The Status and Future of CASPAR

Compact Accelerator System for Performing Astrophysical Research

Michael Wiescher

At the Sanford Underground Research Facility SURF

- Location 2015-2020
- Operation 2017-2020
- Accomplishment 2028-2020
- Mothballed 2021-2023
- Vision 2023⇨

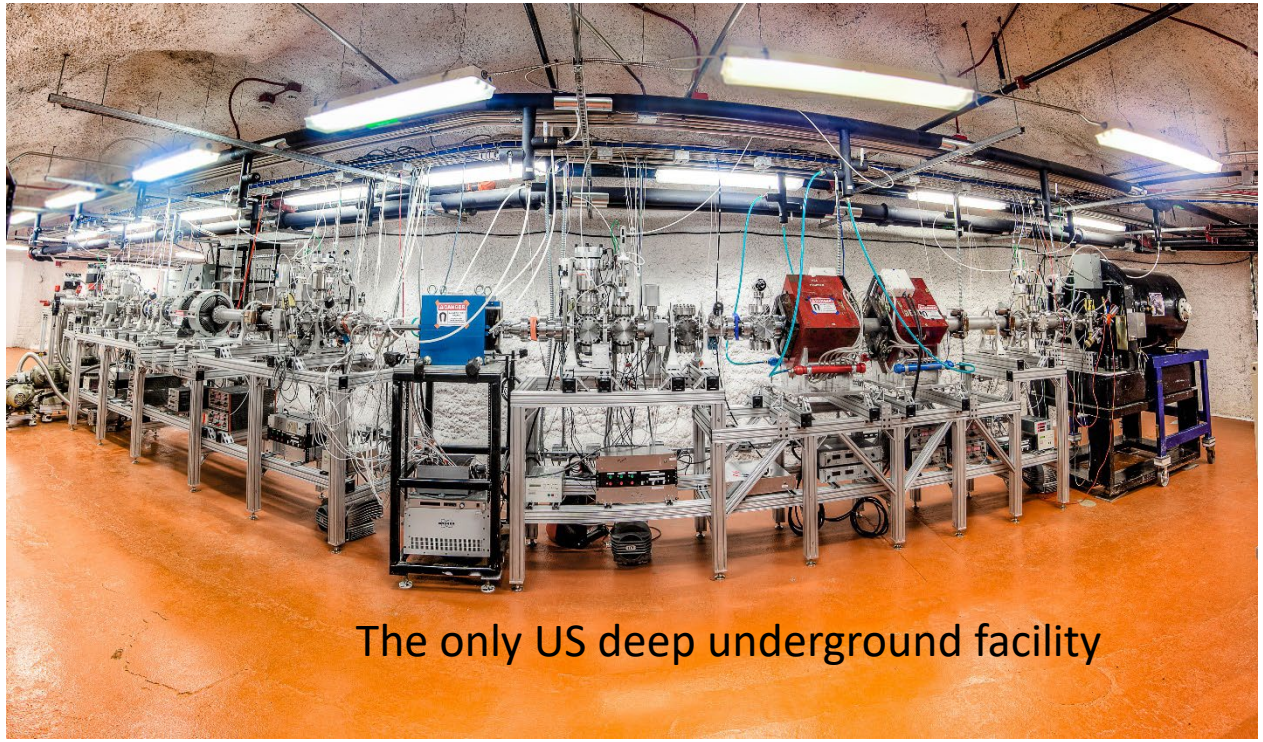
Operation of CASPAR

Operated jointly by the University of Notre Dame and South Dakota School of Mines & Technology, users:
U. Tennessee and ORNL!

Installation: 2015-2017
Operation: 2018-2021

Continuous operation in 2020
2021-2024 shut-down period for DUNE excavation!

24 hour access
I =50 to 200μA. E =150 to 1150 keV

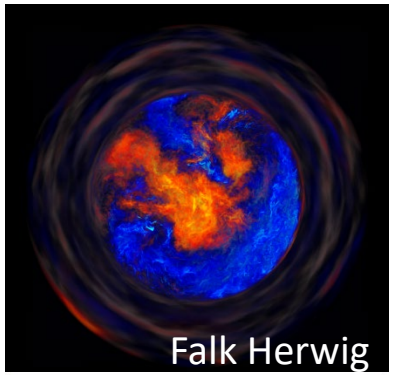


1 PhD theses for SD-Mines, two in preparation
3 PhD theses for Notre Dame, one in preparation

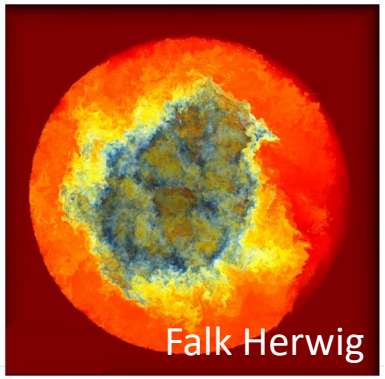
6 scientific publications (PRC and PRL)
4 scientific publications in preparation

Scientific Topics

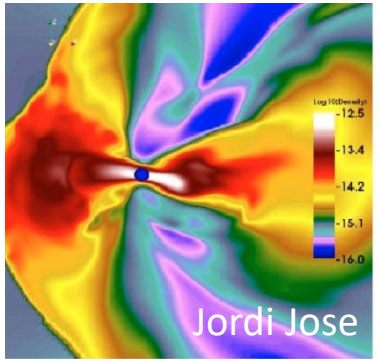
First star nucleosynthesis:
From primordial (H, He, Li) to biological abundances (C, O)
Facilitated by alpha clusters in light nuclei



Neutron sources:
s-, i-, and n-process in quiescent and explosive stellar environments
Fueled by alpha clustering in light nuclei



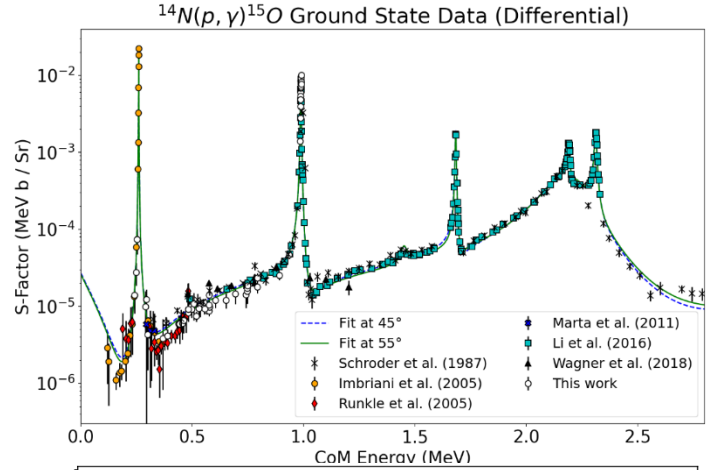
The end-point of nova nucleosynthesis:
Abundance pattern in nova ejecta and meteoritic inclusions
Limited to the single particle configuration of sd-shell nuclei

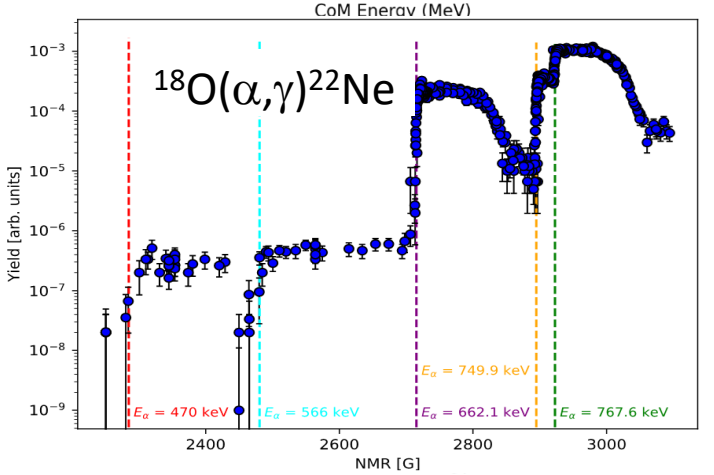


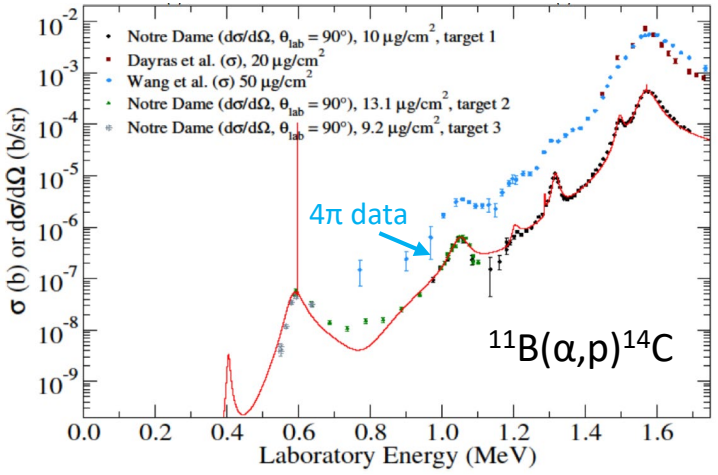
CASPAR Accomplishments

Higher energies and complementary reaction channels were measured at the Notre Dame 5U pelletron accelerator!

CNO neutrino sources:	$^{14}N(p,\gamma)^{15}O$	published
First Star nucleosynthesis:	$^{7}Li(\alpha,\gamma)^{11}B$	in preparation
	$^{10}B(\alpha,n)^{13}N$	published
	$^{11}B(\alpha,n)^{14}N$	in preparation
	$^{11}B(\alpha,p)^{14}C$	accepted
Stellar neutron sources:	$^{13}C(\alpha,n)^{16}O$	published
	$^{18}O(\alpha,\gamma)^{22}Ne$	published
	$^{22}Ne(\alpha,\gamma)^{26}Mg$	published
	$^{22}Ne(\alpha,n)^{25}Mg$	in preparation
Detector tests:	$^{27}Al(p,\gamma)^{15}O$	published
	$^{11}B,^{13}C(\alpha,n)^{16}O$	in preparation



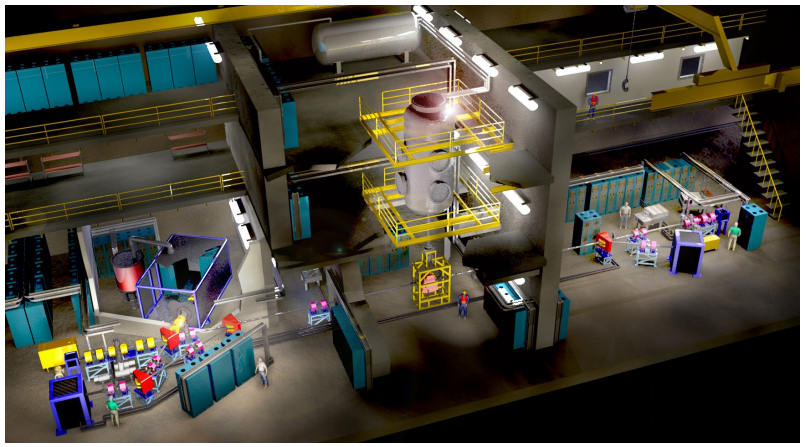




International Complements (last 2 years)

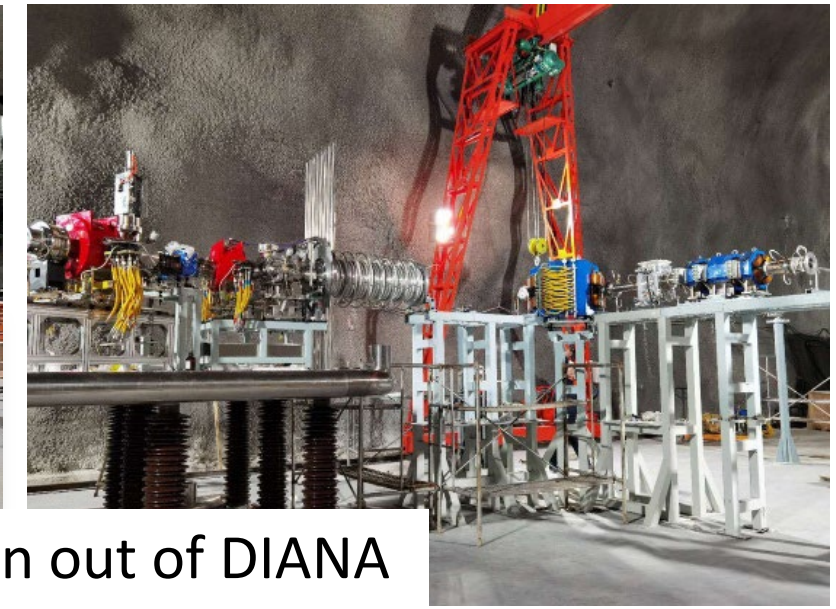
Pioneer in the field

$^{12}C(p,\gamma)^{13}N$
$^{16}O(p,\gamma)^{17}F$
$^{18}O(p,\gamma)^{19}F$
$^{13}C(\alpha,n)^{16}O$



The future is in coupling all these initiatives to optimize the effort, and come to an improved theoretical treatment with the inclusion of the indirect THM data!

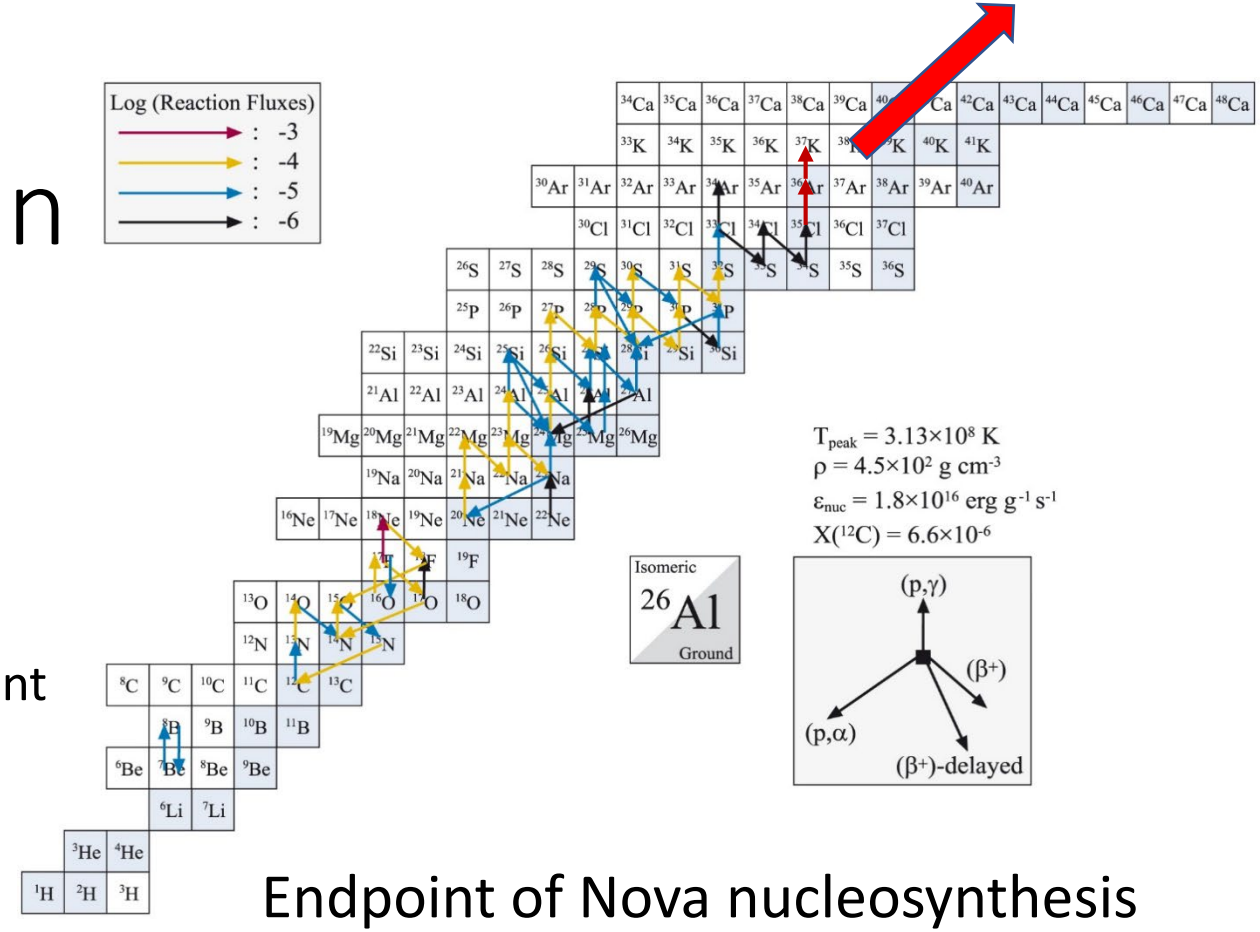
Planned:
$^{14}N(p,\gamma)^{16}O$
$^{22}Ne(\alpha,n)^{25}Mg$
$^{12}C+^{12}C$



Born out of DIANA

$^{19}F(p,\gamma)^{20}Ne$
$^{19}F(p,\alpha)^{16}O$
$^{13}C(\alpha,n)^{16}O$

CASPAR Long Range Plan



First Star nucleosynthesis

$^{10}B(\alpha,d)^{12}C$ towards lower energies

$^{10}B(\alpha,p)^{13}C$ towards lower energies

$^{11}B(\alpha,\gamma)^{15}N$ in high neutron background environment

towards lower energies at LUNA?

Stellar Neutron Sources

$^{22}Ne(\alpha,\gamma)^{26}Mg$ with improved statistics

$^{22}Ne(\alpha,n)^{25}Mg$ with new ND/ORNL developed

$^{21}Ne(\alpha,n)^{24}Mg$ with new ND/ORNL developed

$^{25}Mg(\alpha,n)^{28}Si$ neutron detection techniques

$^{26}Mg(\alpha,n)^{29}Si$

Endpoint of Nova nucleosynthesis

$^{39}K(p,\gamma)^{40}Ca$

$^{40}Ca(p,\gamma)^{41}Sc$

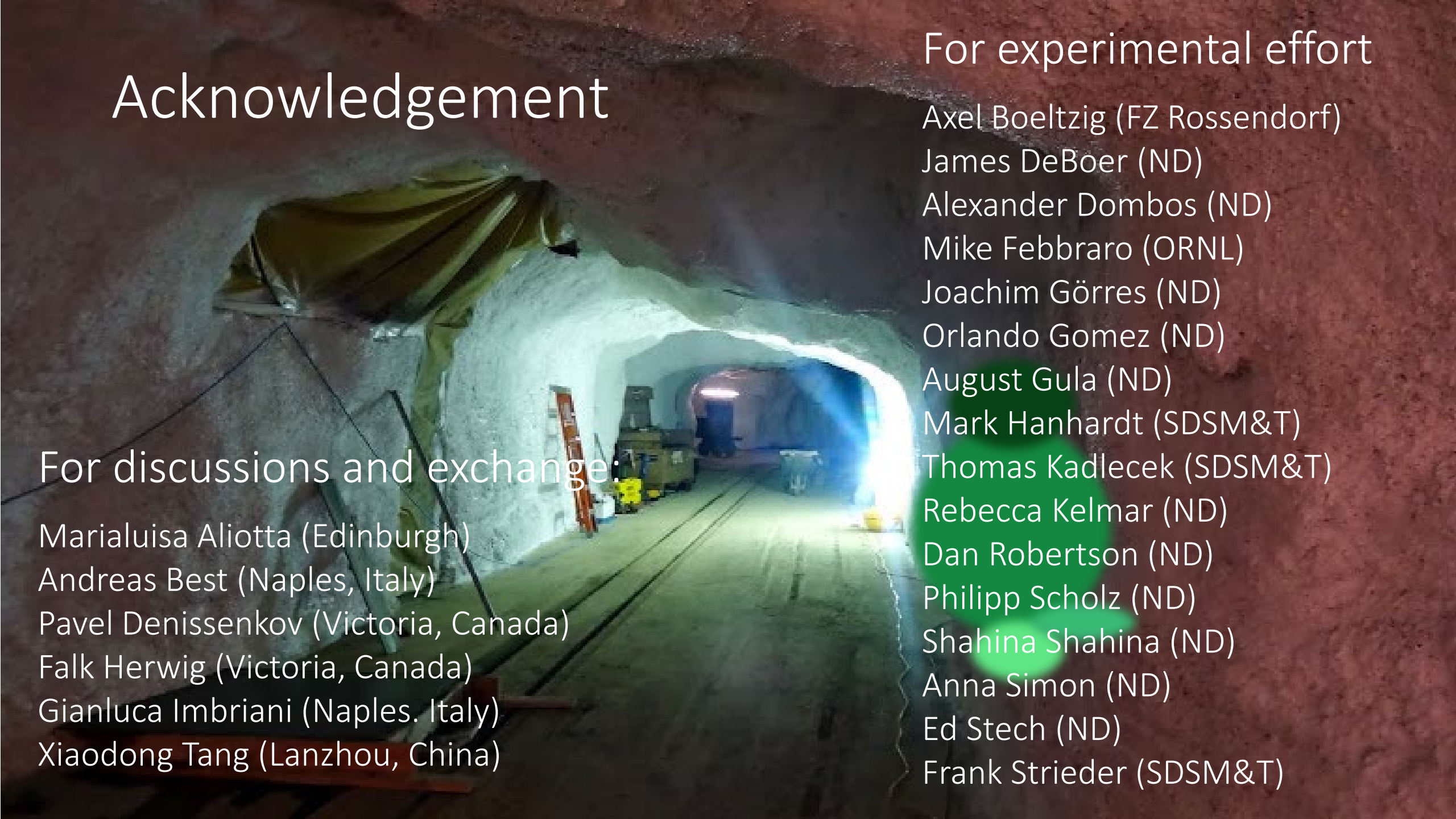
$^{42}Ca(p,\gamma)^{43}Sc$ along the line of stability

$^{45}Sc(p,\gamma)^{46}Ti$

$^{46}Ti(p,\gamma)^{47}Va$ …

taking into account single particle and level density considerations

Acknowledgement



For discussions and exchange:

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Dan Robertson (ND)
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Shahina Shahina (ND)
Anna Simon (ND)
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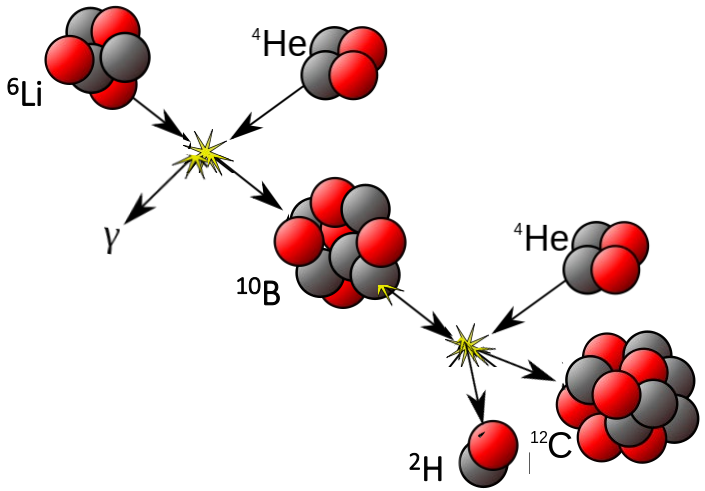
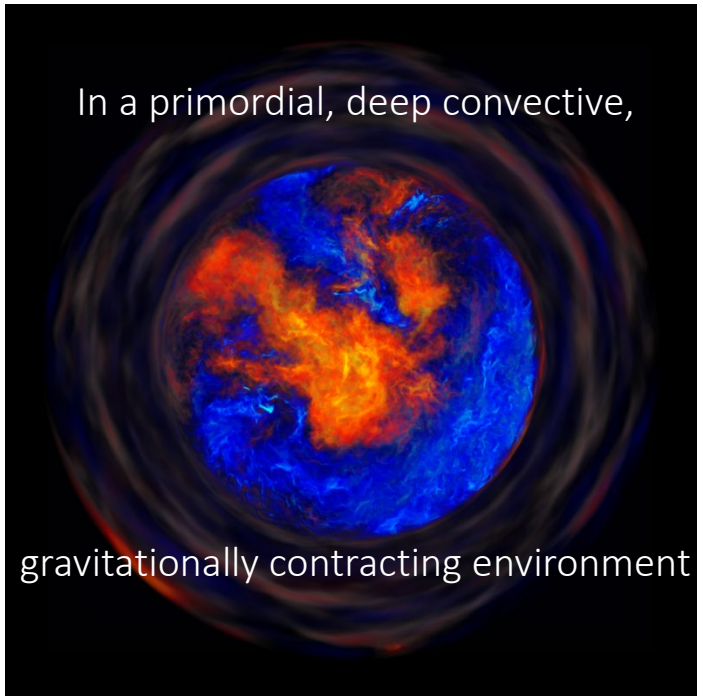
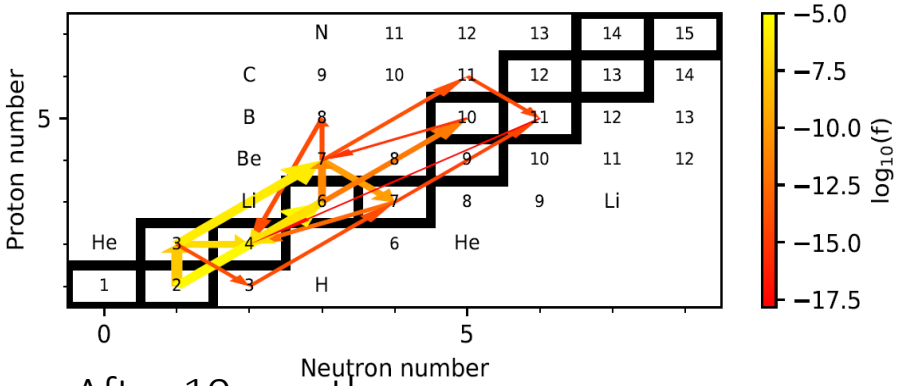
First Star Nucleosynthesis



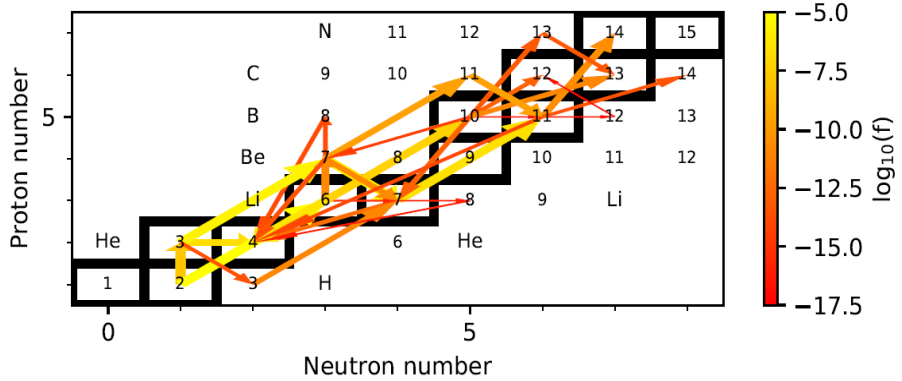
The ^{6}Li(α,γ)^{10}B(α,d)^{12}C
^{10}B(α,n)^{13}N
^{10}B(α,p)^{13}C versus the ^{4}He(2α,γ)^{12}C
And back ^{10}B(p,α)^{7}Be

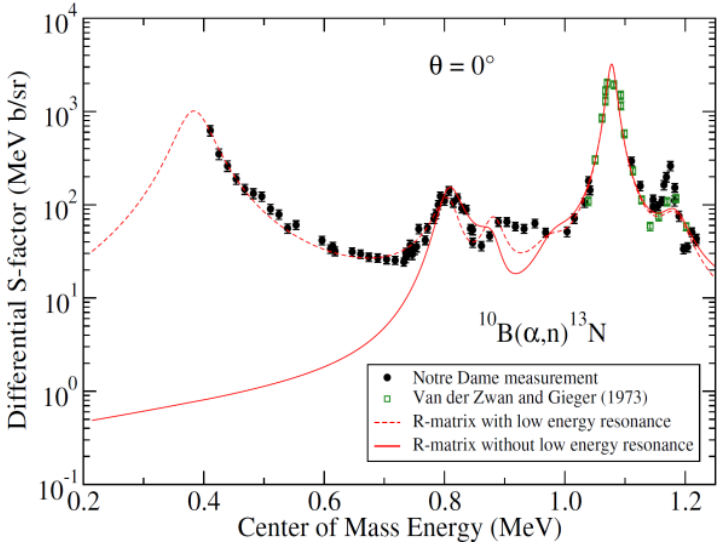


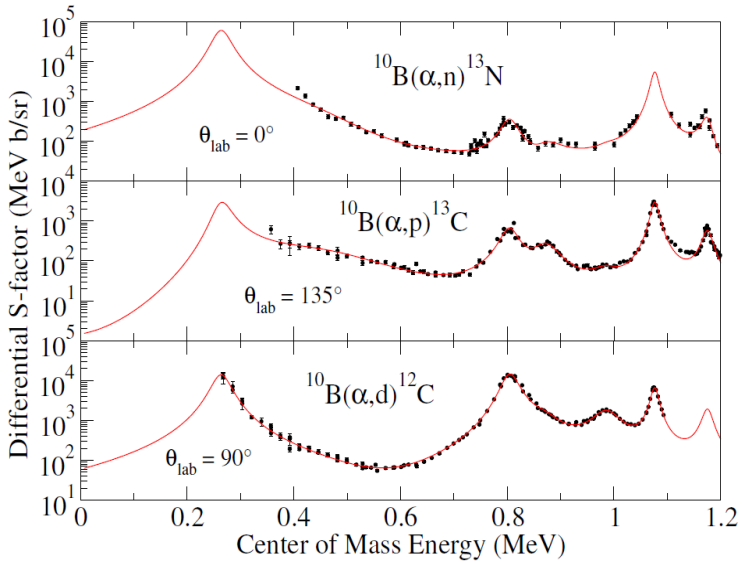
After 1 hour



After 10 months







Alpha cluster states and Stellar Neutron Sources

Over a wide energy range and single resonances complementing above ground experiments:

$^{13}C\ (\alpha,n)^{16}O$	James DeBoer
$^{18}O(\alpha,\gamma)^{22}Ne$	with HECTOR
$^{18}O(\alpha,n)^{21}Ne$	with ODESA
$^{22}Ne(\alpha,\gamma)^{26}Mg$	with HECTOR
$^{22}Ne(\alpha,n)^{25}Mg$	with ODESA
$^{25}Mg(\alpha,n)^{28}Si$	with ODESA
$^{21}Ne(\alpha,n)^{24}Mg$	in planning
$^{26}Mg(\alpha,n)^{29}Si$	in planning