Report from TTC Milano

http://agenda.infn.it/conferenceOtherViews.py?view=standard&confId=3087

W. Weingarten / CERN

SPL cavity working group

7 March 2011

Introduction and Update since Last Meeting

Yoshishige Yamazaki TTC Chair J-PARC, KEK & JAEA TESLA Technology Collaboration (TTC):

- **In contrast to its formal looking from outside, the collaboration and its meeting are very much scientific and technical rather than political, having very frank, active discussion.**
- **The most important mission of the collaboration is to provide highly scientific, technological reports, responding to requests from the member institutes.**
- **I proposed to invite the proton community like SNS and heavy ion one to TTC, since I have been working for the J-PARC proton linac, which will have SC linac in future**

The TTC Member Institutes

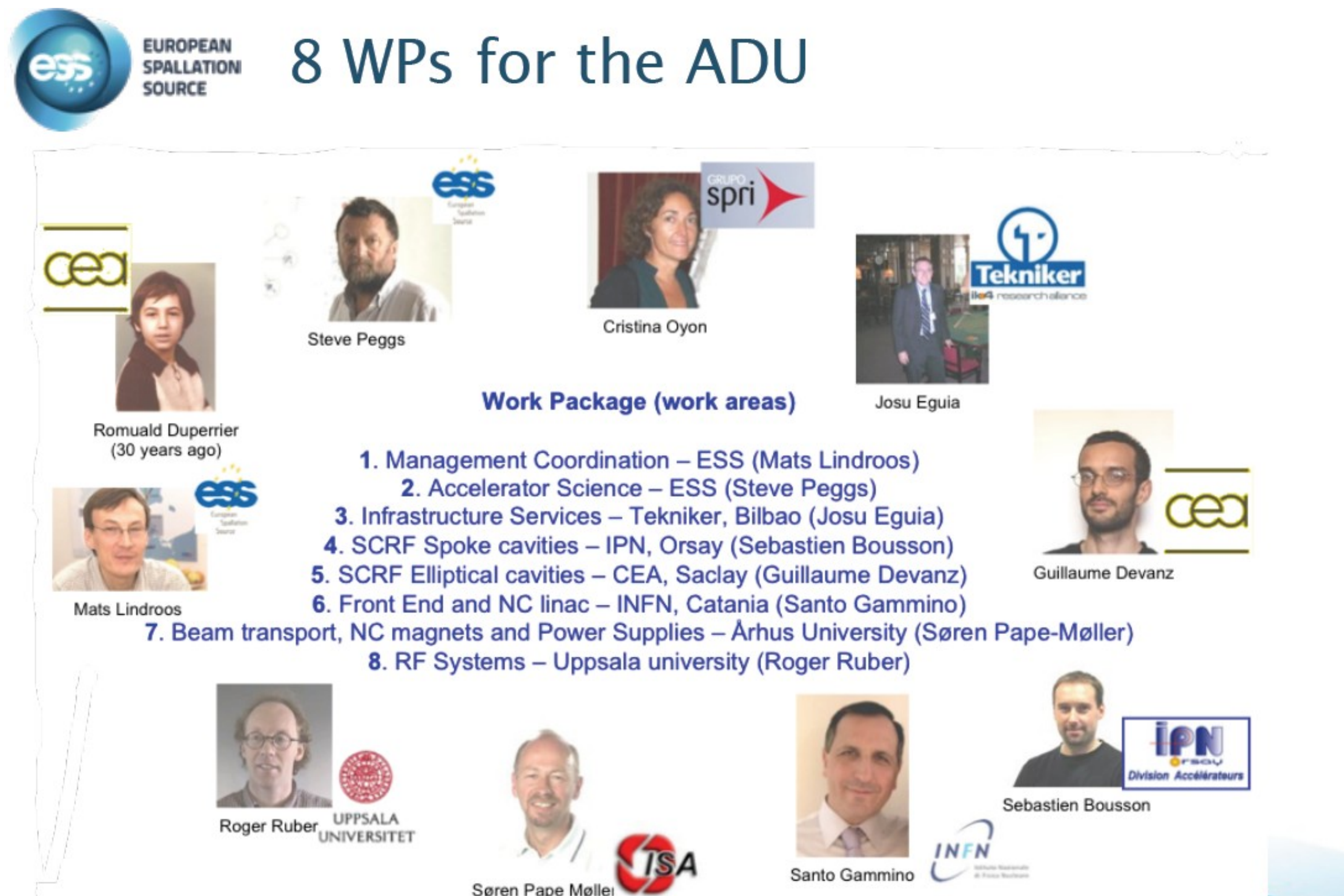
- Armenia: CANDLE, Yerevan; Yerevan Physics Institute, YerPhI, Yerevan;
- Canada: TRIUMF, Canada's National Laboratory for Particle and Nuclear Physics
- China: Institute for High Energy Physics, IHEP, Academia Sinica, Beijing; Tsinghua University, Beijing; Peking University
- France: CEA/DSM DAPNIA, CE-Saclay, Gif-sur-Yvette; Laboratoire de l'Accélérateur Linéaire, LAL, IN2P3-CNR
- Germany: Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung, BESSY, Berlin; Hahn-Meitner Institut, HMI, Berlin; Technische Universität Darmstadt; Universität Frankfurt am Main; GKSS-Forschungszentrum Geesthacht; Deutsches Elektronen-Synchrotron DESY in der Helmholtz-Gemeinschaft, Hamburg und Zeuthen; Universität Hamburg; Forschungszentrum Rossendorf; Universität Rostock; Bergische Universität-GH Wuppertal
- UK: CCLRC-Daresbury Laboratory / ASTeC Department; Royal Holloway, University of London, RHUL / JAI: University College London, UCL; University of Oxford / JAI
- India: Raja Ramanna Centre of Advanced Technology RRCAT, Indore;Bhabha Atomic Research Centre BARC, Mumbai; Inter-University Accelerator Centre, IUAC & Delhi University, DU; Variable Energy Cyclotron Center VECC
- Italy: Laboratori Nazionali di Frascati, INFN, Frascati; Istituto Nazionale di Fisica Nucleare, INFN, Legnaro; Istituto Nazionale di Fisica Nucleare, INFN, Milan; Istituto Nazionale di Fisica Nucleare, INFN, Rome II; Sincrotrone Trieste
- Japan: High Energy Accelerator Research Organisation, KEK
- Poland: The Henryk Niewodniczanski Inst. of Nuclear Physics, Polish Academy of Sciences, Krakow; AGH -University of Science and Technology, Facultyof Physics and Applied Computer Science, Krakow ; The Andrzej Soltan Institute for Nuclear Studies –IPJ, Otwock-Swierk; Institute of High Pressure Physics, Polish Academy of Sciences, Warsaw; Warsaw University, Department of Physics;TU Lodz, Department of Microelectronicsand Computer Science; Warsaw University of Technology, WUT, IS
- Russia: Moscow Engineering and Physics Institute, MEPhI, Moscow; Budker Institute for Nuclear Physics BINP, Novosibirsk; Institute for High Energy Physics IHEP, Protvino; Institute for Nuclear Research, INR, Russian Academy of Sciences, Moscow
- Switzerland: European Center for Nuclear Research CERN
- USA: Argonne National Laboratory, ANL, Argonne IL; Brookhaven National Laboratory, BNL; Fermi National Accelerator Laboratory, FNAL, Batavia IL; Cornell University, Ithaca NY; Jefferson Lab, Newport News VA; SLAC, ILC Division; Lawrence Berkeley National Laboratory, LBNL, Berkeley CA; Michigan State University (MSU); Spallation Neutron Source(SNS)
- Others: Joint Institute for Nuclear Research, JINR, Dubna

Two institutes, VECC and CERN, have just joined us.

54 Institutes now from 13 countries

Highlights from TCC Milano: ESS 1

Duperrier: ESS Accelerator Design Update (ADU)

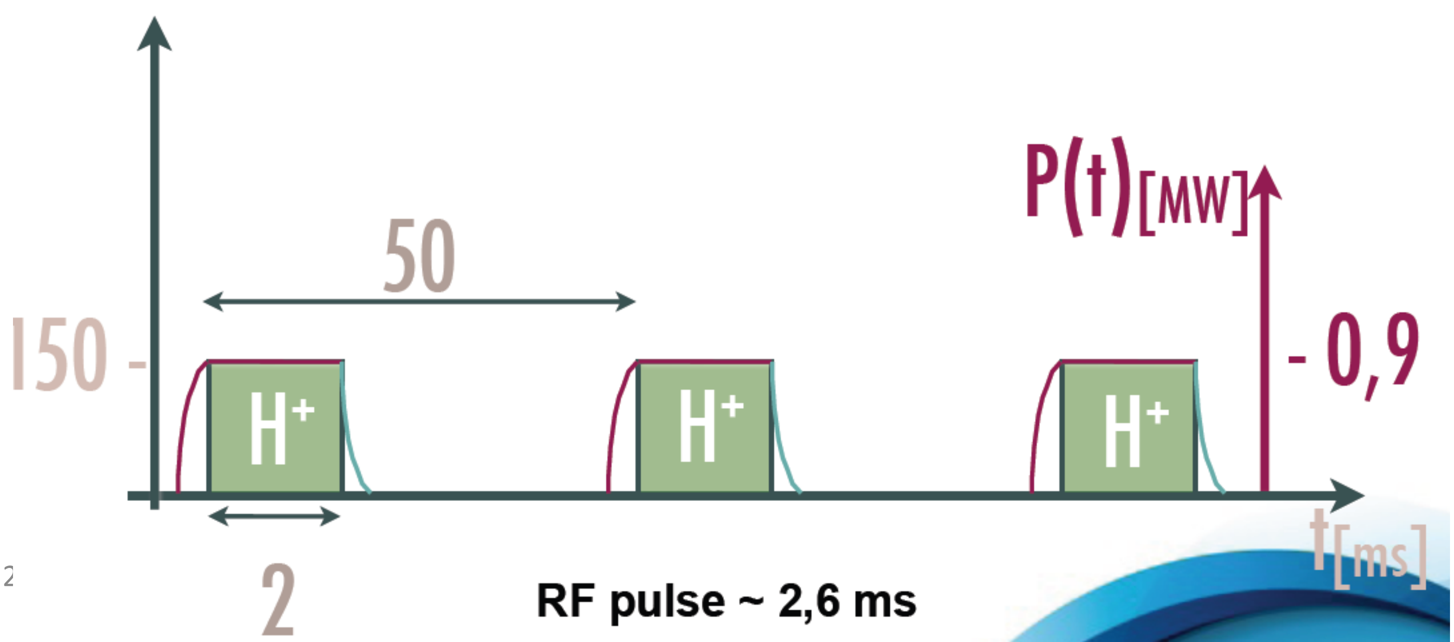


Highlights from TCC Milano: ESS 2

EUROPEAN SPALLATION SOURCE

ESS ultimate goal: 15 MW

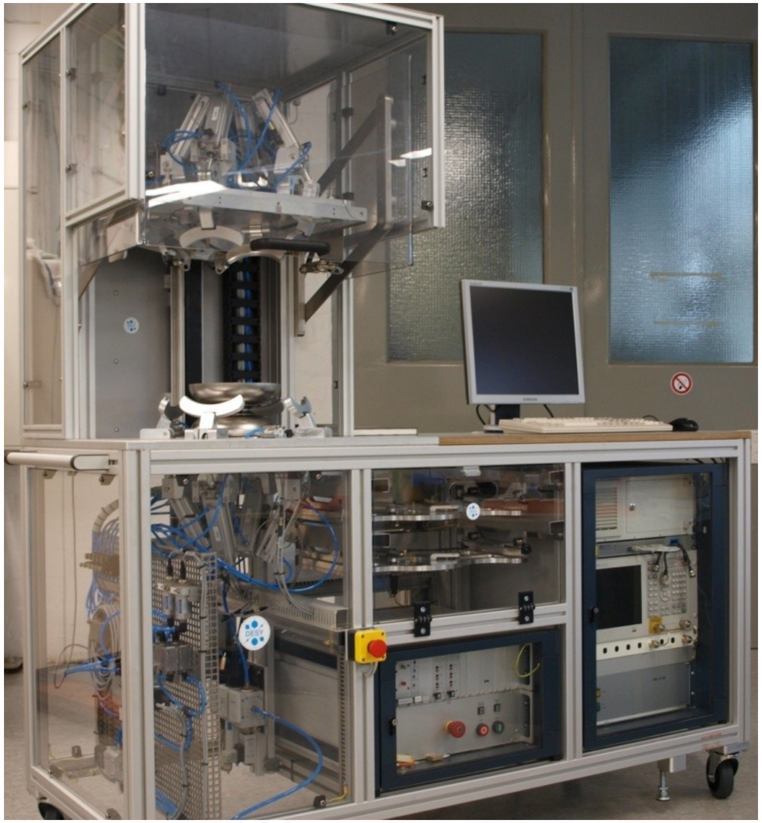
- The plan is to increase the peak current up to 150 mA.
- This would be performed with a double front end followed by a funnel (2003 design).
- Greater power for the coupler and/or more modules.



Highlights from TCC Milano: XFEL

Civil Construction

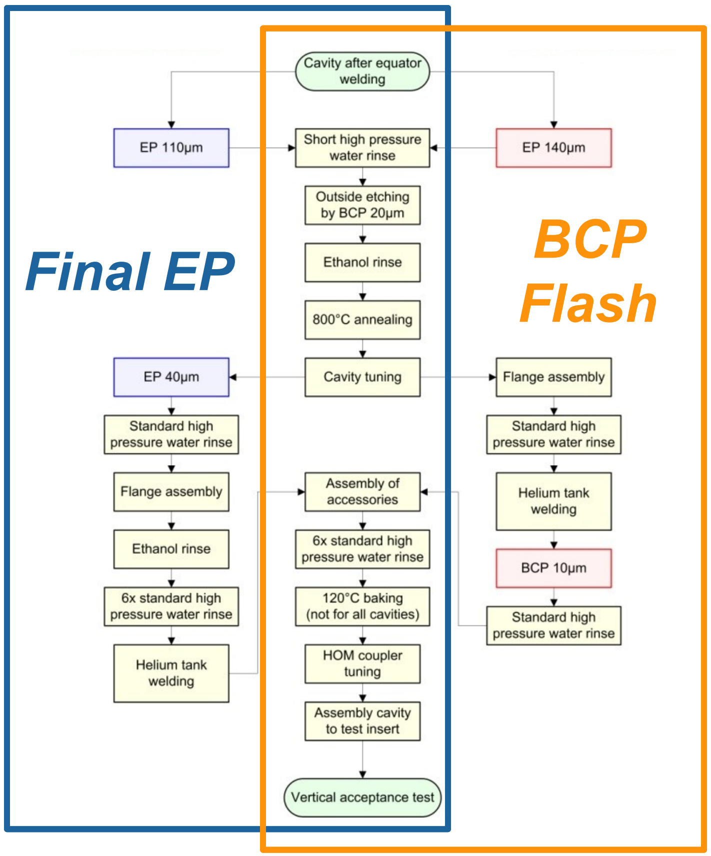
RF Measurement and Field Flatness Tuning using DESY-provided Tools



- Both machines ready to be used at the companies (CE certified).
- Machines can be operated basically by Non-RF-Experts.
- **Considerably shorter measurement / tuning time.**
- Automation and documentation guaranteed.

Cavity Surface Treatment – Based on DESY Experience

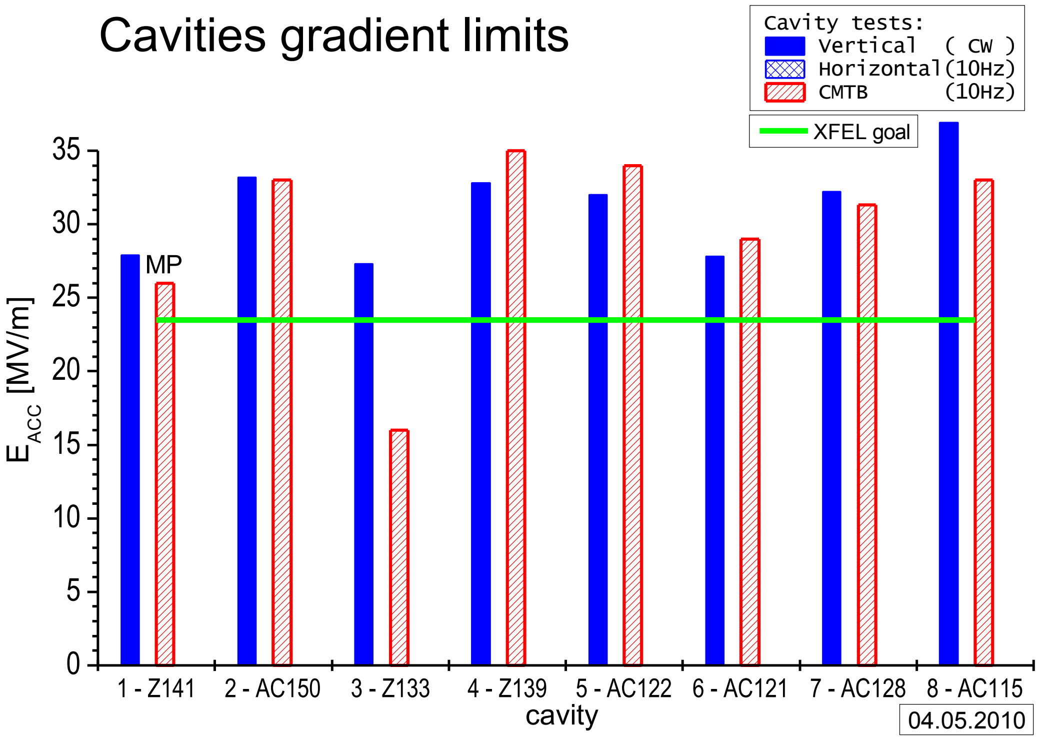
- **Two schemes** for the final surface treatment (***Final EP*** and ***BCP Flash***) were studied with **cavities from two different vendors**.
- The **preparation strategy** to go for a final treatment with the cavity already welded into the He-vessel was investigated.



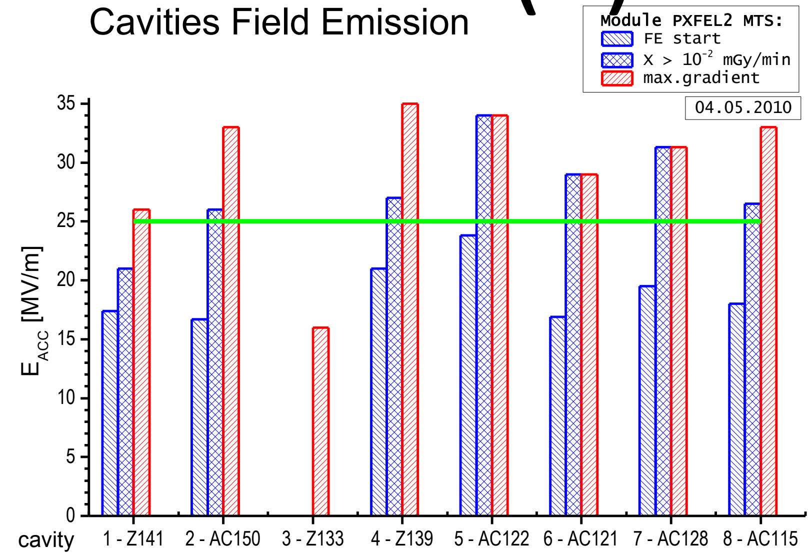
- **Results** are:
  - yield curves for the different schemes
  - yield curves for the different vendors
  - a preparation strategy allowing two different final treatments
- Some **tooling** will come from DESY
- **DESY procedures and experience** described very much in detail in the CFT
- **Specification are now available to the SRF community since end of 1/2011.** (please contact DESY)

Module Test Results: PXFEL2 (1)

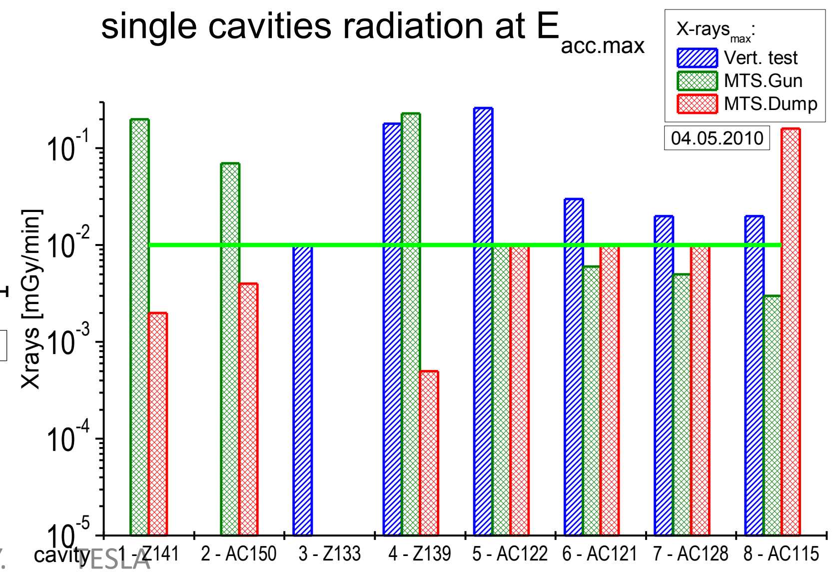
Cavities gradient limits



Cavities Field Emission



single cavities radiation at $E_{acc.max}$



PXFEL2 module was diassembled and reassembled.

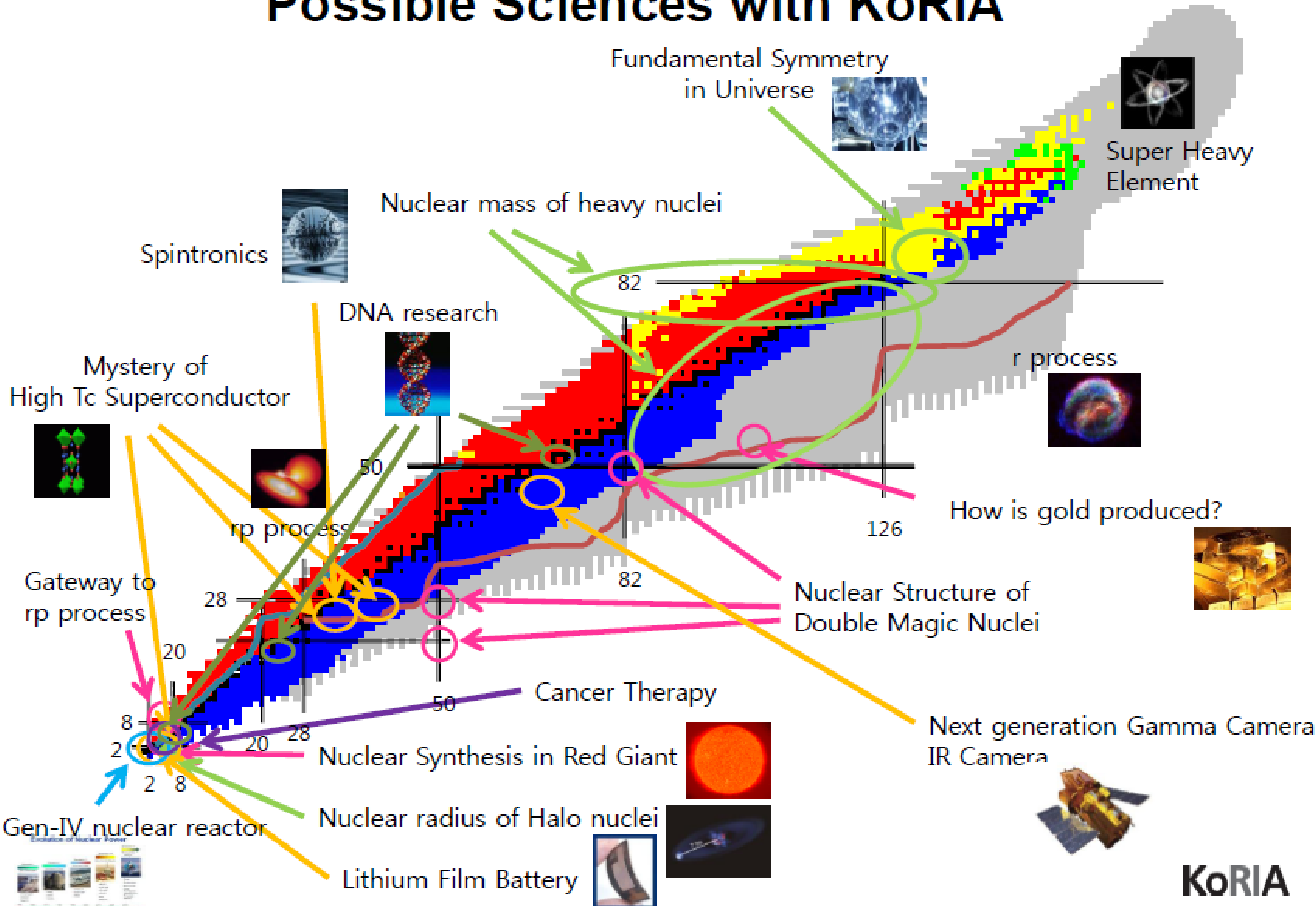
Highlights from TCC Milano: KoRIA

Hong & Park: The KoRIA project

Korea Rare Isotope Accelerator

Multipurpose, heavy-ion accelerator for basic science research

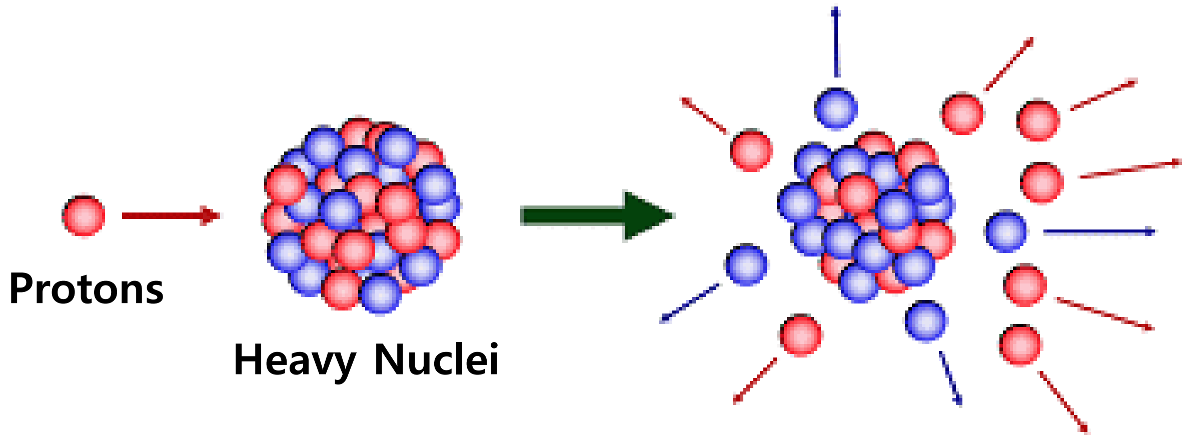
Possible Sciences with KoRIA



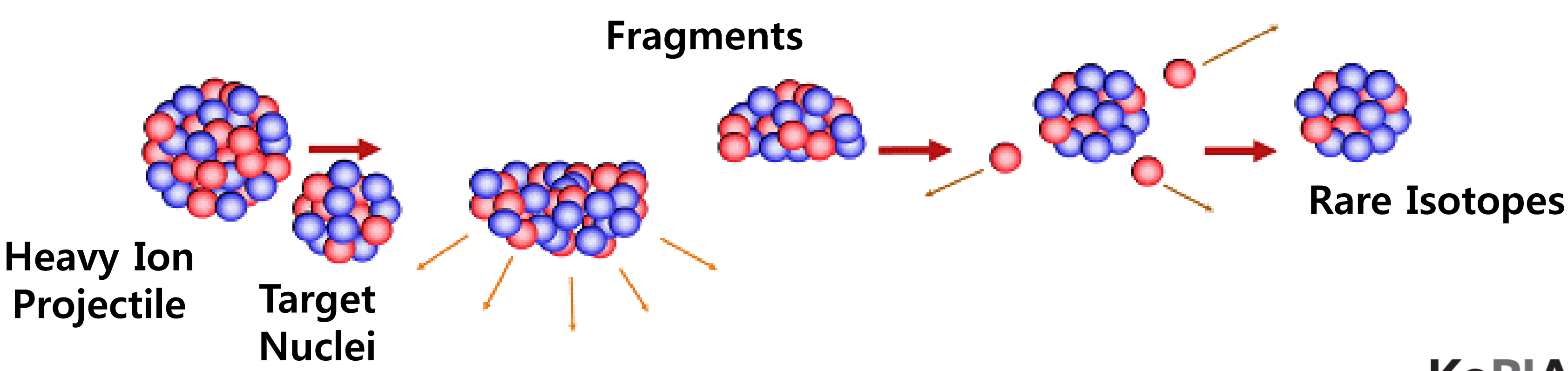
KoRIA

How to produce rare isotopes?

1. Isotope Separator On-Line (ISOL) Method

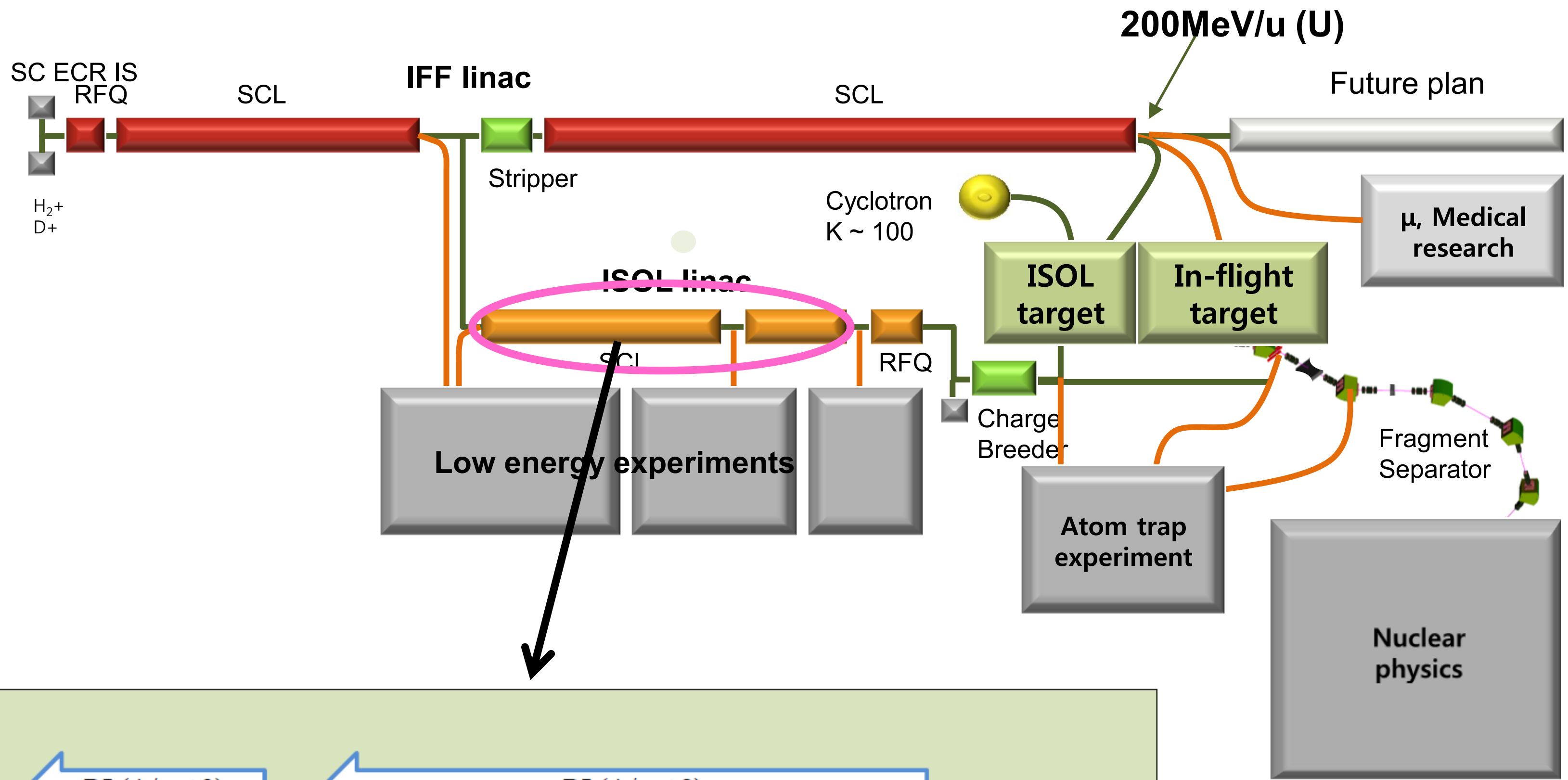


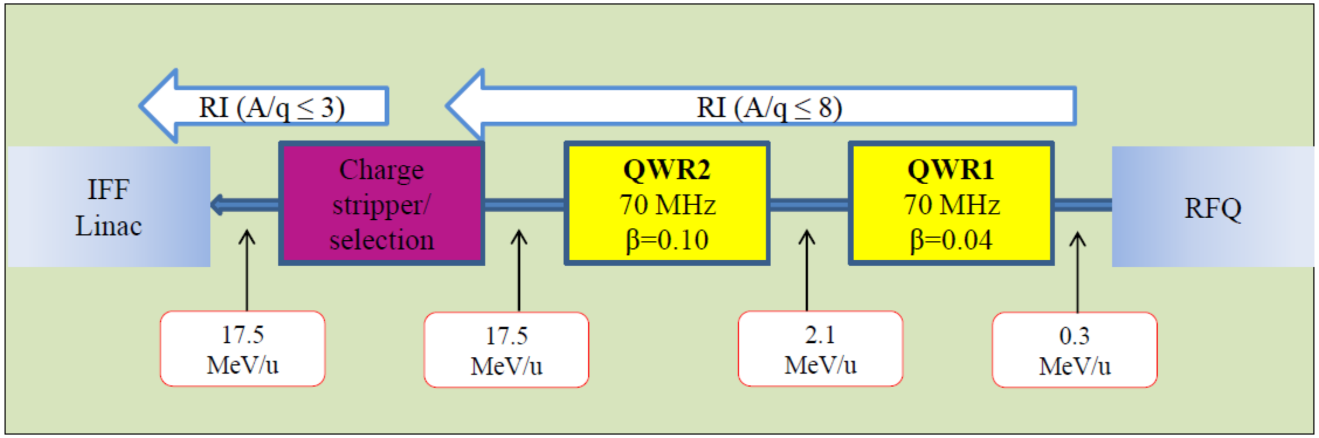
2. In-Flight Fragmentation (IFF) method



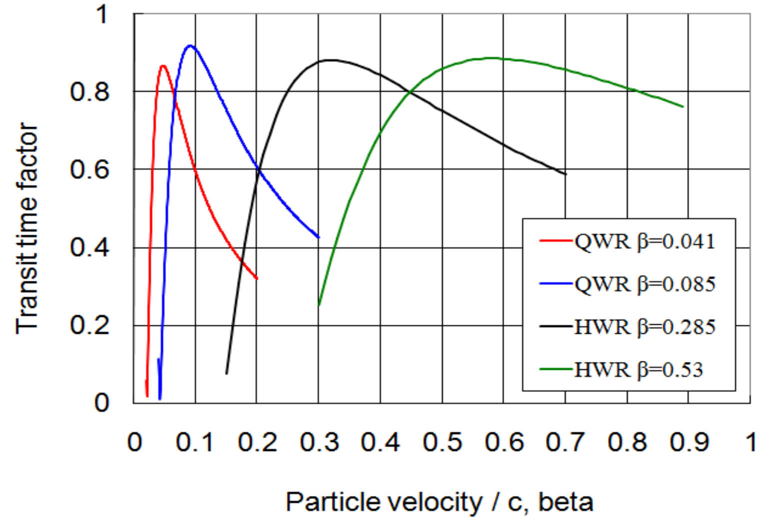
KoRIA

ISOL SC Linac [T. S. Park, SKKU]





SC Cavity for IFF SC Linac [S. K. Ko, KAPRA]

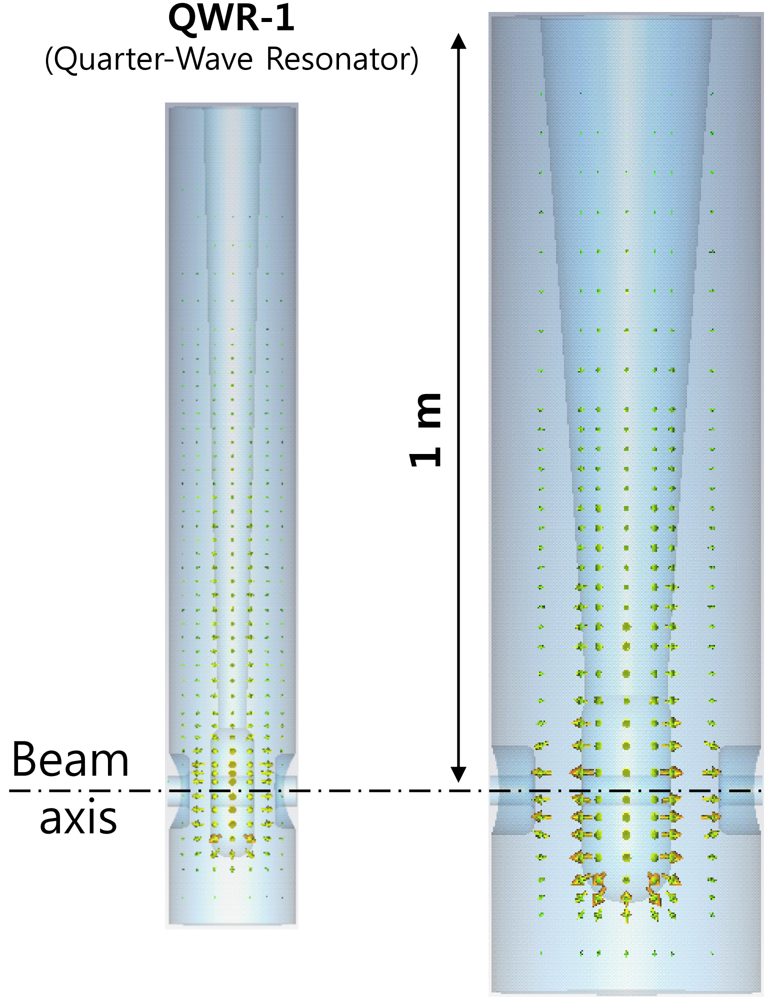


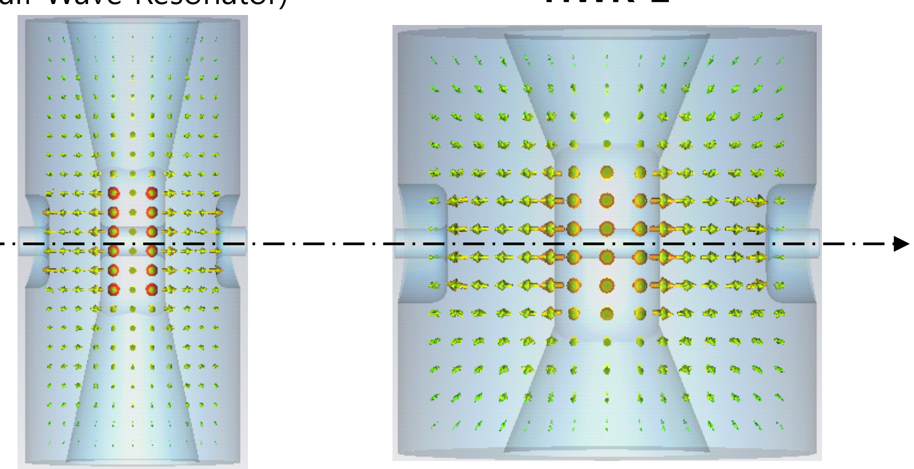
QWR-1
(Quarter-Wave Resonator)

QWR-2

HWR-1
(Half-Wave Resonator)

HWR-2





β_G = 0.041,
f_{res}= 70 MHz

β_G = 0.085,
f_{res}= 70 MHz

β_G = 0.285,
f_{res}= 280 MHz

β_G = 0.53,
f_{res}= 280 MHz

KoRIA

Highlights from TCC Milano: News from other meetings

HOM workshop Cornell

http://www.lepp.cornell.edu/Events/HOM10/Agenda.html

From Closeout Discussion: Antenna / Loop Couplers

Parameter	Current status	Improvement needed	Goal
Frequency range	**3 x fundamental**	Feedthrough, Geometry	6 x fundamental
Power	**100 W**	Transmission line needs improvement	1 kW
Q-factors	Monopole: 1e3 (100 for single-cell); Dipole: **1e5** (100 for single-cell); Quadrupole: 1e9 (quads – limited by field in end-cells)	For Quads: improve cell to cell coupling, cell geometry, reduce number of cells, fluted tube (KEK)	Quads: 1e8 – 1e5
Eacc (CW)	15 MV/m (KEK); 20 MV/m (mod. TTF); > 38 MV/m (CEBAF)	Coupler design, Feedthrough thermal conductivity	
Filling Factor	**good**		
Cleaning	**No problem** (demonstrated by TTF)		
Mechanical issue	Sensitive to tuning; Sensitive to MP & FE bombardment; Feedthrough issues	Use high-pass filter for tuning	
Thermal	Low cryogenic load		
Long term reliability	good (TTF, HERA); poor (SNS)		
Cost	25 kEUR (5 loop couplers including LHe cooling)		
Coupler kicks	**Must symmetrize**		
Other issues	**losses in transmission cable at higher HOM powers -> heating of antenna and feed through?**		

From Closeout Discussion: Waveguide HOM Dampers

Parameter	Current status	Improvement needed	Goal
Frequency range	**Potentially > 40 GHz**	Gentle curves of WG, no (thin) window	
Power	**kW**		
Q-factors	1e3 (mono); **1e5** (dipole); 1e9 (quads)	For Quads: improve cell to cell coupling, cell geometry	
Eacc (CW)	No limit?		
Filling Factor	**Good**		
Cleaning	Easy but more connections		
Mechanical issue	Low frequency resonances due to long WG (microphonics)	Study in test facilities	
Thermal issues	**High static heat leak (Order 1 W per WG)** **High cryogenic load**	Reduce this, e.g., thin wall, improved thermal intercepts	
Long term reliability	Good		
Cost	18 kEUR (to WG flange) for 2 BT with 6 WG stubs; need to add cost for waveguides, thermal intercepts and loads to this	Reduce number of WG (can couple to both polarizations of dipoles!) -> still sufficient damping	
Coupler kicks	**Must symmetrize**	Stubs opposite to symmetrize if only one WG	
Other issues	**need to verify efficient coupling at higher frequencies**		

From Closeout Discussion: Beamline HOM Dampers

Parameter	Beam-tube absorber	Improvement needed	Goal
Frequency range	**> 40 GHz**	Don't worry about it (EPC)	
Power	200 W at 80 K , >5 kW at room temp		
Q-factors	1e2 (mono) **1e4** (dipole), 100 for single cell 1e9 (quads)		
Eacc (CW)	No limit provided the absorber is far enough from the cavity		
Filling Factor	**Poor**		
Cleaning	**Difficult**	Simplified design (e.g. DESY design)	Easy
Mechanical issue	Good thermal contact, Stresses		
Thermal issues	High dynamic cryogenic load	Consider DESY design to extract HOMs to higher temp, check IR radiation load	Moderate cryogenic load.
Long term reliability	Good for RT, Bad for Cryotemps	New materials, Brazing, compression rings, Quality control … connect process parameters with performance	
Cost	10 to 45 kEUR		10 kEUR
Coupler kicks	**None**		
Other issues	Direct interaction with beam	check this for short bunches	< 20%

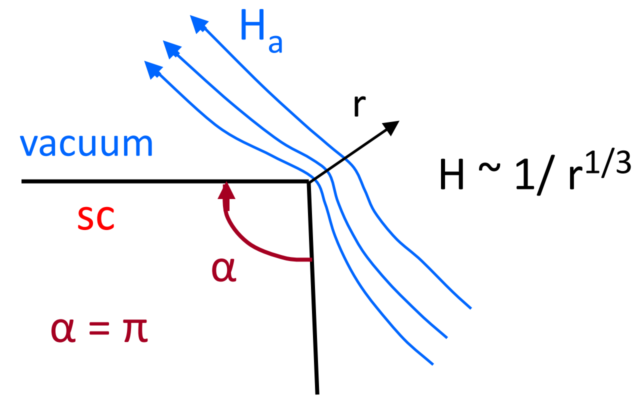
Highlights from TCC Milano: News from other meetings

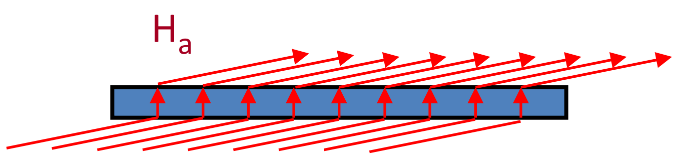
Thin Film Workshop INFN Legnaro University Padova

http://surfacetreatments.it/thinfilms/

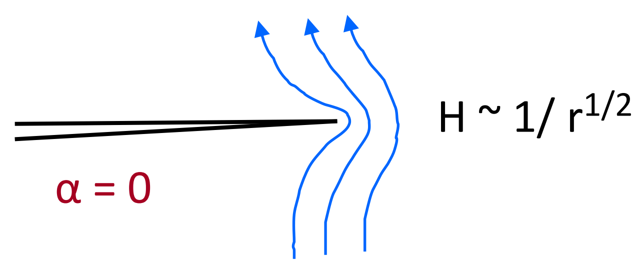
Ideal diamagnet, corner with angle α :

Near corner of angle α the magnetic field diverges as $H \sim 1/ r^{\beta}$, $\beta = (\pi - \alpha)/(2\pi - \alpha)$





Large thin film in tilted mag. field: perpendicular component penetrates in form of a vortex lattice



Nonmagnetic impurities are pairbreakers at high fields

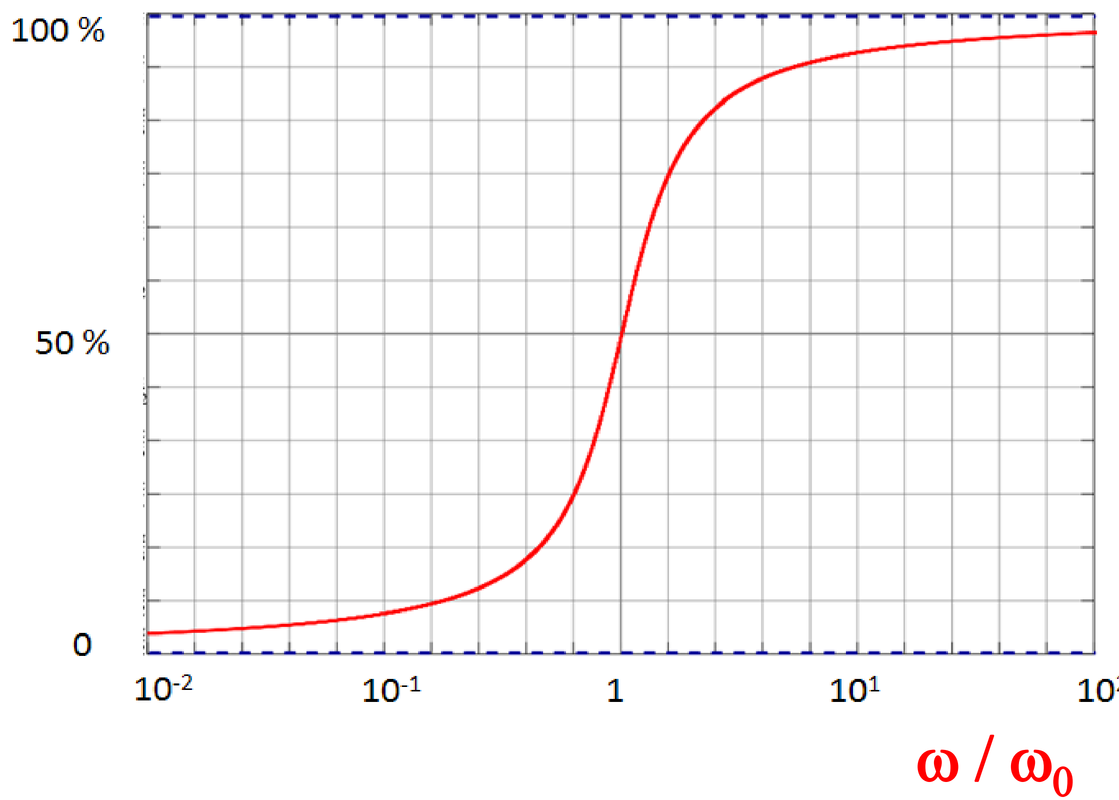
- nonmagnetic impurities are pairbreakers at high fields, reducing the superconducting gap
- Increase of R_s as the field increases

$$R_s \propto \lambda^3(H)\Delta(H)\exp[-\Delta(H)/T]$$

$$\propto \exp\,[C_\Delta(H/H_c)^2\,]\Delta\,/T]$$

Th

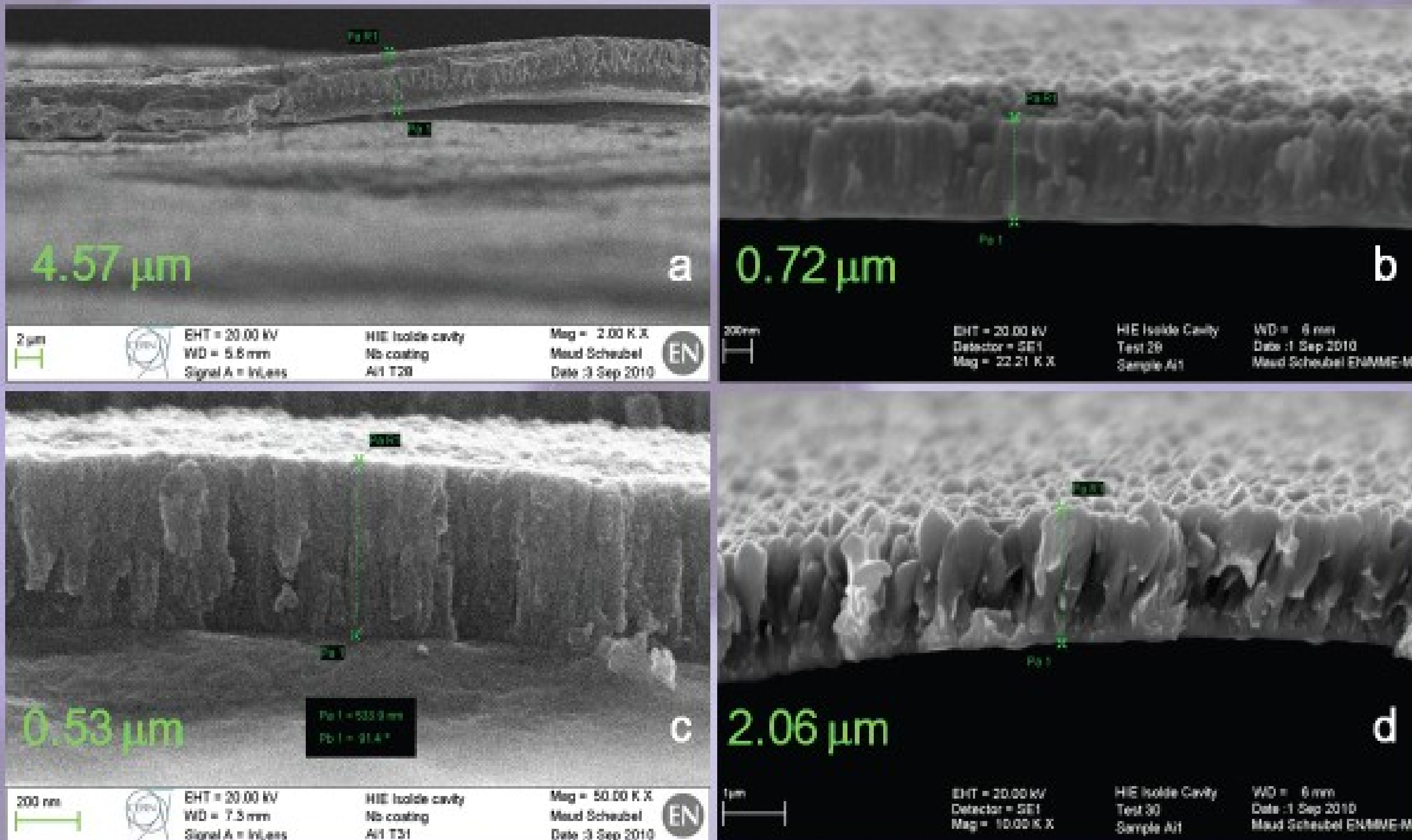
$$\frac{R_n}{\sqrt{2}}\left[\frac{\omega}{\omega_0}\cdot\frac{B}{H_{c_2}}\right]^{1/2}\cdot\frac{1}{\left[1+\left(\frac{\omega}{\omega_0}\right)^2\right]^{1/4}}\cdot\left[\sqrt{1+\frac{1}{\sqrt{1+\left(\frac{\omega_0}{\omega}\right)^2}}}-i\sqrt{1-\frac{1}{\sqrt{1+\left(\frac{\omega_0}{\omega}\right)^2}}}\right]$$



The coating system

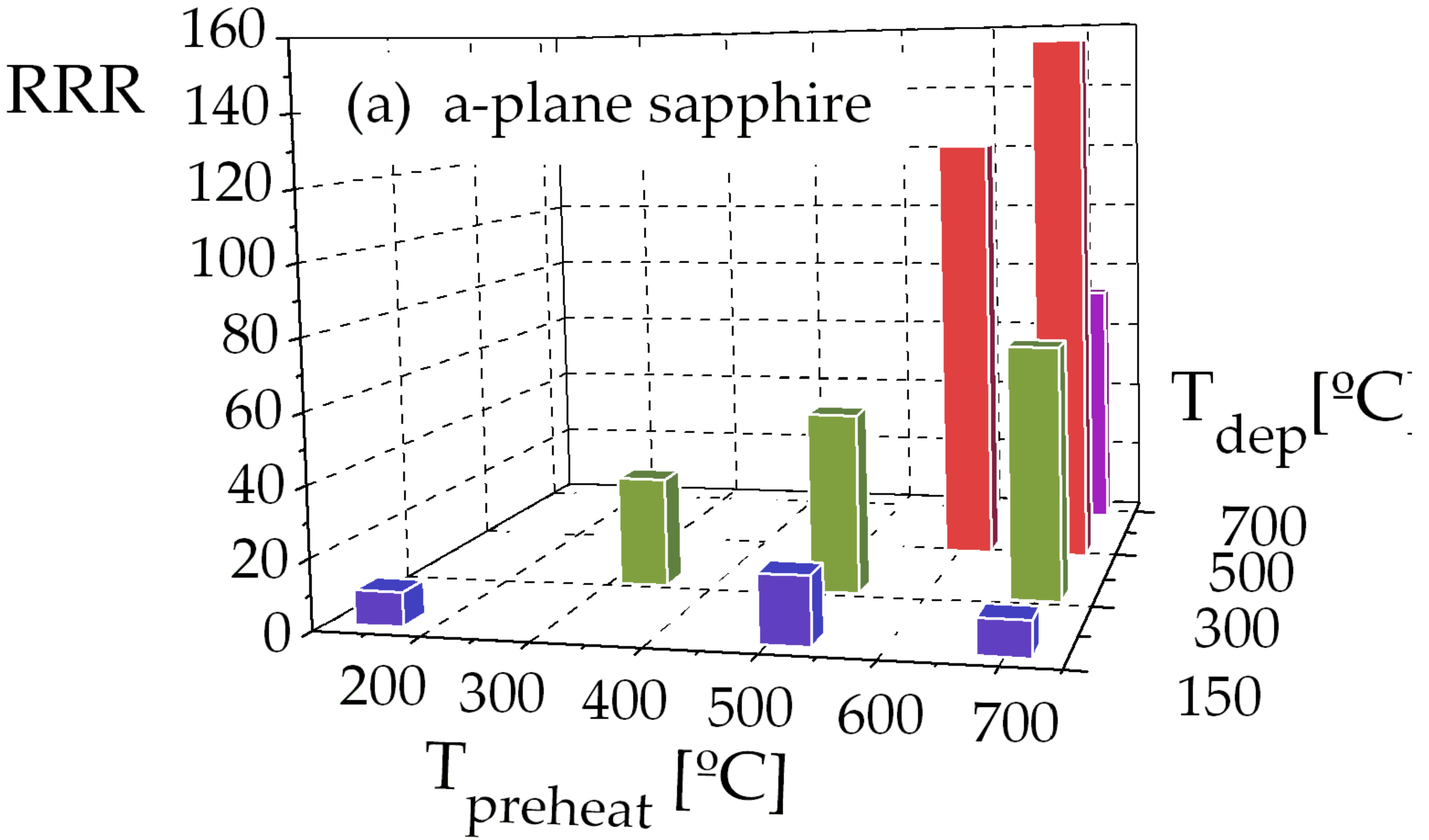
Diode

Magnetron 1,5 x10^{-2} mbar

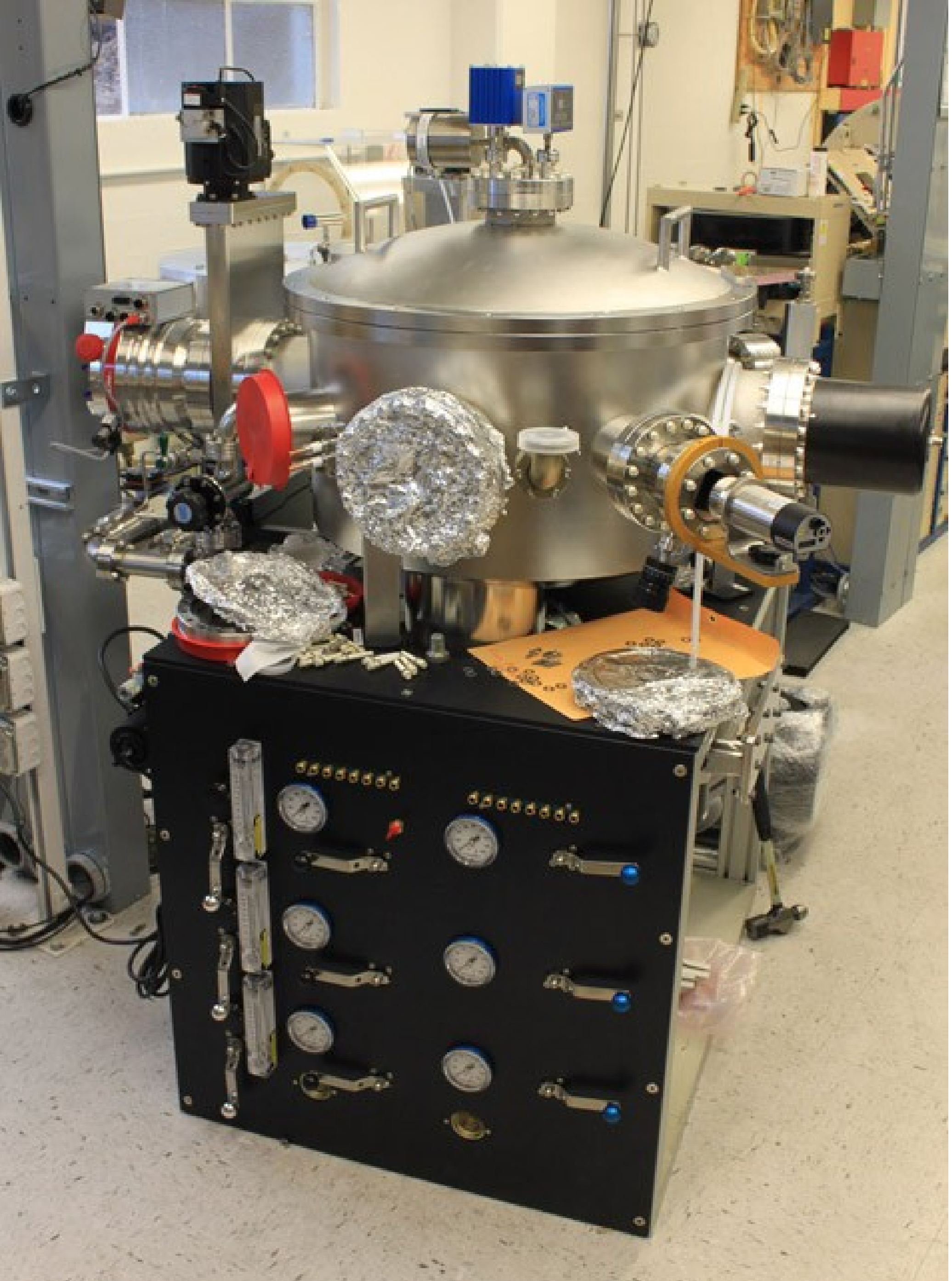


Diode + Magnetron

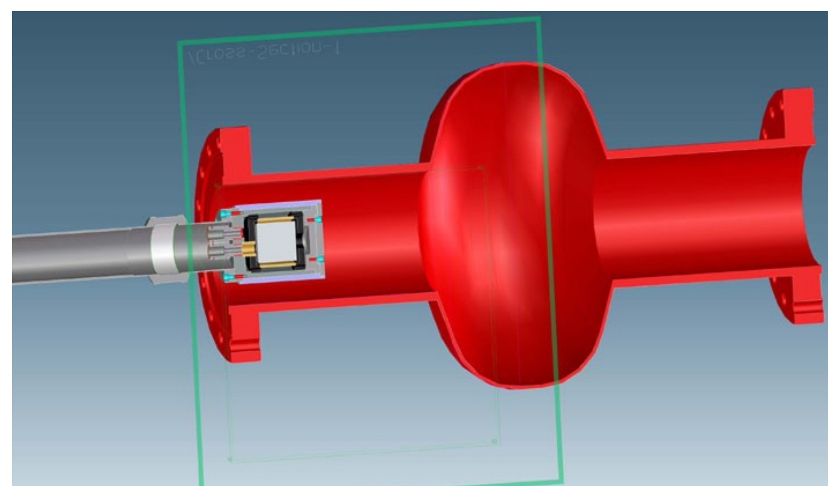
Magnetron 3x10^{-3} mbar



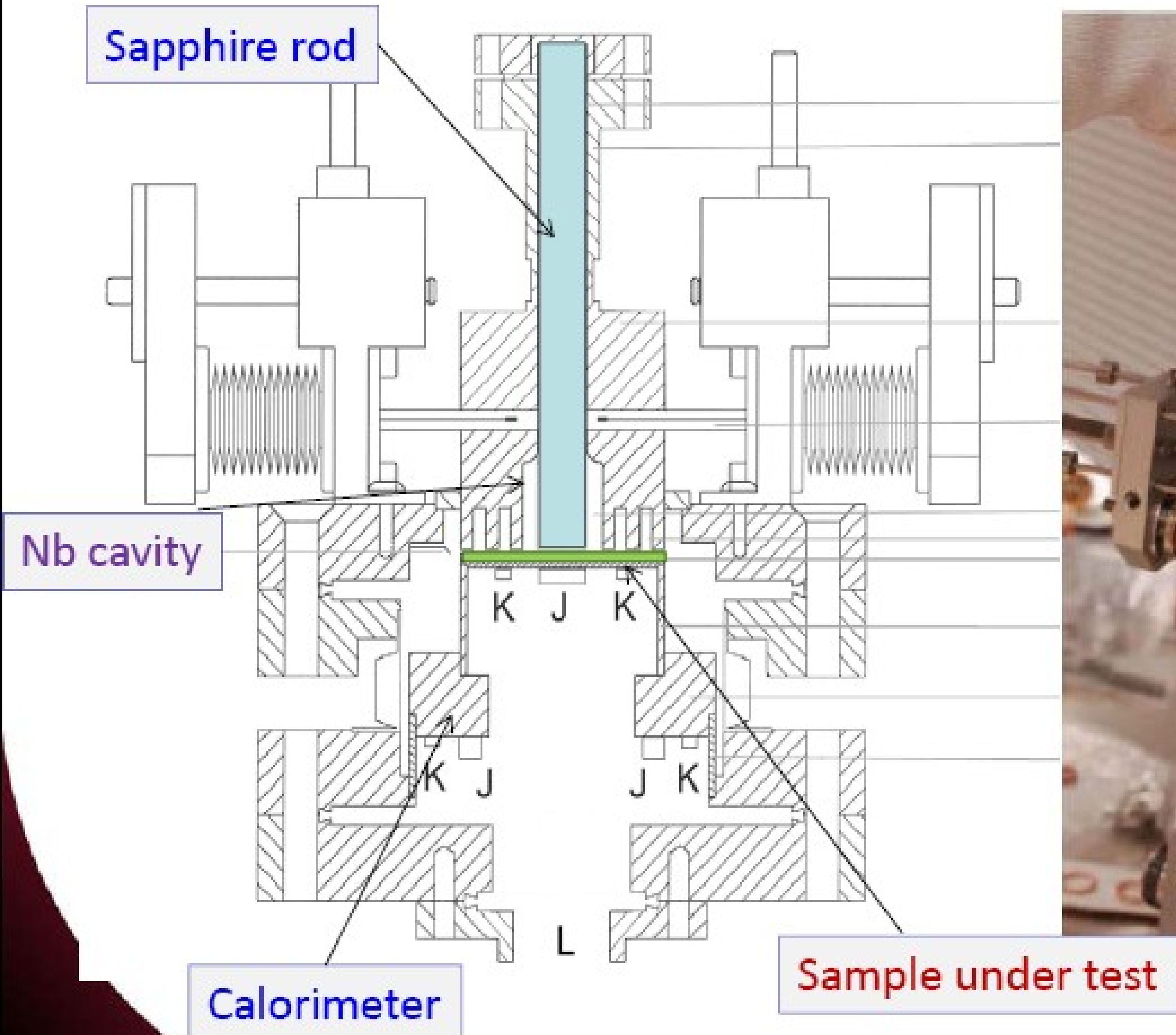
RRR
(a) a-plane sapphire
160
140
120
100
80
60
40
20
0
200
300
400
500
600
700
T preheat [ºC]
T dep [ºC]
700
500
300
150



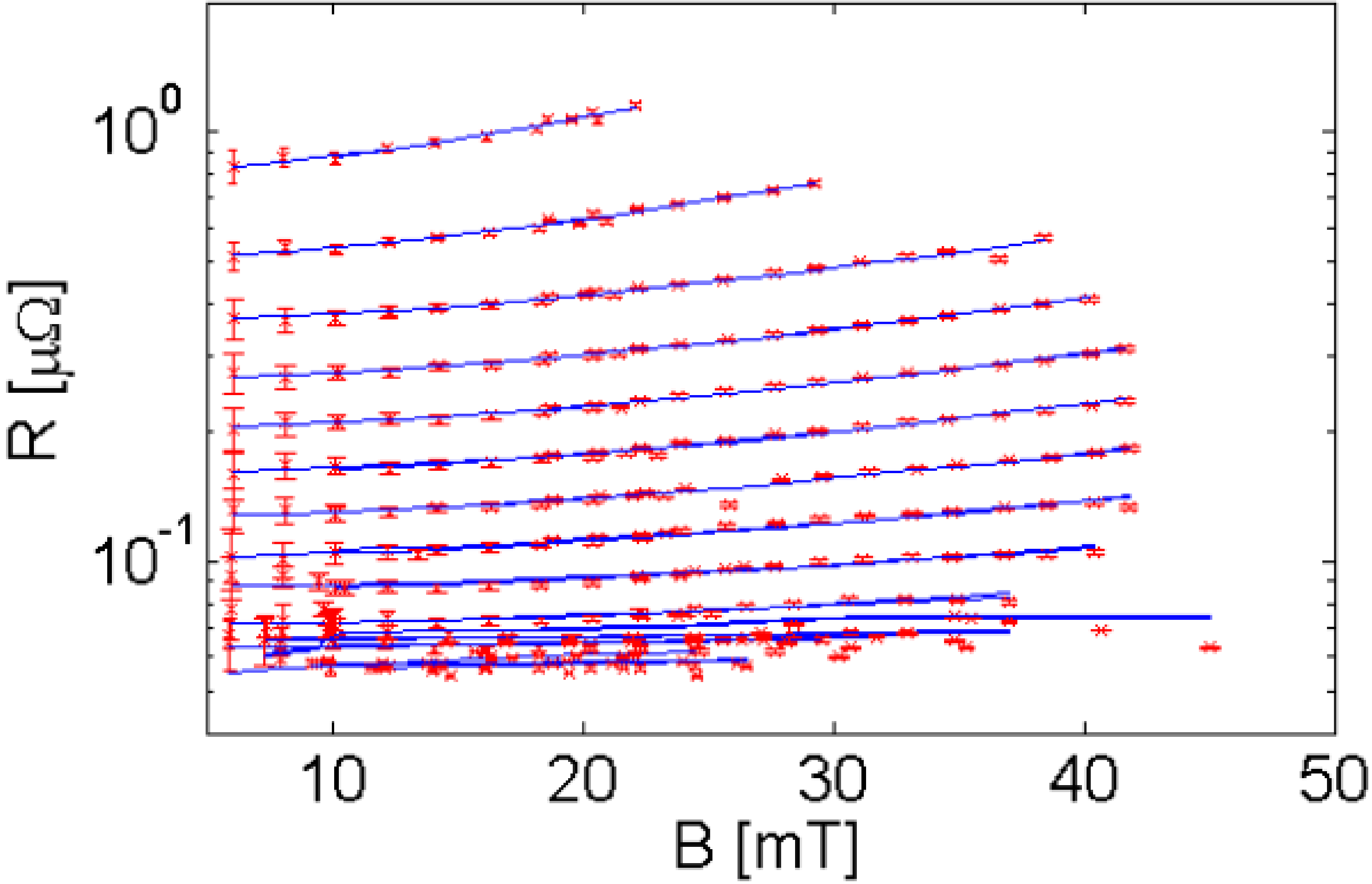
Dedicated Nb-HIPIMS chamber under construction @ Berkeley



7.5 GHz Sapphire loaded TE_{011} Nb cavity



- Bulk niobium sample
- 0.4 GHz
- T=2, 2.5,2.6,2.7, 3,3.5...8 K



Tobias.Junginger@cern.ch

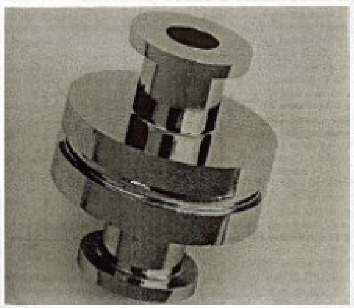
Highlights from TCC Milano: News from other meetings

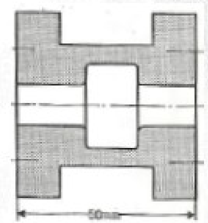
Large Grain Workshop Jefferson Lab

http://conferences.jlab.org/sstin/program.html

Highlights from TCC Milano: News from other meetings

Introductory Remarks on historical data

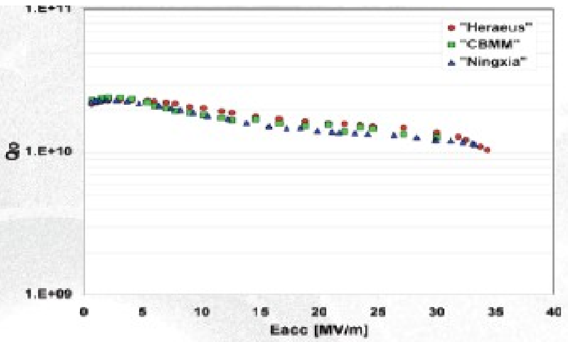




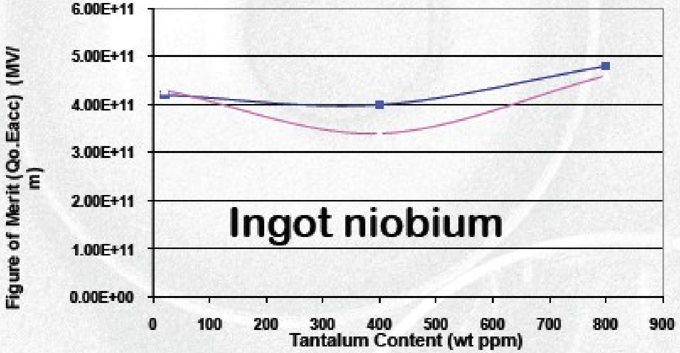
Stanford ca. 1970	Siemens ca. 1973	
BCP	EP	BCP
Qo ~ 1e11 @ 1.2 K CW	130 mT	109 mT
Hpk ~ 108 mT		

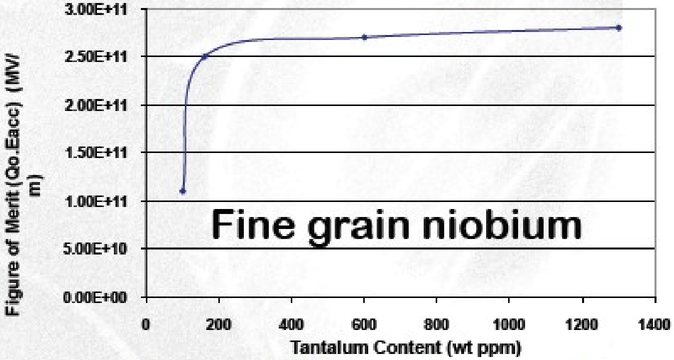
Reactor grade Ep'd Siemens fine grain cavity Hpk ~ 159 mT Qo ~ 1e10 @ 1.45 K

Highlights from TCC Milano: News from other meetings



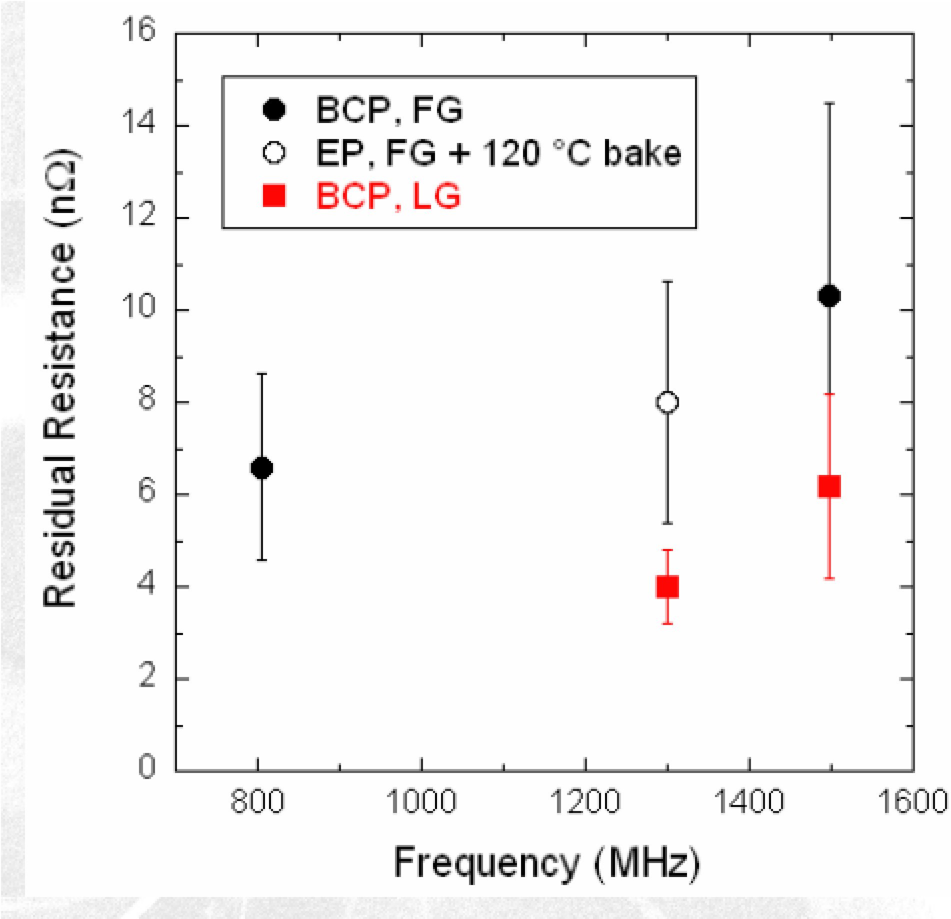
Ingot niobium cavities of different RRR performed equally well – un optimized processes



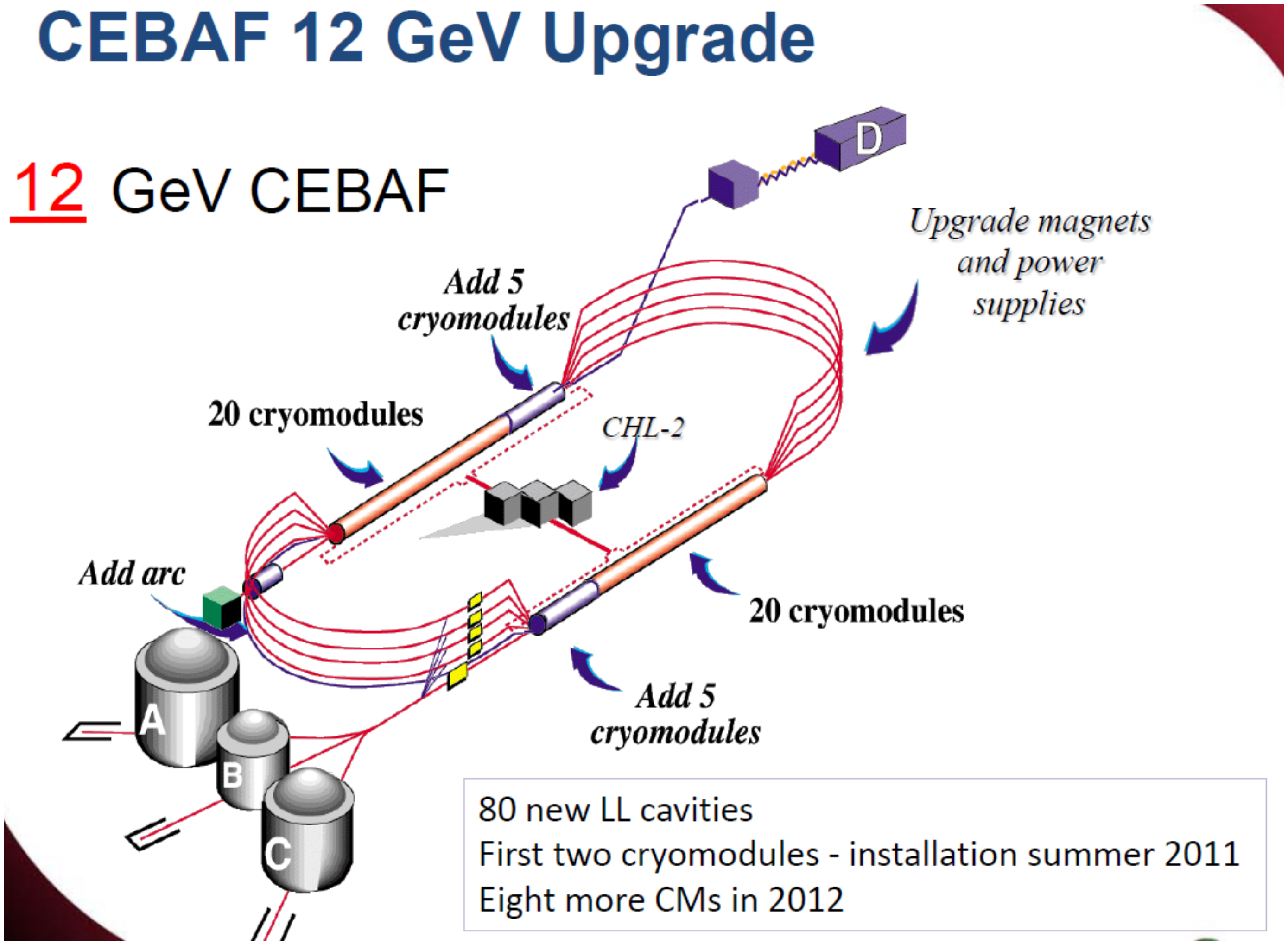


Ingot niobium has higher figure of merit than fine grain

Highlights from TCC Milano: News from other meetings

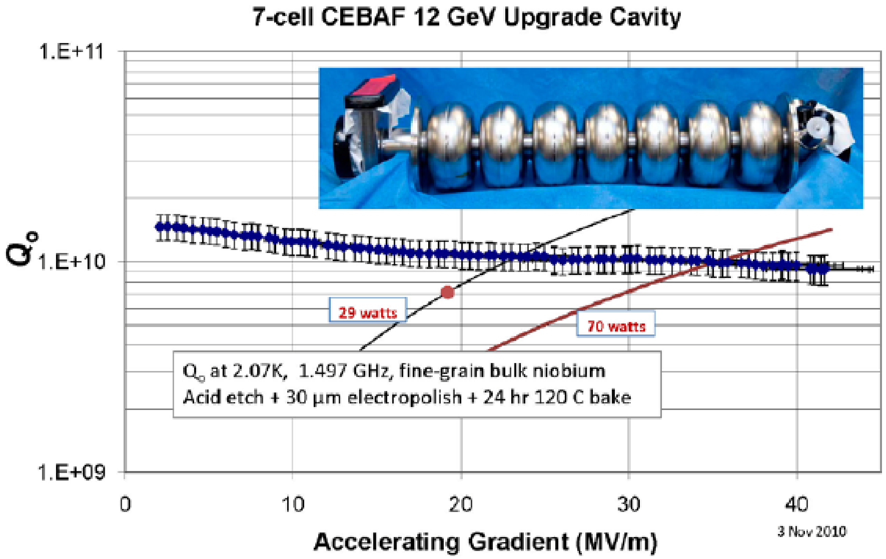


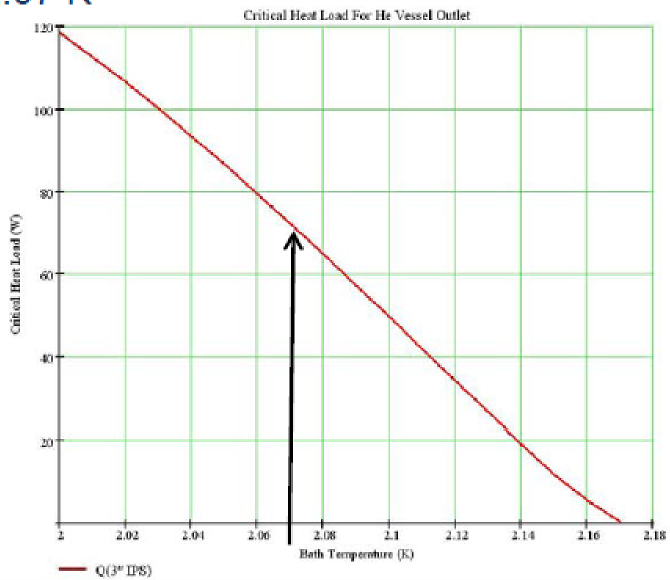
Highlights from TCC Milano: JLAB 1



12 GeV Upgrade Cavities

- Project specification: **19.2 MV/m** average, with 29 W avg. heat
- Operational limit in CEBAF, RF power: **25 MV/m**
- Project conservatism for first two CMs:
  - To avoid any potential risk of degradation from "pushing" gradient
  - **Limiting vertical cavity acceptance testing to 27 MV/m**
  - (rather frustrating to us cavity people who look into the future)
- Vertical rf test only after stainless steel HV attached
  - HV piping size limits heat load to ~70 watts @ 2.07 K





Highlights from TCC Milano: FNAL

Vertical / Horizontal Test

- Have completed 9 horizontal tests of 1.3 GHz 9-cell cavities
- Some difficulty with field emission being addressed
- Procedurally limit to 35 MV/m in HTS
- Good agreement between vertical and horizontal test performance