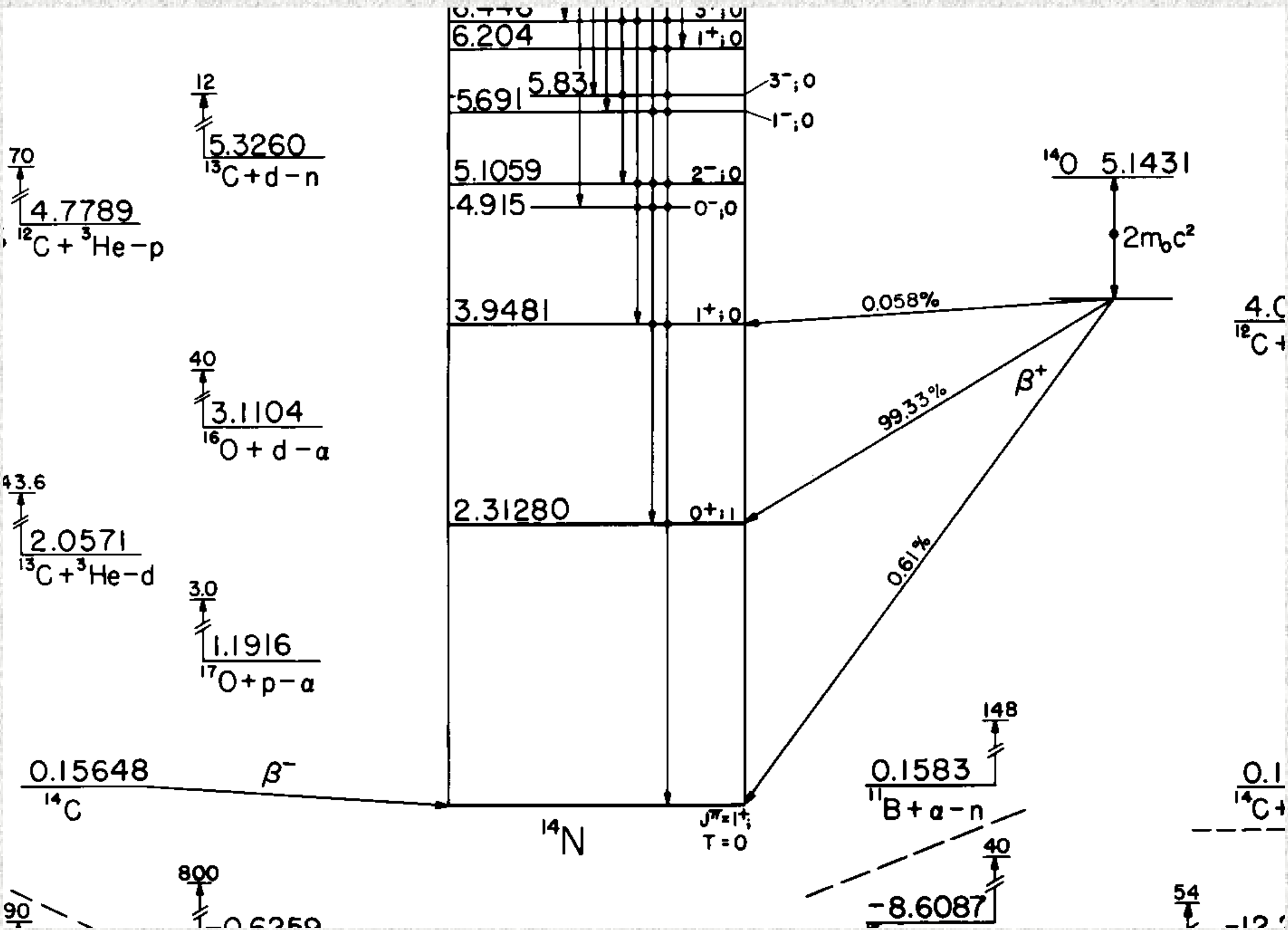
$^{13}C(\vec{d}, n_0)^{14}N$

Evan Sand-GCSU

Advisors
Dr. Ralph France
Dr. Mark Spraker-NGCSU
Dr. Dick Prior-NGCSU
Dr. Sean Stave-Duke



6.204
1+;0
5.83
5.691
3−;0
1−;0
5.1059
2−;0
4.915
0−;0
3.9481
1+;0
2.31280
0+;1
14N
Jπ=1+;
T=0
0.15648
14C
β−
12
5.3260
13C+d−n
70
4.7789
12C+3He−p
40
3.1104
16O+d−α
43.6
2.0571
13C+3He−d
3.0
1.1916
17O+p−α
800
14O 5.1431
2m0c2
0.058%
99.33%
β+
0.61%
148
0.1583
11B+α−n
40
−8.6087
54
90

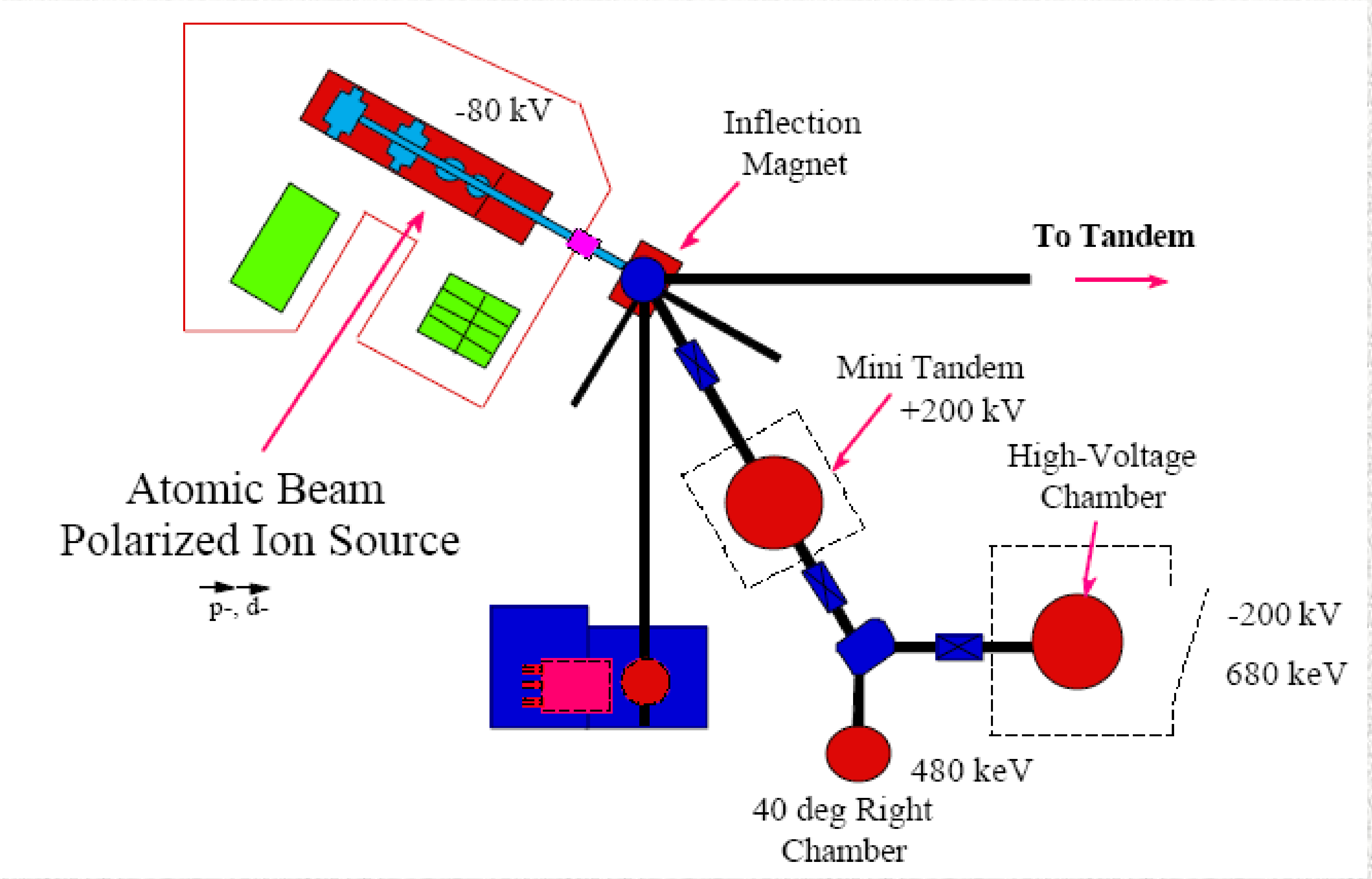
Nucleosynthesis

- Heavy element primordial nucleosynthesis.
- Occurs within the CNO cycle of medium stars

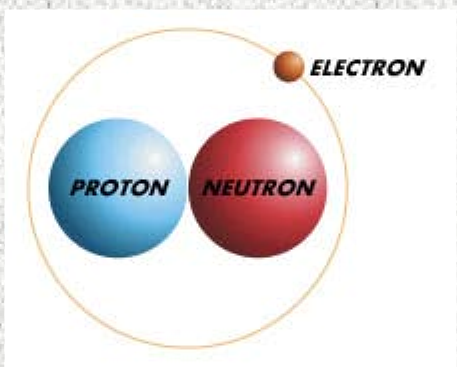
- $^{13}C(d,n_0)^{14}N$ side reaction in the CNO cycle that speeds the production of ^{14}N.

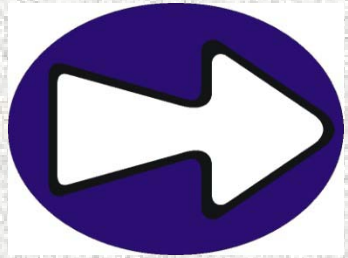
- Understanding dynamics
  - Yields
  - Vector Analyzing powers

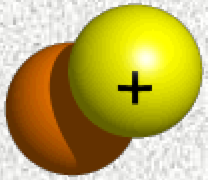
Experiment


-80 kV
Inflection
Magnet
To Tandem
Mini Tandem
+200 kV
High-Voltage
Chamber
Atomic Beam
Polarized Ion Source
p-, d-
-200 kV
680 keV
480 keV
40 deg Right
Chamber

Beam



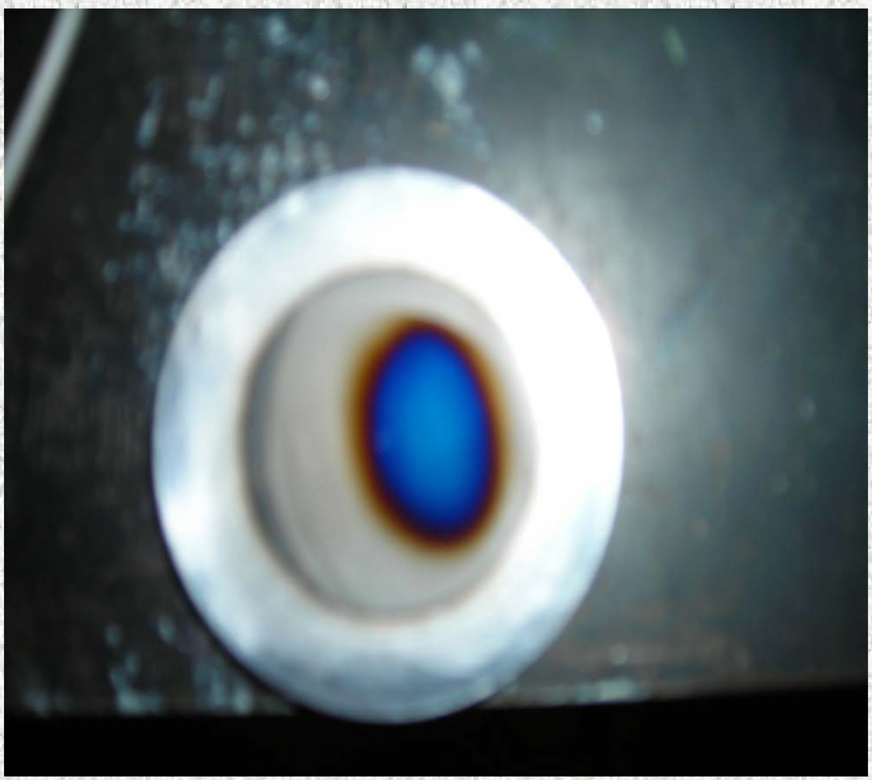




ABPIS produces a polarized deuterium beam with alternating spin up and spin down at a rate of ~10Hz

Deuterium beam through mini-tandem through stripper foil takes away electrons leaving a deuteron beam.

Target

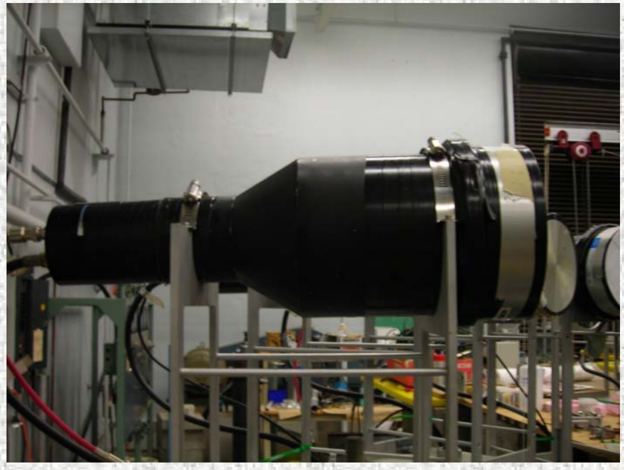


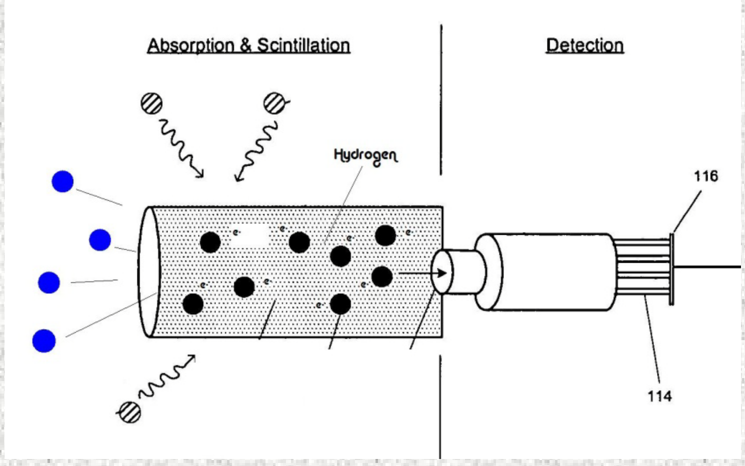
- Enriched ^{13}C
- 200-225ug/cm^2 thick
- Thick Aluminum backing
- Carbon & deuterium buildup require change in target periodically

Carbon- pump oils, vacuum imperfection

d(d,n)- background issue due to deuterium implanting in target

Detection



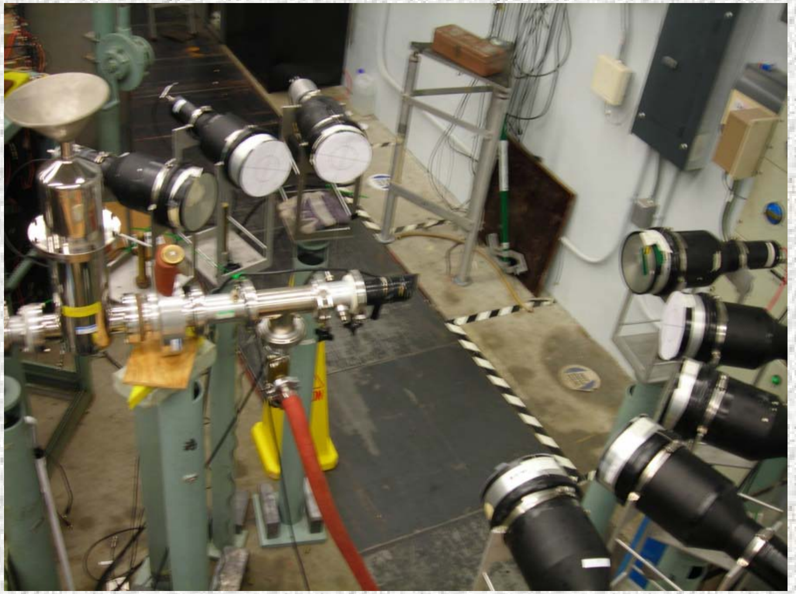


Eight liquid scintillator neutron detectors

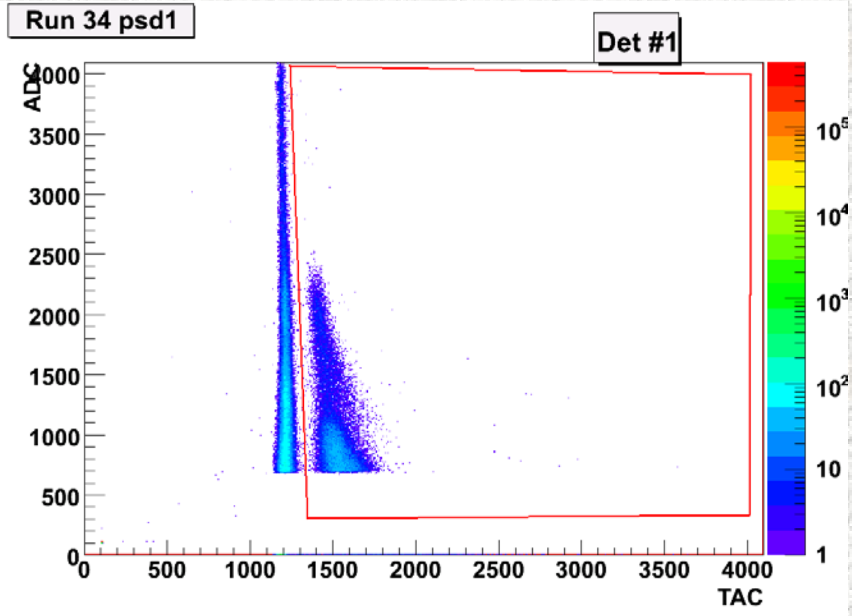
Angles of 0 , 22.5 , 45 , 65.2 , 90 , 112.5 , 135

Pulse Shape Discrimination

- Gamma
- Neutron



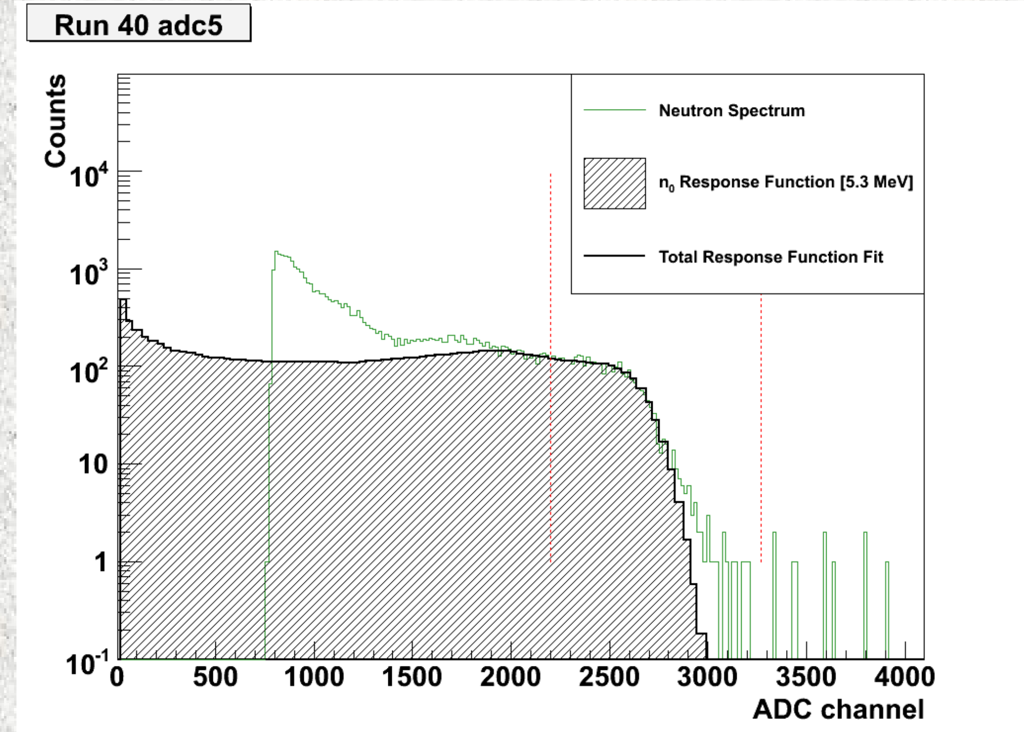
DATA!!!



•Threshold for each detector set at 1 ^{137}Cs

•Detector efficiency

Spectrum fitted with detector response function using a chi-squared minimization routine (minuit)



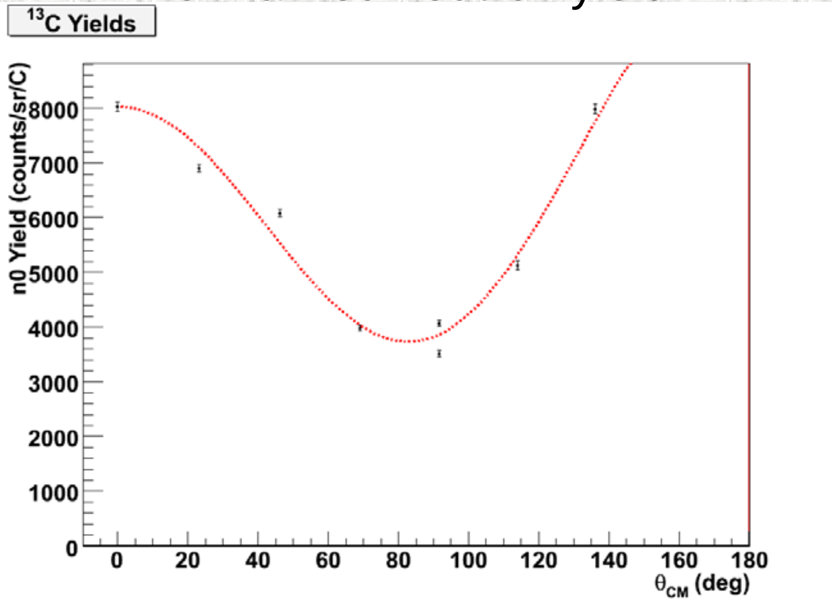
Used fitted response function to calculate the number of neutrons detected

Corrected for :

- Solid angle
- Detector efficiency
- Dead time
- Transformed to center of mass frame

Divided by the charge integrated during the run to give a normalized neutron yield.

$$Y(\theta) = A_0(1 + \sum_{i=1}^{n} a_i P_i(\cos\theta))$$



Allows a simple integration over all angles that in turn gives the total neutron yield at a given beam energy

$$Y_{Tot} = 4\pi A_0$$

Thick Target Yield

The observed neutron yield is the total number of neutrons integrated from the full beam energy down to zero as written:

$$Y(E_d) = C\int_{E_d}^{0} \frac{\sigma(E)\,f}{STP(E)}\,dE$$

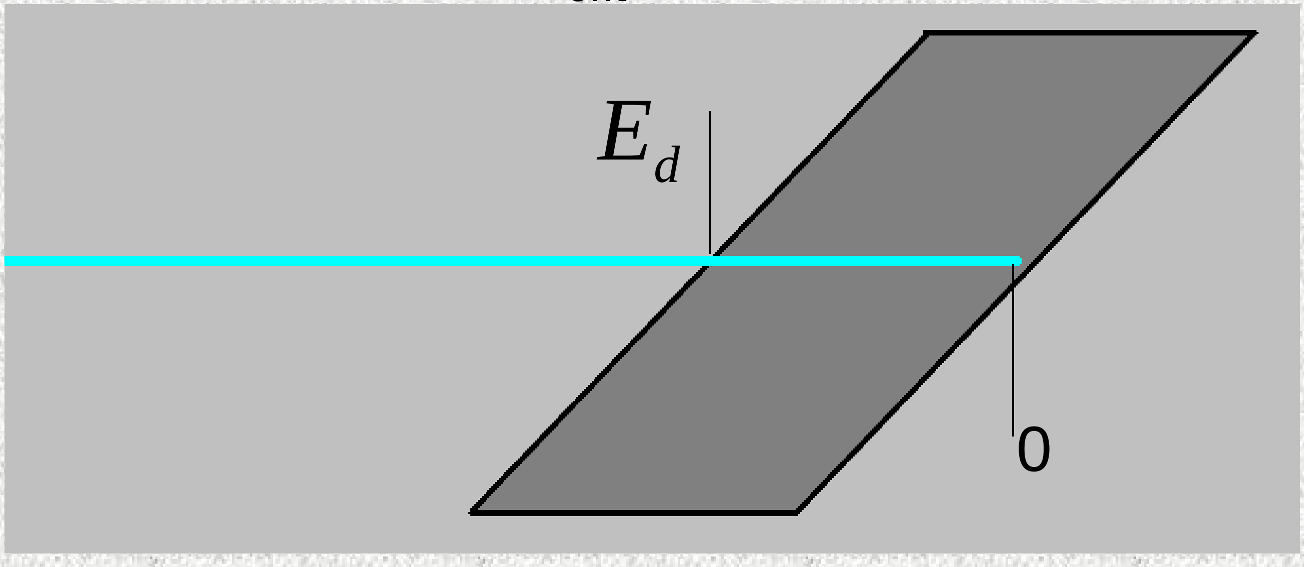
$$\sigma(E_{cm}) = \frac{S(E_{cm})}{E_{cm}}\,e^{-2\pi\eta}$$

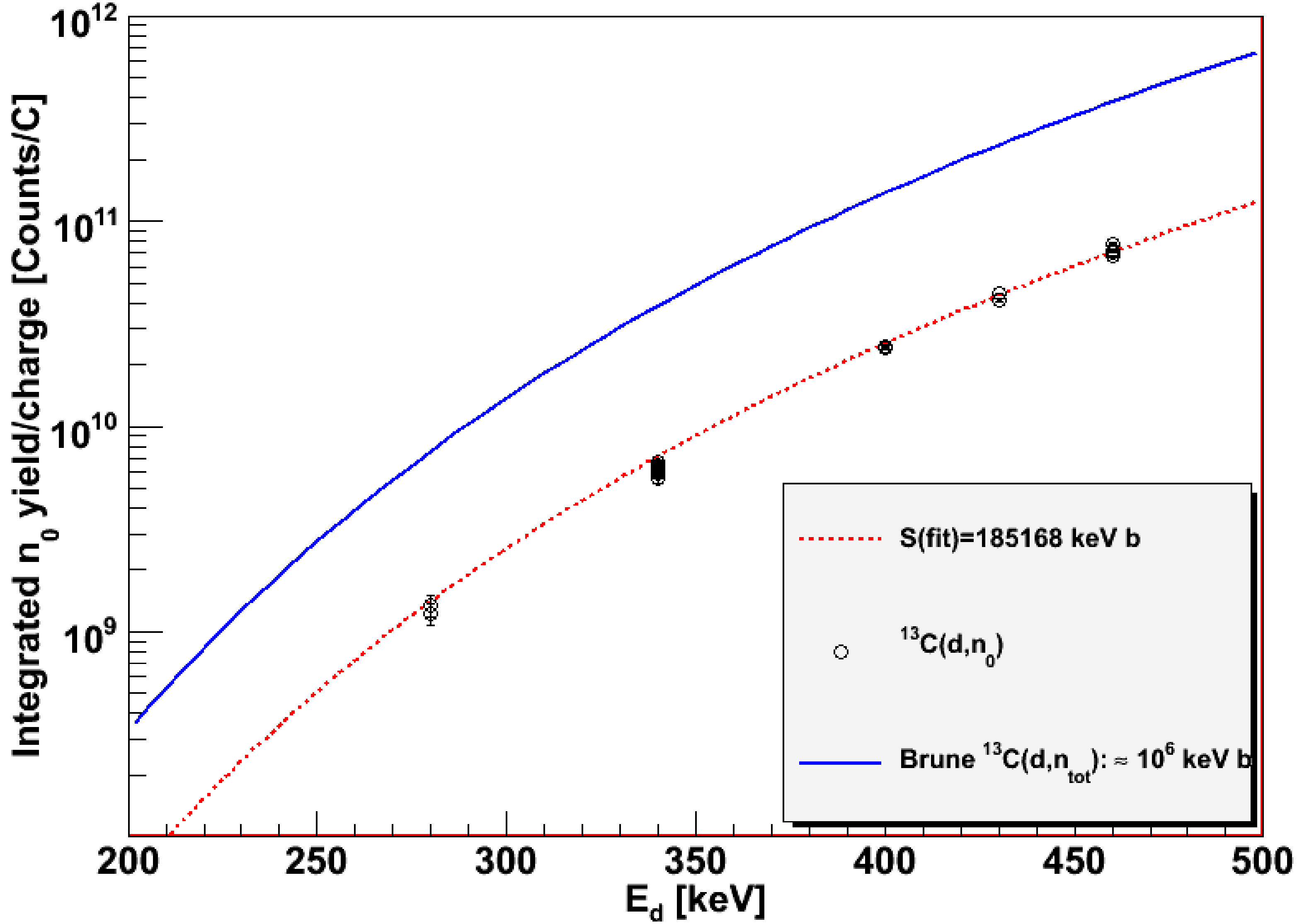
σ(E)= energy dependent cross section

f=atomic fraction of target

STP(E)=stopping power of target

C= constant containing the conversion factors and total number of target particles per cm^2





Integrated n_0 yield/charge [Counts/C]
10^{12}
10^{11}
10^{10}
10^{9}
200
250
300
350
400
450
500
E_d [keV]
S(fit)=185168 keV b
$^{13}C(d,n_0)$
Brune $^{13}C(d,n_{tot})$: ≈ 10^6 keV b

Next..

- Vector analyzing powers
  - Difference in yields produced for two different states of polarization in the beam divided by their sum.

****Special thanks to the following for taking the time to teach me physics well beyond my previous understanding:**

- Dr France
- Dr Spraker
- Dr Prior
- Dr Stave
- Dr Ahmed
- Dr Weller
- Seth Henshaw
- Dr Crowell
- Phil Martel
- Dr Smurzz

**(even when it had to be explained 80 times!!!)