XVII CPAN DAYS

Centro Nacional de Física de Partículas, Astropartículas y Nuclear.

First full β-strength measurement with DTAS across N=126 at FAIR phase-0

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On behalf of DESPEC collaboration

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Valencia

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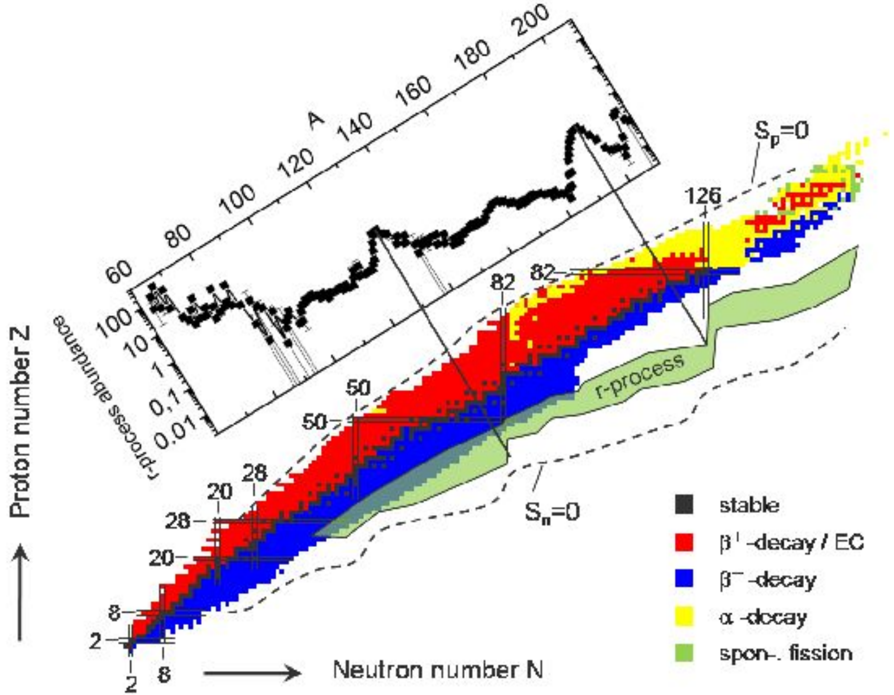
HISPEC DESPEC FAIR GSI CSIC Consejo Superior de Investigaciones Científicas Vniversitat de València IFIC Institut de Física Corpuscular Excelencia Severo Ochoa Gen-T

Aim of the experiment

- Site for the astrophysical r-process is still uncertain
- Nuclear input data is also uncertain: lack of experiments
- In particular data for the 3rd r-process peak (~N=126)
- Benchmarking β-strength theoretical models used for $T_{1/2}$ an P_n predictions on r-process calculations
- Using Total Absorption Gamma-ray Spectroscopy (TAGS) to benchmark directly the β-strength (and not the $T_{1/2}$ and P_n)



! **$T_{1/2}$ and P_n derived from S_β (β-strength) calculations:**

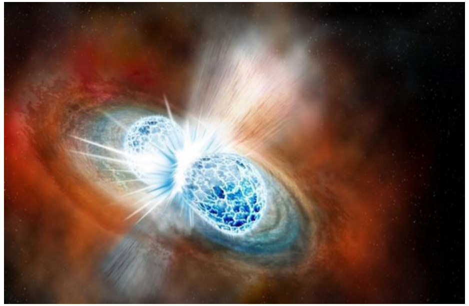
$$\frac{1}{T_{1/2}} = \int_0^{Q_\beta} S_\beta(E_x) \cdot f(Q_\beta - E_x)\, dE_x$$

$$S_\beta^{th}(E_x) = \frac{1}{D}\frac{g_A^2}{g_V^2}\frac{1}{2J_i+1}\left|\langle f \| M^\beta_{\lambda\pi} \| i \rangle\right|^2$$

$$P_n = T_{1/2} \int_{S_n}^{Q_\beta} \frac{\Gamma^n(E_x)}{\Gamma^{tot}(E_x)} S_\beta(E_x) \cdot f(Q_\beta - E_x) \cdot dE_x$$

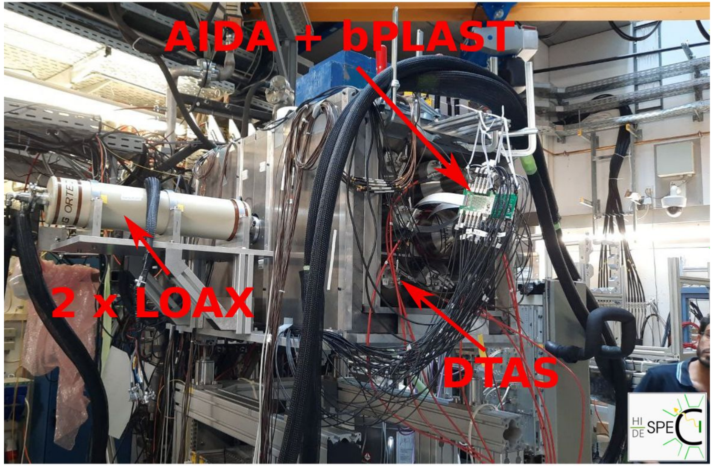
$$S_\beta^{exp}(E_x) = \frac{I_\beta(E_x)}{T_{1/2}\, f(Q_\beta - E_x)}$$

TAGS



S505 - Experimental Set-up at S4

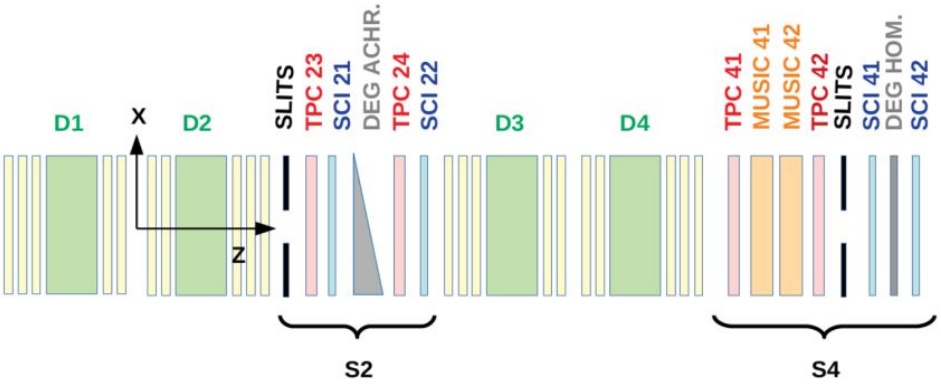
Spokesperson: Jose Luis Tain, Ana Isabel Morales, Enrique Nacher



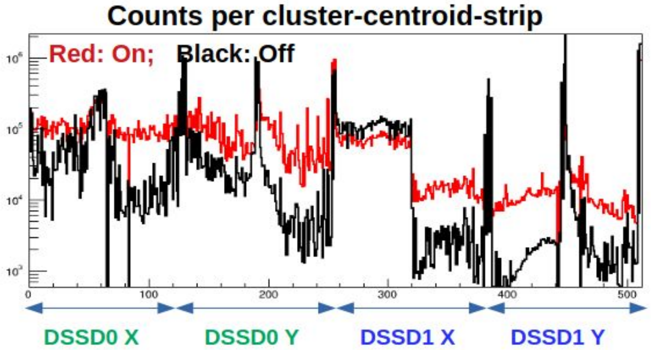
DTAS (16xNaI(TI) det.)
AIDA (2xDSSSDs-80mmx80mm)
2x**bPast** detectors
2x**LOAX** HPGe (1 not operational)

Performed: June 21-28, 2022
Beam/Target: ≤4.5x10^{8} ppb (1.6s/2.2s), 1GeV/u ^{208}Pb on 1.6 g/cm^{2} Be
FRS Settings: ^{204}Pt(~125h), ^{207}Hg (~15h)

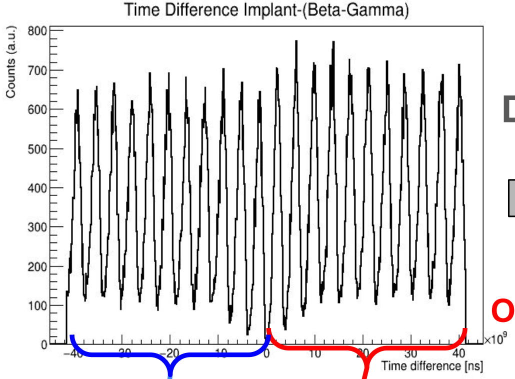
		207Hg 2.9m 4.6MeV (9/2+)
204Au 39.8s 4.0MeV (2-)	205,205mAu 32.5/6s 3.5/4.4MeV (3/2+,11/2-)	206Au 45s 6.7MeV (?)
203,203mPt 22s/12s 3.5MeV (1/2-,?)	204Pt 16s 2.7MeV 0+	



- Implant-beta(gamma) time correlation: forward and backward
- Gamma spectra from forward-backward correlation differences of identified implants

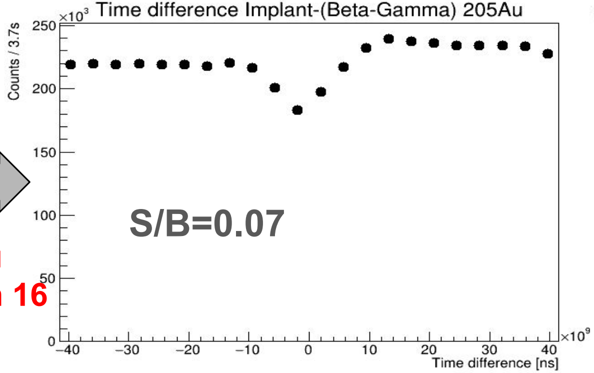


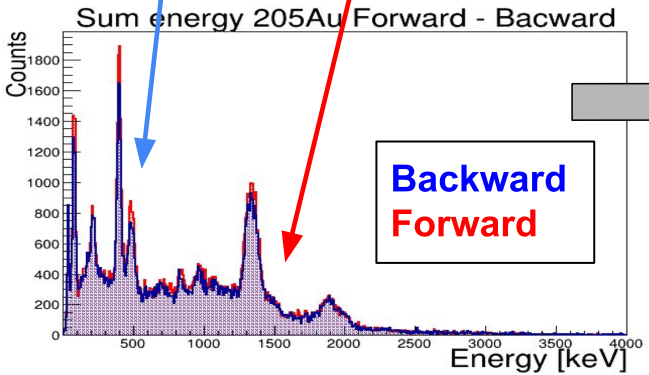
- Huge rate in decay branch, in particular for DSSD0 during spill
- Large noise on most FEE64s
- Noisy strips can be identified
- Large number of strips firing in one decay event

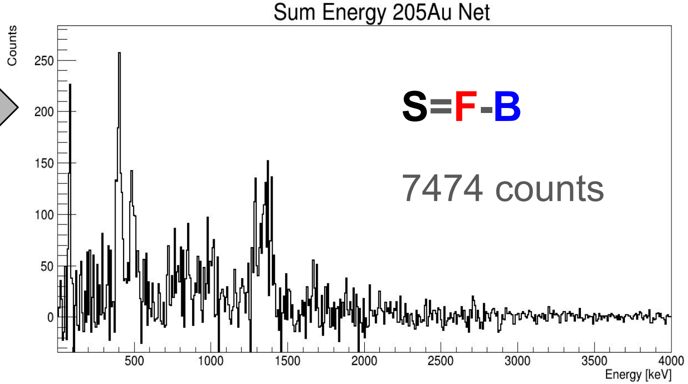


DSSD0

205Au
Only Run 16

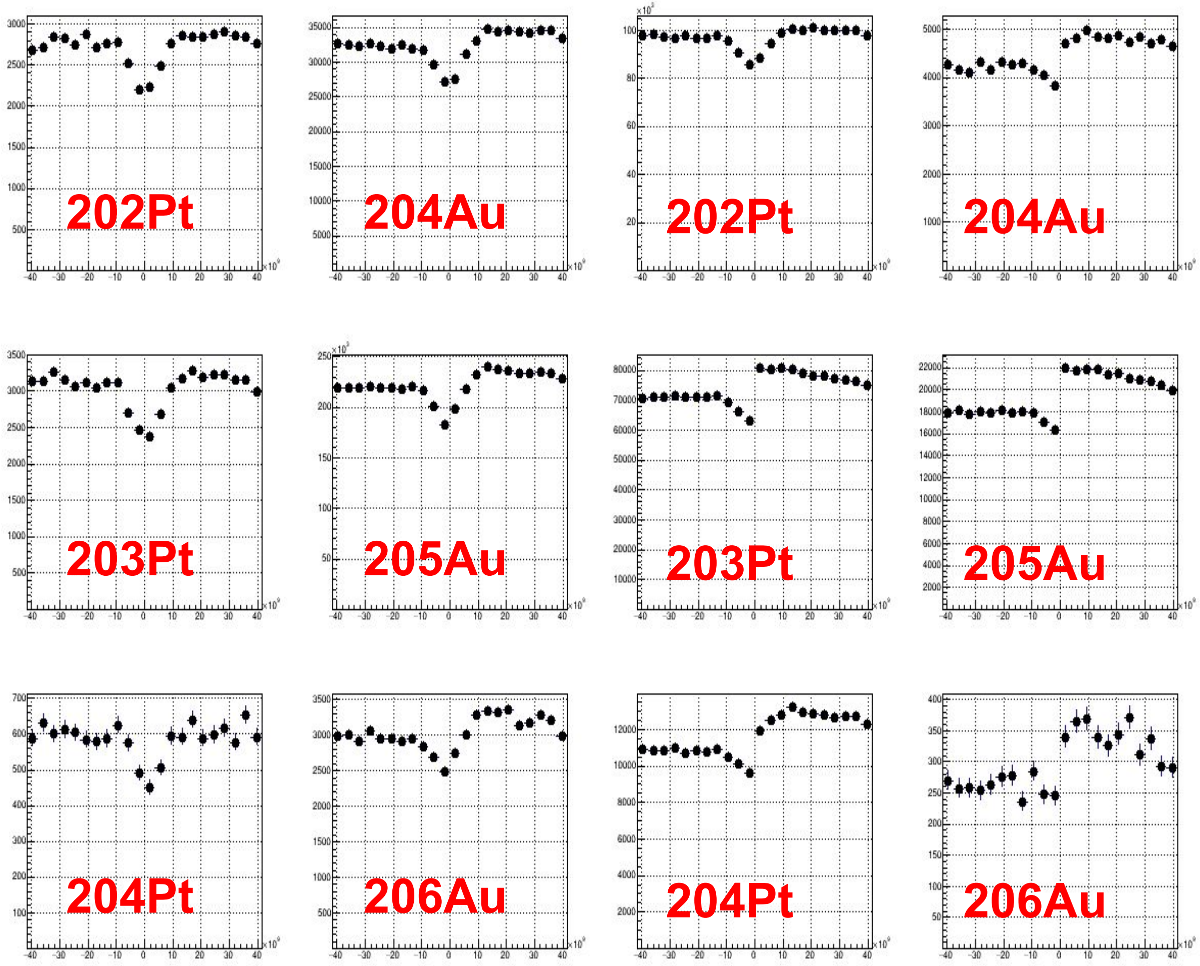






Issue: very poor S/B

DSSD0 (S/B~0.06) **DSSD1 (S/B~0.15-0.20)**

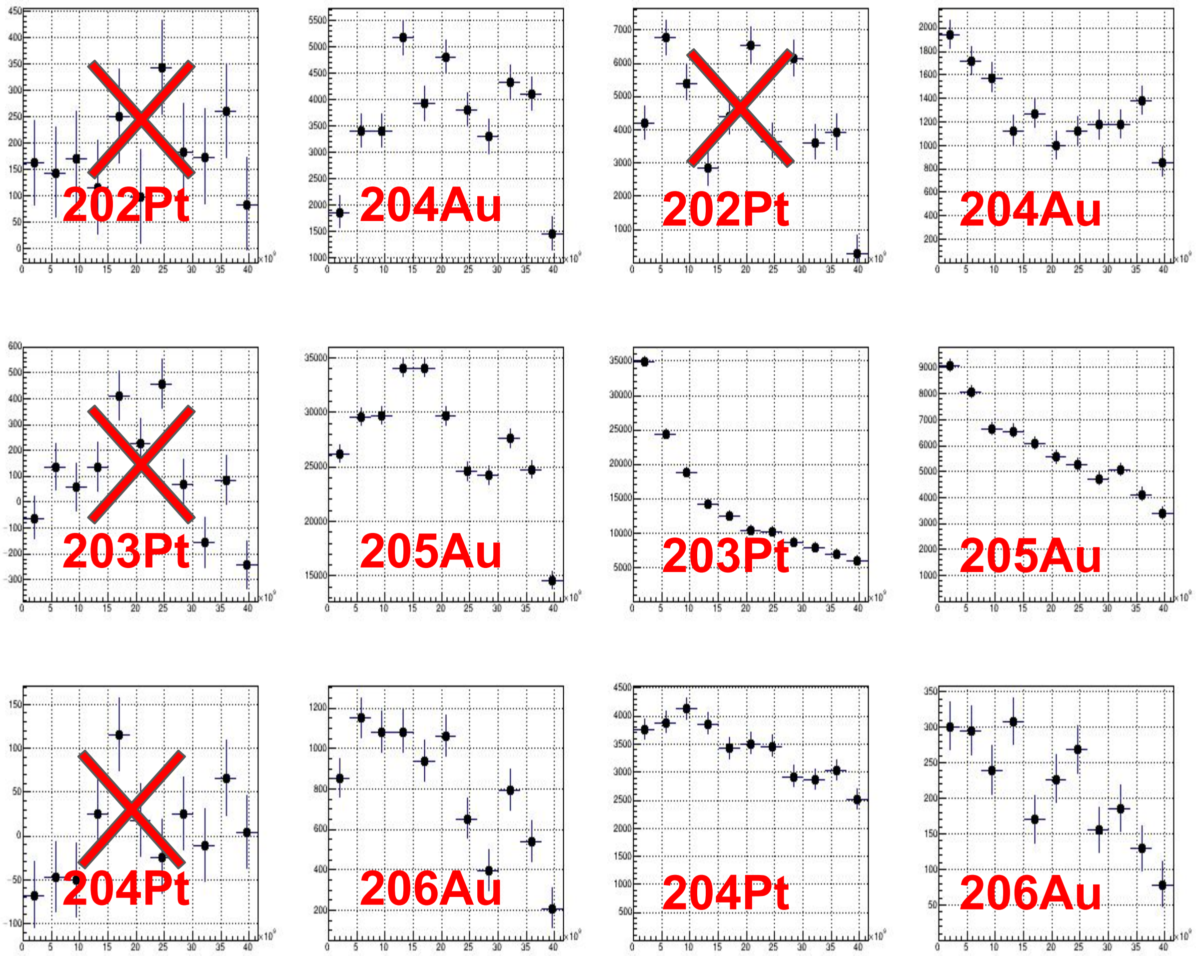


Implant-beta(gamma) time correlation window: ±41.5s

Large difference between DSSD0 and DSSD1, in signal-to-background and shape.

Reminder: We implanted Pt in DSSD1 and Au in both detectors
80% Au implants in DSSD0

DSSD0 (S/B~0.06) DSSD1 (S/B~0.15-0.20)



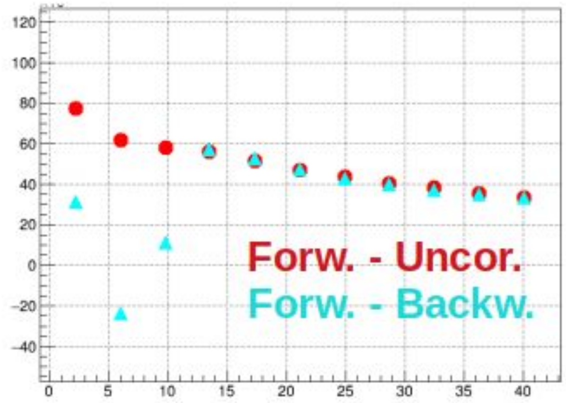
Difference forward - backward in the time correlation implant-beta(gamma).

Strange behaviour in DSSD0
DSSD1 has a better shape

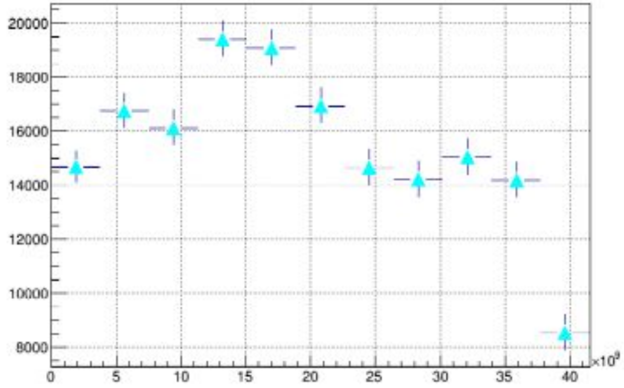
Reminder:
We implanted Pt in DSSD1 and Au in both detectors.
$T_{1/2}$ 202Pt = 45(15)h
80% Au implants in DSSD0

205Au case (10% 205mAu)
DSSD0:

MC

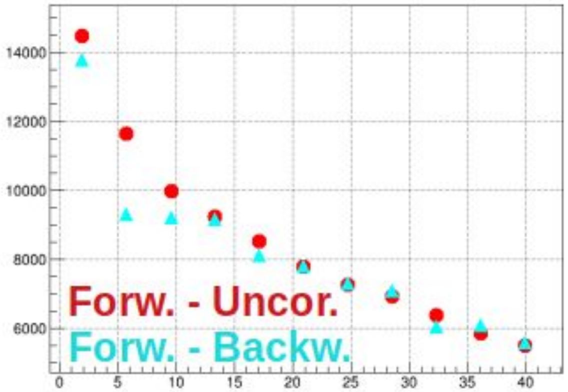


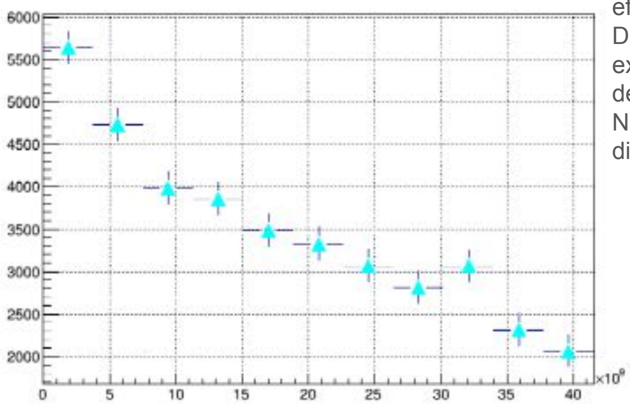
EXP



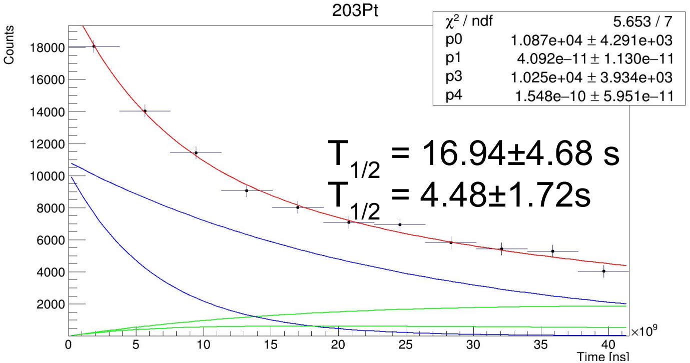
We made a realistic MC simulation of implant-beta correlation trying to understand this behaviour.

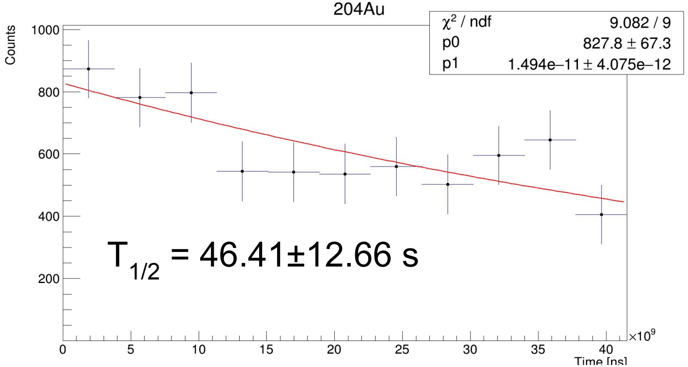
205Au case (10% 205mAu)
DSSD1:



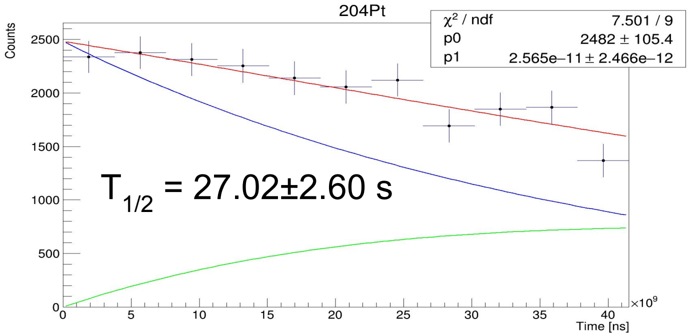


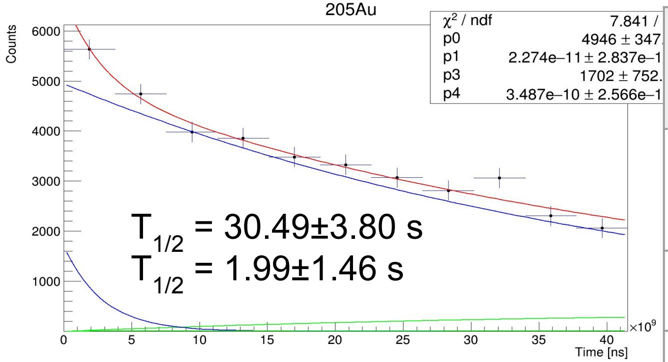
Experimental information used in the simulation:
Spill sequence (1.6s/2.2s), 18 delivered, 3 not delivered.
Implants: time distribution, experimental efficiency and rate XY distribution.
Decay: sequence to stability, experimental beta-gamma efficiency, dead-time and XY distribution.
Noise: rate variation over time and XY distribution.

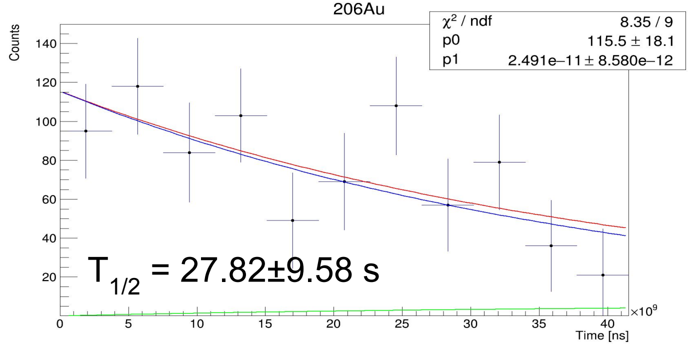




PRELIMINARY



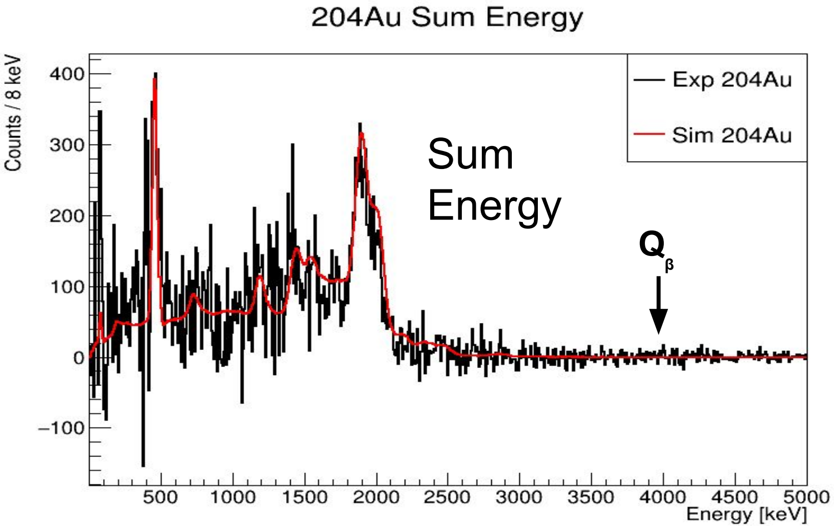


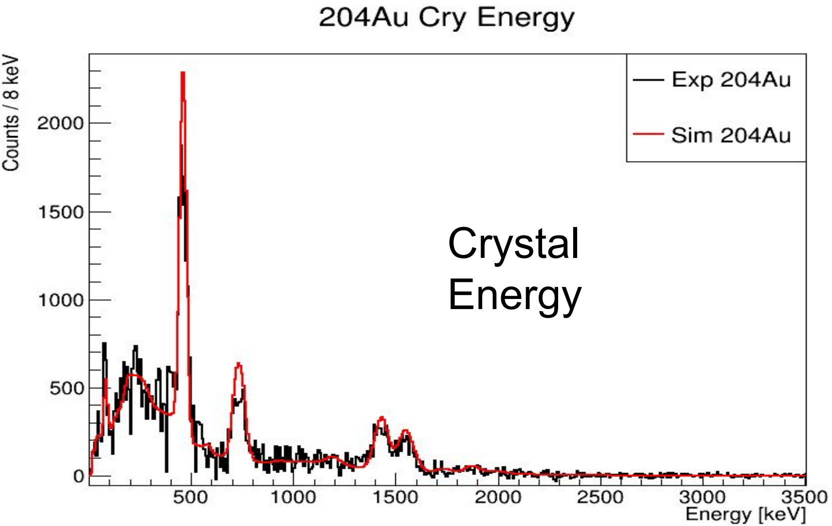


Isotope	Previous (ENSDF)	This work
203Pt **203mPt**	22(4); 12(5)	17(5); 4.5(17)
204Pt	10.3(13)	27(3)
204Au	39.8(9)	46(13)
205Au **205mAu**	32.0(14); 6(2)	30.5(38); 2.0(15)
206Au	40(15)	28(10)

Short (isomer) half-lifes affected by background subtraction (!?)

Preliminary analysis of beta intensity distribution of ^{204}Au and ^{205}Au

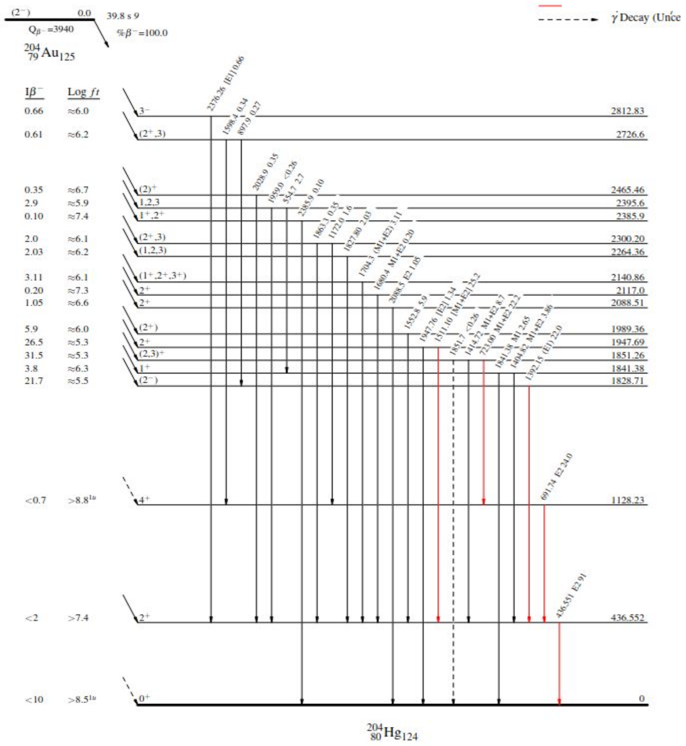




204Au

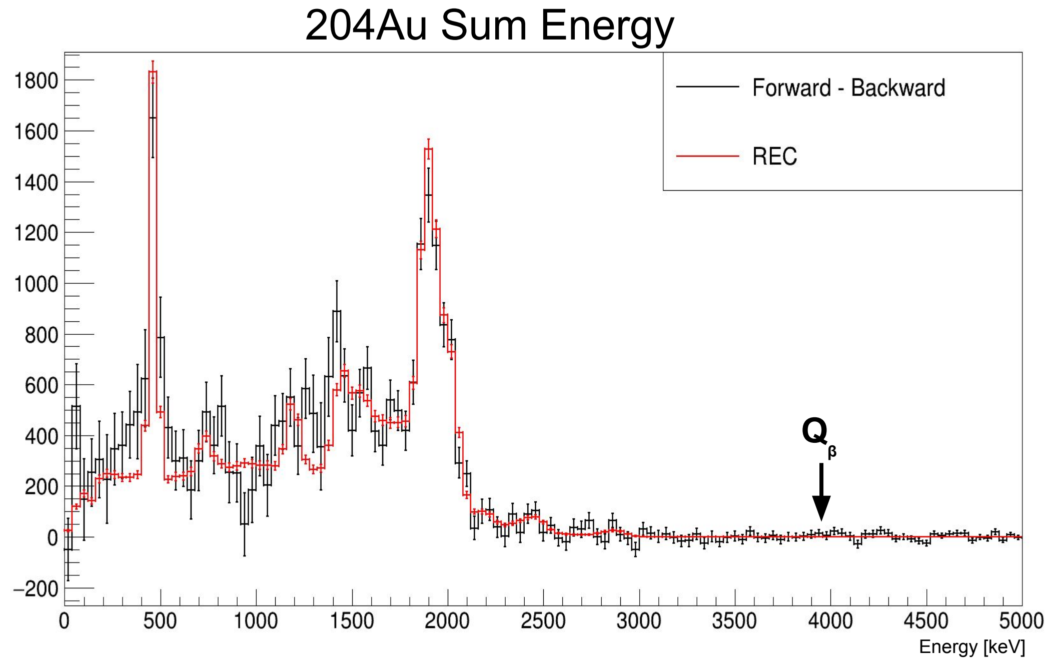
Full statistics: 26.8k counts

Comparison with previous knowledge



D.A. Craig and H.W. Taylor 1984 *J. Phys. G: Nucl. Phys.* **10** 1133

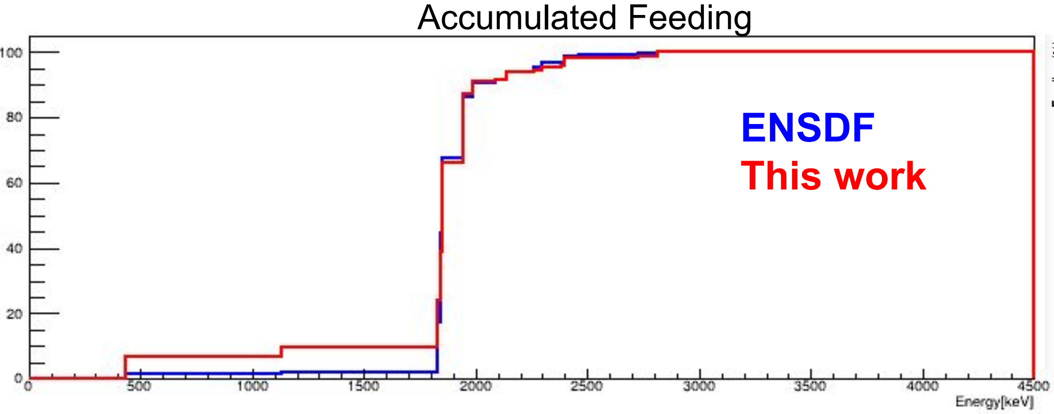
Within our sensitivity, no additional beta intensity

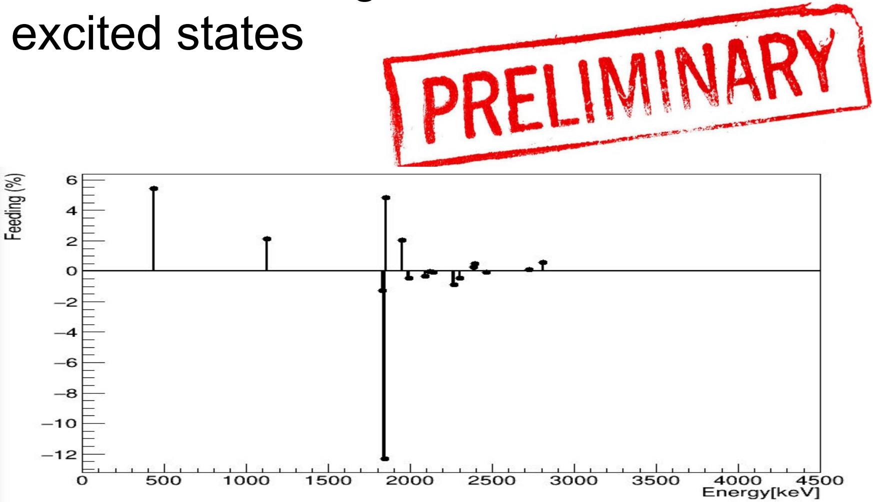


Preliminary beta intensity distribution results for 204Au.

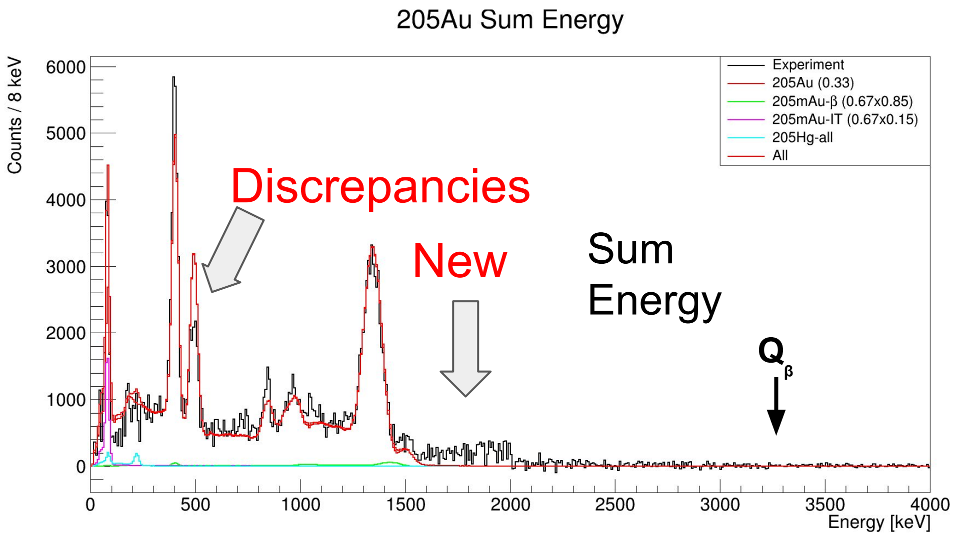
The feeding to g.s. fixed to 0 (Craig et al.)

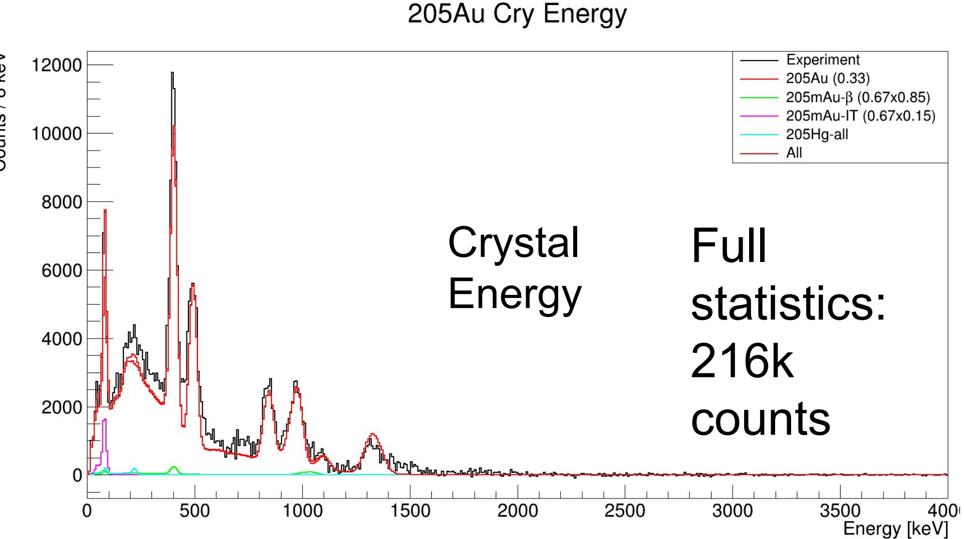
In good agreement with Craig et al., but some feeding to first and second excited states

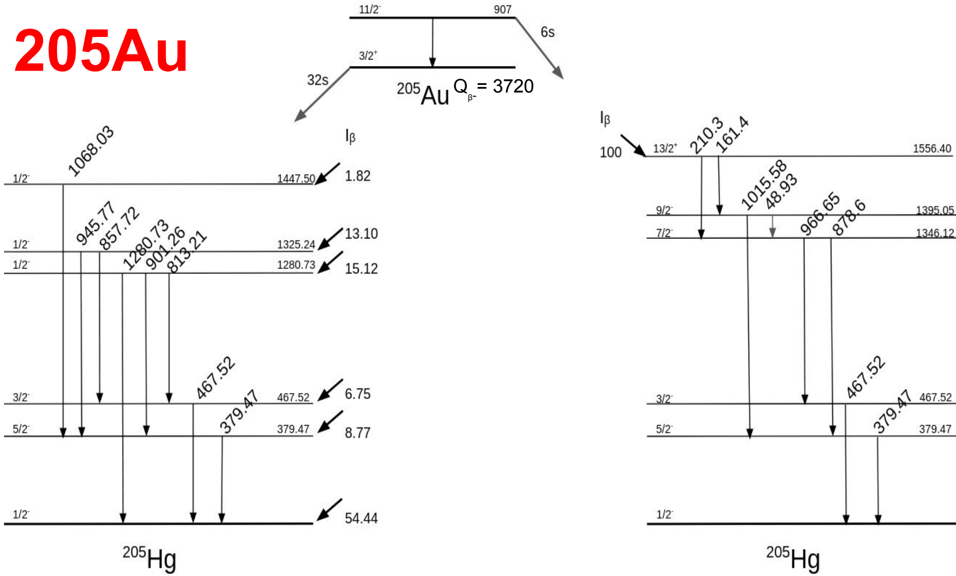




205Au







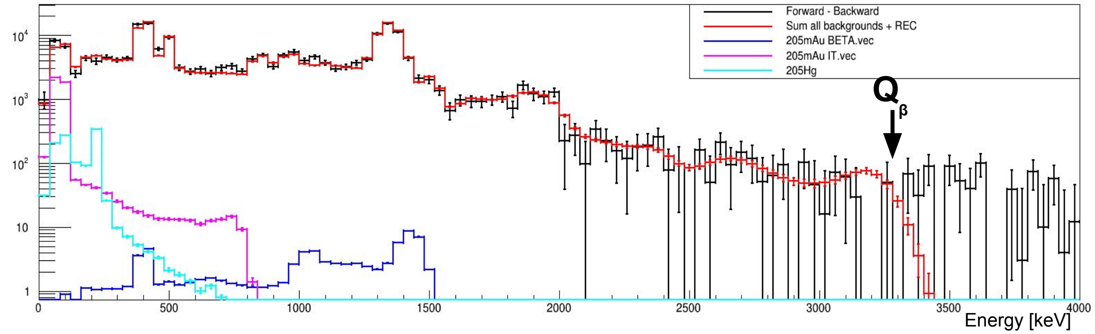
Comparison with previous knowledge

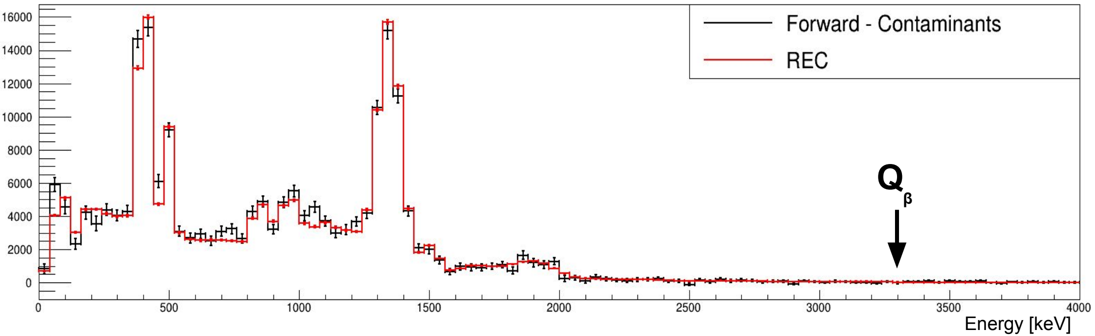
C. Wennemann et al. Z.Phys. A 347, 185-189 (1994)
Z. Podolyák et al. PLB. 672 (2009) 116-119

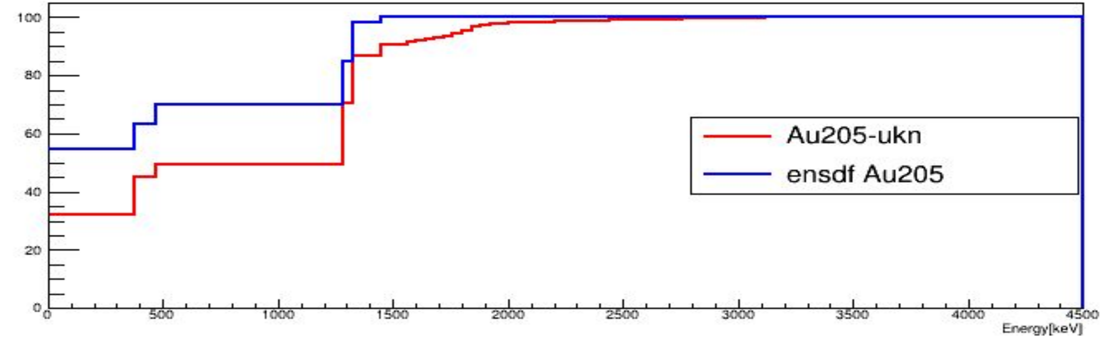
We see additional beta intensity

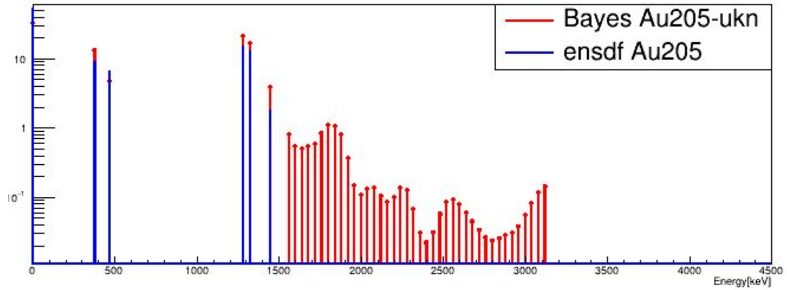
Preliminary beta intensity distribution results for 205Au.

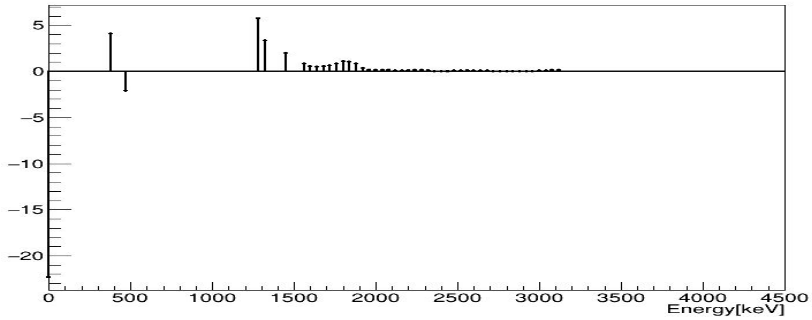
Additional beta intensity above 1.55 MeV, lower g.s. feeding intensity



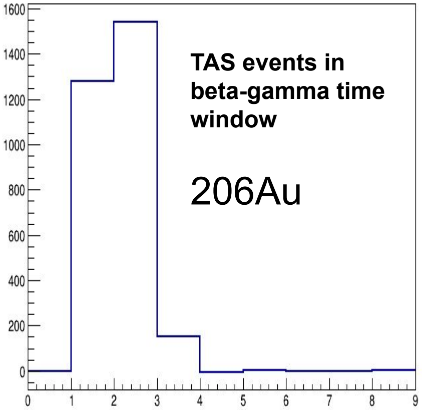


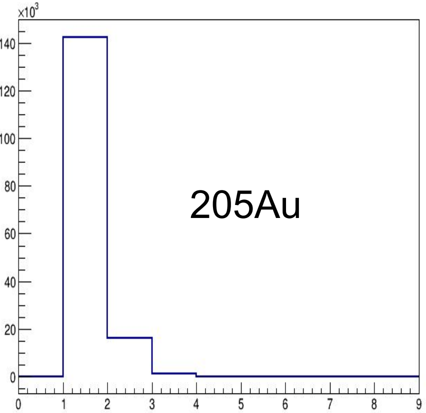


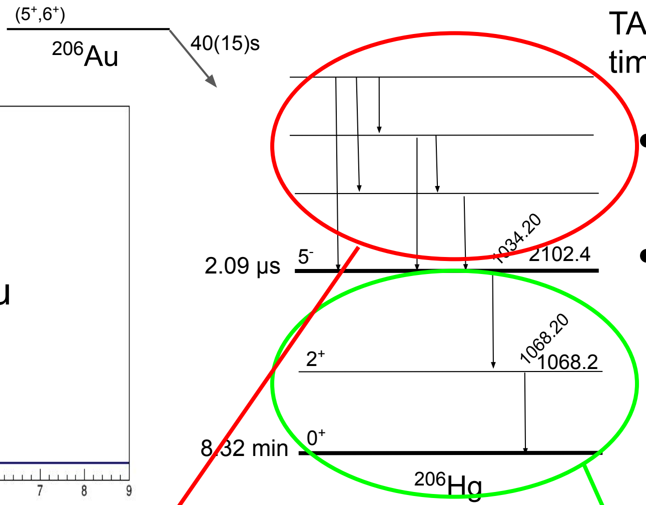




206Au

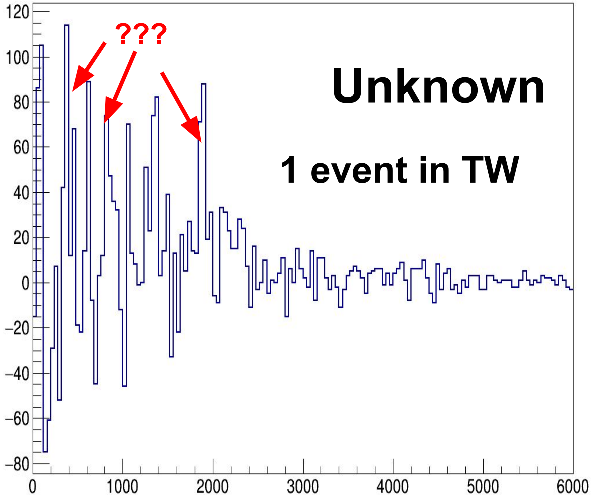


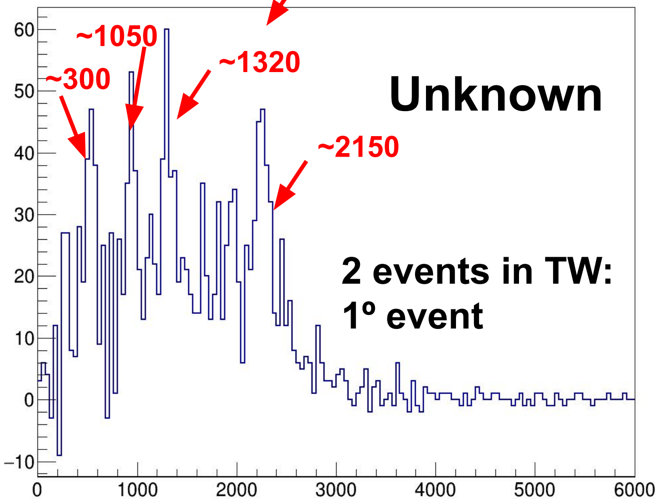


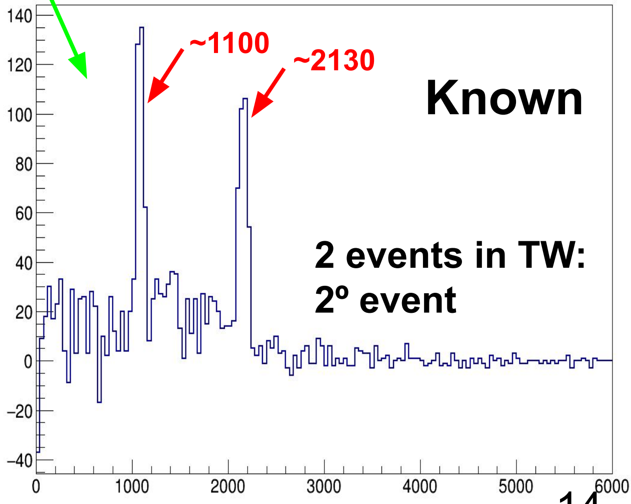


TAS events in a 16 us beta-gamma time window.

- Only 1 TAS event: Feeds levels that decays to gs avoiding the isomer level
- 2 TAS events: 1º TAS event feed level that decay into the isomer level, and 2º event is the decay of the isomer level







Outlook:

- Refining analysis of Au isotopes
- Working on preliminary analysis of $^{203,204}Pt$
- In contact with theoreticians to obtain calculated □-strength functions

S505 Collaboration:

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Thank you very much for your attention

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Excelencia Severo Ochoa
Gen-T

Extra Slides

FRS: PID using Bρ - ToF - ΔE method

- Ion identification combining information for each ion, on magnetic rigidity Bρ in the dipoles, the time-of-flight between detectors in the spectrometer flight path, and the energy loss in suitable "thin" detectors

<u>A/Q calculations:</u>

$$\beta = \frac{L}{c \cdot ToF}$$

$$B\rho = B\rho_0 \cdot \left(1 + \frac{x_4}{D_x^{24}} + \frac{x_2}{D_x^{02}}\right)$$

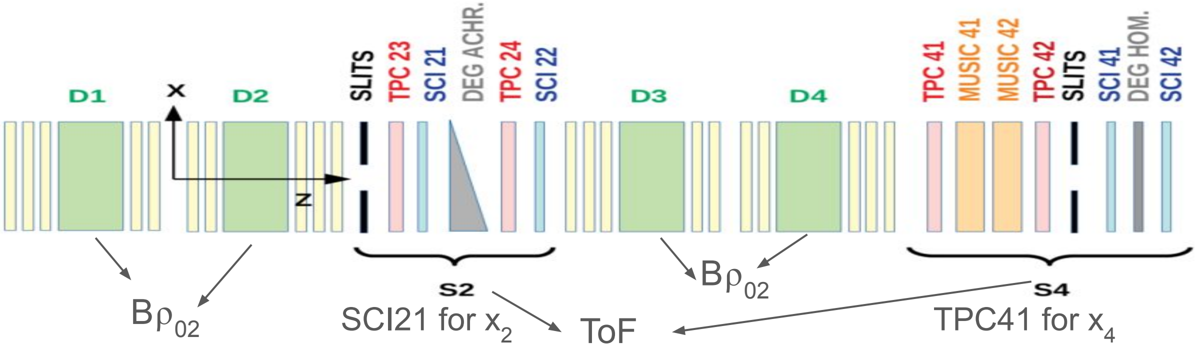
$$\frac{A}{Q} = \frac{e}{u \cdot c} \frac{B\rho}{\beta\gamma}$$

<u>Z identification:</u>
Using the MUSIC

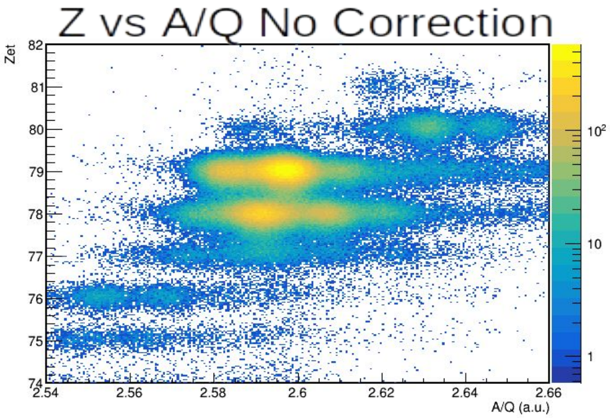
$$\Delta E_{MUSIC} \propto Z^2$$

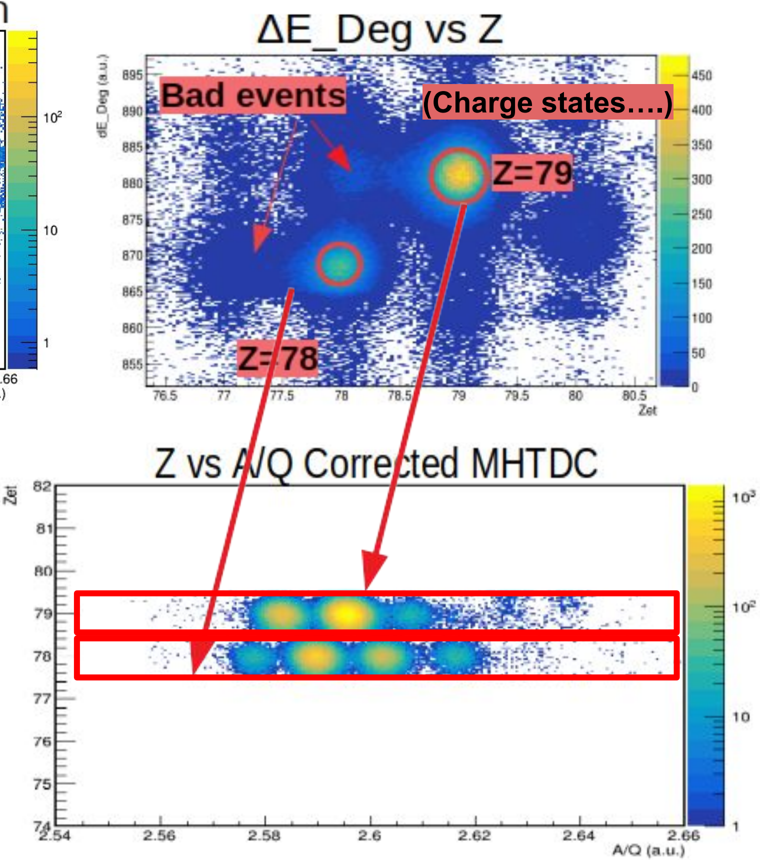
<u>Loss energy in the degrader:</u>

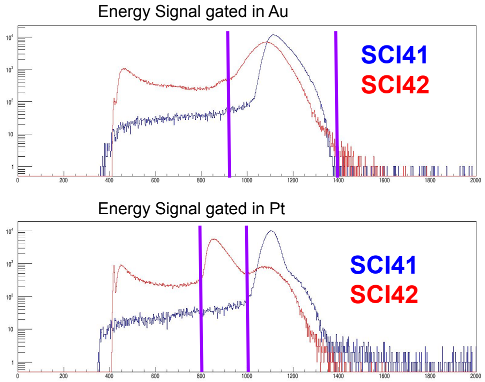
$$\Delta E_{deg} = c \cdot e \cdot Q \cdot \left(\frac{B\rho_{02}}{\beta_{02}} - \frac{B\rho_{24}}{\beta_{24}}\right)$$

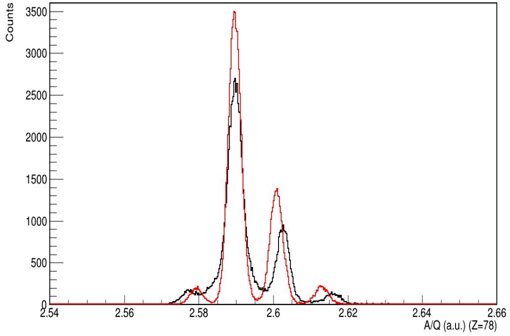


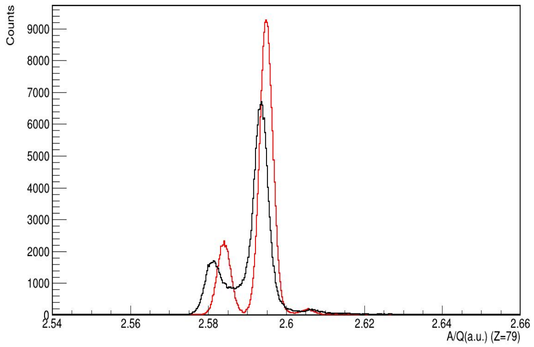
FRS: PID corrections A/Q and ΔE_{deg}



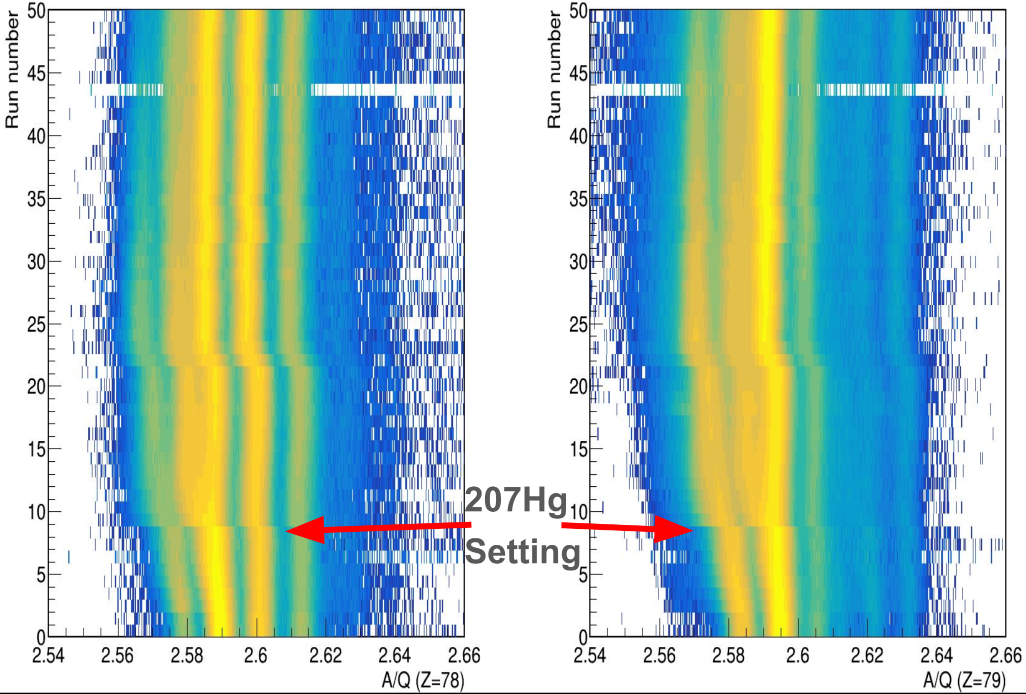


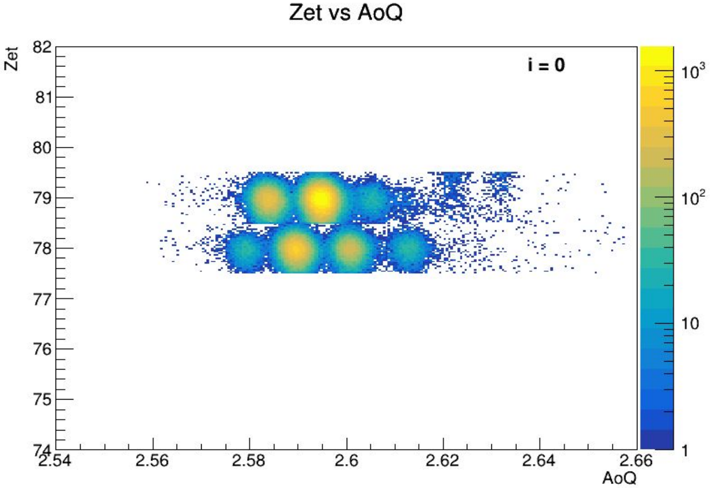


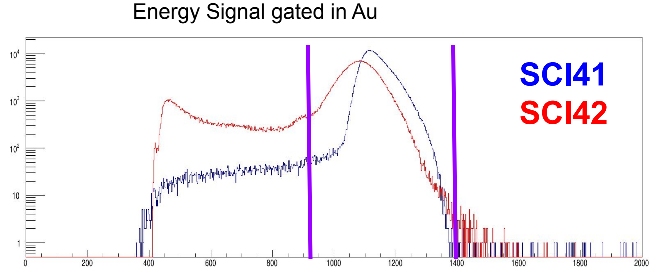


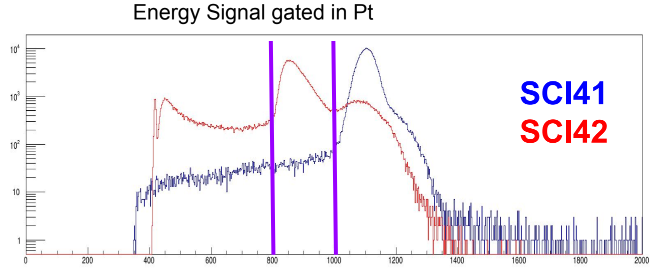


FRS: A/Q drift along experiment



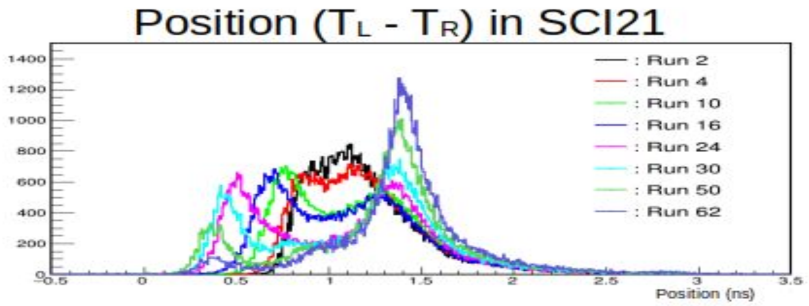


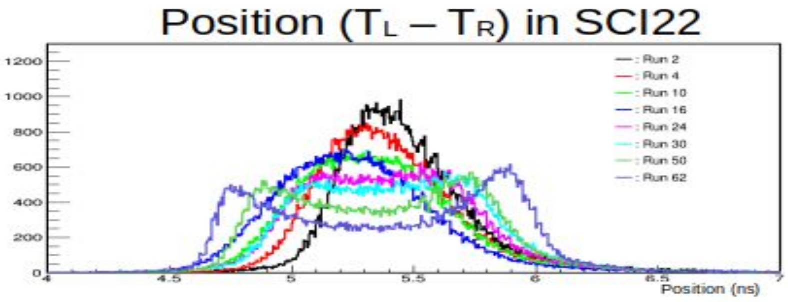


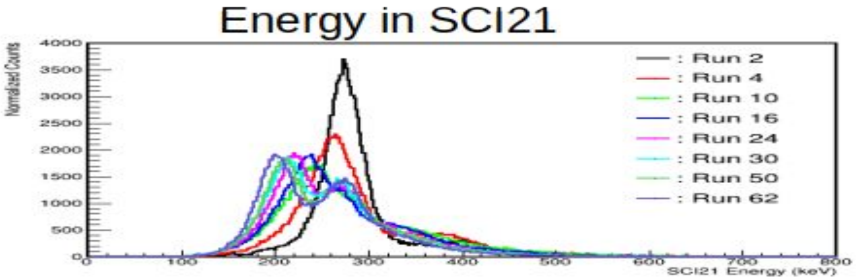


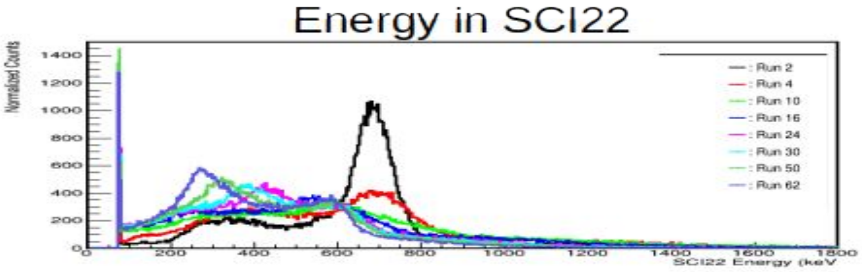
- Drift along the experiment due to damage in SCI21 and SCI22
- We added a energy condition in SCI42 to minimize the effect of secondary reactions in last degrader

FRS: MHTDC: S2 SCI Position and Energy

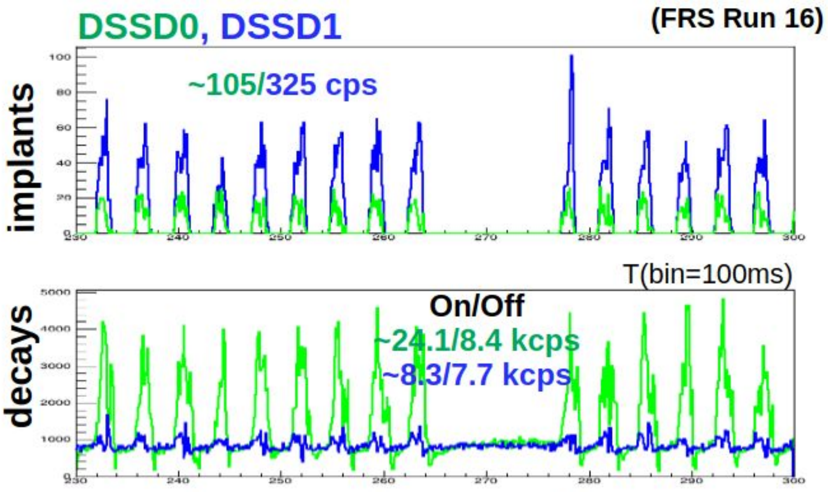




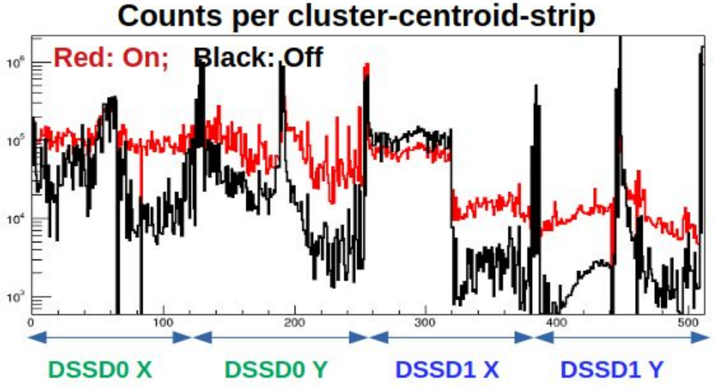




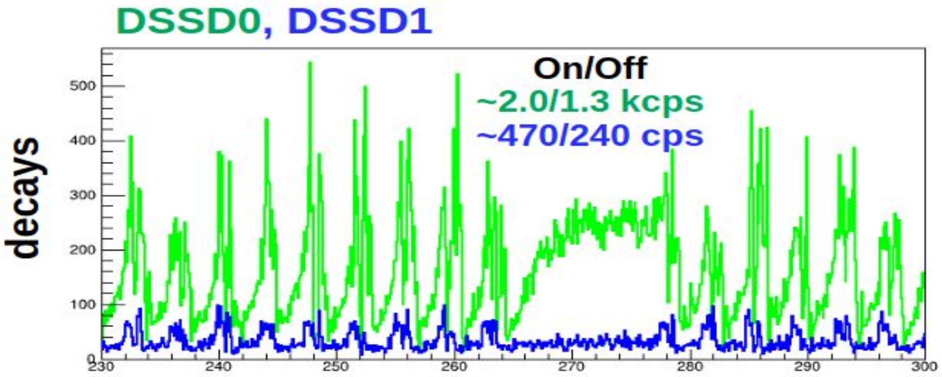
Position distortion: gradual development of side wings
Energy spectrum distortion and light reduction
Consequence of detector damage



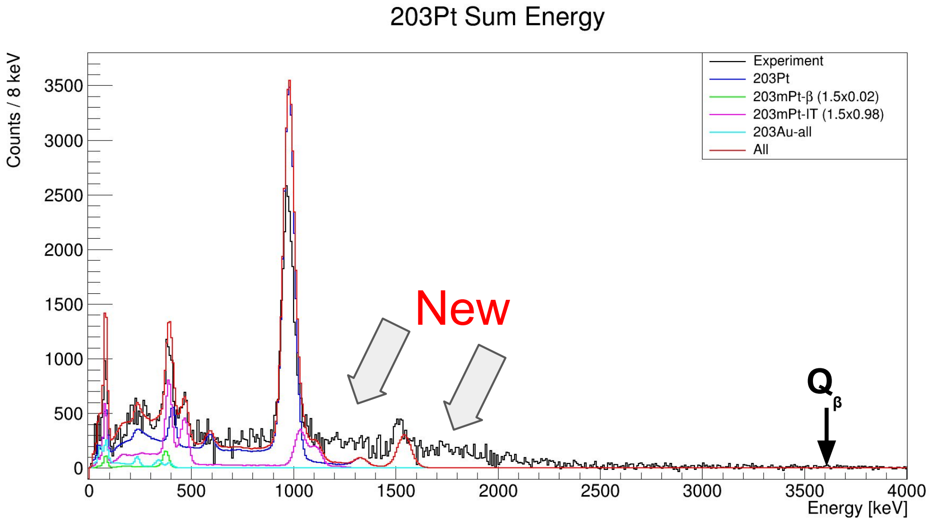
- Huge rate in decay branch, in particular for DSSD0 during spill
- Large noise on most FEE64s
- Noisy strips can be identified
- Large number of strips firing in one decay event

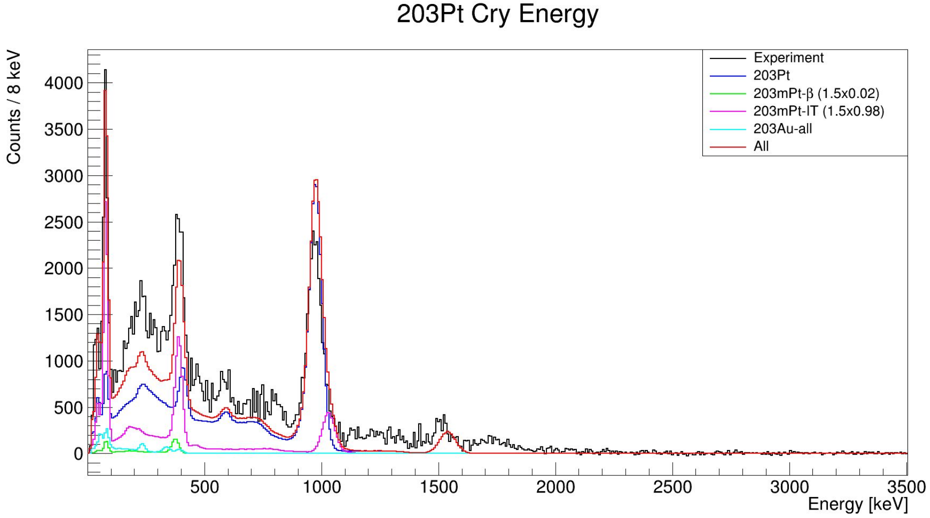


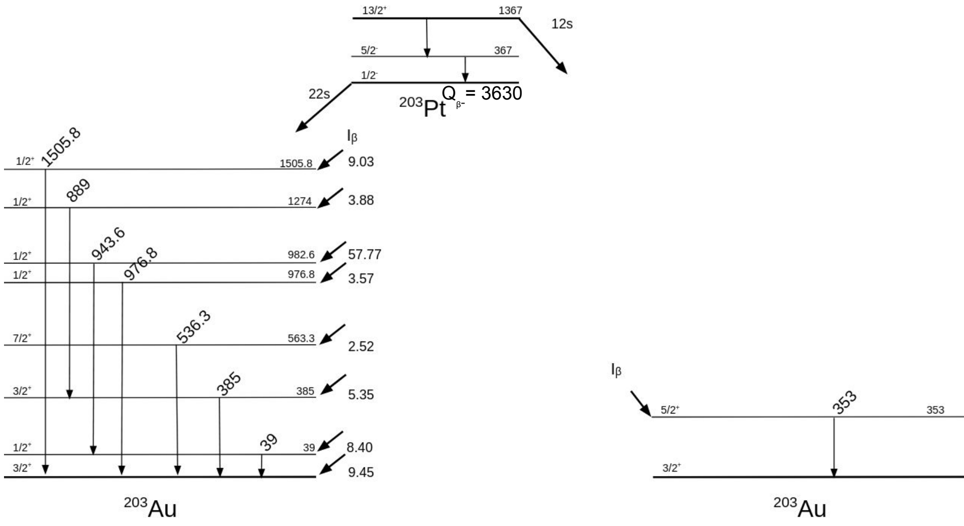
1. Increase threshold (currently 150keV)
2. Limit event strip multiplicity (nx,ny<6)
3. Only analyze off-spill data
4. γ-gating



Strange effect on the rate during spill and first few seconds after spill for DSSD0







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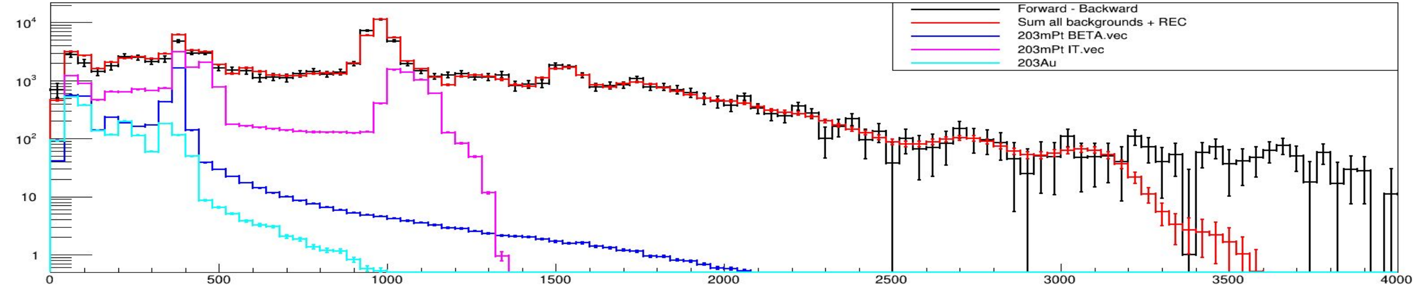
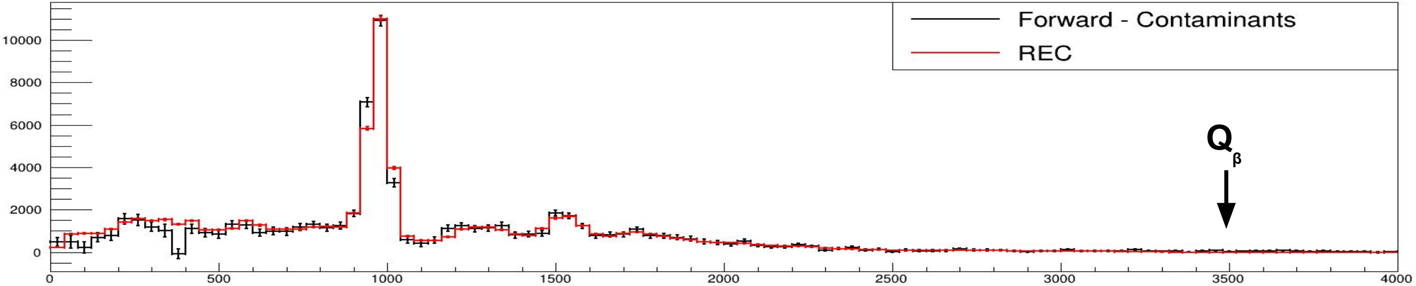
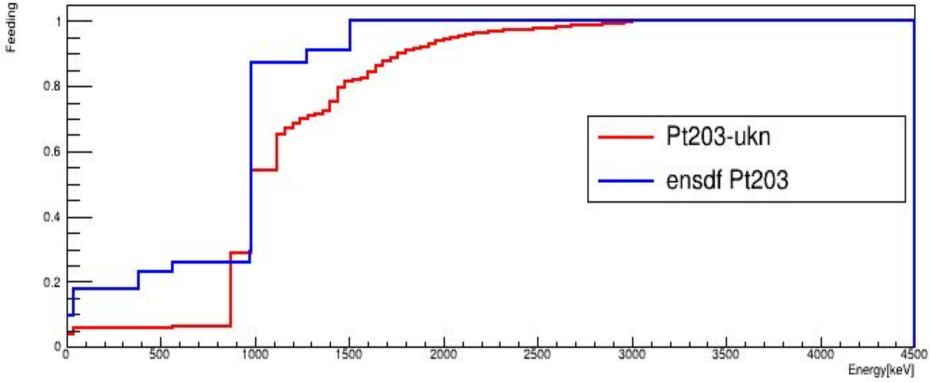
Plot with all the experiment statistics

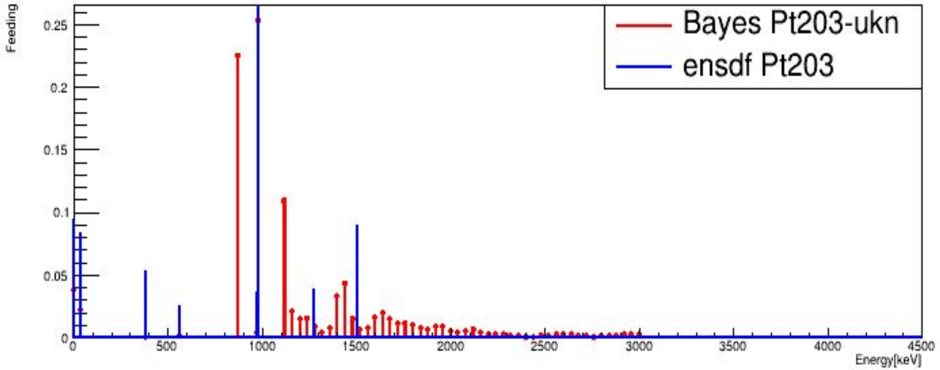
Total statistics in Sum spectrum: 98.7k

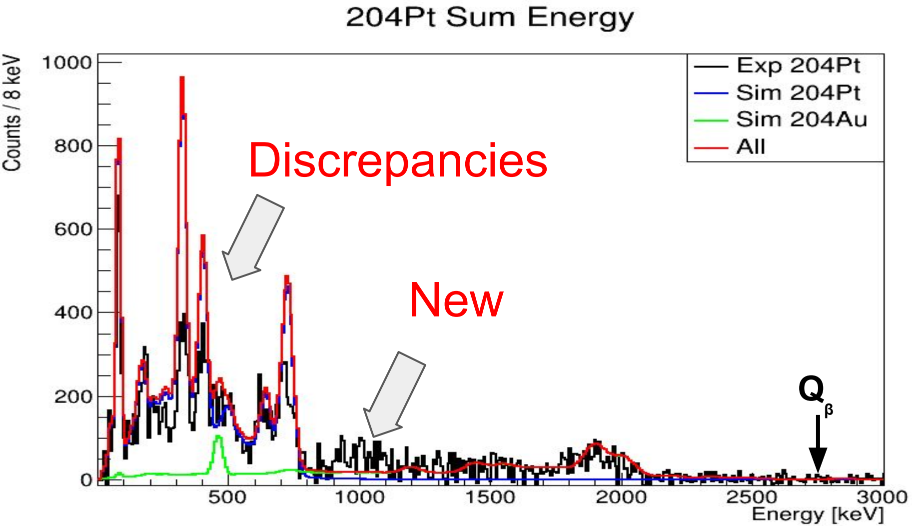
203Pt

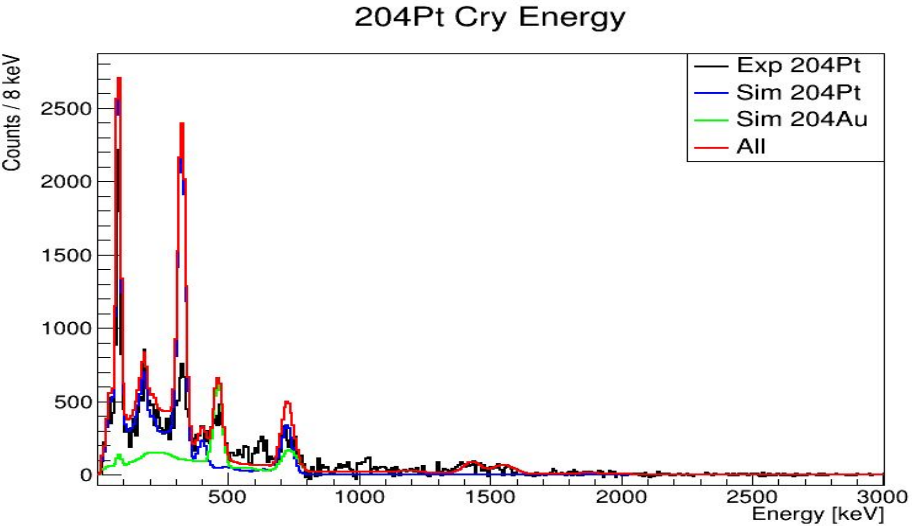

Forward - Backward
Sum all backgrounds + REC
203mPt BETA.vec
203mPt IT.vec
203Au

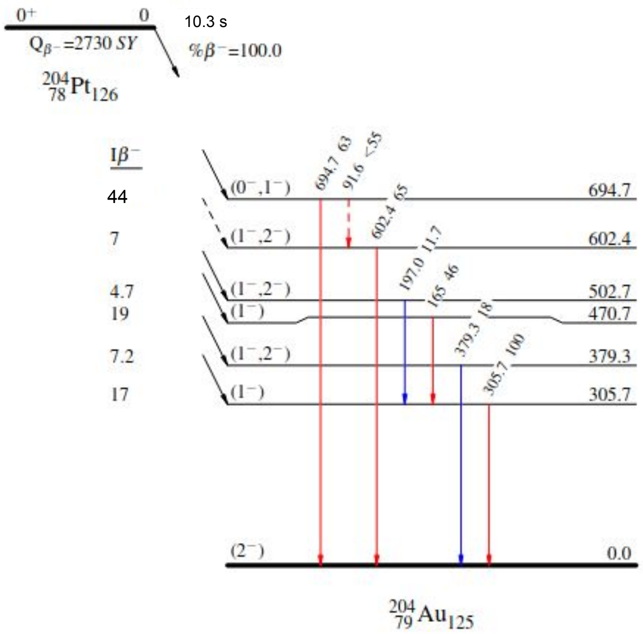

Forward - Contaminants
REC
Q_β


Feeding
Pt203-ukn
ensdf Pt203
Energy[keV]


Feeding
Bayes Pt203-ukn
ensdf Pt203
Energy[keV]







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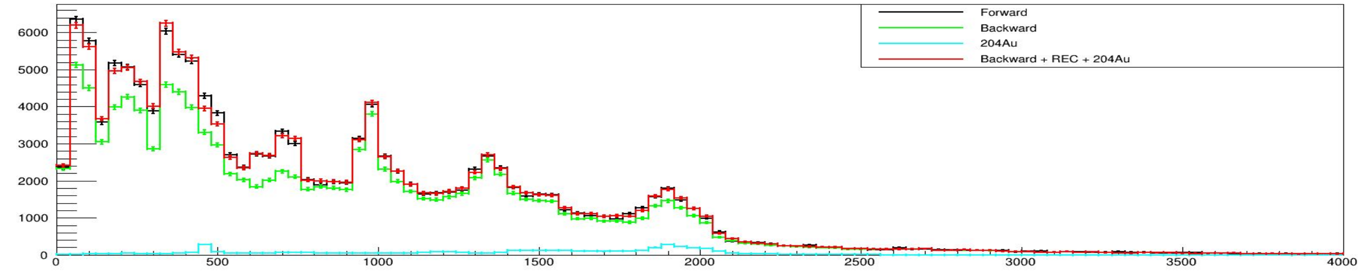
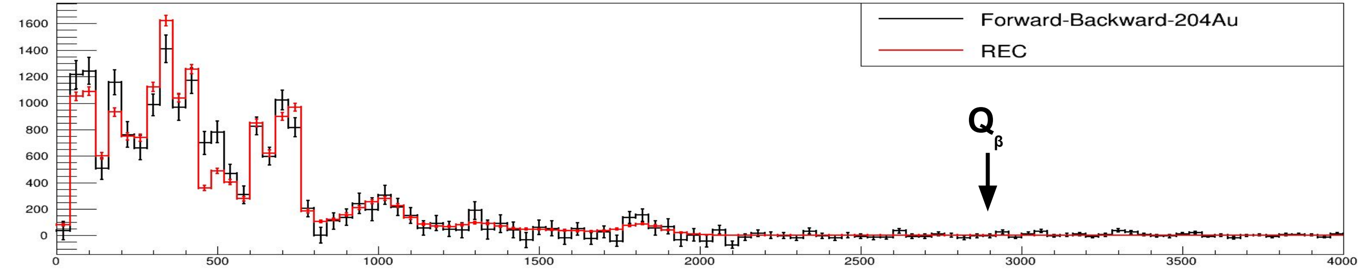
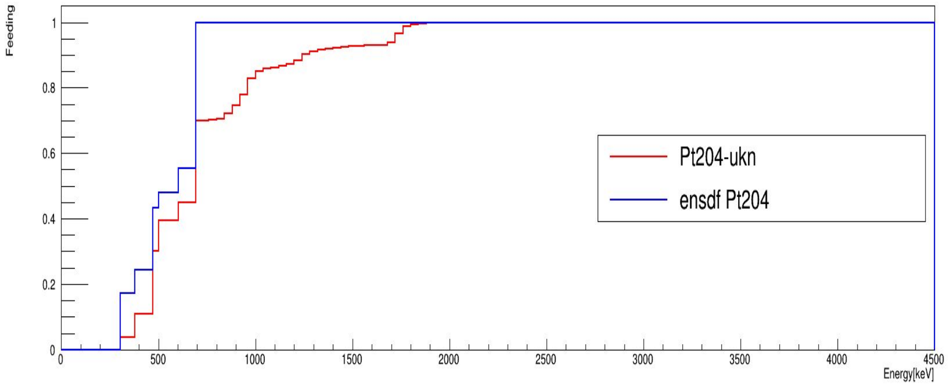
Plot with all the experiment statistics

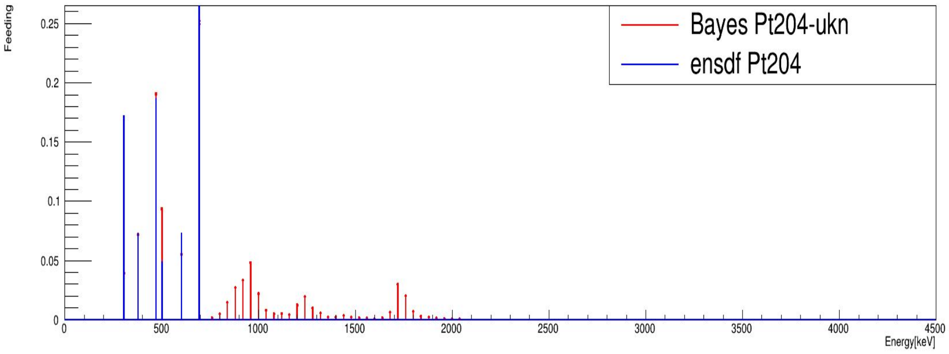
Total statistics in Sum spectrum: 23k

204Pt

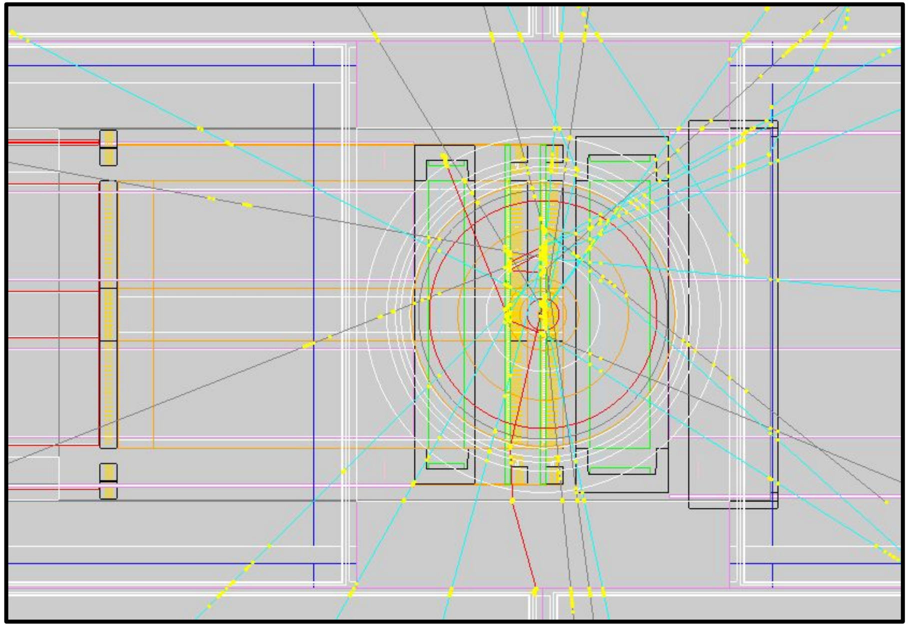

Forward
Backward
204Au
Backward + REC + 204Au

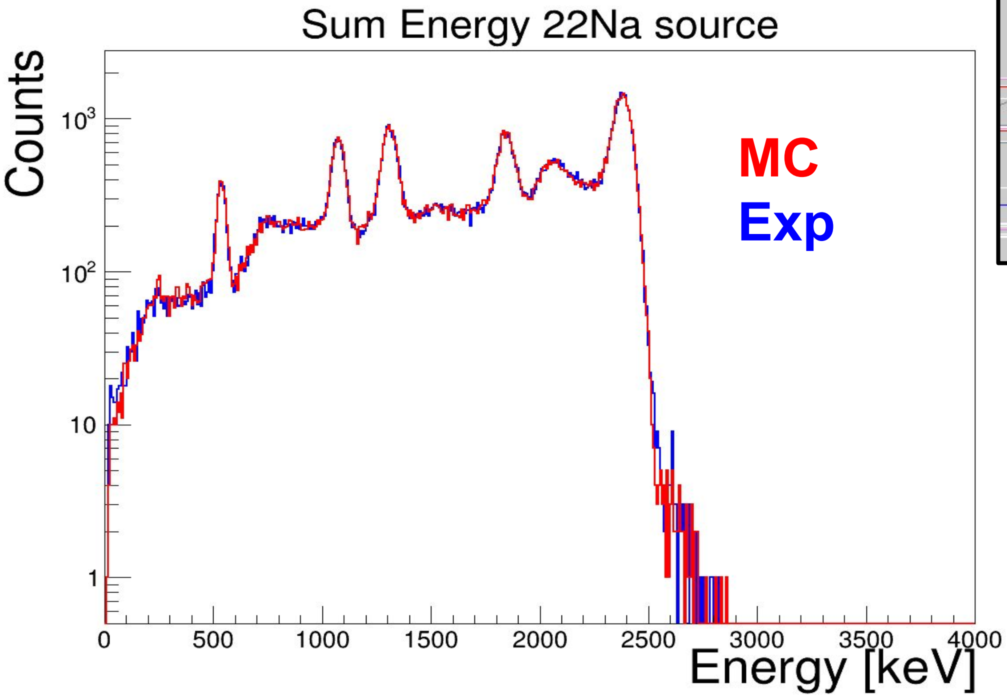

Forward-Backward-204Au
REC
Q_β


Feeding
Pt204-ukn
ensdf Pt204
Energy[keV]


Feeding
Bayes Pt204-ukn
ensdf Pt204
Energy[keV]

Benchmark of MC simulations:
different geometries (DTAS, DTAS+LOAX, DTAS+AIDA, DTAS+AIDA+LOAX) with sources (^{137}Cs, ^{60}Co, ^{22}Na, ^{24}Na)

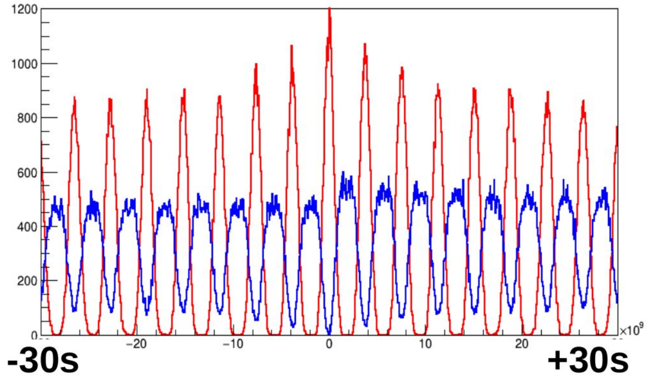




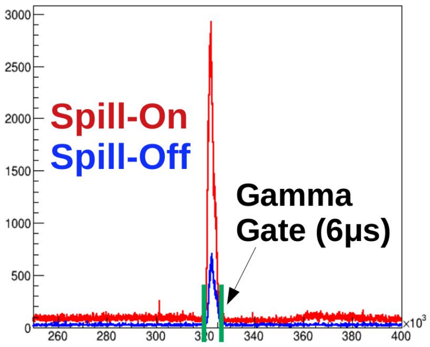
New tree with DTAS event information: TS, number of crystals and crystal energy (time event window: 250ns)

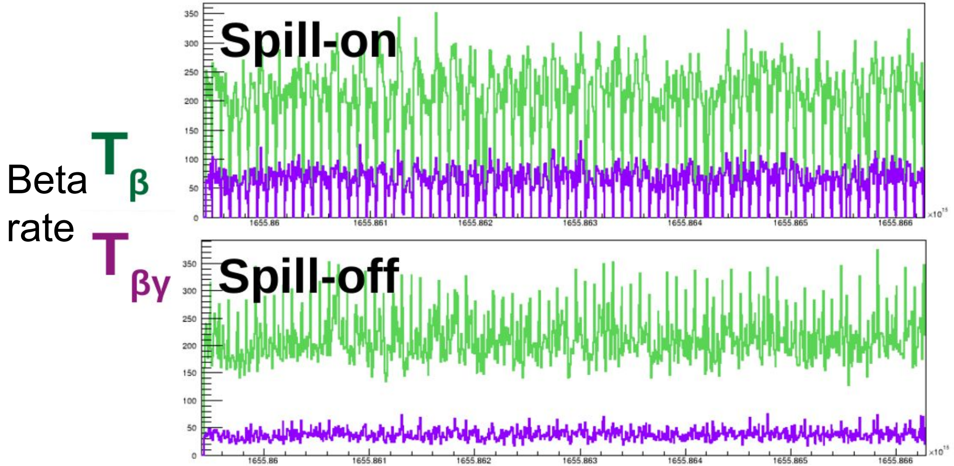
Low intensity run

$T_\beta - T_{imp}$



$T_\beta - T_\gamma$

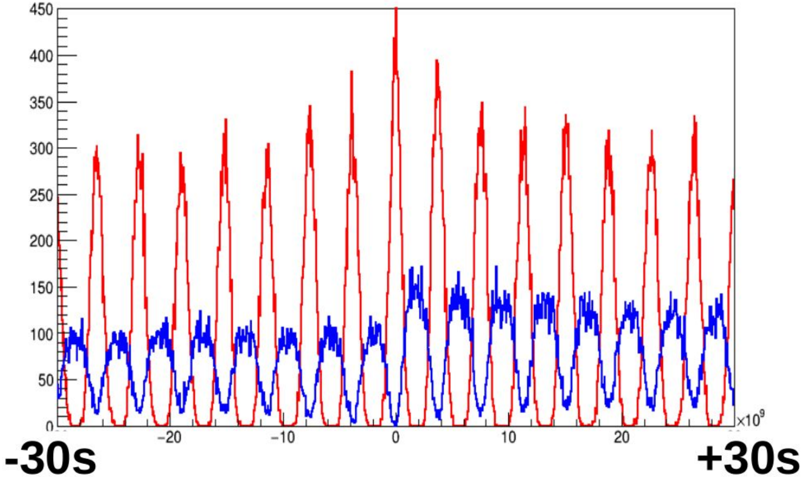




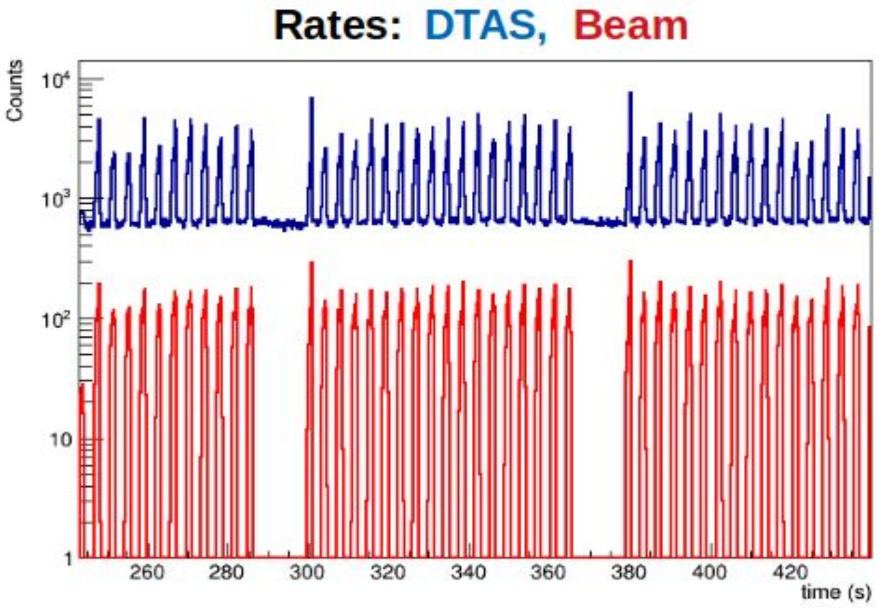
<u>MERGER</u>:
Combines DTAS+AIDA+FRS data (with presorted time-correlations)
Allows the extraction of analyzable data

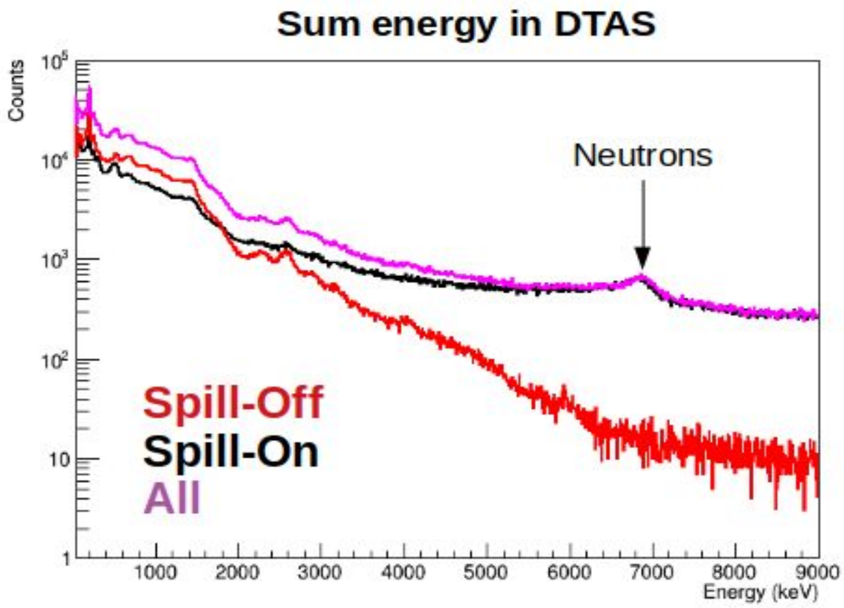
True $\beta\gamma/\beta$-implant correlations are clearly seen in the off-spill data (not so clear on-spill)

$T_{\beta\gamma} - T_{imp}$



DTAS: Rates and comparison: Spill-Off, Spill-On





Beam (spill) → ~1000 pps
DTAS spill-off → ~8000 cps
DTAS spill-on → ~42000 cps

- Huge rate on spill, too high rate off spill
- Particles (neutrons, …) and EM radiation coming with the beam disturbing the spectra
- Possibly only spill-off data is useful