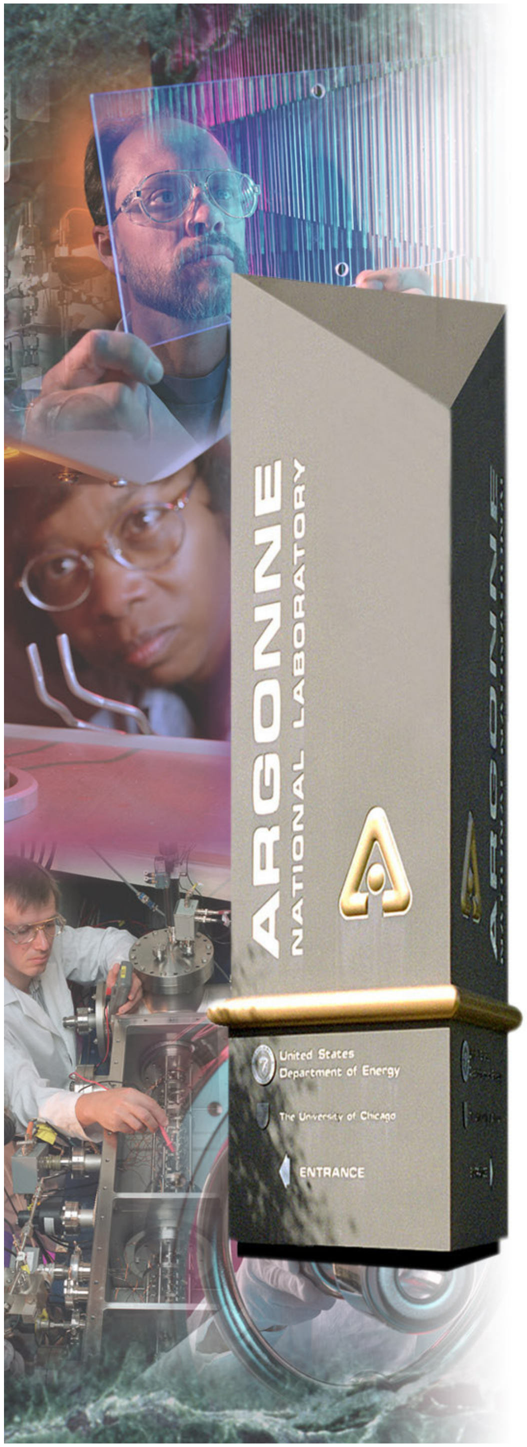


Structures for RIA and FNAL Proton Driver

Speaker: Mike Kelly

12th International Workshop on RF Superconductivity
July 11-15, 2005

Argonne National Laboratory

Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

Introduction: RIA and the Proton Driver

Why discuss these two machines together?

	Particle type	# of Cavities	Duty Factor
RIA	Ion (H thru U)	~400-500	CW
Proton Driver	Ion (H-)	~450	Pulsed ~1%

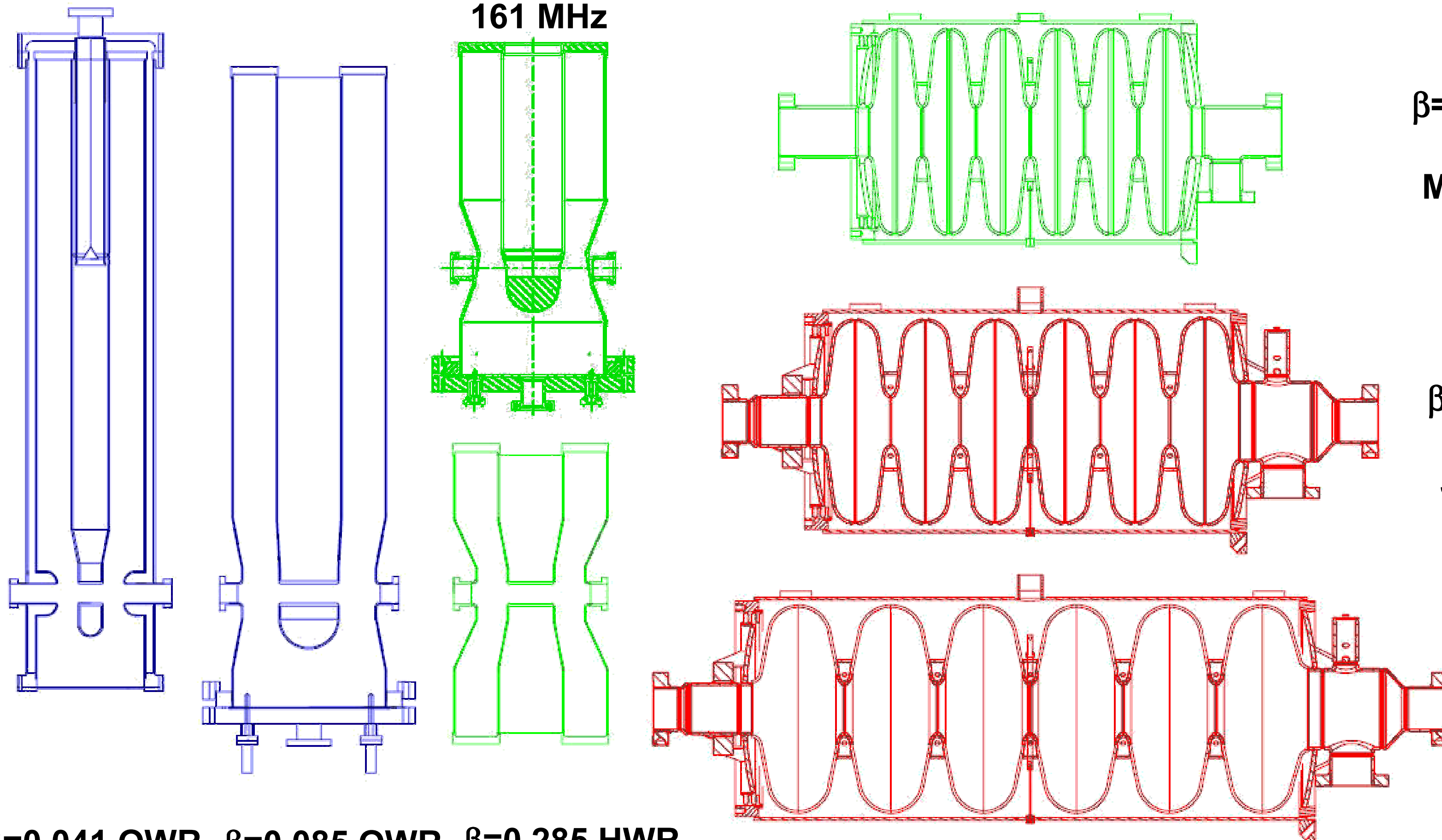
See Talks Friday July 15: "Rare Isotope Accelerator", R. York

"Proton Driver", W. Foster

Outline

- Cavity arrays: RIA and Proton Driver
- Cavity processing, assembly
- Test Results
- Mechanical Issues (microphonics & Lorentz detuning)

Review
MSU Structures for RIA: 805/10 MHz Bunch

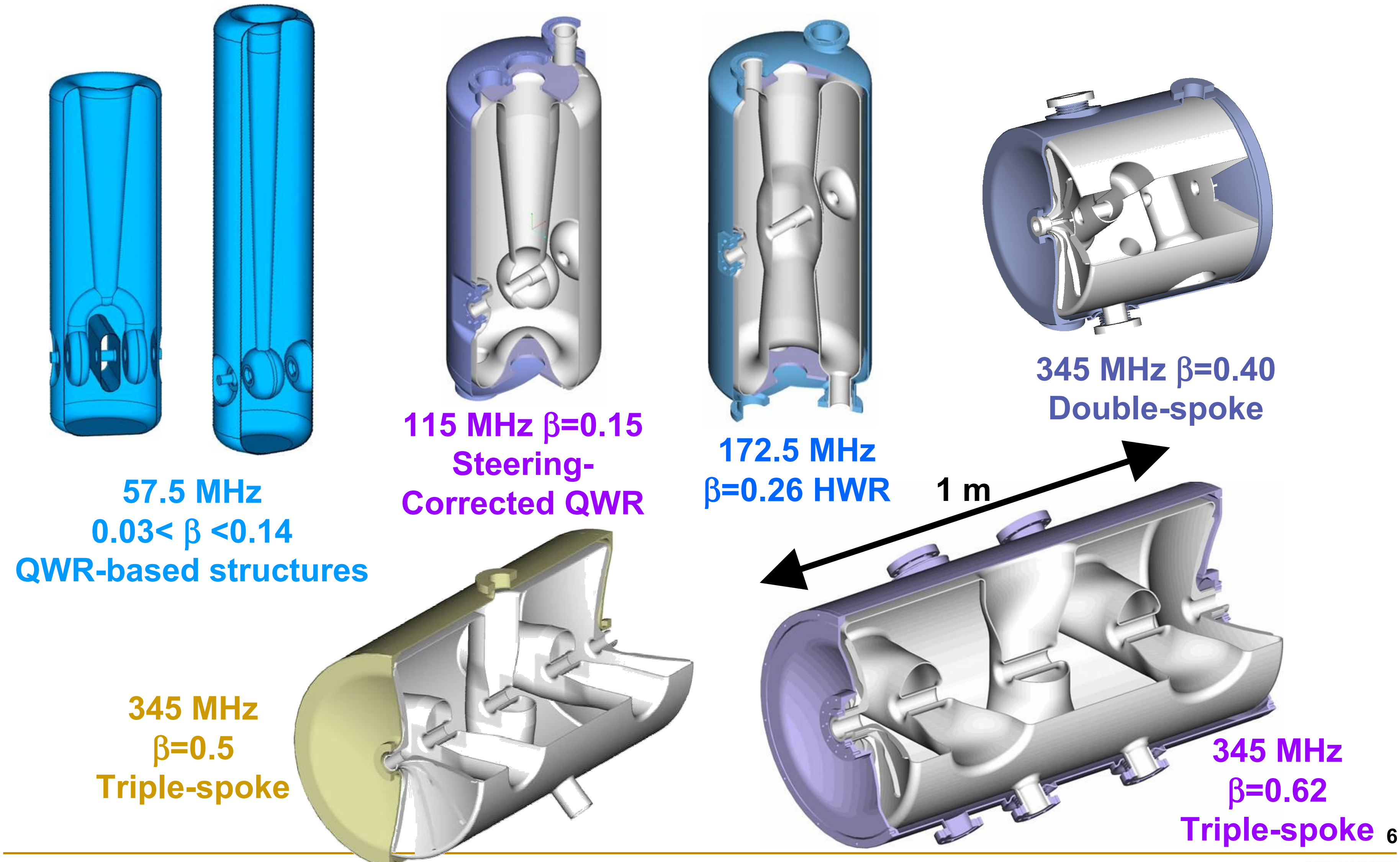


MSU RIA Cavity Baseline (805/10 MHz Bunch)

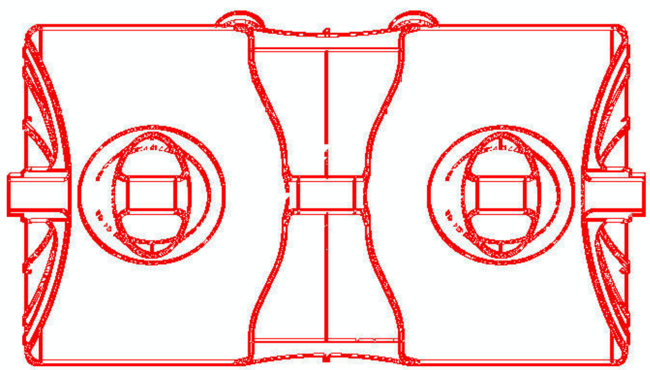
Beta geom	Cavity type	Freq (MHz)	Length (cm)	E_{ACC} (MV/m)	Number Cavities
0.04	QWR	80.5	18	4.1	18
0.06	QWR	80.5	21	5.6	56
0.16	QWR	161.0	19	5.2	90
0.28	HWR	322.0	19	6.8	208
0.47	6-Cell	805.0	55	10	14
0.47	6-Cell	805.0	55	10	44
0.61	6-Cell	805.0	68	12	64
0.81	6-Cell	805.0	91	12.6	32

Total # Cavities ~ 500

Review
ANL Structures for RIA: 805/14 MHz Bunch



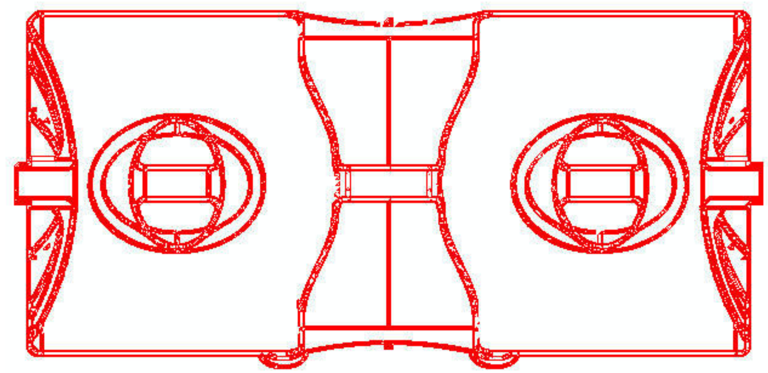
Open Technical Option: Triple-Spoke Resonators



β=0.50 3-Spoke

345 MHz

or 325 MHz (PD)



β=0.63 3-Spoke

345 MHz

or 325 MHz (PD)

See Talks/Discussions "Spoke vs Elliptical cavities for beta = 0.5", Wed, July 13th

"Low-beta cavity design", A. Facco, SRF 2005

"Low and intermediate beta cavity design", J. Delayen, SRF 2003

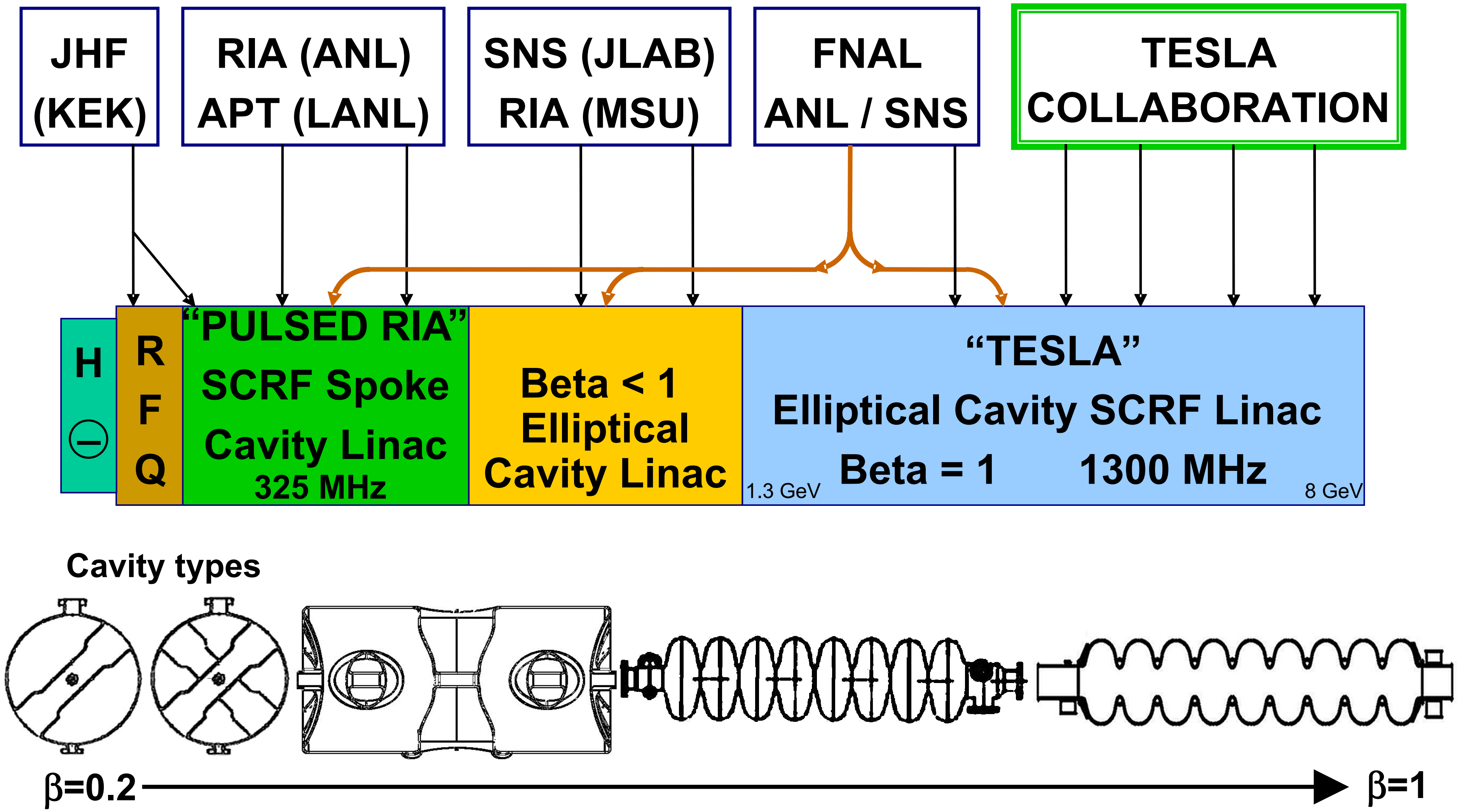
ANL RIA Cavity Baseline (805/14 MHz Bunch)

Beta geom	Cavity type	Freq (MHz)	Length (cm)	E_{ACC} (MV/m)	Number Cavities
0.02	Fork	57.5	20	4.0	2
0.03	Fork	57.5	25	4.0	5
0.06	QWR	57.5	20	6.8	28
0.15	QWR	115.0	25	6.3	48
0.26	HWR	172.5	30	6.9	80
0.39	2-Spoke	345.0	38	6.0	56
0.50	3-spoke	345.0	65	9.9	69
0.63	3-spoke	345.0	82	9.4	96
0.47	6-Cell	805.0	55	8.1	54
0.61	6-Cell	805.0	68	10.2	88
0.81	6-Cell	805.0	91	12.6	32

Open technical choice: 3-Spoke or e-cell

Total # Cavities ~ 400

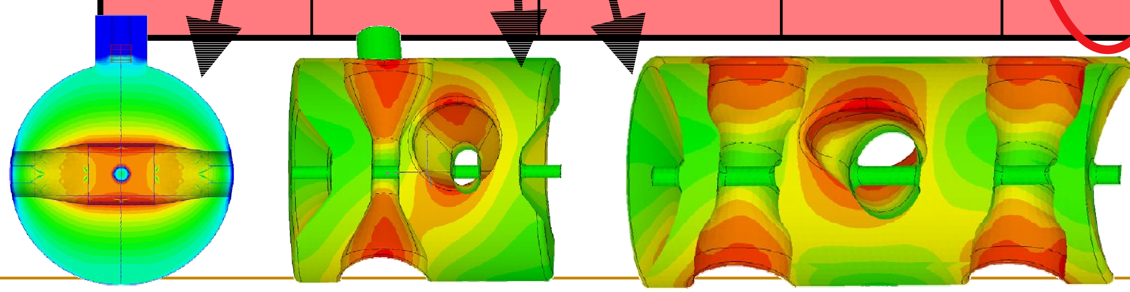
FNAL Proton Driver Linac



Proton Driver Cavity Array

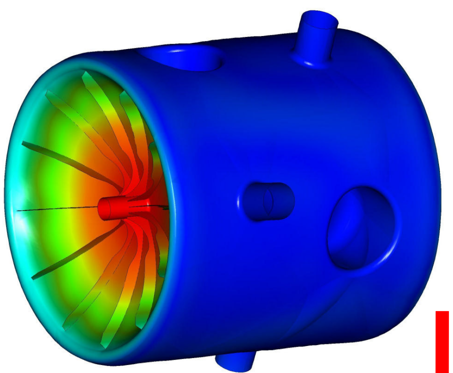
Beta geom	Cavity type	Freq (MHz)	Length (cm)	E_{ACC} (MV/m)	Number Cavities
0.21	1-Spoke	325.0	13.0	10.7	16
0.40	2-Spoke	325.0	36.9	10.7	28
0.61	3-Spoke	325.0	85.8	10.7	42
0.47	6-Cell	1300.0	32.5	15.2	16
0.61	6-Cell	1300.0	42.2	19.2	32
0.81	8-Cell	1300.0	74.8	23.7	48
1.0	9-Cell	1300.0	103.8	26.0	288

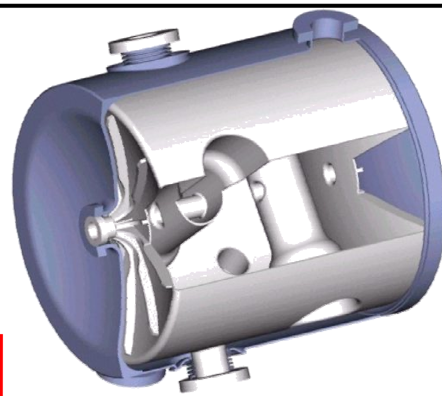
Open technical choice: 3-Spoke or 6-cell



Spoke cavity EM models (HPSL 2005, G. Apollinari)

Design & Fabrication





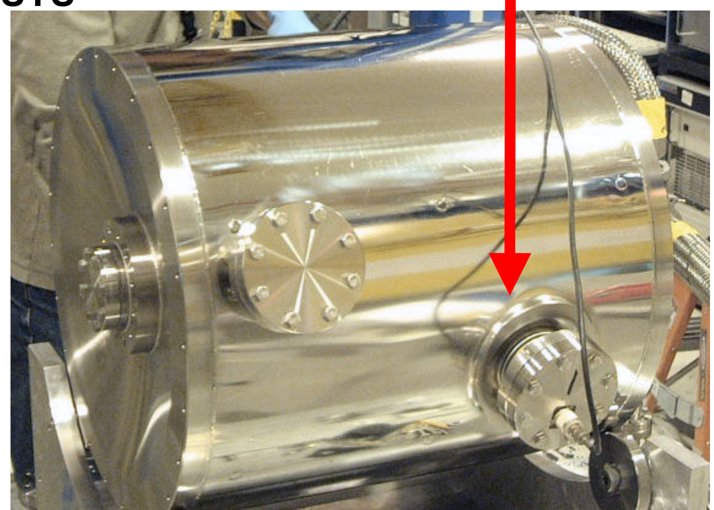
Designed in 3D using modern simulation codes *e.g.* MAFIA, Microwave Studio and ProE/ANSYS

Niobium-to-stainless braze or Niobium-to-NbTi

3 mm (also 2 and 4 mm) RRR=250 niobium sheet

Die formed and EB-welded

Courtesy AES

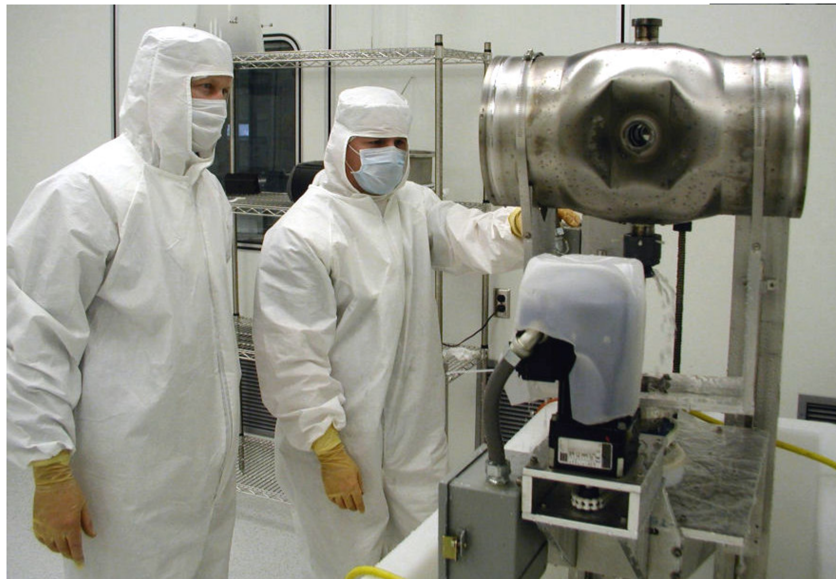


Double-wall with S.S. He jacket; alternatively titanium or niobium

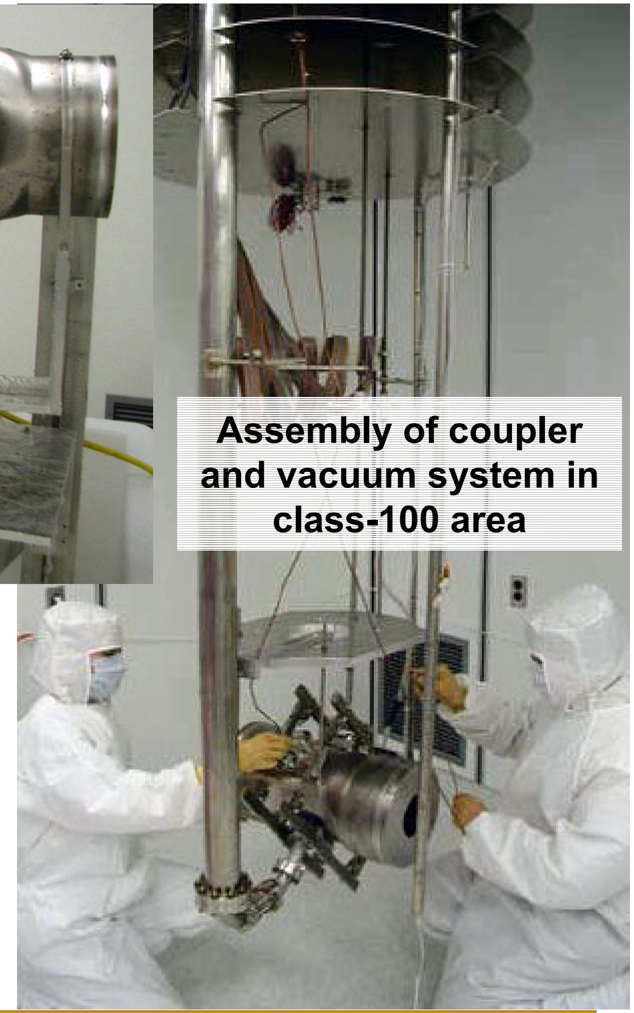
Cavity Surface Preparation, Assembly

- **Low- and mid-beta groups have universally adopted clean techniques developed at DESY, KEK, JLAB**

100-200 microns removed using BCP and/or EP

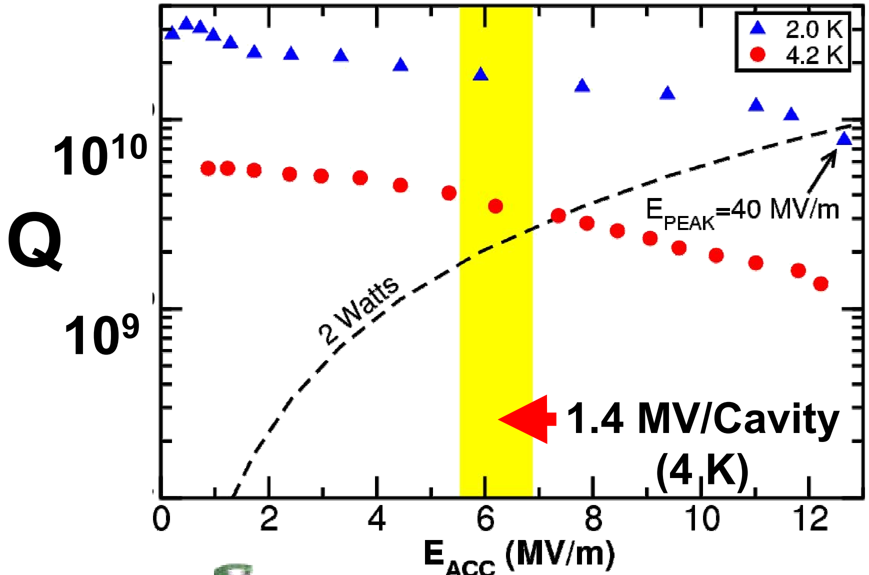


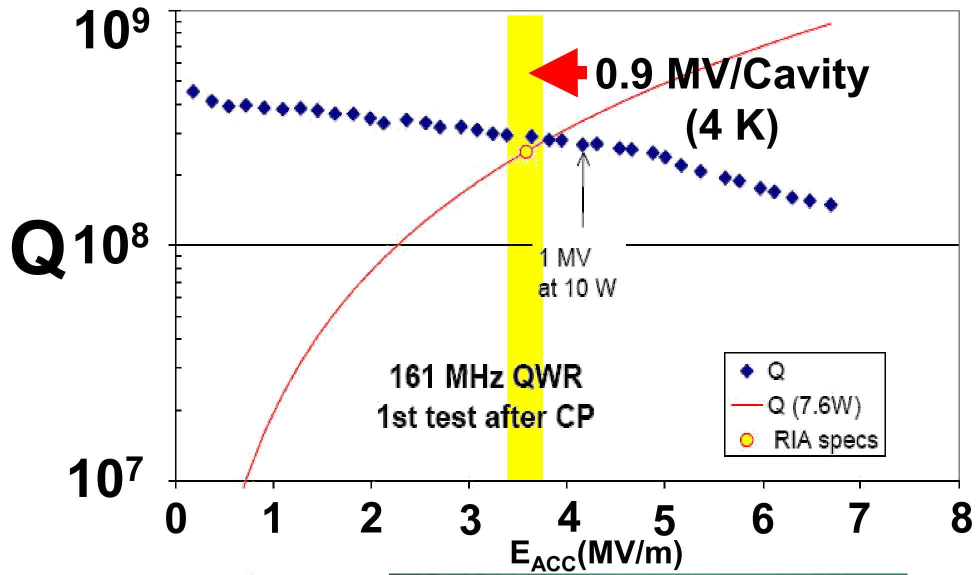
1-hour or more HPR in a clean room area

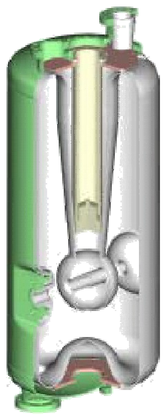


Assembly of coupler and vacuum system in class-100 area

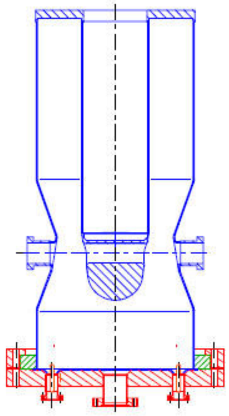
Results:
Beta~0.15-16 Quarter-wave Resonators








β=0.15 QWR, f_0=115 MHz

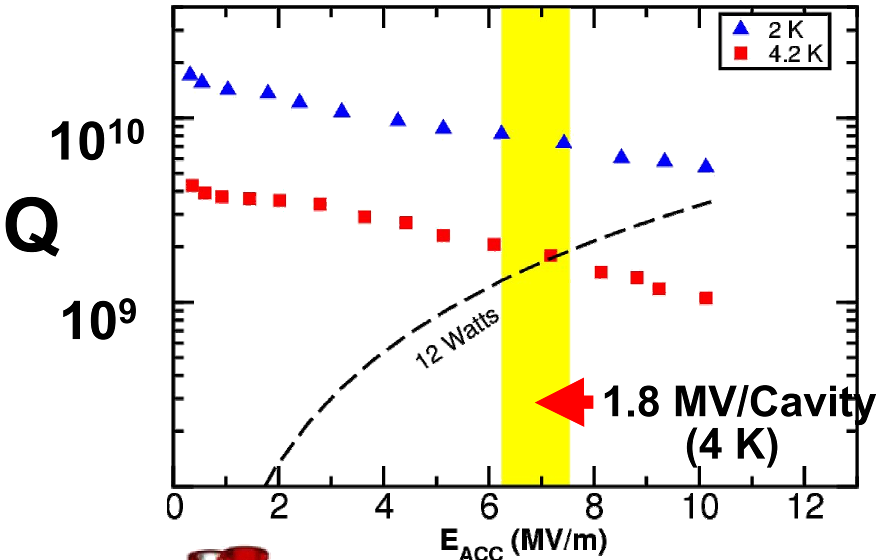


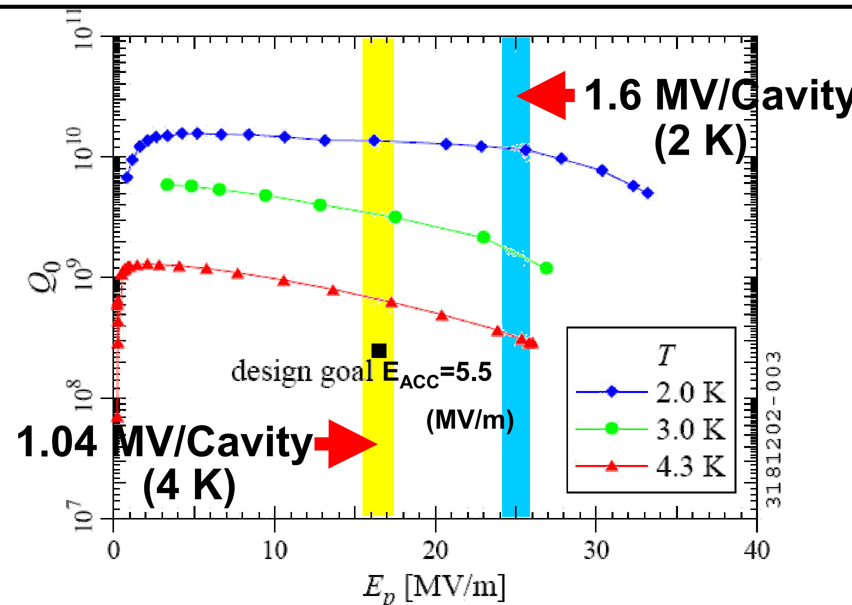

β=0.16 QWR, f_0=161 MHz

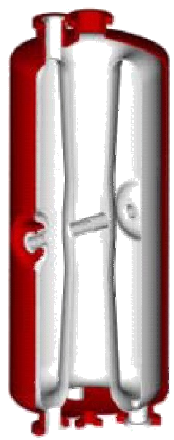
See: "Minimizing transverse-field effects in superconducting quarter-wave cavities", Ostroumov, Shepard, LINAC 2002

"Construction and Testing of a 161 MHz, Beta=0.16 Superconducting QWR With Steering Correction for RIA", A.Facco, EPAC 04

Results:
Beta~0.25 Co-axial Half-wave Resonators

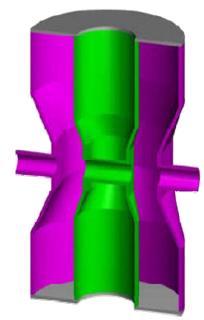






β=0.25 HWR, f_0=172.5 MHz

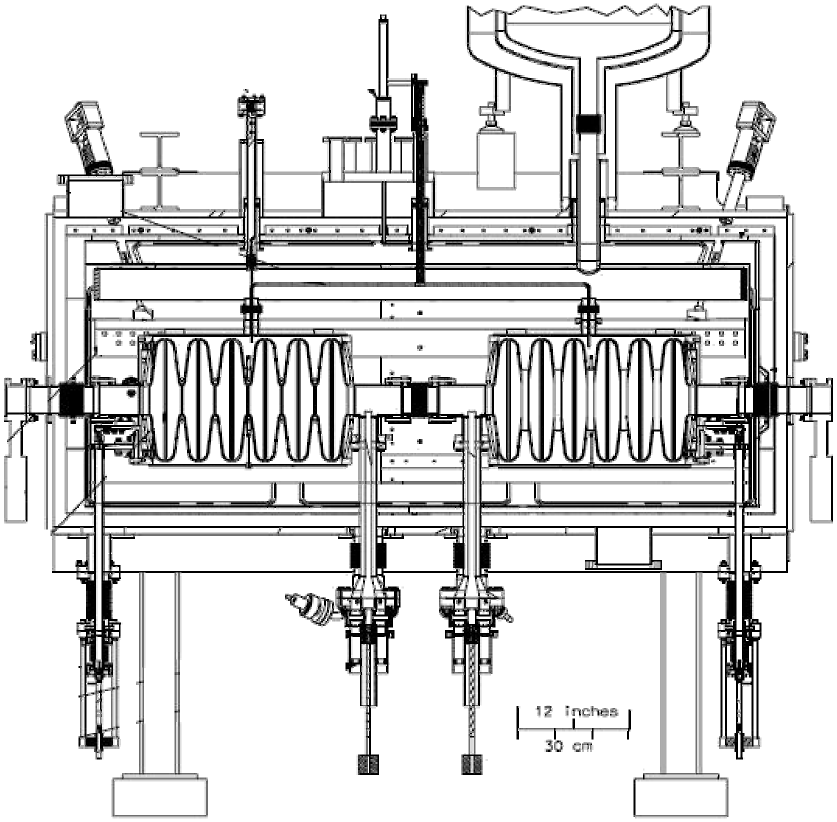
(See Kelly et al. THP06, LINAC 2004)

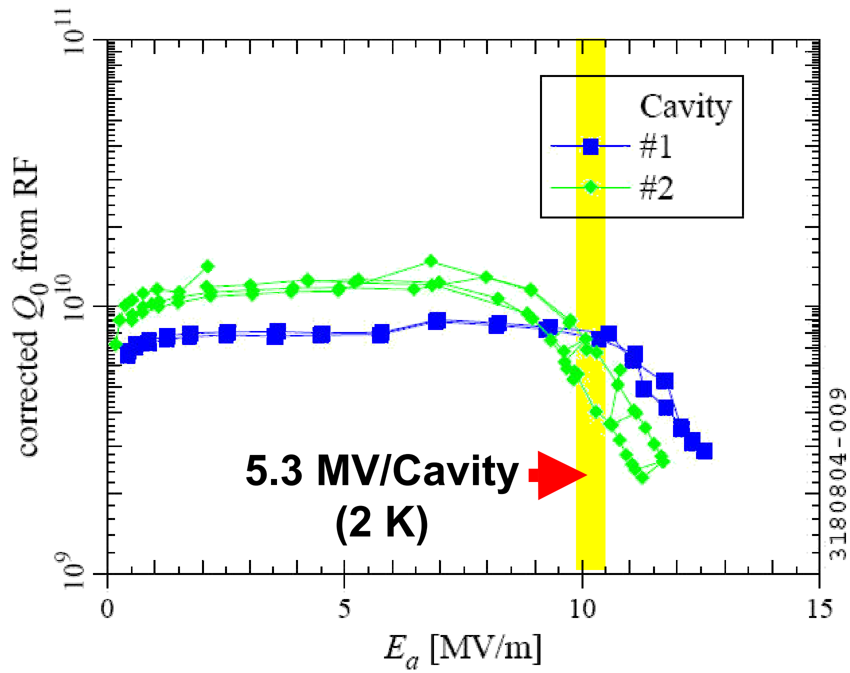


β=0.285 HWR, f_0=322 MHz

(See Grimm et al. TPAB067, PAC 2003)

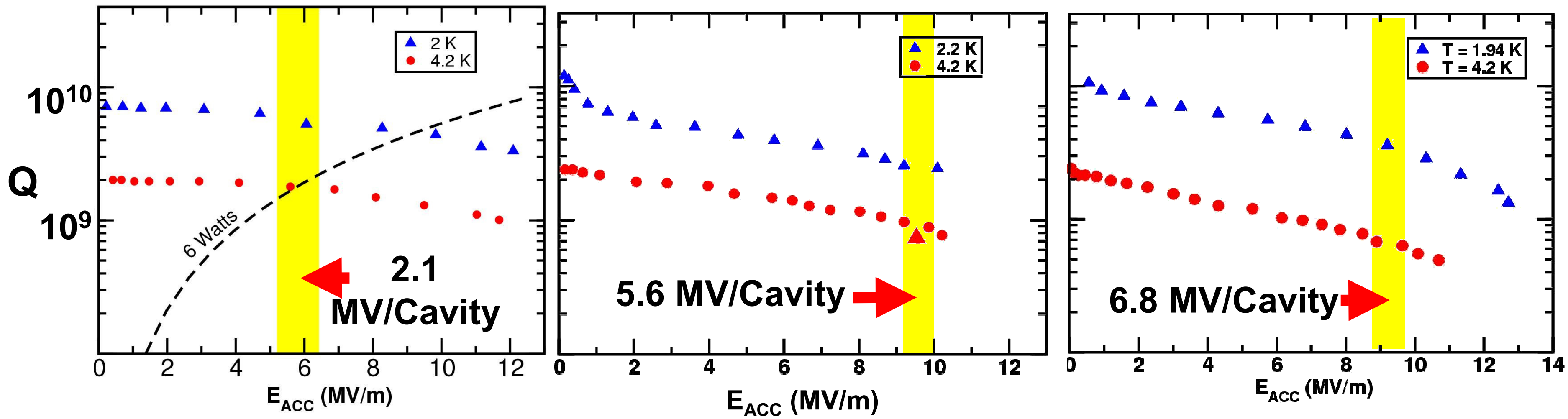
Results:
Beta=0.49 Elliptical-cell Cavities

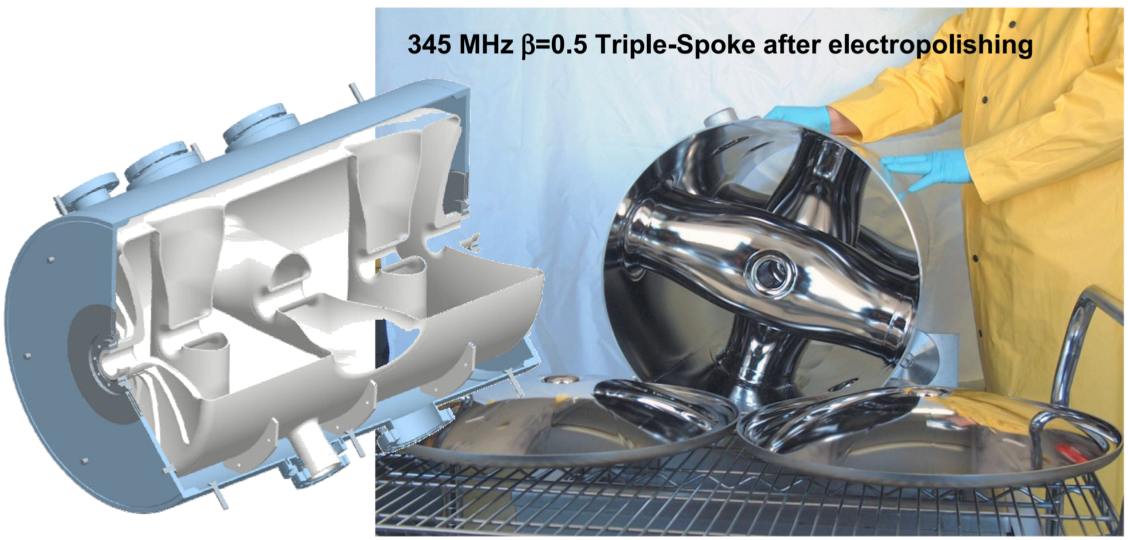




(See Grimm et al. THP70, LINAC 2004)

Results:
Beta=0.40, 0.50 and 0.63 Multi-Spoke Cavities

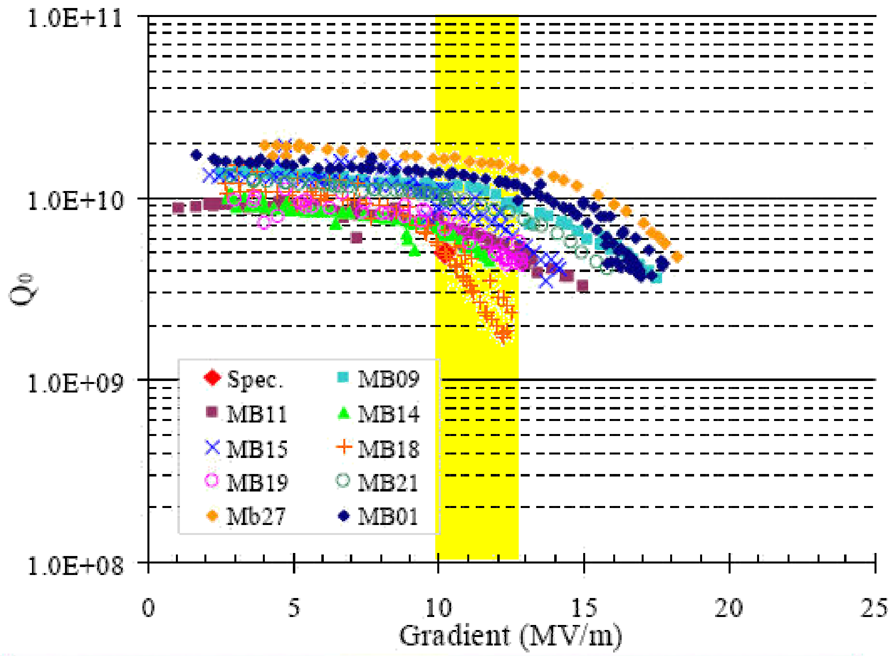


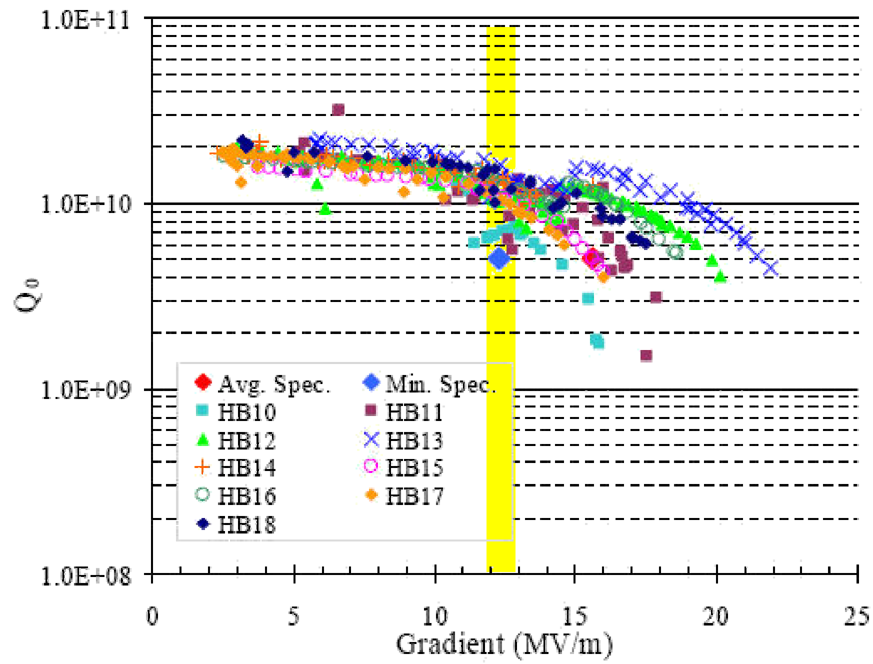


- Q-disease has been observed; hydrogen degassing is planned

See Shepard et al. TPPT099, TPPT100, PAC 2005 and Kelly et al. TuP53 SRF 2003

Results:
Beta=0.61 and 0.81 SNS Elliptical-cell





SEE: Ozelis et al. TPPT079 PAC 2005 and
I. Campisi, MoA02 SRF 2005

Fast Tuning: Microphonics, Lorentz Detuning

- **Overcoupling** One rf supply/cavity (RIA Baseline)

  Klystron/Fast ferrite tuner (Proton Driver Baseline)

- **Piezoelectric or magnetostrictive mechanical tuner**

  Used for compensation of microphonics or Lorentz detuning

- **Voltage Controlled Reactance (VCX)**

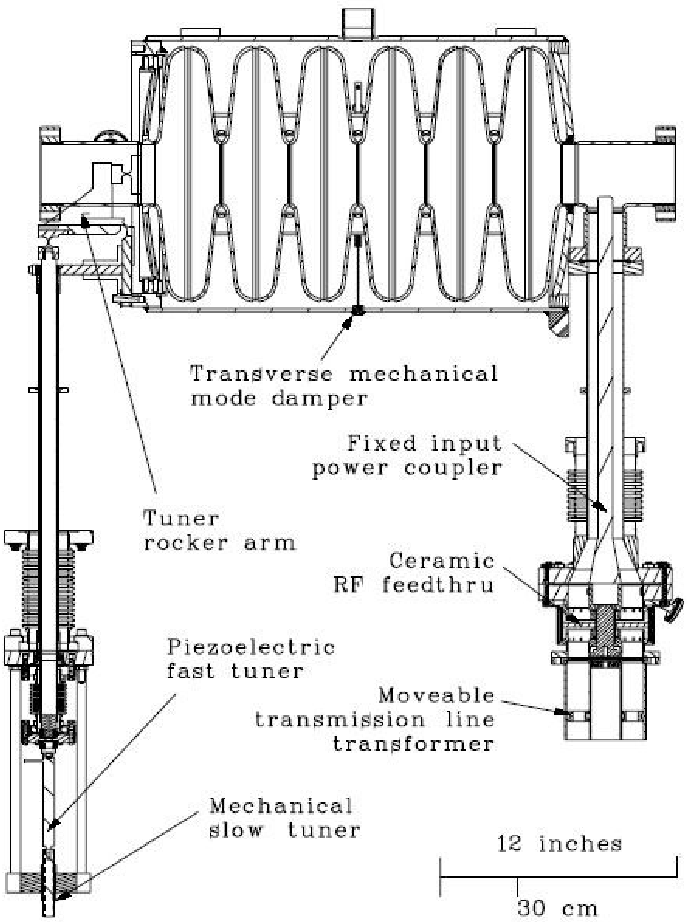
  Currently an option only for low frequency (QWR) structures

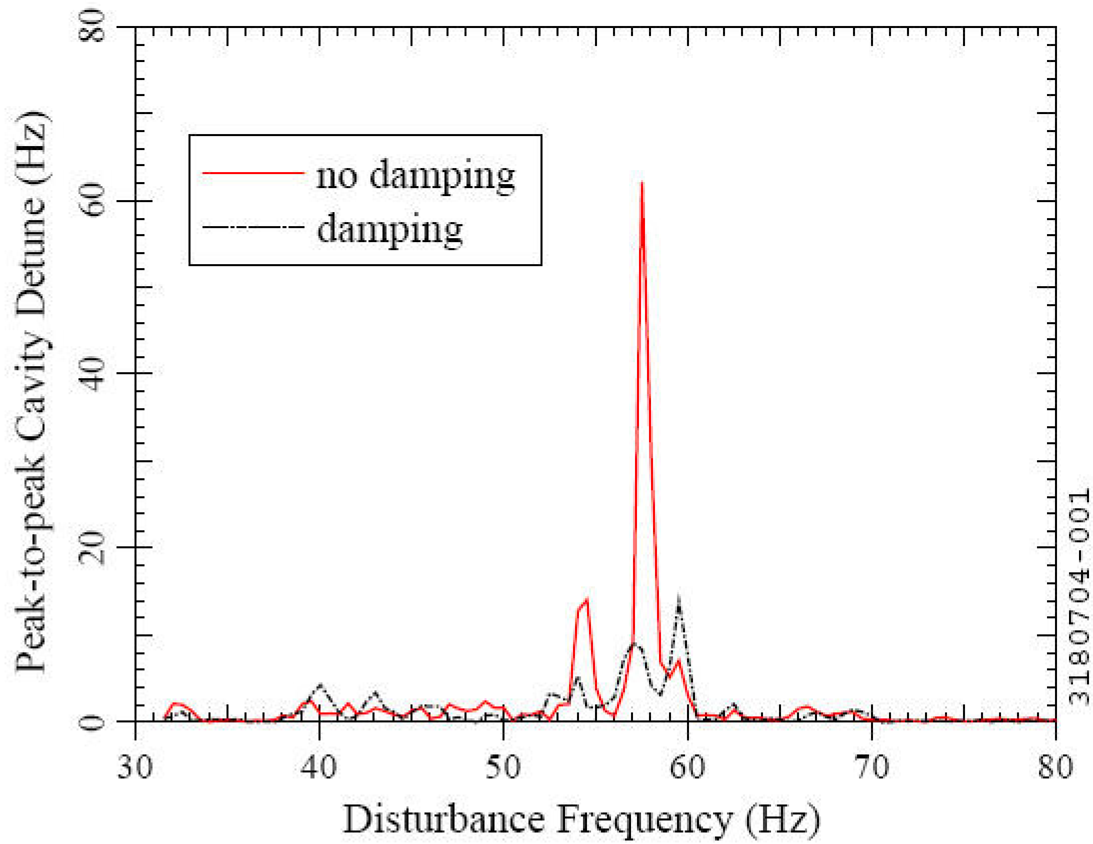
All require further development for mid- and high-beta RIA cavities

See Talk: Tuesday July 12, "Pulsed-operation of SC spoke cavities"

Z. Conway (Argonne)

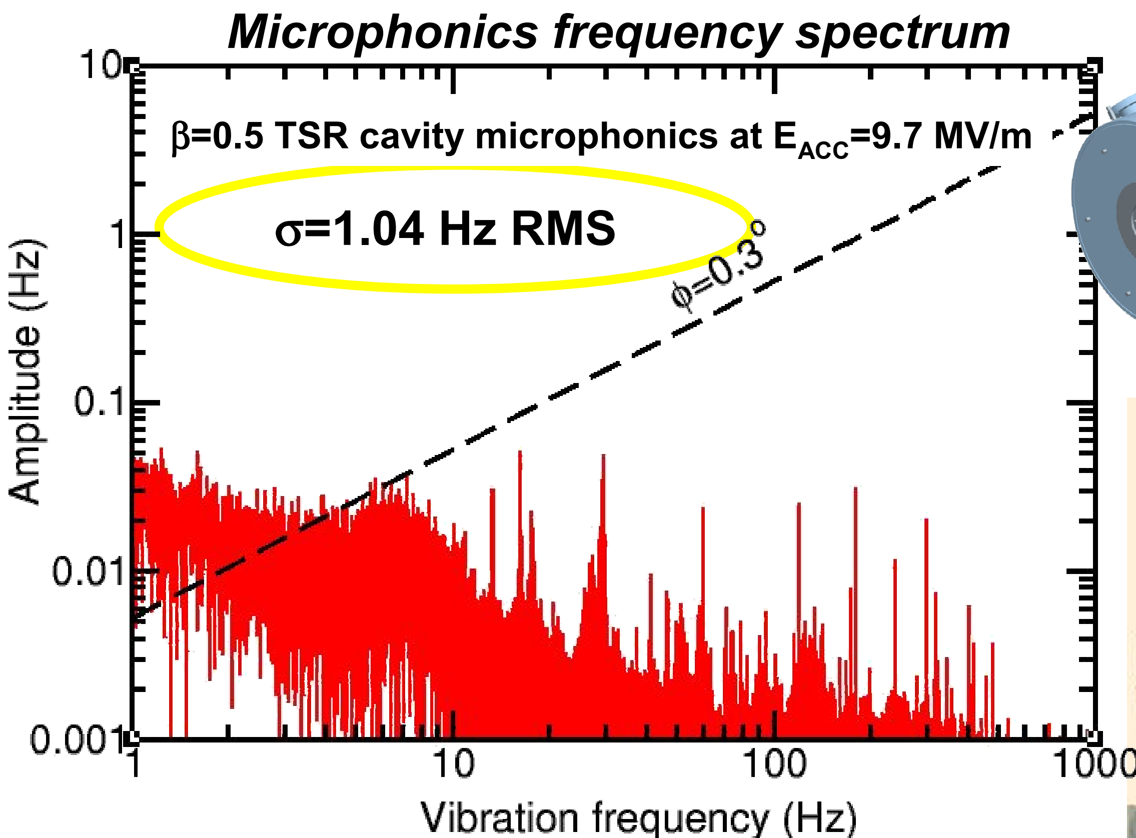
Microphonics, Fast Tuning

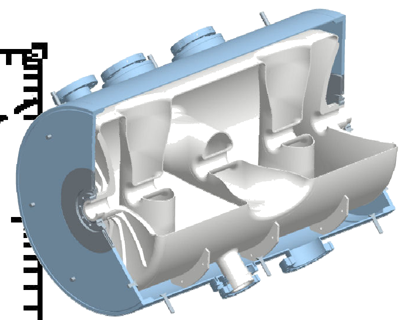


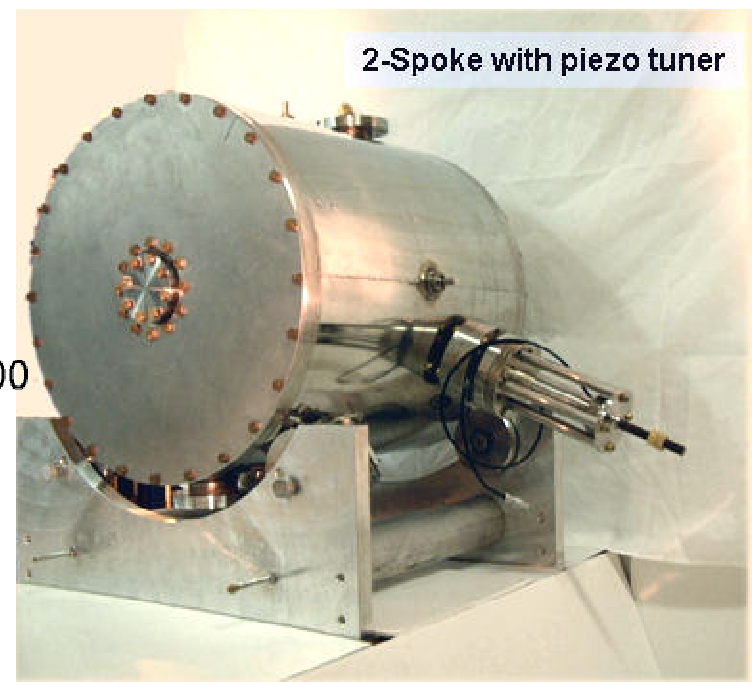


(See Grimm et al. THP66, LINAC 2004)

Microphonics, Fast Tuning







Conclusion

- **Development of superconducting cavities for RIA is well-advanced**

- **Cavity gradients required for RIA have been demonstrated; Proton Driver gradients at the limit of what has been achieved**

- **The most pressing development task:**
  - Fast-tuner system for both cw and pulsed operation