Study on 3.5-cell DC-SC photo-injector

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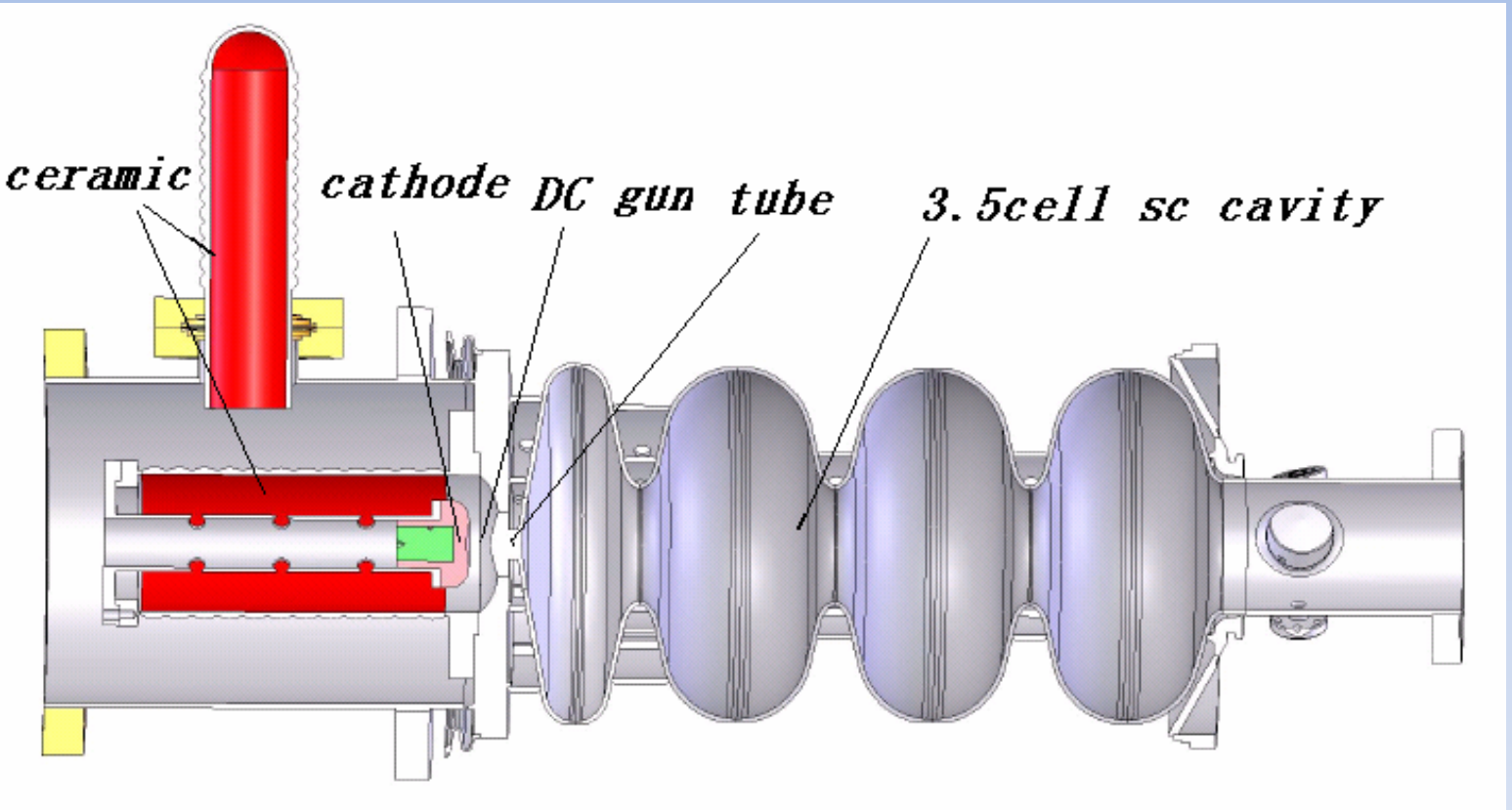
Outline

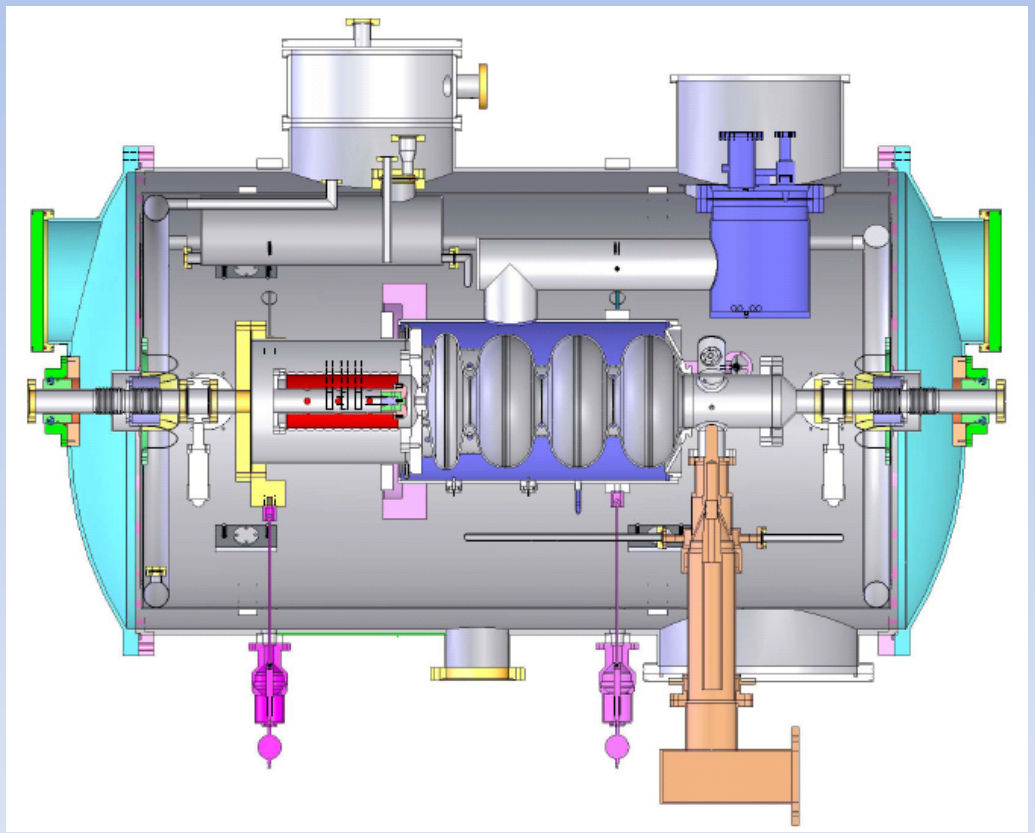
- The design of DC-gun and 3.5- cell sc cavity
- The tuner for the 3.5-cell sc cavity
- Conclusion

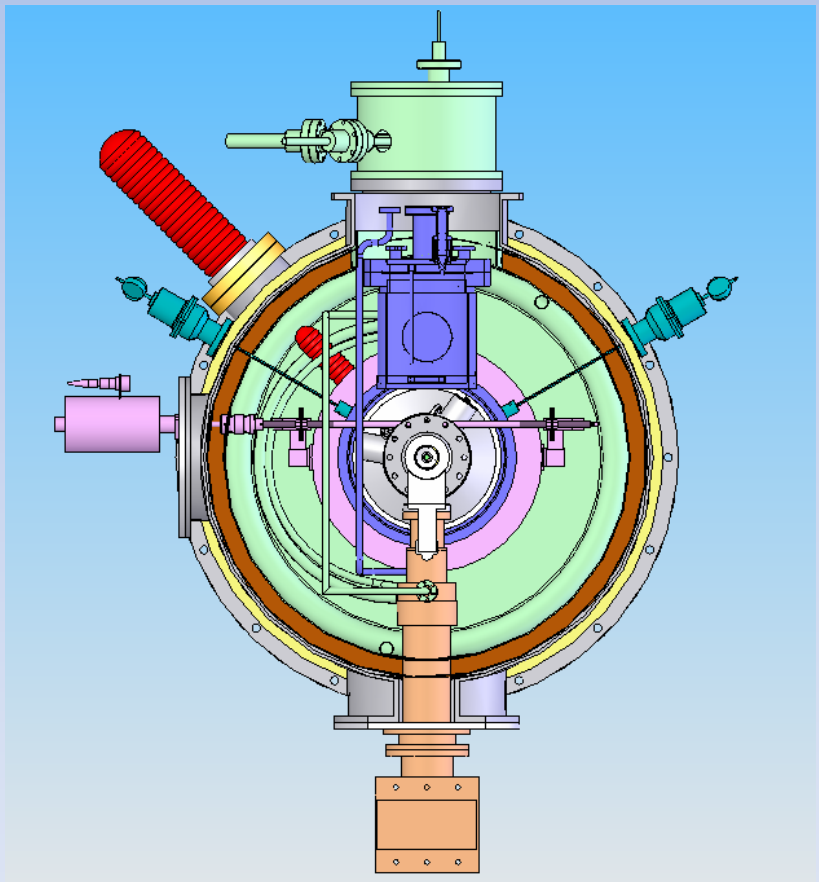
The schematic layout of the DC-SC injector



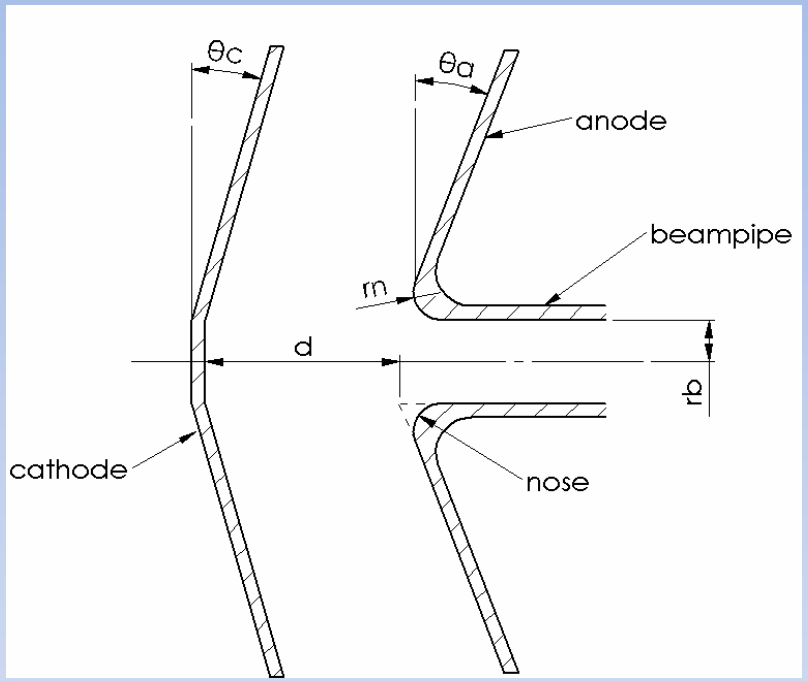
DC-SC injector moves the cathode outside the SC cavity!

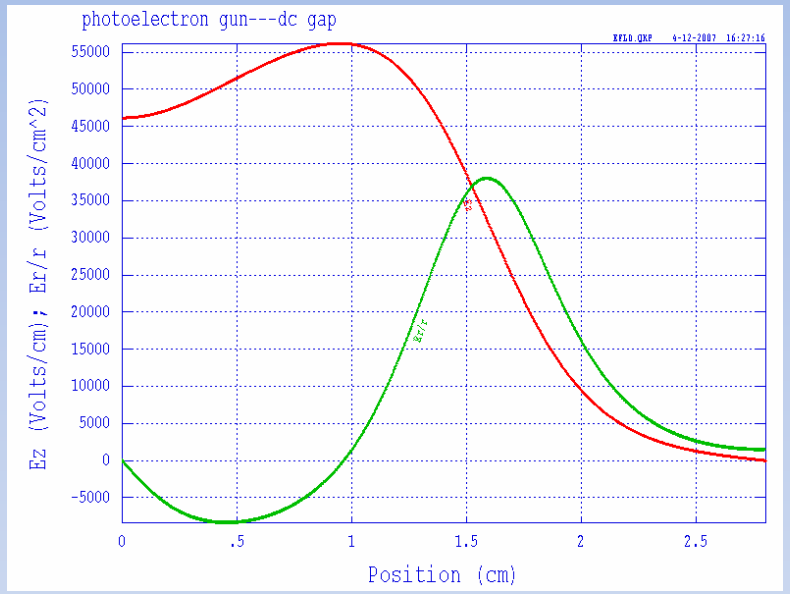
The cryo-module of 3.5- cell DC-SC injector





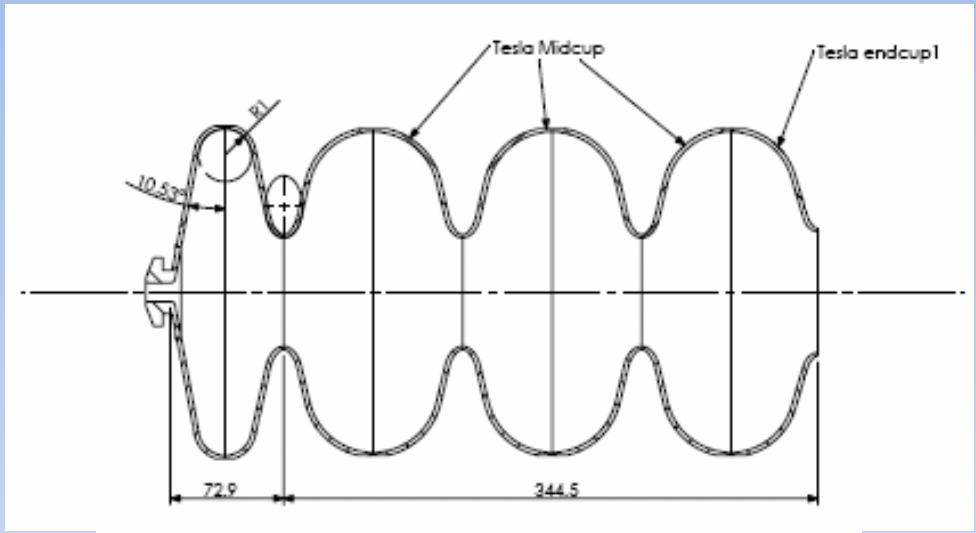
DC-gun

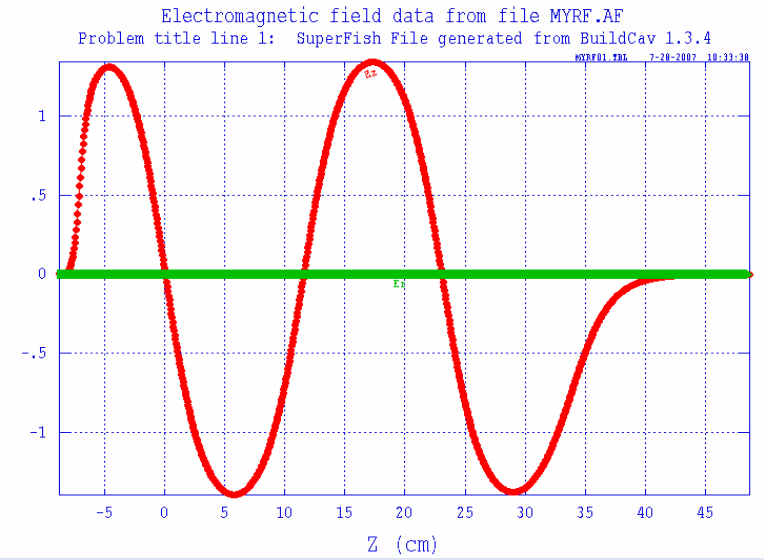




- The angle of electrode, size of cathode and tube are optimized to provide a proper electron beam for the superconducting cavity.
- However, the maximum voltage is limited by the ceramics and surface of the metal.

3.5-cell superconducting cavity





- Freq. 1301.7MHz
- Q_0(@2K) :1.4X10 ^{10}
- R/Q (Ω):418
- Bp/Eacc:4.95
- Ep/Eacc:2.12

- Material: Large grain size Nb

Beam physics in the SC cavity(1)

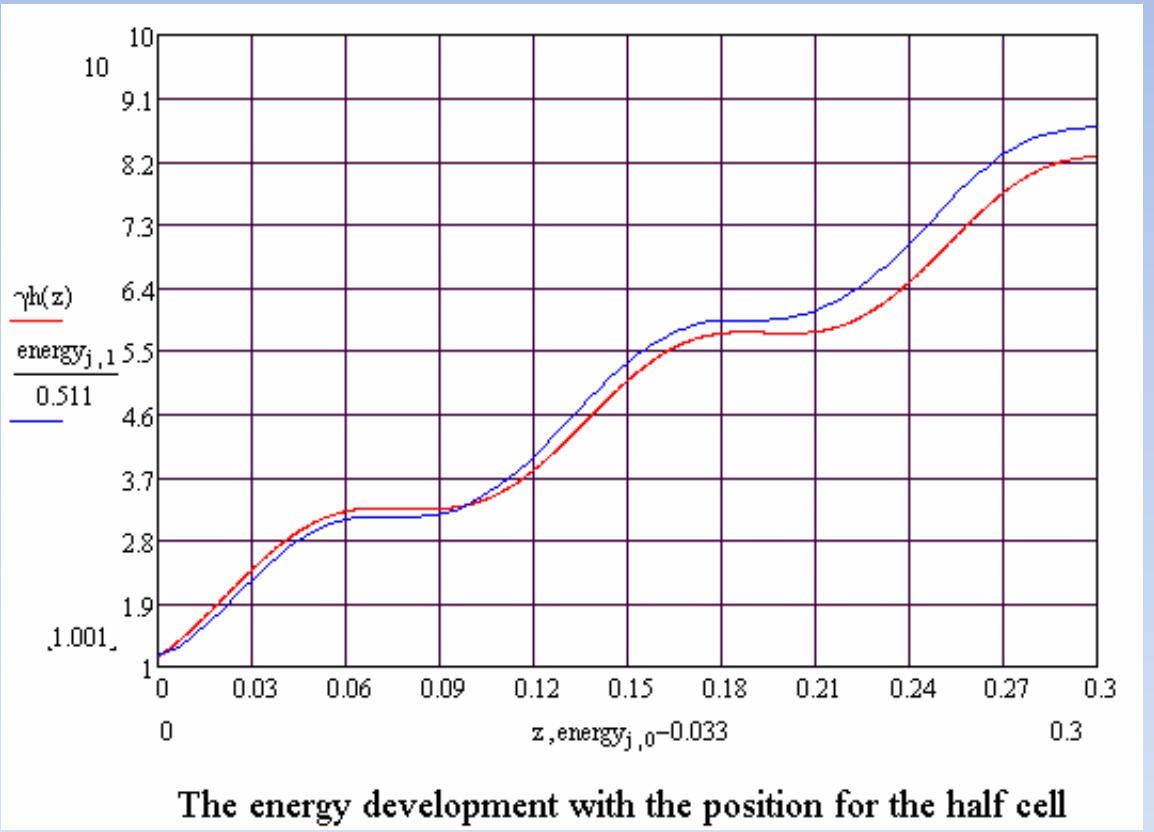
77pc,

DC:70KV,

E0 24MV/m,

Eacc:12.8MV/m

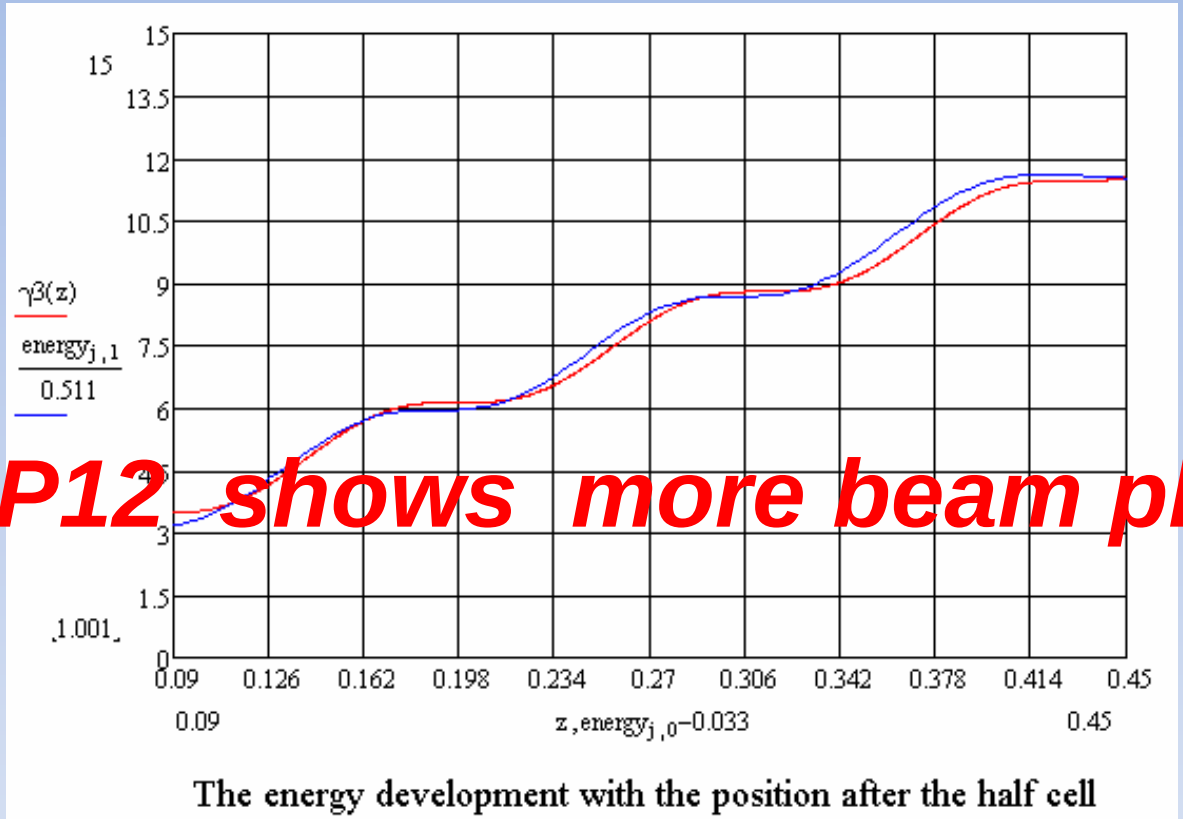
$$\alpha := \frac{ec \cdot E0}{2 \cdot E \cdot \kappa} = 0.862$$



The energy development with the position for the half cell

$$\gamma h(z) := \gamma 0 + \alpha \cdot \kappa \cdot z \cdot \cos\left(\phi 1(0) + \frac{\pi}{8}\right) + \alpha \cdot \sin\left(\phi 1(0) + \kappa \cdot z + \frac{\pi}{8}\right) \sin(\kappa \cdot z)$$

Beam physics in the SC cavity(2)

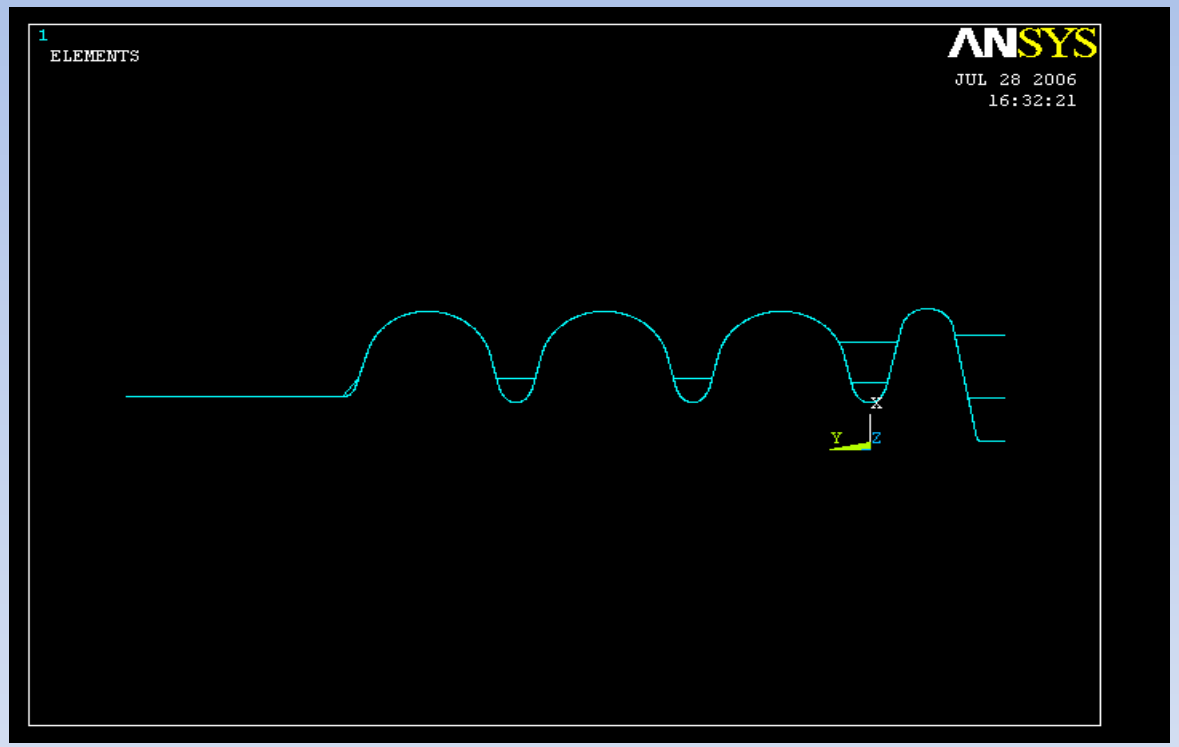


The energy development with the position after the half cell

WEP12 shows more beam physics

$$\gamma 3(z) := \gamma 1(0.00) + \alpha \cdot \kappa \cdot (z) \cdot \cos\left(\phi 1(0.059) - \frac{\pi}{2}\right) + \alpha \cdot \sin\left(\phi 1(0.059) - \frac{\pi}{2} + \kappa \cdot z\right) \sin[\kappa \cdot (z)]$$

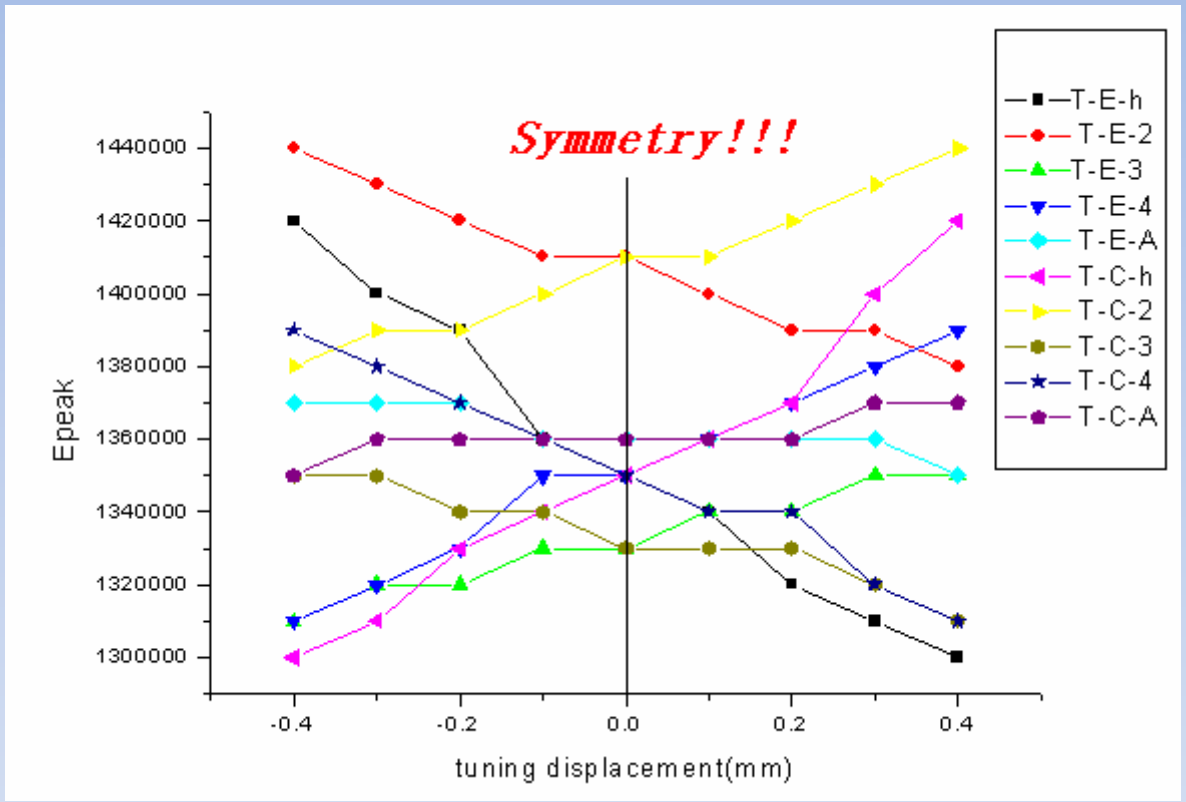
Mechanics of the 3.5-cell sc cavity



Stiffer ring	Position (distance from the axis) /mm
1	38
2	85
3	50
4	80
5, 6, 7	53.5

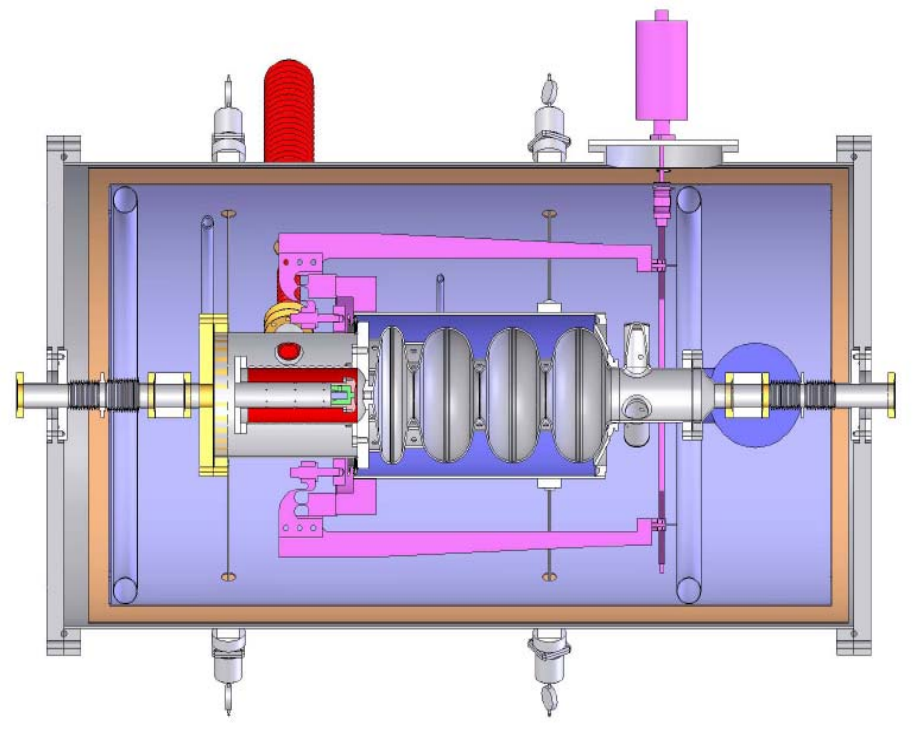
- Lorentz detuning coefficient(KHz/ $(MV/m)^2$):1.2
- Stiffness(kN/mm) :10.101 ; Tuning Sensitive(KHz/mm) :699.25
- Maximum Load (N) :4000 ; Tuning range(mm/KHz) :0.4/279.7

Which side should we locate the tuner ??



- There is not much different either tuning at cathode side or the end cell side.
- For the mechanical consideration, we tune the cavity at cathode side.

The tuner in the cryo-module



Thanks to Rossendorf for their help about the design of tuner .

Conclusion

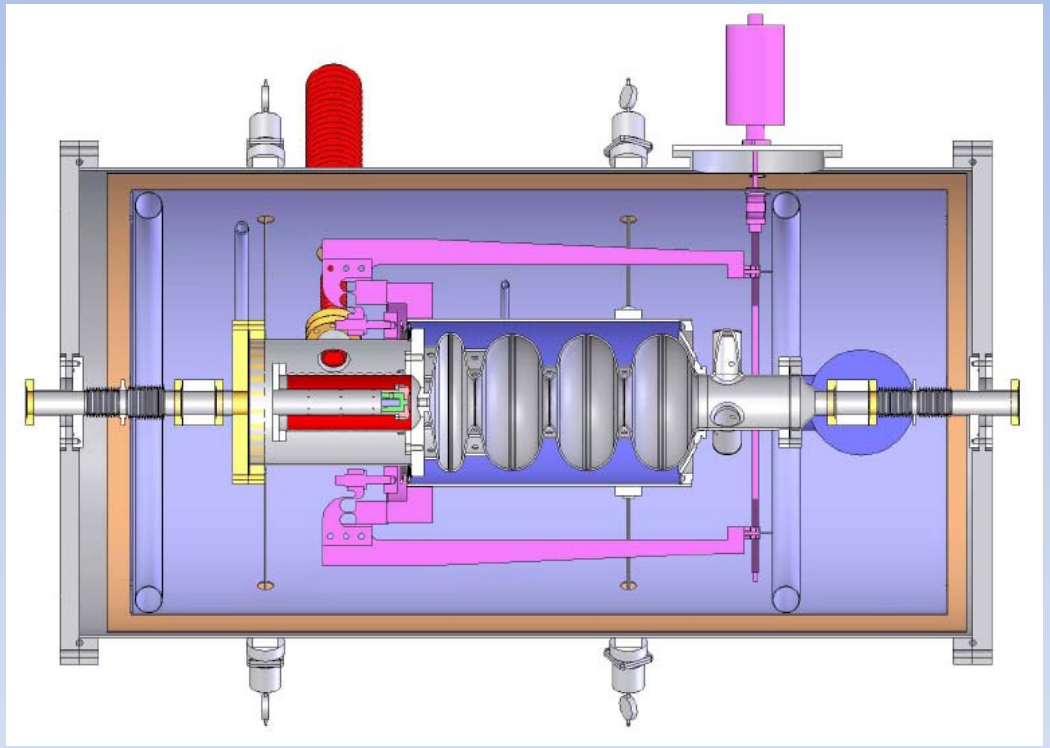
- A 3.5-cell DC-SC injector has been designed. We have gotten a good understanding by codes and analysis method.

- A reasonable tuner has been designed with careful consideration of physics and engineering.

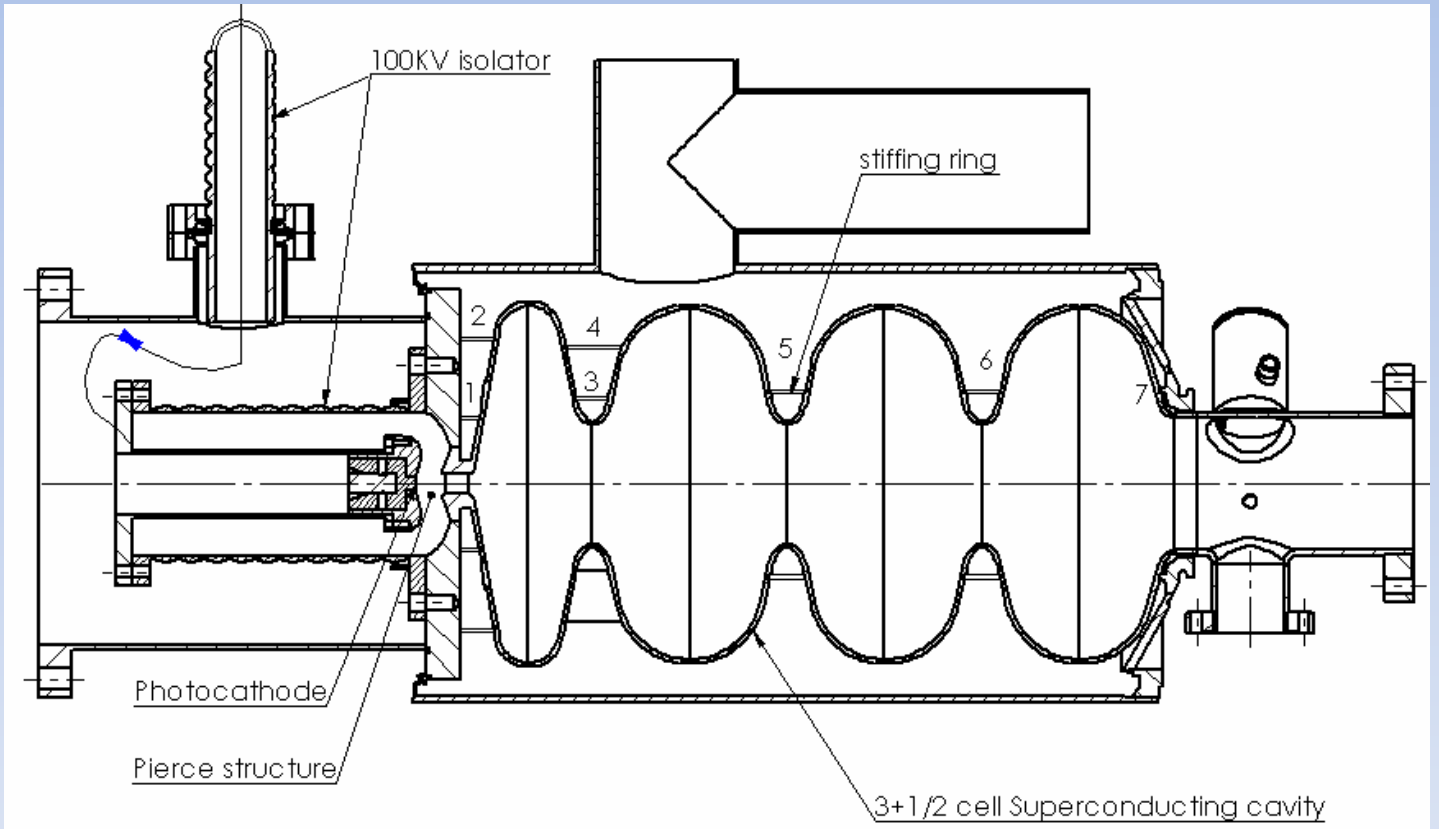
Acknowledge

- *Many people from Rossendorf, DESY, Jlab, Fermilab----*

- *All colleague in SRF group, Peking University.*



Tuning


100KV isolator
stiffing ring
1
2
3
4
5
6
7
Photocathode
Pierce structure
3+1/2 cell Superconducting cavity

Beam envelope in the short tube connected DC and SC

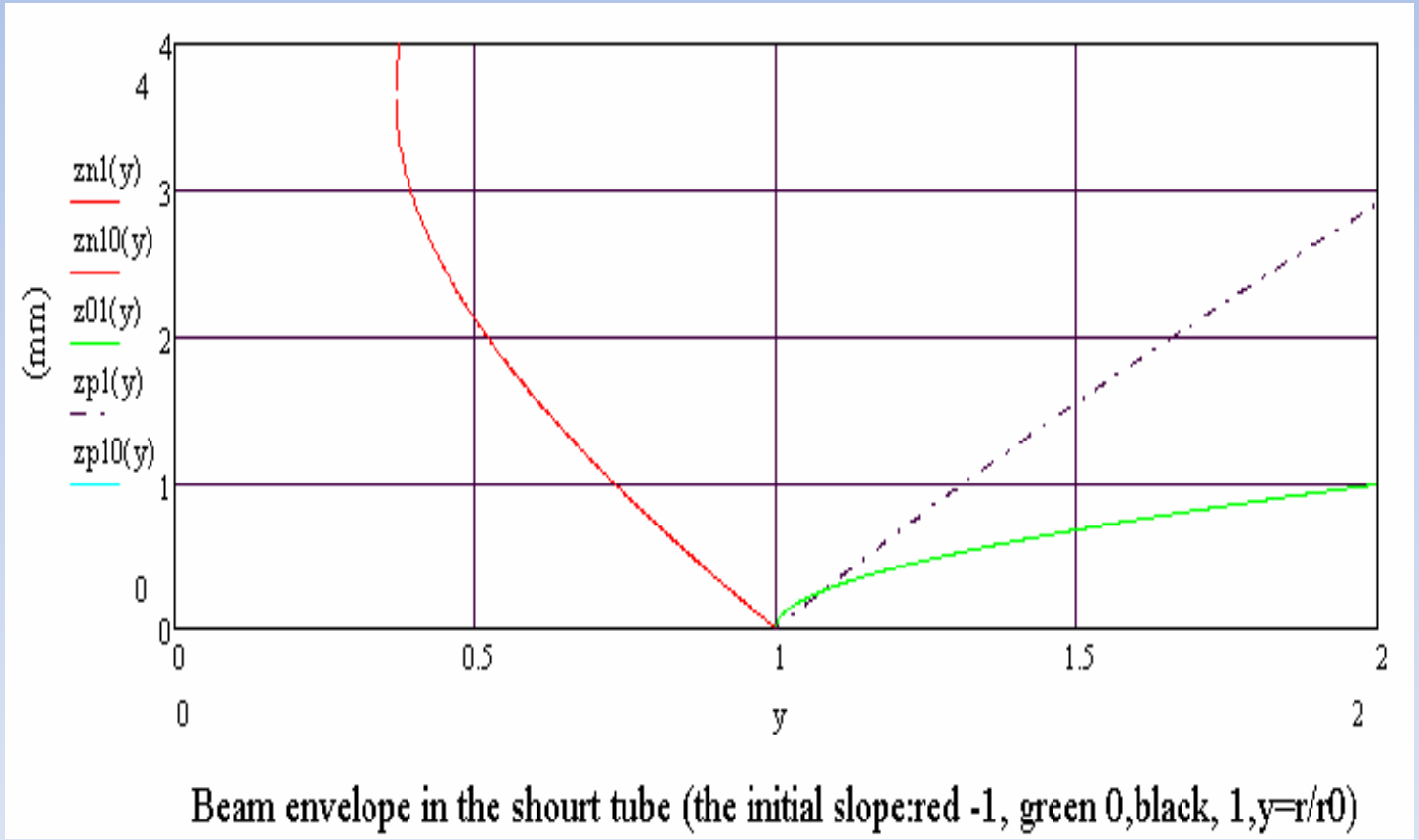


Table 1 simulation results of the upgraded DC-SC photocathode injector.

Drive laser	
Pulse length	8ps
Spot radius	
Repetition rate	26 MHz
Bunch shape	Transverse uniform, longitude Gaussian distribution
3 ½ superconducting cavity	
Accelerating gradient	13 MV/m
Electron bunch	
Charge/bunch	100 pc
Energy	5.0 MeV
Emittance (rms)	1.2 μ m
Longitudinal emittance (rms)	14 deg-KeV
Bunch length	5.6 ps
rms beam size	
Energy spread	~0.5%