Analysis of Nuclear Particles from Independent Replications Using the SPAWAR Co-Dep TGP Protocol and CR-39 Track Detectors

W. Williams[1], L.P.G. Forsley[2], F.L. Tanzella[3], P. Mosier-Boss[4], N. Robertson[5], H. Saito[5], J. Yurkovic[5], S. Zakskorn[5], X[6]

[1]UC Berkeley, Berkeley, CA USA
[2]JWK Technologies Corporation, Annandale, VA USA
[3]SRI International, Menlo Park, CA USA
[4]SPAWAR Systems Center, San Diego, CA USA
[5]UC San Diego, San Diego, CA
[6]University of Anonymity, USA

Replicators

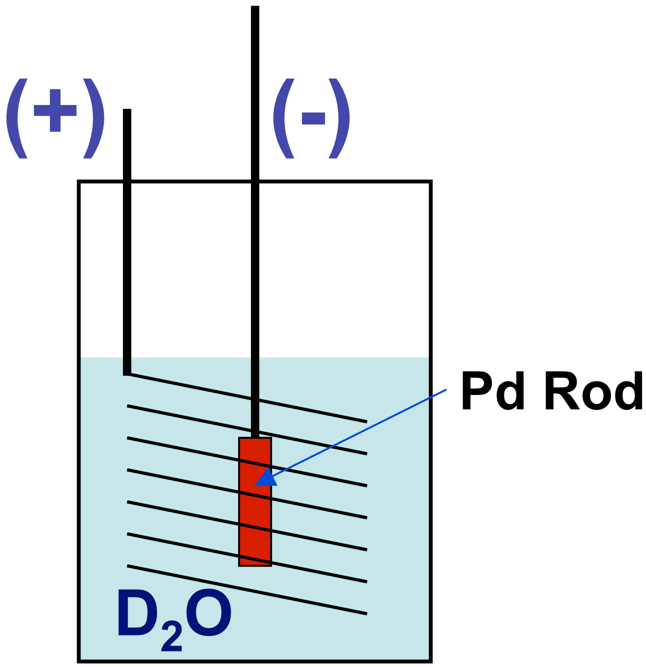
- SPAWAR Systems Center San Diego, CA, USA
- UC Berkeley,Beverly, CA, USA
- UC San Diego, CA   USA
- SRI International, Menlo Park, CA   USA

SPAWAR Co-Dep Protocol
TGP Protocol

- $PdCl_2$, LiCl, D_2O co-dep electrolysis
- Low current operation until all Pd plated out, solution becomes clear
- A few days to a week
- Higher current, 100 mA to 500 mA
- Run for up to 1 week
- No calorimetry
- Different labs used different measurements, different times
  - I,V
  - X-rays or gamma rays
  - Neutron counter (BF_3 REMBALL)
- All labs used CR-39:
  - ***different vendors had different quality!***

Why Many Laboratories Failed to Reproduce the Fleischmann-Pons Effect

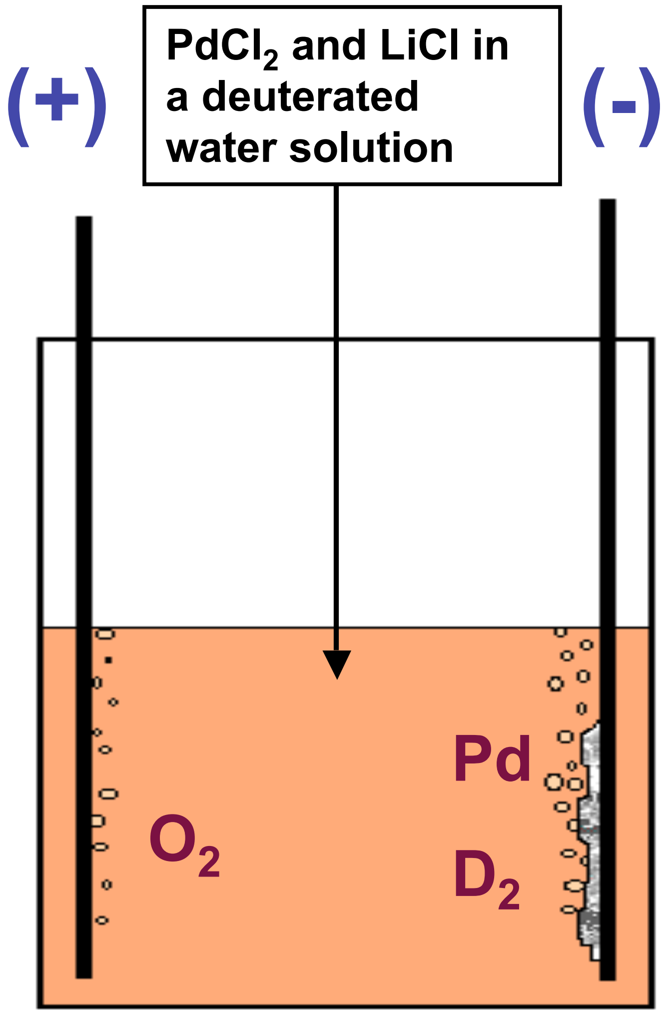
F/P Approach

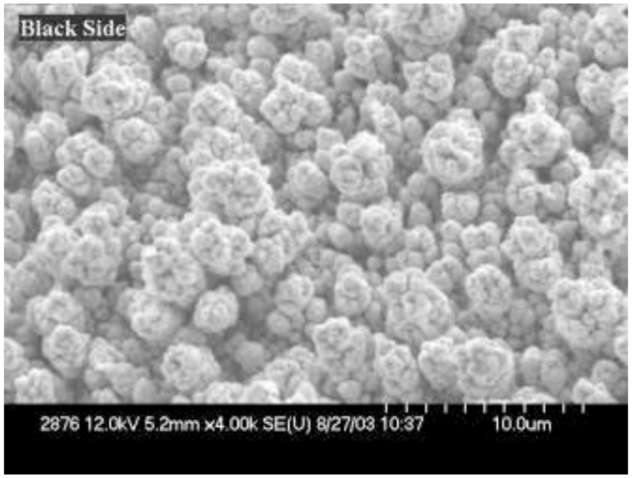


D_2 is loaded into the Pd electrode over a several day period

- Improper cell configuration
  - Cathode was not fully immersed in the heavy water
  - Asymmetrical arrangement of anode and cathode
- Unknown history of the palladium cathodes used in the experiments
- Lack of recognition that an incubation time of weeks was necessary to produce the effect

Another Way to Conduct the Experiment: Pd/D Co-deposition





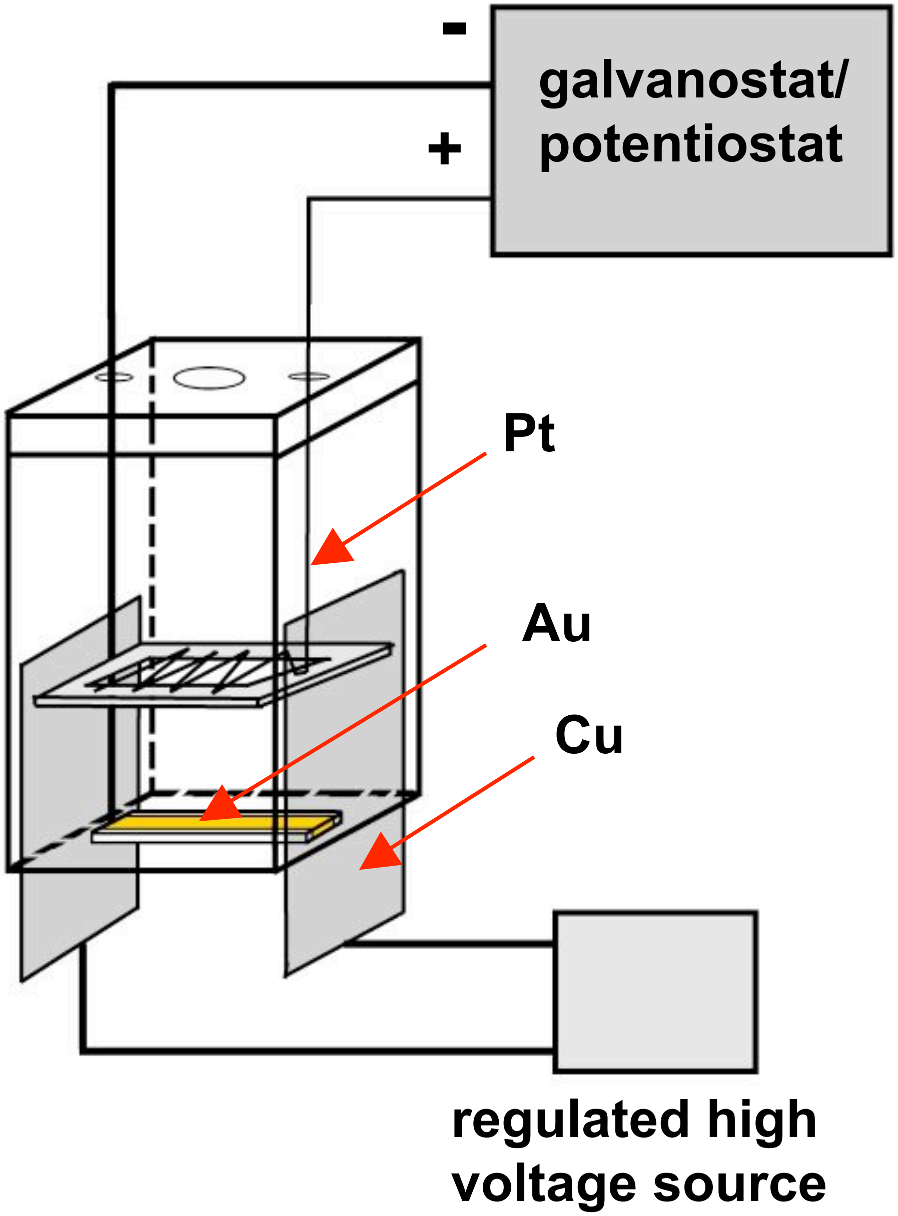
As current is applied, Pd is deposited on the cathode. Electrochemical reactions occurring at the cathode:

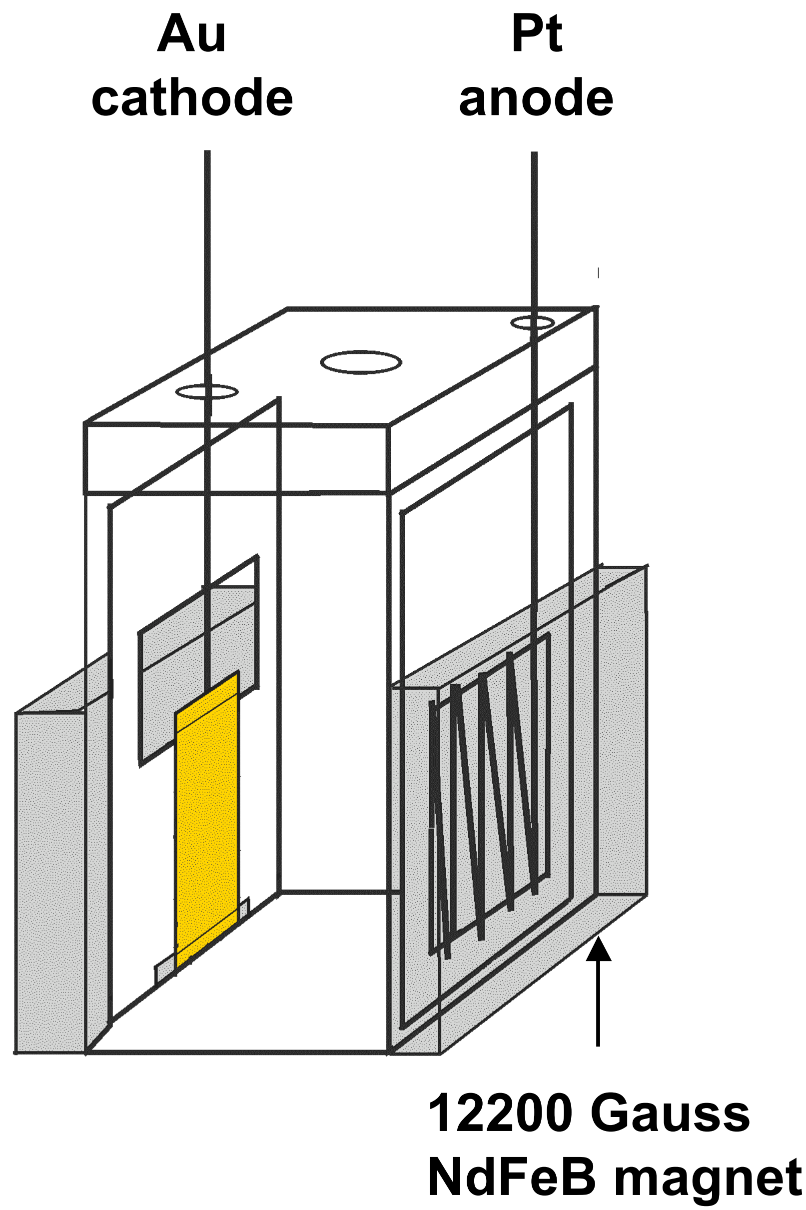
$$Pd^{2+} + 2\,e^{-} \rightarrow Pd^{0}$$

$$D_2O + e^{-} \rightarrow D^{0} + OD^{-}$$

The result is metallic Pd is deposited in the presence of evolving D_2

External E and/or B Field Reactors

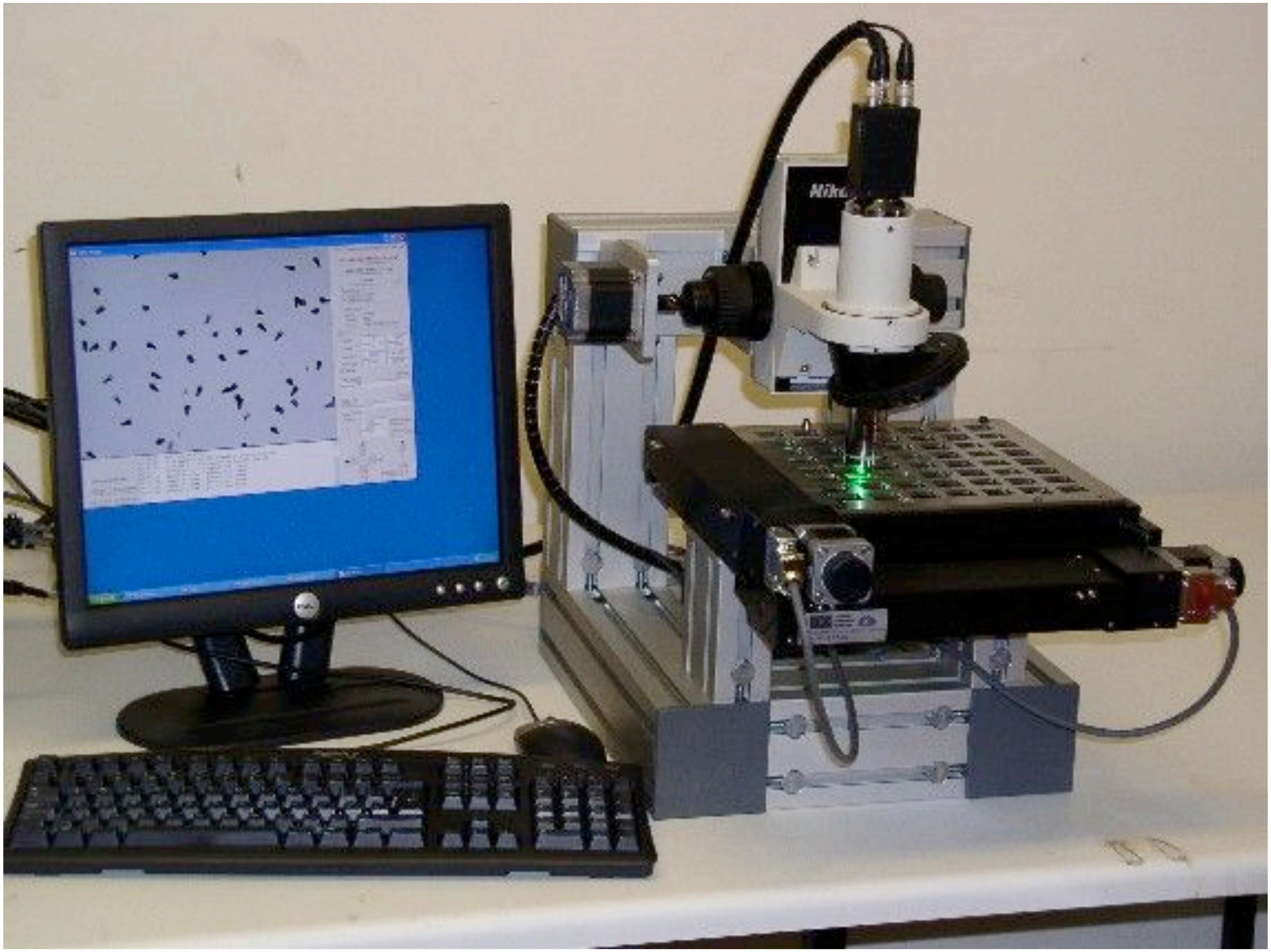




Why use an integrating detector?

- You lose all temporal information, but
  - You integrate with a permanent record
  - Ideal for low count rate experiments
- Can be calibrated for both charge and mass
  - Spectral resolution!
  - The faster the particle the smaller the track
  - The greater the charge the larger the track
- Spatial information as to where the track occurred, allowing comparison with external features and relate track features to one another spatially and spectrally. Detector is 1 cm x 2 cm to 2.5 cm x 2.5 cm.

TASL Automated Scanner



http://www.tasl.co.uk/systems.htm

TASL CR-39 Scanning

- Magnification 200x
- Manual focus
- Field of view
  - 500 microns (y) by 600 microns (x)
- Typical scan
  - 17,500 microns in y
  - 7,500 microns in x
  - Total of 440 frames/side to 600 frames/side
  - 880 to 1200 frames per “chip”

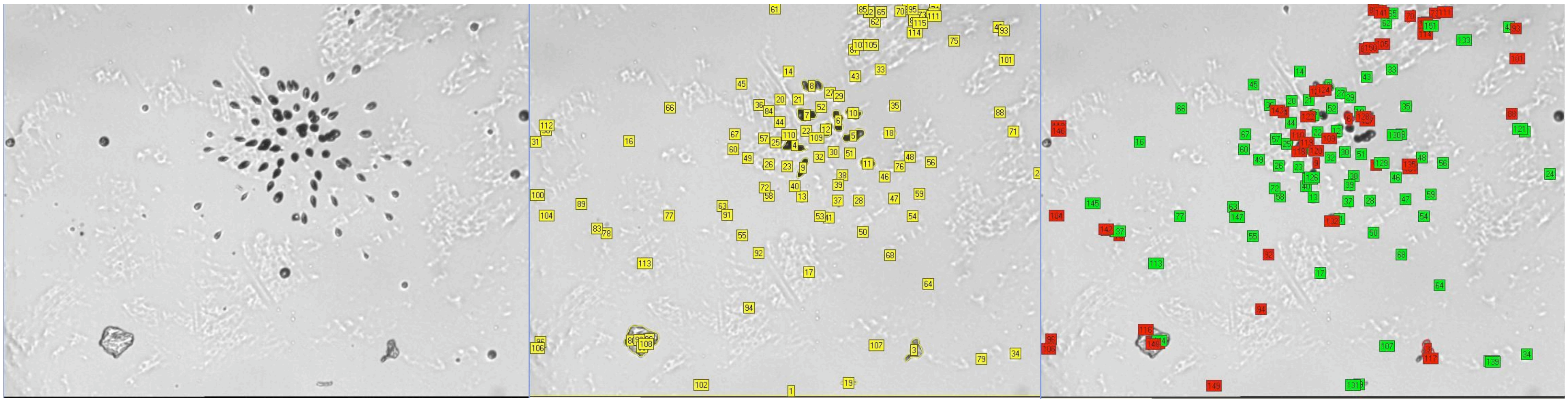
Calibration and “A Cluster”

- B field experiment
- Back side exposed to depleted uranium
- Front side in contact with the cathode

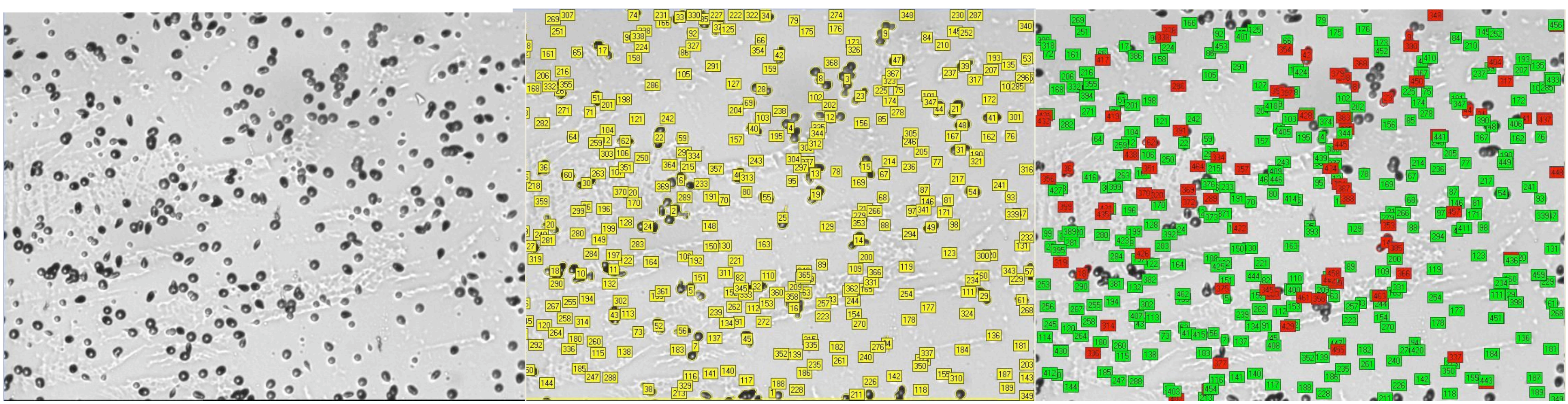
SPAWAR B-Field, Clustered Particle Generation

Clustered particles, away from cathode

raw processed identified

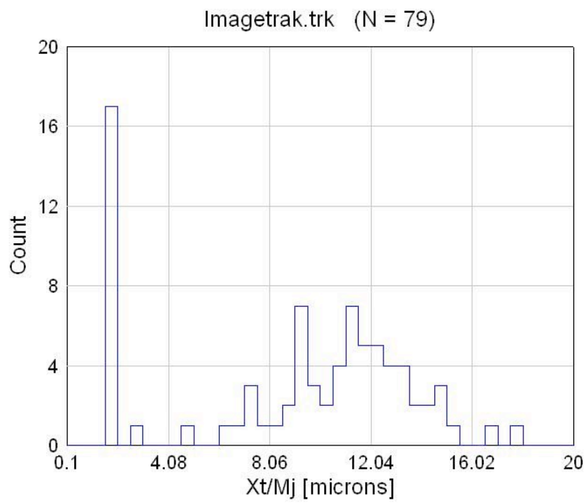


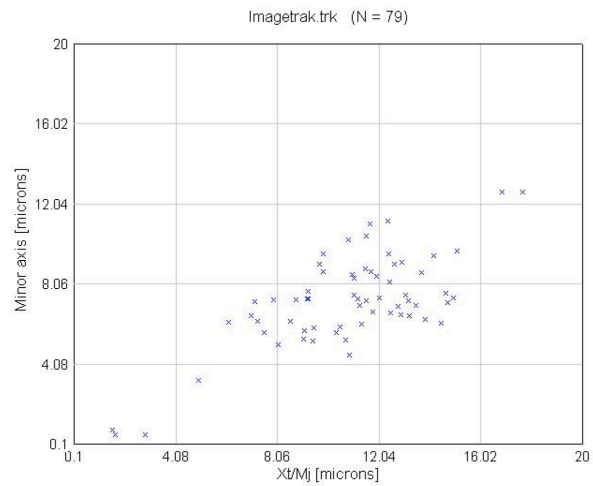
^{234}U, ^{238}U Background, away from cathode



Clustered Particle Quantitative Analysis

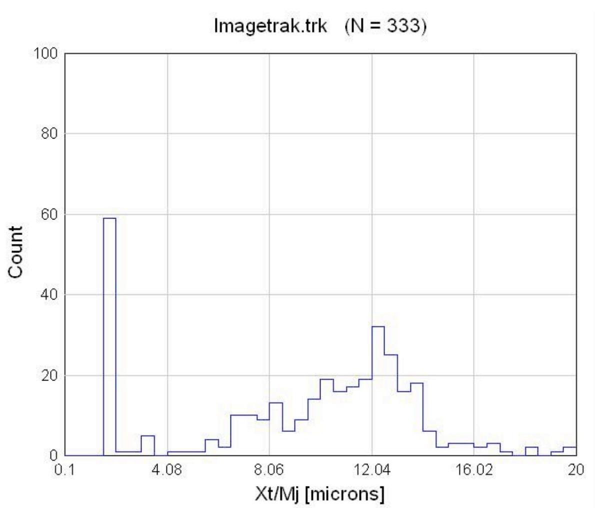
Clustered particles, away from cathode

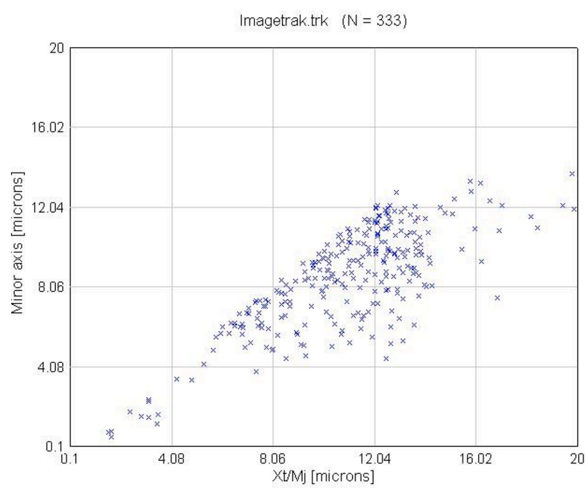




79 tracks in one frame

^{234}U, ^{238}U Background, away from cathode

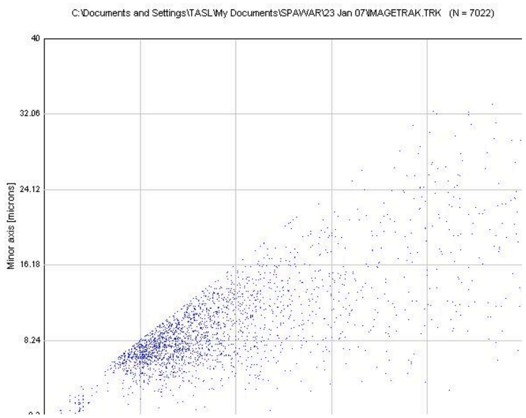


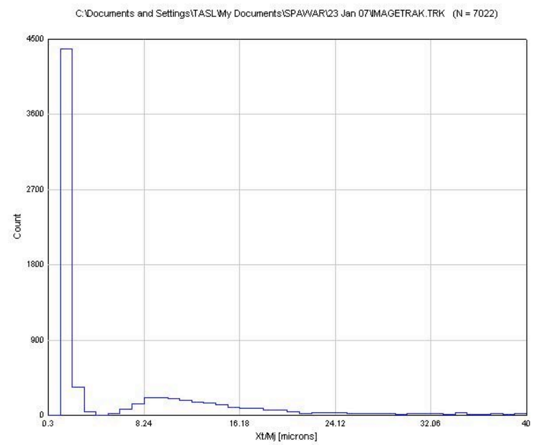


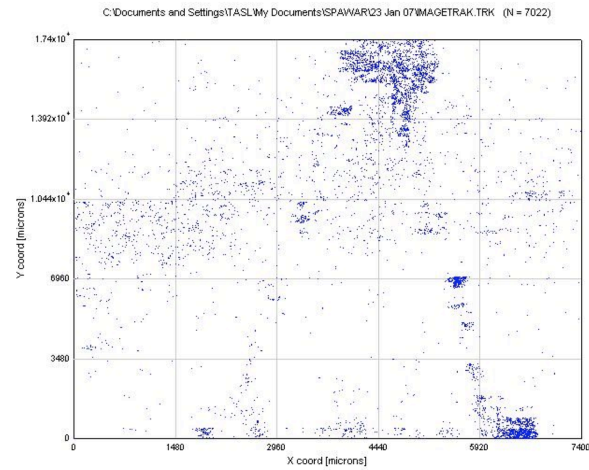
333 tracks in one frame

Berkeley Chip #2

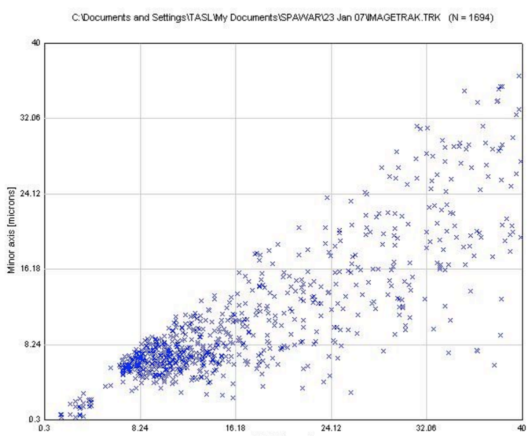
towards cathode, 7022 tracks, whole chip

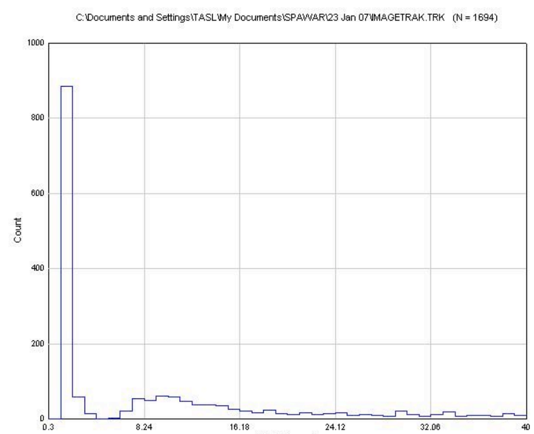


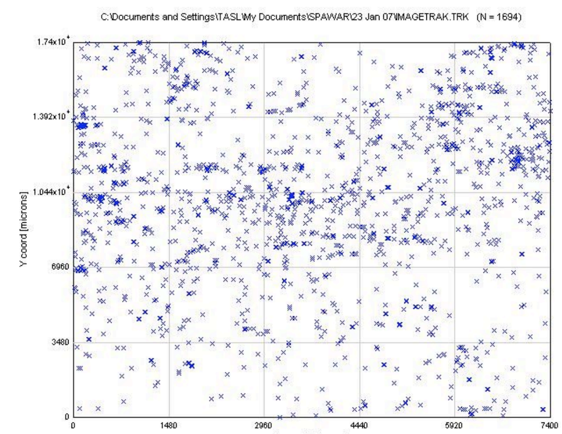




away from cathode, 1694 tracks, whole chip







Chemical Damage?

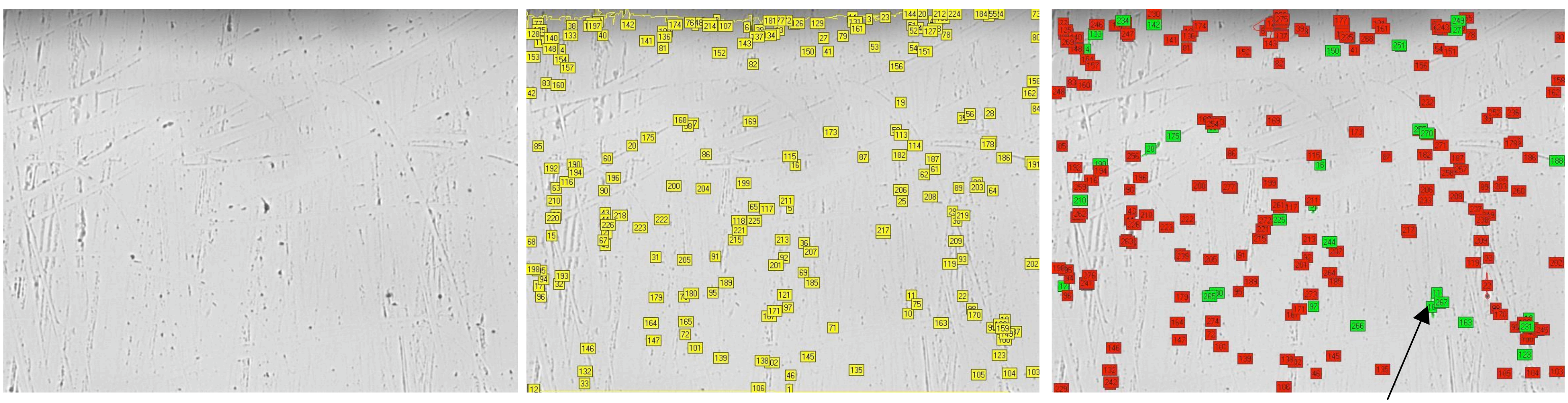
- Experiment carried out with a 6 micron thick mylar window
- CR-39 outside the cell, never in contact with electrolyte

SPAWAR Dry Co-Deposition

No contact between CR-39 and cell electrolyte.

Tracks not caused by chemical or mechanical damage!

← 600 μm →

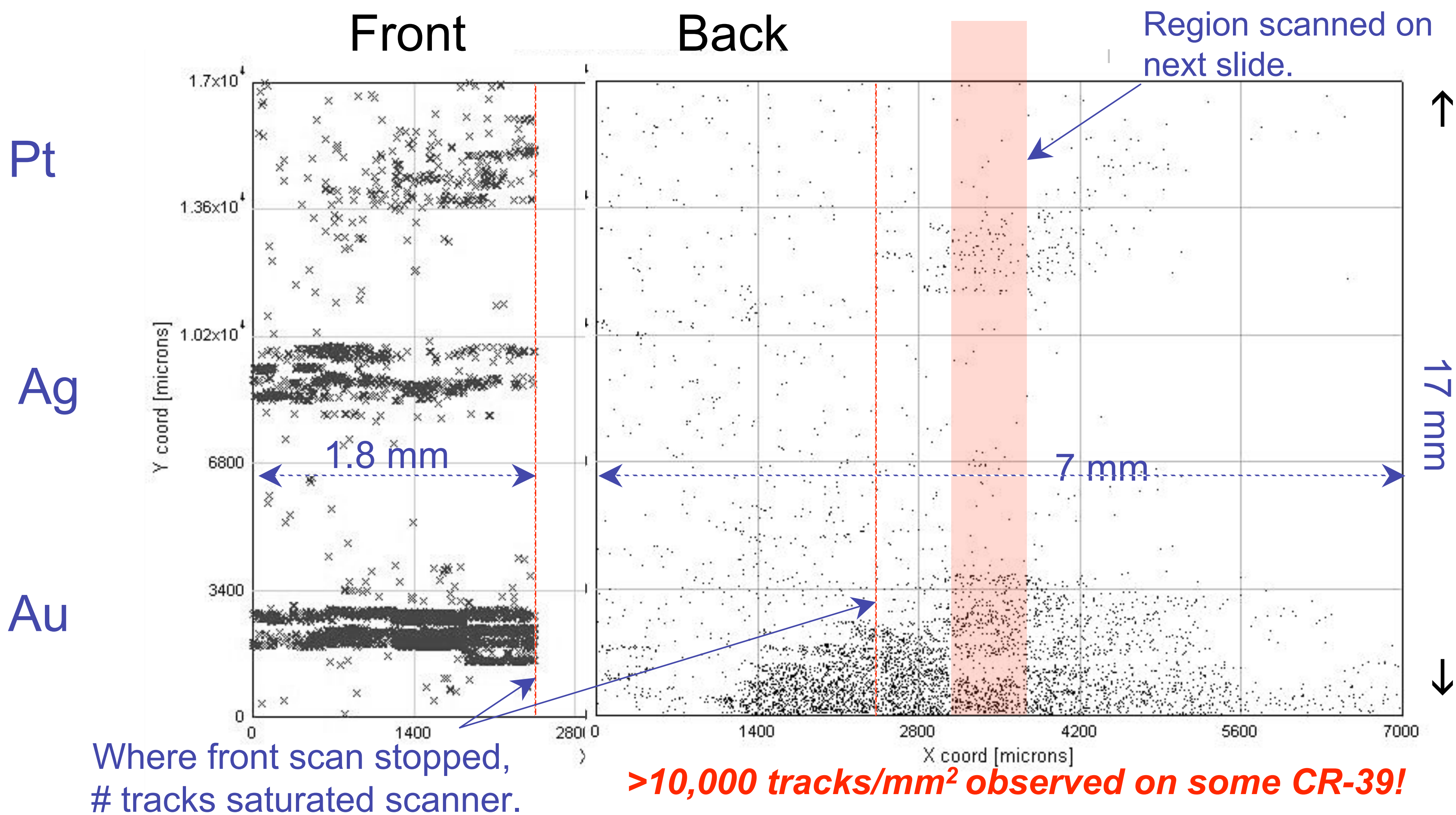


Raw image Computer processed Computer identified

Neutrons?

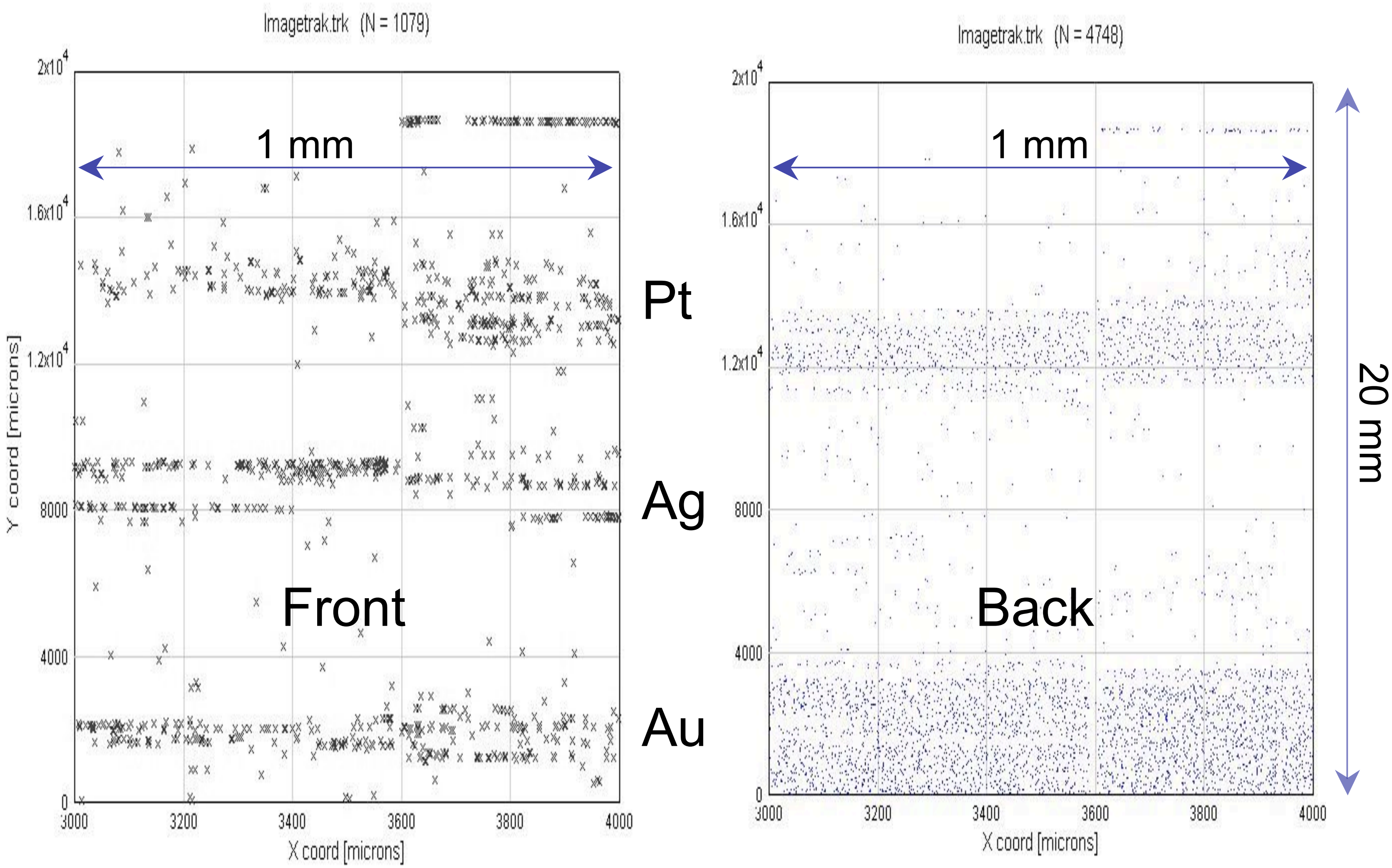
Front and Back Surface Comparison

Particle track locations for 3 wire E-field "wet".
Front faces the cathode and back is away from cathode.



>10,000 tracks/mm² observed on some CR-39!

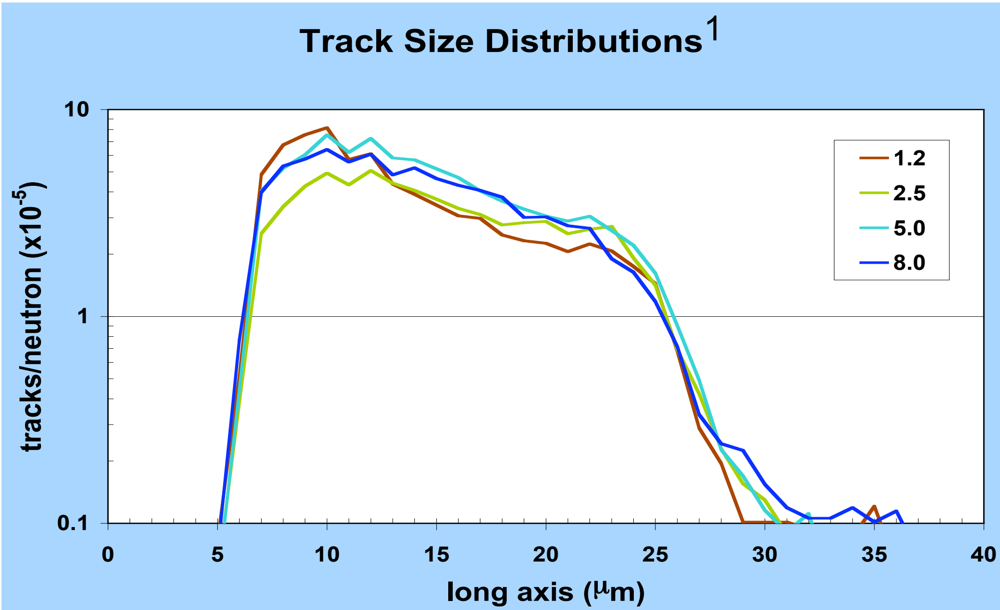
Scan, 1 mm by 20 mm

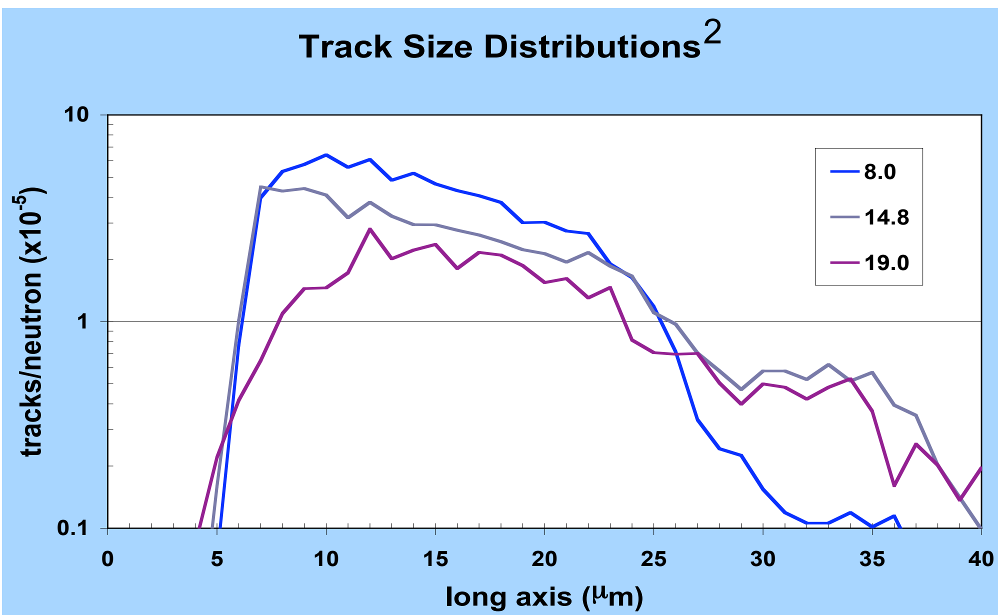


Pt, Ag, Au tracks on front. Pt and Au tracks on back.

No tracks from Ag on back!

Neutron Track Size





CR-39 n efficiency 10^{-4} - 10^{-6} tracks/n

n tracks caused by knock-ons with CR-39 ($C_{12}H_{18}O_7$) atoms:

^{1}H, ^{12}C, ^{16}O

n_e > 12 MeV will break ^{12}C into α particles, leaving a "triple" track.

These α particles will have little momentum and won't move.

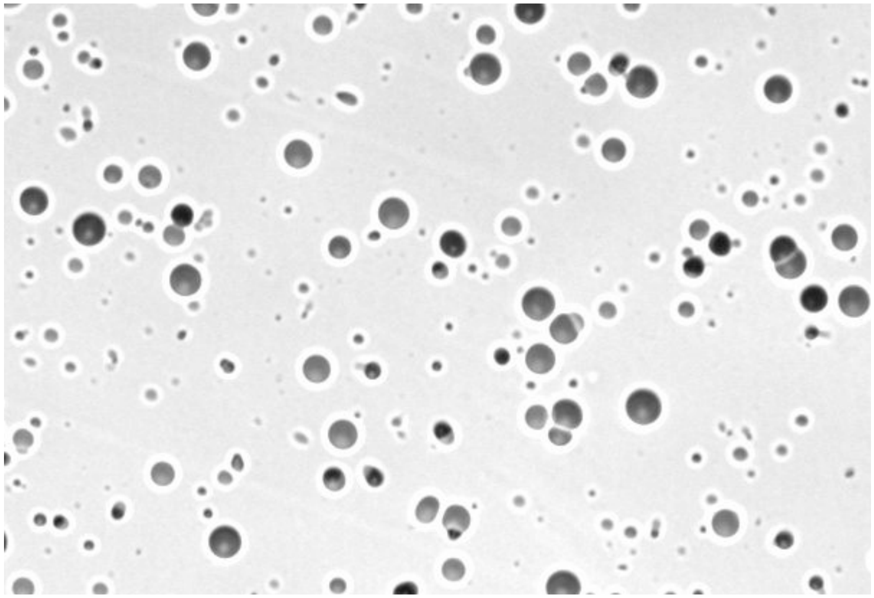
Uniform number of knock-ons throughout CR-39 thickness due to low neutron stopping power.

Track size function of n energy, n_e.

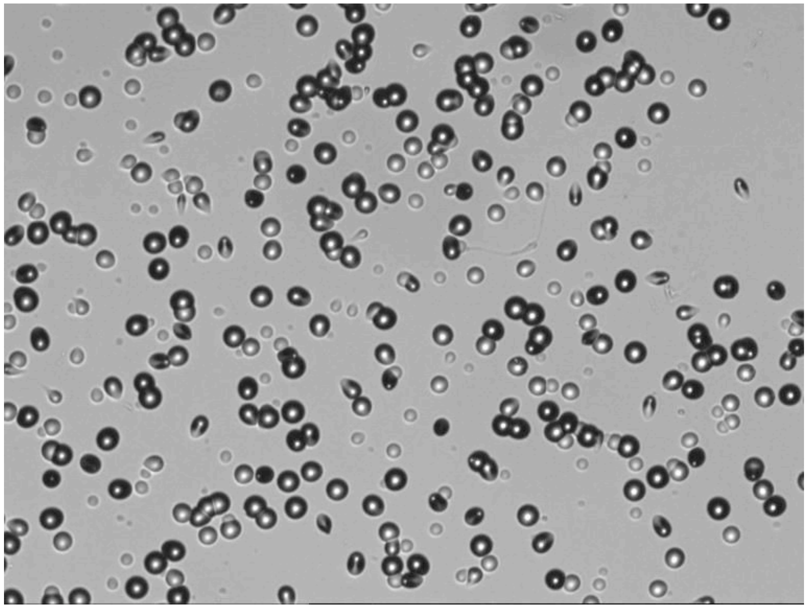
Adjacent plots show n_e range from 1.2 MeV to 19 MeV.

[1,2] Phillips, *et. al.*, "Neutron Spectrometry Using CR-39 Track Etch Detectors", *14th SSD,* 2004.

Large Number of Neutrons Produced

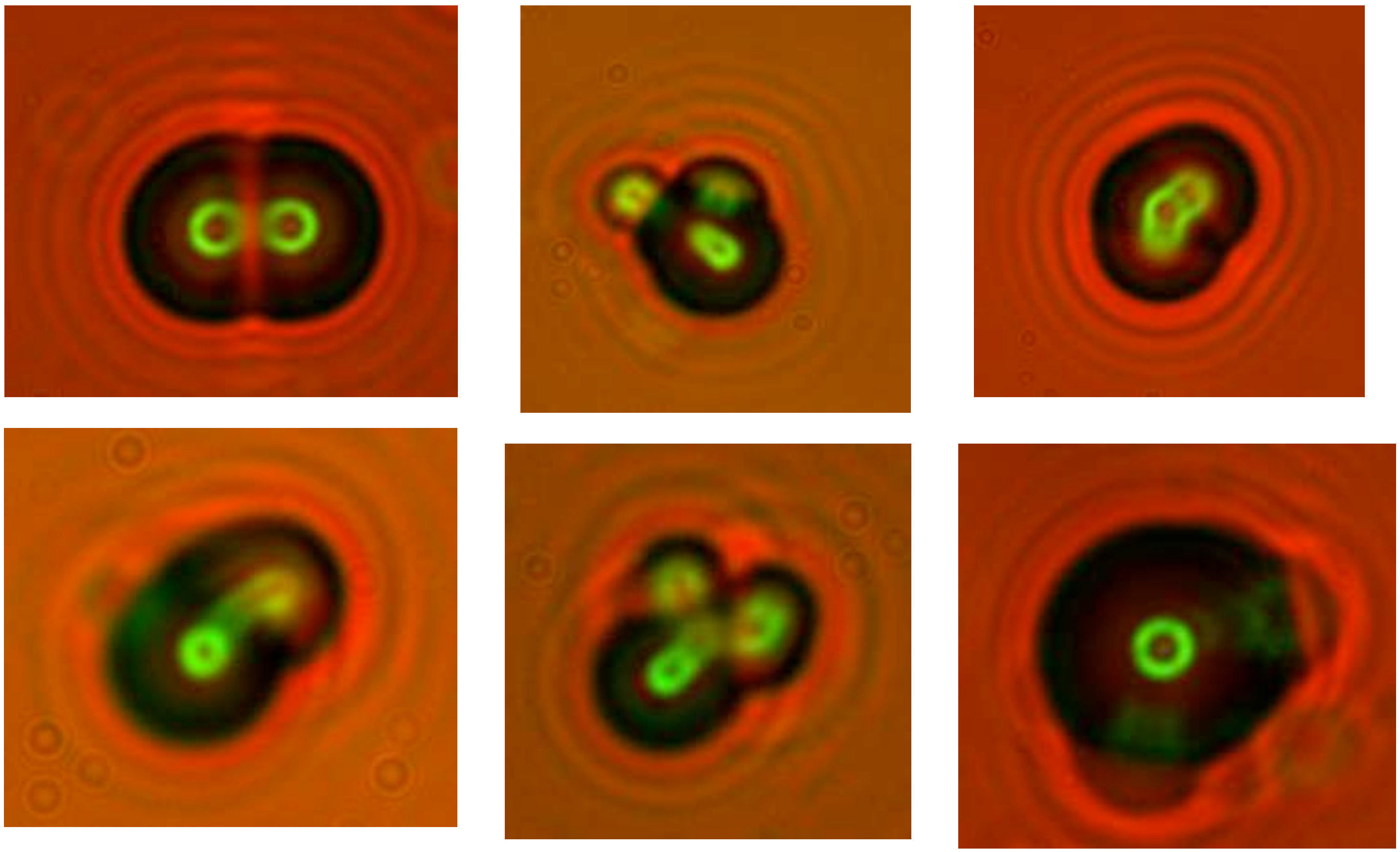


Neutrons produced by conventional Nuclear reaction from ^{238}PuO.

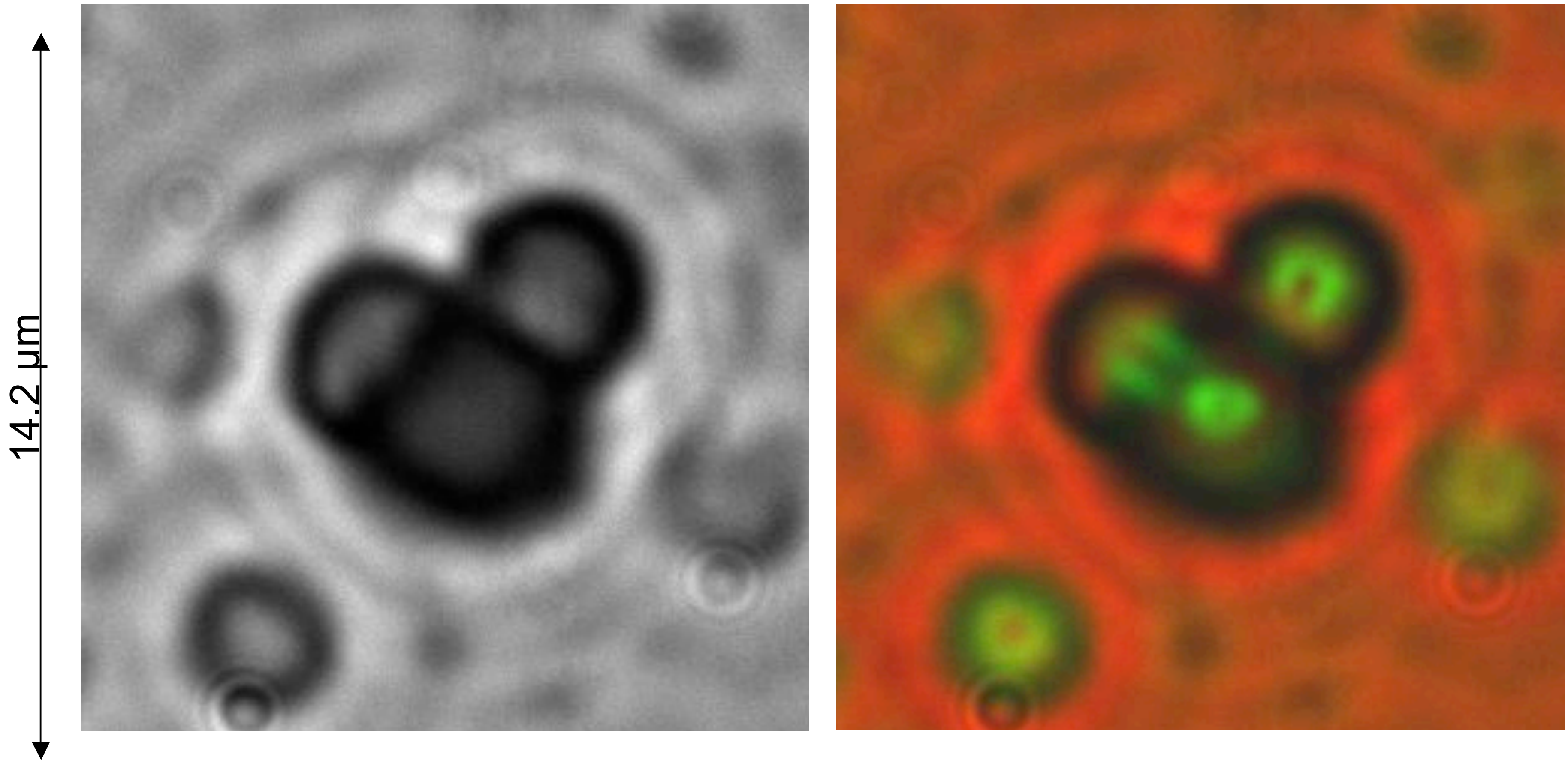


Neutrons produced by Co-Dep reactions.

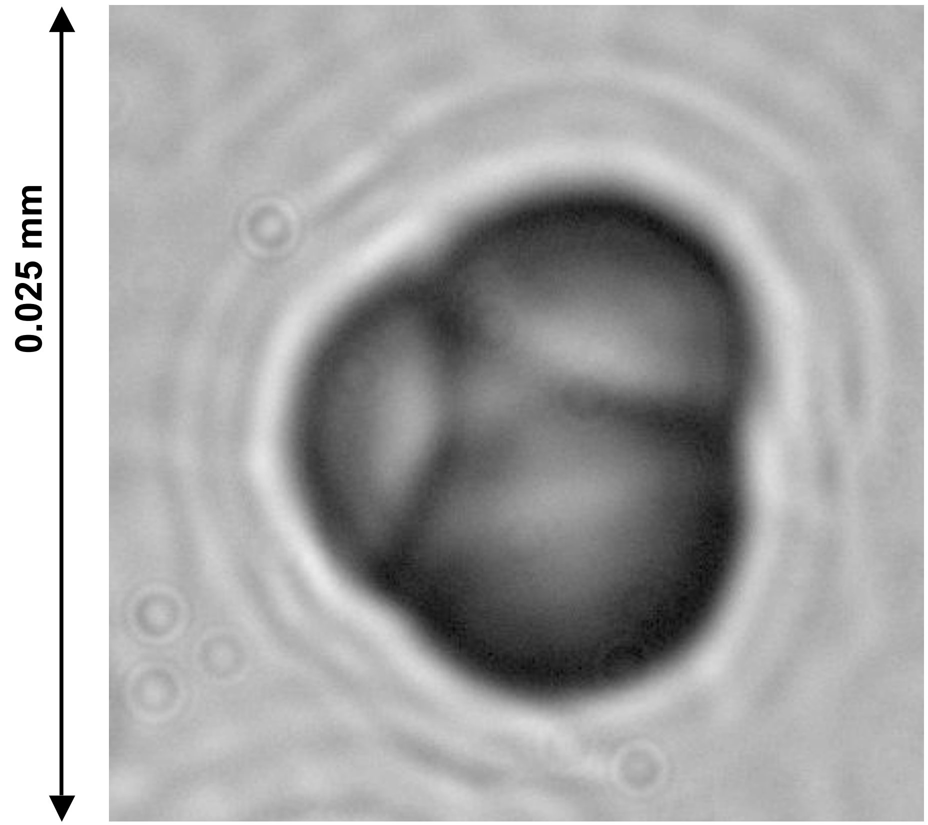
SPAWAR

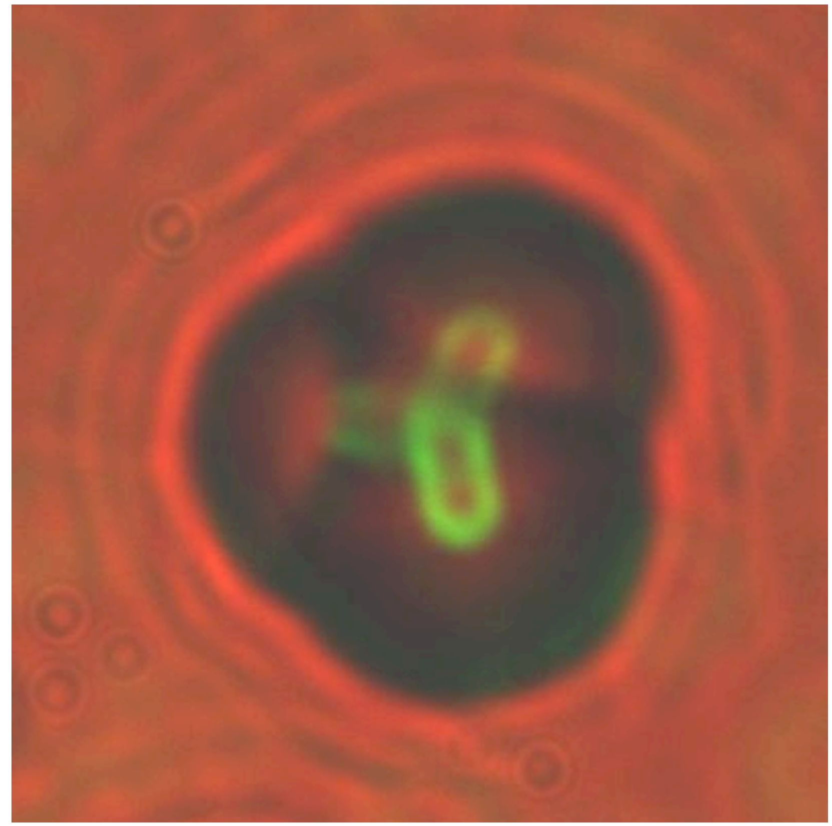


BE010-5 CR-39 (Fukuvi Chips)



UCSD 2007

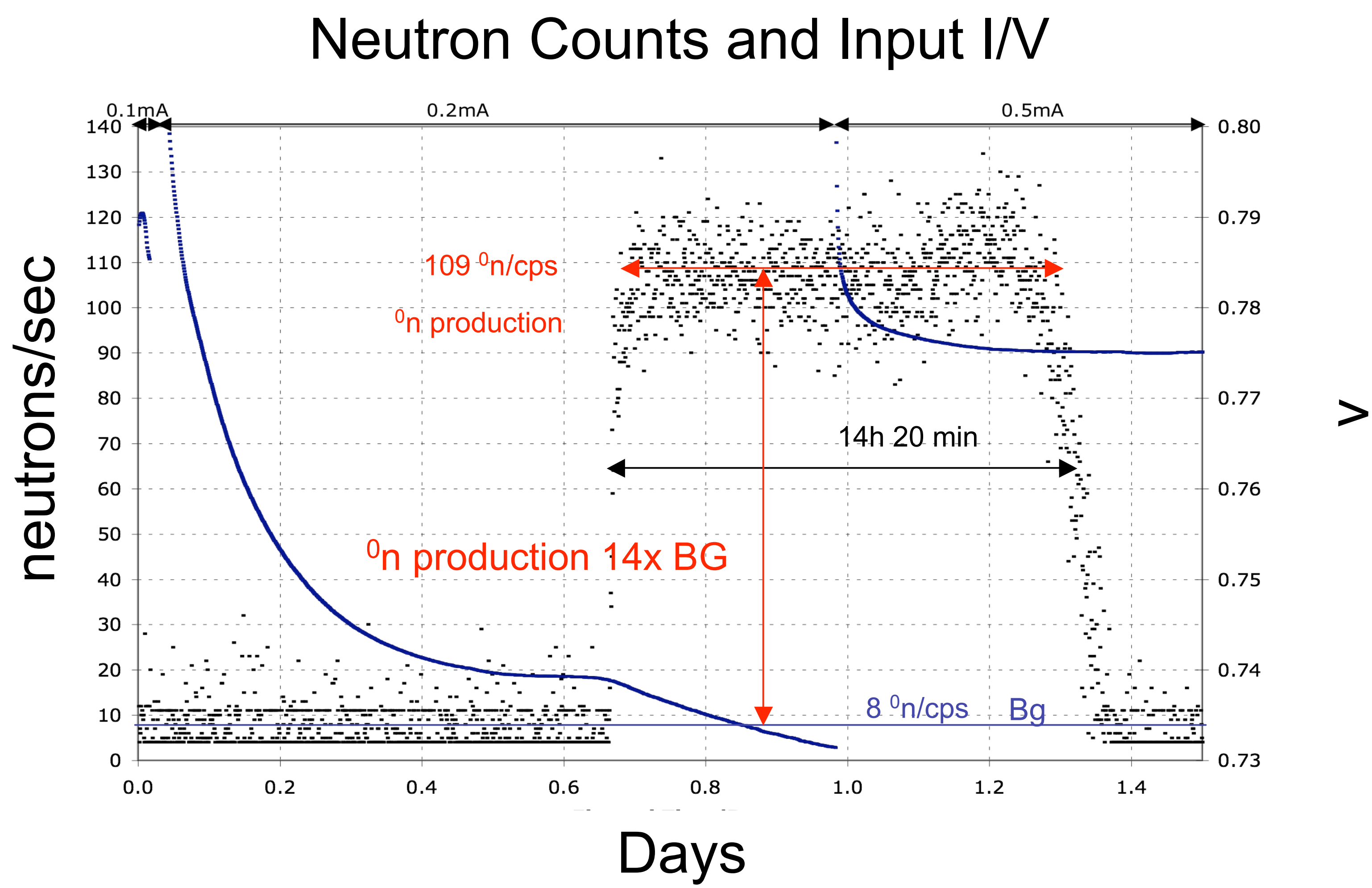




What's going on?

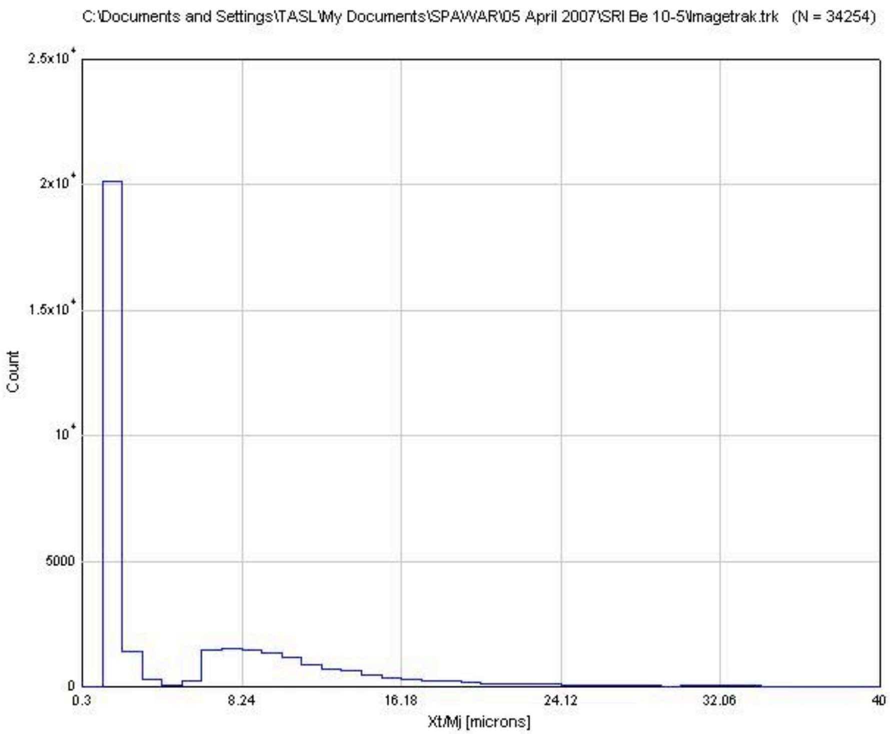
- It appears that we have evidence of a ^{12}C nucleus, present in the CR-39, shattering!
- A typical reaction, seen in ICF (laser fusion) using DT fusion, will result in a 14.1 MeV neutron.
- There are various thresholds above 8 MeV for neutrons that will result in various ways for the ^{12}C to "shatter".
- Above 12 MeV results in 3 alphas, with all of the neutron kinetic energy making up for the mass deficit, by $E=mc^2$, between ^{12}C and 3 alphas.
- The alphas go a very short distance: additional evidence that the neutrons aren't more energetic!
  - *Are there really neutrons?*

SRI Real Time Neutron Counting
Be-10-5



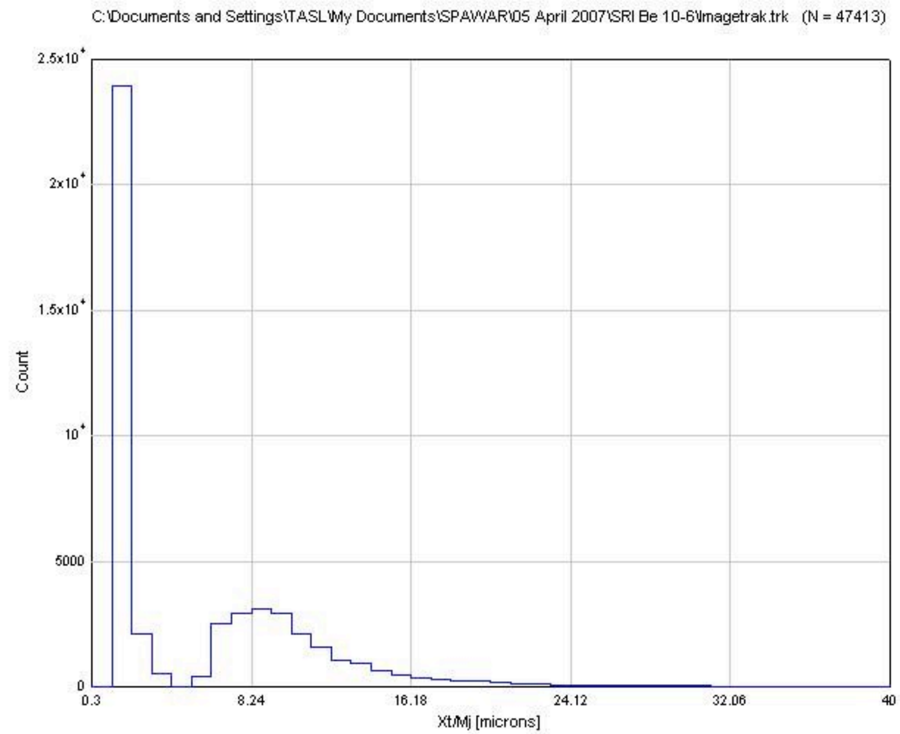
SRI BE-10-5 and BE-10-6 towards cathode

34,254 tracks



BF_3 neutron signal seen, radiator present

47,413 tracks



No BF_3 neutron signal seen, radiator present

Conclusion

- Each of groups saw particles
- The SPAWAR protocol provided a replicable and reliable means of producing nuclear particles.
- On Chip calibration of CR-39 critical
  - Prefer Russian solution using accelerator driven proton, deuteron, triton and alphas
  - Neutron calibration with monochromatic sources
    - DD,DT electrostatic fusion generators (2.2 MeV, 14.1 MeV)
- Many questions, including:
  - Discrepancies between with some Russian analysis
  - Determine quantitative agreement with other Russia analysis.
- Origin of small, < 1 micron, tracks
  - Background?
  - Optical diffraction in TASL?
  - Experimental “noise”?
  - High energy proton (> 10 MeV?)

Acknowledgments

- Thanks to each of the groups participating in the TGP project
- The Galileo Project support from New Energy Times
- JWK Corporation
- US Navy SPAWAR

Real Physics!

- The significance of a physics paper is directly proportional to the number of authors times the number of words:

  S=AW, where A =number of authors and W is number of words in article

- Each picture worth 10,000 words.
- These slides have 28 pictures,

- $S= 9x(10^4x28)=2.52 \times 10^6$