New possible method for a Particle Identification

NIMA 490 (2002) 251-262 "Mass and charge identification of fragments detected with the Chimera Silicon-CsI(Tl) telescopes" suggested by Cardella G.

Bethe-Block

$$-\frac{dE}{dx} = \frac{\rho \cdot Z}{A}\frac{4\pi N_A m_e c^2}{M_U}\left(\frac{e^2}{4\pi\epsilon_0 m_e c^2}\right)^2 \frac{z^2}{\beta^2}\left[\ln\left(\frac{2m_e c^2\beta^2}{I\cdot(1-\beta^2)}\right) - \beta^2\right]$$

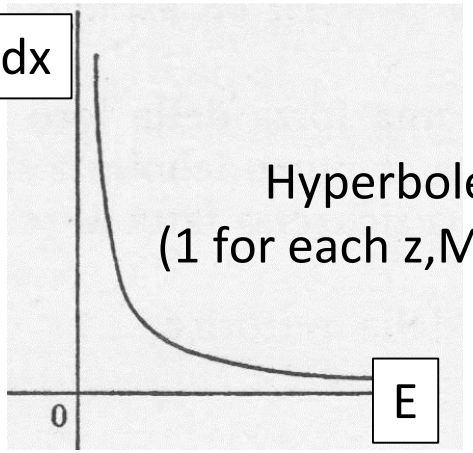
Kinetic Energy E

$$E = \frac{1}{2}Mv^2$$

$$\frac{dE}{dx} \propto K\frac{z^2}{v^2}$$

$$E \propto Mv^2$$

→ not relativistic → $\frac{dE}{dx}\cdot E \propto Kz^2 M \rightarrow$ constant depending on charge and mass



Involved subdetectors:

- dE/dx → **MSD, SCN**
- Ekin → **CALO**

Calo 21.0 **Calo 10.5**

Input data

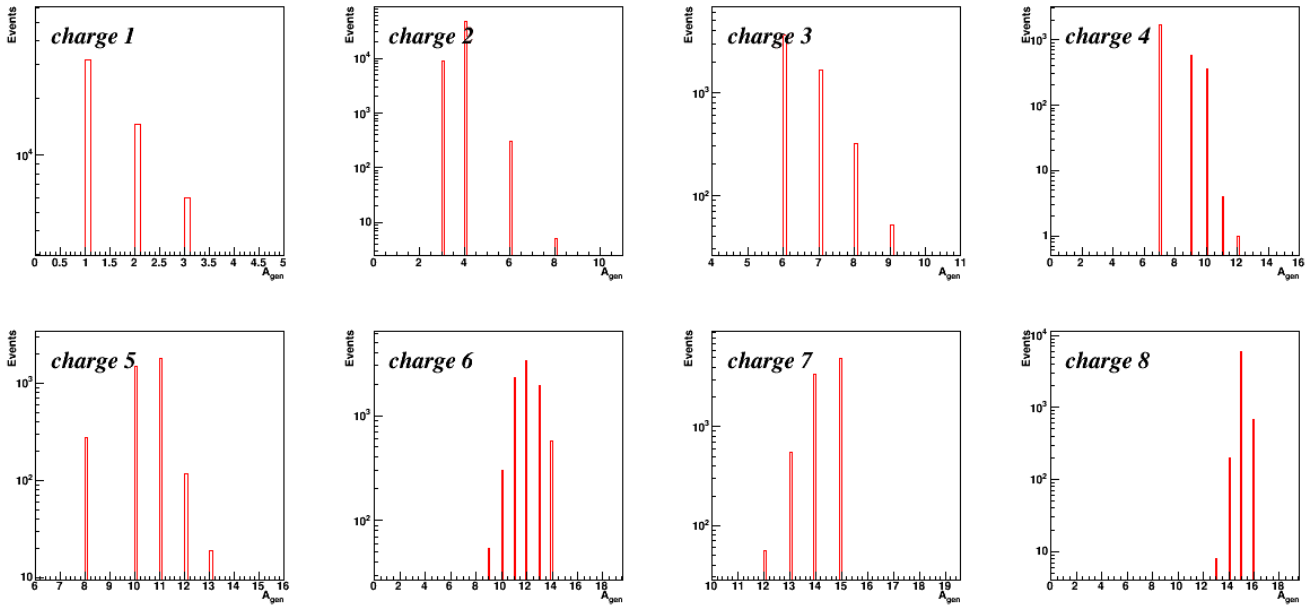
Input files:

- Calo 21 cm
  - /gpfs_data/local/foot/Simulation/**V12.4.1**/16O_C2H4_**200**_1.root
  - /gpfs_data/local/foot/Simulation/**V12.4.1**/16O_C2H4_**350**_1.root
  - /gpfs_data/local/foot/Simulation/**V12.4.1**/16O_C2H4_**700**_1.root
  - Statistics: 50k evts in rootuple → $5x10^6$ primaries per energy
- Calo 10.5 cm
  - /gpfs_data/local/foot/Simulation/**V12.4.1**/16O_C2H4_**200**_1.root
  - /gpfs_data/local/foot/Simulation/**V12.4.1**/16O_C2H4_**350**_1.root
  - /gpfs_data/local/foot/Simulation/**V12.4.1**/16O_C2H4_**700**_1.root
  - Statistics: 50k evts in rootuple → $5x10^6$ primaries per energy

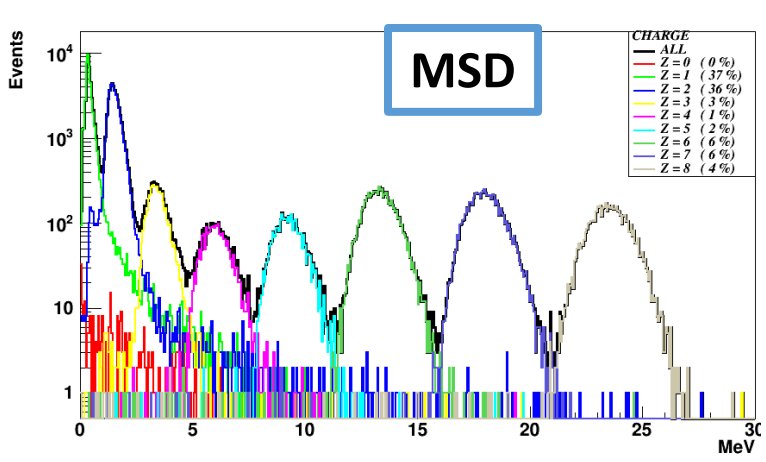
Geometry:
VTX → Si 4x50 µm
ITR → Si 2x50 µm
MSD → Si 6x70 µm
SCN → Scint 2x3 mm
CALO → BGO 21 cm

the same
CALO → BGO 10.5 cm

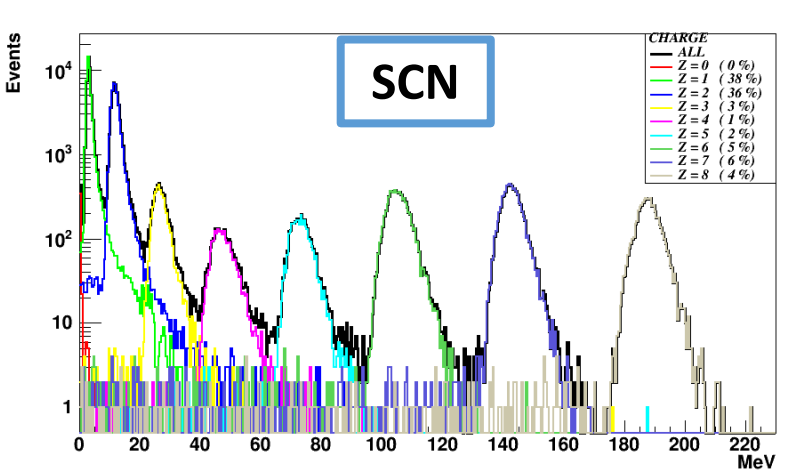
All possible isotopes

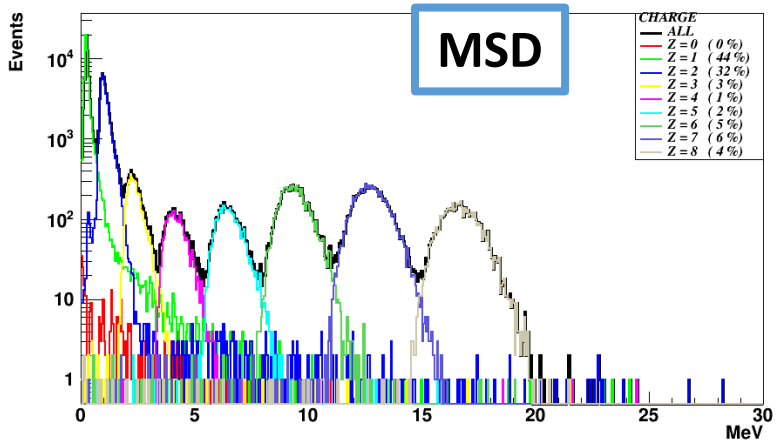


MSD - SCN

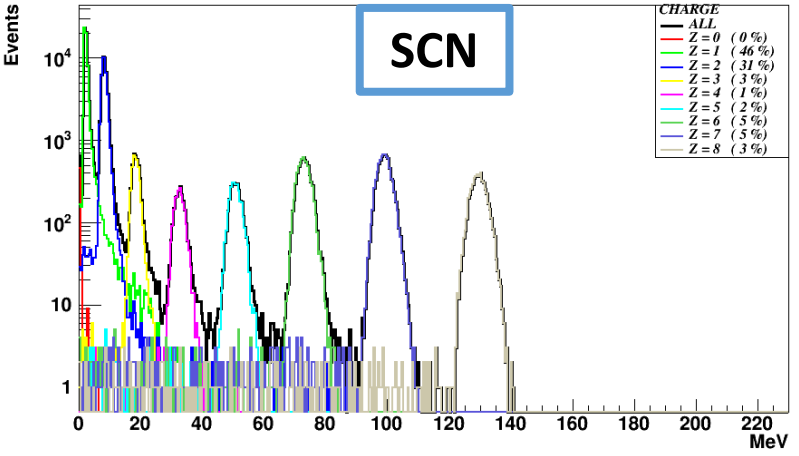


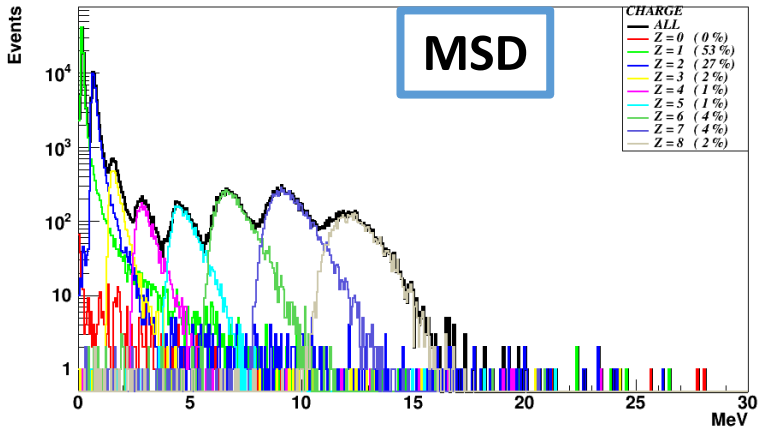
200 MeV/u



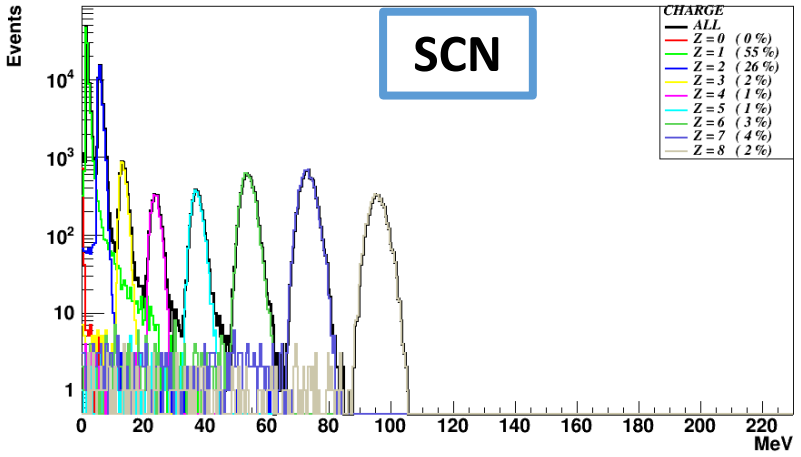


350 MeV/u



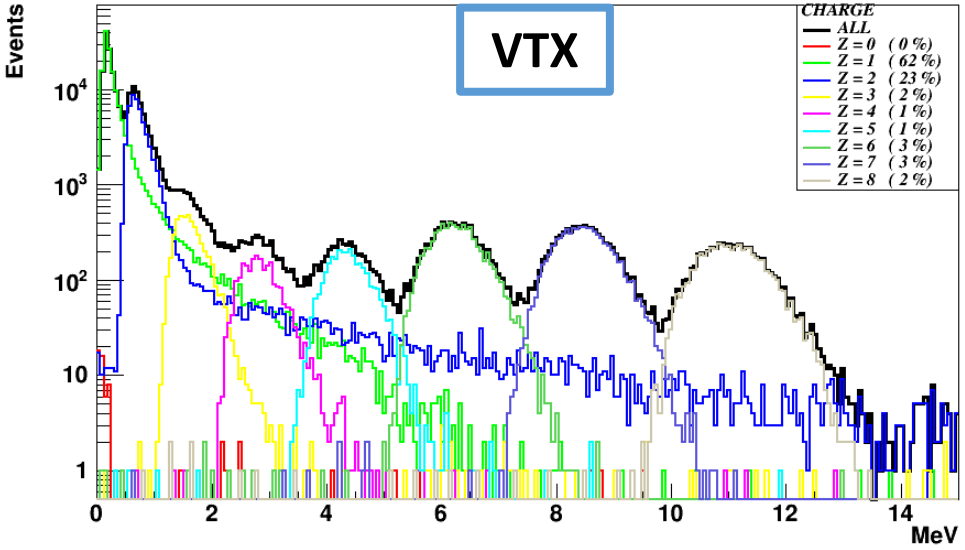


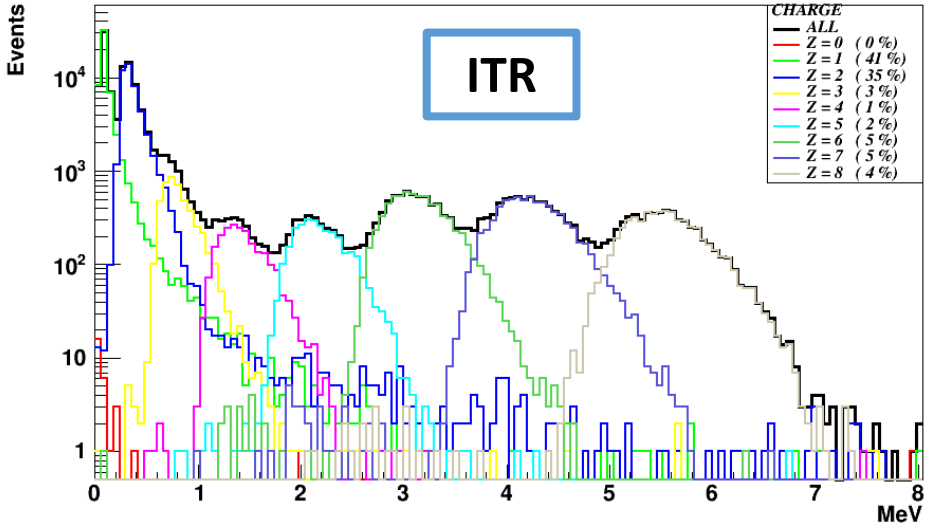
700 MeV/u

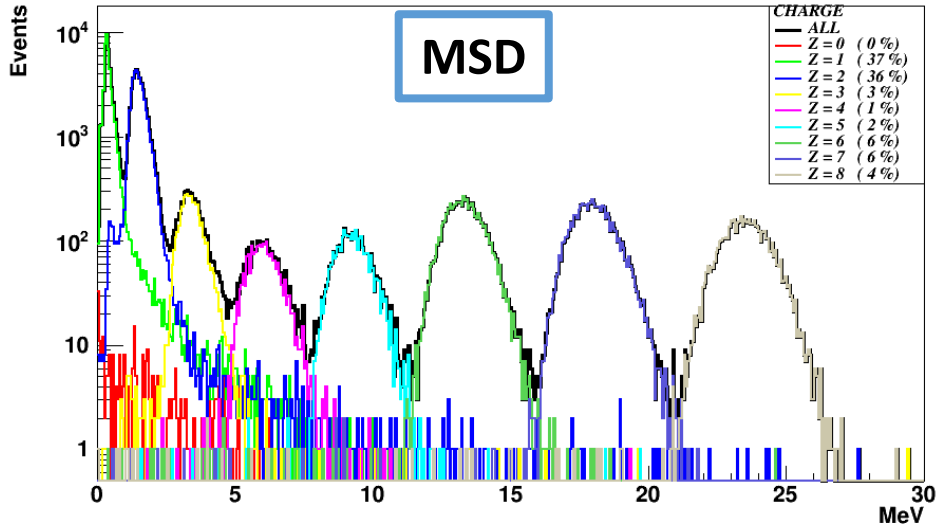


Silicon Detectors

200 MeV/u



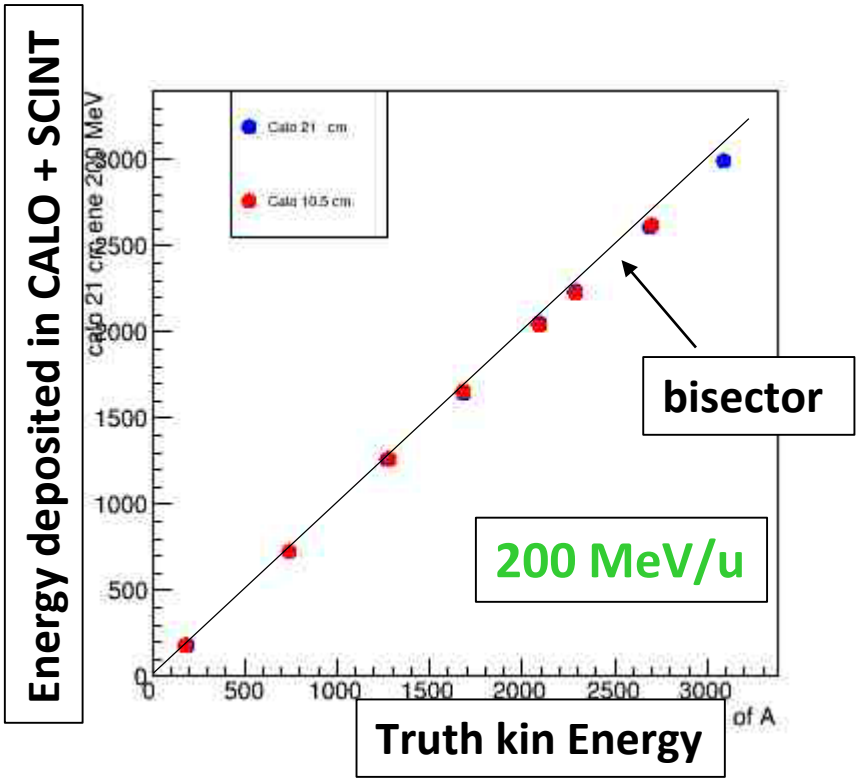


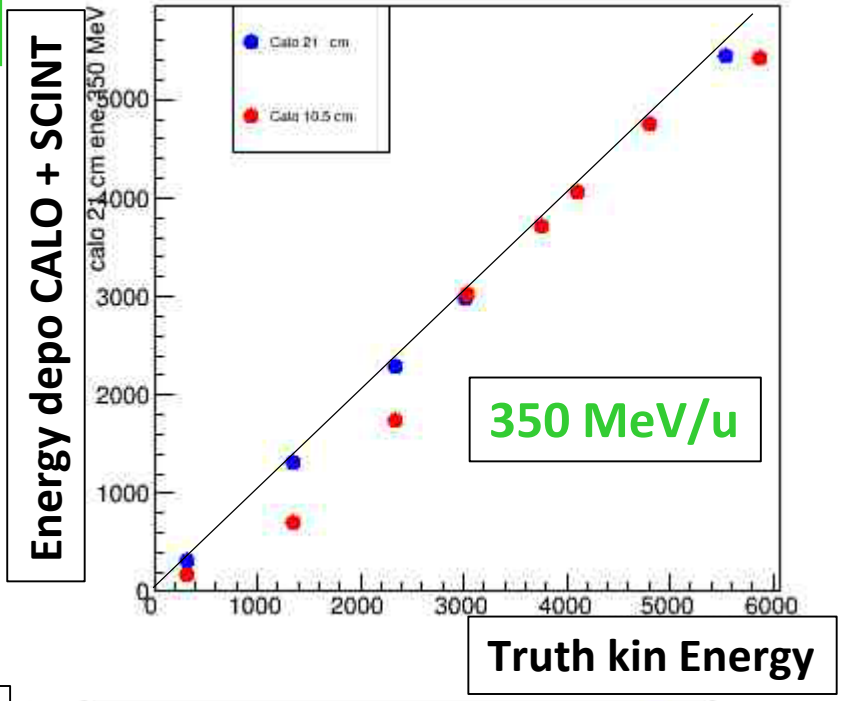


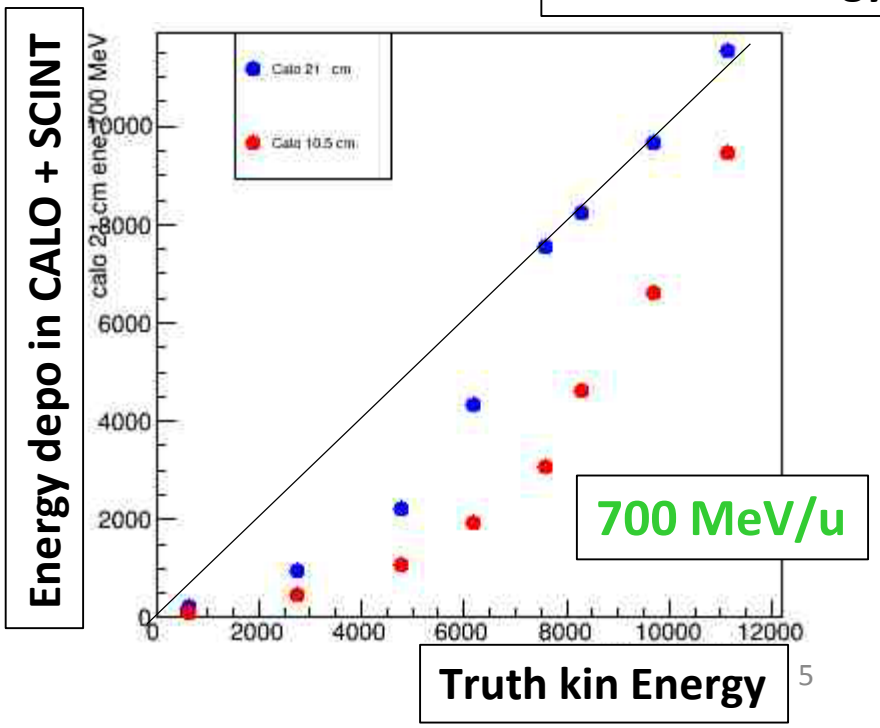
Deposited energy scales as Silicon thickness

- VTX 200 µm
- ITR 100 µm
- MSD 420 µm

Calo 21 vs 10.5: E_depo vs E_thruth







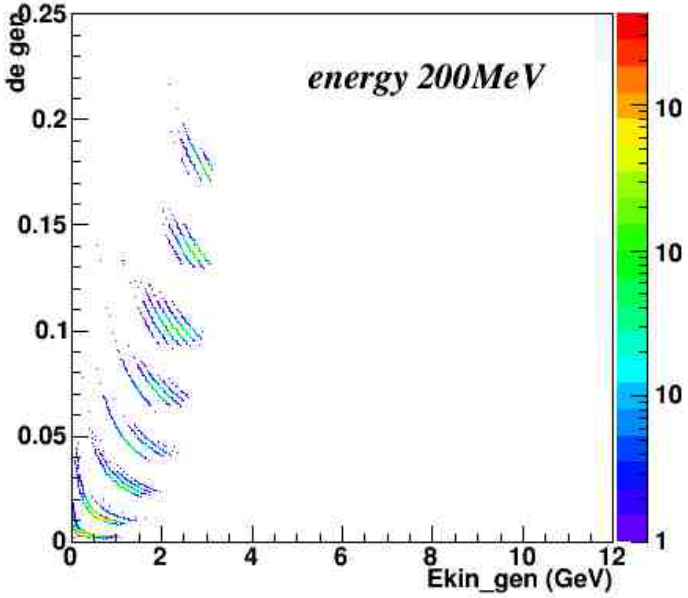
Selected fragments (one per charge)

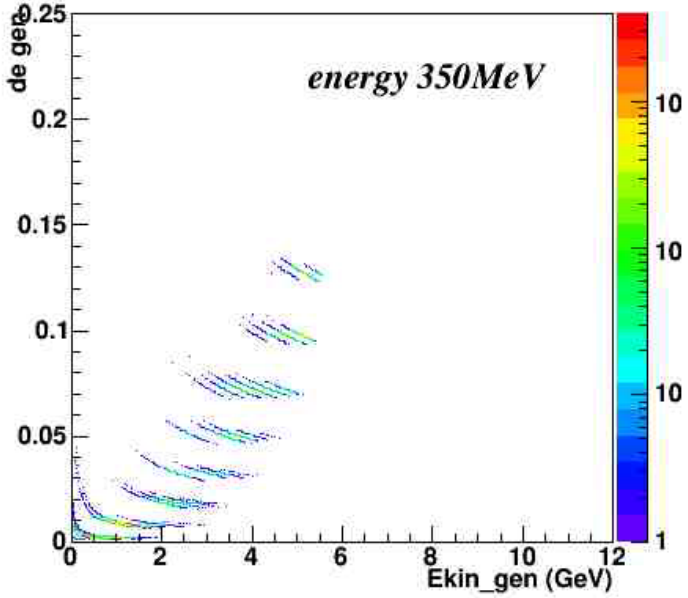
Z	1	2	3	4	5	6	7	8
A	1	4	7	9	11	12	14	16

CALO 21 cm: linear till 350 MeV

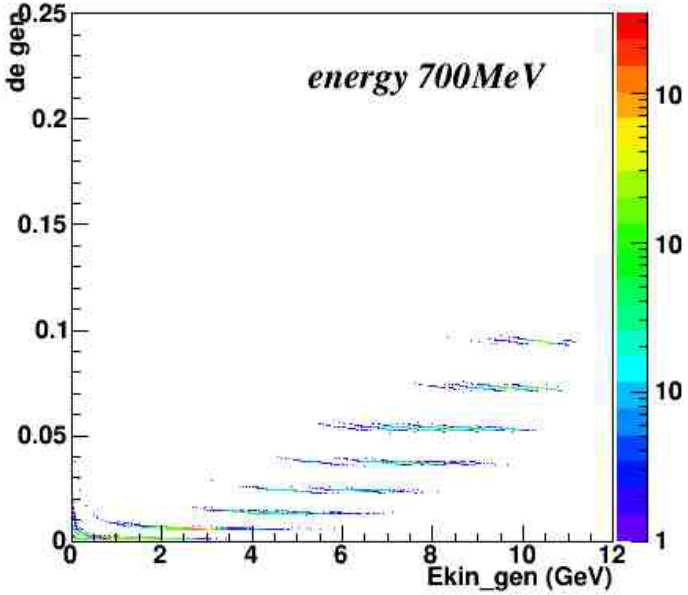
CALO 10.5 cm: linear till 200 MeV

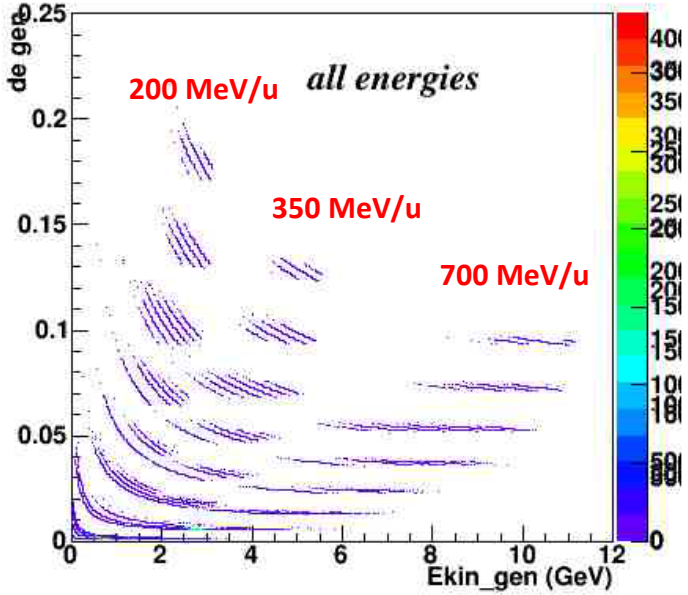
dE/dx vs E @ generation level, 1





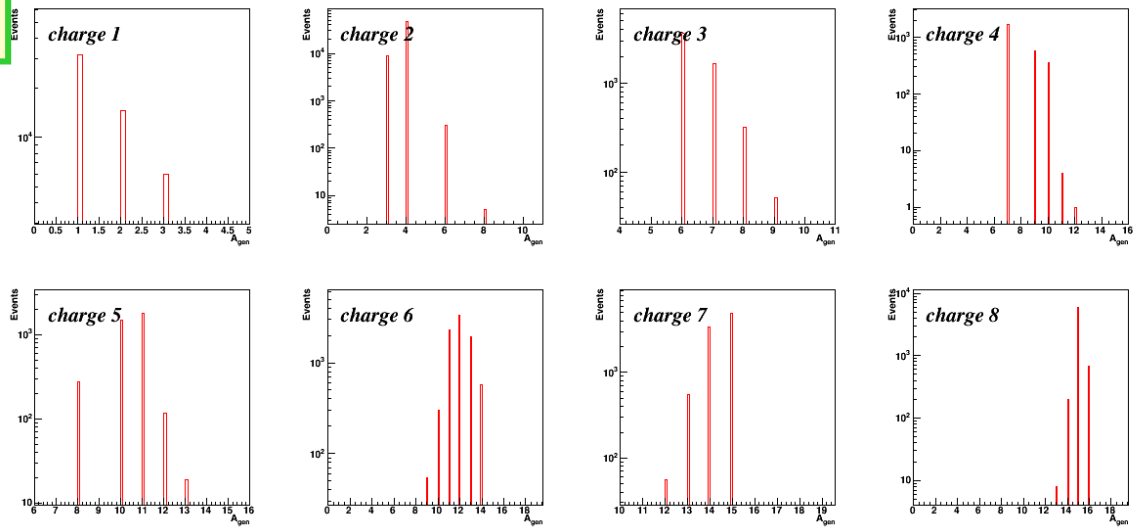
Δe evaluated from Bethe-Block on SCN with truth quantities

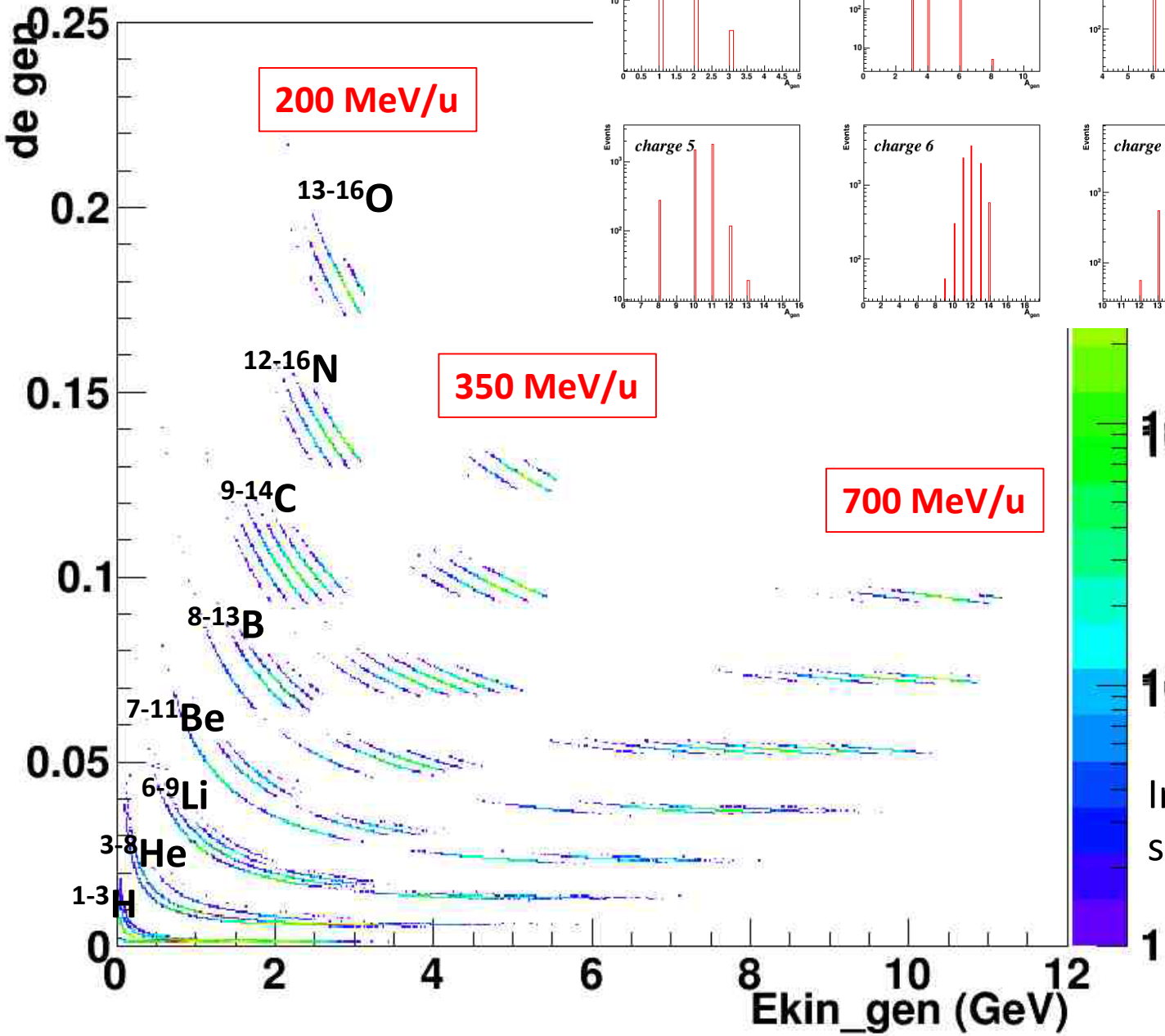




In principle separation is possible

dE/dx vs E @ generation level, 2



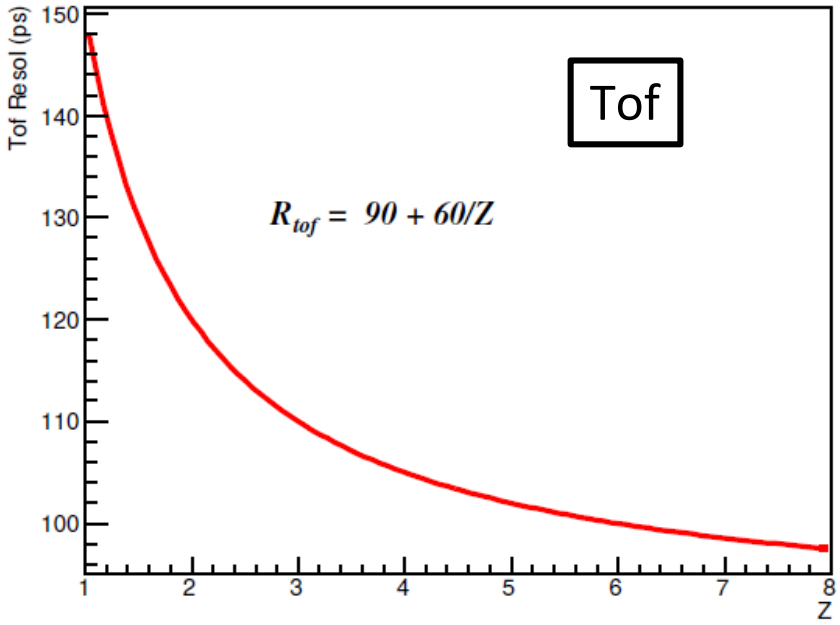


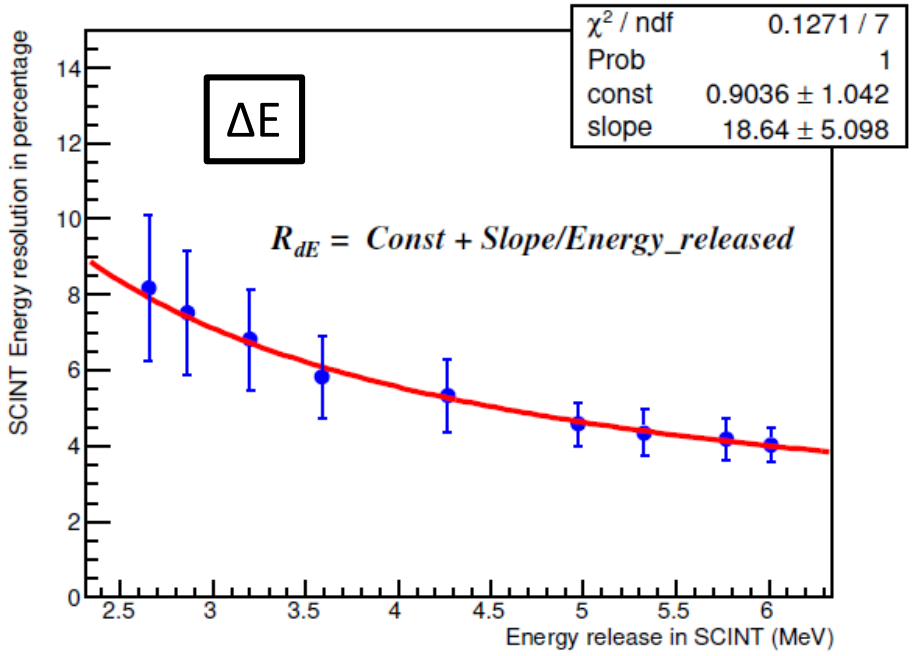
In principle the separation is possible

reconstruction level

INPUT RESOLUTIONS:

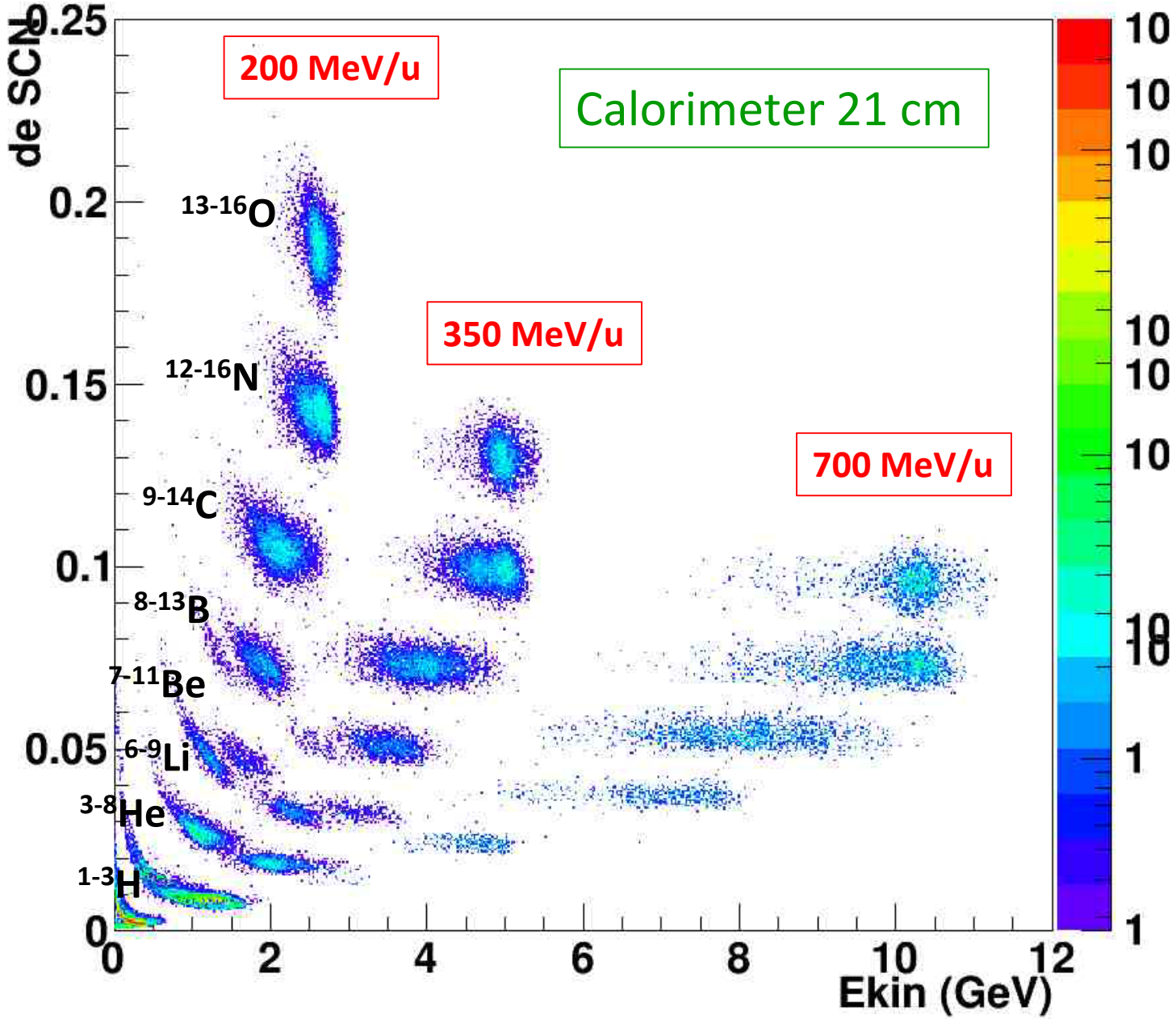
- Momentum → 5%
- Tof : [100:150] ps depending on Z
- Kinetic Energy (Calo) → 1.5%
- ΔE (scint): [3:10]% depending on energy released (msd → perfect resolution)



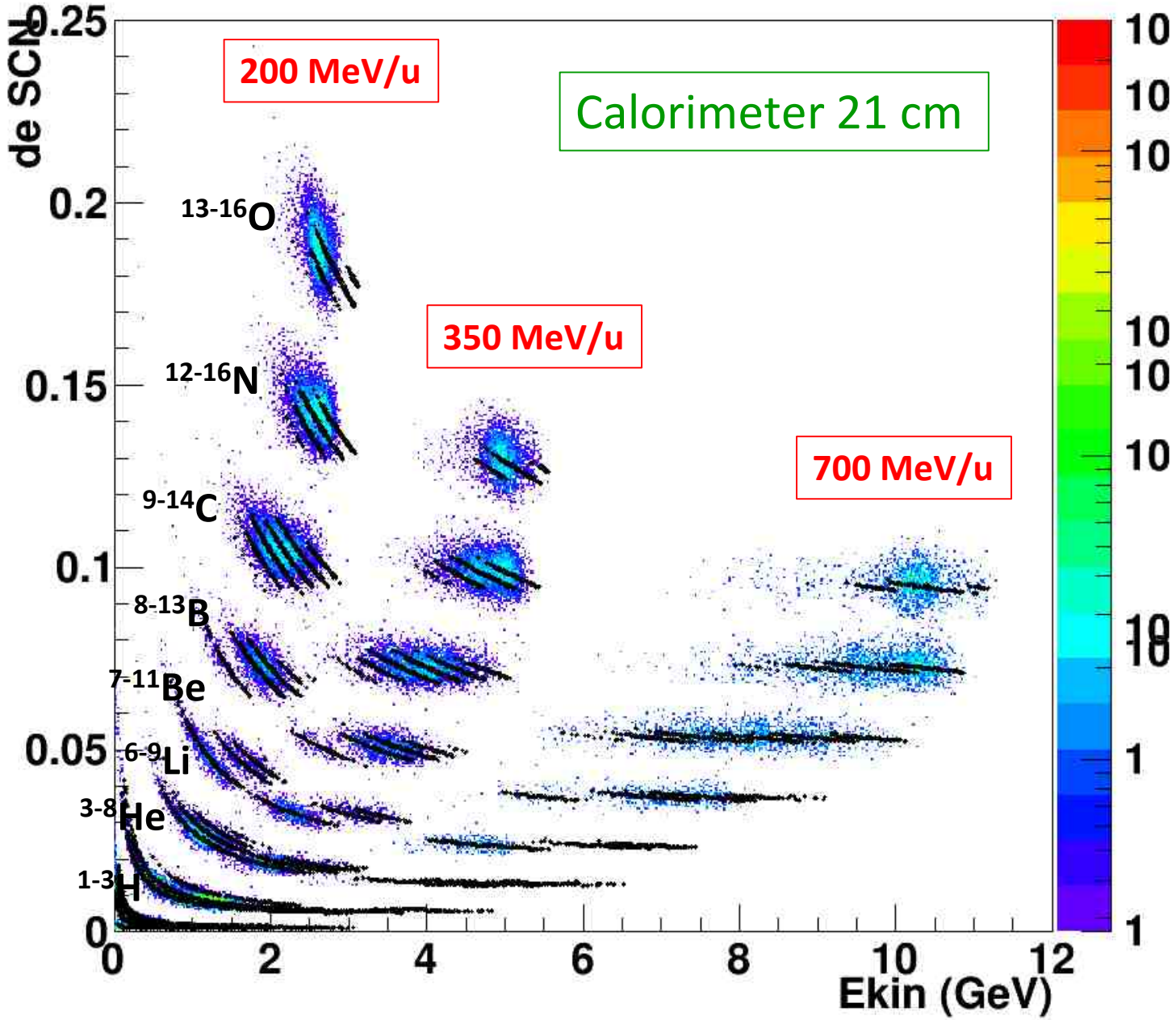


Selected events with $\chi^2 < 5$ (ALM it) to clean the sample

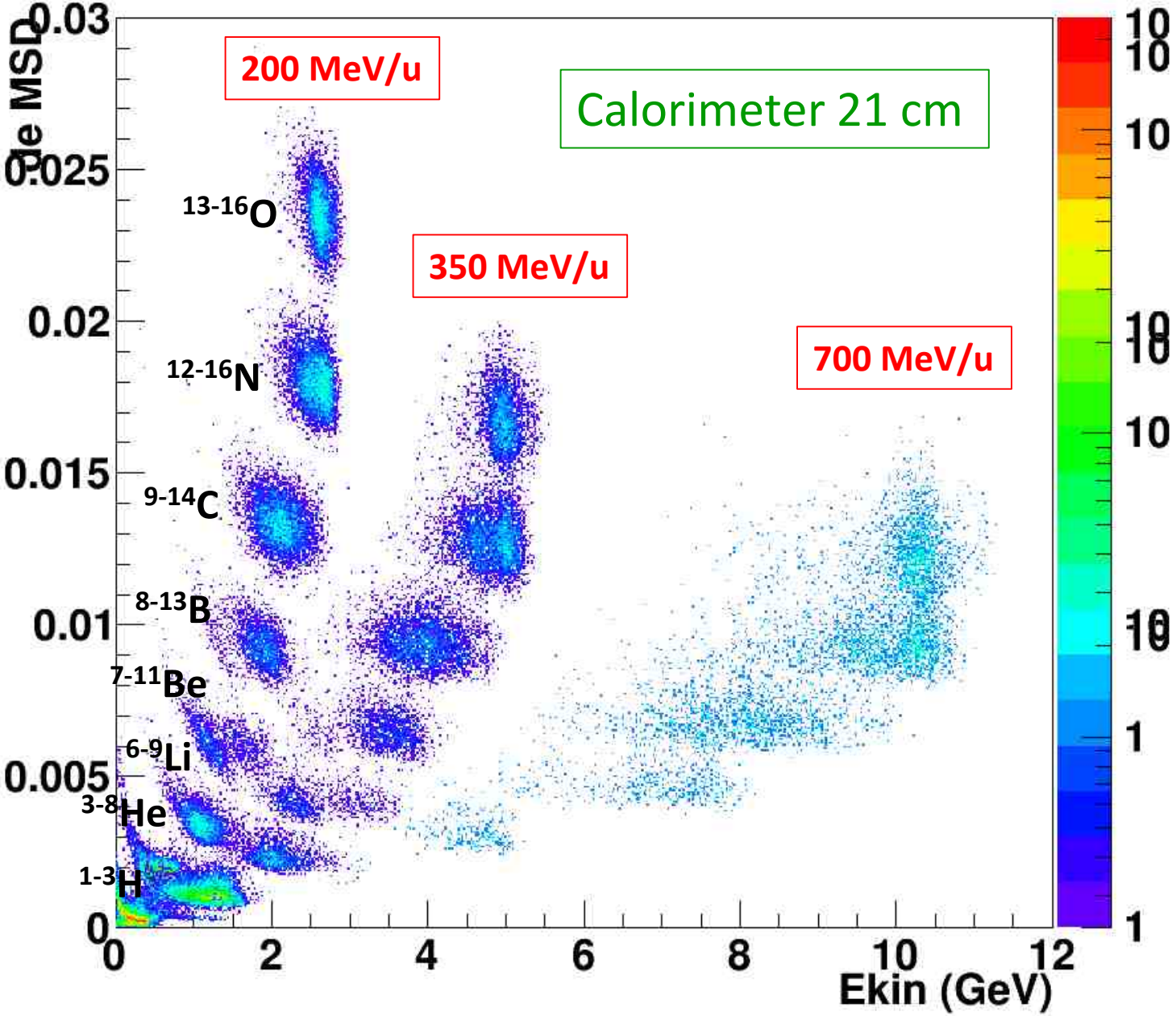
dE/dx vs E @ reconstruction level, SCN



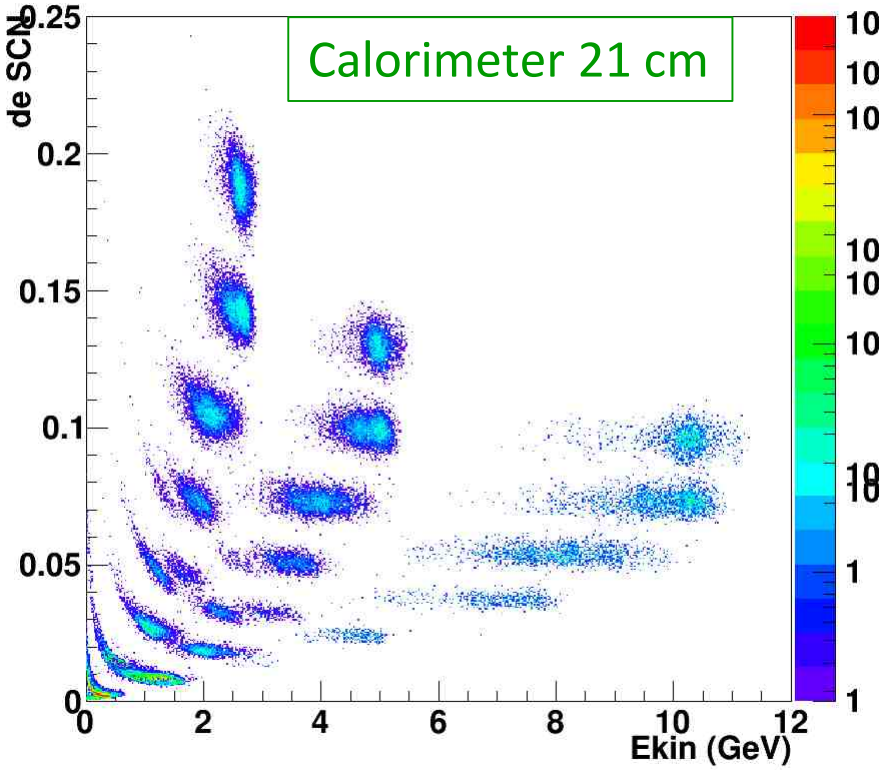
dE/dx vs E @ reconstruction level, SCN

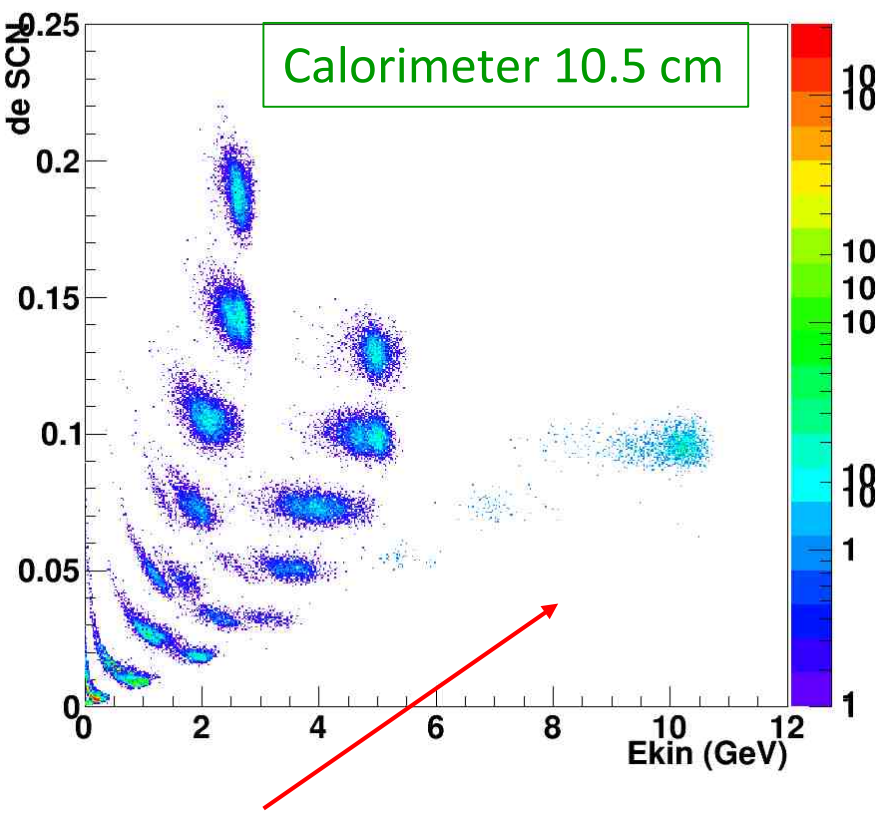


dE/dx vs E @ reconstruction level, MSD



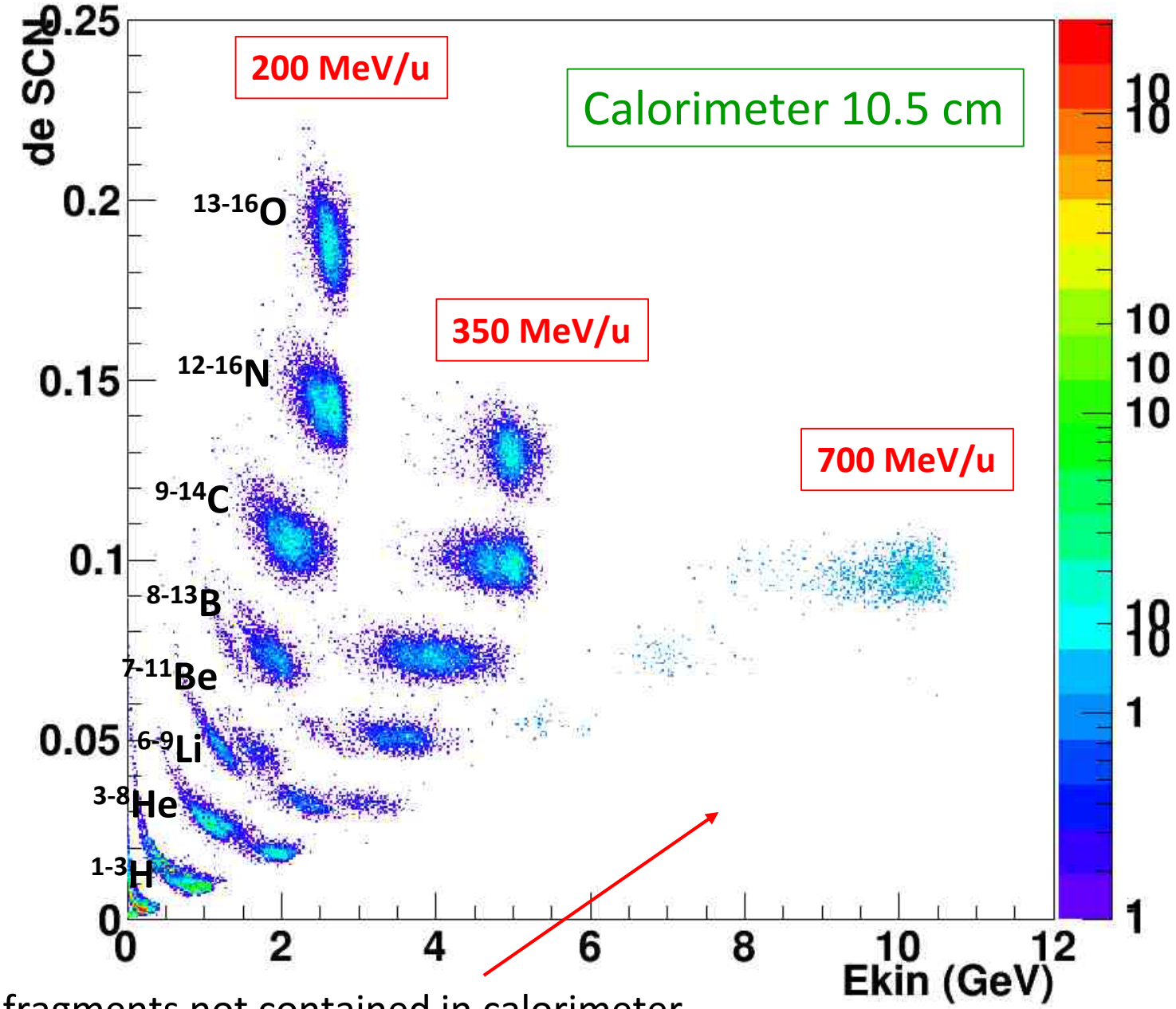
dE/dx vs E @ reconstruction level, SCN: Calo21 vs Calo105





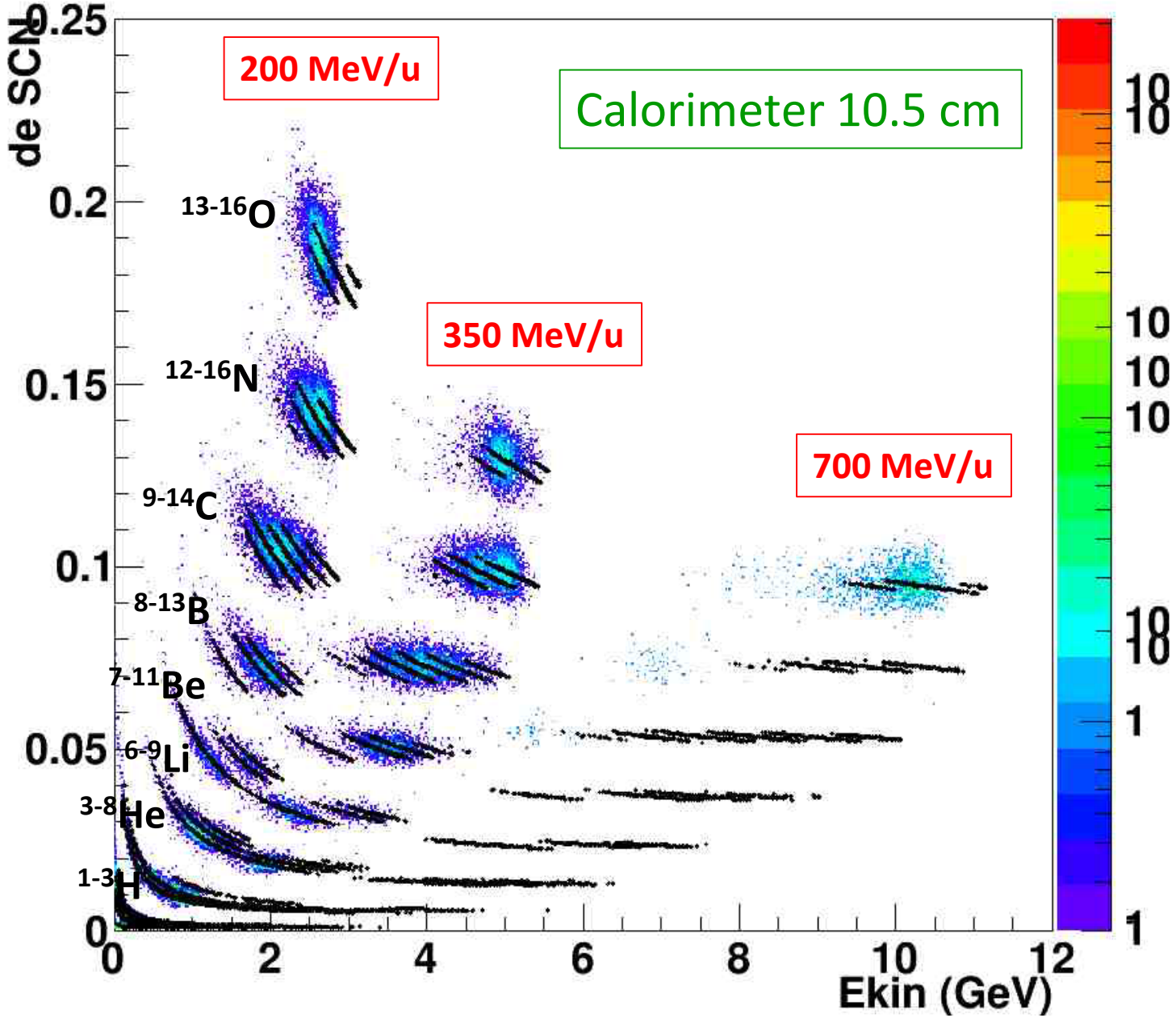
Light fragments not contained in calorimeter

dE/dx vs E @ reconstruction level, SCN

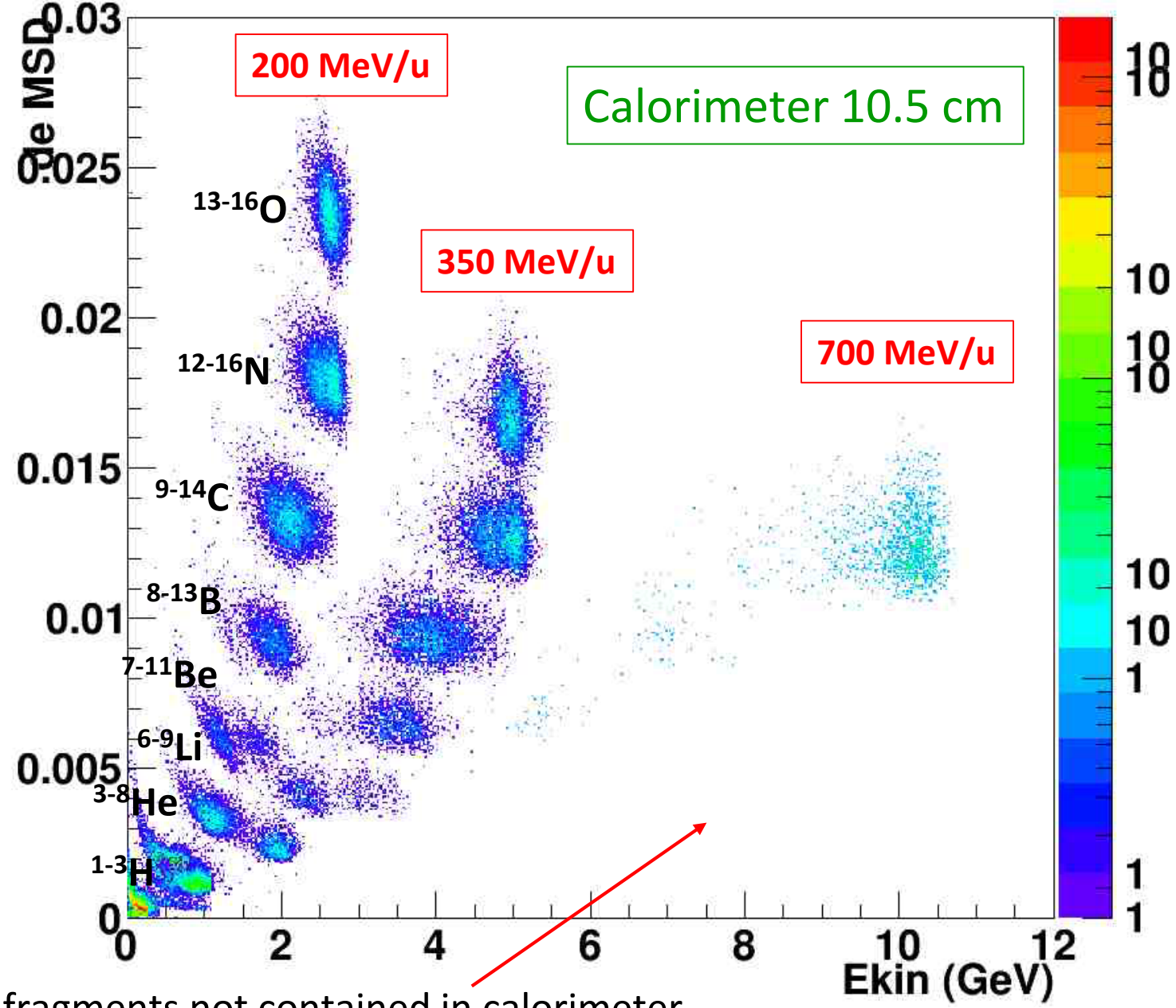


Light fragments not contained in calorimeter

dE/dx vs E @ reconstruction level, SCN



dE/dx vs E @ reconstruction level, MSD



Light fragments not contained in calorimeter

Conclusions

New method for a Particle Identification

- In principle is possible
- need more investigation
- Try to include in the standard particle identification (dE/dx not used)

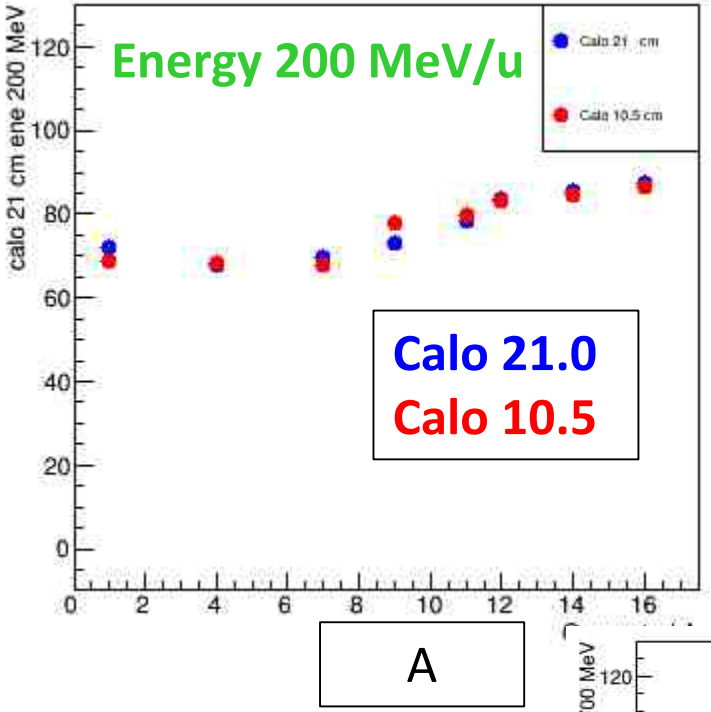
Calo 21 vs Calo 10.5

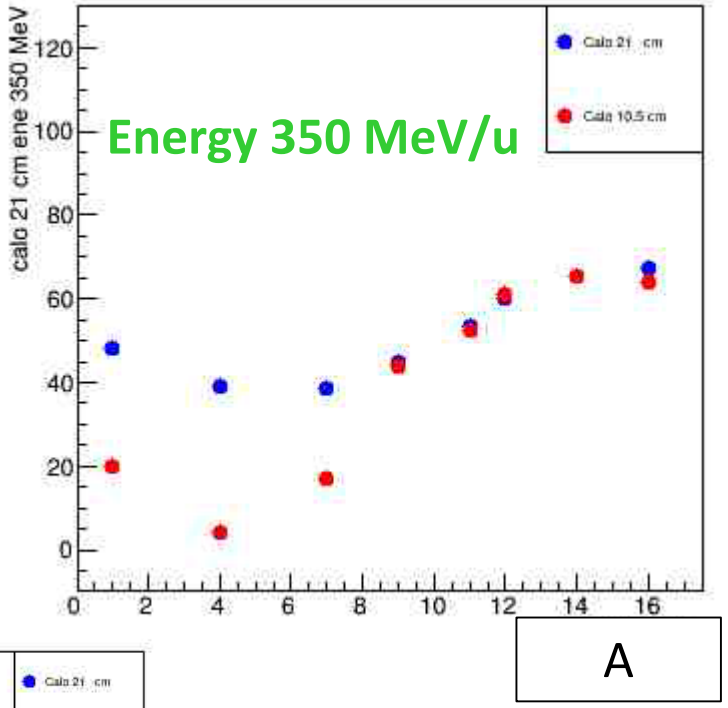
- Linearity:
  - Calo 21
    - till 700 MeV except for light fragments
  - Calo 10.5
    - till 350 MeV except for light fragments
    - Not for 700 MeV

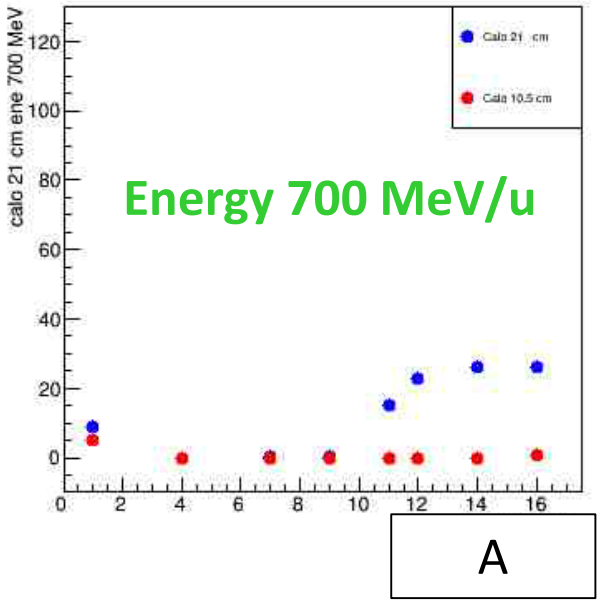
Backup slides

RECO IF $\left(\frac{\text{Energy deposit SCINT + CALO}}{\text{Kin Energy generated}} \right) > 0.9$

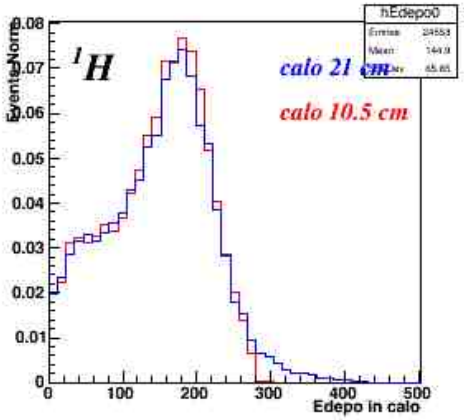
Reconstruction percentage

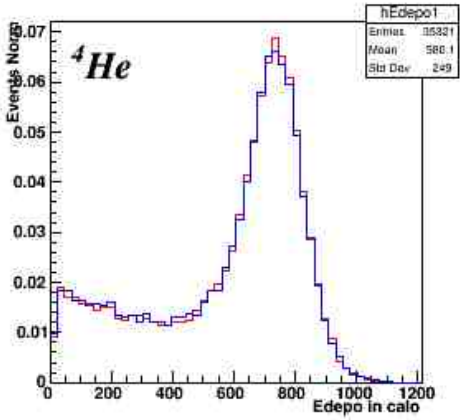


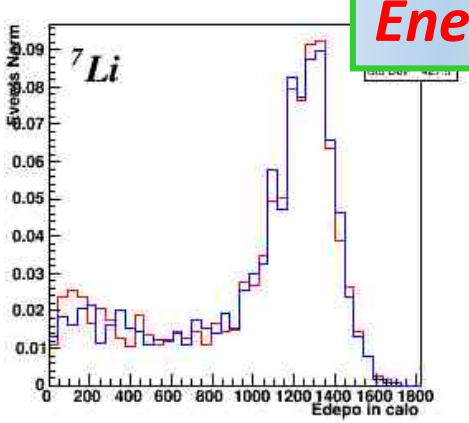


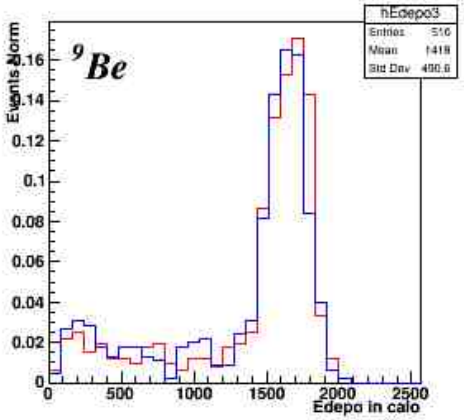


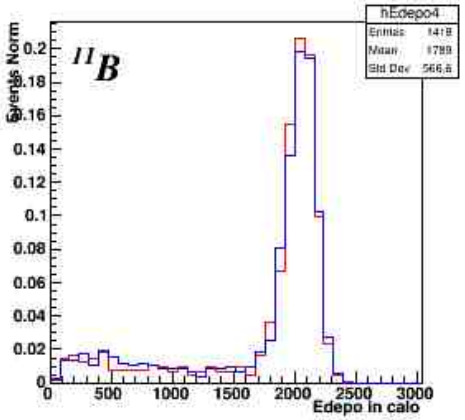
Energy: 200 MeV/u

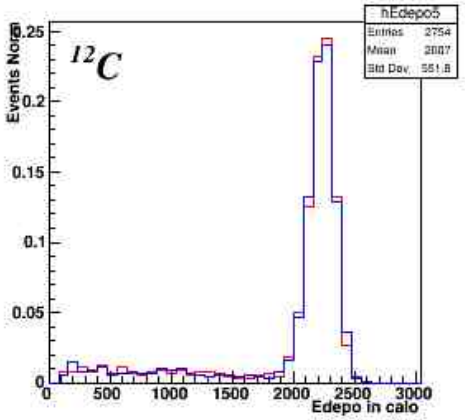


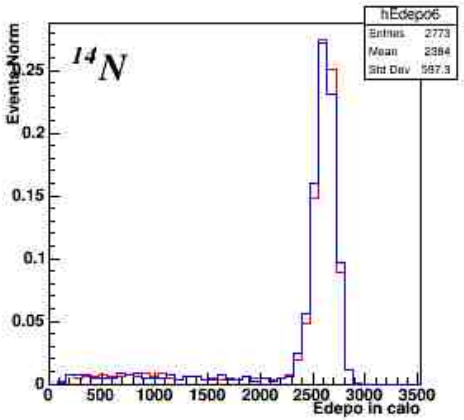


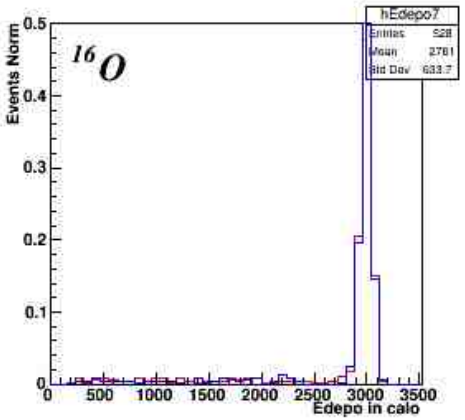










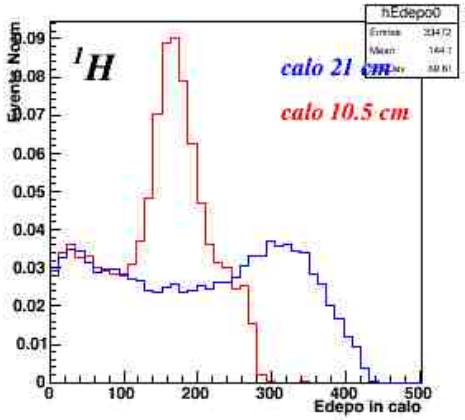


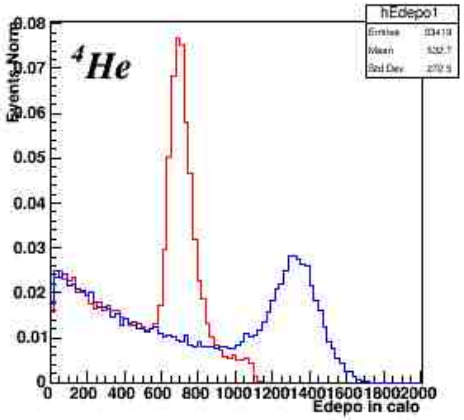
Energy deposited in CALO + SCINT

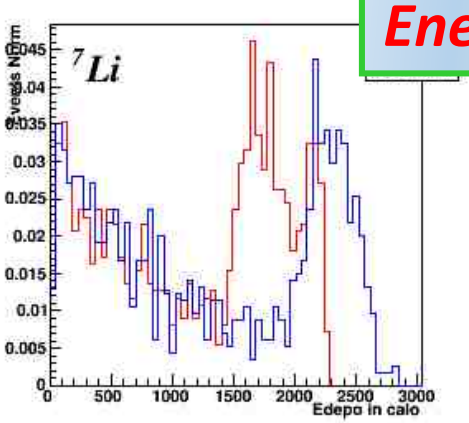
CALO 21 cm

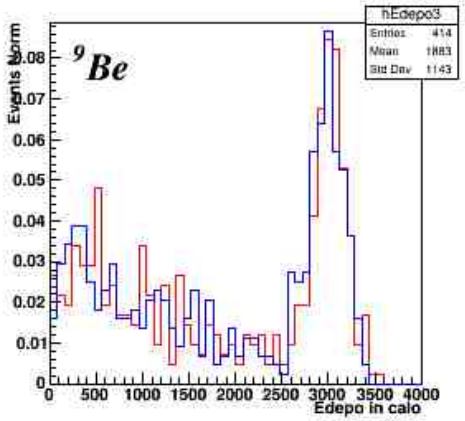
CALO 10.5 cm

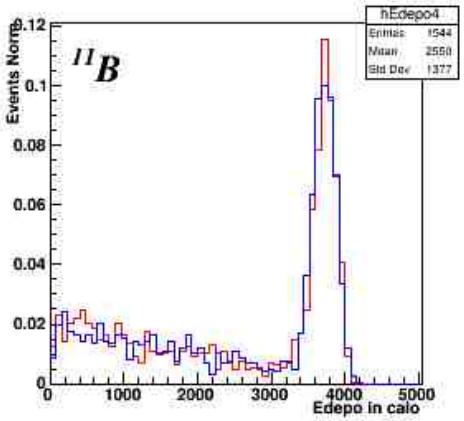
Energy: 350 MeV/u

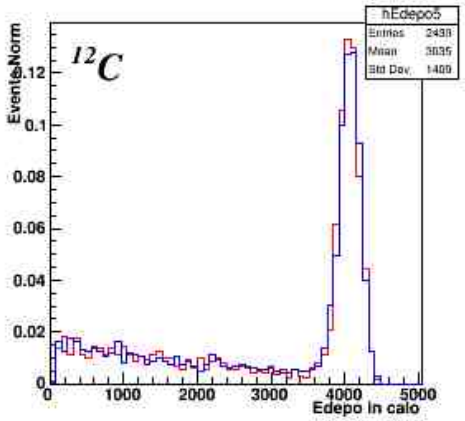


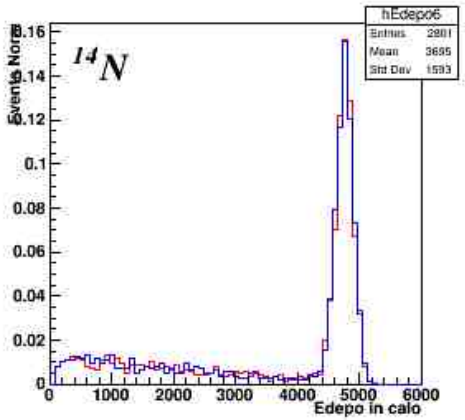


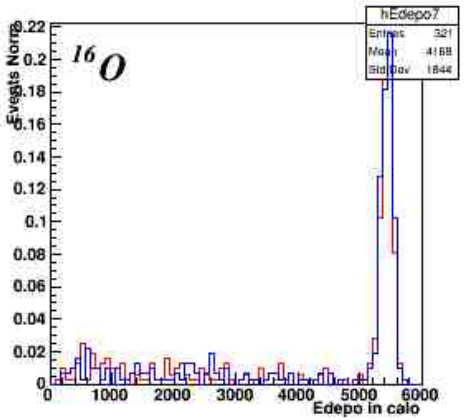










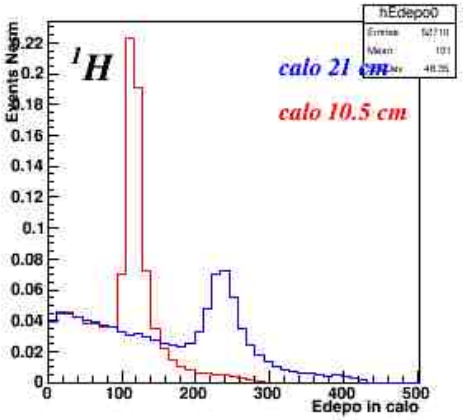


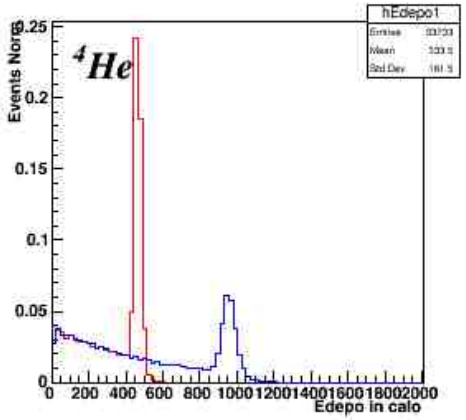
Energy deposited in CALO + SCINT

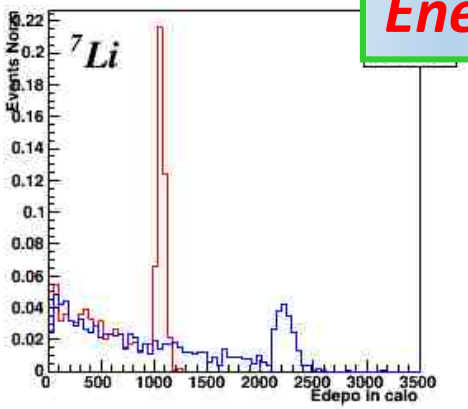
CALO 21 cm

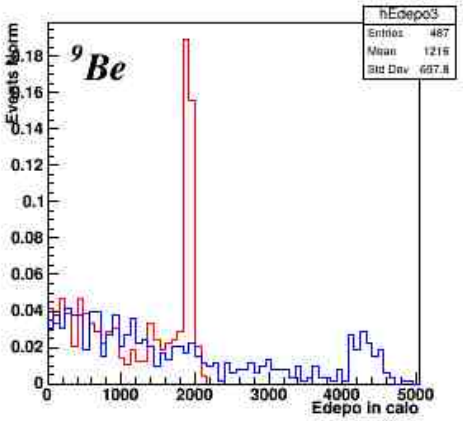
CALO 10.5 cm

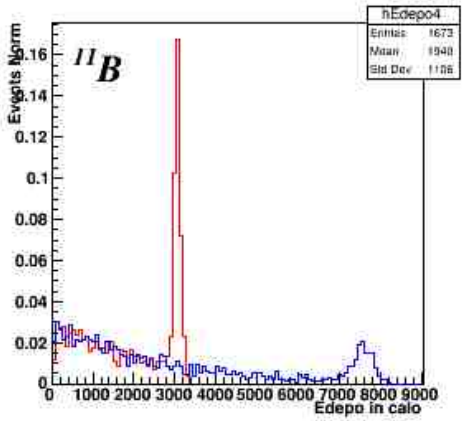
Energy: 700 MeV/u

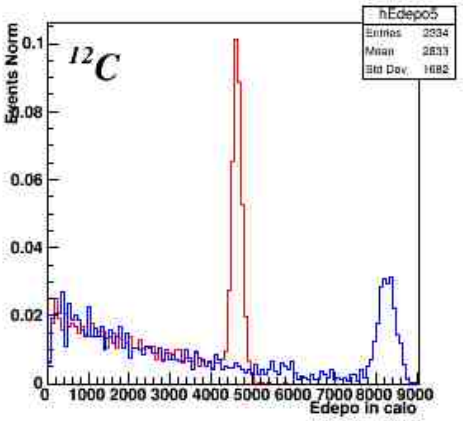


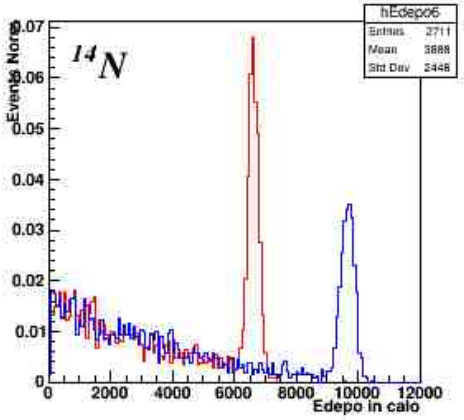


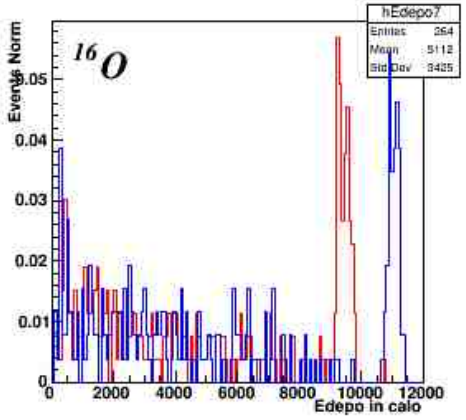










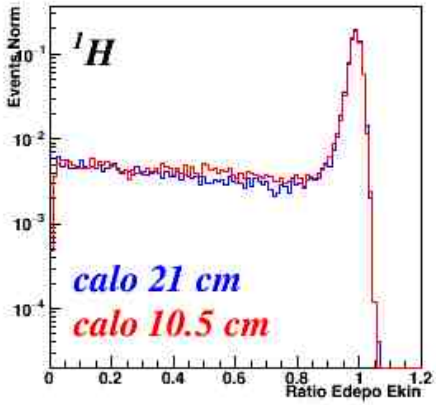


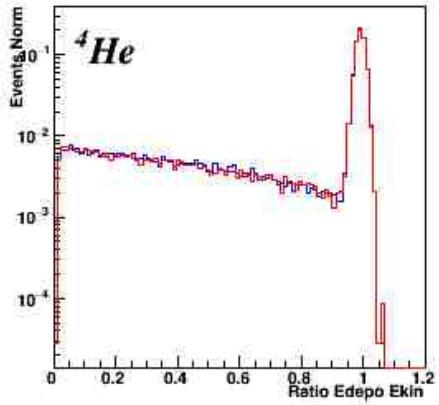
Energy deposited in CALO + SCINT

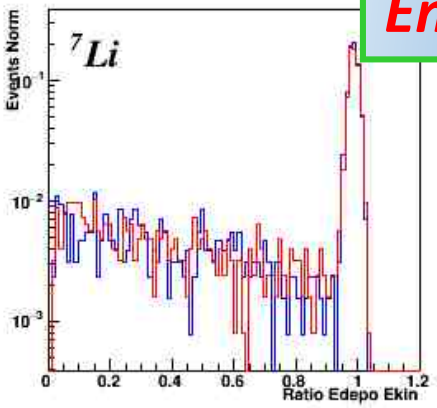
CALO 21 cm

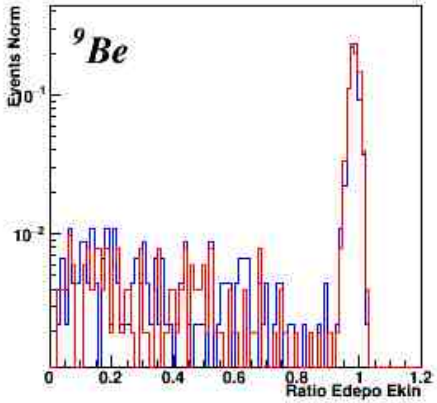
CALO 10.5 cm

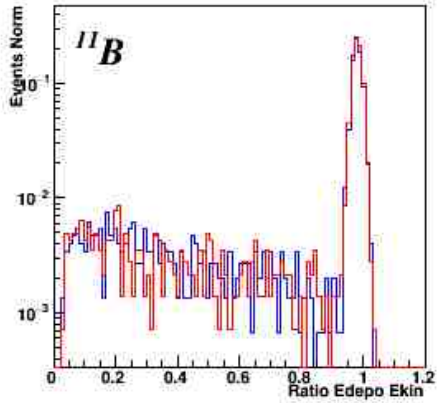
Energy: 200 MeV/u

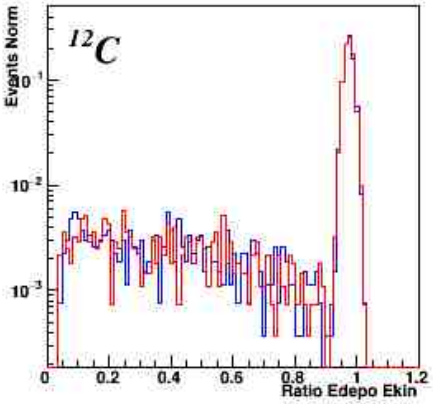


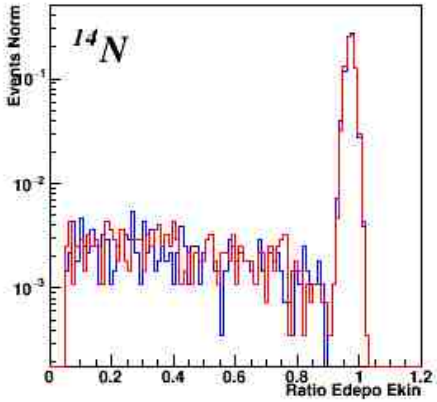


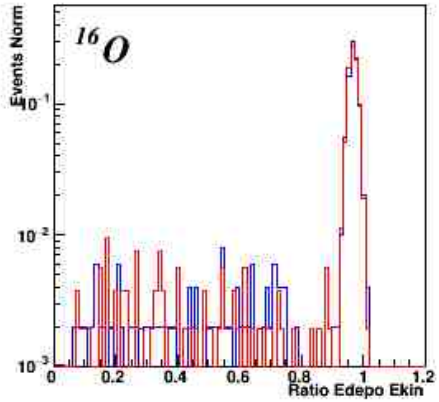






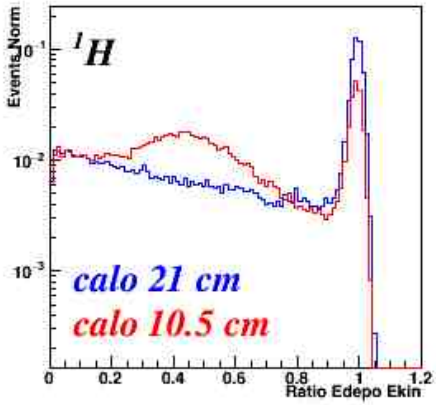


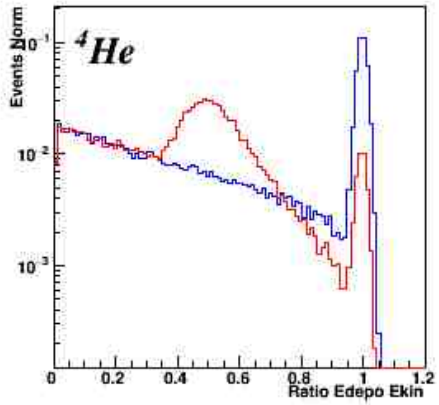


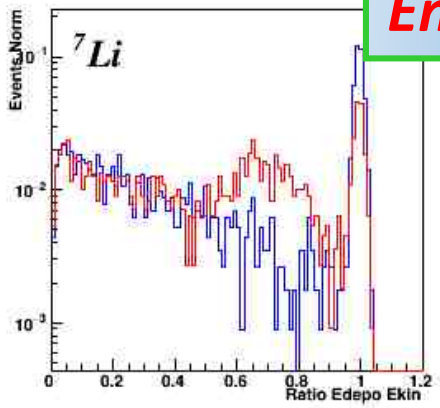


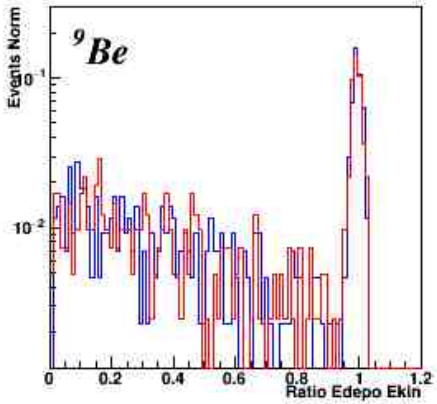
$$\frac{\text{Energy deposit SCINT + CALO}}{\text{Kin Energy generated}}$$

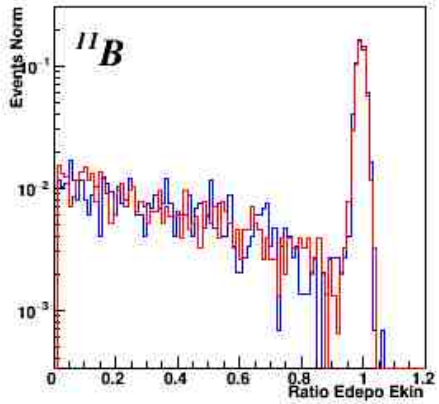
Energy: 350 MeV/u

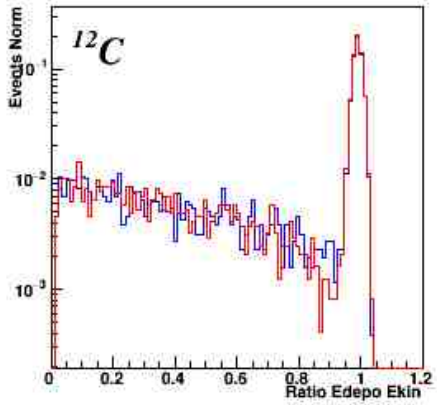


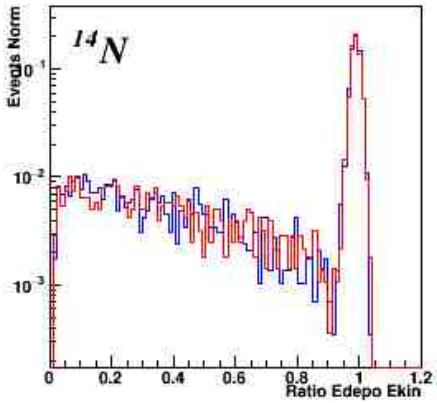


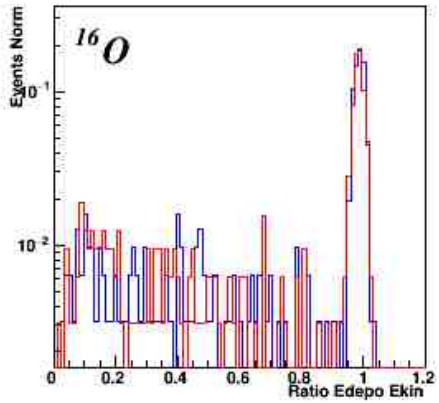








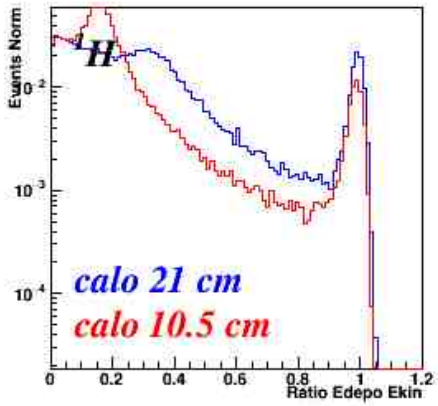


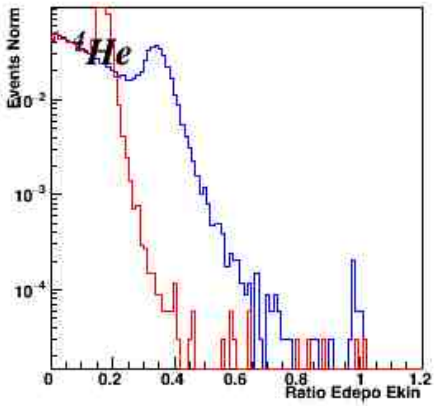


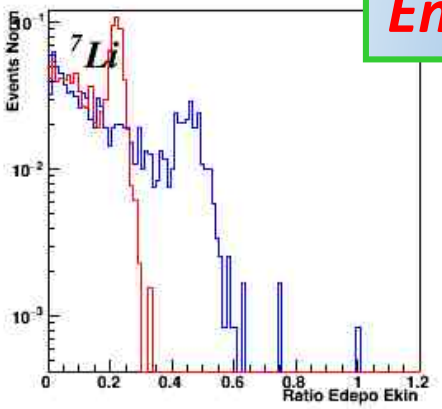
Energy deposit SCINT + CALO

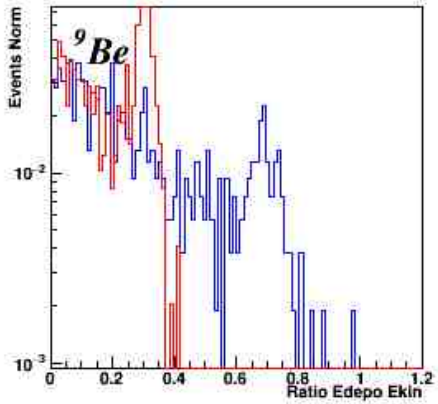
Kin Energy generated

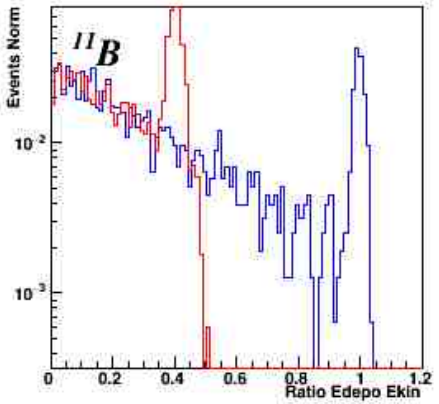
Energy: 700 MeV/u

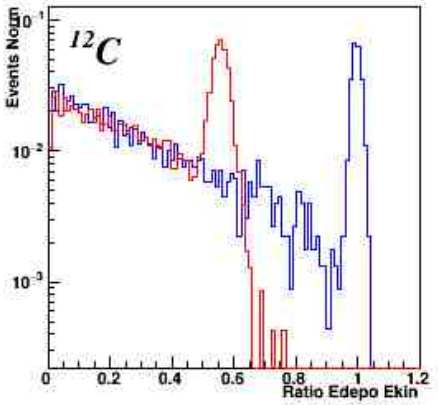


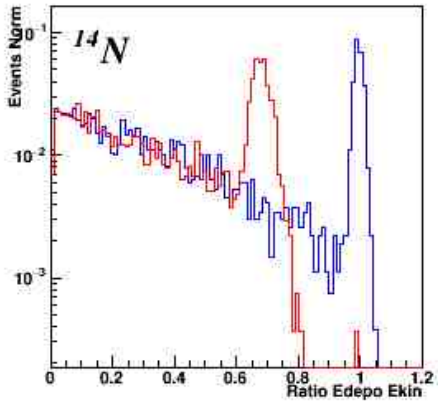


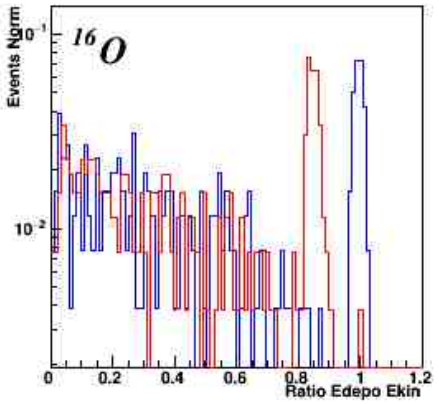






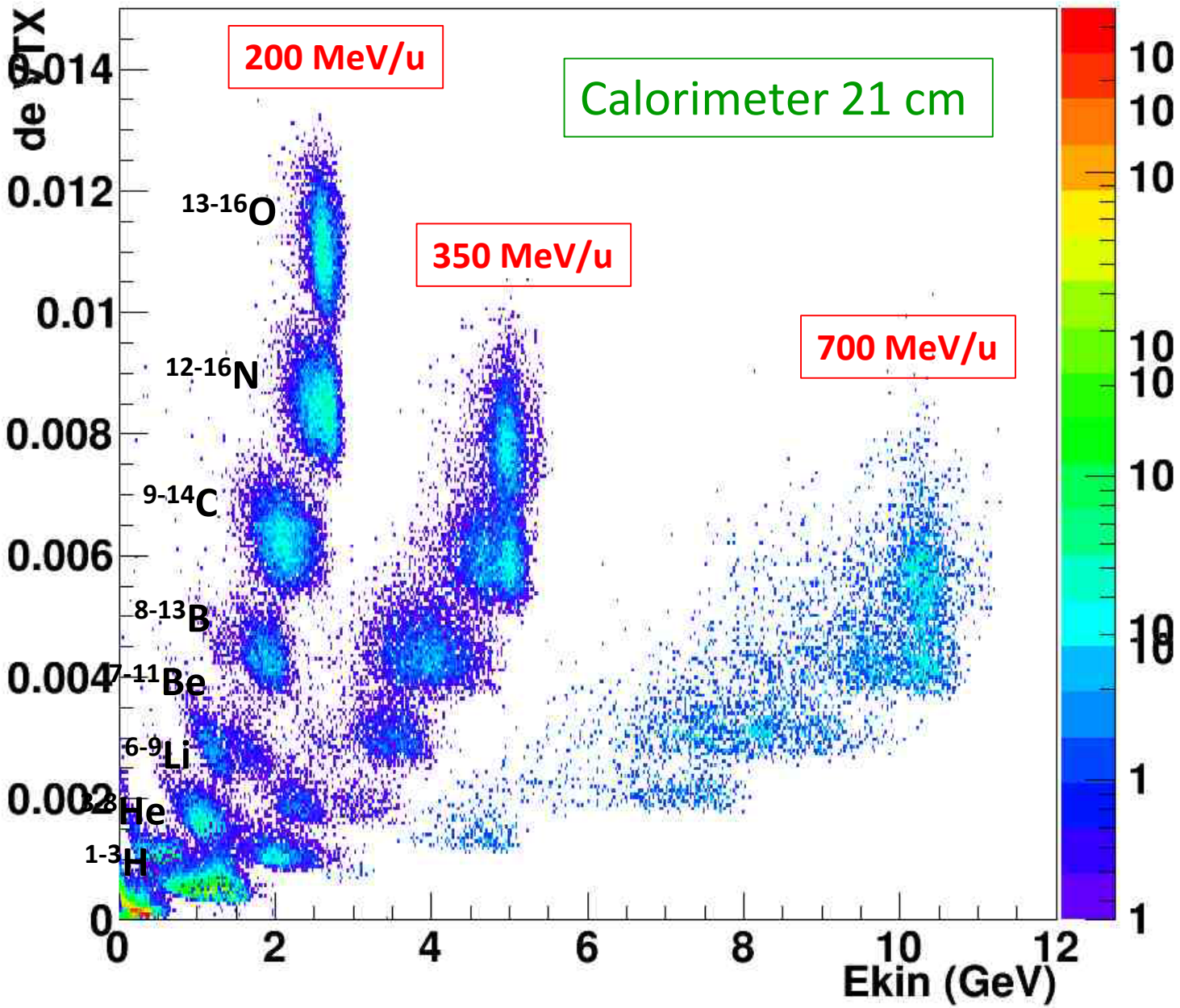




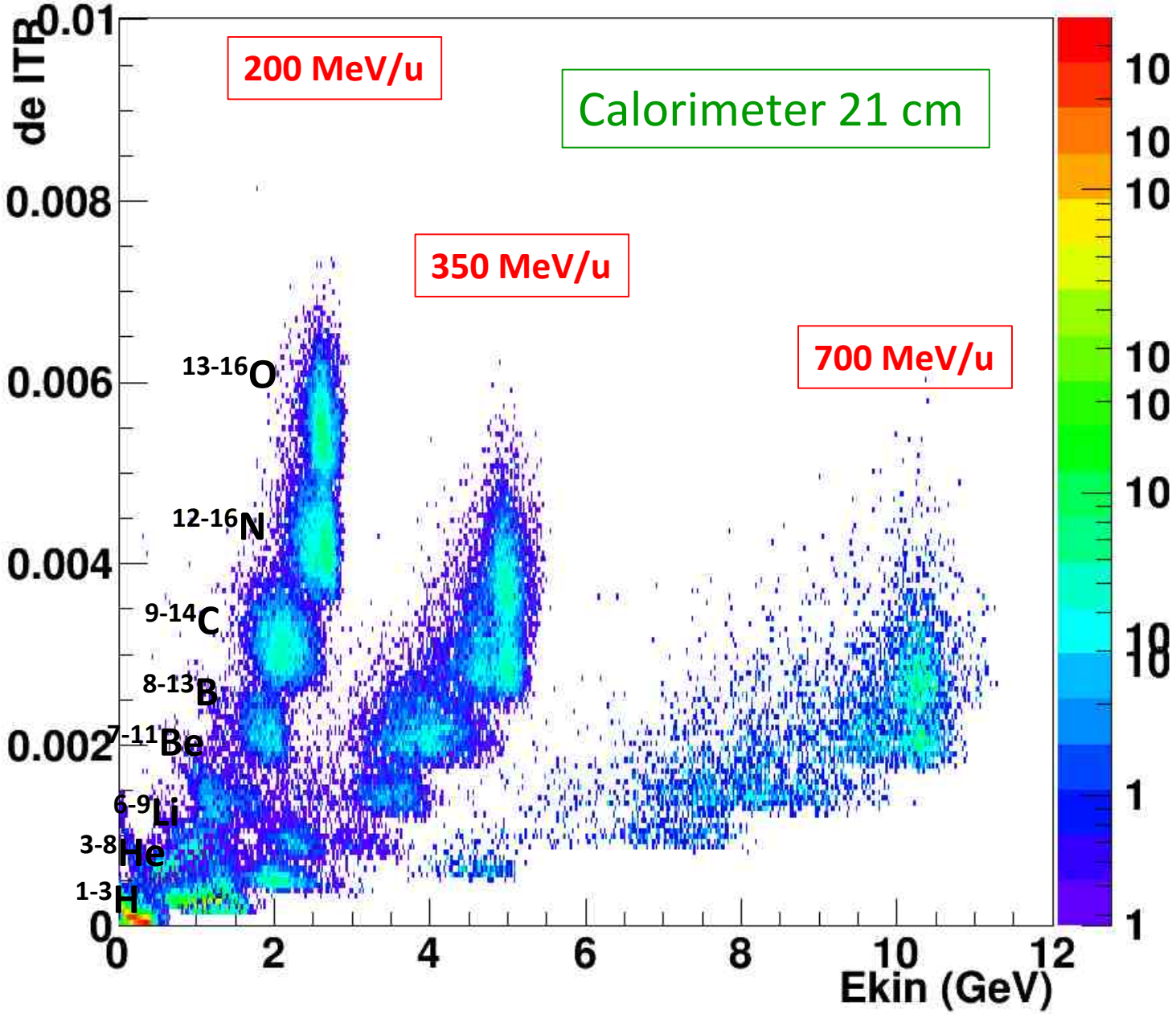


$$\frac{\text{Energy deposit SCINT + CALO}}{\text{Kin Energy generated}}$$

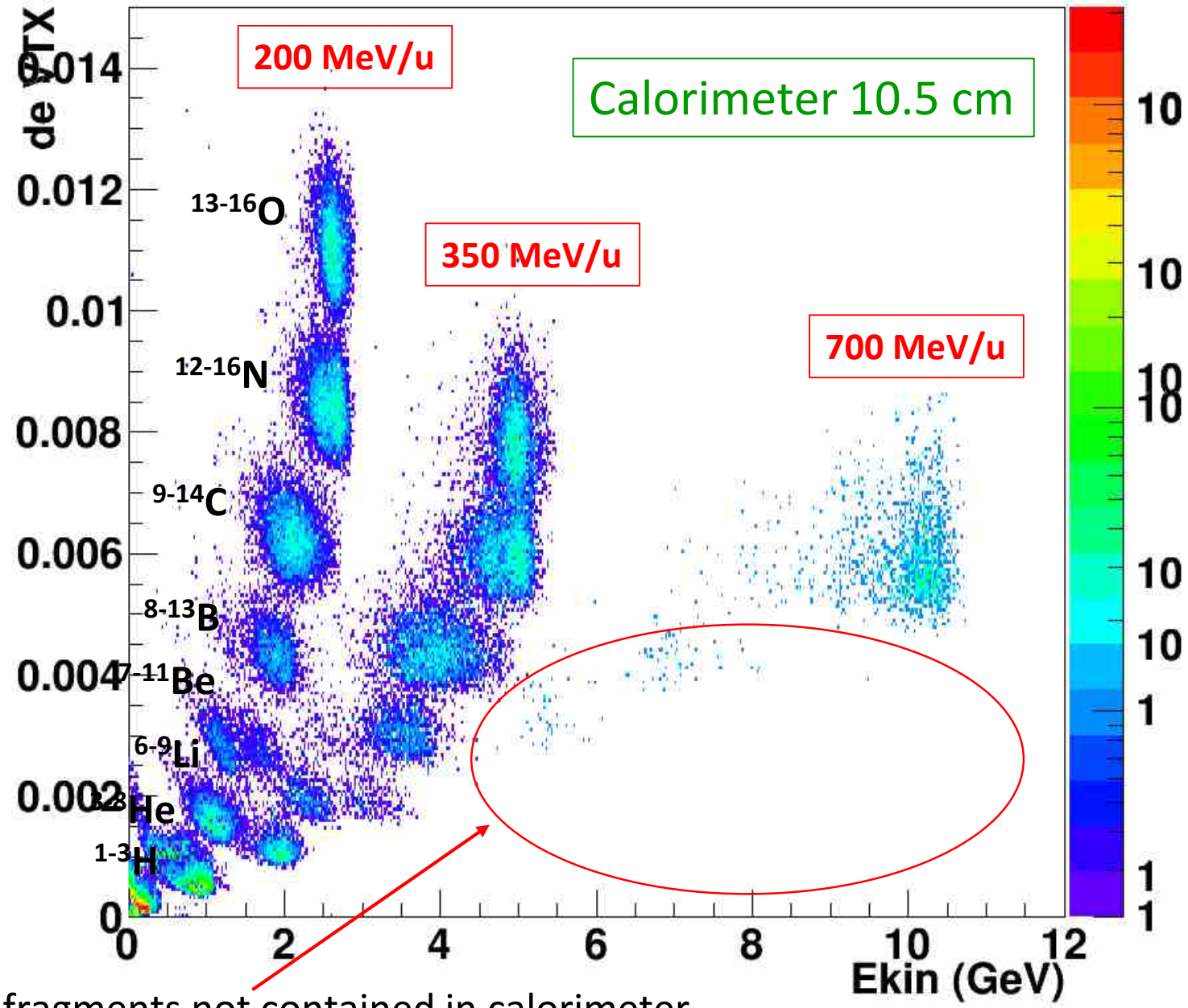
dE/dx vs E @ reconstruction level, VTX



dE/dx vs E @ reconstruction level, ITR

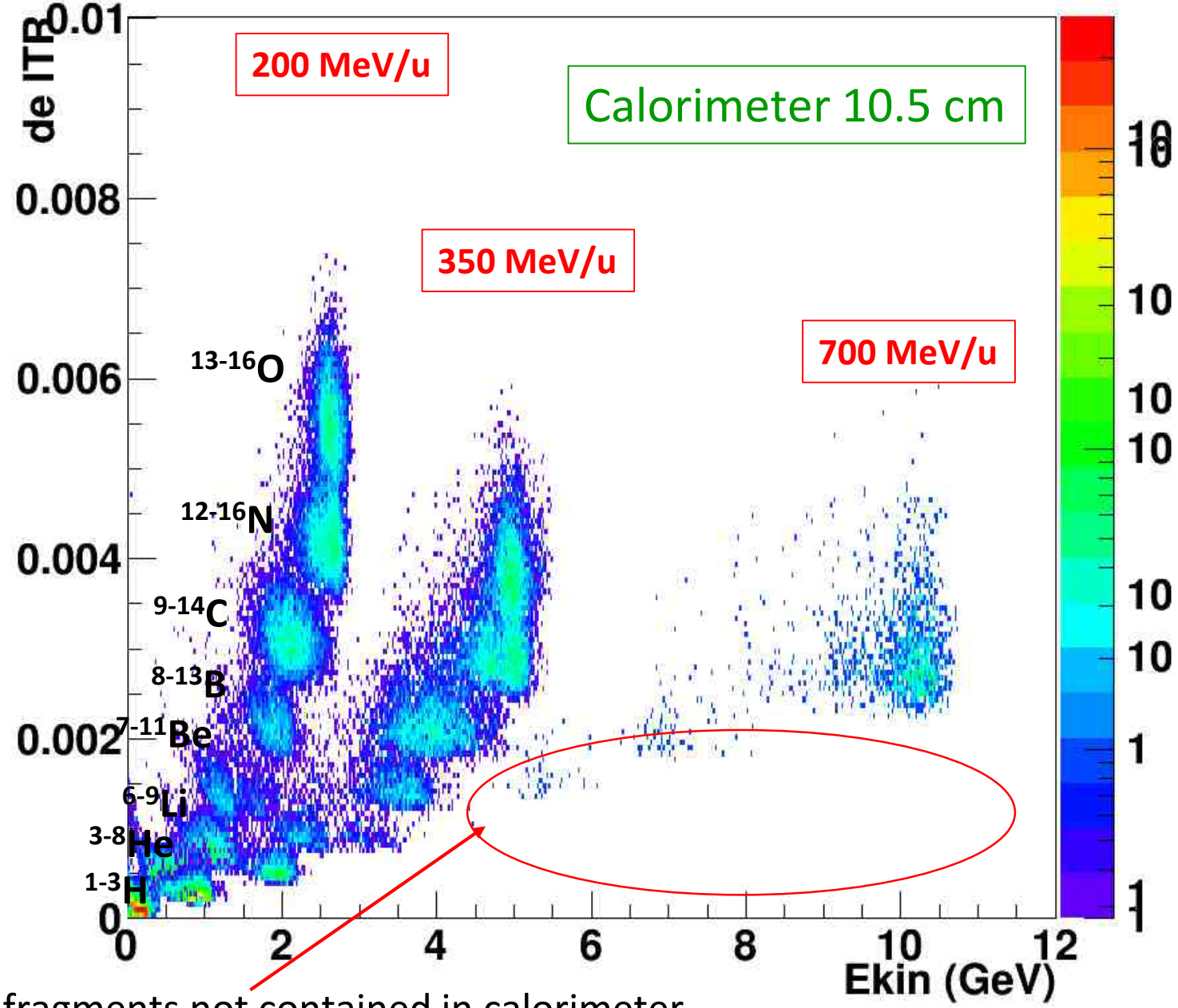


dE/dx vs E @ reconstruction level, VTX



Light fragments not contained in calorimeter

dE/dx vs E @ reconstruction level, ITR



Light fragments not contained in calorimeter