LUNA400 and LUNA-MV: present and future of Nuclear Astrophysics at Gran Sasso

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LUNA400 (2015-2018):

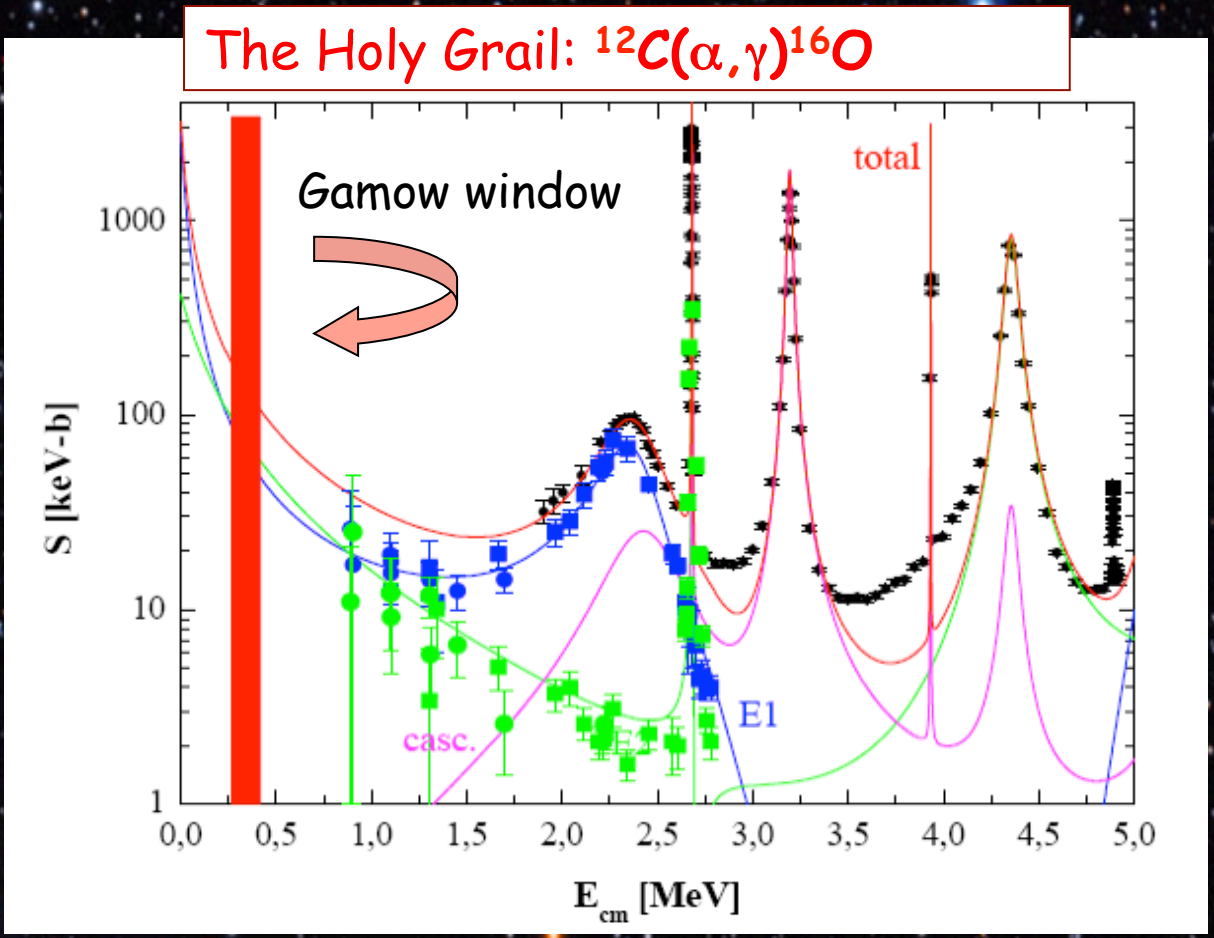
$D(p,\gamma)^3He$	BBN
$^{13}C(\alpha,n)^{16}O$	S-process
$^{12}C(p,\gamma)^{13}N$	Stellar evolution
$^{13}C(p,\gamma)^{14}N$	Stellar evolution
$^6Li(p,\gamma)^7Be$	Nuclear Physics

LUNA-MV:

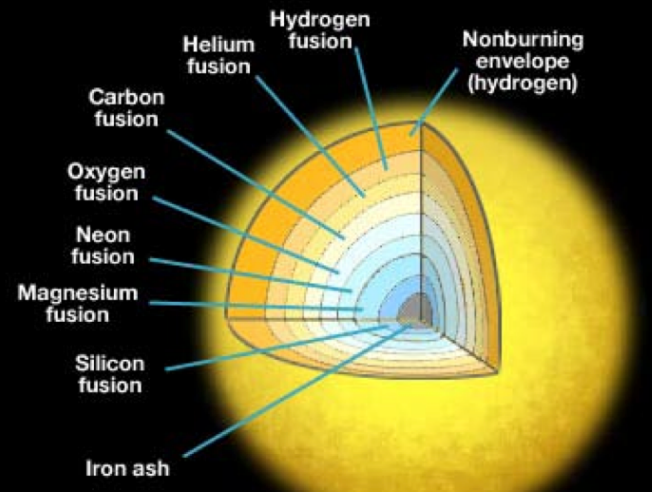
$^3He(^4He,\gamma)^7Be$	pp chain and BBN
$^{12}C(\alpha,\gamma)^{16}O$	He Burning
$^{13}C(\alpha,n)^{16}O$	S-process
$^{22}Ne(\alpha,n)^{25}Mg$	S-process
$^{12}C+^{12}C$ reactions	Carbon burning
$D(\alpha,\gamma)^6Li$	BBN

-Solar Neutrino mixing parameters
-Temperature and metallicity of the Sun
-Age of Universe
-Evolution of stars
-Isotopic abundances
-Cosmology and Particle physics

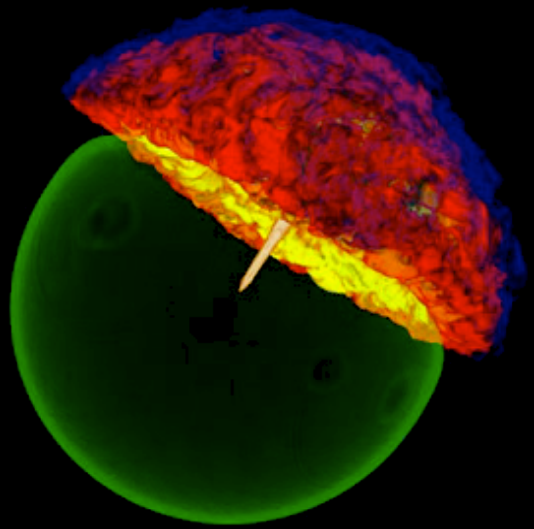
Evolution of stars: Helium Burning



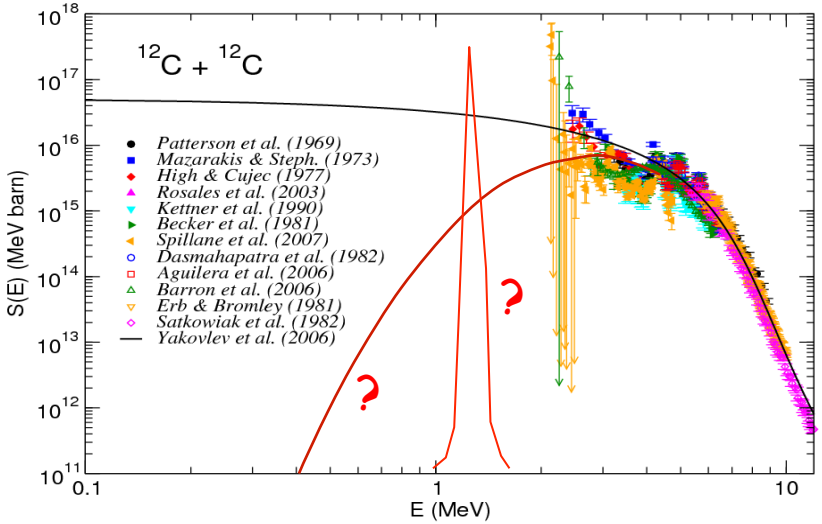
Carbon burning & type Ia supernovae



Massive star



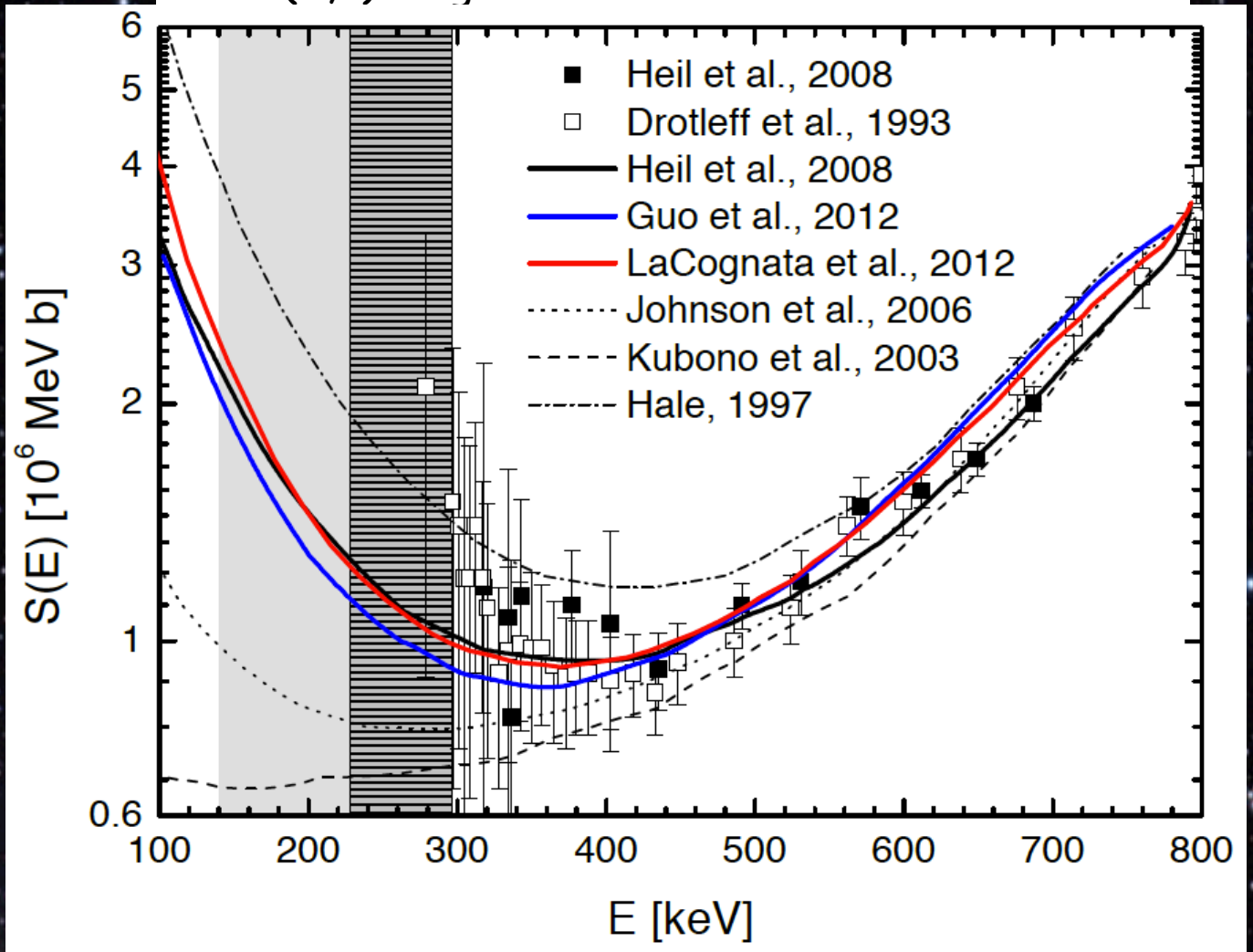
$$^{12}C + {}^{12}C \rightarrow {}^{16}O + 2\,{}^{4}He$$
$$\rightarrow {}^{20}Ne + {}^{4}He$$
$$\rightarrow {}^{23}Na + p^{+}$$
$$\rightarrow {}^{23}Mg + n$$
$$\rightarrow {}^{24}Mg + \gamma$$



S-process

$^{13}C(\alpha,n)^{16}O$ LUNA400 e LUNA-MV

$^{22}Ne(\alpha,n)^{25}Mg$ LUNA-MV



Big Bang Nucleosynthesis: The D(p,γ)^{3}He reactions

The error of computed deuterium abundance $(D/H)_{BBN}$ is mainly due to the D(p,γ)^{3}He reaction, because of the paucity of data in the BBN energy region

Reaction	Rate Symbol	$\sigma_{^2H/H} \cdot 10^5$
$p(n,\gamma)^2\mathrm{H}$	R_1	± 0.002
$d(p,\gamma)^3\mathrm{He}$	R_2	± 0.062
$d(d,n)^3\mathrm{He}$	R_3	± 0.020
$d(d,p)^3\mathrm{H}$	R_4	± 0.013

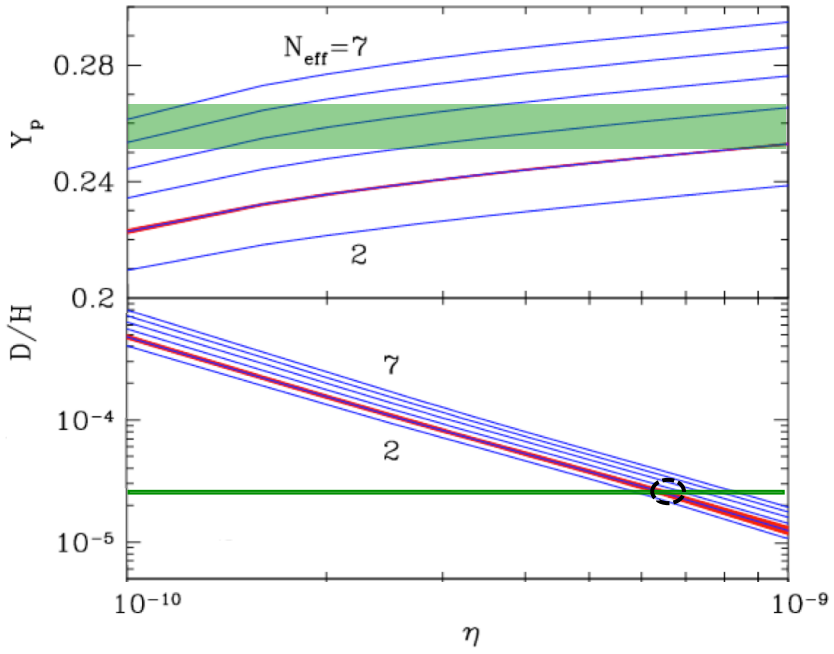
Physics:

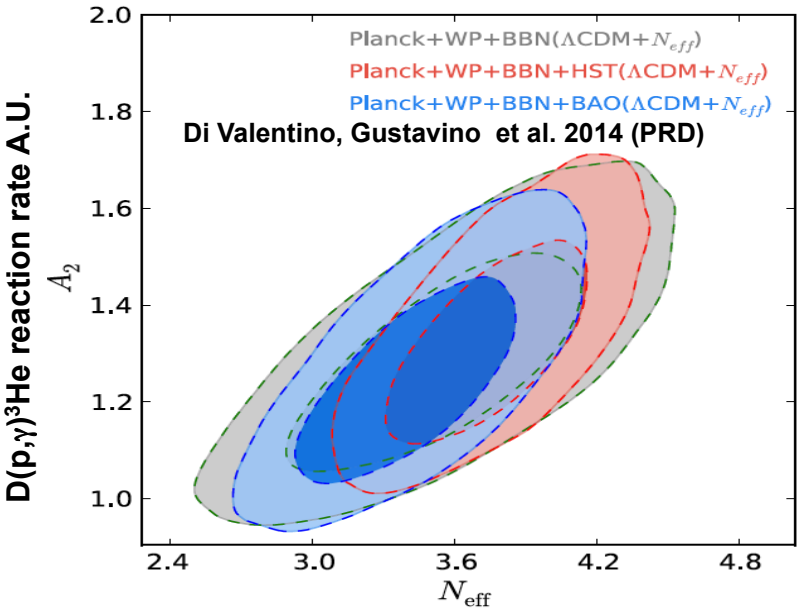
1) Cosmology: measurement of $\Omega_b h^2$.

2) Neutrino physics: measurement of N_{eff}.

3) Nuclear physics: comparison of data with theoretical "ab initio" predictions.

See also D. Trezzi talk





Other reactions?

Future LUNA program is in progress.
Suggestions are Welcome!

Example of a chain

$O^{16} + He^4 \rightarrow F^{19} + H^1$
$F^{19} + H^1 \rightarrow Ne^{20} + h\nu$
$Ne^{20} + He^4 \rightarrow Na^{23} + H^1$
$Na^{23} + H^1 \rightarrow Mg^{24} + h\nu$
$Mg^{24} + He^4 \rightarrow Al^{27} + H^1$
$Al^{27} + H^2 \rightarrow Si^{28} + n$
$Si^{28} + He^4 \rightarrow P^{31} + H^1$
$P^{31} + He^4 \rightarrow S^{34} + H^1$
$S^{34} + He^4 \rightarrow Cl^{37} + H_1$
$Cl^{37} + He^4 \rightarrow A^{40} + H_1$
$A^{40} + He^4 \rightarrow Ca^{43} + n$