(U) SRTE Science Experiment Support at TJNAF

H. Lee Nigg, PhD (SRNL)
Ashley D. Elizondo (SRNL)
Joseph D. Novajosky (TP)
David Meekins, PhD (TJNAF)
Tritium Focus Group (LANL)
Nov 3-5, 2015

Savannah River Tritium Enterprise – Thomas Jefferson National Accelerator Facility
SRTE - TJNAF

SRTE
• SRNL and Tritium Programs Partnership
  Nuclear Weapon Gas Boosting Systems
  R&D – Production - Tritium Supply

TJNAF (also called Jefferson Lab or JLab)
• DOE Office of Science – Fundamental Physics Experiments
  Continuous Electron Beam Accelerator
  6 GeV (12 GeV upgrade) - User Community - 4 Halls
JLab Experiment:
Deep Inelastic Scattering – protium, deuterium, tritium, helium-3
- ratio of neutron to proton inelastic structure functions
- ratio of down to up quark distributions
  - medium and large Bjorken x
- contribution to the EMC effect

Purpose: high energy hadron collider and neutrino oscillation data interpretation
Basic Experiment Layout

Five Target Cells Total:
- dummy
- protium, deuterium, tritium
- helium-3

Stacked Under Cryo System

Cells: Aluminum 7075-T651
Machined from Casting
Cu Conflat
Swagelok valve
Entrance Window 0.01” thin
Exit ~0.016” (curve), 0.011” (tip)
Experiment/Target Operation

Key Parameters:
- 15 microA electron beam
- 42 days
- 200 psia (tritium)
- ~1099 Ci
- 99.5%+ purity
- 35 K pre-beam

Modeling/Testing:
- temperature
- pressure
- hydrogen embrittlement
- permeation
- activation products
- beam/particle mapping

burst test – 3000 psi

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>$T_{1/2}$ (days)</th>
<th>$A_{1day}$ (Bq)</th>
<th>$A_{1month}$ (Bq)</th>
<th>$A_{1year}$ (Bq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{22}$Na</td>
<td>950</td>
<td>$6.02 \times 10^5$</td>
<td>$5.89 \times 10^5$</td>
<td>$4.61 \times 10^5$</td>
</tr>
<tr>
<td>$^{24}$Na</td>
<td>0.625</td>
<td>$2.15 \times 10^5$</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>$^{60}$Zn</td>
<td>244.3</td>
<td>$1.01 \times 10^5$</td>
<td>$9.32 \times 10^3$</td>
<td>$3.6 \times 10^3$</td>
</tr>
<tr>
<td>$^{54}$Cr</td>
<td>27.7</td>
<td>$6 \times 10^3$</td>
<td>$2.9 \times 10^3$</td>
<td>65.7</td>
</tr>
<tr>
<td>$^{7}$Be</td>
<td>53.1</td>
<td>$2.38 \times 10^4$</td>
<td>$1.62 \times 10^4$</td>
<td>$2.08 \times 10^4$</td>
</tr>
<tr>
<td>$^{57}$Co</td>
<td>271.8</td>
<td>$1.73 \times 10^5$</td>
<td>$1.61 \times 10^5$</td>
<td>$6.86 \times 10^5$</td>
</tr>
<tr>
<td>$^{58}$Co</td>
<td>70.9</td>
<td>$3.7 \times 10^5$</td>
<td>$2.78 \times 10^5$</td>
<td>$1.05 \times 10^6$</td>
</tr>
</tbody>
</table>
Experiment Configuration

- Stack assembly
- Scattering chamber
- Cherenkov Detector
Tritium Collaboration

- Tritium Target Cell
  1) Production
  2) Material Compatibility
- Tritium Safety Analysis, Protocols and Reviews

Hall A
100 ft diameter
3 stories high
Tritium Target Cell – 1) Production

A) load 99.5%+ T2
- 200 psia
- 1099 Ci (Type A Shipping Package)
- verification:
  NFW and PVT
  HRMS
B) burst test data review and approval
C) valve type review and approval
D) activation product consideration (Na-22)

Loaded and Shipped September 2016

Collaborative Installation October 2016

Beam Operation Over 10-12 Months

Decay for ~ 2 Months

Returned for Unload
Tritium Target Cell – 2) Material Compatibility

Uncertainty:
- although low permeability in Al(O)
- and low solubility in Al
- and low temperature (< 100 K)
  - beam produces reactive environment
  - tritium exposure for 6 months

INTEGRITY – SAFETY

Al-T Study Implementation
- 28 x Al7075 coupons
- bolt open load (0.5” crack induction)
- exposed to 1850 psi tritium (t=0@RT) up to 1 year
- periodic removal and evaluation of crack propagation with clip gauge
Tritium Safety

• Multiple Reviews Supported

1) Detection Recommendations
   - Kanne
   - Tyne Engineering
   - RGA

2) Handling Support
   - Hut Provision

3) Package Receipt
   - approvals (DOE/DOT)

4) Leak Scenarios
   - scattering chamber
   - Hall A

5) Clean-Up Methods
   - U getter
   - dilute/wait
Tritium Leaks

- Scattering Chamber
  - continuously pumped to <1 x10^-3 torr
  - RGA detection activates bypass to getter bed
  - pumped by CapaciTorr D400-2

- Hall A
  - vented to stack
  - Kanne monitor
  - air turnover and wait
  - possible humidity trapping
Summary and Future

- First Time Tritium Use in TJNAF Experiment
- Necessary to Complete Picture of Nucleon Energetics
- According to PI, One of Top 10 Physics Experiments
- SRTE Handling Target Production and Safe Operation
  - loading, unloading
  - safety reviews, recommendations, equipment
  - material compatibility/effects
- SRNL on Final Paper
- Three More Tritium-Based Experiment Proposals
- Dr. Dave Meekins (PI) 757-269-5434