



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Horizontal Test Stand – 2 (HTS-2)

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PIP-II Collaboration Meeting

9-10 November, 2015

Outline

- Introduction, Requirements
- HTS-2 Facility
- Timeframe

Introduction – Purpose

- PIP-II will require the fabrication of 15 cryomodules containing elliptical cavities operating at a frequency of 650 MHz with two distinct geometrical betas (0.61, 0.92).
- A total of 57 production cavities need to be fabricated, processed, and assembled with He vessels, tuners, & FPCs.
- Some number of these cavities, and some number of prototype cavities, will need to be tested in a facility that allows the evaluation of the (Cavity+HeVessel+Tuner+Power Coupler) entity as a SYSTEM.
- Tuner and coupler development itself, along with potential cooldown schemes for high Q achievement and retention in a CM, can only be fully pursued in a horizontal test facility.
- Horizontal testing has been an integral component of development for ILC, CEBAF 12GeV, XFEL, and LCLS-II, and is being considered for LCLS-II production.

Introduction – Requirements

- A new horizontal test facility at FNAL, called HTS-2, is being established to meet the needs of the PIP-II SRF program.
- Top-level Requirements:
 - Test dressed 650MHz cavities (both beta types)
 - Achieve 2K cryogenic operating conditions
 - Provide RF power and LLRF control & measurement
 - Provide operation capability for tuner
 - Provide diagnostics (thermal, mag field, radiation/dark current)
 - Sufficient margin to operate somewhat above design requirements
- HTS-2 will join 2 other horizontal facilities (HTS-1 (1.3GHz cavities), STC (325MHz cavities)) already operational in the Meson Detector Building (MDB).
 - Substantial fraction of existing cryogenic resources to be shared

HTS-2 Facility – Responsibilities

- HTS-2 is being established at Fermilab as a collaborative effort between Fermilab and the Indian Institutes Collaboration for PIP-II
- A similar horizontal test facility will be established in India @ RRCAT
- We will leverage the developments/contributions being pursued in RF, LLRF, Controls etc., as part of the existing IIFC R&D program for HTS-2
- Joint responsibility for generation/review/approval of Requirements Documents that govern deliverables
- Each institution responsible for development of own infrastructure needed to integrate deliverables and operate the facility, per local guidelines, policies, etc.

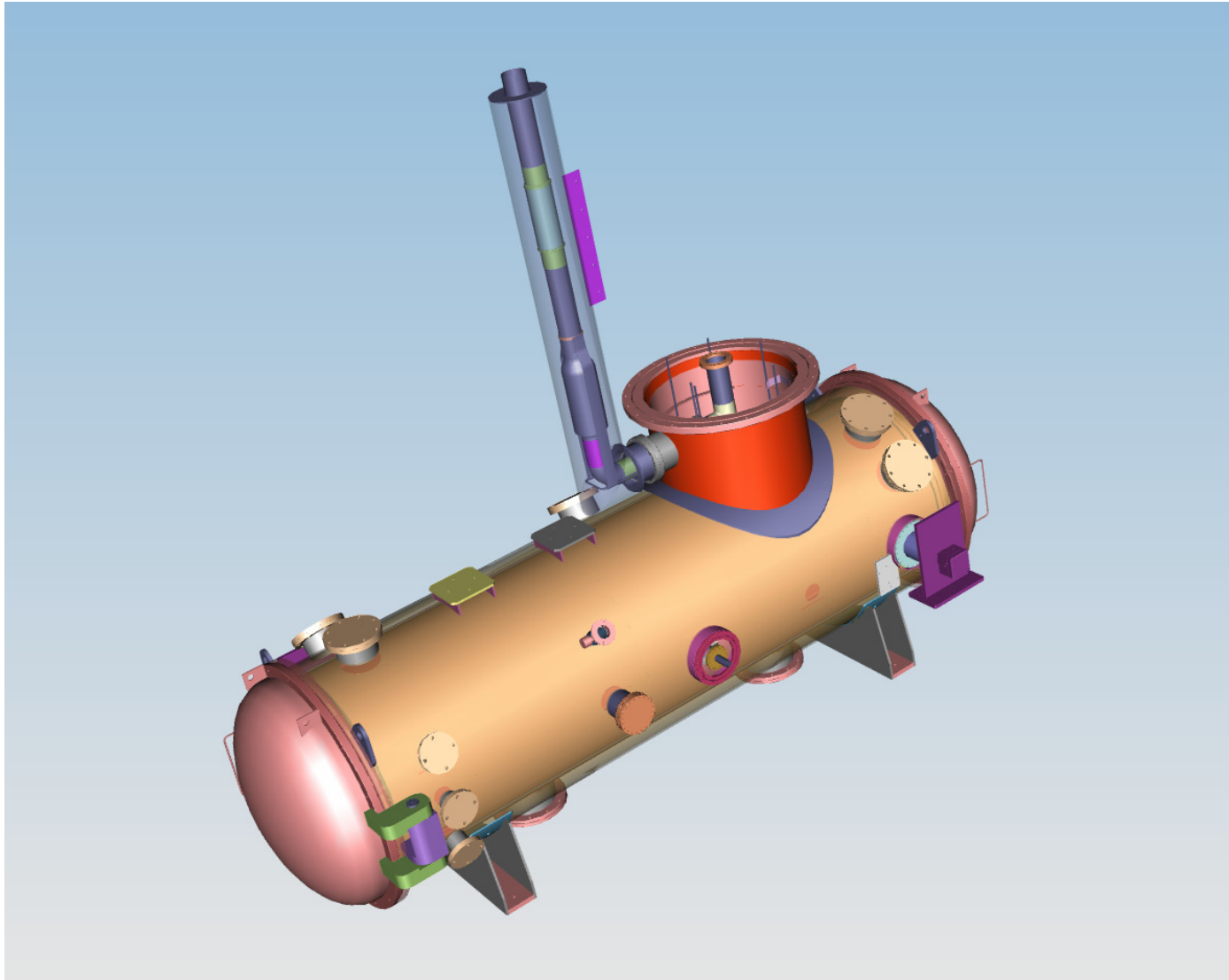
HTS-2 Facility – Details

- Cryostat/Feedcan
 - Based on successful HTS-1 design, with improvements
 - Holds two 650MHz cavities
 - Powered one at a time
 - FPC's at ends
 - 80K shield
 - Separate feed can w/ J-T HX, valves
 - Actively cooled (5K) support rails
 - No 5K shield, multiple 5K intercepts
 - Individual cavity heat load ~33W
- RRCAT designs the cryostat with guidance/input from FNAL (HTS-1 experience), FRS ED0001735, TRS ED0001935
- FNAL designs the feedcan
- RRCAT pursues procurement of fabrication/assembly of 2 units (one eventually delivered to FNAL)

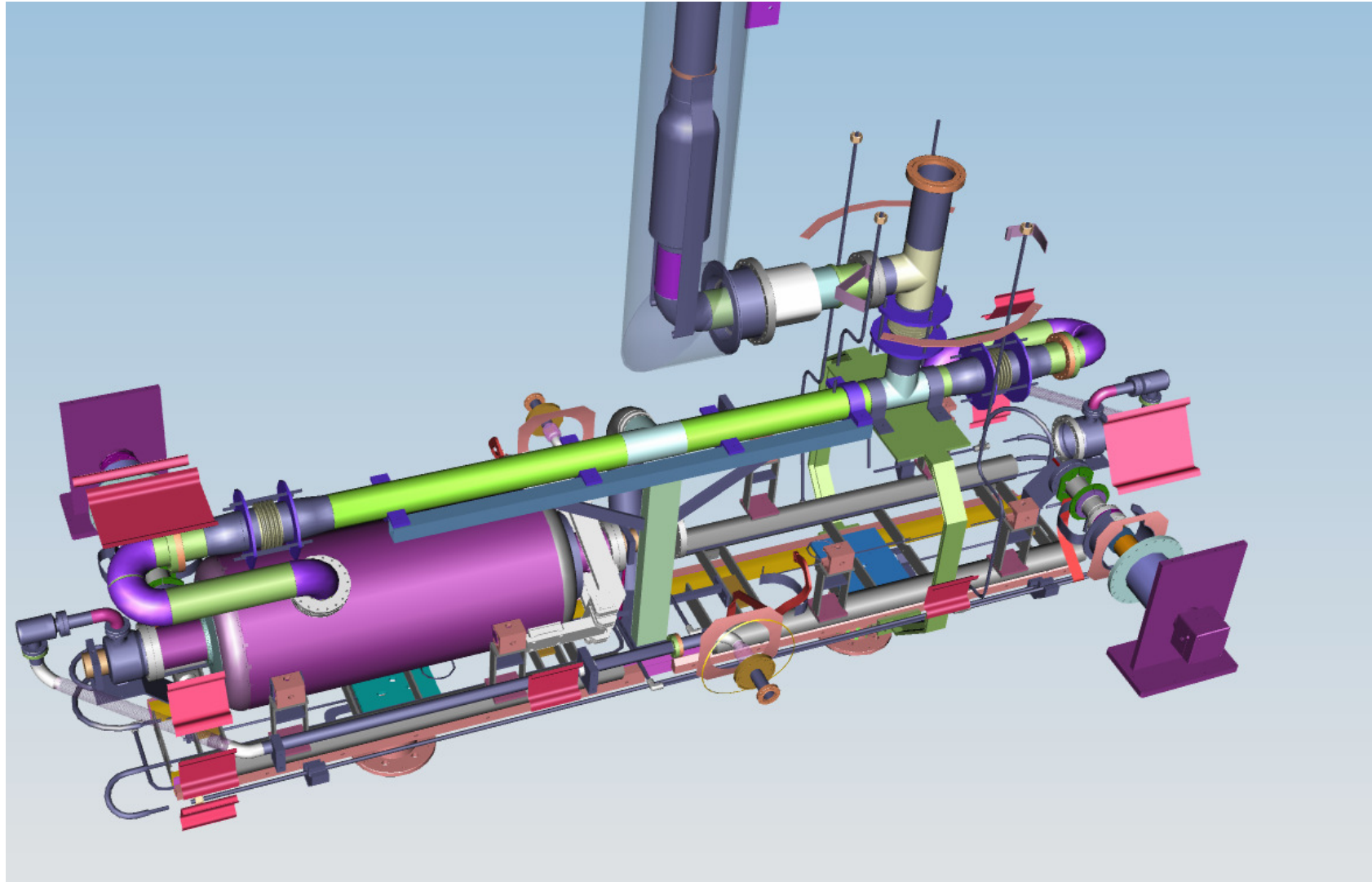
HTS-2 Facility – Details : Cryostat Procurement

- Preliminary Design Review 8/2013
- Intermediate Design Review 11/2014
- Procurement Readiness Review 3/2015
- Fabrication Specification (SOW) for vendors completed end of July 2015
- After internal review FS is now out for vendor bid
 - “Pre-Bid” meeting on 11/20/2015 for vendor Q&A
 - Bids due 12/21/2015, vendor selection begins 12/22/2015
- Based on procurement timeline from RRCAT, expect:
 - Purchase sub-committee and committee approvals by end of Jan 2016
 - RRCAT Council and DAE approvals by mid-April 2016
 - PO placed May 2016
 - Fabrication completed, shipped to RRCAT Feb 2017

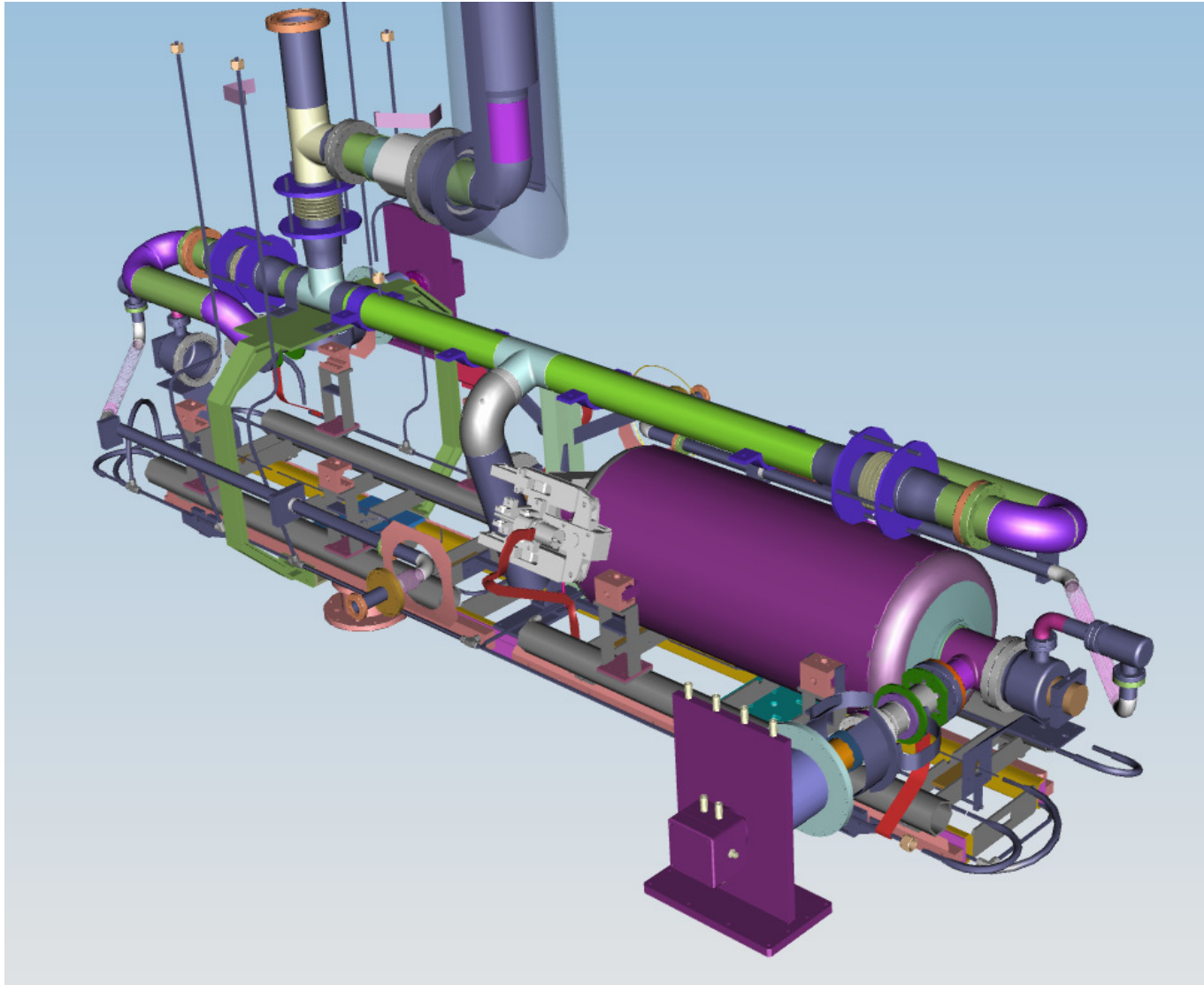
HTS-2 Facility – Details : Cryostat Design



HTS-2 Facility – Details : Cryostat Design (2)

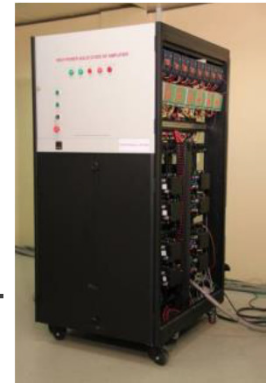


HTS-2 Facility – Details : Cryostat Design (3)



HTS-2 Facility – Details (2)

- HPRF System
 - Solid-State Amplifiers (SSA) being developed by IIFC as part of IIFC R&D effort/deliverables
 - FNAL has developed a FRS for PIP-II Linac (ED0003413)
 - 40kW output power during R&D phase
 - (eventually need 70kW for HB CM operation)
 - 2 40kW SSAs will be deployed for HTS-2 operation at FNAL
 - Prototypes (low power) have been produced and tested
- LLRF System
 - LLRF system being jointly developed by FNAL & BARC for PIP-II; HTS-2 will use the same system
 - Initial design specification and FRS developed, design work underway
 - Will include resonance control circuits and piezo amplifiers for tuner operation
 - But can also be interfaced with RCG development system



HTS-2 Facility – Details (3)

- Controls
 - Again, based upon controls development for PIP-II Linac/Cryomodules already underway as part of IIFC program.
 - Control of cryogenic system (valves, actuators)
 - Interface with LLRF/HPRF/Interlocks
 - HPRF & LLRF not in scope (LLRF system for RF control)
 - EPICS based with interface to ACNET for FNAL
 - Detailed FRS to be developed
- Interlocks/PSS
 - Interlocks developed as part of IIFC effort, use interlock framework for PIP-II
 - Inhibit RF to cavity based on parameter values, e.g.,
 - Cavity/coupler vacuum exceed threshold
 - Coupler arcs or e- activity detected
 - Coupler temperatures above threshold

HTS-2 Facility – Details (4)

- Diagnostics/Instrumentation
 - HTS cryostat and cryogenic distribution instrumented with RTDs, pressure & vacuum transducers, etc. (cryostat /feedcan instrumentation specified in TRS and FS)
 - Additional cavity & coupler test diagnostics to be finalized. Includes:
 - Cavity RTDs
 - Cavity fluxgates
 - Cavity and coupler vacuum sensors
 - Coupler RTDs, IR sensor, e- pickup
 - Faraday cups (dark current measurement)
 - Radiation detectors (field emission detection/measurement)
 - Interfaced to controls/data logging via ACNET or EPICS; GPIB, serial and Ethernet interfaces

HTS-2 Facility – Details (5)

- Conventional Infrastructure
 - LCW systems for SSA cooling
 - HVAC systems for ODH mitigation
 - Shielded test cave, access controls for personnel protection
 - Racks, cable trays, RF distribution
- Requirements for conventional infrastructure under development.
 - Facility layout/design to proceed in 1QFY16.
- Test cave laid out
 - Electrical distribution & lighting in place
 - Prepare for floor and block painting
 - Roof design preliminary
 - Need structural analysis
 - Verify radiation protection requirements

HTS-2 Facility – Details (6)

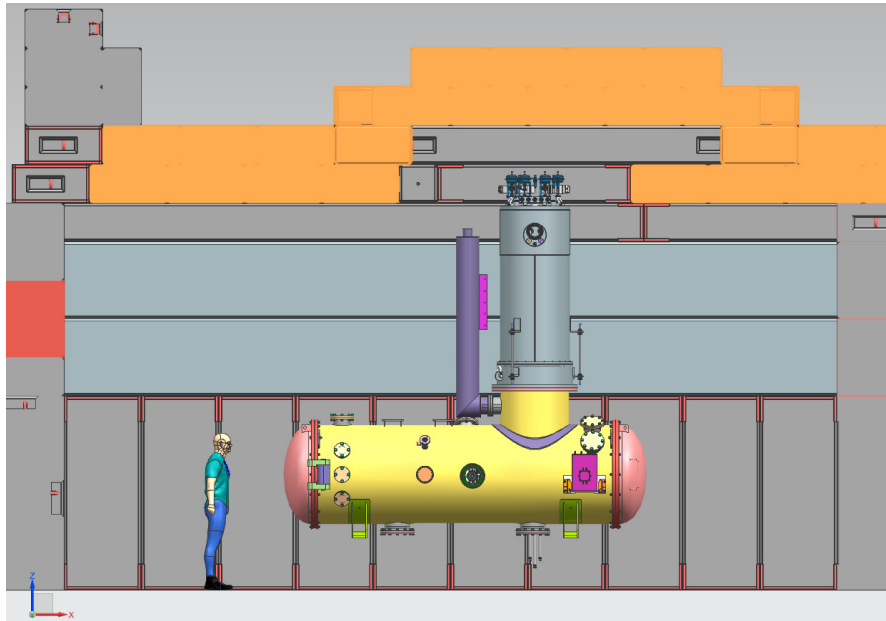


AC power distribution and lighting has been added to the cave.

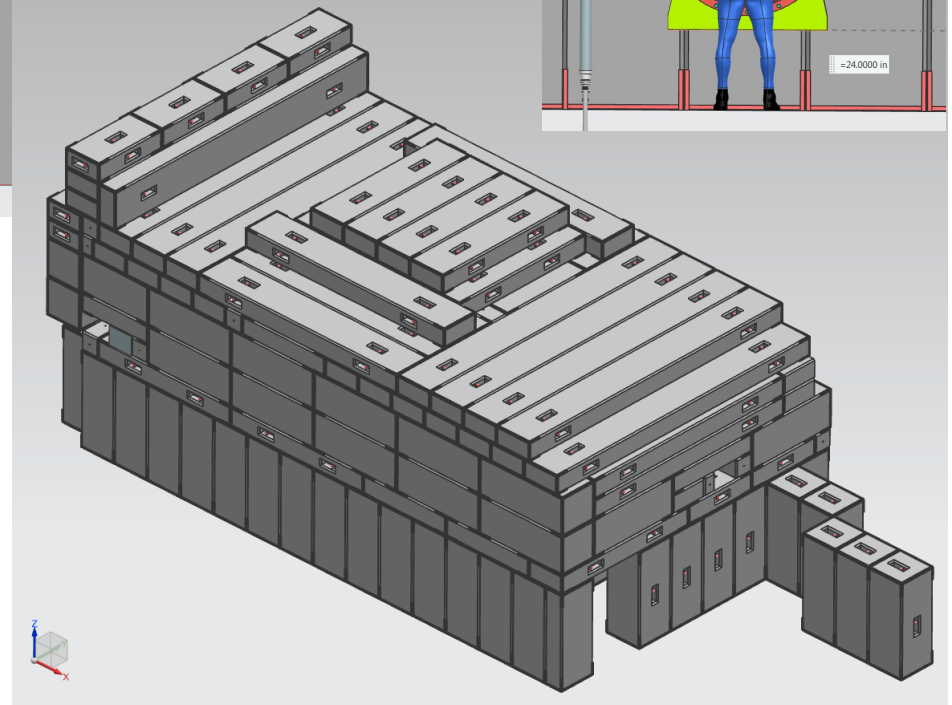
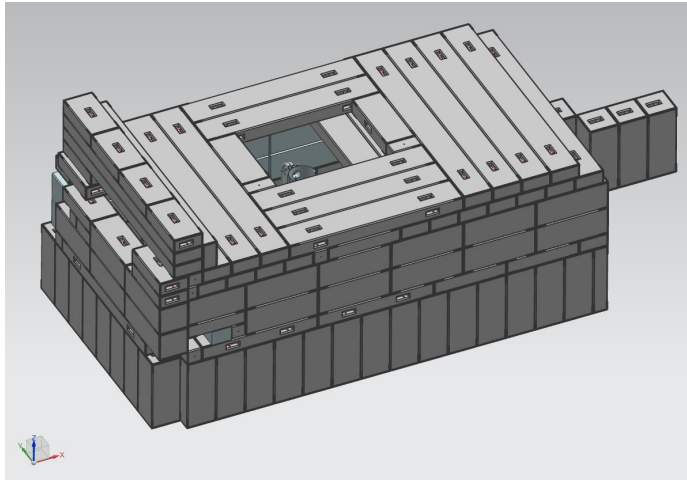
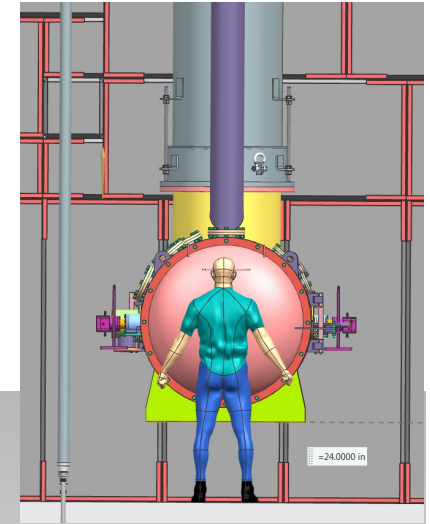
Floors have been prepared for epoxy coating later this month.



HTS-2 Facility – Details (7)



Cave layout with cryostat raised off floor 24", roof modified to provide maintenance access to feedcan



HTS-2 Facility – Timeframe

- IIFC deliverables defined, per R&D agreement:
 - Interlocks – 10/31/2016
 - Controls – 12/31/2016
 - HPRF – 6/30/2017
 - Integration of FC/Cryostat w/RF, cryo, controls @ RRCAT – 7/31/2017
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 - 1st cavity test at HTS-2 at FNAL – 3/31/2018
- What do we need to do to get from Integration @ RRCAT to test @ FNAL?
 - Lots!

HTS-2 Facility – Timeframe (2): FNAL Tasks

- Preparation of infrastructure for FY17 delivery and FY18 commissioning of HTS-2 cryostat
 - Conventional facilities
 - LCW & HVAC
 - Shielding blocks (roof), access gates, PSS systems
 - Racks, cable trays, control room
 - Removal of equipment to provide adequate room
 - Cryogenic systems
 - Install cryo and air/GHe/GN₂ distribution and 2K pumping lines
 - Install control lines, cables, instrumentation
 - Ancillary systems (vacuum pumping, magnetic shielding, etc.)
 - Cavity and coupler pumping stations
 - Insulating vacuum pumping station
 - Design and fabrication of internal magnetic shielding (not in original scope)

HTS-2 Facility – Timeframe (3) : FNAL FY16+ Effort

- FNAL (local) deliverables for FY16 – based on outcome of PIP-II Budget Retreat and Budget Planning
 - Minor preparation work for facility, complete designs/layouts
 - Complete facility design
 - Procure & install racks/cable trays
 - Spec & install LCW
 - Mechanical installation of cryo distribution
 - Magnetic shielding design
- 1.3FTE /110k\$ M&S
- Remainder to be performed during FY17/18, contingent upon budget/resource availability
- Overall cost (M&S) projected at 735k\$, effort at 4.3 FTEs.
 - Shielding blocks, racks, cable trays & cabling, HPRF distribution components, 2K pump skid, safety system infrastructure (gates, chipmunks, interlock HW), cavity & coupler vacuum systems (cavity/coupler/ins vac), HVAC (ODH fans), LCW system, magnetic shielding.

HTS-2 Facility – Summary

- A new horizontal test facility at FNAL, called HTS-2, is being established to meet the needs of the PIP-II SRF program, as a collaborative effort between Fermilab and the Indian Institutes Collaboration for PIP-II.
- We will leverage the developments/contributions being pursued in RF, LLRF, Controls etc., as part of the existing IIFC R&D program for HTS-2.
- Fabrication Specification (SOW) for HTS-2 cryostat completed end of July 2015 and after internal review is now out for vendor bid.
 - Expect fabrication completed, shipped to RRCAT Feb 2017
- FNAL is preparing the facility to accept an integrated HTS-2 and commission it in FY18.
- First dressed 650MHz cavity test planned for 1st quarter CY2018.

HTS-2 Facility – Acknowledgments

Thanks go to the entire HTS-2 (Feedcan/Cryostat) Team:

P. Kush, P. Khare, S. Gilankar, R. Ghosh, A. Jain, A. Laxminarayanan,
R. Chaube – RRCAT

M. Geynisman, A. Hocker, D. Mitchell, V. Poloubutko, C. Reid – FNAL