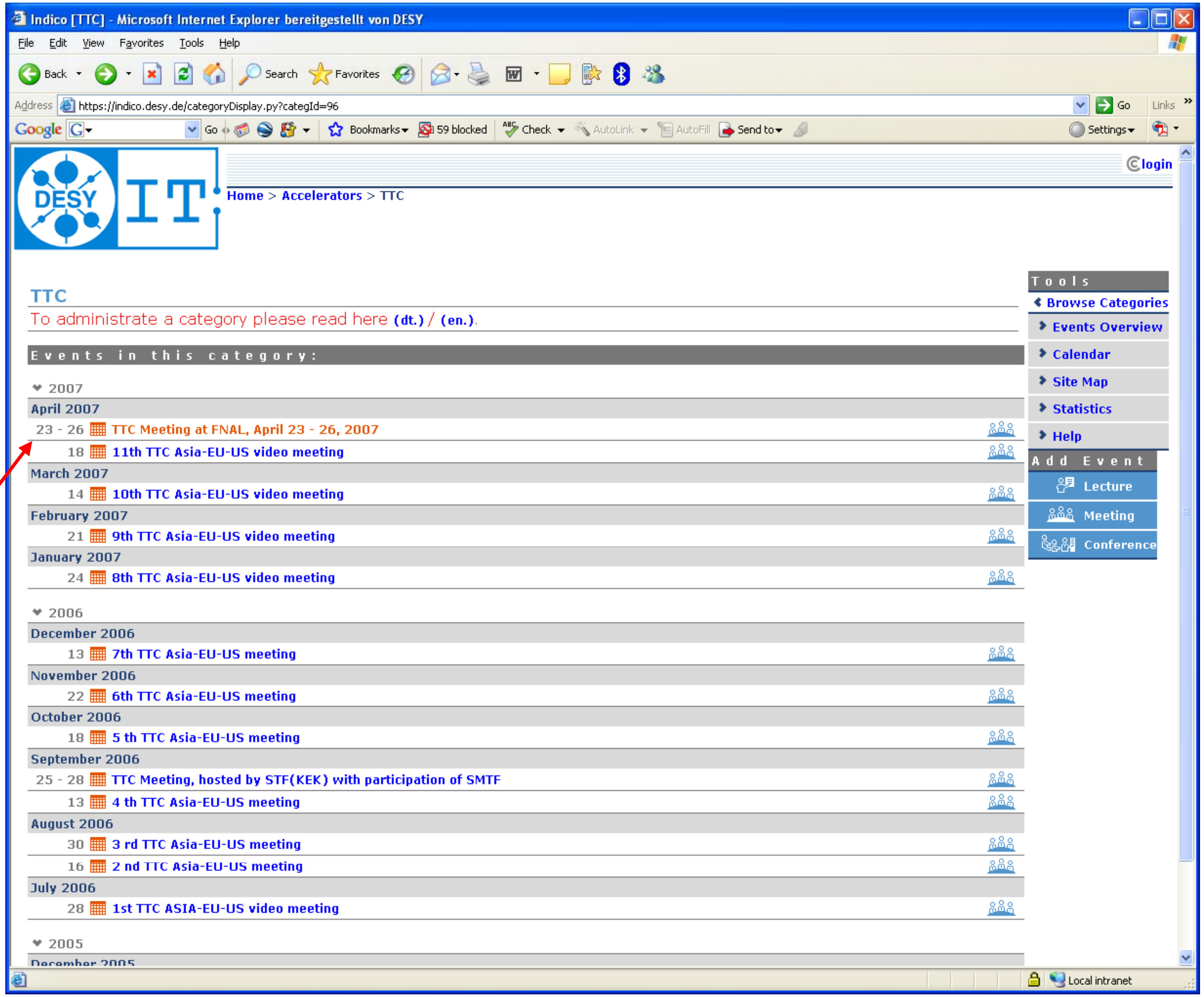
Summary

TTC Meeting, FNAL, April 23-26, 2007

Hans Weise / DESY

May 4, 2007



TESLA Technology Collaboration (TTC) at Fermilab

Hosted by SMTF and FRA (Fermilab) with Participation of STF (KEK)

April 23-26, 2007

Hans Weise

TTC Meeting at FNAL, April 23 - 26, 2007

from **Monday 23 April 2007 (08:00)**
to **Thursday 26 April 2007 (18:00)**
at *1 West*

Description:

Mission of the TTC Meeting FNAL

The mission of the TESLA Technology Collaboration is to advance SCRF technology R & D and related accelerator studies across the broad diversity of scientific applications, and to keep open and provide a bridge for communication and sharing of ideas, developments, and testing across associated projects. Besides other activities the TTC organizes regular collaboration meetings where new developments are reported, recent findings are discussed and technical issues are concluded.

For the FNAL meeting the following Working Groups (WG) are planned:

-WG1 Module issues (XFEL, KEK, ILC, DESY module tests, cw modules)
-WG2 Summary EP, new treatment infrastructure
-WG3 Test facilities: Operating experience, new proposals
-WG4 Input & HOM coupler

In general, the meeting takes place in room 1 West. Few sessions are held in different rooms. In this case the room is indicated on the agenda.

Local webpage: registration & information. **Click here**

TTC Technical areas of interest

Final version, October 06

1 SC Cavity issues

- 1.1 Cavity
  - 1.1.1 Cavity design (layout for fundamental and HOM mode)
  - 1.1.2 Cavity fabrication
  - 1.1.3 Cavity processing
  - 1.1.4 Superconducting materials development
- 1.2 Cavity auxiliaries
  - 1.2.1 Coupler (input, HOM)
  - 1.2.2 Tuner (slow & fast)
  - 1.2.3 Helium vessel, shielding, etc
- 1.3 Industrialization (technology transfer, standards, compatibility)

2 Module issues

- 2.1 Module (design, assembly)
- 2.2 Module auxiliaries (magnets, absorber, diagnostic hardware, etc.)
- 2.3 Cryogenics (including string and plant)
- 2.4 Industrialization (technology transfer, standards, compatibility)

TTC Technical areas of interest (cont.)

Final version, October 06

3 Linac and integration issues

- 3.1 Warm systems
  - 3.1.1 LLRF & timing
  - 3.1.2 RF power
  - 3.1.3 Controls & diagnostics (controls, diagnostics, MPS)
- 3.2 Beam and operation
  - 3.2.1 Beam physics (beam dynamics)
  - 3.2.2 Studies and Operating experience
  - 3.2.3 Alignment, vibration, environment, radiation
  - 3.2.4 Reliability/availability

4 Major test facilities

TTC Technical Board Meeting – Technical Areas

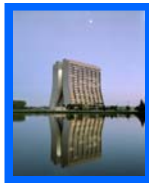
Experts from the different technical areas presented

Highlights

Challenges

expectation for the next 6 months

K. Saito	Cavities
W.-D. Moeller	Couplers
B. Petersen	Cryomodules
S. Simrock	LLRF
S. Schreiber S. Nageitsev H. Hayano	Test Facilities



Cavity Highlights

HL#1: Great step for 35MV/m high gradient demonstration in a CM @ DESY

HL#2: Good startup for ILC S0 tight loop study @ Jlab and KEK

HL#3: Overcome of HOM coupler problem in 3.9 GHz 3^{rd} harmonics cavity at FNAL

HL#4: New processing result by single cell study @ KEK to guide improvement for 9-cells

HL#5: The first active HF concentration measurement in EP acid and the development in the variation in the real EP cavity processing

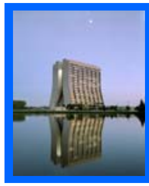
HL#6: Success of the EP facility construction in KEK STF

ILC ACD R&D

HL#7: Principle proof of 50 – 59MV/m by new ACD cavity shape

HL#8: Successful R&D on large grain cavity in three regions

HL#9: TESLA seamless 9-cell cavity by hydroforming



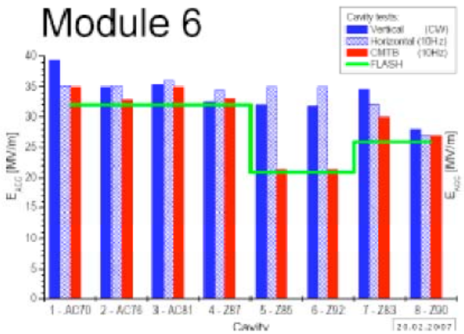
HL#1: Great step for 35MV/m high gradient performance demonstration in cryomodule !

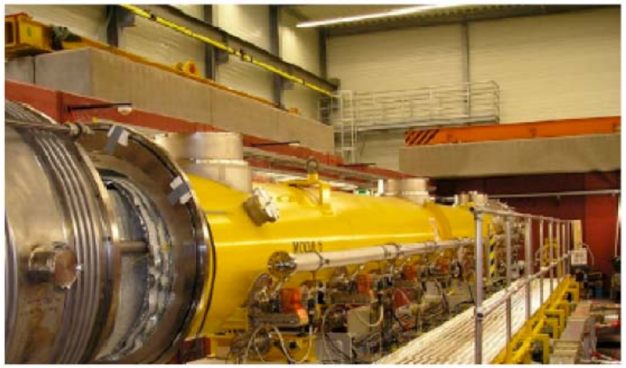
DESY demonstrated 35MV/m high gradient performance with 7/9 cavities on CM#6,
That is a great step for ILC.

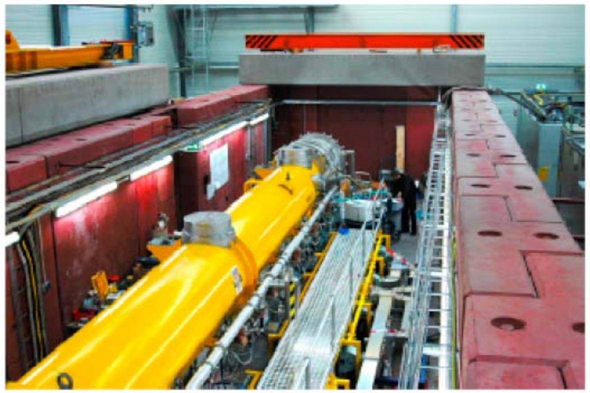
We express congratulation to DESY colleagues and other collaborators
and respect their great effort for ILC.

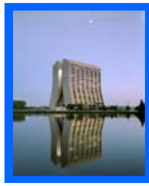
Cryo-Module Test Bench
Operational

(EuroFEL support)









TESLA Technology Collaboration (TTC) at Fermilab
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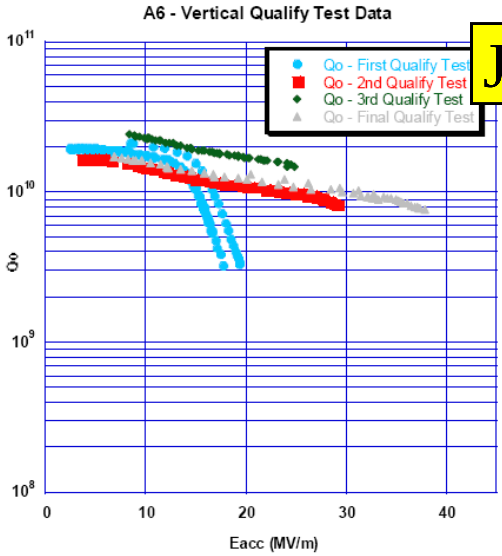
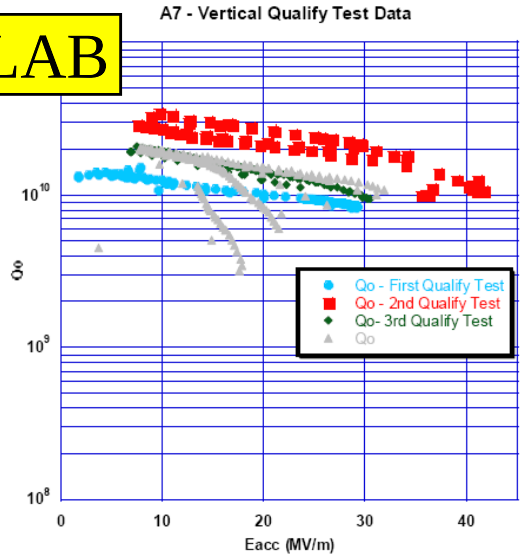
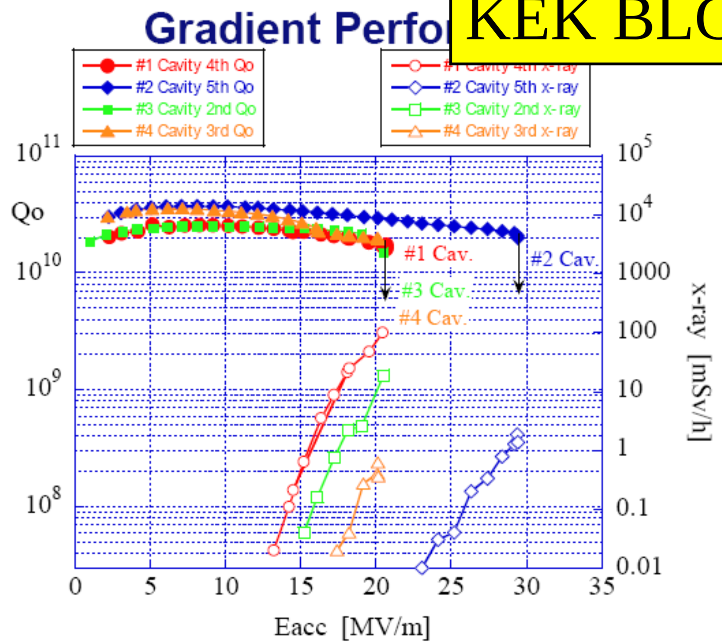
HL#2: Good startup of the S0 tight loop study !



JLAB

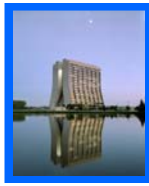


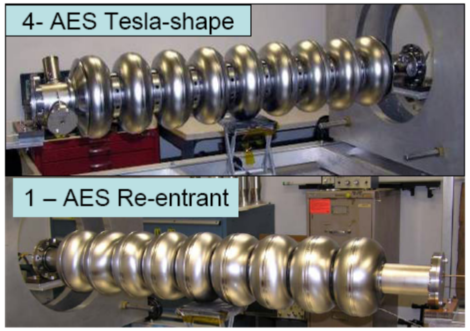
KEK BLG

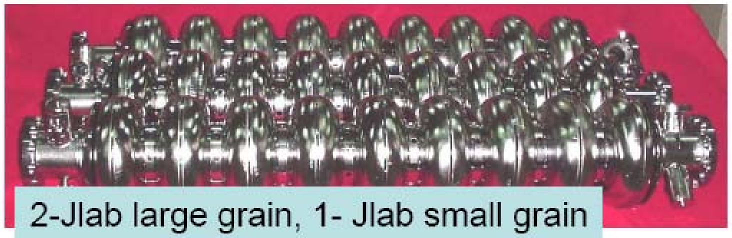


JLAB and KEK, which are major Labs for SRF cavity R&D, have started up for 9-cell testing. John's recipe: degreasing, is very much promising for 35MV/m cavity.

Successfully fabrication of 9-cell cavities by a new vender in US and Jlab







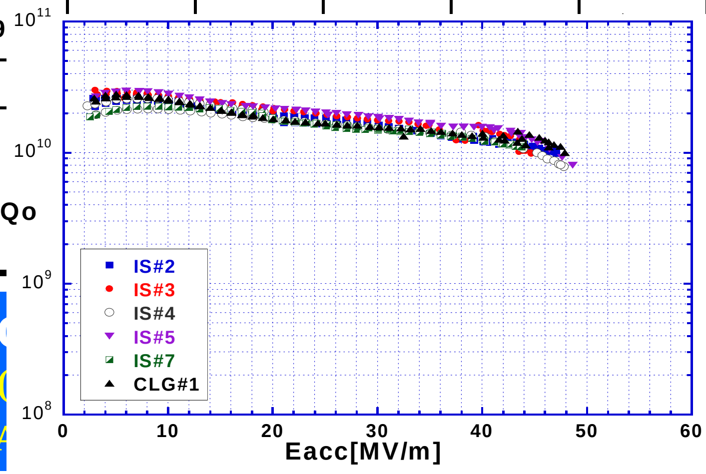
Hans Weise

HL#4: Good understanding of the performance scatter with ep by single cell study @ KEK !

	Eacc,max [MV/m] / Qo @ Eacc,max									Emax average [MV/m]	Scatt. [%]	MP	Acceptability @ 40MV/m [%]
	IS#2	IS#3	IS#4	IS#5	IS#6	IS#7	IS#8	CLG#1	CLG#2				
CBP+CP+AN+EP(80)+HPR+ Bake	36.9	31.4	45.1	44.2	48.8	28.3				39.1 ± 8.2	21	Yes	50
	1.53E10	8.66E9	9.07E9	5.38E9	9.64E9	1.94E9							
CBP+CP+AN+ EP(80+3 fresh) +HPR+Bake		42.0	46.1	44.3	34.3	39.3			43.8	41.7 ± 4.4	11	Yes	67
		9.72E9	9.47E9	1.08E10	8.56E9	1.03E10			3.46E9				
CBP+CP+AN+ EP(40+3 fresh) +HPR+Bake	43.9						49.2*			46.6 ± 3.7	8	Yes	100
	9.47E9						4.33E9						
+EP(20)+HPR+Bake	47.2	52.2	52.9	31.1	48.9	46.5				46.4 ± 8.0	17	Yes	83
	5.98E9	1.51E10	5.23E9	5.21E9	7.56E9	9.03E9							
+EP(20+3 fresh)+HPR +HF+Bake	47.1	44.7	47.8		48.6	43.9		47.9		46.7 ± 1.9	4	Yes	100
	1.06E10	9.80E9	7.80E9		8.00E9	1.17E10		1.00E10					
+EP(20)+H_2O_2+HPR + Bake	52.3			34.1	43.4	40.9				42.7	18	Light	50
	1.09E10			1.37E10	1.39								
+EP(20)+Degreasing (US)+HPR+ Bake	50.1	52.2									.9	Lights	100
	7.80E10	7.08E9											

IS: Ichiro center cell shape, Tokyo Denkai polycrystalline Nb material

CLG: NingXia Large grain, Ichiro center cell shape



HL#6: Successful construction of EP system @ KEK STF

A model EP system for ILC 9-cell cavity

EP, HPR and clean room
are combined.

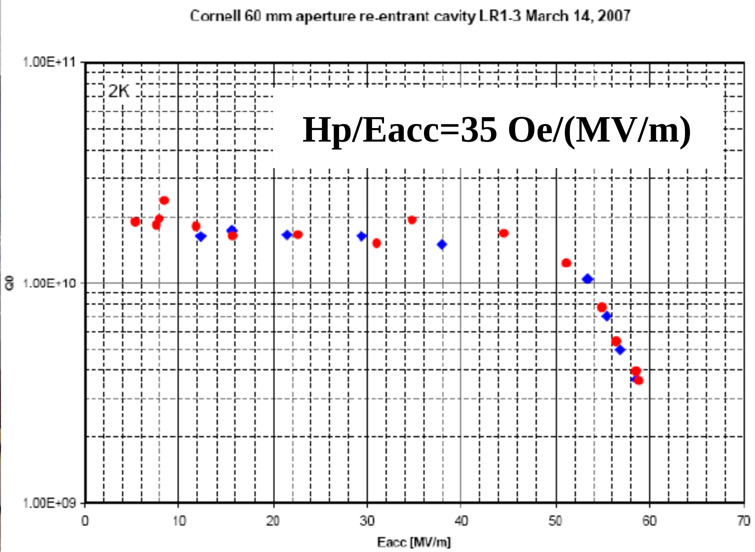
Commissioning will be start from
June 2007.

EP capacity will be 40 cycles /year.

Cornell / KEK Collaboration
60 mm – Aperture Re-Entrant Cavity
Best Eacc = 59 MV/m

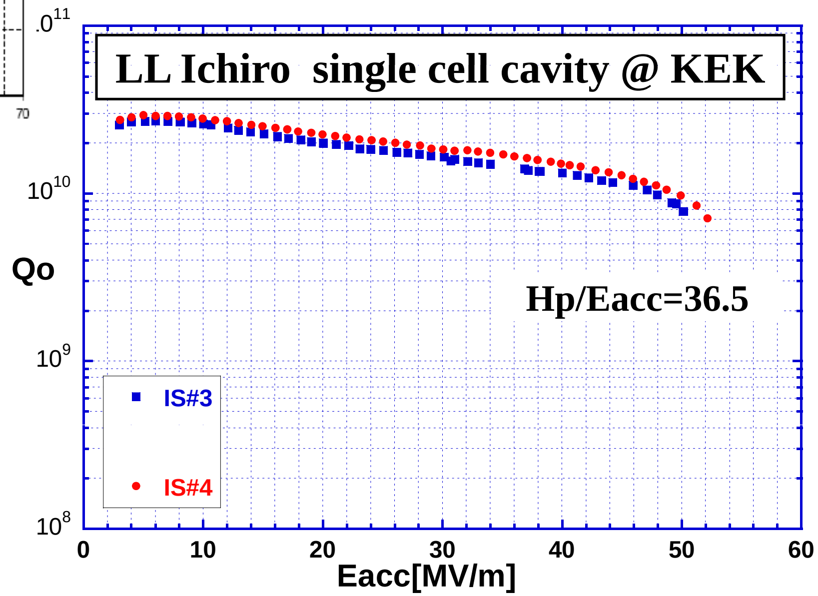
HL#7: Principle proof of the 50-60MV/m high gradient with SRF !

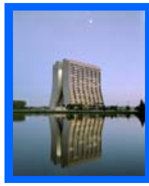
RE-LR1-3



Remind the great degreasing effect behind!

New shape with a low Hp/Eacc
has confirmed high gradient performance.
We have a good guideline for cavity design:
reduce Hp/Eacc as Ep/Eacc.





HL#9: Successful R&D for ILC ACD cavity fabrication !

Nine-Cell Cavity (Hydroformed)

First Seamless Cavity

(TESLA shape)

three Triple-Cell

hydroformed

at DESY

Final Steps at Zanon : end groups completion – stiffening rings – welding on two iris

Outlook next 6 months

- Another information on the high gradient in CM is expected on CM#7 @ DESY
- EP facility operation at KEK STF
- More information between active HF concentration and cavity performance for processing QA @ KEK
- More data on ILC 9-cell S0 tight loop study from three regions
- Results of Ichiro/Reentrant 9-cell cavities @ KEK, Cornell
- Result on improved END group design @ SNS, KEK
- More information about cavity cleaning after EP by single cell study @ Saclay, KEK, DESY
- More results on large grain 9-cell cavity performance @ DESY, JLAB

RF Power coupler

- BCD choice is TTF3 coupler (Snowmass ’05)
- There was a general consensus that different coupler designs incorporating two « disk » type windows could be potential alternatives to the TTF cylindrical window.
- Couplers build as prototypes:
  - KEK ‘Tristan style’ disk window coupler
  - KEK ‘capacitive’ disk window coupler
  - LAL TW60 coupler
  - LAL TTF5 coupler

Power coupler, 2nd

	cold window	warm window	bias	variable Qext	fabricated totally	tested	assembled in modules	operated
TTF3	**cylindrical**	**cylindrical**	**yes**	**yes**	**62**	**62**	**25**	**100,000 coupler*hr**
KEK1	**Tristan disk**	**Tristan disk**	**no**	**no**	**4**	**4**	**1**	
KEK2	**capac. disk**	**capac. disk**	**no**	**no**	**3**	**2**	**1**	
LAL TW60	**disk**	**disk**	**no**	**no**	**2**	**?**		
LAL TTF5	**cylindrical**	**cylindrical**	**yes**	**no**	**2**	**?**		

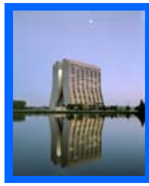
Power coupler, 4^{th}

In order to compare the different designs we need:

- more test & operating experience
  - only 2 modules are tested at a test bench
  - M5 is operated at 25MV/m for every 2^{nd} pulse
- max. electrical fields for different couplers
- multipacting behavior
- conditioning time

Questions / needed R&D:

- is the technical IL sufficient/ overdone for linac operation?
- no experience on long term high power operation at 35Mv/m (1000hr only)
- is a cold part at 60mm diam. needed? (SLAC investigations)
- do we really need tunable Qext?



Status of module designs

1) XFEL-design -> industrialisation

TTF-Type III design is ‚proven‘ for beam operation (FLASH) has been tested extensively on the CMTB (module 6)

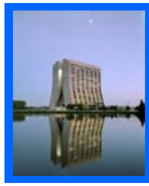
TTF-type III design was subject of industrial assembly studies (will be published on the XFEL web page in the next weeks)

For the next part of the study (module 8, type III plus) industry will take part more actively (they will do parts of the assembly)

Call for tender for 2+1+2 cold masses (test of spec)

XFEL-design is based on type III, each design change (type III plus as an intermediate step) has again to be validated (CMTB tests)

Other ‚design-branches‘ like module IV should proceed in a similar way, if the effort invested already in TTF-design shall be used



Status of module designs

2) First operation of KEK modules in May

3) First Type III cryomodule assembly at FNAL this summer

   modules IV design finalized until October

   quad design/spec ????

4) Tuner design, tests industrialisation

5) 3.9 GHz cryomodule for FLASH /design for XFEL

   design, construction, transportation, tests on CMTB ?

Cryomodule Test Bench (CMTB)

CMTB has proven to be essential for the cryomodule development.

(These tests could not be conducted at FLASH in the last years. A test facillity in addition to a user facility is needed for module development)

Several important test results could be achieved in quite a short period:

Thermal cycling (11) monitored by WPM, vibration measurements

General RF performance

Q(T) demonstrated for a TTF cryomodule (2K,1.8K,1.55K)

Validation of coupler processing

Tuner & piezo operation

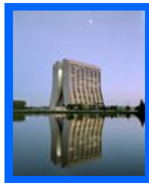
LLRF development

Now: module 7 (type II) is under test

Coming soon: ‚crash-tests' of module 3* (type II)

LLRF Highlights

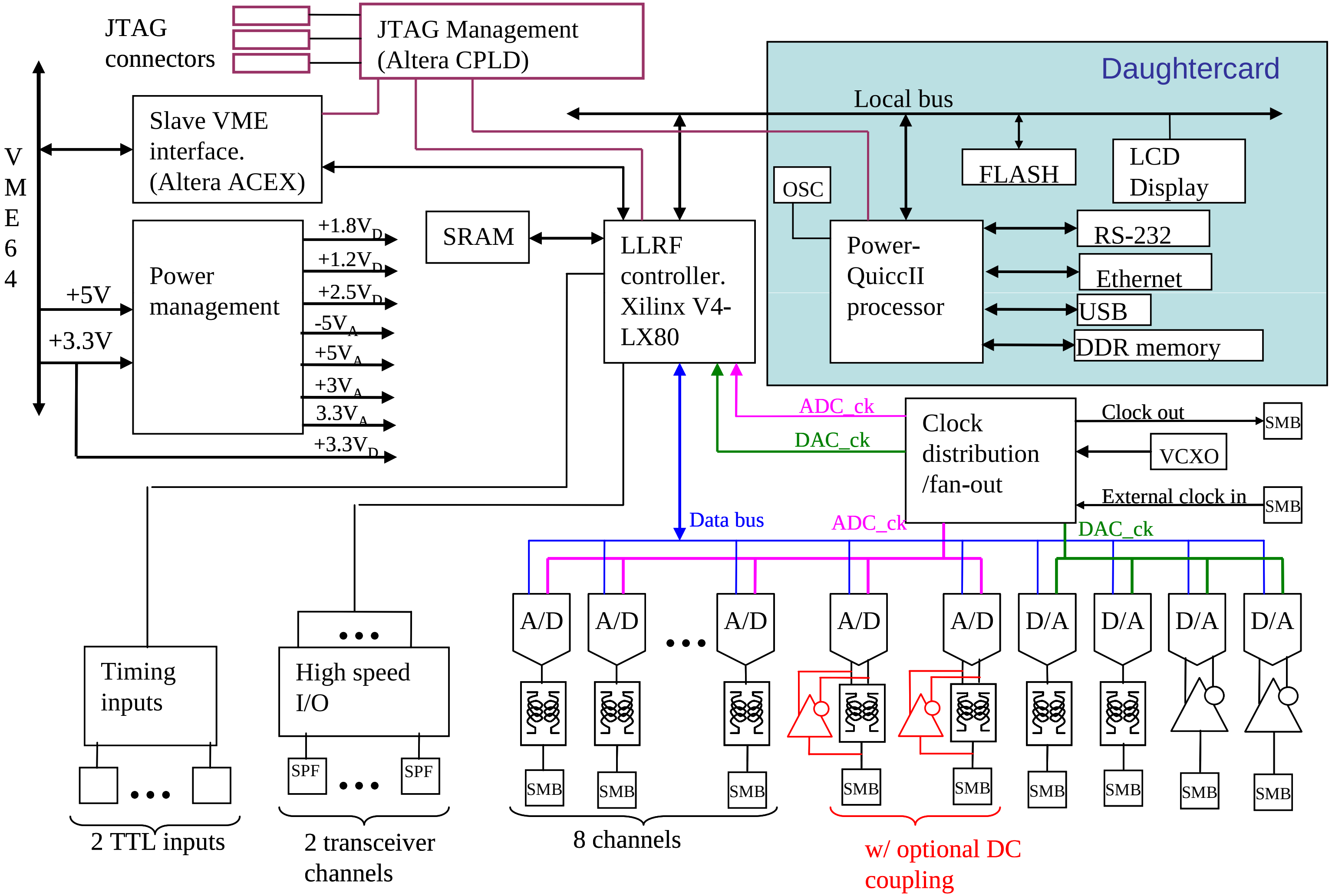
- Control CC2 with SIMCON (FNAL)
- Development of new digital feedback boards (ALL)
- Operate SIMCON based system at FLASH
  - RF Gun, ACC1
- Transient detection
- Beam current based adaptive feedforward
- Lorenz force compensation (MTS)
- RF Gun control without probe (FLASH)
- Alternating gradient operation (FLASH)
- Implementation of on-line of Dosimetry
- Klystron linearization
- Microphonics compensation (BESSY, FNAL)



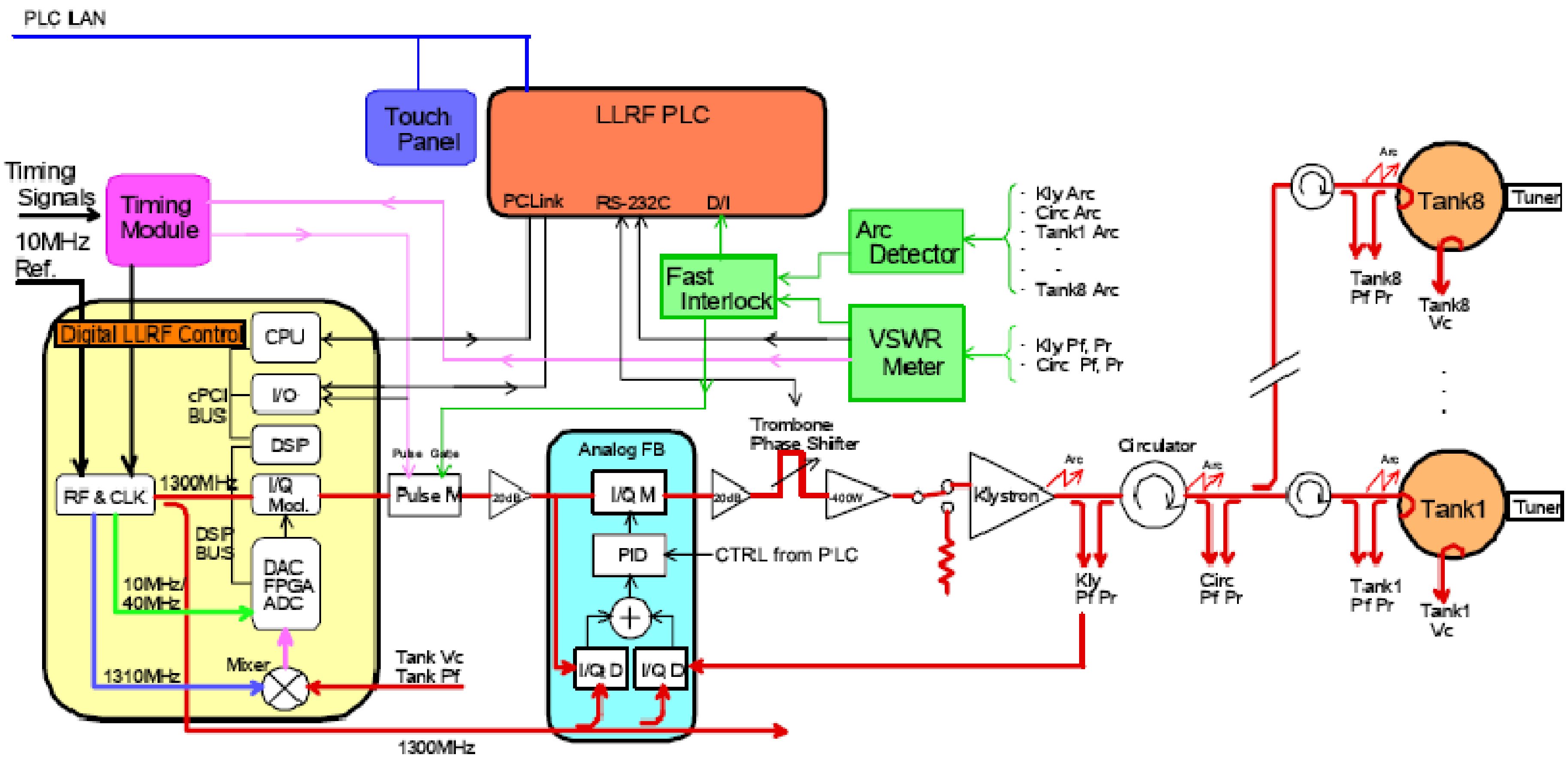
Example: Current Activities at FNAL

- **Hardware developments**
  - A 10 channel in 4 channel out 14-bit resolution LLRF controller has been implemented and it is in its final debugging stage.
  - Design phase of a 32 channel controller and a 96 channel analog receiver.
- **LLRF algorithm development**
  - New 13MHz Digital Down-Converter (DDC) implemented in Simulink/SysGen and compiled for Virtex 2 and Virtex 4 FPGAs. Successfully run with CCII and at Flash.
  - Cavity resonance control with piezo-electric actuator
- **Cavity models and simulations**
  - Studies of beam loading and multi-gradient effects.
  - Development with Upenn of a multi-channel cavity simulator
- **Support of ILC test facilities**
  - CCII LLRF and piezo studies.
- **LLRF management**
  - GDE, RDR

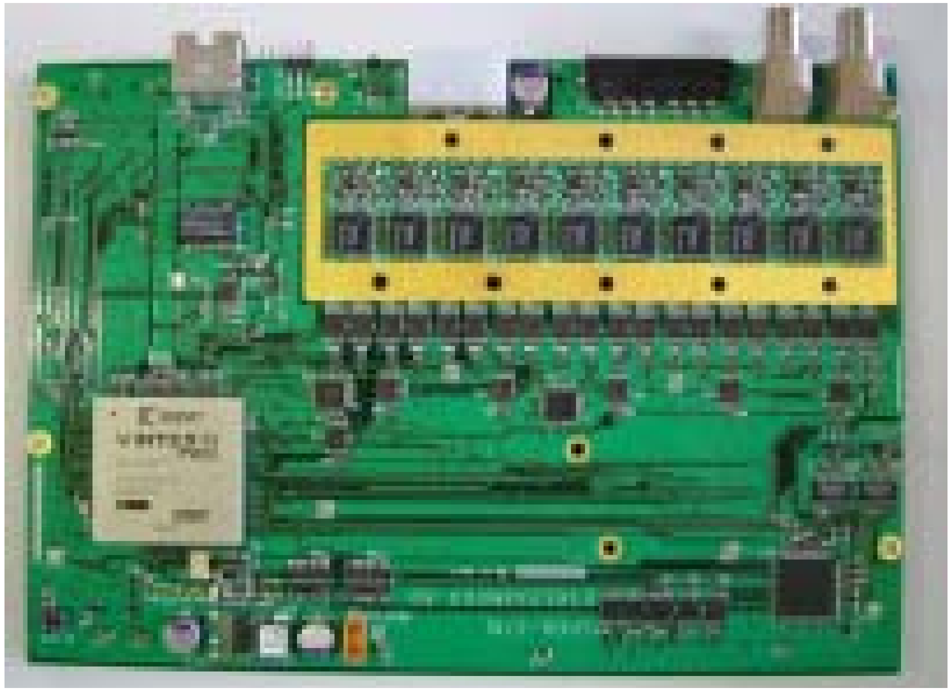
New Controller (FNAL)



LLRF for STF at KEK (1)



Examples for new Boards



KEK STF FPGA board

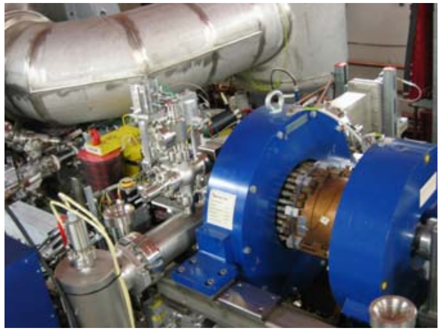
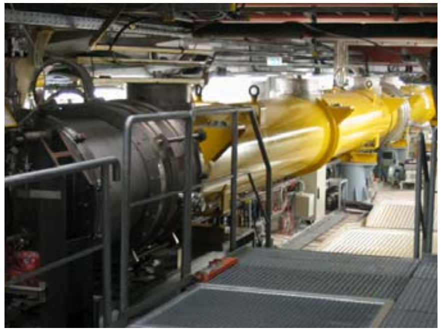
SIMCON DSP Board

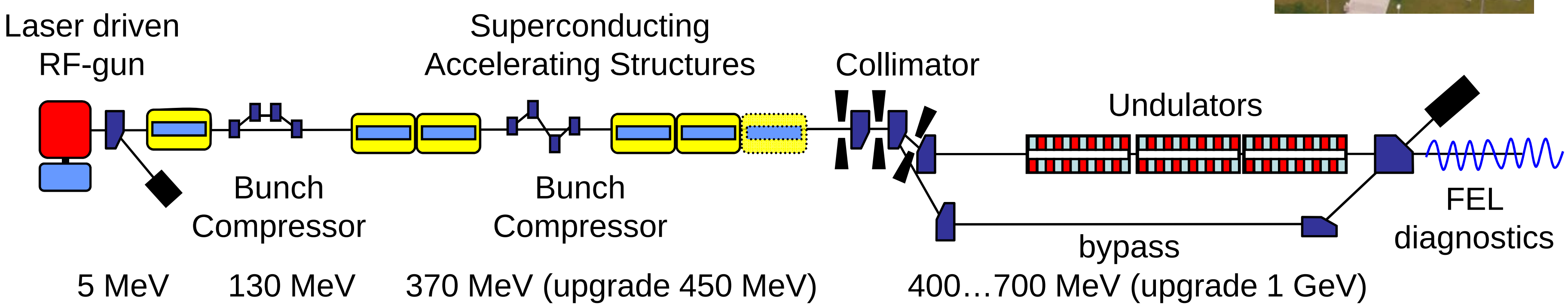
LLRF Challenges and 6 Month Plans

- Vector-sum Calibration
- Power overhead estimation
- Operation at different gradients
- Downconverters for 0.01 deg. control
- LLRF Conversion to ATCA
- Automation
- LLRF Workpackage description for XFEL
- System Integration (HW + SW)
- Software development (incl. algorithms)
- Documentation (Requirements, Concepts …)
- Exception Handling

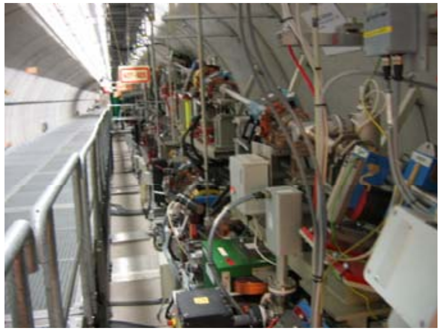
- Evaluate new controller boards (FNAL)
- 3.9 GHz rf system (FNAL, DESY)
- Installation of SIMCON system for ACC1
  - Redundant development system, several boards (3xSIMCON-DSP,1xSIMCON 4) for probe / forward / reflected power
- LLRF Conversion to ATCA by end of 2007
- Software developments strategy
- Industrial study (Requirements/Concepts)
- Commission multi-cavity simulator (RF I/O)
- Evaluate new downconverters
- Install/Commission new M.O. (DESY)

FLASH


Laser driven
RF-gun
Superconducting
Accelerating Structures
Collimator
Undulators
Bunch
Compressor
Bunch
Compressor
bypass
FEL
diagnostics
5 MeV
130 MeV
370 MeV (upgrade 450 MeV)
400…700 MeV (upgrade 1 GeV)






250 m

FLASH operation

- FLASH is operated as an FEL user facility since summer 2005
- beam for FEL experiments, but also for accelerator studies
- FLASH will have 6 modules in operation in summer 2007
  - this includes 3 TESLA type modules in a string = 1 RF unit
- beam: 5 Hz, 10 Hz if required, 800 us bunch train, 1 mA (1 MHz, 1 nC), max. 2-3 nC
- the user experiments determine beam energy and beam parameters, little flexibility
- Part of the overall beamtime is devoted to general accelerator studies, which can be used for S2 related tests (~20%)
- Schemes have been tested using time between user beam pulses: alternating gradient: high/FEL with 5/5 Hz
- many beam instrumentation related experiments have been performed: HOM, BPMs, feedbacks

Highlights of STF

KEK STF Oct.2006 ~Apr.2007

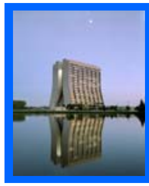
- Vertical test of 4 TESLA style 9cell were finished. (20~29MV/m)
- Vertical test of 3 LL type 9 cell were finished.(12~29MV/m ;one out of three has straight beam pipe)
- 1 TESLA style and 1 LL type 9cell were installed into the cryomodule.
- STF0.5 cryomodule test is in final assembly stage.
  The 1st cool down test is scheduled in May 14.
- New EP facility, new HPR in STF is in final assembly stage.

In next 6 month : May.2007 ~Oct.2007

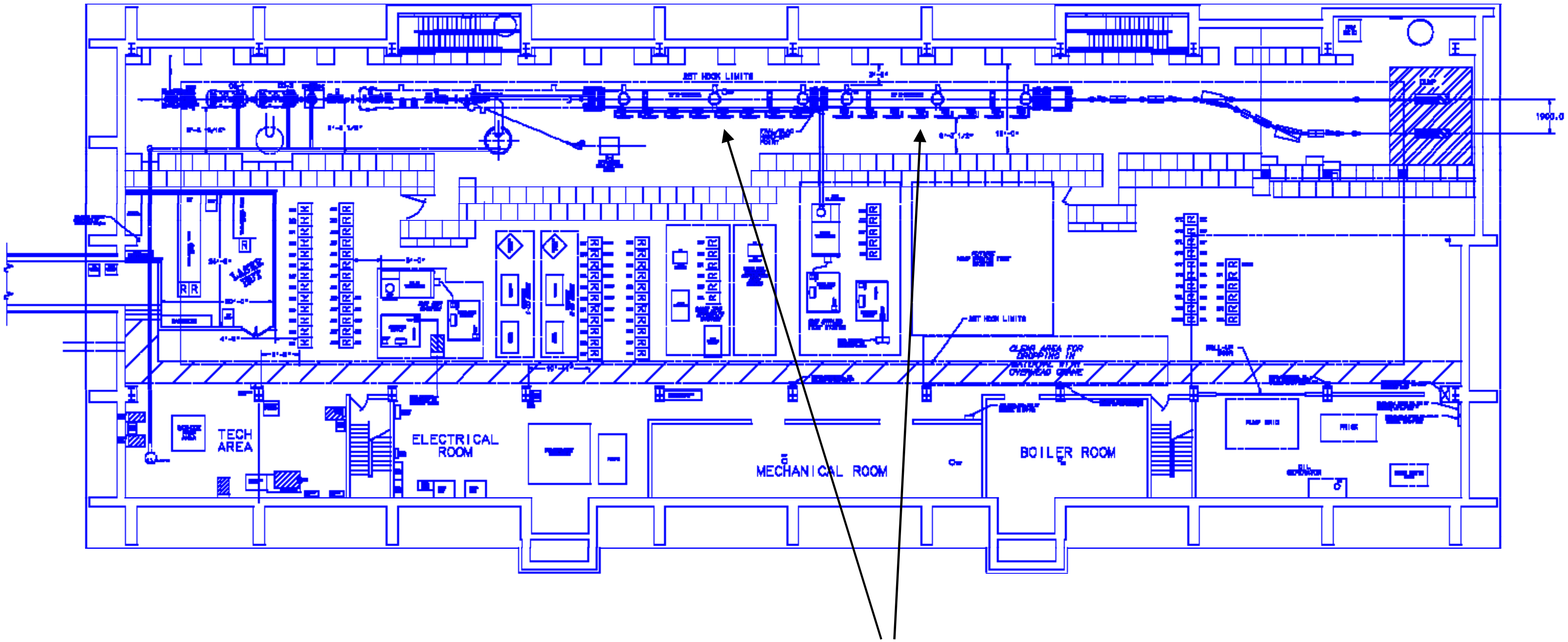
- Result of cool-down test will come out.
- 1st result of new EP, new HPR will come out.
- 4+4 cavities will be under assembly into the cryomodule.
- Beam devices will be under installation.

Outline of NML plans

- Cryomodule delivery
  - 1st (Type 3+) cryomodule is planned to be delivered in fall, 2007
  - 2nd (Type 3+) CM – summer 2008
  - 3rd (ILC Type 4) CM – Mid FY09
  - Replace all three CMs with ILC Type 4+ in FY2010
- The NML facility will start as a Cryomodule Test Stand in FY07-08
- FY08: add beam; start civil construction of the building extension
- Convert to an ILC RF Unit beam test facility in FY11



Two CMs with beam



The existing building is perfect for testing two cryomodules with ILC-like beam. The building can be extended to fit 3 cryomodules.

S2 'Task List'
Phase 1.2 beam tests

- #5: Quench rates & coupler breakdowns at Hi Gradient
- #7: Gradient spread w/ and w/out beam
- #9: Heating from HOMs
- #10: Beam phase and energy stability
- #12: Demonstrate that we can build an ILC RF unit to specs

Concluding discussion in the TB:

Should / can the TB help identifying individuals to study / discuss the above listed items / experimental proposals in detail? Yes!

Follow-up meeting of the TB as video conference in July 2007.

- discuss draft of the answer to the ILC Request
- go through first material about above listed topics

TTC Technical Board Meeting

Cavity:	**P. Kneisel**	(JLAB)	**J. Mammosser (JLAB)**	**WG2**
	L. Lilje	(DESY)		
	D. Reschke	(DESY)		
	K. Saito	(KEK)	**WG2**	
	additional coupler expertise:			
	E. Kako	(KEK)	**WG4**	
	W.D. Moeller	(DESY)	**WG4**	
Module:	**N. Ohuchi**	(KEK)		
	C. Pagani	(INFN)		
	B. Petersen	(DESY)	**WG1**	
	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	**WG3**
ILCTA-NM (old SMTF):	S. Nagaitsev	**WG3**
STF:	H. Hayano	**WG3**

Charge for the Technical Board Members of the Tesla Technology Collaboration (TTC)

According to the MoU of TTC the Technical Board TB ***shall provide advice to the Collaboration on technical activities towards reaching the goals of the Collaboration Mission. To this end, the TB will***

- ***compile information on the technology activities in different technical areas,***
- ***provide findings and recommendations to the CB.***

The complete MoU can be found at http://tesla-new.desy.de/content/about/index_eng.html

The members and the chair of the TB will be selected by the Executive Committee of the Collaboration Board (CB) of the TTC and will be approved by the CB.

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.

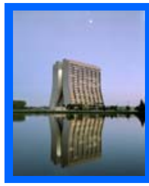
Much of the work to the TTC is carried out in, and as a result of, the semi-annual meetings of the TTC. Working Groups focuses on technical items of current interest as defined by the CB. The TB will discuss and lay plans for advancing the issues under consideration.

Duties of the TTC Technical Board Members

TB members will, if asked, serve as ***conveners of Working Group and sub-Group sessions at the TTC meetings*** and take responsibility for activities, such as ***assembling of reports***, jointly decided upon at the meetings. Examples of the Working Groups assembled at previous meetings can be found by looking at the agenda of past meetings to be found at http://tesla-new.desy.de.

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.

Example: We currently have an assignment resulting from a request to the CB by the Director of the ILC GDE. The questions to be addressed are set forth in a paper by Hayano et al.



Example Request to the TTC and hence to the TB

ILC R&D Board Task Force on High Gradients (S0/S1)

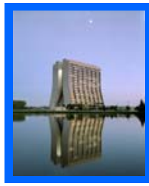
Request for Consultancy from TTC

H. Hayano, T. Higo, L. Lilje, J. Mammosser, H. Padamsee, M. Ross, K. Saito
Version: 31-Aug-06

The TTC has been addressing issues related to the high-gradient performance of bulk niobium cavities since a long time. Although very high gradients have been achieved in individual nine-cell cavities, a significant variation of maximum gradients has been observed in production-like experiments in the preparatory work for the XFEL[1]. For the demanded higher gradients of the ILC the current yield of the cavity preparation cycle is not sufficient. Therefore, a task force has been set up by the GDE R&D board to develop an R&D programme which addresses this issue[2]. The ILC R&D Task Force on High Gradients (or S1 Task Force for short) acknowledges the important work of the TTC in addressing the cavity performance issues.

Specifically, the TTC has addressed the following issues related to cavity surface preparation in the past:

- A comparison of EP parameters in the various EP facilities has been compiled
- A website has been set up for exchange of information and activities on EP[3]
- A proposal for a dedicated programme of single cells has been written up[4]
- A Setup to compare HPR systems[5]
- Experience on acid QC



Example 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 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