Annular Core Research Reactor Pneumatic Transfer System Design

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Outline

- Annular Core Research Reactor Background
- Motivation for Pneumatic Transfer System (PTS)
- PTS Design Requirements
- PTS Components
- Control System Concept Overview
- Sequence of PTS Operations
- Summary and Future Work

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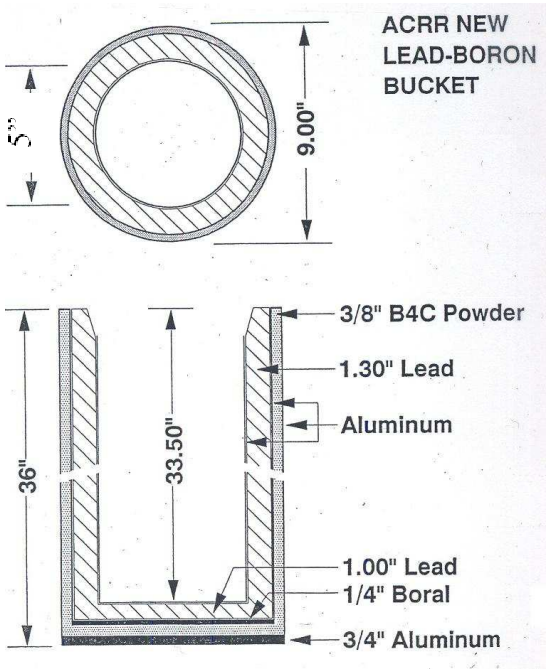
Background
Annular Core Research Reactor (ACRR)

- TRIGA type reactor with special UO_2-BeO fuel
- Features
  - Central Cavity (9” ID)
  - Spectrum Modifying Inserts
- Pb-B_4C Spectrum Modifying Insert (aka “Pb-B_4C Bucket”)
  - Thermal neutrons ↓, γ ↓
  - 9” OD X 36” H
  - 5” ID



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Background
ACRR Primary Mission

- Provide appropriate neutron radiation environments for radiation testing and qualification of electronic components and other devices, such as:
  - Passive neutron and/or gamma dosimetry devices (e.g., activation foils, TLDs)
  - Active neutron and/or gamma dosimetry devices (e.g., SNL developed diamond PCDs, calorimeters)
  - Explosive components (including neutron generators)
- ACRR customer base changed in recent years
  - Pb-B4C spectrum modifying insert
  - More tests, lower dose
  - 1.1 – 3.5” OD packages

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Background
ACRR Operations

- **Irradiation of experiment packages is multi-step process**
  1) **Remove central cavity shield plug (via crane)**
  2) **Lower package into Pb-B_4C Bucket**
  3) **Re-install central cavity shield plug**
  4) **Irradiate package**
- **Pneumatic transfer system (PTS) beneficial for repetitive testing**
  - **Reduced industrial safety concerns (Shield plug)**
  - **Increased operations efficiency**
- **PTS works like a bank system and will have some automation**
- **Funding provided to develop PTS design at ACRR**

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PTS Design Requirements

- PTS shall be capable of irradiating a 3.5” package
- PTS transfer tube shall fit within 5” Pb-B_4C ID
- PTS components exposed to ACRR radiation environment shall be composed of Al6061 (radiation safety)
- Storage container for PTS shuttle shall provide enclosure and radiation shielding
- PTS shall use N_2 gas (radiation safety)
- PTS design shall allow for ACRR facility storage and easy installation
- PTS shall have automation software e.g. time

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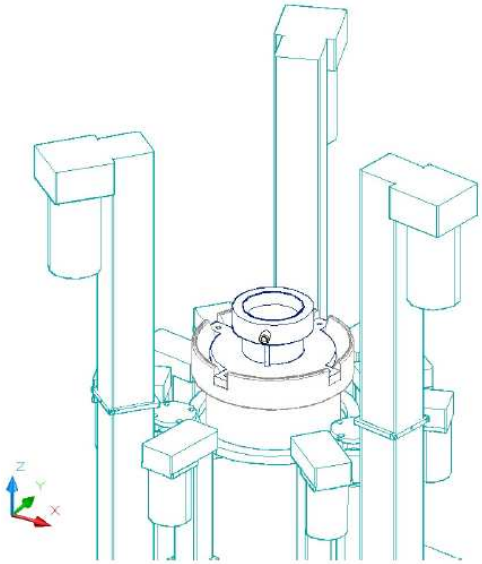
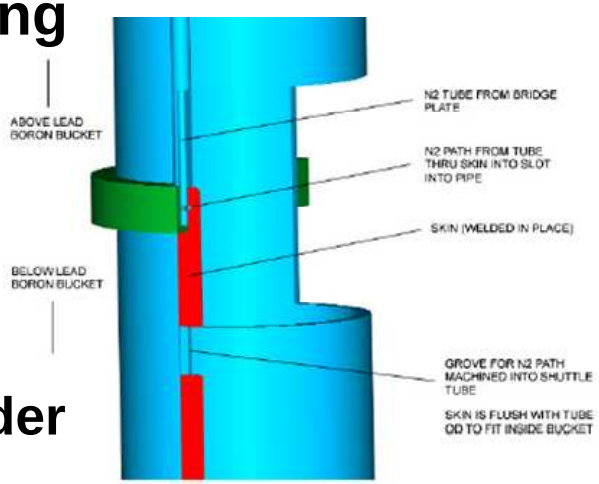
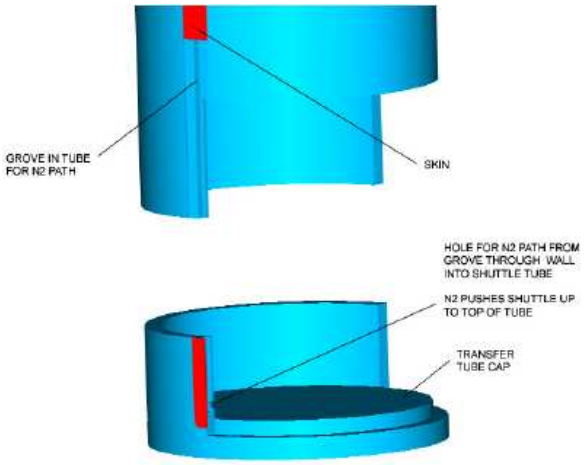
PTS Components
Transfer Tube

- Al6061 Pneumatic cylinder
- 5” OD, 4.5” ID
- 30’ Height
- N_2 tube allows for gas removal and shuttle transport out of transfer tube
  - Utilizes skin welding w/in Pb-B_4C
  - N_2 travels through
    - Tube
    - Grove
    - Pneumatic cylinder

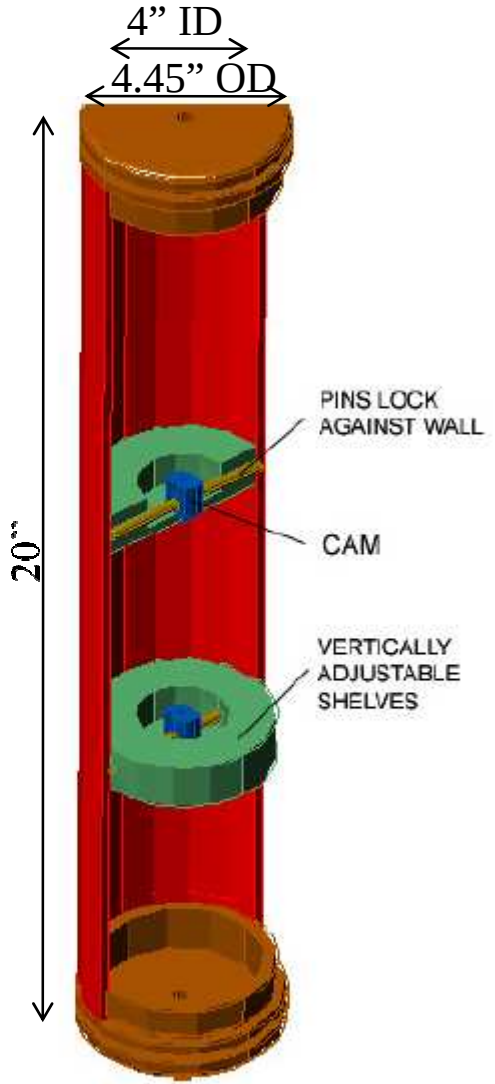






PTS Components
Shuttle

- Cylinder piston
- U-cup seals
- Adjustable shelves
- Caps on tube ends
- Caps contain ½-13 threads for manual retrieval



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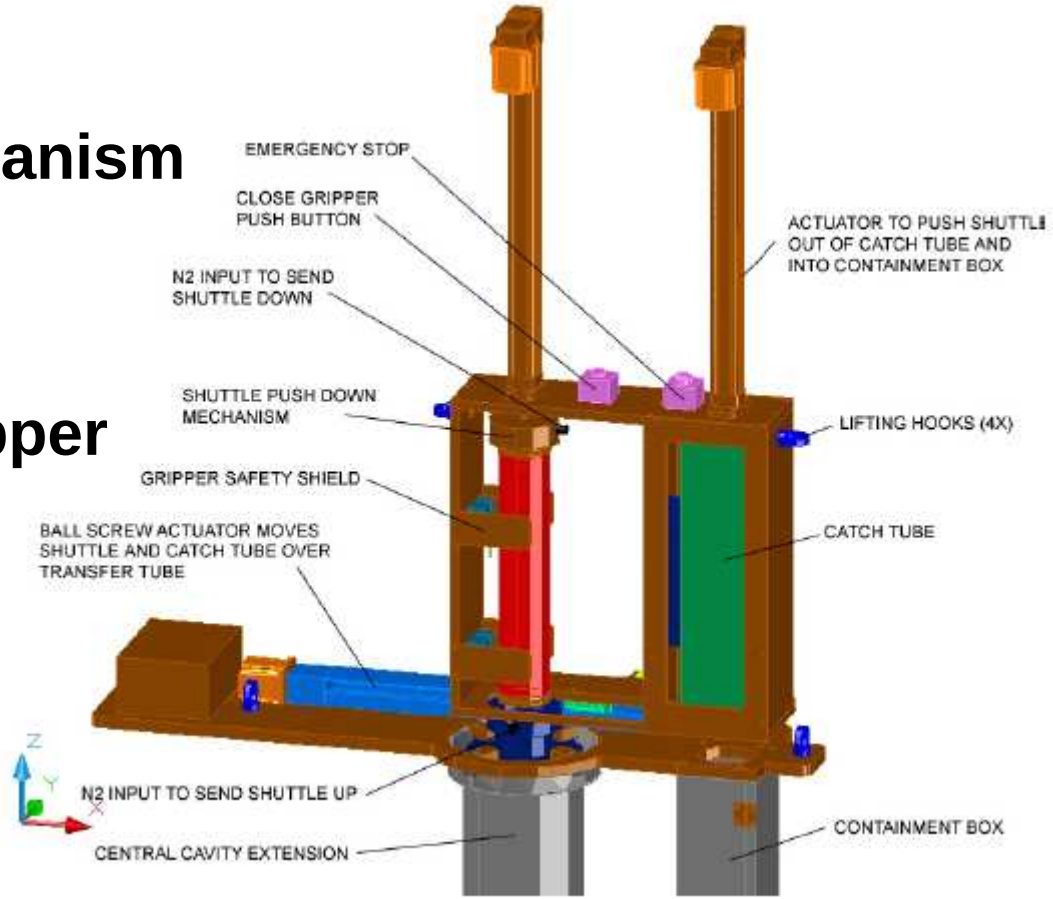
PTS Transfer Shuttle Tube Exchange

- Grippers
- Push down mechanism
- Catch tube
- Containment box
- Actuators w/ stepper motors



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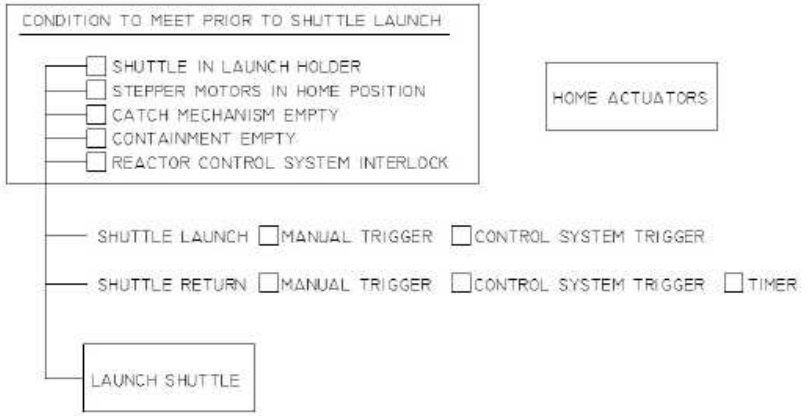
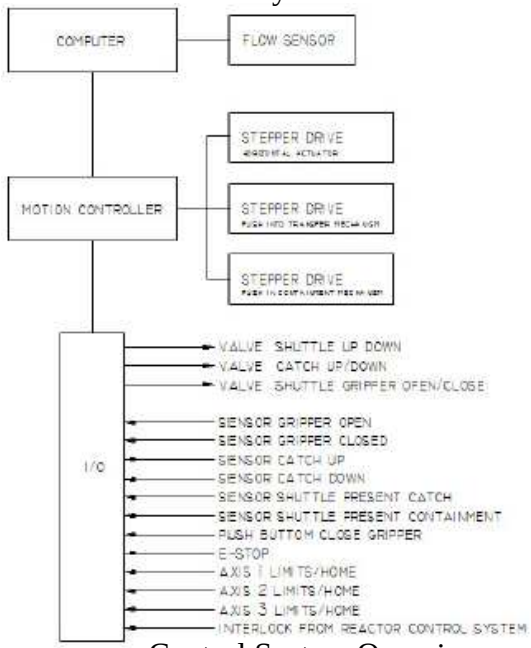
PTS Control System Concept Overview

- Control system overview
  - Interlocks
  - Control Sequences
    - Manual
    - Control System Trigger
    - Timer
- Control system overview
  - Computer
  - Motion controller
  - I/O module



Control System User Interface



Control System Overview

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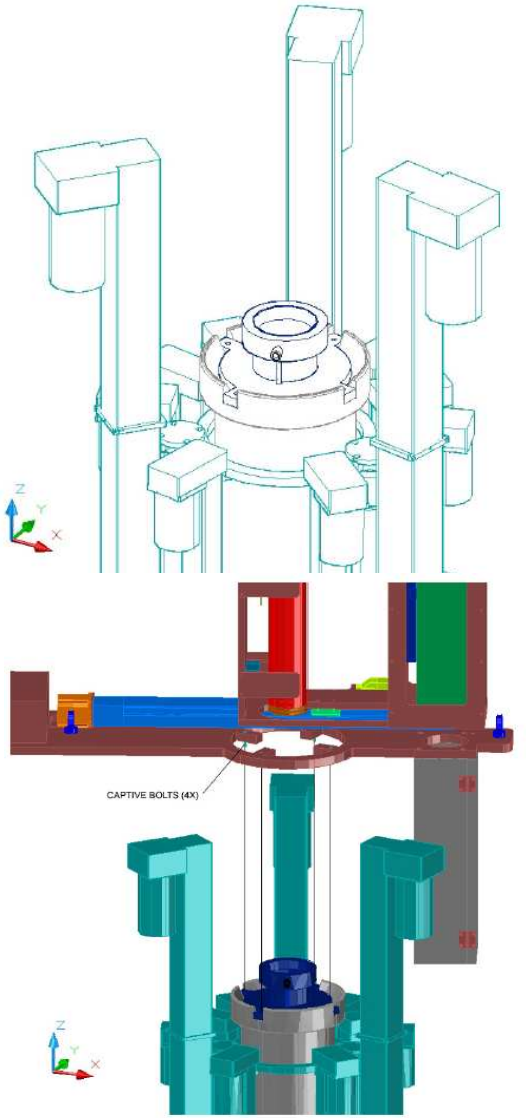
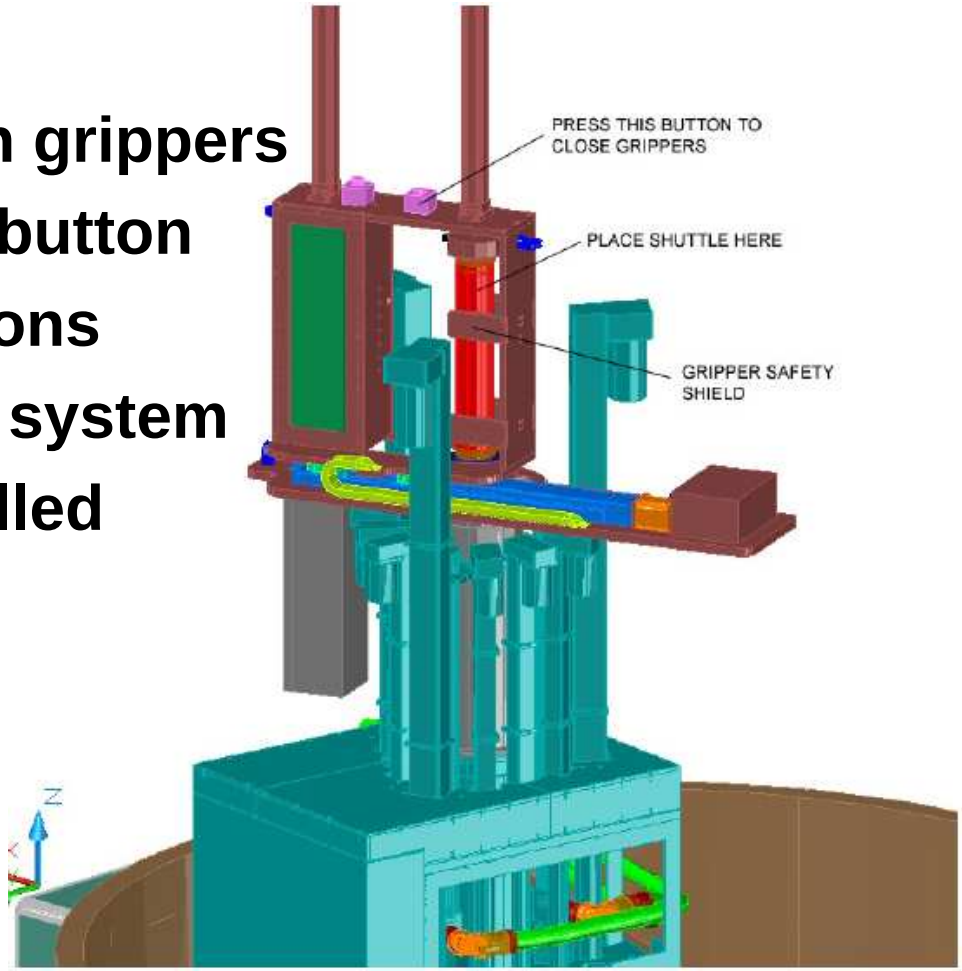
PTS Assembly

- Transfer tube lowered by crane
- Locked in place by tube mount
- Transfer shuttle tube exchange locked in place by captive bolts



PTS Sequence of Operations
Step 1 – Place Shuttle Between Grippers

- Place shuttle between grippers
- Press grippers close button
- Remainder of operations performed by control system
- Optical sensors installed
  - Grippers
  - Catch tube
  - Containment box



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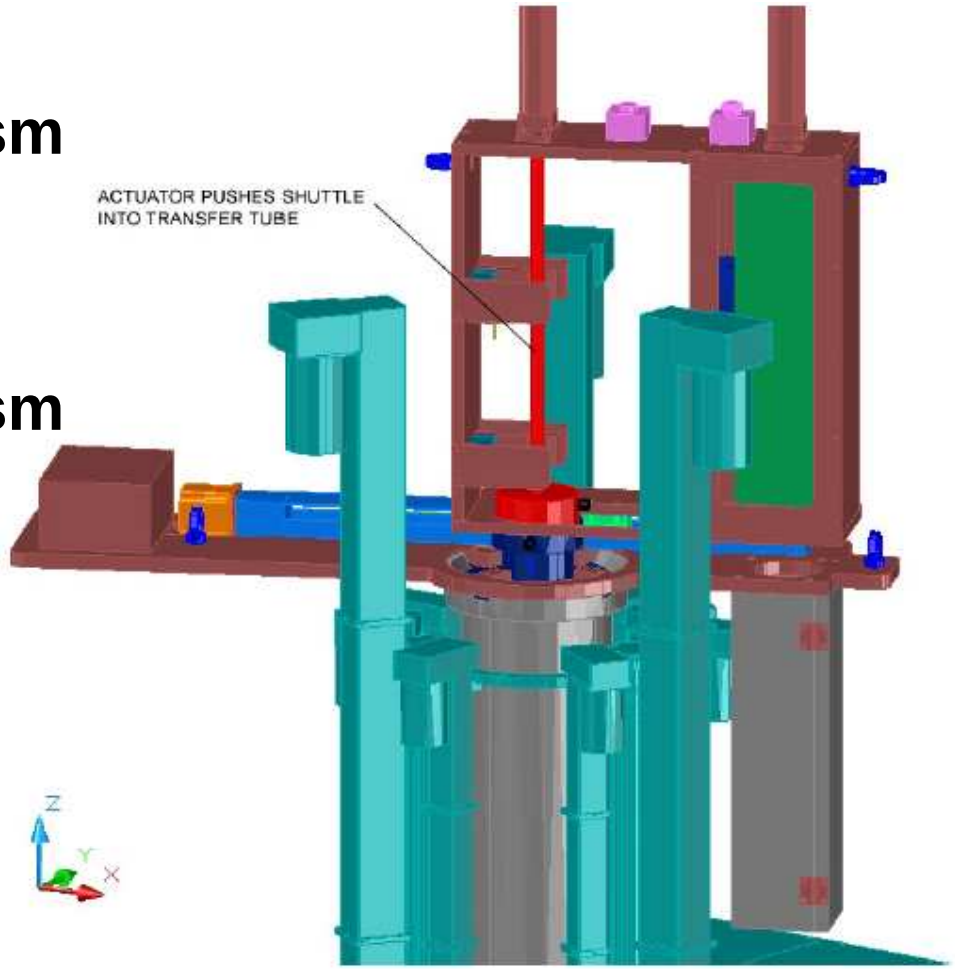
PTS Sequence of Operations
Step 2 – Shuttle Moved into Transfer Tube

- Push down mechanism moves shuttle into transfer tube
- Push down mechanism has O-ring



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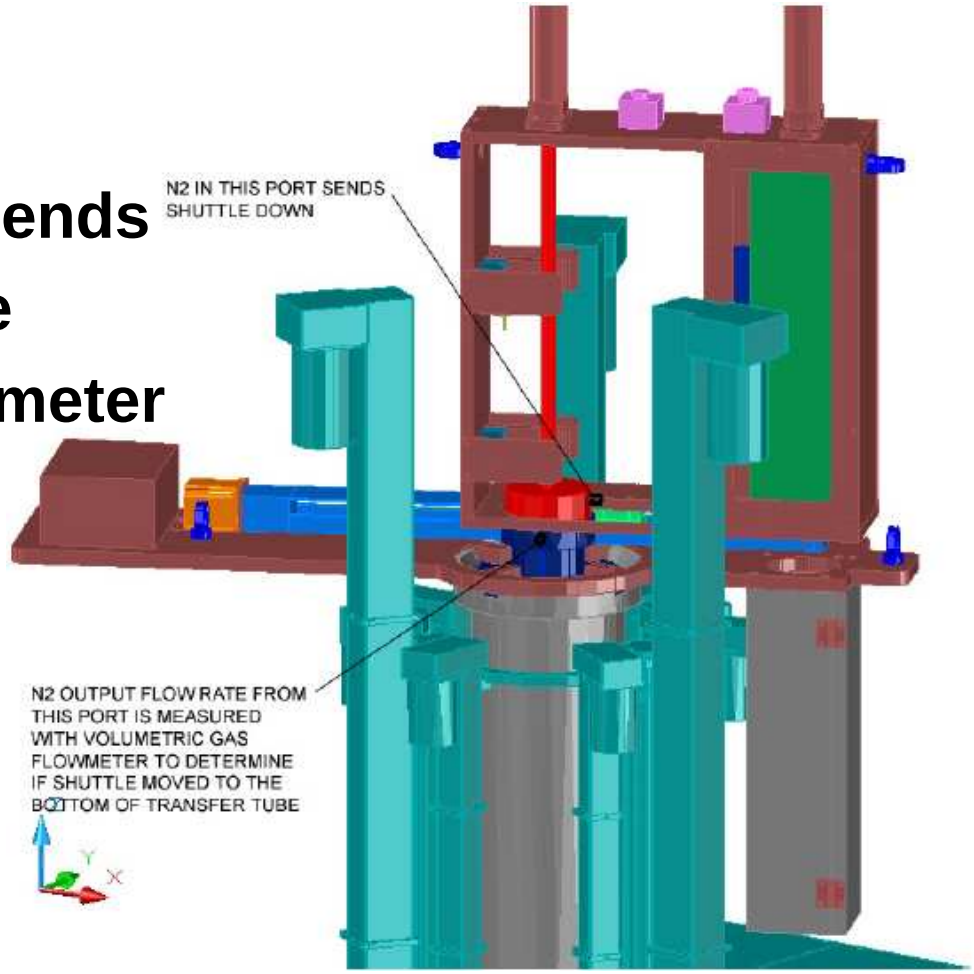
PTS Sequence of Operations
Step 3 – Shuttle Pneumatically Transported

- Valve opens
- Pressurized N_2 gas sends shuttle to ACRR core
- Volumetric gas flow meter measured displaced gas at outlet port



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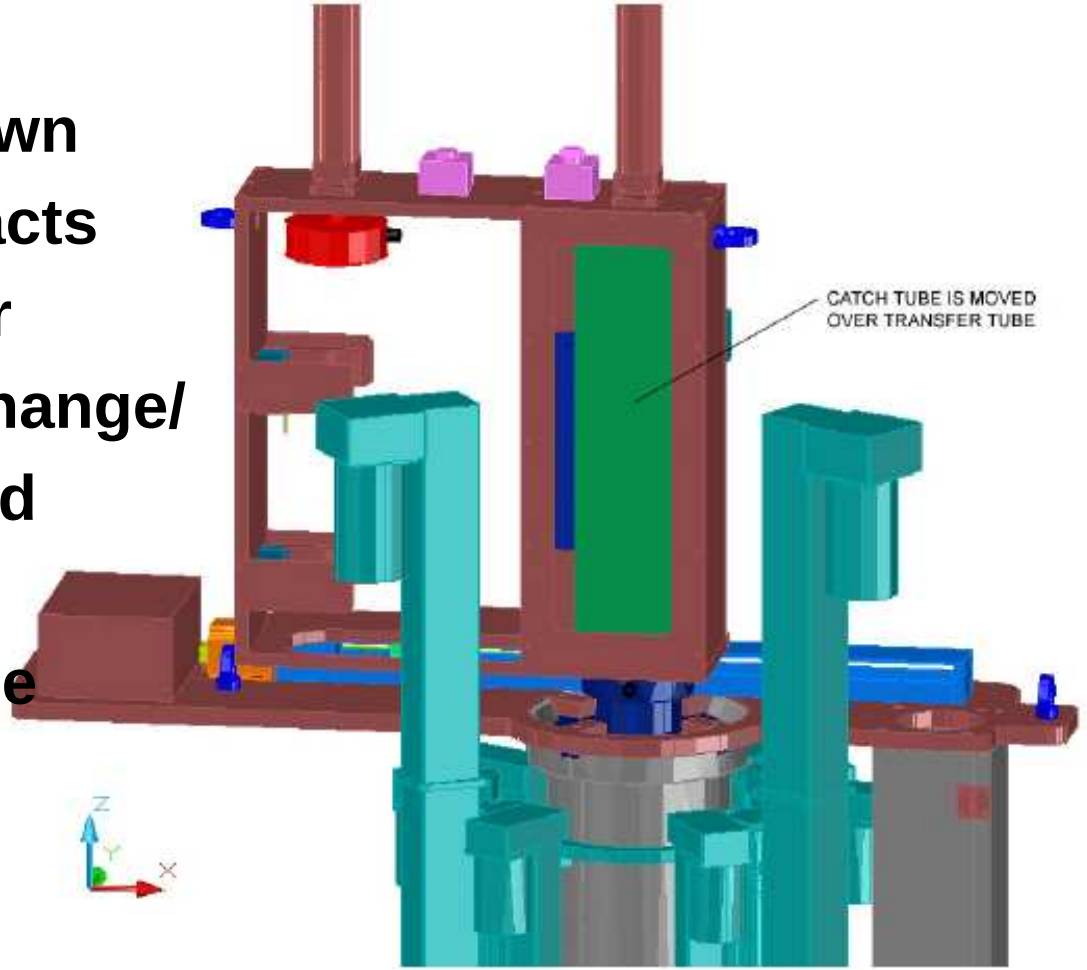
PTS Sequence of Operations
Step 4 & 5 – Pushdown Retracts and Assembly Moves

- **Step 4 – Pushdown mechanism retracts**
- **Step 5 – Transfer shuttle tube exchange/ catch tube moved along rail table over transfer tube**



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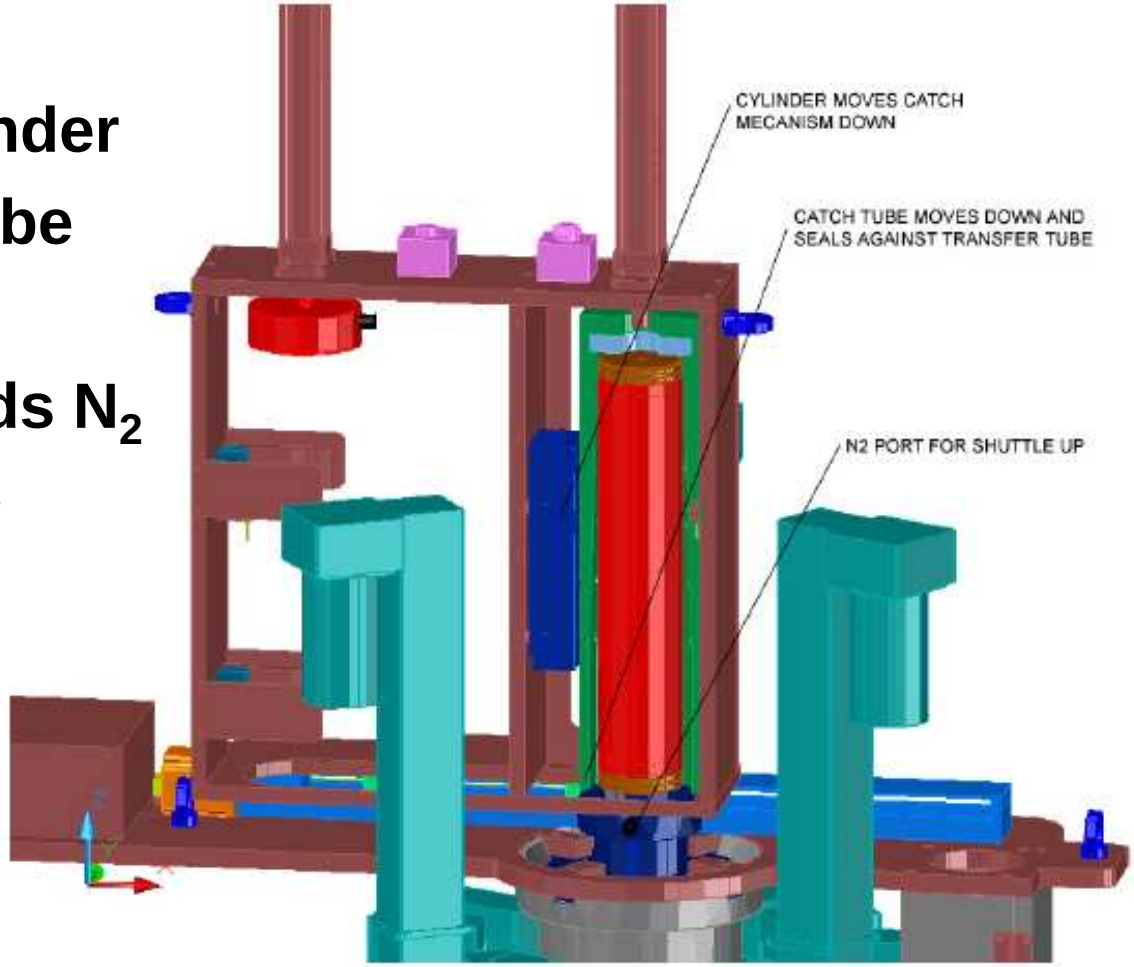
PTS Sequence of Operations
Step 6 – Catch Shuttle

- Pneumatic cylinder lowers catch tube w/ O-ring
- Port outlet sends N_2 to transfer tube bottom
- Transfer tube into catch tube
- Sorbathane padding



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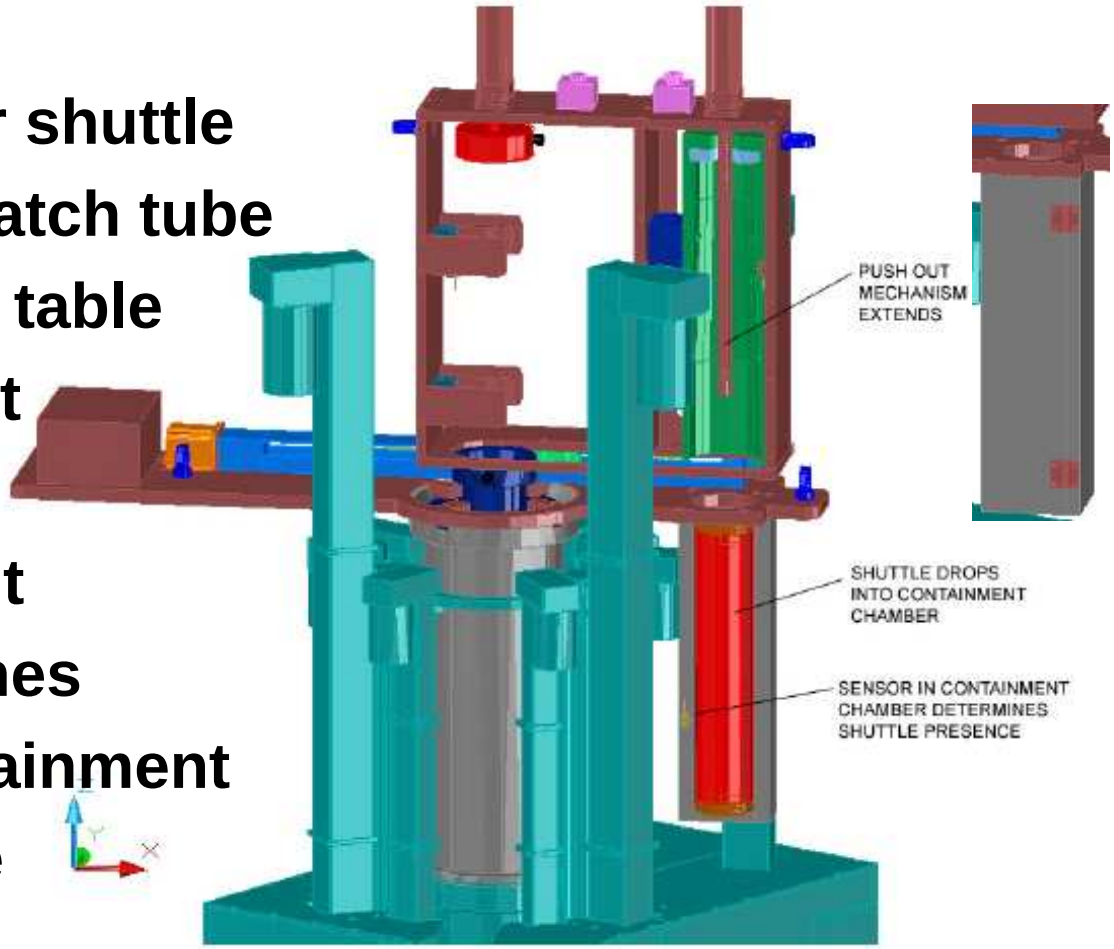
PTS Sequence of Operations
Step 7, 8, 9 – Assembly Moves, Shuttle Pushed Out, Shuttle Retrieval

- **Step 7 – Transfer shuttle tube exchange/catch tube moved along rail table over containment box**
- **Step 8 – Push out mechanism pushes shuttle into containment**
- **Step 9 – Retrieve shuttle**



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Summary and Future Work

- PTS design completed
- PTS allows for speedy irradiation of packages and reduces exposure to industrial hazards
- PTS cost - $90.1k
  - Hardware - $42.7k
  - Labor - $47.4k
- Future work involves:
  - Acquisition
  - Fabrication
  - Installation
  - Testing

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Comments/Questions?

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