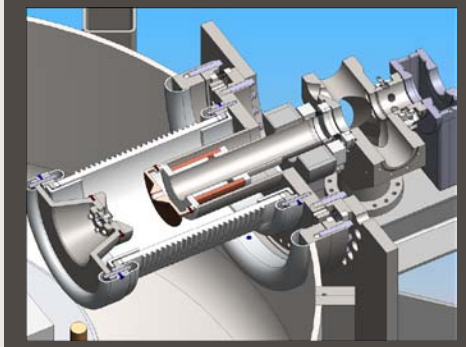
TRIUMF

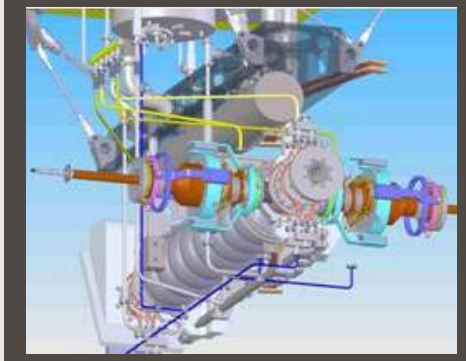
Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

ARIEL Buildings Construction and Electron Linac Photo-Fission Driver for the Rare Isotope Program at TRIUMF

IPAC'12, 2012 May 21

Yu-Chiu Chao for e-linac team

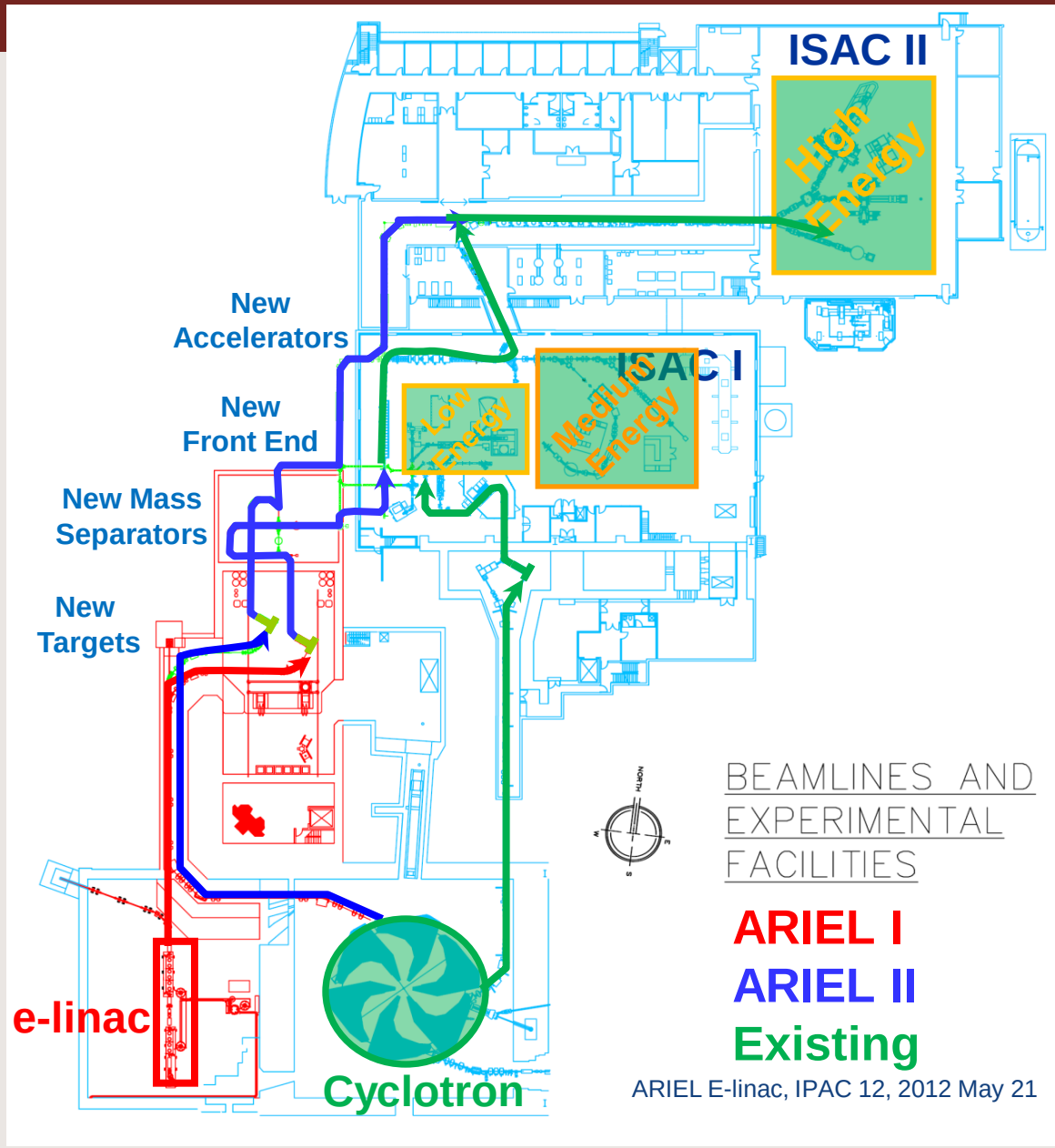




Outline

- **Motivation – RIB science at ISAC**
- **ARIEL Civil Construction**
  - Stores & Badge Buildings
  - Compressor Building
  - ARIEL Targets and RIB Building
  - E-hall renovation
- **E-linac (the machine)**
  - E-Gun
  - ELBT at VECC test area
  - Cryomodules
  - Cryogenic System
  - HPRF
- **Conclusion**

ARIEL triples RIB science at ISAC



10-Year Vision: expanded RIB program with:

- three simultaneous beams
- increased number of hours delivered per year
- new beam species
- increased beam development capabilities

Implementation:

- Complementary electron linac driver for photo-fission
- New target stations and front end
- New proton beamline
- Staged installation

Site Preparation: demolition, relocation, construction

- 2011 October
- CONGESTED SITE
- Old Stores &RH Demolition
- Excavation and shoring
- Makes way for ARIEL building

New GHe compressor building

New Badge building

New Stores building

New Stores Bldg

Ground Breaking:
2011 March

Completion:
2011 September

New Badge Building

Construction started:
2011 August

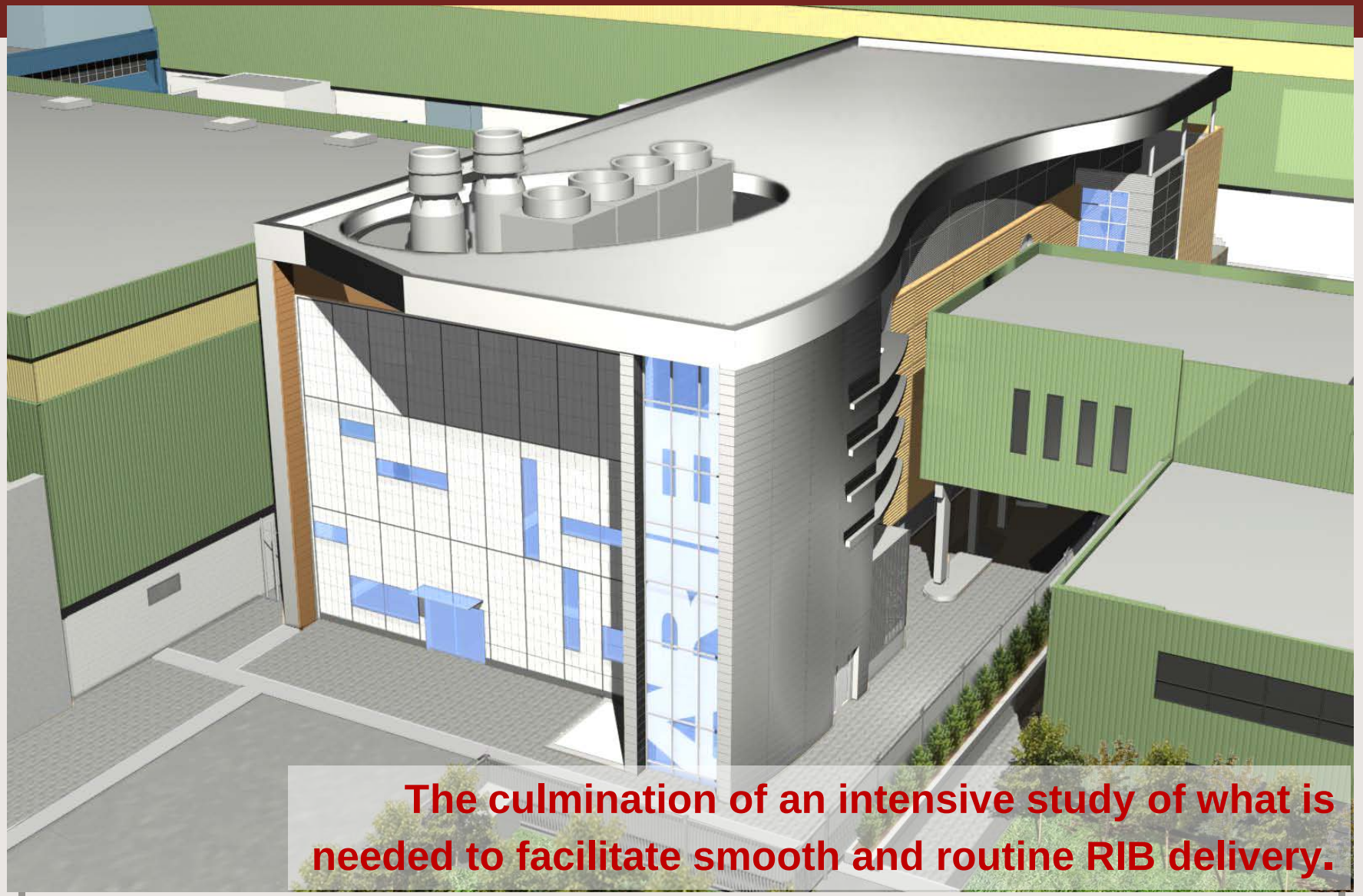
Occupancy:
2011 November

Helium Compressor Building

Ground breaking: 2012 March

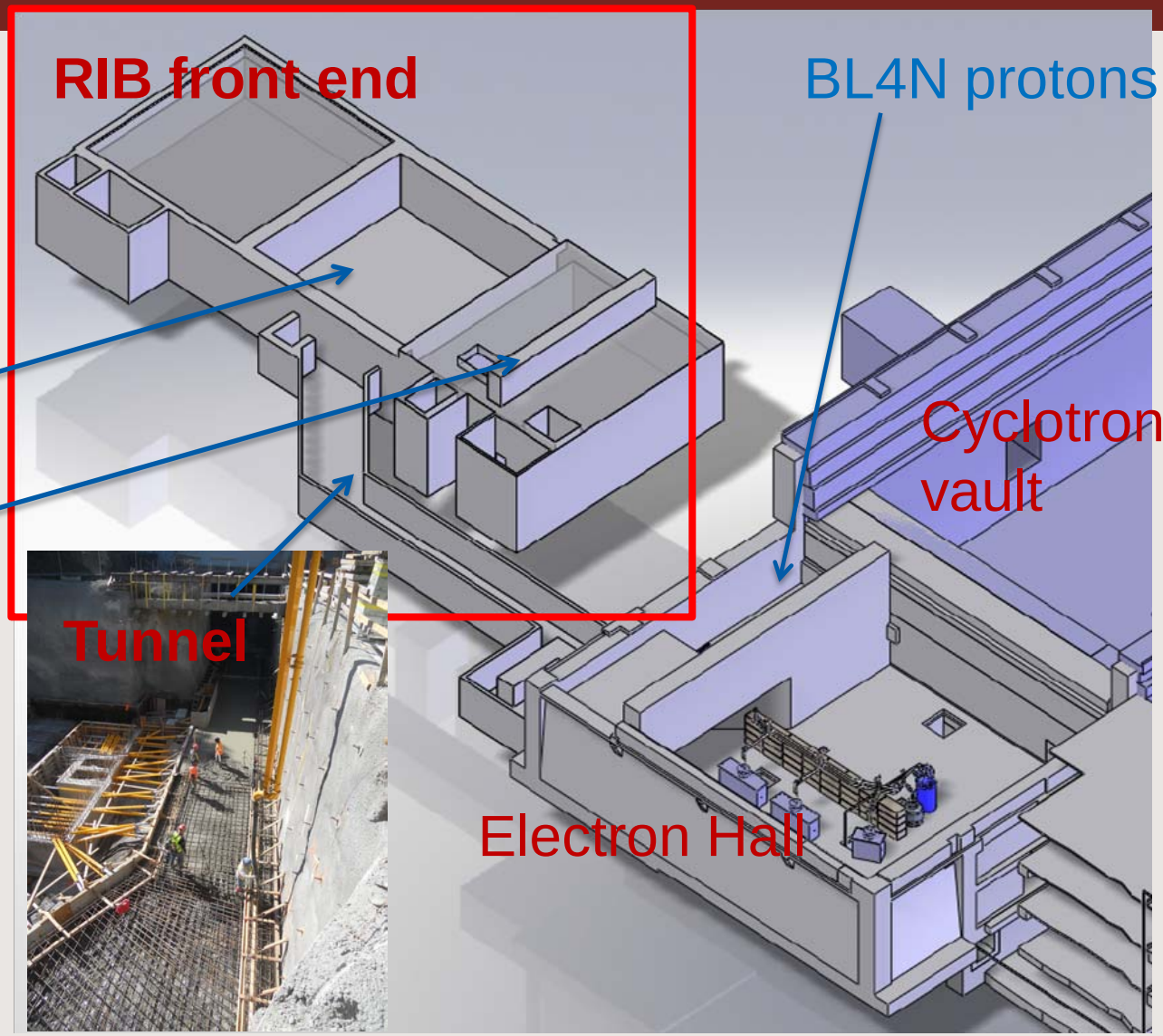
- Foundations: 2012 May
- **Expect occupancy: 2012 December**

ARIEL building design



The culmination of an intensive study of what is needed to facilitate smooth and routine RIB delivery.

ARIEL Layout – below ground



Actinide Annex

Excavation, Shoring, Construction

Excavation started: 2011 November

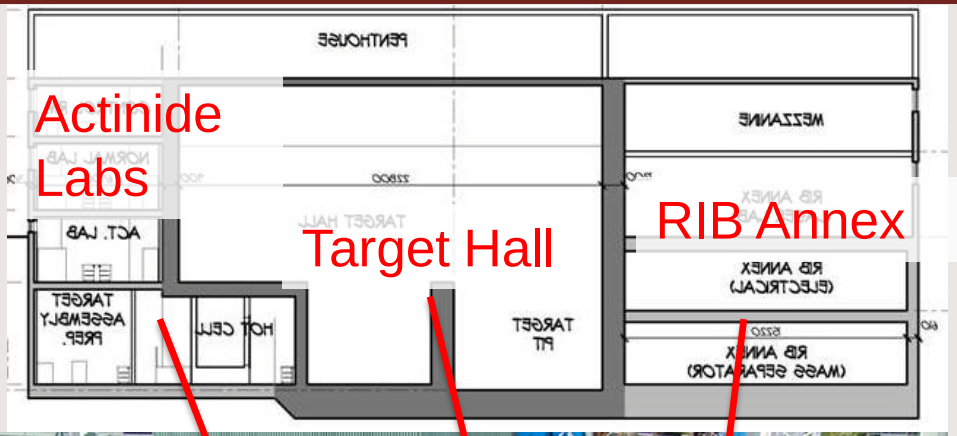
Tunnel

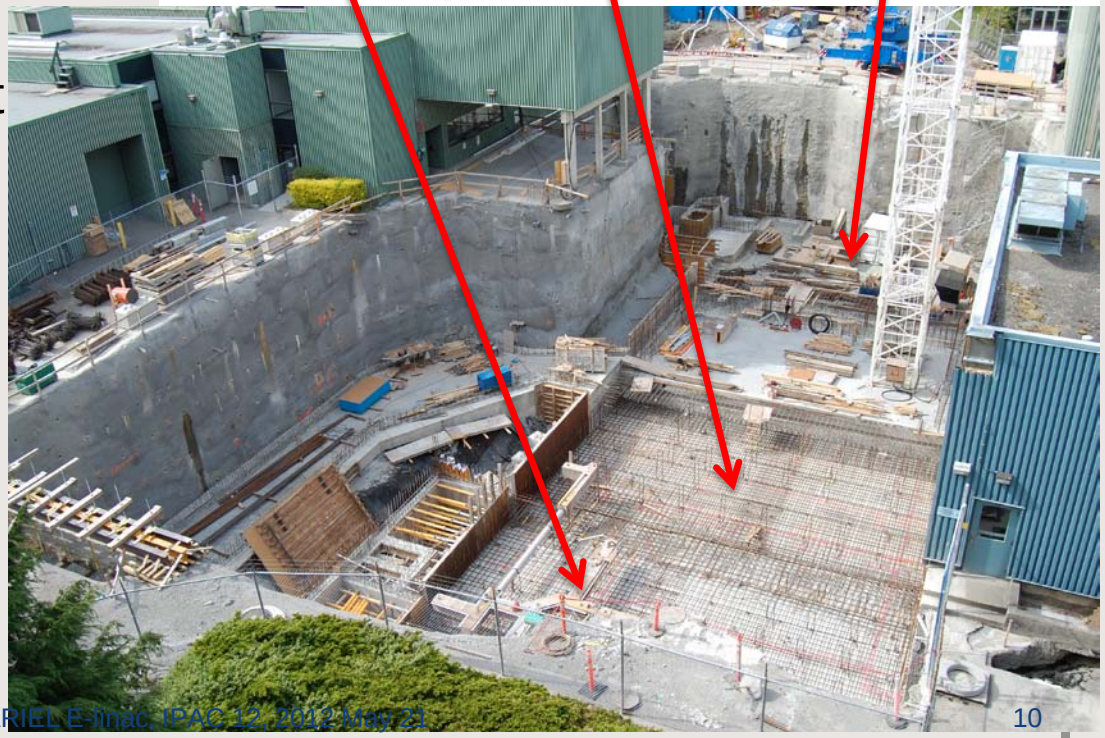
RIB front end

ARIEL site: 2012 Jan

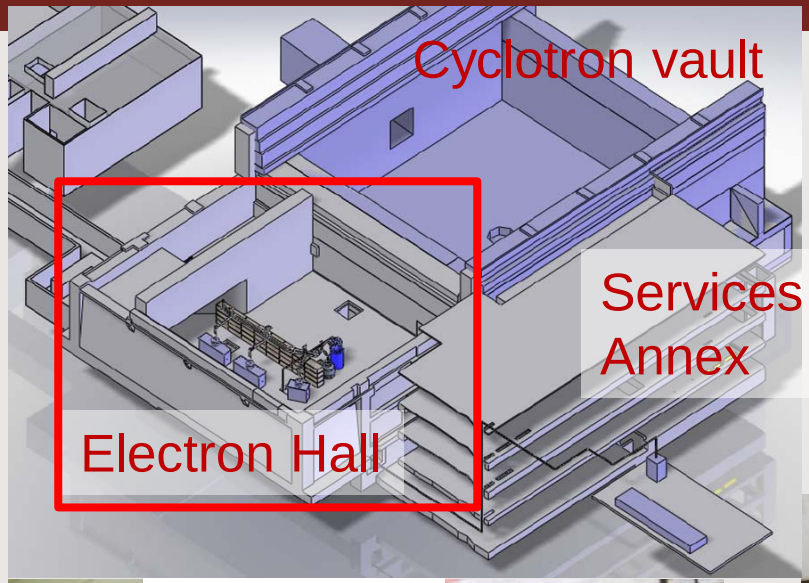
Building occupancy expected: 2013 April

ARIEL site: 2012 May



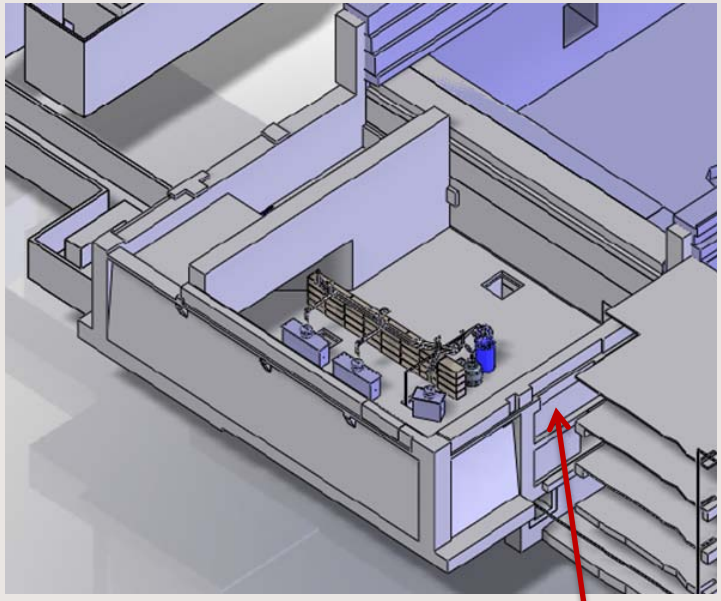


Electron Hall Renovation: Cleanout



- Proton hall clean up complete 2012 Feb
- Construction underway 2012 March
- Expect occupancy 2012 October

Electron Hall Renovation: South shield wall



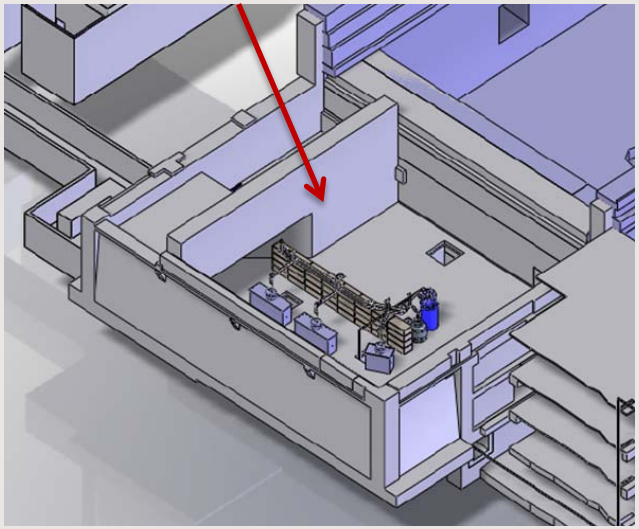
- Shielding upgrades
- South wall B2 up to ground for ERL/RLA operation.

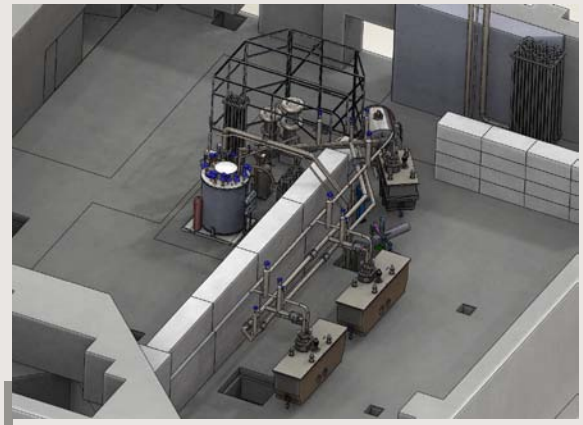
1st concrete pour 2012/March

Final S. wall pour, 2012/April

Electron Hall Renovation: North shield wall

- Poured-in-place concrete
- N. Wall (shield e-hall from BL4N)



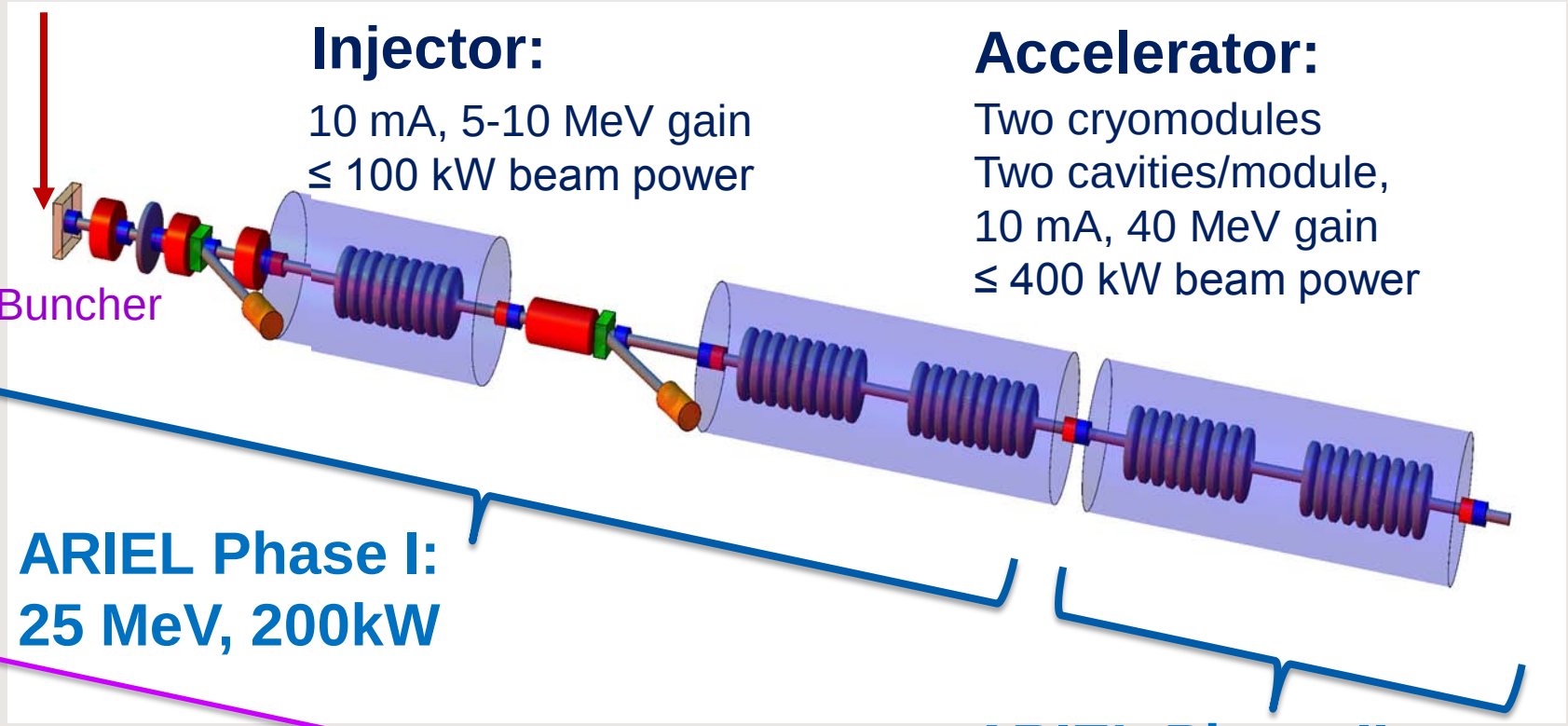


Rebar for N shield wall, 2012/April

1st pour cured 2012/May

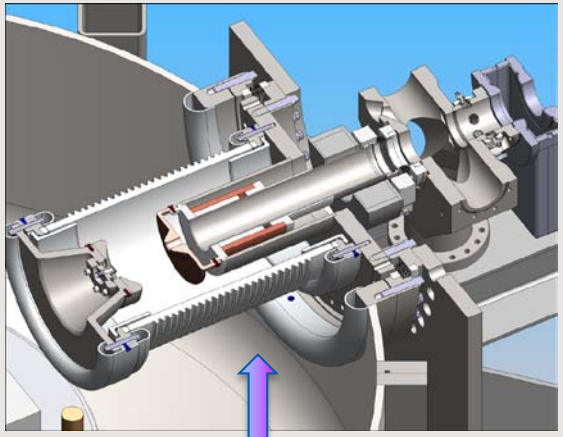
E-Linac: Accelerator Overview

300 keV thermionic gun:
650 MHz modulated

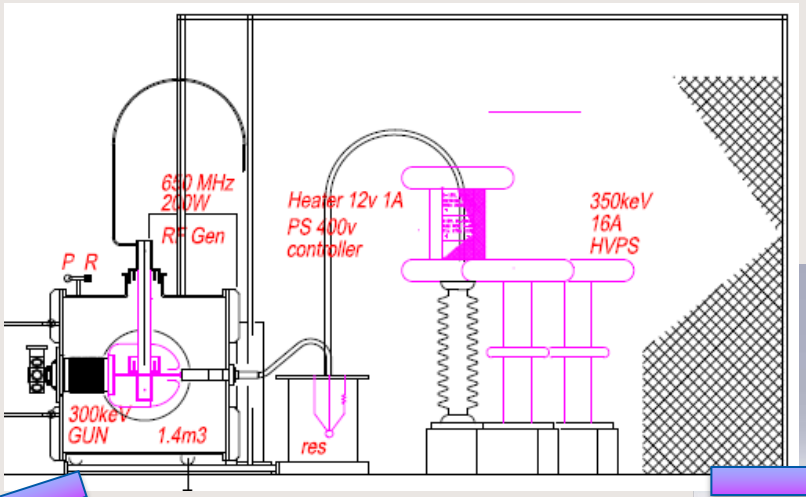


300 kV 10 mA Electron Gun

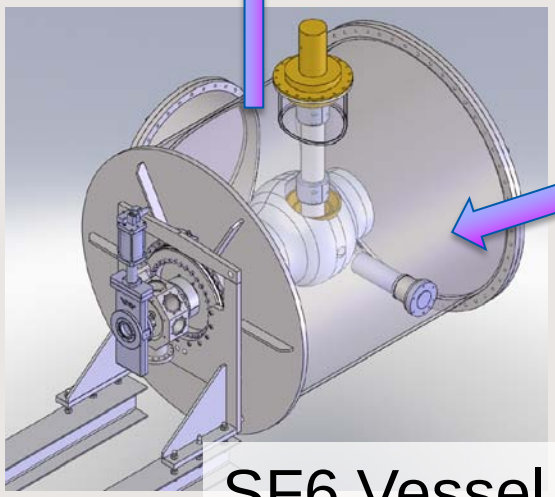
Gun assembly



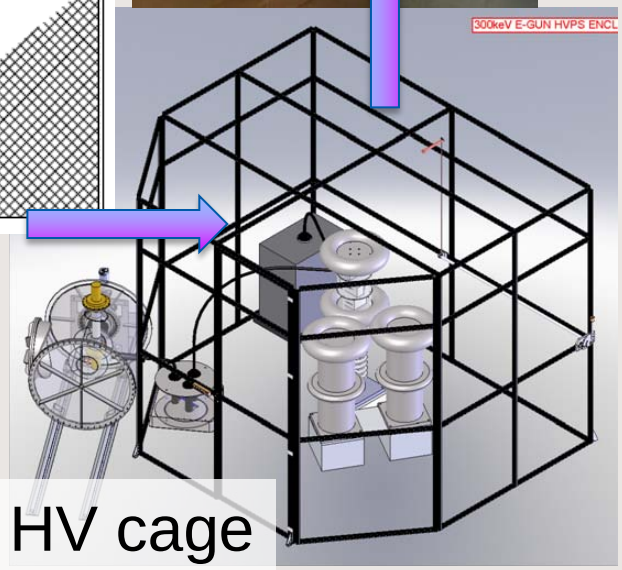
- **Detail design mostly complete**
- **Procurements in progress**
- **Installation begins: 2012 Sept**



HVPS



SF6 Vessel



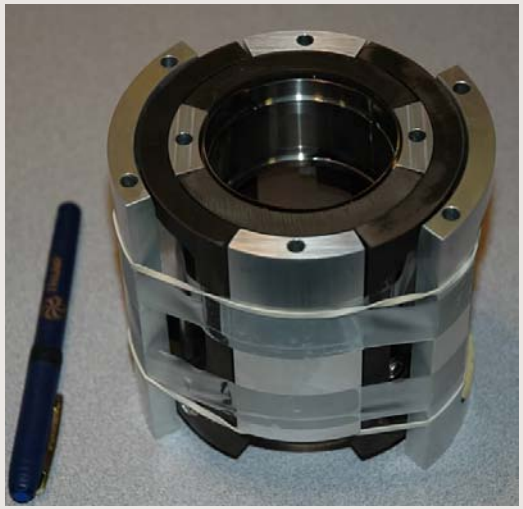
HV cage

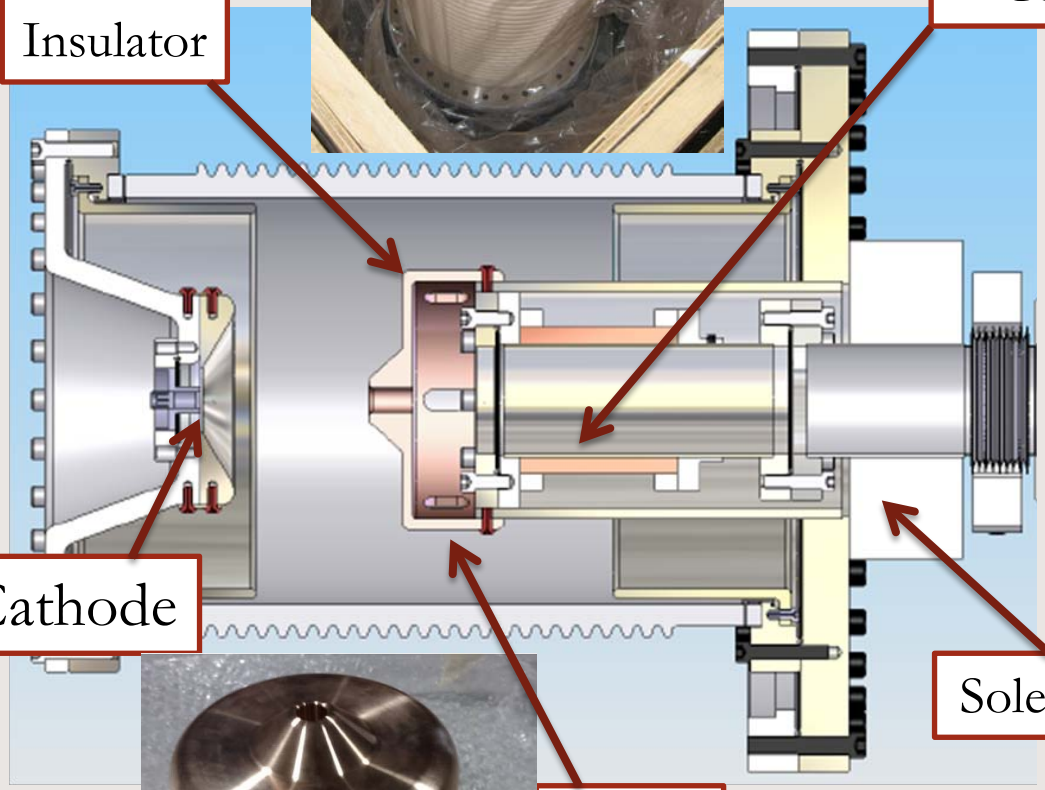
Many long lead items already delivered:
Ceramic, HVPS, ITX, RF Cathodes, Steering coils

Gun Components

Ceramic Insulator

Steering Coil





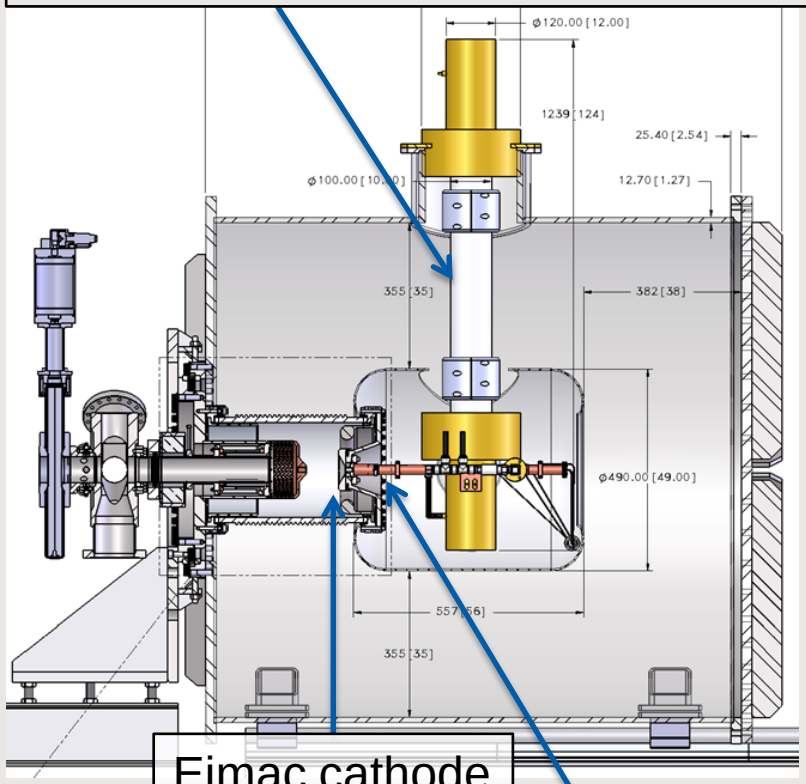
Cathode

Solenoid

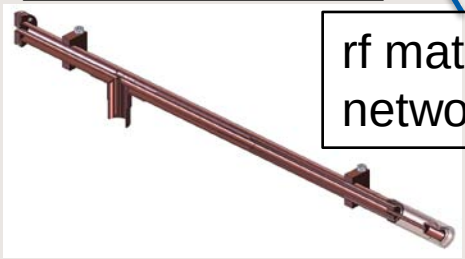
BeCu Anode

SF6 vessel & Gun RF modulation

RF horns and ceramic waveguide

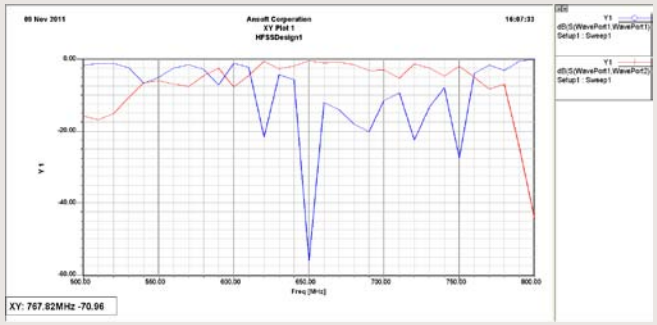


Eimac cathode



rf matching network

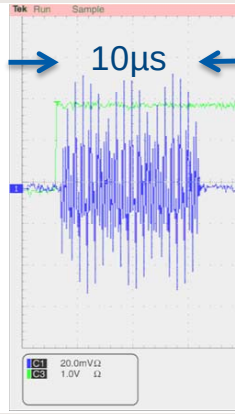
Successful dielectric waveguide R&D program with scale model & HFSS



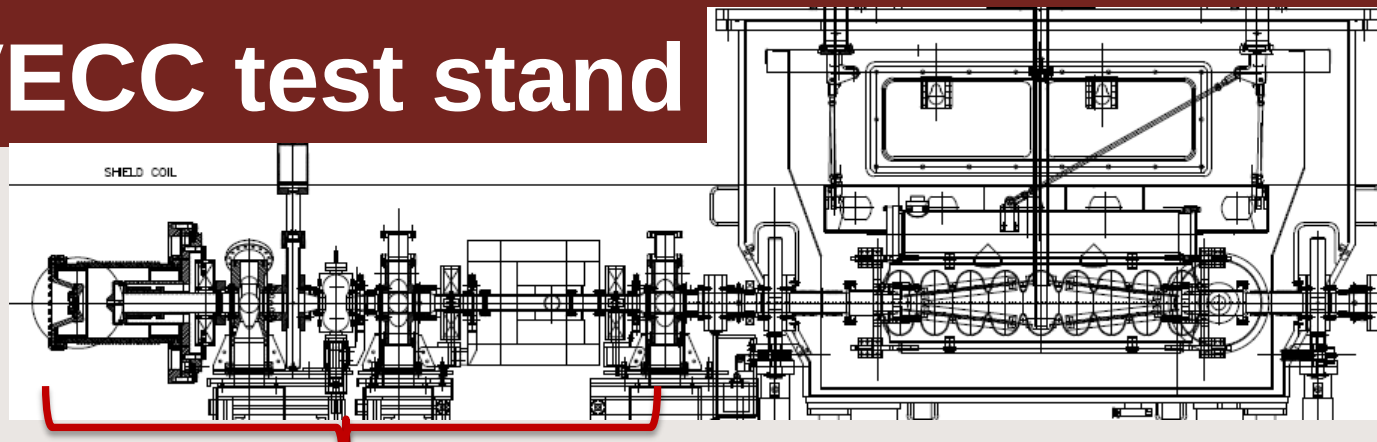
Transmission optimized at 650 MHz

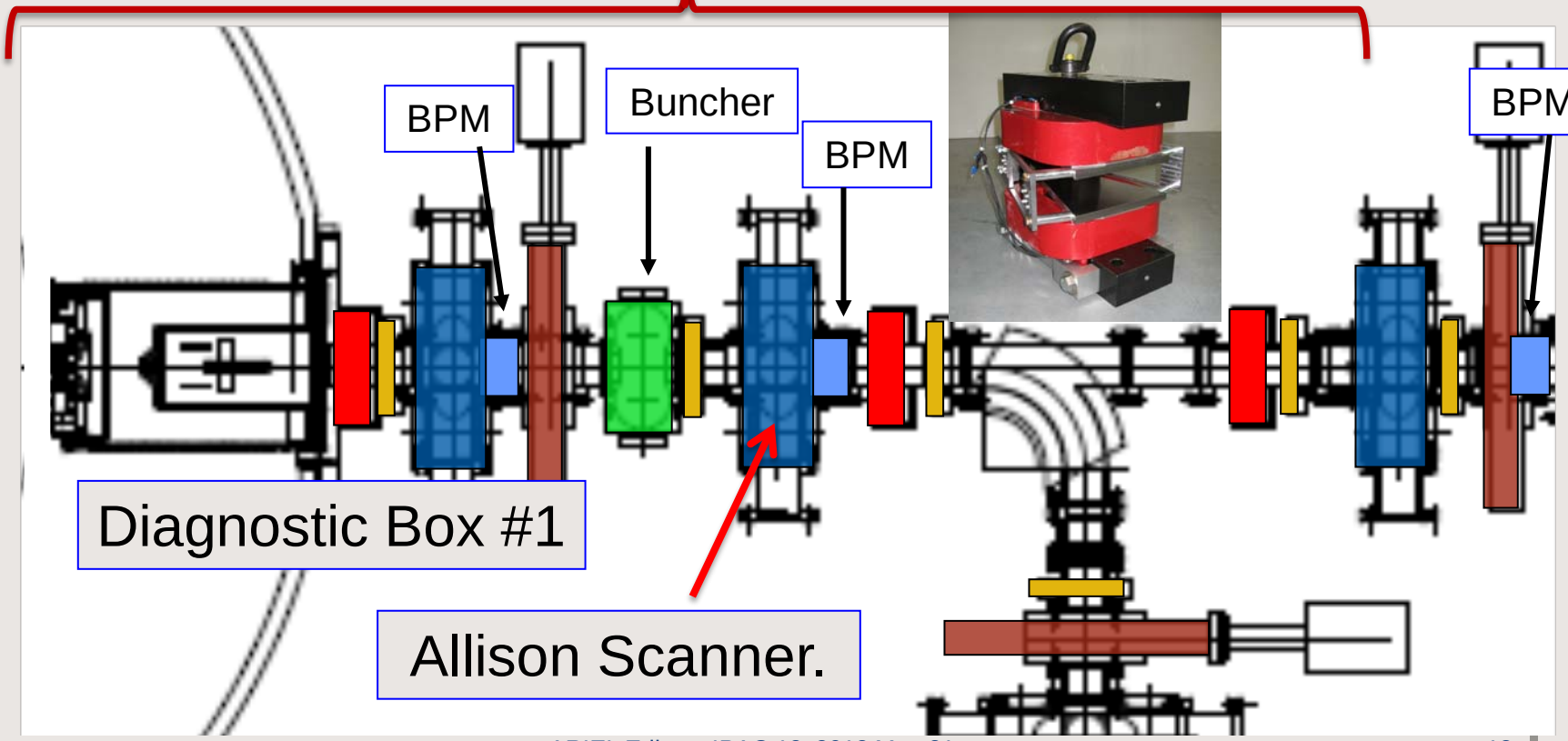
RF modulation on 100kV prototype makes bunched beam at 650MHz

RF power on grid used to generate duty factors 0.1% to 99.9% at rep rates 100Hz to 1kHz

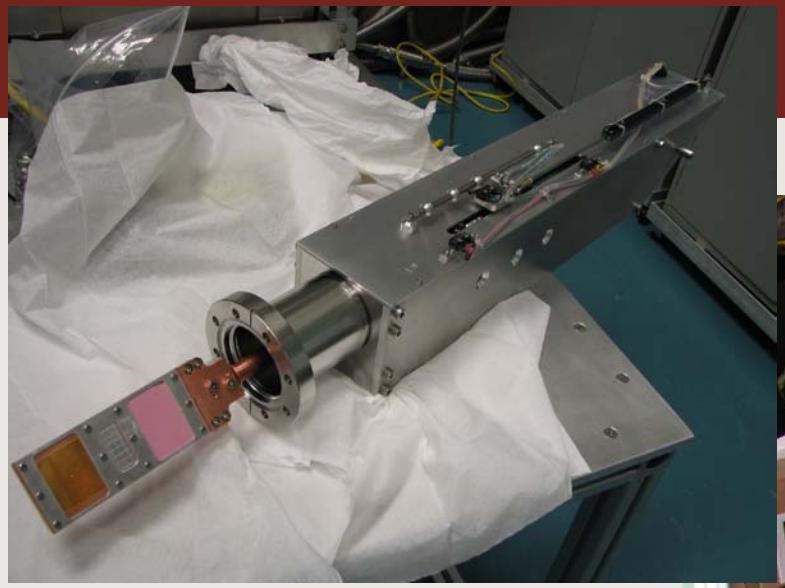


ELBT at VECC test stand



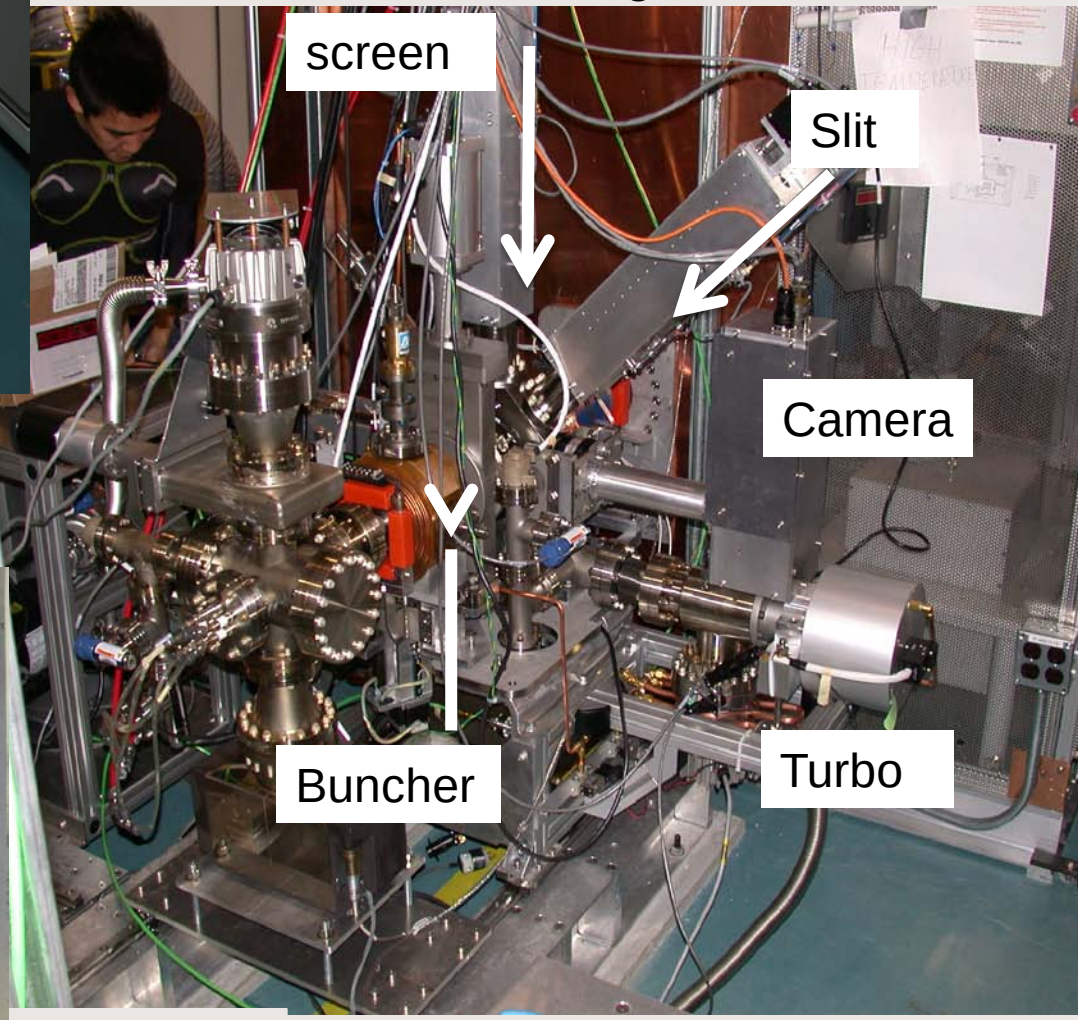


Test 1 Configuration

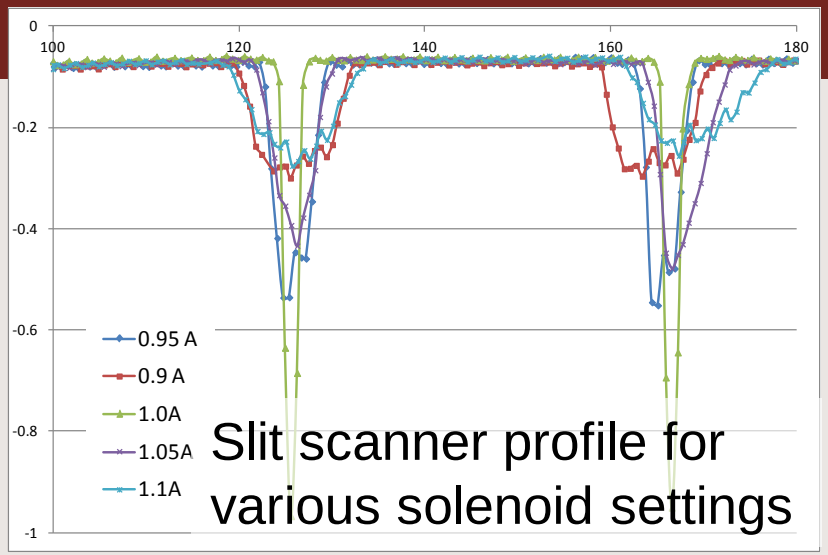


University of Victoria View Screen Profile Monitor

100kV e-gun & solenoid

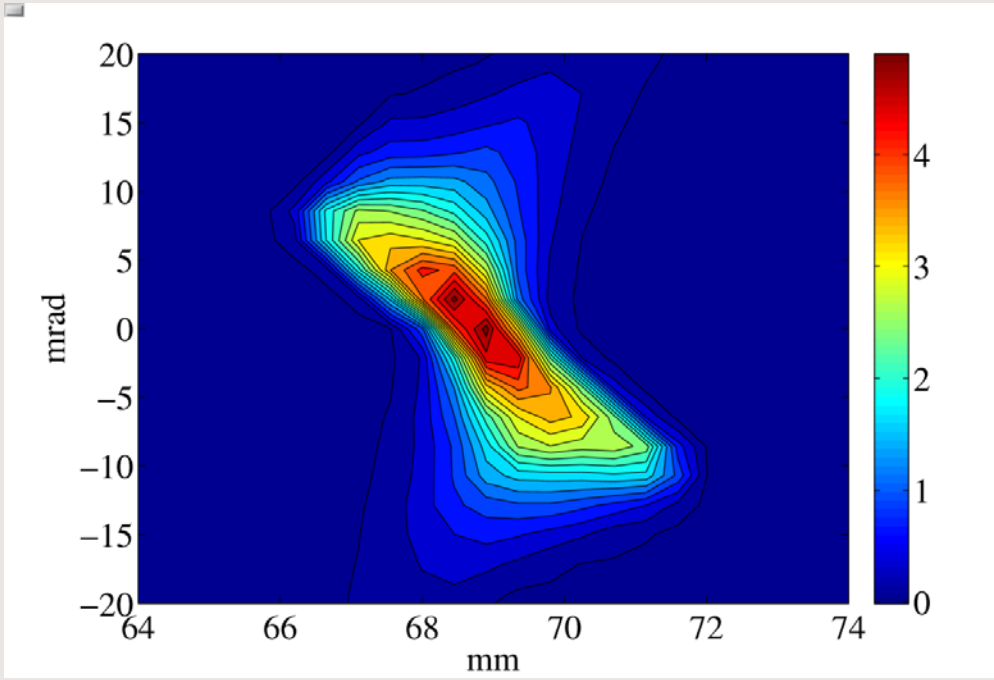


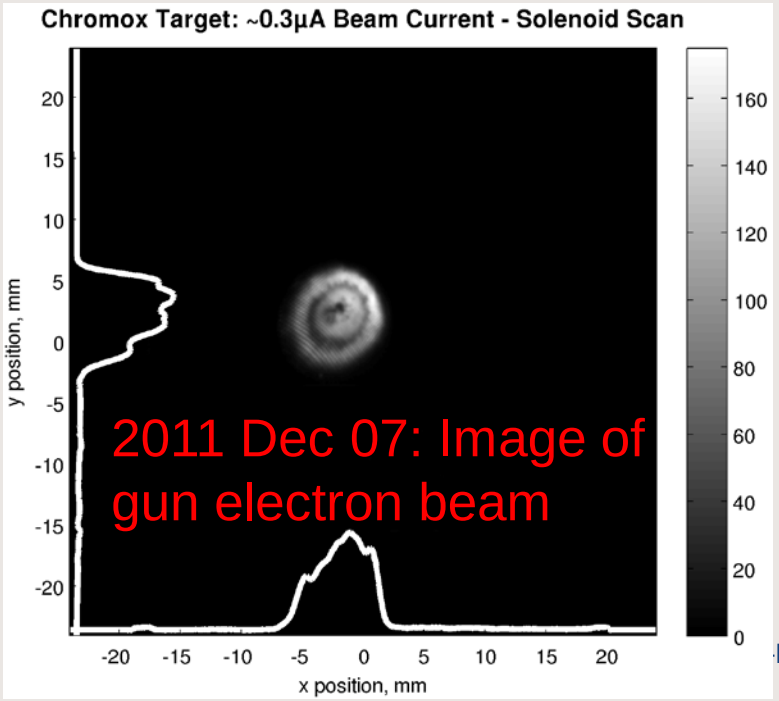
VECC ELBT Test1 – 2011 Dec/2012 Feb



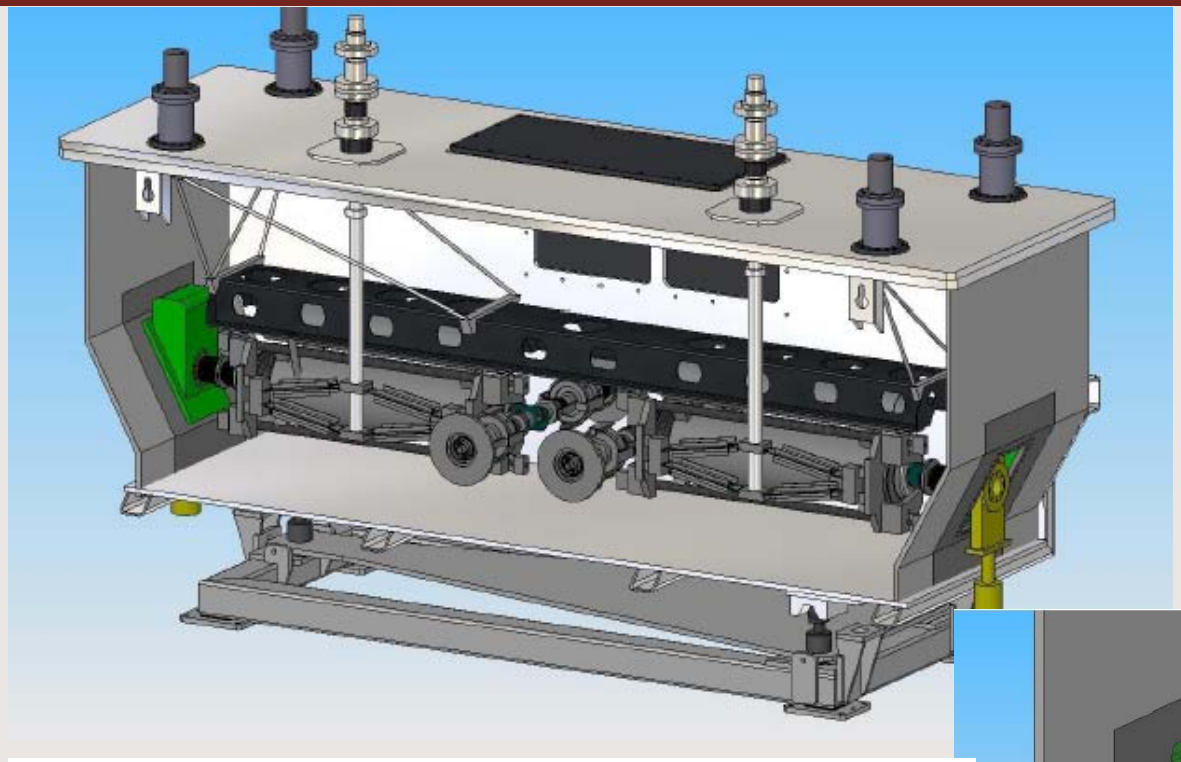
Slit scanner profile for various solenoid settings

Allison emittance scans performed 2012 Feb 09 onward up to to 660W beam power at ~20W/mm

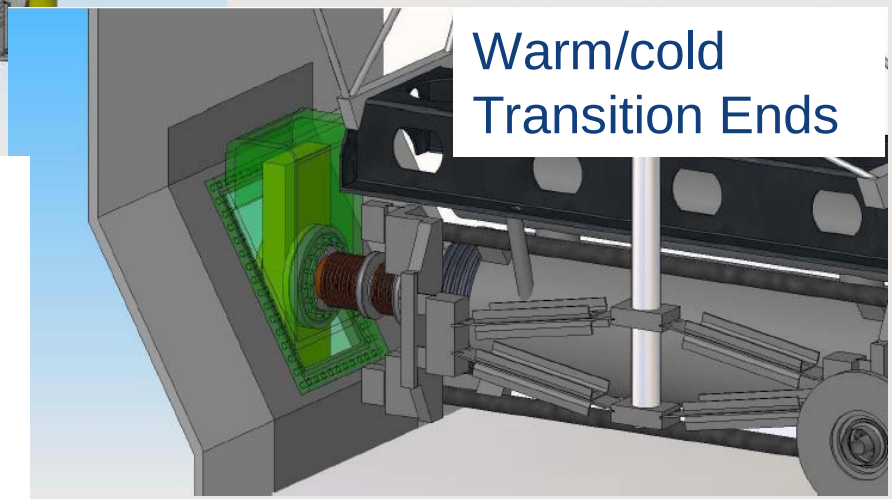




Accelerator Cryomodule



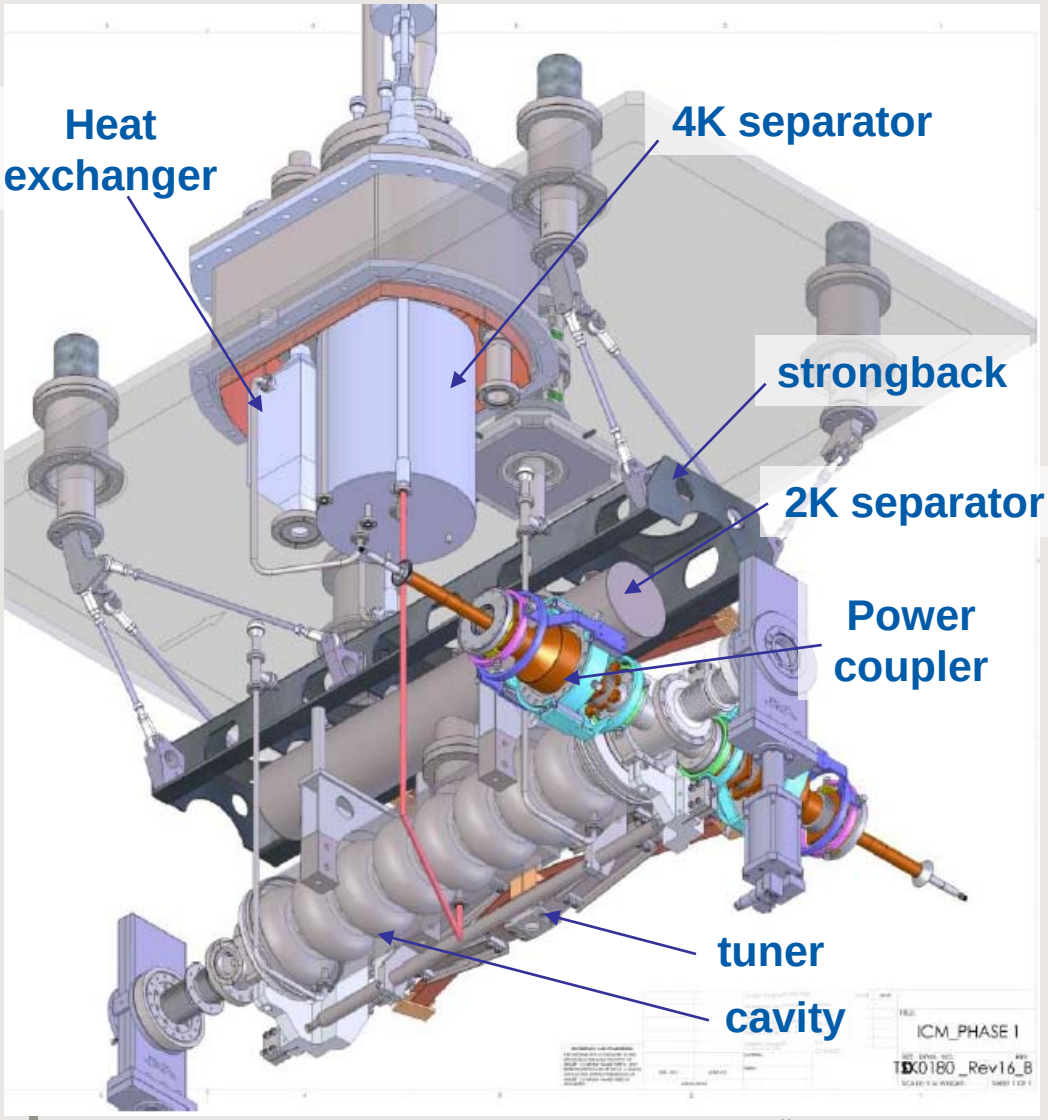
Jlab style Scissor-Tuner prototype



Warm/cold Transition Ends

- **Single-cavity EINJ prototypes most features of two-cavity EACA design.**
- **2011 June: focus narrowed to completion of EINJ design, and fabrication in 2012**

Injector Cryomodule



Cryomodule concept borrows significantly from ISAC-II

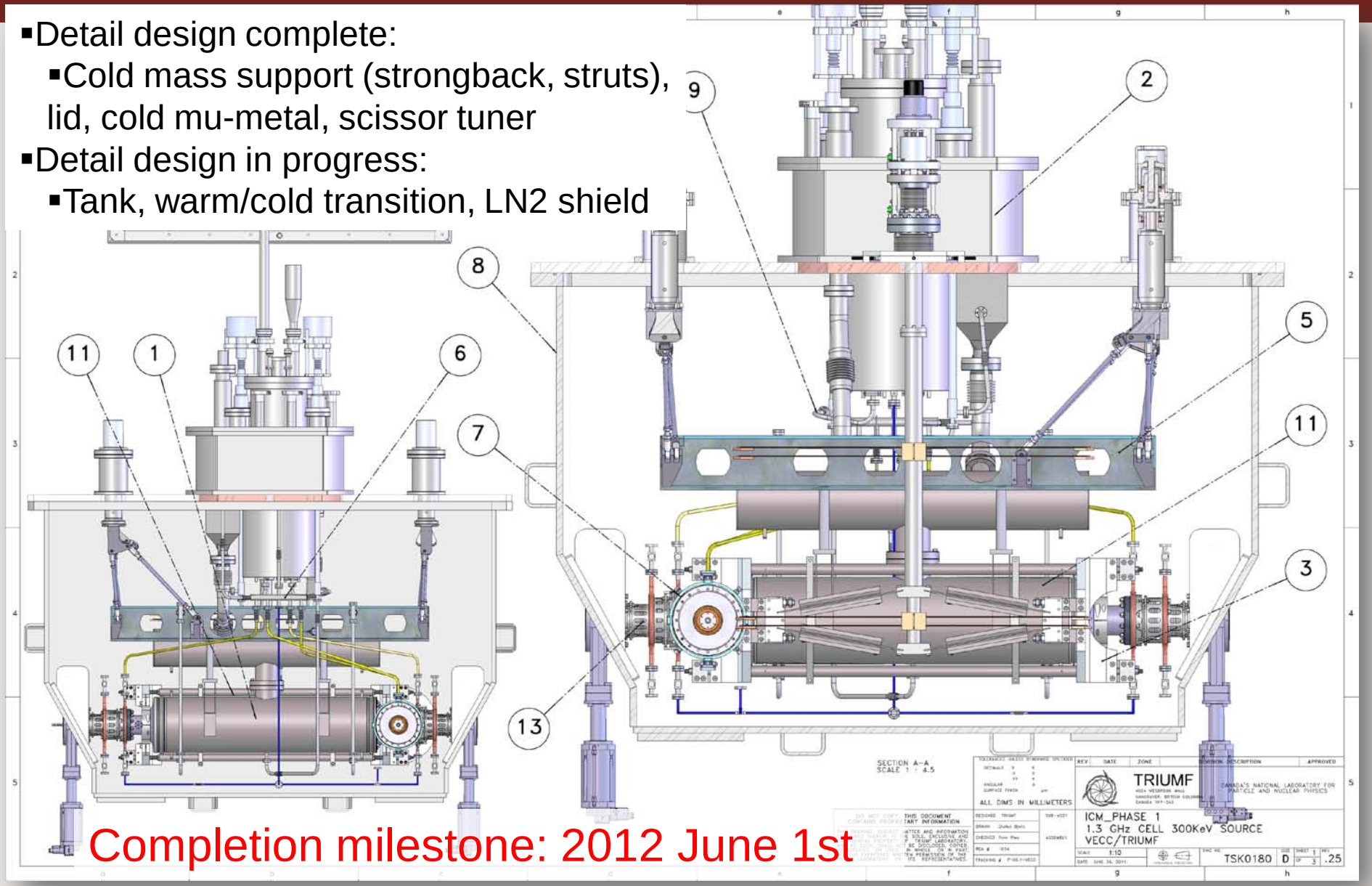
Top loading box concept with cavity mounted to strongback that is suspended from struts

Box gives headroom for on-board 2K/4K heat exchanger & 4K separator

- All procurements in hand
- Fabrication underway
- Cavity, 4K/2K insert (75% done)

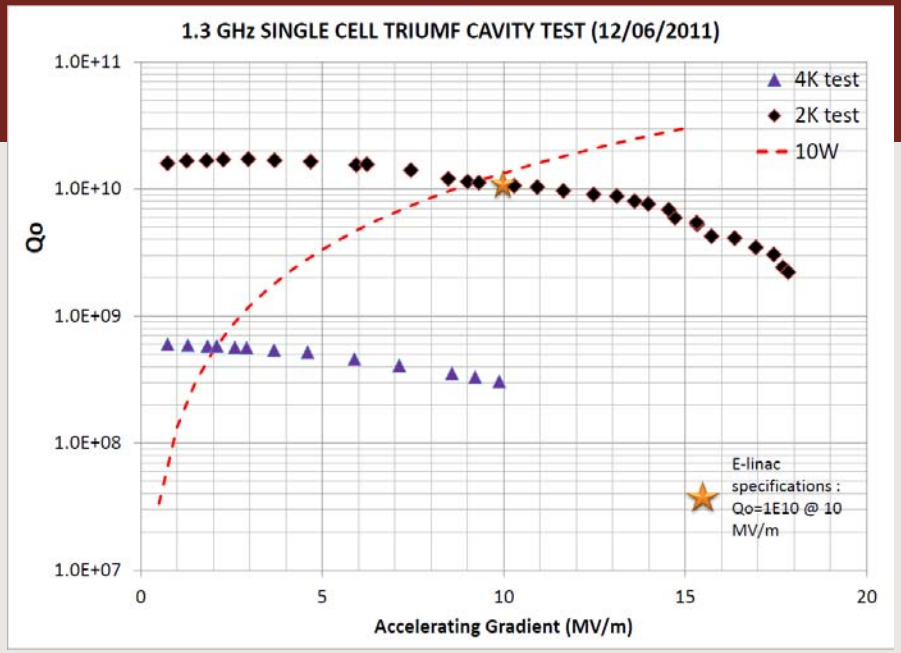
Injector Cryomodule Detailing

- Detail design complete:
  - Cold mass support (strongback, struts), lid, cold mu-metal, scissor tuner
- Detail design in progress:
  - Tank, warm/cold transition, LN2 shield



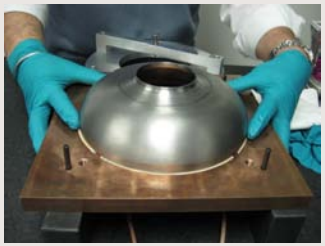
Completion milestone: 2012 June 1st

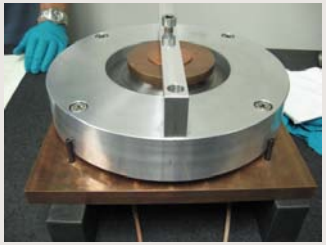
Cavity Status



Success: 7 out of 7 PAVAC/TRIUMF single-cells meet requirements

- 7 cell Cu cavity delivered from PAVAC
- Nine cell cavity design fixed and contract signed
- Tooling optimized
- Four Nb half cells formed and welded



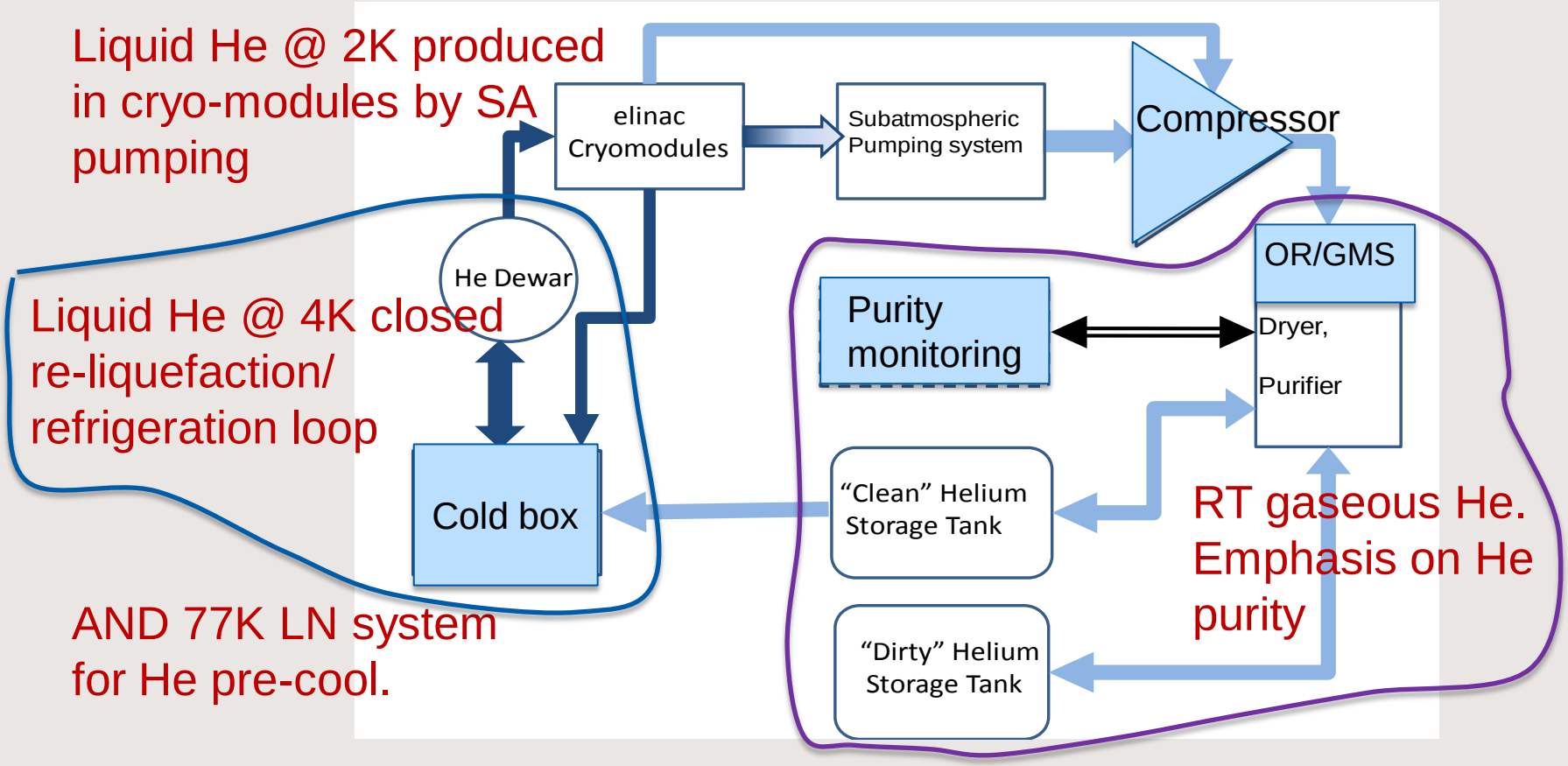


Cryogenic System Design/Procurement

Liquid He @ 2K produced in cryo-modules by SA pumping

Liquid He @ 4K closed re-liquefaction/ refrigeration loop

AND 77K LN system for He pre-cool.



- White boxes: TRIUMF responsibility
- Pale blue boxes: cryoplant ordered from Air Liquide Advanced Technology, 2011 Oct

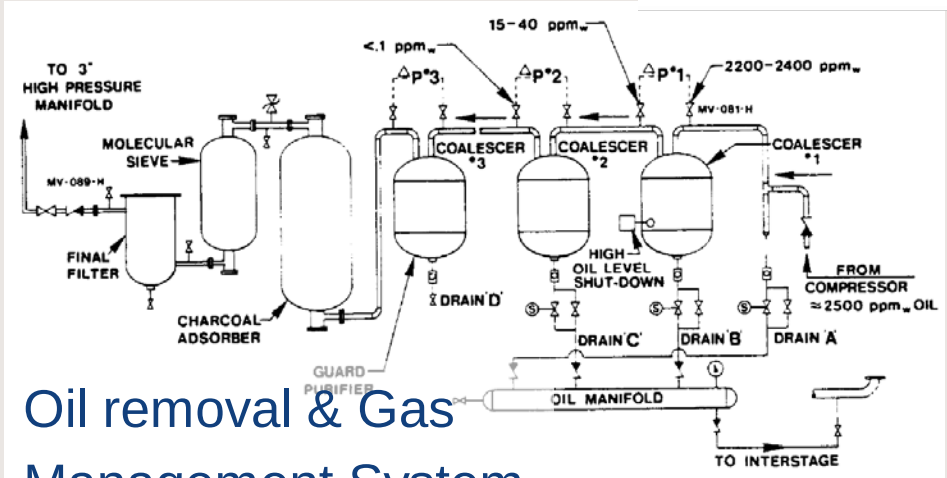
Supplied by ALAT

Helial Cold Box

Main Compressor

Figure 6 : CSD 82 View

Recovery Compressor



Oil removal & Gas Management System

Schedule

2013 March: ALAT cryoplant at TRIUMF

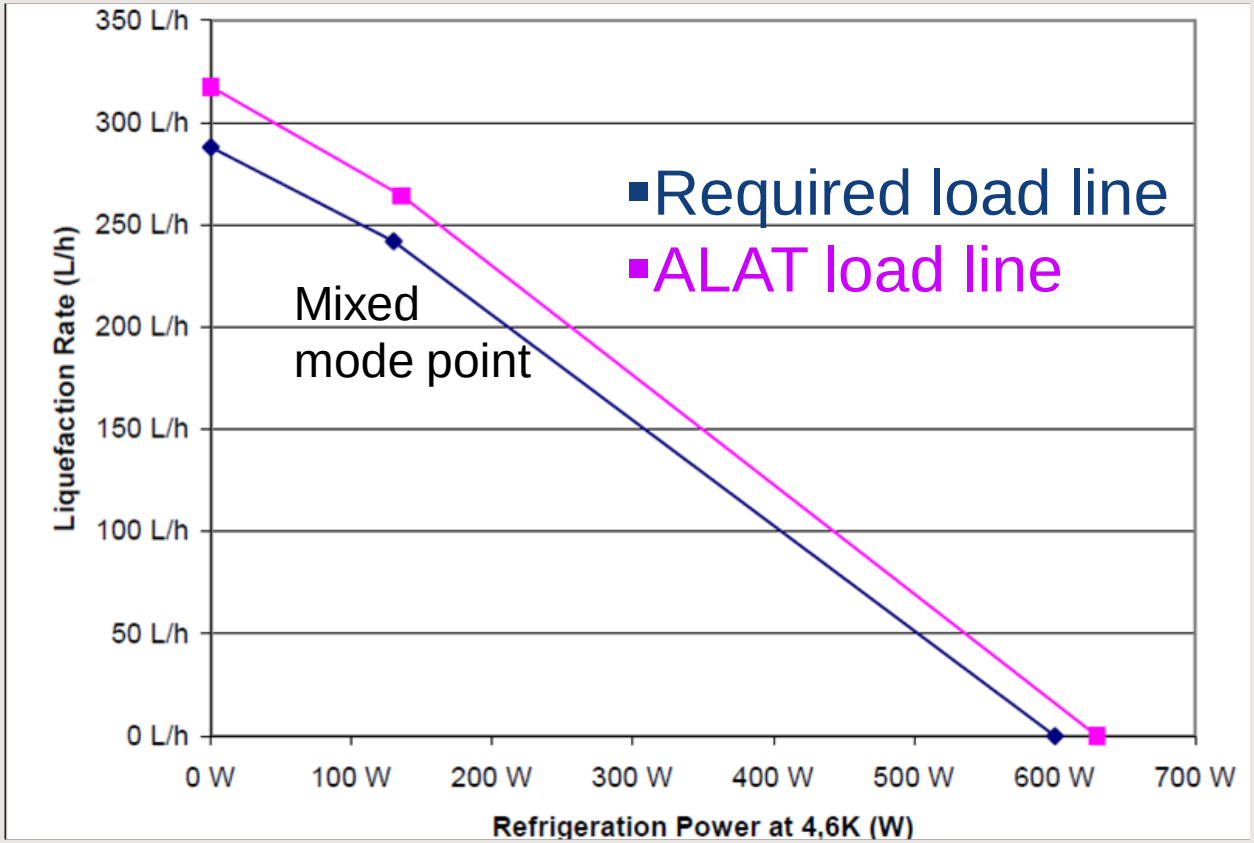
2013 October: commissioned

Successful Final Design Review concluded 2012 May15

Cryo-plant specs

The plant shall demonstrate 3 modes:

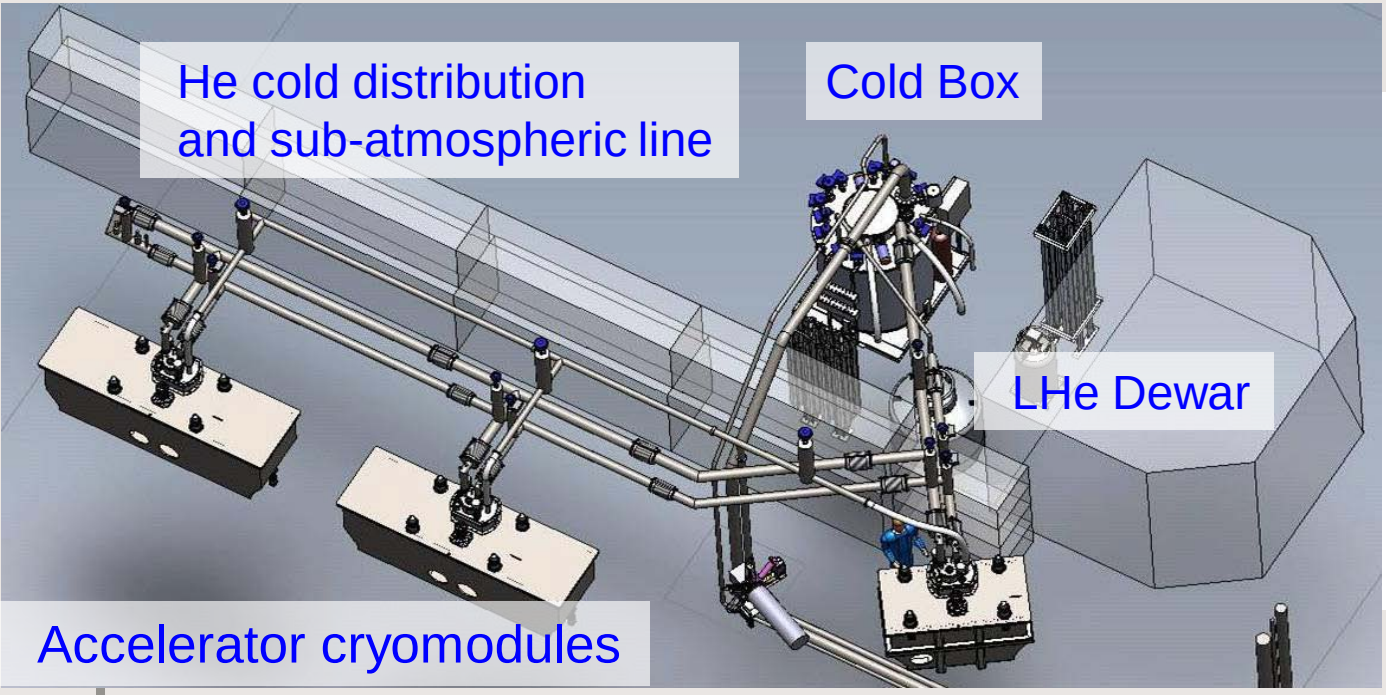
- Mixed Mode: >130W @ 4,6K and 242 L/h rising level
- Pure Liquefaction: 288 L/h at 4.6K in the Dewar rising level
- Pure Refrigeration: 600W at 4.6K in the Dewar (expected)

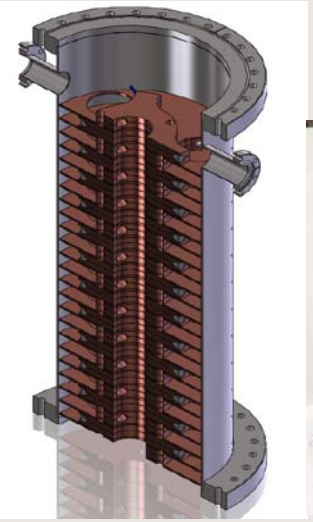


Other major components

- He buffer tanks: delivery expected 2013 Jan
- Dewar in hand; will widen neck
- He Purifier in design stage
- Cold Helium Distribution System: tender mid 2012
- 2K sub-atmospheric components:
  - Pumps: tendere mid 2012
  - He heaters: prototyping

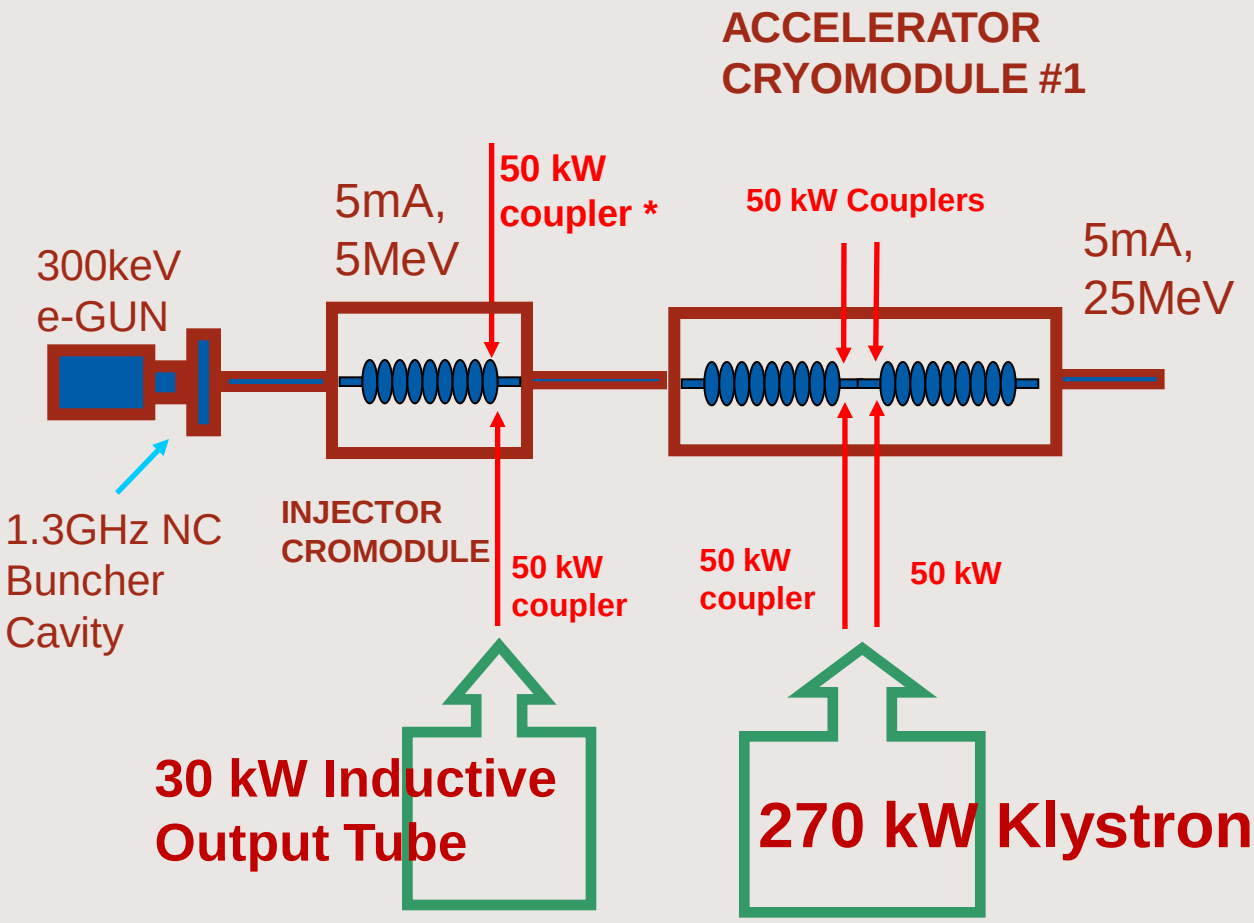
- Tanks rated 15 Bara
- Capacity ~113 m^3 each





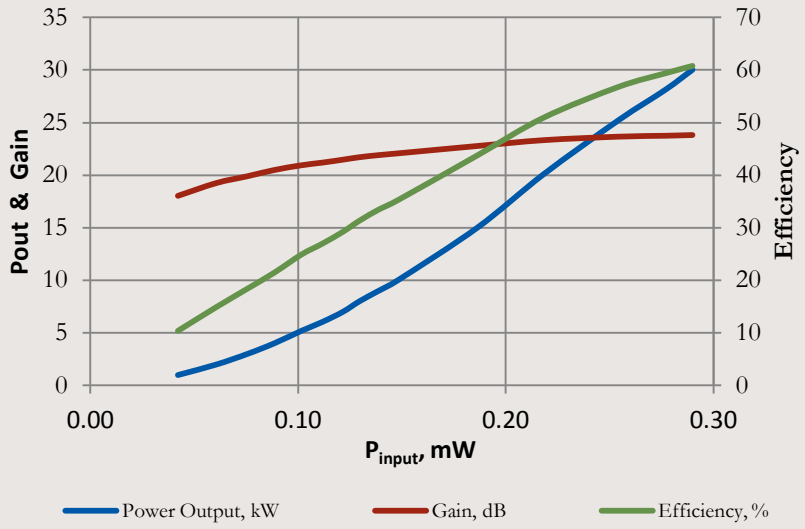
15 Ω Resistive heater prototype

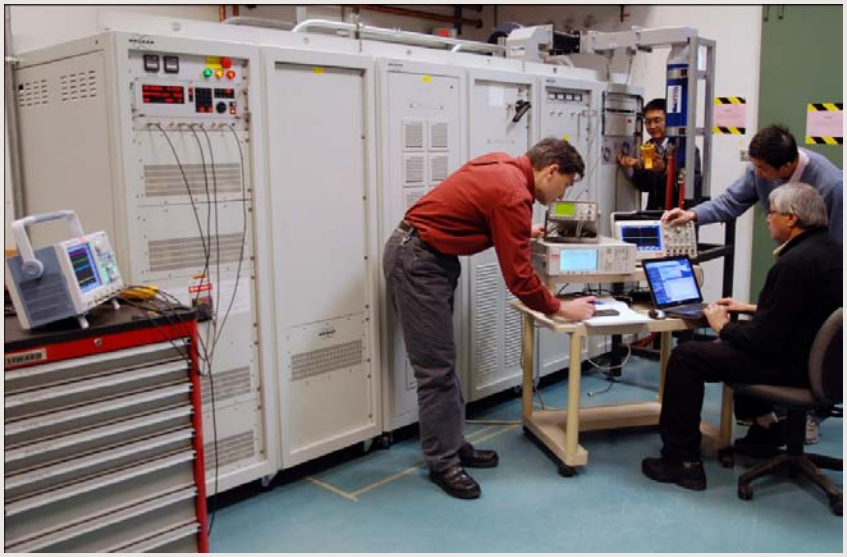
High Power RF staging: 5mA, 25 MeV in 2014



30 kW IOT Transmitter

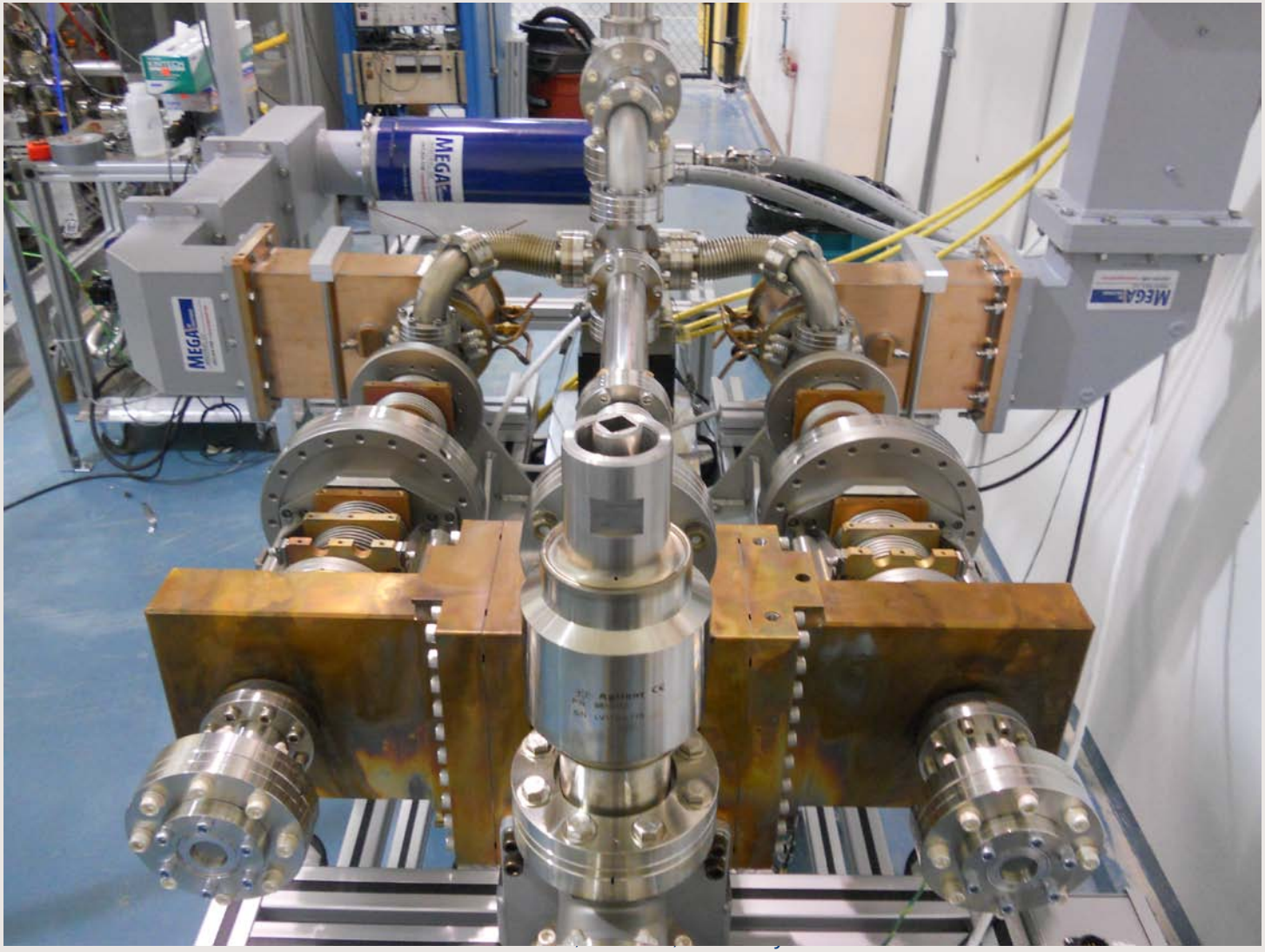
- IOT transmitter will be used for EINJ beam test 2013 Jan;
- RF input coupler conditioning (10kW) 2012 March onward





- 2011 June: Tube operated tube in excess of 30kW
- 2011July: Successful acceptance tests: ran cw at 30 kW for 24 hours, at 25kW for 40 hours and at 20 kW for 7 days without trip.
- Now running routinely

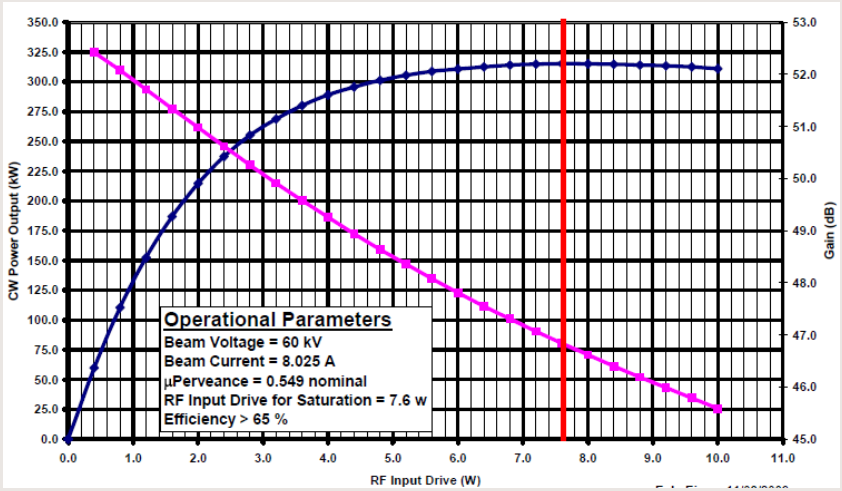
Coupler Conditioning Stand in VECC test area



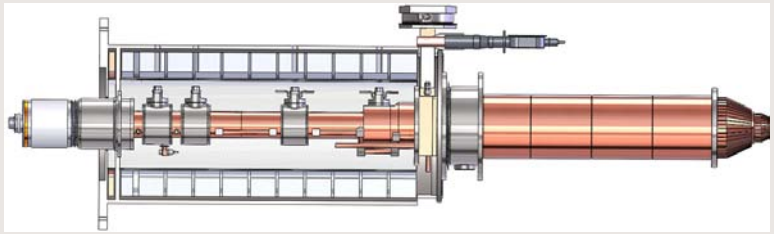
1.3 GHz 290 kW klystron & HVPS procurement

Require 200kW cw for EACA (2-cavity) cryomodule

- 2011 Aug: 290kW Klystron ordered from CPI, USA
- Coordinated purchase with Helmholtz Zentrum Berlin
- 2012 June: Final design review
- 2012 Nov: klystron factory test

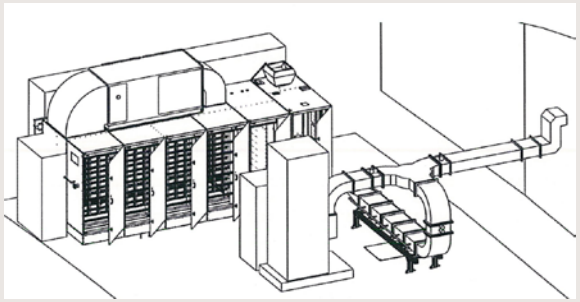


Klystron predicted CW Power Output vs. RF Input Drive



600kW High Voltage Power Supply

- 2012 Feb: Tender issued
- 2012 March: Tender closed
- Vendors under consideration

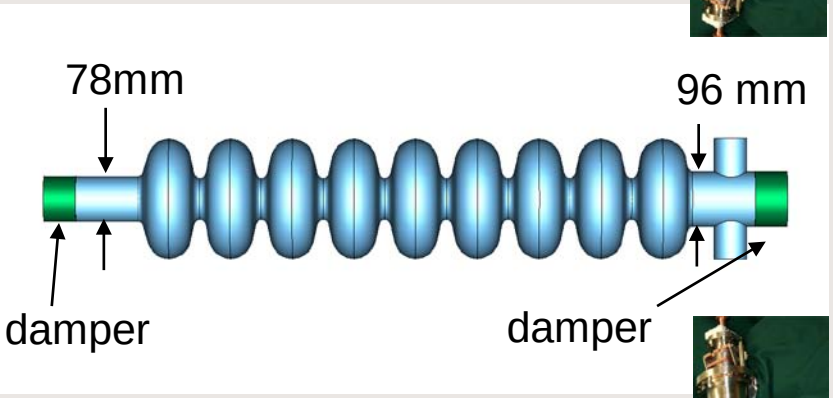


Conclusion

- Outstanding Progress Across All Areas
- Buildings Construction – on schedule for 2013 April
- Injector Cryomodule beam test – on schedule for 2013 March
- Accelerator Cryomodule beam test – on schedule for 2014 June

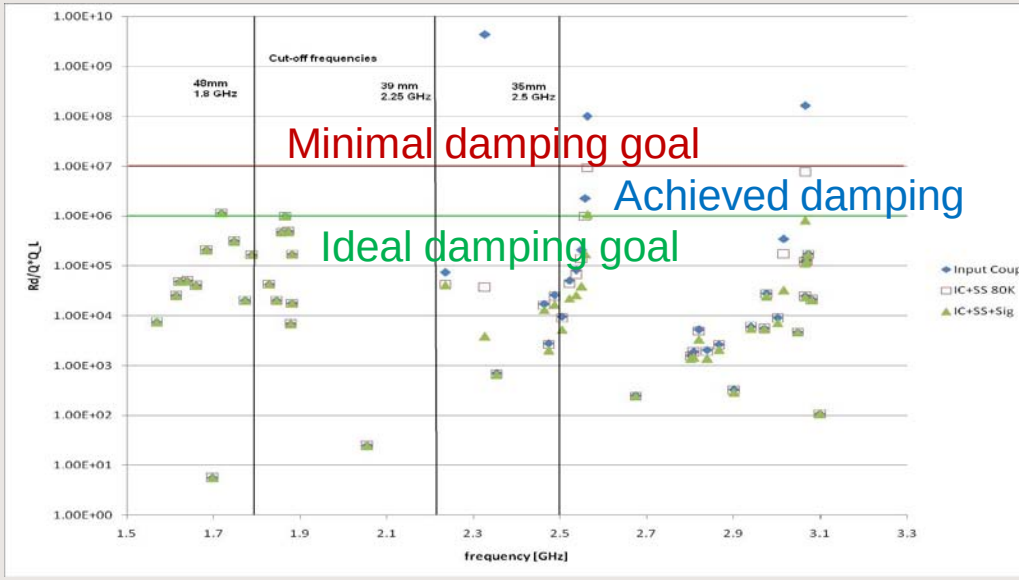
Cavity & HOM Damping

- 9 cell cavity
- Inner 7 cells TTF geometry
- Modified end groups for larger coupler &HOM damping



Two 50 kW Cornell/ CPI coupler per cavity

HOM frequency spectrum and shunt resistance for 9-cell cavity



- HOM damping target set by Regenerative BBU (2-pass)
- 39/35/48 mm iris geometry gives the lowest maximal $(Rd/Q)\times Q_L$
- Damping by SS ring on coupler end, CESIC ring on tuner end
- All modes $(Rd/Q)\times Q_L < 2\times 10^6$ ohm

TRIUMF

EINJ: Injector Cryomodule Detailing