NEXT-100 PMT Enclosure System

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with much valuable input from (among others):

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Goal: Simplify pressure vessel

- PMT/enclosure modules now fully inside pressure vessel
- mounted on a Cu carrier plate fastened to inside of torispheric head

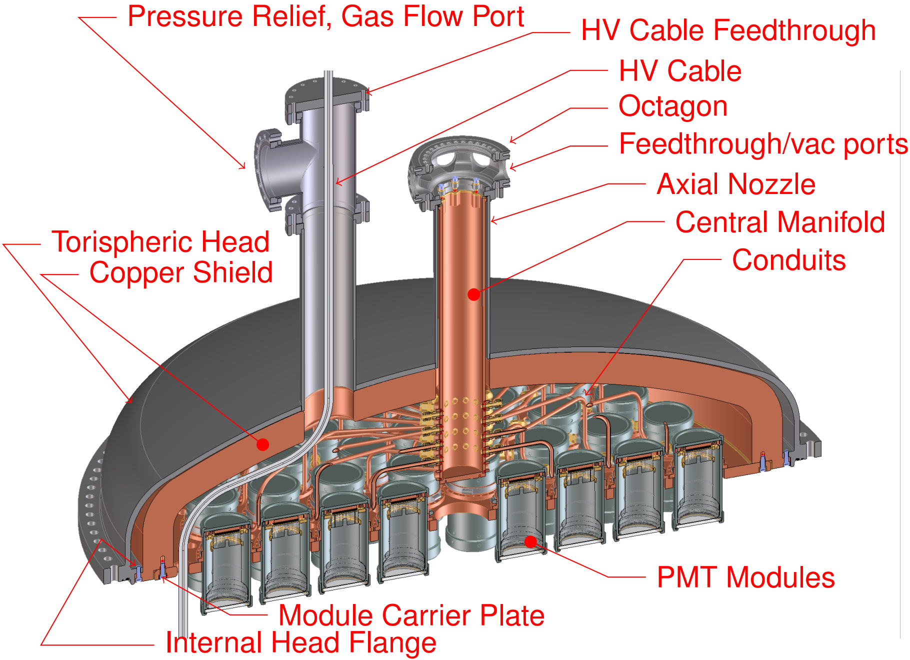
Basic Description of Baseline System

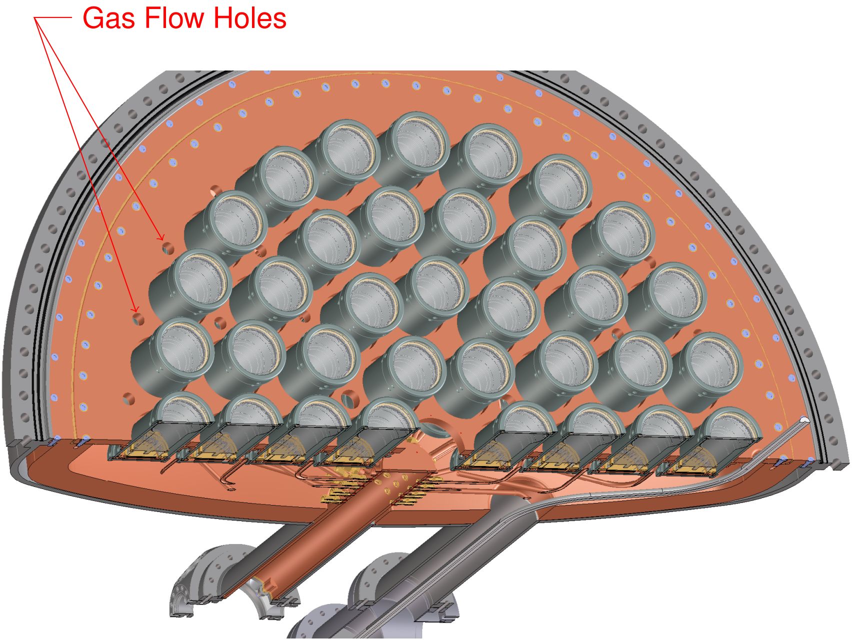
- PMTs (R11410-10) sealed into individual pressure resistant, vacuum tight titanium (Cu OK) enclosures (PMT Module).
- Modules (60 total) mounted to a common carrier plate that attaches to an internal flange of the pressure vessel head.
- Sapphire windows are secured with titanium screw-down rings and O-ring sealed
- PMT bases are potted with heat conducting epoxy to flexible copper heat spreaders thermally connected to enclosures
- PMT cables are enclosed in individual pressure resistant, vacuum tight metal tubing conduits.
- Conduits all lead to a central manifold (vacuum inside), cantilevered from, and sealing to internal flange of axial nozzle

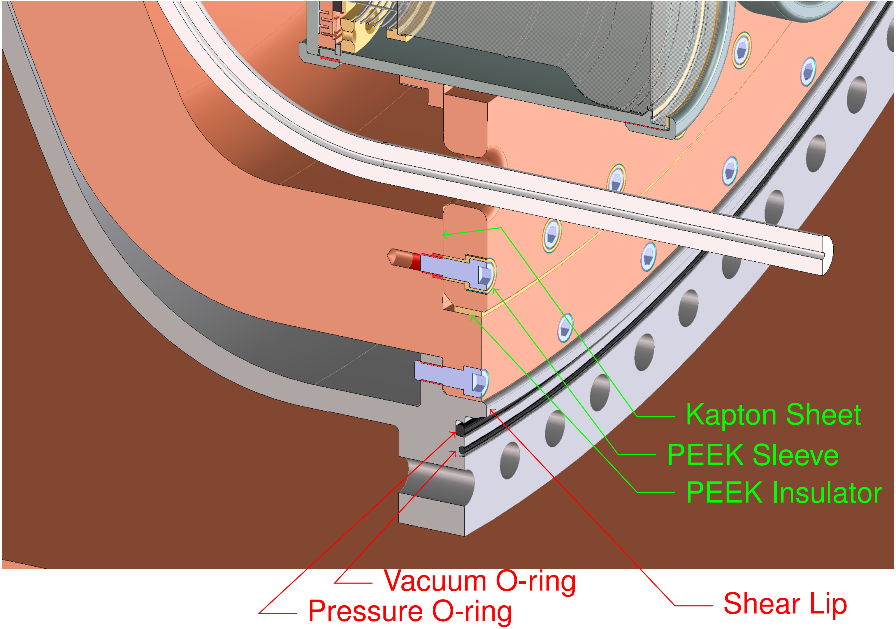
- PMT cables route through central manifold to 41 pin CF feedthroughs on a CF octagon, outside the lead shielding.
- High vacuum($< 10^{-6}$ torr) is applied at octagon port;gives($< 10^{-4}$ torr) inside enclosures.
- Large vacuum tank limits pressure build in central manifold in case of sapphire window failure
- Xenon permeation through seals is recovered with a cold trap.
- Base cooling is by conduction into enclosure and out to vessel flange. (some convection)
- Carrier plate and central manifold can be electrically (but not thermally) isolated from the pressure vessel, if needed.
- Alternately, the cathodes can be grounded, and the anodes and signal run at high positive voltage using only the central 21 pins of each 41 pin feedthrough, to avoid flashover.

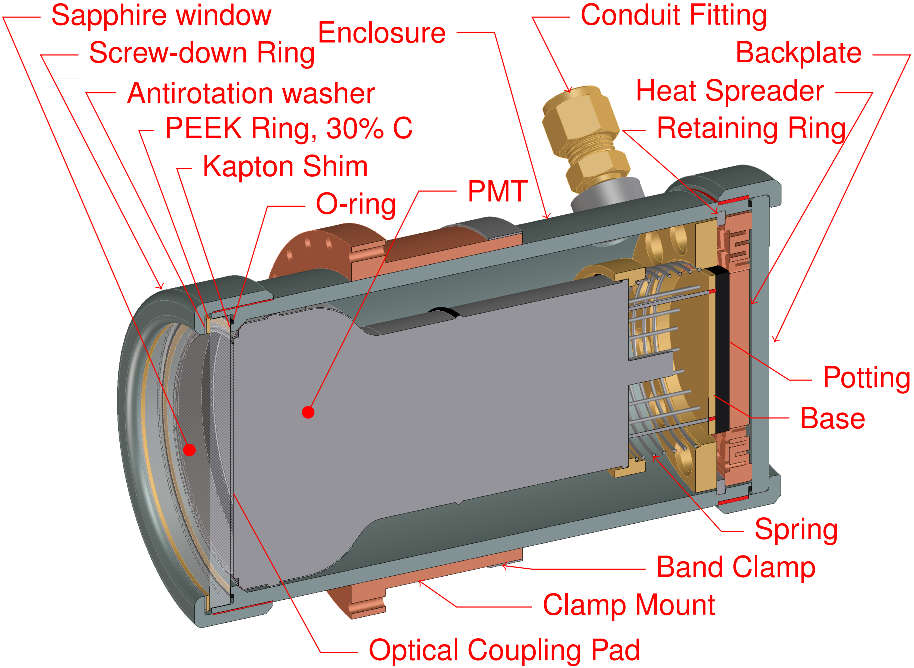
Alternatives Considered

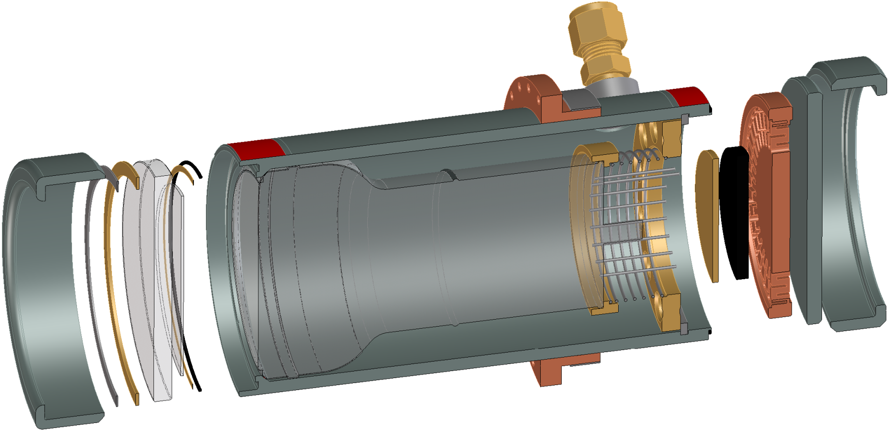
- Hermetically Sealed PMT's
  - Sapphire windows brazed or diffusion bonded to Ti or Nb cans
  - sapphire feedthrough with Nb pins on backplate - weld to enclosure
  - external base
  - long development time needed - high design qualification demands.
  - optical coupling pad perhaps not possible
  - braze possibly not radiopure
- Inert Gas Backfill - better voltage holdoff? better cooling?
  - advantage not clear, vacuum solution seems feasible
  - possible gas contamination of Xe
  - no pressure isolation (PMT to PMT) - check valves needed in conduits
  - difficult to sense Xe leakage
- Common Enclosure single or multiple (making PMT "clusters")
  - Common plate with sapphire window ports
  - pressure isolation very difficult
  - long development time, small prototypes may not show potential problems with full design.

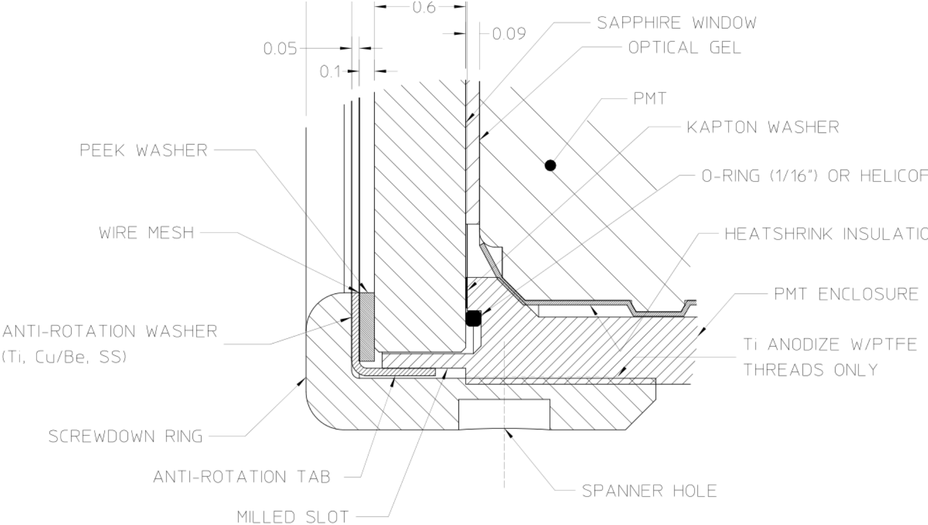

Pressure Relief, Gas Flow Port
HV Cable Feedthrough
HV Cable
Octagon
Feedthrough/vac ports
Axial Nozzle
Central Manifold
Conduits
Torispheric Head
Copper Shield
PMT Modules
Module Carrier Plate
Internal Head Flange

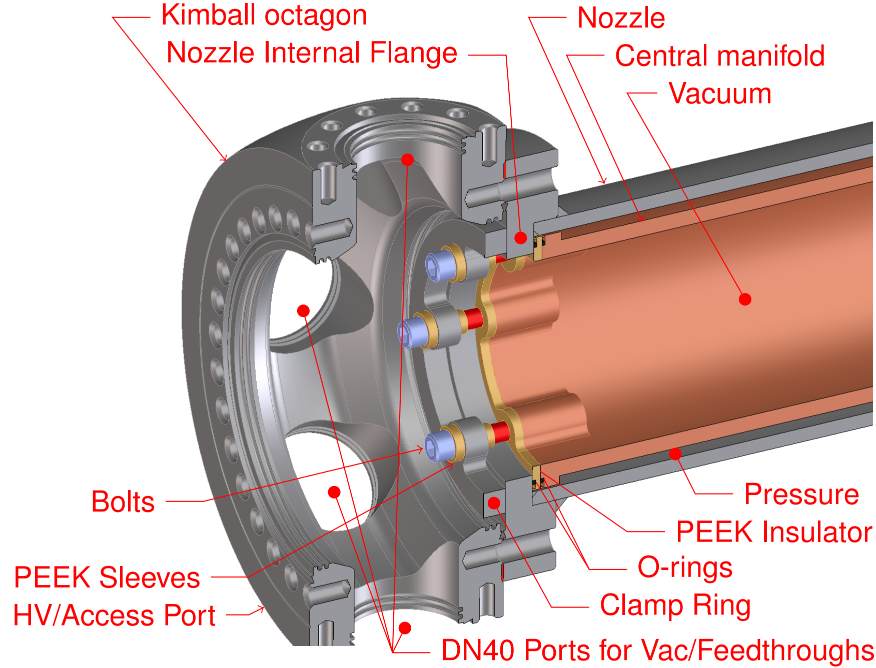

Gas Flow Holes


Kapton Sheet
PEEK Sleeve
PEEK Insulator
Vacuum O-ring
Pressure O-ring
Shear Lip

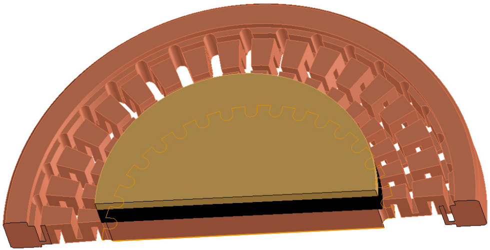

Sapphire window
Screw-down Ring
Enclosure
Conduit Fitting
Backplate
Heat Spreader
Retaining Ring
Antirotation washer
PEEK Ring, 30% C
Kapton Shim
O-ring
PMT
Potting
Base
Spring
Band Clamp
Clamp Mount
Optical Coupling Pad




0.6
0.09
0.05
0.1
SAPPHIRE WINDOW
OPTICAL GEL
PMT
KAPTON WASHER
O-RING (1/16") OR HELICOF
HEATSHRINK INSULATIC
PMT ENCLOSURE
Ti ANODIZE W/PTFE
THREADS ONLY
PEEK WASHER
WIRE MESH
ANTI-ROTATION WASHER
(Ti, Cu/Be, SS)
SCREWDOWN RING
ANTI-ROTATION TAB
MILLED SLOT
SPANNER HOLE

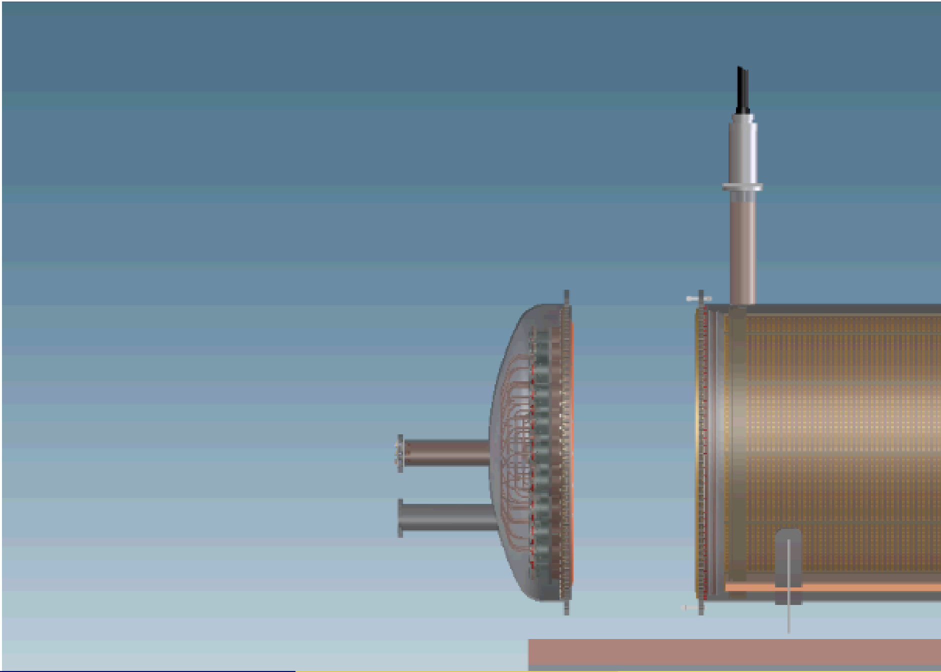

Kimball octagon
Nozzle Internal Flange
Nozzle
Central manifold
Vacuum
Bolts
PEEK Sleeves
HV/Access Port
Pressure
PEEK Insulator
O-rings
Clamp Ring
DN40 Ports for Vac/Feedthroughs

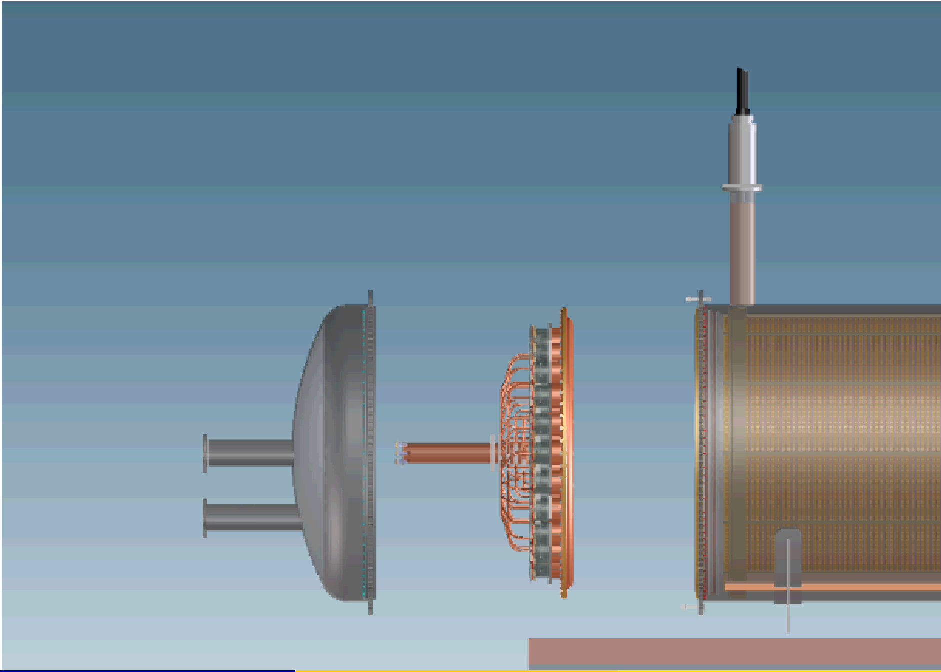
One possibility for conducting base heat to enclosure:

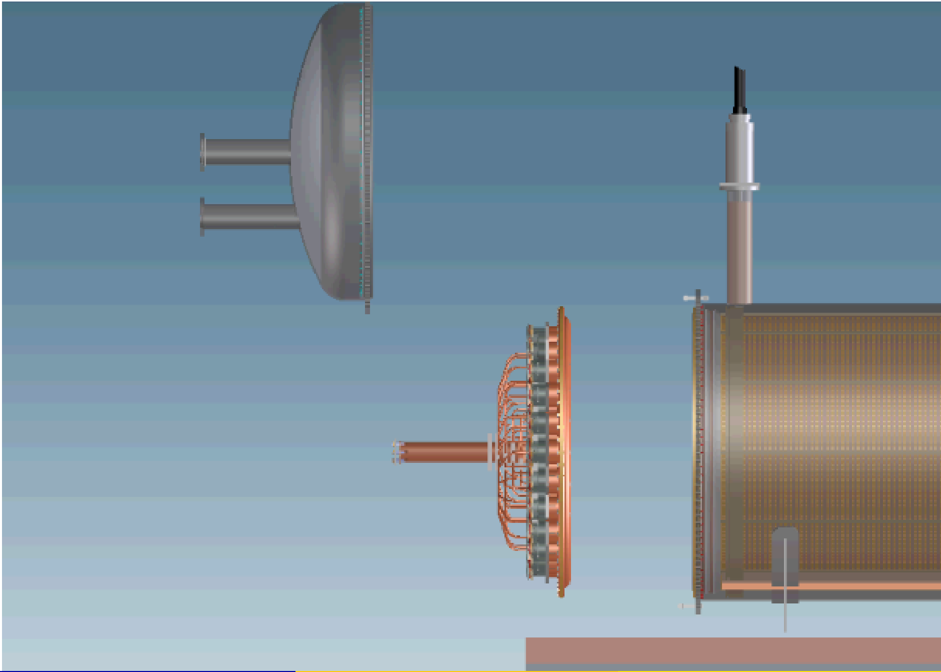


Another possibility: use flat copper braided ground cable

? Do we need to solder bases to pins?







Pressure Resistance

- Enclosure buckling- ASME methodology- 2 mm min thk
- Window thickness determination
  - Use Weibull distribution for acceptance (at a test pressure)
  - Use fracture mechanics to determine test pressure
- Copper tube (1/4” dia.) collapse
  - Buckling - .005” min
  - Ellipticity (0.8 max) at bends – 3 ksi max (bend + press.)

Window strength assurance

- Strength is a strong function of area and finish (as well as intrinsic strength)
- Weibull distribution: failure probability vs. stress-area function
- Sapphire and quartz have well characterized Weibull parameters (moduli and characteristic strength)
- Choose thickness, finish to give low failure probability (5% or less) at a TEST pressure
- Test pressure set to assure: if no failure under test then no failure under fatigue (cyclic or static)
- Pressure Test all windows

Pressure Isolation

- to avoid collateral enclosure pressurization if a window breaks
- Central manifold open to vacuum (emergency recovery tank- 30 m^3)
- 63 gm/s Xe max flow through cable conduit – choked flow condition

Temperature drops PMT(530 mW ea.) to PV conduction, no gas cooling or radiation

Resistor potting	0.23 C	
Heat sink	0.12 C	
Can (Ti)	1.76 C	
Can clamp	0.08 C	
Carrier plate	1.3 C	
Kapton insulation	3.0 C	
PV flange	1.2 C	
TOTAL	7.7 C	

- Windows (3 ea , 5mm thk.) due Jan.
- Fab Enclosure, Screw Rings (Stainless Steel for 1st prototype)
- Design and fab window pressure tester
- Test base and pins for flashover/vac. function
- Test conduits and fittings for robustness
- Measure achievable vacuum inside module
- Design and build enclosure pressure test chamber - for:
    - PMT performance measurements
    - quantify leakage rate
    - check optical coupling integrity under pressure