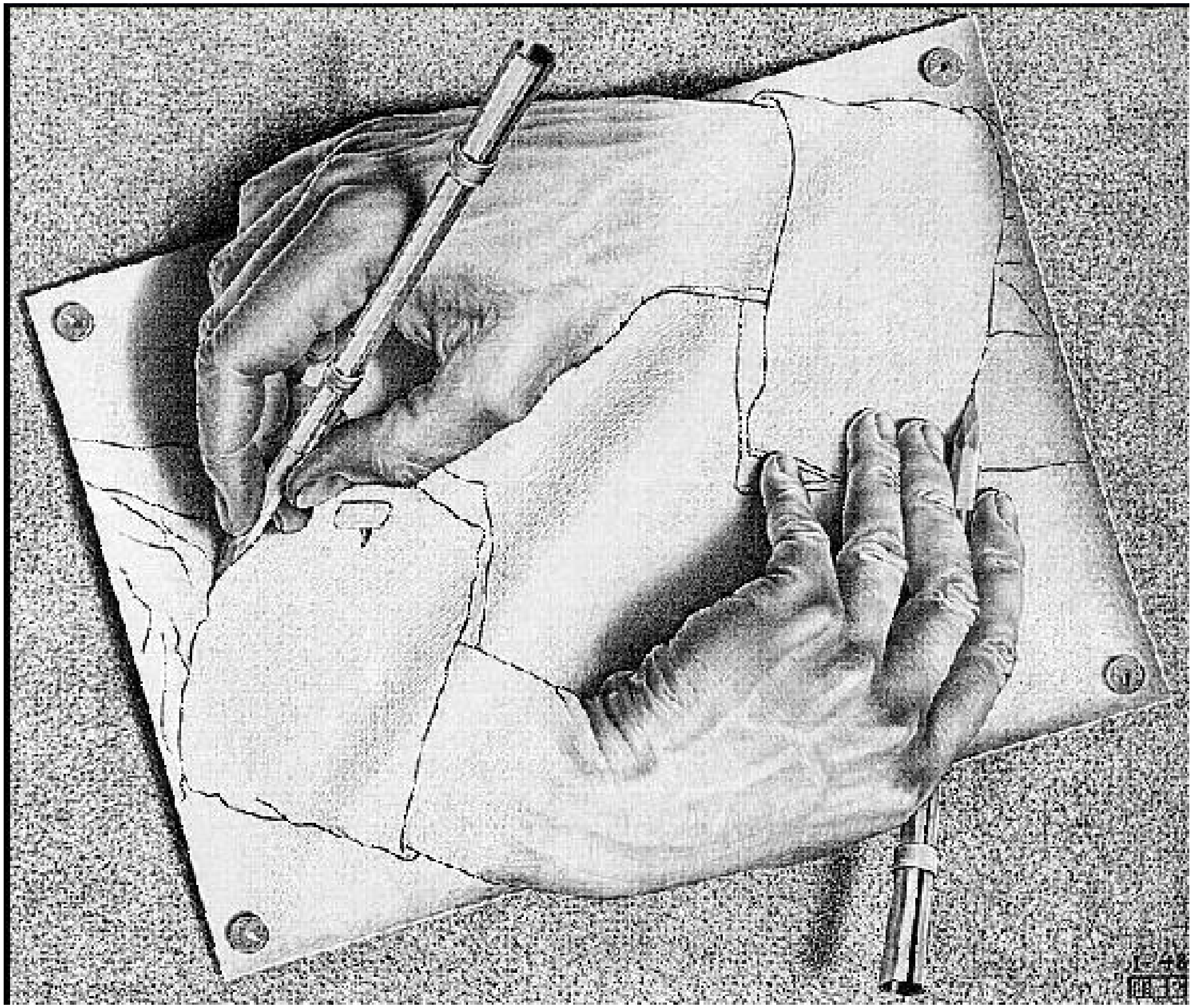
Introductory Remarks

Hasan Padamsee

Where is SRF?
What should we expect?

- State of the art in cavity design
- State of the art in couplers
- State of the art in Eacc, Q
- Gaps in our knowledge
- Gaps in our capabilities
- On-going projects
- Anticipated Projects (10 year)

Cavity Design is a Work of Art and Science
Calling for Imagination, Calculation, Symmetry…..



MC Escher

There are a Variety of Designs from low velocity to velocity-of-light

M. Duchamps,
Nude Descending a Staircase

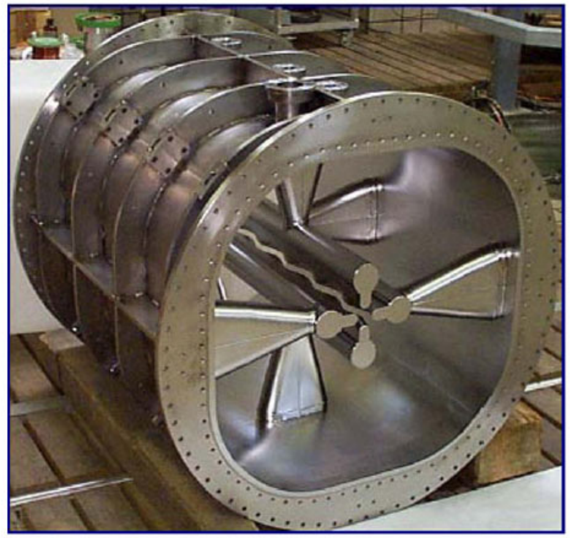
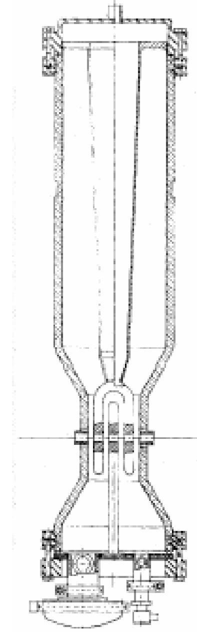
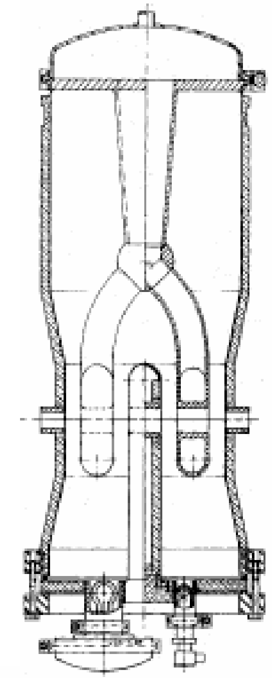
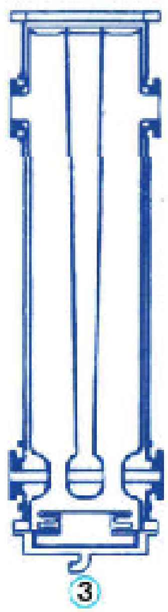
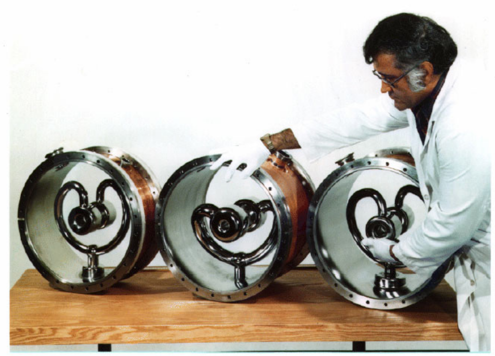


Fig. 2: Photo of SRFQ2 for the heavy ion injector PIAVE.









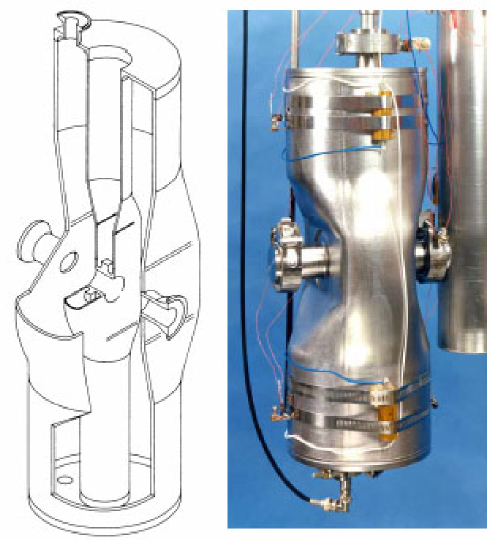
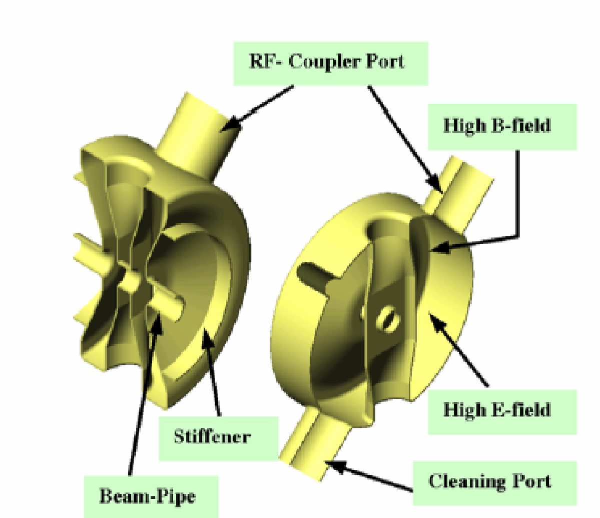
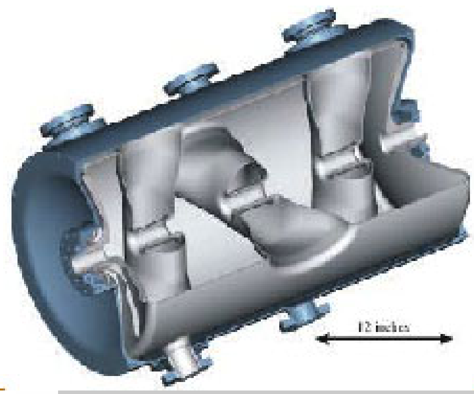


Figure 7: Concept and realization of a 350 MHz, β=0.12 coaxial half-wave resonator [2,23].

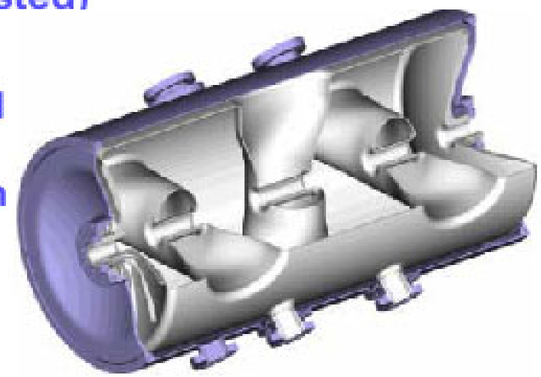
Spokes Everywhere



345 MHz, β = 0.4, double-spoke cavity (built & tested)



345 MHz, β = 0.5 and 0.62, triple-spoke cavities (complete in early 2004))



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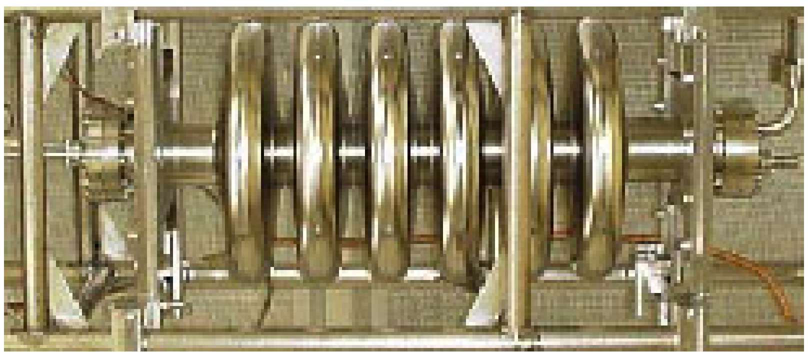
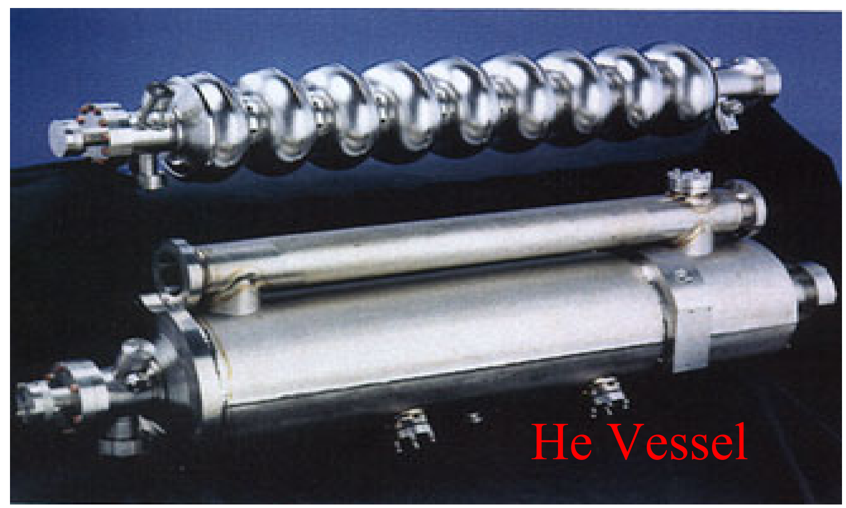
: 10-Gap H-Cavities (700 MHz, β=0.2)

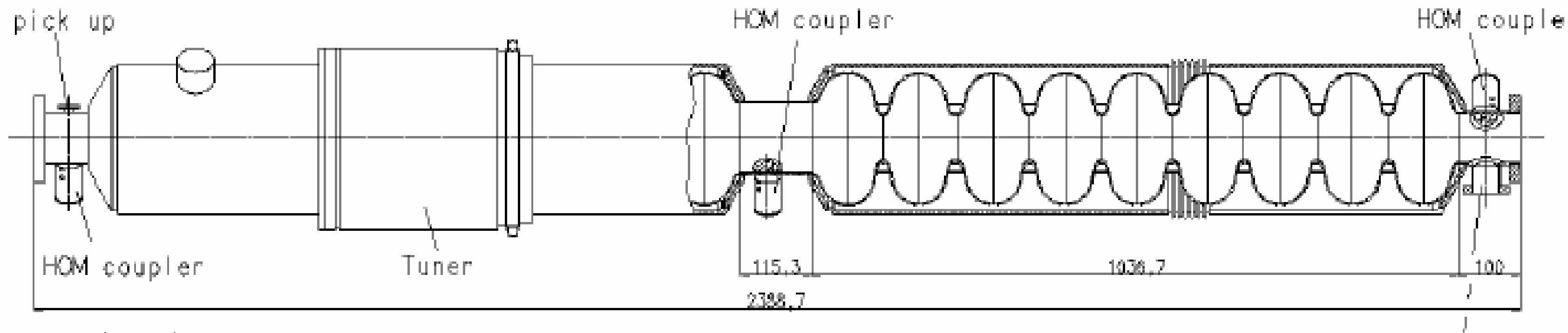
Working Group 2
Ion Accelerating Structures
Intermediate Velocity Cavities

beta = 0.5 -> 1





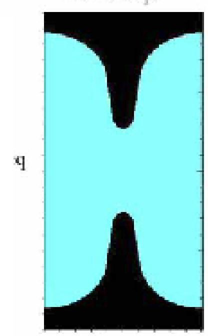
Can We Improve the TESLA Geometry?



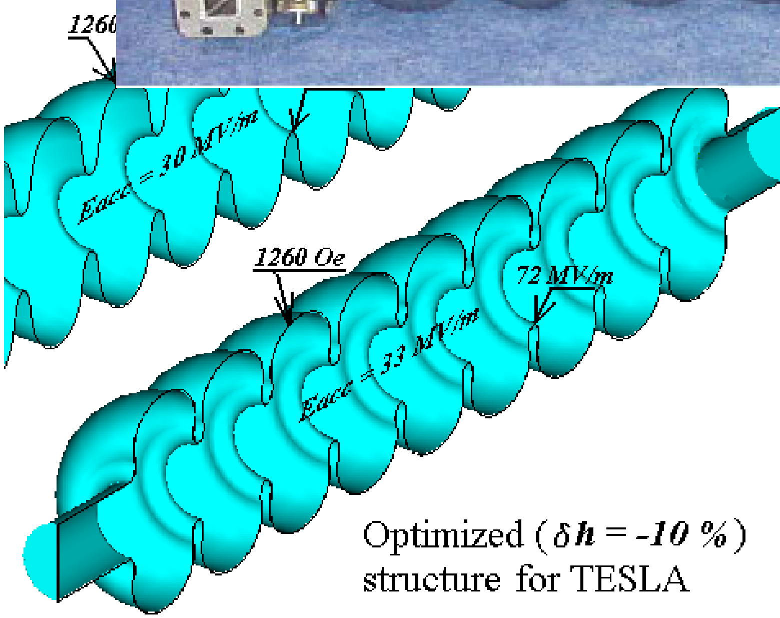
Superstructure

Figure 1: 2x9-cell superstructure

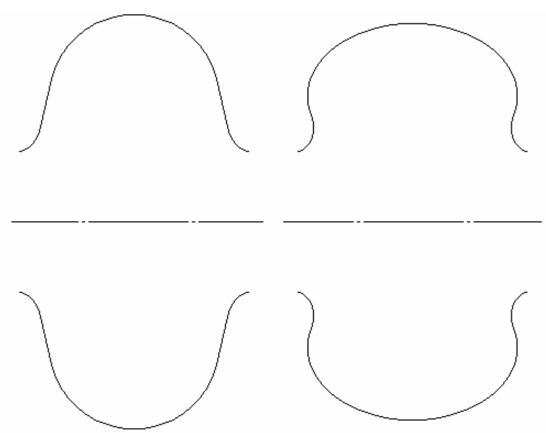
c. LL-shape



Low-Loss

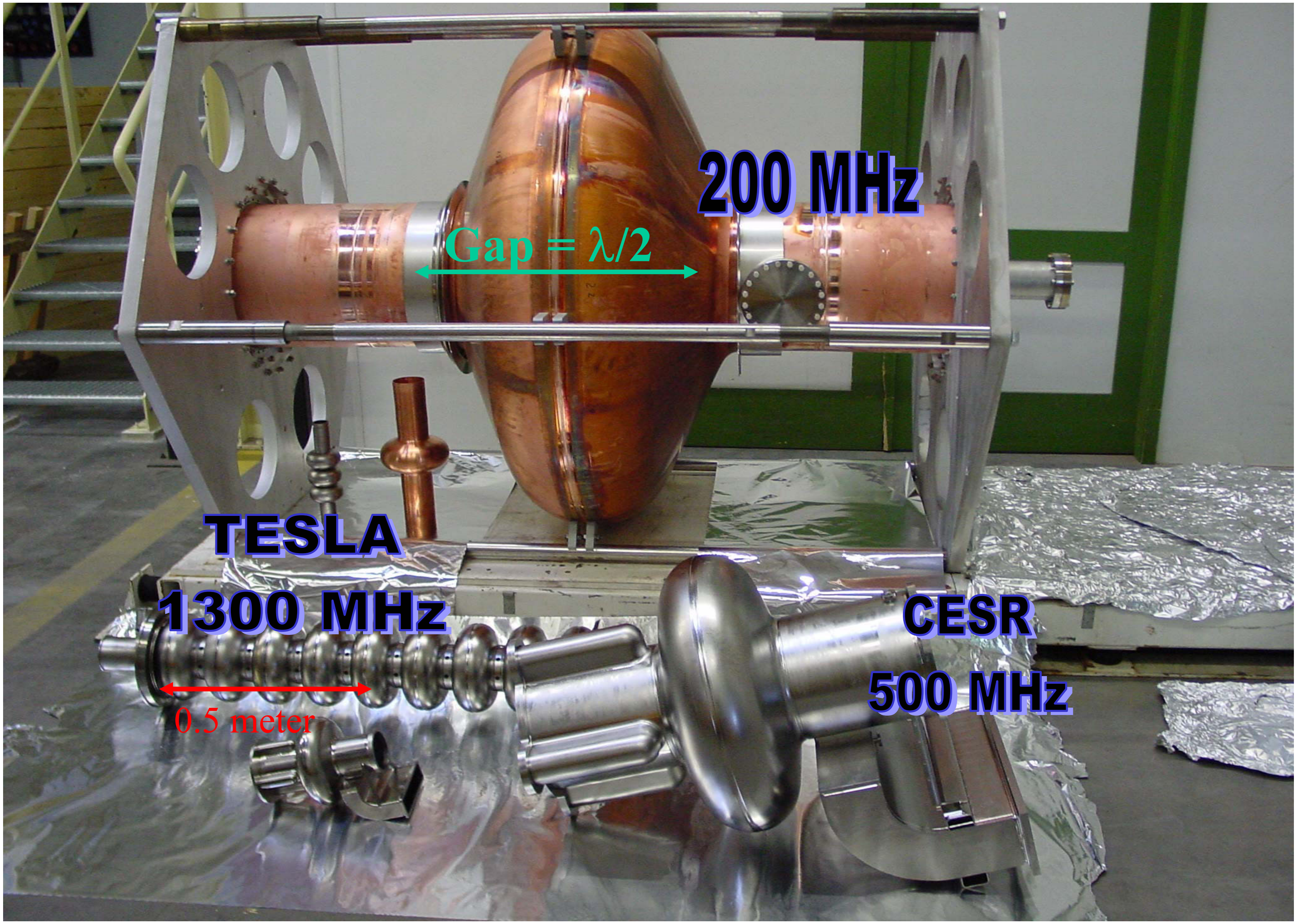


Optimized (δh = -10 %)
structure for TESLA



Re-entrant

A Broad Range of Frequencies



Deflecting Cavities

TM110 Mode

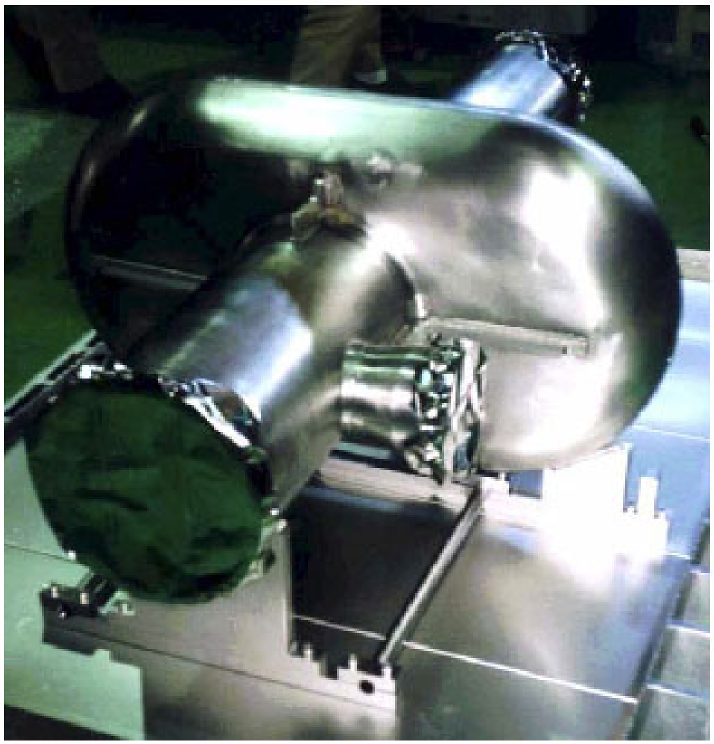
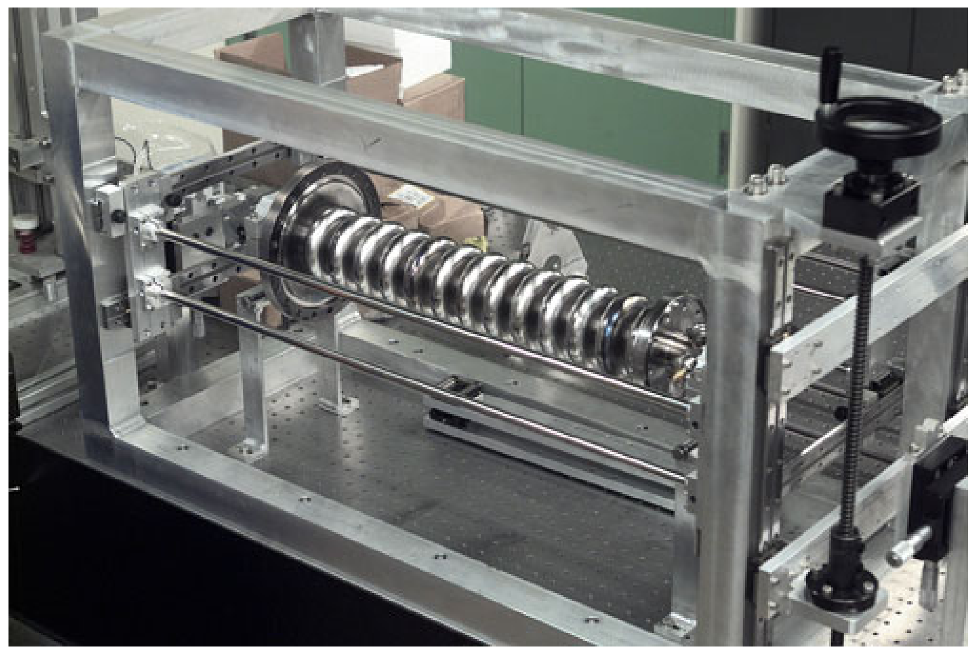
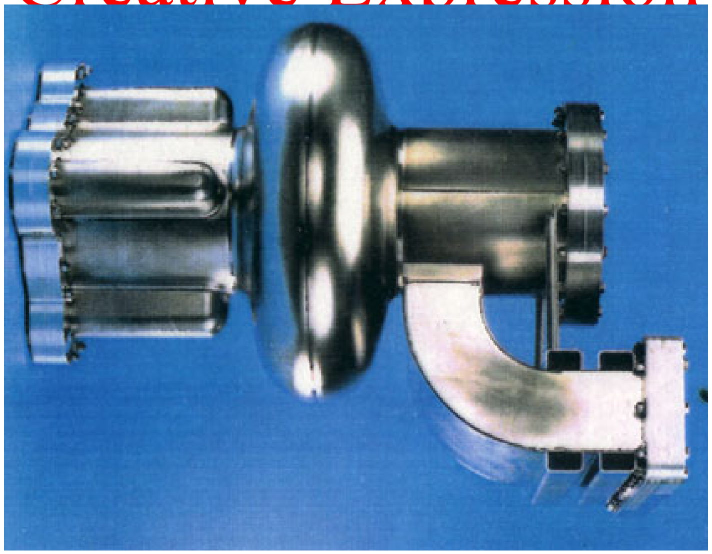


Figure 5: A photo of a KEKB sc crab cavity.



Couplers, Tuners and Cryomdules: More Room for Creative Expression

Girl with a Mandolin
(Pablo Picasso, 1910)



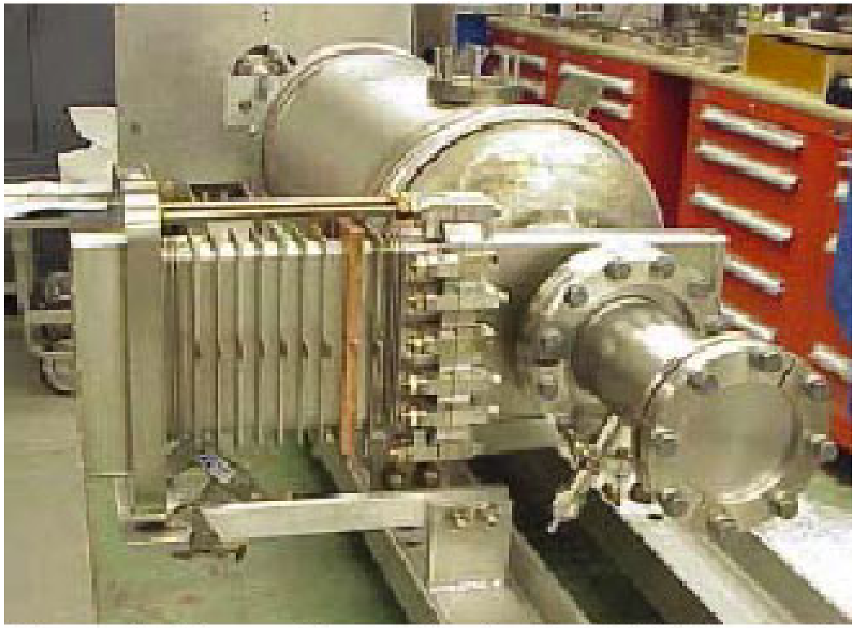


Figure 5. Waveguide coupler for the CEBAF upgrade

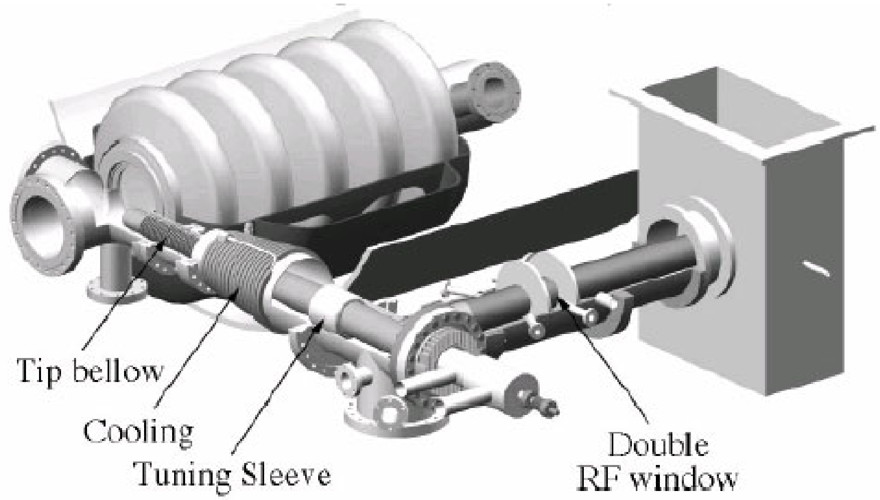
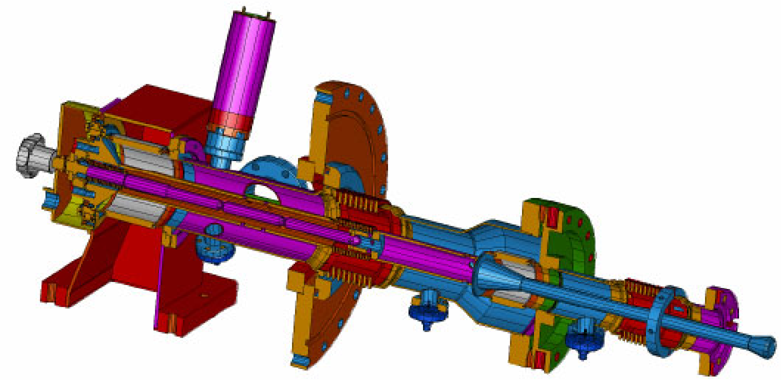


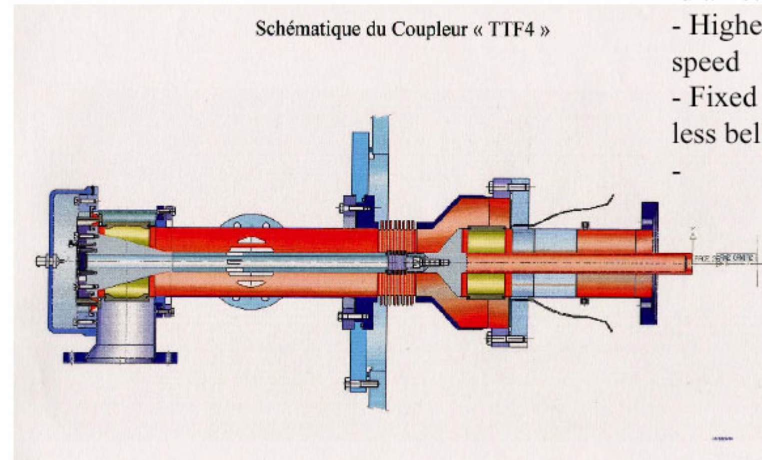
Figure1. The fundamental power coupler for the APT

TTF 3 coupler



TTF 4 coupler

- Coax diameter = 80 mm
- Higher pumping speed
- Fixed coupling, less bellows
-



Wolf-Dietrich Möller, DESY, Hamburg — Workshop on High-Power Couplers for SC Accelerators, JLab, 2002

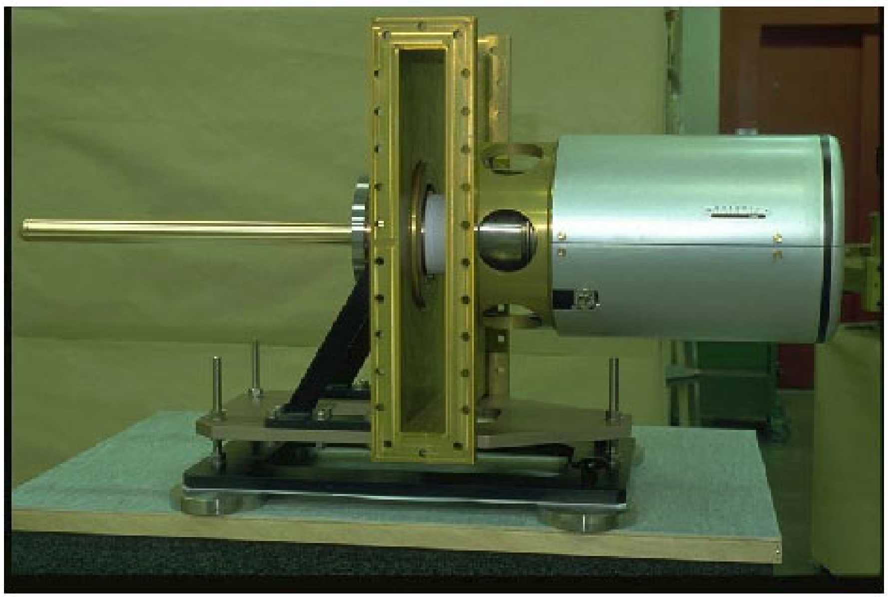
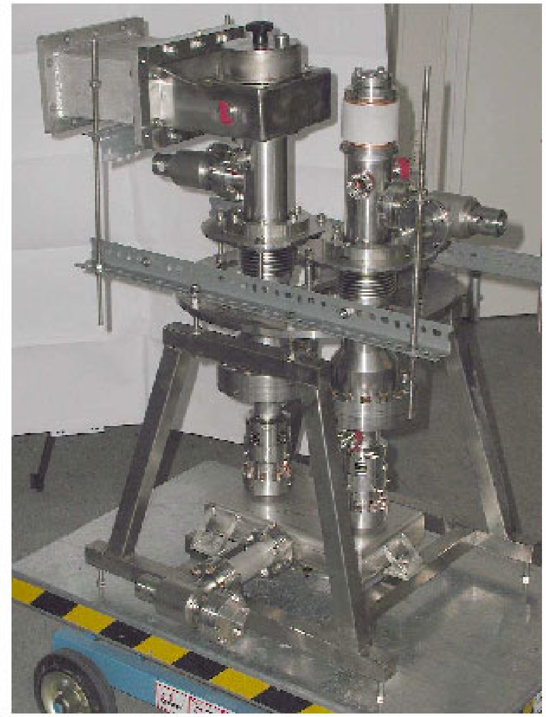


Figure 2. Variable coaxial coupler for the LHC. The

otype input couplers.



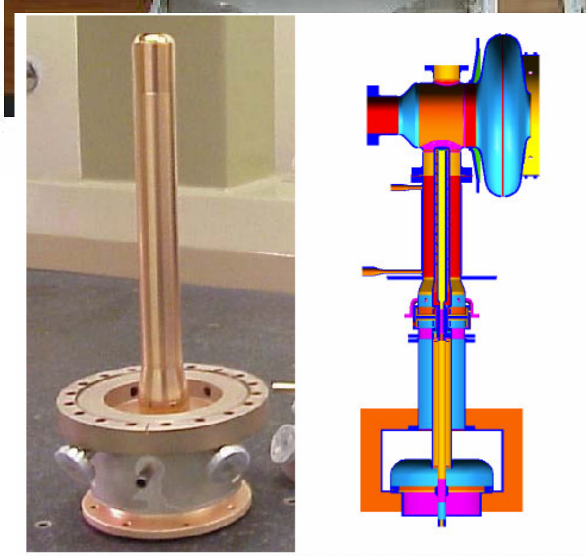
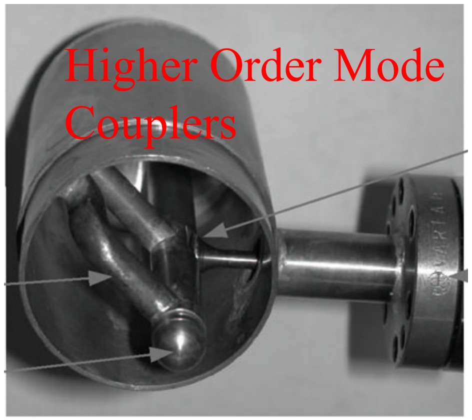
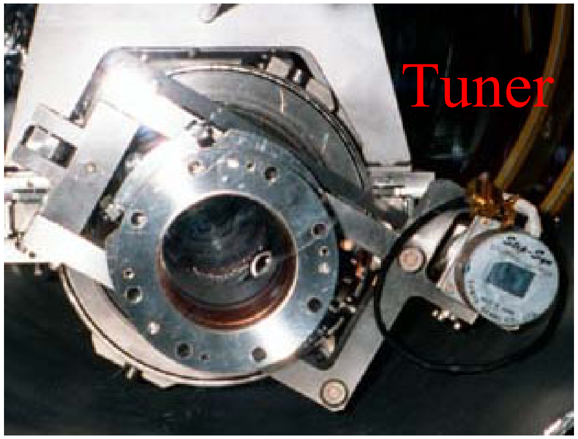
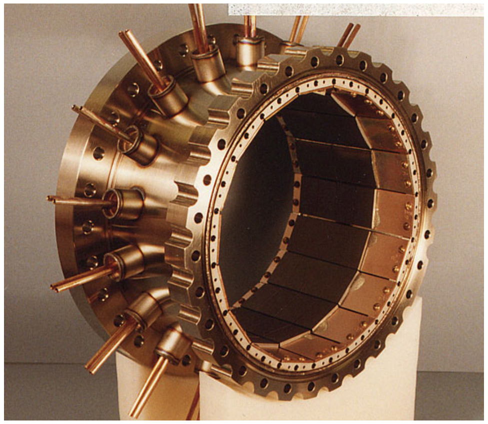


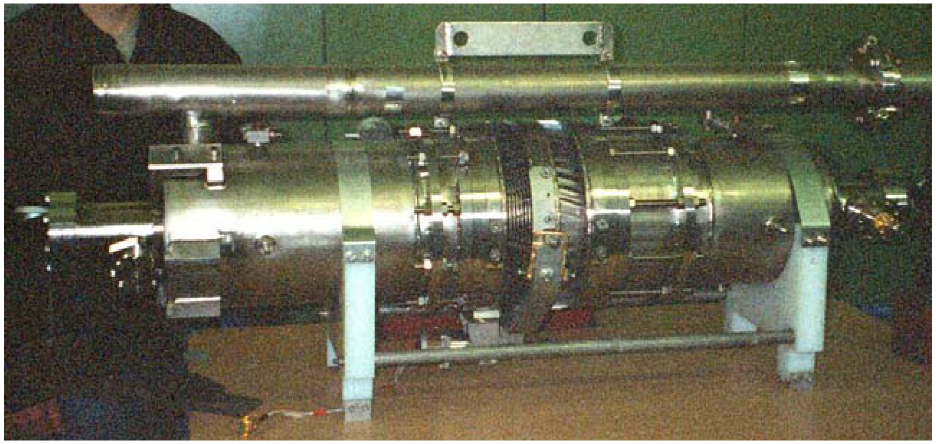
Figure 12. The SNS coupler is based on a modification of the KEK-B coupler. The window matching design has

HOM Couplers, Tuners









WG 3
Couplers, Tuners and Piezo Compensation

Cryomodules, Low beta

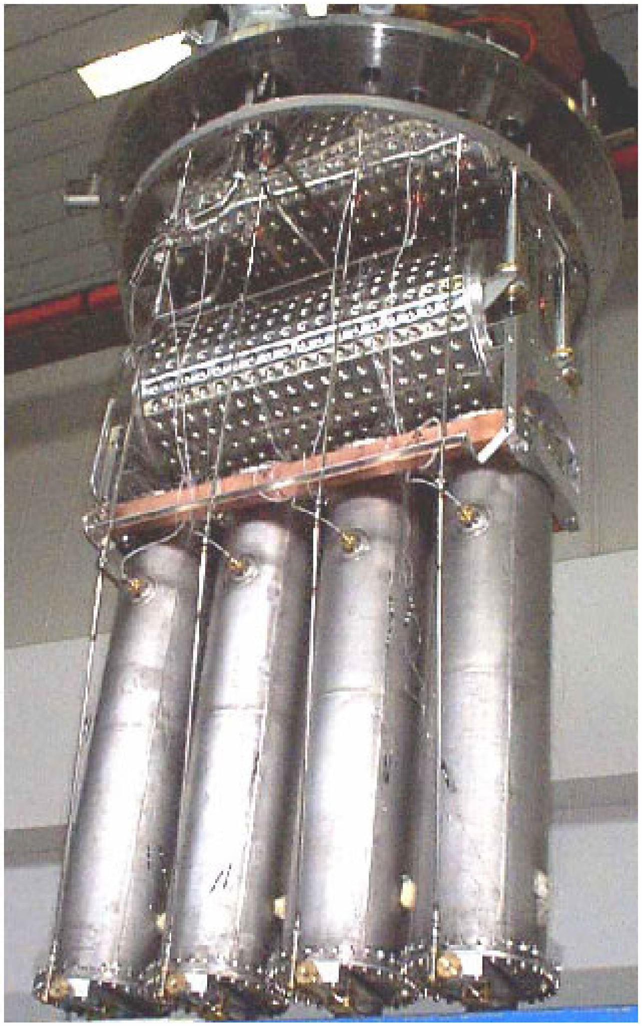
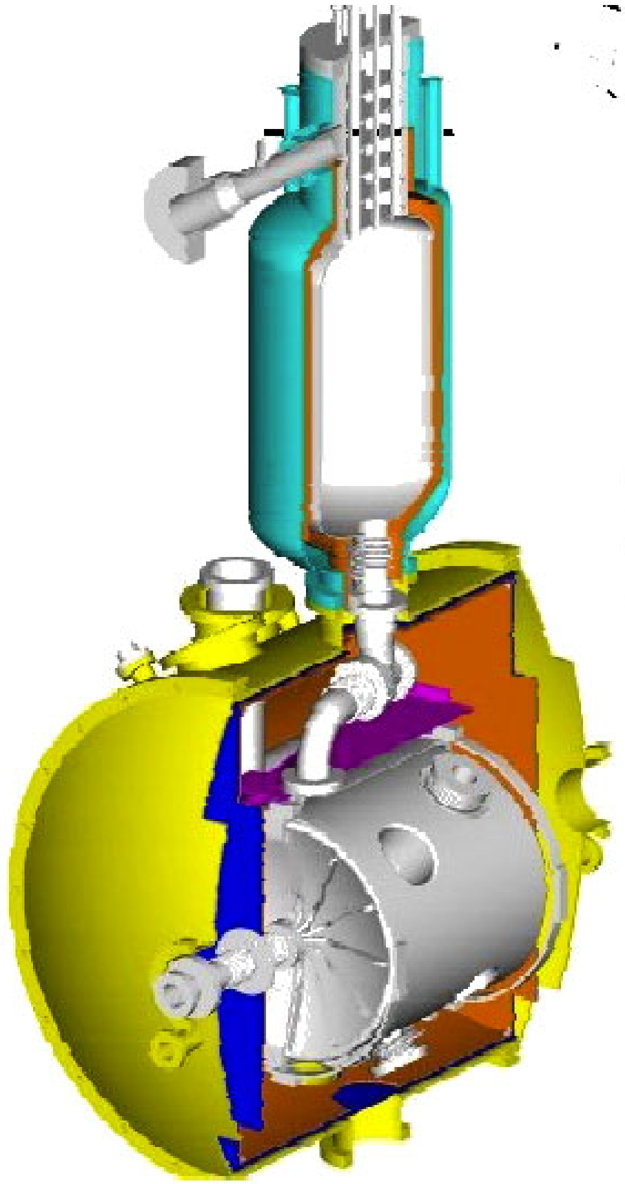


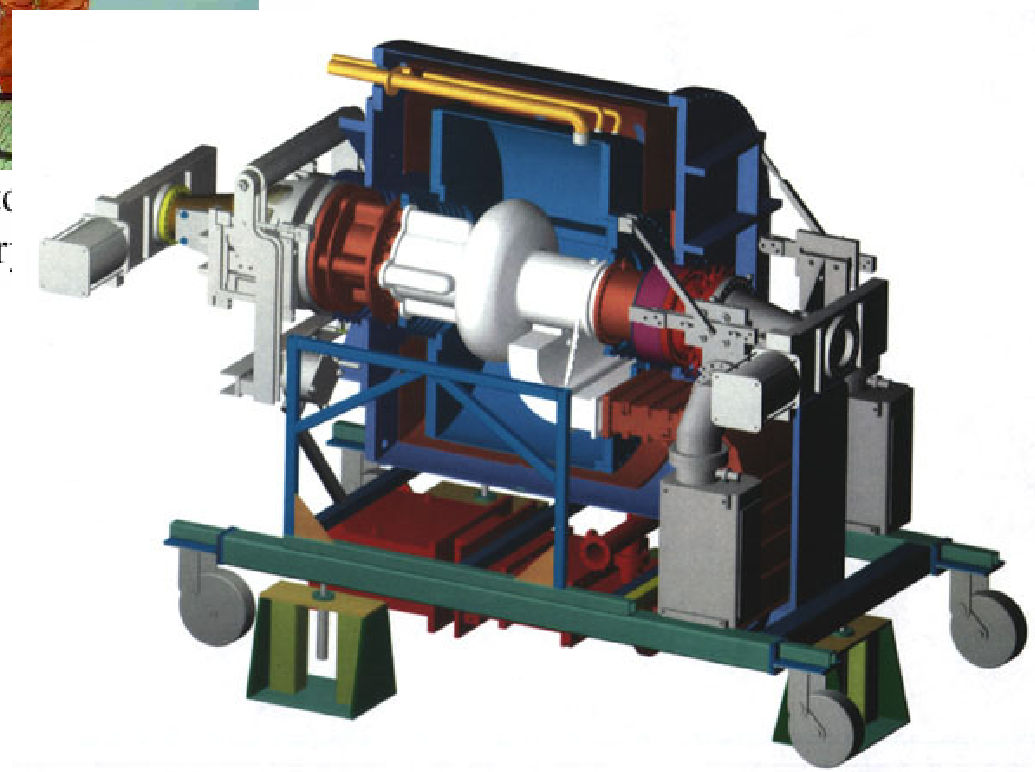
Fig 6: The cryostat top flange with four low β, 80 MHz Bulk Nb resonators.

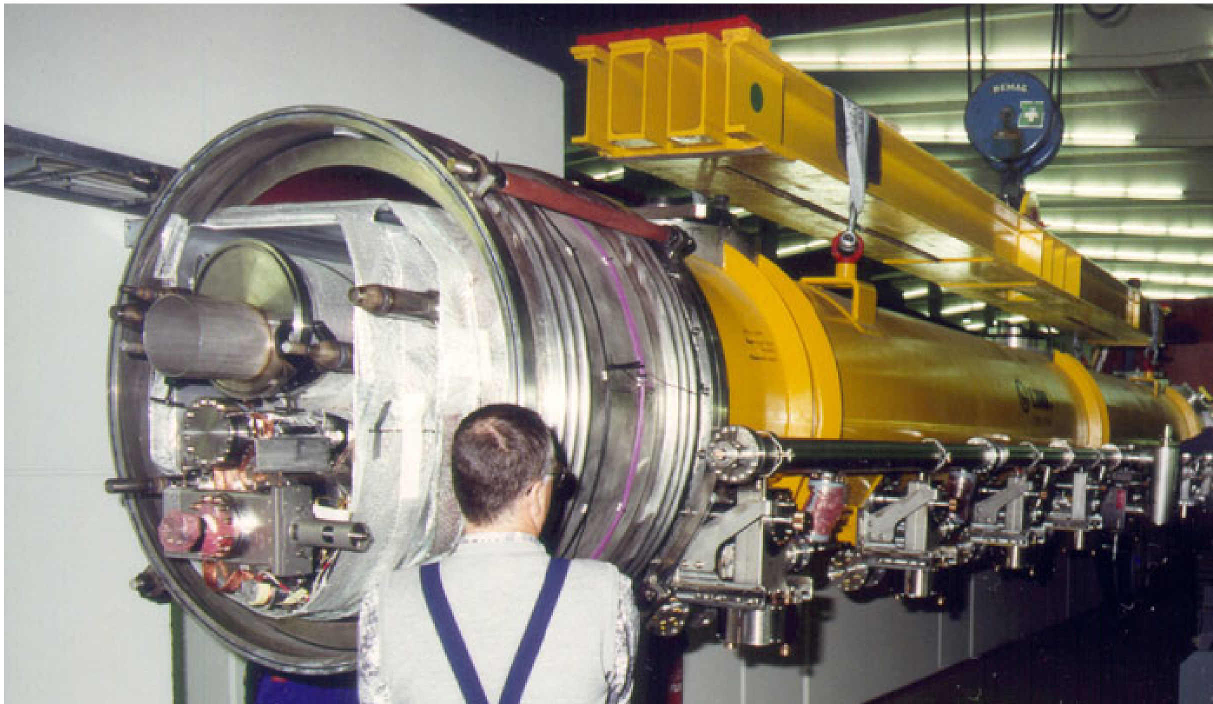


3.1 SOLEIL

Cryomodules, high beta

Figure 3: CEA and CERN staff working tc
CERN clean room on the SOLEIL cr



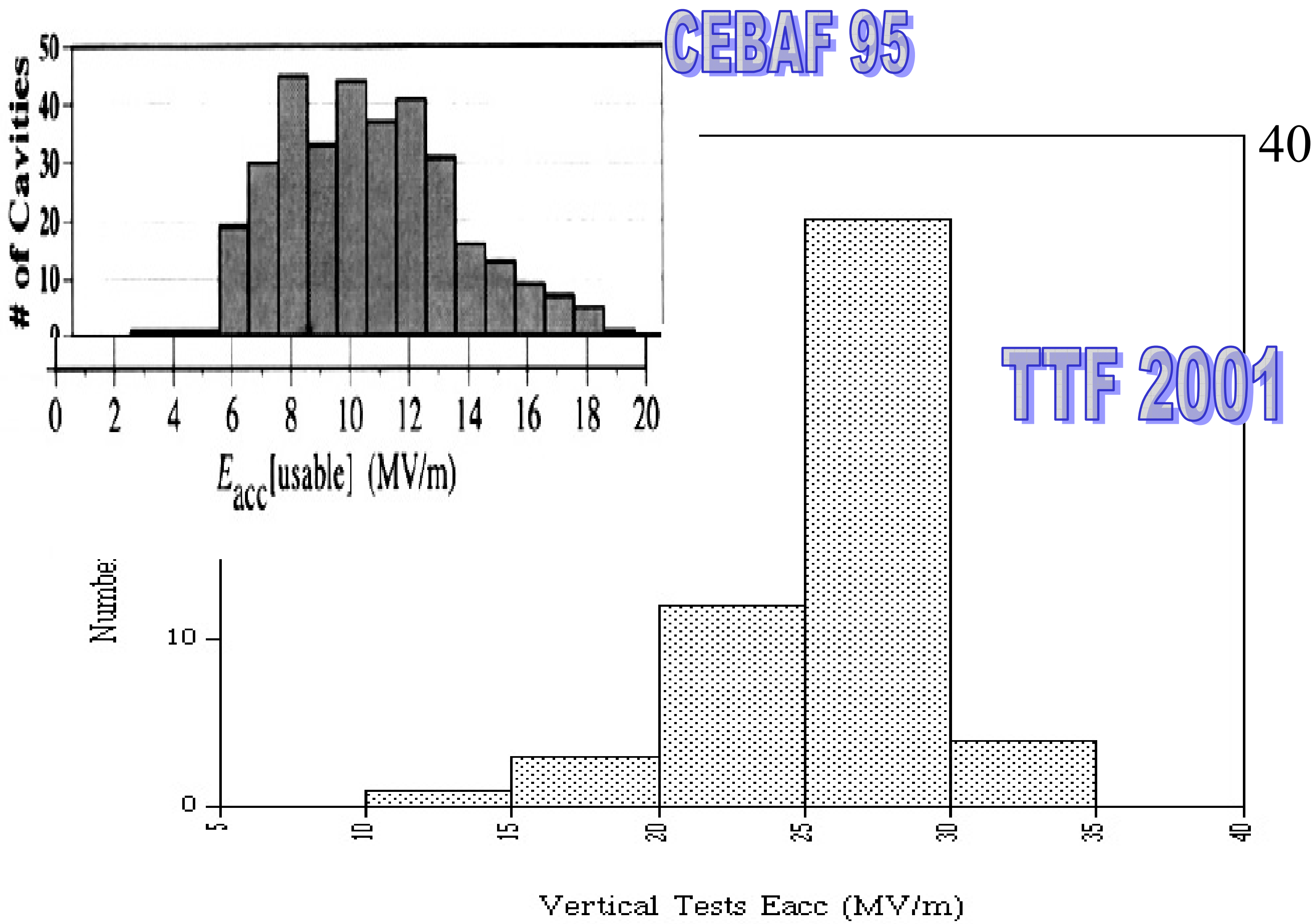


How to run cryomodules
CW at Ea > 20 MV/m ?
E.g. $Q = 10^{10} \Rightarrow P = 40$ W/m

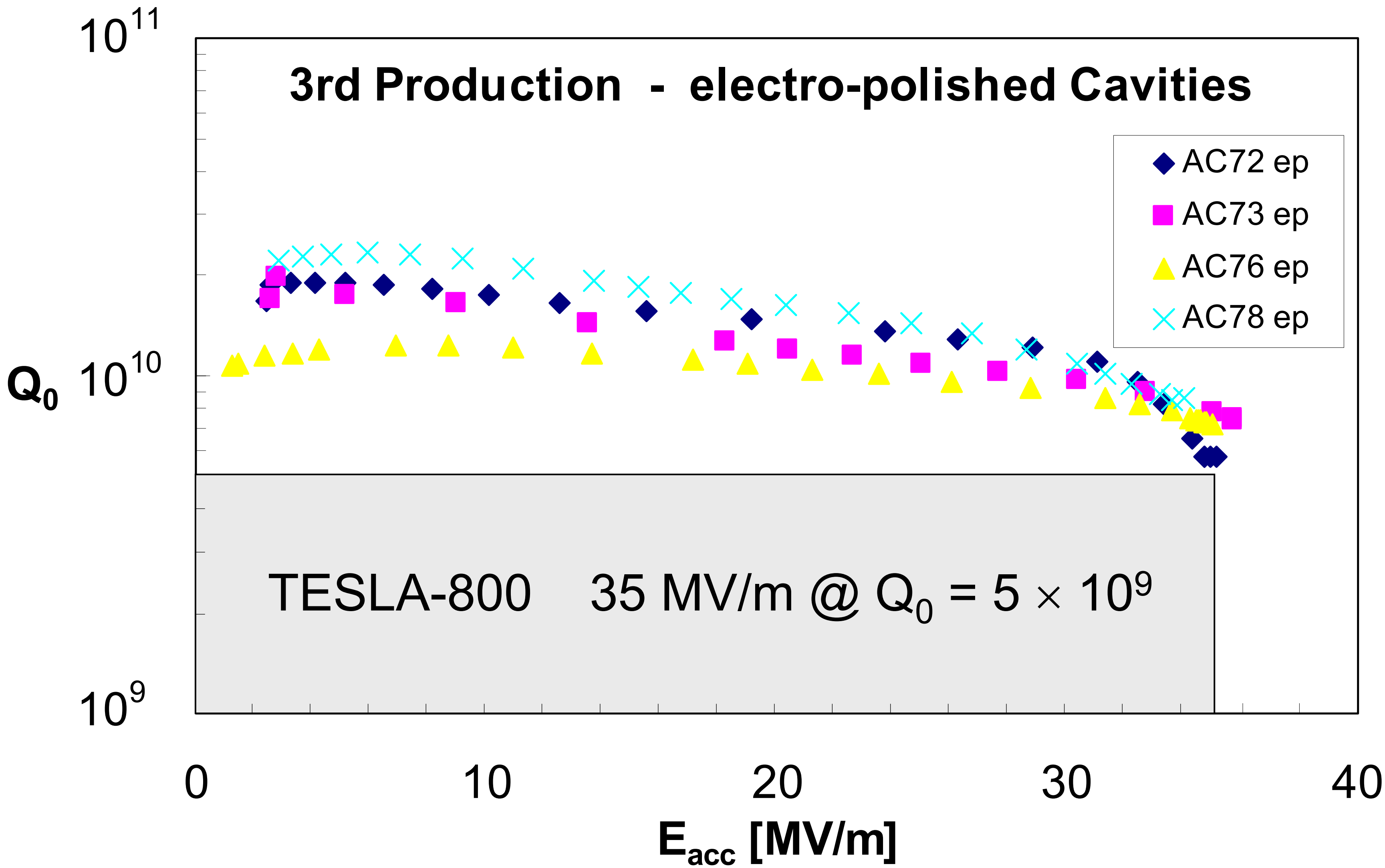
Working Group 4

Figure 1: The first LHC module ready for measurements.

Gradients, State of the Art

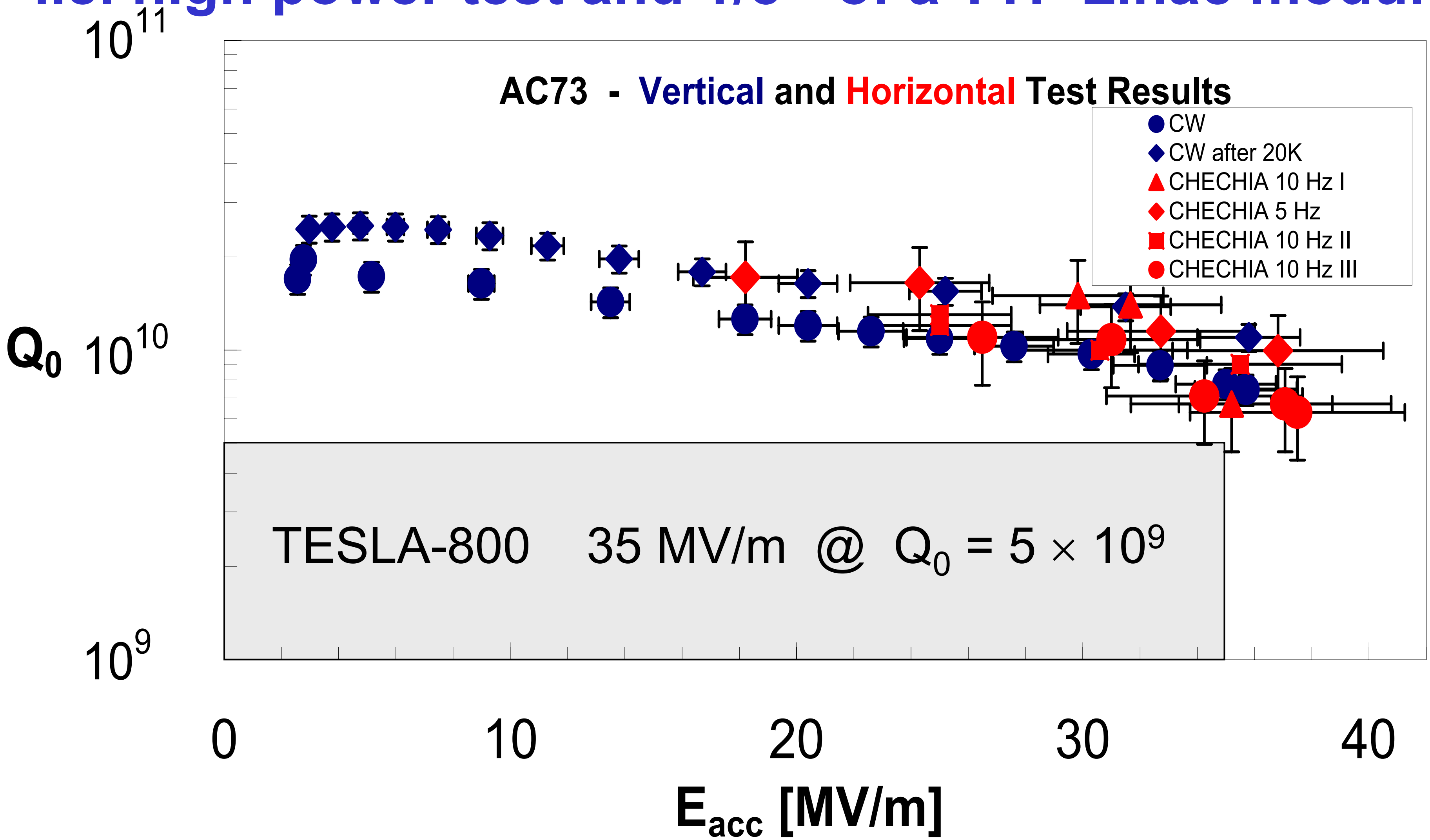


Highest Gradient Performance



More than 35 MV/m in CHECHIA

i.e. high power test and 1/8th of a TTF Linac module



Single Cell Record

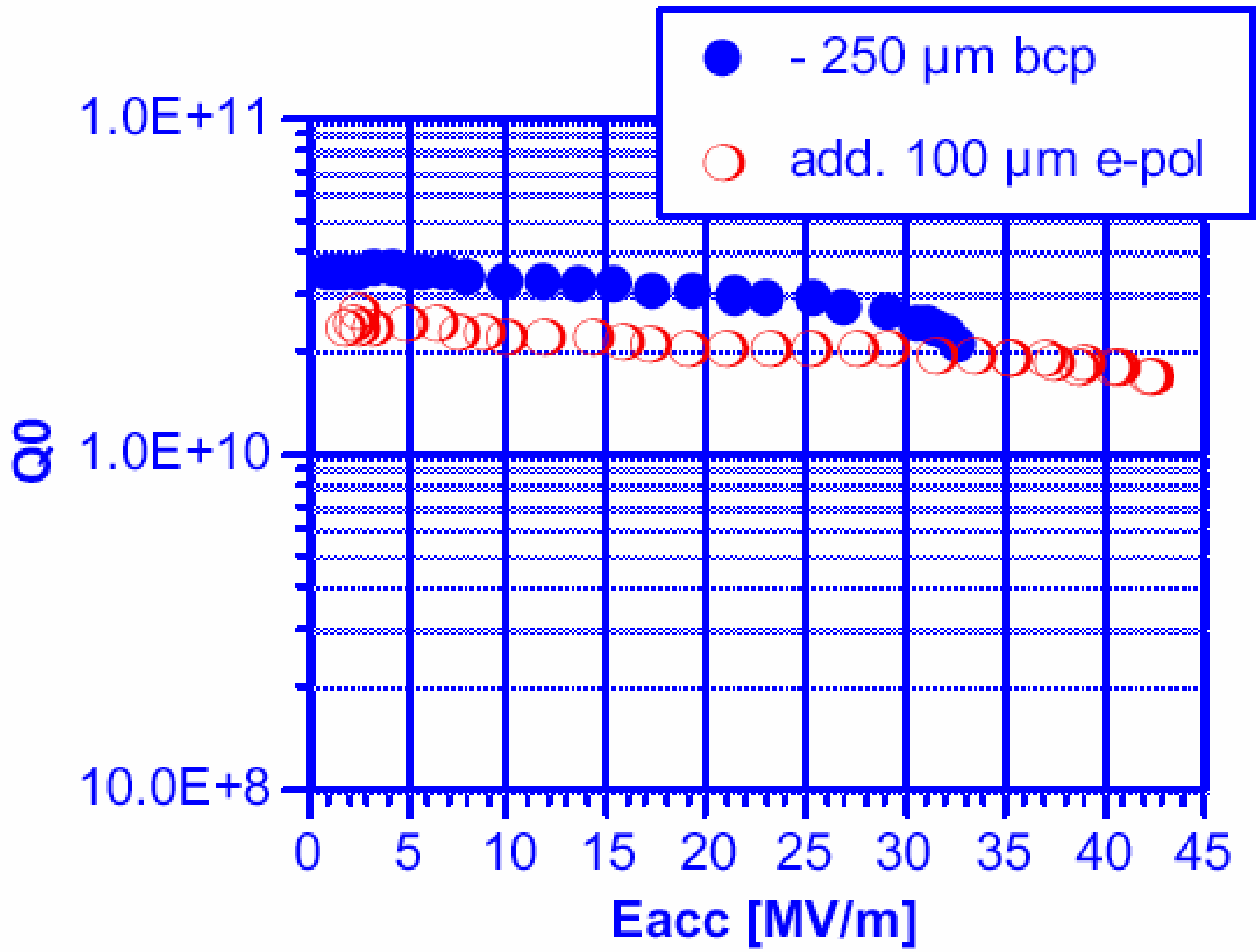


Figure 4: Q vs Eacc for cavity 1K2 after Buffered Chemical Polishing BCP and Electropolishing EP.

Record Q

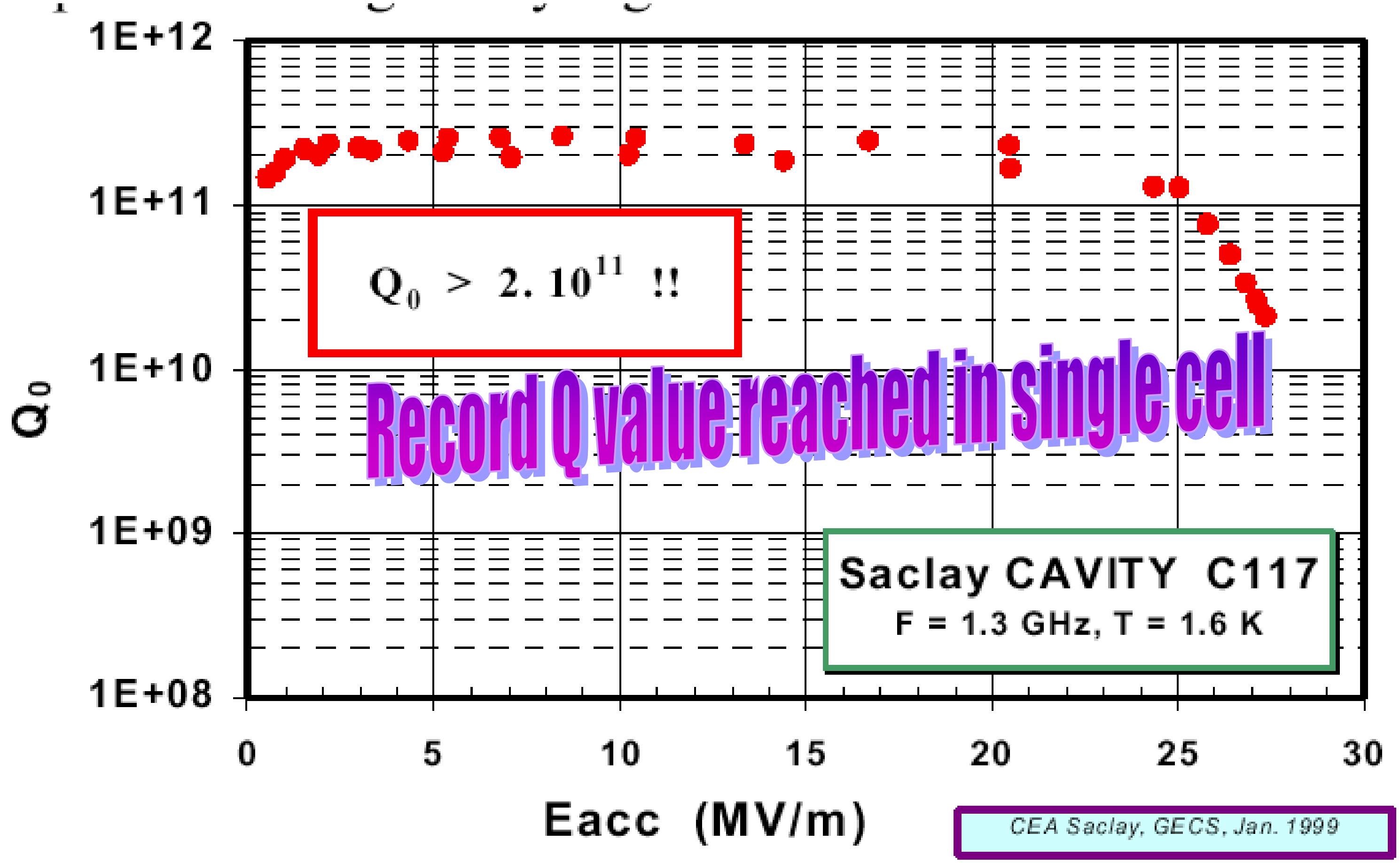
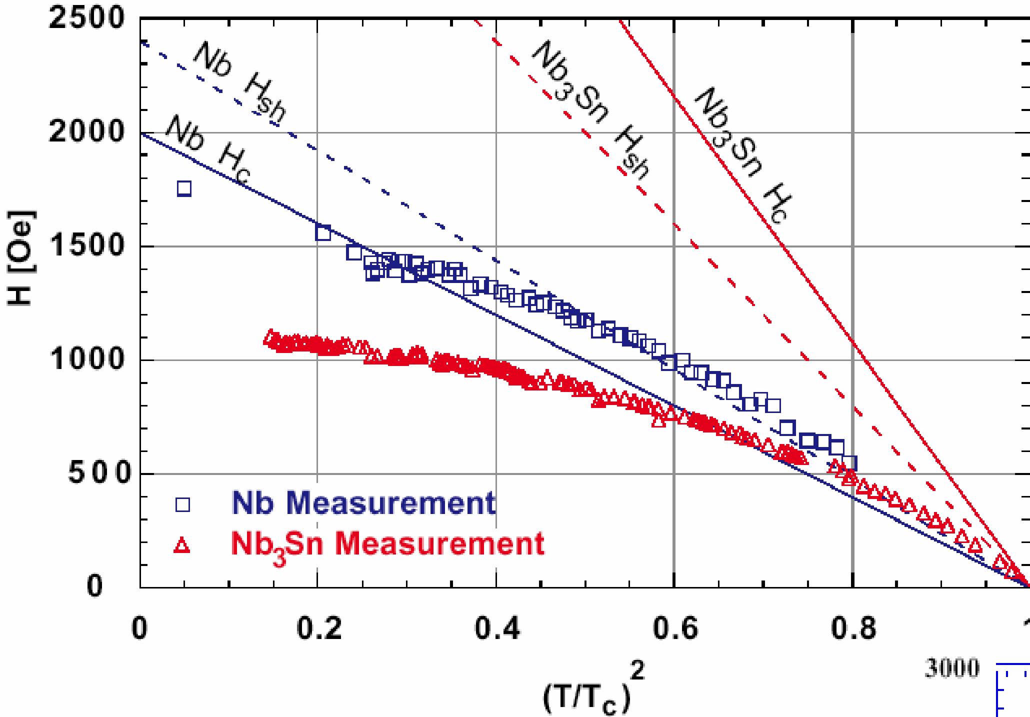


Figure 2 – Residual resistance as low as 0.5 nΩ is actually measured on large area cavities, giving an intrinsic quality factor Q_0 exceeding 2.10^{11}.

Gaps in Knowledge, WG 1

- What is the limiting field for Nb? 50? 40 MV/m?
- What is the cause of high field Q-slope in Nb?
- Why does high-field Q-slope decrease with EP and baking?
- Is field emission completely under control?
- What is the cause of general Q-slope in Nb-Cu?
- Are there materials with higher capability than Nb?



Theoretical Critical RF Magnetic Field ?

What is the limiting field for Nb?
50? 40 MV/m?

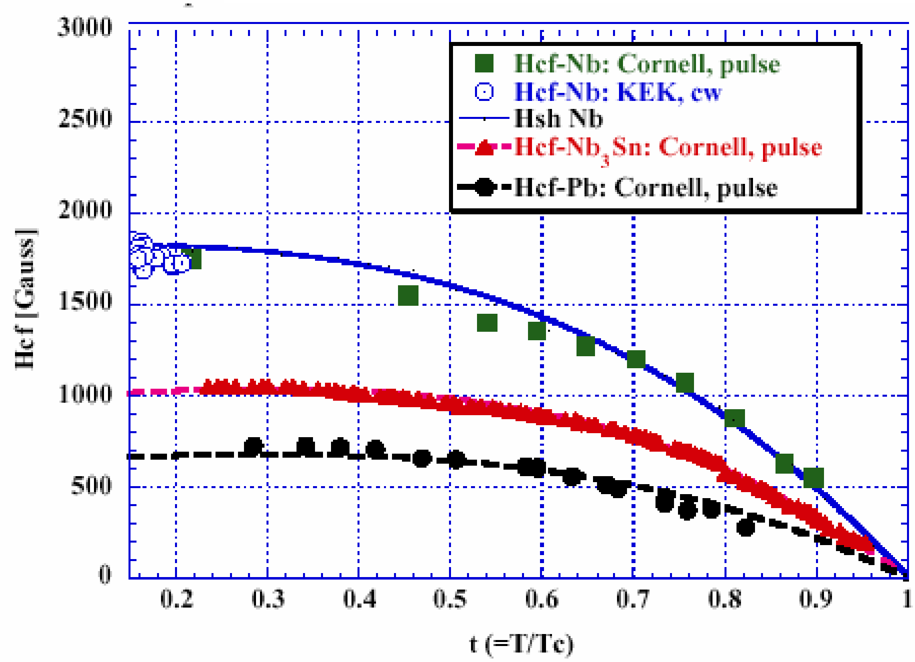
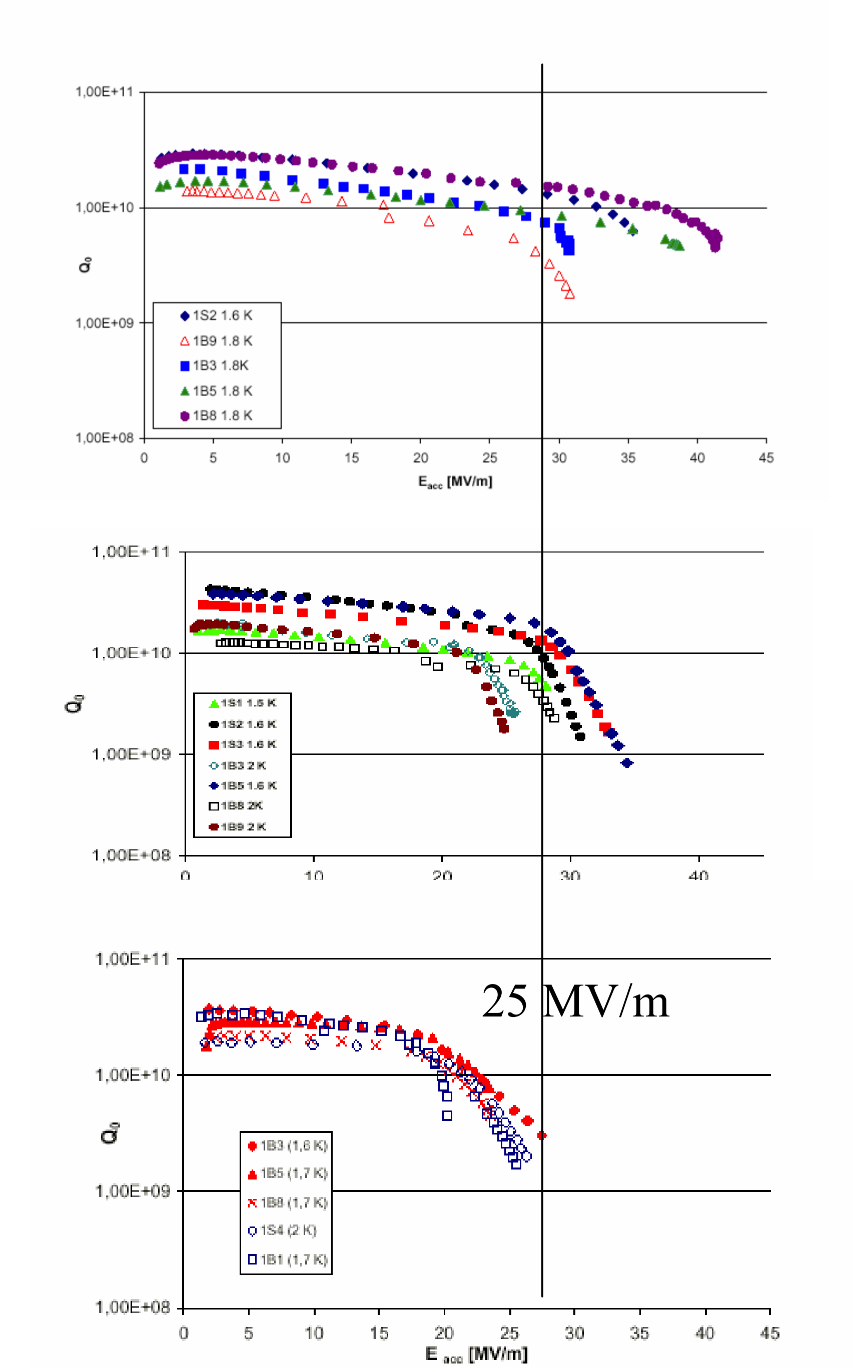


Figure 10: Critical RF fields (Hcf) of sc cavities and Hsh.

EP + 100 C
Bake

EP
cavities
show less
Q-Slope

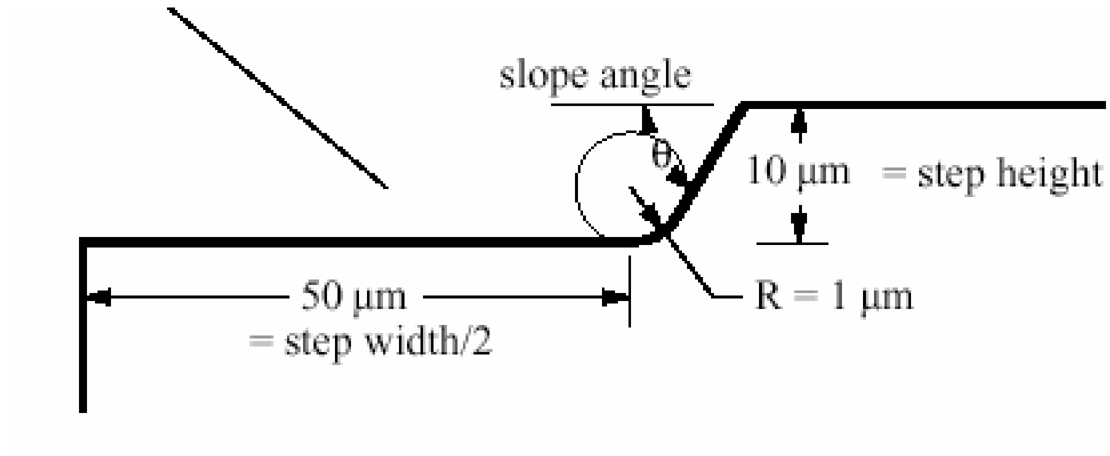
BCP

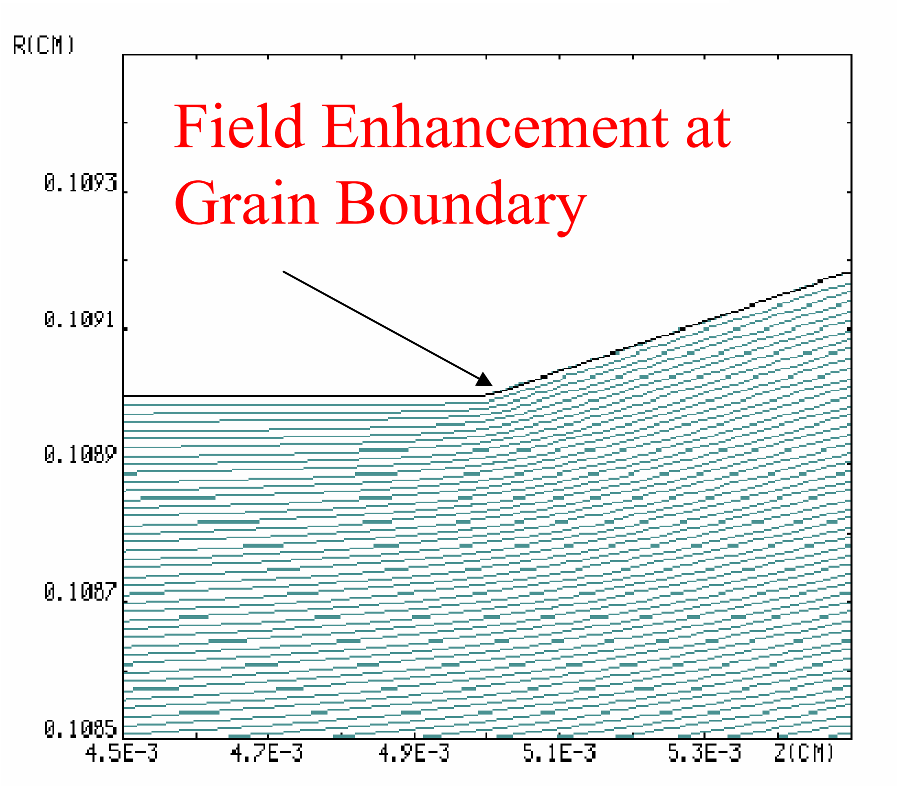


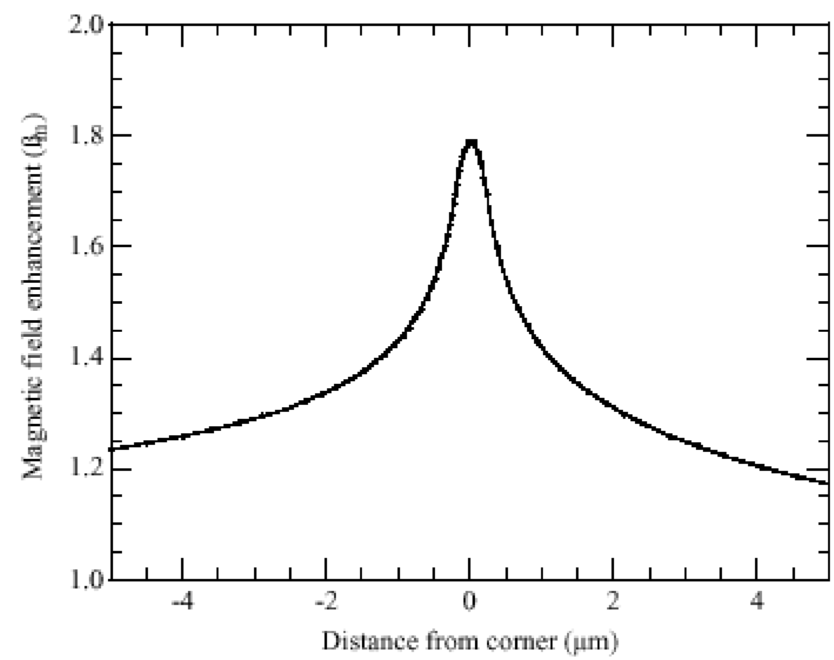
CERN/DESY
Results

What is the
cause of high
field Q-slope
in Nb?

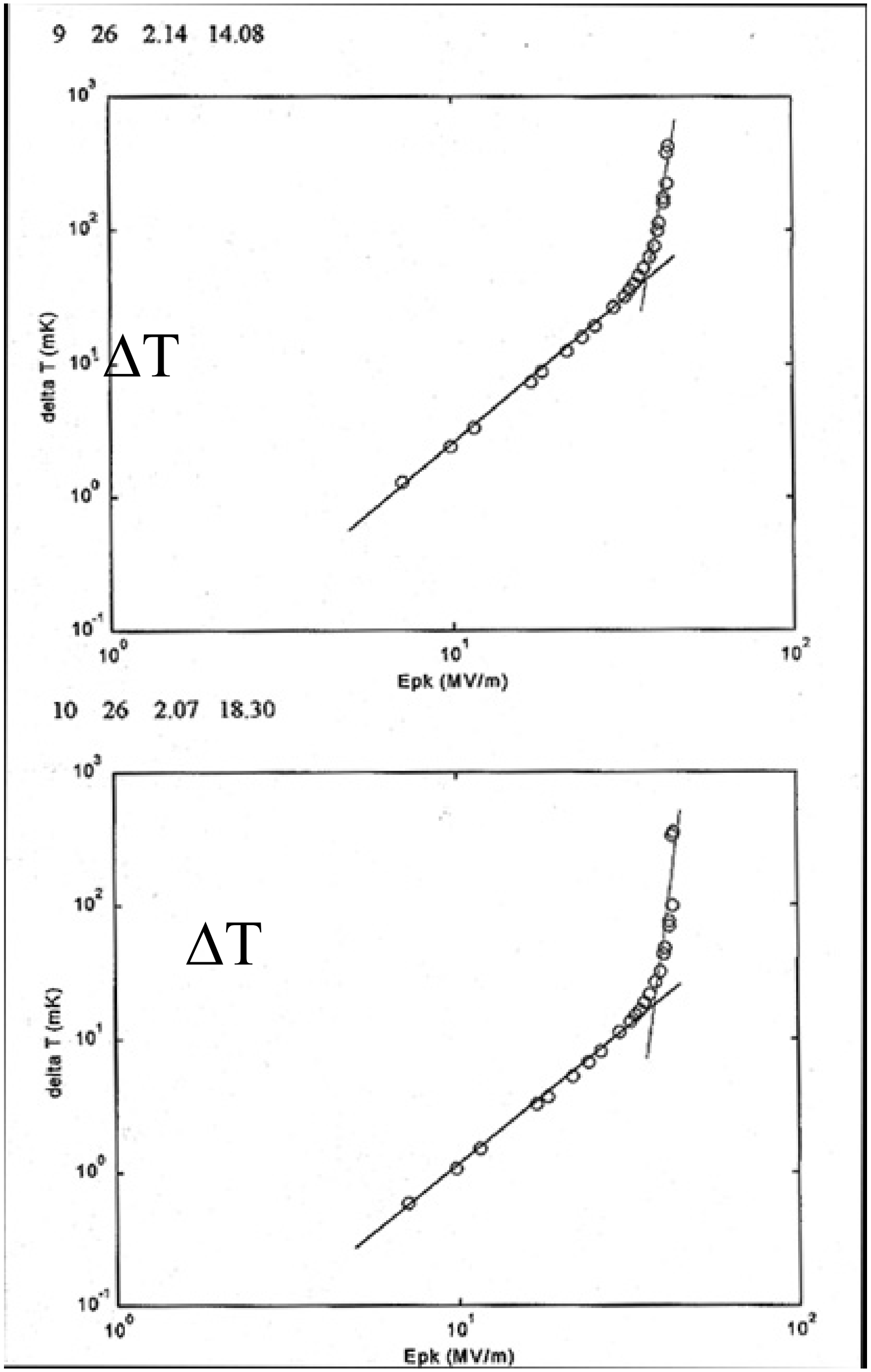
Is it grain boundary field enhancement?







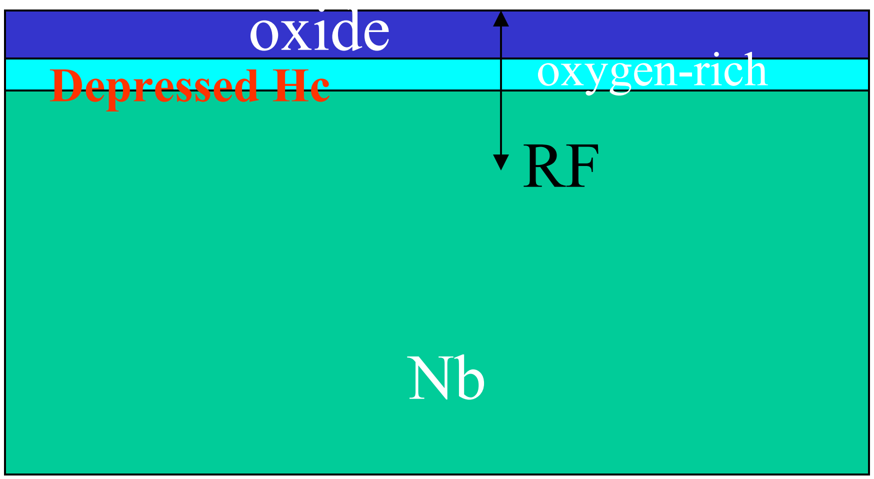
Knobloch et al



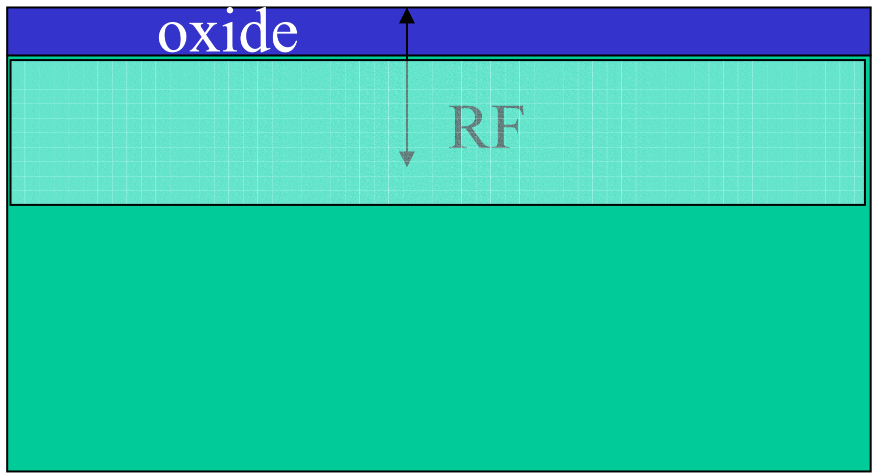
Local Transitions Observed
In temperature maps

Why does high-field Q-slope decrease with baking?
Is it oxygen pollution?

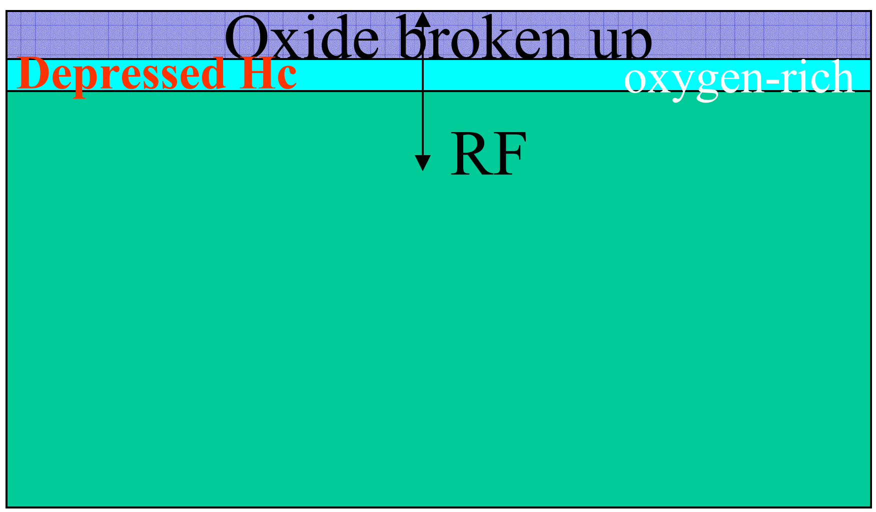
Saclay Model

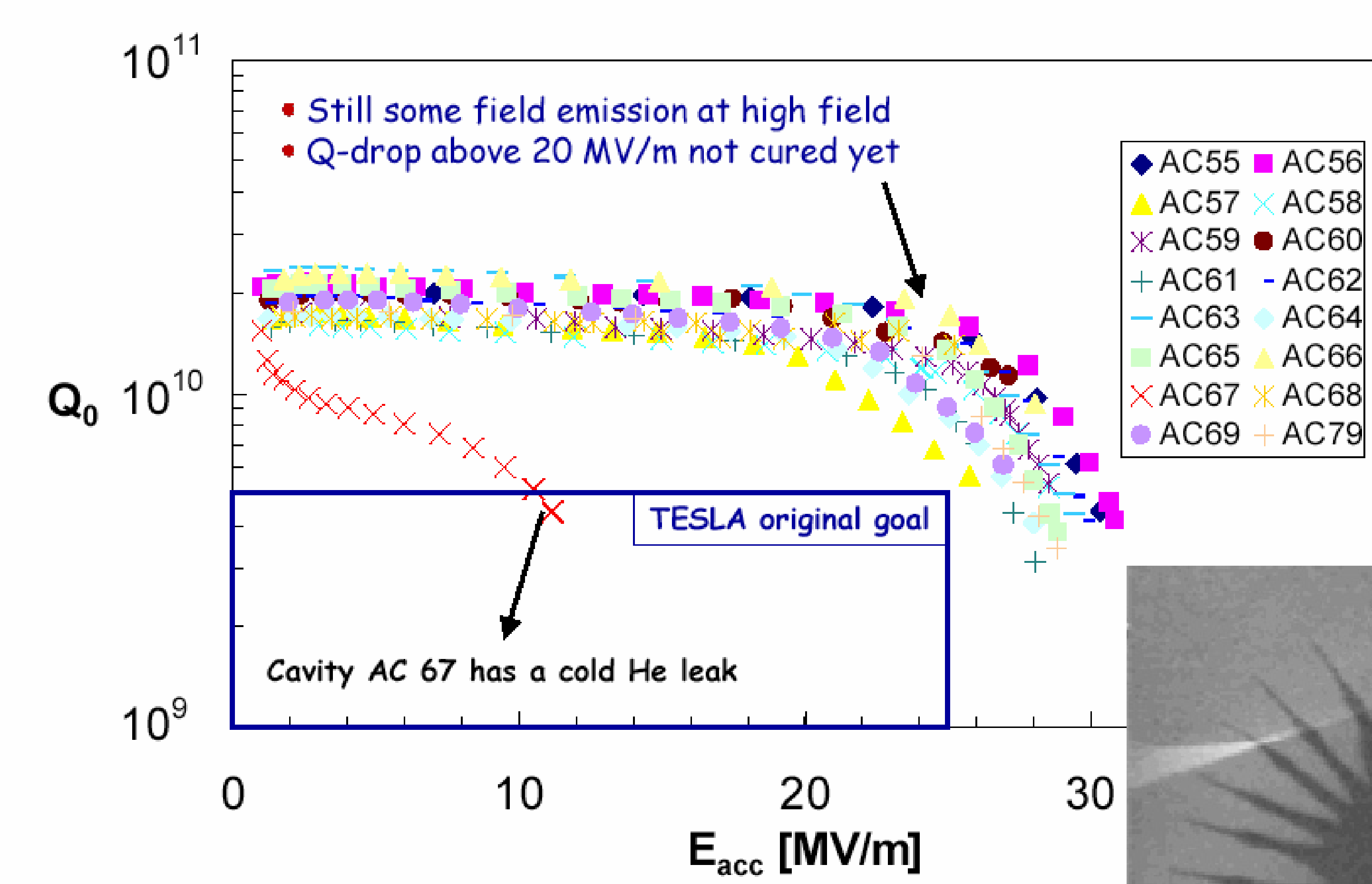


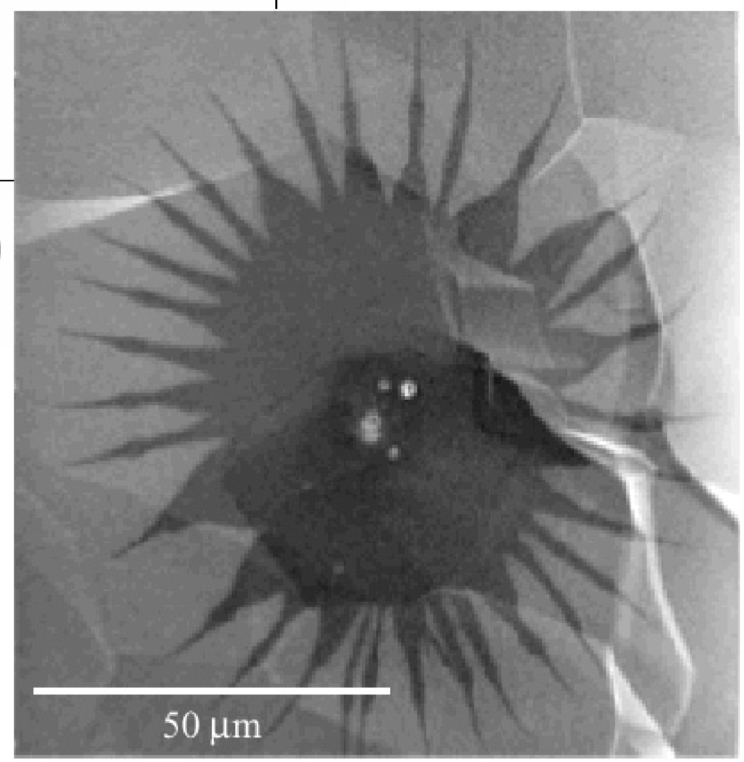
100 C, 48 hours



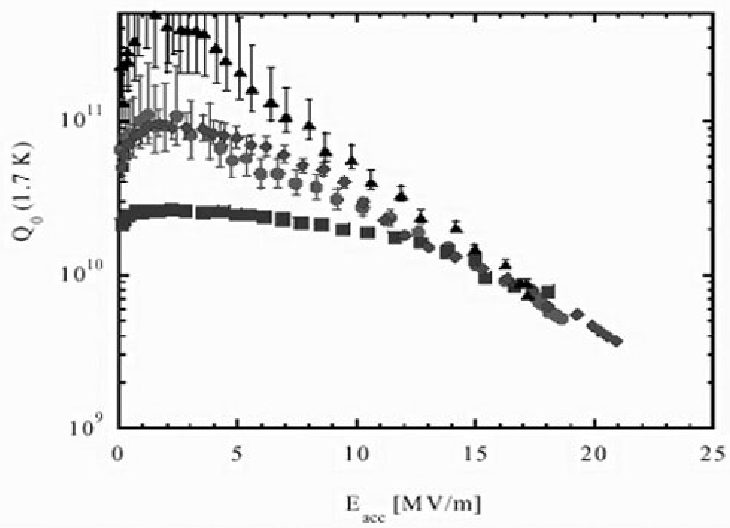
150 C,
48 hours



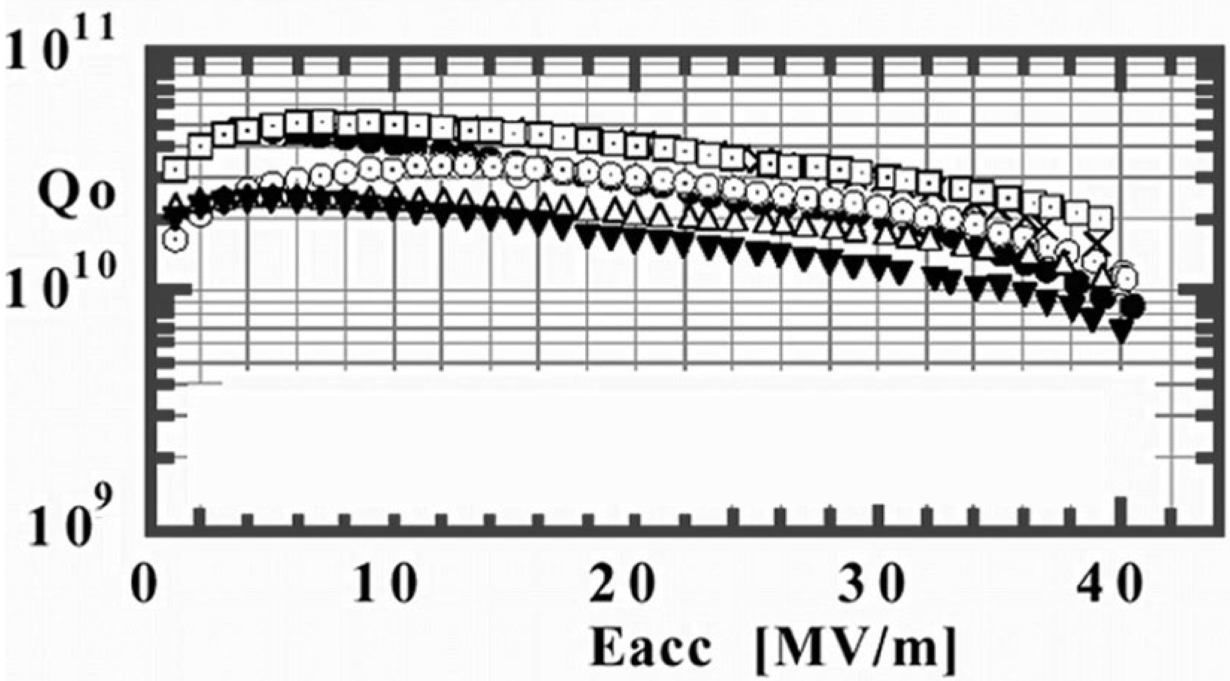




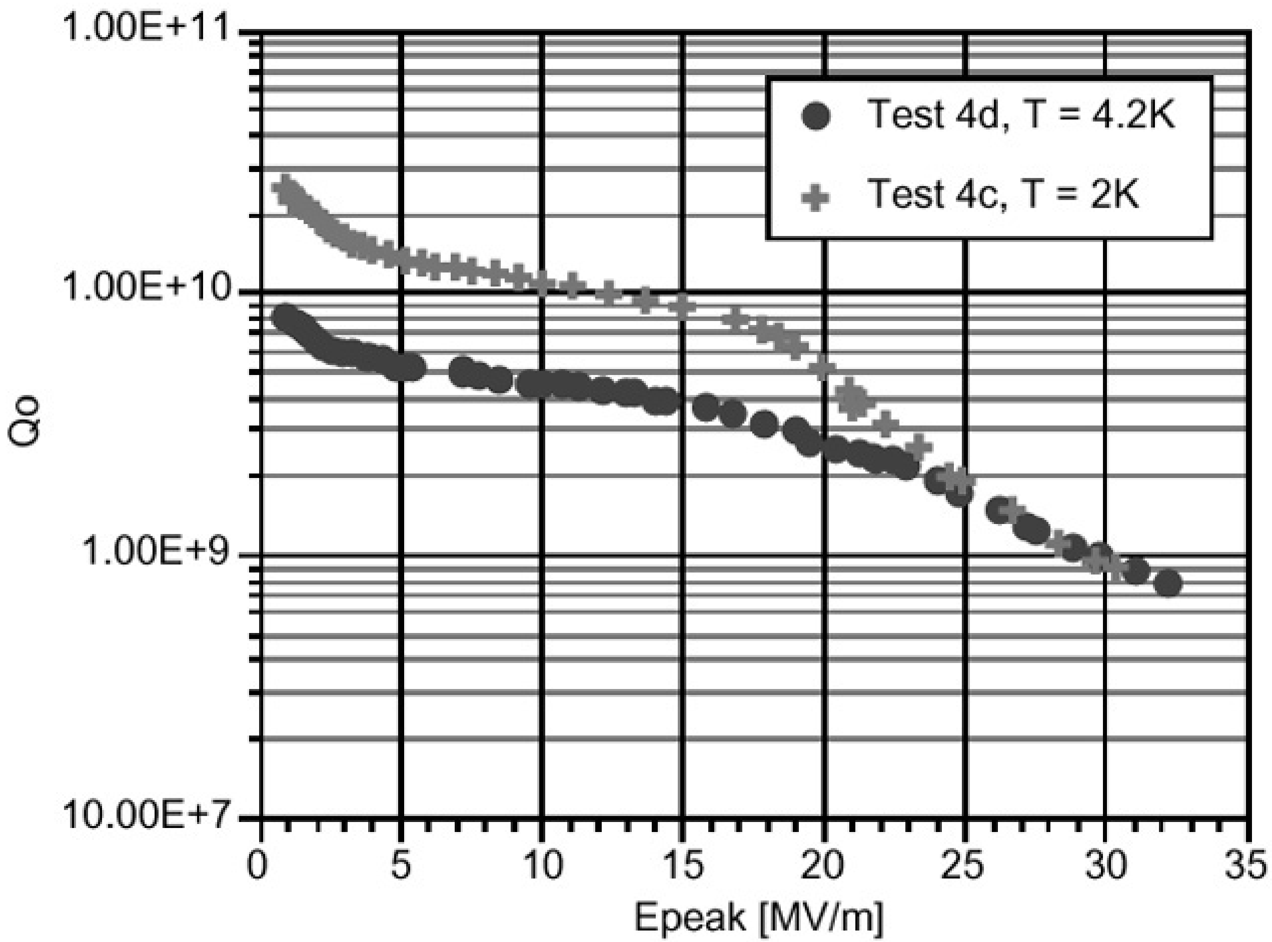
Is field emission completely under control?



What is the cause of general Q-slope in Nb-Cu?



Is there hope for Nb3Sn ?



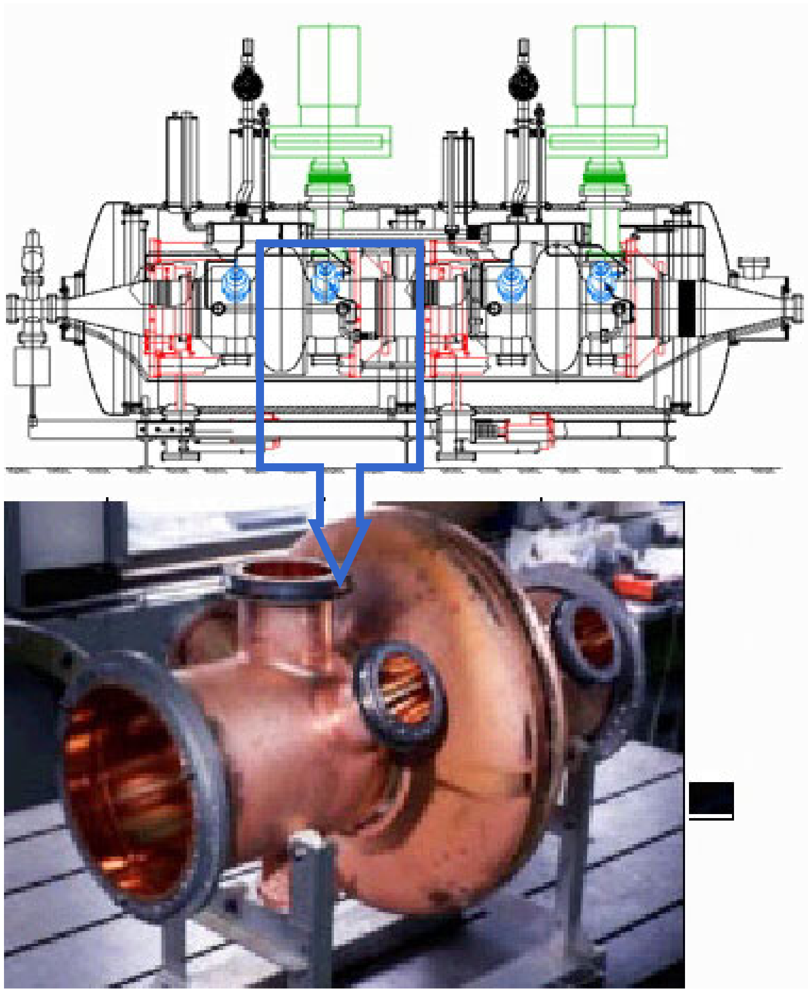
Applications

A Success Story

Storage Rings

- TRISTAN
- HERA
- LEP-II
- CESR-III
- KEK-B
- LHC
- Taiwan Light Source
- Canadian Light Source
- DIAMOND
- SOLEIL
- ESRF, ELETTRA…
  - Recent Tests

- Anticipated
  - Beijing Tau-Charm Factory
  - Shangai Light Source



400 MHz

16 Nb/Cu Cavities

Layout of the LEP tunnel including future LHC infrastructures.

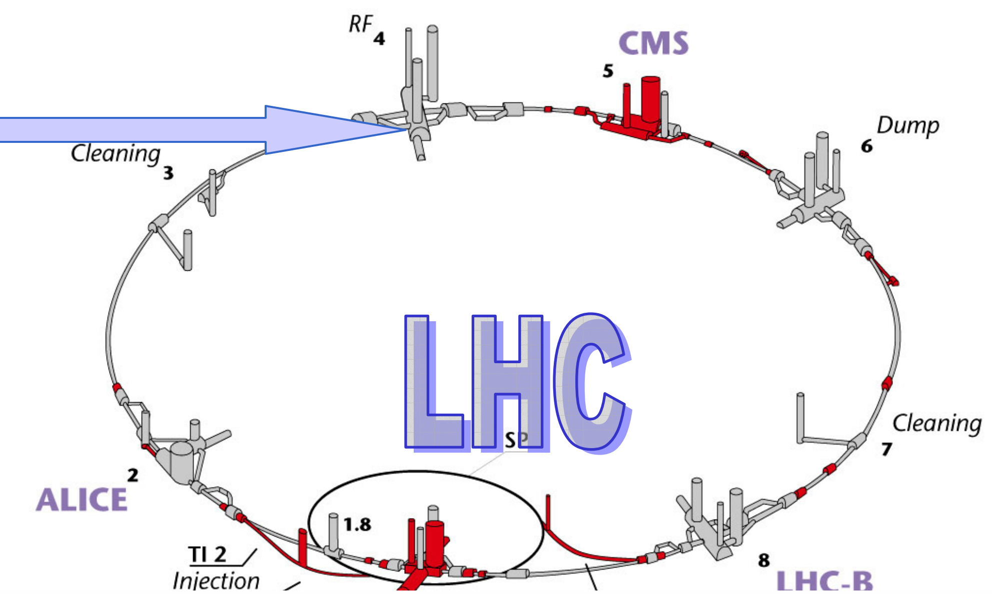


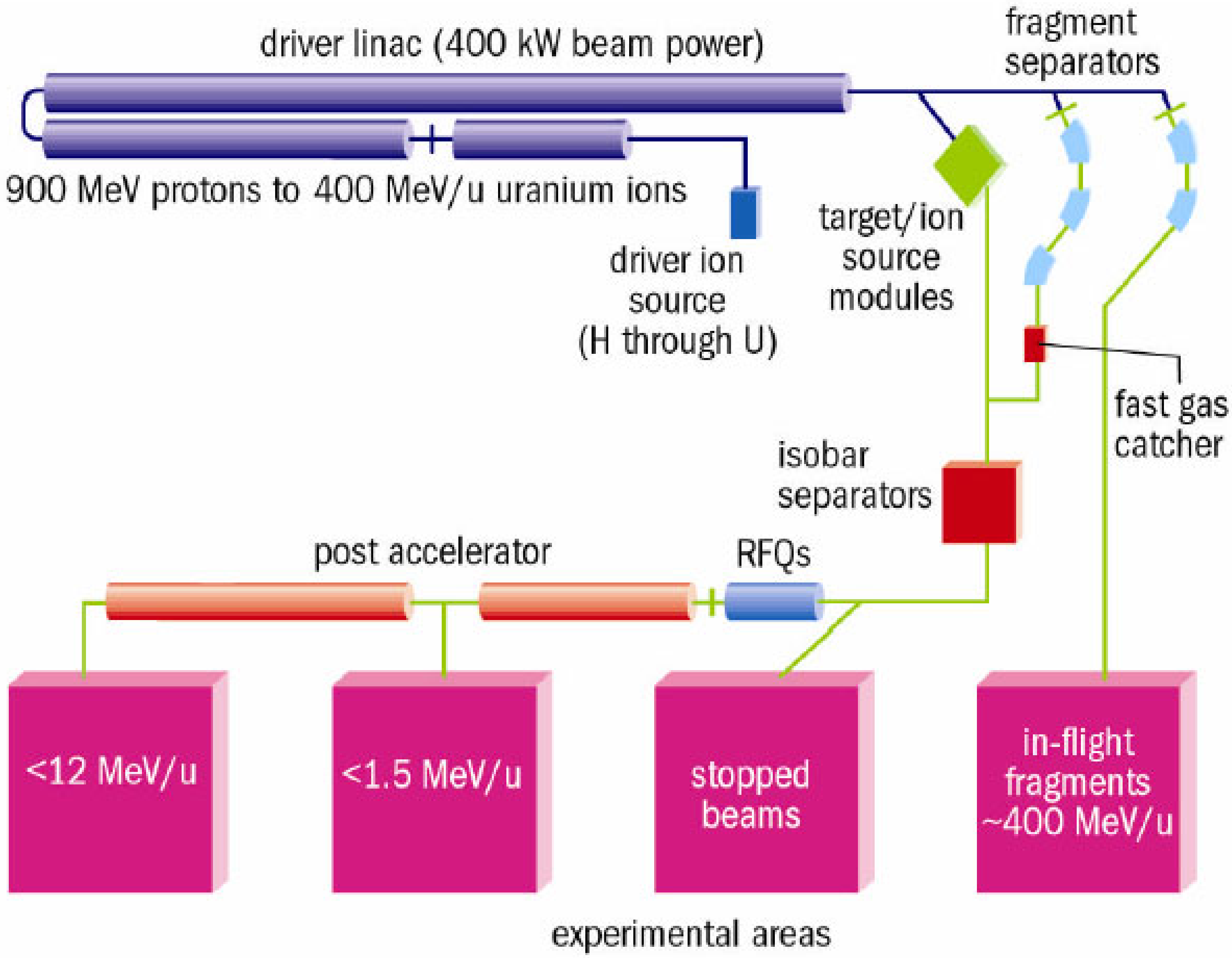
Figure 1: The first LHC module ready for measurements.

Heavy-Ion Linacs

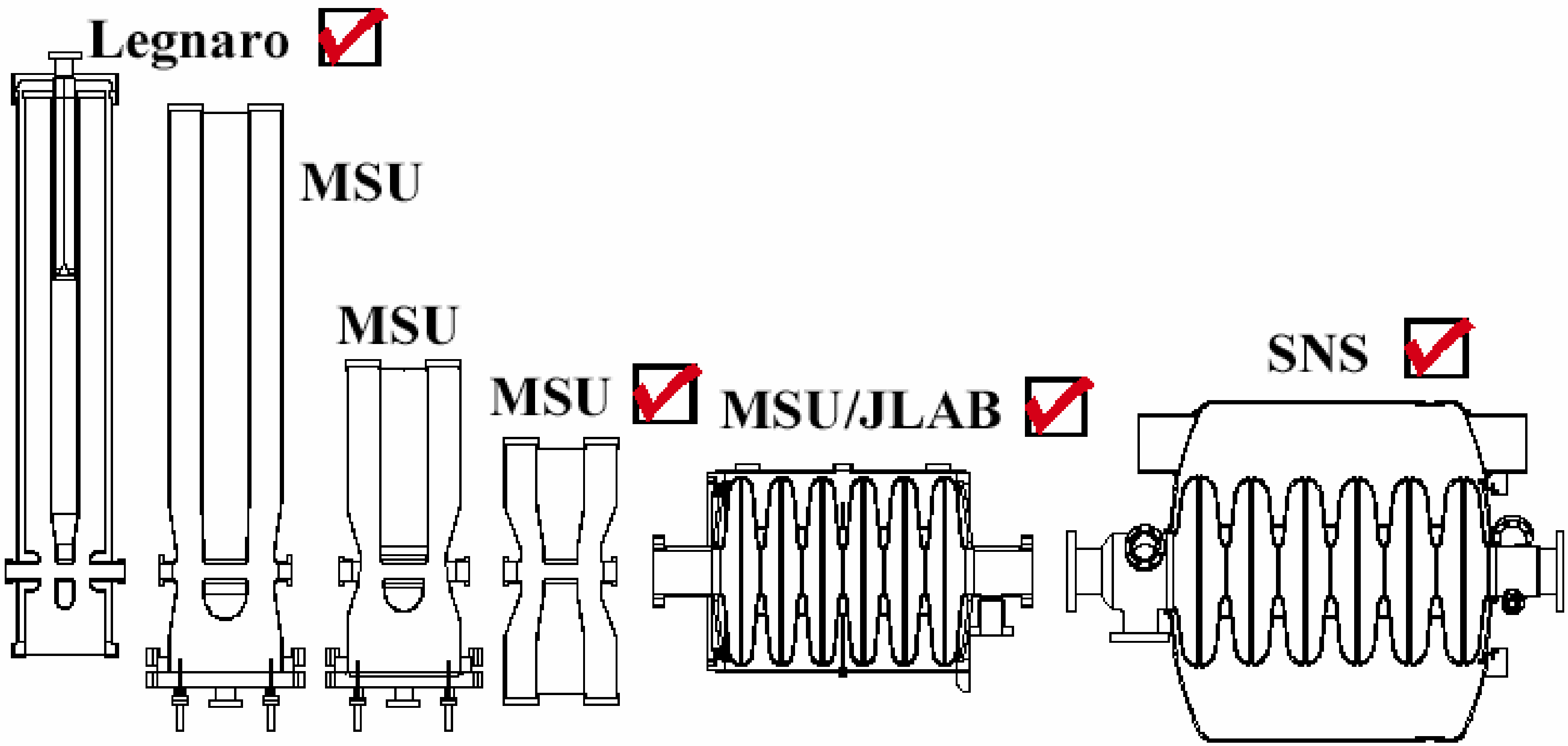
- ATLAS
- Stony-Brook
- U Washington, FSU, KSU, Brazil, Delhi..
- JAERI-Tandem Booster
- ALPI
- ANU
- ISAC-II

- Anticipated
  - RIA
  - EURISOL (SPES)

Schematic of the RIA Facility



MSU RIA Driver Linac Cavities – [1]



β_{opt}	0.041	0.085	0.16	0.285	0.49	0.63
f	80.5	80.5	161	322	805 MHz	805

Electron Linacs

- SCA
- S-DALINAC
- CEBAF
- JLAB-FEL
- JAERI-FEL
- TTF-FEL
- A0

- Anticipated
  - TESLA-XFEL
  - CEBAF-II
  - TTF-II
  - ERLP (Daresbury)
  - PKU-SCAF
  - ……..
  - CORN-ERL
  - E-RHIC
    E-LIC
  - TESLA

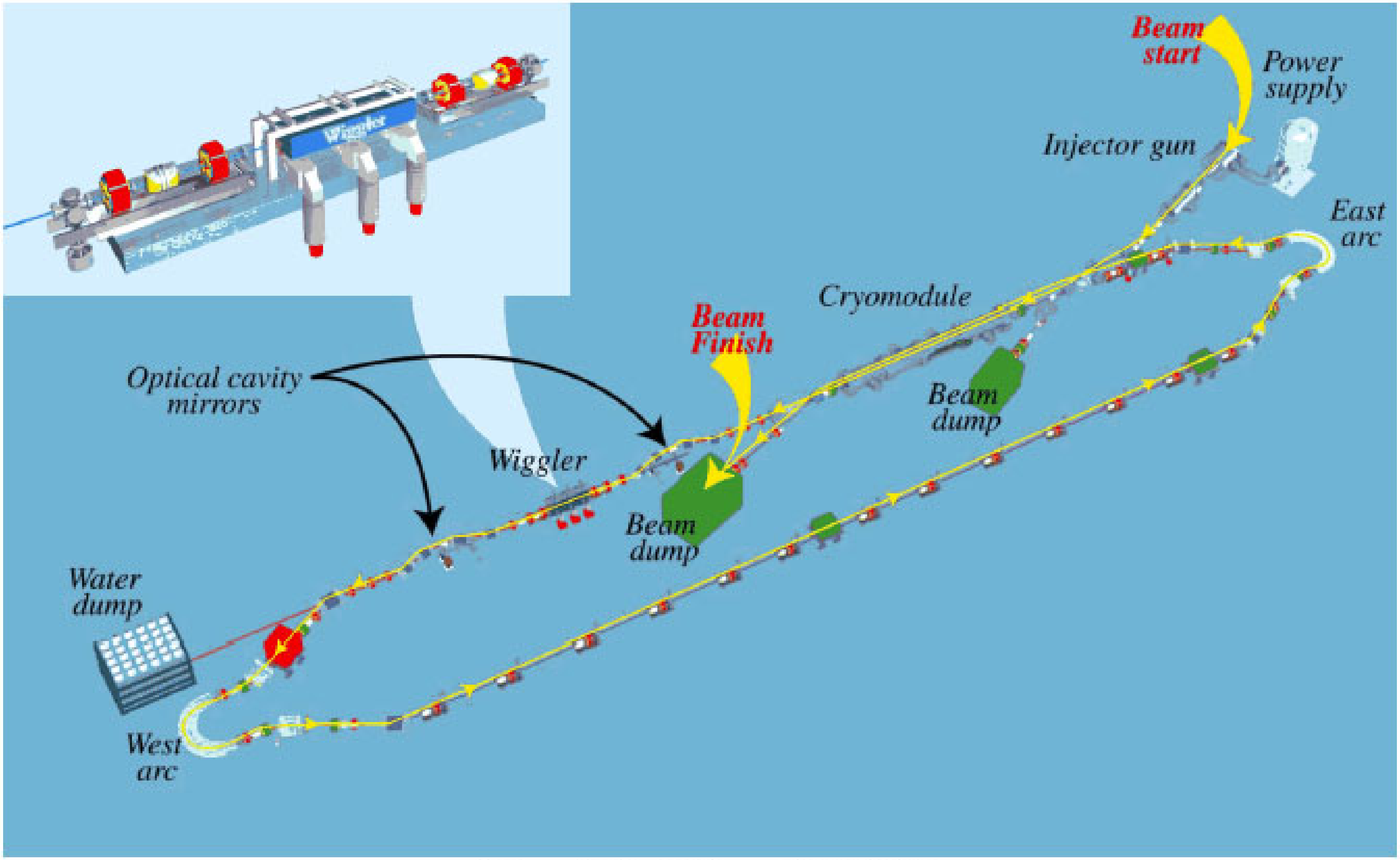
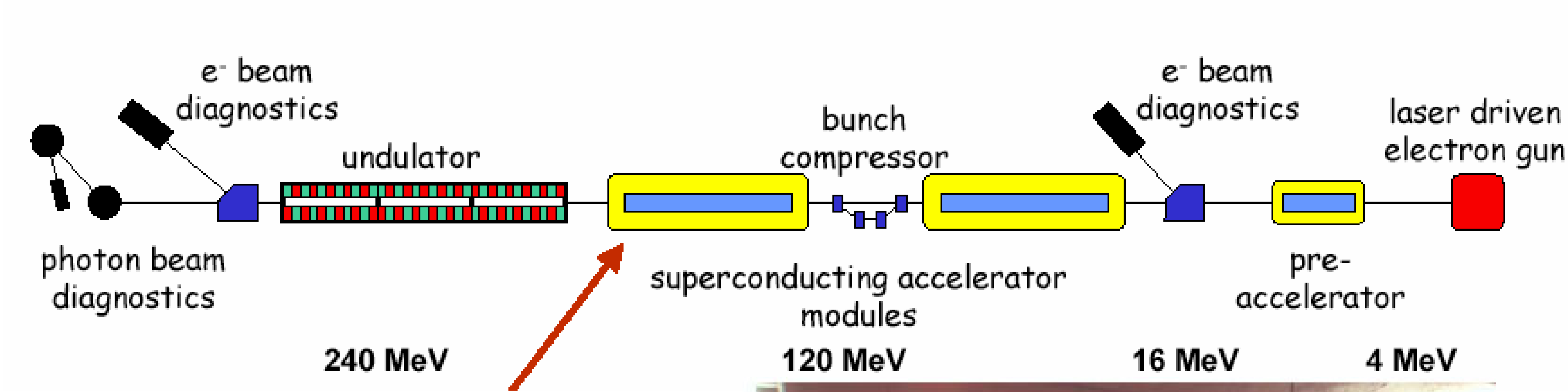
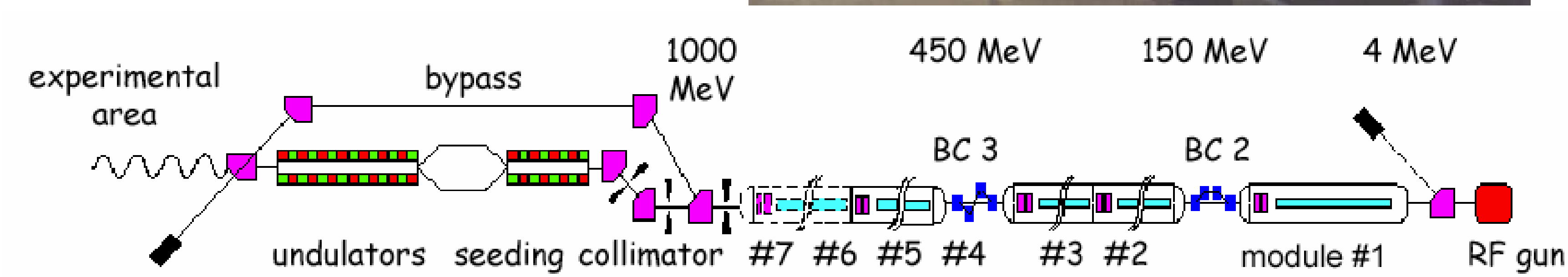


Figure 7: The Jefferson Lab IR FEL.

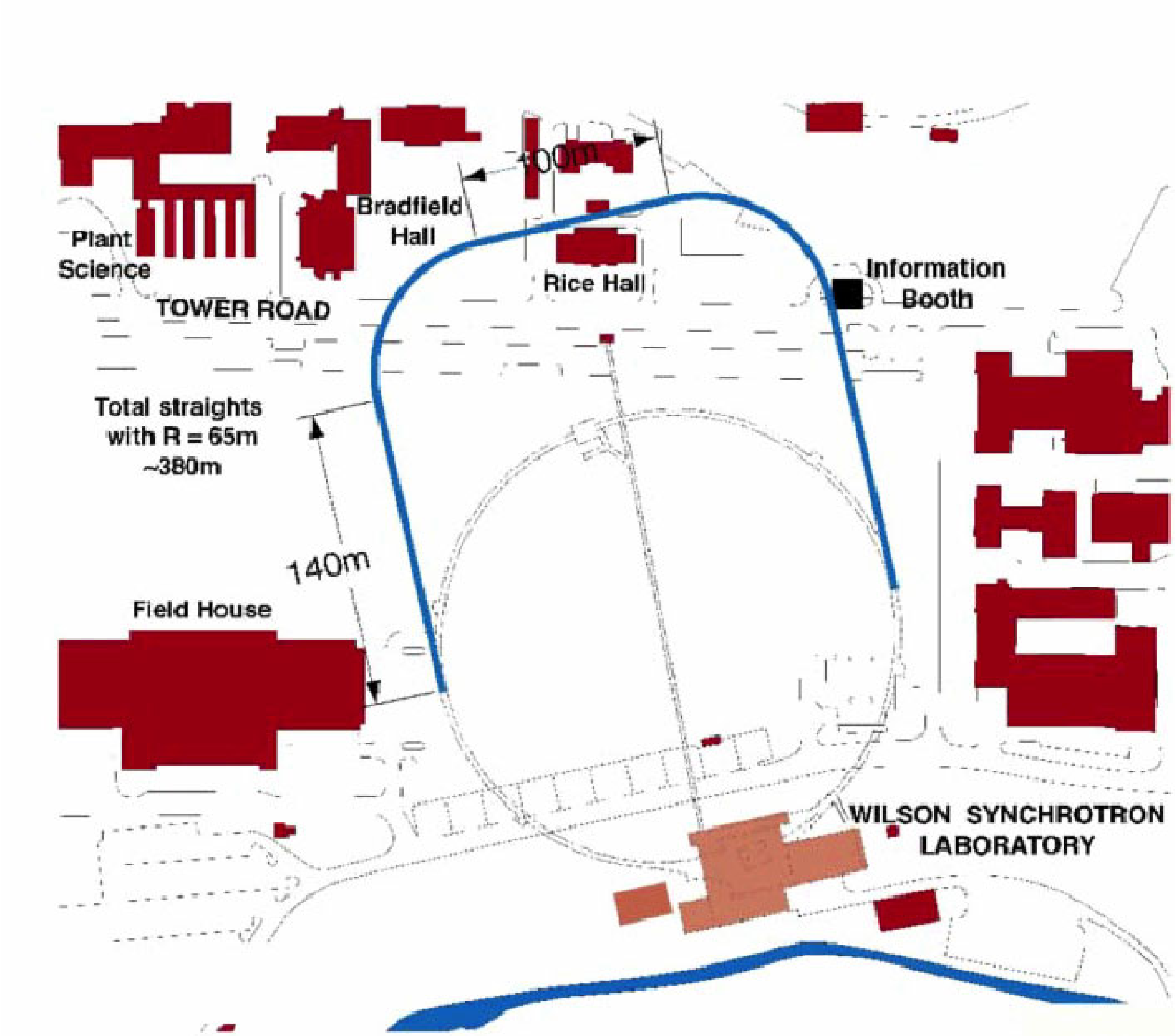

e- beam diagnostics
undulator
bunch compressor
e- beam diagnostics
laser driven electron gun
photon beam diagnostics
superconducting accelerator modules
pre-accelerator
240 MeV
120 MeV
16 MeV
4 MeV

TTF-I

TTF-II


experimental area
bypass
1000 MeV
450 MeV
150 MeV
4 MeV
BC 3
BC 2
undulators
seeding
collimator
#7
#6
#5
#4
#3
#2
module #1
RF gun

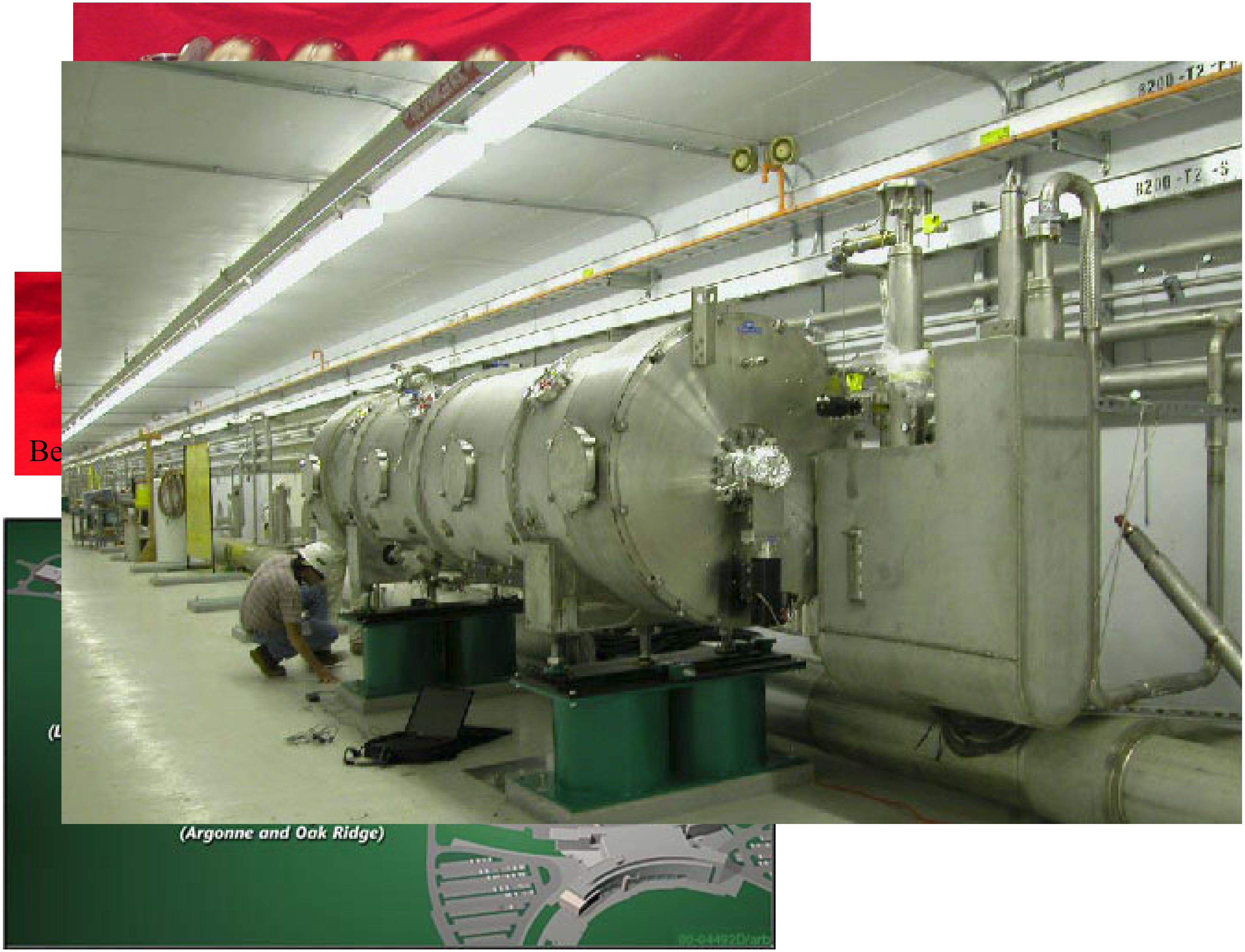
Phase-II (5 Gev) ERL Option ?
In Extended CESR Tunnel



Proton Linacs

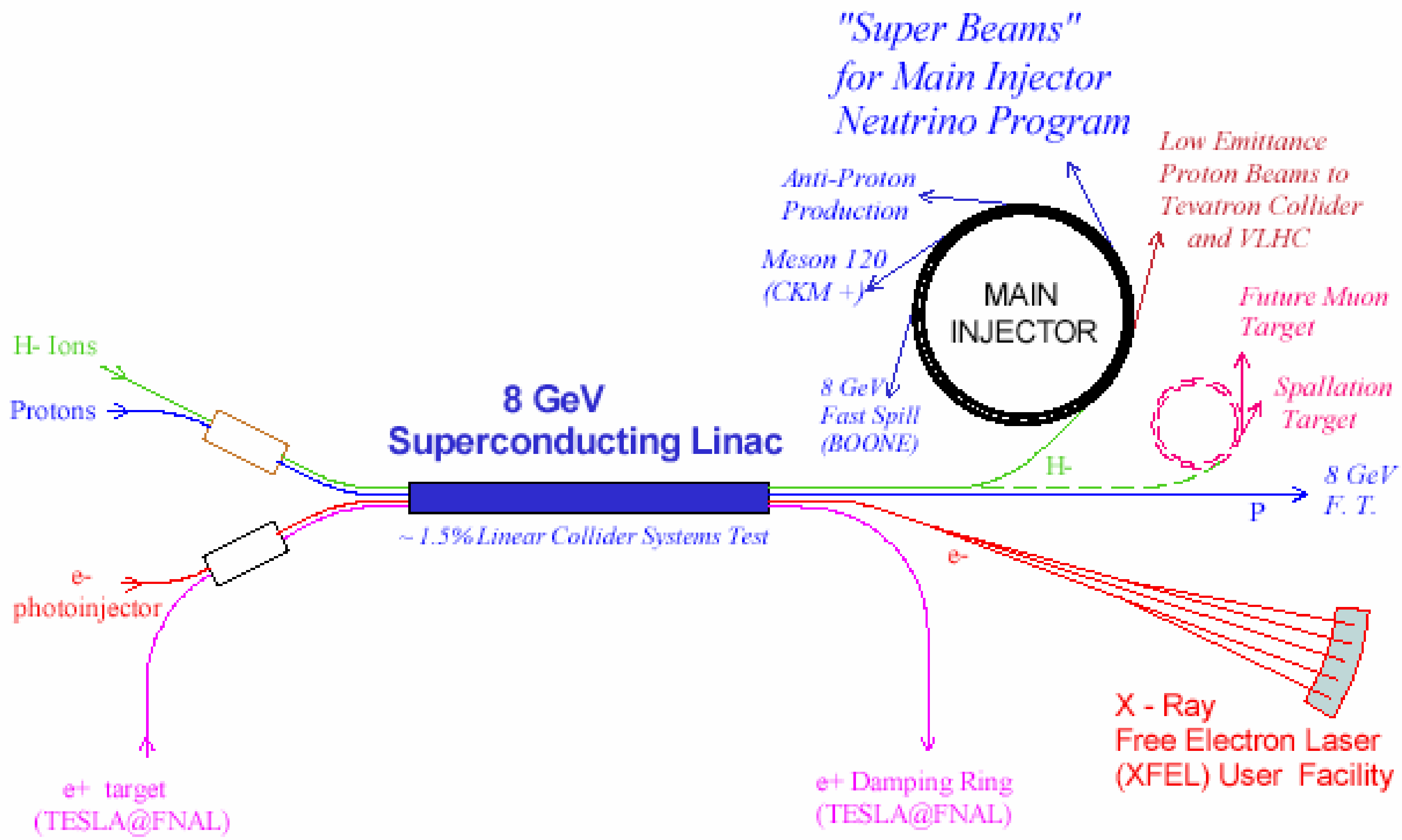
- SNS

- Anticipated
  - SPL (CERN)
  - Trasco...XADS
  - Joint-Project
  - Fermilab 8 GeV Injector Linac

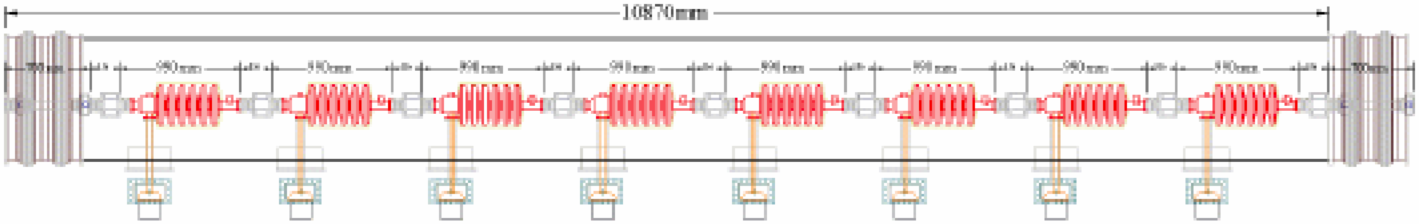

Be
(Argonne and Oak Ridge)

Fermilab

Multi-Mission 8 GeV Injector Linac

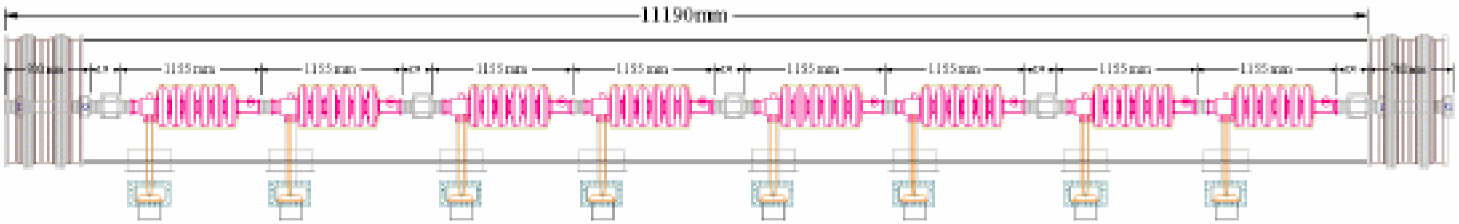


8 GeV Linac Cryomodules - 4 Types



Beta= 0.47 (RIA)

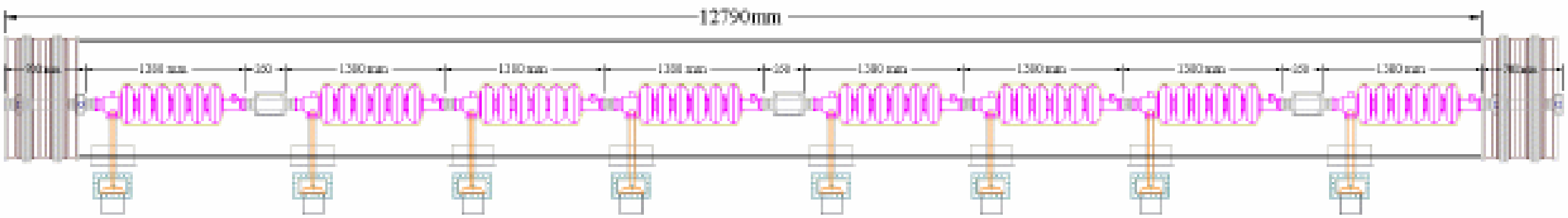
87-175 MeV
2 Cryomodules
16 Cavities (RIA)



Beta= 0.61 (SNS)

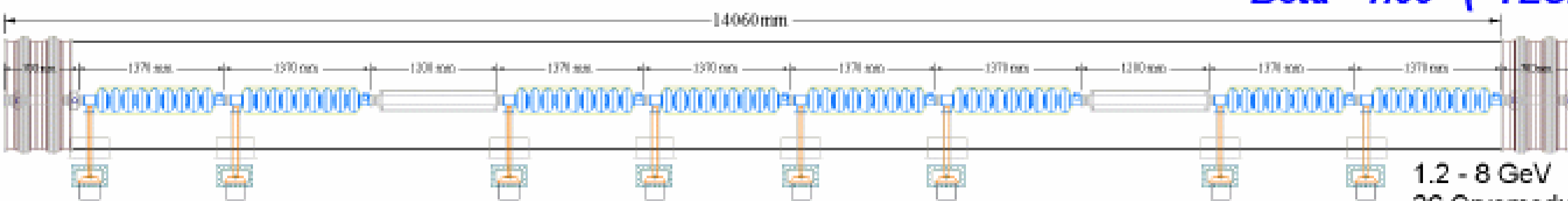
175 - 400 MeV
3 Cryomodules
24 Cavities

Beta= 0.81 (SNS)



0.4 - 1.2 GeV
7 Cryomodules
56 Cavities

Beta= 1.00 ("TESLA")

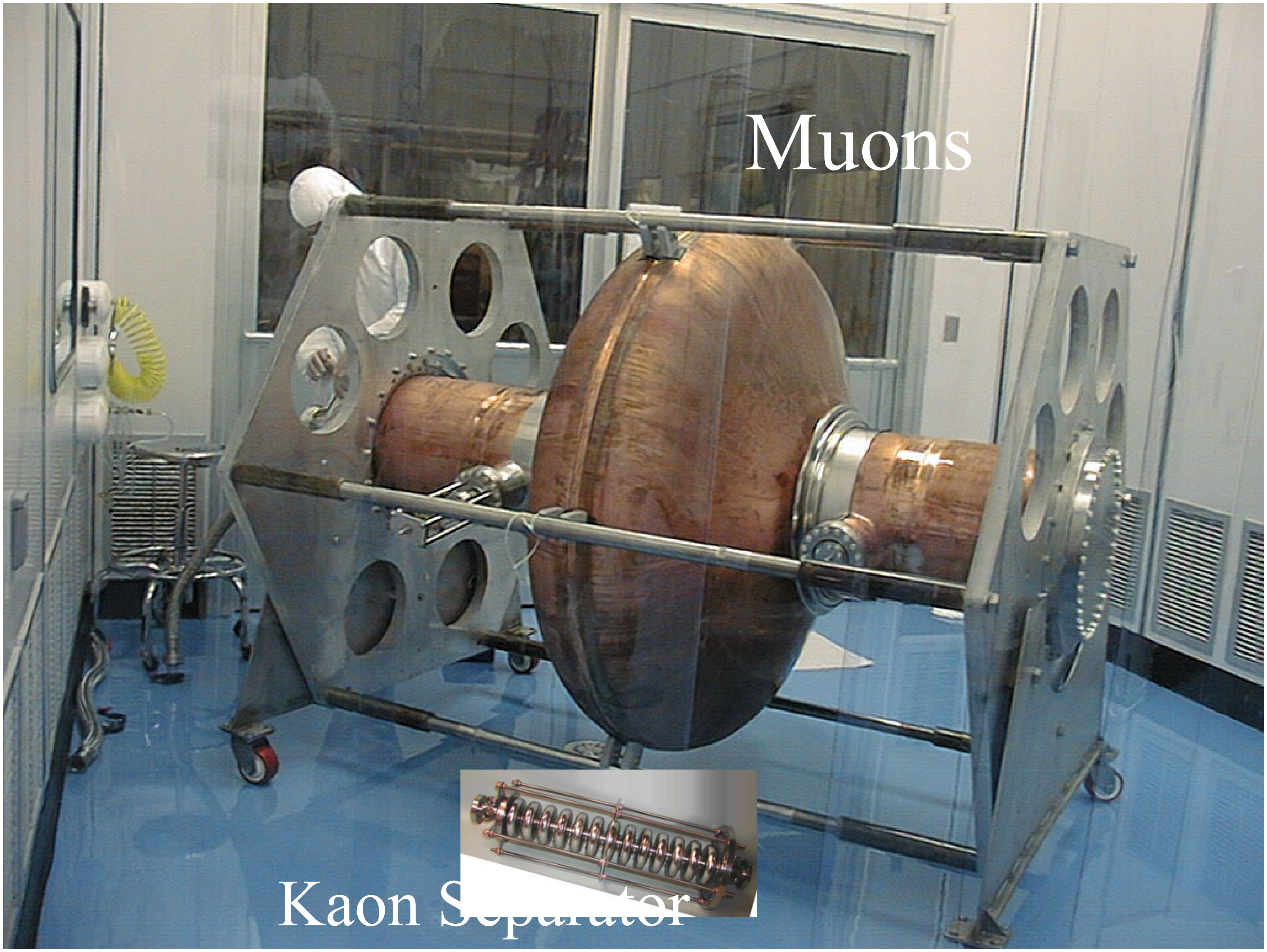


1.2 - 8 GeV
36 Cryomodules
288 Cavities

9 Cell Beta=1 Cavities, 1207.5 MHz

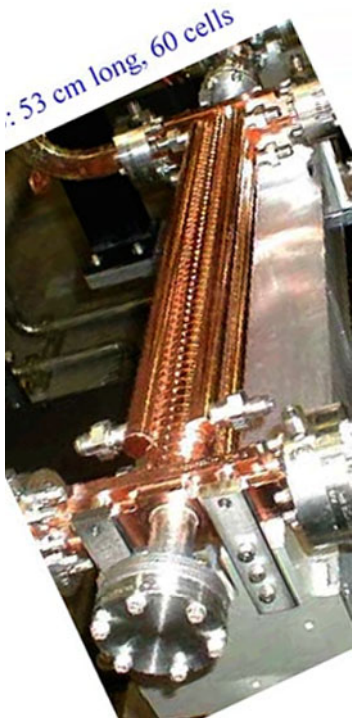
MUONS, PIONS, KAONS

- Anticipated
  - CKM separate Kaon beam from pions and muons
  - Neutrino Factory
  - Muon Collider


Muons
Kaon Separator

And Finally
What About the Linear Collider?

Copper



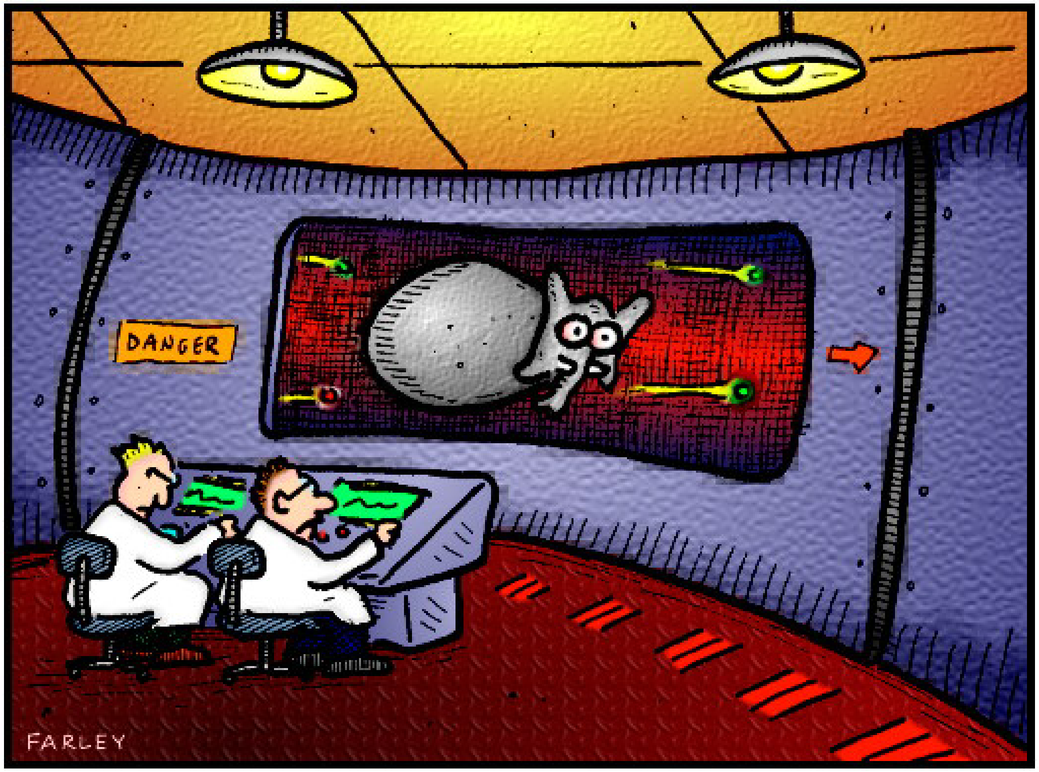
11.4 GHz

Message for the Workshop

Have Fun! Dream Big !

Because

DOCTOR FUN



Deep within that accelerator,
you may finally find the elusive elephantino !