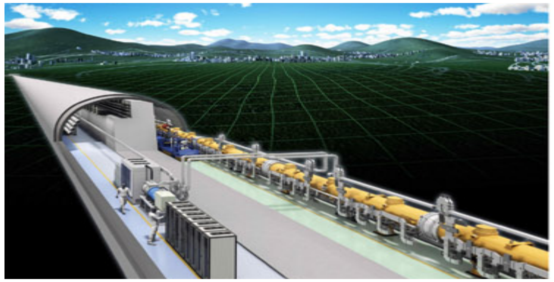


Progress Design to Realization of the International Linear Collider: ILC

Plans for a site specific and bid to host ILC in Japan

Akira Yamamoto
KEK, CERN, and LCC

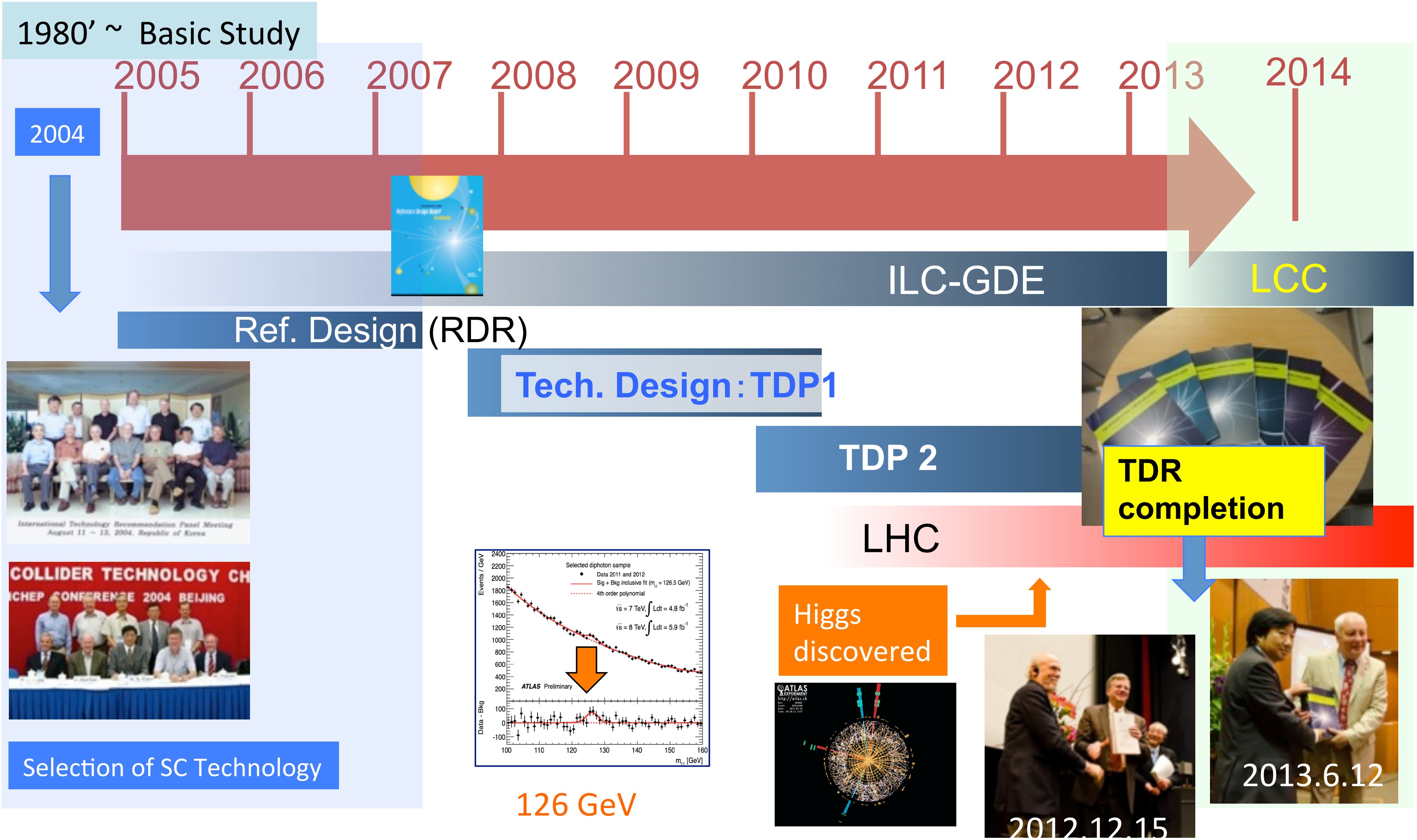
to be presented at
" Perspective on Superconducting RF"
A workshop in celebration of the career of Peter Kneisel
Jlab, 19 May, 2014

Outline

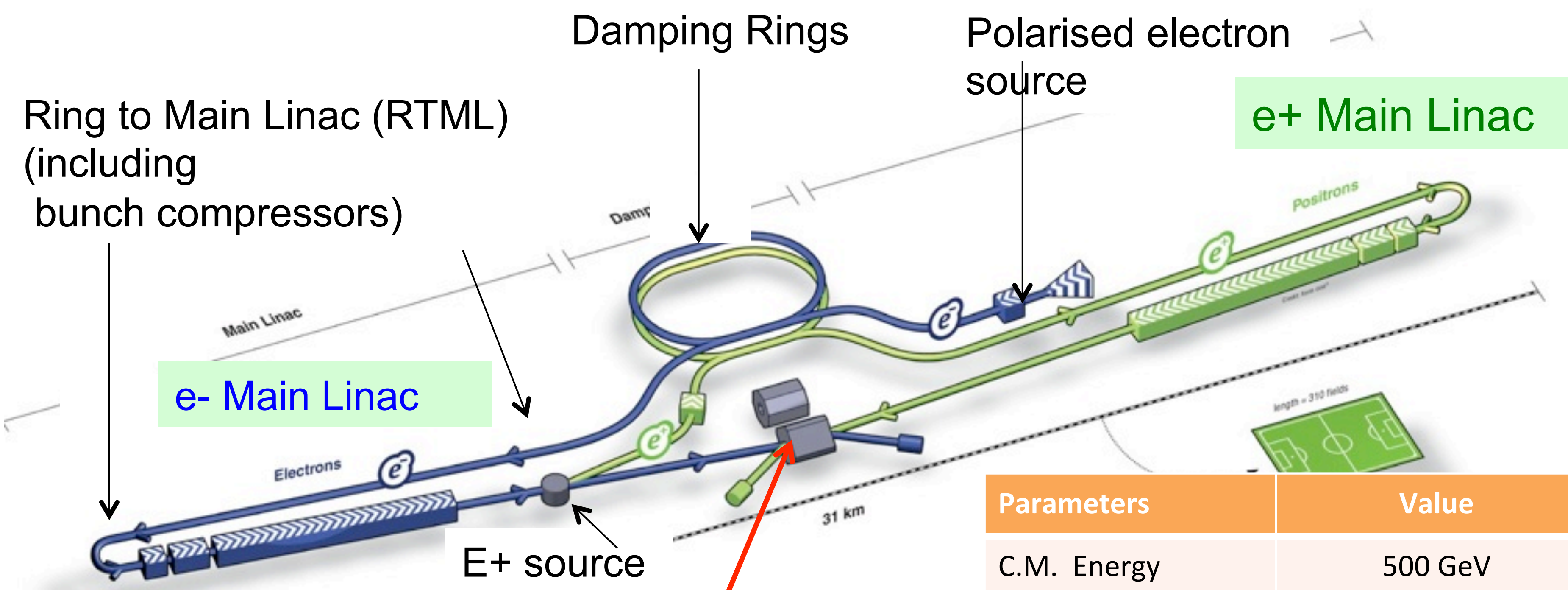
- **Introduction**
- **Progress in SRF technologies**
  - Including High-light in SRF from AWLC-14,
- **Progress in Site Specific Preparation in Japan**
- **Global Cooperation further anticipated**

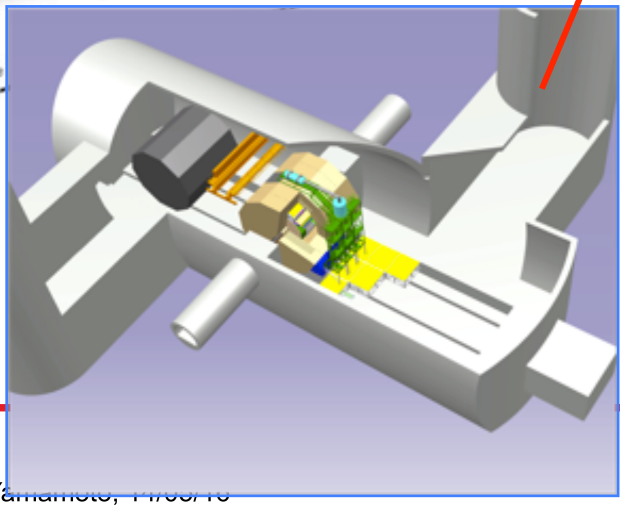
LINEAR COLLIDER COLLABORATION

ILC “Design to Realization”



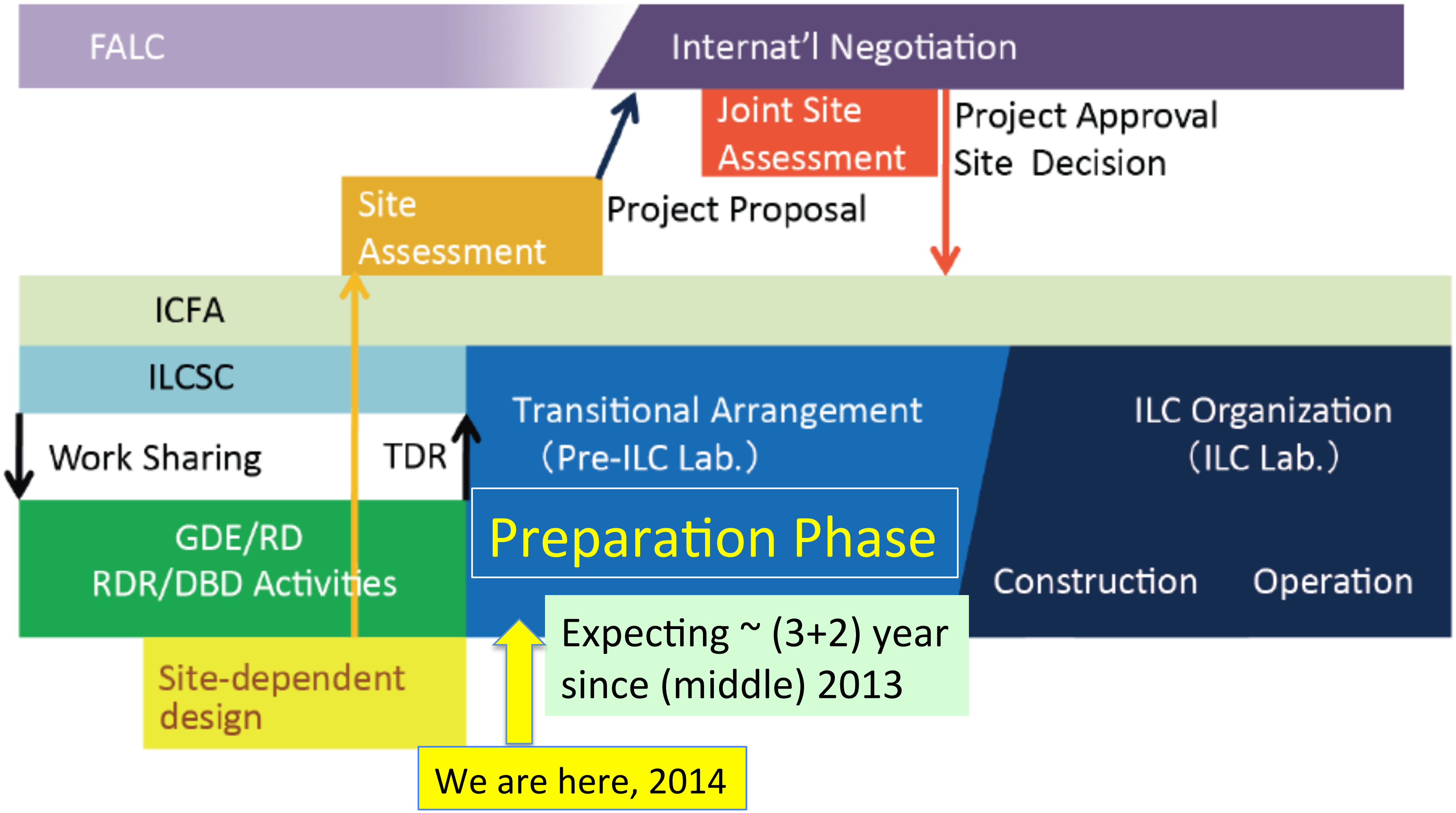
ILC TDR Layout



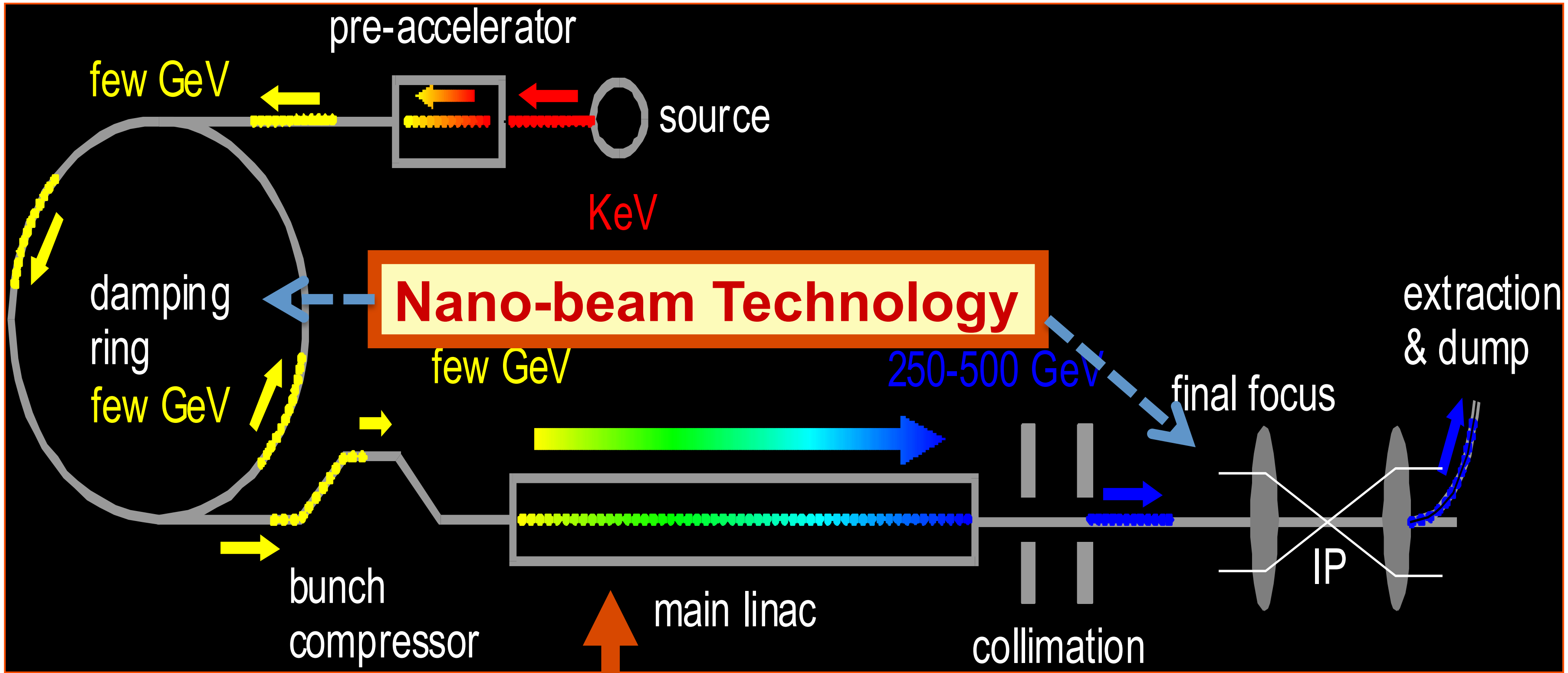


Parameters	Value
C.M. Energy	500 GeV
Peak luminosity	1.8 x10^{34} cm^{-2}s^{-1}
Beam Rep. rate	5 Hz
Pulse duration	0.73 ms
Average current	5.8 mA (in pulse)
E gradient in SCRF acc. cavity	31.5 MV/m +/-20% Q_0 = 1E10

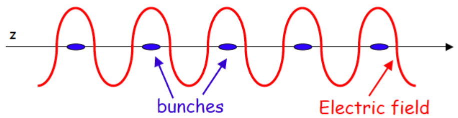
ILC Time Line: Progress and Prospect



ILC Accelerator Concept



SRF Technology



Global Cooperation for Accelerator Test Facilities

TTF/FLASH (DESY) ~1 GeV
ILC-like beam ILC RF unit
(* lower gradient)

DESY

INFN Frascati

DA^{f}NE (INFN Frascati)
kicker development
electron cloud

STF (KEK) operation/construction
ILC Cryomodule test : S1-Gloabal
Quantum Beam experiment

KEK, Japan

ATF & ATF2 (KEK)
ultra-low emittance
Final Focus optics
KEKB electron-cloud

CesrTA (Cornell)
electron cloud
low emittance

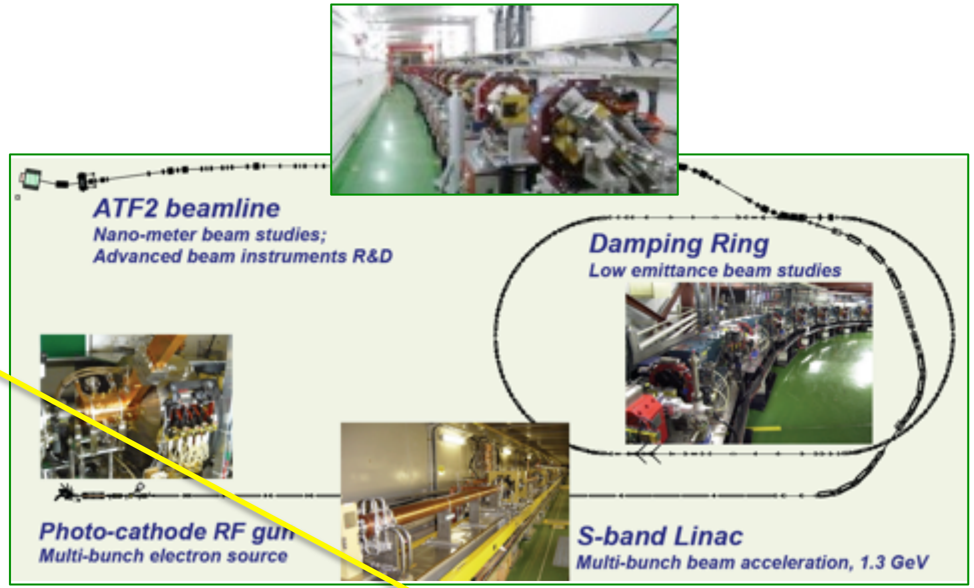
FNAL Cornell

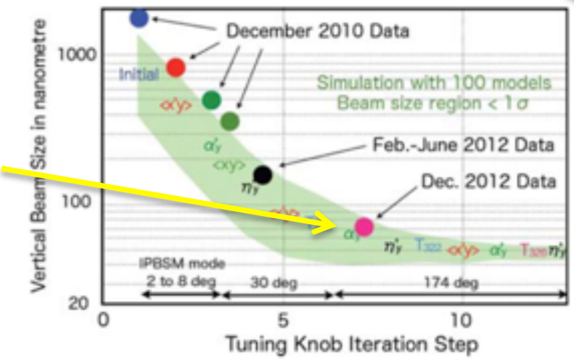
NML facility ILC RF unit test
Under construction

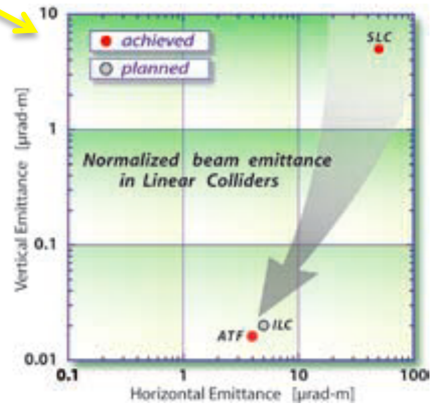
ATF2 Progress by 2013

Ultra-small beam

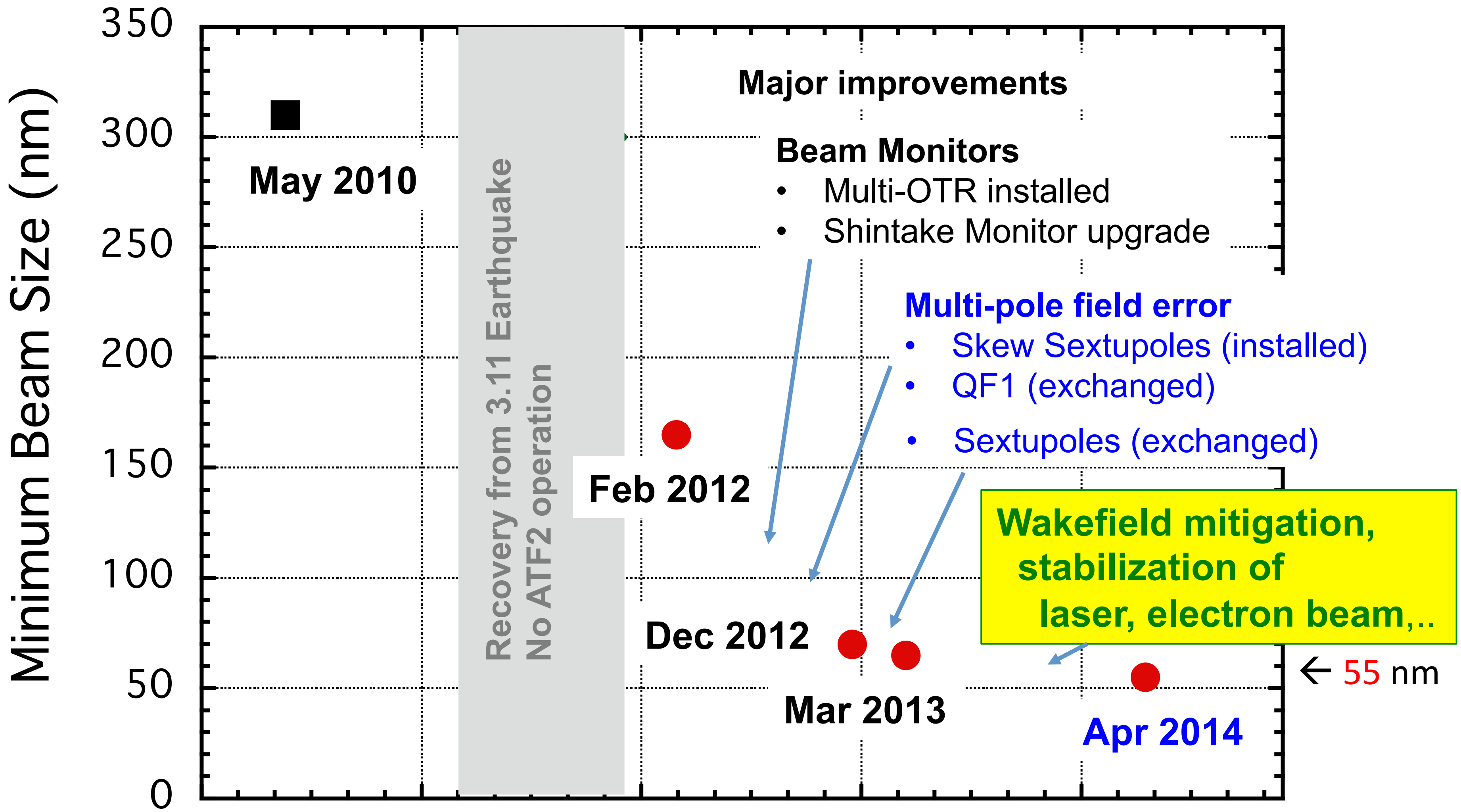
- Low emittance : KEK-ATF
  - Achieved the ILC goal (2004).
- Small vertical beam size : KEK ATF2
  - Goal = 37 nm,
    - 160 nm (spring, 2012)
    - 65 nm (April, 2013) at low beam current



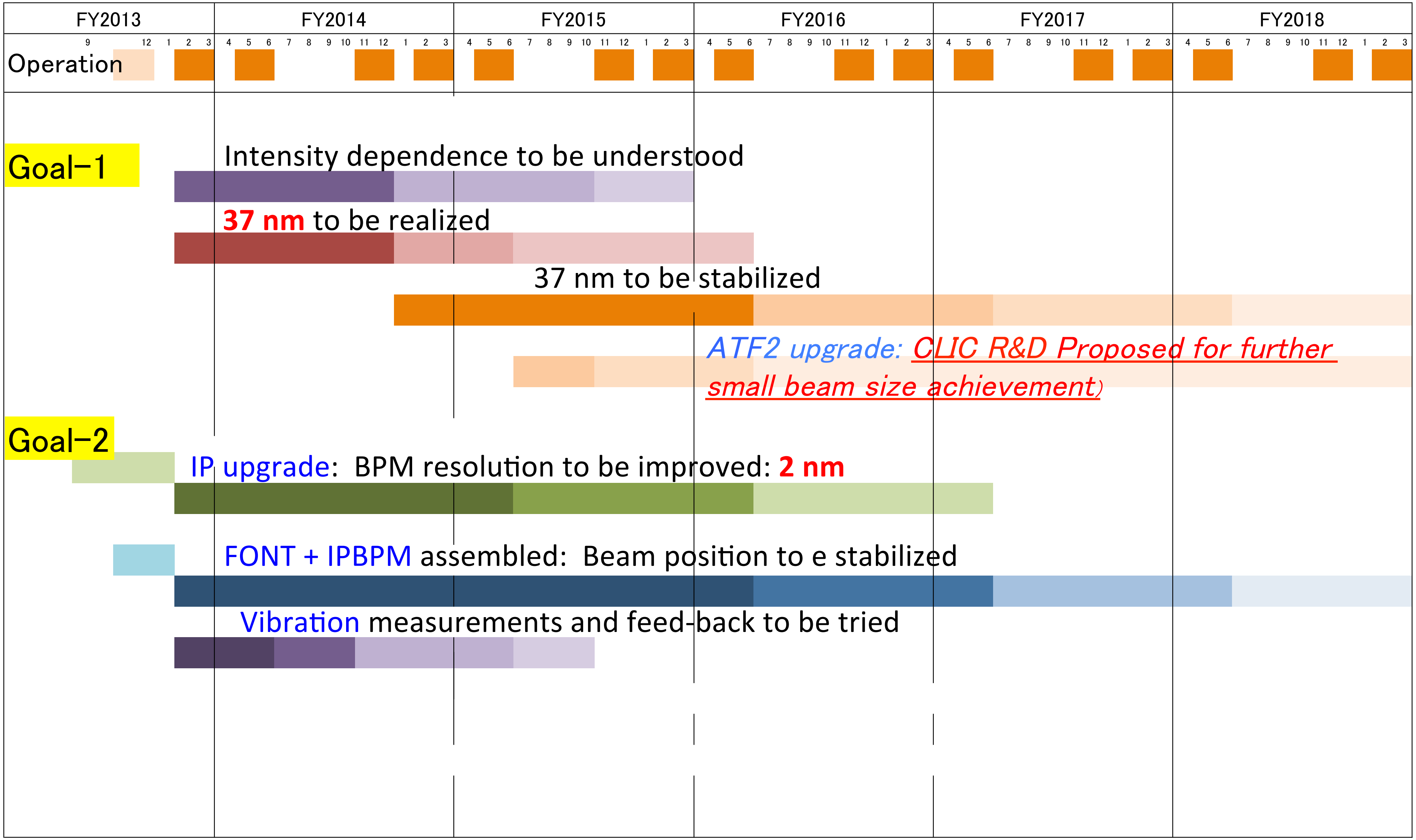




ATF2: Min. Beam Size Update, Apr., 2014



ATF 2 Further Plan



Outline

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  - Including High-light in SRF from AWLC-14,

- Progress in Site Specific Preparation in Japan

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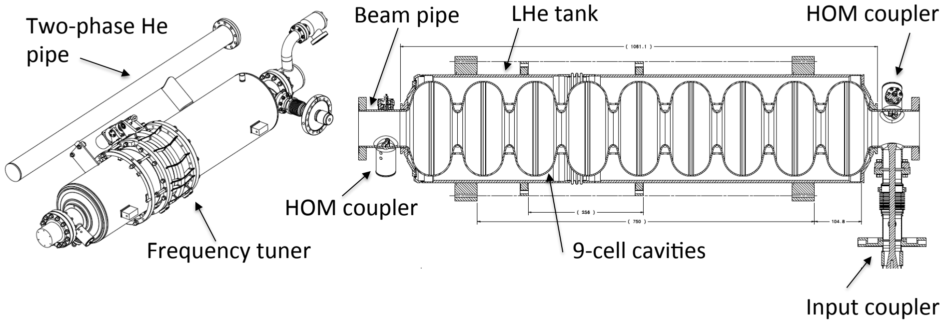
SCRF Linac Technology

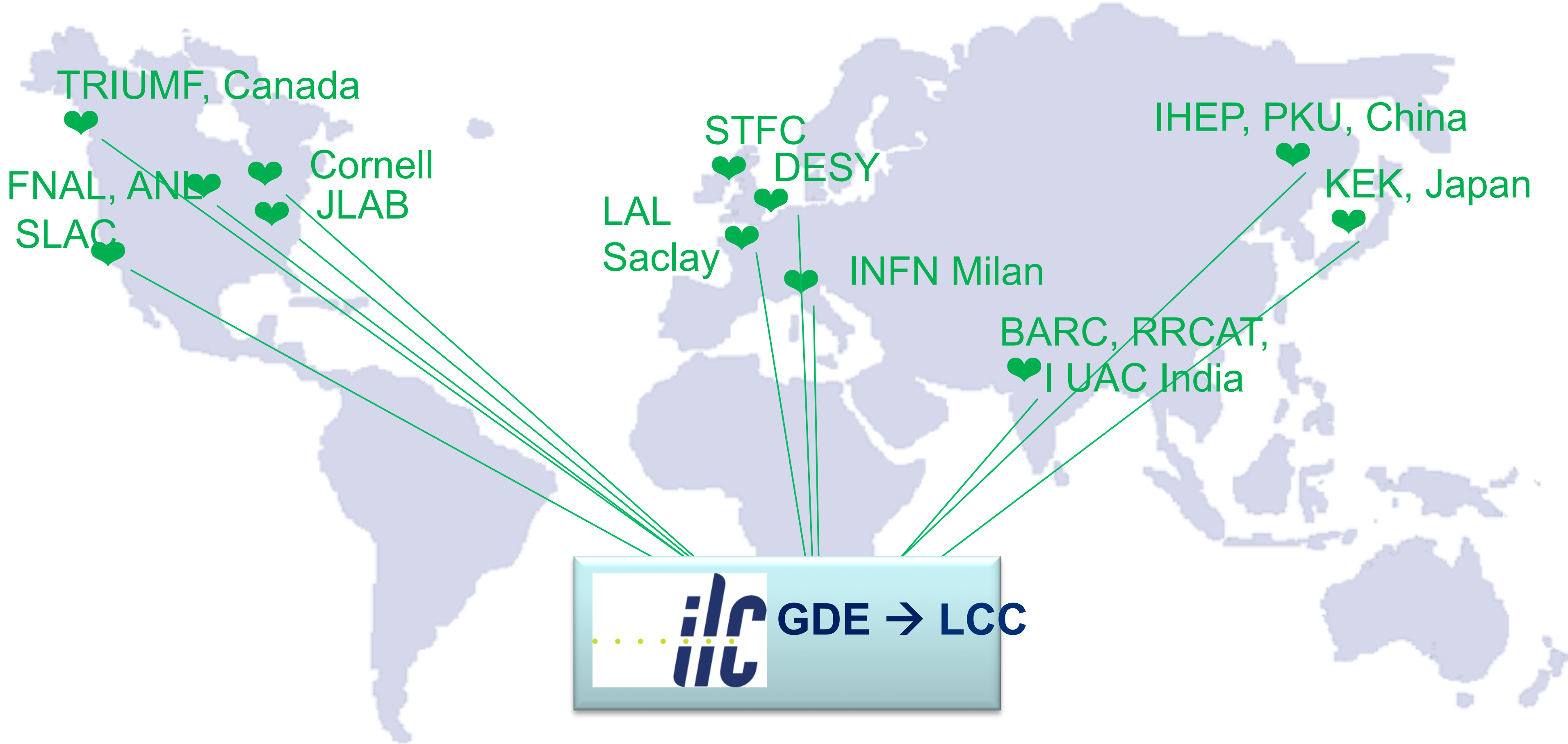


1.3 GHz Nb 9-cellCavities	16,024
Cryomodules	1,855
SC quadrupole pkg	673
10 MW MB Klystrons & modulators	436 *

* site dependent

Approximately 20 years of R&D worldwide
→ Mature technology, overall design and cost

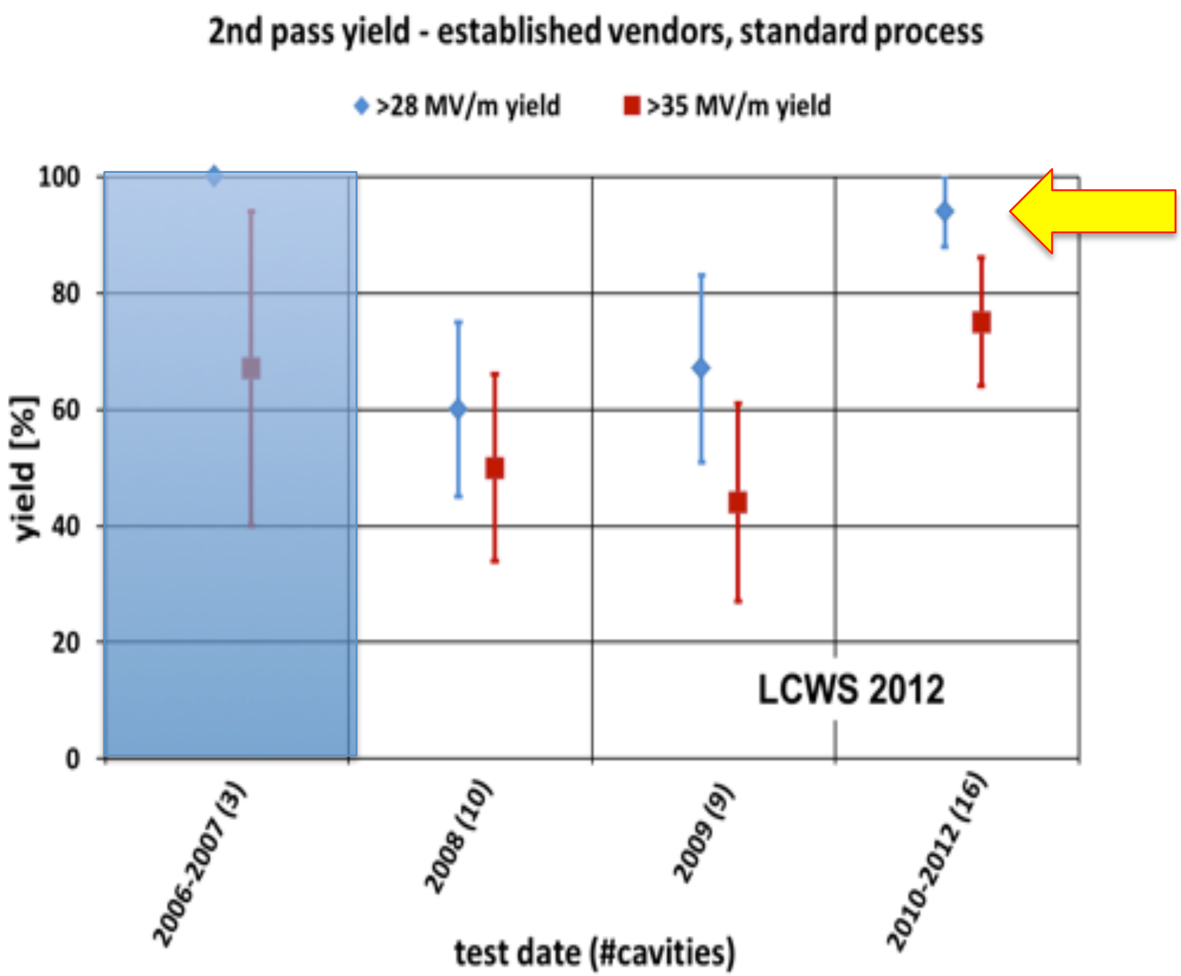
ILC Accelerator Global Cooperation



Global Plan for SCRF R&D

Year	07	2008	2009	2010	2011	2012
Phase	TDP-1			TDP-2		
Cavity Gradient in v. test to reach 35 MV/m	→ Yield 50%			→ Yield 90%		
Cavity-string to reach 31.5 MV/m, with one-cryomodule		Global effort for string assembly and test (DESY, FNAL, INFN, KEK)			We are here	
System Test with beam acceleration		FLASH (DESY) , NML/ASTA (FNAL) QB, STF2 (KEK)				
Preparation for Industrialization			Production Technology R&D			
Communication with industry:	1st Visit Vendors (2009), Organize Workshop (2010) 2nd visit and communication, Organize 2nd workshop (2011) 3rd communication and study contracted with selected vendors (2011-2012)					

Progress in SCRF Cavity Gradient



Production yield:
94 % at > 35+/-20%,

Average gradient:
37.1 MV/m

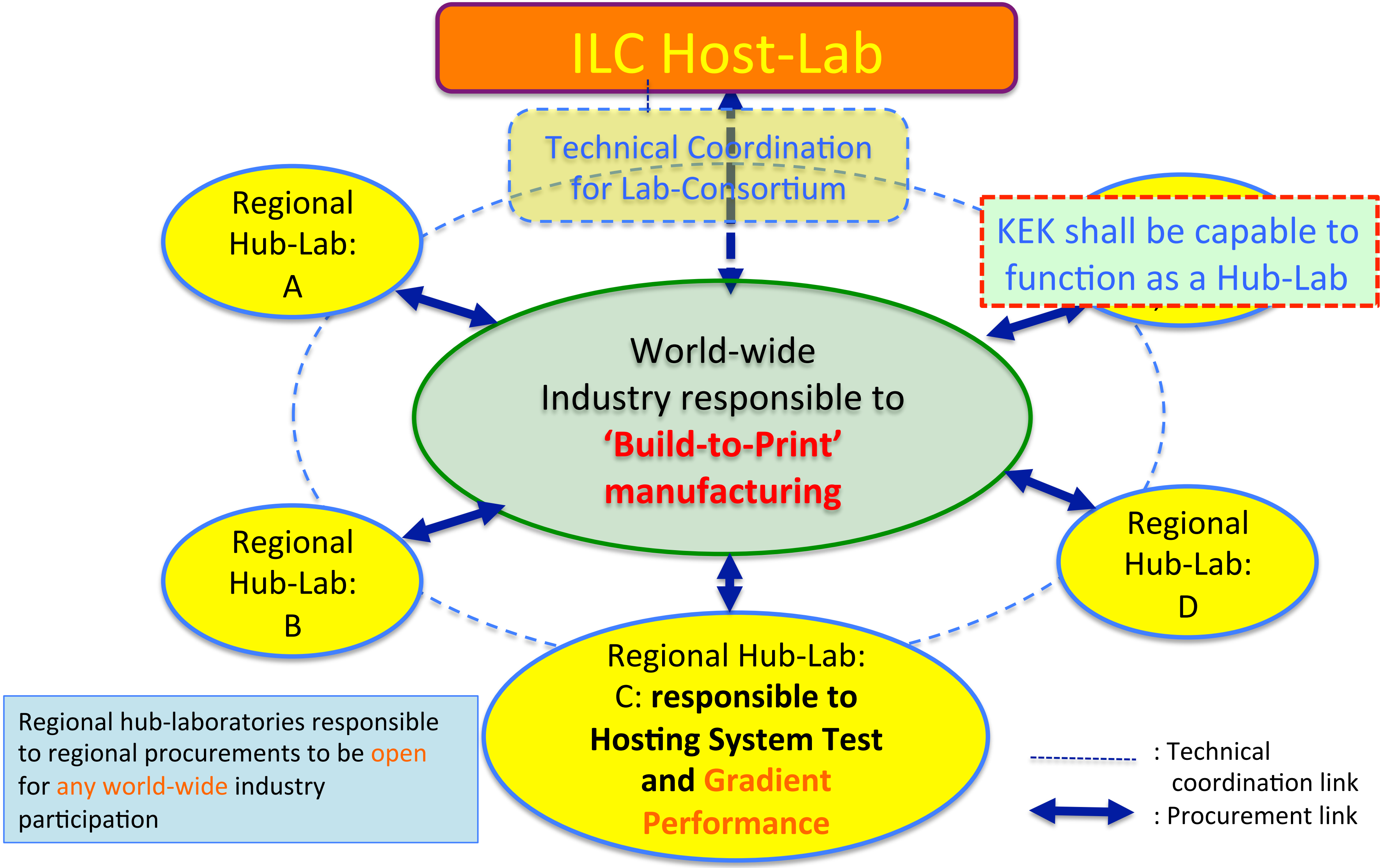
reached (2012)

Progress in 1.3 GHz ILC (35 MV/m) Cavity Production

year	# 9-cell cavities qualified	Capable Lab.	Capable Industry
2006	10	1 DESY	2 ACCEL, ZANON
2011	41	4 DESY, JLAB, FNAL, **KEK**	4 RI, ZANON, AES, MHI,
2012	(45)	5 DESY, JLAB, FNAL, **KEK**, Cornell	5 RI, ZANON, AES, **MHI**, **Hitachi**

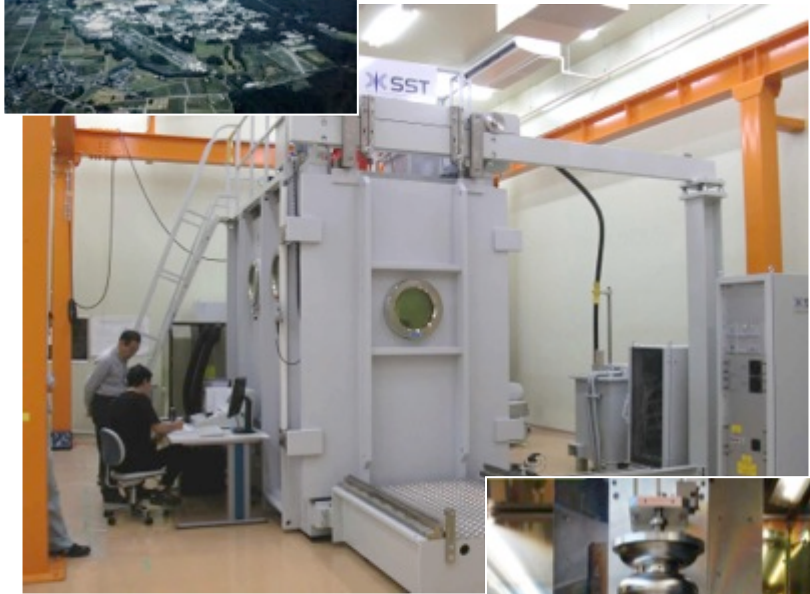
- **Recent Progress at KEK (as of April, 2014)**
  - KEK in-house SCRF cavity reached **37 MV/m** in the first cycle, vertical test at Q = 7 x10^9.

Cooperation of ILC host- and hub-laboratories with worldwide industry (proposed)



Effort to lead industrialization technology at KEK

EBW



SST EBOCAM KS-110 – G150KM
Chamber (Stainless Steel chamber)

Press

AMADA digital-survo-press
SDE1522
150t, 50stroke/min,
225mmstroke

Trim

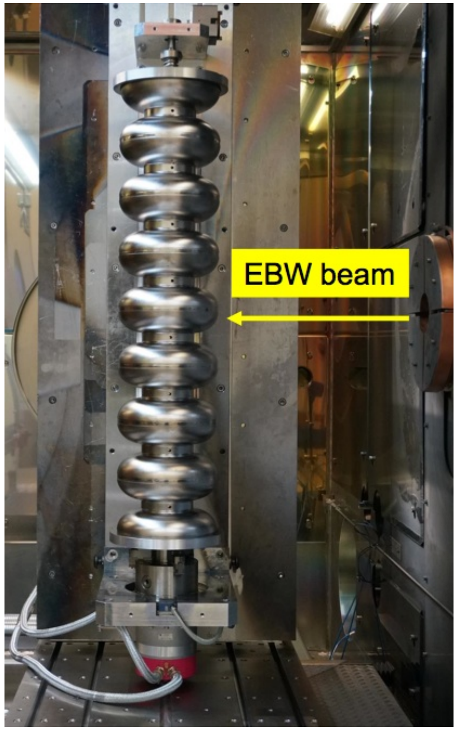
MORI VKL-253
Vertical CNC lathe

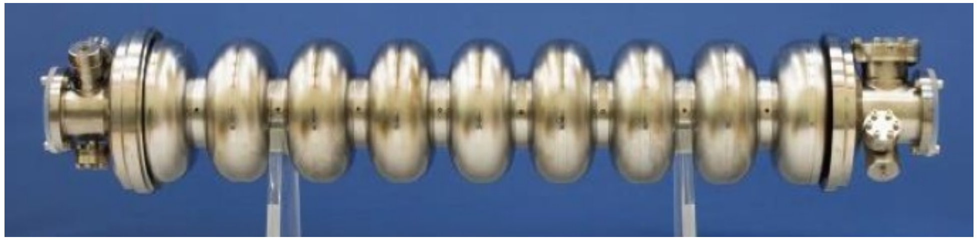
Chemical process

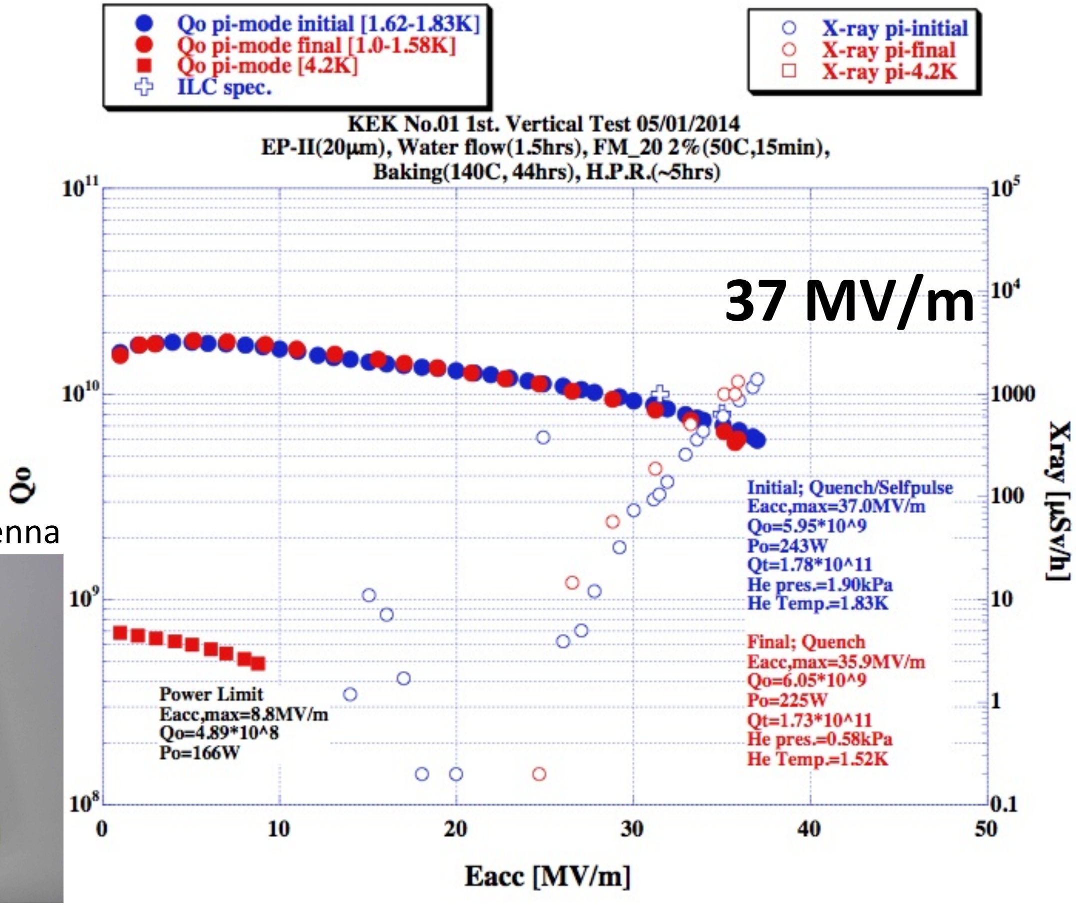
More discuss w/
Y. Yamamoto,
T. Saeki,
H. Hayano

KEK in-house 9-cell cavity; KEK-01

Trials of industrial fabrication







Deep-drawing HOM-cup

Press form HOM-antenna

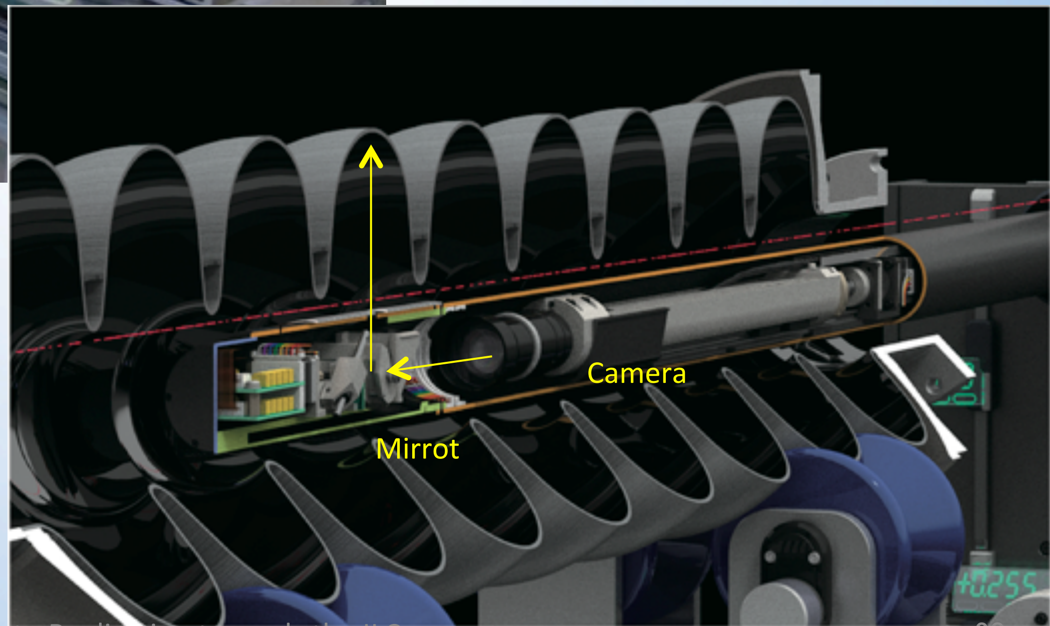
しのはらプレスサービス株式会社

Cavity Surface Inspection Camera developed by Kyoto-KEK

Special lightening combined with Camera enables to provide high resolution image

Tehnology originated
In Japan and
globally distributed
(by Isashita, Hayano et al.)

Japanese Technology :
Delivered to DESY, FNAL, JLAB, CERN



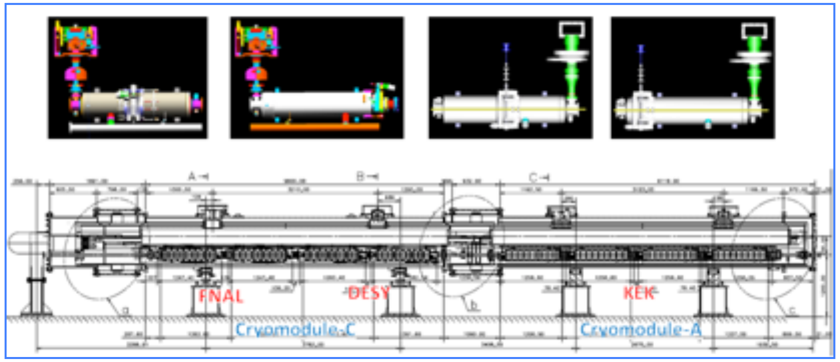
Camera with light, mirros are assembled together (7μm resolution)

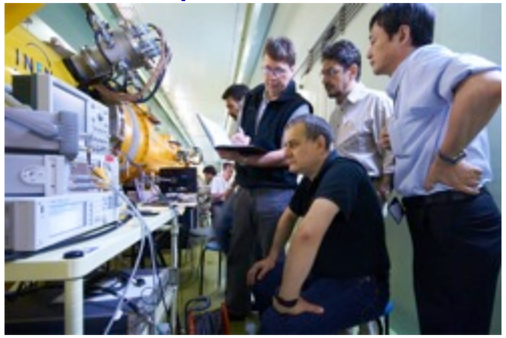
Ken Watanabe
KEK / Kyoto-Univ.

S1-Global hosted at KEK:
Global cooperation to demonstrate SCRF system

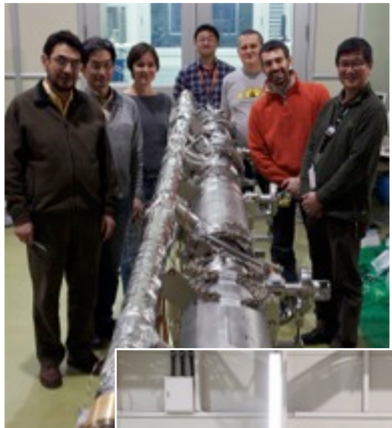
DESY, FNAL, Jan., 2010

DESY, Sept. 2010





FNAL & INFN, July, 2010



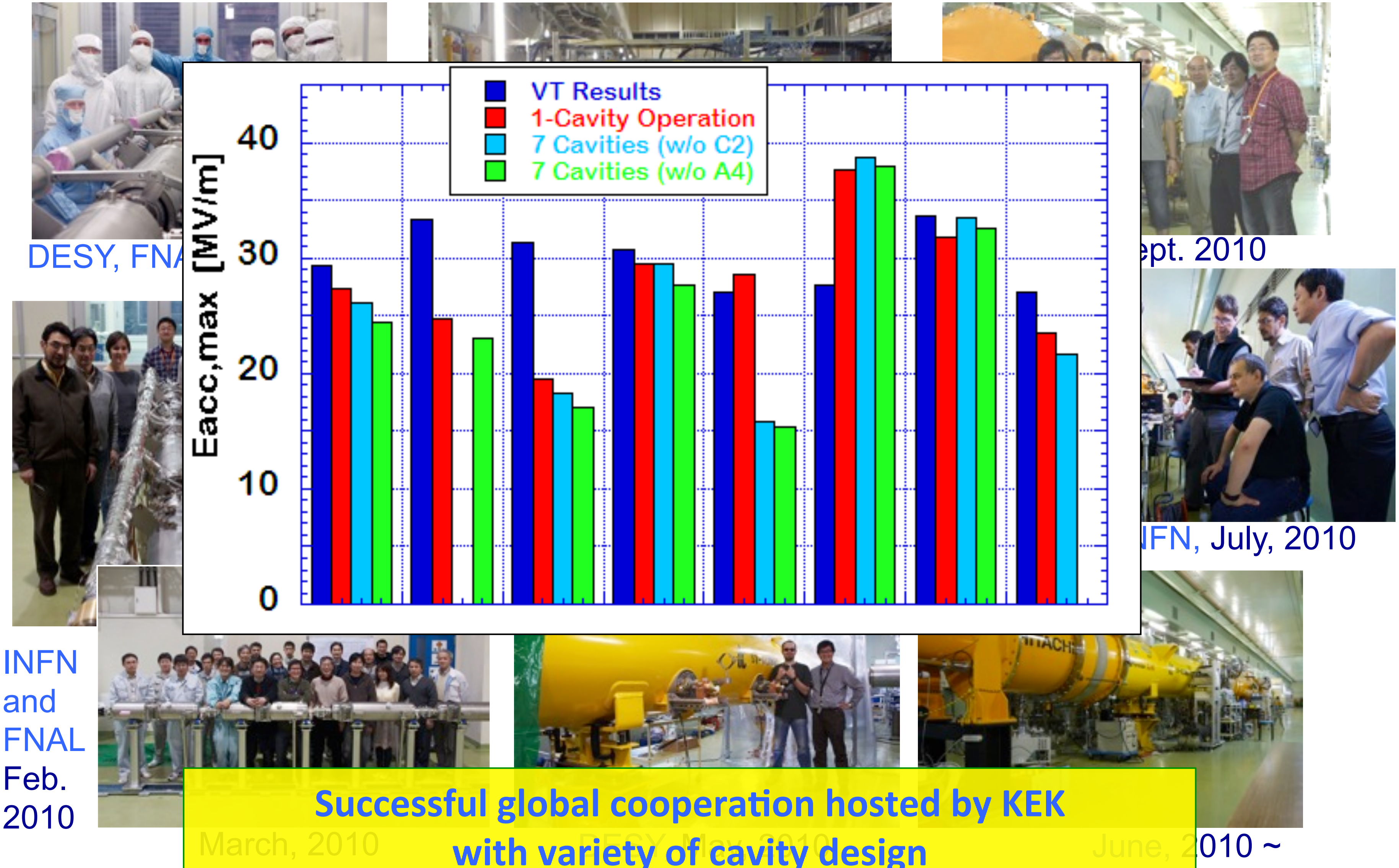
INFN and FNAL Feb. 2010

March, 2010

DESY, May, 2010

June, 2010 ~

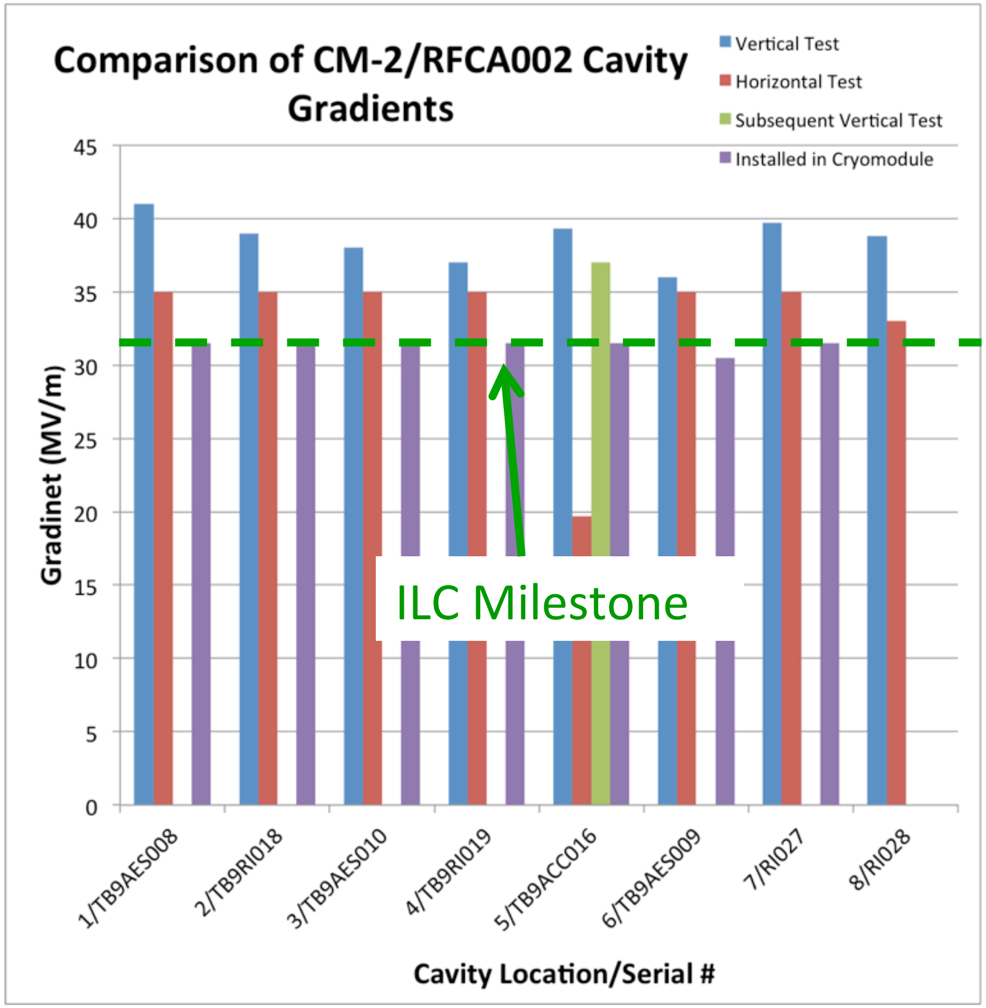
S1-Global hosted at KEK:
Global cooperation to demonstrate SCRF system



Successful global cooperation hosted by KEK with variety of cavity design

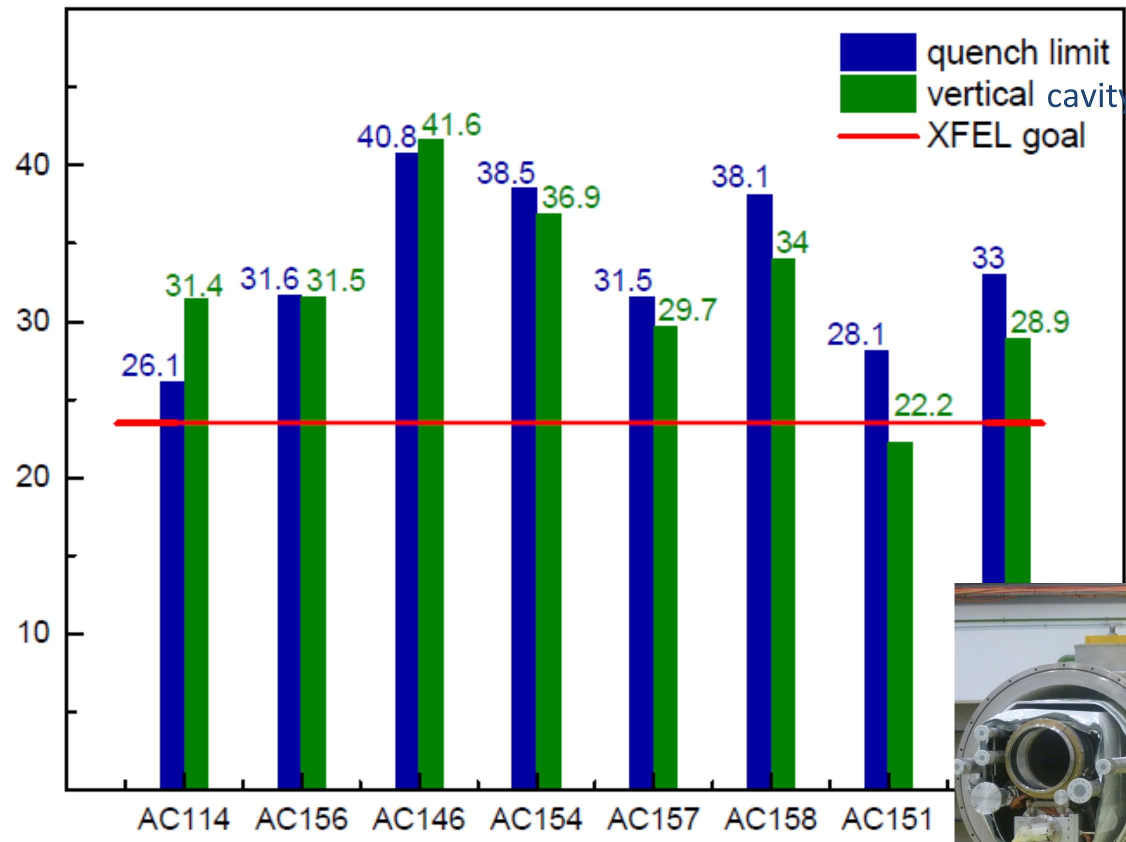
A recent result at FNAL

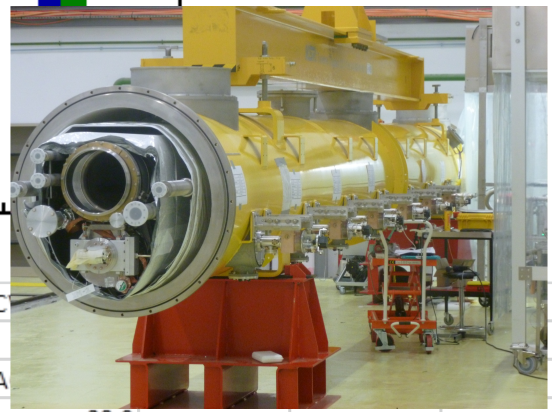
Performance to Date - Gradient



LINEAR COLLIDER COLLABORATION

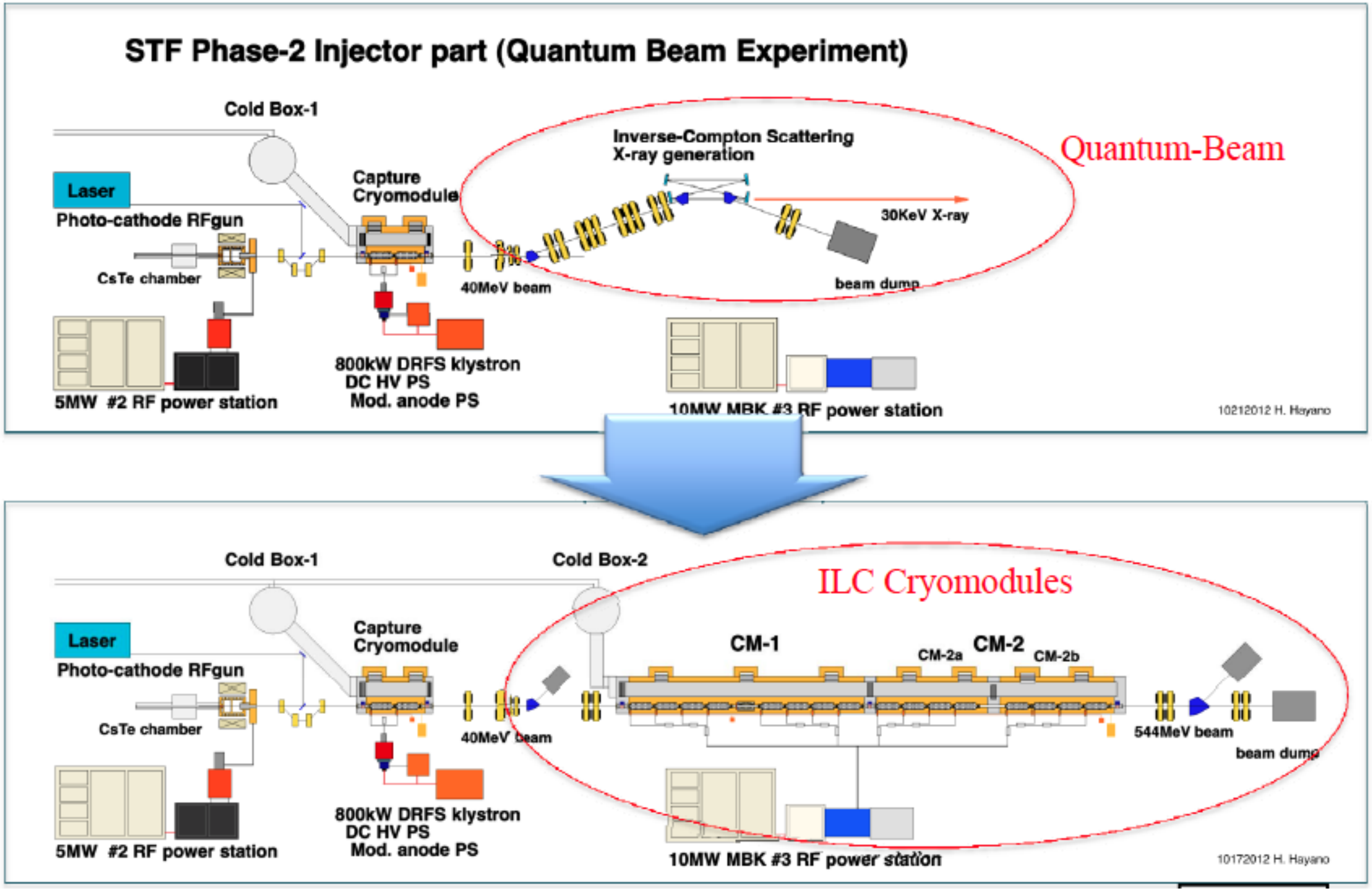
XM-3 RF Test Results (XFEL)





Gate valve	CV 1	CV2	CV3	CV4	CV5	CV6	CV7	C			
	AC114	AC156	AC146	AC154	AC157	AC158	AC151	A			
Eacc (VT)	31,4	31,5	41,5	36,9	29,7	38,8	22,2	28,9			
Fe limit (VT)	31,4	31,5	41	36,9	29,7	38,8	16,8	20		**229,6**	**MV**
CMTB	23,2	31,4	40,8	38,5	31,5	38,1	22,7	33		**231,8**	**MV**
										29,0	MV/m

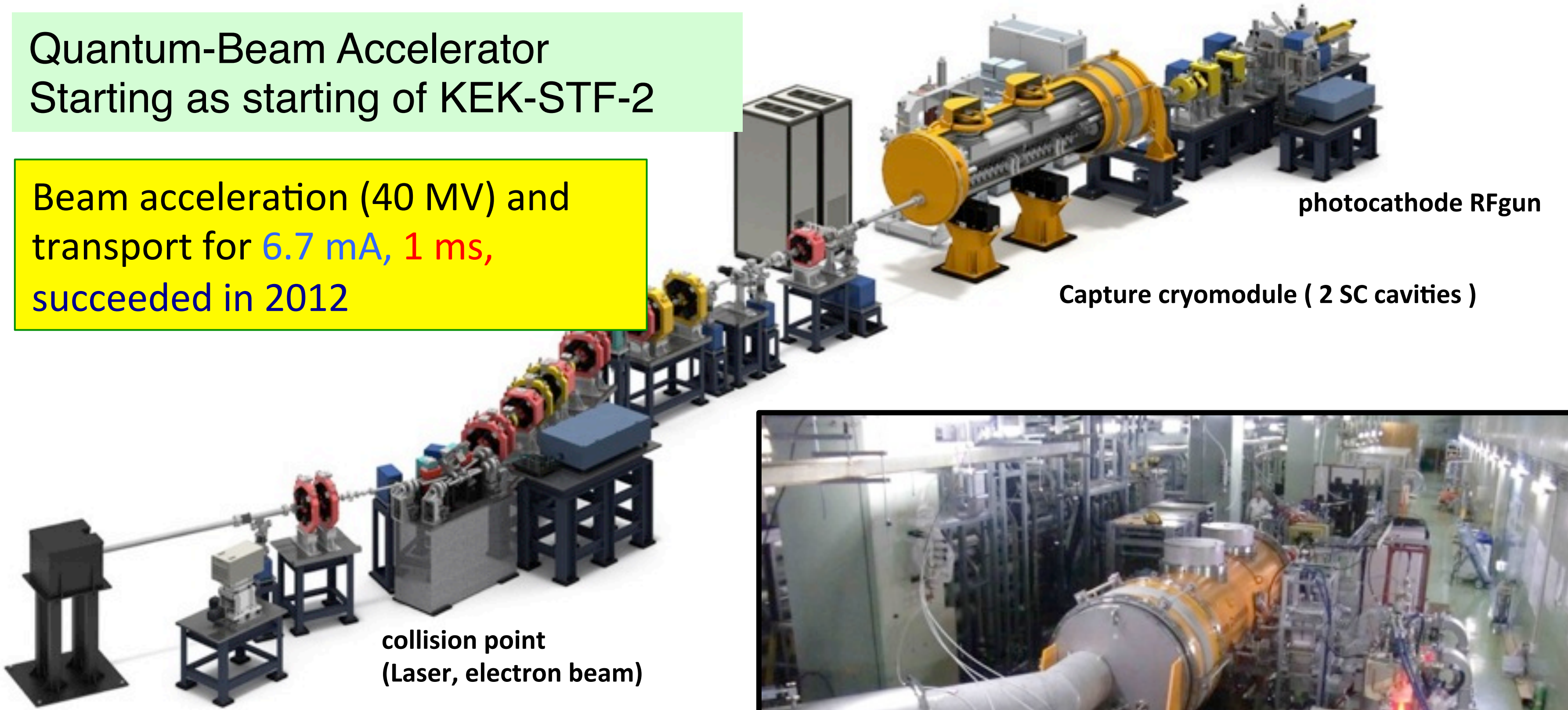
Further Technical System Development in Japan
STF2：Quantum Beam → ILC full-cryomodule Test

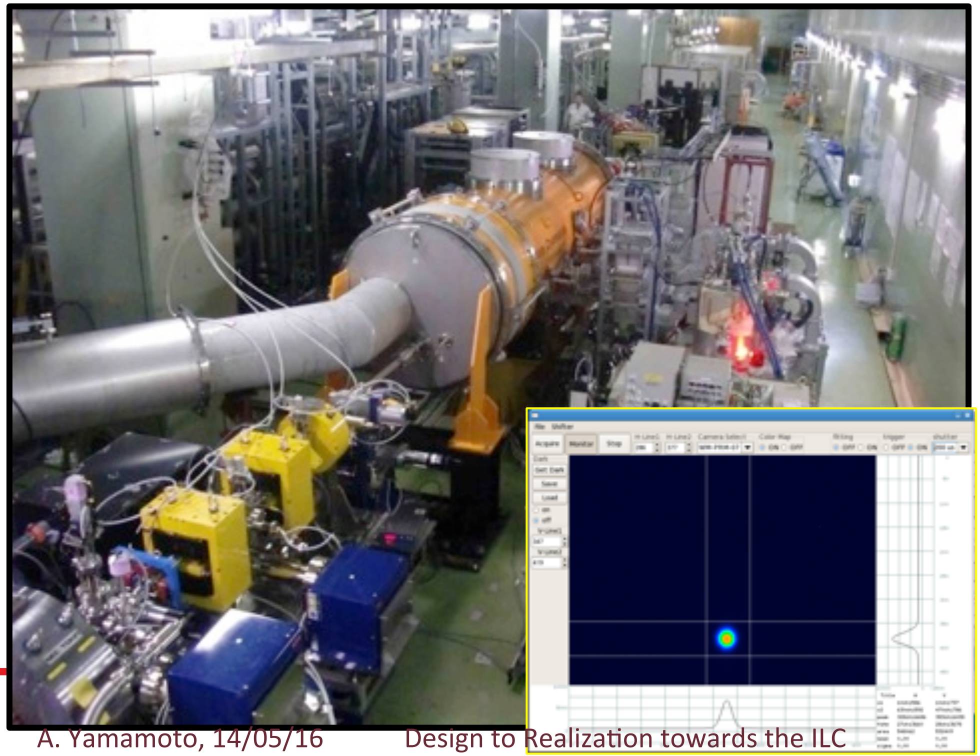


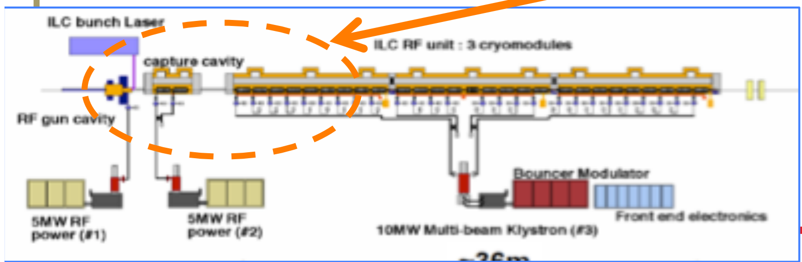
ILC beam condition demonstrated at QB

Quantum-Beam Accelerator
Starting as starting of KEK-STF-2

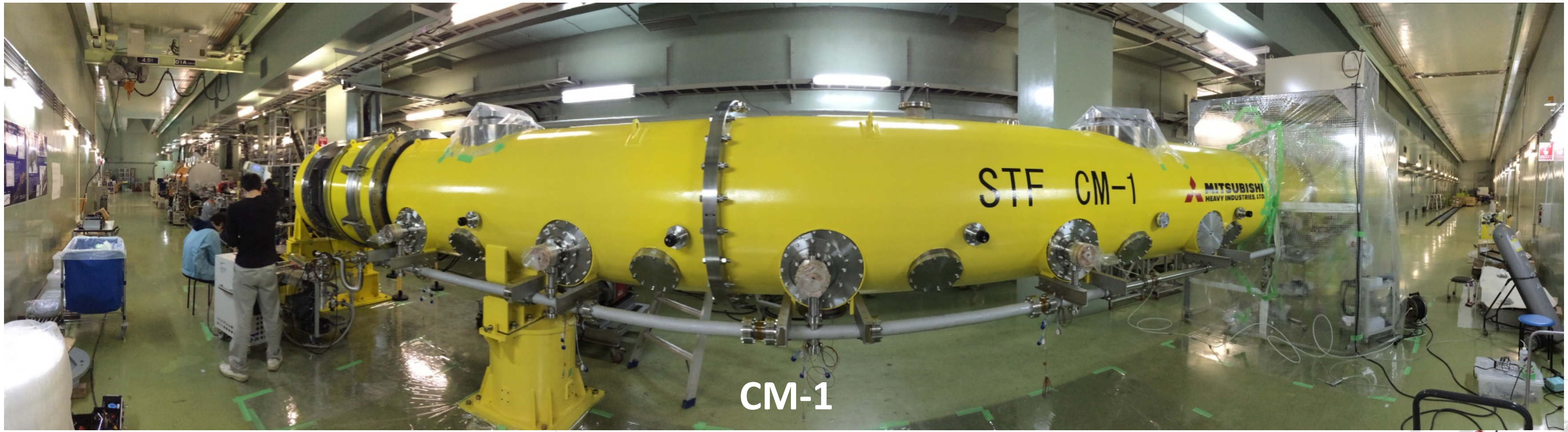
Beam acceleration (40 MV) and transport for 6.7 mA, 1 ms, succeeded in 2012





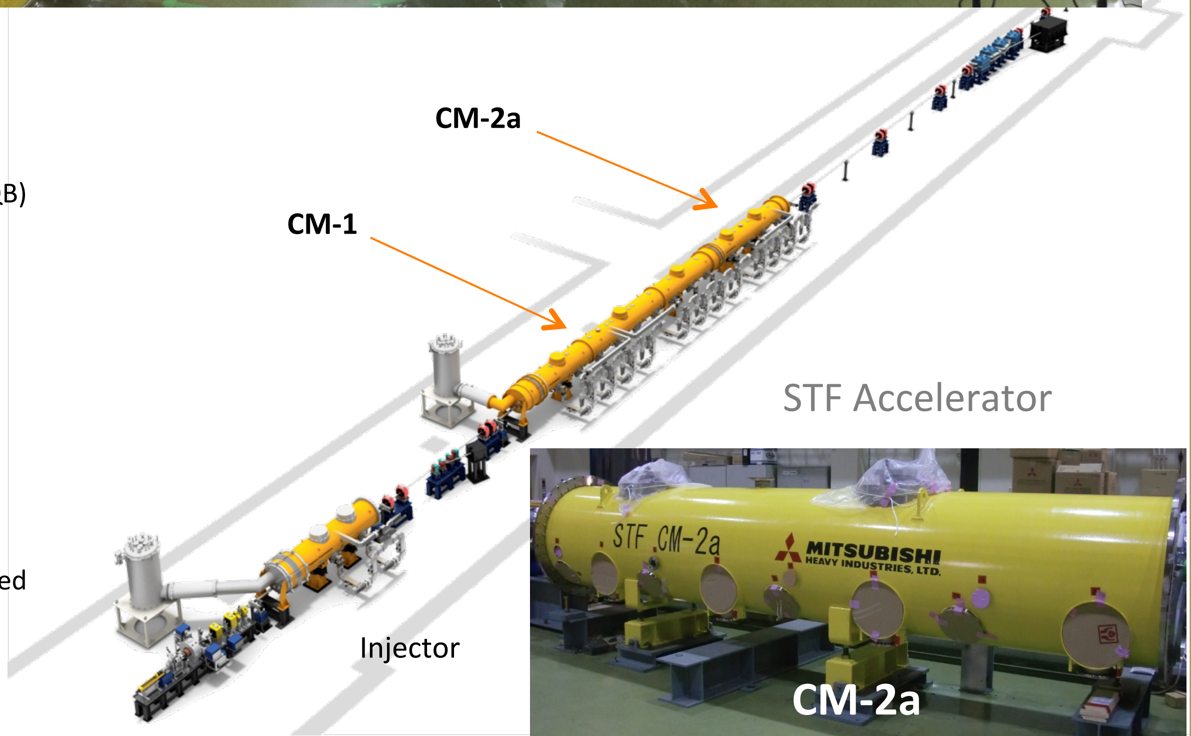


STF accelerator: under construction



STF cryomodule development history

2011 disassemble S1-Global,
start construction of STF accelerator(Injector + QB)
2012 Feb: QB accelerator commissioning
Apr: beam acceleration
Jun: beam focus for Laser-Compton
Jul to Mar: experiment of Laser-Compton (QB)
2013 Apr: disassemble Laser-Compton
start installation of CM-1
Sep: two set of 4-cavity train completed
Oct: Cryomodule assembly in STF tunnel
Dec: CM-1 completed
2014 Apr: start CM-2a assembly
Jul: CM-1 and CM-2a connection will be completed
Oct: Cool-down test

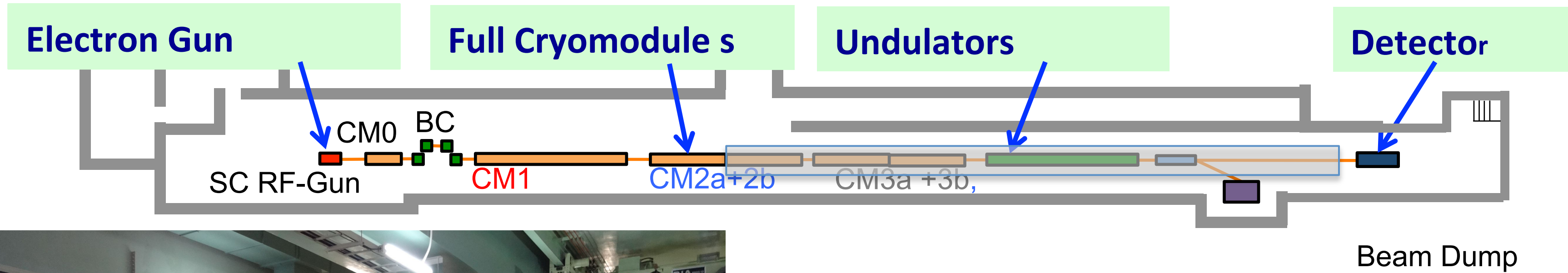


STF2; SCRF ACCELERATOR PLAN AT KEK

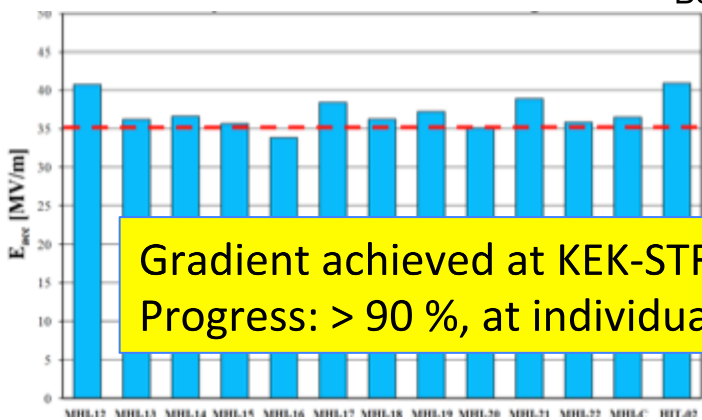
■ Objective
- High Gradient (31.5 MV/m)
  =＞Demonstration of full cryomodule
  ・Pulse and CW operation (for effectuve

- Training for next generation s

Plan:
- Multiple CM for system study
- In-house Cavity to be installed in cooperation with industry
- Wide range application including Photon Science

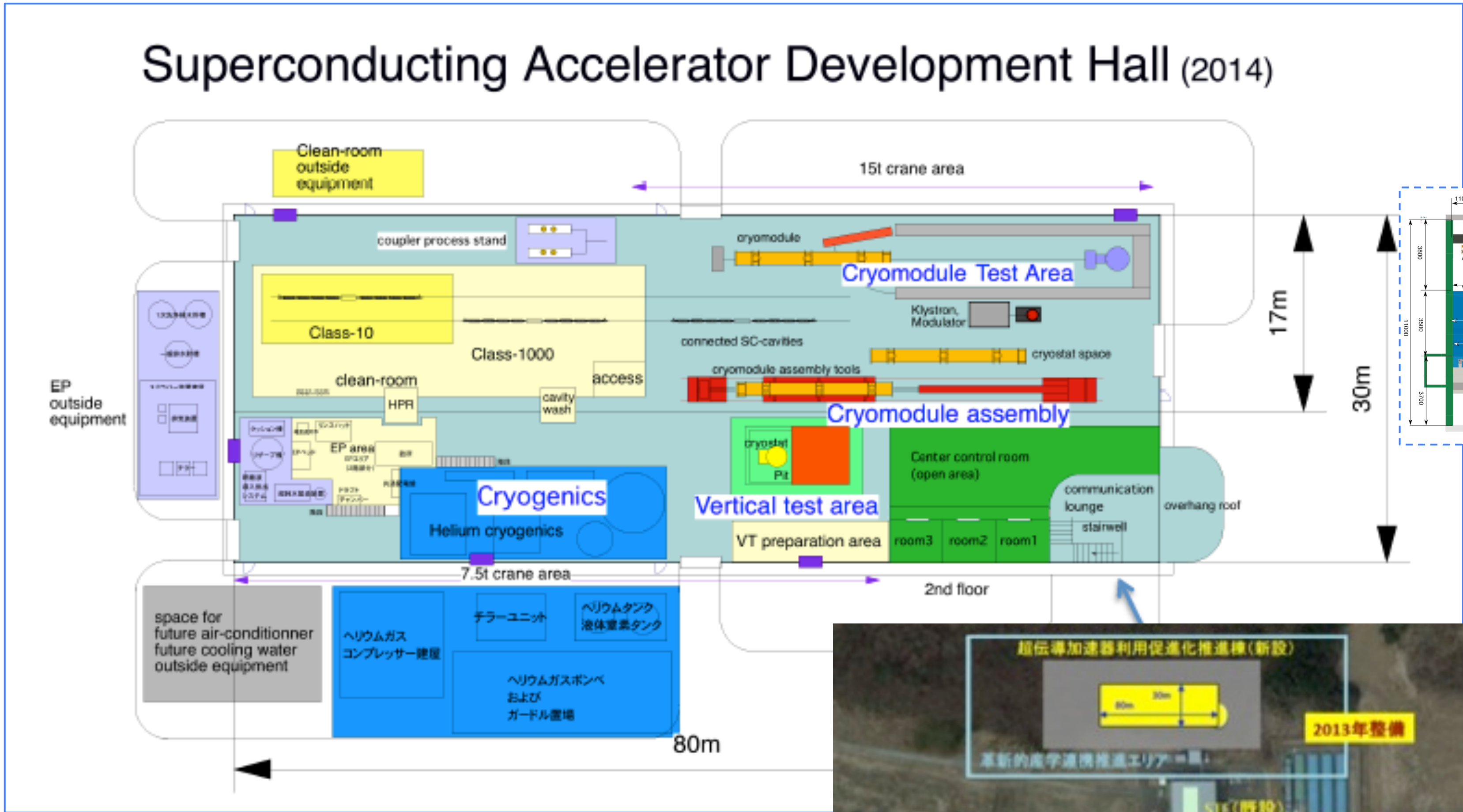


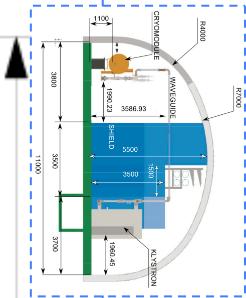
Beam Acceleration to be in 2015



Gradient achieved at KEK-STF: > ~ 35 MV/m
Progress: > 90 %, at individual vertical test

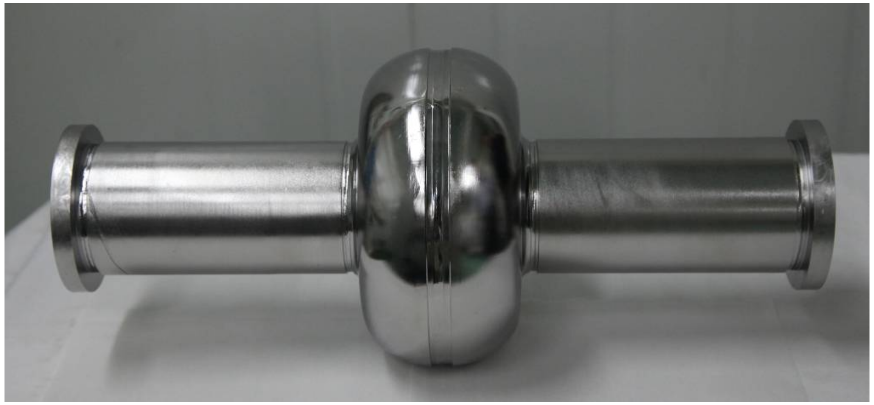
STF-COI: Facility to demonstrate CM assembly/test



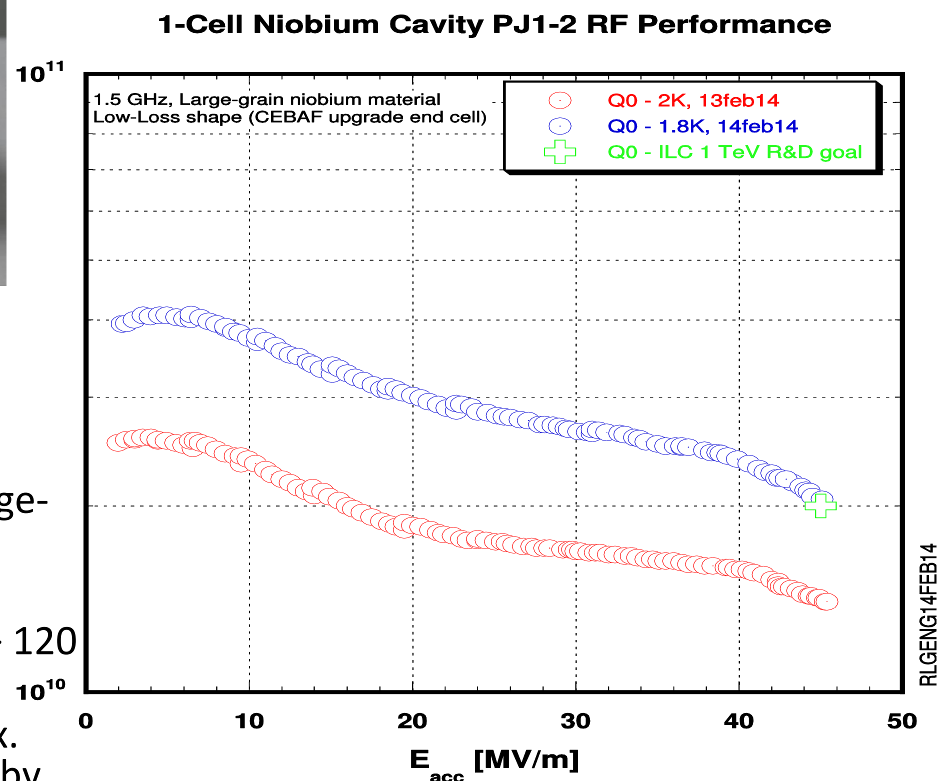


A Hub-laboratory function for ILC to be demonstrated

Large grain single cell 1.5 GHz cavity
(Collaboration of OSTEC, PKU and Jlab)



EBW finished at Ningxia OSTEC



Processing and test at JLab

- In collaboration with Jlab and OTIC, Ningxia large-grain Nb material, fabrication in OSTEC
- CEBAF upgrade cavity Low-loss shape, 1.5 GHz.
- BCP 60 μm + 800°C x 2hr + BCP 60 μ m + HPR + 120 ° C x 48hr.
- Max. Eacc 34 MV/m with Q_0=1.6E10 at 2K, Max. Eacc 34 MV/m with Q_0=2.5E10 at 1.8K, limited by quench, no FE.
- Then, EP treatment and Eacc 45MV/m

45 MV/m

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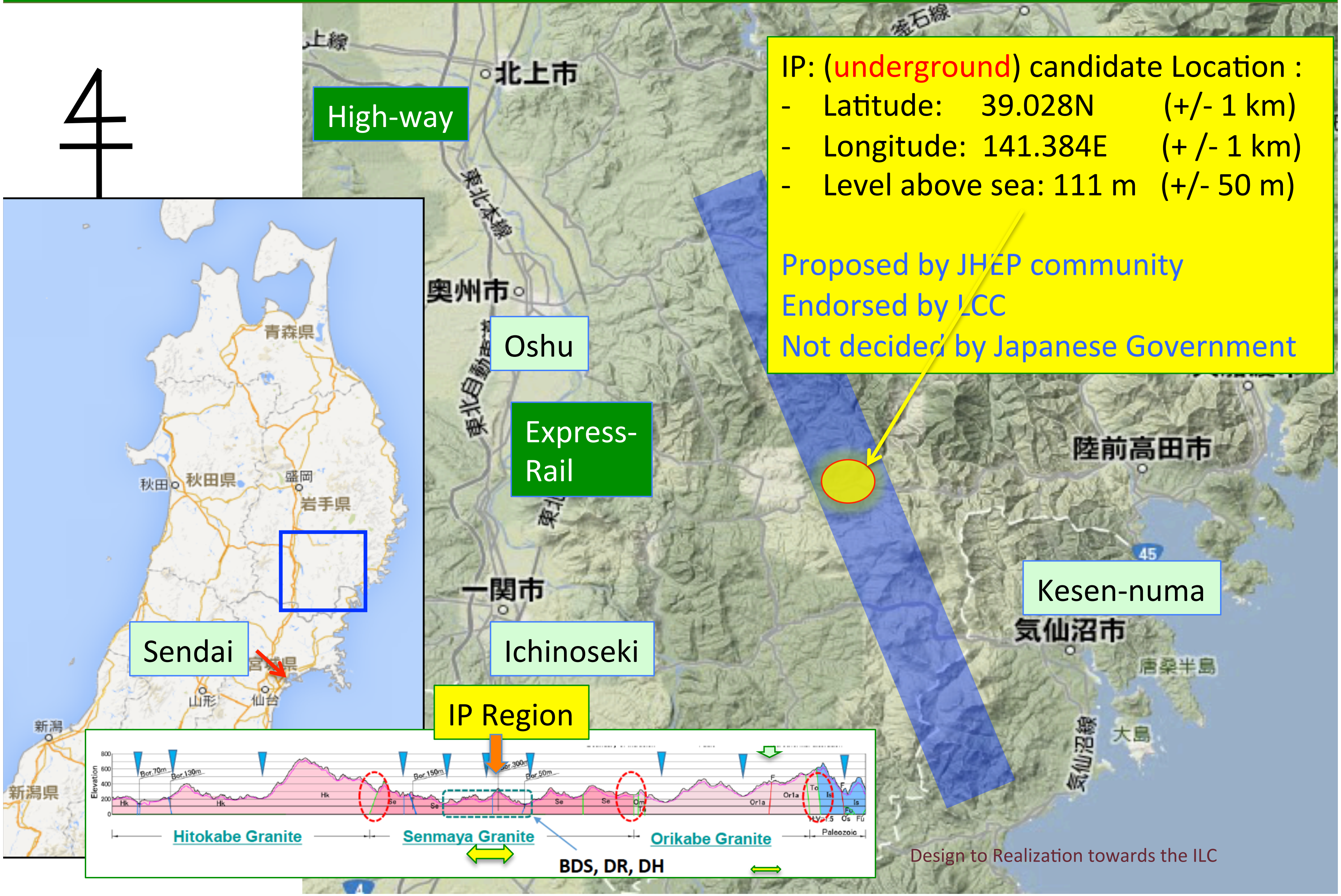
ILC Candidate Location: Kitakami Area

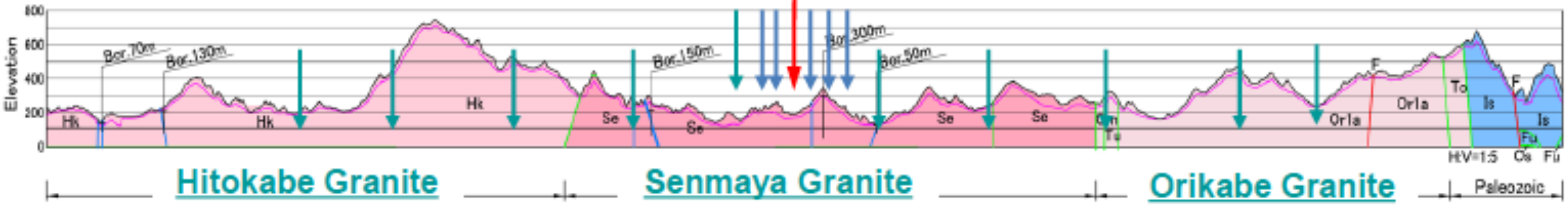


Geological Investigation

☐ Profiles of Geological Surveys along the project

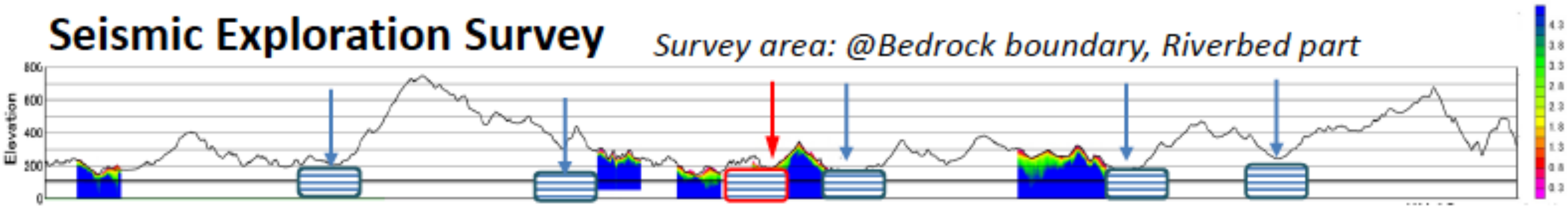
New IR point?

Borehole Survey



Seismic Exploration Survey

Survey area: @Bedrock boundary, Riverbed part



Geological Survey at pre-construction stage

	Basic Planning	Schematic Design	Detailed Design
Borehole Survey	- **1** p DH area	- **5** p DH/DR area	- **10** p along the BL
Seismic Exploration	- **1** area /1,000m	- **5** area /5,000m	**0** (Additional)

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Further Global Cooperation to be emphasized

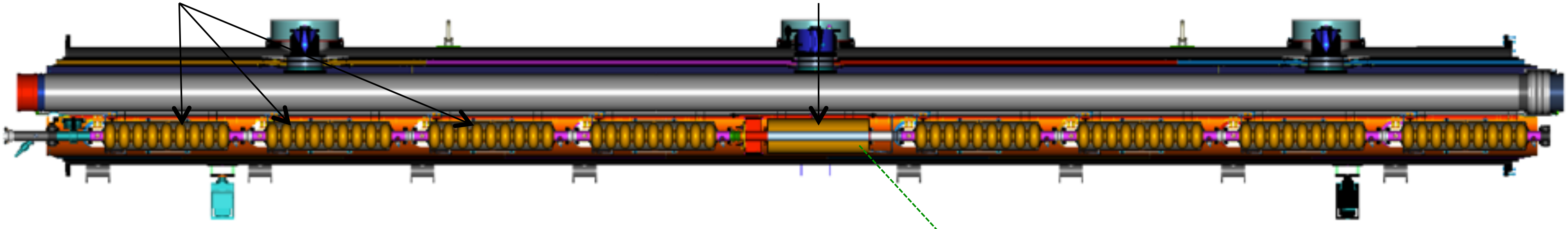
Category	Work-base	Specific subject	Global Collaboration w/
Positron Source		Positron source	PosiPol Collaboration
Nano Beam	ATF	37 nm beam 2 nm stability	ATF collaboration
SCRF Cavity Integration	STF	Power Input Coupler Tuner He-Vessel	CERN-DESY-KEK CEA-Fermi/SLAC-KEK DESY-KEK (WS at CERN? Autumn. 2014)
CM integration	STF, ILC	Conduction-cooled SC Quadrupole	Fermilab-KEK
Cryogenics	ILC	Cryog. Underground He inventry High p. Gas Safety	CERN-Fermilab-KEK (WS at CERN, 18 June)
CFS	ILC	CFS design prep.	CERN-Fermilab-KEK
Radiation Safety	ILC	ML radiation shield	SLAC-DESY-CERN-KEK (Session during this week)

ILC CM Assembly

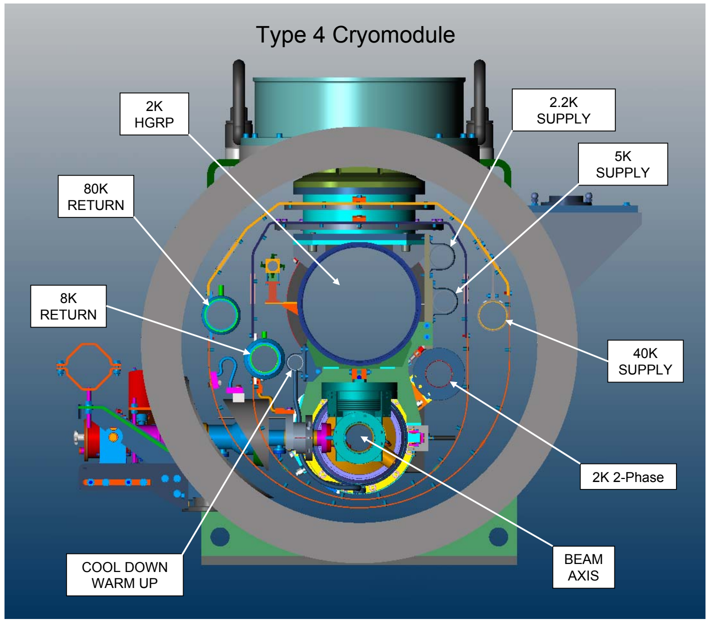
Type-B module
Type-A has 9 cavities and no quadrupole

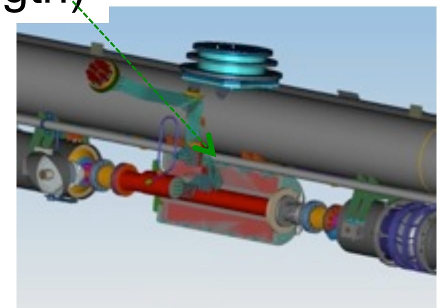
cavities (8)

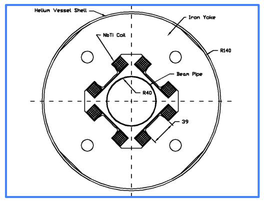
SC quad package

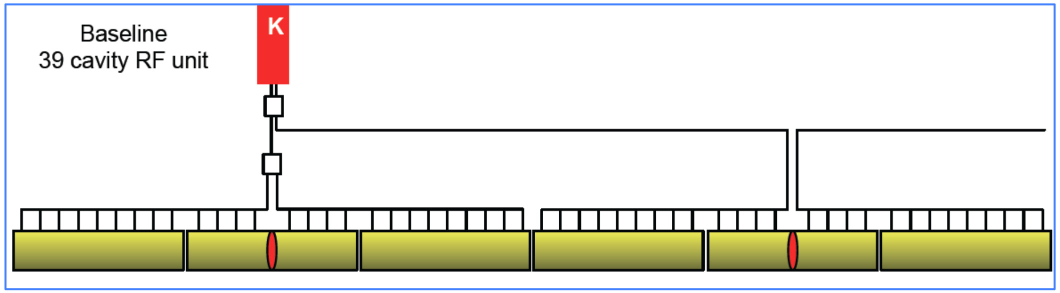


12.652 m (slot length)



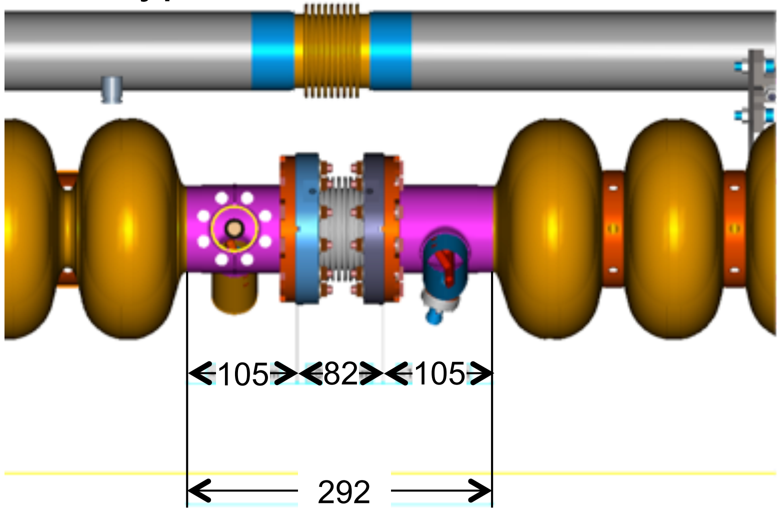




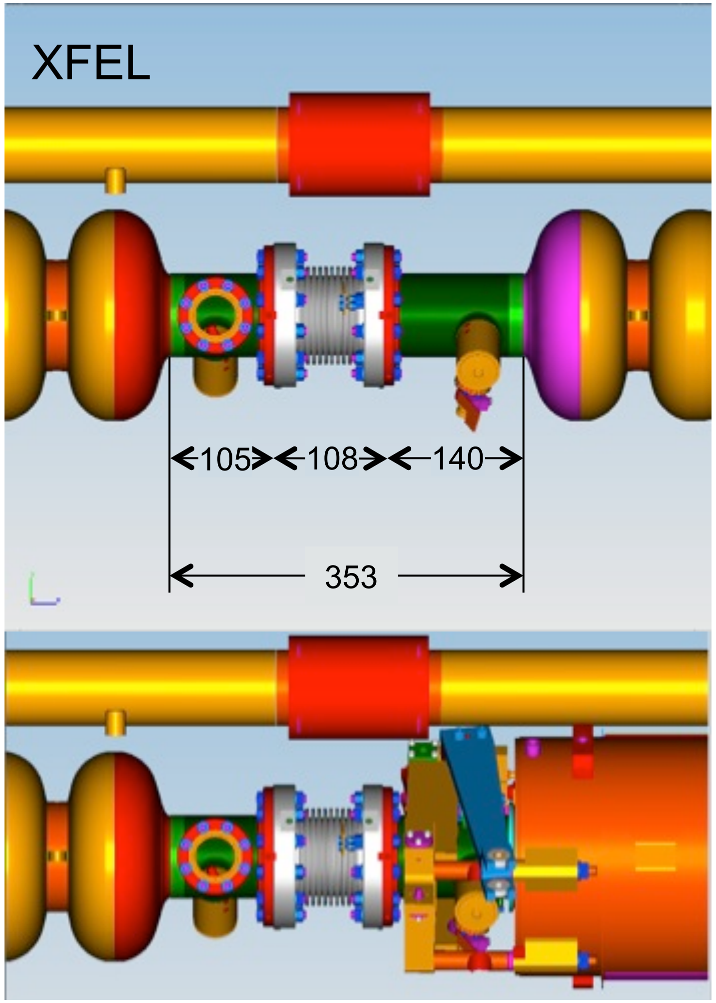


Inter-Cavity Spacing Issue

ILC Type-IV

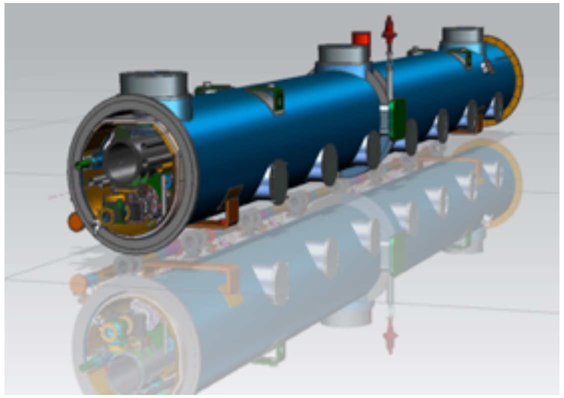


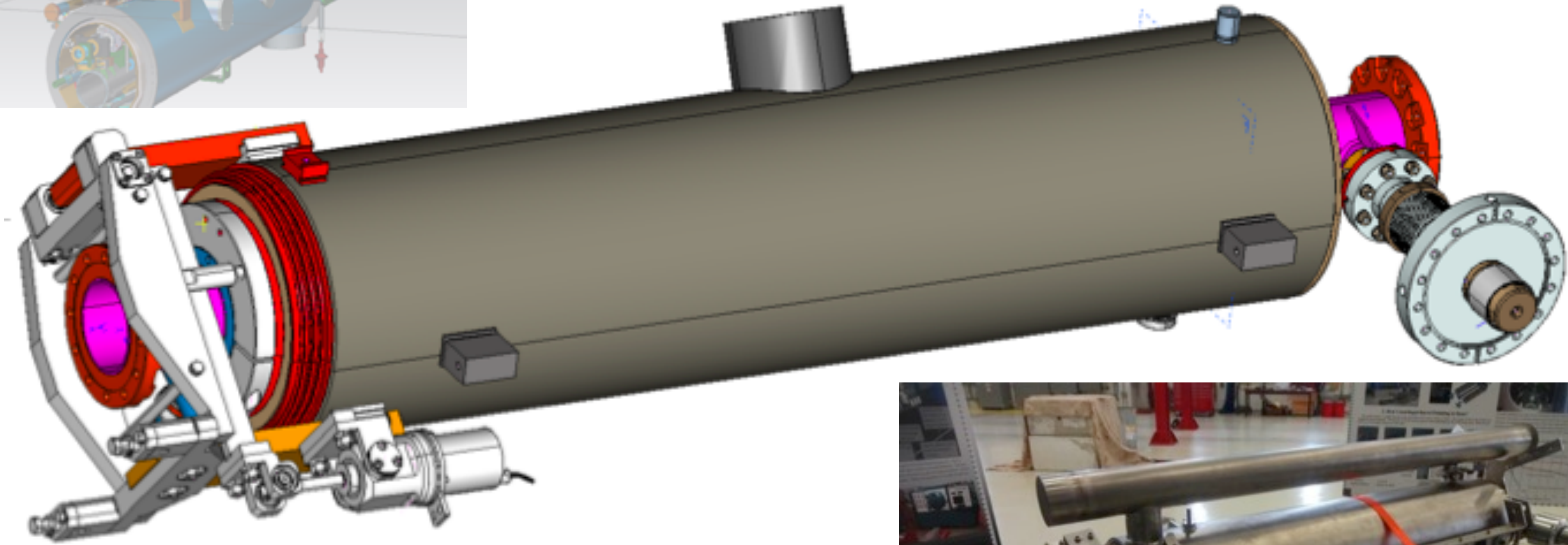
XFEL



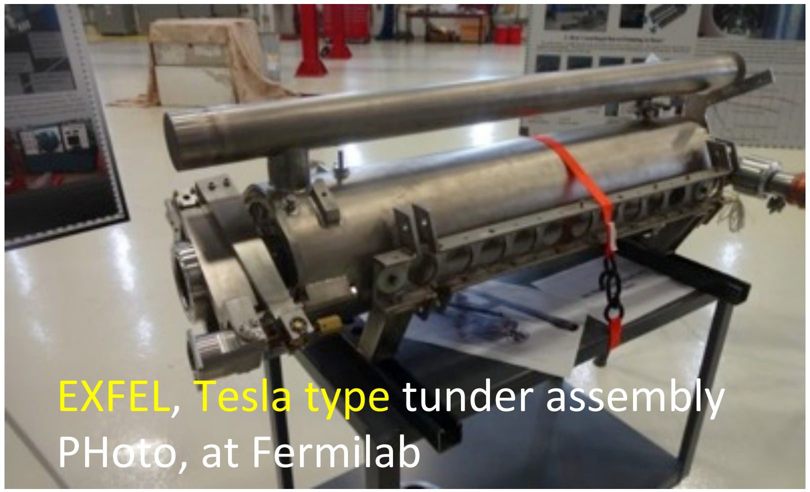
Reduction in inter-cavity spacing		**= 61 mm**
Bellows:	= 108→82	= 26 mm
"Long" cavity end	= 140→105	= 35 mm

LCLS-II Cavity: a Tuner Design Option to be investigated

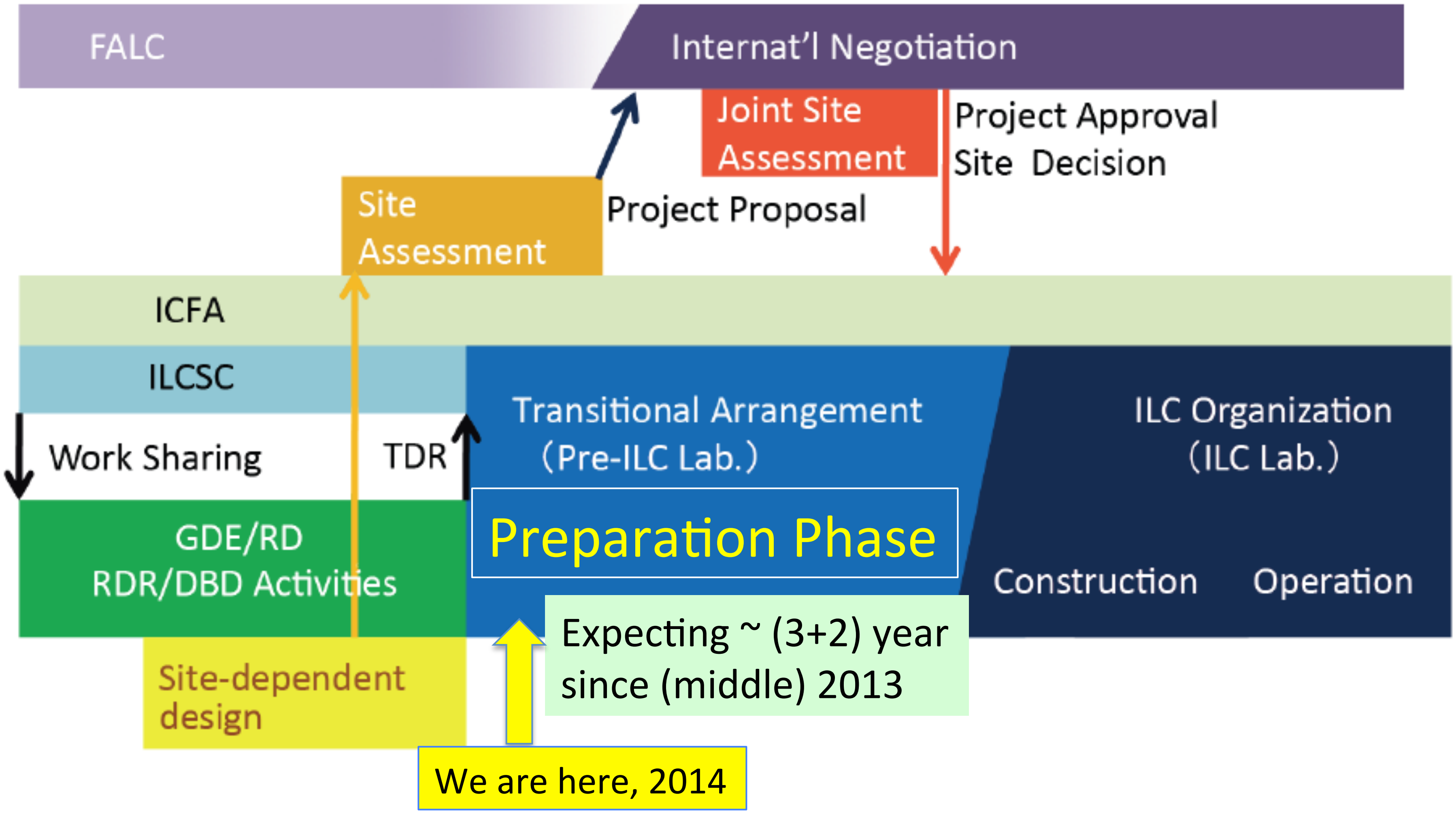




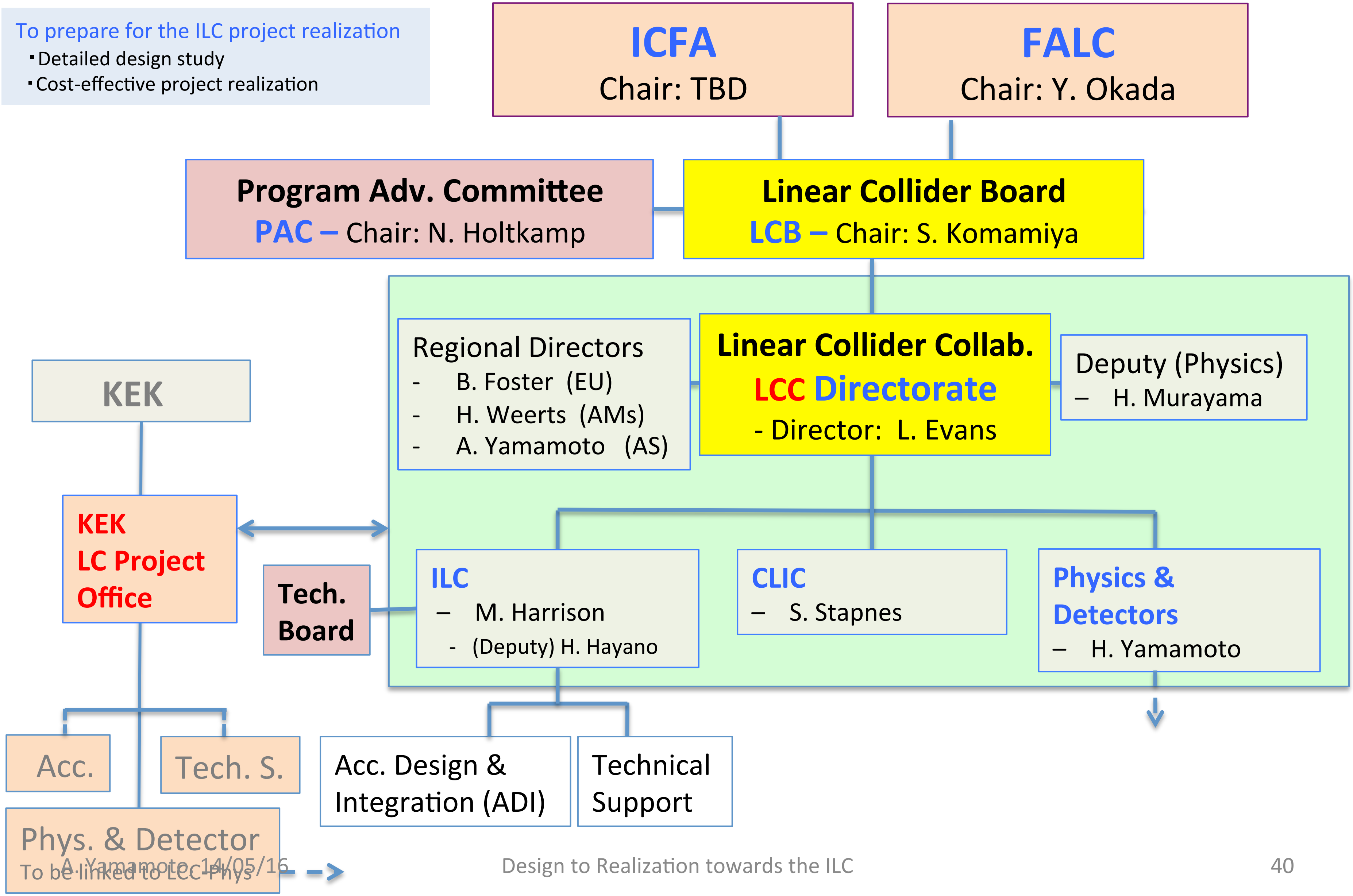
LCLS Tuner design covering the beam Pipe flanges, overcoming a constraint with a shorter beam pipe
T. Peterson, C. Grimm, et al.,



ILC Time Line: Progress and Prospect



ILC in Linear Collider Collaboration



LCC-ILC Accelerator Organization

LCC-ILC Director: M. Harrison, Deputies: N. Walker and H. Hayano *KEK LC Project Office Head: A. Yamamoto

Sub-Group	Global Leader Deputy/Contact p.	KEK-Leader* Deputy	Sub-Group	Global Leader Deputy/Contact P.	KEK-Leader* Deputy
Acc. Design Integr.	**N. Walker (DESY)** K. Yokoya(KEK)	K. Yokoya	**SRF**	**H. Hayano (KEK)** C. Ginsburg (Fermi), E. Montesinos (CERN)	H. Hayano Y. Yamamoto
Sources (e-, e+)	**W. Gai (ANL)** M. Kuriki (Hiroshima U.)	J. Urakawa T. Omori	**RF Power & Cntl**	**S. Michizono (KEK)** TBD (AMs , EU)	Michizono T. Matsumoto
Damping Ring	**D. Rubin (Cornell)** N. Terunuma(KEK)	N. Terunuma	**Cryogenics** (incl. HP gas issues)	**H. Nakai: KEK** T. Peterson (Fermi), D. Delikaris (CERN)	H. Nakai Cryog. Center
RTML	**S. Kuroda (KEK)** A. Latina (CERN)	S. Kuroda	**CFS**	**A. Enomoto (KEK)** V. Kuchler (Fermi), J. Osborne (CERN),	A. Enomoto M. Miyahara
Main Linac (incl. B. Compr. & B. Dynamics)	**N. Solyak (Fermi)** K. Kubo (KEK)	K. Kubo	**Radiation Safety**	**T. Sanami (KEK)** TBD (AMs, EU)	T. Sanami T. Sanuki
BDS	**G. White (SLAC),** R. Tomas (Cern) T. Okugi(KEK)	T. Okugi	**Electrical Support** (Power Supply etc.)	TBD	TBD
MDI	**K. Buesser (DESY)** T. Tauchi (KEK)	T. Tauchi	**Mechanical S.** (Vac. & others)	TBD	TBD
			Domestic Program, Hub Lab. Facilities	TBD	H. Hayano T. Saeki

Major Task: Fix technical design parameters to be optimized, and reflect them to CFS design optimization, within a few years.

ILC Time Scale required, with activities at ATF/STF

	14	15	16	17	18	19	20	21	22	23	24	25	26	27
ILC TDP/TDR														
ATF-II	Beam test													
ATF-future			Extended program											
STF														
QB	Beam test													
STF2-CM1+CM2a		Beam test												
STF-Future				Extended program										
CFS														
Civil eng.														
Site-survey														

After getting Green Sign、
(within a few year, after middle 2013)
・Preparation for contract : ~ 2 years
・Construction period : ~ 9 years
- Comissioning ~ 1 years

ILC to be realized by 2030

Commission.

ILC Contrucion	**14** **16**		**16** **19**		**18** **21**									**27 /** **30**
Fabrication			Preparation for the project		Preparation for industrialization		Fabrication and tests, preparation for installation							
Inst/ commission.											Installation			

Summary

- Japanese effort has been focused on CFS, based on the preferred candidate site unified with “Kitakami” site, and best cost effective design is being studied,
- Accelerator Technologies of “Nano-beam” handling and “Superconducting Beam Acceleration” are to be demonstrated at ATF and STF.
- The hub-laboratory function to be demonstrated in Japan, to keep good global balance and the project reliability
- The preparation of the ILC laboratory in management and finance is being formed, and it is anticipated to complete the preparation in 5 years (2013 – 2018).

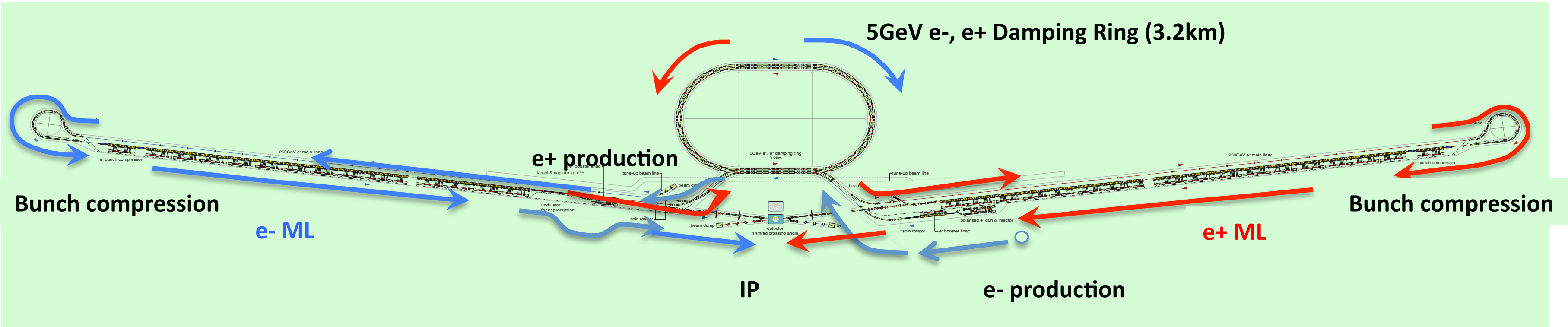
Acknowledgements

- *On behalf of the KEK SRF team, we would like to thank "Peter" for his long term effort and leading us to contribute to SRF technology in particle physics.*

backup

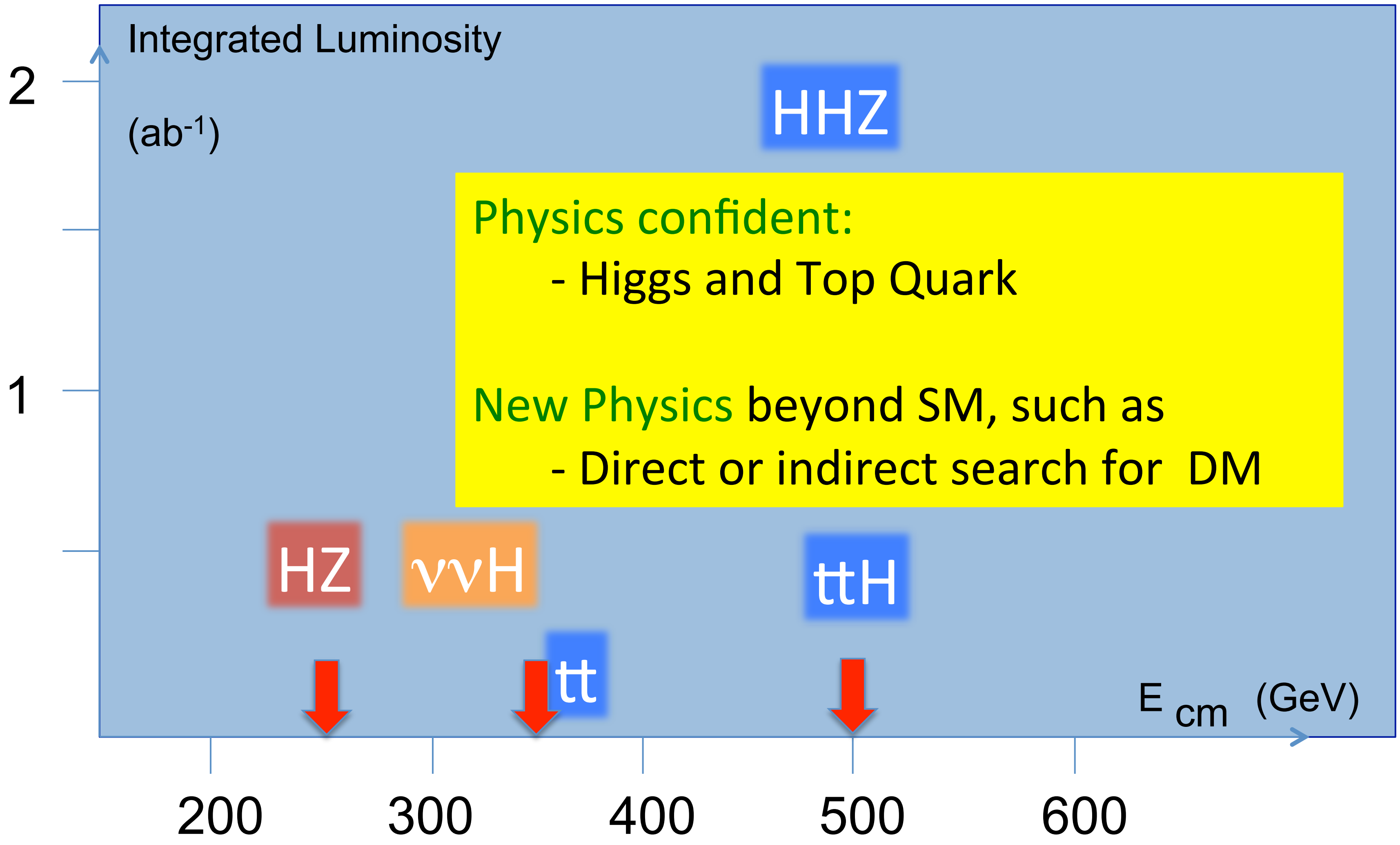
Requirements from Physics/Detectors

- **Basic requirements:**
- Luminosity : $\int Ldt$ = 500 fb^{-1} in 4 years
- E_{cm} : 200 – 500 GeV and the ability to scan
- E stability and precision: < 0.1%
- Electron polarization: > 80%
- **Extend-ability:**
- Energy upgrade: 500 → 1,000 GeV



Physics Prospects with ILC

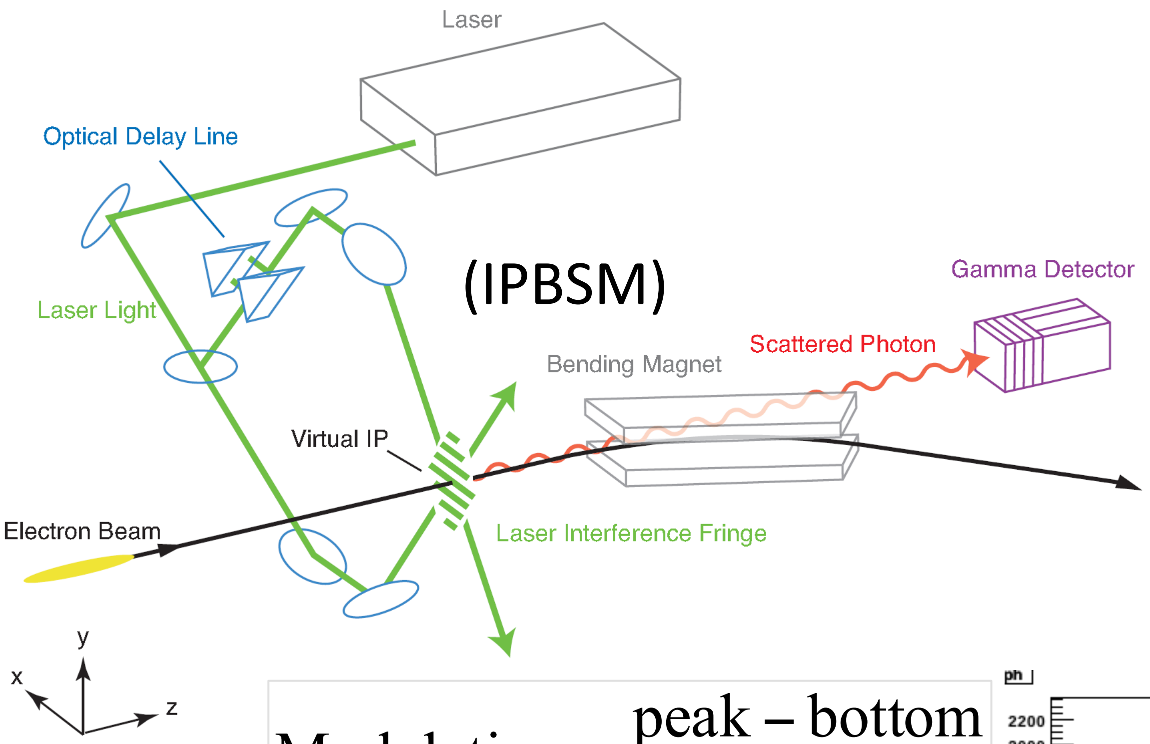
K. Kawagoe



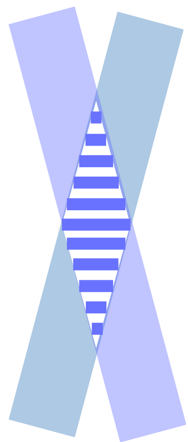
Measurement of Beam Size at ATF2 Focal Point

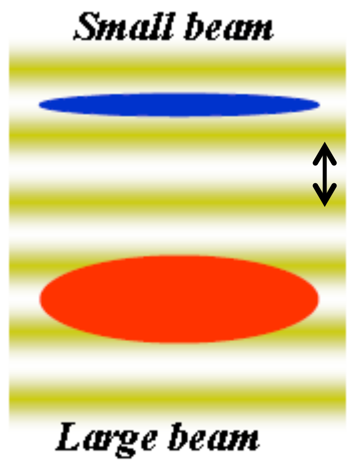
Interference of two laser beams; Shintake-monitor

(IPBSM)



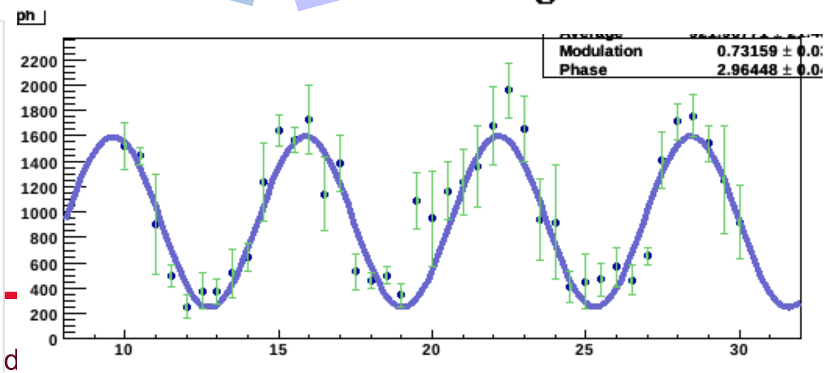
$$h = \frac{\lambda}{2\sin(\theta/2)}$$



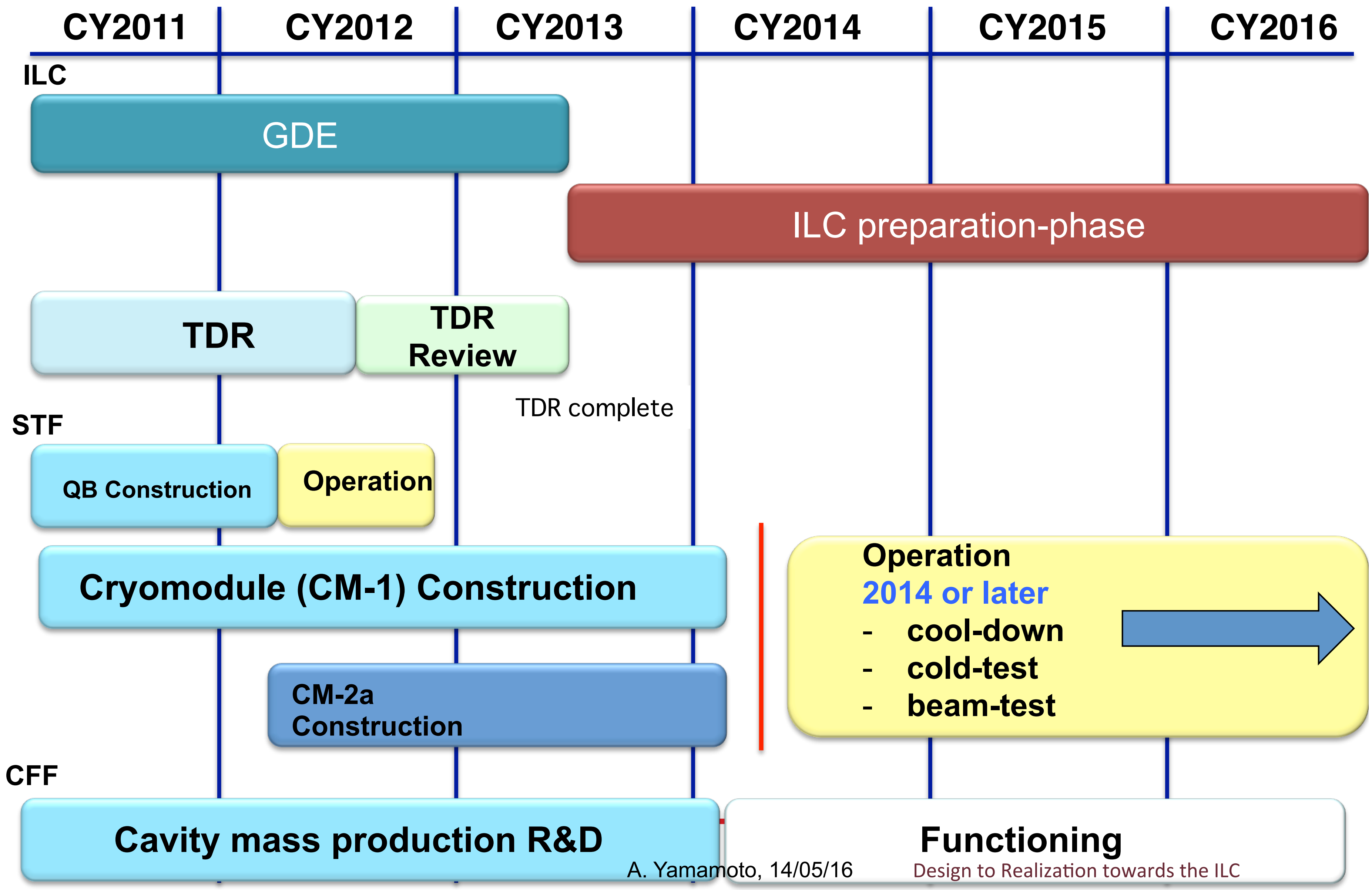


$$\text{Modulation} = \frac{\text{peak} - \text{bottom}}{\text{peak} + \text{bottom}}$$

$$= \left|\cos\theta\right| \exp\left(-\frac{2\pi^2\sigma^2}{h^2}\right)$$

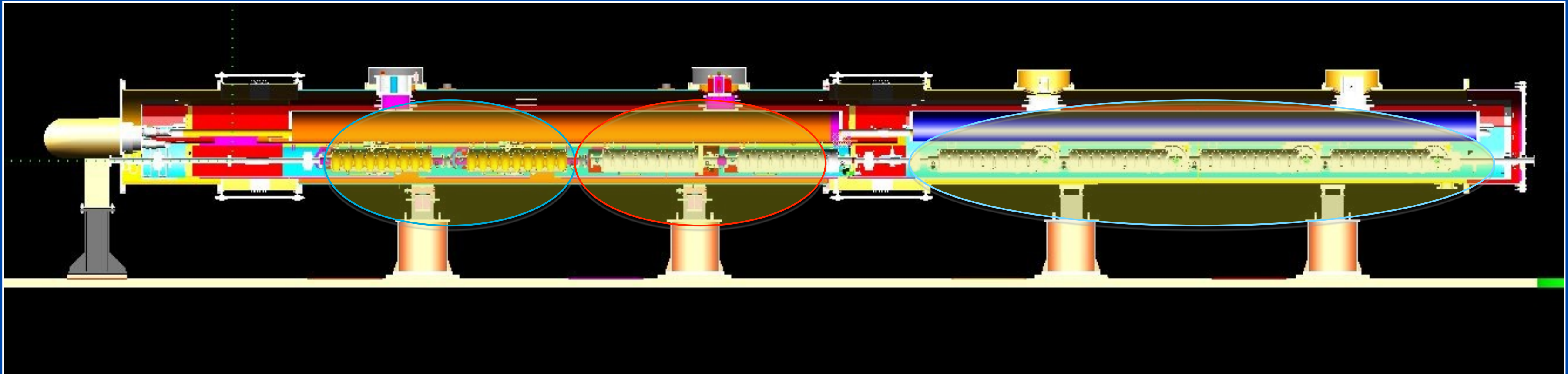


Plan of STF R&D beyond TDR

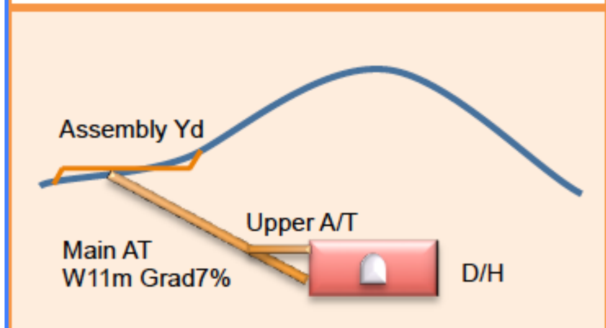
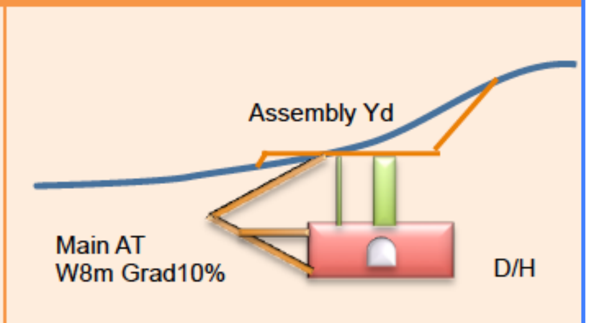


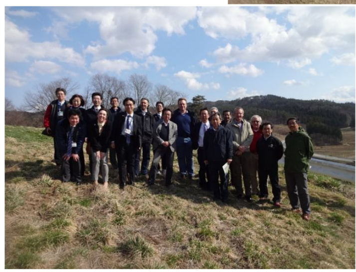
Cavity and Cryomodule Performance Test with Plug Compatibility, in Global Effort

- Cavity integration and the String Test to be organized with:
  - 2 cavities from DESY and Fermilab
  - 4 cavities from KEK
  - Each half-cryomoducle from INFN and KEK

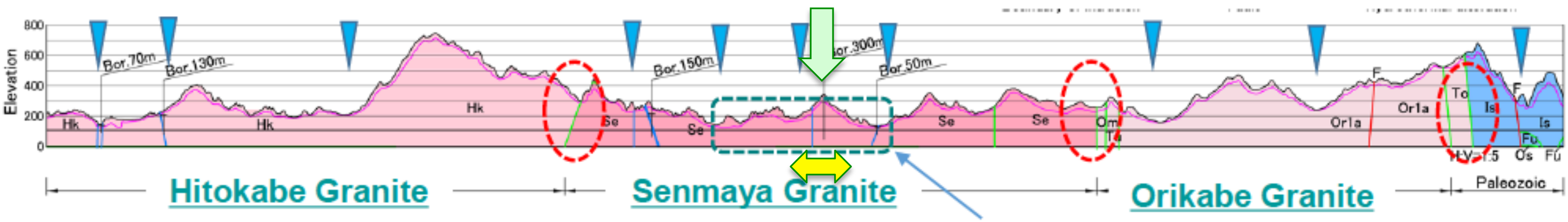


IP Access Design under Re-investigation

Baseline	Hybrid-A
	
• 1 HT (11x11m 7%grad) • Detector assembling is inside of DH	• 1 HT (8.0x7.5m 10%gradl) • 2 VS (D18m, D10m) • Detectors assembling is on-ground.



TDR IP point

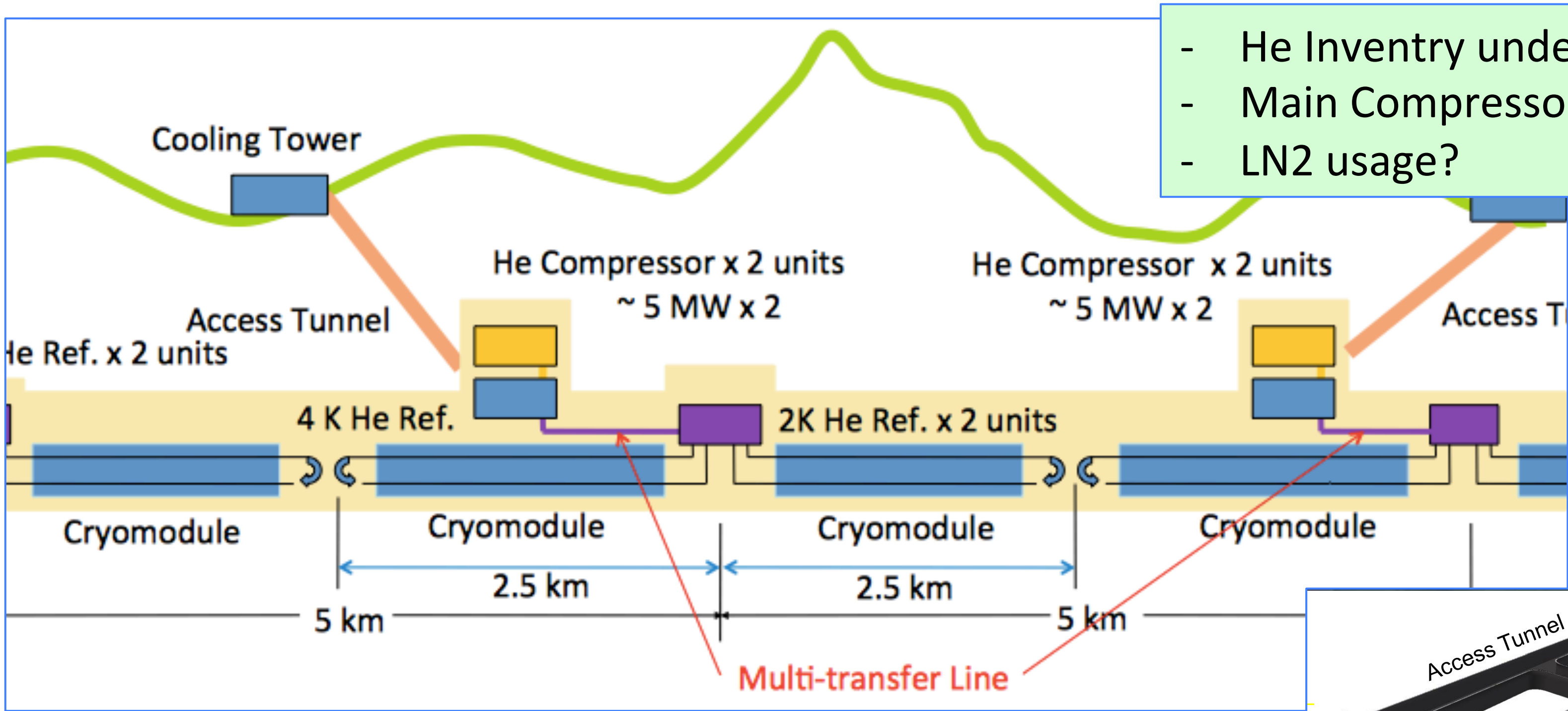


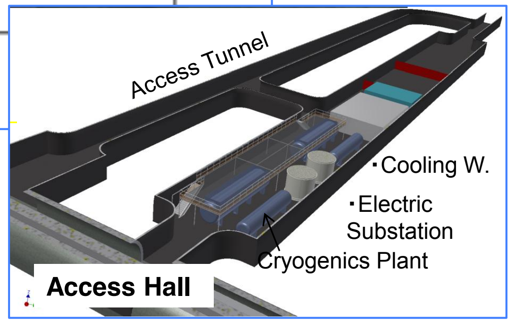
BDS, DR, DH

ILC Cryogenics design to be updated

in cooperation with CERN – Fermilab -KEK

- He Inventry under groud
- Main Compressor location?
- LN2 usage?





- SRF-CFS Joint session, 13 May (tomorrow)
- Cryogenics system also needs a (safety) review – start at CERN >> 18 June, 2014