

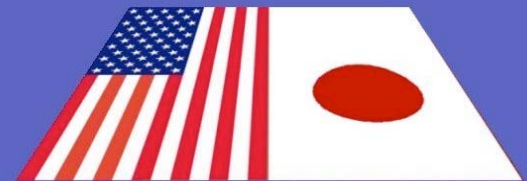
# Current Directions for the University of Wisconsin IEC Research Program

G. Kulcinski, J. Santarius, R. Ashley, H. Schmitt,  
D. Boris, B. Cipiti, G. Piefer, R. Radel, S. Krupakar Murali,  
K. Tomiyasu\*, A. Wehmeyer, J. Weidner\*\*, T. Uchytel,

U.S.-Japan IEC Workshop  
Tokyo, Japan,  
Oct. 20-21, 2003

\*Now at Tokyo Inst. Tech.

\*\* Now at West Point, U. S. Military Academy



# The Wisconsin IEC Team



Dr. H. “Jack”  
Schmitt and  
Major John  
Weidner



10/7/2003

# The Wisconsin Program Currently Has Two Main Thrusts

Performance  
Optimization of IEC  
Device

Near Term Applications



Performance  
Optimization of IEC  
Device

Theory

- J. Santarius
- S. Krupakar Murali
- K. Tomiyasu

Device Op.

- R. Ashley  
D. Boris, T. Uchytíl

Ion Source

- G. Piefer

Near Term Applications

PET Isotopes

- J. Weidner
- B. Cipiti

Strategic Planning

- G. Kulcinski
- H. "Jack" Schmitt

Detection of  
Explosives

- R. Radel
- A. Wehmeyer

Performance  
Optimization of IEC  
Device

Theory

• K. Tomiyasu

Device Op.  
R. Ashley

Ion Source

• G. Piefer

Near Term Applications

PET Isotopes

• B. Cipiti

# Publications/Presentations Since US-Japan IEC 5

1. G.L. Kulcinski, J.W. Weidner, B.B. Cipiti, R.P. Ashley, J.F. Santarius, S.K. Murali, G.R. Piefer, and R.F. Radel, “**Alternate Applications of Fusion – Production of Radioisotopes,**” Fusion Science and Technology, Vol. 44, p. 559 (2003).
2. R.P. Ashley, G.L. Kulcinski, J.F. Santarius, S. Krupakar Murali, G.R. Piefer, B.B. Cipiti, R.F. Radel, and J.W. Weidner, “**Recent Progress in Steady State Fusion Using D-<sup>3</sup>He,**” Fusion Science and Technology, Vol. 44, p. 564 (2003).
3. J.W. Weidner, G.L. Kulcinski, J.F. Santarius, R.P. Ashley, G. Piefer, B. Cipiti, R. Radel, and S.K. Murali, “**Production of <sup>13</sup>N via Inertial Electrostatic Confinement Fusion,**” Fusion Science and Technology, Vol. 44, p. 539 (2003).
4. B.B. Cipiti and G.L. Kulcinski, “**Embedded D-<sup>3</sup>He Fusion Reactions and Medical Isotope Production in an Inertial Electrostatic Confinement Device,**” Fusion Science and Technology, Vol. 44, p. 534 (2003).
5. # 4 was awarded the Best Student Paper in the 15<sup>th</sup> TOFE Conf.
6. #3 was awarded honorable mention in the 15<sup>th</sup> TOFE Conf.

# Collaboration With Other IEC Groups

- **Los Alamos National Laboratory**
  - S. K. Murali spent summer 03 with Dr. R. Nebel
- **Glenn Research Center**
  - G. Piefer spent summer 03 with ion propulsion group
- **Greatbatch Ltd.**
  - UW provided chamber and technical advice to Dr. W. Greatbatch
- **Tokyo Institute of Technology**
  - K. Tomiyasu spent 2002-03 as exchange student at Wisconsin
- **U. S. Military Academy-West Point**
  - Collaboration on compact IEC neutron sources
- **High Average Power Laser Fusion Program (US)**
  - UW irradiated W samples for U. S. Navy led program

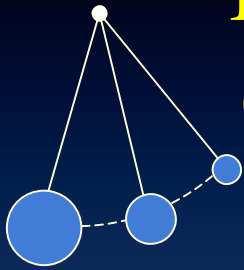


# Theoretical Efforts Have Focused on Computer Simulation and Ion Flow Analyses

- K. Tomiyasu and J.F. Santarius: “Particle-in-cell Simulations” (to be reported at this workshop).
- J.F. Santarius, G.A. Emmert, and G.R. Piefer: “Discrete Simulation Monte Carlo Analysis” (to be reported at next workshop). DOE-funded research to begin January 1, 2004.
- S. Krupakar Murali: “Thermionic Electron Emission Analysis” (in progress).
- S. Krupakar Murali: “High-Voltage Stalk Analysis” (in progress).

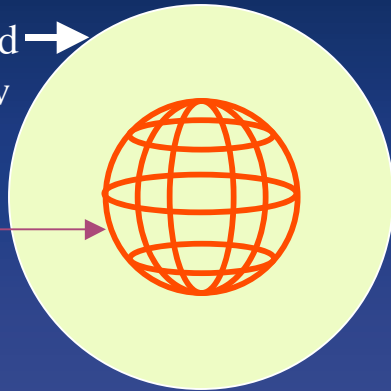
J.F. Santarius: “Phenomenological Ion Flow Analysis” (reported at previous workshop; in progress).

# Eclipse Discs Block Fusion Protons and Give an Idea of the Spatial Distribution of Fusion Events



Proton Solid Angle View

10 cm dia. Cathode



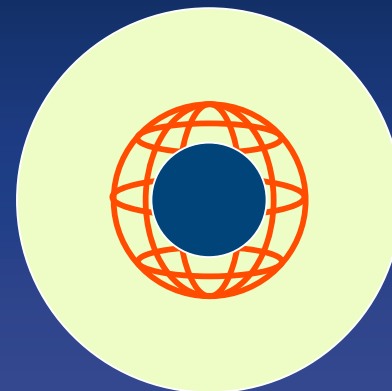
No Eclipse

0% volume blocked



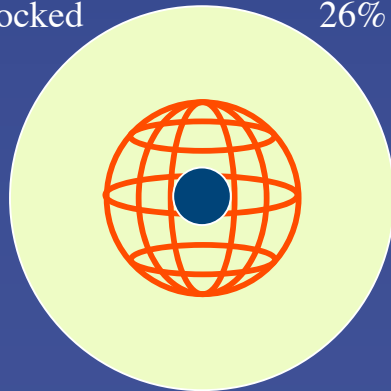
Large Eclipse

26% volume blocked



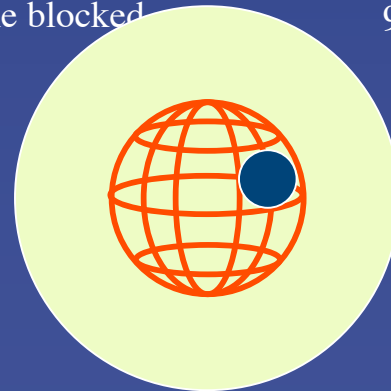
Medium Eclipse

9% volume blocked



Small Eclipse

1% volume blocked



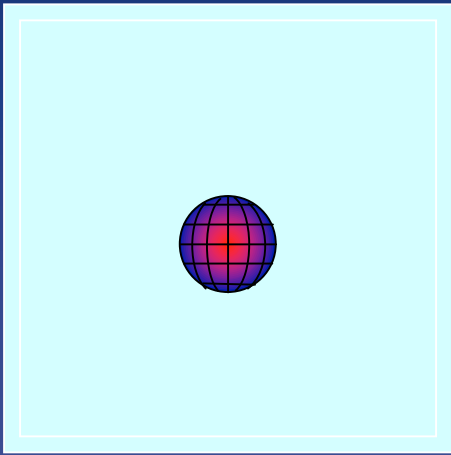
Small Offset

1% volume blocked

# Source Regimes Determined by Eclipse

## Experiments (40-100kV, 2 mTorr)

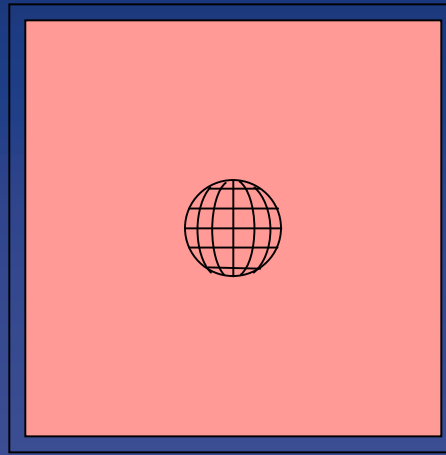
Converged Core



**D-D: 30 %**

**D-<sup>3</sup>He: 10 %**

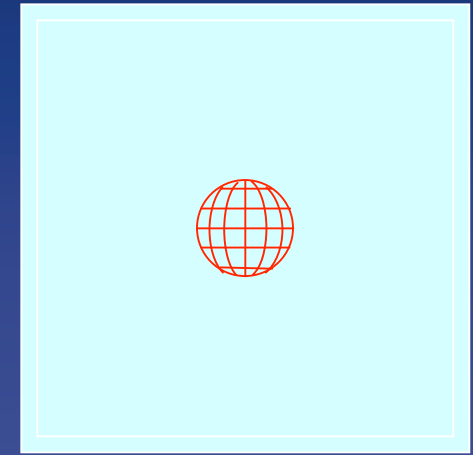
Volume



**D-D: 70 %**

**D-<sup>3</sup>He: Negligible**

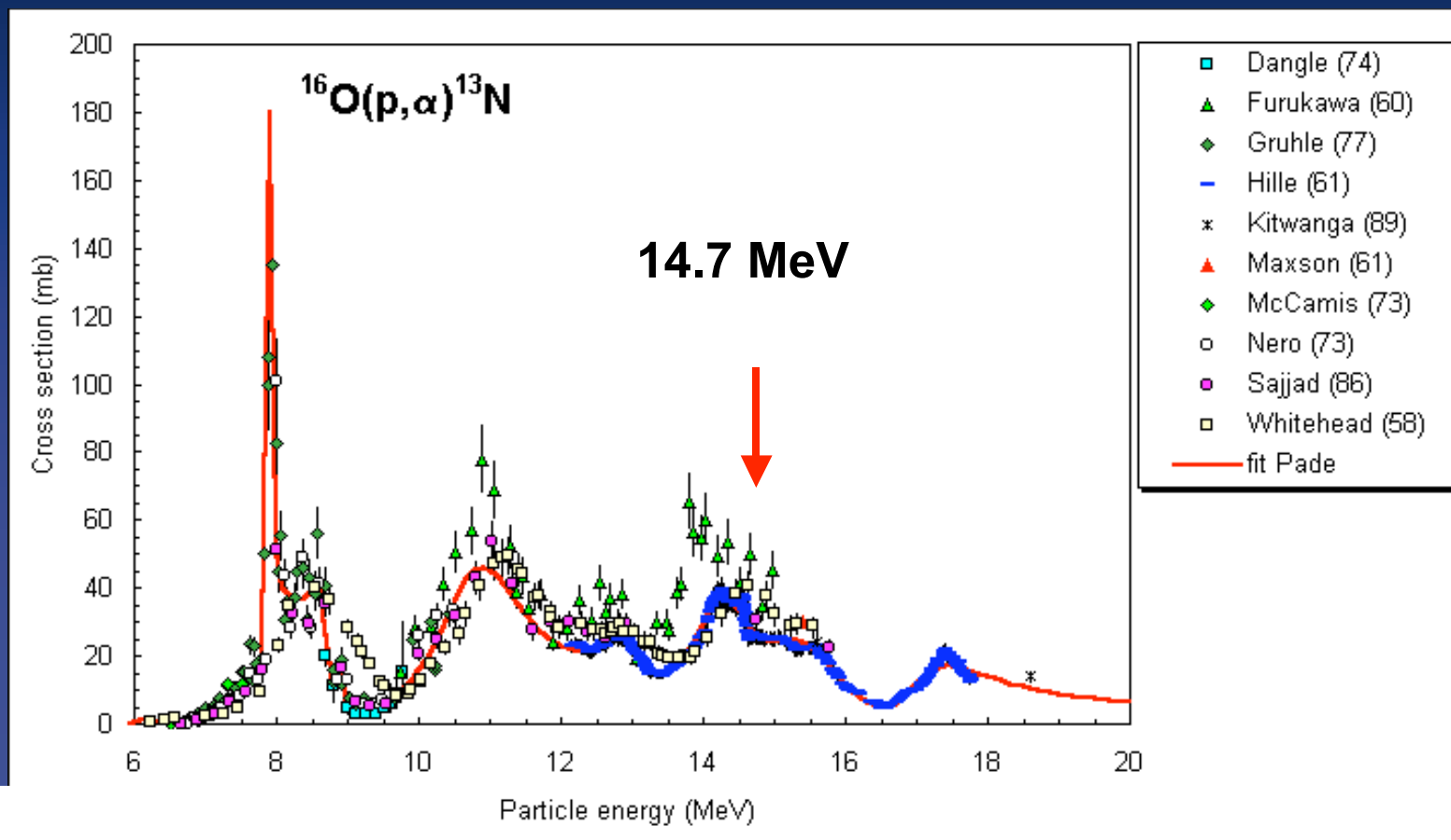
Embedded



**D-D: Negligible**

**D-<sup>3</sup>He: 90 %**

# The Short Half Life Commercial PET Isotope $^{13}\text{N}$ Can Be Made from $\text{D}^3\text{He}$ Protons



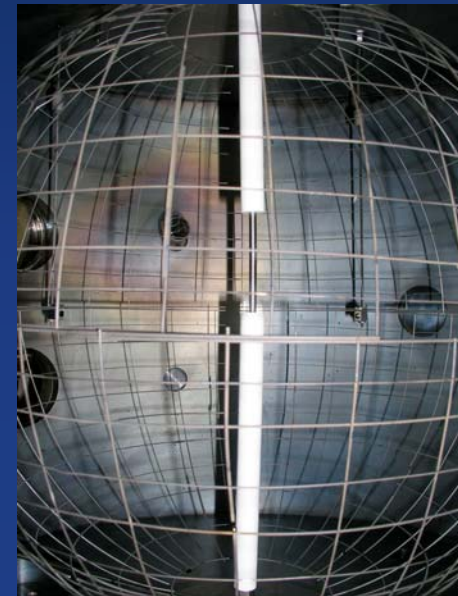
Taken from the IAEA's online charged-particle cross section database 12  
for medical radioisotope production

# Our First PET Isotopes Have Been Made in Two Different Ways

- On Feb 19, 2003 the PET isotope  $^{13}\text{N}$  was made in an IEC device by bombarding water in thin SS tubes with  $\text{D}^3\text{He}$  protons born in the central cathode region



- On June 13, 2003 the PET isotope  $^{13}\text{N}$  was made in an IEC device by bombarding water in a thin SS tube (acting as a cathode) with  $\text{D}^3\text{He}$  protons born in the cathode



# Non-Electric Applications of Fusion

Final Report to Dr. Ray Orbach  
Director, Office of Science  
U. S. Department of Energy  
July 31, 2003

From the Fusion Energy Sciences  
Advisory Committee



# Conclusion: The Most Promising Opportunities for Non-Electric Applications Fall into 4 Categories

- Near-term applications  $Q \ll 1$
  - Transmutation
  - Hydrogen production
  - Space propulsion
- }  $Q \gg 1$

# Two Near-Term Applications Stand Out

- Detection of Clandestine Materials
  - Explosives
  - Chemical weapons
  - Fissile material
- Production of Radioisotopes
  - PET isotopes with very short half-lives



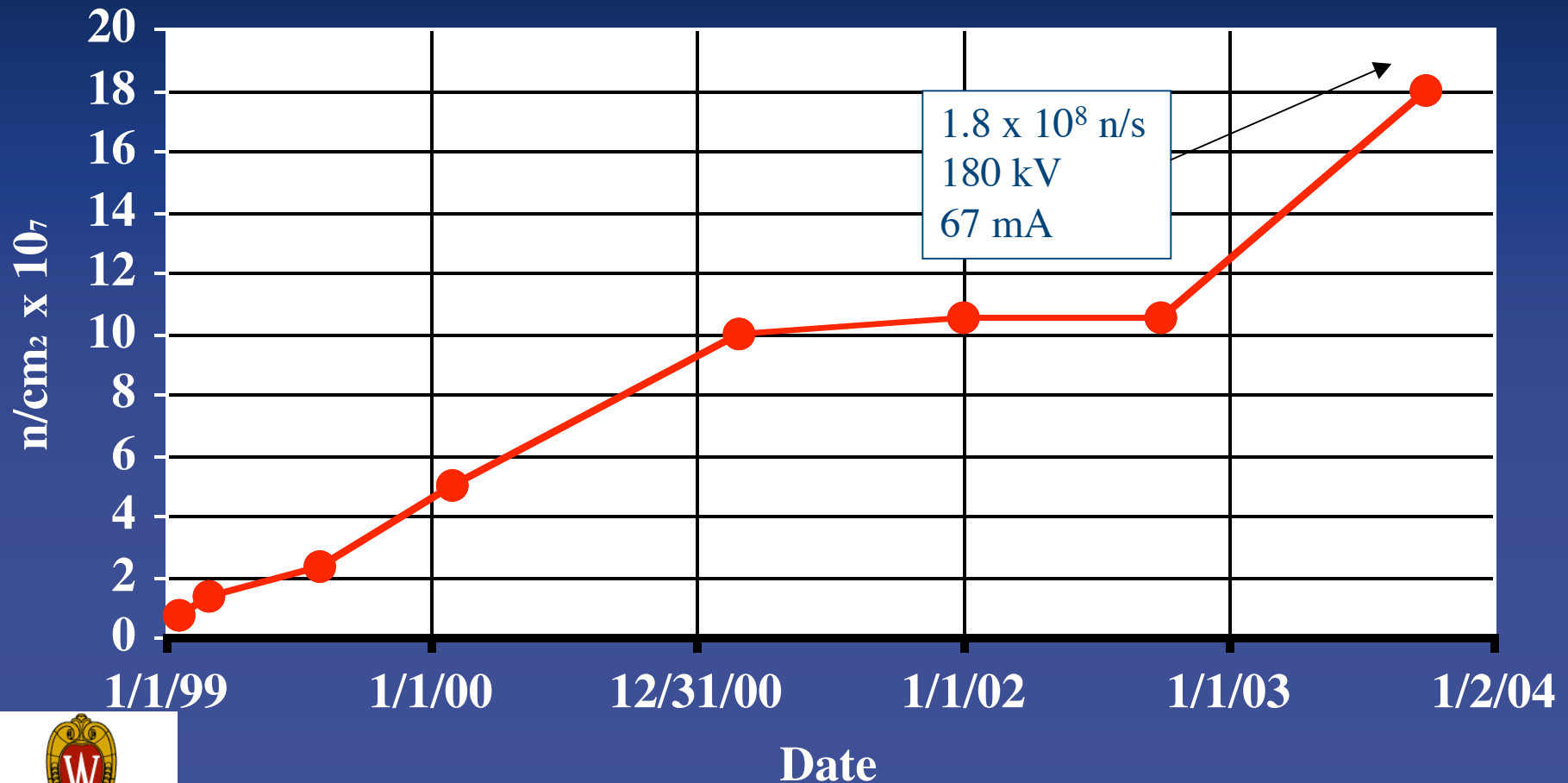
# Recommendations to U. S. DOE- *Near-Term, Non-Electric Applications*

- A small, but steady source of funding should be made available for “SBIR” research activities that include opportunities for Universities, industry, and national laboratories.
- This should not be done at the expense of existing programs

# Implications of FESAC Recommendations to DOE

- There is now an “official” recognition that IEC devices can have a role in the U. S. fusion program
- There is an opening for Industry/Government collaboration in IEC research in the future.

# We Have Increased the DD Neutron Production Rate by 64% Since the 5th IEC Workshop



# Conclusions

- The performance of the University of Wisconsin IEC device continues to improve:
  - Operation improved to 180 kV with DD
  - Neutron production-  $1.8 \times 10^8/s$
  - Developed a new helicon source for He
- Experiments now give insight to fusion source distribution @2 mTorr and 40-100 kV:
  - Embedded ions important for  $D^3He$  (90%)
  - Volume (70%)/converged core (30%) for DD
- The PET isotope  $^{13}N$  has been produced in two different ways from water targets