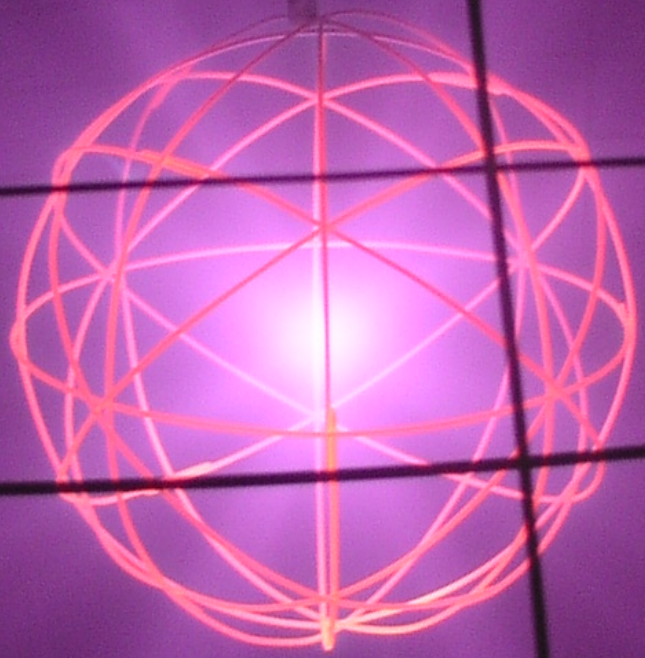
Experimental and Theoretical Highlights from the University of Wisconsin IEC Program



G. L. Kulcinski, J. F. Santarius, G. A. Emmert, R. L. Bonomo, G. E. Becerra, A. N. Fancher, K. B. Hall, K. M. Johnson, M. J. Jasica, A. M. McEvoy, M. K. Michalak, M. Navarro, and C. M. Schuff.

October 1, 2014

The Wisconsin IEC and ^{3}He Recovery Team

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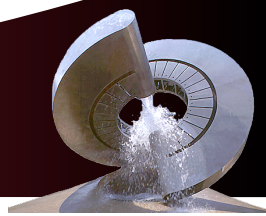
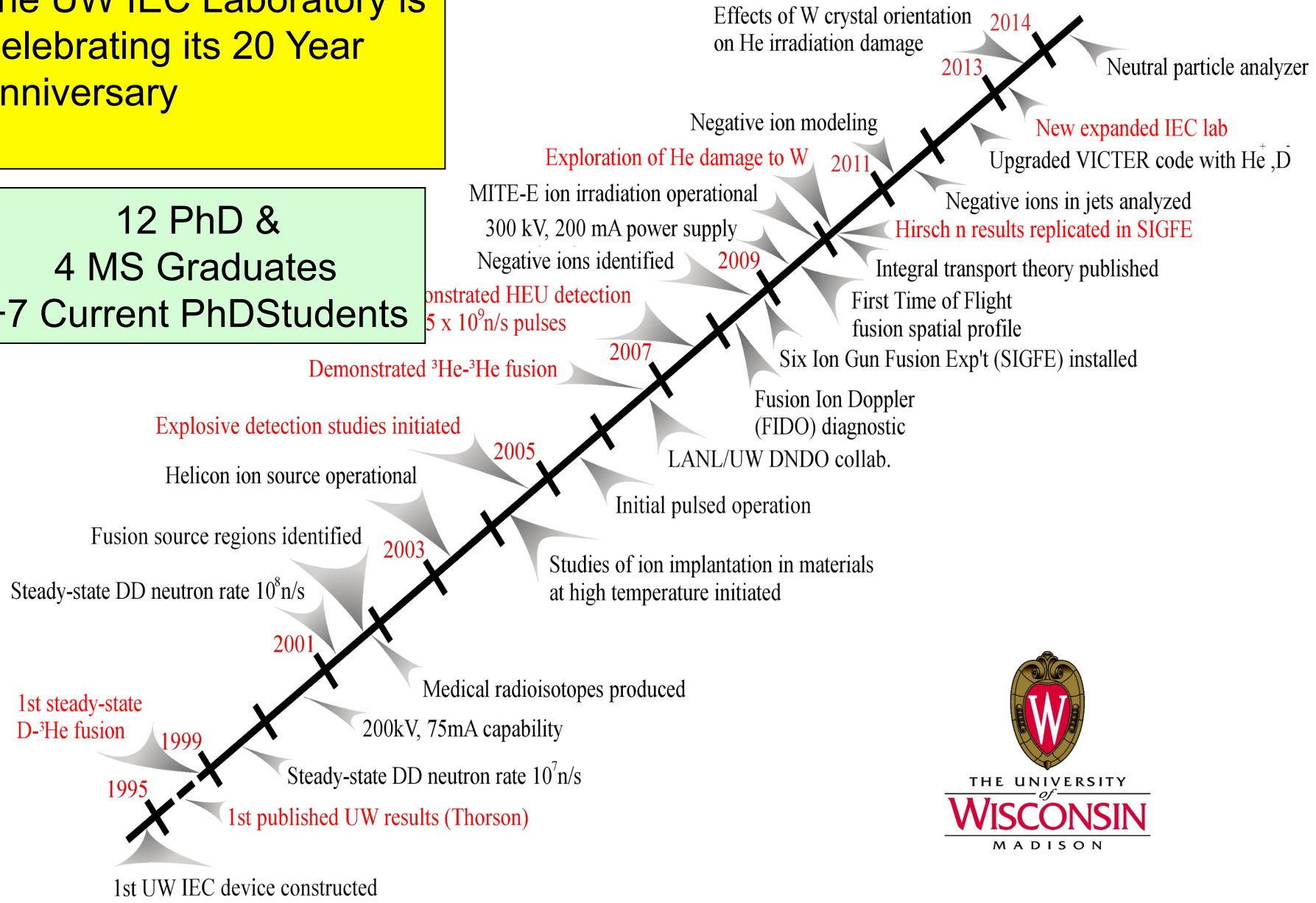
Outline of the Presentation

- History
- Highlights
  - Path to 300 kV Operation
  - Neutron Sources
  - Materials Studies
  - Lab Expansion
  - ^{3}He Procurement
  - Theoretical and Modeling Studies



The UW IEC Laboratory is Celebrating its 20 Year Anniversary

12 PhD &
4 MS Graduates
+7 Current PhDStudents



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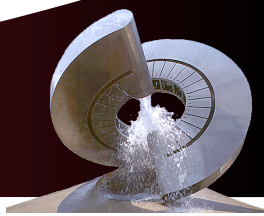
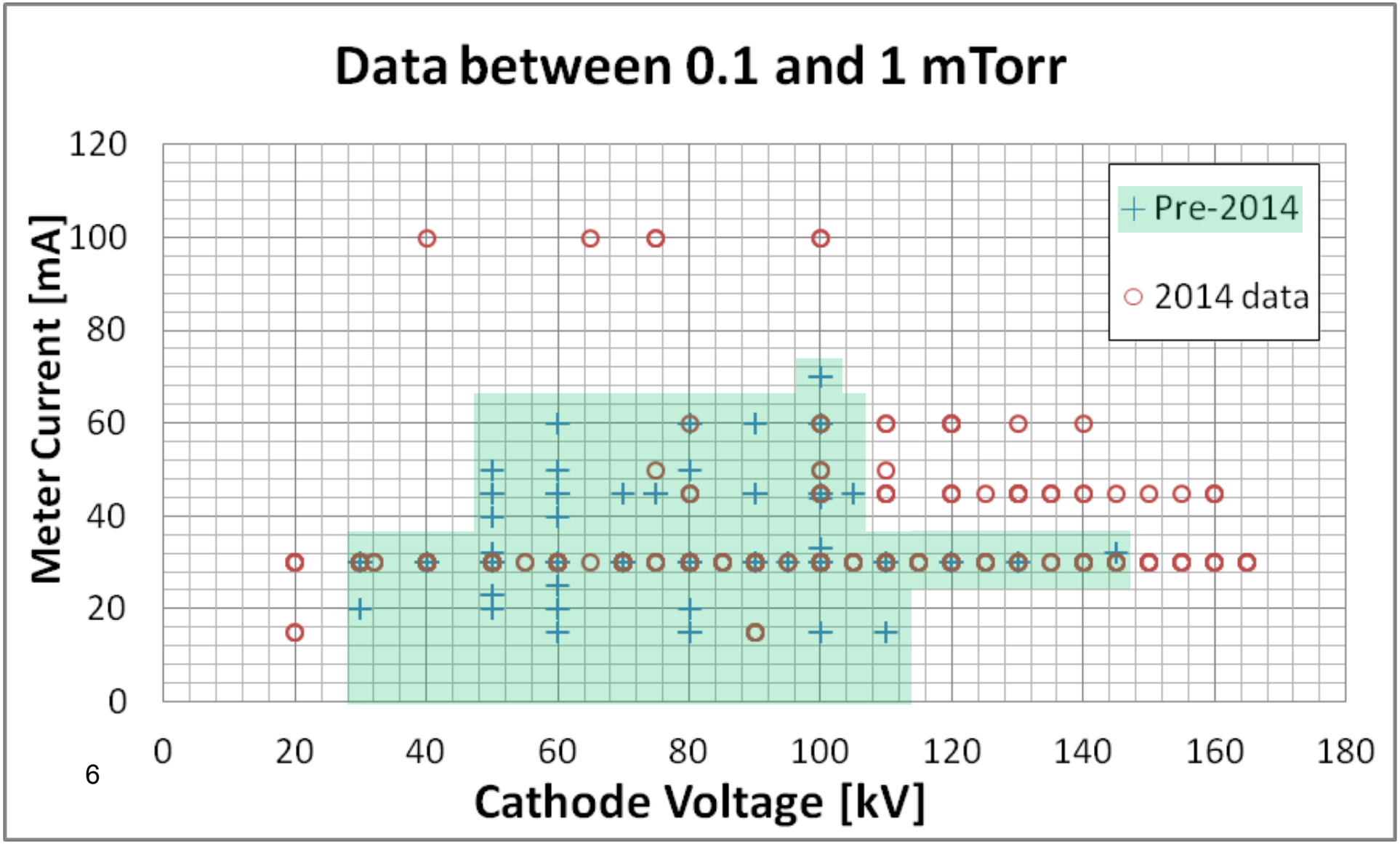
On the Road to 300 kV Operation



Expanded Parameter Space at 1 mTorr and Lower in HOMER *(See M. Michalak Oral Thursday AM)*

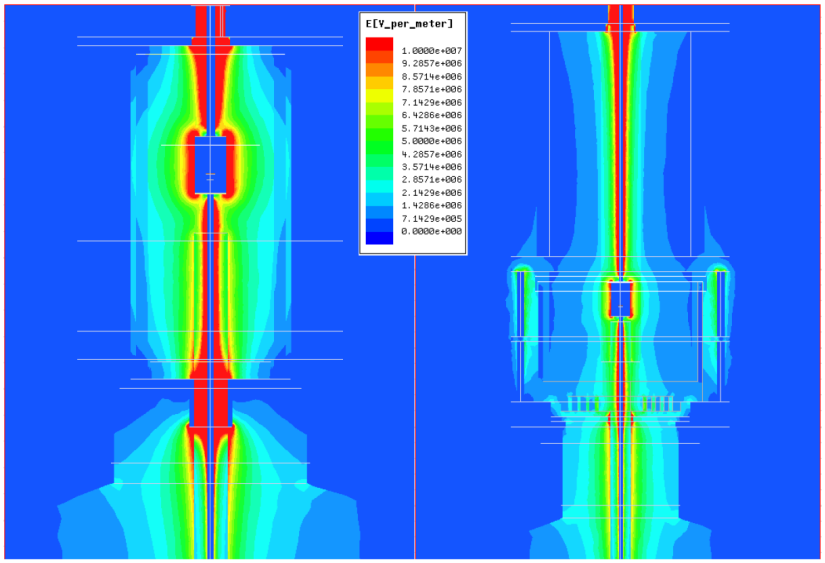


Design and Testing of a High Voltage Feedthrough for Extending IEC Operations to 300 Kilovolts

(See A. Fancher Oral Presentation Thursday Morning)

Design challenges and refinements made with high potential testing of a 300 kV feed-through

200 kV Design 300 kV Design

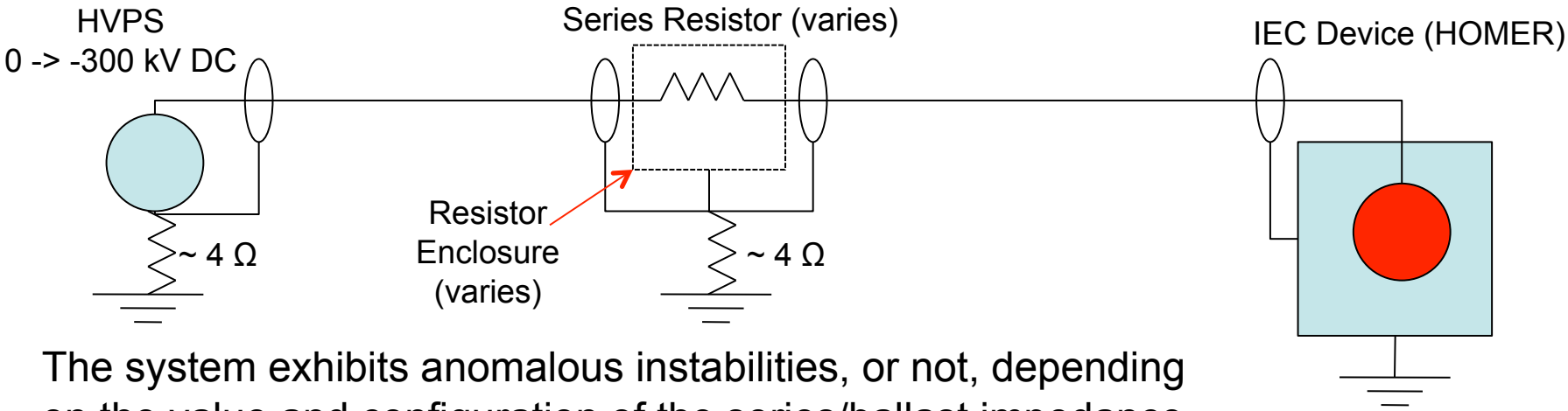


Electric field strengths inside high-voltage feed-through at an applied voltage of 250 kV greatly reduced with new design

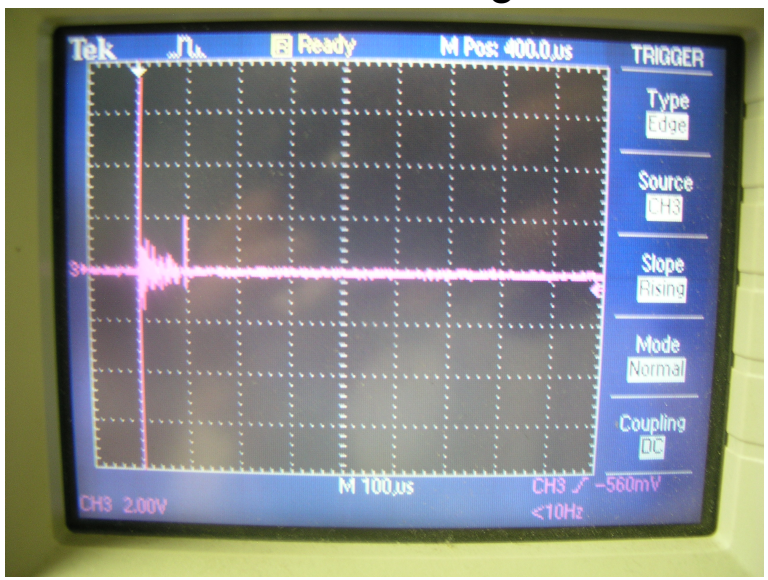
Testing of glass HV stalk as an inexpensive alternative to Boron Nitride

System Stability Studies

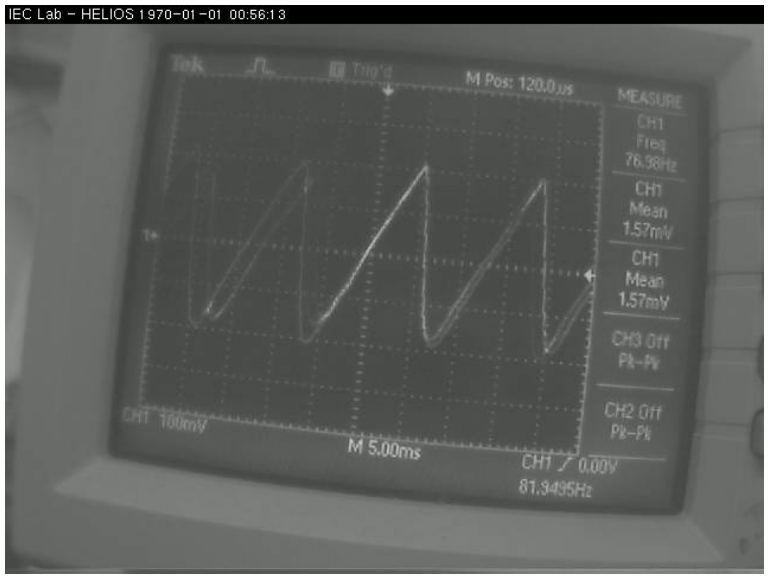
Presented by Bonomo Wednesday Afternoon



The system exhibits anomalous instabilities, or not, depending on the value and configuration of the series/ballast impedance.



Micro-arcs causing short, high-current spikes and shutdown



Anomalous saw-tooth oscillations on high-voltage feed-through

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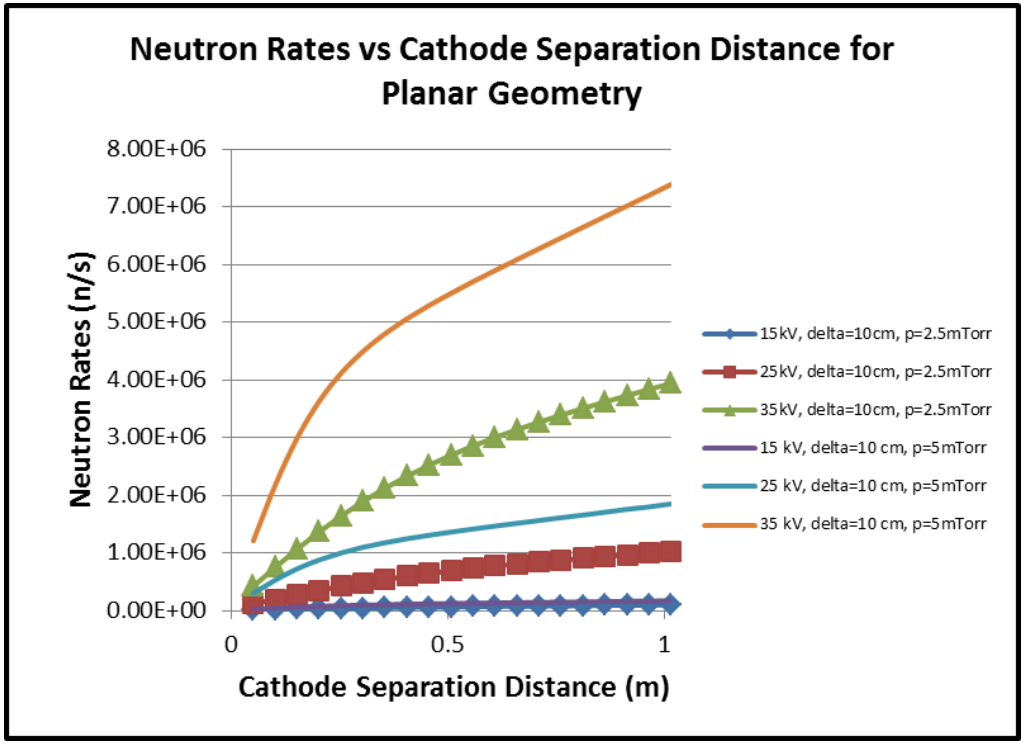
Development of New Neutron Sources

D-D Distributed Neutron Source from a Linear IEC Device

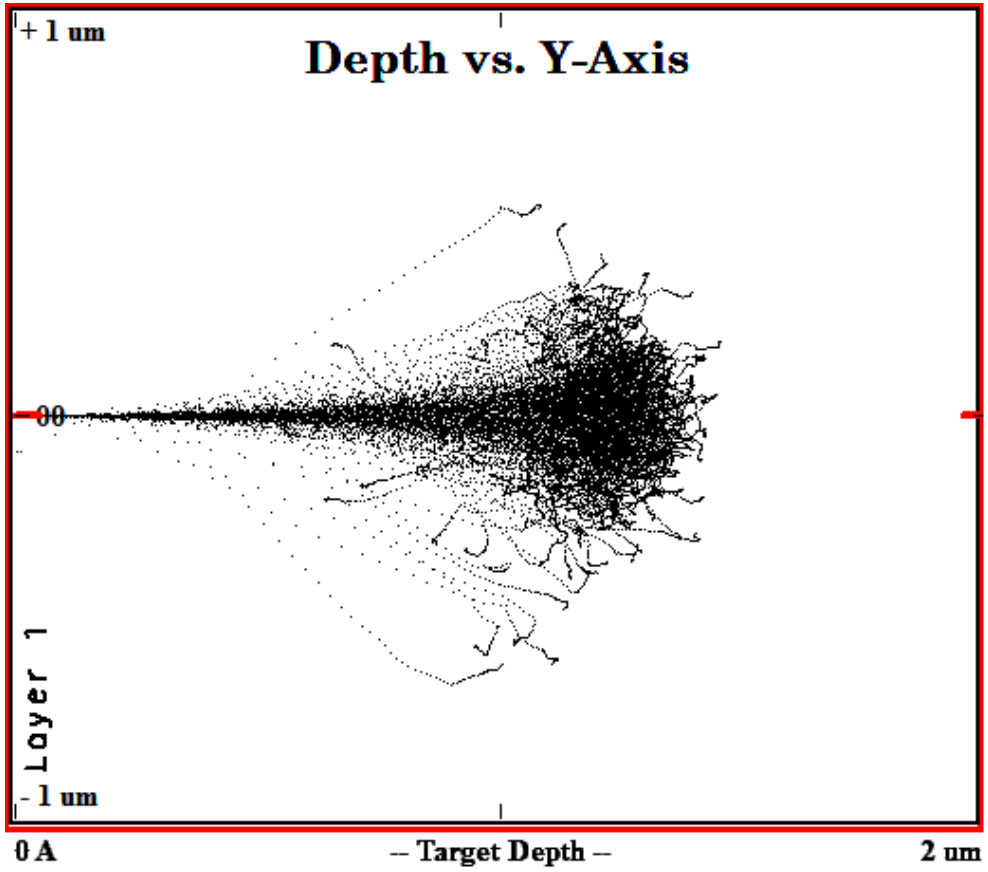
(See M Navarro Poster)

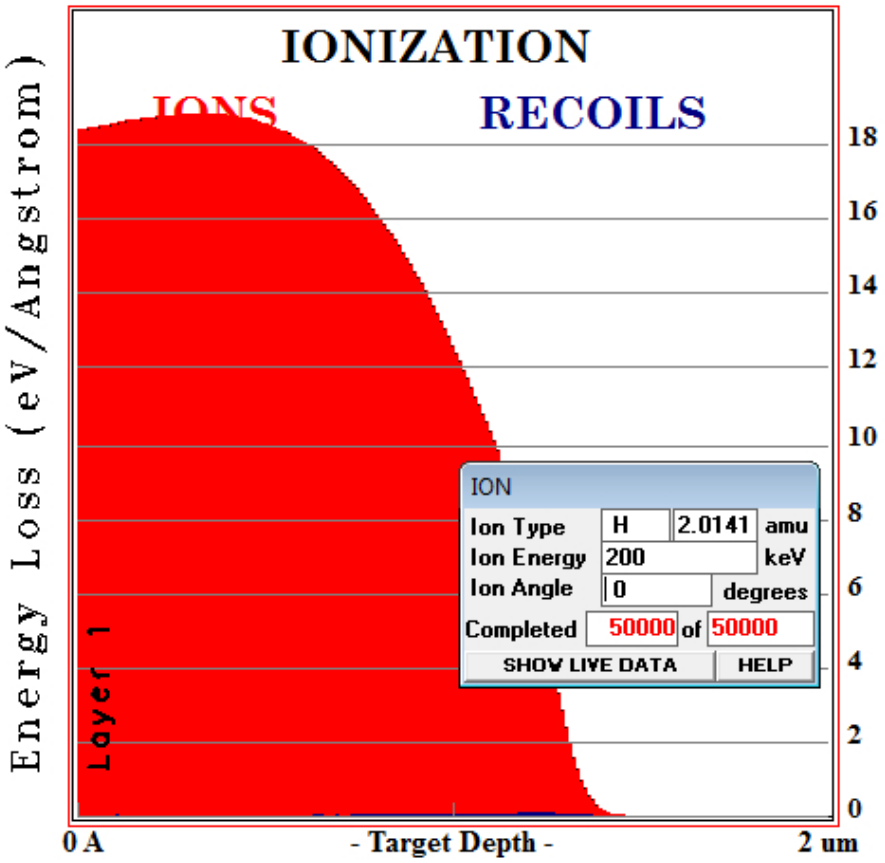
- A neutral particle analyzer and Doppler shift spectrometry will be used to study will be used to study neutral and ion particles arising from charge exchange processes for D-D and D- ^{3}He.
- Device will allow for validation and improvement of VICTER results.
- For planar geometry, higher pressures dominate over larger Δ's, effectively increasing the neutron rates.



Optimization Parameters	
$L_{C\text{-}C}$ (m)	Cathode-Cathode Separation
Δ (m)	Cathode-Anode Separation
V_C (kV)	Cathode High Voltage
P (mTorr)	Chamber Pressure

Ion Energy Loss Rate from 200 keV D^+ Incident on TiD^2 *(See M Navarro Poster)*

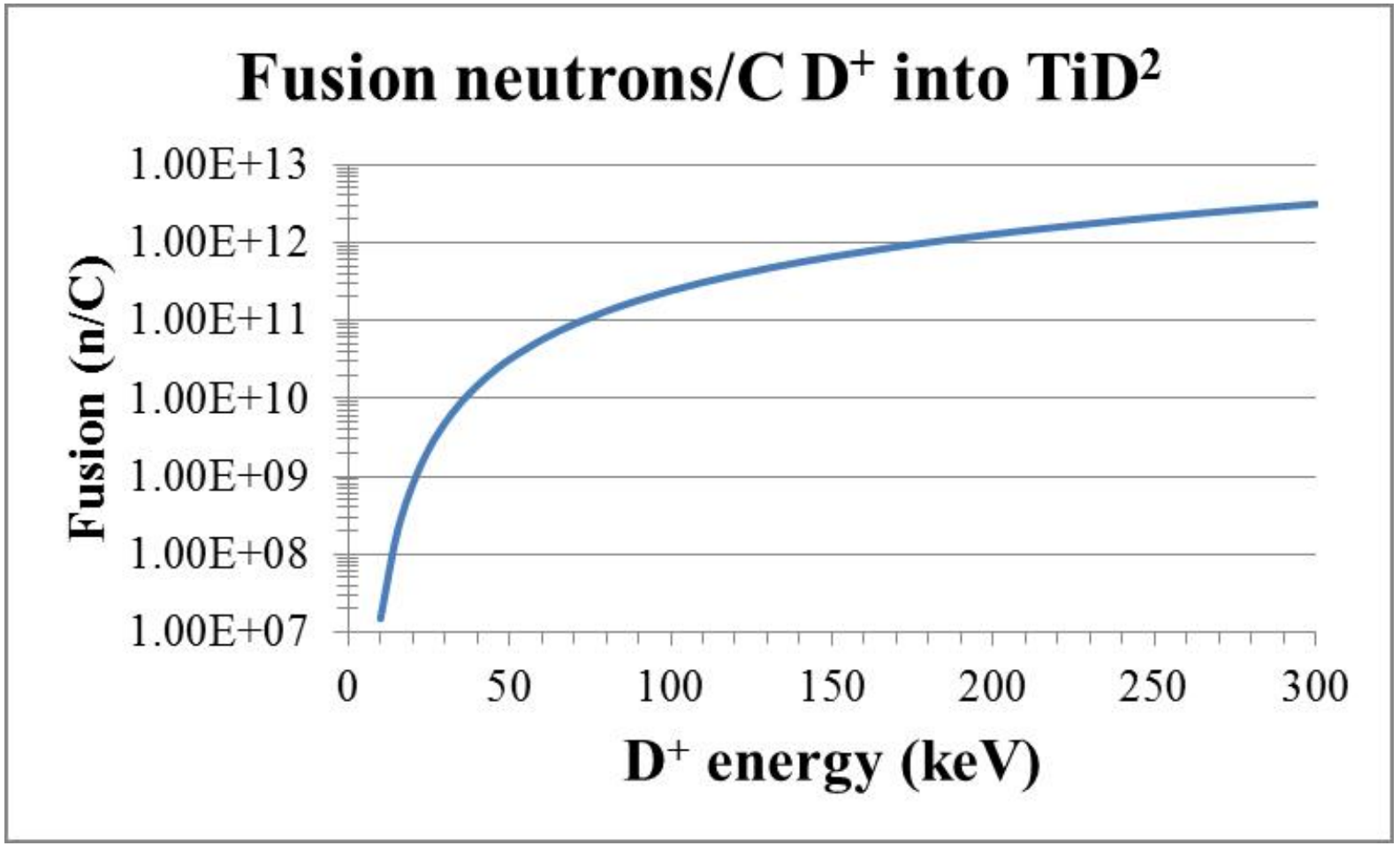




TRIM simulation determines energy loss (e) using a Monte Carlo method

TRIM Simulations 10-300 keV (D^+-TiD^2) Combined With Fusion Cross-Sections

(See M Navarro Poster)



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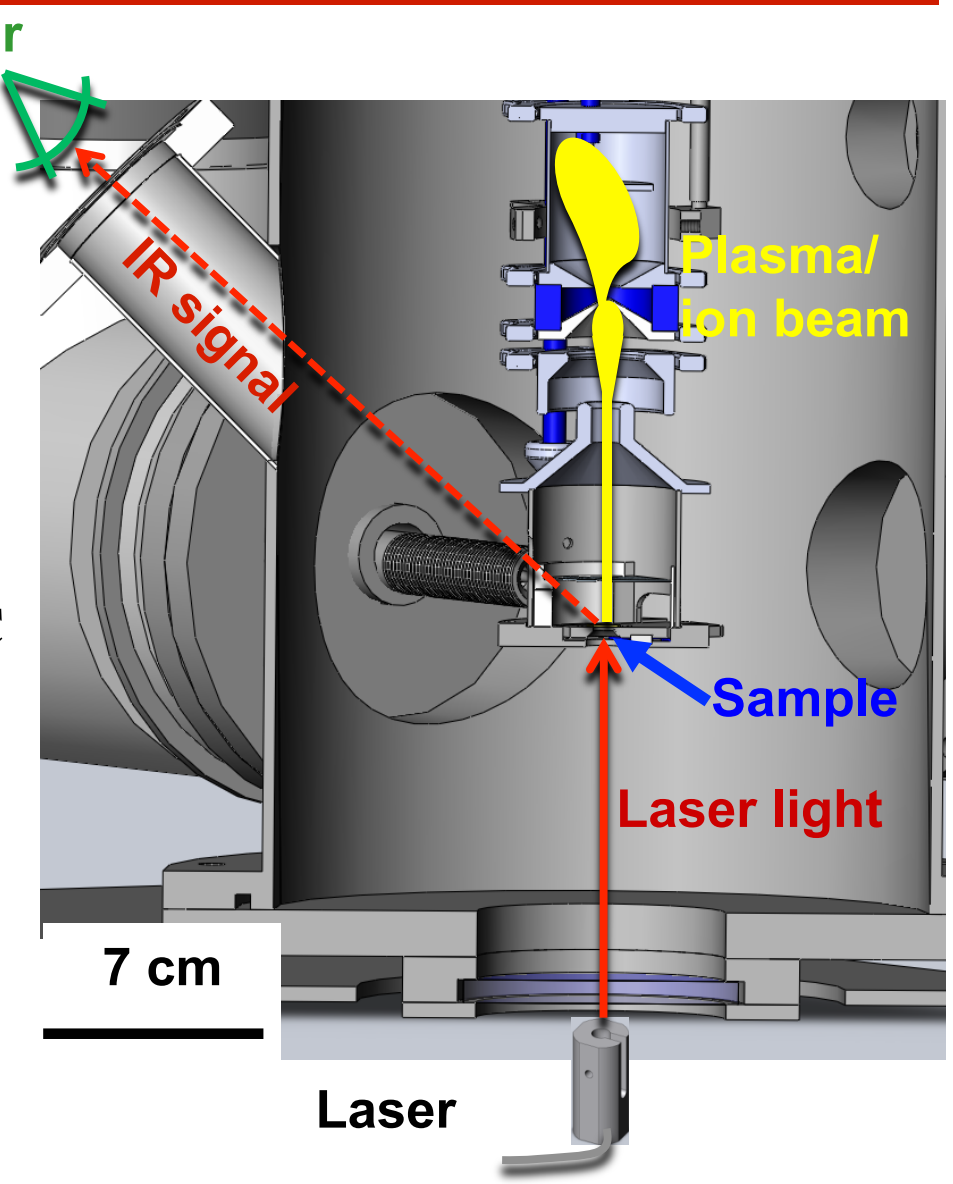
Materials Studies With IEC Technology

W Samples Are Irradiated in the Materials Irradiation Experiment (MITE-E)-*See Karla Hall Poster*

- Ion currents up to 200 μA, flux of ~5×10^{14} He^+/cm^2s
- He^+ accelerated in ion gun to impact sample with 10-60 keV at normal incidence
- Laser provided additional heating to keep sample temperature at 500-1200 °C
- Physical changes in a sample are analyzed with the Scanning Electron Microscope, Focused-Ion Beam, Electron Backscatter Diffraction, and mass loss measurements



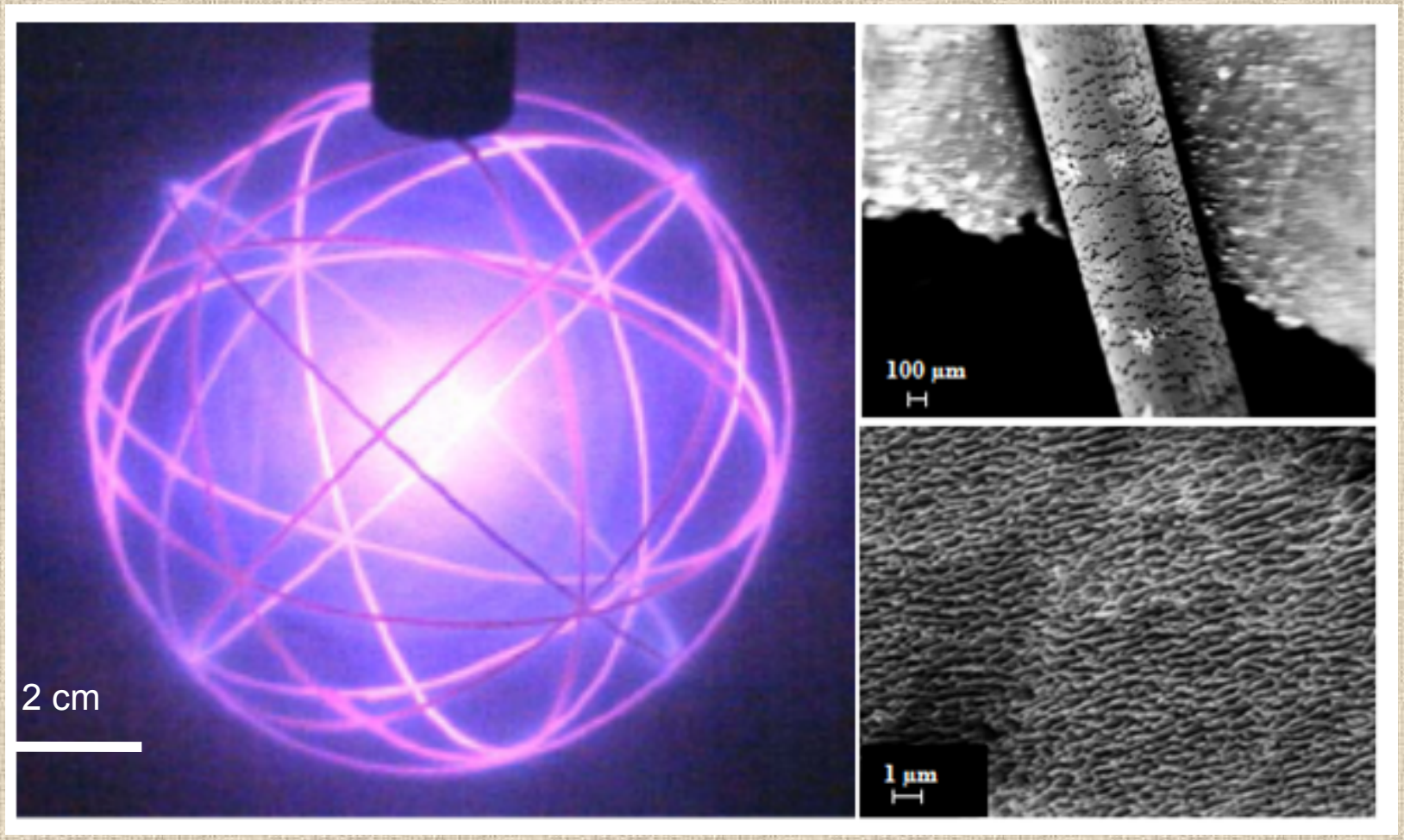
Surface Erosion In Polycrystalline W After 10^{18} He/cm^2 at 900 °C

Overview of Past Work on PCW

- **Surface cleaning and preparation of W metal has an effect on the surface microstructure post-irradiation.**
- **Grains in directions other than [111] are more susceptible to radiation damage and surface erosion.**
- **Every grain shows a grass structure and large mass losses associated with it under multiple energy He bombardment.**
- **Higher fluences and temperatures under mono-energetic He bombardment also show signification mass loss and microstructure growth.**

Operation in He^+ and D^+ Energetic Plasmas Can Severely Degrade W-25Re Cathodes

(See M. Jasica's Poster on Dual Beam Irradiations)



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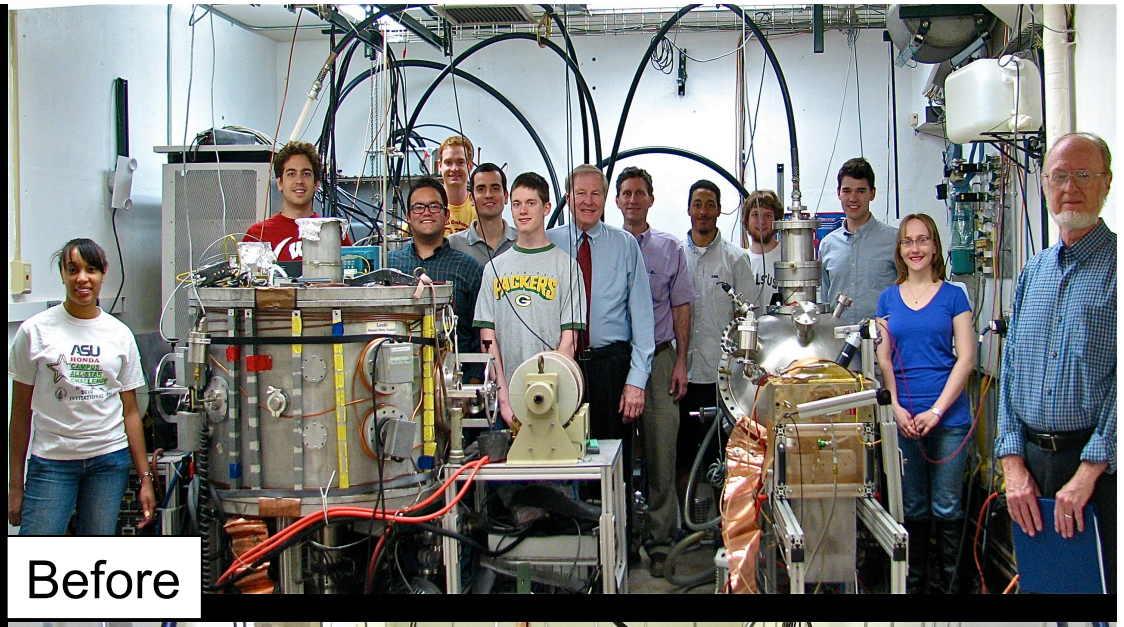
Improvement in UW-IEC Experimental Facilities

Lab Expansion has Been Implemented to Accommodate More Experiments and Access for Students with Disabilities



Before

After

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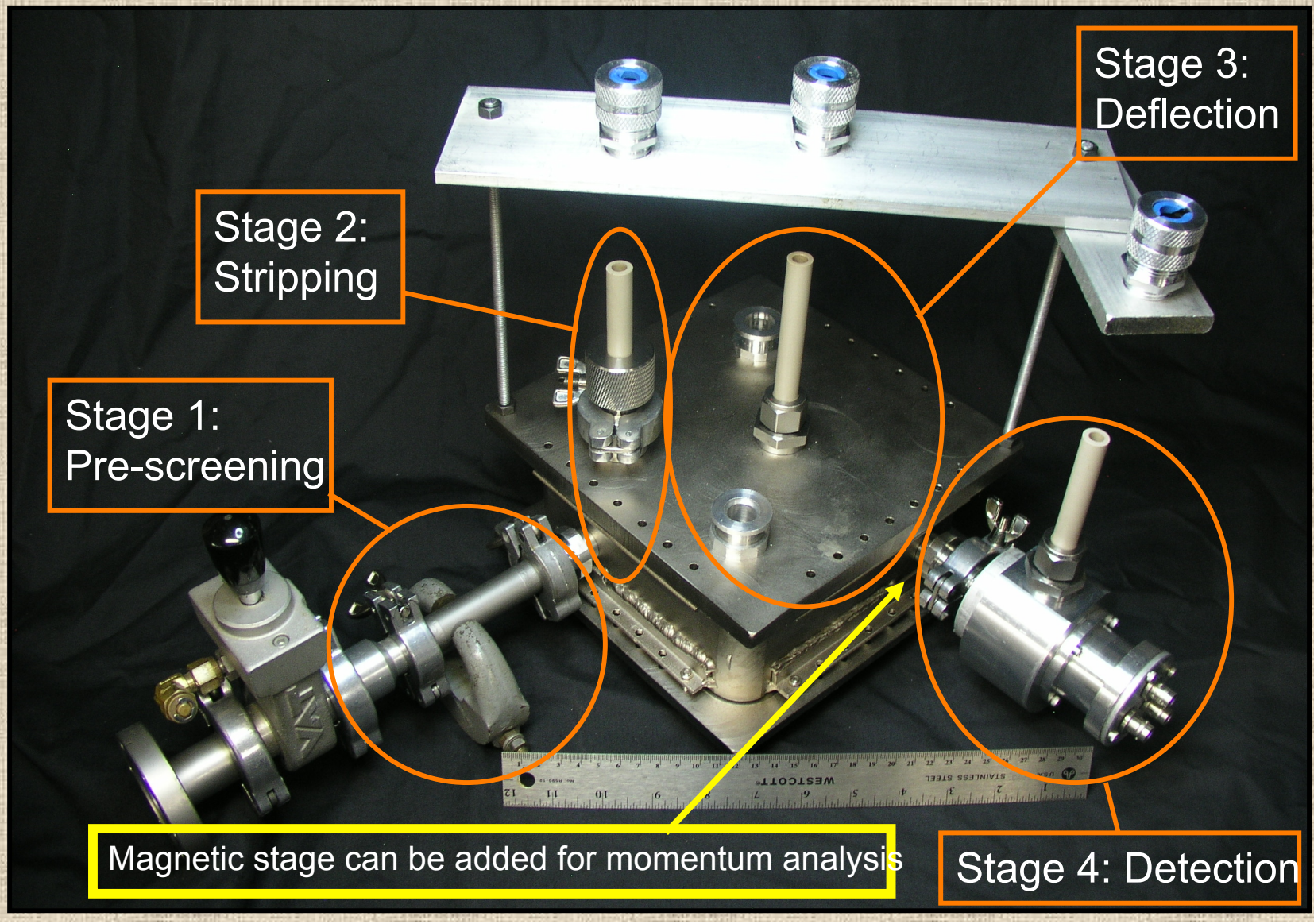
Understanding of How IEC Devices Operate

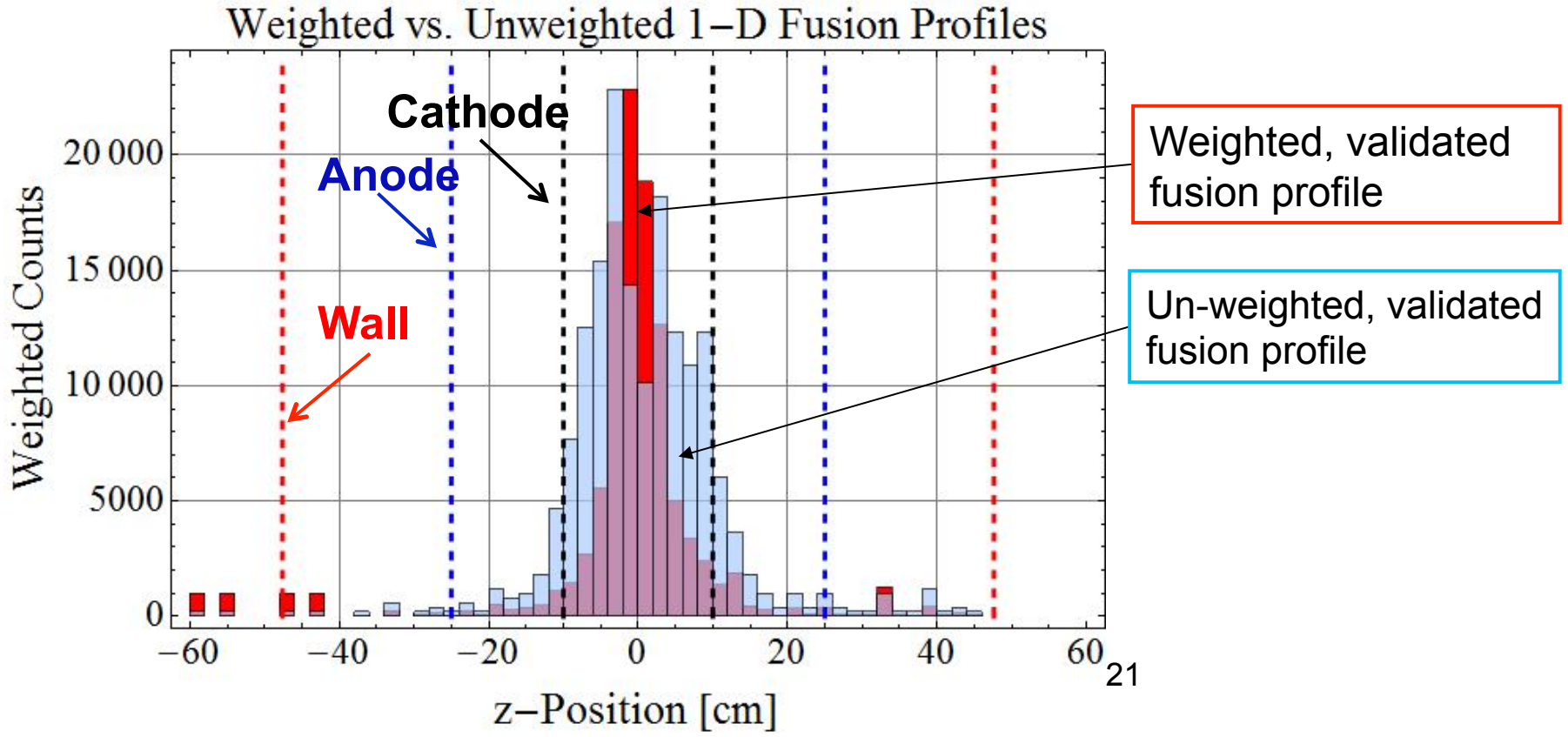
A Neutral Particle Analyzer (NPA) Has Been Designed and Constructed with Modularity in Mind

(see Gabriel Becerra Oral @ Wednesday PM)



Applying the Weighting Factors to the Validated Data Returns the True Fusion Profile for the Observable Region (A. McEvoy)

- Note that the weighted distribution occurs along a chord through the center of the device.



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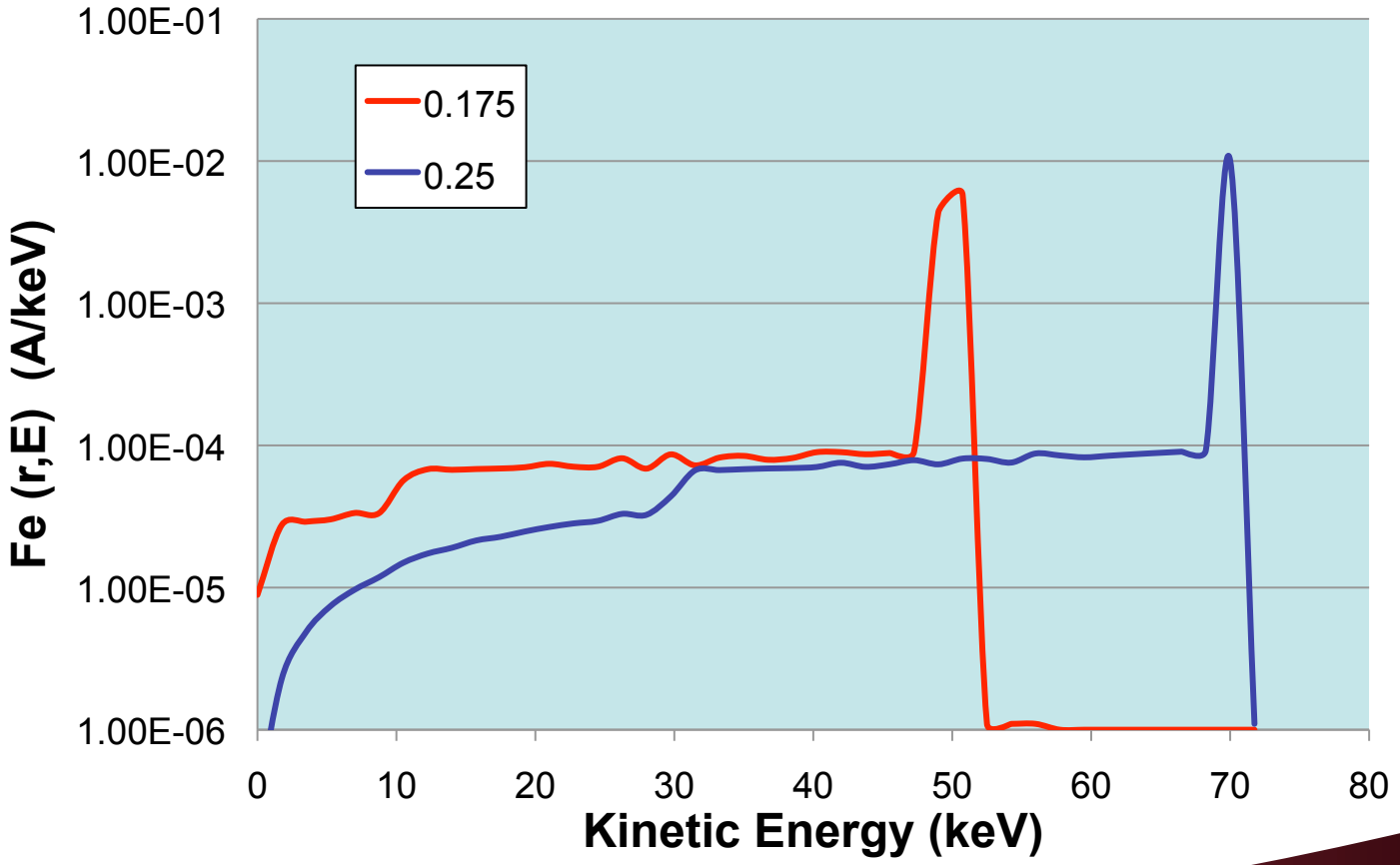
Emmert and Santarius Have Added Electron Kinetics to the VICTER 2.0 Code to Extend its Range of Validity to Lower Potentials and Higher Gas Pressures

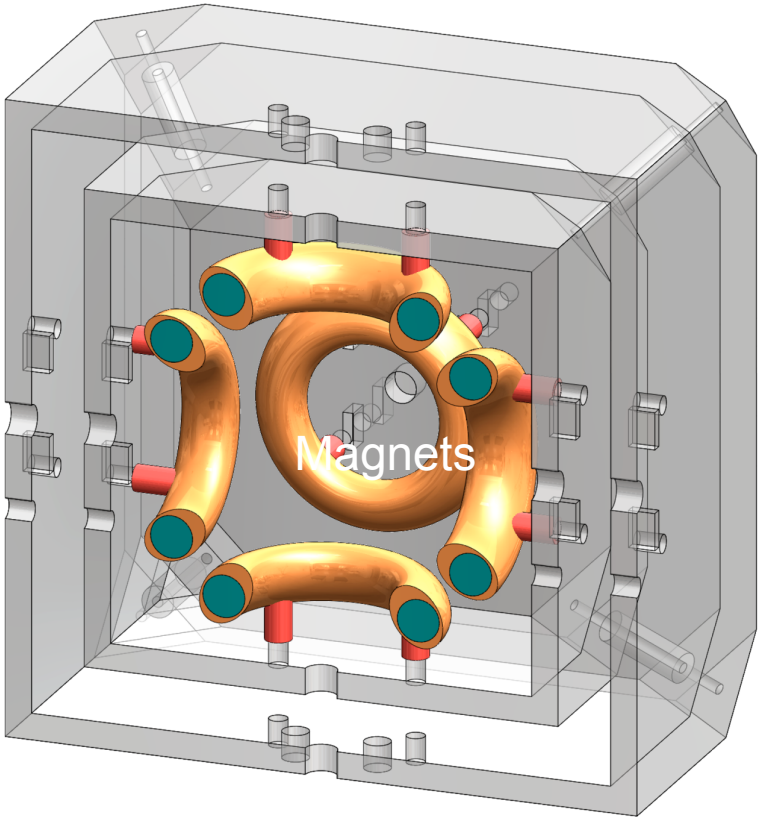
(See Oral Presentations Wed. 10/1/14)



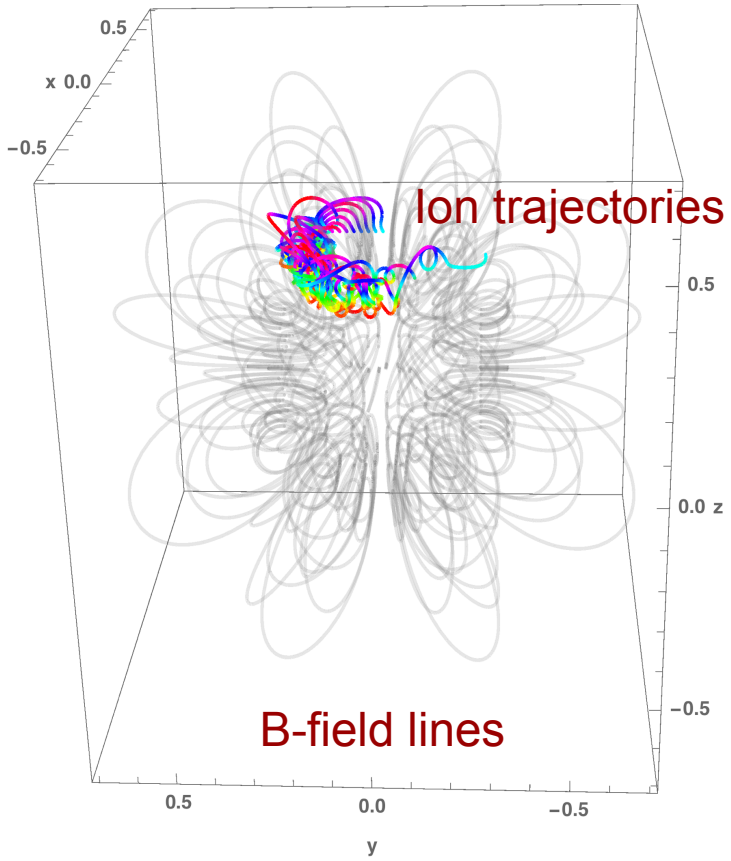
Polywell Physics Modeling Considerations

See J. Santarius Oral, Wednesday PM

Moderate engineering challenges in an accessible environment



Challenging physics modeling, not necessarily indicating lower reactor feasibility



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How Can We Procure a Large, Reliable Supply of ^{3}He?

Demonstrating the Ability to Extract ^{3}He from Lunar Regolith- *See A. Olson Poster*

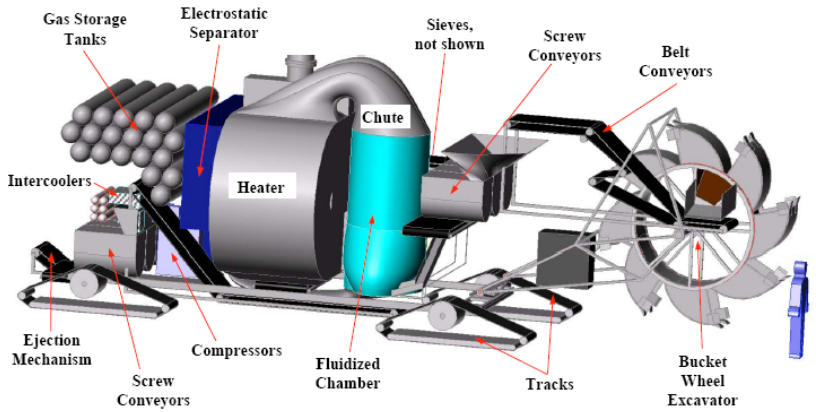
Objective: Demonstrate how lunar regolith could be heated to diffuse out helium-3 and other key solar wind volatiles

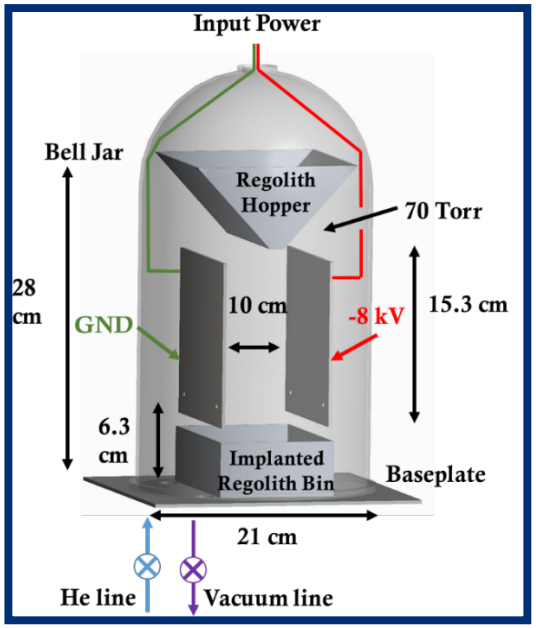
Heater Design: Heat pipe heat exchanger

Significantly reduce thermal energy requirements by recovering heat from processed regolith

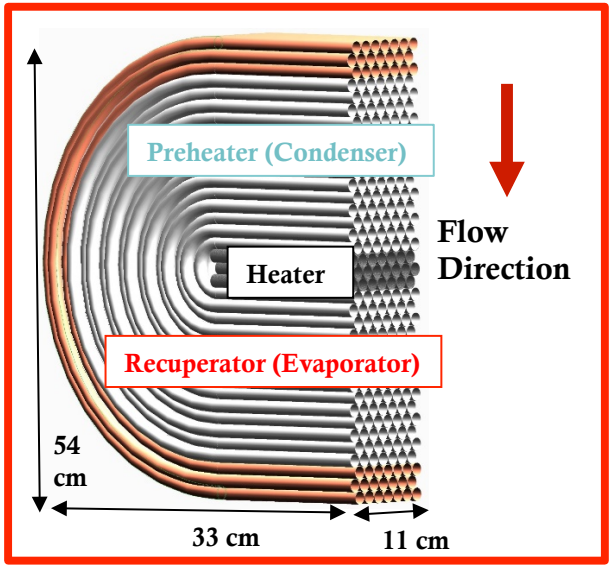
Helium Implantation into regolith simulant (JSC-1A)

Mark-III ^{3}He Lunar Miner

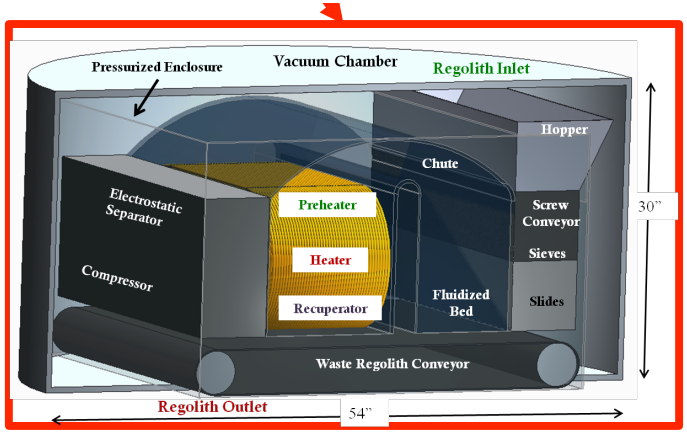




Conceptual DC glow discharge system

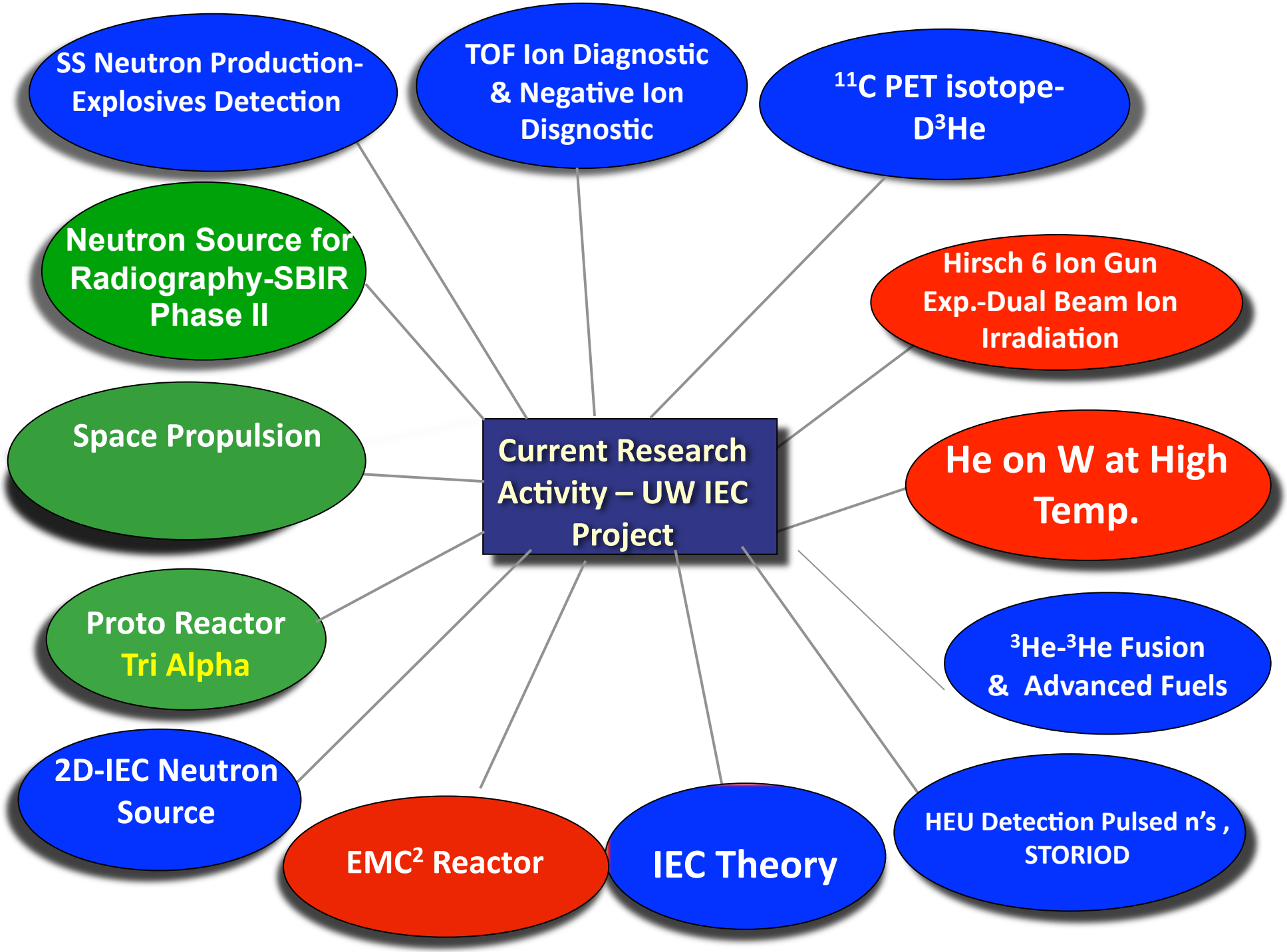


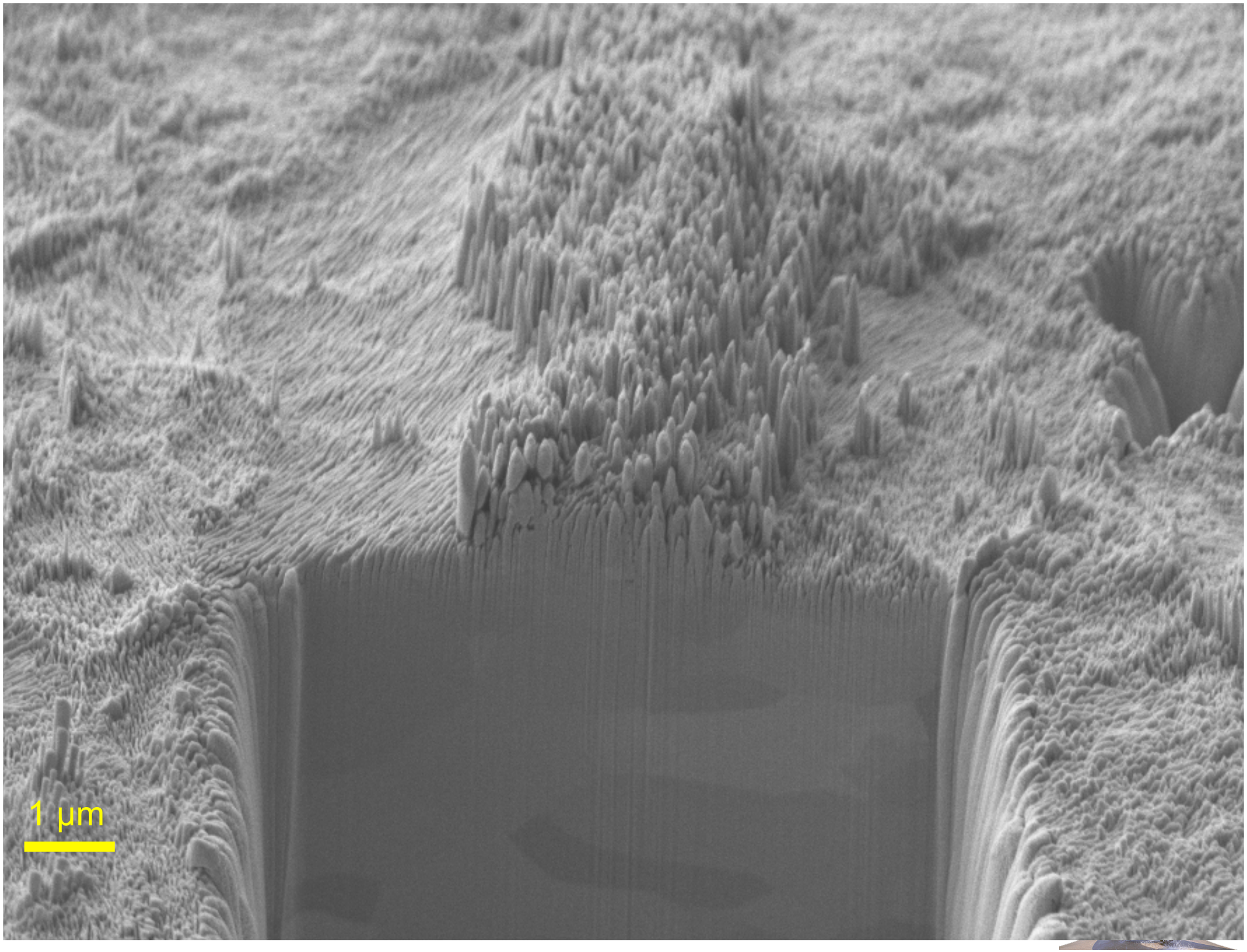
Heat Pipe Heat Exchanger



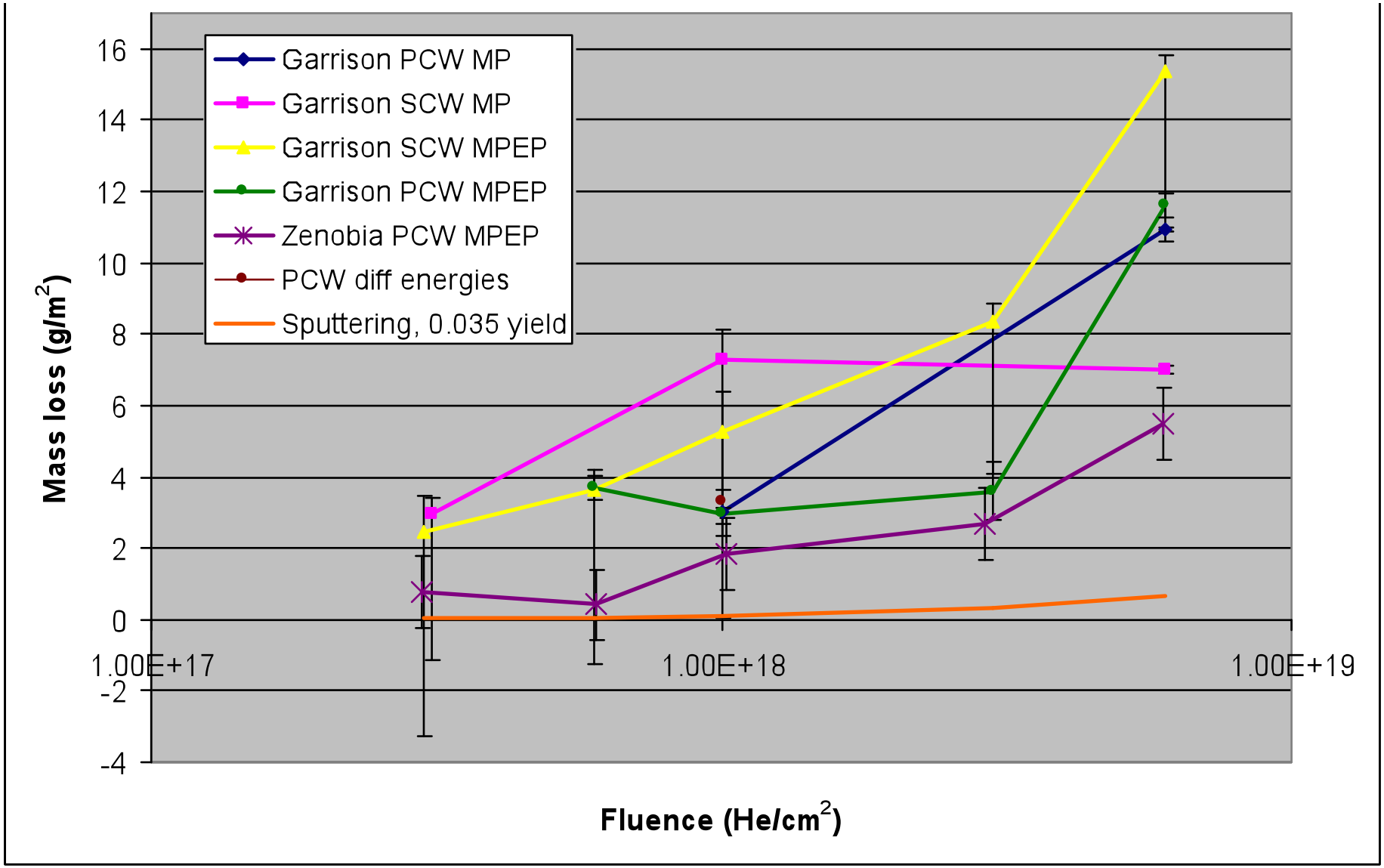
Helium Extraction and Acquisition Test bed (HEAT)


Questions?
2014.03.26 22:52

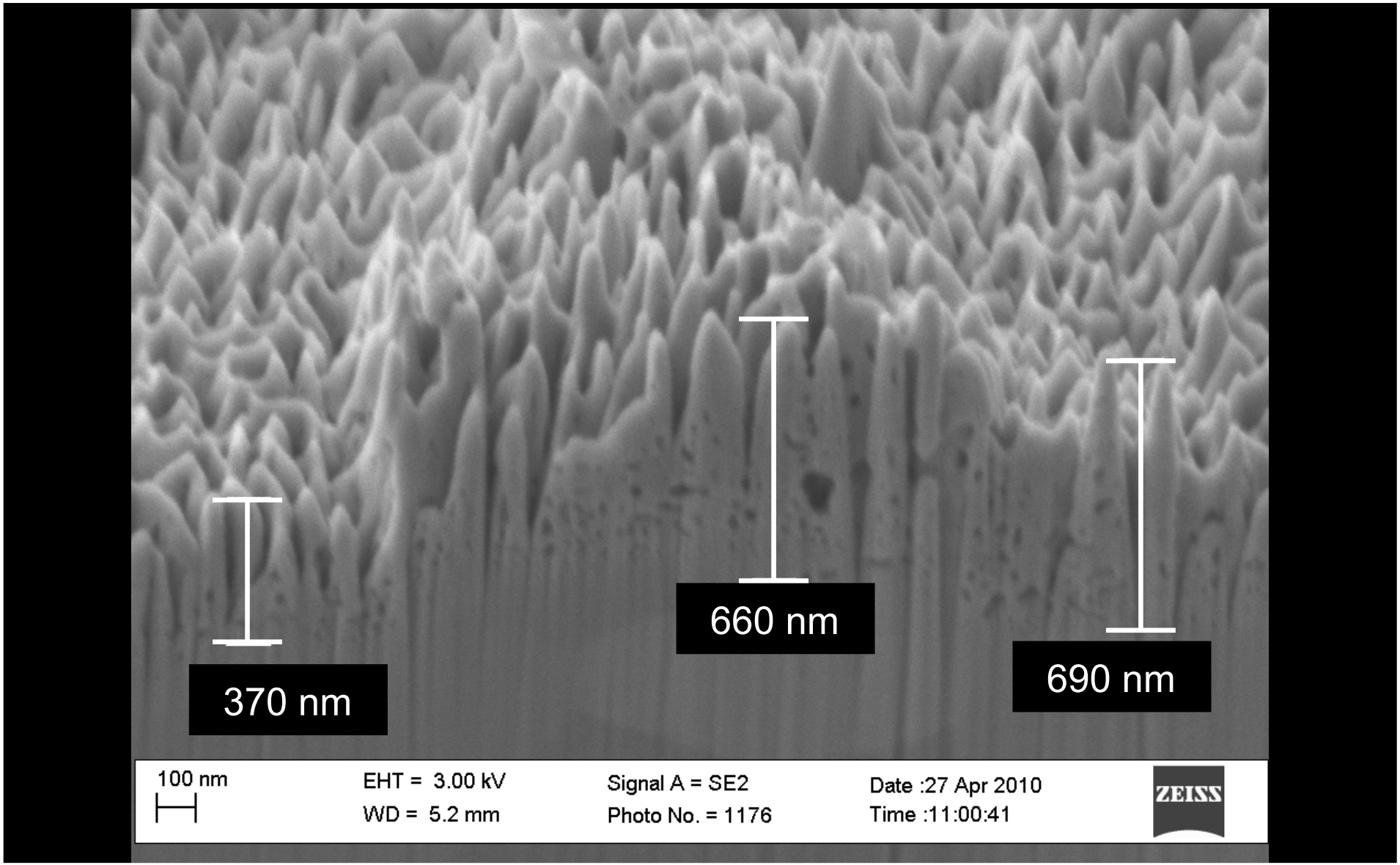

SS Neutron Production-Explosives Detection
TOF Ion Diagnostic & Negative Ion Disgnostic
^{11}C PET isotope-D^{3}He
Neutron Source for Radiography-SBIR Phase II
Hirsch 6 Ion Gun Exp.-Dual Beam Ion Irradiation
Space Propulsion
Current Research Activity – UW IEC Project
He on W at High Temp.
Proto Reactor Tri Alpha
^{3}He-^{3}He Fusion & Advanced Fuels
2D-IEC Neutron Source
EMC^{2} Reactor
IEC Theory
HEU Detection Pulsed n's , STORIOD


1 µm

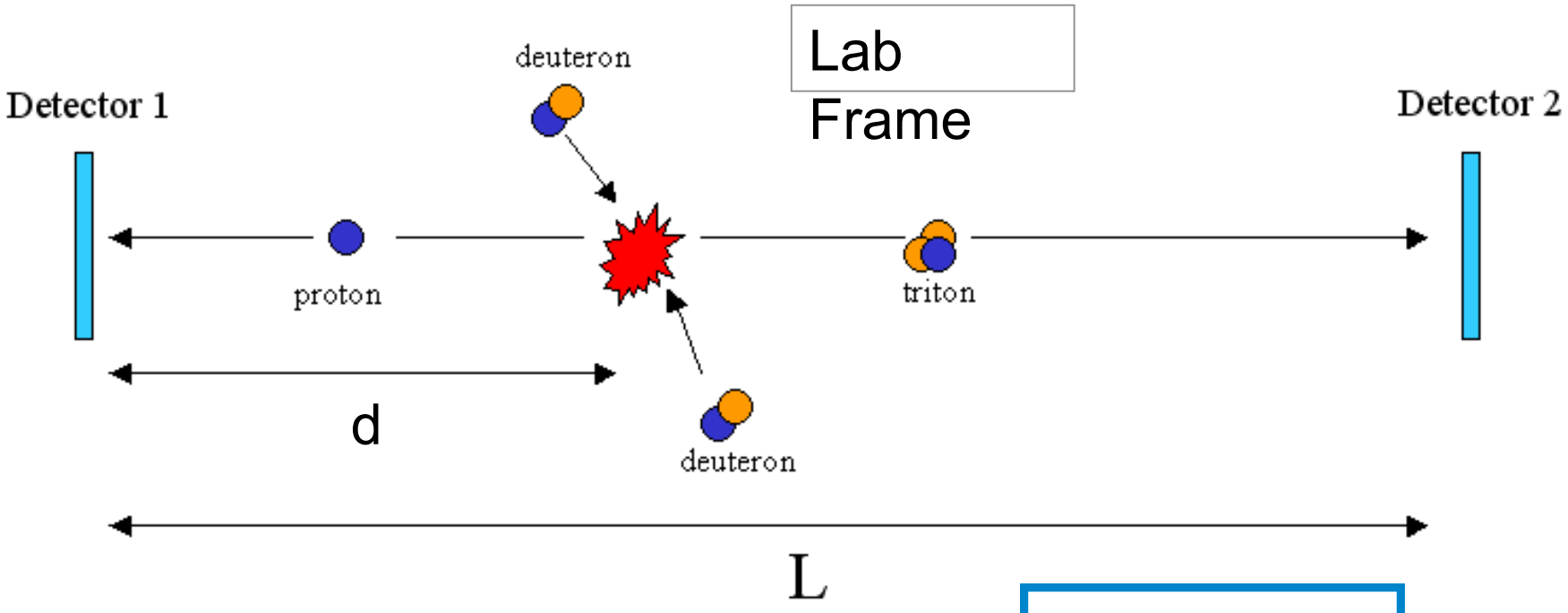
Mass Loss of Tungsten Samples Irradiated With 30 keV He Ions



Sub-Surface Porous Layer in PCW after Implantation with 30 keV He^+ in the *MITE-E*



The energy and timing information specifies the fusion event location in 1-D



$$\Delta t = t_T - t_P = \frac{L - d}{v_T} - \frac{d}{v_P}$$

$$d = \frac{\frac{L}{v_T} - \Delta t}{\frac{1}{v_P} + \frac{1}{v_T}}$$

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Development of a Pulsed Distributed Neutron Source is Progressing-*Craig Schuff*