CERN's SRF activities

W. Weingarten

CERN's ongoing/starting SRF activities

- Introduction
- LHC spare cavities/cryo-modules
- LHC upgrade - crab cavities
- HIE ISOLDE project
- Proton driver study (SPL)
- SRF R&D
- "Exotic" SRF cavities for basic physics research

Introduction

- CERN was and still is committed to the Nb film technology (for LHC, HIE-ISOLDE) and disposes of the related infrastructure
- CERN is widening its competence towards the state-of-the-art Nb technology (high gradient, high Q-value) to be prepared for future accelerator projects (LHC luminosity upgrade with crab cavities, proton driver, …)

LHC spare cavities/cryomodules 1/2 – what we have

D. Boussard et al., PAC1999 New York (USA)

- SC cavities were chosen because of
  - high voltage - few cavities - small impedance presented to beam
  - tolerable phase modulation at collision point from gap structure of beam

$$\Delta\Phi\Big|_{\text{per bunch}} = \frac{R}{Q}\,\omega_0\,\frac{q_b}{V}$$

- 8 mono-cell cavities per beam @ 400 MHz, with 2 MV each (5.3 MV/m) and 0.5 A average beam current

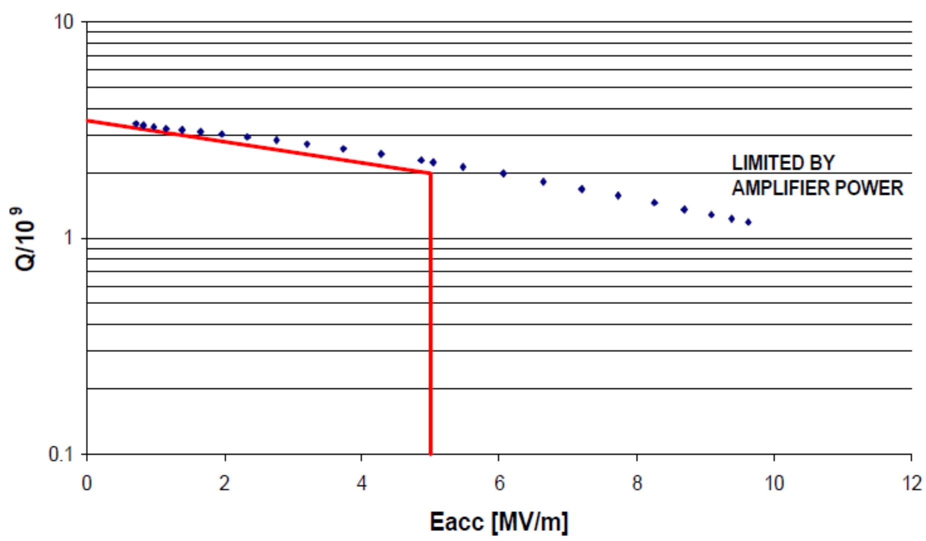


Figure 1: Typical cavity performance and acceptance curve

LHC spare cavities/cryomodules 2/2

LHC cavities

We have 1 spare cryo-module and 1 spare cavity, considered to be marginal => we need 3 more spare cavities (400 MHz, Nb film technology)

Figure 2: Open SC Cryostat Module, showing He Tank and Tuning Frame.

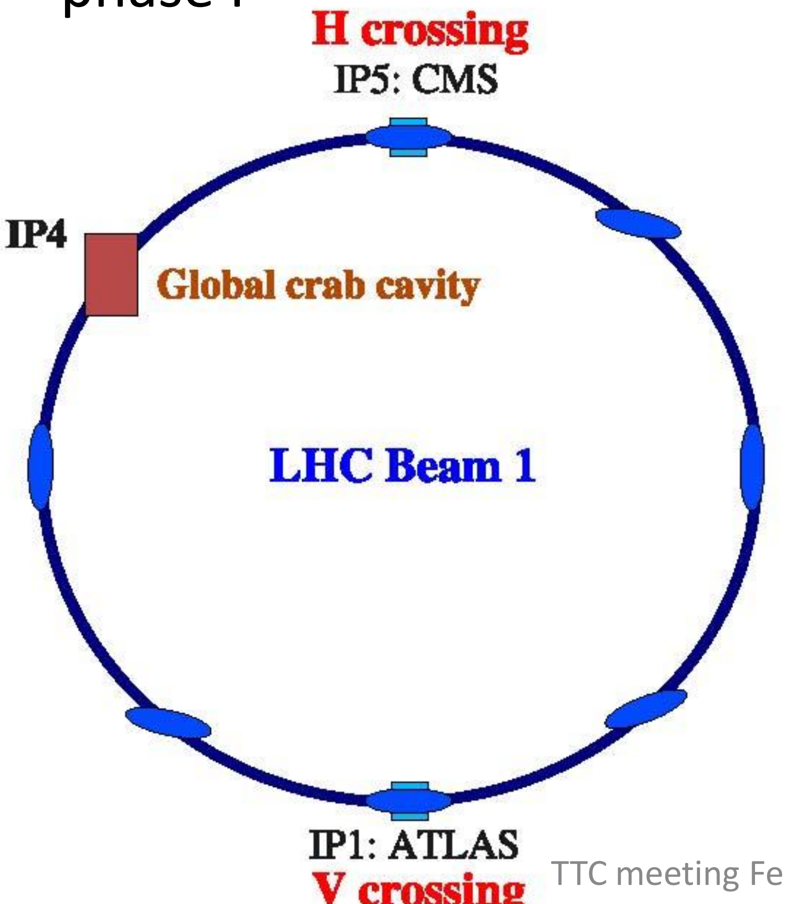
RF Cryo-modules in the LHC tunnel at IP4

LHC upgrade – crab cavities 1/3

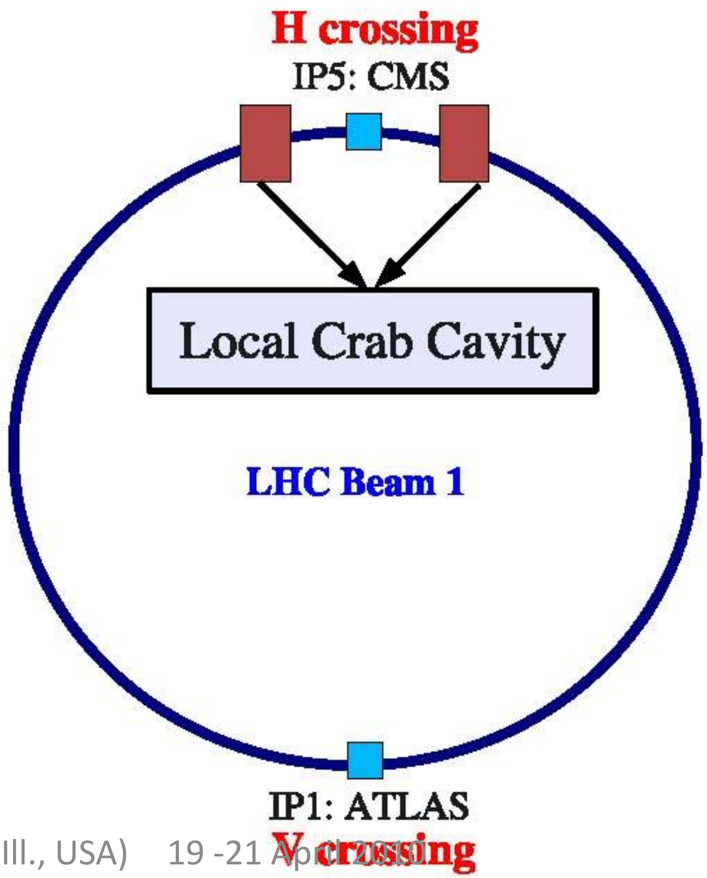
F. Zimmermann

Staged implementation

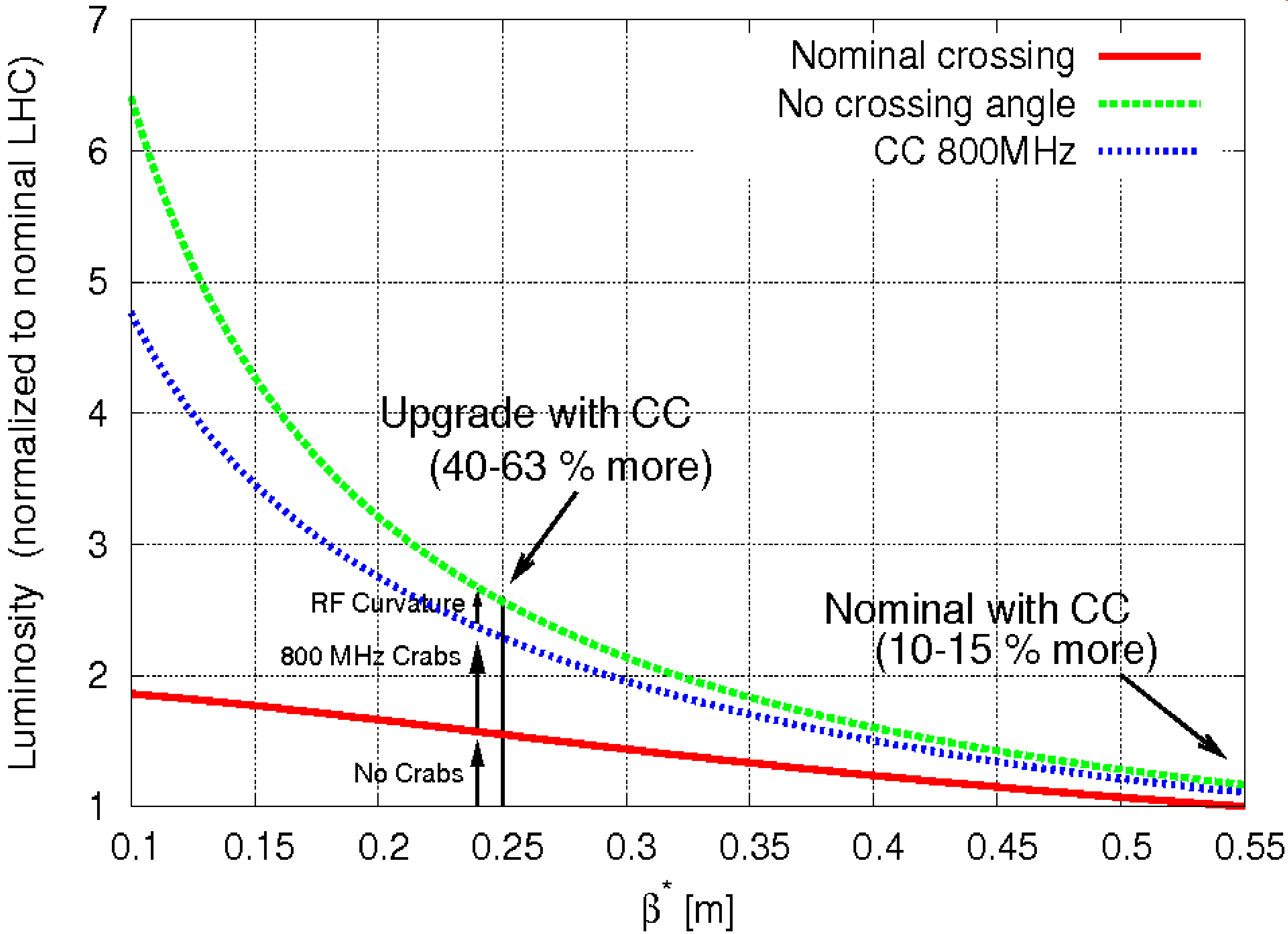
phase I



phase II



LHC upgrade – crab cavities 2/3

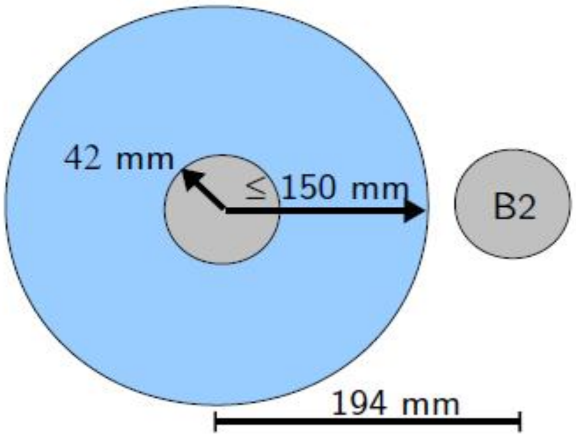


LHC upgrade – crab cavities 3/3

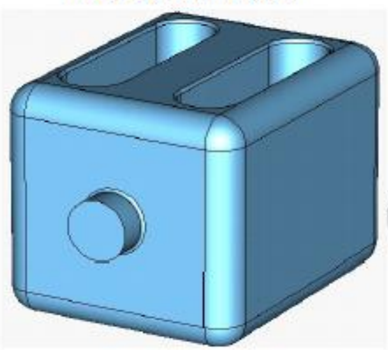
LHC Needs Compact Cavities

2008-2010

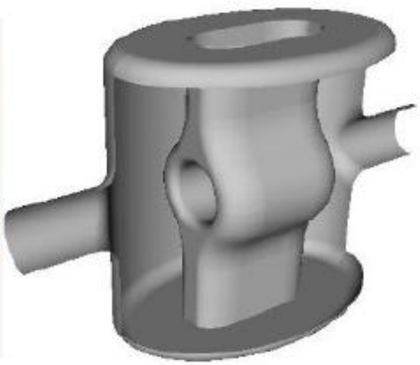
R. Calaga
Chamonix 2010



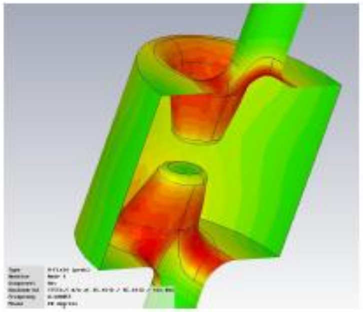
HWDR, JLAB,OD



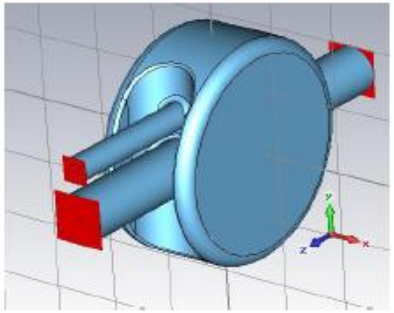
HWSR, SLAC-LARP



DR, UK, TechX

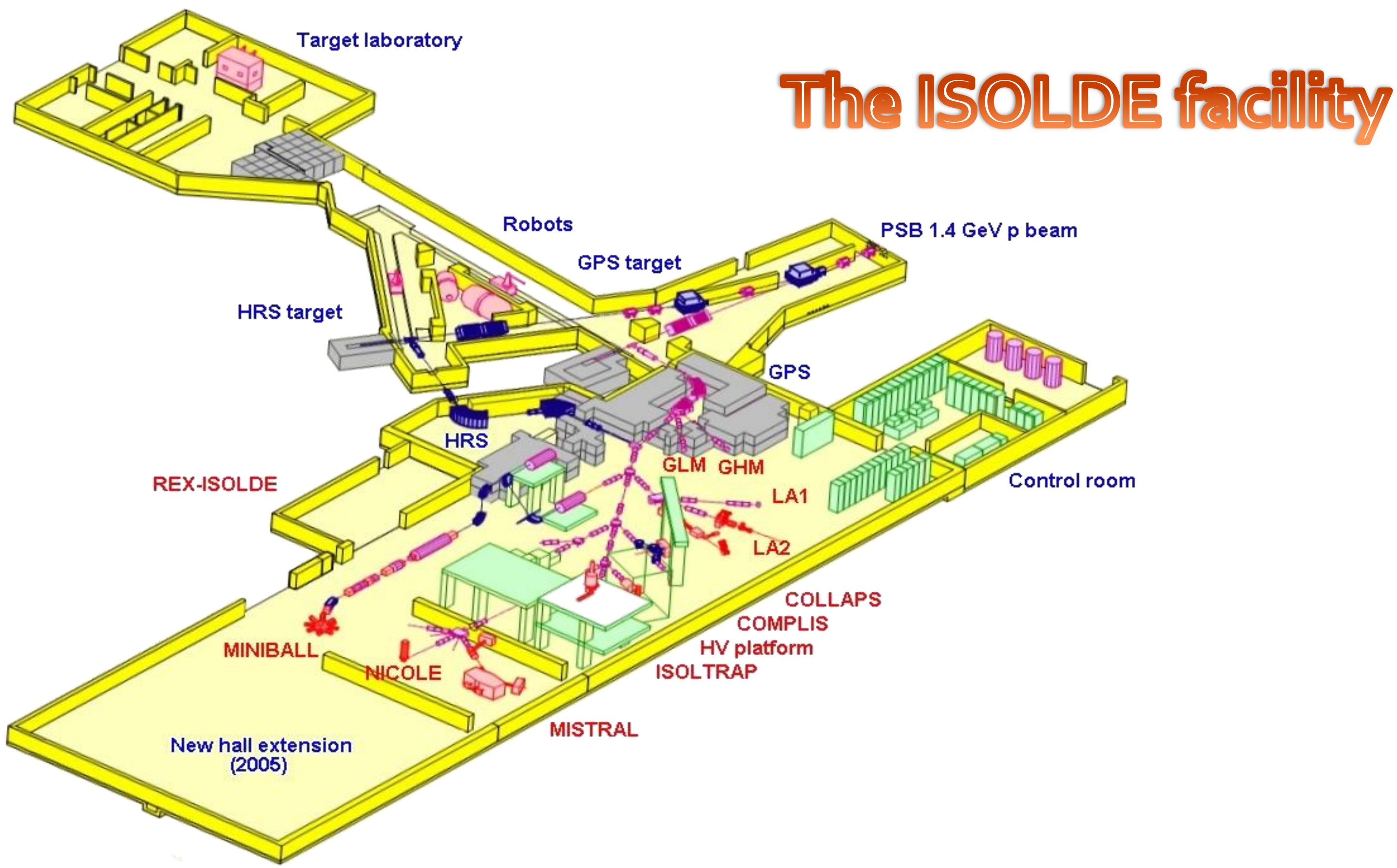


Kota, KEK



Compact cavities aiming at small footprint & 400 MHz, 3-8 MV/cavity

HIE – ISOLDE project 1/4 courtesy M. Pasini



HIE – ISOLDE project 2/4 - QWR cavities (Nb sputtered)

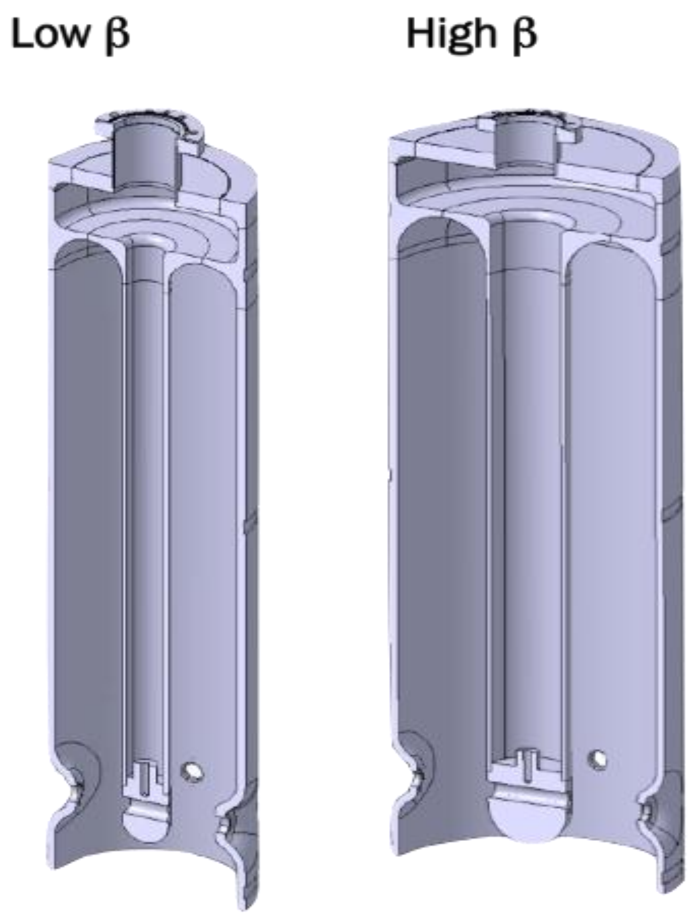
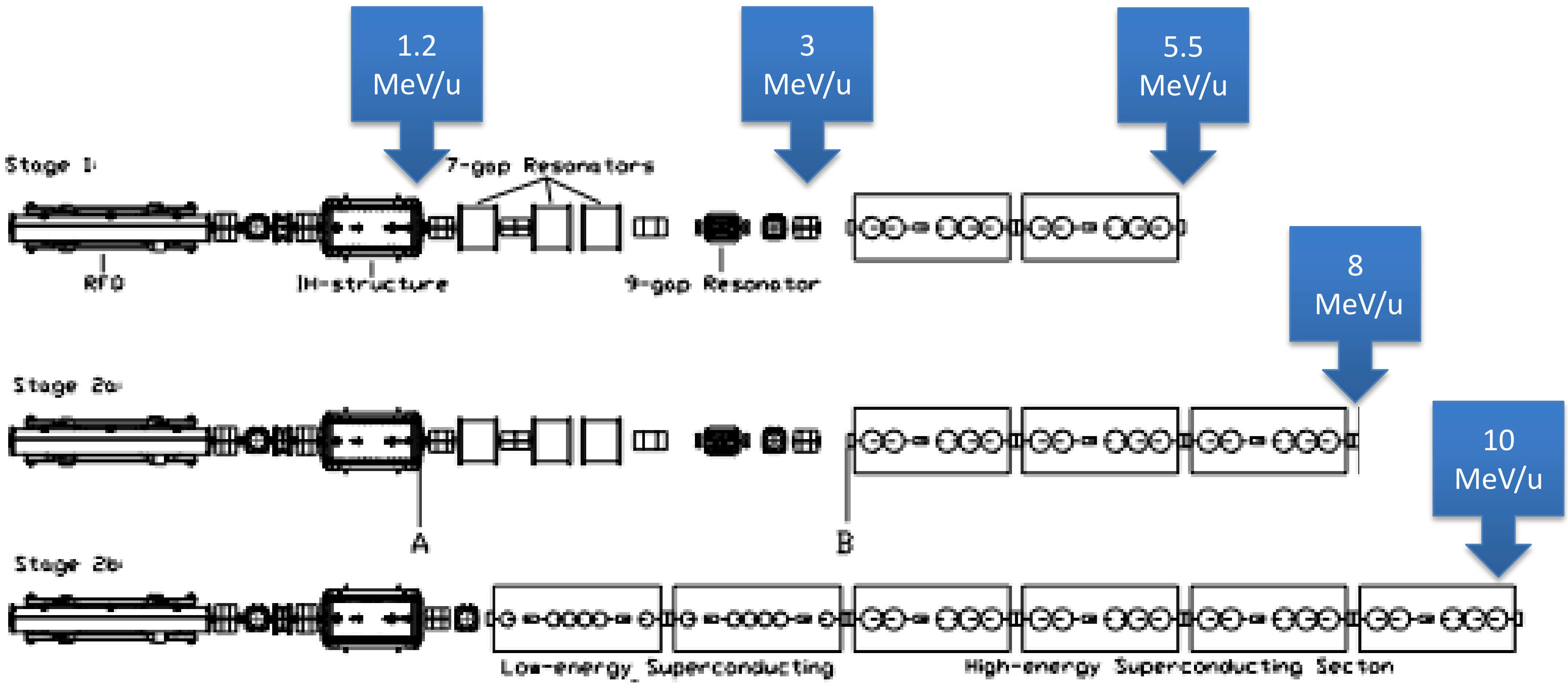


Table 1: Cavity design parameters

Cavity	**Low β**	**highβ**
No. of Cells	2	2
f (MHz)	101.28	101.28
β_0 (%)	6.3	10.3
Design gradient E_{acc}(MV/m)	6	6
Active length (mm)	195	300
Inner conductor diameter (mm)	50	90
Mechanical length (mm)	215	320
Gap length (mm)	50	85
Beam aperture diameter (mm)	20	20
$U/E_{acc}{}^2$ (mJ/(MV/m)^2	73	207
E_{pk}/E_{acc}	5.4	5.6
H_{pk}/E_{acc} (Oe/MV/m)	80	100.7
R_{sh}/Q (Ω)	564	548
$\Gamma = R_S \cdot Q_0$ (Ω)	23	30.6
Q_0 for 6MV/m at 7W	$3.2 \cdot 10^8$	$5 \cdot 10^8$
TTF max	0.85	0.9
No. of cavities	12	20

HIE – ISOLDE project 3/4 - SC Linac Layout staged installation

3 stages installation

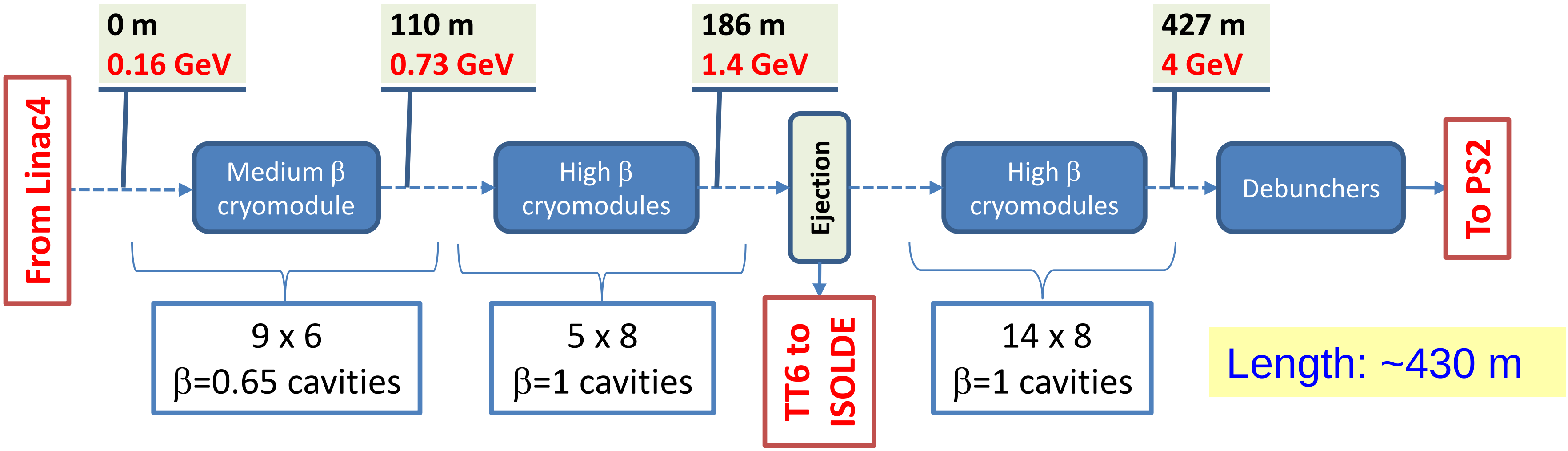


HIE – ISOLDE project 4/4 courtesy S. Calatroni

Proton driver study at CERN (SPL) 1/4 - Generalities

Objective: have a 4-cavity fully equipped horizontal test cryostat available in first half 2013 for RF testing at high power (1 MW)

Possible layout of a proton driver:



Proton driver study (SPL) 2/4 - Participants

- CERN
  - BE-RF (coordination, low and high power RF tests, rinsing, clean rooms, ancillaries, inspection)
  - TE-CRG (cryogenics SM18)
  - TE-VSC (surface preparation)
  - EN-MME (manufacture)
- CEA - Saclay (manufacture, low power RF tests, ancillaries, surface preparation)
- CNRS - Orsay (manufacture)
- TEMF Uni Darmstadt (e-m simulations: interaction of power coupler with beam)
- Uni Rostock (e-m simulations of HOM coupler)
- BNL (manufacture)
- TRIUMF (manufacture)

- Possibly ESS Lund (joint ESS-SPL collaboration meeting foreseen on 30 June)

Proton driver study (SPL) 3/4 - networking

- "Contribution de la France au CERN"
  - helium vessels, 8 (+1) tuners for β = 1 cavities
  - Design of 704 MHz 1 MW power coupler
  - Design frequency tuner for 704 MHz elliptical cavities (**√**)
  - equipment (EP, field flatness tuning, HPWR, vertical crostat…)
- BMBF German Universities (Rostock, Darmstadt, …)
  - electromagnetic simulations (power coupler HOM coupler)
- FP 7
  - Eucard
    - Networking activities
      - Work Package 4: Accelerator Science Networks: EuroLumi and RFTech
    - Joint Research activities
      - Work Package 10: Superconducting RF technology for proton accelerators and electron linear accelerators
- SLHC-pp
  - WP RF systems
    - Study of field stabilization in pulsed mode
    - Power test of RF system at CEA-Saclay 704 MHz test stand

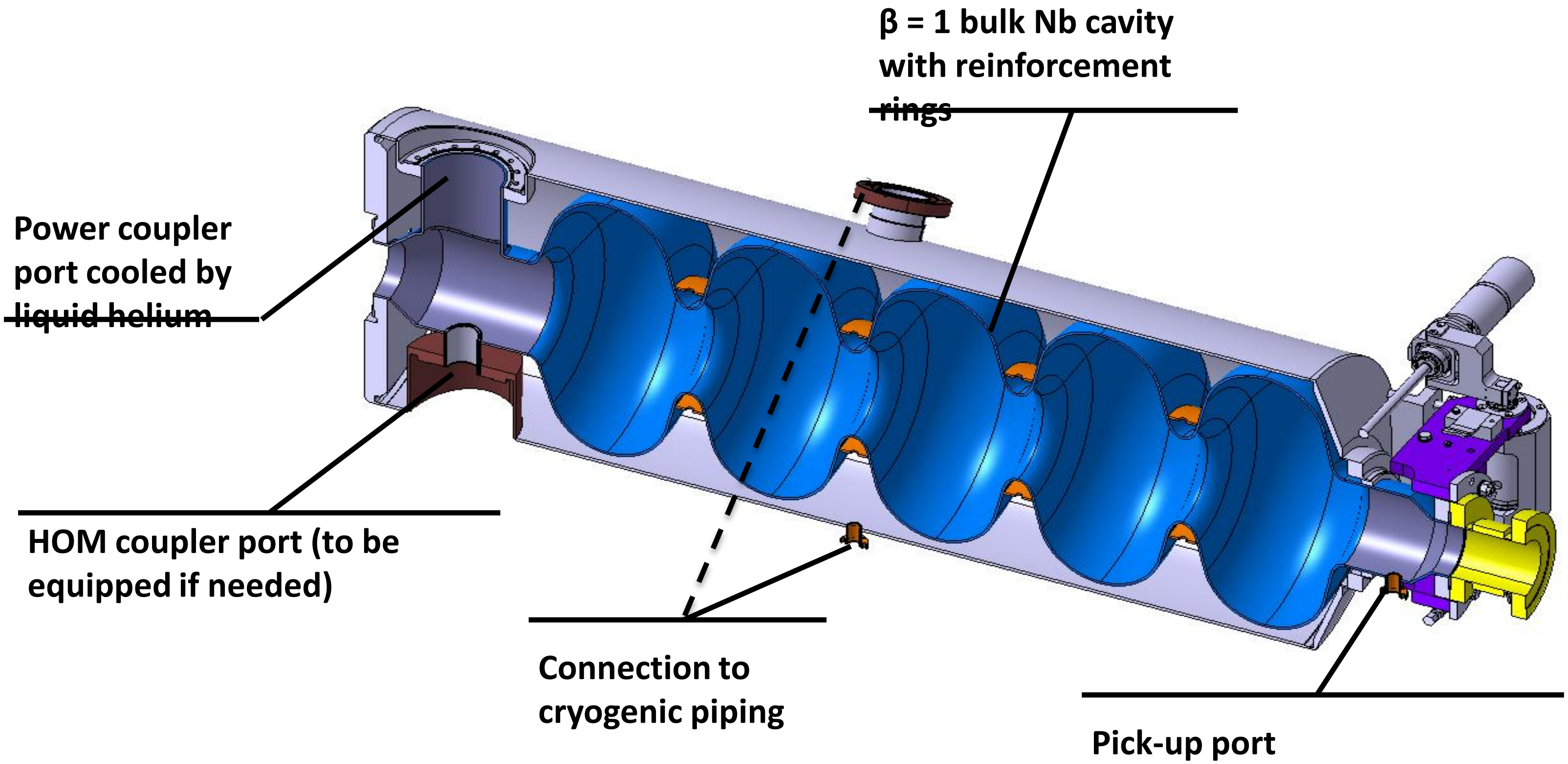
Proton driver study (SPL) 4/4

β = 1 cavity-tuner-He-tank unit courtesy O. Capatina

General configuration for the demonstrator

Based on design from CEA - Saclay

704 MHz, E_a = 25 MV/m @ $Q_0 = 1 \cdot 10^{10}$, 2 K

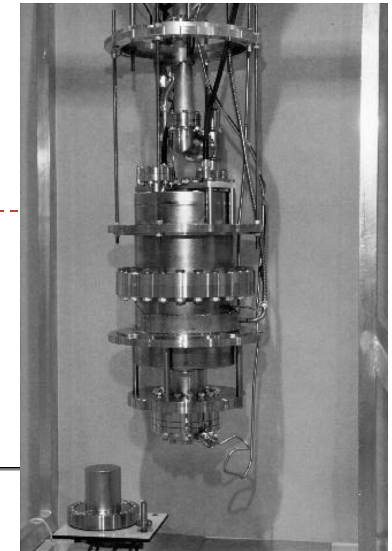


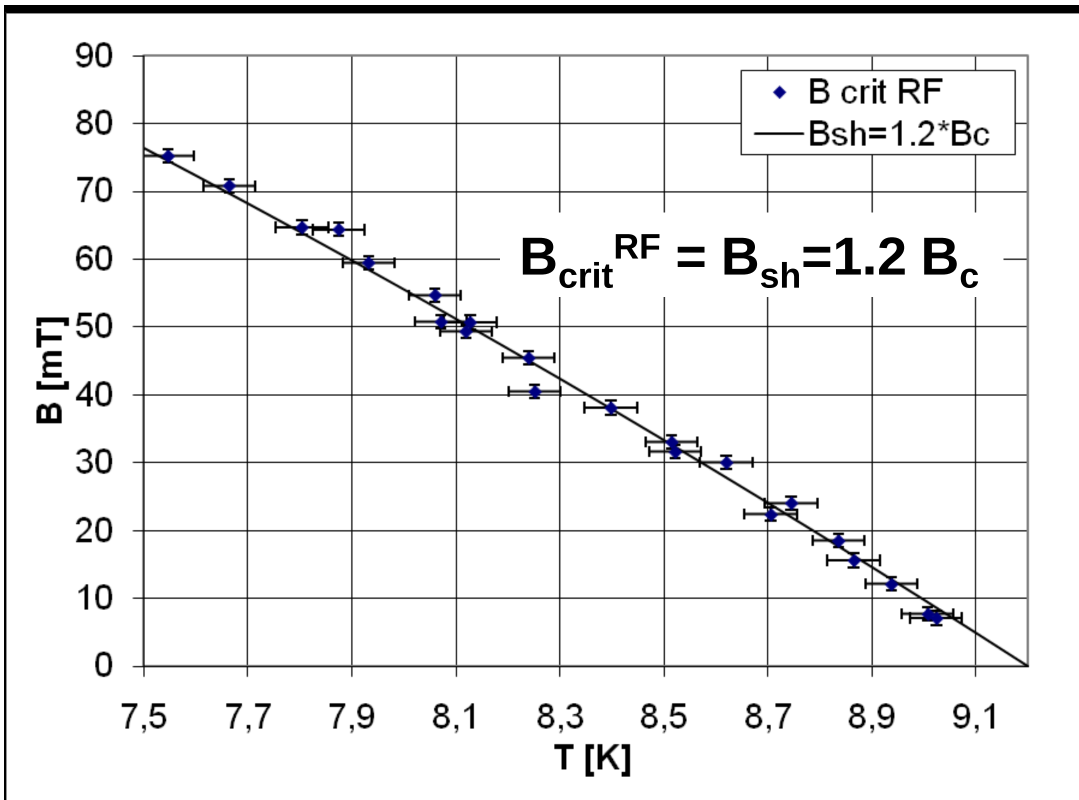
SRF R&D 1/2

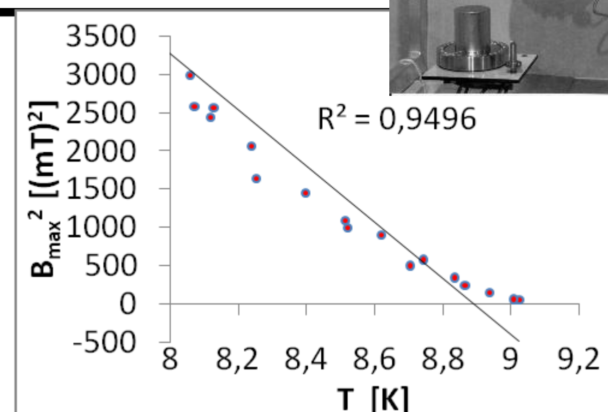
Nb is approaching the theoretical predicted limit

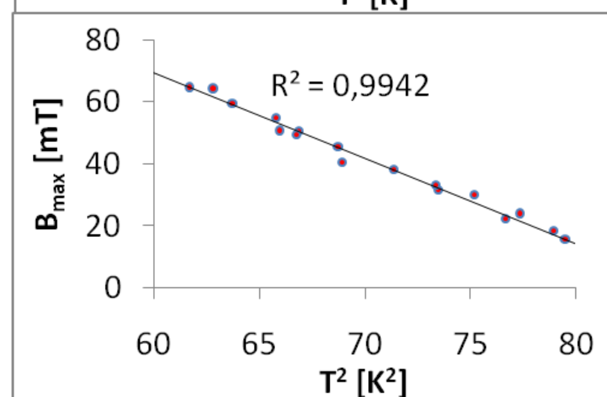
Plots courtesy T. Junginger / CERN

Quadrupole resonator/ CERN







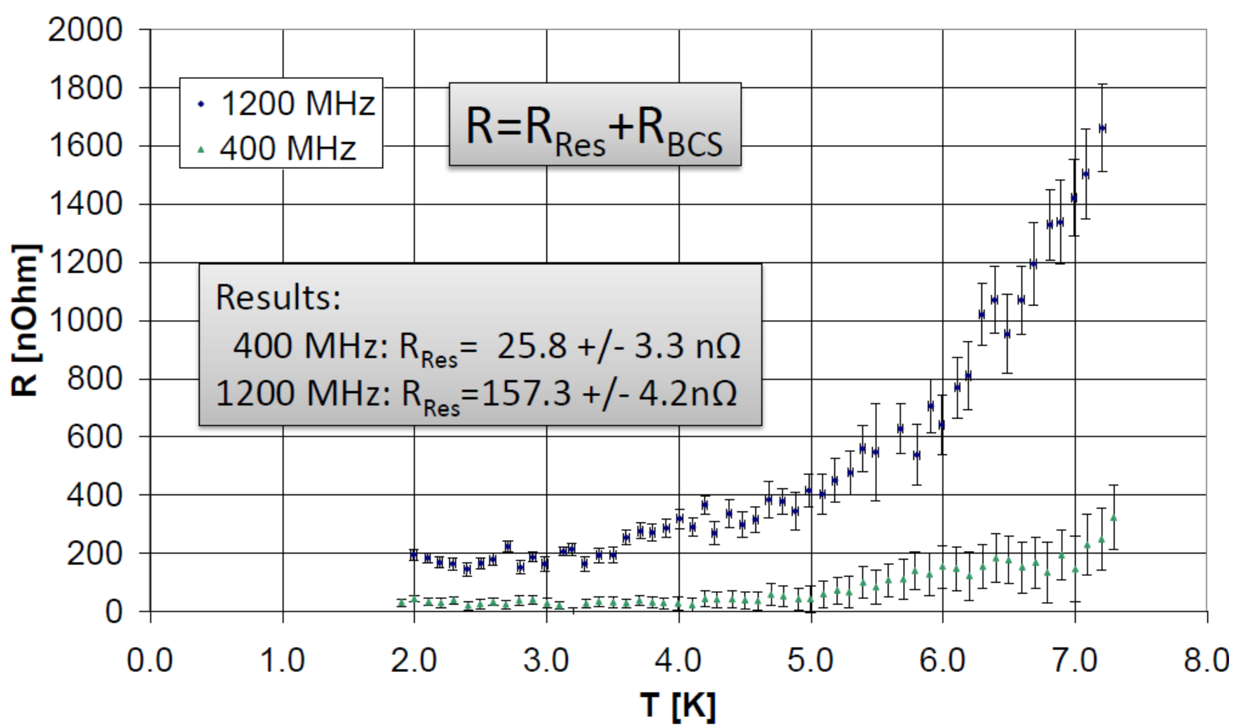


SRF R&D 2/2

RESIDUAL RESISTANCE

Collaboration with W. Weingarten / Thanks to G. Ciovati

- Reactor grade bulk niobium sample
- Chemically etched
- 400 and 1200 MHz



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"Exotic" SRF cavities for physics research courtesy D. Barna

A Superconducting Paul-trap for Antiprotons
(... to produce antihydrogen)
CERN, Asacusa experiment

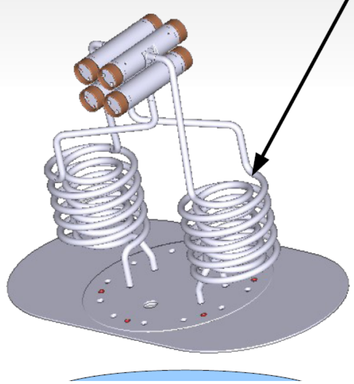
Atomic Spectroscopy And Collisions Using Slow Antiprotons

Abstract

We are developing a linear superconducting Paul-trap to capture and cool the antiprotons emerging from our RFQ decelerator and further slowed down when passing through a degrader foil window to about $E_{kin} \sim 5$ -10 keV.

Construction, design

(Upside down view)



Coaxial double-coils

- provide superfluid liquid-He supply to the electrodes
- shielded path for the endcap segments' bias cable (-2 kV)

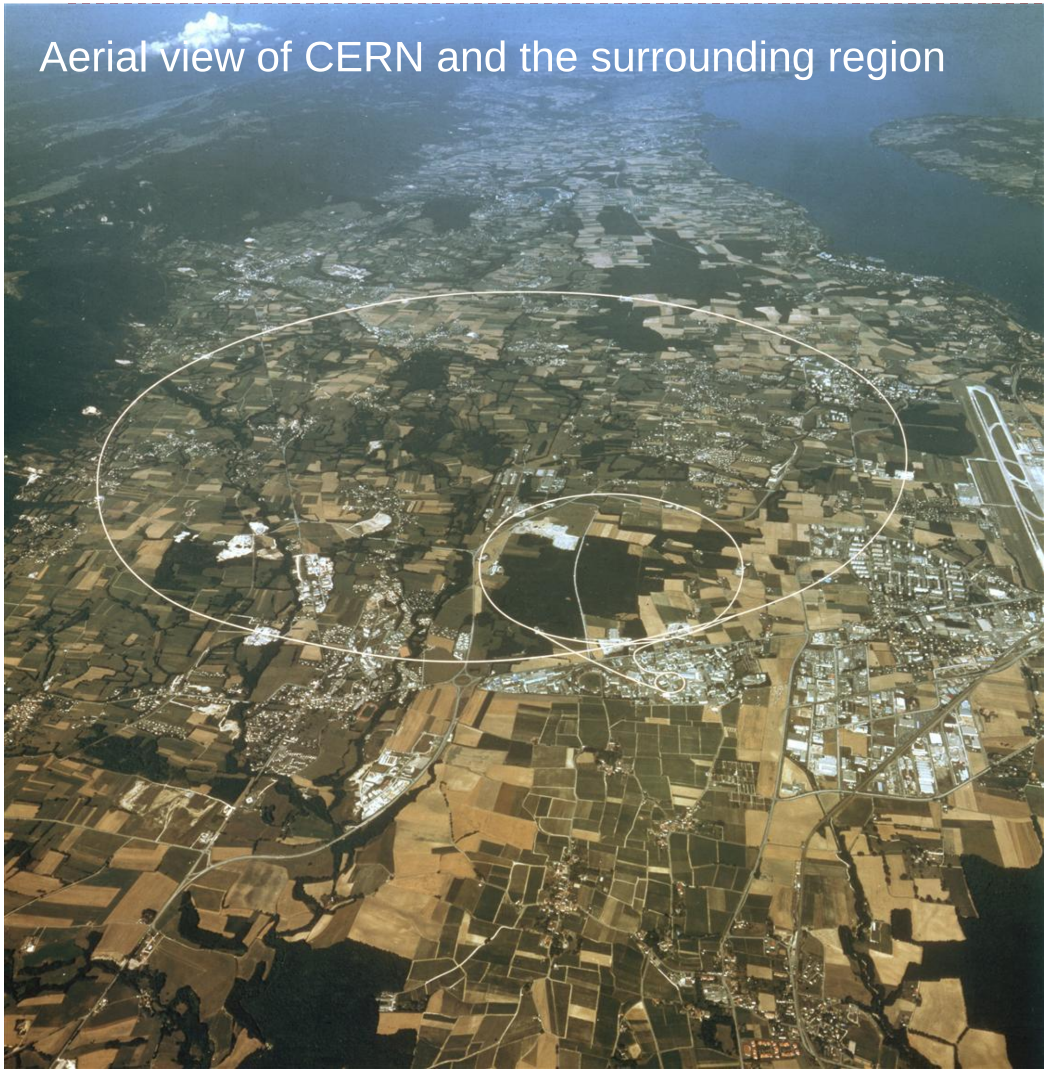
Test cavity for the linear trap

Modeling the quadrupole mode, "half" of the real resonator

Vessel, immersed in superfluid helium

- Microphonics ??
- RF, cryogenic properties, etc

Thank you for your attention



Three rings are visible, the smaller shows the underground position of the PS, the middle ring is the SPS with a circumference of 7 km and the largest ring (27 km) is that of the former LEP accelerator with part of Lake Geneva in the background.