Technology Challenges for SRF Guns as ERL Sources in View of Rossendorf work

Dietmar Janssen, Hartmut Buettig, Pavel Evtushenko, Ulf Lehnert, Peter Michel, Karsten Moeller, Petr Murcek, Christof Schneider, Rico Schurig, Friedrich Staufenbiel, Jochen Teichert, Rong Xiang, (FZR, Dresden), Juergen Stephan (IKS Dresden), Wolf-Dietrich Lehmann (IfE Dresden), Thorsten Kamps, Dirk Lipka (BESSY GmbH, Berlin), Vladimir Volkov (BINP SB RAS, Novosibirsk), Ingo Will (MBI, Berlin)

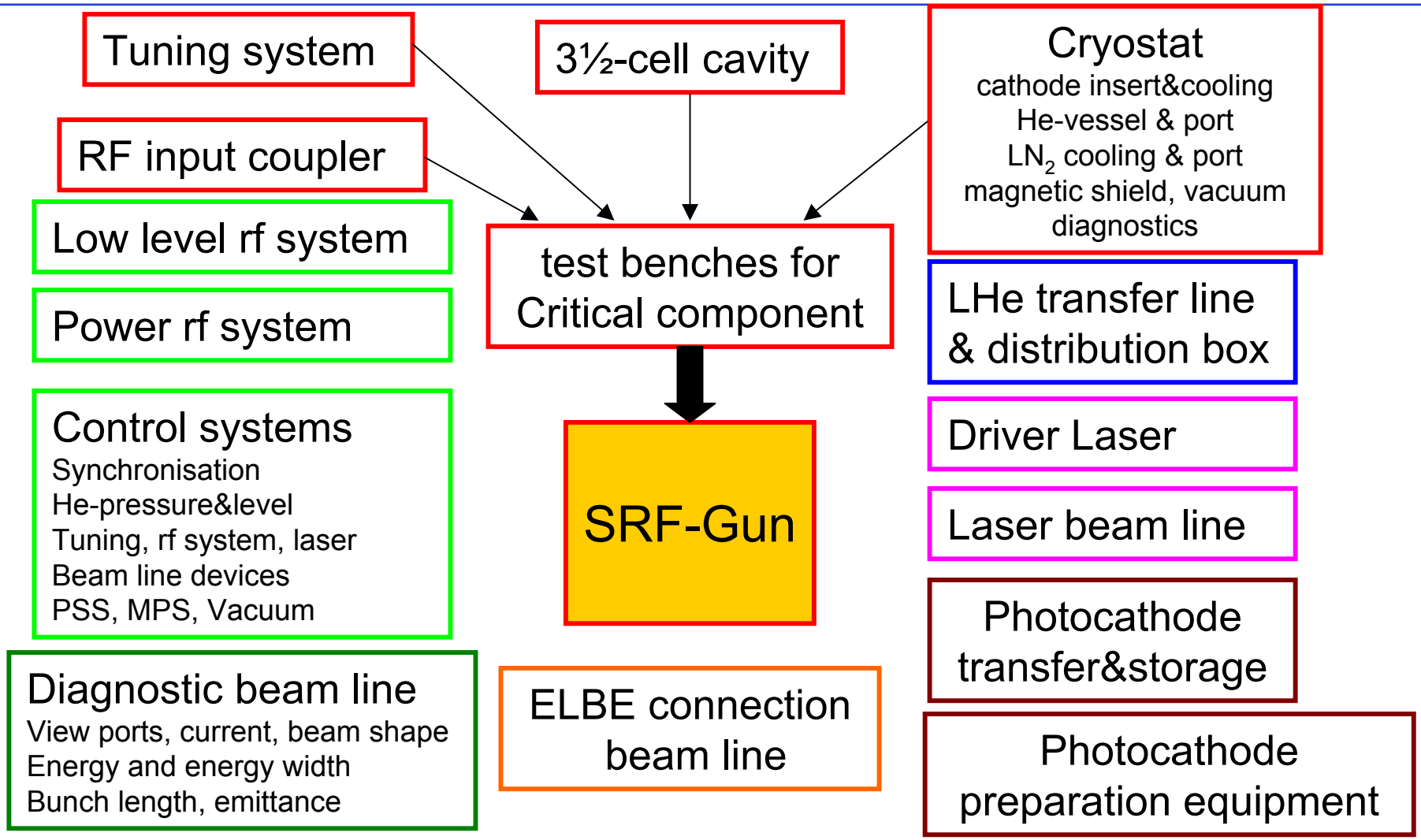
Basic Design

Normal-conducting cathode inside SC cavity

Successful Proof of Principle Experiment, D. Janssen et al., NIM A507(2003)314

Cavity:	Niobium 3+½ cell (TESLA Geometry)
	Choke filter
Operation:	T = 1.8 K
Frequency:	1.3 GHz
HF power:	10 kW
Electron energy:	10 MeV
Average current:	1 mA
Cathode:	Cs_2Te
	thermally insulated, LN_2 cooled
Laser:	262 nm, 1W
Pulse frequency:	13 MHz & < 1 MHz
Bunch charge:	77 pC & 1 nC

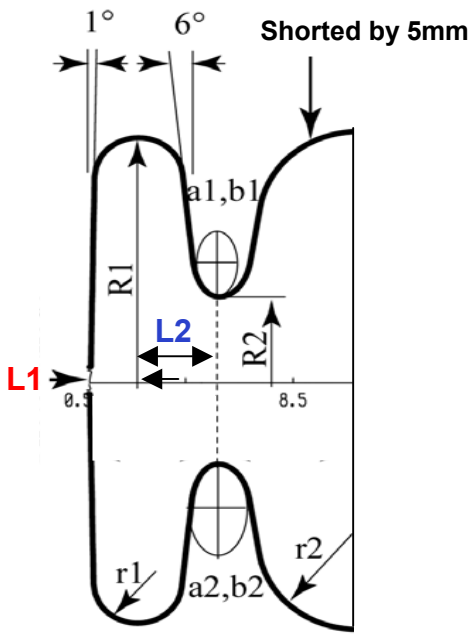
Main Components of the SRF Photogun in Rossendorf

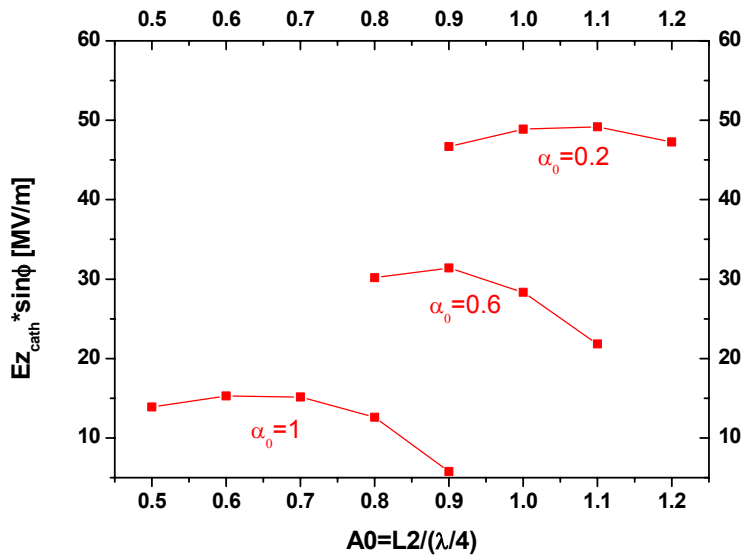


Design consideration of the gun cell

L1 is mainly determinated by technological conditions (pressure, multipacting , etching)

The optimal L2 value follows from the beam properties
One dimensional model calculation:
$E(\Phi) \rightarrow max$, $Ez_{cath}*\sin(\Phi) \rightarrow max$



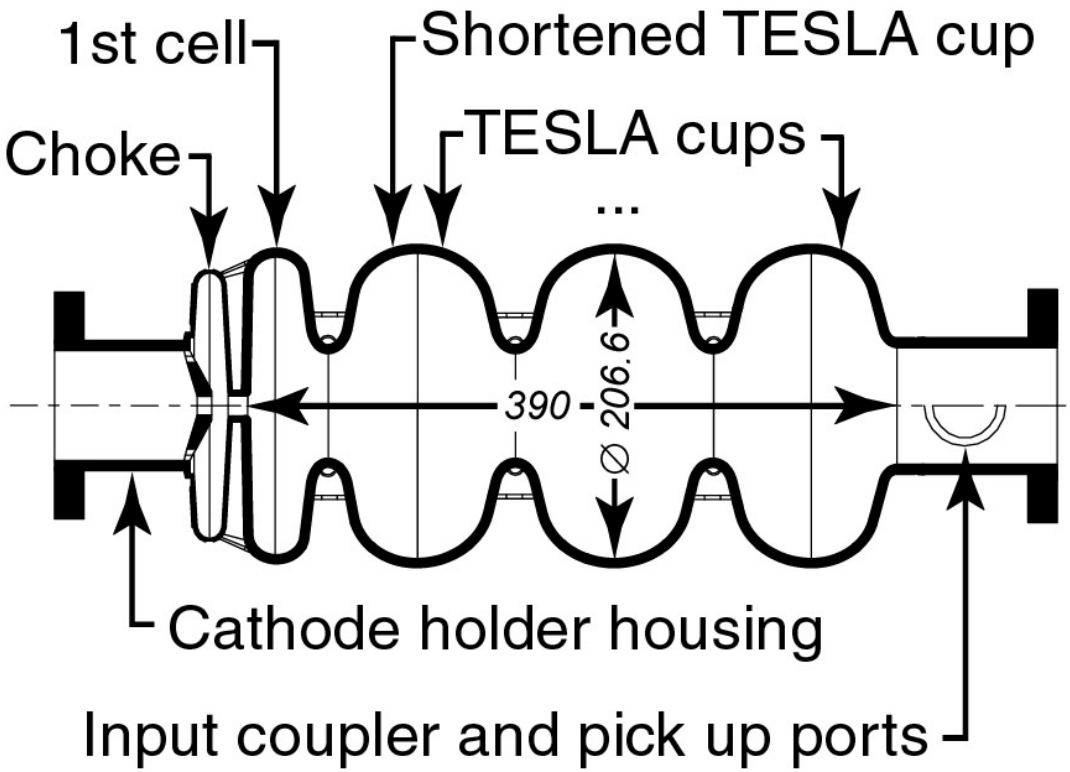


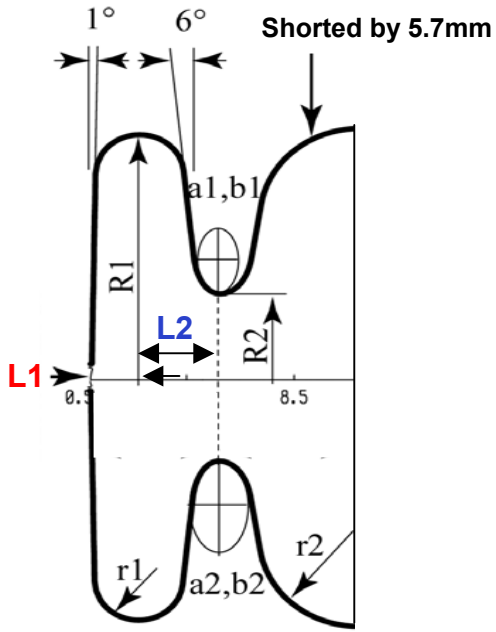
L=L1+L2 width of the gun cell

$L1 = \alpha_0 * A0 * \lambda / 2\pi$

Result of numerical optimization

Numerical minimization of the beam emittance by variation of the gun cell shape with the condition, that Bs_{max}< 115mT and Es_{max}< 52MV/m when E_{acc}= 25MV/m

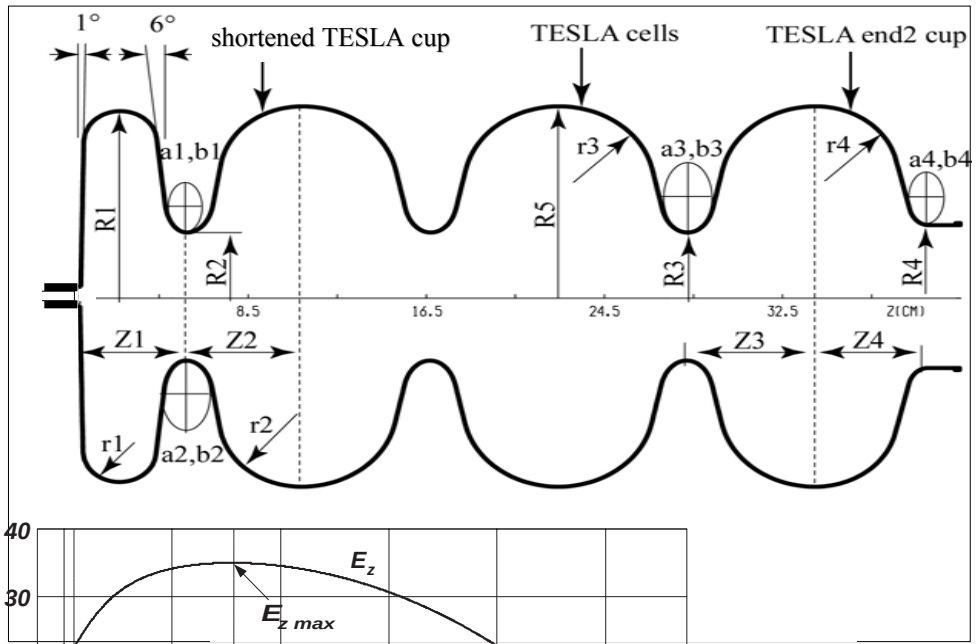


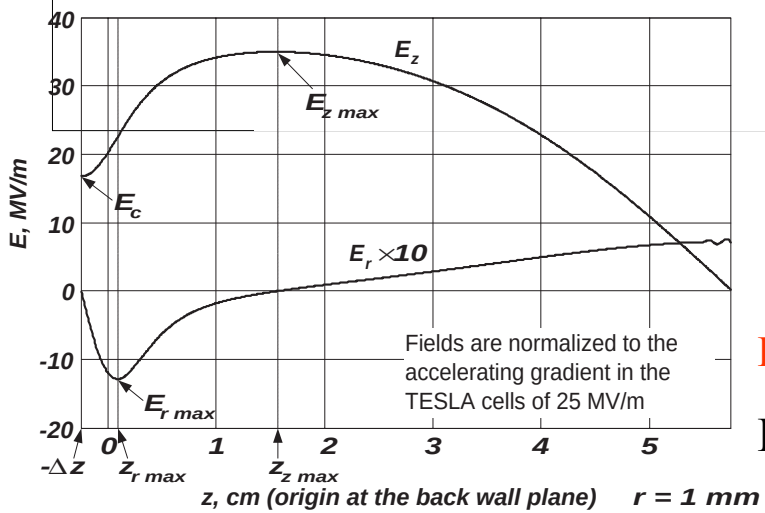


Obtained result: [mm]
L1+L2= λ/4-20 = 37.7
a1=9, b1=16,
R1=102.5, r1=11.4,

RRR40 and RRR300 cavity of the SRF gun

Cavity Design Parameter



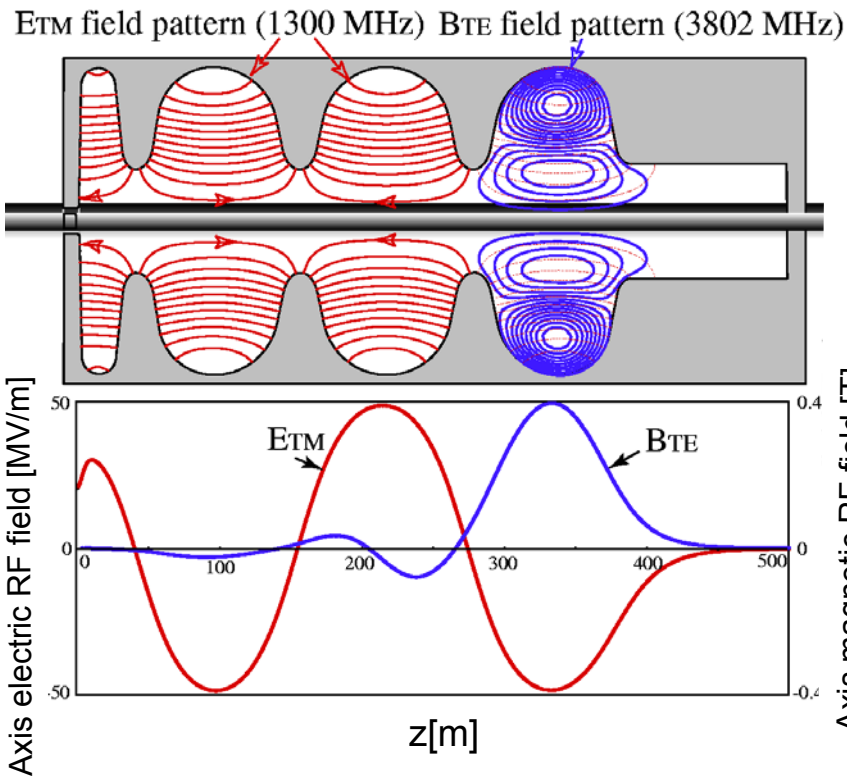


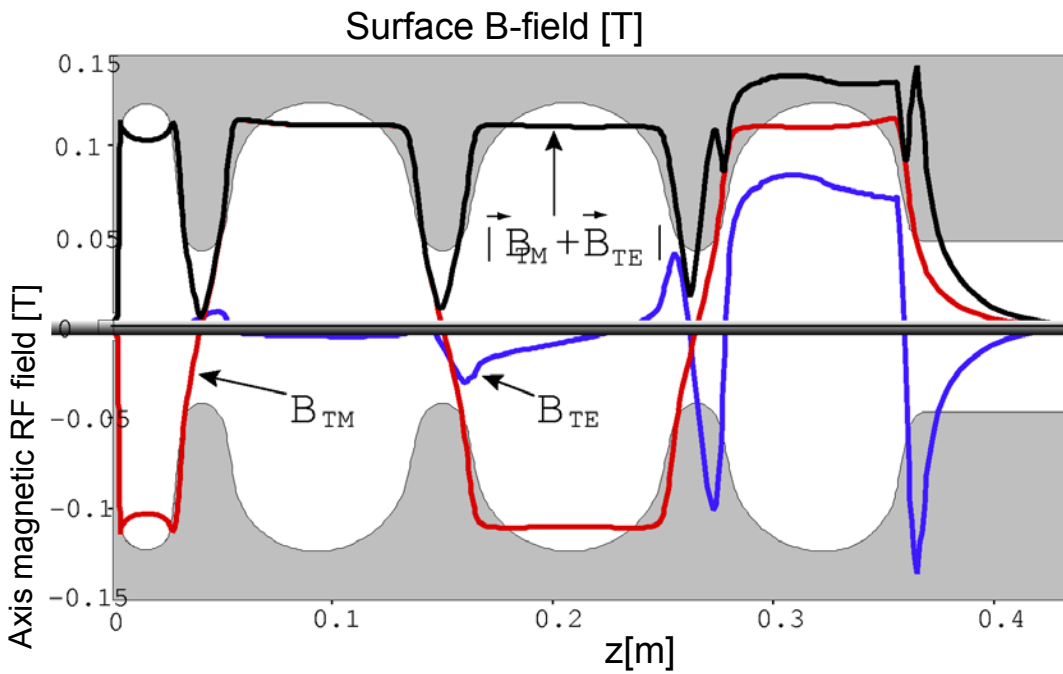
1. 3 GHz, 10 kW optimized half cell & 3 TESLA cells $E_{z,max}$= 50 MV/m (T cells) = 33 MV/m (1/2 cell)	
77 pC	1 nC
I_{av}= 1 mA	
E = 9.5 MeV	
0.5 mm mrad	2.5 mm mrad

RF focusing in SC gun cavities

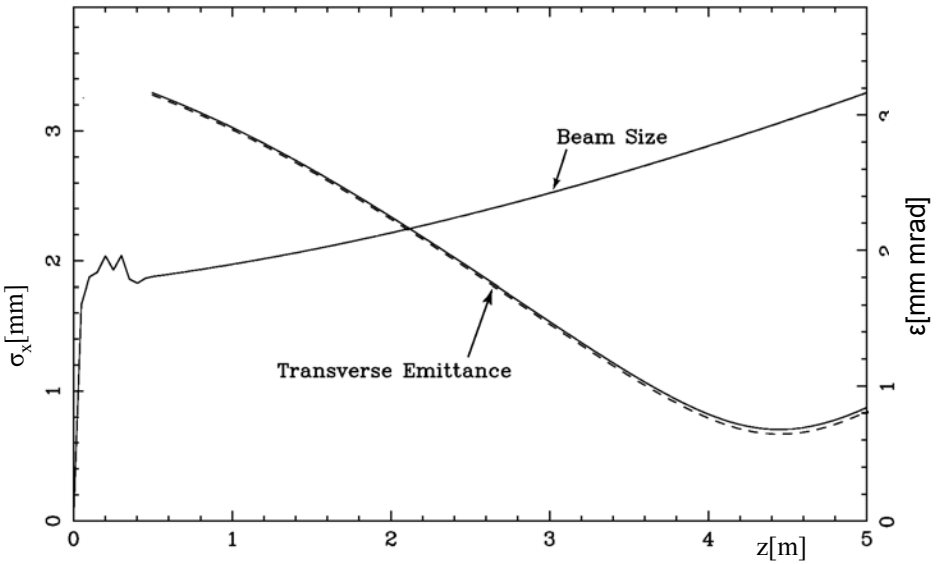
D. Janssen, V.Volkov, NIM A452(2000)34

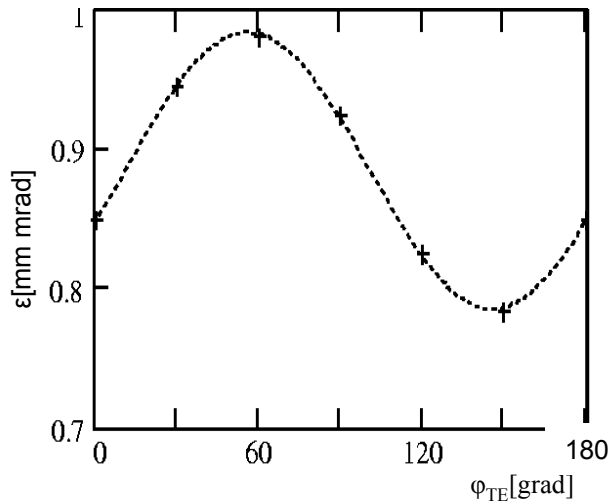
Magnetic RF field inside the cavity





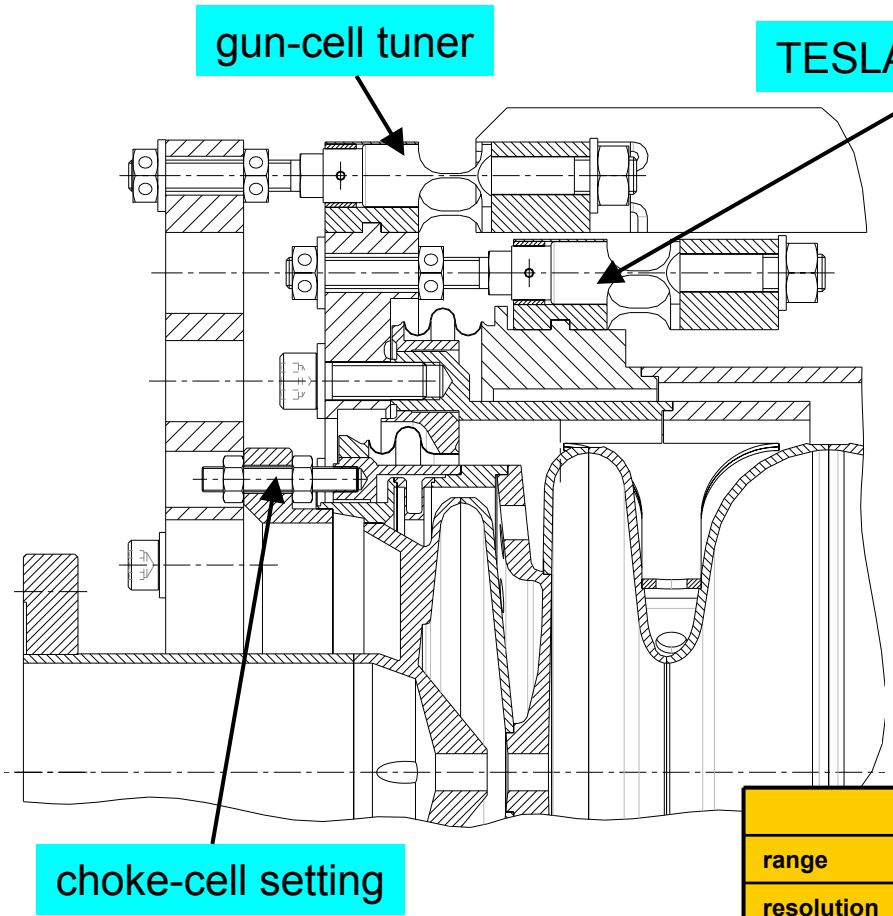
Designparameter including the magnetic mode

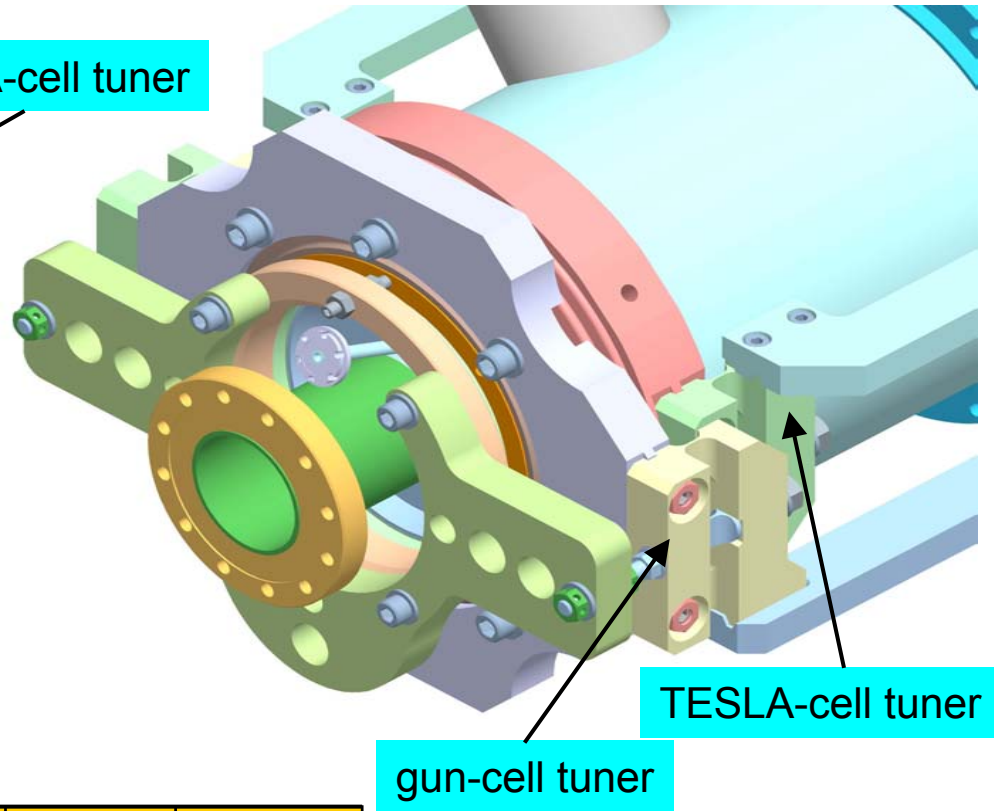




Beam parameter		Field parameter		Laser parameter	
ε_x[mm mrad]	0.78 – 0.98	B_{TMsurf}[mT]	115	Puls length [ps]	20
σ_x[mm]	3.06	B_{TEsurf}[mT]	136	Raise time [ps]	1
ε_z[keV mm]	72.4	$\lvert B_{TM} + B_{TE} \rvert_{surf}$[mT]	144	Spot size [mm]	2.6
Δz[mm]	2.79	$E_{TM,axis}$[MV/m]	50	Bunch charge[nC]	1
E_{av}[MeV]	8.82	φ_{TM}[grad]	74.6		
ΔE_{rms}[keV]	53.9	φ_{TE}[grad]	0 - 180		

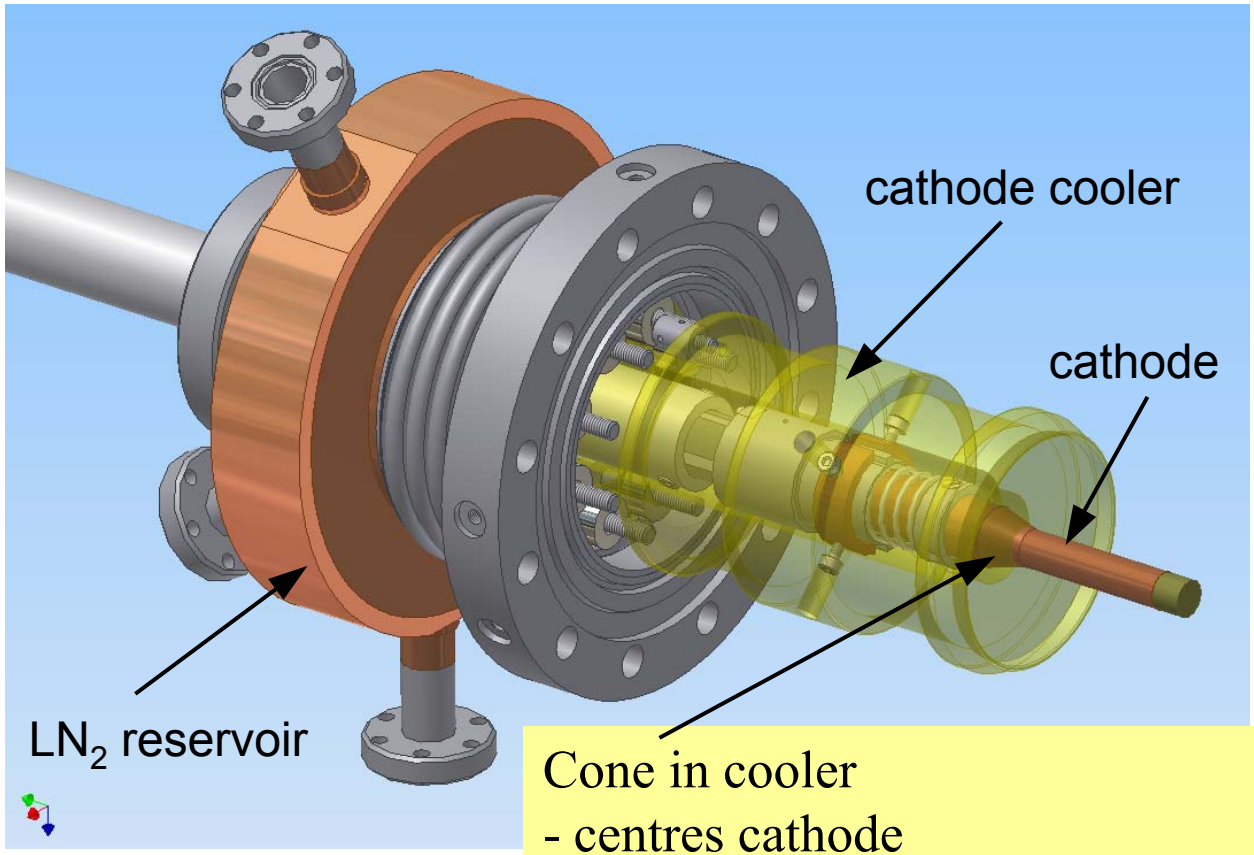
Dual tuning system





	Gun cell	TESLA cells
range	±0.25mm	±0.3mm
resolution	2nm	2nm
load	±2250N	±2700N
frequency	±137kHz	±286kHz

Liquid N_2 Cathode Cooling

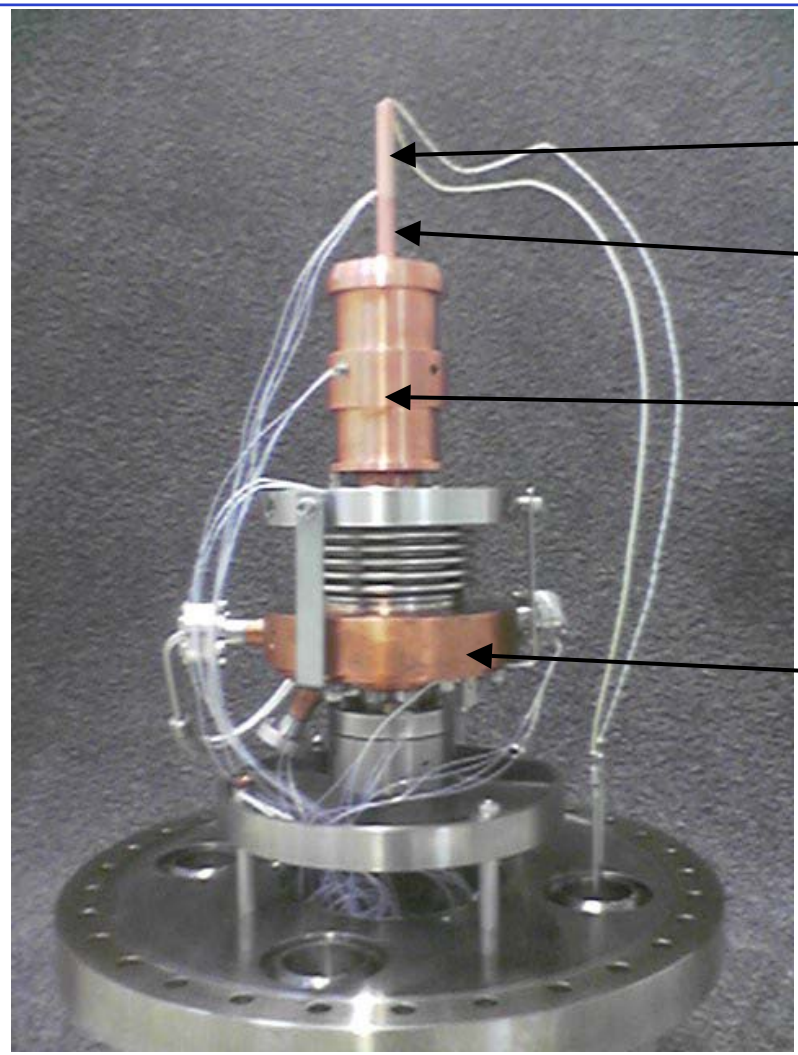


Test bench

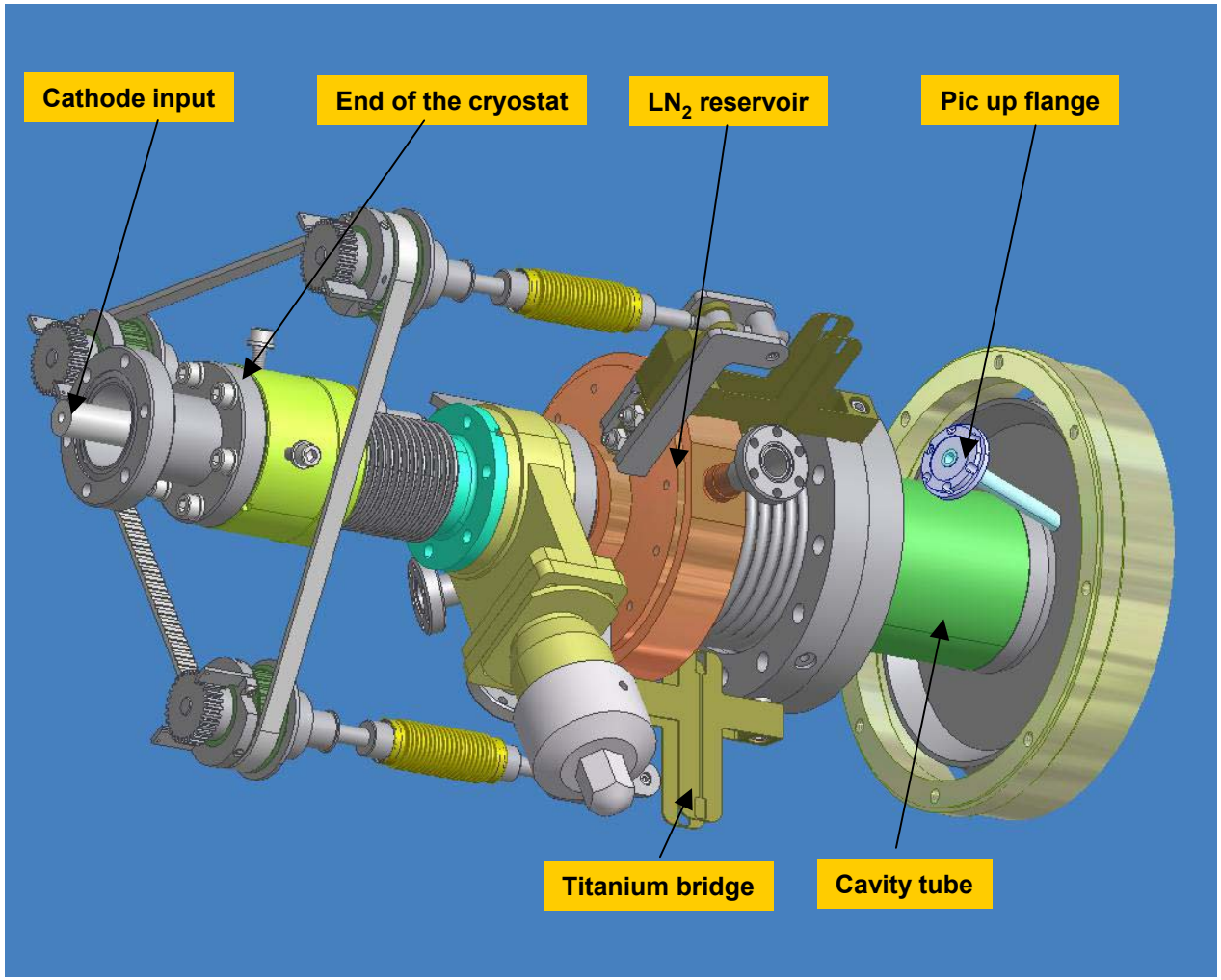
thermal conductance measurements, cathode temperature?
&
test of the cathode transfer system

Cone in cooler
- centres cathode
- cathode is pressed in by spring
- **thermal contact of cone surface ?**

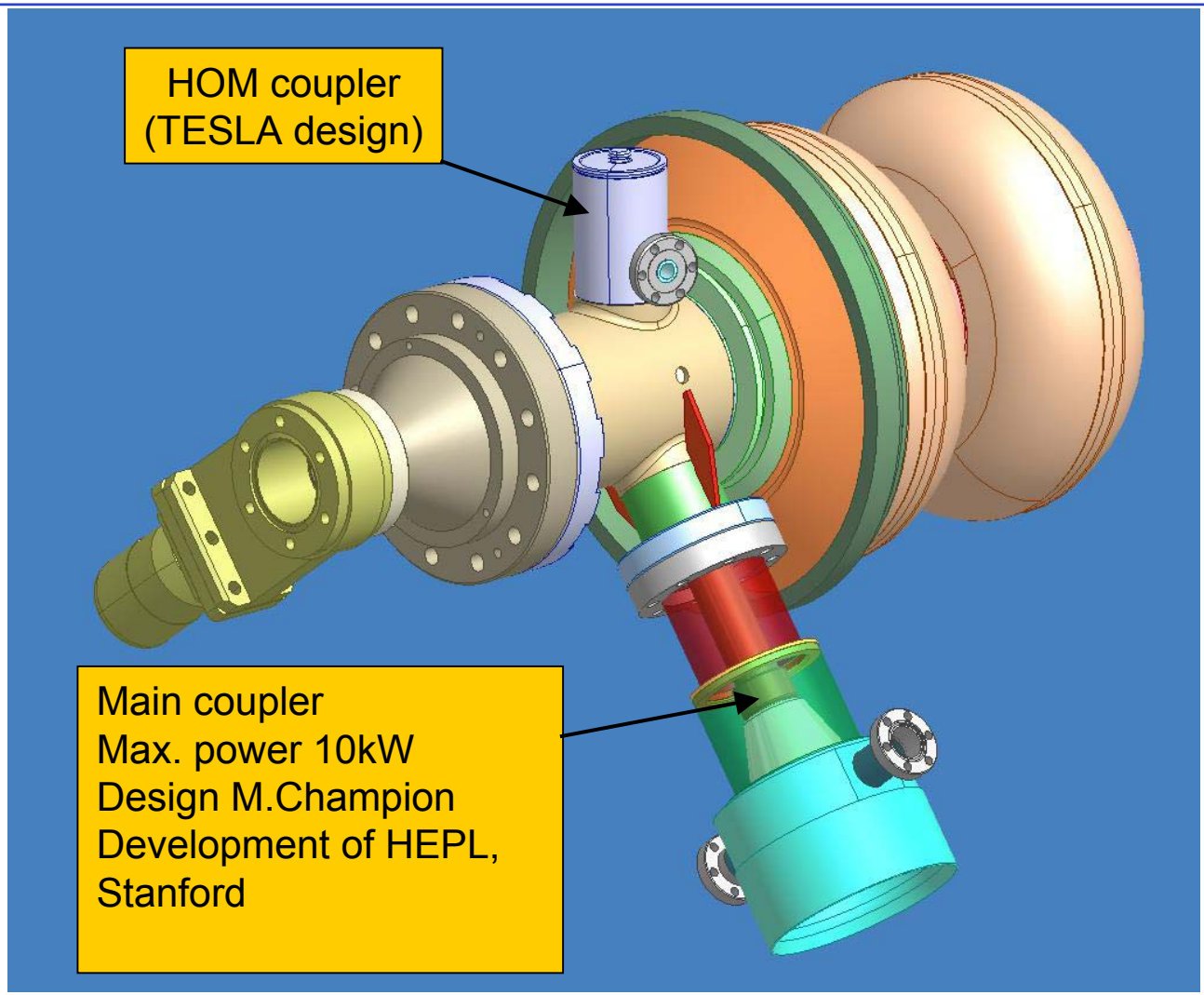
Test bench for the cathode cooler



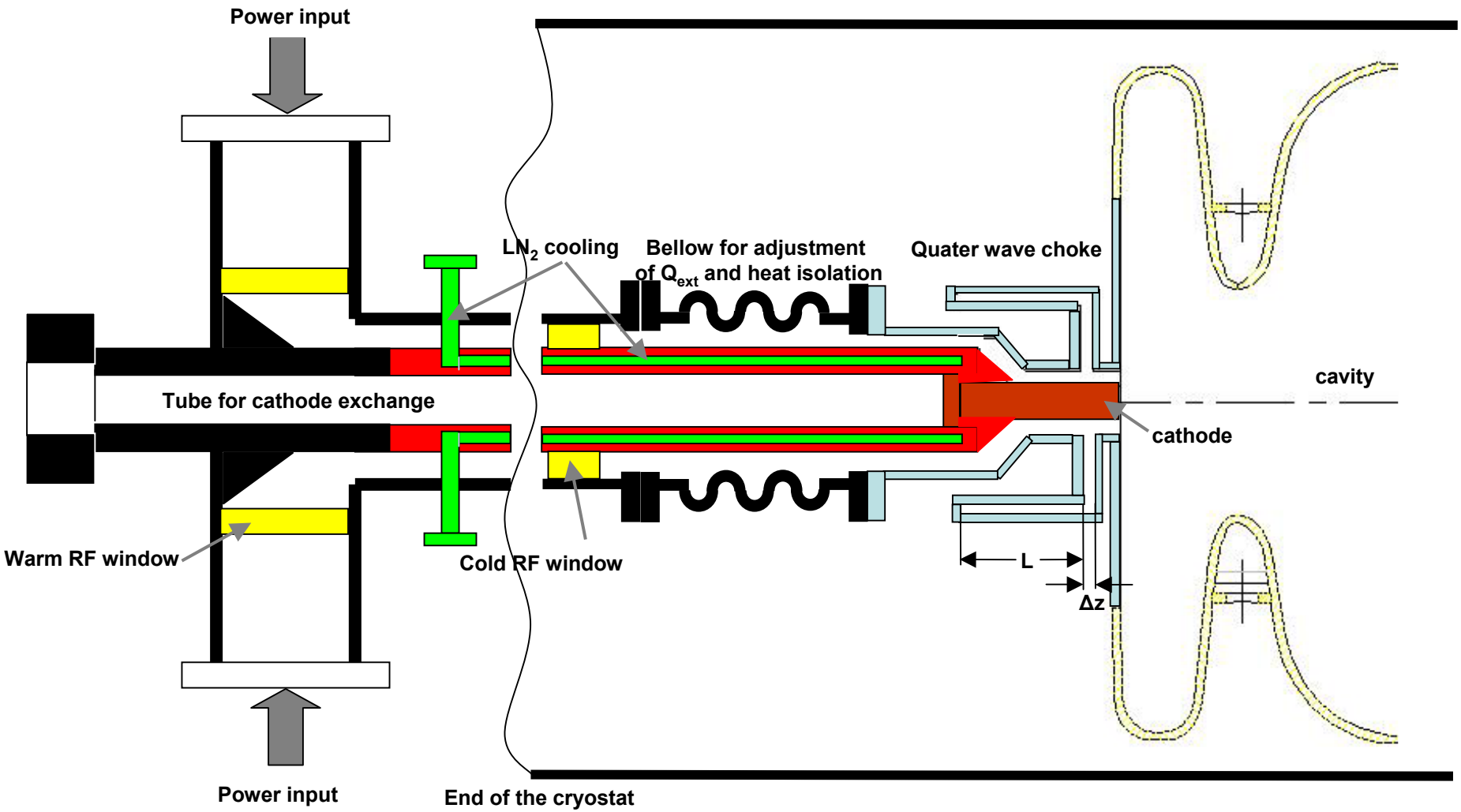
Cavity with cathode tuning system



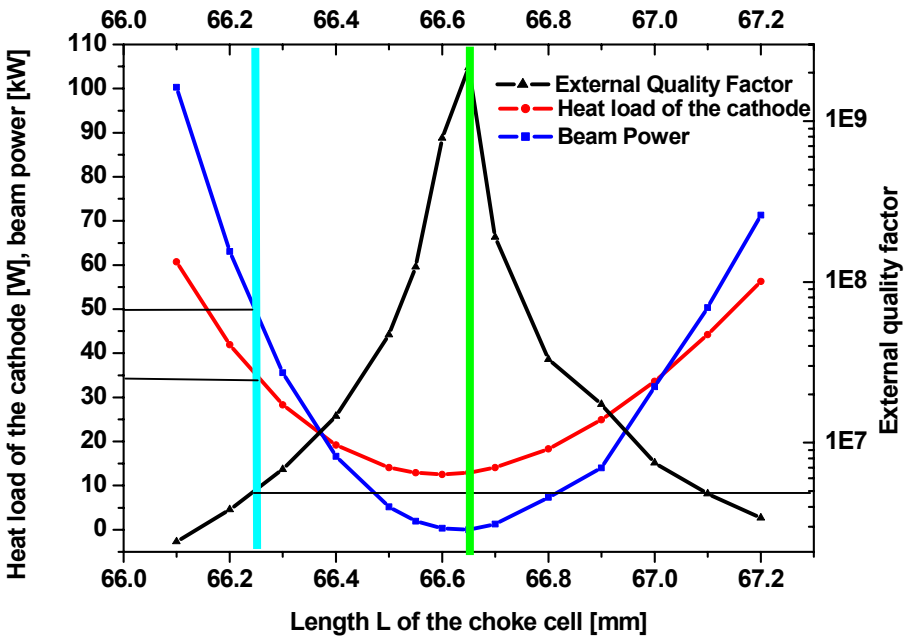
Beam tube with higher order mode – and main coupler

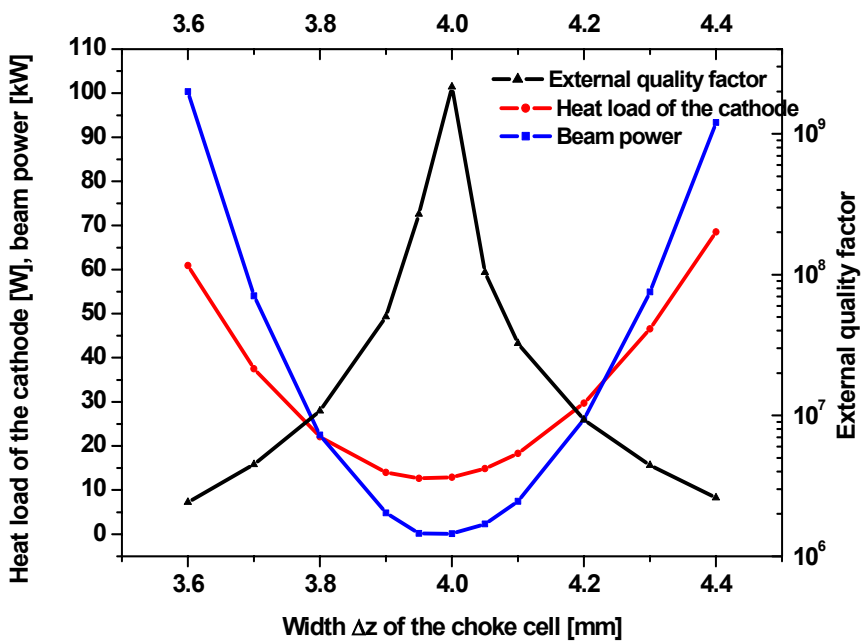


RF power input around the cathode



External quality factor and head load of a cathode-RF coupler



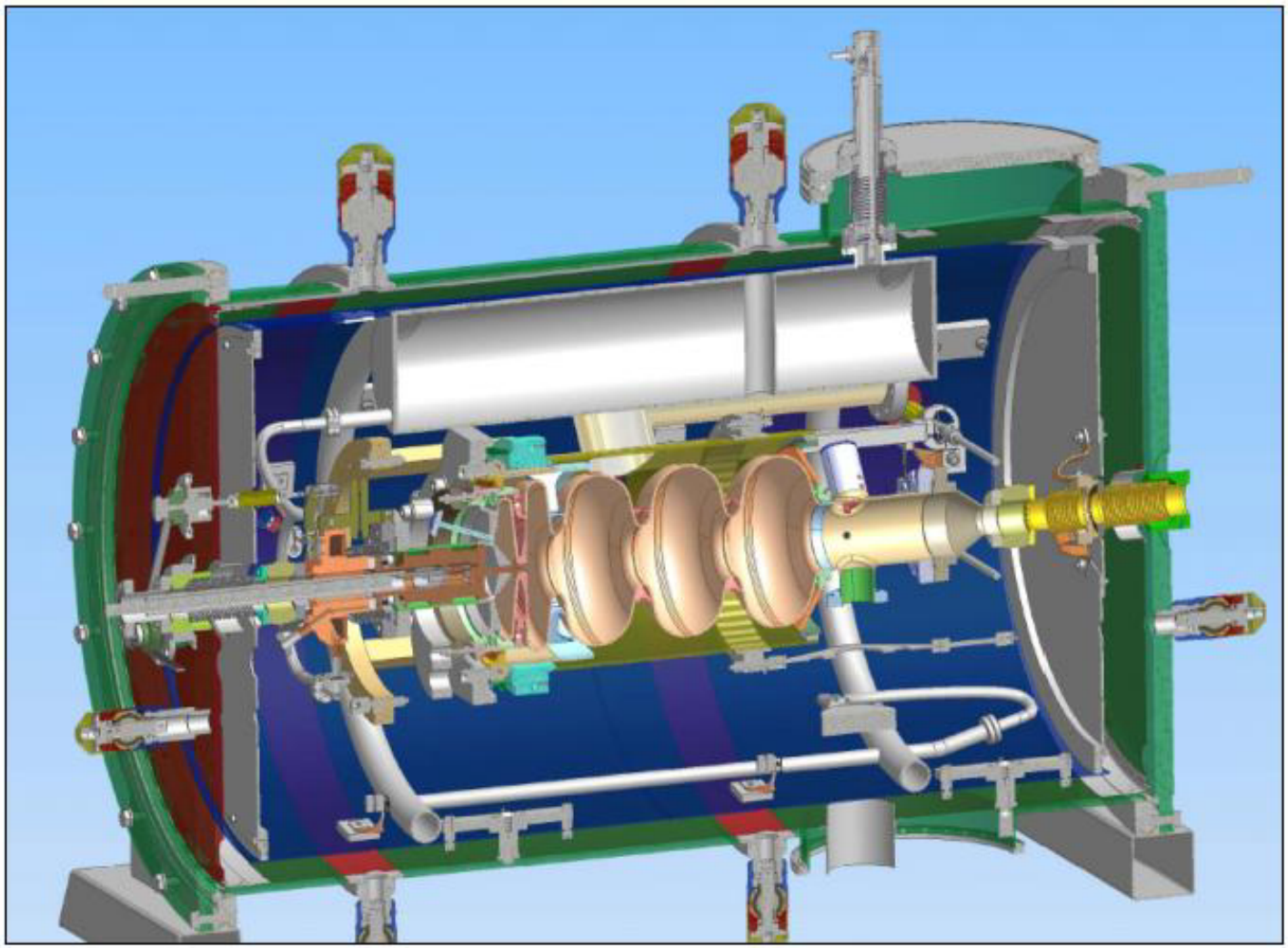


Field parameters for W = 29.755J

$Ez_{max}(r=0)$ = 50MV/m, Ur_{max}= 6.5kV

Es_{max}= 43.6MV/m, Bs_{max}= 0.11T

Cryomodule design of the SRF gun



LN_2 cooling shield of the cryostat

Present Status and next steps

Cavity: **Fabrication finished**
Fabrication of 2 (RRR 40 & 300) cavities at ACCEL finished
next steps: warm tuning in Rossendorf,
BCP, HPR, tests at 2K at DESY

Cavity tuners: **Fabrication finished**
design of a test bench

Cathode cooling system:
Fabrication finished
tests are running

Cathode transfer system:
Design finished, in the workshop

Cathode preparation chamber:
Design and fabrication finished, assembling and tests

Cryomodule: Design finished, in fabrication