ILC-GDE "Dubna" Meeting

News from Superconducting RF Technology

- Status and Global Cooperation Plan-

Akira Yamamoto

ILC-GDE Project Managers for SCRF

Presentation at JINR, Dunba, June 4, 2008

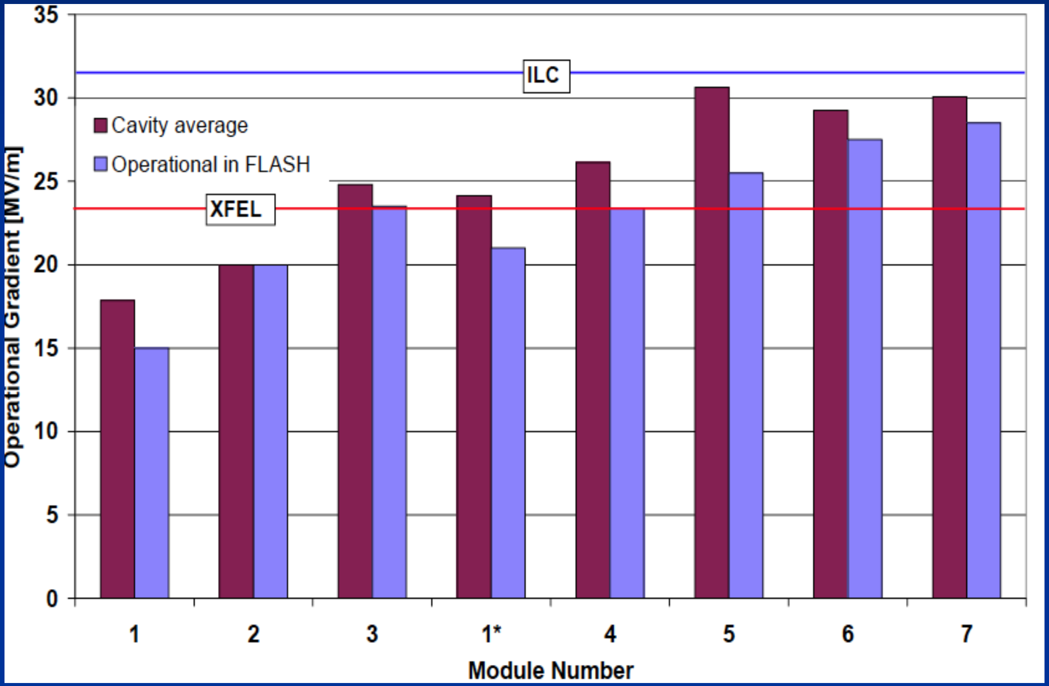
First of All

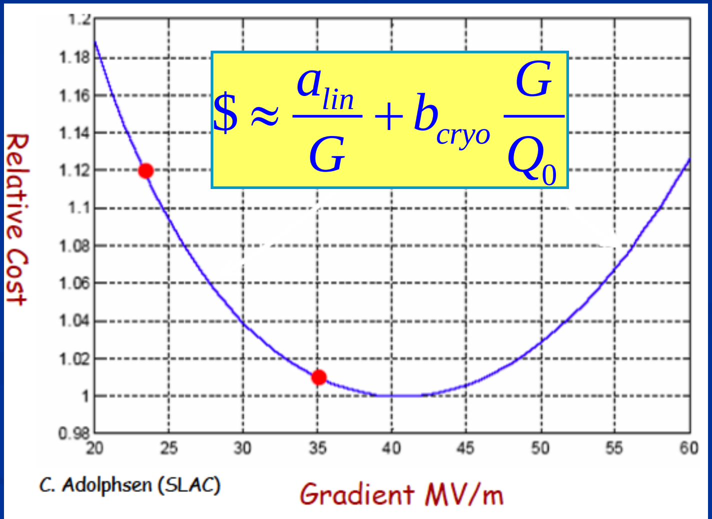
- **Many thanks for**
  - **All the arrangement and organization for the ILC-GDE "Dubna" meeting, this week,**
- **Objectives of Presentation**
  - Overview the **status** of superconducting RF technology for the ILC,
  - Discuss possible, further **global cooperation** in Technical Design Phase (TDP) and beyond.

Why Superconducting?

- **Advantages:**
  - Small RF surface resistance and Small power loss
  - Large Q
  - Low frequency and large aperture and small beam loss
- **Works required:**
  - Cryostat (vacuum insulation)
  - Power for cryogenics,
  - Improvement of Gradient Limit

"E" in Progress at TTF/DESY and Optimum "E" with ILC Main Linac





- R&D Status : < ~ 30 MV/ m >
- ILC target : **30 ~ 35 MV/m**

R&D Plan for Technical Design Phase

reported to FALC-RG by B. Barish, May 14, 2008

- **ILC GDE should produce a technical design of the ILC in sufficient detail that project approval from all involved governments can be sought.**
  - **Critical R&D demonstrations complete**
  - **Document the design having reliable costing**
  - **Develop a project plan**
- **Timescale:** Be prepared when LHC results justify the project
- Central coordination of the GDE is even more essential, if we want to prepare to propose an ILC project
- **Recovery plan** from UK and US actions developed with reduced goals, strict prioritization & stretched out timescale
- **A two stage** Technical Design Phase (TDP I 2010 and TDP II 2012 is proposed

Global SCRF R&D Plan

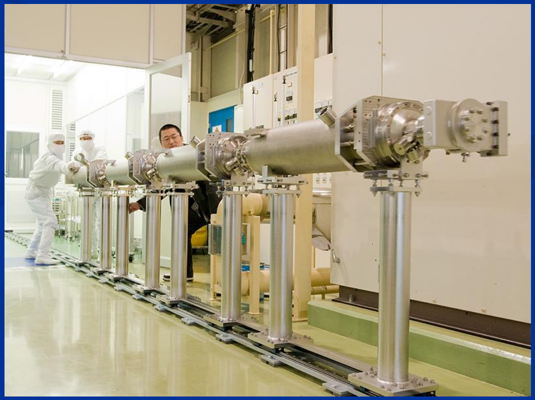
Calender Year		2008	2009	2010	2011	2012
EDR	TDP1				TDP-II	
S0: Cavity Gradient (MV/m)	30			35 (> 50%)		35 (>90%)
KEK-STF-0.5a: 1 Tesla-like/LL						
KEK-STF1: 4 cavities						
S1-Global (AS-US-EU) 1 CM (4+2+2 cavities)			CM ($4_{AS}+2_{US}+2_{EU}$) <31.5 MV/m>			
S1(2) -ILC-NML-Fermilab CM1- 4 with beam			CM2 CM3 CM4			
S2:STF2/KEK: 1 RF-unit with beam			Fabrication in industries		STF2 (3 CMs) Assemble & test	

R&D Plan updated for TDP
focusing on Cavity Gradient

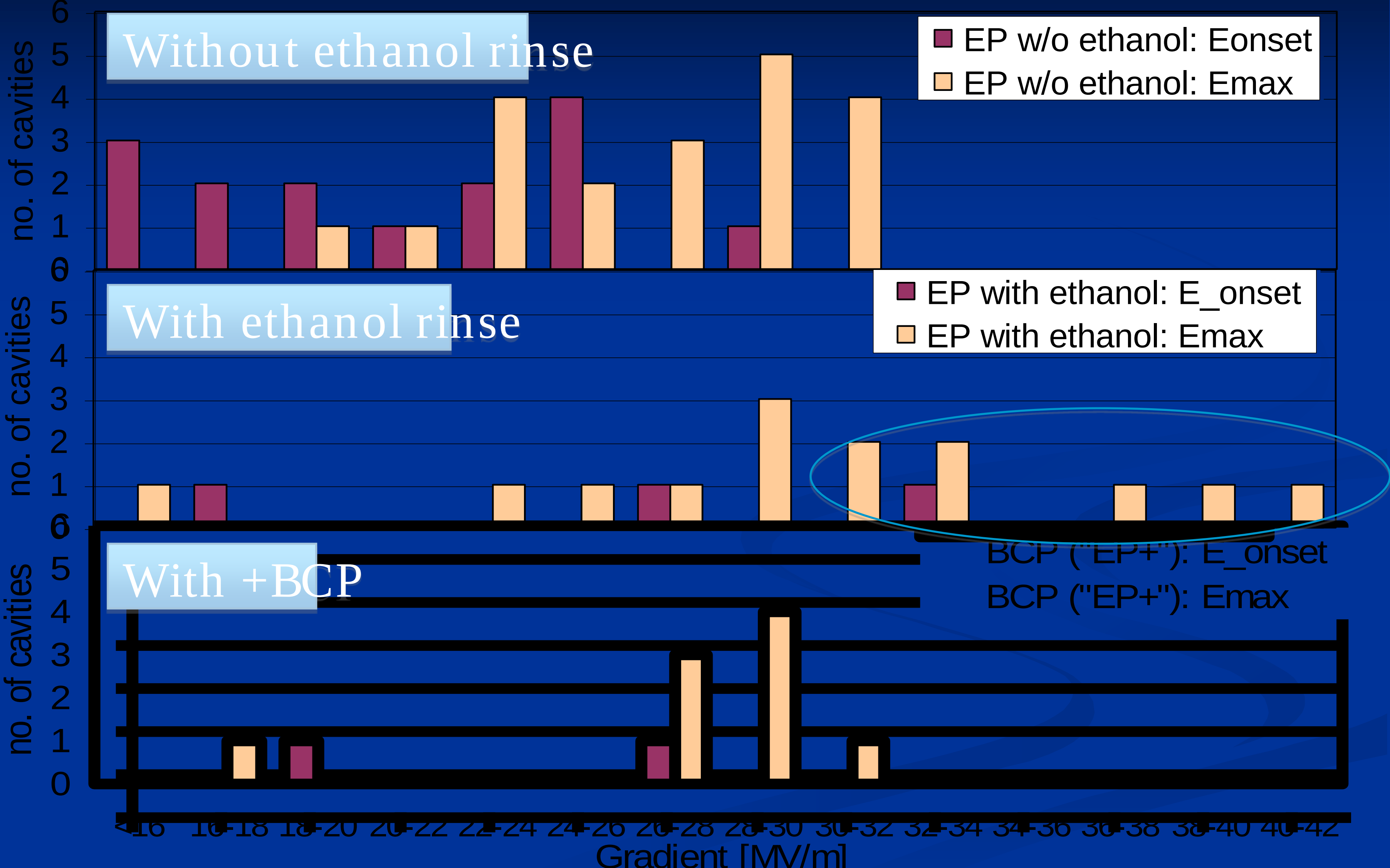
	EDR by 2010	TDP-1 (by 2010)	TDP-2 (by 2012)
Cavity Field Gradient (S0)	35 MV/ m, 90%	35 MV/ m, 50% (chem. Process)	35 MV/ m, 90% (product. +chem.)
Cavity-string Performance (S1)	<31.5 MV/ m> S1 at FNAL w/ beam	<31.5 MV/ m> S1 + S1-global: FNAL + DESY/ FNAL/ KEK/ INFN	
Cryomodule-string with a RF unit with acc. beam (S2)	<31.5 MV/ m> FNAL, KEK (2012)	--- >	<31.5 MV/ m> FNAL, KEK: 2012

Further R&D Efforts Required

- **Cavity** (fundamental process)
  - Fabrication: Forming and welding (EBW)
  - Surface treatment
    - Electro-polishing, (Chemical etching),
  - Cleaning/ Rinsing
    - Ethernol, detergent, Micro-EP
    - High pressure rinsing,
  - Surface observation (tool, technique)

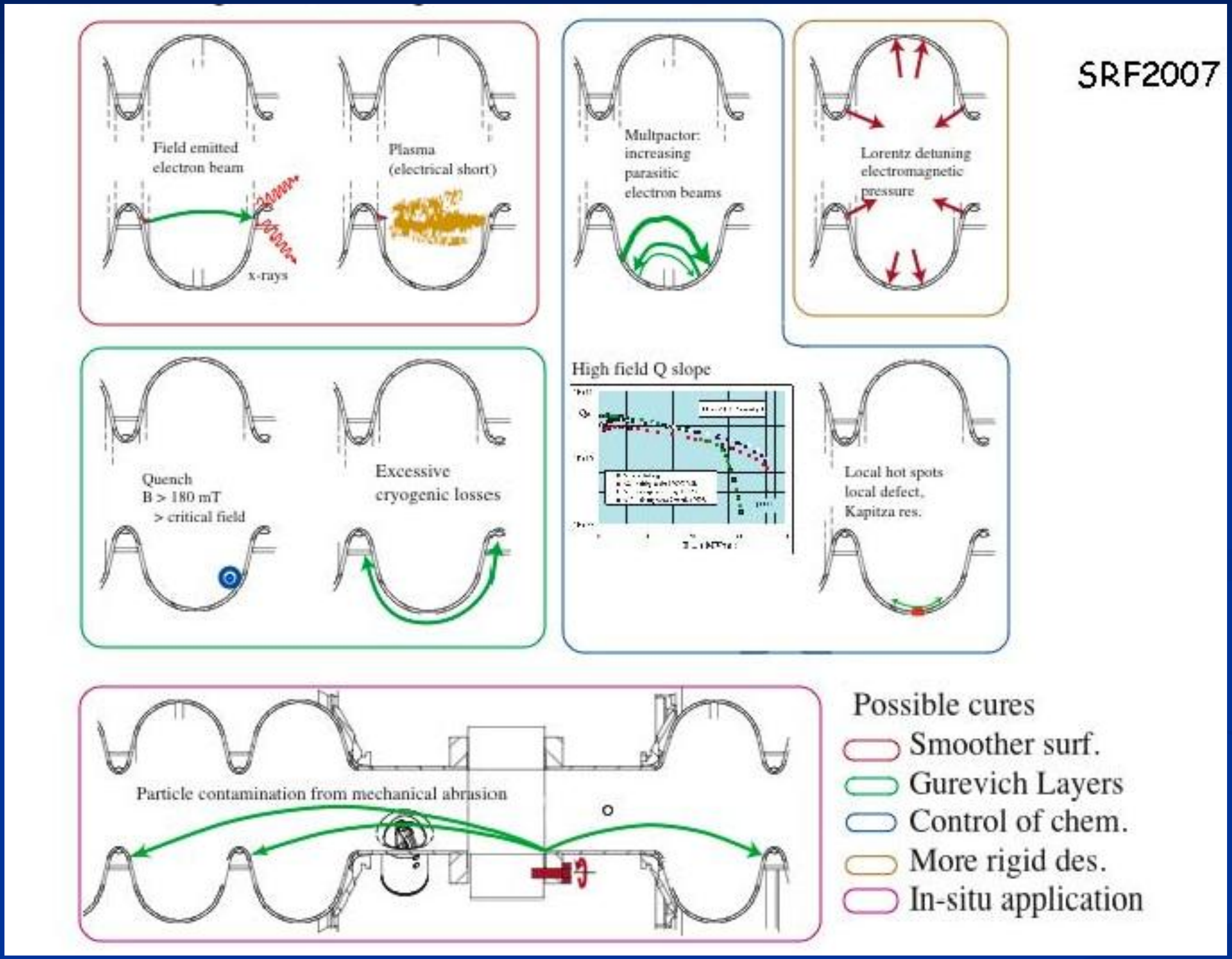


DESY 4th: Field Emission Analysis



Cavity gradient are shifted to High Gradient by 'ethanol rinse'

Gradient Limiting Mechanism in SCRF



- Field Emission
  - Emitted electron
- Plasma
  - Electrical short
- Quench
  - > Critical field (> 180 mT)
- Excessive cryogenic loss
- Multipactor
  - Increasing palastic electron beam
- Local hot-spots
  - Local defect,
  - Kapitza resistance
- Particle coming out
  - Contamination

High Gradient R&D Plan in TDP

Americas	US FY06 (actual)	US FY07 (actual)	US FY08	US FY09	US FY10	TDP-1 Totals**	US FY11	US FY12
Cavity orders	22	12		10	10	**52**	10	10
Total 'process and test' cycles		40	5	45	30	**113**	30	30
Asia	**JFY06 (actual)**	**JFY07 (actual)**	**JFY08**	**JFY09**	**JFY10**		**JFY11**	**JFY12**
Cavity orders	8	7	8	25	15	**44**	39	39
Total 'process and test' cycles		21	40	75	45	**147**	117	117
Europe	**CY06 (actual)**	**CY07 (actual)**	**CY08**	**CY09**	**CY10**		**CY11**	**CY12**
Cavity orders	60	8		834		**902**		
Total 'process and test' cycles		14	18	26	30	**73**	380	406
Global totals								
Global totals - cavity fabrication	90	27	8	869	25	997	49	49
Global totals - cavity tests		75	65	135	175	333	501	501

- In total **~ 330 cavities** to be processed

High Gradient R&D

- step 1: research to **find cause** of low gradient
  - for quench: high resolution camera
  - for field emission: confirm what are the residuals on the surface (SEM, XPS)
  - for Q-disease: confirm what is diffused into the surface (XPS)
- step 2: **develop countermeasure**
  - for quench: (remove beads & pits, material impurities & defect scan, …)
  - for field emission: (ethanol rinse, degreaser rinse, sponge wipe, Ultra-sonic, HPR,...)
  - for Q-disease: (baking, Argon baking, …)
- step 3: apply & **verify** countermeasure
  - exchange problem cavities and apply the countermeasure
- step 4: evaluate **statics** for the countermeasure
  - install the countermeasure world-wide, get statistics

Guideline: Standard Procedure and Feedback Loop

	Standard Fabrication/Process	(Optional action)	Acceptance Test/Inspection
Fabrication	Nb-sheet purchasing		Chemical component analysis
	Component (Shape) Fabrication		Optical inspect., Eddy current
	Cavity assembly with EBW		**Optical inspection**
		(Tumbling)	(Optical Inspection)
Process	EP-1 (Bulk: ~150um)		
	Ultrasonic degreasing (detergent) or ethanol rinse		
	High-pressure pure-water rinsing		**Optical inspection**
	Hydrogen degassing at 600 C (?)		
	Field flatness tuning		
	EP-2 (~20um)		
	Ultrasonic degreasing or ethanol	(Flash/Fresh EP) (~5um))	
	High-pressure pure-water rinsing		
	General assembly		
	Baking at 120 C		
Cold Test (vertical test)	Performance Test with temperature mapping		If cavity not meet specification **Optical inspection**

Topic from Americas: General Progress (reported by Mark Champion)

- **Completed Americas Region FY08-09 plan** that was presented at Fermilab SCRF meeting in April
- AES3 at Los Alamos for testing of temperature-mapping system
- **Accel7 electro-polished at Argonne May 12**
  - **To be tested this week at Jefferson Lab**
- **Accel6 at** Fermilab (preparation at Jefferson Lab)
- Two new Accel cavities delivered to Jefferson Lab; third to follow shortly.
- New Accel cavity delivered to Argonne

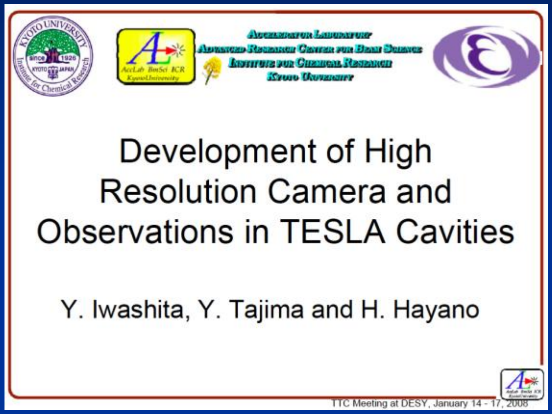
First nine-cell electro-polishing performed at Argonne, May 12

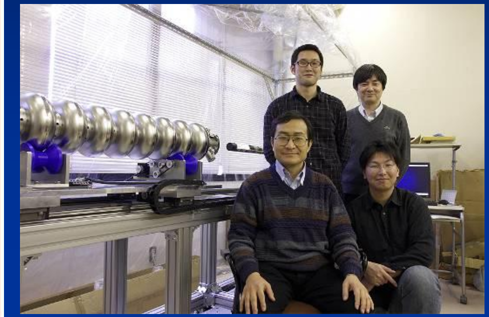
- Accel cavity A7 electro-polished; <removal> ~27 microns.
- Upon completion of low-pressure rinsing, cavity was filled with ultra-pure water and shipped to Jefferson Lab.
- Ultrasonic cleaning, high-pressure rinsing, and assembly complete.
- Testing scheduled for June 4th.

Photos courtesy of Mike Kelly

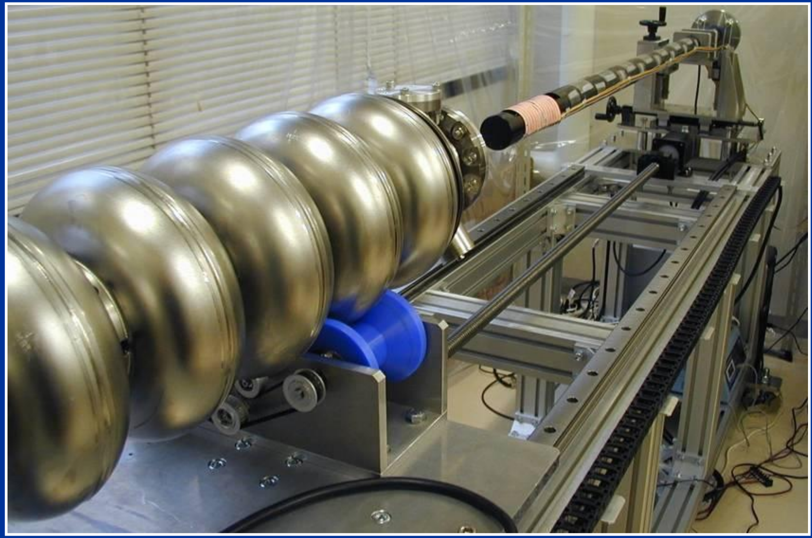
A Technology Developed at Kyoto/ KEK collaboration

Visual Cavity Surface Inspection





AES001 #3 cell 169°
Edge of heat-affected zone

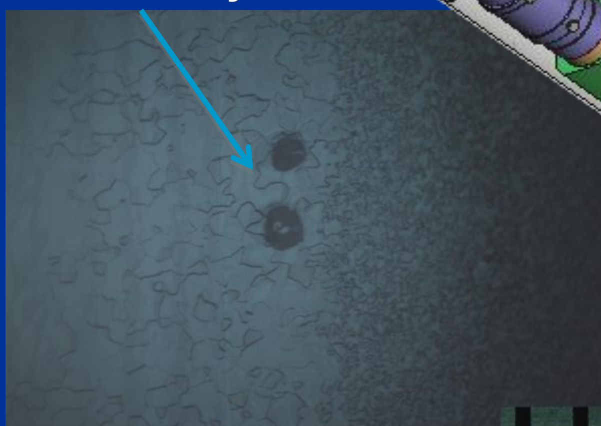


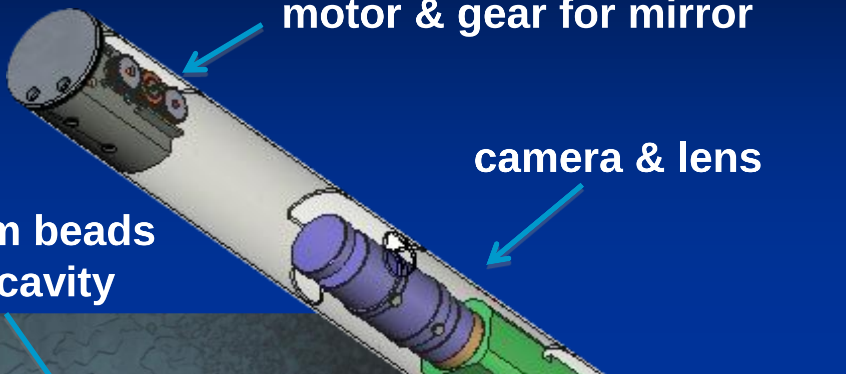
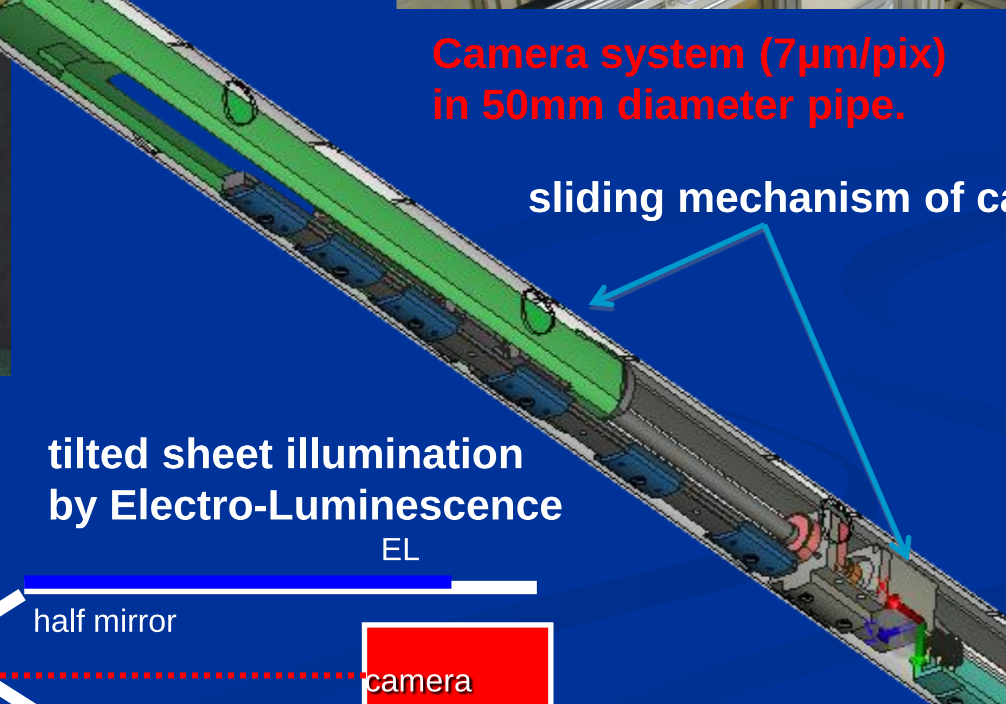
A New High Resolution, Optical Inspection System in TDP

For visual inspection of cavity inner surface.

Camera system (7μm/pix) in 50mm diameter pipe.

~600μm beads on Nb cavity



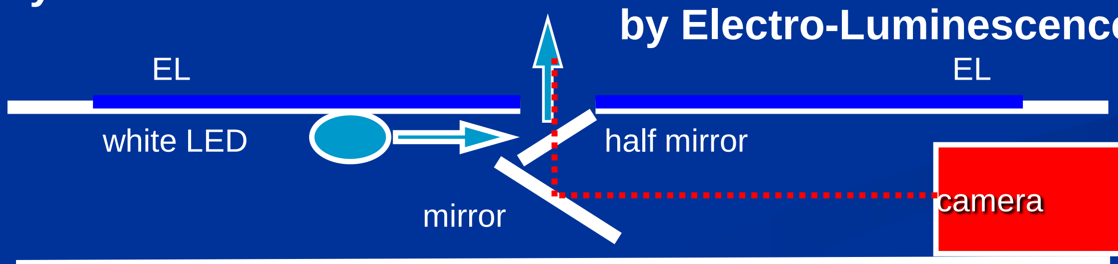
motor & gear for mirror

camera & lens

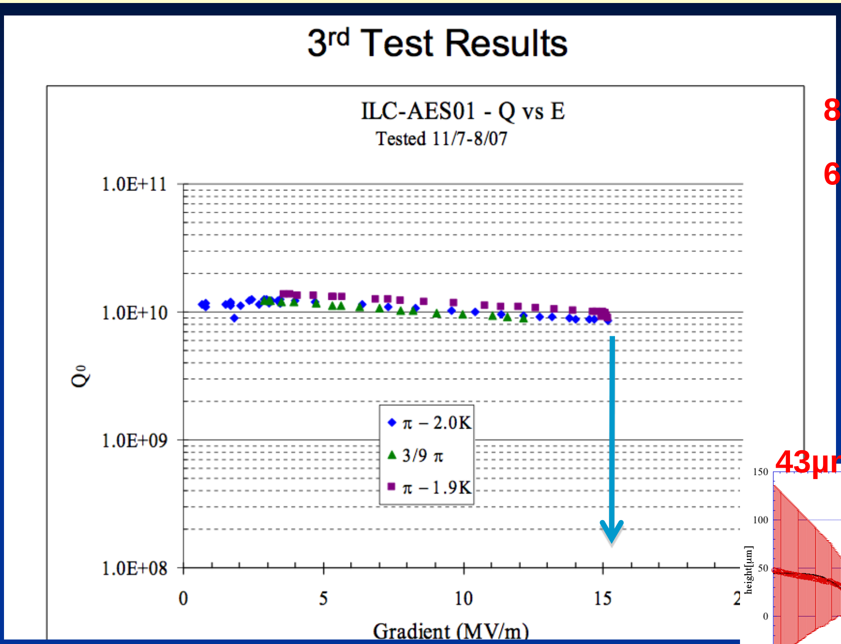
sliding mechanism of camera

perpendicular illumination by LED & half mirror

tilted sheet illumination by Electro-Luminescence



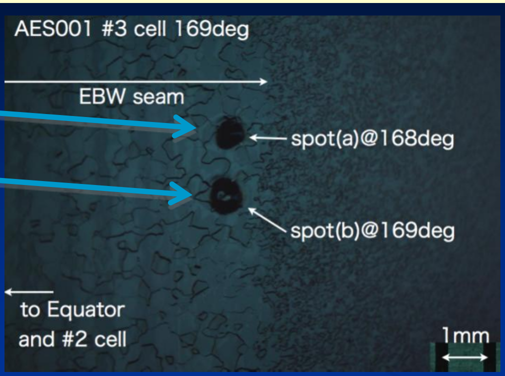
Very consistent with Thermal Measurement



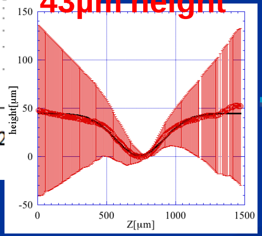
84µm height

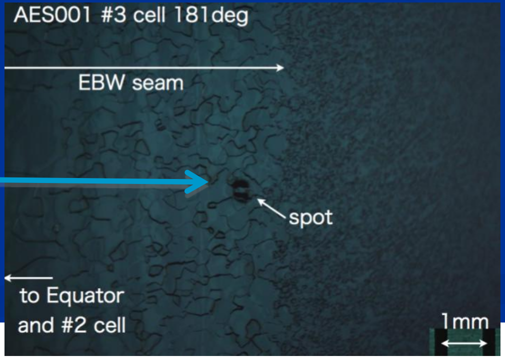
60µm height

~21mm

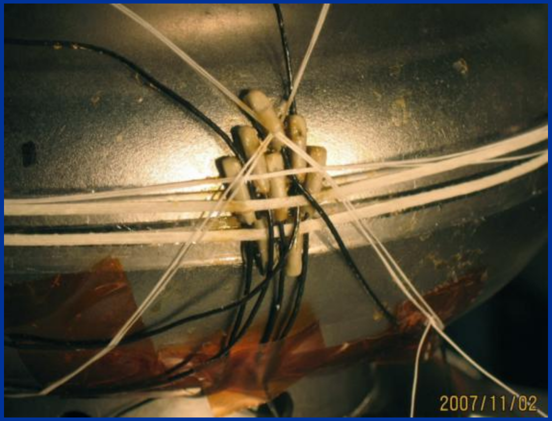


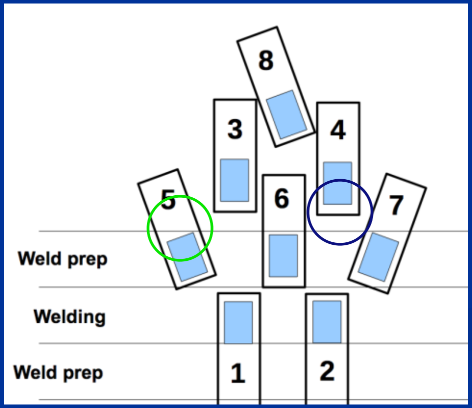
43µm height

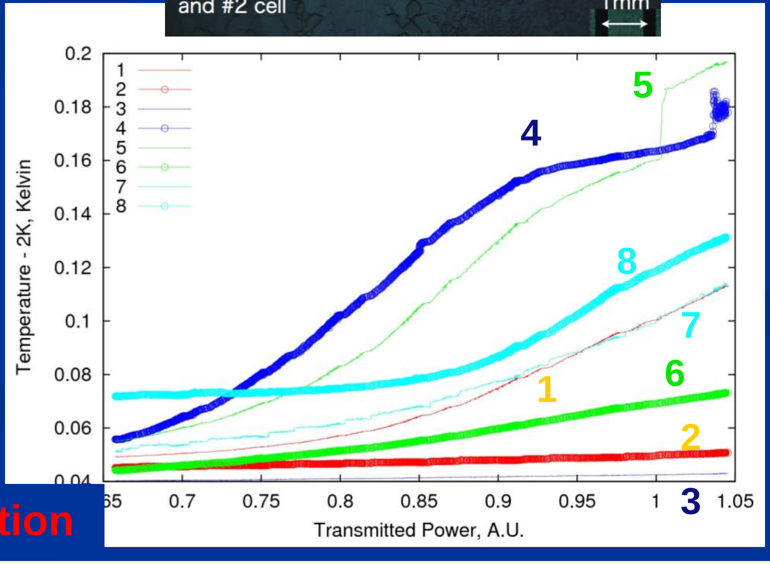




AES01 has hard quench at 15MV/m,
its location was identified by Cernox at FNAL.

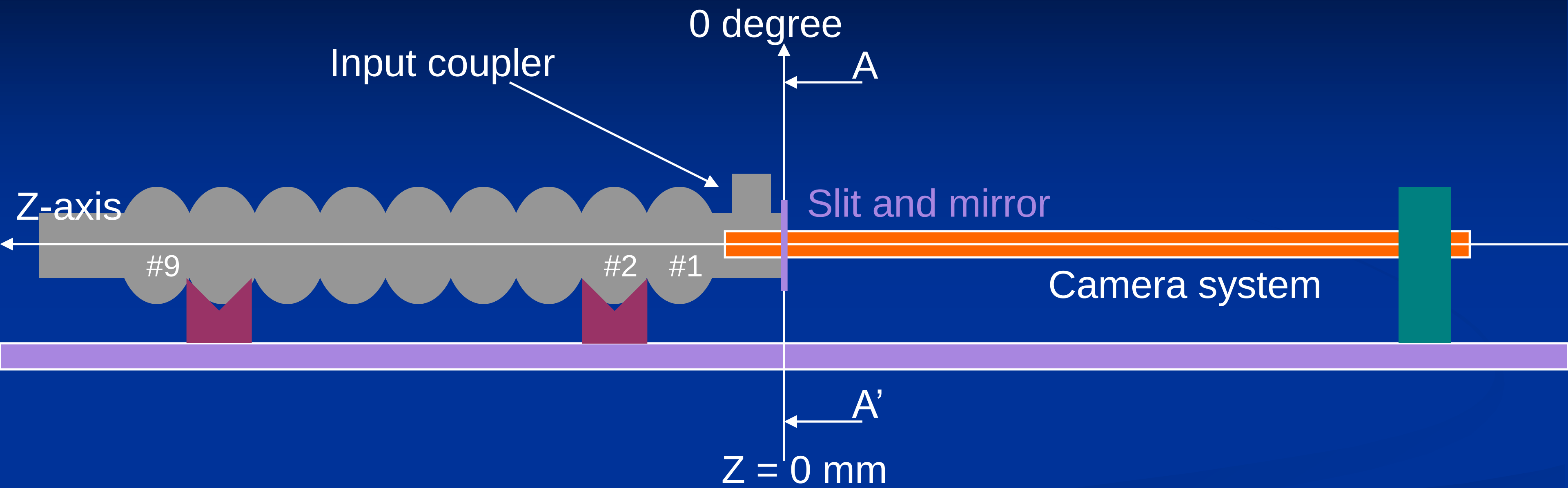


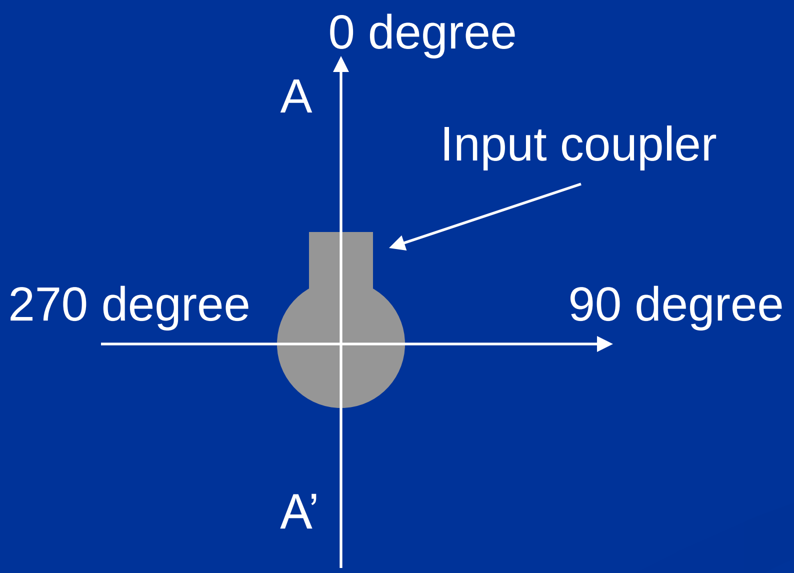




Kyoto-camera found 3 spots in their exact location

Coordinate system





rotation angle：

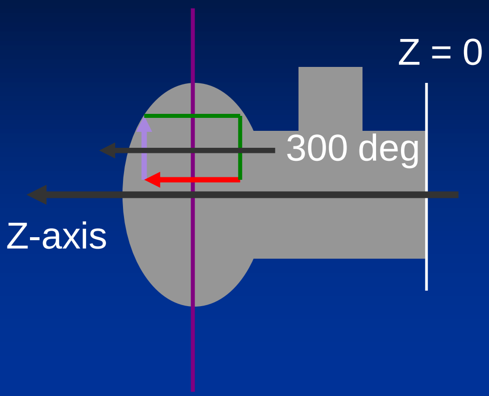
Define 0 degree when the input coupler flange is in horizontal.

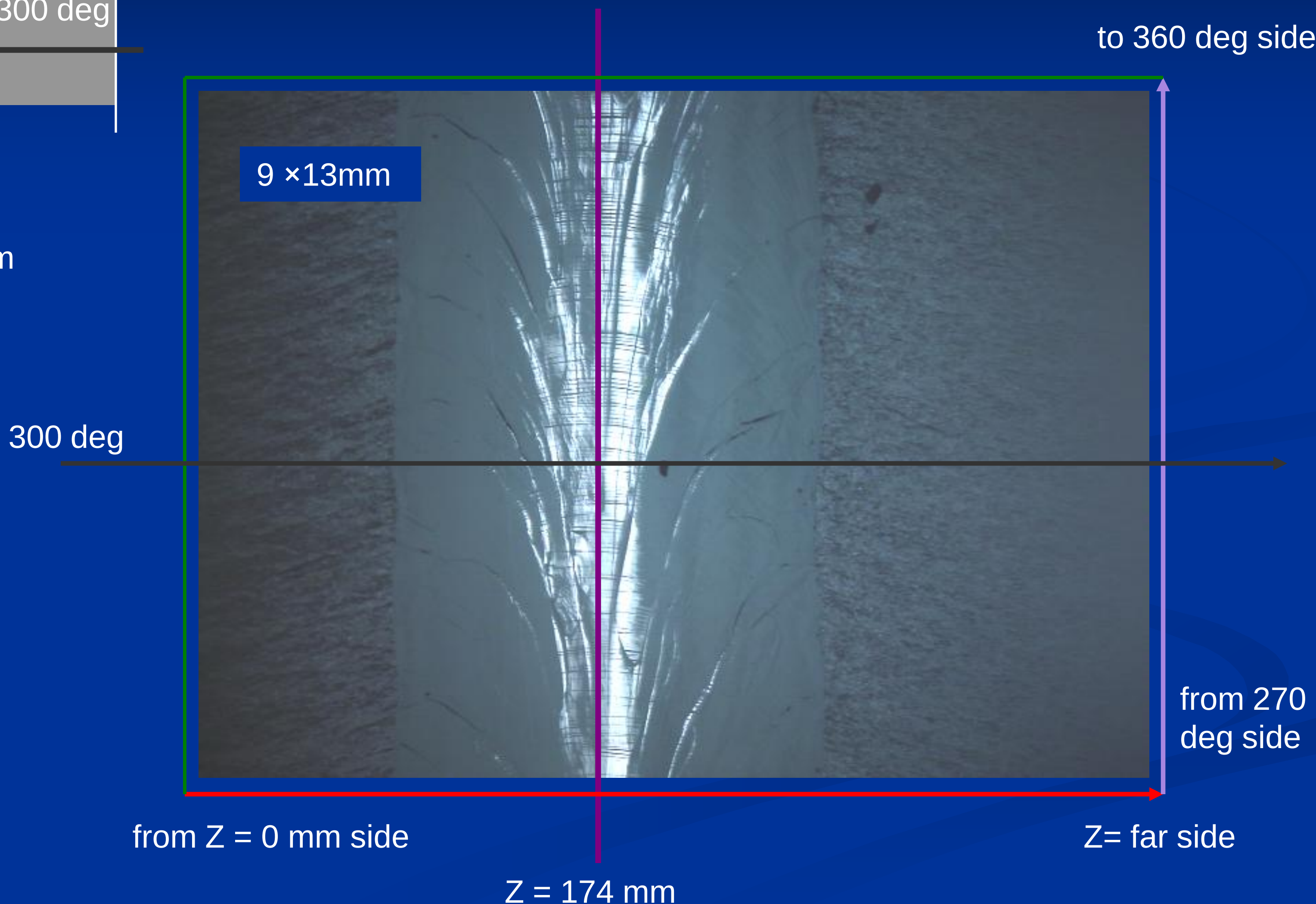
Z-axis：

Define 0mm(origin) at the input coupler side flange end surface. Cell number starts from the input coupler, #1, #2,….. #9.

view size

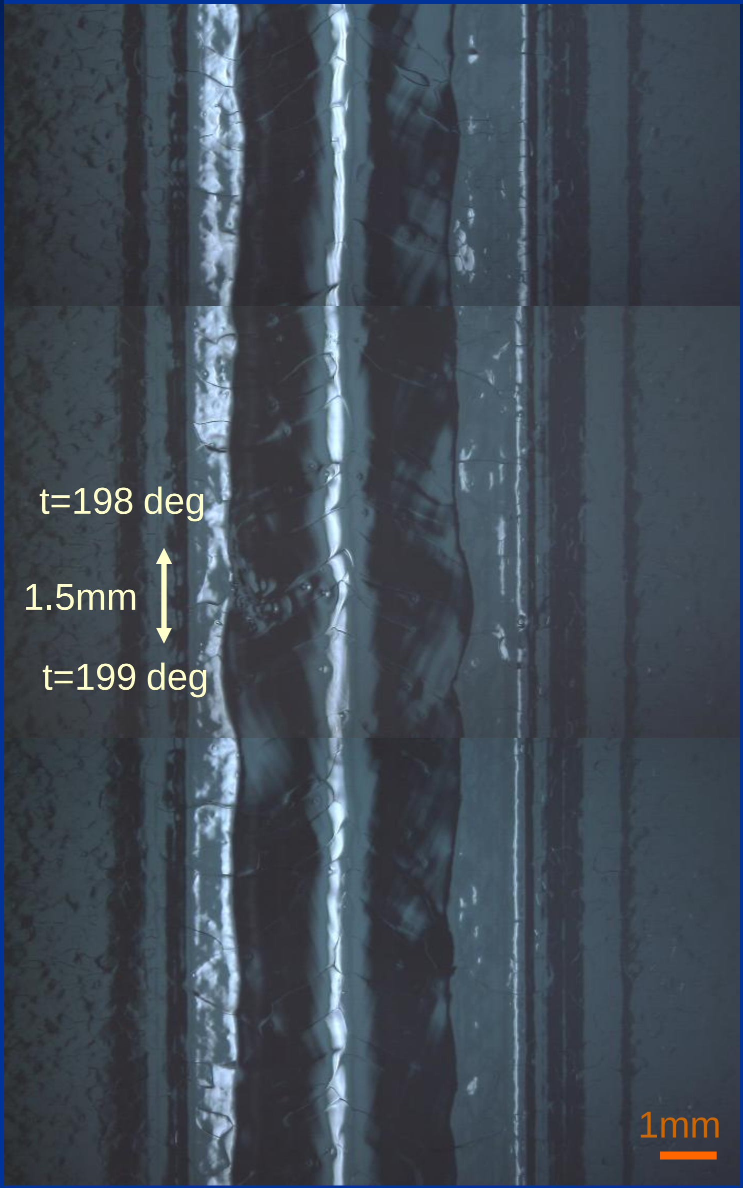
example: Z=174mm, angle = 300 degree



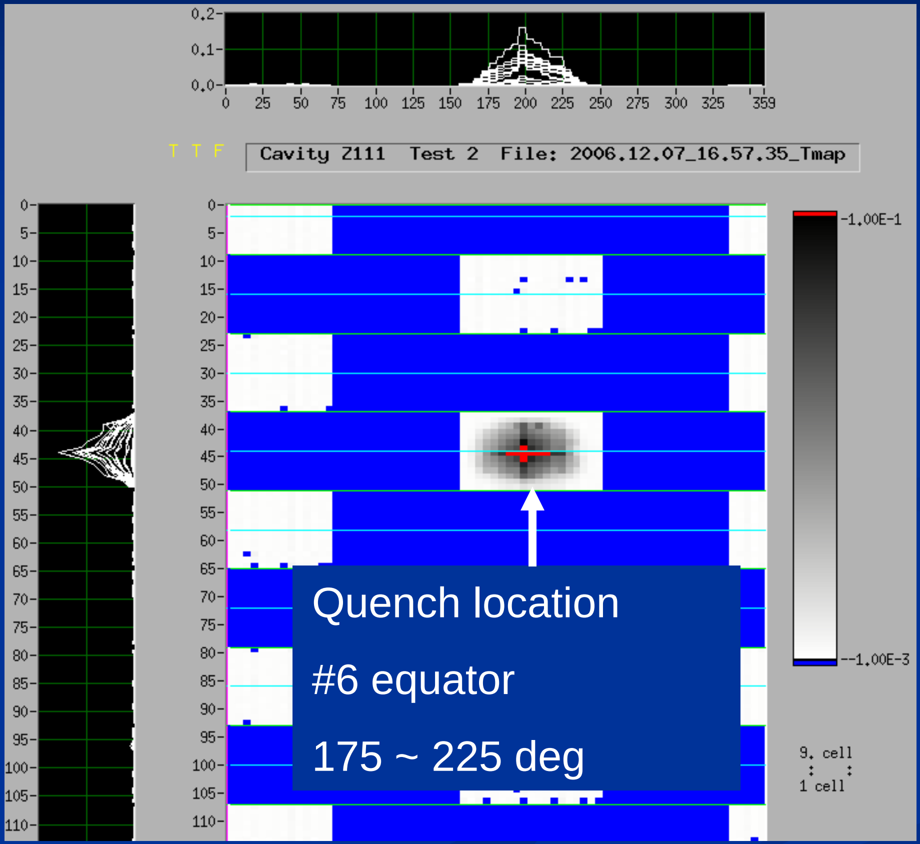


TESLA cavity Z111: #6 cell equator

#6 equator, t=193 ~ 204 deg



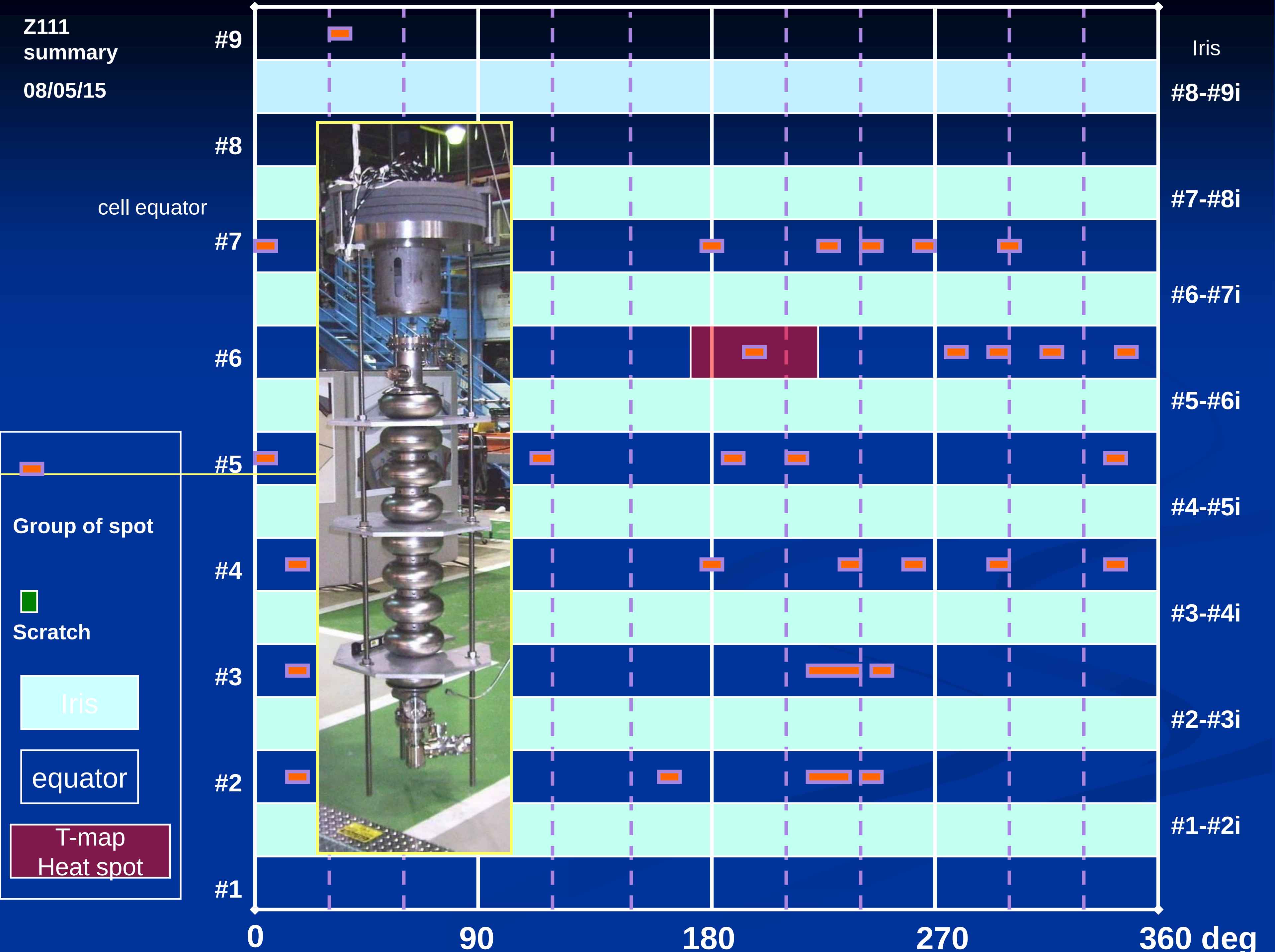
T-map data in test 2, 16.0 MV/m



group of beads(?) with 1.5mm wide were observed.

Z111 summary

08/05/15



Global R&D Plan

Consensus in SCRF-TA

Calender Year		2008	2009	2010	2011	2012
EDR	TDP1				TDP-II	
S0: Cavity Gradient (MV/m)	30	35 (> 50%)				35 (>90%)
KEK-STF-0.5a: 1 Tesla-like/LL						
KEK-STF1: 4 cavities						
S1-Global (AS-US-EU) 1 CM (4+2+2 cavities)			CM (4$_{AS}$+2$_{US}$+2$_{EU}$) <31.5 MV/m>			
S1(2) -ILC-NML-Fermilab CM1- 4 with beam			CM2 CM3 CM4			
S2:STF2/KEK: 1 RF-unit with beam			Fabrication in industries		STF2 (3 CMs) Assemble & test	

SCRF General Test Facilities

- Europe DESY TTF/ FLASH

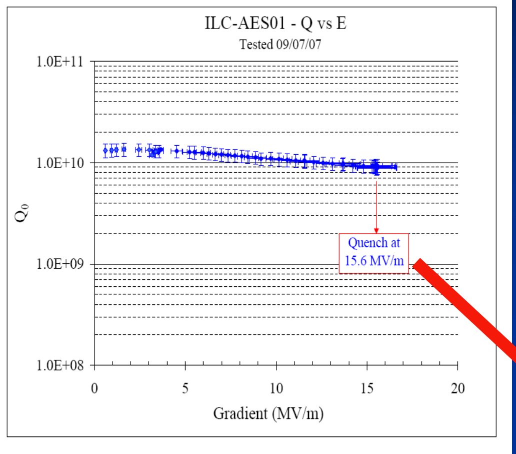
Being Ready:

- Americas FNAL **ML/NML**
- Asia KEK **STF**

New Vertical Test @FNAL

- Recently commissioned (IB1)
  - Existing 125W@1.8 K Cryogenic plant
  - RF system in collaboration with Jlab
  - Capable of testing ~50 Cavities/ yr
  - Evolutionary upgrades:
    - Thermometry for 9-cells, 2 cavities at a time, 2 top plates, Cryo upgrades
    - Plan for two additional VTS cryostats
  - Ultimate capacity ~ 264 cavity tests/ yr

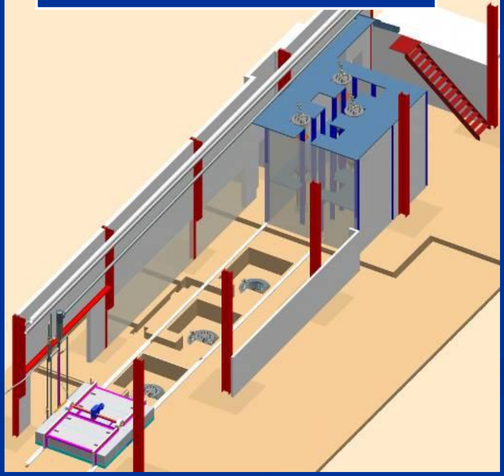
Nine-cell Tesla-style cavity



VTS Cryostat:IB1

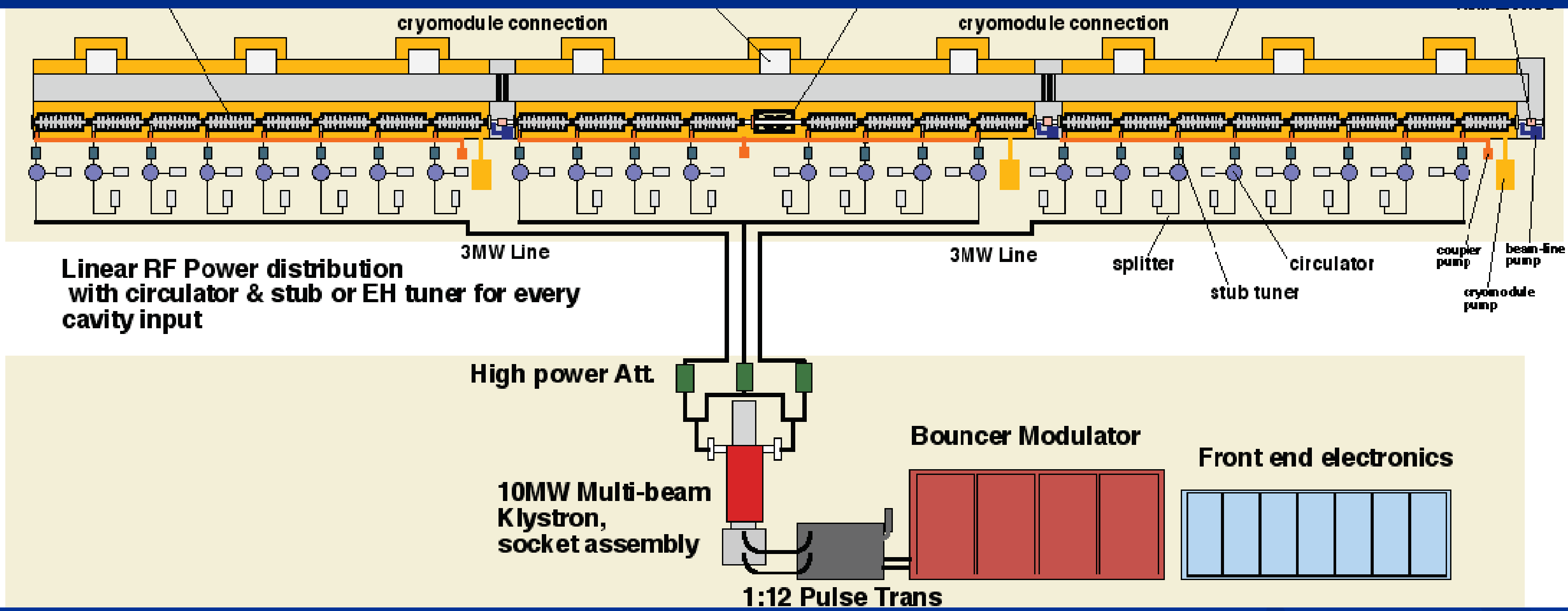
New RF & Control Room

Plan for 2 more VTS pits



ML basic building block

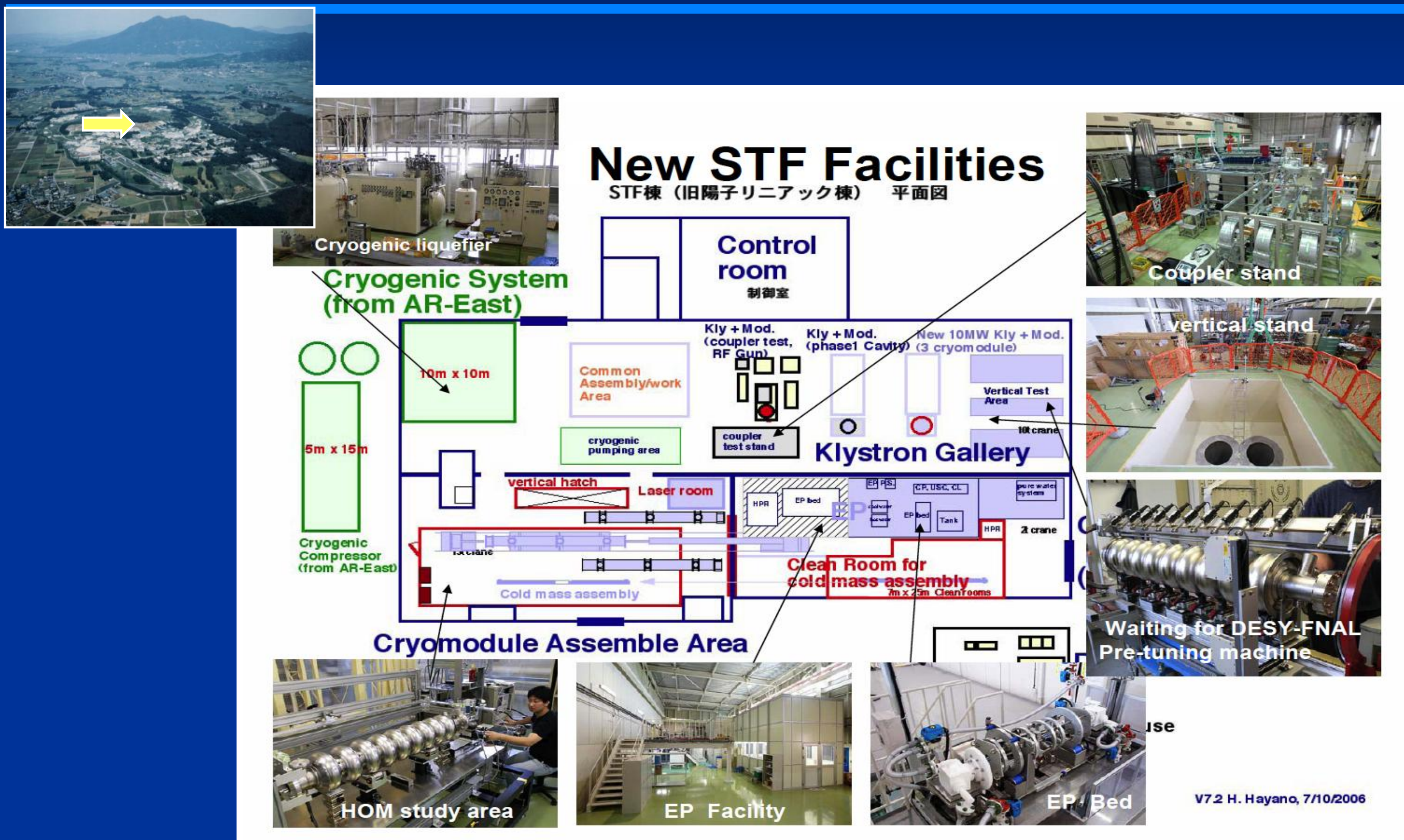
ILC RF Unit: 3 CM, klystron, modulator, LLRF



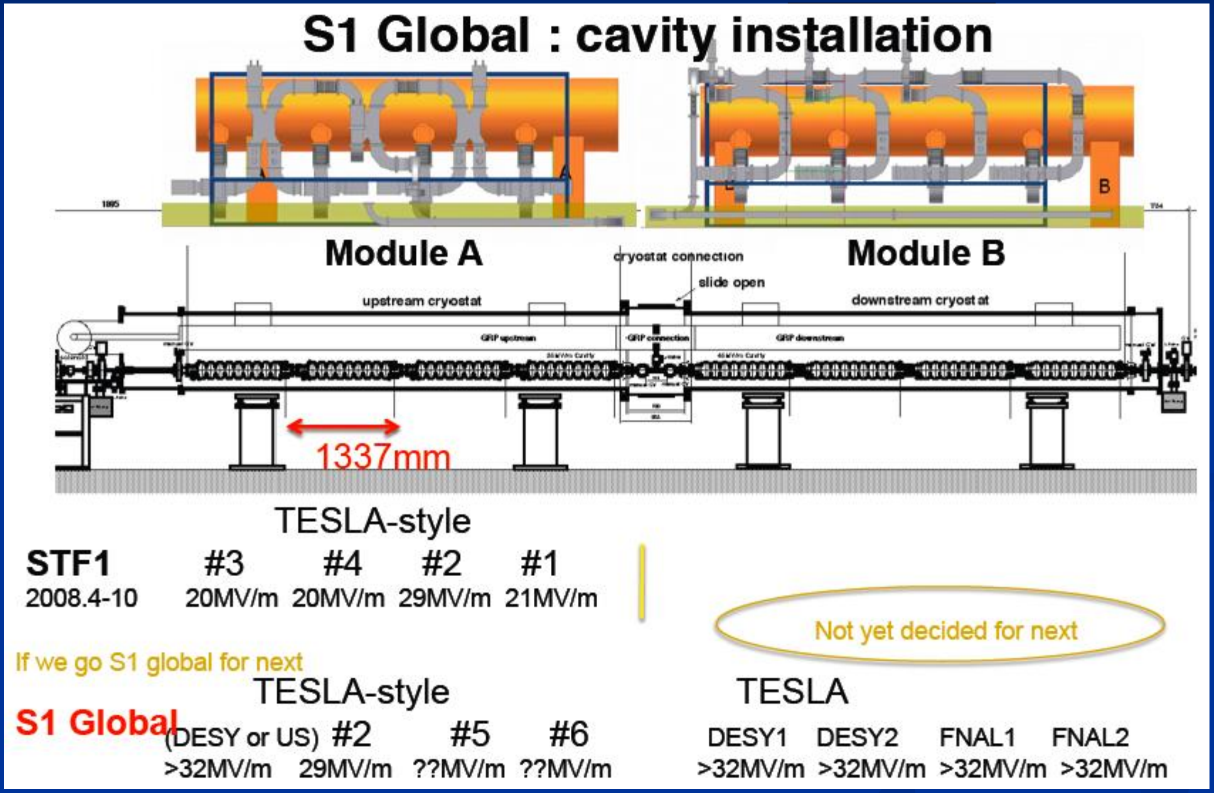
Baseline design now has 2 CM with 9 cavities, 1 CM with 8 cavities + quad

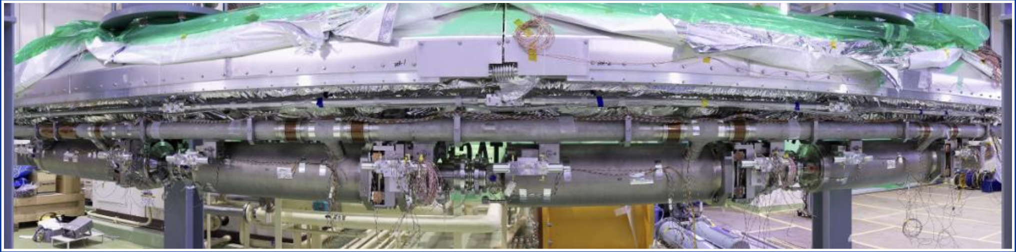
KEK: SCRF Test Facility (STF)

to be an Asian Test Facility for ILC



STF -1 at KEK


S1 Global : cavity installation
Module A
Module B
cryostat connection
slide open
upstream cryostat
downstream cryostat
1337mm
TESLA-style
STF1
2008.4-10
#3 20MV/m
#4 20MV/m
#2 29MV/m
#1 21MV/m
Not yet decided for next
If we go S1 global for next
TESLA-style
TESLA
S1 Global
(DESY or US) >32MV/m
#2 29MV/m
#5 ??MV/m
#6 ??MV/m
DESY1 >32MV/m
DESY2 >32MV/m
FNAL1 >32MV/m
FNAL2 >32MV/m



STF-2: Beam Acceleration with One RF unit (3 cryomodule)

ILC RF unit test, in the existing STF tunnel,

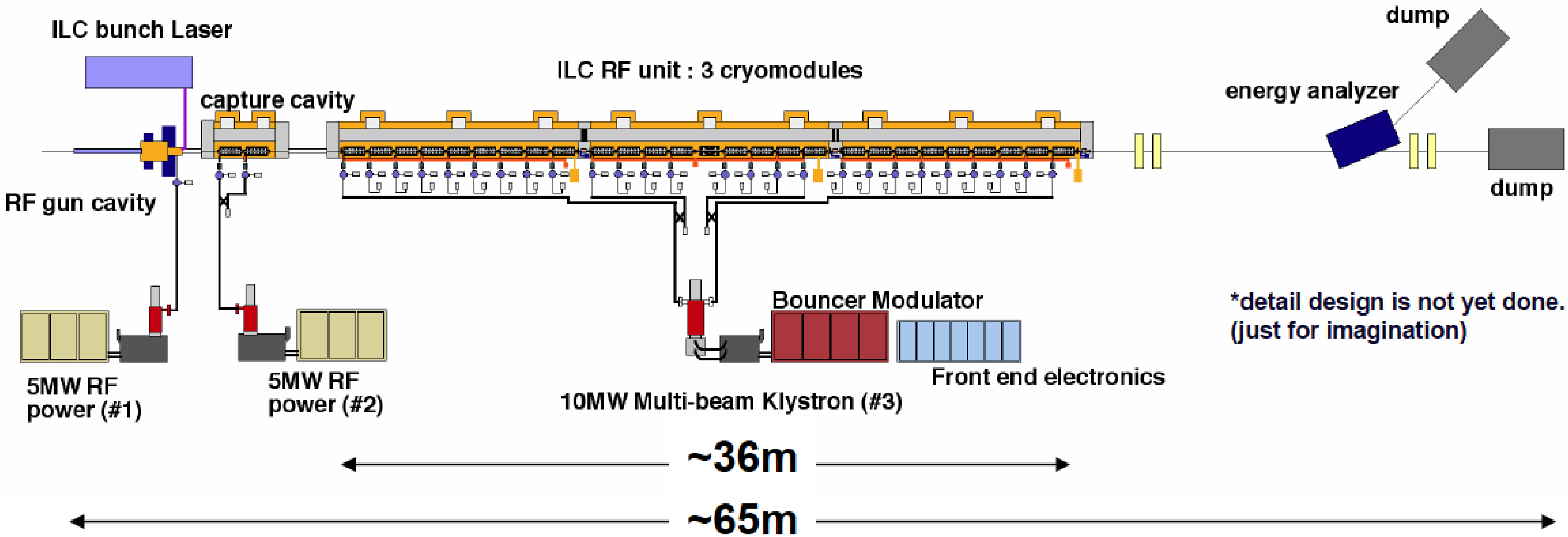
With ILC beam by L-band RF-gun.

design and preparation of vessel code : 2008

fabrication : 2009 - 2010

operation : 2011

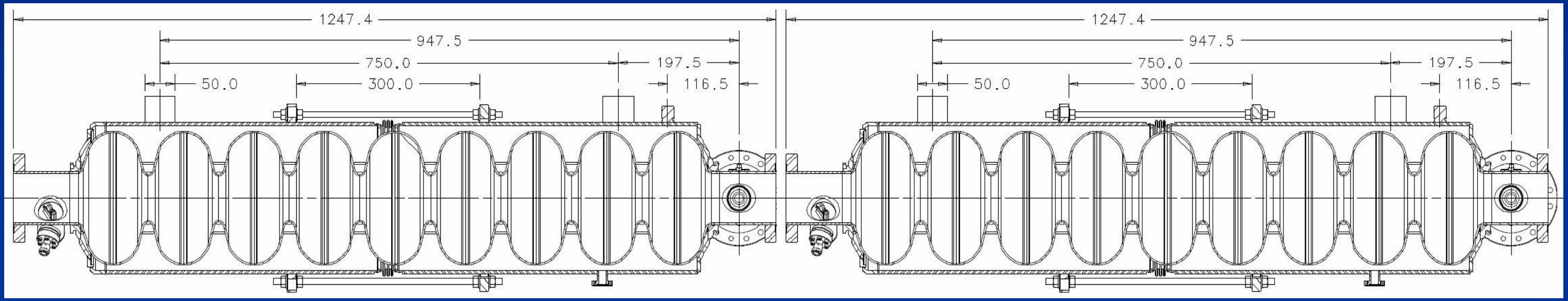
STF Phase 2 Plan

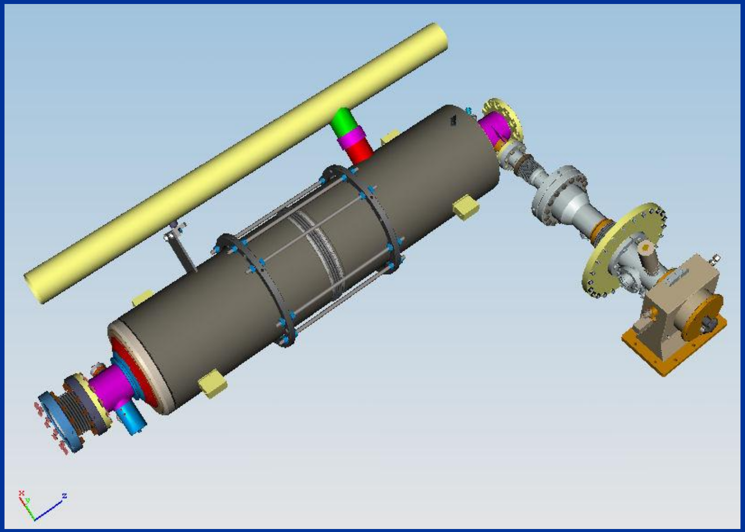


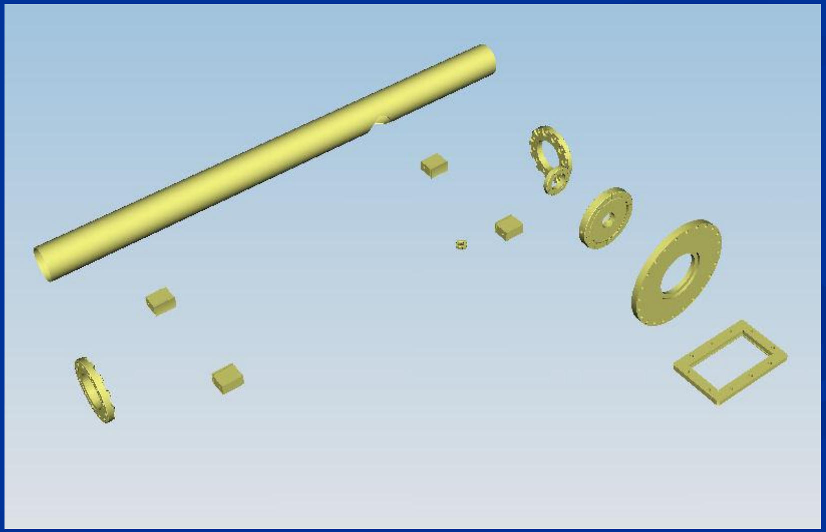
Engineering Design Work to be Made

- **Cavity, Cryomodule, and Cryogenics**
  - Standardization and Industrialization
    - Plug-compatible Interfaces important
      - Cavity units (cavity, tuner, HOM, end-flange, coupler etc.)
      - Magnets, BPMs, Piping (plumbing), vacuum vessel
    - High pressure design (world-wide applicable)
      - Special material (such as Nb) have to be accepted
    - Thermal balance, power balance, (capital cost vs operational)

Plug-compatibly of Cavities
for convenience in Global Cooperative effort





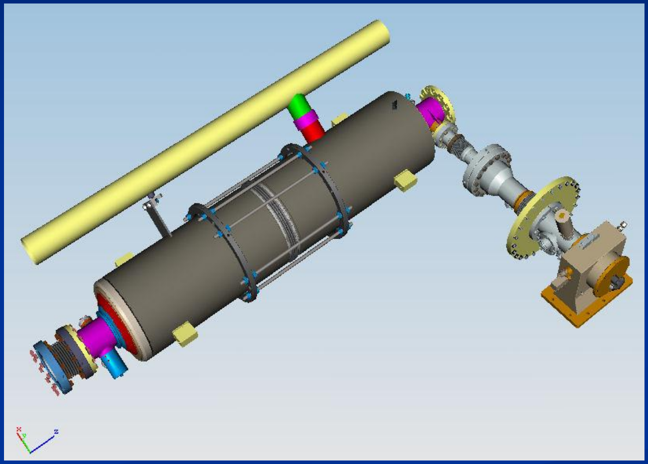


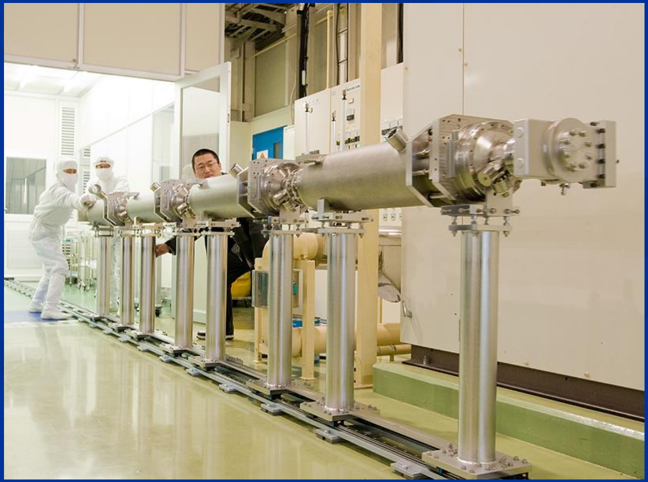
***Many thanks for Don** Mitchell and Lars Hagge for 3D-CAD and EDMS*

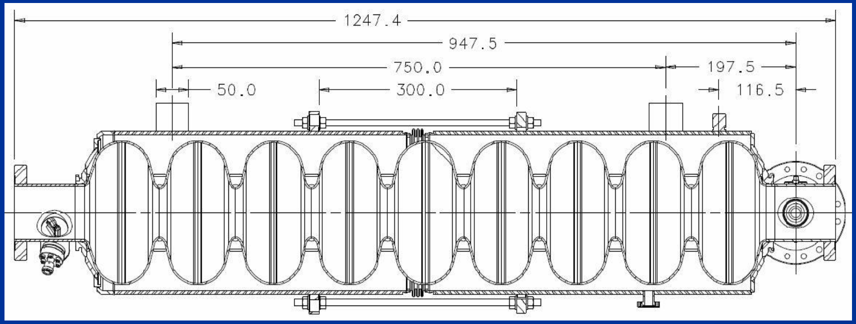
Further Efforts Required

Cavity Unit Assembly

- End interface
  - Axial end, tuner, couplers, etc….
- Bi-metal-joint (transition) Nb >> SUS
  - Cost-saving with SUS He-vessel
- Plug Compatibility
- Alignment

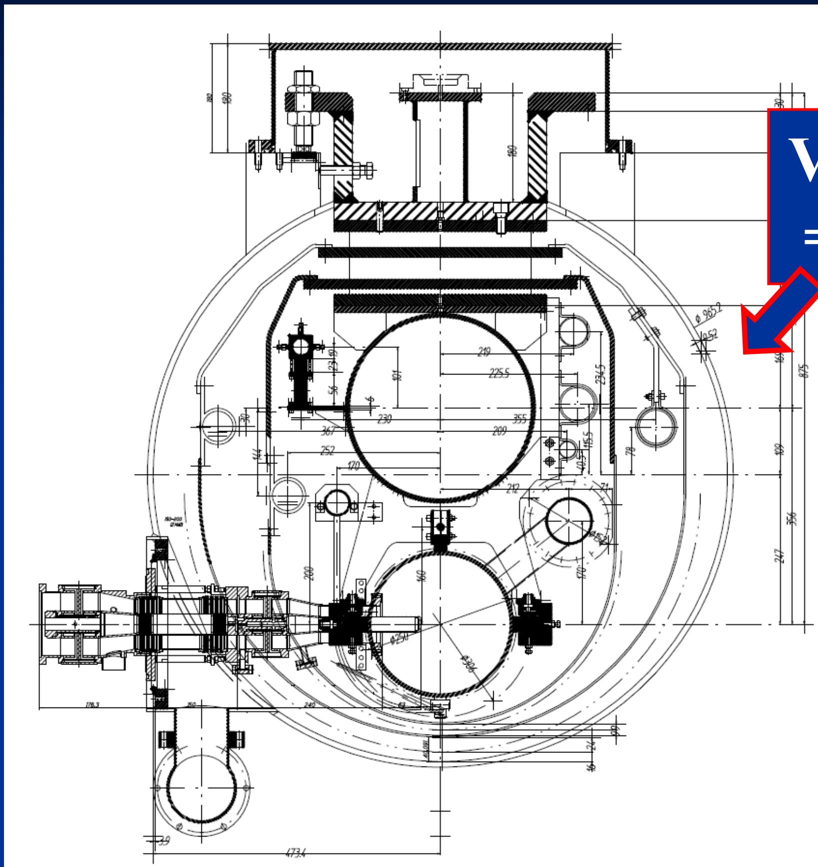






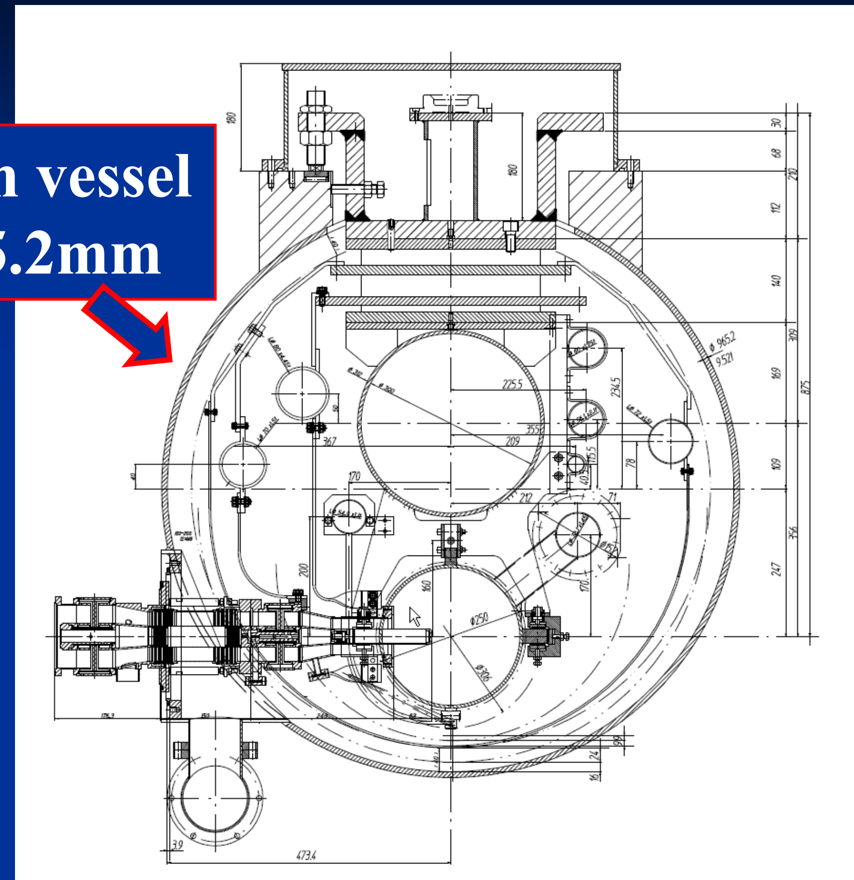
Study of the cryomodule cross-section (1)

Vacuum vessel = ϕ 965.2mm



Two shields model based on TTF-III with KEK input coupler

1.40K-80 K shield with 30-layer-SI
2.5K-8K shield with 10-layer-SI
3.5-layer-SI around cavity jacket, GRP and LHe supply pipe



One shield model

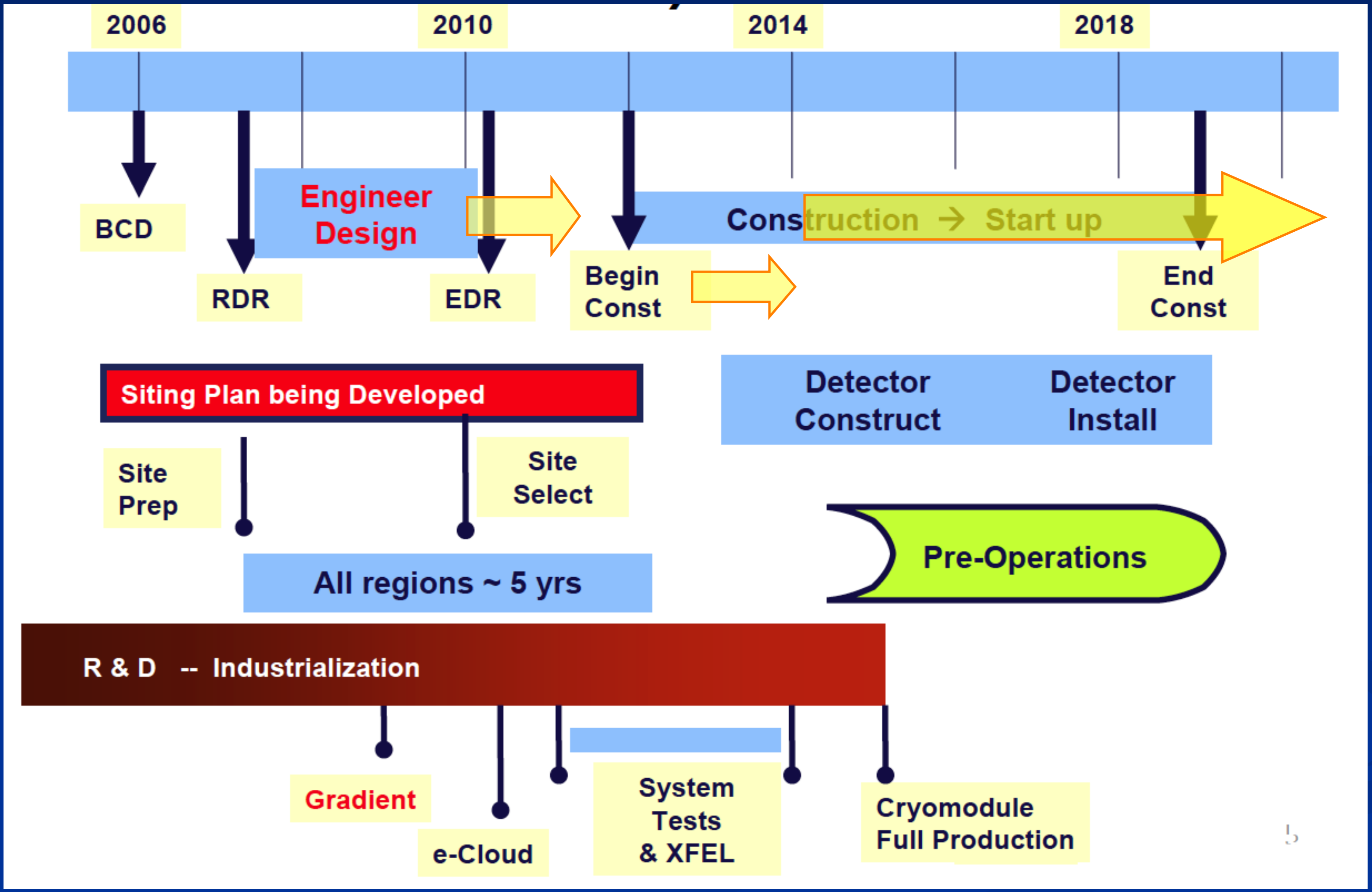
1.40K-80 K shield with 30-layer-SI
2.5-layer-SI around cavity jacket, GRP and LHe supply pipe
3.5K cooling pipe support

Engineering Design Work to be made (2)

- **RF Power System**
  - Power source to be cost-effective
    - Advanced Klystron, **Marx Generators,**
  - **Power distribution** system to be efficient, tunable
  - Control

- **Integration for Linear Accelerators**
  - Beam handling/ transport
  - Alignment (static), and the adjustability (in long term)
  - Dynamic alignment/ steering
    - Control at the level of < 100 nm

General Plan (as of 2008)



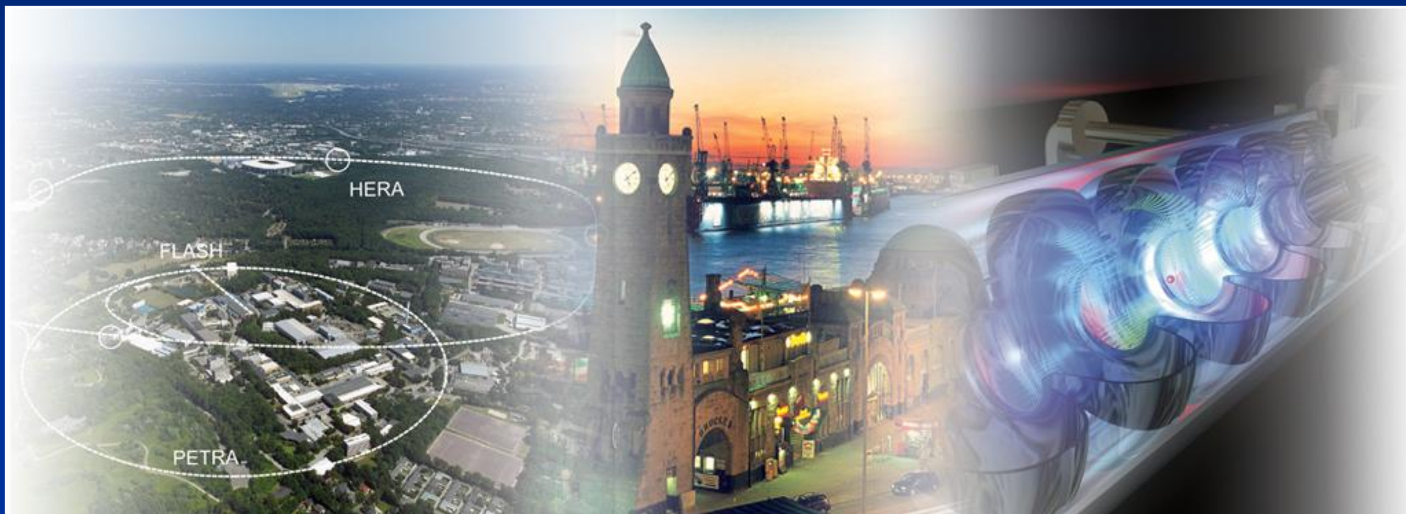
EDR >> TDP to be extended, two years

Preparing for Industrialisation

- We propose to re-plan the "industrialization"
  - **TDP-1: Basic R&D and Design**
    - Cavity in the "basic R&D" stage (S0)
      - Guideline for the cavity fabrication, chemical process, and inspection
      - The cavity performance to be stabilized at above 31.5 MV/ m and to reach 35 MV/ m with the yield 90%.
    - Cryomodule may be in the engineering desingn
    - One-unit of Cavity and Cryomodule assembly and tests (S1)
  - **TDP-2: to proceed "pre-industrialisation"**
    - Prototype work for Cavity & Cryomodule string with one RF unit (S2),
  - Beyond TDP-2: Pre-production efforts
    - Multiple prototype modules as pre-production efforts with parallel effort of the project realization as parallel effort.

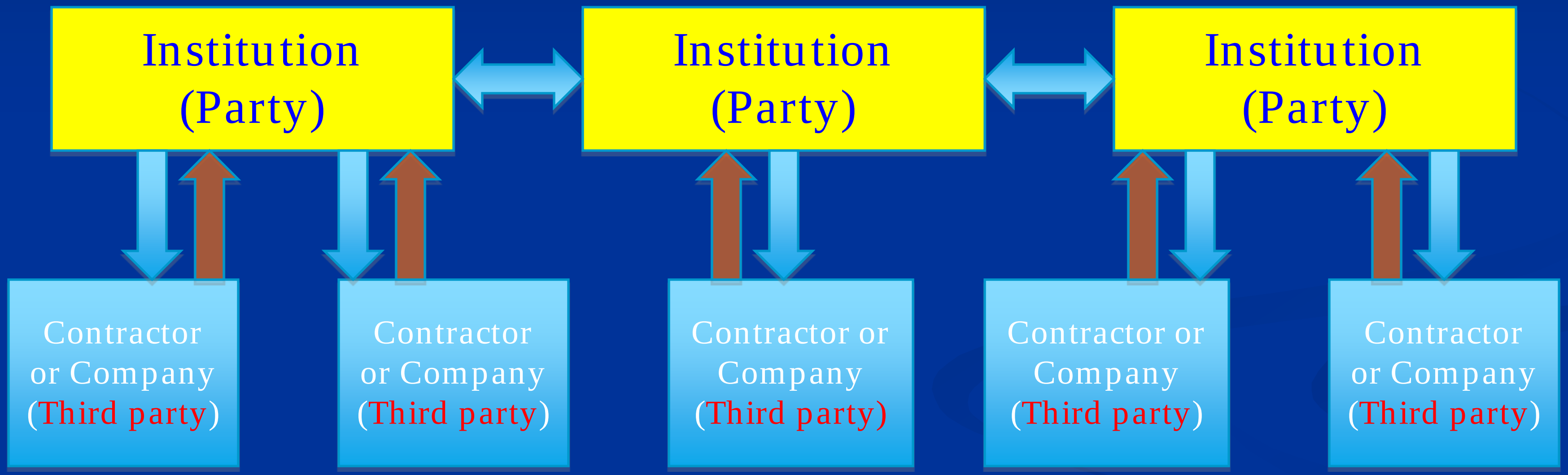
EU XFEL：

A technically important milestone toward ILC



- SRF design gradient： 25 MV/m
- ~ 100 SCRF cryomodule, based on the experience at TTF, DESY,
- Leading SCRF industrialization (scale: **1/20 of ILC**, in coming 5 years)
- In-kind contribution base、 EU centered, international collaboration

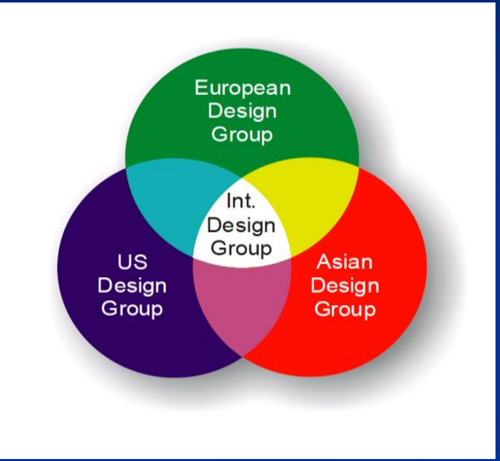
Intellectual Property to be appropriately treated

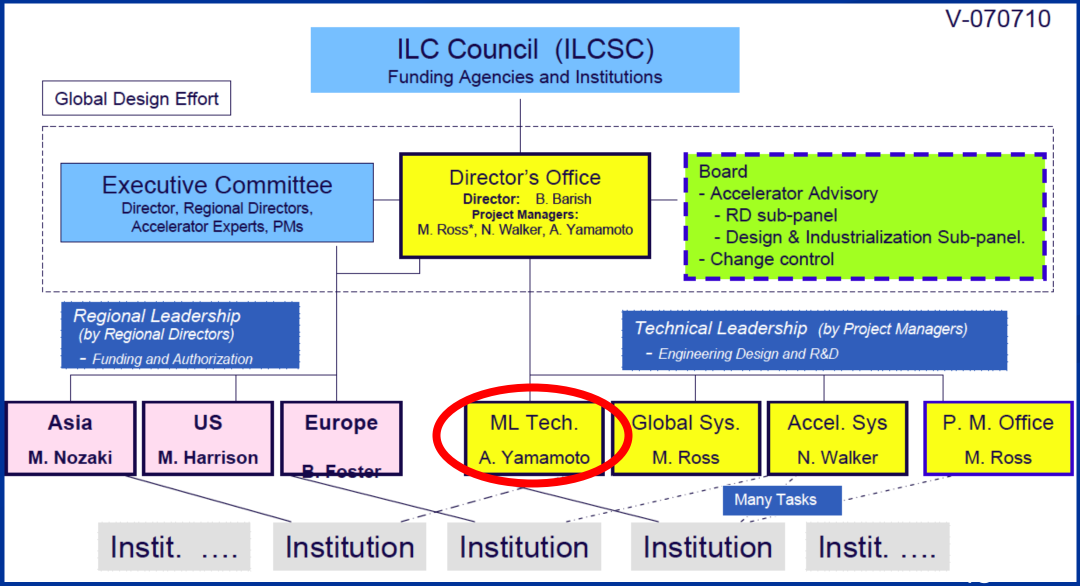


Blue: “Party” to “Party”, and “Party” to third party with royalty-free
Orange: Third party to “Party” needed to be protected by Royalty

International Linear Collider: ILC

- Construction
  - One in the world
- Development
  - Americas, EU, Asia:
    - Three region's cooperation
- GDE
  - Global design effort
  - Technical Areas
    - SCRF
    - CF&S
    - AS





SCRF Project Management Structure

(March, 4, 2008, still to be updated)

Regional/Intsitutional Effort: - Director-Americas: Mike Harrison - Director-Eerope: B. Foster - Director-Asia: M.Nozaki			Technical Effort (ML (SCRF) Technology): - Project Manager: A. Yamamoto - Associate Managers: T. Shidara, J. Kerby, * Group leader, ** Co-leader					
Regions	Institute	Institute Leaders	Cavity (Process) L. Lilje*	Cavity (Prod./Int.) H. Hayano*	Cryomodule N. Ohuchi* -H. Carter**	Cryogenics T. Peterson*	HLRF S. Fukuda*	ML Integr. C. Adolphsen
AMs	Cornell Fermilab SLAC ANL J-lab	H. Padamsee R. Kephart T. Raubenhaimer W. Funk	Padamsee. Champion	Adolphsen	Champion	Peterson	Adolphsen	Adolphsen
EU	DESY CERN Saclay Olsay INFN Spain	R. Brinkman J. Delahaye O. Napoly G. Wormser C. Pagani	Lilje TBD	Lilje TBD Pratt Pagani	Parma Pierini	Tavian		
AS	KEK Korea Inst. IHEP Indian Inst.	K.Yokoya	Hayano, Noguchi, Saito TBD	Hayano TBD	Tsuchiya/ Ohuchi TBD	Hosoyama/ Nakai TBD	Fukuda TBD	Hayano/Ohuchi TBD

Further Plan and Meetings

- SCRF Webex meetings:
  - 5/ 14, 6/ 11, 7/ 9, 8/ 6?, 9/ 3, 10/ 1,
- Work-package meetings:
  - Determined by WP coordinator,
- TTC meeting (at Delhi) and SCRF meeting followed :
  - Oct. 20 – 23, and
  - Oct. 24 for ILC-SCRF (hopefully),
- GDE meeting (at Chicago)
  - November, 16-20
- AAP review (to be harmonized with CF&S and AS)
  - Interim review for TDP-1
  - Early in 2009

Summary

- ILC is in Technical Design Phase
  - Reference design report submitted to ILCSC in 2007,
  - Technical design phase (1 and 2) starting,
    - TDP 1 by 2010: technical feasibility demonstrated,
    - TDP2 by 2-012: technical reality demonstrated, with documentation,
- SCRF technology is fundamental base to Realize the ILC
- Global cooperation will be crucially important

backup

Draft MOU: 6. Intellectual Properties

1. Intellectual property shall mean all property, including know-how, in such forms as drawings, designs, documents, inventions, software programs, reports, processes and protocols that is protected by such means as secrecy, patents, copyrights and trademarks.
2. Except as may be agreed otherwise, the rights in intellectual property created by a Party, or jointly by several Parties, prior to the conclusion of this MoU or in the execution of this MoU shall remain vested or be vested respectively, in that Party or jointly in those Parties.
3. Subject to such pre-existing restrictions as it shall disclose in writing when making its contribution available, each Party making a contribution under this MoU herewith **grants a royalty-free**, non-exclusive, non-transferable, un-assignable and irrevocable license to the other Parties to use the intellectual property for the exclusive purpose of the execution of this MoU. The term "use" shall include any integration, modification, enhancement and redistribution, including by any third party participating in the execution of the purpose. The using Party shall agree in writing with such third parties that their use of the intellectual property shall be for the exclusive purpose of the execution of this MoU. Prior to making its contribution, the contributing Party shall ensure that it is entitled to license the intellectual property in its contribution to the other Parties on the terms defined in this paragraph.

Draft MOU: 6. Intellectual Properties

4. The contributing Party provides no representations or warranties in respect of its intellectual property. The using Party or Parties shall hold the contributing Party harmless from liability resulting from its or their use of such intellectual property. The contributing Party shall have no obligation to participate in any legal actions regarding such intellectual property.

5. The obligations defined in this article shall apply whether or not the intellectual property is pre-existing or developed in the execution of the contribution, and whether or not it was developed by a team or individual.

Cavity: Work-packages

	Dec. 07 (ED-plan)	TDP-R&D (proposed)	Coordinator
1.1.1	Gradient performance	Gradient performance & specification	LL, HH, MC
1.1.2	Fabrication specification		
1.1.3	Process specification		
1.1.4	Specification		
1.1.5		Industrialization and cost ?	LL, TS

Cavity Integration: Work-packages

	Dec. 07 (ED-plan)	TDP-R&D (proposed)	Coordinator
1.2.1	Tuner	Tuner	HH
1.2.2	Input coupler	Input coupler	SP
1.2.3	Magnetic shield	Mag. Shield and He-vessel	
1.2.4	He-vessel		
1.2.5	Integration and test	Integration and test High Pressure Code issue	HH
1.2.6	Industrialization	Industrialization & Cost	HH , TS

Cryomodule: Work-packages

	Dec. 07 (ED-plan)	TDP-R&D (proposed)	Coordinator
1.3.1	Standardization	Standardization/Plug-compatibility	
1.3.2	Cooling pipe config.	Cold-mass engineering	NO
1.3.3	5-K shield		
1.3.4	Quadrupole assembly	Quadrupole installation	
1.3.5	Assembly process	Assembly and Eng. w/CAD work	
1.3.6	Engineering w/ CAD		
1.3.7	Sys. Performance eval.	System test and evaluation	NO
1.3.8	Transportation	Transportation	
1.3.9	Industrialization/Cost	Industrialization & Cost	NO, TS

Cryogenics: Work-packages

	Dec. 07 (ED-plan)	TDP-R&D (proposed by TP)	Coordinator
1.4.1	Heat loads	Heat loads	
1.4.2	Cryoplant design	Cryoplant design and surface impact	
1.4.3	Reliability, repair	Tunnel cryogenic system and Integration	
1.4.4	Venting pressure limit	Venting press. Limits & vessel/piping standard	
1.4.5	Surface impact		
1.4.6	Hazard		
1.4.7	Cryobox design		
1.4.8	Liquid control		
1.4.9	Optimization of cryogenics		
1.4.10	2K heat exchanger		
1.4.11	Standard (H.P. code)		
1.4.12	E+/e- cryogenics	E+/- sources cryogenics	
1.4.13	DR cryogenics	Damping ring cryogenics	
1.4.14	BDS cryogenics	BDS cryogenics	
1.4.15	RTML cryogenics	RTML cryogenics	
1.4.16	MLI vacuum	Main Linac vacuum	
1.4.17	RTML vacuum	RTML vacuum	
1.4.18		Cost	TP, TS

HLRF: Work-packages

	Dec. 07 (ED-plan)	TDP-R&D (proposed)	Coordinator
1.5.1	Modulator	Modulator	
1.5.2	Klystron	Klystron	
1.5.3	RF power distr. system	RF power distr. system	
1.5.4	HV charger system	HV charger system	
1.5.5	Interlock and control	Interlock and control	
1.5.6		Industrialization and Cost	SF, TS

MLI: Work-packages

	Dec. 07 (ED-plan)	TDP-R&D (proposed)	Coordinator
1.6.1	Quadrupole design	Quadrupole design	
1.6.2	Quadrupole prototype	Quadrupole prototype	
1.6.3	Latt. opt. & Emittance	Latt. opt. & Emittance	
1.6.4	Initial alignment	Initial alignment	
1.6.5	Energy errors	Energy errors	
1.6.6	Static tuning	Static tuning	
1.6.7	Dynamic tuning	Dynamic tuning	
1.6.8	Topics	Topics	
1.6.9		Cost	CA, TS

How We Work Together?

- Project Managers are responsible for:
  - Facilitating the world-wide technical development effort,
  - Setting technical direction and executing the project for realization of the ILC.

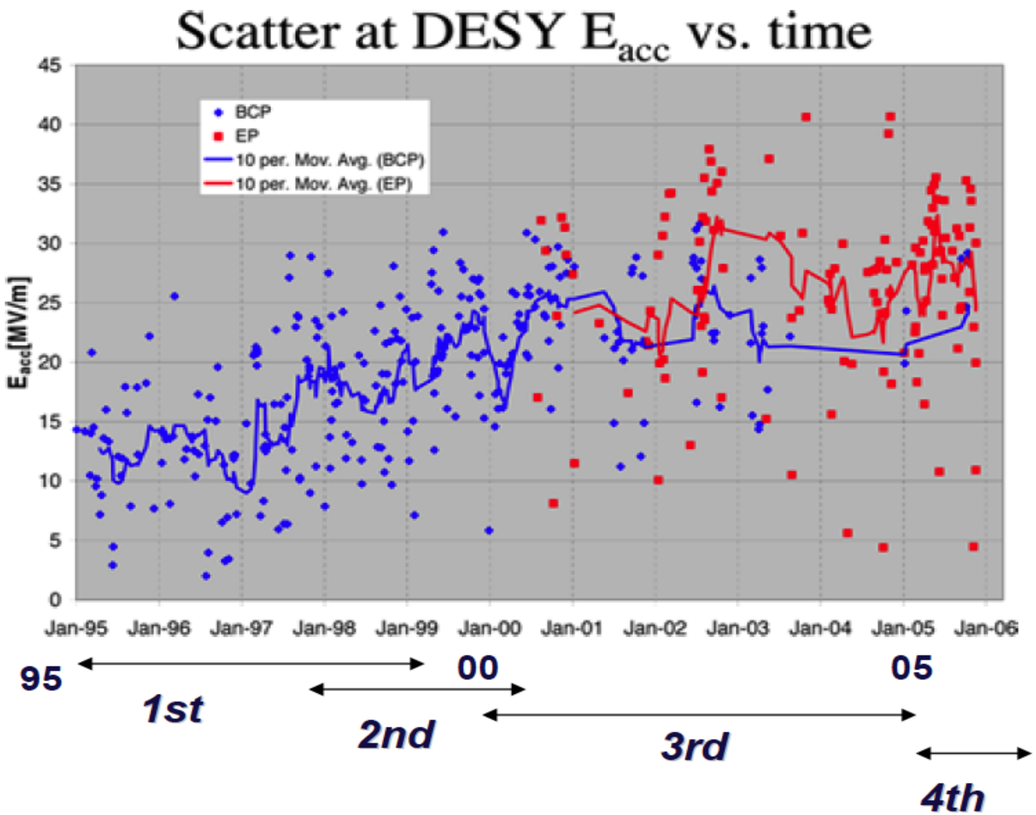
- Regional Directors and Institutional Leaders are responsible for:
  - Promoting, funding and authorizing the cooperation program.

How We Work Together?

Regional Effort and Project Management

- *Project Managers are responsible for*
  - Leading the world-wide technical development effort
    - efficiently and effectively
  - Setting technical direction and executing the project toward realization of the ILC
    - Day-to-day project execution and communication
- *Regional Directors and Institutional Leaders are responsible for*
  - Promoting, funding and authorizing the cooperation programs.
    - Formality to start institutional activities, and periodical oversiting the technical progress,

10



4 Production Cycles
with 26~33 cavities each;
(total >100 cavities)

1st : no eddy-curr and BCP+1400
2~20MV/m by field emission and defect welding not matured

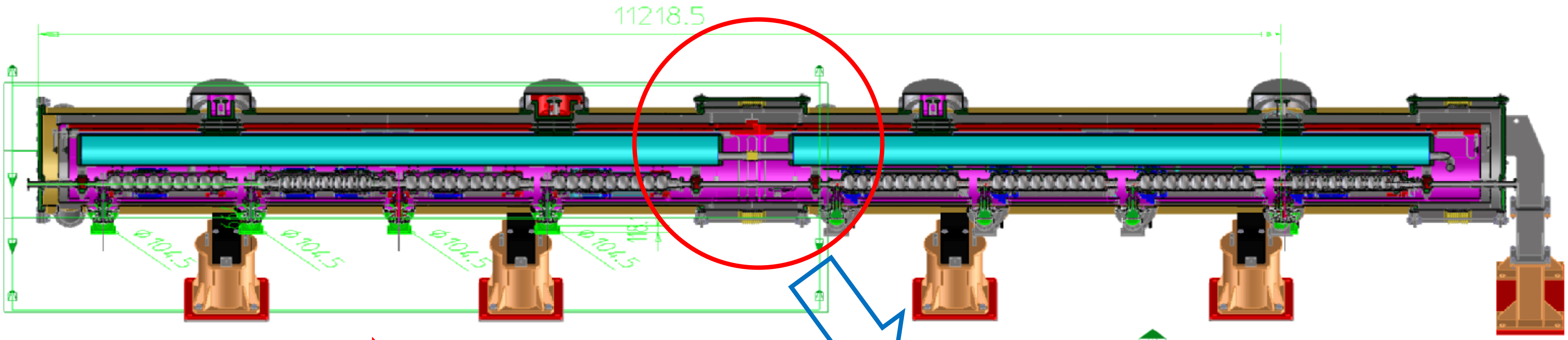
2nd : eddy-curr and BCP+1400
15~30MV/m by field emission

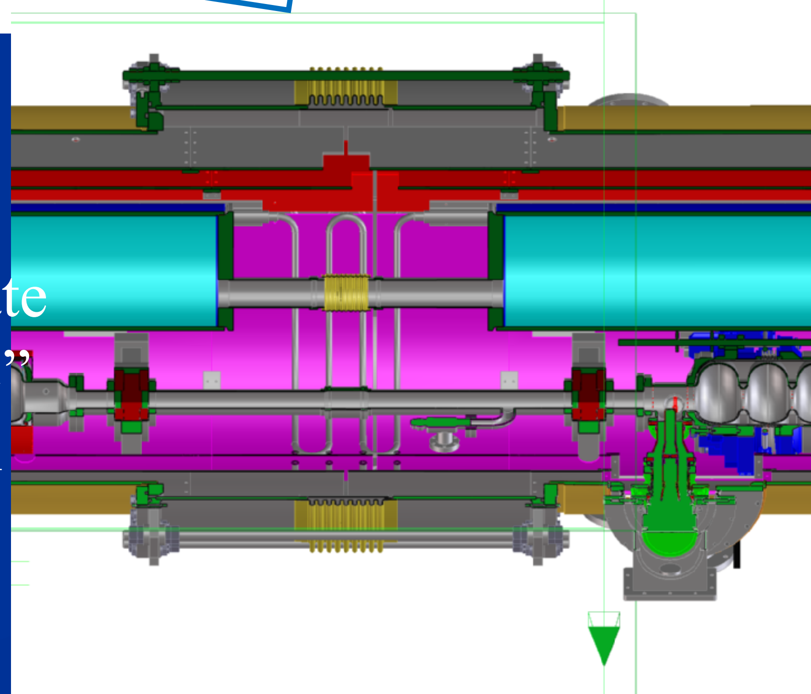
3rd : eddy-curr scan and
22: BCP+1400, 15~32MV/m
11: EP+1400(or800) 10~40MV/m
limited by field emission and Q-disease, etc

4th : Eddy-cur scan and EP+800
15~35MV/m by field emission
5~10MV/m by Q-disease

S1-Global Cryomodule

Norihito Ohuchi





INFN-KEK will collaborate to develop Cryomodule "C" to be plug-compatible with Type III