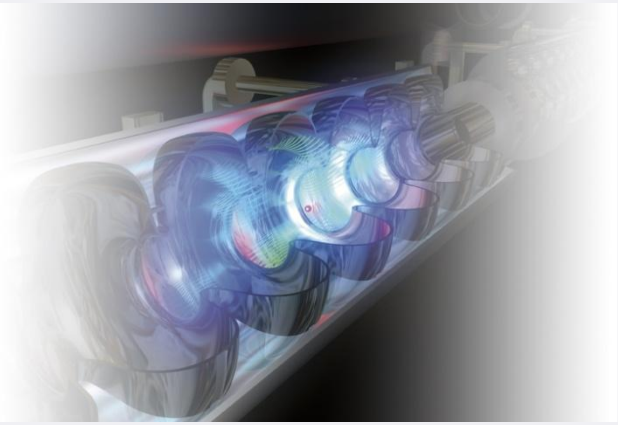
Report from the TTC Technical Board Meeting

Hans Weise / DESY



TESLA Technology Collaboration Meeting
DESY, January 14th – 17th, 2008

TTC Technical Board

Cavity:	**P. Kneisel**	(JLAB)	**(J. Mammosser (SNS))**
	L. Lilje	(DESY)	
	D. Reschke	(DESY)	
	K. Saito	(KEK)	
	additional coupler expertise:		
	E. Kako	(KEK)	
	W.D. Moeller	(DESY)	
Module:	**N. Ohuchi**	(KEK)	
	C. Pagani	(INFN)	
	B. Petersen	(DESY)	
	T. Peterson	(FNAL)	
Linac and and Integration:	**H. Edwards**	(FNAL)	
	S. Michizono	(KEK)	
	S. Simrock	(DESY)	
	H. Weise	(DESY)	Chair

Ex-Officio (per TTC MOU) Spokespersons of major test facilities

TTF / FLASH:	**S. Schreiber**
ILCTA-NM (old SMTF):	**S. Nagaitsev**
STF:	**H. Hayano**

Agenda

Monday 17:00 - 18:30

General remarks (summaries last meeting, general studies to be triggered…)

The Optimum Cavity Preparation Process (present material; invite additional participants)

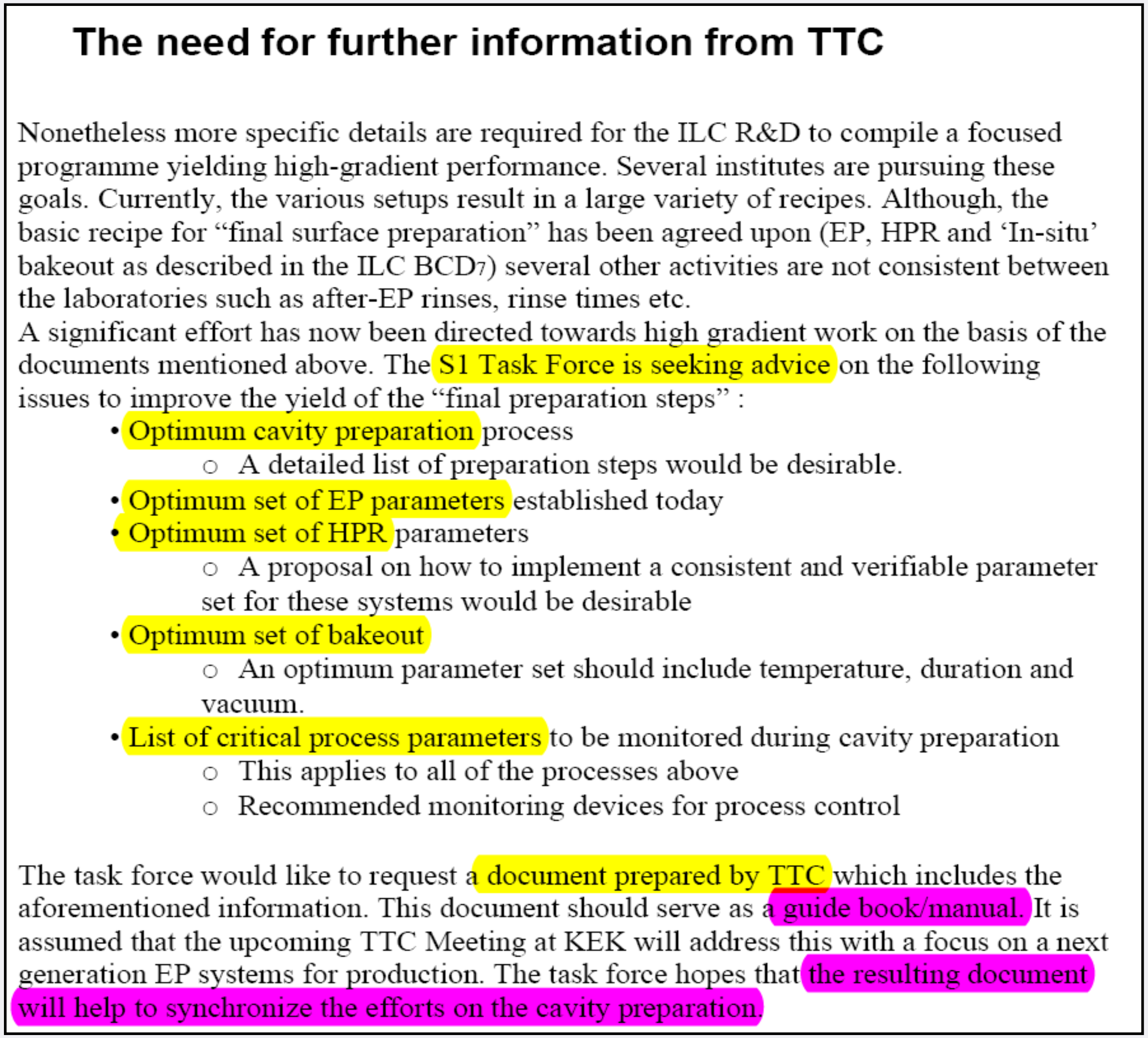
John Mammosser / Axel Matheisen / Paolo Michelato / Bernard Visentin

Tuesday 17:00 - 18:30

Like last time... **highlights and work to come** in the different areas
(some ‘service’ to the Collaboration Board)

Cavities	(Kneisel / Lilje / Reschke)
Coupler	(Kako / Moeller)
Module	(Ohuchi / Pagani / Petersen)
Linac	(Michizono / Simrock / Weise)
Test Facilities	(Schreiber / Hayano)

ILC Request to the TTC and hence to the TB



The need for further information from TTC

Nonetheless more specific details are required for the ILC R&D to compile a focused programme yielding high-gradient performance. Several institutes are pursuing these goals. Currently, the various setups result in a large variety of recipes. Although, the basic recipe for “final surface preparation” has been agreed upon (EP, HPR and ‘In-situ’ bakeout as described in the ILC BCD[7]) several other activities are not consistent between the laboratories such as after-EP rinses, rinse times etc.
A significant effort has now been directed towards high gradient work on the basis of the documents mentioned above. The S1 Task Force is seeking advice on the following issues to improve the yield of the “final preparation steps” :

- Optimum cavity preparation process
  - A detailed list of preparation steps would be desirable.
- Optimum set of EP parameters established today
- Optimum set of HPR parameters
  - A proposal on how to implement a consistent and verifiable parameter set for these systems would be desirable
- Optimum set of bakeout
  - An optimum parameter set should include temperature, duration and vacuum.
- List of critical process parameters to be monitored during cavity preparation
  - This applies to all of the processes above
  - Recommended monitoring devices for process control

The task force would like to request a document prepared by TTC which includes the aforementioned information. This document should serve as a guide book/manual. It is assumed that the upcoming TTC Meeting at KEK will address this with a focus on a next generation EP systems for production. The task force hopes that the resulting document will help to synchronize the efforts on the cavity preparation.

Prep. official answer

- **extract the essence from existing material**
- **produce a well structured document**
- **add background information completing the picture**

The structured answer as proposed by the TTC TB

incl. suggested authors, partly tbc(onvinced)

1.	Optimum cavity preparation process	H.Padamsee, K.Saito
	general overview based on Sect. 2-4; incl. assembly techniques	
2.	Optimum set of EP parameters for 9-cell cavities as established today	J. Mammosser
2.1	Recommended EP parameter	J. Mammosser
2.2	Recommended acid quality monitoring	A. Matheisen
2.3	Recommended rinsing parameter	J. Mammosser
	Supporting material	
	Comparison EP parameter	T. Higo
	Status of acid quality monitoring	A. Matheisen
	Results rinsing studies; list of possible rinsing methods and current status	
	HF rinsing / short EP	K. Saito
	Ultrasound degrease	J. Mammosser
	Alcohol	A. Matheisen
	H2O2	E. Kako
3.	Optimum set of HPR parameter	P. Kneisel
3.1	Recommended HPR parameter	P. Kneisel
3.2	Recommendations wrt process quality monitoring, e.g. force, particle count	D. Reschke / P. Michelato
	Supporting material	
	Comparison of HPR systems	P. Michelato
	water quality	Rothgeb /Saeki
4.	Optimum set of bakeout parameter	
4.1	Recommend bakeout parameter	B. Visentin
	Supporting material	
	Comparison of bakeout procedures	Visentin / Ciovati / Furuta

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Optimum set of EP parameters for 9-cell cavities as established today
J. Mammosser (ed.)

1.0 Background

The niobium electropolishing process has evolved from the original Siemens recipe over the last 10 years. Today's procedures are a combination of learned experiences and new developments that were generated from Kenji Saito's effort working with Nomura Plating Companies to develop higher gradients as well as DESY's effort to utilize this process for large scale production of cavities for their XFEL project. The results of these efforts, has progressed the basic knowledge of this complicated process and has demonstrated the utility of this method in producing the highest gradients achievable in superconducting cavities to date. This document is meant to be used as a guide to aid additional users of this method as well as to document the current best parameters being used today. Process parameters are strongly dependent on the hardware and system designs, therefore variation in these parameters is evitable at different locations as well as different systems in use. For the critical details of this process it is necessary to fully understand each system and therefore an explanation is provided as well as the parameters currently being used at each laboratory.

2.0 Basic Chemical Equations

Oxidation

$2\,Nb + 5\,SO_4^{--} + 5\,H_2O \rightarrow Nb_2O_5 + 10\,H^+ + 5\,SO_4^{--} + 10\,e^-$

Reduction

$Nb_2O_5 + 6\,HF \rightarrow H_2NbOF_5 + NbO_2F\,0.5\,H_2O + 1.5\,H_2O$

$NbO_2F\,0.5\,H_2O + 4\,HF \rightarrow H_2NbOF_5 + 1.5\,H_2O$

Optimum set of EP parameters for 9-cell cavities as established today
J. Mammosser (ed.)

3.0 Standard Electropolishing Procedure for Cavity Qualification

Note: This procedure assumes that the cavity has already undergone bulk chemistry, RF tuning and furnace treatment to remove hydrogen.

a. The cavity is **ultrasonically cleaned** in a detergent degreaser in a de-ionized (DI) water bath that's typically heated. Process takes place in a clean area or cleanroom environment. Process time of ~1 hour is typical with minimal of a few percent by volume of concentrated detergent as the degreasing agent within the DI water.

b. Cavity **surfaces are rinsed** with DI water to remove residual detergent and they are dried in a clean or cleanroom environment.

c. Cavity is then inserted into the **electropolish system** (horizontal position), personnel must keep cavity clean and avoid contact when possible, and appropriate gloves must be used during handling and contact. Additionally, contact of any material with interior surface of the cavity must be avoided through out the processing operations.

d. Next the **assembly of hardware** for the rotation device, electrode contacts, plumbing connections and diagnostics takes place.

e. **Electrolyte temperature is adjusted** to the appropriate starting temperature and a significant acid chilling system with adequate heat exchanger must be used to maintain acid temperature during the process.

f. **Cavity is filled with acid** and the level is maintained at ~60 % volume completely covering the cathode.

g. **DC power is turned on** and voltage is set to ~17 volts constant voltage. Current is monitored and voltage is adjusted to maintain acid temperature below 35 C at exit of cavity. Cavity is processed for enough time to adequately remove 10-20um from the equator. Typical time for this amount of etching is around 25-50 minutes.

h. Cavity is raised to the vertical position and electrolyte is drained from the cavity. The darning process takes about 1-3 minutes.

Optimum set of EP parameters for 9-cell cavities as established today
J. Mammosser (ed.)

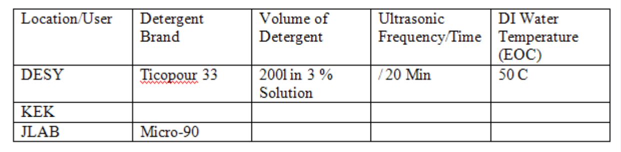
3.0 Standard Electropolishing Procedure for Cavity Qualification (continued)

i. The cavity is then filled and drained several times with DI water until the pH of the exiting rinse water is raised to a level of 4 to5 depending on the system design. This exchange of water on the surface followed by draining is the fastest method to achieve higher pH on the cavity surface.
j. Cavity is then rinsed again by overfilling for ~60 minutes.
k. The final steps of the electropolish procedure of the removal of rinse water and the cathode are differs drastically for each laboratory.
    a. **Jlab** – positions cavity horizontally, drains the DI water and then removes the cathode. Next the cavity is completely disassembled and ultrasonically cleaned as in above step.
    b. **DESY** – removes the cathode vertically and the cavity remains filled with water until reaching the next cleaning steps
    c. **KEK** – removes the cathode then fills the cavity with DI water before proceeding
l. Next the residual contamination from the chemistry, mainly sulfur particulates should be removed to reduce field emission. Methods under investigation are: HF acid rinsing, alcohol rinsing and ultrasonic degreasing. All methods have shown significant reduction of onset of field emission. Each method differs slightly in procedure but all are carried out in clean conditions with internal rinsing of the cavity surface. Additionally a light BCP etch has been used at DESY and has also shown good results but adds additional steps of rinsing to the process.

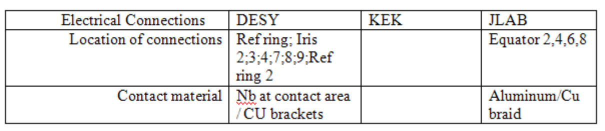
Optimum set of EP parameters for 9-cell cavities as established today
J. Mammosser (ed.)

4.0 Typical Electropolishing Parameters

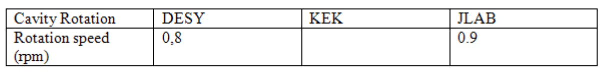
4.1 Degreasing the Cavity
4.2 Electrical connections
4.2 Cavity Rotation
4.3 Electrolyte Temperature
4.4 Electrolyte Mixing
4.5 Depletion of Hydrofluoric Acid From Use
4.6 Electrolyte Flow Rate
4.7 Cathode Shielding
4.8 Typical Etch Rates
4.9 Water Rinsing After Processing



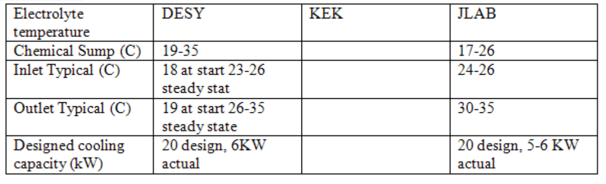
Location/User	Detergent Brand	Volume of Detergent	Ultrasonic Frequency/Time	DI Water Temperature (EOC)
DESY	Ticopour 33	200l in 3 % Solution	/ 20 Min	50 C
KEK				
JLAB	Micro-90			



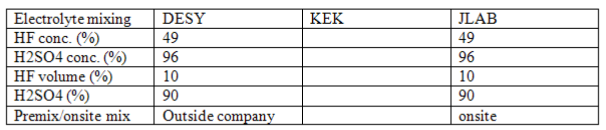
Electrical Connections	DESY	KEK	JLAB
Location of connections	Ref ring; Iris 2;3;4;7;8;9;Ref ring 2		Equator 2,4,6,8
Contact material	Nb at contact area / CU brackets		Aluminum/Cu braid



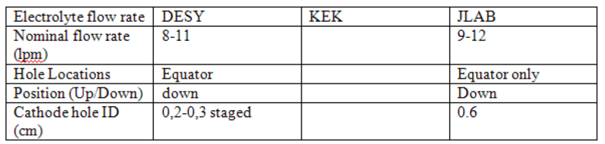
Cavity Rotation	DESY	KEK	JLAB
Rotation speed (rpm)	0,8		0.9



Electrolyte temperature	DESY	KEK	JLAB
Chemical Sump (C)	19-35		17-26
Inlet Typical (C)	18 at start 23-26 steady stat		24-26
Outlet Typical (C)	19 at start 26-35 steady state		30-35
Designed cooling capacity (kW)	20 design, 6KW actual		20 design, 5-6 KW actual



Electrolyte mixing	DESY	KEK	JLAB
HF conc. (%)	49		49
H2SO4 conc. (%)	96		96
HF volume (%)	10		10
H2SO4 (%)	90		90
Premix/onsite mix	Outside company		onsite



Electrolyte flow rate	DESY	KEK	JLAB
Nominal flow rate (lpm)	8-11		9-12
Hole Locations	Equator		Equator only
Position (Up/Down)	down		Down
Cathode hole ID (cm)	0,2-0,3 staged		0.6

all tables come with comments / explanations

Optimum set of EP parameters for 9-cell cavities as established today
Supporting material (example: acid quality monitoring)

Supporting material

Comparison EP parameter	T. Higo
Status of acid quality monitoring	A. Matheisen
Results rinsing studies; list of possible rinsing methods and current status	
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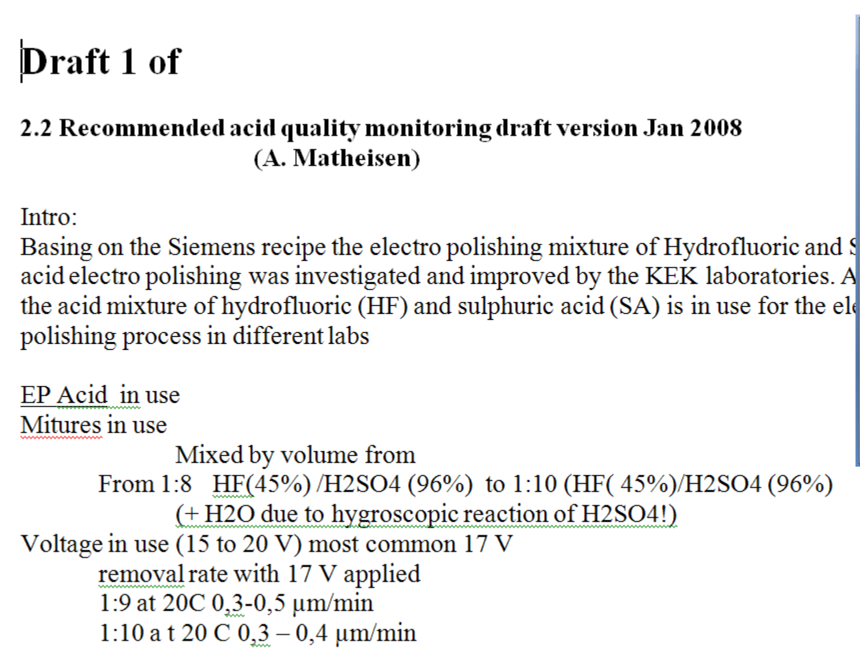
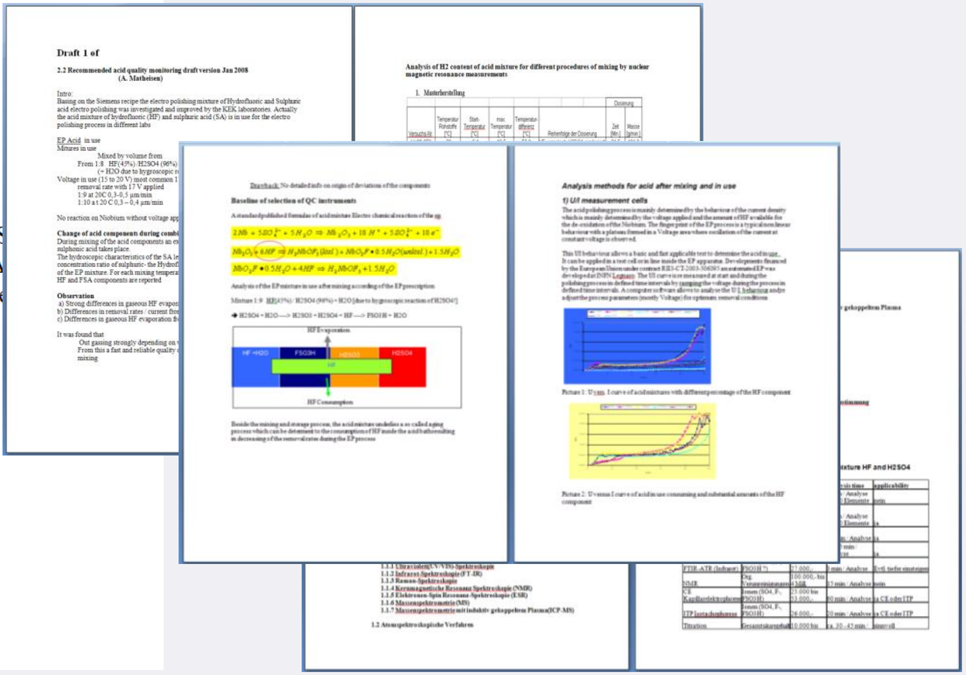


Draft 1 of

2.2 Recommended acid quality monitoring draft version Jan 2008
(A. Matheisen)

Intro:
Basing on the Siemens recipe the electro polishing mixture of Hydrofluoric and S
acid electro polishing was investigated and improved by the KEK laboratories. A
the acid mixture of hydrofluoric (HF) and sulphuric acid (SA) is in use for the el
polishing process in different labs

EP Acid in use
Mitures in use
Mixed by volume from
From 1:8 HF(45%) /H2SO4 (96%) to 1:10 (HF(45%)/H2SO4 (96%)
(+ H2O due to hygroscopic reaction of H2SO4!)
Voltage in use (15 to 20 V) most common 17 V
removal rate with 17 V applied
1:9 at 20C 0,3-0,5 µm/min
1:10 a t 20 C 0,3 – 0,4 µm/min



Optimum set of EP parameters for 9-cell cavities as established today
Supporting material (example: alcohol rinsing)

Supporting material

Comparison EP parameter		T. Higo
Status of acid quality monitoring		A. Matheisen
Results rinsing studies; list of possible rinsing methods and current status		
	HF rinsing / short EP	K. Saito
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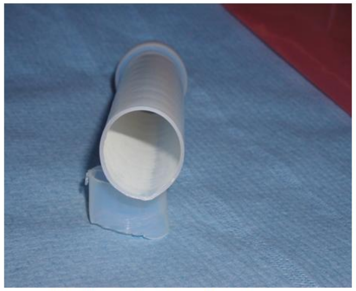
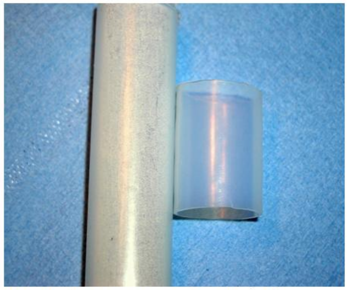
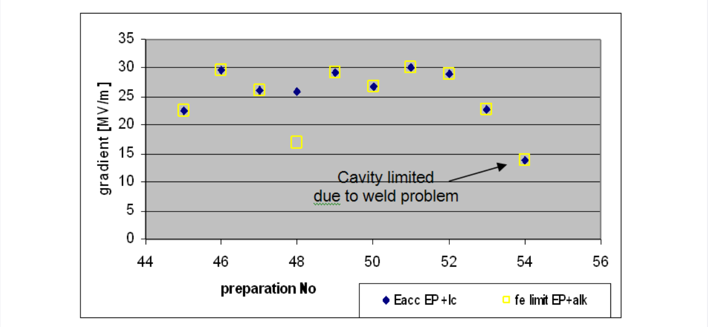
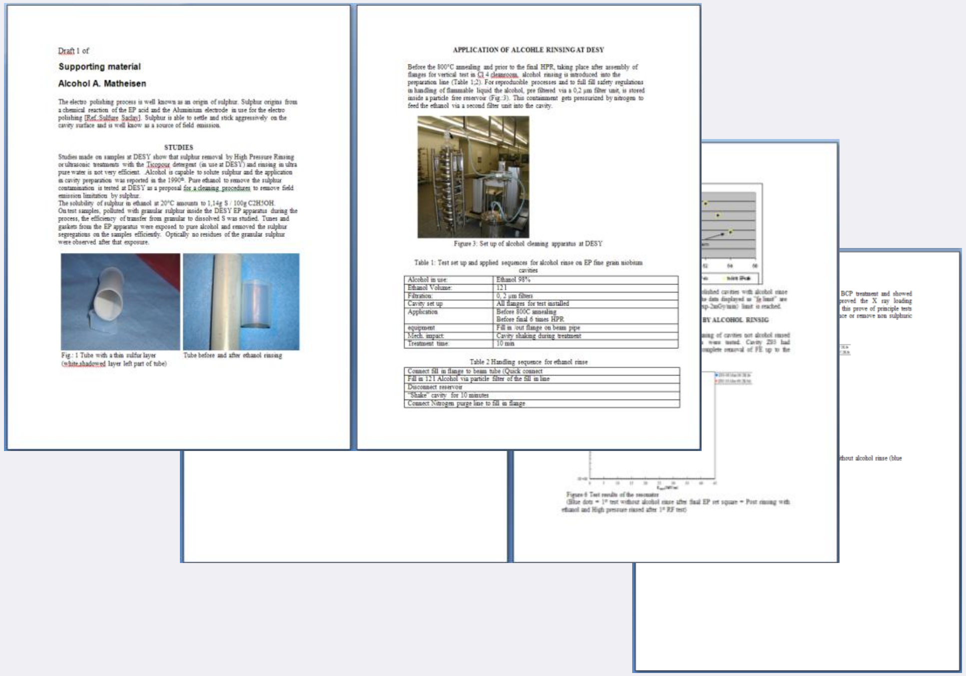


Fig.: 1 Tube with a thin sulfur layer (white,shadowed layer left part of tube)


Tube before and after ethanol rinsing




Draft 1 of

Supporting material

Alcohol A. Matheisen

The electro polishing process is well known as an origin of sulphur. Sulphur origins from a chemical reaction of the EP acid and the Aluminium electrode in use for the electro polishing [Ref.Sulfure Saclay]. Sulphur is able to settle and stick aggressively on the cavity surface and is well know as a source of field emission.

STUDIES

Studies made on samples at DESY show that sulphur removal by High Pressure Rinsing or ultrasonic treatments with the Ticopour detergent (in use at DESY) and rinsing in ultra pure water is not very efficient. Alcohol is capable to solute sulphur and the application in cavity preparation was reported in the 1990th. Pure ethanol to remove the sulphur contamination is tested at DESY as a proposal for a cleaning procedures to remove field emission limitation by sulphur.
The solubility of sulphur in ethanol at 20°C amounts to 1,14g S / 100g C_2H_5OH.
On test samples, polluted with granular sulphur inside the DESY EP apparatus during the process, the efficiency of transfer from granular to dissolved S was studied. Tunes and gaskets from the EP apparatus were exposed to pure alcohol and removed the sulphur segregations on the samples efficiently. Optically no residues of the granular sulphur were observed after that exposure.

Fig.: 1 Tube with a thin sulfur layer (white,shadowed layer left part of tube)

Tube before and after ethanol rinsing

APPLICATION OF ALCOHLE RINSING AT DESY

Before the 800°C annealing and prior to the final HPR, taking place after assembly of flanges for vertical test in Cl 4 cleanroom, alcohol rinsing is introduced into the preparation line (Table 1;2). For reproducible processes and to full fill safety regulations in handling of flammable liquid the alcohol, pre filtered via a 0,2 µm filter unit, is stored inside a particle free reservoir (Fig.:3). This containment gets pressurized by nitrogen to feed the ethanol via a second filter unit into the cavity.

Figure 3: Set up of alcohol cleaning apparatus at DESY

Table 1: Test set up and applied sequences for alcohol rinse on EP fine grain niobium cavities

Alcohol in use:	Ethanol 98%
Ethanol Volume:	12 l
Filtration:	0, 2 µm filters
Cavity set up	All flanges for test installed
Application	Before 800C annealing Before final 6 times HPR
equipment	Fill in /out flange on beam pipe
Mech. impact:	Cavity shaking during treatment
Treatment time:	10 min

Table 2 Handling sequence for ethanol rinse

Connect fill in flange to beam tube (Quick connect
Fill in 12 l Alcohol via particle filter of the fill in line
Disconnect reservoir
"Shake" cavity for 10 minutes
Connect Nitrogen purge line to fill in flange

Optimum set of HPR parameters for 9-cell cavities as established today

P. Kneisel (ed.)

3.1 Pure Water Systems

- 3.1.1. Layout and Parameters of an Ultrapure Water System
- 3.1.2 Quality Control

3.2 Overview of existing HPR Systems

3.3 Process Quality Monitoring

- 3.3.1 Force Measurements of HPR Jets
- 3.3.2 Water Particle Counting at HPR Systems
- 3.3.3 Other Quality Control Measures

3.4 Supporting Material

(Standards, References..)

Optimum set of HPR parameters for 9-cell cavities as established today
Summary (1)

- A stable and reliable pure water supply is fundamental for the successful operation of High Pressure Ultrapure Water Rinse (HPR) systems.
- The technology of ultra pure water generation is well established and any facility should adhere to the standards (ASTM,SEMI…)
- Quality control of the water system by particle monitoring, TOC, resistivity, Si contents.. is desirable, but not everywhere implemented in existing systems
- There is **no optimal set of high pressure rinse parameters**: as collected in table 1, each laboratory applies its own “best / successful“ procedures
- **HPR is also only one facet of a successful procedure**: re-contamination is a major concern

Optimum set of HPR parameters for 9-cell cavities as established today
Summary (2)

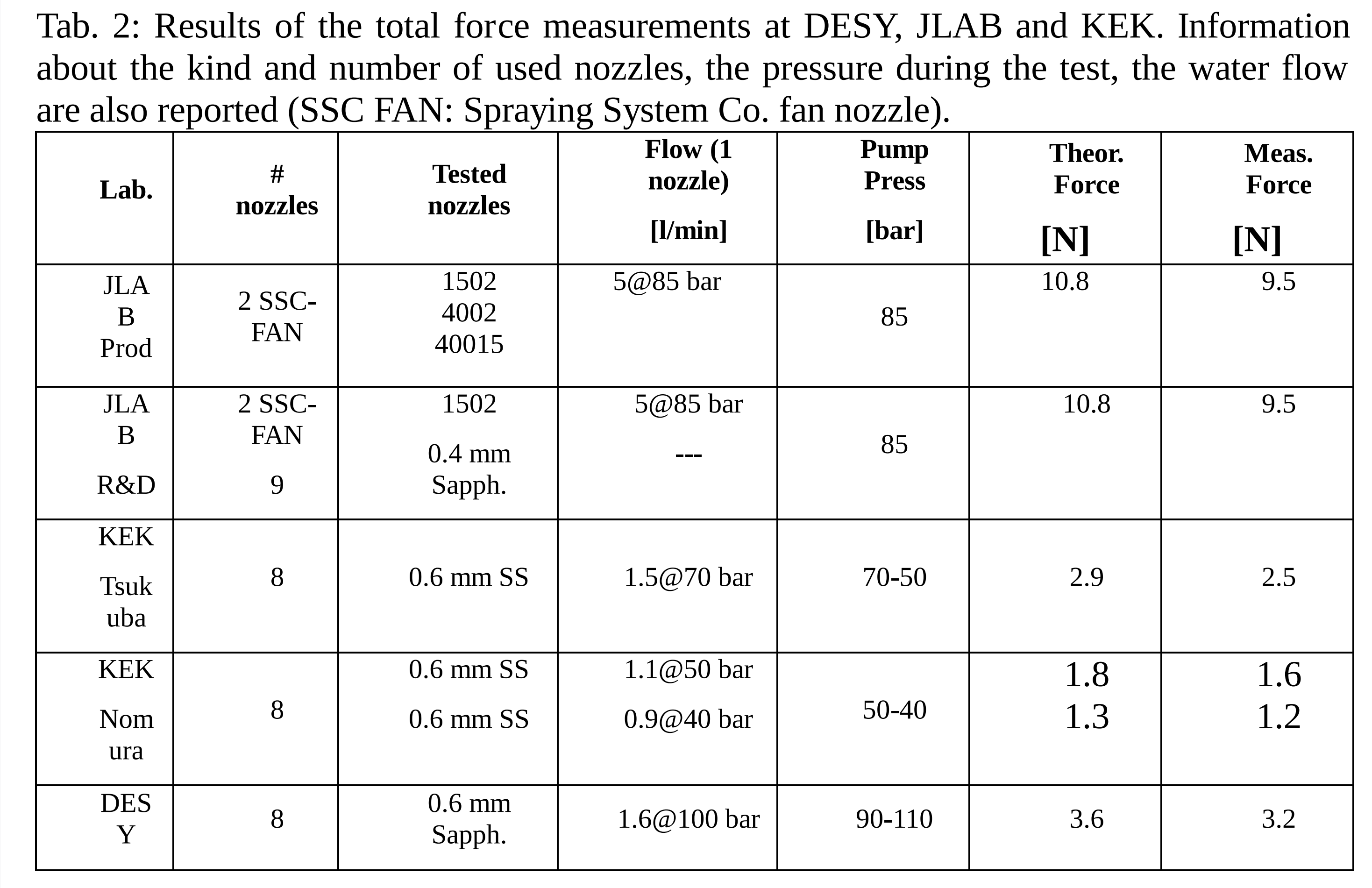
- A **measuring system has been developed at INFN** for measuring high pressure water jet parameters and forces generated by the systems at the surfaces to be cleaned.
- **Comparative measurements** employing this system have been done at DESY, Jlab and KEK/Nomura Plating
- Even though there are significant differences in the system parameters, there is - at present- **no evident correlation** of the measured quantities with the quality of the cleaning process
- In principle the data could be used to “optimize” the HPR process, for instance, producing a constant pressure distribution or constant energy deposition on the cavity surface. However, since the adhesion forces for contaminating particles depend on particle size, nature of particle…., one needs to know more about the contamination distribution.

Optimum set of HPR parameters for 9-cell cavities as established today
Force Measurements

Carried out by P. Michelato and co-workers at DESY,KEK,Nomura Plating, Jlab Production and Jlab R&D

- **Significant variations in forces** generated at the surfaces by the water jets
- **Significant differences in the basic water jet** parameters at distances equivalent to iris diameter and equator diameter of a TESLA cavity
- At present there is **no evident correlation** of the measured quantities with the quality of the cleaning process.
- However the acquired and calculated data can be used to **compare different systems**, as a diagnostic tool for controlling periodically the quality of the HPR water jet, to develop and to compare the behavior of the jets produced by different nozzle geometries, nozzle head structures, water HP pumps, etc

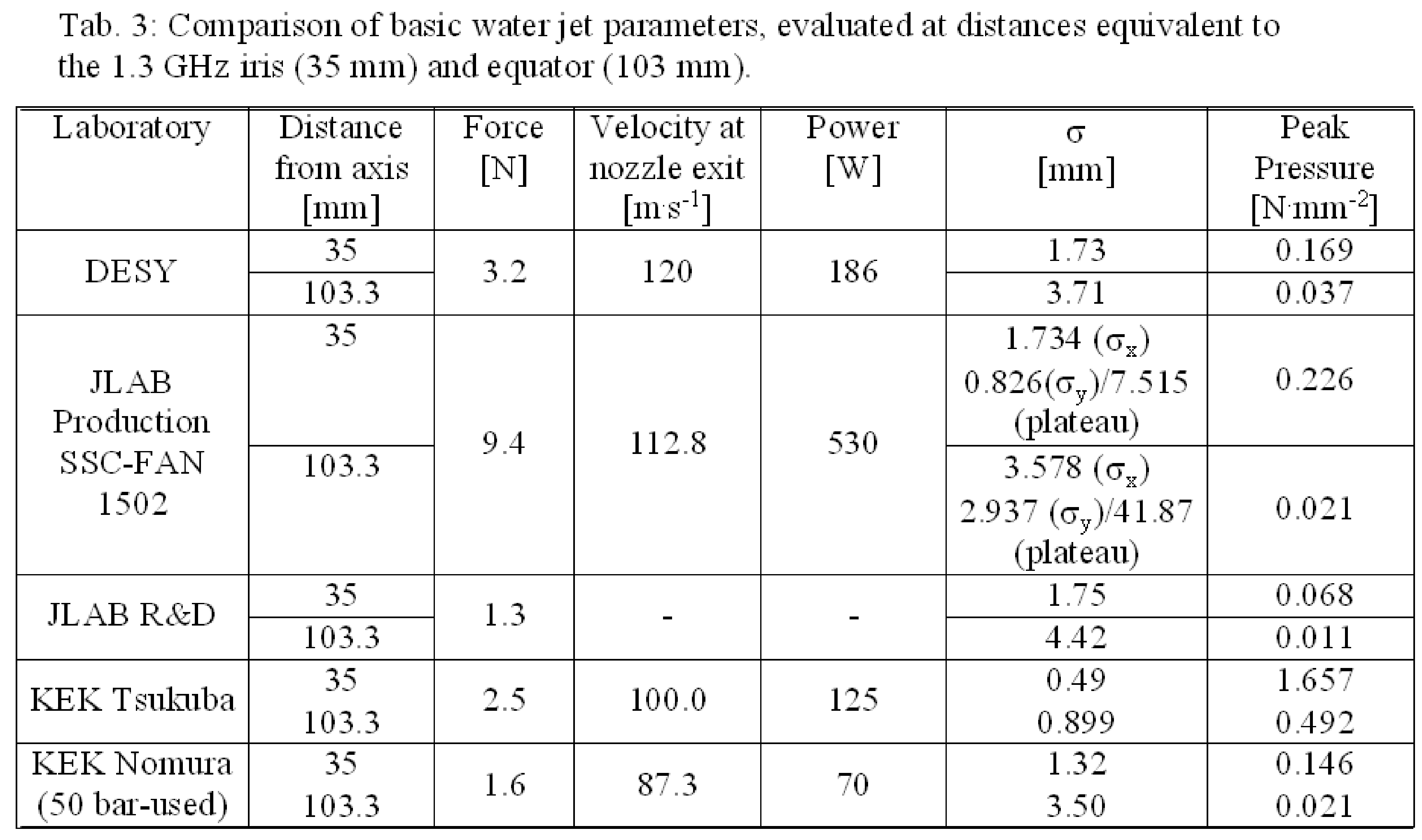
Optimum set of HPR parameters for 9-cell cavities as established today
Force Measurements



Tab. 2: Results of the total force measurements at DESY, JLAB and KEK. Information about the kind and number of used nozzles, the pressure during the test, the water flow are also reported (SSC FAN: Spraying System Co. fan nozzle).

Lab.	**# nozzles**	**Tested nozzles**	**Flow (1 nozzle) [l/min]**	**Pump Press [bar]**	**Theor. Force [N]**	**Meas. Force [N]**
JLAB Prod	2 SSC-FAN	1502 4002 40015	5@85 bar	85	10.8	9.5
JLAB R&D	2 SSC-FAN 9	1502 0.4 mm Sapph.	5@85 bar ---	85	10.8	9.5
KEK Tsukuba	8	0.6 mm SS	1.5@70 bar	70-50	2.9	2.5
KEK Nomura	8	0.6 mm SS 0.6 mm SS	1.1@50 bar 0.9@40 bar	50-40	1.8 1.3	1.6 1.2
DESY	8	0.6 mm Sapph.	1.6@100 bar	90-110	3.6	3.2

Optimum set of HPR parameters for 9-cell cavities as established today
Jet Profiling



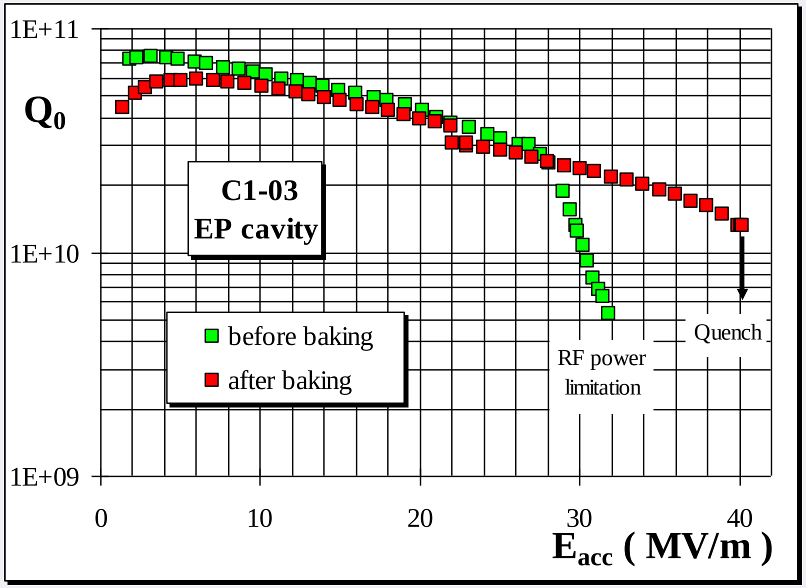
Tab. 3: Comparison of basic water jet parameters, evaluated at distances equivalent to the 1.3 GHz iris (35 mm) and equator (103 mm).

Laboratory	Distance from axis [mm]	Force [N]	Velocity at nozzle exit [$m \cdot s^{-1}$]	Power [W]	σ [mm]	Peak Pressure [$N \cdot mm^{-2}$]
DESY	35	3.2	120	186	1.73	0.169
	103.3				3.71	0.037
JLAB Production SSC-FAN 1502	35	9.4	112.8	530	1.734 (σ_x) 0.826(σ_y)/7.515 (plateau)	0.226
	103.3				3.578 (σ_x) 2.937 (σ_y)/41.87 (plateau)	0.021
JLAB R&D	35	1.3	-	-	1.75	0.068
	103.3				4.42	0.011
KEK Tsukuba	35 103.3	2.5	100.0	125	0.49 0.899	1.657 0.492
KEK Nomura (50 bar-used)	35 103.3	1.6	87.3	70	1.32 3.50	0.146 0.021

Optimum set of HPR parameters for …..……………… as established today Jet Profiling?

What is the best method???

Optimum set of bake-out parameters as established today
B. Visentin (ed.)



Baking Effect :

to remove
High Field Q-Drop

Standard " In-Situ " Baking

- Definition & Set-up worldwide
  Saclay, DESY, JLab, KEK, Cornell
- BCP & EP chemistries on Fine Grain Niobium
- Large Grain & Single Cristal Cavities
- Best parameters

Drawbacks of "In-Situ" Process

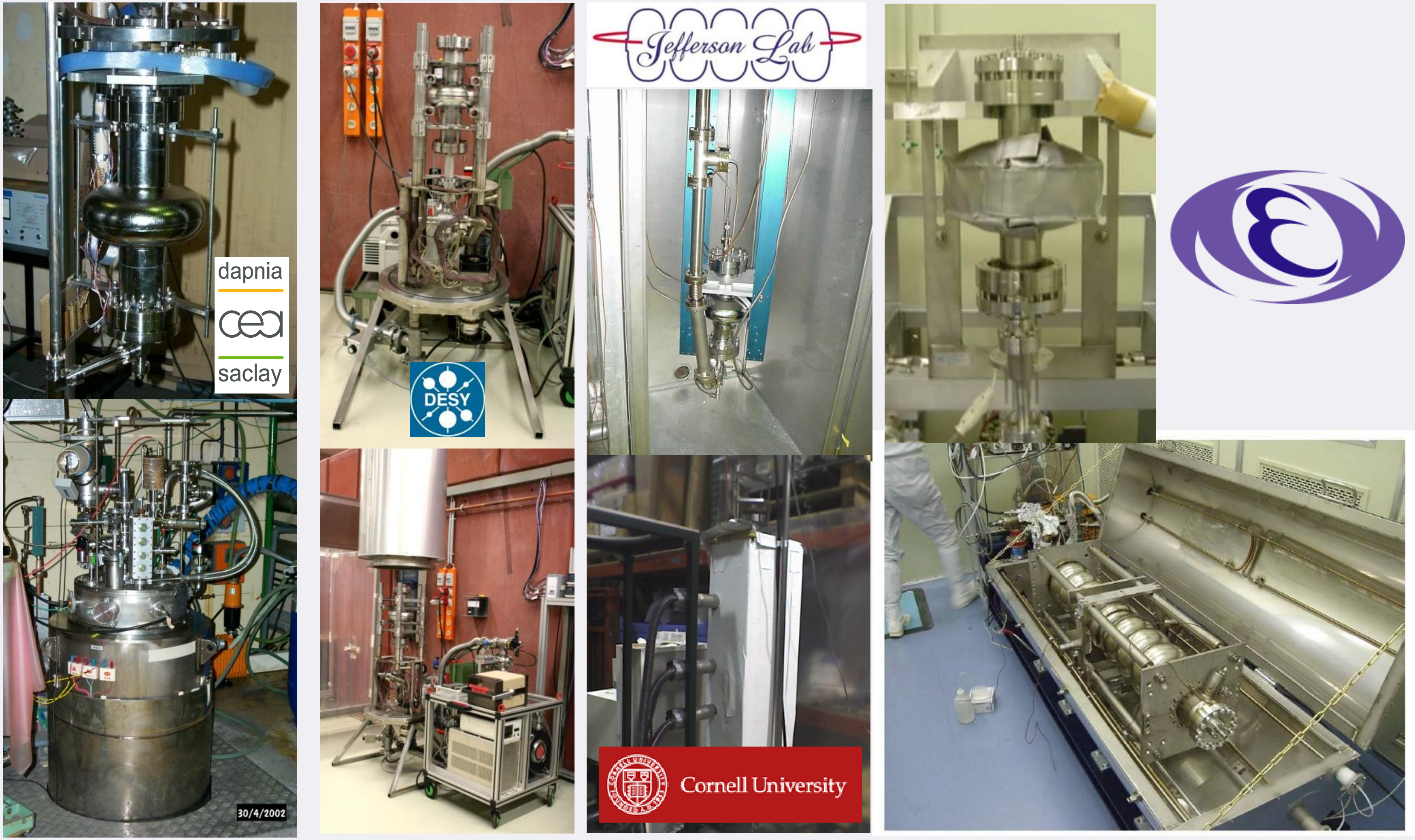
Temperature rise time → Infra Red heaters
Vacuum requirements → Oxygen-Free atmosphere

" Fast " Baking

(total treatment duration < 3 hours)

- Description of Saclay Set-up
- Last Results
- Best parameters (EP on Fine Grain Nb)

Optimum set of bake-out parameters as established today
Different ovens…



Optimum set of HPR parameters for 9-cell cavities as established today … for almost the identical baking parameters

Laboratory		**Saclay**	**DESY**	**JLab**	**KEK**			**Cornell**
Correspondent		B. Visentin	D. Reschke	G. Ciovati	F. Furuta		E. Kako	W. Ashmanskas
			-	-	-		-	-
					ICHIRO 1-cell	ICHIRO 9-cell	STF 9-cell	
Temperature	°C	110	120 - 130	120	120	120	120	105
Period (Fine Grain)	hours	60	48	48	48	48	40 - 48	48
Period (Large Grain)	hours	-	-	12	48 if 12 or 24 not enough	-	-	-
Heater		resistance	resistance + fan	resistive blower	resistance	resistance	resistance	resistance + blower
Place		cryostat	box	box	jacket	box	jacket	box
External Environnement		helium gas	nitrogen / argon	nitrogen	air	air	air	air
Cavity		closed	closed	closed	closed	closed	closed	closed
RF test ready		yes	yes	yes	yes	yes	yes	yes
Gasket		Sn helicoflex	Al alloy	indium wire	indium	indium / Al - indium	indium helicoflex	Al alloy
Inside Requirement		vacuum	vacuum	vacuum	vacuum	vacuum	vacuum	vacuum
Pressure	mbar	1.10^{-9}	2.10^{-8}	1.10^{-8}	1.10^{-8}	1.10^{-8}	2.10^{-9}	3.10^{-7}
Pump		ionic	turbo molecular	turbo molecular	ionic	ionic	ionic	ion pump

baking time depends on Nb material

Optimum set of HPR parameters for 9-cell cavities as established today
Drawbacks of "in-situ" Baking

Since the baking effect discovery in 1998
the procedure is the same :

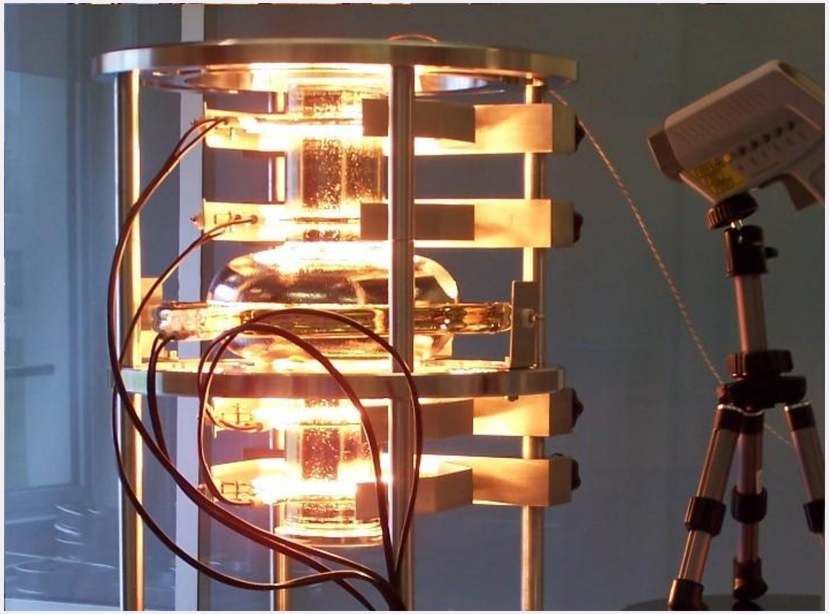
1. hot buffer gas (He, N_2, air) to bake homogeneously the cavity (external wall)
2. inner part under vacuum (flanges, gaskets, RF antennas)

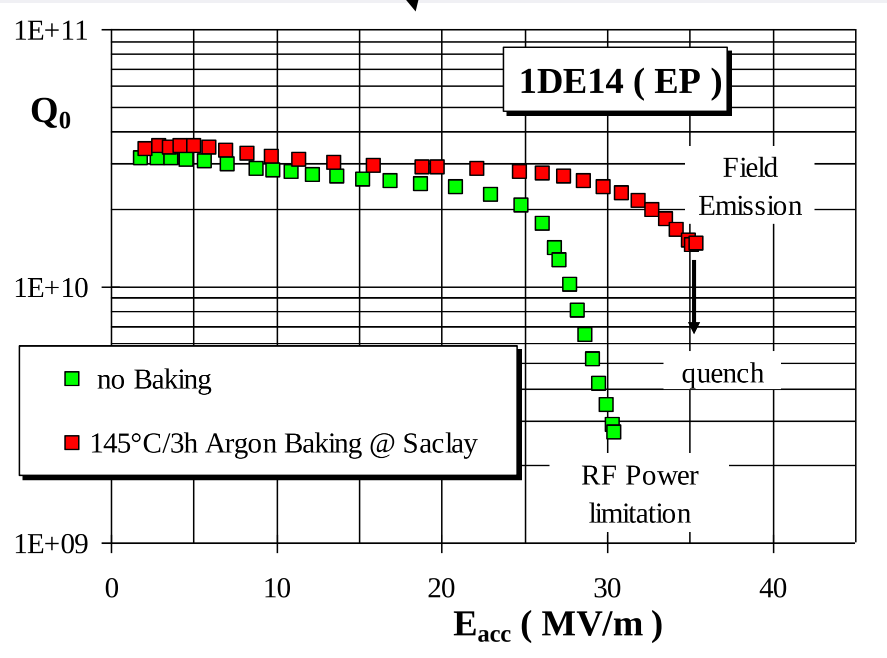
Drawbacks :

1. → **Temperature rise time** up to 120 °C takes **at minimum 2 hours** for a good regulation. It is the same for the temperature drop time. Not important if baking time is 48 hours but very important when we want to decrease it down to few hours.
2. → Cavity has to be assembled before baking. **Risk of leak** after baking (UHV required for RF test at He II temperature) : no guarantee of gaskets at 120°C and higher value

Optimum set of HPR parameters for 9-cell cavities as established today
Saclay Solutions

1. → Infra-Red Heaters (145 °C in 5 minutes) working in Clean Room
2. → Cavity Baking in Oxygen-free atmosphere : 1 atm. of Argon
   Equivalent to UHV baking (SRF Workshop 2007 : TUP69)



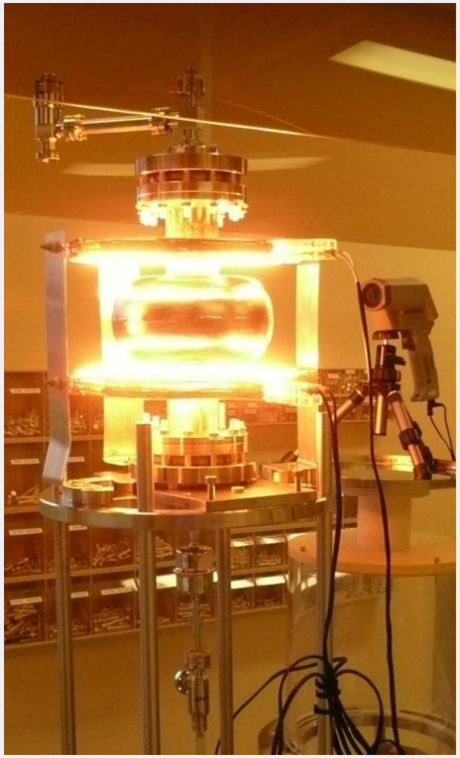


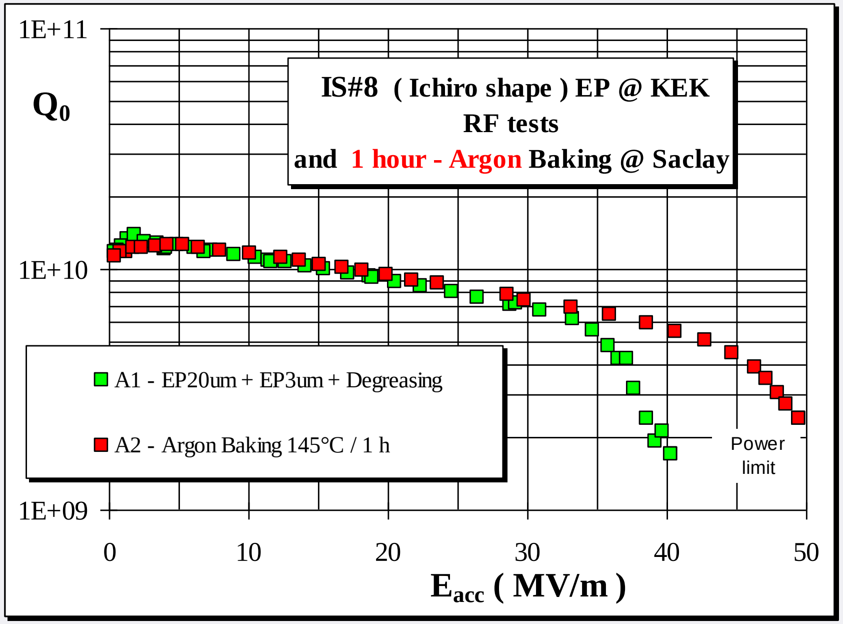
Optimum set of HPR parameters for 9-cell cavities as established today
« Fast » Baking Parameters at Saclay

IR heaters – Argon (1 atm.) – T = 145 °C for x hours

Very high gradient cavity (50 MV/m)

→ EP on Ichiro shape (KEK – LIA collaboration)





1 hour – 49.5 MV/m – no field emission - no quench
residual Q Drop → additional baking (+1 hour)

Optimum set of HPR parameters for 9-cell cavities as established today
Summary: Best Baking Parameters

Baking	"in-situ" vacuum		"fast" argon
Chemistry	**BCP**	**EP**	**EP**
Fine Grain Nb	110°C/60h	120°C/48h	145°C 2 or 3 h
Large Grain Nb	-	120°C/12h	-
Single Crystal Nb	120°C/12h	-	-

Optimum set of HPR parameters for 9-cell cavities as established today
Next steps to be done at Saclay

“Fast” Baking can replace “In-Situ” procedure

→ Find the right baking time @ 145 °C (~ 2 hours)

→ Applied this procedure on an open-ended cavity (vessel with IR)

Advantages

→ time saving (cavity mass production)

→ cavity only assembled after baking

→ bake after rinse following chemistry or after HPR (clean room)

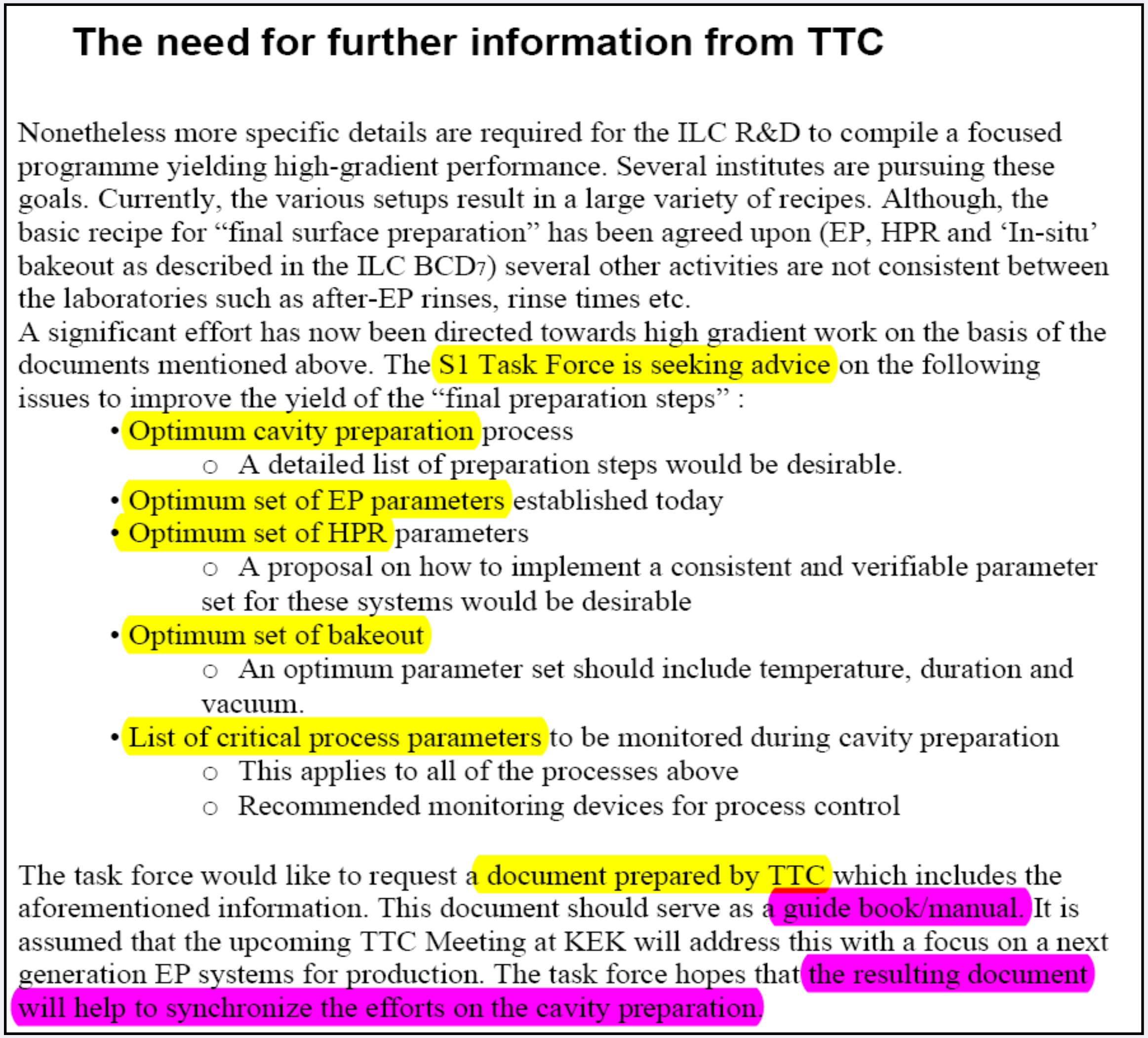
→ avoid oxygen penetration through outer cavity wall (RRR preserved)

→ possible application for XFEL

The structured answer can be delivered to H. Padamsee and K. Saito for further processing around end of 1/2008

1.	Optimum cavity preparation process	H.Padamsee, K.Saito
	general overview based on Sect. 2-4; incl. assembly techniques	
2.	Optimum set of EP parameters for 9-cell cavities as established today	J. Mammosser
2.1	Recommended EP parameter	J. Mammosser
2.2	Recommended acid quality monitoring	A. Matheisen
2.3	Recommended rinsing parameter	J. Mammosser
	Supporting material	
	Comparison EP parameter	T. Higo
	Status of acid quality monitoring	A. Matheisen
	Results rinsing studies; list of possible rinsing methods and current status	
	HF rinsing / short EP	K. Saito
	Ultrasound degrease	J. Mammosser
	Alcohol	A. Matheisen
	H2O2	E. Kako
3.	Optimum set of HPR parameter	P. Kneisel
3.1	Recommended HPR parameter	P. Kneisel
3.2	Recommendations wrt process quality monitoring,	
	e.g. force, particle count	D. Reschke / P. Michelato
	Supporting material	
	Comparison of HPR systems	P. Michelato
	water quality	Rothgeb /Saeki
4.	Optimum set of bakeout parameter	
4.1	Recommend bakeout parameter	B. Visentin
	Supporting material	
	Comparison of bakeout procedures	Visentin / Ciovati / Furuta

Request to the TTC and hence to the TB



The need for further information from TTC

Nonetheless more specific details are required for the ILC R&D to compile a focused programme yielding high-gradient performance. Several institutes are pursuing these goals. Currently, the various setups result in a large variety of recipes. Although, the basic recipe for “final surface preparation” has been agreed upon (EP, HPR and ‘In-situ’ bakeout as described in the ILC BCD7) several other activities are not consistent between the laboratories such as after-EP rinses, rinse times etc.

A significant effort has now been directed towards high gradient work on the basis of the documents mentioned above. The S1 Task Force is seeking advice on the following issues to improve the yield of the “final preparation steps” :

- Optimum cavity preparation process
  - ○ A detailed list of preparation steps would be desirable.
- Optimum set of EP parameters established today
- Optimum set of HPR parameters
  - ○ A proposal on how to implement a consistent and verifiable parameter set for these systems would be desirable
- Optimum set of bakeout
  - ○ An optimum parameter set should include temperature, duration and vacuum.
- List of critical process parameters to be monitored during cavity preparation
  - ○ This applies to all of the processes above
  - ○ Recommended monitoring devices for process control

The task force would like to request a document prepared by TTC which includes the aforementioned information. This document should serve as a guide book/manual. It is assumed that the upcoming TTC Meeting at KEK will address this with a focus on a next generation EP systems for production. The task force hopes that the resulting document will help to synchronize the efforts on the cavity preparation.

The resulting document will help to synchronize the efforts in the cavity preparation.

“Let’s take a minute, read the published document, and develop new plans in order to go from XFEL-like to ILC-like cavity behaviour.”

Cavities / Coupler / Modules / Linac / Test Facilities
Highlights and Outlook

Presentations & Comments from

Cavities	(Kneisel / Lilje / Reschke)
Coupler	(Kako / Moeller)
Module	(Ohuchi / Pagani / Petersen)
Linac	(Michizono / Simrock / Weise)
Test Facilities	(Schreiber / Hayano)

Cavity Highlights and Outlook
Discussion / Comments (L. Lilje, D. Reschke, P. Kneisel et al.)

Highlights:

- Ethanol Data DESY & CEA (alcohol rinsing, see above)
- Fast bake at Saclay (bakeout, see above)
- high power test of TESLA type cavity at KEK
- one good AES cavity
- inspection of AES cavity at KEK (impressive!)
- assembly of modules #8 and #9 (see modules)
- Agreement: need of a standardized data set taken during vertical tests

Proposal:
Think about a cw optimzed cavity R&D program; cryogenics is the big cost driver…

Lowlights:

- Other shape multicells (Ichiro w/o end groups only 30 MV/m, with below 20 MV/m)
- still field emission (although a bit less)
- multi-cell large grain cavity with EP do not perform yet

Summary WG2 (1) by Peter Kneisel

- QA of niobium sheets for cavity cells is important to weed out “bad candidates”

  Resolution of squid and eddy current systems app. 50 – 100 μm; might be marginal
- T-mapping systems are very important for diagnostic purposes and should be used as often as possible: Several are in operation, others are near to being commissioned
- Inspection of cavities after (or before) a tests with T-mapping (BD location) are very desirable.

  The inspection system developed at Kyoto University/KEK is very powerful and it should be applied/duplicated as often as possible.

  Most importantly, it should be used to inspect a very good cavity

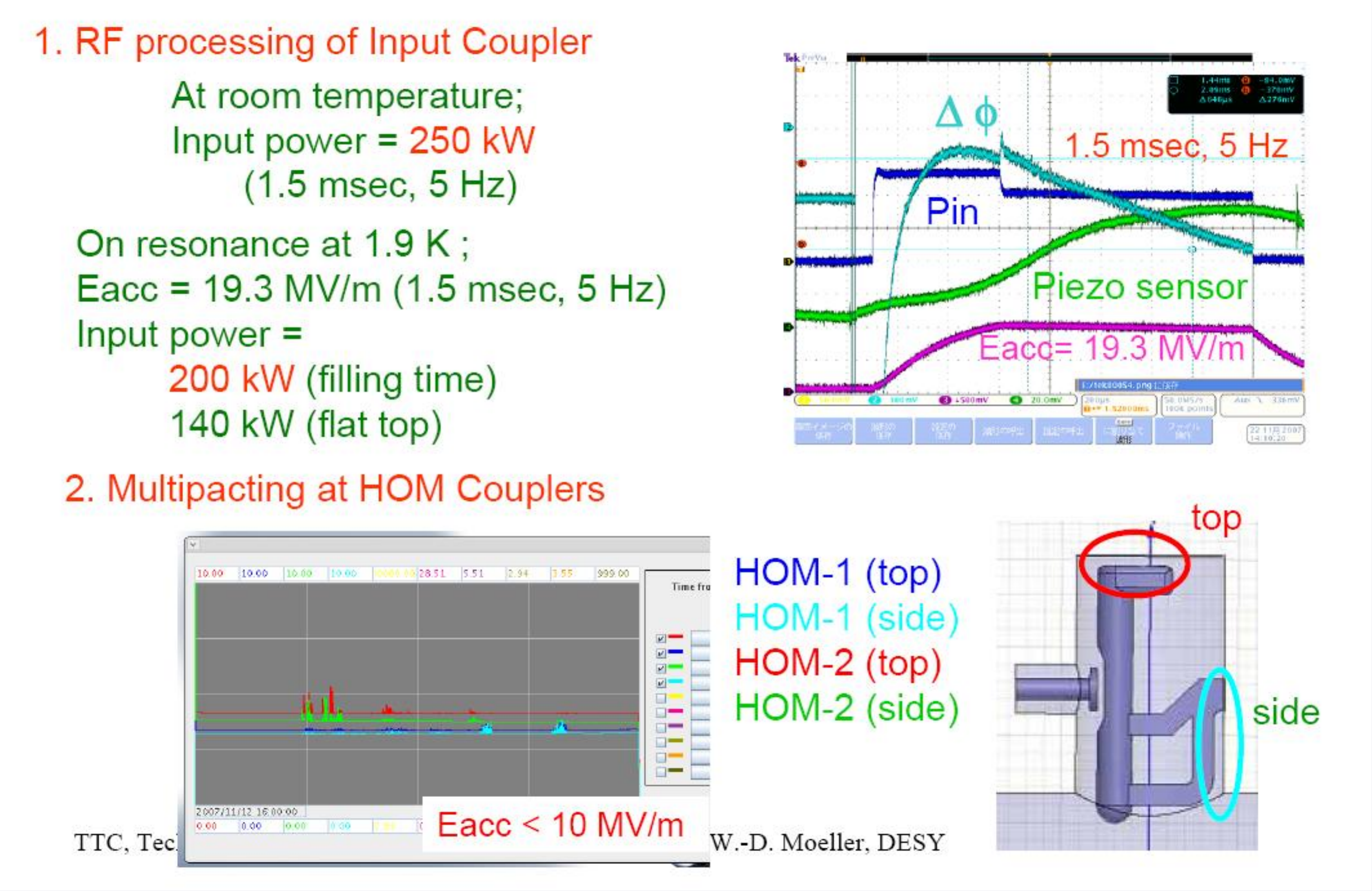
Summary WG2 (2) by Peter Kneisel

- Other diagnostic methods such as e.g. surface analysis, replica techniques..should be applied to the identified areas to learn about the causes for the quenches (topology, defects)
- “Data Mining” from existing data banks is important to gain more understanding of the nature of problem areas in a cavity

Coupler Highlights and Outlook
W.-D. Moeller / E. Kako

- Cryomodule Test of STF Baseline cavity at KEK
- Input Coupler at DESY-Hamburg and LAL-Orsay
- HOM absorber at DESY
- ERL Cryomodule test at Cornell
- HOM feedthrough with high thermal conductivity

Coupler Highlights and Outlook
Cryomodule Test of STF Baseline cavity at KEK



1. RF processing of Input Coupler

At room temperature;
Input power = 250 kW
(1.5 msec, 5 Hz)

On resonance at 1.9 K ;
Eacc = 19.3 MV/m (1.5 msec, 5 Hz)
Input power =
200 kW (filling time)
140 kW (flat top)

2. Multipacting at HOM Couplers

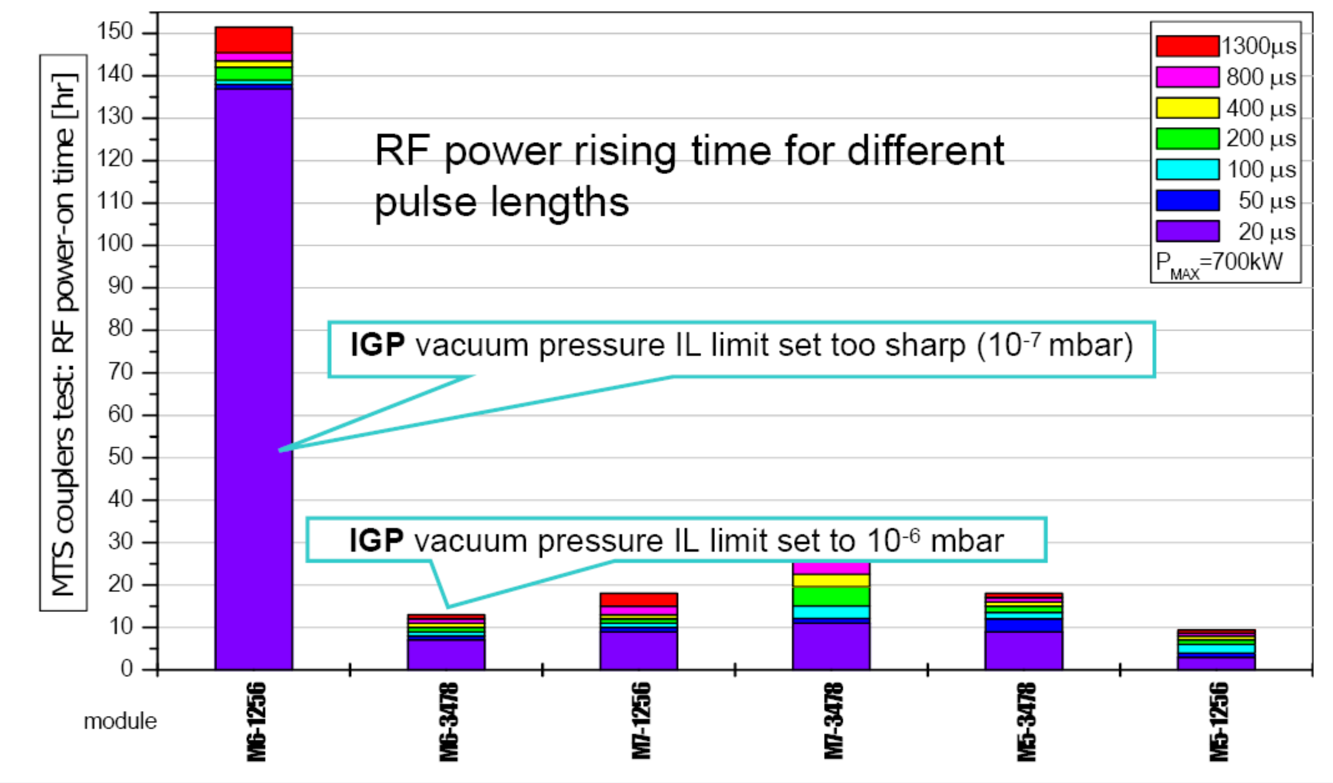
Eacc < 10 MV/m

HOM-1 (top)
HOM-1 (side)
HOM-2 (top)
HOM-2 (side)

TTC, Tec
W.-D. Moeller, DESY

Coupler Highlights and Outlook
Input Coupler at DESY-Hamburg and LAL-Orsay

- 24 TTF3 couplers are assembled to modules: M7, M8, M9 (at Fermilab)
- M5: TTF3 coupler warm parts were taken apart and reassembled (same couplers)
- several wave guide boxes were replaced after sparks on soldering (prototype prod.)



RF power rising time for different pulse lengths

IGP vacuum pressure IL limit set too sharp (10^{-7} mbar)

IGP vacuum pressure IL limit set to 10^{-6} mbar

Coupler Conditioning Time on Module Test Stand

Coupler Highlights and Outlook XFEL Input and HOM Coupler at DESY

60 TTF3 couplers are ordered at two companies

- 14 are delivered so far
- some industry is doing the same or worse mistakes than at last coupler fabrication and have to learn again

industrial study is well in time

- three companies will deliver two couplers each in March ’08
- tests will be done as early as possible (XFEL order to be placed in 2008)

one HOM absorber prototype assembled at the end of module 6 in FLASH

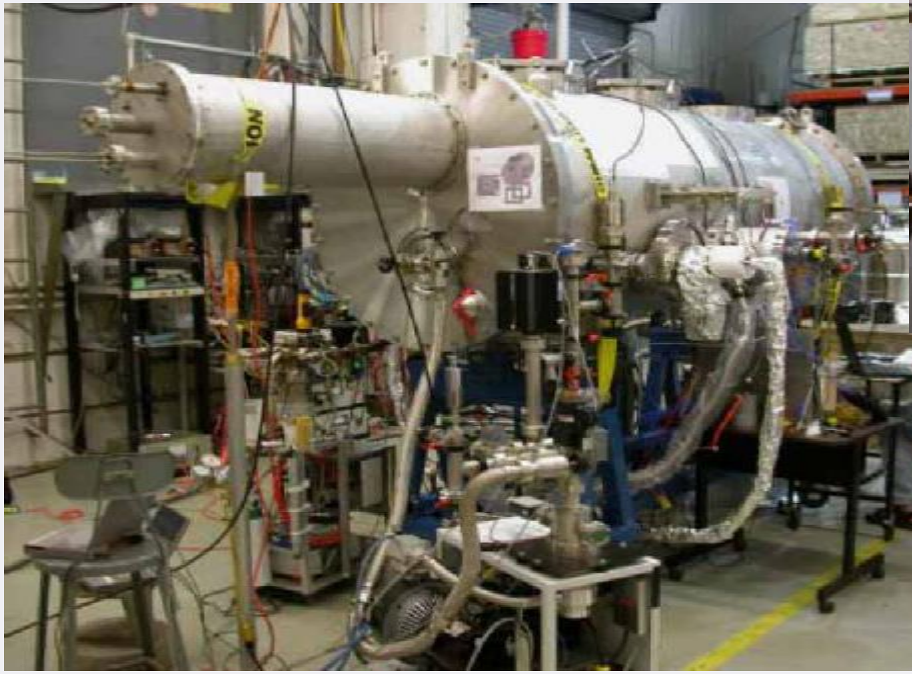
- waiting for test

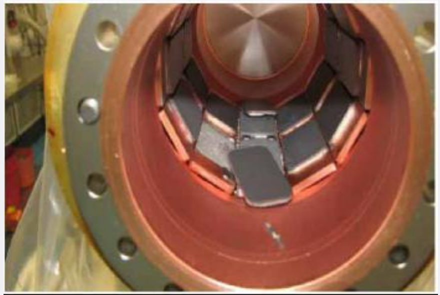
second prototype is under fabrication at Poland

- XFEL in-kind contributor

Coupler Highlights and Outlook
ERL Injector Cryomodule Test Assembly

‘Only minor coupler processing was required at RF power levels above 10 kW.’, cw (<4h)
=> very successful



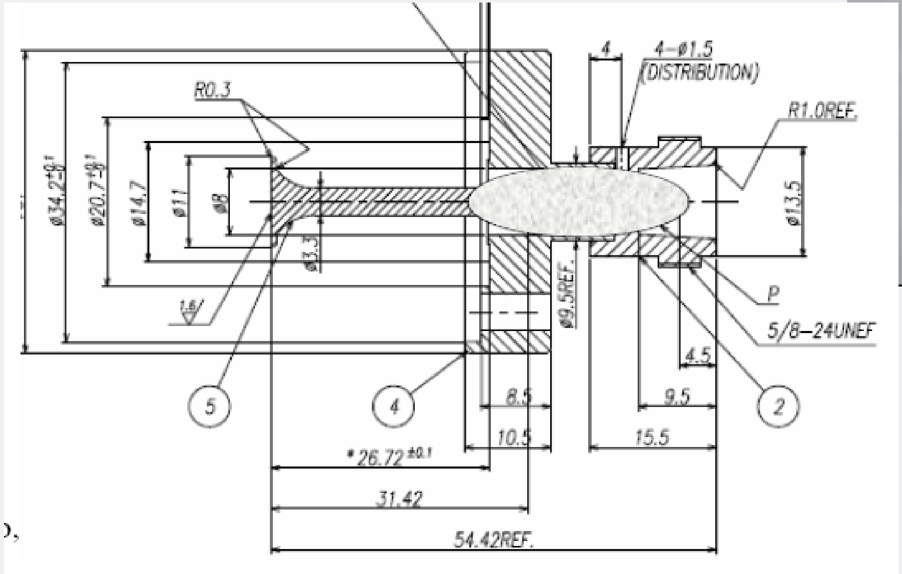


Some material problem discovered with the HOM load.

Coupler Highlights and Outlook
high thermal conductivity HOM feedthrough

there is a vendor for the Jlab feedthrough design

new design by Kyocera



Module Highlights and Outlook (N. Ohuchi)
Asia: The 1st cold test of the STF Cryomodule

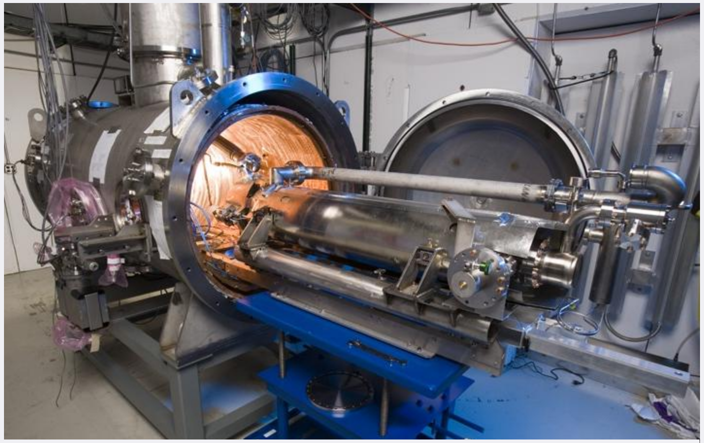
Program:

Oct. 03-12: cool down test,
suspended by SRF workshop
Oct. 22 -26: re-cool down
Oct.29 - Nov. 02 : 4K Test (1 week)
Nov.05 - Nov. 09 : 2K Test(1 week)
Nov.12 - Nov 22 : 2K with HLRF on
(2 weeks)

Study Item:

- Cool down control
- Heat load measurements
- Cavity fundamentals(Q,Eacc,f0..)
- Lorentz detuning
- Piezo compensation
- Mechanical vibration
- GRP distortion by WPM
- etc.

Module Highlights and Outlook
America: Assembly of Cryomodule 9 at FNAL



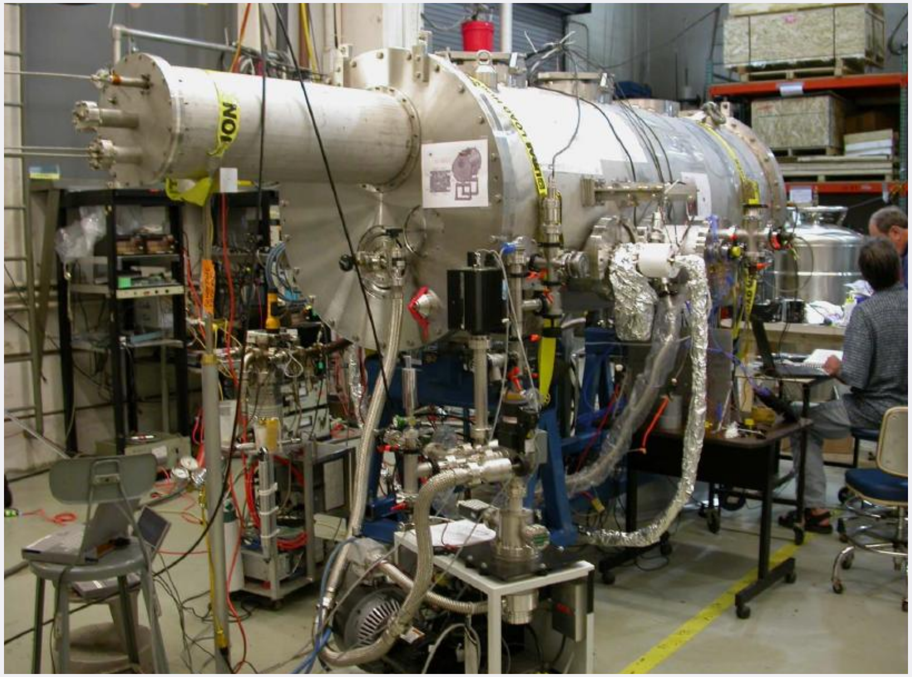
Horizontal Test Cryomodule, C22 tested

String Assembly with DESY Cavities

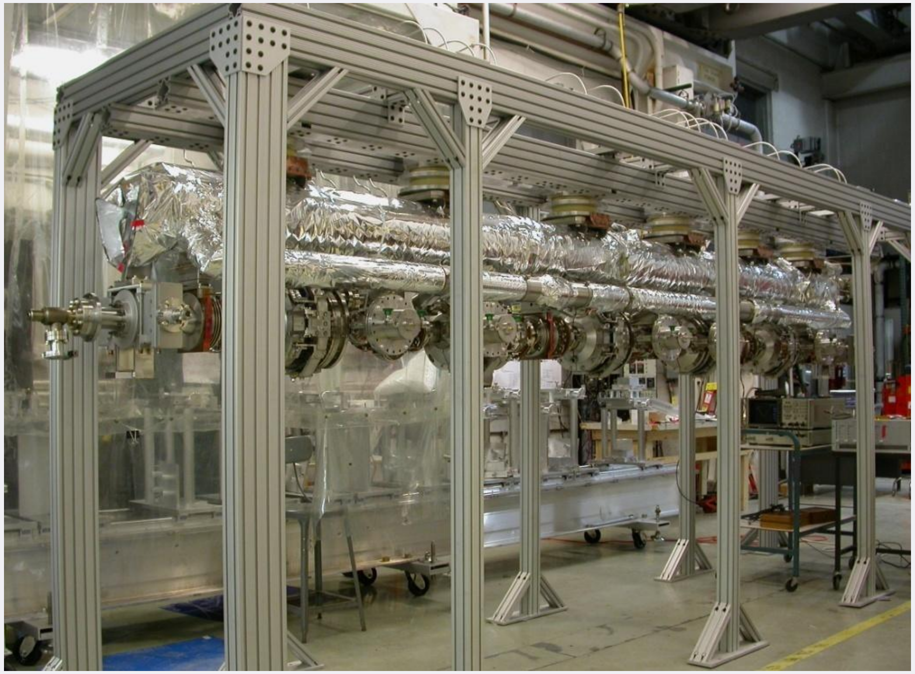
Cryomodule Assembly with DESY Assistance

First CM Ready for Test Facility

Module Highlights and Outlook
America: ERL Injector, 2-cell Cavity Cryomodule Assembly at Cornell



Finished Test Cryomodule



String on Helium Gas Return Pipe

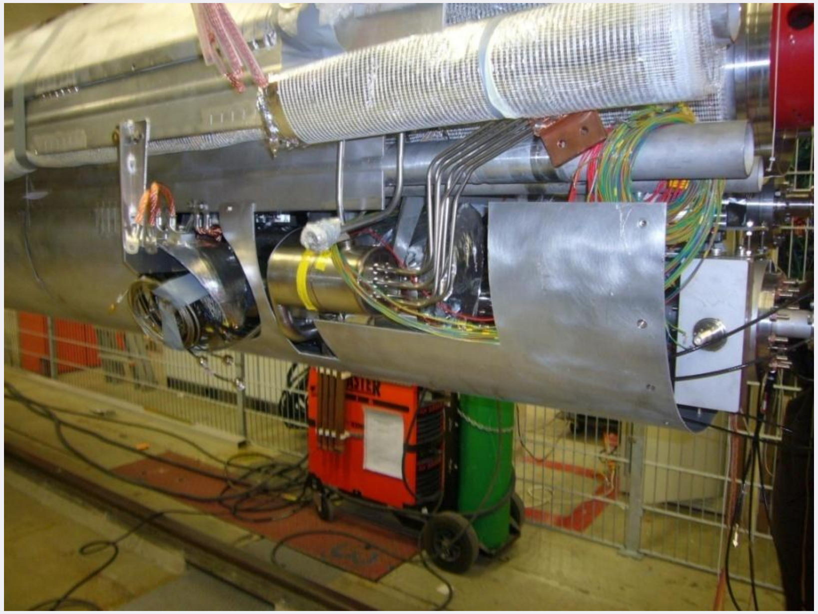
Test Anticipated April 2008

Module Highlights and Outlook
Europe: Assembly of Cryomodule 8 at DESY

Second part of Industrial Assembly Study:
Industry experts were actively involved in the assembly - study is now finished.

Mutual transfer of information and experience between DESY and Industry.

Transport experiment of cryomodule 8 from DESY to Saclay, and from Saclay to DESY. CMTB test before and after the transport.
Installation at FLASH as ACC7 at 2009.



Highlight:

First assembly of
XFEL prototype superferric quad
in a cryomodule including LHC type
conduction cooled current leads.

Quad will be cooled in the 2K helium II bath.

Module Highlights and Outlook
Worldwide Cryomodule R&D in 2008

The **KEK cryomodule** with the one **LL cavity** will be re-assembled in January 2008. The cool down of the cryomodule will start mid February, and the cold test will be carried out.

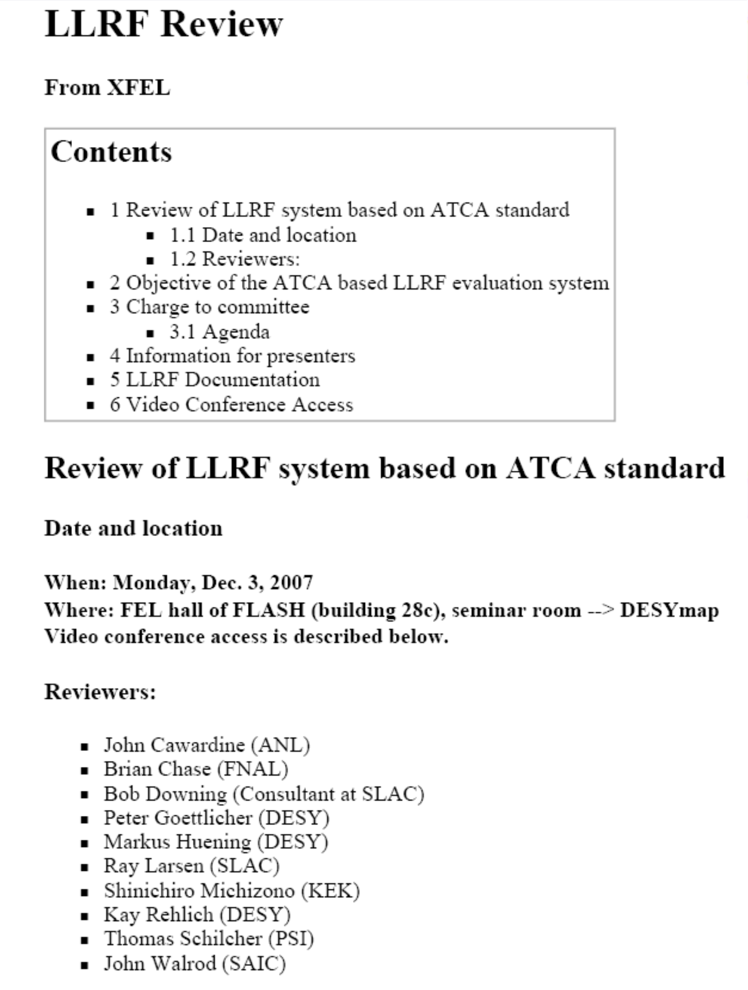
The construction of the **KEK cryomodule** with **4 Tesla-like cavities** is ongoing, and it will be completed in March. The cold test of the cryomodule is planned for this summer.

‚Crash-Tests‘ of module 3* at the DESY CMTB are scheduled for Q1/2008.

- Air venting of insulation vacuum and beam vacuum….+….
- So far only calculations exists for the pressure built up after catastrophic events in TESLA cryomodules (based on LEP and JLab experiments)

  -> new input expected for FLASH, XFEL and ILC cryogenic systems layout (…hopefully the present layout will be confirmed)

LLRF Highlights and Outlook
XFEL Review at DESY (S. Michizono)



LLRF Review

From XFEL

Contents

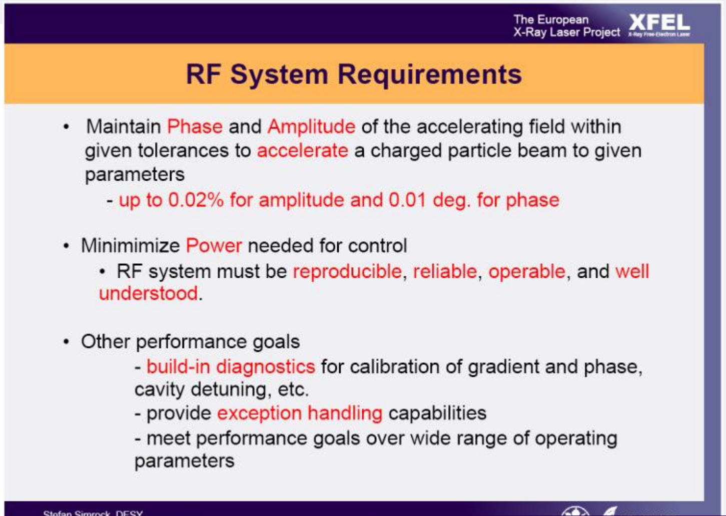
Review of LLRF system based on ATCA standard

Date and location

When: Monday, Dec. 3, 2007
Where: FEL hall of FLASH (building 28c), seminar room --> DESYmap
Video conference access is described below.

Reviewers:

- John Cawardine (ANL)
- Brian Chase (FNAL)
- Bob Downing (Consultant at SLAC)
- Peter Goettlicher (DESY)
- Markus Huening (DESY)
- Ray Larsen (SLAC)
- Shinichiro Michizono (KEK)
- Kay Rehlich (DESY)
- Thomas Schilcher (PSI)
- John Walrod (SAIC)

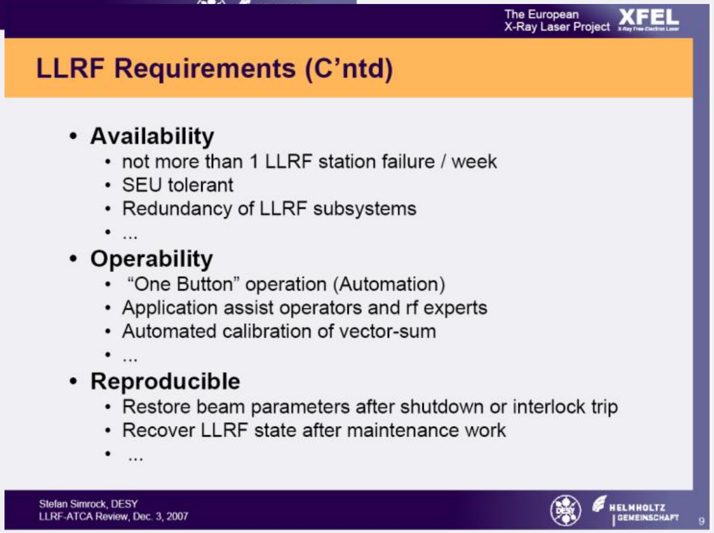


The European X-Ray Laser Project XFEL

RF System Requirements

- Maintain Phase and Amplitude of the accelerating field within given tolerances to accelerate a charged particle beam to given parameters
  - up to 0.02% for amplitude and 0.01 deg. for phase
- Minimimize Power needed for control
  - RF system must be reproducible, reliable, operable, and well understood.
- Other performance goals
  - build-in diagnostics for calibration of gradient and phase, cavity detuning, etc.
  - provide exception handling capabilities
  - meet performance goals over wide range of operating parameters

Stefan Simrock, DESY
LLRF-ATCA Review, Dec. 3, 2007



The European X-Ray Laser Project XFEL

LLRF Requirements (C'ntd)

- **Availability**
  - not more than 1 LLRF station failure / week
  - SEU tolerant
  - Redundancy of LLRF subsystems
  - ...
- **Operability**
  - "One Button" operation (Automation)
  - Application assist operators and rf experts
  - Automated calibration of vector-sum
  - ...
- **Reproducible**
  - Restore beam parameters after shutdown or interlock trip
  - Recover LLRF state after maintenance work
  - ...

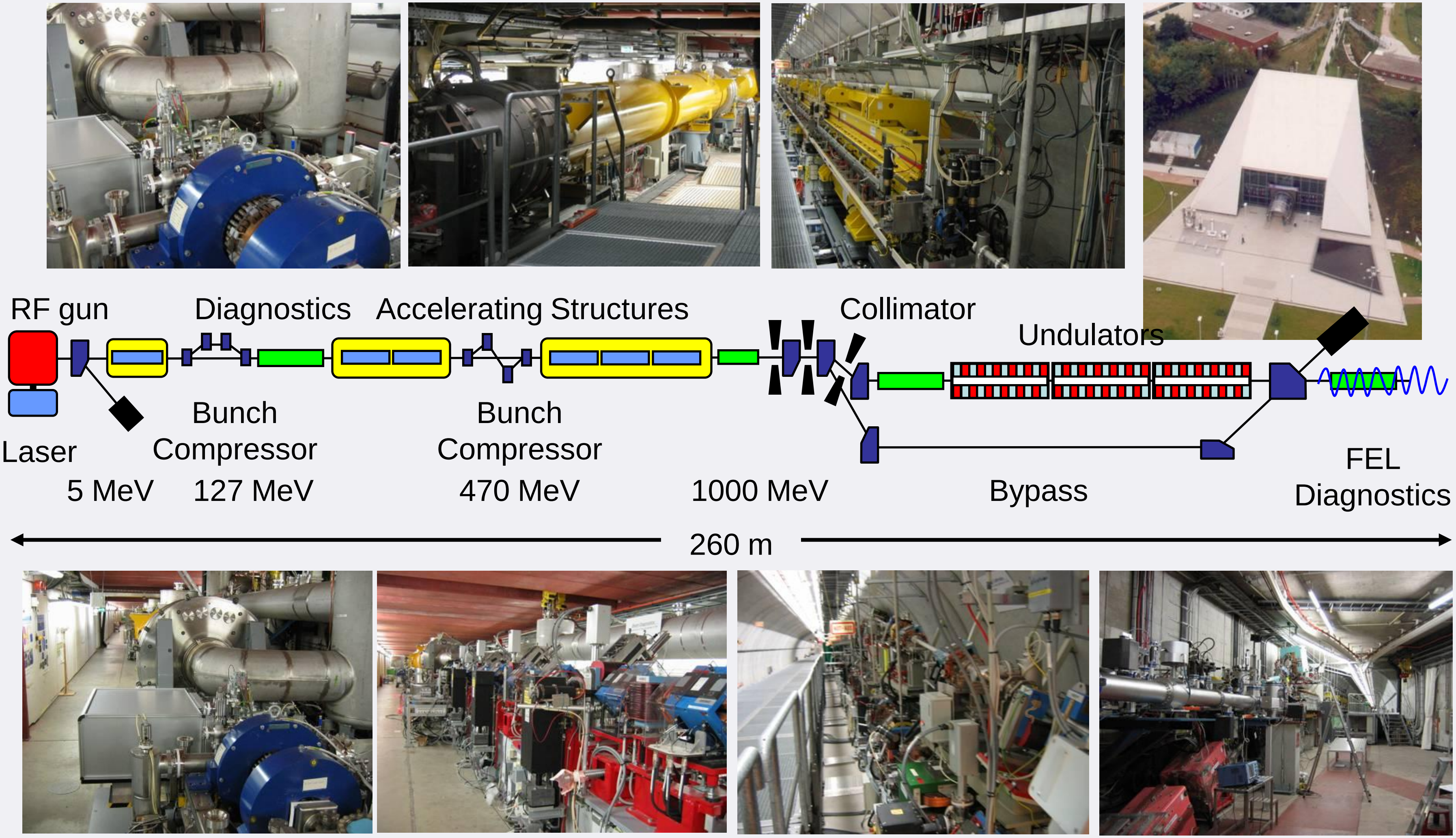
Stefan Simrock, DESY
LLRF-ATCA Review, Dec. 3, 2007

9

LLRF Highlights and Outlook
Highlights at STF / KEK (S. Michizono)

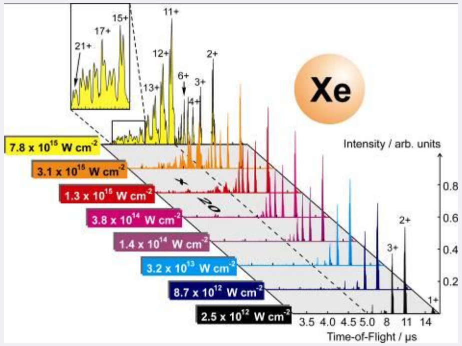
- One shift study was carried out on last November.
    - Stability: 0.04%rms (amplitude) and 0.1 deg.rms (phase)
    - Instability (8/9π mode) study was carried out.
    - FFT analysis indicates the instability observed was due to both 7/9 and 8/9π modes.
    - First IF mixture method was demonstrated.
    - This method enables to reduce the number of ADCs by using multiple IFs.
    - The performance was 0.05%rms(amplitude), 0.04deg.rms(phase) in 2 IFs. (better than single input owing to the vector sum effects.)
- 6 Month plan
    - _Preparation for STF-1
    - Design work for STF-2

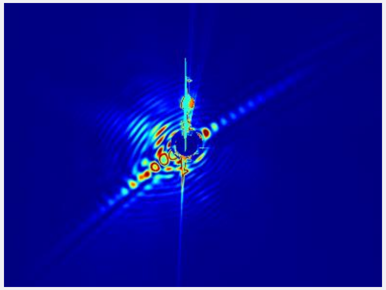
(Test) Facilities Highlights and Outlook
FLASH Overview (S. Schreiber)

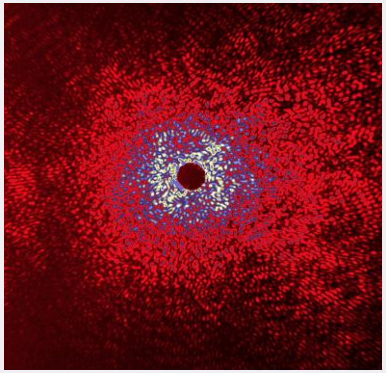


RF gun
Diagnostics
Accelerating Structures
Collimator
Undulators
Laser
Bunch Compressor
Bunch Compressor
FEL Diagnostics
5 MeV
127 MeV
470 MeV
1000 MeV
Bypass
260 m

(Test) Facilities Highlights and Outlook
Experiments with the FLASH FEL Beam



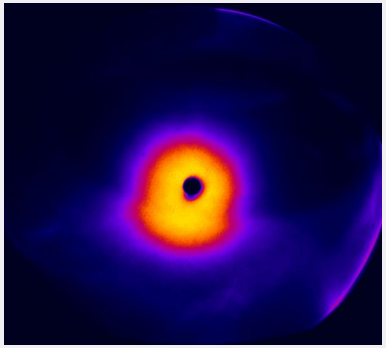


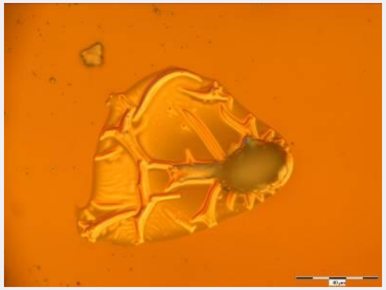


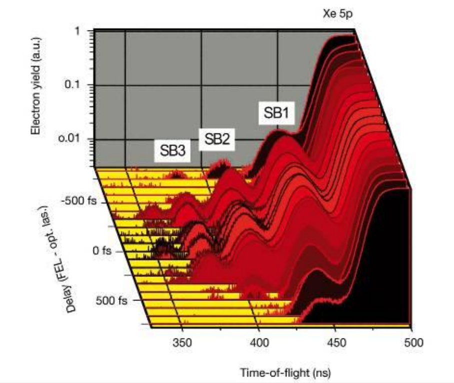
Already about 25 publications,
many more to come

- 4 PRL
- 6 APL
- 1 Nature,
- 1 Nature Physics
- 1 Nature Photonics
- …

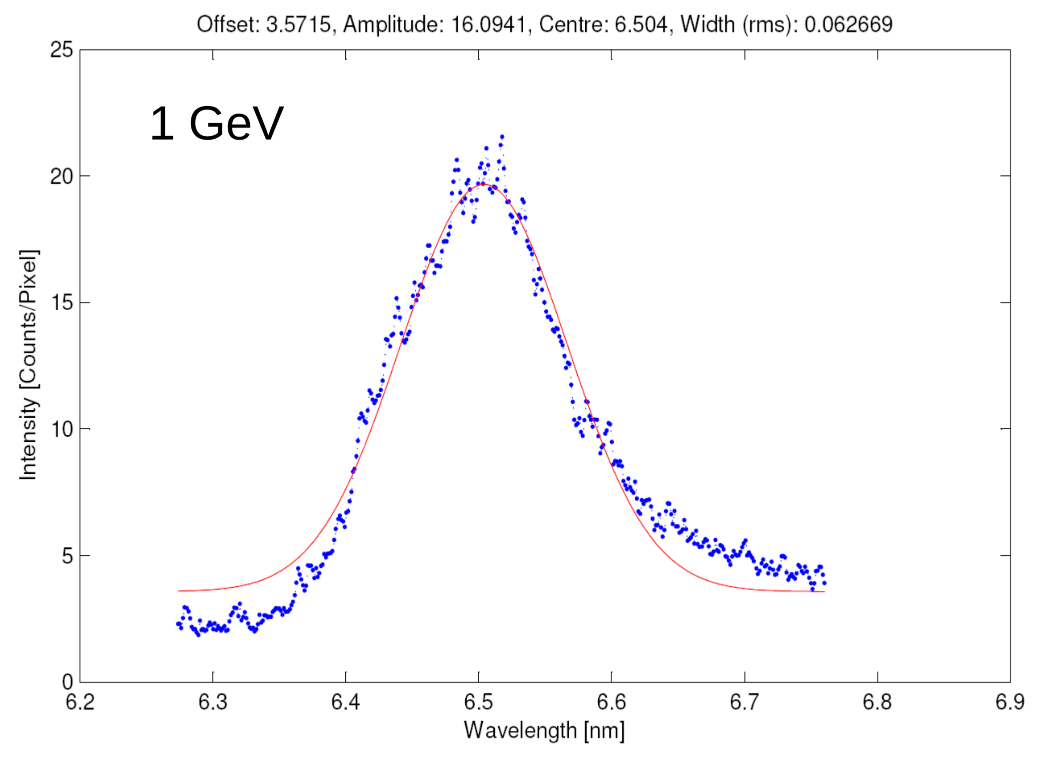
See, e.g.,
http://hasylab.desy.de/facilities/flash/publications

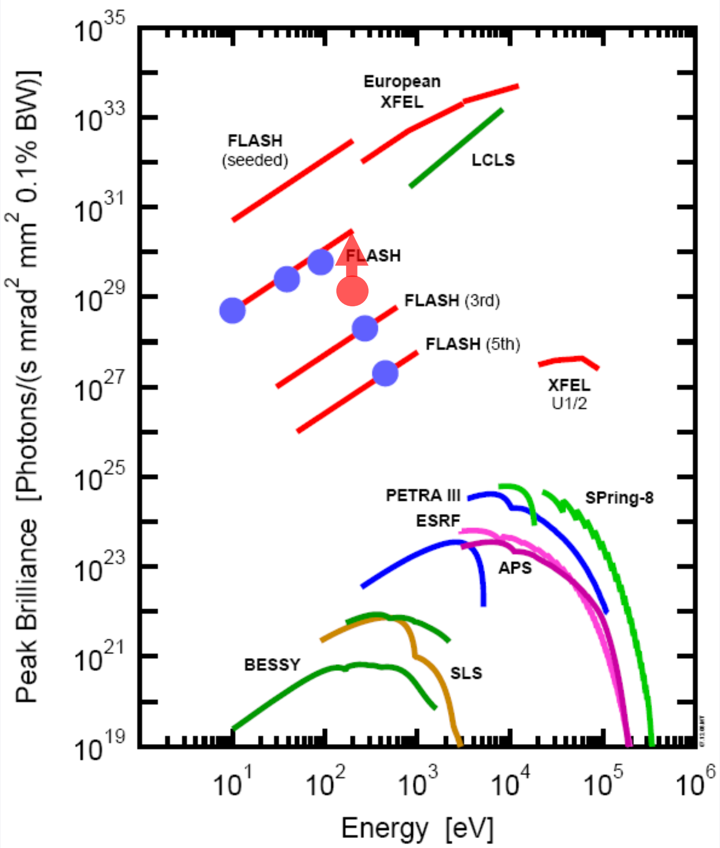






(Test) Facilities Highlights and Outlook
FLASH FEL Lasing at 1 GeV

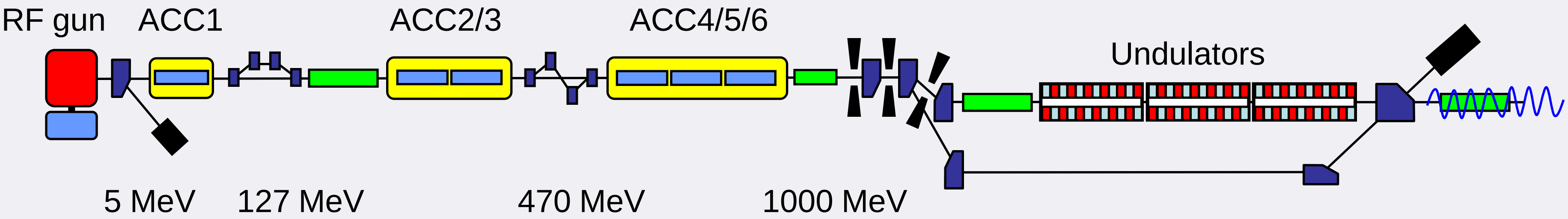




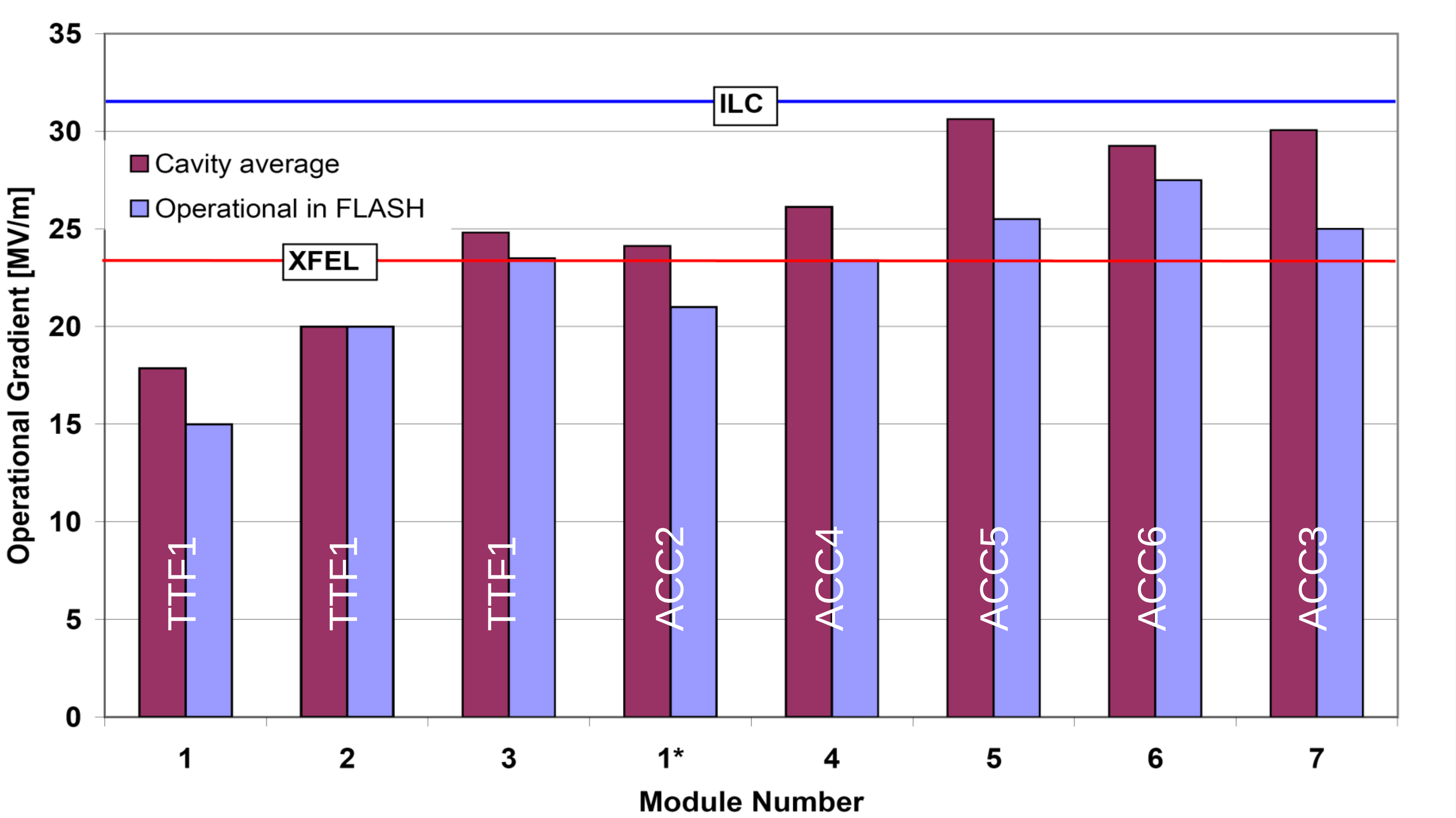
(Test) Facilities Highlights and Outlook
On-Crest Energies from RF Measurements at FLASH

Energy gain (MeV)	RF Gun	ACC1	ACC2	ACC3	ACC4	ACC5	ACC6
before	5	122	140	101	171	171	
sum		127		370			710
after shutdown	5	124	140	205	166	161	205
sum		129		474			1006

note: off crest with bunch compression, we loose ~ 20 MeV → 980 MeV or 6.5 nm
present rf distribution has room for improvement

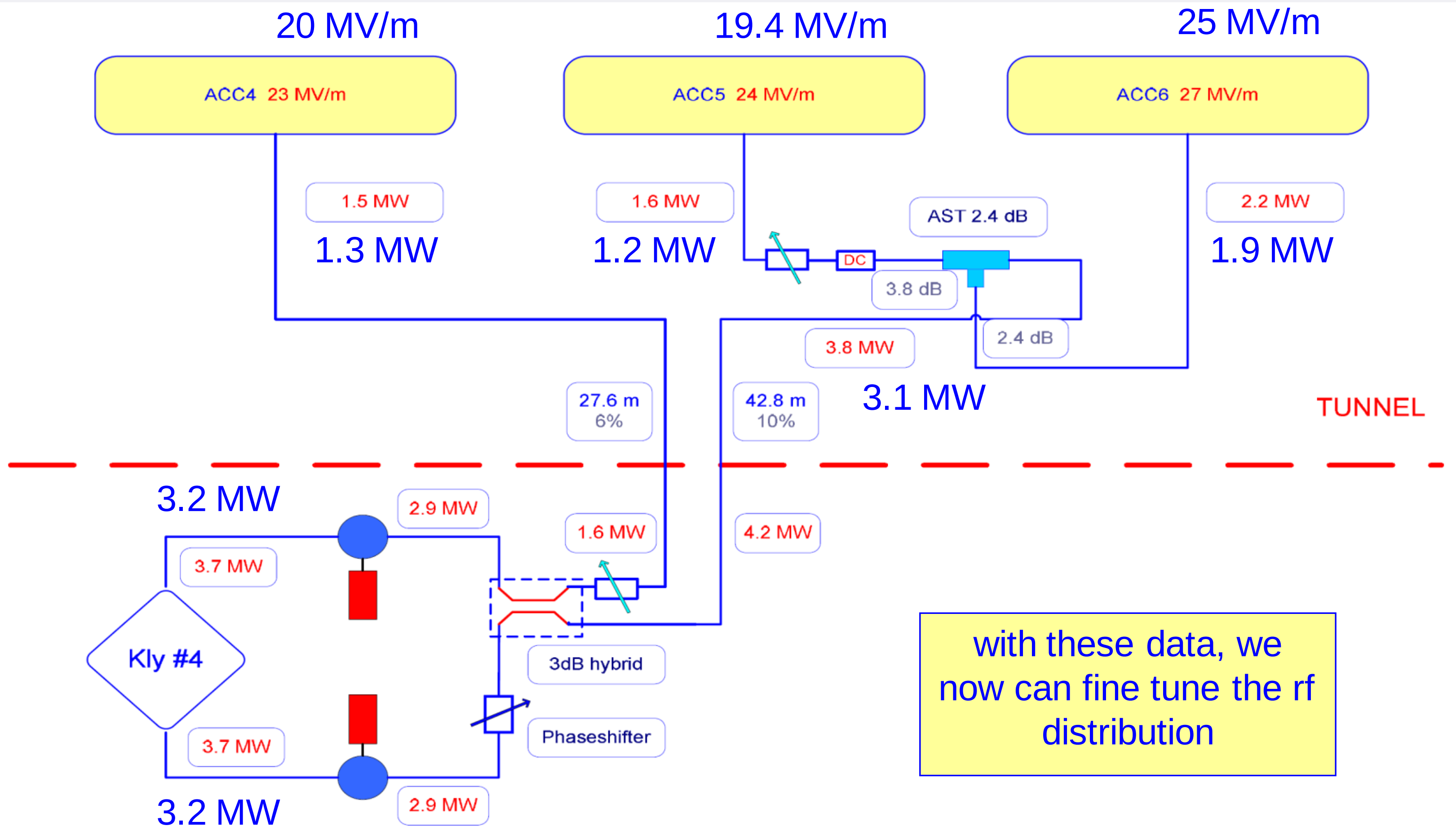


(Test) Facilities Highlights and Outlook
Accelerator Module Performance at FLASH



(Test) Facilities Highlights and Outlook
FLASH RF Distribution ACC4/5/6

measured with beam:



with these data, we now can fine tune the rf distribution

Tasks for the TTC TB

The TB can be described as the technical arm of the Tesla Technology Collaboration, TTC. As such its primary duties are to carry forward the technical program of the TTC.

Some activities of the TB and its members will be self-assigned while some will result from responses to requests from outside by leaders of the various projects which depend on superconducting RF.

Tasks for the TTC TB
How to deal with project orientated requests?

We have seen the above reported ILC-GDE request concerning cavity preparation as a chance to describe the state-of-the-art of our work.

Project orientated requests might show up in future.
TTC with its TB can not provide reviews but can continue

- collecting material
- creating links between projects
- point to possible support in case of fundamental scrf problems

We can also work on establishing…

- common definitions (e.g. rrr measurement method)
  (e.g. coordinate syste, for cavities)
- standard specifications (e.g. for vert. test measurements)

… and therfore will follow such requests.