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# Summary & Thoughts on the IEC Workshop

John F. Santarius

Fusion Technology Institute  
University of Wisconsin

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Inertial Electrostatic Confinement Fusion*

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# The 13<sup>th</sup> IEC Workshop Displayed Significant Progress

- Research institution overviews
- Applications
- Gridded IEC device experiments
- Gridded IEC device theory
- Polywells
- Beam IEC devices
- Posters



## Research Institution Overviews -- I

- Profs. Kulcinski, Hotta, Masuda, and Utsumi gave histories and overviews of the increasing capabilities of the Japanese and U.S. IEC research programs. Some highlights:
  - Jerry Kulcinski summarized UW's work on the FIDO and TOF diagnostics, clandestine materials detection, and the D and He ion-implantation materials studies on MITE-E.
  - Eiki Hotta gave an overview of Tokyo Inst of Technology projects, ranging over many configurations and using techniques from spectroscopy to neutron transmutation doping.

## Research Institution Overviews -- II

- More highlights:
  - Kai Masuda described Kyoto Univ efforts on the IEC25 landmine detection system ( $5 \times 10^7$  n s<sup>-1</sup>, continuous 8 h) and a combined neutron and x-ray radiography detection of special nuclear material (SNM).
  - Michiaki Utsumi gave an overview of the Tokai Univ research on cathode geometry and potential distributions in low power IEC devices.
  - Masami Ohnishi presented details of the work by the Kansai Univ and Kyoto Univ team to investigate the application of IEC fusion to neutron radiography.



# Applications Progress

- Yasushi Yamamoto described experimental results and MCNP calculations for an IEC device surrounded by neutron reflector and moderator materials aimed at creating a neutron beam.
- Hiroshi Horibe described how to keep I and V constant in a power supply plus designing the electrical circuit to protect against arcing.
- Rich Bonomo described preparations for operating UW's new power supply (300 kV, 200 mA), including the cables and high-voltage switch.



## Gridded IEC Device Experimental Progress -- I

- Yasuhiro Ishikura discussed a “diamond-shape ” cathode that provides stable discharges down to 0.3 Pa pressures.
- Kei Takakura summarized studies of a cylindrical IEC device with a cusped, azimuthal magnetic field.
- Yu Yamagaki described a 5-stage, high-voltage feedthrough that reduces the number of ions impacting the high-voltage stalk and improves the ion lifetime 3-fold.



## Gridded IEC Device Experimental Progress -- II

- Gabriel Becerra summarized research aimed at extending earlier  $^3\text{He}$ - $^3\text{He}$  reaction studies by Greg Piefer.
- Taiju Kajiwara presented results of simulating the RS-MIS magnetron ion source IEC device, including an interesting trajectory following approach that speeds the calculation for low-collisionality particles.
- Eric Alderson showed preliminary results from an azimuthal scan of three IEC microchannels using a Faraday trap



## Gridded IEC Device Theoretical Progress

- Yukari Nakajima simulated IEC discharges using a 3-D Monte Carlo PIC code including atomic processes that showed collisions spreading out the distribution.
- Gil Emmert discussed UW's Volterra Integral Code for Transport in Electrostatic Reactors (VICTER) approach to a moderate-pressure, gridded IEC device, and compared the code's predictions to UW's FIDO diagnostic.
- Eric Alderson described the UW campaign to understand negative ions in IEC devices, including their addition to VICTER.
- John Santarius explored the results of parametric variation for UW's VICTER integral equation code.

## Polywell Progress

- Matthew Carr reported on the progress being made in point cusp confinement theories in a Polywell context.
- David Gummersall showed preliminary orbit calculations for the Sydney Polywell.
- Joel Rogers presented simulations of a p-<sup>11</sup>B Polywell power reactor that would reach  $Q \sim 1$  at  $R = 13$  m.

## Beam IEC Device Progress

- Matt Michalak summarized Brian Egle's research on a "Hirsch" six-gun fusion experiment (SIGFE) and laid out plans for extending that research.
- Alex Klein described two converging-beam fusion ideas:
  - MIX: the multipole ion-beam experiment, and
  - MARBLE: the multiple ambipolar recirculating beam line experiment.

## Posters

- Hodaka Osawa displayed simulations of miniaturized IEC device, with dimensions down to a 30 mm anode.
- Rehan Bandara described an instability that appeared in simulations of an opposite polarity, spherical IEC device.
- Scott Cornish showed an innovative electron gun that uses collimated IEC microchannels to produce the e-beam.
- Adam Israel provided a very nice overview the Sydney Univ research on using charge-exchange neutrals to create an ion thruster.

# Summary

- The progress in IEC research described at this meeting has been very impressive:
  - experimental capabilities,
  - modeling accuracy,
  - applications,
  - generation of new ideas, and
  - research into new directions.