Recent Measurement of the $^{14}N(p, \gamma)^{15}O$ Reaction in the CNO Cycle

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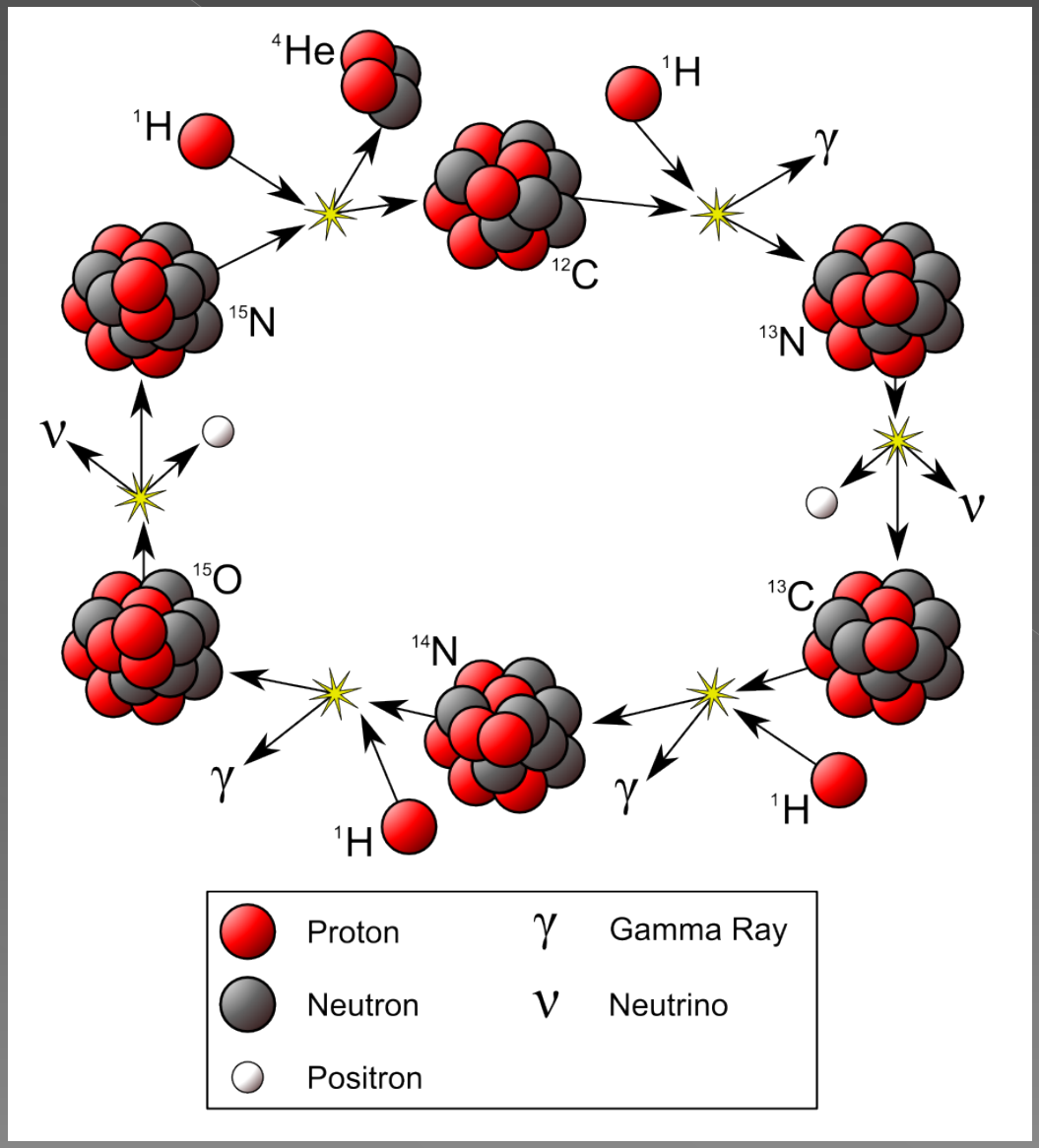
The CNO Cycle



Picture from http://en.wikipedia.org/wiki/File:CNO_Cycle.svg

- The dominant source of energy in stars more massive than the Sun.
- Becomes dominant at $T_6 \geq 17$
- $4H \rightarrow {}^4He + 2e^+ + 2\nu + 26.73MeV$
- The slowest reaction in the chain is ${}^{14}N(p, \gamma){}^{15}O$

Basic Formulas

- Yield and Cross Section

$$Y(E) = \frac{N_\gamma}{N_p \cdot (1 - DT\%) \cdot \eta(E_\gamma) \cdot w(\theta)}$$

$$Y(E_0) = \int_{E_0-\Delta}^{E_0} \frac{\sigma(E)}{\varepsilon(E)} dE = \frac{1}{\varepsilon(E_0)} \int_{E_0-\Delta}^{E_0} \sigma(E) dE$$

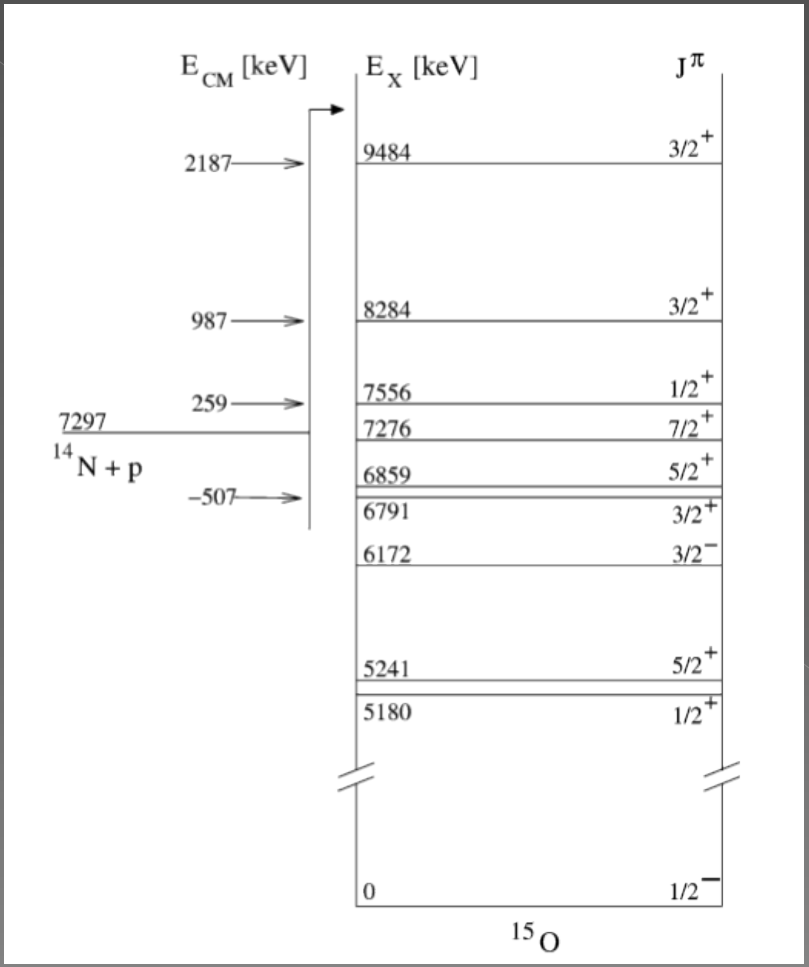
$$\sigma(E_0) = Y(E_0)\varepsilon(E_0)/\Delta$$

- S-factor:

$$S(E) = E_{cm} \cdot \sigma(E) / e^{-2\pi\eta}$$

$$2\pi\eta = Z_1 Z_2 \alpha c / v = 31.29 Z_1 Z_2 \left(\mu / E_{cm}\right)^{1/2}$$

The Energy Structure of ^{15}O



A. Formicola et al. Phys. Lett. B 591, 61 (2004)

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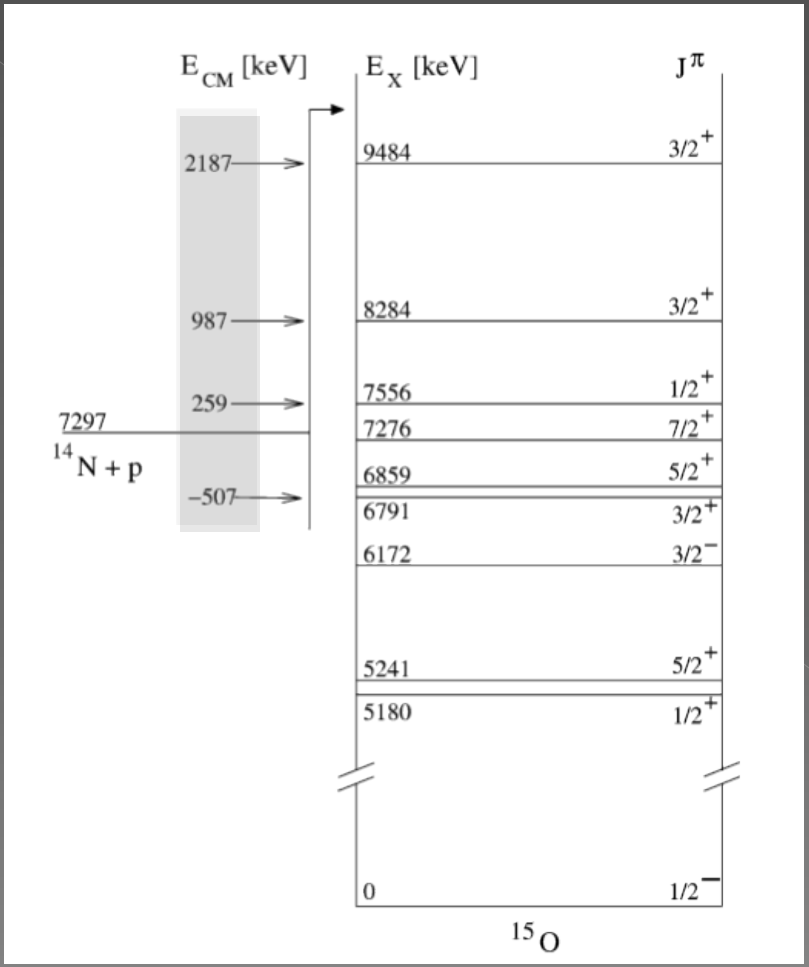

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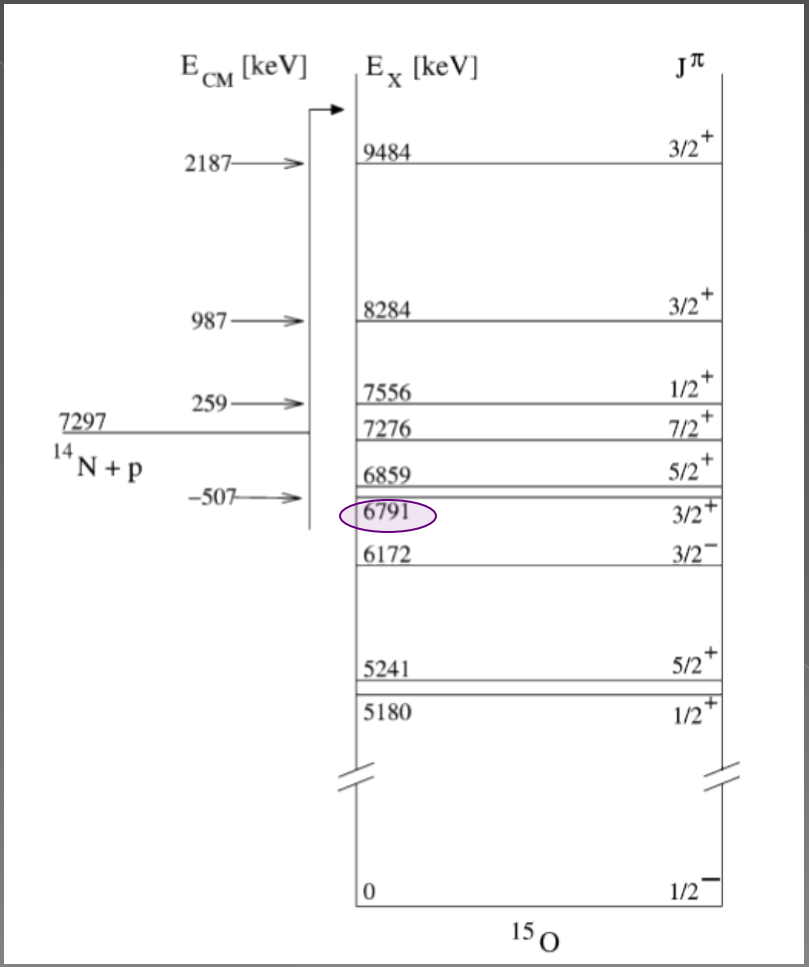

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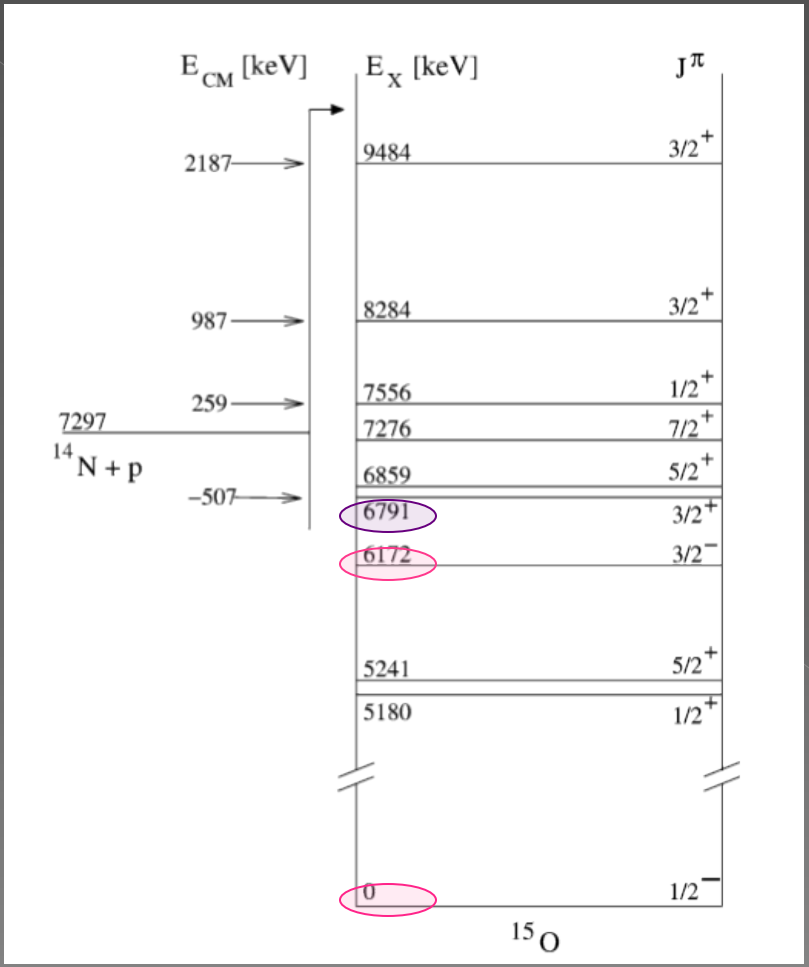

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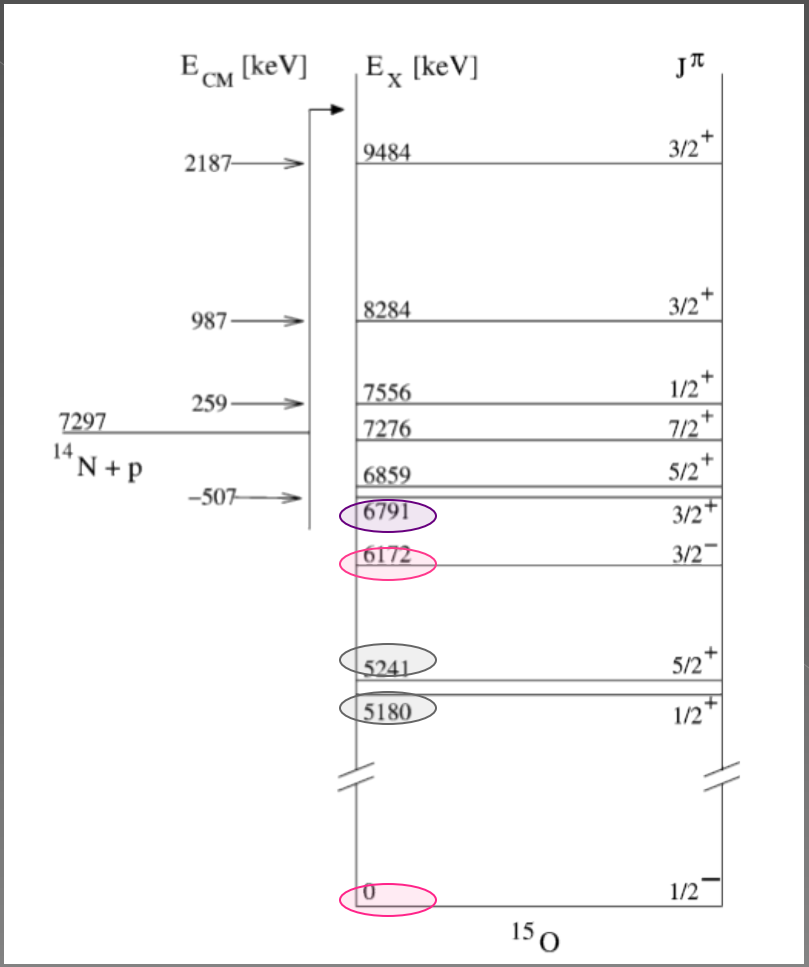

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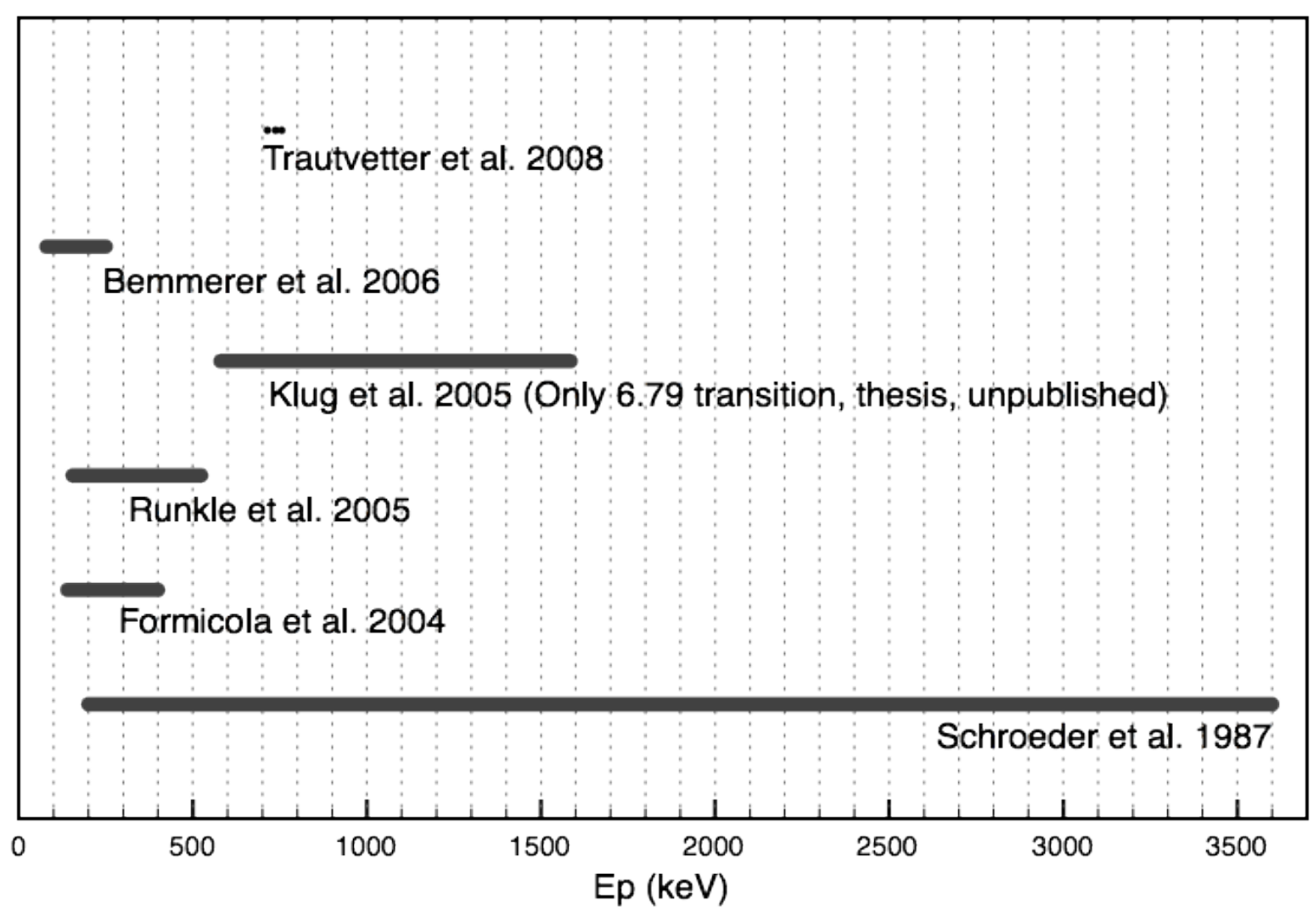
Previous Measurements

---Energy Ranges



Previous Calculations

---S-factor

		Astrophysical S-factor S(0) (keV b)			
Year	Group	R/DC→0.00	R/DC→6.79	R/DC→6.18	Total
1987	Schröder	1.55±0.34	1.41±0.02	0.14±0.05	3.20±0.54
2003	Mukhamedzhanov	0.15±0.07	1.40±0.20	0.13±0.02	1.70±0.22
2005	Angulo	0.25±0.08	1.35±0.04	0.06±0.02	1.70±0.07
2005	Imbriani	0.25±0.06	1.20±0.05	0.08±0.03	1.61±0.08
2005	Runkle	0.49±0.08	1.15±0.05	0.04±0.01	1.68±0.09
2008	Marta	0.20±0.05	1.35±0.10*	0.09±0.07*	1.57±0.13
2010	Azuma	0.28	1.30	0.12	1.81

*Values were adopted from Schröder, Imbriani and Runkle

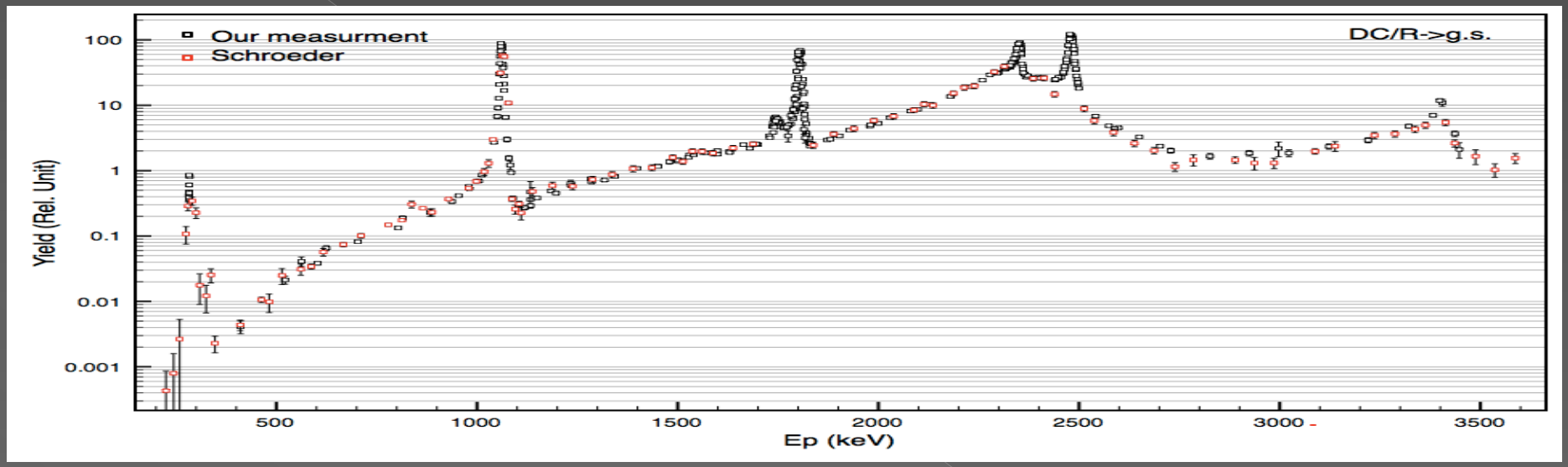
Our Experiment

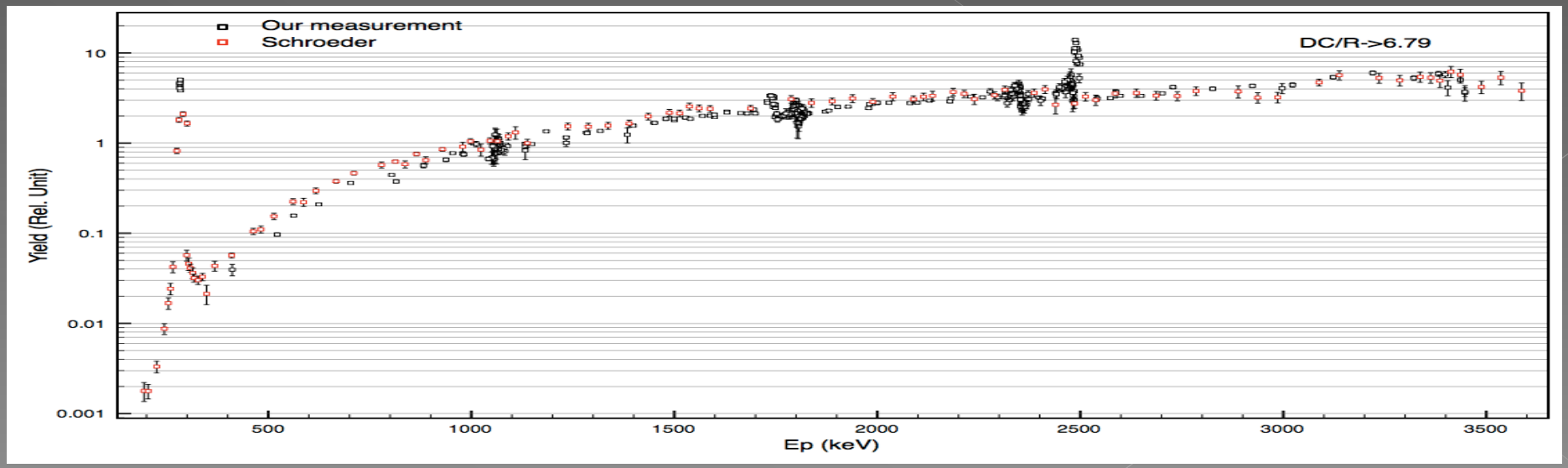
- Energy Range from 0.4MeV~3.6MeV
- Two different setups
- $Ti^{14}N$ and implanted ^{14}N targets were used

Experiment Setup

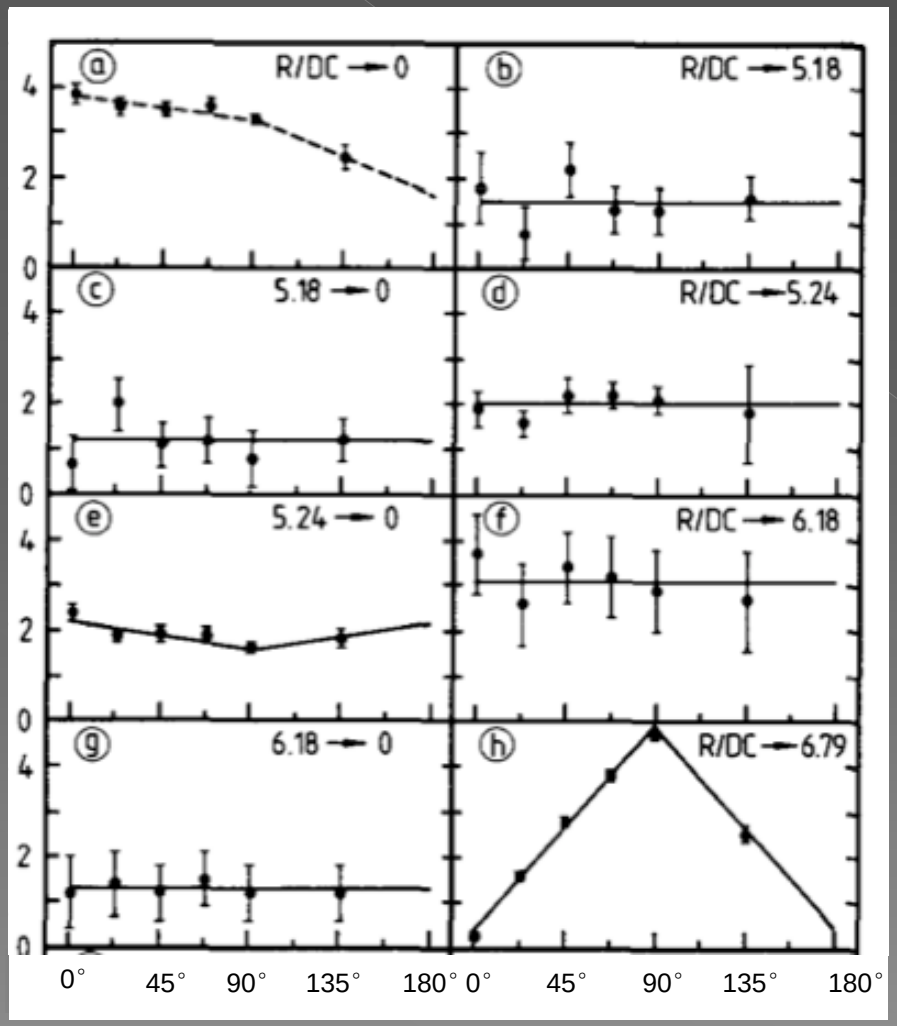
Yield Curve:

---Clover Detector





Angular Distribution Measurement ---Schröder



$$w(\theta) = 1 + \sum a_k Q_k P_k(\theta_\gamma)$$

- Energy range: 0.5-3.1MeV
- Ep = 850keV for the left plot
- The ground state transition has a non-zero a1 coefficient.

Forward/Backward Asymmetry

---25% Ge Detector

Future Analysis

- Finalize data and correct target effects from the yield curve
- R-matrix calculations

Thank You!