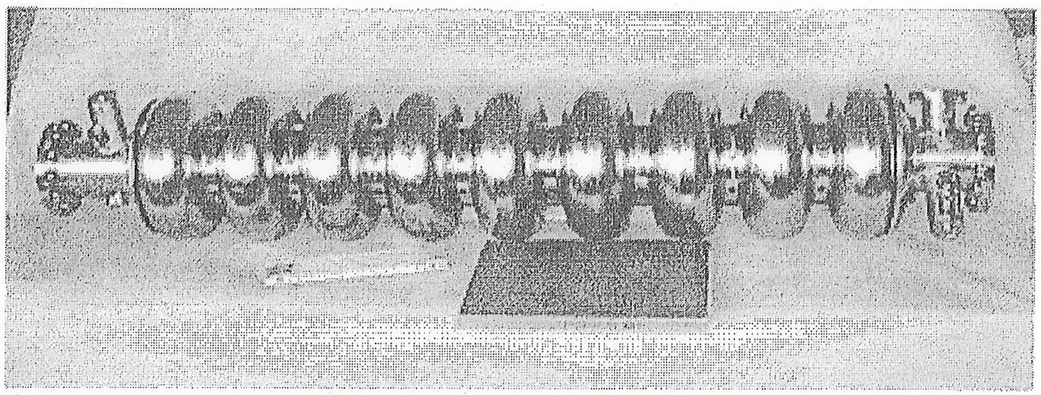
Status of International Linear Collider
Global Design Effort

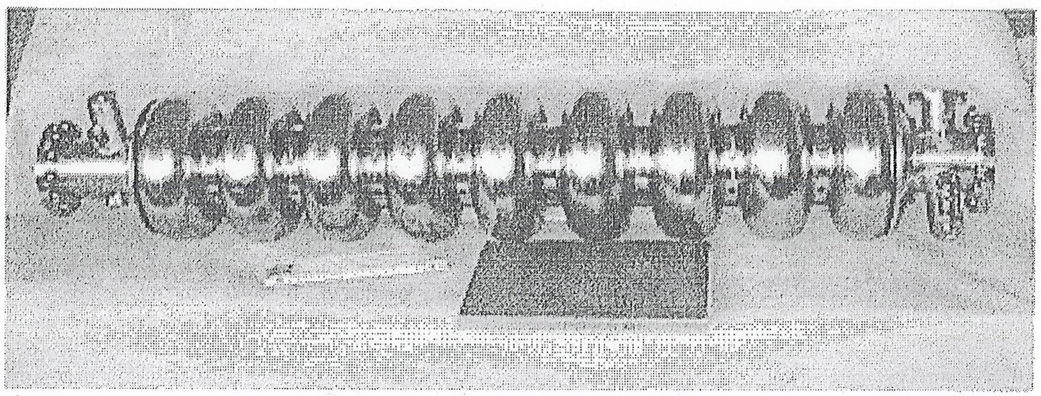


Barry Barish
(by telecon)

HEPAP
Washington DC
18-May-05

Status of International Linear Collider

Global Design Effort



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The Recommendation

- **We recommend that the linear collider be based on superconducting rf technology**
  - 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).
  - The superconducting technology has several very nice features for application to a linear collider. They follow in part from the low rf frequency.

What's Next?

- A new global design based on superconducting rf technology will be undertaken by the combined warm and cold experts.
- We need to fully capitalize on the experience from SLC, FFTB, ATF and TTF as we move forward. The range of systems from sources to beam delivery in a LC is so broad that an optimized design can only emerge by pooling the expertise of all participants.
- The R&D will be coordinated by an International Central Design Team, which the ITRP endorses.
- The first collaboration meeting at KEK in November.

The Technology Recommendation

- The recommendation was presented to ILCSC & ICFA on August 19 in a joint meeting in Beijing.

- ICFA unanimously endorsed the ITRP's recommendation on August 20

Statement of Funding Agency (FALC)

17-Sept-04 @ CERN

Attendees: Son (Korea); Yamauchi (Japan); Koepke (Germany); Aymar (CERN); Iarocci (CERN Council); Ogawa (Japan); Kim (Korea); Turner (NSF - US); Trischuk (Canada); Halliday (PPARC); Staffin (DoE - US); Gurtu (India)

Guests: Barish (ITRP); Witherell (Fermilab Director,)

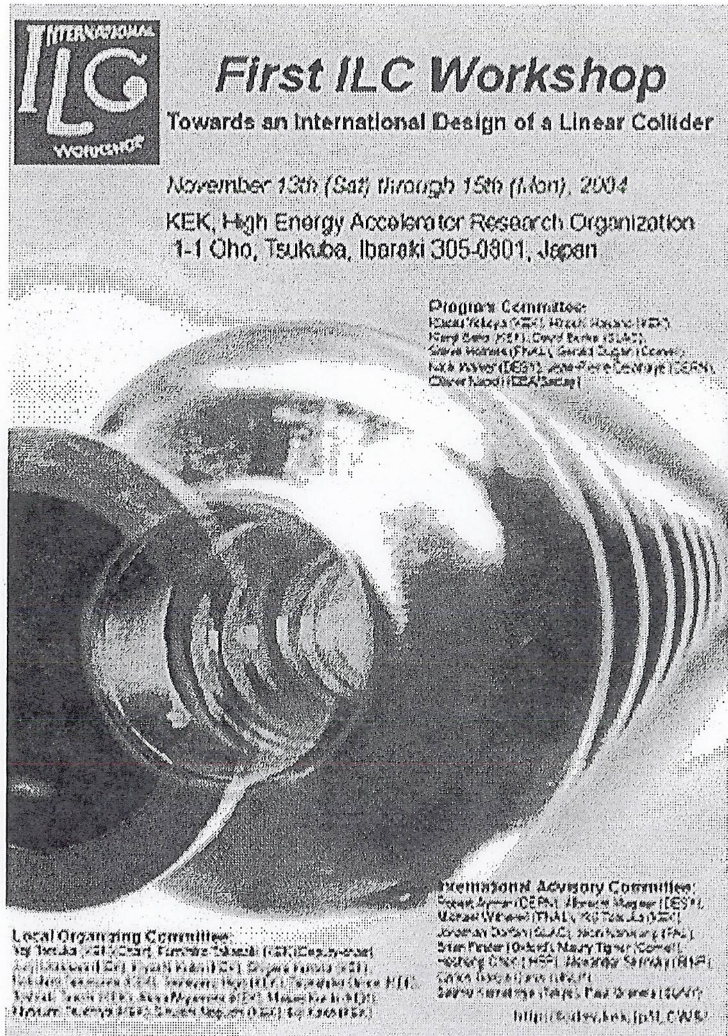
"The Funding Agencies praise the clear choice by ICFA. This recommendation will lead to focusing of the global R&D effort for the linear collider and the Funding Agencies look forward to assisting in this process.

The Funding Agencies see this recommendation to use superconducting rf technology as a critical step in moving forward to the design of a linear collider."

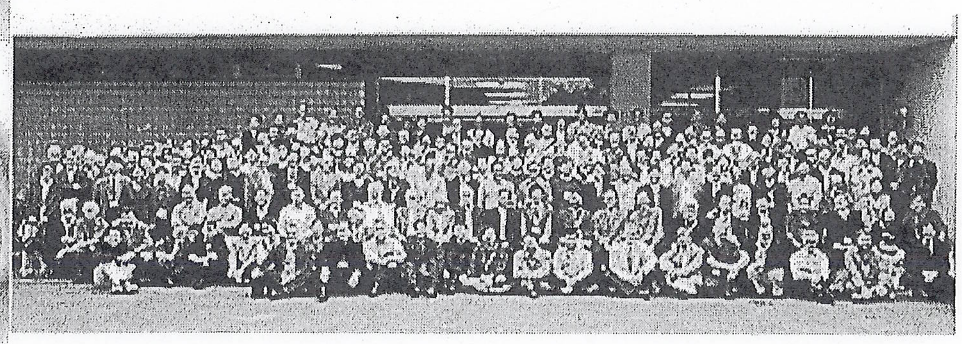
FALC is setting up a working group to keep a close liaison with the Global Design Initiative with regard to funding resources.

The cooperative engagement of the Funding Agencies on organization, technology choice, timetable is a very strong signal and encouragement.

The Community then Self-Organized



Nov 13-15, 2004



~ 220 participants from 3 regions, most of them accelerator experts

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The First ILC Meeting at KEK

- There are 19/49/60 participants registered for Asia/Europe/North America and total number is 128 + ILCSC = 146. An additional 66 Japanese scientists are registered – attendance > 210 expected.
- There will be 5 working groups:
  WG1: Overall Design
  WG2: Main Linac
  WG3: Injector, including damping rings
  WG4: BDS, including collimator, final focus etc.
  WG5: Cavity design: higher gradients, etc.

  Each has 3 convenors, one from each region.
- There will be three plenary talks, one from each region, outlining activity; then almost all of the meeting will be in working parallel sessions.

Brian Foster - CARE04

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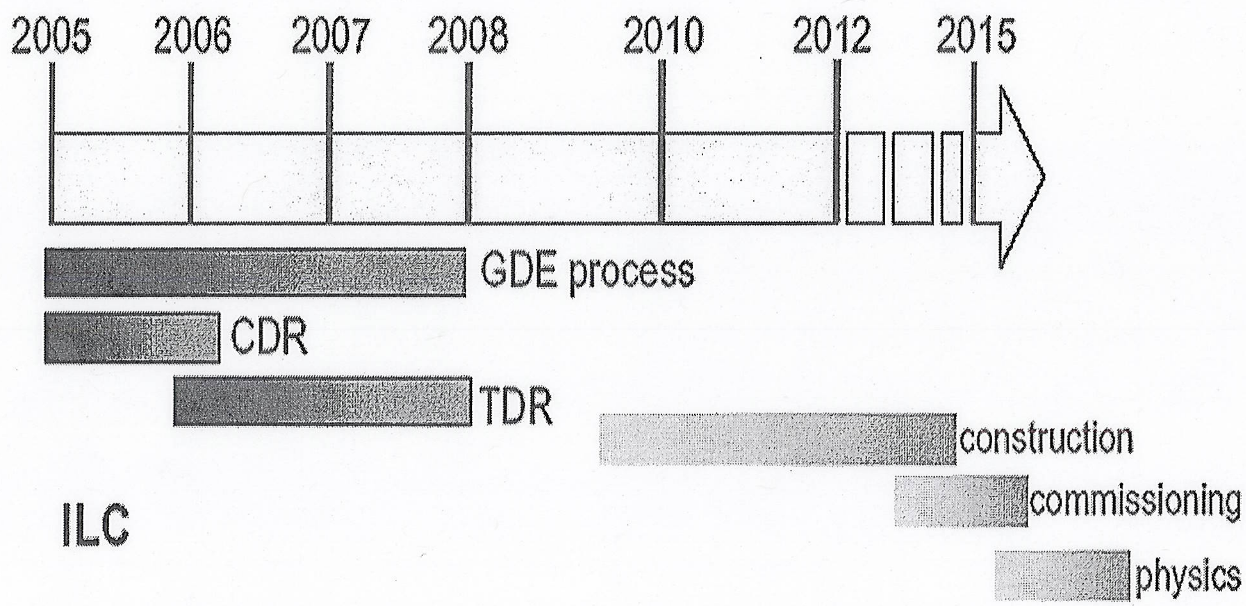
The Global Design Effort

Formal organization begun at LCWS 05 at Stanford in March 2005 when I became director of the GDE



Technically Driven Schedule

GDE – Near Term Plan

- Staff the GDE
  - Administrative, Communications, Web staff
  - Regional Directors (each region)
  - Engineering/Costing Engineer (each region)
  - Civil Engineer (each region)
  - Key Experts for the GDE design staff from the world community (please give input)
  - Fill in missing skills (later)

Total staff size about 20 FTE (2005-2006)

GDE – Near Term Plan

- Schedule
  - Begin to define Configuration (Aug 05)
  - Baseline Configuration Document by end of 2005

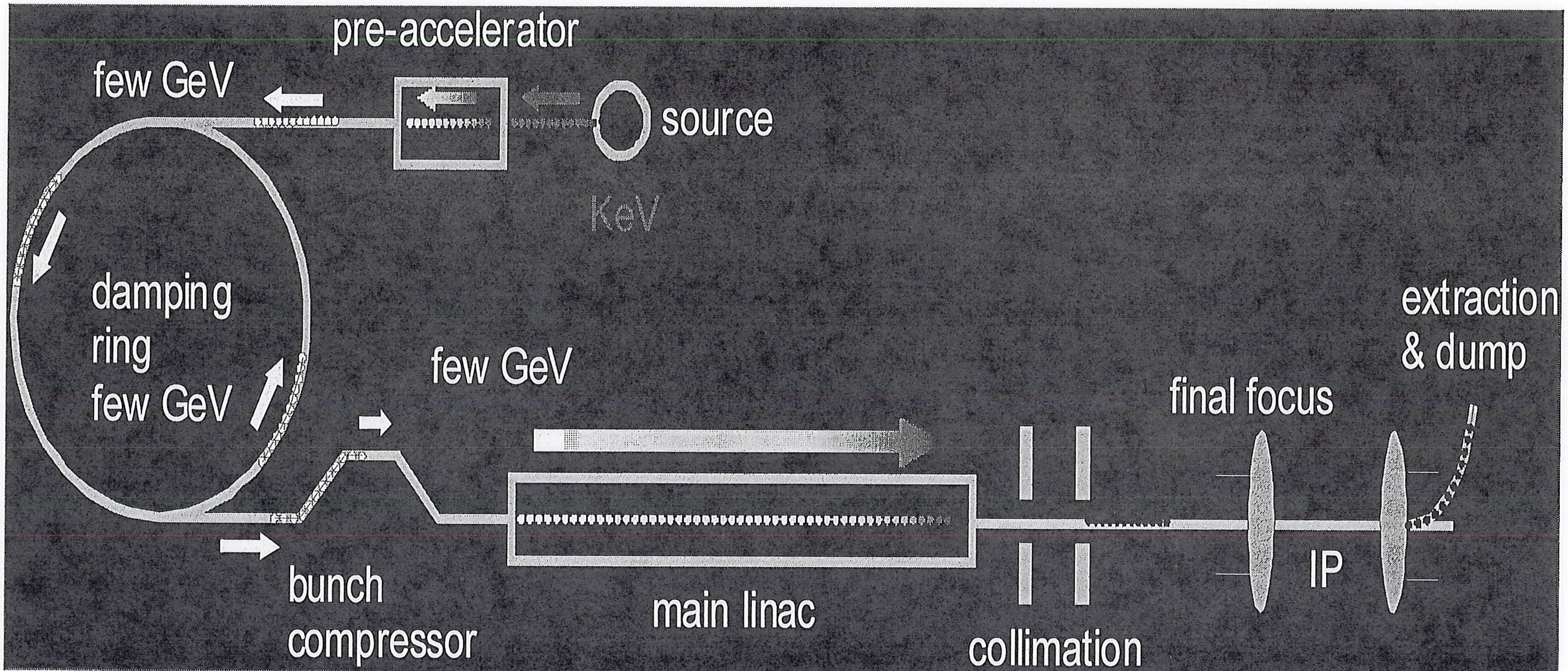
  - Put Baseline under Configuration Control (Jan 06)
  - Develop Conceptual Design Report by end of 2006

- Three volumes -- 1) Conceptual Design Report; 2) Shorter glossy version for non-experts and policy makers ; 3) Detector Concept Report

GDE – Near Term Plan

- Organize the ILC effort globally
  - First Step --- Appoint Regional Directors within the GDE who will serve as single points of contact for each region to coordinate the program in that region.
  - Make Website, coordinate meetings, collaborative R&D, etc
- R&D Program
  - Coordinate worldwide R & D efforts, in order to demonstrate and improve the performance, reduce the costs, attain the required reliability, etc. (Proposal Driven to GDE)

Starting Point for the GDE



Superconducting RF Main Linac

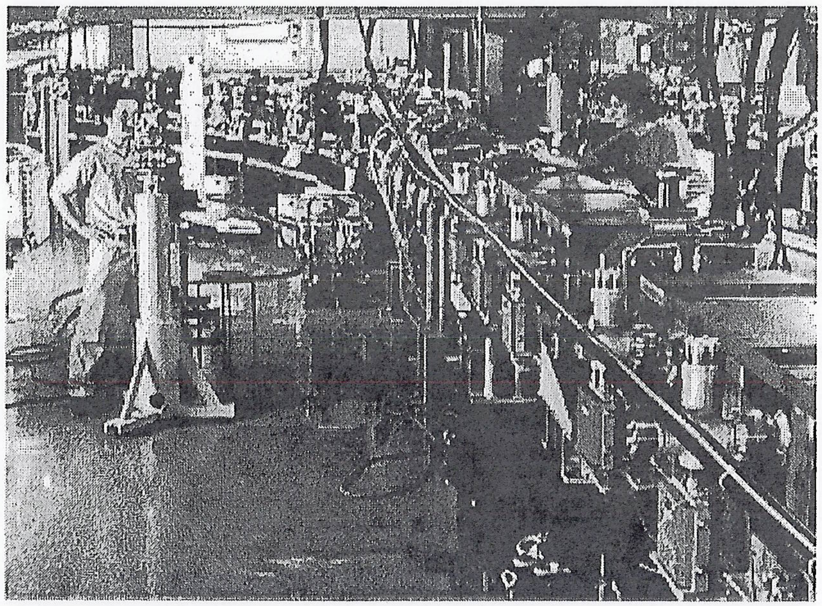
Parameters for the ILC

- E_{cm} adjustable from 200 – 500 GeV
- Luminosity → $\int L dt$ = 500 fb^{-1} in 4 years
- Ability to scan between 200 and 500 GeV
- Energy stability and precision below 0.1%
- Electron polarization of at least 80%

- The machine must be upgradeable to 1 TeV

Experimental Test Facility - KEK

- Prototype Damping Ring for X-band Linear Collider
- Development of Beam Instrumentation and Control

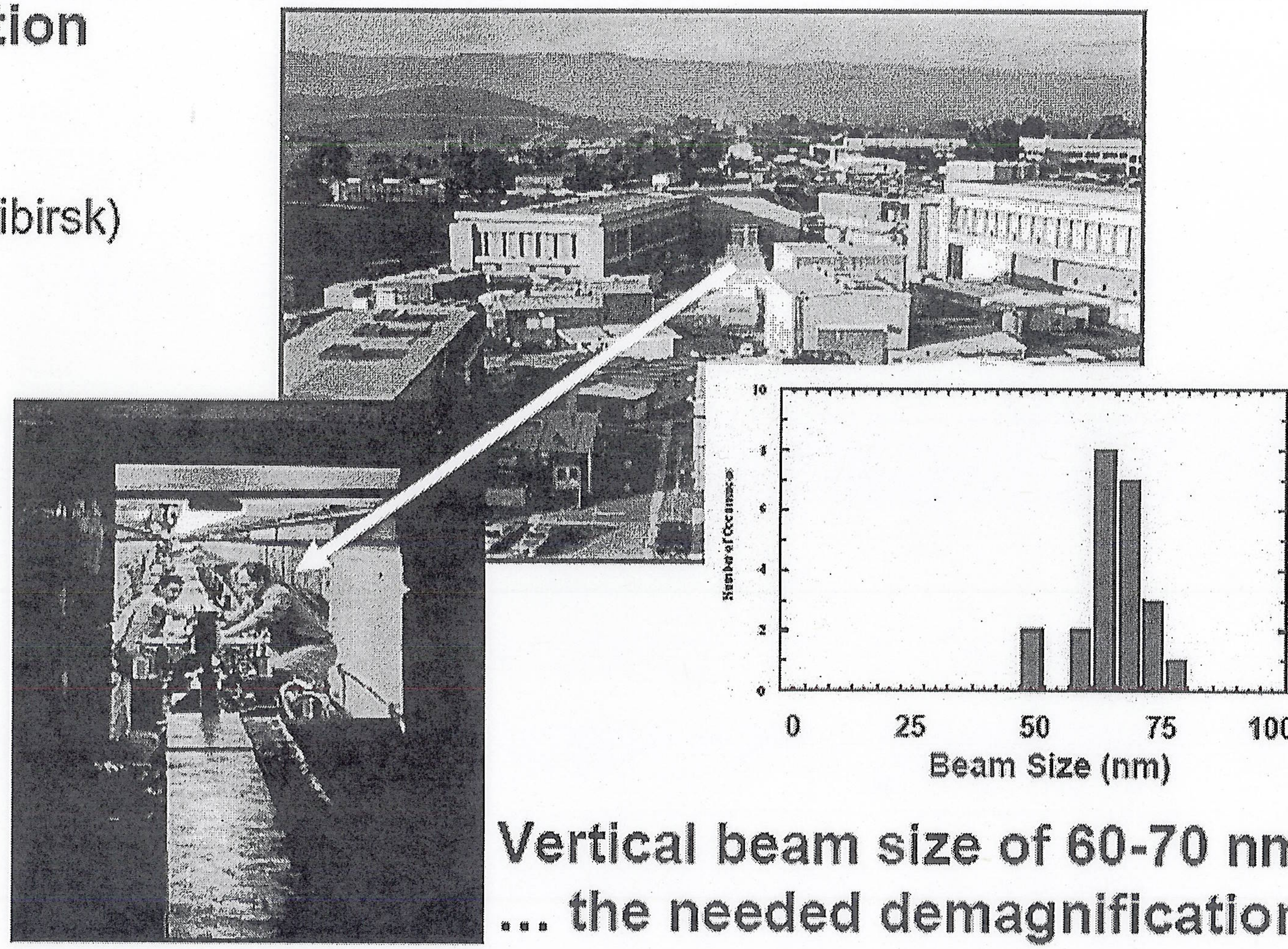


	ATF	*GLC/NLC-DR*	
E_b	1.28 (1.54 max)	1.98	GeV
N_e	~ 10^{10}	0.75 10^{10}	e-/bunch
S_b	2.8	1.4	ns
N_b	20	192	/pulse
$\gamma\varepsilon_x$	~4	3	µm.rad
$\gamma\varepsilon_y$	~0.015	0.02	µm.rad

Final Focus Test Faclity - SLAC

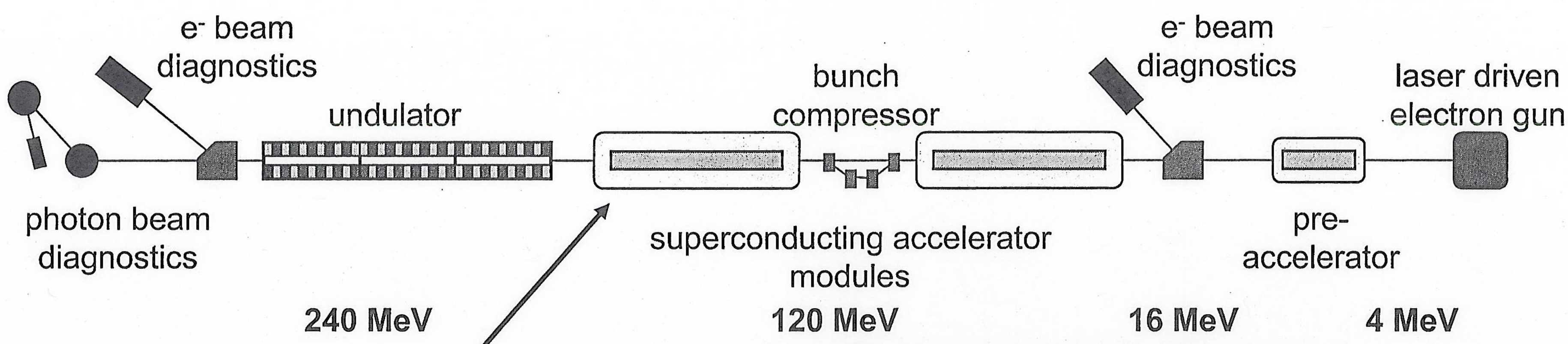
Final Focus Test Beam Collaboration

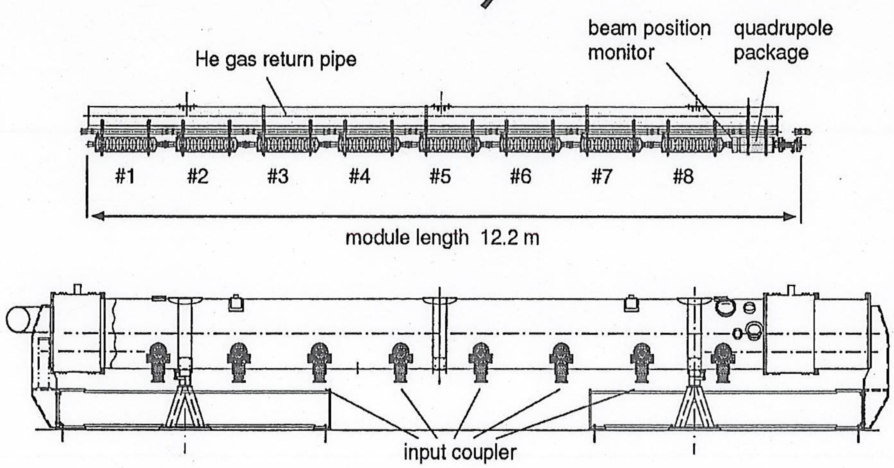
BINP (Novosibirsk)
DESY
Fermilab
IBM
Kawasaki
KEK
LAL (Orsay)
MPI(Munich)
Rochester
SLAC

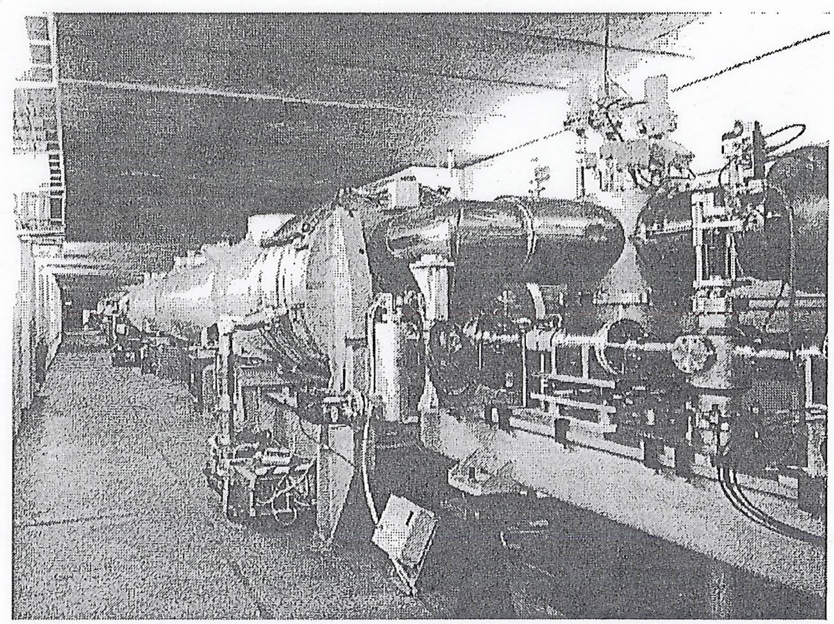


Vertical beam size of 60-70 nm ... the needed demagnification.

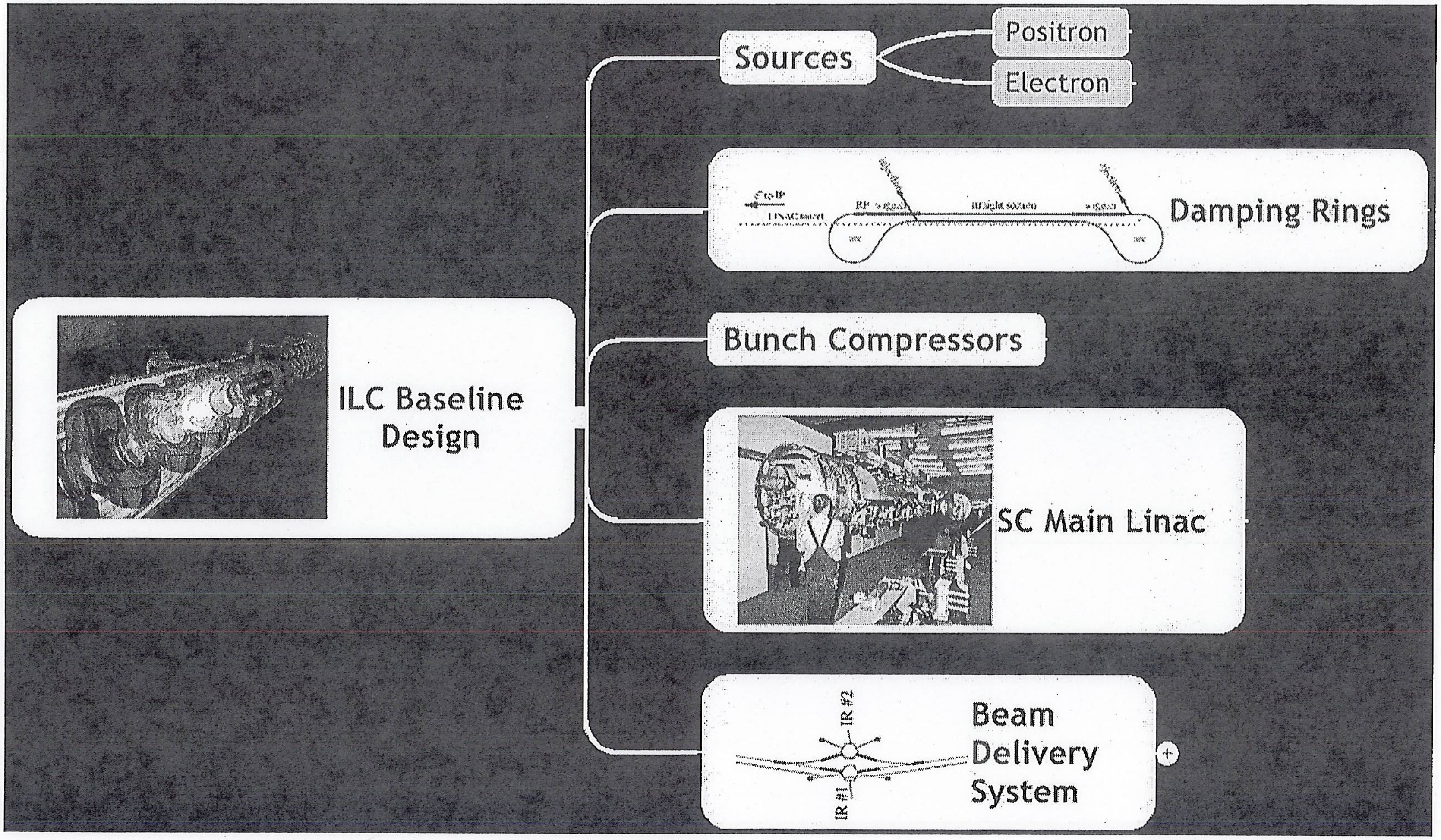
TESLA Test Facility Linac - DESY







Towards the ILC Baseline Design



Specific Machine Realizations

rf bands:

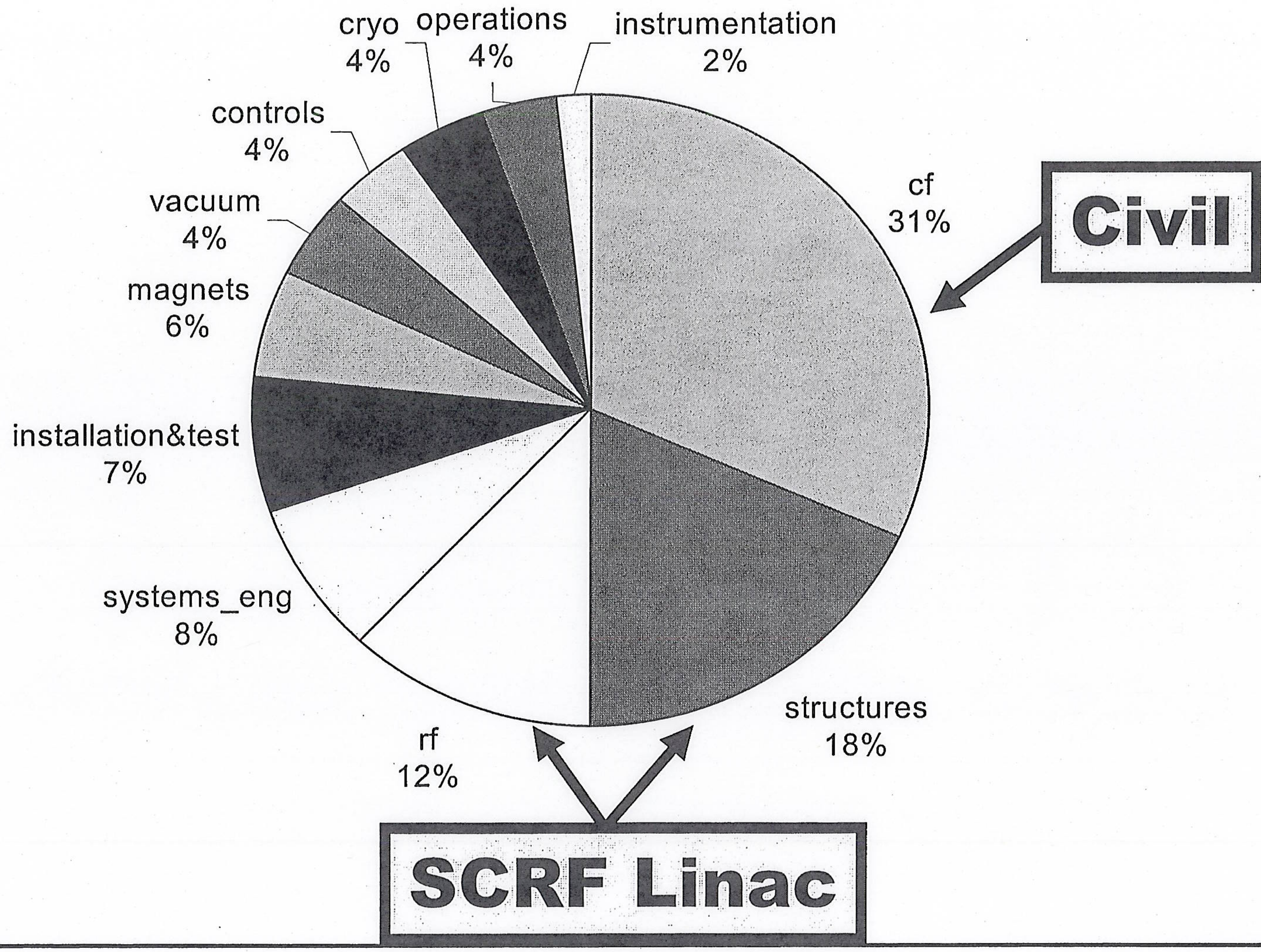
L-band (TESLA)	1.3 GHz	λ =	3.7 cm
S-band (SLAC linac)	2.856 GHz	/	1.7 cm
C-band (JLC-C)	5.7 GHz		0.95 cm
X-band (NLC/GLC)	11.4 GHz		0.42 cm
(CLIC)	25-30 GHz		0.2 cm

Accelerating structure size is dictated by wavelength of the rf accelerating wave. Wakefields related to structure size; thus so is the difficulty in controlling emittance growth and final luminosity.

- Bunch spacing, train length related to rf frequency
- Damping ring design depends on bunch length, hence frequency

Frequency dictates many of the design issues for LC

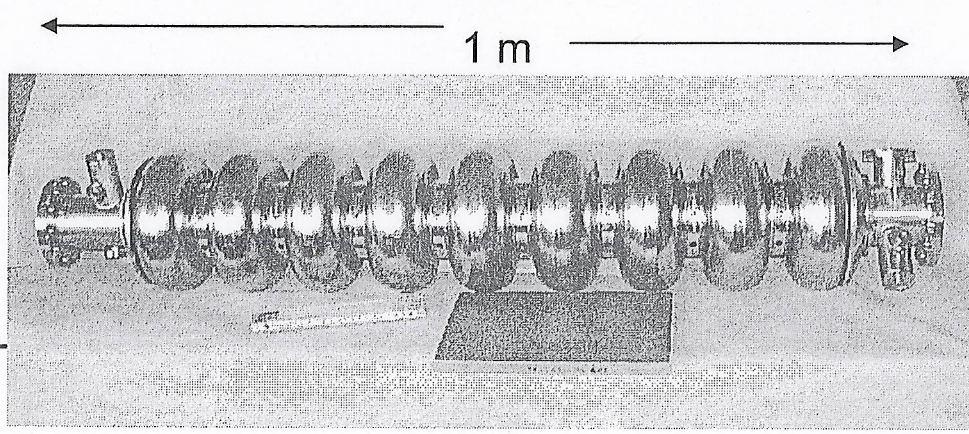
Cost Breakdown by Subsystem

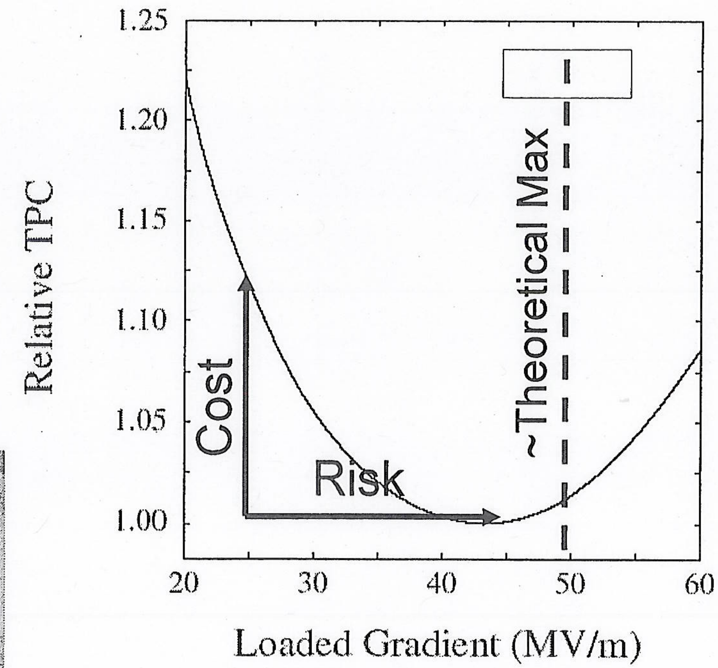


RF SC Linac Challenges

Energy: 500 GeV, upgradeable to 1000 GeV

- RF Accelerating Structures
  - **Accelerating structures must support the desired gradient <u>in an operational setting</u> and there must be a <u>cost effective means of fabrication</u>.**
  - ~17,000 accelerating cavities/500 GeV
  - **Current performance goal is 35 MV/m, (operating at 30 MV/m)**
    - **Trade-off cost and technical risk.**

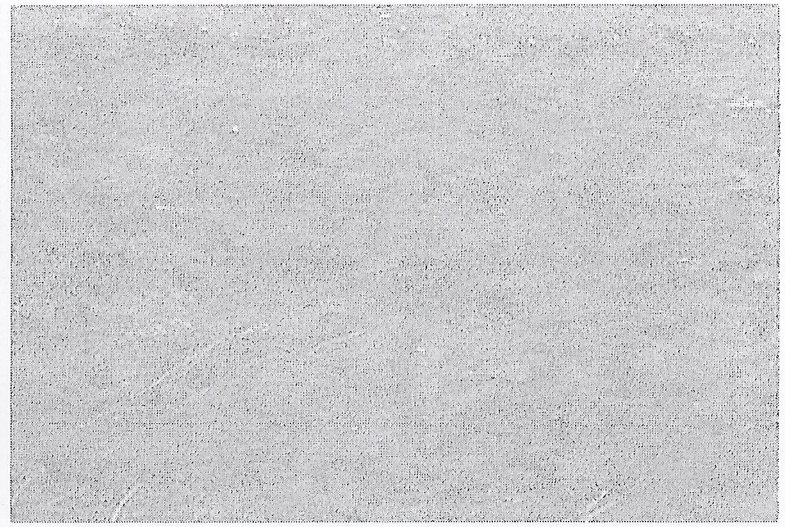




Electro-polishing

(Improve surface quality -- pioneering work done at KEK)

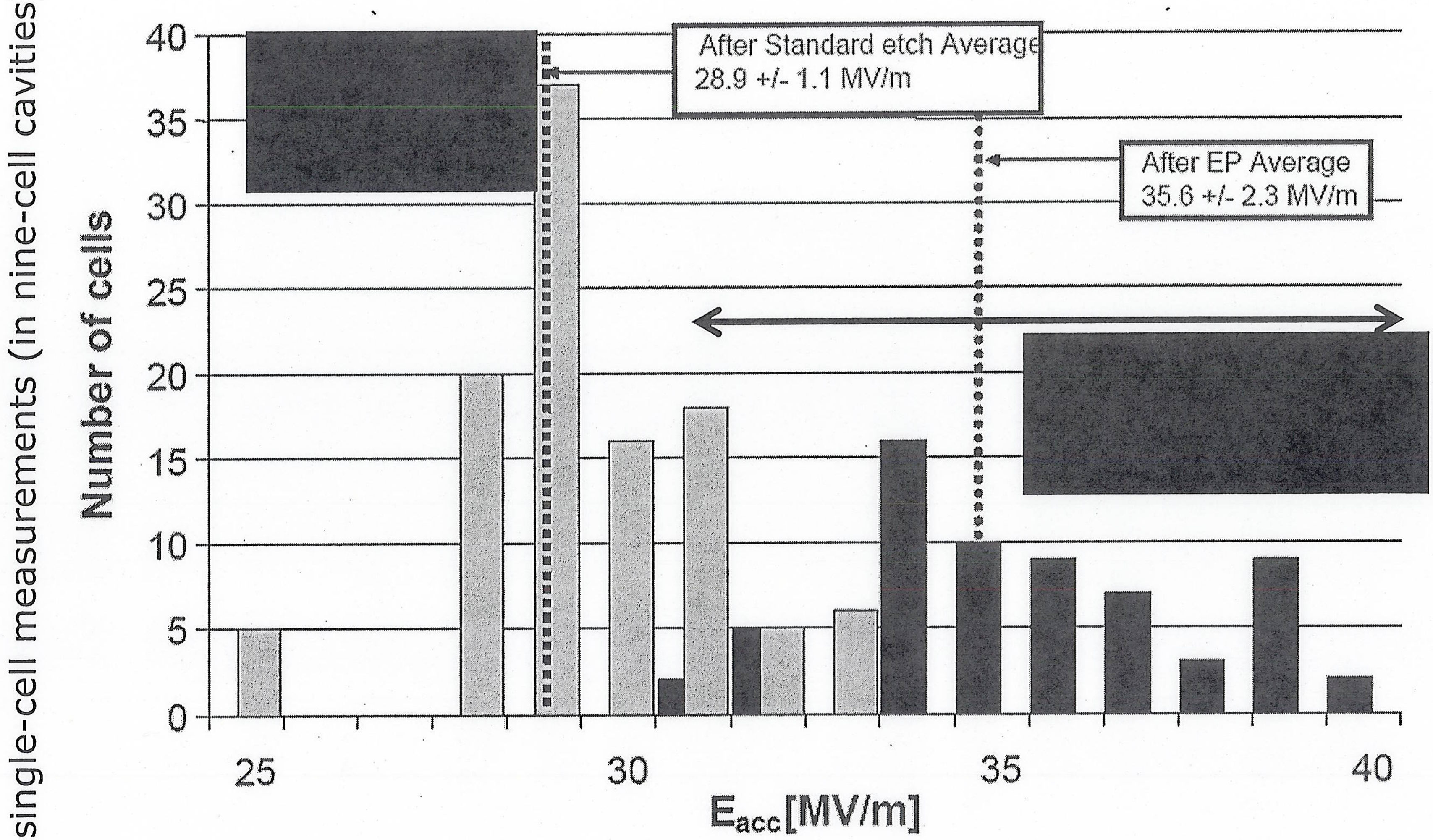
BCP



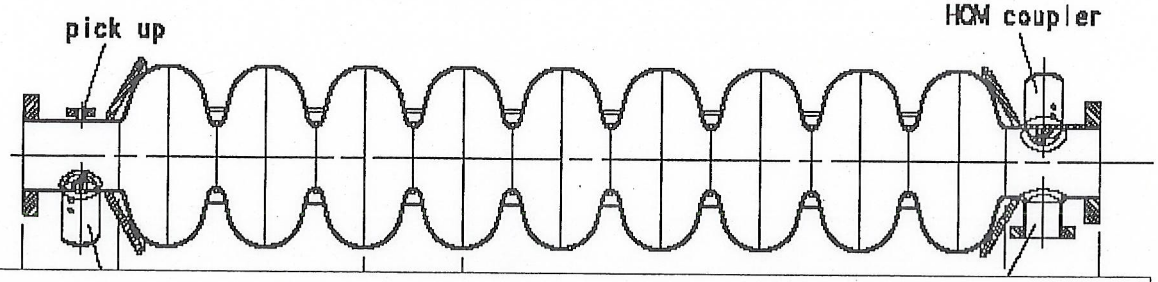
EP

- Several single cell cavities at g > 40 MV/m
- 4 nine-cell cavities at ~35 MV/m, one at 40 MV/m
- Theoretical Limit 50 MV/m

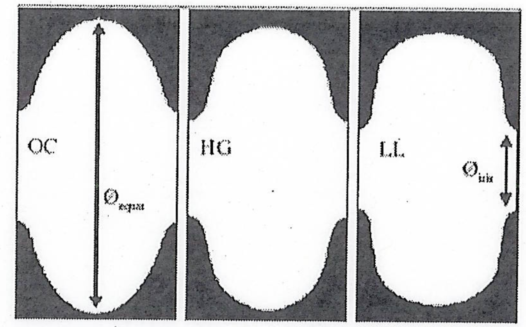
Gradient


single-cell measurements (in nine-cell cavities)
Number of cells
40
35
30
25
20
15
10
5
0
After Standard etch Average
28.9 +/- 1.1 MV/m
After EP Average
35.6 +/- 2.3 MV/m
25
30
35
40
E_{acc}[MV/m]

New Cavity Shape for Higher Gradient?



TESLA Cavity



Alternate Shapes

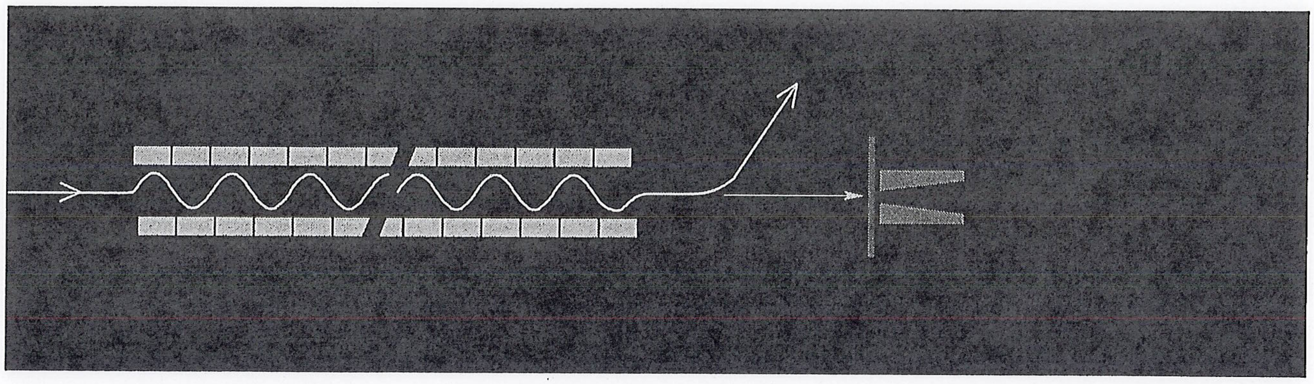
- A new cavity shape with a small Hp/Eacc ratio around 35Oe/(MV/m) must be designed.
  - Hp is a surface peak magnetic field and Eacc is the electric field gradient on the beam axis.
  - For such a low field ratio, the volume occupied by magnetic field in the cell must be increased and the magnetic density must be reduced.
  - This generally means a smaller bore radius.
  - There are trade-offs (eg. Electropolishing, weak cell-to-cell coupling, etc)

Parameters of Positron Sources

	rep rate	# of bunches per pulse	# of positrons per bunch	# of positrons per pulse
TESLA TDR	5 Hz	2820	$2 \cdot 10^{10}$	$5.6 \cdot 10^{13}$
NLC	120 Hz	192	$0.75 \cdot 10^{10}$	$1.4 \cdot 10^{12}$
SLC	120 Hz	1	$5 \cdot 10^{10}$	$5 \cdot 10^{10}$
DESY positron source	50 Hz	1	$1.5 \cdot 10^{9}$	$1.5 \cdot 10^{9}$

Positron Source

- Large amount of charge to produce
- Three concepts:
  - undulator-based (TESLA TDR baseline)



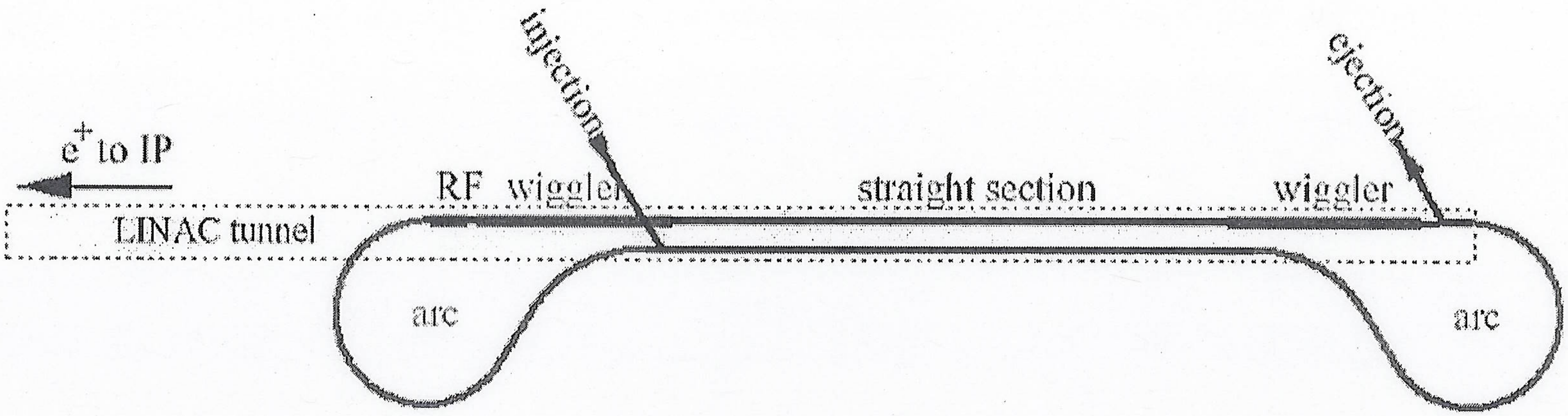
  - ‘conventional’
  - laser Compton based

DR Design Approaches: Example #1, the TESLA TDR lattice

5 GeV, 17 km lattice (arcs 1 km each, straights 15 km total).

Bunches spaced by 20 ns, injected and extracted individually.

Positron damping ring requires 440 m of wiggler to achieve damping time of 27 ms.



Schematic of Dogbone Damping Ring from TESLA TDR

Strengths:

- Relatively small amount of extra tunnel required.
- Large circumference reduces average current, and helps mitigate some instabilities.
- Flexibility in modes of operation (e.g. could double number of bunches)

Weaknesses:

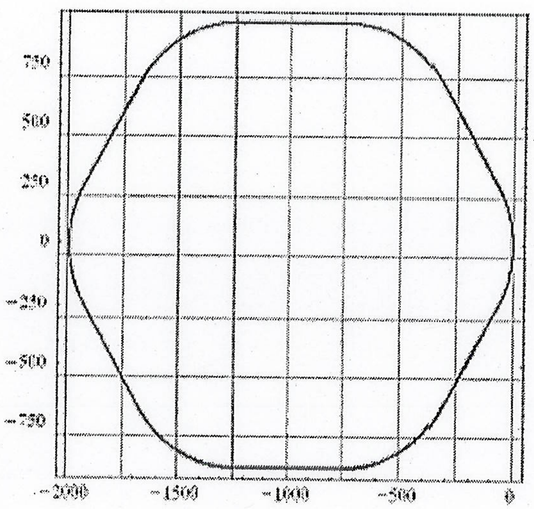
- Large space-charge tune shift needs to be corrected using coupling-bumps.
- Sensitive to stray magnetic fields.

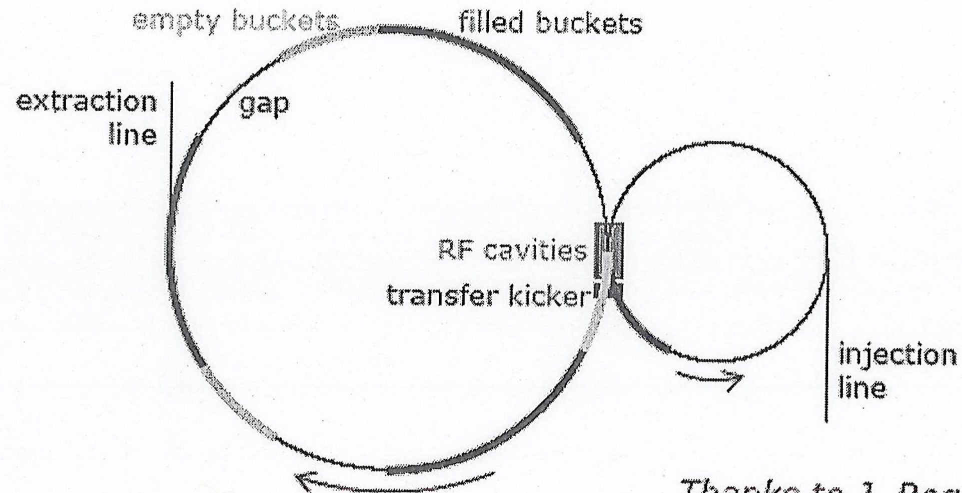
DR Design Approaches: Example #2, the FNAL 6 km lattice

5 GeV, 6 km lattice (six-fold symmetry).

Injection/extraction scheme uses 6 ns rise-time, 60 ns fall-time kicker.

Lattice documented in FERMILAB-TM-2272-AD-TD
http://www.hep.uiuc.edu/home/g-gollin/linear_collider/Fermilab_damping_ring_report.pdf





Thanks to J. Rogers and G. Dugan (Cornell)

Strengths:

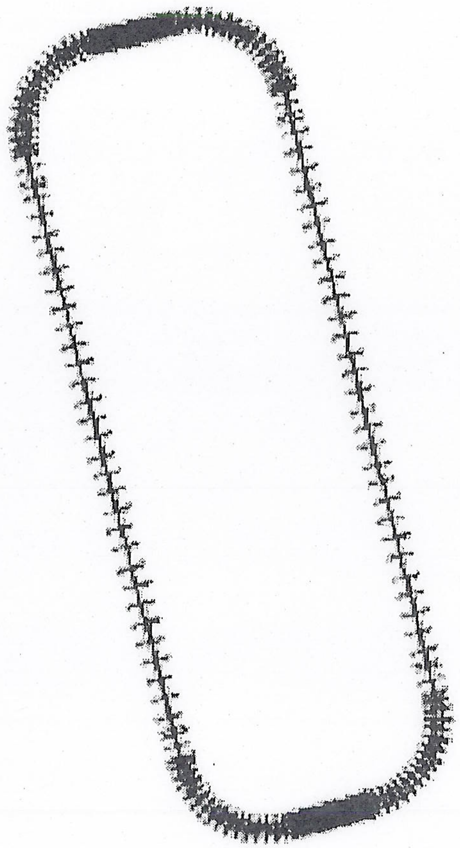
- Relatively small circumference reduces space-charge effects.
- Reduced amount of wiggler needed to achieve required damping rate.
- Injection/extraction scheme allows use of slow fall-time kicker.

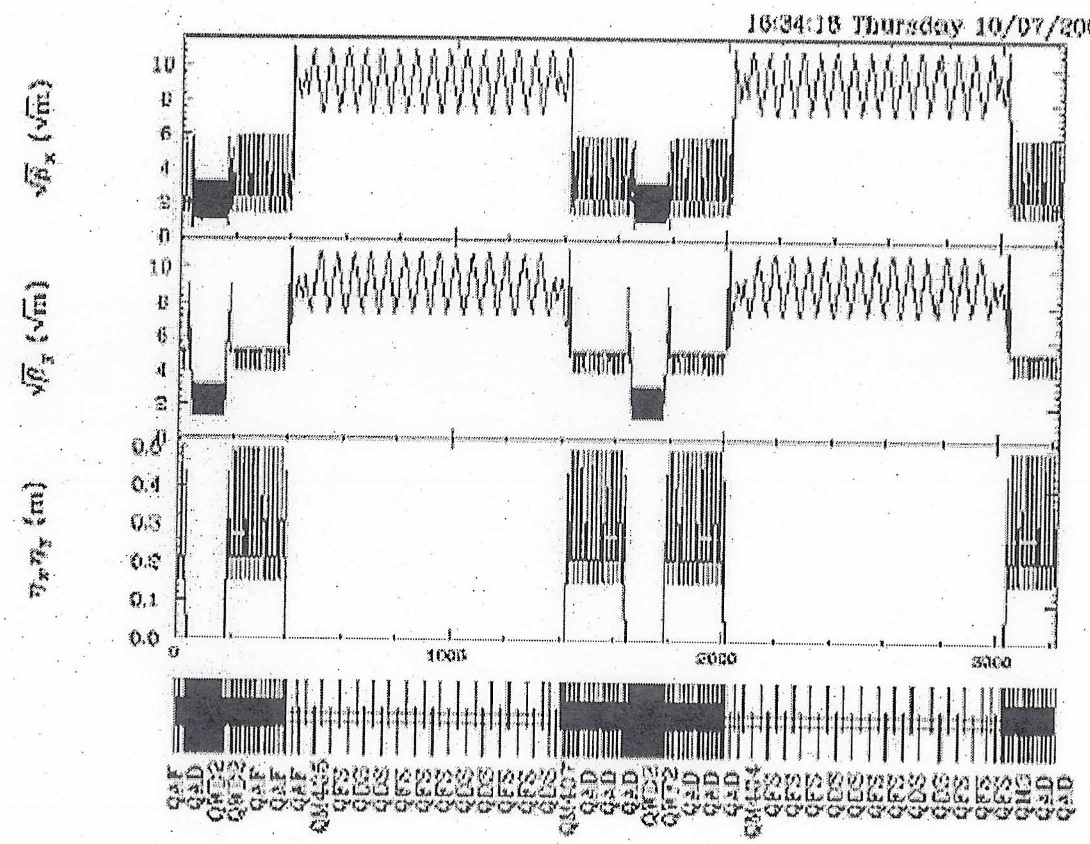
Weaknesses:

- Higher average current makes electron-cloud and ion effects more difficult.

DR Design Approaches: Example #3, the KEK 3 km lattice

5 GeV, 3.2 km lattice (racetrack design).



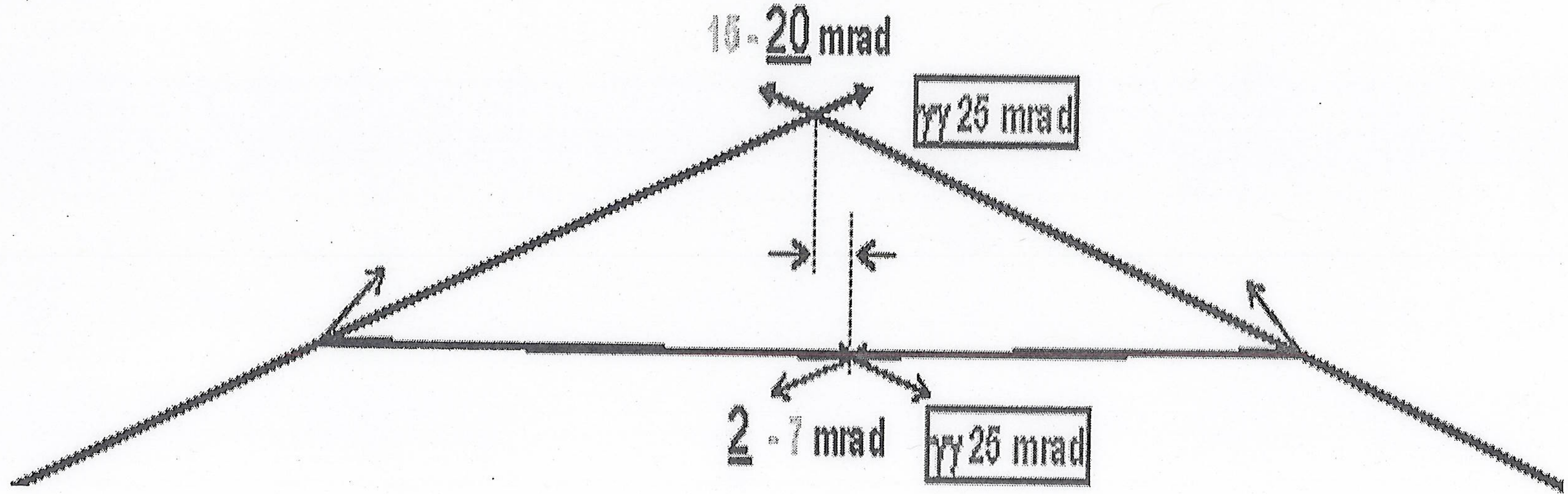


Lattice layout and optical functions in KEK 3 km damping ring.

Strawman Final Focus

Recommendations from the WG4

Tentative, not frozen configuration, working hypotheses, "strawman"



Summary of Progress since ITRP

- FALC endorsed the decision and wants to be engaged in the next steps.
- The ‘warm’ laboratories (KEK and SLAC) quickly reorganized toward the design of a ‘cold’ machine.
- The community “self-organized” toward cold machine at a workshop at KEK in November
- The Global Design Effort (GDE) began in March with the appointment of BB as director.
- The Snowmass meeting will make first steps toward defining a “baseline” for the ILC
- Baseline configuration determined and documented by the end of 2005
- Conceptual Design Report by end of 2006