Chalk River Tritium Activities: Select Topics

Presented by Hugh Boniface

Tritium Focus Group Meeting, Princeton, NJ, 2015 May

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

Topics

- Canadian Nuclear Labs – former AECL
- New Tritium Facility
- Tritium-resistant e-cell materials
- Beta-voltaics
- Helium-3 recovery

Chalk River Labs

- Main campus of Canadian Nuclear Labs – former AECL
- Established 1952 Crown Corporation
- 3100 employees (500 advanced degrees)
- 600 M$ in revenue and funding
- 9000 acres in Ontario, next to the Ottawa River

Restructuring Canadian-style

GOCO model (government owned, company operated).

AECL split: AECL(crown) + CNL(corporation)

- CNL corporate entity sold to private company with operating contract (term)
- AECL represents Government to manage operating contract and retain ownership of physical assets and liabilities

Restructuring Canadian-style (cont.)

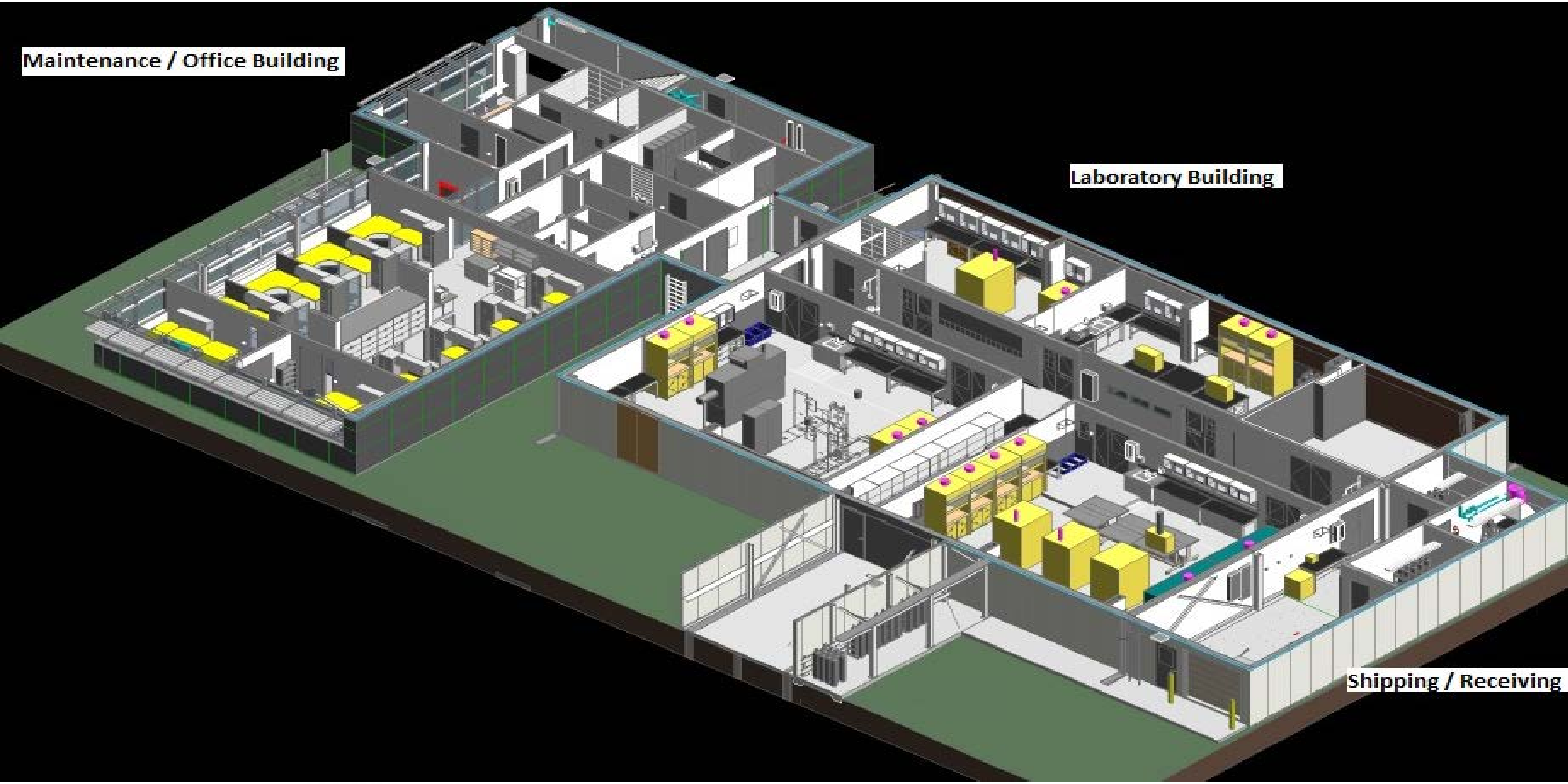
- **Private operator selected May, transfer October**
- **Bidders:**
  - **ICA – Babcock & Wilcox, Cavendish Nuclear & Battelle Memorial Institute**
  - **CNEA – Energy Solutions, CH2M Hill, Kinectrics, Lockheed Martin & SNC Lavalin**
  - **CNRP – Golder, Bechtel GCSC & Hatch**
  - **NNLA – URS corporation, McMaster U & Ontario Power Generation**

CNL Tritium Facility

- Set up before 1980
- One-of-a-kind in Canada
- Six R&D Labs in an old building
- Commercial and R&D Operations
- Handles up to 1 MCi T_2 (100 g)
- Tritiated water to 1000 Ci/kg
- 15 technical staff

New Tritium Laboratories

New Tritium Laboratories



New Tritium Laboratories

- Two inert atmosphere glove boxes (IAGB) – dispensing, CECE-T
- Gas standards preparation fumehood (FH)
- Cylinder paint booth and conditioning booth
- Air-purged GBs (maintenance)
- Gas sampling FH
- Tritium assay FH
- Tritium counting room
- Tritium storage vault
- Gas storage areas
- 15 general use FHs (three active drains)

T-resistant PEM-Cell Materials

- New proton-exchange membrane materials capable of retaining integrity and performance in high-tritium environment
- Demonstrate full-scale cell with new materials
- Nafion is most widely-used, breaks down with 100 kGy
- Two new membrane materials developed at Chalk River show promise at >100 kGy
- Initial exposure tests in 1000 Ci/kg water show improved tolerance for new materials
- Tests in full-scale e-cell requires exposure followed by decontamination and this has been difficult – tritium is strongly bound to membrane

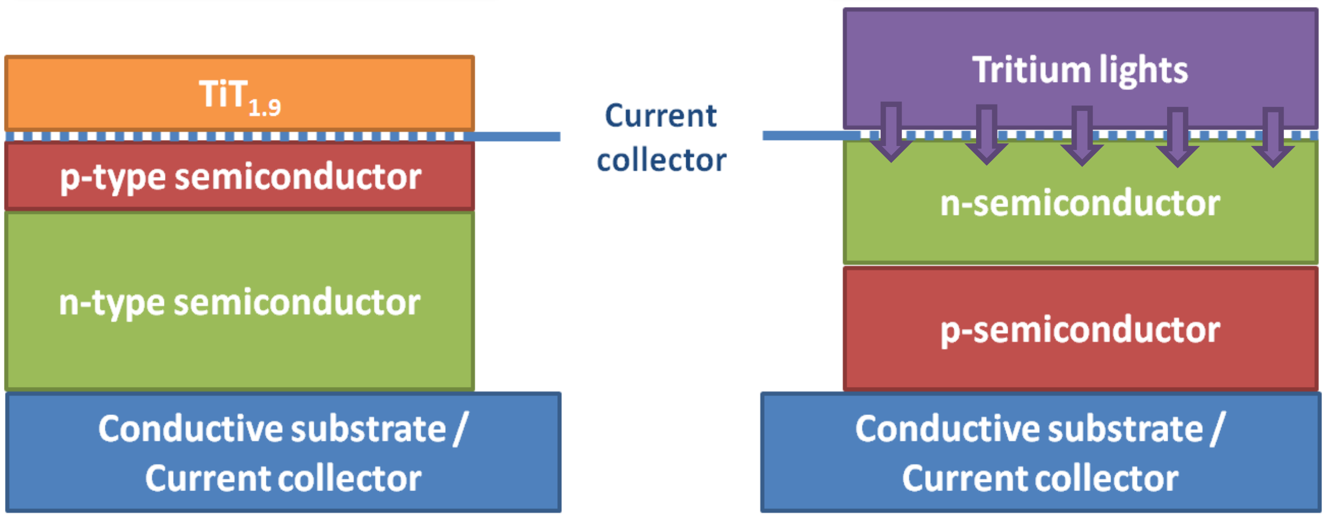
Tritium-Powered Batteries

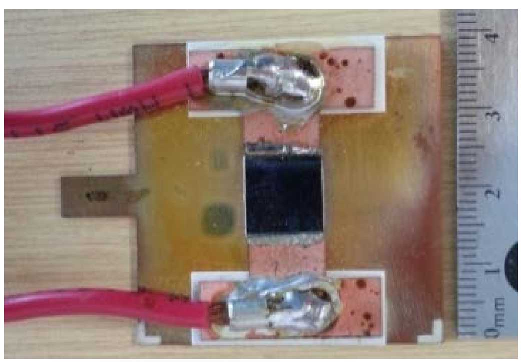
- Use of tritium decay-energy as power source
- Convert high-energy electrons into low-voltage current
- Two methods:
  - Indirect: beta → photons → conduction electrons
  - Direct: beta → conduction electrons

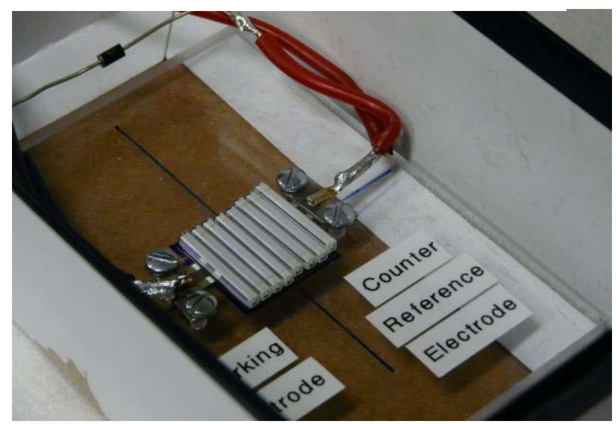
Tritium-powered batteries

Direct Conversion

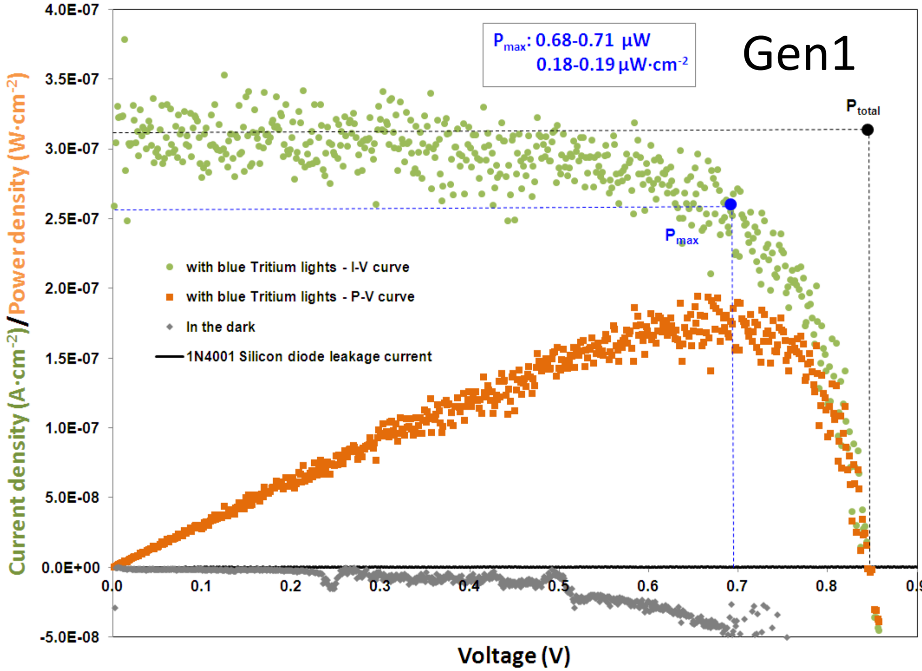
Indirect Conversion

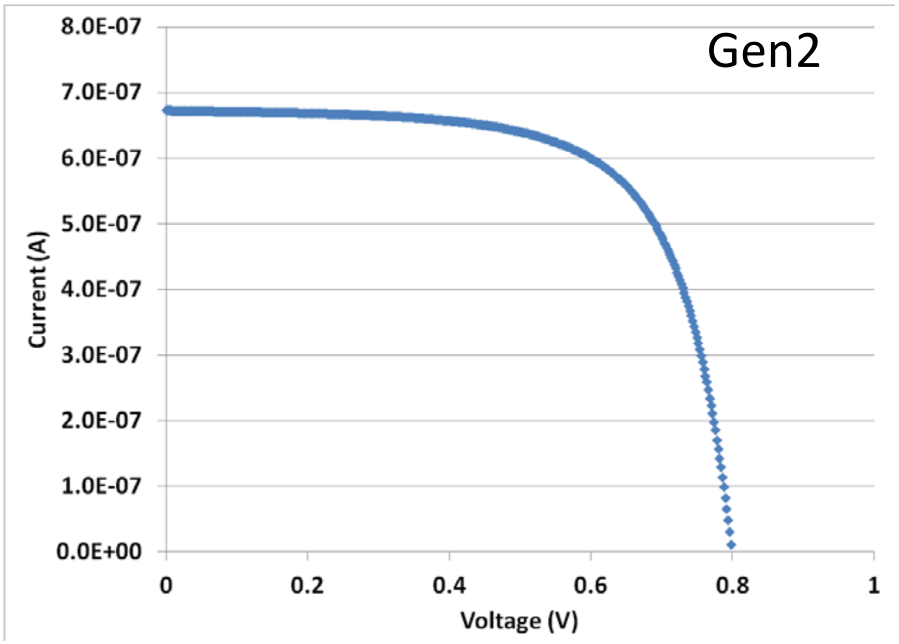






Indirect Tritium battery-Tritium lights plus photocell

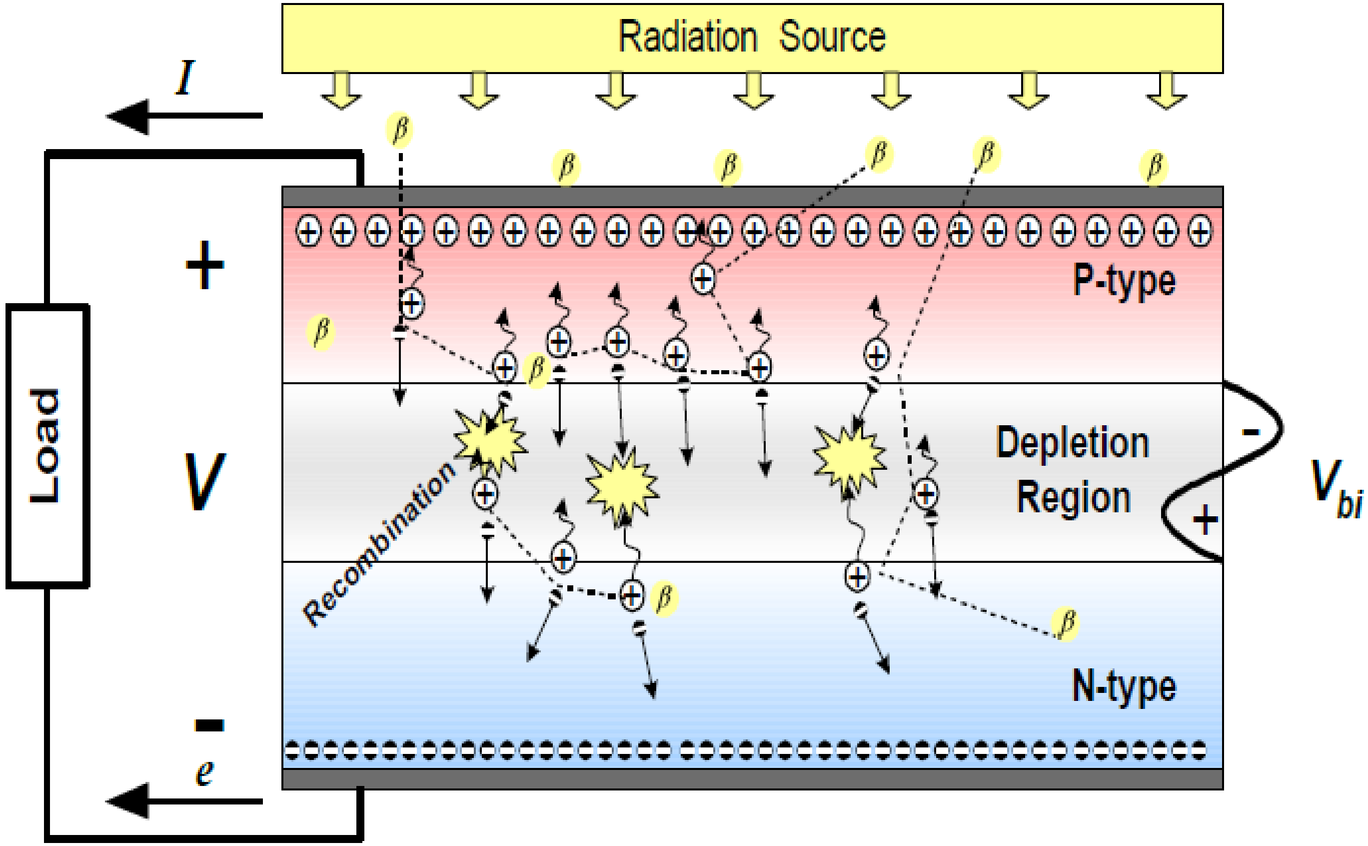




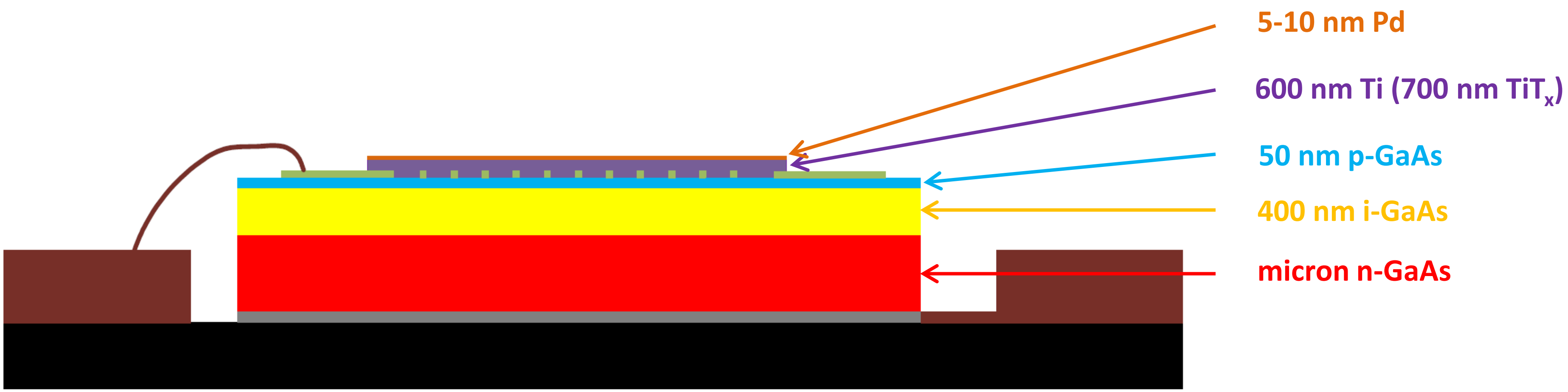
- Cells degraded on repeated exposure to tritium, dead after ~ 10 hours

- Max power: 0.4 µW, 0.1 µW/cm^2
- About 4 Ci tritium
- No loss in several days

Direct Tritium battery-Immobilized Tritium Layers

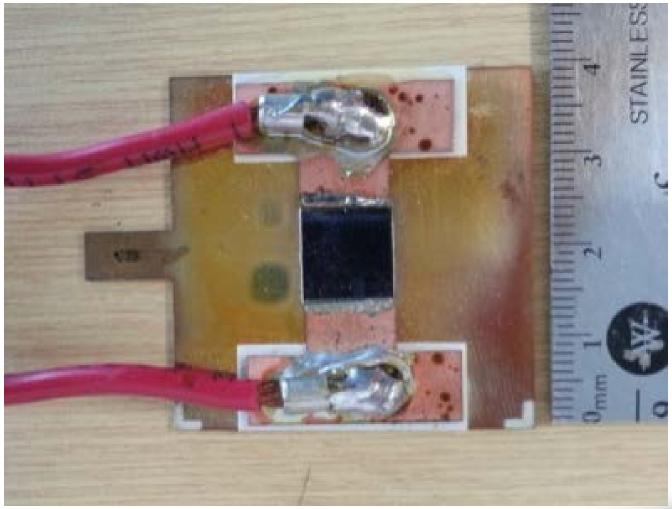


Direct Tritium battery

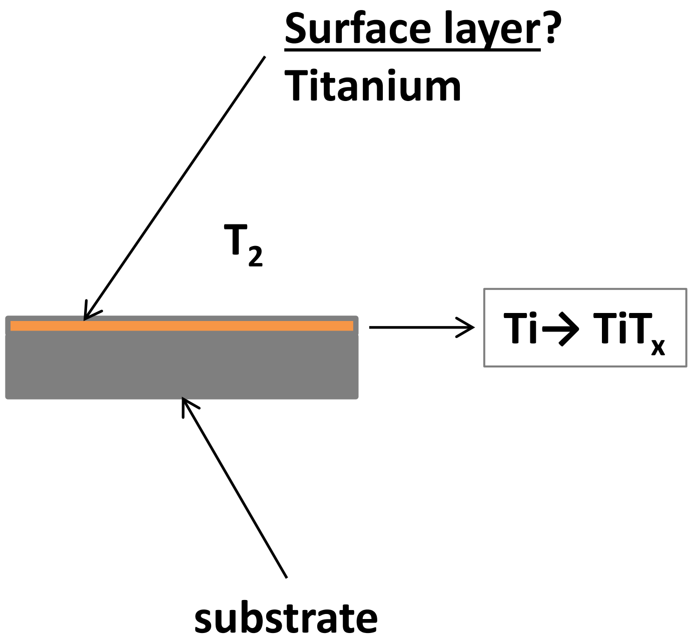


Legend:

- Packaging base plate
- N contact
- GaAs n type
- GaAs i type
- GaAs p type
- P contact
- Ti
- Pd
- Contact pads (Au or Al)

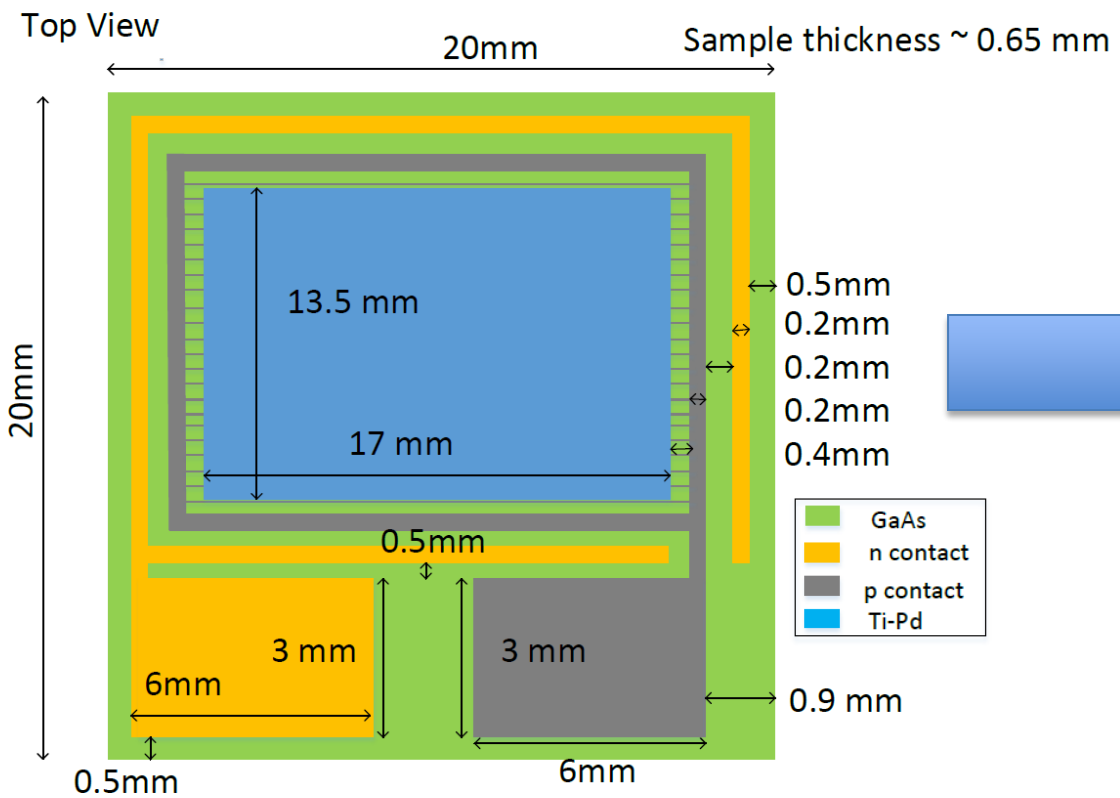


Direct Tritium battery-Immobilized Tritium Layers



Metal vapour deposition

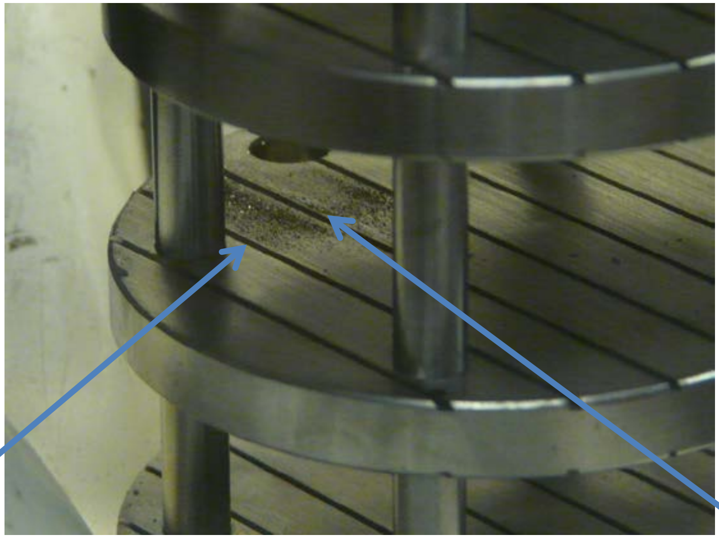
Sample Design

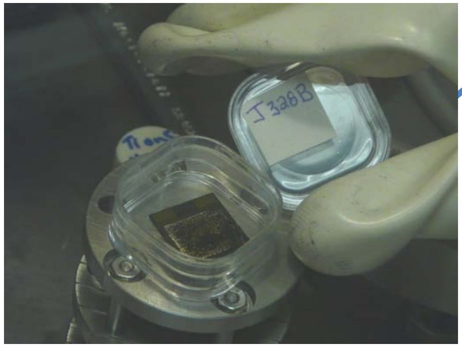


- **GaAs substrate**
- **Large contacts for clips**

Samples and Vessel

Delamination of Titanium Metal



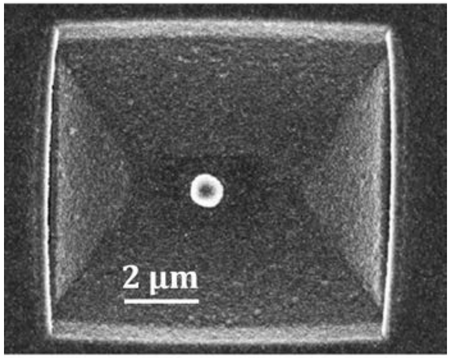


J328B

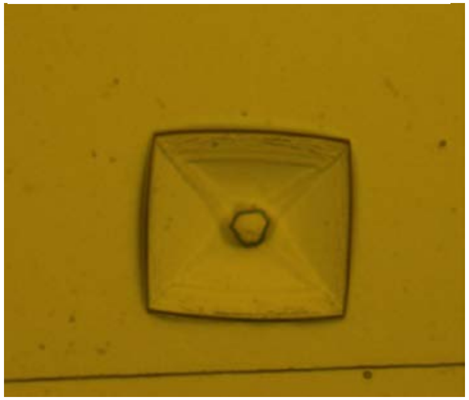
J328E

Flecks of metal left behind in sample holder from these two samples

Betavoltaic “Pitfalls”



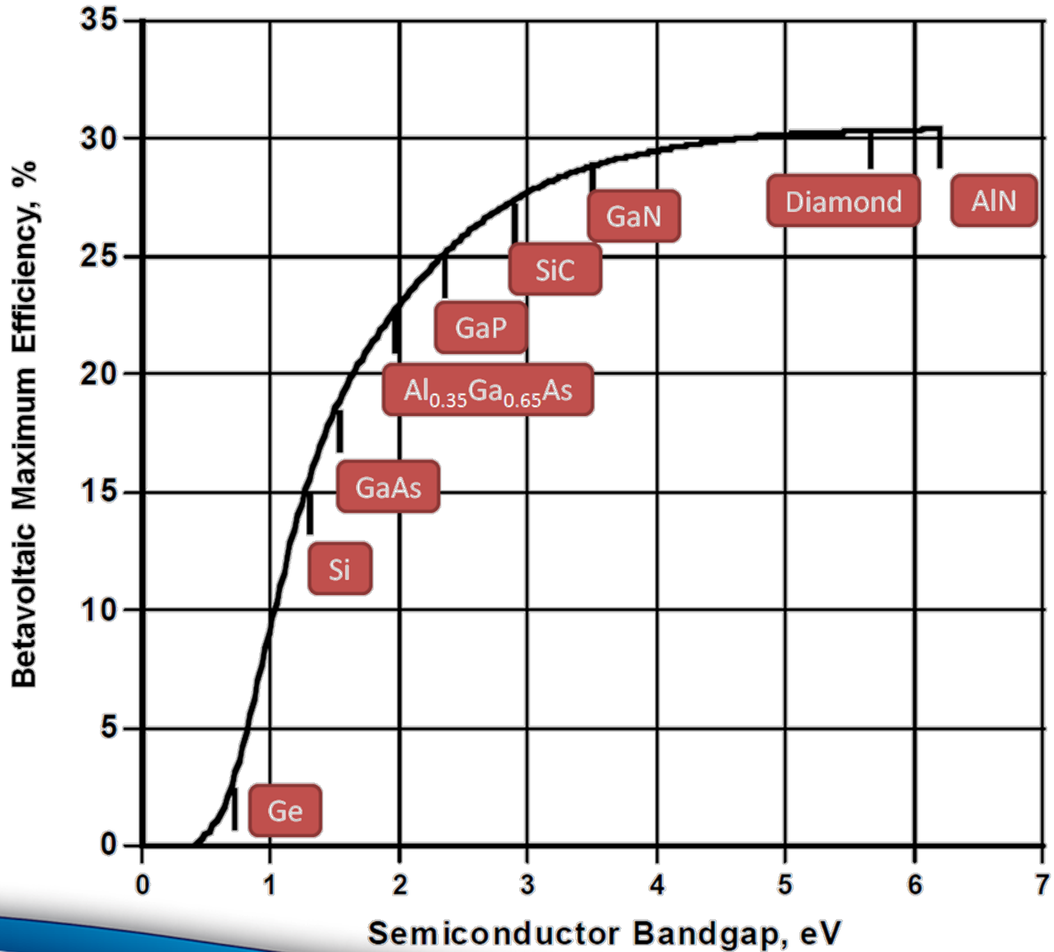
• Large pits (up to 10 µm x 10 µm) form in the GaAs wafers after multiple etching steps, short circuits with Ti layer



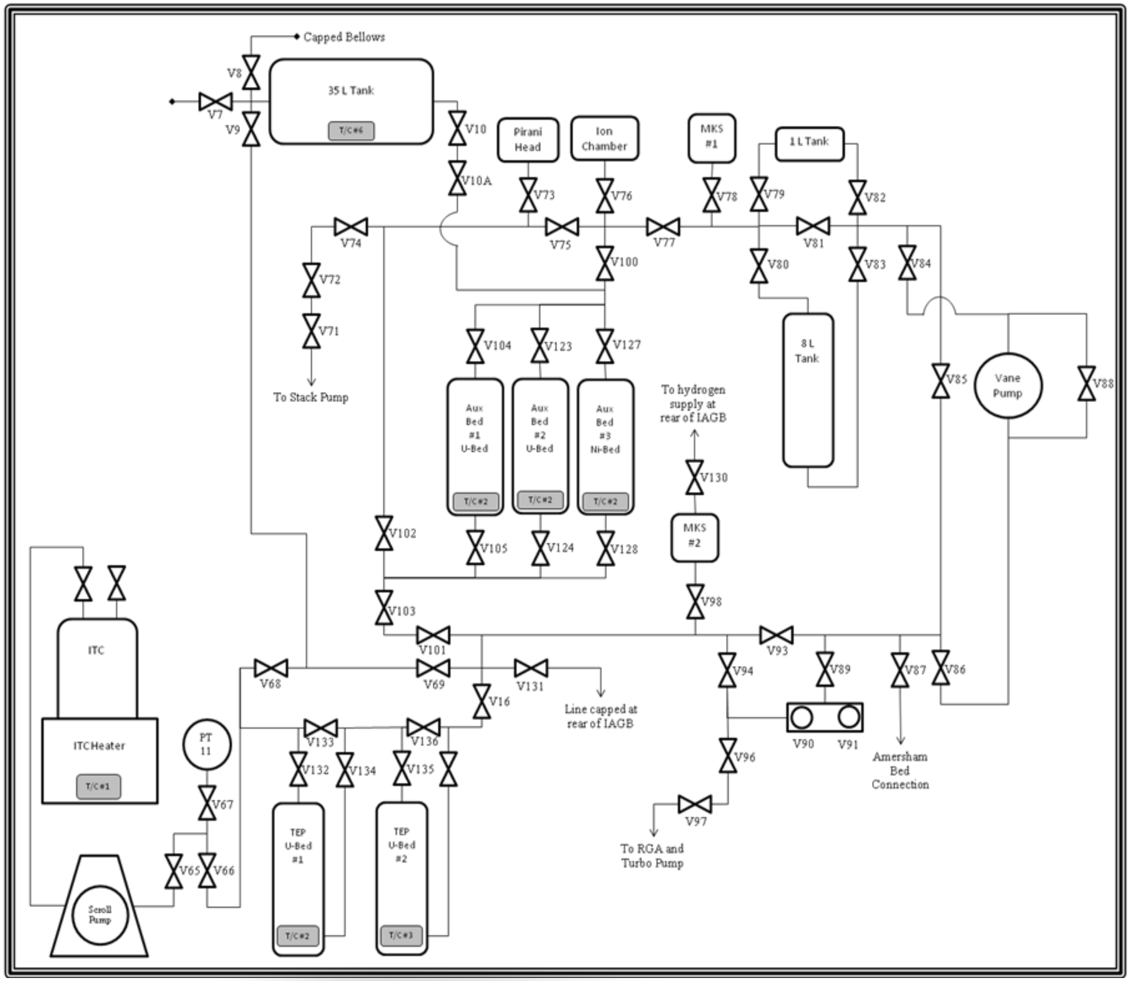
• Thin stabilizing oxide layer to minimize damage from etching

• Materials which are resistant to chemical etching such as GaN or SiC

Choice of Semiconductor by Bandgap



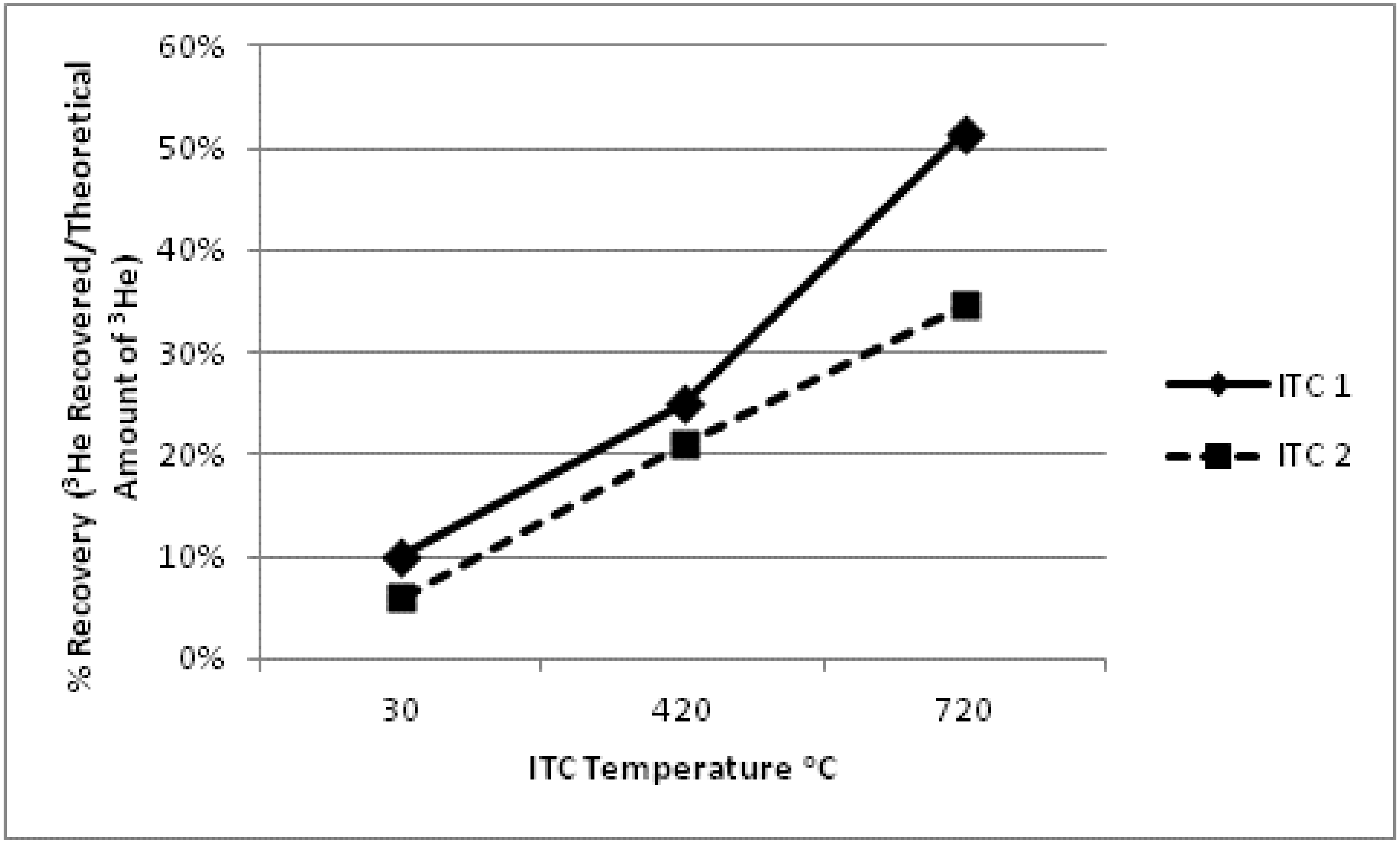
Helium-3 recovery



- Heat ITCs to ?
- Determine He-3 recovery as function of temperature
- Determine recovery as function of decay time
- Determine if a one-step purification can be effective
- Determine best means of collecting and storing He-3

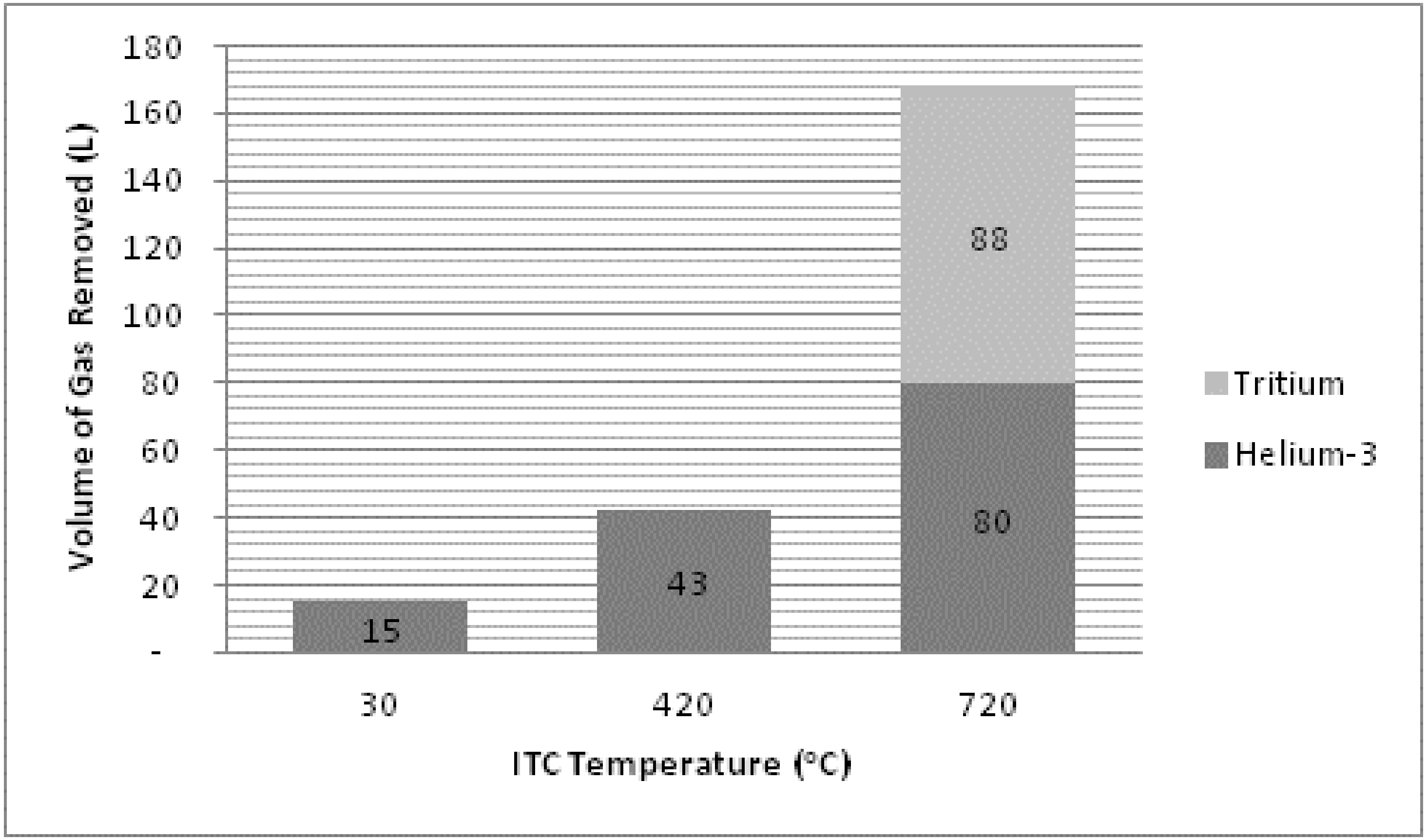
Helium-3 recovery from ITCs

8 years decay measured recovery



Helium-3 recovery from ITCs

12 years decay estimated recovery



Helium-3 purification

- Minimium steps to clean up He-3 for use:
  - In-house (non-hazardous)
  - For general sale (free-release)
- After heating, see tritiated methane, water, ammonia(?)
- Current work to investigate cleanup and storage

Thank you - Merci

Main IAGB