$$n + {}^3_1H \longrightarrow {}^3_1H + e^- + \bar{\nu}_e$$

Q	0	1	1	-1	0	✗
B	1	2	3	0	0	
L	0	0	0	+1	-1	

$$n + {}^3_1H \longrightarrow {}^3_1H \longrightarrow {}^3_2He + e^- + \bar{\nu}_e$$
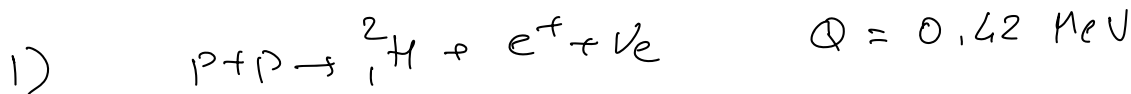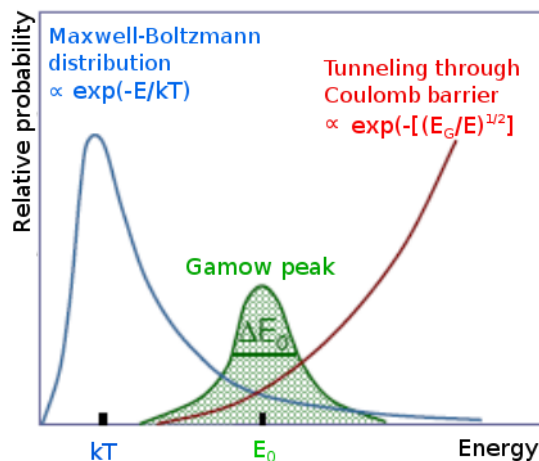$$\underbrace{\quad trizio \qquad helio-3 \quad}$$

Fusione Nucleare nelle stelle.

$$p + p \longrightarrow X + Q \qquad\qquad U(2R) \simeq 550 \ keV$$
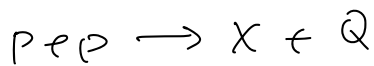
$$4p \longrightarrow {}^4_2He + 26 \ MeV$$
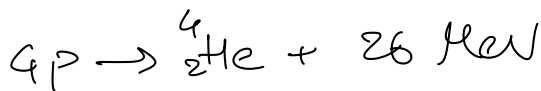
<u>sole</u>: $\quad T \simeq 1.5 \times 10^7 \ K \qquad \bar{E} = \frac{3}{2}kT \Rightarrow \bar{E} \simeq 190 \ keV$

Effetto funnel necessario per fusione $p+p$

1) $\qquad p + p \longrightarrow {}^2_1H + e^+ + \nu_e \qquad\qquad Q = 0.42 \ MeV$

$\qquad\qquad$ processo debole

$\qquad\qquad p + p \longrightarrow (pp) \longrightarrow (pn) + e^+ + \nu_e$
$\qquad\qquad\qquad\qquad\qquad\qquad {}^2_1H$
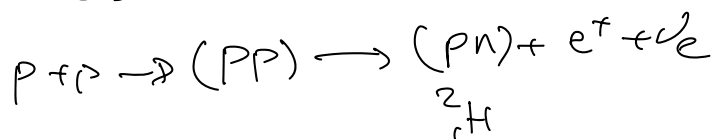
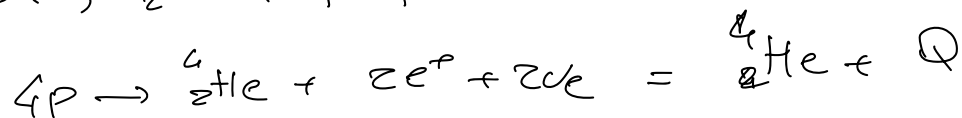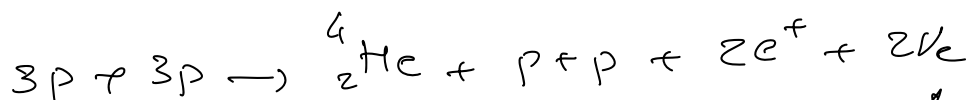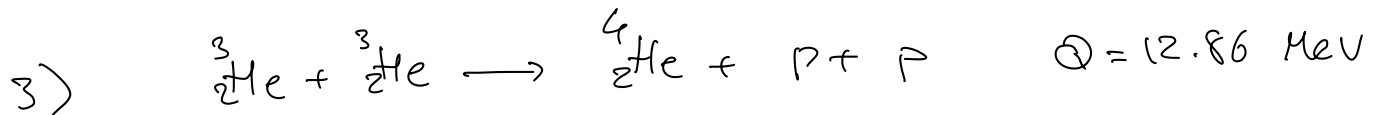$\qquad\qquad \sigma \sim 10^{-55} \ cm^2 \qquad = 10^{-31} \ b$

$$\frac{dN}{dt} \propto \sigma \cdot \frac{dN_p}{dt} \qquad T_{SS} \simeq 5\times10^9 \, yr$$
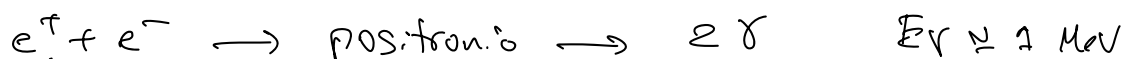
processo nero $\Rightarrow$ Sole a metè delle sue vita.

2) $\quad p + {}^{2}_{1}H \longrightarrow {}^{3}_{2}He + \gamma \qquad Q = 5.49 \, MeV$
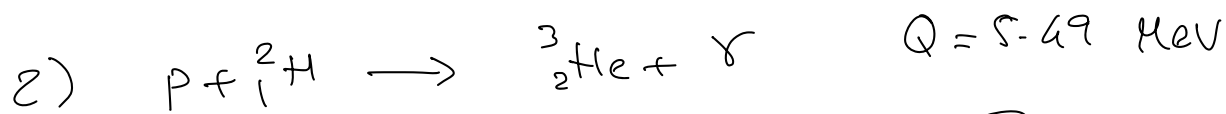
in funzione del temp # ${}^{3}_{2}He$ $\nearrow$

3) $\quad {}^{3}_{2}He + {}^{3}_{2}He \longrightarrow {}^{4}_{2}He + p + p \qquad Q = 12.86 \, MeV$

$3p + 3p \longrightarrow {}^{4}_{2}He + p + p + 2e^{+} + 2\nu_e$

$4p \longrightarrow {}^{4}_{2}He + 2e^{+} + 2\nu_e = {}^{4}_{2}He + Q$

$Q = 4m_p - m_\alpha - 2m_e - 2\not{m_\nu} = 24.7 \, MeV$

$\langle E_\nu \rangle \simeq 0.3 \, MeV$

$e^{+} + e^{-} \longrightarrow positronio \longrightarrow 2\gamma \qquad E_\gamma \simeq 1 \, MeV$

$Q_{netto} = 24.7 \, MeV - \underbrace{2\times 0.3 \, MeV}_{2\nu} + \underbrace{2 \times 1 \, MeV}_{2\gamma \, da \, 2e^+} \simeq 26 \, MeV$

$E_i = E_f$

$E_i = M_i + K_i = M_f + K_f \implies Q = M_i - M_f = K_f - K_i$

$4p \longrightarrow {}^{4}_{2}He + 26 \, MeV \qquad \eta = 7\times10^{-3}$

$$p+p\to {}^{2}H+e^{+}+v_{e} \qquad p+p+e^{-}\to {}^{2}H+v_{e}+0.42 MeV$$
$$99.77\% \qquad\qquad\qquad 0.23\%$$

$$^{2}H+p\to {}^{3}He+\gamma +5.49 MeV$$

$$^{3}He+{}^{3}He\to \alpha +2p+12.86 MeV \qquad\qquad {}^{3}He+p\to \alpha +e^{+}+v_{e}$$
$$84.92\% \qquad\qquad\qquad\qquad\qquad \approx 10^{-5}\%$$

$$^{3}He+\alpha \to {}^{7}Be+\gamma +1.59 MeV$$
$$15.08\%$$
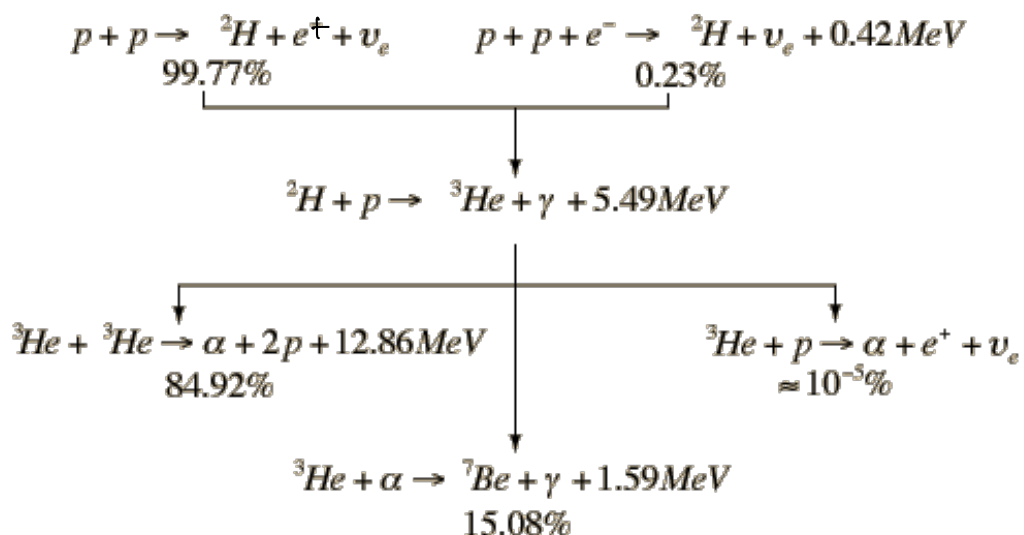
Nucleosintesi: Stellare

$$n \to p + e^- + \bar{\nu}_e$$
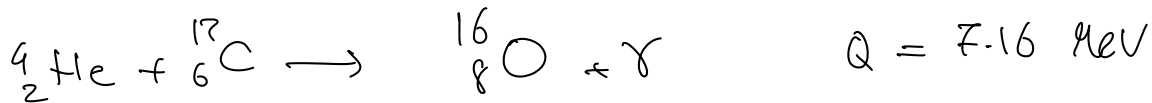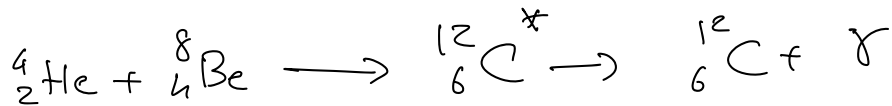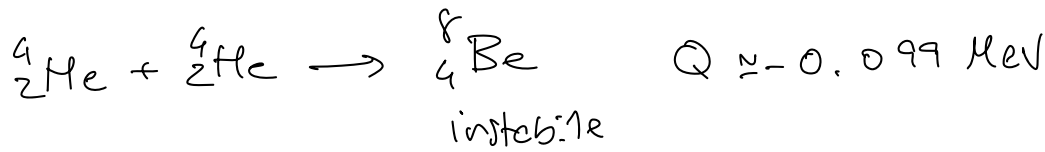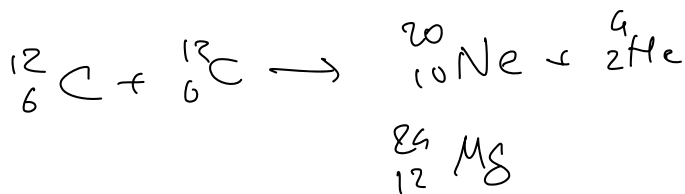$$\bar{\nu}_e + p \to n + e^+$$
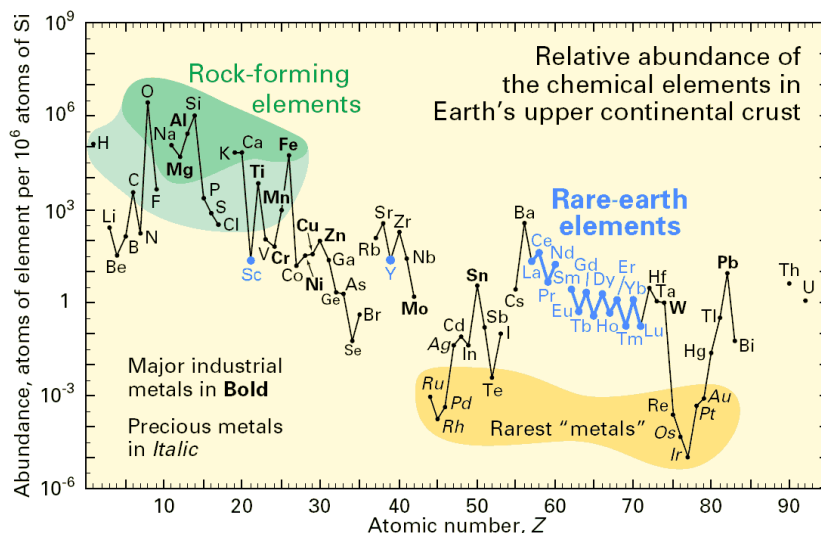
^4_2He S: produce fino a escaurimento di protoni:

$$^4_2He + ^4_2He \longrightarrow ^8_4Be \qquad Q \simeq -0.099 \text{ MeV}$$
$$\text{instabile}$$

$$^8_4Be \to ^4_2He + ^4_2He \qquad \tau \simeq 0.7 \times 10^{-16} \text{ s.}$$

$$^4_2He + ^8_4Be \longrightarrow ^{12}_6C^* \longrightarrow ^{12}_6C + \gamma$$

$$^4_2He + ^{12}_6C \longrightarrow ^{16}_8O + \gamma \qquad Q = 7.16 \text{ MeV}$$

$$^4_2He + ^{16}_8O \longrightarrow ^{20}_{10}Ne + \gamma \qquad Q = 4.73 \text{ MeV}$$

$$^4_2He + ^{20}_4Ne \longrightarrow ^{24}_{12}Mg + \gamma \qquad Q = 9.31 \text{ MeV}$$
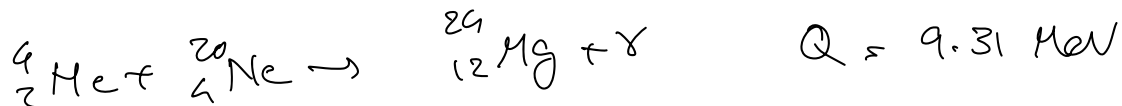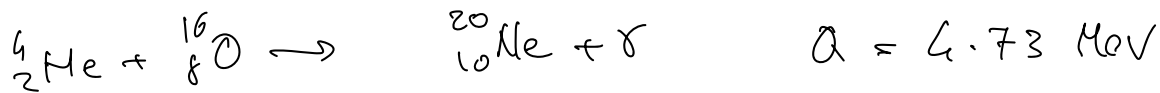
^4_2He escanisce — collasso gravitazionale $\Rightarrow$ T cresce

$\Rightarrow$ cresce $\overline{K}$ di elementi più pesanti di ^4_2He

$$^{12}_6C + ^{12}_6C \longrightarrow ^{20}_{10}Ne + ^4_2He$$
$$^{24}_{12}Mg$$

Dopo magnesio $\Rightarrow$ $^{28}_{14}Si$

· continua fino a $\dfrac{\partial B}{\partial A} > 0$ fino al Ferro $A \simeq 56$
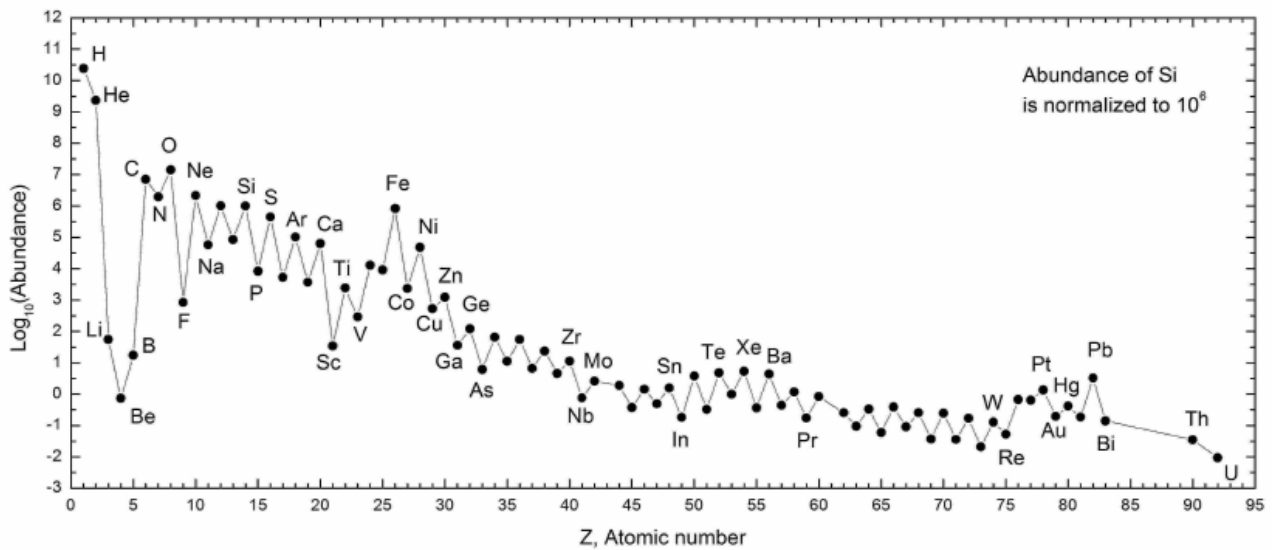
Relative abundance of the chemical elements in Earth's upper continental crust. Abundance, atoms of element per 10^6 atoms of Si, vs Atomic number, Z. Rock-forming elements, Rare-earth elements, Major industrial metals in **Bold**, Precious metals in *Italic*, Rarest "metals".

Abundance of Si is normalized to 10^6

28 Maggio   NO Ricevimento

Giovedì   9-15

Rutherford $\longrightarrow$ esiste il nucleo.

Sorgente $\longrightarrow$ ⊘ Bersaglio $\rightleftharpoons$

$\dfrac{dN_r}{dt} = \sigma \cdot \dfrac{dN_i}{dt} \, n_b \cdot \partial x$

$\overbrace{}^{}$
$\underbrace{}_{\partial x}$
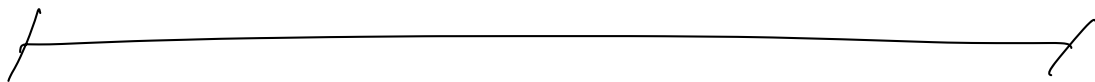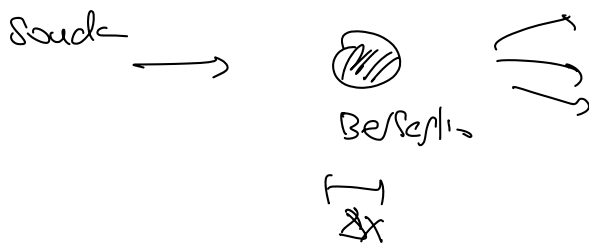
$\alpha \rightarrow \rightarrow p \rightarrow e^-$

E_p : Rutherford $K_p \simeq 5$ MeV.

LHC: $E_p = 6500$ GeV   protoni

$\qquad\qquad L = 27$ KM   CERN.

Futuro acceleratore Circolare

$\qquad E_p \simeq 50'000$ GeV $= 50$ TeV

$\qquad\qquad L \simeq 100$ KM.
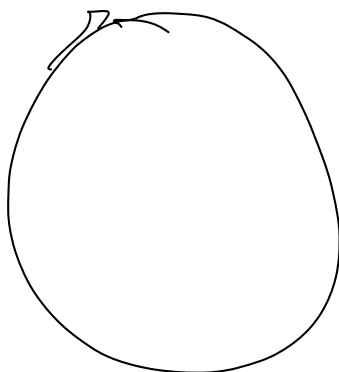
Eq. Sincrotrone $\propto \dfrac{1}{m_5}$

$e^- + p \longrightarrow e^- + X$ $Ee \simeq 70$ GeV

$\Rightarrow$ probne ne strutture. (non elementare
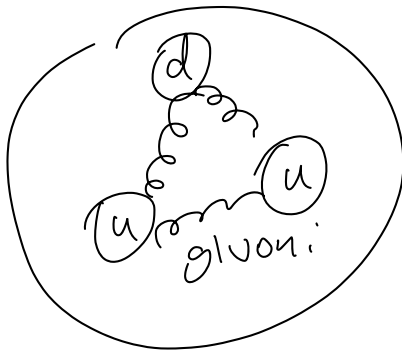
protone fatto da 3 querk
neutrone fatto da 3 querk

1994

$\begin{pmatrix} u \\ d \end{pmatrix}^{up}_{down}$ $\begin{pmatrix} Charm & c \\ Strange & s \end{pmatrix}$ $\begin{pmatrix} top & t \\ beauty & b \end{pmatrix} \begin{matrix} Q = + \frac{2}{3} \\ Q = - \frac{1}{3} \end{matrix}$

$p \equiv uud = +\frac{2}{3} + \frac{2}{3} - \frac{1}{3} = \frac{9}{?}$

$n \equiv udd = +\frac{2}{3} - \frac{1}{3} - \frac{1}{3} = \emptyset$

interazione mediate da gluoni: (8 gluoni)
  carica di colore per querk, gluoni: $m_g = \emptyset$
QCD: Quantum Curomodynamics. $S = 1$
Cariche colore: R, G, B

For 7e elettrico: $Q = \pm 1$
    1 solo mediatore γ : $m = \emptyset$.
                        $S = 1$

Querk non esistono liberi in nature.
  particelle fisiche: Barioni: $(q_i q_j q_3)$ neutrone protone.
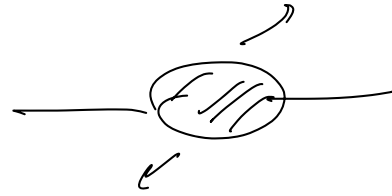
                    Mesoni: $(q_i \bar{q}_j)$

$\pi^+ = u \bar{d}$
            $\begin{matrix} Q = +\frac{1}{3} \\ -\frac{2}{3} \end{matrix} \begin{pmatrix} \bar{d} \\ \bar{u} \end{pmatrix}$ $\begin{pmatrix} \bar{s} \\ \bar{c} \end{pmatrix}$ $\begin{pmatrix} \bar{b} \\ \bar{t} \end{pmatrix}$ Fermioni $S = 1/2$

$$Q_{\pi^+} \doteq +\frac{2}{3} + (+\frac{1}{3}) = +\frac{3}{3} = +1$$

LHC: $p + p \longrightarrow$

$$\sqrt{S} = 13 \ TeV$$
$$= 13\,000 \ GeV$$

$$p + p \longrightarrow \sqrt{S} = 13 \ TeV \longrightarrow a + b$$
$$M_a \simeq \frac{\sqrt{S}}{2} = 6500 \ GeV$$

$Q = +2/3$
$Q = -1/3$
$\begin{pmatrix} u \\ d \end{pmatrix} \begin{pmatrix} c \\ s \end{pmatrix} \begin{pmatrix} t \\ b \end{pmatrix}$

$Q = -1$
$Q = 0$
$\begin{pmatrix} e^- \\ \nu_e \end{pmatrix} \begin{pmatrix} \mu^- \\ \nu_\mu \end{pmatrix} \begin{pmatrix} \tau^- \\ \nu_\tau \end{pmatrix}$

$\longrightarrow$ massa cresce.

$M_e = 0.511 \ MeV$ $M_\mu = 106 \ MeV$ $M_\tau = 1.8 \ GeV$

$$M_{\nu_e} \simeq \emptyset$$

$m_{top} \simeq 170 \ GeV$ $\gg m_b \sim 5 \ GeV \gg m_c \simeq 1.5 \ GeV$

$\gg m_{u,d.} \sim MeV$

$$\bar{\nu}_e + p \longrightarrow n + e^+$$

$$\bar{\nu}_\mu + p \longrightarrow n + \mu^+$$

$$X + p \longrightarrow e^+ + n$$
$$\cancel{\mu^+ + n} \quad \text{non si vede}$$

$$n \longrightarrow p + e^- + \bar{\nu}_e \qquad Q \geqslant 0$$

$$p + \mu^- + \bar{\nu}_\mu \qquad Q < 0 \quad Q = m_n - m_p - m_\mu = -105 \ MeV$$

$$\mu^- \longrightarrow e^- + \gamma \qquad Q = 106 - 0.5 = 105.5 \ MeV$$
$$N \simeq \emptyset \qquad \text{violazione del numero leptonico}$$