

The R&D on TEM-type SRF cavities for high-current applications at IHEP

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Institute of High Energy Physics (IHEP)

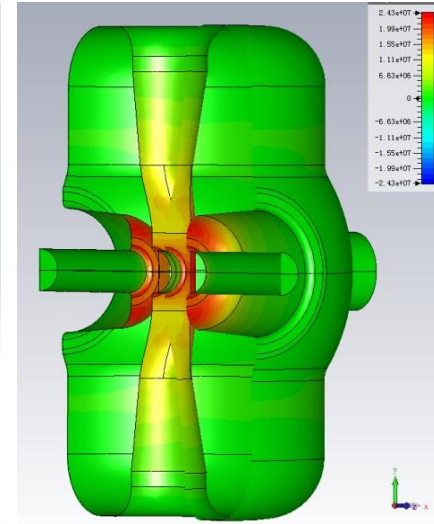
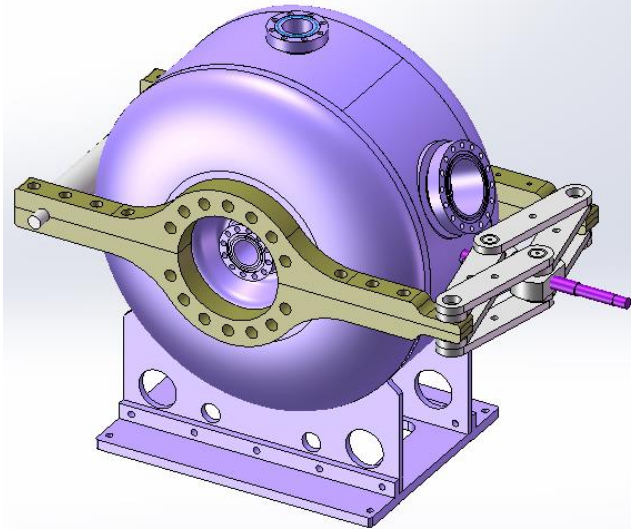
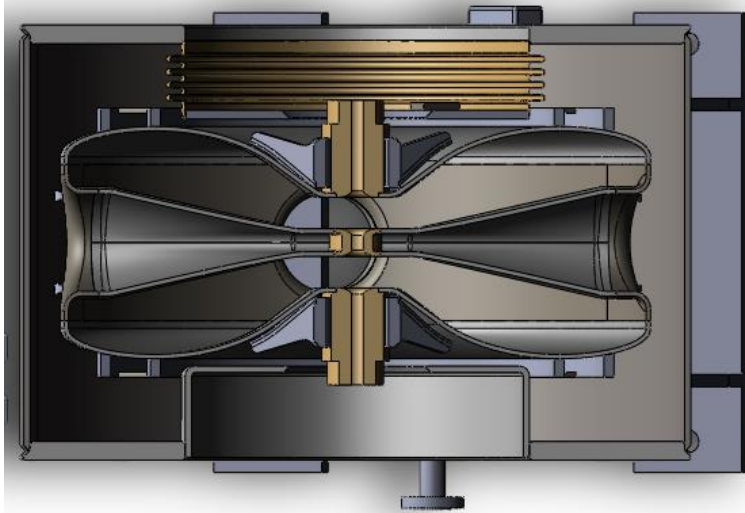


Outline

- Background
 - Spoke cavities for CADS project
 - QWR for HEPS project
- Fabrication and quality control
- Post processing
- Vertical test statistics
- Operation with beam



Spoke cavities for CADS linac (2)



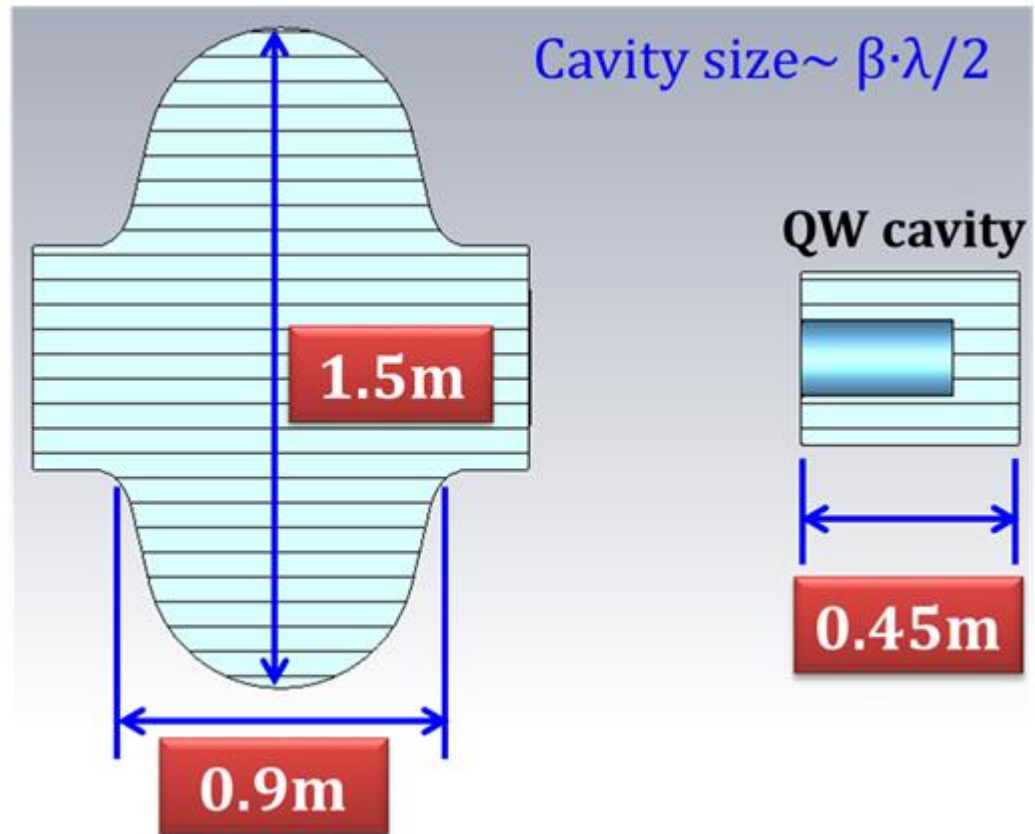
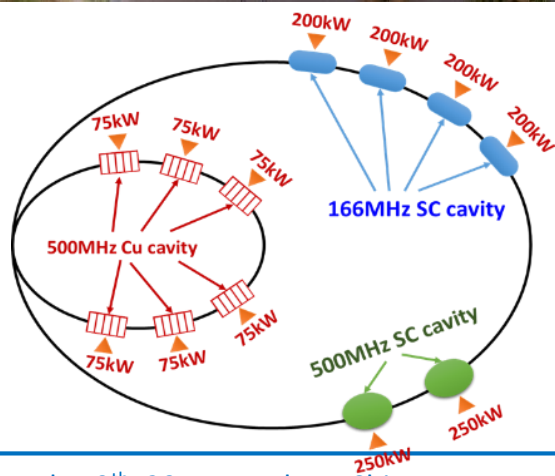
	Spoke 012	Spoke 021	Spoke 040	Spoke 024	HWR 325
β_0	0.14	0.24	0.46	0.24	0.14
E_p/E_{acc}	5.0	4.4	3.9	4.0	4.6
B_p/E_{acc} $mT/(MV/m)^2$	6.9	9.4	9.2	6.4	4.8
$G-\Omega$	60	71	104	81	73
$R/Q-\Omega$	150	191	265	206	197

Note: E_{acc} normalized with $\beta_0 \lambda$;



QWR cavity for HEPS project

- 166MHz is chosen due to on-axis beam accumulation
- Challenges: Reasonable size & HOM damping

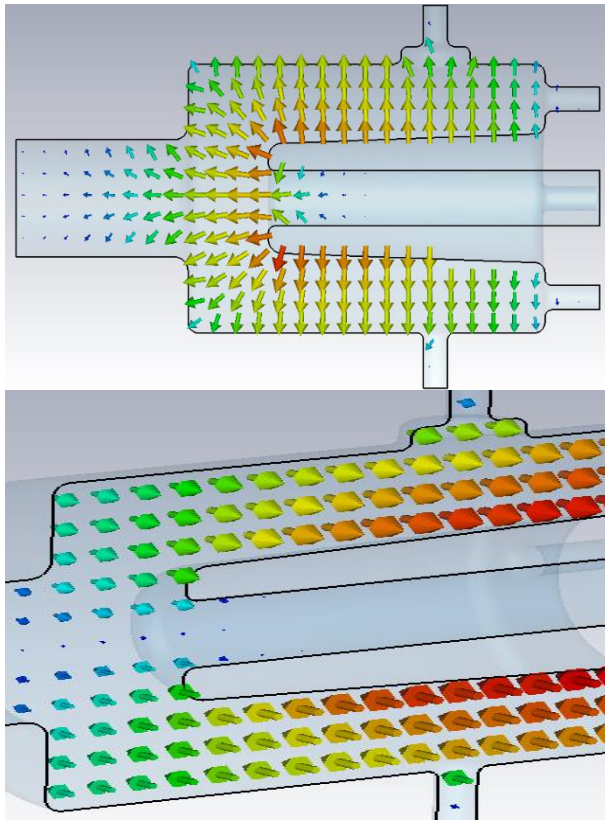




QWR cavity for HEPS project (2)

Two-step approaches:

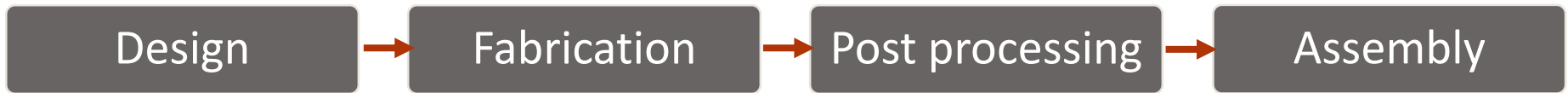
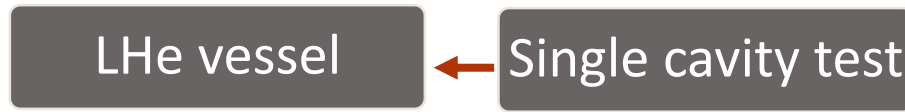
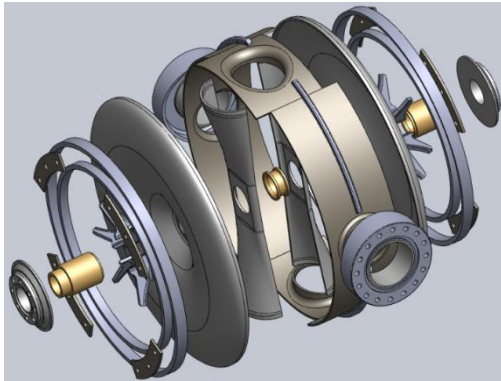
1. Proof-of-Principle (PoP) cavity: Production technics, surface treatment
2. Prototype cavity: including higher order mode coupler/absorber



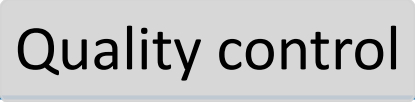
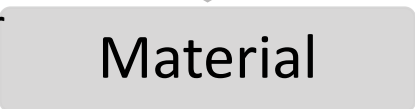
Parameters	Design	Nominal
RF frequency	166.6 MHz	
Operating temperature	4.2 K	
$R_{sh}/Q_0 (=V^2/P_c)$	136 Ω	
$G (=R_s \cdot Q_0)$	54.8 Ω	
RF voltage [MV]	1.5	1.2
Eacc [MV/m]	14.5	11.5
Epeak at Vc=1.5MV [MV/m]	42	34
Bpeak at Vc=1.5MV [mT]	64	51



Fabrication of IHEP ADS spoke cavities

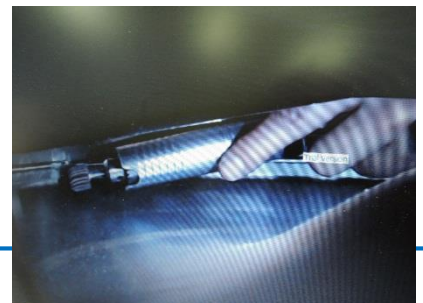
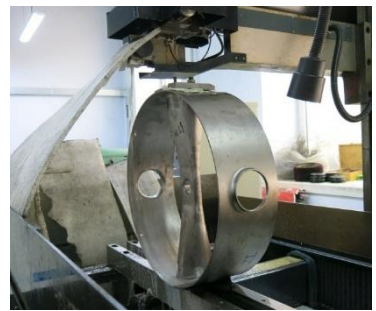


Certification from vendor
Eye inspection



Defect inspection and grinding before final EBW, size control, frequency control

Deep drawing, annealing, machining, frequency control, grinding, EBW





Surface quality control

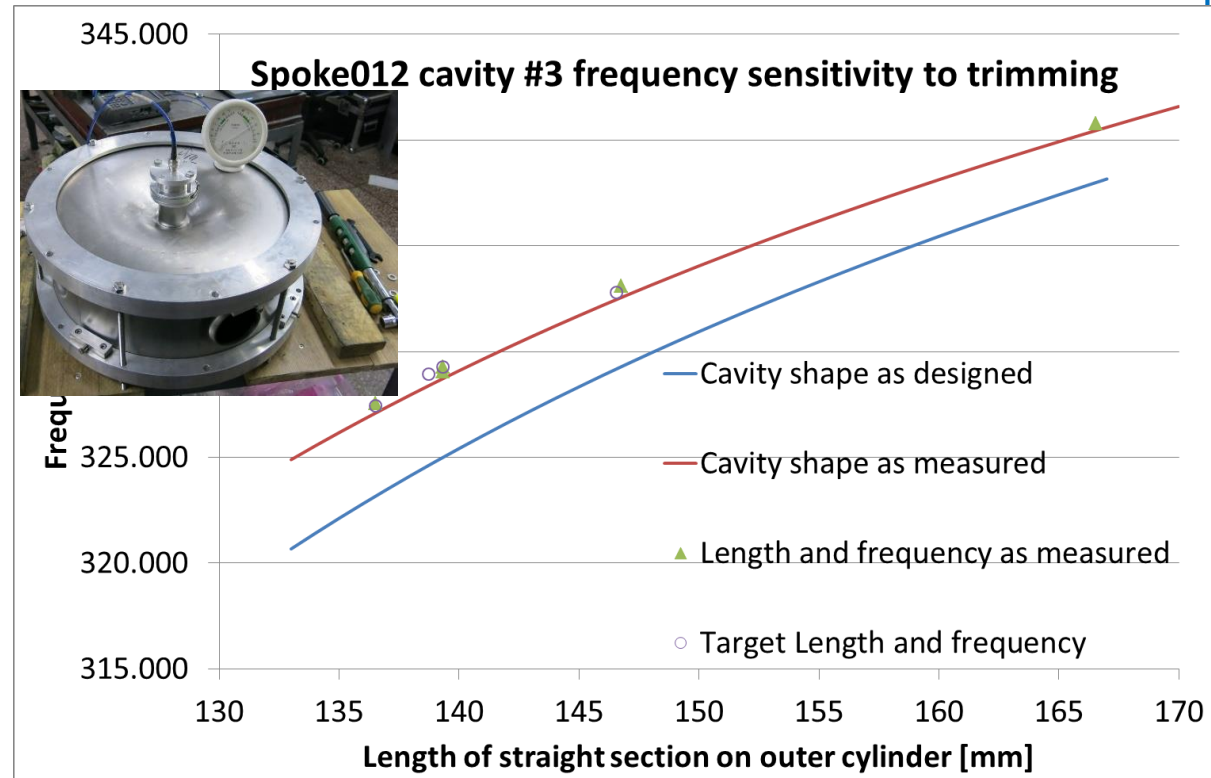
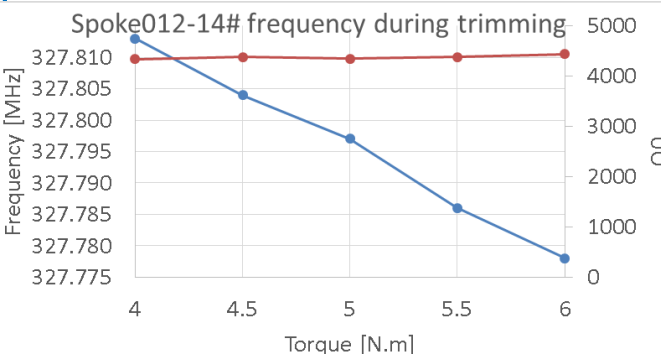
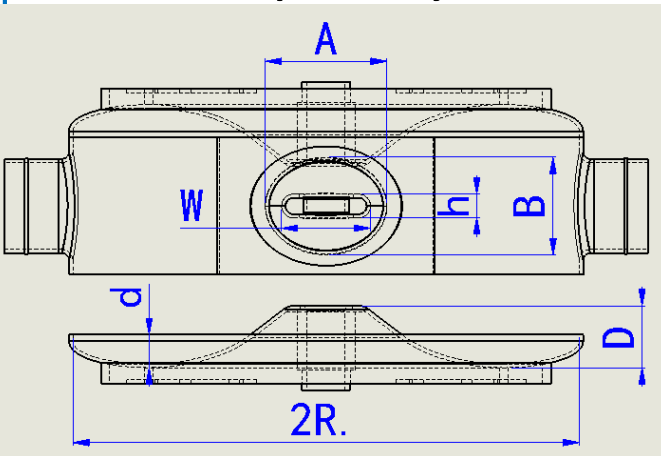
- Before final EBW it is the last chance to get easy access to the cavity inner surface
- Defect, e.g. pits in diameter 0.1mm, could be addressed by eye inspection. Sometimes magnifier or very light BCP helps to find defects.





Frequency control

- Frequency tuning is typically done by stacking parts together before EBW, and trim the cylindrical part after frequency measurement.





HEPS QWR Cavity production

Nb sheet (RRR>300)



Deep drawing



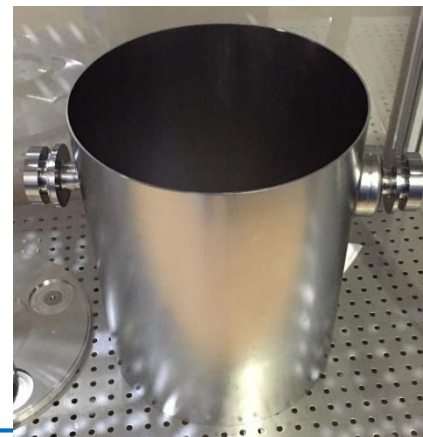
Cavity



HPR port plate



Port flanges

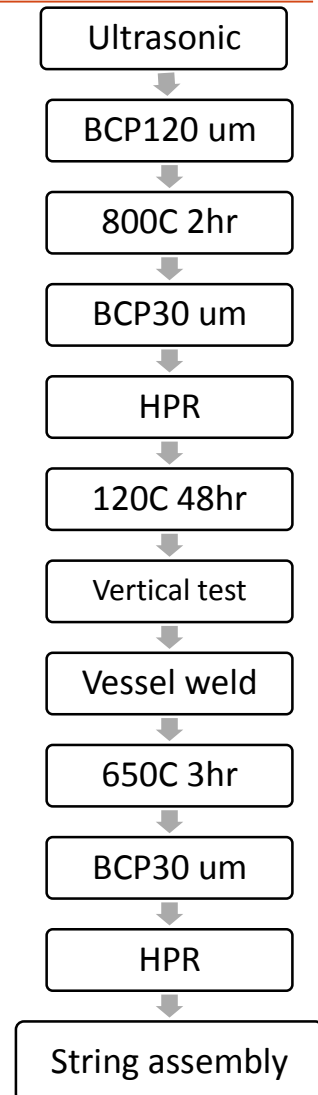


Outer cylinder



Post processing of Spoke cavities

- BCP in Ningxia OTIC; re-HPR and clean assembly in IHEP





Post processing of QWR cavity

BCP



Annealing



Leak check



Frequency tuning



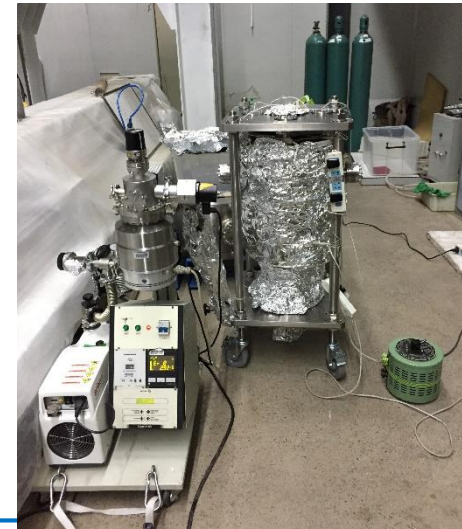
Vacuum assembly



HPR



Baking



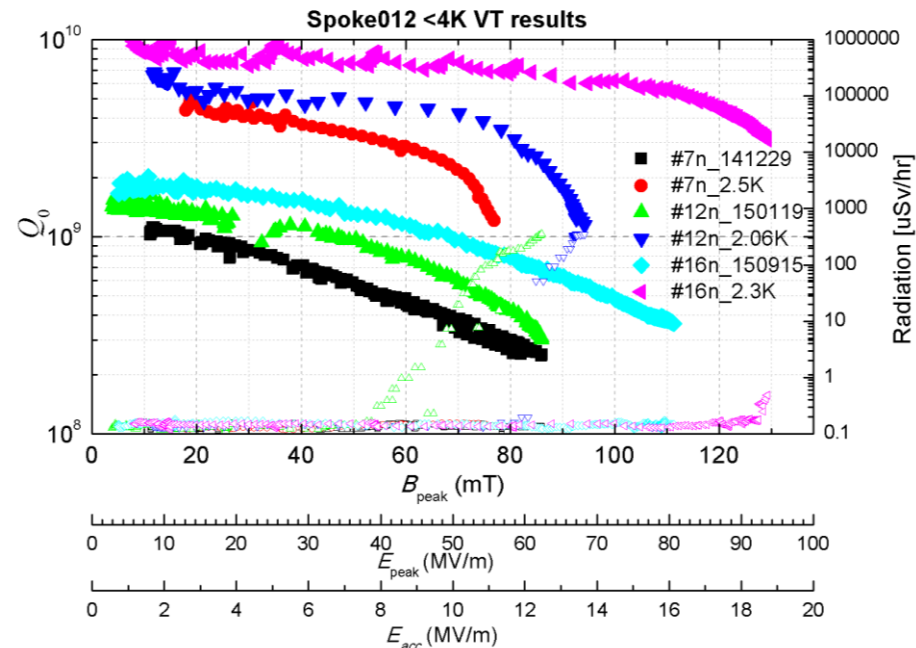
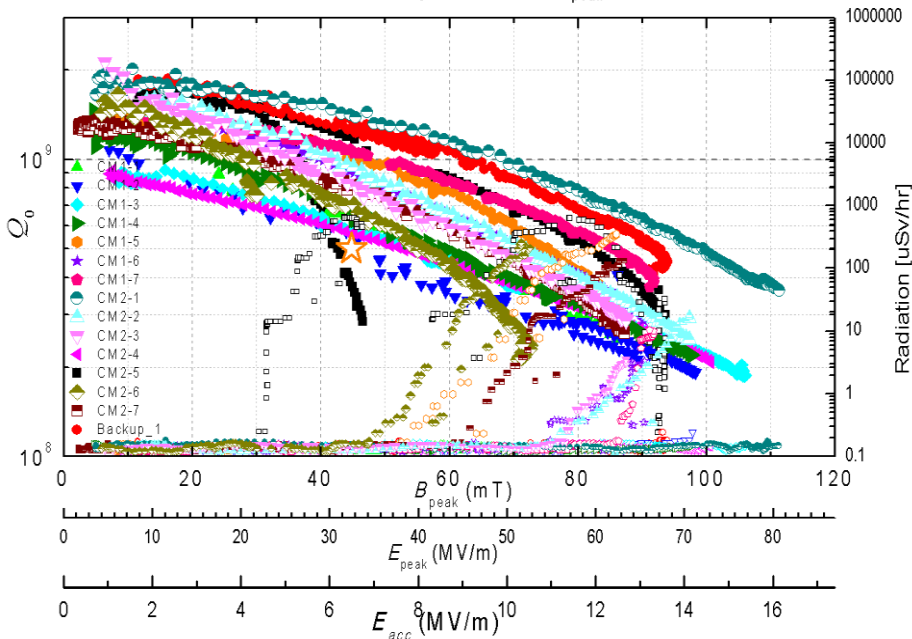


VT results of the spoke012 cavities

- MP conditioned in 1 hour with variable coupler
- Eacc increased by 2 MV/m with better cooling
- 120C baking increases Q_0 by about 50-100%
- At 2K, Q_0 is 6 times higher, $B_p \sim 125\text{mT}$ achieved.



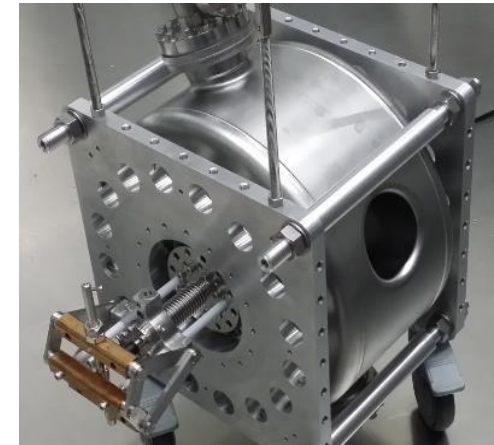
Spoke012 4.2K VT, Designed $Q_0 = 5 \times 10^8$ @ $E_{peak} = 31.5 \text{ MV/m}$



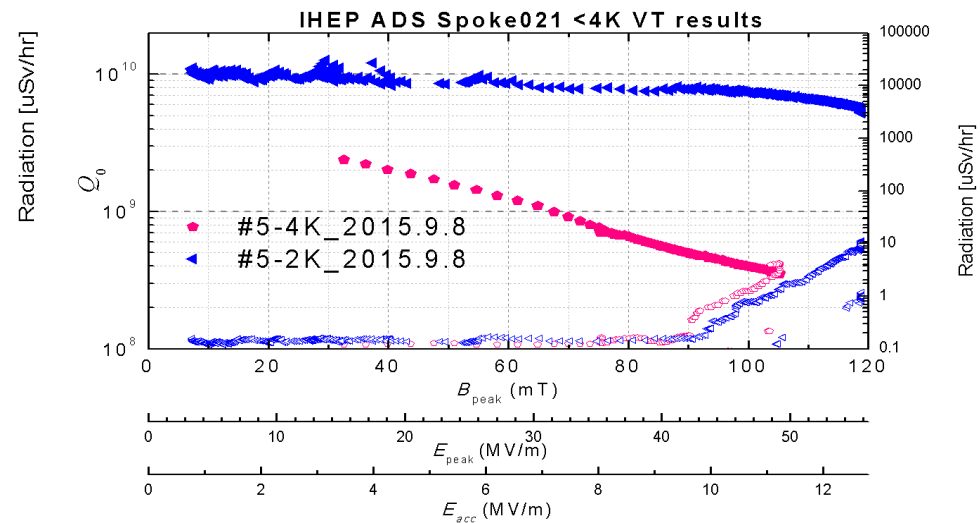
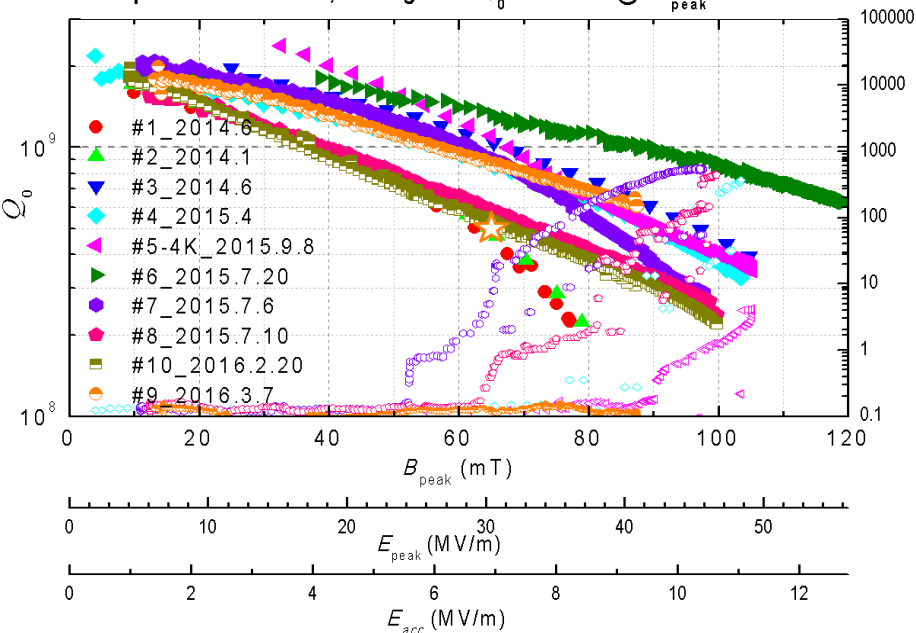


Spoke021 testing results

- MP conditioned in 1 hour
- Design target consistently exceeded
- Bp of 120mT and Rres of 7nΩ achieved at 2K



Spoke021 4K VT, Designed $Q_0 = 5 \times 10^8$ @ $B_{peak} = 65$ mT

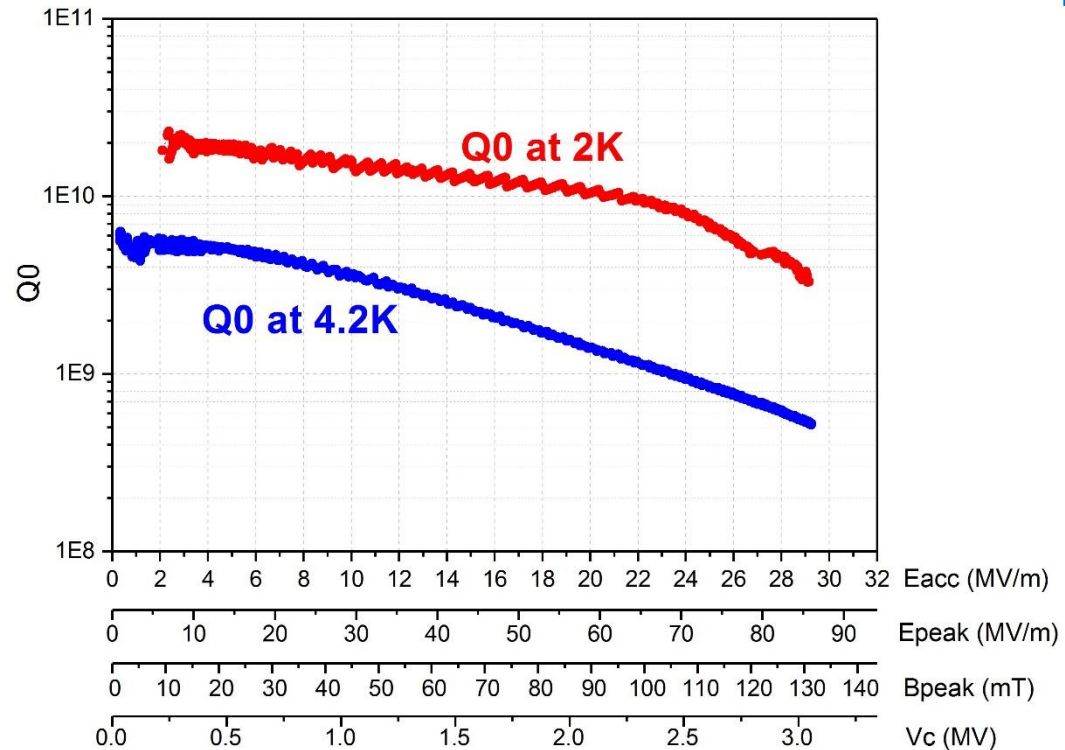




QWR VT result



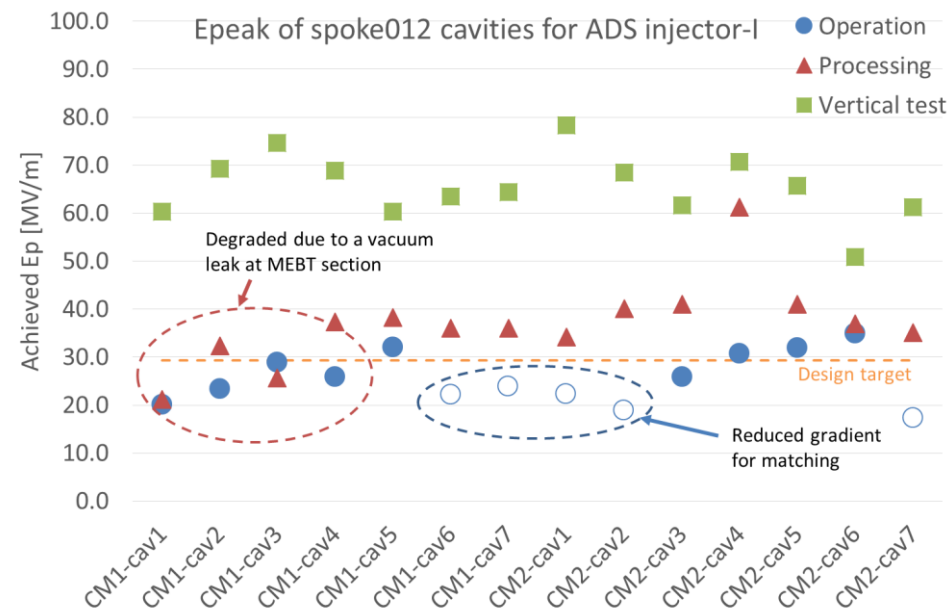
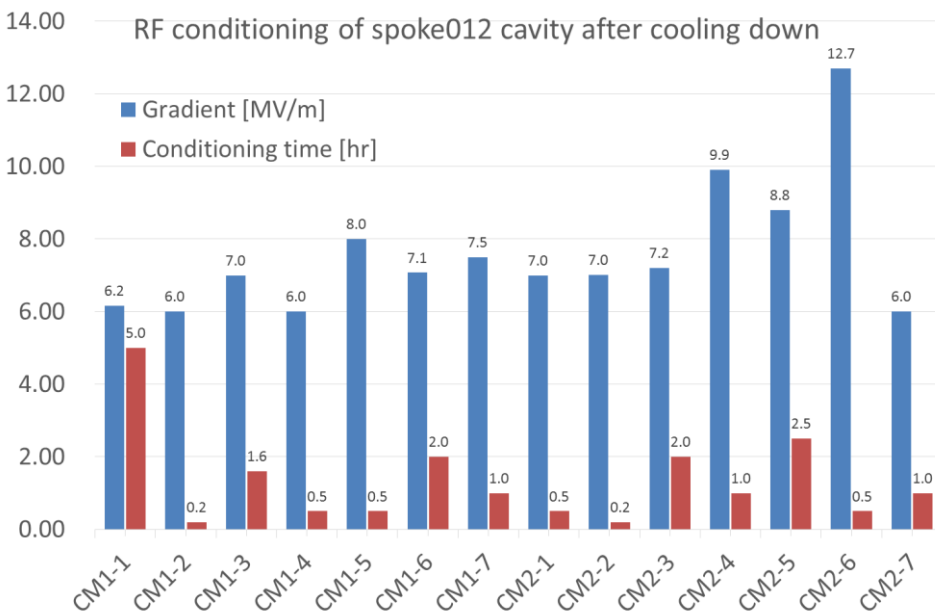
Max E_{peak} reached: 86 MV/m
Max B_{peak} reached: 131 mT
Residual resistance: 2.3 n Ω





Spoke cavity conditioning and operation

- Cavity conditioning at 4K typically takes 1-2 days
- Cavity was conditioned to 8MV/m before beam operation (FE for cav 1-4#, administrative for Cav5-14#)
- On CW beam operation of 2mA@10MeV mode, average cavity gradient is 6MV/m, i.e. $E_p \sim 27\text{MV/m}$





Thanks for your attention!