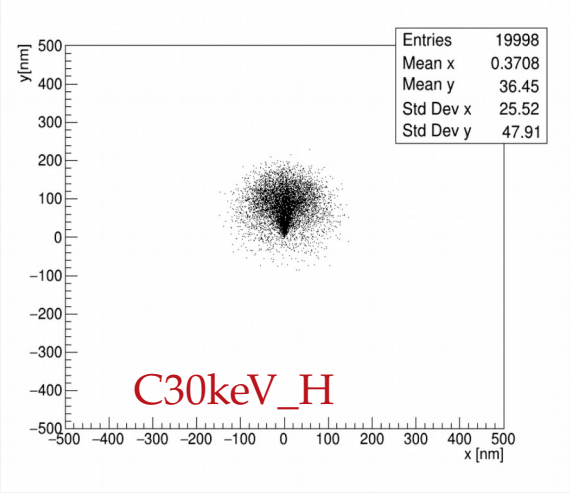
Projection of the first and last hit of the tracks in the emulsion plane

Scattering hides directional information for low energy ions



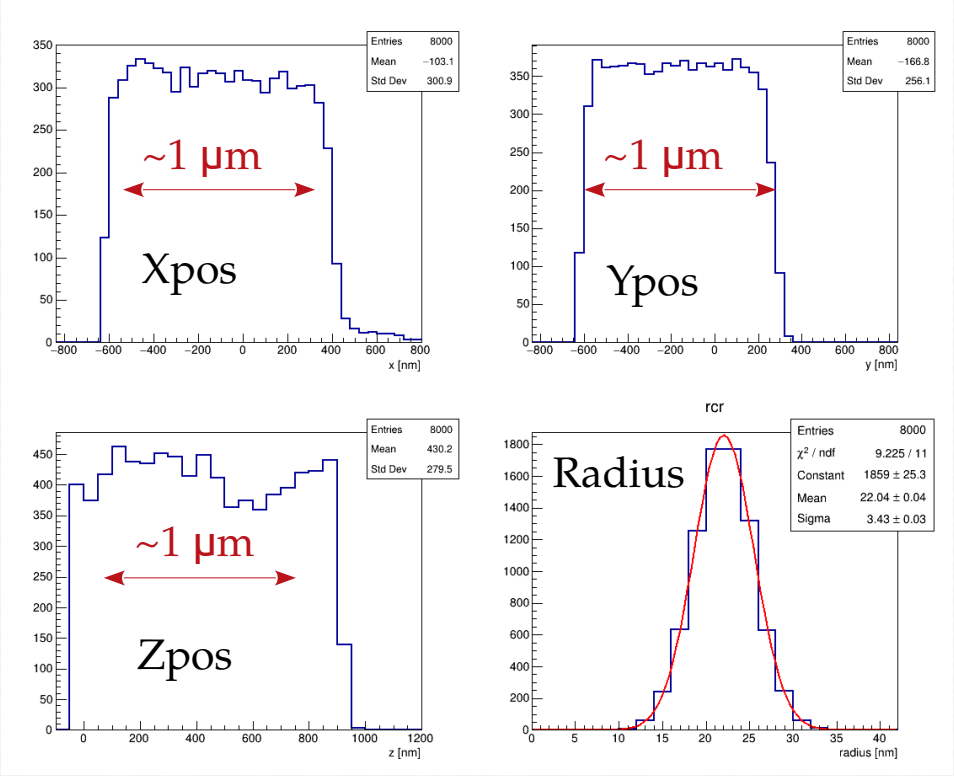






CRYSTALS SIMULATION

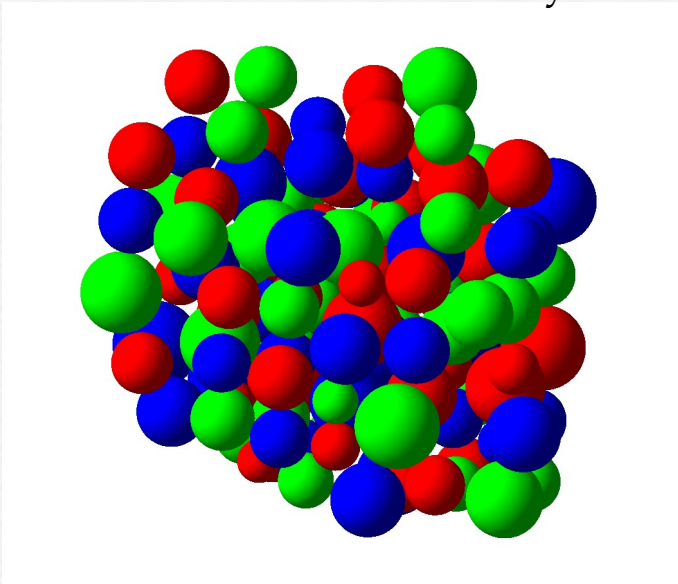
Simulation of crystals in μm^3 of NIT



Crystal radius generated with a gaussian distribution (22.04, 3.43) nm

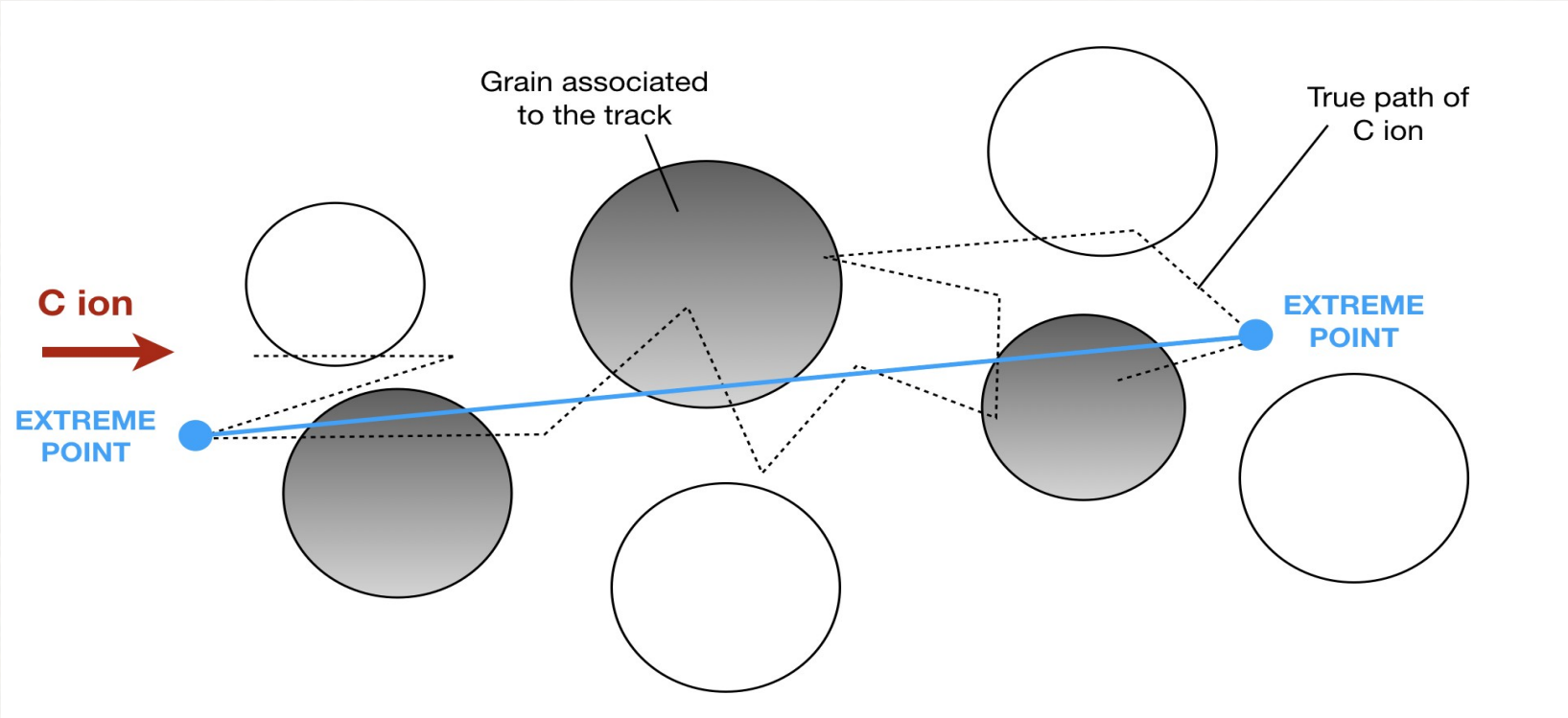
Volume density ~ 0.45

Illustration of simulated crystals



CRYSTALS + SRIM SIMULATION

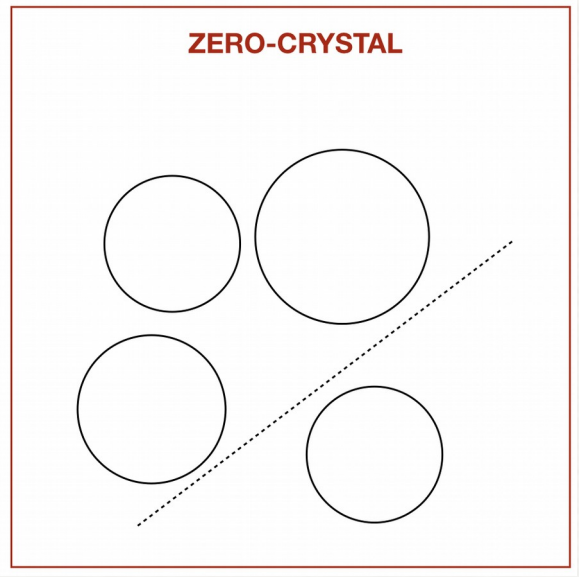
Each event generated by SRIM has been translated in the crystal framework



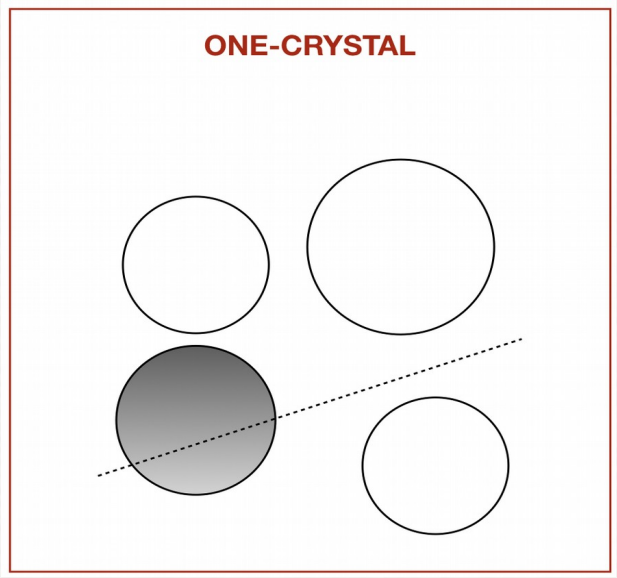
CRYSTALS + SRIM SIMULATION

Each event generated by SRIM has been translated in the crystal framework

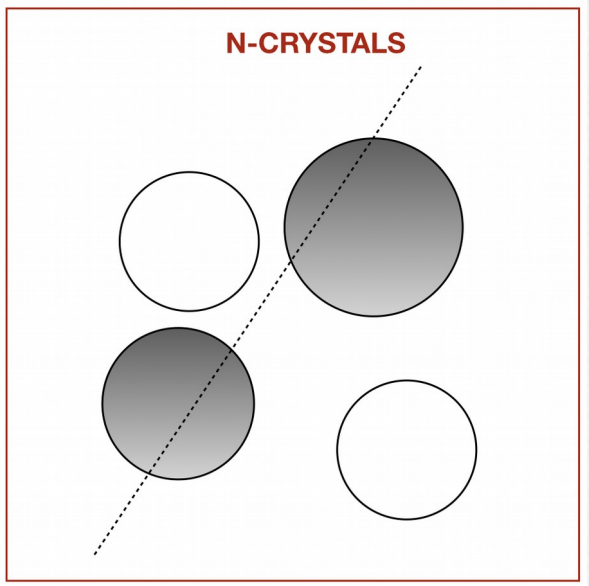
Not detected



Bkg-like



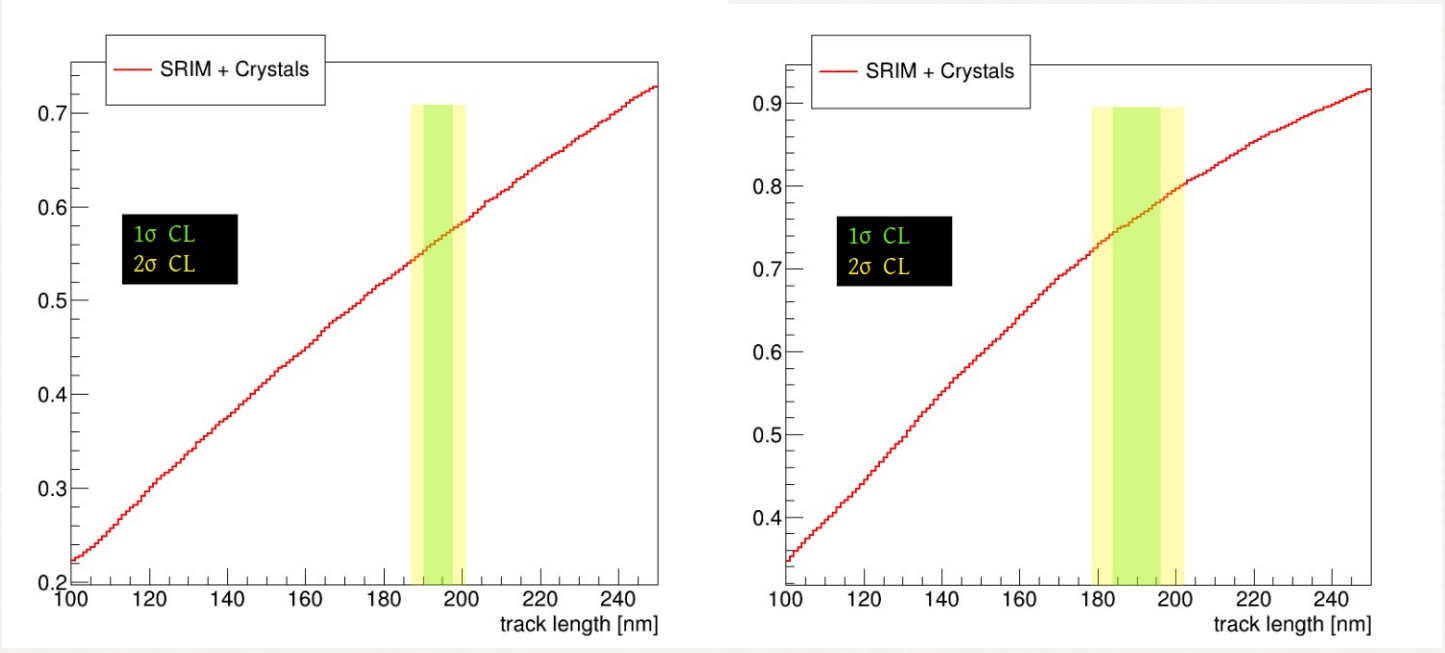
Signal-like



For n-crystals the track length is constructed as the distance between two randoms points in the nearby of the furthest crystals sensitized

SHAPE ANALYSIS

Clusters with elliptical shape hide more than one grains inside → They are n-crystals in simulation
It is possible to evaluate the track length threshold with the shape analysis by comparing the efficiencies achieved for C100keV and C60keV with the CDFs obtained by the model

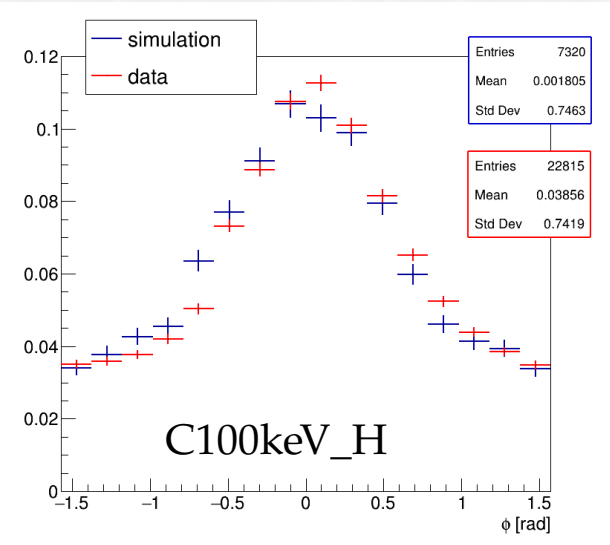


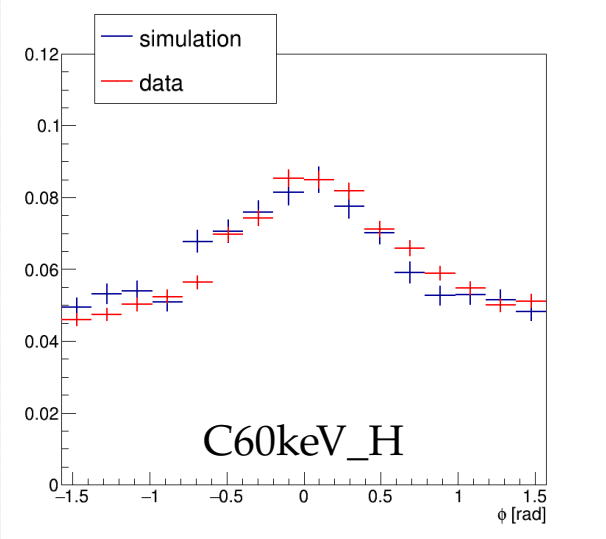
Track length threshold with shape analysis ranges around 185 nm

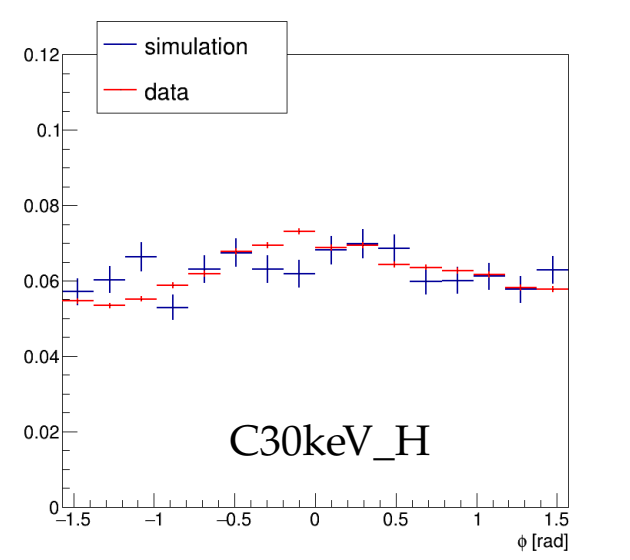
SHAPE ANALYSIS

A cross-check was performed to test the goodness of the model
Tracks with length smaller than 185 have been reconstructed with a random direction
2D angular distribution: Data / Monte Carlo comparison

Simulation and data are in agreement

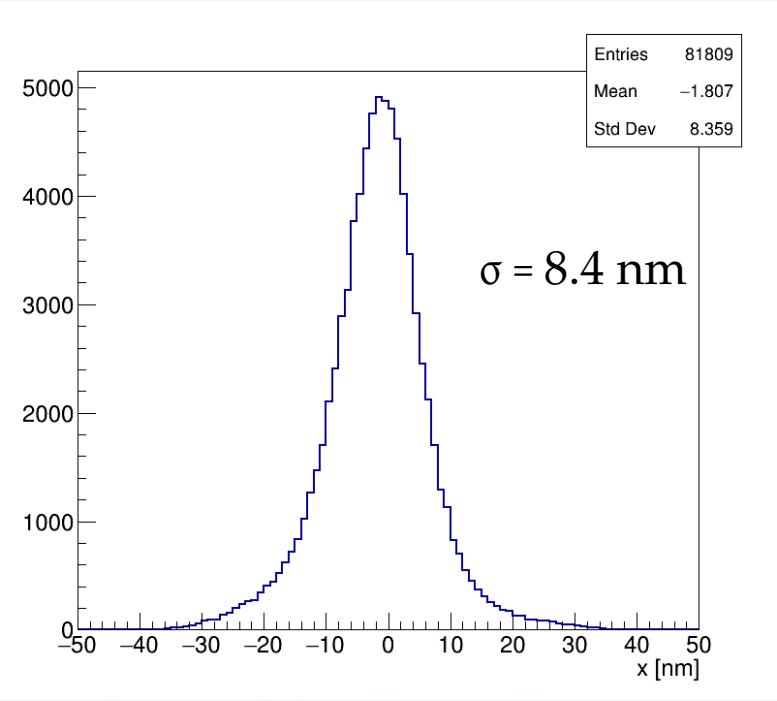




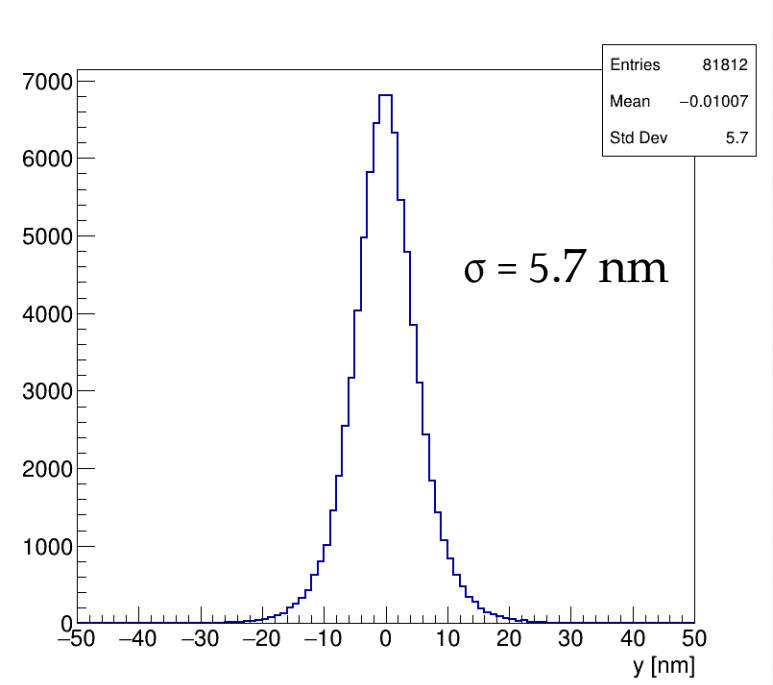


PLASMON ANALYSIS

The reference sample (C10keV_V) is used to evaluate the position accuracy and define the threshold for the barycenter shift



X – position accuracy



Y – position accuracy

PLASMON ANALYSIS

Accuracy (x): 8.4 nm
Accuracy (y): 5.7 nm

Simga: $(8.4^2 + 5.7^2)^{0.5}$ ~ 10 nm
Barshift cut (> 3σ) : ~ 30 nm

Isolated grains can be divided in two categories:

Static grains (under barshift cut)
Moving grains (over barshift cut)

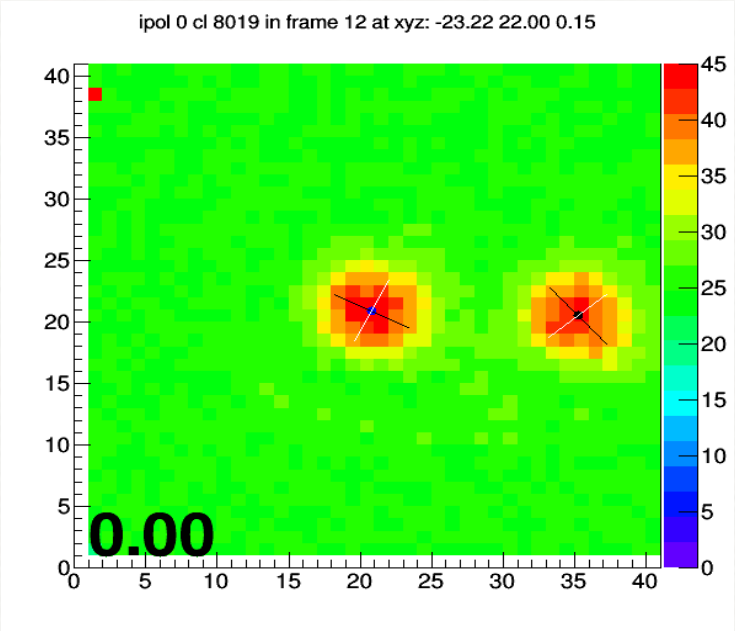
Study of dynamic sequence of best focus clusters for each polarization angle

Bfcl coordinates
(schematic representation)

Cluster moving their barycenter over the threshold show the LSPRs effect
They are considered signal-like events

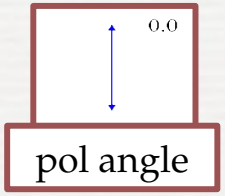
PLASMON ANALYSIS

Microtracks

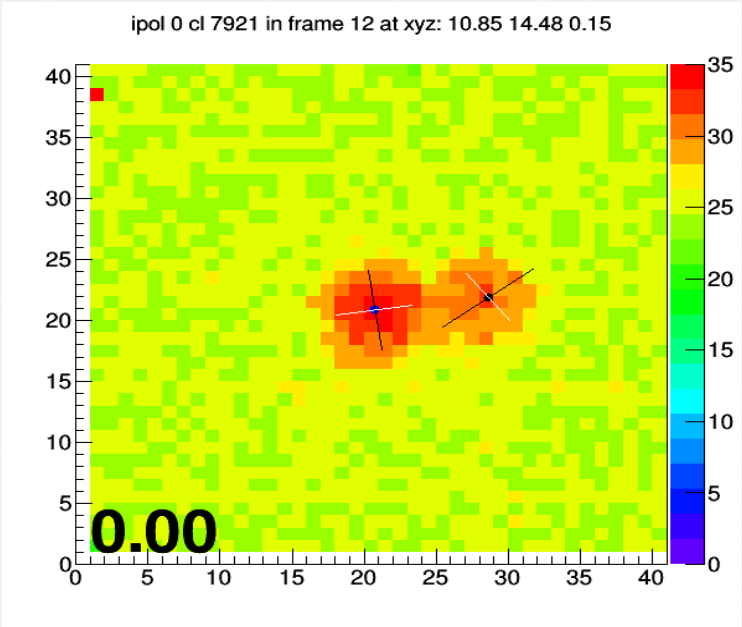


L = 404 nm

Φ ~ 4°



Npeaks



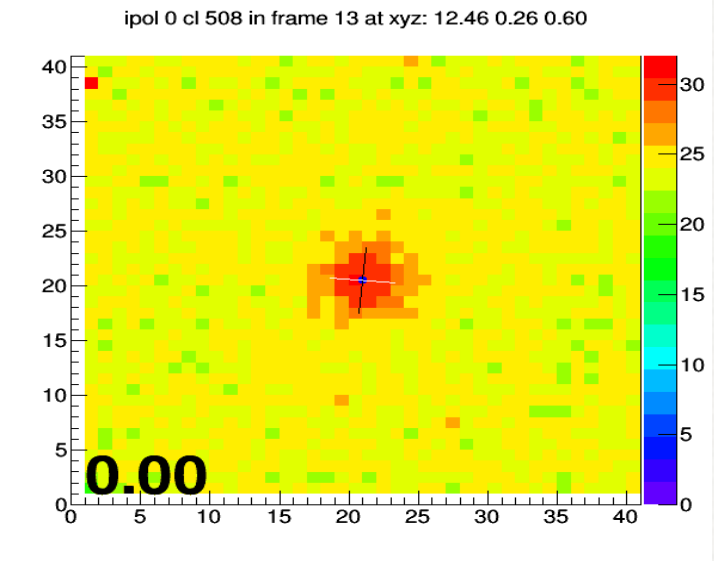
L = 216 nm

Φ ~ 4°

PLASMON ANALYSIS

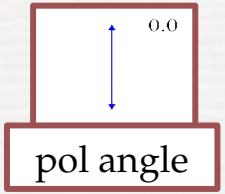
Dynamic sequence of best focus clusters for each polarization angle

Barshift = 14 nm

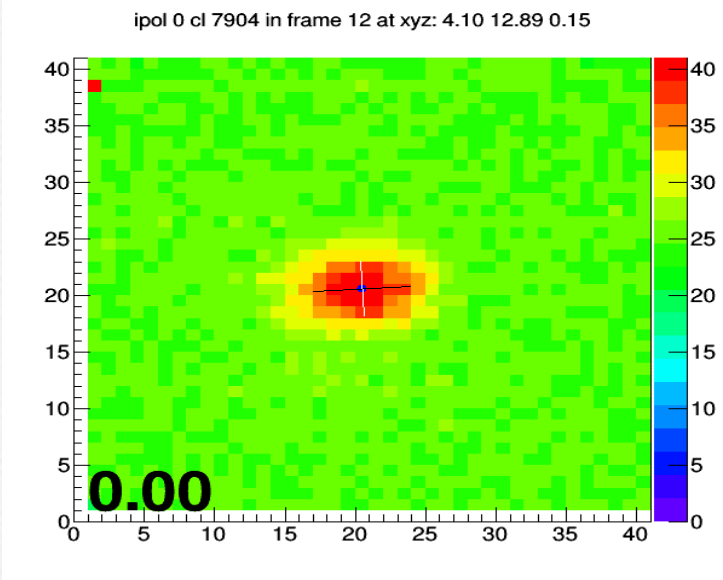


No Barycenter shift (10keV C ion)

Static grain



Barshift = 68 nm Φ ~ 4°



Barycenter shift (100keV C ion)

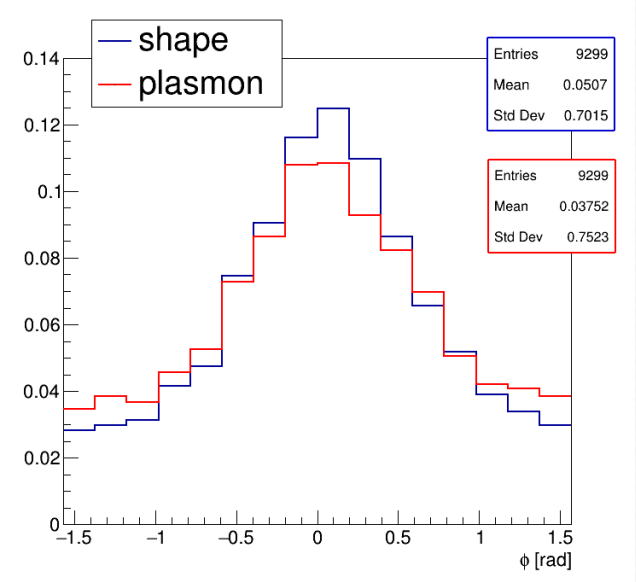
Moving grain

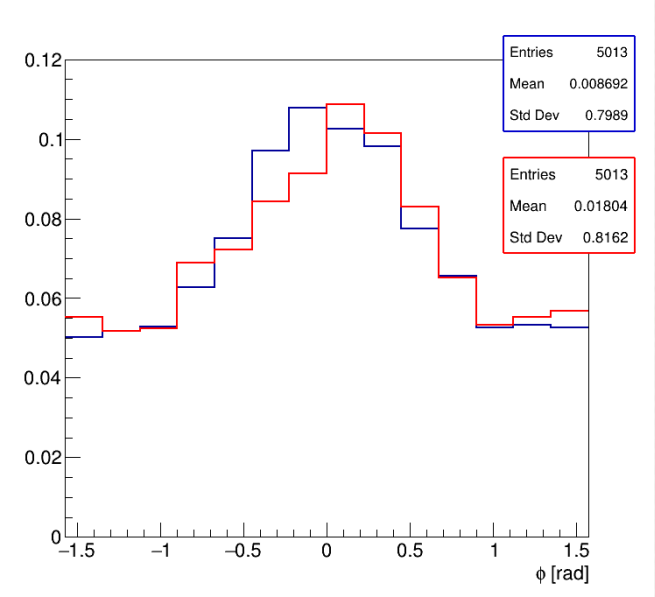
MOVING GRAINS

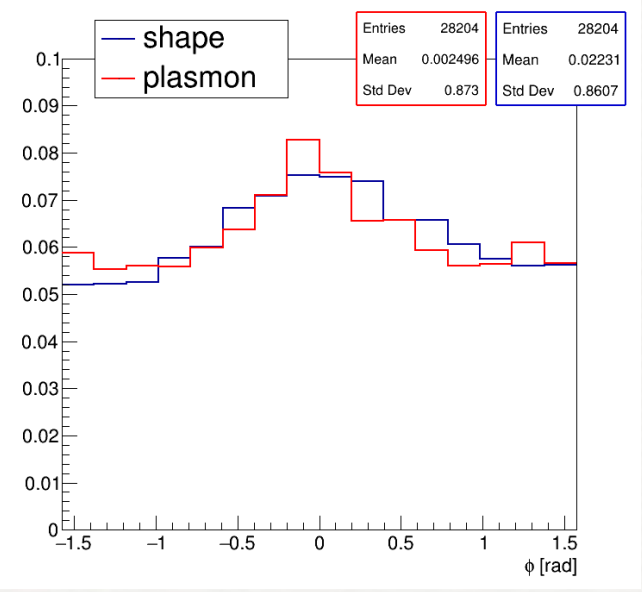
Moving grains 2D angular distribution

Shape analysis looks more precise in the directional reconstruction

In particular for C100keV_H and C60keV_H samples





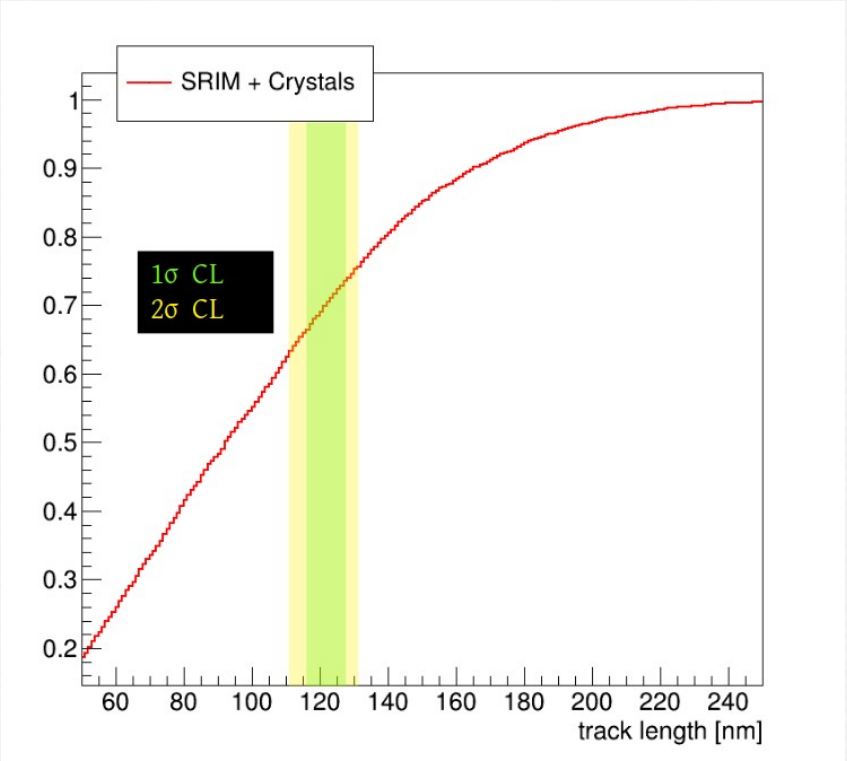


PLASMON THRESHOLD

Npeaks and Moving grains represent n-crystals in simulation

It is possible to evaluate the track length threshold with the plasmon analysis by comparing the efficiencies achieved for C30keV with the CDF obtained by the model

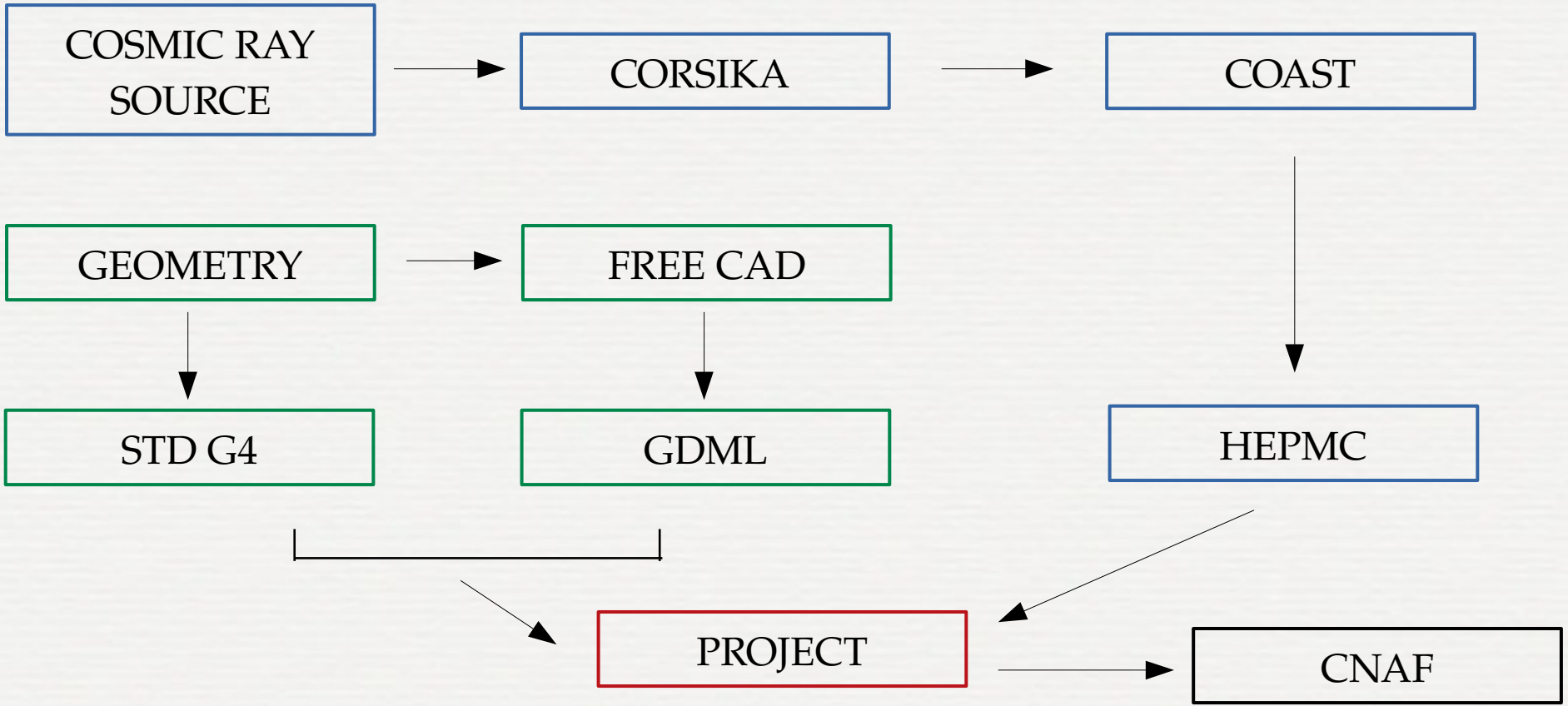
A track length threshold is obtained around 120 nm



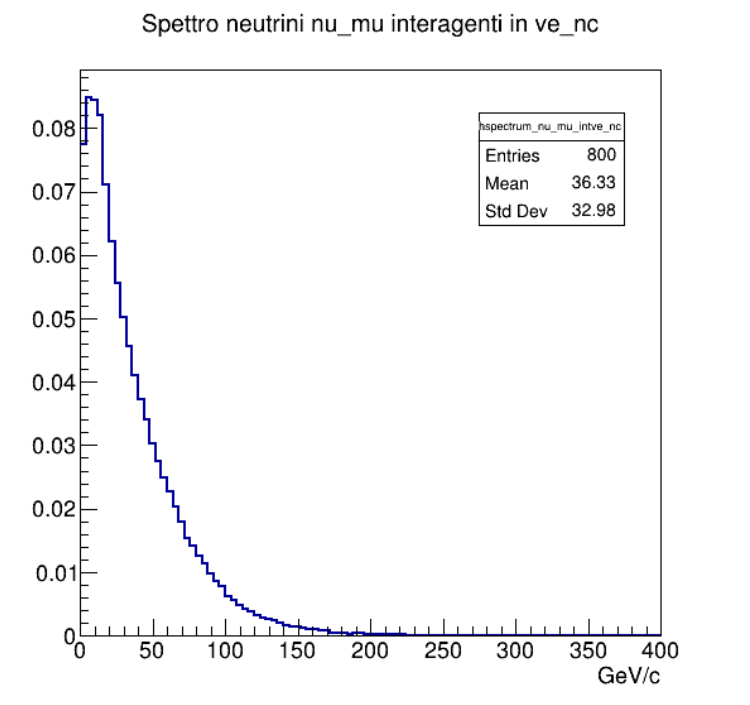
THANK YOU !

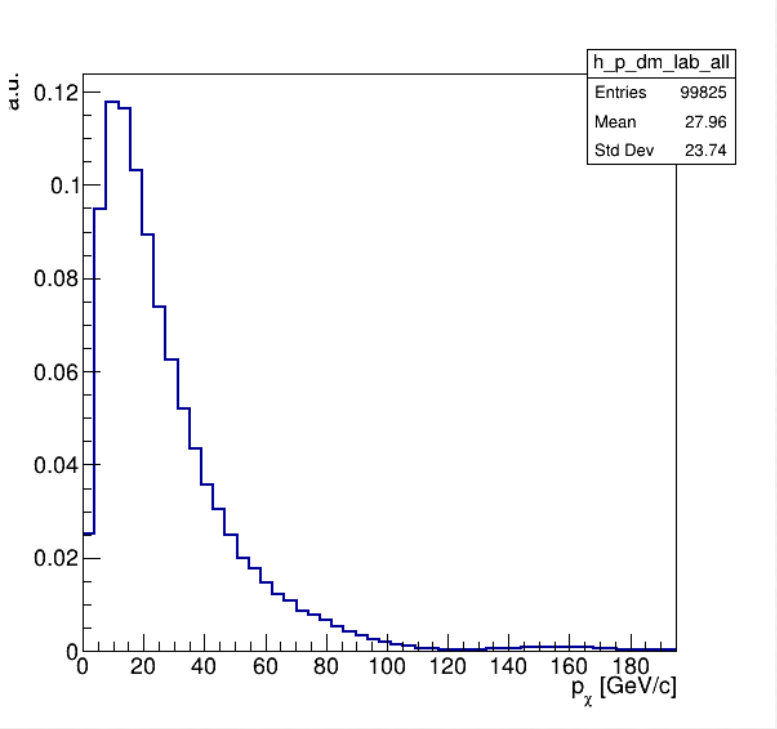
BACKUP

SIMULATION FOR MUON RADIOGRAPHY

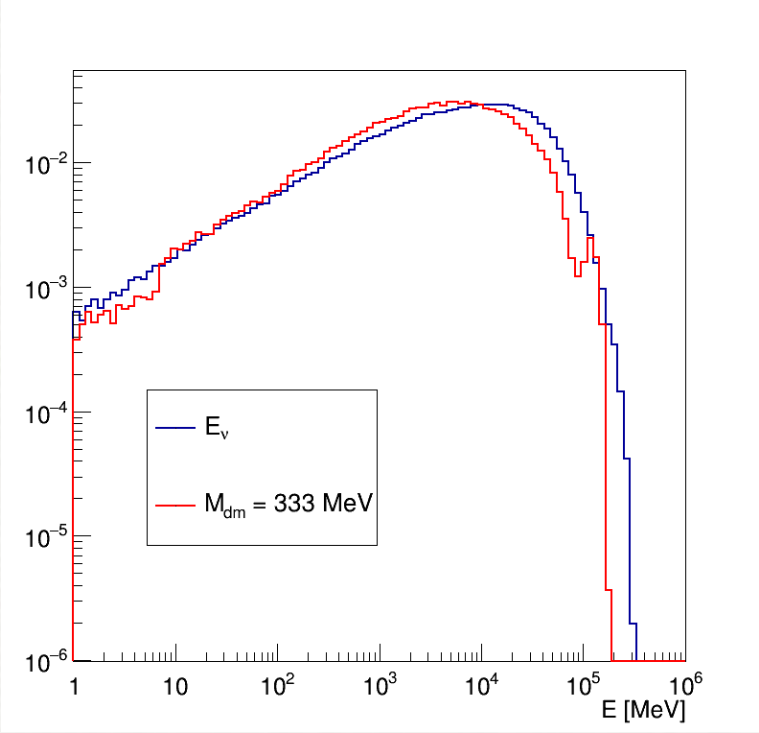


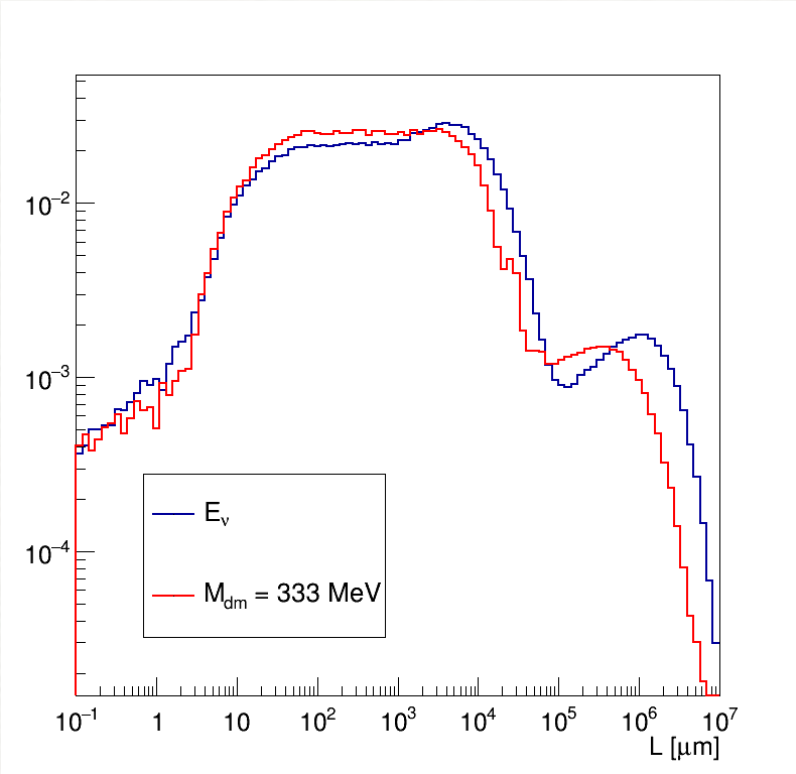
LDM WITH NIT EMULSIONS



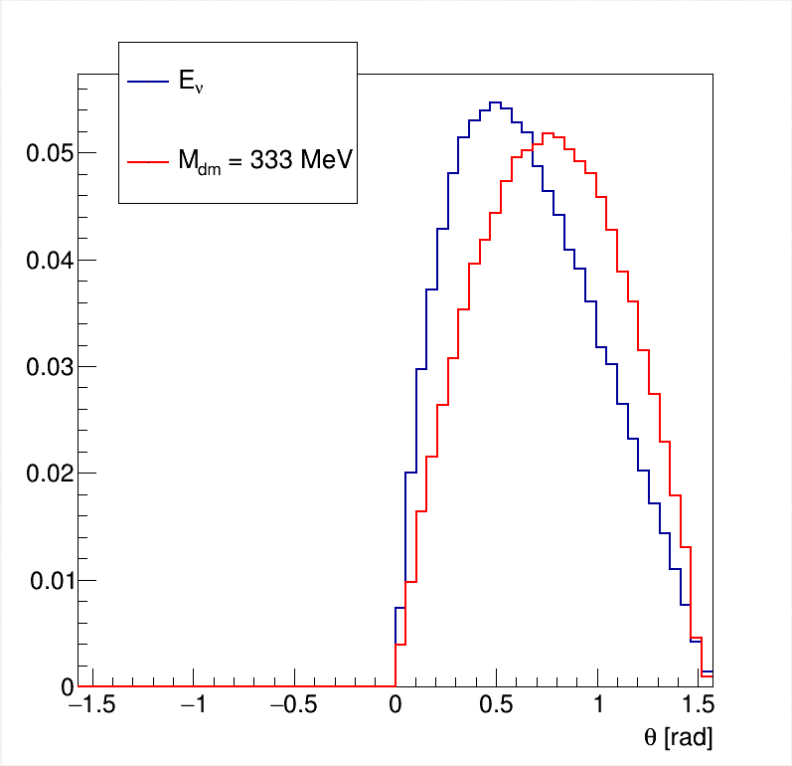


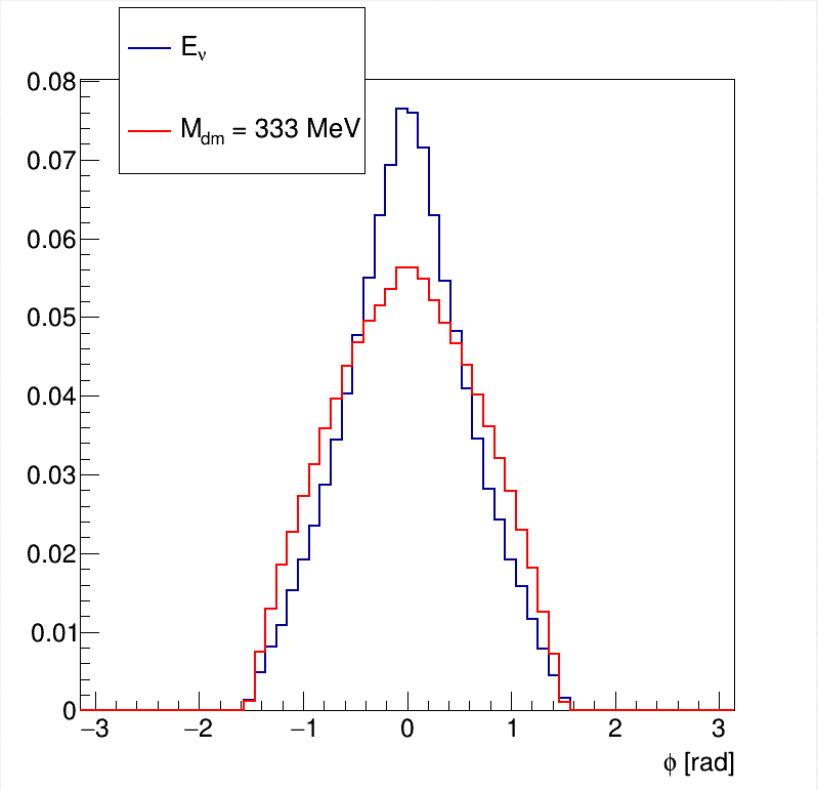
LDM WITH NIT EMULSIONS





LDM WITH NIT EMULSIONS





LDM WITH NIT EMULSIONS