Development of the Superconducting CH-Cavity and Applications to Proton and Ion Acceleration

SRF Workshop

15. October 2007

Beijing, China

Holger J. Podlech

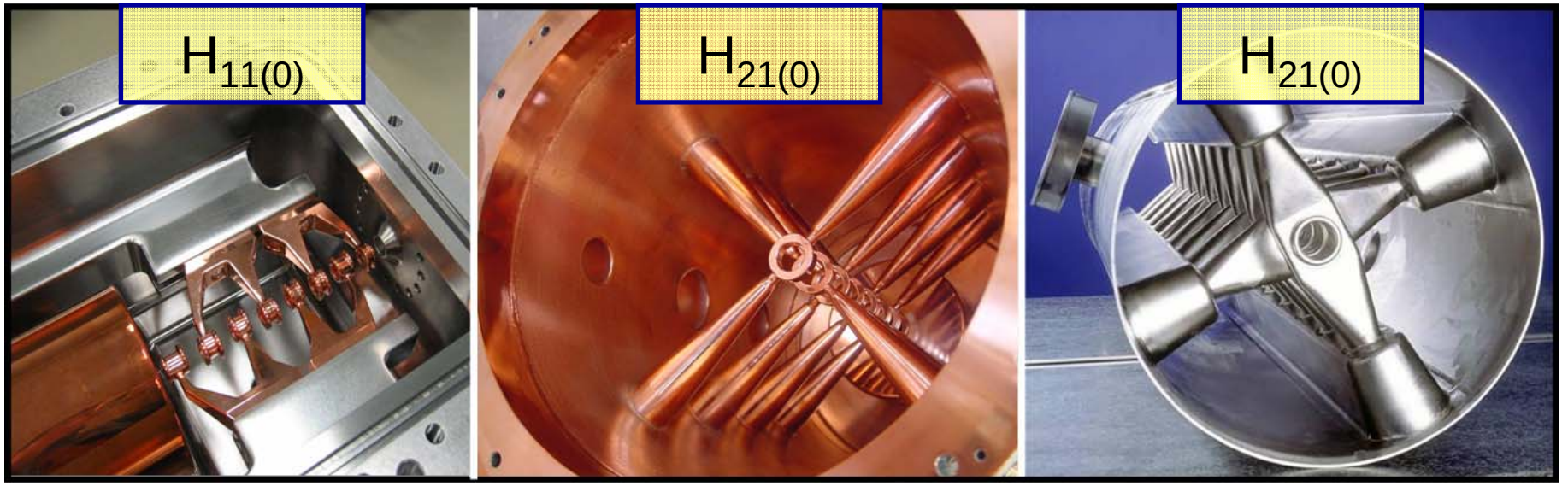
Institut für Angewandte Physik

J.W. Goethe-Universität, Frankfurt am Main, Germany

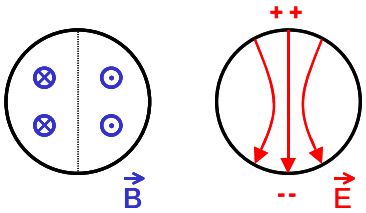
Overview

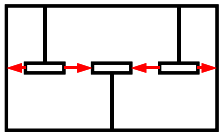
- Introduction
- Design issues
- Test results
- Projects
- Summary and outlook

The Family of H-mode DTL Cavities



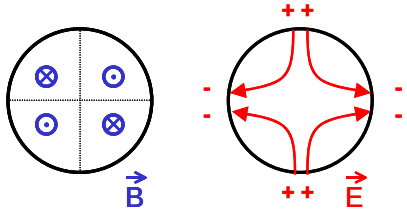
r.t. IH-DTL

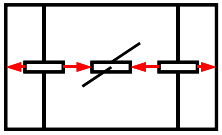




Interdigital H-Mode (IH)

r.t. CH-DTL





Crossbar H-Mode (CH)

s.c. CH-DTL

Motivation for the Development of the Superconducting CH-Structure

Several fixed velocity accelerators with cw operation are under discussion
(i.e. Spallation neutron sources, IFMIF, Transmuter, isotope production...)

→ Superconducting operation

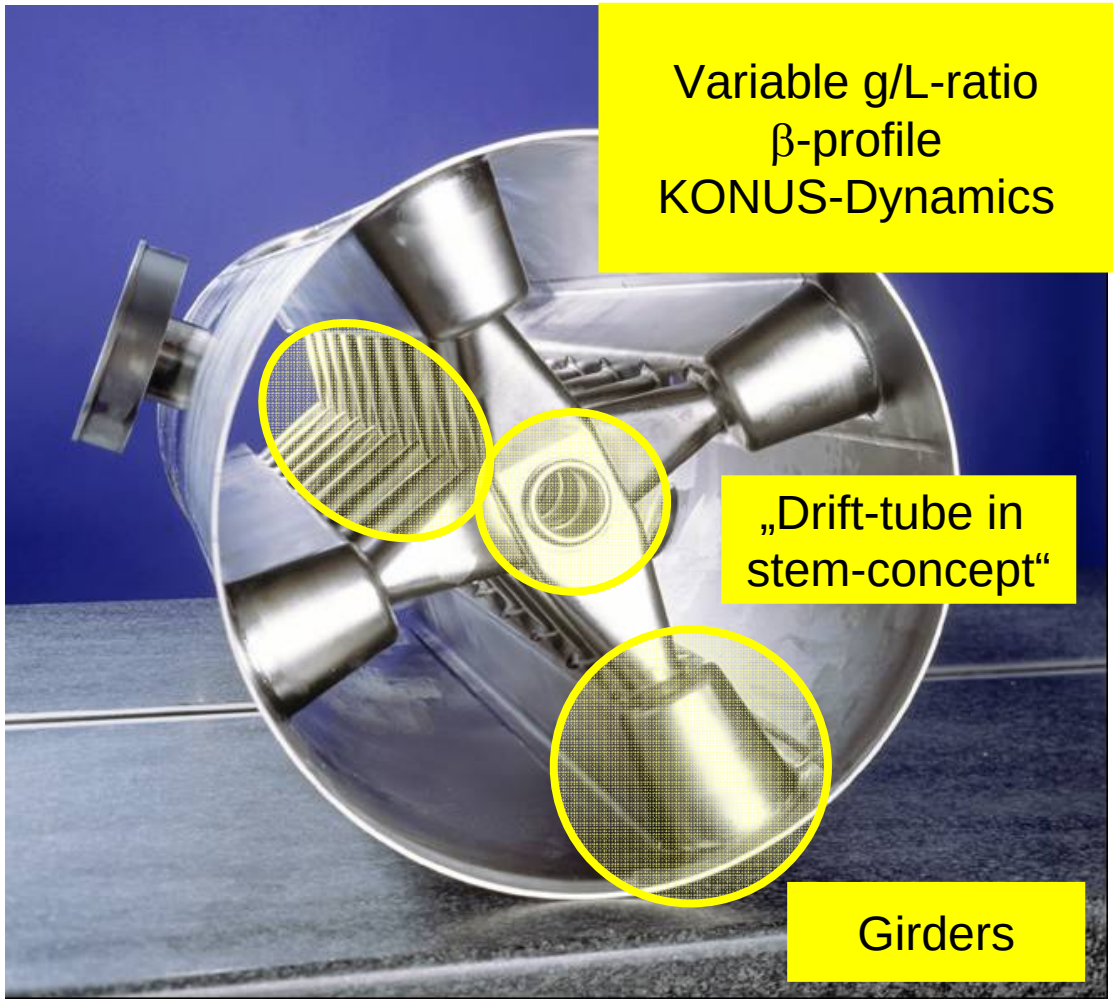
→ lack of efficient superconducting low β cavities, whereas efficient means large energy gain per cavity

Superconducting CH-Prototype

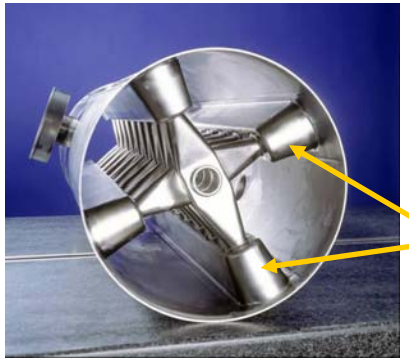
The first sc „real“ **multi cell** cavity for the low energy range

Gap number	**19**
Length (mm)	**1048**
Frequency (MHz)	**360**
β	**0.1**
E_p/E_a ($\beta\lambda$-definition)	**5.2**
B_p/E_a (mT/(MV/m))	**5.7**
$G=R_sQ_0$ (Ω)	**56**
R_a/Q (Ω) (T incl.)	**3180**
$(R_a/Q)G$ (Ω^2)	**178000**
Q_0 (BCS, 4.2K, 360 MHz)	**1.5×10^9**
Q_0 (total R_s=150 nΩ)	**3.7×10^8**
W (mJ/(MV/m)^2)	**92**

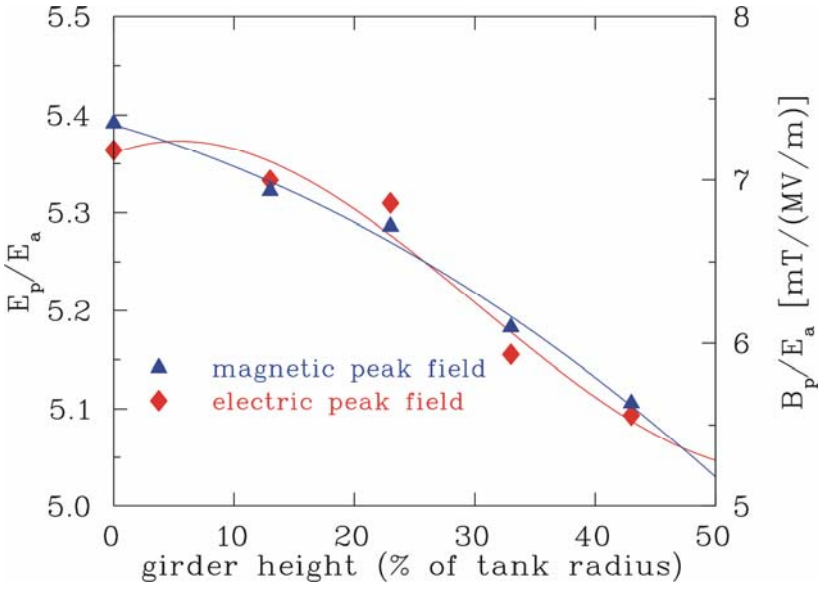
CH-cavity = Multi-Spoke??

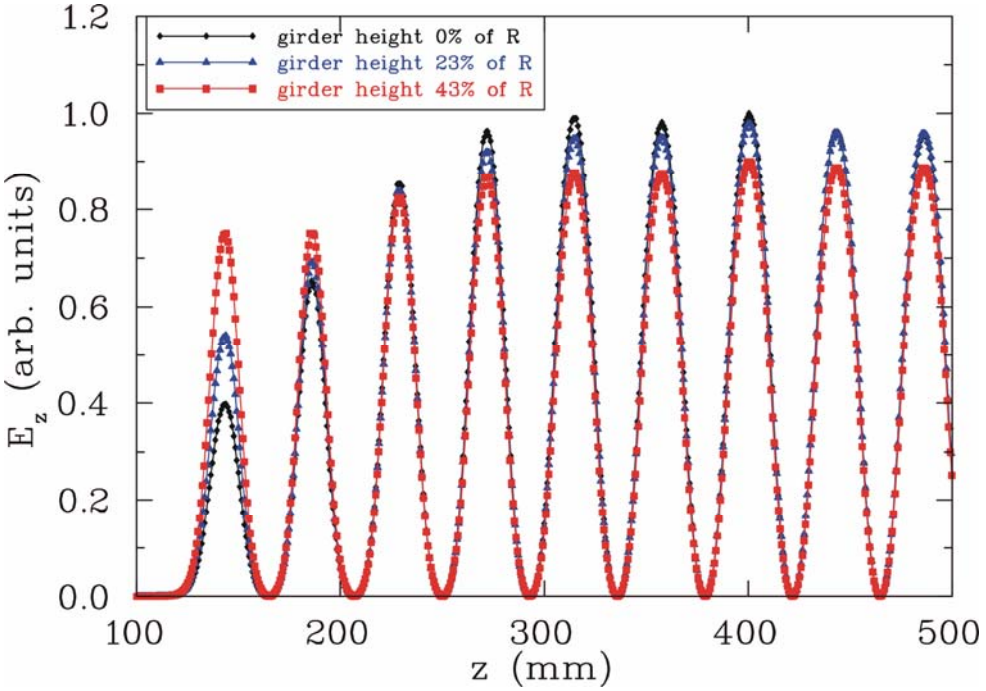


Design Issues of sc CH-cavities

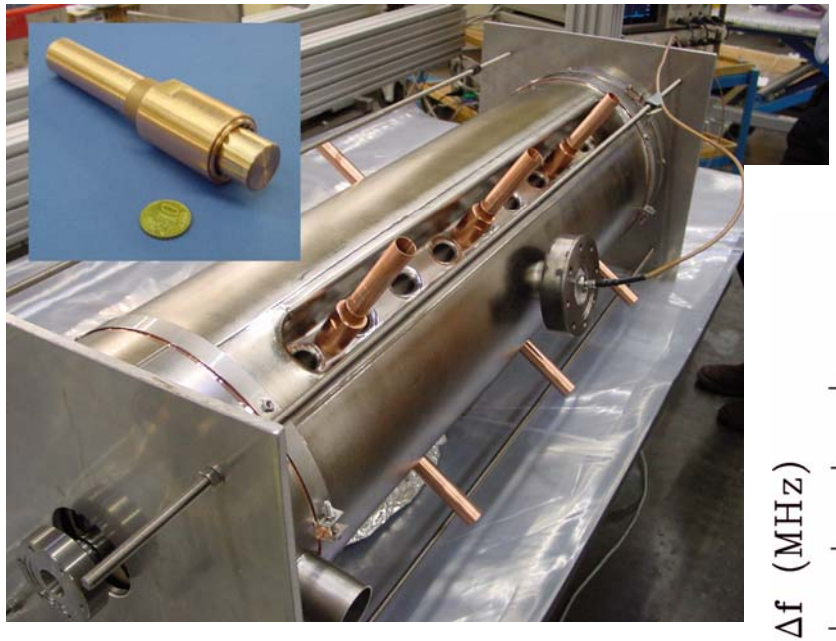


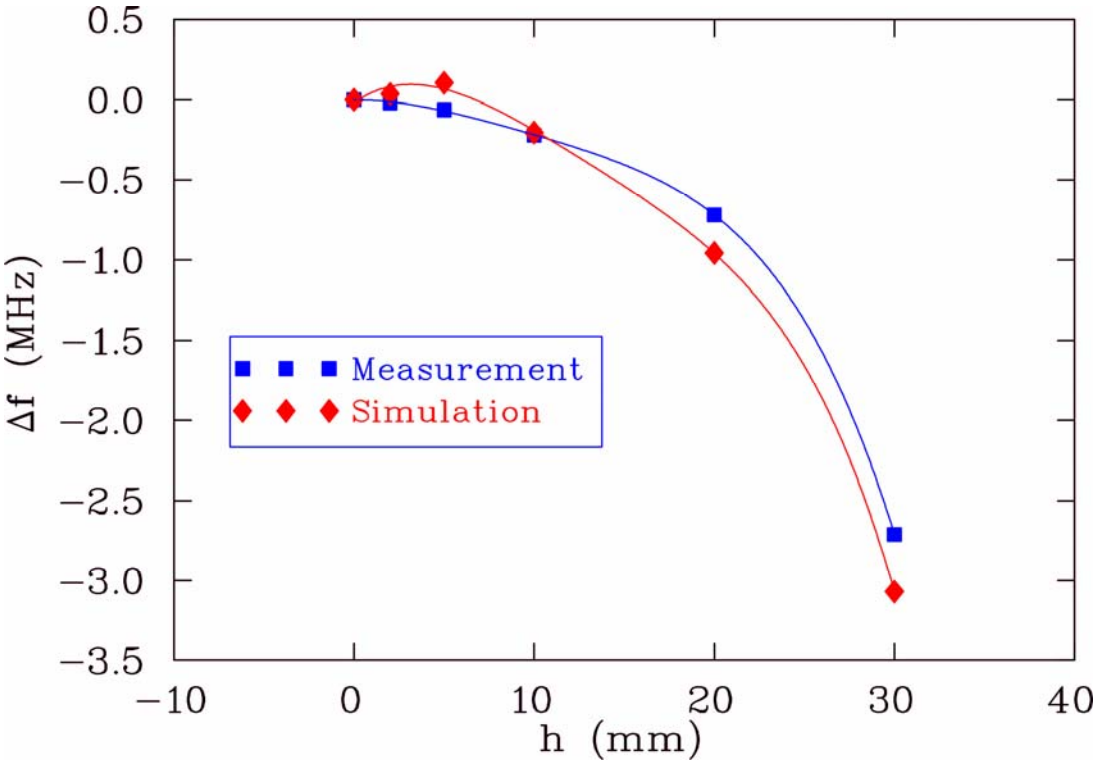
Influence of the girders on peak fields and field distribution



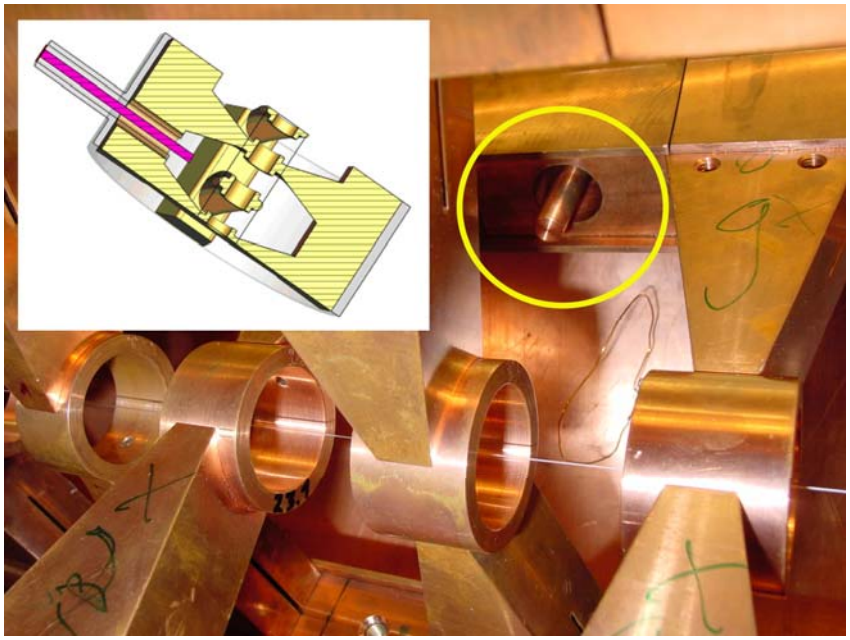


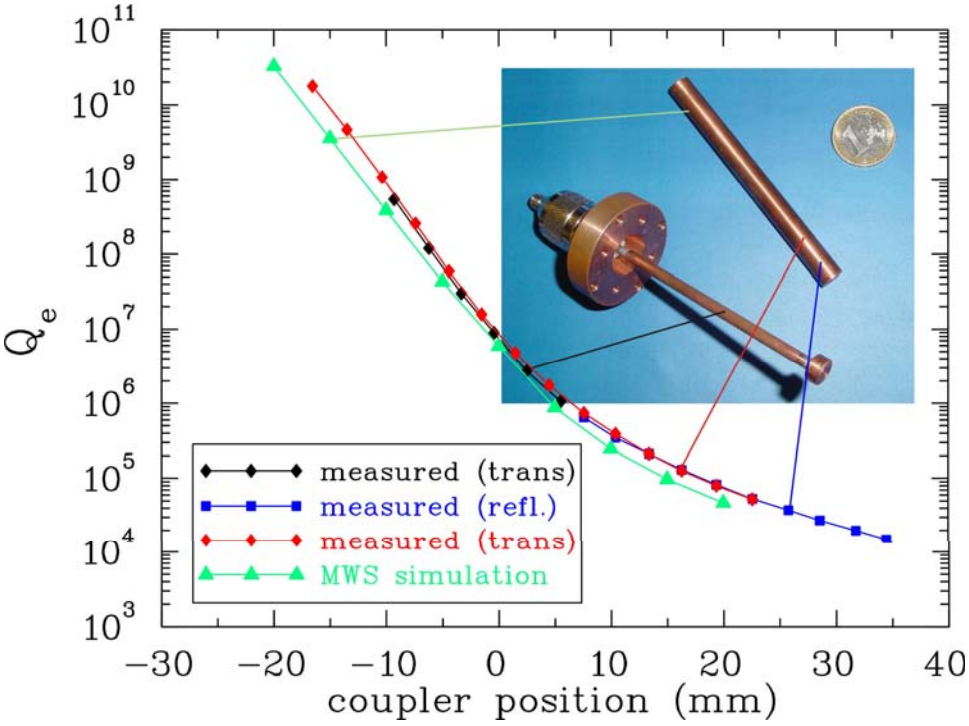
Tuning during Fabrication





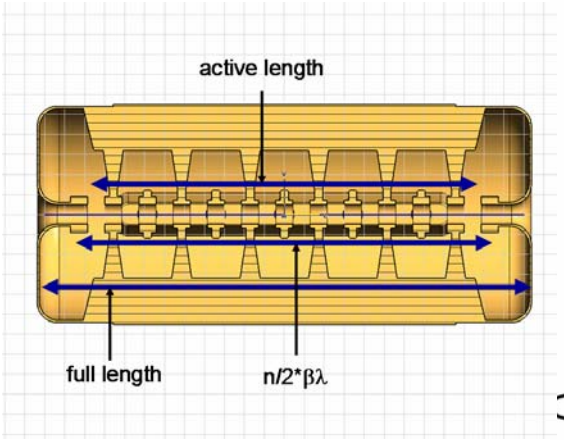
RF Coupling to sc CH-cavities



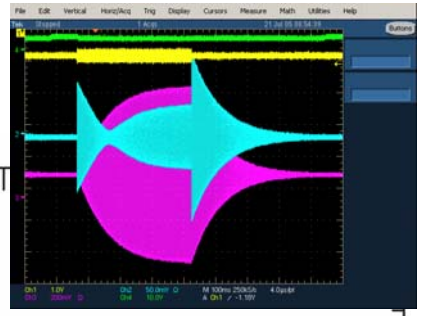


Q_0 versus Gradient E_a

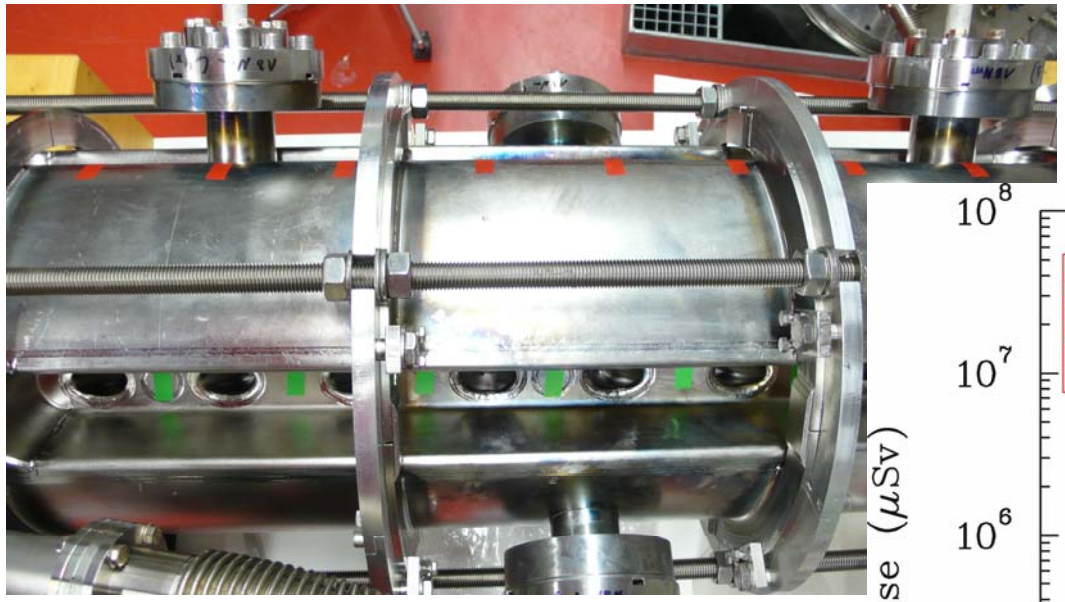
Definition of gradient

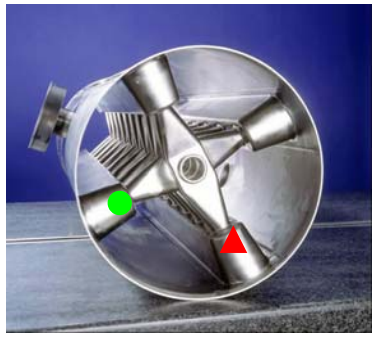


βλ-definition used →



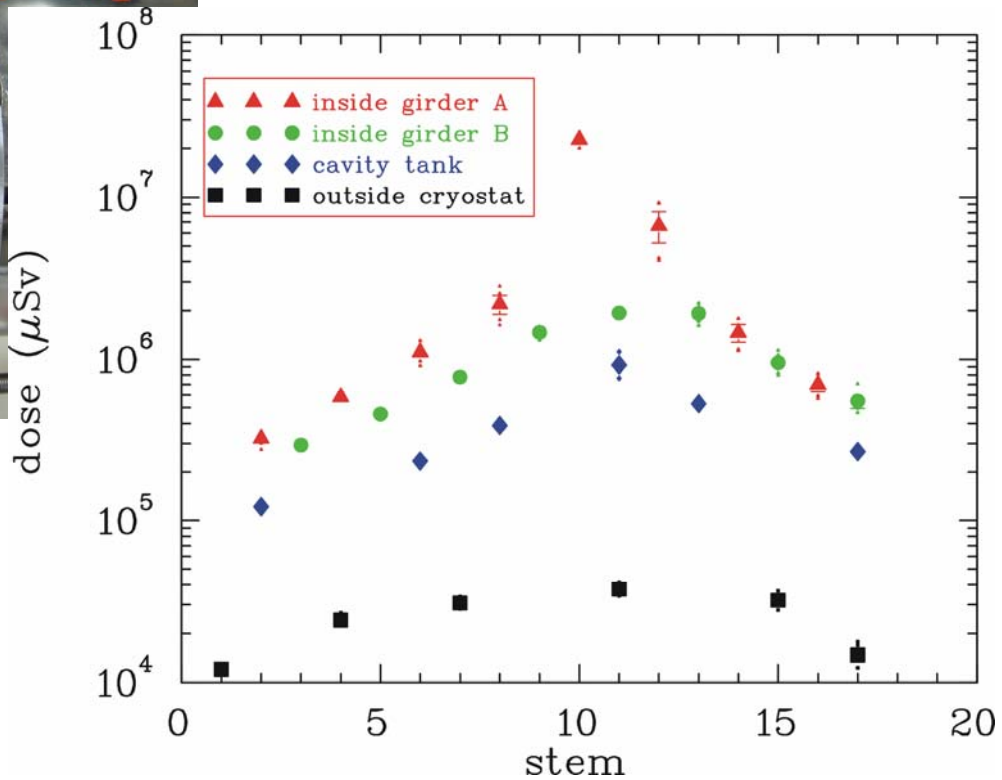
Measurement of X-rays



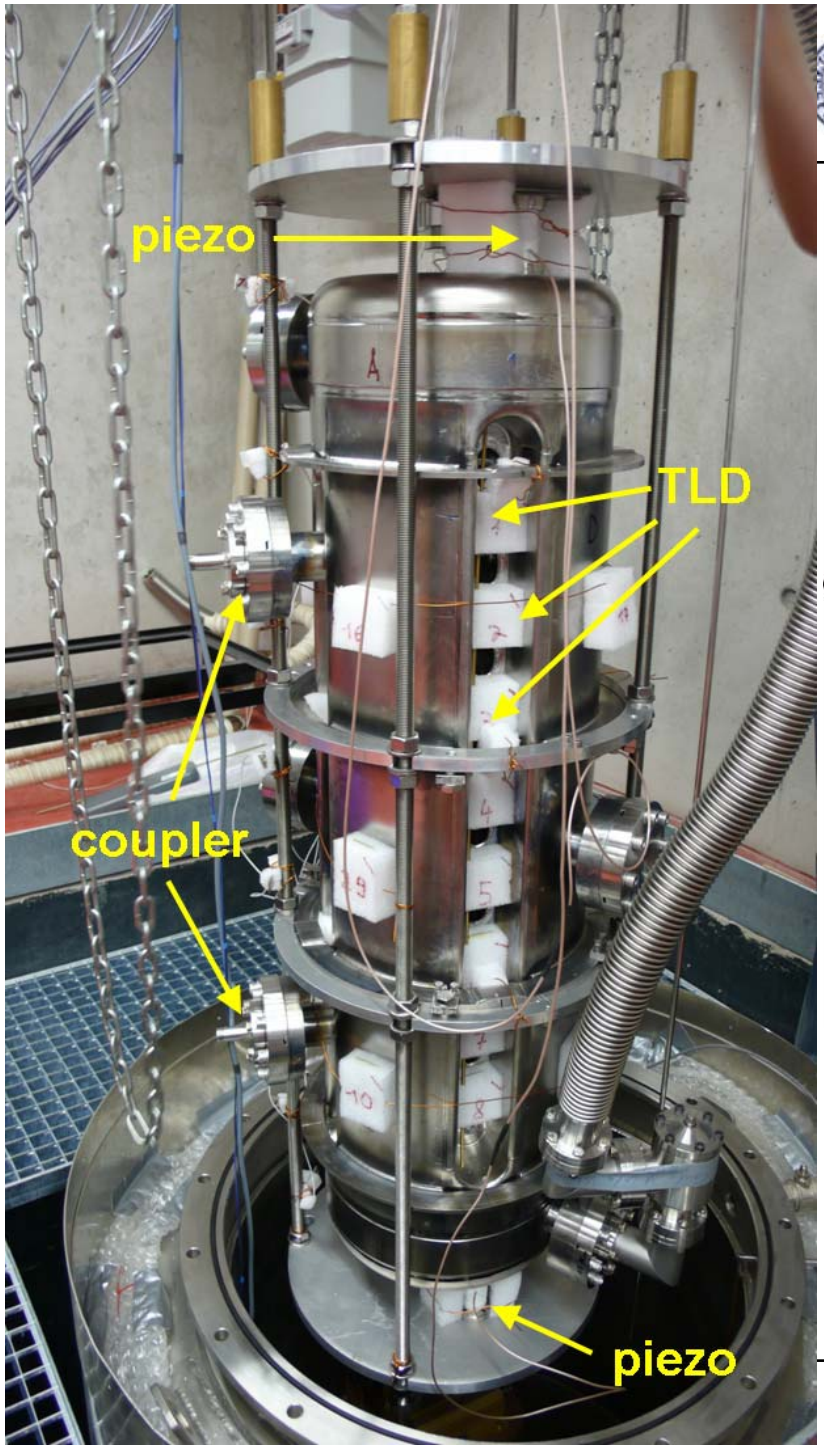


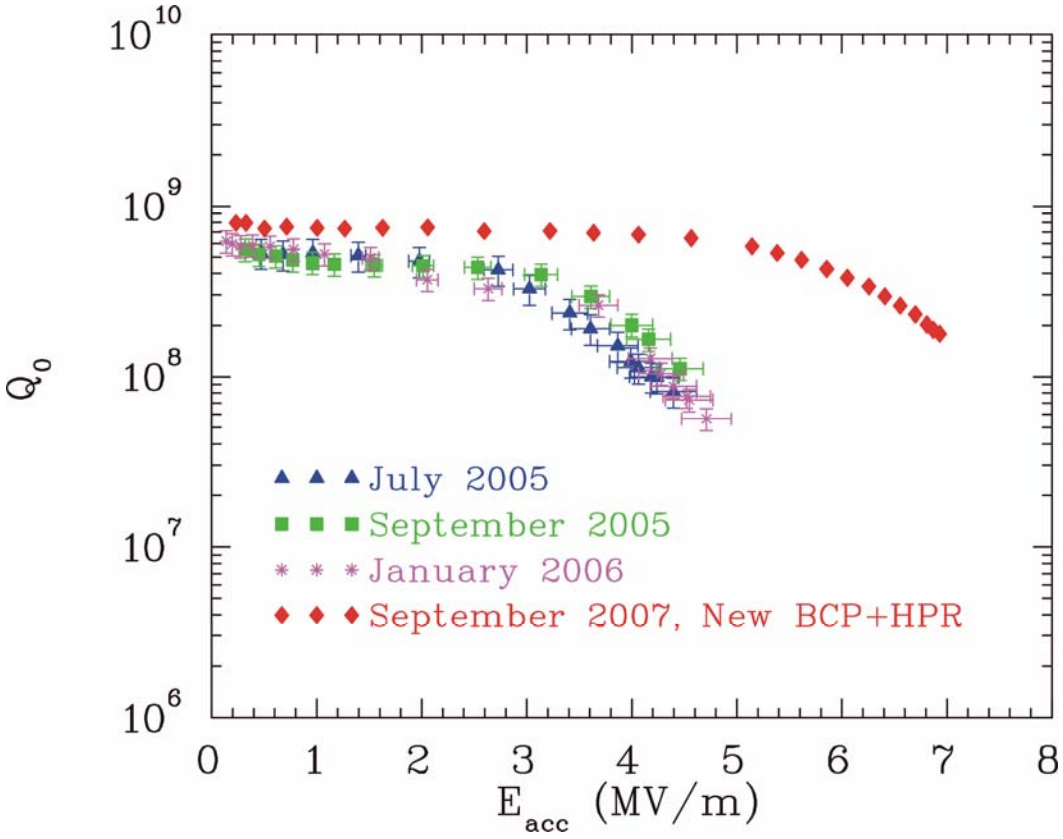
TLD

(Thermo-Luminescence-Dosemeter)



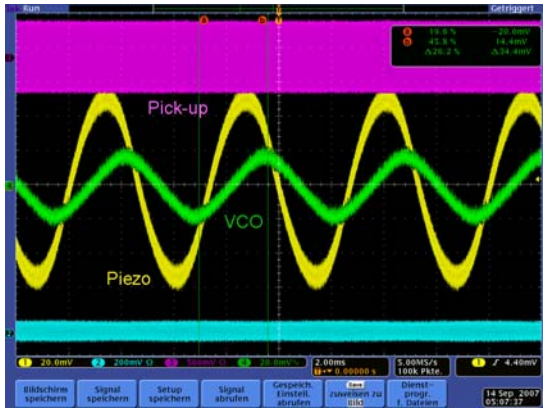
New preparation

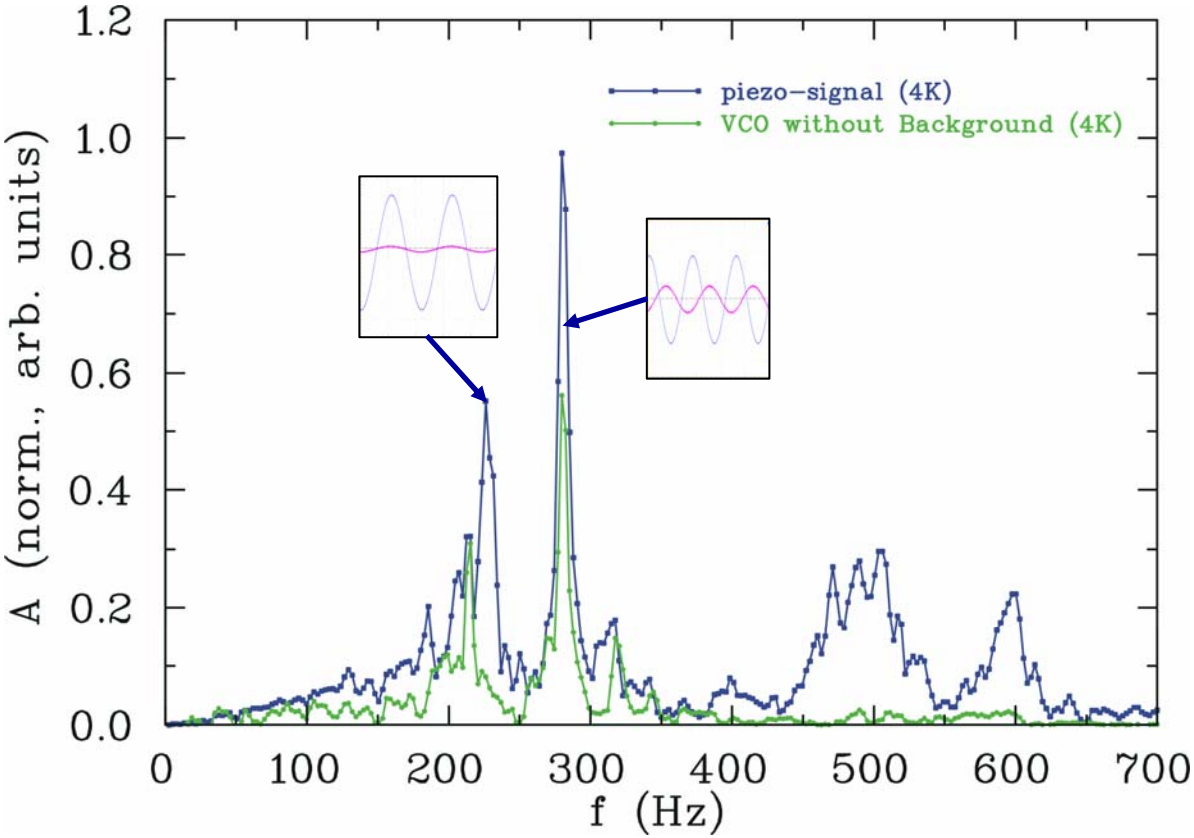




E_a=7 MV/m
U_a=5.6 MV
E_p=36 MV/m
B_p=40 mT

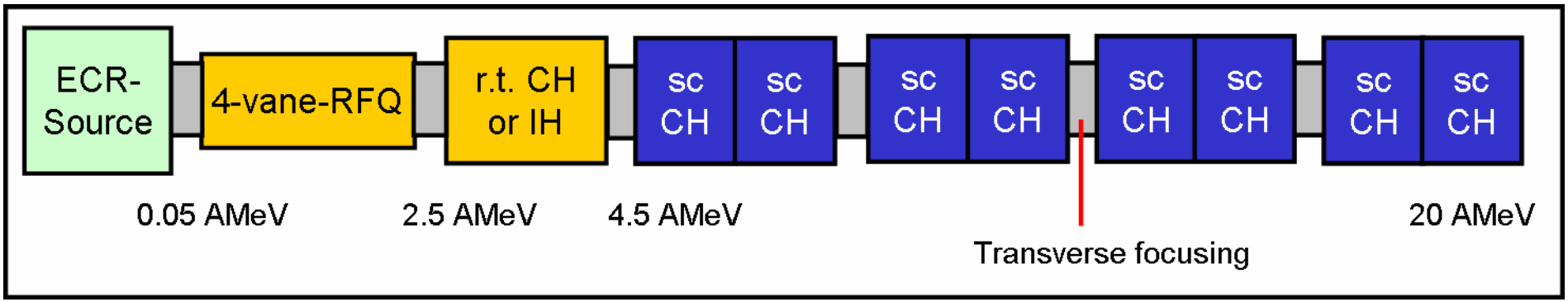
Microphonics Measurements



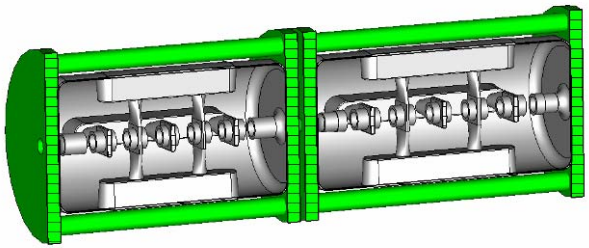


Poster A. Bechtold

r.t./s.c. CH-linac for IFMIF



- One room temperature H-mode cavity (2.5-4.5 AMeV)
- 8 superconducting CH-cavities (per linac)
- Sc cavity RF power: <30 W
- Static losses: 20 W per meter
  → 1 kW@4K →
- 3 Cryo plants (600 W each) for IFMIF, 2 in operation ,1 stand by
- Beam loading per cavity 400-500 kW
- Power couplers: 2 coaxial-couplers per cavity with 250 kW



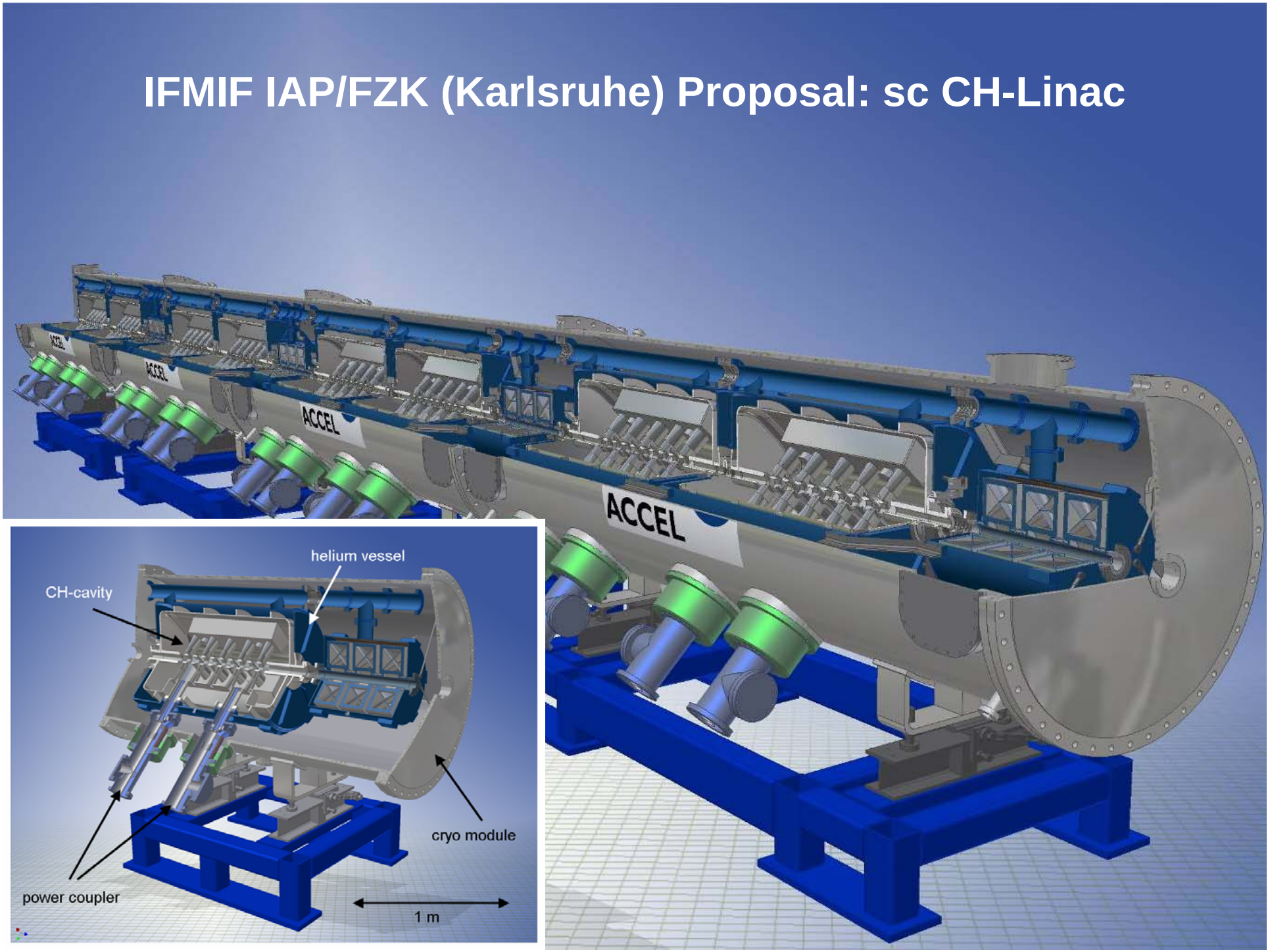
s.c. cavity doublet with tuner

Main advantages

Stable cw operation without thermal problems

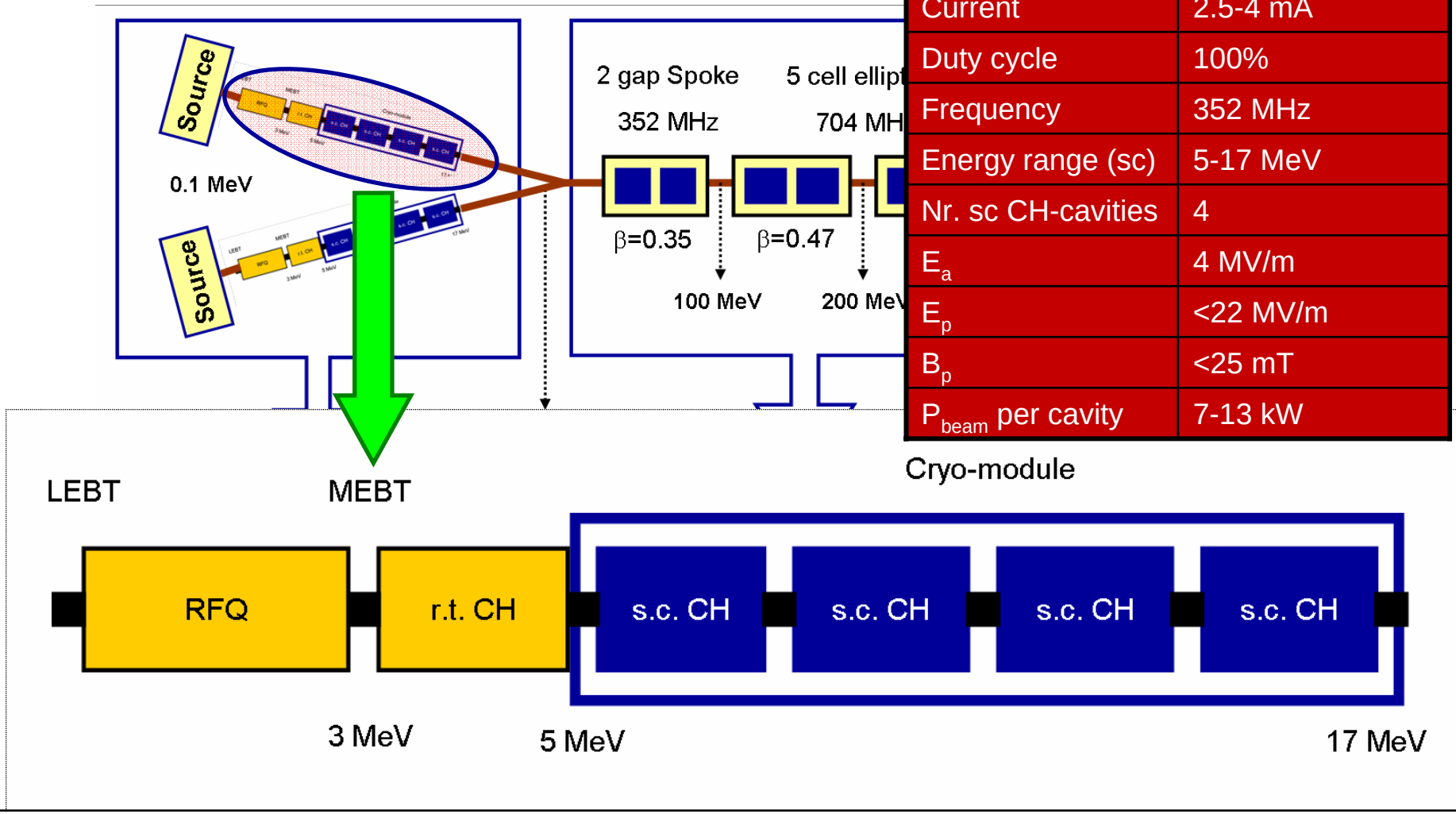
Significant operational cost savings: 5 MW → 44 Mio kWh/a

IFMIF IAP/FZK (Karlsruhe) Proposal: sc CH-Linac



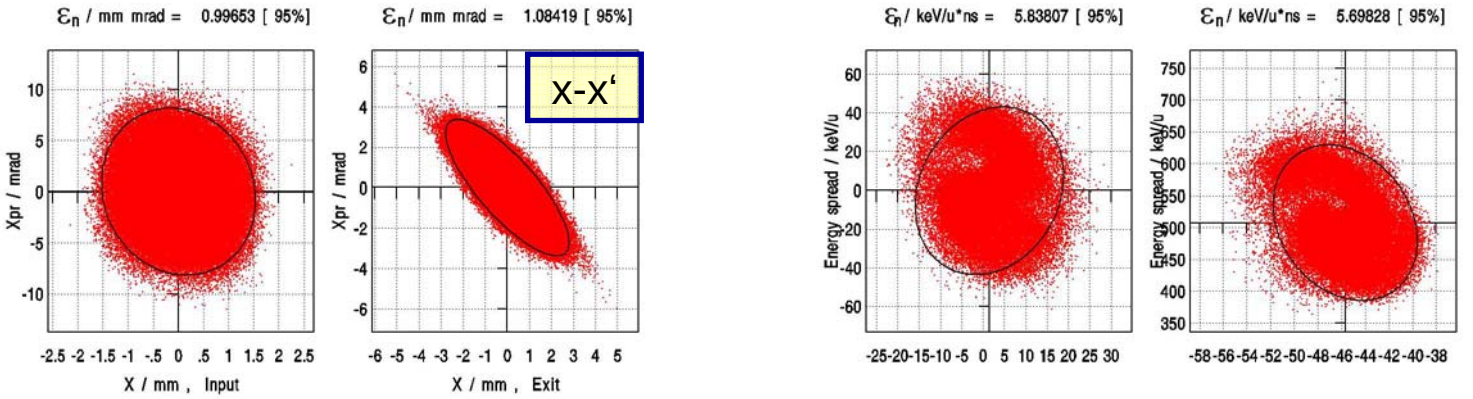
A CH-Injector for XADS/EUROTRANS

Particles	Protons
Current	2.5-4 mA
Duty cycle	100%
Frequency	352 MHz
Energy range (sc)	5-17 MeV
Nr. sc CH-cavities	4
E_a	4 MV/m
E_p	<22 MV/m
B_p	<25 mT
P_{beam} per cavity	7-13 kW



EUROTRANS CH-linac layout: phase space

in | out | in | out



ΔW-φ

C. Zhang

Summary

- The s.c. CH-cavity is the first „real“ multi-cell structure in the low energy range
- A 19 cell, β=0.1 prototype has been built and tested
- Gradients of up to 7 MV/m have been achieved
- Good candidate for fixed velocity ion and proton drivers with high duty cycles (EUROTRANS, IFMIF,…)

People

- U. Ratzinger
- H. Podlech
- H. Klein
- A. Bechtold
- H. Liebermann
- C. Zhang
- M. Busch
- I. Müller (Technician)
- D. Bänsch (Technician)

Thank you for your attention