TOTAL ABSORPTION SPECTROSCOPY AT ISOLDE, PRESENT & FUTURE

E. Nácher for the ISOLDE-TAS collaboration

IFIC – CSIC, Valencia

Outlook

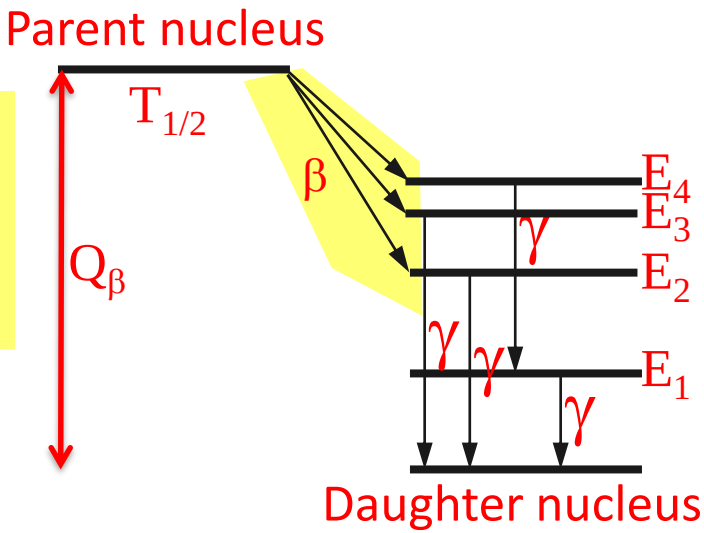
- Introduction
- Experiments and publications
- Technical status
- TAS Collaboration
- Technical / Scientific plans

Beta decay measurements

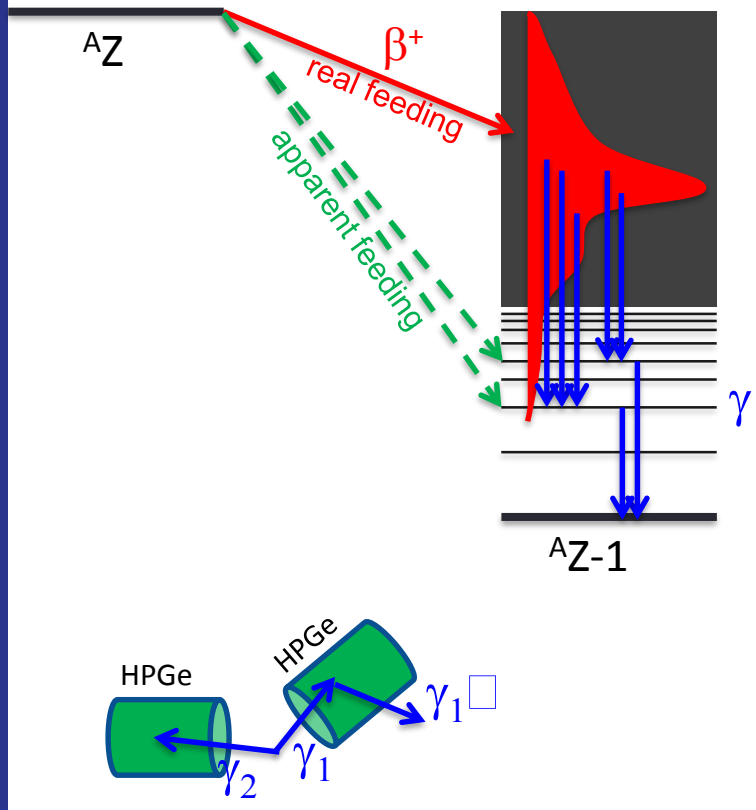
- β-decay is an important source of nuclear structure information.

- From direct measurements one can obtain half-lives, energy levels, beta intensity distributions B(GT) → Overlap between parent & daughter wave functions → nuclear astrophysics, nuclear shapes, reactor decay heat, beta-pigmy, anti-neutrino spectra, GT quenching, mirror symmetry

- Measuring the β feeding distribution is far from being trivial!!



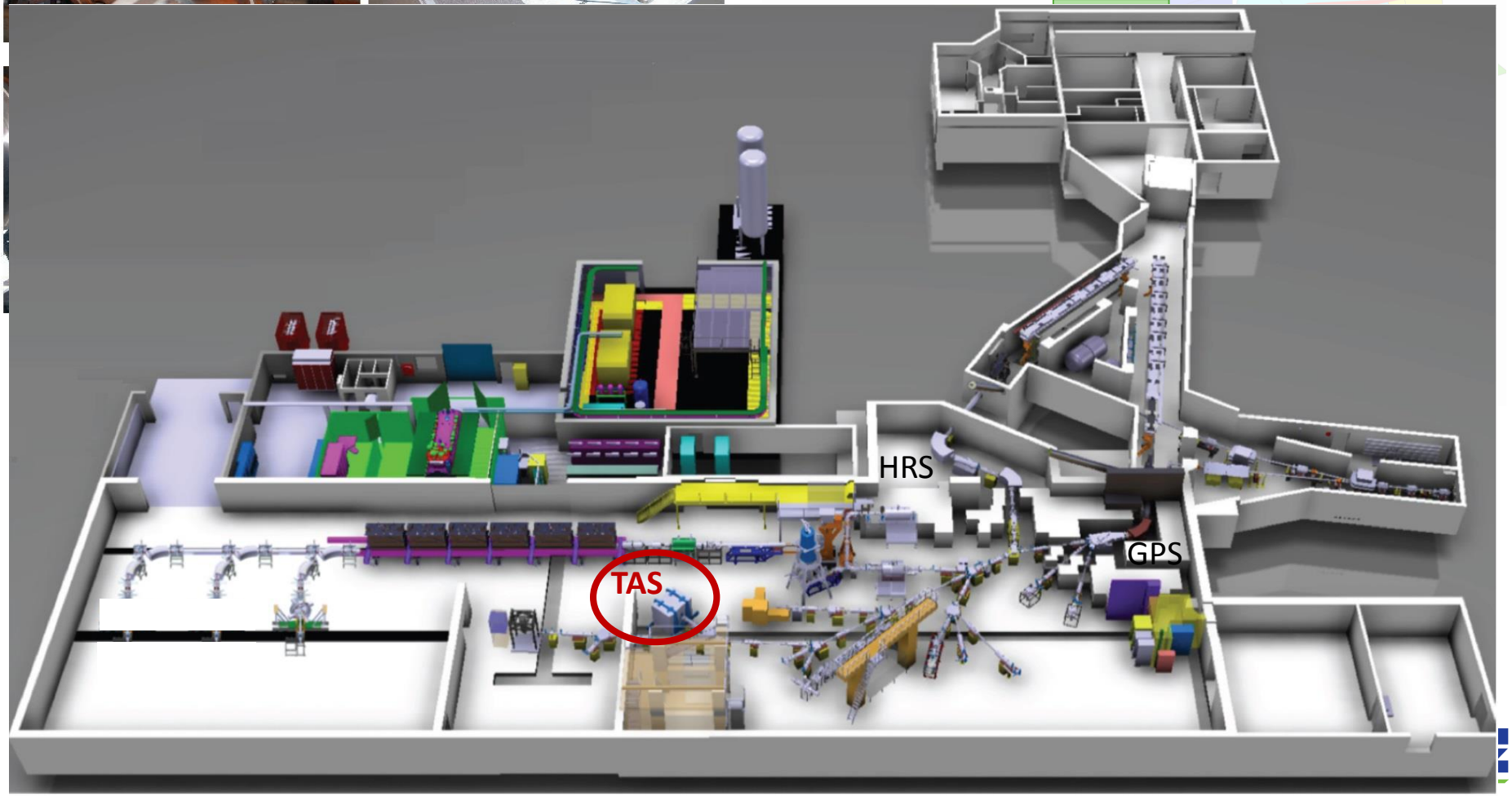
Beta decay measurements



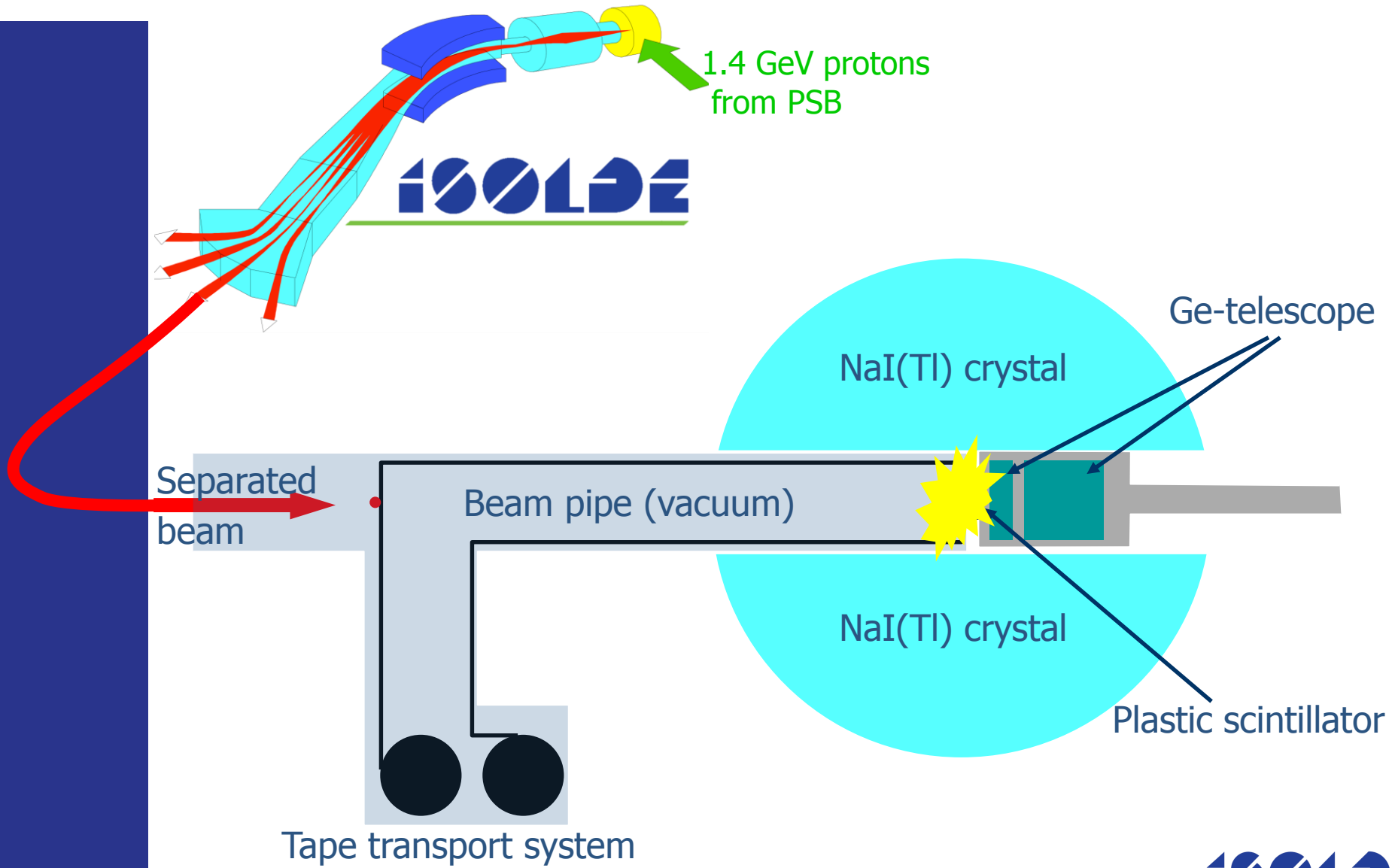
- Medium mass and heavy nuclei: large level density at high energy.
- Very fragmented feeding distr. and γ-deexcitation pattern.
- HPGe arrays fail to detect systematically the upper part of the γ-cascade resulting in a wrong feeding and B(GT) distr.

Lucrecia, the TAS at ISOLDE

- Permanent TAS setup at ISOLDE "Lucrecia"

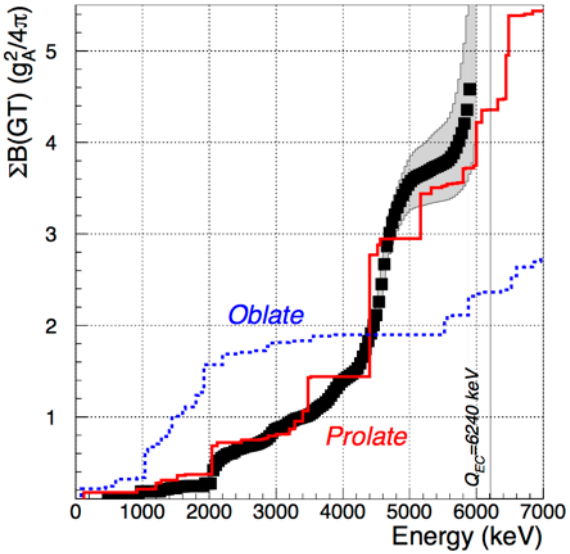


TAS experiments around N=Z

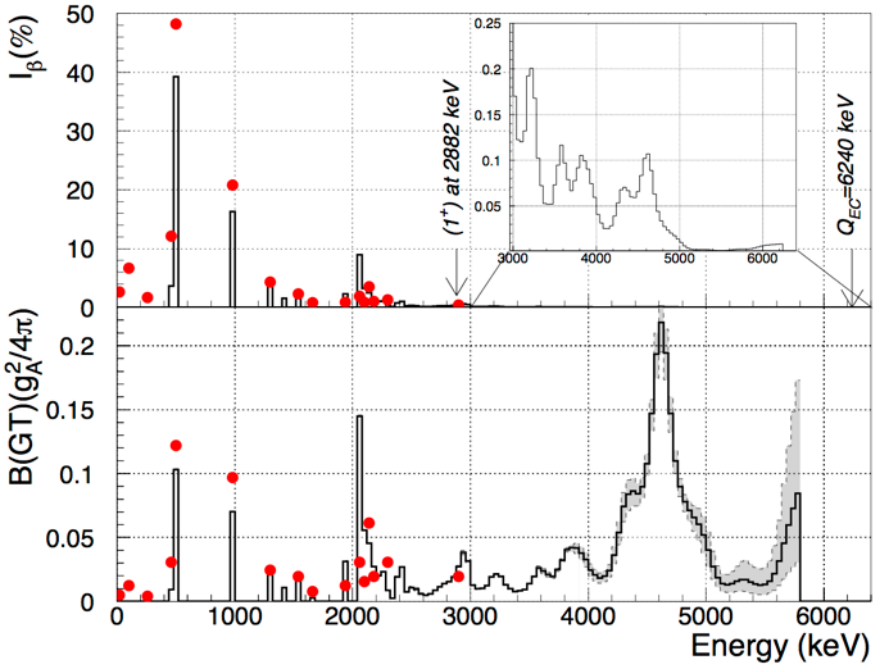


Experiments and publications

- N~Z & A~70, the first cases we measured at ISOLDE. With ^{76}Sr, free of shape admixtures, we could validate the QRPA calculations for the first time and the method to infer shape from beta decay



^{76}Sr decay [1]



Ph. Dessagne et al. Eur. Phys. J. 20 (2004)

QRPA calculations in both cases [3]

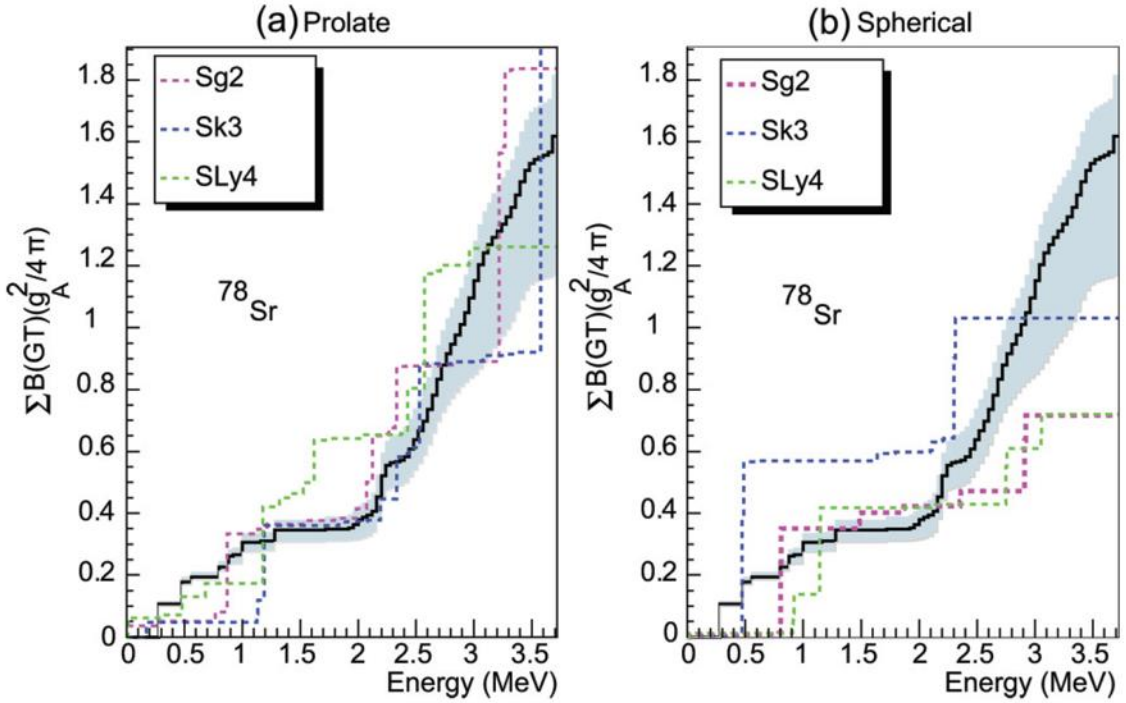
[1] E. Nácher et al. Phys. Rev. Lett. 92 (2004)

[2] E. Poirier et al. Phys. Rev. C69 (2004)

[3] P. Sarriguren et al. Nucl. Phys. A 691 (2001)

Results: ^{78}Sr

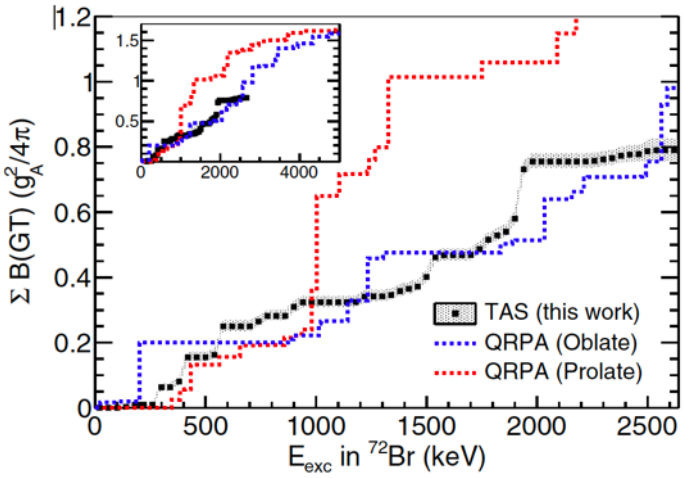
- Comparison with QRPA but with different residual interactions
- Even with considerable variations between the calculations for one particular shape, a strong prolate signature is obvious

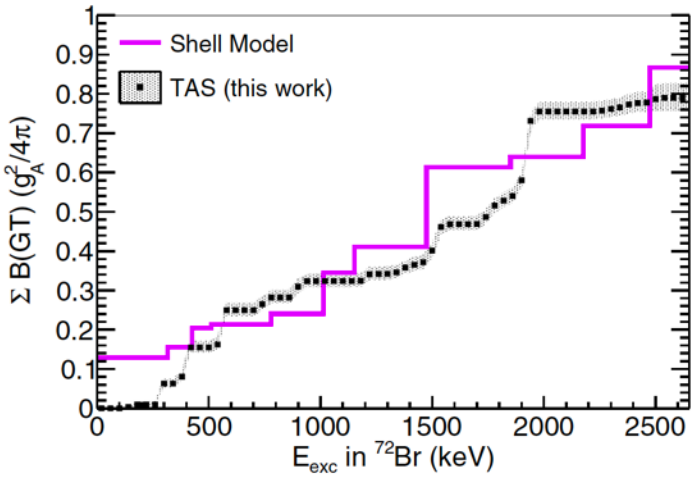


A.B. Pérez-Cerdán et al. Phys Rev C88 (2013)

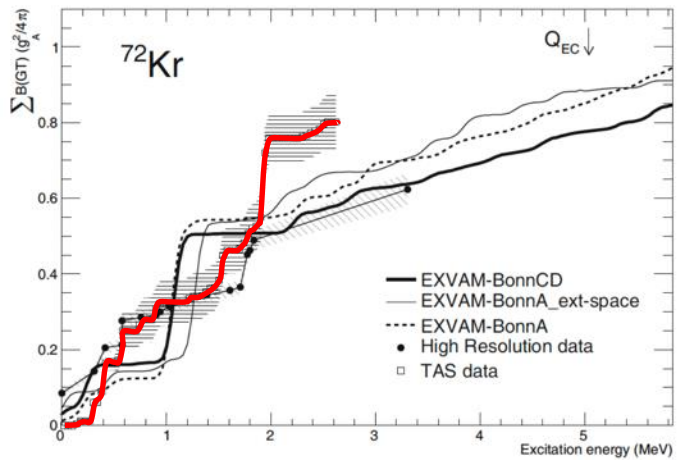
Results: ^{72}Kr

- The only case where the experimental B(GT) is compared to 3 different theoretical models used to calculate weak-decay rates



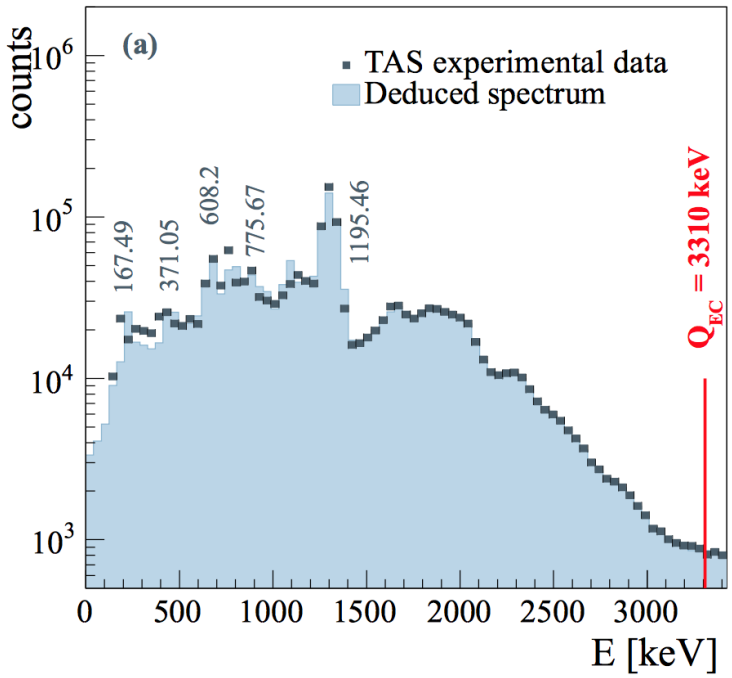


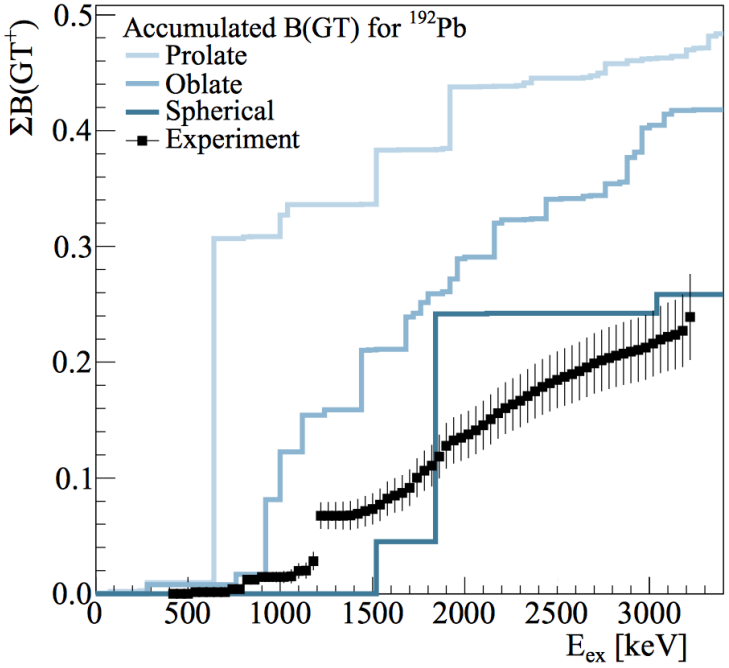
- **J.A. Briz et al. Phys Rev C92 (2015)**: P. Sarriguren QRPA & A. Poves SM



- A. Petrovici et al. Eur. Phys. J. A51 (2015): beyond mean field (exc. VAMPIR model, no quenching)

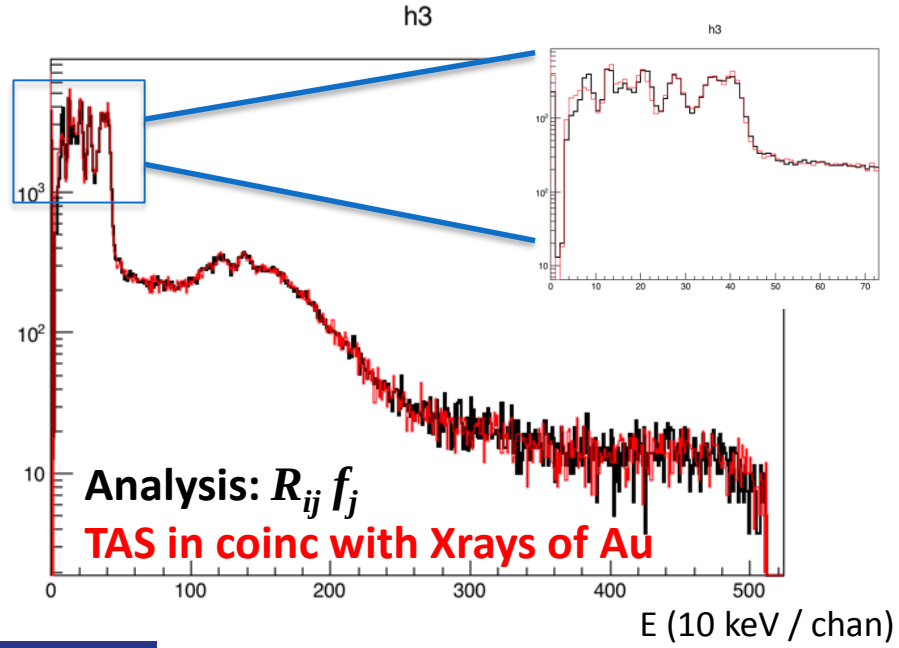
Results: ^{192}Pb

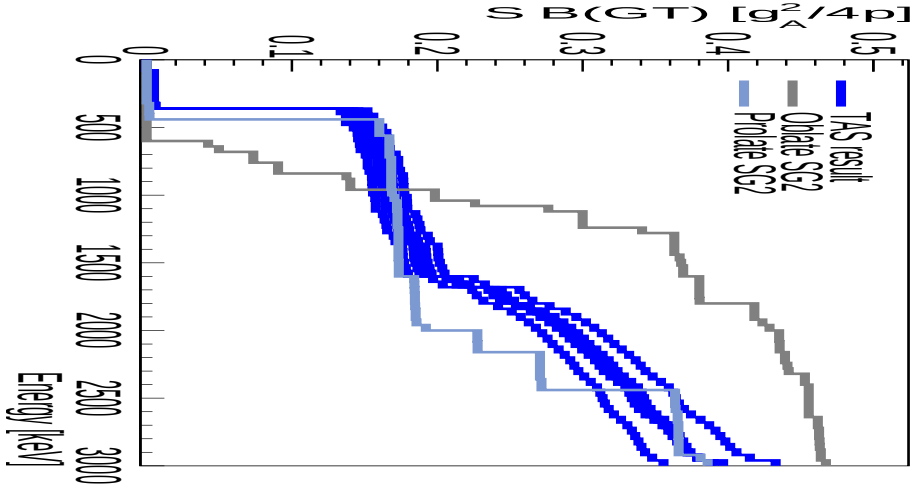




- **E. Estevez et al. Phys Rev C92 (2015)**

To be published: ^{186}Hg





- IS539: beta decay of ^{182,184,186}Hg. Analysis ongoing (E. Ganioglu & A. Algora).
- ^{186}Hg consistent with a strong **prolate signature in the g.s.** (SG2 & SLy4)

Ongoing analysis: ^{64}Ge

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Beta decay of the $N=Z$, rp-process waiting points: ^{64}Ge, ^{68}Se and the $N=Z+2$: ^{66}Ge, ^{70}Se for accurate stellar weak-decay rates

[May 29th - 2013]

E. Nácher, J.A. Briz, M. Carmona, A. Illana, A. Jungclaus, A. Perea, V. Pesudo, G. Ribeiro, J. Sánchez-del-Río, P. Sarriguren, J. Taprogge, O. Tengblad
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L.M. Fraile, I. Marroquín, O. Moreno, B. Olaizola, V. Paziy, J.M. Udías, V. Vedia
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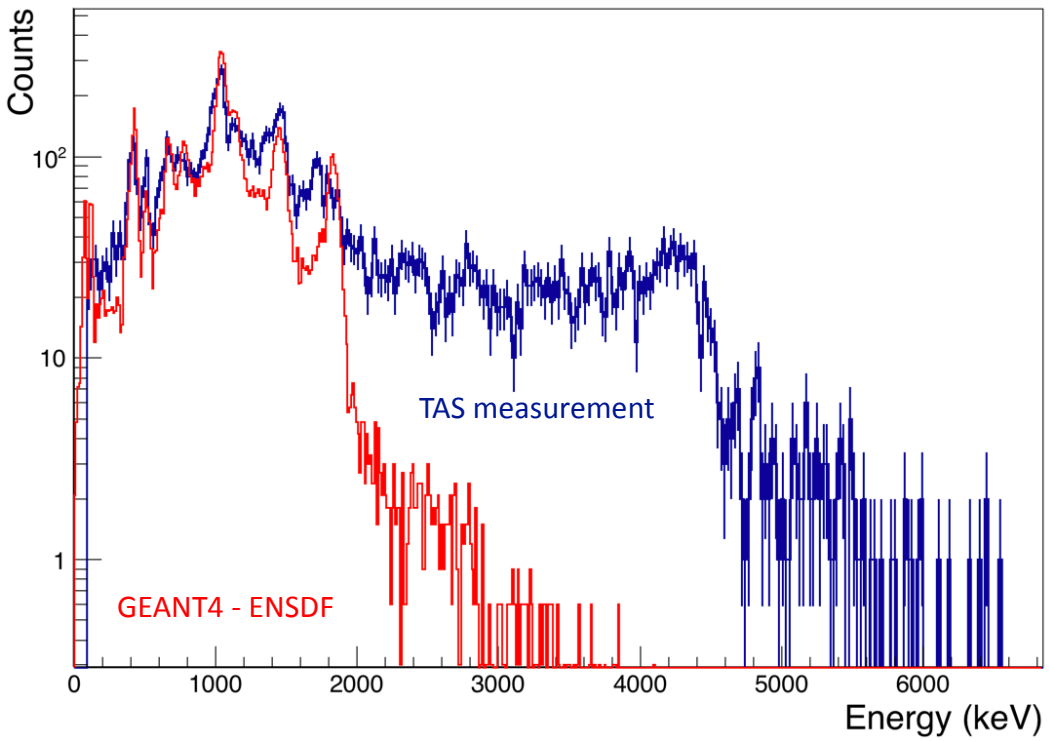
CERN-INTC-2013-009 / INTC-P-374
29/05/2013



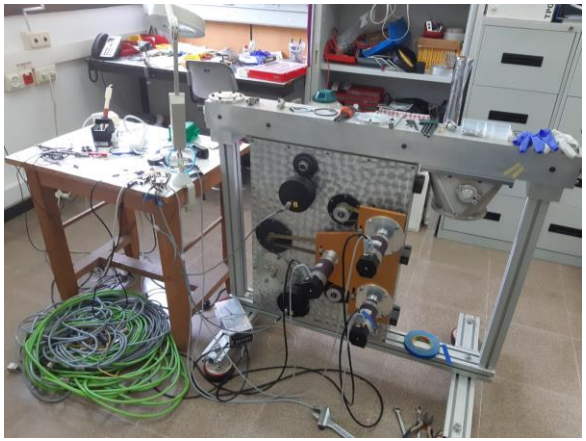
- IS570: First ,measurement ^{64,65,66}Ge, ^{64,65}Ga in May 2016. Analysis ongoing.
- ^{68,70}Se, ^{68,70}As, addendum for after the LS2(?)

Technical status

- ***Detection system, electronics and DACQ working perfectly***

- ***Tape transport system***: based on a differential pumping system where the samples go from vacuum to air. Problems to keep the vacuum of the last beam-pipe section if moving cycles shorter than 1 min

- Action taken → **New tape transport system** where the tape and samples are kept in vacuum. To be in place before the end of LS2



ISOLDE TAS Collaboration

- **IFIC-CSIC, Valencia**: A. Algora, E. Nácher, B. Rubio, JL. Taín
- **Univ. of Surrey**: W. Gelletly, P. Reagan, Z. Podolyák
- **IEM-CSIC, Madrid**: MJ. G. Borge, O. Tengblad, A. Jungclaus, J.A. Briz
- **UCM, Madrid**: L. Fraile, B. Olaizola
- **Subatech, Nantes**: M. Fallot, A. Porta, V. Guadilla, M. Estienne
- **CCHEN, Santiago de Chile**: F. Molina, M. Zambra

- **Univ. of Warsaw**: M. Pfutzner, Z. Janas, Ch. Mazzocchi
- **Univ. of York**: A. Andreyev
- **Univ. of Istambul**: Ela Ganioglu

PhD students & other resources

- **5 PhD thesis so far**: E. Poirier (2003), E. Nácher (2004), E. Estevez (2011), A. Pérez-Cerdán (2012), J.A. Briz (2014)

- PhD students dedicated to the setup:
- **IFIC, Valencia**: 1 from next national project (FPN), starting after LS2
- Depending on approved proposals: **U. of Warsaw** could dedicate 1, **IEM-CSIC** could dedicate 1, **UC Madrid** could dedicate 1, **CCHEN** could dedicate 1, **U. of Surrey** could dedicate 1

- Technical staff: 1 engineer for 6 to 12 months (2020 tape transport system) will be requested at the next national call FPN (IFIC, Valencia)

Technical & Scientific plans

- **During LS2**:
  - finish & install tape transport system (2020)
  - TAS workshop in Valencia (Autumn?) to discuss next Physics cases

- **Proposals to be presented**:
  - E. Nácher, B. Rubio: n-γ competition above S_n around ^{132}Sn (^{133}In)
  - E. Nácher, A. Algora: Weak-decay rates for x-ray burst calculations (^{68}Se)
  - M. Pfutzner: Mirror symmetry in ^{27}Na and ^{27}S
  - A. Algora, L.M. Fraile: Nuclear shapes of neutron-deficient odd Hg

- **Ideas to become proposals**:
  - F. Molina, E. Nácher: First *ab-initio* calculations of GT quenching (^{42}Ti, ^{42}Sc)
  - M. Fallot: beta pygmy / gamma strength for nuc. astroph.
  - A. Andreyev: beta-delayed fission (^{180}Tl, ^{178}Au)

REQUEST

- **The ISOLDE-TAS collaboration kindly asks the ISCC**
  - **to consider the work done so far and the work being done during this LS2 to upgrade the setup and prepare proposals**
  - **to take into account the interest of the physics cases under study for upcoming proposals and the potential of the setup to complement the IDS for complete beta-decay studies**
  - **<u>To keep the space in the hall for the ISOLDE-TAS</u> for the upcoming campaigns after LS2**

MANY THANKS!!

- To **ALL OF YOU** for your kind attention and the easy questions
- To the **ISOLDE crew** for making these series of experiments possible

BACKUP SLIDES

Volume 71B, number 2 PHYSICS LETTERS 21 November 1977

THE ESSENTIAL DECAY OF PANDEMONIUM: A DEMONSTRATION OF ERRORS IN COMPLEX BETA-DECAY SCHEMES

J.C. HARDY *, L.C. CARRAZ, B. JONSON ‡ and P.G. HANSEN ‡

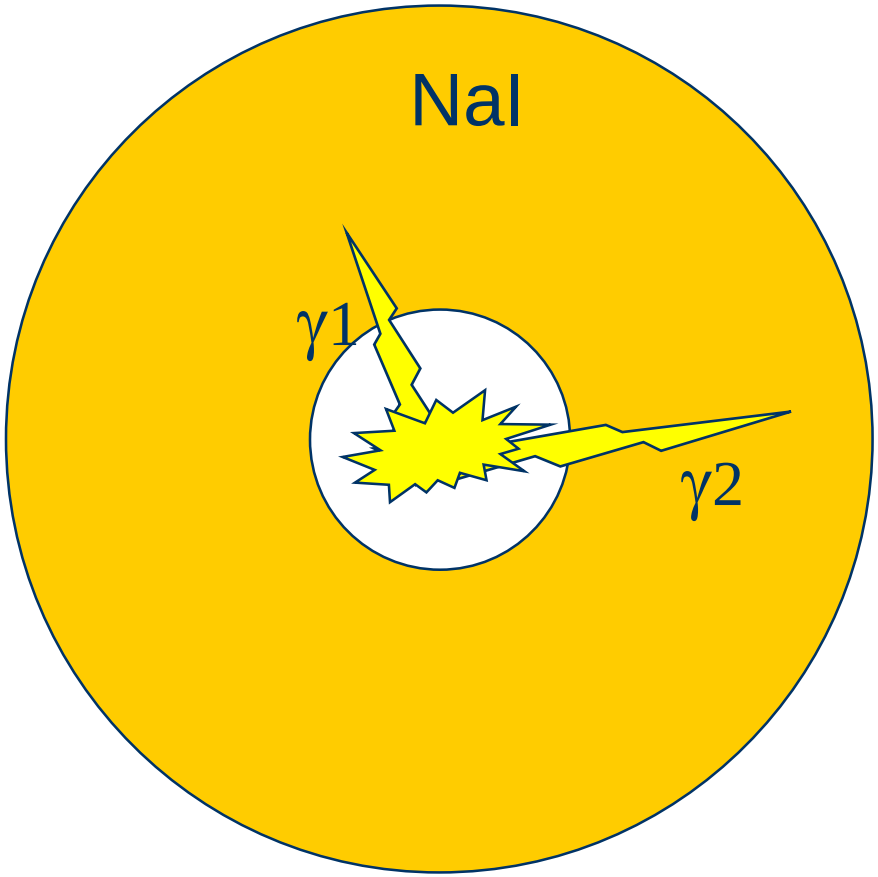
CERN, Geneva, Switzerland

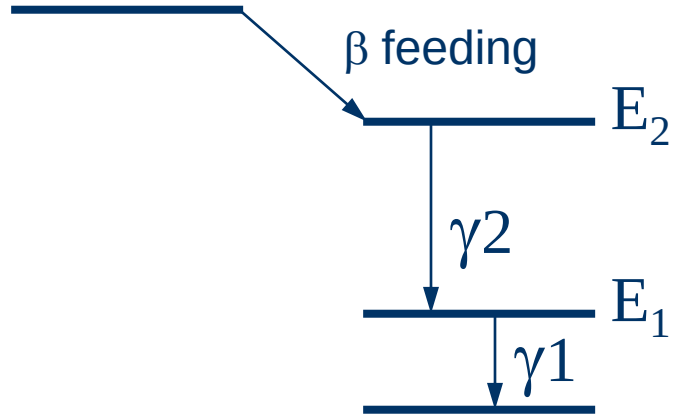
Received 14 September 1977

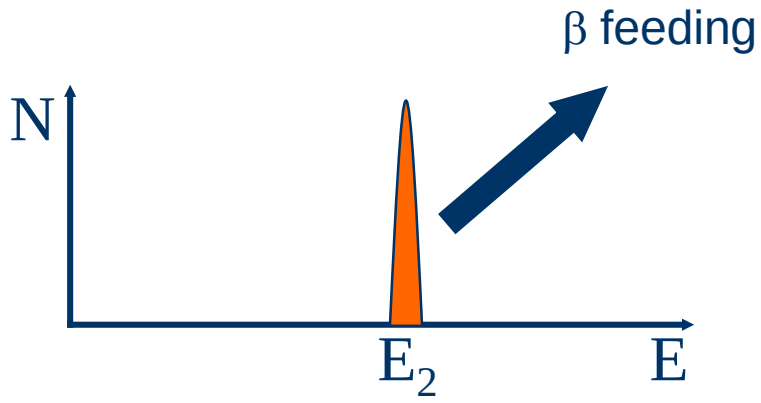
Obviously our results have wider implications than simply to the decay of ^{145}Gd. Every complex β-decay scheme that is based on γ-ray peak analysis and intensity balances must now be regarded as doubtful. In such schemes, the β-decay feeding to each level is assumed to be the difference between the total γ-ray intensity depopulating the level and that seen feeding it. If significant γ-ray intensity remains unobserved, these differences are incomplete and the derived β-decay branching ratios, for all but the strongest transitions, could be wrong by orders of magnitude. In discrediting the "measured" ft values for most β-transitions in complex decay schemes, this conclusion reflects on a large body of existing data, and surely indicates the need to reevaluate the usefulness of a whole class of experiments.

CSIC

Total Absorption Spectroscopy (TAS)

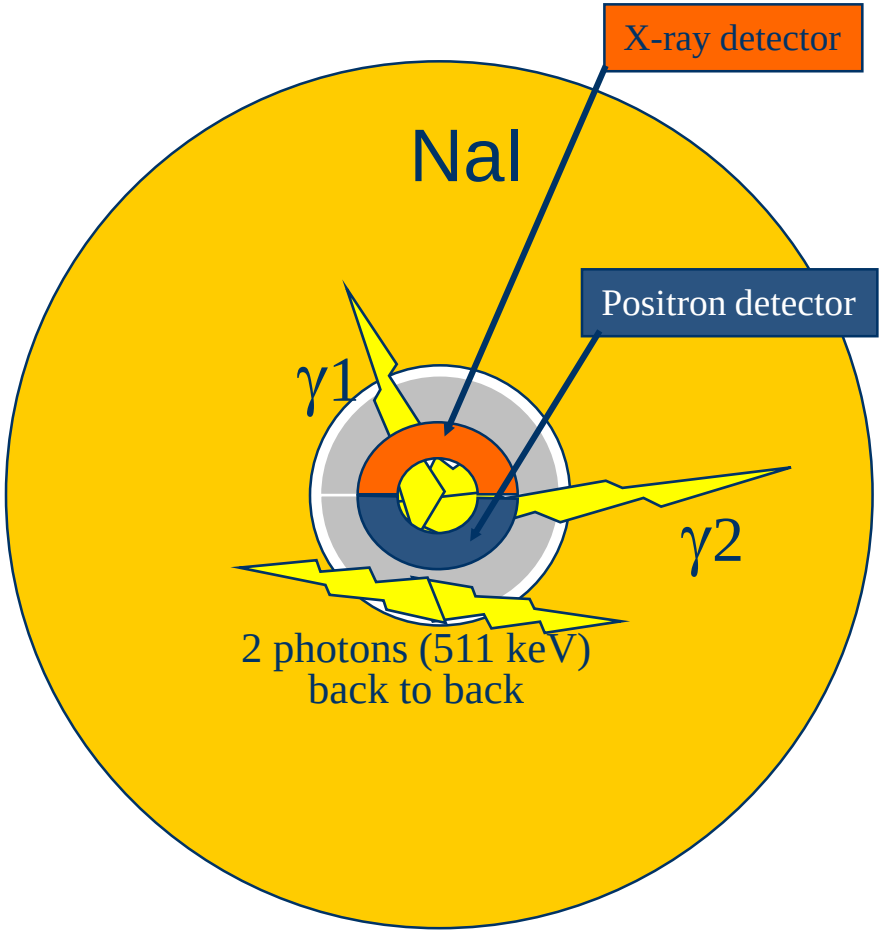


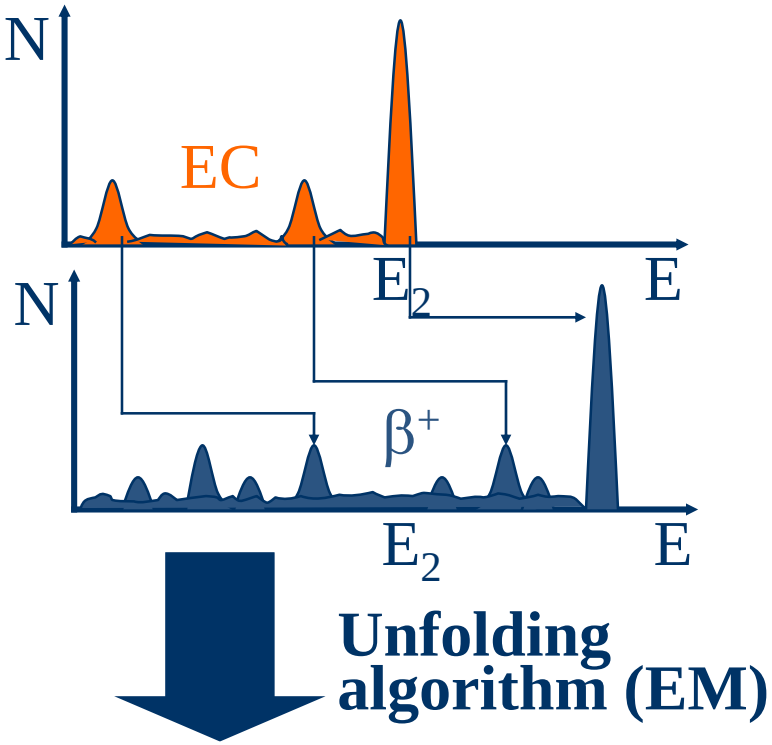


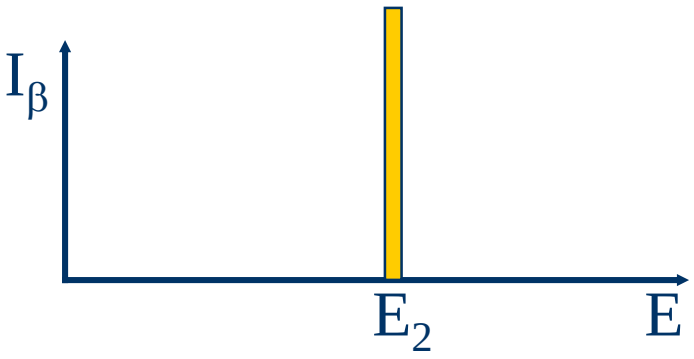


Ideal case

Total Absorption Spectroscopy (TAS)







Real case

The TAS Inverse Problem

- The number of counts detected in channel j relates to the beta feeding to level i through the linear equation:

$$d_j = \sum_i R_{ij} f_i$$

f_i: Feeding to energy level *"i"*

d_j *:* Counts in channel *"j"* of the spectrum

R_{ij} *:* Response Function (matrix) to the decay

The TAS Inverse Problem

- The number of counts detected in channel j relates to the beta feeding to level i through the linear equation:

$$d_j = \sum_i R_{ij} f_i$$

- We can then use the EM algorithm to unfold the data:

$$f_i^{(k)} = \sum_j \frac{R_{ij} f_i^{(k-1)}}{\sum_m R_{mj} f_m^{(k-1)}} d_j \quad , \quad i = 1, \; 2 \ldots m$$

Calculation of R_{ij} from individual γ's and β's: D. Cano, J.L. Taín, NIM A430 (1999) 333
Study of the EM and others applied to TAS: J.L. Taín, D. Cano, NIM A571 (2007) 728

CSIC