

Embedded Fusion & Isotope Production in the UW IEC Device

Ben Cipiti

G.L. Kulcinski, J.F. Santarius, R.P. Ashley, G.R. Piefer,
S. Krupakar Murali, J.W. Weidner, R.F. Radel

5th US-Japan IEC Workshop
University of Wisconsin-Madison
October 9-10, 2002

Outline

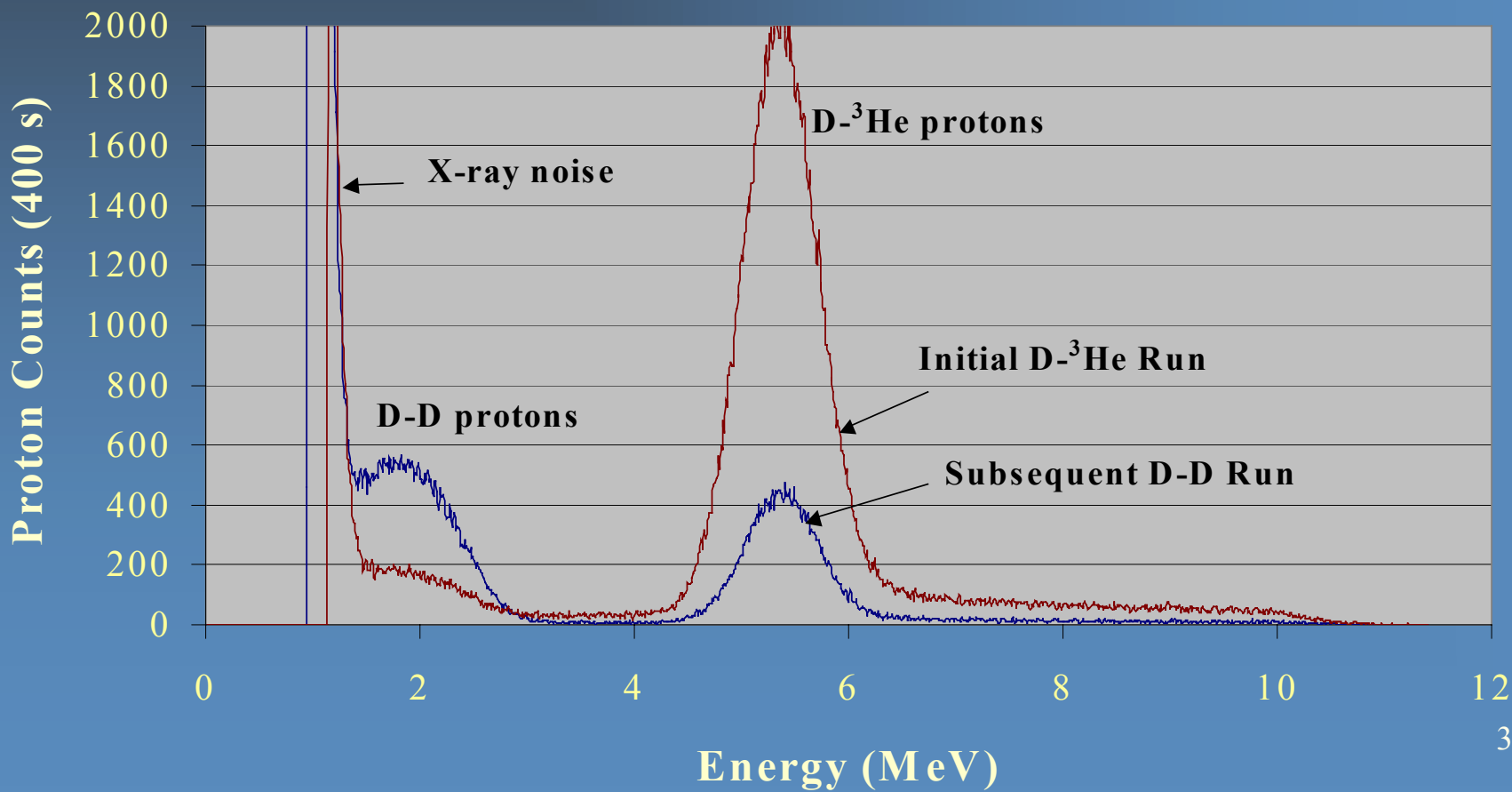


- Evidence of Embedding
- D^+ vs. ${}^3\text{He}^+$ Embedding
- Non-Transparent Cathode Experiments
- Isotope Production
- Summary

D-³He Proton Peak Evident In D-D Runs Following D-³He Runs

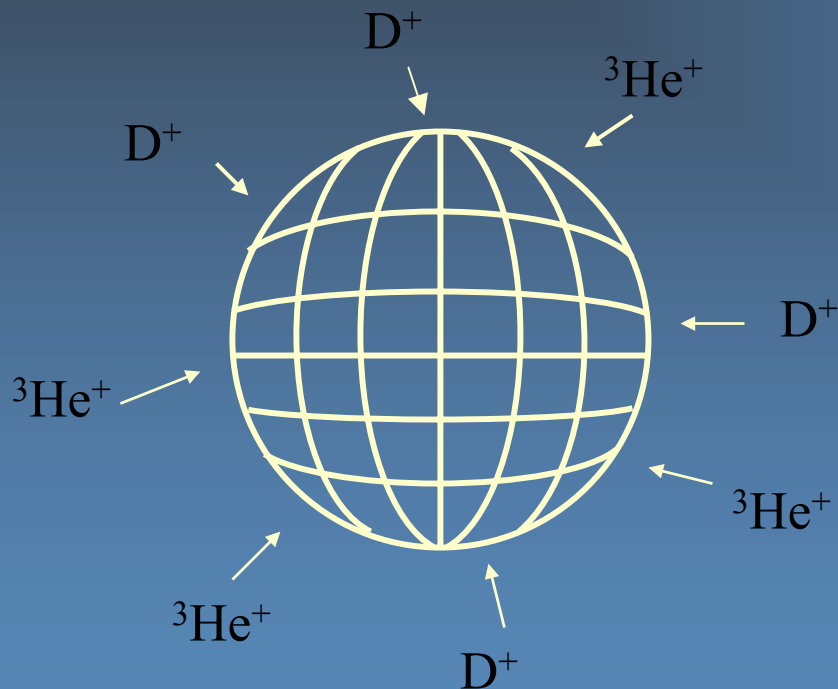
MCA Proton Energy Spectrum

100 kV, 30 mA
2.1 mTorr

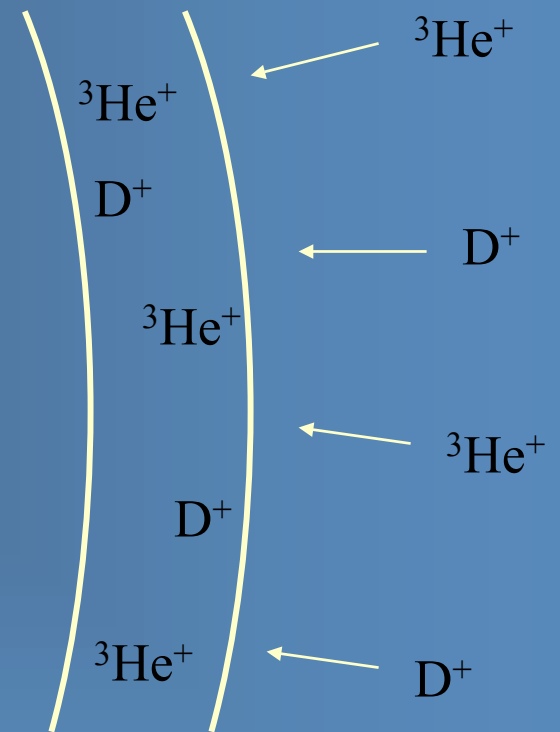


Embedded Regime

(100 keV ${}^3\text{He}^+$ ions penetrate 0.3 μm in tungsten)



Cathode



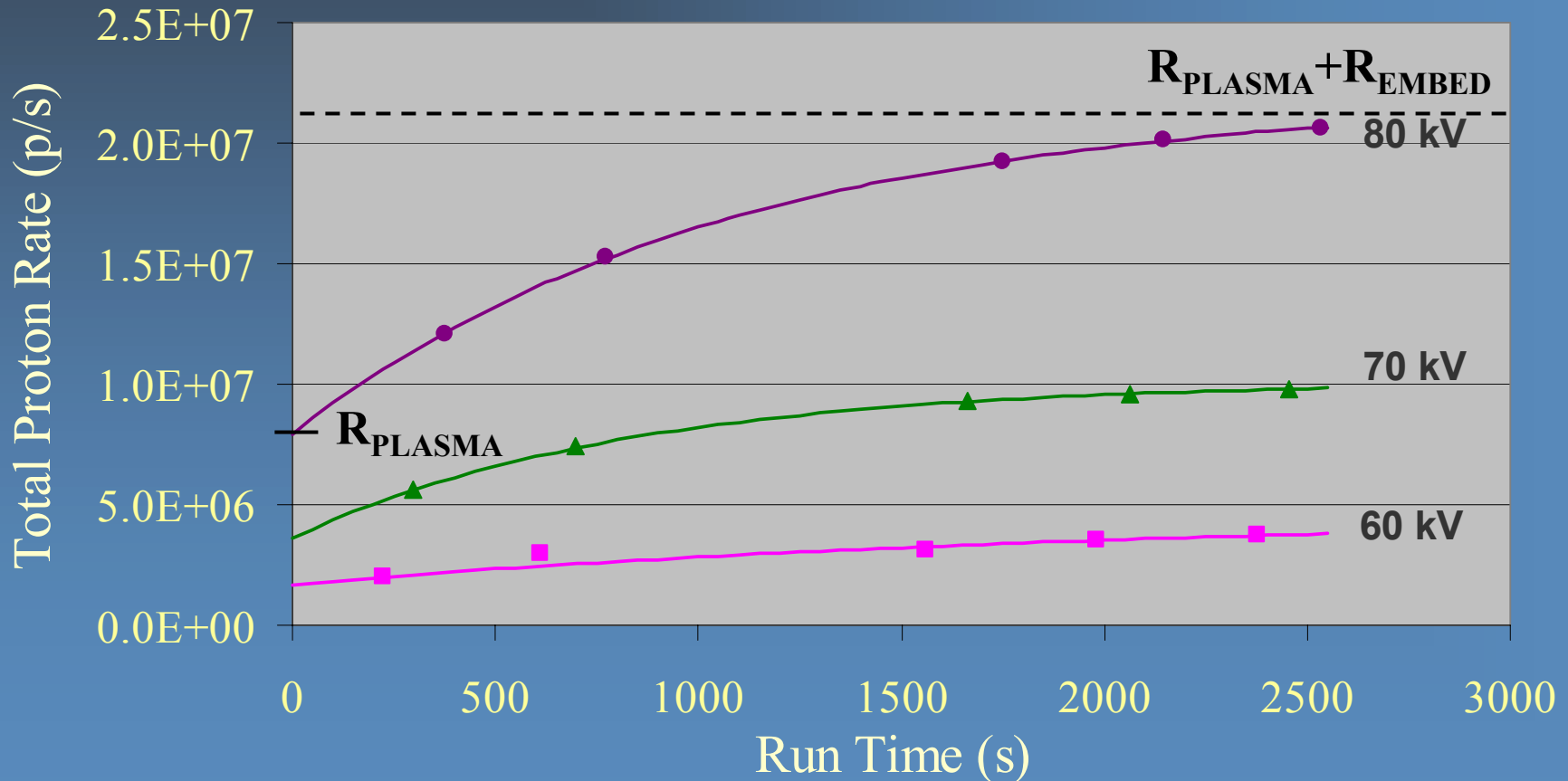
Grid Wire

D-³He Fusion Rates Increase With Run Time After Installing Virgin Grid



D-³He Proton Rate vs. Time

30 mA
2 mtorr



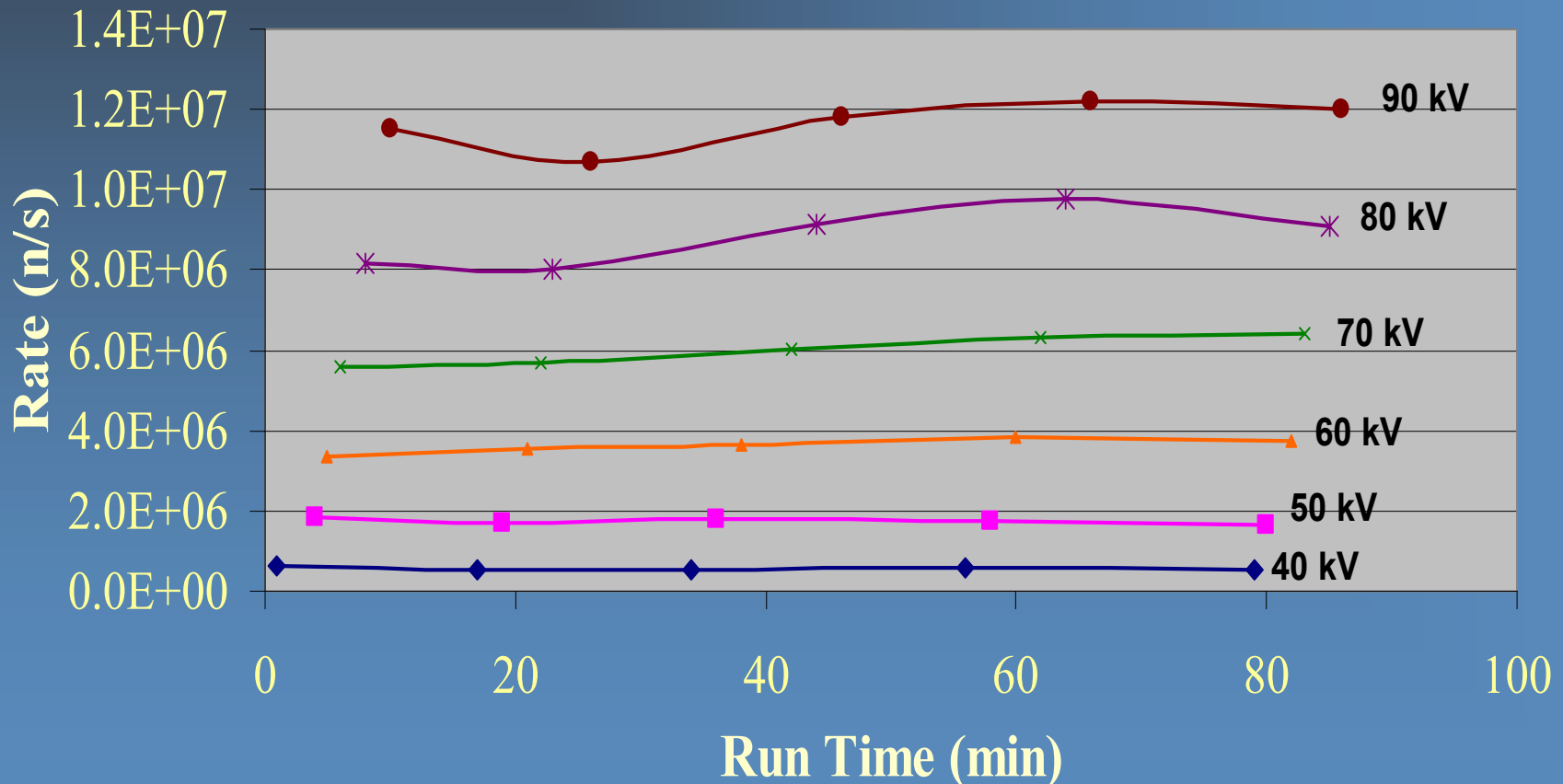
D-³He Fusion Rates Appear To Saturate



- Exponential saturation equations were fit to the curves
- $R_{\text{TOTAL}} = R_{\text{PLASMA}} + R_{\text{EMBED}}(1 - e^{-\lambda t})$
- For the three voltages, $\sim 2/3$ of the maximum rate was due to embedded reactions.

D-D Fusion Rates Are Generally Constant With Run Time

D-D Neutron Rates vs. Run Time



Non-Transparent Cathode Experiments

- A large fraction of D-³He reactions occur at the cathode
- The 14.7 MeV proton flux is higher at that location
- A non-transparent cathode forces only embedded reactions to occur

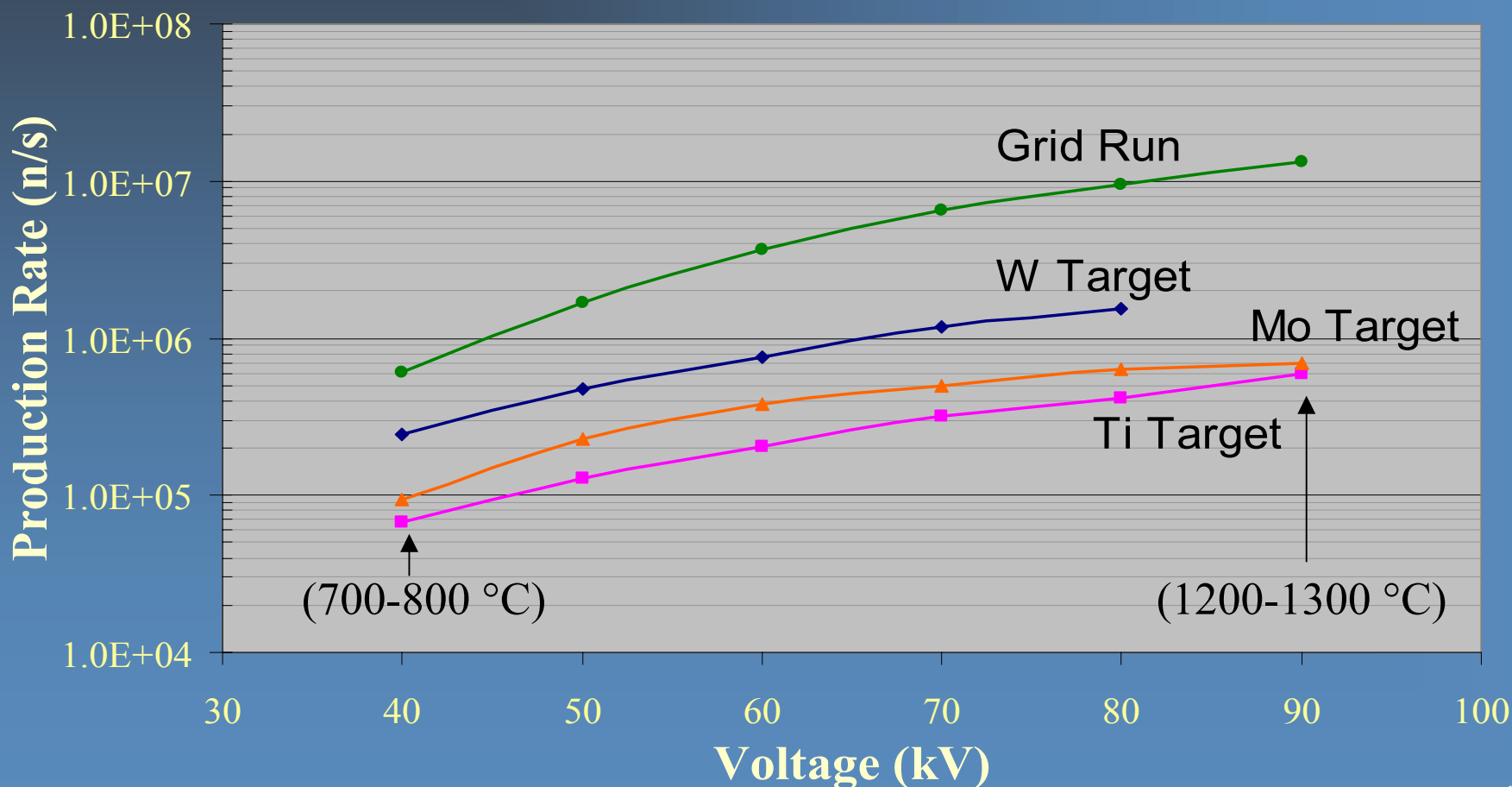
Tungsten, Titanium, & Molybdenum Targets Were Fabricated



D-D Neutron Rates With Targets Are Low Compared to Grid Runs

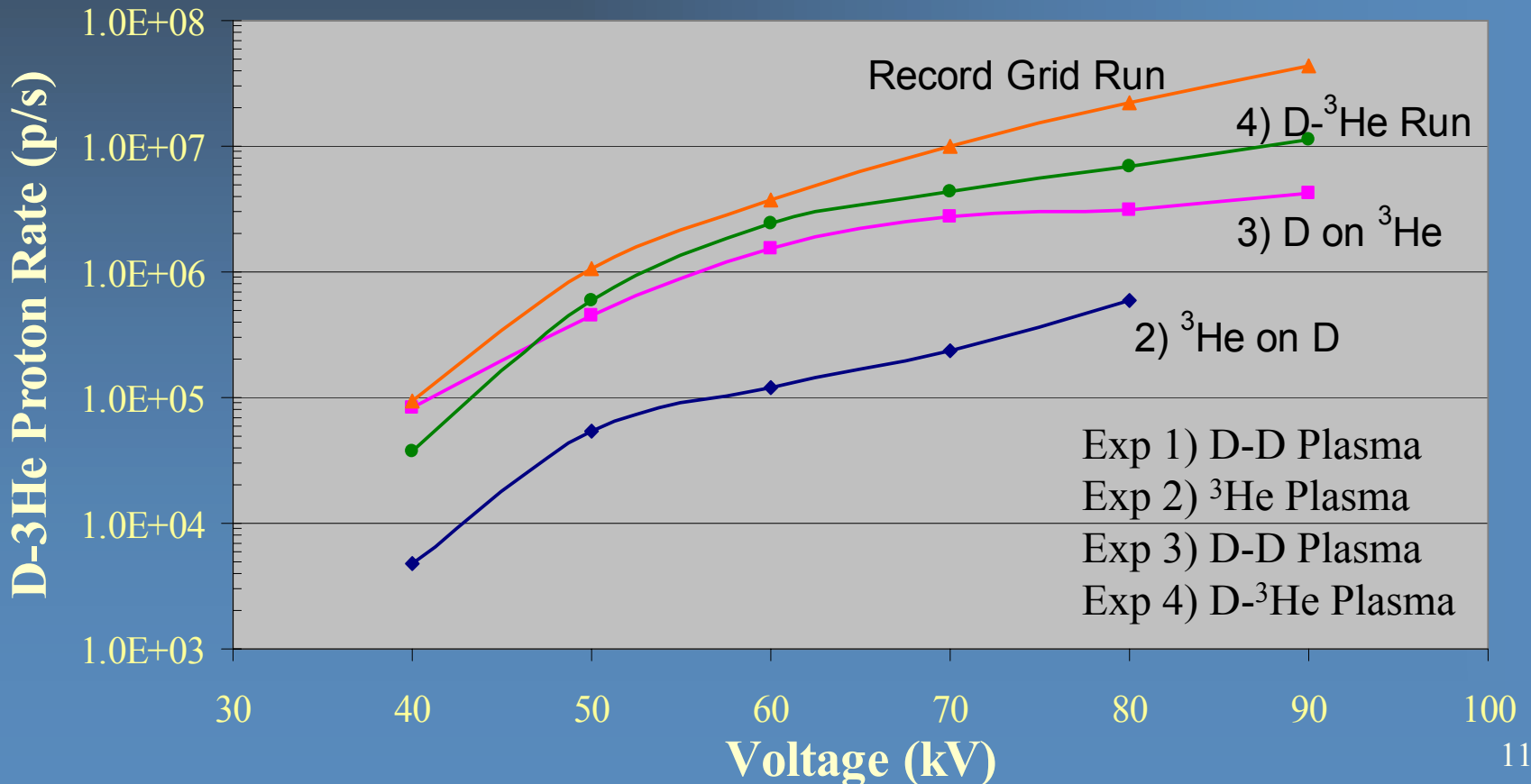


D-D Neutron Production (30 mA)



D-³He Fusion Rates Depend on D⁺ and ³He⁺ Implantation

Deuterium vs. Helium Embedding (W Target-30 mA)



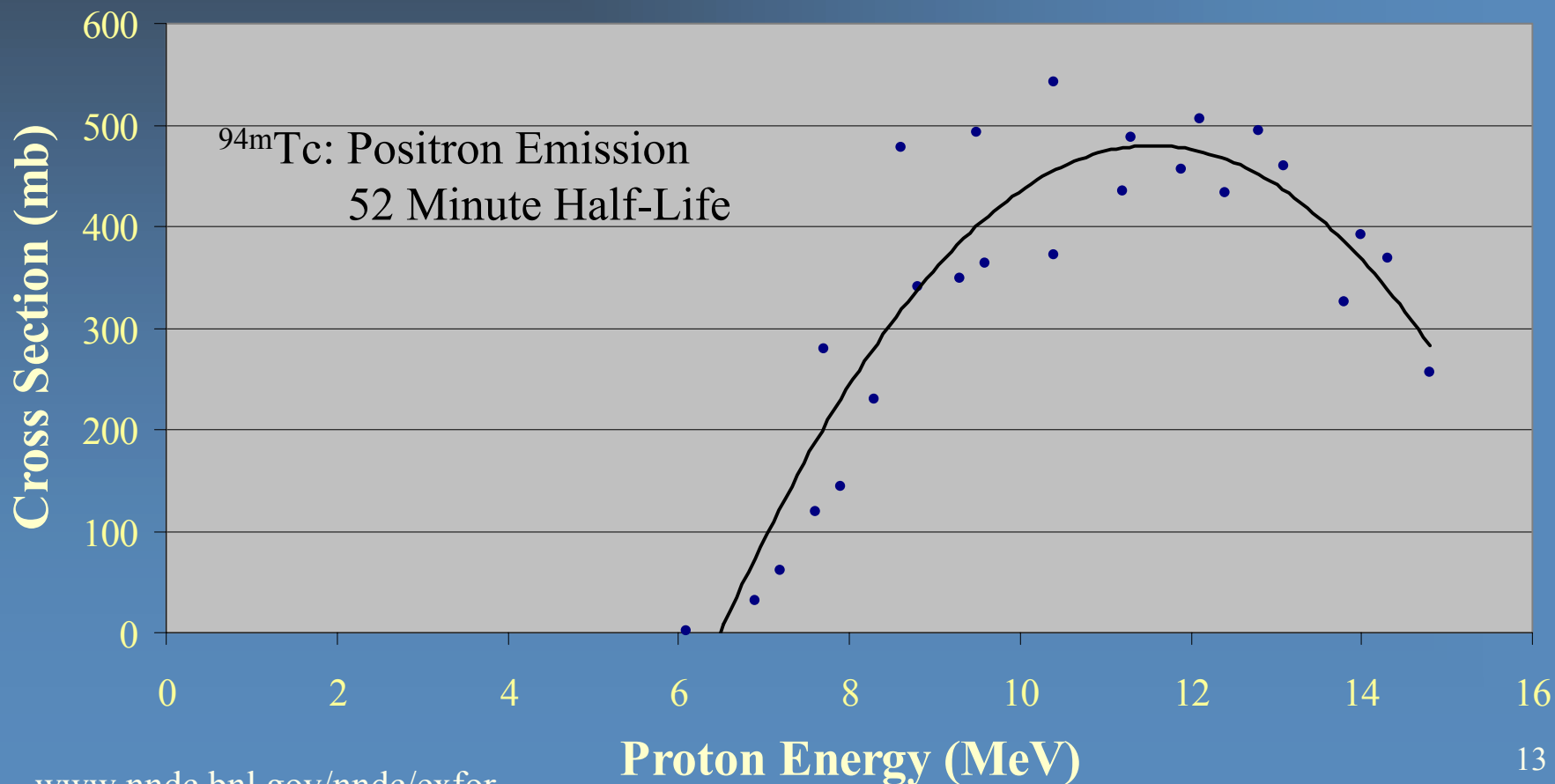
Isotope Production

- Can a solid cathode be used to produce isotopes?
- Reactions occur in the outer layer of the target, protons created isotropically
- Protons activate the target material below the surface
- Initial studies concentrated on $^{94}\text{Mo}(p,n)^{94\text{m}}\text{Tc}$ reaction

^{94}Mo Has A Significant Cross-Section For 14.7 MeV Protons



$^{94}\text{Mo}(p,n)^{94\text{m}}\text{Tc}$ Cross Section



Molybdenum Irradiation Experiment



- Both deuterium and helium-3 were run in the chamber
- Voltage was increased from 40 to 110 kV, keeping current constant at 30 mA
- Voltage was held at 110 kV for 15 minutes
- On average, about 5×10^6 p/s were created at the cathode surface for 20 minutes
- Then, chamber was vented, target was removed and counted (NaI detector)

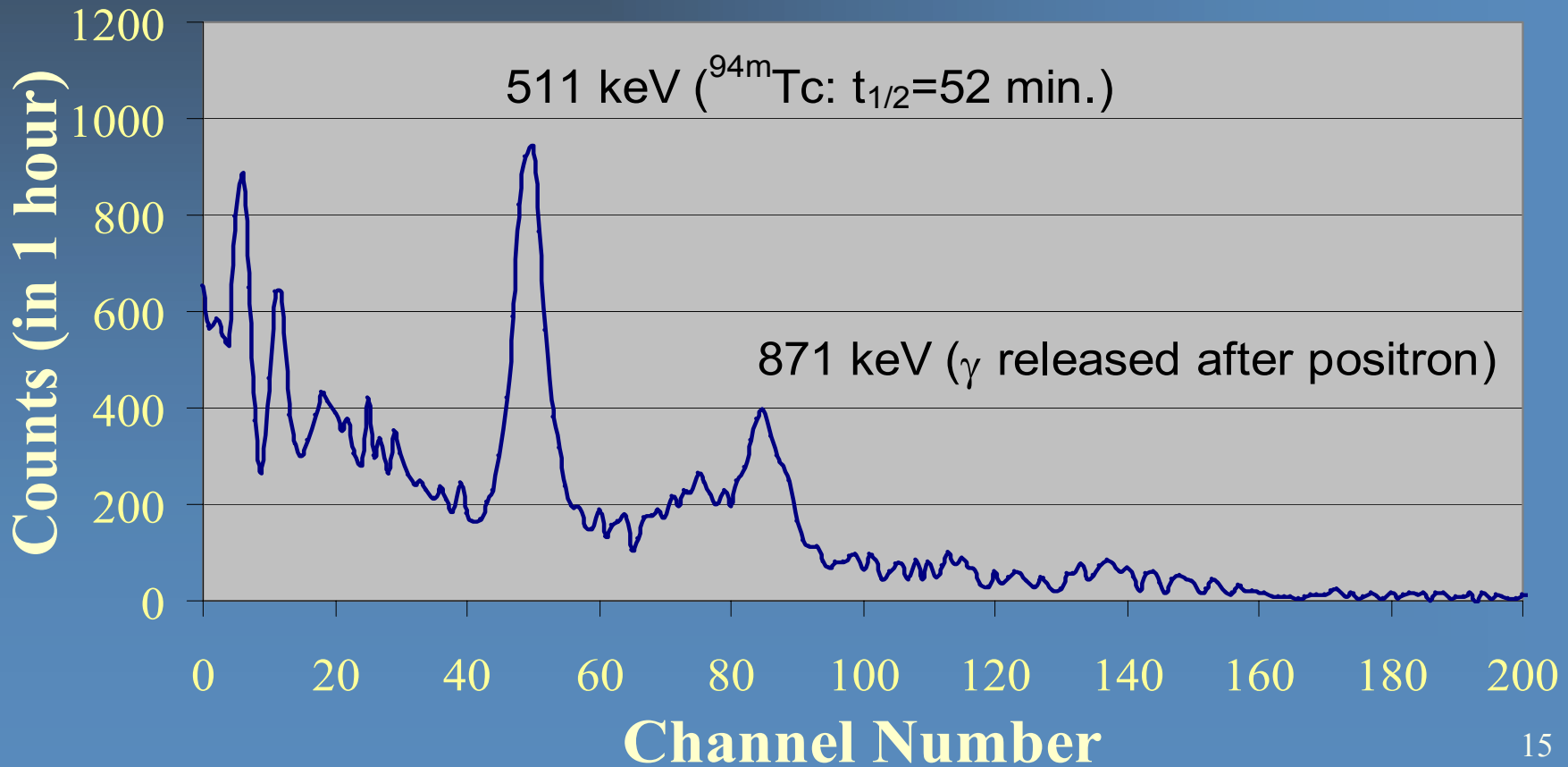
About 1 nCi of ^{94m}Tc Was Created



Run 684
9-16-02

Moly Target Activation Spectrum (Background Subtracted)

40 min
after run



Summary

- Retention of $^3\text{He}^+$ seems to be higher than D^+ in W, Ti, Mo
- Metals with low hydrogen diffusivities seem to hold more implanted ions (W>Mo>Ti)
- Embedded reactions can be used to produce isotopes in an IEC beam-target setup