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3.5-cell Superconducting Cavity for DC-SRF Photoinjector at Peking University

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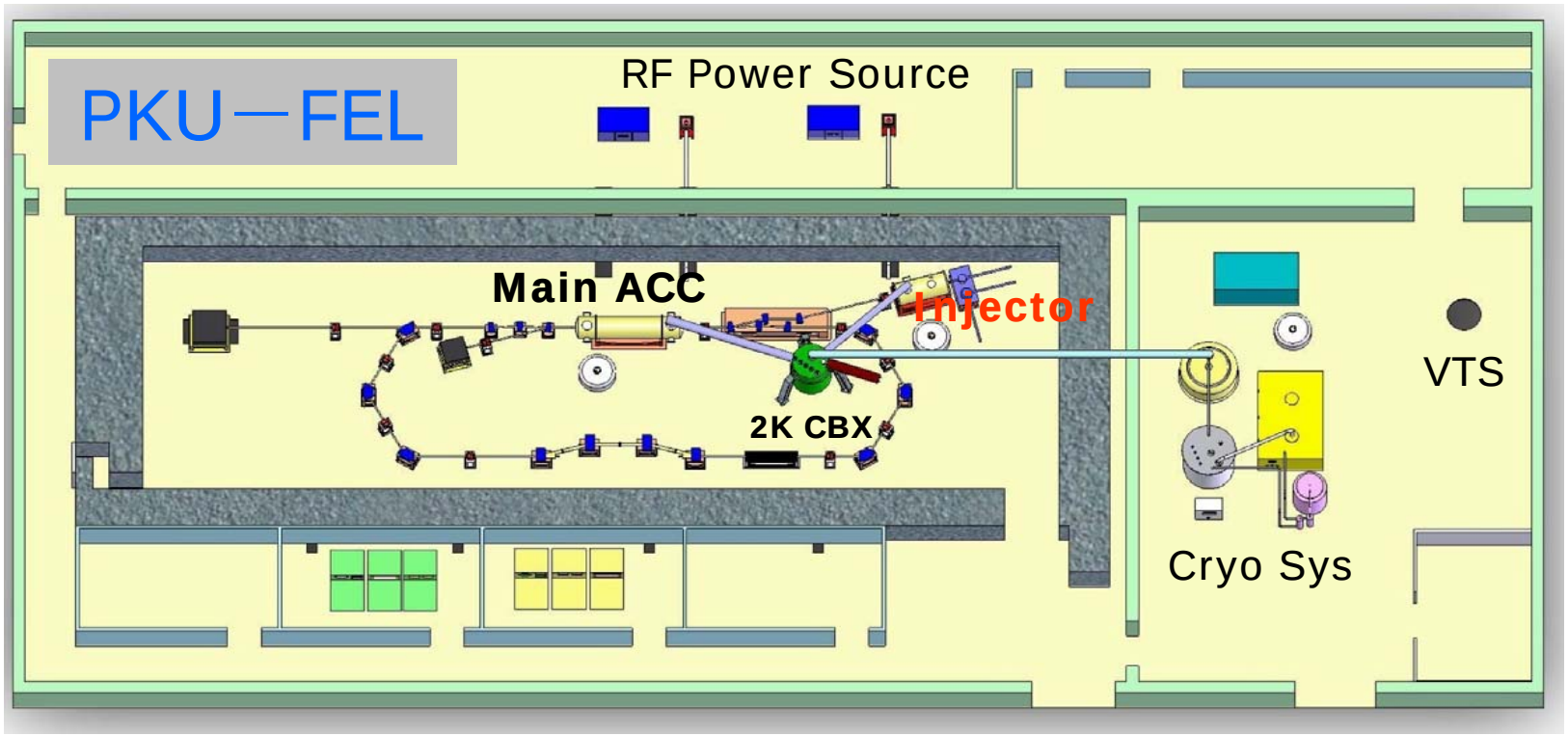
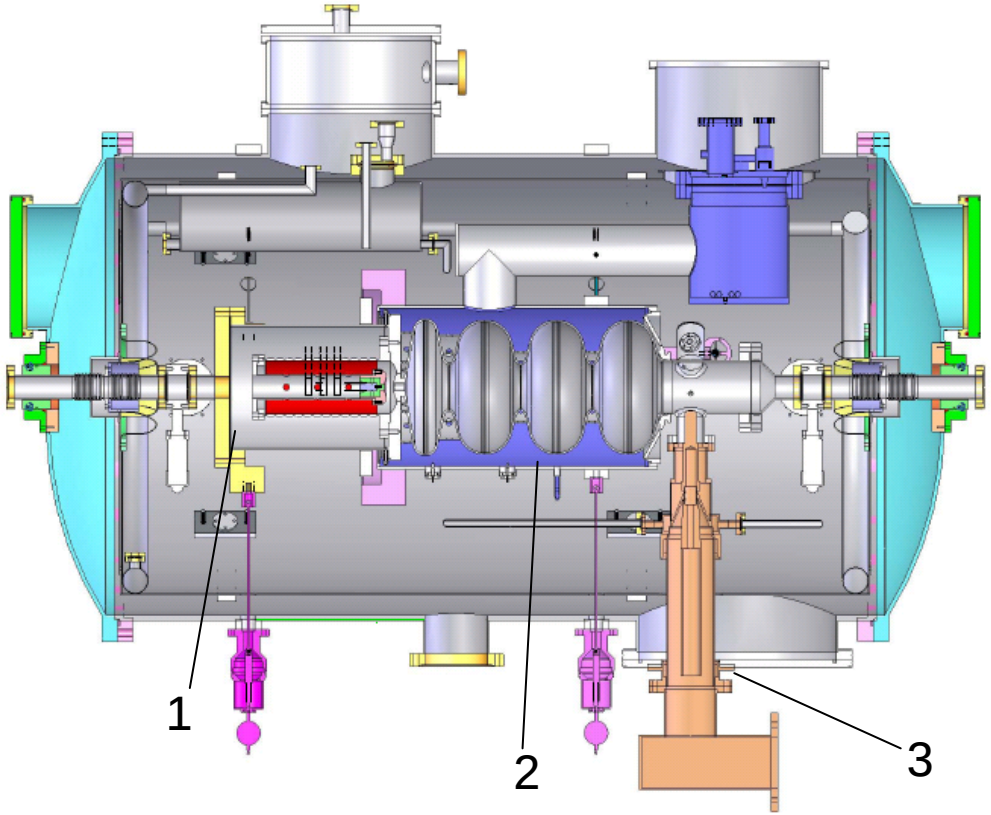
DC-SRF photoinjector was upgraded for PKU-FEL. A 3.5-cell SC cavity is the key component of the DC-SRF photoinjector. Two 3.5-cell SRF cavities was fabricated with large grain and fine grain niobium (from Ningxia OTIC) at Peking University. Vertical test shows the Eacc reaches 23 MV/m with $Q=1.2\times10^{10}$ at highest gradient. The 3.5-cell LG Nb cavity was installed to the new DC-SRF photoinjector and will be tested with the cryomodule.

PKU—FEL



DC-SRF Photoinjector

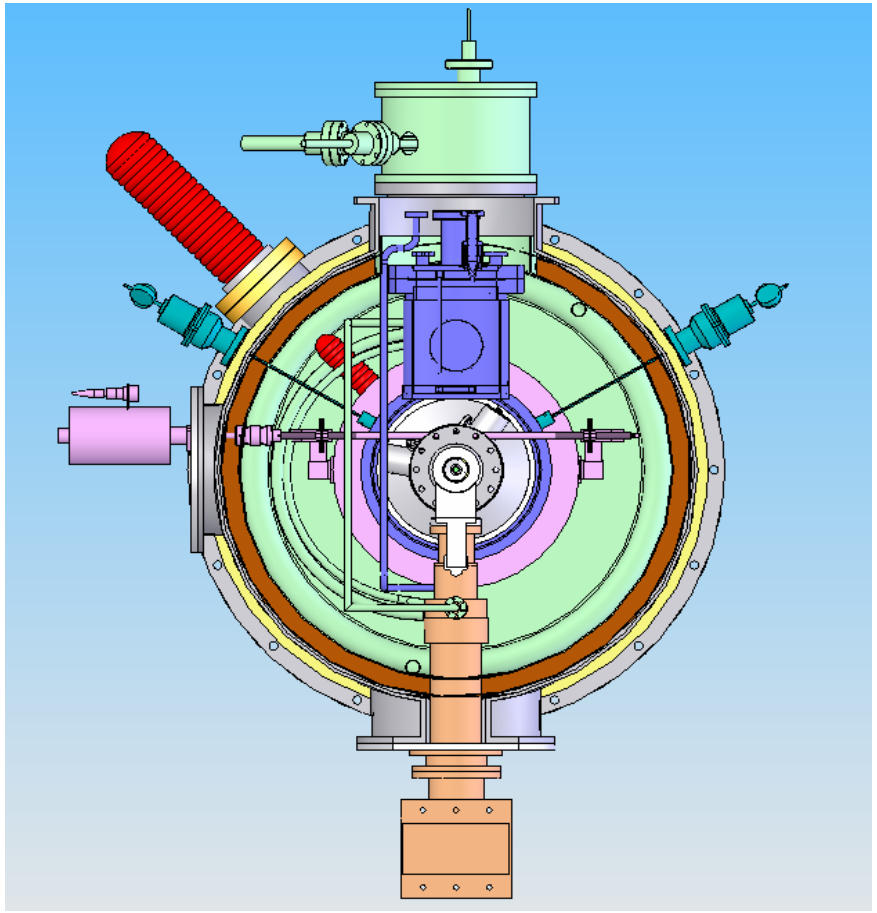


1. DC gun 2. 3.5-cell SC cavity
3. Power coupler and Cryostat

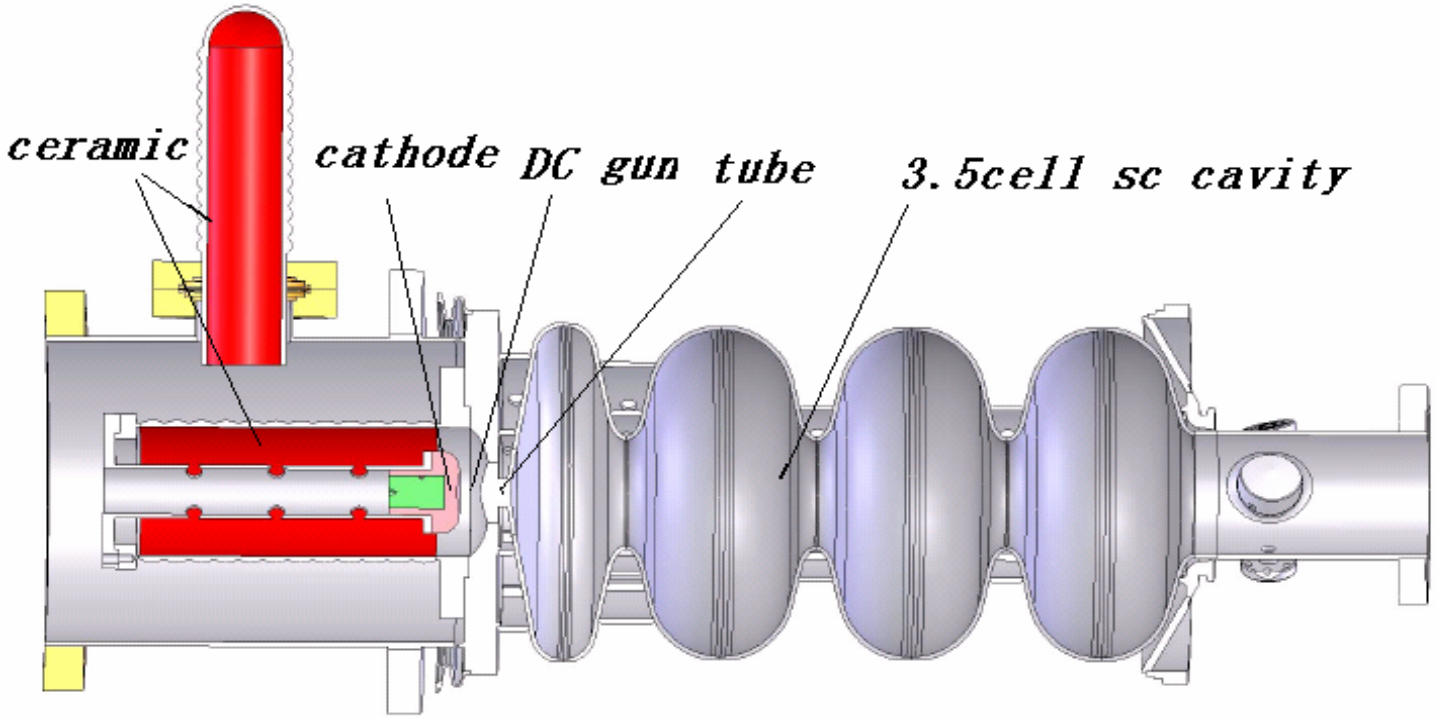
The DC-SRF photoinjector consists of a DC Pierce gun with a 1.3 GHz 3.5-cell SC cavity.

- Compatibility of photocathode and SC cavity
- Compact structure
- CW mode
- Provide high average current (mA)
- High quality electron beams

DC-SRF Cryomodule



Key component: 3.5-cell SC Cavity



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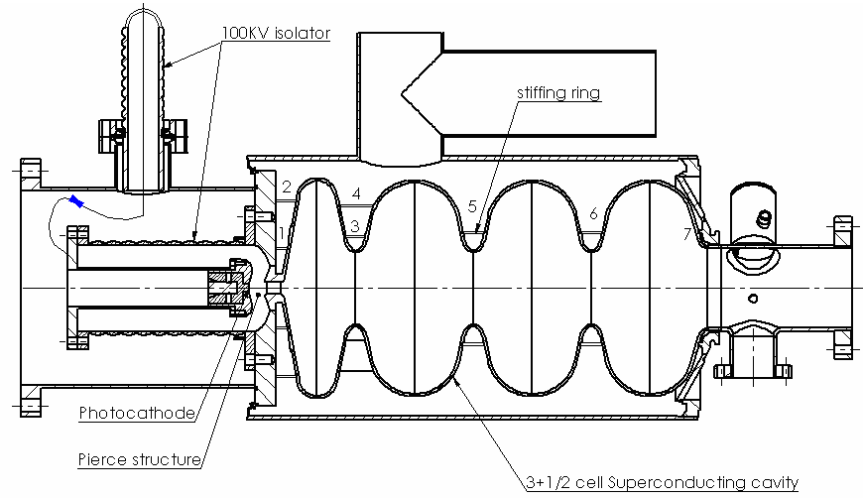
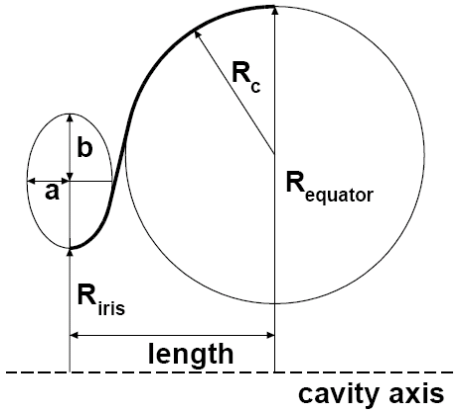
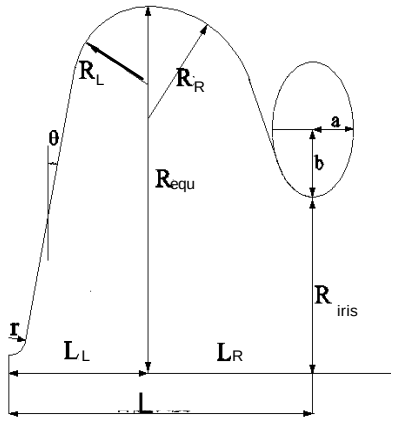
Design Parameters





Mid-cell (TESLA-type)

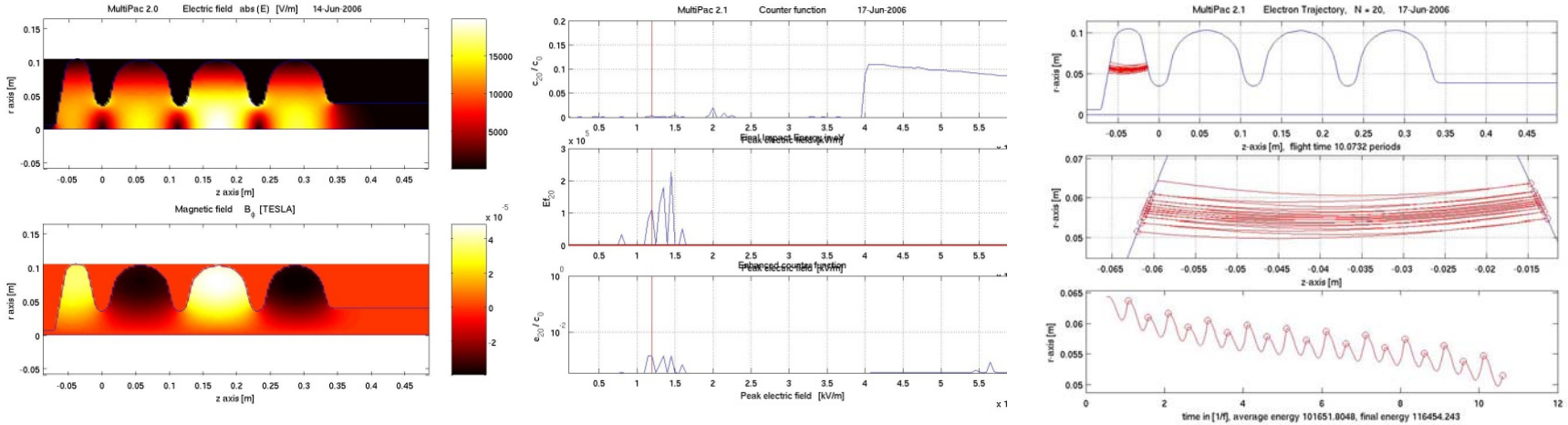


First-cell

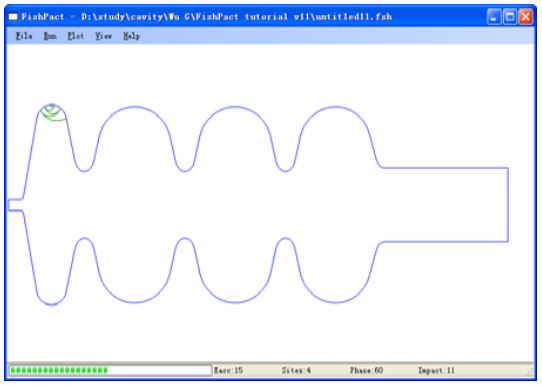
Mode	TM010, π -mode
Frequency	1300MHz
Q_0	$\geqslant 5\times 10^9$
Eacc	15 MV/m
Effective acc length	0.417 m
G	242 Ω
r/Q	417 Ω
E_{peak}/E_{acc}	2.12
B_{peak}/E_{acc}	4.95 mT/(MV/m)

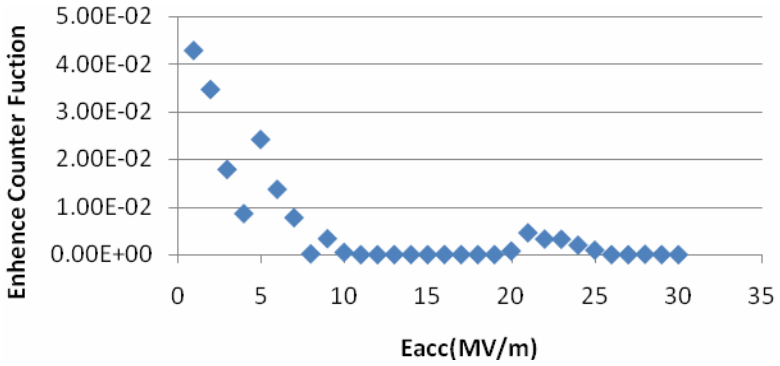
	Mid-cell	Left cup (1st cell)	Right cup (1st cell)	End-cup
R*equator*	103.3	105.3	105.3	103.3
R*iris*	35	6	35	39
R*c*	42.0	17.14	17.14	40.3
a	12	3	12	10
b	19	3	20	13.5
Length	57.7	35.19	37.72	56.0

No multipacting for good surfac treatment



Simulation with MultiPac



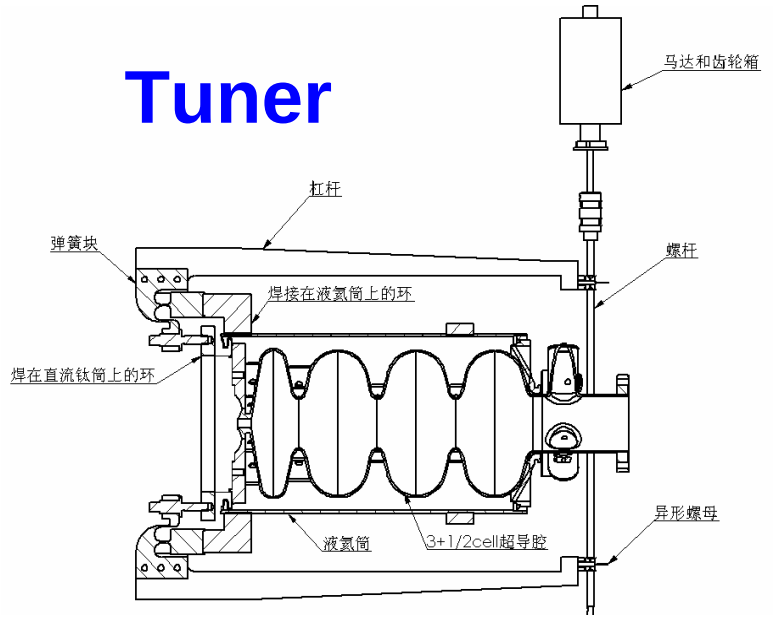


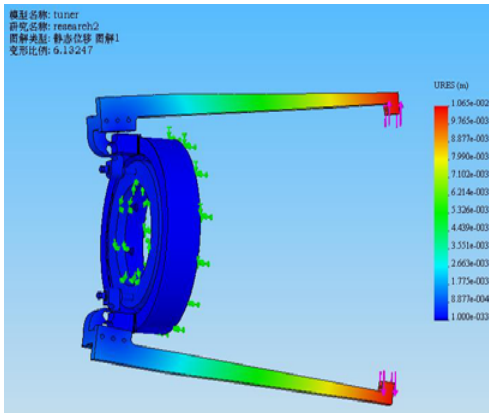
Simulation with FishPact

Stiffen Ring Optimization

Lorentz force facror	Tuning range	Δf/0.1mm	Force /0.1mm	Flatness change (±0.4mm deformation)
1.2 Hz/(MV/m)^2	±200 kHz	70 kHz	1000 N	<3%

Tuner

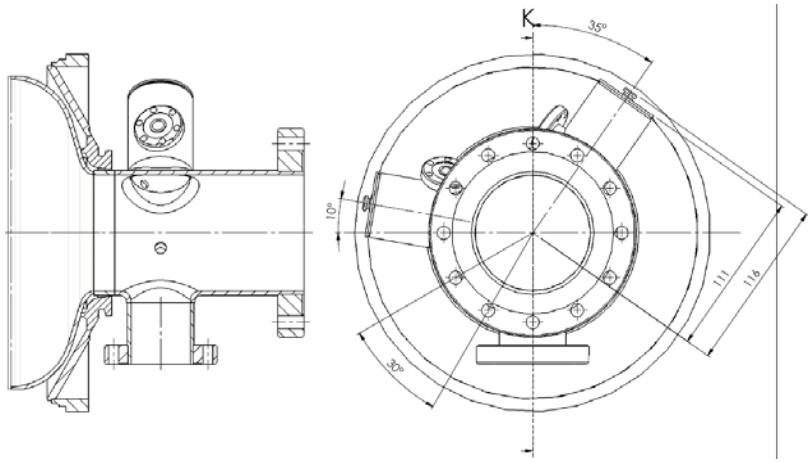


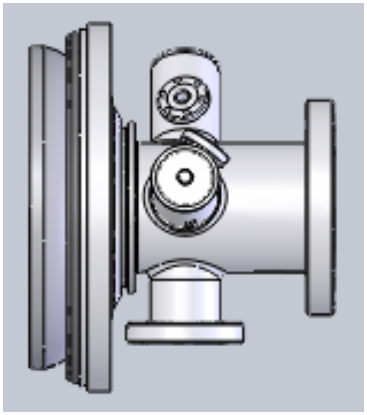


test with 1-cell cavity

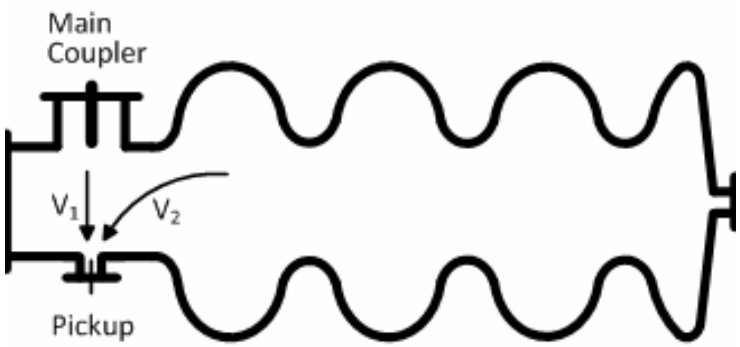
No influence on DC structure within ±0.4 mm

End Group





Cross talk between Pickup and main coupler

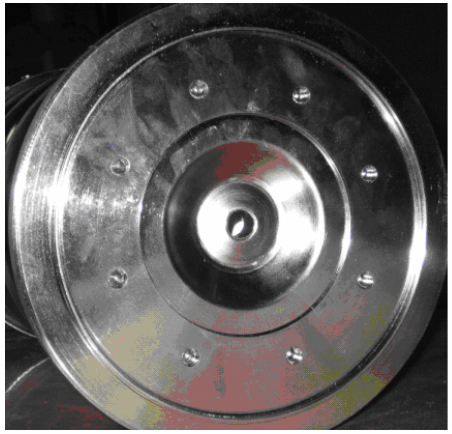


2-cell copper cavity meas. → $P_{tt} \approx P_{ct}$

SC status → $\frac{P_{tt}}{P_{ct}} = 10^6$

cross-talk can be neglected

LG 3.5-cell cavity



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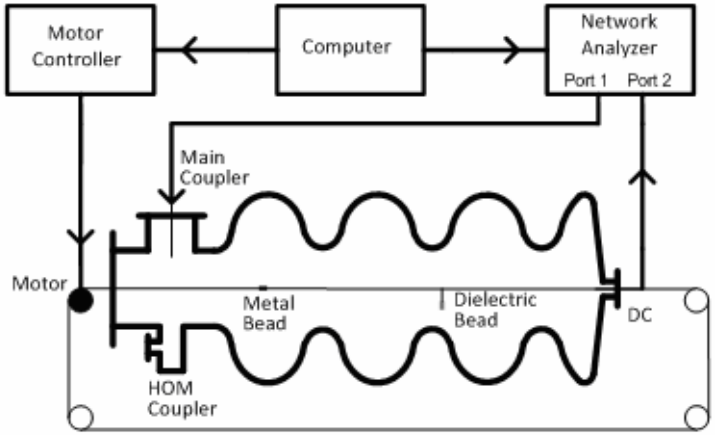
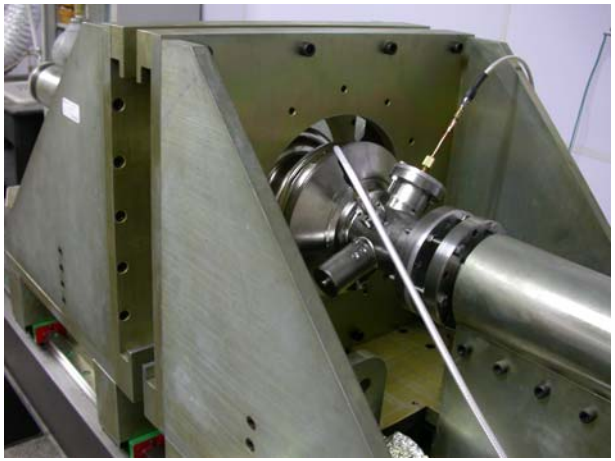
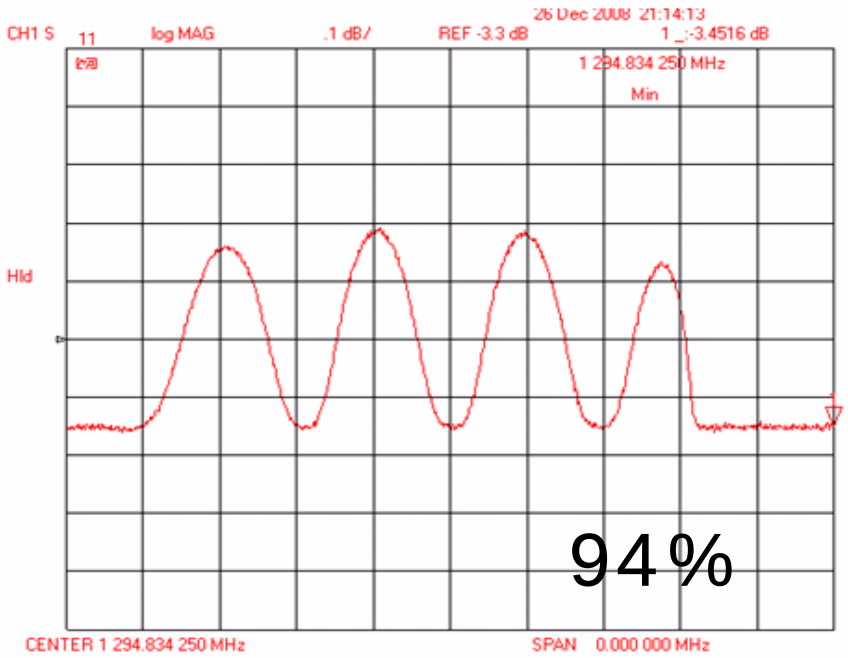
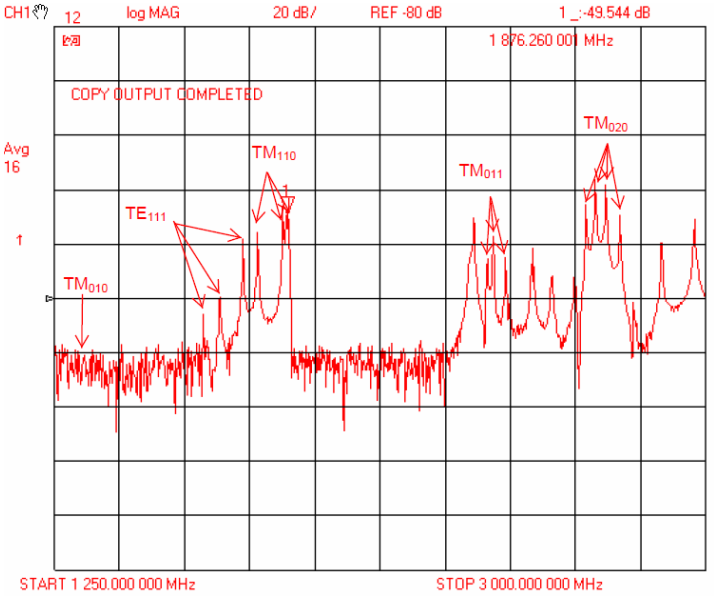
RF Measurement





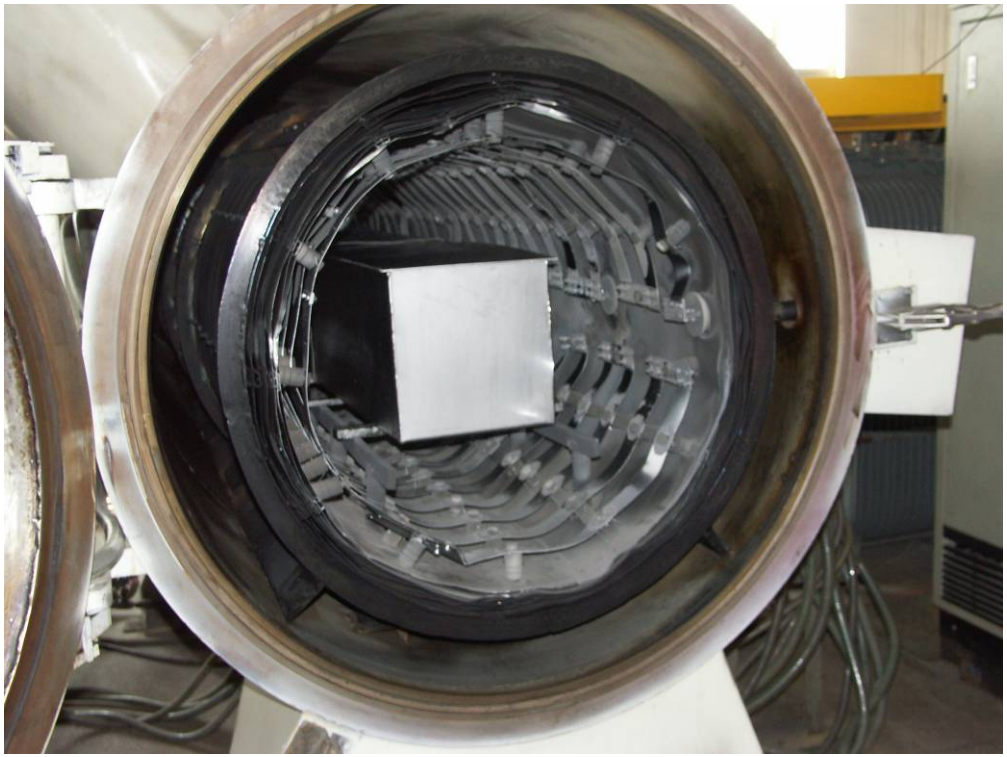




Field Flatness Tuning

HOM

BCP & 1250°C purification in China



Vertical test at Jlab

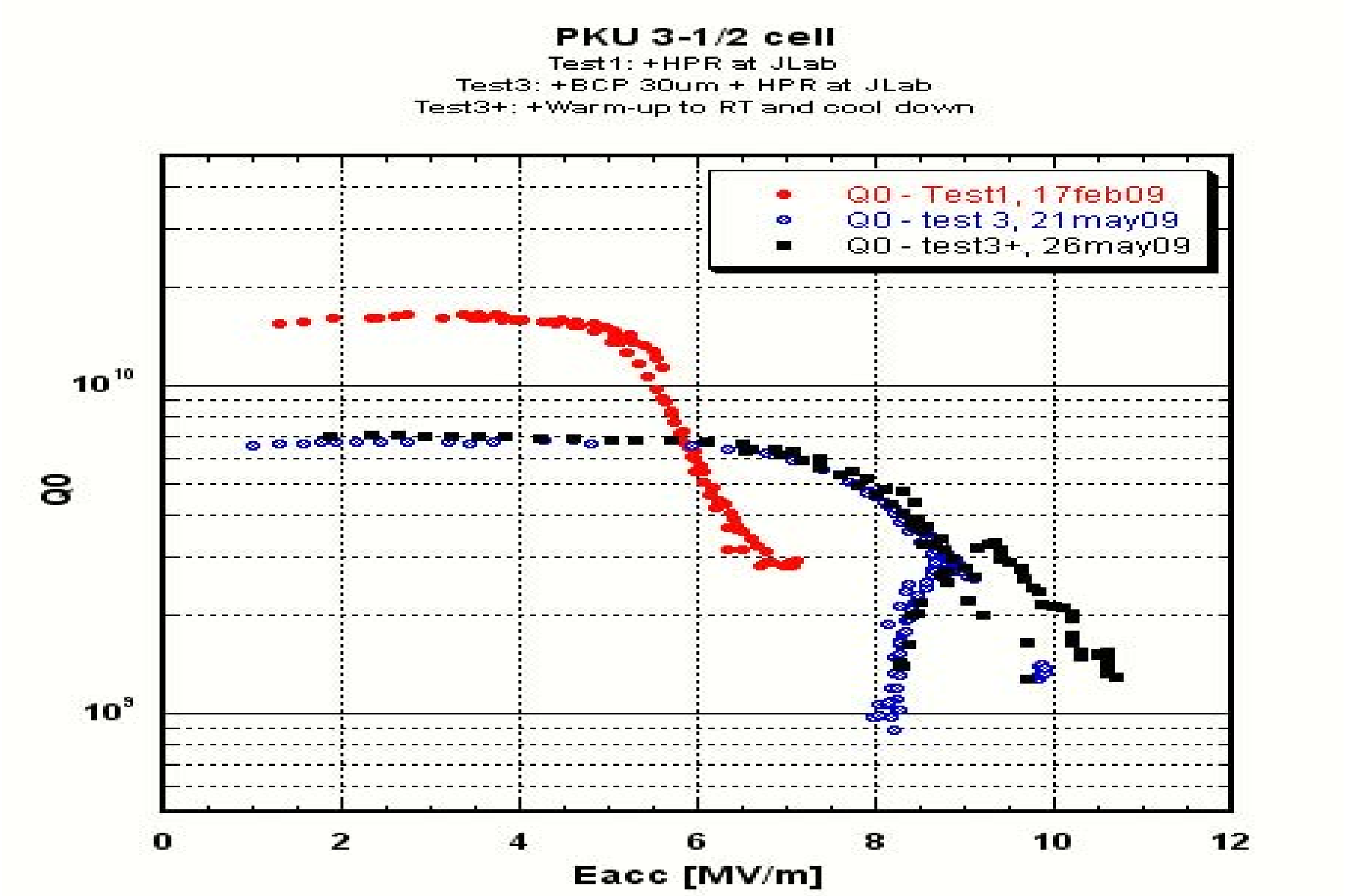
Cavity actions since second test

1. Bead pull for field flatness
2. Ultrasonic cleaning
3. BCP etching (30 micron at equators and ~ 100 um near cathode hole)
4. HPR, 1 passes
5. First assembly
6. HPR, 4 passes
7. Final assembly
8. Pump down and leak check
9. Cool down
10. RF test at 2 Kelvin
11. warm up to room temperature and cool down again
12. re-test at 2 Kelvin

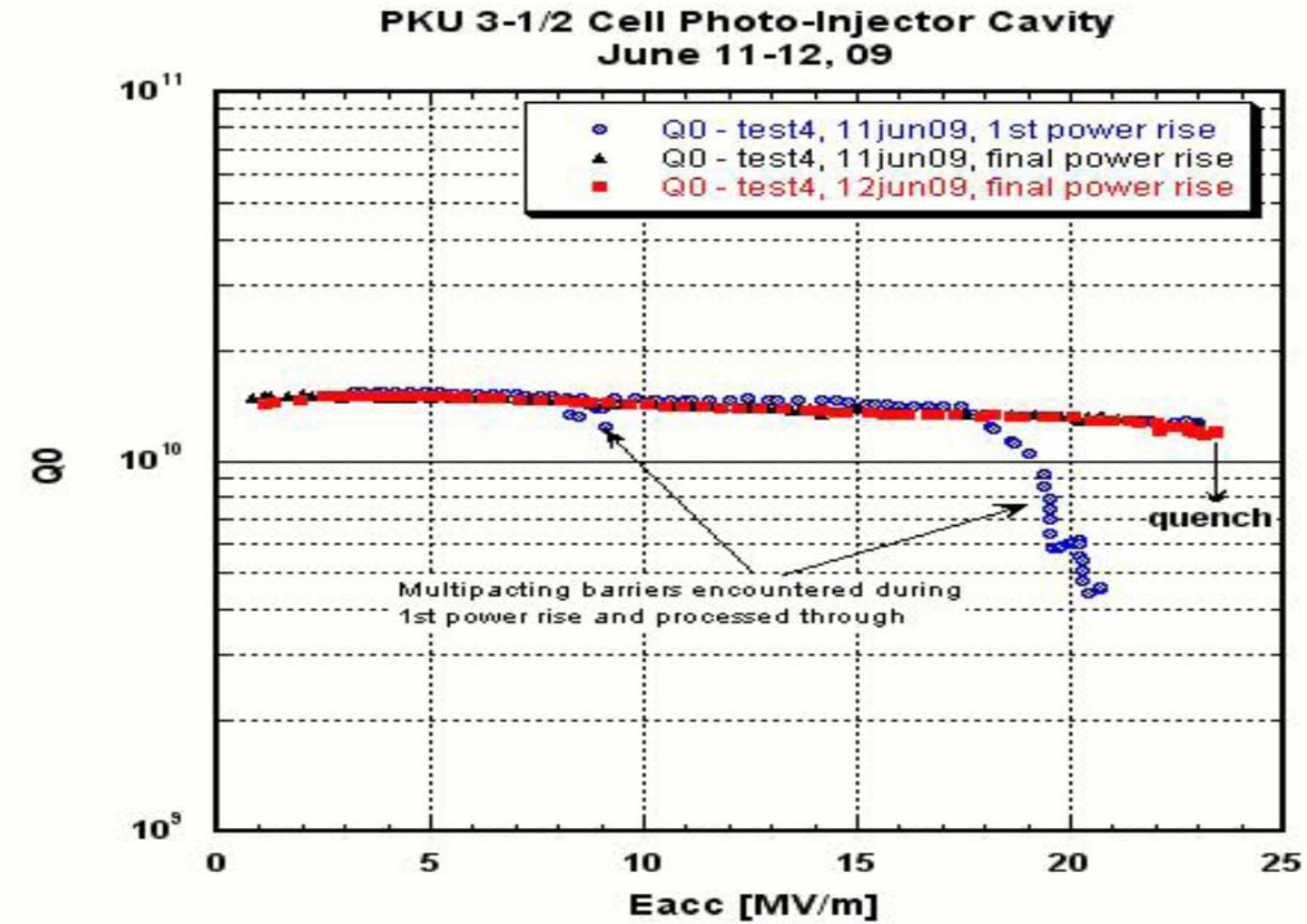
Cavity actions since third test

1. Ultrasonic cleaning
2. Vacuum furnace treatment 800C X 2hr
3. Ultrasonic cleaning
4. BCP etching (~25 micron at equators)
5. HPR, 3 passes (nozzle head w/ 45 degree jet)
6. First assembly (all parts except bottom flange)
7. HPR, 3 passes (nozzle head w/ 45 degree jet)
8. Final assembly
9. Pump down and leak check
10. Cool down
11. RF test at 2 Kelvin
12. More LHe transfer
13. re-test at 2 Kelvin

3rd RF Test


PKU 3-1/2 cell
Test1: +HPR at JLab
Test3: +BCP 30um + HPR at JLab
Test3+: +Warm-up to RT and cool down
Q0 - Test1, 17feb09
Q0 - test 3, 21may09
Q0 - test3+, 26may09
Q0
10^10
10^9
0
2
4
6
8
10
12
Eacc [MV/m]

4th RF test


PKU 3-1/2 Cell Photo-Injector Cavity
June 11-12, 09
Q0 - test4, 11jun09, 1st power rise
Q0 - test4, 11jun09, final power rise
Q0 - test4, 12jun09, final power rise
Q0
10^11
10^10
10^9
0
5
10
15
20
25
Eacc [MV/m]
quench
Multipacting barriers encountered during
1st power rise and processed through

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