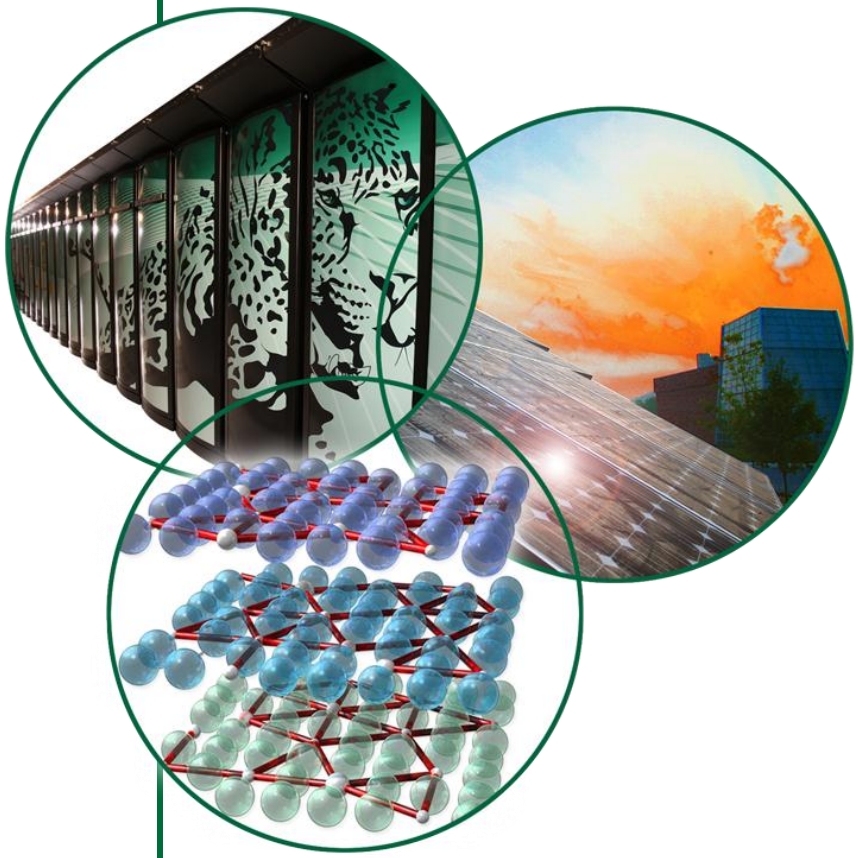
SNS HYSPEC (Beamline 14B) Technical Discussion

September 2012

David C. Anderson
Melissa Harvey



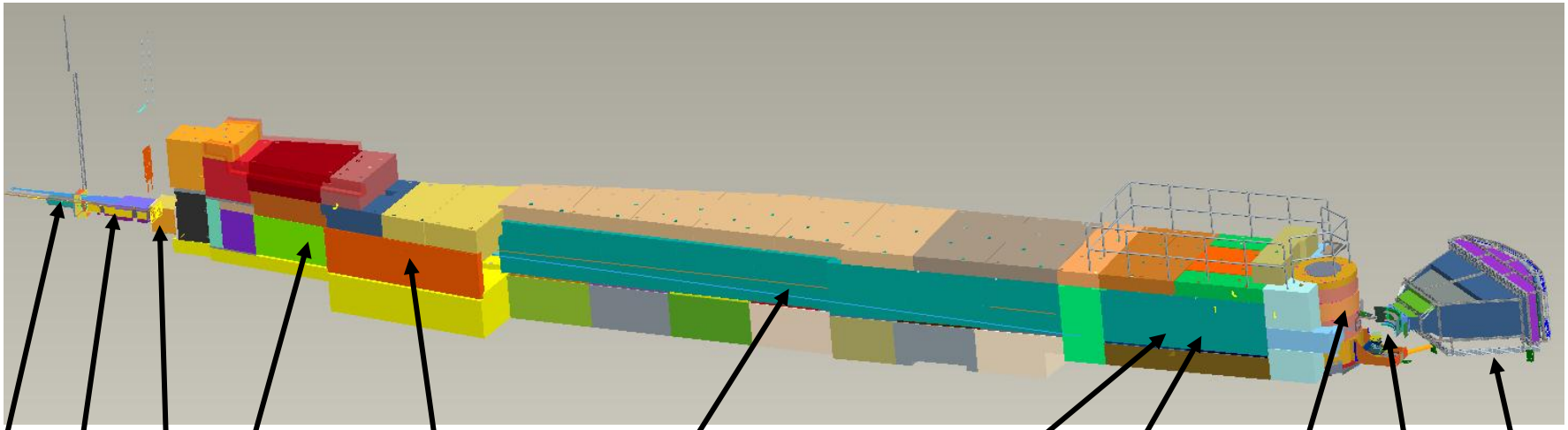
U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

HYSPEC Timeline

- CD0 (Mission Need) in May 2003
- Mark Hagen hired as Lead Scientist in 2003
- CD1 (Preliminary Baseline Range) in April 2004
- Engineering began on HYSPEC in 2004, when Bill Leonhardt was hired to be the lead engineer for the instrument
- Work continued at Brookhaven National Laboratory (BNL) until June 2005, when Mark Hagen relocated to oak Ridge
- CD2 (permission to proceed into detailed design) achieved in October 2005
- CD3 (procurement phase) in 2006
- Anderson replaces Leonhardt as Lead Engineer in April 2008
- CD4 (Project Complete) in August 2011

Beamline Components



CVI

Shutter Insert

BSI

Chopper Box A
T0 chopper
T1a disk chopper

6-15m Shielding

15-33m Shielding + Curved Guide

Chopper Box B Shielding

Chopper Box B
T1b disk chopper
T2 Fermi chopper
Secondary shutter
Isolation valve

Drum Shield + Focusing Crystals

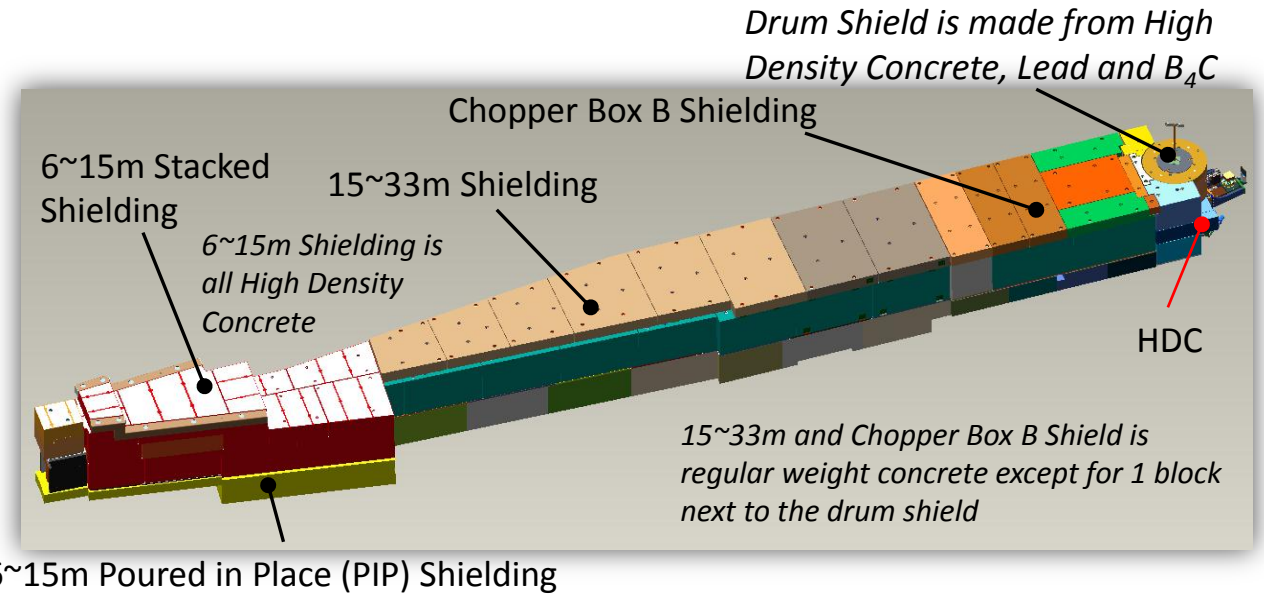
Drum Shield to Sample Arm + Sample Stage

Detector Vessel

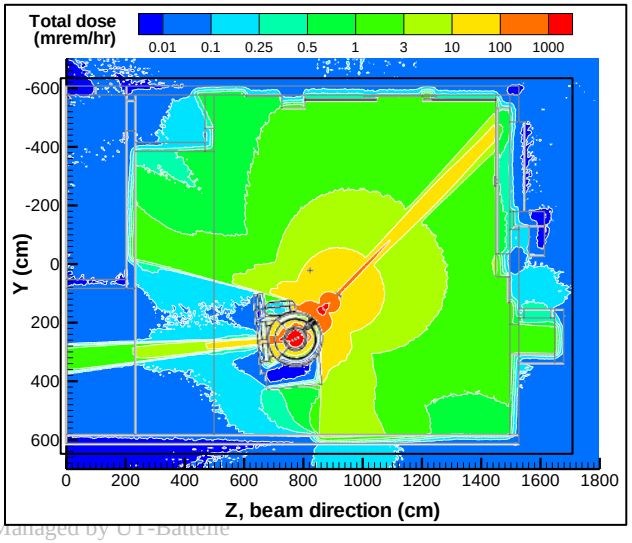
^{3}He Polarization Analyzer

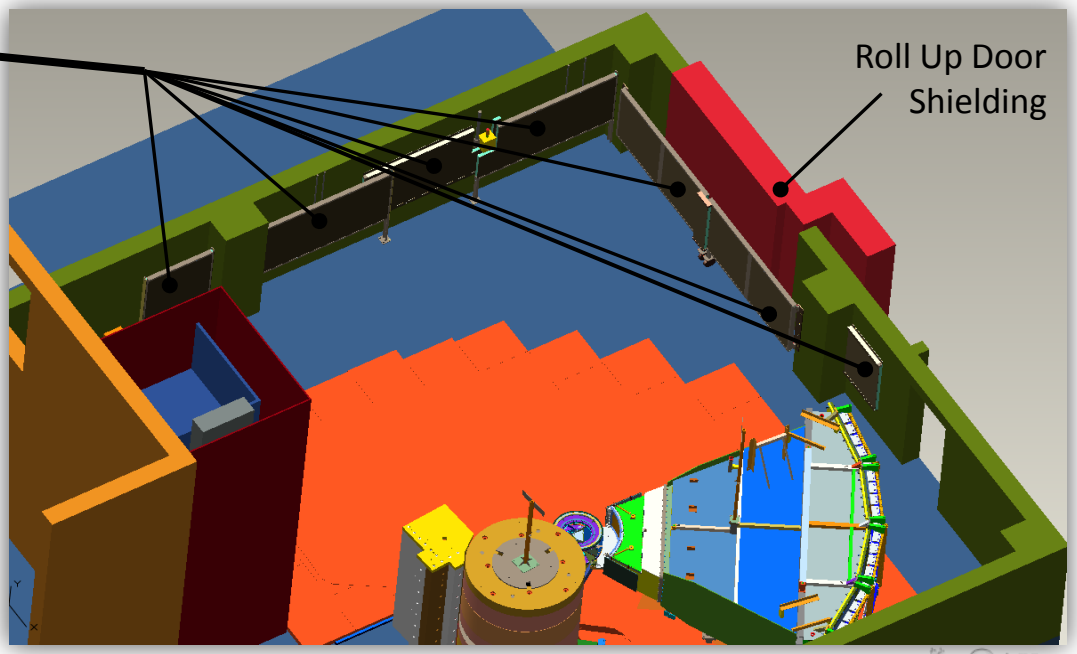
Shielding

- **Shielding is qualified both Seismically and by Neutronics Analysis**



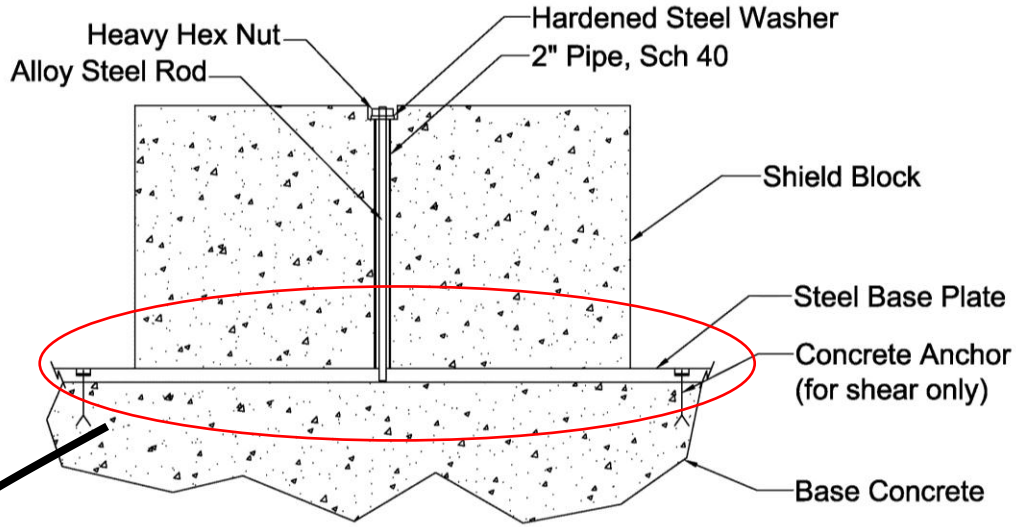
Borated Panel Shielding
(Borated Polyethylene with Aluminum skins, painted with B4C loaded paint)



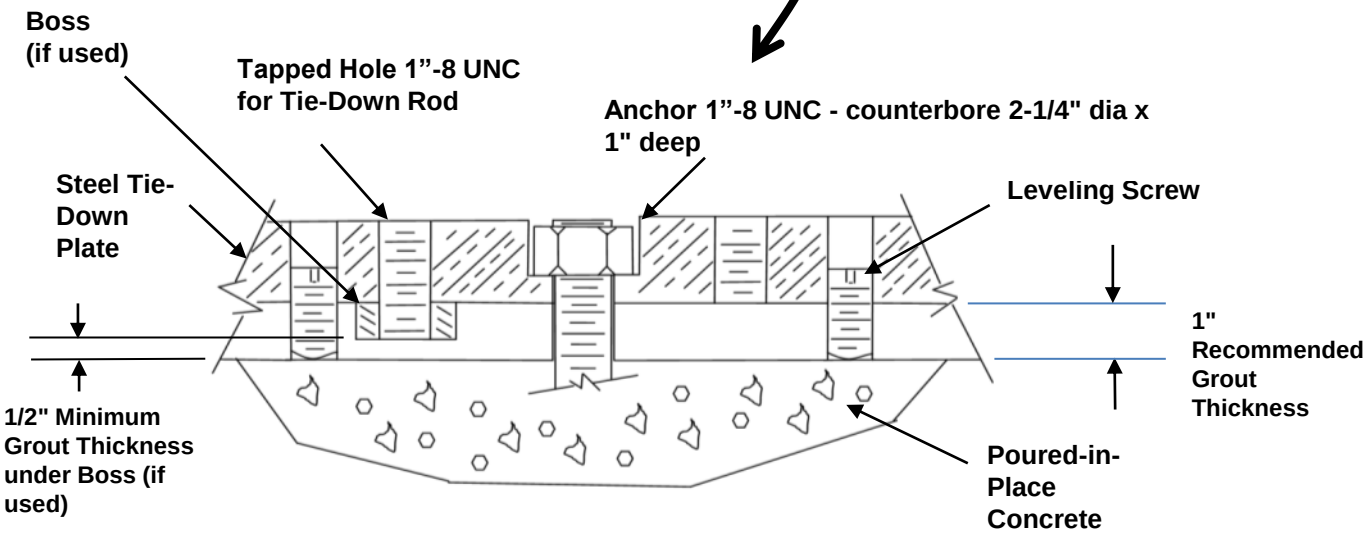


SNS Standardized Shielding Design

- **HYSPEC Shielding construction follows the SNS Standard Design**



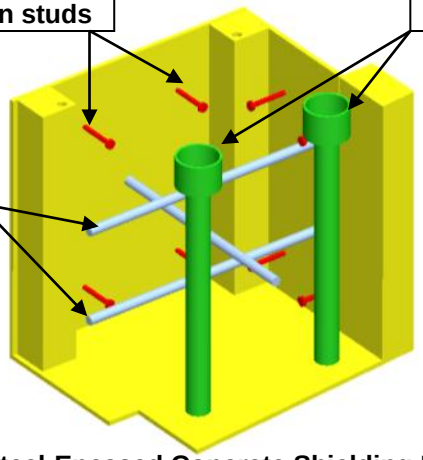
Friction Connections for Stacked Shielding Blocks

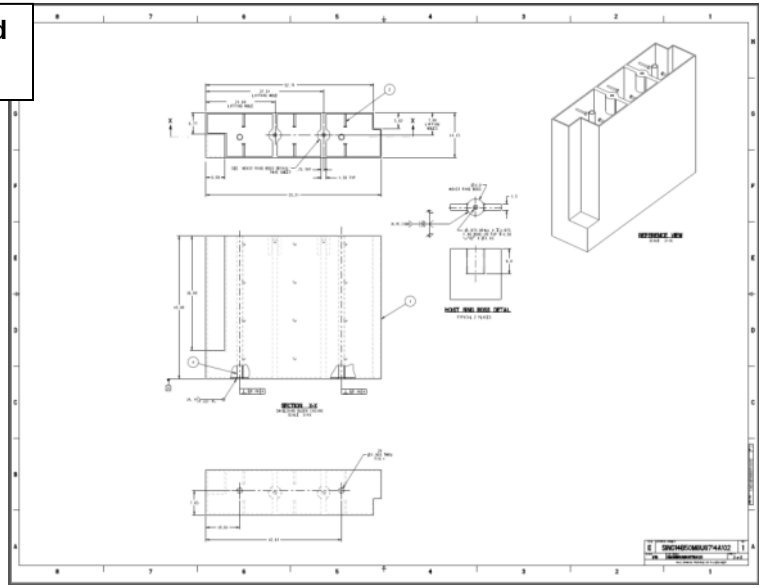


Tie-Down Details for Stacked Shielding Blocks Mounted on Poured-in-Place Shielding

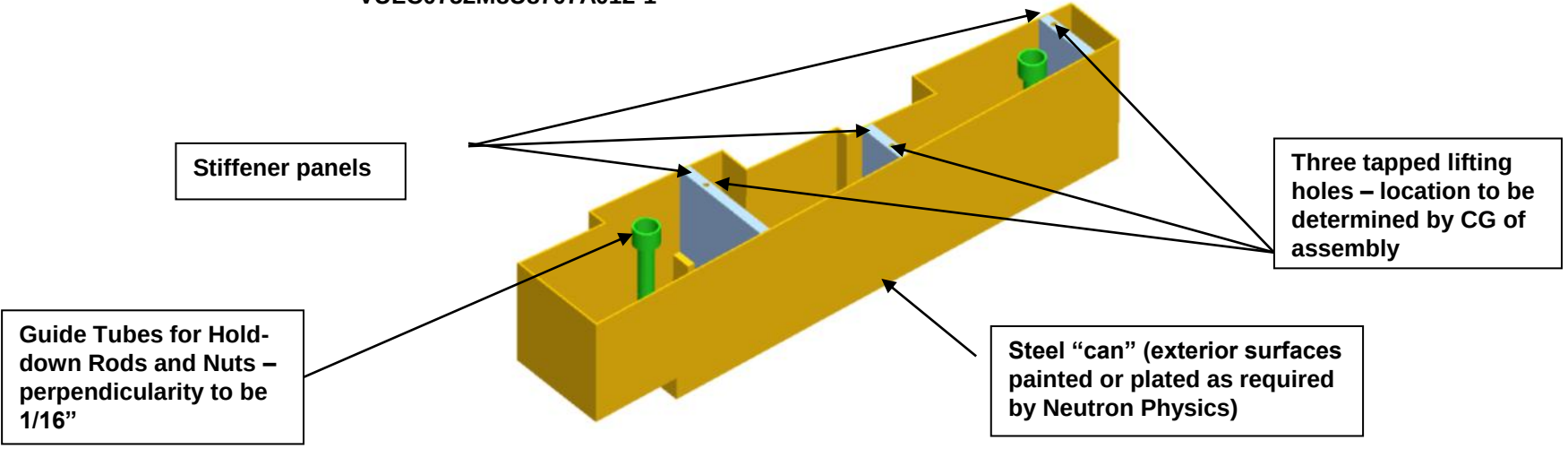
•<u>7.0 STANDARDIZATION OF MECHANICAL COMPONENTS</u>

SNS Standardized Shielding Design





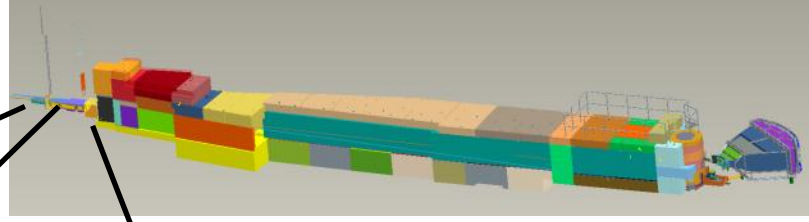
Typical Steel-Encased Concrete Shielding Block (Swift-Lift Option) – Alternate Method of Construction – reinforcing bar omitted for clarity
VULC0752M8U8707A012-1

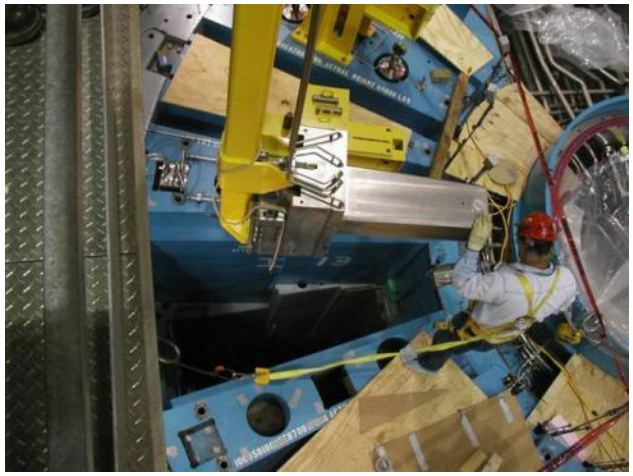


Typical Steel-Encased Concrete Shielding Block (Swivel Hoist Ring Option) – Preferred Method of Construction – Nelson studs omitted for clarity
SING0350M8U8703A020-1

Upstream Optics

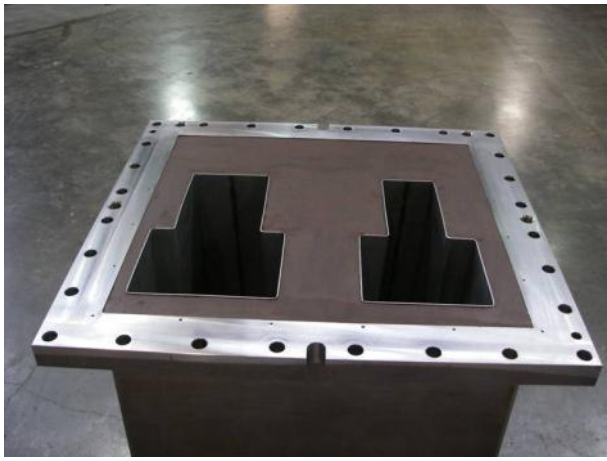
- Procured and installed very early in the Project





CORE VESSEL INSERT

Shutter Insert

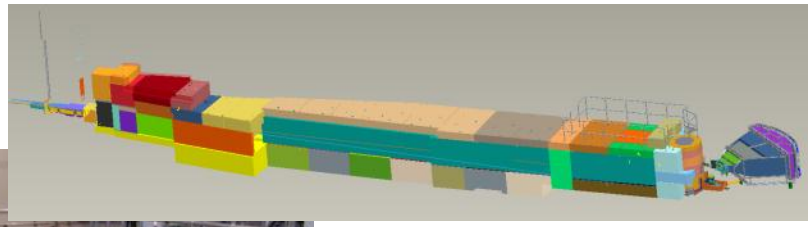


BULK SHIELD INSERT

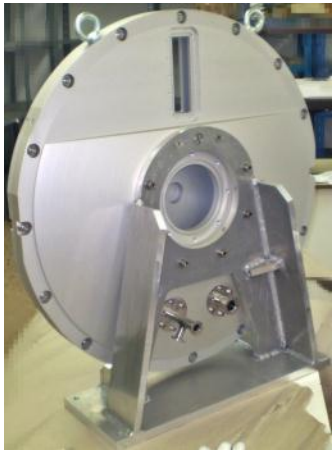
Choppers and Beam Guide

- Vertical axis T0 Chopper procured from SKF Magnetic, operates at 30Hz and 60Hz
- Upstream Disk Chopper operates at 60Hz (frame overlap)
- Downstream Disk Chopper operates at 60Hz (order suppression)
- Straight, short bladed, Fermi chopper which can run at 30, 60, 90, 120,…, 420Hz
  (this is the chopper that monochromates the beam) – nominal frequency is 180Hz

T0 Chopper



Beam Guide



Disk Chopper

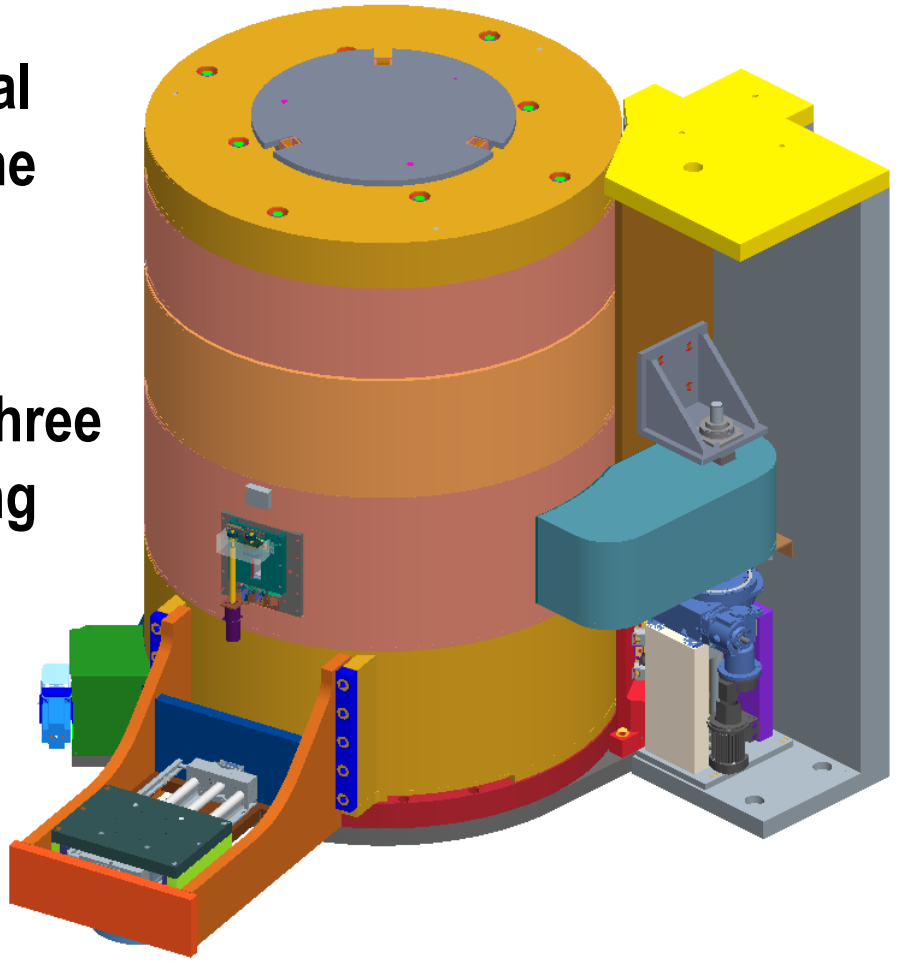
Fermi Chopper

Gate valve

Secondary shutter

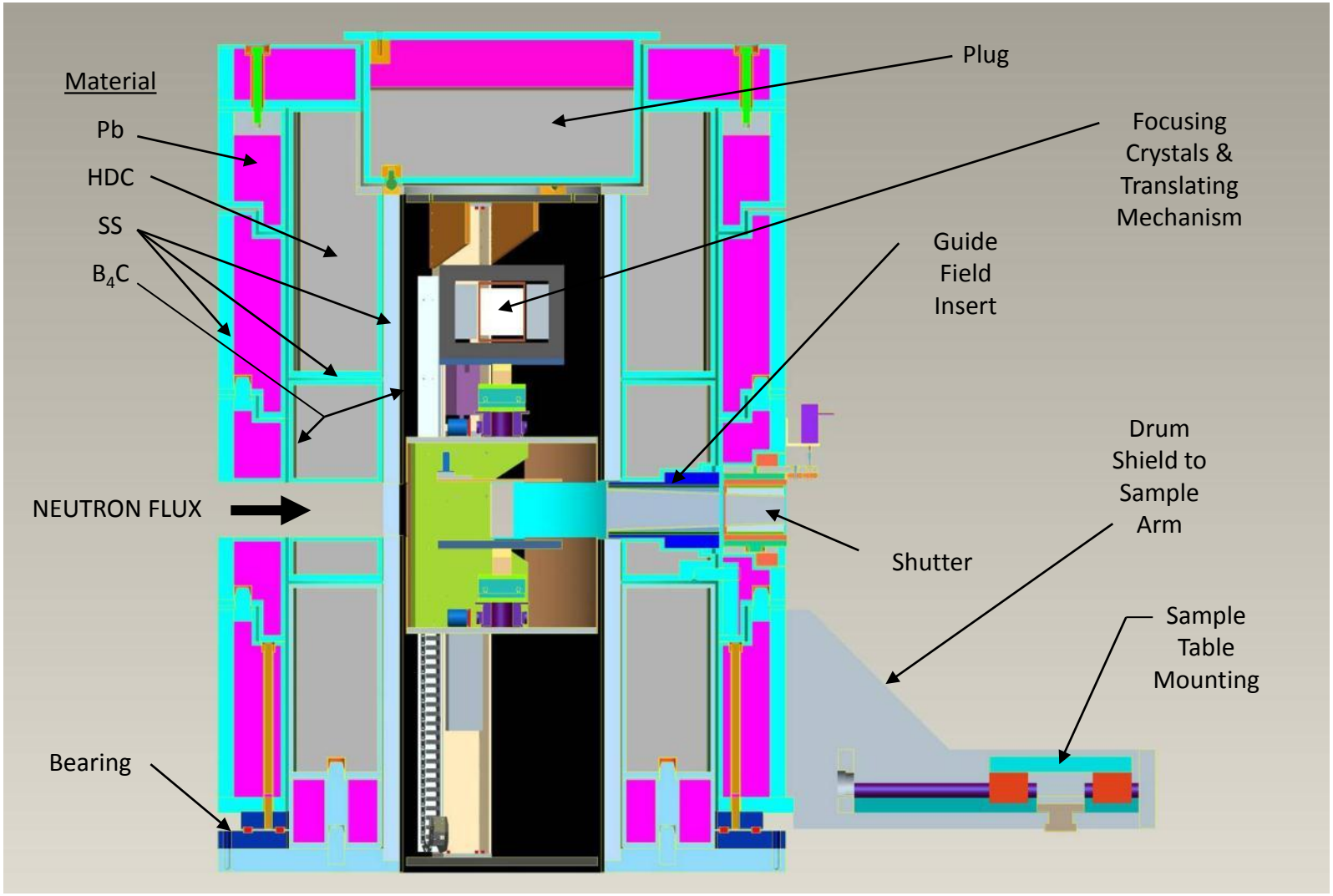
Drum Shield

- Detail Design took ~10 months
- Design began at Brookhaven National Laboratory with one engineer and one designer
  - Used AutoCAD and Inventor
- Completed at SNS with as many as three engineers and four designers working simultaneously
  - Used Pro-E
- Weighs ~120,000 pounds
- Rotates from 14° to 90°
- Contains 2 monochromators
- Serves as primary beam stop for the instrument



Drum Shield Construction

- Gray = High Density concrete
- Pink = Lead
- Dark Gray = B_4C



Manufacturing

Forming

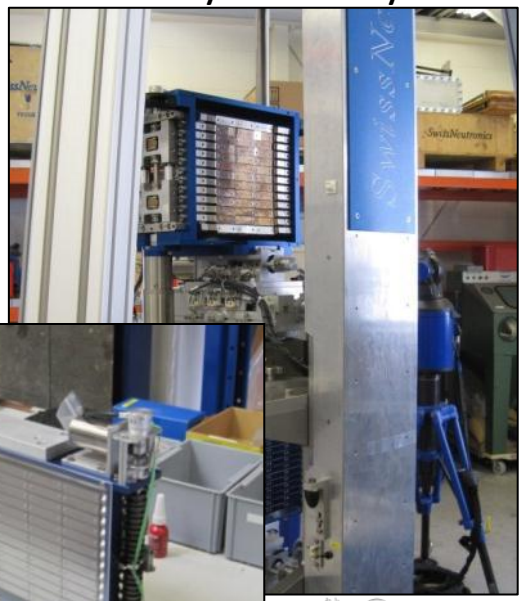
Welding

Lead Casting

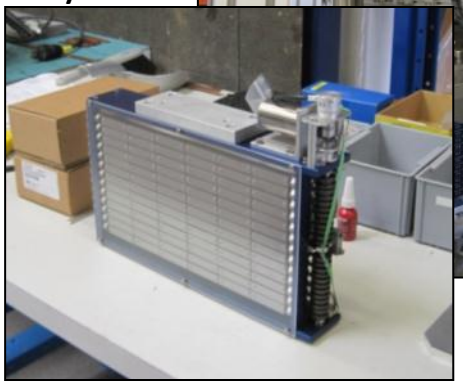
MAXUS™ B4C / Aluminum parts

Drum Shield Installation and Testing

Heusler Crystal Array

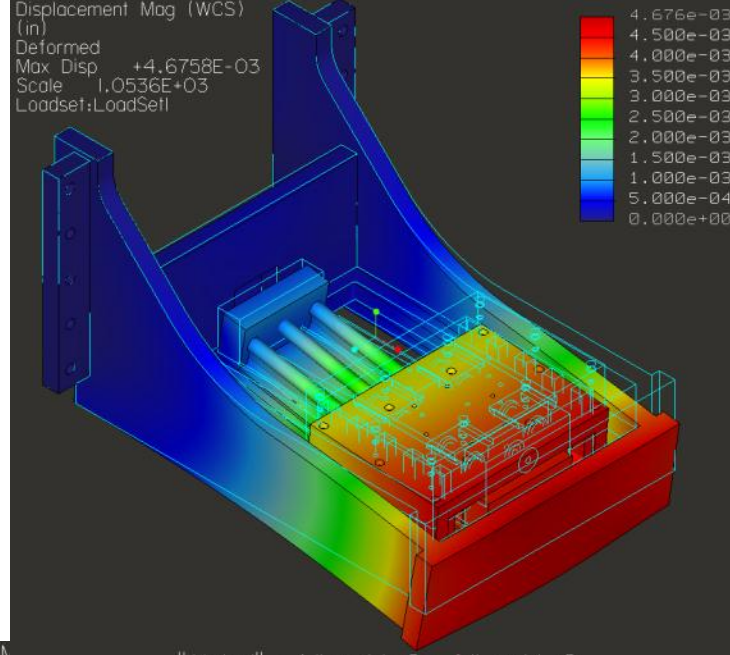


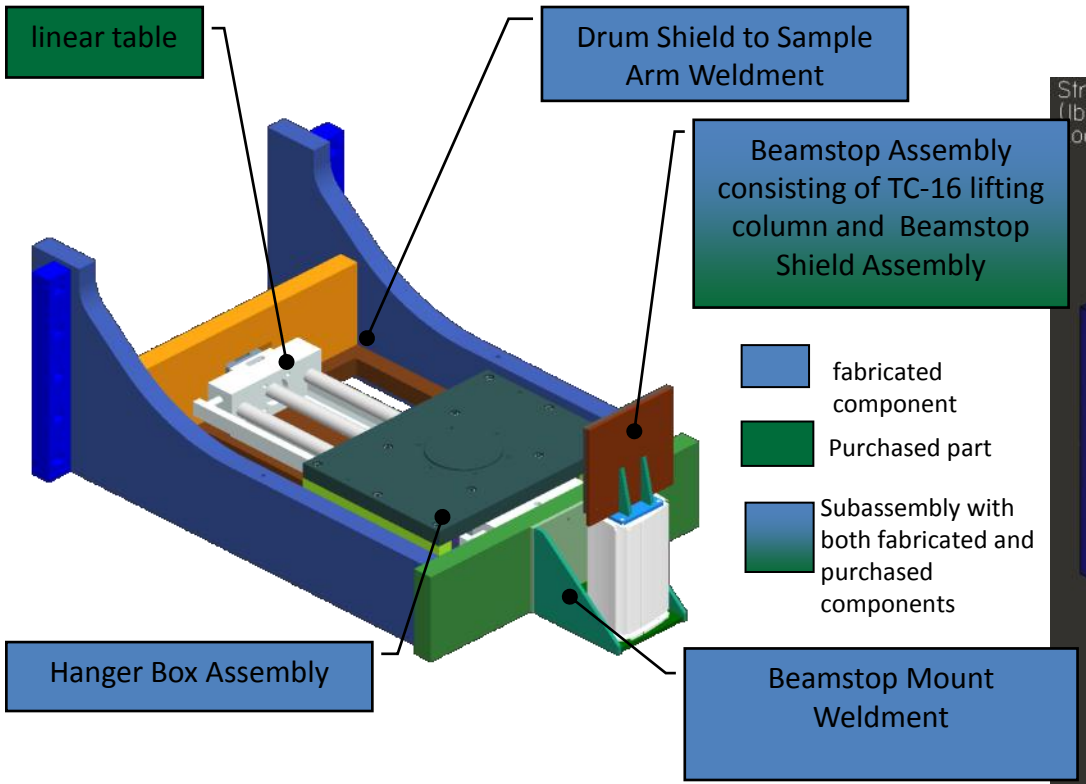
HOPG Crystal Array

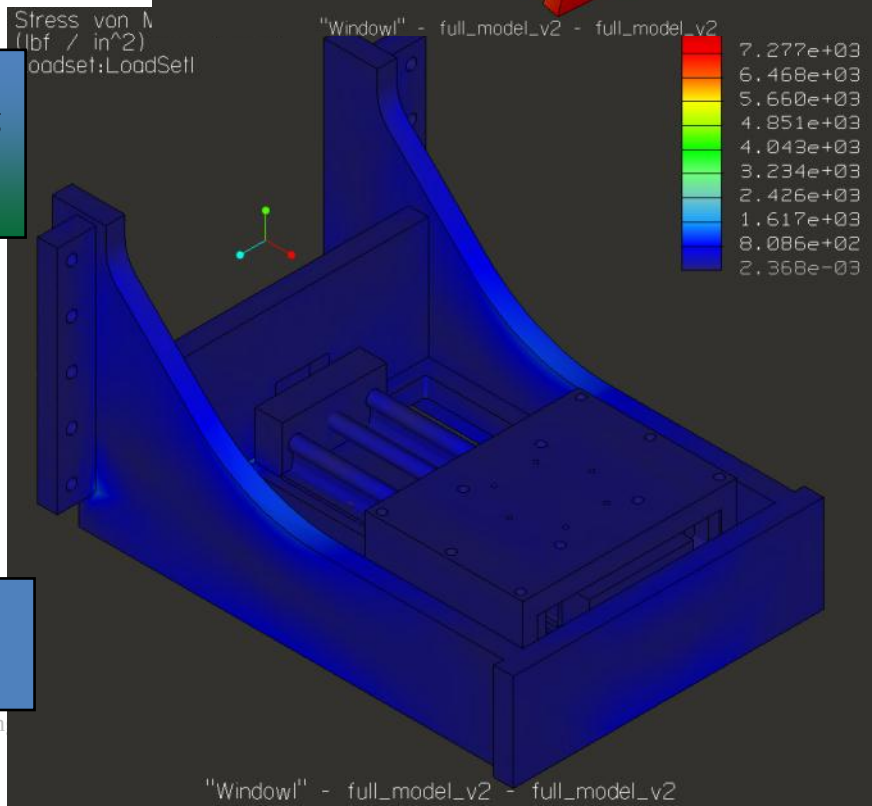


Drum Shield to Sample Arm

- Drum Shield to Sample Arm was designed to carry the 16T compensated magnet (2.2 tons) with minimum deflection.
- Linear table moves the sample from 1.4m to 1.8m from Drum Shield rotation axis

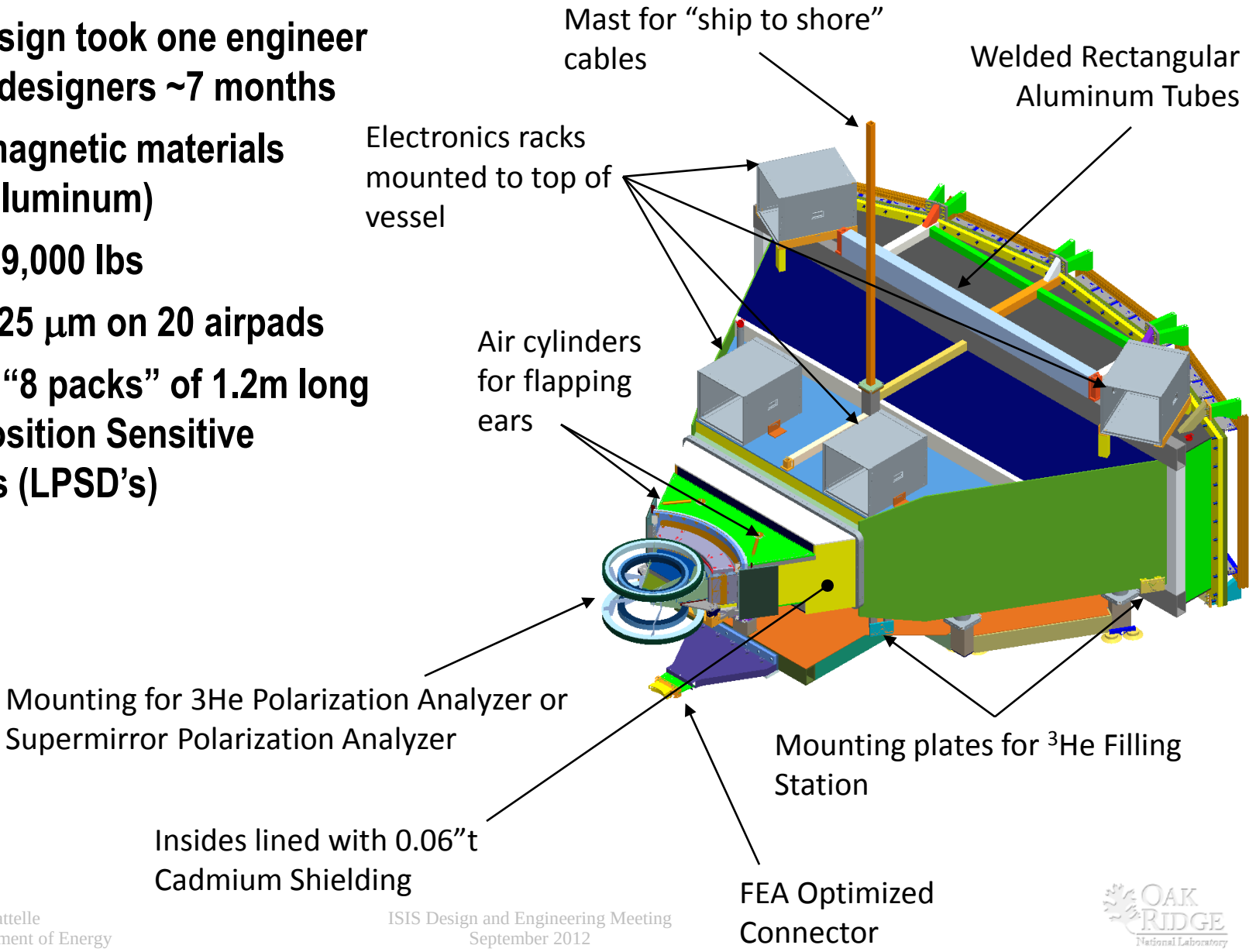






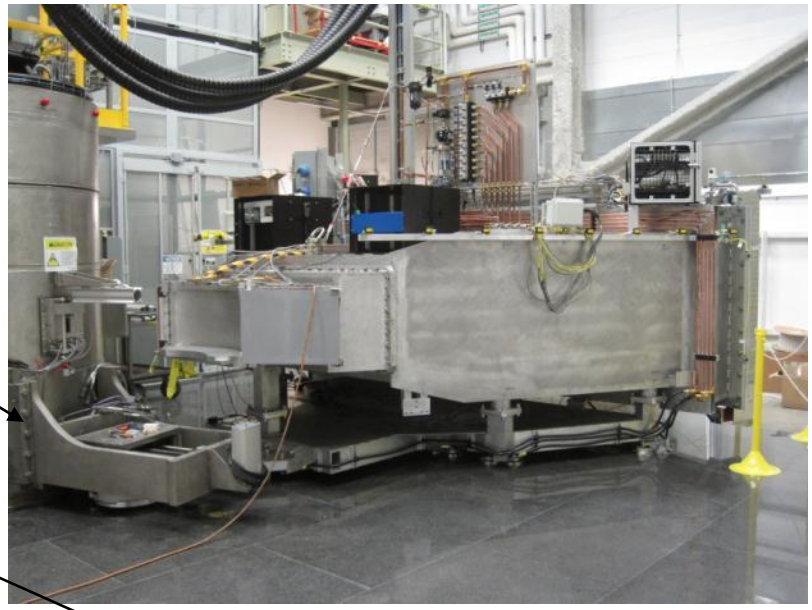
HYSPEC Detector Vessel Overview

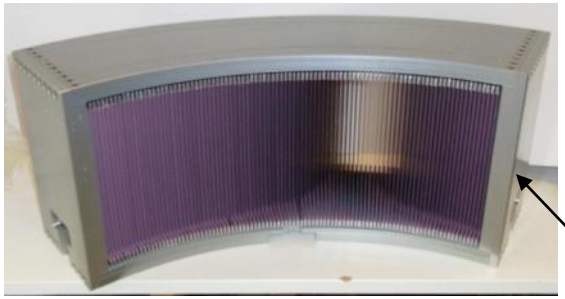
- **Detail Design took one engineer and four designers ~7 months**
- **All non-magnetic materials (mostly aluminum)**
- **Weighs ~9,000 lbs**
- **Hovers ~25 μm on 20 airpads**
- **Holds 20 "8 packs" of 1.2m long Linear Position Sensitive Detectors (LPSD's)**



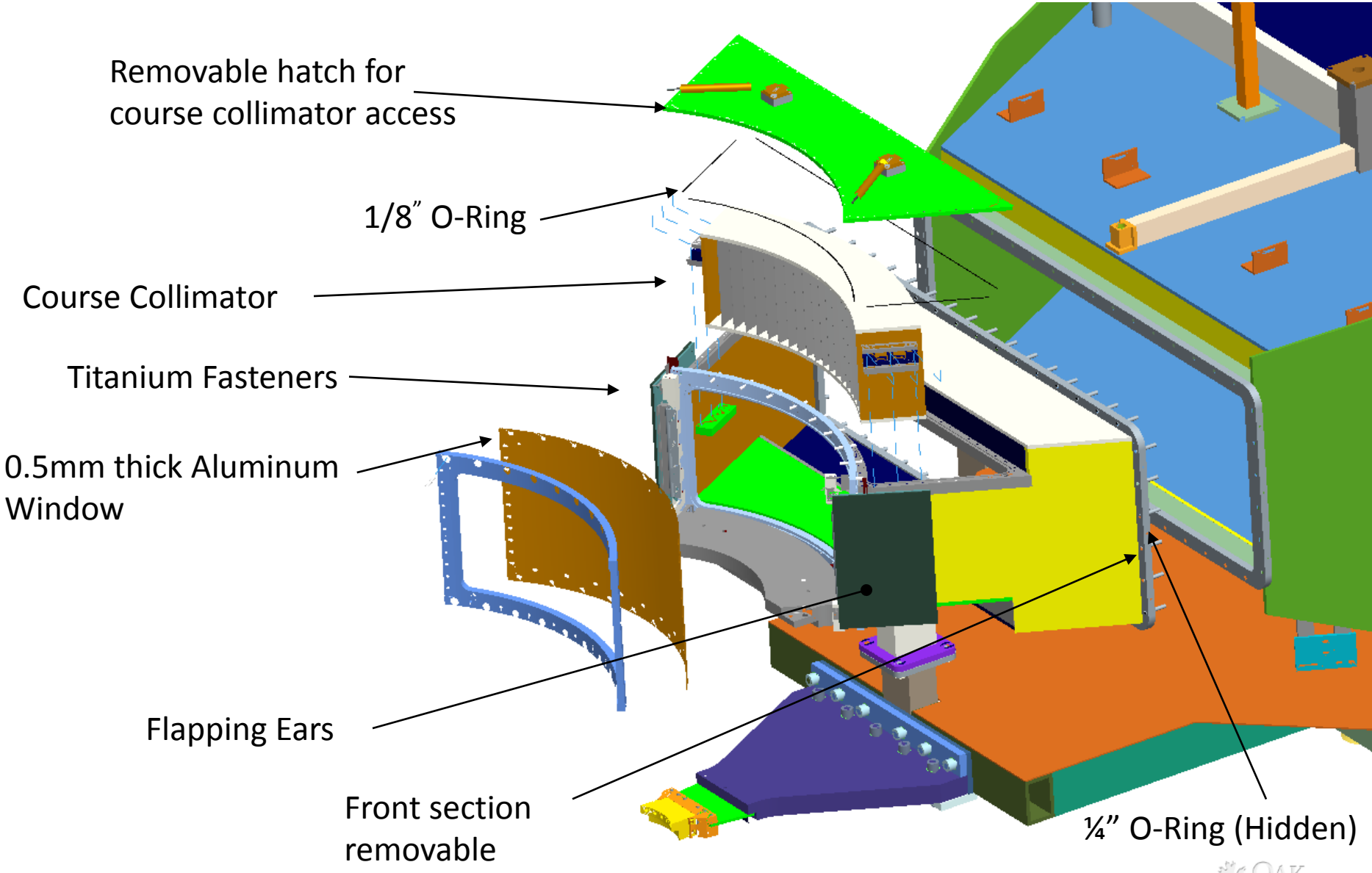
Detector Vessel Overview

- Filled with low pressure Argon
- Large rear window required to keep detectors in air
- Ship to shore lines carry data, power, air etc.
- can carry a fine radial collimator – for unpolarized or ^{3}He polarization analysis (will also work with 16T magnet)
- Front is also able to carry the Helmholtz coils for ^{3}He analyzer system

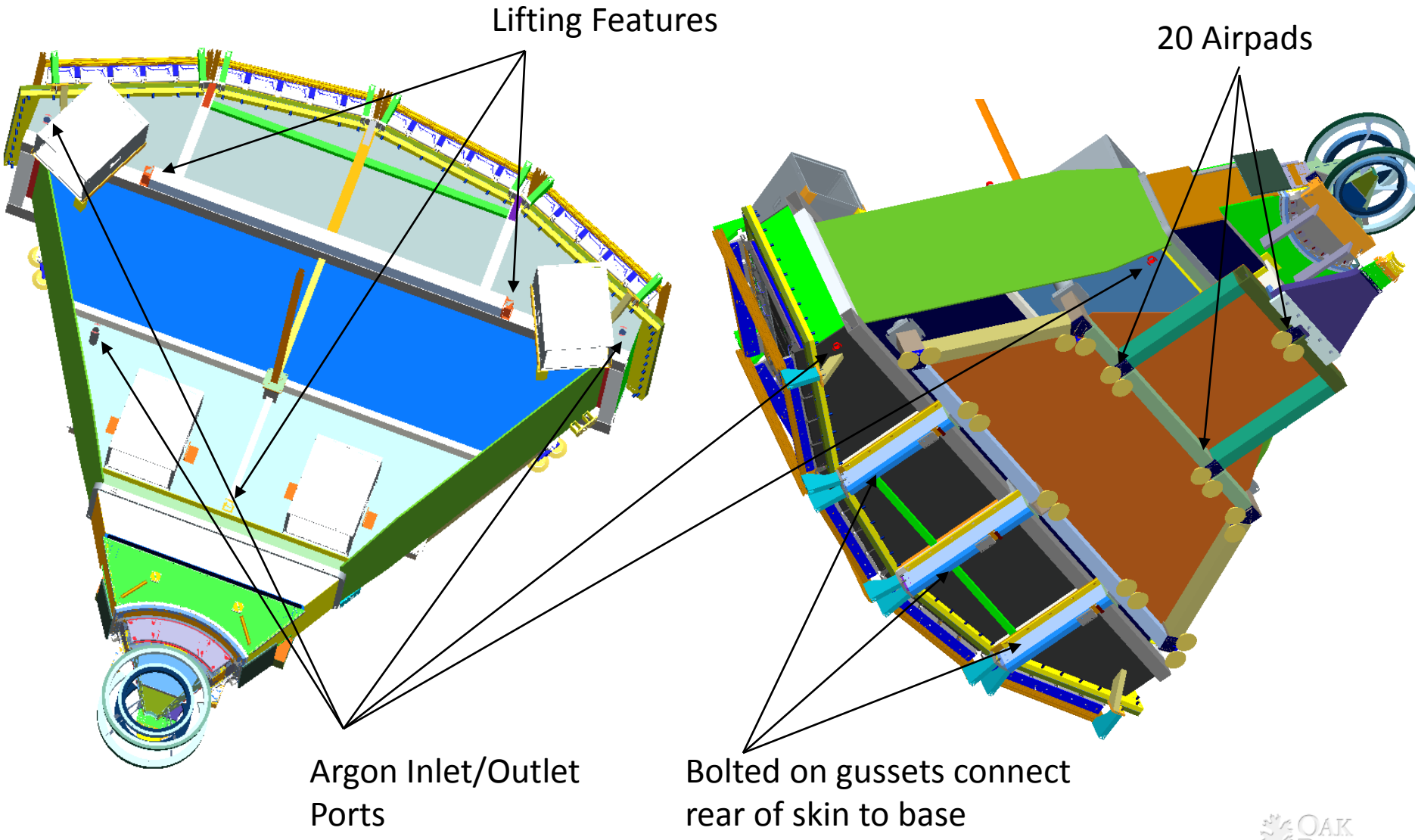




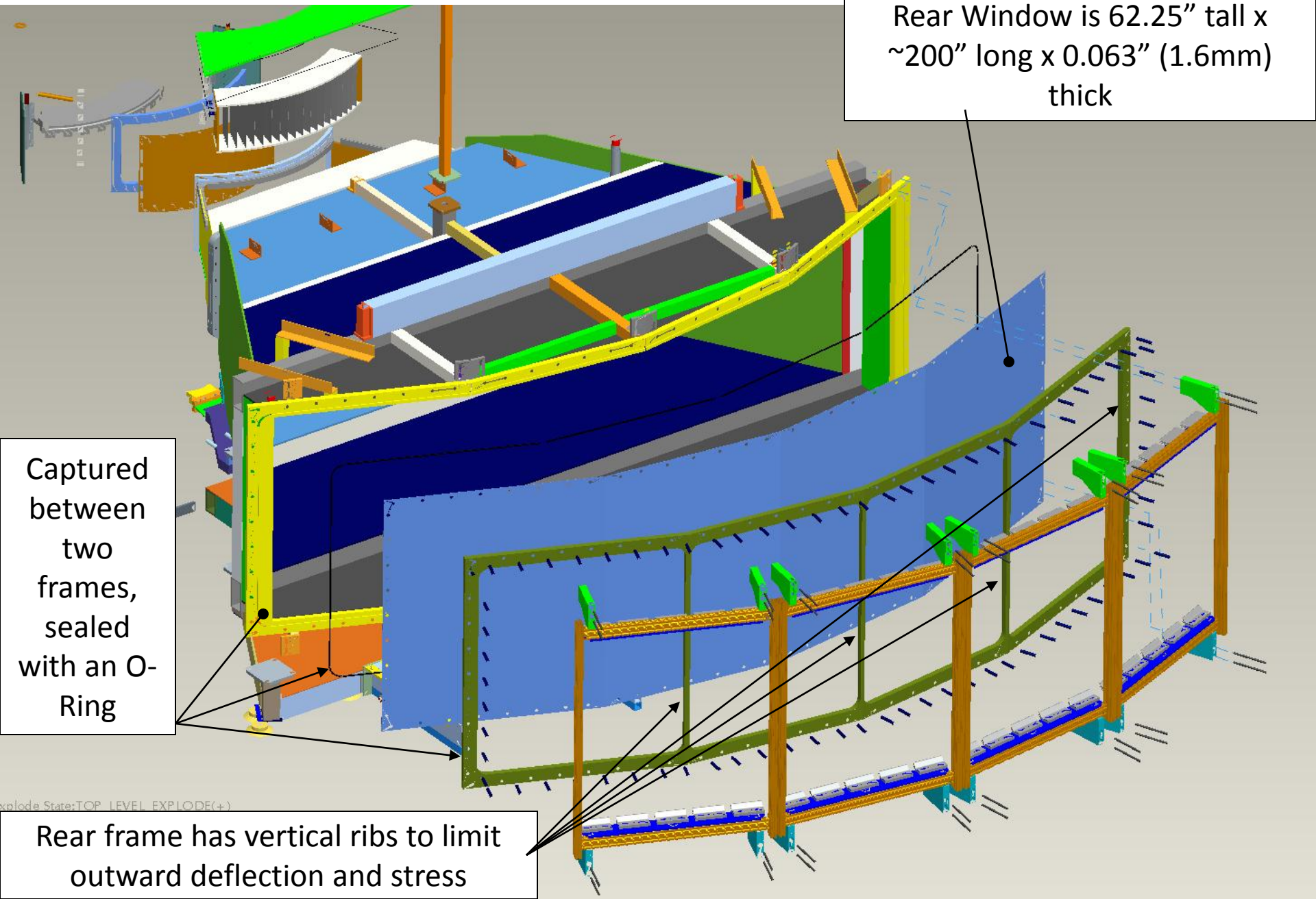
Detector Vessel Front End



Detector Vessel

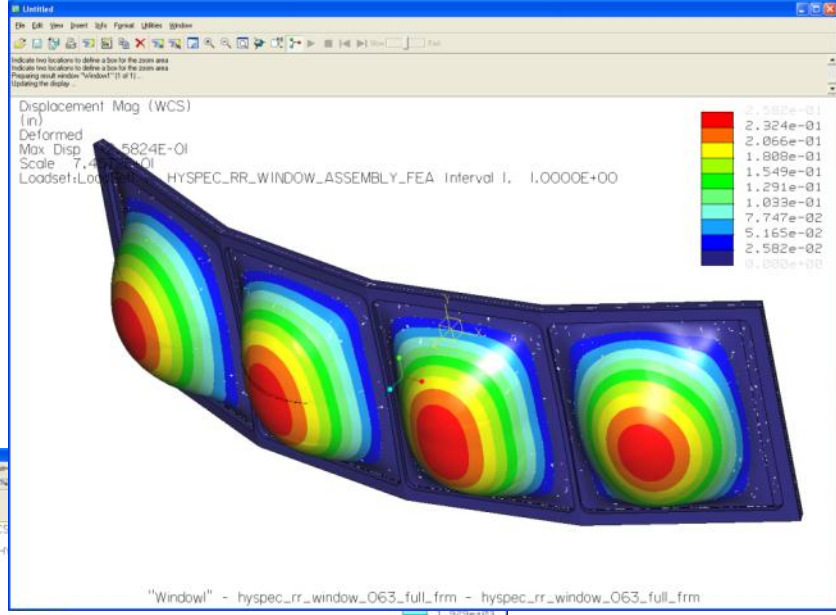


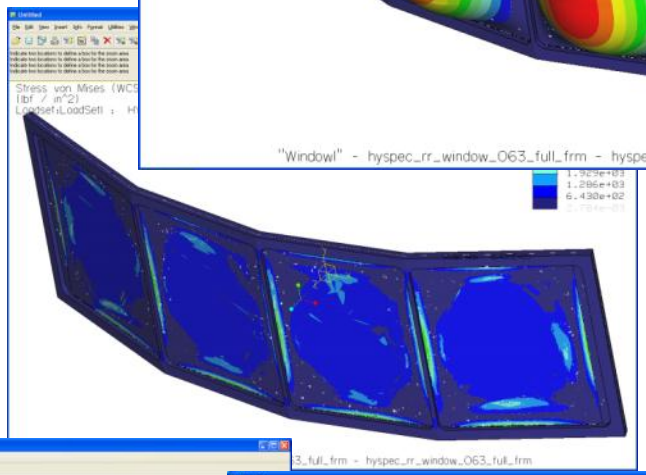
Rear Window

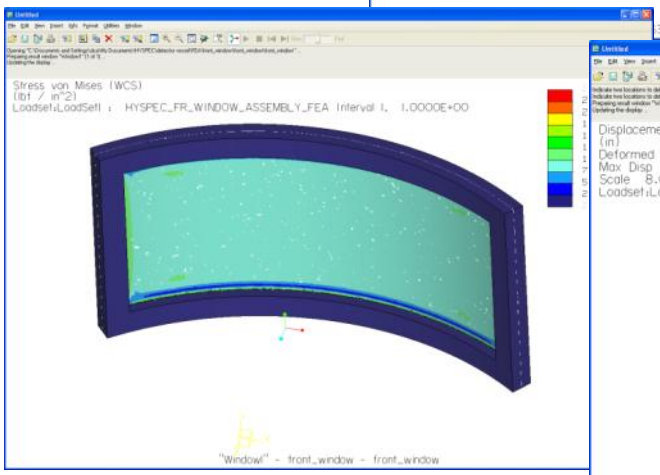

Rear Window is 62.25” tall x ~200” long x 0.063” (1.6mm) thick
Captured between two frames, sealed with an O-Ring
Rear frame has vertical ribs to limit outward deflection and stress

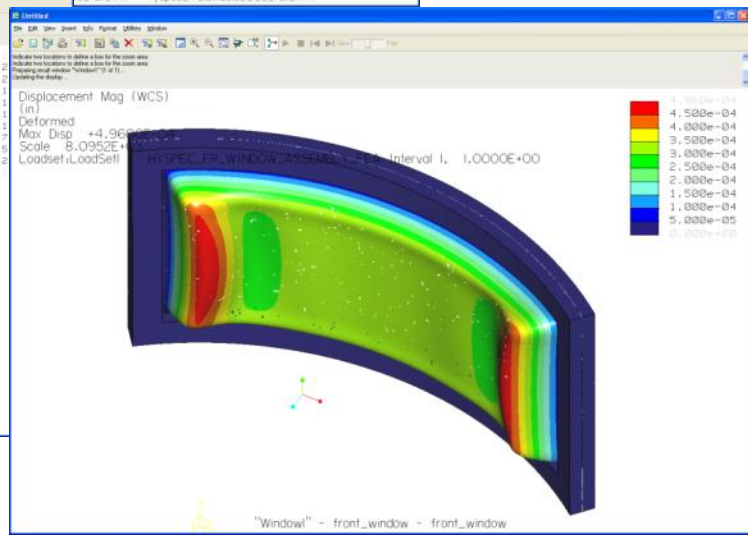
Window Analysis

- Window thicknesses and construction were determined through iterative FEA
- Large rear window required ribs to limit deflection and keep stress low
  - Ribs strategically placed to avoid shadowing detectors



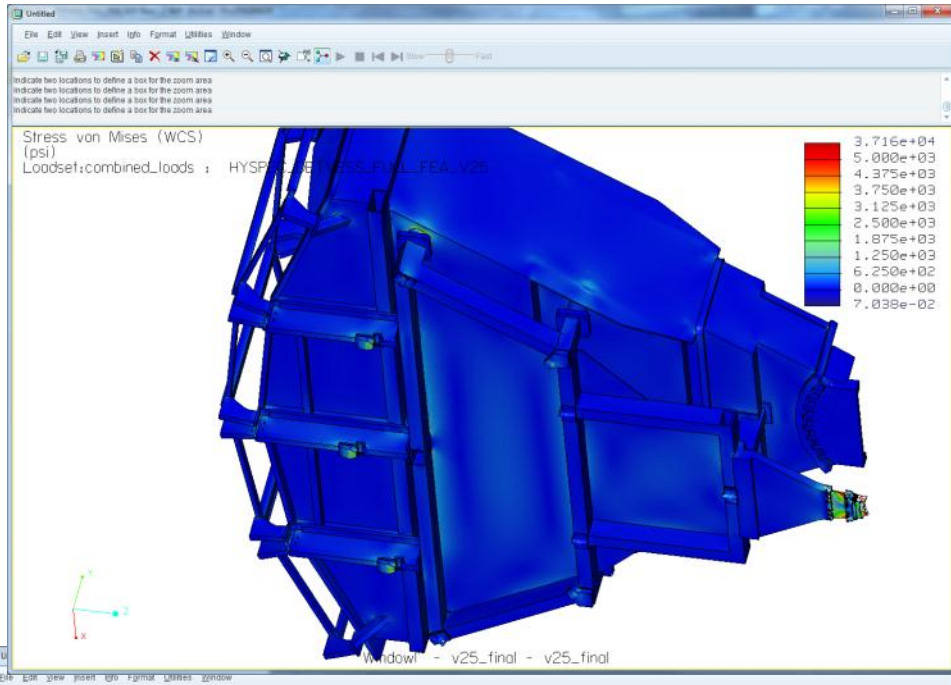


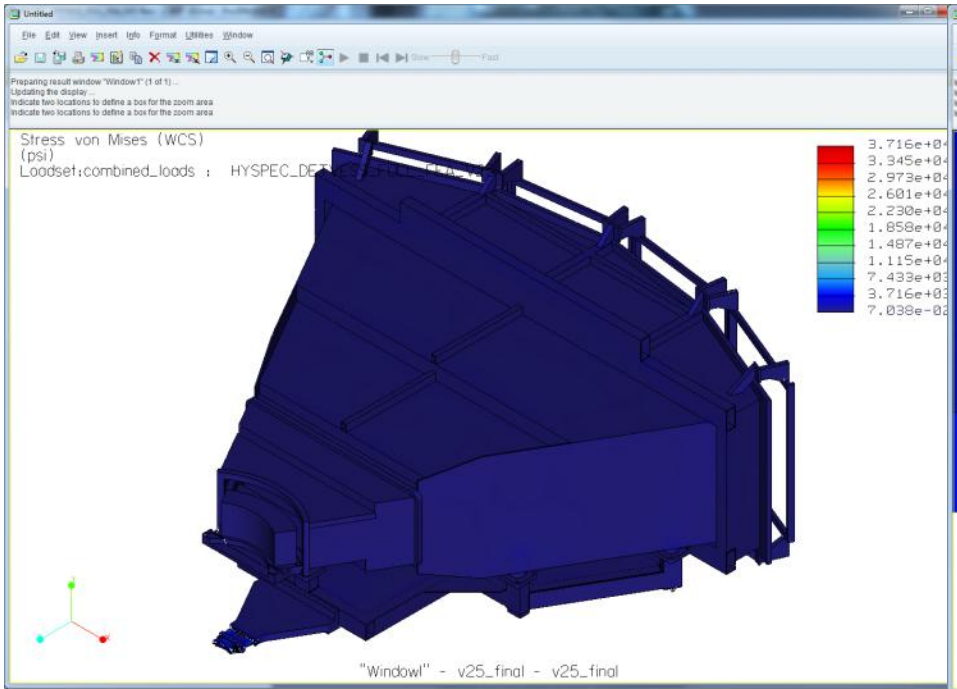


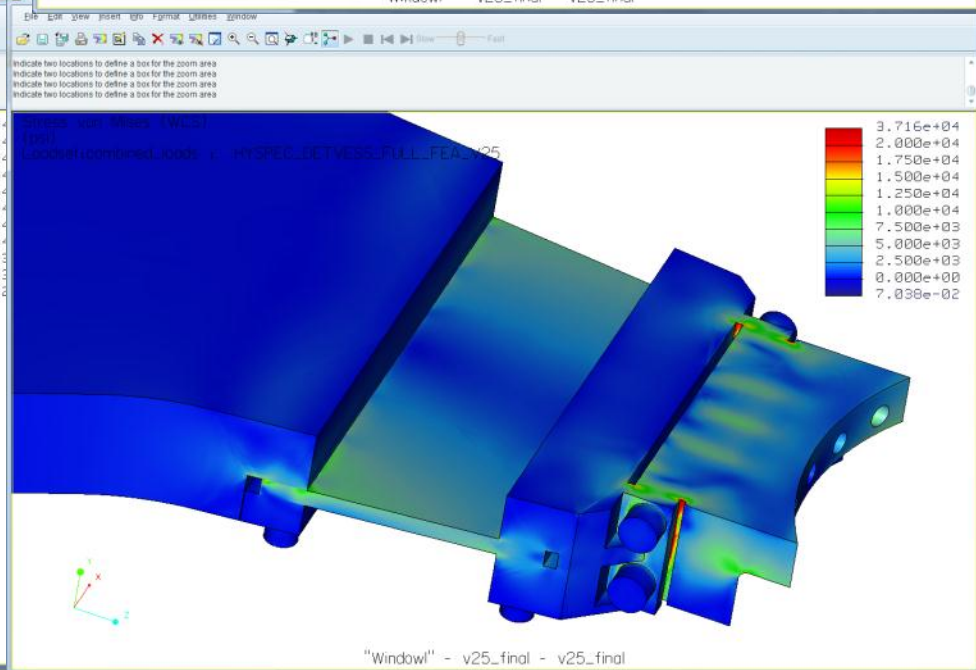


Design Through Analysis

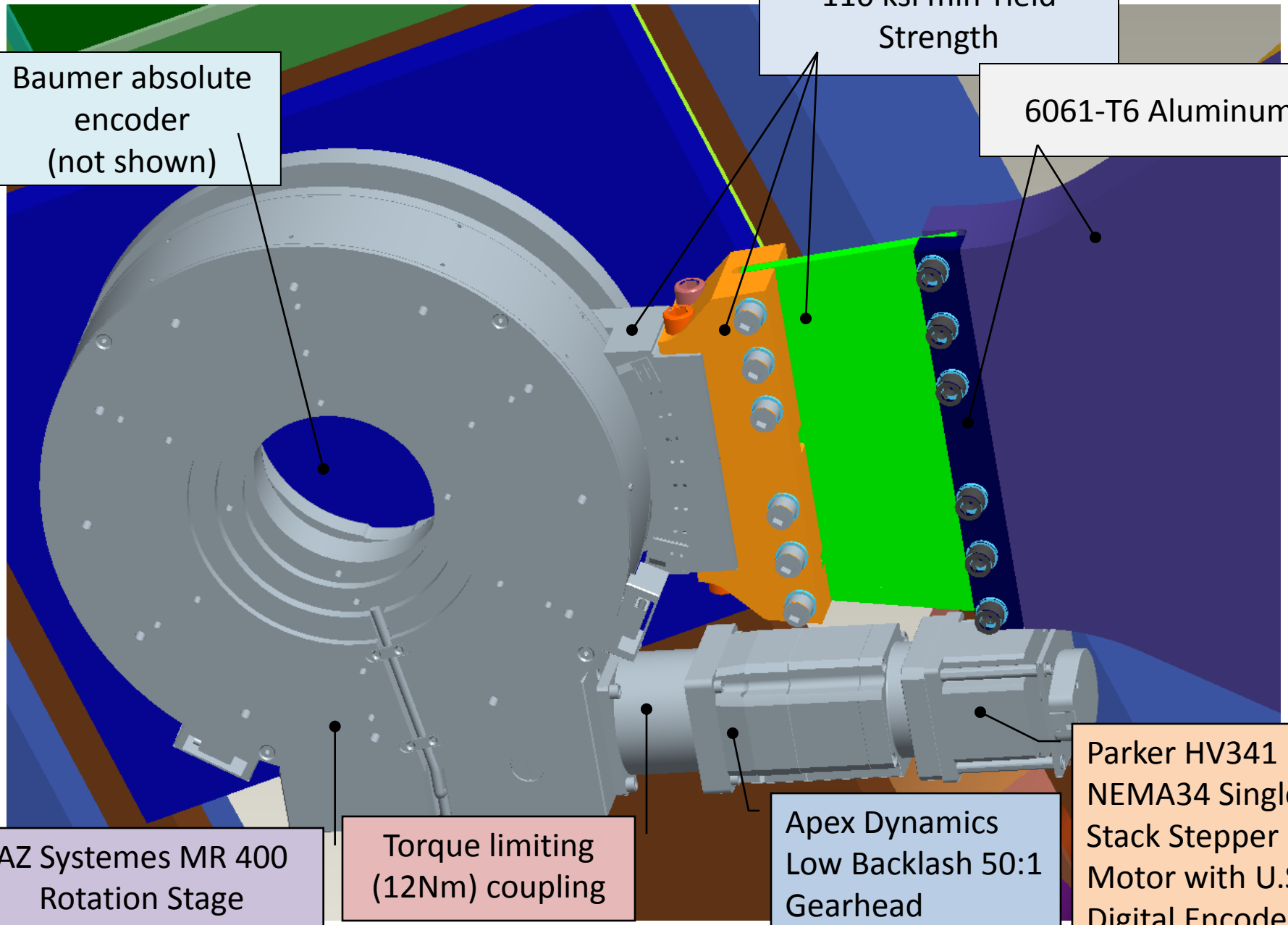
- Design of vessel was optimized through iterative FEA
- Highest stresses, most difficult design was connection to rotation stage
- Controlling deflection at rear of vessel was also challenging







Rotation


17-4 PH Stainless Steel, 110 ksi min Yield Strength
6061-T6 Aluminum
Baumer absolute encoder (not shown)
AZ Systemes MR 400 Rotation Stage
Torque limiting (12Nm) coupling
Apex Dynamics Low Backlash 50:1 Gearhead
Parker HV341 NEMA34 Single Stack Stepper Motor with U.S. Digital Encoder

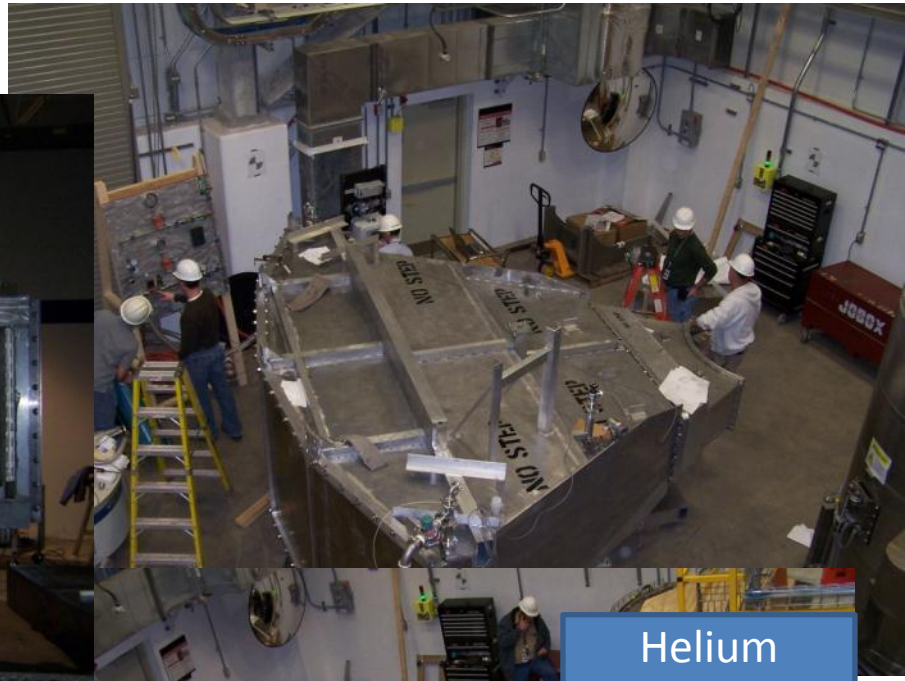
Installation of Detector Vessel

Nose section is reattached

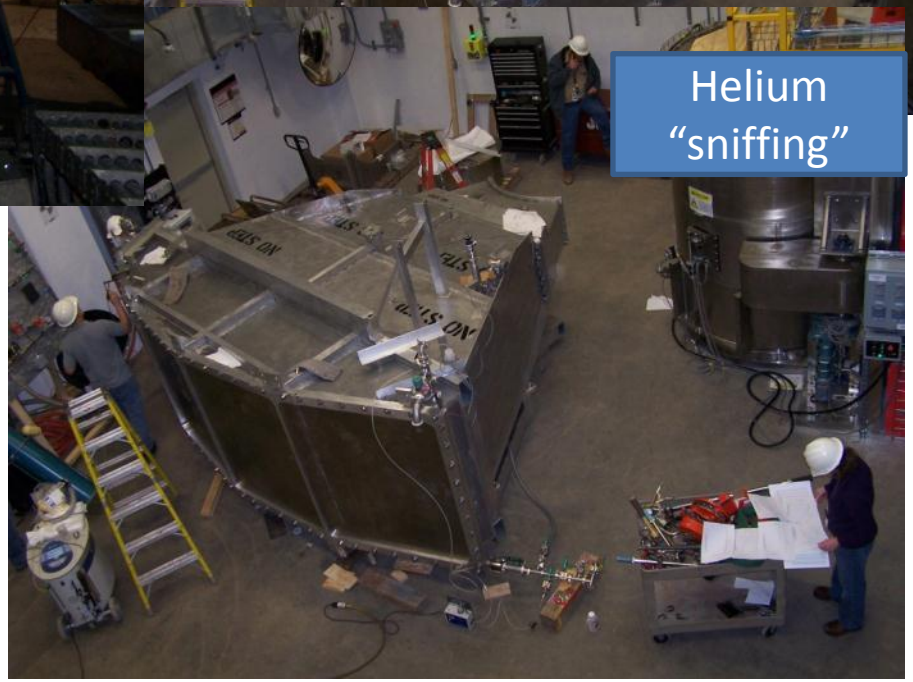
Detector and general electrical installation

Leak Testing

Ultrasonic leak testing at Vendor site



On Site leak testing



Helium "sniffing"

Dance Floor





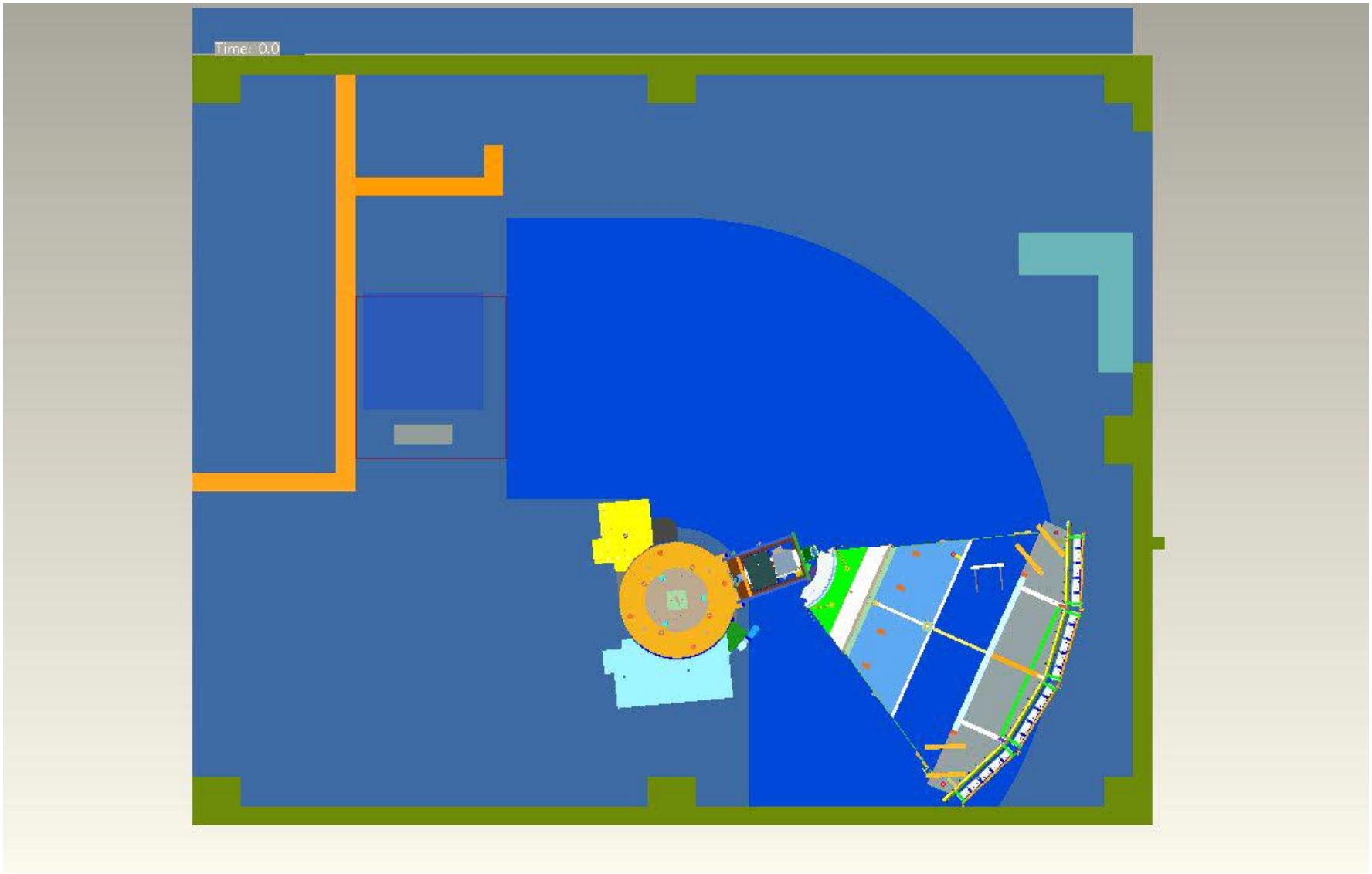




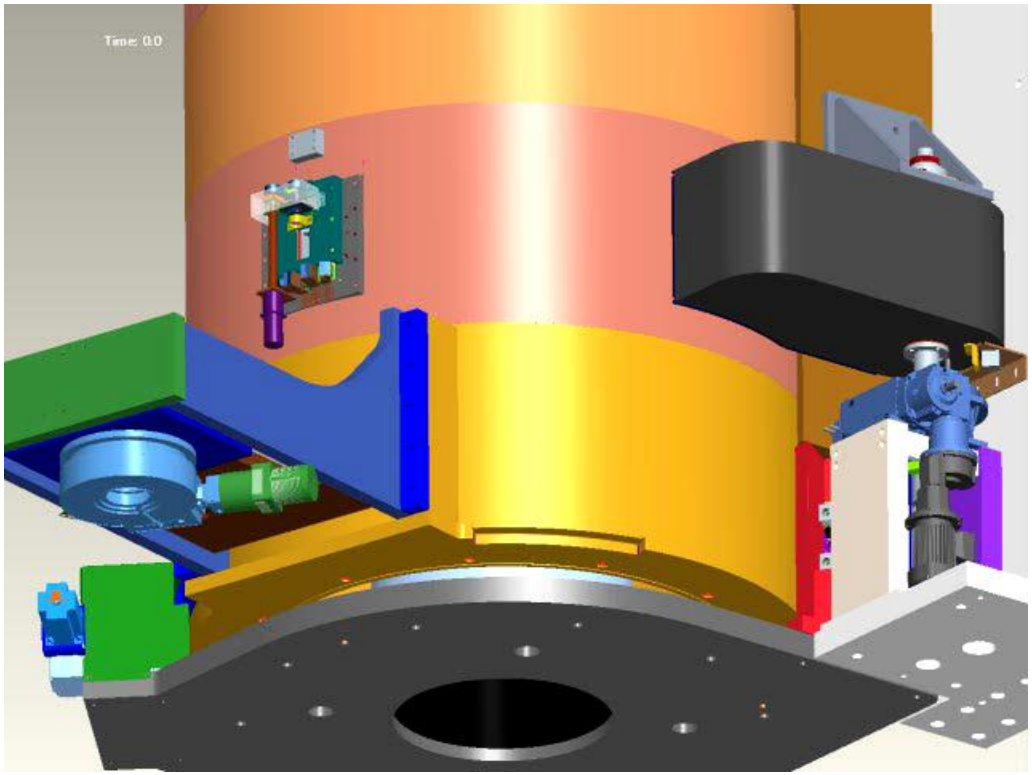
Motion

- Not including choppers or primary shutter, has 24 axes of motion
- Secondary shutter – 1 axis
- Focusing crystal mechanism – 9 axes (tilt, translate, rotate, focus x 2 + lift)
- Drum shield – rotate, swing arm, translate pin, rotate tertiary shutter = 4 axes
- Drum Shield to sample arm – translate sample, translate beamstop, rotate detector vessel = 3 axes
- Sample table – rotate, translate x2, tilt x 2 = 5 axes
- Detector vessel – rotate ears x 2 = 2 axes

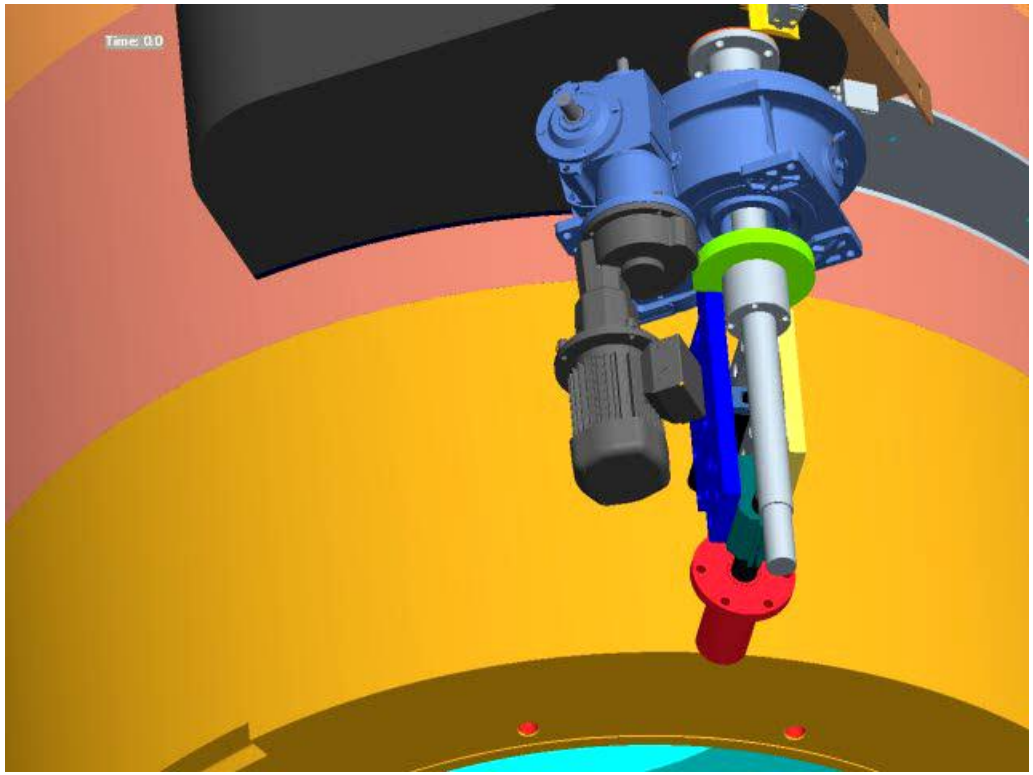
Detector Vessel Motion



Drum Shield Motion



Drum Shield Swinging Arm Lock Motion



Flapping Ears, “Beamstop” and Cam