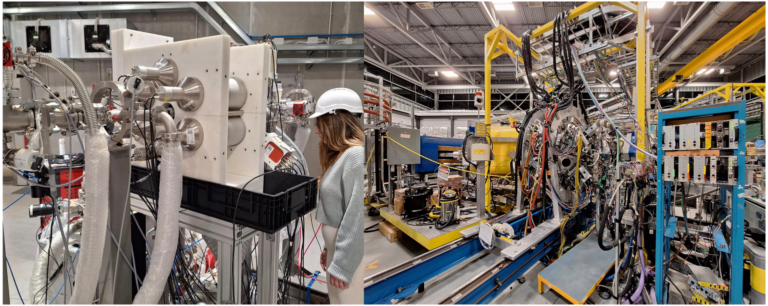
Status of the ^{22}Ne(α,n)^{25}Mg reaction
HELIUM25, HZDR, DE



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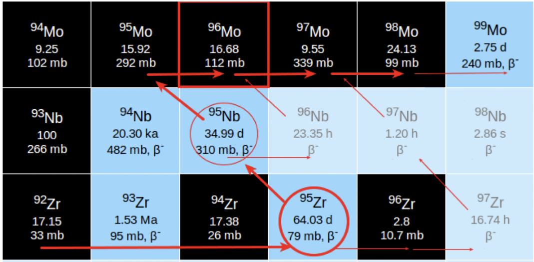
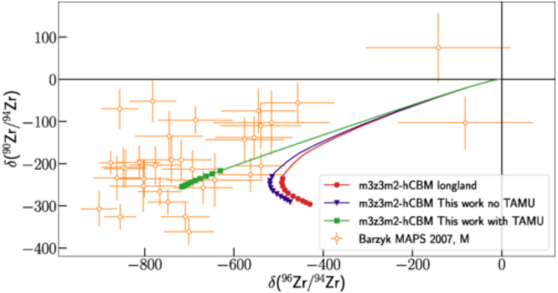
University of Naples "Federico II"

European Research Council
Established by the European Commission

^{22}Ne(α, [n, γ])^{25,26}Mg





Adsley et al. PRC 103, 015805

- ^{22}Ne(α, n)^{25}Mg contributes during late stages of main s process
- Determines branch point population
- Main source for weak s process
- Mg isotope observations in stellar atmospheres: γ vs. n channel
- Both channels important, both channels highly uncertain

State of the Art

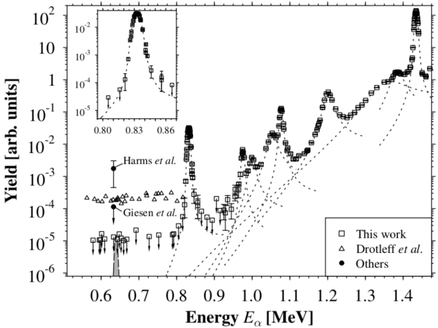


Table 1. Properties of states in ^{26}Mg between the neutron threshold and the 832 keV resonance. Values taken from [15], except for the last row, which is from [14].

E_n [keV]	E_x [keV]	E_α [keV]	Jπ	Neutron width [eV]
19.92	11112	589	2+	2095
72.82	11163	649	2+	5310
79.23	11169	656	3-	1940
187.95	11274	779	2+	410
194.01	11280	786	3-	1810
243.98	11328	843 ?	?	171
235 [14]	11319	832	2+	Total width = 250 eV

Massimi et al. 2017 PLB

- Direct (α, n): Jaeger et al. 2001
- Very few remeasurements at E_α = 832 keV since then: Shahina et al.; Caspar in pipeline?
- External background limiting factor
- **Lots** of indirect measurements: some agree, some don't
- α widths need to be known...

Holiday reading list

PHYSICAL REVIEW C **103**, 015805 (2021)

Reevaluation of the ^{22}Ne(α, γ)^{26}Mg and ^{22}Ne(α, n)^{25}Mg reaction rates

Philip Adsley,[1,2,3,*] Umberto Battino,[4,†] Andreas Best,[5,6] Antonio Caciolli,[7,8] Alessandra Guglielmetti,[9] Gianluca Imbriani,[5,6] Heshani Jayatissa,[10] Marco La Cognata,[11] Livio Lamia,[12,11,13] Eliana Masha,[9] Cristian Massimi,[14,15] Sara Palmerini,[16,17] Ashley Tattersall,[4,†] and Raphael Hirschi[18,19,†]

Eur. Phys. J. A (2023) 59:11
https://doi.org/10.1140/epja/s10050-023-00917-9
THE EUROPEAN PHYSICAL JOURNAL A
Check for updates
Regular Article - Experimental Physics

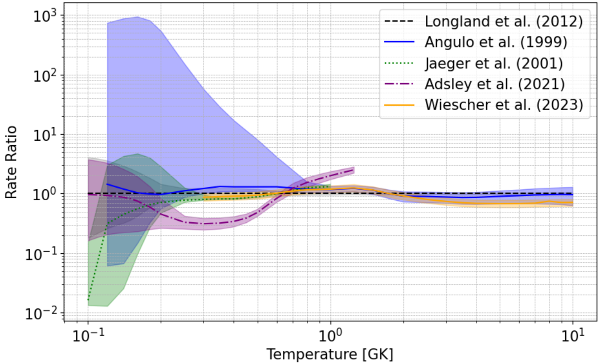
The resonances in the ^{22}Ne+α fusion reactions

M. Wiescher[a], R. J. deBoer[b], J. Görres

Eur. Phys. J. A (2025) 61:99
https://doi.org/10.1140/epja/s10050-025-01572-y
THE EUROPEAN PHYSICAL JOURNAL A
Check for updates
Review

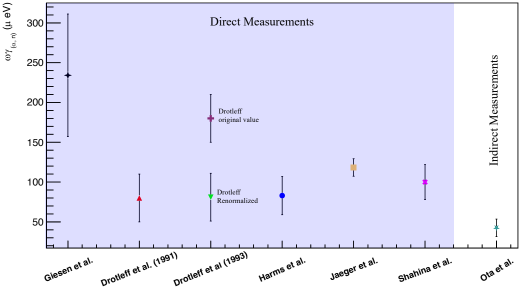
The ^{22}Ne(α,n)^{25}Mg reaction - state of the art, astrophysics, and perspectives

Andreas Best[1,2,a], Philip Adsley[3,4], Ryan Amberger[3,4], Umberto Battino[1,5], Thomas Chillery[6], Marco La Cognata[7], Richard James deBoer[8], Daniela Mercogliano[1,2], Shuya Ota[9], David Rapagnani[1,2], Ragandeep Singh Sidhu[10], Roberta Spartà[7,11], Aurora Tumino[7,11], Michael Wiescher[8]



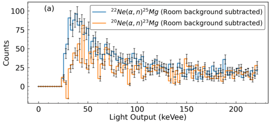
- ^{22}Ne(α, [n, γ])^{25,26}Mg excellent review generator!
- Unfortunately we're still not there yet
- Rate depends on choice of parameters

The 835 keV (706 keV c.m.) resonance - mostly ok?



Reference	$\omega\gamma_{(\alpha,n)}$ [μeV]	
	706 keV	540 keV
Wolke *et al.* [41]	$\leq$ 340	-
Harms *et al.* [29]	83 $\pm$ 24	-
Drotleff *et al.* [42]	80 $\pm$ 30	-
Drotleff *et al.* [43]	180 $\pm$ 30	-
[a]Drotleff *et al.* [43]	81 $\pm$ 30	-
Giesen *et al.* [44]	234 $\pm$ 77	$\leq$ 5
Jaeger *et al.* [19]	118 $\pm$ 11	$\leq$ 0.06
Shahina *et al.* [30]	100 $\pm$ 22	-
[b]Ota *et al.* [10]	42 $\pm$ 11	-

[a] renormalised. [b] indirect measurement.



Shahina et al. 2024

- CASPAR measurement rumoured to be much higher, but no publication or value
- Measurement at LNGS IBF done - more below
- DRAGON planned this winter, JUNA in preparation
- We should be able to pin this one down

Low energy? Still a bit of a mess

Table 2 Partial width predictions for states near the neutron threshold in the ^{26}Mg compound system

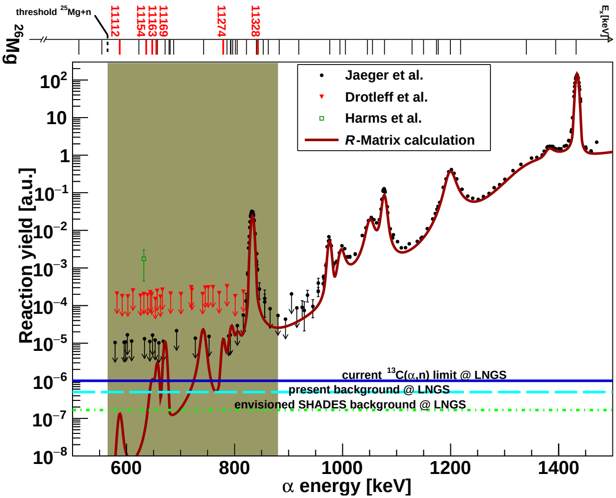
E_x (MeV)	$E_{c.m.}$ (MeV)	J^π	Talwar et al. (2016) [23] Γ_α (eV)	Ota et al. (2021) [26] Γ_α (eV)	Jayatissa et al. (2020) [24] Γ_α (eV)	Adsley et al. (2018) [35] Γ_α (eV)	Γ_γ (eV)	Γ_n (eV)
10.719	0.104	1^-	2.5×10^{-36}					
10.950	0.336	1^-	6.7×10^{-14}	3.00×10^{-14}	3.00×10^{-14}			–
11.085	0.471	2^+	$\leq 8.4\times10^{-12}$	5.70×10^{-11}	5.70×10^{-11}	5.70×10^{-11}	3^a	–
11.165	0.551	4^+	$< 1.3\times10^{-11}$					$\Gamma_n < 0.1\ \Gamma_\gamma$
		2^+	1.00×10^{-7}	$<1.3\times10^{-11}$				$\Gamma_n < 0.1\ \Gamma_\gamma\ ^c$
11.320	0.702	1^-	5.00×10^{-5}	3.00×10^{-5}	1.30×10^{-5}	2.70×10^{-5}	$0.4\text{-}1.0^b$	1.3^d

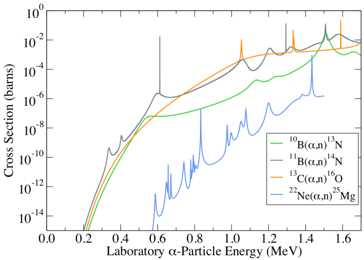
[a] An estimate made by [28]
[b] Calculated range found using Γ_n from [36] and Γ_n/Γ_γ from direct measurements and from that of [25]
[c] See Refs. [17,23]
[d] See Ref. [36]

Wiescher et al.

- See also next talk by Heshani

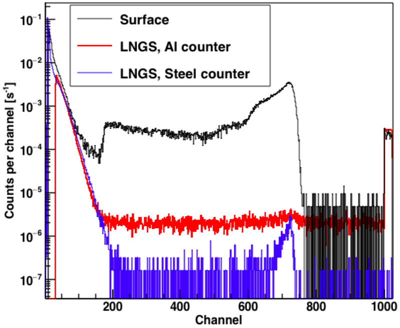
What to do (for direct c.s.)?





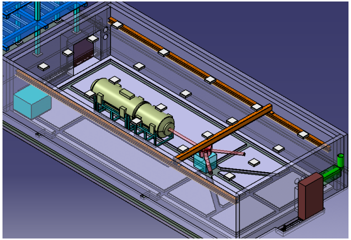
- Suppression/identification of beam-induced background
- Drastic background reduction
- Large beam current increase
- → measure underground @ Bellotti IBF MV with new detector array

Deep underground: not nice, but neccessary



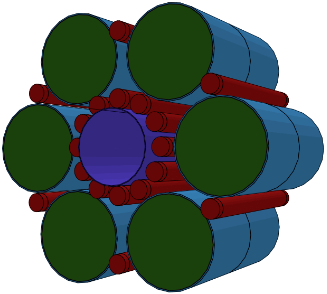
- Atmospheric neutrons removed
- Remainder (10^{-3}): decays in environment
- Material choice now makes a difference
- Add PSD and passive shielding
- Example: $^{13}C(\alpha,n)^{16}O$ 2 bg count/hour vs ca. 100/h Jaeger et al.

New MV accelerator of the INFN Bellotti Ion Beam Facility




- Specifically designed to fit nuclear astrophysics needs
- Reaction rates of < 1/hour:
  - Beam current ($\approx 5\times$ Jaeger et al.): push signal-noise ratio
  - Current stability: measurements of the order of weeks
  - Energy stability: must not drift over long periods
- 300 - 3500 kV: cover entire astrophysical energy range
- Sen et al. NIM B 450 (2019), 390
- Taken into operation with ^{14}N(p,γ)

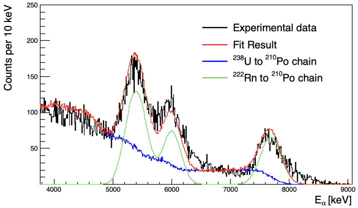
SHADES project

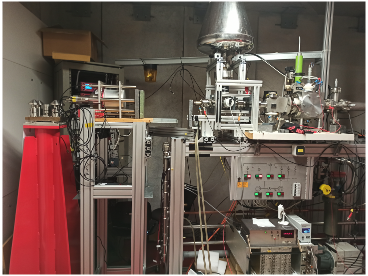


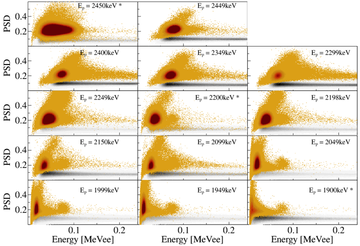
- Hybrid detector array: ^{3}He counters & liquid scintillator
- Provides good efficiency with certain energy sensitivity
- Clean apertures against BIB
- Gas target (recirculating) for long, uninterrupted runs

erc
European Research Council
Established by the European Commission

Preparation

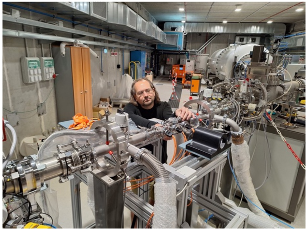


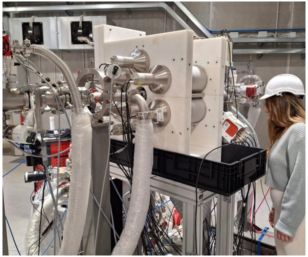


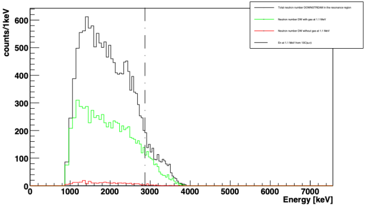


- 1st target setup and characterisation at CIRCE
- Scintillator background Ananna et al. NIM A 1060 (2024) 169036
- Detector characterisation at FRANZ
- Paper including ML PSD - Chillery et al. J Phys G accepted
- Assembled at LNGS in 2023

Underground status







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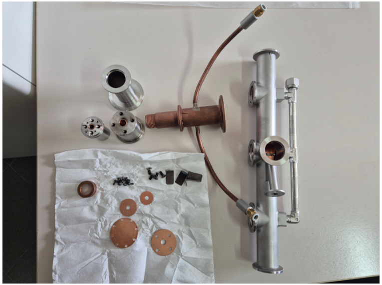
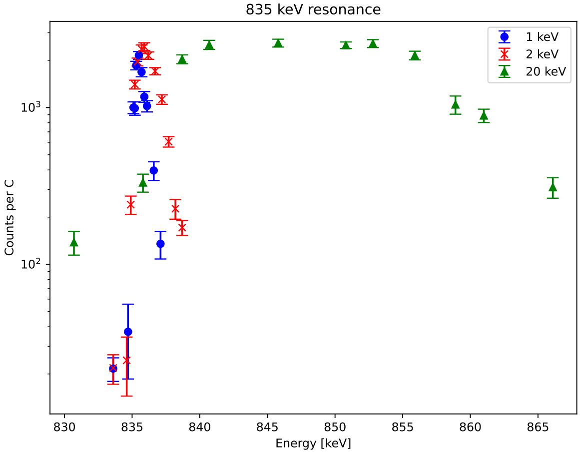


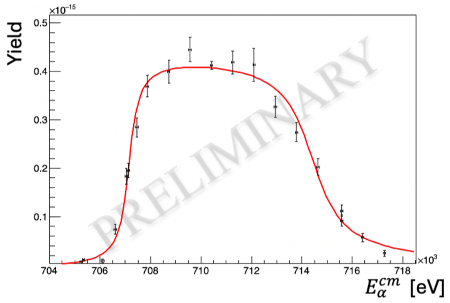
- Everything installed at a brand new beamline
- First beam into target and array summer 2024
- October-December 24 first runs with ^{22}Ne - BIB
- Test runs in March and May 25
- Covered chamber, collimators with OFHC
- Still BIB, but in May we broke Jaeger barrier: ca. 10-15 cts/h total bg from threshold to 835 keV res

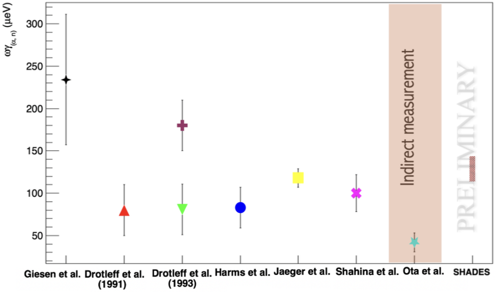
SHADES status



- 835 resonance easy to measure < – really!
- So far between 1 keV - ca. 35 keV scans
- Array efficiency measured at ATOMKI April 25: $^{51}V(p,n)$ activation

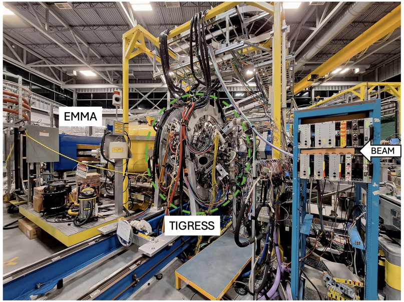
SHADES 835 keV preliminary

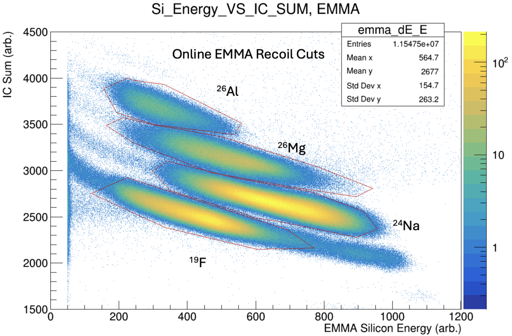




- Under analysis
- Preliminarily agree with Jaeger et al.
- Can extract $\omega\gamma$ (of course), E_x and improved total width

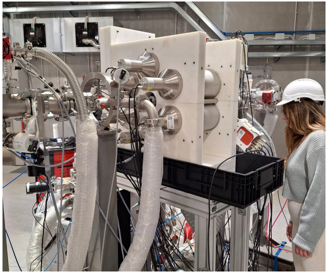
S2223 @ TRIUMF EMMA-TIGRESS





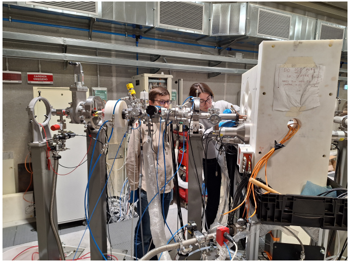
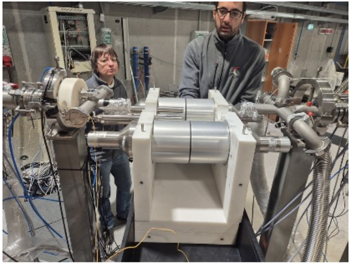
- ^{22}Ne(^{7}Li, t)^{26}Mg @ 3 MeV/u
- $\approx 500\mu g/cm^2$ LiF target (INFN-LNS)
- backwards S3, EMMA, TIGRESS
- 2 wks of beamtime in December 2024
- Γ_α and γ branchings, $\frac{d\sigma}{d\Omega}$

Summary



- Steady influx of indirect data, need some direct input
- Push to improve direct cross section upper limits with Shades and at JUNA (soon?)
- EMMA-TIGRESS under analysis, TAMU in planning, Trojan Horse under investigation (R. Sparta talk)
- Hopefully next year we will be in better situation

Thanks


- A lot of tedious, frustrating work
- SHADES team: D. Mercogliano (PhD no. 2), D. Rapagnani, T. Chillery (postdoc), C. Ananna (PhD no. 1), A. di Leva, G. Imbriani
- Thanks to LNGS IBF operators and support
- LNGS mechanical workshop ♥
- EMMA-TIGRESS team
- The global community for the constant effort
- And of course LUNA collaboration