Progress on Offline ^{136}Ba Draft

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MONUMENT Analysis Meeting

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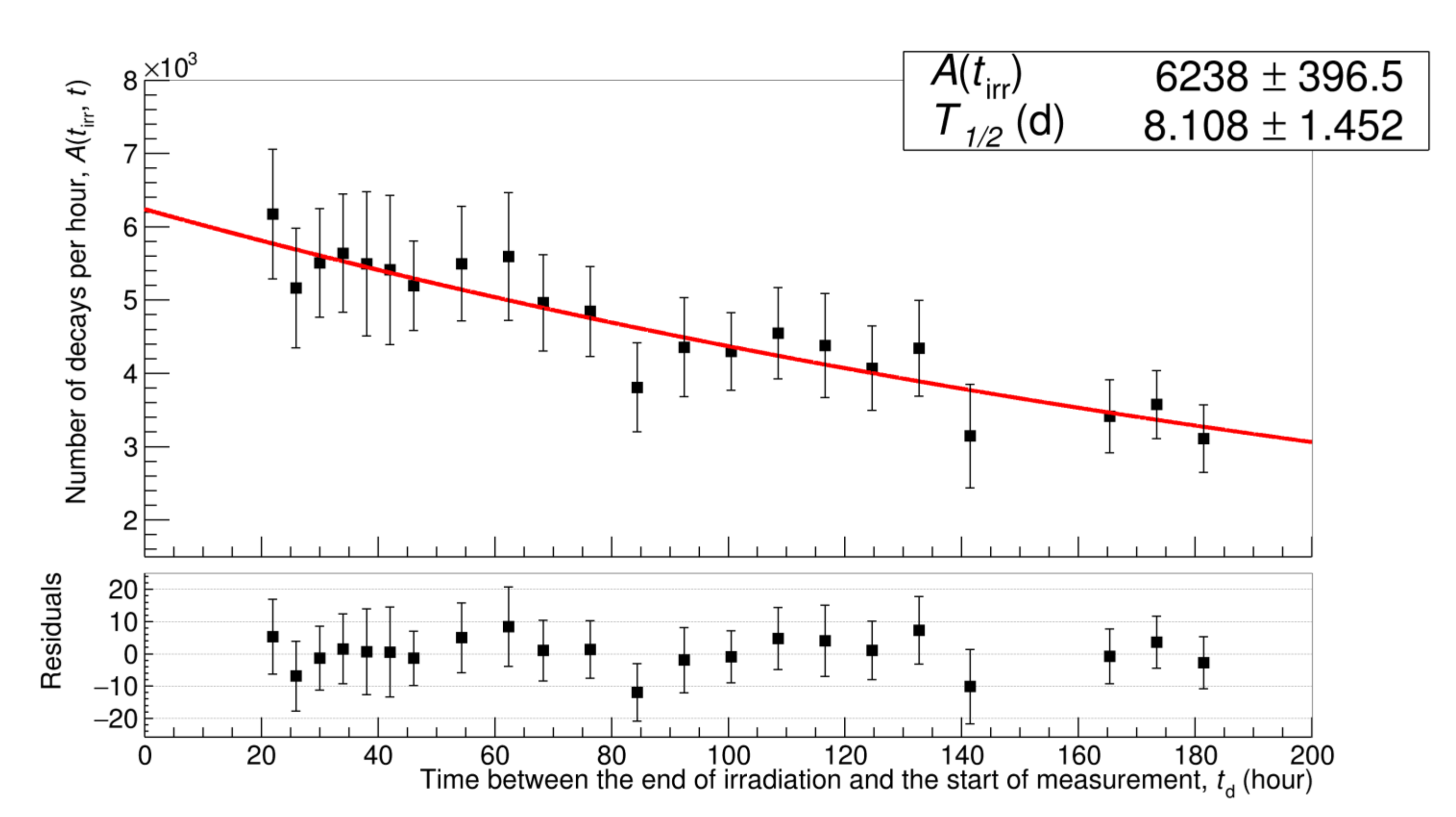
Changes in Peak Fitting

- Previous:
  The energy Gaussian width is obtained via fitting the peak in energy domain. Then, it is converted to the channel Gaussian width which is needed for calculation.

- Now:
  The peak is fitted in the channel domain directly. The parameters such as amplitude and the channel Gaussian width are now taken from here.

Observation of ^{131}I

- As discussed before, the ^{131}I is observed at 364.5 keV.
- For verification, the measured half-life is 8.0(15) days [NuDat: 8.0247(15) days].
- ^{131}I is the only (studied) isotope which can be observed at 364.0 – 365.0 keV with a half-life of 6.6 – 9.6 days.
- The above statement is added to the draft along with the decay curve.



Reaction Channel of ^{131}I

- The separation energy is now renamed as the binding energy, *B* since the latter is more understandable generally.
- The terms "total energy required" is removed since it is not accurate.
- For now, the binding energy and Coulomb barrier are discussed separately in the draft.

Table 5. The binding energy B and Coulomb barrier V for all possible reactions which produces ^{131}I from the OMC on ^{136}Ba.

Reaction	B (MeV)	V (MeV)
$(\mu^-, \nu_\mu \alpha n)$	9.4	15.7
$(\mu^-, \nu_\mu dt)$	27.0	15.0
$(\mu^-, \nu_\mu ptn)$	29.2	15.4
$(\mu^-, \nu_\mu\ ^3\mathrm{He}\ 2n)$	30.0	15.1
$(\mu^-, \nu_\mu 2dn)$	33.2	14.6
$(\mu^-, \nu_\mu pd2n)$	35.5	15.1
$(\mu^-, \nu_\mu 2p3n)$	37.7	15.6

- The emitting particles have to overcome *B* (and Coulomb barrier, *V* for charged particles).
- Despite having slightly higher *V*, the 1α1n reaction channel has significant lower *B* than other possible reactions. Hence, 1α1n reaction channel should be dominant in producing ^{131}I.

Coulomb Barrier, *V*

- The Coulomb barrier, *V* [1, 2]:

$$V = k_j k_e \frac{zZe^2}{r_0 A^{\frac{1}{3}} + \rho}$$

z, Z: the atomic number of the outgoing particle and of the residual nucleus respectively
e: electron charge
r_0 = 1.35 fm
A = mass number of the residual nucleus
ρ = 0 for protons and 1.2 fm for alpha particles
k_e = Coulomb's constant = $1/4\pi\varepsilon_0$
k_j = penetrability coefficient (0.7 for protons, 0.83 for alpha particles)

[1] Dostrovsky I, Rabinowitz P and Bivins R 1958 *Physical Review* **111** 1659
[2] Dostrovsky I, Fraenkel Z and Friedlander G 1959 *Physical Review* **116** 683

The article mentioning the equation is added.

Error Analysis: Coincidence Summing Effect

- In the offline measurement, we noticed that the coincidence summing effect is not negligible. Summed peaks were observed.

- Calculation can be done for obtaining the correction factor, but the total efficiency is required.

- There are two method on obtaining the total efficiency:
  - Experiment on single gamma emitters with the same setup
  - Monte Carlo calculation

- Currently, a free software called EFFTRAN [3] was found for performing Monte Carlo calculation. It can estimate the correction factor but some information are required:
  - Geometry of the detector and the target (including thickness of the target holder)
  - Material information of the crystal and target (including target holder)

[3] Vidmar T 2005 *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* **550** 603-608

Error Analysis: Coincidence Summing Effect

- The geometry of the detector and target were known, but we need the thickness of the plastic holder. Also, the type of plastic is required.

- The most problematic part is the material information of target, holder and some parts of detector, the information includes partial interaction coefficients and total attenuation coefficients.

- EFFTRAN has built-in information for some common materials only, such as germanium, polystyrene, air and vacuum.

- The material information is not required only if the target is a point source.

- Another problem is the exact distance between target and detector. Since we place the target directly on top of the detector, a slight gap can gradually change the correction factor.

Rough Estimation of Correction Factor (^{136}Cs: 340.5 keV)

Assumption:

- Target is a point source
- Detector window is plexiglass (actual one is epoxy)
- Thickness of holder is negligible

Target-to-detector distance (mm)	Correction Factor
0	1.484
1	1.442
2	1.406
3	1.374
4	1.346
5	1.321
10	1.229
20	1.132
30	1.086
40	1.060
50	1.044
100	1.015

Comparison with Other Materials

Target-to-detector distance (mm)	Correction Factor for 340.5 keV (^{136}Cs)			
	Point source	Fe	Ge	Pb
0	1.484	1.523	1.499	1.582
1	1.442	1.481	1.459	1.536
2	1.406	1.445	1.424	1.495
3	1.374	1.412	1.393	1.459
4	1.346	1.383	1.365	1.427
5	1.321	1.356	1.340	1.397

Same size as $BaCO_3$ target
(2.4 mm thick, 20 mm diameter)

Unsolved Major Issues

- Correction factor or error for summing effects
- Muon intensity and stopping rate