DOE/NV/25946--1806

EXPERIMENTAL DETERMINATION OF DT YIELD IN HIGH CURRENT DD DENSE PLASMA FOCII

D.R. Lowe[1], E.C. Hagen[1], B.T. Meehan[1], R.K. Springs[2], R.J. O'Brien[2]

[1]National Security Technologies
[2]University of Nevada Las Vegas

This work was done by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

National Security Technologies LLC
Vision • Service • Partnership

specialised imaging

Dense Plasma Focus at NNSS

- 2 primary machines at NNSS
  - 2 MJ Gemini
    - DD machine
    - Demonstrated > 1E12 yield per shot, 3000 shots in 3 years
  - 350 kJ Sodium
    - DT machine
    - Demonstrated > 2E11 DD yield, > 1E13 DT yield
    - DT operations in late August

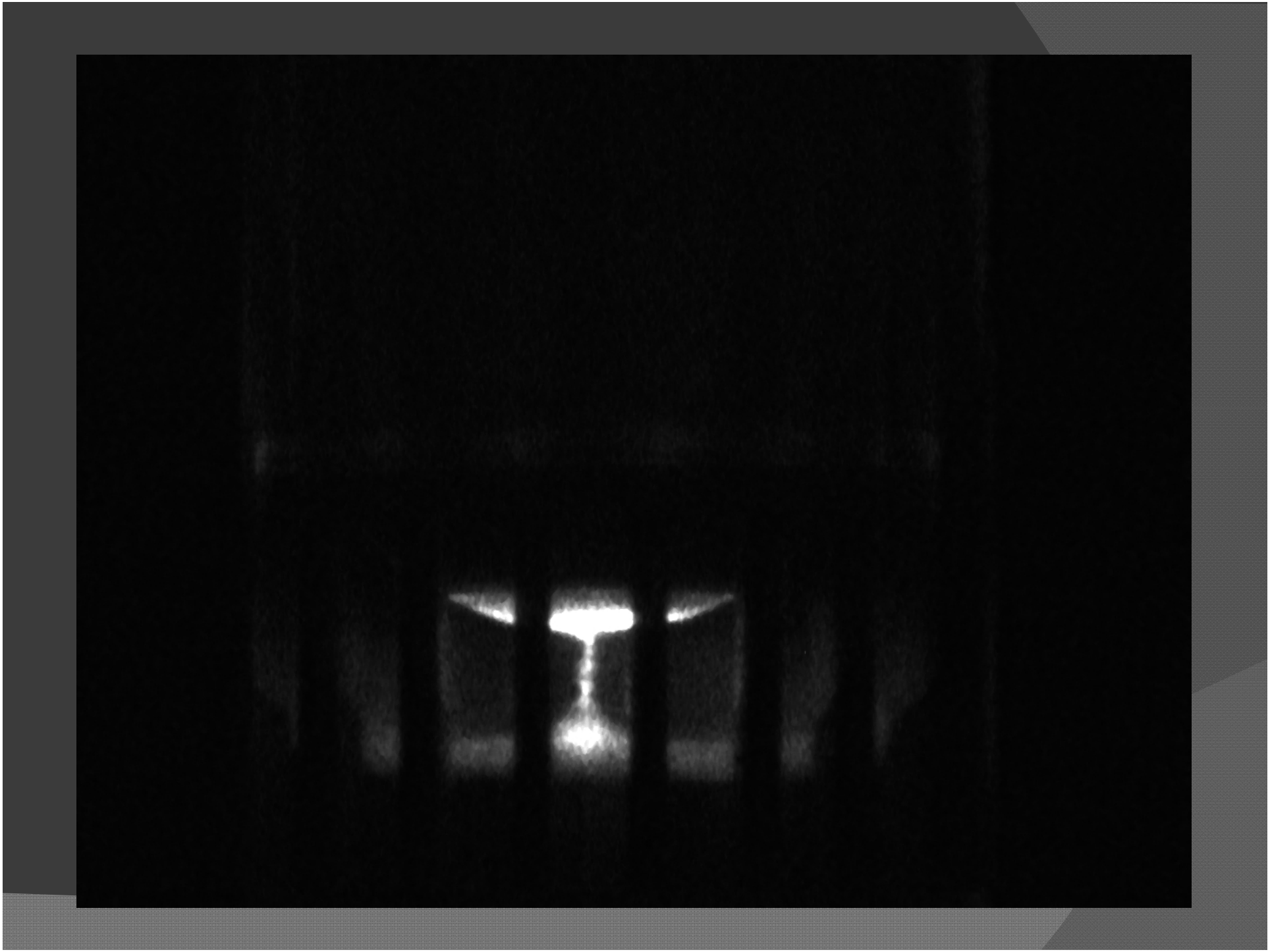
Motivation

- Past 30 years
  - Thermonuclear vs. beam target
  - Evidence can point in either direction depending on the decade
  - More current studies suggest beam target fusion
    - Our specific data also suggests this
    - Need more data points for verification

MHD Simulation

Framing Camera 1

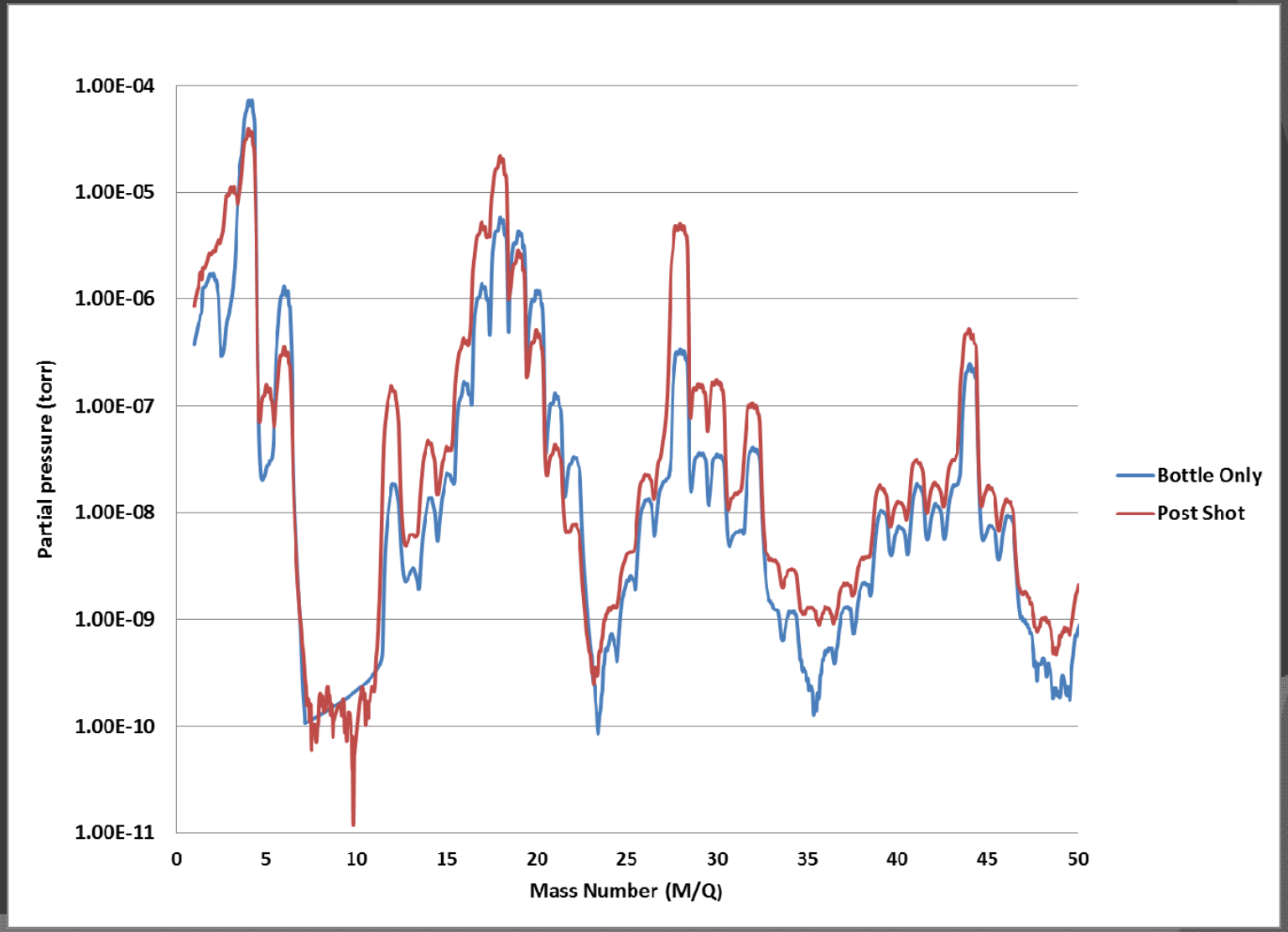
Framing Camera 2



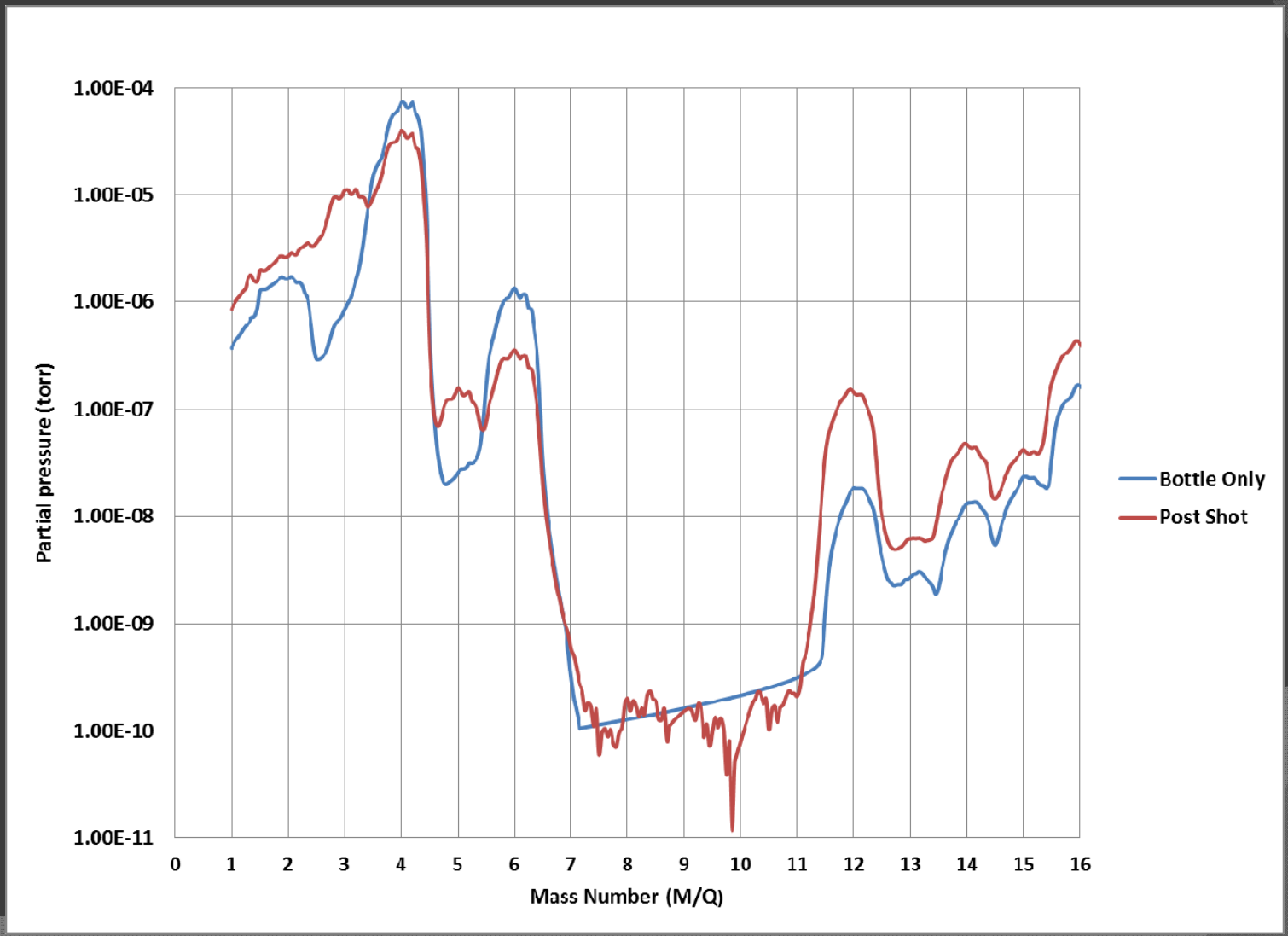
How to find DT

- DD fusion has 2 main branching ratios
  - D + D → ^{3}He + n
  - D + D → ^{3}T + p
- 2 methods
  - RGA (T made)
  - ^{141}Pr activation (DT reaction in flight)
- RGA (SRS system)
- ^{140}Pr activation
  - 800 grams of ^{140}Pr, HPGe detector, rapid retrieval system (3 min half life)

How to find DT (RGA)



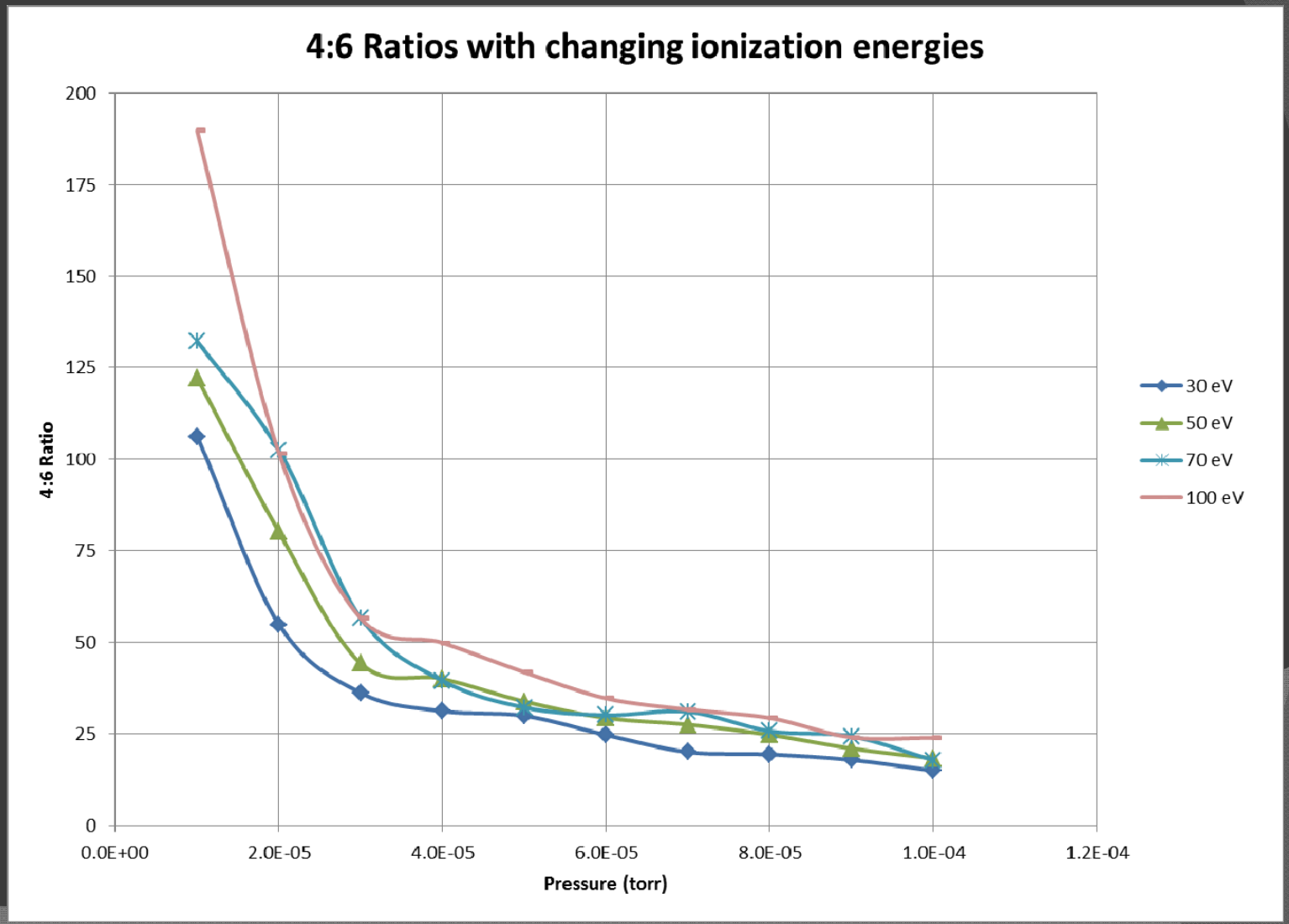
How to find DT (RGA)



M/Q of 6

- Triatomic forms of hydrogen/deuterium
  - H_3, D_3, D_2H, H_2D
- M/Q of 6 = D_3 or T_2
- Half life of D_3 anion/cation ~ 100 ms
  - Created in the ionizer of the RGA
  - Long enough to be counted
  - Creation of D_3 from D_2 gas strong function of RGA pressure and ionizer voltage

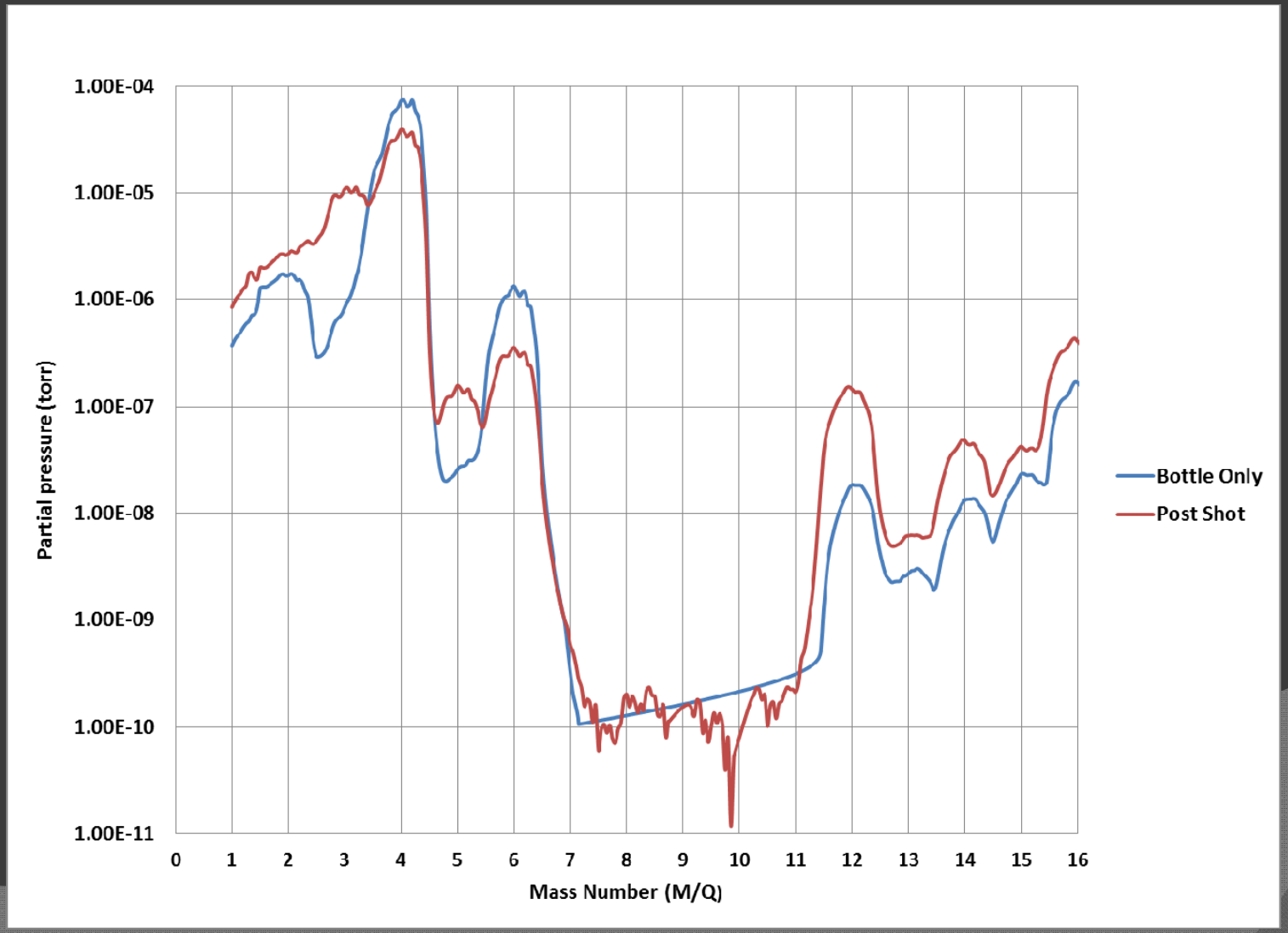
M/Q of 4:6


4:6 Ratios with changing ionization energies
4:6 Ratio
200
175
150
125
100
75
50
25
0
0.0E+00
2.0E-05
4.0E-05
6.0E-05
8.0E-05
1.0E-04
1.2E-04
Pressure (torr)
30 eV
50 eV
70 eV
100 eV

M/Q of 5

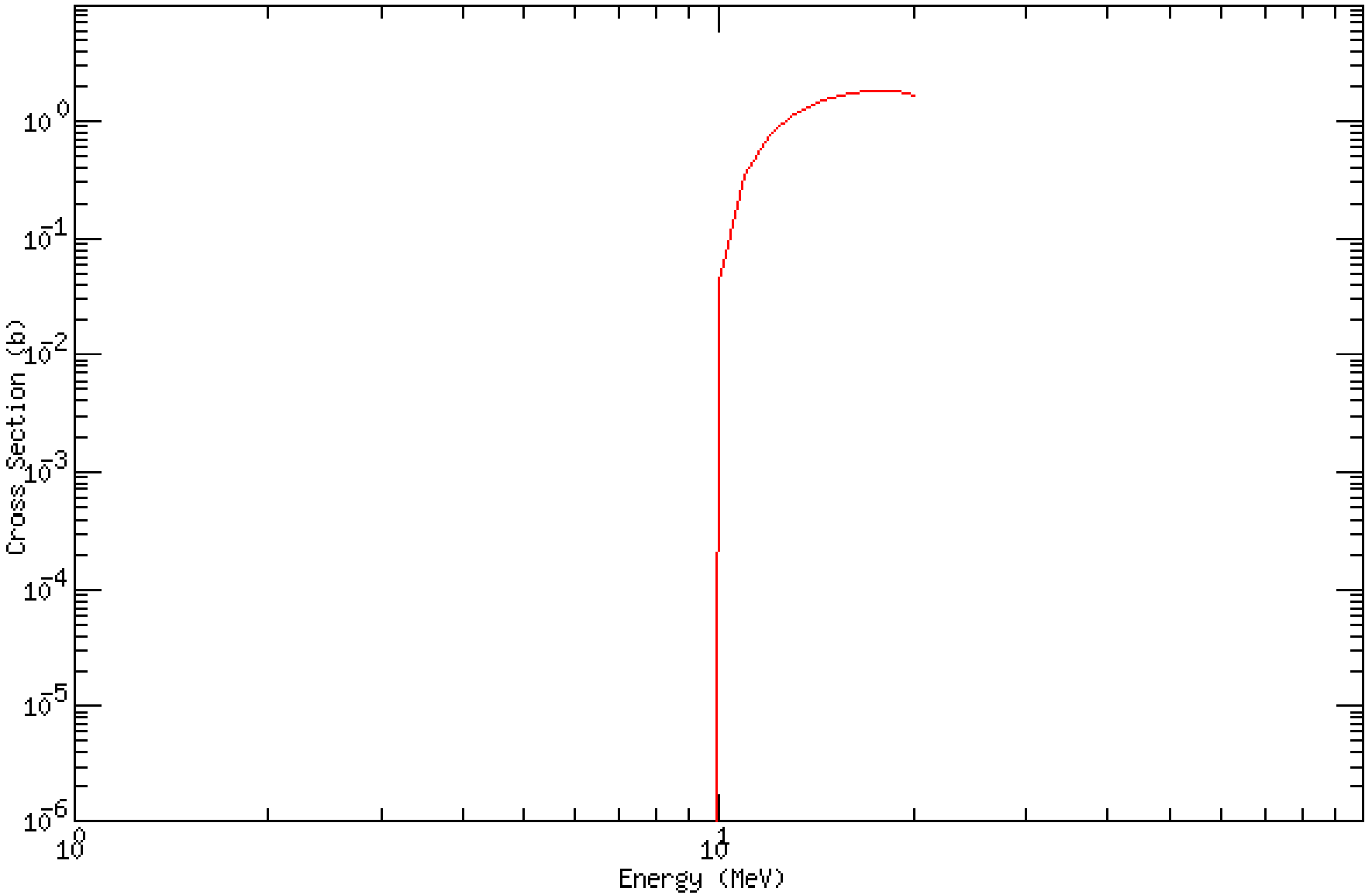
- Triatomic forms of hydrogen/deuterium
  - H_3, D_3, D_2H, H_2D
- M/Q of 5 = D_2H or DT
- D_2H very unlikely
  - Short life span (< 1 us)
  - Little hydrogen to capture

How to find DT (RGA)

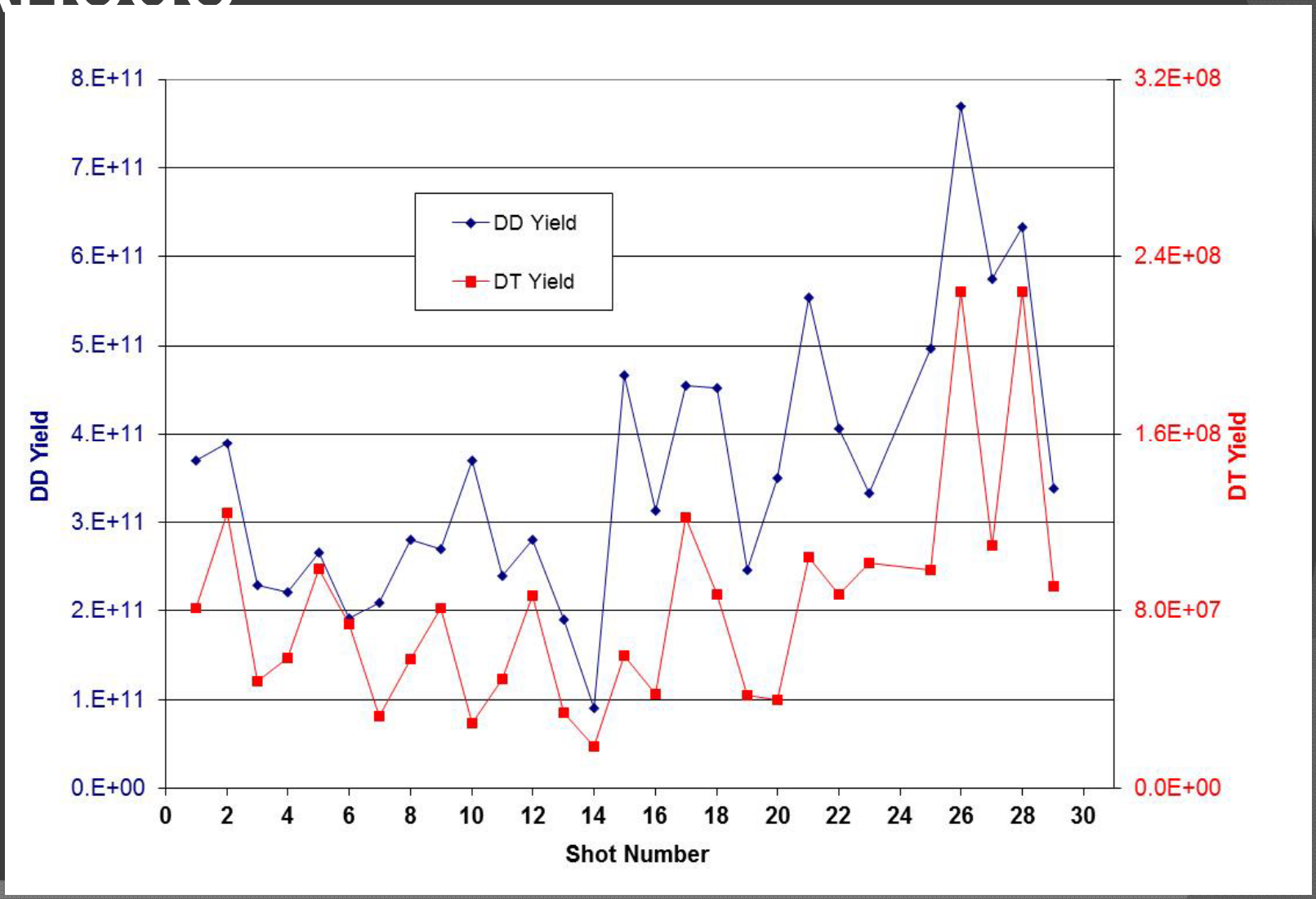


Using ^{141}Pr Activation

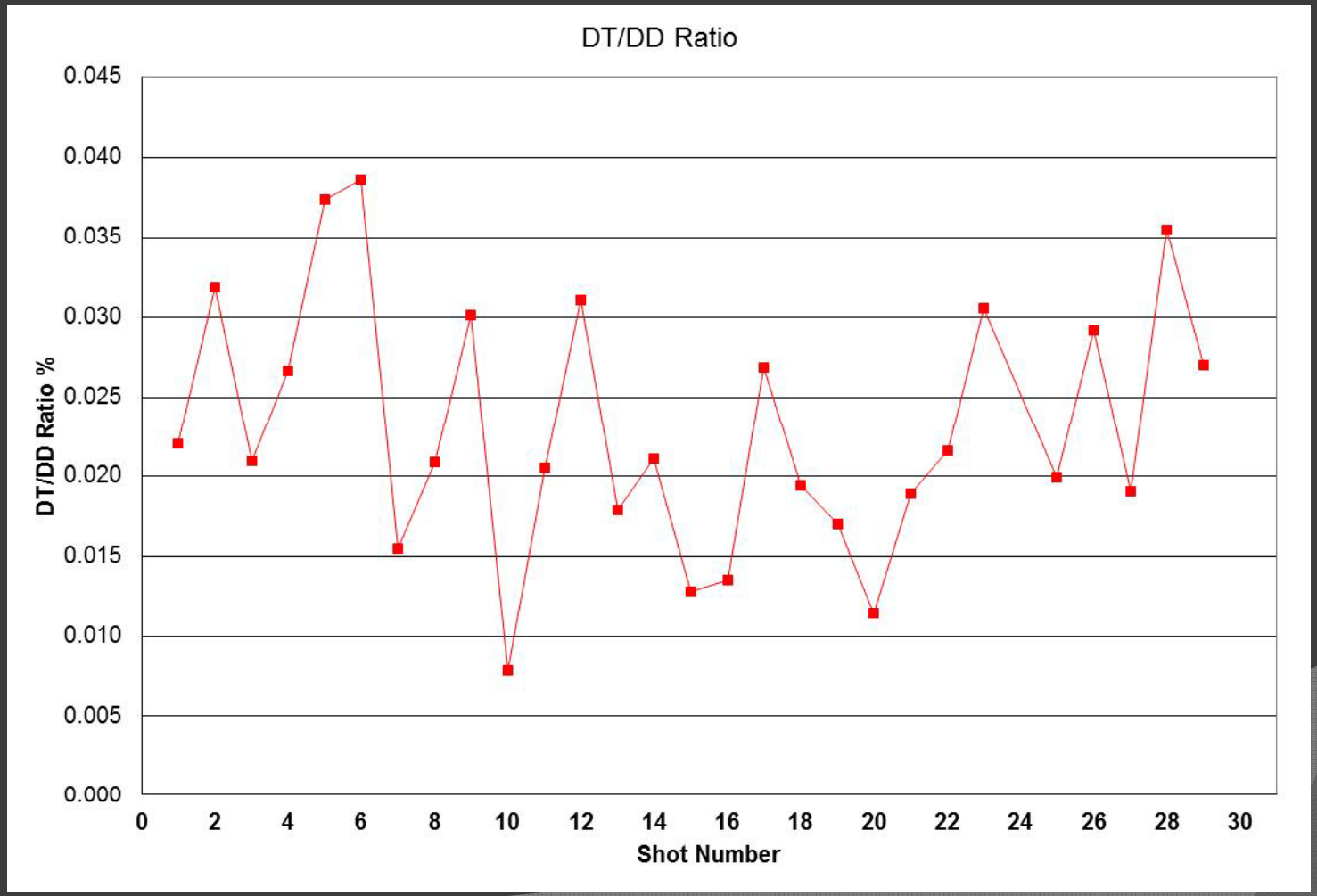
- ^{141}Pr 100% stable isotope
- Uses $^{141}Pr(n,2n)^{140}Pr$
- ^{140}Pr
  - 3.39 minute half life
  - β^+ emitter
- Various disks used, from 400 grams to 1200 grams
- 800 gram disk ideal for activation, 511 escape (MCNP)


Cross Section (b)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^0
10^1
Energy (MeV)

DD/DT Ratio in Curved Anode



DD/DT Ratio in Curved Anode



DT/DD Ratio in Flattop Anode

- Repeated experiments for flattop anodes at high yield (>1E11 DD neutrons per shot)
- RGA showed same DT component
- 14 MeV neutron production lower than MDL of 0.01% (2E7 DT neutrons)

Conclusions

- DT reaction-in-flight neutrons produced in DD DPF at ~ 0.02% of total DD yield for round top anode
- No measureable DT neutrons for flat top anode
  - Possibly due to zipper effect in round top anode?
  - Does this imply shorter neutron pulse for flattop anodes?