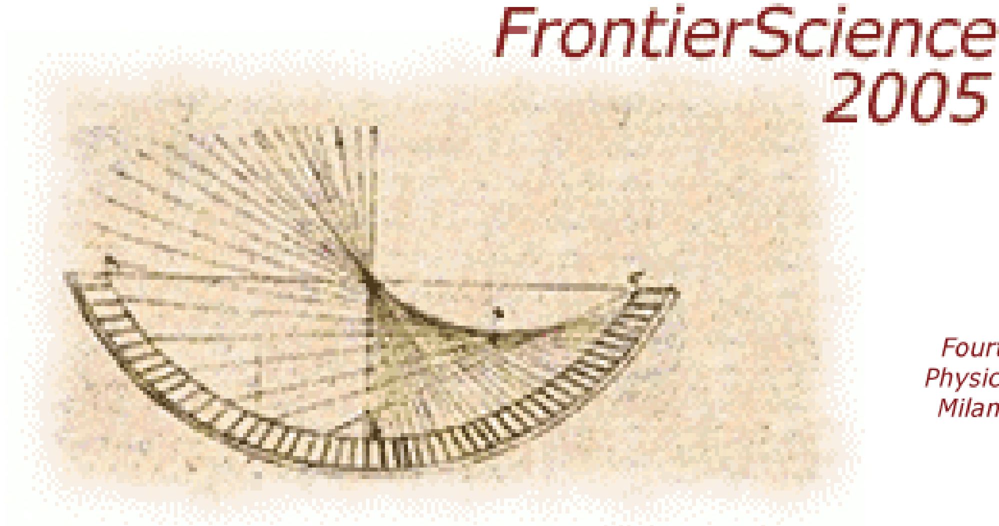


New Frontiers in Subnuclear Physics

New Frontiers in Subnuclear Physics
Fourth International Conference on Frontier Science
Physics Department "G. Occhialini" of the University of Milano Bicocca, Milan, Italy, September 12-17, 2005

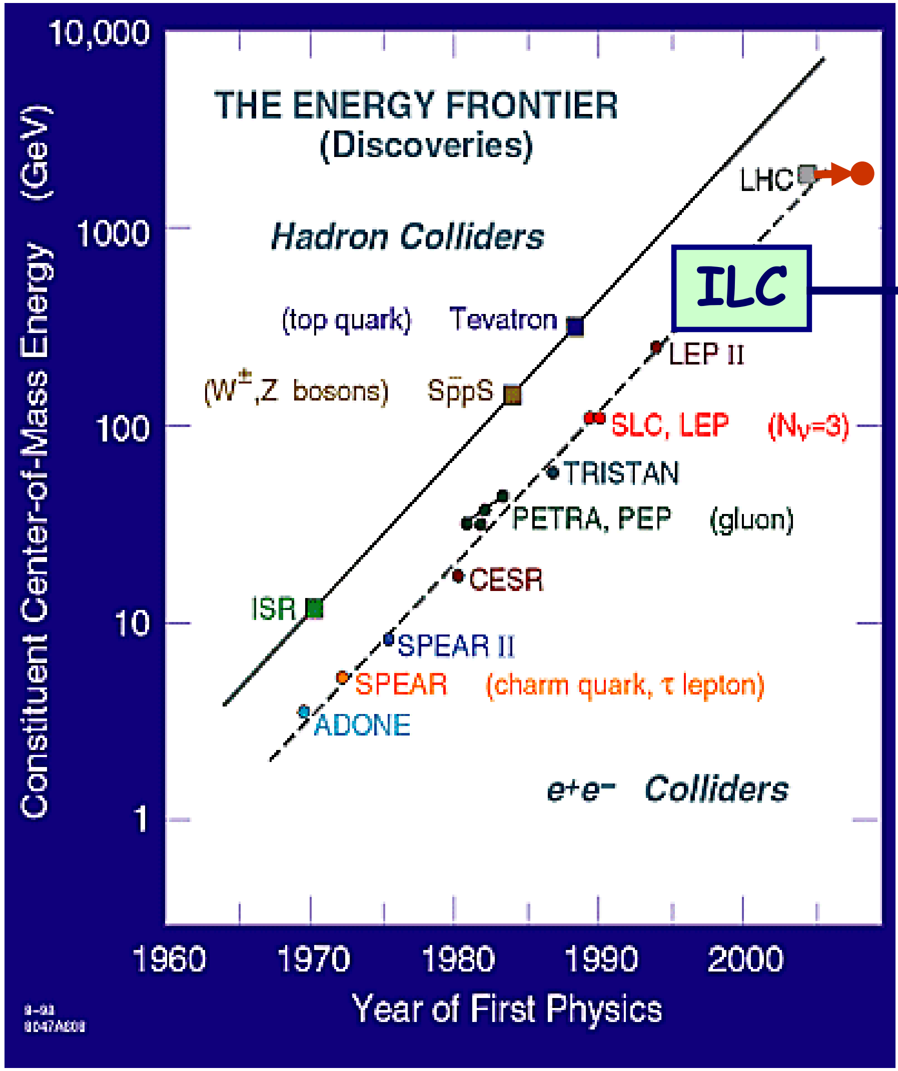
From TESLA to the International Linear Collider

Carlo Pagani

INFN Milano and DESY

On leave from University of Milano

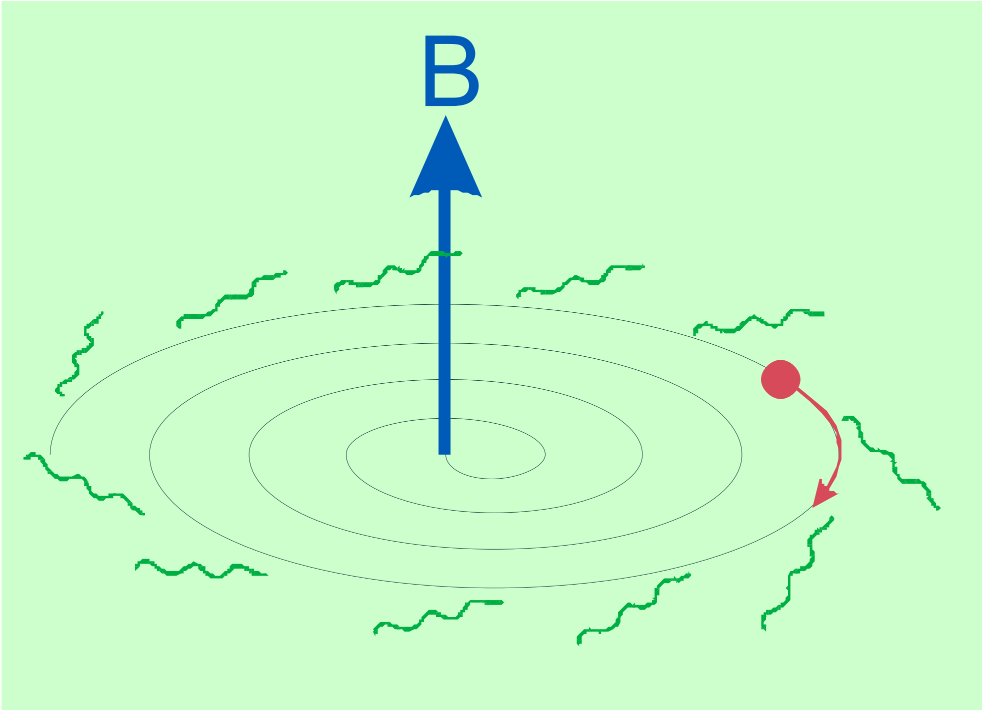
Energy Frontier and e^+e^- Colliders



Why a Linear Collider?

Synchrotron Radiation

From an electron in a magnetic field:



Energy loss must be replaced by RF system

cost scaling $ $\propto E_{cm}^2$

A Simple Exercise

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

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

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

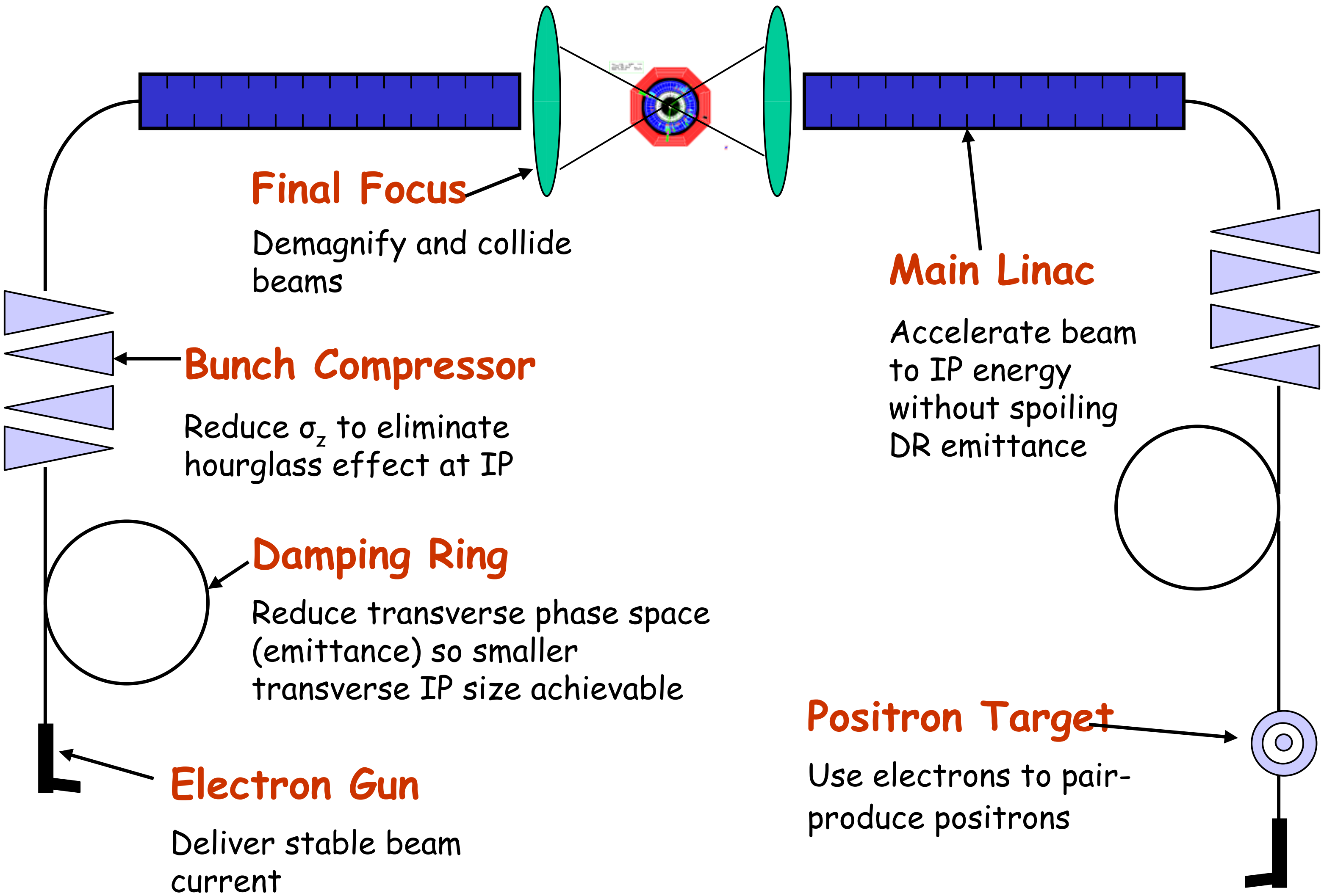
$\gamma_{250GeV} = 4.9 \cdot 10^5$

- Consider also the luminosity
  - For a **luminosity of ~ 10^{34}/cm²/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

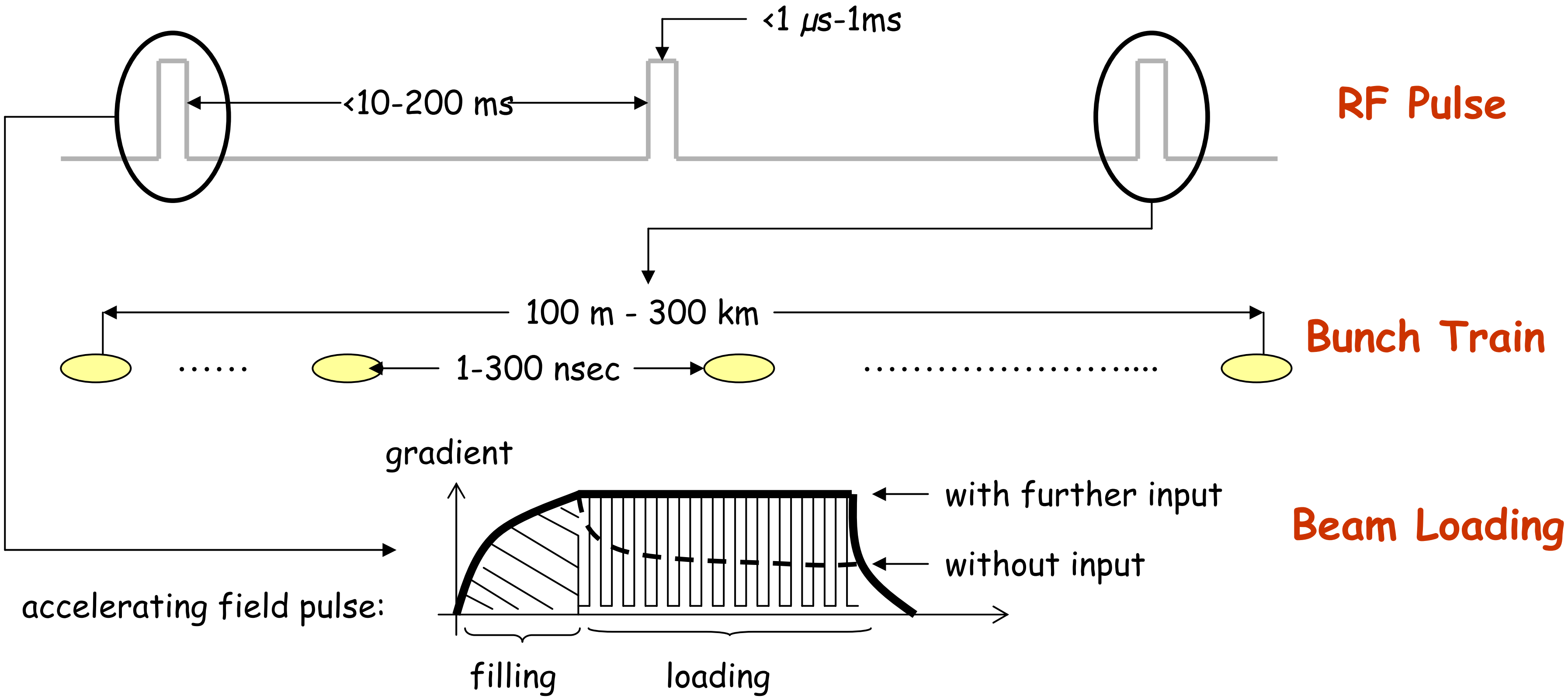
LC conceptual scheme



Linear Colliders are pulsed

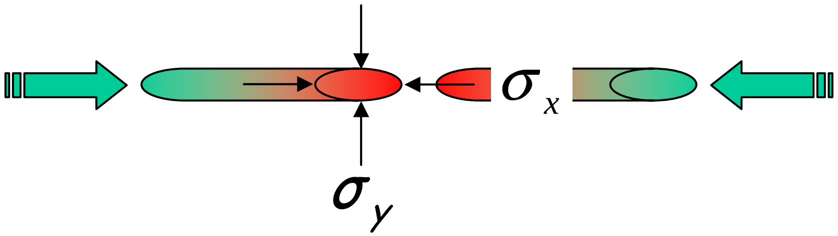
LCs are pulsed machines to improve efficiency. As a result:

- duty factors are small
- pulse peak powers can be very large



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

ILC-TRC (Greg Loew Panel)

International LC Technical Review Committee

- International Collaboration for R&D toward TeV-Scale e^+e^- LC asked for first ILC-TRC in June 1994
- ILC-TRC produced first report end of 1995
- 2001: ICFA requests that ILC-TRC reconvene to produce a second report with the following charge:
  - To assess the present technology status of the four LC designs at hand, and their potential for meeting the advertised parameters at 500 GeV c.m.
  - Use common criteria, definitions, computer codes, etc., for the assessments
  - To assess the potential of each design for reaching higher energies above 500 GeV c.m.
  - To establish, for each design, the R&D work that remains to be done in the next few years
  - To suggest future areas of collaboration
- ILC-TRC produced second report January 2003

  http://www.slac.stanford.edu/xorg/ilc-trc/2002/2002/report/03rep.htm

LC status at first ILC-TRC

End 1995 — E_{cm} = 500 GeV

	TESLA	SBLC	JLC-S	JLC-C	JLC-X	NLC	VLEPP	CLIC
f [GHz]	1.3	3.0	2.8	5.7	11.4	11.4	14.0	30.0
$\mathcal{L}\times10^{33}$ [cm^{-2}s^{-1}]	6	4	4	9	5	7	9	1-5
P_{beam} [MW]	16.5	7.3	1.3	4.3	3.2	4.2	2.4	1-4
P_{AC} [MW]	164	139	118	209	114	103	57	100
$\gamma\varepsilon_y$ [$\times10^{-8}$m]	100	50	4.8	4.8	4.8	5	7.5	15
σ_y* [nm]	64	28	3	3	3	3.2	4	7.4

Tasks to be addressed

Baseline cm Energy stays at 500 GeV

- Push Luminosity to the maximum value
- Technology:
  - Demonstrate that the proposed technology can be pushed to the limits required for a Linear Collider
  - Demonstrate that the proposed technology can be produced in large scale by industry with high reliability and reasonable cost
  - Find solution for all critical items
- Design issues:
  - Demonstrate that very small spot sizes ($\sigma_x \cdot \sigma_y < 1\ \mu m^2$) are possible
  - Investigate all beam physics critical issues
  - Support all design features with cross-checked simulations
  - Address reliability and availability issues
- Roadmap for energy upgrade
- Test Facilities

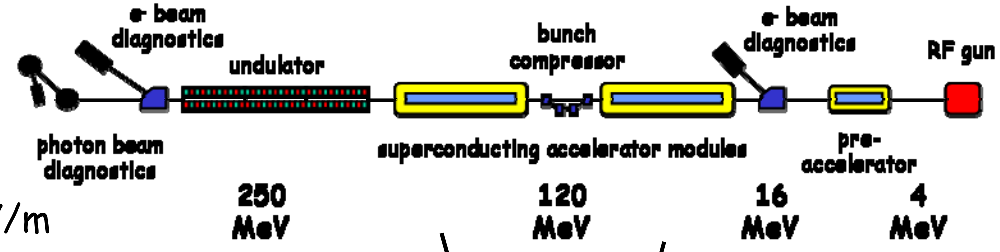
TTF for TESLA

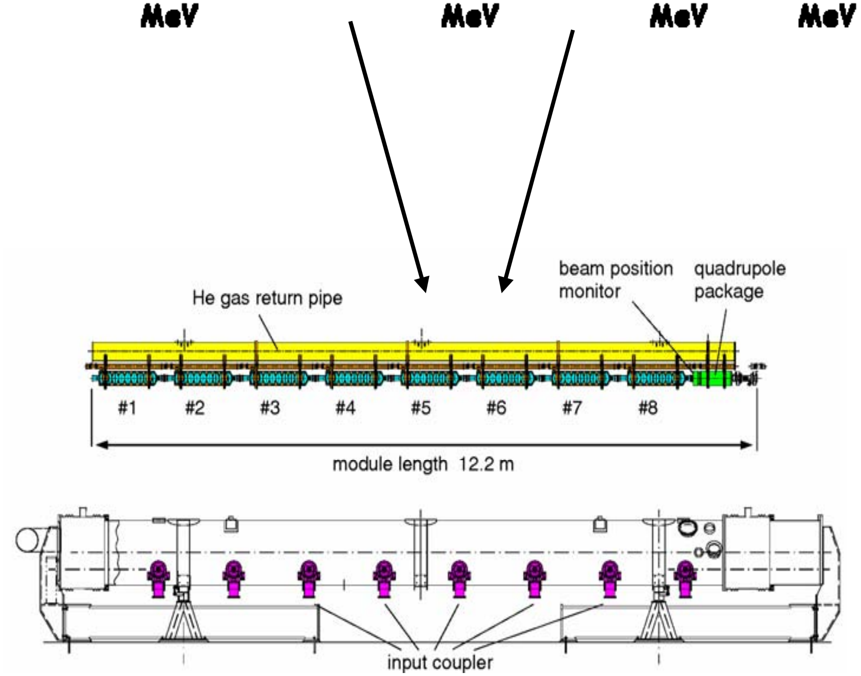
TTF = TESLA Test Facility

TTF as operated for SASE FEL

TTF Goals:

- Demonstrate that Superconducting RF technology is suitable for LC
- Operate TTF at E_{acc} > 15 MV/m
- Develop cavity technology for Eacc > 25 MV/m



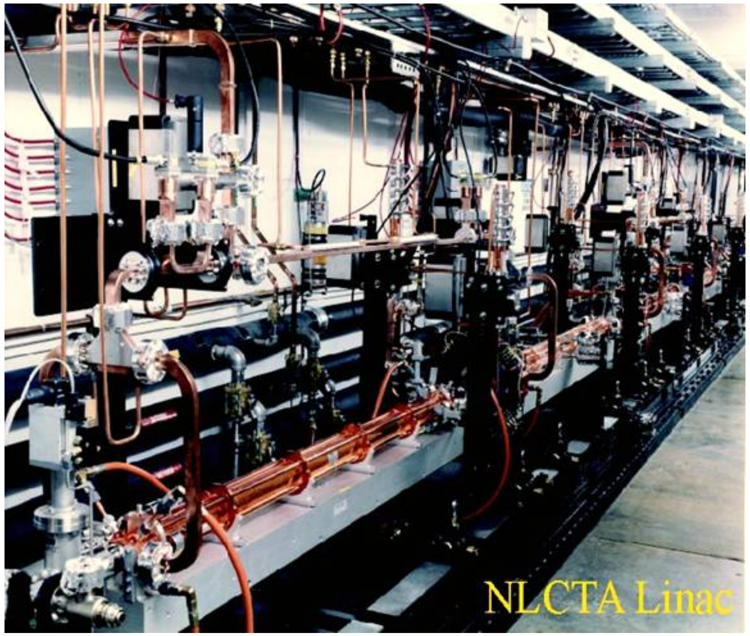


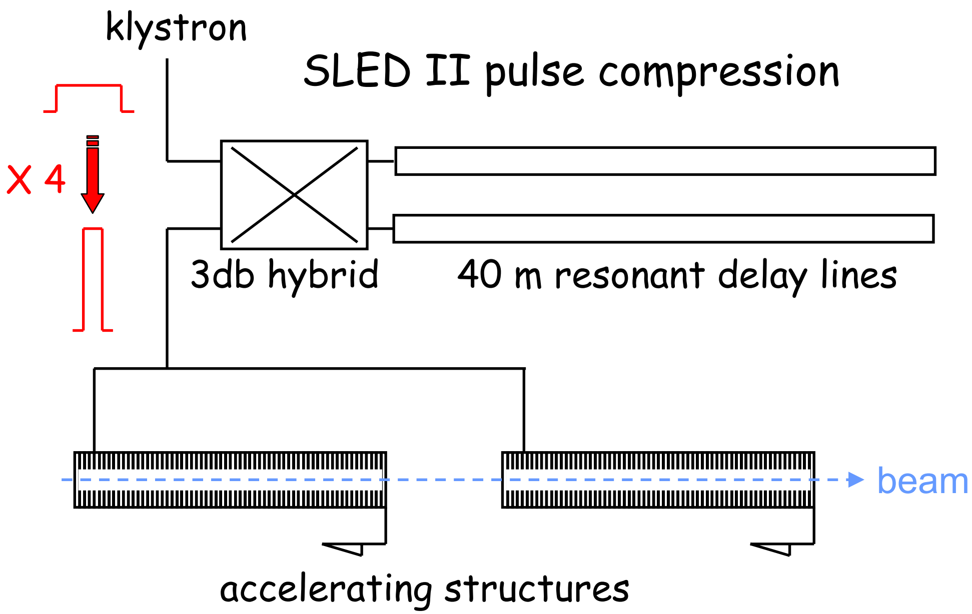
NLCTA for NLC

NLCTA = NLC Test Accelerator

NLCTA Goals:

- RF system integration test of a NLC linac section
- Test efficient, stable and uniform acceleration of a NLC-like bunch train





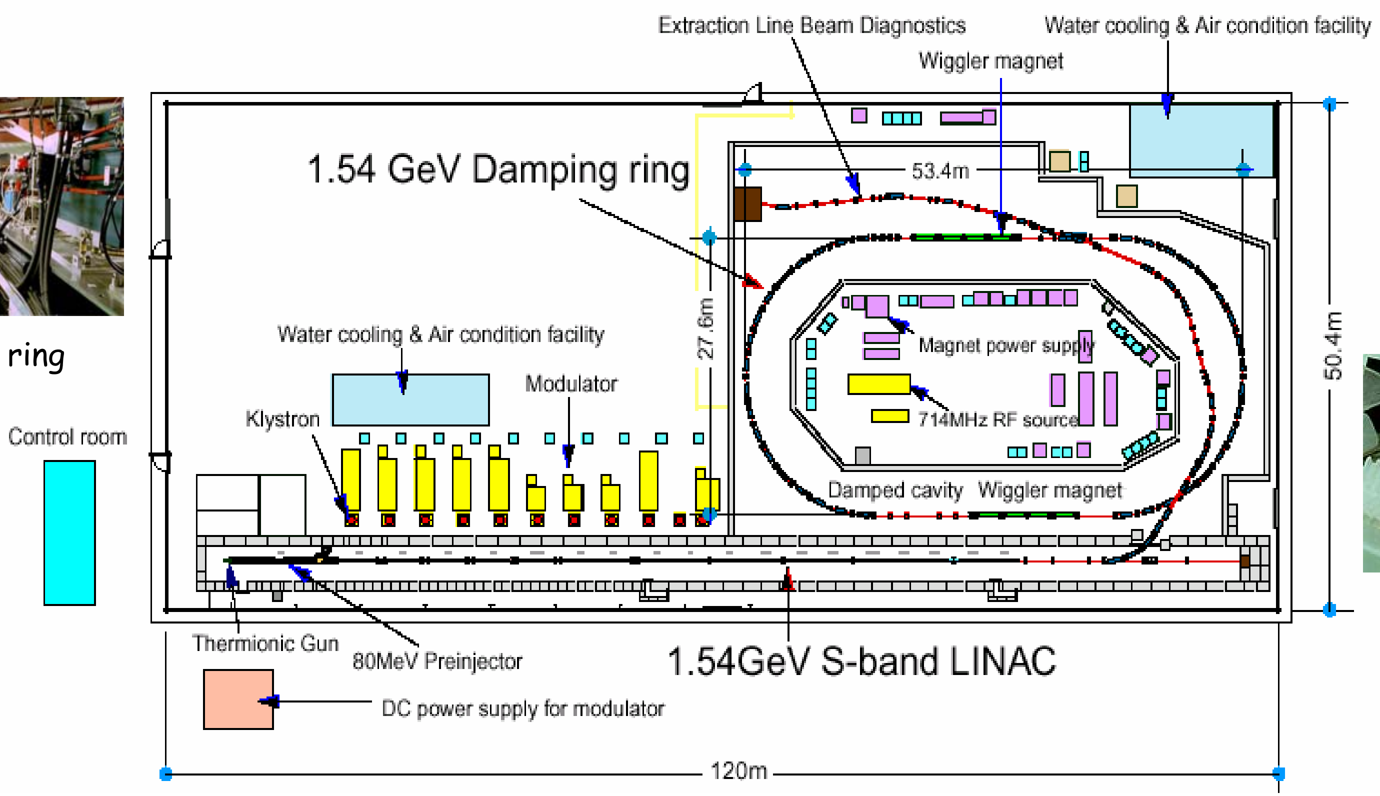
ATF for JLC

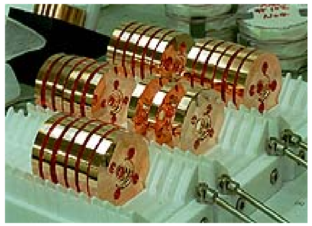
ATF = Accelerator Test Facility

ATF Goals:

- Demonstrate very low beam emittance
- Develop RF technology

Damping ring

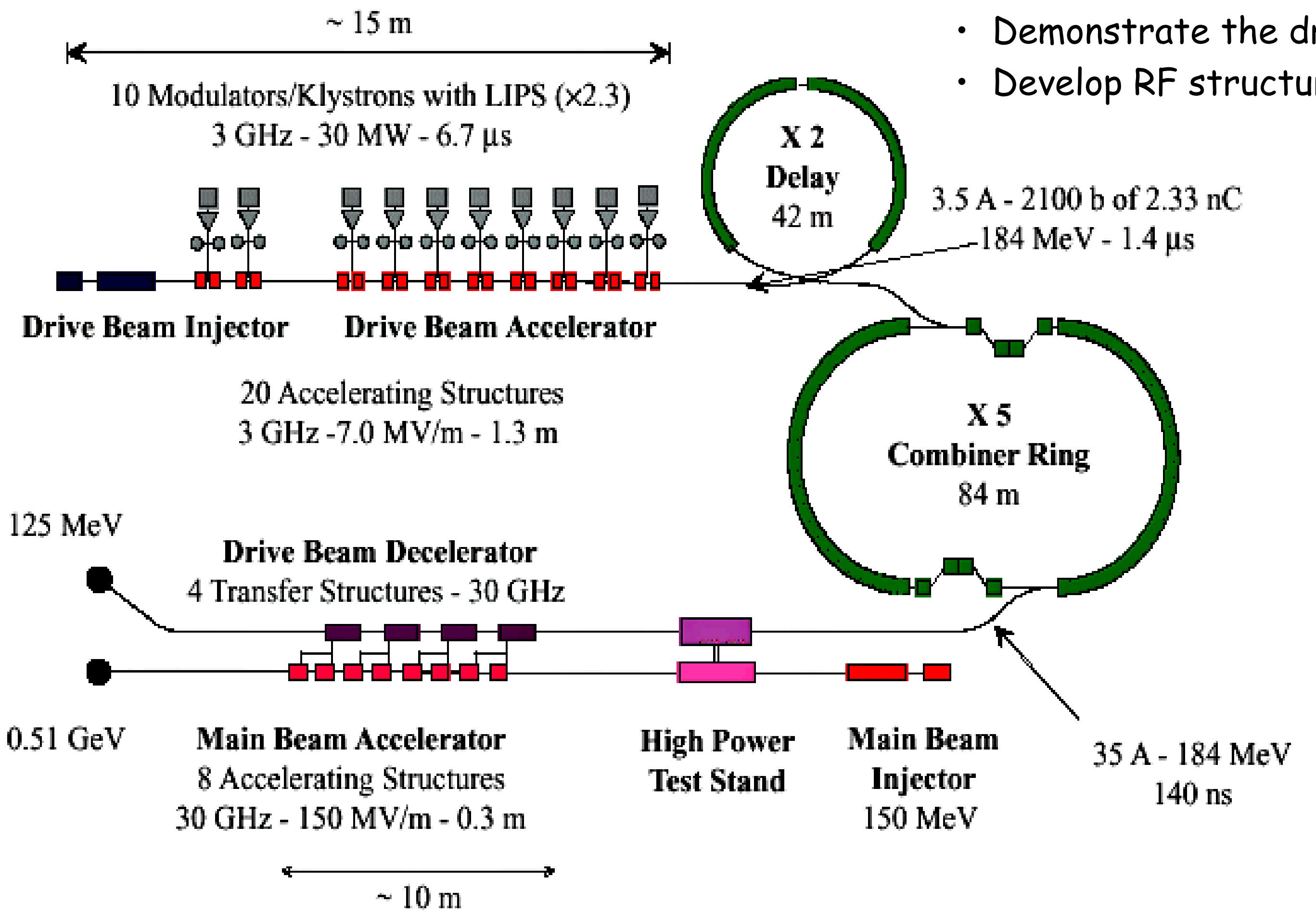




Cavity Production

CTF for CLIC

CTF3 = CLIC Test Facility #3 (Under construction after CTF1 and CTF2)

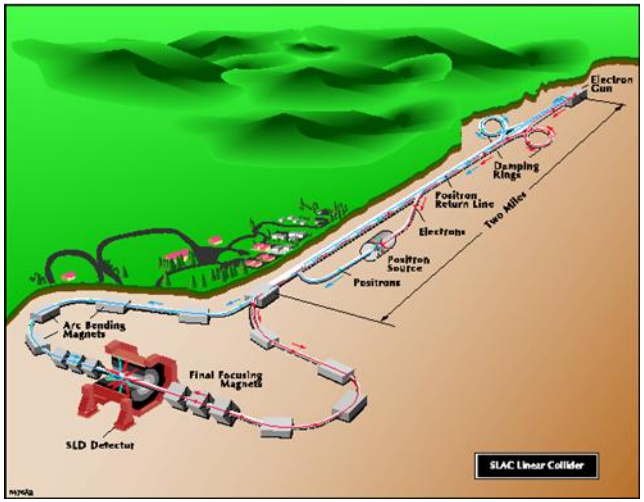


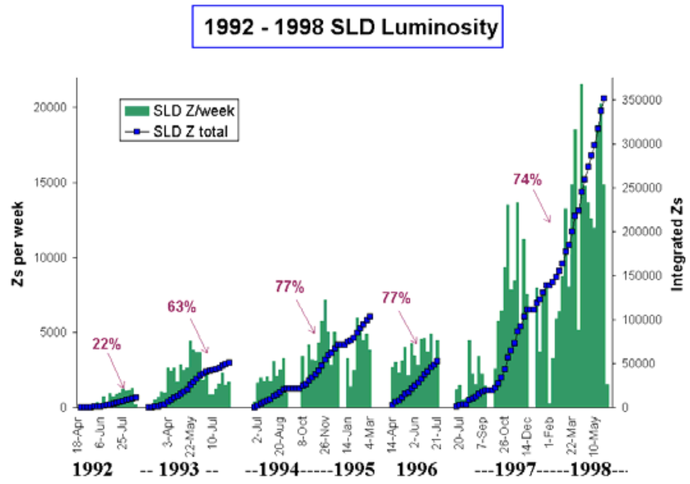
CTF3 Goals:

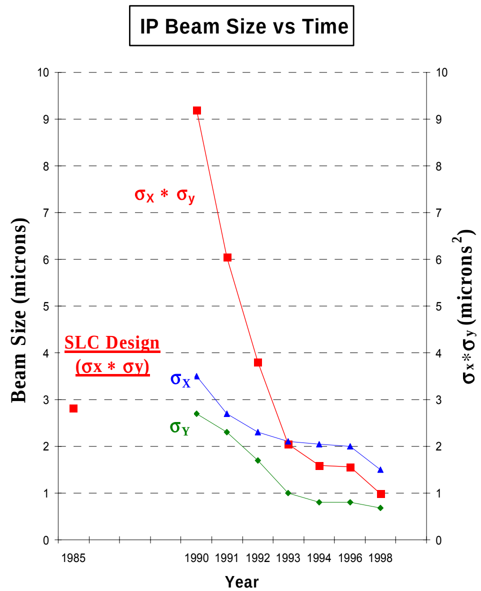
- Demonstrate the drive beam scheme
- Develop RF structures and technology

Lessons from the SLC

SLC = SLAC Linear Collider







New Territory in Accelerator Design and Operation

- Sophisticated on-line modeling of non-linear beam physics.
- Correction techniques (trajectory and emittance), from hands-on by operators to fully automated control.
- Slow/fast feedback theory and practice.

LC status at second ILC-TRC

January 2003 E_{cm} = 500 GeV

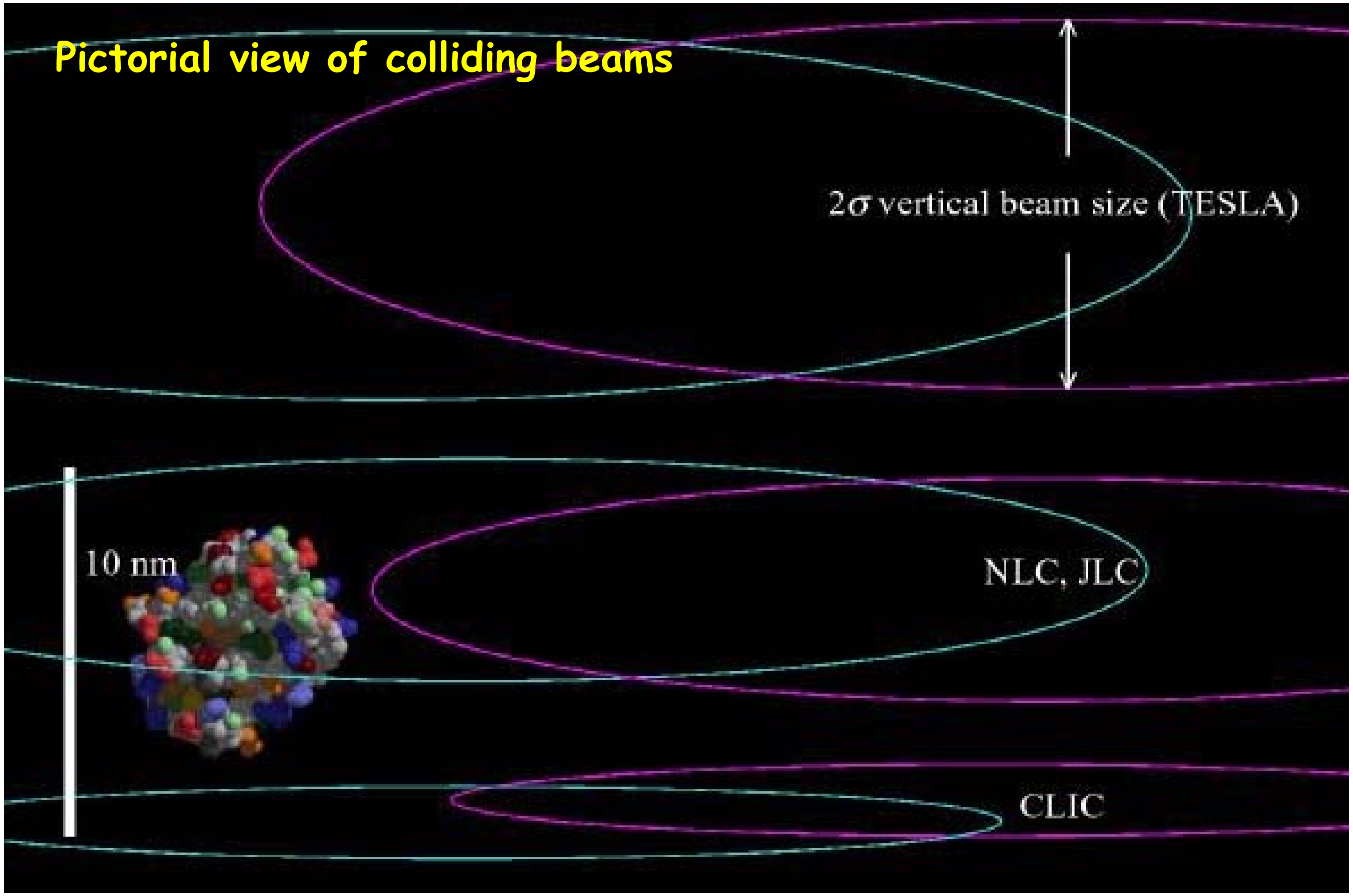
	TESLA	SBLC	JLC-S	JLC-C	JLC-X/NLC	VLEPP	CLIC
f [GHz]	1.3			5.7	11.4		30.0
$\mathcal{L} \times 10^{33}$ [$cm^{-2}s^{-1}$]	34			14	20		21
P_{beam} [MW]	11.3			5.8	6.9		4.9
P_{AC} [MW]	140			233	195		175
$\gamma\varepsilon_y$ [$\times 10^{-8}$m]	3			4	4		1
σ_y^* [nm]	5			4	3		1.2

Second to first ILC-TRC Comparison

2003 vs. 1995 E_{cm} = 500 GeV

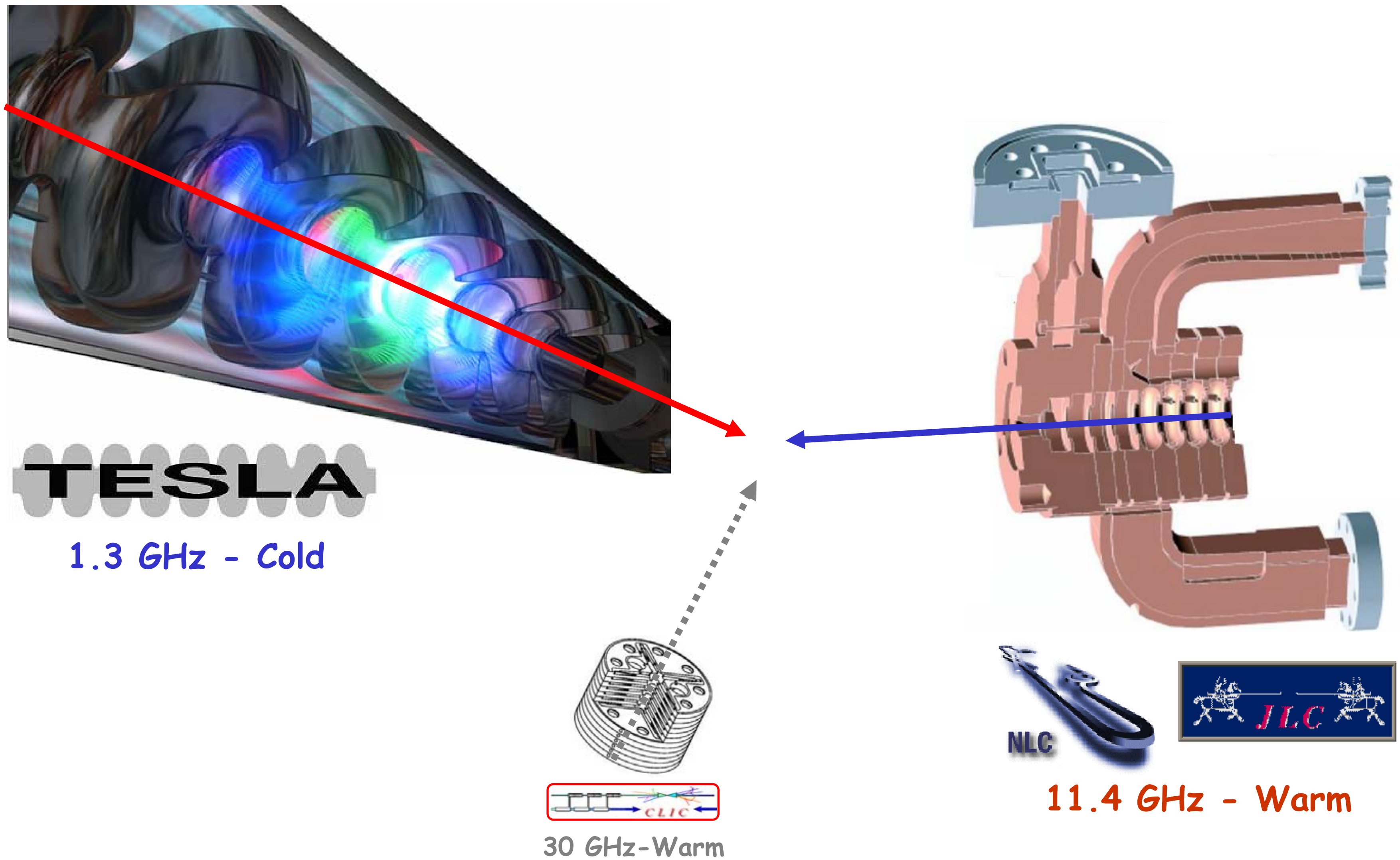
	TESLA 2003	TESLA 1994	JLC/NLC 2003	<JLC/NLC> 1994	CLIC 2003	CLIC 1994
f [GHz]	1.3	1.3	11.4	11.4	30.0	30.0
$\mathcal{L}\times10^{33}$ [$cm^{-2}s^{-1}$]	34	6	20	6	21	1-5
P_{beam} [MW]	11.3	16.5	6.9	3.7	4.9	1-4
P_{AC} [MW]	140	164	195	110	175	100
$\gamma\varepsilon_y$ [$\times10^{-8}$m]	3	100	4	5	1	15
σ_y^* [nm]	5	64	3	3	1.2	7.5

That's what we have to do…

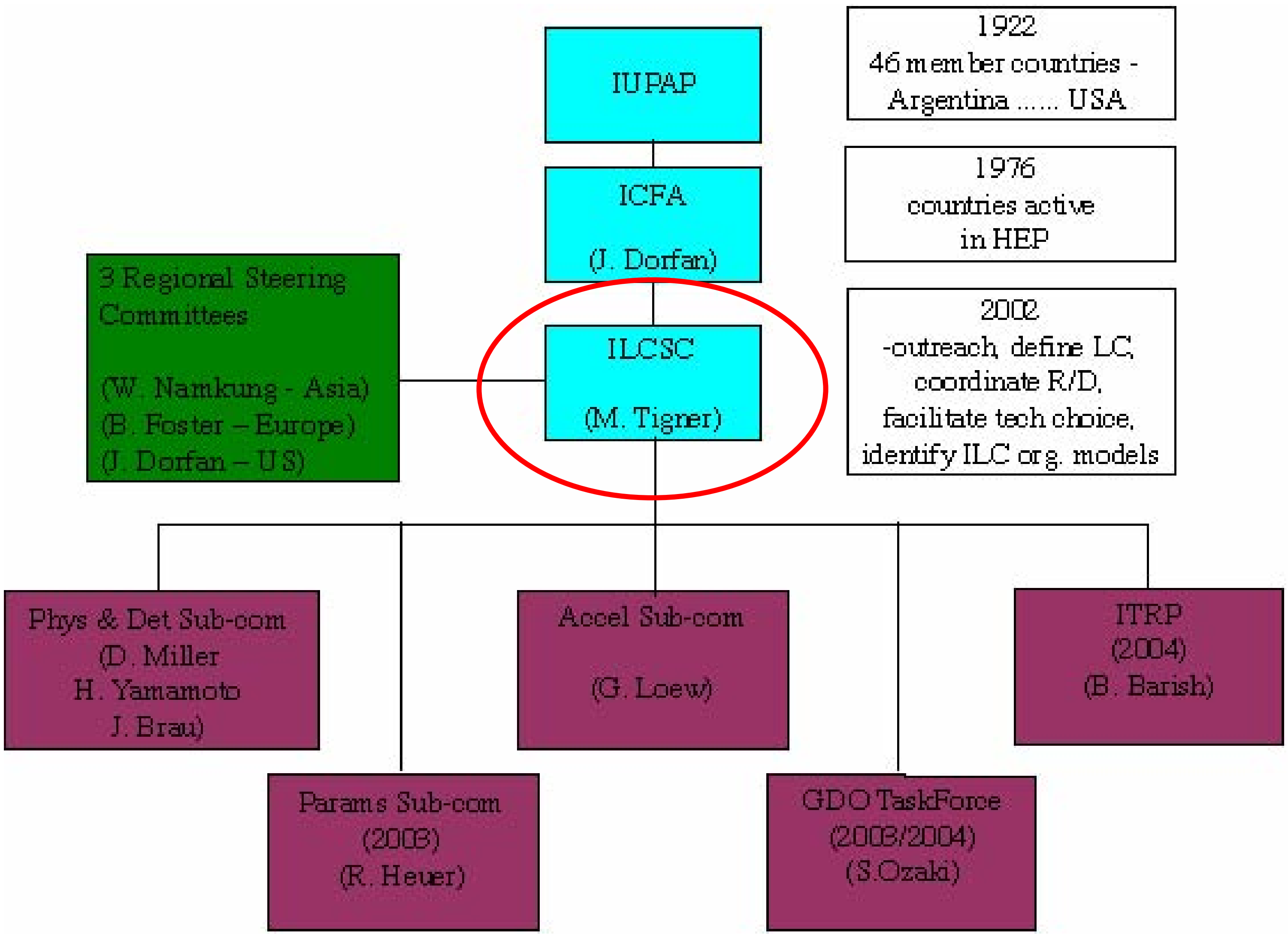


From Hasan Padamsee

Competing technologies



LC Organisation up to August 2004



ILCSC as in 2002

International Linear Collider Steerng Committee

Membership of the ILCSC in 2002

H. Chen (IHEP, Beijing)
J. Dorfan (SLAC)
B. Foster (Bristol, UK)
C. Garcia Canal (La Plata, Argentina)
P. Grannis (Stony Brook, US)
S. Komamiya (Tokyo)
L. Maiani (CERN)
D. Miller (UCL, UK)
W. Namkung (POSTECH, Korea)
A. Skrinsky (BINP)
H. Sugawara (KEK)
M. Tigner (Cornell) – Chair
Y. Totsuka (Tokyo)
A. Wagner (DESY)
M. Witherell (Fermilab)

First proposed on Feb. 2002 (J. Dorfan), very active since Aug. 2002

Extract from the mandate of the ILCSC

- Engage in outreach, explaining the intrinsic scientific and technological importance of the project.
- Based upon the extensive work already done in Asia, Europe and N. America, engage in defining the scientific roadmap, the scope and primary parameters for machine and detector.
- Monitor the machine R&D activities and make recommendations on the coordination and sharing of R&D tasks as appropriate.
- Identify models of the organizational structure, based on international partnerships, adequate for constructing the LC facility.
- Carry out such other tasks as may be approved or directed by ICFA.

Technology Choice: NLC/JLC or TESLA

The International Linear Collider Steering Committee (ILCSC) selected the twelve members of the International Technology Recommendation Panel (**ITRP**) at the end of 2003:

Asia:	Europe:	North America:
G.S. Lee	J-E Augustin	J. Bagger
A. Masaike	G. Bellettini	**B. Barish (Chair)**
K. Oide	G. Kalmus	P. Grannis
H. Sugawara	V. Soergel	N. Holtkamp

First meeting end of January 2004 at RAL

Mission: one technology by end 2004

Result: recommendation on 19 August 2004

From the ILC Birthday

From the ILC Birthday

The Charge to the International Technology Recommendation Panel

General Considerations

The International Technology Recommendation Panel (the Panel) should recommend a Linear Collider (LC) technology to the International Linear Collider Steering Committee (ILCSC).

On the assumption that a linear collider construction commences before 2010 and given the assessment by the ITRC that both TESLA and JLC-X/NLC have rather mature conceptual designs, the choice should be between these two designs. If necessary, a solution incorporating C-band technology should be evaluated.

Note -- We have interpreted our charge as being to recommend a technology, rather than choose a design

19-Aug-04 ITRP - LC Technology Recommendation 8

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.

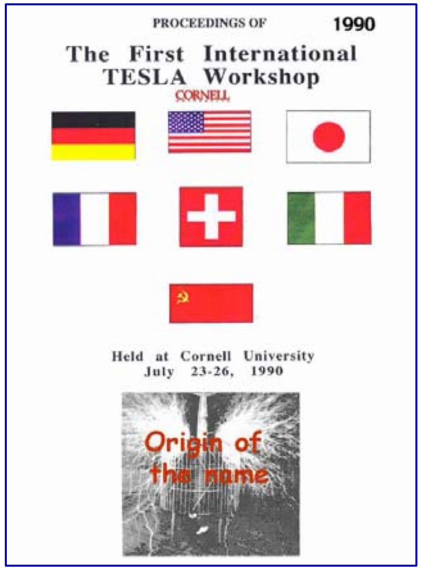
19-Aug-04 ITRP - LC Technology Recommendation 14

From the Day After

- Robert Aymar (CERN): “A linear collider is the logical next step to complement the discoveries that will be made at the LHC. The technology choice is an important step in the path towards an efficient development of the international TeV linear collider design, in which CERN will participate.”
- Yoji Totsuka (KEK): “This decision is a significant step to bring the linear collider project forward. The Japanese high-energy community welcomes the decision and looks forward to participating in the truly global project.”
- Jonathan Dorfan (SLAC): “Scientific discovery is the goal. Getting to the physics is the priority. The panel was presented with two viable technologies. We at SLAC embrace the decision and look forward to working with our international partners.”
- Similar Declarations from: Albrecht Wagner (DESY), Hesheng Chen (HEP), Michael Witherell (FNAL) et al.

From the ICFA press release, Beijing, 20 August 2005

The TESLA Collaboration



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

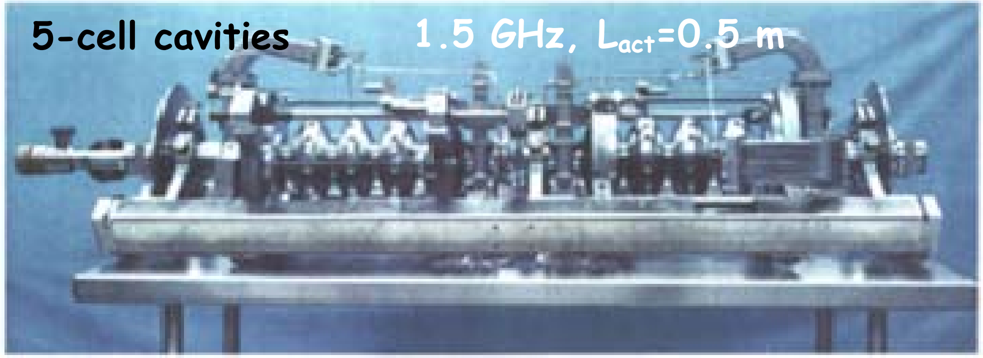
- **Higher conversion efficiency**: more beam power for less plug power consumption
- **Lower RF frequency**: relaxed tolerances and smaller emittance dilution

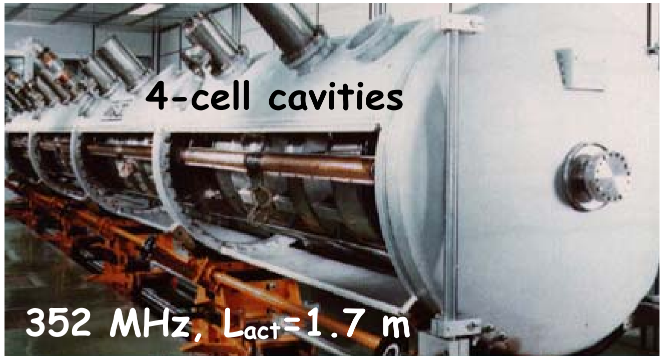
References for TESLA Technology

CEBAF at TJNAF

338 bulk niobium cavities

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





LEP II at CERN

32 bulk niobium cavities

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

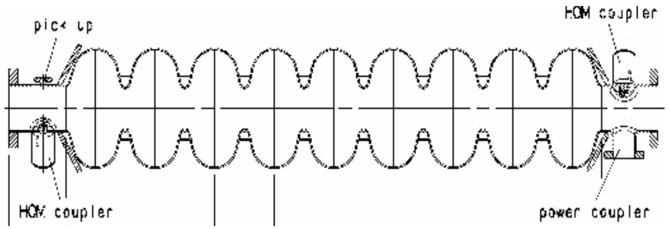
256 sputtered cavities

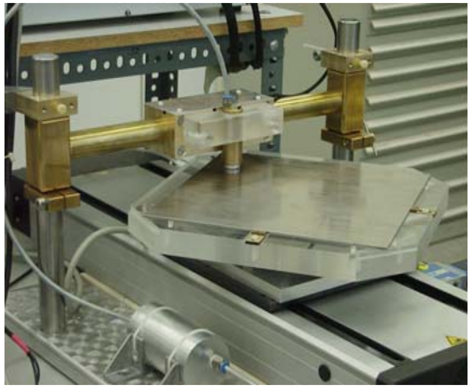
- Magnetron-sputtering of Nb on Cu
- Completely done by industry
- **Field improved with time**
  $\langle E_{acc} \rangle$ = 7.8 MV/m (Cryo-limited)

Optimized cavity design and rules

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

- 9-cell, 1.3 GHz





Eddy-current scanning system for niobium sheets

Cleanroom handling of niobium cavities

TESLA cavity parameters

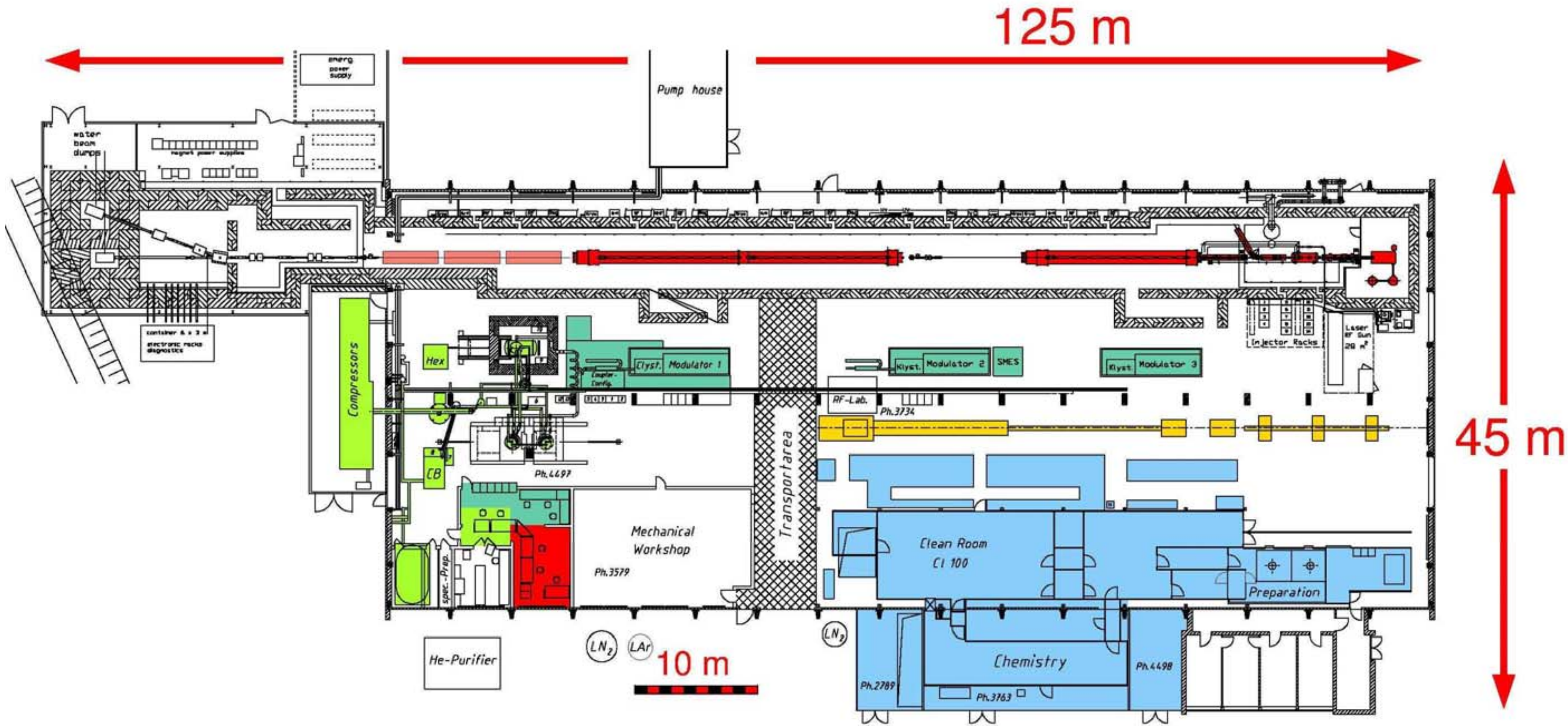
R/Q	1036	Ω
E_{peak}/E_{acc}	2.0	
B_{peak}/E_{acc}	4.26	mT/(MV/m)
$\Delta f/\Delta l$	315	kHz/mm
$K_{Lorentz}$	≈ -1	$Hz/(MV/m)^2$

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

A dedicated new infrastructure at DESY

- Scanning niobium material for inclusion
- Clean closed loop chemistry (Buffer Chemical Polishing – BCP)
- High Pressure Rinsing, HPR, and clean room drying
- Clean Room handling and assembling (Class 10 and 100)



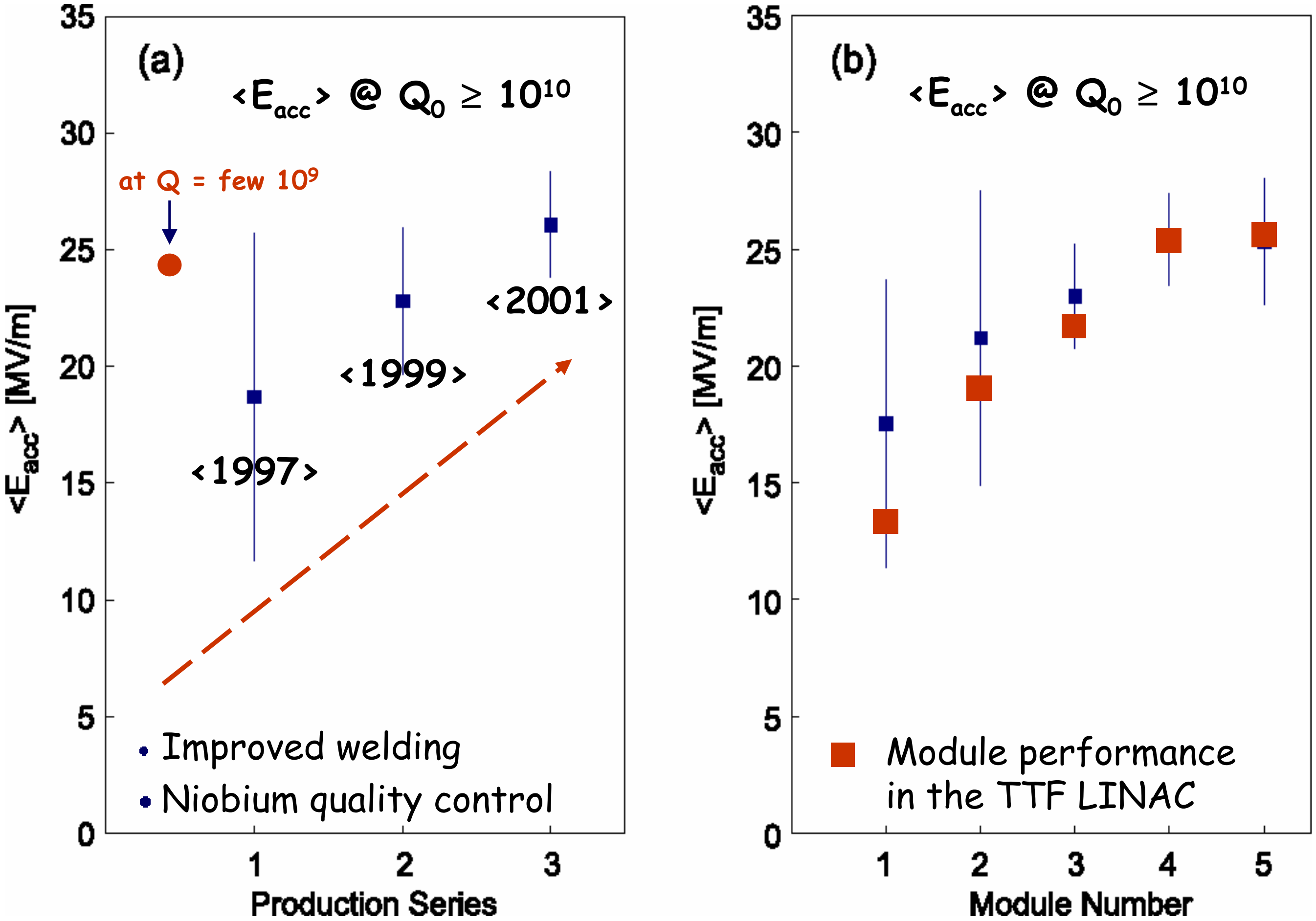
Learning curve with BCP

BCP = Buffered Chemical Polishing

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

Cornell 1995 ●

5-cell



Electro-Polishing & Baking for 35 MV/m

The AC 70 example

EP at the DESY plant

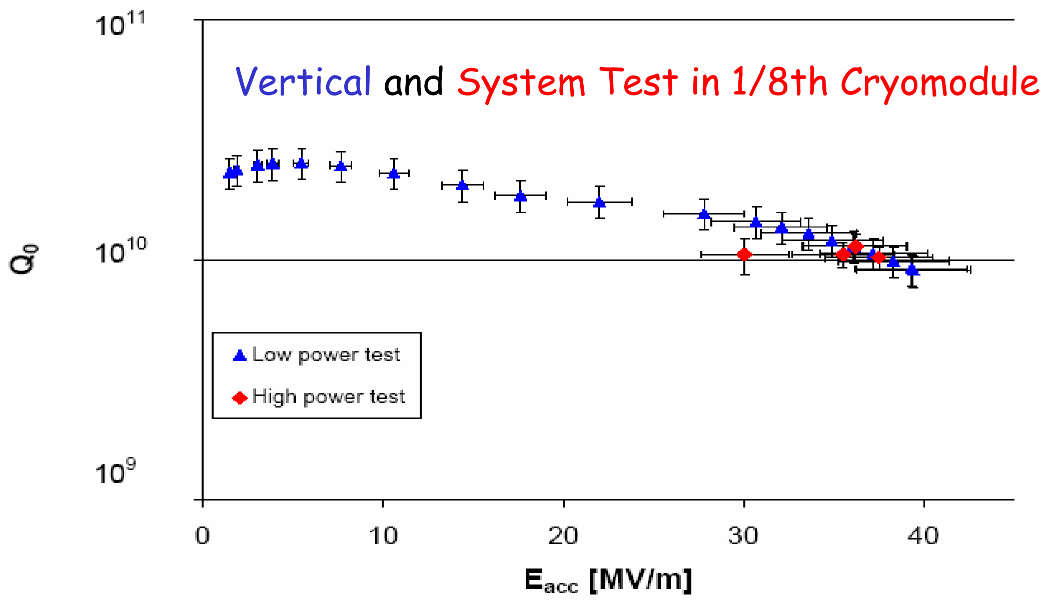
• Low Field Emission

800°C annealing

120°C, 24 h, Baking

• high field Q drop cured

High Pressure Water Rinsing



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

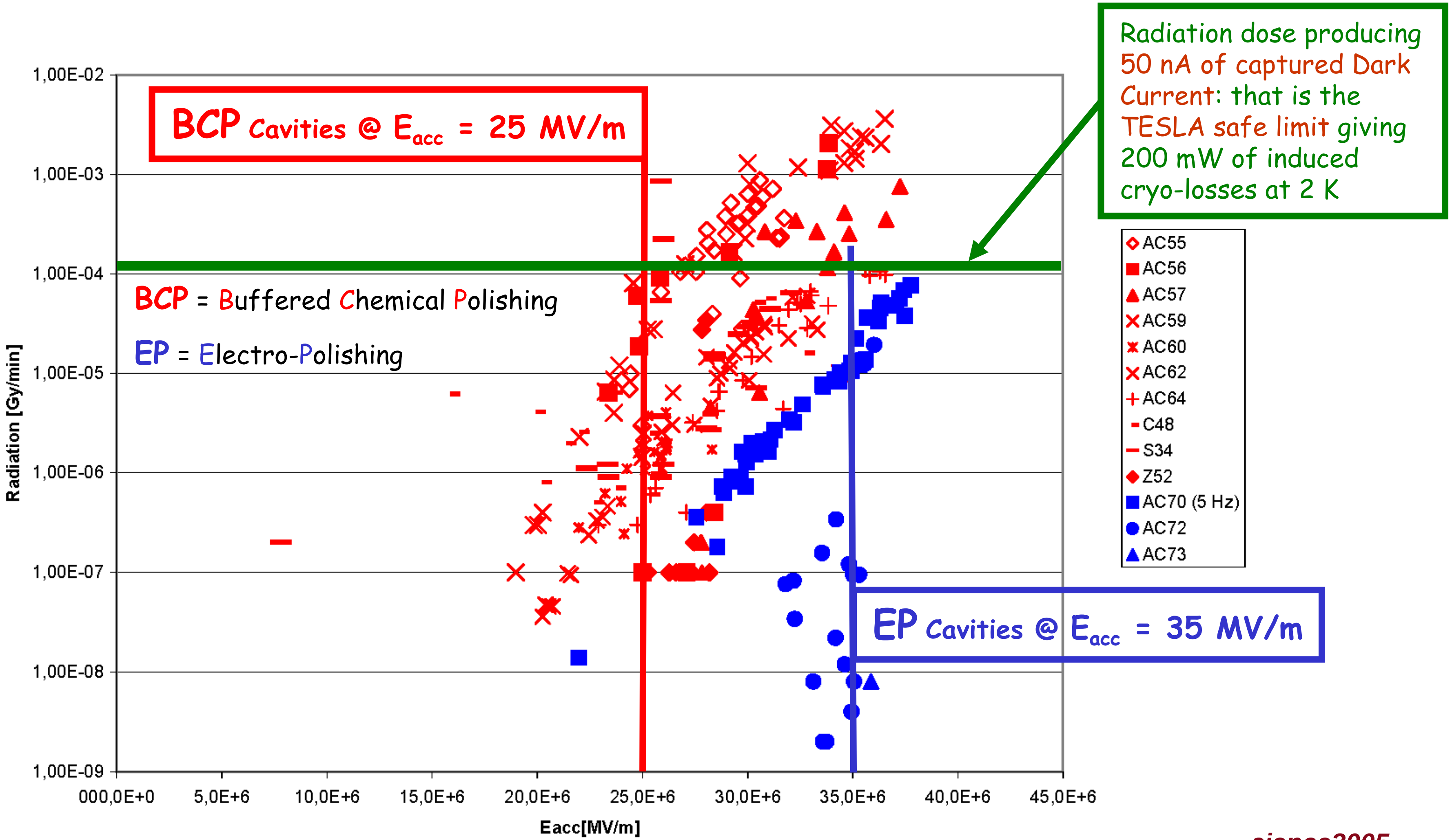
- to re-distribute oxygen at the surface
- cures Q drop at high field

Field Emission pushed to very high field

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

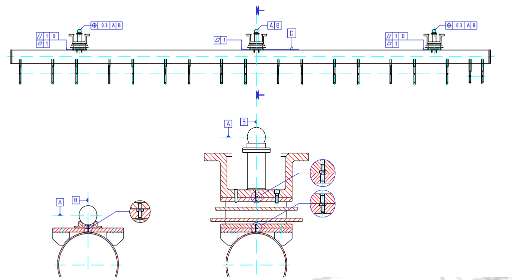


Performing Cryomodules

Three cryomodule generations to:

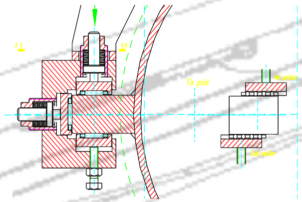
- improve simplicity and performances
- minimize costs

Reliable Alignment Strategy



"Finger Welded" Shields

Sliding Fixtures @ 2 K

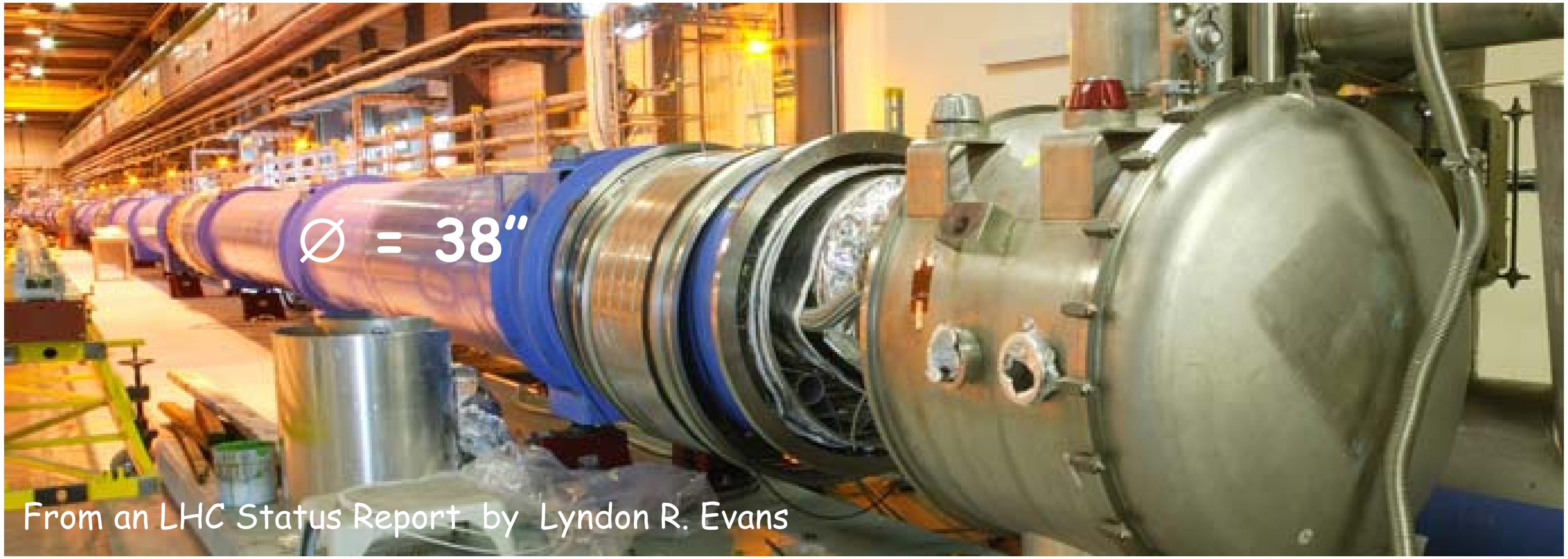


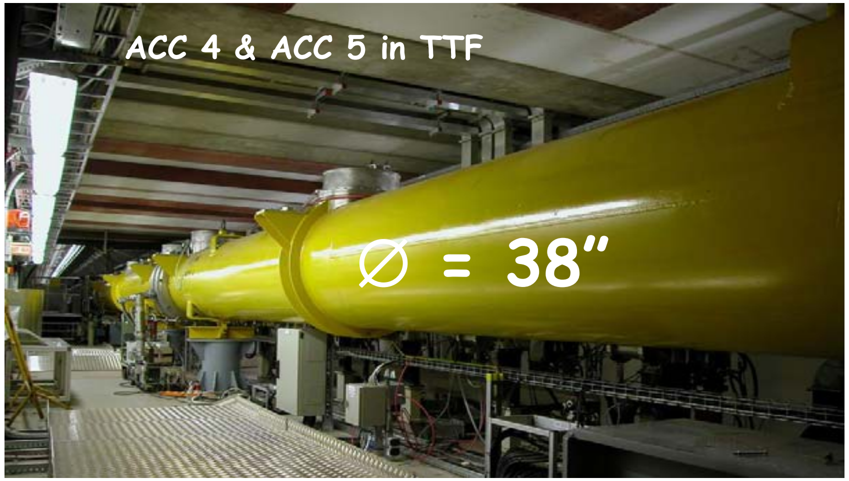
Required plug power for static losses < 5 kW/(12 m module)

TTF Module Installation

	Type	Installation date	Cold time [months]
CryoCap		Oct 96	50
M1	1	Mar 97	5
M1 rep.	2	Jan 98	12
M2	2	Sep 98	44
M3	2	Jun 99	35
M1*	2	Jun 02	25
MSS	2		8
M3*	2	Apr 03	14
M4	3		14
M5	3		14
M2*	2	Feb 04	11

LCH and TESLA/ILC Module Comparison



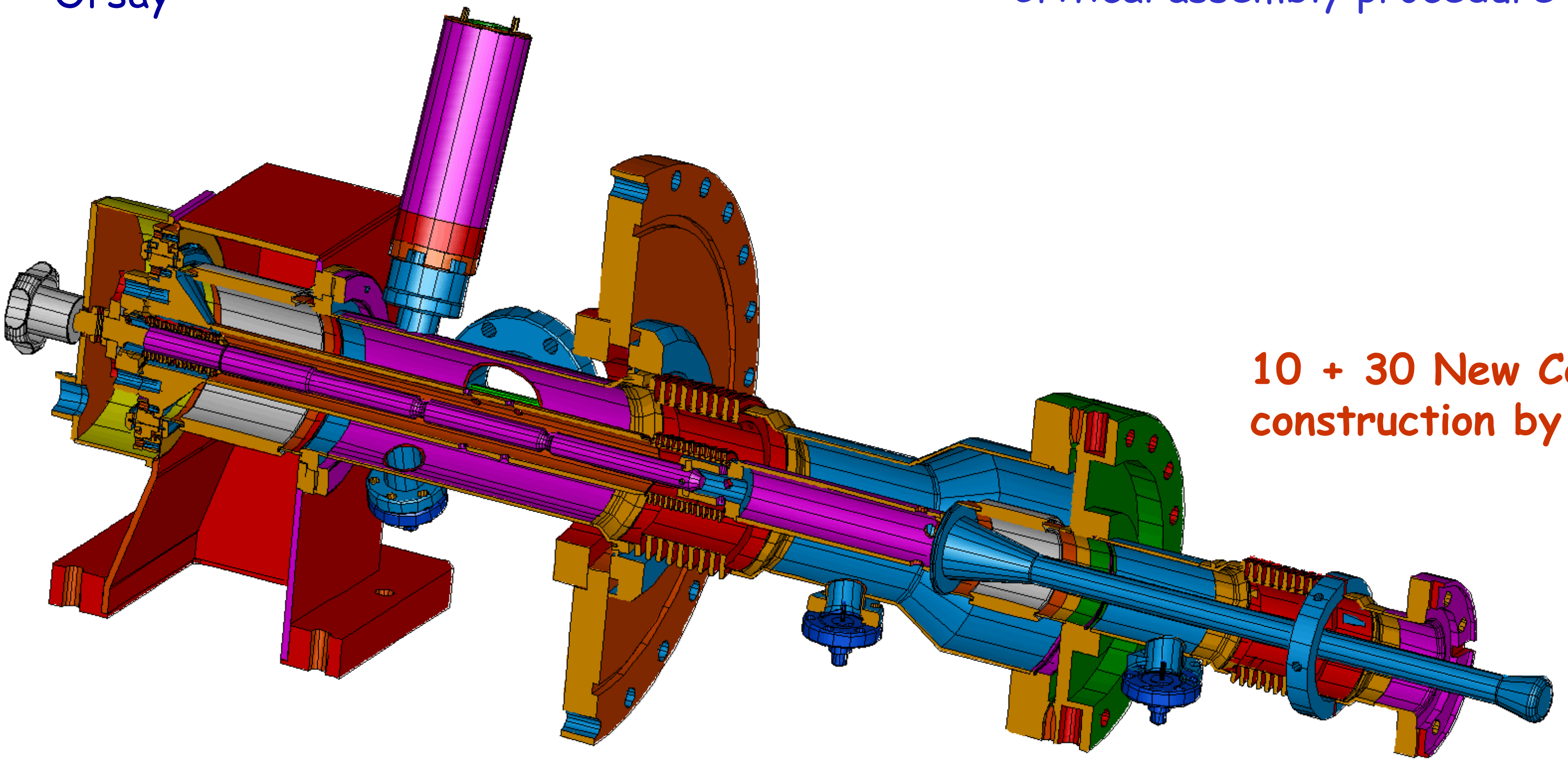


Power Coupler

- TTF III Coupler has a robust and reliable design.
- Extensively power tested with significant margin
- New Coupler Test Stand at LAL, Orsay

Pending Problems

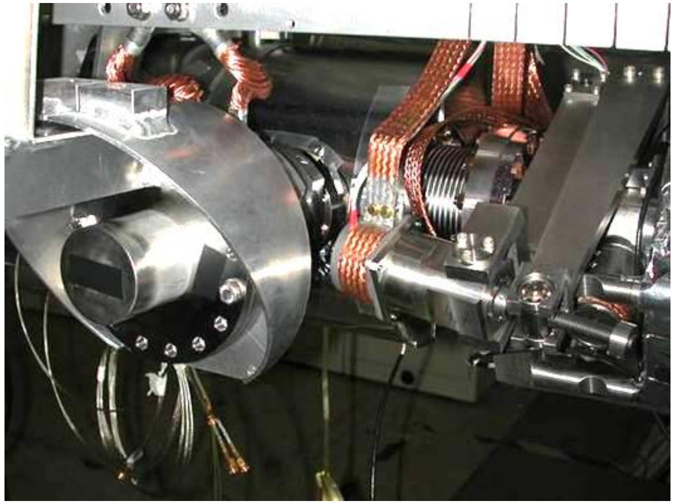
- Long processing time: ~ 100 h
- High cost (cavity/2)
- Critical assembly procedure

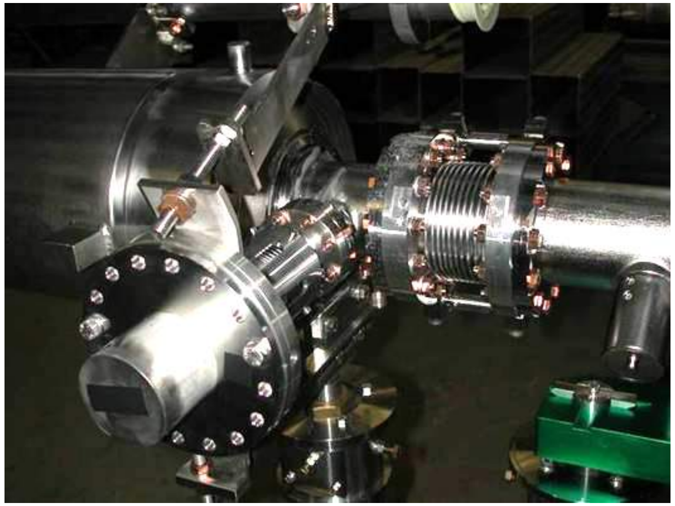


10 + 30 New Couplers in construction by industry

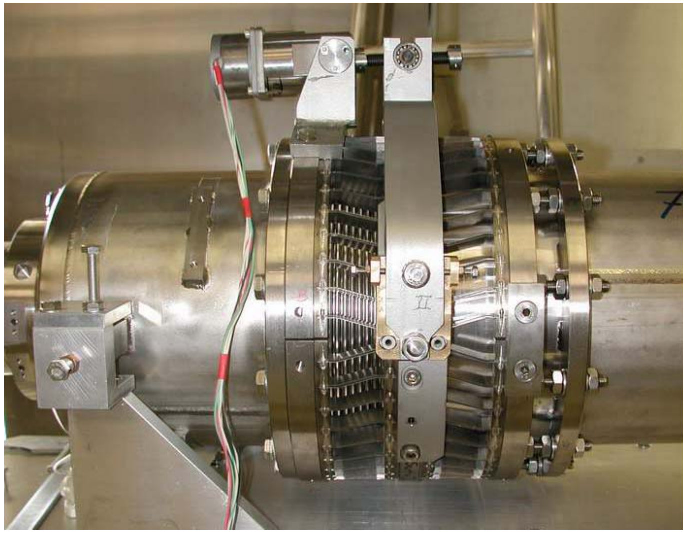
SC Cavity Tuners

TTF Tuner

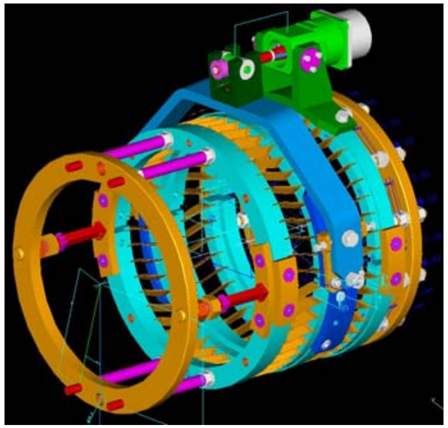




INFN Blade-Tuner for ILC



Successfully operated with superstructures

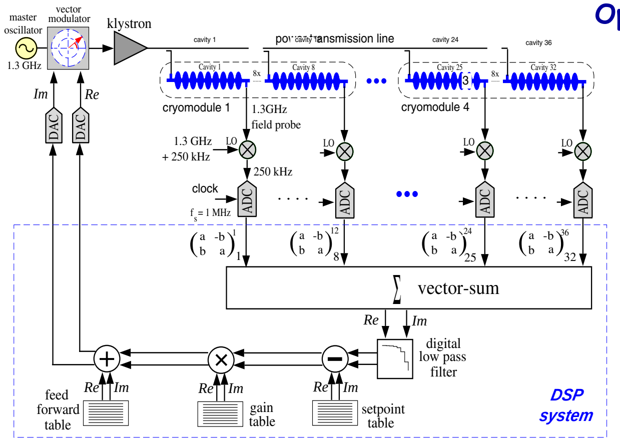


Integration of piezos completed for Lorentz force compensation and microphonics.

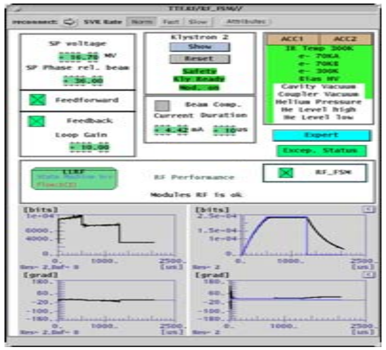
Cold tests by fall 2005 (DESY, BESSY, Cornell)

LLRF performance in TTF

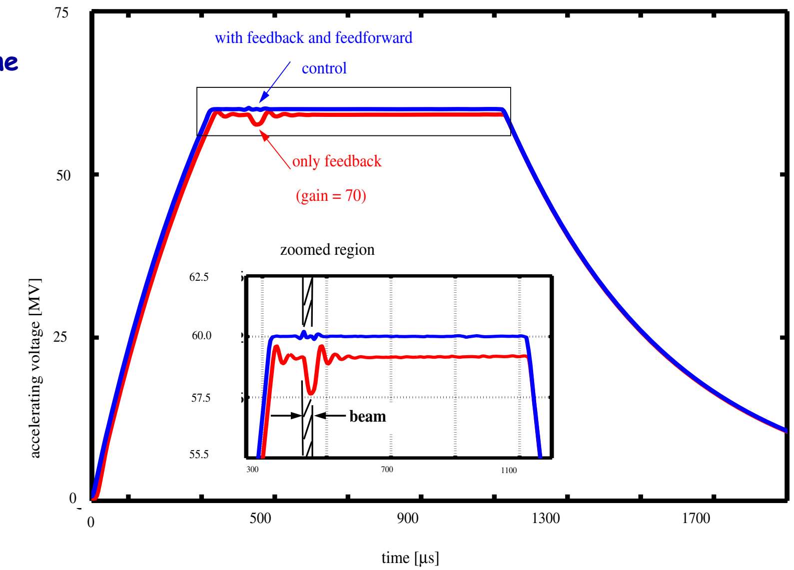
Principle of RF Control



Operation with Final State Machine



from TTF Console in Milano



Contributions to Energy Fluctuations

1. Lorentz Force
2. Microphonics
3. Bunch-to Bunch Charge Fluctuations
4. Calibration error of the vector-sum
5. Phase noise from master oscillator
6. Non-linearity of field detector
7. Klystron Saturation
8. RF curvature (finite bunch length)
9. Wakefield and HOMs

Microphonics

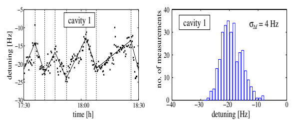


Figure 2: Fluctuations of the cavity resonance frequency. a) Slow drifts over a period of one hour and b) probability density of the cavity resonance frequency with an rms width of 2Hz - 7Hz.

Lorentz Force Detuning

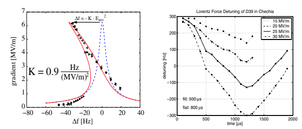
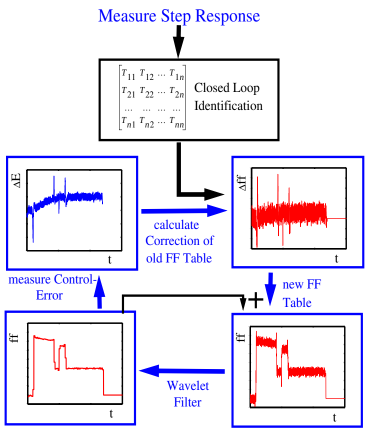


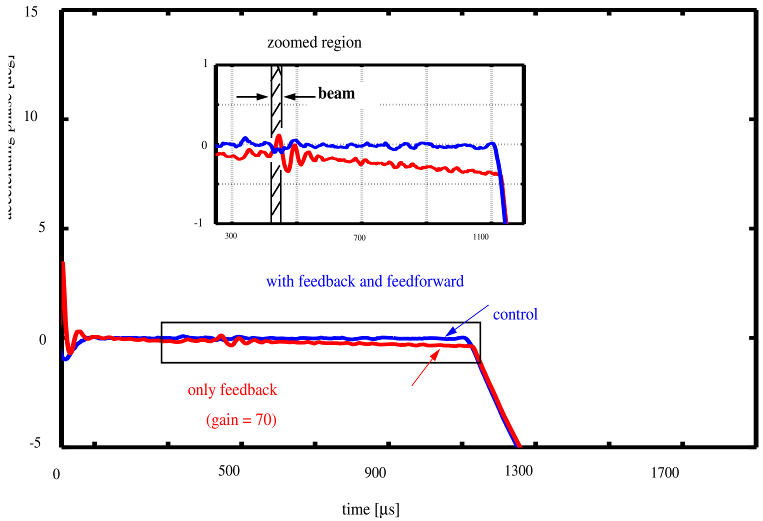
Figure 3: Influence of radiation pressure on the resonance curve of a sc cavity. a) Static detuning during cw operation and b) dynamical detuning during nominal TESLA pulse.

Adaptive Feedforward



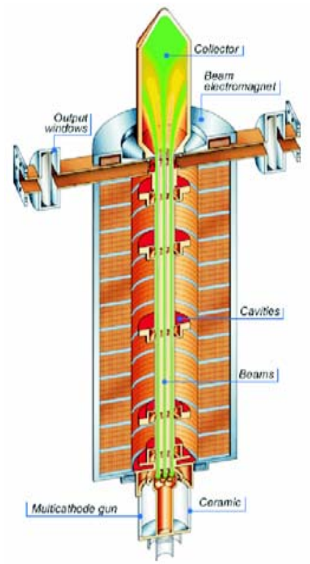
Adaptive Feed Forward can handle nonlinear systems through linarisation around the operating point.

The calculation of a new feed forward table needs only a few seconds.



Multi Beam Klystrons

Three **Thales** TH1801 Multi Beam Klystrons produced and tested



Achieved efficiency	65%
RF pulse width	1.5 ms
Repetition rate	5 Hz
Operation experience	> 5000 h

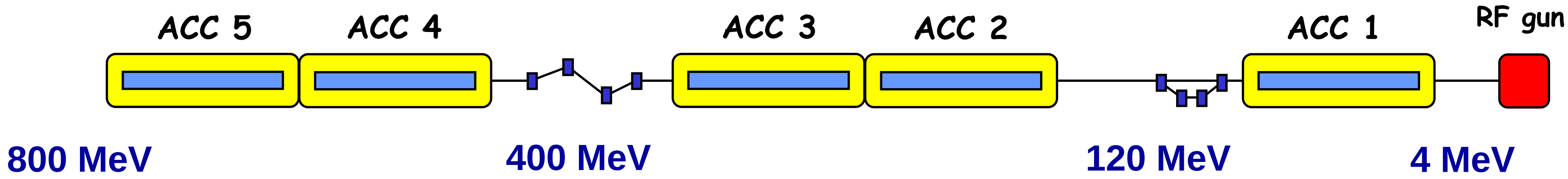
10% of operation time at full spec's

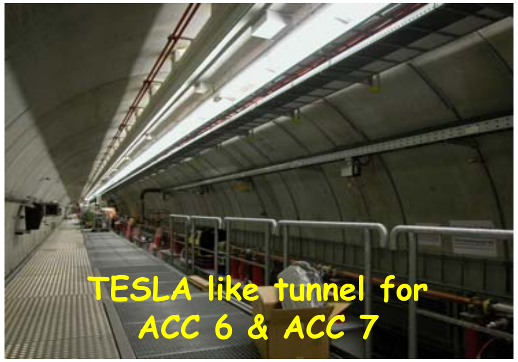
Indipendent beam design proposed and built by **CPI**. Prototype on test.

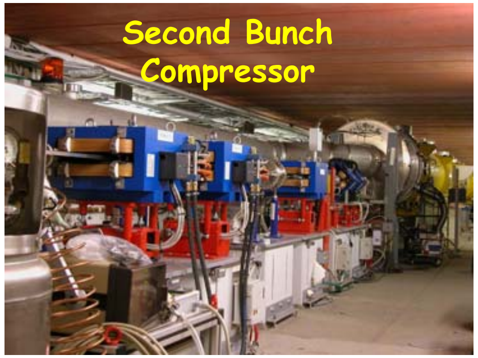
A new design proposed by Toshiba looks robust and should reach 75% efficiency

First prototype successfully test - Cathode loading < 2.1 A/cm^2

TTF II and the VUV FEL facility





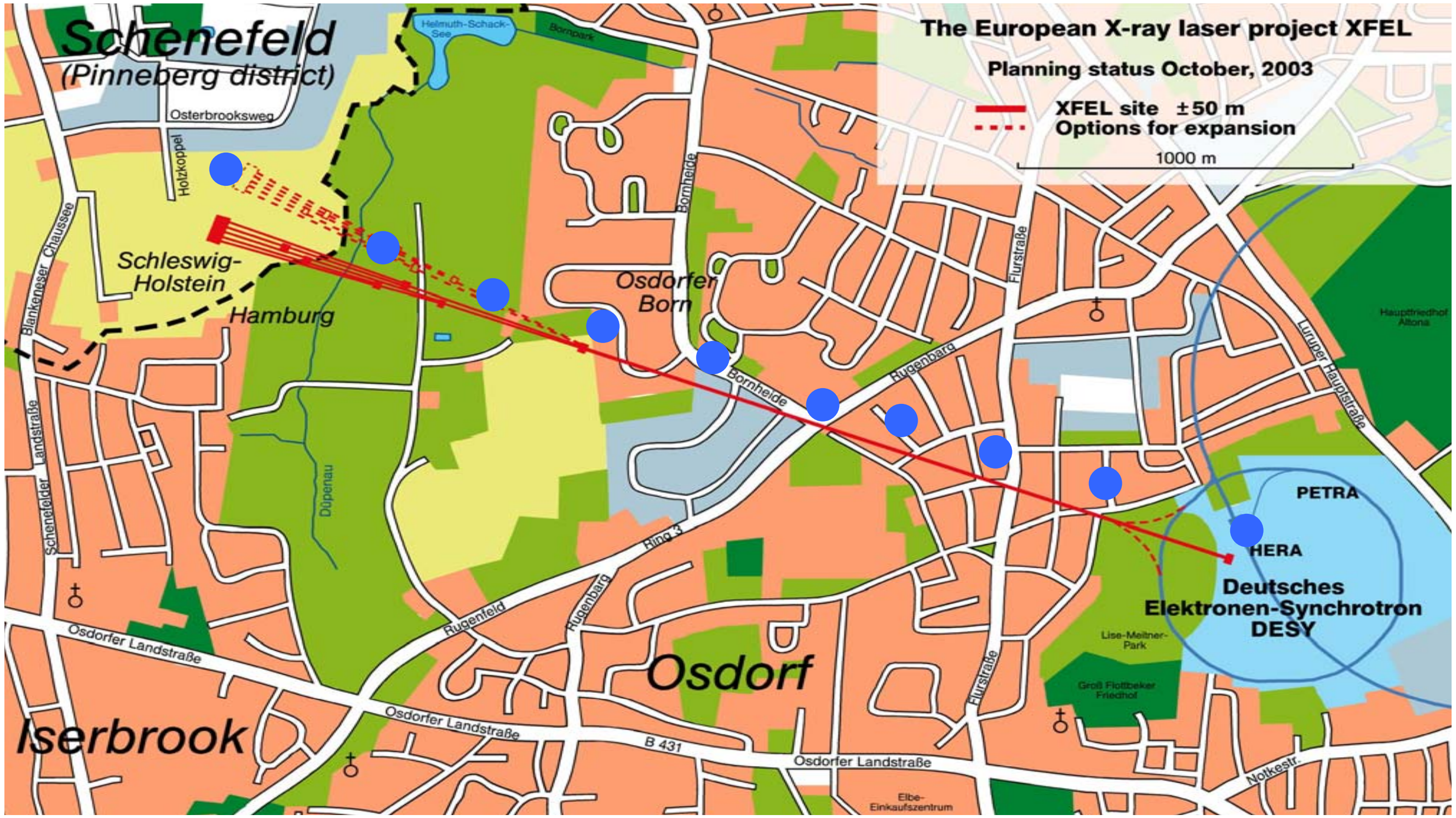


VUV FEL User Facility

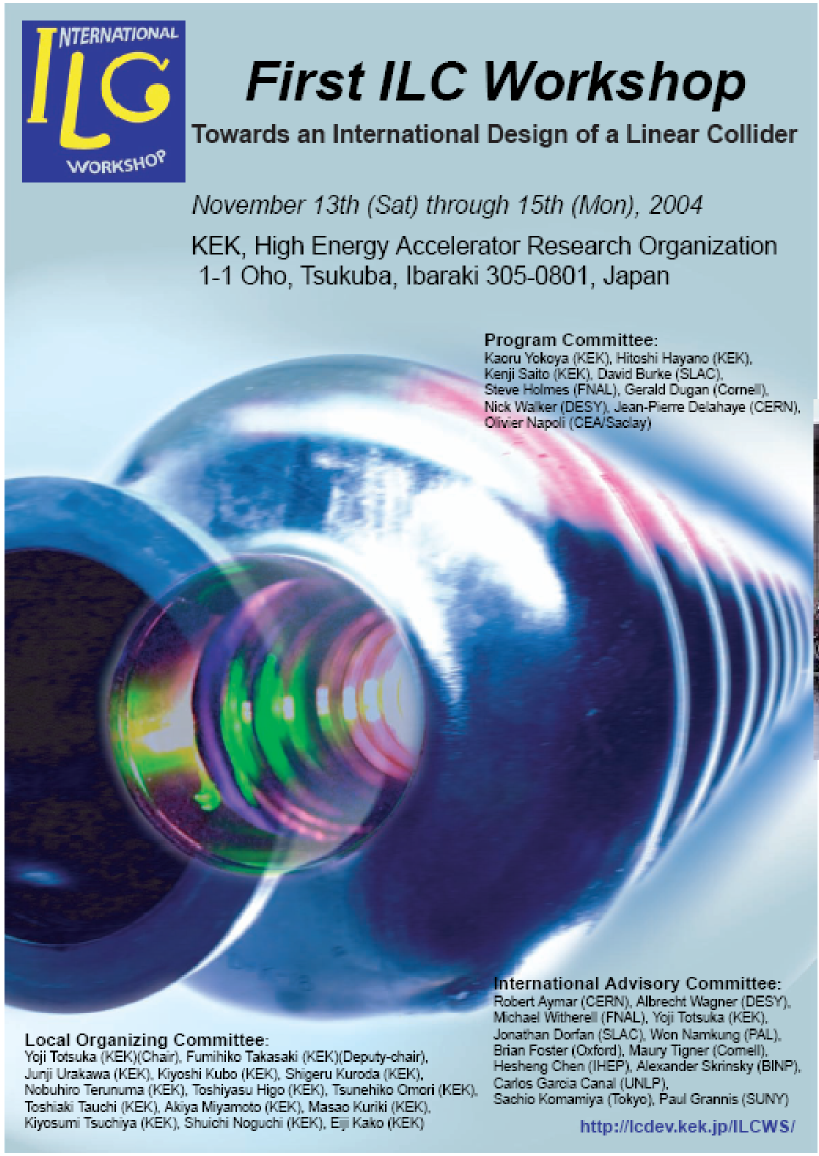
- Linac Commissioning completed
- SASE FEL Commisssioning under way

X-FEL coming soon

- 50% funded by the German Government - European consensus being established
- **Great opportunity for ILC**
  - Machine reliability according to SRL standards
  - Industrial mass production of cavities (~ 1000) and modules (> 120)



Start of the Global Design Initiative



~ 220 participants from 3 regions

most of them accelerator experts

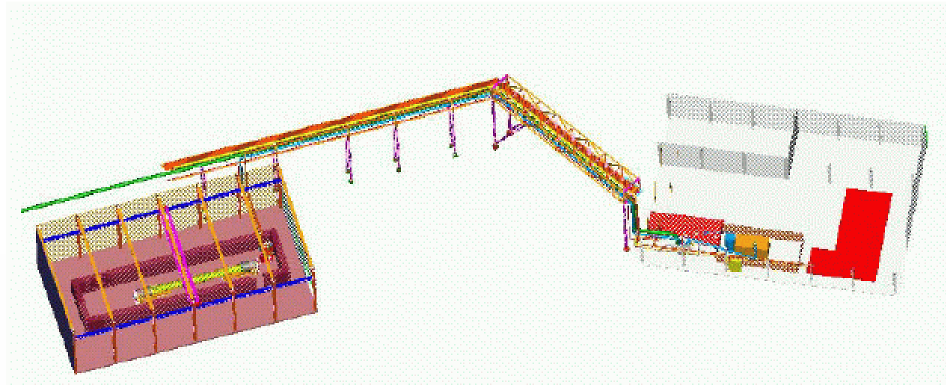
Global SCRF Test Facilities for ILC

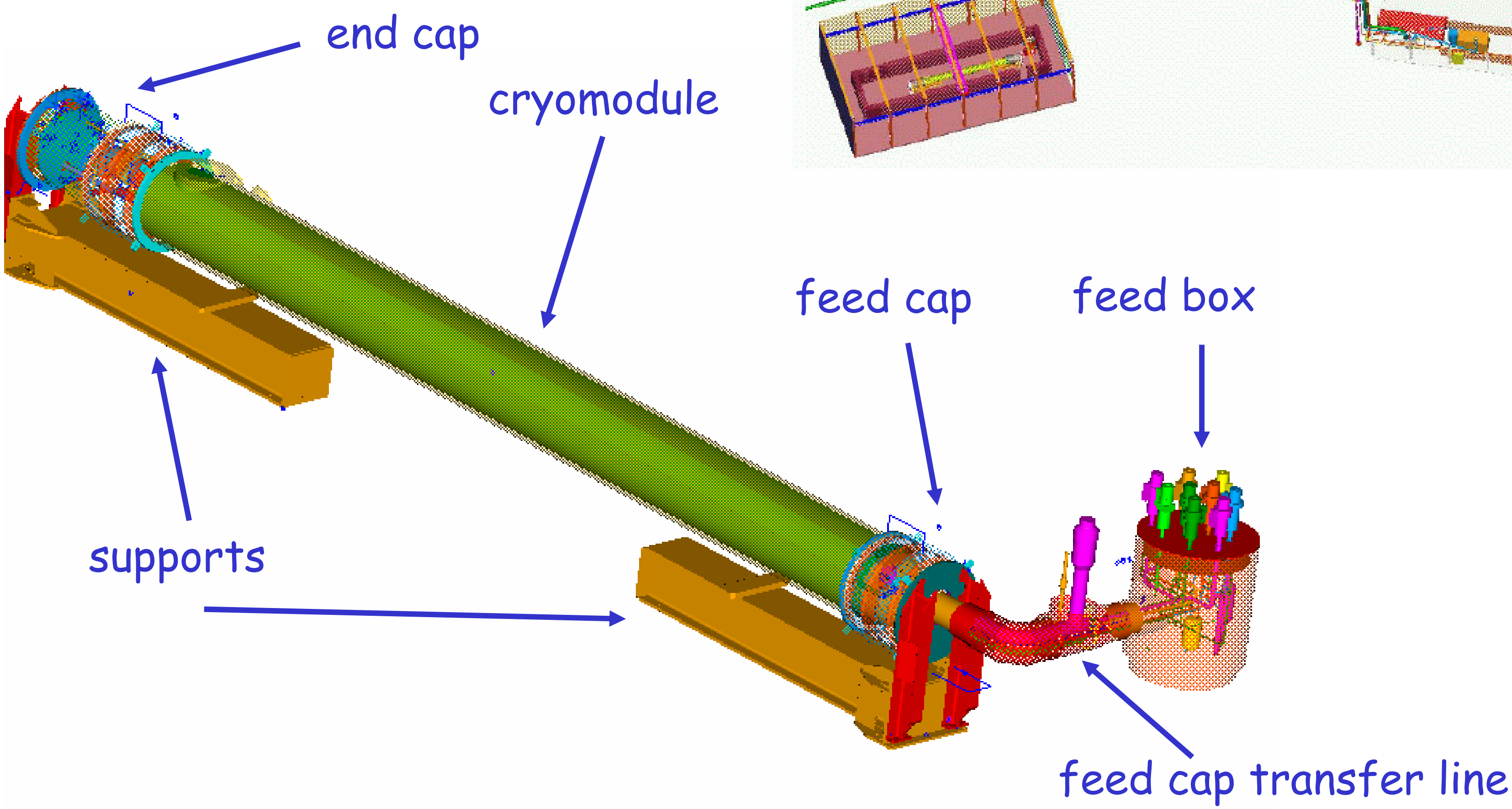
- **TESLA Test Facility (TTF II) @ DESY**
  TTF II is currently unique in the world
  VUV-FEL user facility
  test-bed for both XFEL & ILC
  Cryomodule Test Stand under construction
- **SMTF @ FNAL**
  Cornell, JLab, ANL, FNAL, LBNL, LANL, MIT, MSU, SNS, UPenn, NIU, BNL, SLAC
  TF for ILC, Proton Driver,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

Cryomodule Test Stand @ DESY

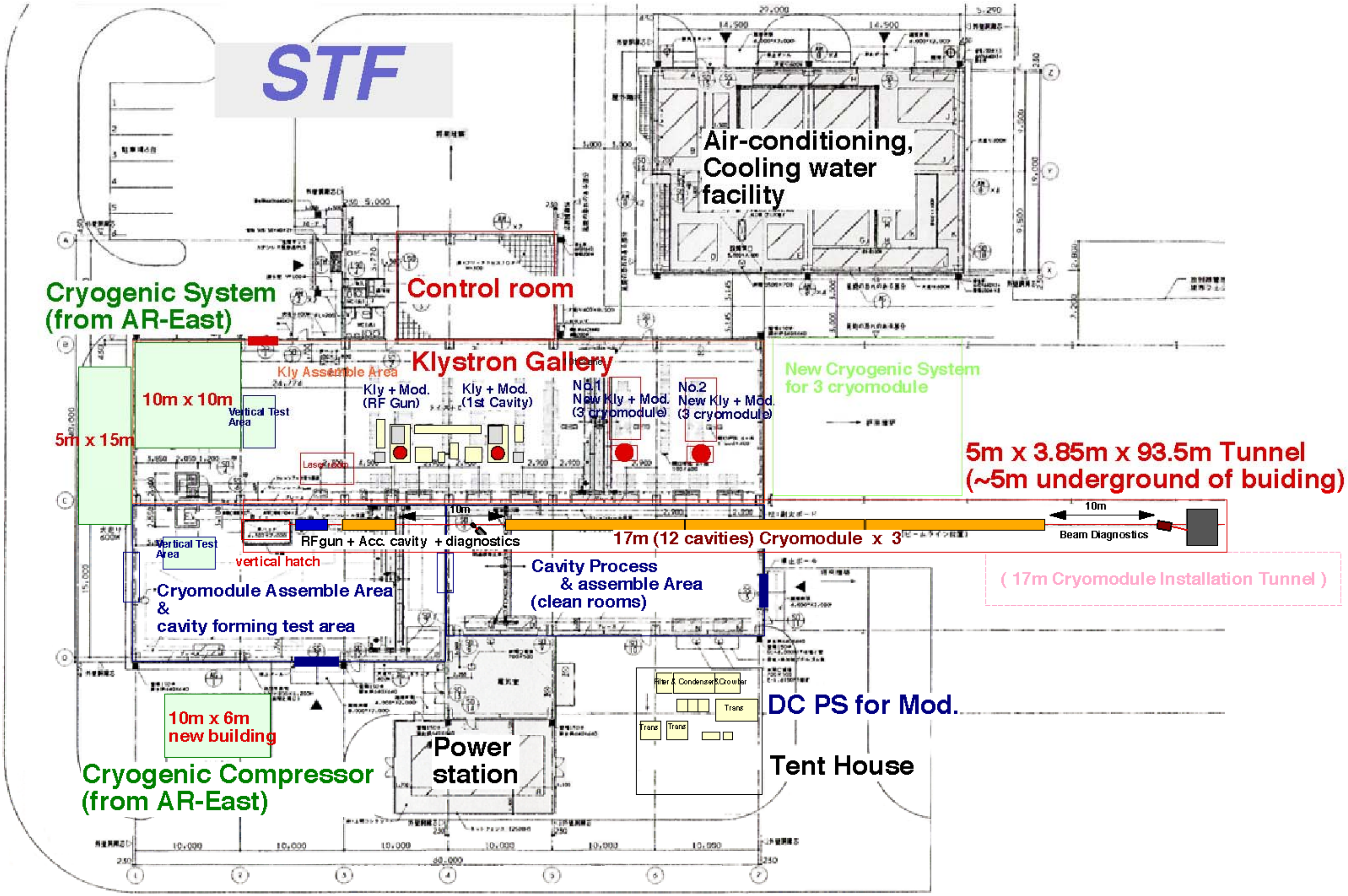
Under construction at DESY

Commissioning 2005/06





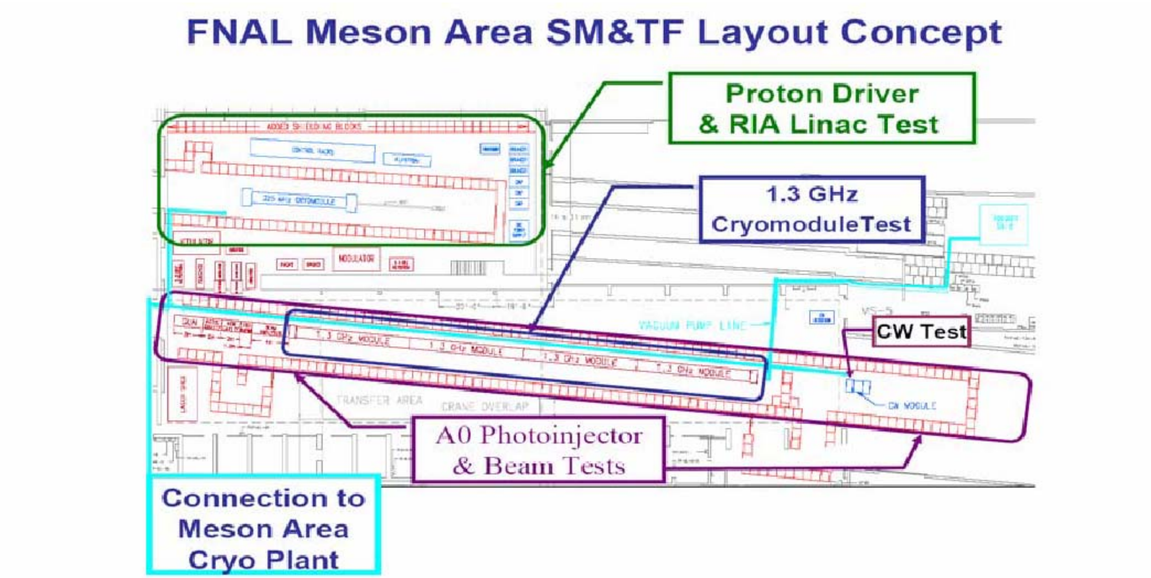
STF @ KEK

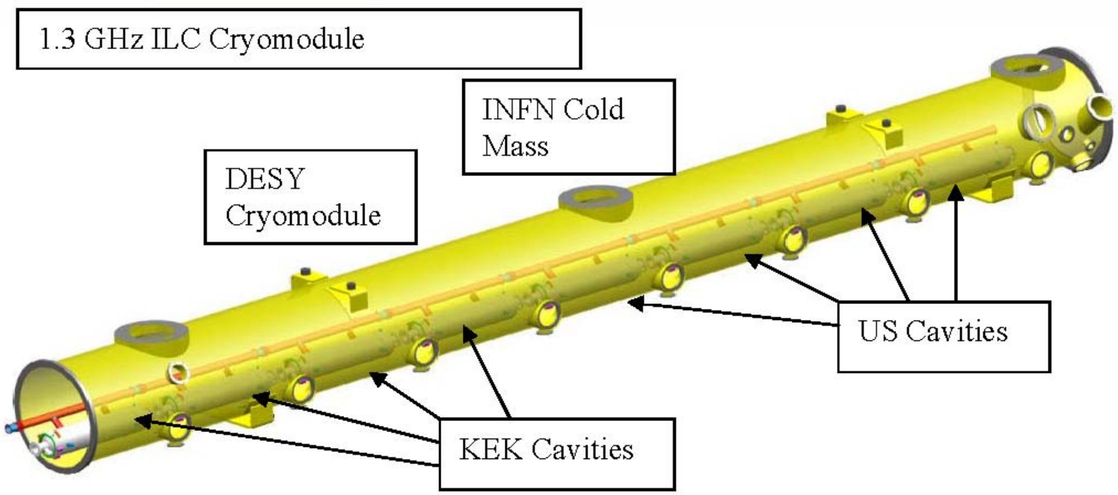


Plan of Superconducting Cavity Test Facility (STF)

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

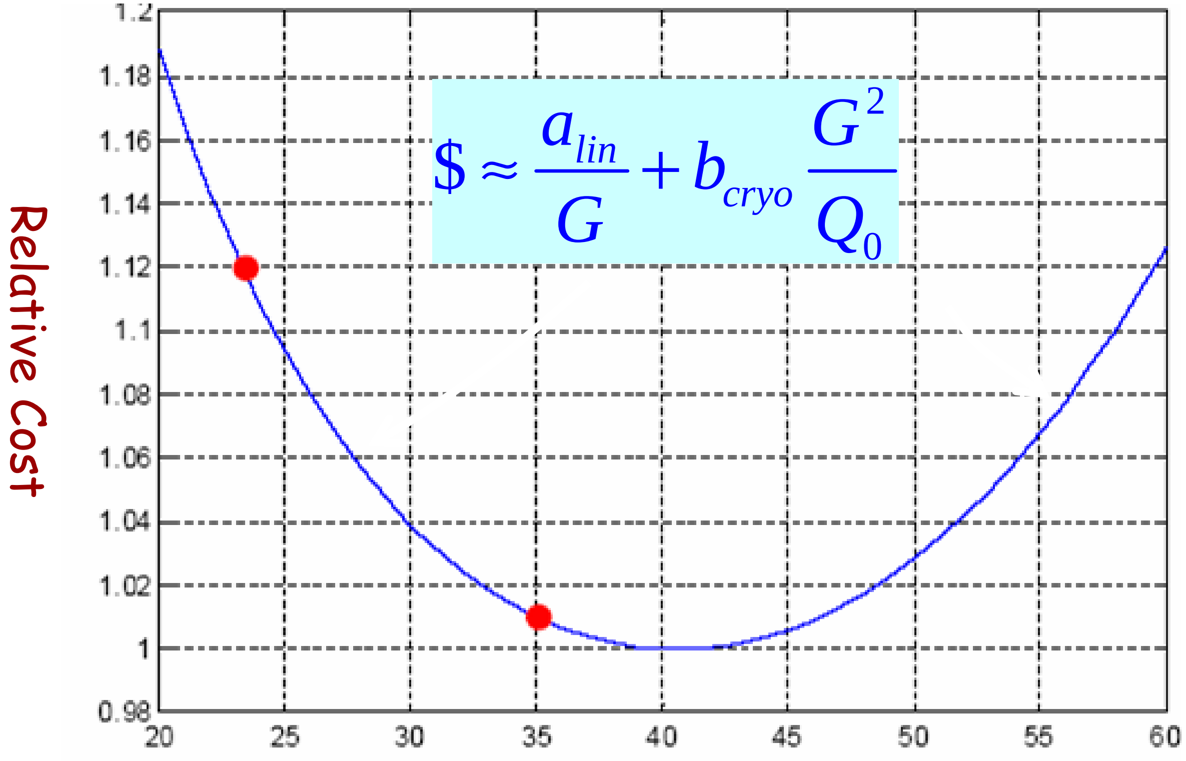
International Linear Collider
Proton Driver
RIA
4th Generation Light Sources
Electron coolers
lepton-heavy ion collider
and other accelerator
projects of interest to U.S
and the world physics
community."

Main Linac: The Cost Driver

- Main Linacs are the biggest single cost item
- 10 years of R&D by the TESLA collaboration has produced a mature technology
  - But we're not quite there yet…
- Primary focus of future R&D *should* be
  - successful tech. transfer to industry
  - cost reduction through industrialisation
  - need extensive effort to achieve high reliability !!!
- XFEL project is already doing much of this within Europe
- Within 'brave new ILC world', there is still room for discussion
  - One important question:
    "What should the design gradient be?"

About the Gradient for ILC

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



C. Adolphsen (SLAC)

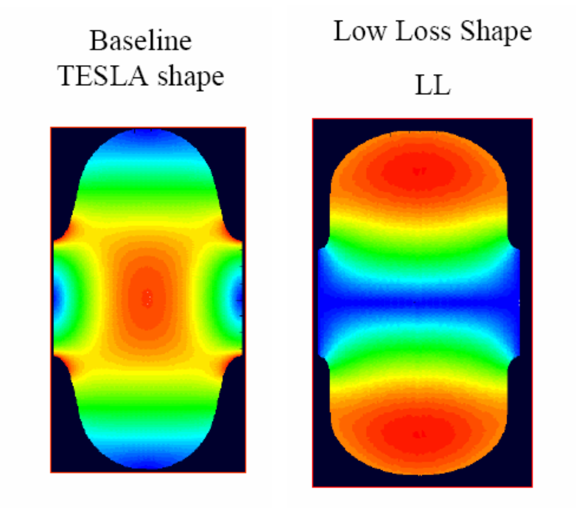
Gradient MV/m

Japanese are pushing for 40-45MV/m

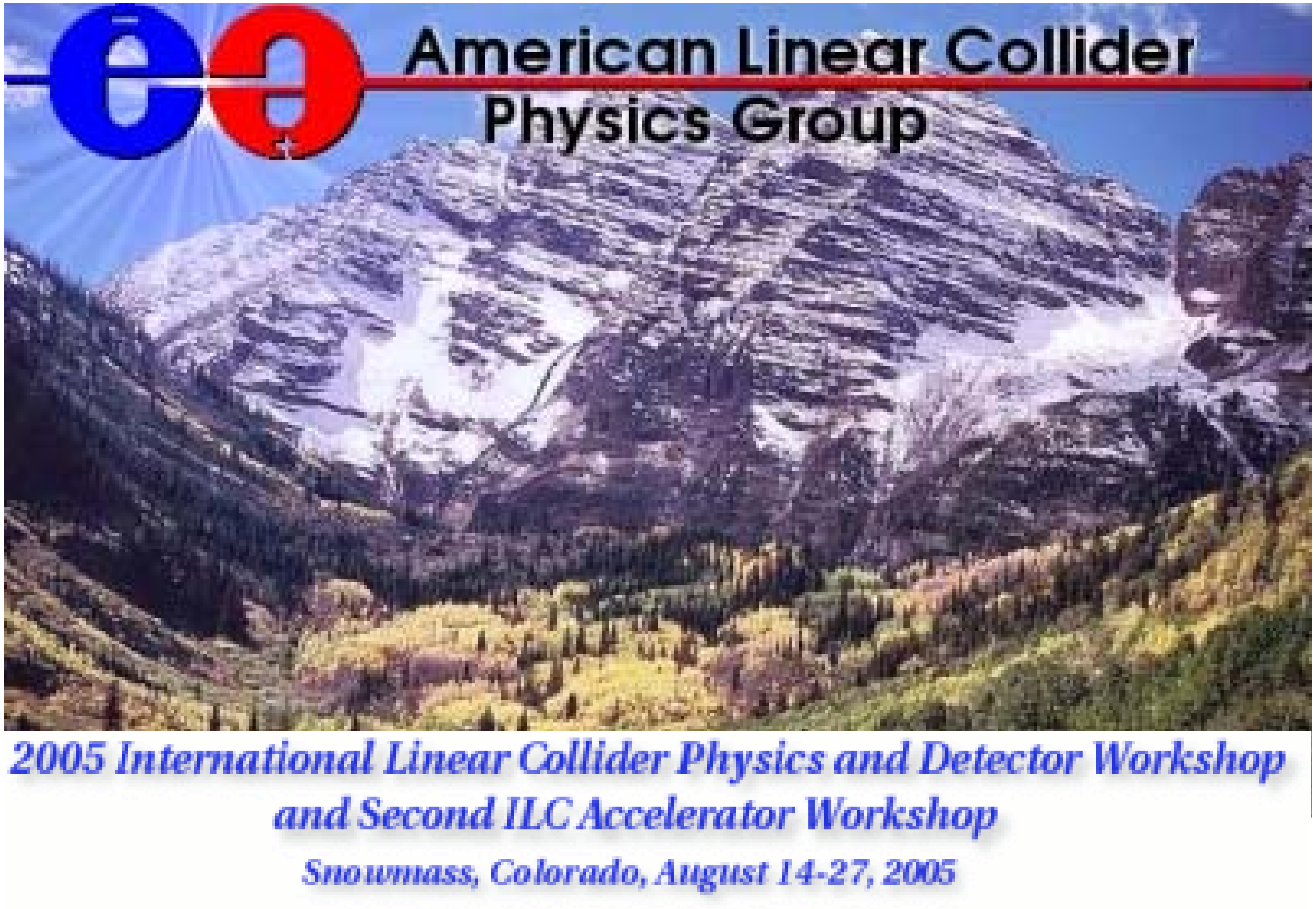
"ICHIRO" cavity

Larger magnetic volume

Lower peak magnetic field



The 2nd ILC Workshop



Goals of the 2nd Workshop

- Continue process of making a recommendation on a

  Baseline Configuration

- Identify longer-term

  Alternative Configurations

- Identify necessary R&D
  - For baseline
  - For alternatives

- Priorities for detector R&D

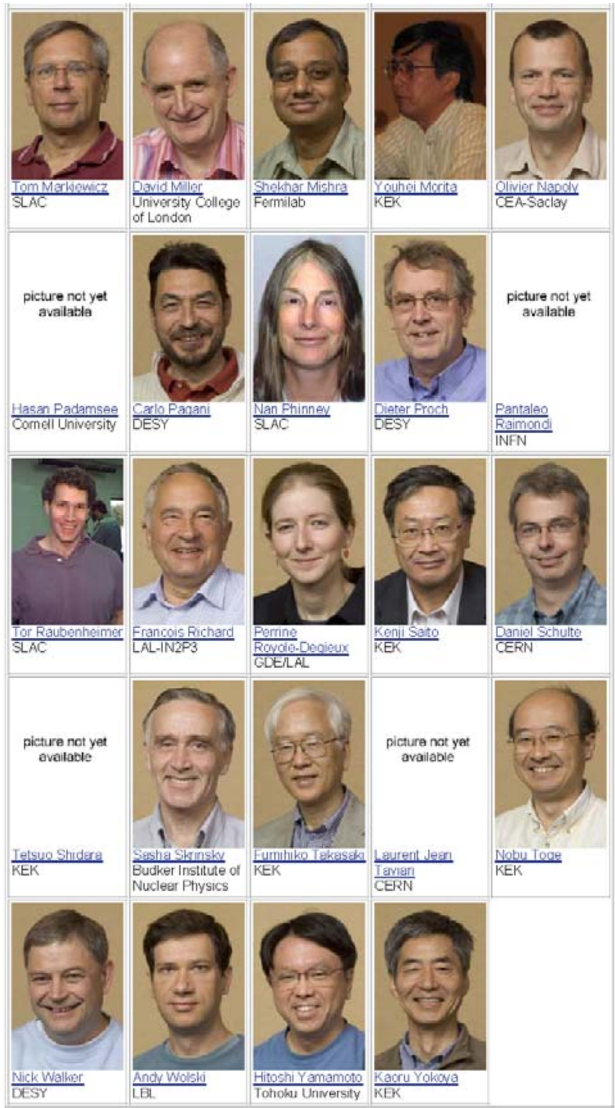
This workshop has been a major step towards these milestones

The Global Design Effort, GDE

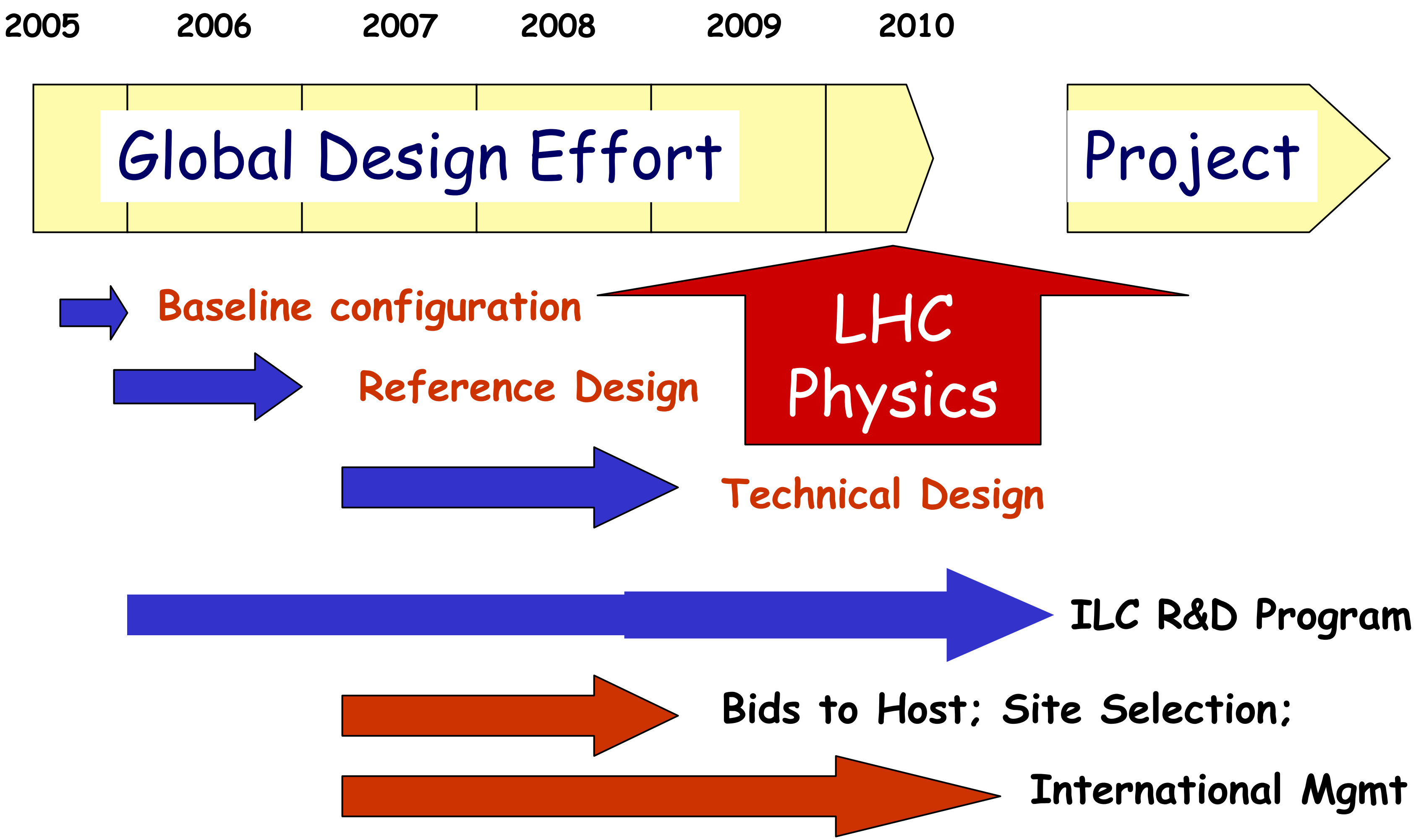
The Mission of the GDE

- 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.)

The GDE Members



The GDE Plan and Schedule



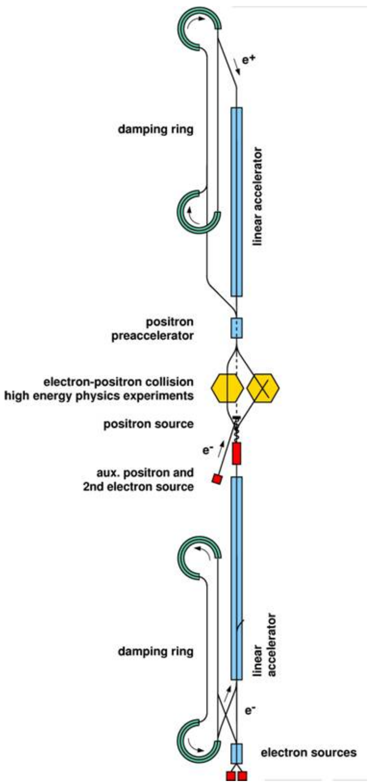
Baseline/Alternative: some definitions

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

ILC Possible Variants

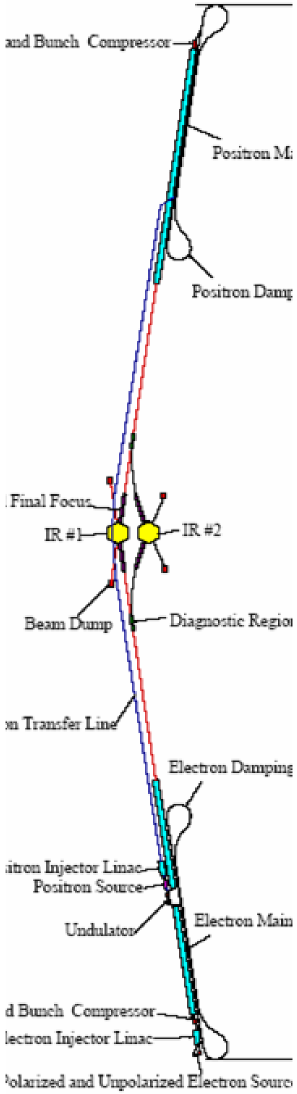


33km

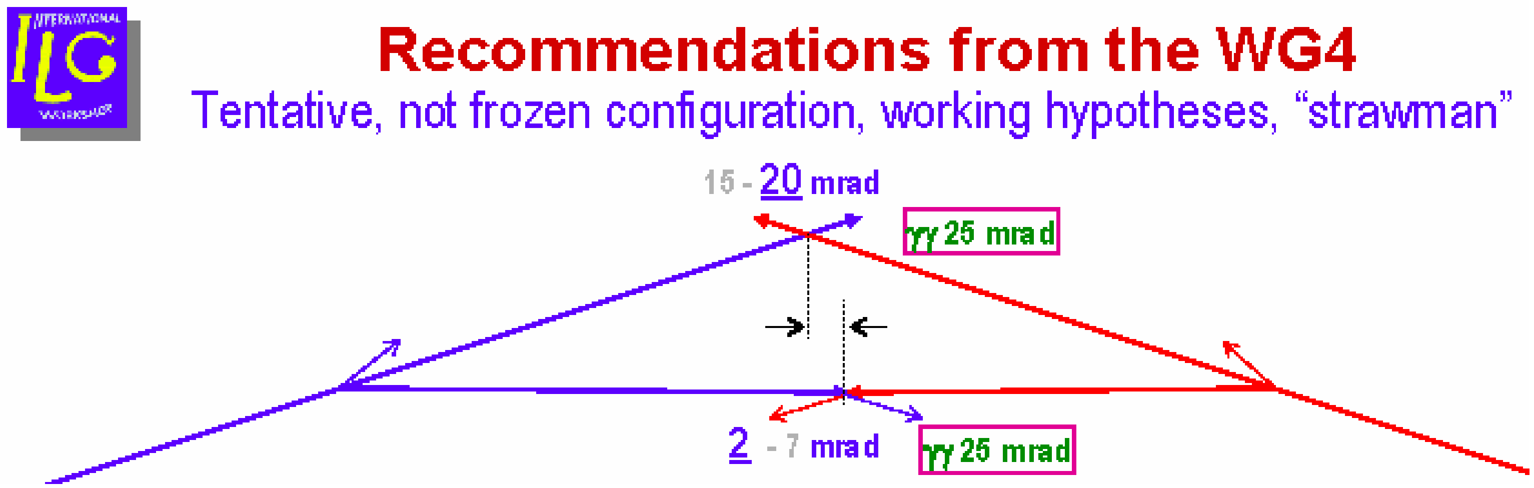
TESLA TDR (2001)
500 GeV (800 GeV)

US Options Study (2003)
500 GeV (1.3 TeV)

47 km



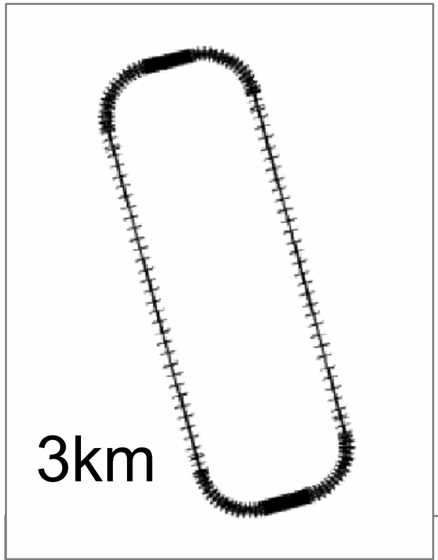
BDS Strawman Model

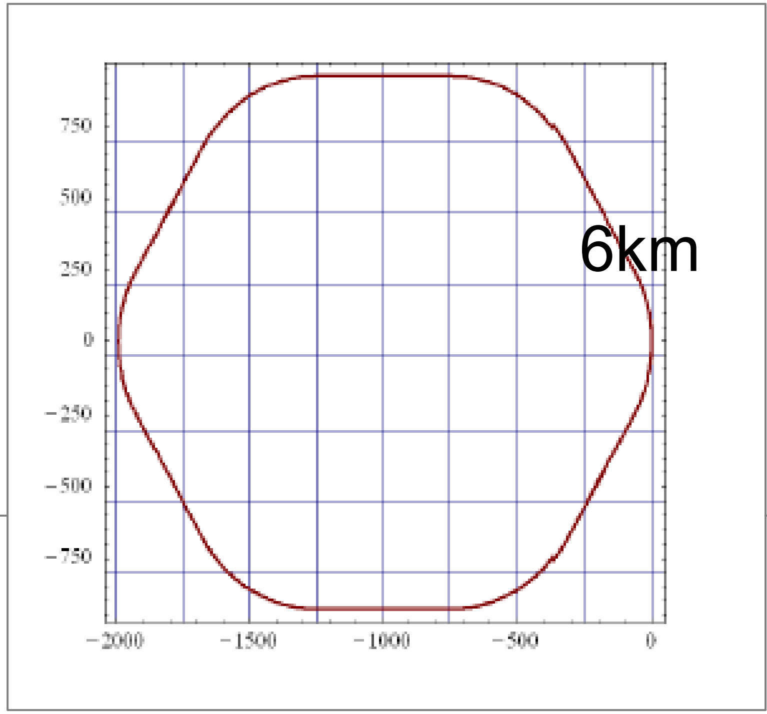


Discussion on angles between the Linacs was again hot:

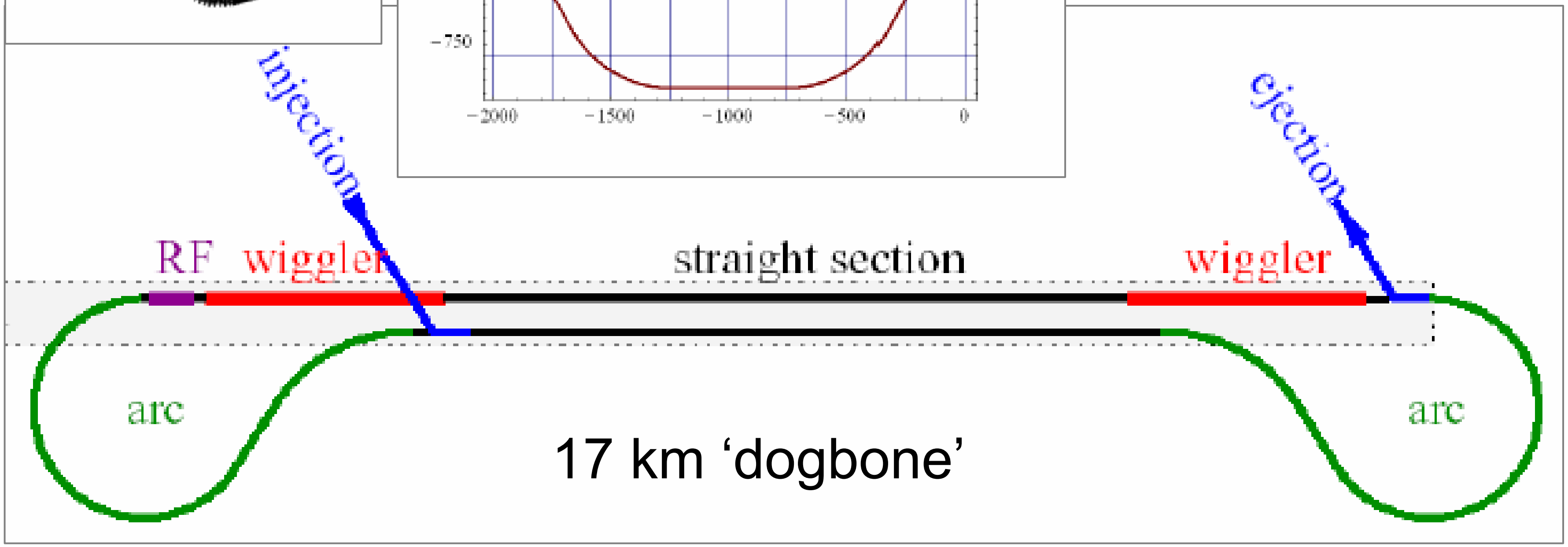
- Multi-TeV upgradeability argument is favoured by many
- Small crossing angle is disfavoured by some

Damping Rings: Three variants





- Need to compress 300 km (~1ms) bunch train into ring
- Compression ratio (i.e. ring circumference) depends on **speed of injection/extraction kicker**.



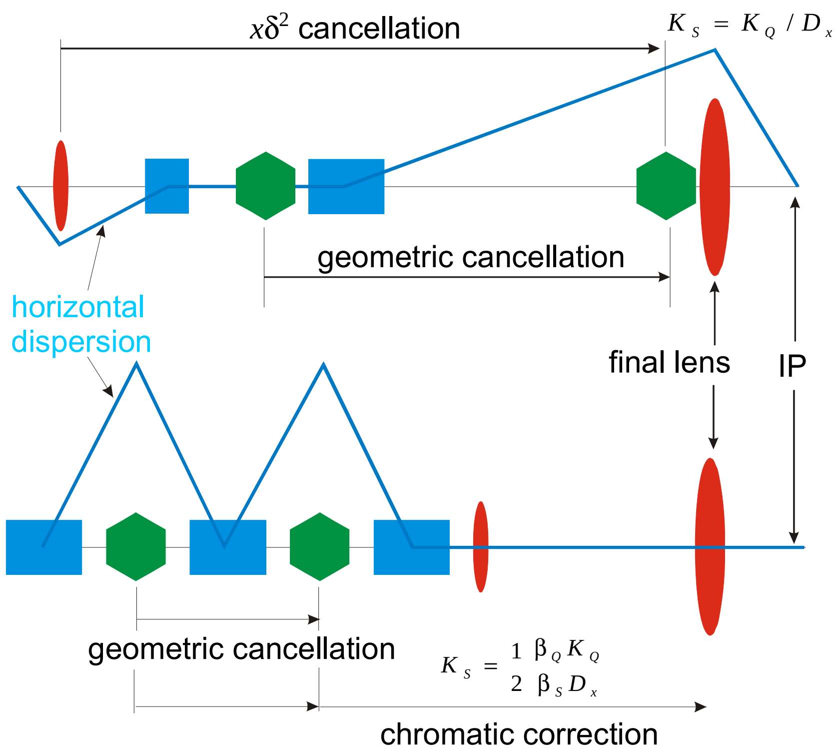
Beam Delivery System Functionality

- Focus and collide *nanobeams* at the interaction point (IP)
- Remove (collimate) the beam halo to reduce detector background
- Provide beam diagnostics for the upstream machine (linac)

Each one of these is a challenge!

Focusing and Colliding Nanobeams

- Correction of chromatic and geometric aberrations becomes principle design challenge
- A consequence: systems have extremely tight alignment (*vibration*) tolerances: stabilisation techniques a must!



Local correction
with D' at IP
[*Raimondi*, 2000]

Non-local correction
(CCS)
[*Brown*, 1985]

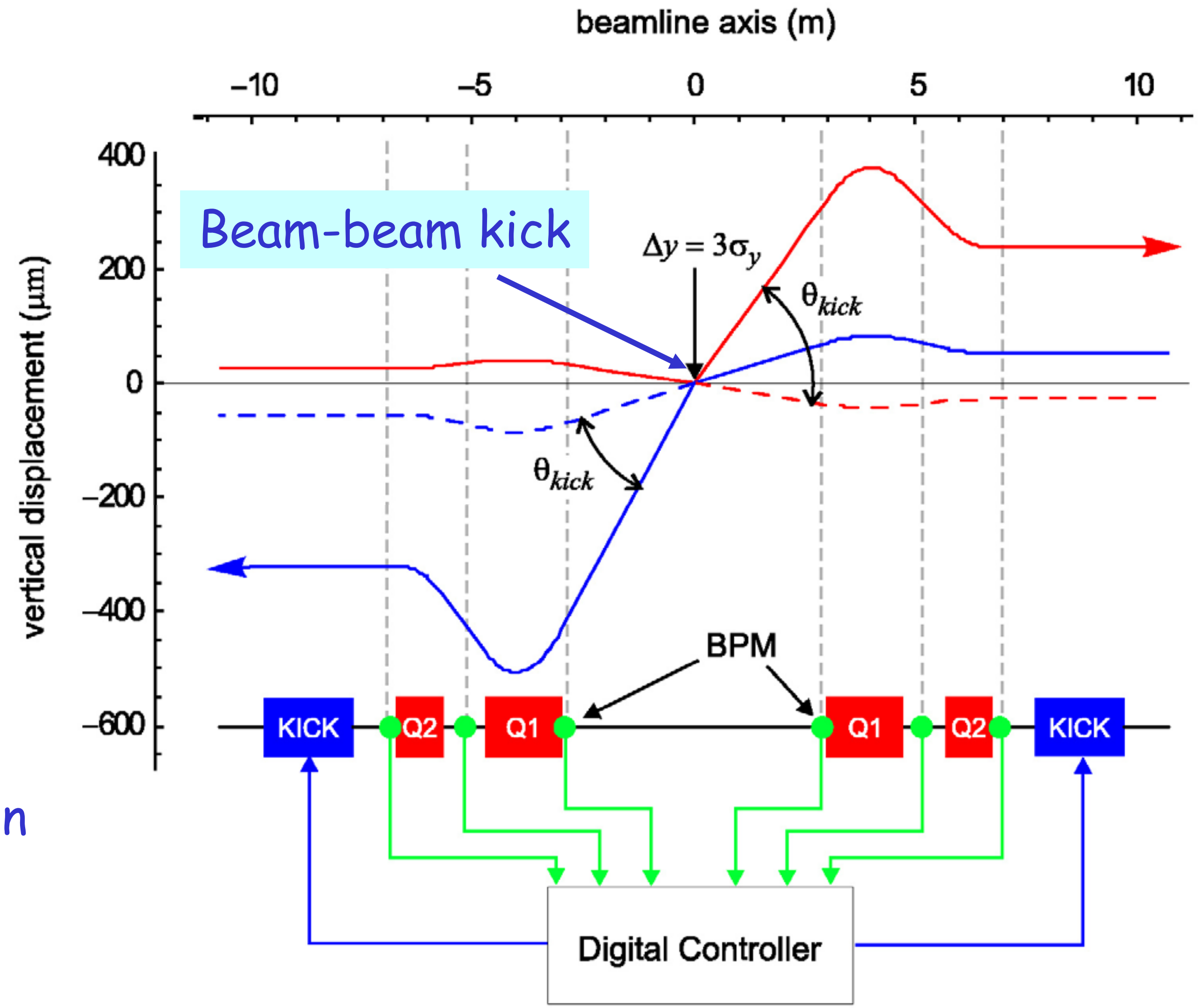
IP Fast (Orbit) Feedback

Long bunch train:

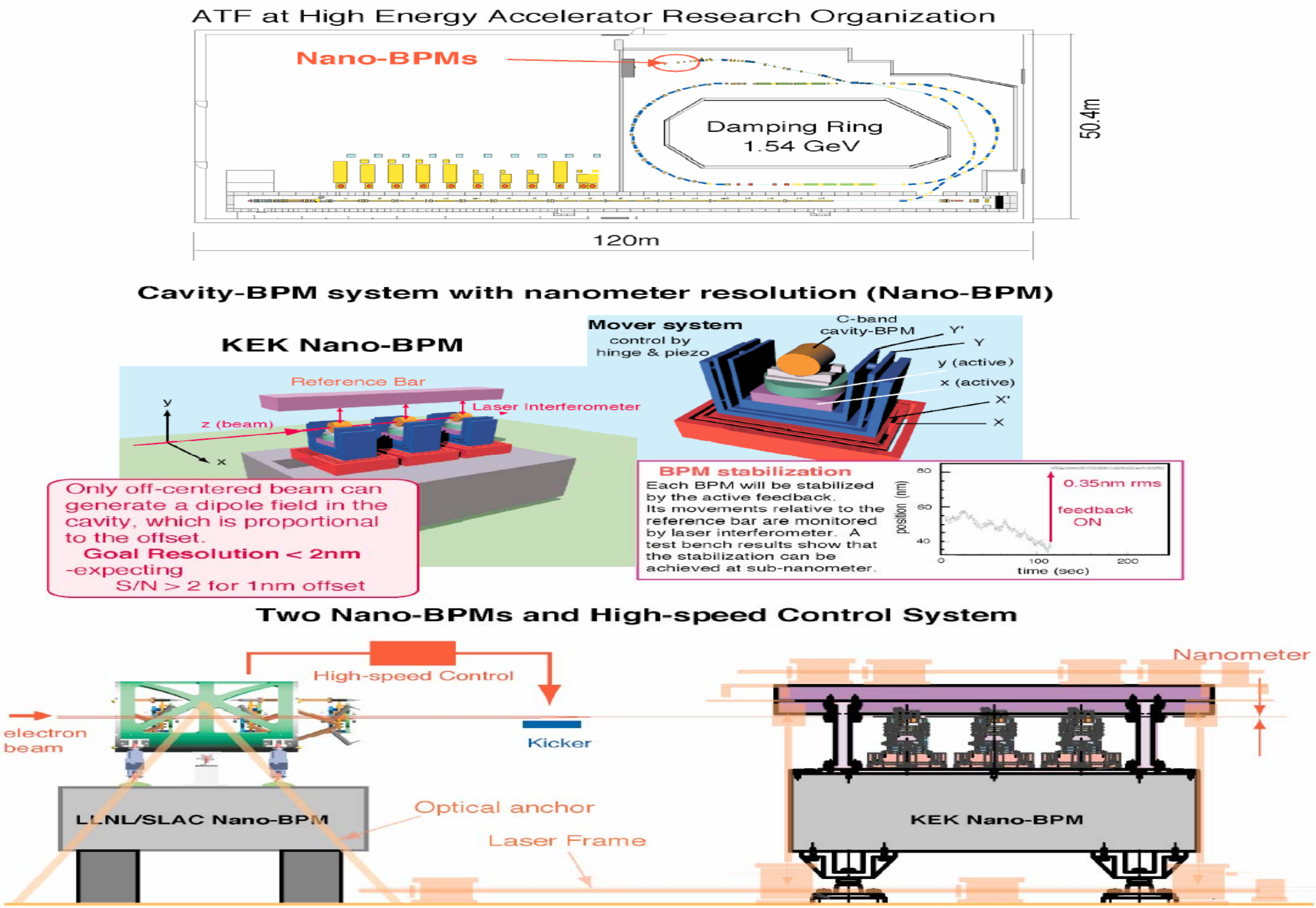
~ 3000 bunches

t_b = 337 ns

Multiple feedback systems will be mandatory to maintain the *nanobeams* in collision



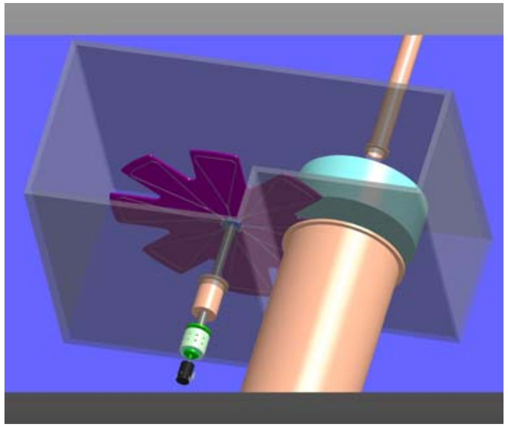
Nano-beams control @ ATF (KEK)



Positron source options

Conventional

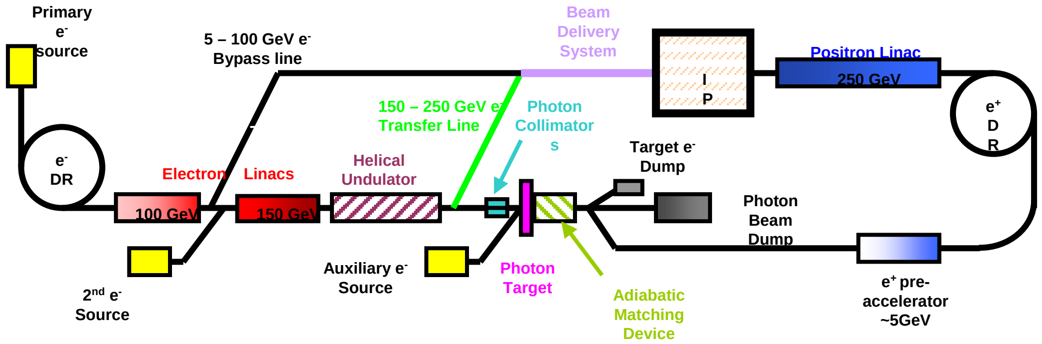
Positron are not polarized



- Target material WRe
- 56kW absorbed
- Target rotates at 360m/s
- Operates at fatigue stress of material

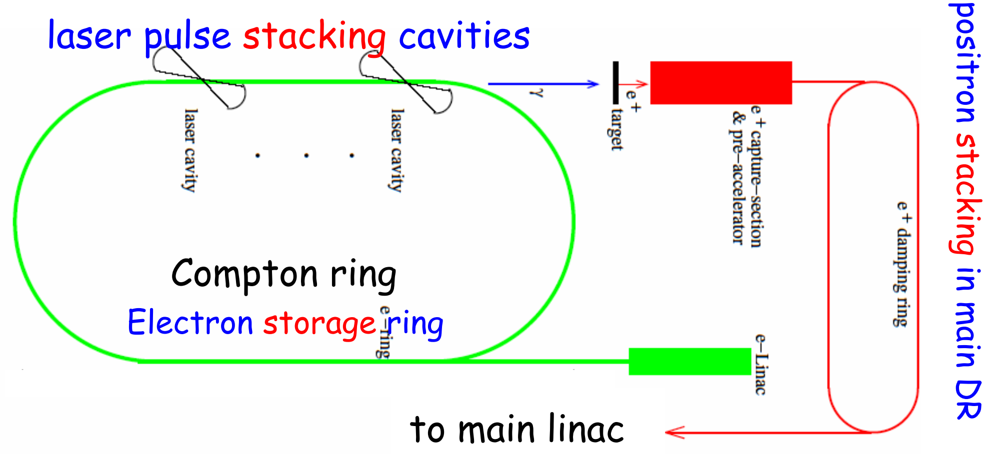
Undulator based

Up to 80 % polarization with helical undulator

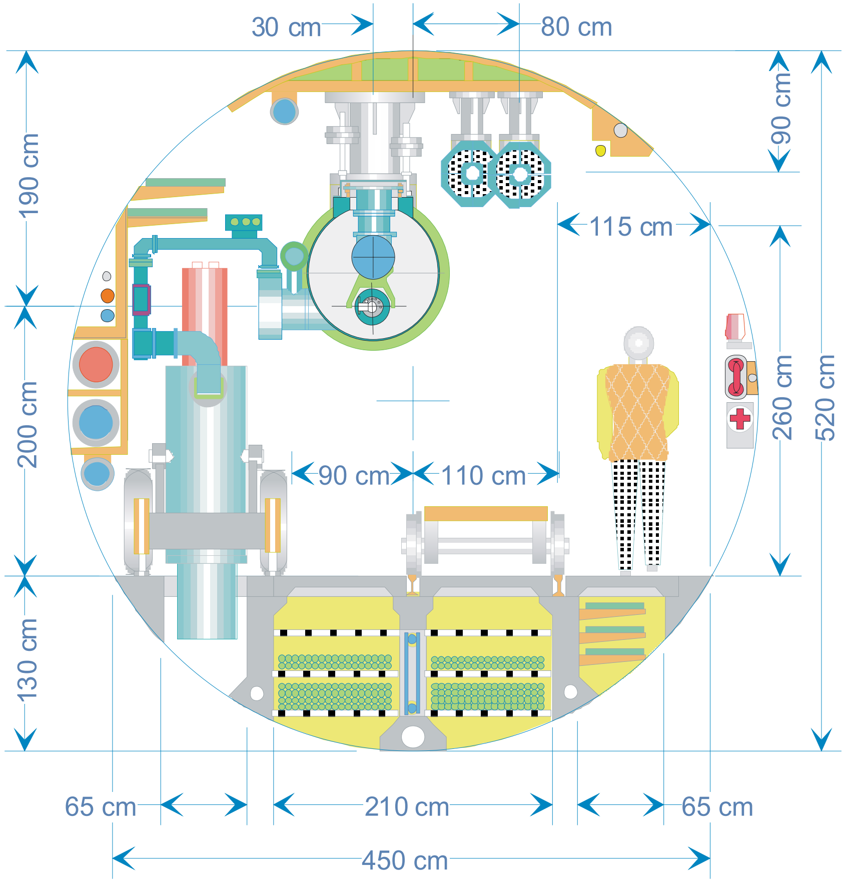


Compton back-scattering based

Up to 80 % polarization is conceivable

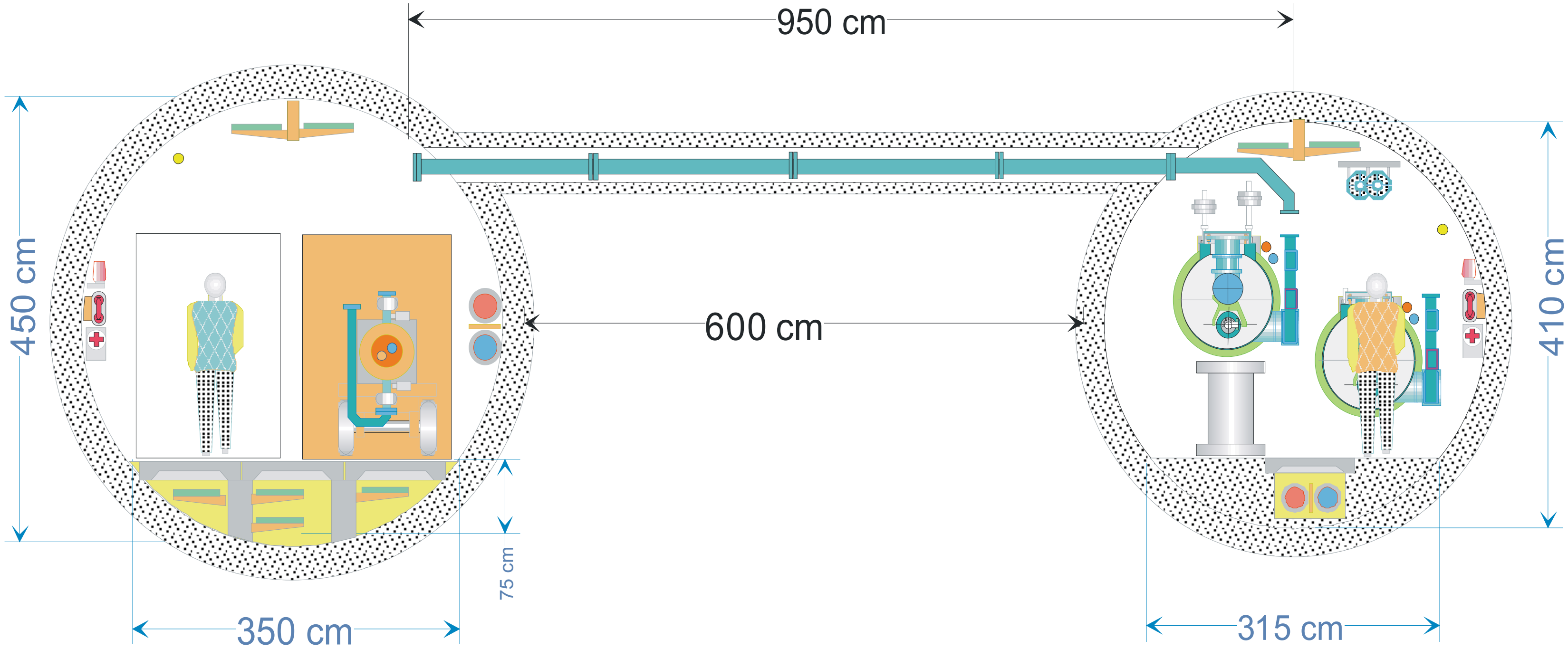


1 or 2 Tunnels ?



Single tunnel solution
a la TESLA TDR
(and for the XFEL)

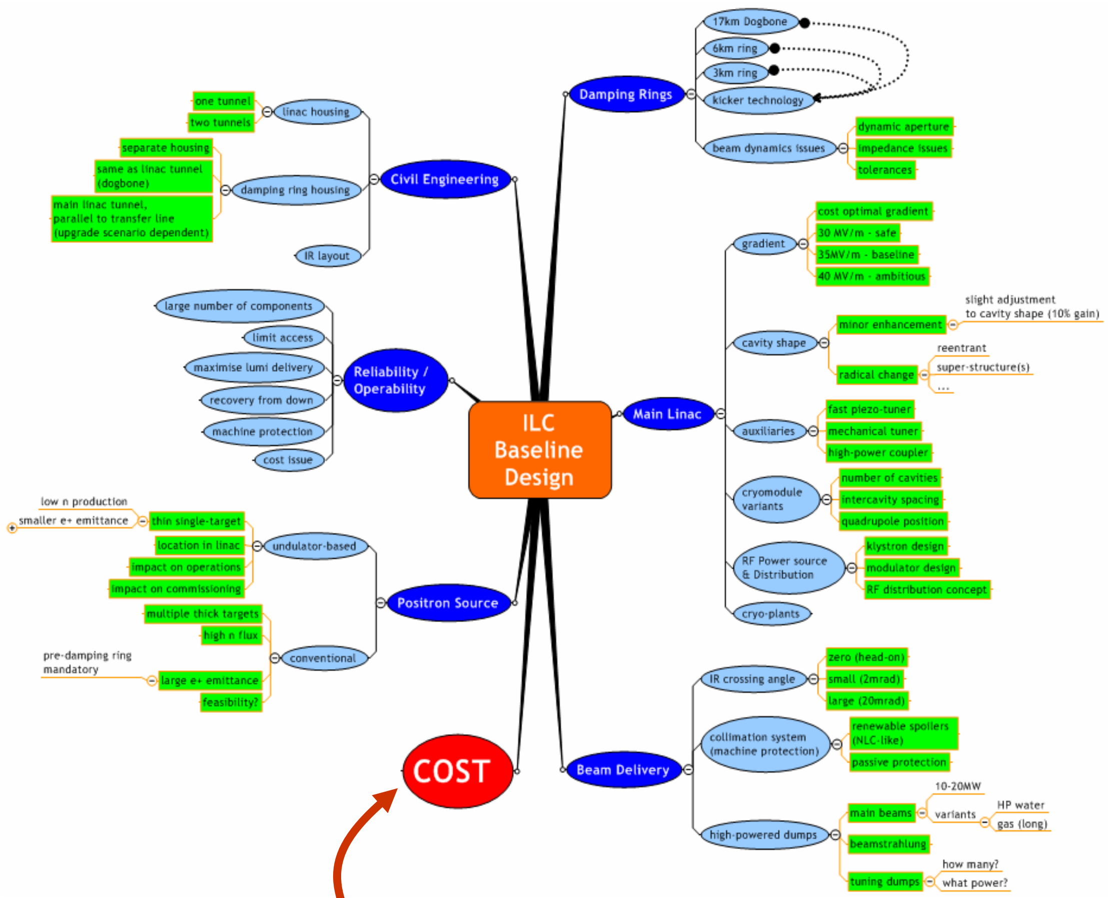
1 or 2 Tunnels ?



Two-tunnel (possible) option

klystrons/modulators(?)/LLRF/PS in Service Tunnel to allow access during operation (availability arguments).

Much To Do



don't forget this one!!!

It would seem we still have a great deal to do.

However, we can make decisions towards a baseline design relatively quickly ($\rightarrow$ end 2005)

Critical R&D:

- industrialisation
- cost reduction
- 'value engineering'

European Funding for ILC R&D

Structured and integrated European area in the field of accelerator research and related R&D.

3 Networking Activities and 4 Joint Research Activities.

European Design Study

(27 institutions, including CERN and DESY)

With top marks (score: 4.8/5), EU funding: ~ 9 M€

Summary

- The ILC is ambitious project which pushed the envelope in every subsystem:
  - Main SCRF linac — cost driver
  - sources
  - damping rings
  - beam delivery

  (sources, damping rings, beam delivery) } ***ILC*** performance bottleneck

- Still many accelerator physics issues to deal with, but **reliability** and **cost issues** are probably the **greater challenge**

- Probably in excess of 3000 man-years already invested in design work.

Concluding Remarks

- ILC is a great opportunity for HEP
- Physics expectations are great
- The interest for the cold technology is enormous
- As in the past, HEP can play a leading role in technology development for scientific and human applications