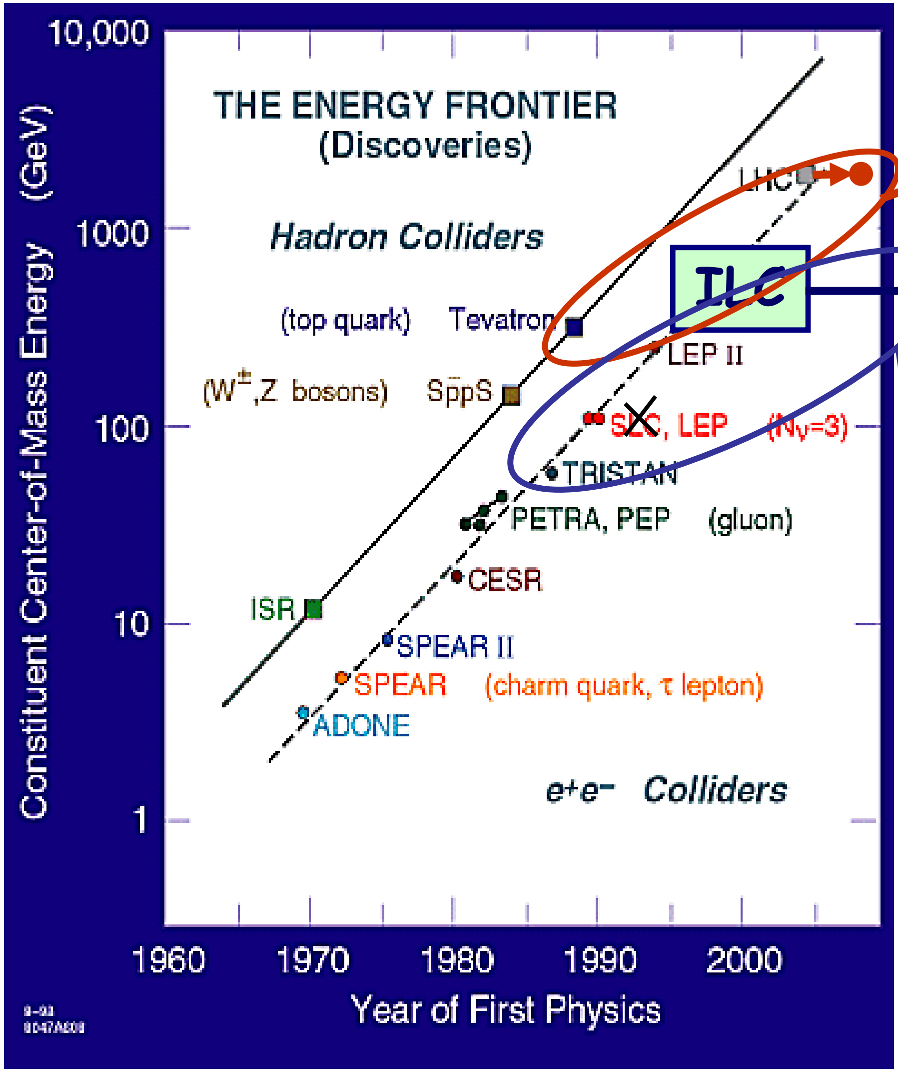
Overview of ILC

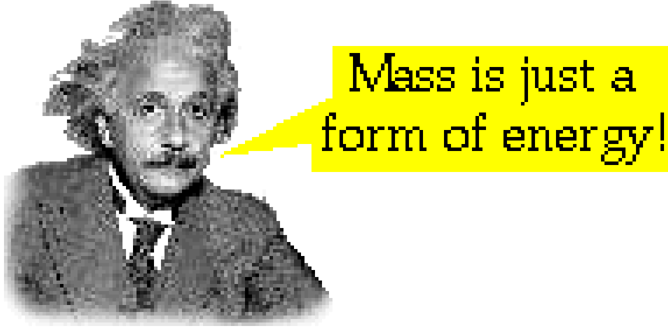
Carlo Pagani
University of Milano
INFN Milano-LASA & GDE

Energy Frontier and Accelerator Tech.



Superconducting Magnets

Superconducting RF Cavities



o Remind…

$$m = \gamma m_0 \qquad E_0 = m_0 c^2$$

$$\gamma = (1-\beta^2)^{-1/2} \qquad \beta = v/c$$

$$E = m c^2$$

Momentum $\quad \boldsymbol{p} = m \boldsymbol{v} \approx m_0 \gamma \boldsymbol{c}$

Kinetic energy $\quad K = E - E_0 = (\gamma - 1)\, m c^2$

Speed of light: c = 2.9979· 10^8 ms^{-1}
Energy unit: 1 eV = 1.6021· 10^{-19} J

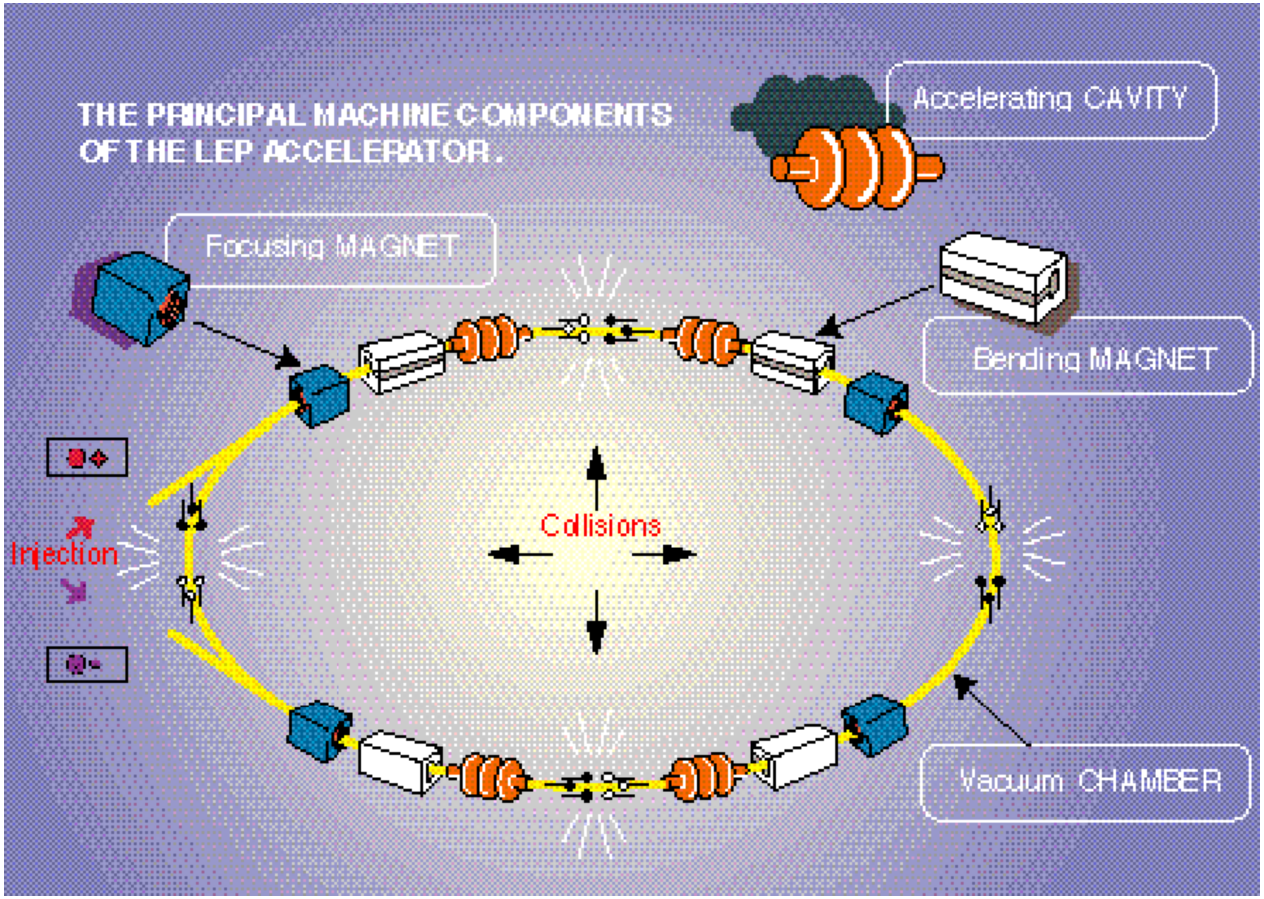
Electron rest energy: E_0 = 0.511 MeV
Proton rest energy: E_0 = 938 MeV

RF acceleration: Synchrotron

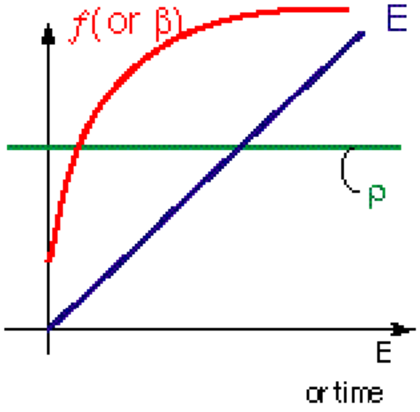
The LEP Example

Cyclotron: constant B Synchrotron: constant ρ

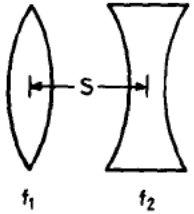
$$B\rho = \frac{mv}{q} = \frac{p}{q}$$



Accelerating cycle



Strong focusing concept

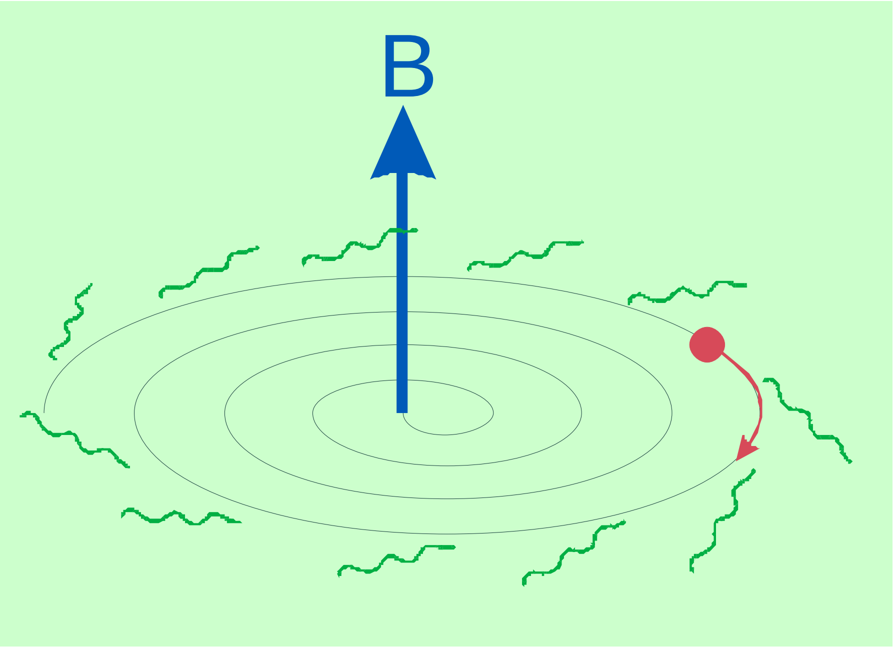


$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{s}{f_1 \cdot f_2}$$

For $v \approx c \longrightarrow E\,[GeV] \approx 0.3\, B\,[T] \cdot \rho\,[m]$

No Circular e^+e^- Collider after LEP

Synchrotron Radiation:
charged particle in a magnetic field:



Energy loss dramatic for electrons

$$U_{SR}\,[\mathrm{GeV}] = 6 \cdot 10^{-21} \cdot \gamma^4 \cdot {}^{1}\!/_{r[km]}$$

U_{SR} = energy loss per turn
γ = relativistic factor
r = machine radius

$$\gamma_{proton} / \gamma_{electron} \approx 2000$$

Energy loss replaced by RF power
cost scaling $\$ \propto E_{cm}^2$

A Simple Exercise

- Synchrotron Radiation (SR) becomes prohibitive for electrons in a circular machine above LEP energies:

$$U_{SR}[\mathrm{GeV}] = 6 \cdot 10^{-21} \cdot \gamma^4 \cdot {}^{1}\!/_{r[\mathrm{km}]}$$

U_{SR}	=	energy loss per turn
γ	=	relativistic factor
r	=	machine radius

- RF system must replace this loss, and r scale as E^2
- LEP @ 100 GeV/beam: 27 km around, 2 GeV/turn lost
- Possible scale to 250 GeV/beam i.e. **E_{cm} = 500 GeV**:
  - **170 km** around
  - **13 GeV/turn** lost

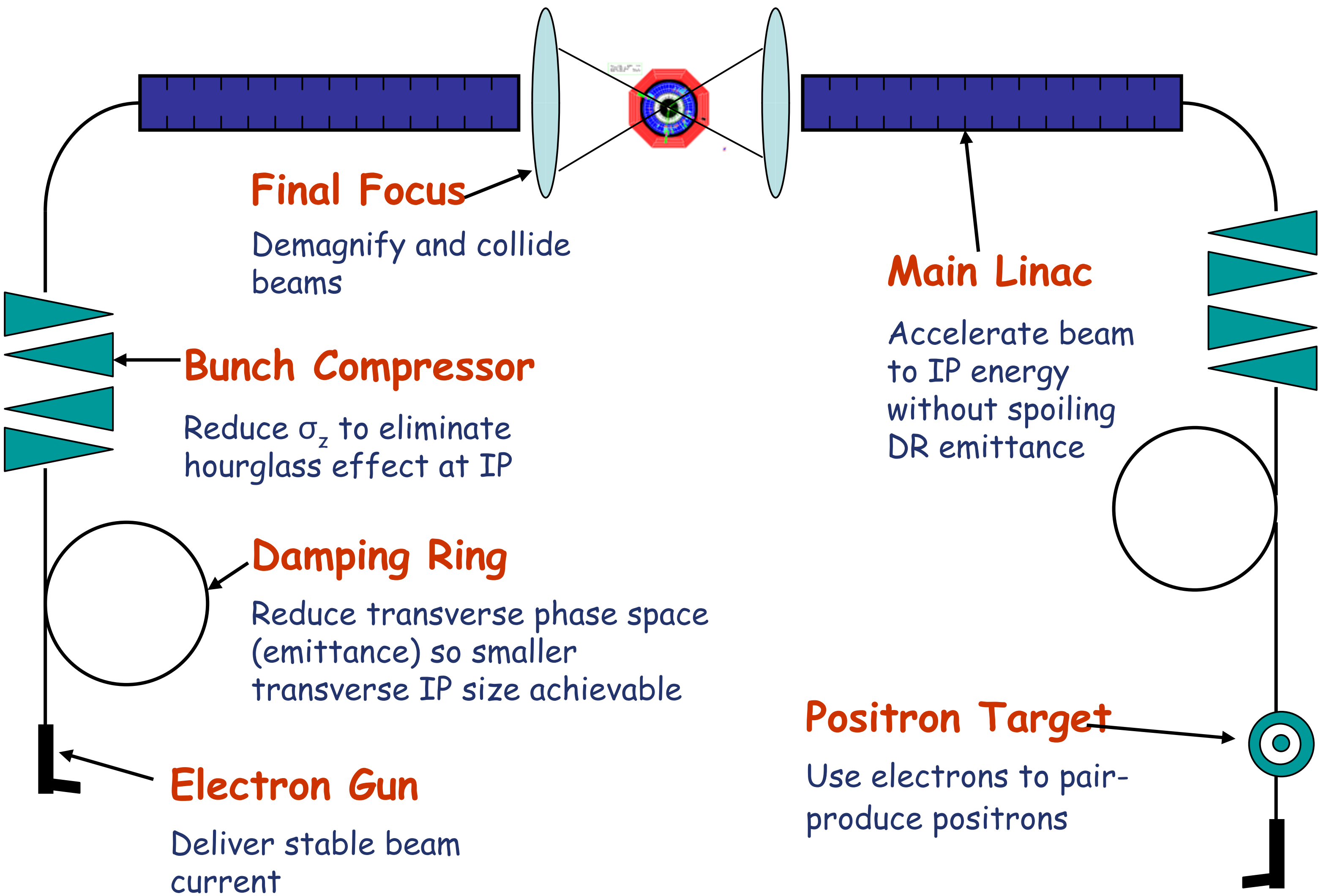
$\gamma_{250GeV} = 4.9 \, . \, 10^5$

- Consider also the luminosity
  - For a luminosity of ~ 10^{34}/cm^2/second, scaling from b-factories gives ~ 1 Ampere of beam current
  - 13 GeV/turn x 2 amperes = **26 GW RF power**
  - Because of conversion efficiency, this collider would consume more power than the state of **California in summer: ~ 45 GW**

Circulating beam power = 500 GW

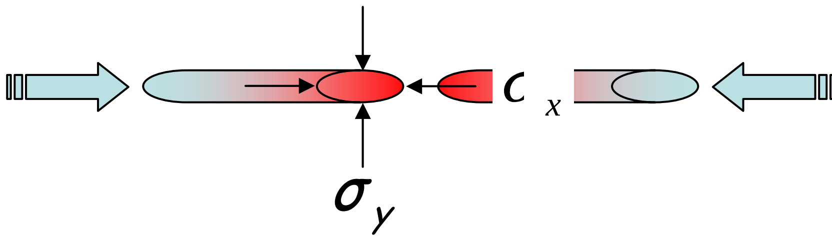
- Both size and power seem excessive

LC conceptual scheme



Fighting for Luminosity

$$L \propto \frac{N_e^2}{\sigma_x \sigma_y}$$



$$L \propto n_b \times f_{rep}$$

L = Luminosity

N_e = # of electron per bunch

$\sigma_{x,y}$ = beam sizes at IP

IP = interaction point

$$L \propto \frac{P_b}{E_{c.m.}} \times \frac{N_e}{\sigma_x \sigma_y}$$

n_b = # of bunches per pulse

f_{rep} = pulse repetition rate

P_b = beam power

$E_{c.m.}$ = center of mass energy

Parameters to play with

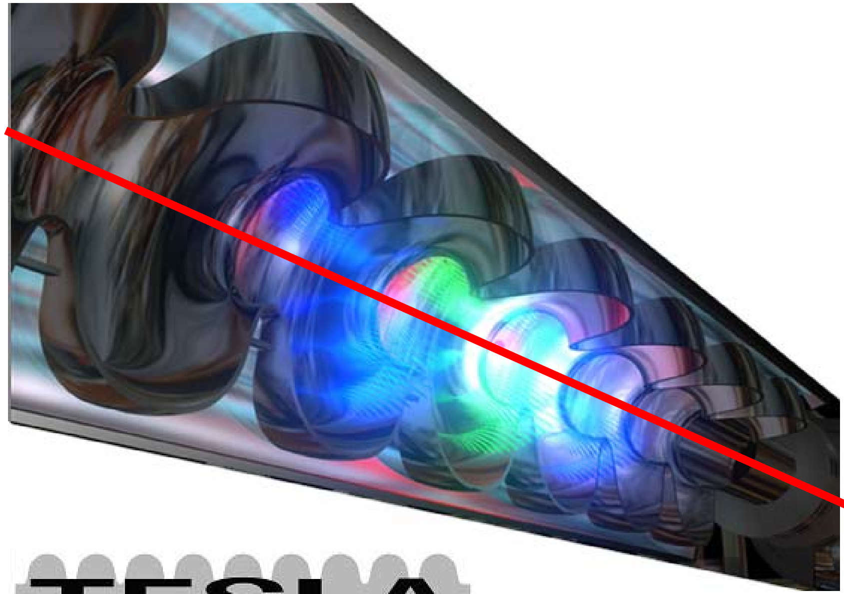
↓ Reduce **beam emittance** $(\varepsilon_x \cdot \varepsilon_y)$ for smaller beam size $(\sigma_x \cdot \sigma_y)$

↑ Increase bunch population (N_e)

↑ Increase beam power $(P_b \propto N_e \times n_b \times f_{rep})$

↑ Increase **beam to-plug power efficiency** for cost

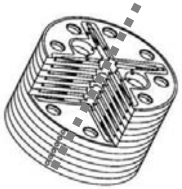
Competing technologies for the ILC



TESLA

1.3 GHz - Cold

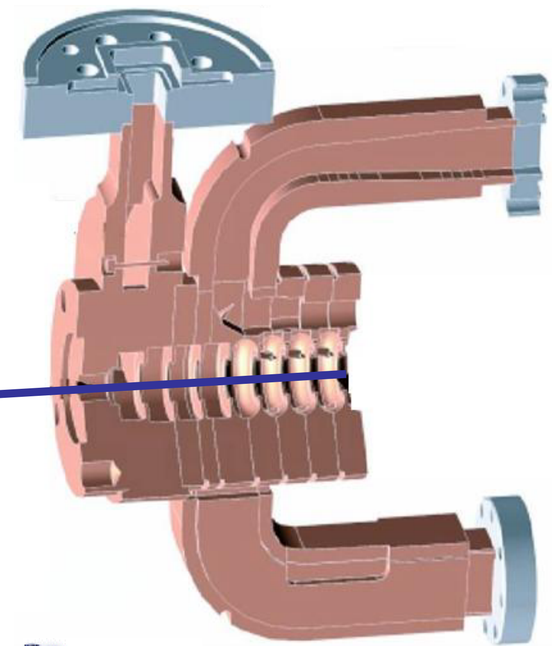
Evolution from: CEBAF & LEPII
+ TRISTAN, HERA, etc.



CLIC

30 GHz-Warm

Evolution from: SLAC & SLC
+ hundreds for research & application



NLC

JLC

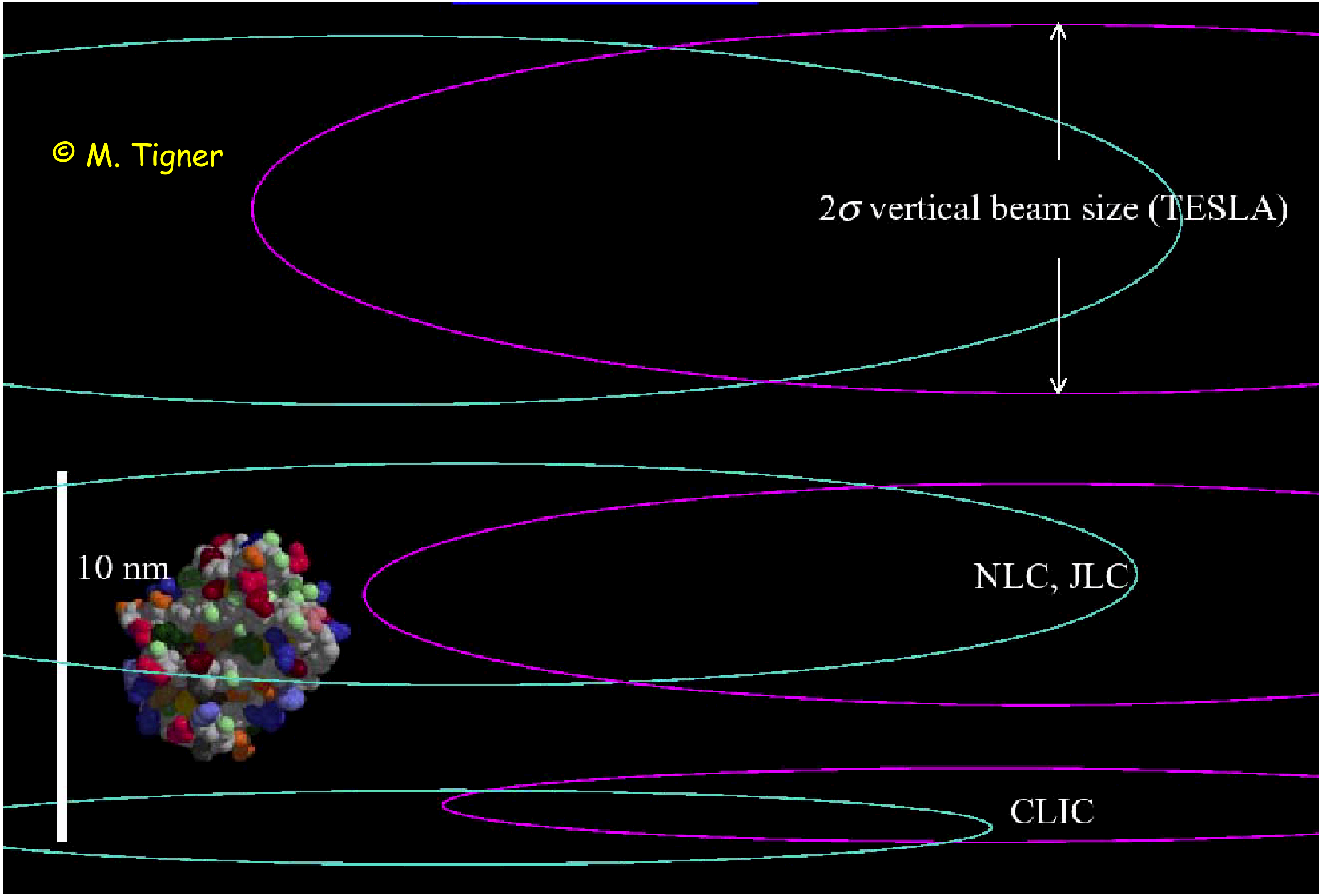
11.4 GHz - Warm

LC status at second ILC-TRC

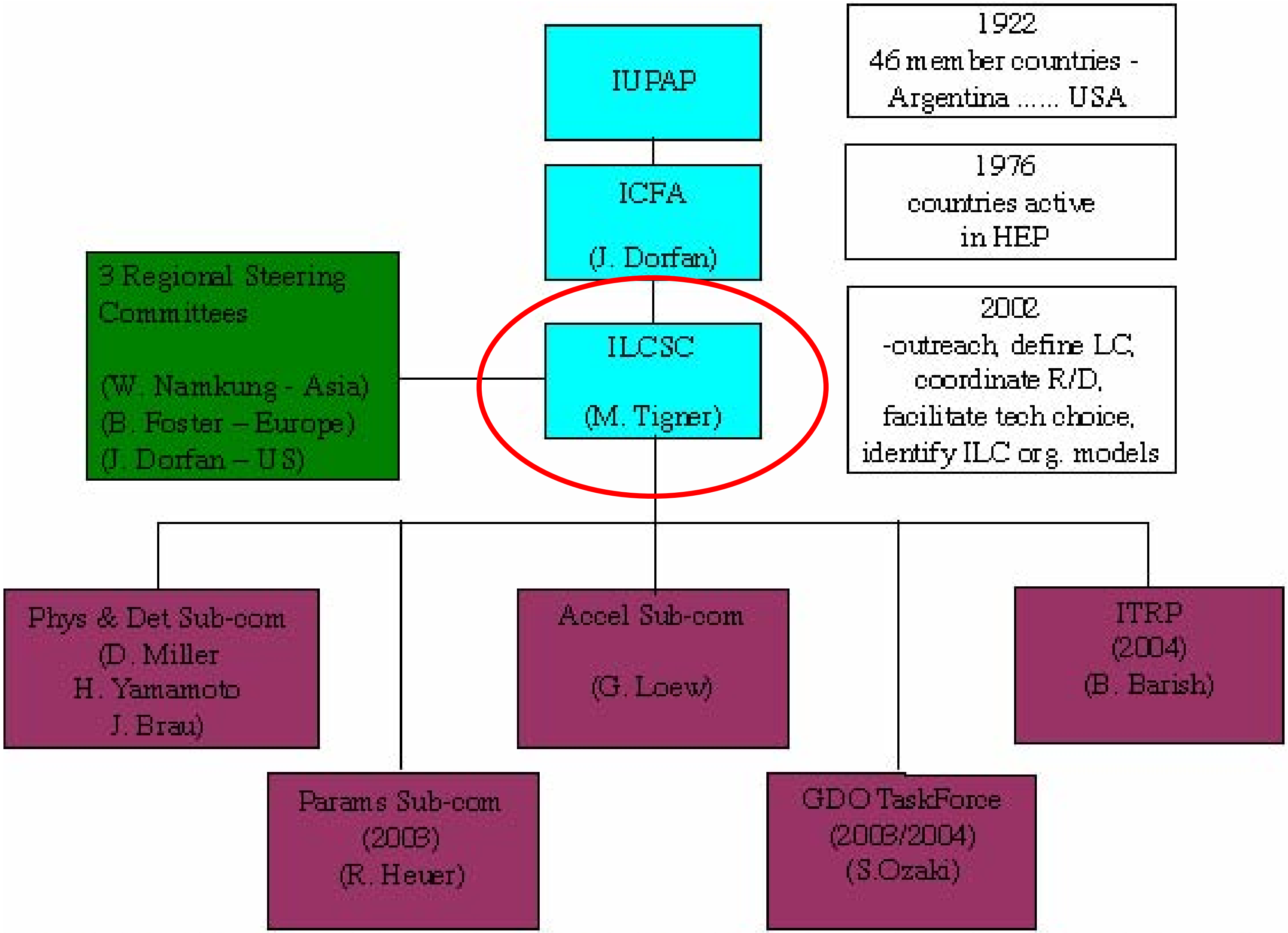
January 2003 E_{cm} = 500 GeV

	TESLA	SBLC	JLC-S	JLC-C	JLC-X/NLC	VLEPP	CLIC
f [GHz]	1.3			5.7	11.4		30.0
$\mathcal{L} \times 10^{33}$ [$cm^{-2}s^{-1}$]	34			14	20		21
P_{beam} [MW]	11.3			5.8	6.9		4.9
P_{AC} [MW]	140			233	195		175
$\gamma\varepsilon_y$ [$\times 10^{-8}$m]	3			4	4		1
σ_y^* [nm]	5			4	3		1.2

Beam Sizes



LC Organisation up to August 2004



From the ILC Birthday

The Recommendation

- We recommend that the linear collider be based on superconducting rf technology (from Exec. Summary)
  - This recommendation is made with the understanding that we are recommending a technology, not a design. We expect the final design to be developed by a team drawn from the combined warm and cold linear collider communities, taking full advantage of the experience and expertise of both (from the Executive Summary).
  - We submit the Executive Summary today to ILCSC & ICFA
  - Details of the assessment will be presented in the body of the ITRP report to be published around mid September
  - The superconducting technology has features that tipped the balance in its favor. They follow in part from the low rf frequency.

19-Aug-04 ITRP - LC Technology Recommendation 13

From the ILC Birthday

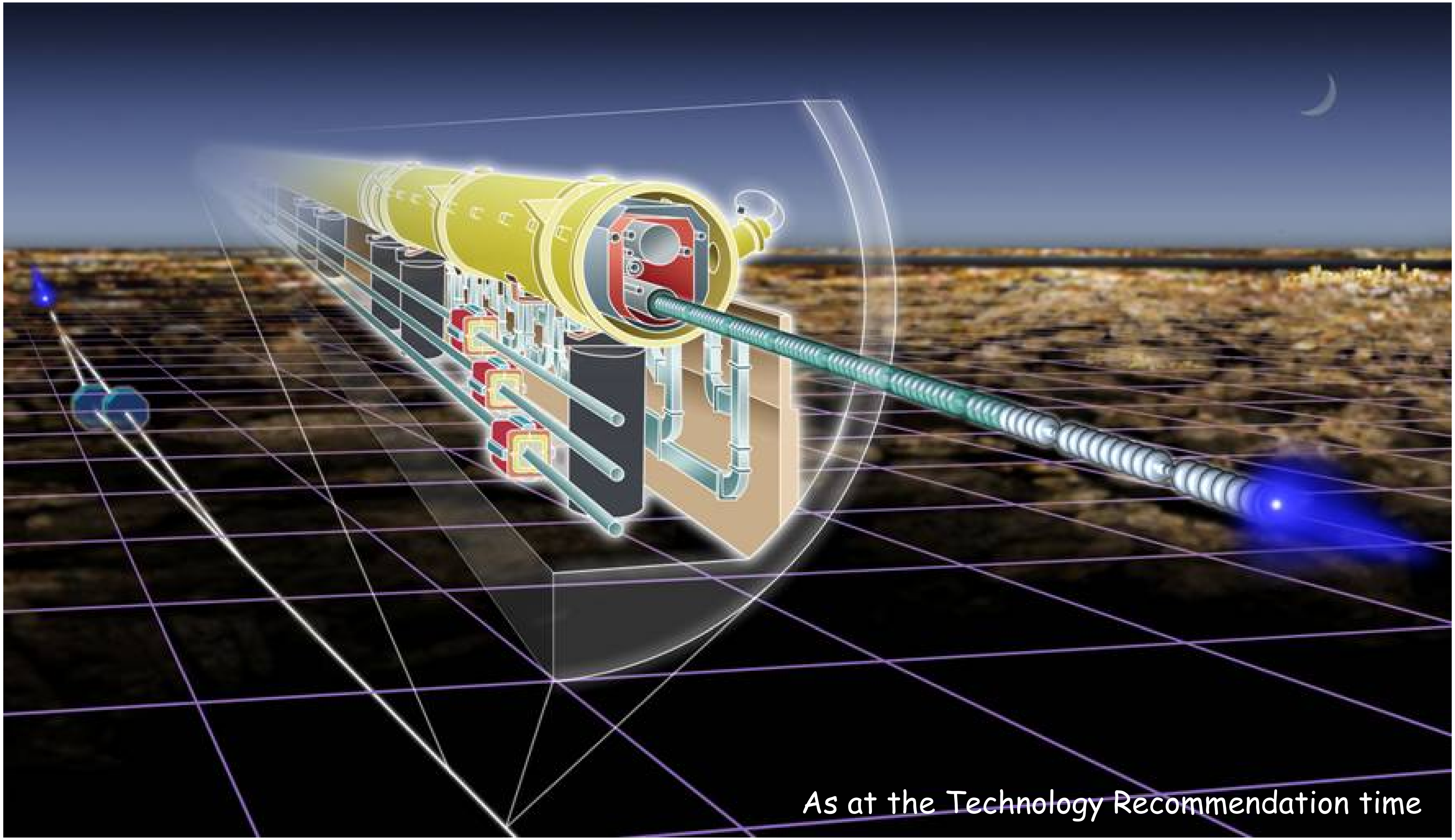
Some of the Features of SC Technology

- The large cavity aperture and long bunch interval reduce the complexity of operations, reduce the sensitivity to ground motion, permit inter-bunch feedback and may enable increased beam current.
- The main linac rf systems, the single largest technical cost elements, are of comparatively lower risk.
- The construction of the superconducting XFEL free electron laser will provide prototypes and test many aspects of the linac.
- The industrialization of most major components of the linac is underway.
- The use of superconducting cavities significantly reduces power consumption.

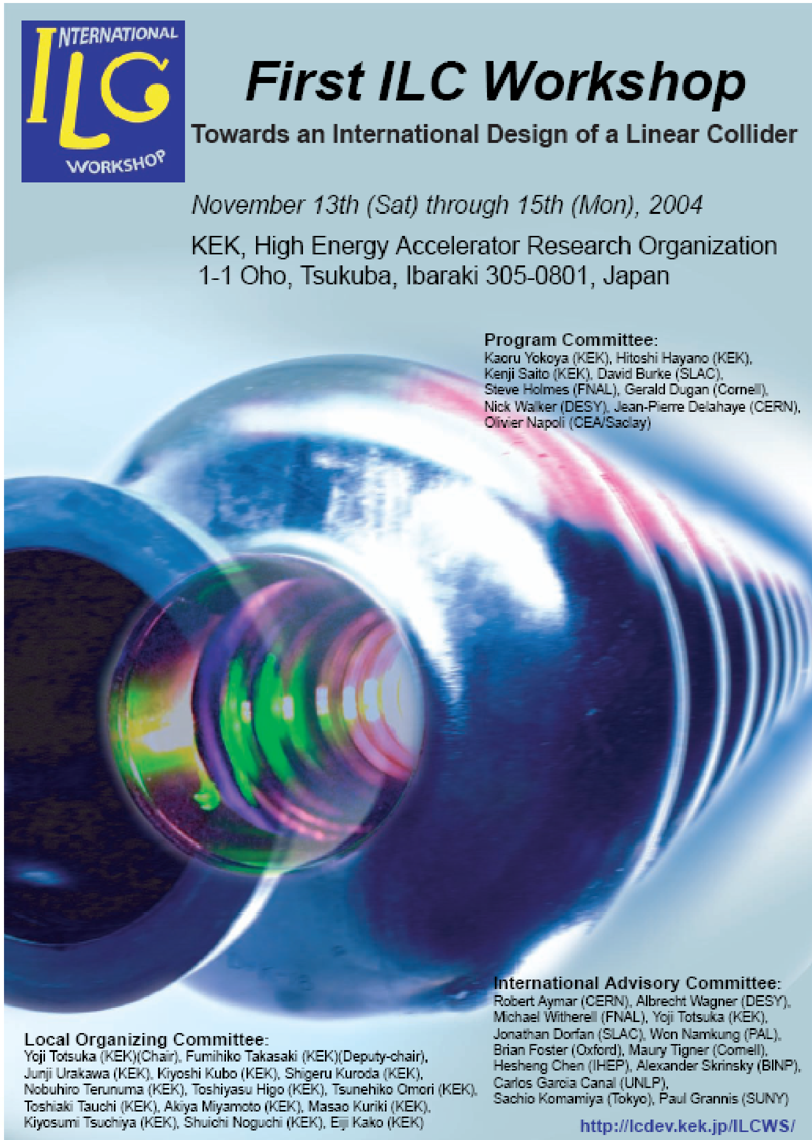
Both technologies have wider impact beyond particle physics. The superconducting rf technology has applications in other fields of accelerator-based research, while the X-band rf technology has applications in medicine and other areas.

19-Aug-04 ITRP - LC Technology Recommendation 14

ILC Pictorial View (TESLA Like)



Start of the Global Design Initiative

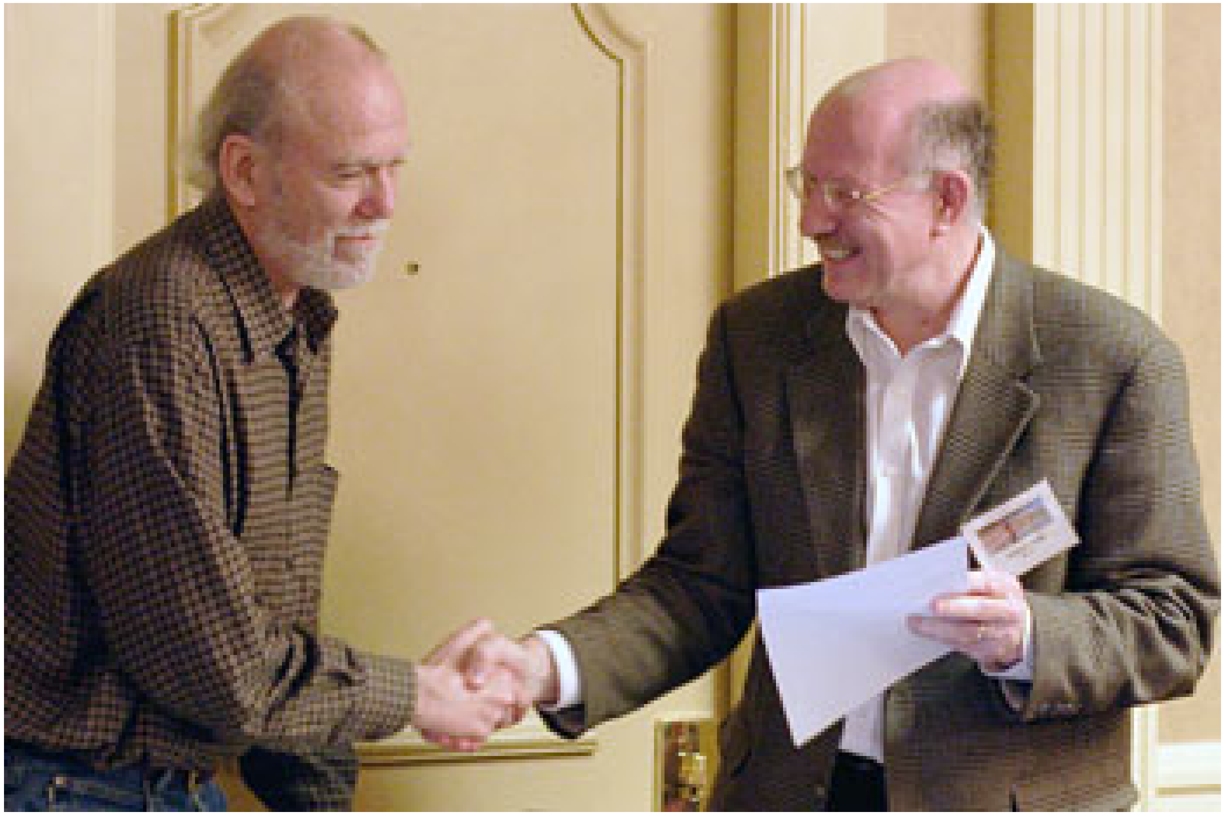


~ 220 participants from 3 regions

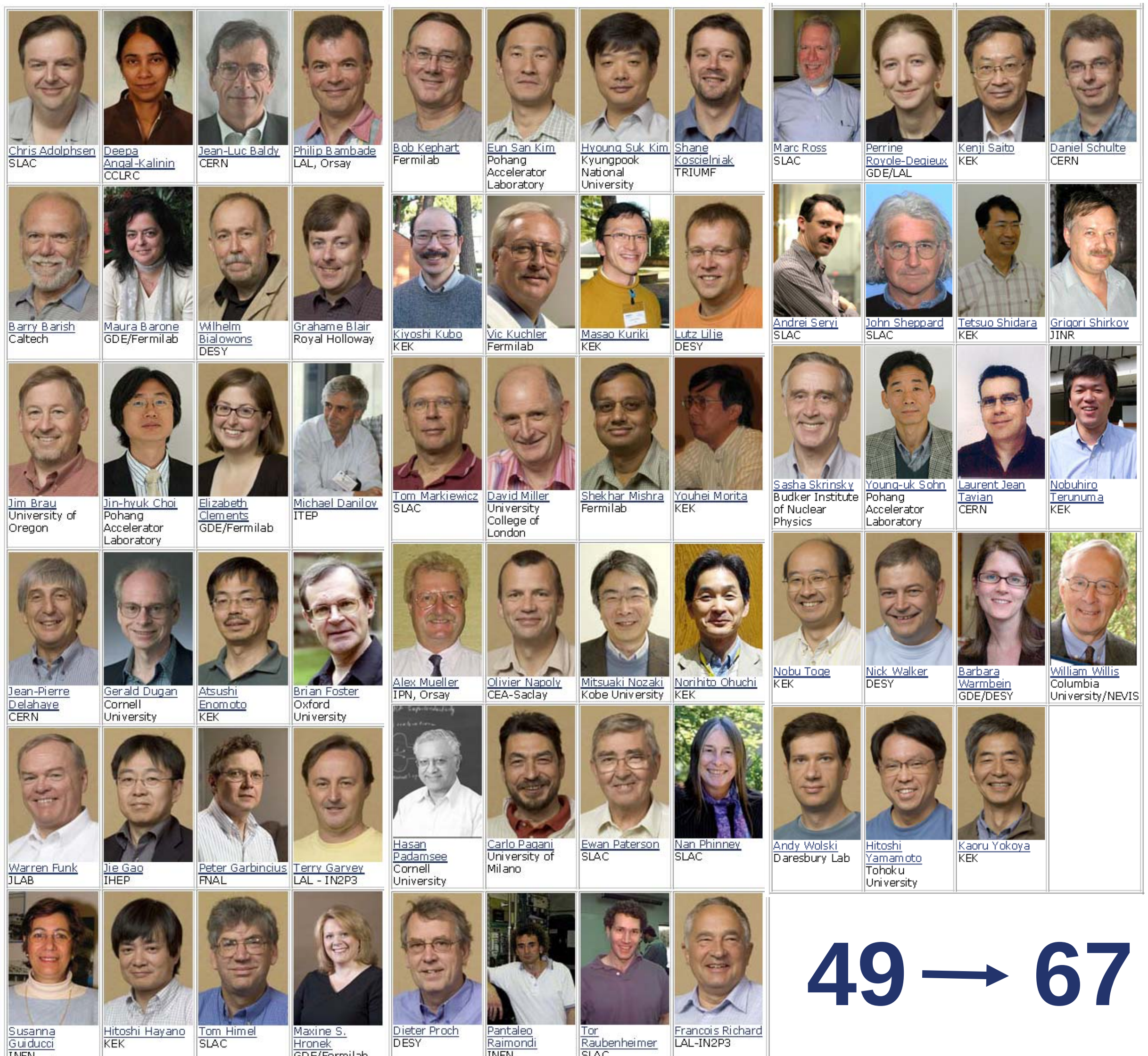
most of them accelerator experts

Global Design Effort (GDE)

On March 18, 2005, during the opening of *LCWS05* workshop at Stanford University, **Barry Barish** officially accepted the position of Director of the **G**lobal **D**esign **E**ffort, **GDE** (yet to be formed)



GDE Actual Members



49 → 67

Linacs are made of RF cavities

- To give energy to a charged particle beam, apart from "details", you need to let him move across a region in which an electric field exists and is directed as the particle motion.

$$\Delta E_{particle} = \int \vec{F}_{Lorentz} \cdot d\vec{s} = q \int \vec{E} \cdot \vec{v}\, dt$$

- In the accelerator's world RF take care of all the variety of items that are required to accomplish this task of creating a region filled of electromagnetic energy that can be sucked by the beam while crossing it.
- An "RF power source" is used to fill, via a "coupler", the "RF cavity", or resonator that is the e.m. energy container from which the beam is taking its energy.
- What we ask to a good cavity?

High Q for losses:

U = stored energy

P_{diss} = dissipated power

$$Q = \omega \frac{U}{P_{diss}}$$

Small R_s for high Q:

R_s = surface resistance

G = cavity geometrical factor

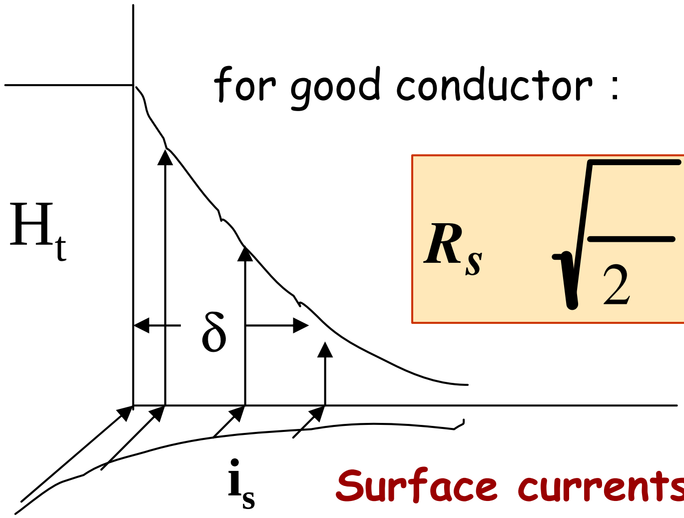
$$Q = \frac{G}{R_s}$$

Why Cold RF ?

Normal conducting	Superconducting
δ = **skin depth of microwave**	λ = **London penetration depth**

for good conductor : $\quad — \quad 1$

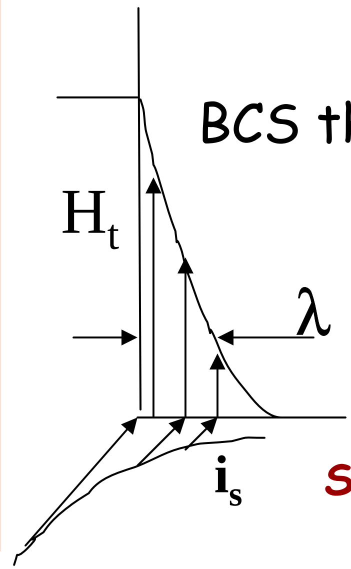
$$R_s \quad \sqrt{\frac{\quad}{2}} \quad \frac{1}{\quad}$$



BCS theory

$$R_s \quad \frac{2}{T} \, e^{\frac{\quad}{k_B T}}$$

$$\Delta/k_B \approx 1.85\, T_C$$



$$P_{diss} = \frac{R_S}{2} \int_S H^2 dS$$

Nb

Cu

$$R_S\,[\mathrm{n}\Omega] = 9 \times 10^4 \frac{f^2\,[\mathrm{GHz}]}{T\,[\mathrm{K}]} \exp\left(-\frac{17.6}{T\,[\mathrm{K}]}\right)$$

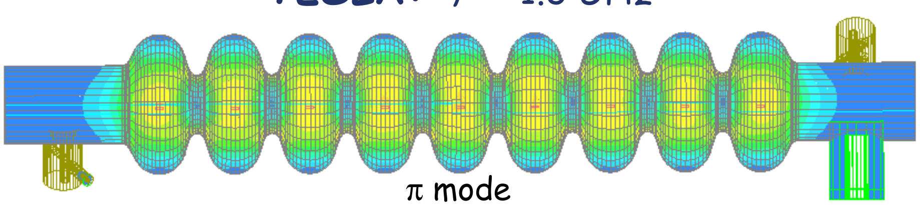
$$R_S\,[\mathrm{m}\Omega] = 7.8\, f^{\frac{1}{2}}\,[\mathrm{GHz}]$$

SC
Superconducting
NC or RT
Normalconducting

The ILC technology choice

Standing wave: $V_{ph} = 0$ and $Vg = c$

TESLA: f = 1.3 GHz



The power is deposited at the operating temperature of 2 K

We need to guarantee and preserve the 2 K environment

- Cavity is sensitive to pressure variations, only viable environment is sub-atmospheric vapor saturated He II bath

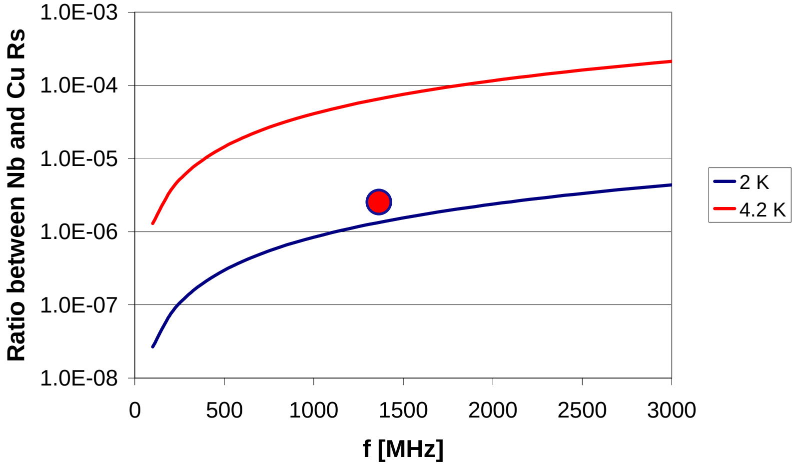
We need a thermal "machine" that performs work at room temperature to extract the heat deposited at cold

- We can't beat Carnot efficiency!

Remembering that the power dissipated on the cavity walls to sustain a field is:

$$P_{diss} = \frac{R_s}{2} \int_S H^2 dS$$ standing wave case

a pulsed operation is required to reduce the time in which the maximum allowable field is produced to accelerate the particles



→ Cryogenics and cryomodules

How is spent the cold advantage?

The gain in RF power dissipation with respect to a normal-conducting structure is spent in different ways

$$W \geq Q \frac{T_h - T_c}{T_c}$$

- Paying the price of supplying coolant at 2K
  - This include ideal Carnot cycle efficiency
  - Mechanical efficiency of compressors and refrigeration items
  - Cryo-losses for supplying and transport of cryogenics coolants
  - Static losses to maintain the linac cold
- Increasing of the duty cycle (percentage of RF field on)
  - Longer beam pulses, larger bunch separation, but also
  - Larger and more challenging Damping Rings
- Increasing the beam power (for the same plug power)
  - Good for Luminosity

The Residual Resistance

$$R_s = \frac{A\omega^2}{T}\exp\left(-\frac{\Delta}{k_B T}\right) + R_{res}$$

- Constant R_{res} at $T \rightarrow 0$ for small H_0 is inconsistent with the BCS theory
- Mechanisms of R_{res} are likely unrelated to superconductivity
- Field, temperature and frequency dependences of R_{res} are poorly understood
- Effect of surface oxides (hydrides) or more fundamental mechanisms?

$R_{res} \approx$ 1-20 nΩ

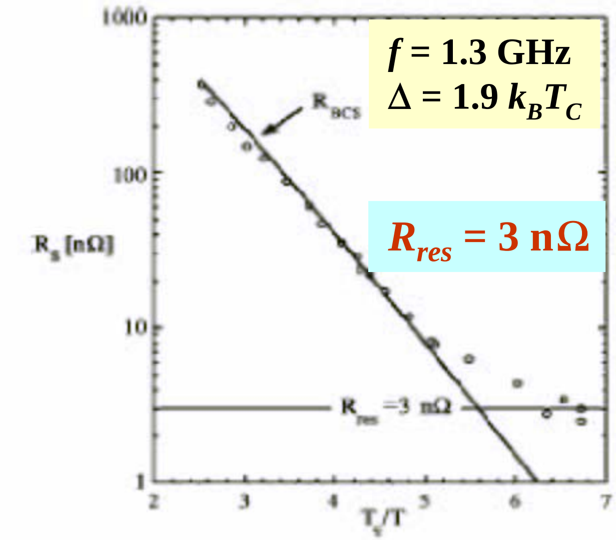
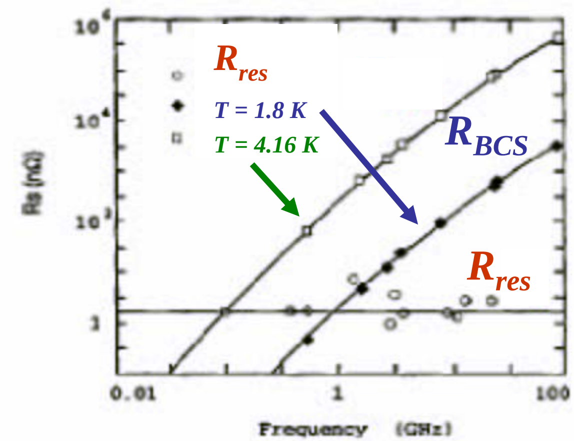


Figure 16. Measured temperature dependence of the surface resistance of a Nb cavity at 1.3 GHz. In this semi-log plot, the linear region gives an energy gap of $\Delta = 1.9kT_c$. The residual resistance is 3 nΩ.

From: H. Padamsee's Book



Other Physical Limits

Critical Magnetic Field Limit

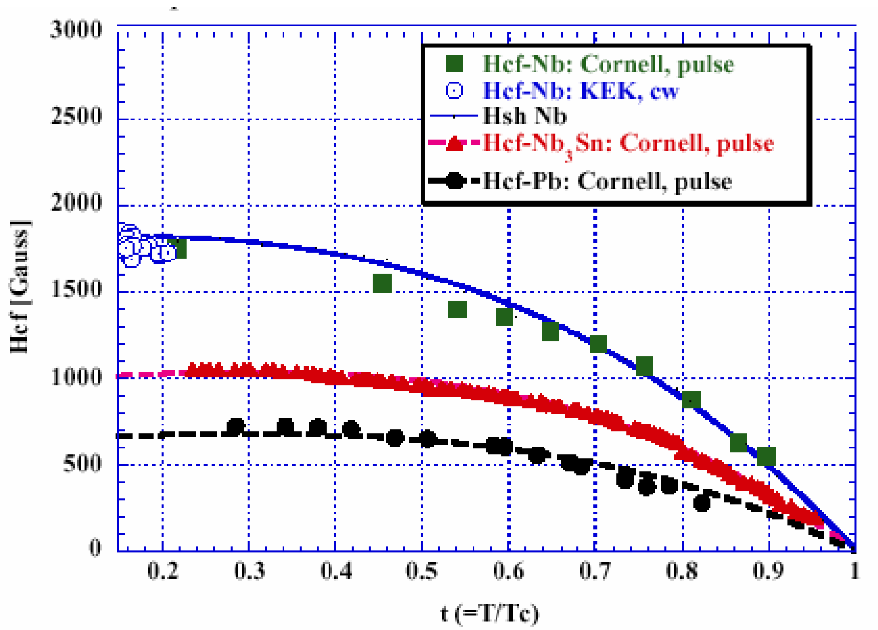
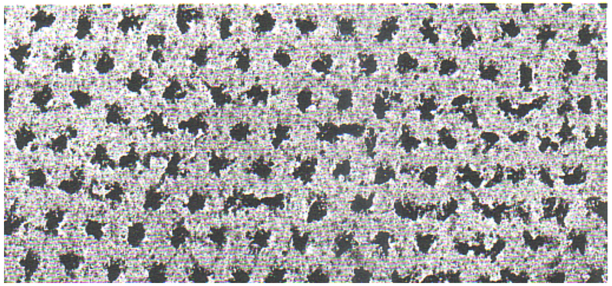


Figure 10: Critical RF fields (Hcf) of sc cavities and Hsh.

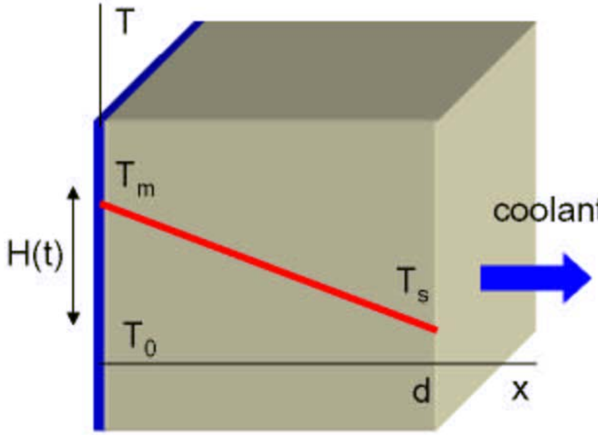
$B_{max} \leq 180\ mT$

Vortex state of trapped Magnetic Field



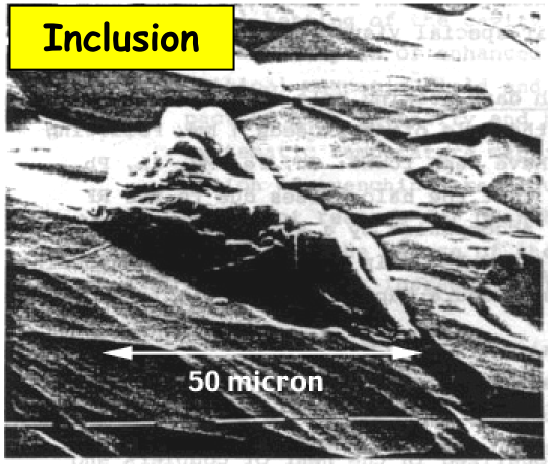
Limited thermal conductivity

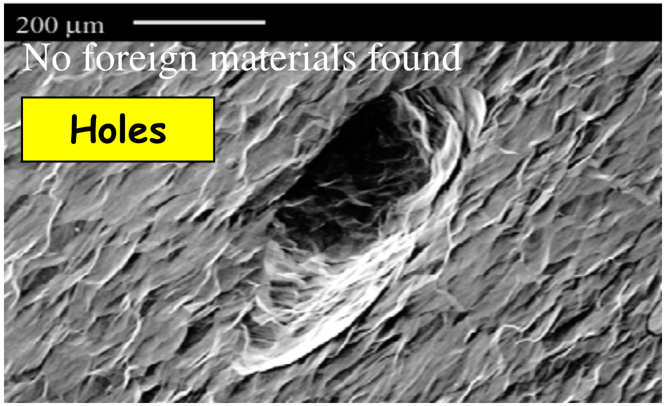
- Thermal Conductivity of the bulk Nb
- Kapitza resistance at the surface

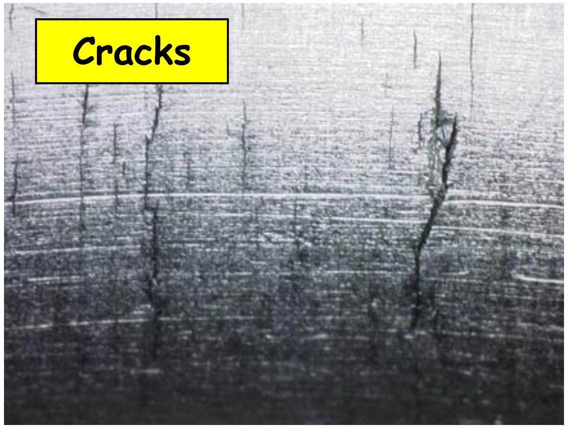


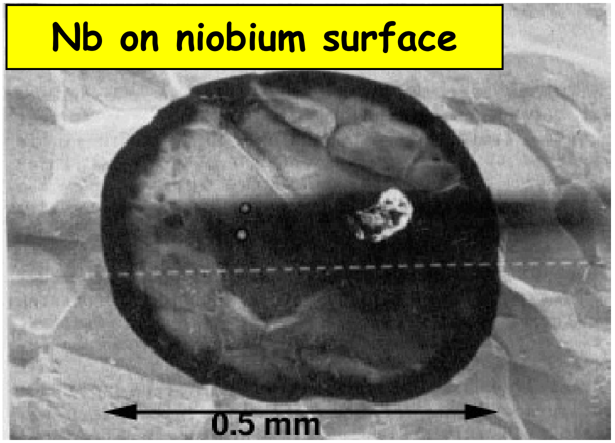
Low Field Quenches: Surface Defects

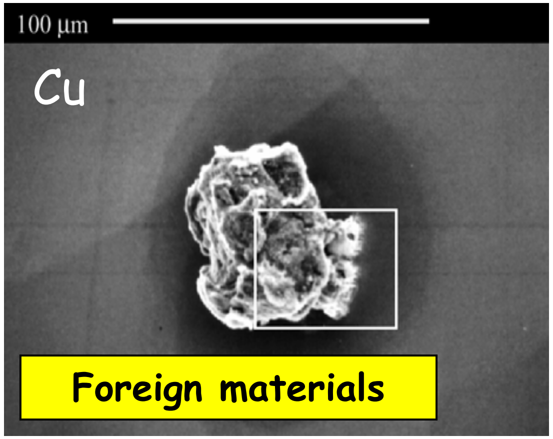
For decades Niobium has been a by-product of Tantalum production

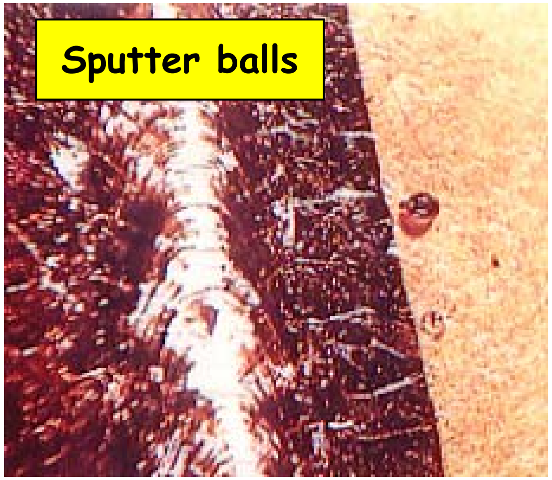










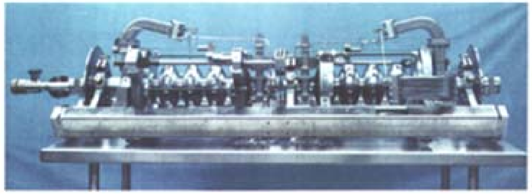


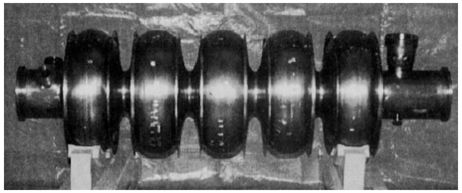
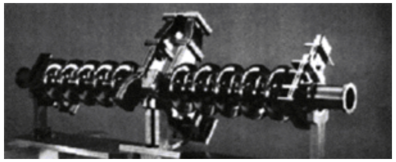
SRF before TESLA

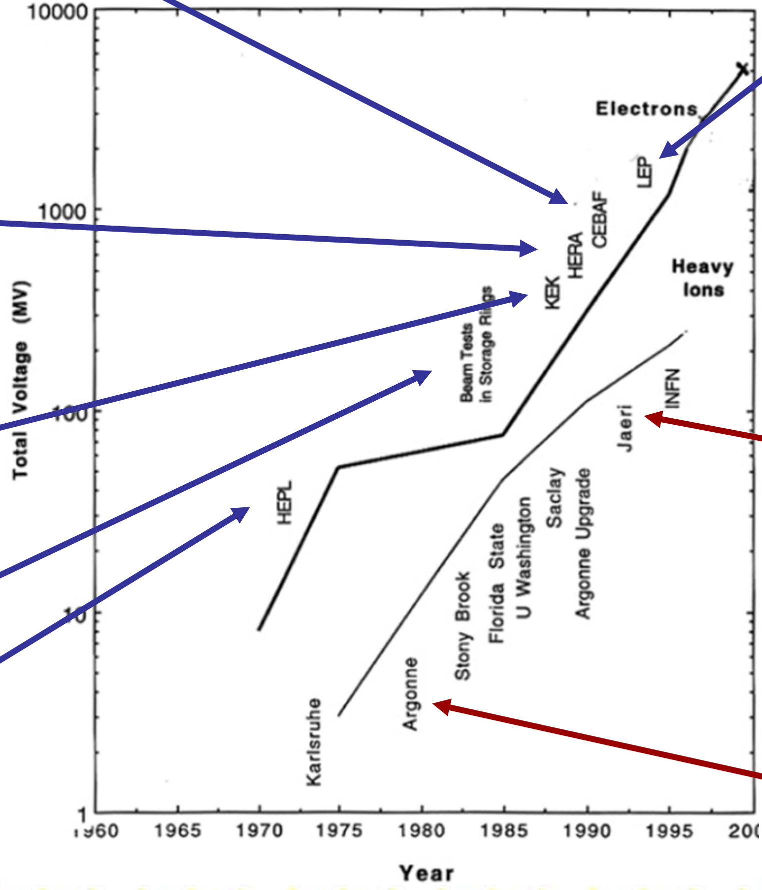
"Livingston Plot" from Hasan Padamsee

Total Installation > 1000 m

Provided > 5 GV





Limiting Problems

Poor material properties

- Moderate Nb purity (Niobium from the Tantalum production)
- Low Residual Resistance Ratio, RRR → Low thermal conductivity
- Normal Conducting inclusions → Quench at moderate field

Poor cavity treatments and cleanness

- Cavity preparation procedure at the R&D stage
- Poor rinsing and clean room assembly not yet introduced

Microphonics

- Mechanical vibrations in low beta structures → High RF power required

Multipacting

- Major limit for HEPL and electron linacs to 1984
- Poor codes and surface status

Quenches/Thermal breakdown

- Low RRR and NC inclusions

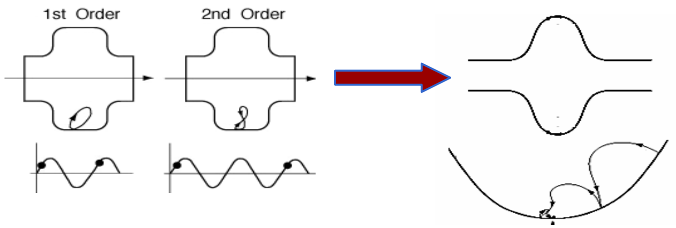
Field Emission

- General limit at those time because of poor cleaning and material defects

R&D waiting for big projects

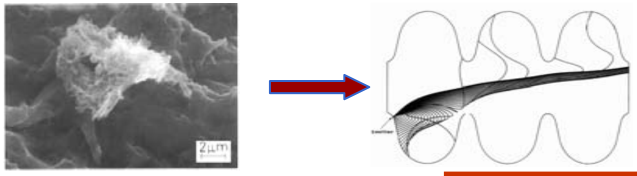
Multipactoring

- A few computer codes developed
- Spherical shape realized at Genova and qualified at Cornell & Wuppertal



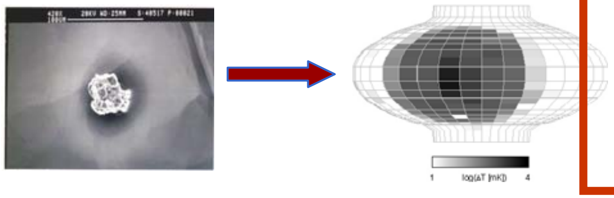
Field Emission

- Emitters were localized and analyzed
- Improved treatments and cleanness

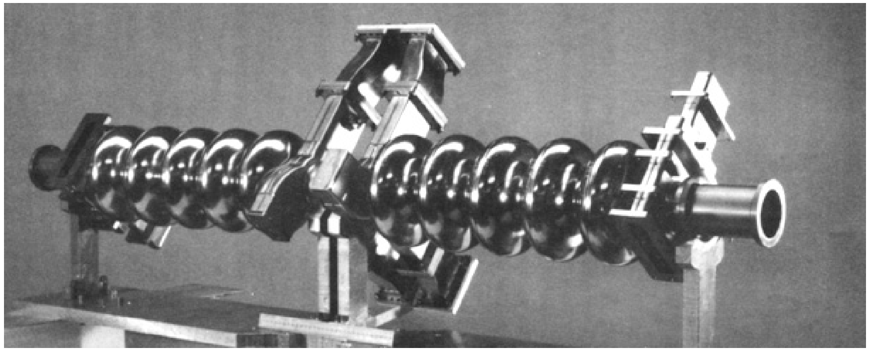


Quenches/Thermal Breakdown

- Higher RRR Nb



E_{acc} > 5 MV/m



1984/85: First great success

- A pair of 1.5 GHz cavities developed and tested (in CESR) at Cornell
- Chosen for CEBAF at TJNAF for a nominal E_{acc} = 5 MV/m

Large Project Impact on SRF

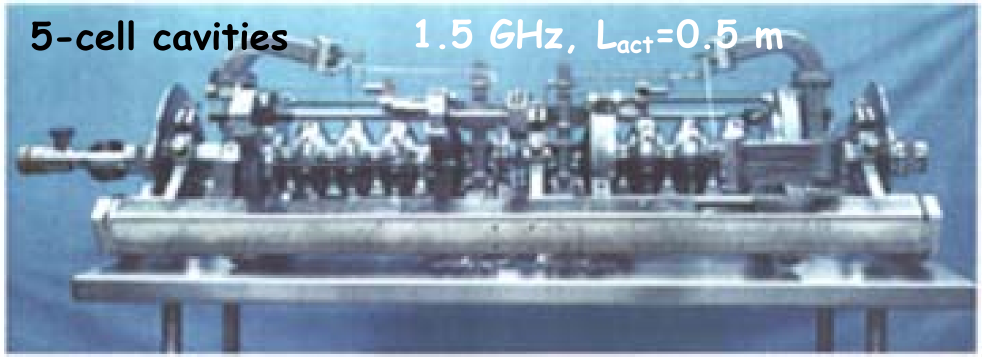
- The decision of applying this unusual technology in the largest HEP and NP accelerators forced the labs to invest in Research & Development, infrastructures and quality control
- The experience of industry in high quality productions has been taken as a guideline by the committed labs
- At that time TJNAF and CERN played the major role in SRF development, mainly because of the project size
- The need of building hundreds of cavities pushed the labs to transfer to Industry a large part of the production
- The large installations driven by HEP and NP produced a jump in the field
- R&D and basic research on SRF had also a jump thanks to the work of many groups distributed worldwide

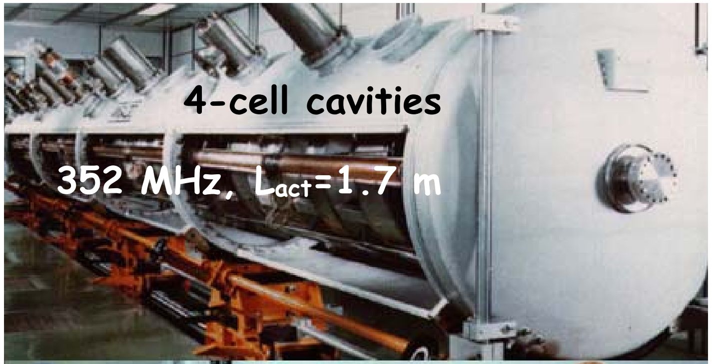
CEBAF and LEP II

CEBAF

338 bulk niobium cavities

- Produced by industry
- Processed at TJNAF in a dedicated infrastructure





LEP II & CERN

32 bulk niobium cavities

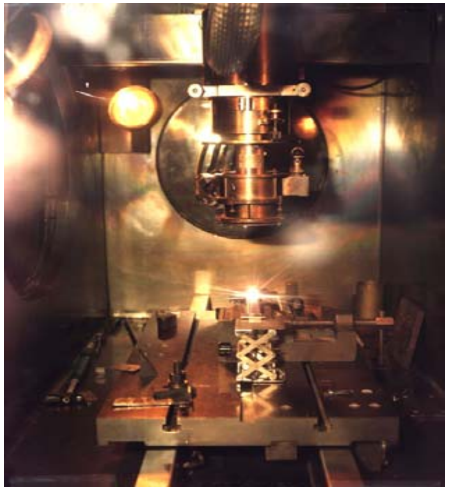
- Limited to 5 MV/m
- Poor material and inclusions

256 sputtered cavities

- Magnetron-sputtering of Nb on Cu
- Completely done by industry
- Field improved with time
  $\langle E_{acc} \rangle$ = 7.8 MV/m (Cryo-limited)

Important technological steps

- Use of the best niobium (and copper) allowable in the market at the time
- Industrial fabrication of cavity components with high level quality control
- Assembly of cavity components by Industry via Electron Beam welding in clean vacuum
- Use of ultra pure water for all intermediate cleaning
- Use of close loop chemistry with all parameters specified and controlled
- Cavity completion in Class 100 Clean Room
  - **Final water cleaning and drying** (UV for bacteria and on line resistivity control)
  - **Integration of cavity ancillaries**



That is

New level on Quality Control

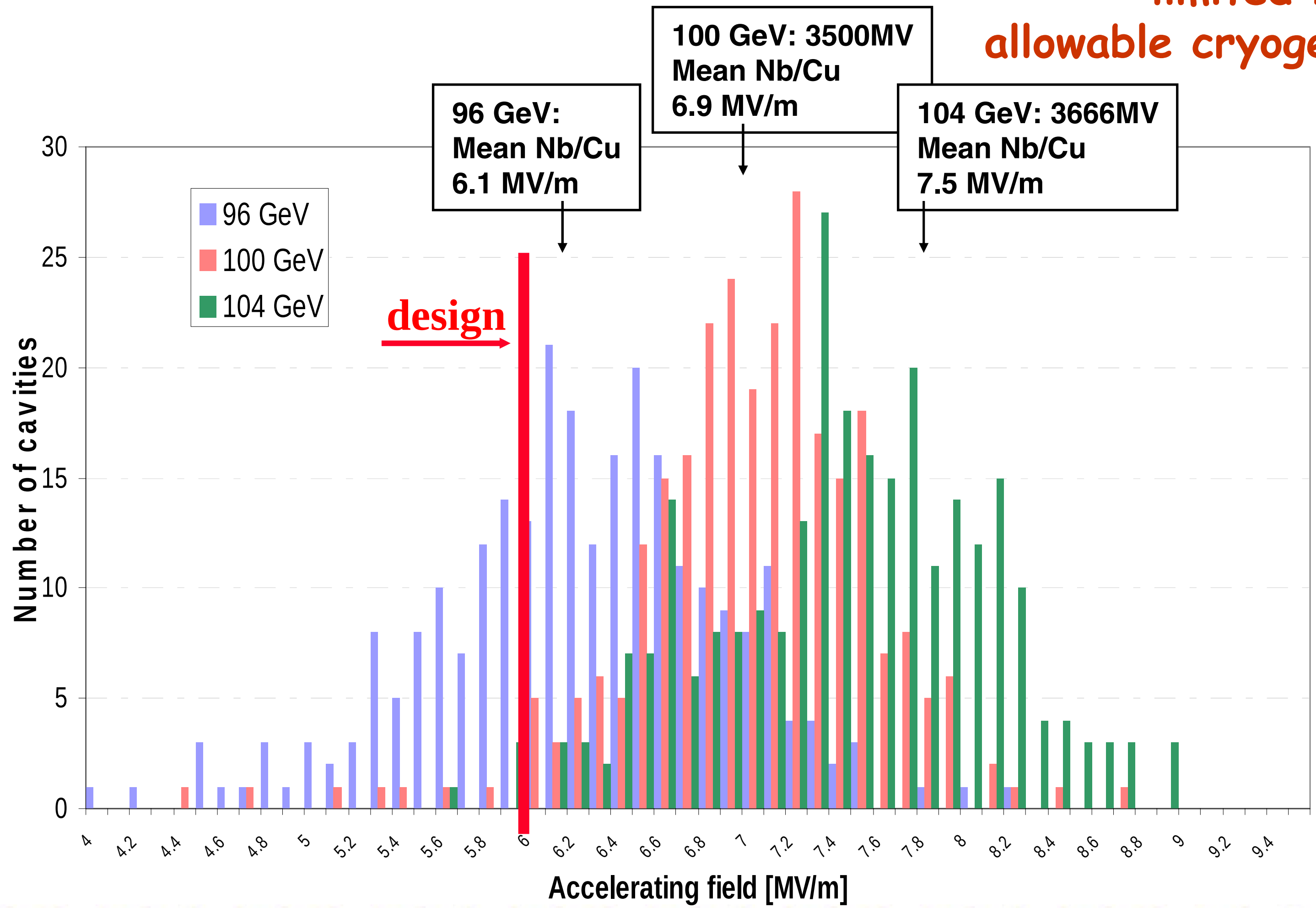
A great success for LEP II

Accelerating Field Evolution with time

from G. Geschonke's Poster for the ITRP visit to DESY

Final energy reach

limited by
allowable cryogenic power



The TESLA Collaboration Mission

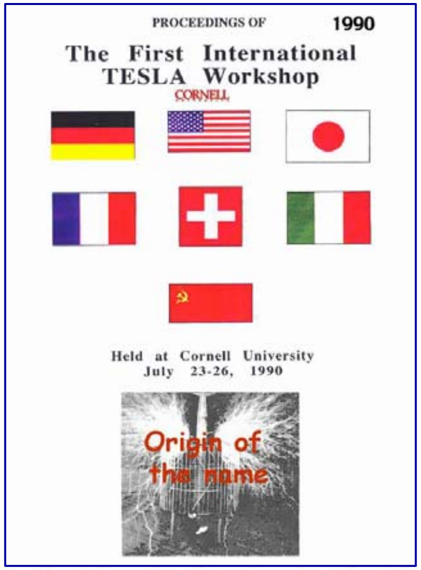
Develop SRF for the future TeV Linear Collider

Basic goals

- **Increase gradient by a factor of 5** (Physical limit for Nb at ~ 50 MV/m)
- **Reduce cost per MV by a factor 20** (New cryomodule concept and Industrialization)
- **Make possible pulsed operation** (Combine SRF and mechanical engineering)

Major advantages vs NC Technology

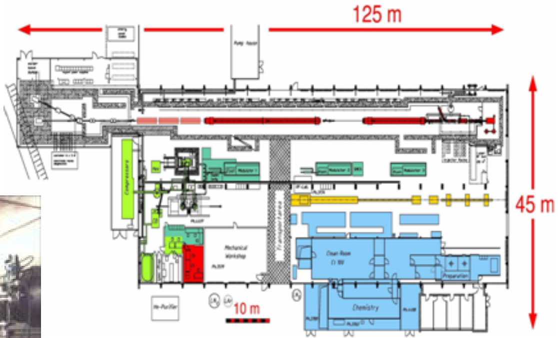
- **Higher conversion efficiency**: more beam power for less plug power consumption
- **Lower RF frequency**: relaxed tolerances and smaller emittance dilution



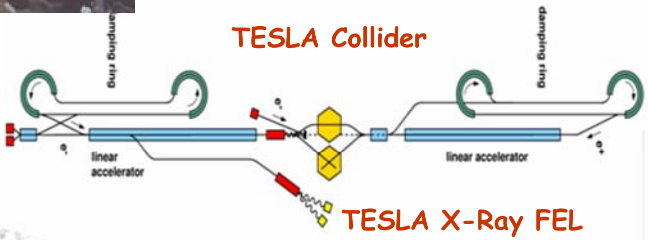
TESLA Coll. Milestones up to 08/2004

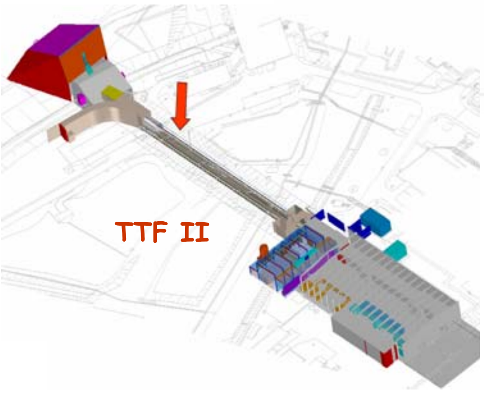
- February 1992 – 1° TESLA Collaboration Board Meeting @ DESY
- March 1993 - “A Proposal to Construct and Test Prototype Superconducting RF Structures for Linear Colliders”
- **1995 – 25 MV/m in multi-cell cavity**
- May 1996 – First beam at TTF
- March 2001 – First SASE-FEL Saturation at TTF
- March 2001 – TESLA Technical Design Report
- February 2003 –TESLA X-FEL proposed as an European Facility, 50% funding from Germany
- 2004 – TTF II Commissioning start
- **April 2004 - 35 MV/m with beam**
- **August 2004 - TESLA Technology chosen for ILC**

Infrastructure @ DESY in Hall 3



TTF I

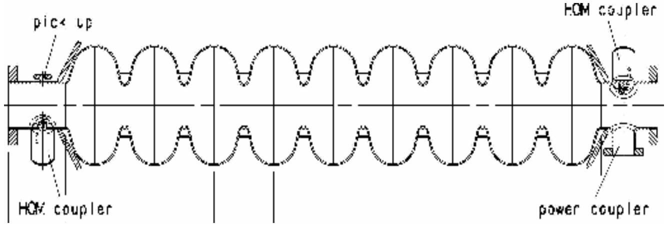


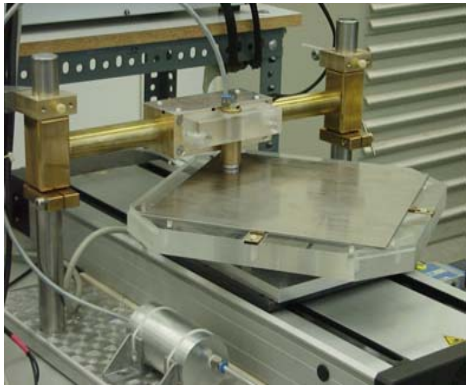


TESLA cavity design and rules

Major contributions from: CERN, Cornell, DESY, CEA-Saclay, INFN

- 9-cell, 1.3 GHz





Eddy-current scanning system for niobium sheets

Cleanroom handling of niobium cavities

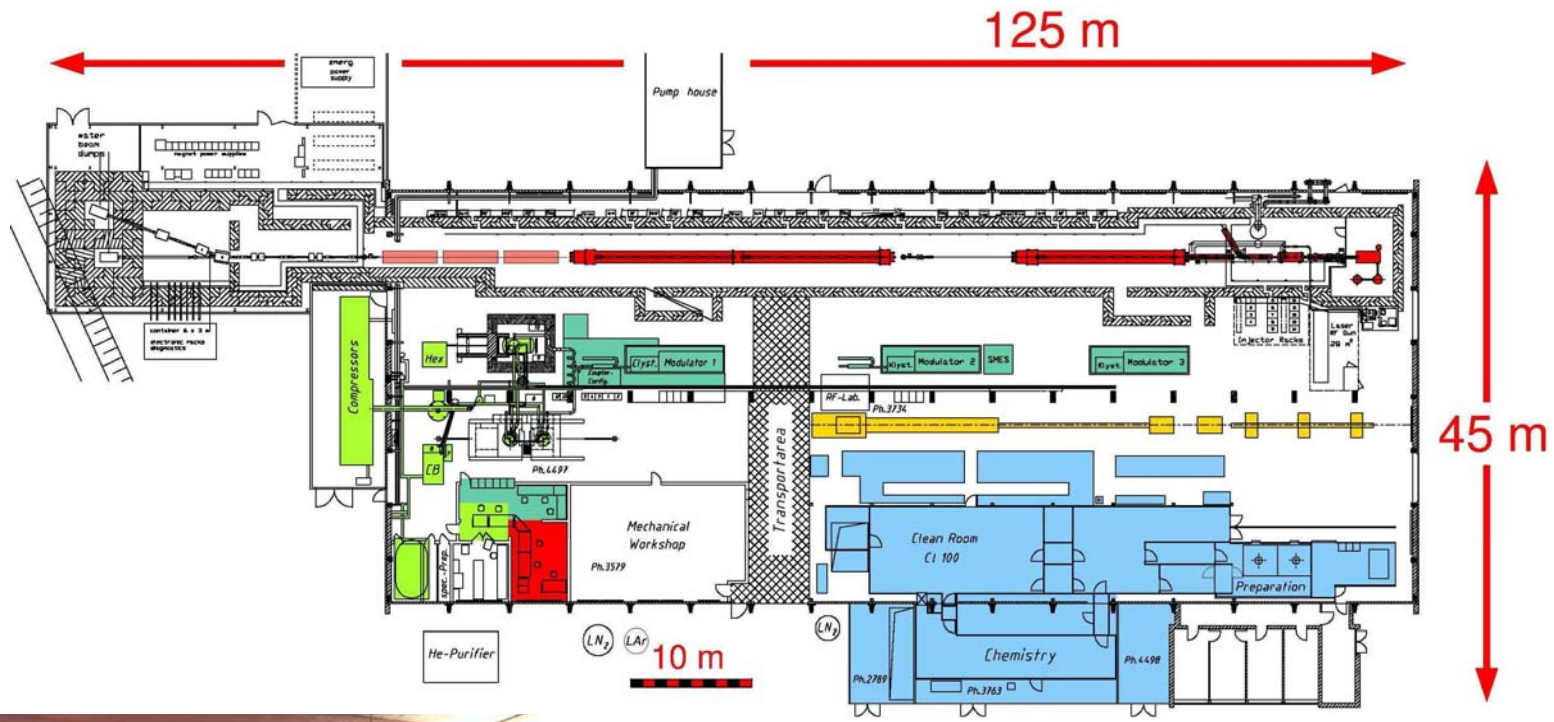
TESLA cavity parameters

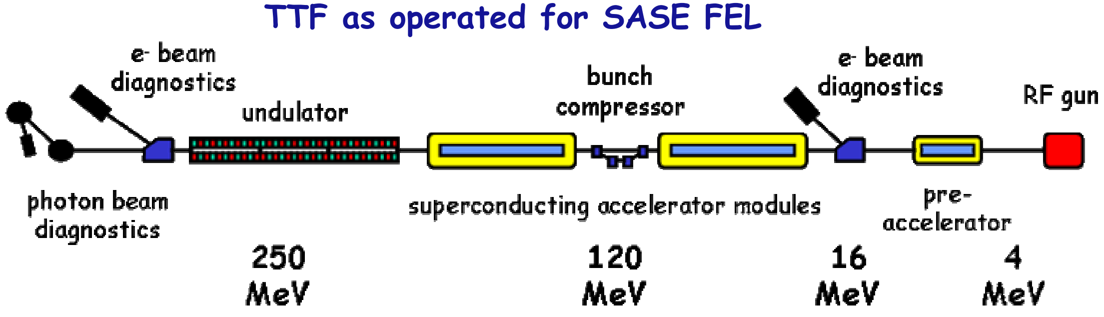
R/Q	1036	Ω
E_{peak}/E_{acc}	2.0	
B_{peak}/E_{acc}	4.26	mT/(MV/m)
$\Delta f/\Delta l$	315	kHz/mm
$K_{Lorentz}$	≈ -1	$Hz/(MV/m)^2$

Preparation Sequence

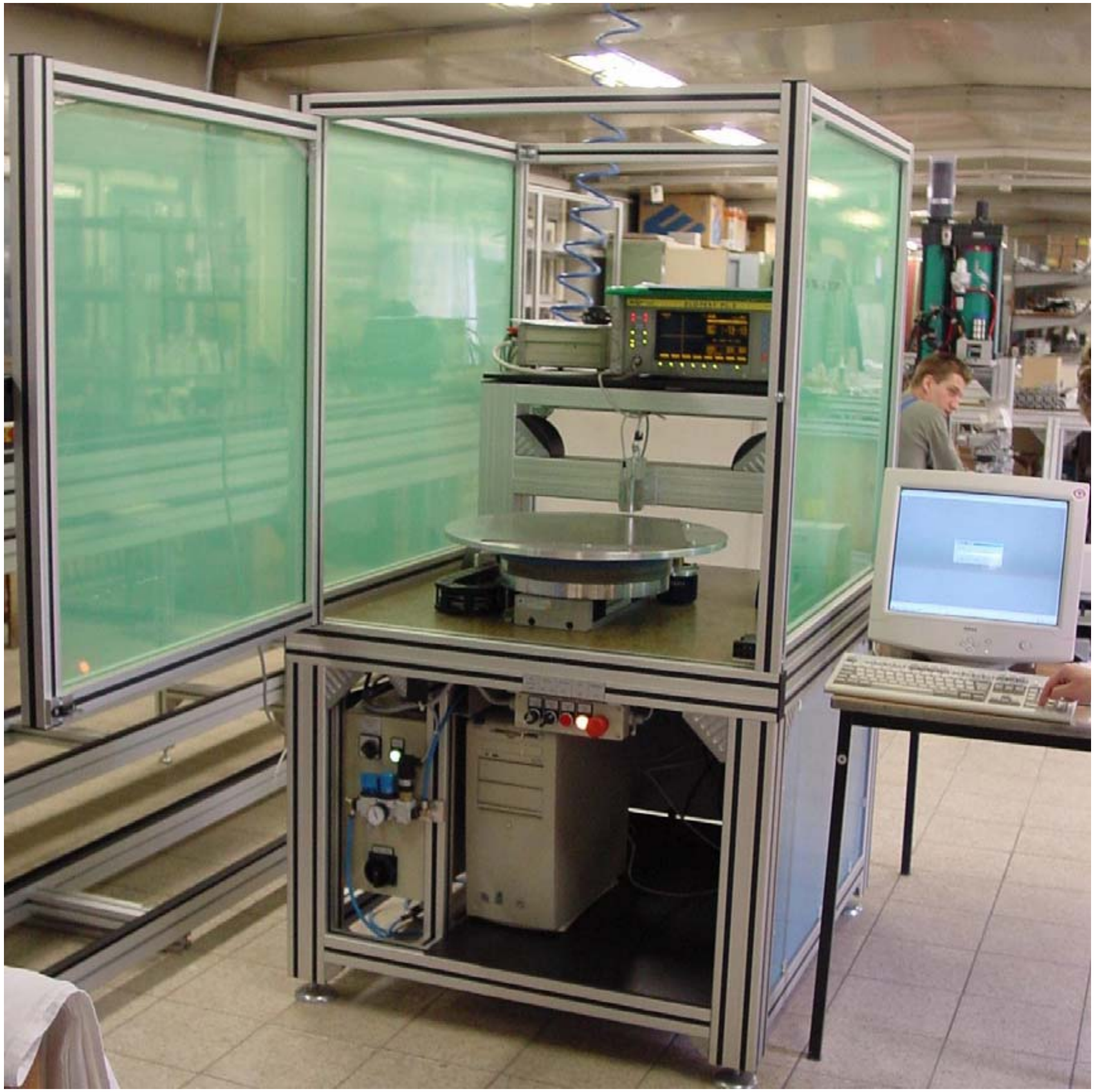
- Niobium sheets (RRR=300) are scanned by eddy-currents to detect avoid foreign material inclusions like tantalum and iron
- Industrial production of full nine-cell cavities:
  - Deep-drawing of subunits (half-cells, etc.) from niobium sheets
  - Chemical preparation for welding, cleanroom preparation
  - Electron-beam welding according to detailed specification
- 800 °C high temperature heat treatment to stress anneal the Nb and to remove hydrogen from the Nb
- 1400 °C high temperature heat treatment with titanium getter layer to increase the thermal conductivity (RRR=500)
- Cleanroom handling:
  - Chemical etching to remove damage layer and titanium getter layer
  - High pressure water rinsing as final treatment to avoid particle contamination

TTF: a new infrastructure at DESY

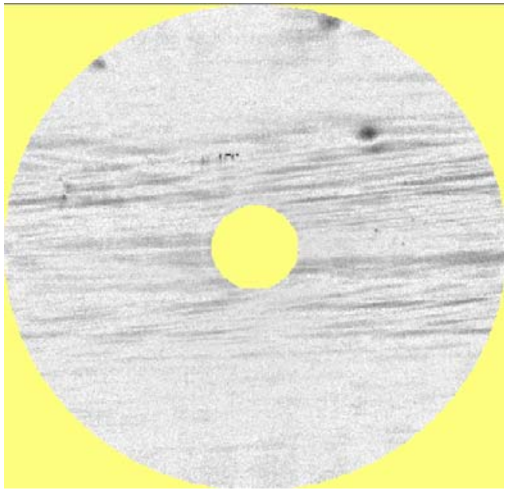




Eddy Current Scanner for Nb Sheets



Scanning results



- Rolling marks and defects are visible on a niobium disk to be used to print a cavity half-cell.
- Surface analysis is then required to identify the inclusions

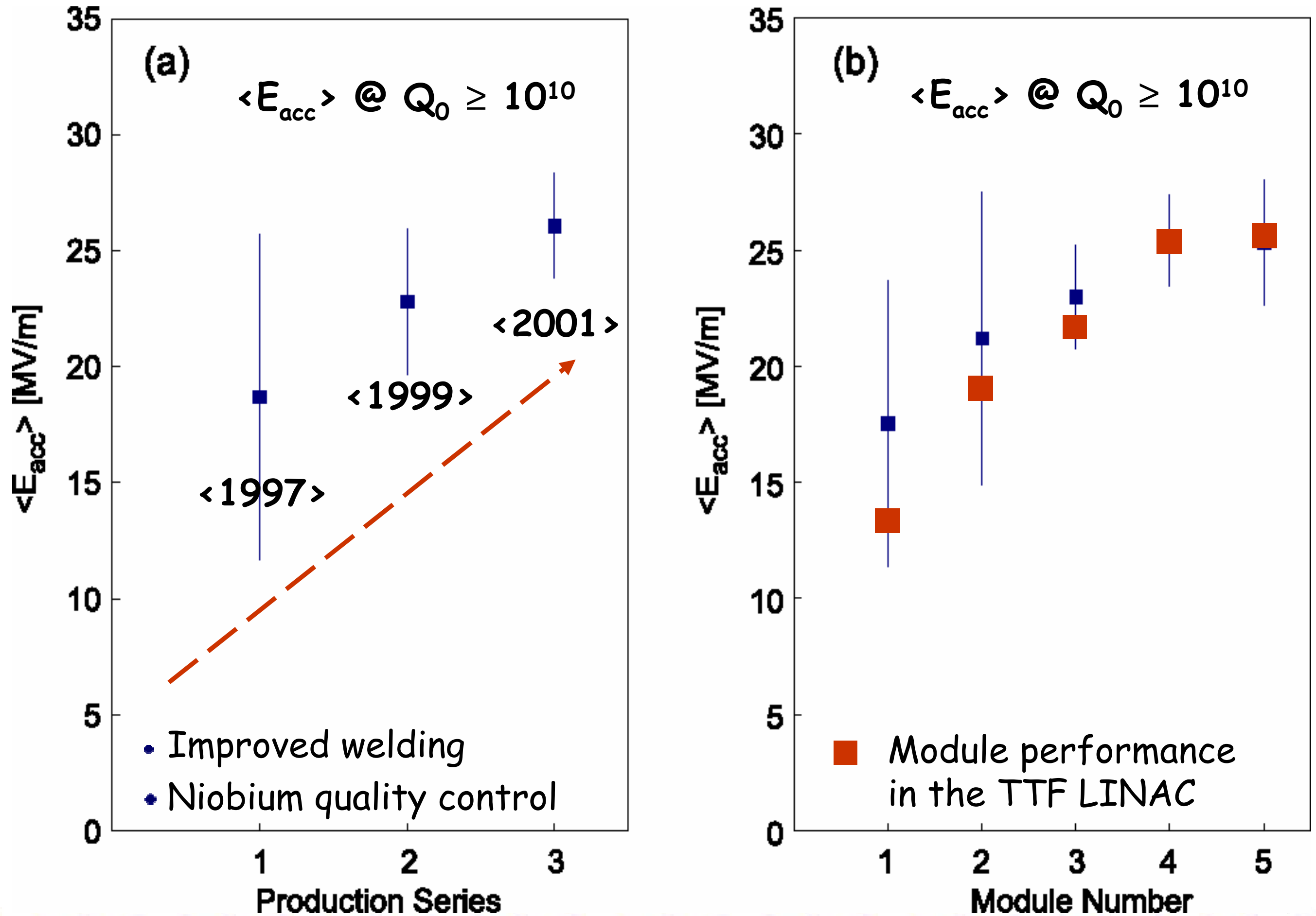
Chemistry, HPR and String Assembly

Learning curve with BCP

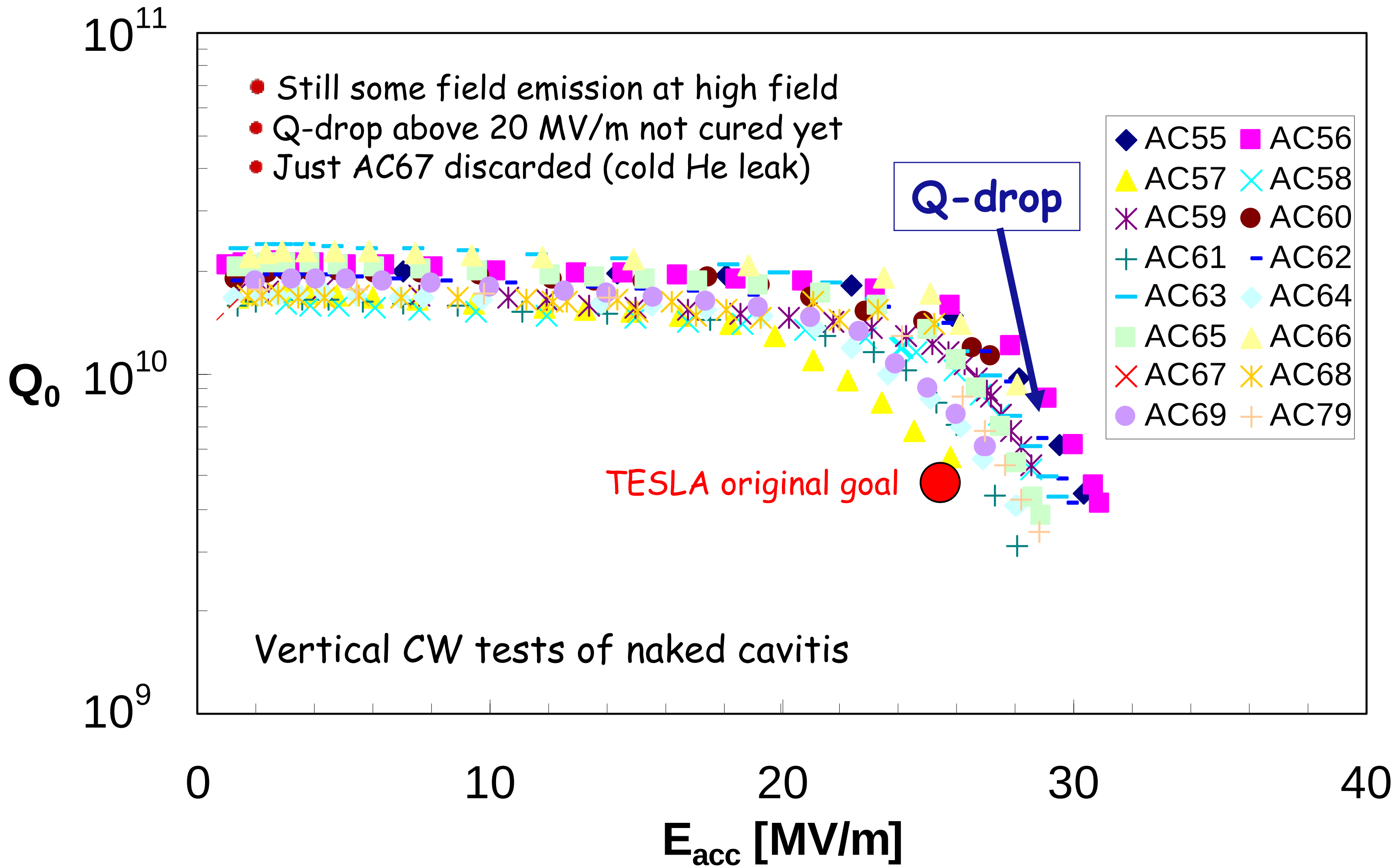
BCP = Buffered Chemical Polishing

3 cavity productions from 4 European industries: Accel, Cerca, Dornier, Zanon

4th production of 30 cavities concluded, also to define Quality Control for Industrialization



3rd cavity production with BCP



EP & Baking for 35 MV/m

Electro-Polishing (EP)

instead of

Buffered Chemical Polishing (BCP)

- less local field enhancement
- High Pressure Rinsing more effective
- **Field Emission onset at higher field**

In Situ Baking

@ 120-140 ° C for 24-48 hours

- to re-distribute oxygen at the surface
- **cures Q drop at high field**

The AC 70 example

EP at the DESY plant

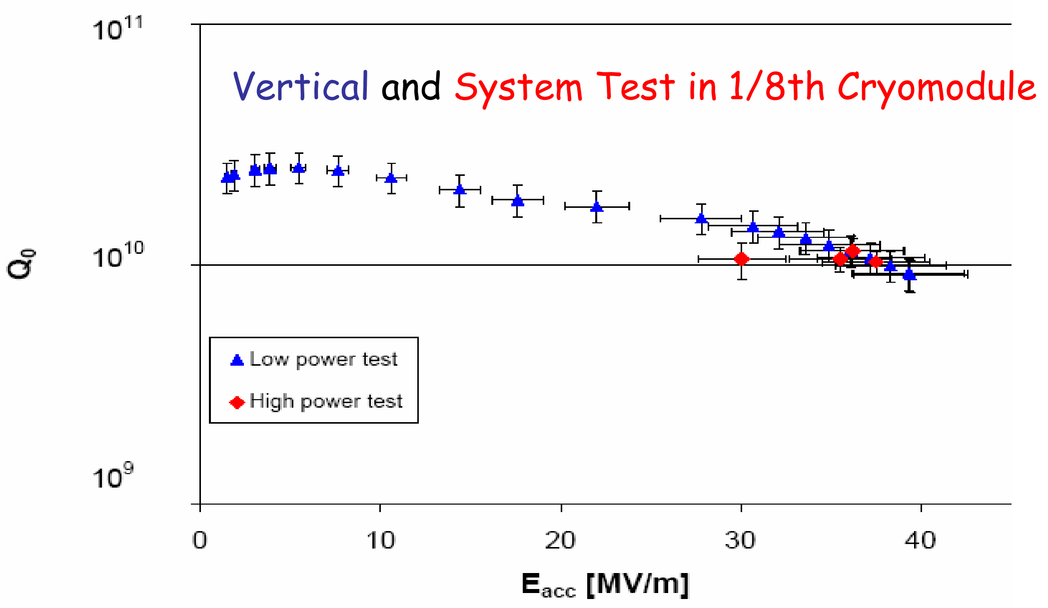
- **Low Field Emission**

800°C annealing

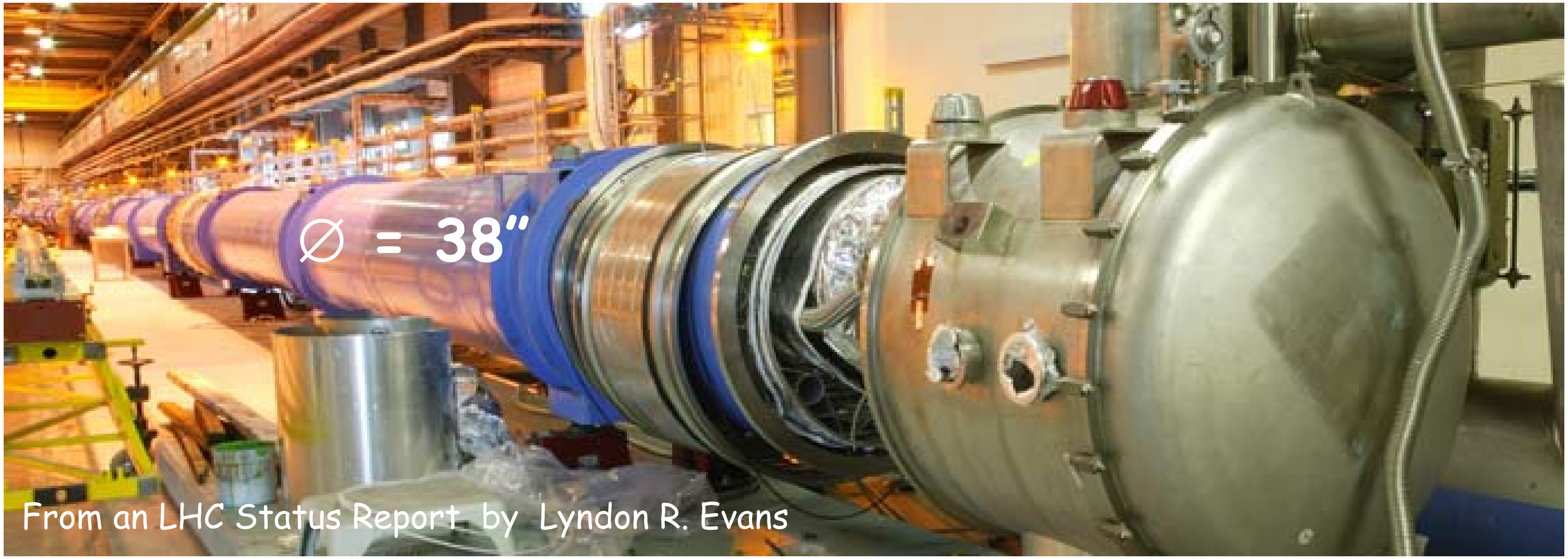
120°C, 24 h, Baking

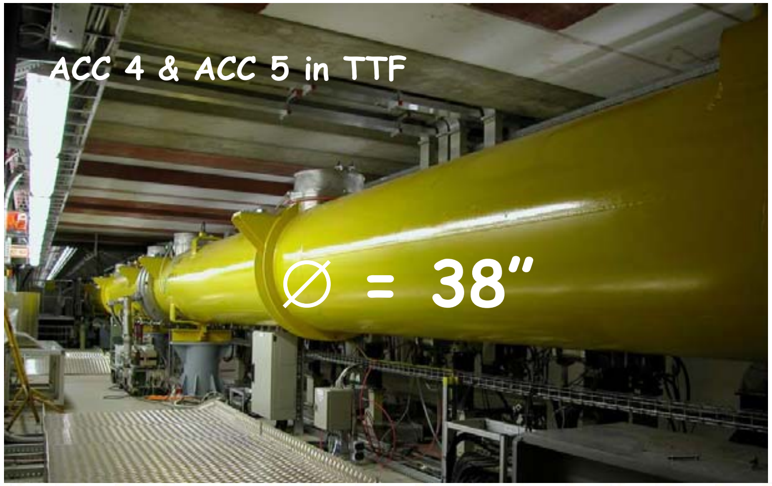
- high field Q drop cured

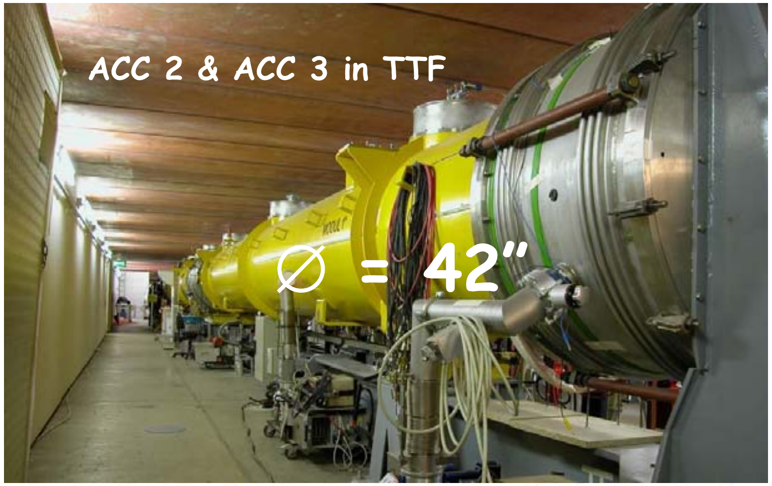
High Pressure Water Rinsing



LCH and ILC Module Comparison



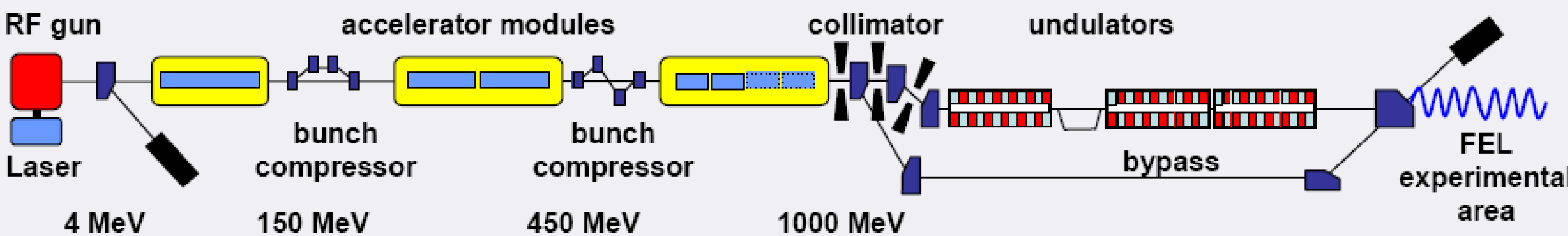


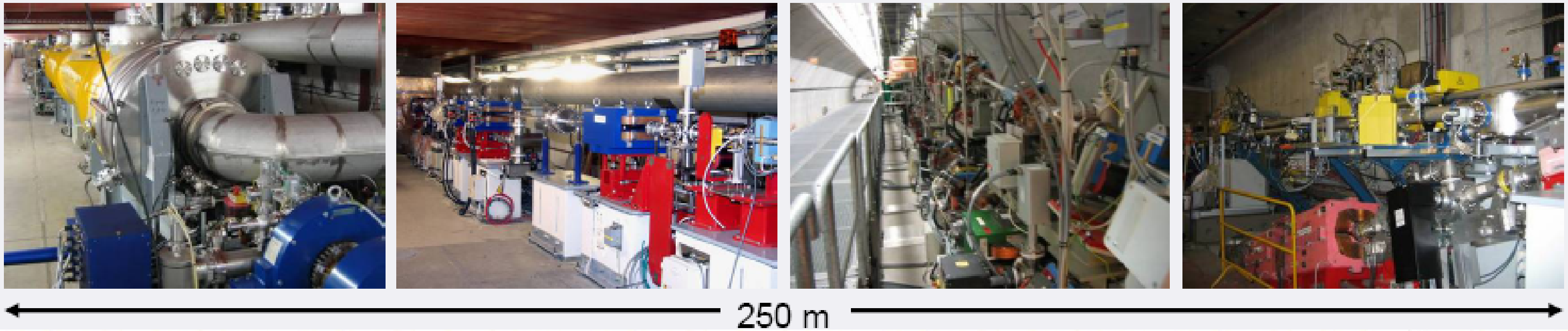


Global SCRF Test Facilities for ILC

- **TESLA Test Facility (TTF II) @ DESY**
  TTF II is currently unique in the world
  VUV-FEL user facility (now called FLASH)
  test-bed for both XFEL & ILC
  Cryomodule Test Stand under commissioning
- **SMTF @ FNAL**
  Cornell, JLab, ANL, FNAL, LBNL, LANL, MIT, MSU, SNS, UPenn, NIU, BNL, SLAC
  TF for ILC, Proton Driver, RIA (and more)
- **STF @ KEK**
  aggressive schedule to produce high-gradient (45MV/m) cavities / cryomodules
- **Others?**

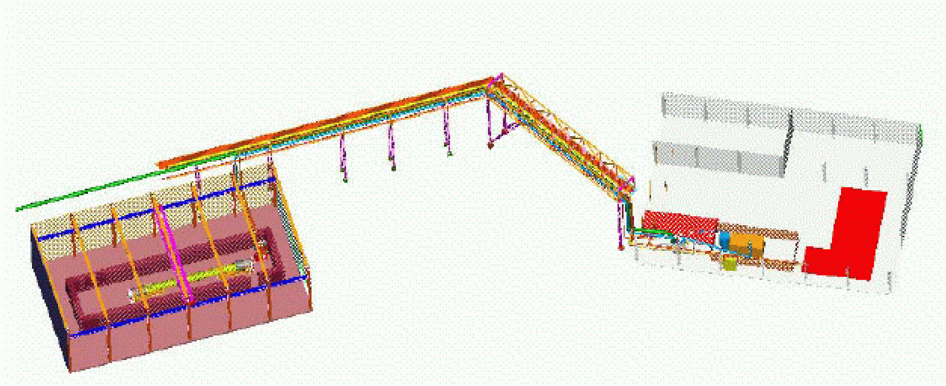
FLASH (VUV-FEL) as XFEL Prototype

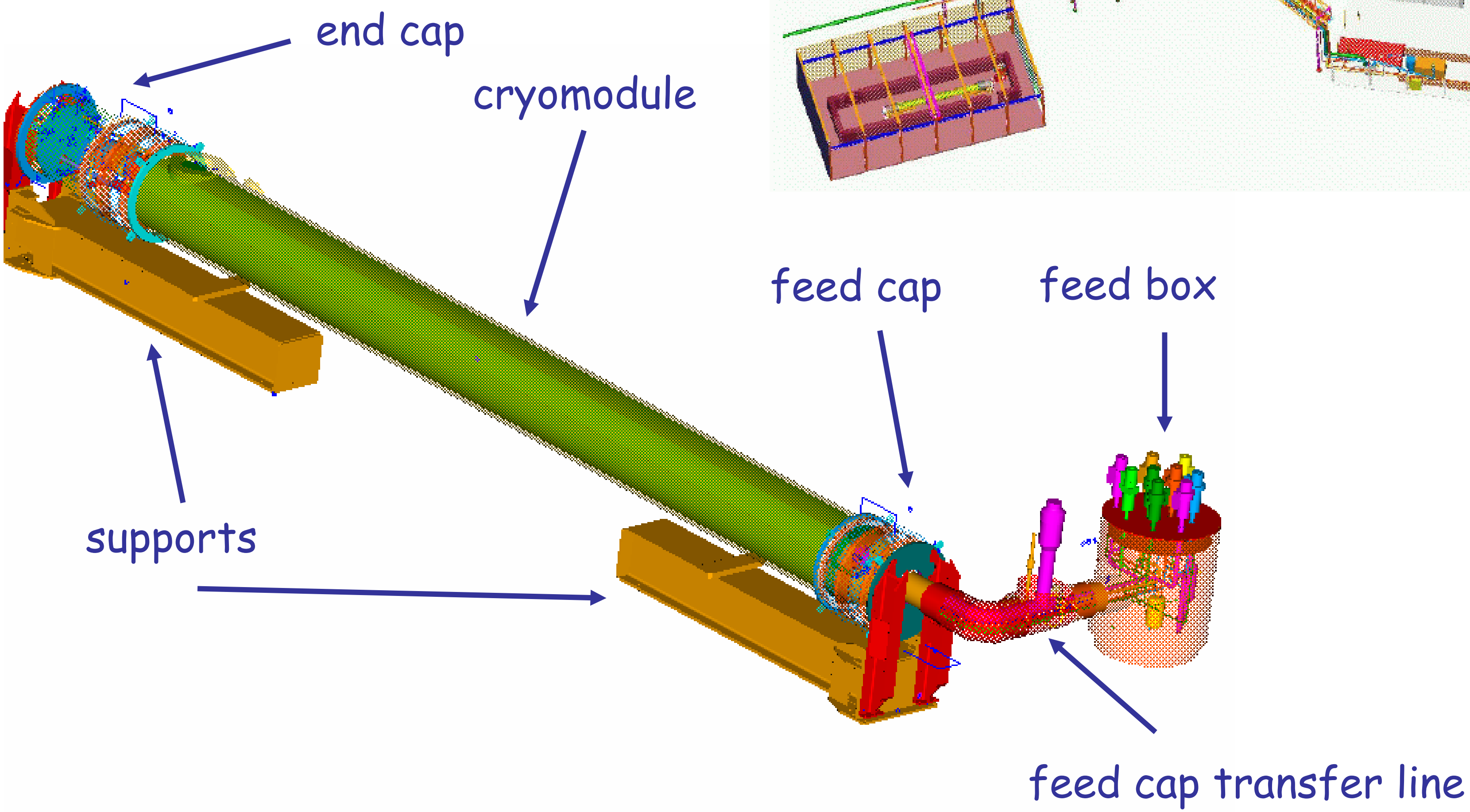




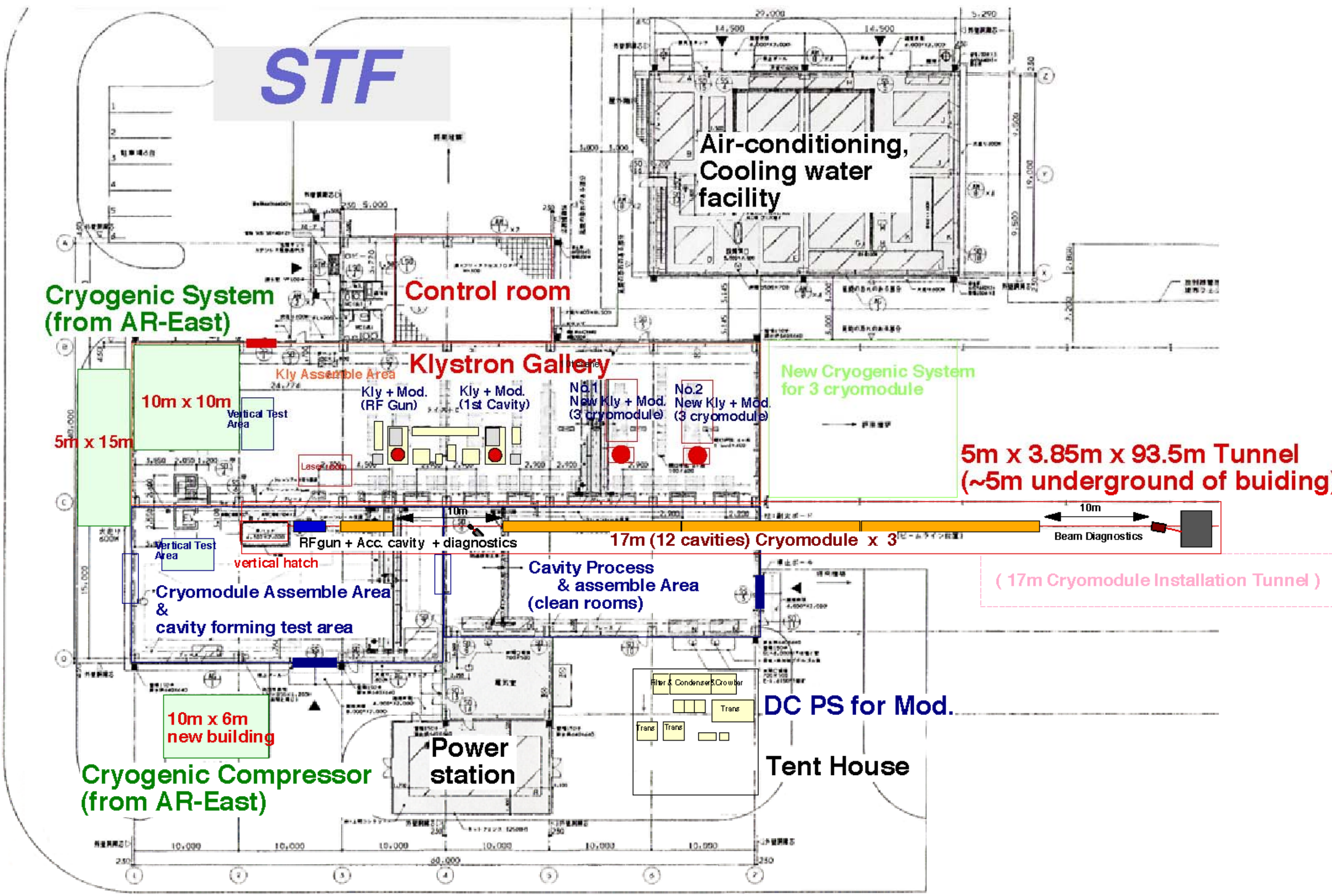
Cryomodule Test Stand @ DESY

Commissioning in these days





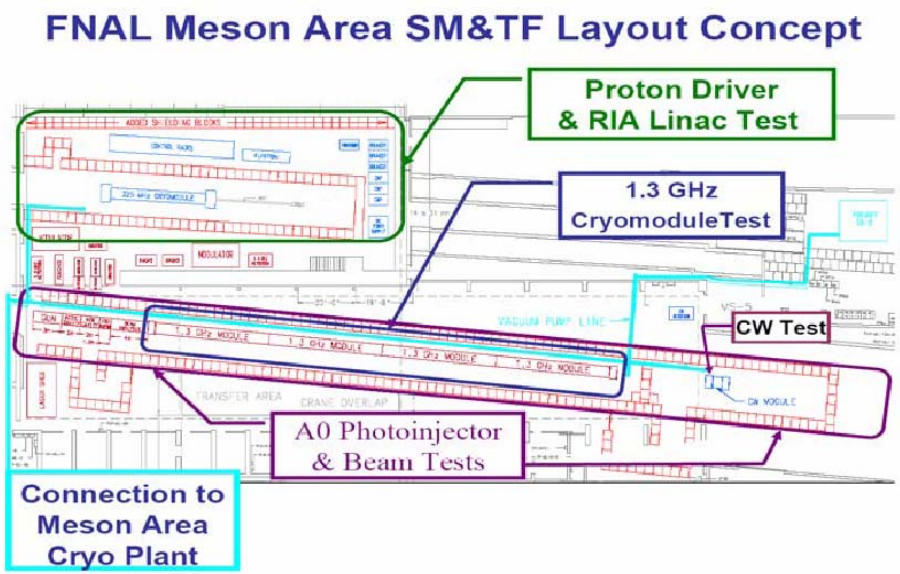
STF @ KEK

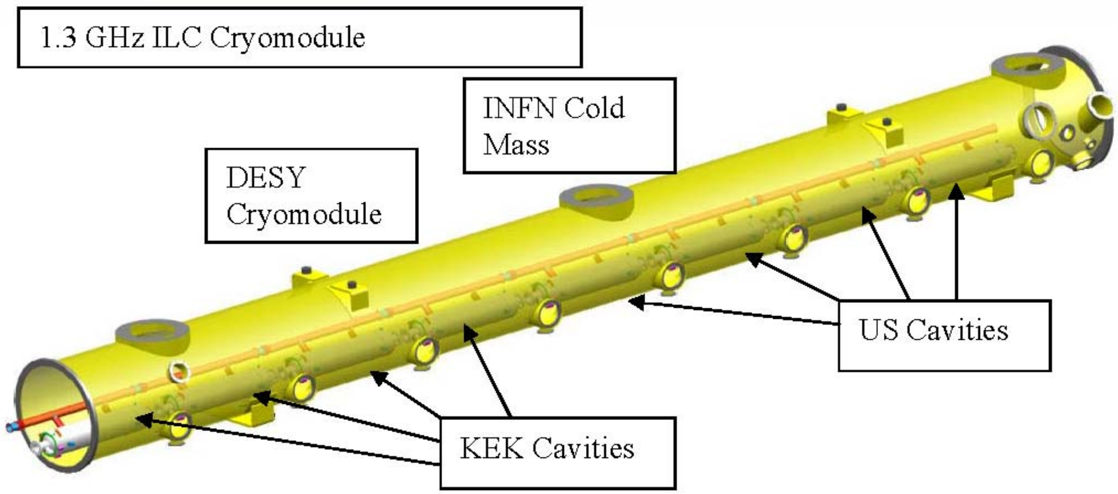


Plan of Superconducting Cavity Test Facility (STF)

V2.1 Hitoshi Hayano, 11/03/2004

SMTF @ FNAL as presented to DOE





"The **SMTF proposal is to develop U.S. Capabilities** in high gradient and high Q superconducting accelerating structures

in support of

International Linear Collider
Proton Driver
RIA
4th Generation Light Sources
Electron coolers
lepton-heavy ion collider
and other accelerator
projects of interest to U.S
and the world physics
community."

One Industrial Forum in Each Region

Summary of findings & discussion: Industry forum

- Industry Fora about SC accelerator technology in all 3 regions
  - Asia: operating since 2 years
  - Europe: under formation
  - USA: under planning

Both Operational

- All with strong local commitment
  - Critical to secure funds for ILC from ministries in all regions
  - Strong local commitment might be necessary at this moment because of differences in technical expertise and political boundary conditions
  - But: danger of too large diversity in technology/design: Is the 1/3 linac per region the right approach for ILC?

Summary Industrialization Sympossium, SRF 2005, D.Proch 19

European Industrial Forum for SCRF

https://trac.lal.in2p3.fr/SCRF

EIFast - Workshop on the European X-FEL Project

9-10 May 2006 **DESY**

- Author index
- Overview
- Contribution List
- Scientific Programme
- Timetable
- EIFast Home Page
- Participants
- Participant's Profiles
- Questions or comments?

Home > Timetable

Display options

Show day - - all days - - Show session - - all sessions - -

Detail level session View mode Parallel

apply [other views]

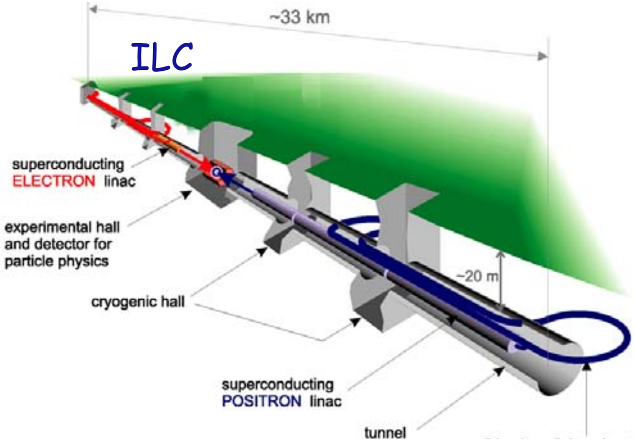
Tuesday, 09 May 2006

08:00	**Registration & Coffee** (Foyer Auditorium: 08:00 - 08:30)			
09:00	**Opening Plenary** Conveners: Michael PEINIGER (ACCEL) (Auditorium: 08:30 - 10:30)			
10:00	**Coffee Break** (1st floor building 1b: 10:30 - 11:00)			
11:00 / 12:00	**WG 1 Civil Engineering, Building Services & Utilities** Conveners: Markus KöRFER (DESY); Thomas HOTT (DESY); Kurt EBBINGHAUS (Babcock Noell Nuclear GmbH) (Sem. Room 5: 11:00 - 12:30)	**WG 3 Cryogenics & Cryostats** Conveners: Bernd PETERSEN (DESY); Michael PEINIGER (ACCEL) (Sem. Room 1: 11:00 - 12:30)	**WG 5 Diagnostics, Controls & Laser** Conveners: Dirk NOELLE (DESY); Kay REHLICH (DESY); David WILCOX (E2V Technologies) (Sem. Room 3: 11:00 - 12:30)	**WG 7 Cavities & Couplers** Conveners: Dieter PROCH (DESY); Giorgio CORNIANI (Ettore Zanon) (Sem. Room 2: 11:00 - 12:30)
	Lunch (Sem. Room 4a/b: 12:30 - 13:30)			
13:00 / 14:00 / 15:00	**WG 1 Civil Engineering, Building Services & Utilities** Conveners: Markus KöRFER (DESY); Thomas HOTT (DESY); Kurt EBBINGHAUS (Babcock Noell Nuclear) (Sem. Room 5: 13:30 - 15:30)	**WG 3 Cryogenics & Cryostats** Conveners: Bernd PETERSEN (DESY); Michael PEINIGER (ACCEL) (Sem. Room 1: 13:30 - 15:30)	**WG 5 Diagnostics, Controls & Laser** Conveners: Dirk NOELLE (DESY); Kay REHLICH (DESY); David WILCOX (E2V Technologies) (Sem. Room 3: 13:30 - 15:30)	
	Coffee Break (1st floor building 1b: 15:30 - 16:00)			
16:00 / 17:00	**WG 2 RF System** Conveners: Stefan CHOROBA (DESY); Eric GIGUET (Thales Electron Devices) (Sem. Room 4a: 16:00 - 18:30)	**WG 4 Magnets & Powersupplies** Conveners: Heinrich-Dieter BRUECK (DESY); Hans-Joerg	**WG 6 Vacuum cold & warm** Conveners: Kirsten ZAPFE (DESY); Pieter VAN OTTERLOO	**WG 7 Cavities & Couplers** Conveners: Dieter PROCH (DESY); Giorgio CORNIANI

https://indico.desy.de/conferenceTimeTable.py?confId=61

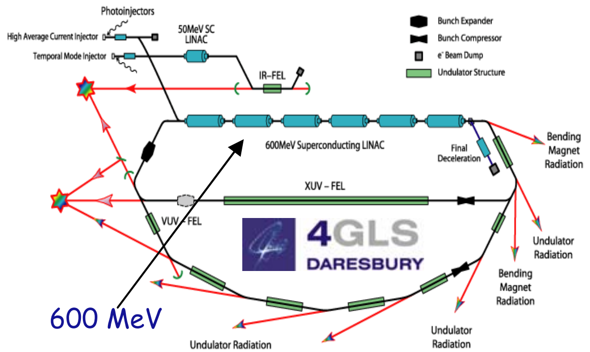
Great Impulse from TESLA Results

- High Energy Physics: Leptons and Hadrons
  - ILC is growing cold
  - 8 GeV Proton Driver for FNAL
  - SPL for CERN: neutrinos and LHC upgrade
  - Electron coolers
  - ……



- Nuclear Physics: Ions and Electrons
  - Spiral 2
  - RIA
  - Eurisol
  - Spes
  - CEBAF Upgrade
  - ……

- Applied Physics: Electrons
  - Spallation Neutron Sources: SNS
  - 4th Generation Light Sources: European X-FEL
  - Storage Rings
  - Energy Recovery Linacs: 4GLS in Europe and many others
  - ……



- ADS for Nuclear Waste Transmutation
  - EuroTrans

The Mission of the GDE

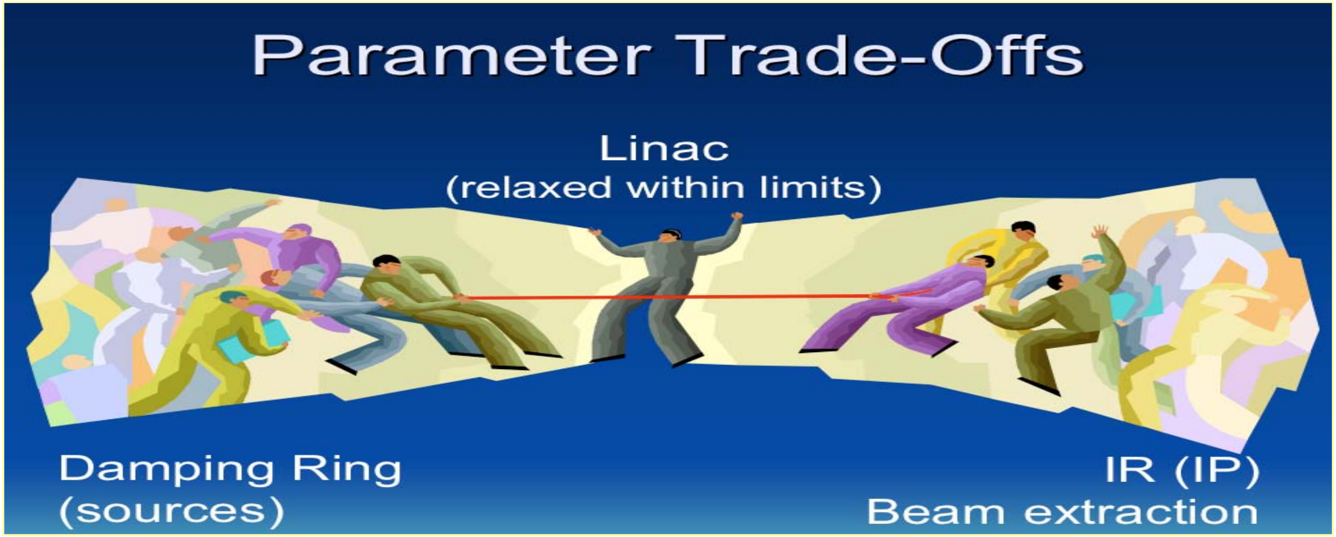
- Produce a design for the ILC that includes a detailed design concept, performance assessments, reliable international costing, an industrialization plan , siting analysis, as well as detector concepts and scope.

- Coordinate worldwide prioritized proposal driven R & D efforts (to demonstrate and improve the performance, reduce the costs, attain the required reliability, etc.)

© Barry Barish

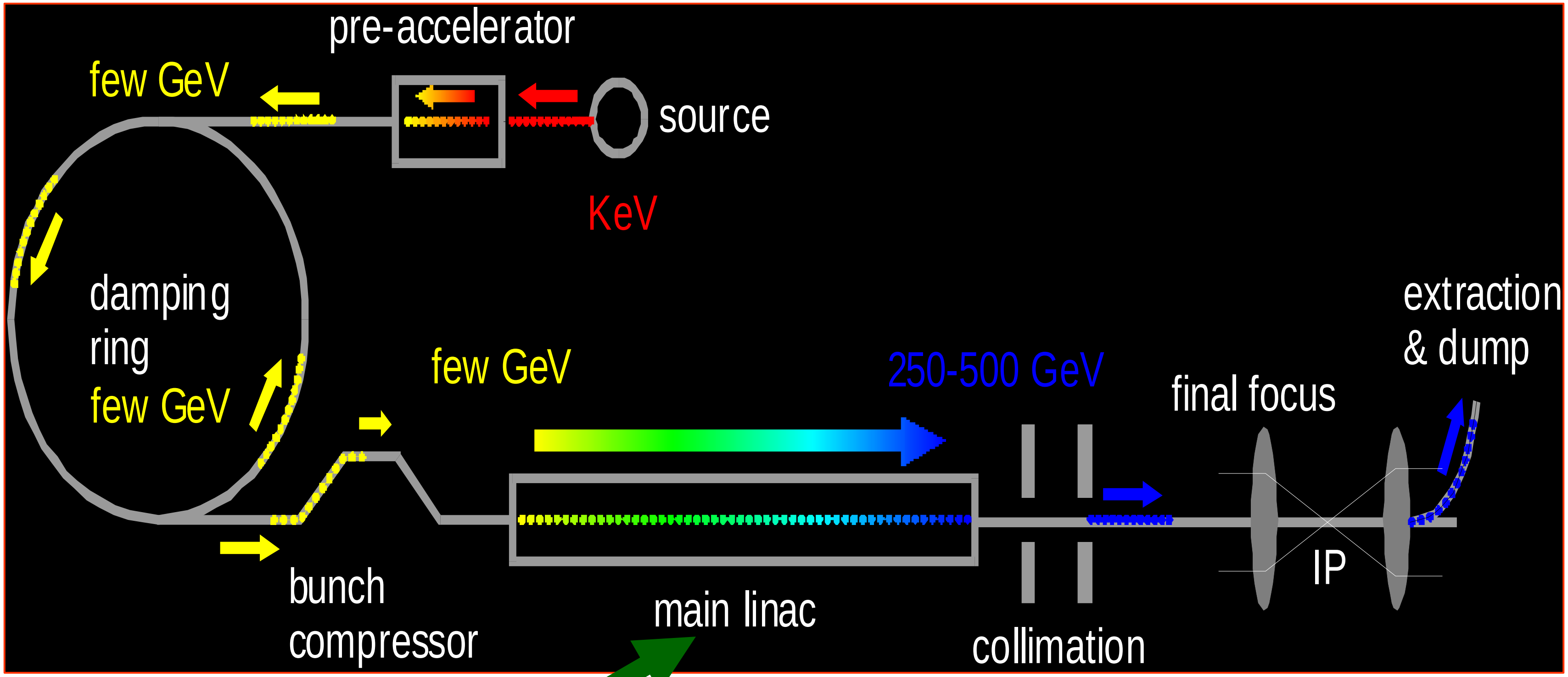
Parametric Approach

A working space - optimize machine for cost/performance

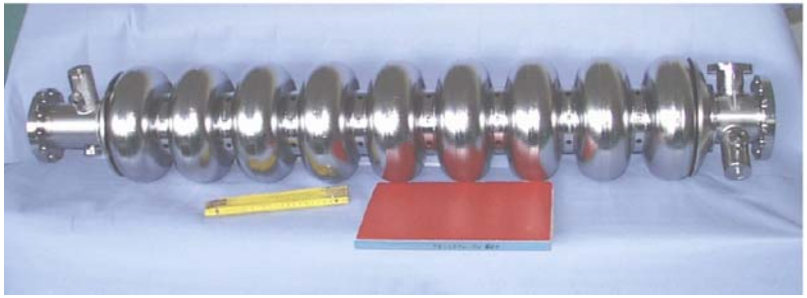


		min		nominal		max	
Bunch charge	N	1	-	2	-	2	$\times 10^{10}$
Number of bunches	n_b	1330	-	2820	-	5640	
Linac bunch interval	t_b	154	-	308	-	461	ns
Bunch length	σ_z	150	-	300	-	500	μm
Vert.emit.	$\gamma\epsilon_y^*$	0.03	-	0.04	-	0.08	mm·mrad
IP beta (500GeV)	β_x^*	10	-	21	-	21	mm
	β_y^*	0.2	-	0.4	-	0.4	mm
IP beta (1TeV)	β_x^*	10	-	30	-	30	mm
	β_y^*	0.2	-	0.3	-	0.6	mm

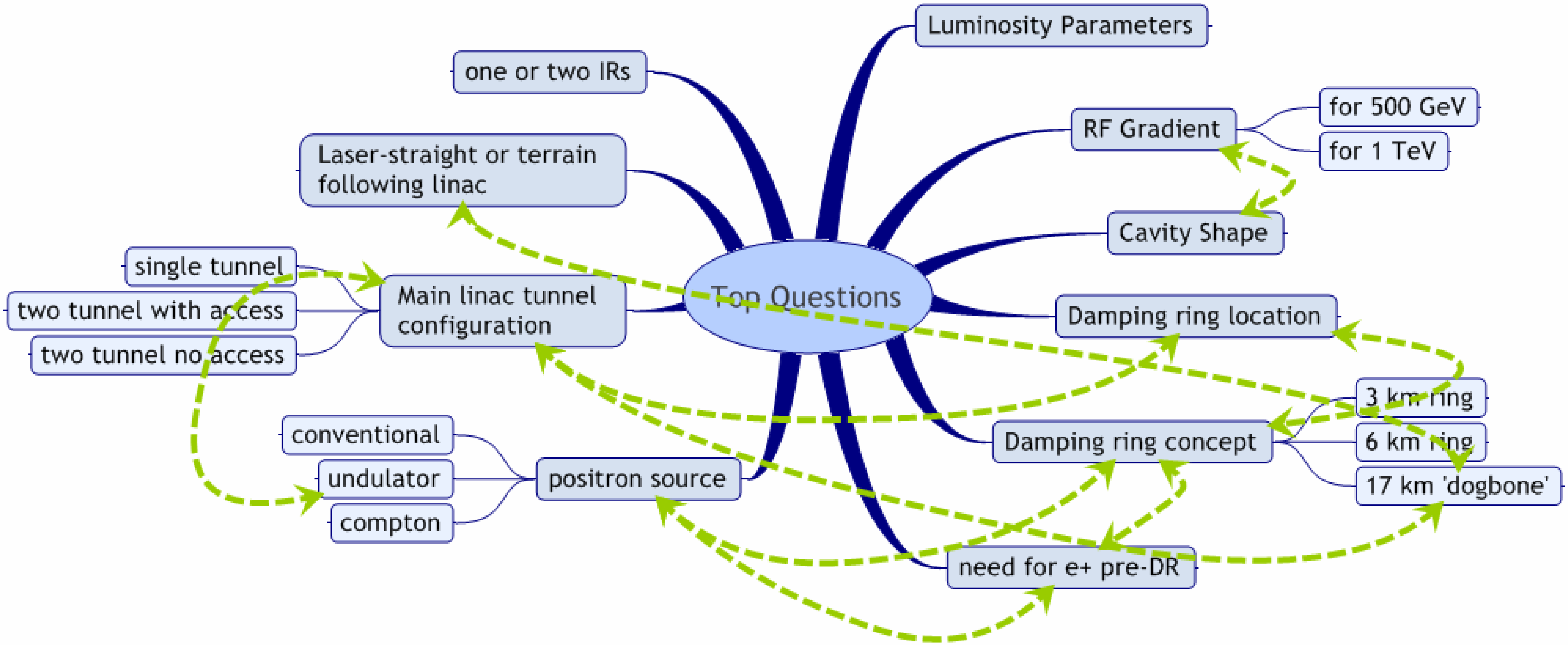
Designing a Linear Collider



Superconducting RF Main Linac



Making Choices – The Tradeoffs



Many decisions are interrelated and require input from several WG/GG groups

From Snowmass to a Baseline

Snowmass

2005

August | September | October | November | December

WW/GG summaries

Response to list of 40+ decisions

All documented 'recommendations available on ILC Website (request community feedback)

Review by BCD EC

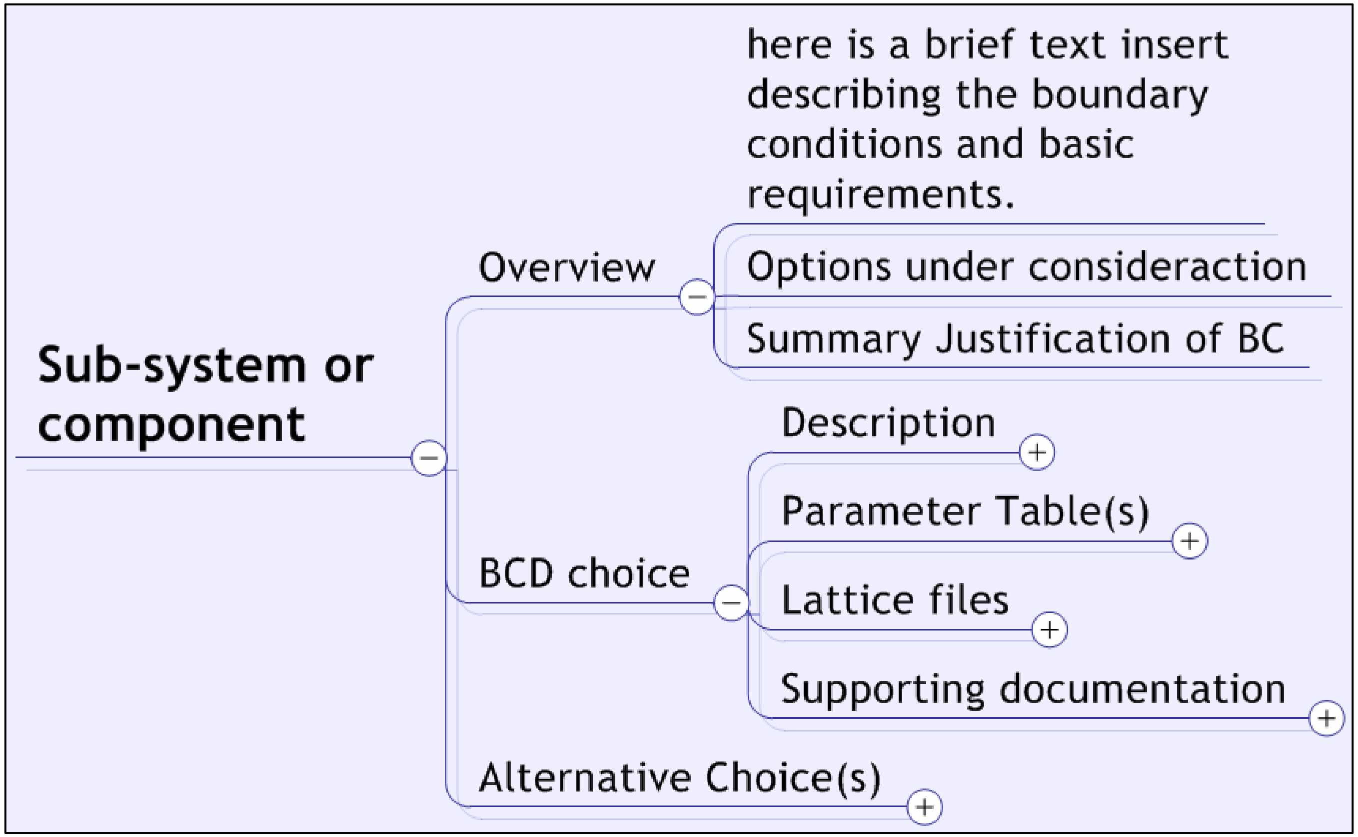
BCD EC publishes 'strawman' BCD

Public Review

Frascati GDE meeting

BCD Executive Committee:
Barish
Dugan, Foster, Takasaki
Raubenheimer, Yokoya, Walker

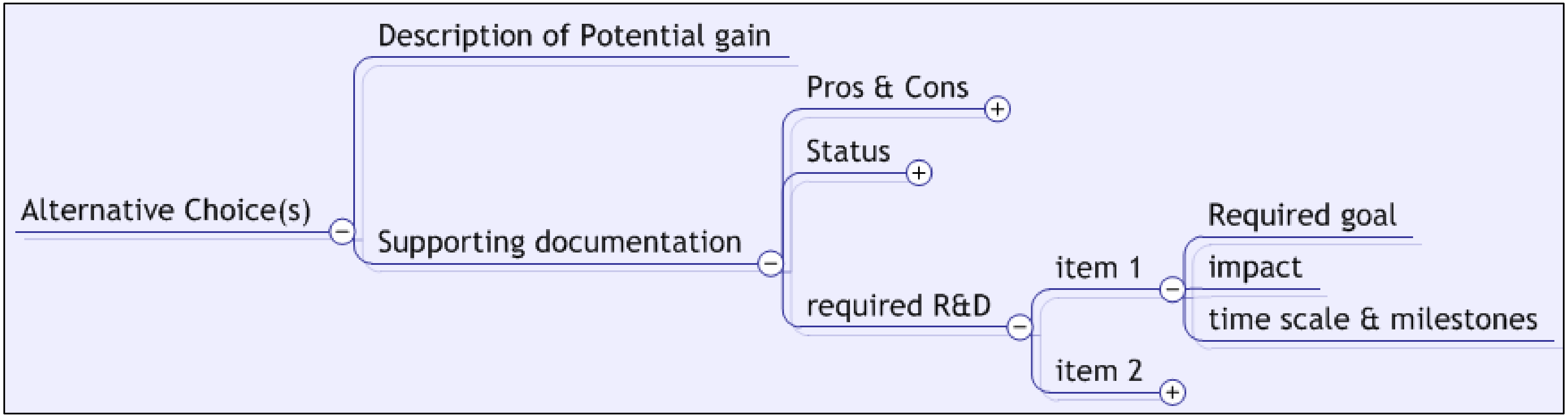
Structure of the BCD



Summary-like overview for those who want to understand the **choice** and the **why**

Technical documentation of the **baseline**, for engineers and acc. phys. making studies towards RDR

Alternatives Section



ACD is part of the BCD

Baseline/Alternative: some definitions

Baseline: a forward looking configuration which we are reasonably confident can achieve the required performance and can be used to give a reasonably accurate cost estimate by mid-end 2006 (→ RDR)

Alternate: A technology or concept which may provide a significant cost reduction, increase in performance (or both), but which will not be mature enough to be considered baseline by mid-end 2006

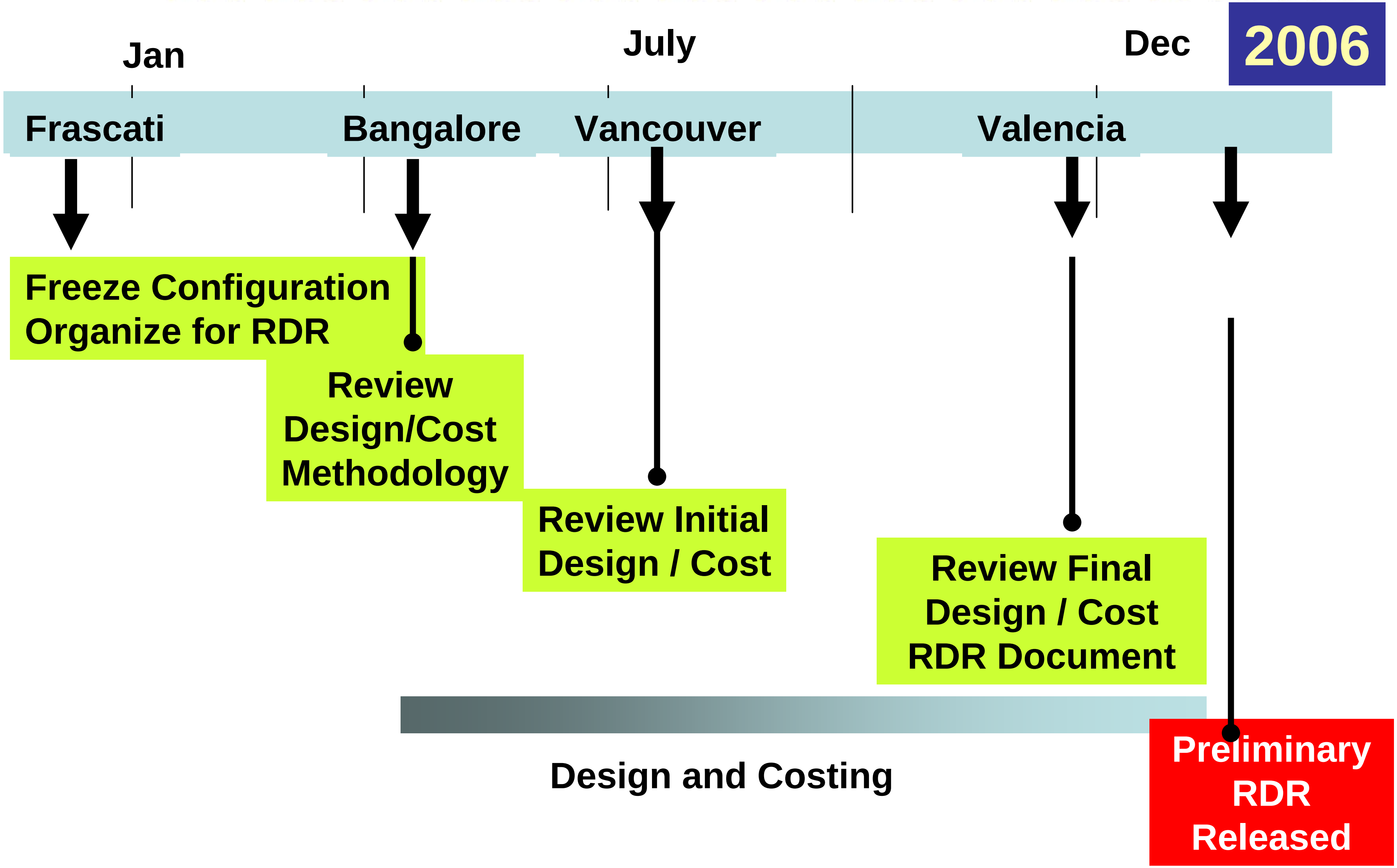
Note:
Alternatives will be part of the RDR
Alternatives are equally important

Single Crystal Niobium is a crucial alternative

GDE Organization for RDR

- Selected some selected new members for the GDE following the BCD completion who have needed skills in design, engineering, costing, etc
- Change Control Board
  - The baseline will be put under configuration control and a Board with a single chair will be created with needed expertise.
- Design / Cost Board
  - A GDE Board with single chair will be established to coordinate the reference design effort, including coordinating the overall model for implementing the baseline ILC, coordinating the design tasks, costing, etc.
- R&D Board
  - A GDE Board will be created to evaluate, prioritize and coordinate the R&D program in support of the baseline and alternatives with a single chair

From Baseline to a RDR



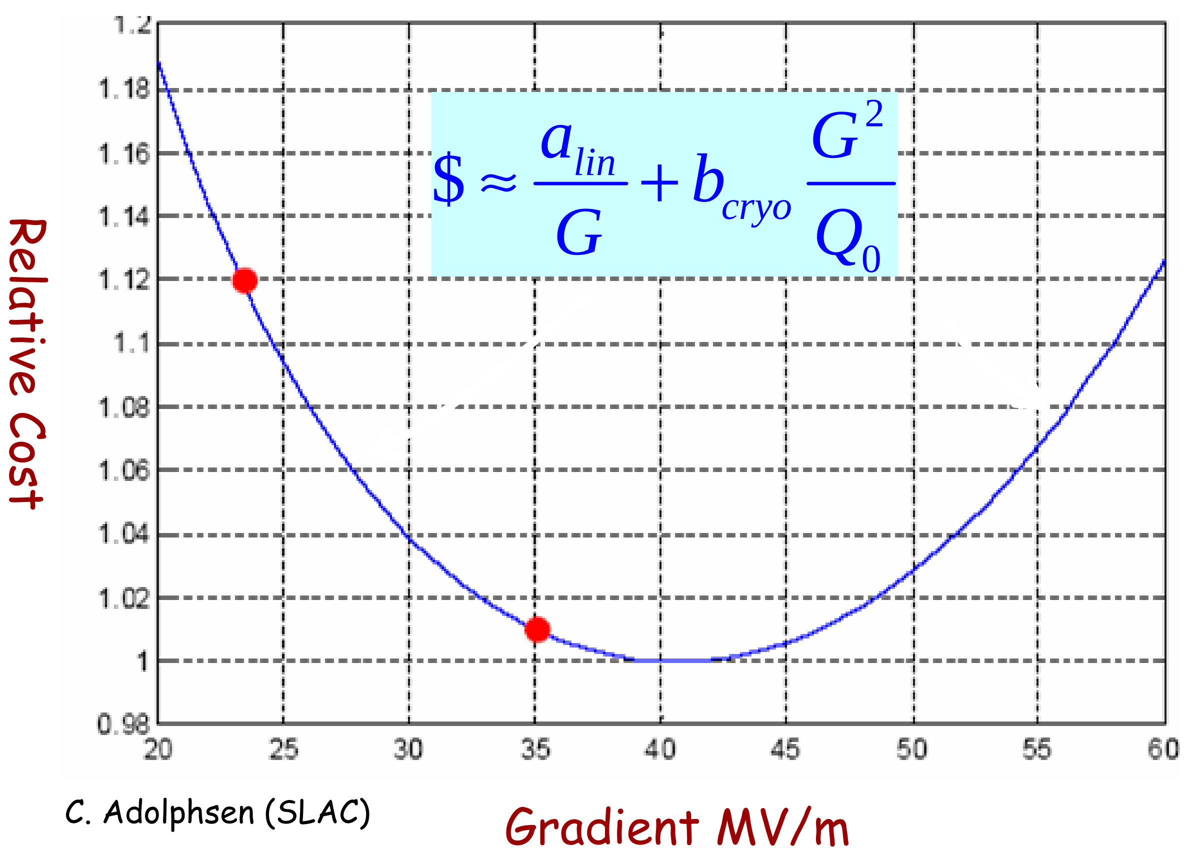
SRF Cavity Gradient

	Cavity type	Qualified gradient	Operational gradient	Length*	energy
		MV/m	MV/m	Km	GeV
initial	TESLA	35	31.5	10.6	250
upgrade	LL	40	36.0	+9.3	500

Total length of one 500 GeV linac ≈ 20km (* assuming 75% fill factor)

ILC Gradient and the R&D on Shapes

- 35MV/m is close to optimum
- 30 MV/m would give safety margin



C. Adolphsen (SLAC)

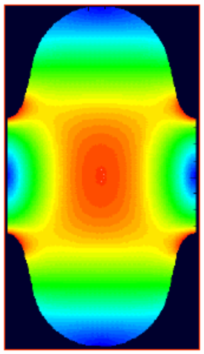
KEK is pushing for 40-45MV/m

"ICHIRO" cavity

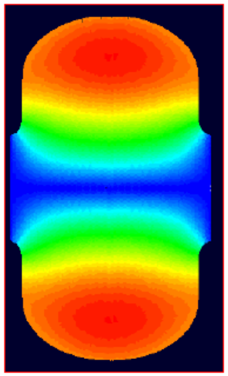
Larger magnetic volume:

- Lower peak magnetic field
- Lower cryogenic losses
- But: higher field emission?

Baseline TESLA shape



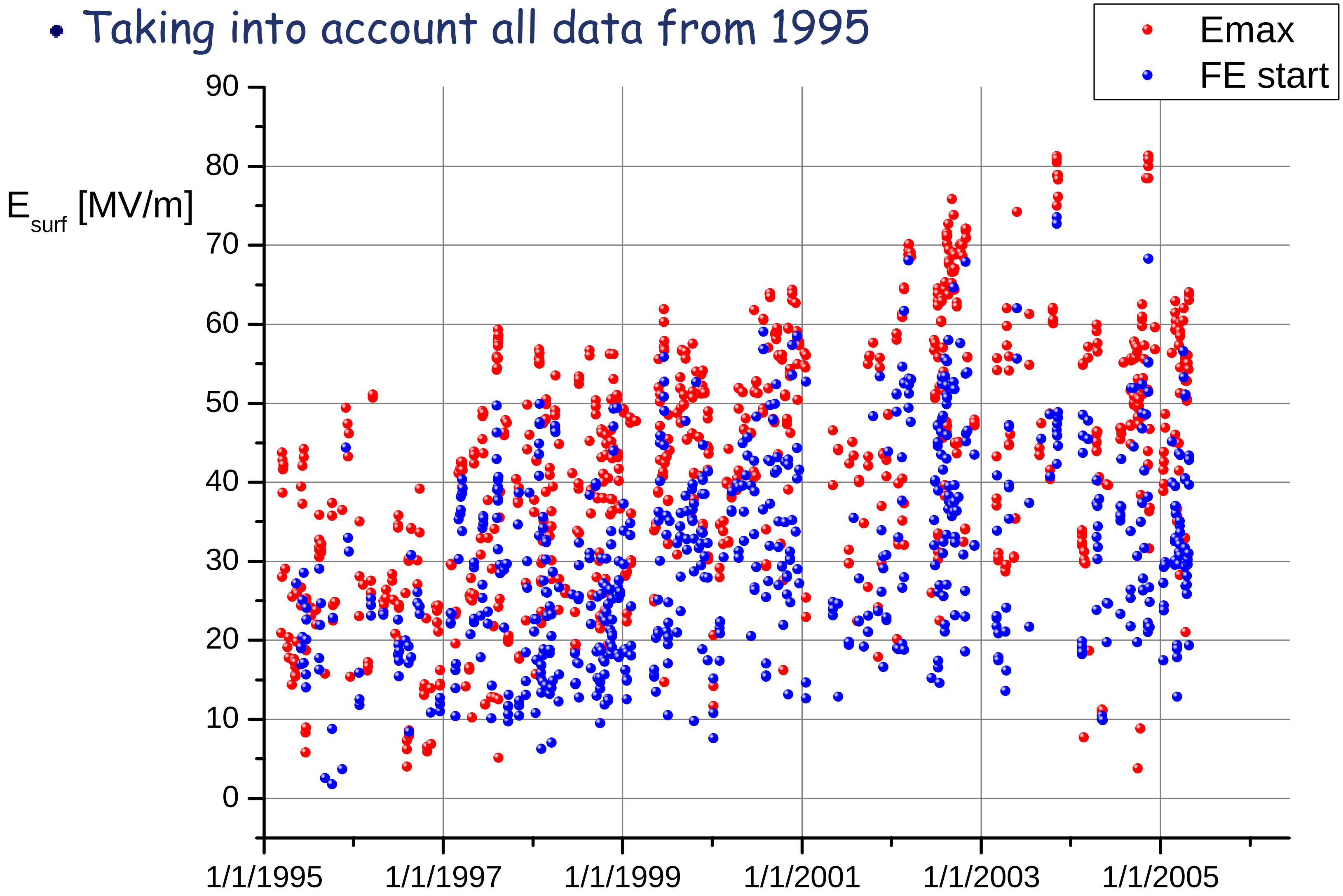
Low Loss Shape LL



Cornell and JLab are also testing low B geometries

TTF: Raw data for trends

- Taking into account all data from 1995

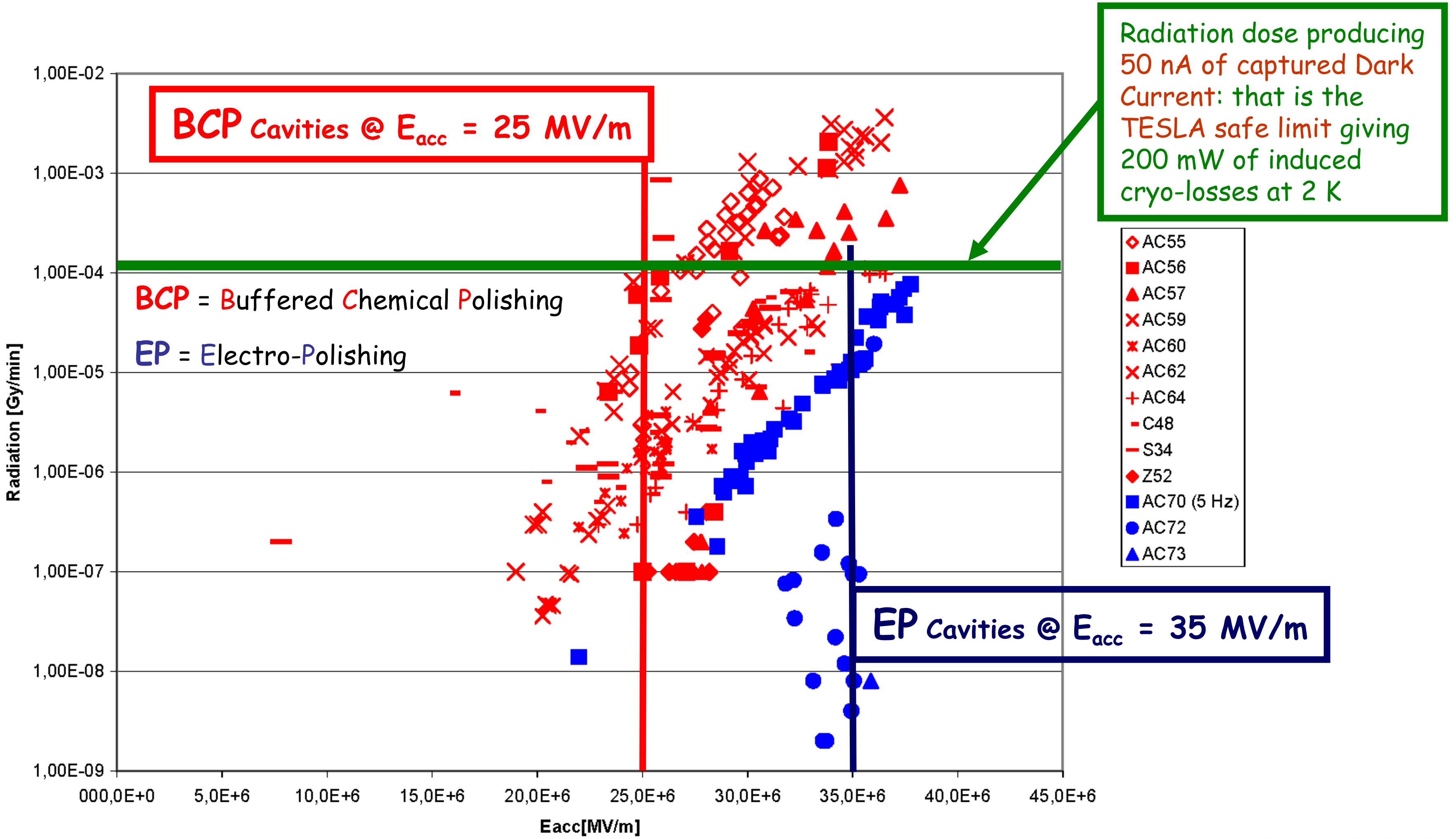


Field Emission level still a concern

BCP Cavities used in Modules 4 & 5 are in red, EP cavities in blue

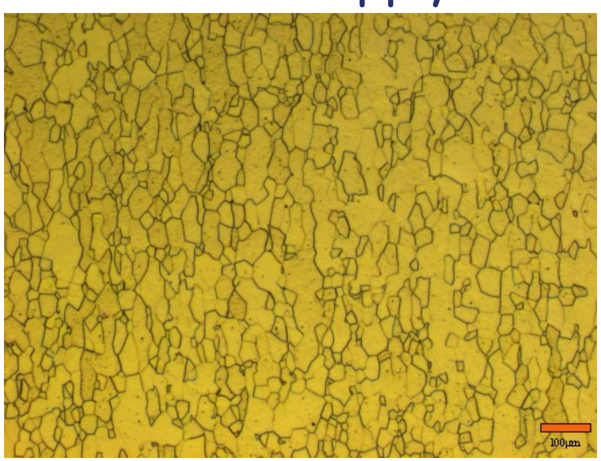
Radiation Dose from the fully equipped cavities while High Power Tested in "Chechia"

"Chechia" is the horizontal cryostat equivalent to 1/8 of a TTF Module

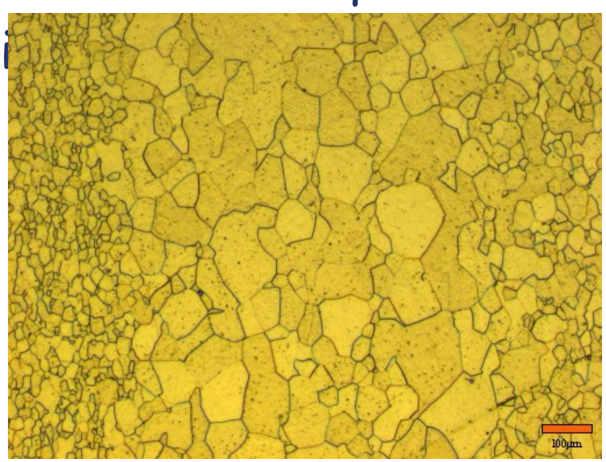


JLab is driving an essential R&D on Nb

- Niobium quality remains the major issue to completely understand and define Quality Control & Quality Assurance parameters
- Most of the niobium cost is determined by the effort of preserving quality through casting rolling and heat treatments required for "homogenous" grain and reasonable isotropy
- Many producer could deliver pure Nb at the ingot state but few can supply sheets with the required minimal properties



As received



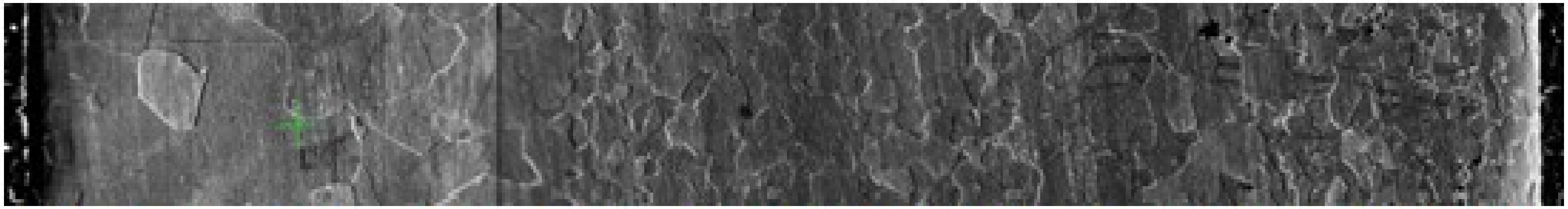
After 800 °C annealing

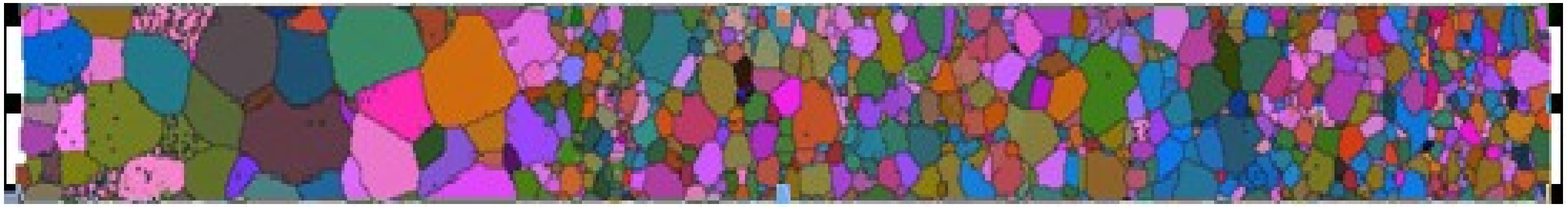
Microstructure is Heterogeneous (Banded)

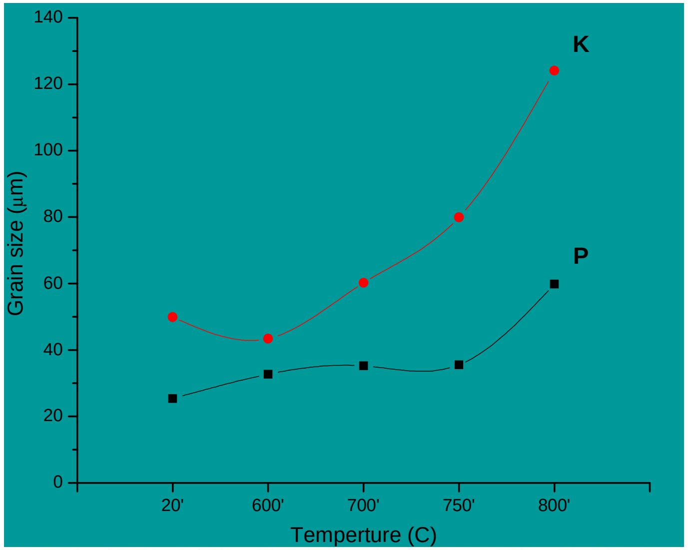
Crystal grains change with the 800 °C heat treatment for de-hydrogenization and stress release

Grain Problems in nowadays Niobium

Niobium sheet cut after the 800 ° annealing. Colors refers to crystal orientations







Grain size grow and orientation depend from the batch used and varies from sheet to sheet of the same batch

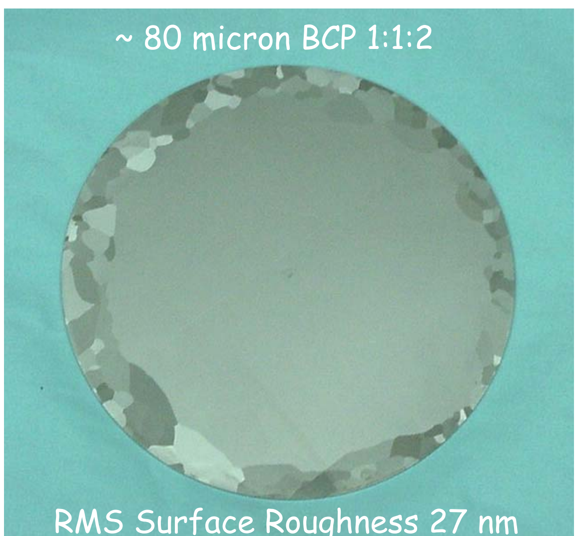
Define QC and QA for the required mechanical properties is a concern

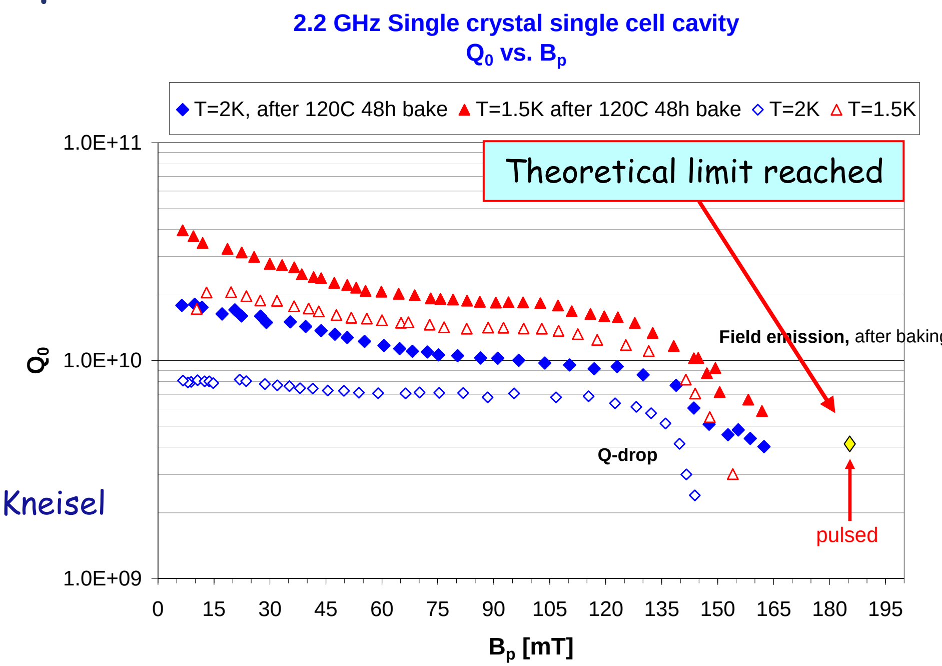
Cavity shape and treatment results are effected by this heterogeneity, grain boundaries and their orientation

Inclusions or clusters in the bulk at the several μm level are not detectable

Large or Single Crystals are promising

- Peter Kneisel at JLab is leading a collaboration that try to qualify niobium sheets obtained by EDM (Electron Discharge Machining) directly from the ingot
- Preliminary results are very promising
- In case of success, material QC and QA would be much easier and the cost possibly cheaper





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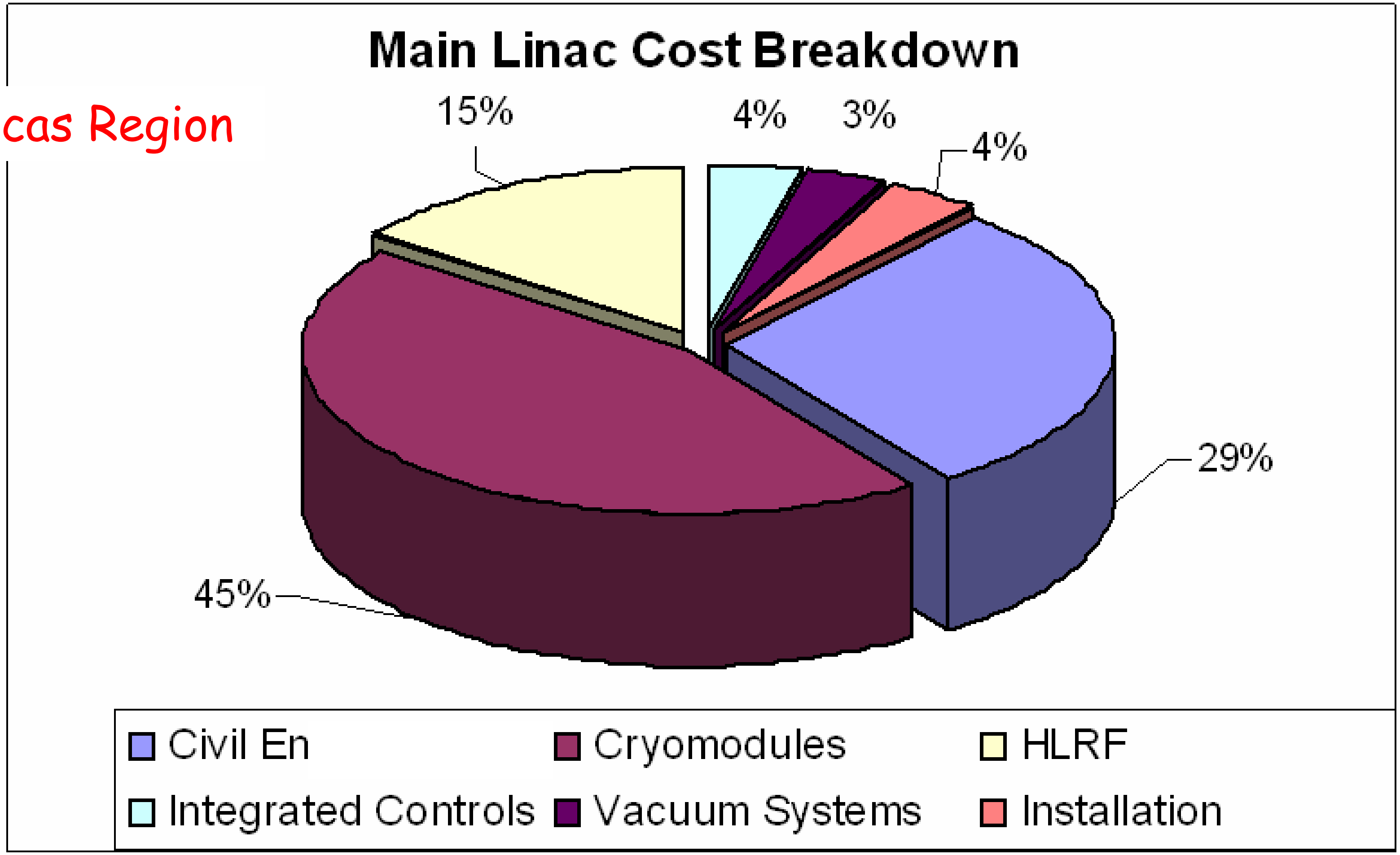
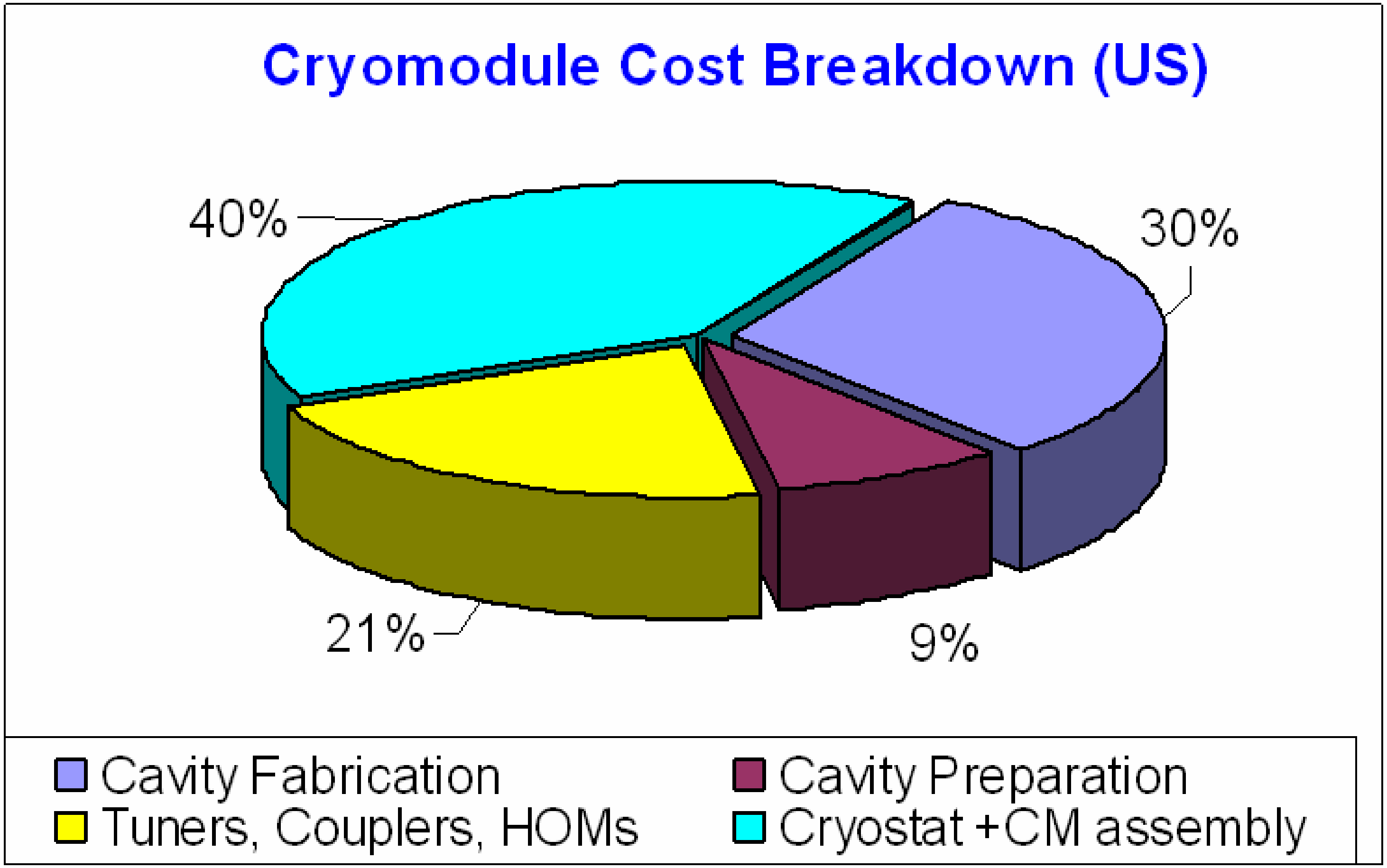
Major Cost drivers in Main Linac

Americas Region



Cryomodule cost estimation



* Cavity Fabrication cost includes cost of materials
** Facilities costs are included in each item

From Basic Research to Industry

- High Energy Physics is pushing the limits of Acc. Technology
  - Goals beyond the actual technology limits
  - Large, internationally supported, projects
  - Strong participation from Industry
  - Strict Requirements on Quality Assurance and Quality Control
- Other science fields are applying results and making progress
  - Future energy plants: Fusion and Nuclear Waste Transmutation
  - Spallation Neutron Sources
  - Synchrotron Light Sources
  - Free Electron Lasers
  - Humane Science: Medicine and Biology
- Industry took benefit from supported R&D
  - Industrial and medical applications of SLAC type linacs
  - Medical applications of Superconducting Magnets
  - and many other examples