Report from the GDE

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GDE Project Managers

To be presented at ILD Collaboration Meeting
Kyushu Univ., May 23, 2012

Outline

- **Accelerator Design Overview toward TDR**
- **Progress in SCRF and MDI**
- **Progress in Cost Study for TDR**
- **Further Effort required**

Timeline to establish TDR baseline

- **Top-Level Change Control (TLCC) process**
  - **high-level layout decisions** with broad sweeping implications
  - Based on SB2009 proposal (**cost constraint**)
  - Proposals established at **Baseline Assessment Workshops** (BAW)
  - Decision level (after review) – **Director**

BAW 1 & 2	7-10.09.2010	KEK	• Average accelerating gradient **(31.5 MV/m)** • Supported operational gradient **(≤ ±20%)** • **Single** Main Linac Tunnel variants • Approach to RF power generation and distribution (KCS, DRFS, **RDR as back-up**)
BAW 3 & 4	18-21.01.2011	SLAC	• **Relocation** of undulator-based positron source to central region • **Reduced** beam power option (smaller DR, less installed RF power) • Parameters for E_{cm} < 500 GeV (**10-Hz** mode for e+ production)

Timeline to establish TDR baseline

- **Next-Level Change Control process**
  - **lower-level technical details** for baseline (many!)
  - Systematically **review** of **every system (Baseline Tech. Reviews)**
  - Affect decisions (**down-selects**) where necessary
  - **Consolidate parameters**, documentation *etc* (**EDMS**)
  - **Decision** level (after review) – **Project Managers**

BTR 1	6-8.07.2011	INFN	• Damping Rings
BTR 2	24-27.10.2011	DESY	• Electron Source • Positron Source • RTML (bunch compressor) • Beam Delivery System and MDI
BTR 3	19-20.01.2012	KEK	• SCRF Technology • Main Linac layout

BTR 4	20-23.03.2012	CERN	• CFS (concluding review)
			  • Civil construction
			  • Mechanical and Electrical Systems*
			  • (Site variants)
			• Schedule, installation, alignment
			• Detector Hall

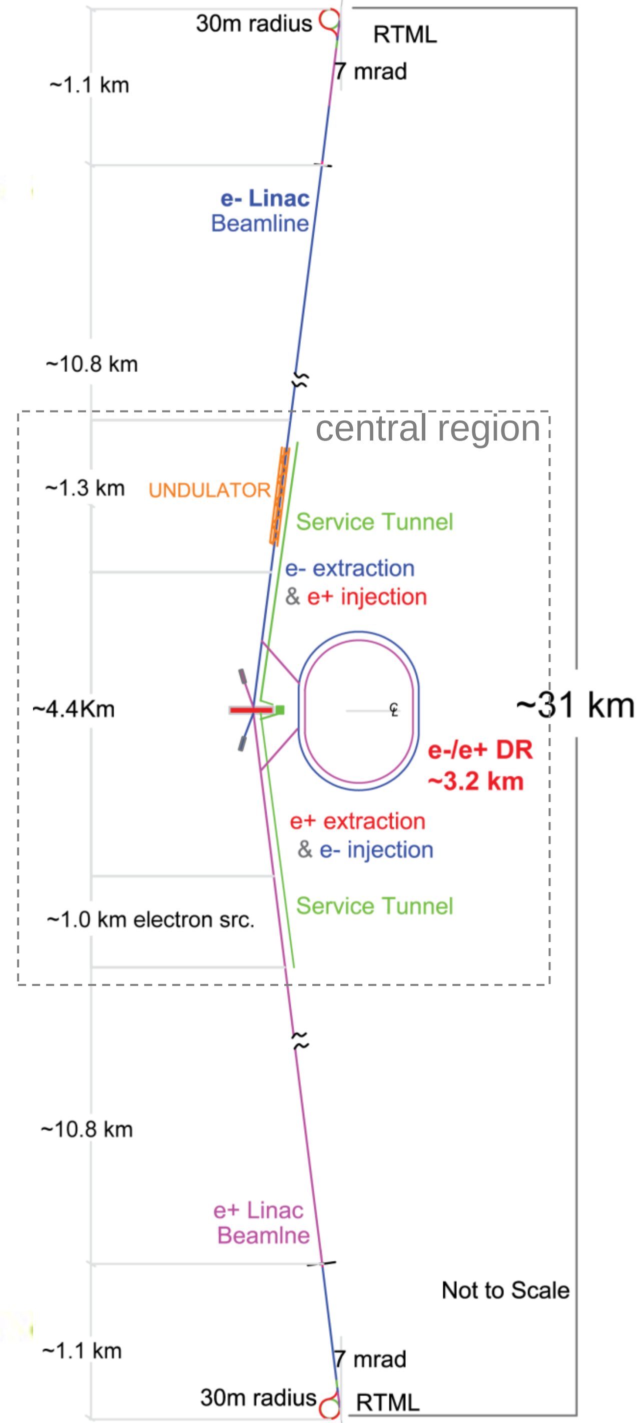
* included an external review of electrical and mechanical systems

General Approach

- **Attempt to include all stakeholders**
  - BAW / BTR open workshops
  - Physics and detector groups always represented
- **Maintain a transparent process**
  - summaries and good documentation
- **Cost impact always explicitly included in review and analysis**
  - cost consciousness

Footprint

- **Overall length unchanged from RDR**
- **Central region integration**
  - sources
  - damping rings (3.2km sharing tunnel)
  - BDS & detectors
  - main dumps
- **Remainder ('off campus')**
  - linacs
  - bunch compressors
  - (turn around)



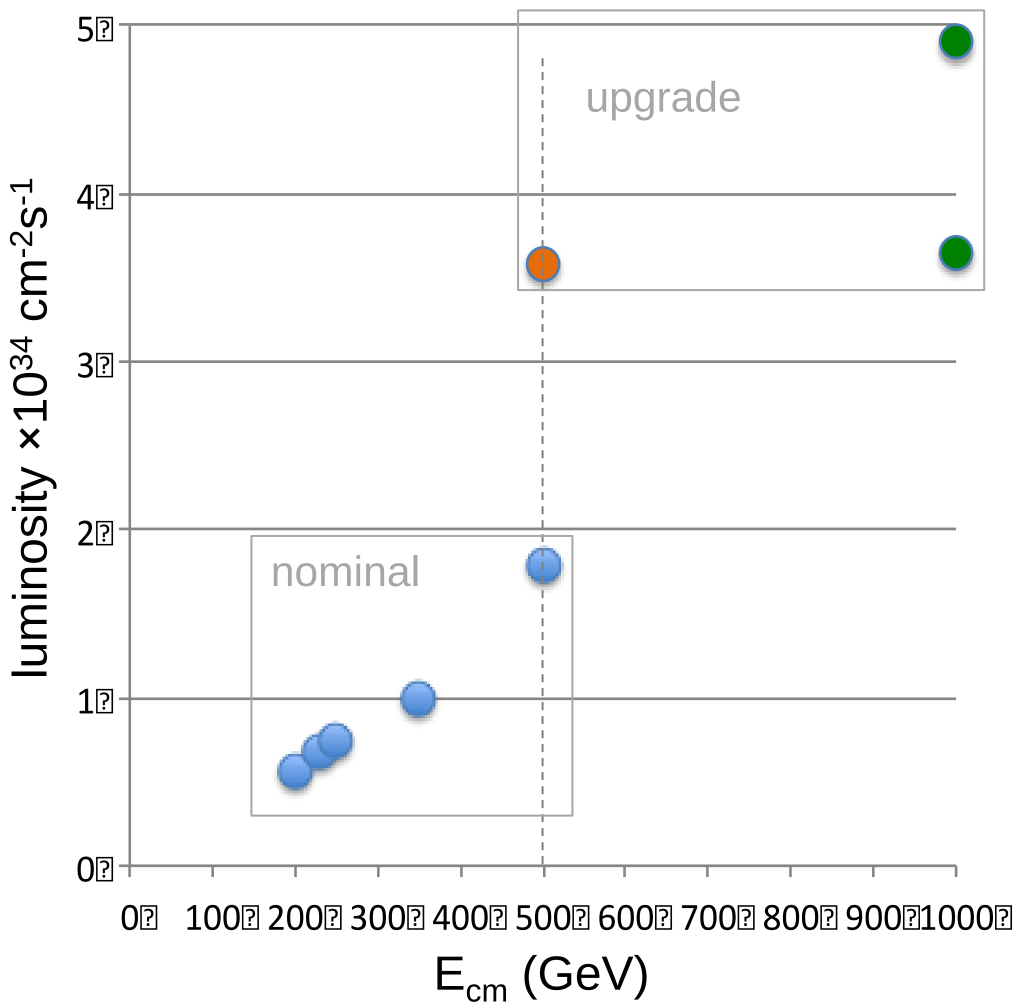
ILC-TDR: Baseline Parameters

In TDR Part-2, Chapter 2, drafted by N. Walker

Centre-of-mass energy	E_{CM}	GeV	200	230	250	350	500
Luminosity pulse repetition rate		Hz	5	5	5	5	5
Positron production mode			10 Hz	10 Hz	10 Hz	nom.	nom.
Bunch population	N	$\times 10^{10}$	2	2	2	2	2
Number of bunches	n_b		1312	1312	1312	1312	1312
Linac bunch interval	Δt_b	ns	554	554	554	554	554
RMS bunch length	σ_z	μm	300	300	300	300	300
Normalized horizontal emittance at IP	$\gamma\epsilon_x$	μm	10	10	10	10	10
Normalized vertical emittance at IP	$\gamma\epsilon_y$	nm	35	35	35	35	35
Horizontal beta function at IP	β_x^*	mm	16	14	13	16	11
Horizontal beta function at IP	β_y^*	mm	0.34	0.38	0.41	0.34	0.48
RMS horizontal beam size at IP	σ_x^*	nm	904	789	729	684	474
RMS horizontal beam size at IP	σ_y^*	nm	7.8	7.7	7.7	5.9	5.9
Vertical disruption parameter	D_y		24.3	24.5	24.5	24.3	24.6
Fractional RMS energy loss to beamstrahlung	δ_{BS}	%	0.65	0.83	0.97	1.9	4.5
Luminosity	L	$\times 10^{34}\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$	0.56	0.67	0.75	1.0	1.8
Fraction of L in top 1% E_{CM}	$L_{0.01}$	%	91	89	87	77	58
Electron polarisation	P_-	%	80	80	80	80	80
Positron polarisation	P_+	%	30	30	30	30	30
Electron relative energy spread at IP	$\Delta p/p$	%	0.20	0.19	0.19	0.16	0.13
Positron relative energy spread at IP	$\Delta p/p$	%	0.19	0.17	0.15	0.10	0.07

TDR Luminosity Parameters

- **Nominal based on SB2009 with n_b = 1312**
- **Dropped travelling focus scheme**
  - technical difficult to implement
  - very high disruption parameter → high risk
- **Adjusted vertical disruption ~25**
  - vertical β_y*
- **Reviewed collimator wakefield and emittance growth issues**



[EDMS D*0925325](http://ilc-edmsdirect.desy.de/ilc-edmsdirect/document.jsp?edmsid=D00000000925325)

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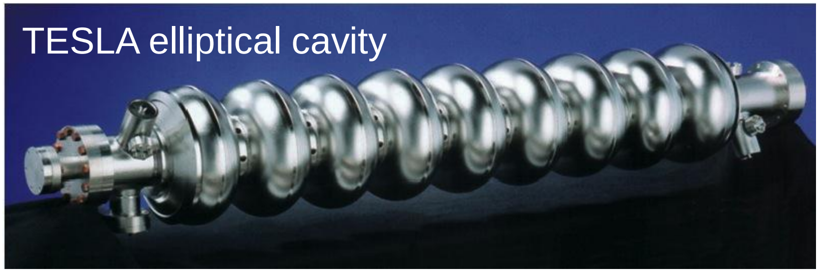
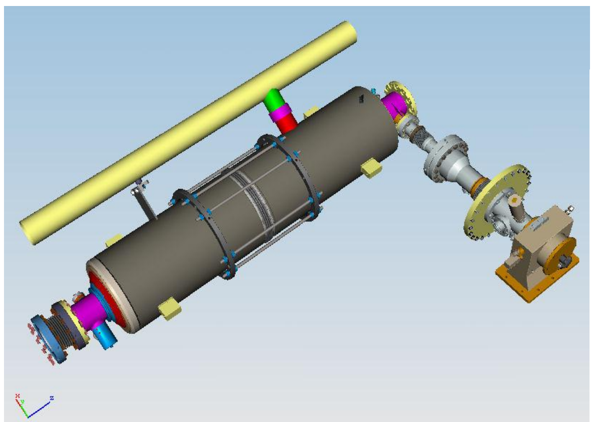
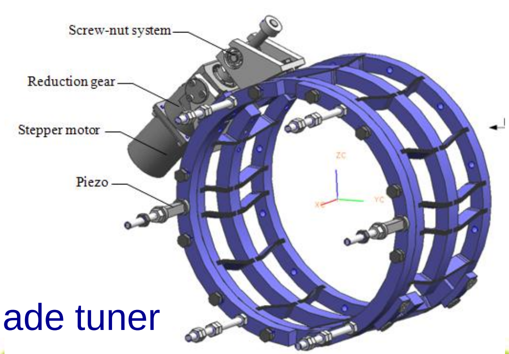
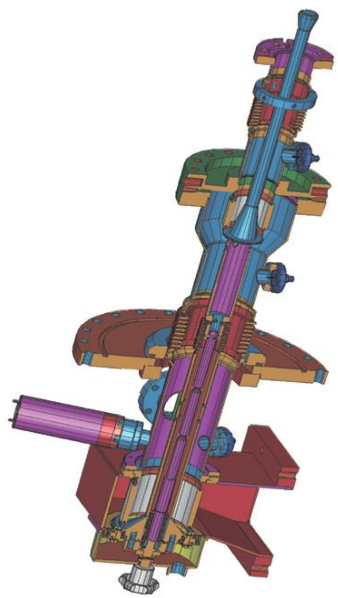
SCRF Technology Cavity Package


TESLA elliptical cavity





Blade tuner

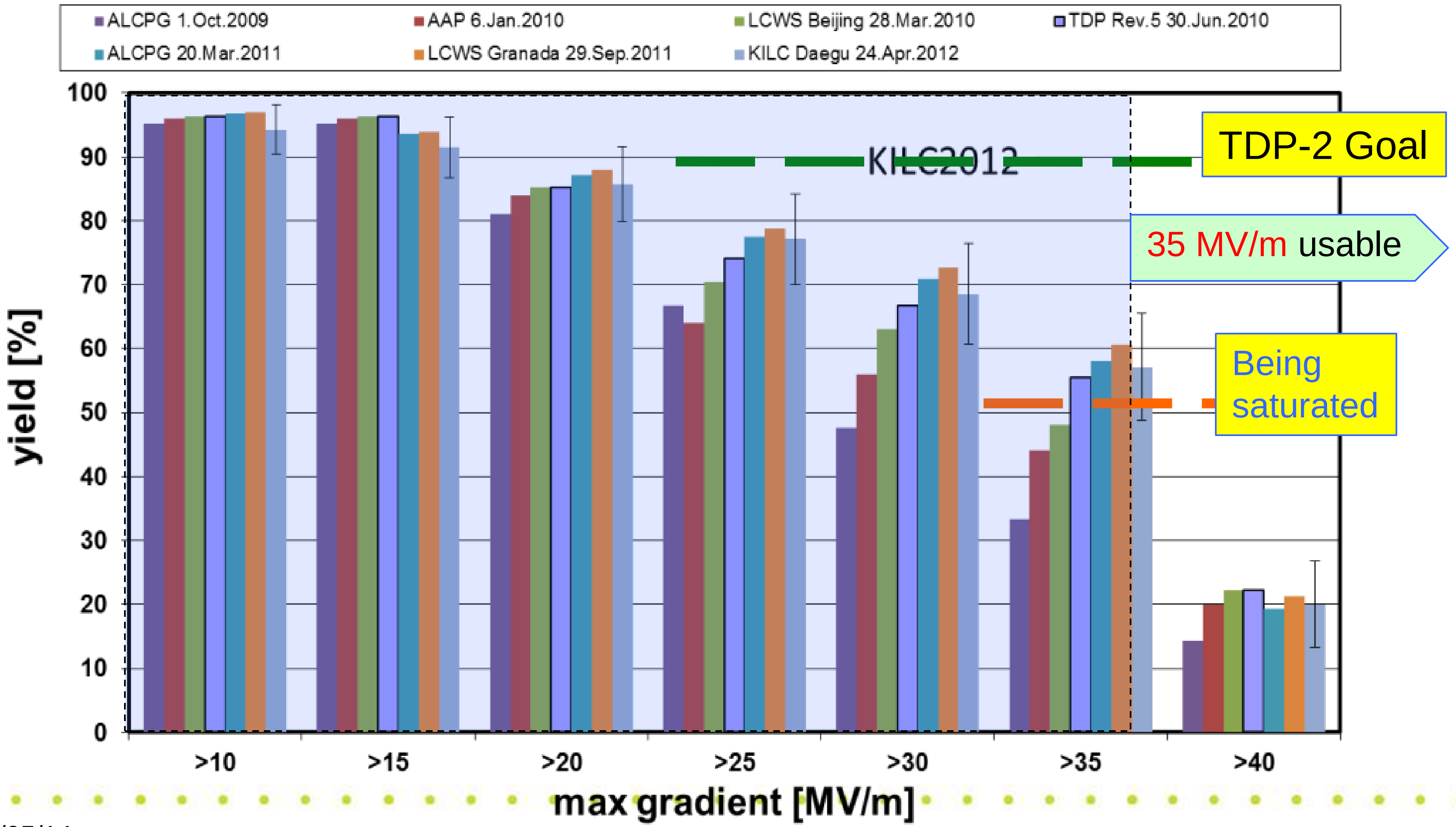

TTF Type III coupler

- **ML SCRF BTR**
  - KEK Jan 2012
- **Reviewed**
  - cavity design (including production process)
  - Helium tank and magnetic shield
  - High power coupler
  - Mechanical tuner
  - Plug compatibility interfaces
  - …

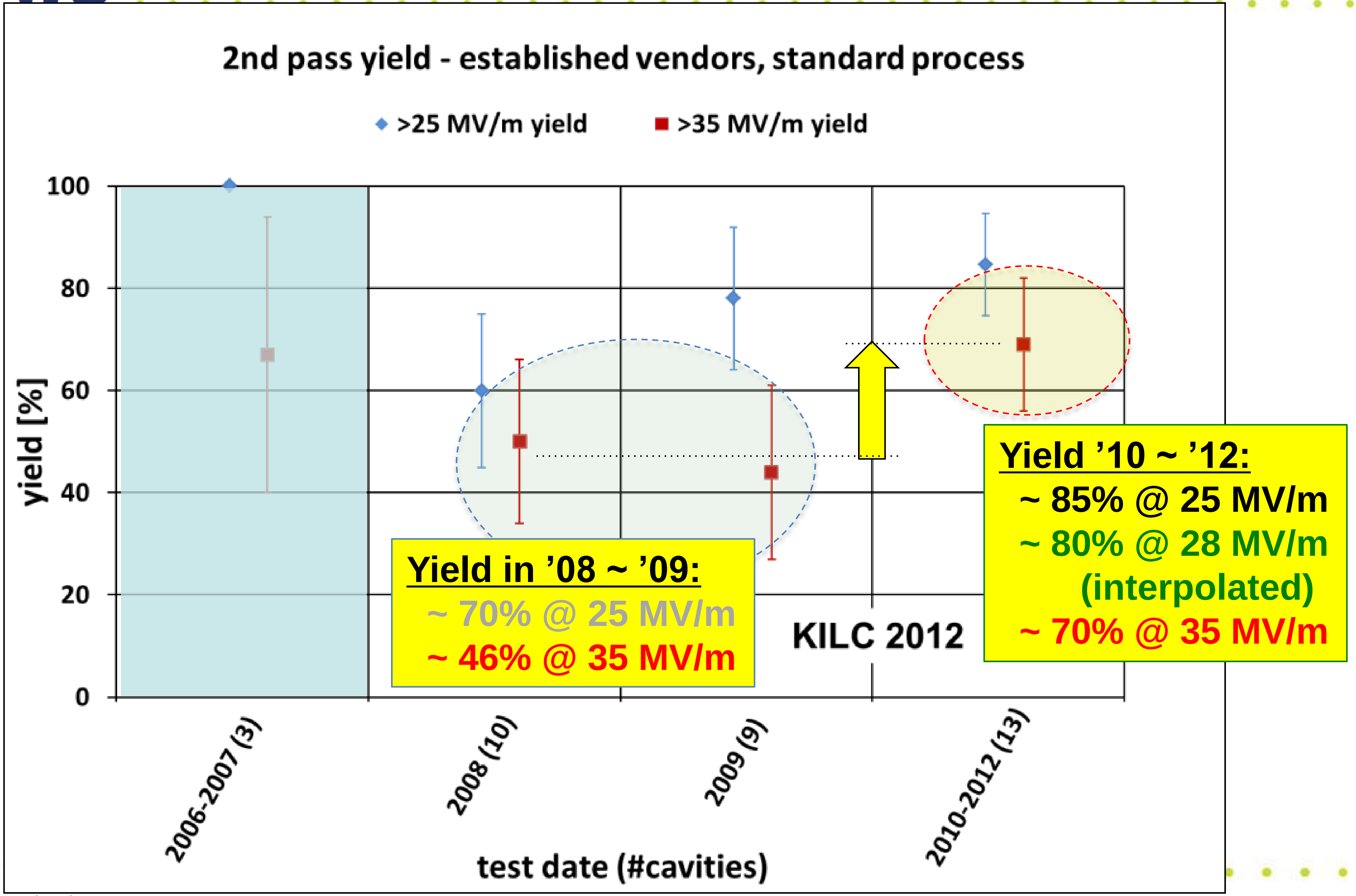
Progress Integrated in Cavity Gradient Yield

Updated, April., 24, 2012

Plot courtesy
Camille Ginsburg of FNAL



Yearly Progress in Cavity Gradient Yield
as of April 24, 2012



Industrial Participation to ILC Cavity Production

year	# 9-cell cavities qualified	# of Labs reaching 35 MV/m processing	# of Industrial manufacturers reaching 35 MV/m fabrication
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 and others joining soon	5 RI, ZANON, AES, MHI, Hitachi and others joining soon

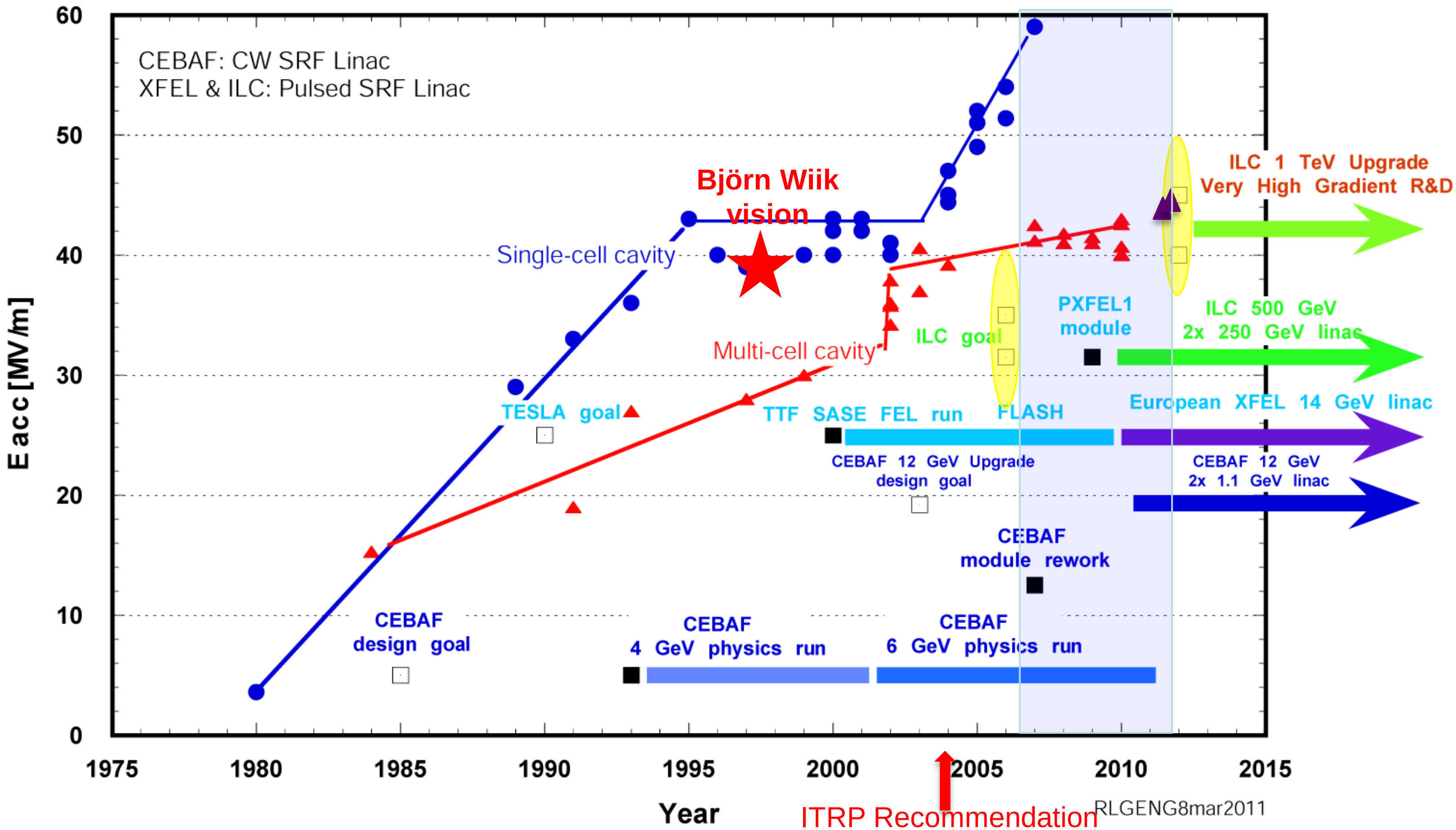
- **Recent Progress in Industry/Lab**
  - Niowave-Roark/Fermilab (TB9NR004): reached 29.7 MV/m (Nov. 2011
  - Hitachi/KEK (HIT02): reached 35 MV/m with HOM (April, 2012)
  - Toshiba/KEK (TOS-02): reached 30 MV/m w/o HOM (March 2011)
  - Accel (RI)/Cornell (A9) : reached 39.5 MV/m w/ HOM (April, 2012)
- **Progress in EXFEL** (courtesy by D. Reschke: the 2nd EP at DESY)
  - RI: 4 reference cavities with Eacc > 28 MV/m, (~ 39 MV/m max.)
  - Zanon: 3 reference cavities with Eacc > 30 MV/m (~ 35 MV/m max.)

Technical Development beyond TDR

- **SCRF**
  - Higher Gradient in cavity toward 1 TeV
  - Industrialization and cost-saving technology
- **CFS**
  - Geological survey and/or study
  - Civil engineering study
- **Accelerator Systems**
  - e+ source Target R&D, and undulator R&D
  - Preparing to be ready for 250 GeV ~1 TeV LC

Courtesy: R. Geng

SCRF Cavity Gradient Progress



- Continued progress in SRF gradient : breakthrough of 45 MV/m in 1-cell, ~60 MV/m record; 45 MV/m in 9-cell
- GDE began in 2005: produce a design for ILC and coordinate worldwide R&D efforts
- New SRF Test Facilities in operation: STF at KEK and NML at Fermilab
- Upgrade of CEBAF to 12 GeV underway at Jefferson Lab (80 cavities)
- FLASH operation and construction of European XFEL underway (640 cavities)

A 2-cell cavity w/ end-G reached > 50 MV/m

Target

* Accelerate to 10 MeV

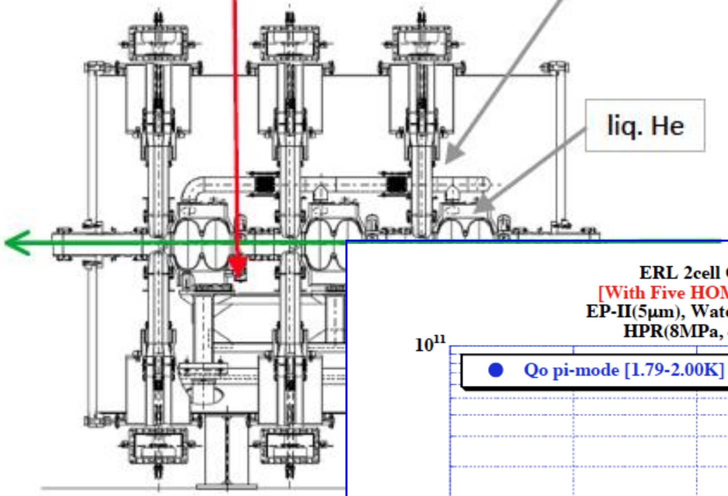
Require

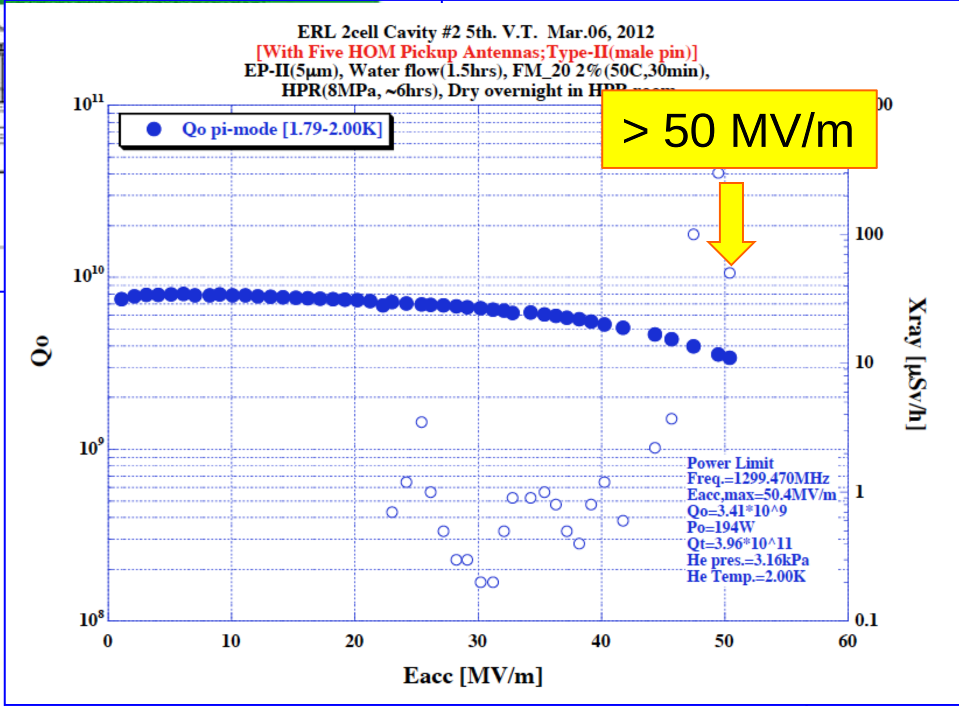
* 15 MV/m / cavity at CW

Cavity : 3 x 2-cell cavities
Slide-Jack tuner and piezo tuner

5 coaxial HOM couplers
for one cavity

Input coupler
(double feed)
167kW/coupler





To be installed in
KEK cERL injection beam line

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 (FNAL) STF2 (KEK, test start in 2013)			
Preparation for Industrialization				Production Technology R&D		
Communication with industry:	1st Visit Venders (2009), Organize Workshop (2010) 2nd visit and communication, Organize 2nd workshop (2011) 3rd communication and study contracted with selected vender (2011-2012)					

Communication with Companie

Further study in contract in 2011-2012

	Date	Company	Place	Technical sbject
1	2/8, 2011	**Hitachi**	Tokyo (JP)	Cavity/Cryomodule
2	2/8	**Toshiba**	Yokohana (JP)	Cavity/Cryomodule, SCM
3	2/9	**MHI**	Kobe (JP)	Cavity / Cryomodule
4	2/9	Tokyo Denkai	Tokyo (JP)	Material (Nb)
5	2/18	OTIC	NingXia (CN)	Material (Nb, NbTi, Ti)
6	(3/3), 9/14	Zanon	Via Vicenza (IT)	Cavity/Cryomodule
7	3/4,	**RI**	Koeln (DE)	Cavity
8	(3/14), 4/8	**AES**	Medford, NY (US)	Cavity
9	(3/15), 4/7	Niowave	Lansing, MI (US)	Cavity/Cryomodule
10	4/6	PAVAC	Vancouver (CA)	Cavity
11	4/25	ATI Wah-Chang	Albany, OR (US)	Material (Nb, Nb-Ti, Ti)
12	4/27	Plansee	Ruette (AS)	Material (Nb, Nb-Ti, Ti)
13	5/24	SDMS	Sr. Romans (FR)	Cavity
14	7/6	Heraeus	Hanau (DE)	Material (Nb, Nb-Ti, Ti)
15	10/18	**Babcock-Noell**	Wurzburg (DE)	CM assembly study
16	11/11	SST	Maisach (DE)	Electron Beam Welder

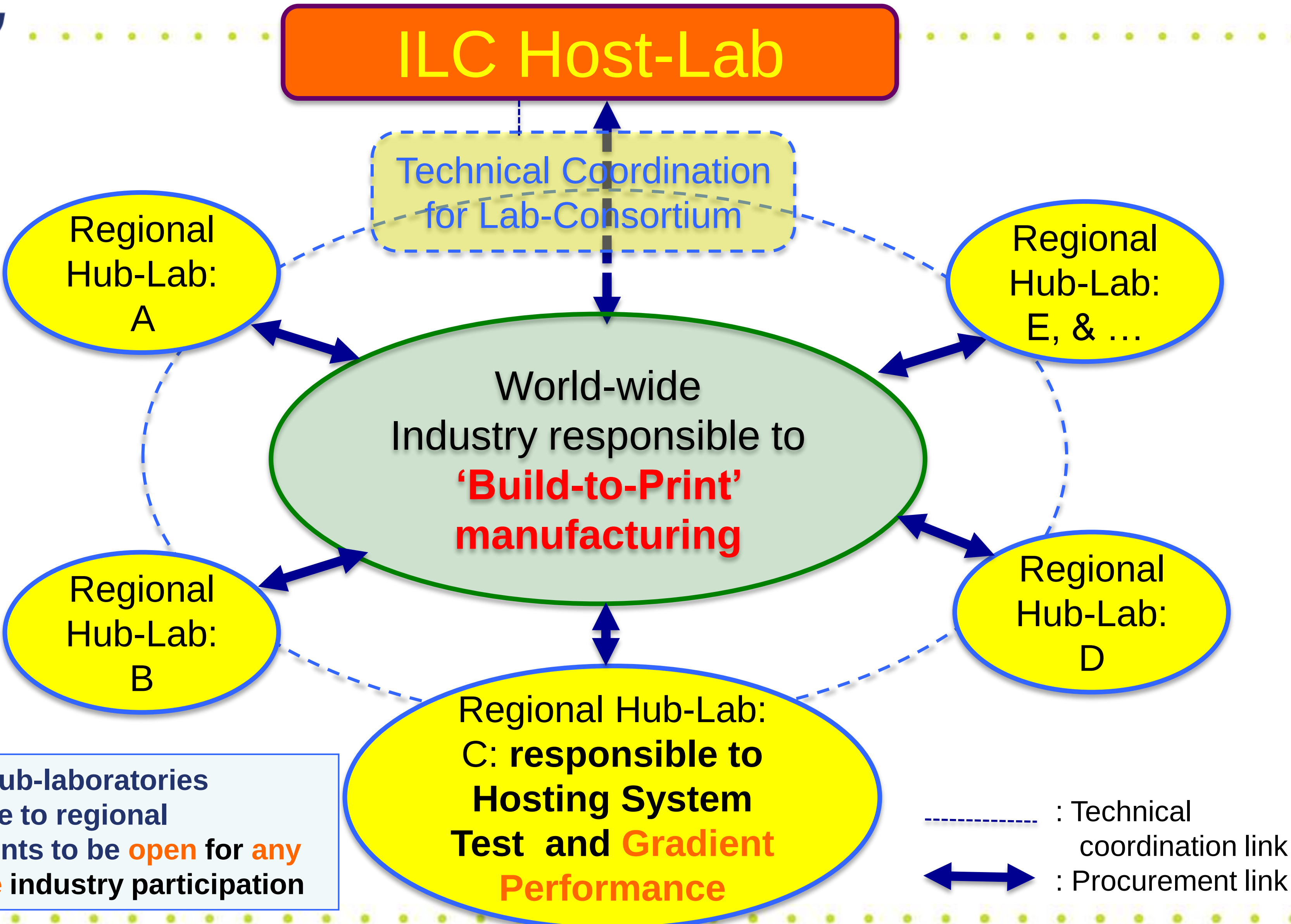
Mass-Production Studies

in contracts

	Company	Mass production model	Contract funded/hosted by
Cavity	RI	100% (50%)	DESY
	AES	20 %	DOE/Fermilab
	MHI	20, 50, 100%	KEK
Quadrupole	Toshiba	100 %	KEK
CM and assembly	Hitachi	20, 50, 100%	KEK
	AES	25%	DOE/Fermilab
CM assembly	BN	100, 33 %	CERN

In parallel, EXFEL experience kindly informed by DESY, INDFN, CES/Saclay

SCRF Procurement/Manufacturing Model



Regional hub-laboratories responsible to regional procurements to be open for any world-wide industry participation

What we are progressing in ?

- **Cavity gradient yield**
  - Reaching ~80 % at 35 MV/m, and more report by J. Kerby
- **Technical preparation for industrialization**
  - Plug-compatible interface condition established for industrial study and cost estimate for TDR
  - Cost effective fabrication being studied at also lab.
- **Communication with industry**
  - Communication cost-estimate progressing under more practical boundary conditions, and more report on costing by G. Dugan

What is still to be investigated?

- **Cavity**
  - Input-coupler's cost to be significantly reduced,
- **Cryomodule**
  - Assembly and test plan with communication with labs.
    - Fraction of cryomodule testing and conditioning of input-couplers will much affect on the cost
- **Industrialization and costing**
  - Guideline for mass-production and costing:
  - How to rely on world-wide market and single/multiple vender

System Tests

NML (FNAL)

- Under construction
- Up to 6 cryomodules
- Operation: end 2012
  - (3 CM)

FLASH (DESY)

- TDP focus
- 7 CM → 1.2 GeV beam
- photon user facility

“9mA experiment” achieved ~1800 bunches at 9mA in 09.2009

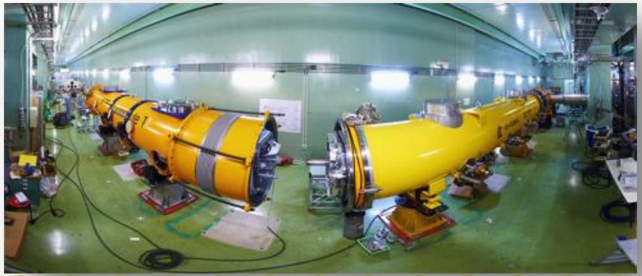
$\Delta E/E_{RMS}$ ~0.5% (@ 0.8 GeV)

~0.1% within pulse

Full systems integration testing

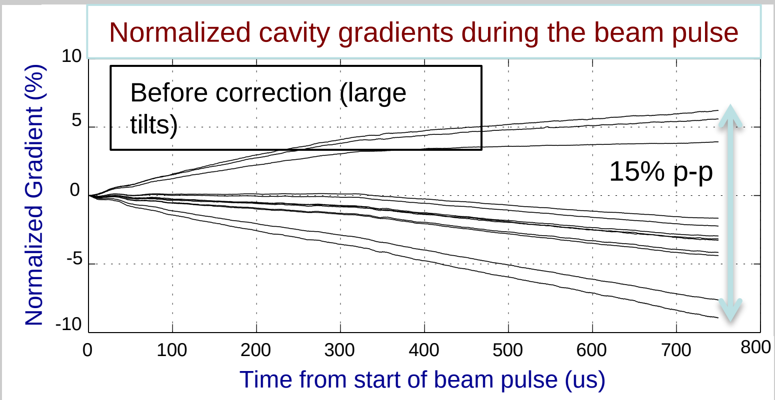
STF , **ATF** (KEK)

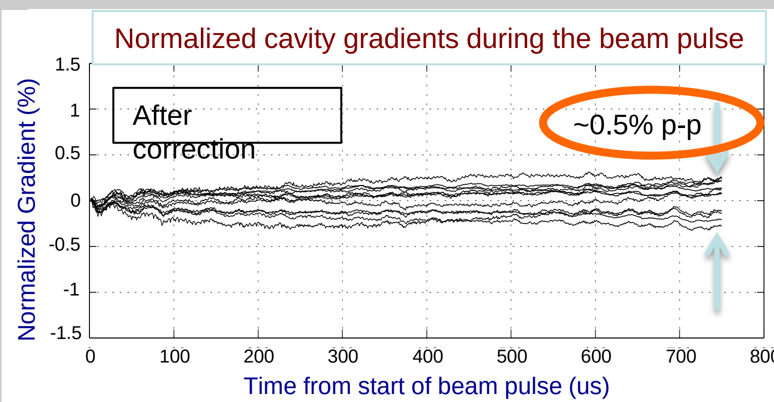
- “Quantum Beam” experiment 2011
- 1 CM with beam 2013
- (2 CM 2015)



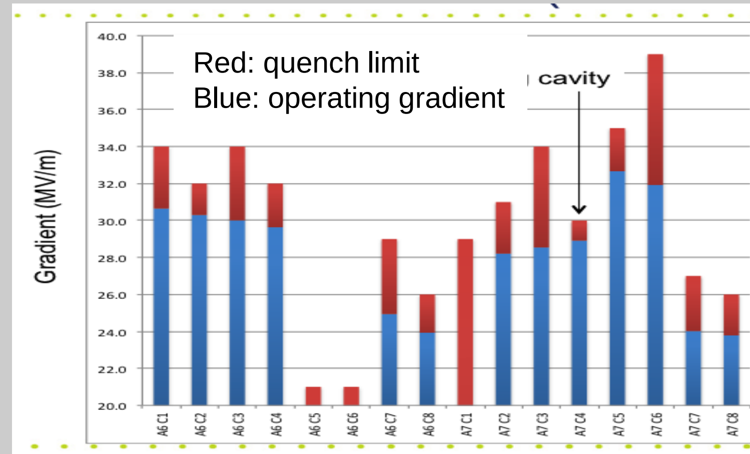
FLASH 9mA Studies: beam operation close to cavity gradient limits (4.5mA/800us bunch trains)

Tailored cavity Loaded-Qs to cancel beam-loading induced gradient tilts





Operation at 380MeV on ACC67 (13 cavities)

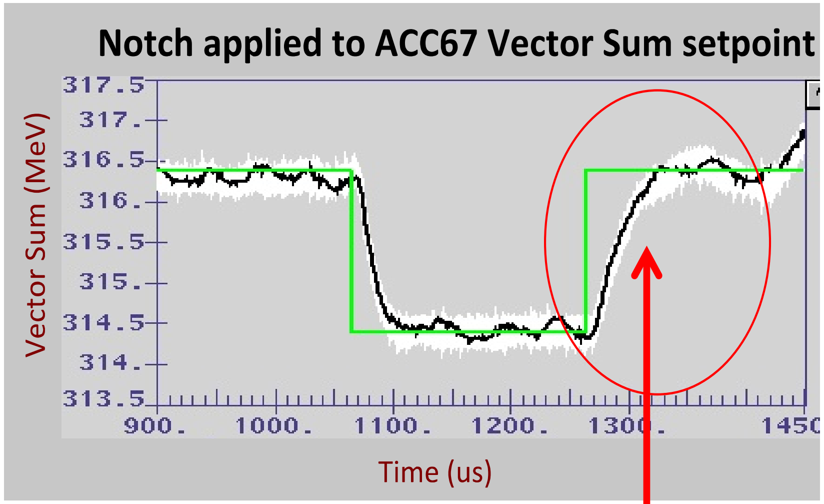


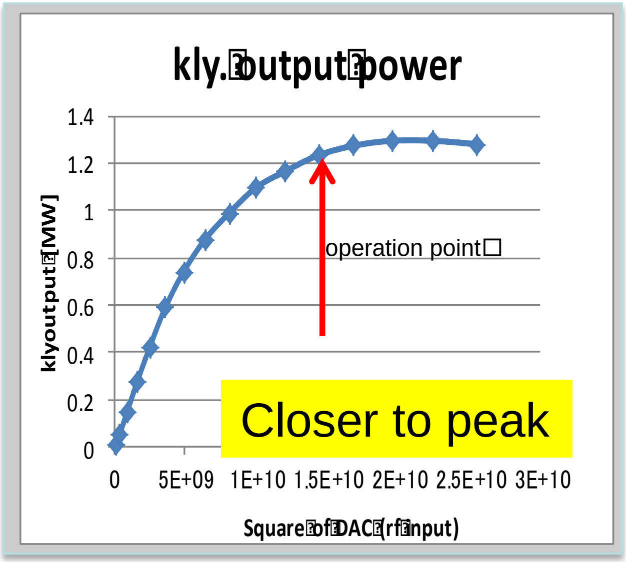
The limiting cavity is within 5% of quench

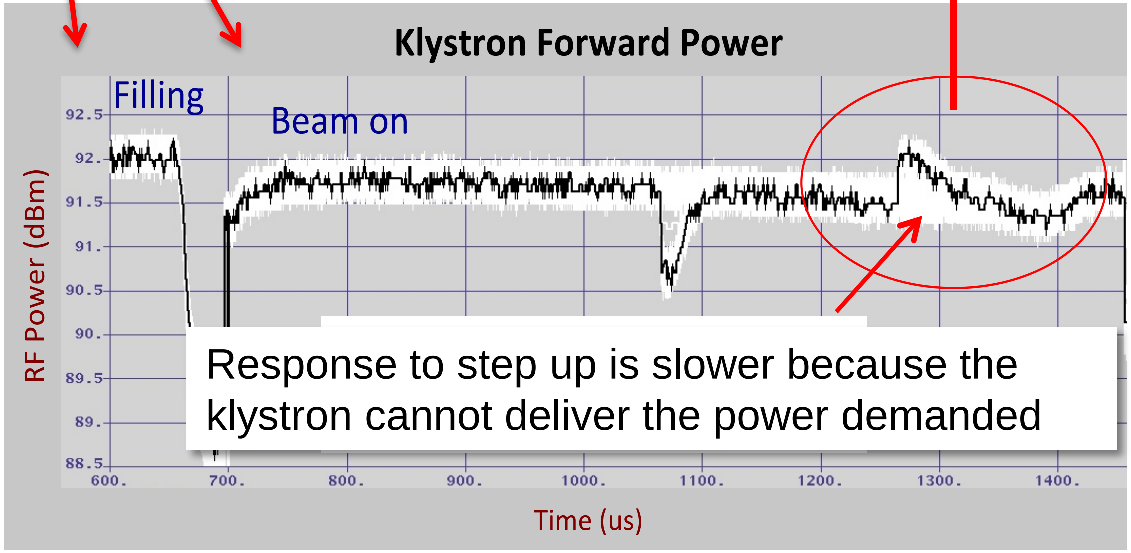
- Flattened individual gradients to **<<1% p-p**
- Several cavities within 10% of quench
- ‘Crash test’: very rapid recovery of 800us / 4.5mA after beam trip
- Ramped up current from ~zero to 4.5mA with ACC67 gradients approaching quench
- ‘Cavity gradient limiter’ to dynamically prevent quenching without turning off the rf

9mA Studies: evaluating rf power overhead requirements (4.5mA/800us bunch trains)

- Klystron high voltage was reduced from 108KV to 86.5KV so that the rf output just saturated during the fill
- The required beam-on power ended up being ~7% below saturation





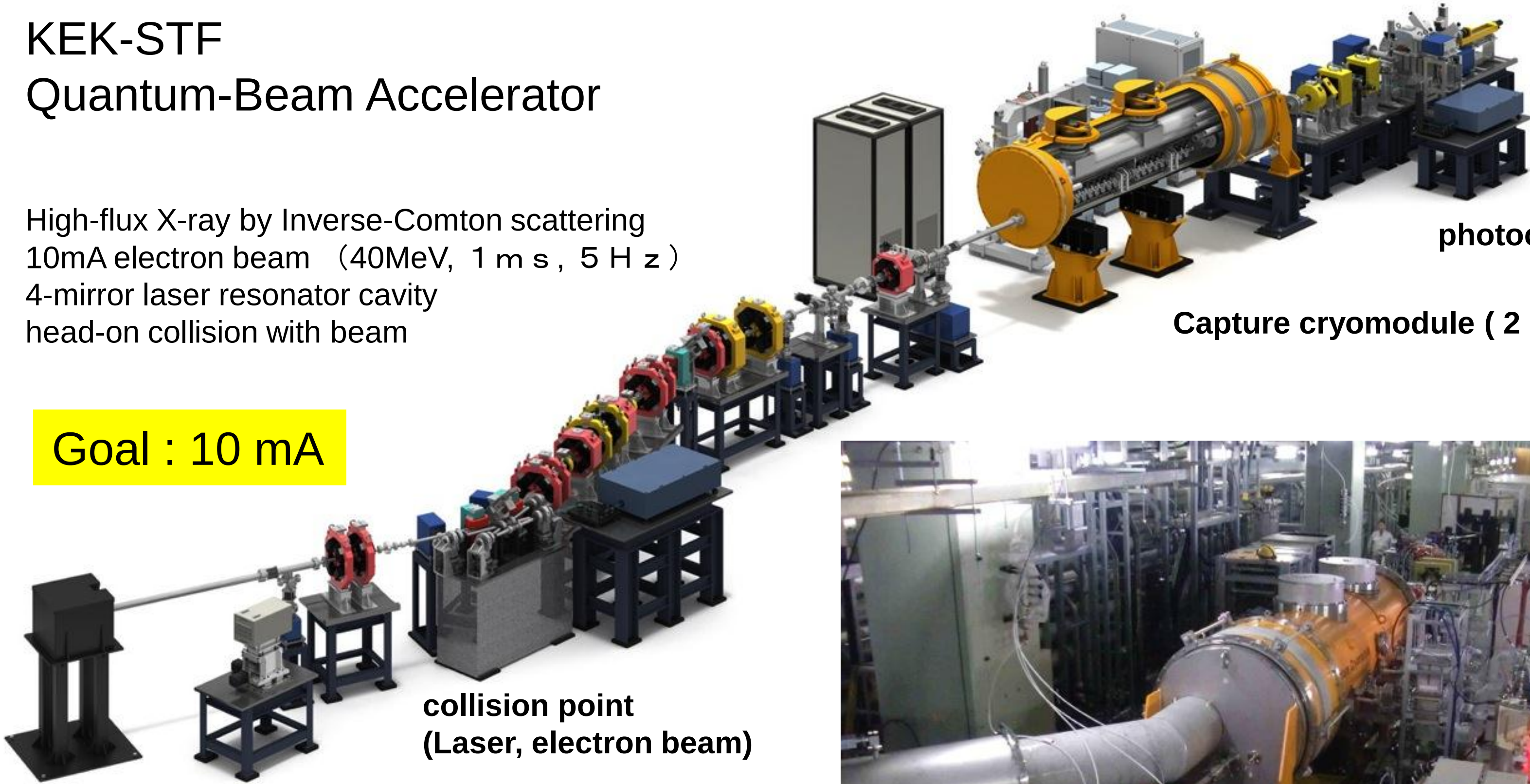


STF Quantum-Beam experiment

KEK-STF
Quantum-Beam Accelerator

High-flux X-ray by Inverse-Comton scattering
10mA electron beam （40MeV, １ｍｓ, ５Ｈｚ）
4-mirror laser resonator cavity
head-on collision with beam

Goal : 10 mA



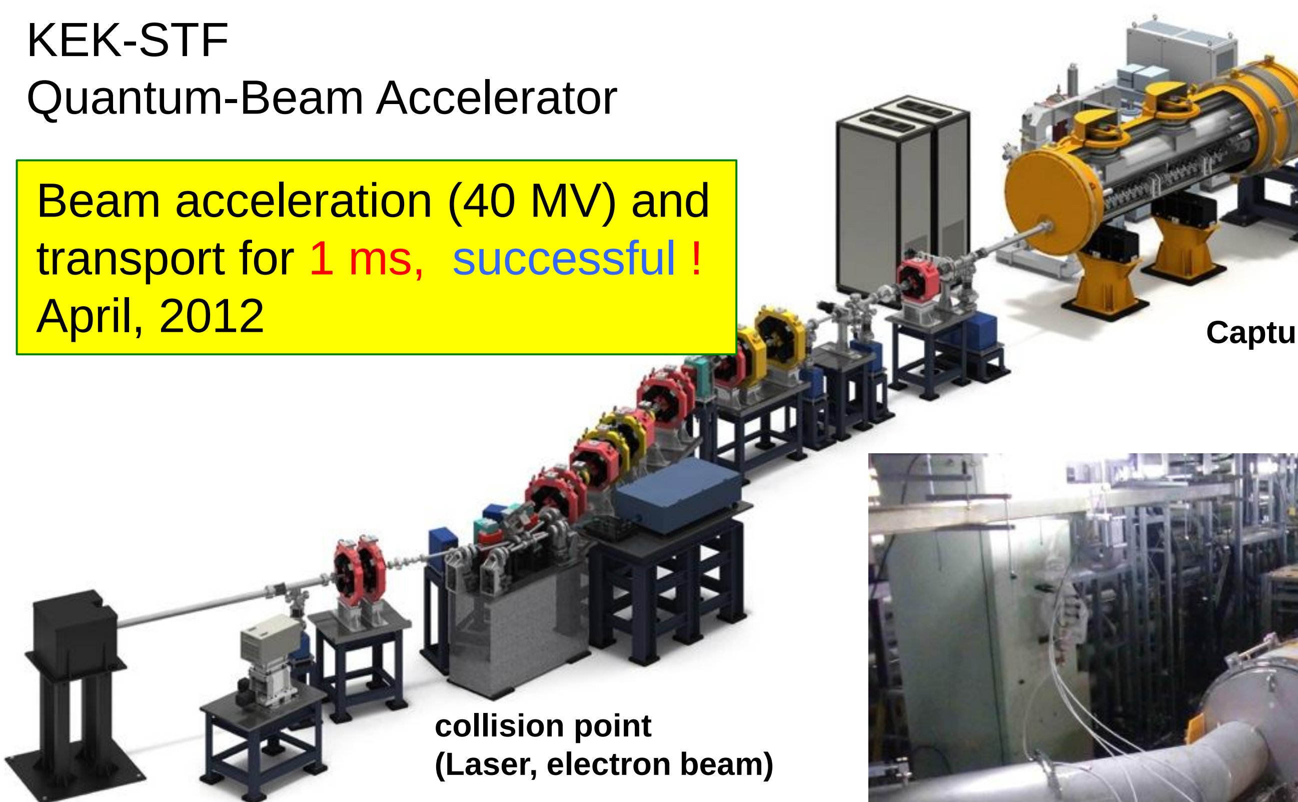
Target: 1.3 x 10^{10} photons/sec 1%bandwidth

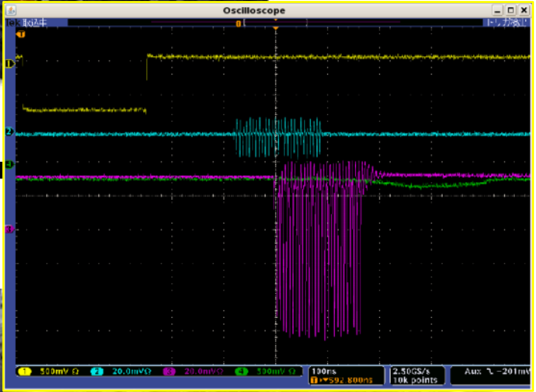
2012. Feb : cool-down started,
April : beam acceleration

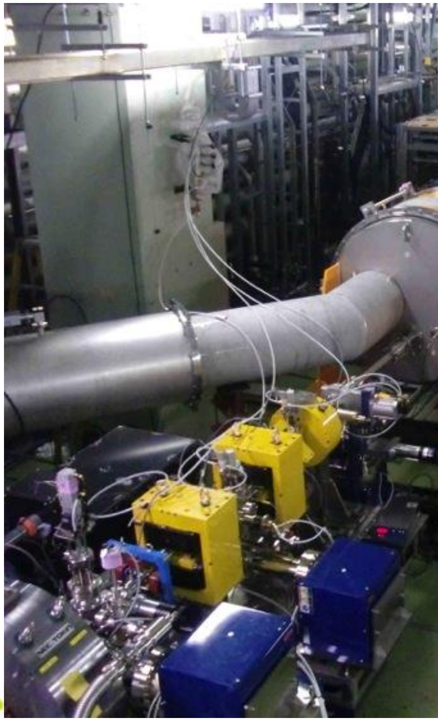
STF Quantum-Beam experiment

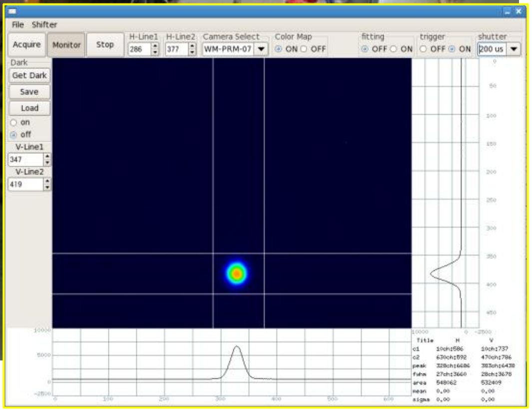
KEK-STF
Quantum-Beam Accelerator

Beam acceleration (40 MV) and transport for 1 ms, successful !
April, 2012









Target: 1.3 x 10^{10} photons/sec 1%bandwidth

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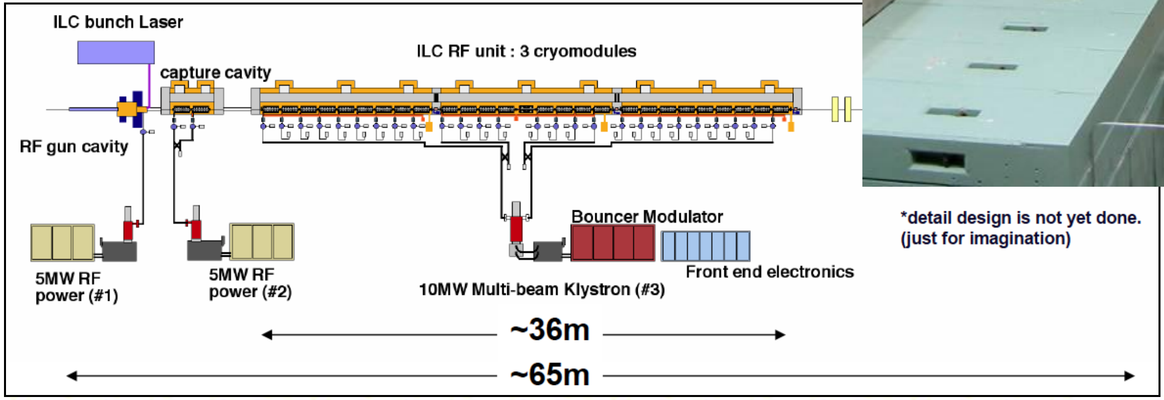
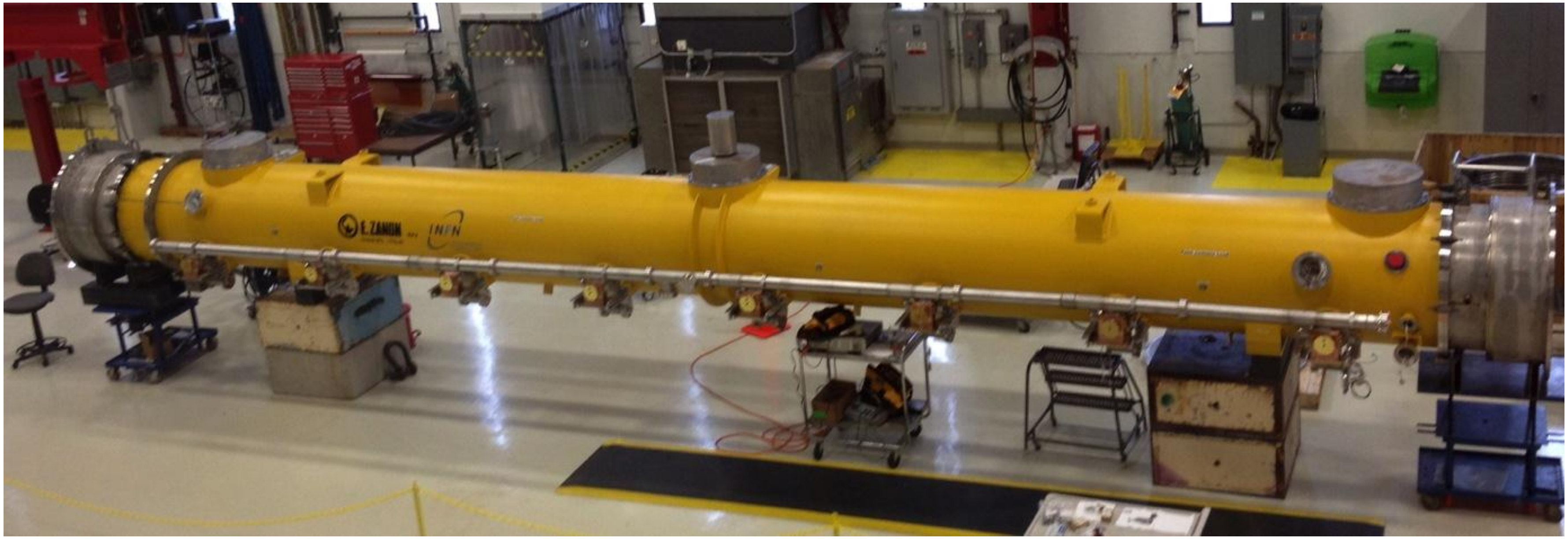
Beam Acceleration Test Plan at FNAL



CM-2 Cold Test Coming Soon going to NML, today!!

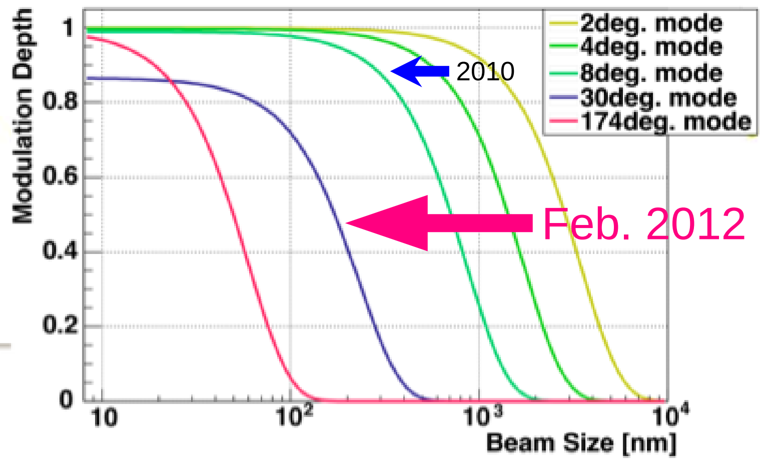
- **Assembly is largely complete**
  - Leak checking, some wiring remains
- **Expect CM-2 to arrive at NML mid-April**
  - After CM-1 is removed and transported
  - Then bring CM-2 to NML
  - Expect > 30 MV/m on average (7 cavities recorded > 35 MV/m in vertical test)



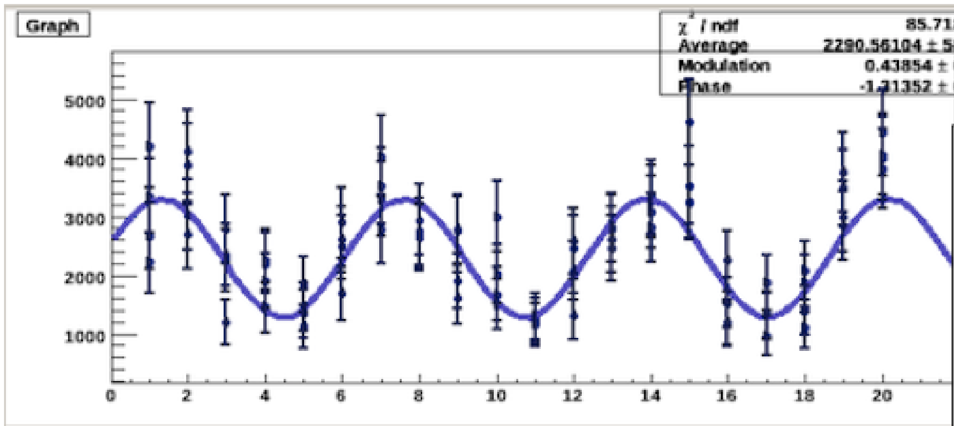
Accelerator System

- **BDS**
  - ATF recovery after “earth quake” in 2011
- **Damping Ring**
- **e+ source**
- **RTML and ML beam dynamics**

ATF2 status after the recovery of the 3.11 earthquake



Commissioning of 30 deg mode



σ_y^* = 201 ± 4.4 (stat.) nm

M_{meas} = 0.429 ± 0.012 (stat.)

From 10 stable consecutive scans
30 deg, Feb 17, 2012
(1((10 β^*_x x 10 β^*_y optics)

largest M_{meas} = 0.522 ± 0.042 ←→ $\sigma_{y,meas}$ ~ 165 nm

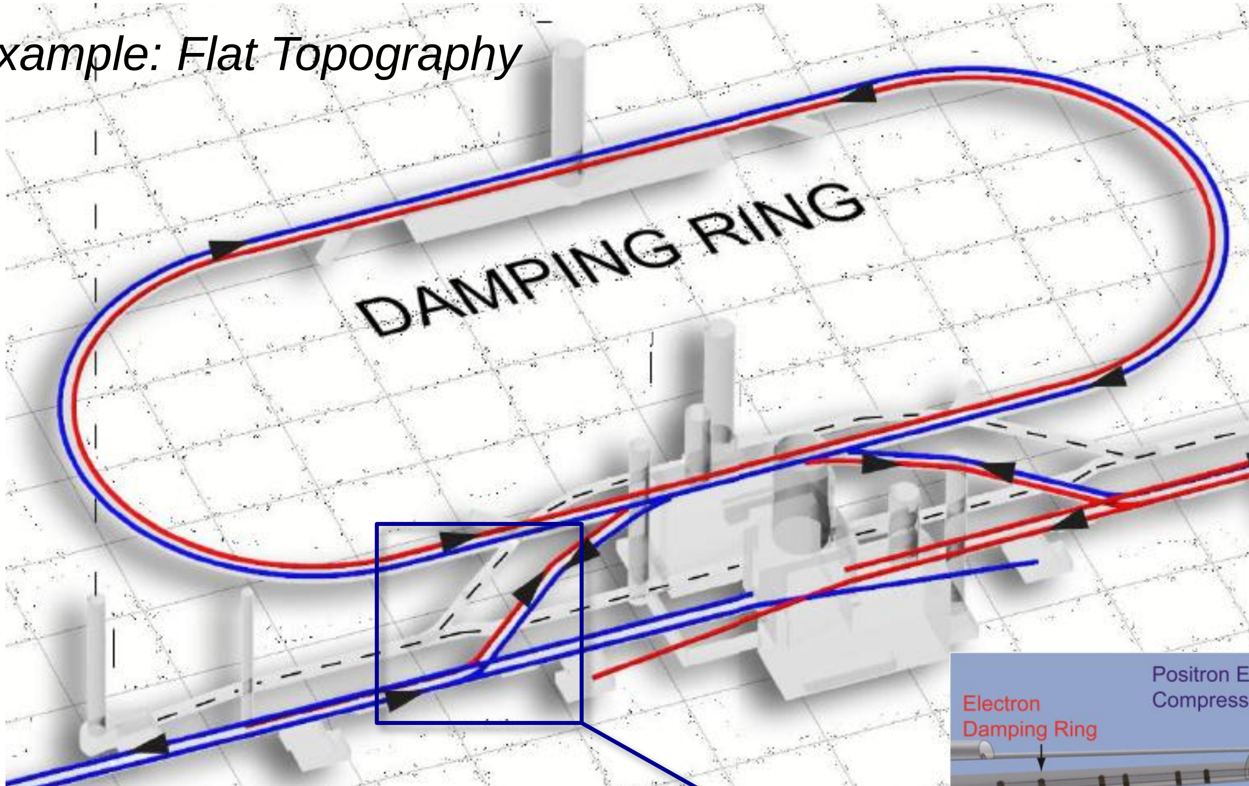
2/17: 30 deg	M	ΔM	σ_y^*	$\Delta\sigma_y^*$	avg E_{sig}/ ICT [GeV / 10^9e]
18:07	0.426	0.039	194.98	6.21	2.359
18:09	0.390	0.043	206.63	6.48	2.403
18:12	0.433	0.036	192.55	5.73	2.269
18:14	0.439	0.034	190.82	5.49	2.290
18:16	0.437	0.038	191.29	6.16	2.303
18:18	0.460	0.040	183.86	6.78	2.267
18:20	0.444	0.035	189.20	5.77	2.450
18:22	0.39	0.042	206.67	6.902	2.292
18:24	0.453	0.037	186.17	6.203	2.356
18:26	0.389	0.042	207.029	6.205	2.360

- *S/N : 4 – 5*
- *Signal jitter ~ 22%*
- *BG fluc. ~ 15%*

stable beam current

Central Region

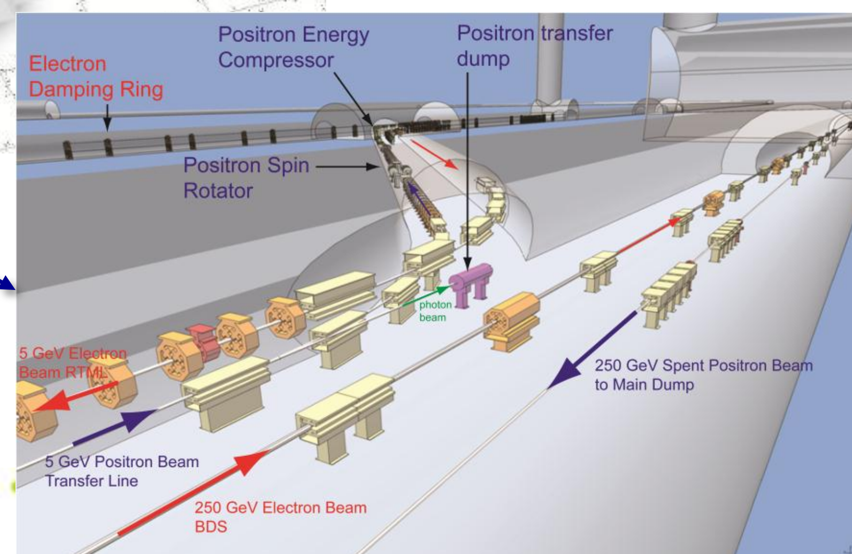
Example: Flat Topography



The central region **beam tunnel** remains a **complex region**.

Complete, detailed and **integrated lattices** are now available

(*independent of site*)

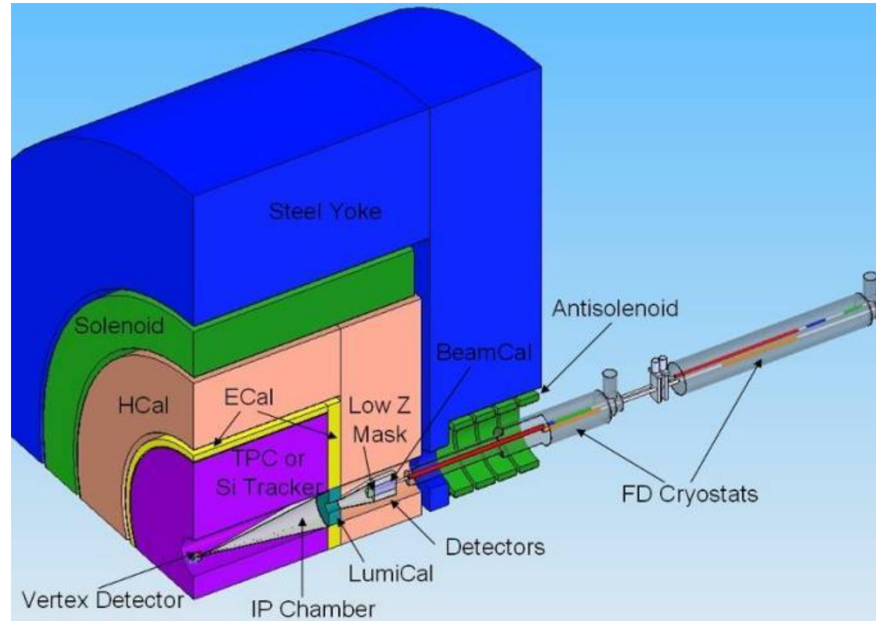


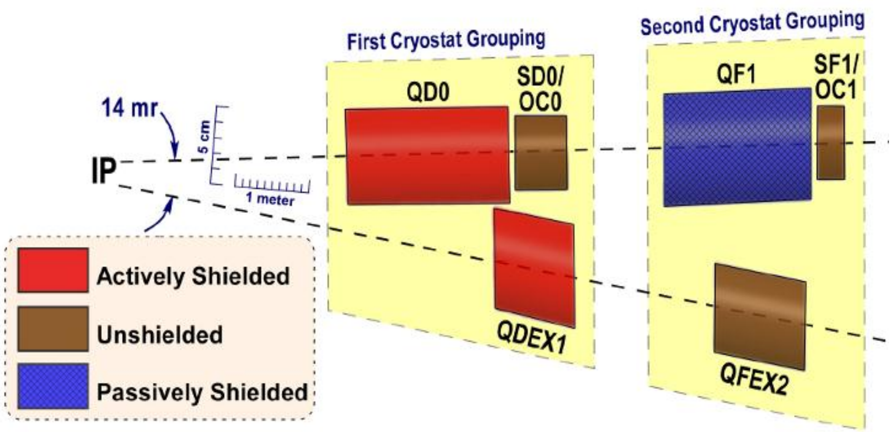
Generic design used for **geometry** and generating **component counts** and **CFS requirements**.

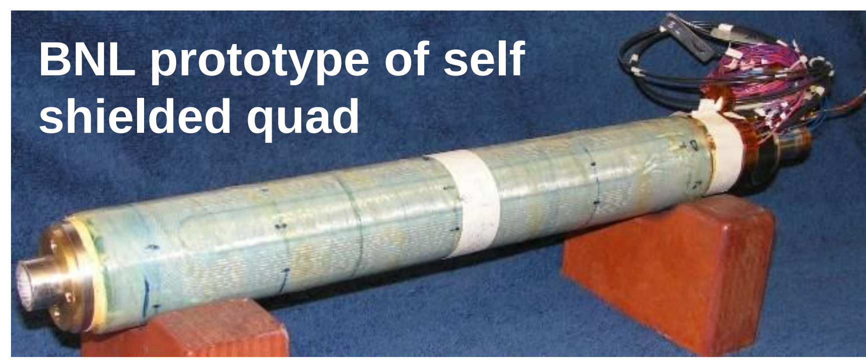
*CFS (particularly **CE**) solutions are **site-dependent**!*

IR region and Final focusing

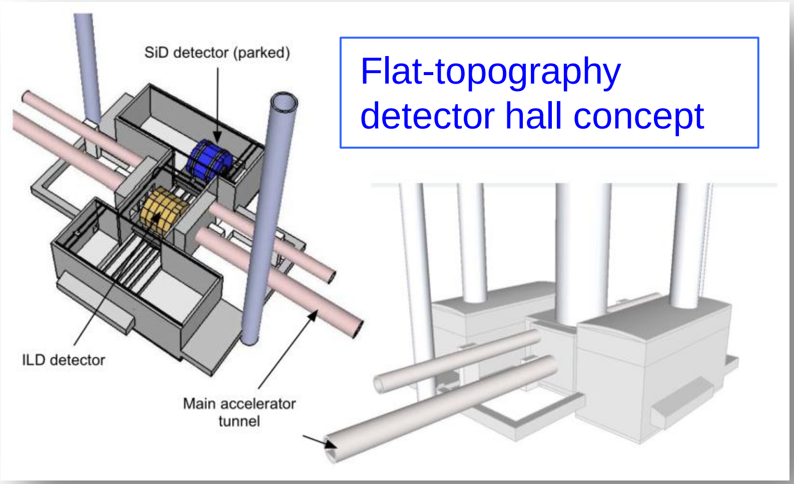
- **FD arrangement for push pull**
  - different L*
  - ILD 4.5m, SiD 3.5m
- **Short FD for low E_{cm}**
  - Reduced β_x*
    - increased collimation depth
  - “universal” FD
    - avoid the need to exchange FD
    - conceptual - requires study
- **Many integration issues remain**
  - requires engineering studies beyond TDR
  - No apparent show stoppers

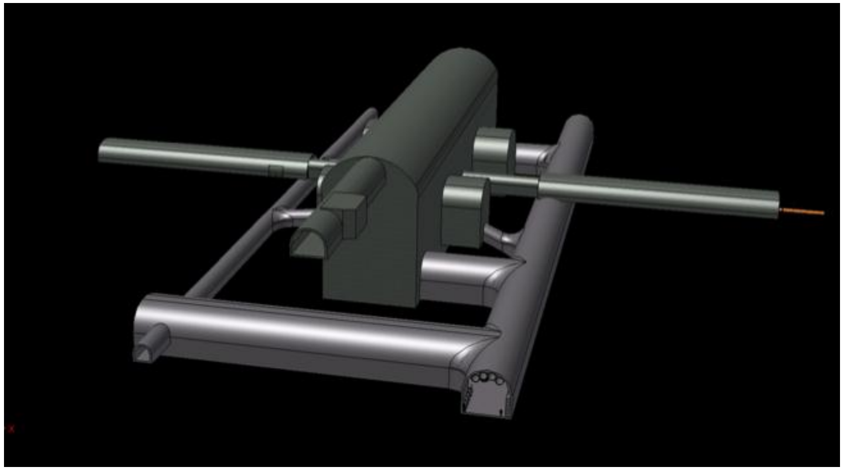






Detector Hall CFS Review





- **Review Questions:**
  - Criteria understood?
  - Design satisfy the criteria?
  - What are the cost-drivers?
  - What are the outstanding issues?
- **Presentations:**
  - Alignment requirements (special tunnels)
  - Underground Assembly schemes
  - Cryogenic systems
  - Cost roll-up
- **Report to be written.**

Machine-Detector-Interface

Detector Hall Review

May 16, 2012

Summary of Machine-Detector-Interface Detector Hall Review

Held at	KILC 12, Daegu Korea, April 25, 2012
Reviewed and Reported by:	
	GDE Project Managers (PMs):
	Akira Yamamoto, Marc Ross, and Nick Walker
Attendance:	KILC 12 GDE-WG4, GDE-WG6 and ACFA MDI WG.
Organized by ACFA MDI Conveners:	
	Gao Jie, Guinyum Kim, Toshiaki Tauchi, Hubert Gerwig, Thomas Markiewicz

A Review of the Detector Hall was held during the GDE / ACFA Plenary meeting 'KILC 12'. This is the Detector Hall Review Report. See:
http://ilcagenda.linearcollider.org/conferenceOtherViews.py?view=standard&confId=5414

Purpose of Detector Hall Review and Outcome

The following questions were asked at the review:

1) Are the Criteria understood? Has the CFS team correctly understood the detector hall functional requirements?
2) Does the Design satisfy the criteria? Has the CFS team produced a design that meets those criteria?
3) What are the cost-drivers? Which components of the design seem to have high cost; perhaps more than is justified by their function?
4) What are the outstanding issues? Which focus-points for CFS value engineering are recommended?

Yes

Yes

Shafts (KCS)
Installation (DKS)

See recommendation

Recommendations:

1) Consider and report further, (in writing to the Reviewers), on the AMs basis of estimate of the flat-topography shafts. In addition, tabulate and provide the EU estimate for shaft and detector hall construction with EU basis of estimate information that can be compared with the AMs estimate presented at the Review. (CFS)
2) Develop 'proof-of-principle' detector and machine installation schemes to show the single 11m wide access tunnel will work. (MDI)
3) Consider retaining Arup for a comparative evaluation of all three sample sites. (CFS)

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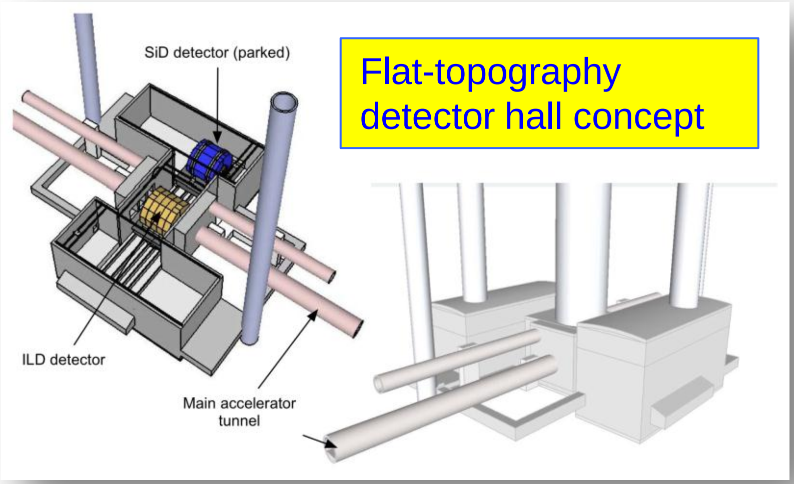
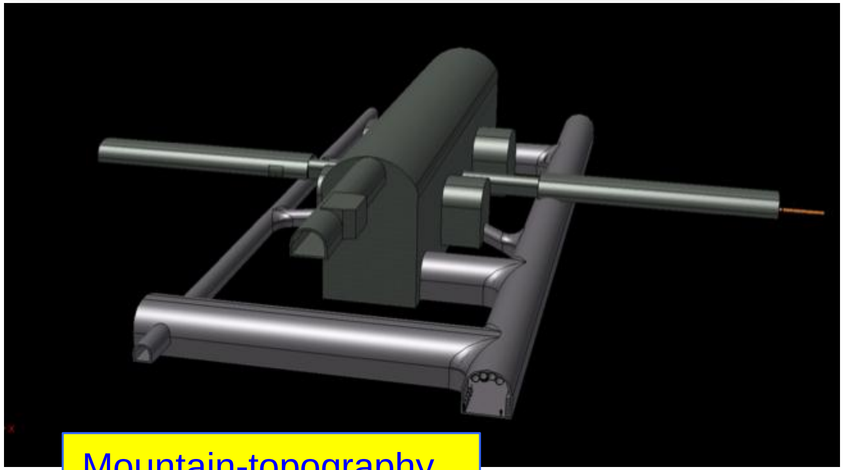
3) Consider retaining Ar

How can the ILD / SiD / MDI groups do this alone without a working agreement between themselves and between ILD and the machine installation group **?**

Detector Installation



Flat-topography detector hall concept



Mountain-topography detector hall concept

Comments by M. Ross:

- In mountain region,
  - an 11-m diameter access tunnel may need to be shared with SiD and ILD, under very careful coordination.
- Please consider an example:
  - the installation and assembly of ILD with the use of the access tunnel restricted to only one 8 hour shift per day (1/3 occupancy).
  - The other two shifts will be used by SiD and machine installation.

Technical Design Report

2007

2011

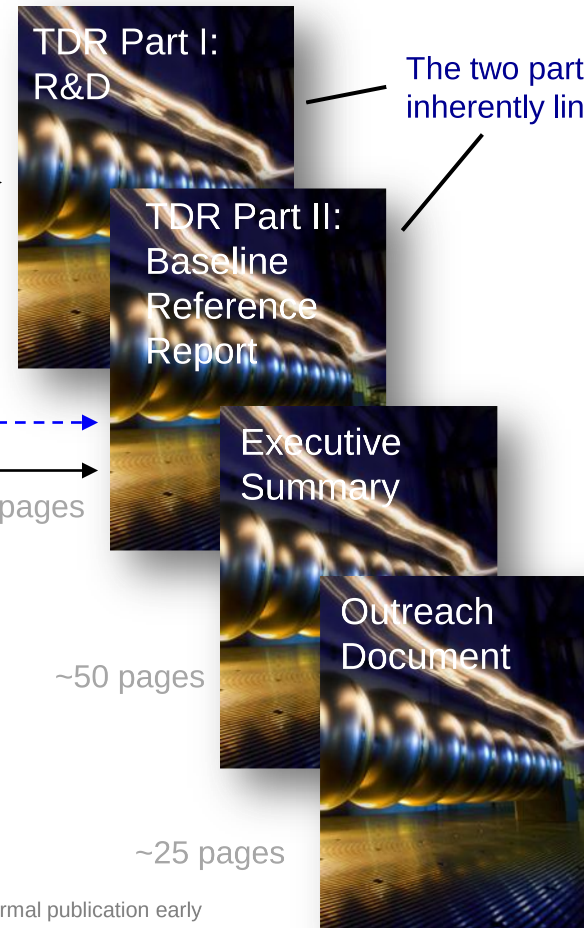
2013*

ILC Technical Progress Report
(“*interim report*”)

AD&I

Reference Design Report

Technical Design Report



~250 pages

~300 pages

~50 pages

~25 pages

The two parts are inherently linked

* end of 2012 – formal publication early 2013

Publication and Review

First-draft sections	*** 23 April ***
Complete edited draft	22 October (ILCWS 12)
Final draft (for PAC)	15 November
PAC review	15-16 December

Formal publication at Lepton Photon Conf. (SF, June 2013)

→

Expect international reviews:
Both technical and cost (Q1-22 2013)

Summary

- **ILC accelerator technology**
  - SCRF R&D rogressin to demonstrate the cavity gradient toward the ILC requirement, 35 MV/m,
  - Beam test facilities progressing to demonstrate the ILC accelerator requirements,
- **Technical Design Report (TDR)**
  - Contents being settled w/ flat and mountainous cases,
  - Draft being submitted, and the final draft due LCWS-12, Oct., 2012
- **Further work beyond 2012**
  - Further communication on BDS/MDI and Project Implementation Plan **including both detector assemblies** under expected boundary conditions
  - Advanced accelerator R&D for cost saving and upgrade capability
  - Further studies to be ready for various energy operation

Backup

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