A Measurement of the $^{12}C(n,2n)^{11}C$ Cross-Section for Use as an Inertial Confinement Fusion Diagnostic

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Inertial Confinement Fusion (ICF)

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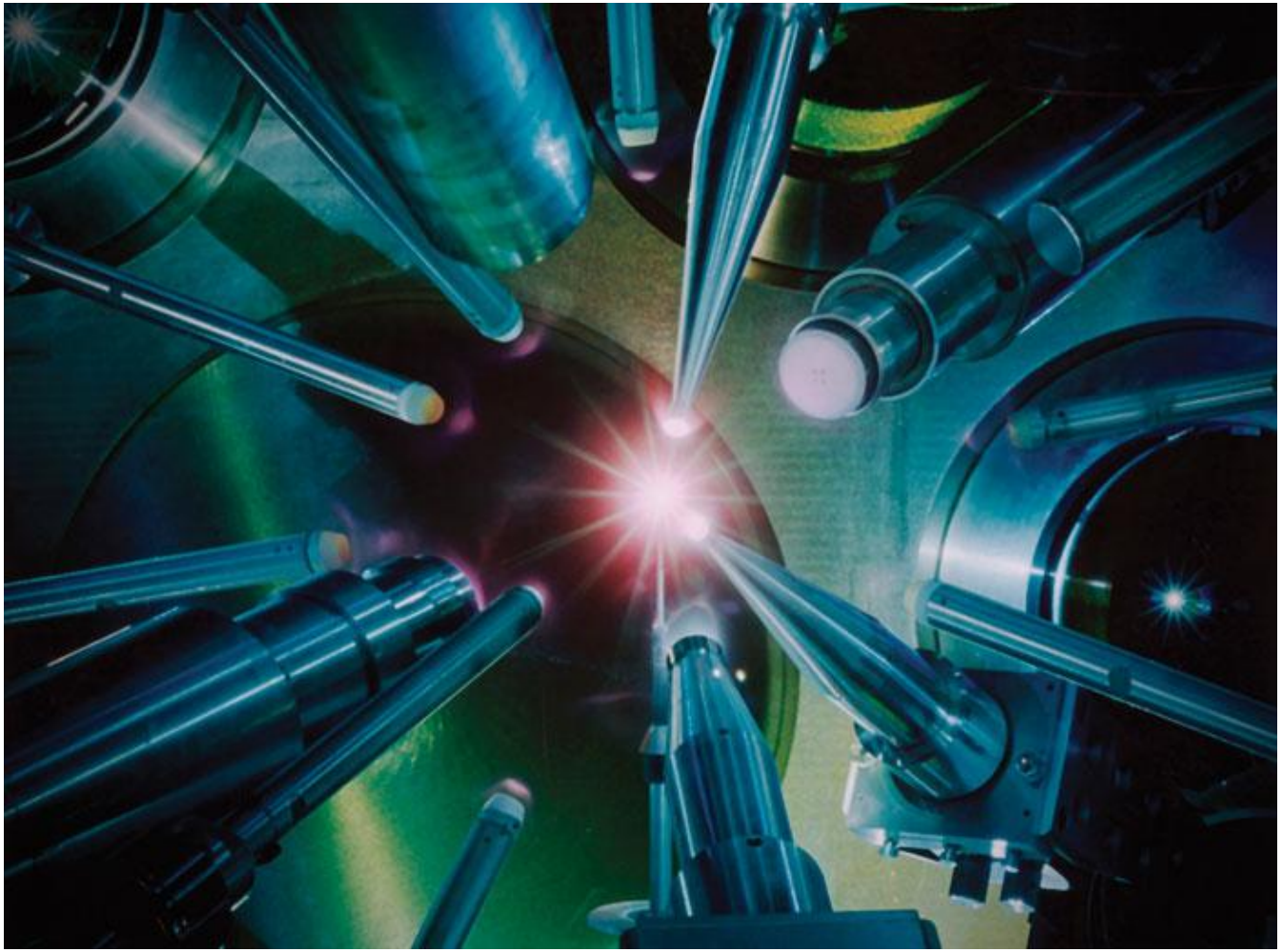

Credit:
Lawrence Livermore
National Laboratory

ICF Reactions

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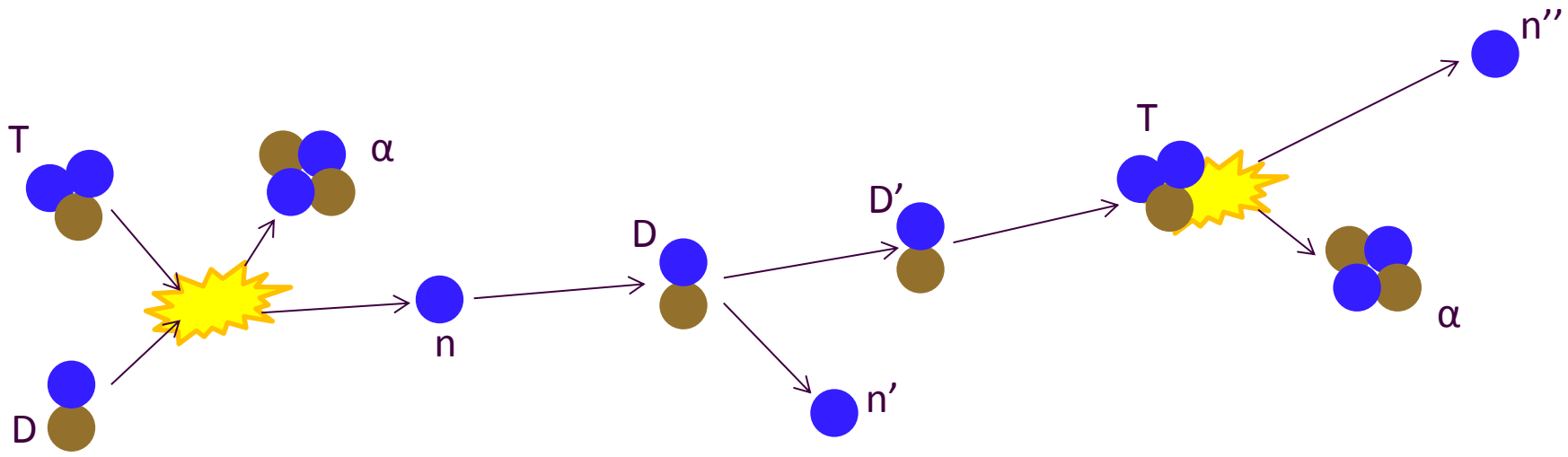
$$\mathrm{D} + \mathrm{T} \rightarrow \alpha + n(14.1\ \mathrm{MeV})$$

$$n + \mathrm{D}\ (\mathrm{or}\ \mathrm{T}) \rightarrow n' + \mathrm{D}'(\mathrm{or}\ \mathrm{T}')$$

$$\mathrm{D}' + \mathrm{T}\ (\mathrm{or}\ \mathrm{D} + \mathrm{T}') \rightarrow \alpha + n''(12 - 30\ \mathrm{MeV})$$



$^{12}C(n,2n)^{11}C$ Reaction and Decay

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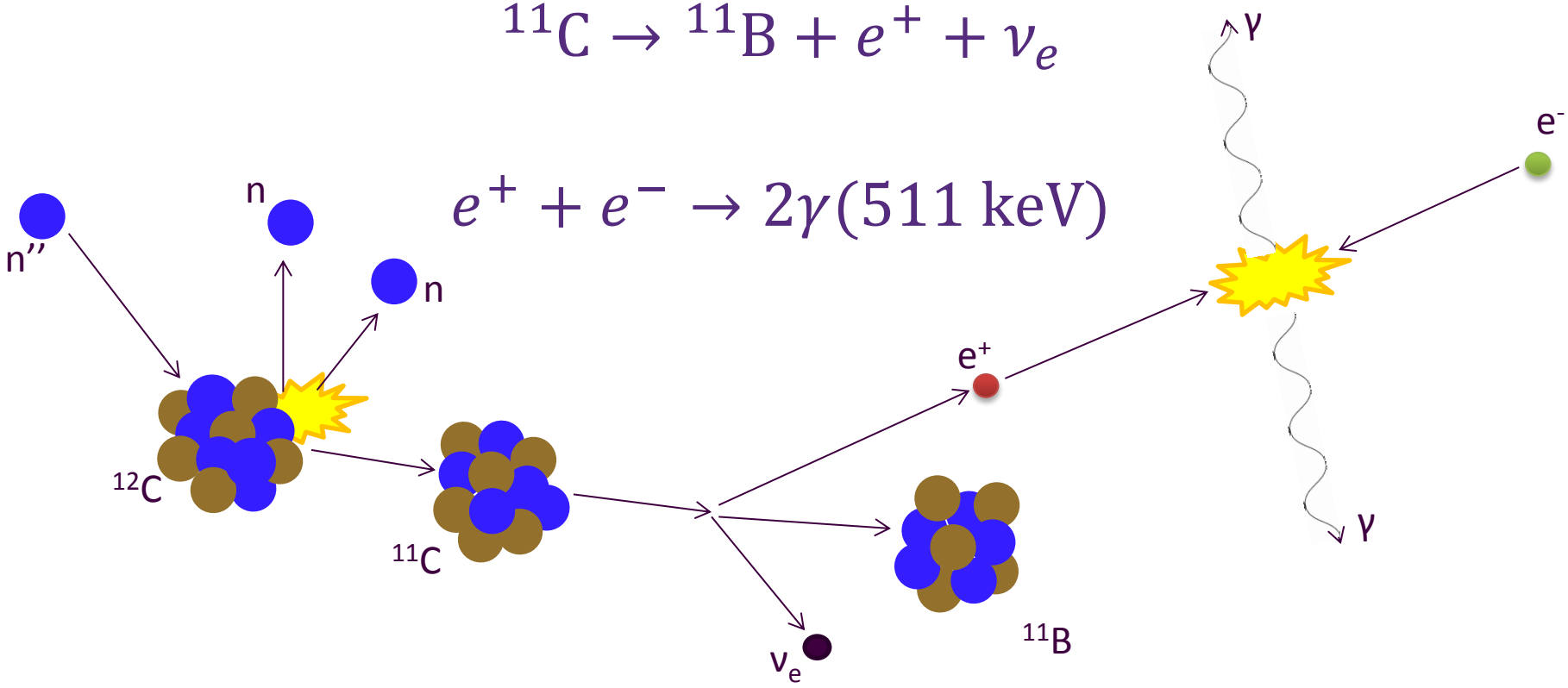
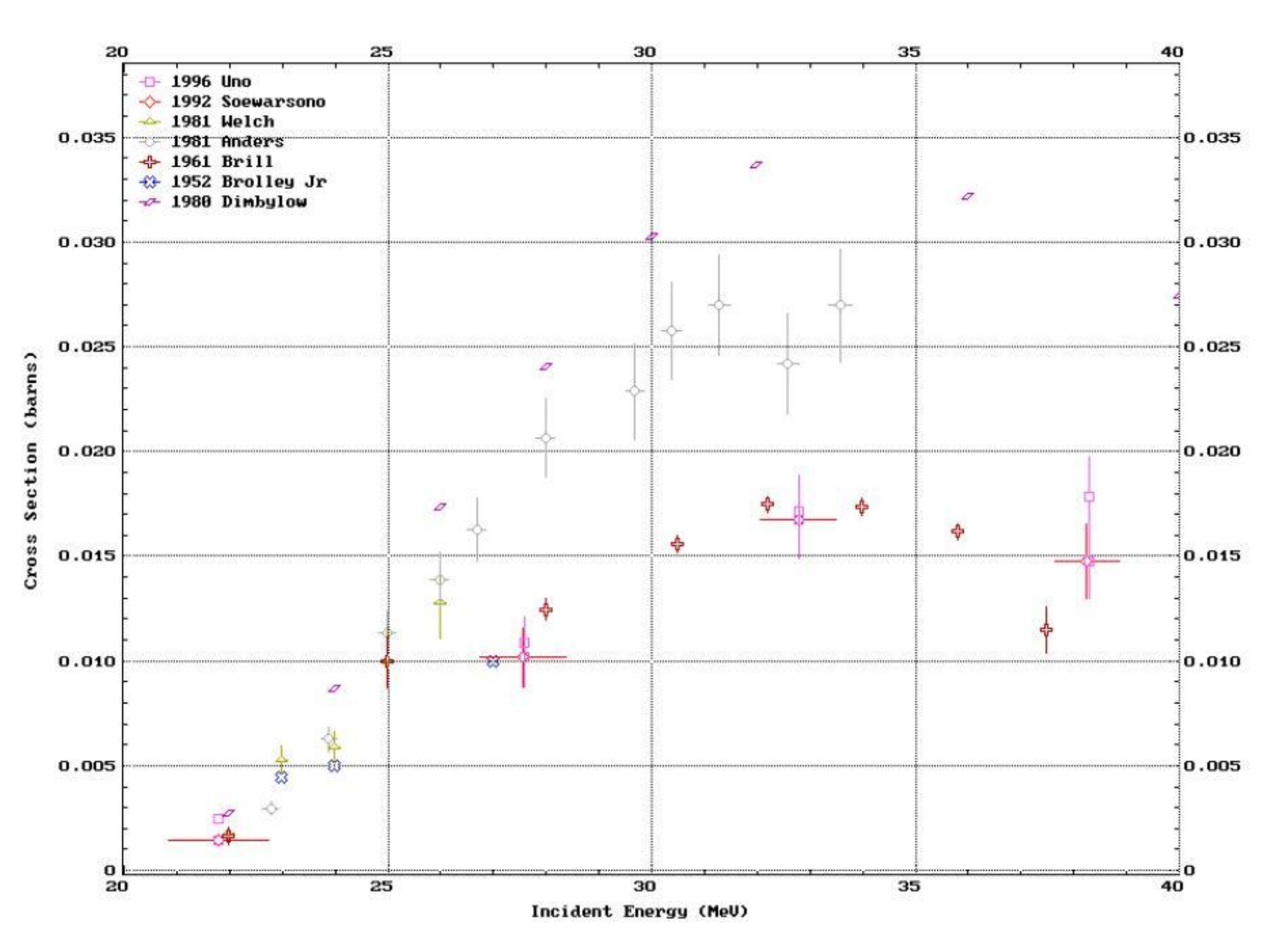
$$n'' + {}^{12}\mathrm{C} \rightarrow 2n + {}^{11}\mathrm{C}$$

$${}^{11}\mathrm{C} \rightarrow {}^{11}\mathrm{B} + e^{+} + \nu_e$$

$$e^{+} + e^{-} \rightarrow 2\gamma(511\ \mathrm{keV})$$




1996 Uno
1992 Soewarsono
1981 Welch
1981 Anders
1961 Brill
1952 Brolley Jr
1988 Dimbylow
Cross Section (barns)
Incident Energy (MeV)
0
0.005
0.010
0.015
0.020
0.025
0.030
0.035
20
25
30
35
40

Measurements for Cross Section Determination

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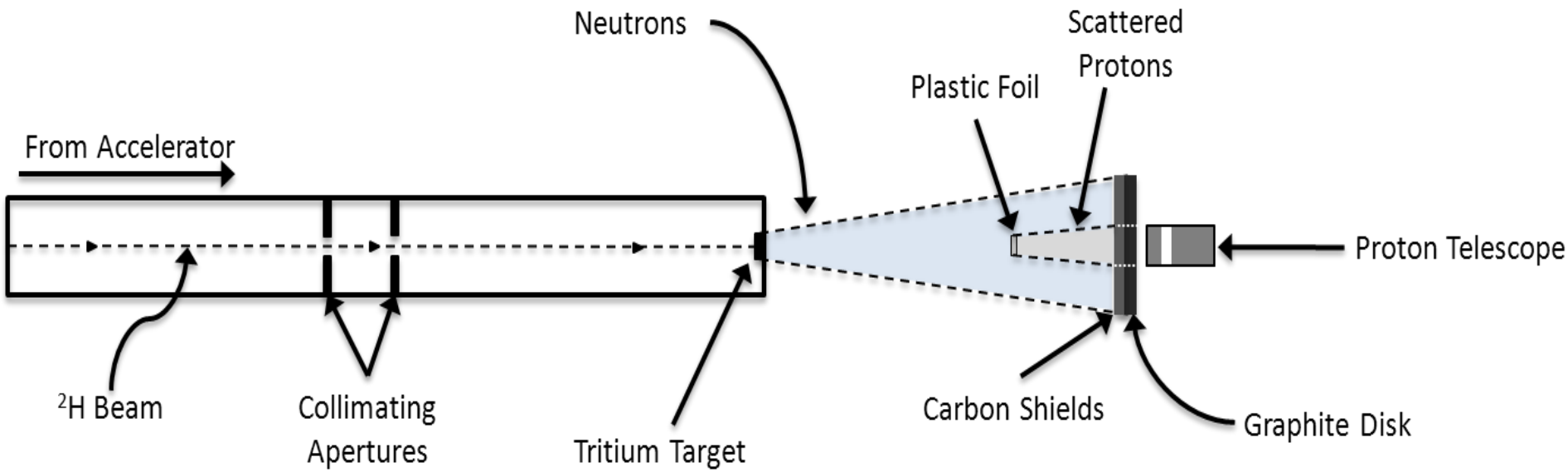
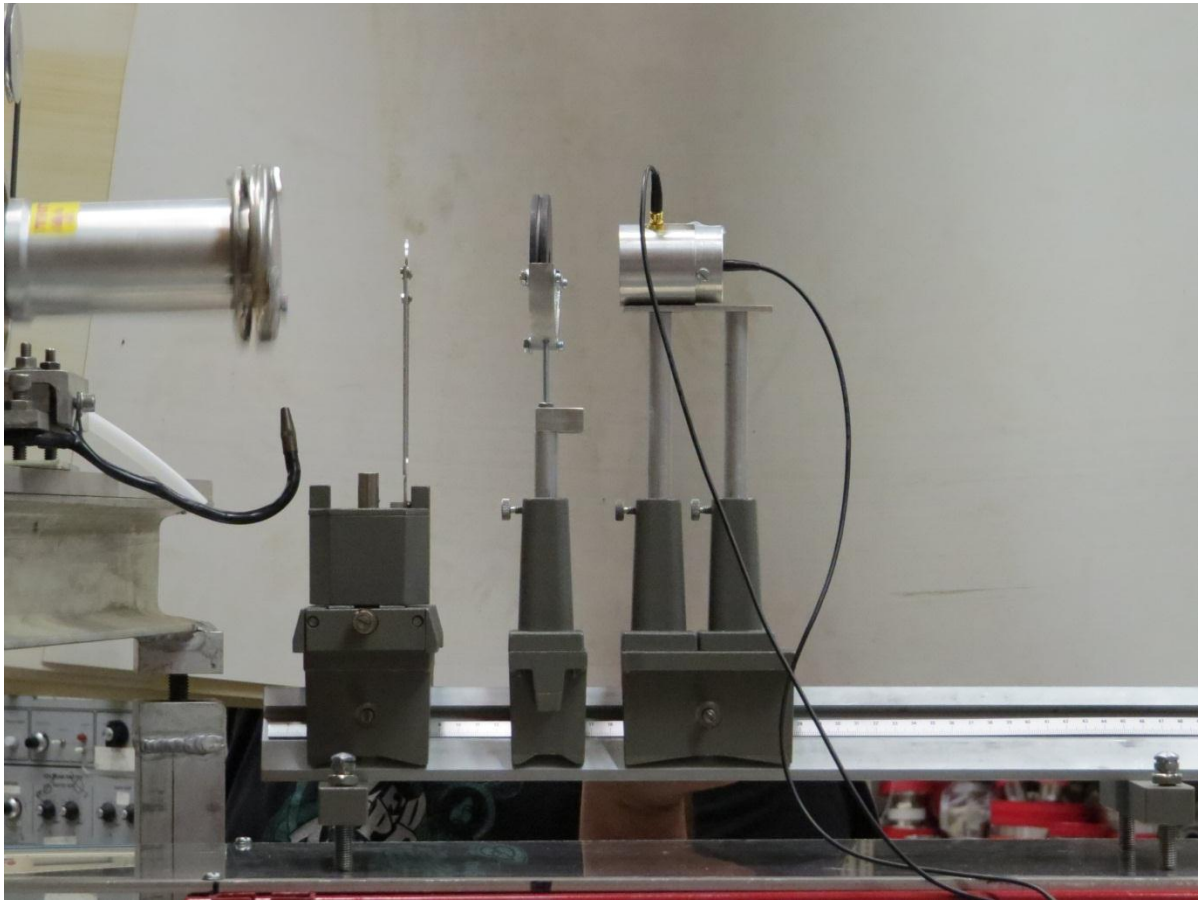


$$\sigma_{n,2n} \propto \frac{N_{^{11}C}}{N_{n"}}$$

$$N_{n"} \propto N_p$$

Experiment at Ohio University

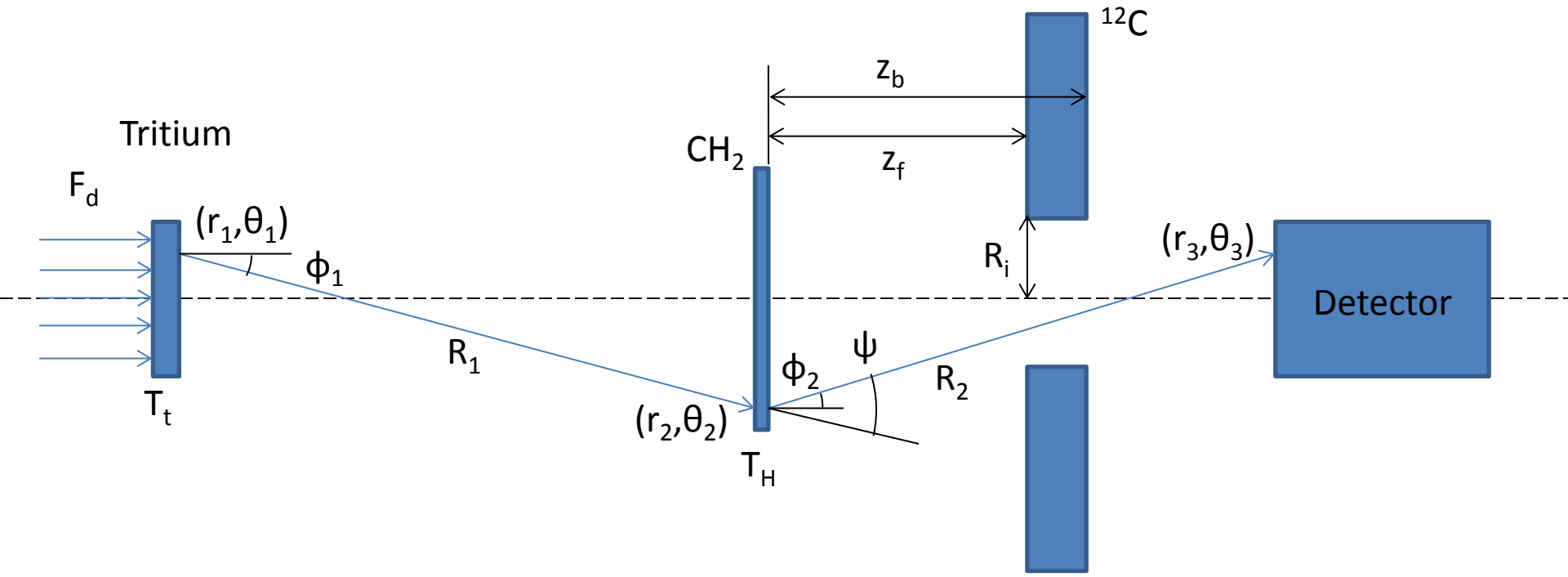


Cross-Section Calculation

$$\frac{dN_{^{11}C}}{dt} = \sigma_{n2n} N_n T_C - \lambda N_{^{11}C}$$

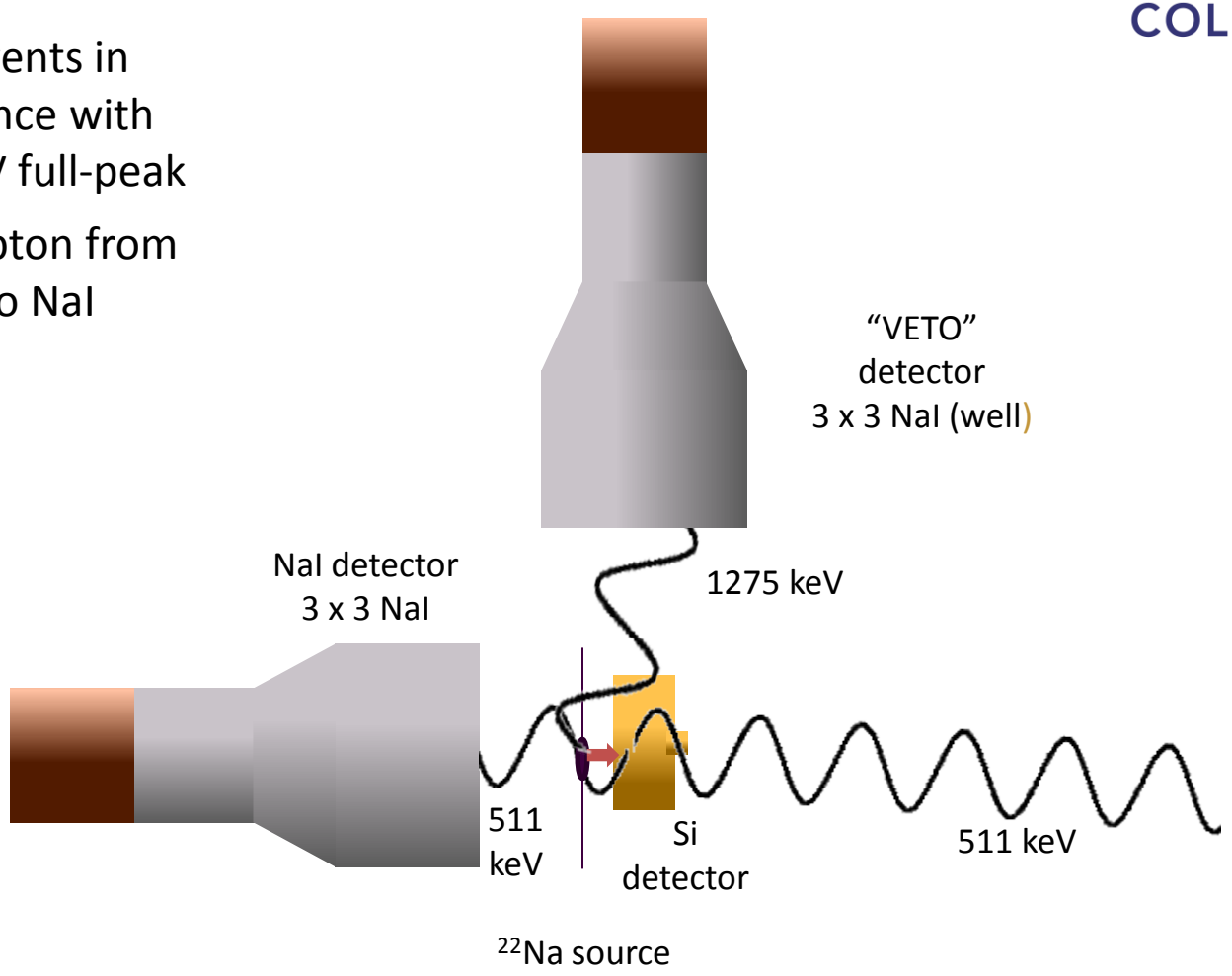
$$\sigma_{n2n} = \frac{N_{^{11}C}\,\lambda}{N_n T_C (1 - e^{-\lambda t})} = \frac{N_{^{11}C}\,\lambda}{T_C (1 - e^{-\lambda t})} \left(\frac{N_p}{N_n}\right) \frac{1}{N_p}$$

Neutron to Proton Ratio

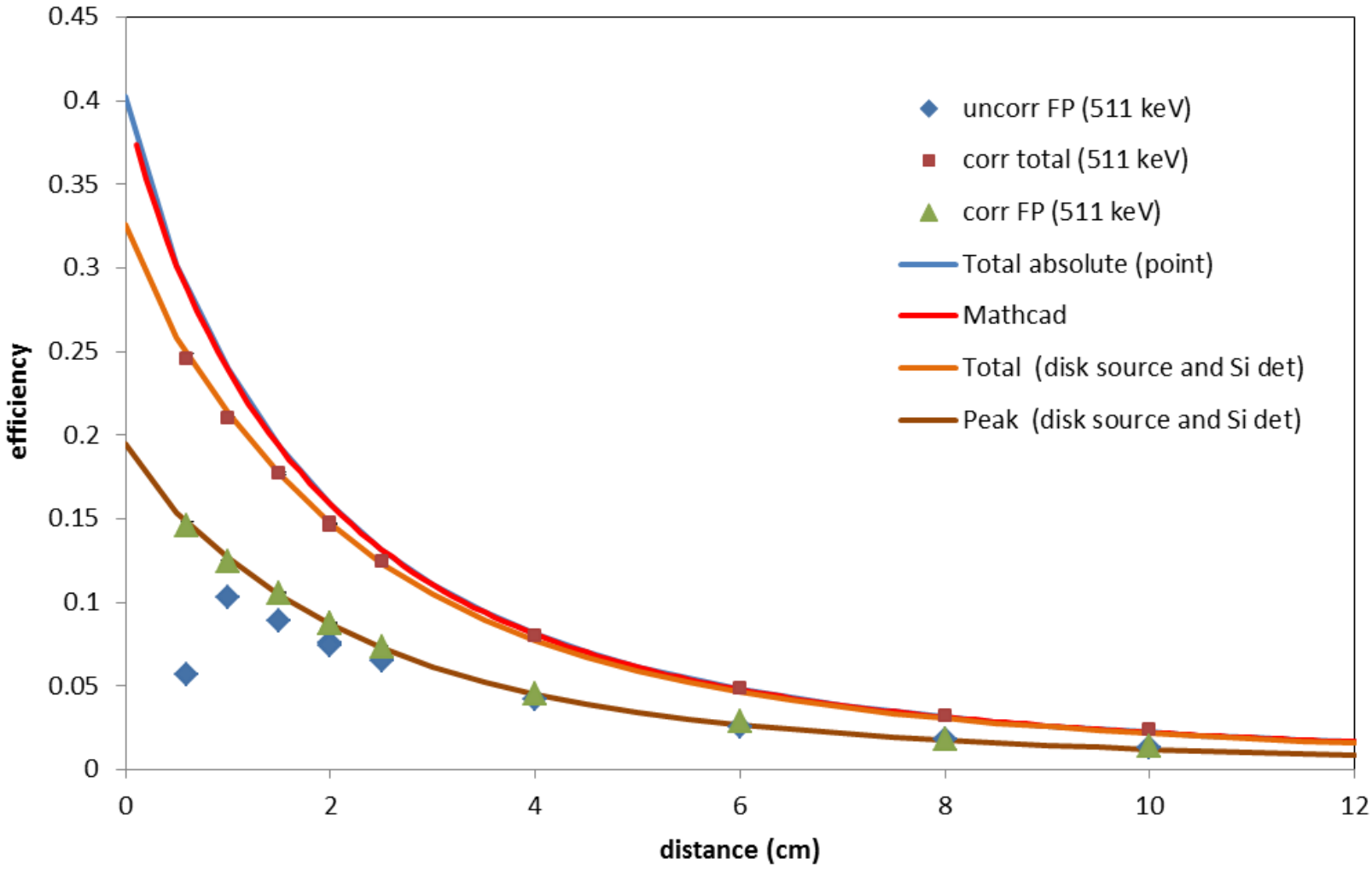


NaI Detector Efficiency

- Select events in coincidence with 1275 keV full-peak
- No Compton from VETO into NaI



Results


0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
efficiency
0
2
4
6
8
10
12
distance (cm)
uncorr FP (511 keV)
corr total (511 keV)
corr FP (511 keV)
Total absolute (point)
Mathcad
Total (disk source and Si det)
Peak (disk source and Si det)

Proposed experiment