Muon induced nuclear recoil cross-section measurement

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@NEWS meeting

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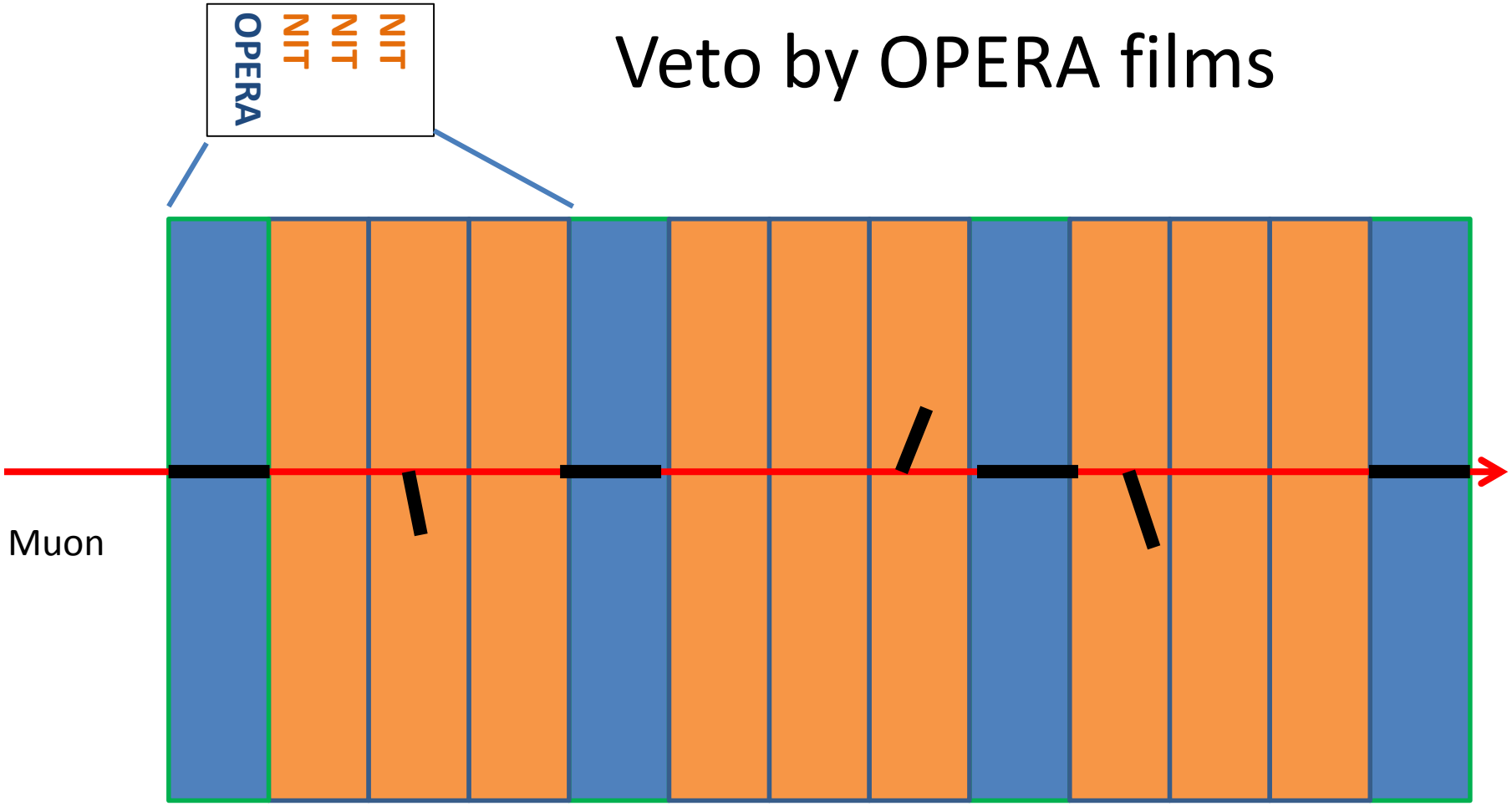
Motivation

- How many CNO recoils could be induced by cosmic ray muons ?

- Veto for such recoils with OPERA type films should be demonstrated .
- Muon beam test should be considered.

Veto by OPERA films

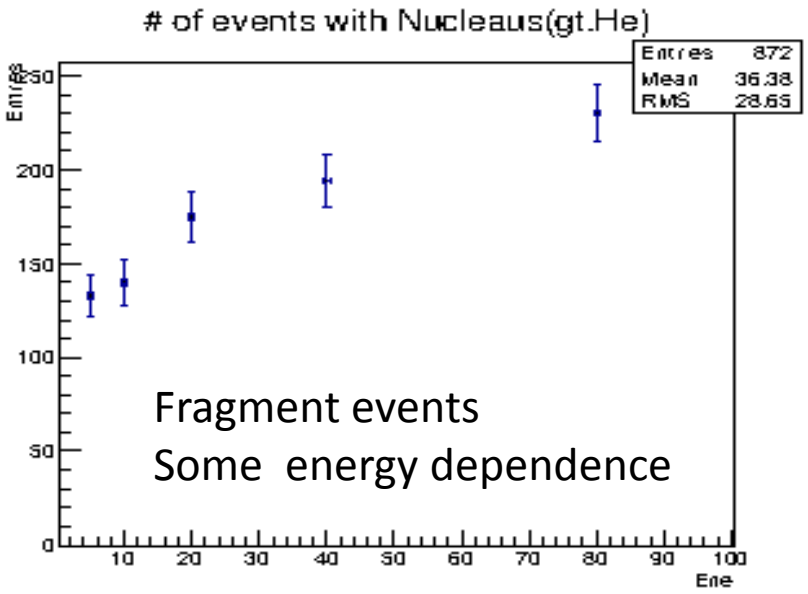


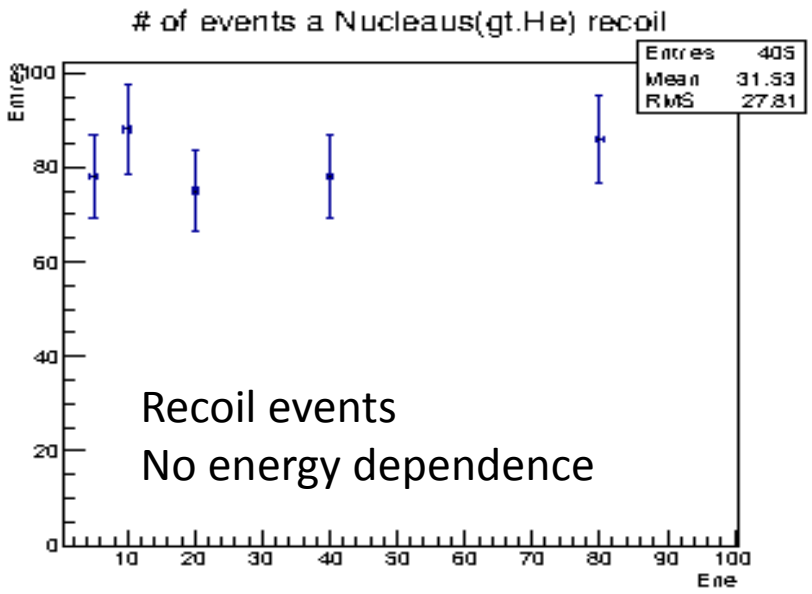
Simple MC

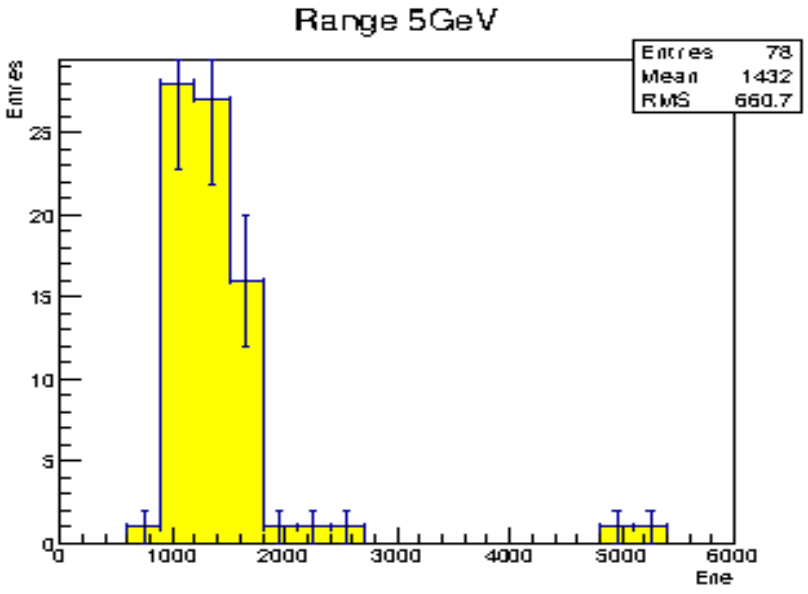
- GEANT4
- 10^{6} Muons are injected to 10cm x 10cm x 10cm bulk NIT, for each 5, 10, 20, 40, 80 GeV.

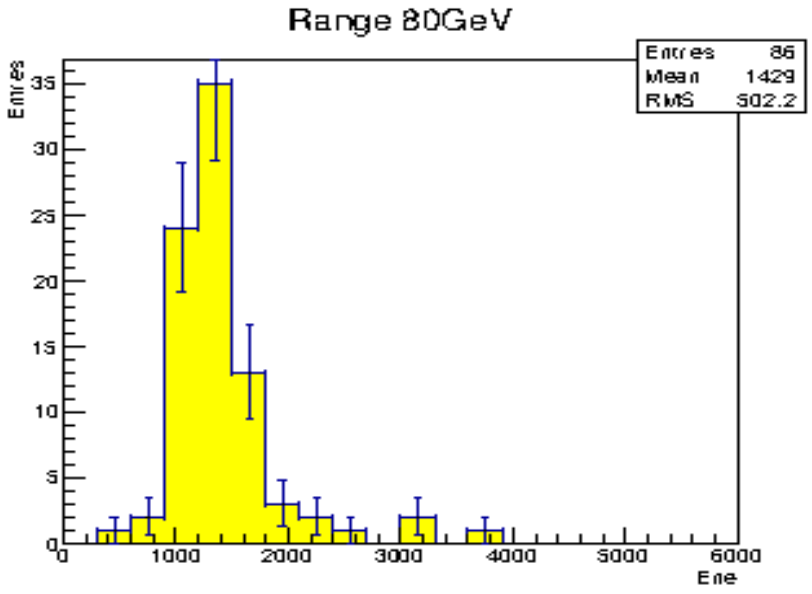
- Total muon track length 10^{7} cm for each energy.
- Corresponding 10^{9} muons for 100 um NIT layer

10^6 Muon injection









Result

- Recoil (more than 0.5um) mean free path

10^7 cm / 80 recoils = 1.25 x 10^5cm (No energy dependence)

→ 1 recoil by 1.25 x 10^7 muons in 100um

- Muon flux assumed as 0.001 /cm2/ min
- 1kg NIT volume is about 10cm x 10cm x 3cm

  = 100cm2 x 300 x100um

  = **30000 cm2** x 100um
- 1yr = **5.256 x 10^5 min**
- 1kg x 1yr case

  3.0 x10^4 cm2 x **5.256 x10^5 min** x10^{-3} muons/cm2/min

  = **1.58 x 10^7 muons in 100um**

So 1.26 muon induced recoils in 1kgx1yr exposed NIT.

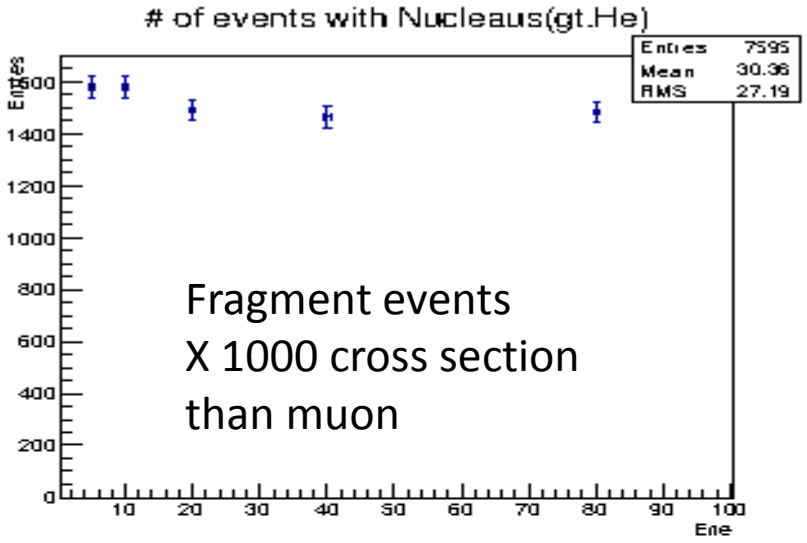
Muon Beam test

- 12cm x 10cm x 100um(em) films is assumed to be used.

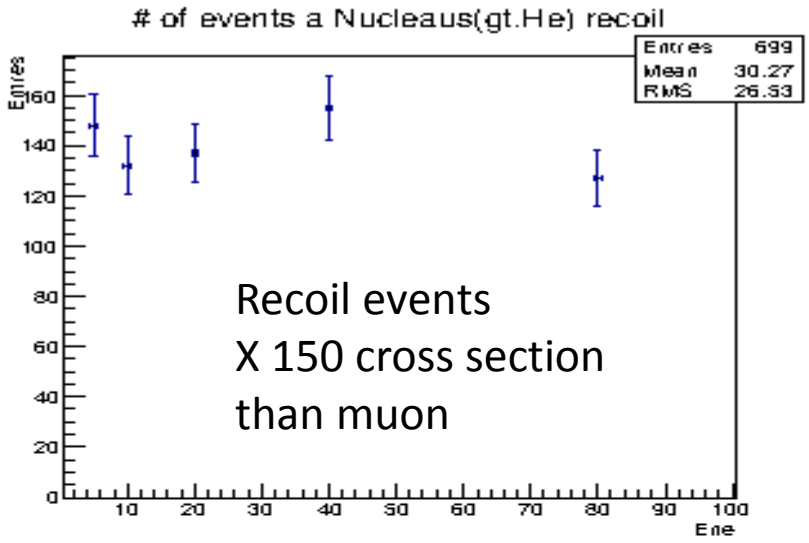
- If we want to collect **N Recoil events** by muon
- **N x 1.25 x 10^7 muons/film** should be exposed.

- Given track density < 10^5 cm2 (1.2 x 10^7 in a film)
- More than **N films** should be exposed.
- So **severalx10 to 100 films** to measure the cross section, correcting observed 10-100 recoil events.
- A few 10-100 g scanning is needed.
- A good demonstration of scanning power.

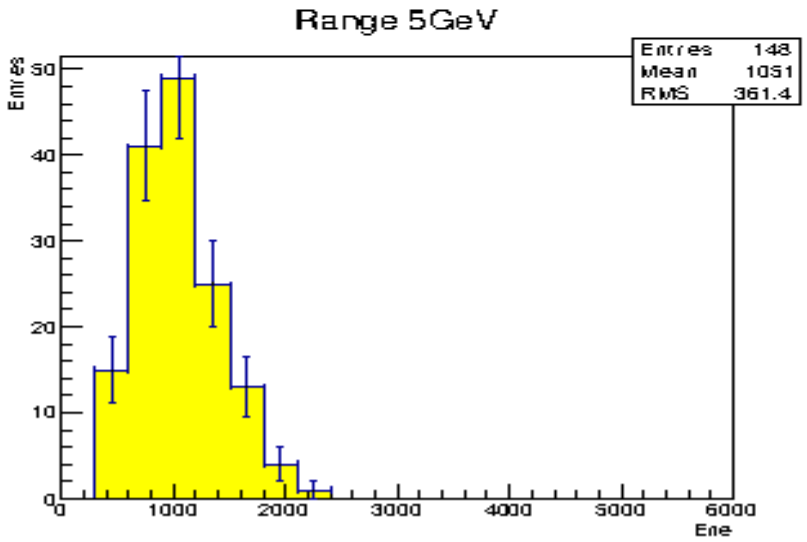
10^4 pion injection

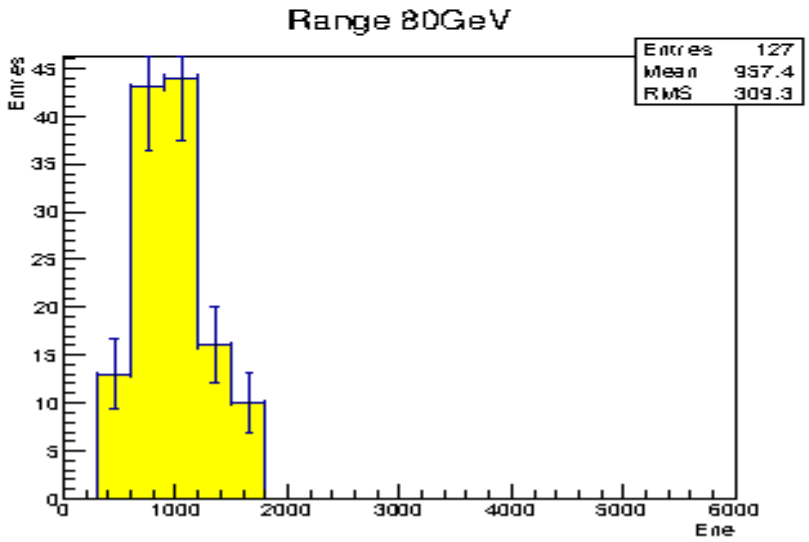


Fragment events
X 1000 cross section
than muon



Recoil events
X 150 cross section
than muon





Summary

- **Muon induced CNO recoils become a background source for > 1kgx1yr exposure.**
- The Recoil (>0.5um) Mean free path (1.25 x 10^5cm) is independent with muon energy.

- OPERA + NIT ECC beam test for detecting muon induced recoils and veto performance test should be considered.

Under beam density 10^5 /cm2 consideration.

- **N(10-100 events) films(12x10cm2), A few 10-100 g NIT** scanning could make it possible to measure the muon induce recoil cross section.

- **Veto performance test** could be done by **pion beam** with **a few (0.1 -1.0) g NIT scanning . 1 film(12x10cm2) is enough** for this test.

- I requested muon beam in SHiP beam test 2017, probably it could be in September 2017.
- We have enough time to design the ECC (Polishing, MC cross checks) for the beam test.
- pi contamination in muon beam should be well understood for muon induced recoil measurement.