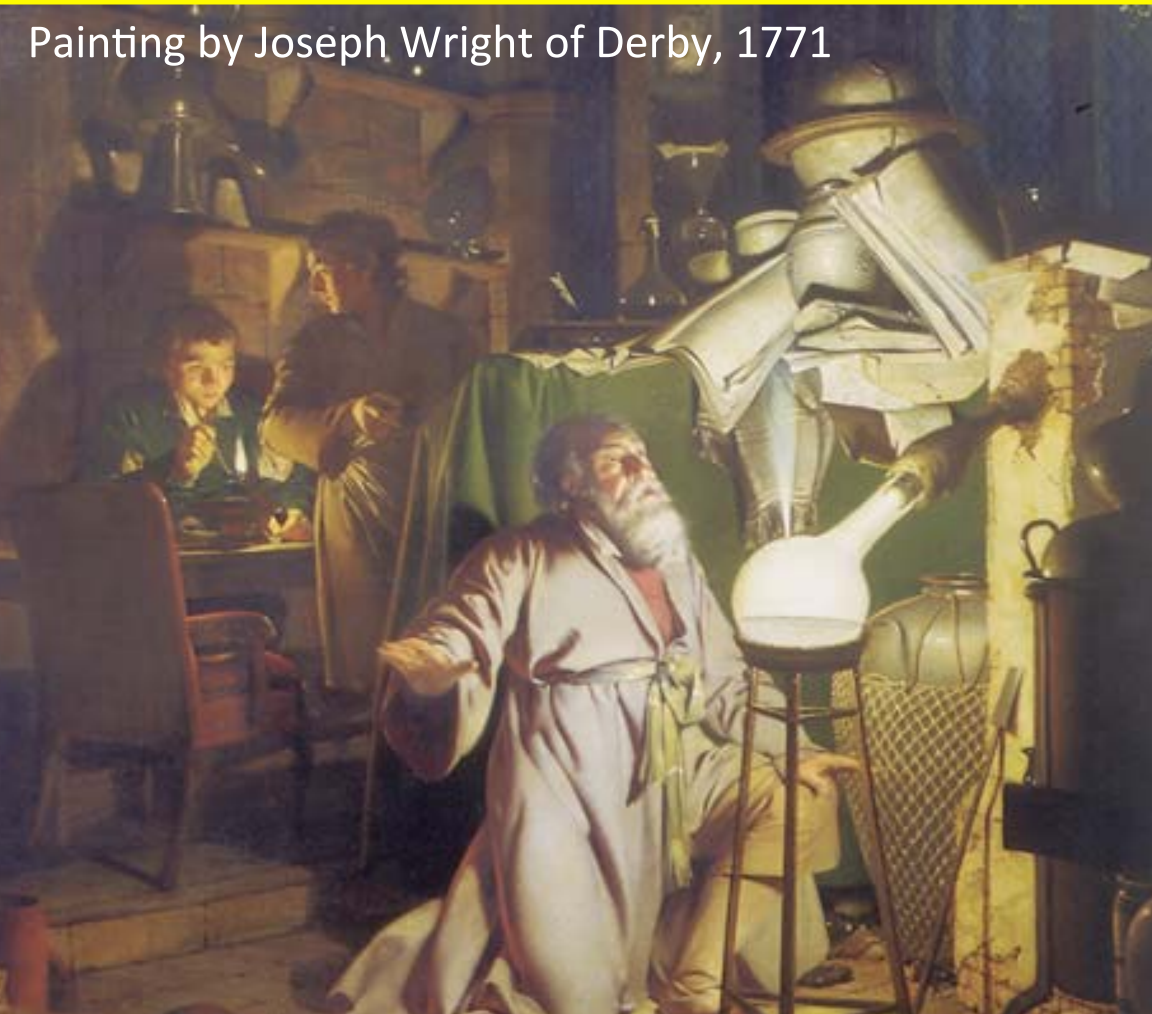
“Modern alchemy”: producing gold from mercury to study deformation

A. Algora

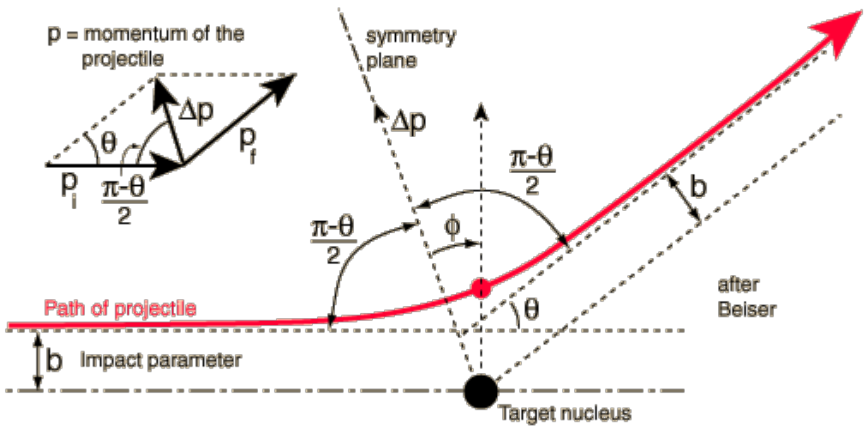

Painting by Joseph Wright of Derby, 1771

Outline

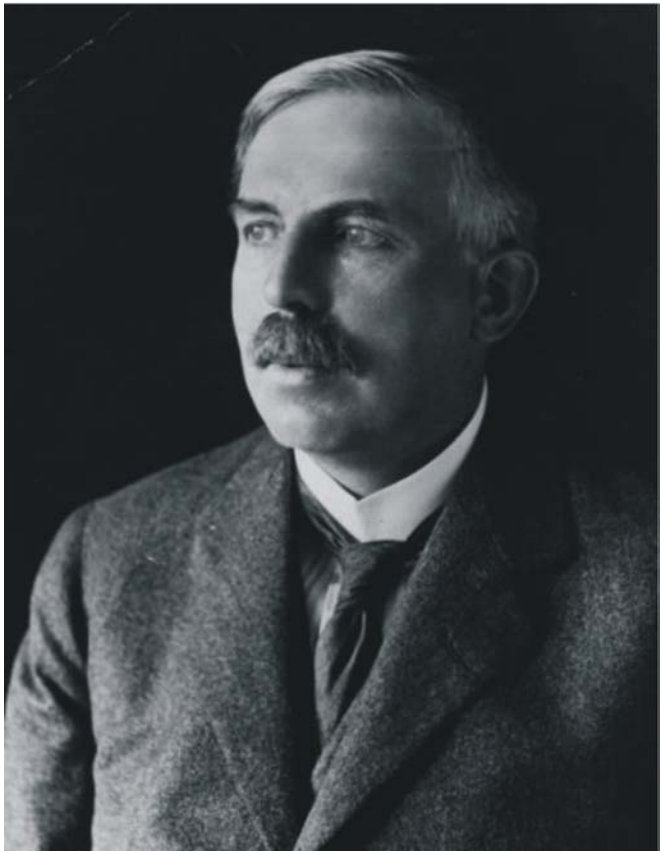
How we use beta decay to study the shape of 186Hg ….

- Introduction to nuclear shape
- How nuclear shape is deduced from experiments?
- Brief introduction of beta decay
- Introduction to total absorption spectroscopy
- Example of our recent study of 186Hg

A little history …



A little more than 100 years ago, nuclear physics was born with an scattering experiment. As a new born the nucleus was first very small. The nucleus was only point like …



E. Rutherford

The nuclear shape concept evolution …

• Rutherford model: point like shape (approx. little more than100 years ago)
• To interpret the binding energies the liquid drop model is introduced (spherical shapes), later it evolves into the droplet model with diffuse surface
•The interpretation of fission requires the assumption of elongated shapes, or a very drastic shape change.
• Revolution in the 50´s: collectivity and static deformed shapes are born. Shape becomes a concept and a tool for testing nuclear models. It is a necessity to interpret data on nuclear multipoles, Coulomb excitation data, etc.
•Strutinsky shell correction it combination with the liquid drop model predicts deformed minima
• Direct measurements of nuclei by means of scattering experiments …
• Nilsson model, and shell model relation (Elliot Model), mean field
• Shape coexistence
• SD bands, HD states, etc, etc, etc.
(more than 8290 entries in APS journals 1940-2018, if you search for "nuclear deformation")

THE FLAT EARTH SOCIETY

"Deprogramming the masses since 1547"

Welcome to the Flat Earth Society Homepage! Please, be our guest. Just sit back at your computer, and let us do the talking. We'll tell you who we are, what we're doing, and what we're accomplishing in the world. You can look at some of our latest theories and insights, and, if you're interested, you can even become an honorary member of the Flat Earth Society. So stick around.

Mission Statement-

- Background information on the Flat Earth Society
- The Flat Earth Society's purpose - why we do what we do

Why a Flat Earth?

- Why we don't believe the world is round
- Scientific data and measurements backing up our claims

Fighting the "Evidence"-

- Dispelling common myths about "proof" regarding round earth theory
- Uncovering the conspiracy to withold the truth from the public

Current Events-

- What the Flat Earth Society is doing
- What you can do to help out in your own community

Nuclear electric quadrupole moment measurements

How to measure the spatial extension of the nucleus ?

$$Q_z = \sum_{i=1}^{A} Q_z(i) = \sum_{i=1}^{A} e_i(3z_i^2 - r_i^2)$$

Classical definition (measure of departure from spherical shape)

$$Q_2^0 = Q_z = \sqrt{\frac{16\pi}{5}} \sum_{i=1}^{A} e_i r_i^2 Y_2^0(\theta_i, \phi_i)$$

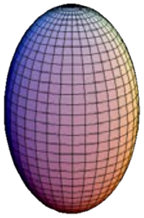
z- component of the quadrupole moment

$$Q_s(I) = \langle I, m = I \,|Q_2^0|\, I, m = I \rangle = \sqrt{\frac{I(2I-1)}{(2I+1)(2I+3)(I+1)}} (I\,||Q||\,I)$$

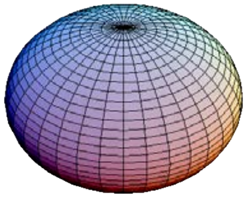
Spect. quadrupole moment of a nucl. state with spin I (expectation value)

Under certain assumptions (axially symmetric nuclei, strong coupling)

$$Q_s = \frac{3K^2 - I(I+1)}{(I+1)(2I+3)} Q_0 \qquad Q_0 = \frac{3}{\sqrt{5\pi}} Z R^2 \beta\,(1 + 0.36\beta)$$



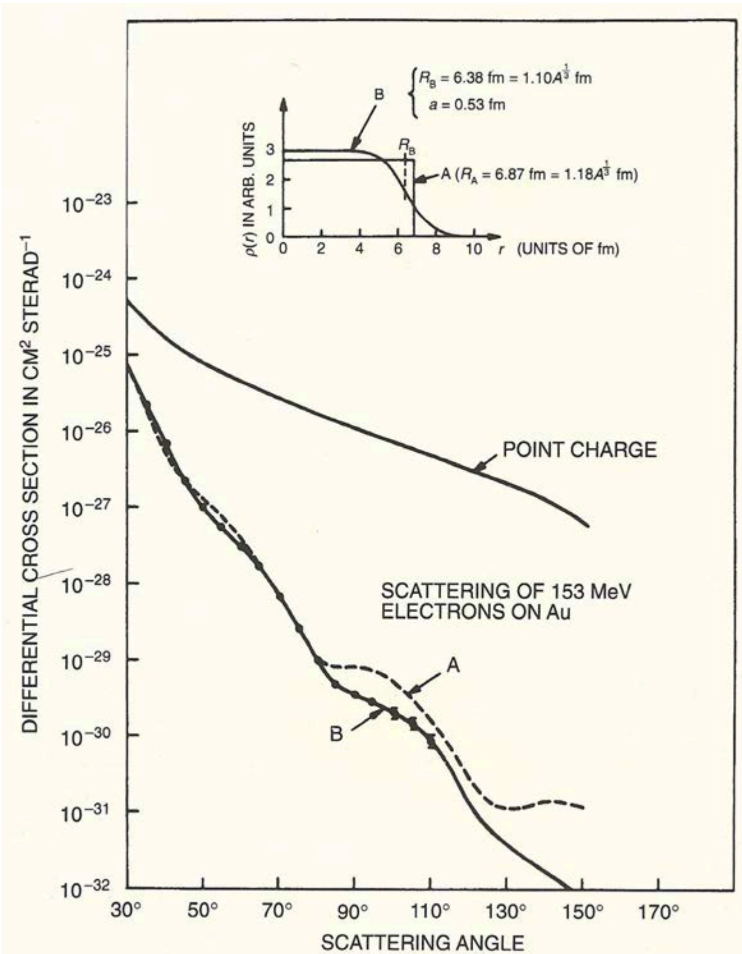
β>0



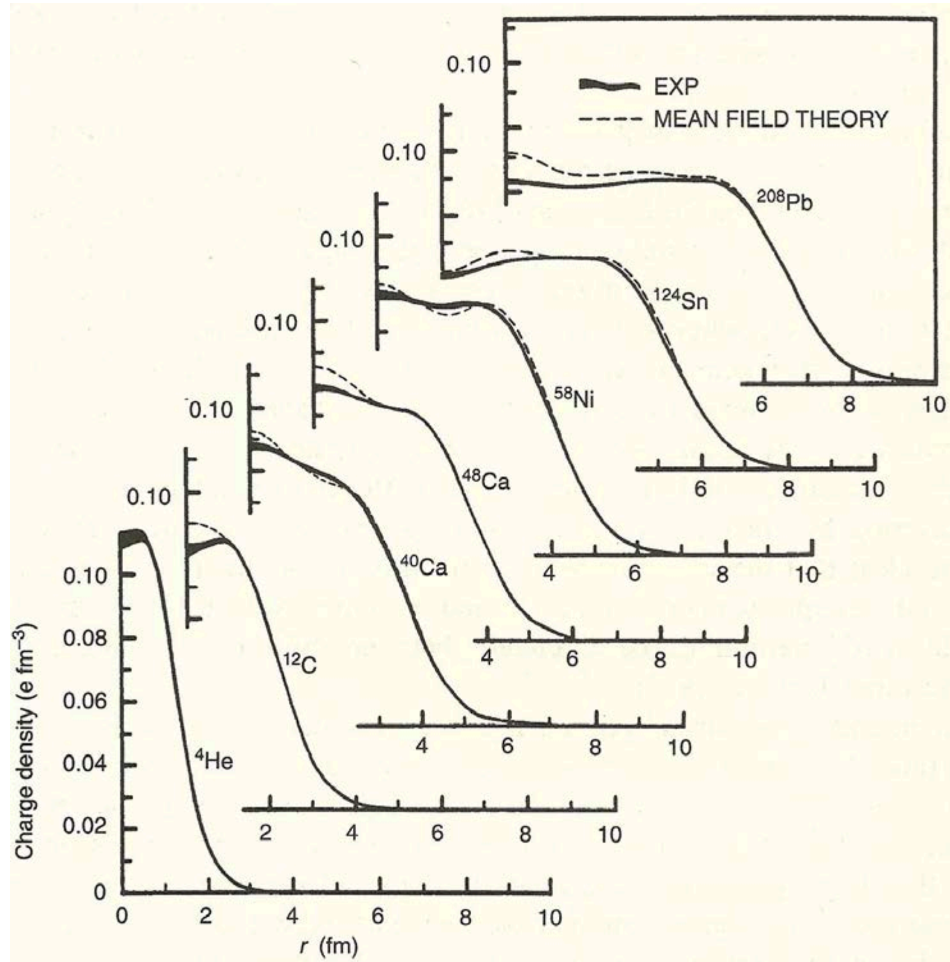
β<0

$$R(\theta,\varphi) = R_o(1 + \beta Y_{20}^{*}(\theta) + \ldots.)$$

Nuclear radii determination by means of scattering experiments.

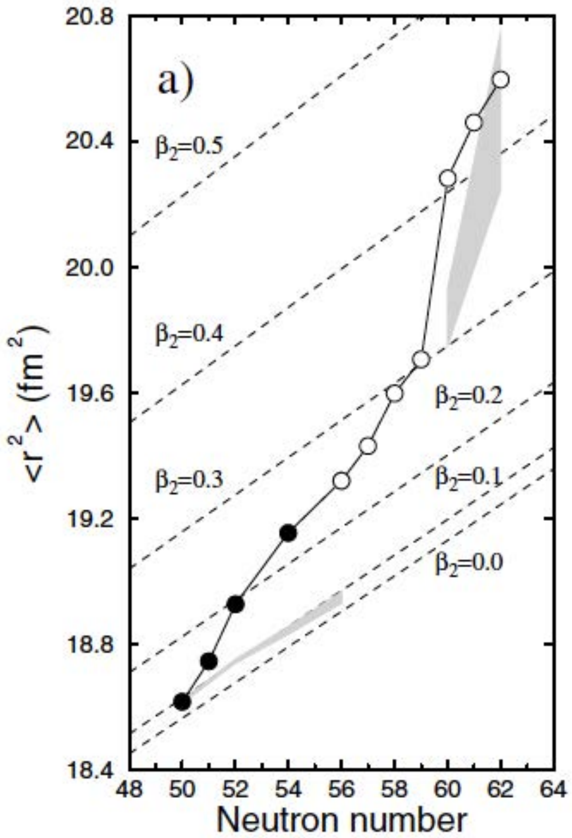


Differential cross sections of 153 MeV electrons on Au Bohr-Mottelson, 1969

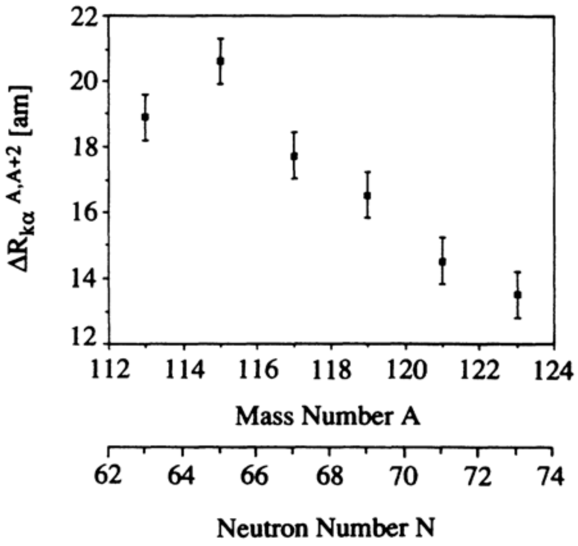


Nuclear ground state charge distributions compared with mean field calculations. B. Frois, Proc. Int. Conf. Nucl. Phys., Florence, 1983

Nuclear radii determination by means of isotope shifts (muonic atoms, laser spectroscopy, etc.)



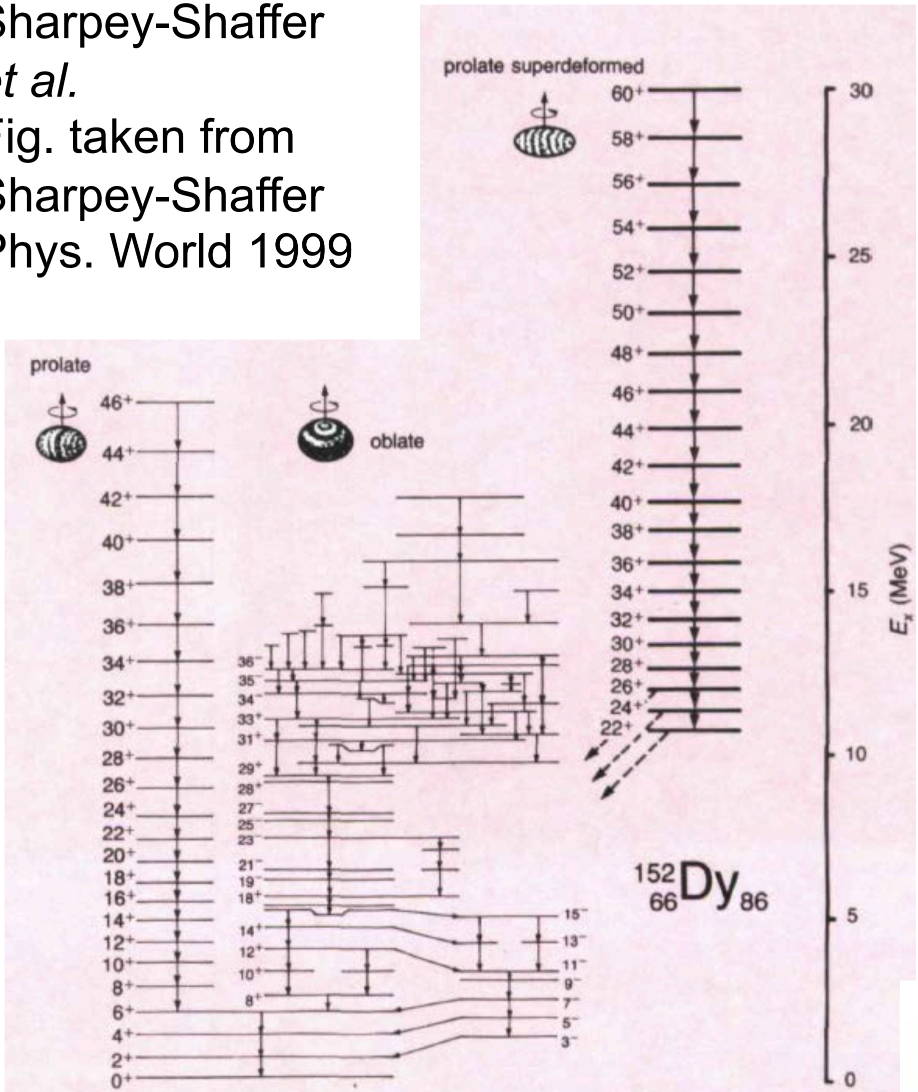
Laser spectroscopy of cooled Zr fission products (Campbell PRL 89, 2002) Mean square charge radii deduced from the measurements compared with droplet model predictions.

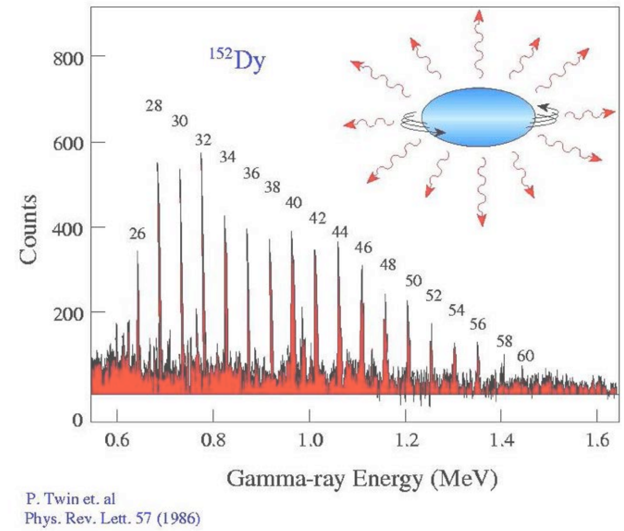


Nuclear charge radii differences in Sn isotopes from muonic atoms (C. Piller *et al*. PRC 42 , 1990)

Shapes from nuclear spectroscopic information (mainly gamma spectroscopy)

Twin, Nyako, Sharpey-Shaffer *et al.*
Fig. taken from Sharpey-Shaffer Phys. World 1999

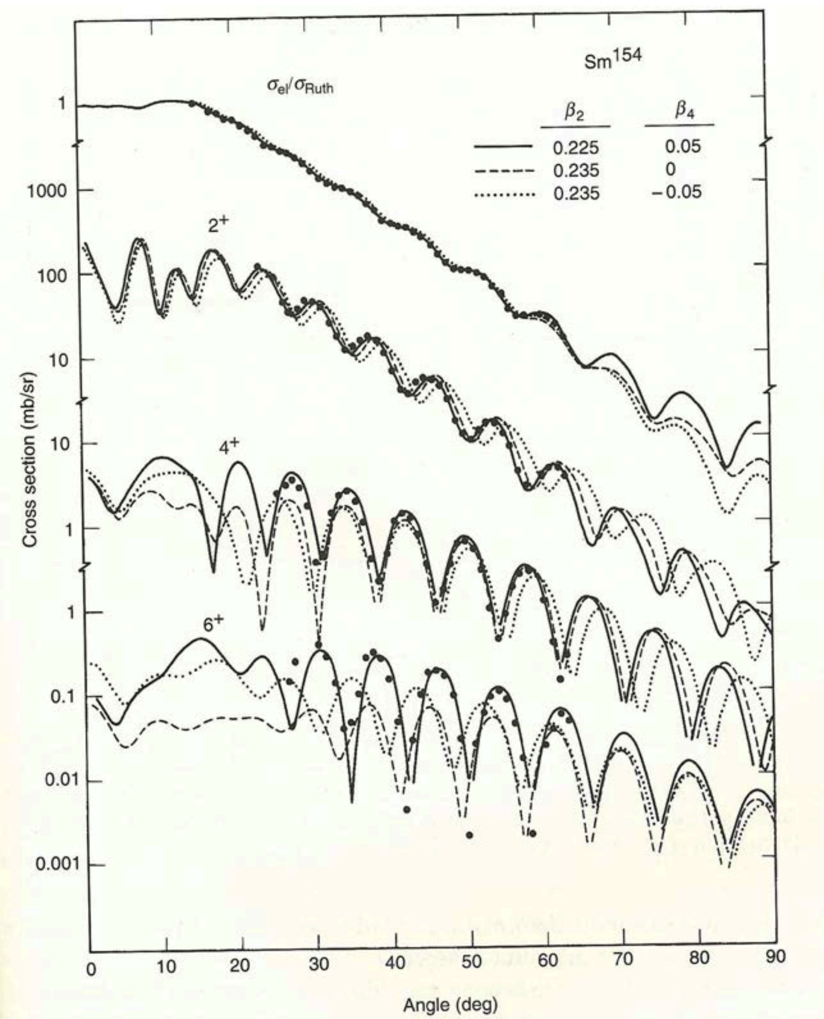




- From level lifetimes, B(E2)-s, deformation can be deduced
- From in-band multipole mixing ratios (angular distributions) the sign of the Q can be deduced
- E0 (electric monopole transitions) are associated with shape changes

$$|Q| = \sqrt{16\pi B(E2{:}2_1^+ \to 0_1^+)} = \frac{3Ze}{\sqrt{5\pi}} R_0^2(\beta + 0.16\beta^2),$$

Coulomb excitation



Alpha scattering cross sections (50 MeV) on ^{154}Sm. Glandening, Proc. Int. School E. Fermi, 1967

Coulomb excitation excites low-lying collective bands with cross sections that are a direct measurement of the Eλ matrix elements involved in the excitation.

Collectivity and deformation can be inferred.

Reorientation effects can provide the sign of Q

$$\beta = \frac{4\pi}{3ZR_o^2}\sqrt{B(E2\uparrow)/e^2}$$

$$R_o = 1.2A^{1/3}\,fm$$

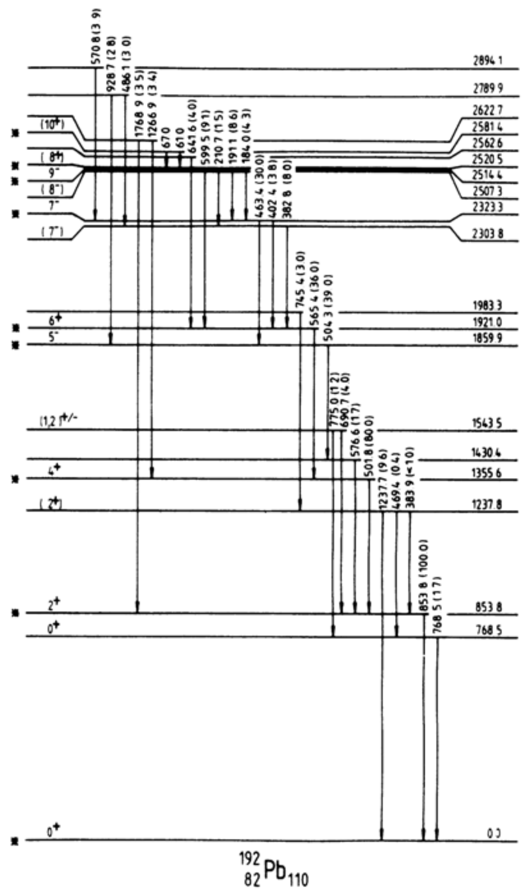
S. Raman, At. Dat. Nucl. Tab. 78

What about beta decay …

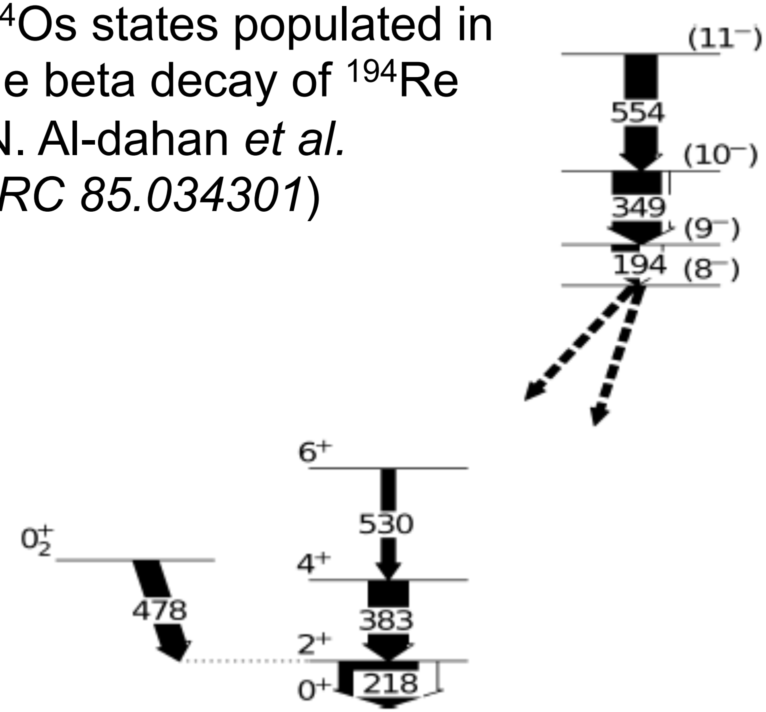
Shapes and shape changes can be deduced from the conventional spectroscopy data of the populated states in beta decay (gamma, and electron conversion, half-life measurements, etc).

P. Van Duppen
PRC 35 (1987) 1861
^{192}Pb populated in the beta decay of ^{192}Bi

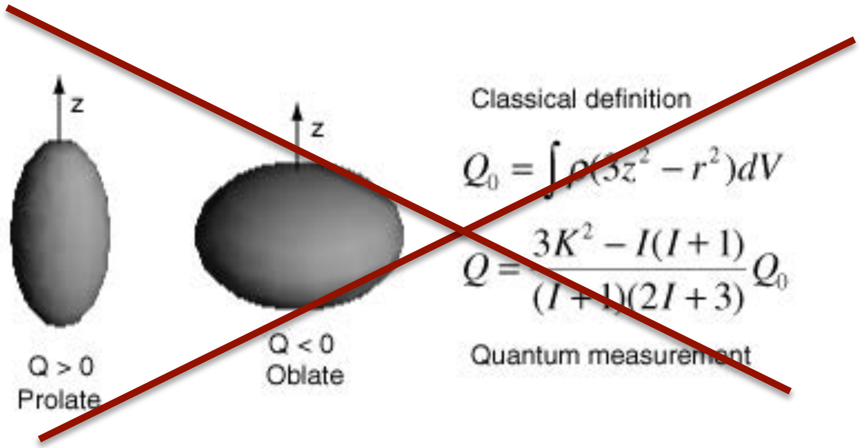
E0 (electric monopole transitions) are associated with shape changes



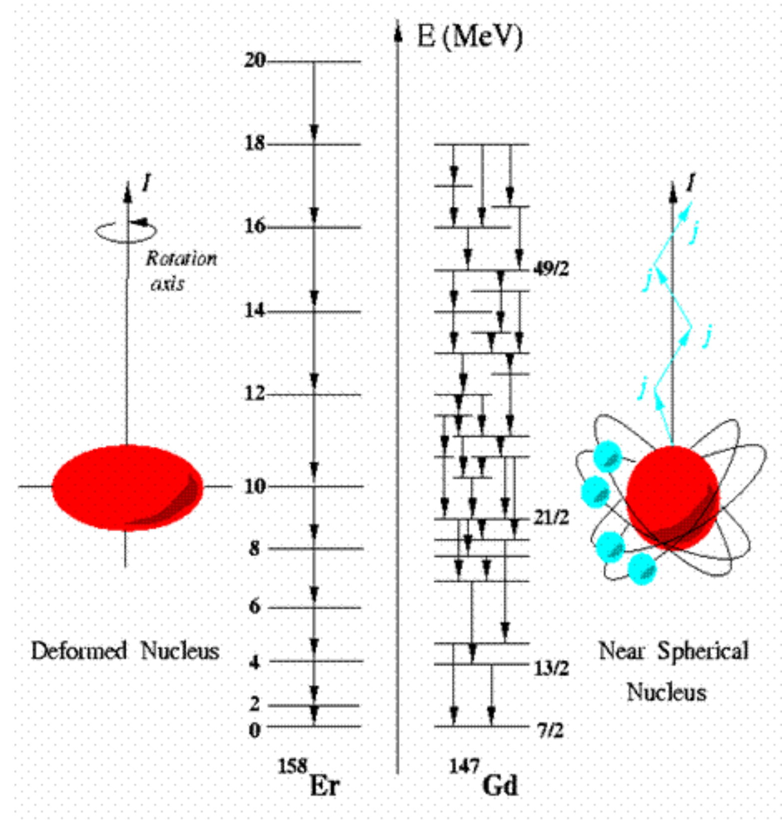
^{194}Os states populated in the beta decay of ^{194}Re (N. Al-dahan *et al.* *PRC 85.034301*)



How do we deduce the nuclear shape of the ground state when it is a 0+ state …



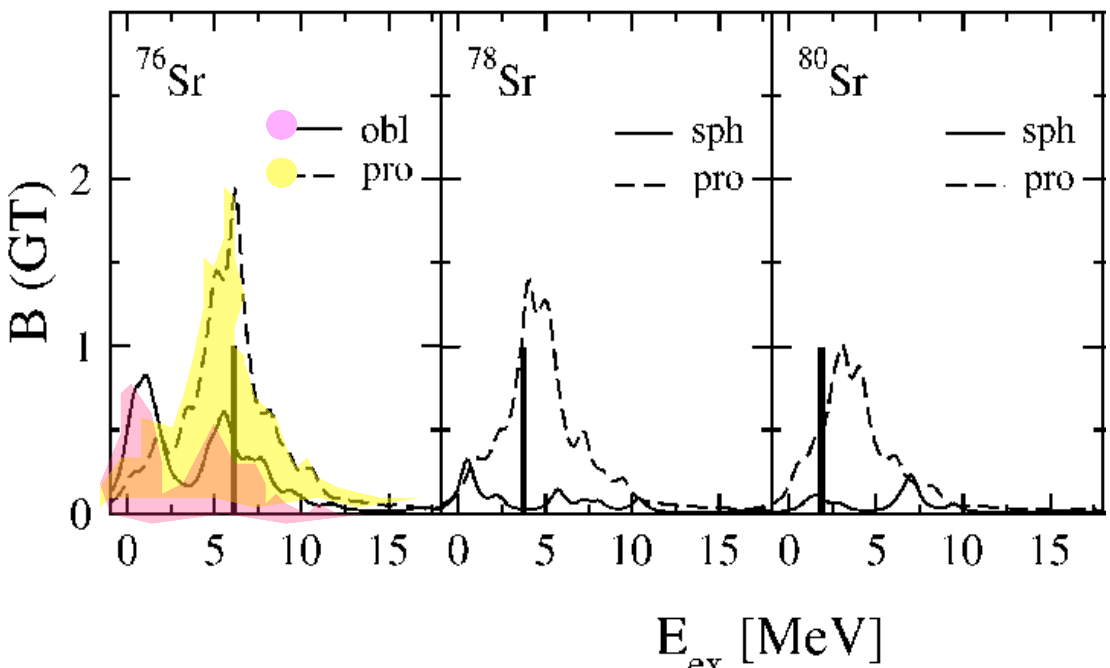
- Nuclear radii determination (isotope shifts)
- Analysis of spectroscopic information (B(E2)-s, $T_{1/2}$ and assuming that we have a band with the same deformation
- ???

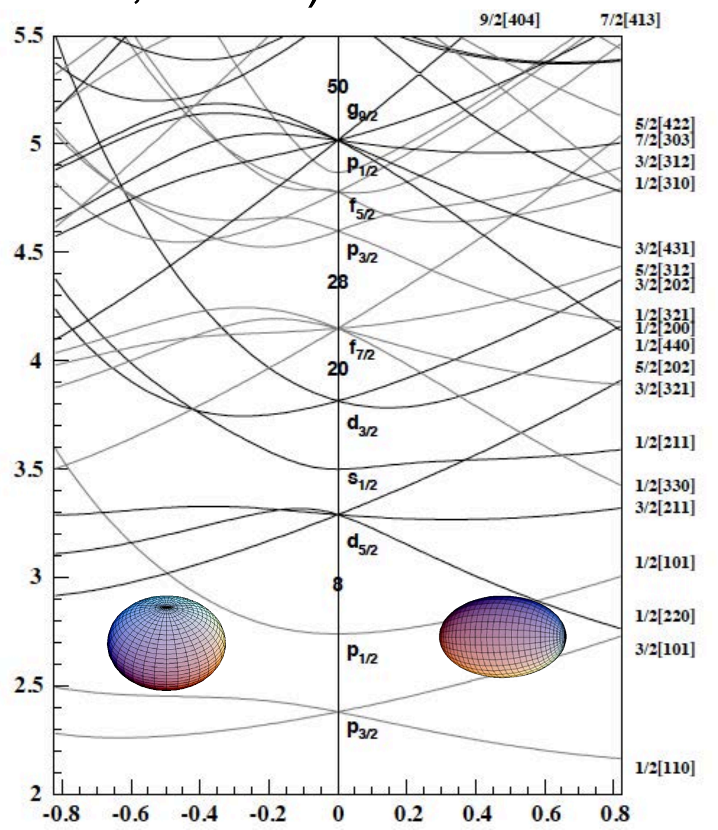


What can beta decay offer apart from spectroscopy?

Another alternative, based in the pioneering work of I. Hamamoto, (Z. Phys. A353 (1995) 145) later followed by studies of P. Sarriguren *et al*., Petrovici *et al*. is related to the dependency of the strength distribution in the daugther nucleus depending on the shape of the parent. It can be used when theoretical calculations predict different B(GT) (strength) distributions for the possible shapes of the ground state (prolate, spherical, oblate).

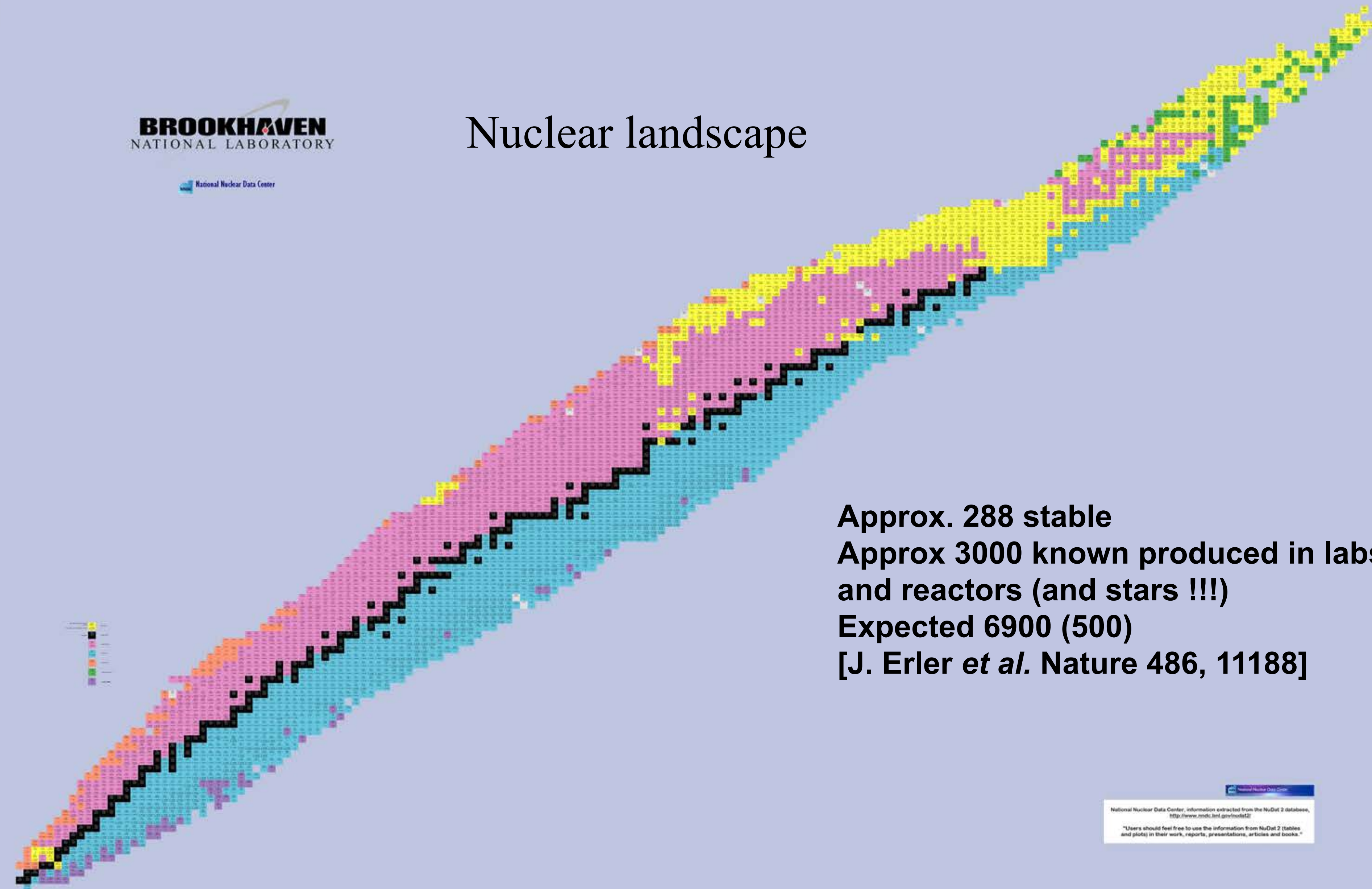
P. Sarriguren *et al*., Nuc. Phys. A635 (1999) 13





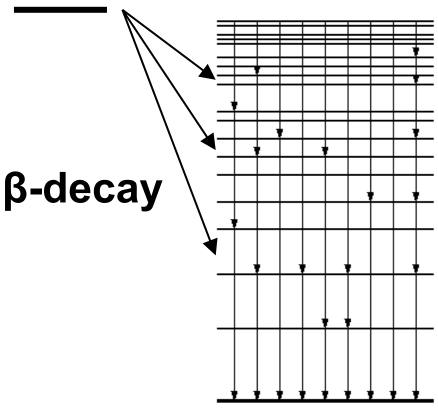
Apart from that, why beta decay is so important ?

Nuclear landscape



Approx. 288 stable
Approx 3000 known produced in labs and reactors (and stars !!!)
Expected 6900 (500)
[J. Erler *et al.* Nature 486, 11188]

Some basic relations of beta decay



$$ {}_{Z}A_{N} \rightarrow {}_{Z+1}A_{N-1} + e^{-} + \overline{\nu} \qquad \beta^{-} $$

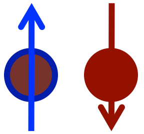
$$ {}_{Z}A_{N} \rightarrow {}_{Z-1}A_{N+1} + e^{+} + \nu \qquad \beta^{+} $$

$$ {}_{Z}A_{N} + e^{-} \rightarrow {}_{Z-1}A_{N+1} + \nu + X_{ray} \qquad \mathrm{EC} $$

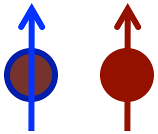
Selection rules of beta decay

The emitted leptons have s=1/2

S=0 (Fermi)



S=1(Gamow-Teller)



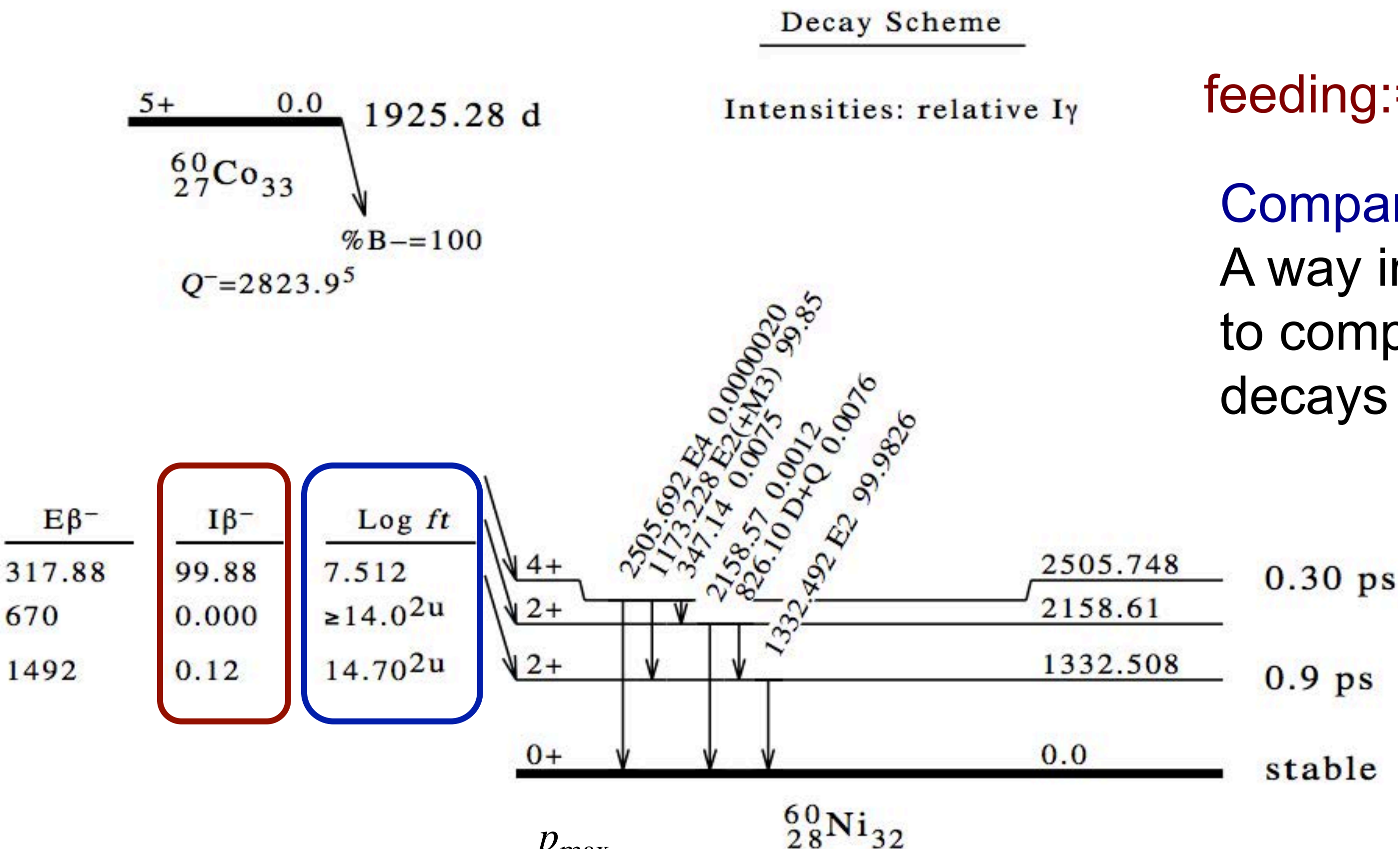
Allowed Transitions (L=0)

$$ \Delta I = \left| I_i - I_f \right| = 0 \quad \text{Fermi} $$

$$ I_i = I_f + 1,\ \Delta I = 0,\ 1 \quad \text{Gamow - Teller} $$

$$ \Delta\pi = (\text{-}1)^{\mathrm{L=0}} = 1, \text{ no change} $$

Example: ^{60}Co decay from http://www.nndc.bnl.gov/



feeding:=$I_\beta = P_f$*100

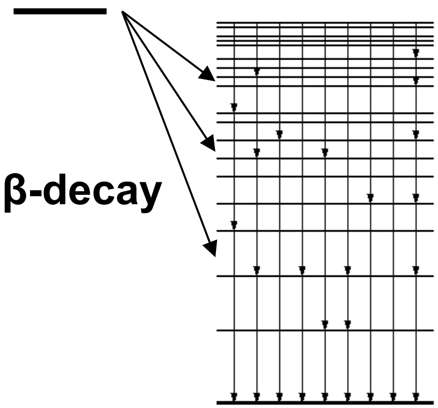
Comparative half-life: ft

A way introduced by Fermi to compare the different decays (Q, Z')

$$f(Z',Q) = const \cdot \int_0^{p_{max}} F(Z',p)p^2(Q-E_e)^2\,dp, \qquad t_f = \frac{T_{1/2}}{P_f}$$

$$ft_f = const' \frac{1}{|M_{if}|^2} \qquad B(GT) \sim |M_{if}^{\sigma\tau}|^2 \qquad T_{1/2} = \frac{\ln(2)}{\lambda} = \tau \ln(2)$$

Beta decay: feeding /strength distribution



$$ft_f = const' \frac{1}{|M_{if}|^2} = const' \frac{1}{B_{if}}$$

Fermi / Gamow-Teller:

$$B_{i\to f} = \frac{1}{2J_i + 1} \left| \left\langle \Psi_f \right| \tau^{\pm} \ or \ \sigma\tau^{\pm} \left| \Psi_i \right\rangle \right|^2$$

Strength function (experimental)

$$S_\beta(E) = \frac{P_\beta(E)}{f(Z', Q_\beta - E) T_{1/2}} = \frac{1}{ft(E)}$$

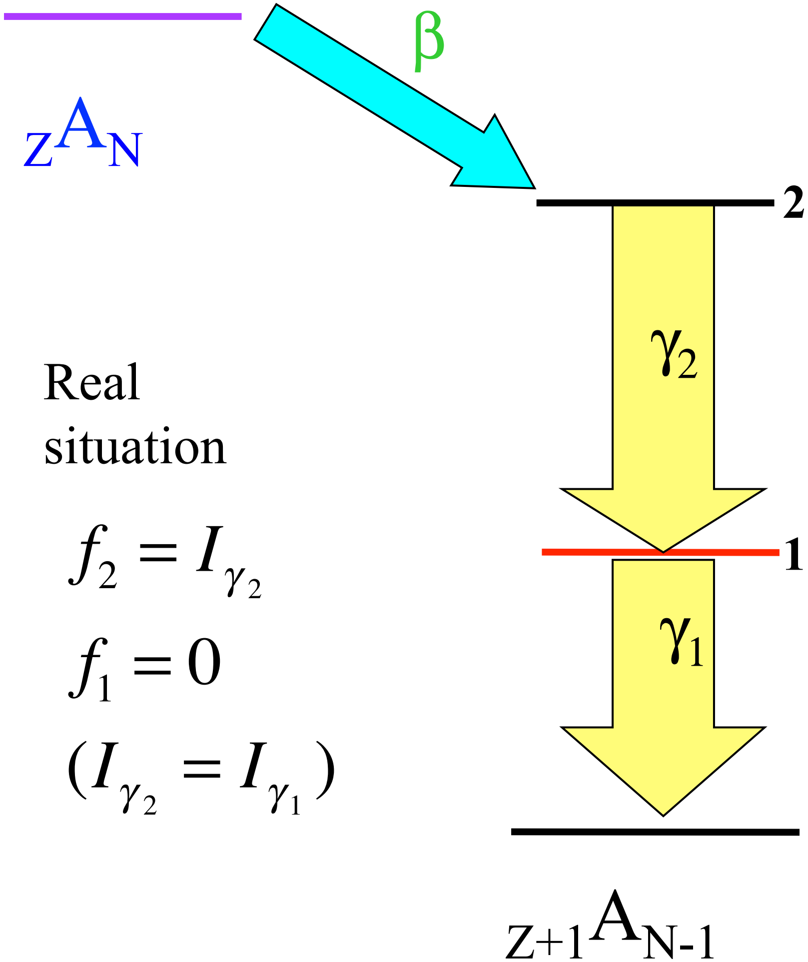
Theory

$$S_\beta = \frac{1}{6147 \pm 7} \left(\frac{g_A}{g_V} \right)^2 \sum_{E_f \in \Delta E} \frac{1}{\Delta E} B_{i\to f}$$

Global beta decay properties are related to the strength

$$\frac{1}{T_{1/2}} = \int_0^{Q_\beta} S_\beta(E_x) \cdot f(Q_\beta - E_x) dE_x \qquad P_n = \frac{\int_{S_n}^{Q_\beta} S_\beta(E_x) \cdot f(Q_\beta - E_x) \cdot \frac{\Gamma^n}{\Gamma^n + \Gamma^\gamma} dE_x}{\int_0^{Q_\beta} S_\beta(E_x) \cdot f(Q_\beta - E_x) dE_x}$$

The starting point: measuring the β-feeding

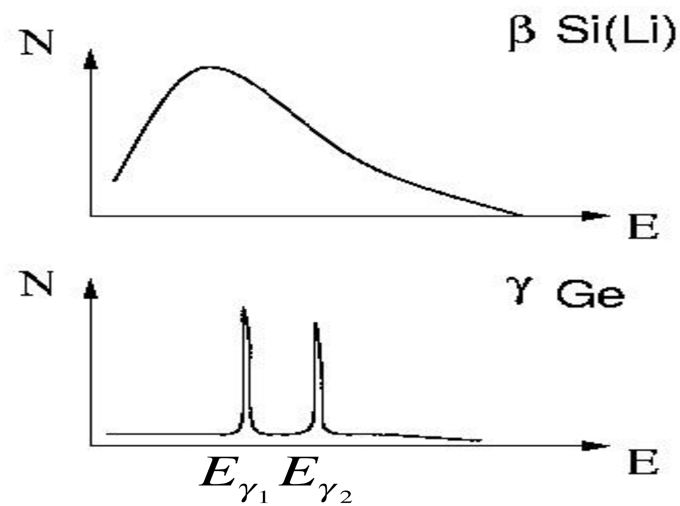


Real situation

$$f_2 = I_{\gamma_2}$$

$$f_1 = 0$$

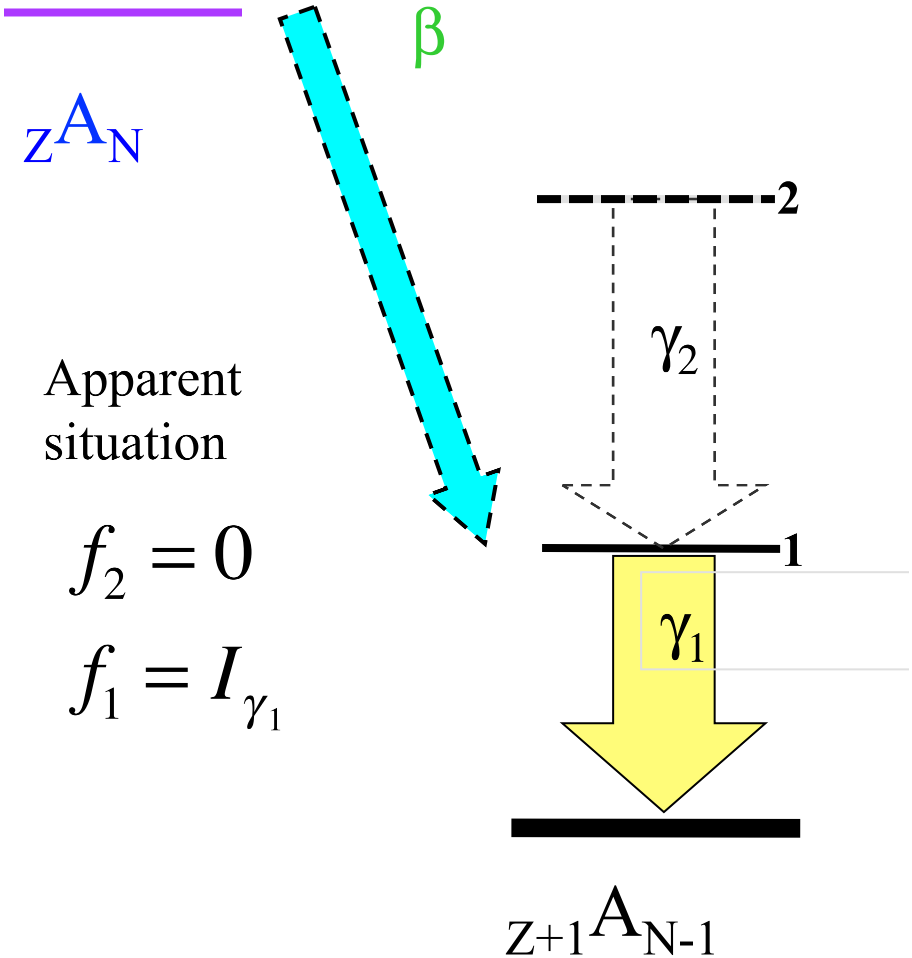
$$(I_{\gamma_2} = I_{\gamma_1})$$



- Ge detectors are conventionally used to construct the level scheme populated in the decay

- From the γ intensity balance we deduce the β-feeding

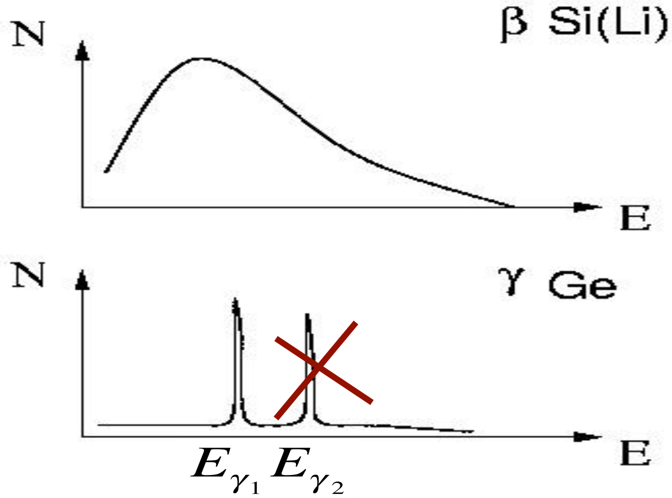
Experimental perspective: the problem of measuring the β- feeding



Apparent situation

$$f_2 = 0$$

$$f_1 = I_{\gamma_1}$$



- What happens if we miss some intensity

$$Single\ \gamma \sim \varepsilon$$

$$Coinc\ \gamma_1\gamma_2 \sim \varepsilon_1\varepsilon_2$$

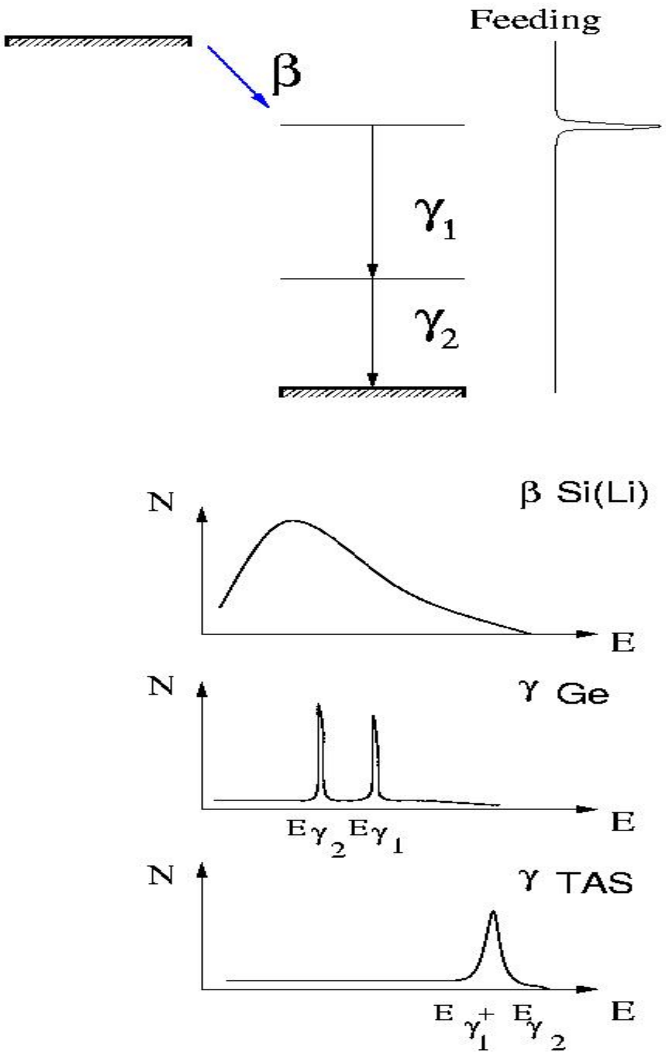
Pandemonium (The Capital of Hell)

introduced by John Milton (XVII) in his epic poem Paradise Lost

John Martin (~ 1825), presently at Louvre

Hardy et al., Phys. Lett. 71B (1977) 307

TAGS measurements



Since the gamma detection is the only reasonable way to solve the problem, we need a highly efficient device:

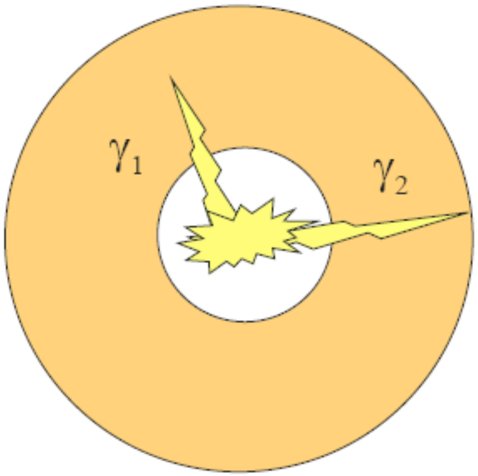
A TOTAL ABSORPTION SPECTROMETER

But if you built such a detector instead of detecting the individual gamma rays you can sum the energy deposited by the gamma cascades in the detector.

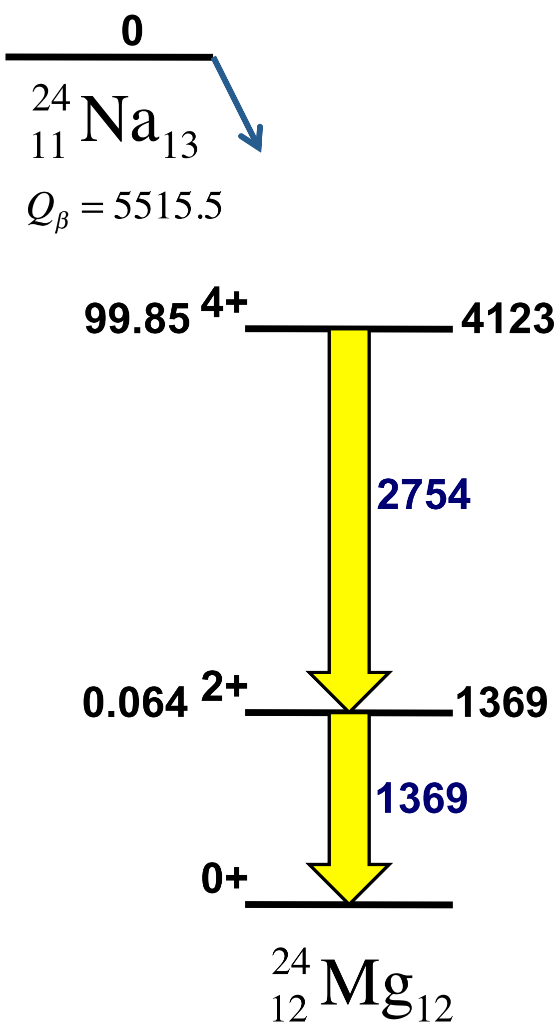
A TAS is like a calorimeter!

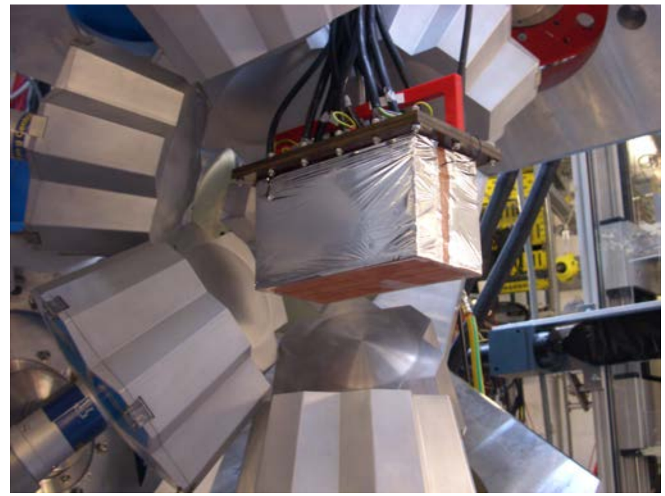
Big crystal, 4π

$$d = R(B) \cdot f$$



Ge detector case: ^{24}Na decay





RISING

Stopped Beam Configuration:

15 clusters, 105 Ge capsules

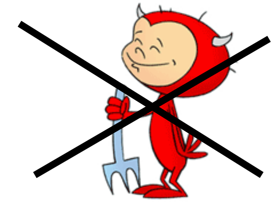
$$\varepsilon_{p1} = 0.10 \quad \gamma_1 = 1369 \text{ keV}$$

$$\varepsilon_{p2} = 0.06 \quad \gamma_2 = 2754 \text{ keV}$$

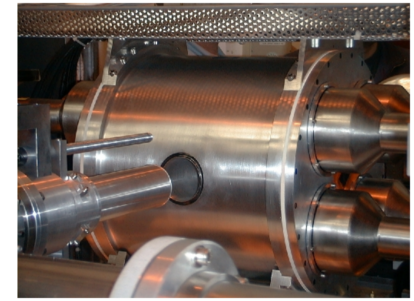
$$\varepsilon_{coinc} = \varepsilon_{p1} \cdot \varepsilon_{p2}$$

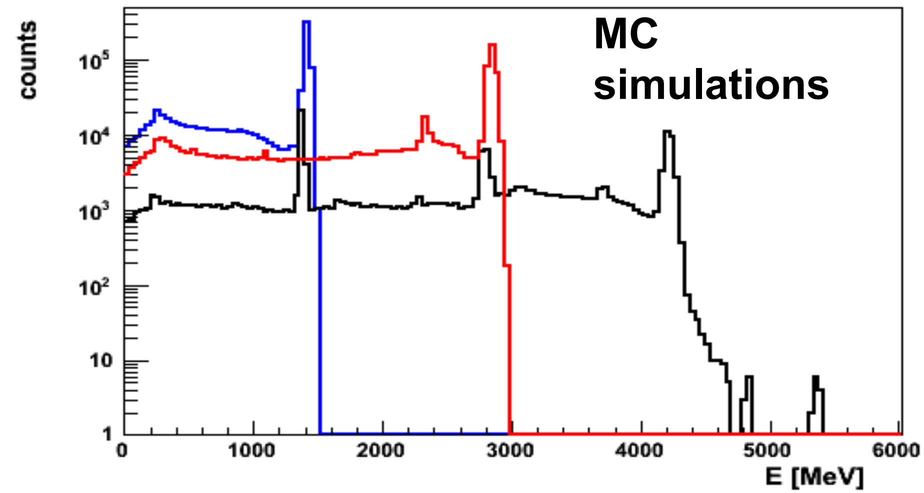
$$\varepsilon_{coinc} = 0.006$$

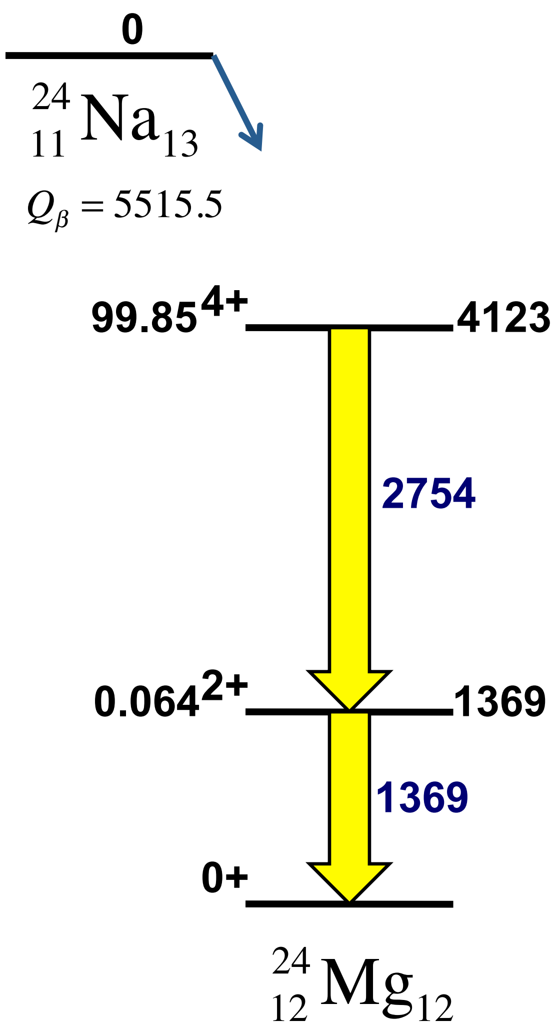
TAS case: ^{24}Na decay



$$d = R(B)\cdot f$$







$$\varepsilon^{\gamma_1}_{Total}(1369\ \mathrm{keV}) = 0.81$$

$$\varepsilon^{\gamma_2}_{Total}(2754\ \mathrm{keV}) = 0.72$$

$$\varepsilon_{Total}(cascade) = \varepsilon^{\gamma_1}_{Total} \otimes \varepsilon^{\gamma_2}_{Total} =$$

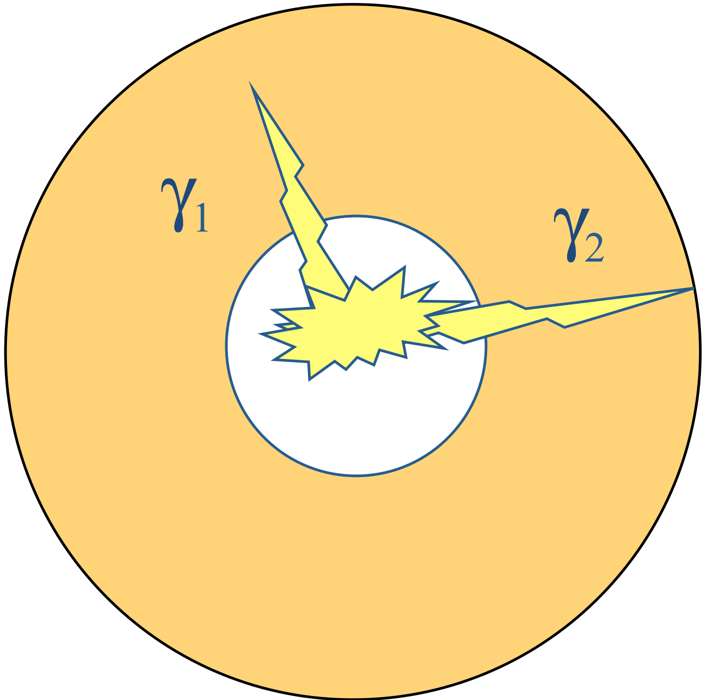
$$\varepsilon^{\gamma_1}_{Total}(1-\varepsilon^{\gamma_2}_{Total}) + \varepsilon^{\gamma_2}_{Total}(1-\varepsilon^{\gamma_1}_{Total}) + \varepsilon^{\gamma_1}_{Total}\varepsilon^{\gamma_2}_{Total} = 0.95$$

Problems associated with TAS (TAZ ?)

• The analysis is difficult and lengthy since it requires a careful calculation of the response function of the detector to the decay (but nowadays we have the tools to attack the problem)

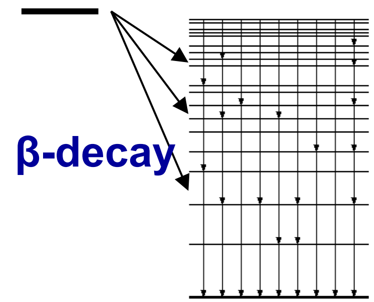
• Special care have to be taken with the contaminants

TAZ (hungry beast)



Analysis

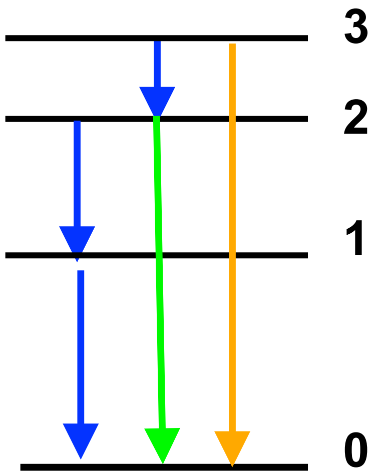
$$d_i = \sum_j R_{ij} f_j \quad or \quad \mathbf{d} = \mathbf{R} \cdot \mathbf{f}$$



R is the response function of the spectrometer, $\boldsymbol{R_{ij}}$ means the probability that feeding at a level ***j*** gives counts in data channel ***i*** *of the spectrum*

The response matrix **R** can be constructed by recursive convolution:

$$\mathbf{R_j} = \sum_{k=0}^{j-1} b_{jk} \mathbf{g_{jk}} \otimes \mathbf{R_k}$$

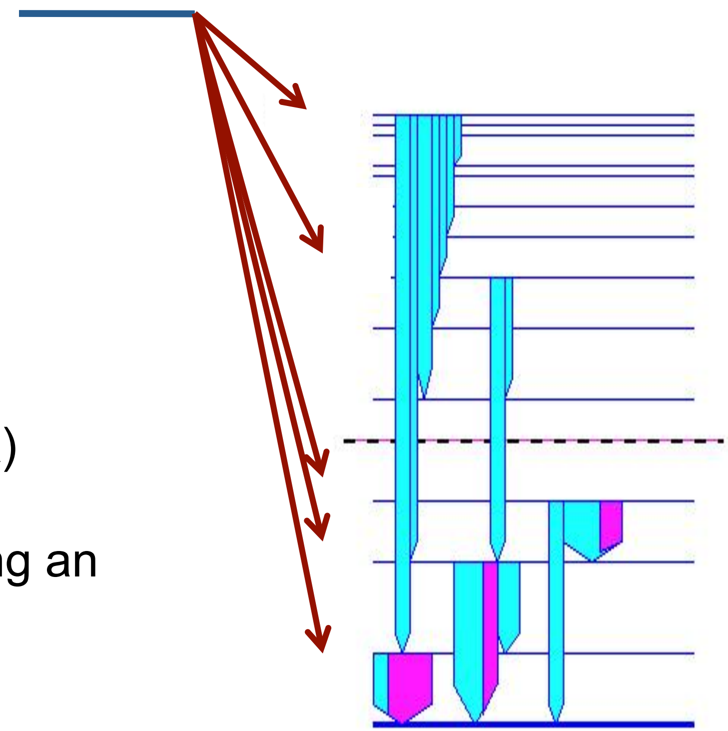


$\mathbf{g_{jk}}$: γ-response for *j* ➔ *k* transition
$\mathbf{R_k}$: response for level *k*
b_{jk}: branching ratio for *j* ➔ *k* transition

Mathematical formalization by Tain, Cano, et al.

The complexity of the TAGS analysis: an ill posed problem

$$d = R(B) \cdot f$$



Steps:

1. Define B (branching ratio matrix)
2. Calculate R(B)
3. Solve the equation d=R(B)f using an appropriate algorithm

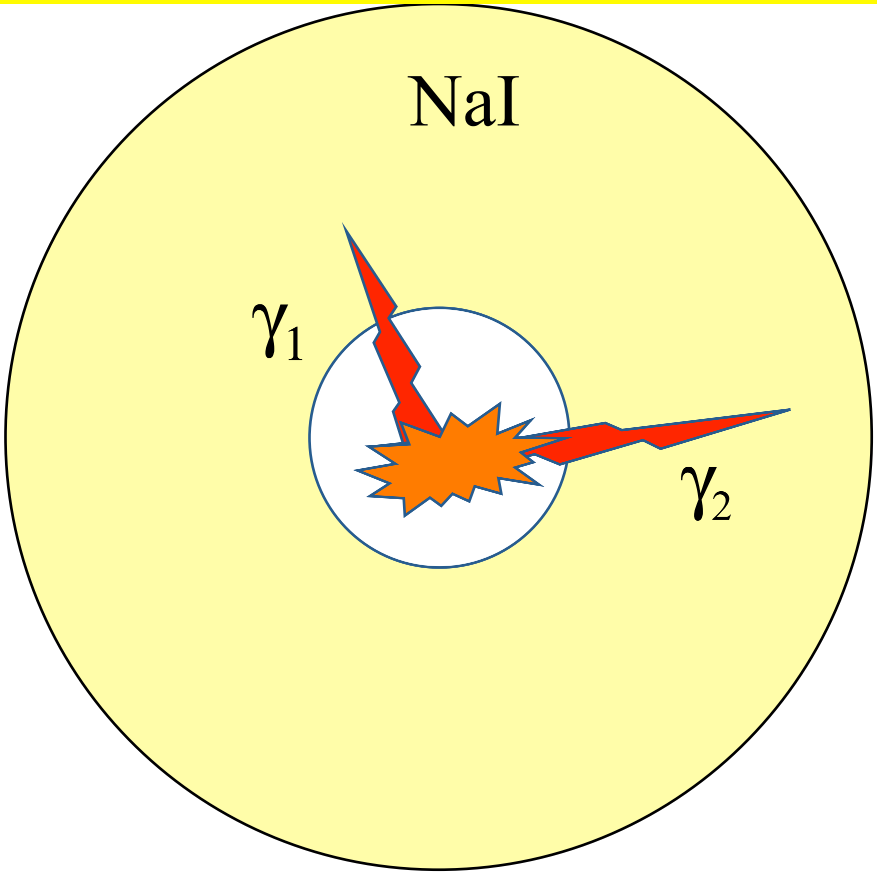
Expectation Maximization (EM) method:
modify knowledge on causes from effects

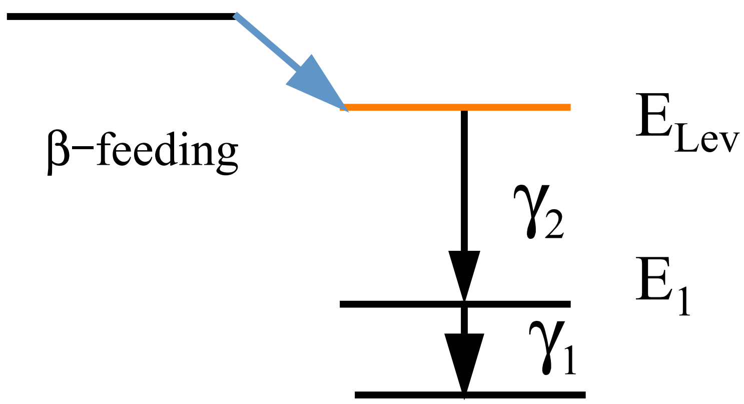
$$P(f_j \mid d_i) = \frac{P(d_i \mid f_j) P(f_j)}{\sum_j P(d_i \mid f_j) P(f_j)}$$

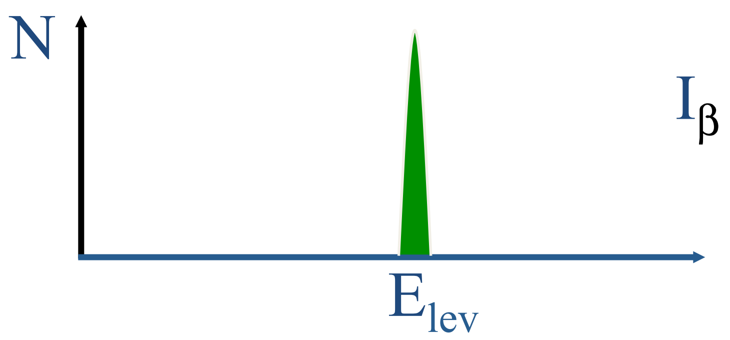
Algorithm:

$$f_j^{(s+1)} = \frac{1}{\sum_i R_{ij}} \sum_i \frac{R_{ij} f_j^{(s)} d_i}{\sum_k R_{ik} f_k^{(s)}}$$

Total absorption spectroscopy (β- case, ideal case)



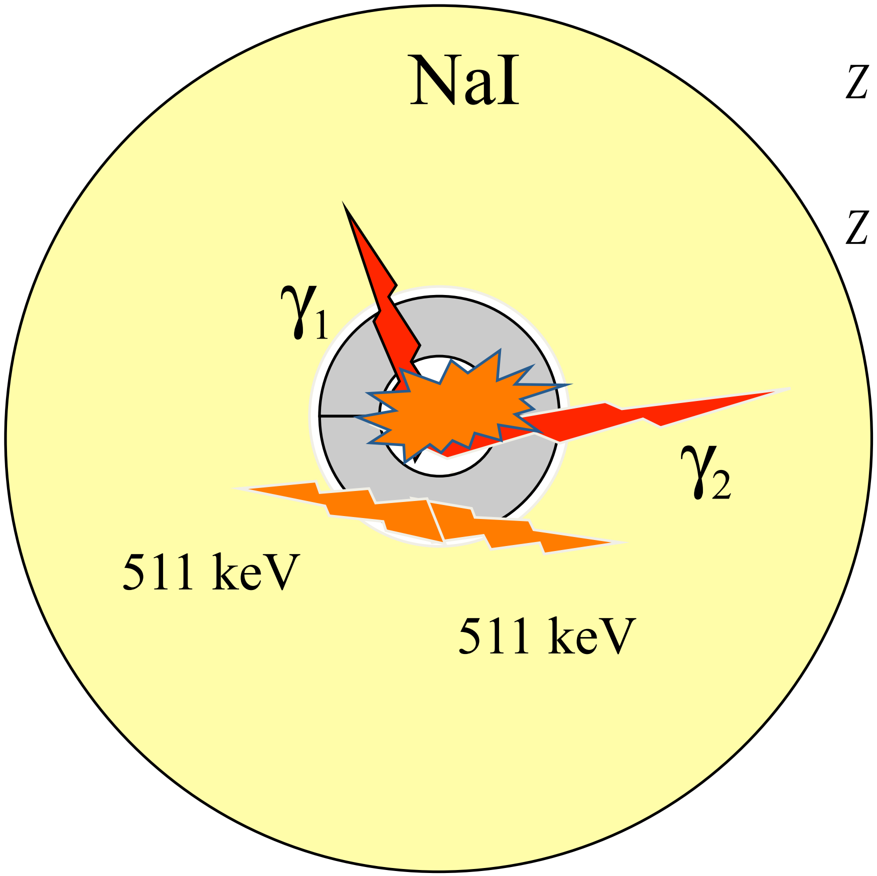




Ideal case: beta (minus) decay, and no contamination.
There is need for a 100% efficient summing device

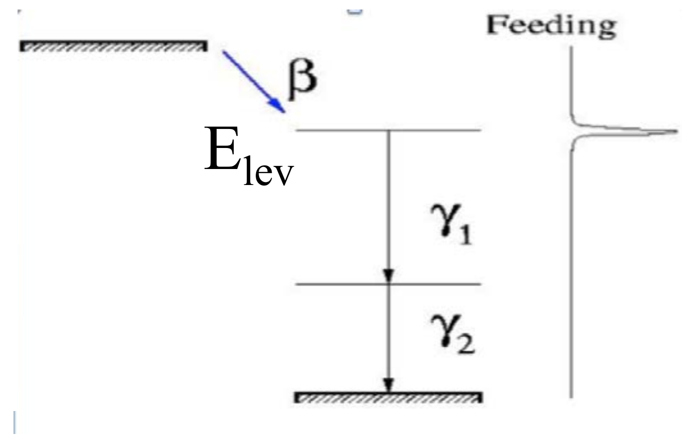
$$d = R(B) f$$

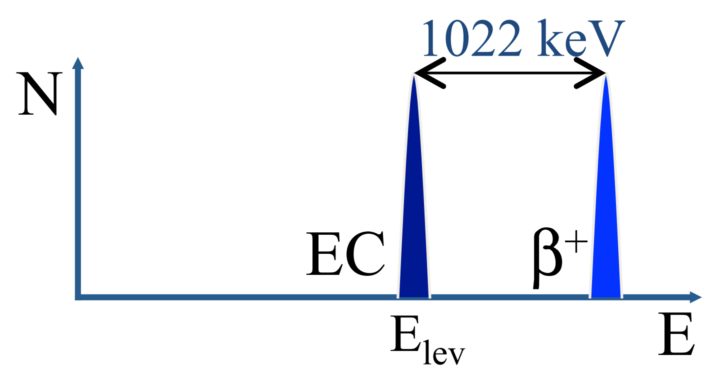
Total absorption spectroscopy (β+/EC, ideal case)



$${}_{Z}A_{N} \rightarrow {}_{Z-1}A_{N+1} + e^{+} + \nu \qquad \beta^{+}$$

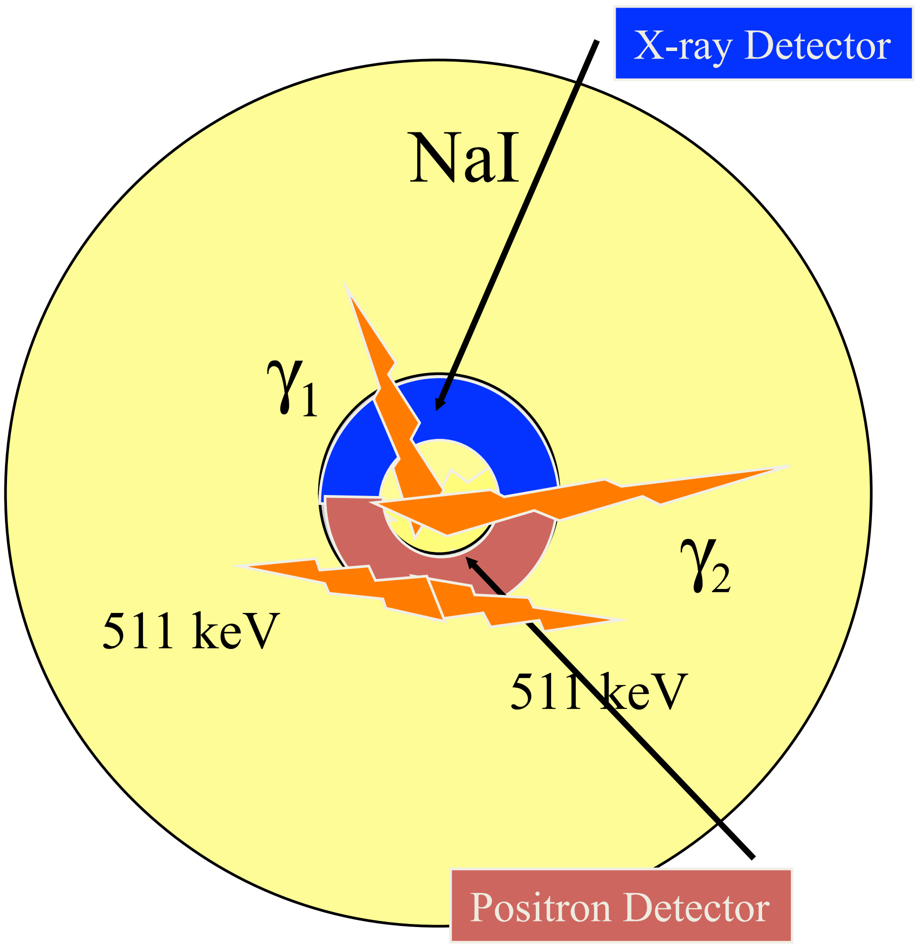
$${}_{Z}A_{N} + e^{-} \rightarrow {}_{Z-1}A_{N+1} + \nu + X_{ray} \qquad \text{EC}$$

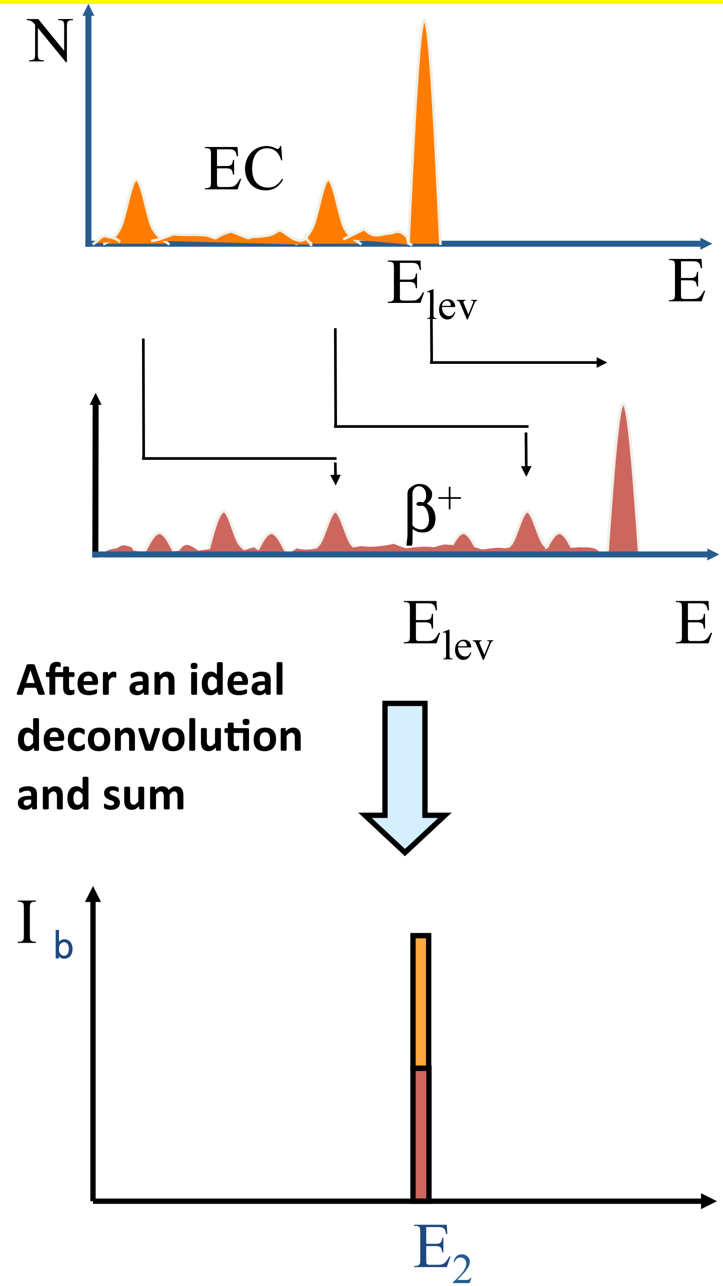




Ideal case: two processes in the beta plus/EC case.
We need to distinguish between them.

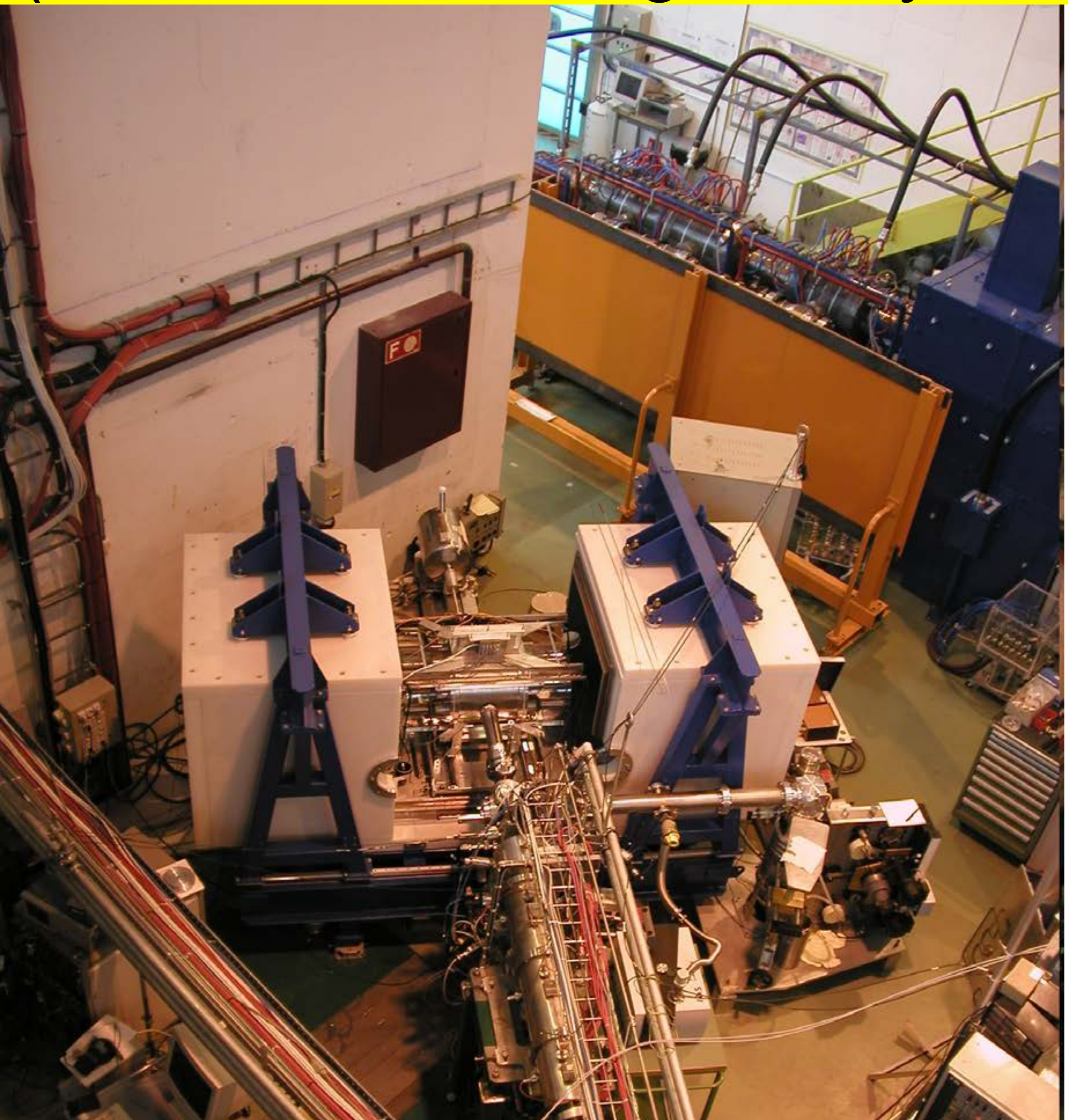
Total absorption spectroscopy :(β+/EC case)

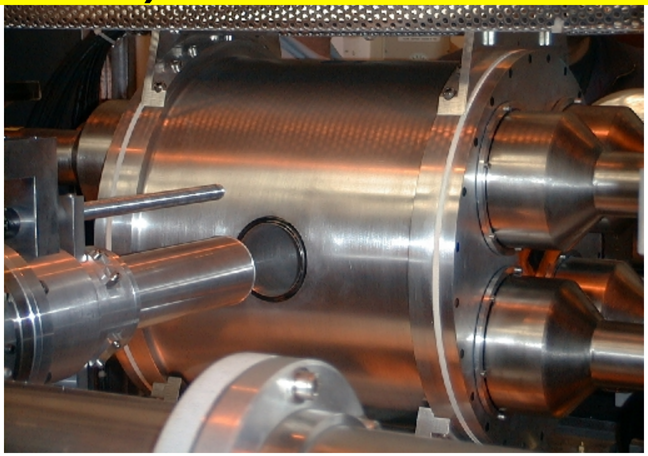




Problem: complexity of the spectra.
Solution: use of coincidences with ancillary detectors

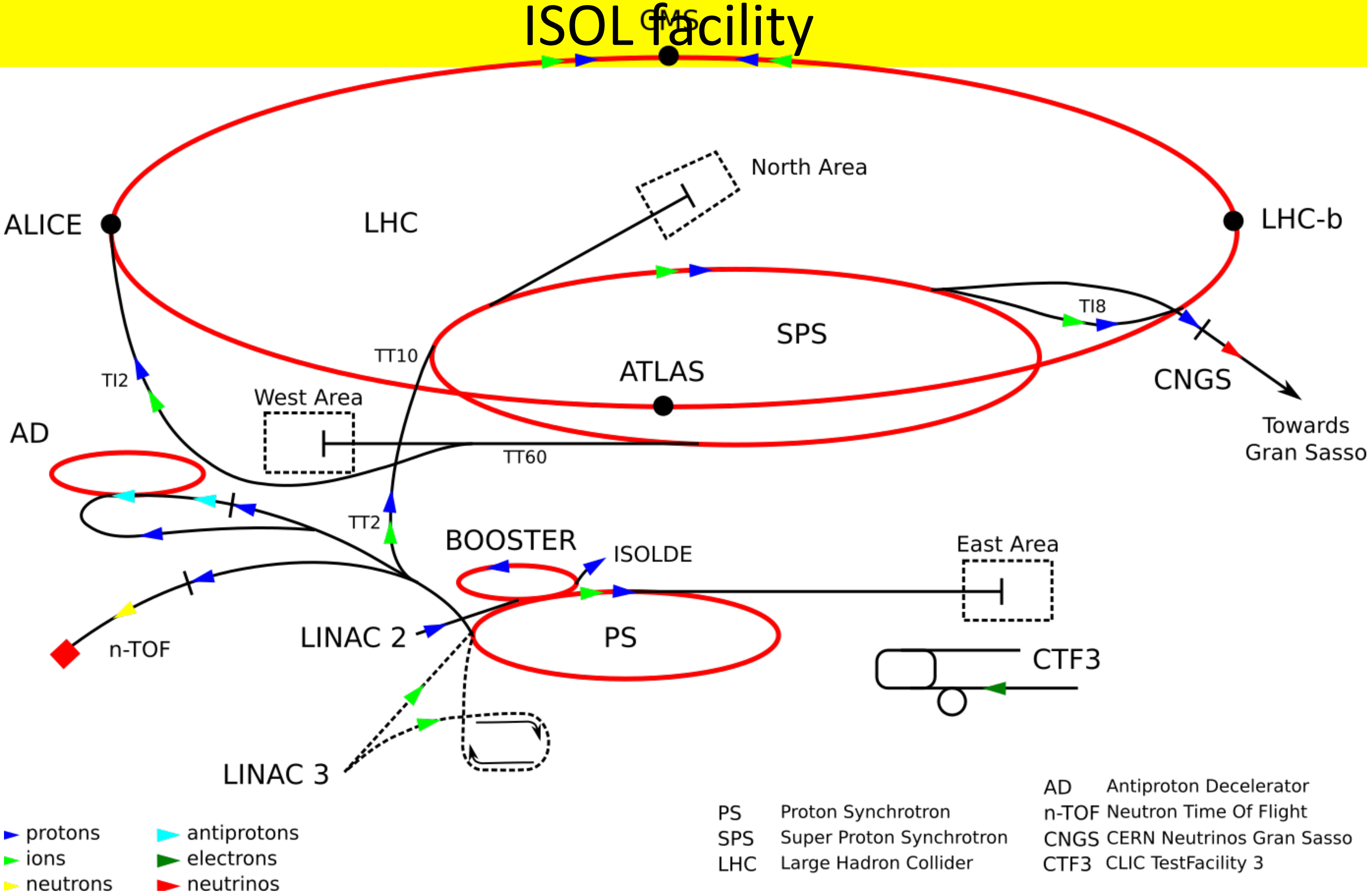
Lucrecia: the TAS at ISOLDE (CERN) (Madrid-Strasbourg-Surrey-Valencia)



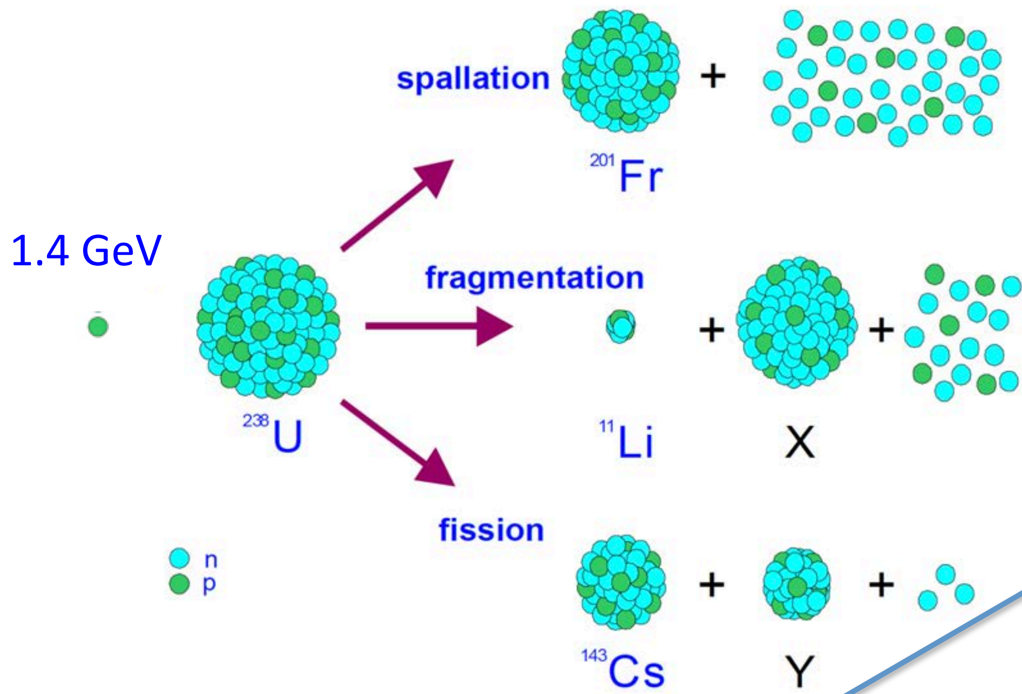


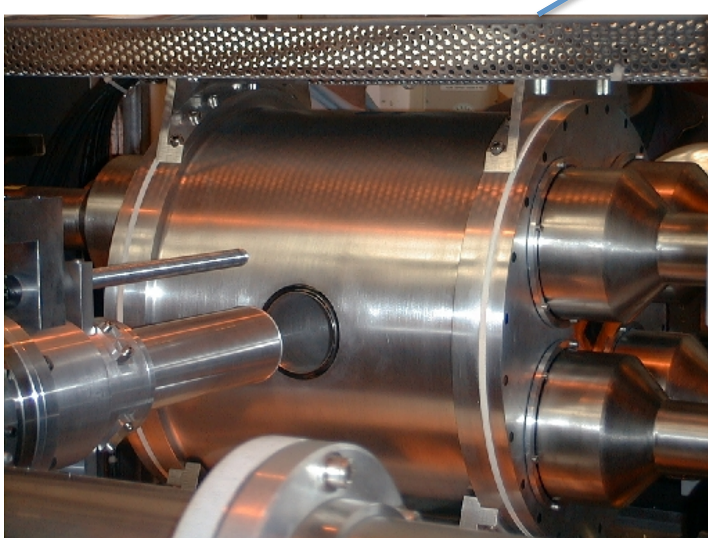
- A large NaI cylindrical crystal 38 cm Ø, 38cm length
- An X-ray detector (Ge)
- A β detector
- Possibility of collection point inside the crystal

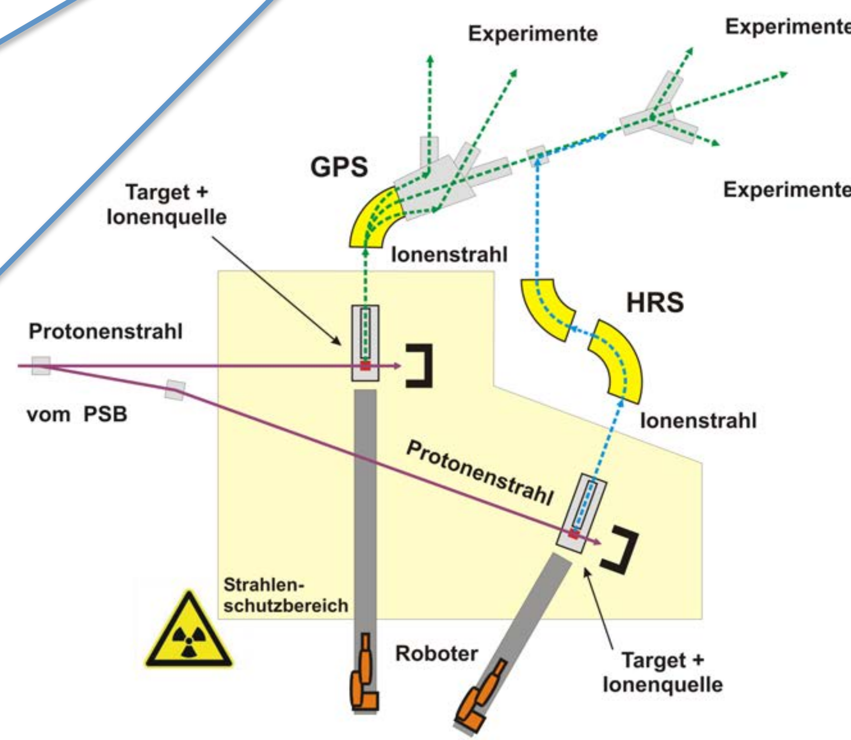
Nuclear physics at CERN (ISOLDE), the quintessential ISOL facility



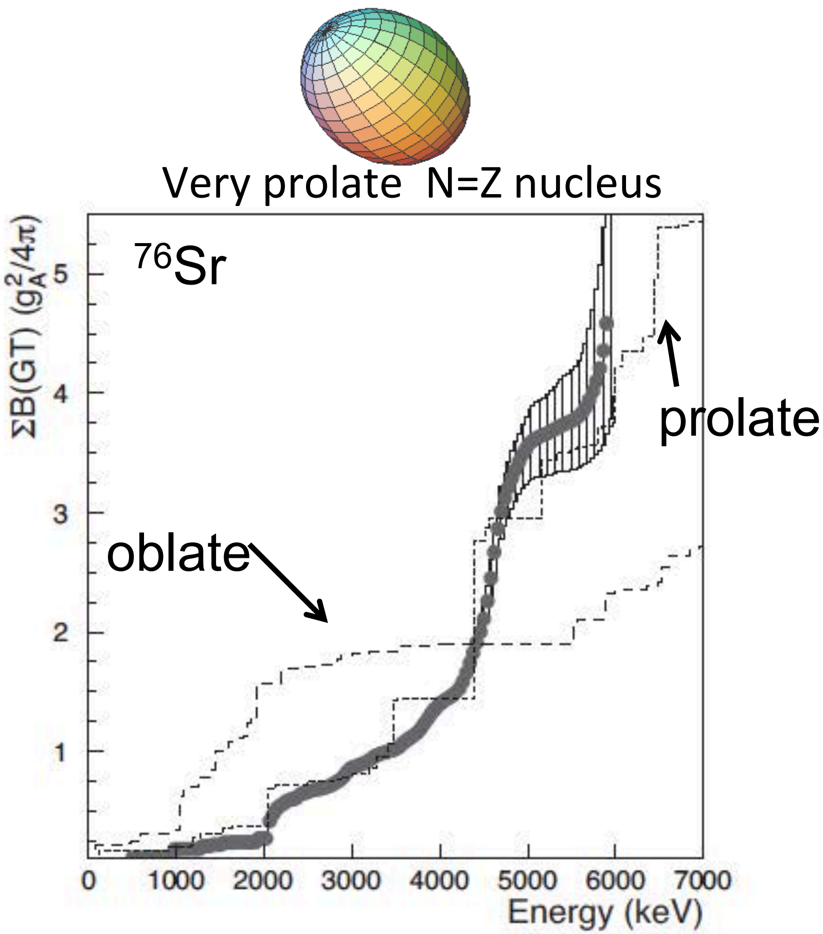
How exotic nuclei are produced at ISOLDE, CERN

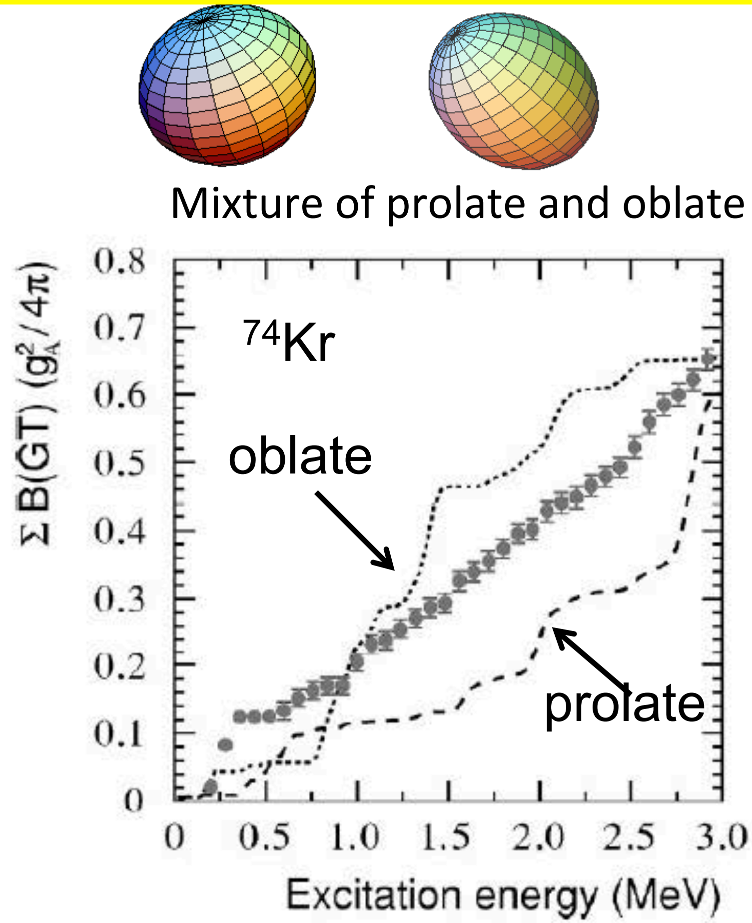






Some earlier examples
(proposals by Rubio and Dessagne)





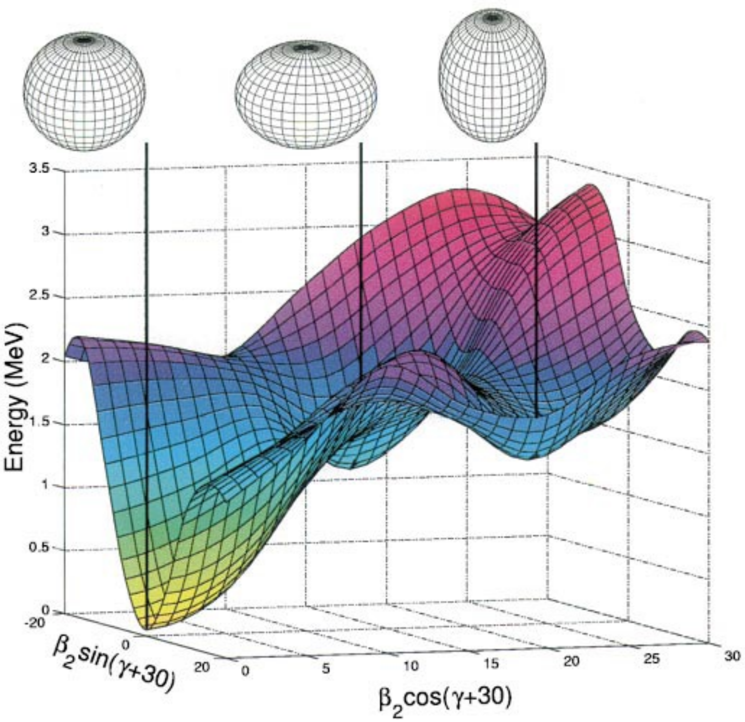
E. Nácher *et al. PRL 92 (2004) 232501 and PhD thesis Valencia*
Ground state of ^{76}Sr prolate (β_2 ~0.4) as indicated in Lister et al., PRC 42 (1990) R1191

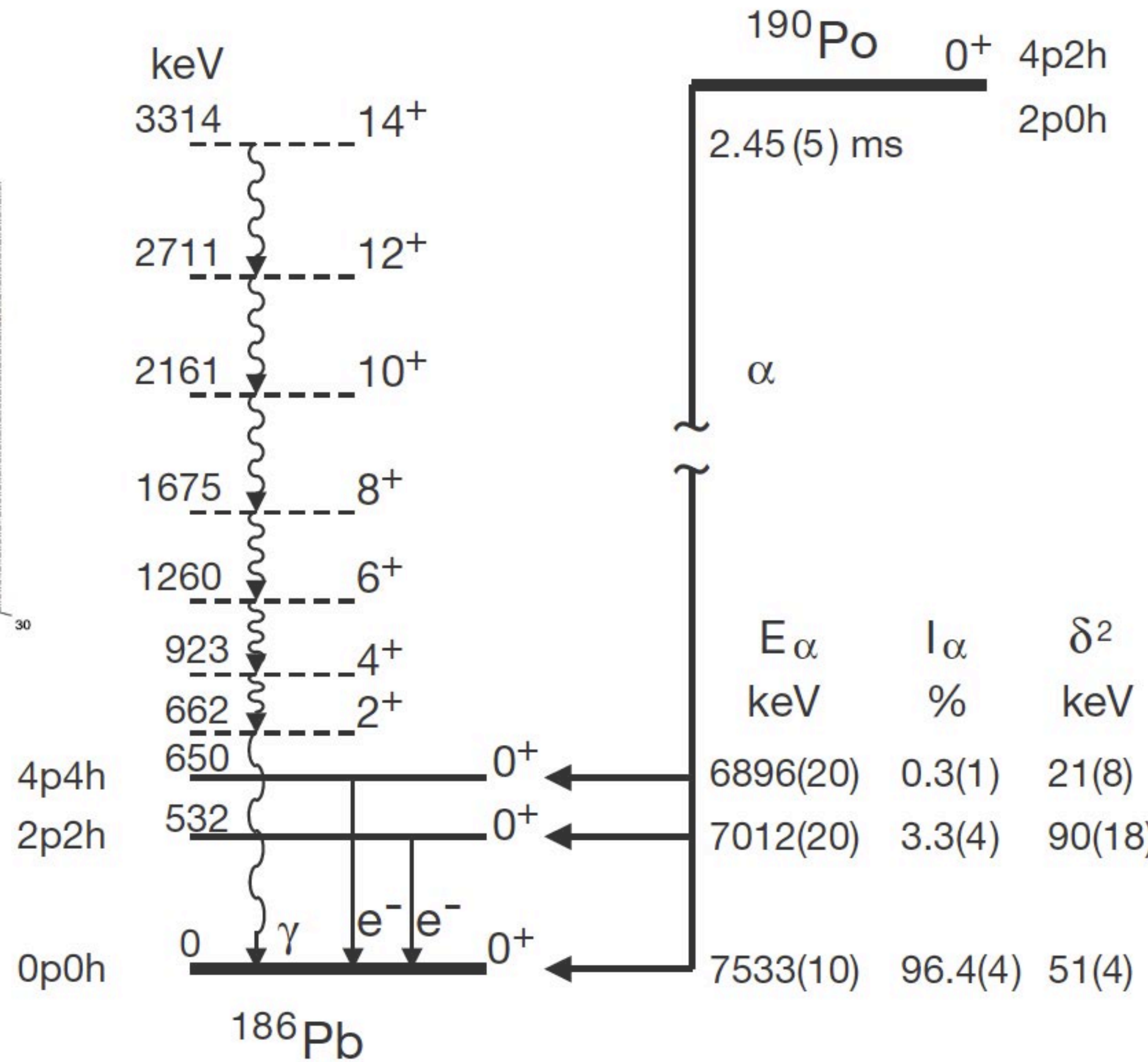
E. Poirier *et al., Phys. Rev. C 69, 034307 (2004) and PhD thesis Strasbourg*
Ground state of ^{74}Kr:(60±8)% oblate, in agreement with other exp results and with theoretical calculations (A. Petrovici et al.)

Possible questions

- is the method only valid for A~80 ?
- was the good agreement accidental ?
- because the method can be useful for exotic nuclei
- So it is worth explore heavier domains …

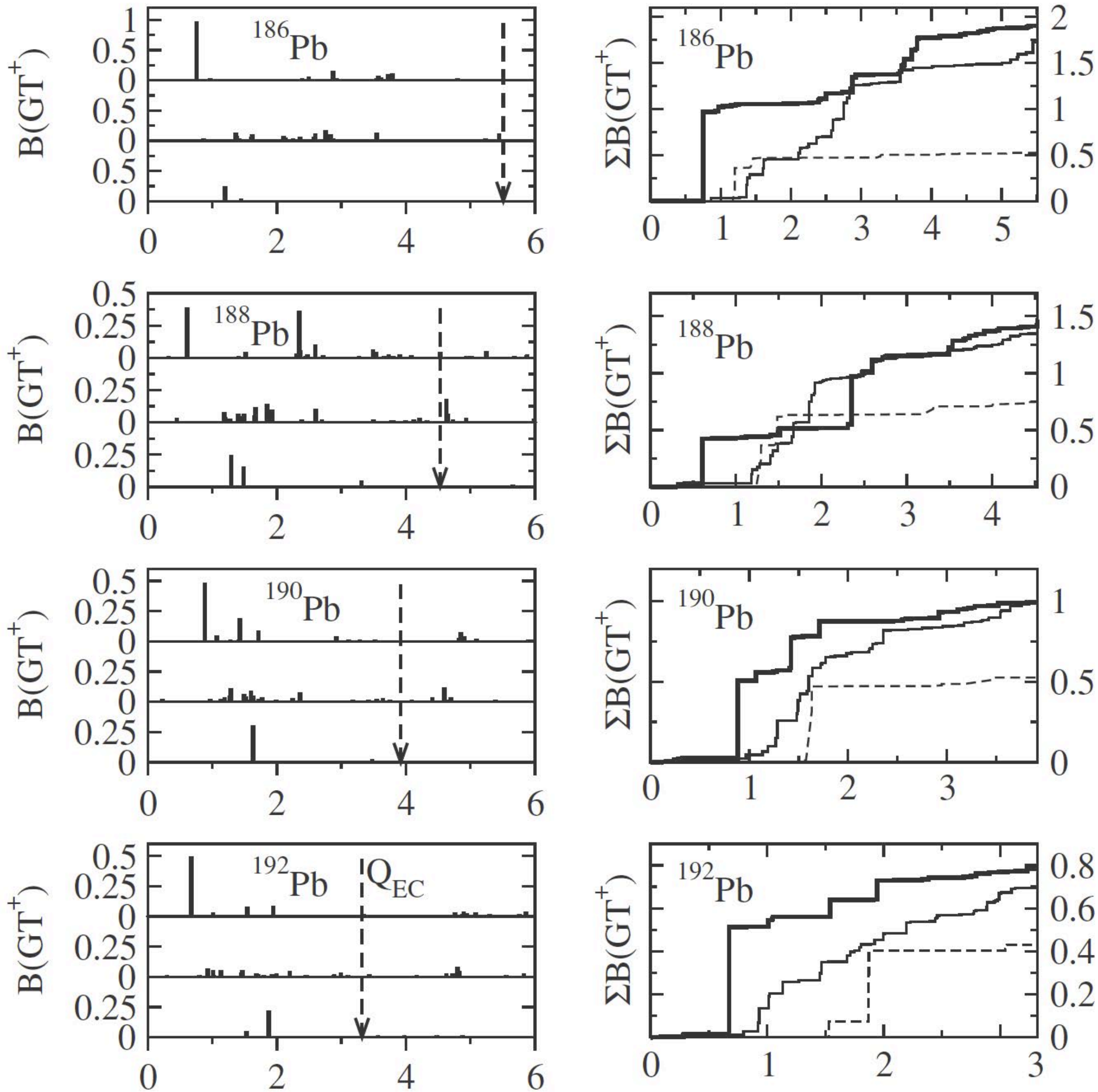
Intruder 0+ states in ^{186}Pb

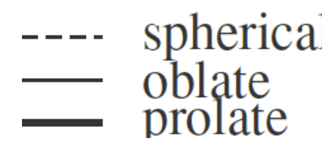




A. N. Andreyev *et al*.
Nature 405 (2000) 430

The B(GT) profiles



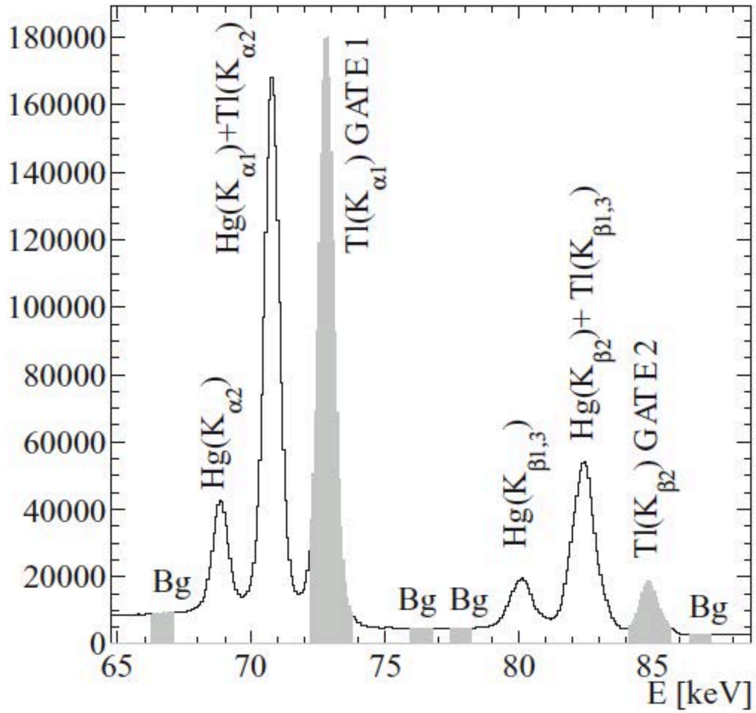


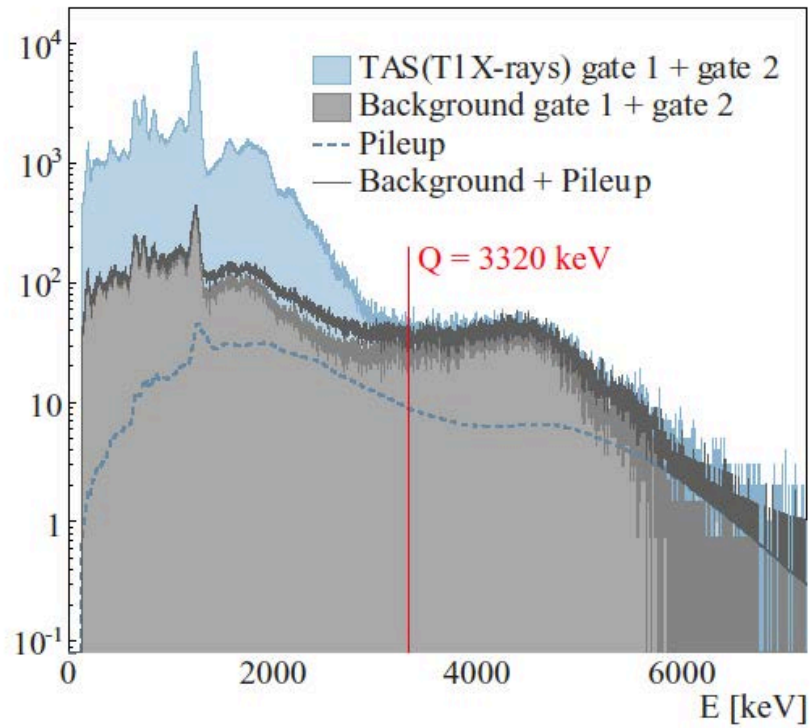
Moreno, Sarriguren
PRC 73 (2006) 054317

IS440 results: ^{192}Pb->^{192}Tl example

$$_{Z}A_{N} \rightarrow {}_{Z-1}A_{N+1} + e^{+} + \nu \qquad \beta^{+}$$

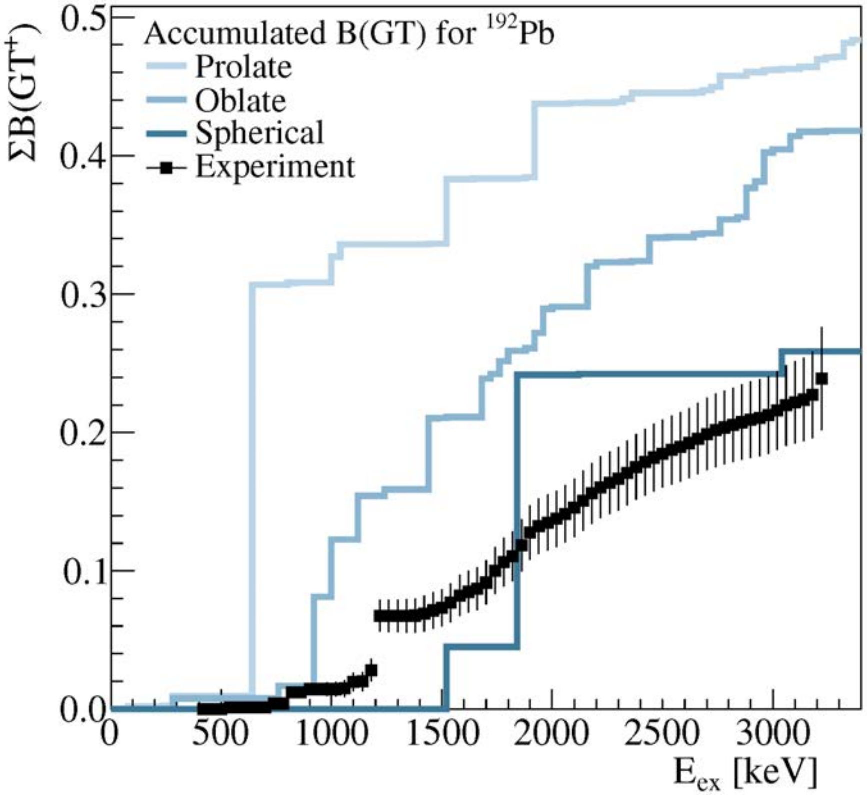
$$_{Z}A_{N} + e^{-} \rightarrow {}_{Z-1}A_{N+1} + \nu + X_{ray} \qquad \text{EC}$$

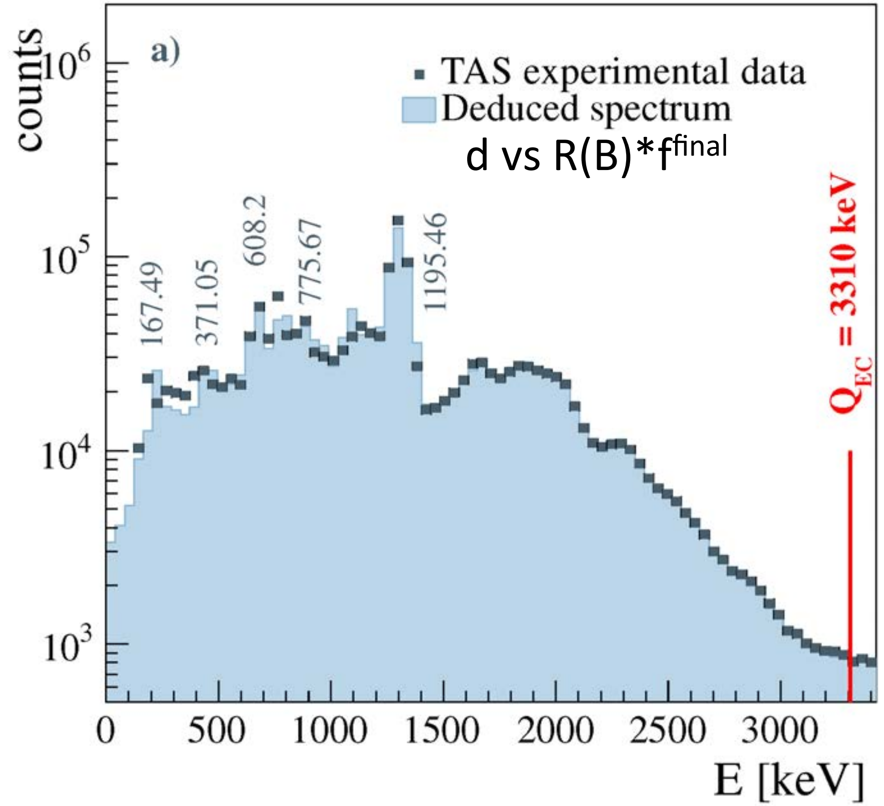




Thesis work of M. E. Estevez 2011, and M. E. Estevez *et al. PRC 92, 044321 (2015)*.

IS440 results: ^{192}Pb example

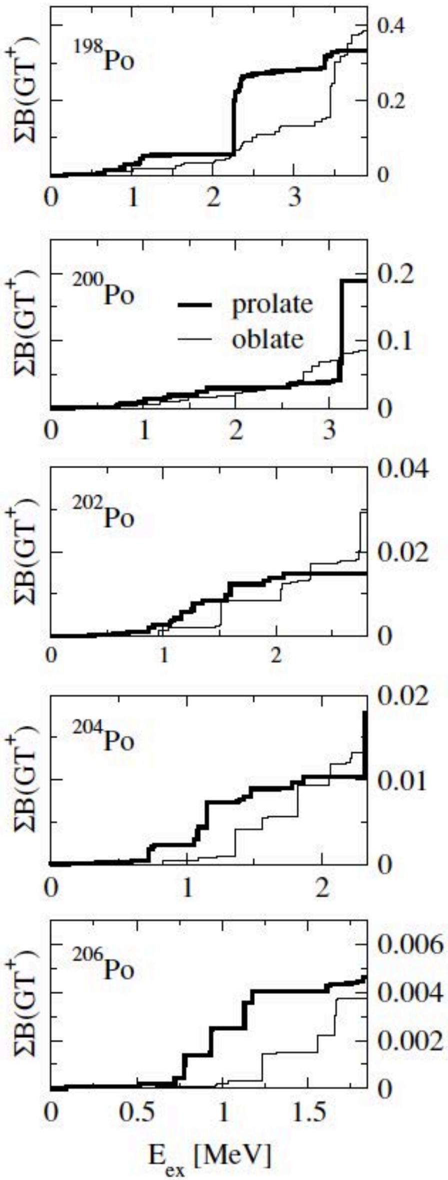




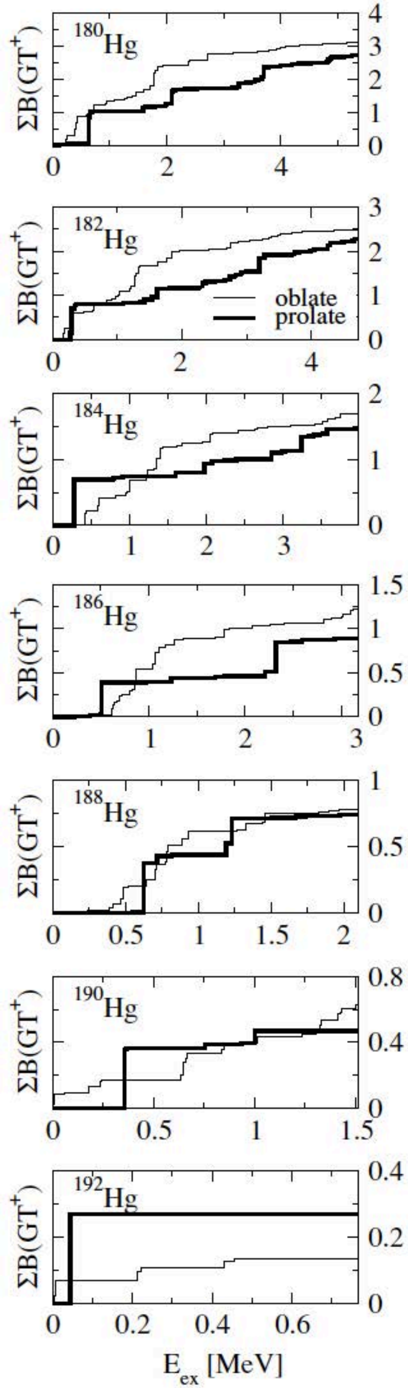
Thesis work of M. E. Estevez 2011, and M. E. Estevez *et al. PRC 92, 044321 (2015)*. Theory from PRC 73 (2006) 054317)

Results consistent with spherical picture, but less impressive than in the A≈80 region. Similar situation for ^{190}Pb. *Possible explanation, the spherical character of the Pb nuclei, but requires further testing.*

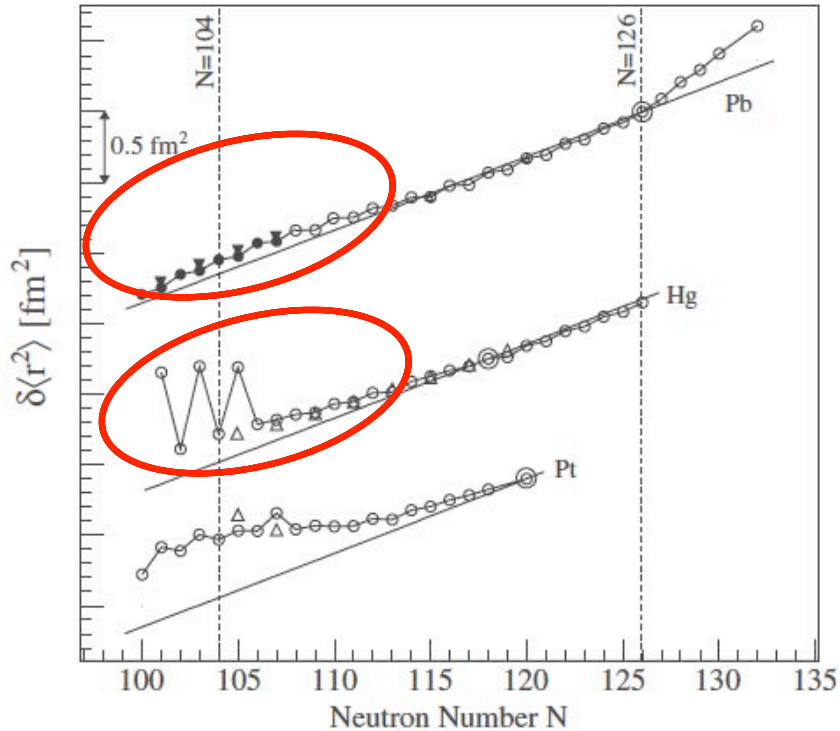
Other cases of interest in the region (Hg)



O. Moreno *et al.*
PRC 73, 054302



H. De Witte *et al.*
PRL 98, 0112502



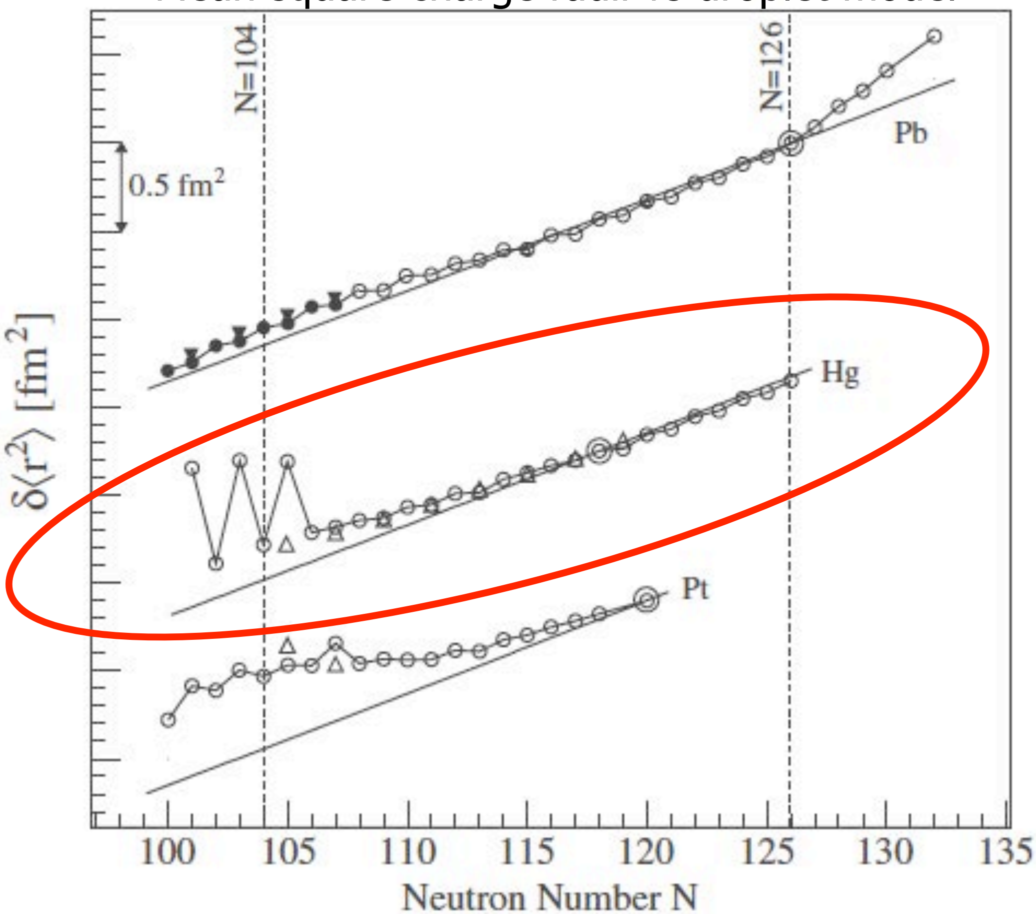
Also T. Cocolios *et al*. *PRL 106, 052503*
More recently B. A. Mash *et al. Nature s41567-018-0292-8*

Why is $_{80}Hg$ interesting?

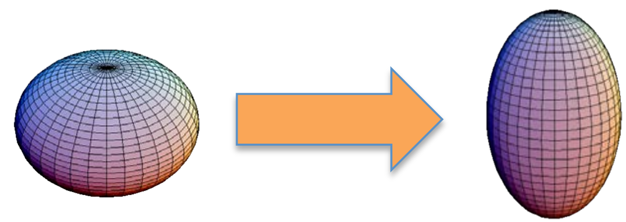
Apart from its fantastic appeal as a liquid metal at room temperature

Why are the $_{80}$Hg-s interesting?

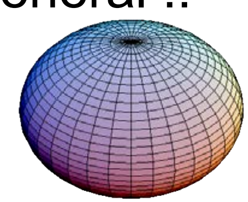
Mean square charge radii vs droplet model



Drastic shape change between the odd-mass ^{185,187}Hg (interpreted as a transition from **oblate** to a more deformed **prolate** shape)



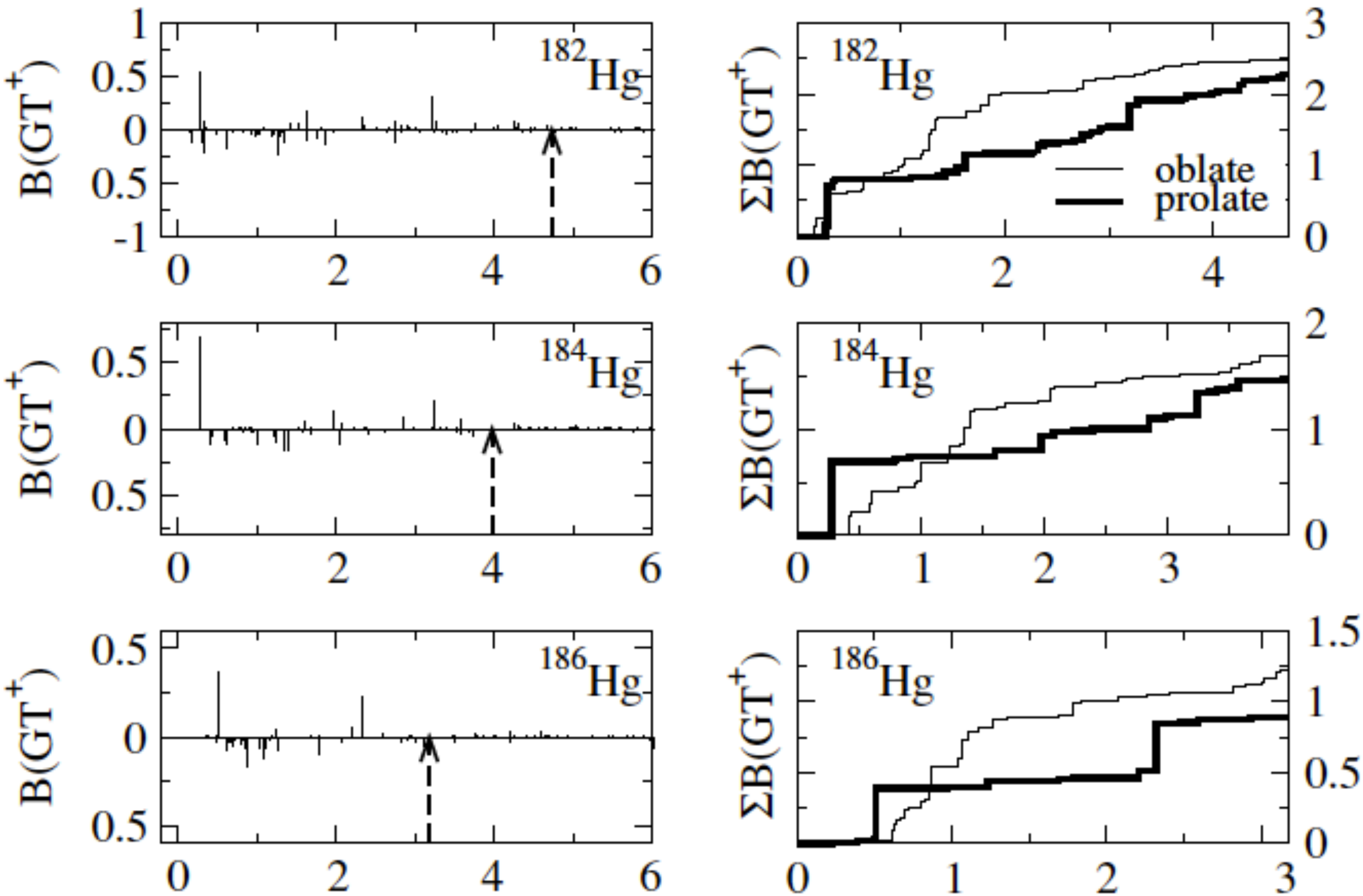
The even-mass nuclei are assumed to be **oblate** nuclei. Which are not so common in general !!



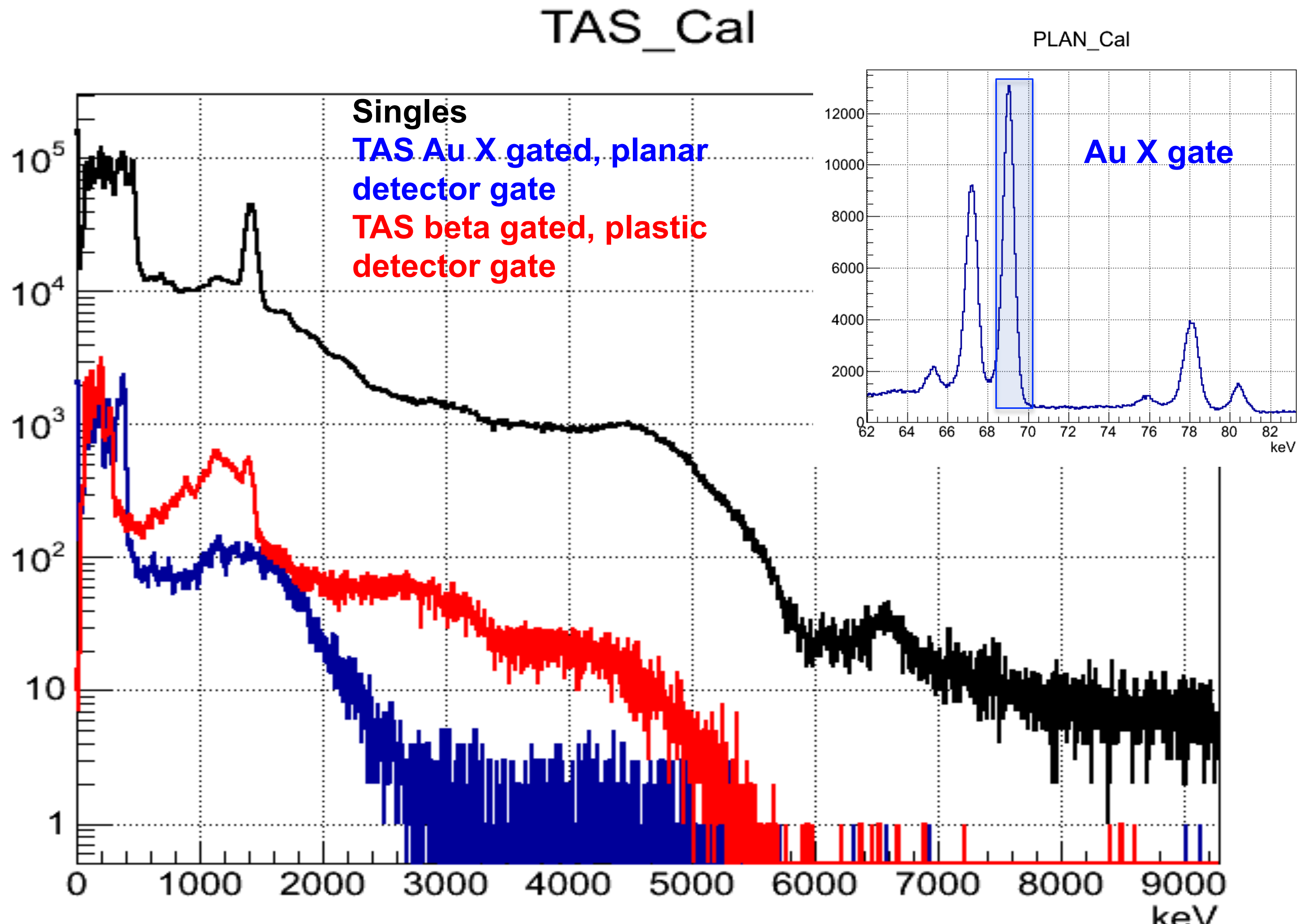
Ulm, Z.Phys. A325 (1986) 247 and De Witte PRL 98
B. A. Mash et al. Nature s41567-018-0292-8

The B(GT) profiles for the decay of the nuclei of interest

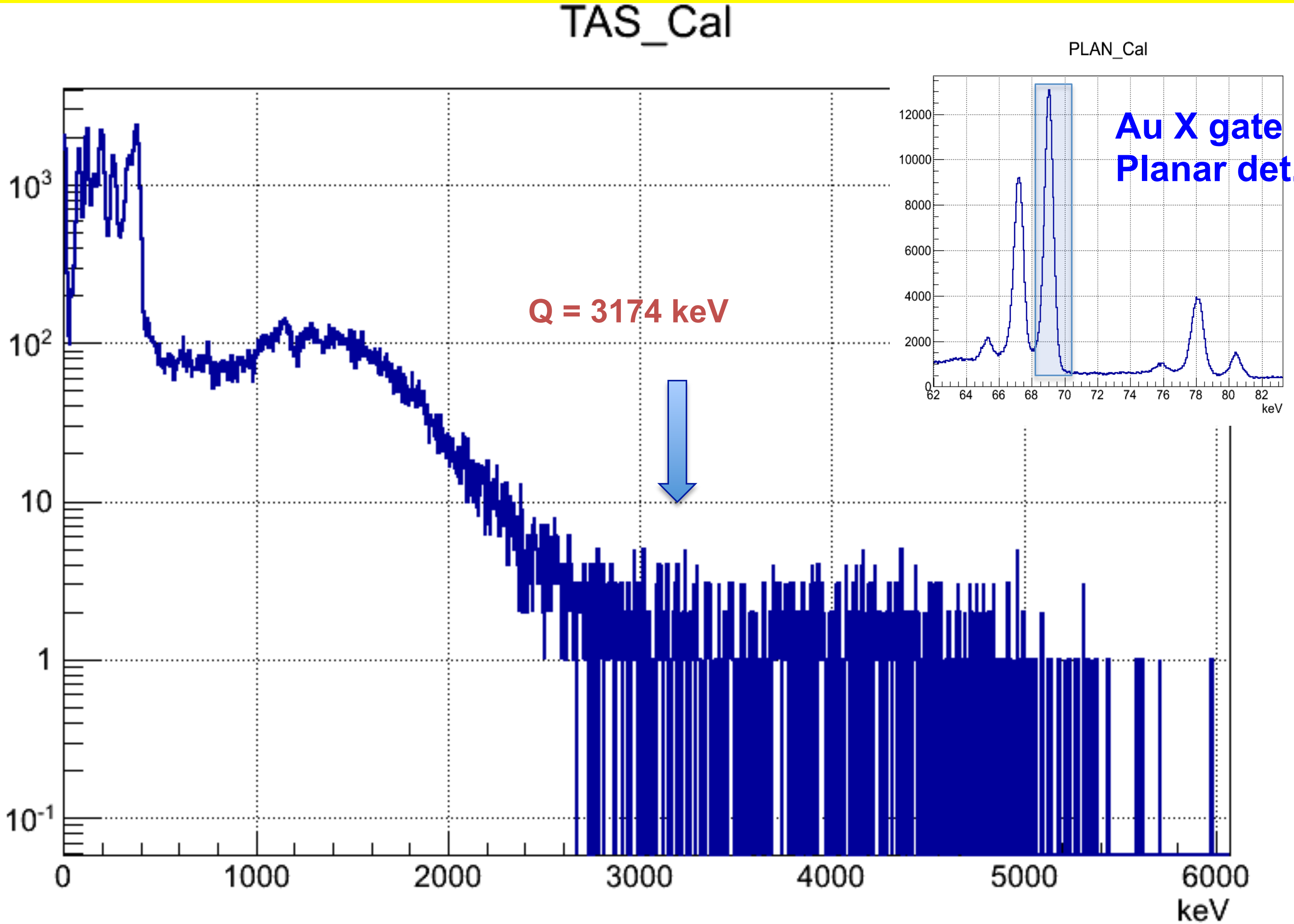
O. Moreno, P. Sarriguren *et al.* PRC 73 (2006) 054317



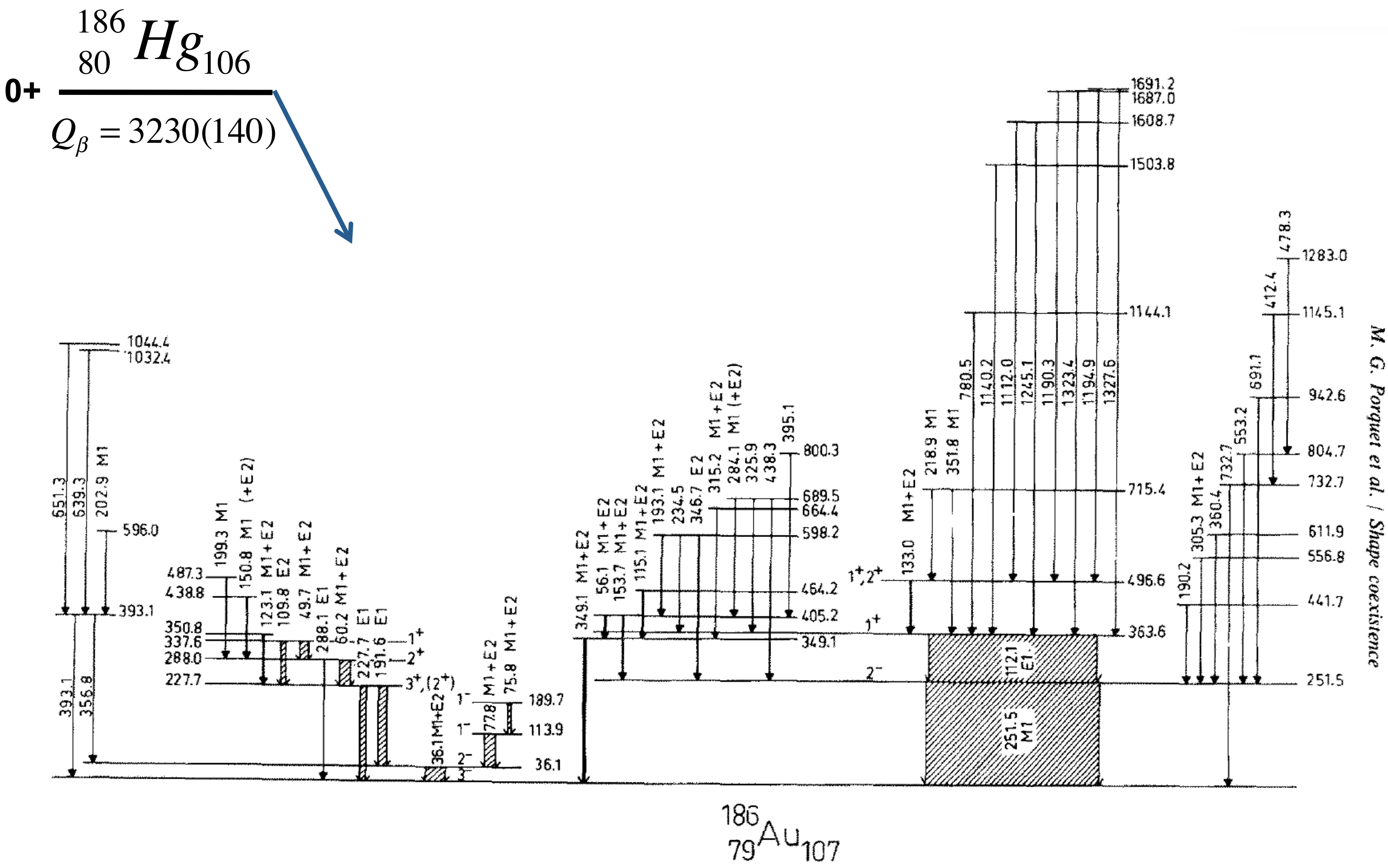
On-line spectra from mass 186, the alchemist dream (^{186}Hg -> ^{186}Au))



On-line spectra TAS spectrum from mass 186 (EC component, only two list mode files)



Known level scheme (high. res.)



The problem in a nut shell

- There has been a serious delay in the analysis of the 186Hg decay caused by a problem that was not present in early studied Lucrecia cases (Kr, Sr, Pb), at least not so evidently as in this decay
- In practical terms it was not possible to reproduce reasonably the analyzed spectra with the normal procedure of analysis using the X-ray gates set in the planar detector, which is necessary to clean the TAS spectrum from contaminants

Possible causes explored

We considered several possible causes

- Wrong level scheme scenario (in the daughter Au)
- Possible existence of an isomer decaying by E0 transition
- Since the spectra is dominated by an structure at low energies, we also though that the light generation in the Monte Carlo might not work so well at those low excitation energies (the Hg decay spectra is dominated by a group of peaks at low energy)
- Etc., etc.

The real cause of the problem

- The problem was caused by the penetration and consequently sum of the Au X-rays in the X-ray gated TAS spectra. Additional X-rays (beyond the ones coming from the EC) come from the internal conversion mentioned earlier (in transitions 112, 251 mainly). The X-rays have enough energy to penetrate the TAS detector and be summed with the gamma cascades.
- This problem was not present in the Kr, Sr cases because of the low energy of the X-rays and probably the effect was very small in the earlier analyzed Pb cases.
- Conversion coefficients are taken into account in our conventional TAS analysis, but normally we do not generate X-rays and we do not convolute the gamma responses with X-rays. So this was the cause of the poor reproduction in the analysis.

Proposed solution

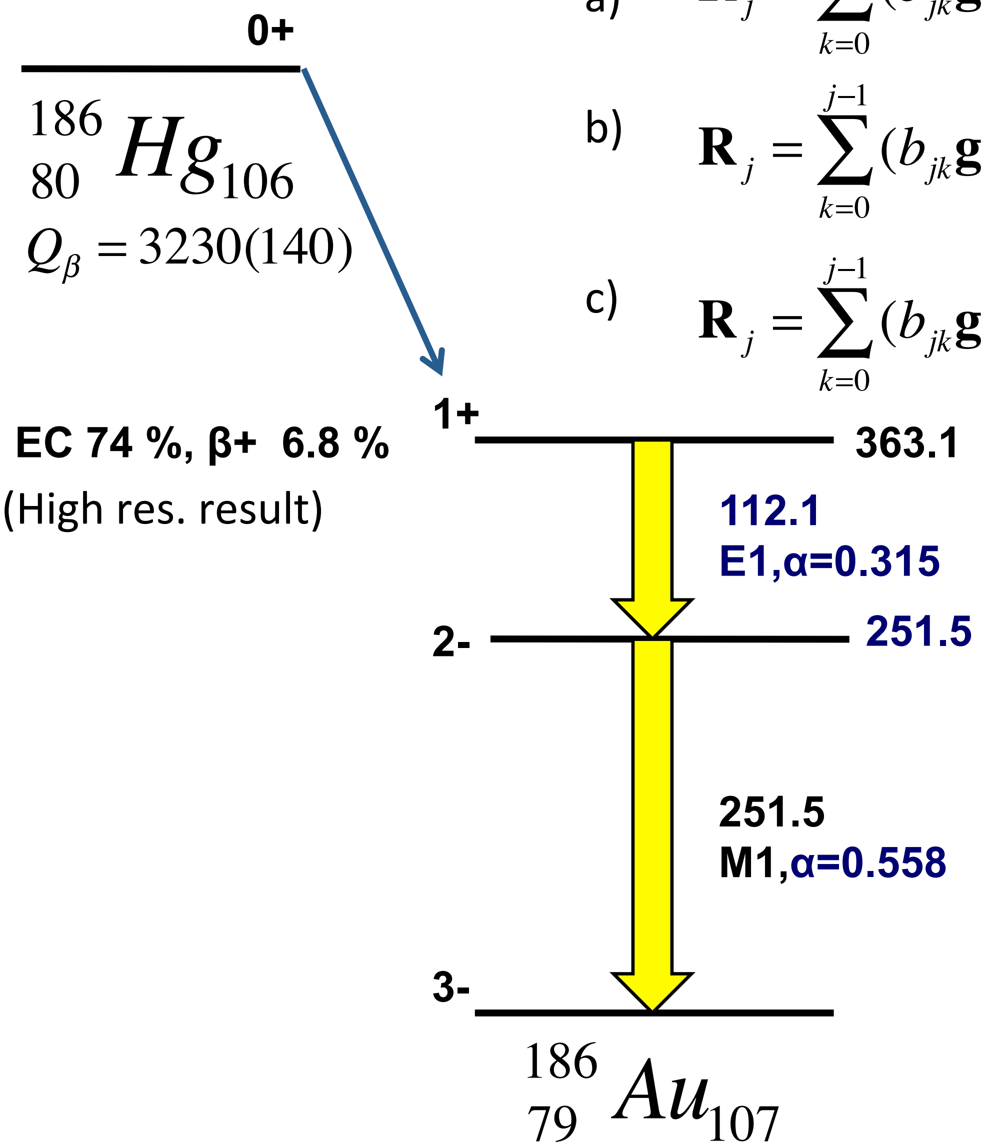
- The problem required a new approach for calculating the response matrix of the decay
- We decided to calculate the "level responses" using the "Radioactive Decay" utility of Geant4, and using all the features of Geant4 for generating X-rays.
- This required the development of new tools to calculate the level responses and to combine them in the new response matrix.
- The new approach can be also useful in cases when there is some mixing of beta plus contamination in the X-rays gated TAS spectra (beyond the EC component).

The Challenge: to calculate properly the response matrix

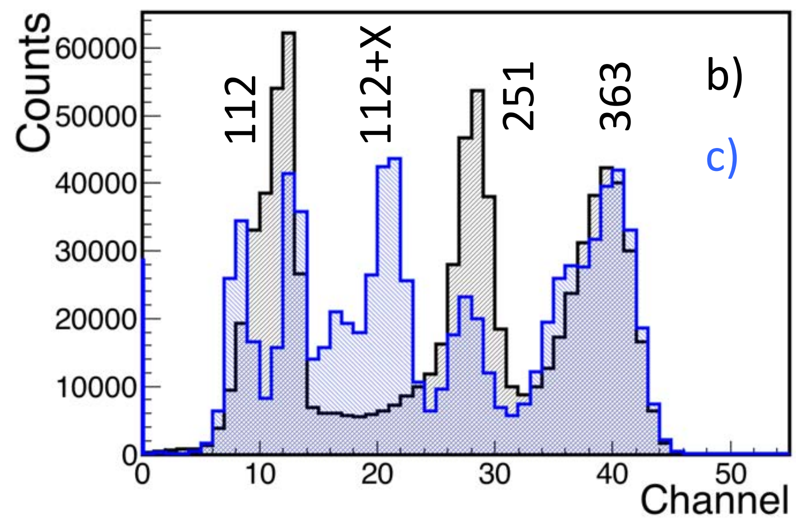
a) $$\mathbf{R}_j = \sum_{k=0}^{j-1} (b_{jk}\mathbf{g}_{jk} \otimes \mathbf{R}_k$$

b) $$\mathbf{R}_j = \sum_{k=0}^{j-1} (b_{jk}\mathbf{g}_{jk}\frac{1}{1+\alpha_{jk}} + b_{jk}\mathbf{0}_{jk}\frac{\alpha_{jk}}{1+\alpha_{jk}}) \otimes \mathbf{R}_k$$

c) $$\mathbf{R}_j = \sum_{k=0}^{j-1} (b_{jk}\mathbf{g}_{jk}\frac{1}{1+\alpha_{jk}} + b_{jk}\frac{\alpha_{jk}}{1+\alpha_{jk}}\mathbf{e}^k_{jk} \otimes \mathbf{X}) \otimes \mathbf{R}_k$$



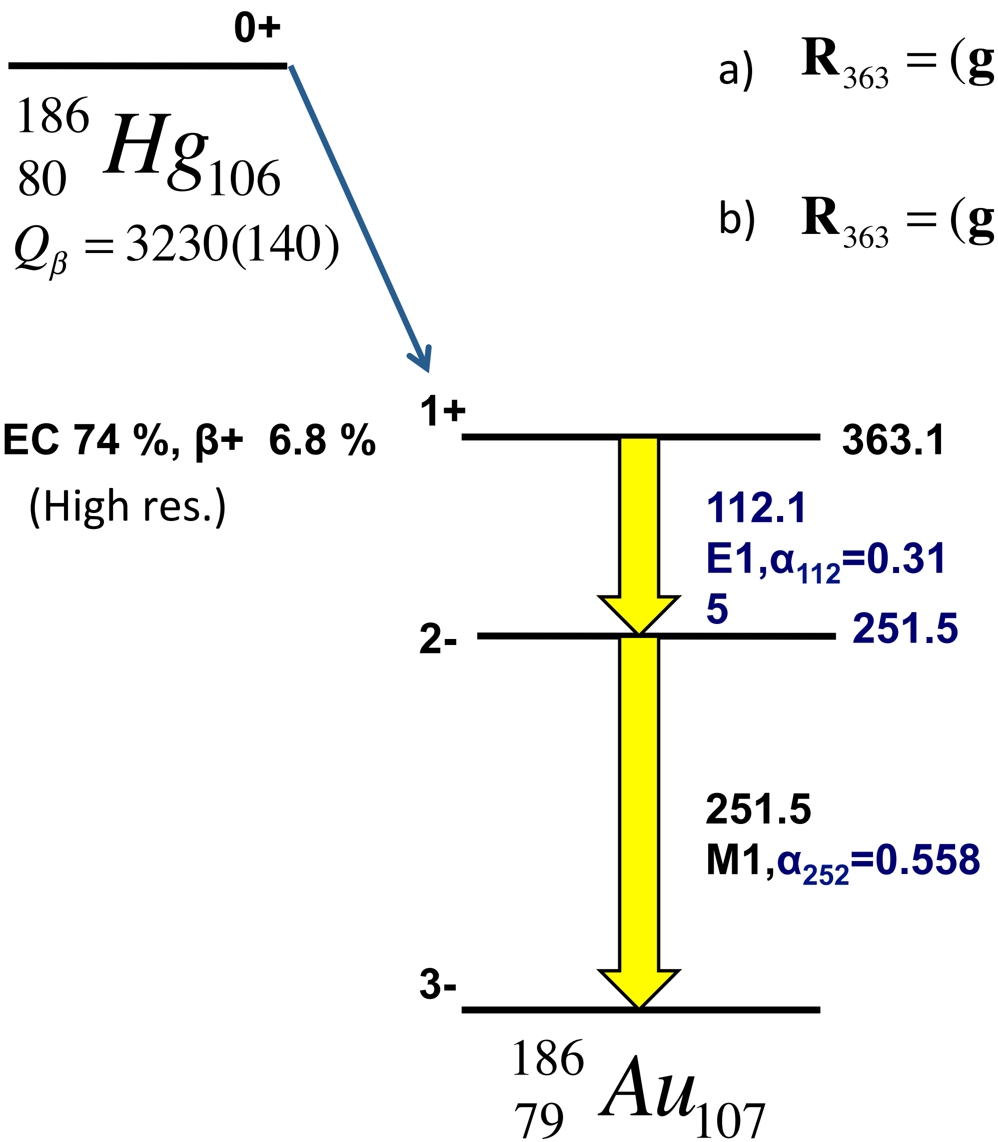
Response to the 363 level



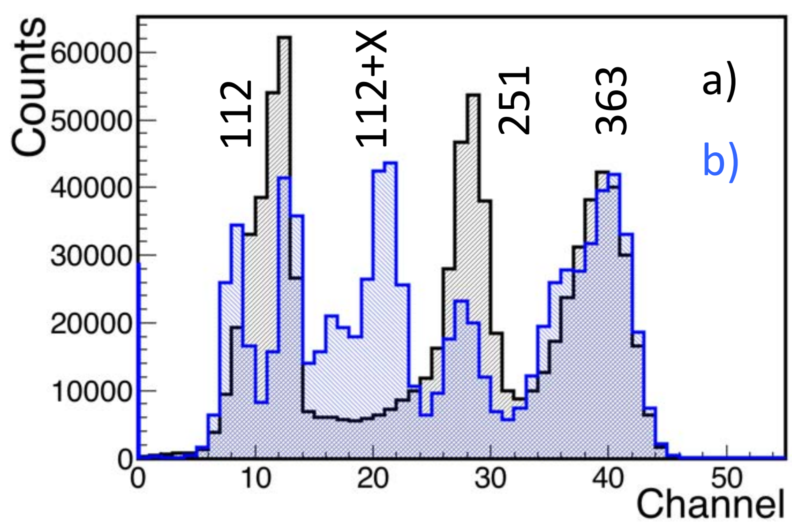
The solution to the challenge: G4 radioactive decay

a) $\mathbf{R}_{363} = (\mathbf{g}_{112}\frac{1}{1+\alpha_{112}} + \mathbf{0}\frac{\alpha_{112}}{1+\alpha_{112}}) \otimes \mathbf{R}_{252}$

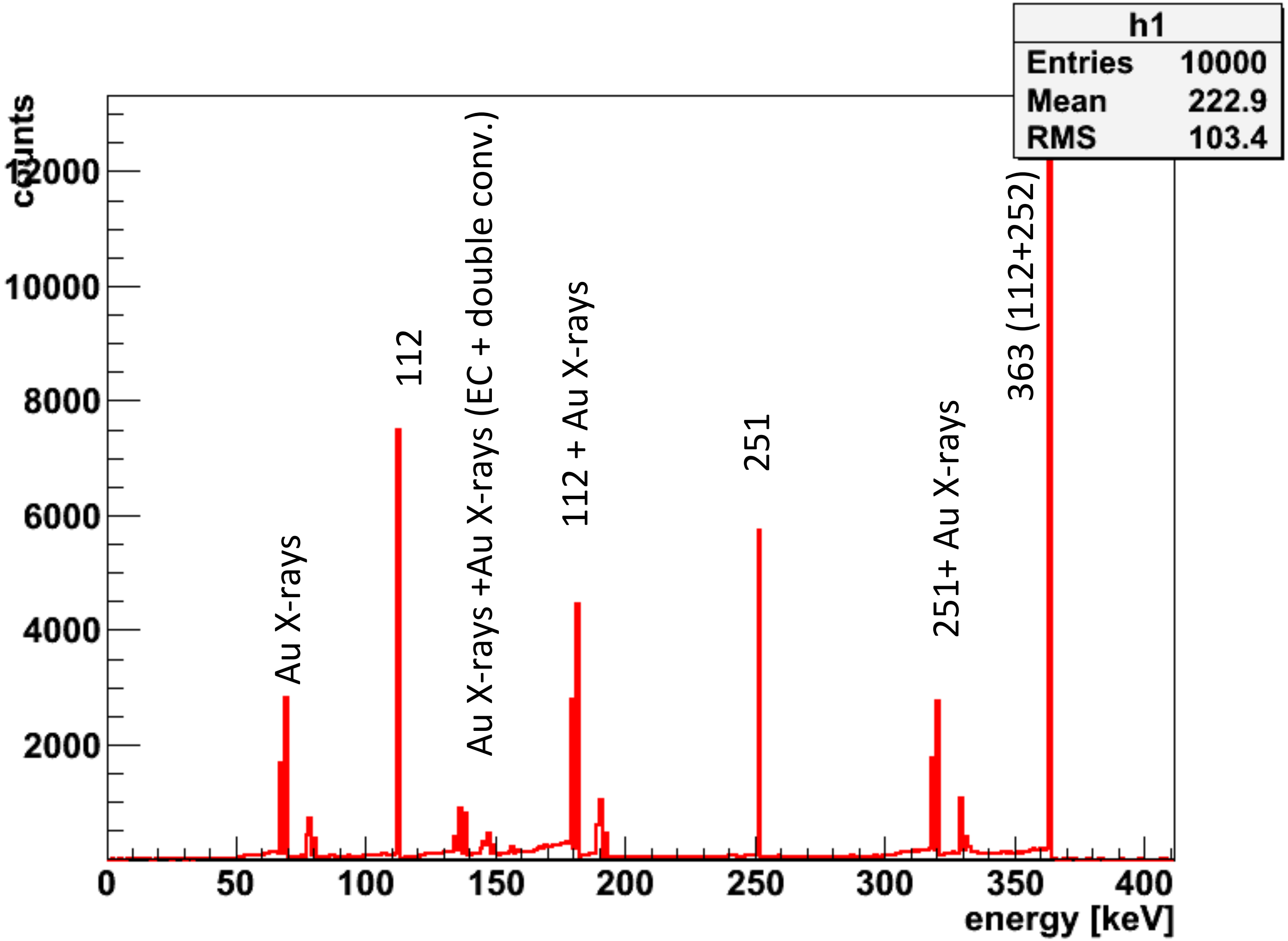
b) $\mathbf{R}_{363} = (\mathbf{g}_{112}\frac{1}{1+\alpha_{112}} + \frac{\alpha_{112}}{1+\alpha_{112}}\mathbf{e}^{k}_{112} \otimes \mathbf{X}) \otimes \mathbf{R}_{252}$



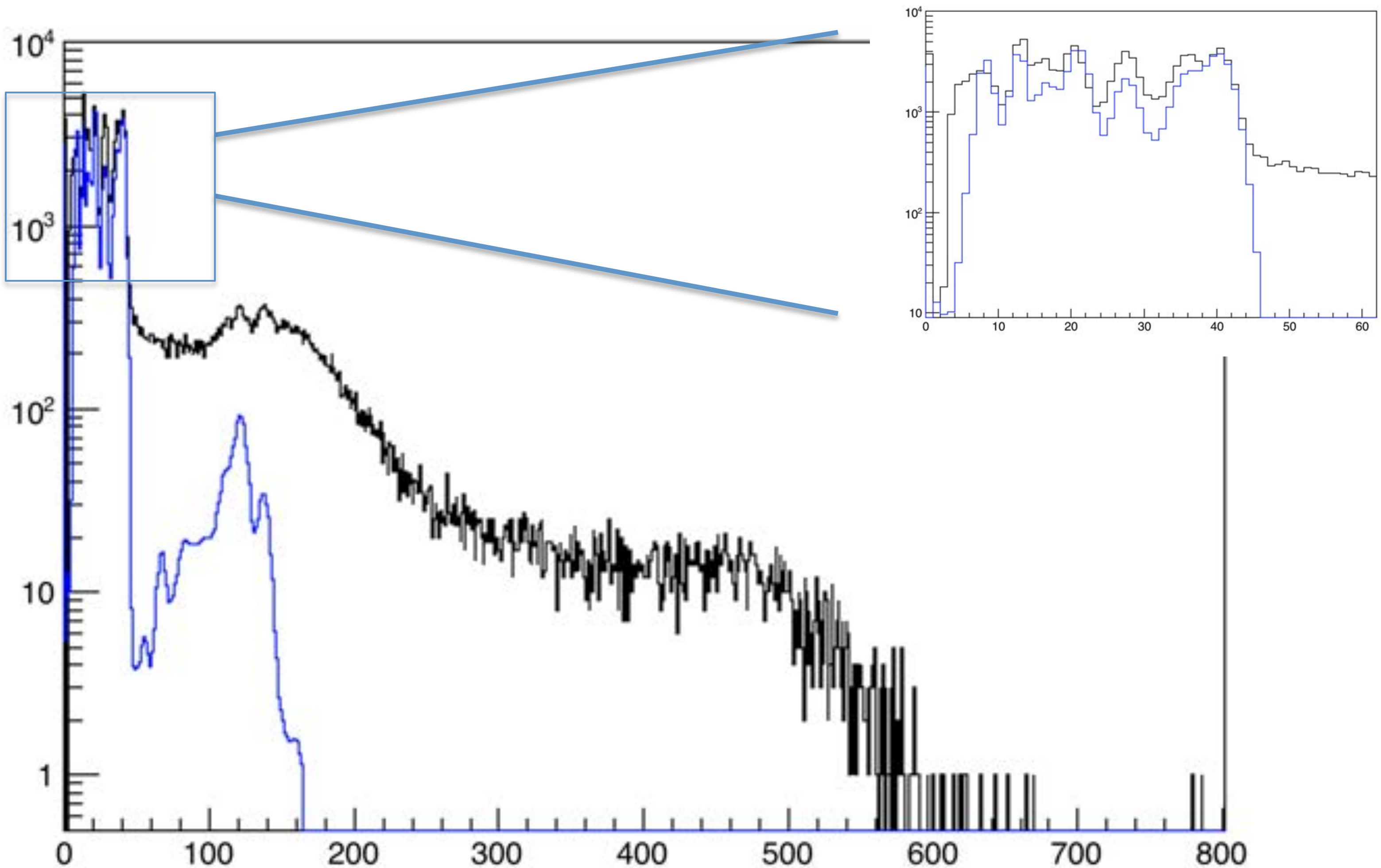
Response to the 363 level



Response to level 363 expanded, Xray gate, showed TAS (energy, not light)

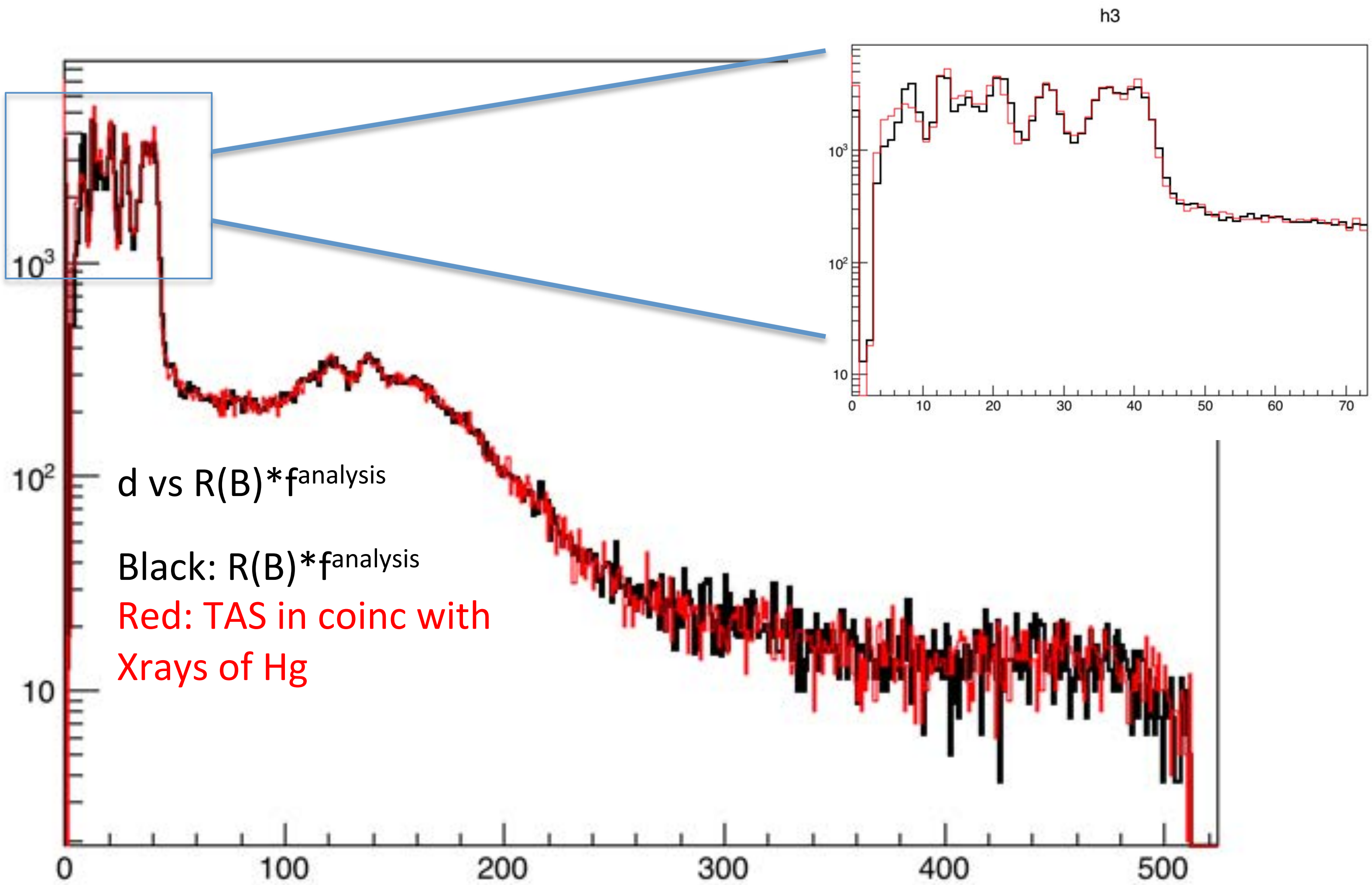


Some illustrations



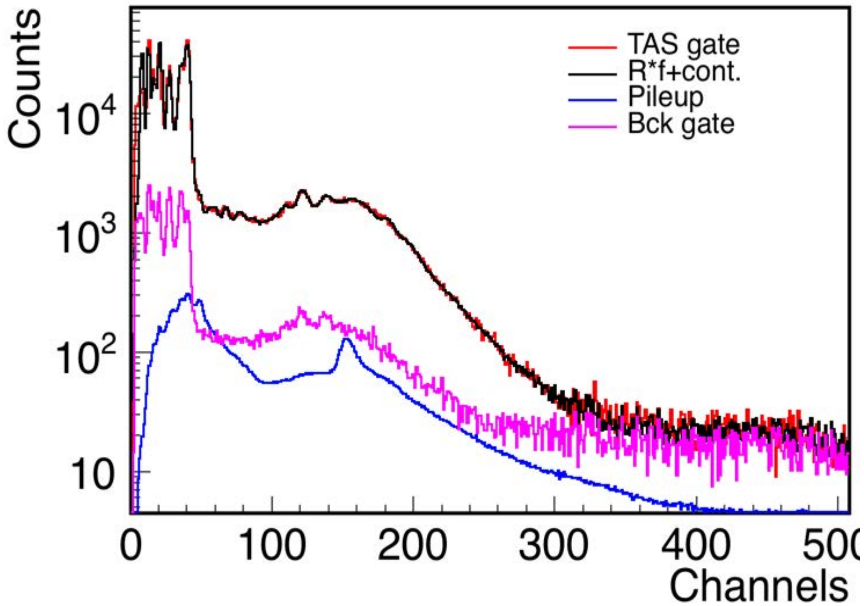
Comparison of the analysed spectra with the response of the level 363 (arbitrary normalization, new procedure). To show the similitude of the behaviour at low energies. Response calculated with Radioactive decay. Note also the small bplus component (bining of 10 keV)

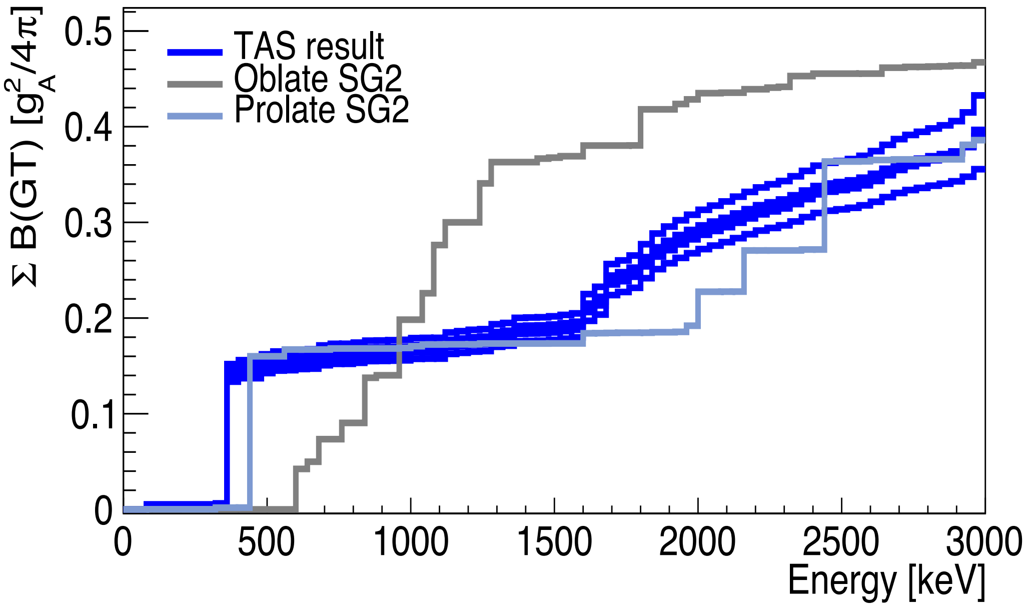
First analysis: very preliminary



Analysis in red (R*f), TAS X-ray gated in black (d)

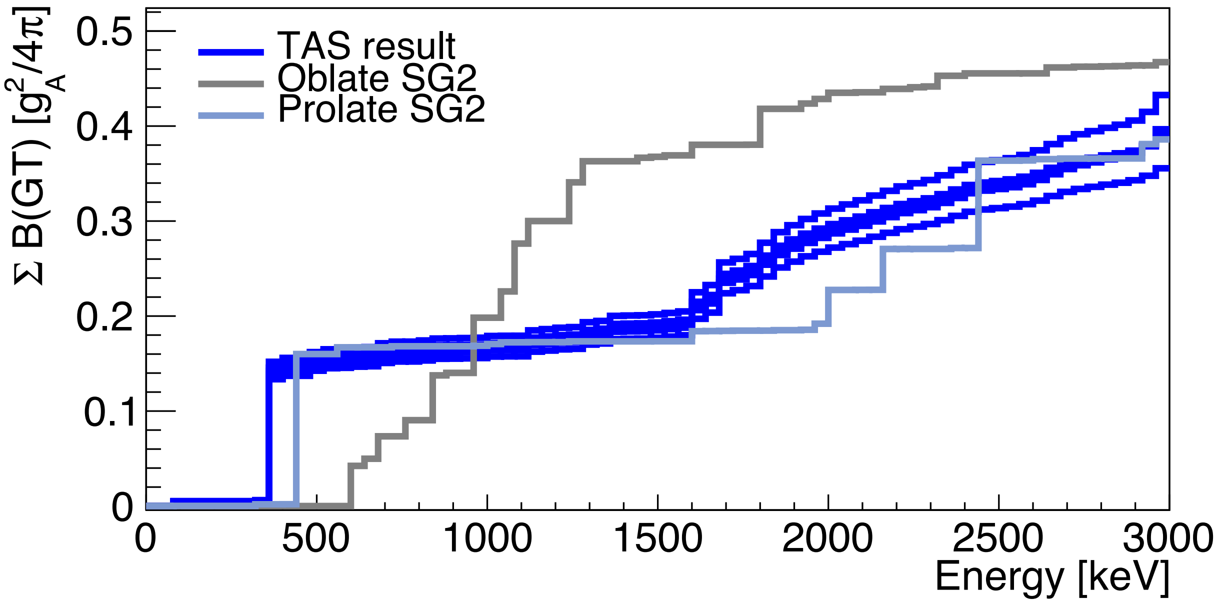
IS539 results: ^{186}Hg example





Summary: A very particular TAS spectra. Analysis by E. Ganioglu and A. Algora. Results consistent with prolate picture, independent of the force used (SG2, SLy4). Required the development of new analysis technique because the penetration of the X-rays and the summing of those (strong conversion from the gamma cascade de-exiting the mainly populated state). A publication is in preparation. Calculations by P. Sarriguren

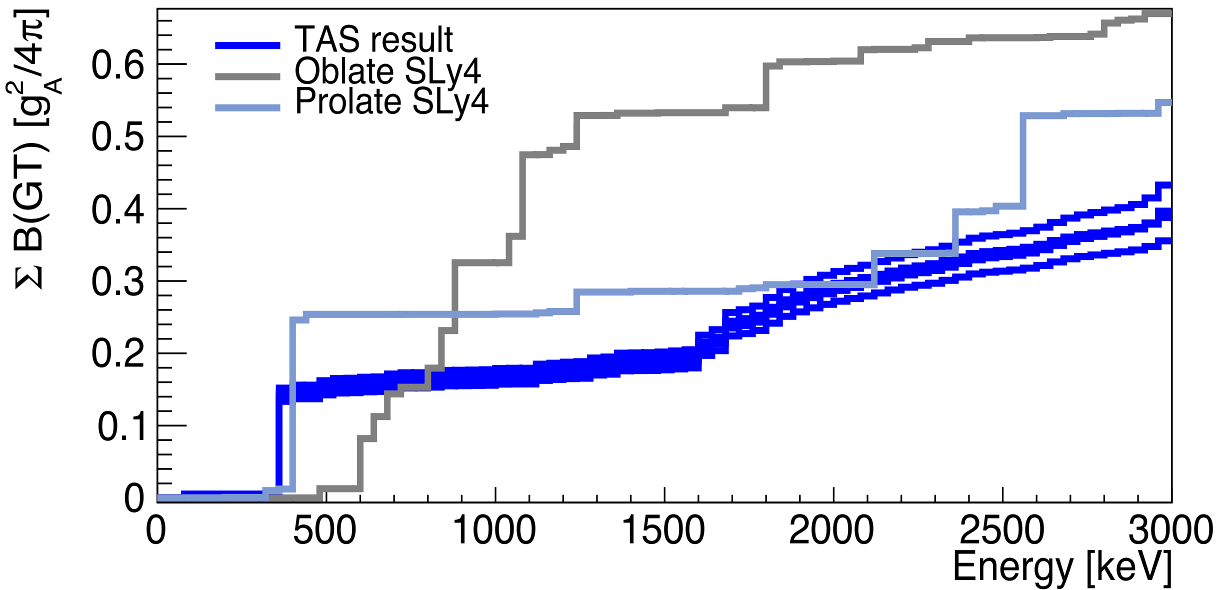
IS539 results: ^{186}Hg example



The results are consistent with a **prolate ground state** independent of the force used (SG2, SLy4). Better agreement with SG2 Calculations by P. Sarriguren

Error bands determined by the error in the Q value and in the T1/2 and by the different possible solutions.

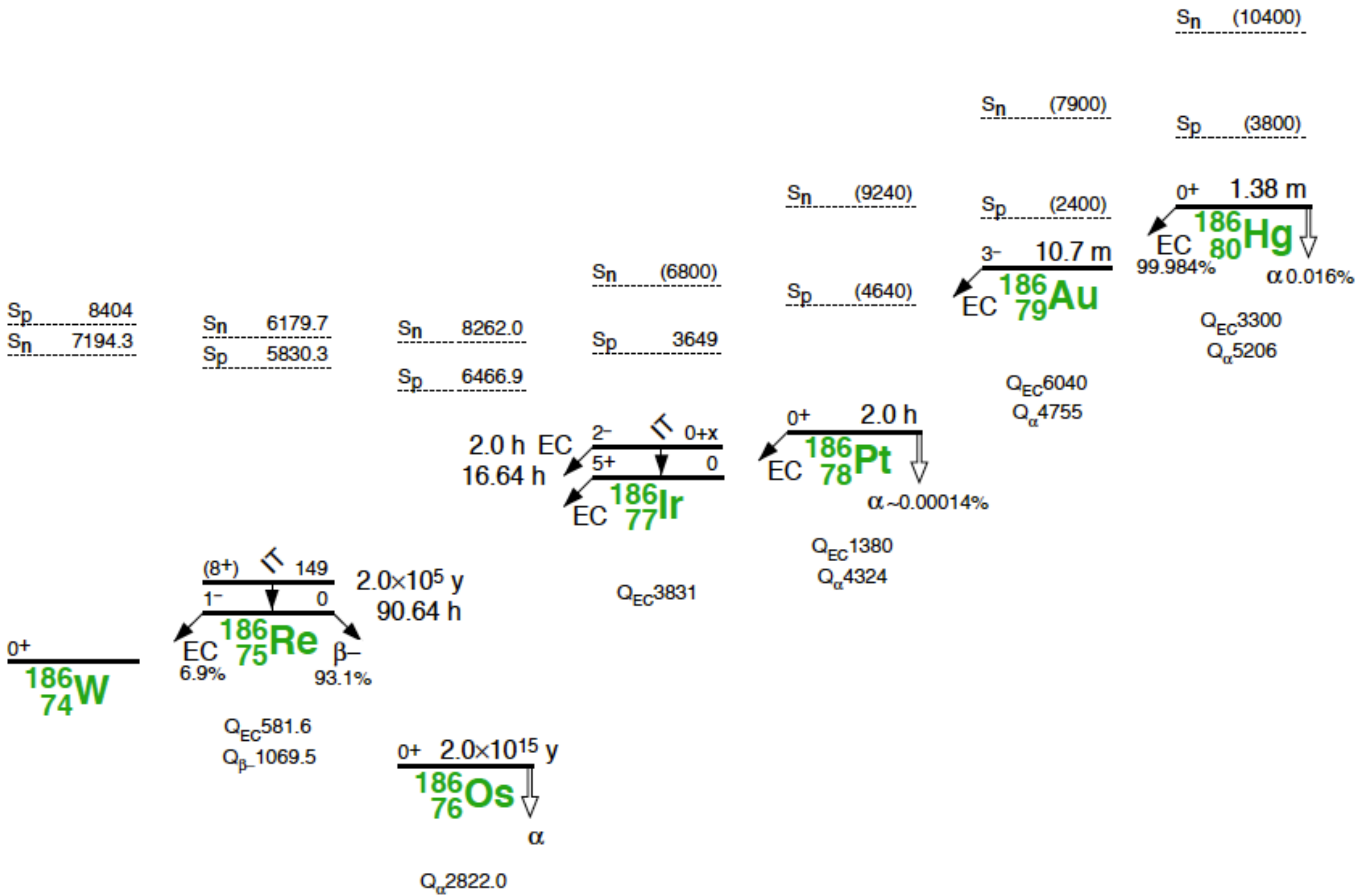
182,184Hg cases analysis on-going

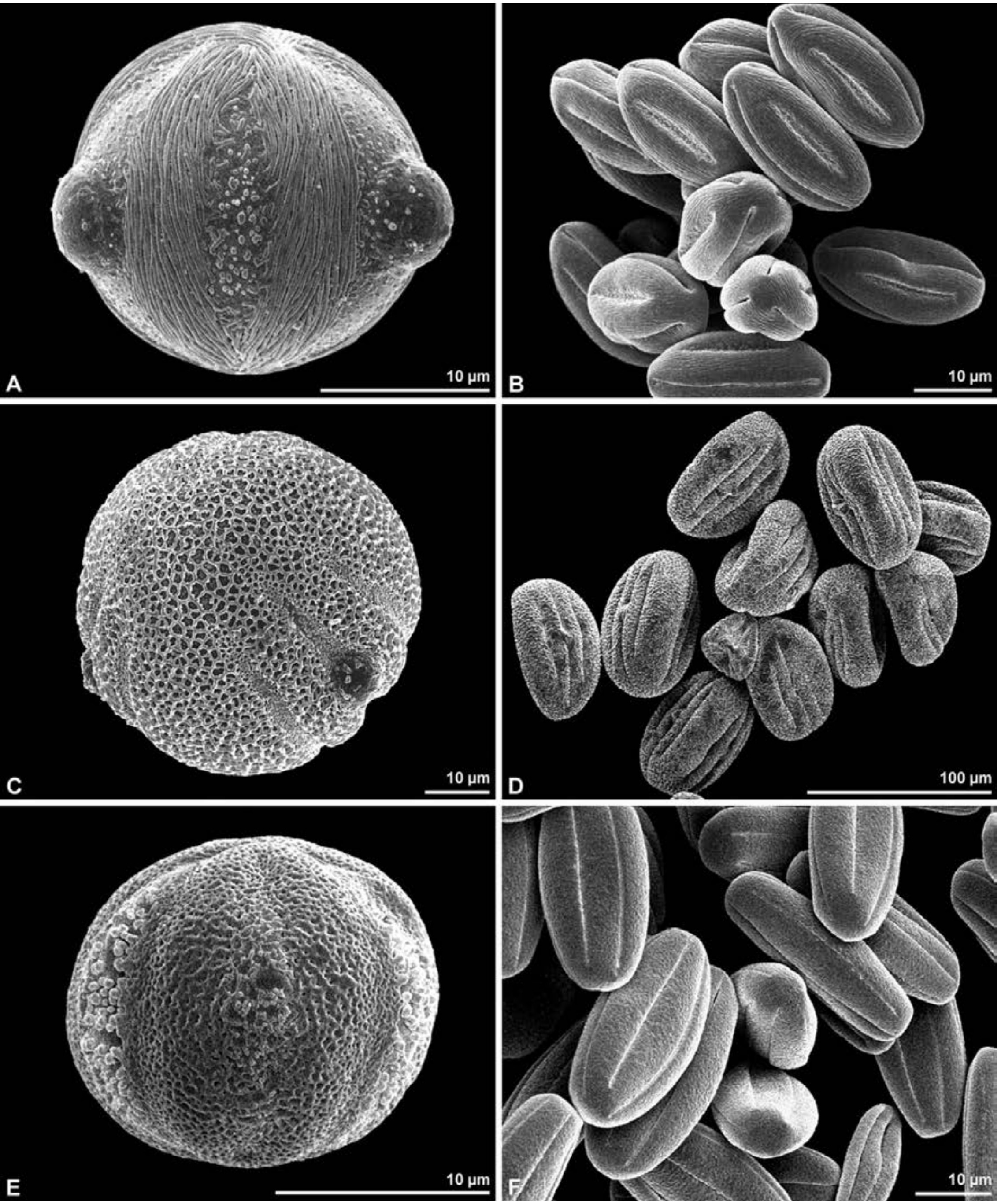


Conclusions/last comments

- I hope I have shown you the utility of the TAS technique, for obtaining information on nuclear shapes
- The Hg has attracted considerable attention in recent years. It is still a hot topic (see very fresh result in Nature).
- We have added a new tool to study this interesting region. We have obtained a complementary information for the shape of the gs of 186Hg
- There is still a lot of work ahead of us, the analysis of the decay of 182,184Hg
- And hope we can convince the referees of the correctness of our technique.

Cheating a little bit ..., in the long term producing Os





E. Ganioglu, E. Estevez, J .L. Tain, B. Rubio, E.Nácher, J. Agramunt, A. B. Perez, L. Caballero, F. Molina, D. Jordan, A. Krasznahorkay, M. Hunyadi, Zs. Dombrádi, W. Gelletly, P. Sarriguren, O. Moreno, M. J. G. Borge, O. Tengblad, A. Jungclaus, L. M. Fraile, D. Fedosseev, B. A. Marsh, D. Fedorov, A. Frank, A. Algora

THANK YOU