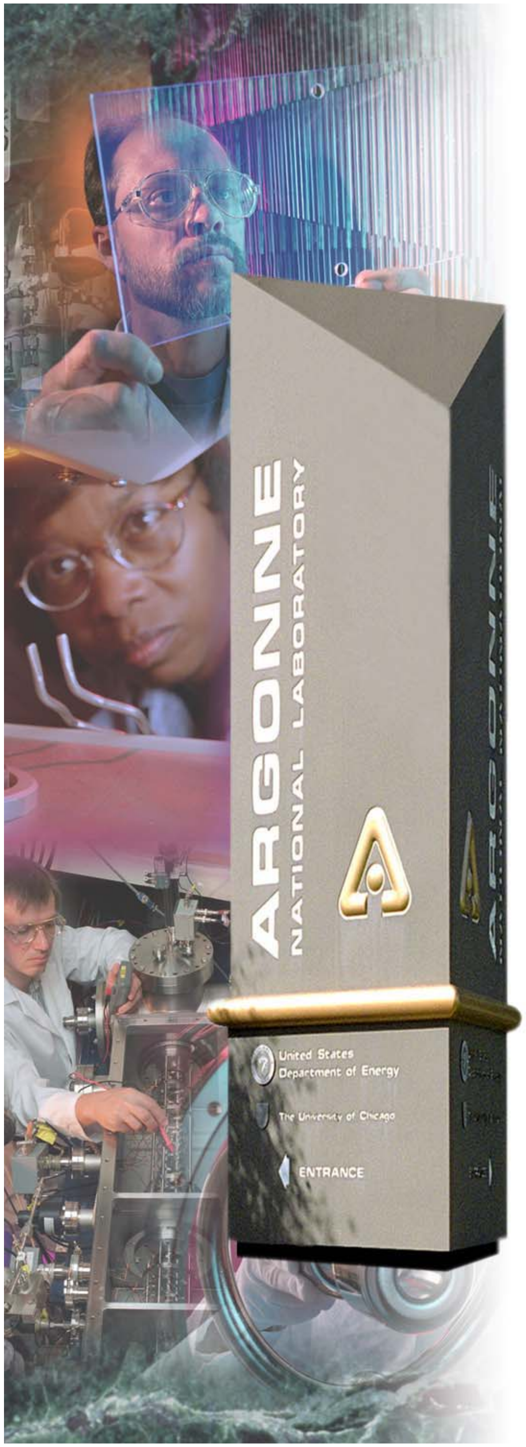

Development of SC Intermediate-velocity Cavities for the U.S. RIA Project

Presented at the

11th Workshop on RF Superconductivity

Lubeck-Travemunde, Germany

September 10, 2003

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Argonne National Laboratory

Office of Science
U.S. Department of Energy

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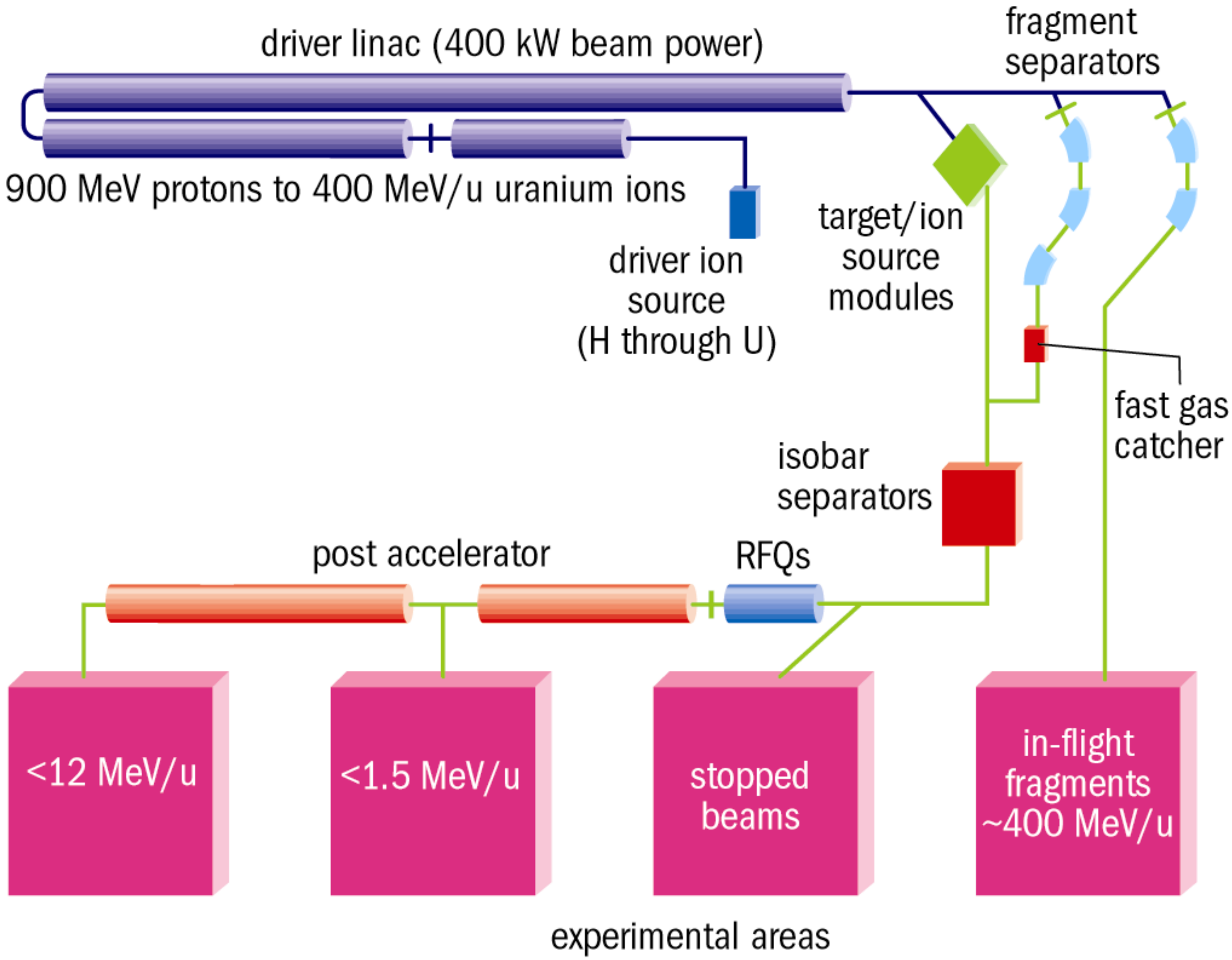
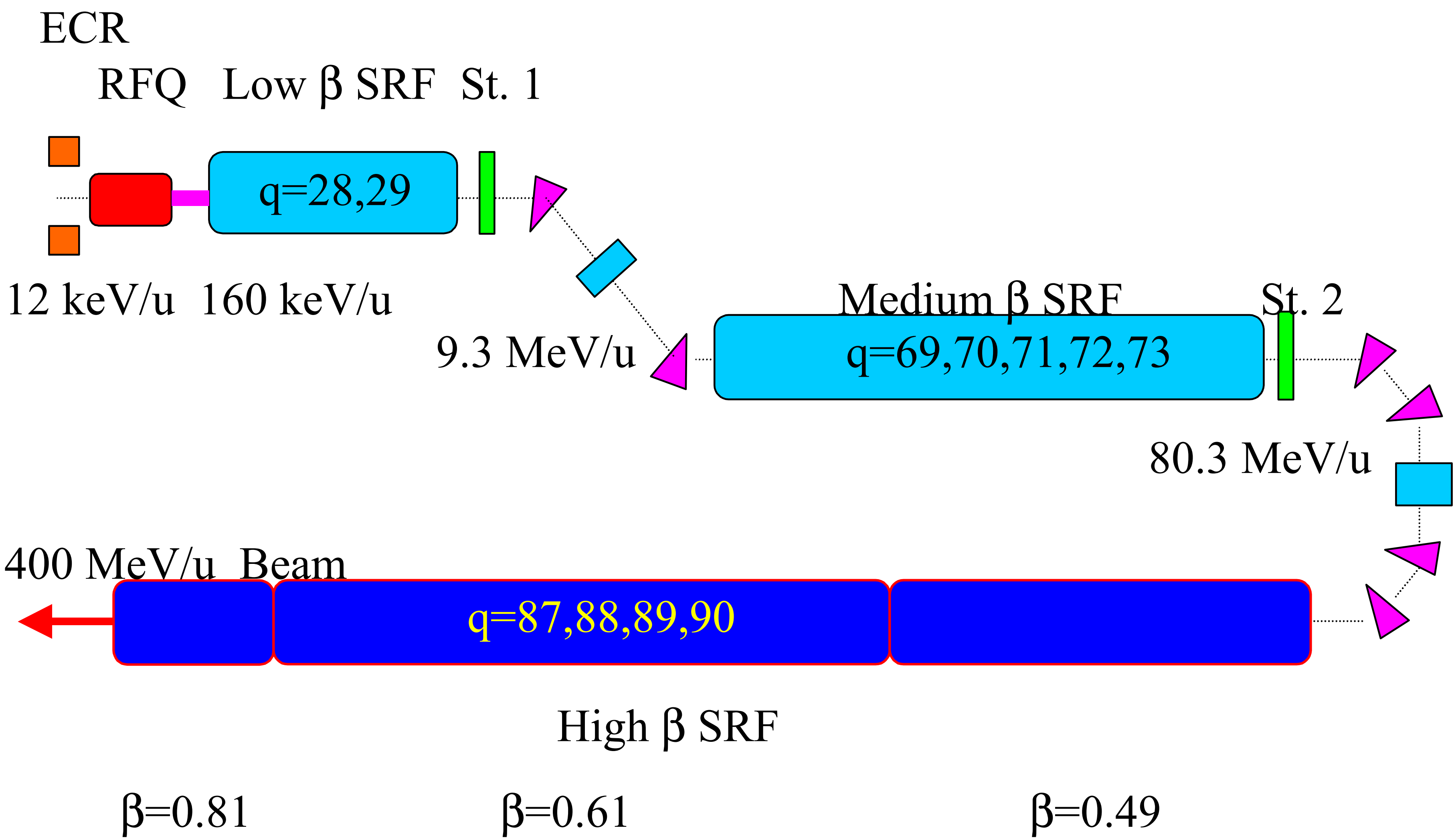
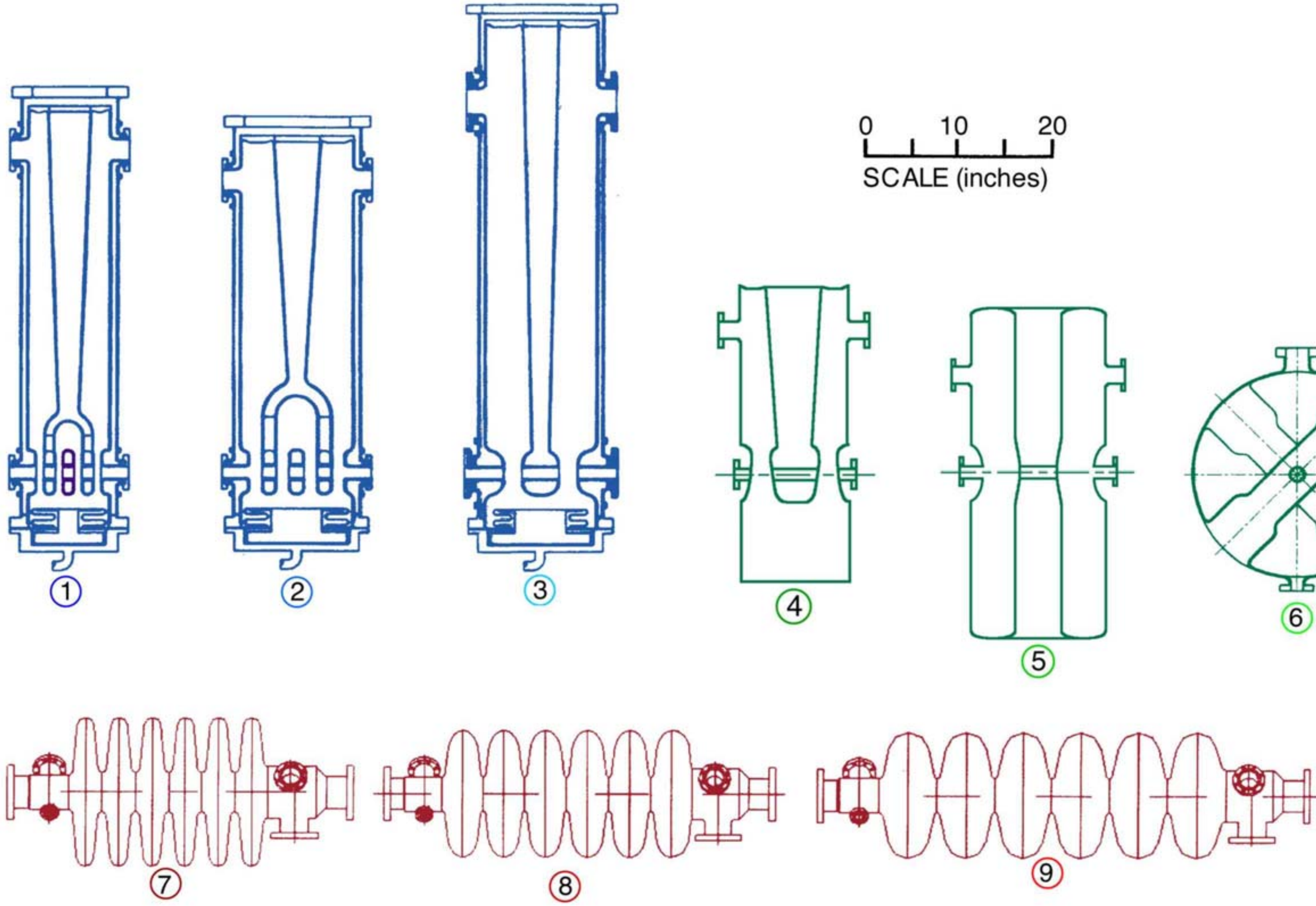
The U.S. RIA Project (see Stan Schriber's talk in the closing plenary session)



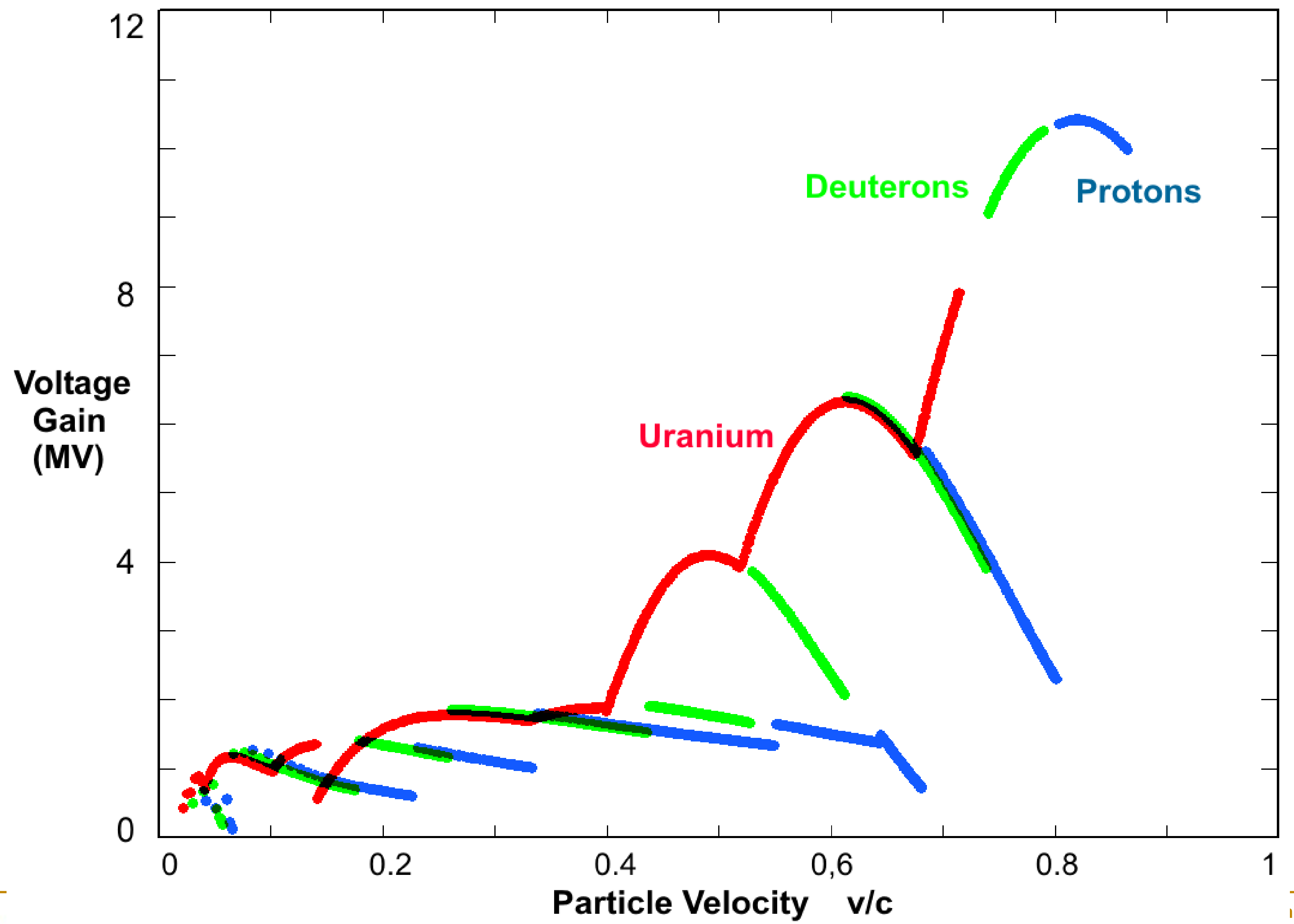
RIA Driver Linac: 400 kW, protons - uranium



Driver Linac Cavity Array *(ANL updated baseline)*



“Cavity-Walk” (voltage gain per cavity) for the Baseline RIA Driver Design



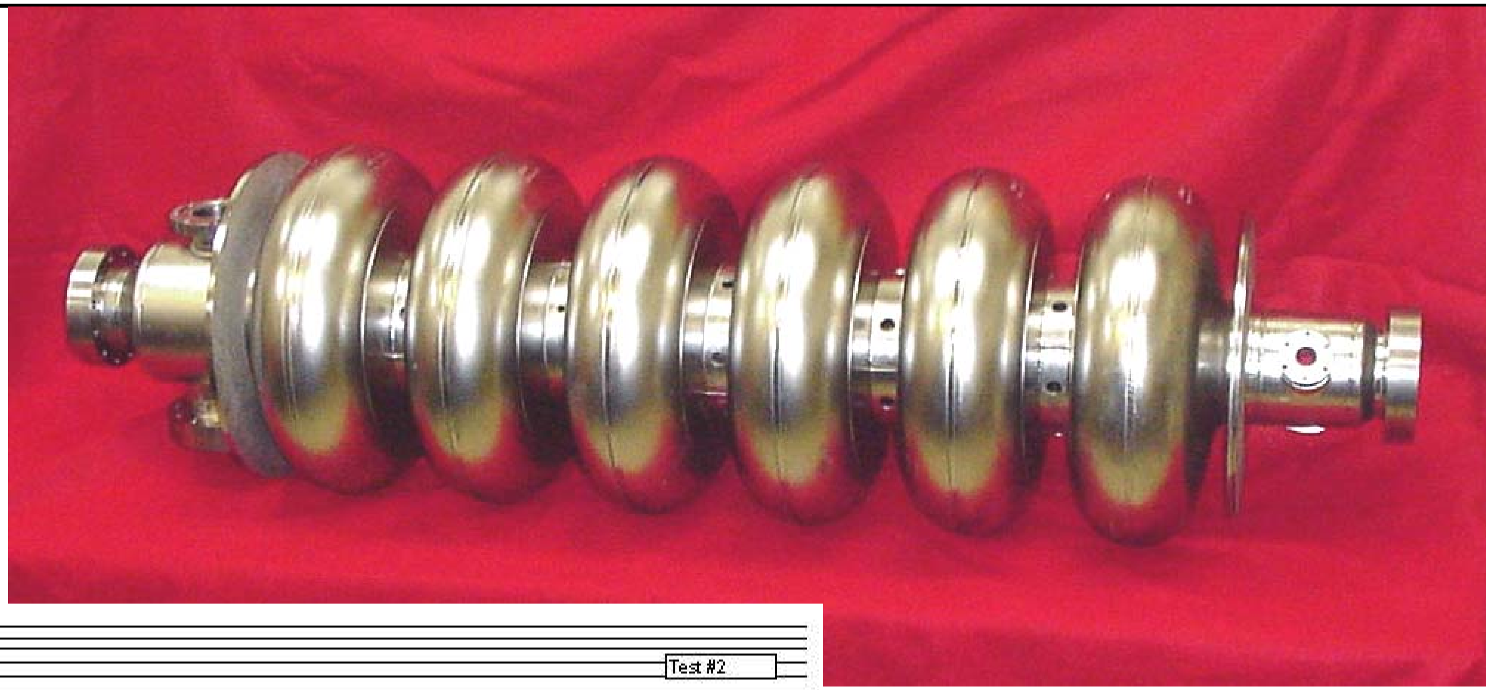
RIA Driver Linac Cavity Array *(ANL Baseline Design)*

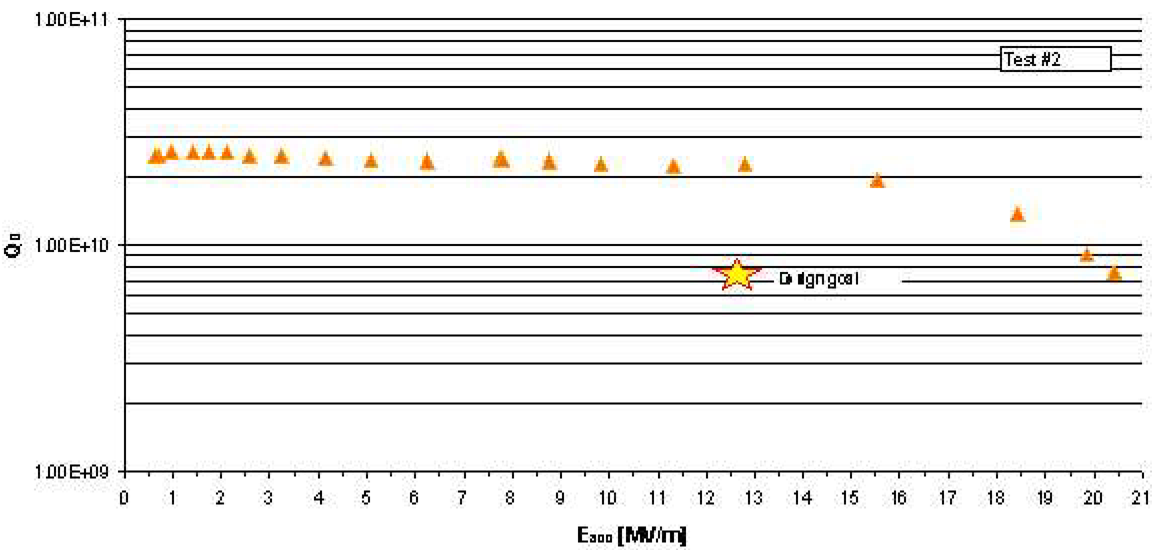
Type	Beta	Freq (MHz)	Length (cm)	Maximum RF E-Field	Number of Cavities
FORK	0.02	57.5	20	16	2
FORK	0.03	57.5	25	16	5
QWR	0.06	57.5	20	20	28
QWR	0.15	115	25	20	48
HWR	0.26	172.5	30	20	80
2 SPOKE	0.39	345	38	20	56
6-CELL	0.47	805	53	27.5	54
6-CELL	0.61	805	68	27.5	88
6-CELL	0.81	805	91	27.5	32
				Total # =	393

Intermediate-beta cavity development for RIA $0.2 < \beta < 0.8$

- **ANL and MSU are independently developing designs for RIA (for MSU perspective see papers by Terry Grimm, et al. at this conference MoPO3, TuP14, TuPO8, ThP26, ThP35, and also Stan Schriber in FrO04)**
- **The ANL design is based on 805/14 MHz bunch**
- **The MSU design is based on a 805/10 MHz bunch**
- **Both designs require the development of intermediate-velocity superconducting cavities and support systems**

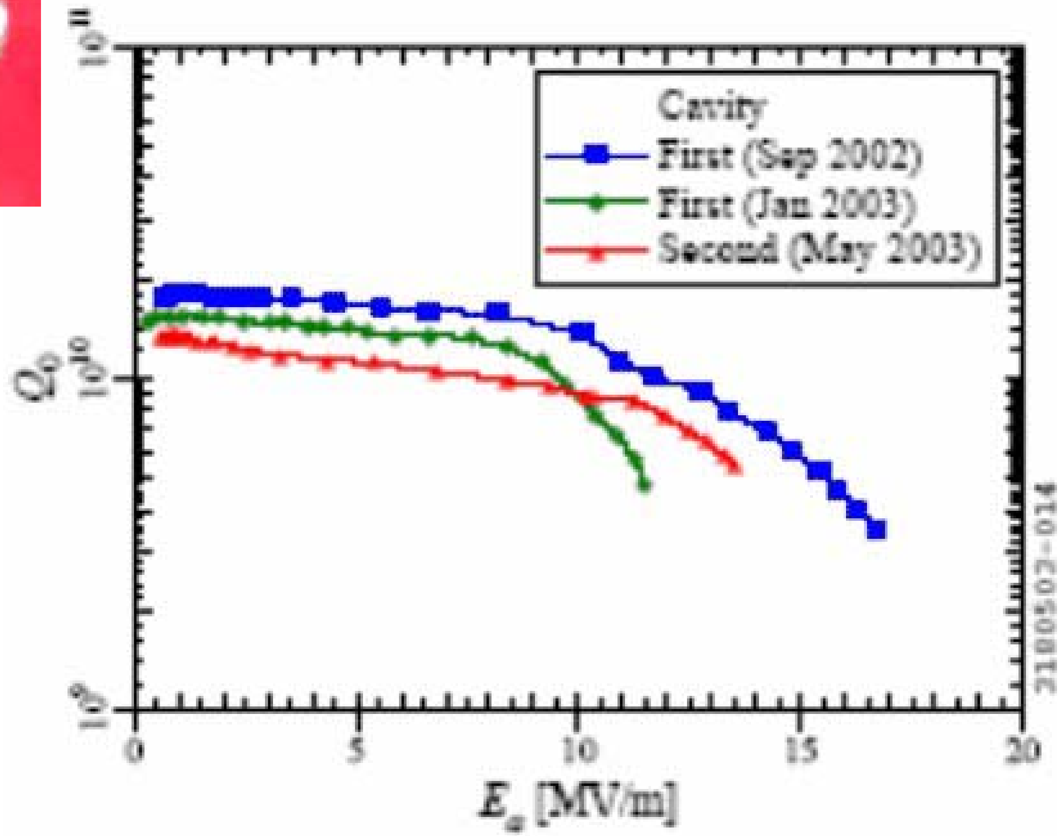
JLAB 805 MHz 6-Cell β=0.61&0.81 Cavities





Elliptical-cell results were discussed in Lilje's talk TuO03

Beta 0.47 6-cell Elliptical-cell (JLAB/MSU)



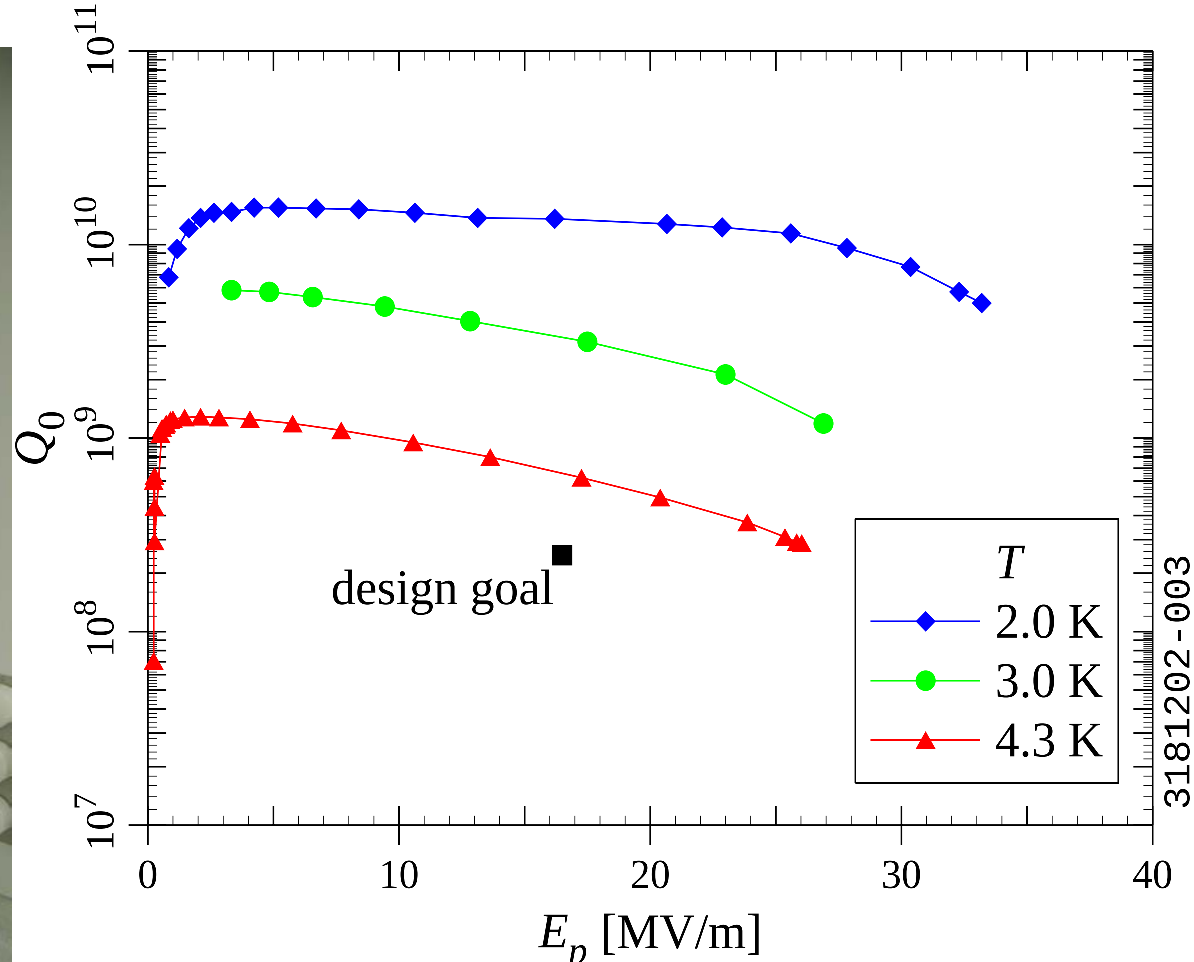
Lilje included early results on a bare-niobium β=0.47 six-cell.

Determining the mechanical and micropohonics properties of a complete, jacketed cavity is the next task.

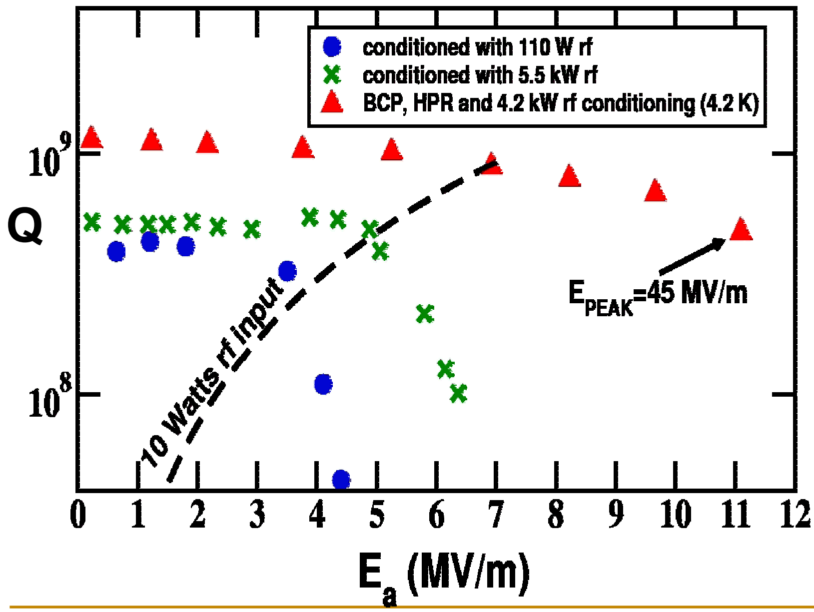
TEM-Structures for β>0.2

- The three types 6-cell elliptical-cell cavity seem well in hand. These cavities form the high-energy section of the RIA driver in the current baseline design for BOTH ANL and MSU
- Present plans at MSU call for a 322 MHz coaxial half-wave cavity for the lower portion of the intermediate-velocity section.
- Present plans at ANL call for a 172 Mz half-wave and either one or two types of 345 MHz multiple-cell spoke-loaded cavity.

MSU/NSCL 322 MHz, β=0.285, Half-wave resonator (paper MoP03)

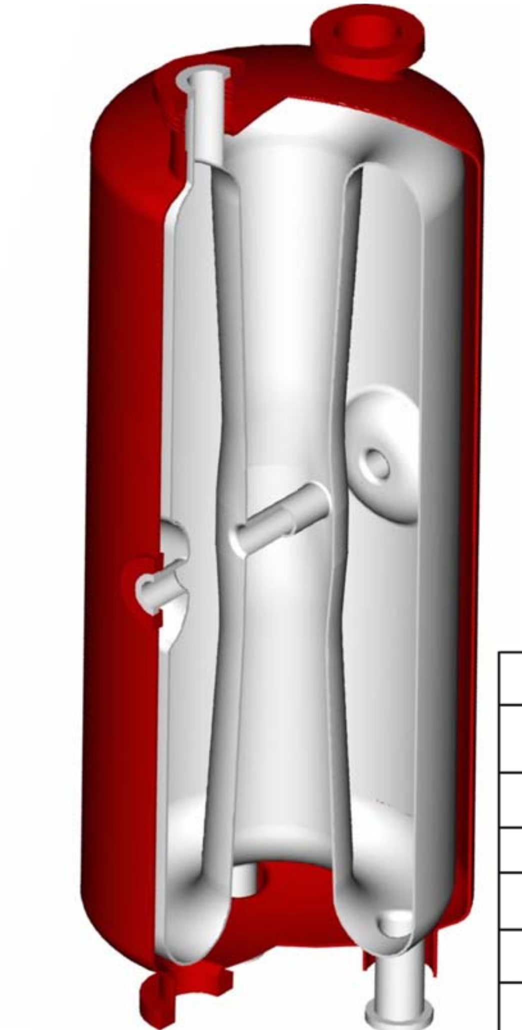


At the last workshop, we saw that HPR gives a dramatic improvement in performance for TEM cavities



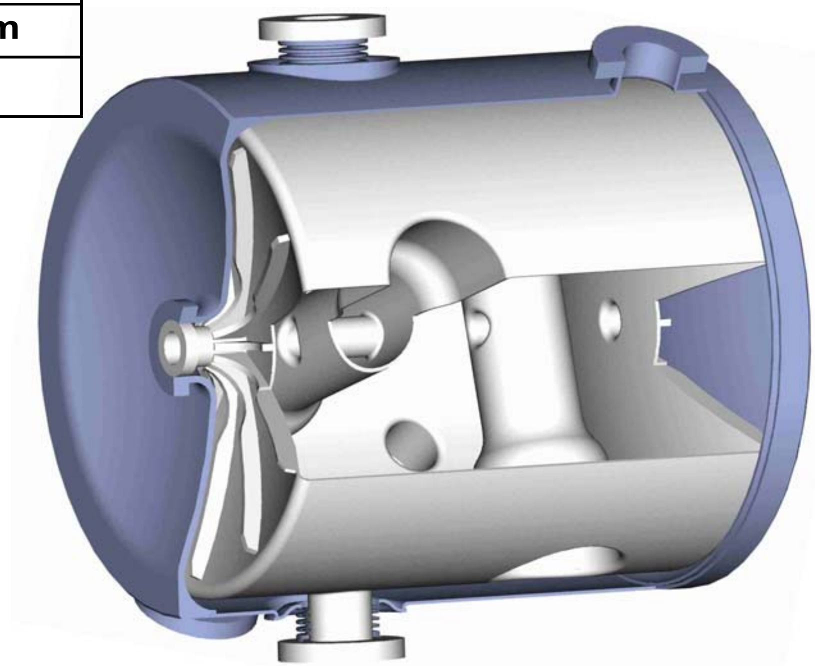
Excellent performance of drift-tube cavities at 4.2 K is consistent and repeatable when the cavity is kept clean (April 2001)

Intermediate-velocity cavities for RIA at ANL



345 MHz Double-Spoke

QR_S =	71
β_{Geom} =	0.393
Eff. Length =	38.1 cm
At 1 MV/m	
RF Energy =	151 mJ
E_{peak} =	3.47 MV/m
B_{peak} =	69 G



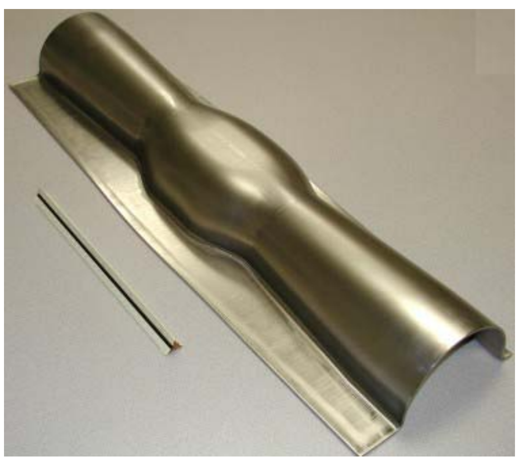
172.5 MHz HWR

QR_S =	58
β_{Geom} =	0.26
Eff. Length =	30 cm
At 1 MV/m	
RF Energy =	345 mJ
E_{peak} =	2.9 MV/m
B_{peak} =	78 G

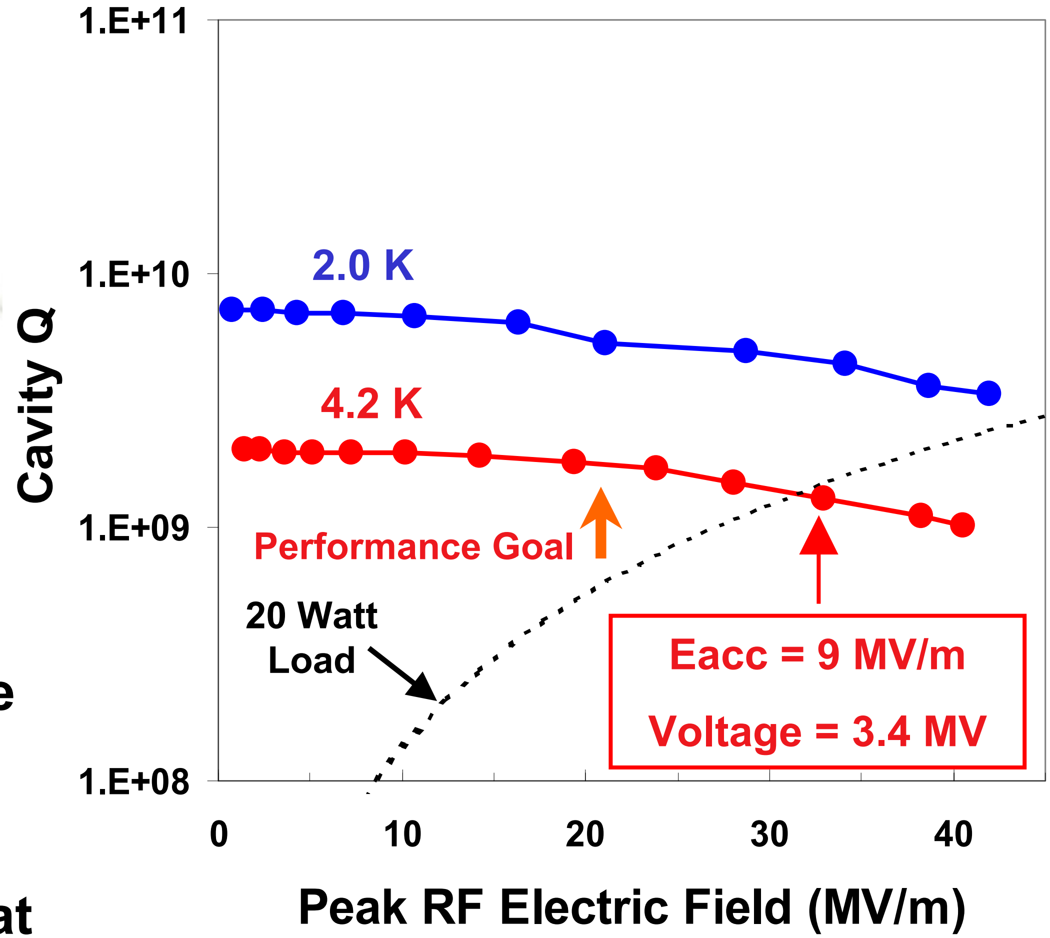
Prototype niobium β=0.26 half-wave and β=0.15 QWR near completion

Complete in 1~2 months.

Some construction details in paperTuP11



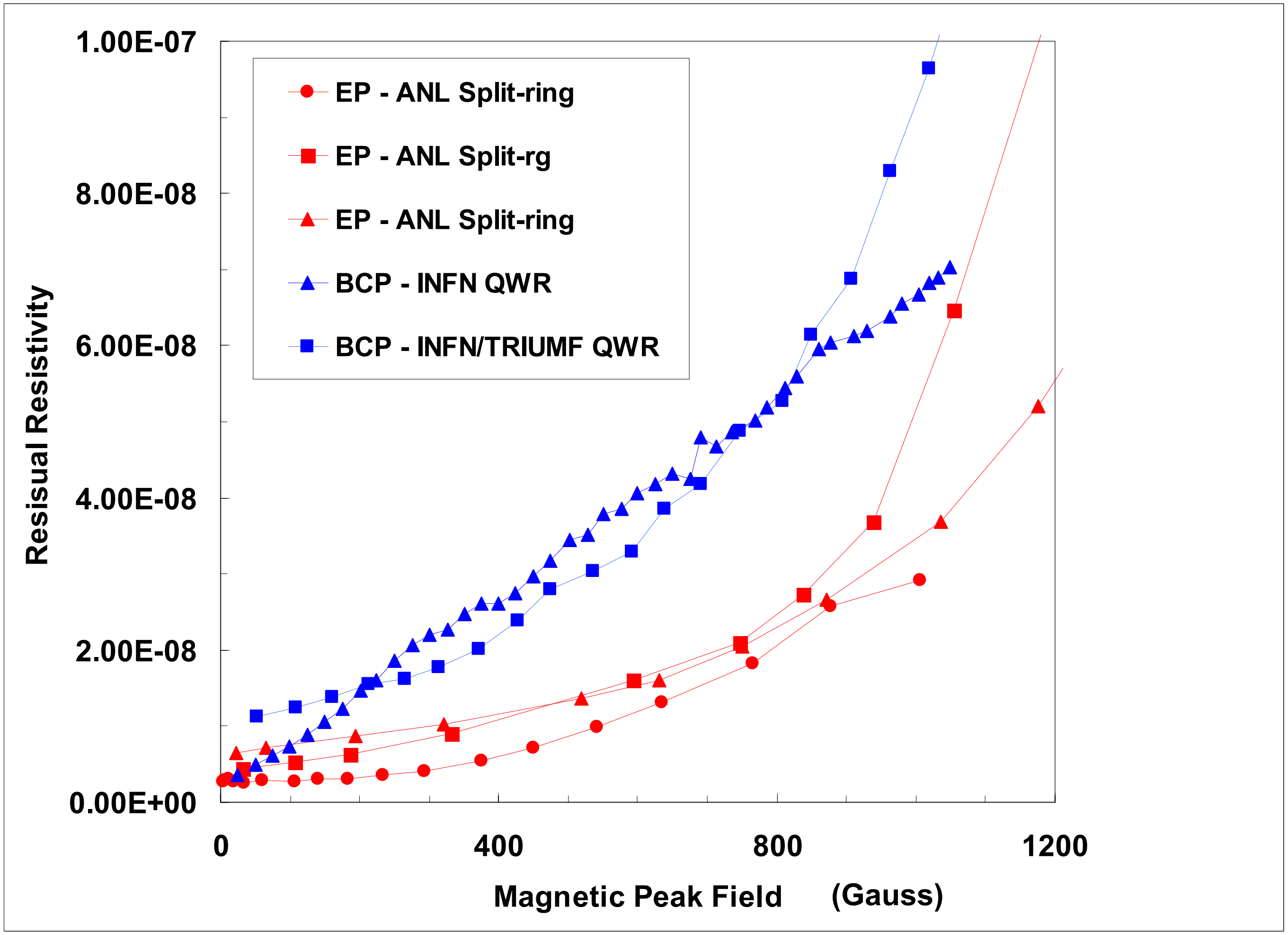
Recent test results for the fully-jacketed, 345 MHz Double-spoke cavity



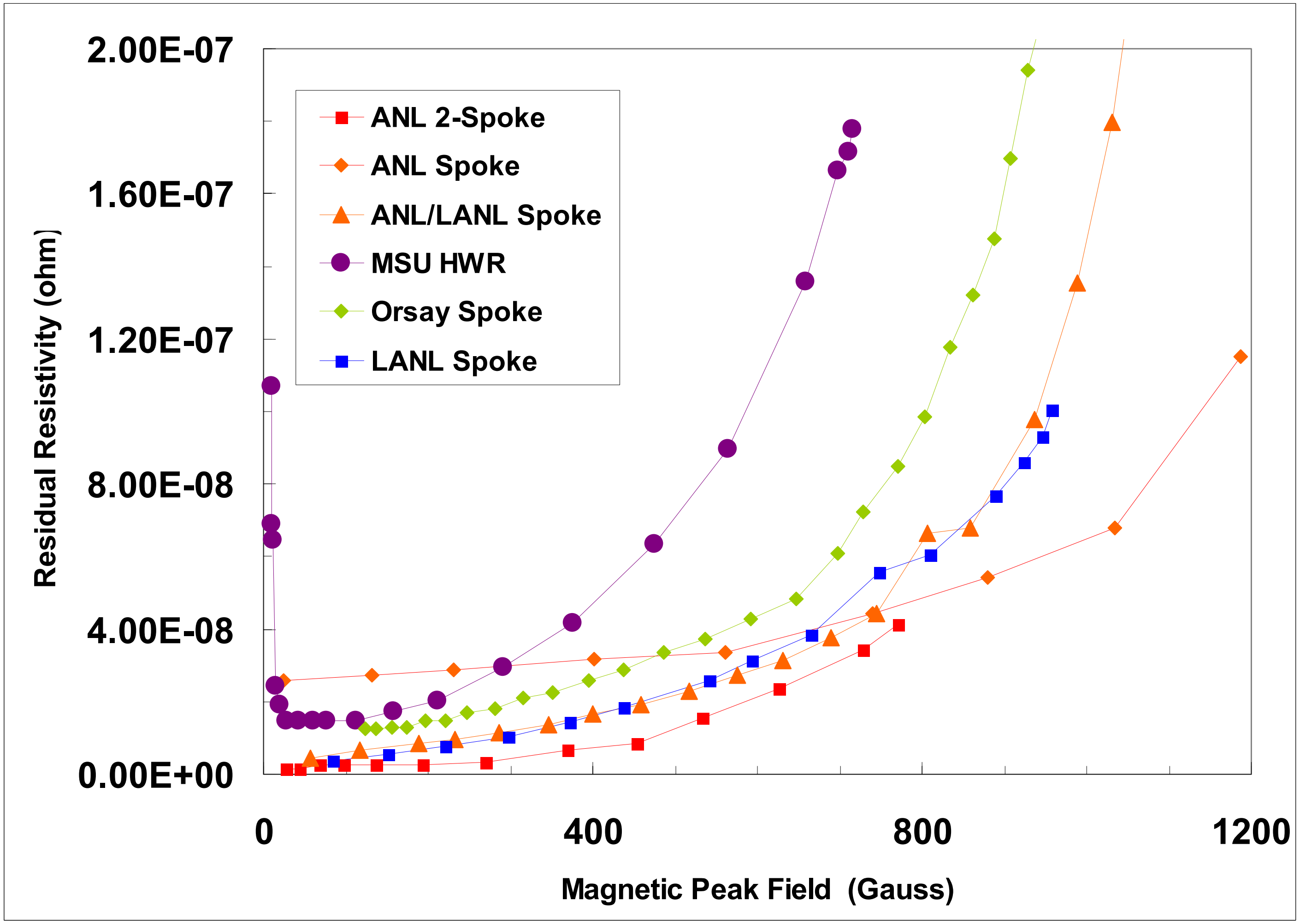
(See Kelly TuP53 and ThP29)
Processing: Heavy EP before closure welds

Final: Light BCP and HPR before testing, 48 hour bake at 100 C.

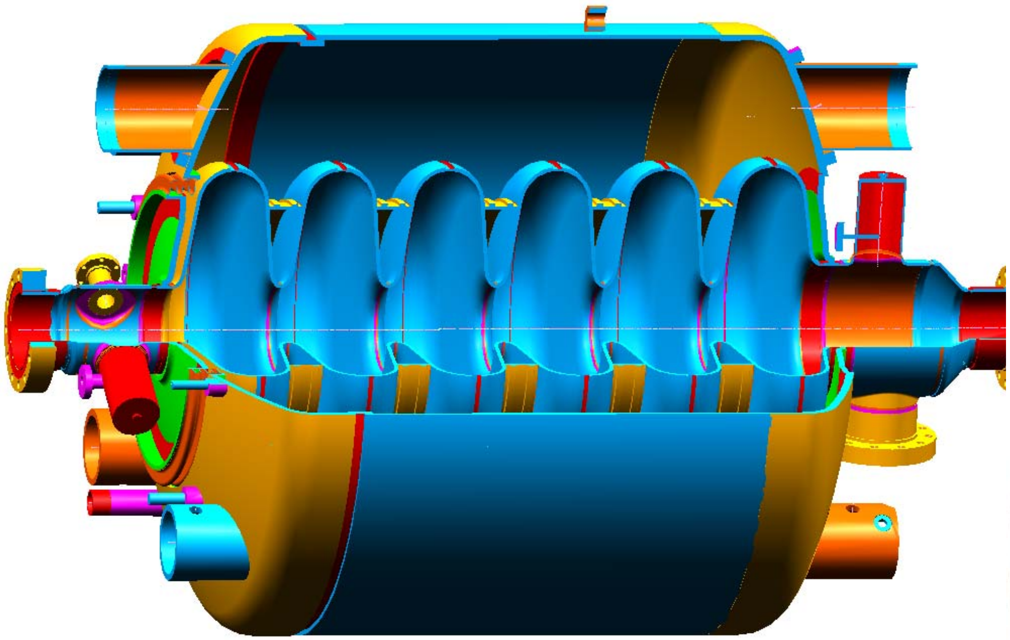
4.2 K Residual resistivity – 80-100 MHz Quarter-wave structures



4.2 K Residual Resistivity – 322-352 MHz Half-wave Class Structures

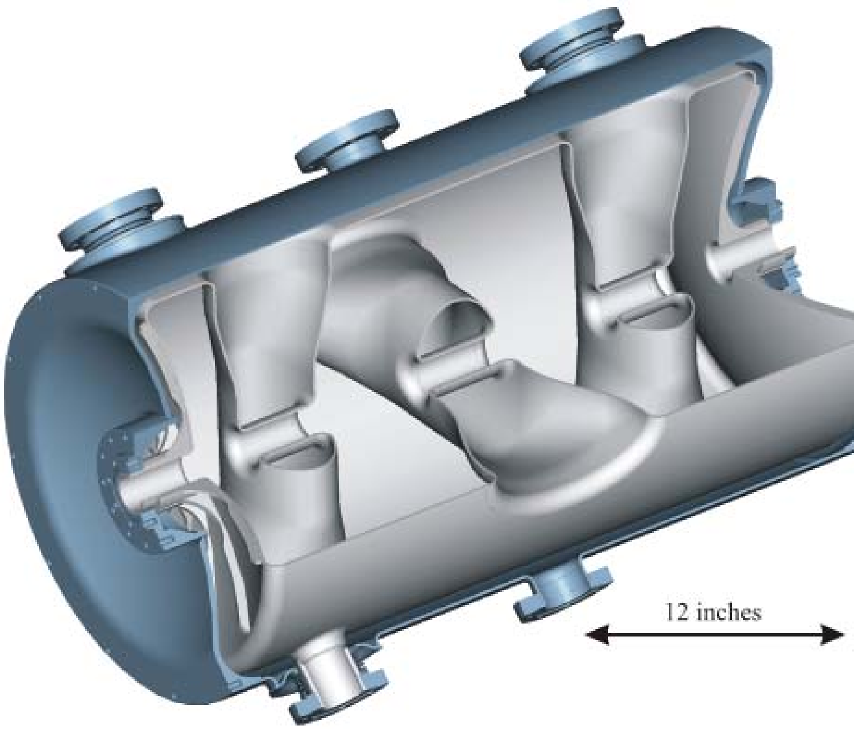


Elliptical-Cell or Triple-Spoke for the RIA Driver Linac?



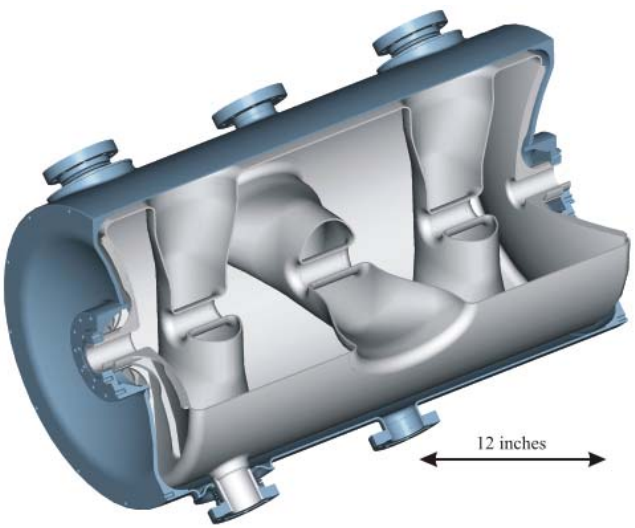
805 MHz at 2K

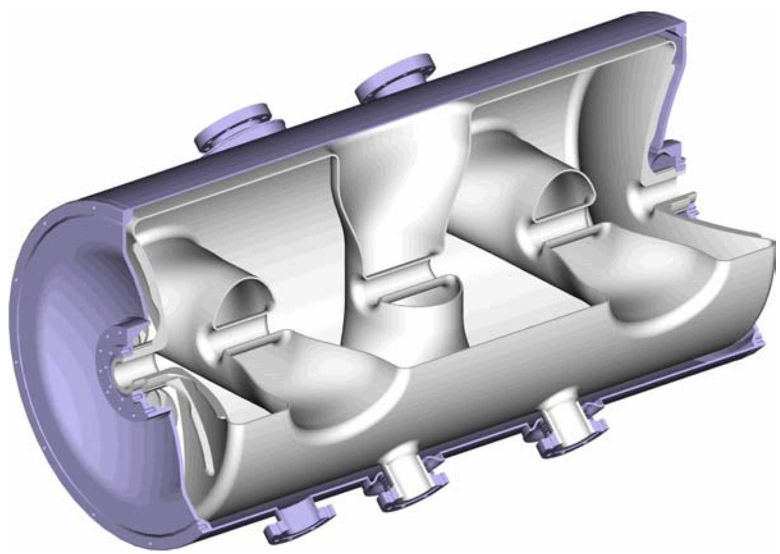
345 MHz at 4K



Two triple-spoke cavities for 0.4 < β < 0.8

Freq (MHz)	Beta (geom)	Lngth (cm)	U (mJ)	QRs (ohm)	R/Q (ohm)	Epk (MV/m)	Bpk (MV/m)
345	0.50	65	397	85.7	494	2.9	86
805	0.47	53	341	137	160	3.4	69
345	0.63	81	580	93	520	3.0	89
805	0.61	68	330	179	279	2.7	57



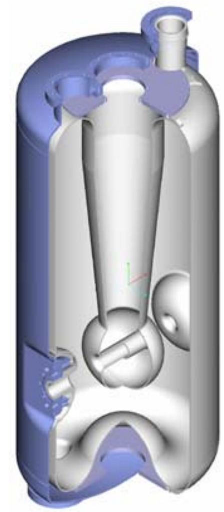


RIA Driver Linac Nb SC Cavity Array

57.5 MHz QWR-based structures .02< β <0.14

115 MHz β=0.15

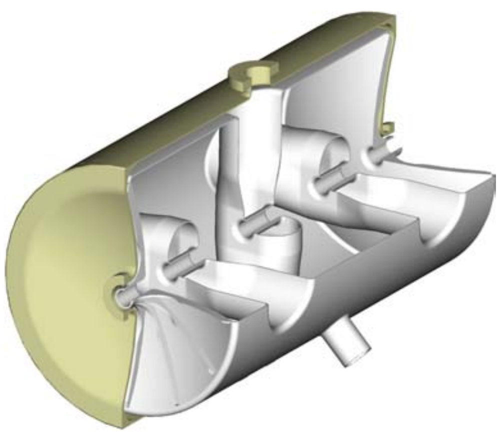
Corrected QWR

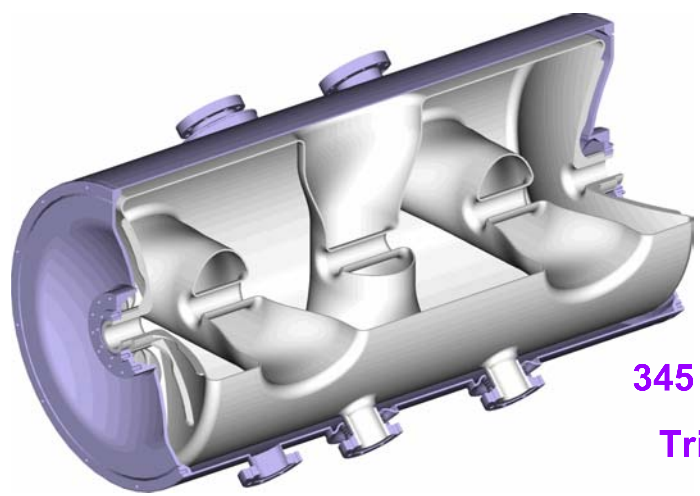


172.5 MHz β=0.14 HWR

345 MHz β=0.5

Triple-spoke

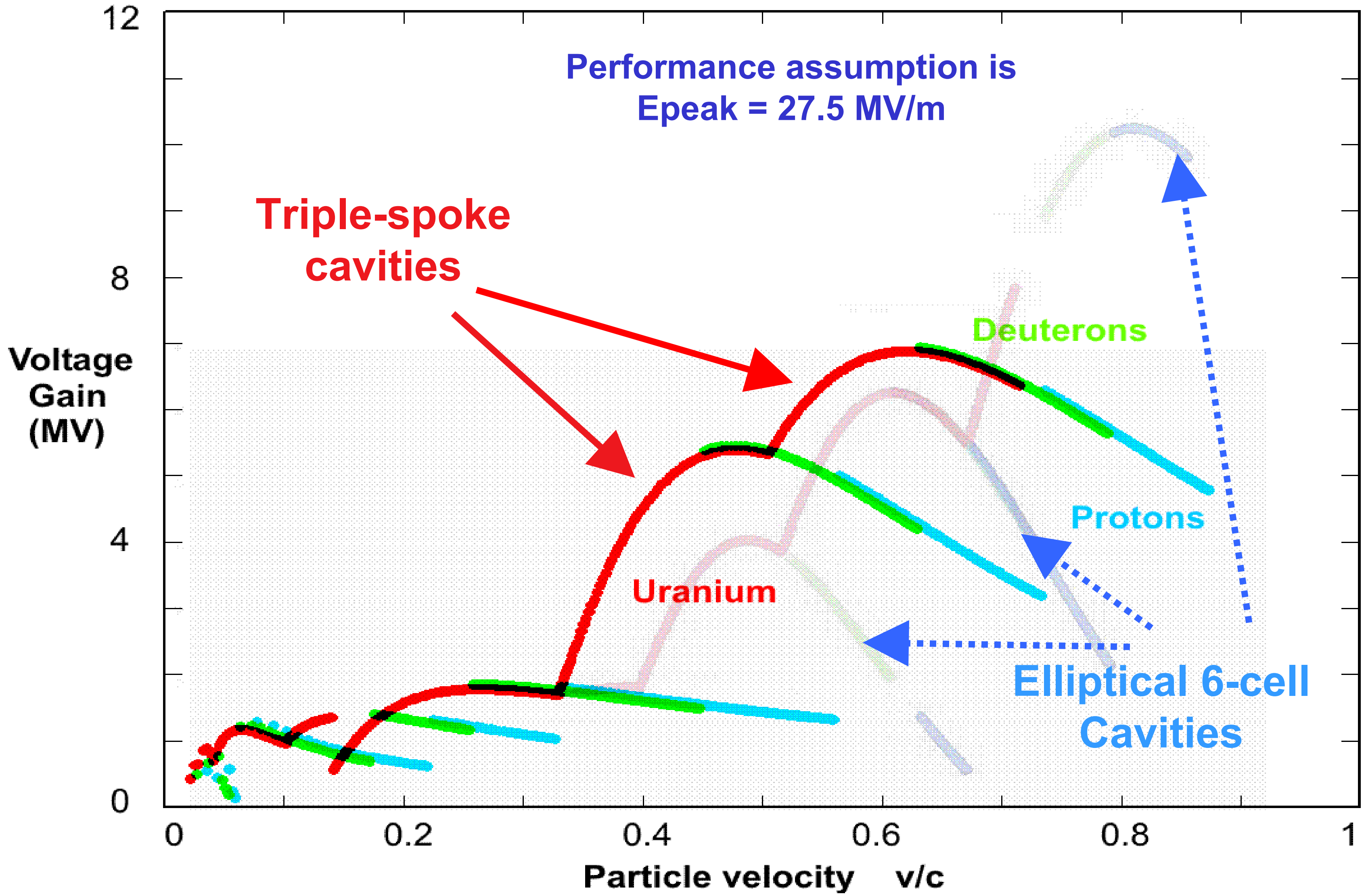




345 MHz β=0.62

Triple-spoke

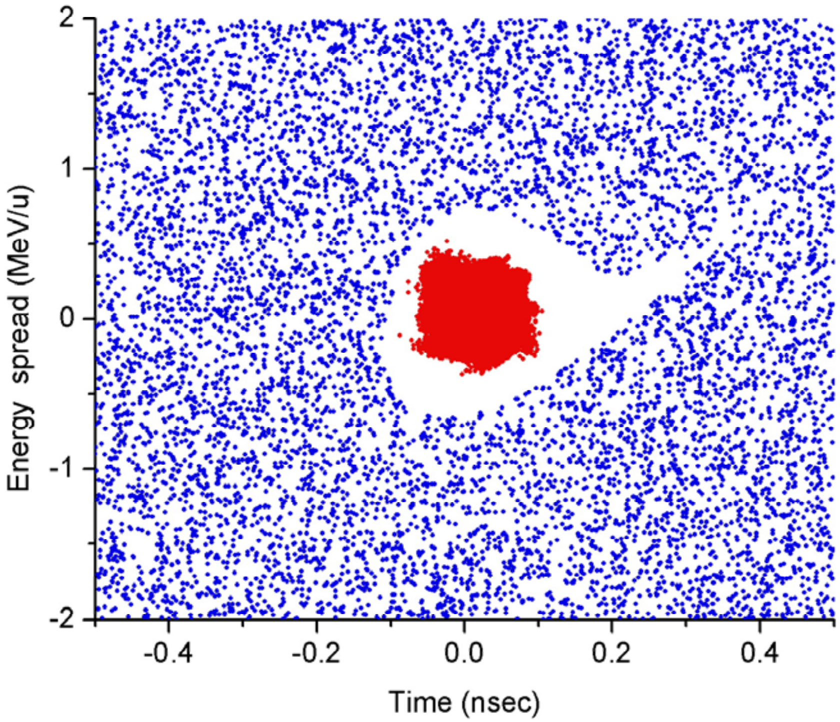
Voltage gain per cavity vs. velocity for 345 MHz spoke cavity option



Comparison of Longitudinal Acceptance

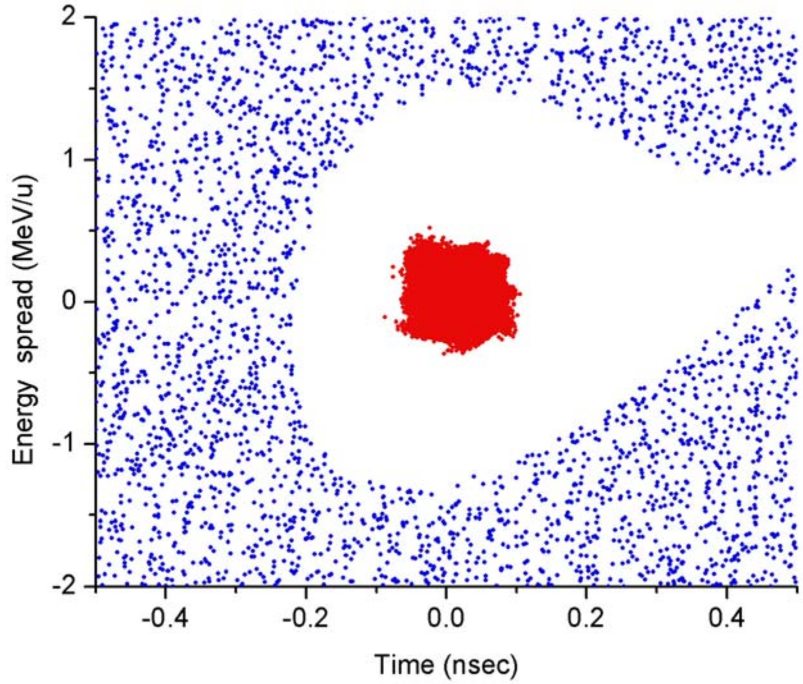
805 MHz Elliptical-Cell

φ_S=-30°

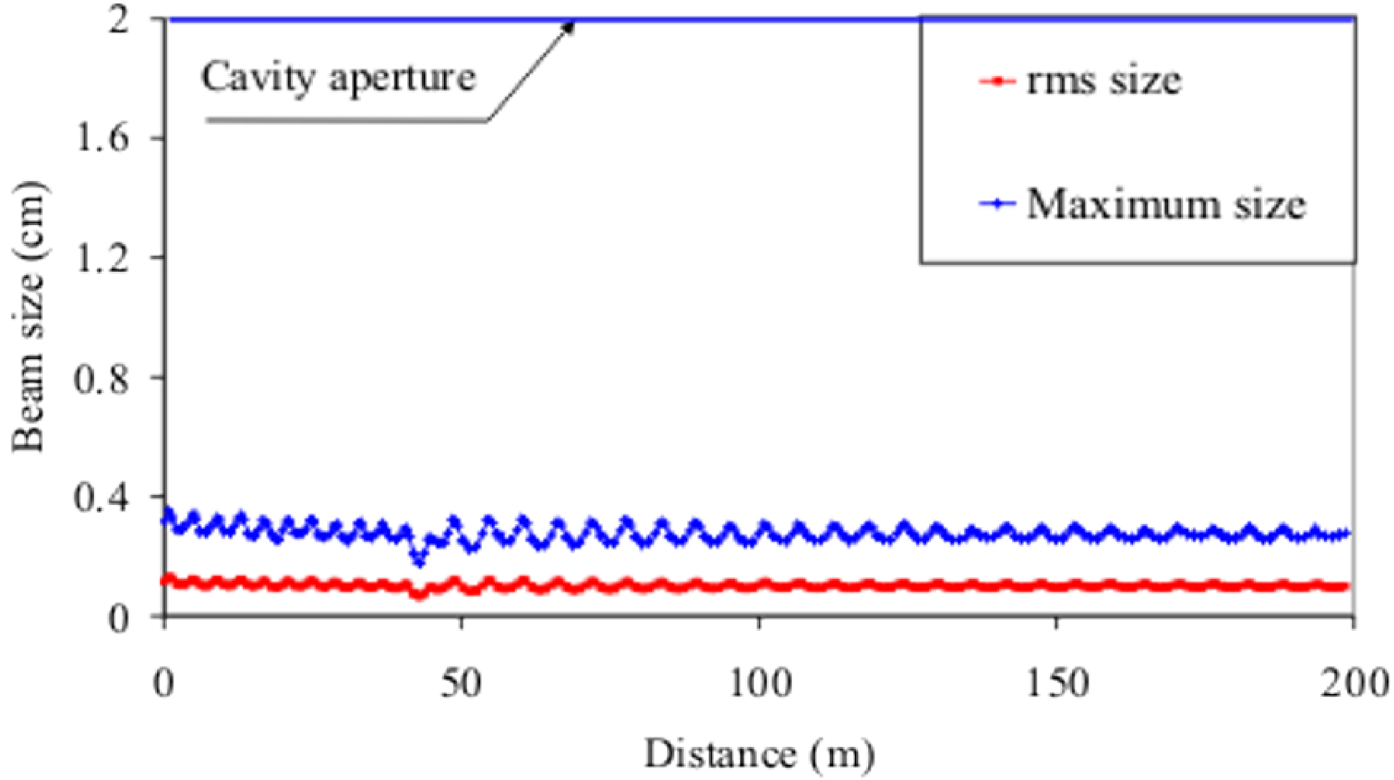


345 MHz Triple-Spoke

φ_S=-25°

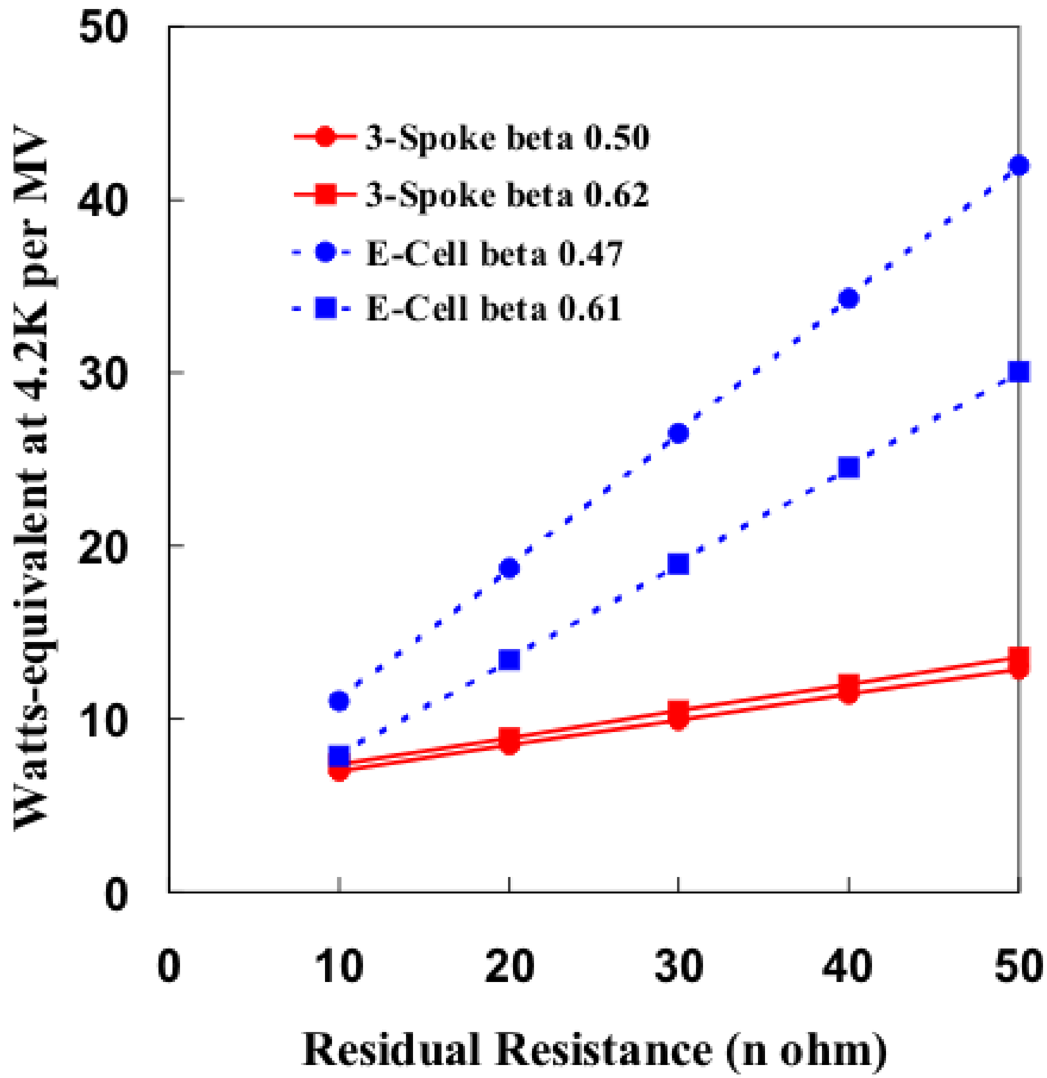


Longitudinal and Transverse Acceptance



Acceptance (Norm.)	*Triple-spoke*	*Elliptical-cell*
Trans. (π·mm·mrad)	**35**	**70**
Long. (π·keV/u-nsec)	**280**	**60**

Refrigerator Heat Load: Triple-Spoke vs. Elliptical-cell

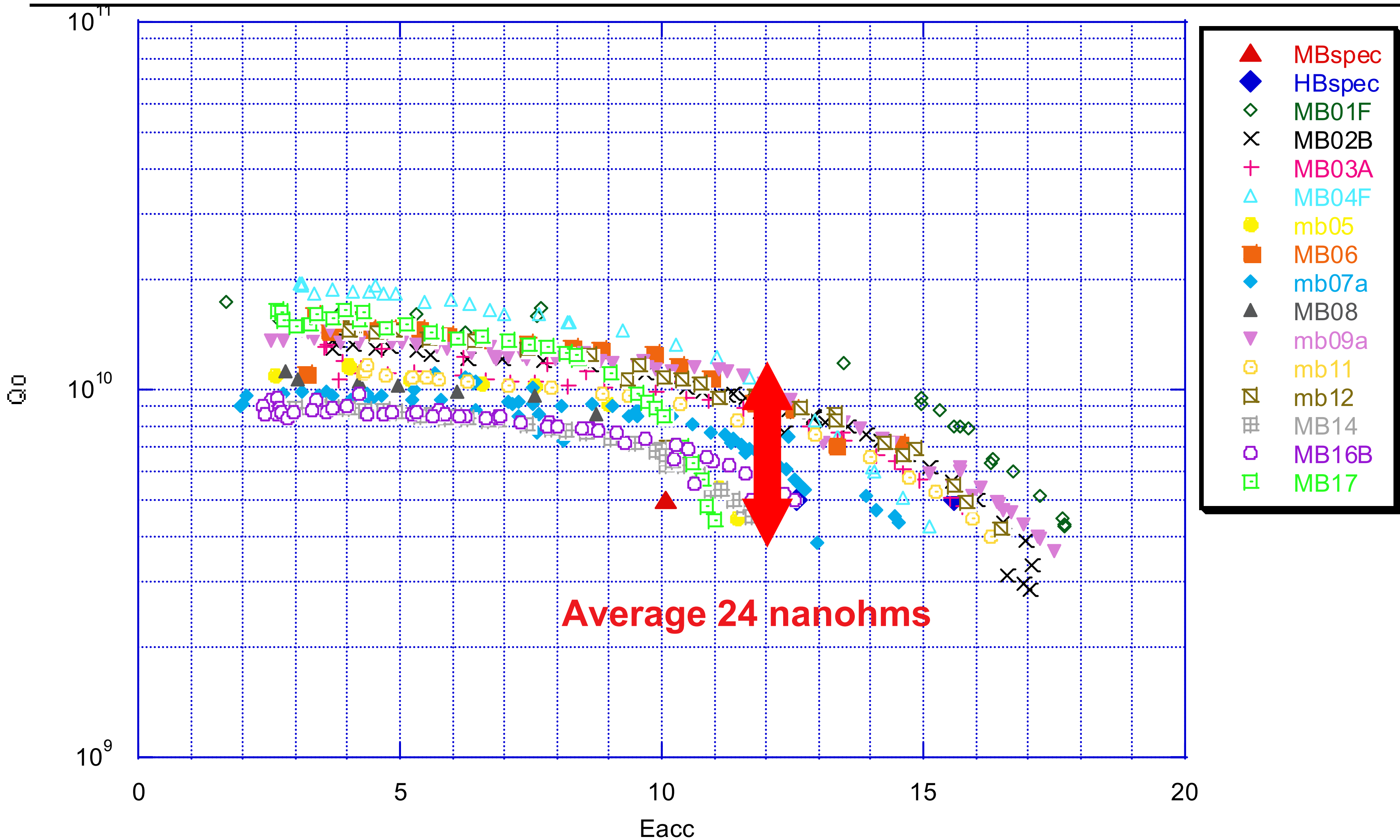


All cavities assumed to operate at Epeak = 27.5 MV/m

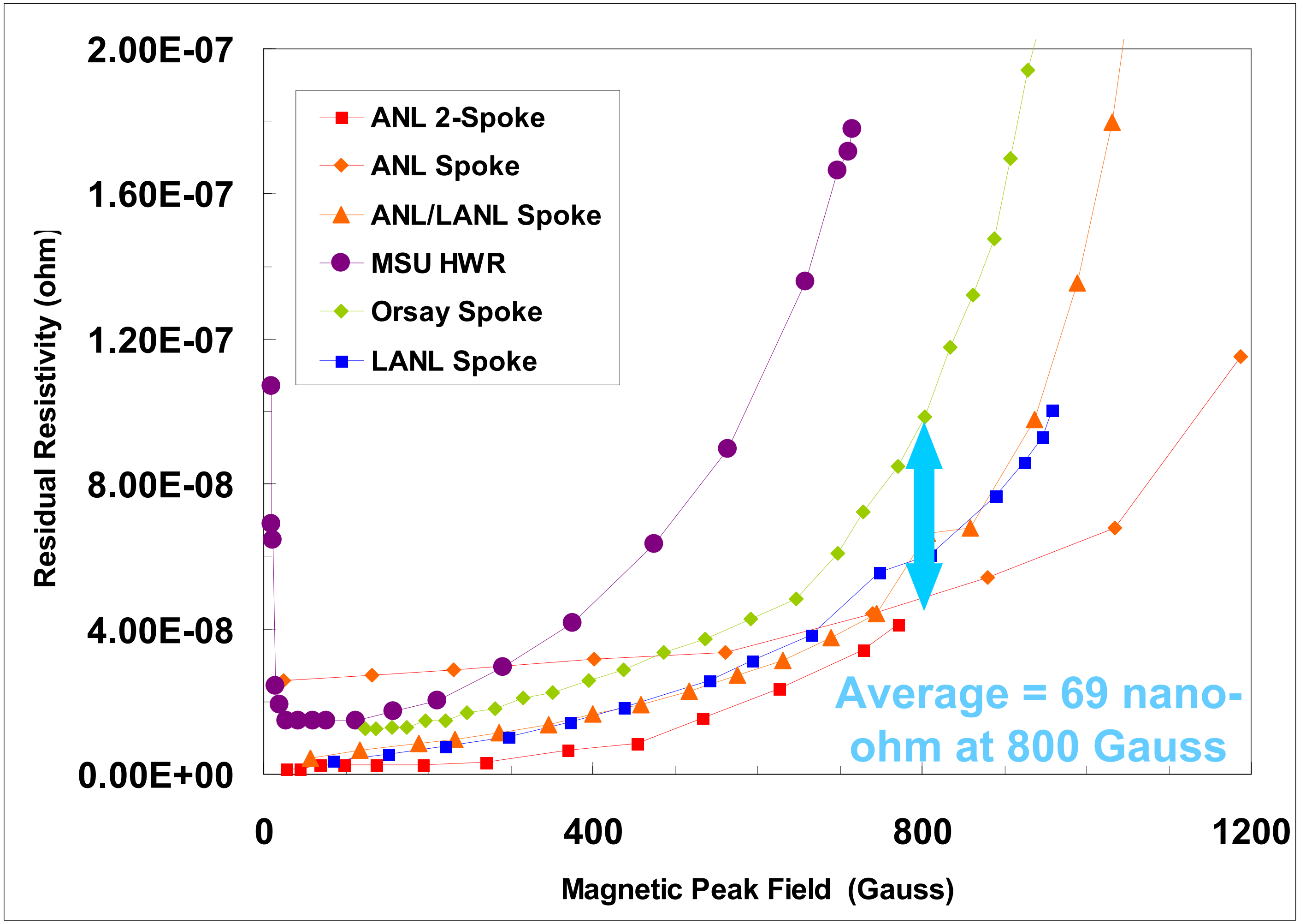
Assumes triple-spokes at 4.2 K

Assumes E-cell at 2 K and that 1 watt at 2K is equivalent to 4 w at 4.2K

SNS Production β=0.6 Elliptical-cell at 2K



4.2 K Residual Resistivity – 322-352 MHz Half-wave Class Structures



Some parameters for two linac designs

Type	Beta	Freq (MHz)	Temp K	Epeak MV/m	Volts/Cav MV	# Cav	RF Loss at 4.2K
			805/14 MHz Linac				
FORK	0.031	57.5	4.2	16	1.00	5	0.02
QWR	0.061	57.5	4.2	20	1.35	28	0.2
QWR	0.151	115.0	4.2	20	1.58	48	0.4
HWR	0.263	172.5	4.2	25	2.58	83	3.1
3SPOKE	0.500	345.0	4.2	27.50	6.23	69	6.7
3SPOKE	0.620	345.0	4.2	27.50	7.49	96	11.9
					Total	329	22 kW
			805/10 MHz Linac				
QWR	0.041	80.5	4.2	16.5	0.55	18	0.1
QWR	0.085	80.5	4.2	20	1.17	104	1.3
HWR	0.285	322.0	4.2	25	1.54	208	4.1
6 Cell	0.470	805.0	2.0	32.5	5.01	68	8.8
6 Cell	0.610	805.0	2.0	32.5	8.18	64	9.7
6 Cell	0.810	805.0	2.0	32.5	13.44	32	5.2
					Total	494	29 kW

If the triple-spoke cavity can be developed in time for RIA, we can:

1) Reduce number of cavities (by 12 cryomodules worth)
2) Operate at 4.2K, eliminate 2K helium refrigerator
3) Reduce refrigerator power requirement substantially
4) Increase acceptance / reduce beam loss
5) Increase proton energies
6) Improved mechanical stability

Conclusions

- Intermediate-velocity cavities are in a period of rapid development (not only for RIA – see work toward Eurisol at this workshop)
- Several viable design options for the RIA driver linac have been demonstrated
- Remaining work will focus on cost-performance-schedule optimization
- The time window for further development may be short, BUT present developments are exciting – things are moving fast, so stay tuned!