Update on CYGNO 30 GEANT4 simulation

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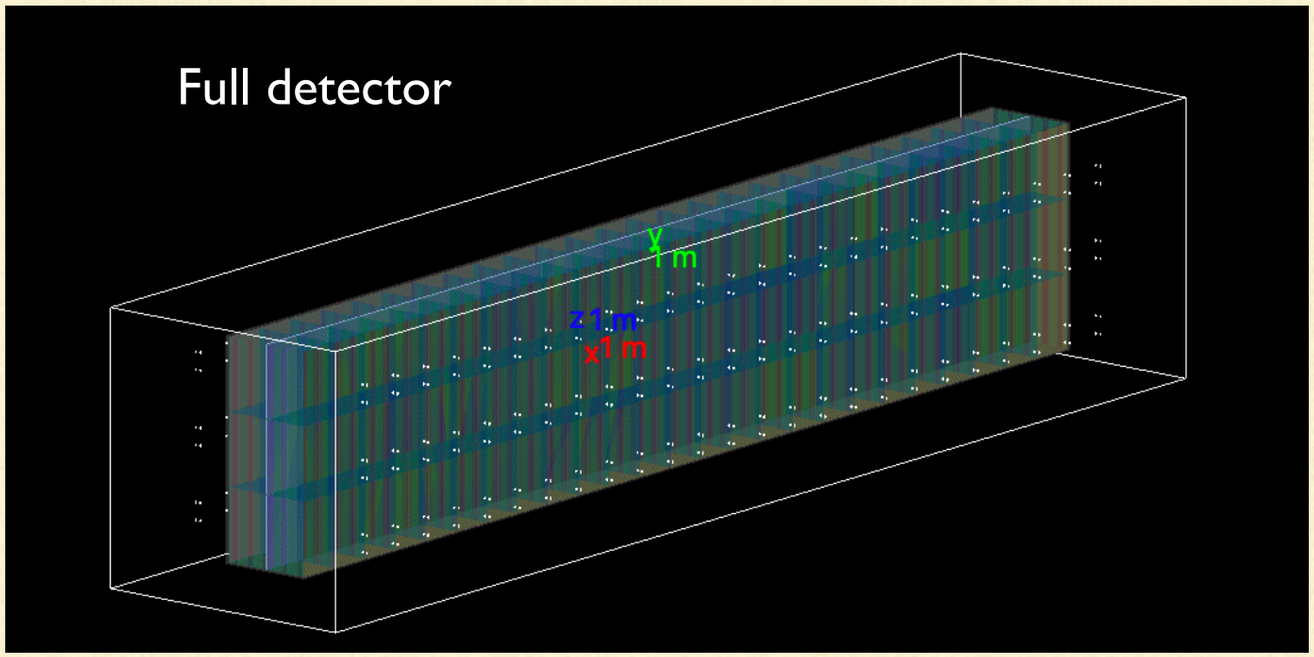
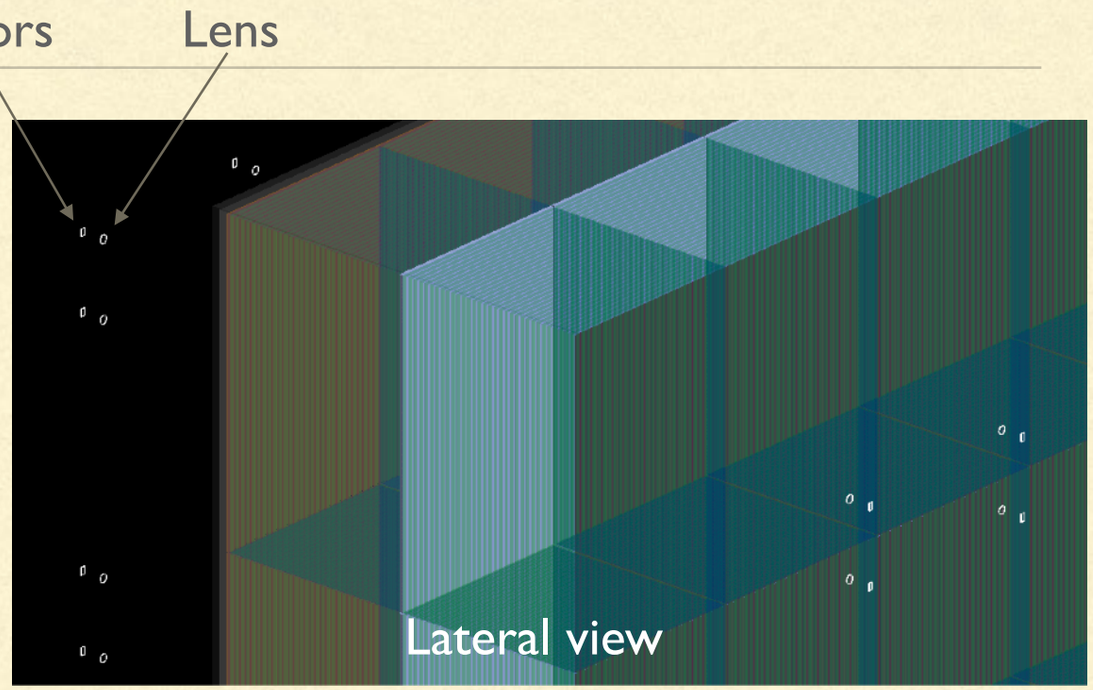
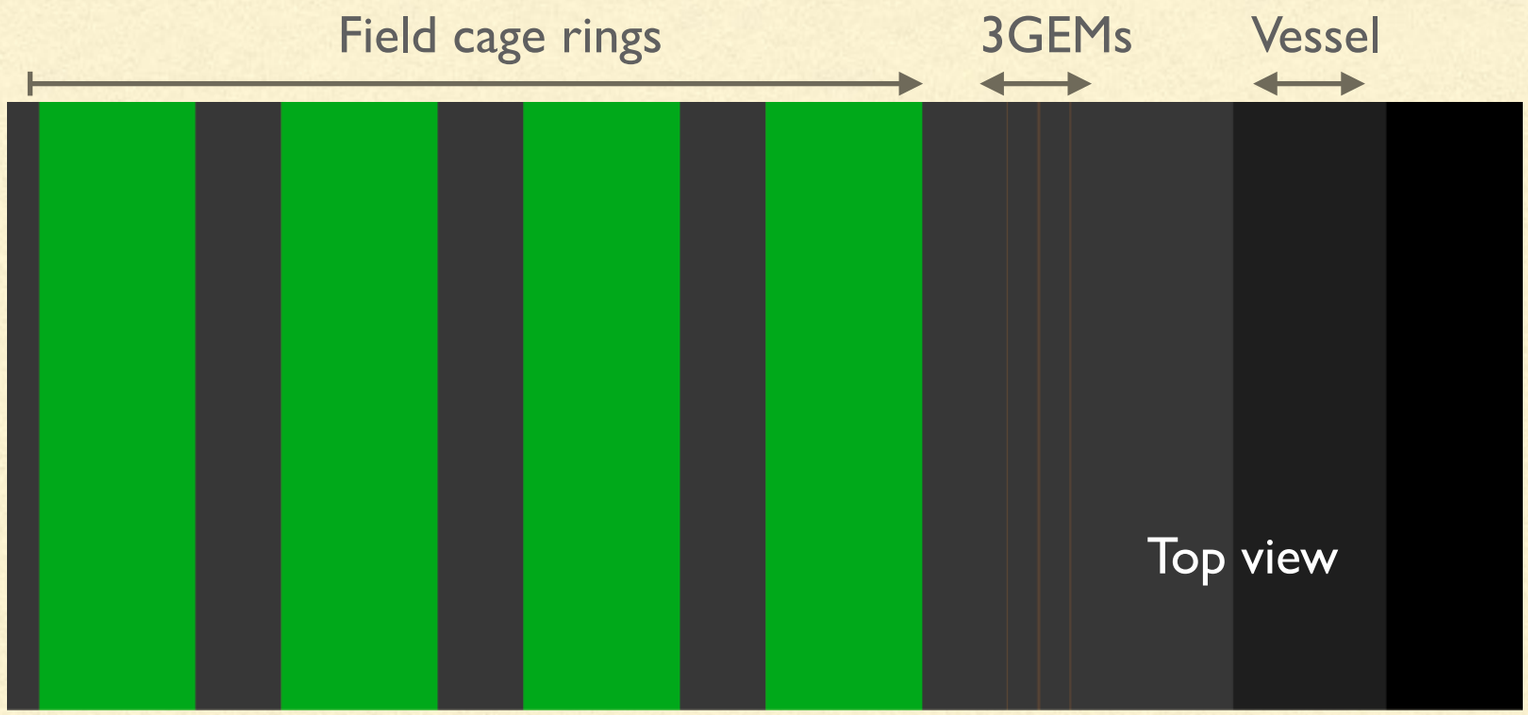
Detector geometry







Detector sizes

Cathodes	50 cm x 80 cm x 1 cm
Rings inner	50 cm x 80 cm x 1 cm + 2 mm thickness
Rings spacer	Such that 32 rings fit equidistantly in 50 cm lenght
GEMs	50cm x 80cm x 60 μm
GEMs spacing	2 mm thickness
Vessel	1 cm with respect to the detector + 1 cm thickness
Lens	1 cm Ø x 2 mm 57.7 cm from the GEMs
Sensors	10mm x 18mm x 1 mm 6 cm distance from Lens

Radioactive decay simulation

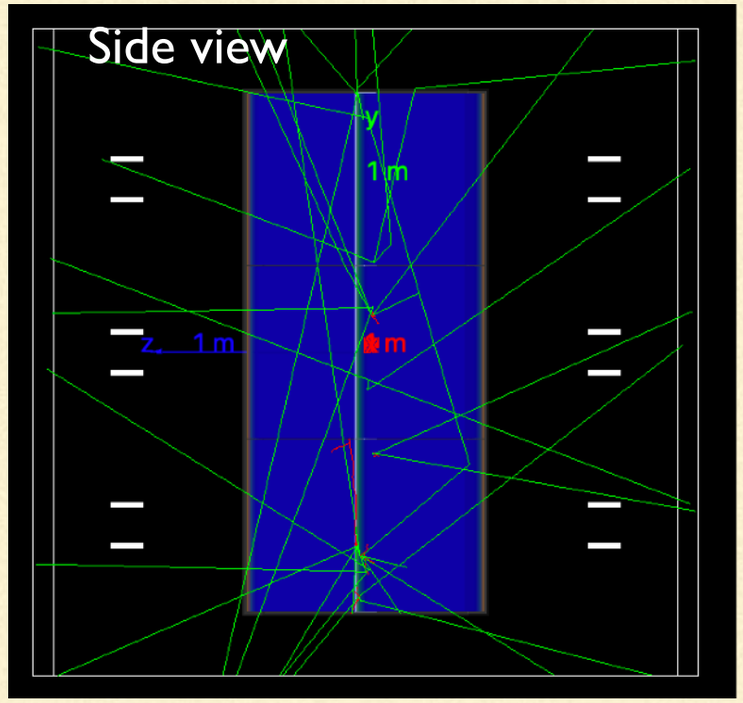
- Physics list used: FTFP_BERT_HP: for "radiation protection and shielding application"

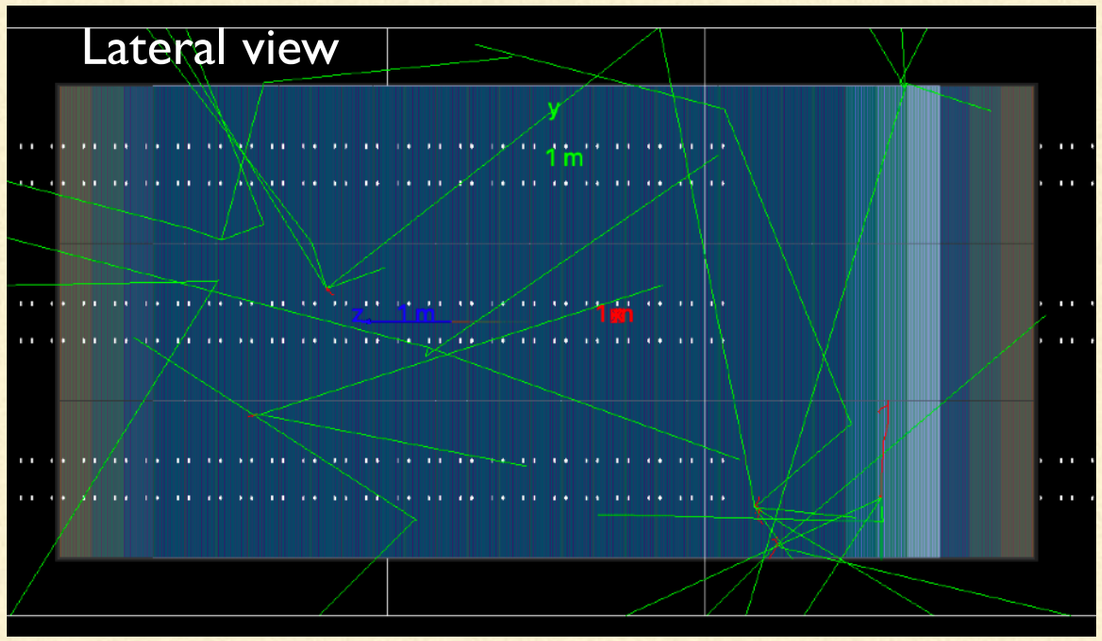
- For every detector element (GEMs, Cathodes, Rings, ecc…):
  - For every contaminant (U238,U235,K40, ecc…):

  - N iteration of:

    1. Extraction of a random detector element (GEM_34, GEM_75)
    2. Extraction of a random point on the element volume
    3. Simulation of the whole decay chain of the element, taking into account also atomic excited states

Example of 10 U238 simulated on Cathodes



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G4WT0 >     End of event. Decay chain: U238 ---> Th234 ---> Pa234[166.300X] ---> Pa234[73.920X] ---> U234 ---
> Th230[53.227] ---> Th230 ---> Ra226 ---> Rn222 ---> Po218 ---> Pb214 ---> Bi214[295.223] ---> Bi214[53.228] ---
> Bi214 ---> Po214[2192.537] ---> Po214[609.316] ---> Po214 ---> Pb210 ---> Bi210[46.539] ---> Bi210 ---> Po210 ---
> Pb206
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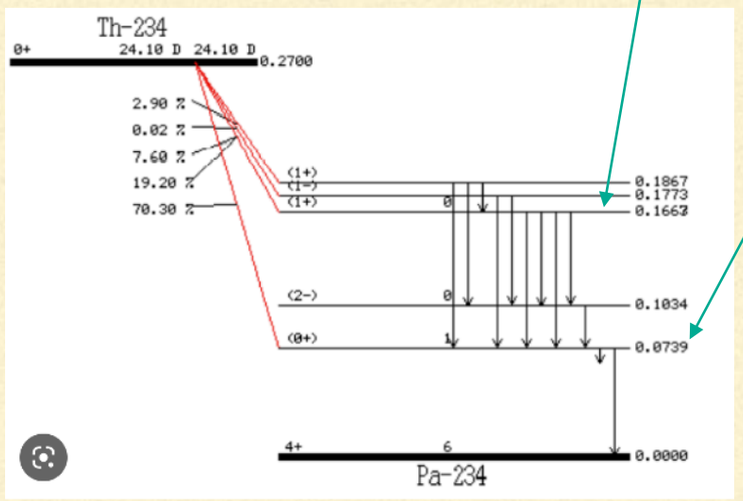
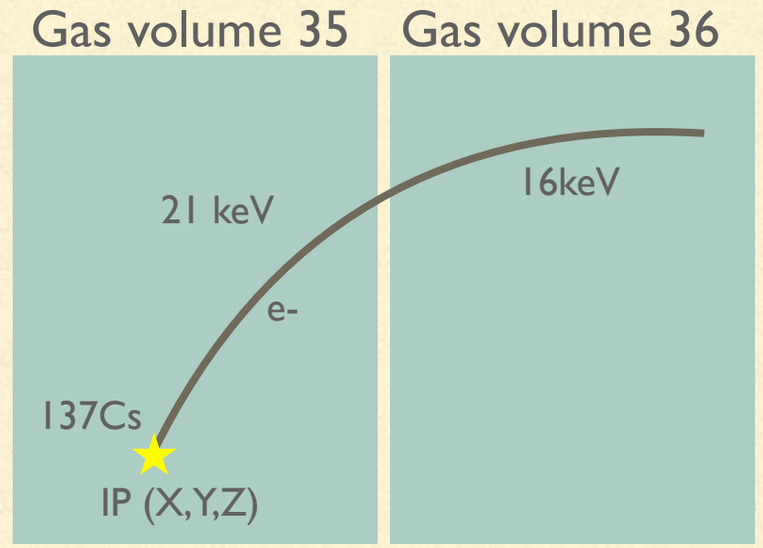


Spectra production and normalization

- Given the computational time of the chain simulations, for every detector elements:
  - 1.000.000 primary nuclides decays have been generated for U238, U235, Th232
  - 10.000.000 primary nuclides decays have been generated for K40, Co60, Cs137

- For each particle entering the gas volume the information saved are:
  - Particle name
  - Total energy deposit in the single volume
  - The number of the volume in which the energy is deposited
  - The primary nucleus
  - X, Y, Z of the vertex



37 keV electron in the final spectrum

- Final spectra produced taking into account we can reconstruct the total energy of the electron and the impact point

- Each histogram scaled by the quantity:

$$N = \frac{1}{N_{ev}} \cdot A \left[\frac{dec}{s \cdot kg}\right] \cdot M[kg] \cdot 3.15 \cdot 10^{7} \left[\frac{s}{y}\right]$$

- N_{ev} is the number of events
- A is the activity of the element
- M is the total mass of the detector component

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{"Cathodes",809.7}, {"GEMs",18.75}, {"Lens",0.4995},
{"Rings",1114.74}, {"Sensors",0.1392}, {"Vessel",1102.24}
```

- List of each component total mass in Kg

Comparison full decay chain vs single elements

Comparison done on GEMs contribution from Th232

- 10^5 events of Th232 simulating the full chain

1 histogram normalized with $N = \frac{1}{N_{ev}} \cdot A\left[\frac{dec}{s \cdot kg}\right] \cdot M[kg] \cdot 3.15 \cdot 10^7 \left[\frac{s}{y}\right]$

Primary

Vs

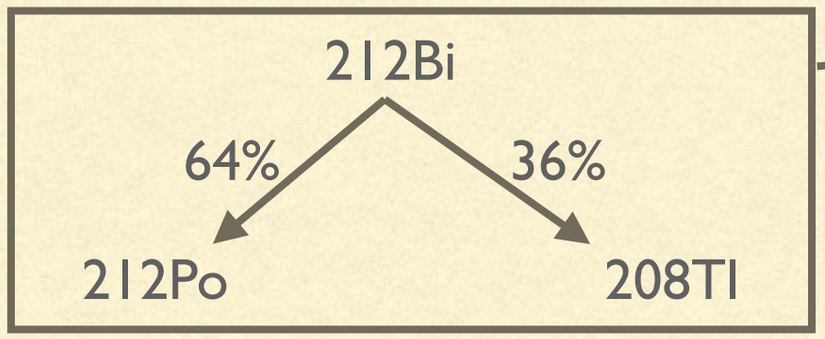
- 10^5 events of every single component of the whole decay chain

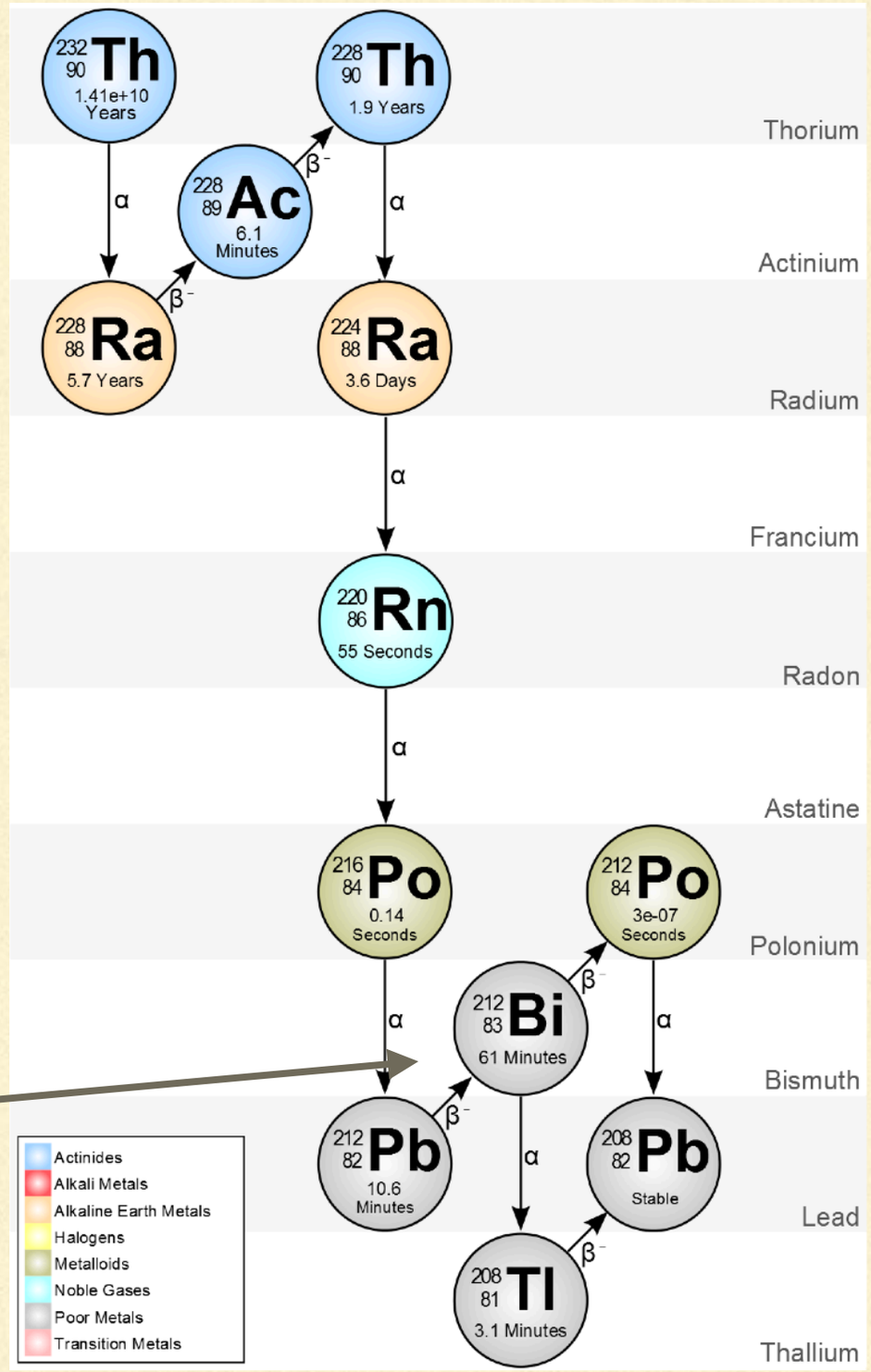
11 histograms each normalized with $N = \frac{1}{N_{ev}} \cdot A\left[\frac{dec}{s \cdot kg}\right] \cdot M[kg] \cdot 3.15 \cdot 10^7 \left[\frac{s}{y}\right]$

and summed

Primary — Same activity

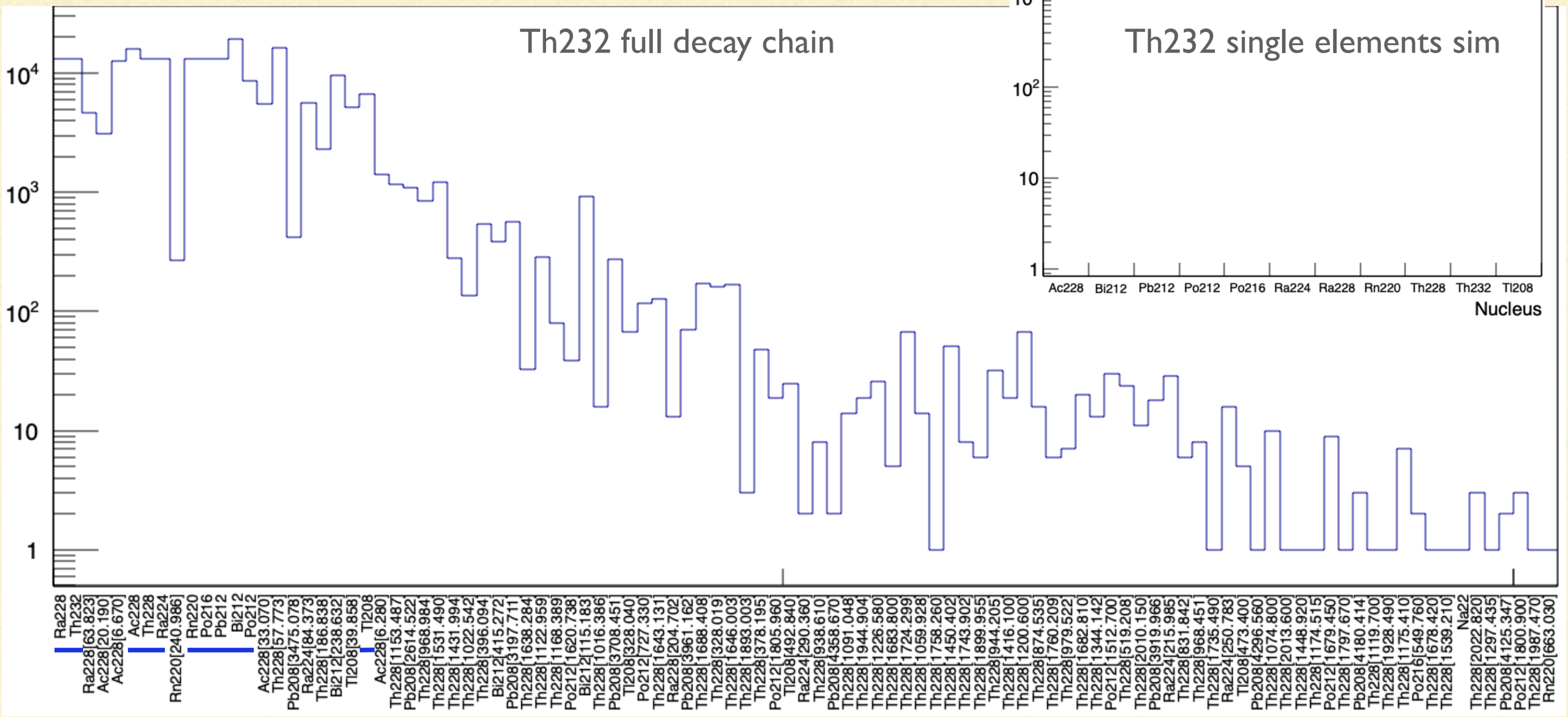
Where:



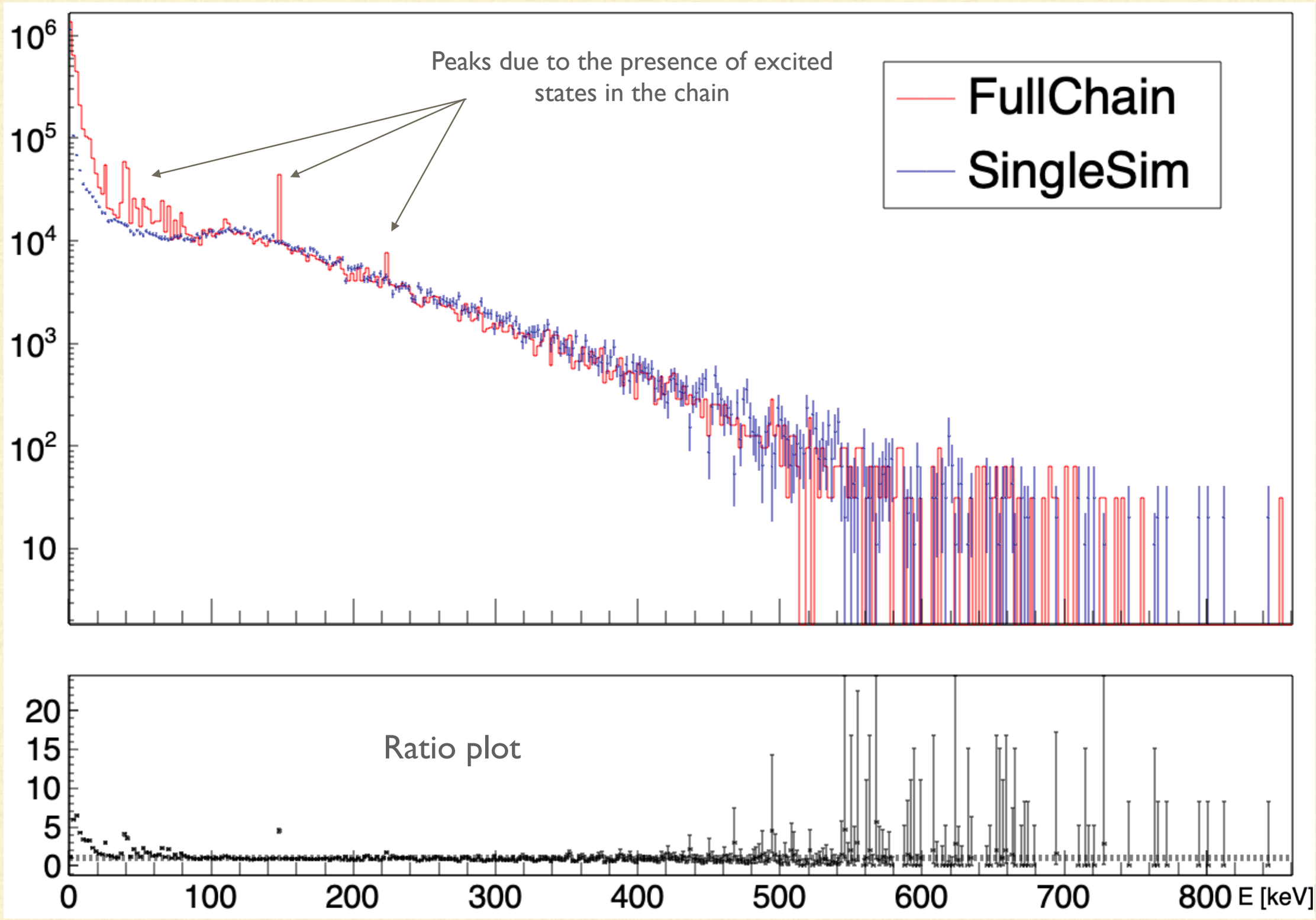


Total simulated decays in the full chain sim

Number of nuclei of each kind that produce an interaction in the detector

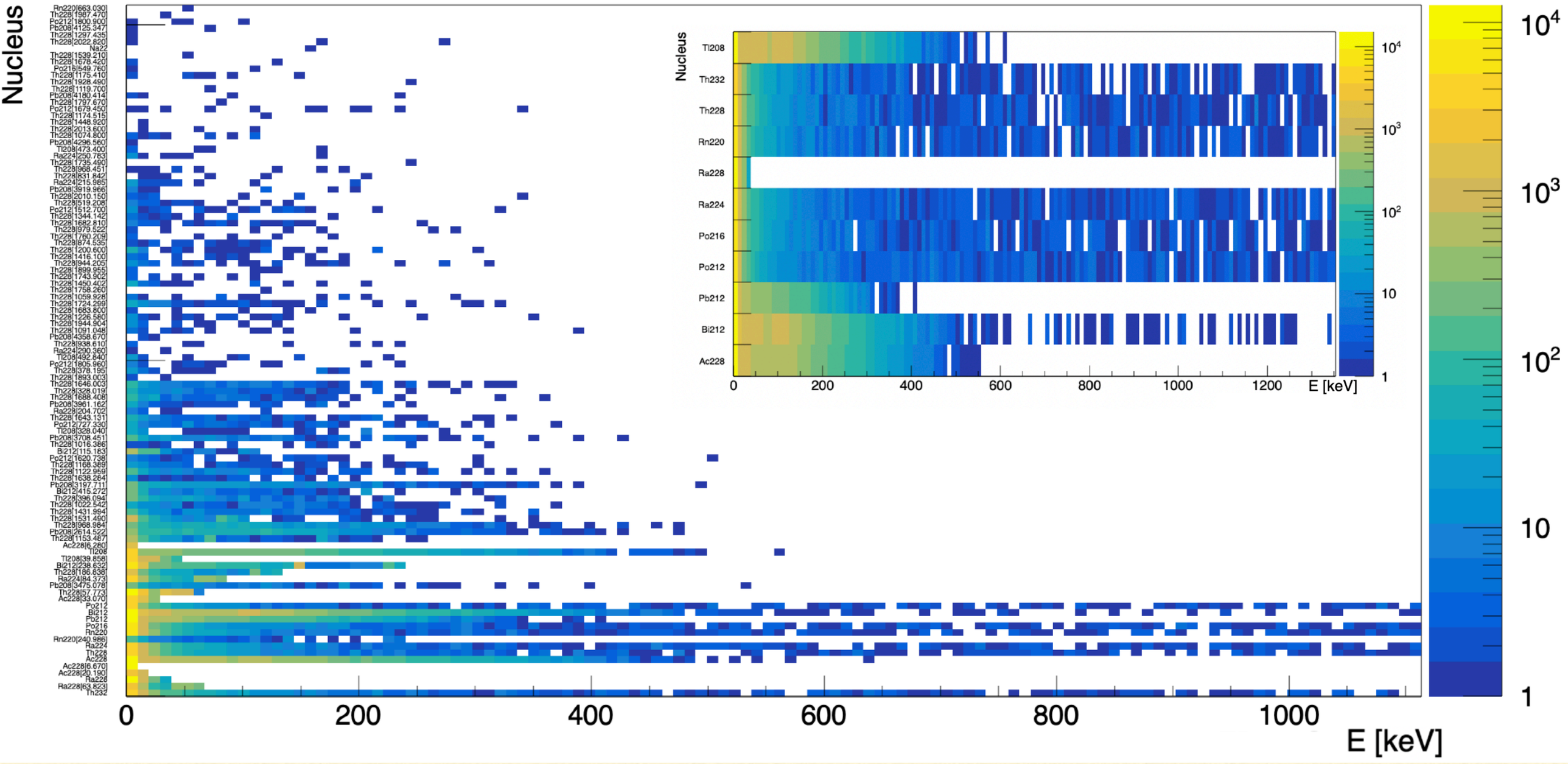


Energy spectra

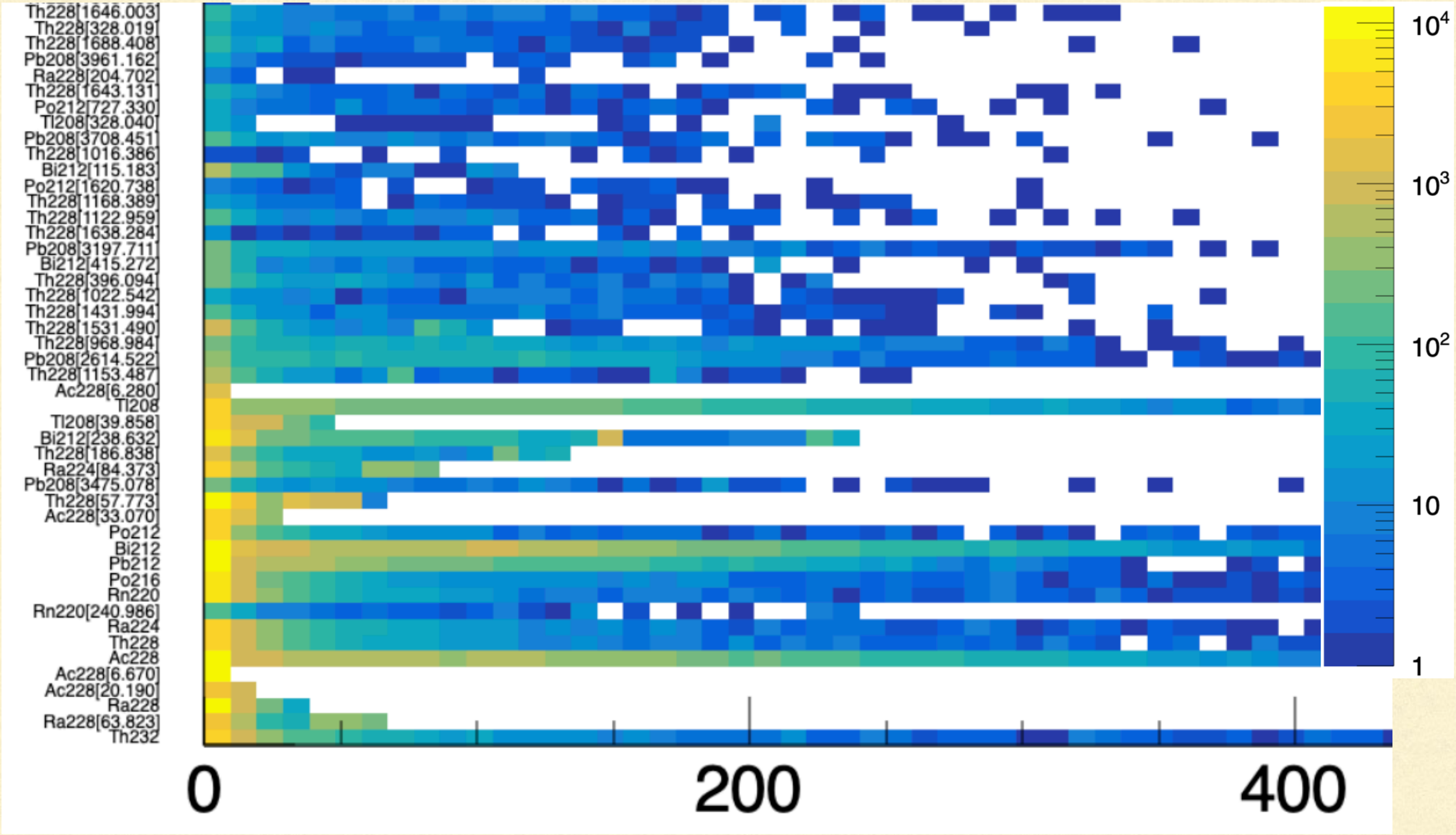


Single element contribution

Plot of energy spectra separated for the different nuclei involved



Zoom of the most interesting region



Single element contribution