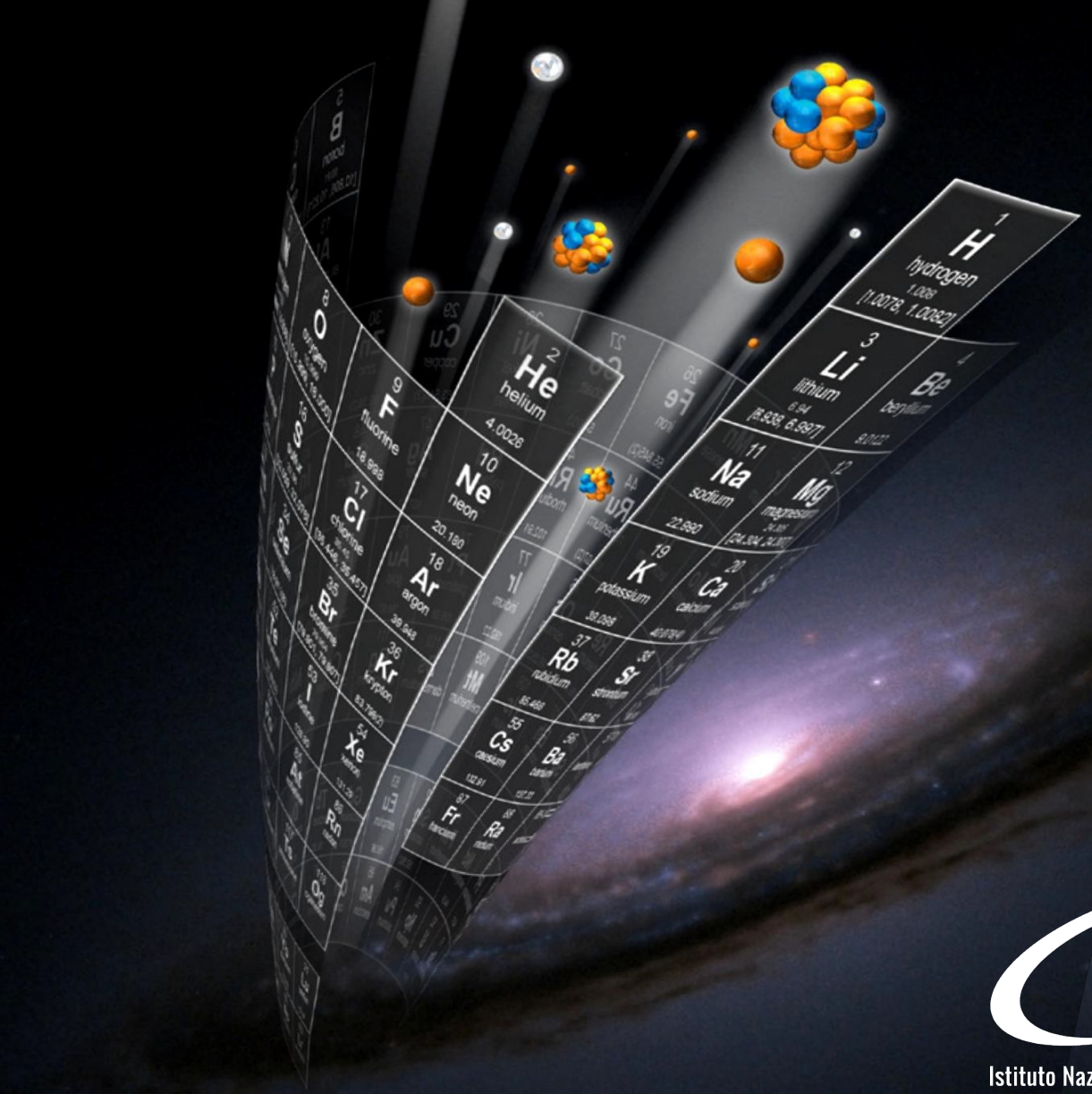


Astrofisica Nucleare @

A.D. 1308

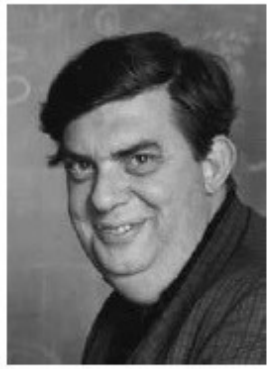
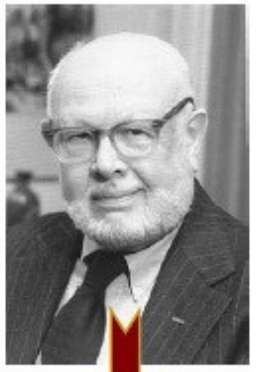
unipg

DIPARTIMENTO
DI FISICA E GEOLOGIA

INFN
Istituto Nazionale di Fisica Nucleare

Sara Palmerini
sara.palmerini@unipg.it

Burbidge | Burbidge | Fowler | Hoyle


1983
Nobel Prize

"for his theoretical and experimental studies of the nuclear reactions of importance in the formation of the chemical elements in the universe"

B²FH

REVIEWS OF
MODERN PHYSICS

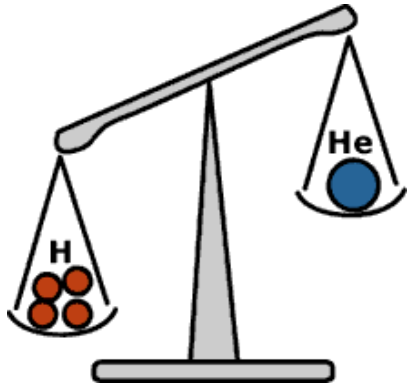
VOLUME 29, NUMBER 4 — OCTOBER, 1957

Synthesis of the Elements in Stars*

E. MARGARET BURBIDGE, G. R. BURBIDGE, WILLIAM A. FOWLER, AND F. HOYLE

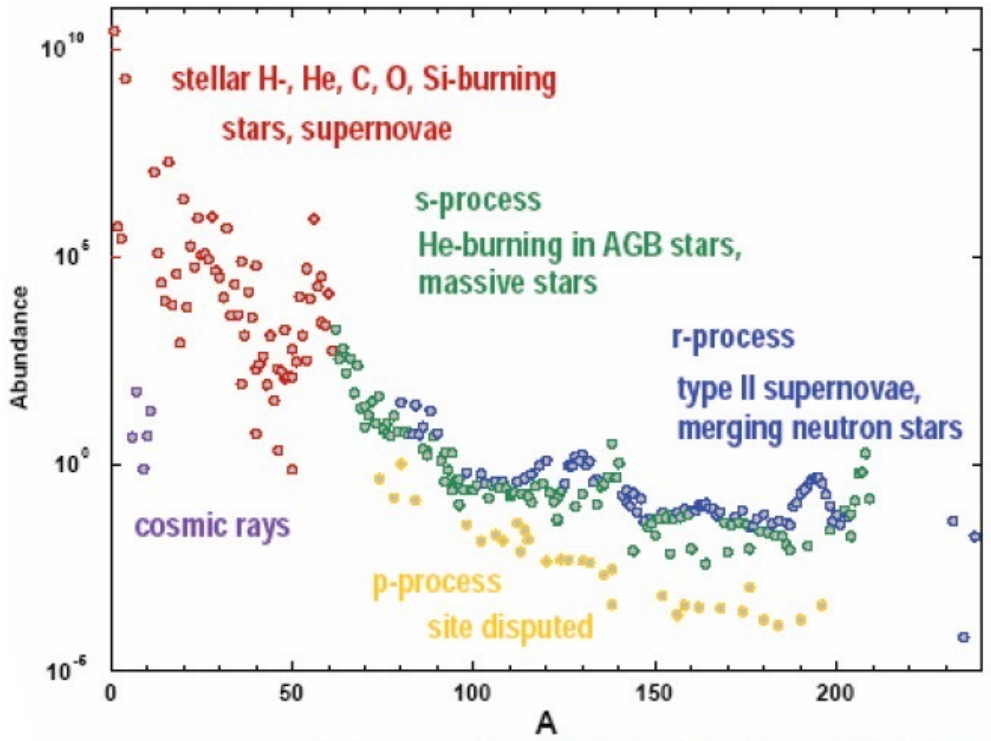
Le reazioni nucleari nelle stelle producono:

Energia
Elementi

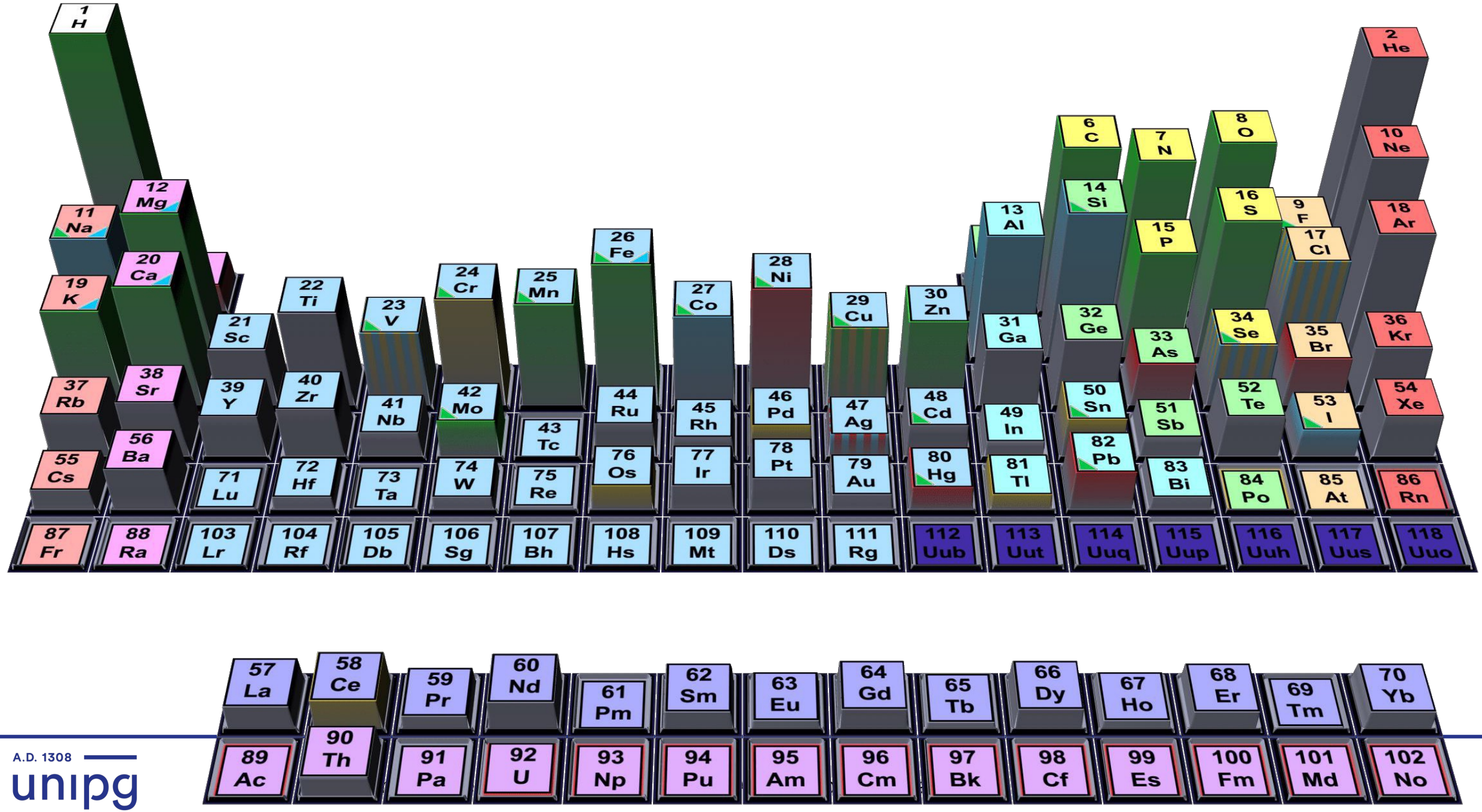


$E=mc^2$

Burbidge, Burbidge, Fowler & Hoyle (B²FH): Rev. Mod. Phys. 29 (1957) 547

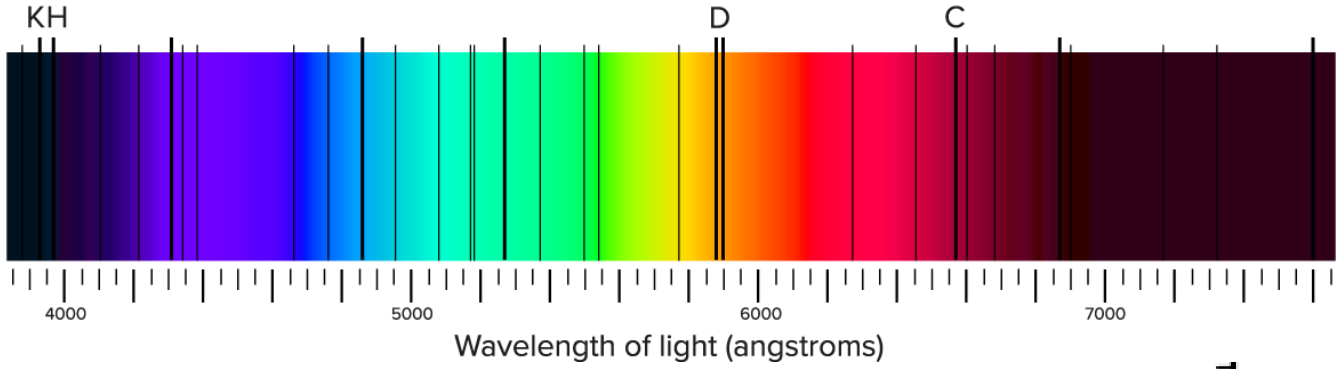


from: M. Wiescher, JINA lectures on Nuclear Astrophysics


1 H
2 He
11 Na
12 Mg
10 Ne
19 K
20 Ca
18 Ar
21 Sc
22 Ti
23 V
24 Cr
25 Mn
26 Fe
27 Co
28 Ni
29 Cu
30 Zn
13 Al
6 C
14 Si
7 N
15 P
8 O
16 S
9 F
17 Cl
37 Rb
38 Sr
39 Y
40 Zr
41 Nb
42 Mo
43 Tc
44 Ru
45 Rh
46 Pd
47 Ag
48 Cd
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
55 Cs
56 Ba
71 Lu
72 Hf
73 Ta
74 W
75 Re
76 Os
77 Ir
78 Pt
79 Au
80 Hg
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
87 Fr
88 Ra
103 Lr
104 Rf
105 Db
106 Sg
107 Bh
108 Hs
109 Mt
110 Ds
111 Rg
112 Uub
113 Uut
81 Tl
82 Pb
83 Bi
84 Po
85 At
86 Rn
114 Uuq
115 Uup
116 Uuh
117 Uus
118 Uuo
57 La
58 Ce
59 Pr
60 Nd
61 Pm
62 Sm
63 Eu
64 Gd
65 Tb
66 Dy
67 Ho
68 Er
69 Tm
70 Yb
89 Ac
90 Th
91 Pa
92 U
93 Np
94 Pu
95 Am
96 Cm
97 Bk
98 Cf
99 Es
100 Fm
101 Md
102 No

Solar System Abundances

Starting with the work of Suess and Urey (195



^{1}H: 71.1%

^{4}He: 27.4%

^{12}C and ^{16}O are more than half of the remaining mass (1.5%)

Fe peak (A = 50–65 region)

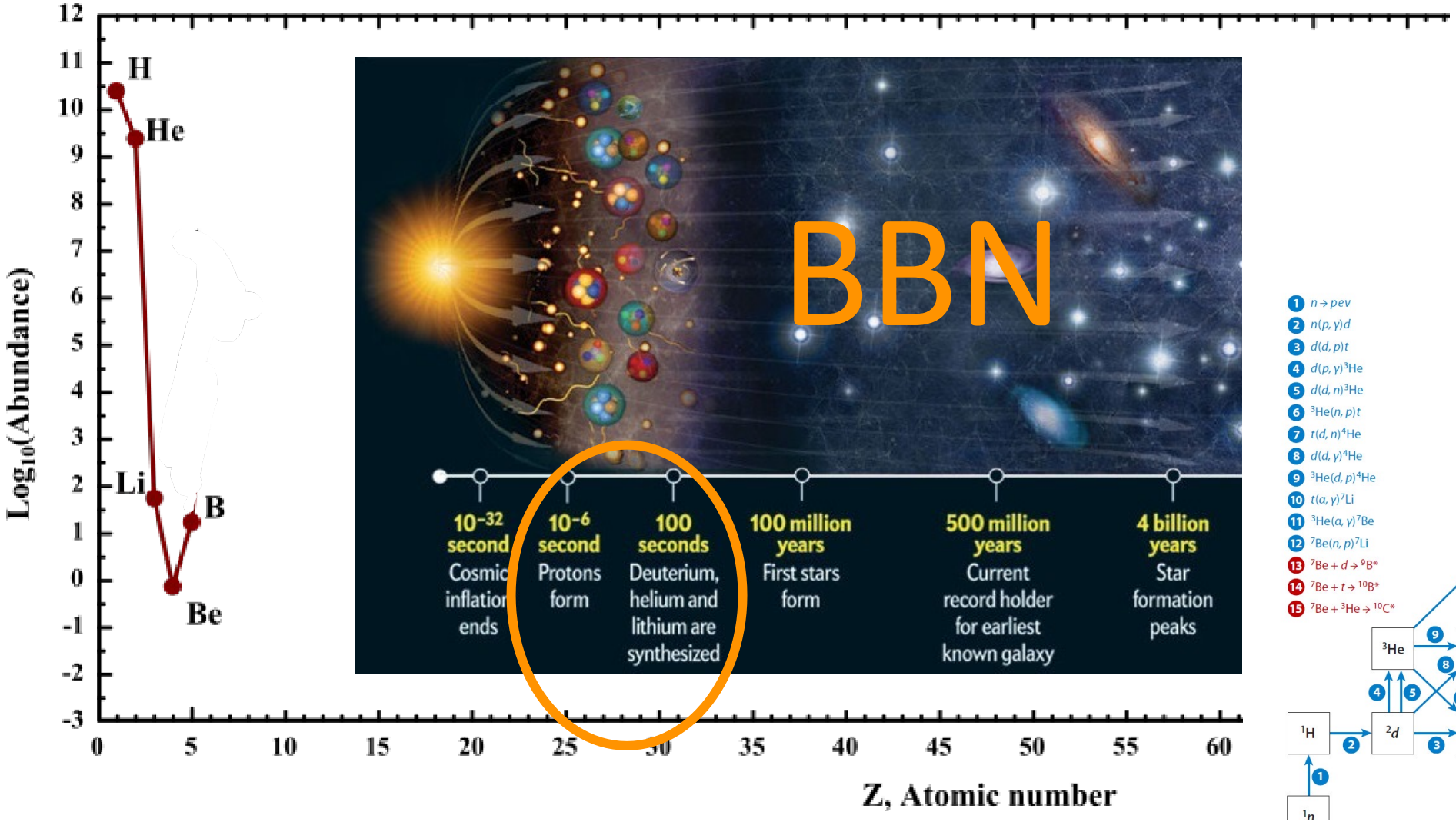
A = 110–150 peak

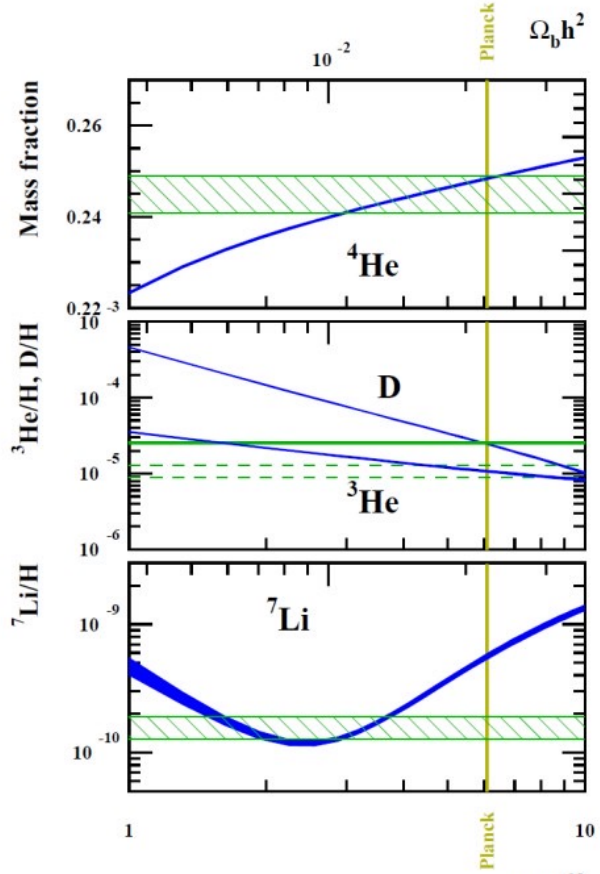
A = 180–210 peck

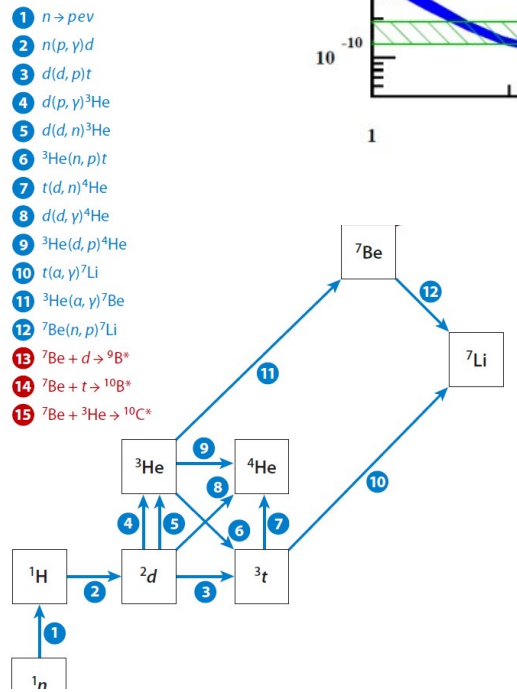
A = 5–11 MINIMUM REGION

Solar System Abundances

Starting with the work of Suess and Urey (1956)....

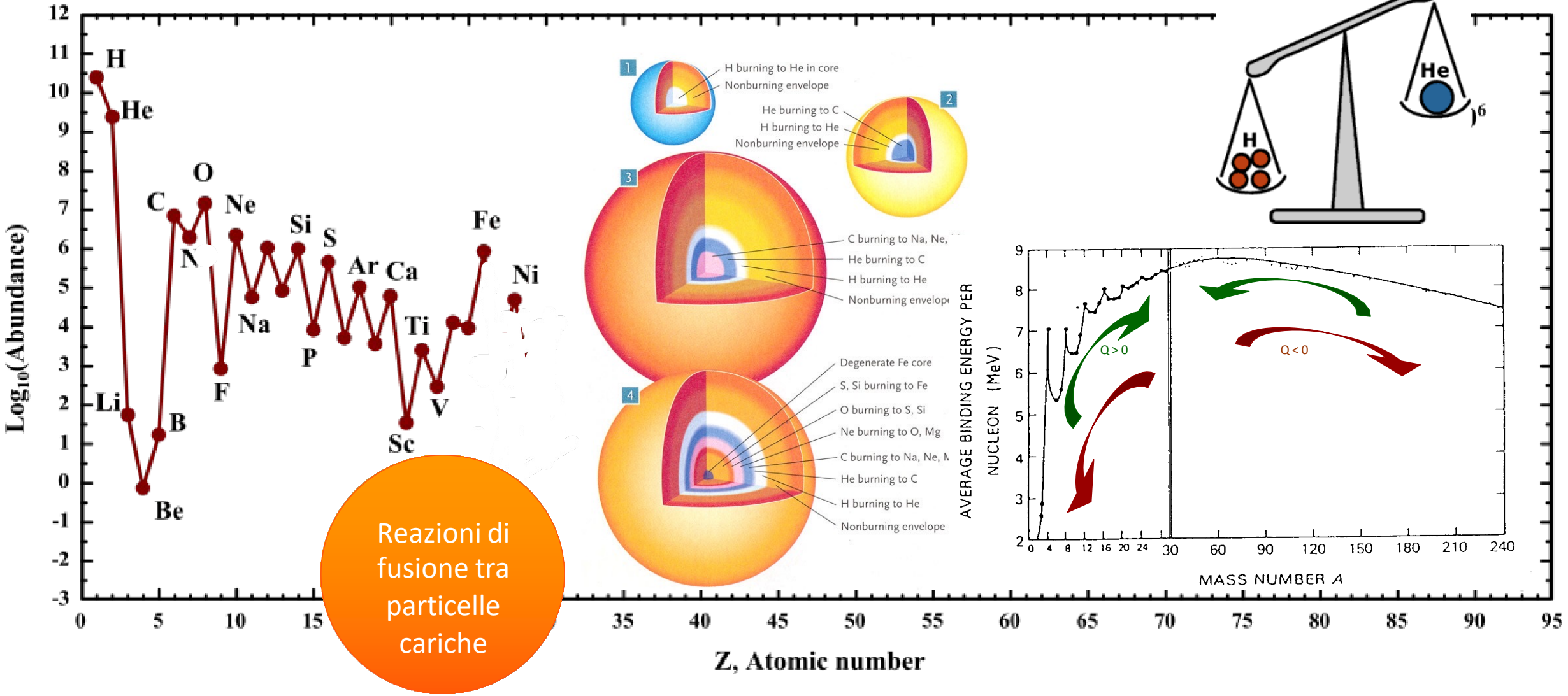






Solar System Abundances

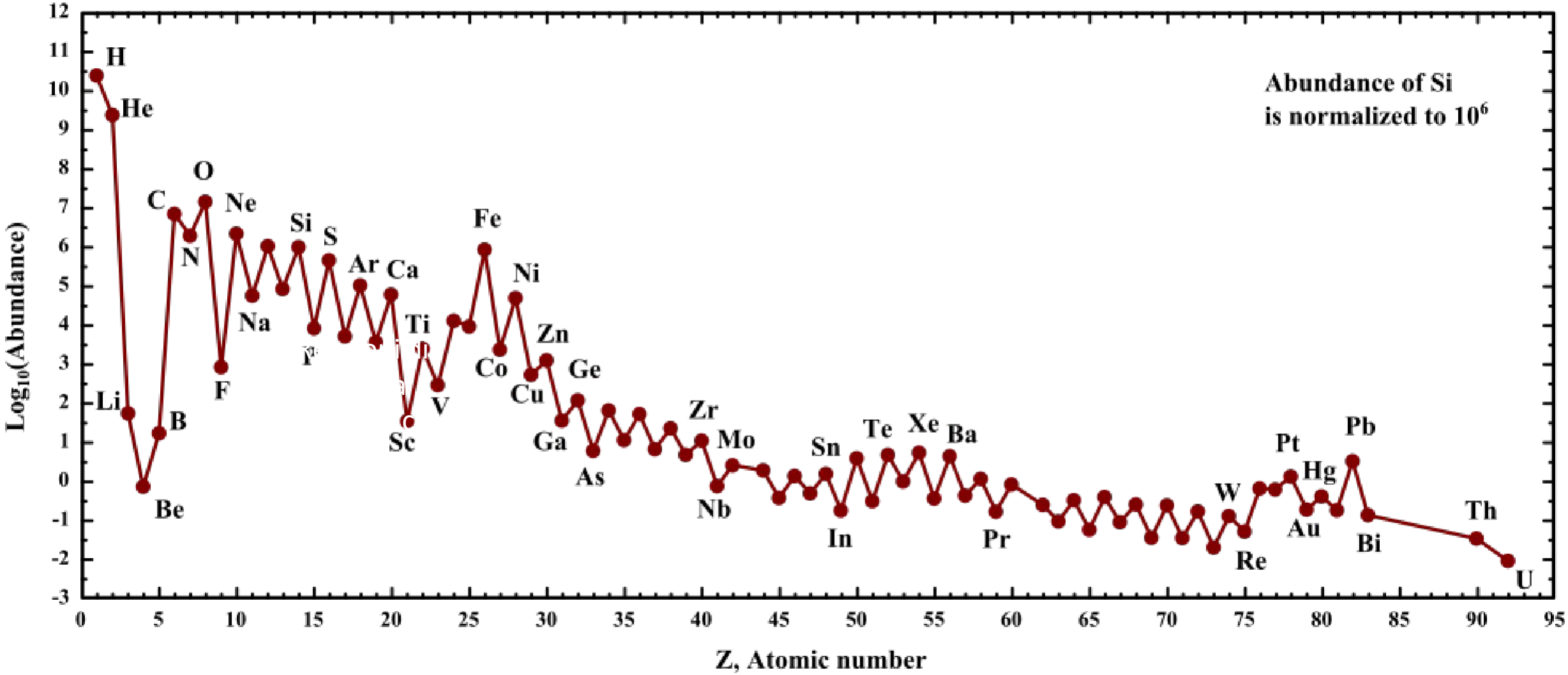
Starting with the work of Suess and Urey (1956)....



Reazioni di fusione tra particelle cariche

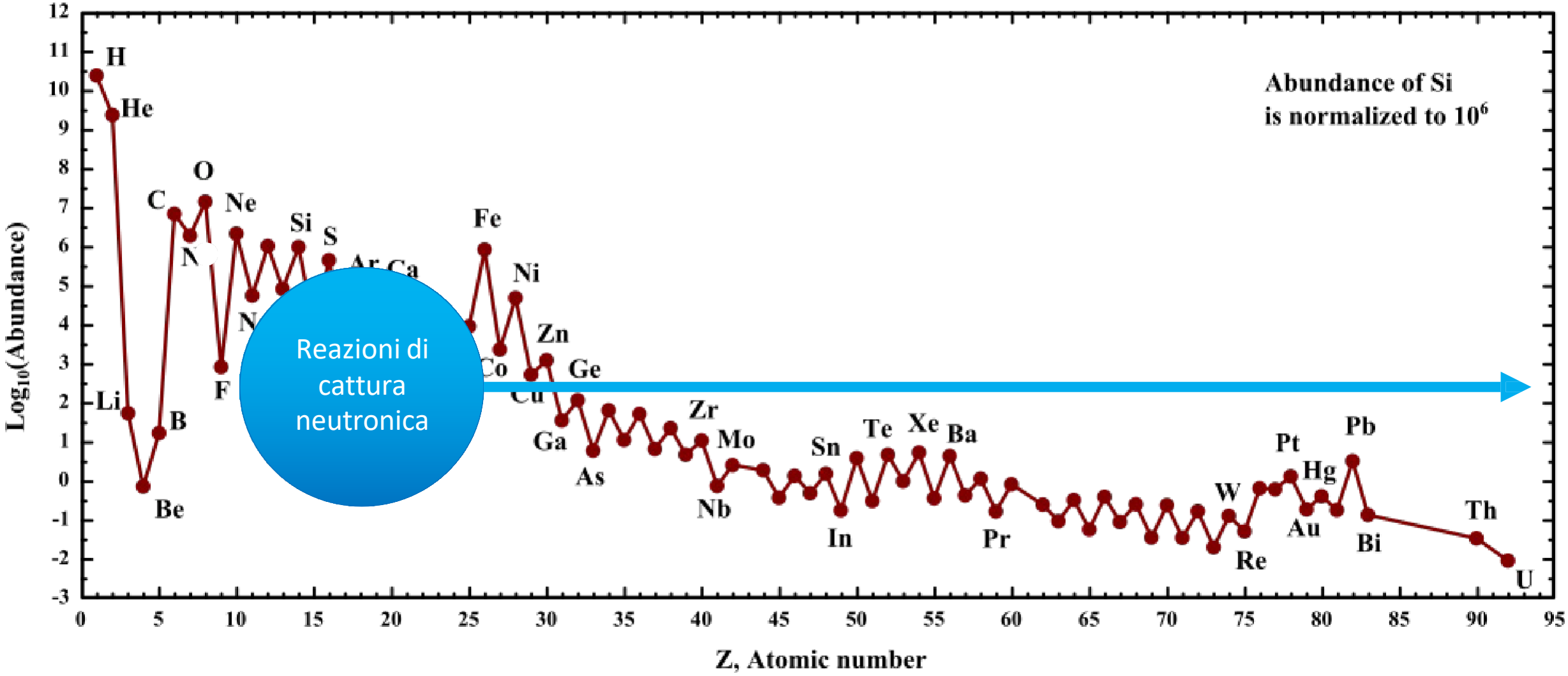
Solar System Abundances

Starting with the work of Suess and Urey (1956)....



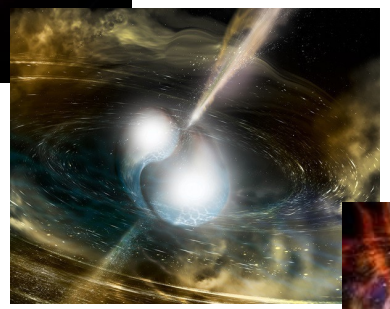
Solar System Abundances

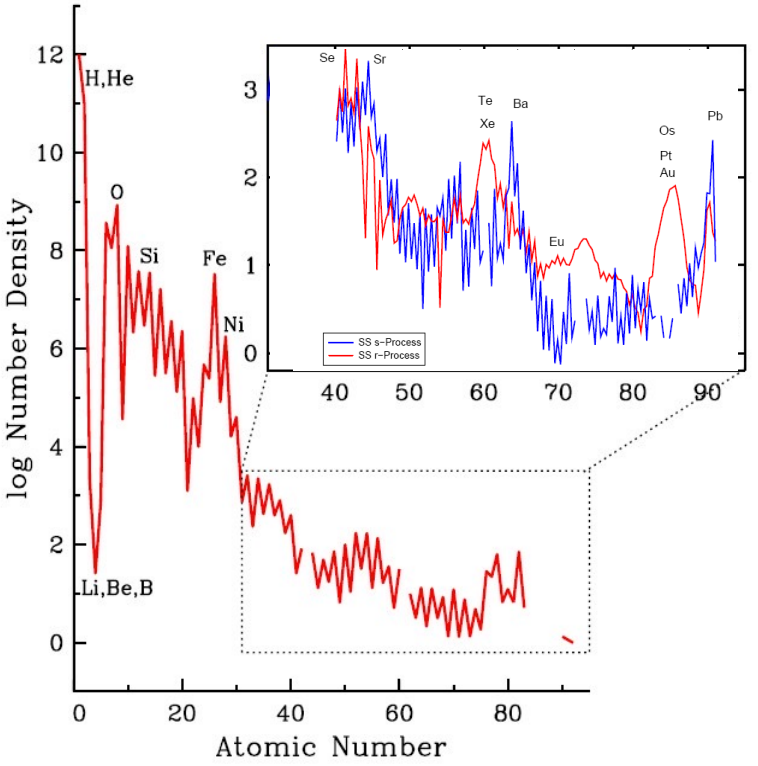
Starting with the work of Suess and Urey (1956)....



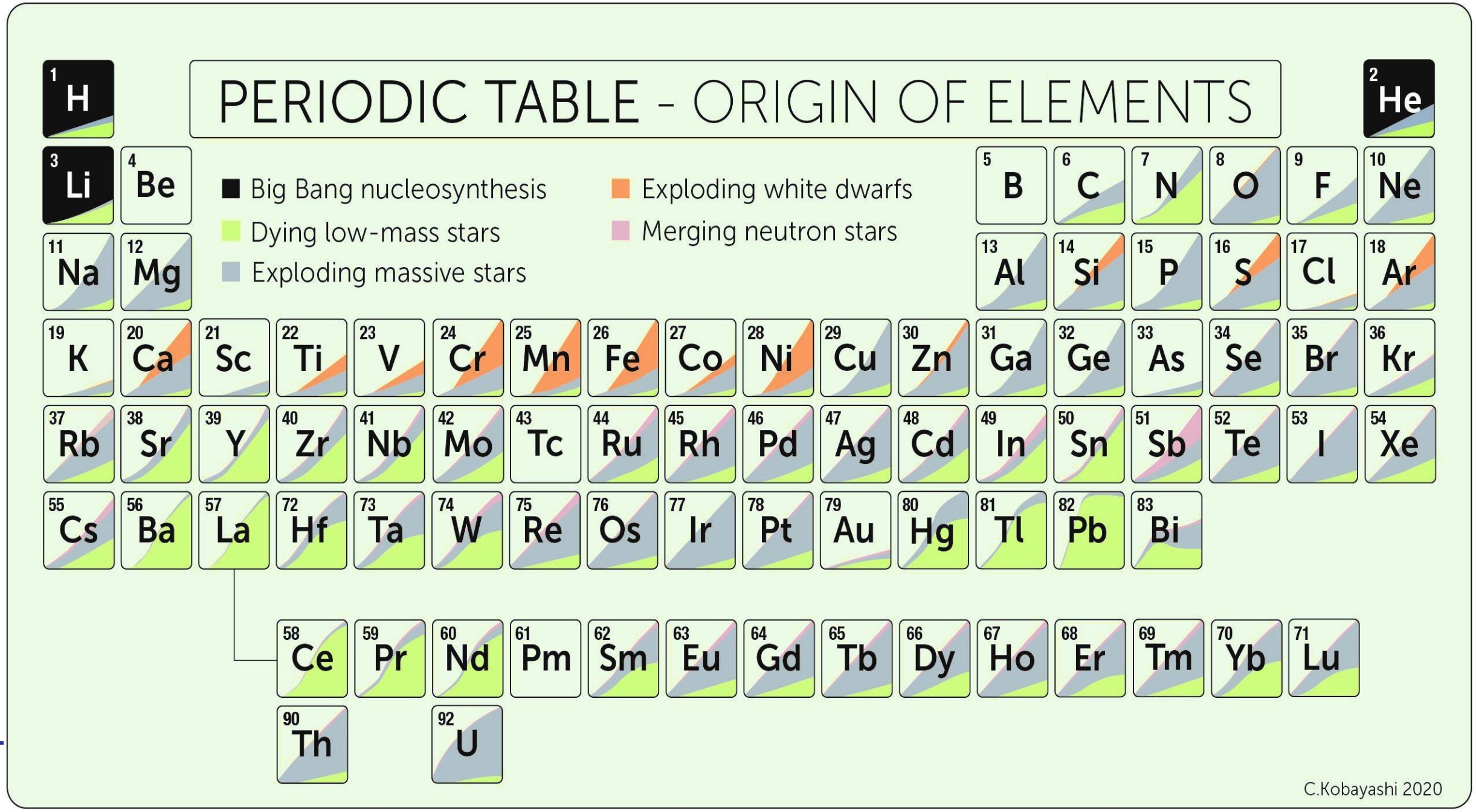
Solar System Abundances

Starting with the work of Su 56)....

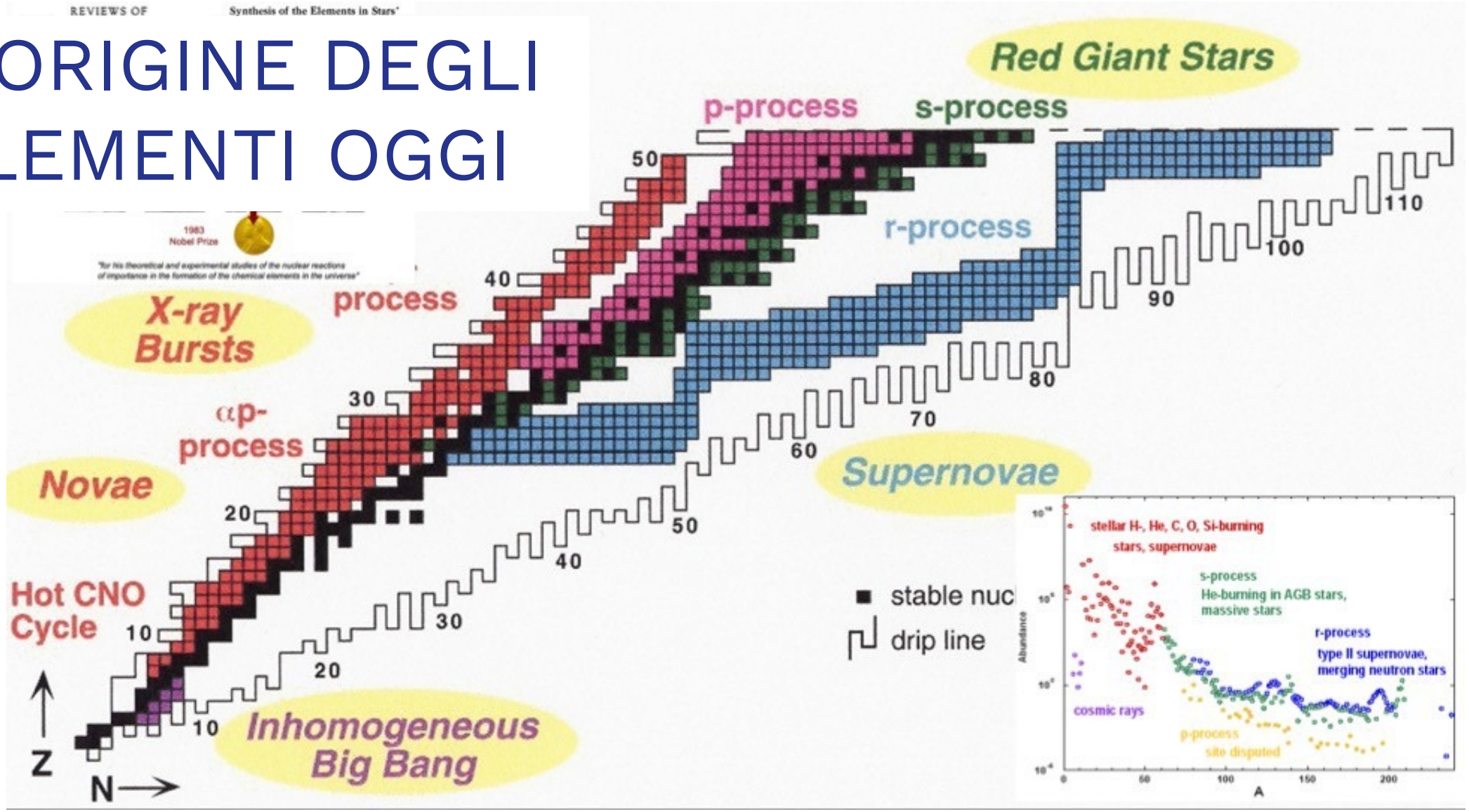




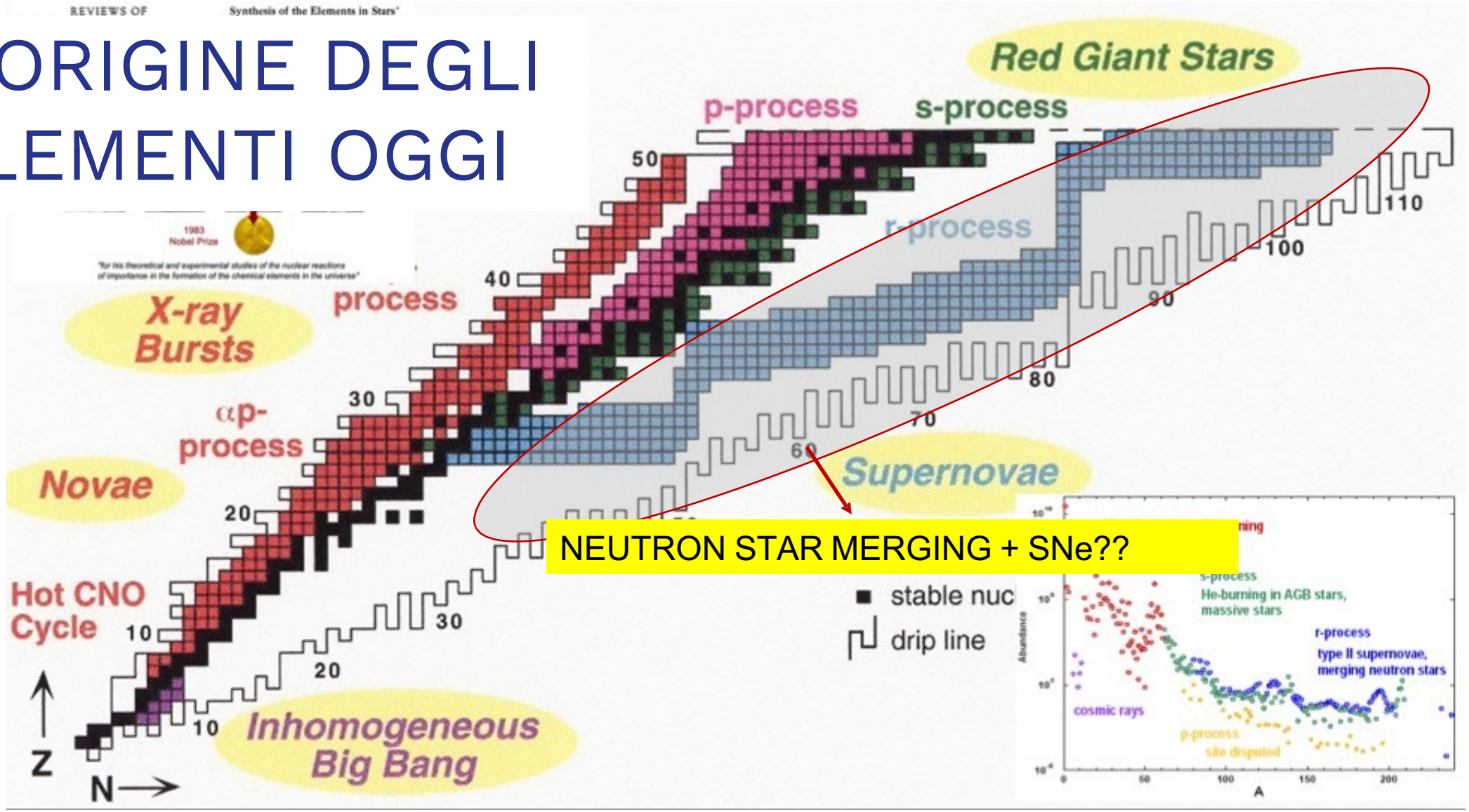
Processo s, processo r.....processo i (?)

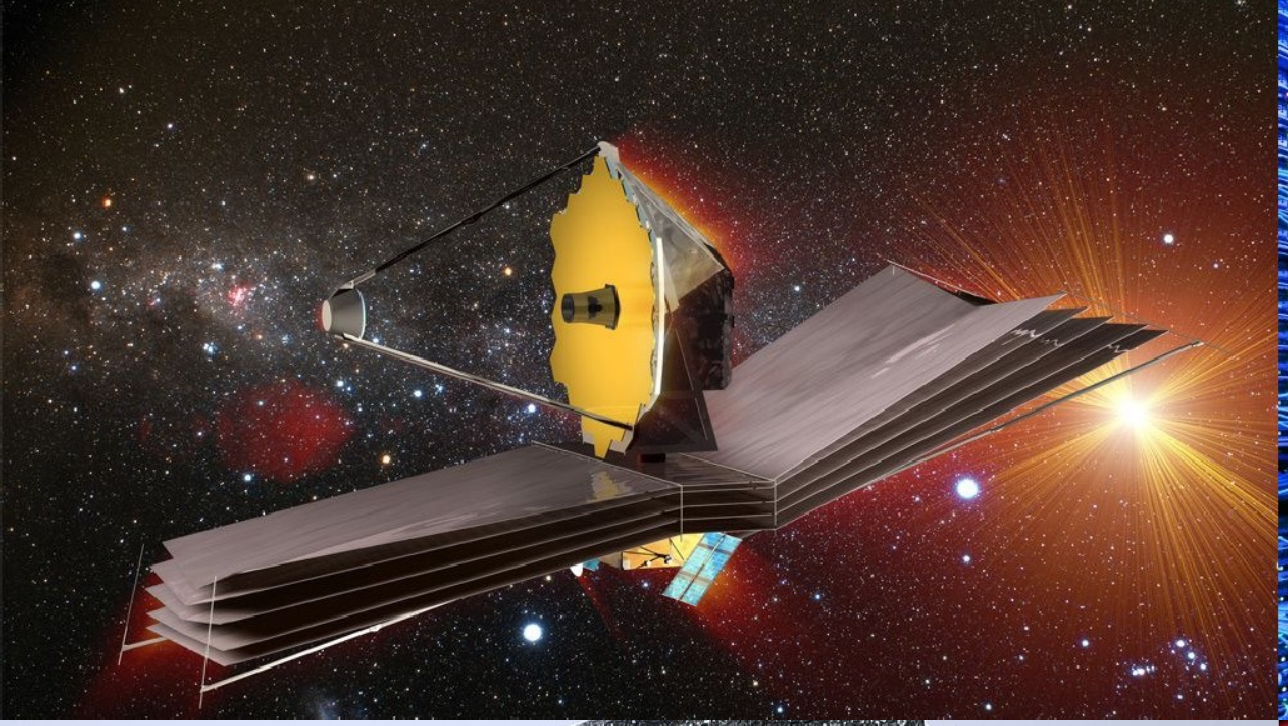

PERIODIC TABLE - ORIGIN OF ELEMENTS
Big Bang nucleosynthesis
Dying low-mass stars
Exploding massive stars
Exploding white dwarfs
Merging neutron stars
1 H
2 He
3 Li
4 Be
5 B
6 C
7 N
8 O
9 F
10 Ne
11 Na
12 Mg
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
19 K
20 Ca
21 Sc
22 Ti
23 V
24 Cr
25 Mn
26 Fe
27 Co
28 Ni
29 Cu
30 Zn
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
37 Rb
38 Sr
39 Y
40 Zr
41 Nb
42 Mo
43 Tc
44 Ru
45 Rh
46 Pd
47 Ag
48 Cd
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
55 Cs
56 Ba
57 La
72 Hf
73 Ta
74 W
75 Re
76 Os
77 Ir
78 Pt
79 Au
80 Hg
81 Tl
82 Pb
83 Bi
58 Ce
59 Pr
60 Nd
61 Pm
62 Sm
63 Eu
64 Gd
65 Tb
66 Dy
67 Ho
68 Er
69 Tm
70 Yb
71 Lu
90 Th
92 U
C.Kobayashi 2020

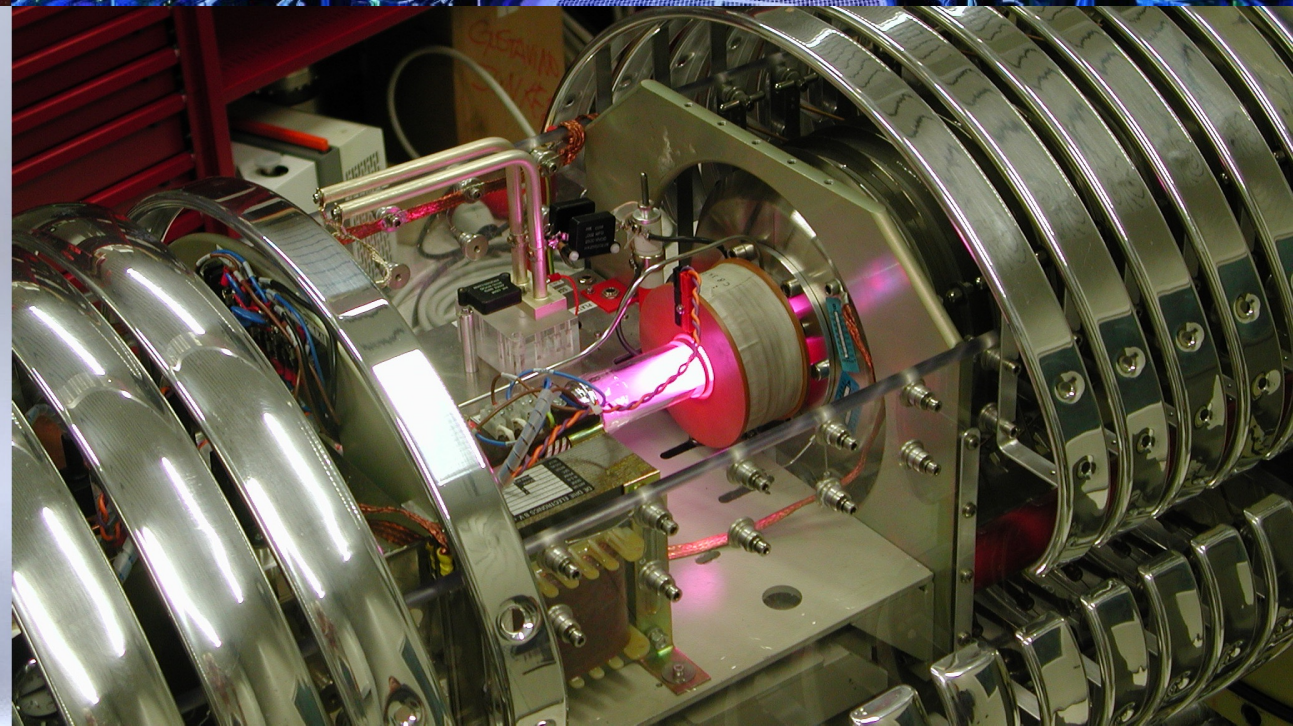
L'ORIGINE DEGLI ELEMENTI OGGI



L'ORIGINE DEGLI ELEMENTI OGGI







NUCLEAR PHYSICS

Experiments & Theory:
cross sections, resonance parameters,
masses, β-decay rates…

Reaction Rates

Data Compilations

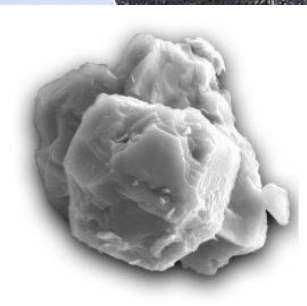
ASTRONOMY

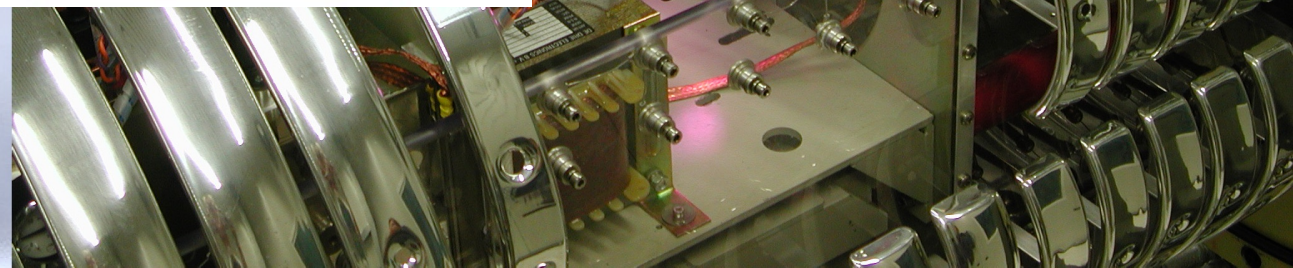
Observations
(on Earth, satellites),
meteorites

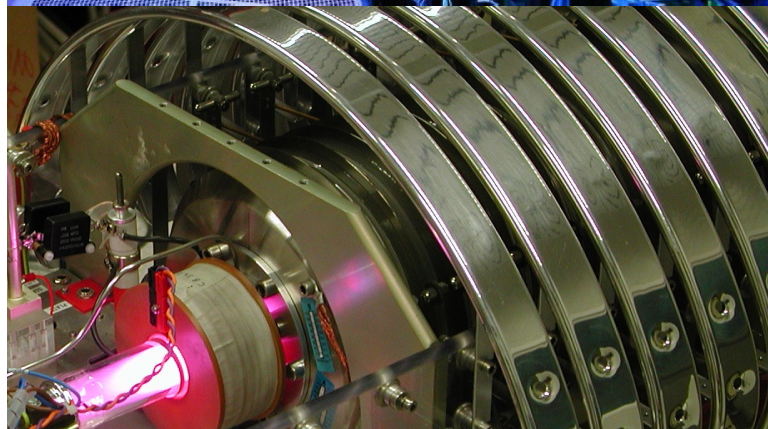
ASTROPHYSICS

Network calculations:
Thousand of reactions involving
thousand of nuclei

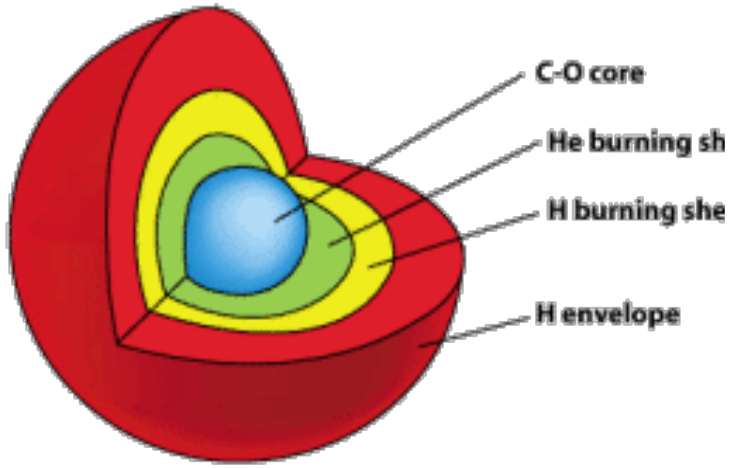
Modelisation of
stellar evolution and
nucleosynthesis

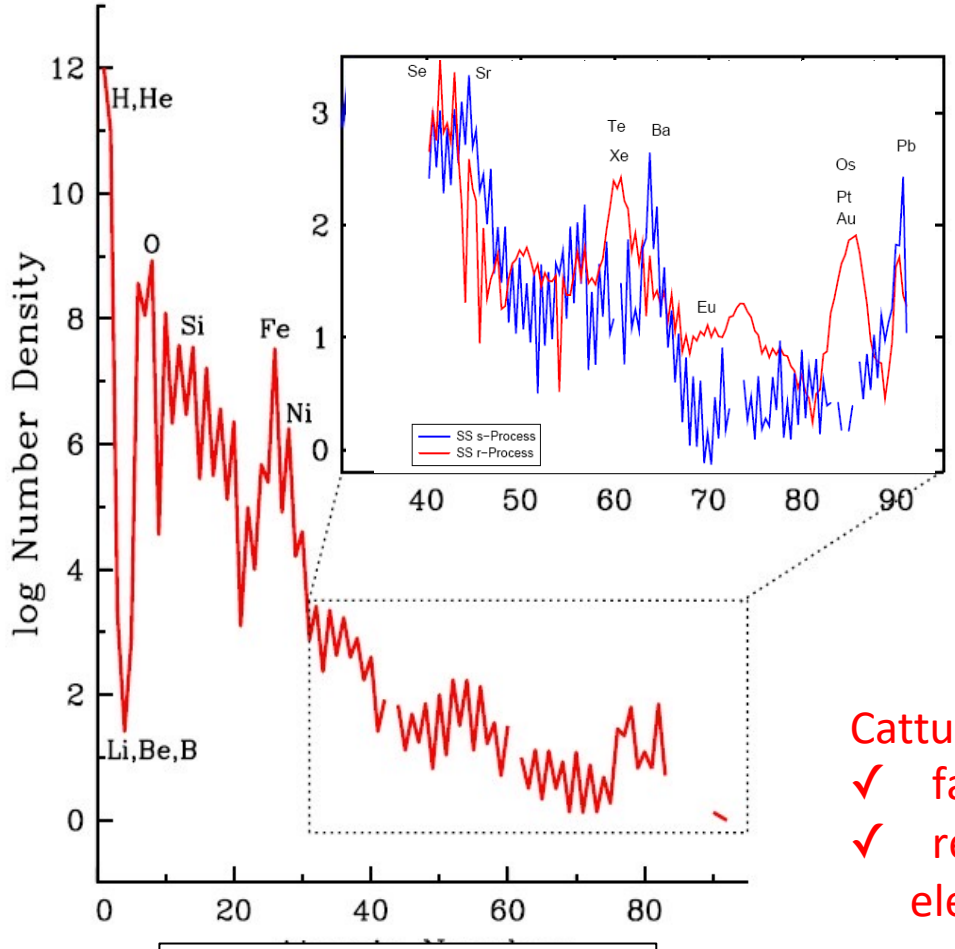


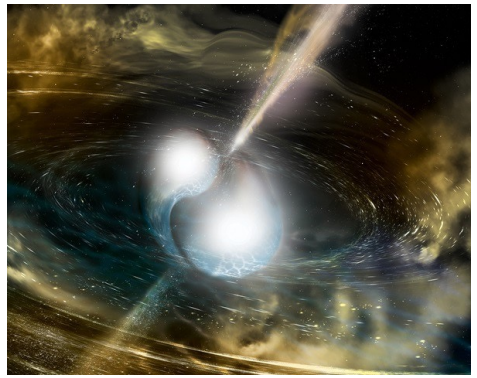




Asymptotic Giant Branch Stars





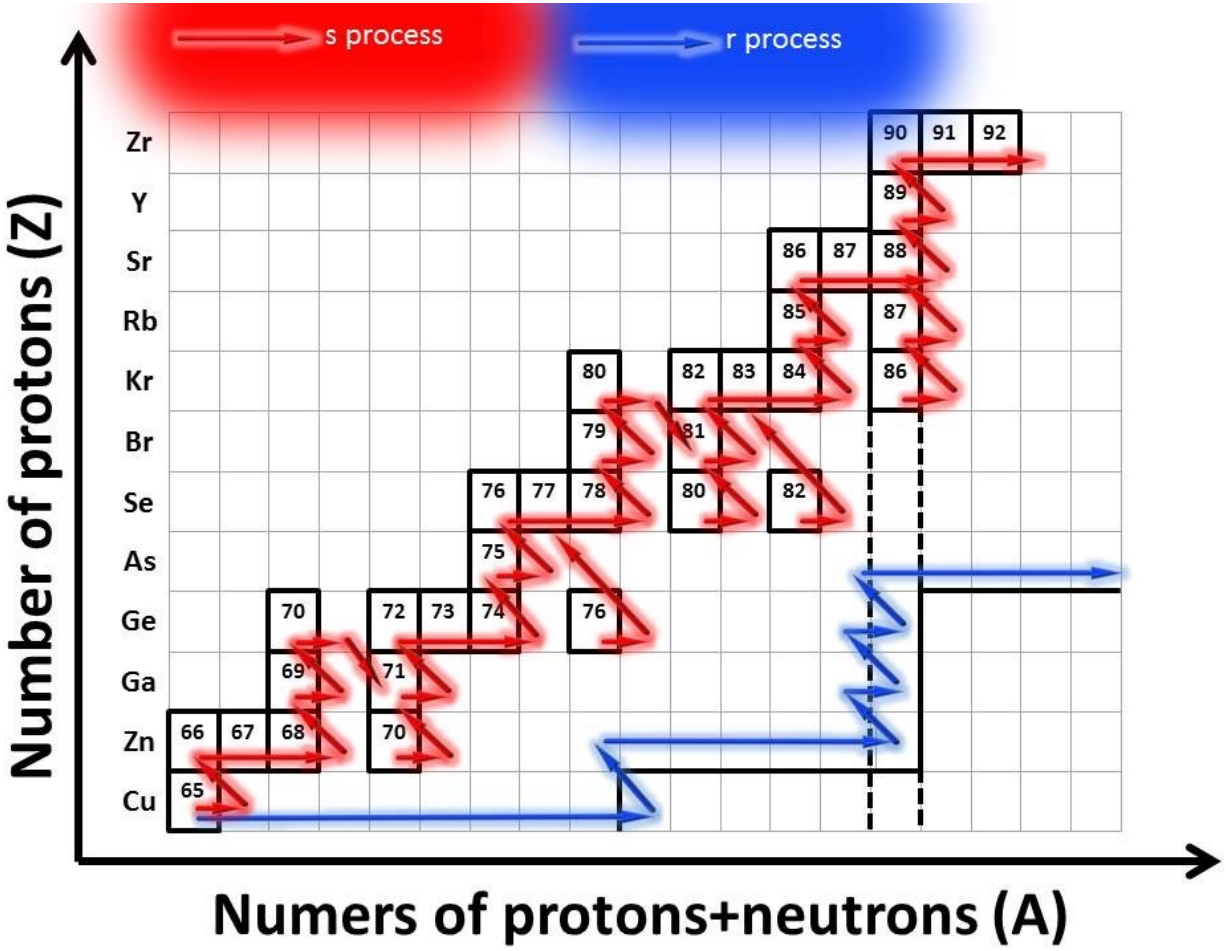


Catture lente:
- ✓ fasi quiescenti dell'evoluzione stellare
- ✓ responsabile per circa il 50% degli elementi "pesanti"

Catture rapide:
- ✓ fasi esplosive dell'evoluzione stellare
- ✓ responsabile per circa il 50% degli elementi "pesanti"

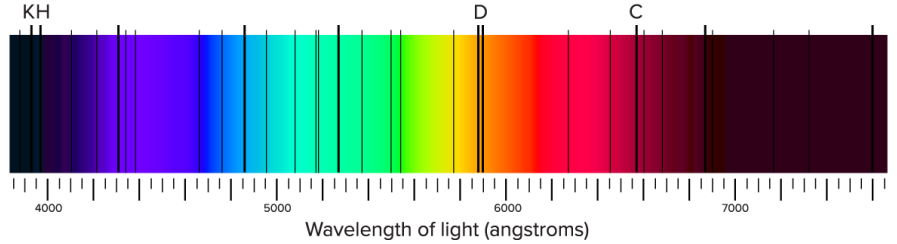
$$r + s = 1$$

Processo s e procsso r



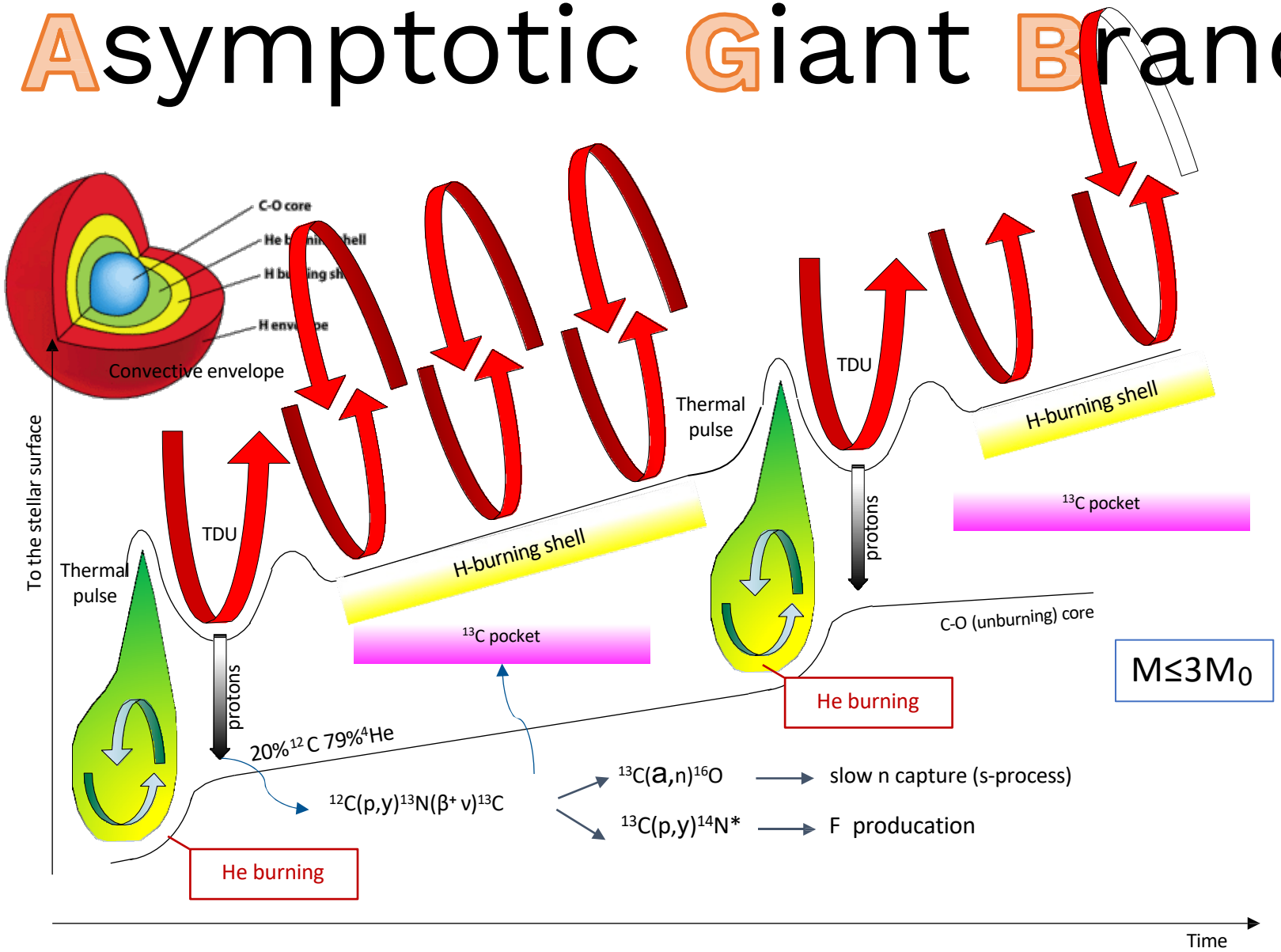
Sezioni d'urto di reazioni di cattura neutronica
soprattutto di isotopi instabili

Processi mediati dall'interazione debole nei plasmi
(decadimento β e cattura elettronica)

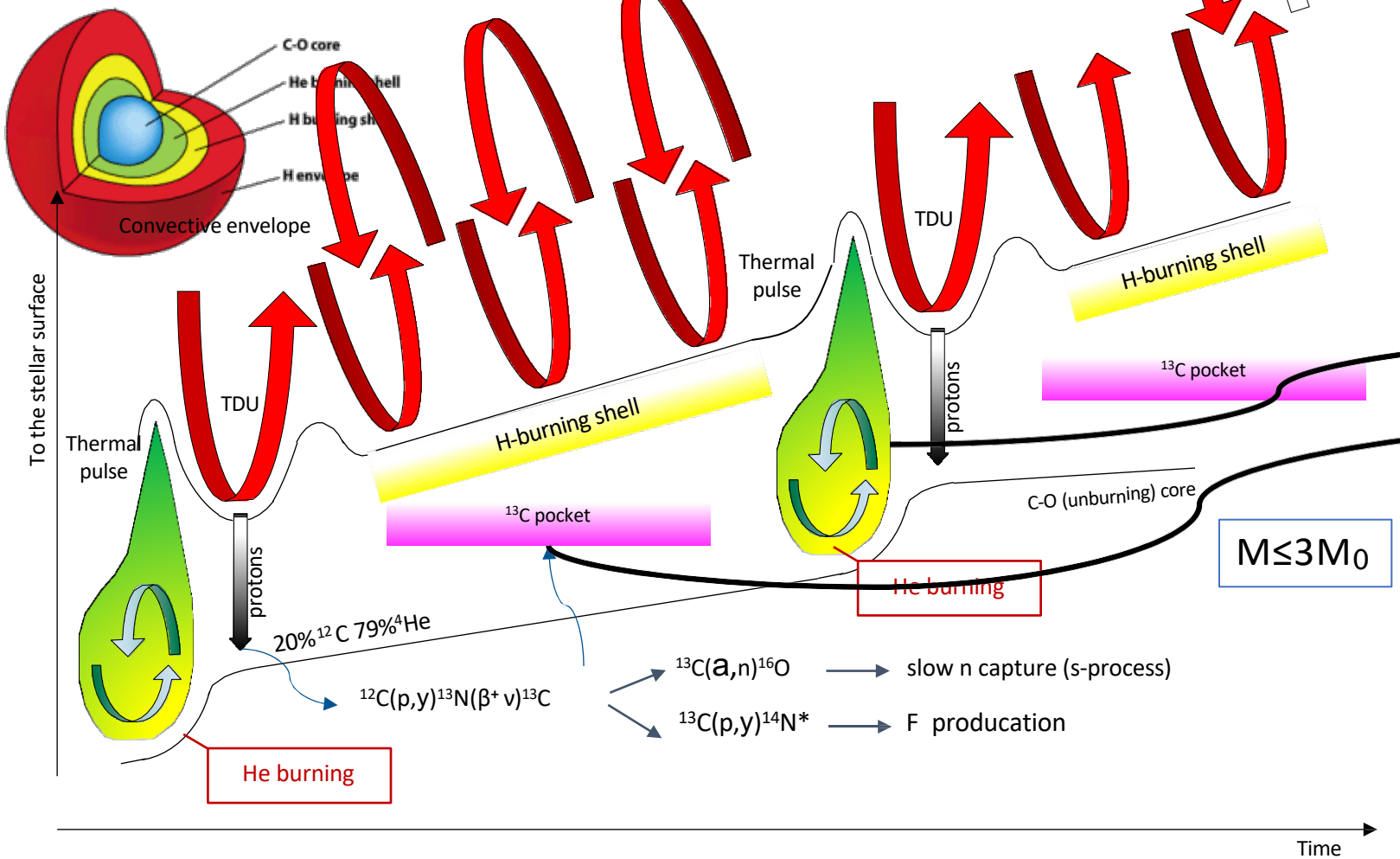


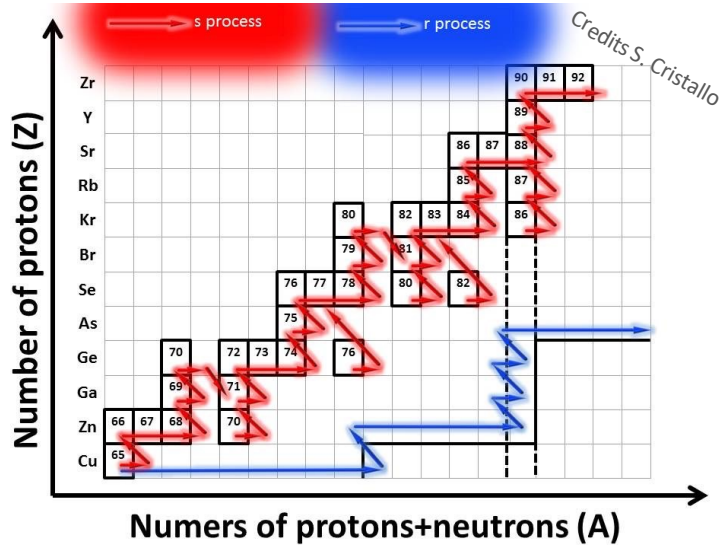
$$r + s = 1$$

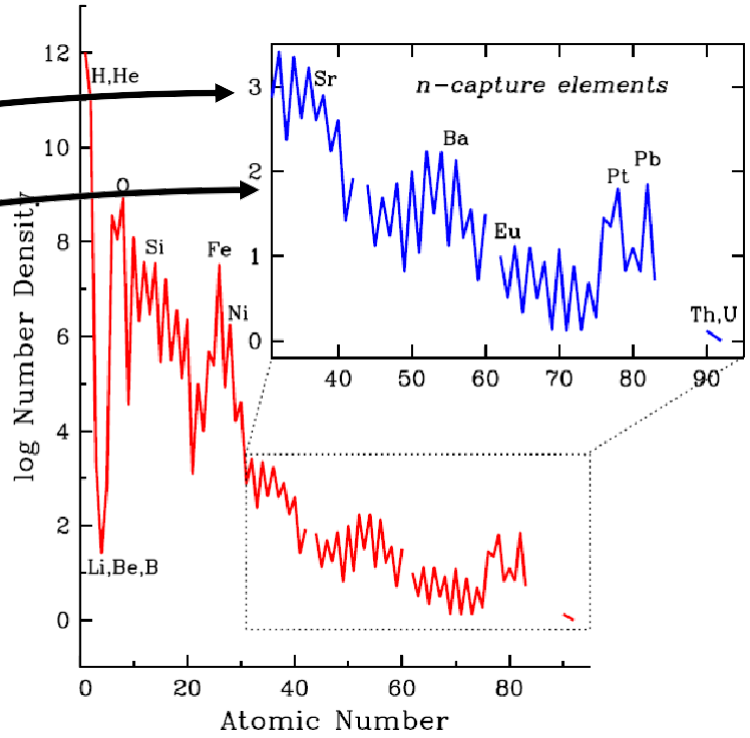
Asymptotic Giant Branch Stars



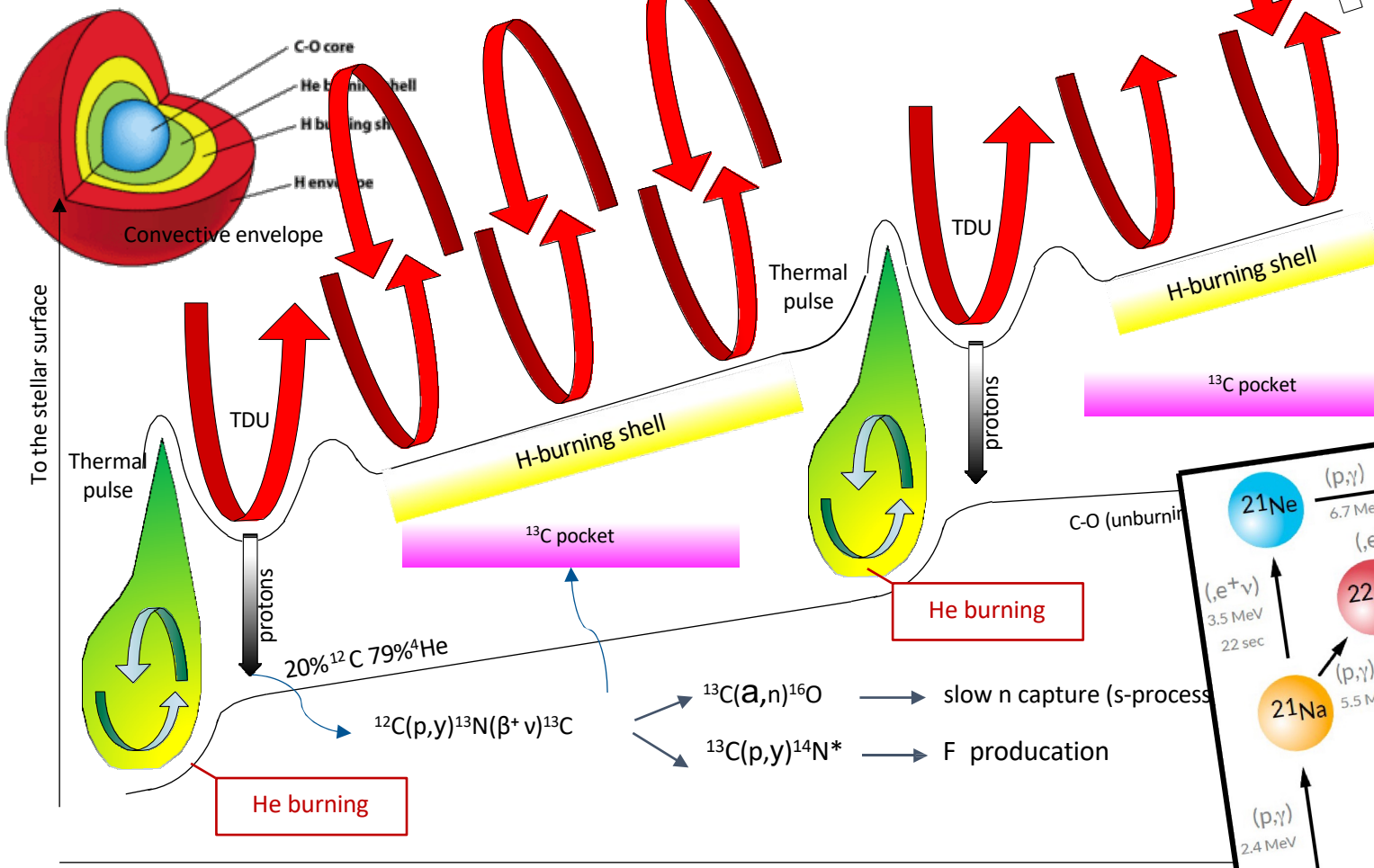
Asymptotic Giant Branch

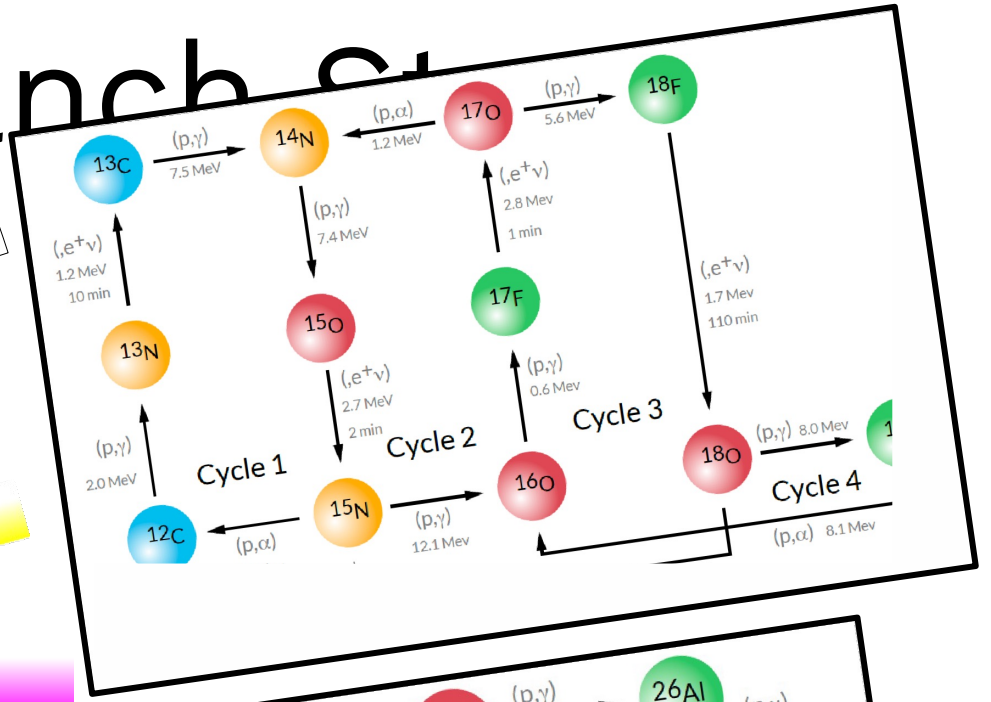


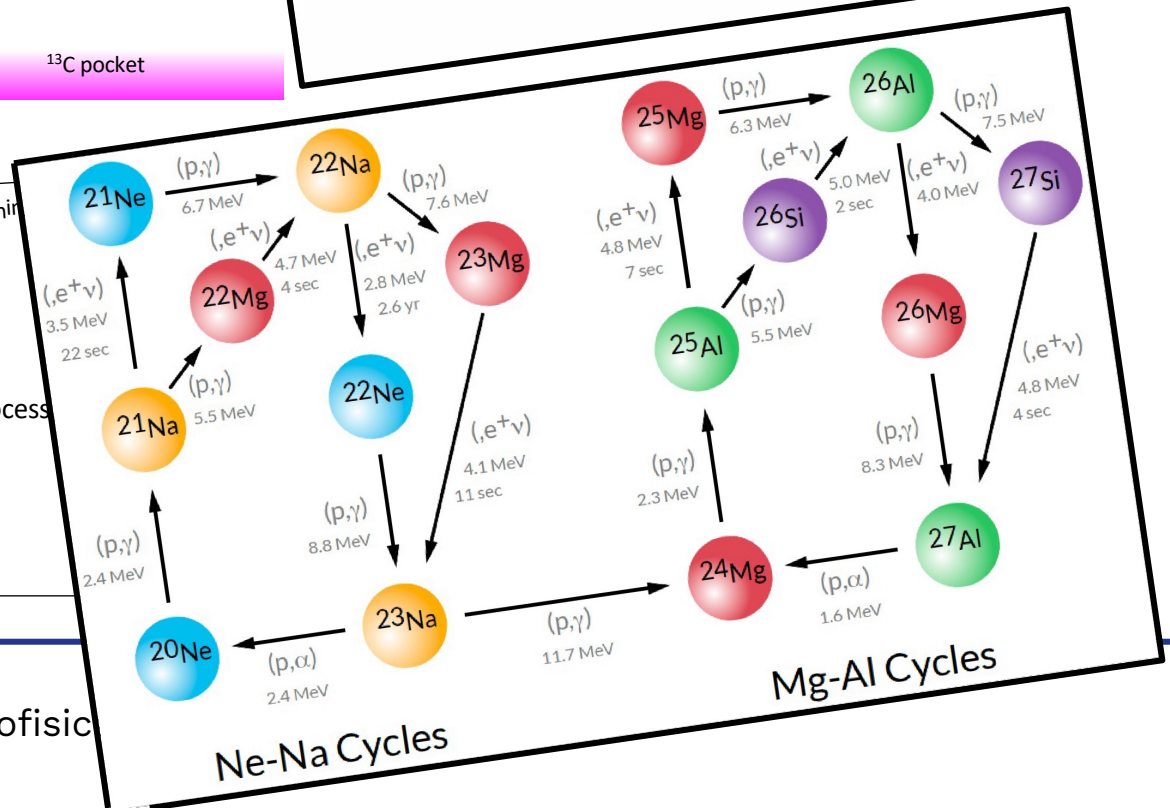




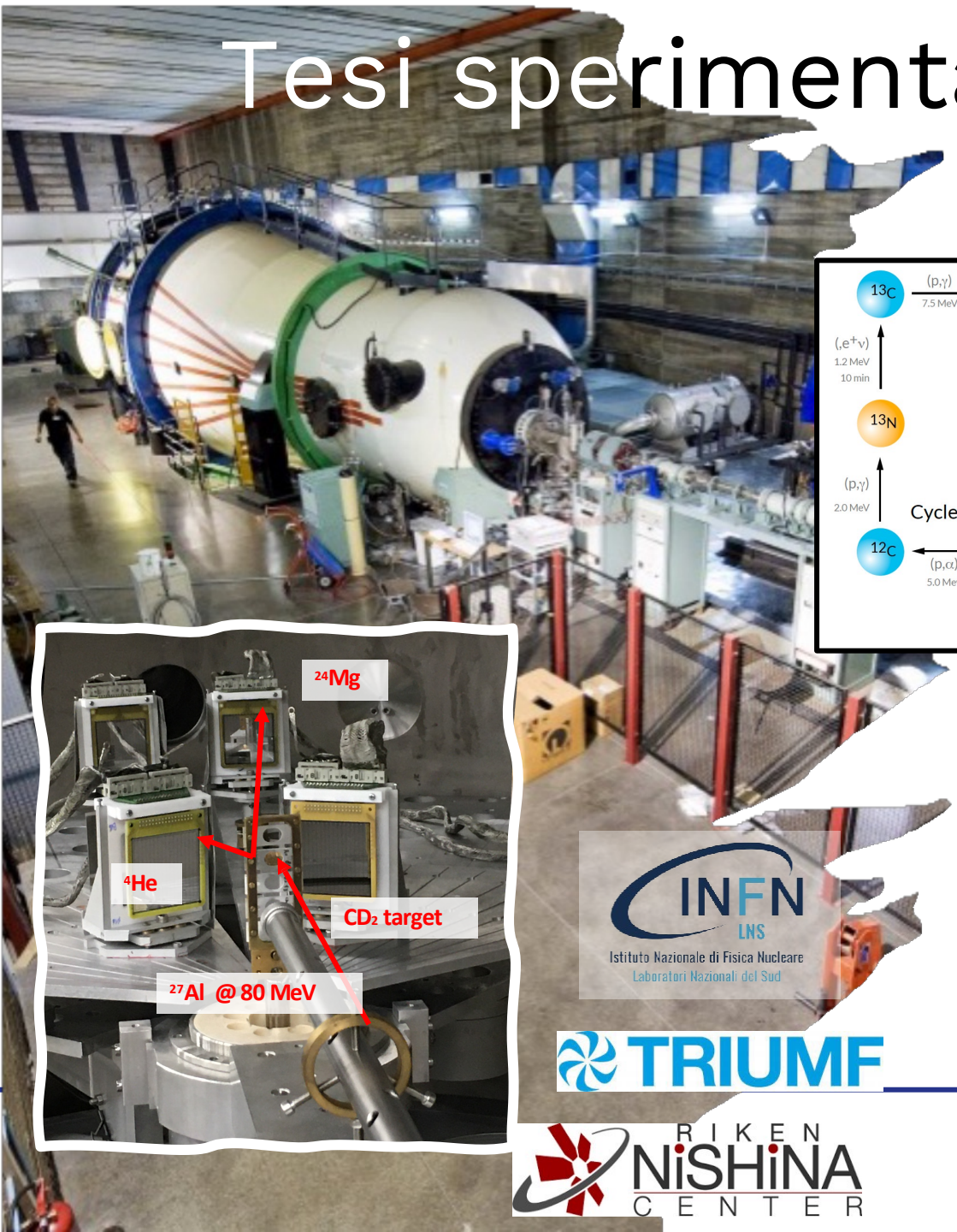
Asymptotic Giant Branch St

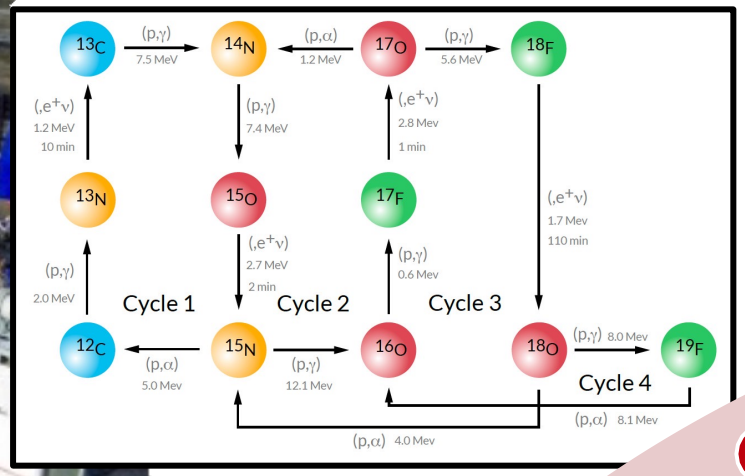


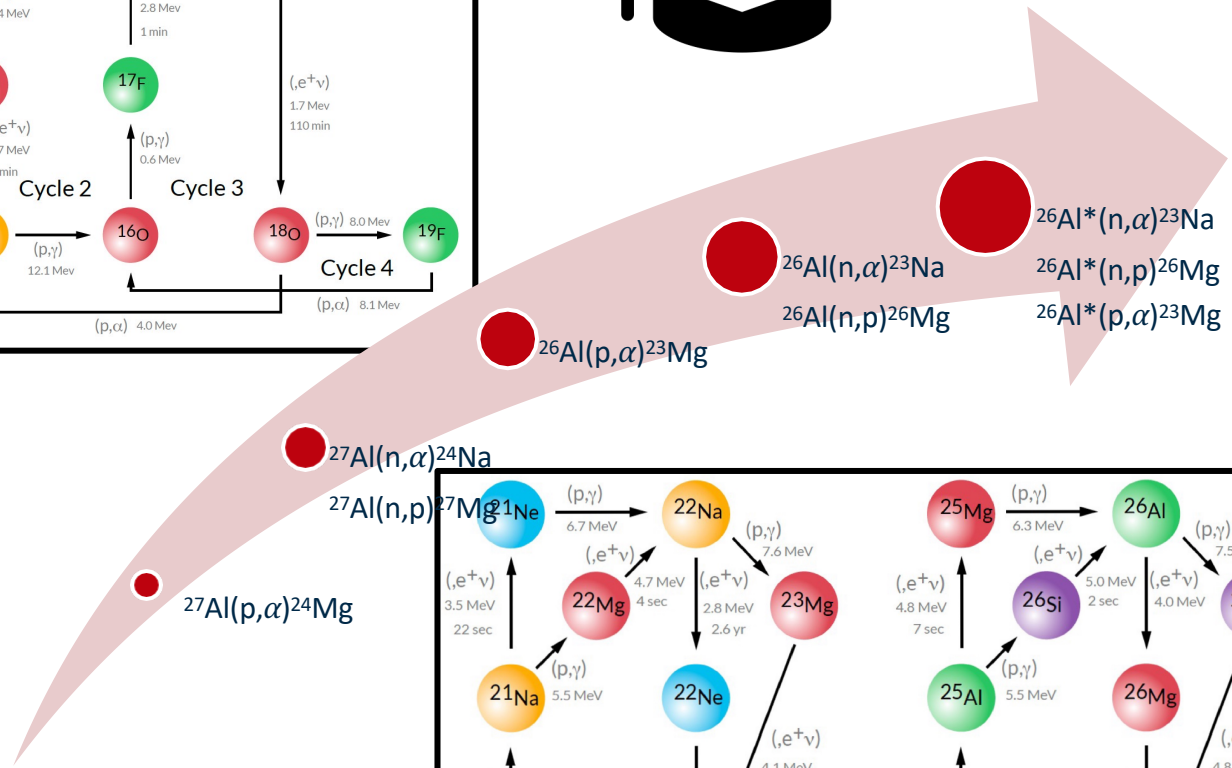




Tesi sperimentali: misura delle sezioni d'urto ^{26}Al+p/n

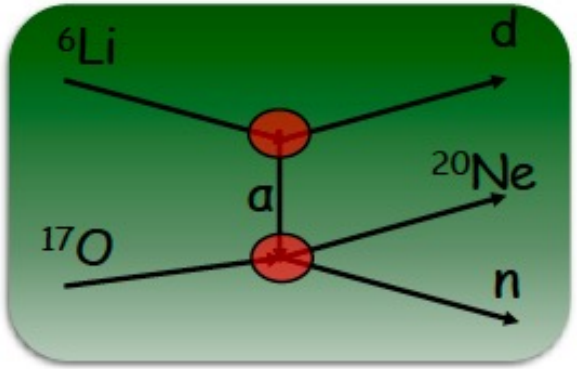




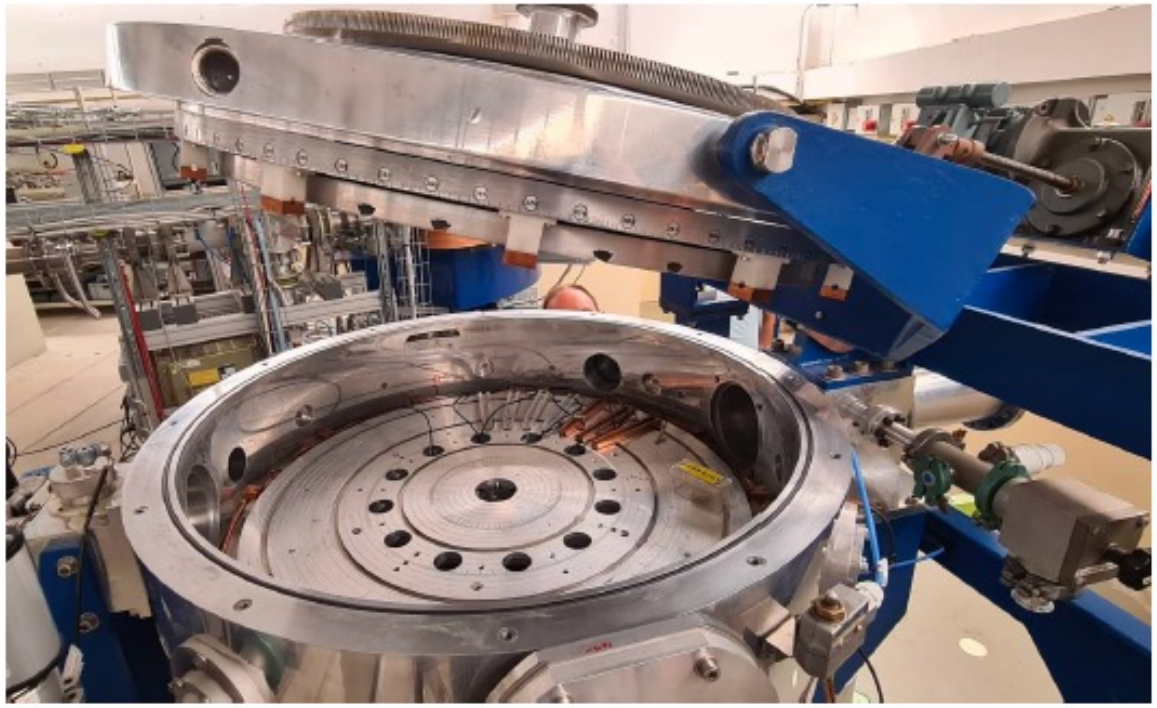


Tesi sperimentali: misura delle sezioni d'urto $^{17}O+\alpha \rightarrow {}^{20}Ne + n$ alla ricerca di una sorgente di neutroni «alternativa»

The $^{17}O(\alpha,n)^{20}Ne$ reaction at the astrophysical energies studied via the Trojan Horse Method: the ÄONEN experiment



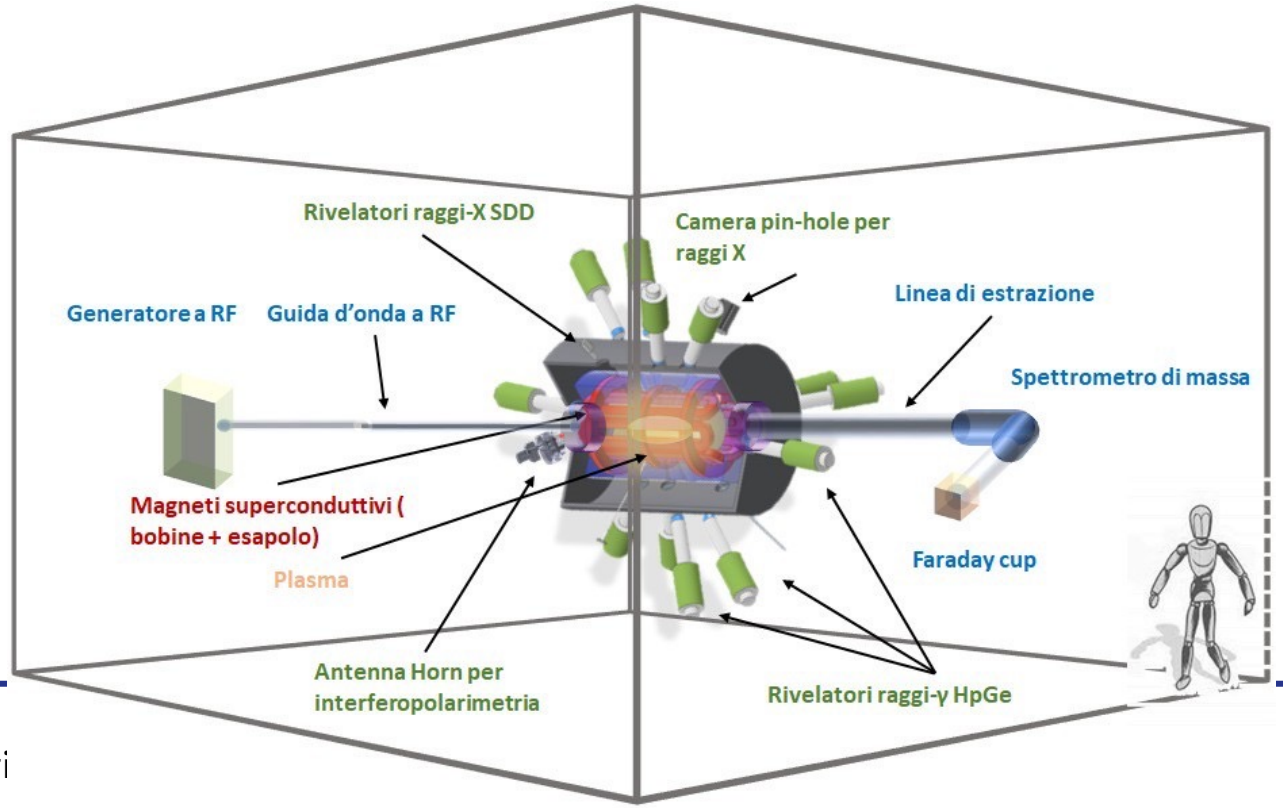
- ✓ $E_{beam}(^6Li)$= 4.5 MeV;
- ✓ Target thickness WO enriched with ^{17}O ~100 μg/cm^2;
- ✓ High position resolution needed;
- ✓ Beam intensity of at least 0.5 pnA;
- ✓ α beam for scattering measurement
- ✓ 4-15 MeV, 1 MeV step, 5-10 pnA



Plasmas for Astrophysics Nuclear Decay Observation and Radiation for Archaeometry

Tesi a metà (tra teoria ed esperimento): Studi di sensibilità della nucleosintesi ai tassi di decadimento di....^{7}Be, ^{85}Kr, ^{94}Nb ~~$^{134-135}$Cs, $^{134-136}$Cs,~~ Os-Re

Coltivare una stella in bottiglia per studiare le interazioni deboli al suo interno (plasma)



INFN LNS
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Sud

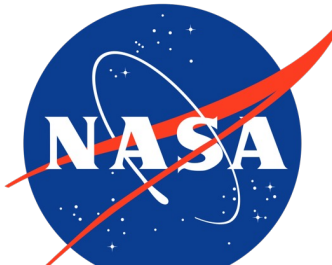
Calcoli di nucleosintesi da cattura neutronica:

ATON vs FUNs

modelli stellari a confronto

INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

Da dove viene? Studio della composizione isotopica di grani presolari per rinconoscerne la stella progenitrice



Corsi

Fisica del Sistema Solare – 3°LT 1°semestre prof. Busso

Astrofisica Nucleare - 1°LM (3°LT) 2°semestre prof.ssa Palmerini

Fondamenti di Astronomia - 2°LT 2°semestre prof.ssa Palmerini

sara.palmerini@unipg.it