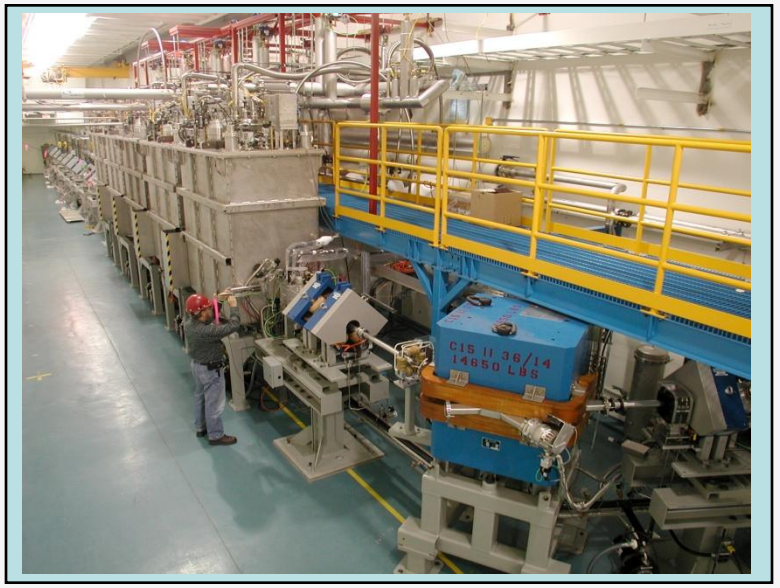

ISAC-II: Status of the 20MV Upgrade

Bob Laxdal, Sept. 21, 2009, SRF09 Berlin

Outline

- Introduction
  - ISAC-II Linac
    - Phase I and II
  - SRF Facilities at ISAC
- Phase II cavities
  - Design and prototyping
  - Production
    - Tests, problems/solutions
- Cryomodule
  - Design
    - Modifications to CM and rf ancillaries
  - Status and tests
  - Installation schedule
- Summary

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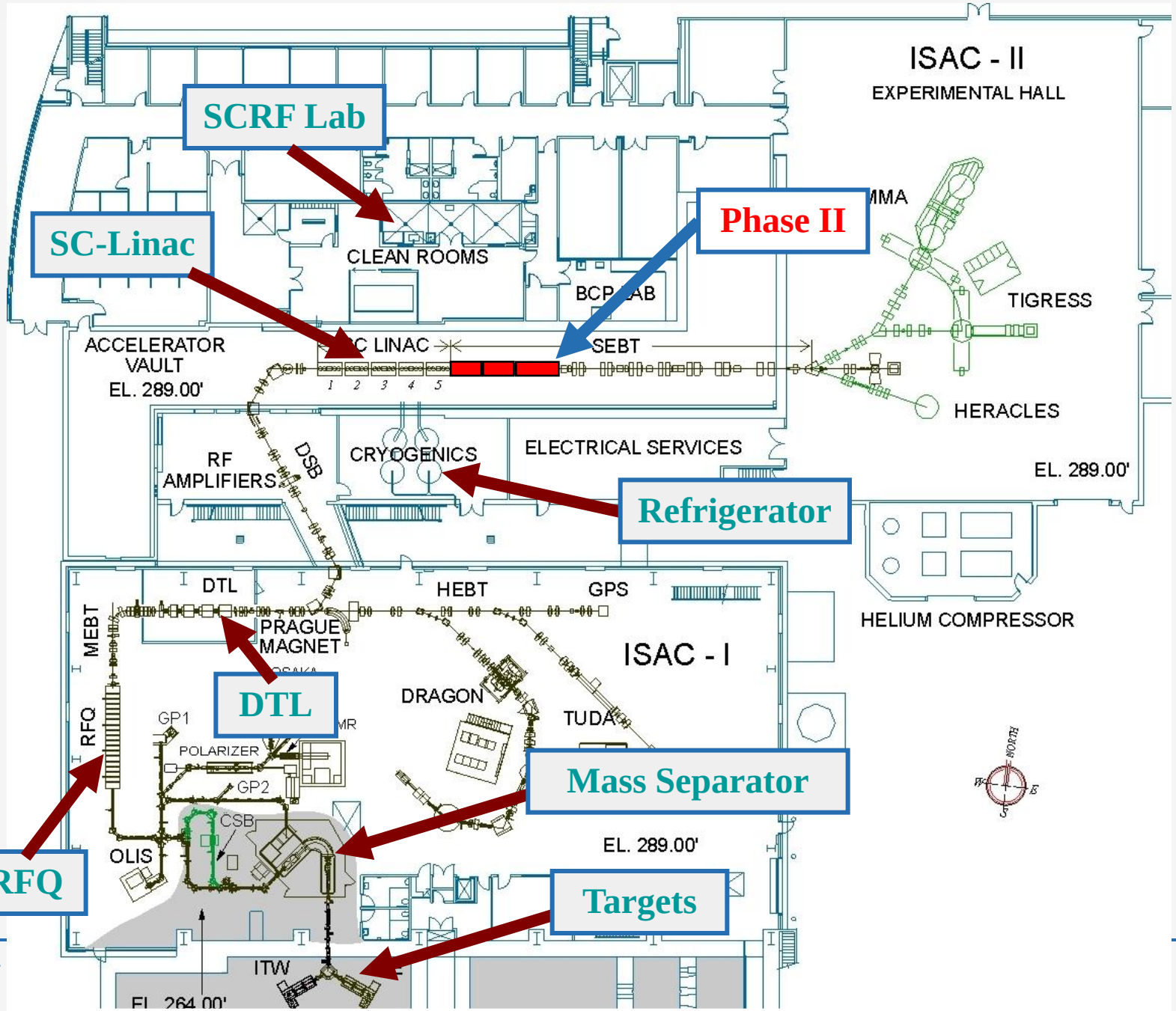
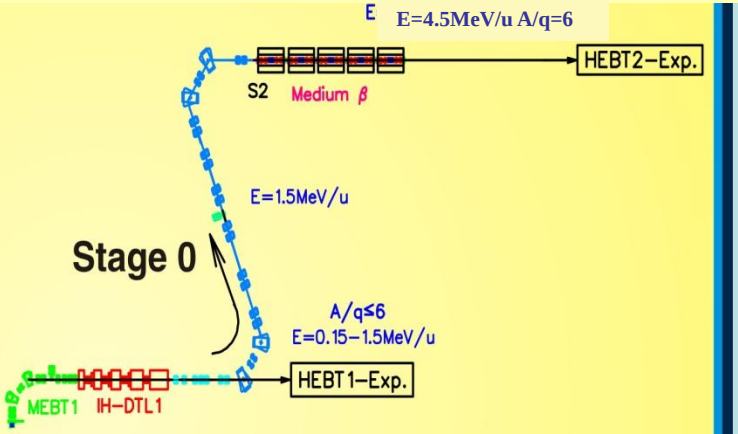
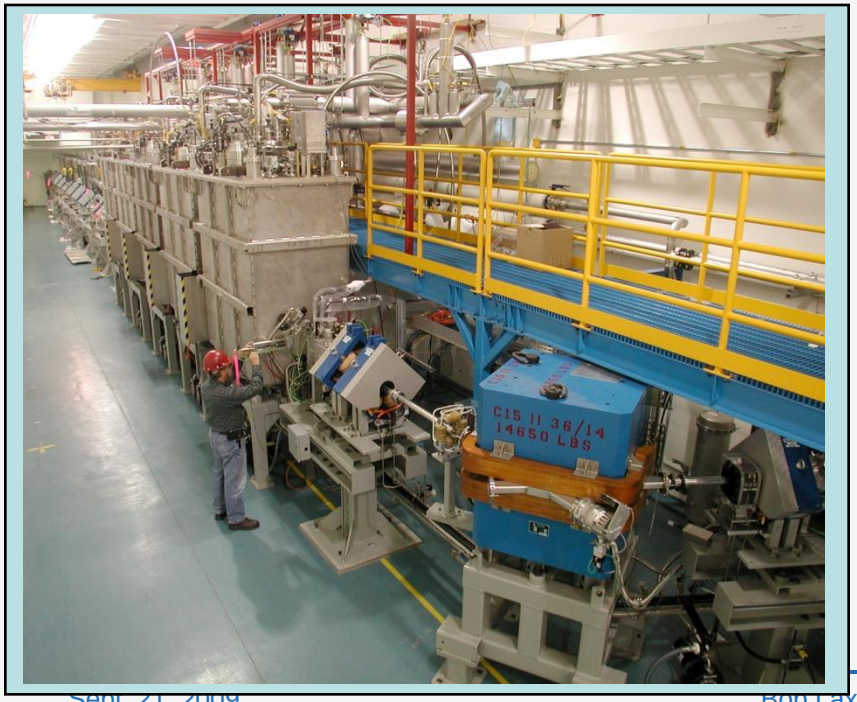

SCRF Lab
SC-Linac
Phase II
Refrigerator
DTL
Mass Separator
RFQ
Targets
ISAC - II
EXPERIMENTAL HALL
CLEAN ROOMS
TIGRESS
HERACLES
ACCELERATOR
VAULT
EL. 289.00'
SEBT
RF
AMPLIFIERS
DSB
CRYOGENICS
ELECTRICAL SERVICES
EL. 289.00'
HELIUM COMPRESSOR
DTL
HEBT
GPS
MEBT
PRAGUE
MAGNET
ISAC - I
RFQ
DRAGON
TUDA
GP1
POLARIZER
GP2
CSB
OLIS
EL. 289.00'
ITW
NORTH

ISAC-II SC-Linac

- Phase I – commissioned in 2006
  - First stage boosts radioactive ion beams by 20MV from 1.5MeV/u
  - Twenty quarter wave cavities (β=0.057, 0.071) give average cw performance corresponding to Ep=30-35MV/m
  - Little or no degradation in gradient over first three years of performance
- Phase II
  - consists of the addition of a further 20MV by the end of 2009
  - Add 20 QWR's at β=0.11

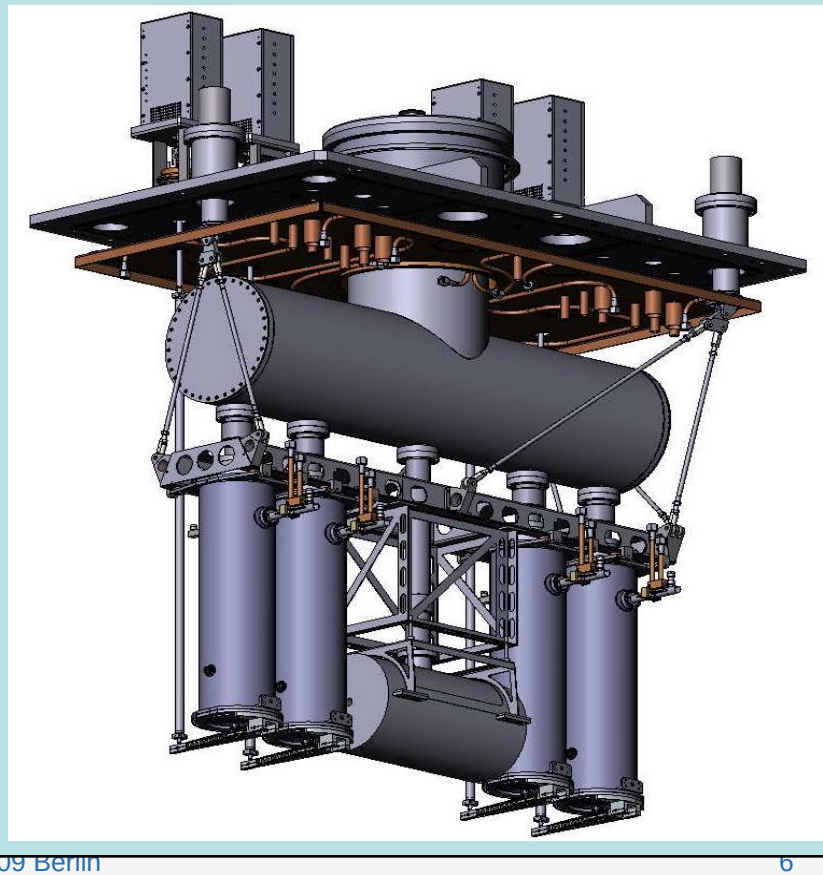
ISAC-II (Phase I - Medium Beta Section)





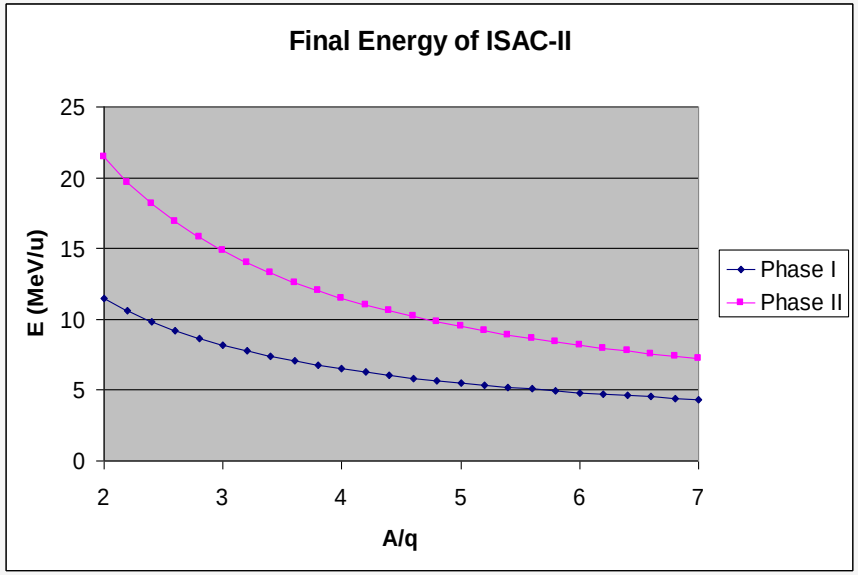
ISAC-II 106MHz Superconducting Linac

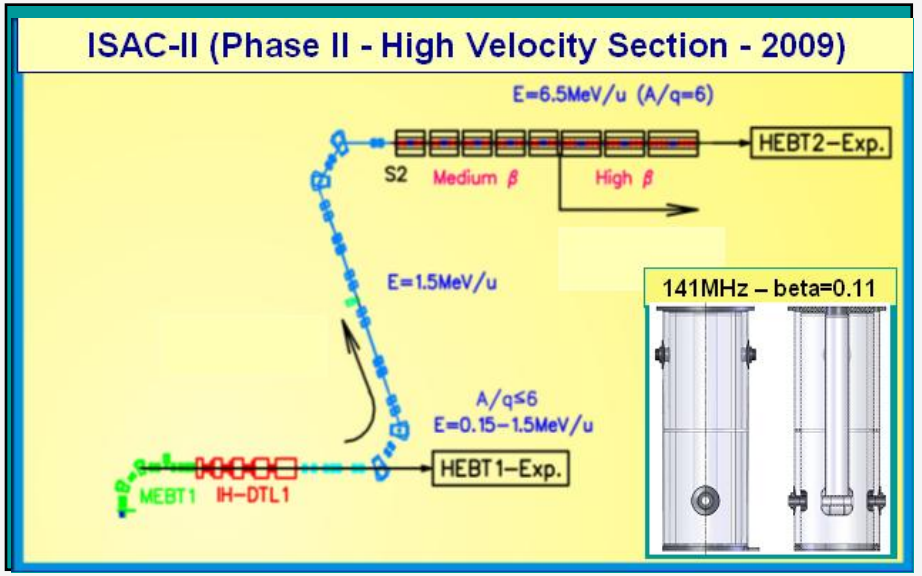
- Twenty bulk niobium quarter wave cavities housed in five cryomodules
- Boosts ion energy by 20MV to provide stable and RIB's above the Coulomb Barrier



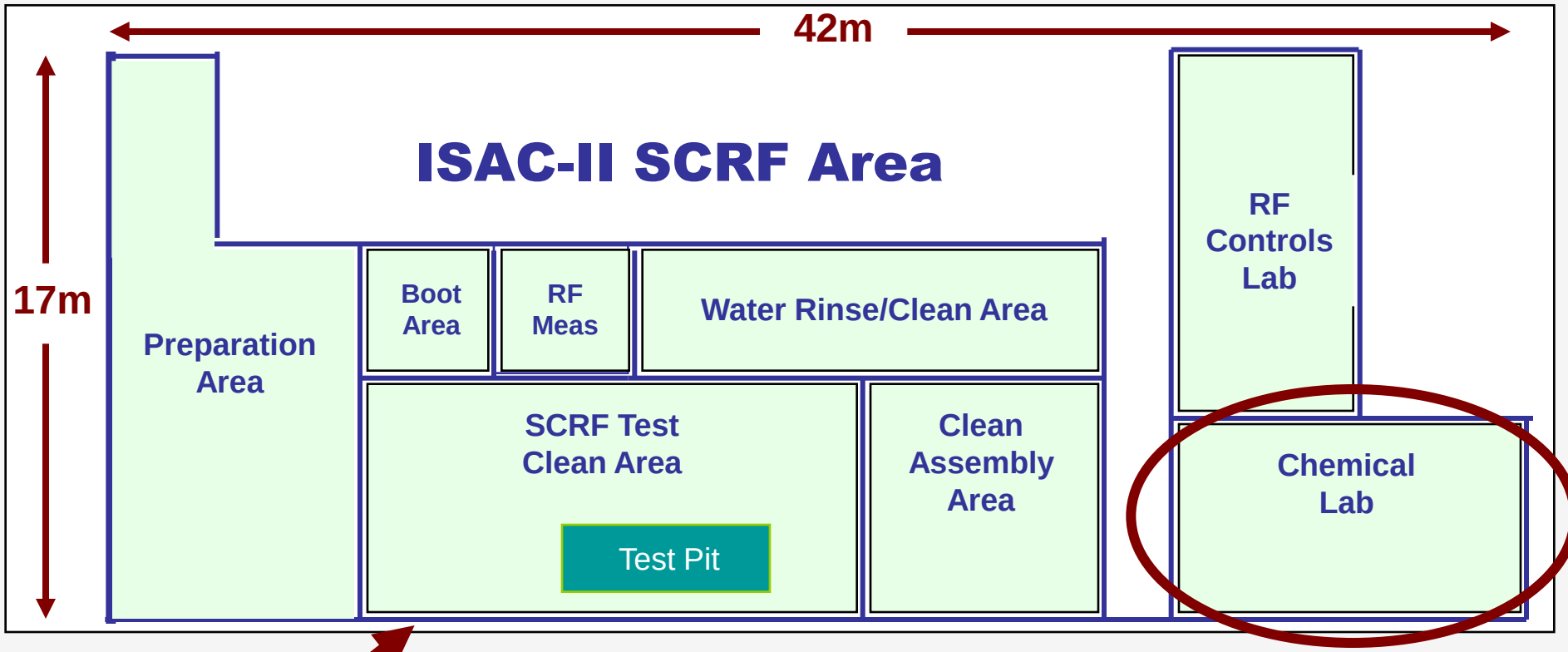
ISAC-II Phase II Linac

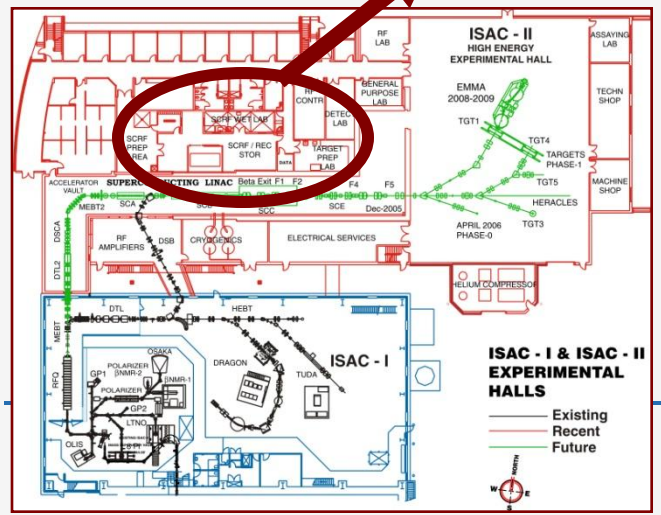
- Goal is to boost the energy of the heavy ions above the Coulomb barrier for all masses
- Total superconducting installation voltage of >40MV





SCRF Infrastructure





- The ISAC-II building houses the SCRF test and assembly areas
  - 500m^2 of floor space, overhead crane
  - Ultrasound cleaning tanks, High Pressure Water Rinse area, shielded rf test area, cryomodule assembly area, chemical etching lab
  - Over 60 single cavity tests performed and six cryomodules assembled since 2004

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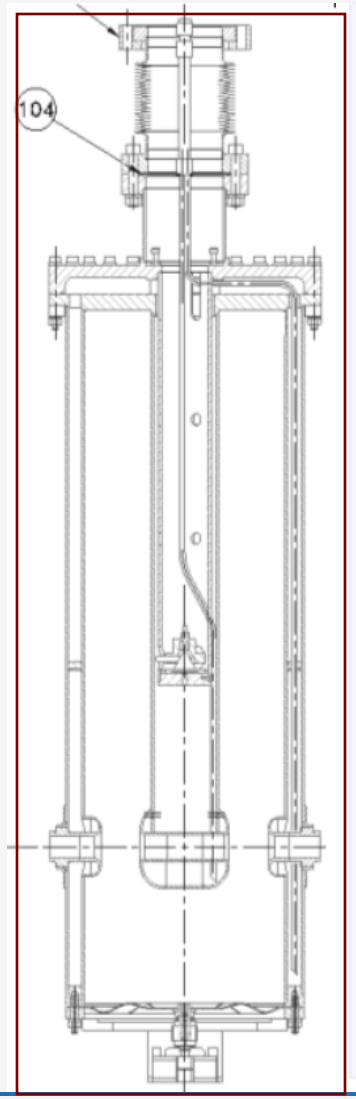
Phase II QWR (Beta=0.11)

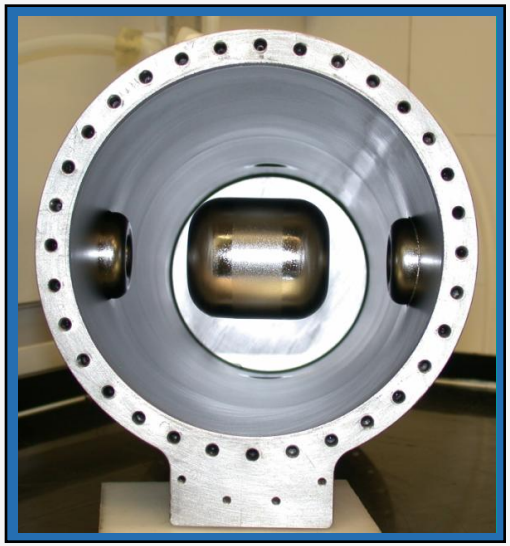


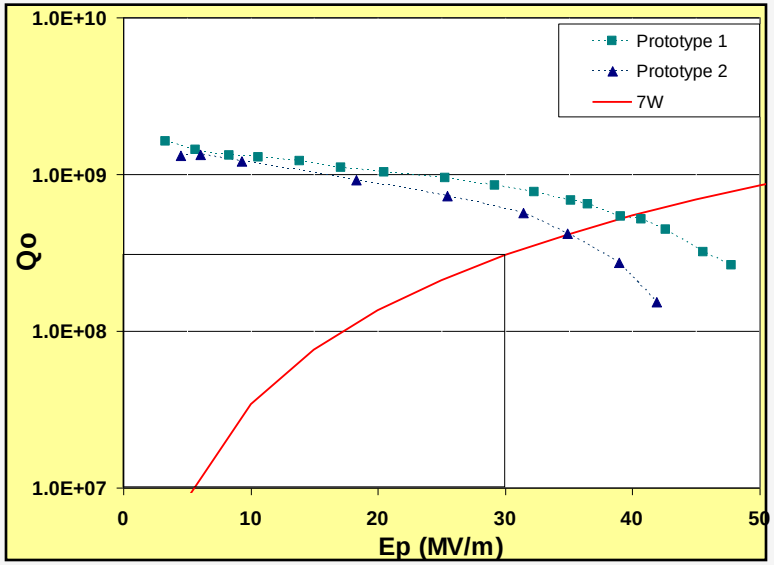
Parameter	Units	Value
Frequency	MHz	141.44
E_P/E_a		4.9
B_p/E_a	mT/ (MV/m)	10
β_0		0.11
$G=R_sQ_0$	Ω	26

ISAC-II Specification		
P_{cav}	W	7
V_{eff}	MV	1.1
E_a	MV/m	6
E_p	MV/m	30
B_p	mT	60

Phase-II Cavity Report

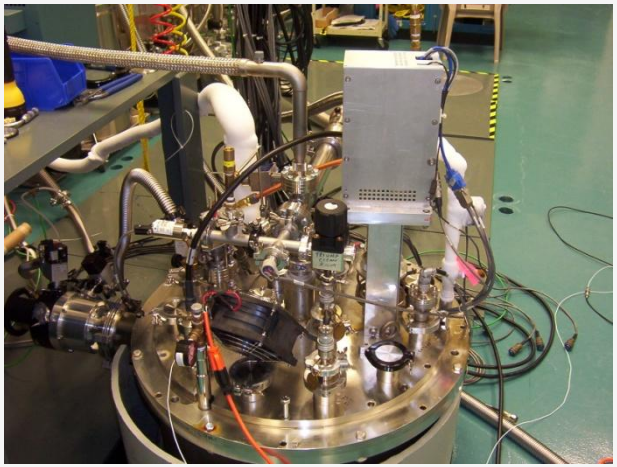
- Cavities ordered from PAVAC Industries of Richmond BC
  - Two prototype cavities tested
    - Ep=38MV/m @ 7W
  - Twenty production cavities ordered
    - fifteen cavities received

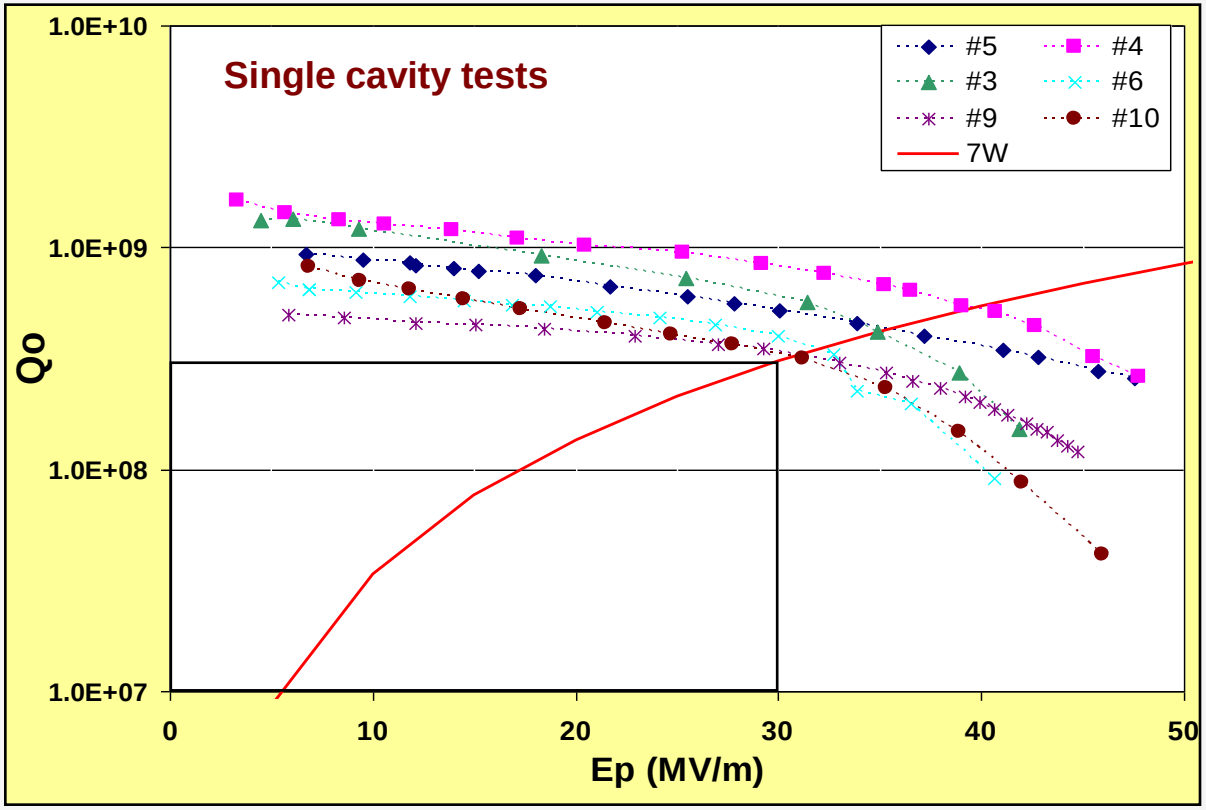




Single Cavity Tests

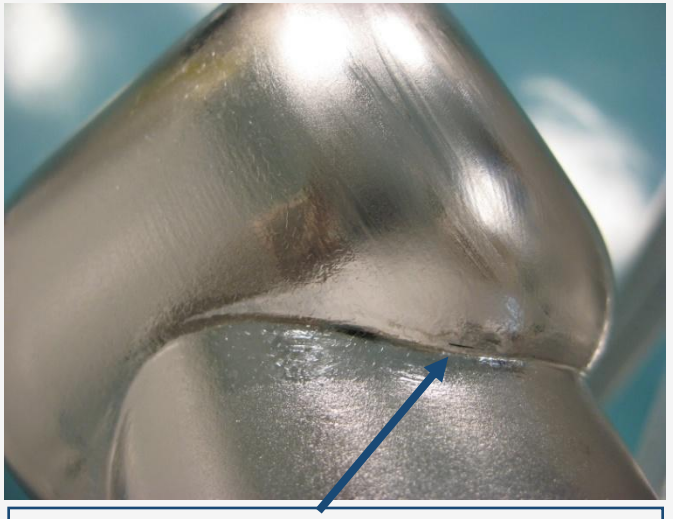
- Single cavity tests have an average performance of Ep=35MV/m at Pcav=7W
- Medium field Q-slope being investigated – see Anna Grassellino – TUPP0062
- Some signs of Q-disease in test results



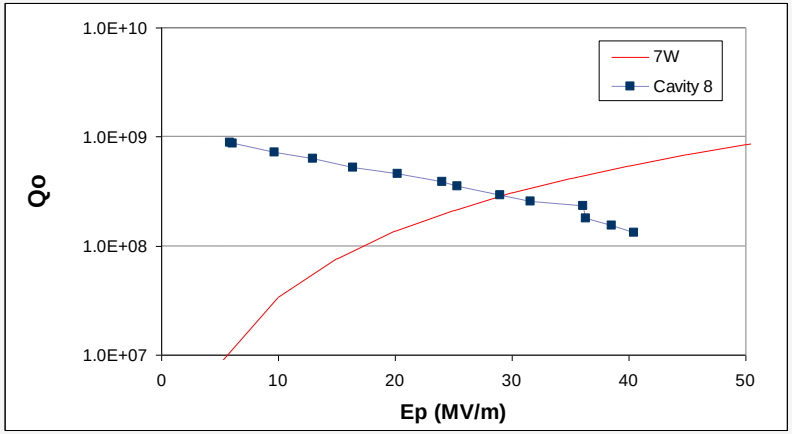


Cavity Summary

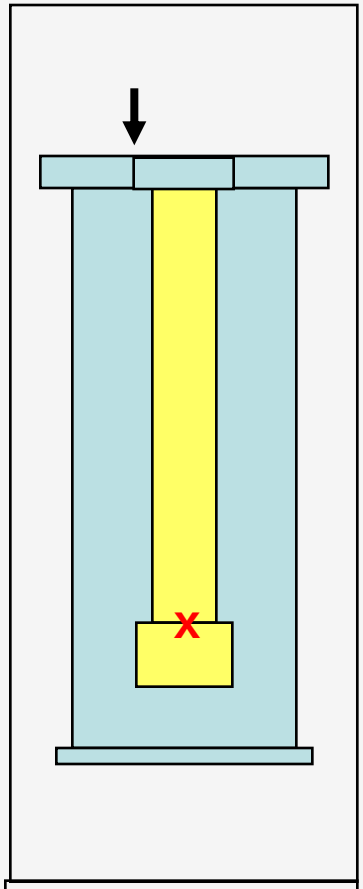
- Seventeen cavities received in total
  - seven cavities tested OK
    - Six used for first cryomodule
  - six cavities awaiting tests
  - four cavities with vacuum leaks after BCP etching of 60microns
    - leak in the saddle weld from inner conductor to beam tube
    - Cavity 8 repair complete and cold tested OK



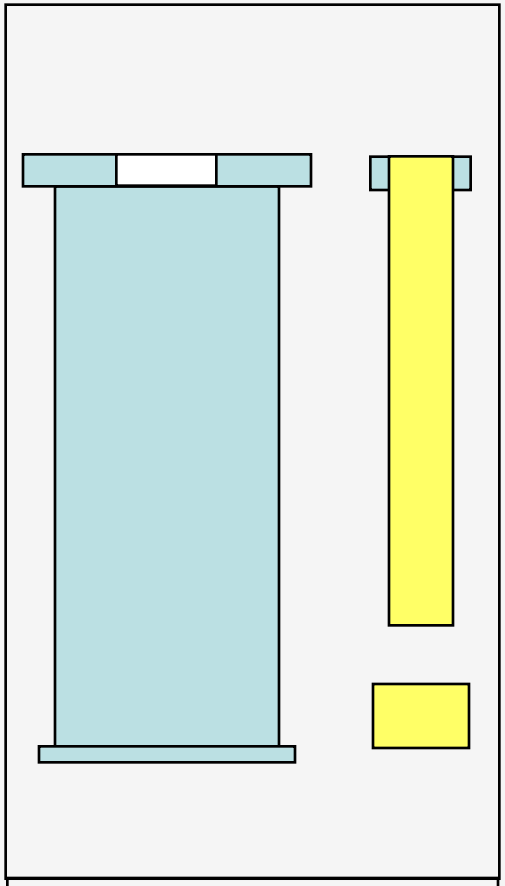
Vacuum leak appears in weld region after BCP etc after BCP etching



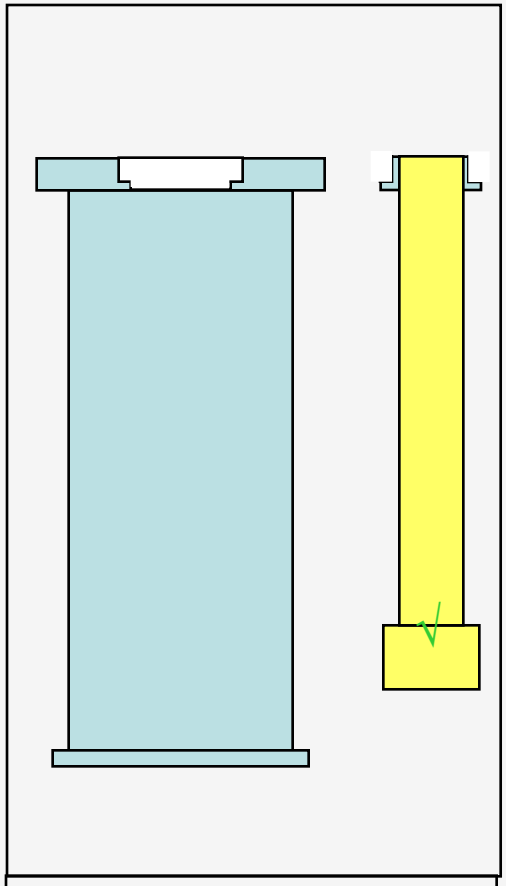
Leak Repair (Pavac)



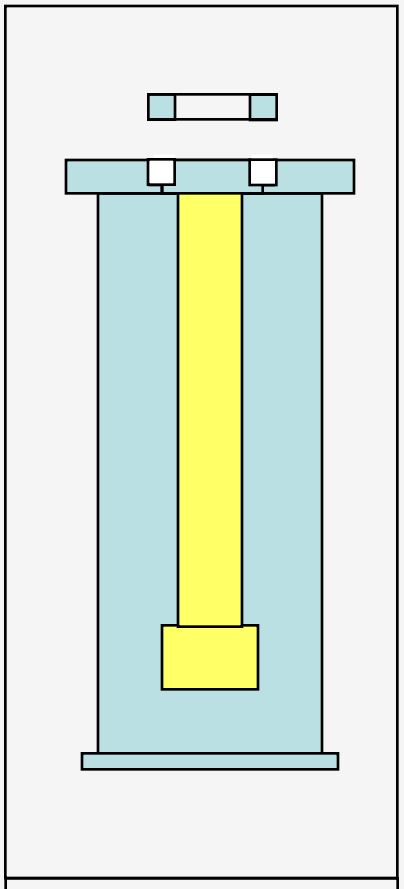
1. Cut out inner conductor



2. Remove beam tube and repair leaky weld



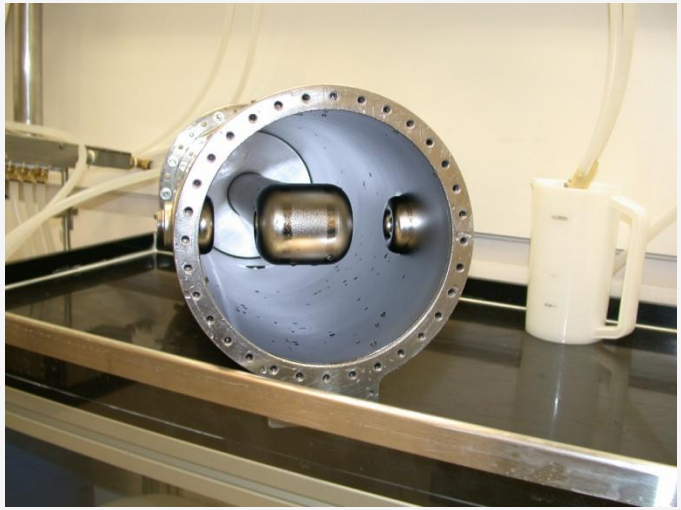
3. Machine weld prep on cavity flange and inner conductor



4. Weld inner conductor to cavity and add reinforcing ring

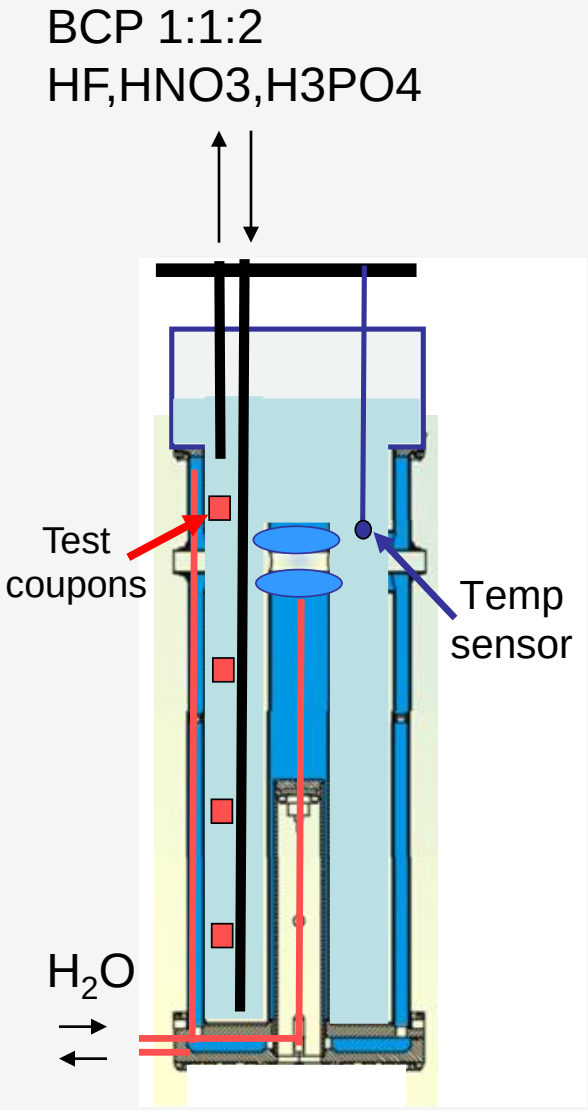
BCP Processing Lab Opens

- Now operational
- Large fume hood accepts ISAC-II quarter wave cavities and elliptical cavities to ~1.5m in length
- twelve production cavities processed plus parts etched prior to welding for production series
- Custom etching gives predictable frequency shift



Custom Etching

- Typically want to remove 80 microns from the surface of a completed cavity
- Uniform etching of the cavity will result in a ~neutral frequency change
  - Etching from the `root end' results in a -2kHz/micron frequency swing
  - Etching from the drift tube end results in a +2kHz/micron frequency swing
- We aim +20kHz high in manufacture and use custom etching to establish an exact operating frequency
  - Fill the cavity 50% full for a prescribed time then fill 100% and complete the etch



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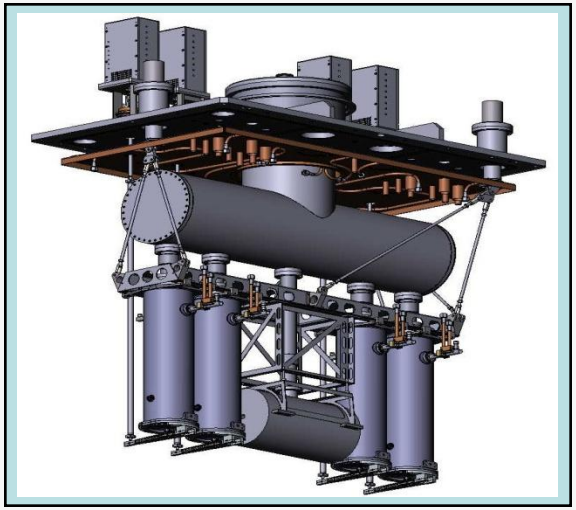
ISAC-II Phase-II Cryomodules

- Based on Phase I cryomodule design
  - Single vacuum space for rf and thermal isolation
  - Modifications
    - went from three point to four point mounting system
    - More rigid strongback
    - Enlarged cryogenic services stack to support more diagnostics
    - LN2 circuit made parallel through the coupling loops
    - RF ancillaries modified

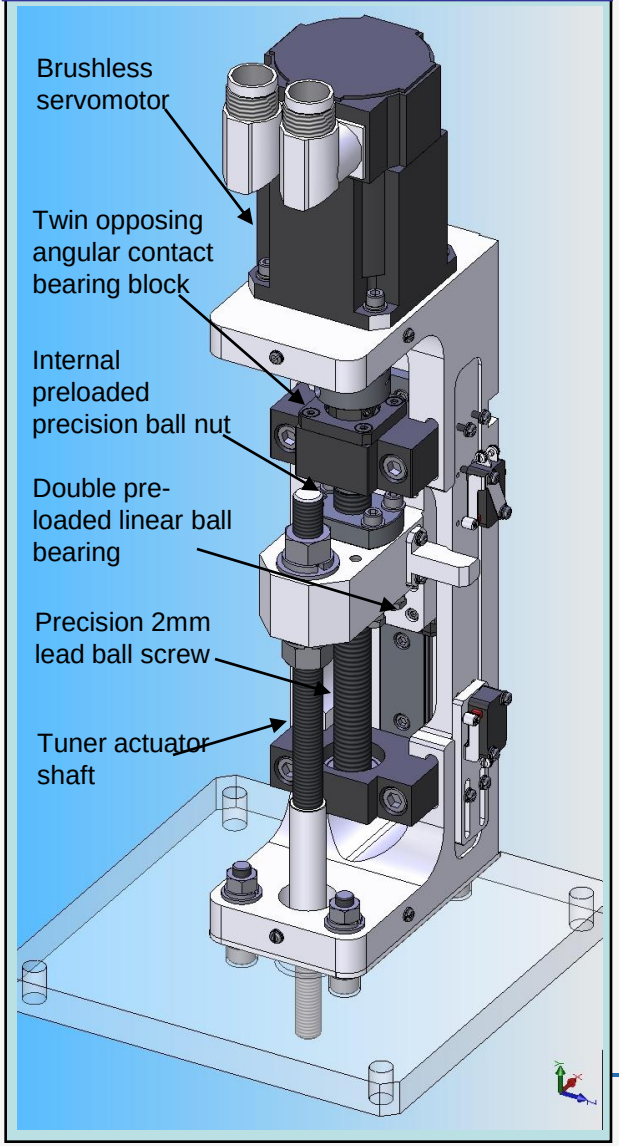


ISAC-II Phase-II hardware modifications

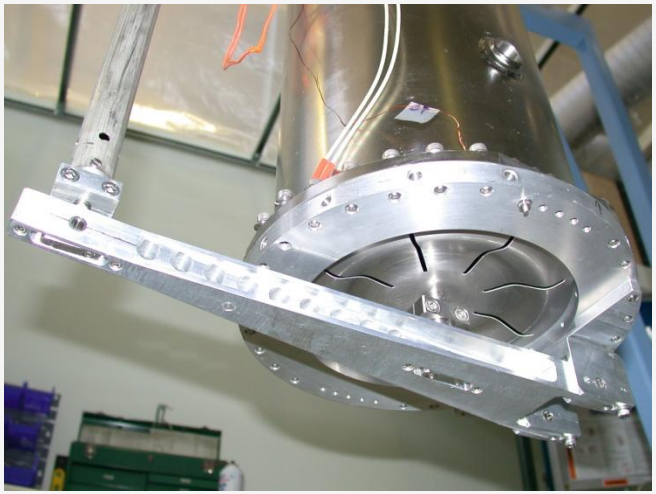
- New mechanical tuner
  - brushless servo-motor and ball screw
  - Prototyping complete; meets specifications
  - Production tuners assembled on SCC1
- New coupling loop
  - Improved mechanical stability using cross roller bearing support
- Solid state 141MHz rf amplifiers
  - Performance tested against tube amplifier
  - Show improved noise characteristics
  - twelve delivered; ten to come
- Clean vent system through rf pick-up feedthrough
  - Filtered N2 vents to inside of cavity to reduce pollution from cryomodule

ISAC-II Phase-II tuner

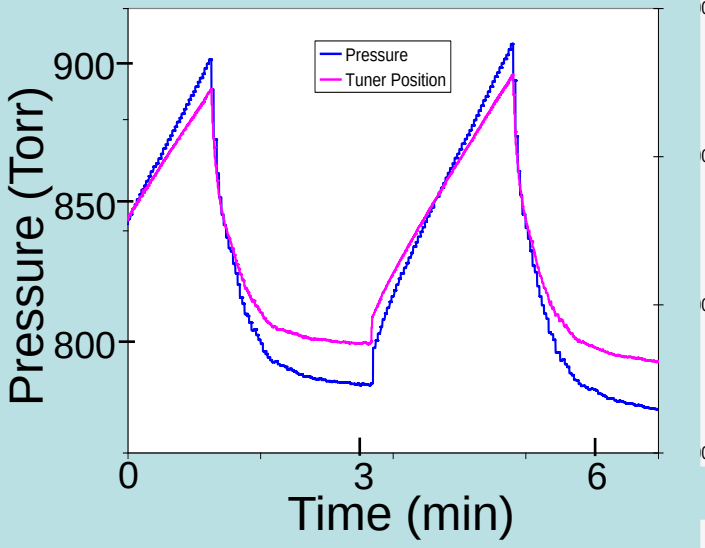
New Tuner Motor Developed



- precision brushless servo-motor and ball screw on top of cryomodule
- Actuator extends (through bellows) to a lever mechanism to the tuning plate
- Tuner Position resolution 0.04 Hz/step; corresponds to 5nm/step



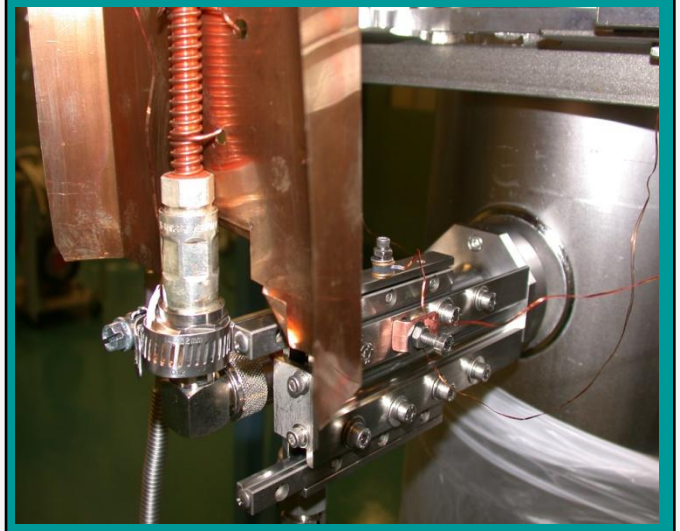
- Tuner operation in locked phase loop @ 6.4MV/m, Pf=166W, Pc=3.3W, Qo=7.13e8 coupling beta~200, bandwidth ~±20
- Force helium pressure fluctuations to test tuner
- ΔP=137 T, Δf=330Hz;
- compensation is Δf/Δt =13Hz/sec.
- No increase in phase noise during test.

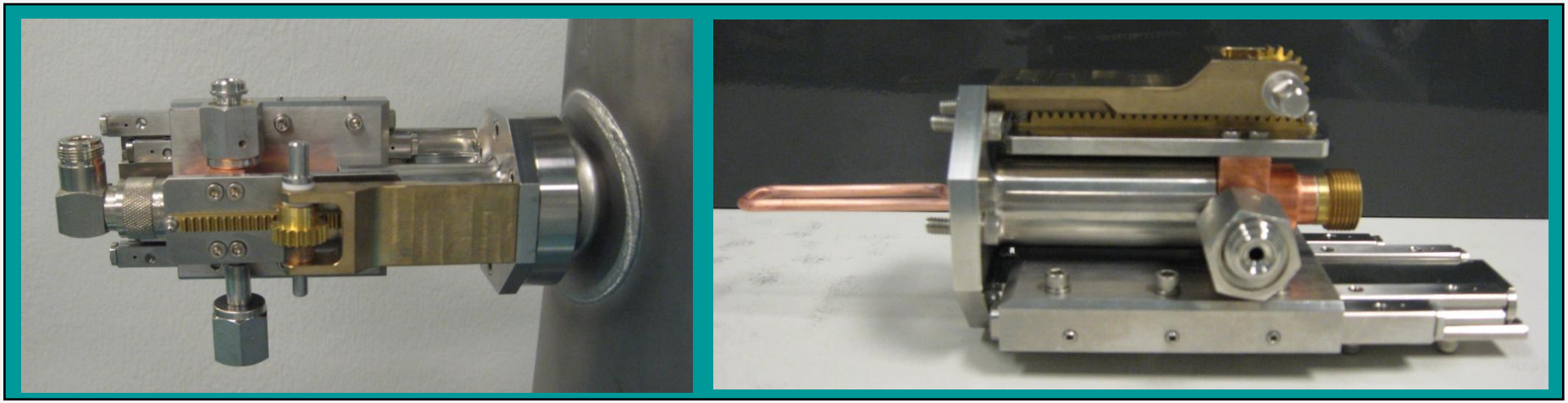


Phase II Coupling loop

- Developed new coupling loop with improved mechanical drive
  - Uses non-magnetic cross roller bearings
  - Reduce side loads by making the LN2 feed more symmetric
  - Performance tests show at P_f=200W the heat load to the helium is <0.5W

SCC coupling loop



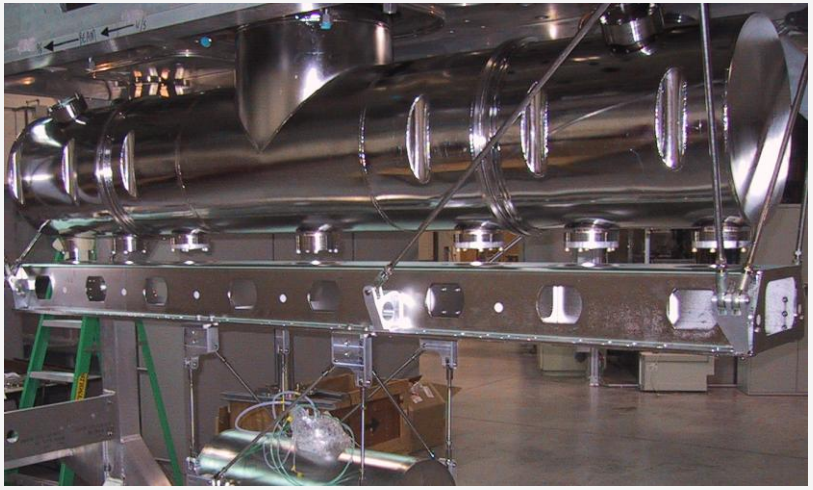


Direct Venting System

- Added direct venting line to the rf pick-up port
- Allows venting the cavity directly with filtered nitrogen
- To be used during top assembly installation or repair to keep positive pressure inside cavities and reduce the risk of particulate contamination

ISAC-II Phase-II cryomodule status

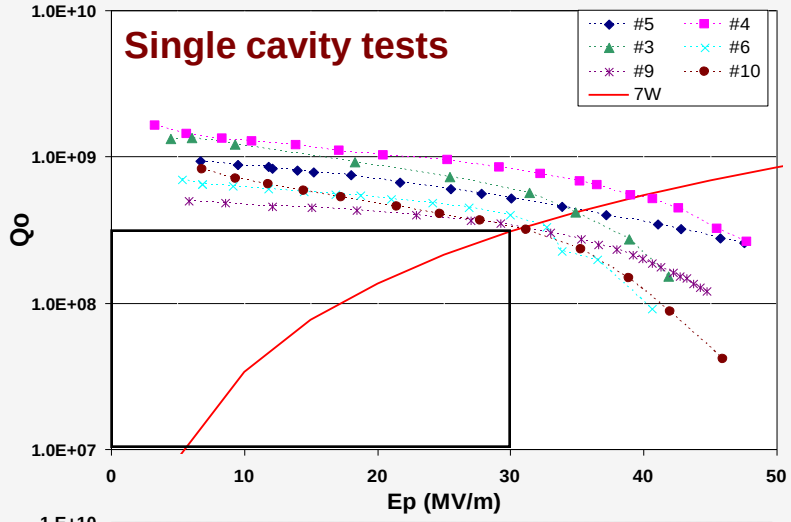
- Three cryomodules to be assembled, tested and installed in 2009
  - SCC1
    - cold tests completed
  - SCC2
    - In final assembly
    - Cavities available
    - Cold test in four weeks
  - SCC3
    - Dirty assembly complete

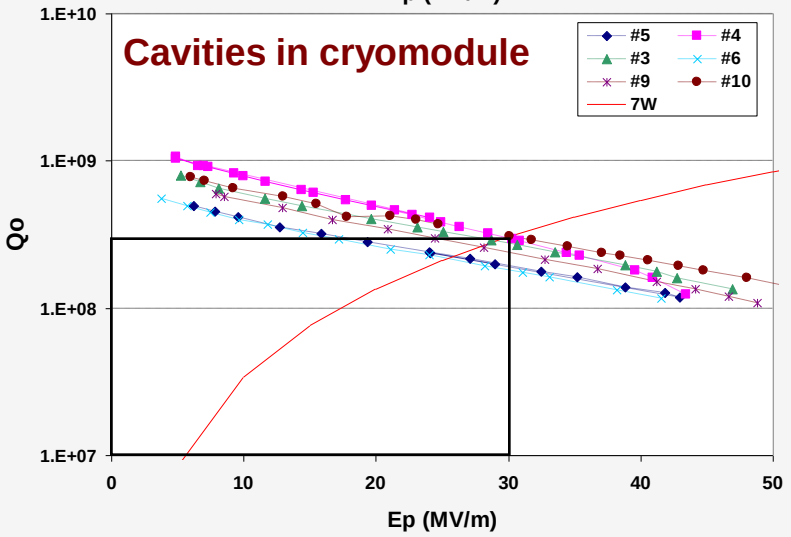


ISAC-II Phase-II Cryomodules

- **SCC1 cold tests complete**
  - established warm off-sets for cold alignment using WPM and optical targets
  - Checked cavities and rf systems
  - Measured static load
    - 24W @4K compared to 13W for Phase I (heat leak?)
    - 5ltr/hour LN2

SCC1 Cold Test - Cavities

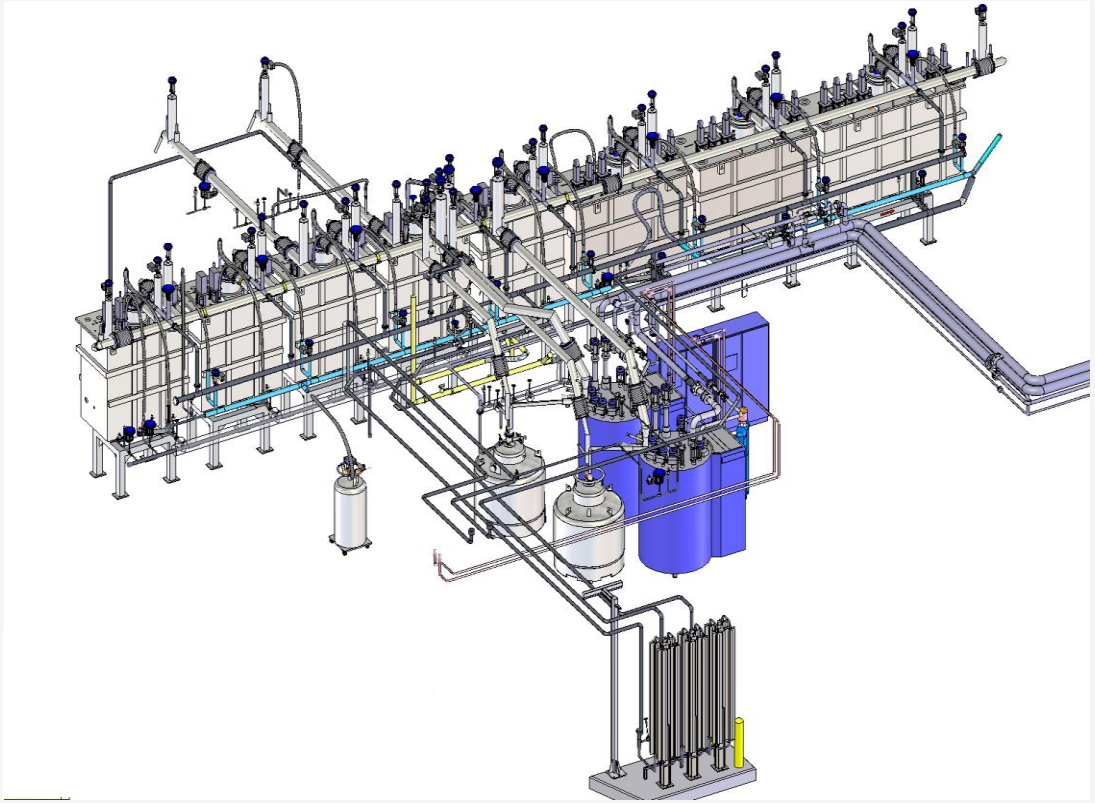




- Single cavity tests have an average performance of Ep=35MV/m at Pcav=7W
- Cavity performance in the cryomodule is significantly below – Ep=28MV/m
  - Q-disease is suspected
- Other checks
  - Magnet shielding checked ok
  - Water tested ok

Cryogenic system

- A second Linde TC50 (600W) refrigerator has been installed and commissioned
- Cold distribution piping now installed and commissioned
- LN2 piping and CM warm return lines now being installed



Installation Schedule

- Vault installation has begun
  - Beamline removed
  - Cryogenics installation underway
- SCC1 to be installed Oct 15
  - Will be fully tested after installation
- SCC2/3 – Nov. 15/Dec. 15
- Beam commissioning in Jan.-March 2010
  - first experiments April 2010

Summary

- Phase-II linac extension will add 20MV to ISAC-II SC-linac
  - On schedule for 2009 installation
- Fifteen production cavities received
  - Cavities for first module meet specification
  - Some problems with leaks – solution developed
  - Utilize custom etching for frequency tuning
- First cryomodule tested
  - All systems work; alignment good
  - Signs of Q-disease in on-line cavities
  - Direct venting system implemented
- Installation has begun
  - Installation of all cryomodules by end of 2009
  - Commissioning in Jan. 2010

Thanks

Note: We are now hiring a SRF Engineer
TRIUMF web page for details