Development of the CH-DTL accelerating structure

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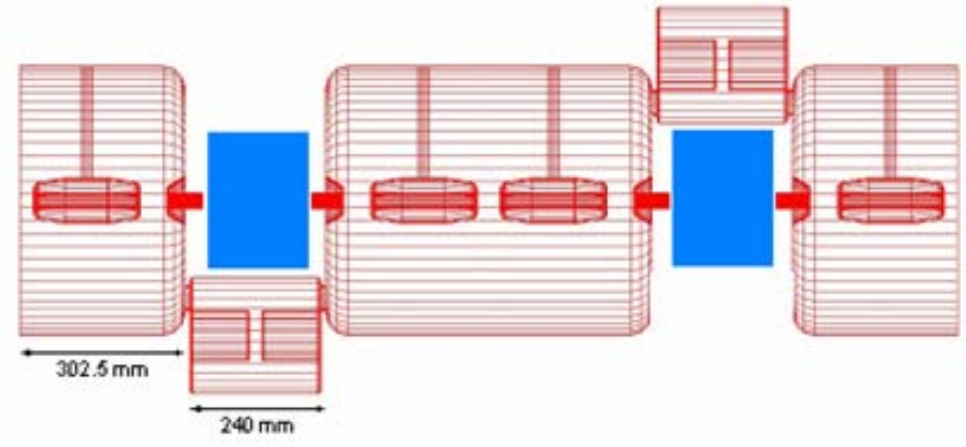
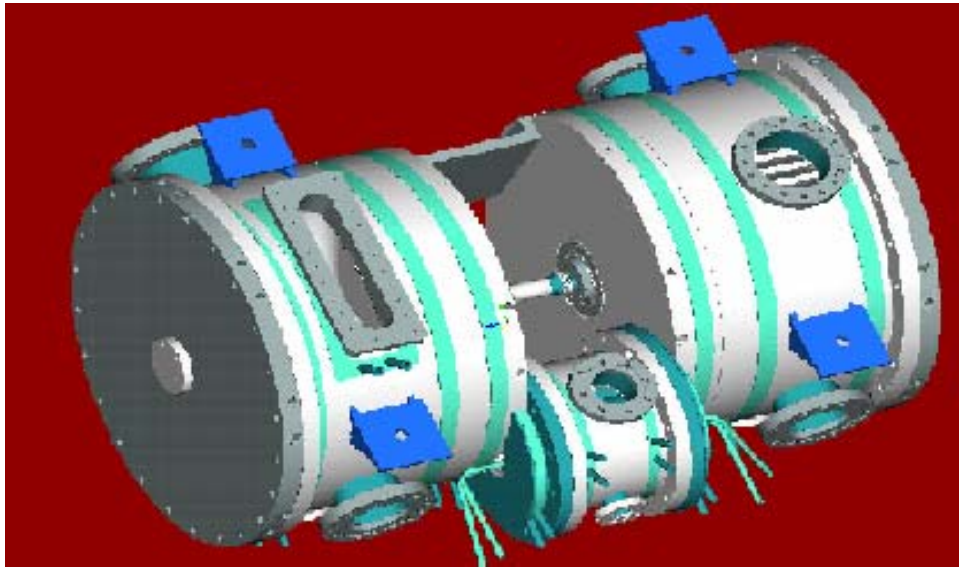
Annual Care Meeting, November 23rd - 25th, 2005

Overview

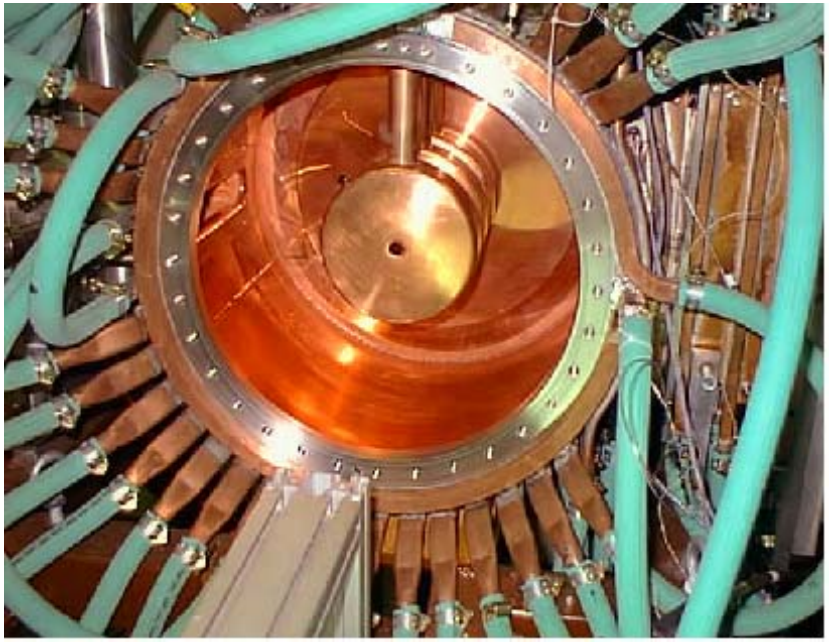
- Proton acceleration up to 100 MeV
- H-Linac and the CH-DTL: general overview and properties
- Konus Beam Dynamics
- The 70 MeV, 70 mA Proton Injector at GSI-FAIR
- The Superconducting CH – development
- Summary
- Team members

Proton Acceleration Structures up to 100 MeV





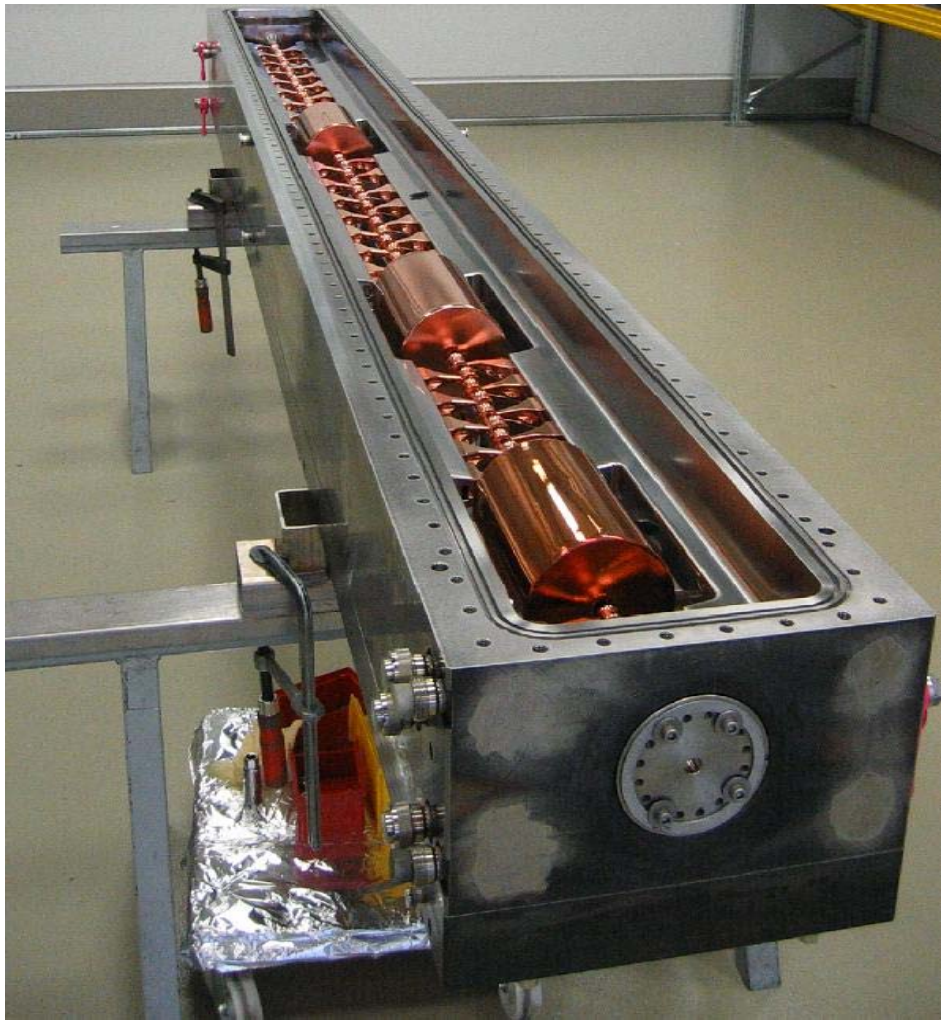
CCDTL (Linac 4-team, CERN)

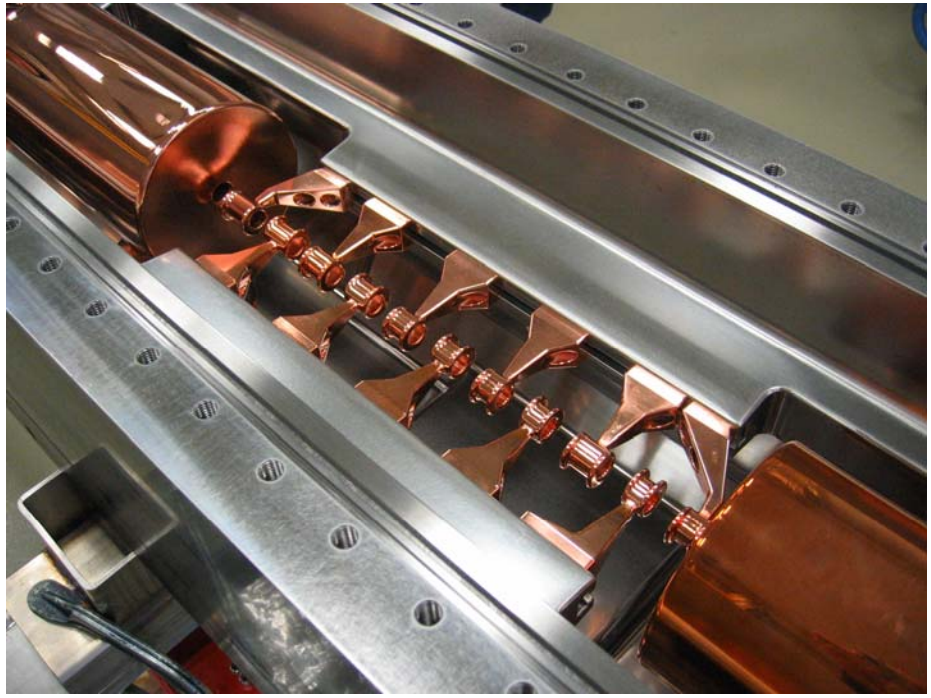


Standard ALVAREZ DTL

(IPHI-Team, France)

The IH Linac [3]



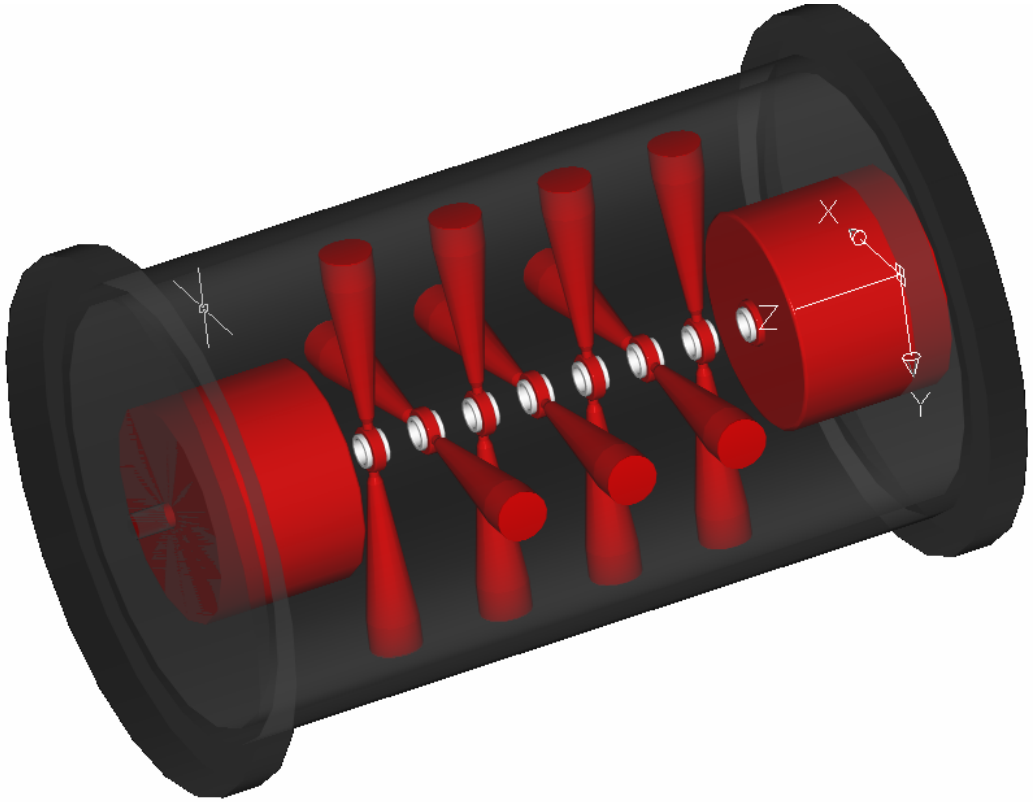


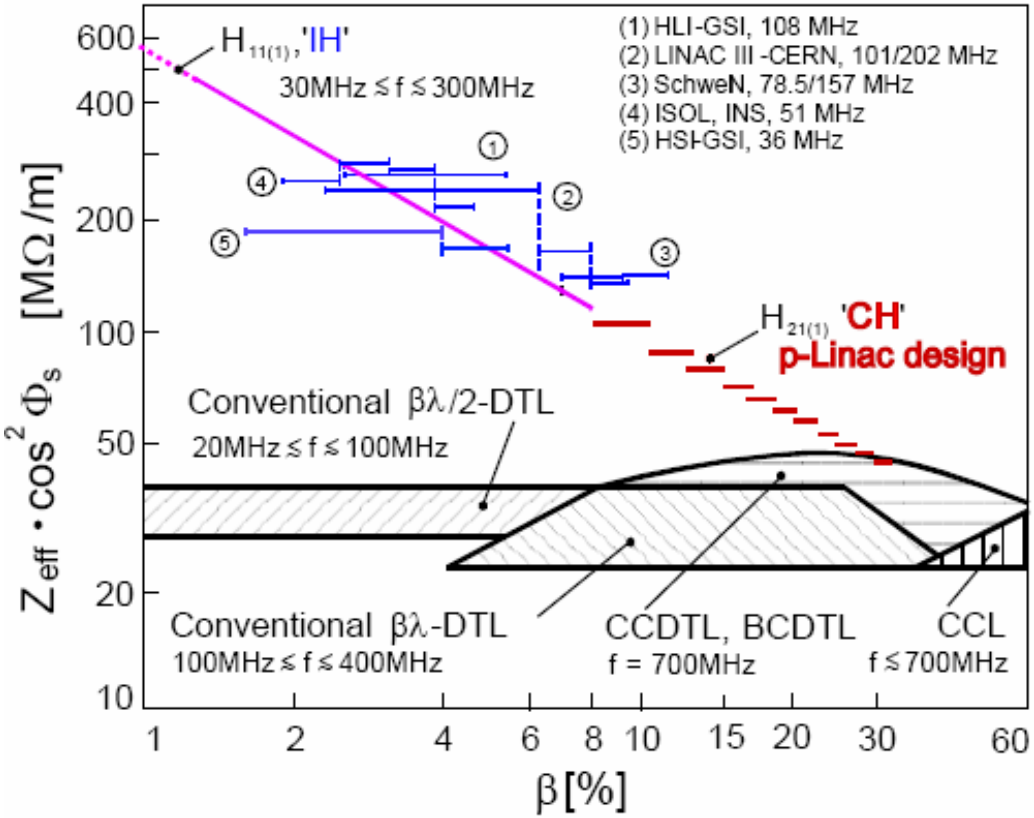
IAP-Frankfurt University

GSI, Darmstadt

View of the 0.4 -7 A MeV C^{4+} IH Injector for HICAT-Heidelberg

The CH-DTL

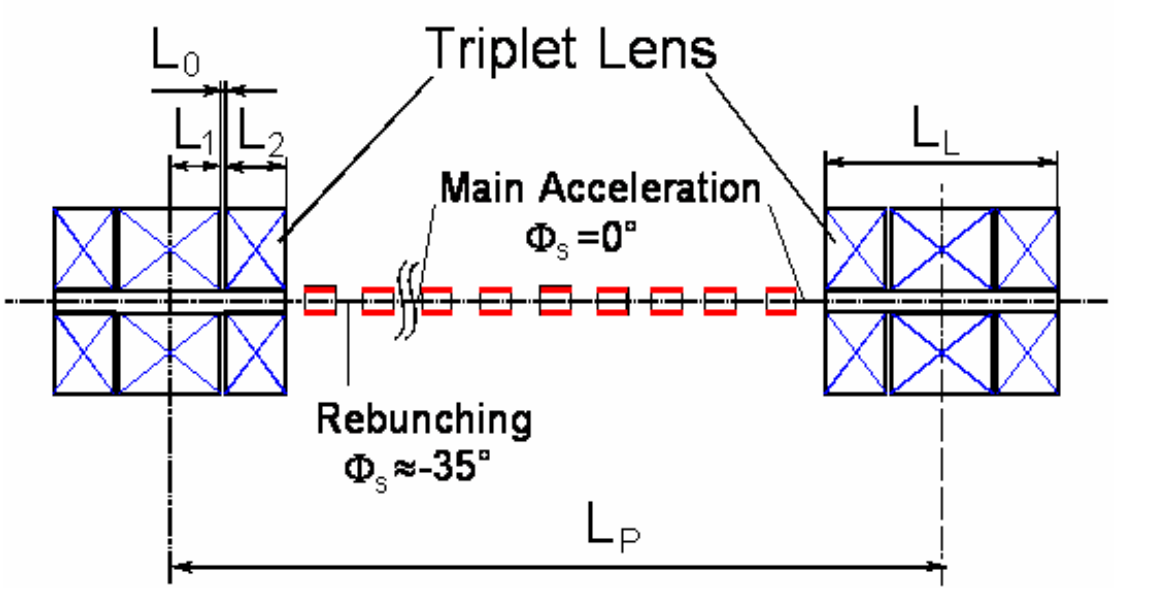




The CH-DTL operates in the $H_{21(0)}$ Mode and, at beam energies between 5 and 150 AMeV, it shows a large potential[3] as well for room temperature as for superconducting designs. At the moment besides IAP, ANL and FNAL[4] are considering CH-Cavities for proton acceleration.

KONUS Beam Dynamics [3]

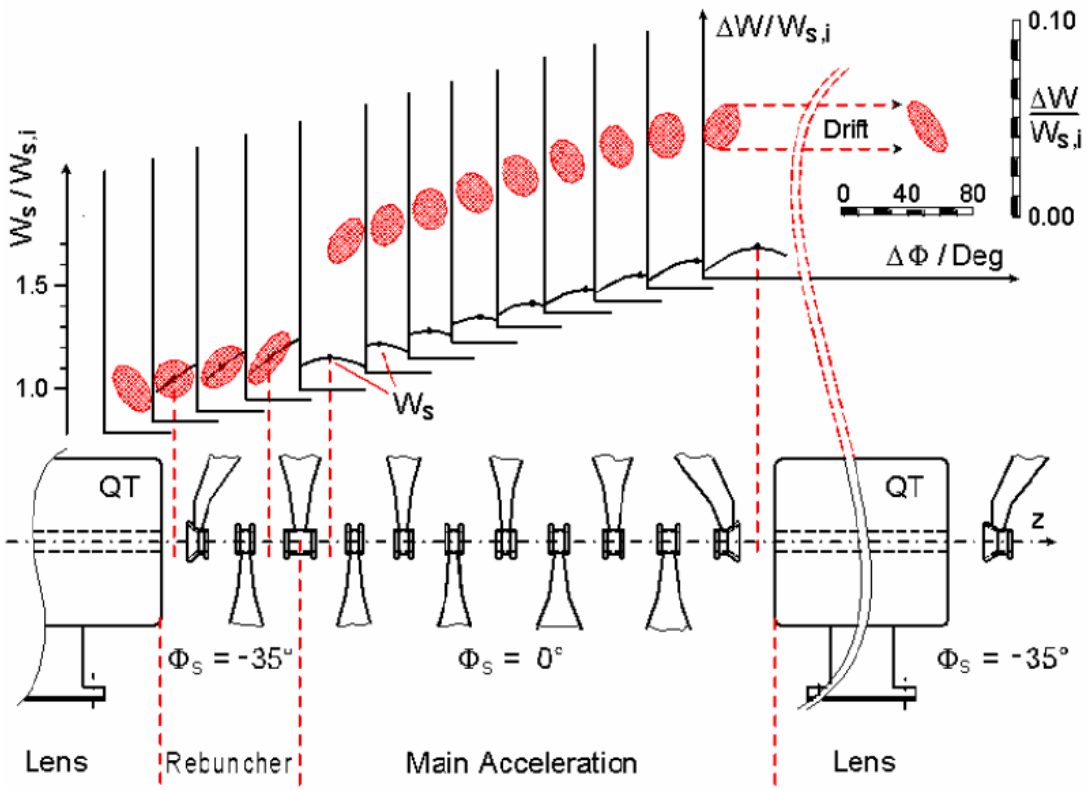
- **The Shunt Impedance of the H-type linacs can be quite high:**



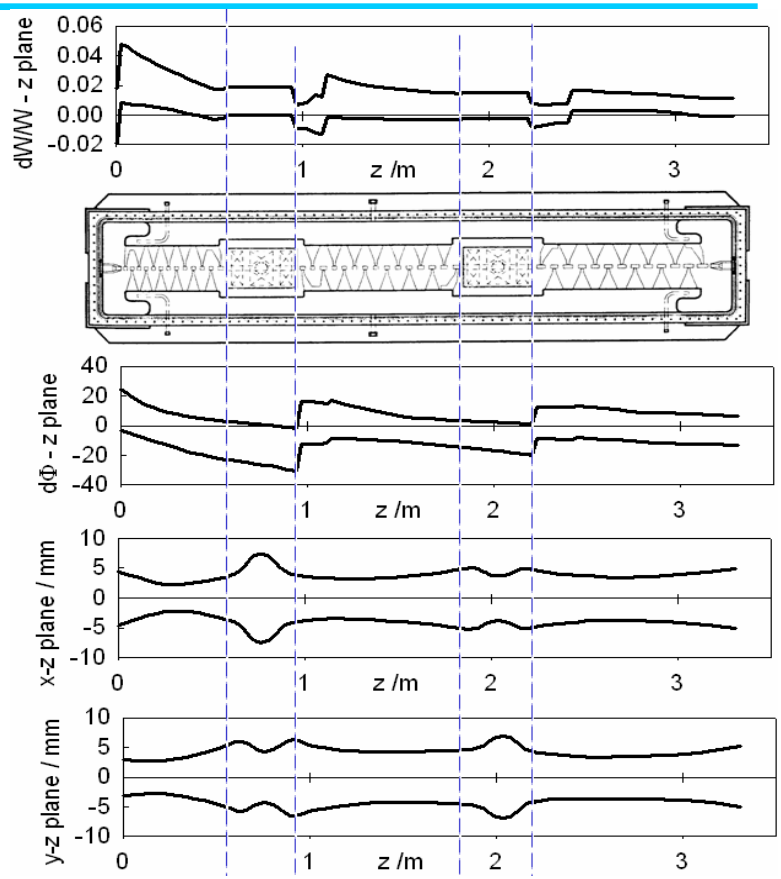
Main Characteristics:

- **slim drift tubes, effective field grad. up to 7 MV/m, KONUS Beam Dynamics:**

KONUS Beam Dynamics



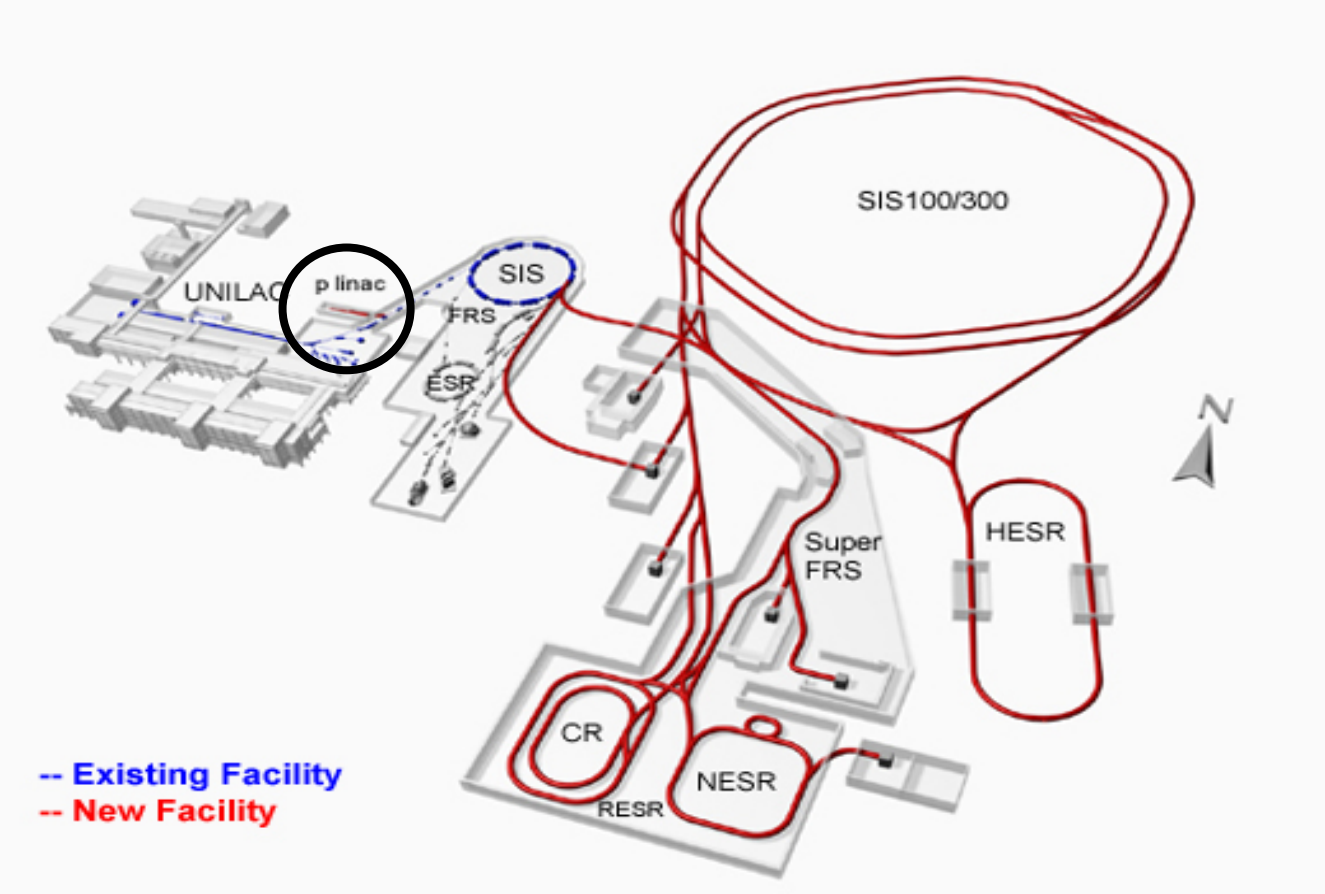
Konus principle



108 MHz GSI Cavity

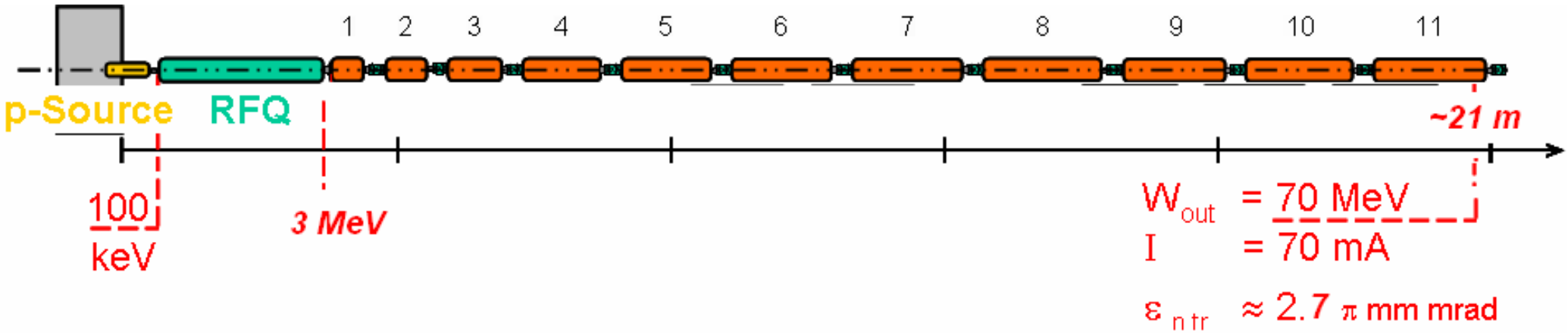
The KONUS has been successfully applied in many projects as the Pb Injector at CERN, the HSI and HLI at GSI and the TRIUMF ISAC Facility, and it is implemented in several actual projects.

Layout of the GSI-FAIR Project [1]



For the p-bar project at the High Energy Storage Ring (HESR) a particle number in the SIS18 of ~ 6 x10^{12} p/cycle is requested. This will be provided by a 10 turn injection of a 70 MeV, 70 mA beam from the new proton injector linac.

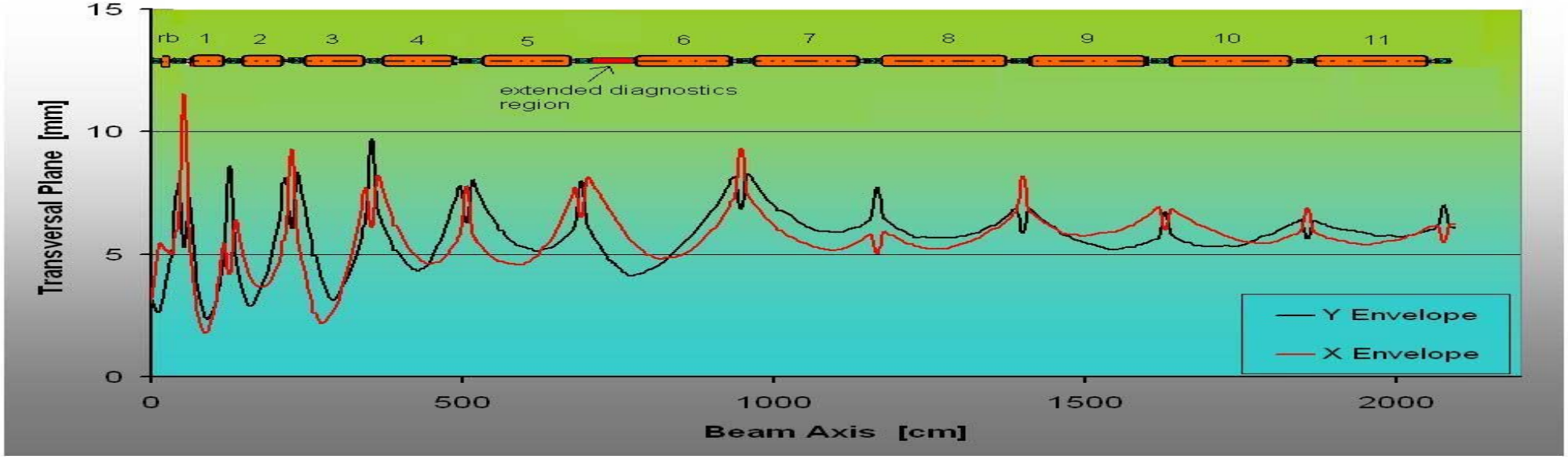
70 MeV -70 mA FAIR Proton Injector [2]

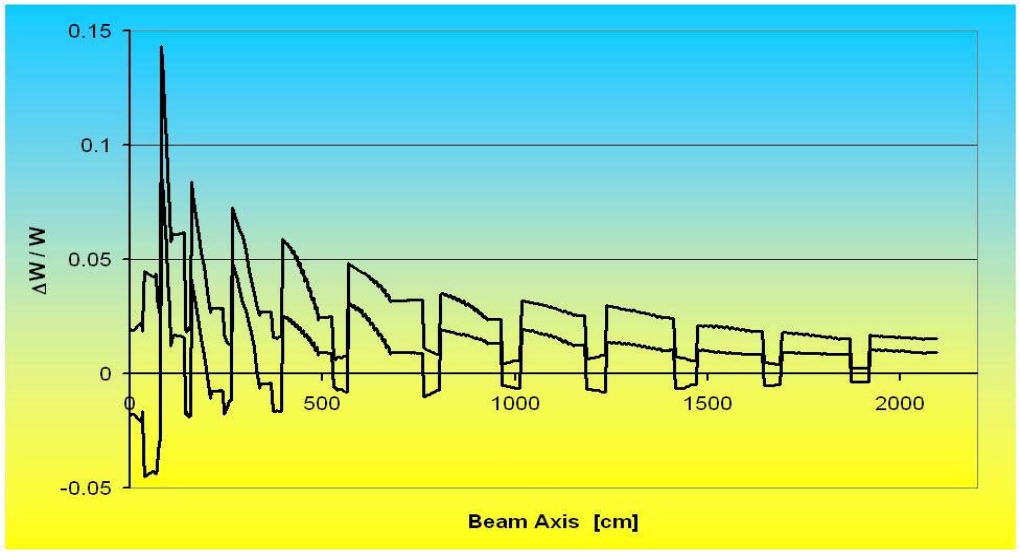


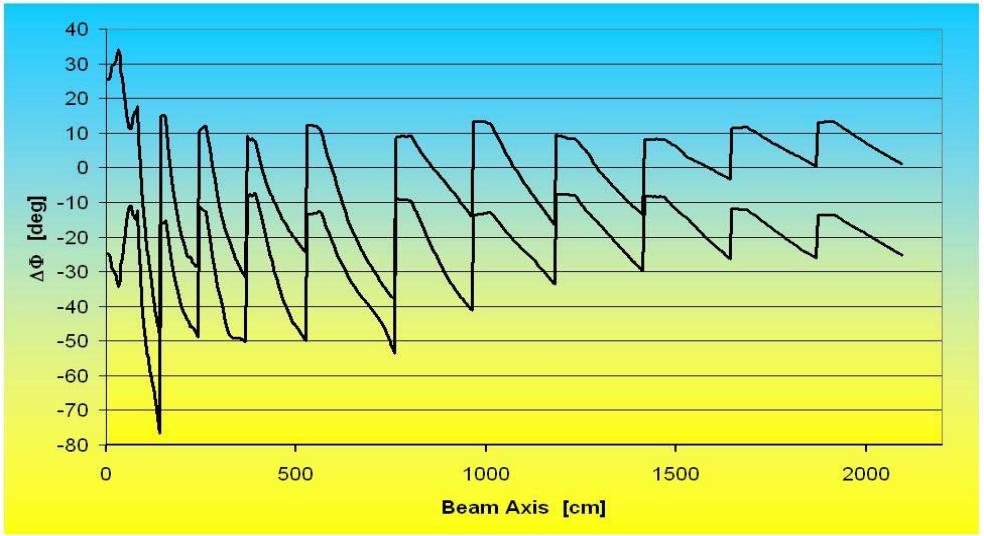
- An absolute emittance of 7 mm mrad is required to fill SIS 18 up to the space charge limit with about 10 turns.

ENERGY Range (MeV)	3 - 70
Pulsed Current (mA)	70
Bunch Frequency (MHz)	352.21
Klystron Power (MW)	1.3
Beam Pulse Length (µs)	0.1
Repetition Rate (Hz)	4
Total norm.Transv. Emittance (µm)	2.8
Transv. SIS Acceptance	150 mm mrad
Longitudinal Emmitance	17 KeV ns

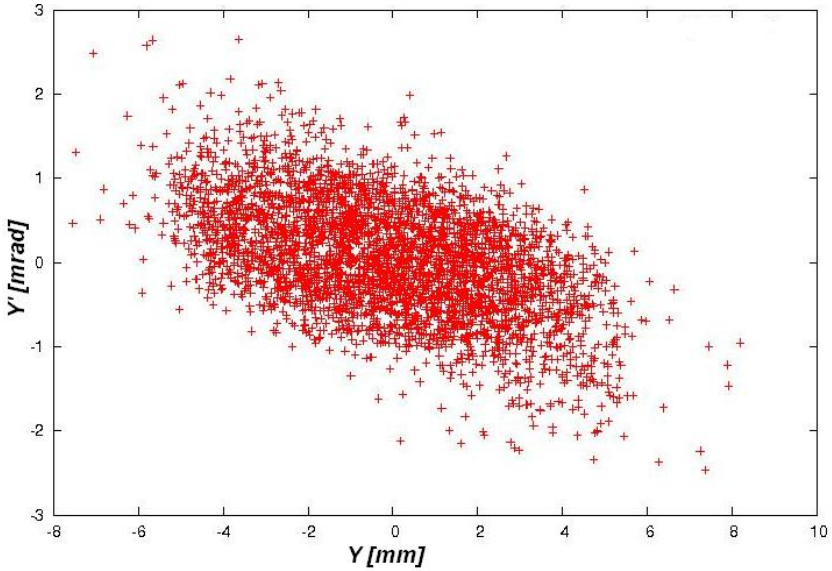
70 MeV -70 mA FAIR Proton Injector

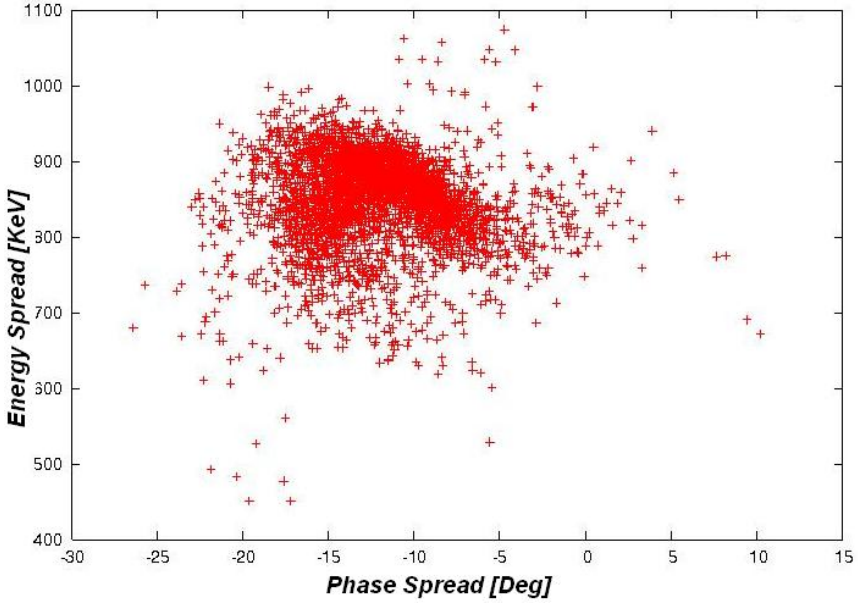


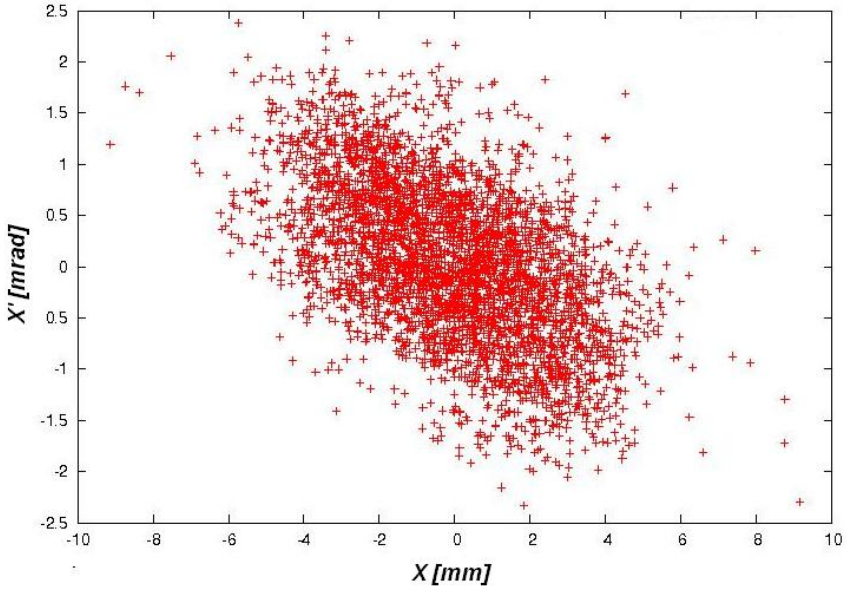




70 MeV -70 mA FAIR Proton Injector





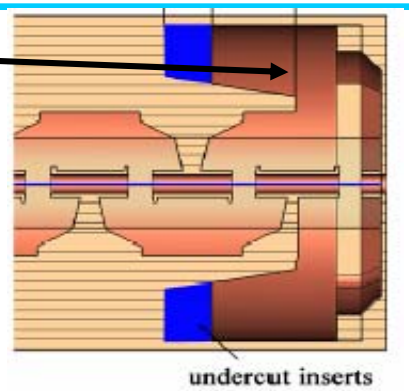


Beam Parameter	Input	Output
X-X' 95% RMS ε_{nm} (mm mrad)	0.35	0.55
X-X' 95% ε_{nm} (mm mrad)	1.68	3.44
Y-Y' 95% RMS ε_{nm} (mm mrad)	0.36	0.53
X-X' 95% ε_{nm} (mm mrad)	1.74	3.00
ΔW- $\Delta\Phi$ 95% RMS ε (KeV ns)	1.19	1.89
ΔW- $\Delta\Phi$ 95% ε (KeV ns)	9.00	13.62
Transmission Rate	100 %	

Resonant End Cells [6]

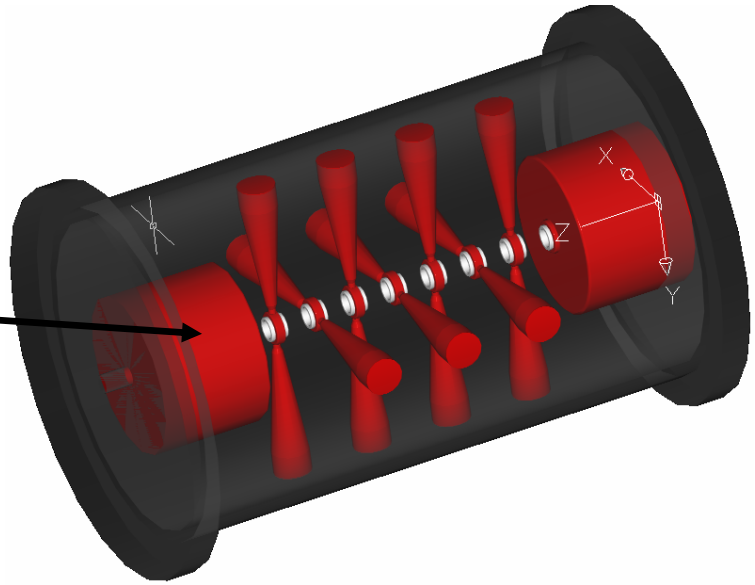
Standard IH design with undercuts

(realisation of the “0” Mode)



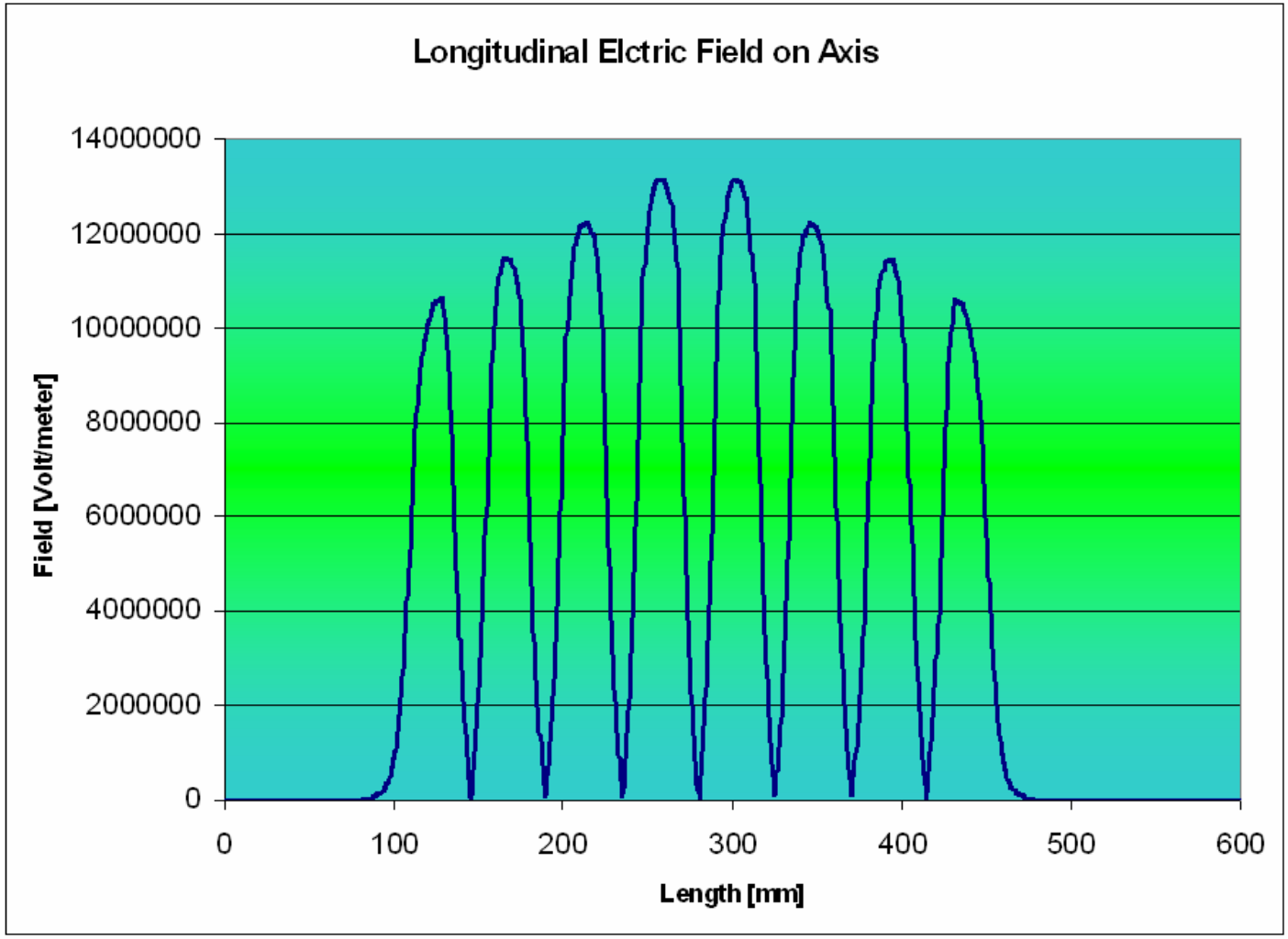
CH design: end half drift tubes with enlarged diameter result in resonant end-cells at an optimized length

End half drift tube



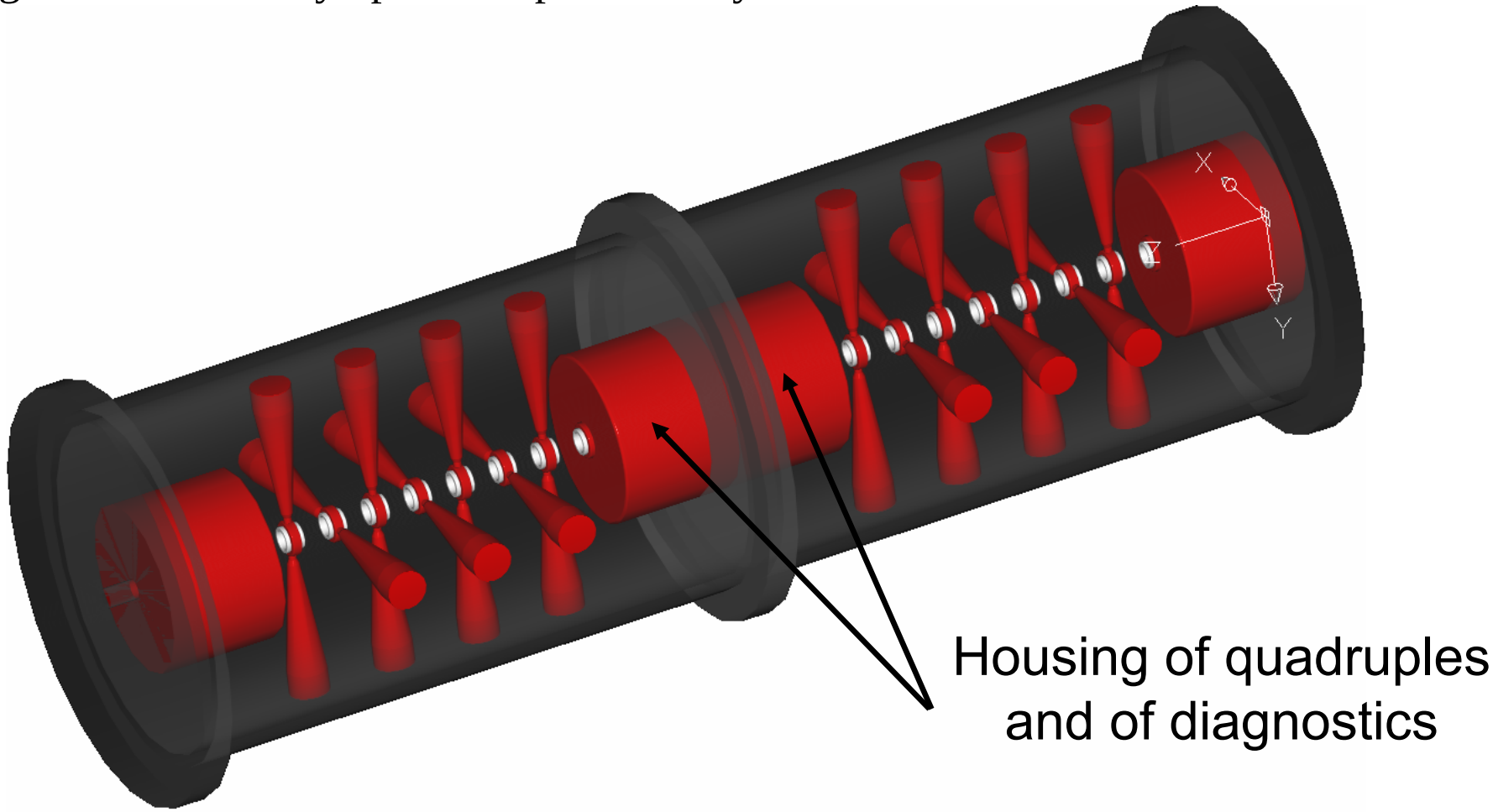
Longitudinal Field Distribution

Example of a typical field distribution inside a short tuned CH - cavity.

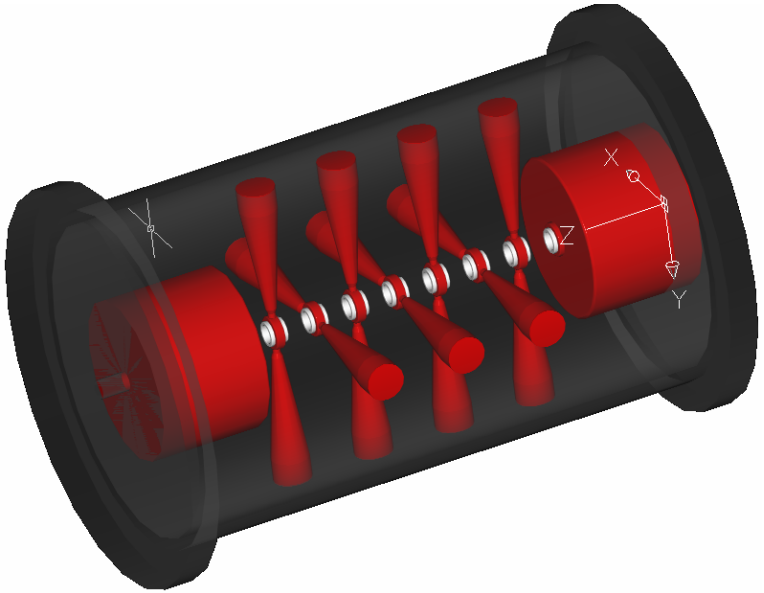


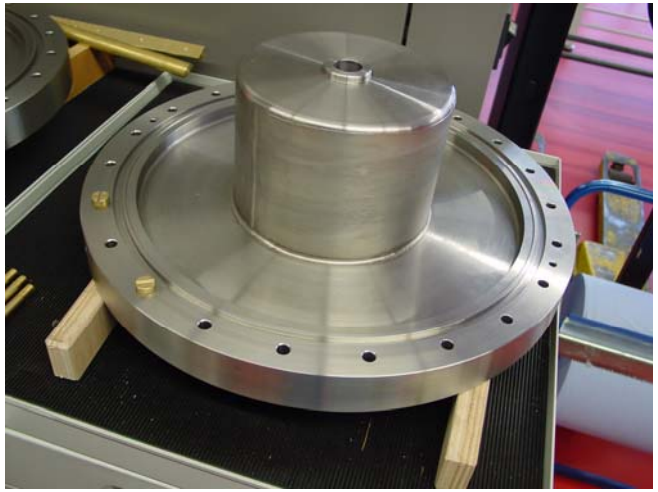
CH-Linac Array

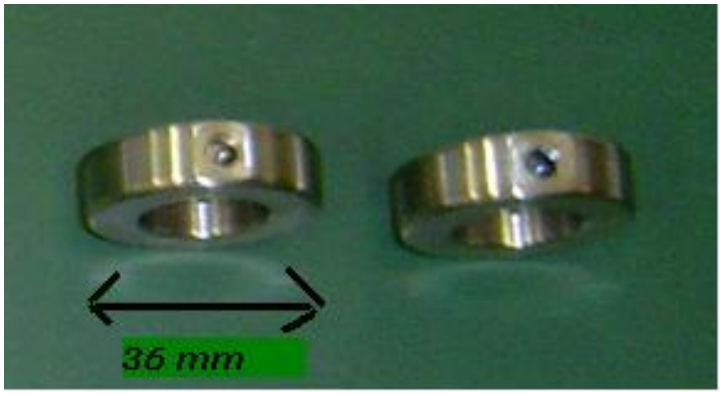
The result will be a very compact structure with an RF power requirement below 1 MW for each individual cavity. The linac will be mounted on rails and the intertank flanges could be easily opened to perform any kind of maintenance.

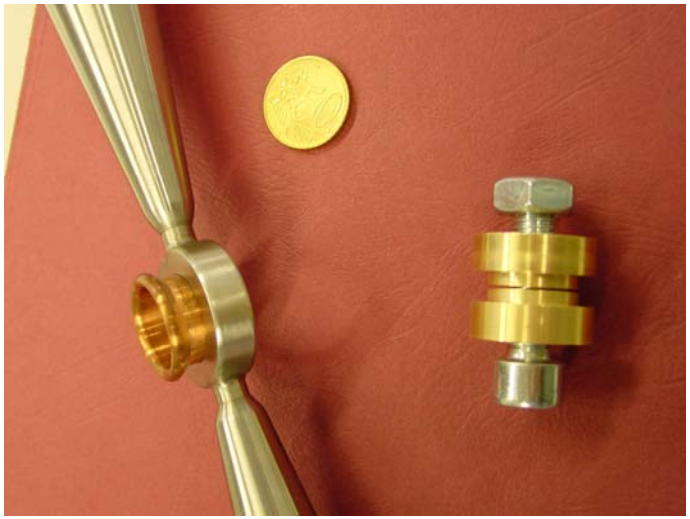


Prototype CH-Cavity Development









Construction of an 8-gap prototype cavity ($\beta\lambda/2$ =45 mm)

Superconducting CH - Cavity Development

SC Prototype before the final welding [5]

19 cells

bulk niobium

β=0.1, ∅=276mm

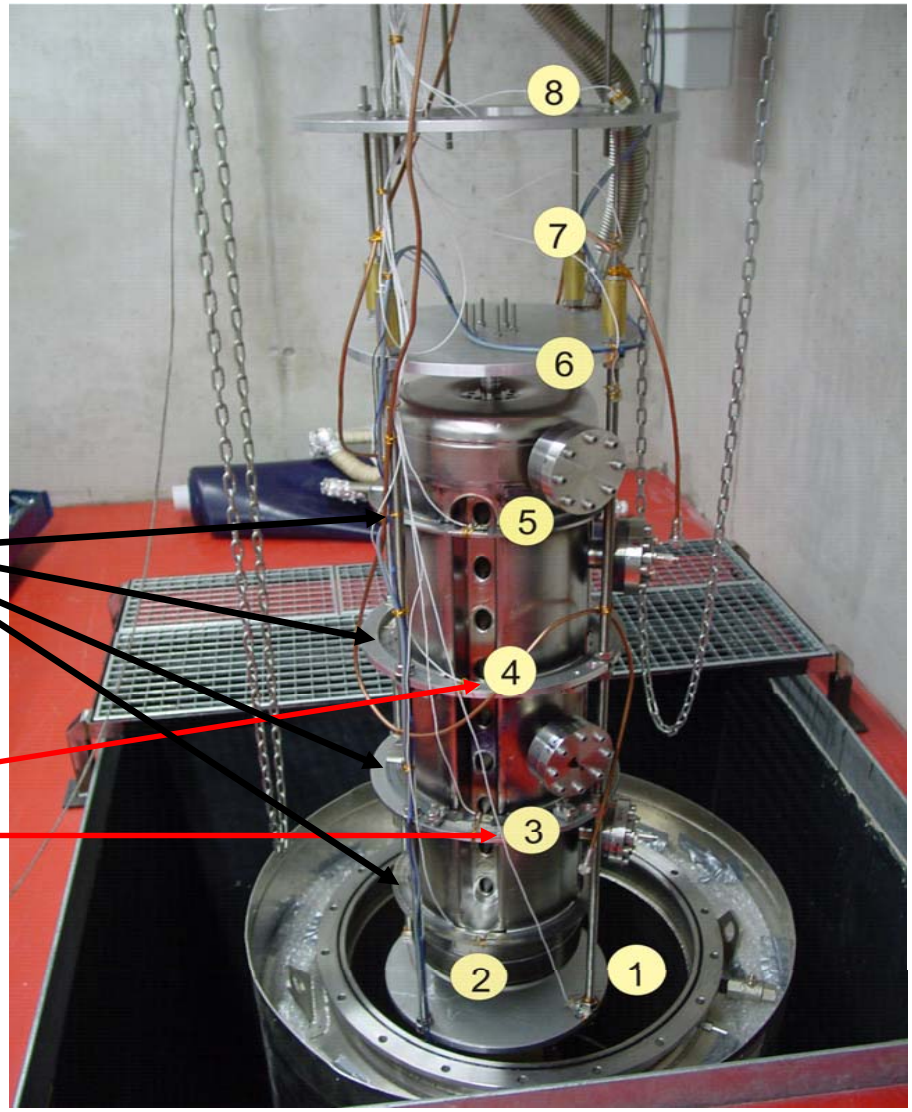
f=357 MHz

Fabrication: ACCEL Company, Bergish Gladbach, Germany

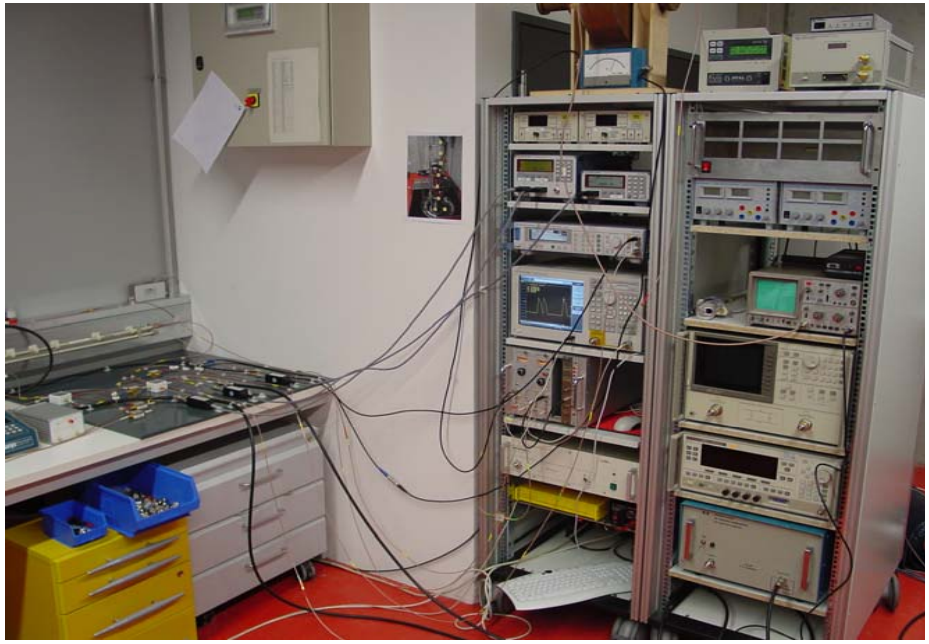
CH-cavity ready for the test in Frankfurt

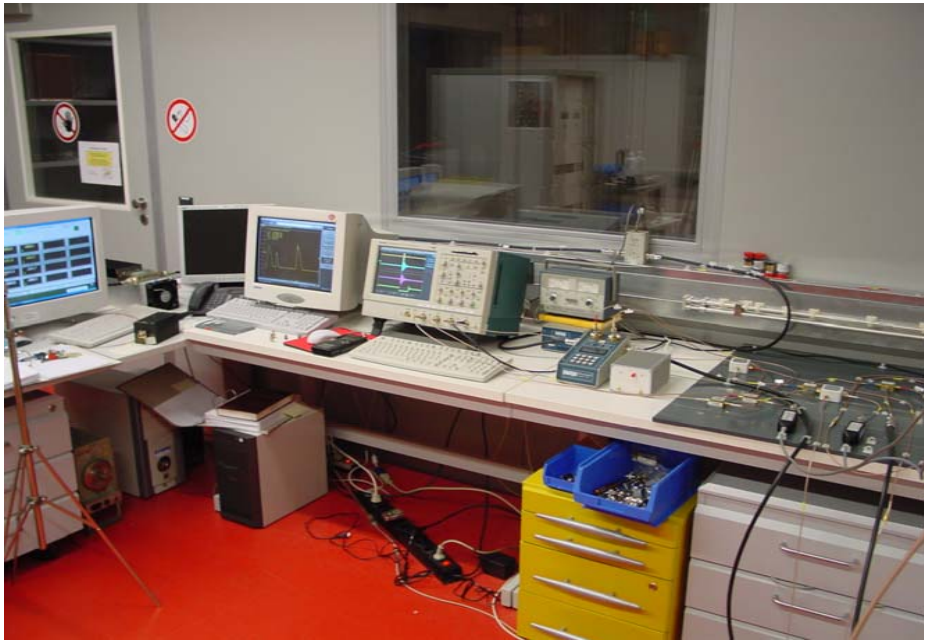
Stabilizing Rings

T-sensors

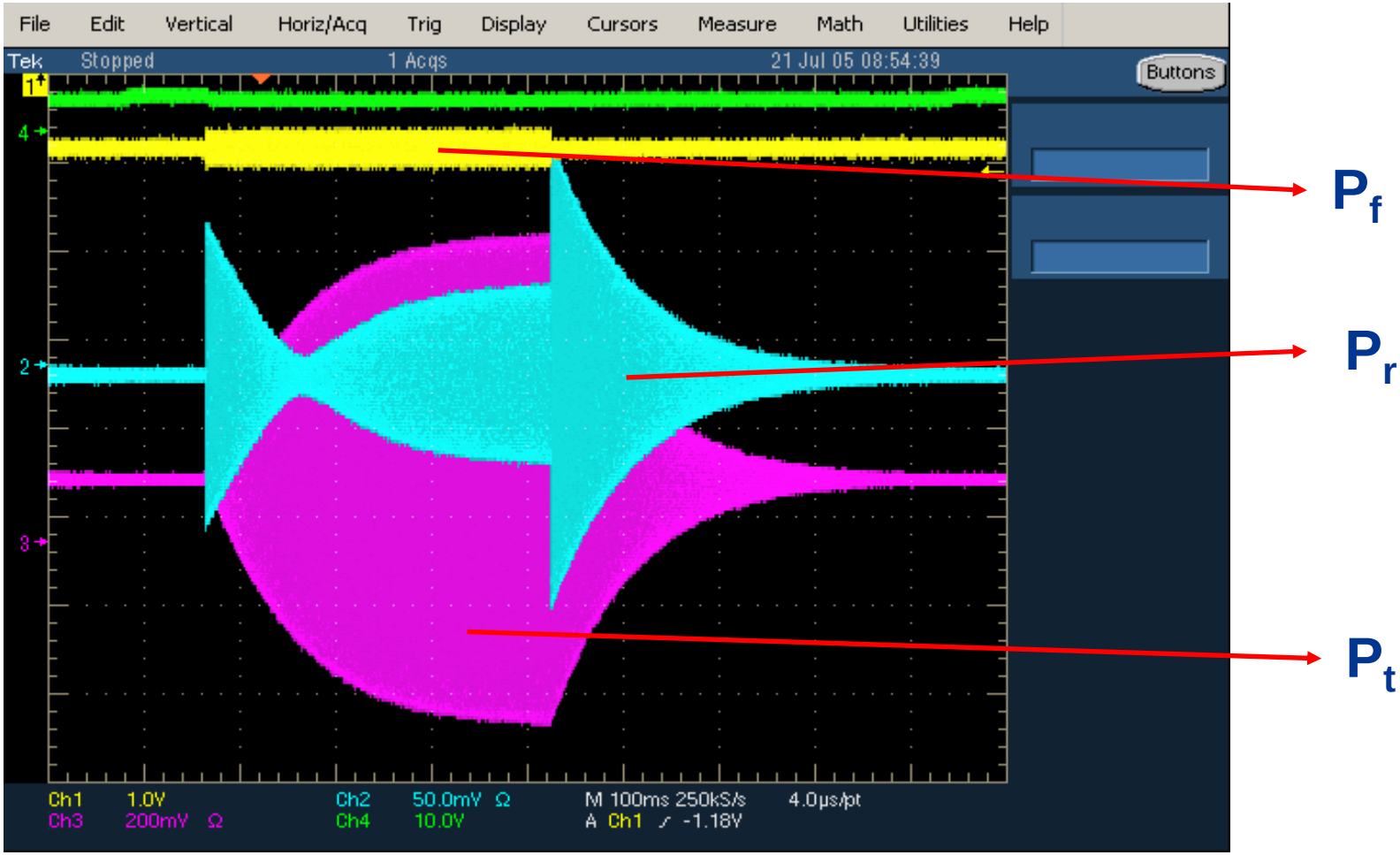


Cryogenic RF-Laboratory in Frankfurt

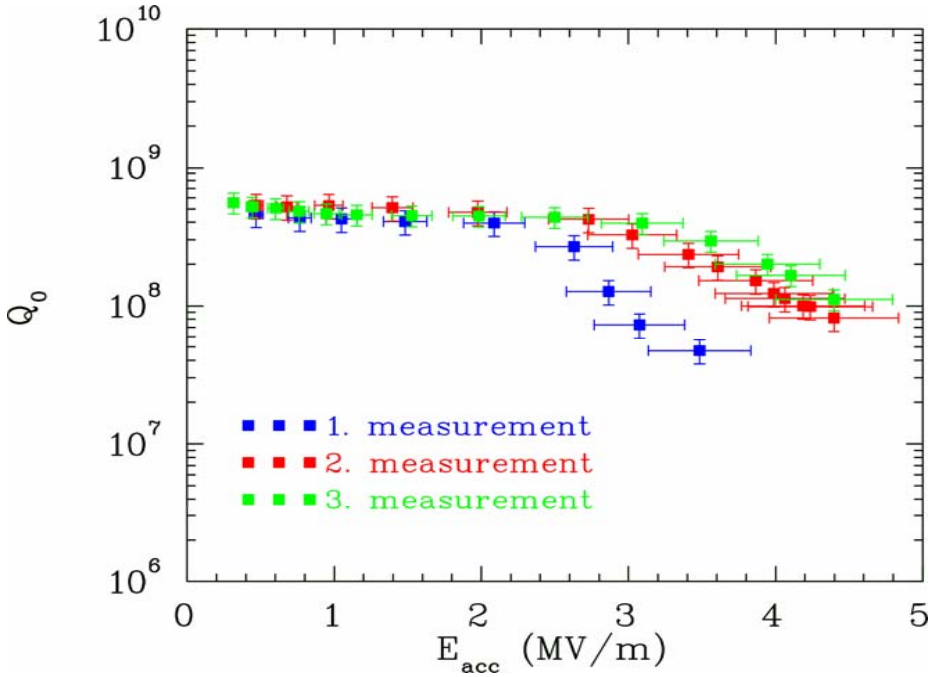


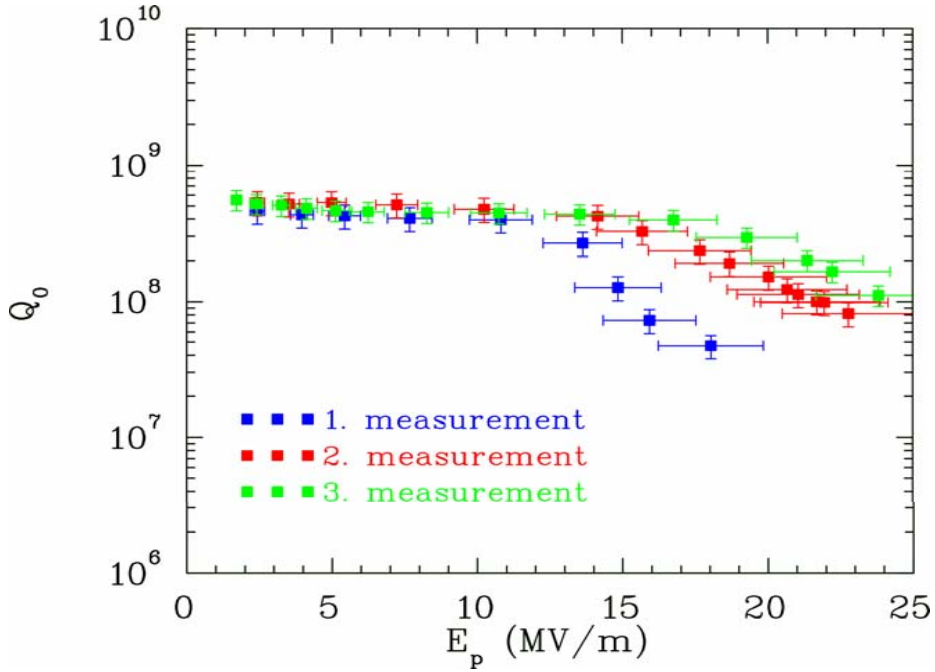


RF Signals of the SC CH-cavity



Q_0 versus Gradient/Voltage





$L=n/2\beta\lambda=9.5\beta\lambda$

$\rightarrow E_p$ = 23.8 MV/m
$\rightarrow B_p$ = 26 mT

Summary and Outlook

- The CH-type structure looks promising for beam energies up to about 100 AMeV.
- Room temperature as well as superconducting versions are under development.
- The stem configuration allows for a very efficient water cooling of r.t. CH – structures.
- The KONUS beam dynamics allows to realize simple cavities without internal focusing lenses.
- Intertank lenses can be well integrated at a minimum request of extra drift space.
- A CH-DTL is developed for high current proton injection into the FAIR facility at GSI, Darmstadt.

People and Institutes

- J.W.Goethe University, Frankfurt am Main- IAP

  G.Clemente, H.Liebermann, H.Podlech, U.Ratzinger R.Tiede, A.Sauer

  S.Minaev (ITEP, IAP Guest)

- GSI, Darmstadt- LINAC TEAM

  W.Barth, L.Groening, K. Dermati.

Bibliography

[1] "The Future GSI Facility: beams of ions and antiprotons". H. Henning, Proceed. of the PAC '03, Portland, Oregon.

[2] "The 70 MeV p-Injector for FAIR". U.Ratzinger et al, AIP Conference Proceedings, 2005, Volume 773, pp. 249-253 .

[3] "Habilitationsschrift". U.Ratzinger, Frankfurt University

[4] "Front End Design of a Multi-GeV H-Minus Linac". P.N. Ostrumov et al., Proceed. of the PAC '05, Knoxville, Tennessee, May 14-23 2005.

[5] "Development of superconducting CH-Structures for low and medium beta beams and the status of the 352 MHz prototype cavity", H.Podlech et al, AIP Conference Proceedings, 2005, Volume 773, pp. 107-109.

[6] "Development of a normal conducting CH-DTL" G.Clemente et al., Proceed. Of the PAC '05 Conference, Knoxville, Tennessee, May 14-23 2005.