ILC WG5 Topics 0.
Cavity gradient and Q

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Mission

1. Make argument about the BCD nominal operation performance for ILC500

   Nominal operation gradient Eacc and Qo @ Eacc
   Cavity performance before installation Eacc and Qo
   R & D program goa Eacc and Qol

2. Propose the ACD and the Goals for ILC500

The overall parameters for the ILC are listed in the ILC Scope document from the ILCSC, which can be found at: http://www.fnal.gov/directorate/icfa/LC_parameters.pdf. This specifies three integrated luminosity goals:

1) 500 fb^{-1} at 500 GeV after the 1st 4 years of physics operation and
2) 500 fb^{-1} at 500 GeV in the following two to three years or
3) 1000 fb^{-1} at 1 TeV in the following four years

In the absence of a GDE, it is probably not possible to modify the overall requirements specified by the ILCSC although in the future these specifications may also need review.

Three possible examples that meet these requirements are:

1) a gradient of 35 MV/m with a 10 MW klystron feeding 20 cavities and a beam current of 10.4 mA and a bunch spacing of 384 buckets, or,
2) a gradient of 40 MV/m with a 10 MW klystron feeding 16 cavities and a beam current 11.8 mA and a bunch spacing of 352 buckets, or,
3) a gradient of 30 MV/m with a 10 MW klystron feeding 24 cavities and a beam current of 10.8 mA and a bunch spacing of 400 buckets.

BCD nominal potential gradient and Q for ILC500

35MV/m @ Qo = 0.8E10

Cavity performance before installation
Eacc =35MV/m @ Qo= 0.8E10

R & D program goal
X = Eacc ≥35 MV/m, Qo > 0.8E10

AND

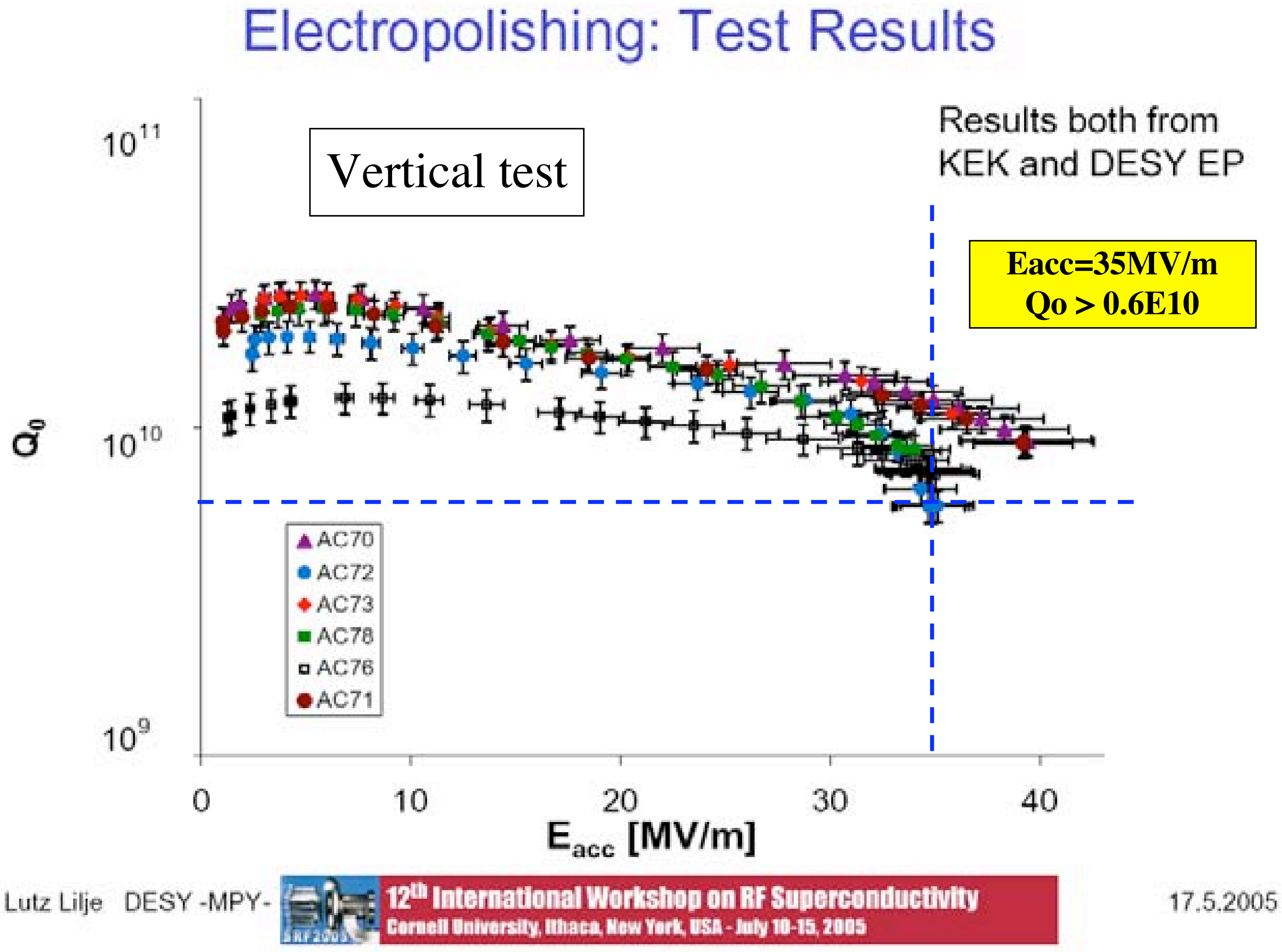
Goals of the R&D program for ACD
Eacc=40MV/m @ 1E10

GG4
1TeV tunnel design
@ 35MV/m

WG2
RF power distribution
for 35MV/m

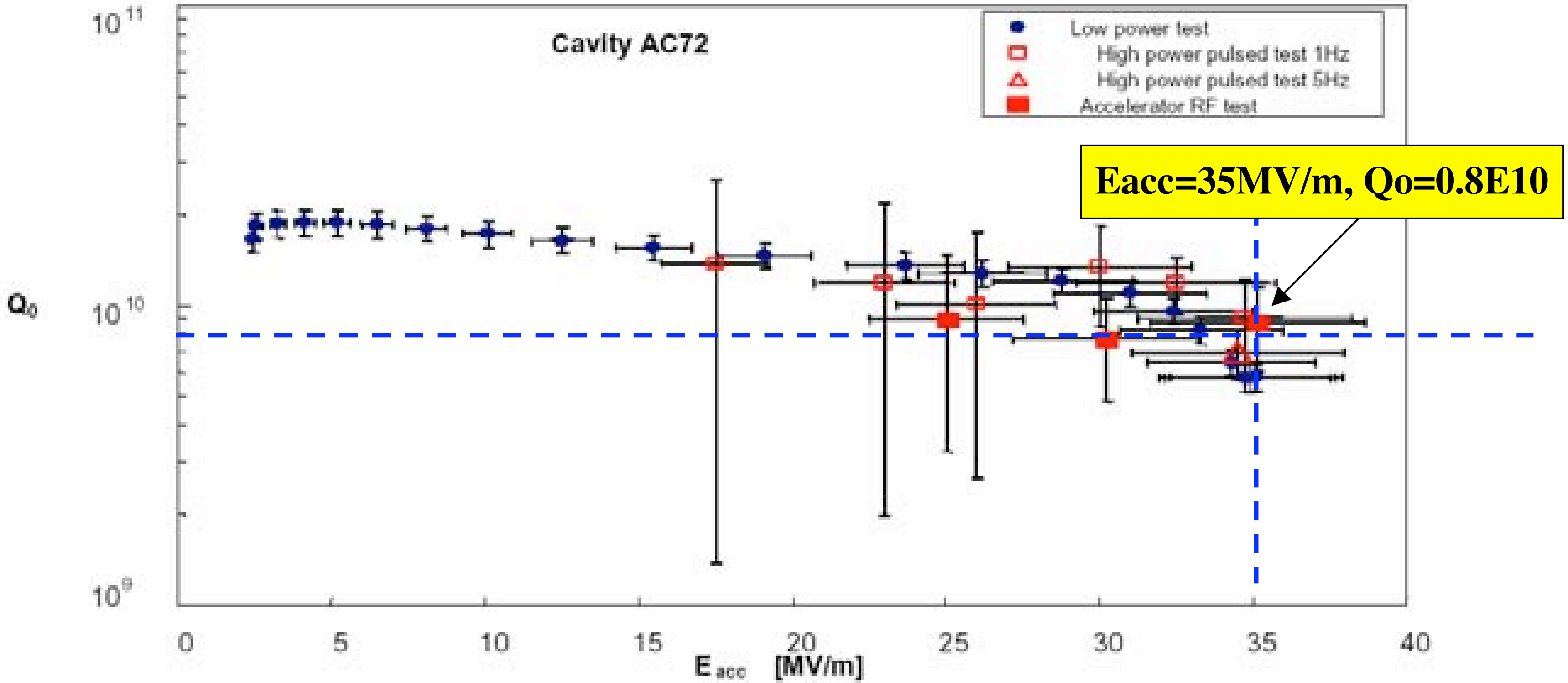
Experimental evidence - I

Reason-1: Evidence is there.



Experimental evidence - II

Cavity Test Inside a Module (ctd.)



- One of the electropolished cavities (AC72) was installed into an accelerating module for the VUV-FEL
- Very low cryogenic losses as in high power tests
- Standard X-ray radiation measurement indicates no radiation up to 35 MV/m

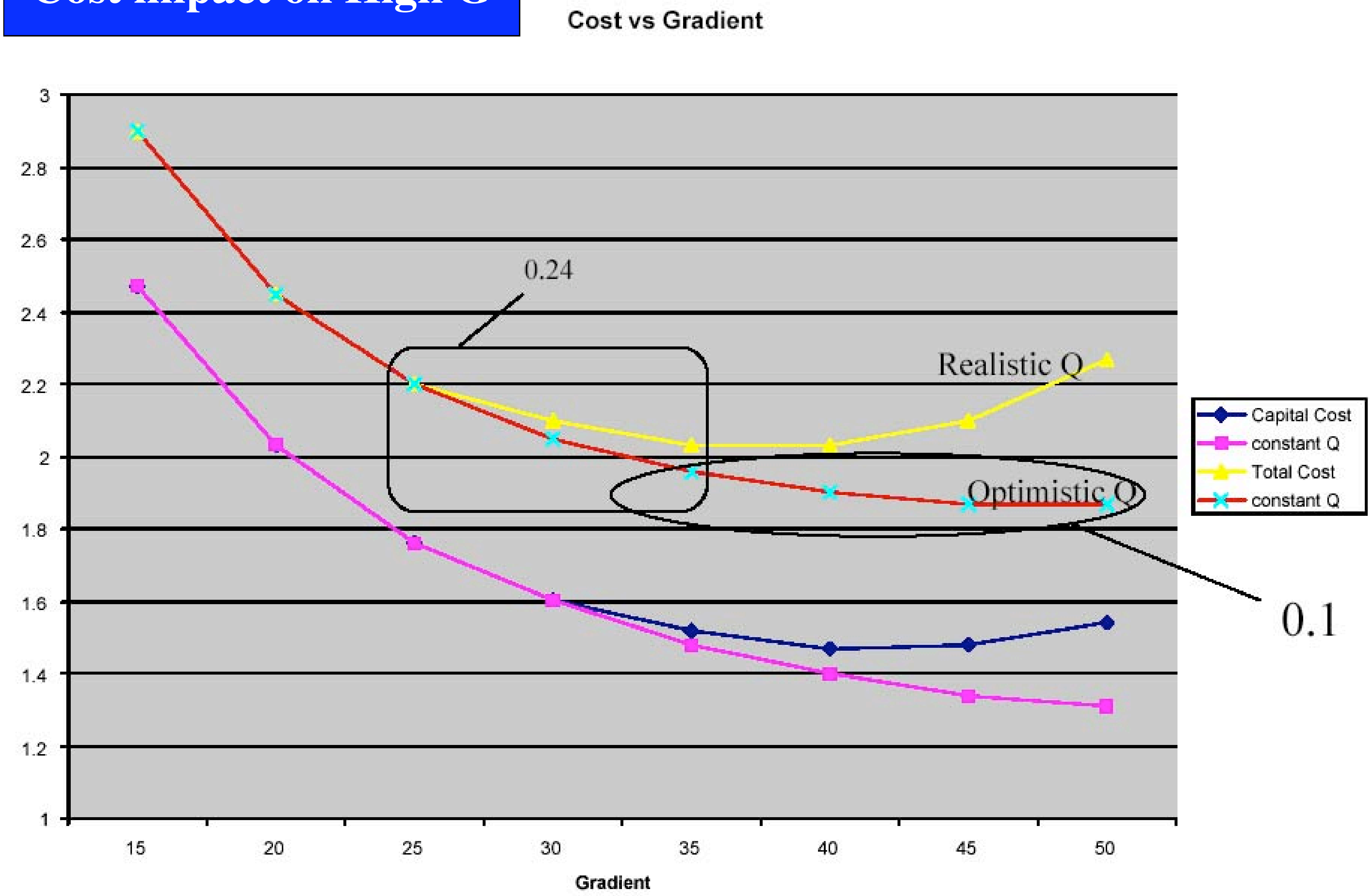
Reason-2: Cost impact

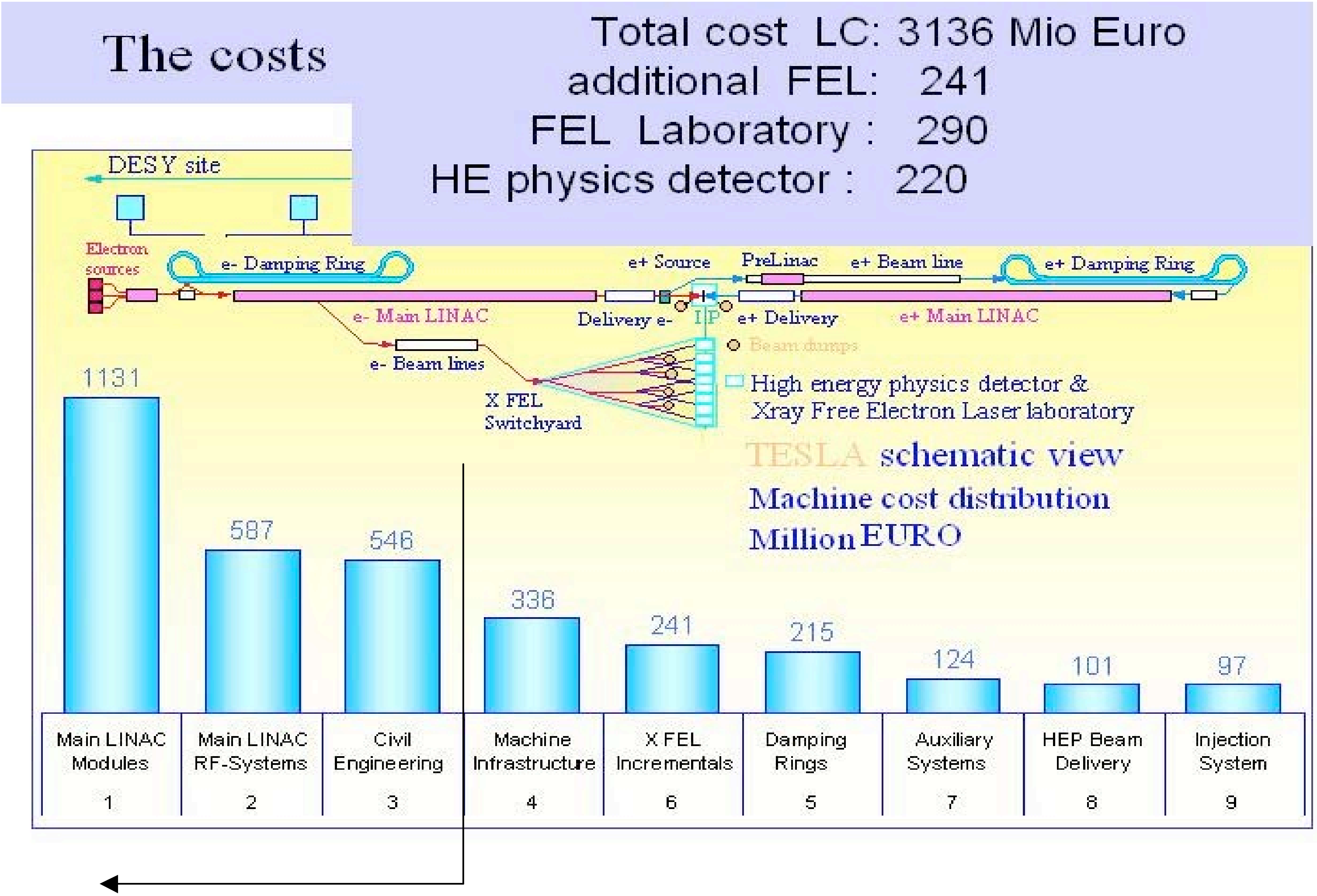
In one model, presented at ILC- KEK in Nov 04 (see Padamsee's PAC05 paper) the total linac cost (capital plus operating), which includes cryomodules, RF and refrigeration, drops by 6.4% from 25 to 30 MV/m, another 2.9% from 30 to 35 MV/m and stays constant for 35 to 40 MV/m. In this model the tunnel costs are not included.

Even, 3 percent makes a big cost benefit for such a large project as ILC

The ILC tunnel length is to be determined for one TeV machine.
Then the higher gradient makes it shorter and results in further cost reduction.

Cost impact on High G





1131+587+548 = 2266M EU(capital cost)

3% cost reduction in ILC total cost > 70M EU or 90M$, 100Okuen

Reason-3:

Shorter tunnel can make easy tunnel site selection.

Reason-4: Ongoing Plans are existing.

Ongoing Plan for 35MV/m operation

1) 35MV/m modlue demonstration in spring 2006 in TTF.

2) KEK is aggressively pushing STF,
where 35(baseline design)-45MV/m(LL-shape) operation will start commissioning from end of 2006.

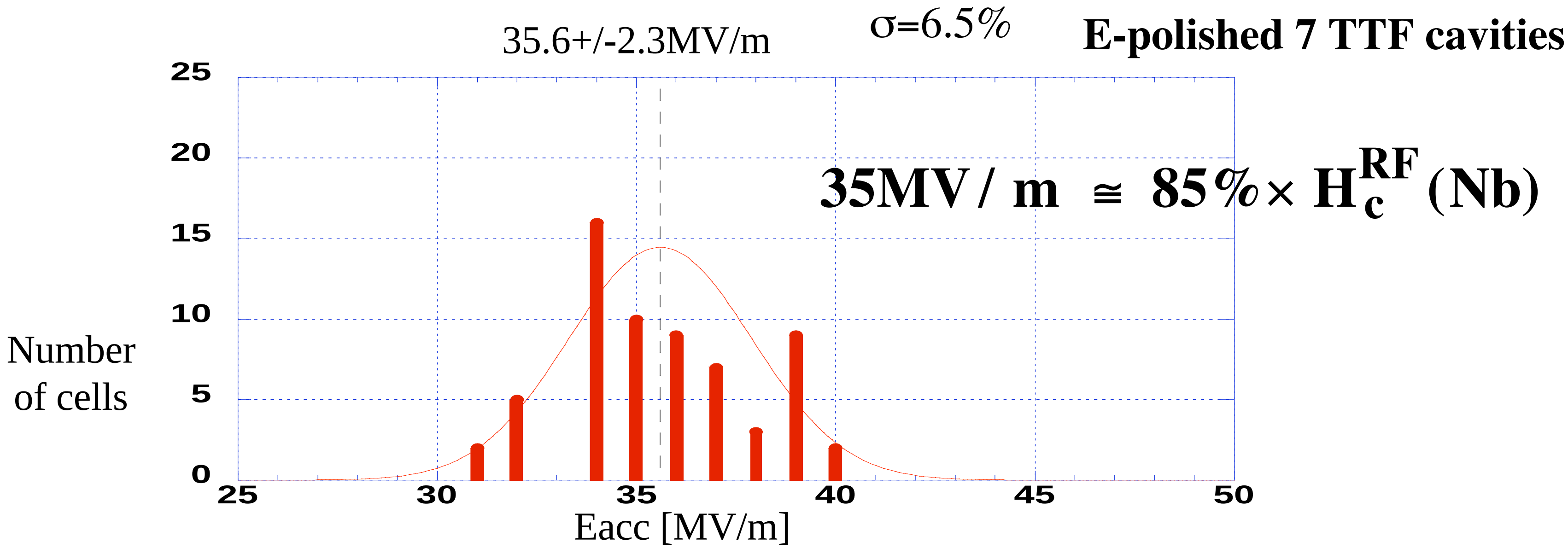
3) FNAL has also similar purpose for SMTF and will start soon.

Reason-5: Consensuses on installed cavity gradient 35MV/m

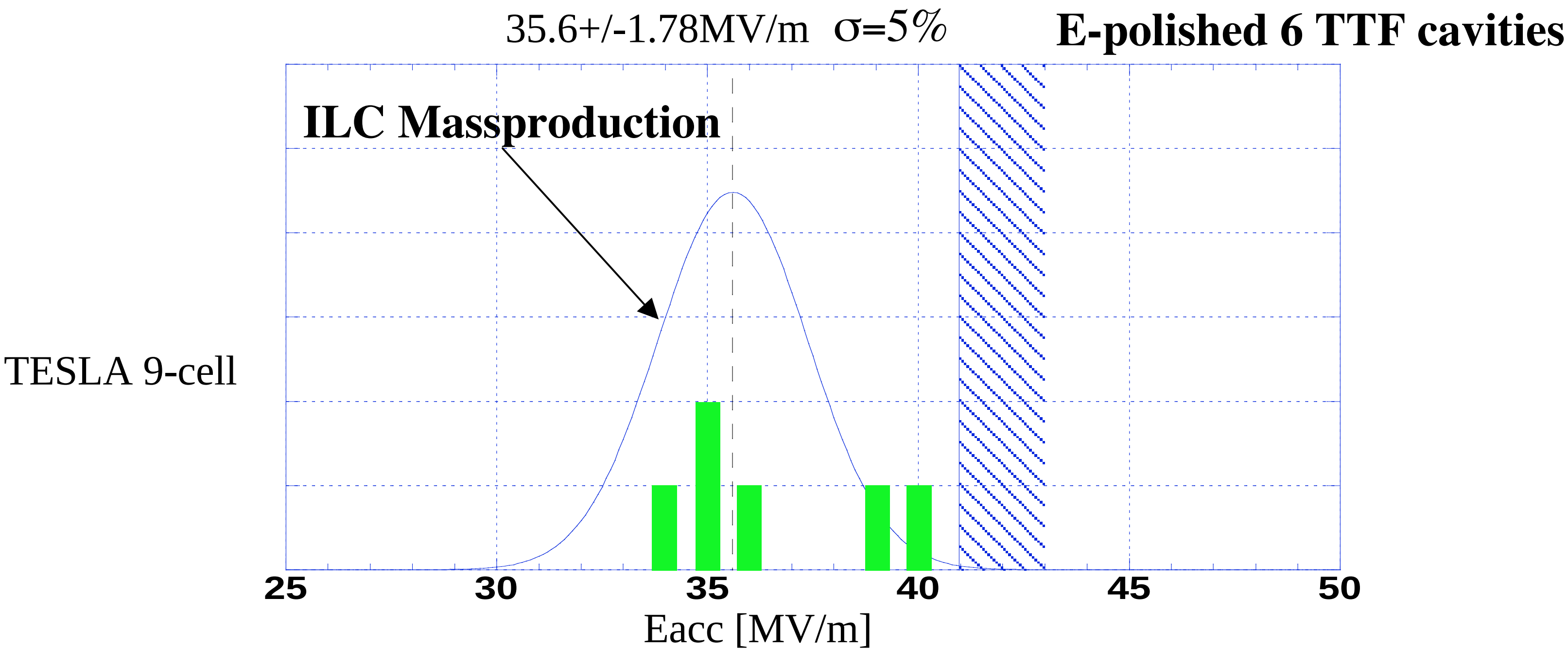
both the TESLA TDR and the US options study concluded that to provide the upgrade capability, the installed cavity gradient should be 35 MV/m.

WG5 Asia will be no problem with this statement.

Scattering in Eacc is the future QA issue.



$$35MV/m \cong 85\% \times H_c^{RF}(Nb)$$



EUR XFEL will start in 2006,
This project will take a very important role to improve QA with cavity performance,
The scattering in gradient and gradient also will be much improved.

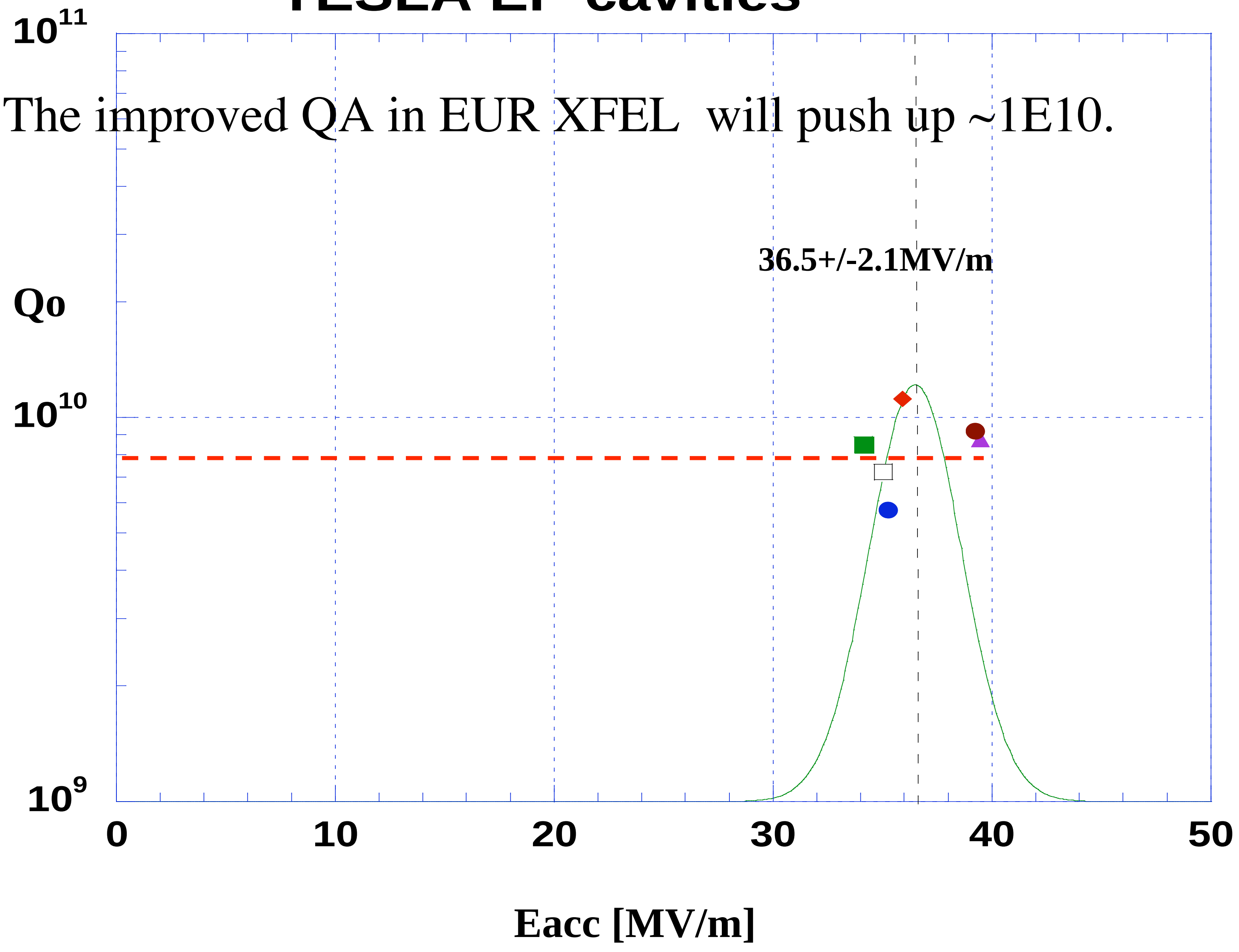
There is no reason to decrease the gradient to 30MV/m at present on August 2005.

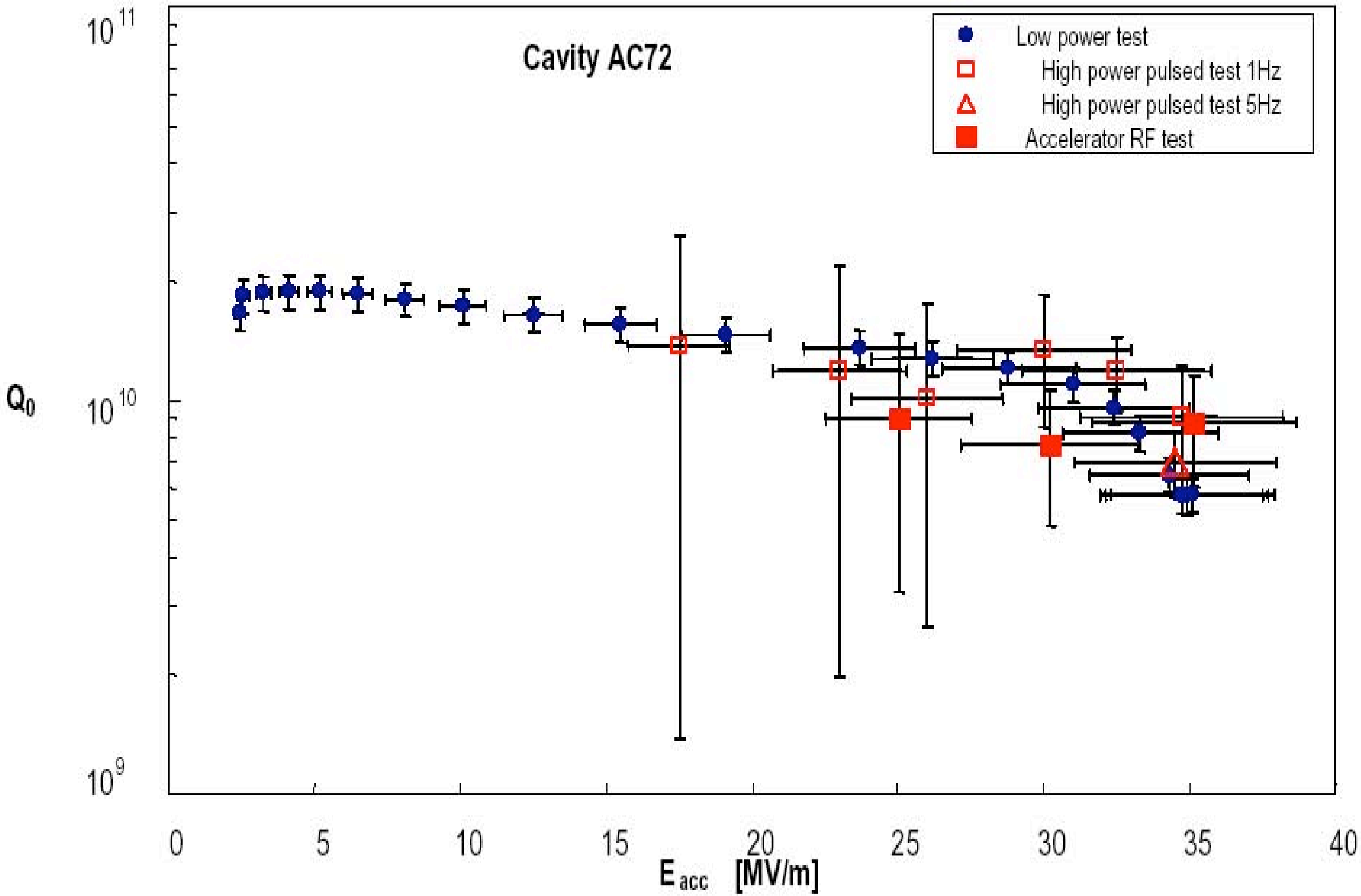
How about Qo

ILC500 BCD : Qo = 0.8E10 @ 35MV/m

TTF result shows no degradations with Eacc and Qo from vertical test in TTF cryomodule pulse operation

TESLA EP cavities





TTF result shows no degradations with Eacc and Qo from vertical test in TTF cryomodule pulse operation

Previous discussion is based on TESLA-shape cavity.

Even considering above things,
if you still feel 35MV/m is too risky for ILC nominal gradient.
It should be related to the close value to fundamental limitation.
Thus need ACD and the R&D goals.

ACD for ILC500

$E_{acc} \geq$ 40 MV / m, $Q_o \geq$ 1E10 @ 40MV / m before installation,

ILC500 operation at

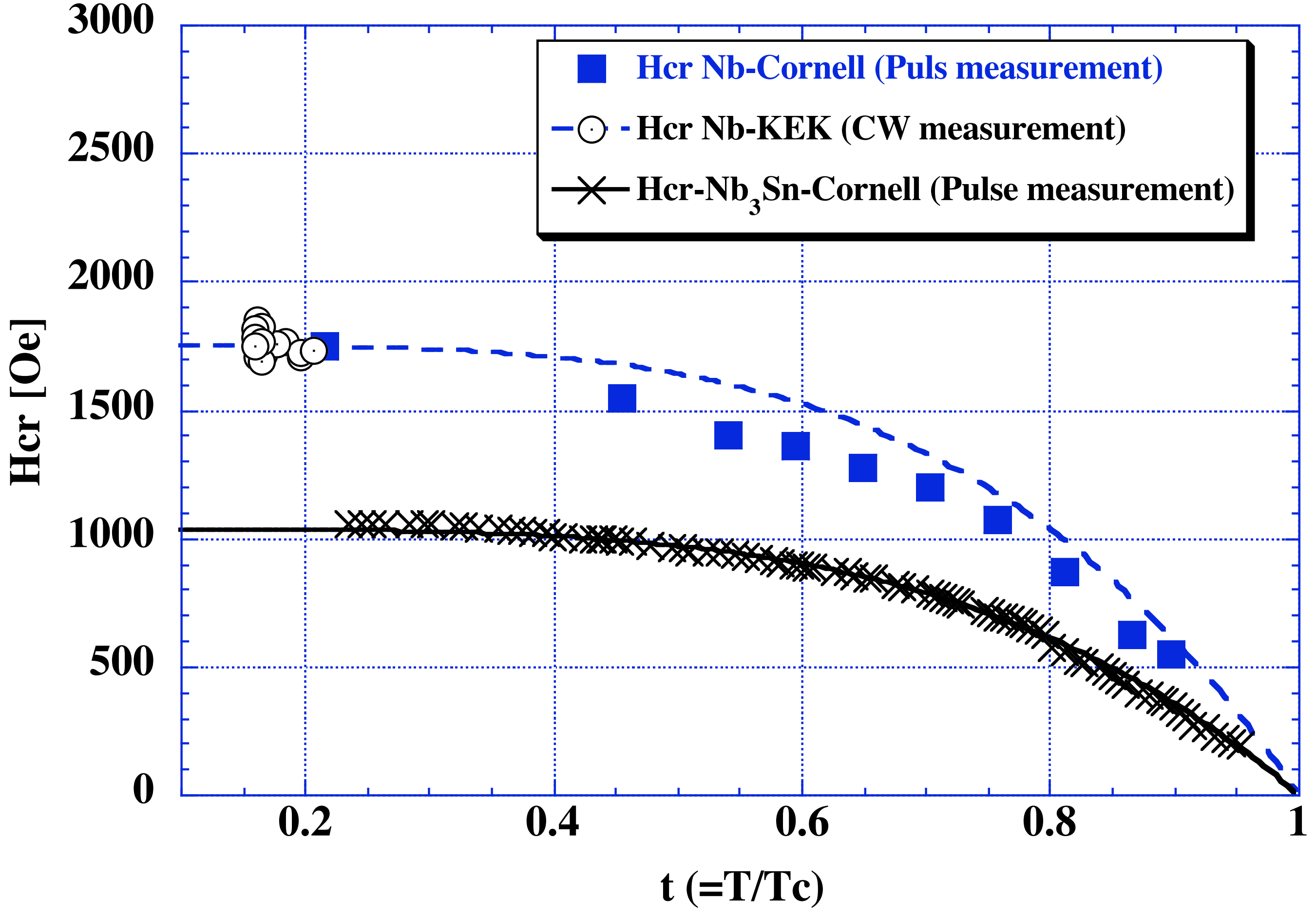
E_{acc} = 35MV / m ··· for more margin

or

E_{acc} = 40MV / m ··· for 85% criteria

KEK is aggressively pushing this way.

RF Critical magnetic field limitation

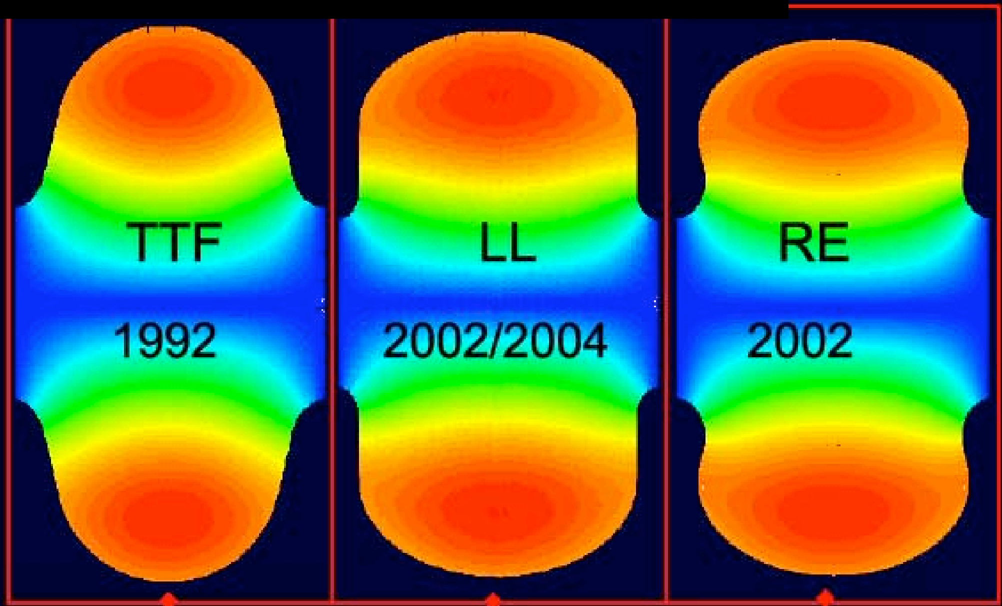


$$H_{cr}^{Nb}(t) = 1750 \cdot [1 - t^4], \quad H_{cr}^{Nb} = 1750 \text{ Oe at 2K}$$

$$t = 2/9.25, \; t^4 = 0.0022$$

Cavity Design

from J.Sekutowicz lectuer Note



r_{irisb}	[mm]	35	30	33	
k_{cc}	[%]	1.9	1.52	1.8	field flatness
E_{peak}/E_{acc}	-	4.26	2.36	2.21	max gradient (E limit)
B_{peak}/E_{acc}	[mT/(MV/m)]	4.15	3.61	3.76	max gradient (B limit)
R/Q	[Ω]	113.8	133.7	126.8	stored energy
G	[Ω]	271	284	277	dissipation
R/Q*G	[Ω*Ω]	30840	37970	35123	dissipation (Cryo limit)

Table 1: Comparison of high gradient between cavity shapes likely applied in ILC

Cavity Shape	TESLA	LL	Reentrant
Hp/Eacc [Oe/(MV/m)^2]	42.6	36.1	37.3
Theoretical Hp@2K [Oe]	1750	1750	1750
Theoretical Emax [MV/m]	41	48	47
Experiment result @2K [MV/m]	42	45*	46**, 47**
85% theoretical Emax [MV/m]	35	41	40
90% theoretical Emax[MV/m]	37	43	42
Proposed operation gradient	30, 35	35, 40-45	35

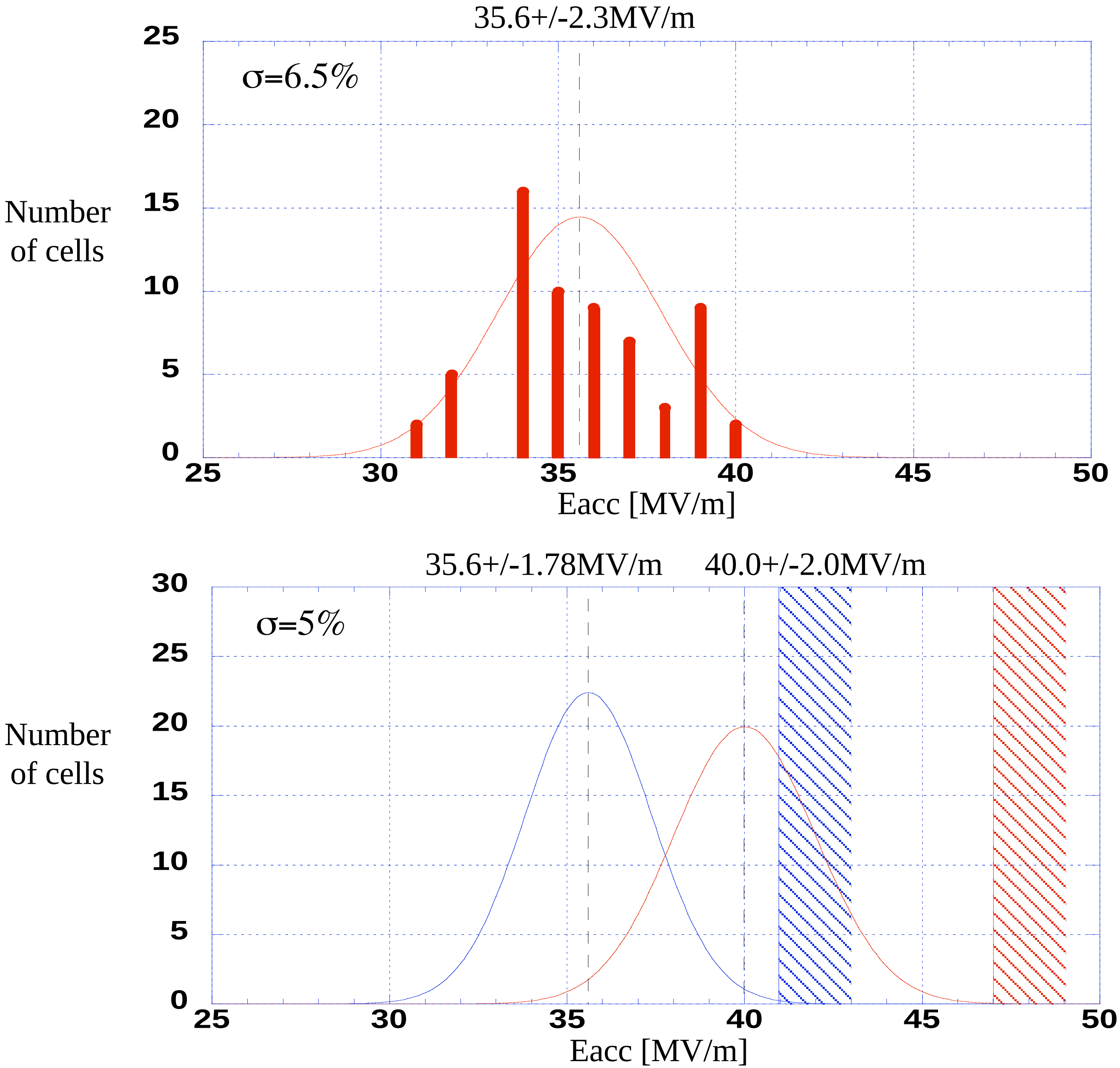
*2.6GHz single cell cavity made from single crystal niobium sheets,

** Single cell cavity made from polycrystalline niobium sheets

85% criteria : Realistic operation gradient should be about 85% of fundamental limitation.

See Higo's presentation

Example : LL-shape 85% criteria Eacc=40MV/m
but No risk at Eacc = 35MV/m

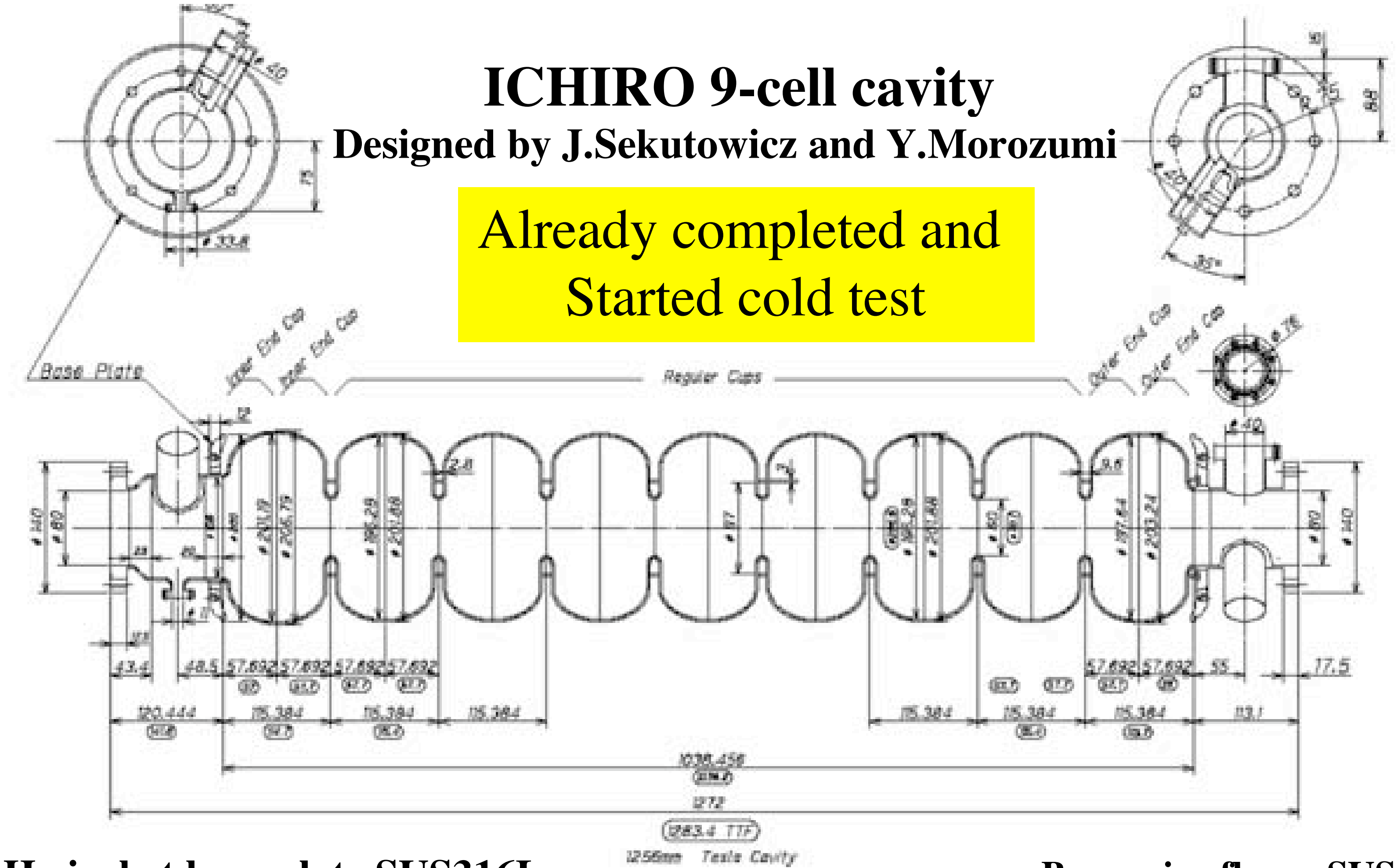


35.6+/-2.3MV/m
σ=6.5%
Number of cells
Eacc [MV/m]
25
20
15
10
5
0
25
30
35
40
45
50
35.6+/-1.78MV/m
40.0+/-2.0MV/m
σ=5%
Number of cells
Eacc [MV/m]
30
25
20
15
10
5
0
25
30
35
40
45
50

ICHIRO 9-cell cavity

Designed by J.Sekutowicz and Y.Morozumi

Already completed and
Started cold test



He jacket base plate SUS316L

Beam pipe flange SUS316L

4 ICHIRO 9-cell cavities have been completed.
Cold test just started.

Coaxial ball-screw tuner on ICHIRO 2nd 9-cell cavity

Summary

BCD nominal potential gradient and Q for ILC500

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Cavity performance before installation
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R & D program goal
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AND

Goals of the R&D program for ACD
Eacc = 40MV/m @ 1E10
Three years R&D

The rule for when the ACD would be considered to be replace the present BCD should be proposed. Such a point might be when ~6 cavities have achieved gradient in excess of 40MV/m with Qo of 1E10.

Coupler operationable power at current stage
AND
Presective for further high power operation

Menteinable tuner control range against Lorentz detuning at current stage
AND
Prospective for upgrade

1TeV ILC tunnel length should be consider at Eacc = 35MV/m

BCD at Snowmass

ILC nominal operation gradient and Q: X?
e.g. X=30MV/m@ 1*E10 at binging of ILC 500
BUT
Finally push up to 35MV/m operation by

Initial operation might be in a lower gradient, ex. 30MV/m, due to operational limitations like dark current.

But finally the operation level should be 35MV/m with Q_0=0.8E10 (final goal).

If 35MV/m operation is done without change in the configuration,
RF power distribution should be fixed