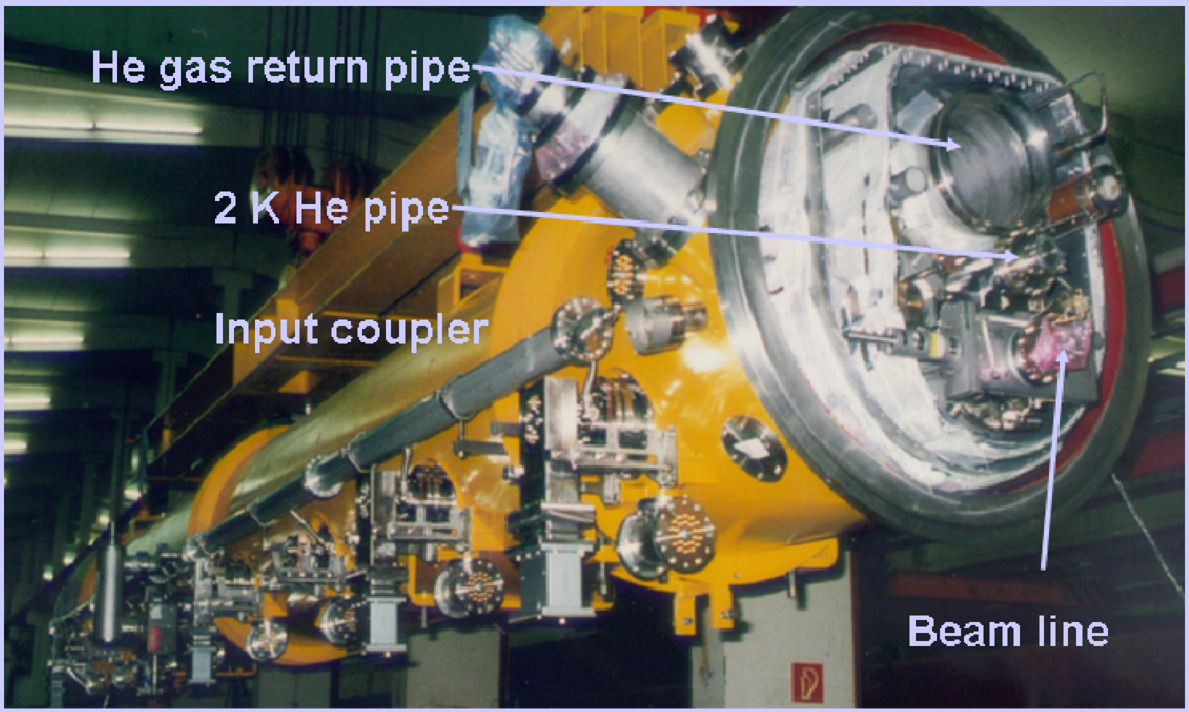
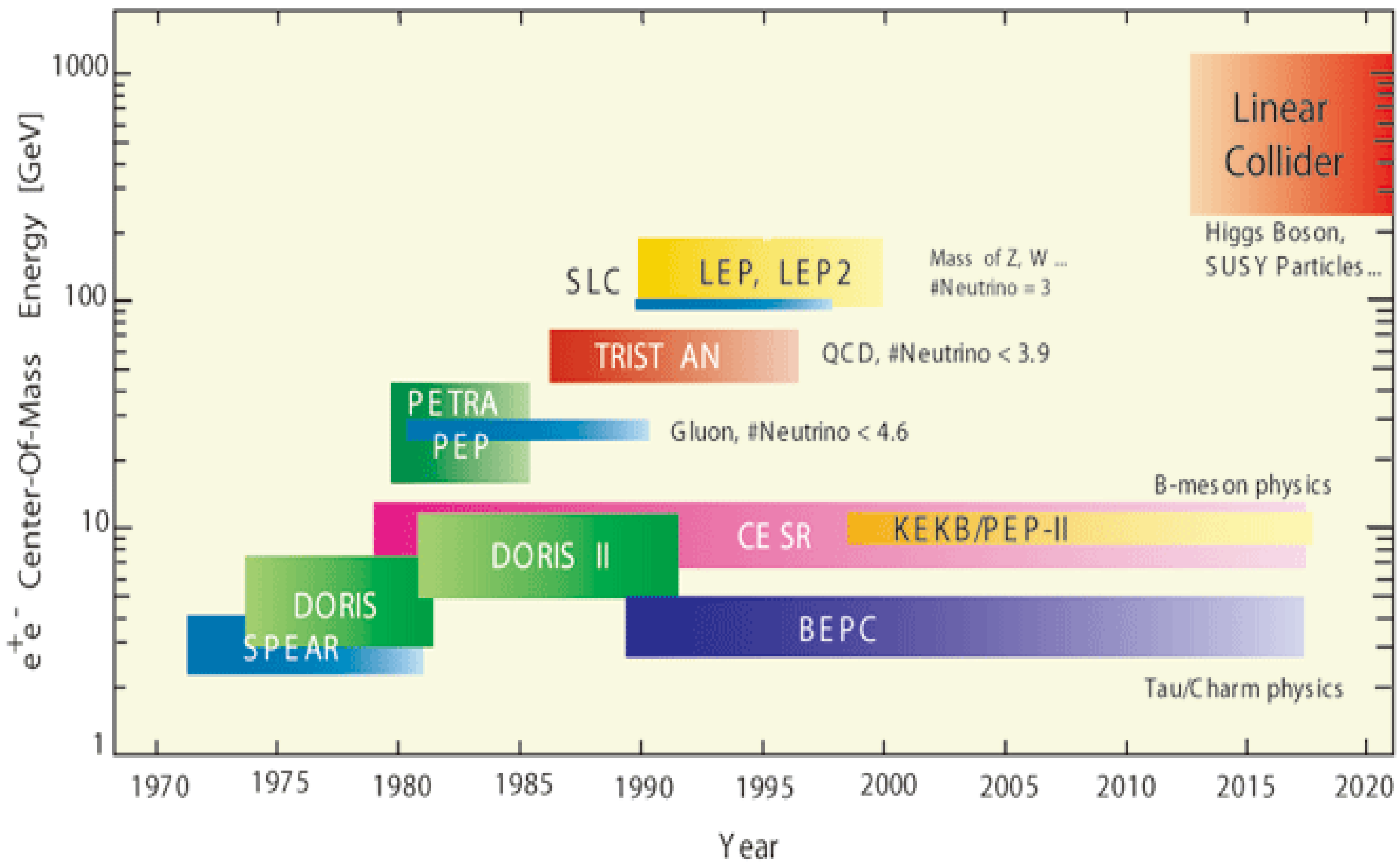
GDE expectations from the SRF community



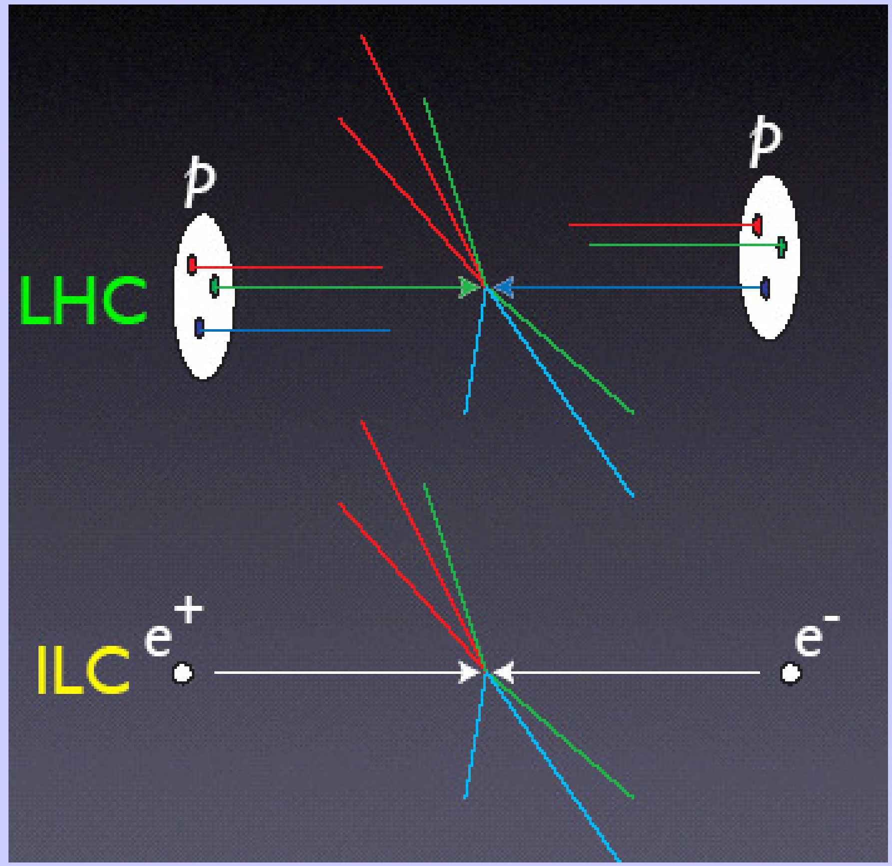
Barry Barish
Cornell SRF Mtg
15-July-05

The Energy Frontier

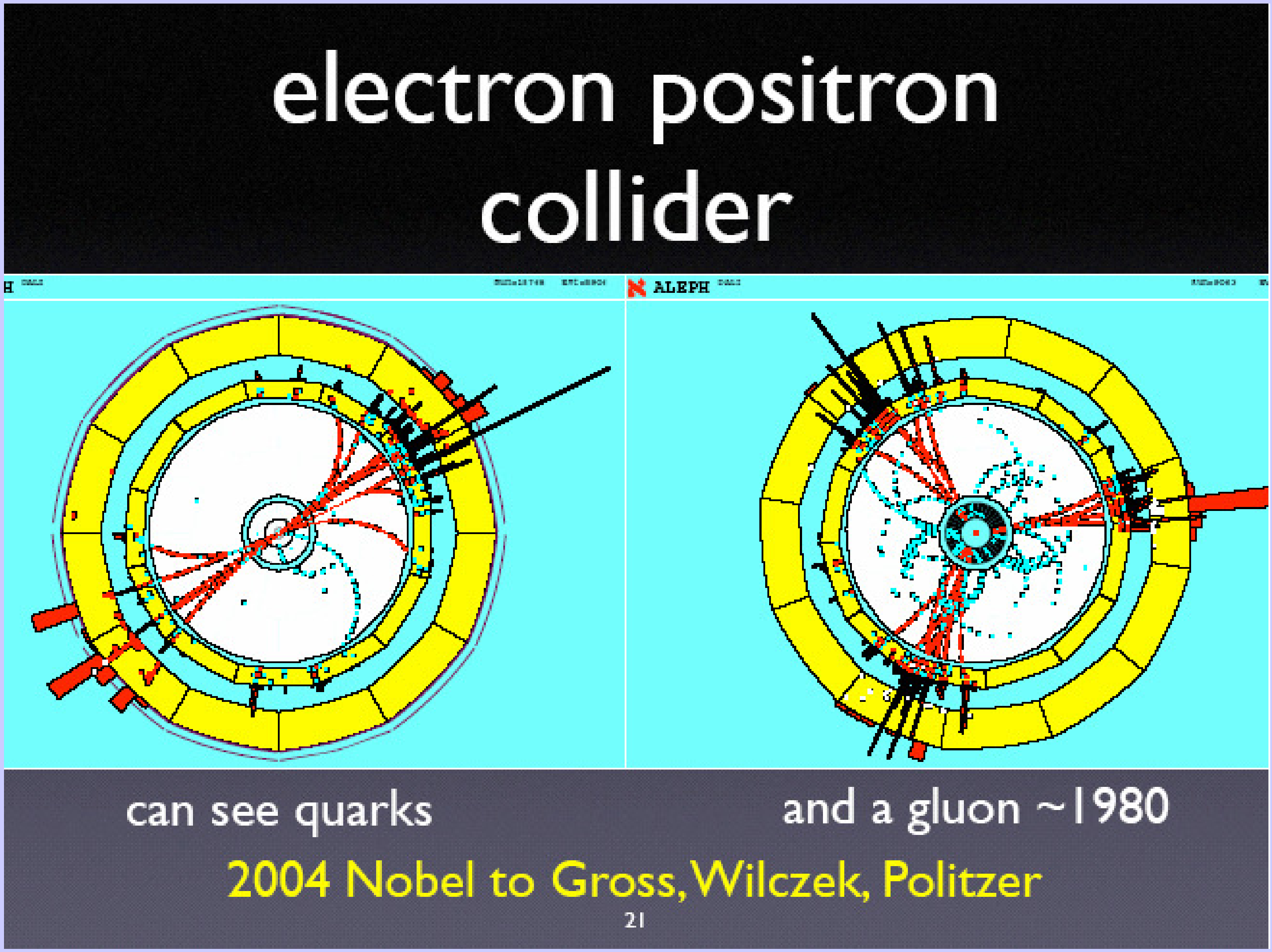


Why e^+e^- Collisions?

- elementary particles
- well-defined
  - energy,
  - angular momentum
- uses full COM energy
- produces particles democratically
- can mostly fully reconstruct events



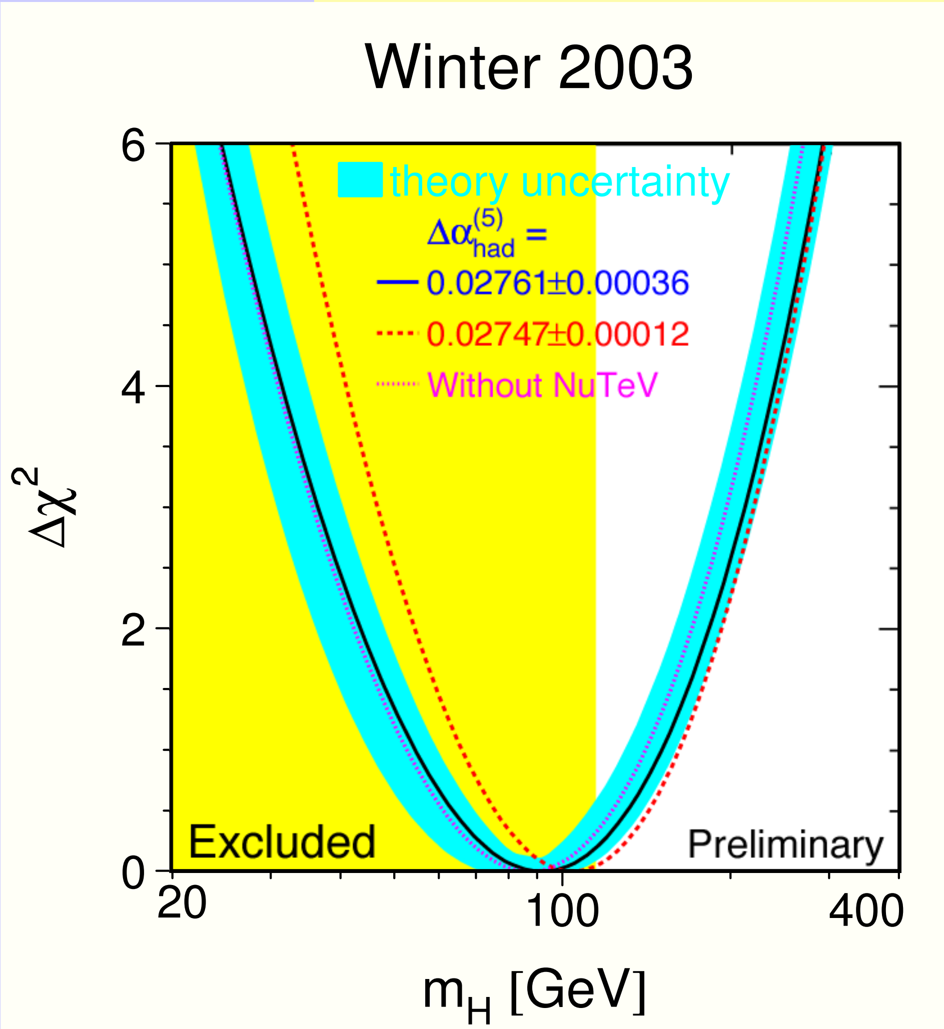
A Rich History as a Powerful Probe



Why a TeV Scale?

- **Two parallel developments over the past few years (the science & the technology)**
  - The precision information e^+e^- and ν data at present energies have pointed to a low mass Higgs; Understanding electroweak symmetry breaking, whether supersymmetry or an alternative, will require precision measurements.
  - There are strong arguments for the complementarity between a ~0.5-1.0 TeV ILC and the LHC science.

Electroweak Precision Measurements



e^+e+ and neutrino scattering results at present energies strongly point to a low mass Higgs and an energy scale for new physics < 1TeV

Why a TeV Scale e^+e^- Accelerator?

- **Two parallel developments over the past few years (the science & the technology)**
  - **The precision information from LEP and other data have pointed to a low mass Higgs; Understanding electroweak symmetry breaking, whether supersymmetry or an alternative, will require precision measurements.**
  - **There are strong arguments for the complementarity between a ~0.5-1.0 TeV LC and the LHC science.**

LHC/ILC Complementarity

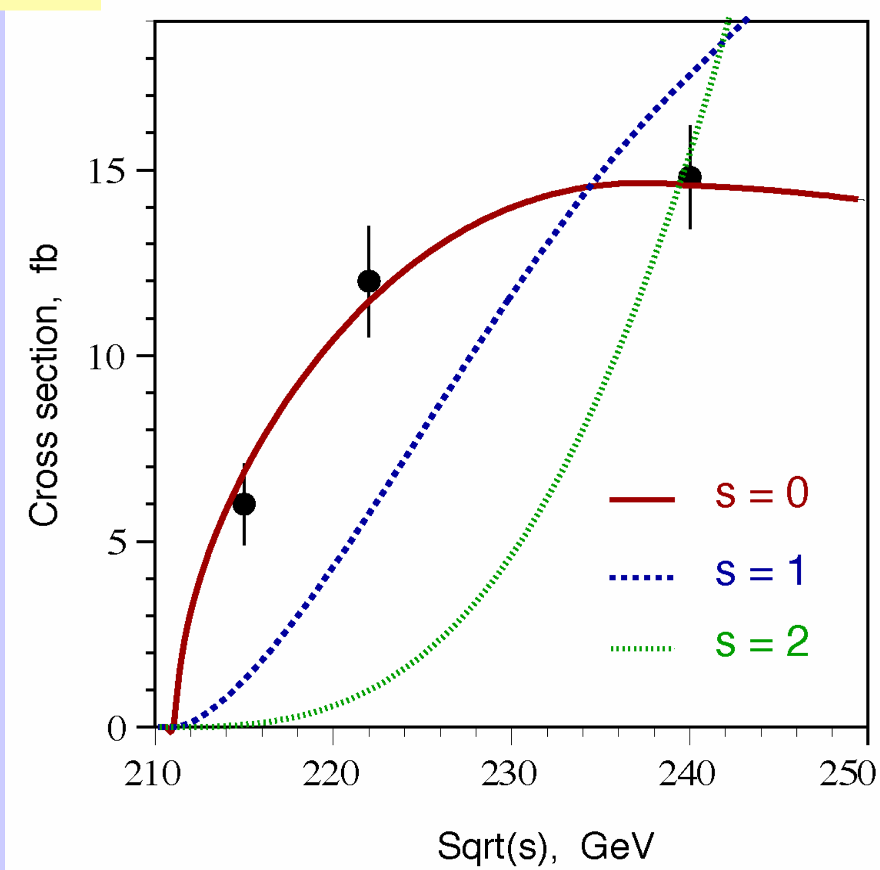
Linear Collider Spin Measurement

The Higgs must be spin zero

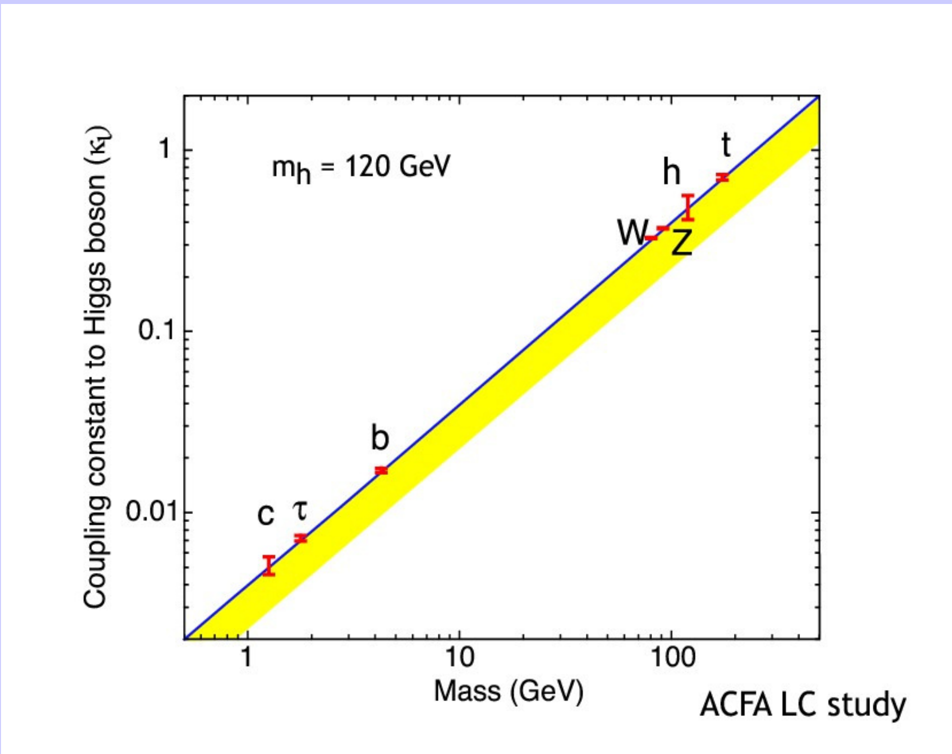
LHC should discover the Higgs

The linear collider should measure its spin

The process $e^+e^- \rightarrow HZ$ can be used to measure the spin of a 120 GeV Higgs particle.



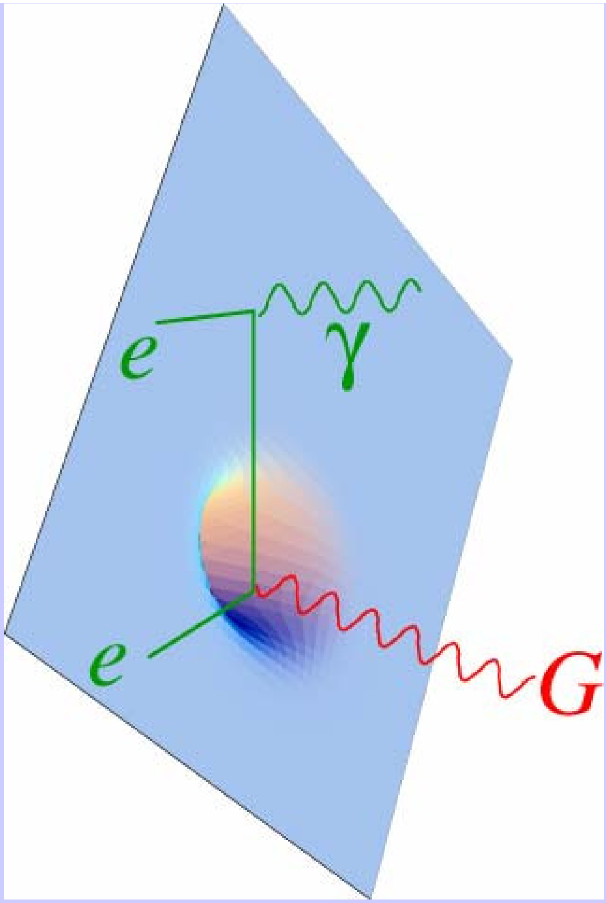
Higgs Coupling and Extra Dimensions

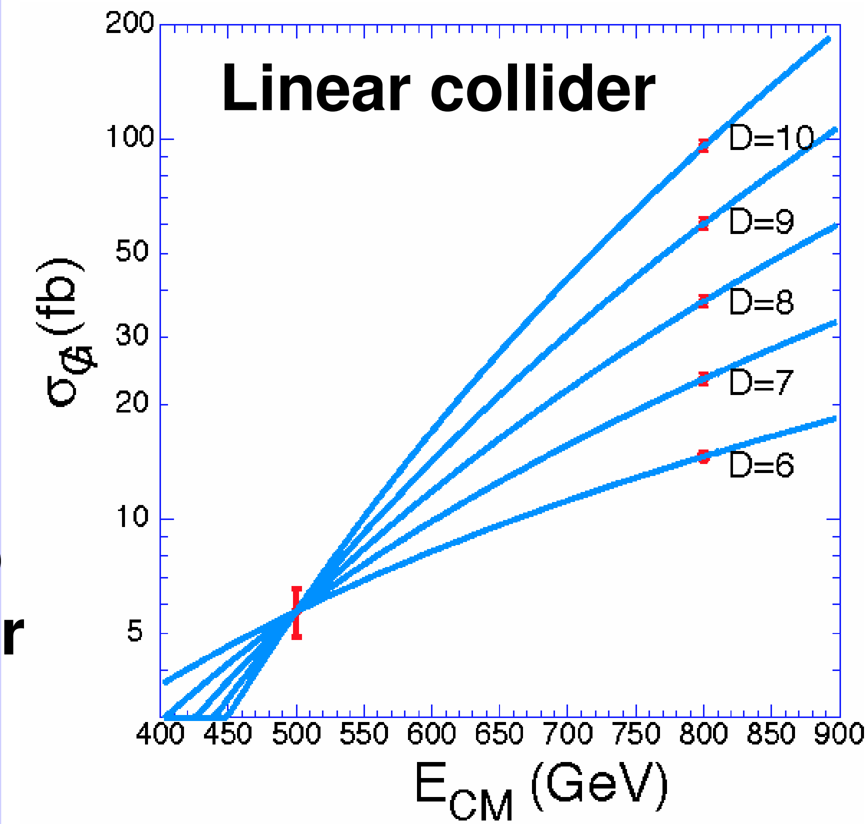


- ILC precisely measures Higgs interaction strength with standard model particles.
- Straight blue line gives the standard model predictions.
- Range of predictions in models with extra dimensions -- yellow band, (at most 30% below the Standard Model
- The models predict that the effect on each particle would be exactly the same size.
- The red error bars indicate the level of precision attainable at the ILC for each particle
- Sufficient to discover extra dimensional physics.

LHC/ILC Complementarity

Extra Dimensions



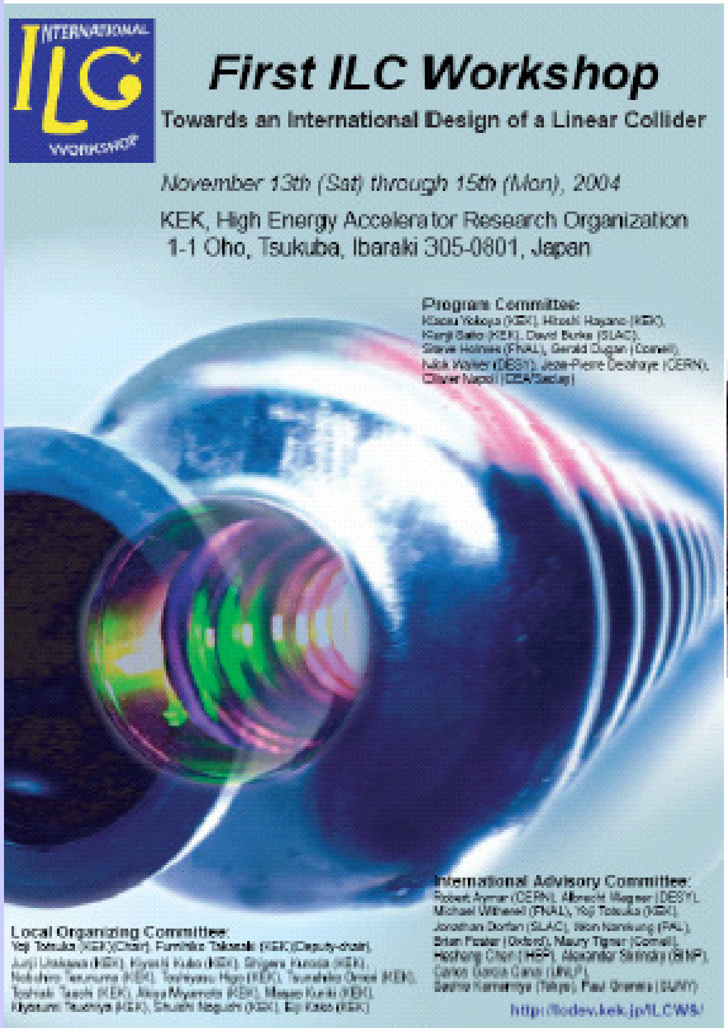


Map extra dimensions: study the emission of gravitons into the extra dimensions, together with a photon or jets emitted into the normal dimensions.

The SCRF Technology Recommendation

- The recommendation of ITRP was presented to ILCSC & ICFA on August 19, 2004 in a joint meeting in Beijing.
- ICFA unanimously endorsed the ITRP's recommendation on August 20, 2004

The Community then Self-Organized



Nov 13-15, 2004

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

15

The First ILC Meeting at KEK

There were 220 participants divided among 6 working groups

Working Group 1: Overall Design
Working Group 2: Main Linac
Working Group 3: Injector, including damping rings
Working Group 4: Beam Delivery Systems, including collimator, final focus, etc.
Working Group 5: Cavity design: higher gradients, ..
Working Group 6: Strategic communication

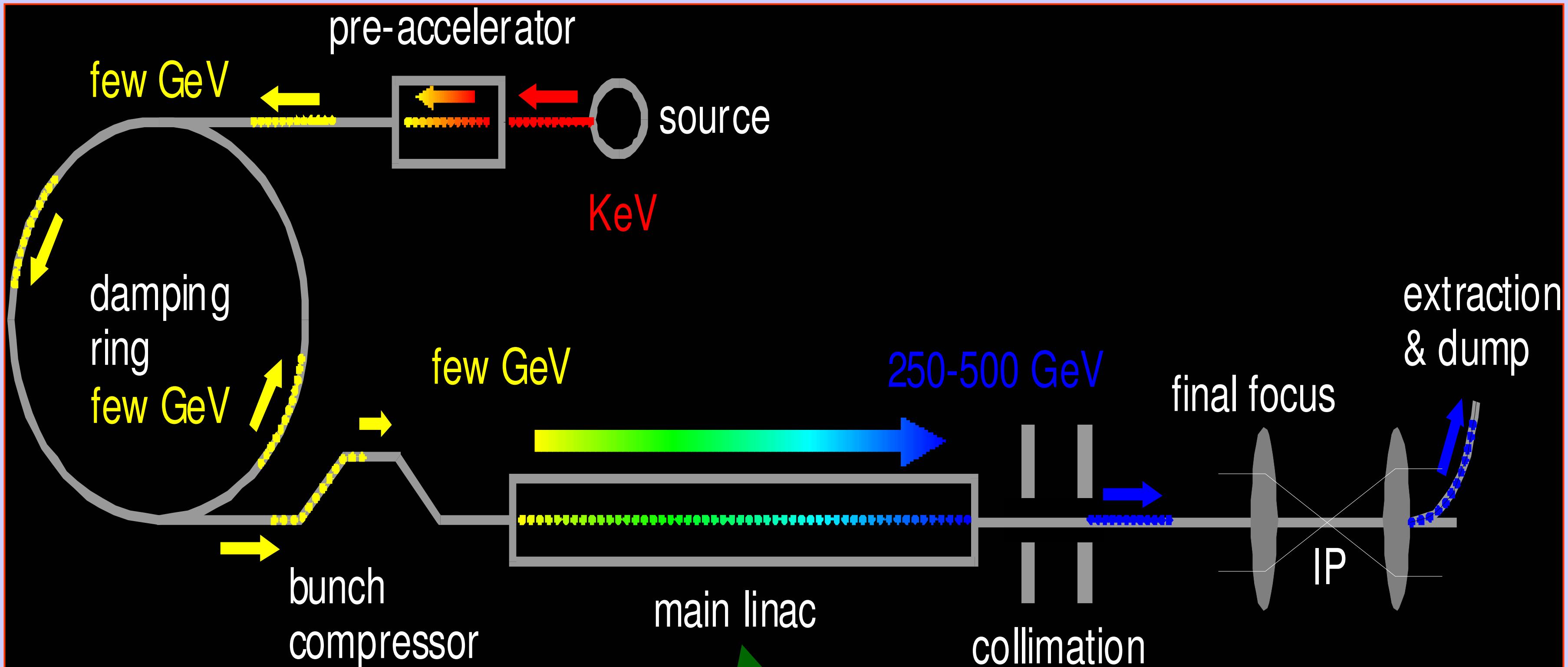
Each working group had three convenors, one from each region

Snowmass – GDE Takes Over

- ‘Global Groups’ are being formed, in addition to the 7WGs (sub-system working groups)

Subsystem Working Groups		Global Groups	
WG1	Beam dynamics from DR exit to IP, incl. bunch compressor design	GG1	Parameters, layout
WG2	Linac except cavities	GG2	Instrumentation
WG3a	Particle sources (e^-, e^+)	GG3	Reliability, MPS, availability, etc.
WG3b	Damping ring	GG4	Cost engineering
WG4	Beam delivery	GG5	Civil engineering
WG5	Accelerating cavities	GG6?	Options (γ-γ, e^-e^-, GigaZ, etc)
WG6	Communication		

Starting Point for the GDE



Superconducting RF Main Linac

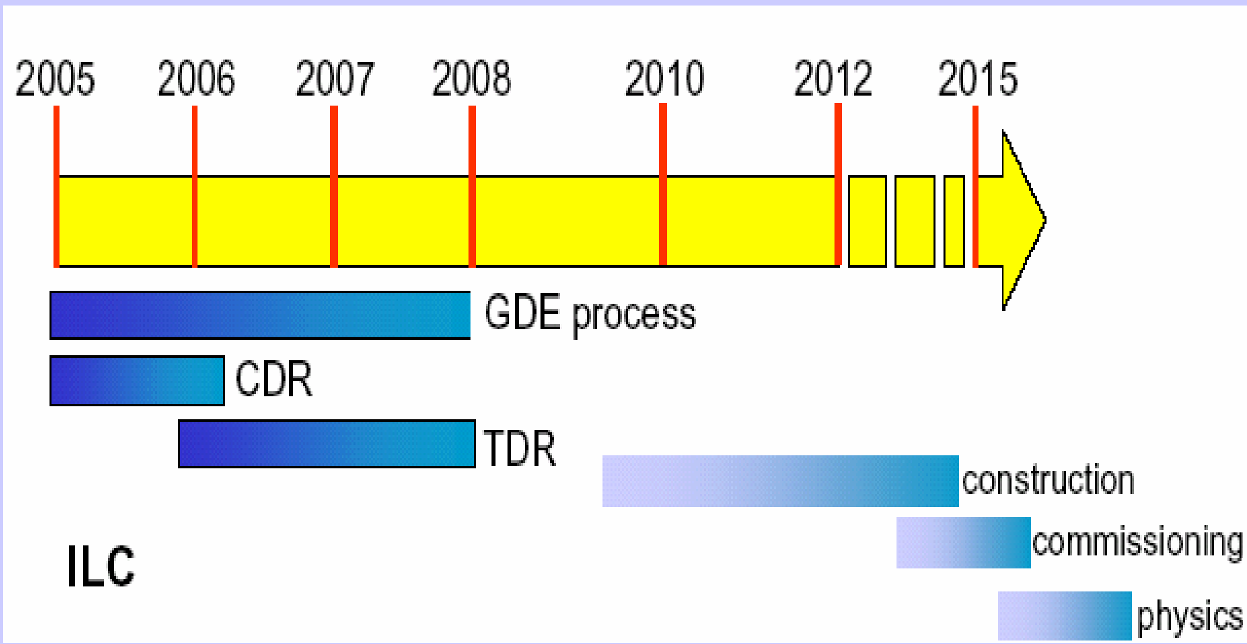
Parameters for the ILC

- 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**

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

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

  - Put Baseline under Configuration Control (Jan 06)
  - Develop Reference Design Report by end of 2006
- Three volumes -- 1) Reference 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.** (Gerry Dugan (North America), Fumihiko Takasaki (Asia), Brian Foster (Europe))
  - **Make Website, coordinate meetings, coordinate R&D programs, 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)**

GDE – Near Term Plan

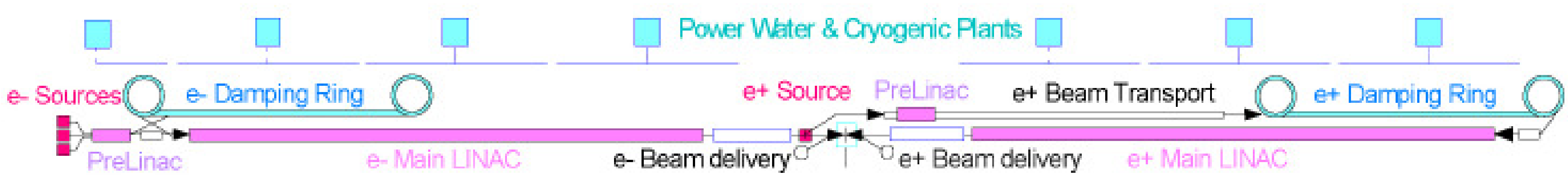
- **Staff the GDE**
  - **Administrative, Communications, Web staff**
  - **Regional Directors (one per region)**
  - **Engineering/Costing Engineer (one per region)**
  - **Civil Engineer (one per region)**
  - **Key Experts for the GDE design staff from the world community**
  - **Fill in missing skills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

Total staff size about 20 FTE (2005-2006)

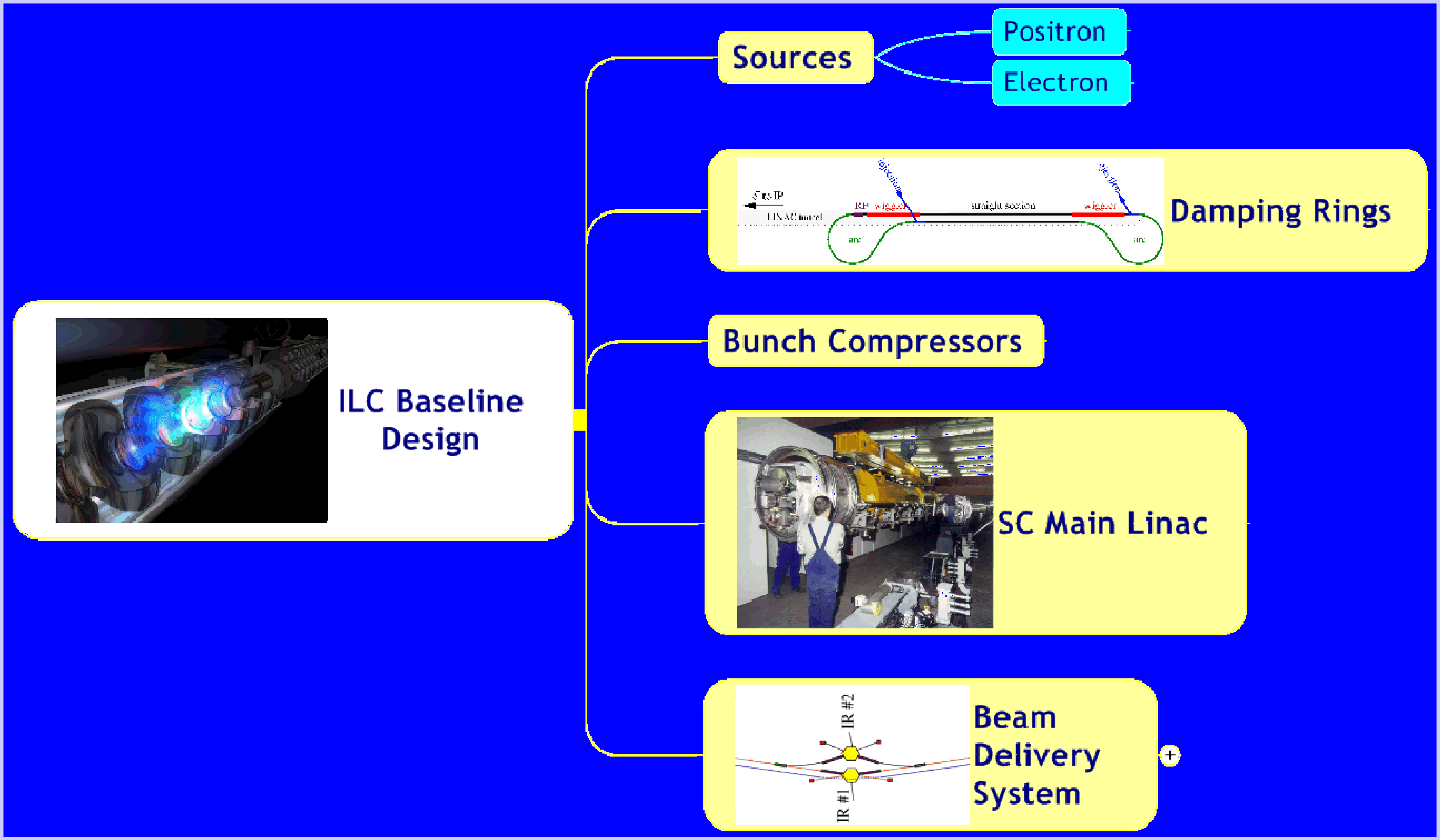
Design Issues

Many design alternatives still remain after cold/warm decision
(blue: TESLA TDR for 1TeV, red: alternatives)

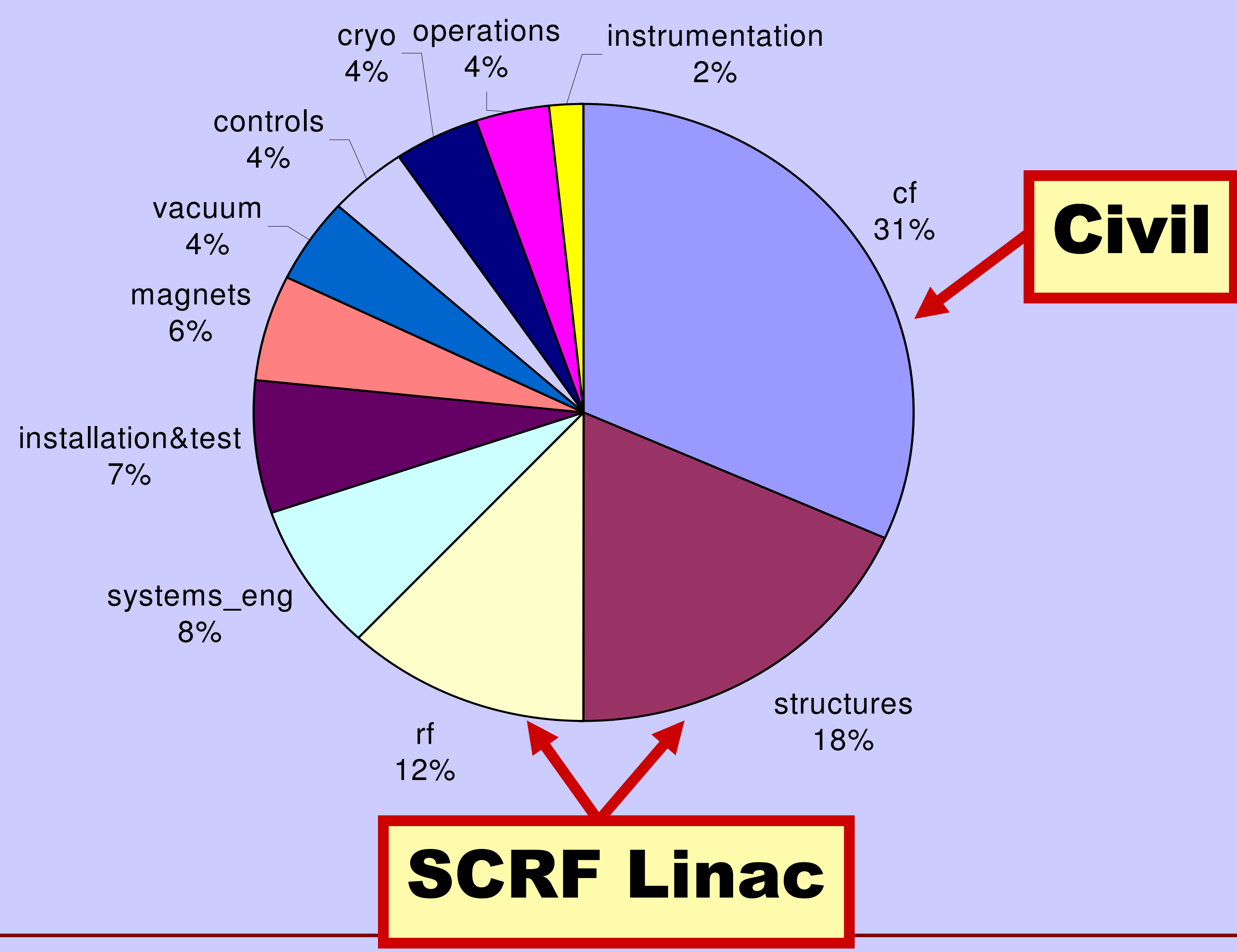
- Accelerating gradient: 35MV/m or higher ?
- Tunnel: Single or double (or triple) ?
- Positron production: undulator or conventional ?
- Damping ring shape & size: dogbone or small ?
- Number of bunch compressors: 1, or 2 (or 3) ?
- Crossing angle: zero or small or large ?



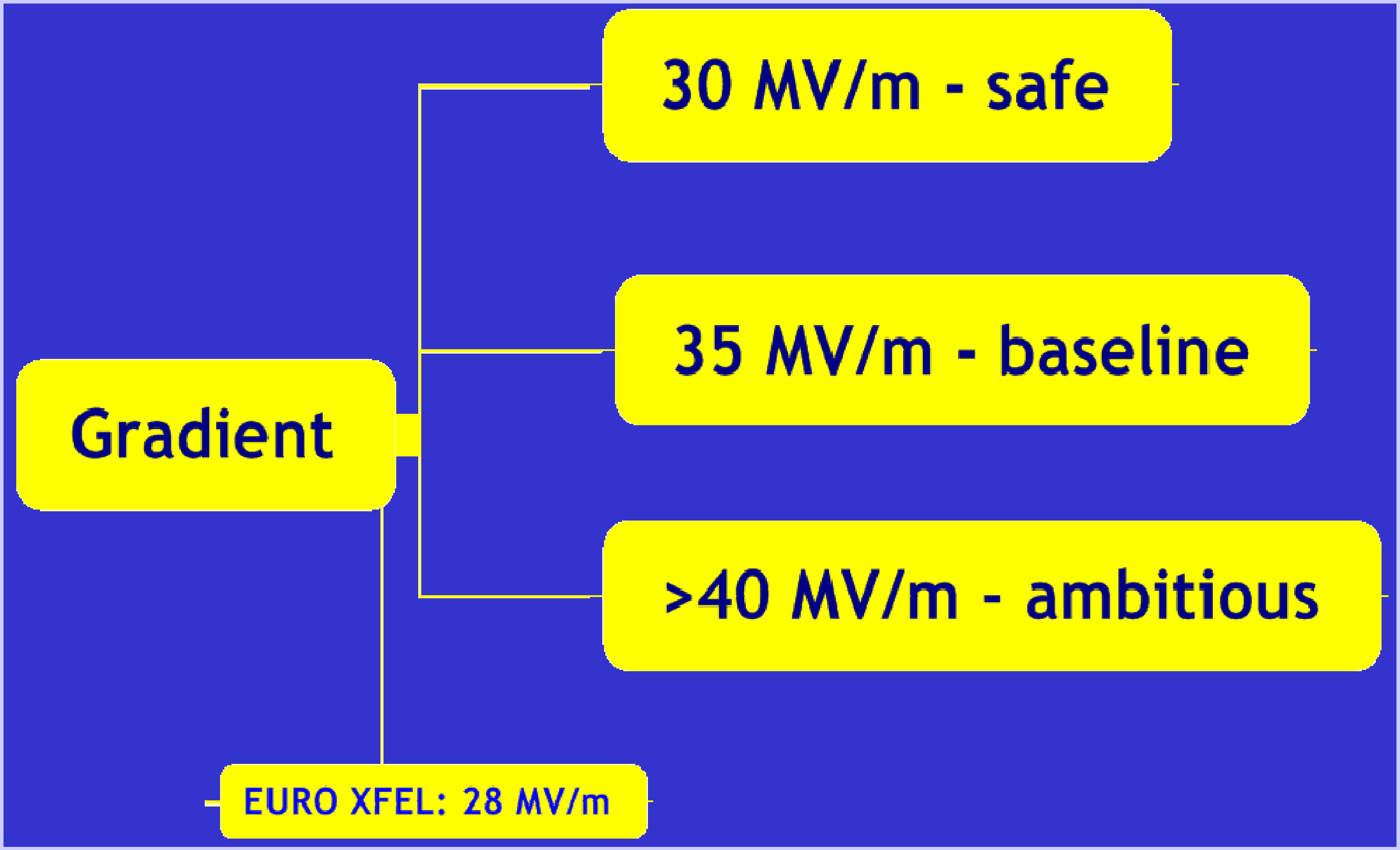
Towards the ILC Baseline Design



Cost Breakdown by Subsystem

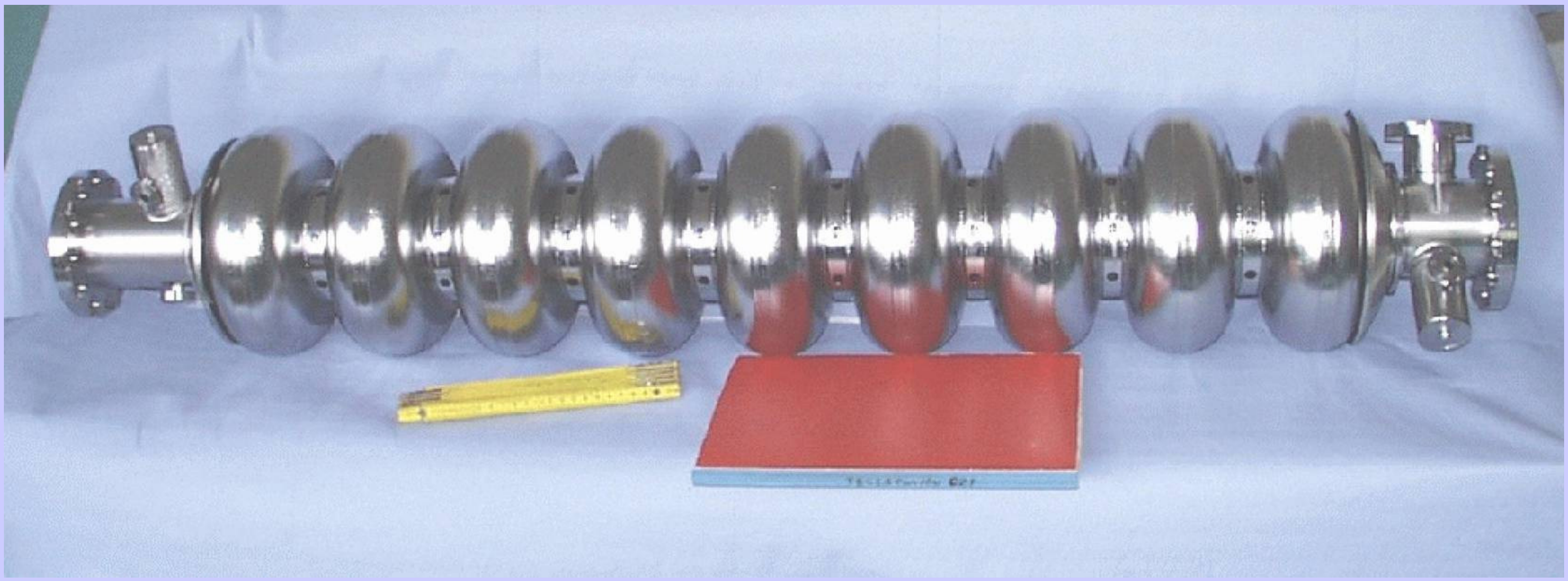


What Gradient to Choose?



TESLA Cavity

~1m

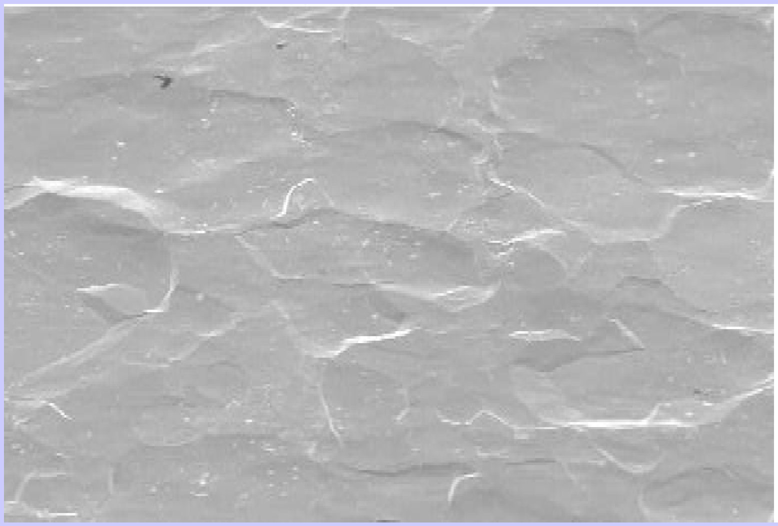


9-cell 1.3GHz Niobium Cavity

Reference design: has not been modified in 10 years

Electro-polishing

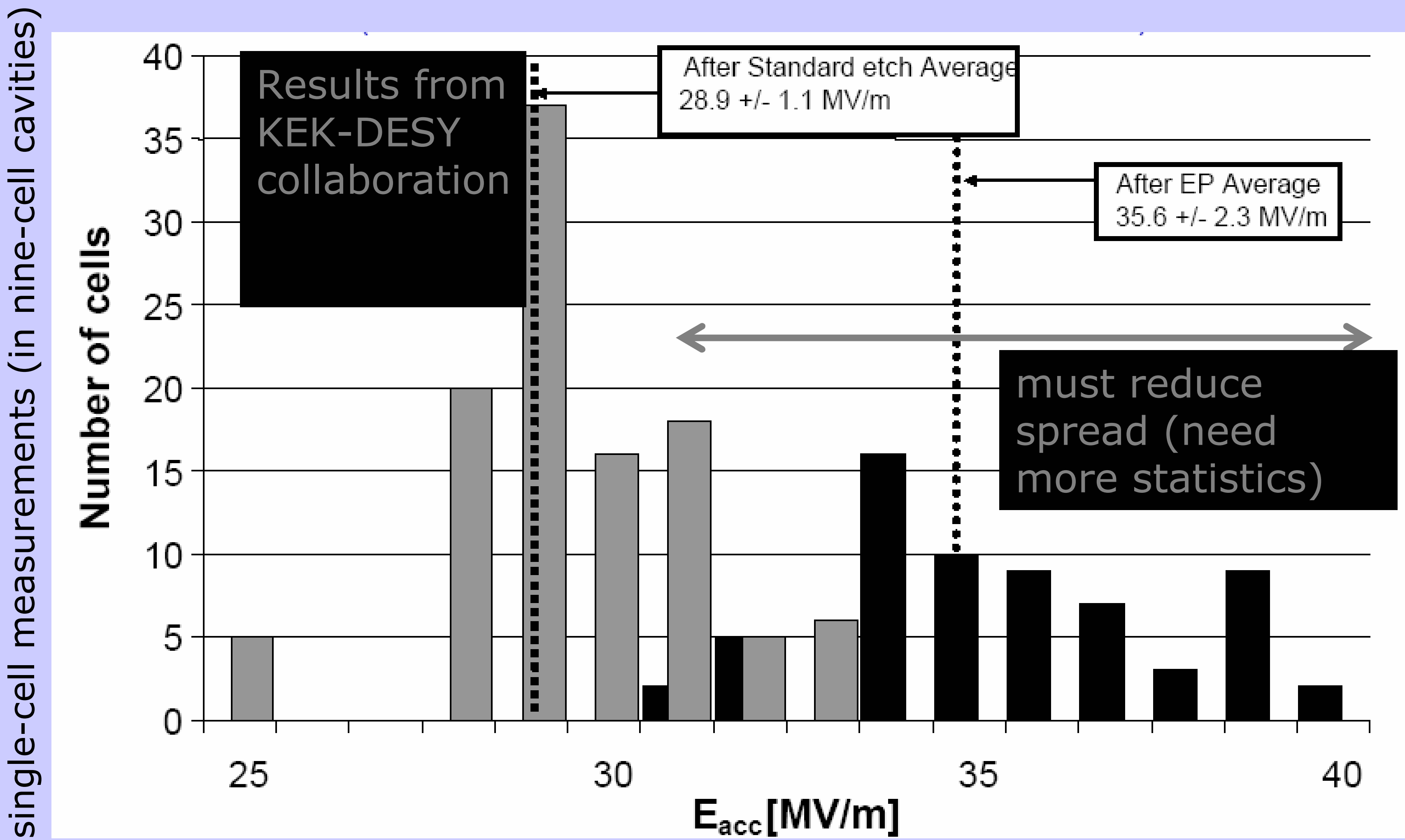
(Improve surface quality -- pioneering work done at KEK)



BCP **EP**

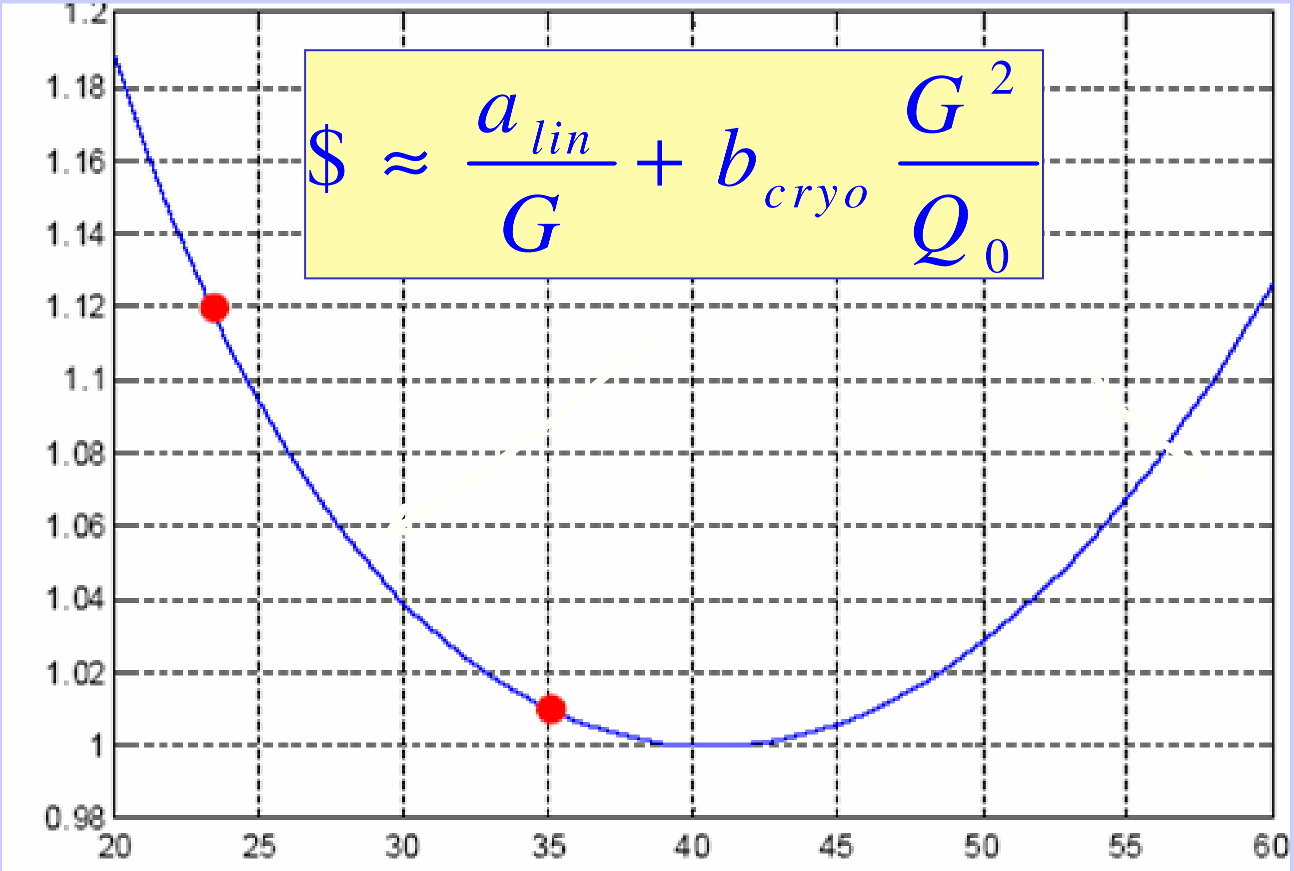
- **Several single cell cavities at g > 40 MV/m**
- **4 nine-cell cavities at ~35 MV/m, one at 40 MV/m**
- **Theoretical Limit 50 MV/m**

Gradient


single-cell measurements (in nine-cell cavities)
Number of cells
40
35
30
25
20
15
10
5
0
25
30
35
40
E_{acc}[MV/m]
Results from KEK-DESY collaboration
After Standard etch Average 28.9 +/- 1.1 MV/m
After EP Average 35.6 +/- 2.3 MV/m
must reduce spread (need more statistics)

How Costs Scale with Gradient?

Relative Cost



$$\$ \approx \frac{a_{lin}}{G} + b_{cryo} \frac{G^2}{Q_0}$$

C. Adolphsen (SLAC)

Gradient MV/m

35MV/m is close to optimum

Japanese are still pushing for 40-45MV/m

30 MV/m would give safety margin

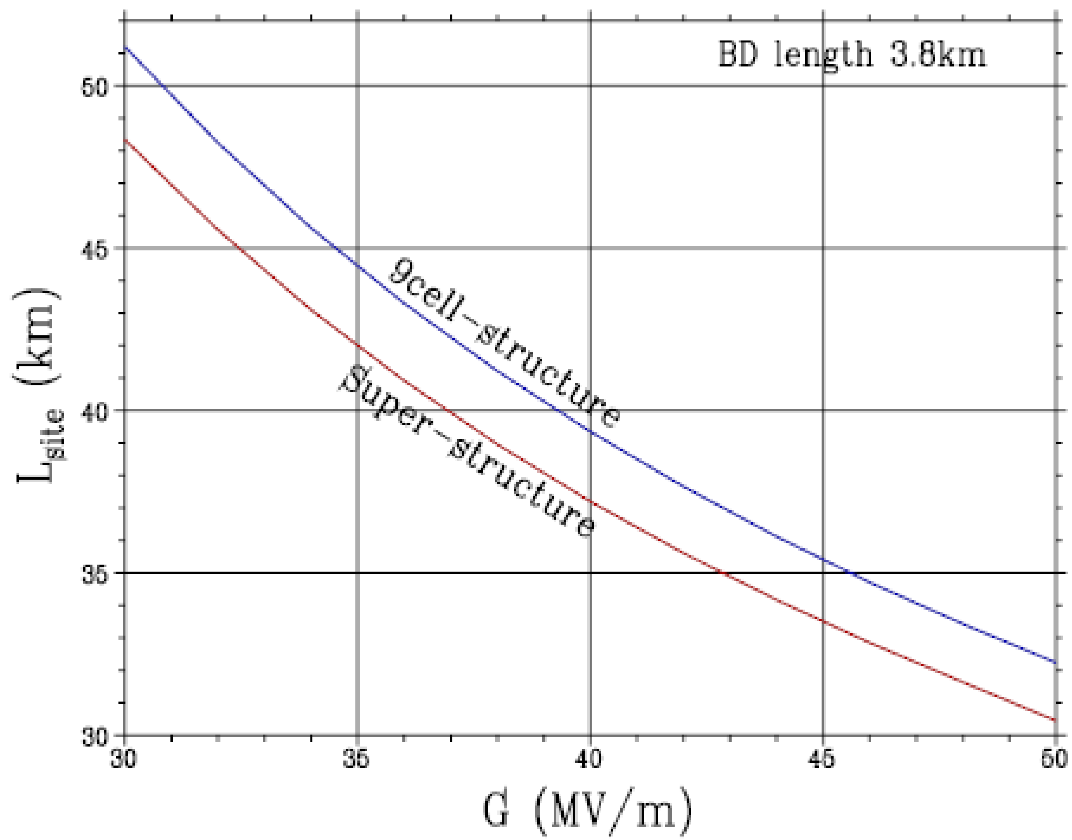
Gradient

- Must reach 1TeV
- Impact on the site length
- Cost minimum
  35-40MV/m
- Conclusion of the WG5
  in 1st WS at KEK

25MV/m in hand
35MV/m needs essential work
45MV/m for ILC upgrade

- LCWS2005 by N. Walker

30MV/m safe
35MV/m beaseline
40MV/m ambitius



Site length vs. Gradient for 1TeV

Evolve the Cavities

Minor Enhancement

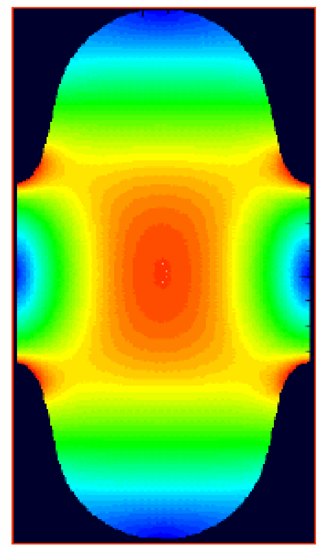
Low Loss Design

Modification to cavity shape reduces peak B field. (A small Hp/Eacc ratio around 35Oe/(MV/m) must be designed).

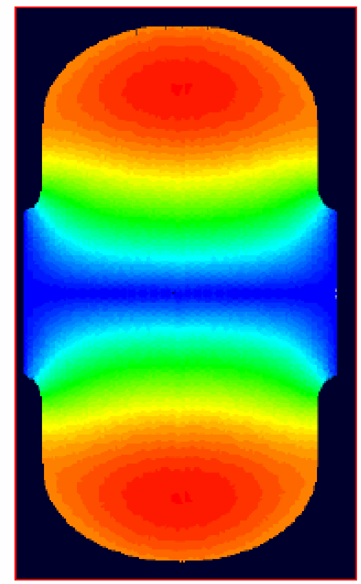
This generally means a smaller bore radius

Trade-offs (Electropolishing, weak cell-to-cell coupling, etc)

Baseline
TESLA shape

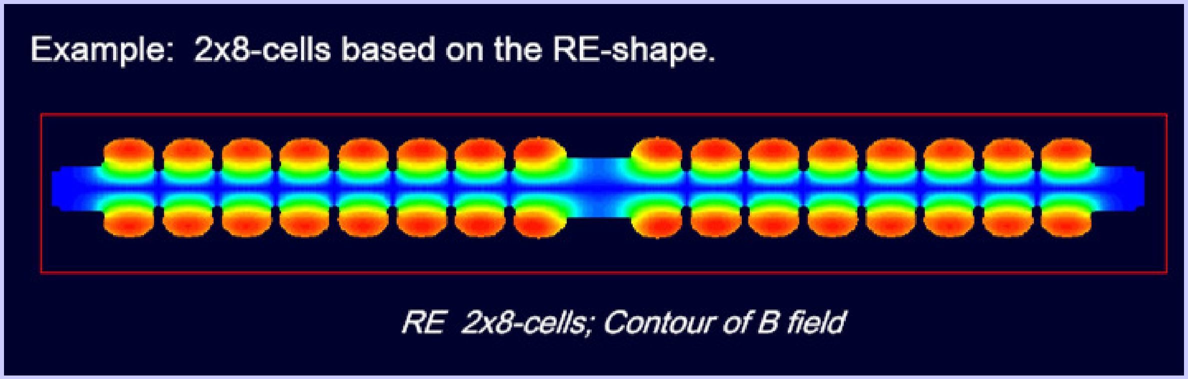


Low Loss Shape
LL



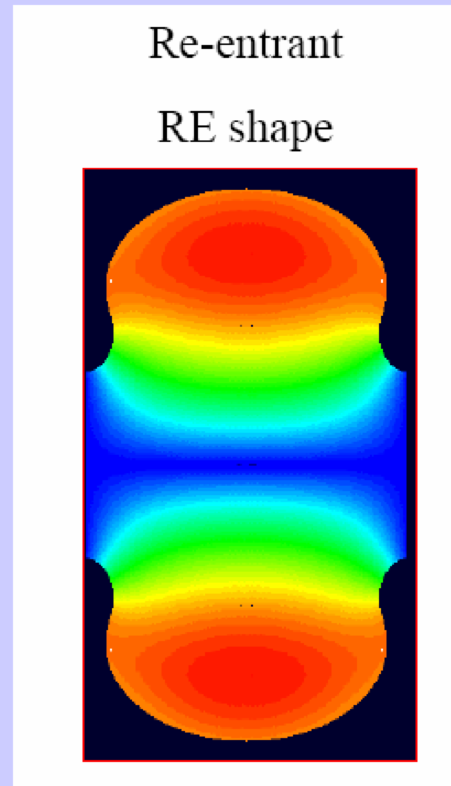
KEK currently producing prototypes

New Cavity Design



2×8 cell Super-structure

Re-entrant



More radical concepts *potentially* offer greater benefits.

But require time and major new infrastructure to develop.

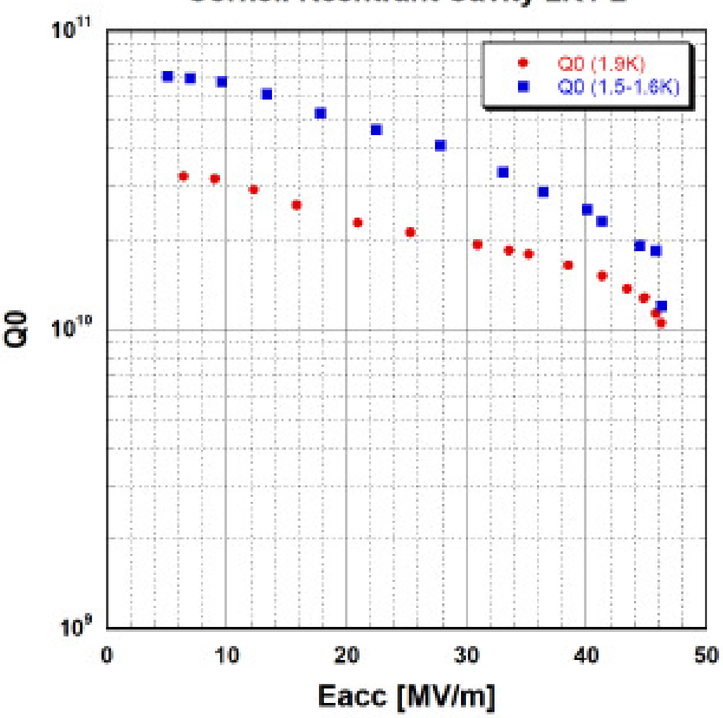
single-cell achieved 45.7 MV/m Q_0 ~10^{10} (Cornell)

Experimental Status

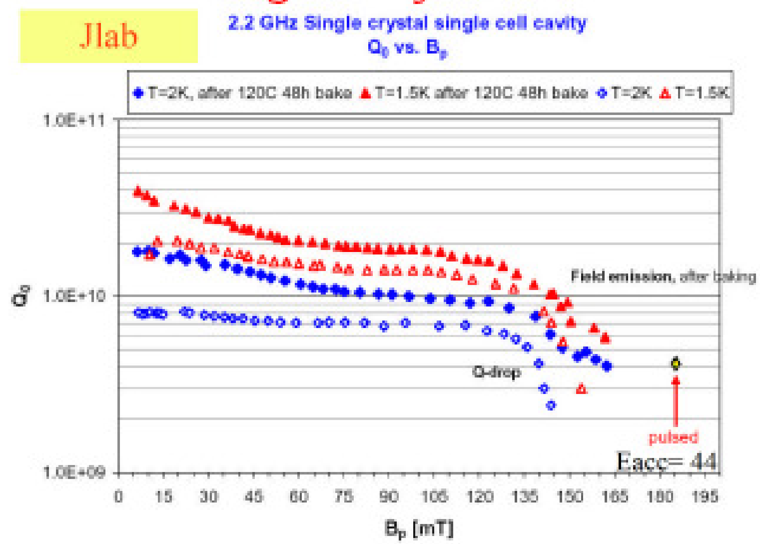
single cell

Cornell Reentrant 1.3GHz

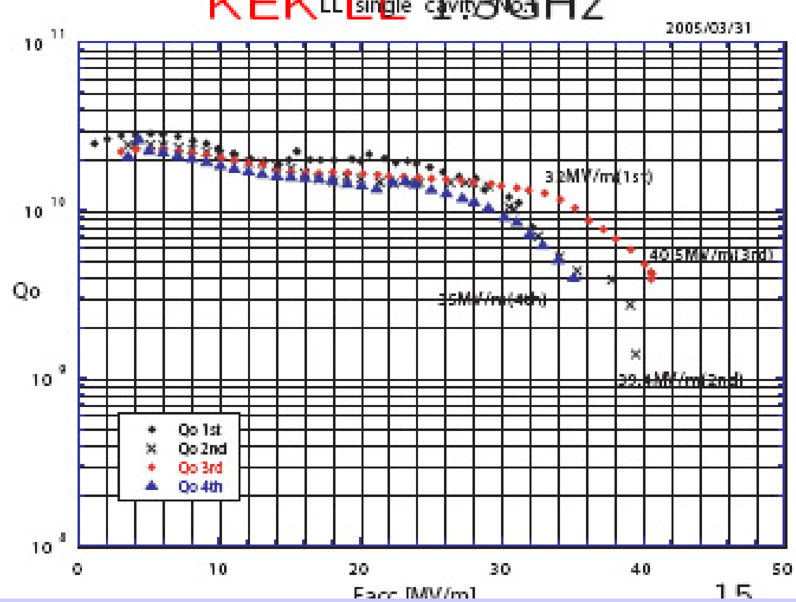
47MV/m (pulsed) 1800 Oe



JLab Single Crystal 2.2GHz



KEK LL 1.3GHz



Accelerator Physics Challenges

- Develop High Gradient Superconducting RF systems
  - Requires efficient RF systems, capable of accelerating high power beams (~MW) with small beam spots(~nm).
- Achieving nm scale beam spots
  - Requires generating high intensity beams of electrons and positrons
  - Damping the beams to ultra-low emittance in damping rings
  - Transporting the beams to the collision point without significant emittance growth or uncontrolled beam jitter
  - Cleanly dumping the used beams.
- Reaching Luminosity Requirements
  - Designs satisfy the luminosity goals in simulations
  - A number of challenging problems in accelerator physics and technology must be solved, however.

The GDE Plan

- **The Machine**
  - **Accelerator baseline configuration will be determined and documented (BCD) by the end of 2005**
  - **R&D program and priorities determined (proposal driven)**
  - **Baseline configuration will be the basis of a reference design done in 2006**
- **The Detector(s)**
  - **Determine features, scope: one or two, etc (same time scale)**
  - **Measure performance of the baseline design**
  - **Beam delivery system and machine detector interfaces**
  - **Define and motivate the future detector R&D program**