CERN-INTC-2020-030 / INTC-P-557
13/05/2020

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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

Measurement of the decay scheme of ^{142}Cs

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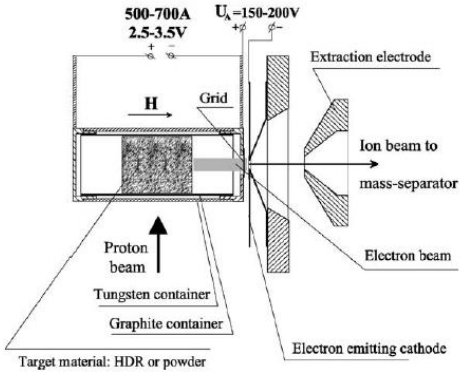
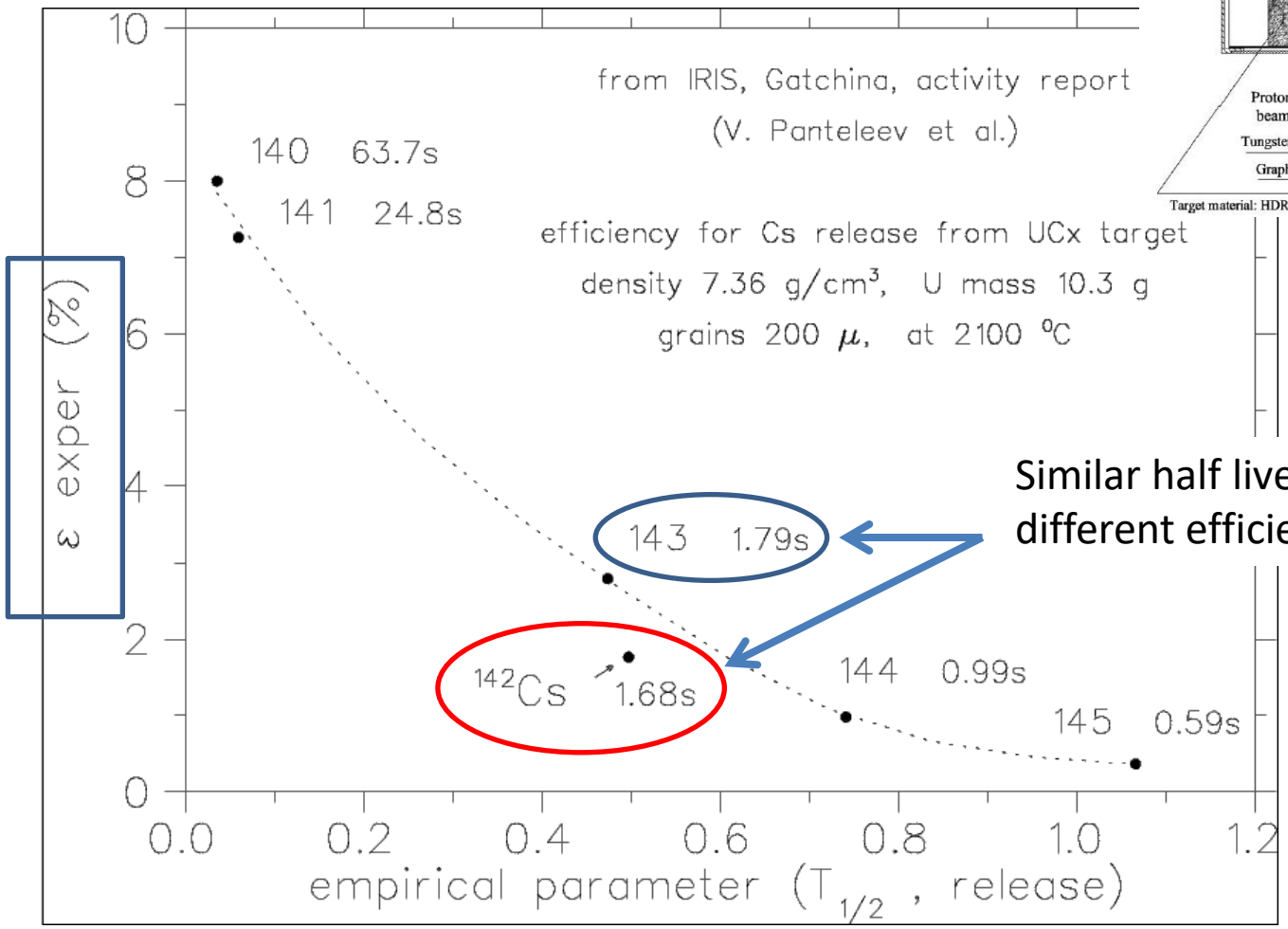
Decay Scheme of ^{142}Cs

- Measurements by decay spectroscopy of yields of Cs isotopes in various fission reactions systematically show a *discontinuity* for ^{142}Cs when plotted versus the decay half-life.
- Solving it by a mere renormalisation of beta feeding, however, would suggest a lower log ft value for the first-forbidden transition to the ^{142}Ba ground state, which at 5.6 is already one of the *lowest* known.
- Recently a [1]TAS measurement suggested the whole pattern of beta feedings to be different from the evaluation on ENSDF.
- Interesting other physics and measurement challenges.

[1]B.C. Rasco, et al., Phys. Rev. Lett. 117, 092501 (2016)

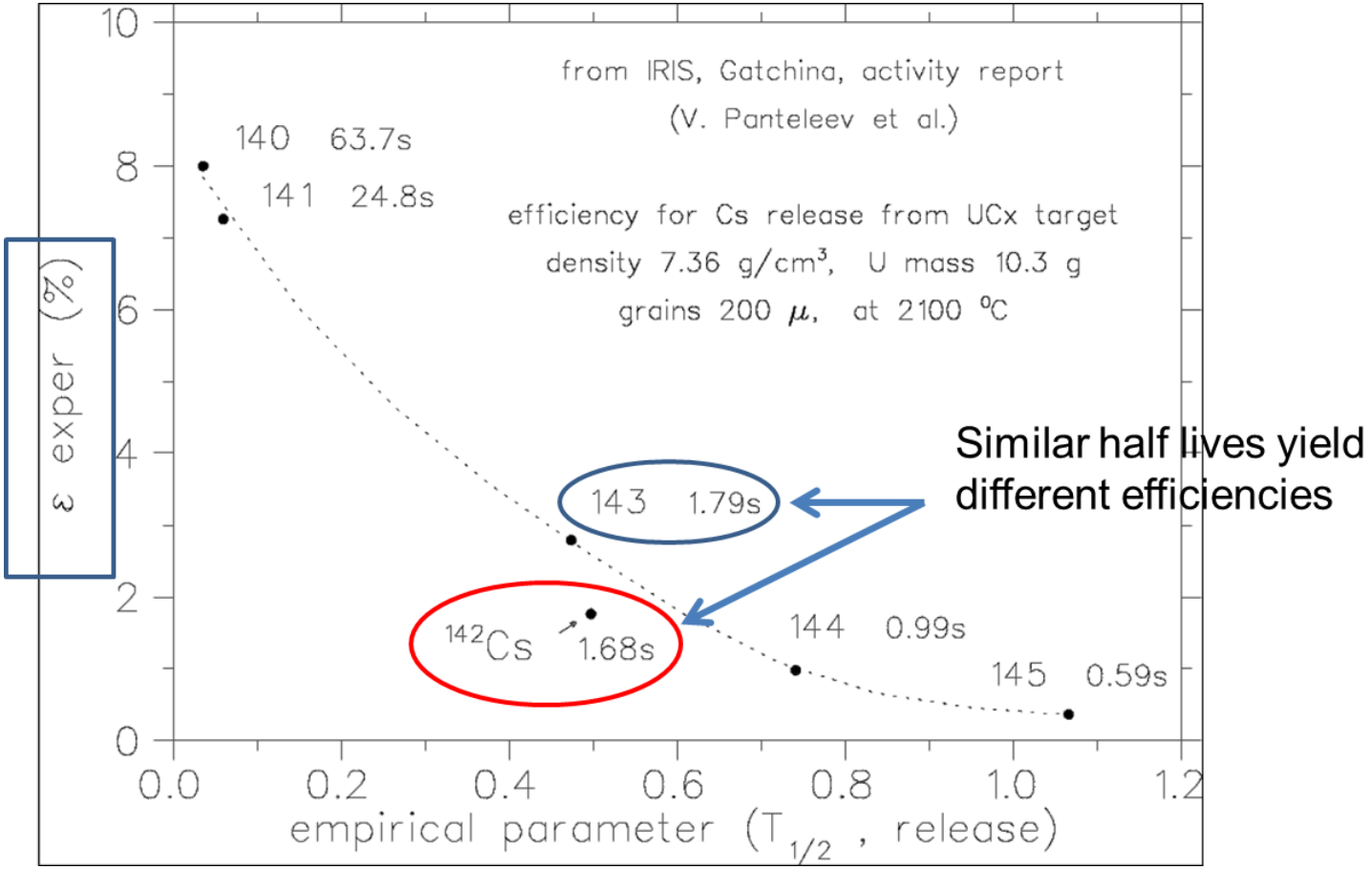
Yield anomaly





Similar half lives yield different efficiencies

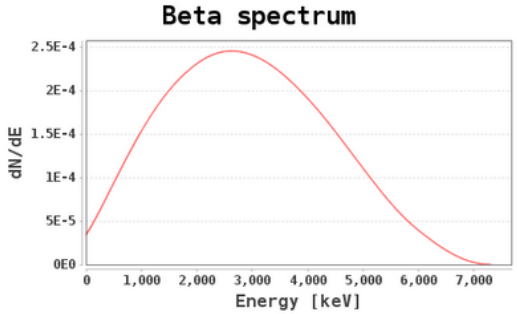
Garchina IRIS Group - V.N.Panteleev et al. Nucl. Instr. and Meth.B 240, 888 (2005)
G. Lhersonneau, Priv. Comm.

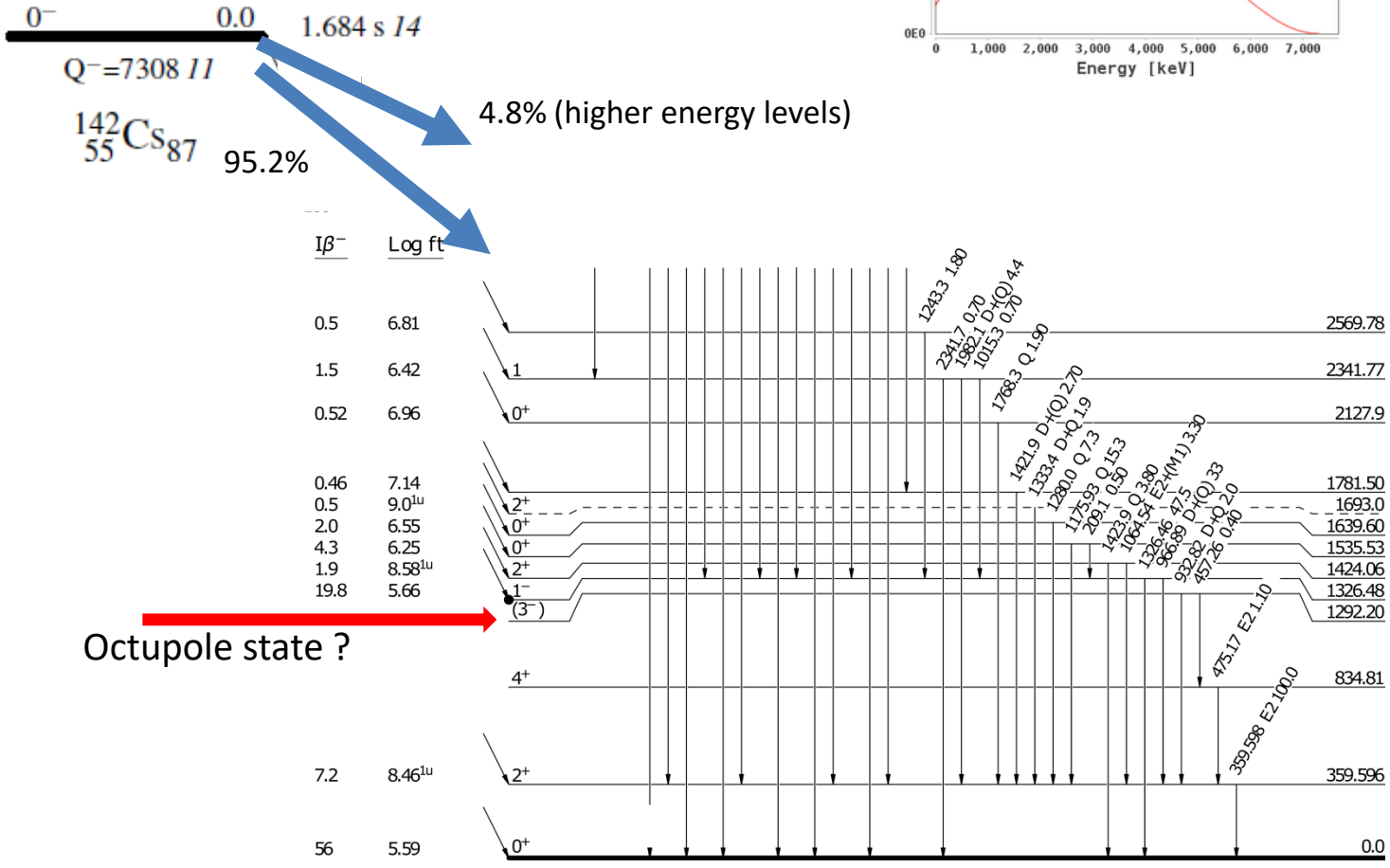


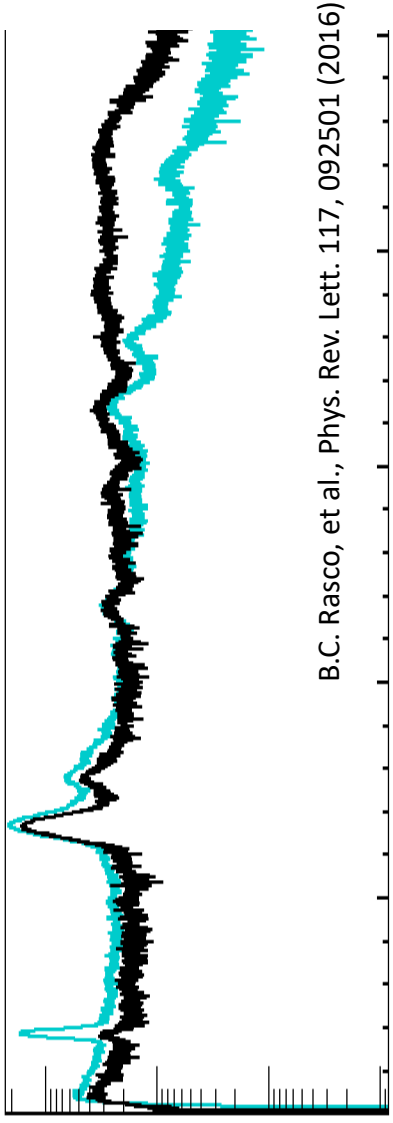
Experimental efficiency contains release parameters depending on chemistry of Cs in UC (temperature obviously, high T→ faster release → higher efficiency) and on decay half-life

Singularity for ^{142}Cs shows that the nuclear decay data of ENSDF used by the Gatchina group are not correct

ENSDF Data







T. Johnson et al., Nucl. Data Sheets 112, 1949 (2011) $^{142}_{56}Ba_{86}$ 10.6 min

Open Questions and MTAS data

Q_β= 7325 (9) keV $T_{1/2}$= 1.684 (14) s

0^+ 56% feeding ?

359 keV (hardly fed @7.2%)

Pandemonium ?

ENSDF Ground State Feeding: 56±5%

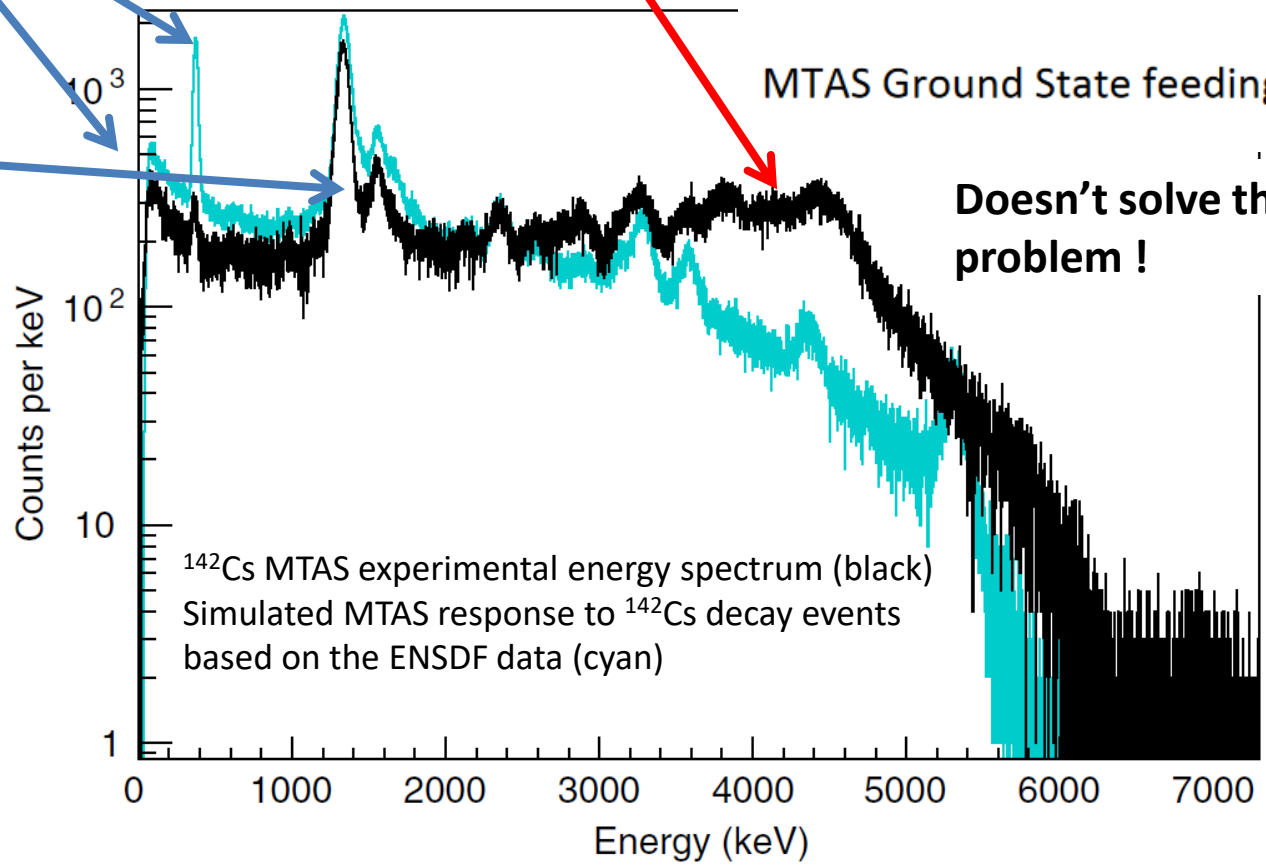
MTAS Ground State feeding: **44±2%**

Decay to 1^- only ?

What about 0^+ states

Doesn't solve the yield problem !

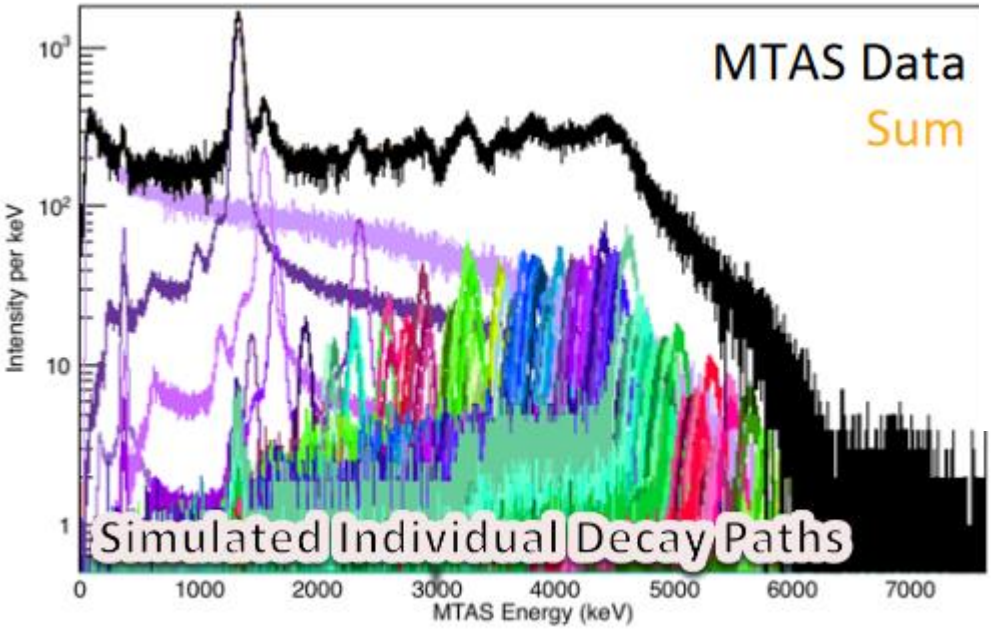
Iβ%	Log ft	#	Jp	En [keV
0.8	5.07	19		5280.
0.4	6.03	18	(1)	4369.
1.0	6.07	17	(1)	3573.
1.3	6.09	16	(1)	3283.
0.5	6.52	15	(1)	3261.
0.6	6.49	14	(1)	3144.
0.17	7.2	13	(1,2+)	2882.
0.5	6.81	12		2569.
1.5	6.42	11	1	2341.
0.52	6.96	10	0+	2127.
0.46	7.14	9		1781.
0.5	9.0	8	2+	1693.
2.0	6.55	7	0+	1639.
4.3	6.25	6	0+	1535.
1.9	8.58	5	2+	1424.
19.8	5.66	4	1-	1326.
		3	(3-)	1292.
		2	4+	834.8
7.2	8.46	1	2+	359.5
56	5.59	0	0+	0.0



B.C. Rasco, et al., Phys. Rev. Lett. 117, 092501 (2016)

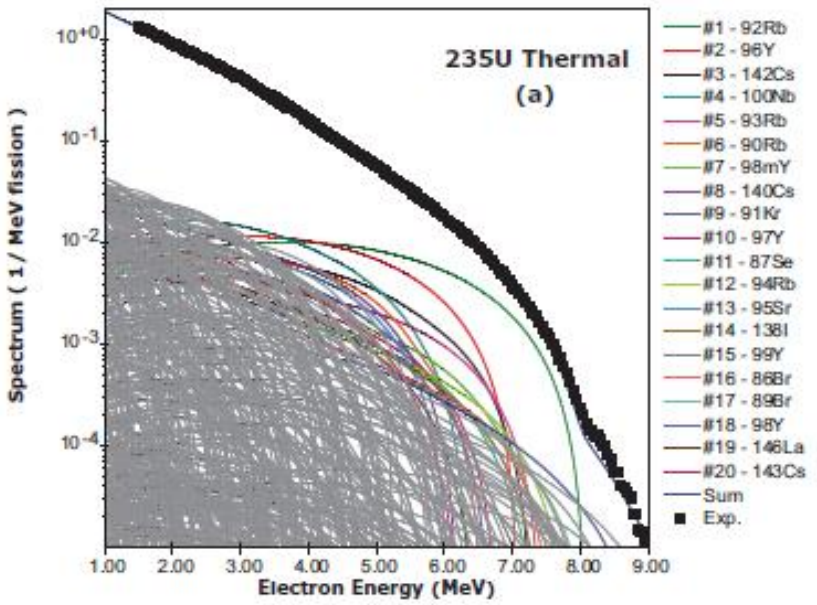
Open Questions and MTAS data

Estimate 21% of total above 3.4 MeV missing



Missed high-energy gamma rays ?
E0 transitions from 0^+ states ?
Lifetimes / isomers
→Understanding of 1st Forbidden transitions

Nuclear structure insights into reactor antineutrino spectra

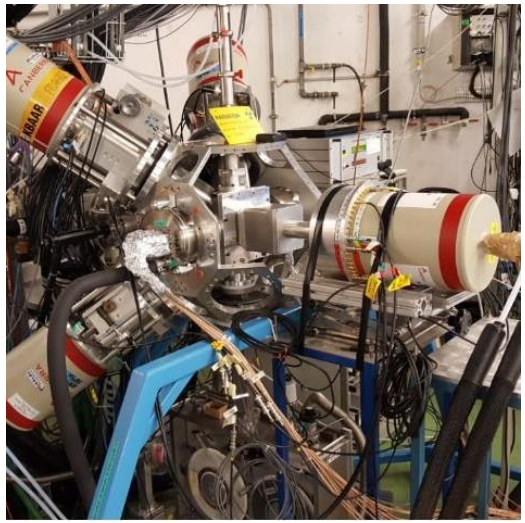


Largest contribution at 6-7 MeV for ^{235}U

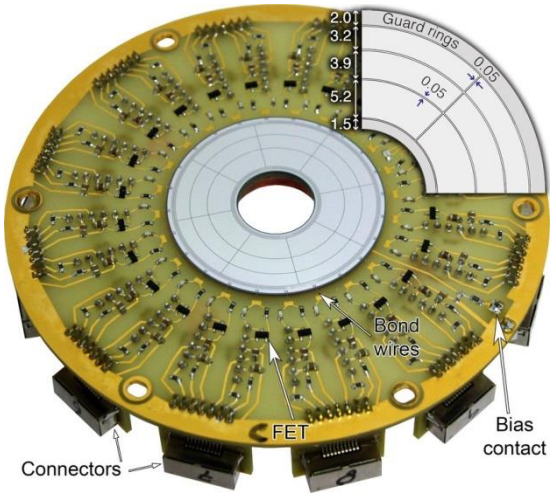
- #1 - 92Rb
- #2 - 96Y
- #3 - 142Cs

B.C. Rasco, et al., Phys. Rev. Lett. 117, 092501 (2016)
A.A. Sonzogni, et al., Phys. Rev. C 91, 011301(R) (2015)

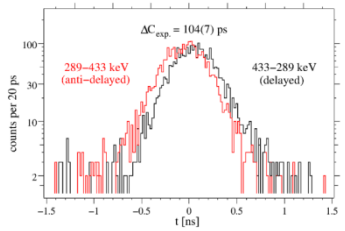
Aims of Measurement



- Measure angular correlations of gamma rays using multi-gamma detector array
- Complete the scheme by looking for high energy gamma-ray transitions
- Use good timing reference (beam pulse, release) to get gamma-ray energy versus time matrices to:
  - assign lifetime of nucleus (or contaminants)
  - to identify possible isomer(s)



- Electron spectroscopy of E0 transitions and investigation of excited 0^+ states
- Measure conversion coefficients of low lying E2 transitions in decay scheme

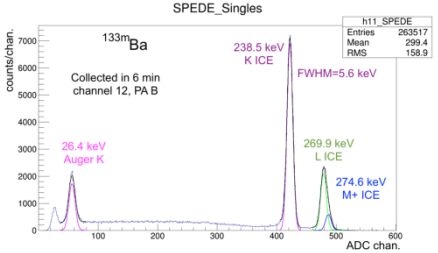


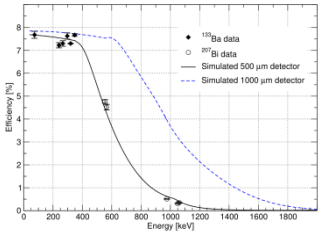
- Measurement of lifetime of low-lying transitions or from 0^+ to 2^+ decays lifetimes

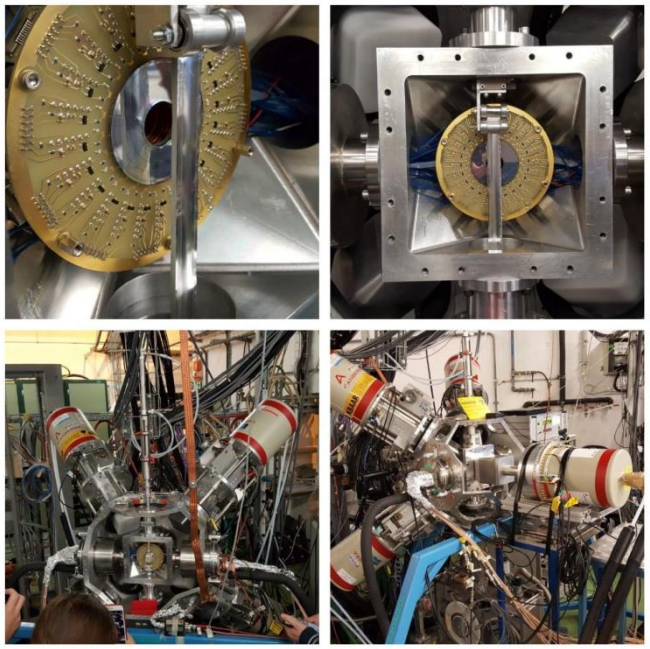
Experimental Setup at IDS

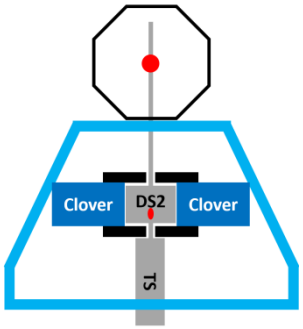
- 6 HPGe Clover Detectors - 2 Romania, 4 Leuven – 2 (with 600µm C window)
- New frame to accommodate 4 clovers with electron spectroscopy setup

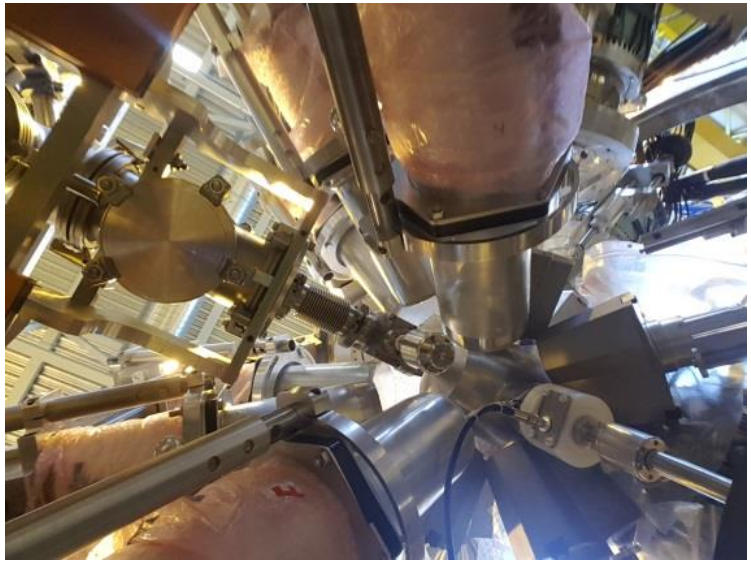
- SPEDE – 1mm detector – FWHM ~6 keV
- Tape Station moving > 1/20s







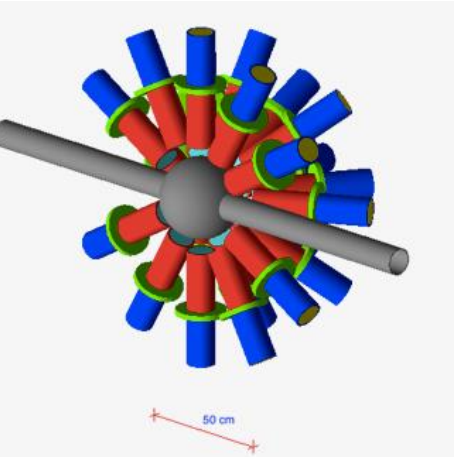


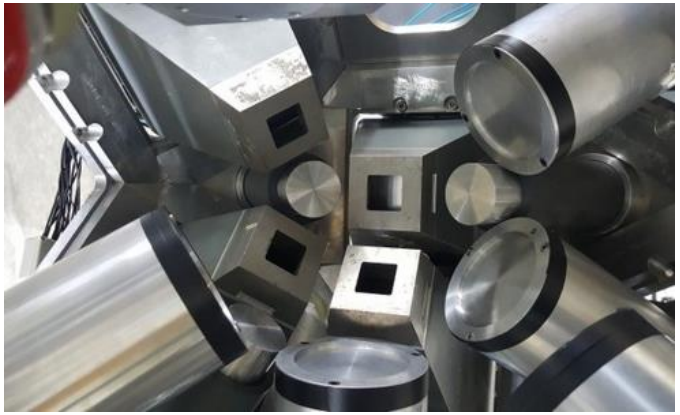


Papadakis et al. EPJ A 54 42 (2018)

Miniball at ISOLDE (IS559) + 3.5”x8” $LaBr_3$

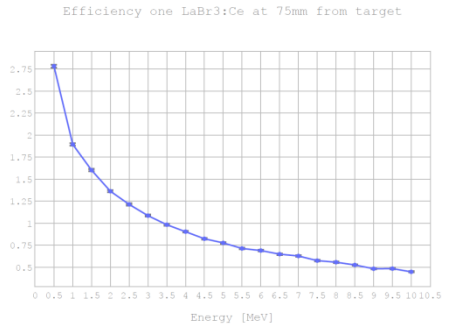
ALBA and Fast-Timing Detectors

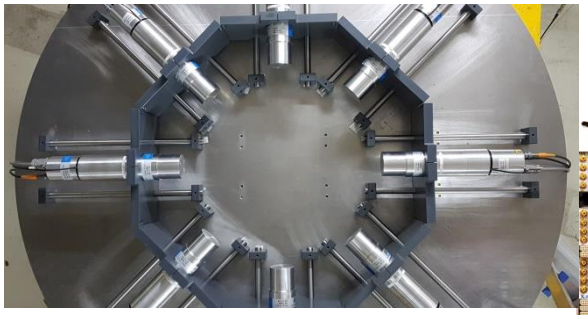


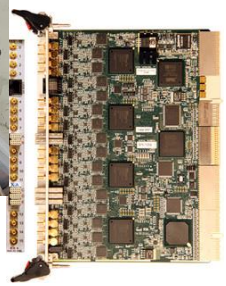


We will collaborate with other experiments benfitting from these detectors

ALBA: African Lanthanum Bromide Array: 3.5”x8”
Fast-Timing Array: 2”x2”







INTC 64 Technical Advisory Committee recommendation

Measurement of the decay scheme of 142Cs					
CDS#	**Proposal #**	**IS #**	**Setup**	**Shifts**	**Isotopes**
CERN-INTC-2020-030	INTC-P-557		IDS/SPEDE	10	142Cs
Beam intensity/purity, targets-ion sources	The beam request has been based on the production of 142Cs from a target equipped with a quartz line: intended to suppress isotopes such as Cs. From a normal target and ion source unit this will be a very strong beam of the order of 10^9 ions /uC. The beam request should therefore be re-evaluated with this in mind. Can the setup handle an order of magnitude stronger beam or would some limits of proton intensity be required? What beam intensity is required?				
General implantation and setup	Higher intensity w.r.t to the project proposal will require adding shielding to the set-up to limit the dose rate (~7 mSv/h at 40 cm with 2e9 ions/s)				
General Comments	A stronger beam may require running ISOLDE is a limited mode as has been seen for other strong primary beams.				
Safety	Safety clearance of IDS set- up can be found at 1807224 – No additional hazards. The ISIEC file shall be updated.				
TAC recommendation	**The TAC recommends that the beam request is re-evaluated with the stronger secondary beam which is likely from a standard target/ion source combination. The maximum intensity required for the setup will allow a better estimation of how long is required for this experiment.**				

Proposal based on $2x10^5$ ions/sec, however as the TAC notes, the available yield is much higher (10^9) After a review of the rates estimation and the possibility to acquire an improved dataset (especially in terms of gamma-electron coincidences) can review this proposal with an order of magnitude in beam.

Estimation of Running Time

- Yield $2x10^5 \rightarrow 10^6$ ions per second (reconfigure some efficiencies)
- γ-ray decay branching of 0.45%
- typical α_{tot} conversion of $7x10^{-3}$
- typical average photon total detection efficiencies (15% at 600 keV, 8% at 2 MeV) of 11%

Decay Mode	Transition Intensity (γ) % or ICC (e^-)	Detection / sec (x 10^{-2})	Shifts per measurement
γ	0.45	3540	0.01
γ-γ	0.45	33.46	10.38
CE	3.2x10-3	32.76	10.60
CE-γ	3.2x10-3	3.60	9.64

We therefore request a total of ten shifts (9 spectroscopy, 1 for IDS optimisation) to complete the detailed spectroscopy of the decay scheme, using both γ rays and conversion electrons.

Thank you for your attention!

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