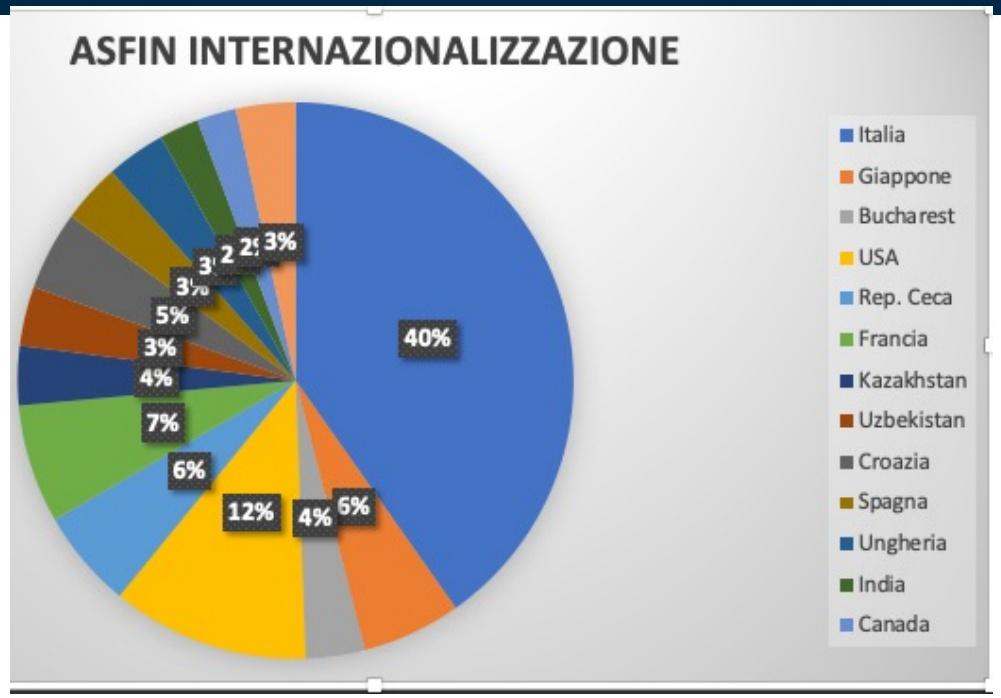
Scientific highlights and activity for 2023/24

Responsabile Locale: Sara Palmerini

Alessandro Chieffi, Marco Limongi, Maria Clara Nucci, Nikola Vukman

5 ricercatori 4 fte

AsFiN



FTE 2022:

-LNS	18.0 FTE	28 ricercatori
-NA	2.7 FTE (tbc)	4 ricercatori
-PG	4.0 FTE	5 ricercatori
-PD	1.1 FTE	2 ricercatori
TOT	25.7	39 ricercatori INFN (60 coll.)

LNSSTREAM2
Nuclear structure

EXOTIC
Sviluppo di RIBS

Applicazione di metodi indiretti (THM & ANC) per la misura di sezioni d'urto reazioni di interesse per l'Astrofisica ad energie prossime (o minori) al picco di Gamov

Analisi delle conseguenze nella nucleosintesi stellare delle sezioni d'urto misurate

Reazioni tra particelle cariche (nuclei stabili) THM come sorgente di neutroni RIBs

Misura di sezioni d'urto di fusione in laser driven plasma

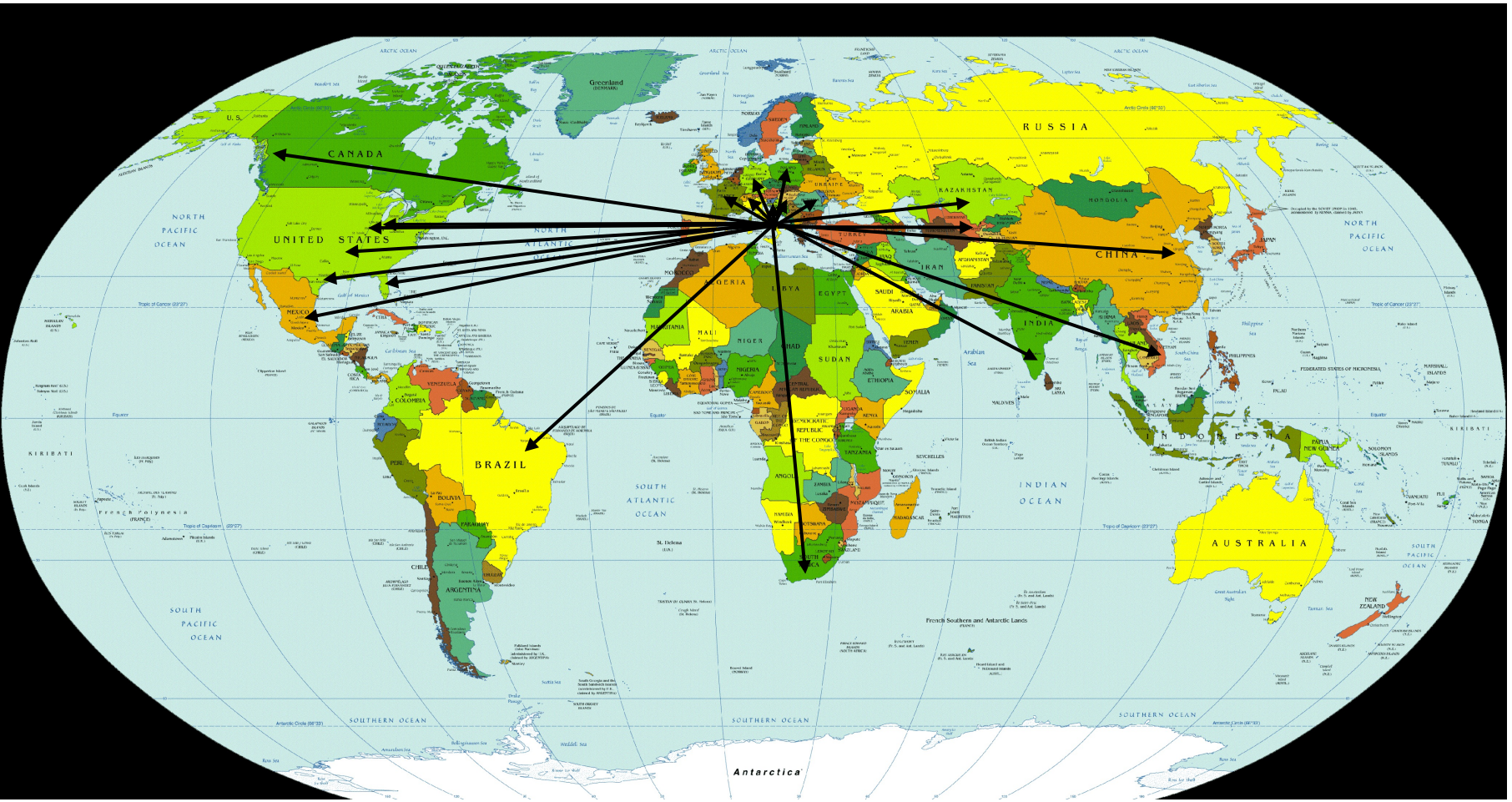
Many astrophysical contexts were then explored:

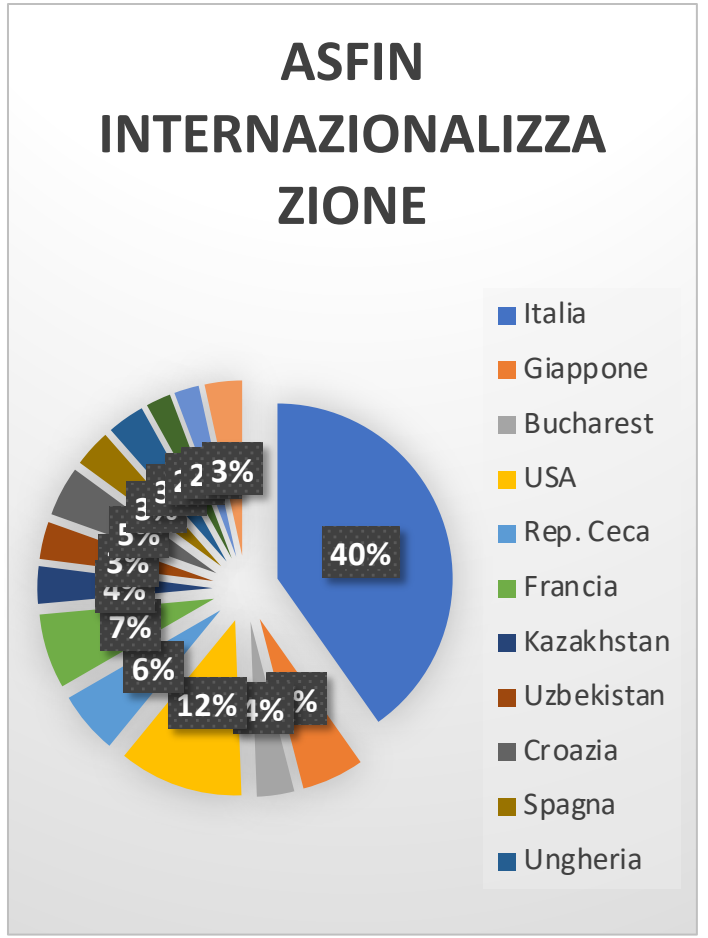
- Primordial nucleosynthesis
- Light elements depletion
- Stellar nucleosynthesis

Goal:

Measurement at Gamow energy
and better separation of sub-threshold levels.

AsFiN



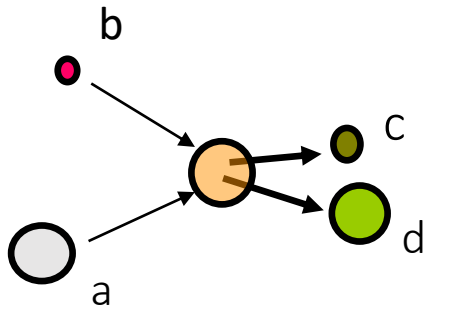


Collaborators: NDU, FSU, MSU, TAMU, UT (USA) - TRIUMF(Canada), S.Paolo Univ. (Brazil), UNAM (Mexico), iTemba (S. Africa) – Riken (Japan), Mombay Physics Inst (India)- .... – RBI Zagreb….

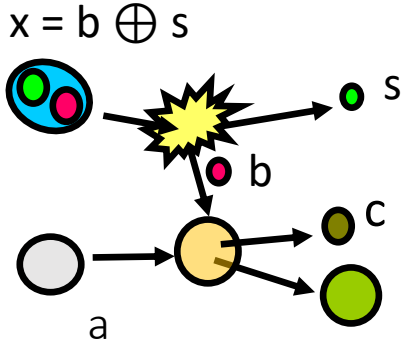
AsFiN e metodo del cavallo di Troia

Sfrutta il cambiamento di sistema di riferimento dal laboratorio al centro di massa

La sezione d'urto della reazione a due corpi a + b -> c + d può essere determinata misurando un'appropriata reazione a tre corpi a + x -> c + d + s, dove x = b $\oplus$ s



a(b,c)d



x(b,cd)s

- ✓ Poiché $E_{CM(a,b)} = E_{c,d} - Q_{a+b->c+d}$ le energie ''astrofisiche'' possono essere raggiunte con fasci di energia più alta (1-10 AMeV)
- ✓ Le misure a energie al disotto della barriera coulombiana sono sono possibili in quanto nella processo del cavallo di Troia la particella «b» trasferita è virtuale e quindi non risente della repulsione coulombiana

Programma sperimentale 2023

Experiment @HIGS photodissociation: beam scheduled and moved from 2022. ✓

$^{23}Na(p,\gamma)$ Experiment (III run): waiting for the beam schedule! T.B.A.

OEDO ^{56}Ni experiment at Riken: performed in May 2022; ✓

$^{19}F+p$ Experiment @IFIN with Elissa: beam scheduled 5-17/09/22; Ottobre

Test beams@iThemba for experiments on Nova-nucleosynthesis Dicembre

$^{14}N(\alpha,p)^{17}O$ THM experiment @Astana Settembre

$^{19}F+p$ Experiment @TRIUMF: beam scheduled late spring 2023; Settembre

Experiment @HIGS photodissociation: beam scheduled and moved to 03/2023 ✓

^{7}Li electron screening Experiment (II run) @Lubiana: if run scheduled 2022; Agosto

$^{26}Al+n$ Experiment @TRIUMF: new run May 2023 ✗

Delayed to Summer 2024 because of machine issues/failure @ TRIUMF

Programma sperimentale 2024

^{26}Al+n Experiment @TRIUMF

^{23}Na(p,a) THM Experiment @LNS (Covid + upgrade backlog)

^{16}C investigation @TRIUMF

^{11}B+p Experiment @IFIN with ELISSA

^{6}He+p and ^{6}He+d experiment @Riken

Beam tests @LNL to forsen THM experiments witth RIBs from SPES

Runs @LNL in collaboration with GAMMA for (n,g) reactions

Spokesperson from PG

D+d fusion LASER Experiment @ GIST (South Corea)

^{6}Li electron screening Experiment @Lubiana

^{12}C+^{16}O THM experiment @ University of Koln

PRINCIPALI RISULTATI 2022-2023

Eur. Phys. J. Plus (2021) 136:898
https://doi.org/10.1140/epjp/s13360-021-01872-4

THE EUROPEAN PHYSICAL JOURNAL PLUS

Regular Article

The ^{27}Al(p, α)^{24}Mg reaction at astrophysical energies studied by means of the Trojan Horse Method applied to the ^{2}H(^{27}Al, α^{24}Mg)n reaction

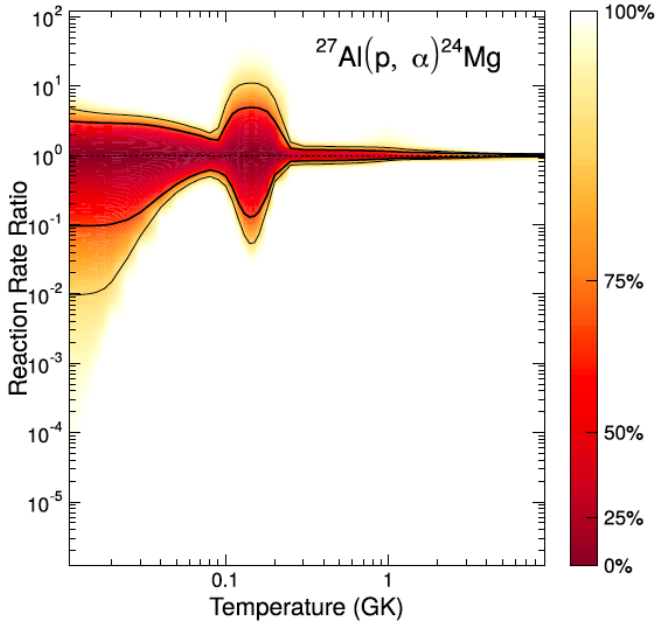
S. Palmerini[1,2,a], M. La Cognata[3], F. Hammache[4], L. Acosta[5], R. Alba[3], V. Burjan[6], E. Chávez[5], S. Cherubini[3,7], A. Cvetinović[8], G. D'Agata[6], N. de Séréville[4], A. Di Pietro[3], P. Figuera[3], Z. Fülöp[9], K. Gaitán De Los Rios[5], G. L. Guardo[3,7], M. Gulino[3,10], S. Hayakawa[11], G. G. Kiss[9], M. La Commara[12,13], L. Lamia[3,7], C. Maiolino[3], G. Manicó[3,7], C. Matei[14], M. Mazzocco[15,16], J. Mrazek[6], T. Parascandolo[13], T. Petruse[14,17], D. Pierroutsakou[13], R. G. Pizzone[3], G. G. Rapisarda[3,7], S. Romano[3,7], D. Santonocito[3], M. L. Sergi[3,7], R. Spartà[3,7], A. Tumino[3,10], H. Yamaguchi[11]

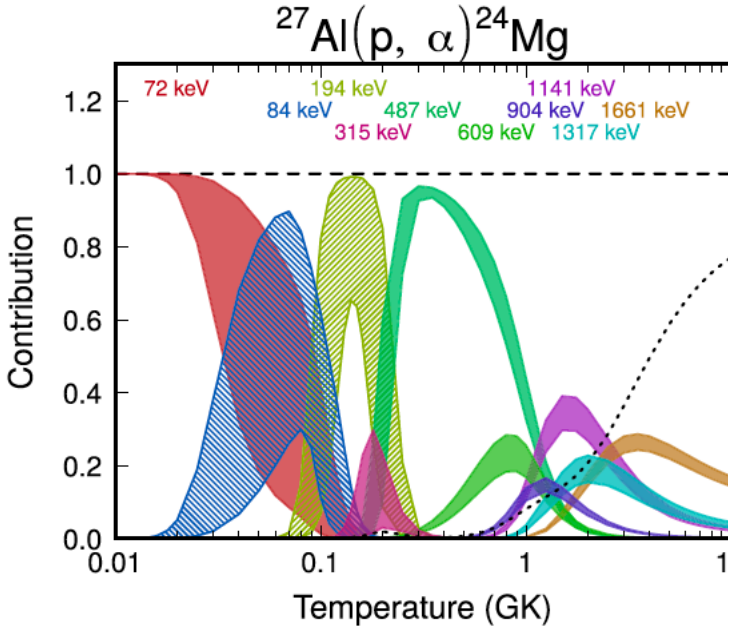
THE ASTROPHYSICAL JOURNAL, 941:96 (14pp), 2022 December 10 https://doi.org/10.3847/1538-4357/ac9c5e

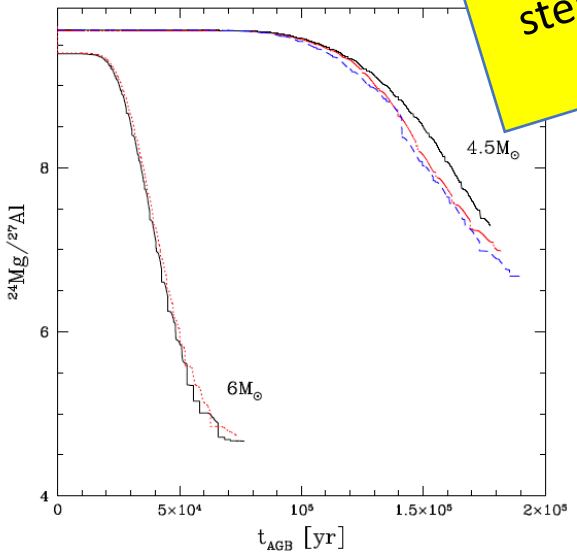
A New Reaction Rate of the ^{27}Al(p/α)^{24}Mg Reaction Based on Indirect Measurements at Astrophysical Energies and Implications for ^{27}Al Yields of Intermediate-mass Stars

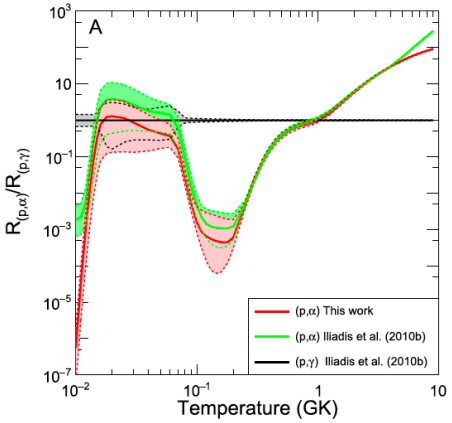
M. La Cognata[1], S. Palmerini[2,3,4], P. Adsley[5,6], F. Hammache[7], A. Di Pietro[1], P. Figuera[1], F. Dell'Agli[4], R. Alb[1], S. Cherubini[1,8], G. L. Guardo[1,8], M. Gulino[1,9], L. Lamia[1,8], D. Lattuada[1,9], C. Maiolino[1], A. Oliva[1,8], R. C[1], P. M. Prajapati[1,10], G. G. Rapisarda[1,8], S. Romano[1,8], D. Santonocito[1], R. Spartá[1,8], M. L. Sergi[1,8], A. T[1]

Analisi dell'impatto della nucleosintesi di Mg e Al in stelle di massa piccola e intermedia by PG



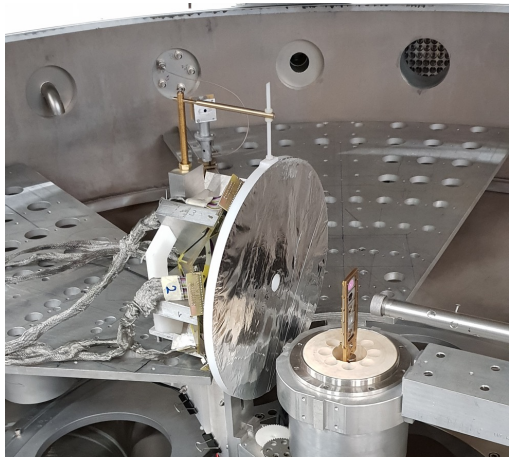






PRINCIPALI RISULTATI 2022-2023

Study of the $^{19}F(p,\alpha_0)^{16}O$ at LNS (published on EPJA)



Direct measurement of the $^{19}F(p,\alpha_0)^{16}O$ reaction at E_{cm}=0.4-0.9 MeV using the LHASA detector array

G.L. Guardo[1], T. Petruse[2,3], D. Lattuada[1,4], M. La Cognata[1], D.L. Balabanski[2], E. Açıksöz[2], L. Acosta[5], L. Capponi[2], D. Carbone[1], S. Cherubini[1,6], D. Choudhury[2], G. D'Agata[1,6], A. Di Pietro[1], P. Figuera[1], M. Gulino[1,4], A. I. Kilik[7], M. La Commara[8], L. Lamia[1,6,9], C. Matei[2], S. Palmerini[10,11], R.G. Pizzone[1], G.G. Rapisarda[1,6,9], S. Romano[1,6,9], M.L. Sergi[1,6,9], P.-A. Söderström[2], R. Spartà[1], A. Tumino[1,4] and S. Viñals[12]

[1] Laboratori Nazionali del Sud INFN, Catania, Italy
[2] Extreme Light Infrastructure Nuclear Physics/IFIN-HH, Magurele, Romania
[3] Scoala Doctorala de Ingineria si Aplicatiile Laserilor si Acceleratorilor, Universitatea Politehnica, Bucuresti
[4] Università di Enna "Kore", Enna, Italy
[5] Instituto de Física, Universidad Nacional Autónoma de México, Mexico City, Mexico
[6] Dipartimento di Fisica e Astronomia "E. Majorana", Università degli Studi di Catania, Catania, Italy
[7] Nuclear Physics Institute of ASCR, Rez, Czech Republic
[8] Dipartimento di Fisica, Università di Napoli Federico II, Napoli, Italy
[9] Centro Siciliano di Fisica Nucleare e Struttura della Materia (CSFNSM), Catania, Italy
[10] Dipartimento di Fisica e Geologia, Università di Perugia, Perugia, Italy
[11] INFN - Sezione di Perugia, Perugia, Italy
[12] Instituto de Estructura de la Materia, Consejo Superior de Investigaciones Científicas, Madrid, Spain

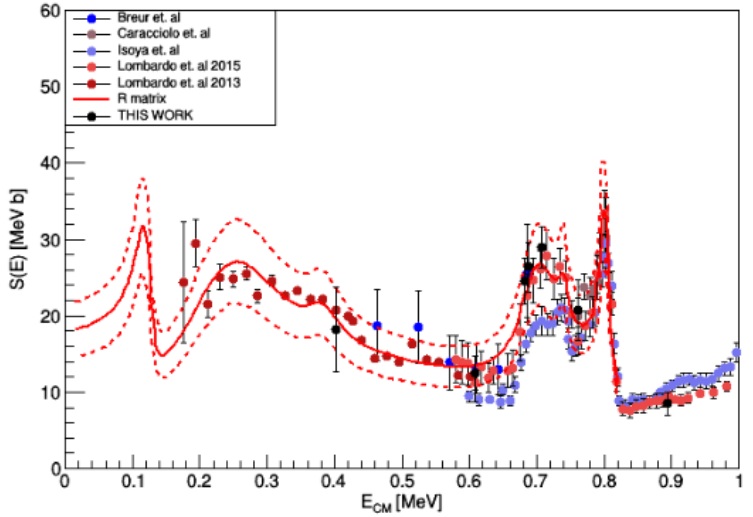


Fig. 6. Astrophysical S(E)-factor for the $^{19}F(p,\alpha_0)^{16}O$ reaction measured in the present experiment (full black points) compared with available data in literature.

Table 1. Energies used in the experiment with the corresponding values in the center-of-mass system. The CMS energy are calculated considering the energy loss in the middle of the used target, which thickness is also shown (values are approximated to the first two digits).

Beam energy	Energy in CMS	Target thickness
9 MeV	400 keV	150 $\mu g/cm^2$
13 MeV	600 keV	100 $\mu g/cm^2$
14 MeV	680 keV	50 $\mu g/cm^2$
14.5 MeV	690 keV	100 $\mu g/cm^2$
15 MeV	700 keV	100 $\mu g/cm^2$
16 MeV	750 keV	100 $\mu g/cm^2$
18.5 MeV	900 keV	100 $\mu g/cm^2$

New analysis of the $^{19}F(p,\alpha_\pi)^{16}O$ channel reaction **ONGOING**

This reaction is addressed by THM, directly and in metal lattice for retrieving information on screening

PRINCIPALI RISULTATI 2022-2023

PHYSICAL REVIEW C
covering nuclear physics

Highlights Recent Accepted Collections Authors Referees Search Press About

Editors' Suggestion

Experimental study of the $^{30}\mathrm{Si}\left(^{3}\mathrm{He},d\right)^{31}\mathrm{P}$ reaction and thermonuclear reaction rate of $^{30}\mathrm{Si}\left(p,\gamma\right)^{31}\mathrm{P}$

D. S. Harrouz, N. de Séréville, P. Adsley, F. Hammache, R. Longland, B. Bastin, T. Faestermann, R. Hertenberger, M. La Cognata, L. Lamia, A. Meyer, S. Palmerini, R. G. Pizzone, S. Romano, A. Tumino, and H.-F. Wirth
Phys. Rev. C **105**, 015805 – Published 14 January 2022

EPJ A **279**, 11001 (2023) https://doi.org/10.1051/epja/202327911001

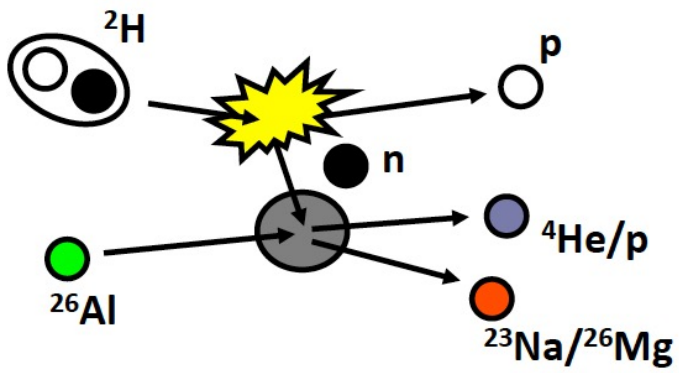
Determination of the $^{3}\mathrm{He}(\alpha,\gamma)^{7}\mathrm{Be}$ and $^{6}\mathrm{Li}(p,\gamma)^{7}\mathrm{Be}$ astrophysical factors down to zero energy using the asymptotic normalization coefficients.

M. La Cognata[1,*], *G. G.* Kiss[2], *R.* Yarmukhamedov[3], *K. I.* Tursunmakhatov[3,4], *I.* Wiedenhöver[5], *L. T.* Baby[5], *S.* Cherubini[1,6], *A.* Cvetinović[1,7], *G.* D'Agata[1,8], *P.* Figuera[1], *G.L.* Guardo[1], *M.* Gulino[1,9], *S.* Hayakawa[10], *I.* Indelicato[1,6], *L.* Lamia[1,6,11], *M.* Lattuada[1,6], *F.* Mudò[1,6], *S.* Palmerini[12,13], *R.G.* Pizzone[1], *G.G.* Rapisarda[1,6], *S.* Romano[1,6,11], *M. L.* Sergi[1,6], *R.* Spartà[1,6], *C.* Spitaleri[1,6], *O.* Trippella[12,13], *A.* Tumino[1,9], *M.* Anastasiou[5], *S.A.* Kuvin[5], *N.* Rijal[5], *B.* Schmidt[5], *S. B.* Igamov[3], *S. B.* Sakuta[14], *Zs.* Fülöp[2], *Gy.* Gyürky[2], *T.* Szücs[2], *Z.* Halász[2], *E.* Somorjai[2], *Z.* Hons[8], *J.* Mrázek[8], *R. E.* Tribble[15], and *A.M.* Mukhamedzhanov[15]

ALFA: on the way to 26Al*@SPES passing through ^{27}Al @ LNS and ^{26}Al@TRIUMF

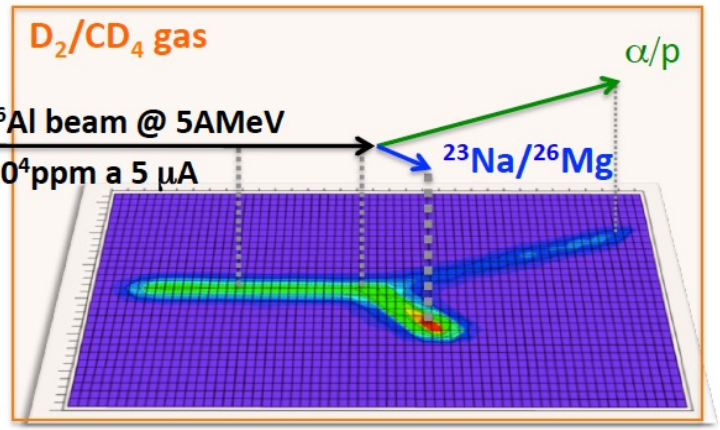
$^{26}Al^*(n,\alpha)^{23}Na$ via $^{26}Al^*(d,\alpha^{23}Na)p$

$^{26}Al^*(n,p)^{26}Mg$ via $^{26}Al^*(d,p^{26}Mg)p$



- ✓ Only events occurring at the energy of interest can be selected
- ✓ Two-rays events will be singled out to select reactions with p_s=0 (QF contribution is maximum)

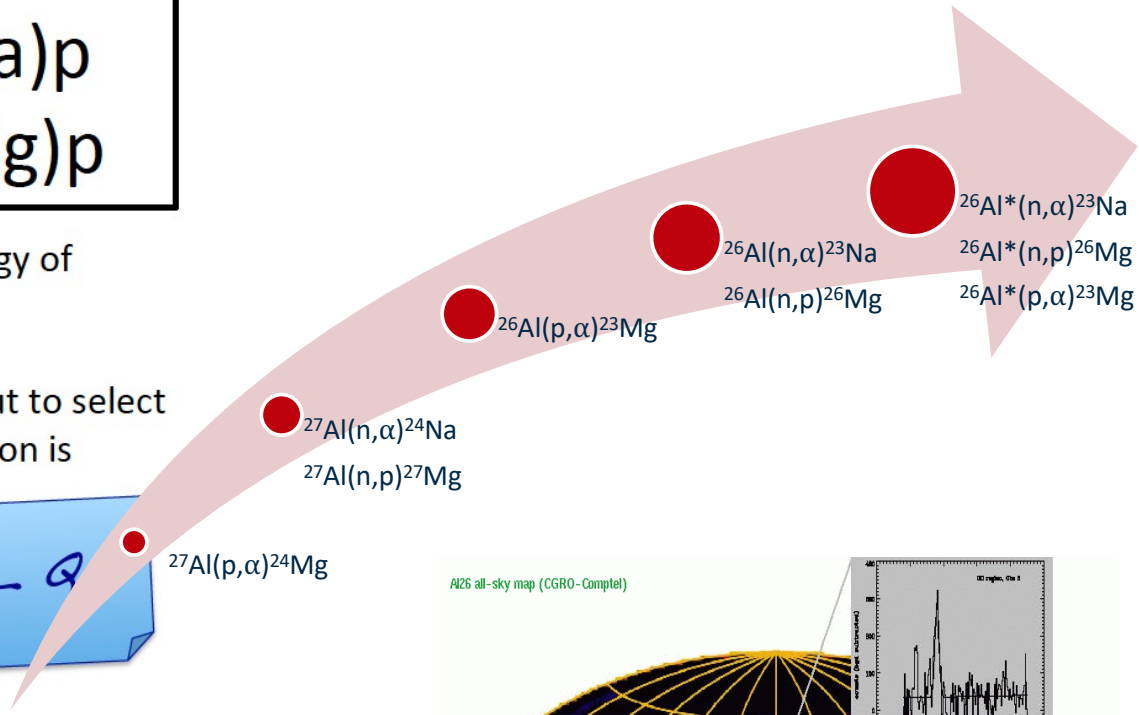
$$E_{QF} = \frac{M_n}{M_n + M_{26Al}} E_{26Al} - Q$$

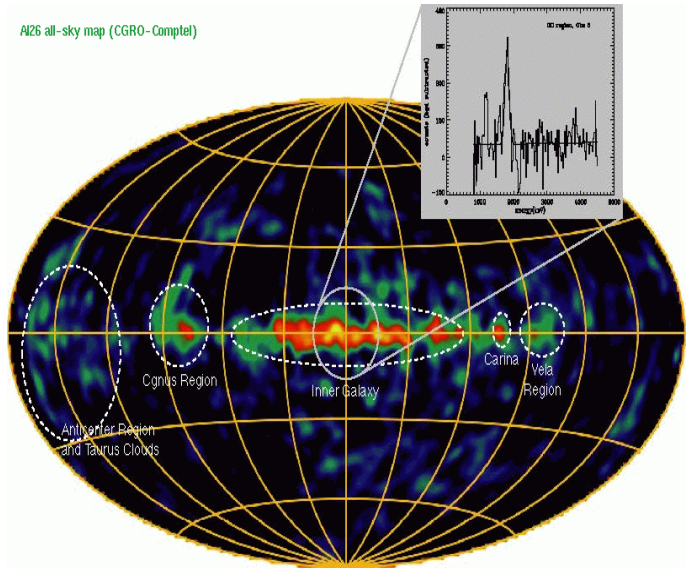


E_{beam} / E_{cm}	113MeV 2MeV	60MeV 0 MeV
400 mbar CD_4	17.5mm	68mm
1000 mbar D_2	51 mm	240mm

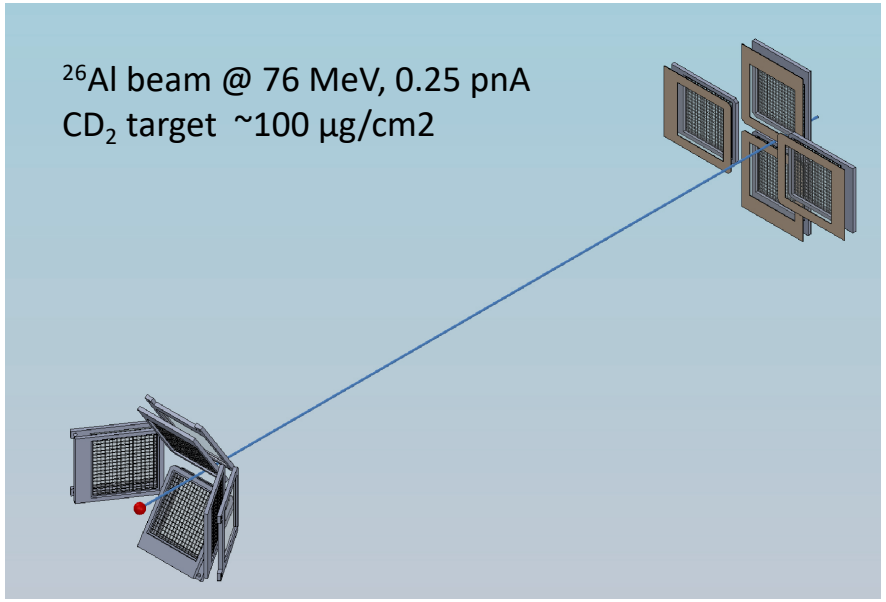
actar TPC

TPC might be very well suited to measure T/M reactions



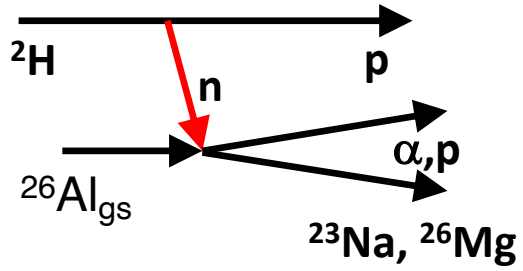


ALFA: on the way to 26Al*@SPES passing through ^{27}Al @ LNS and ^{26}Al@TRIUMF

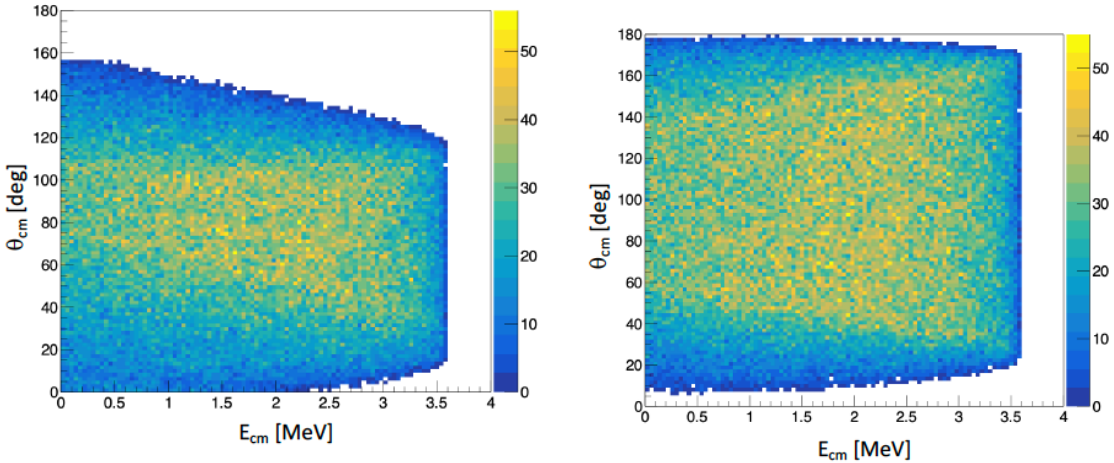


NEFASTA detector array
(NEar FAr Silicon Telescope Array),
made up of 8 telescopesarranged
into two groups

$^{2}H(^{26}Al_{gs},p\ ^{26}Mg)p$
$^{2}H(^{26}Al_{gs},\alpha\ ^{23}Na)p$



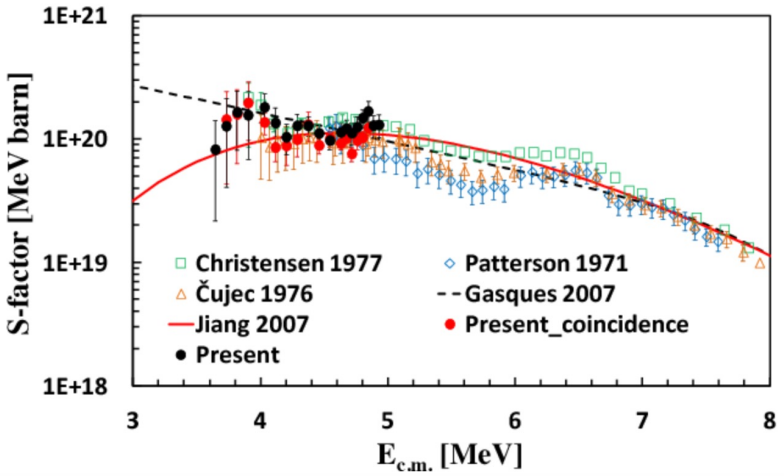
$^{26}Al_{gs}$ @ LNS
$^{26}Al_{m}$ @ LNL -> TRIUMF/SPES

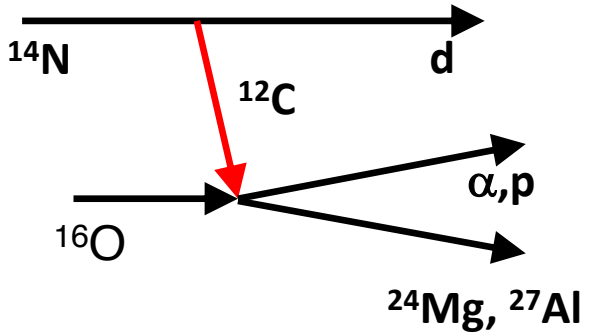


$^{26}Al_{gs}(n,p)^{26}Mg$
$^{26}Al_{gs}(n,\alpha)^{23}Na$.
angular end energy ranges we will cover, assuming quasi-free kinematics.

Study of the ^{26}Al (p,γ)^{27}Si reaction using the ANC indirect method

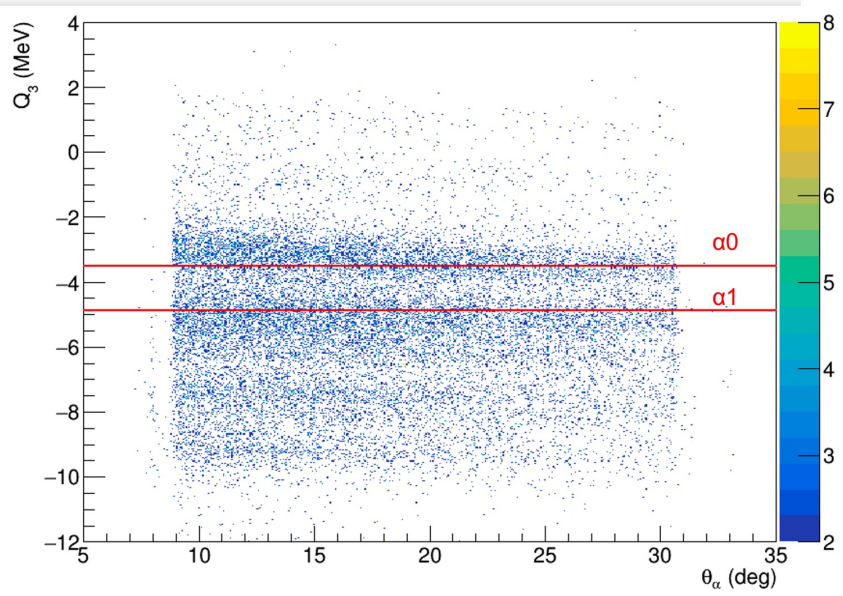
Study of the $^{12}C+^{16}O$ Fusion via the Trojan Horse Method

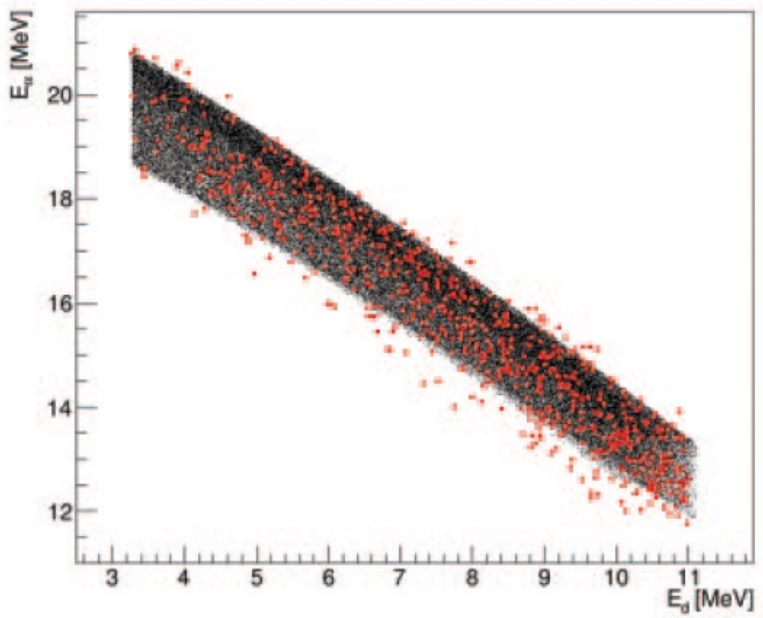


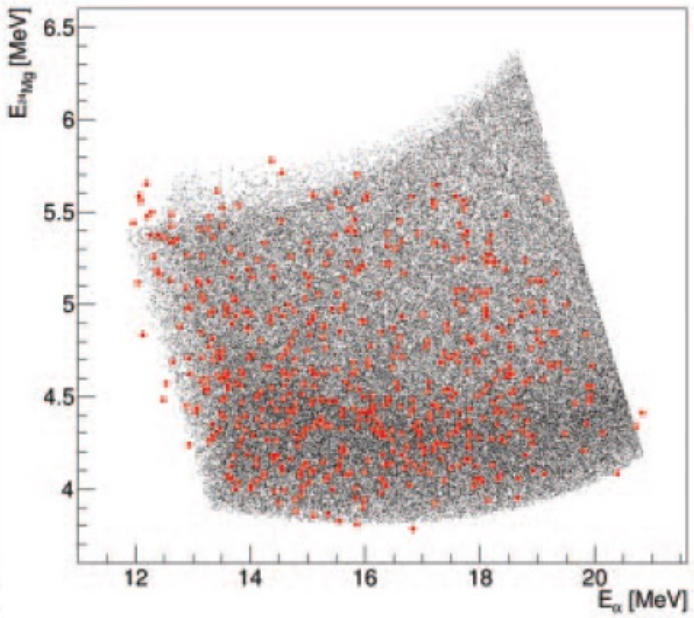


- Stellar nucleosynthesis
- Cluster physics
- Massive TH nucleus

2019 run @ LNS => THM works
but we need more statistics



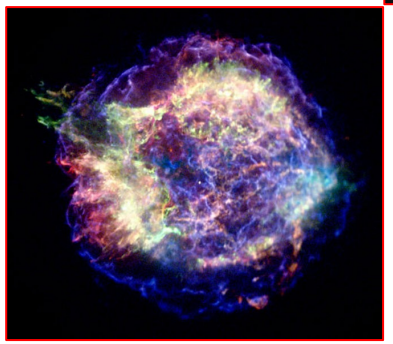




Attività di ricerca «teorica» @ PG

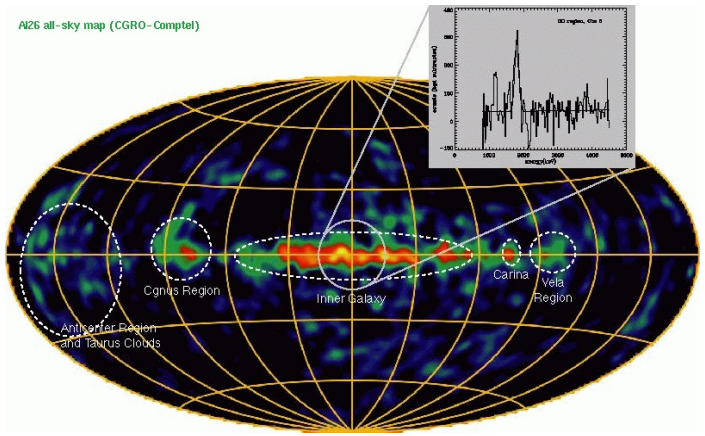
Nucleosintesi da cattura neutronica:

- r-process
- s-process
- SNII & AGB



$^{17}O(\alpha,n)^{20}Ne$
$^{22}Ne(\alpha,n)^{25}Mg$

$^{12}C+^{12}C$
$^{16}O+^{16}O$
$^{12}C + ^{16}O$



$^{(22)}Ne$

$^{(26)-27}Al$

$^{(23)}Na$

$^{(18-19)}F$

PRINCIPALI RISULTATI 2021-2022

☆Analisi degli effetti sulla nucleositesi stellare delle sezioni d'urto $^{12}C+^{12}C$, $^{12}C+^{16}O$ e $^{16}O+^{16}O$;

The Astrophysical Journal, 916:79 (9pp), 2021 August 1 https://doi.org/10.3847/1538-4357/ac06ca

Impact of the New Measurement of the $^{12}C + ^{12}C$ Fusion Cross Section on the Final Compactness of Massive Stars

Alessandro Chieffi[1,2,3], Lorenzo Roberti[4,5], Marco Limongi[3,5,6], Marco La Cognata[7], Livio Lamia[7,8], Sara Palmerini[3,9], Rosario Gianluca Pizzone[7], Roberta Spartà[7], and Aurora Tumino[7,10]
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5123, Catania, Italy
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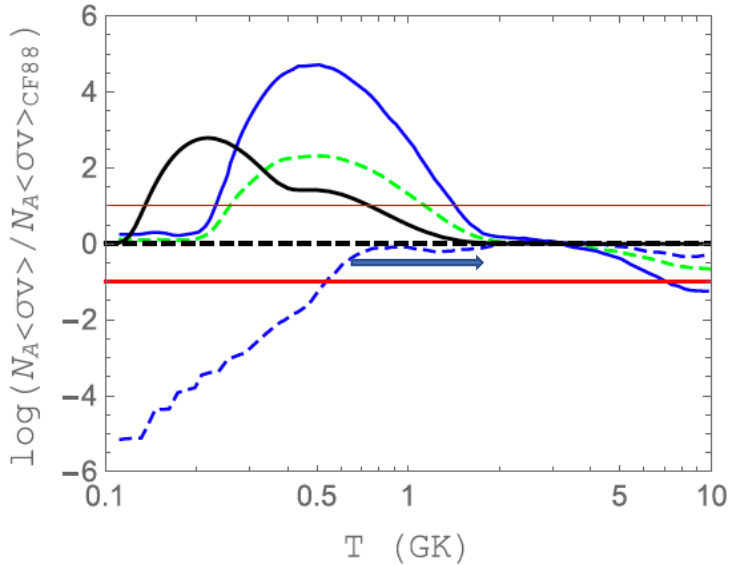
hed 2021 July 30



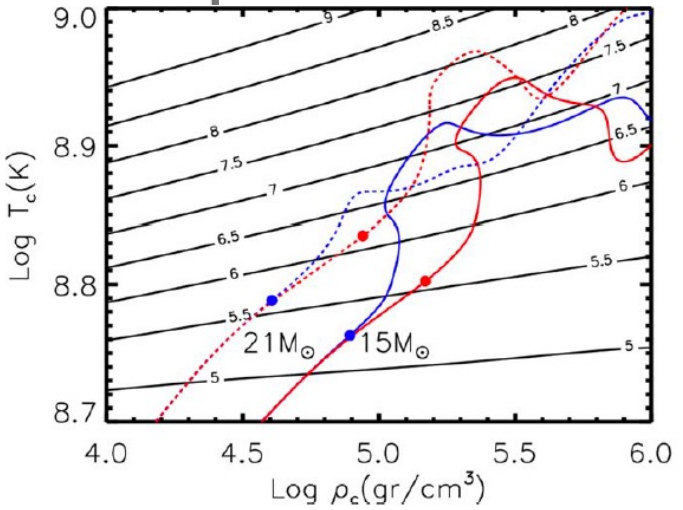


Figure 3. Logarithm of the isoneutrino energy losses (erg per gram per second) in black. Path followed by the 15 $M_\odot$ (solid lines) and the 21 $M_\odot$ (dashed lines). The THM and the CF88 models are shown in blue and red, respectively.

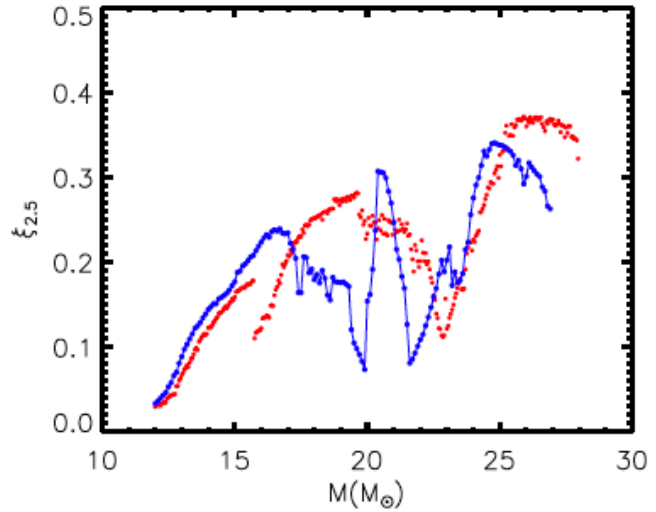


Figure 9. Comparison between the final compactness obtained by adopting the $^{12}C + ^{12}C$ nuclear cross section provided by CF88 (red dots) and the new one measured by Tumino et al. (2018) (blue dots).

Preventivi 2023

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Progetto ASFIN_2 - PG (CSN3) - Preventivo anno 2024 -

In questa pagina sono elencate le richieste di fondi (in K€) inserite per il progetto sulla struttura PG

13-07-2023: La presa dati per questa commissione chiuderà alle 23.59 del 26-07-2023

Responsabili del progetto: Sara Palmerini

Vai al progetto nazionale

Scarica la tabella in formato CSV

Capitolo	Descrizione	Parziali (k€)		Rimuovi	Modifica	Totale (k€)	
		Richieste	SJ			Richieste	SJ
missioni	laser induced deuterium fusion in Korea 1 ric. x 21gg (0.9 kEuro travel + 130 Euro x 21)=3.5 kEuro	3.50	0.00			19	8
	6Li(p,a) and 7Li(p,a) experiment at Mumbay Tandem 1 ric. x 15gg (0.9 kEuro travel + 130 Euro x 15)=3kEuro s.j. assegnazione fascio	0.00	3.00				
	26Al(n,p) and (n,a) experiment at TRIUMF 1 ric. x 15gg (0.9 kEuro travel + 130 Euro x 15)=3kEuro s.j. calendarizzazione fascio	0.00	3.00				
	6He+ p and 6He +d experiment at RIKEN 1 ric x 15 gg (0.9 kEuro travel + 130 Euro x 15)=3kEuro	3.00	0.00				
	7Be+208Pb, p(12C,12C*)p' perimental runs at LNL 2ric x 10gg (0.5kEuro [2A/R in treno] + 2x10x130 Euro)= 3kEuro	3.00	0.00				
	C+O fusion measurements by THM at Koeln: 1ric x 21gg (spokeperson) + 1 ric x10 gg 2 x 0.5 kEuro travel + 130 Euro x 31gg = 7.5kEuro	7.50	0.00				
	23Na(a,p) measurement by THM at LNS 2 ric. x 15gg (2x(0.5 Keuro travel + 130 Euro x 15))= 4kEuro Il 50% dell'importo sj j alla riapertura della foresteria degli LNS che se si verificasse abbatterebbe notevolmente i costi delle missioni	2.00	2.00				
Totale						19	8

Aggiungi Richiesta