RDR Cavity System

Mandatory and Optional Changes

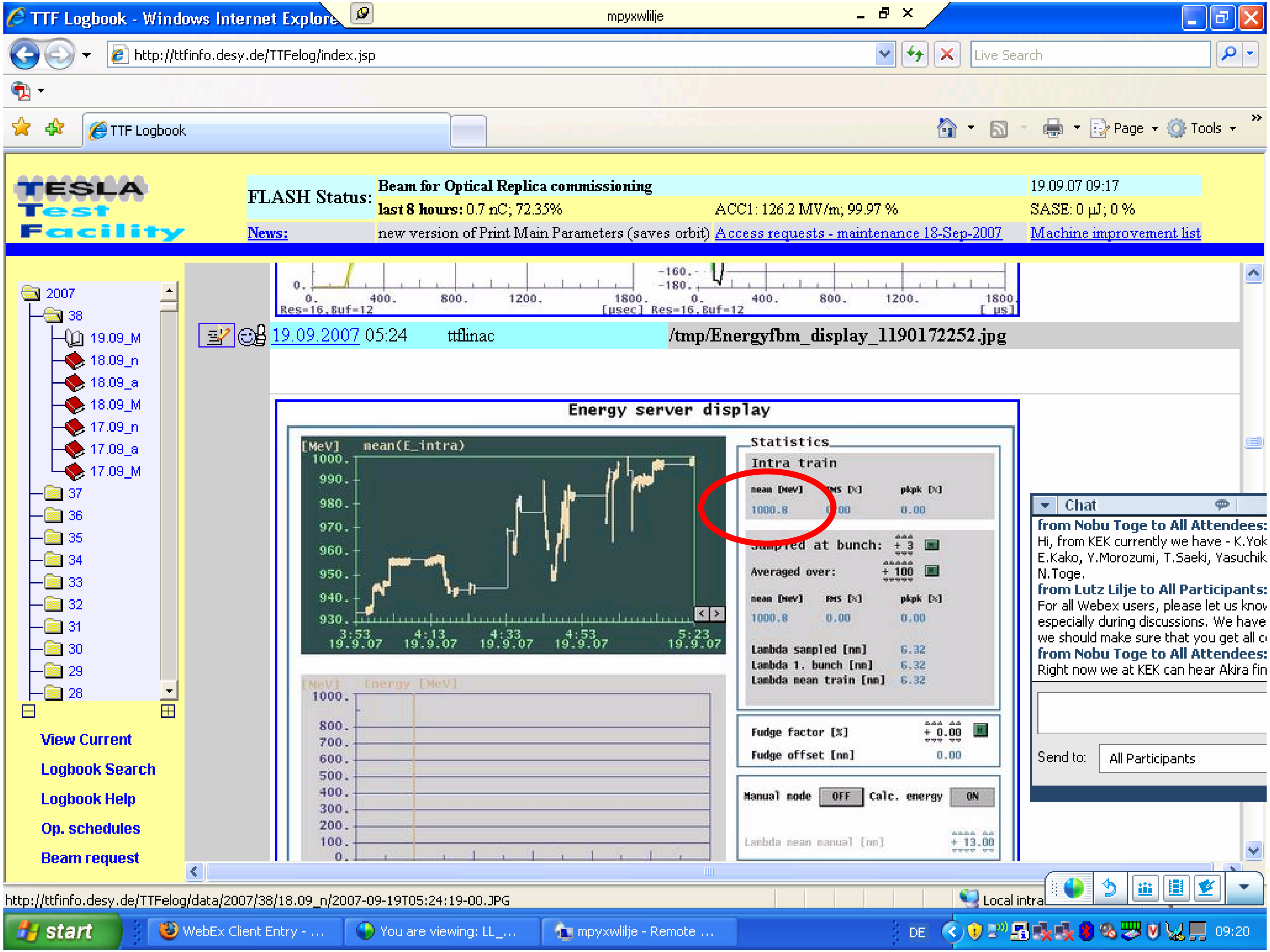
Lutz Lilje

GDE

But before...

- Morning Newspaper:

TTF@1 GeV



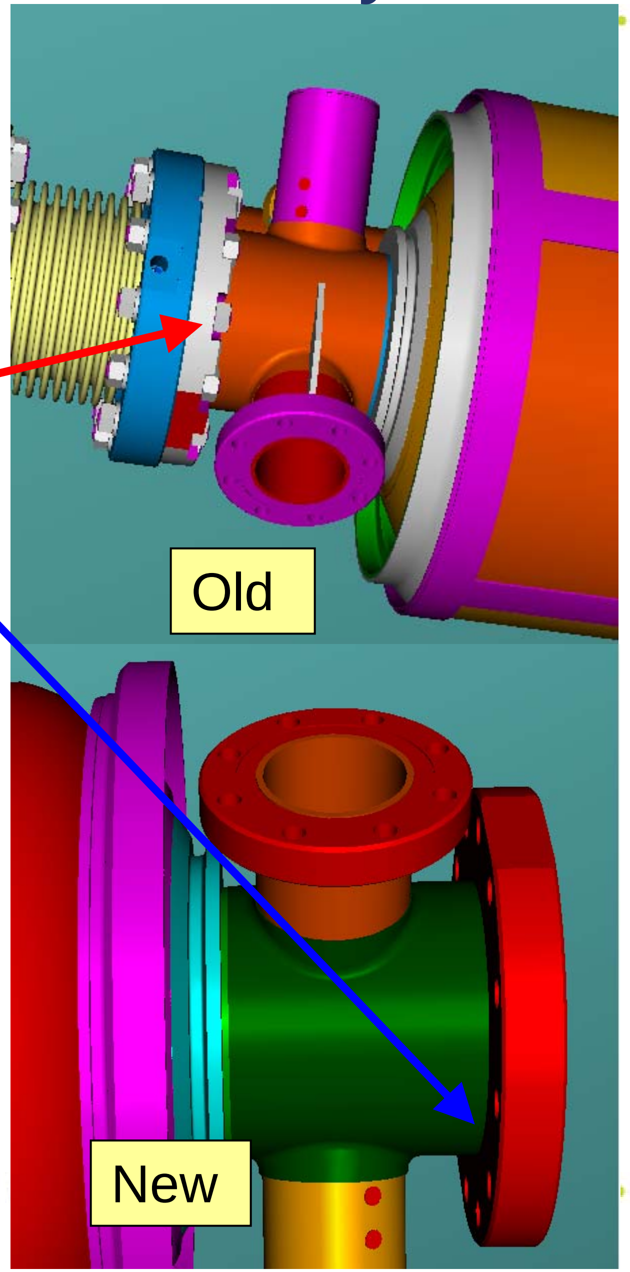
TTF Logbook - Windows Internet Explorer
http://ttfinfo.desy.de/TTFelog/index.jsp
TTF Logbook
TESLA Test Facility
FLASH Status:
Beam for Optical Replica commissioning
19.09.07 09:17
last 8 hours: 0.7 nC; 72.35%
ACC1: 126.2 MV/m; 99.97 %
SASE: 0 µJ; 0 %
News:
new version of Print Main Parameters (saves orbit)
Access requests - maintenance 18-Sep-2007
Machine improvement list
19.09.2007 05:24
ttflinac
/tmp/Energyfbm_display_1190172252.jpg
Energy server display
mean(E_intra)
Statistics
Intra train
Sampled at bunch:
Averaged over:
Lambda sampled [nm]
Lambda 1. bunch [nm]
Lambda mean train [nm]
Fudge factor [%]
Fudge offset [nm]
Manual mode
Calc. energy
View Current
Logbook Search
Logbook Help
Op. schedules
Beam request
Chat
from Nobu Toge to All Attendees:
Hi, from KEK currently we have - K.Yok
E.Kako, Y.Morozumi, T.Saeki, Yasuchik
N.Toge.
from Lutz Lilje to All Participants:
For all Webex users, please let us know
especially during discussions. We have
we should make sure that you get all c
from Nobu Toge to All Attendees:
Right now we at KEK can hear Akira fin
Send to:
All Participants

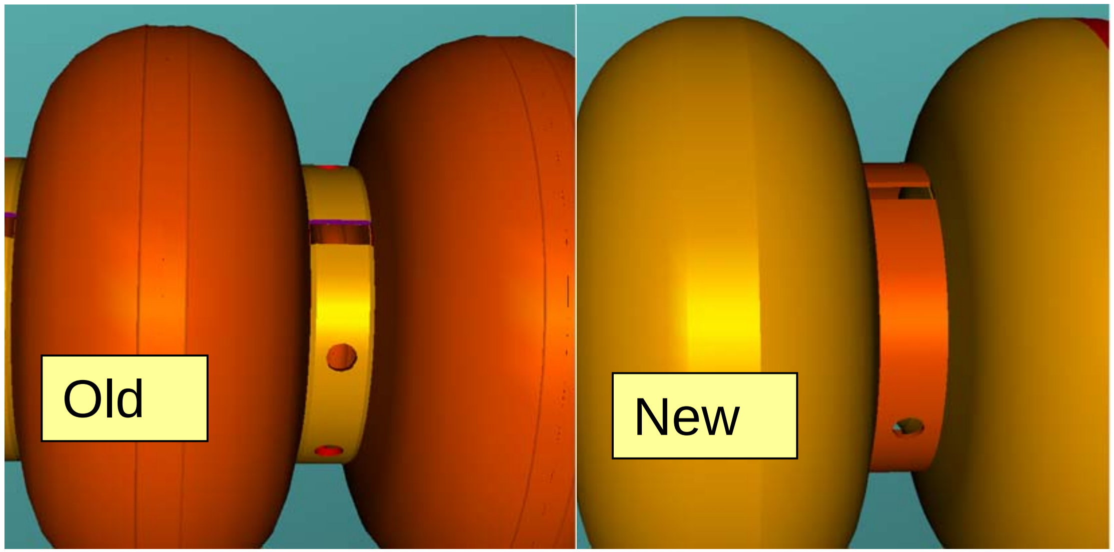
Outline

- Cavity and cavity system design:
  – **compare XFEL choices with mandatory and potential design changes for the baseline**
- Review of RDR work for cavity system,
  – **possible design changes,**
    - fabrication changes for baseline cavity
    - HOM,
    - tank material,
    - seal,
    - endgroup welding,
    - thicker endplate,
- Indication of how 'scoring' cost/benefit will be done

TTF Cavity Today and XFEL Cavity

- Only minor design changes to reduce cost/simplify manufacturing will be done e.g.
  - **Removal of coupler port stiffener**
  - **Removal of ‘pockets’ short side**
  - **Removal of outside recess**
  - **Less holes in stiffener ring**
  - **Thinner stiffener ring**
  - **Review tolerances**
    - Loosen where possible e.g. stiffeners rings





Mandatory Changes to Baseline: Cavity

- Cavity Length
  - **Only real necessary change to increase ILC fill factor**
  - **Main issues**
    - Need more compact tuner design
    - XFEL will not change this

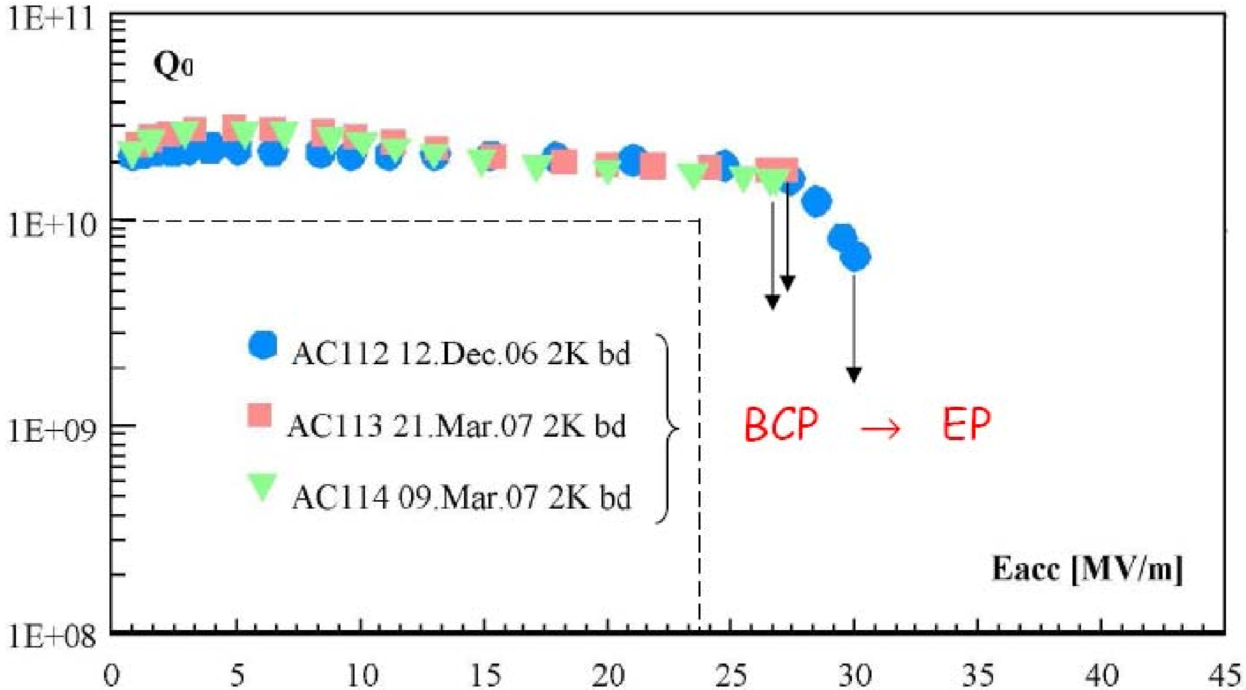
Optional changes: Cavity

- Material
  - **Large-grain**
    - Straight-forward implementation if material available
      - See W. Singer talk
    - Still need thorough analysis of cost-benefit
    - Performance demonstration on multi-cells needed
      - So far only BCP result available
      - EP underway at DESY (stay tuned…)
- HOM design
  - **Coupler kicks**
- Tank material
  - **Cost**
- Thicker endplate
  - **Lorentz-force detuning**
- Seal
- End-group welding

Large Grain Material: Multi-Cells (XFEL option)

Option : Large Grain cavities / BCP

Heraeus /Accel (three cavities)



Less fabrication steps (lower cost)

no forging-rolling

disk from ingot

(less material pollution)

High RRR ~ 500

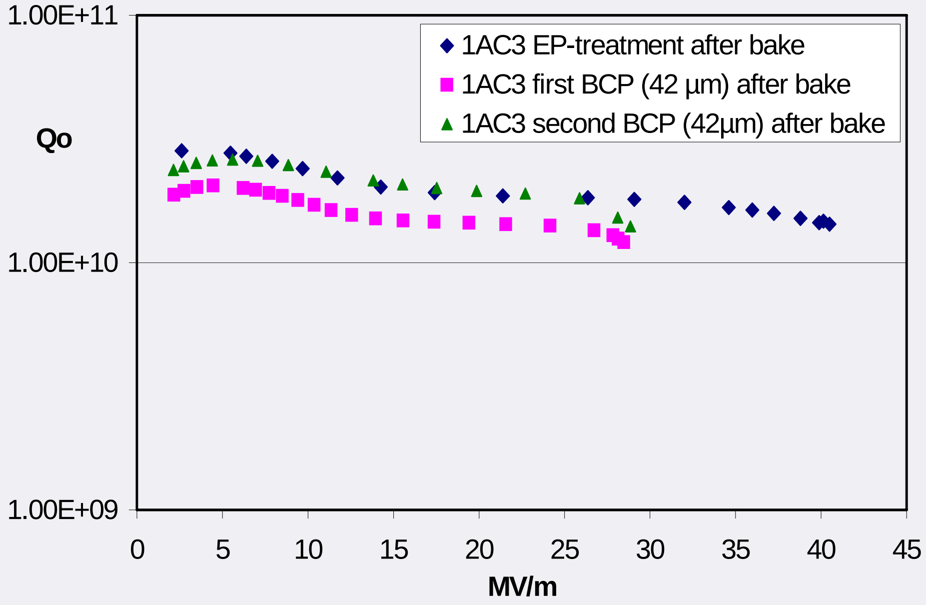
(avoid HT to ↗ K)

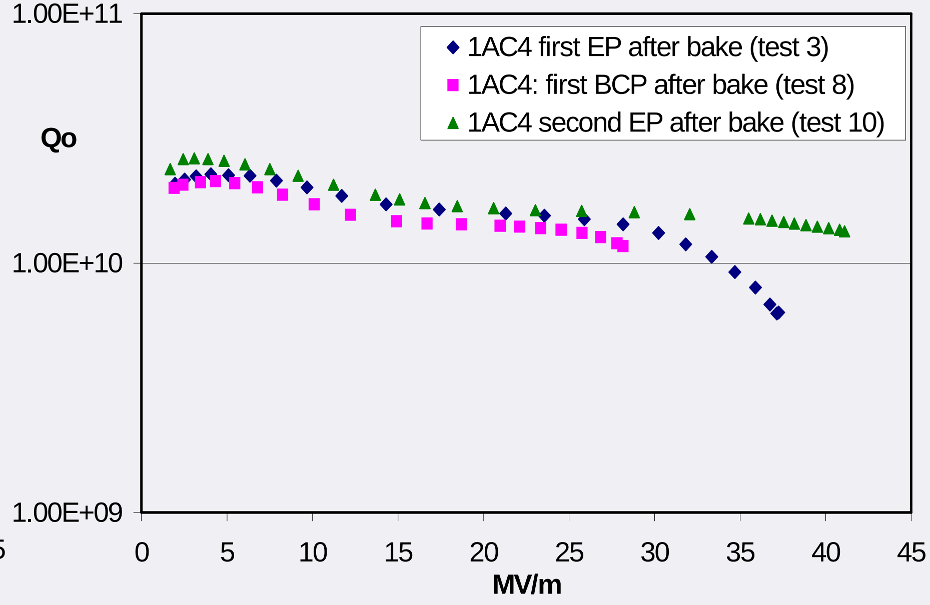
Probably higher gradients after Electropolishing (coming tests)

Large Grain Nb: Comparison of EP vs. BCP

Two cavities (deep drawn cups) of Heraeus Nb with RRR 500;

Reproducible gain of 10 and 13 MV/m after EP compared to BCP





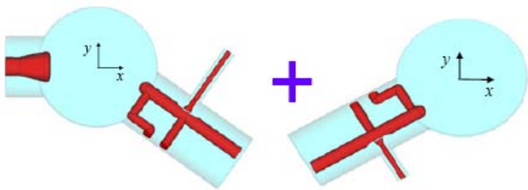
Optional changes: Cavity

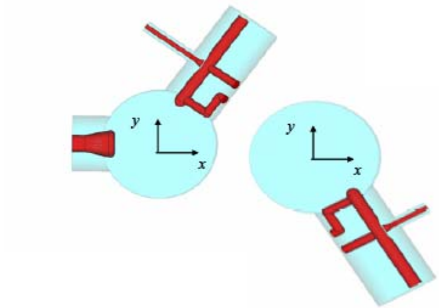
- Material
  - Large-grain
- HOM design
  - Coupler kicks
    - Needs further evaluation
    - Mitigation could be straight-forward
- Thicker endplate
  - Lorentz-force detuning
- Tank material
  - Cost
- Seal
- End-group welding

Coupler Kick

Igor Zagorodnov and Martin Dohlus
ILC Workshop, DESY
31 May, 2007

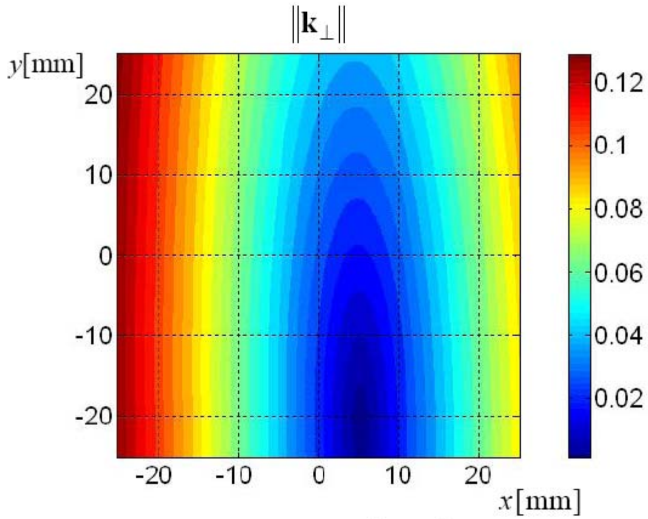
Wake kick for the new orientation

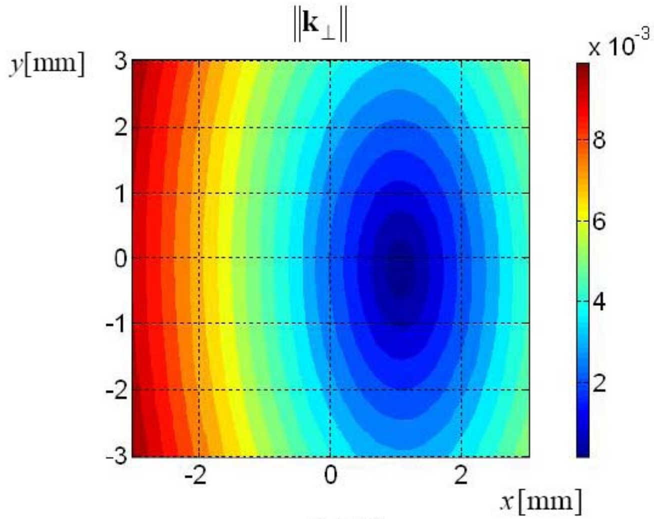




$$\mathbf{k}_\perp(x,y)=\begin{pmatrix}-0.021\\-0.019\end{pmatrix}+\begin{pmatrix}4.3 & 0.07\\0.03 & -0.9\end{pmatrix}\begin{pmatrix}x[\mathrm{m}]\\y[\mathrm{m}]\end{pmatrix}\left[\frac{\mathrm{kV}}{\mathrm{nC}}\right]$$

$$\mathbf{k}_\perp(x,y)=\begin{pmatrix}-0.0025\\-0.0002\end{pmatrix}+\begin{pmatrix}2.33 & 0.04\\-0.02 & 1.1\end{pmatrix}\begin{pmatrix}x[\mathrm{m}]\\y[\mathrm{m}]\end{pmatrix}\left[\frac{\mathrm{kV}}{\mathrm{nC}}\right]$$





$$\mathbf{r}_c=\begin{pmatrix}5.3\\-21.3\end{pmatrix}\mathrm{mm} \quad\longrightarrow\quad \mathbf{r}_c=\begin{pmatrix}1.1\\-0.2\end{pmatrix}\mathrm{mm}$$

$$\|\mathbf{k}_\perp\|_{\min}=5e-5\frac{\mathrm{kV}}{\mathrm{nC}}$$

$$\|\mathbf{k}_\perp\|_{\min}=8e-5\frac{\mathrm{kV}}{\mathrm{nC}}$$

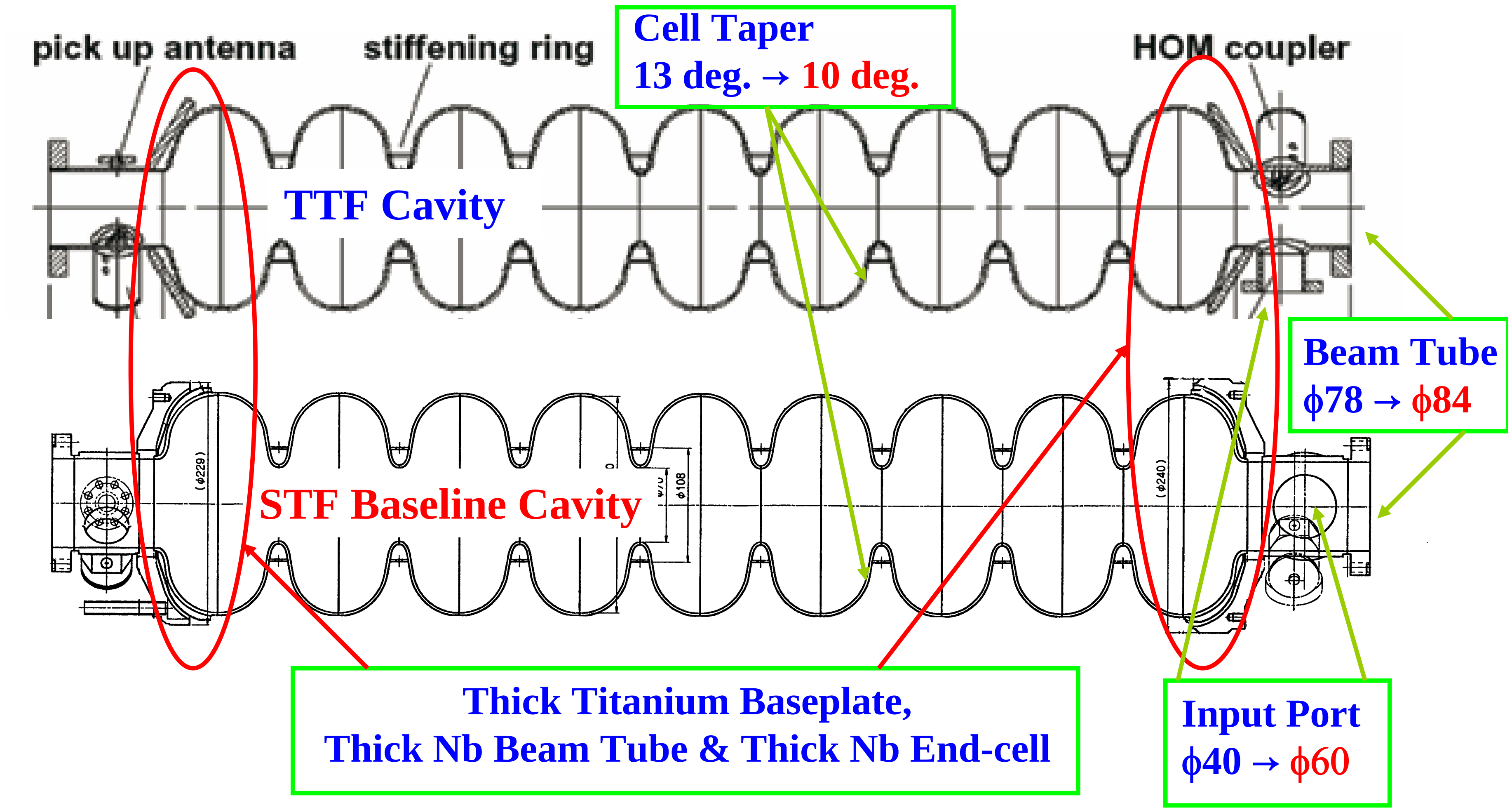
HOM Wake Mitigation Options

- Following Chris Adolphsen there are fixes:
  - **“Igor's solution of rotating the HOM relative the FPC - this reduces the effect by a factor of 10”**
    - Cavity design change
    - Needs beam test
  - **“feeding every other cavity or every other cryomodule from the opposite side (like is done in the SLAC linac).”**
    - Straight-forward solution
    - Is this still feasible from RF unit to RF unit?
      - Possibly simplest way to alter tunnel layout
  - **“reducing the beam pipe diameter to 60 mm so the HOM and FPC antennae are not 'seen' directly by the beam (this is not a problem for the LL cavity for example - note the irises could still be 70 mm diameter, but the wake would still be larger due to the smaller beam pipe size)”**
    - Cavity design change
    - Needs beam test

Optional changes: Cavity

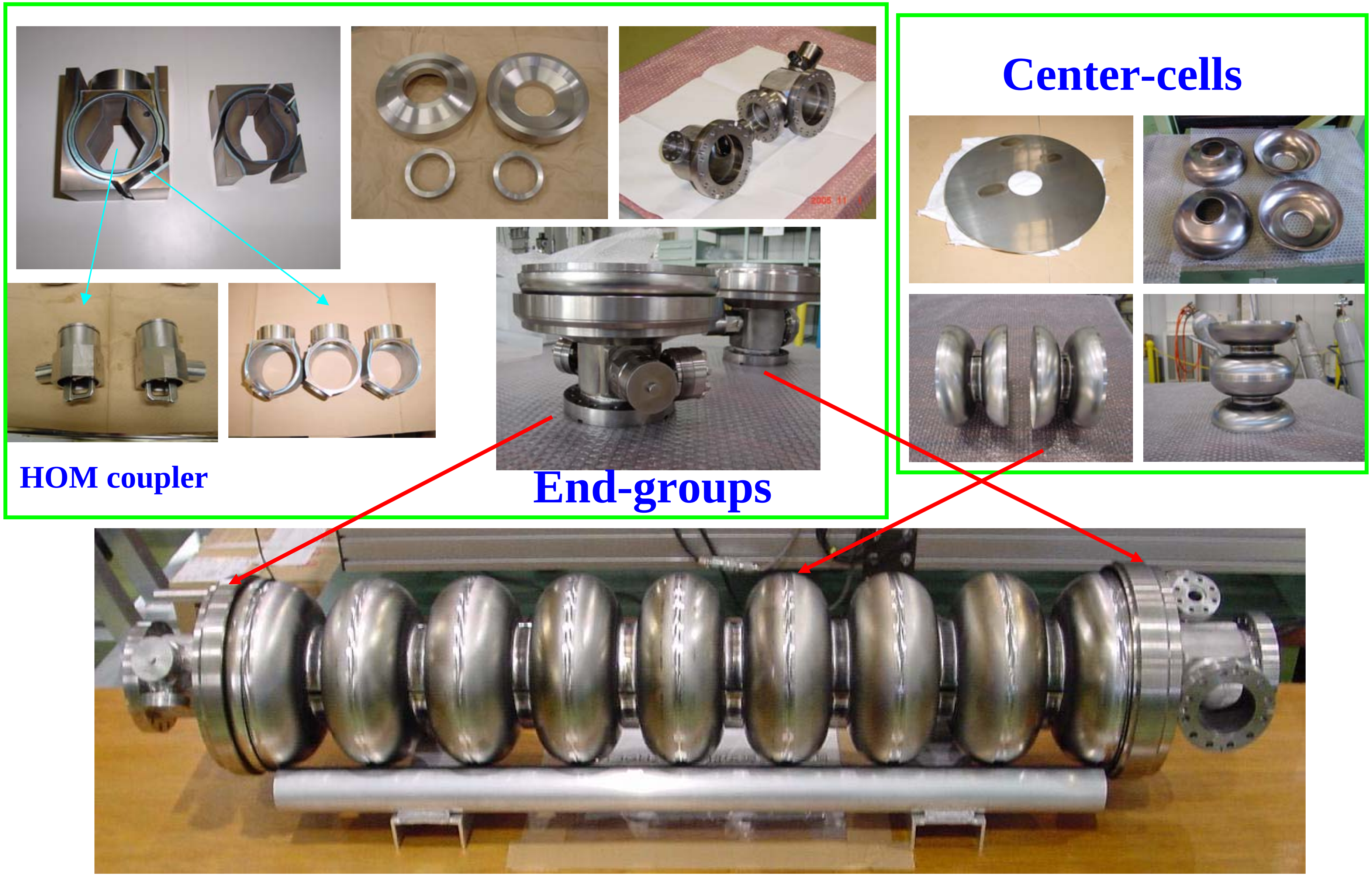
- Material
  - **Large-grain**
- HOM design
  - **Coupler kicks**
- Thicker endplate
  - **Lorentz-force detuning**
    - E.g. TESLA-type cavities at KEK
      - Thicker endplate design necessitated other design changes
    - Need to prove improvement in stiffness reduces Lorentz-force detuning
- Tank material
  - **Cost**
- Seal
- End-group welding

Improvement in the STF Baseline Cavities



	STF Baseline Cavity	TTF Cavity	
Stiffness of Cavity			
Fixing Support	90 kN/mm	13 kN/mm	
Lorentz Detuning	-500 Hz	-900 Hz	(31.5 MV/m)

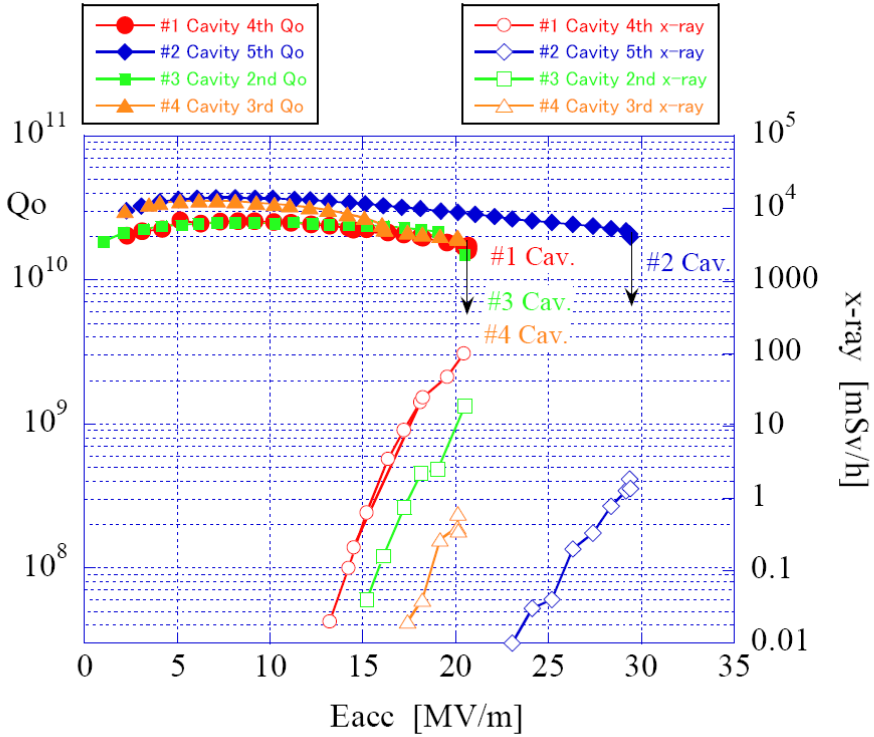
Fabrication of the STF Baseline Cavities



KEK TESLA-type Multi-Cells

(Kako, Noguchi)

Final Performance in Vertical Tests



Eacc,max

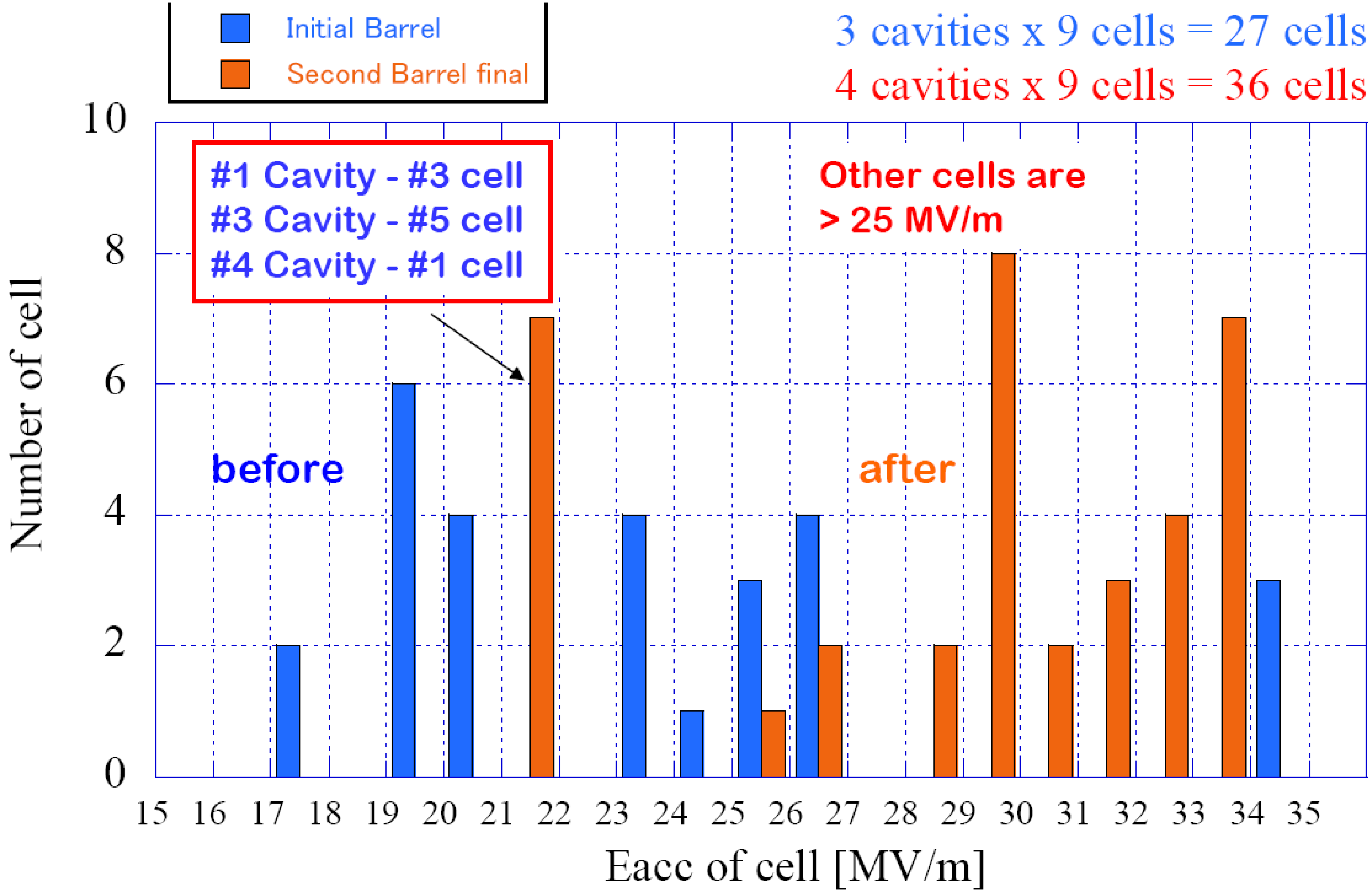
#1 20.8 MV/m
#2 29.4 MV/m
#3 20.5 MV/m
#4 20.2 MV/m

high Qo > 10^{10}

- New cavity vendor
- Surface treatment at ‘standard‘ company
- Field emission in first processing
- Only few cells are limited at low field ~21 MV/m
    - Similar to first 2 production runs at TTF few bad cells, but larger number gaussian distribution at higher gradient
- Best cavity at 29 MV/m!
- Tighter QC for future production runs will be implemented

Vertical Test Results, Eacc of cells

Before (total~250 μm), after 2nd BP (total~500 μm)



Optional changes: Cavity

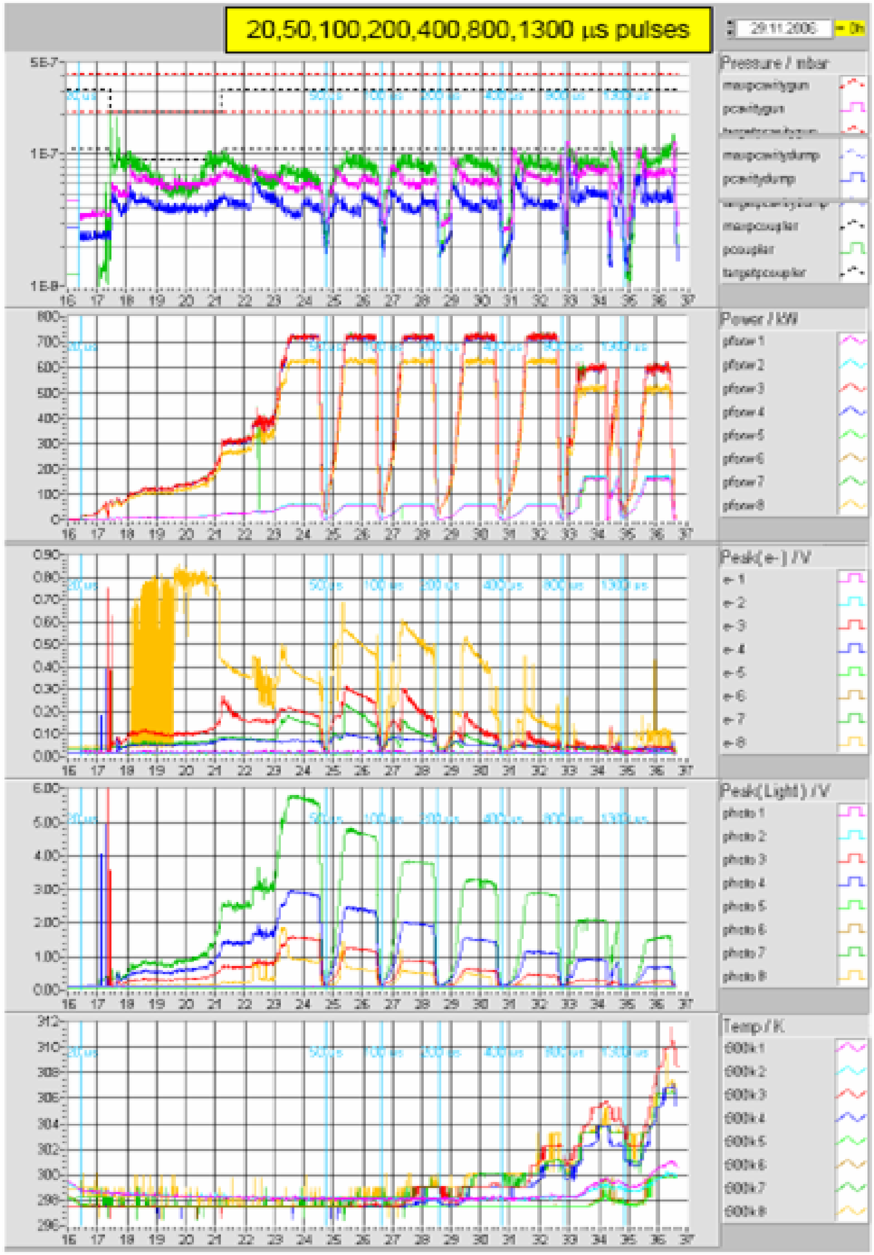
- Material
  - **Large-grain**
- HOM design
  - **Coupler kicks**
- Thicker endplate
  - **Lorentz-force detuning**
- Tank material
  - **Cost**
    - Need to understand cost differences between regions for Ti as tank material
    - Need to understand technical issues with stainless better
- Seal
  - **Reliability**
    - DESY ‘diamond’-shaped seal choice for XFEL
    - Each lab tends to have its favorite sealing technology
      - Need ‘neutral’ technical analysis on pros and cons
      - Need data on reliability e.g. number of re-assemblies needed
- End-group welding
  - **Cost**
    - Need performance demonstration
    - Need cost-benefit analysis

Mandatory changes: Coupler

- TTF-III is baseline
  - **Has performed up to at least 37 MV/m without problems**
  - **Processing time reduced significantly**
    - Protection with dry nitrogen led to significant improvement
  - **Problems have only been observed in case of assembly accidents e.g.**
    - Wrong screw material (gripping)
  - **XFEL choice**
    - Minor design changes to reduce cost
      - Mainly result from industry study by LAL Orsay
- There is no mandatory change!

Module Coupler Processing

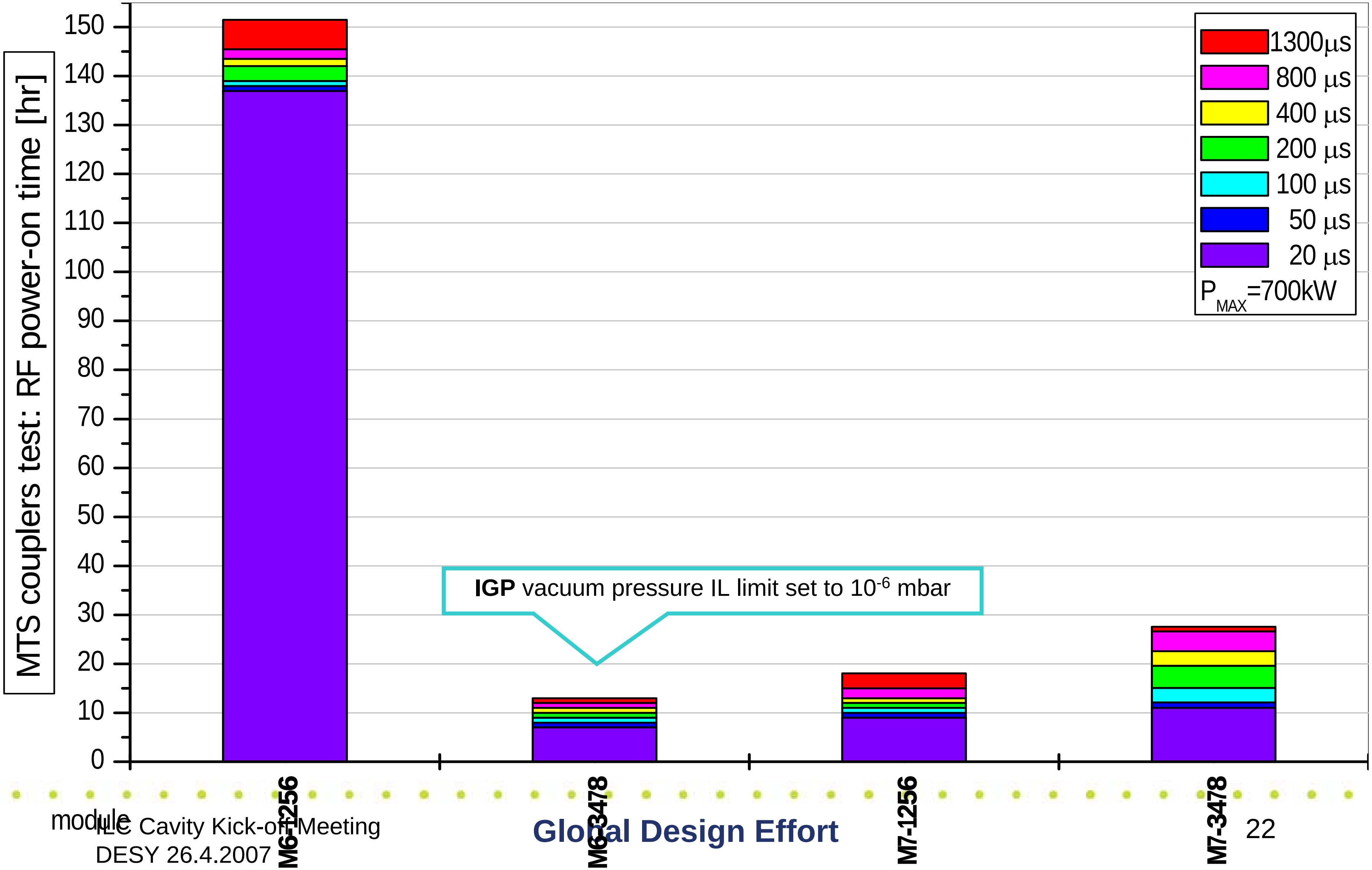
- Done in to steps
  - 1st set of 4 couplers
    - Very tight vacuum interlock thresholts
  - 2nd set of 4 couplers
    - Used 'relaxed' vacuum interlock thresholts
- Very fast processing
  - Due to improved handling after pre-processing at LAL Orsay
  - Comparable to individual cavity high power test results
  - M7 preliminary!



D. Kostin

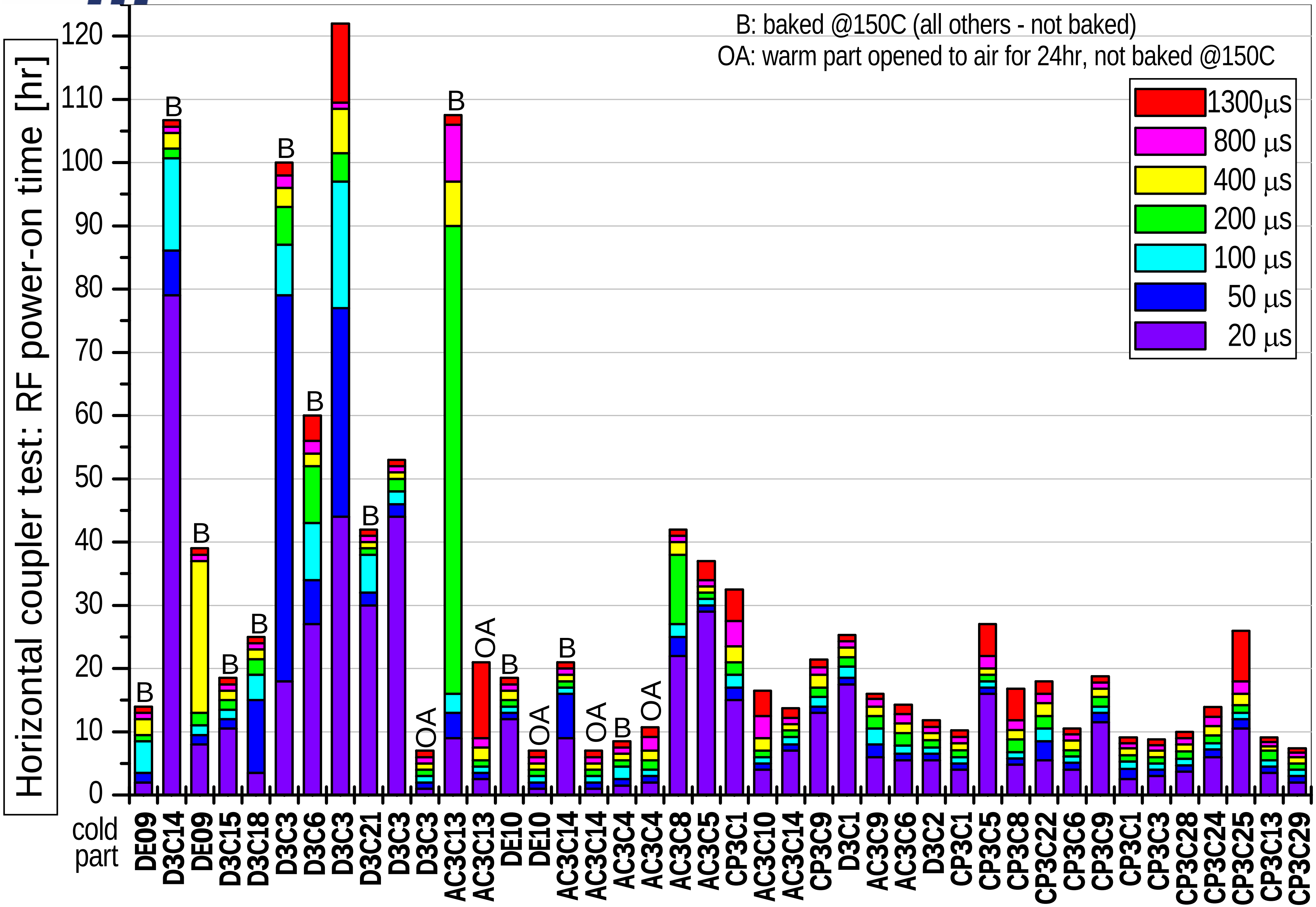
M6 and M7 RF conditioning

D. Kostin



Comparison with Horizontal Test Coupler Processing

D. Kostin



Optional changes: Coupler

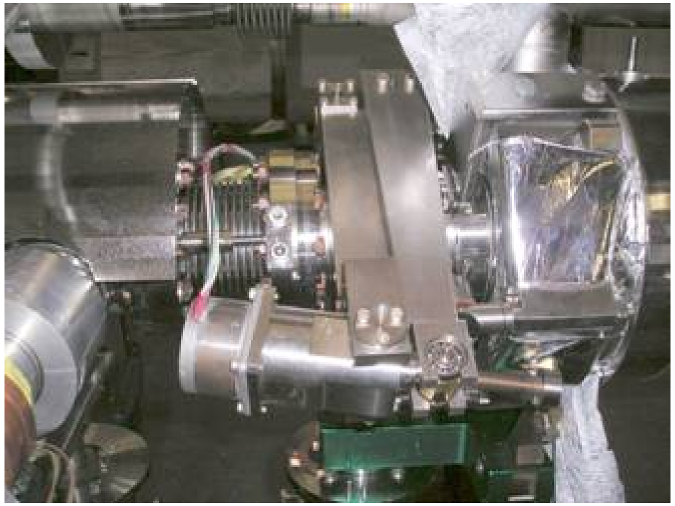
- Several Changes have been proposed
  - **Need full cost-benefit analysis on each**
  - **Fixed coupling**
- Several Designs have been tested on test stands successfully
  - **Need still tests with cavities**
- Disk-type windows
  - **TESLA-type at KEK**
- Capacitive coupling
  - **Ichiro system at KEK**
- Larger diameter ports
  - **SLAC, LAL Orsay**

Mandatory Changes: Tuner

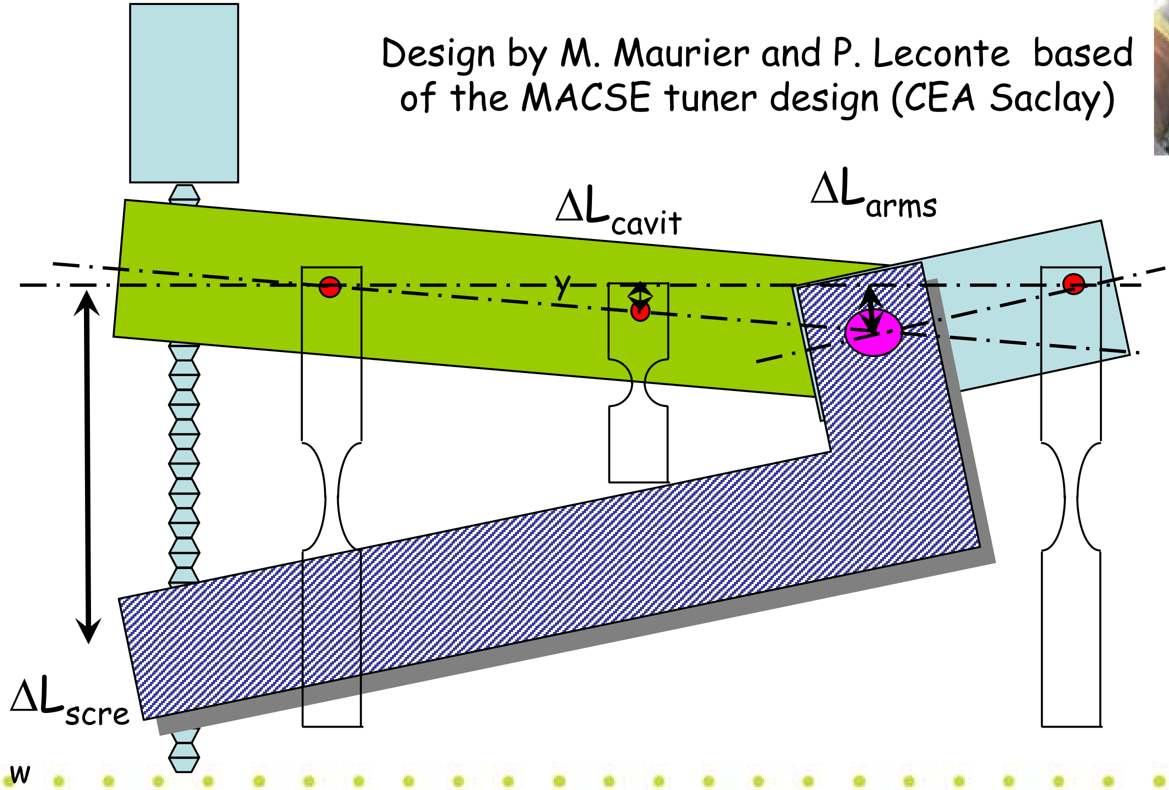
- Must be compact
  - **Cavity length change removes space**
- XFEL Tuner
  - **Cavity length not changed**
  - **Choice is Saclay I with piezo integration done by DESY**
    - Performance demonstrated up to 35 MV/m
    - Endurance test in FLASH soon
      - 3 Modules equipped with fast piezo tuners
    - For optimum piezo performance cavities must be pretuned to lower frequency for tank welding

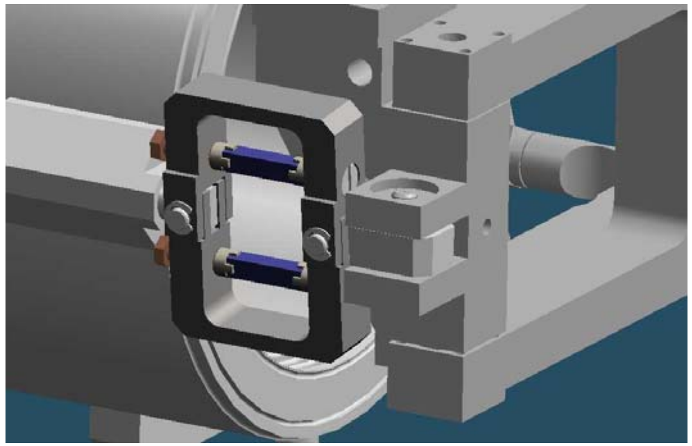
Tuner Setup

- Current design in use at FLASH
  - Design by CEA
  - Fast piezo detuning introduce not from beginning
  - Is the backup solution for XFEL

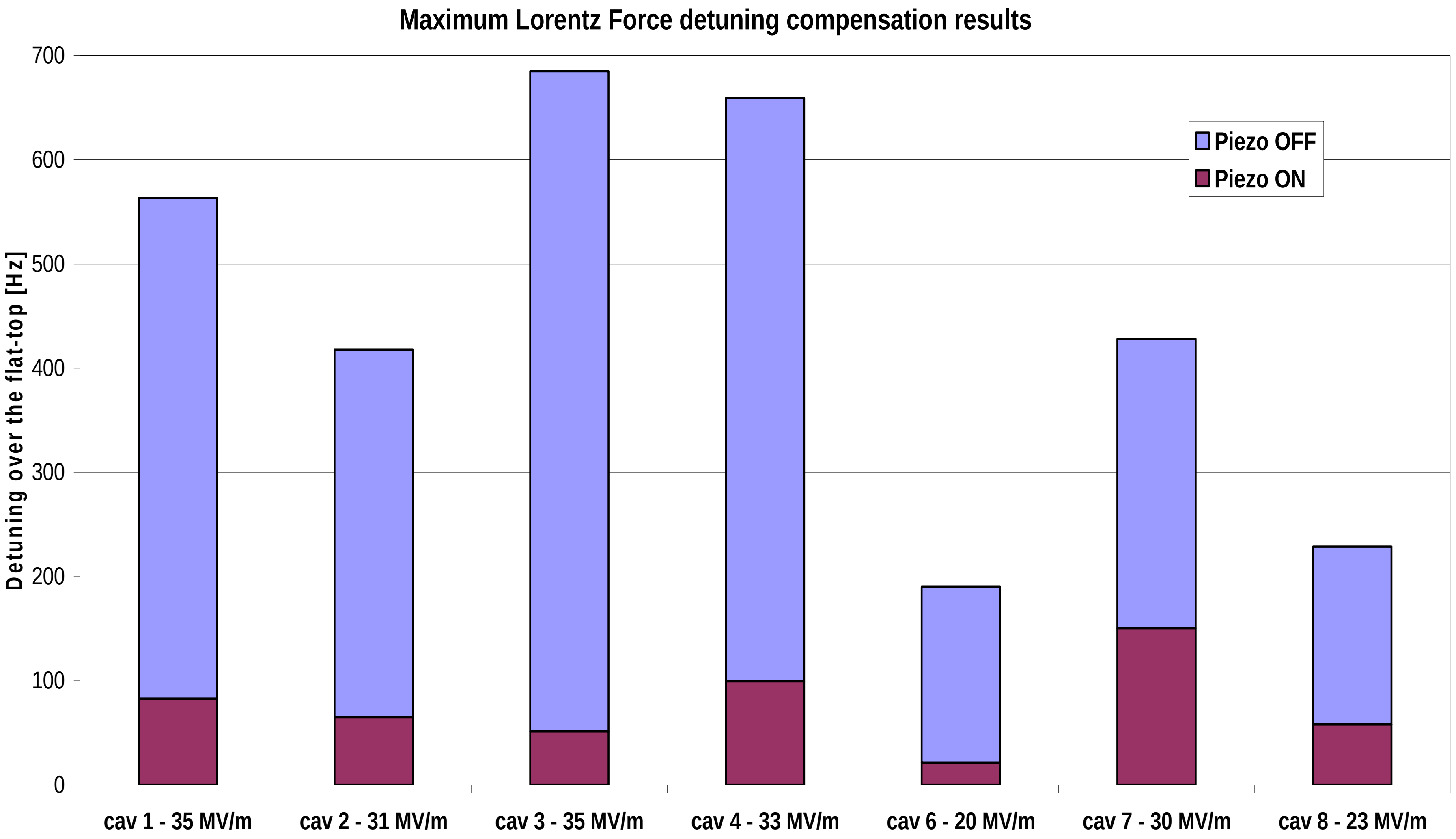


Design by M. Maurier and P. Leconte based of the MACSE tuner design (CEA Saclay)





Compensated Detuning per Cavity



Optional Changes: Tuner

- Motor accessibility
  - **Motor outside cryostat**
    - TESLA-type at KEK
    - Need additional feedthrough on cryostat
  - **Motor accessible via special flange**

- Piezo accessibility
  - **Piezo accessible from outside**
    - Through larger coupler flange TESLA-type at KEK
    - Extra-flange for Ichiros at KEK
- Piezo temperature level
  - **80 K**
    - Ichiros at KEK
- These changes need a cost-benefit analysis
  - **Driving argument for inside motor was cost**
- In addition, a model for module repair in ILC needed
  - **All these options need to warm up the machine (except for outside motor) to repair**
  - **As this is the critical time scale to which everything else is short TESLA philosophy was to swap broken modules with spare ones**
    - Repair done outside of the tunnel

Mandatory changes: Magnetic shield

- Baseline is outside helium vessel
- Performance demonstrated
  - **Achieve Q_0 >10^{10} regularly**

Optional changes: Magnetic shield

- Inside Helium vessel
  - **TESLA-type at KEK**

Synthesis

- Main issue is cost
- Performance is as important
- Time available is short

Main Issue is Cost

- But many options are poorly justified
  - **Thorough analysis of cost–benefit has not been done in many cases**
    - e.g. no thorough study available on large-grain material, but very rough estimates
  - **Understanding of regional cost differences in RDR is needed as this has driven optional developments**
    - e.g. tank material is a candidate in this category

Performance is as important

- We (the ILC project) ...
  - **have to agree on components test**
  - **need to get a systematic overview of what tests are needed to make us comfortable with design changes**
    - Cavity shape changes need beamtest
    - Cavity material changes need ‘only‘ performance test

Timeline is short

- Depending on the impact of the options testing might exceed EDR timeline
  - **certainly true for the ILC module**
- How many tests?
  - **How many couplers would you like to built to be sure of the cost reductions you think of?**

Conclusion

- XFEL is baseline in many cases
  - **Performance tested up to ILC levels for cavities, couplers and tuners**
- Need to establish common set of criteria for making an option a candidate for ILC
  - **Thorough cost-benefit analysis must be first in line**
  - **Agreed-upon tests are needed (‘fair‘)**
  - **A realistic timeline provided by proponent is needed to assess what could be achieved by the EDR**
    - also could decide certain demonstrations being postponed beyond EDR