Determination of \((X, \gamma)\) reaction rates with \(\gamma\)-ray beams

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- The target density is 1000-10000x higher than gas targets.
- Superheated water will nucleate from \(\alpha\) and \(^{12}\)C recoils
- The detector is insensitive to \(\gamma\)-rays.
- Reciprocity -> 100x
- Prototype tested at H\(\gamma\)S

\[ \gamma + ^{16}\text{O} \rightarrow ^{12}\text{C} + \alpha \]

Monochromatic \(\gamma\)-ray beam from H\(\gamma\)S

H\(_2\)O bubble chamber

STAR
HI\gamma S at TUNL, Duke University
$^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ at $E = 300$ keV

\[ \text{Yield} \sim N_1 N_2 \sigma g \]
\[ g = \epsilon \ast (1 - \text{bkgd/signal}) \]
\[ 0 < g < 1 \]

**Kunz 2001**

N1 = $2 \times 10^{18}$ Carbon implanted particles
N2 = 0.5 mA = $3.12 \times 10^{15}$ $\alpha$-particles/s in 1 year
N1 N2 = $1.97 \times 10^{41}$
Yield = 2 events in one year

**DIANA + JENSA (DUSEL)**

N1 = $1 \times 10^{19}$ helium particles gas target
N2 = 10 mA = $6.24 \times 10^{16}$ carbon part/s in 1 year
N1 N2 = $1.97 \times 10^{43}$
Yield = 200 events in one year

**LUNA-MV (Gran Sasso)**

N1 = $2 \times 10^{18}$ Carbon implanted particles
N2 = 0.5 mA = $3.12 \times 10^{15}$ $\alpha$-particles/s in 1 year
N1 N2 = $1.97 \times 10^{41}$
Yield = 2 events in one year

**Bubble + HI/$\gamma$S2**

N1 = $3.35 \times 10^{23}$ particles in liquid target
N2 = $2 \times 10^{10}$ $\gamma$/s in 1 year
N1 N2 = $2.11 \times 10^{41}$, Reciprocity $\rightarrow$ x100
Yield = 200 events in one year
Next generation light sources

ELI-NP, Romania 2015 V. Zamfir 2011

Phase 1
Very intense \((10^{13} \, \gamma/s)\), brilliant \(\gamma\)-ray beam, 0.1 % bandwidth, with \(E = 19 \, \text{MeV}\)

Phase 2 (2018-2020) \(\rightarrow 10^{15} \, \gamma/s\)

Bubble + ELI-NP (Phase 1)

- \(N_1 = 3.35 \times 10^{23} \) particles in liquid target
- \(N_2 = 1 \times 10^{13} \, \gamma/s\)

in 1 year
- \(N_1 \, N_2 = 2.11 \times 10^{44}\)
- Reciprocity \(\rightarrow x100\)
- Yield = 200,000 events in one year