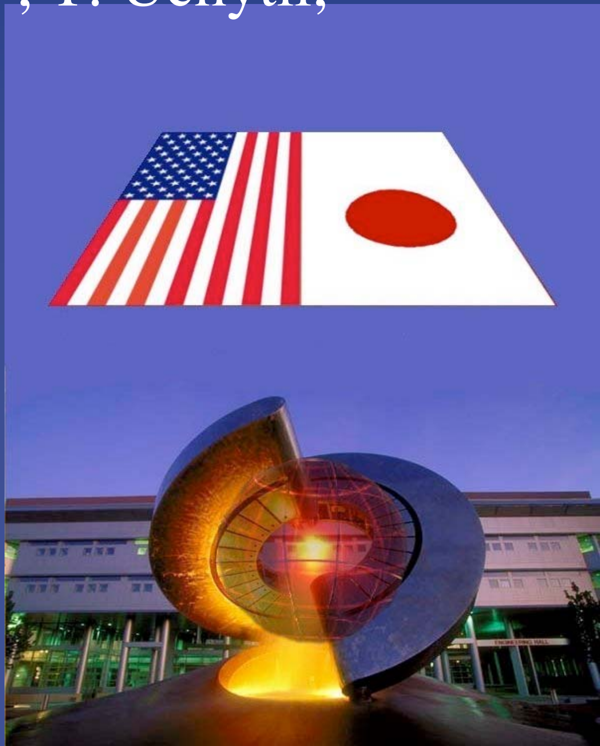
Current Directions for the University of Wisconsin IEC Research Program

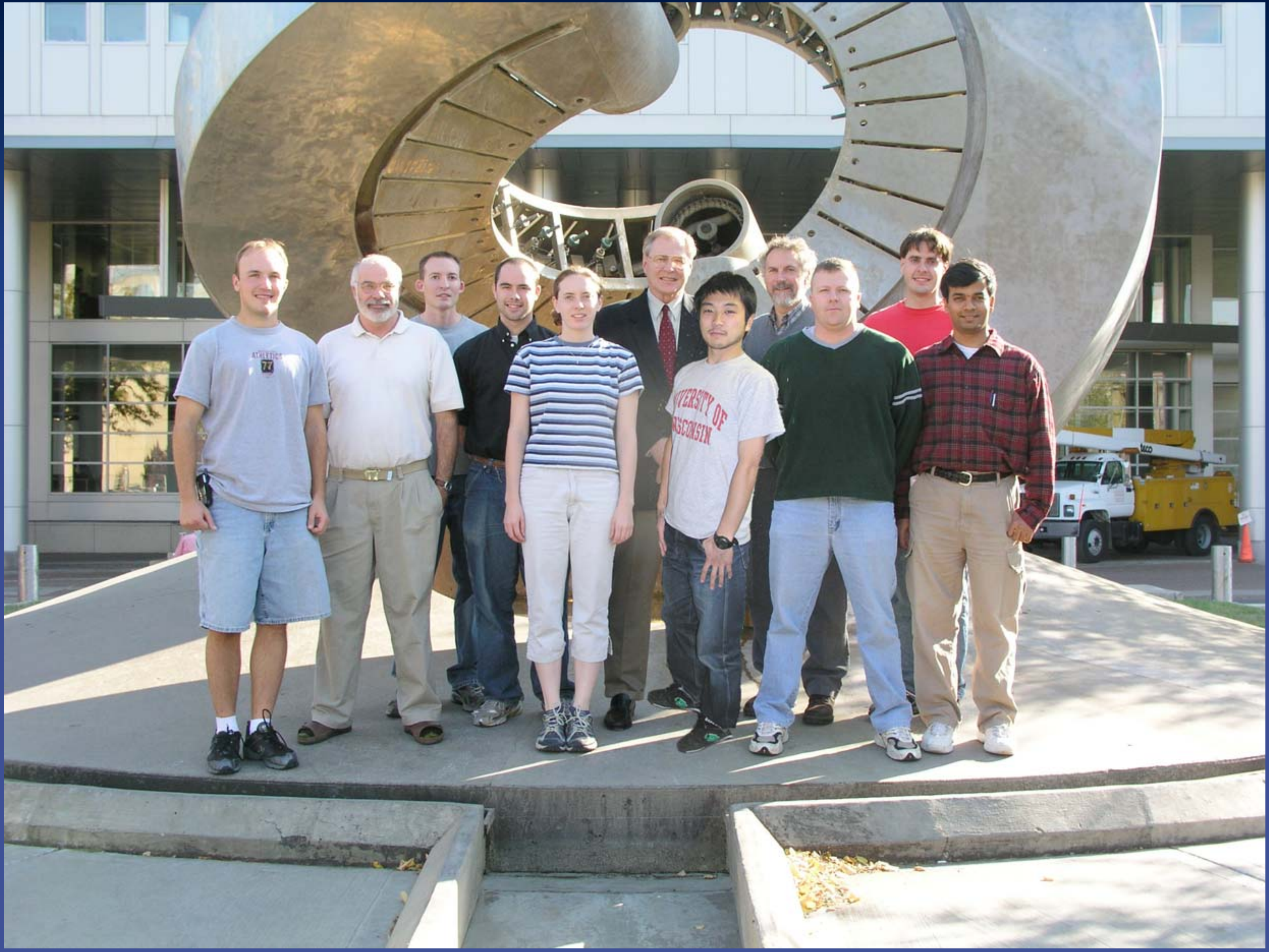
G. Kulcinski, J. Santarius, R. Ashley, H. Schmitt,
D. Boris, B. Cipiti, G. Piefer, R. Radel, S. Krupakar Murali,
K. Tomiyasu*, A. Wehmeyer, J. Weidner**, T. Uchytil,

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

The Wisconsin Program Currently Has Two Main Thrusts

Performance Optimization of IEC Device

Near Term Applications

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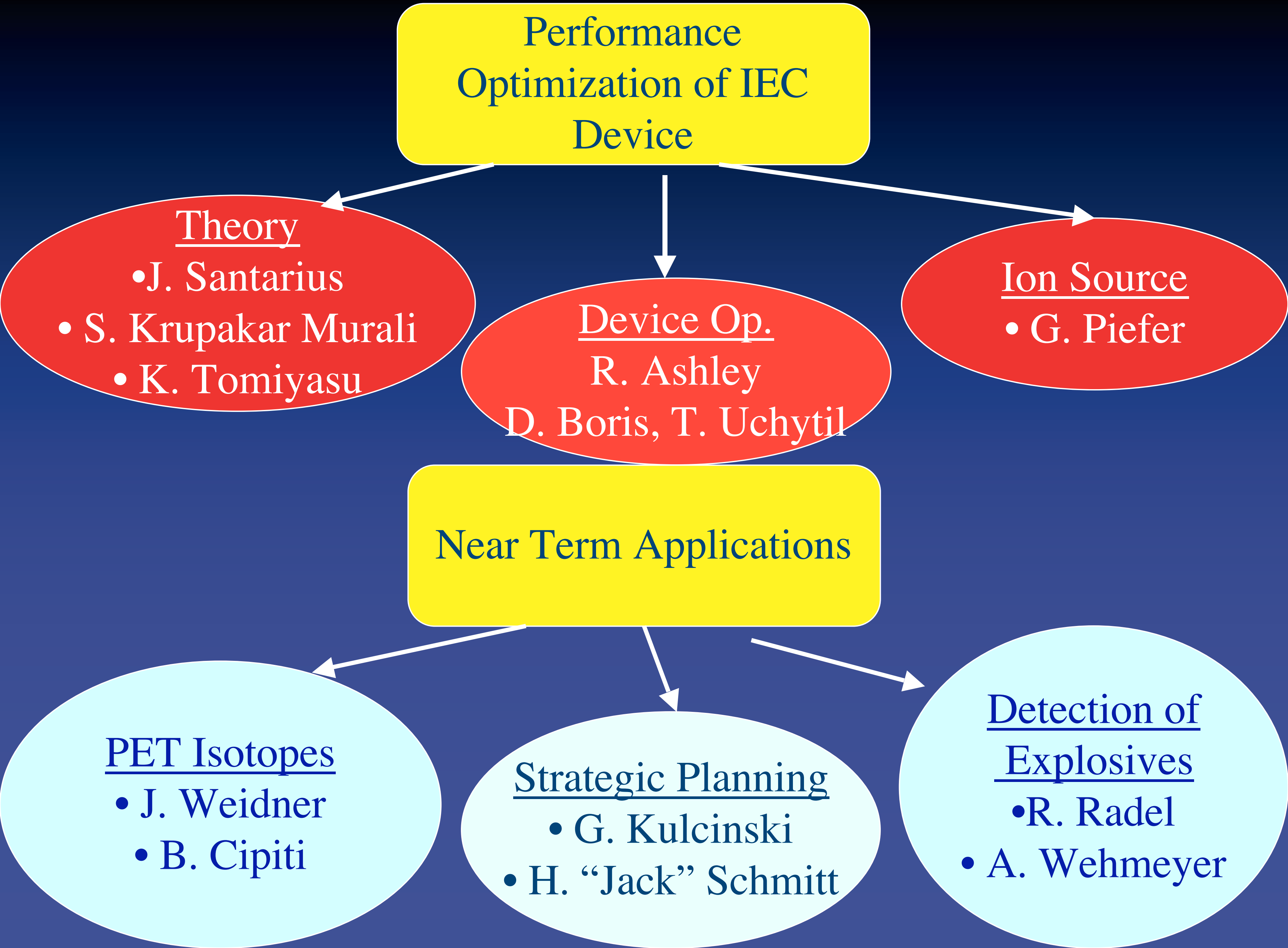
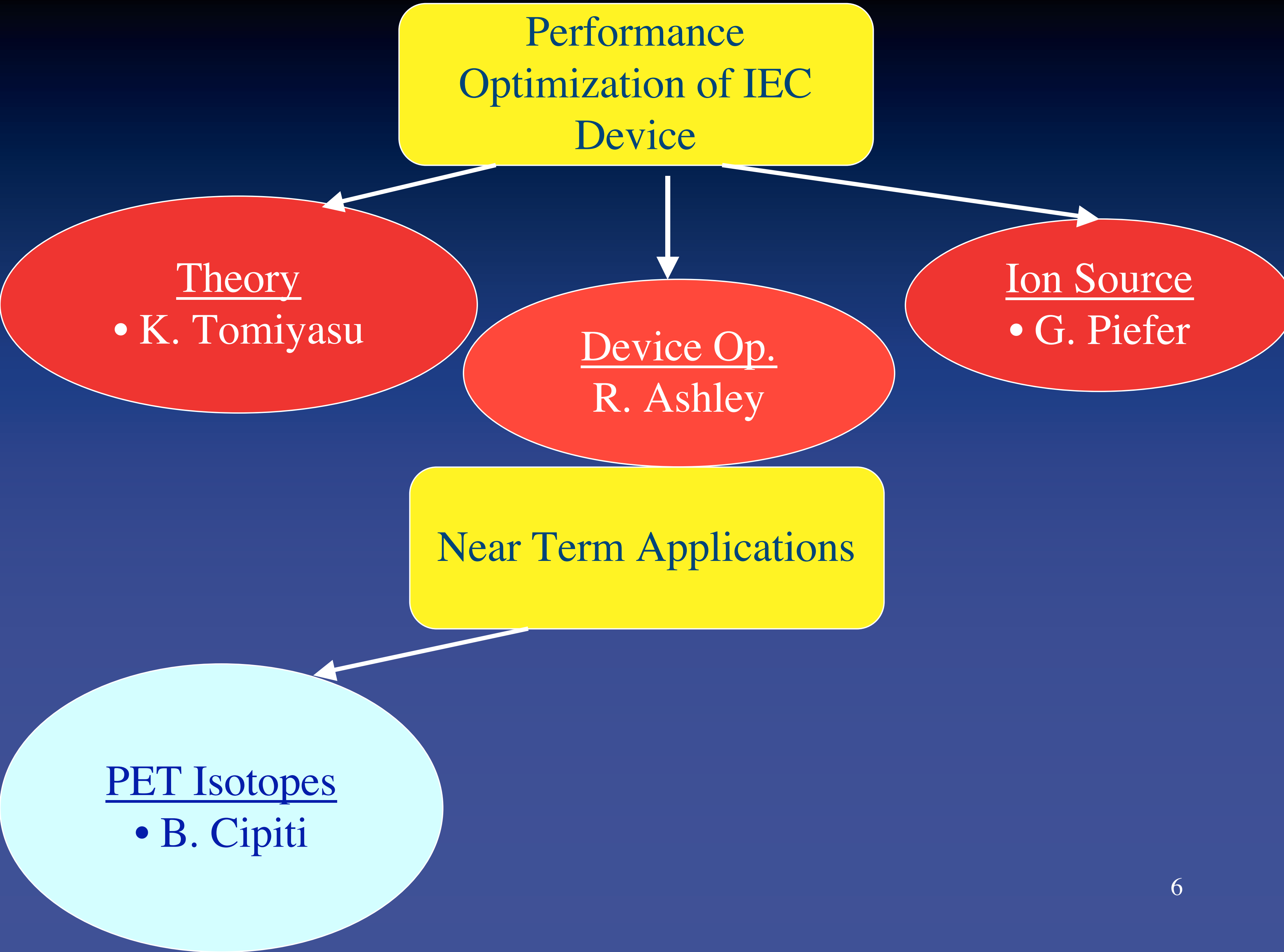


Performance Optimization of IEC Device
Theory
•J. Santarius
• S. Krupakar Murali
• K. Tomiyasu
Device Op.
R. Ashley
D. Boris, T. Uchytil
Ion Source
• G. Piefer
Near Term Applications
PET Isotopes
• J. Weidner
• B. Cipiti
Strategic Planning
• G. Kulcinski
• H. "Jack" Schmitt
Detection of Explosives
•R. Radel
• A. Wehmeyer


Performance Optimization of IEC Device
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• 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-^{3}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 ^{13}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-^{3}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 15th TOFE Conf.
6. #3 was awarded honorable mention in the 15th 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

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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).

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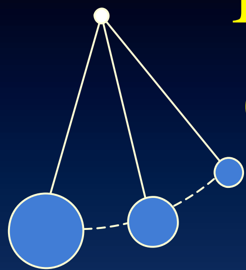
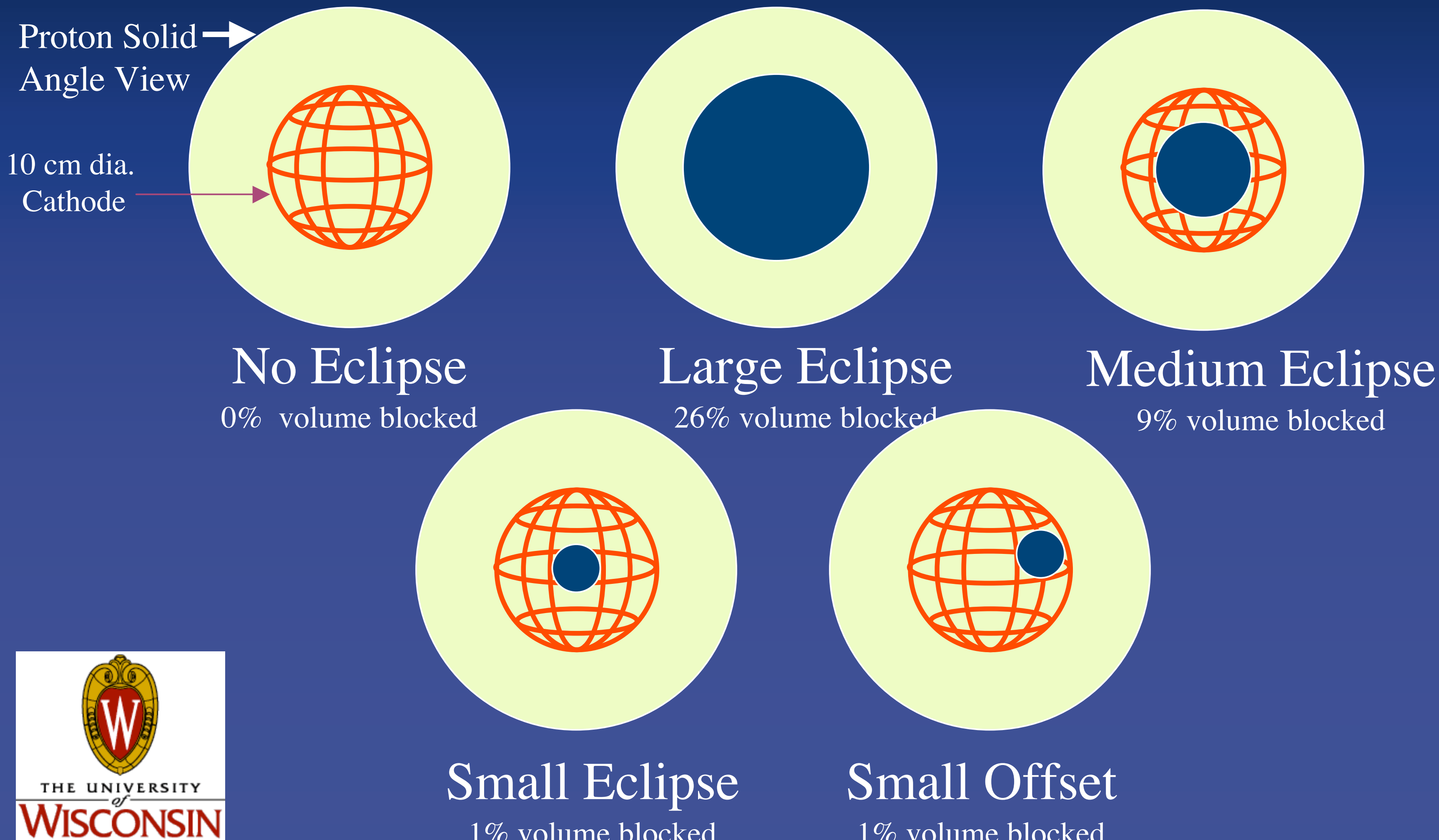
Eclipse Discs Block Fusion Protons and Give an Idea of the Spatial Distribution of Fusion Events

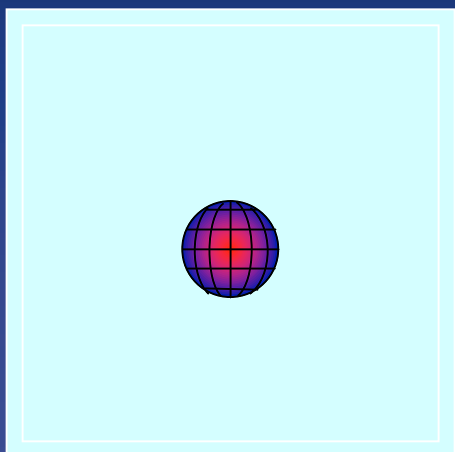




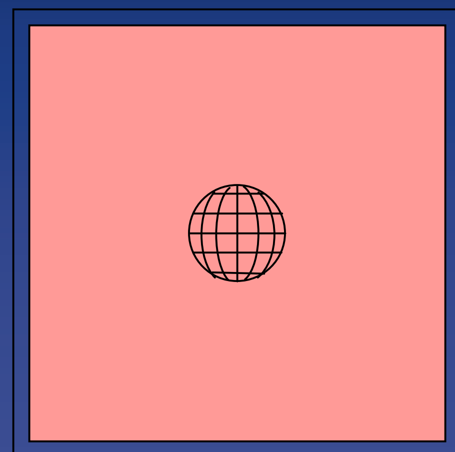
Source Regimes Determined by Eclipse Experiments

(40-100kV, 2 mTorr)

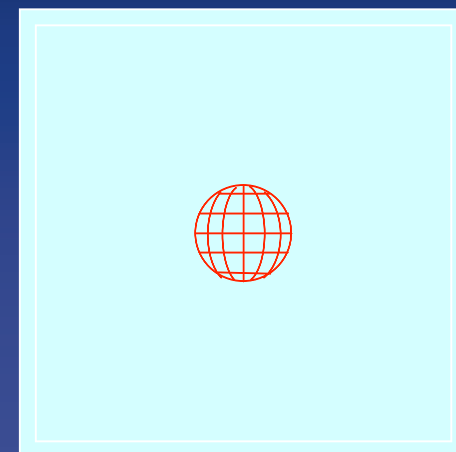
Converged Core



Volume



Embedded



D-D: 30 %

D-^{3}He: 10 %

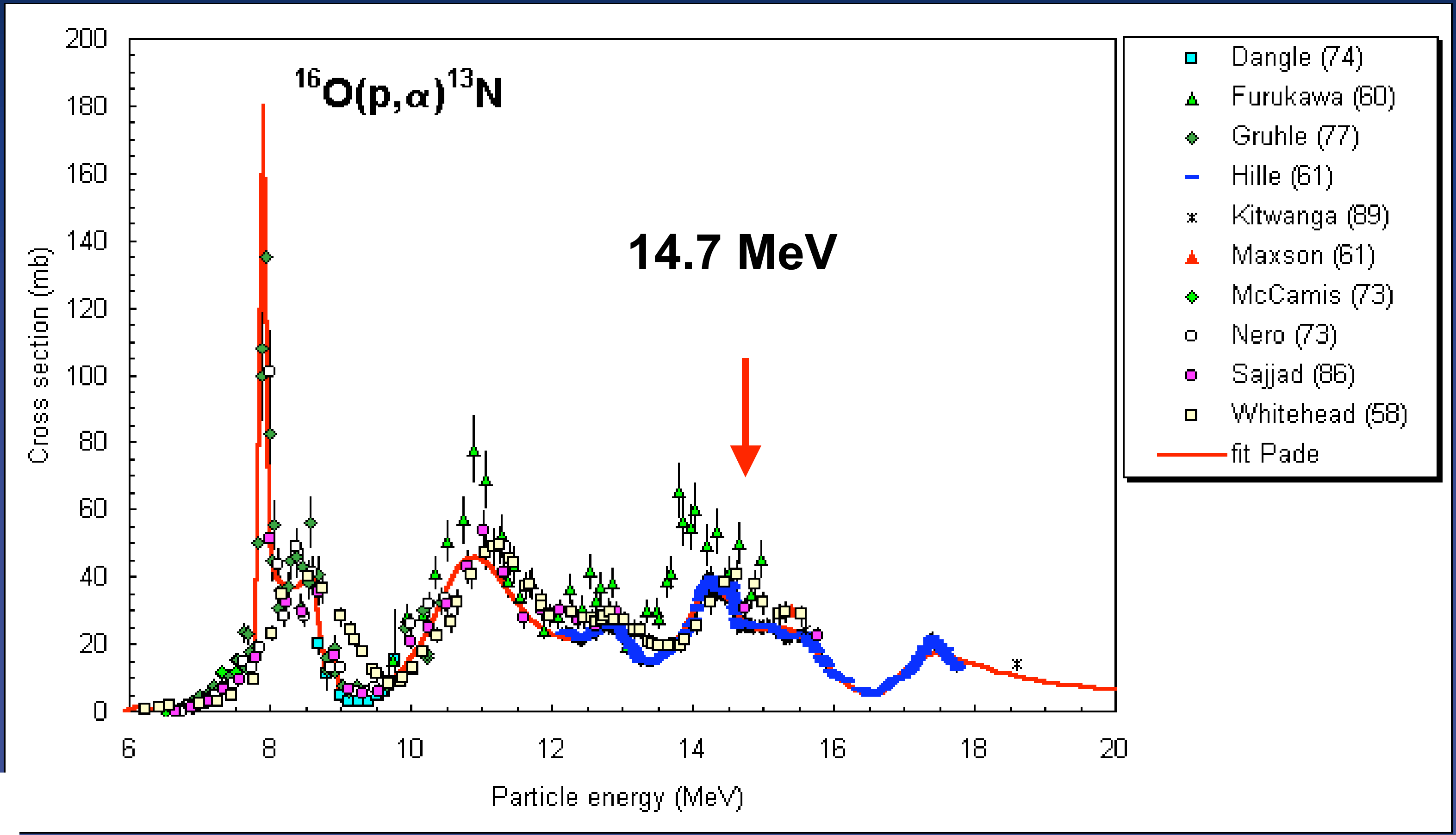
D-D: 70 %

D-^{3}He: Negligible

D-D: Negligible

D-^{3}He: 90 %

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

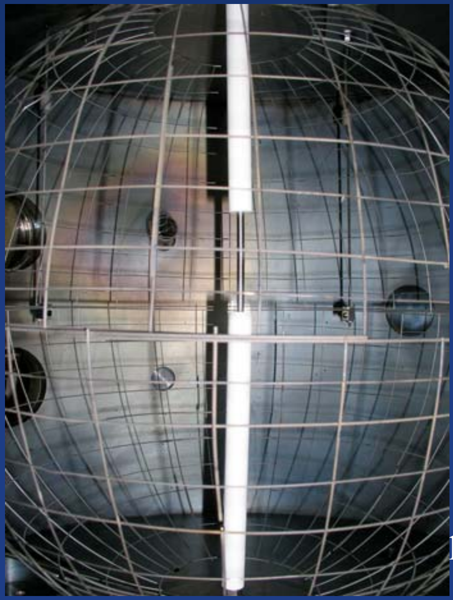


Taken from the IAEA's online charged-particle cross section database for medical radioisotope production

Our First PET Isotopes Have Been Made in Two Different Ways

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

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



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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

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

- Near-term applications — Q<<1
- Transmutation
- Hydrogen production
- Space propulsion

(Transmutation, Hydrogen production, Space propulsion: Q>>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

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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

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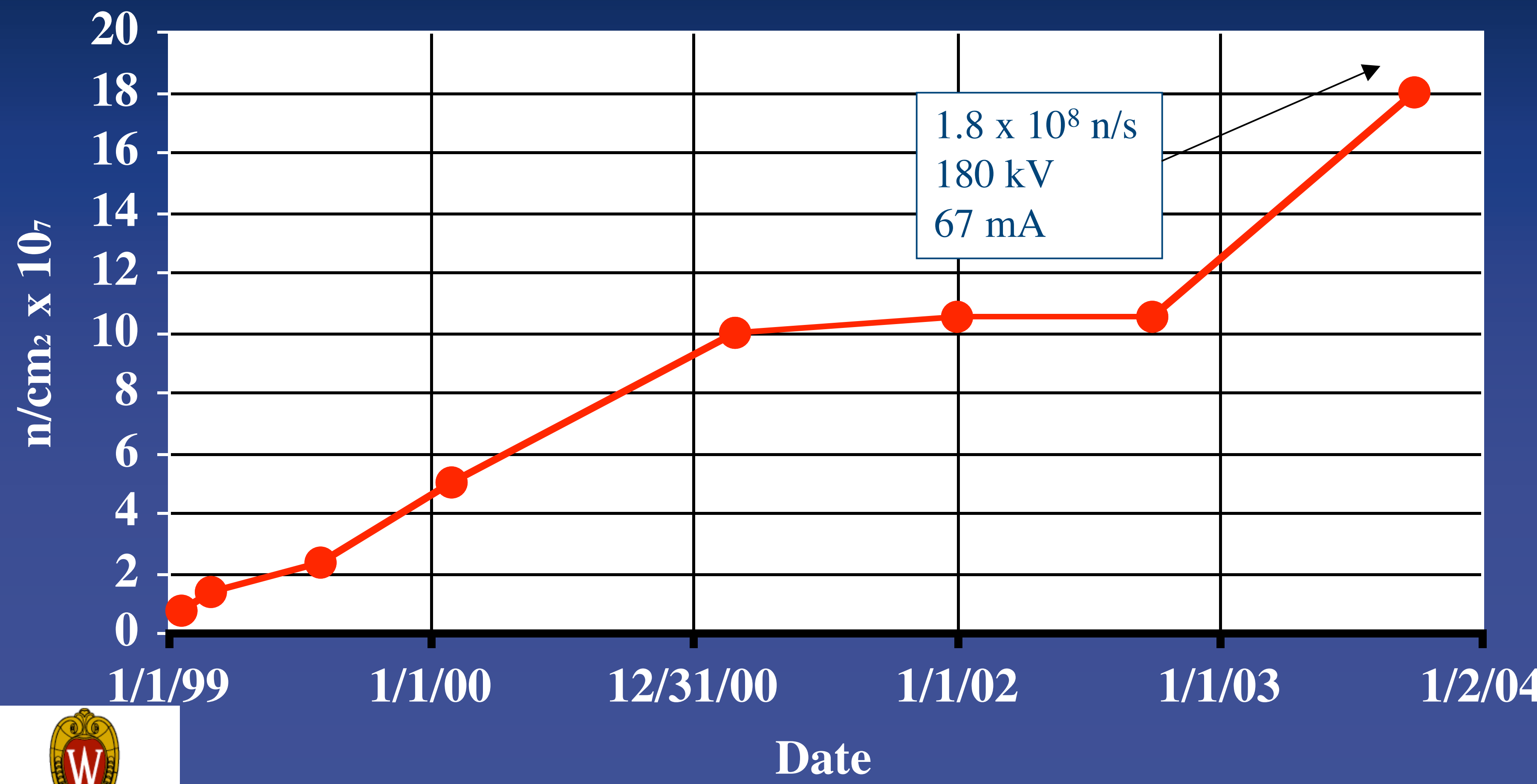
Implications of FESAC Recommendations to DOE

- 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 x 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

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