# GDE Summary

A. Yamamoto, N. Walker, and Marc Ross
ILC-GDE Project Managers

*KILC12-Closing Plenary , 12-04-26*

# Outline

- **GDE Technical update/progress, since LCWS11, Granada**
  - SCRF and Beam Test Facilities
    - Gradient yield, after Sept. 2011
    - Test facilities: FLASH, STF/QB, NML, and ATF,
    - Industrialization studies in contracts w/ RI, AES, MHI, Hitachi, Toshiba, and BN
  - CFS
    - Progress in two categories: Flat and Mountainous layout
    - Detector hall review
  - Accelerator System
    - Damping ring design
    - Target R&D
    - ML lattice and parameters
- **Technical Design Report**
  - Progress in writing and plan to complete it by Dec. 2012
- **Technical studies beyond TDR**
  - R&D: such as high-gradient, industrialization, target, and …
  - Study: to be prepared for variety of energy requirements including upgrade up to 1 TeV

# Plan and Progress in SCRF/ATF

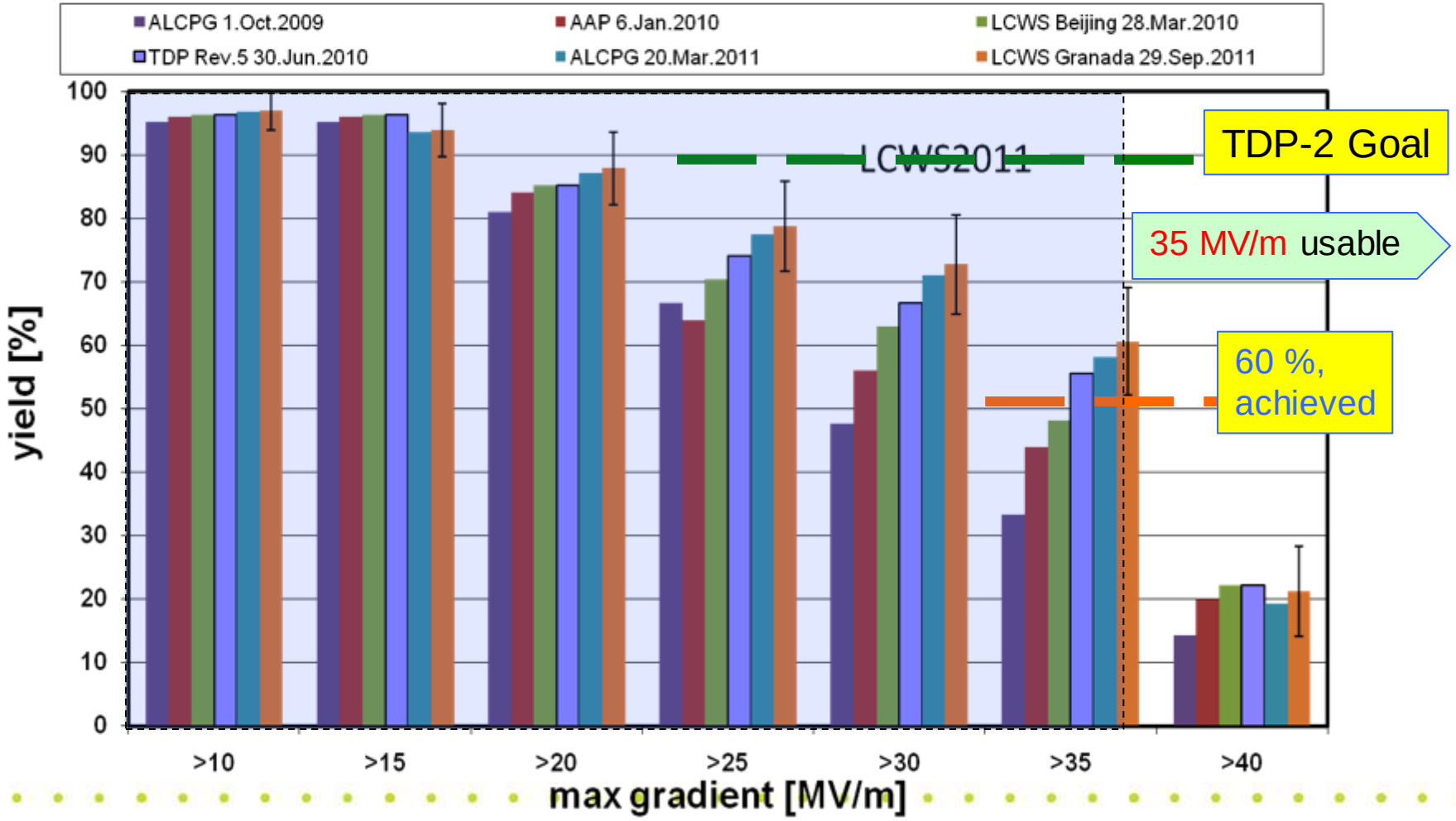
| Year | 07 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Phase | TDP-1 | | | | TDP-2 | |
| Cavity Gradient in v. test to reach 35 MV/m | → Yield 50% | | | | → Yield 90% | |
| Cavity-string to reach 31.5 MV/m, with one-cryomodule | | Global effort for string assembly and test (DESY, FNAL, INFN, KEK) | | | We are here | |
| System Test with beam acceleration | | | FLASH (DESY) , NML (FNAL) STF2 / ATF (KEK) | | | |
| Preparation for Industrialization | | | | Production Technology R&D | | |
| Communication with industry: | 2011-2012: Mass production studies in contract | | | | | |

# Progress Integrated in Cavity Gradient Yield

## Updated, Sept., 2011

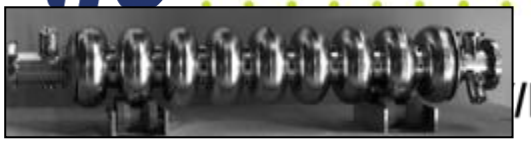
Plot courtesy
Camille Ginsburg of FNAL

**Electropolished 9-cell cavities**
**/KEK (combined) up-to-second successful test of**
**cavities from established vendors**



# Progress Integrated in Cavity Gradient Yield

## Updated, April., 24, 2012



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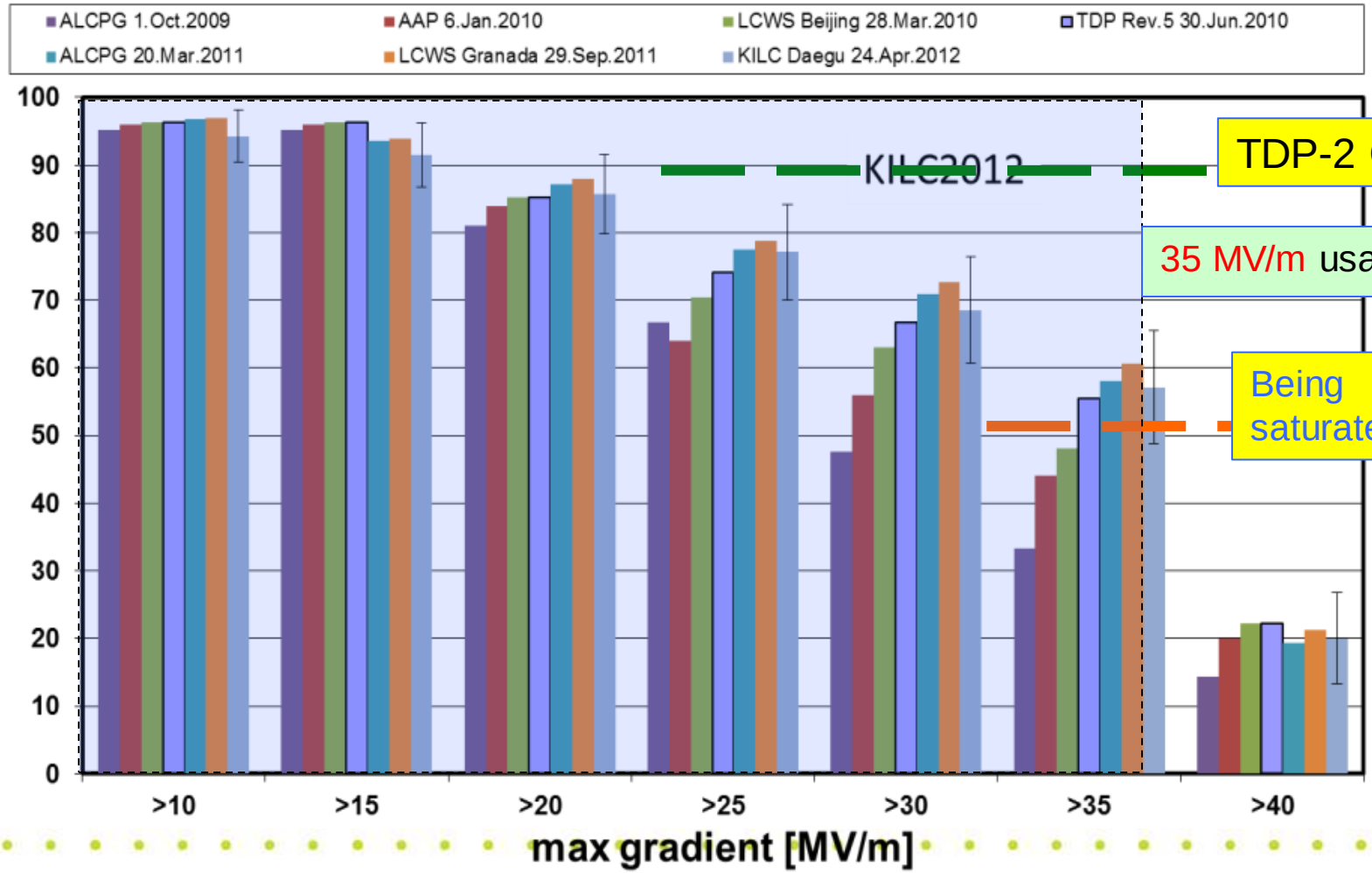
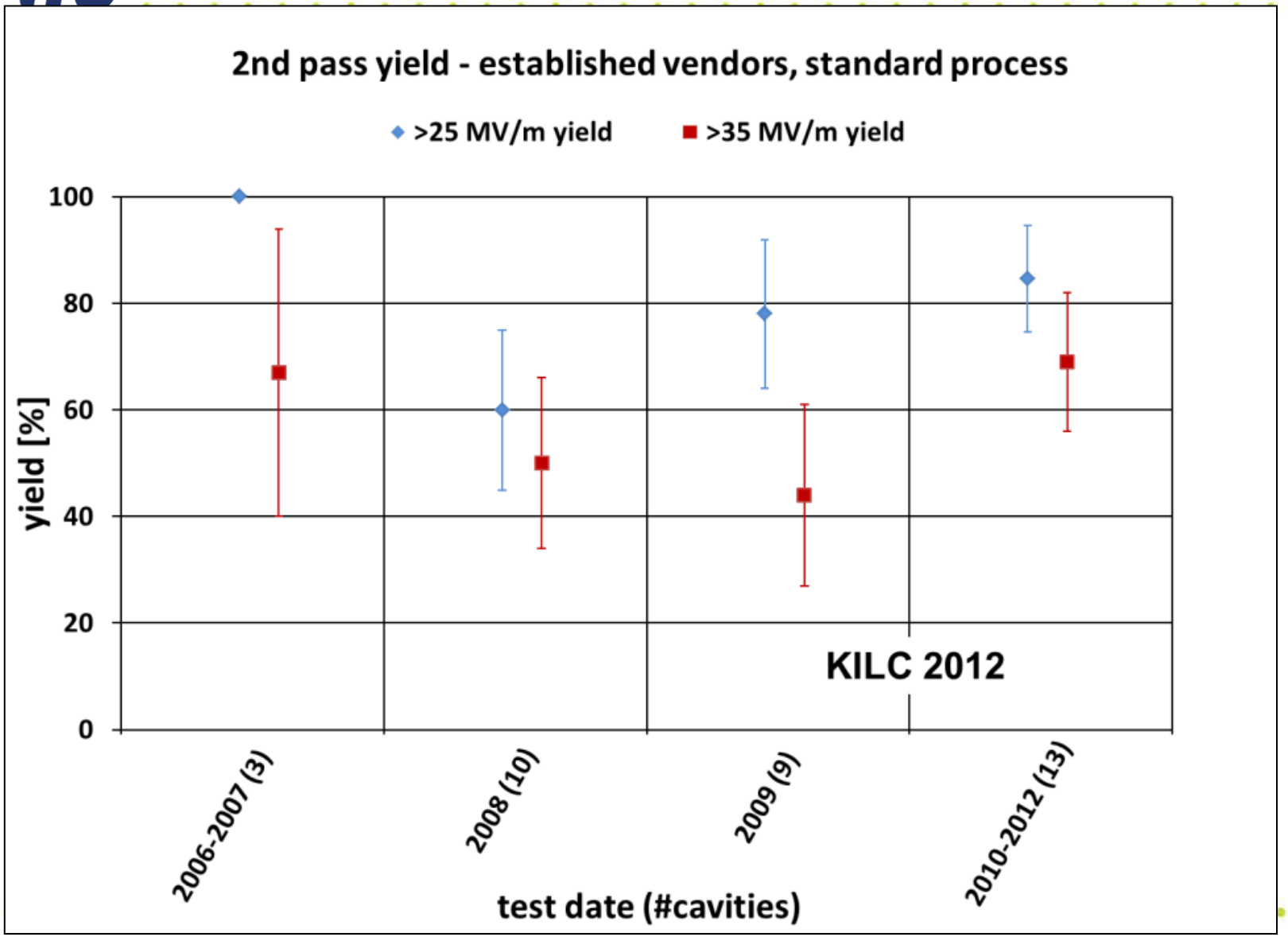


# Yearly Progress in Cavity Gradient Yield

## as of April 24, 2012



# Yearly Progress in Cavity Gradient Yield

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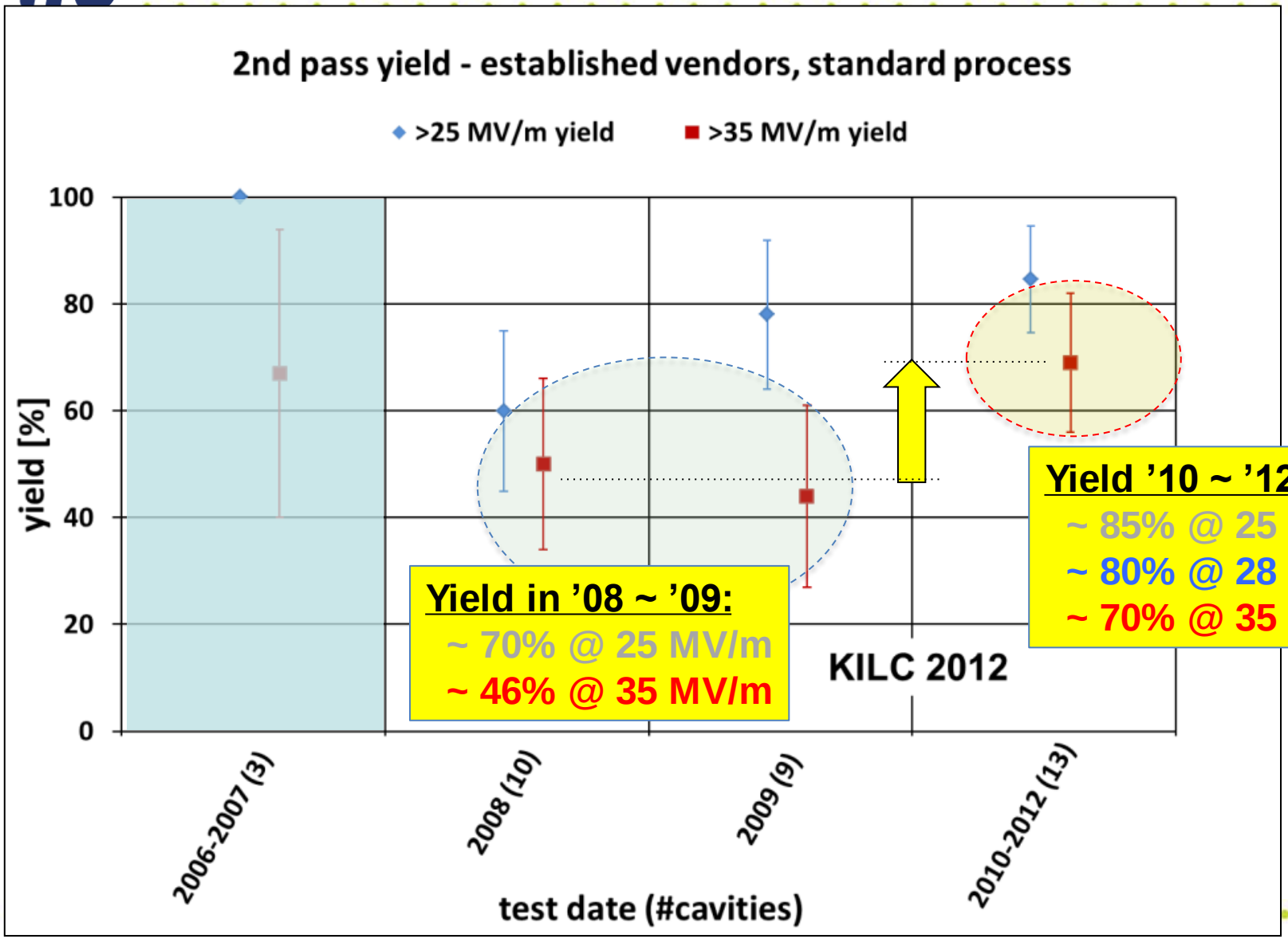
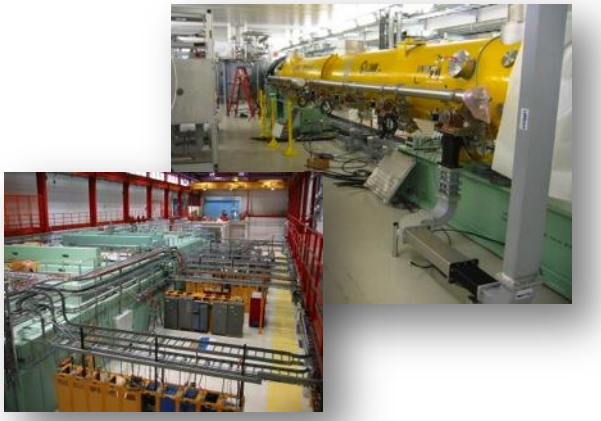


# System Tests

**FLASH** (DESY)
- TDP focus
- 7 CM → 1.2 GeV beam
- photon user facility

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



**STF** , **ATF** (KEK)
- "Quantum Beam" experiment 2011
- 1 CM with beam 2013
- (2 CM 2015)

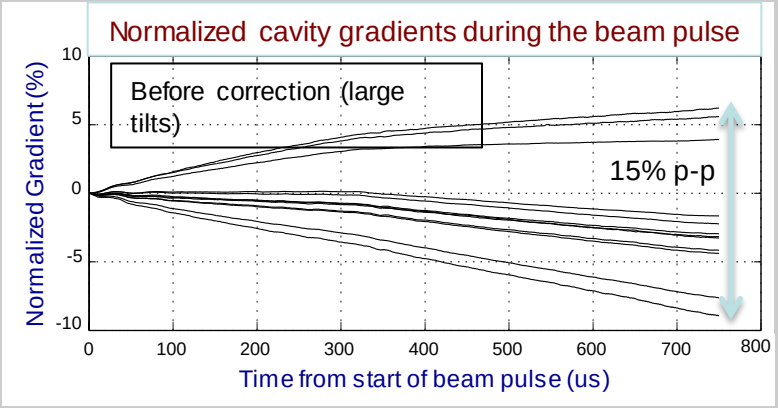
"9mA experiment"
achieved ~1800 bunches at 9mA in 09.2009

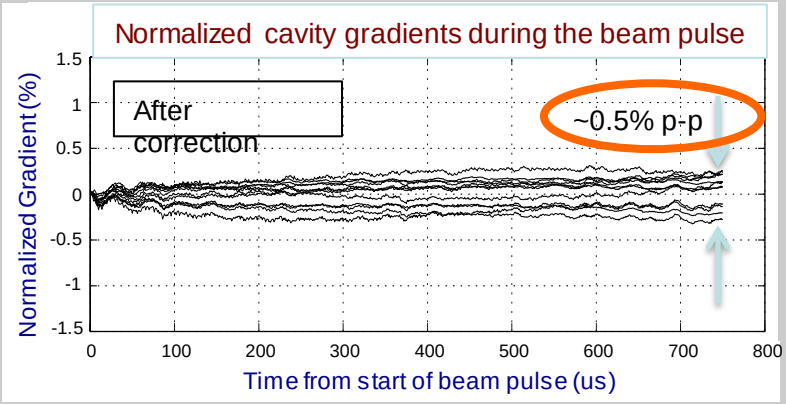
$\Delta E/E_{RMS}$ ~0.5% (@ 0.8 GeV)
~0.1% within pulse

Full systems integration testing

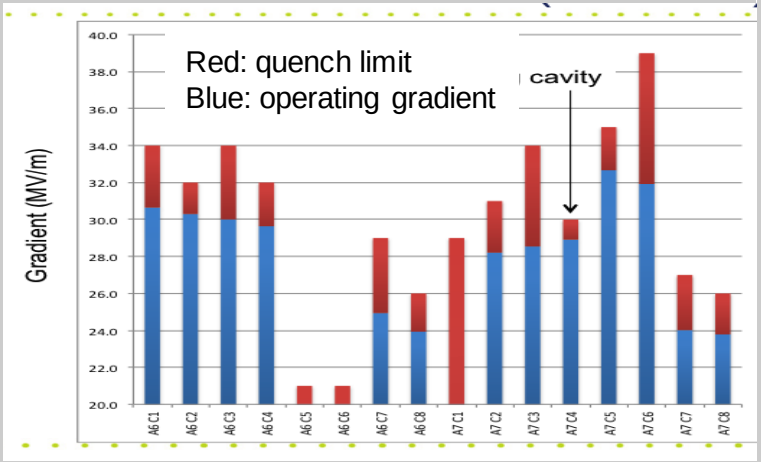
# FLASH 9mA Studies: beam operation close to cavity gradient limits (4.5mA/800us bunch trains)

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




## Operation at 380MeV on ACC67 (13 cavities)

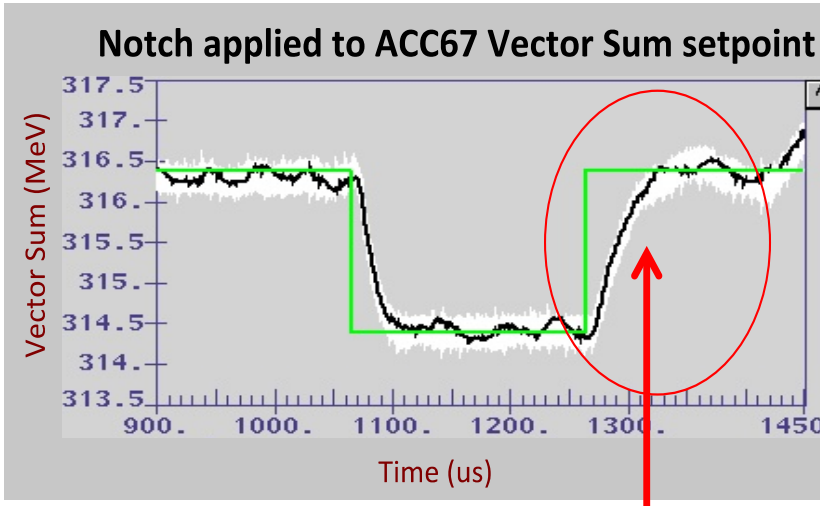


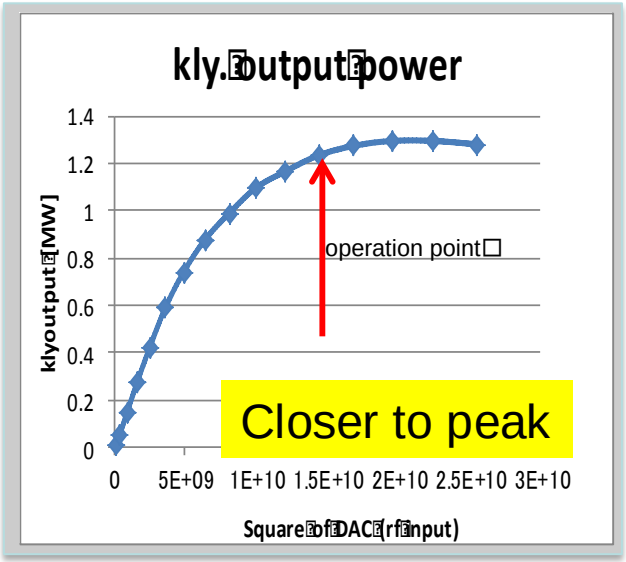

The limiting cavity is within 5% of quench

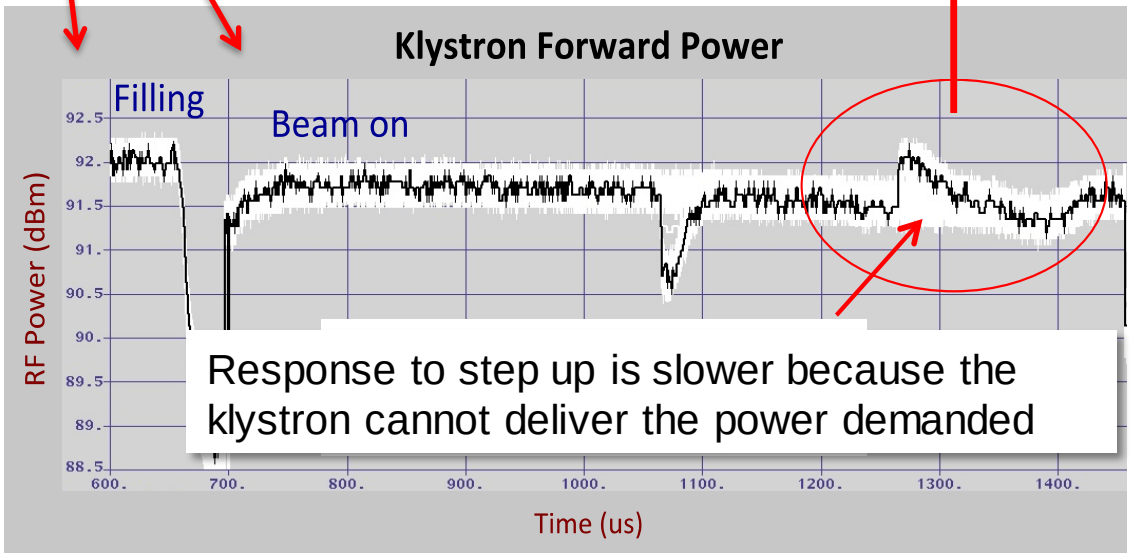
- Flattened individual gradients to **<<1% p-p**
- Several cavities within 10% of quench
- 'Crash test': very rapid recovery of 800us / 4.5mA after beam trip
- Ramped up current from ~zero to 4.5mA with ACC67 gradients approaching quench
- 'Cavity gradient limiter' to dynamically prevent quenching without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



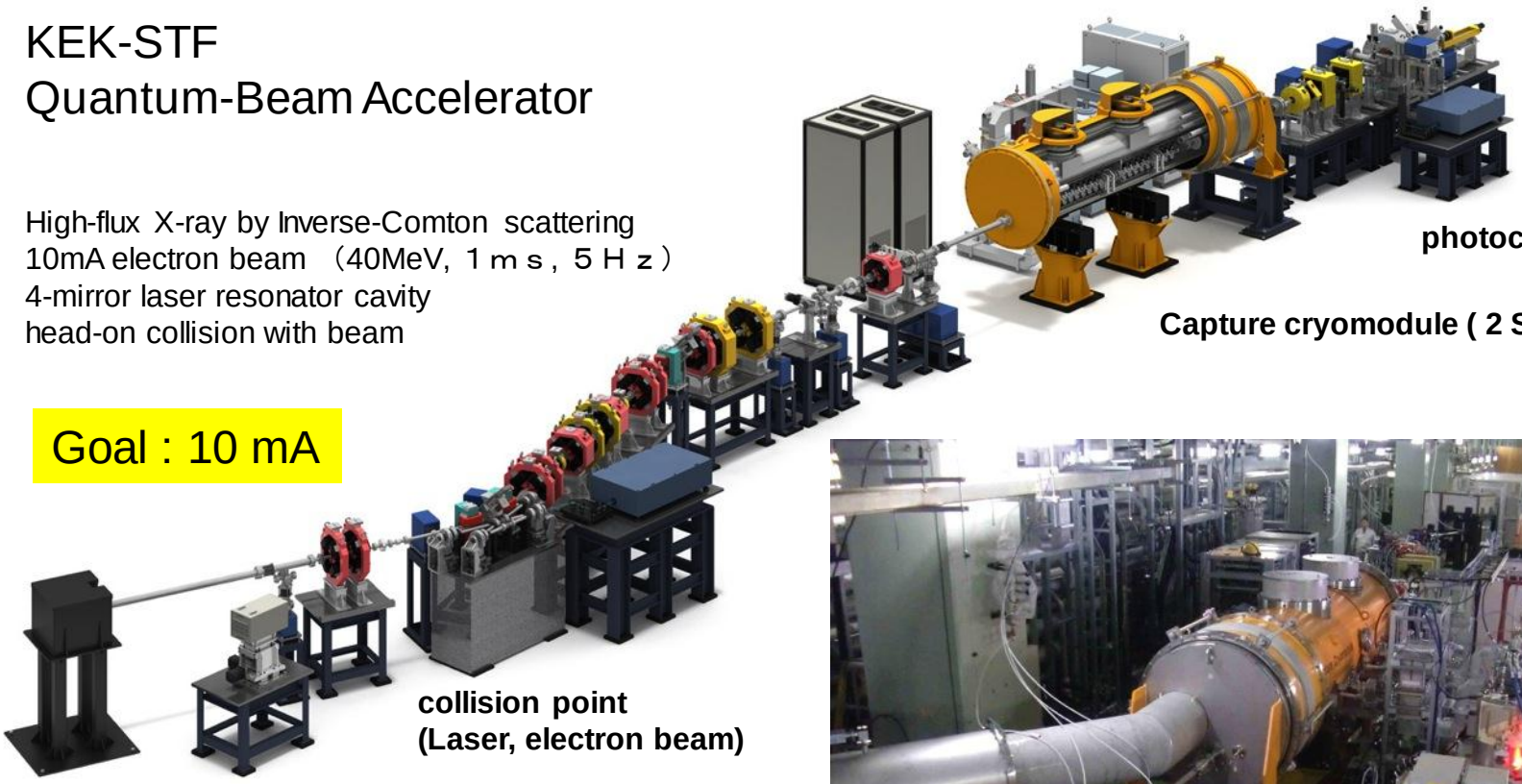



# STF Quantum-Beam experiment

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



**photocathode RFgun**

**Capture cryomodule ( 2 SC cavities )**

**collision point**
**(Laser, electron beam)**

Goal : 10 mA

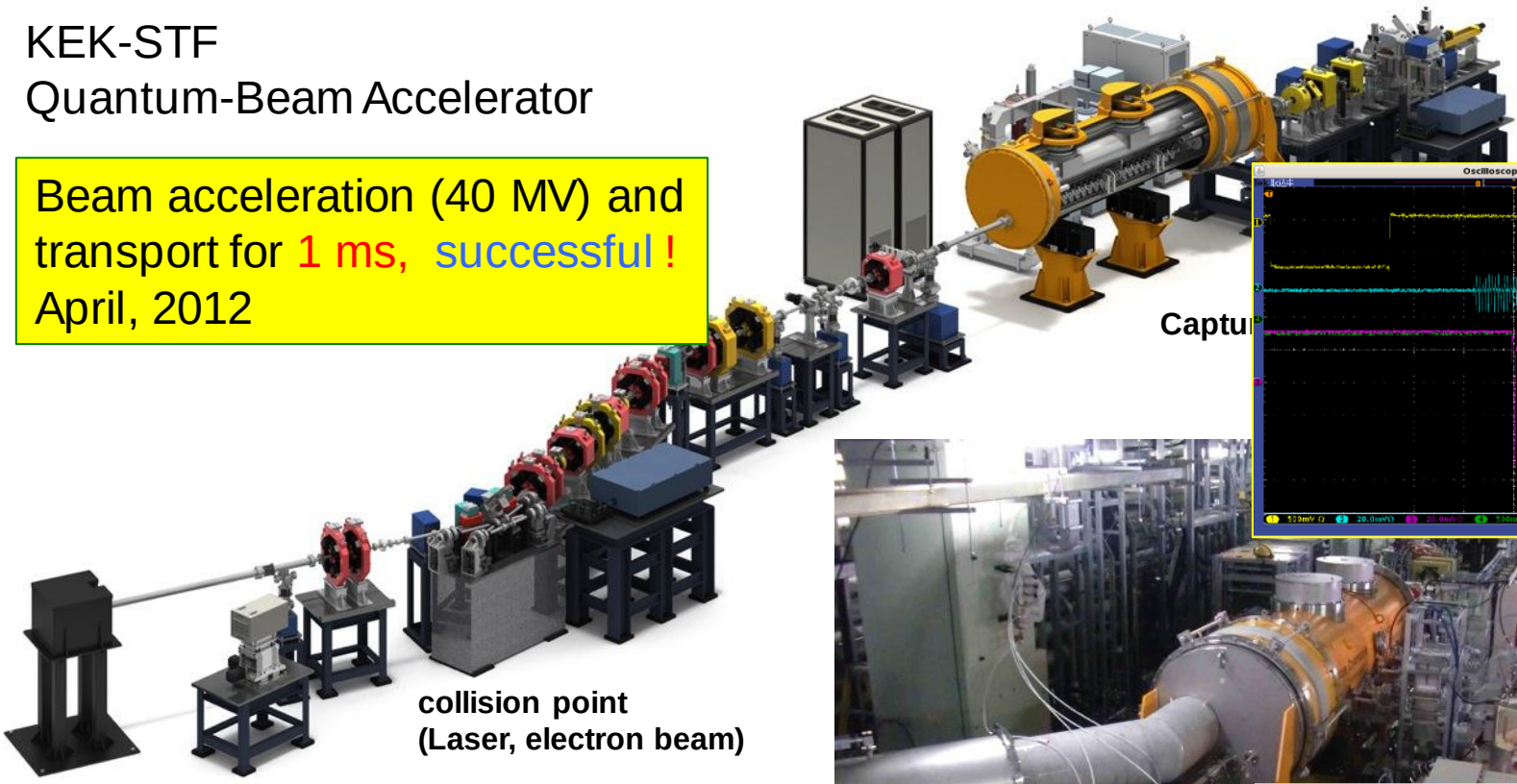
Target: 1.3 x $10^{10}$ photons/sec 1%bandwidth

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

# STF Quantum-Beam experiment

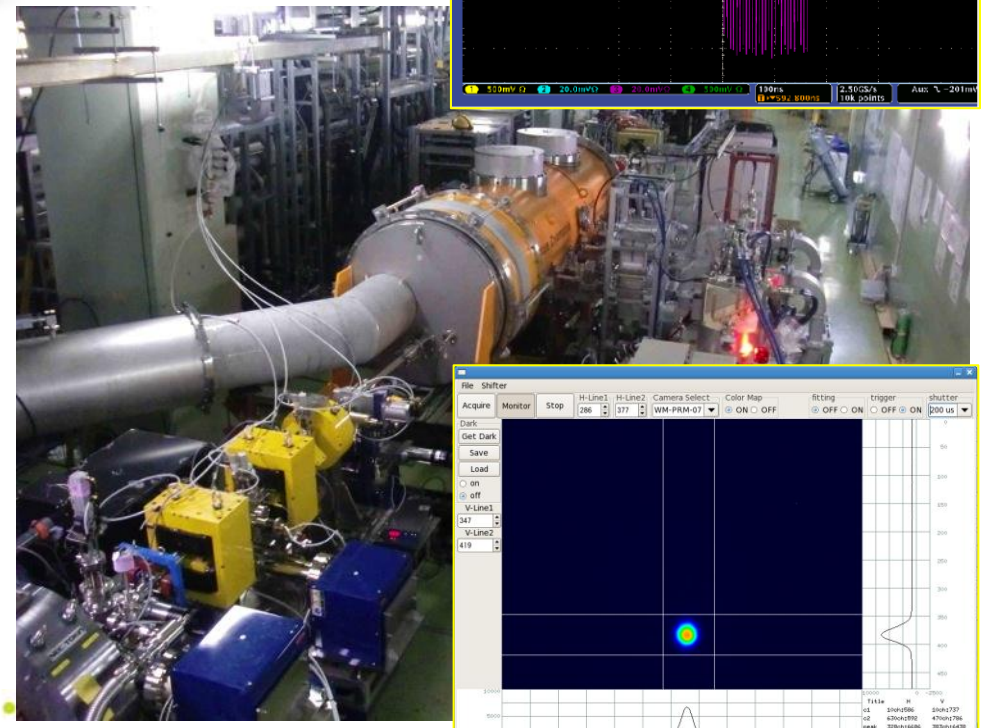
KEK-STF
Quantum-Beam Accelerator

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



collision point
(Laser, electron beam)



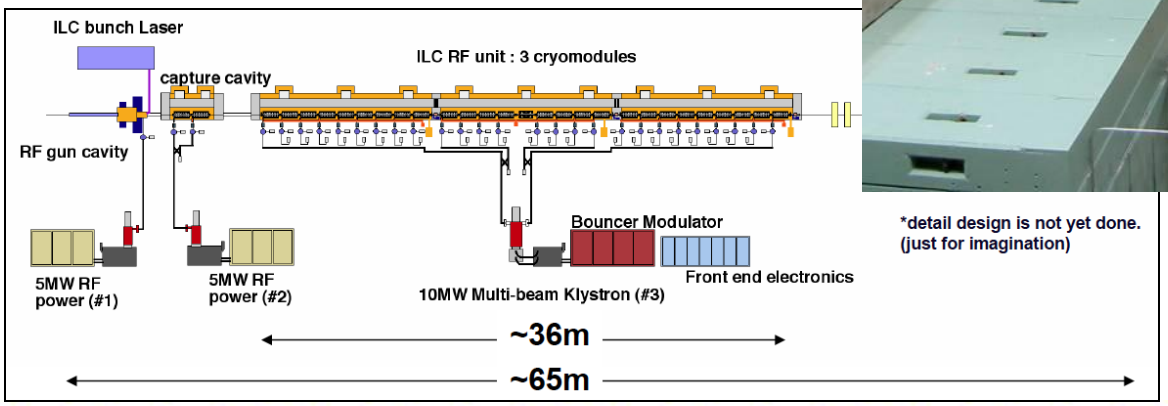





Target: 1.3 x $10^{10}$ photons/sec 1%bandwidth

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

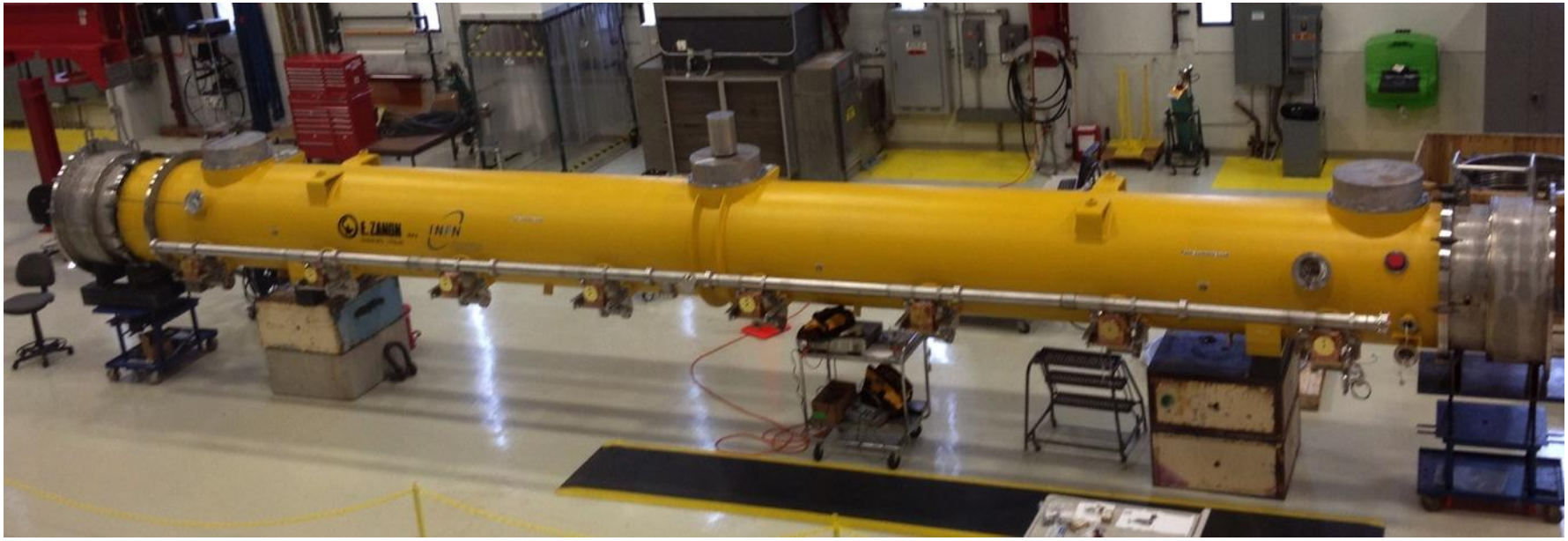
# Beam Acceleration Test Plan at FNAL



# CM-2 Cold Test Coming Soon

## going to NML, today!!

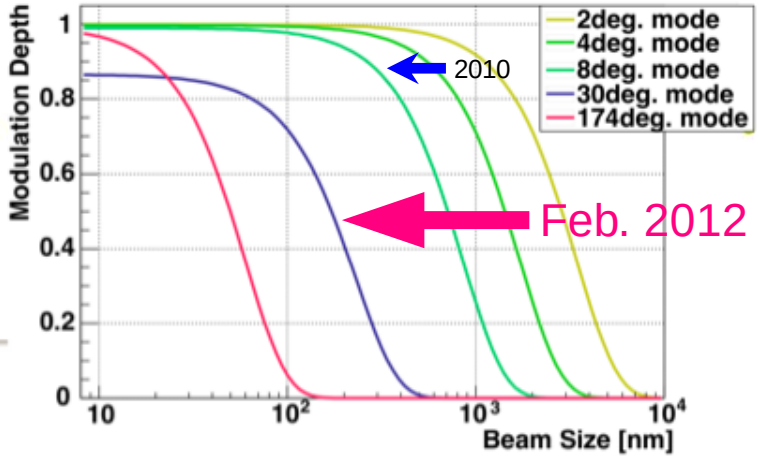
- **Assembly is largely complete**
  - Leak checking, some wiring remains
- **Expect CM-2 to arrive at NML mid-April**
  - After CM-1 is removed and transported
  - Then bring CM-2 to NML
  - Expect > 30 MV/m on average (7 cavities recorded > 35 MV/m in vertical test)



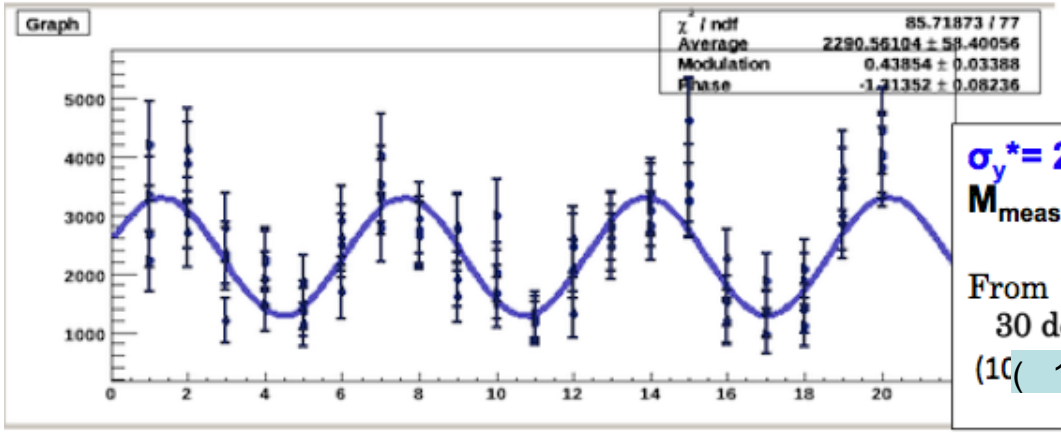
# Accelerator System

- **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




**$\sigma_y$*= 201 ± 4.4 (stat.) nm**
**$M_{meas}$ = 0.429 ± 0.012 (stat.)**

From 10 stable consecutive scans
30 deg, Feb 17, 2012
(10( 10 $\beta^*_x$ x 10 $\beta^*_y$ optics )

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

| 2/17: 30 deg | $M$ | $\Delta M$ | $\sigma_y^*$ | $\Delta\sigma_y^*$ | avg $E_{sig}$/ ICT [GeV / $10^9$e] |
|---|---|---|---|---|---|
| 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 |

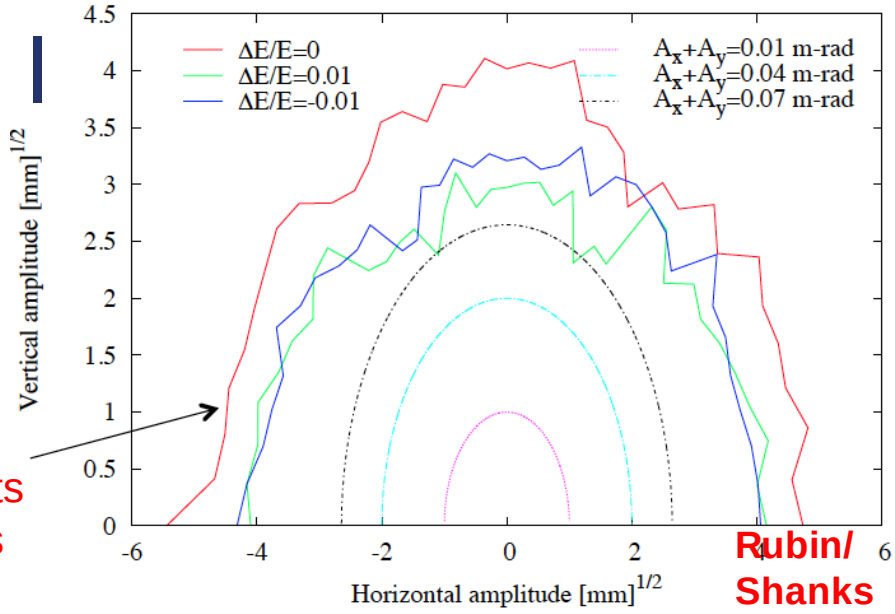
- *S/N : 4 – 5*
- *Signal jitter ~ 22%*
- *BG fluc. ~ 15%*

stable beam current

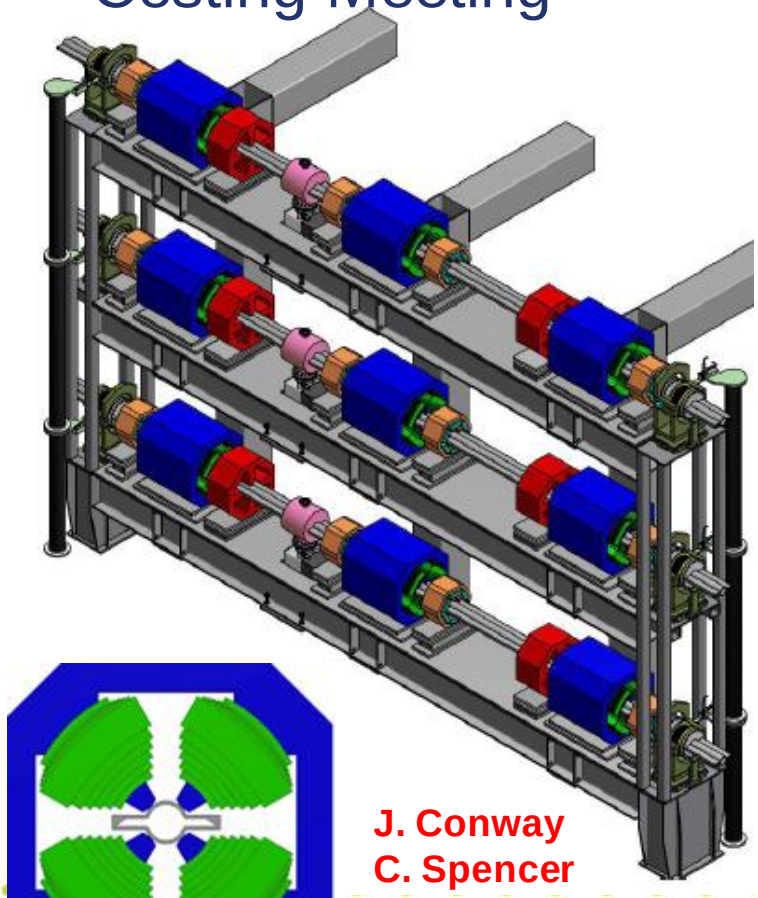
# Damping Rings I

- DTC04 Lattice Evaluations
- Magnet Design & Layout Review
- Costing Meeting

DA with misalignments & field errors




Rubin/ Shanks





J. Conway
C. Spencer

| Parameter | RMS |
|---|---|
| BPM – Differential resolution | 2 μm |
| BPM – Absolute resolution | 100 μm |
| BPM – Tilt | 10 mrad |
| BPM button – Gain variation | 1% |
| Quads + Sexts – Offset (H+V) | 50 μm |
| Quads – Tilt | 100 μrad |
| Dipole – Roll | 100 μrad |
| Wiggler – Offset (V only) | 200 μm |
| Wiggler - Roll | 200 μrad |

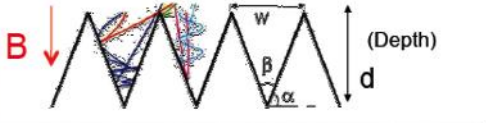
Ring Tolerances Evaluation for $\varepsilon_y$=2 pm using current LET Algos

# Damping Rings II

Pivi Talk

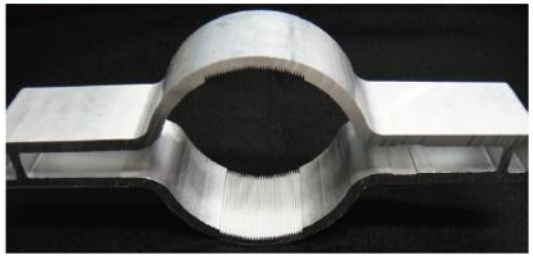
- EC Mitigations & Status
- Vacuum System Design/Costing
  - **SuperKEKB VCs in production with similar designs to ILC DR**

***SuperKEKB Dipole Chamber***




et al.

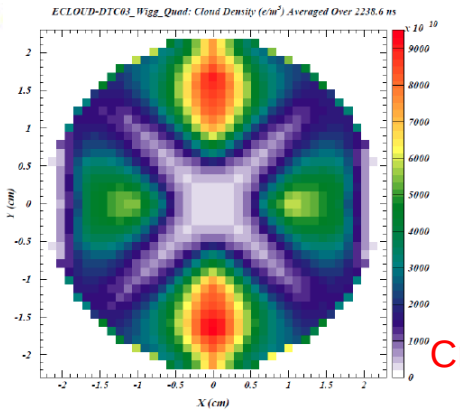
Valley : R0.1~0.12
Top : R0.15
Angle : 18~18.3°

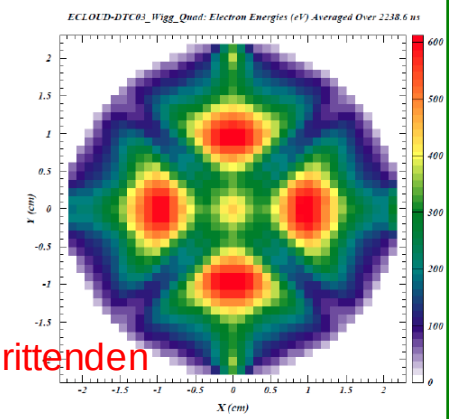


Y. Suetsugu

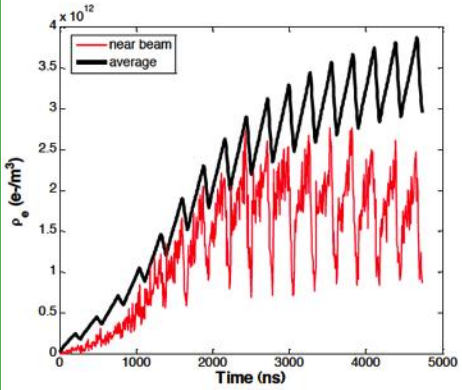
## EC Build-up in Quads in Wiggler Straight

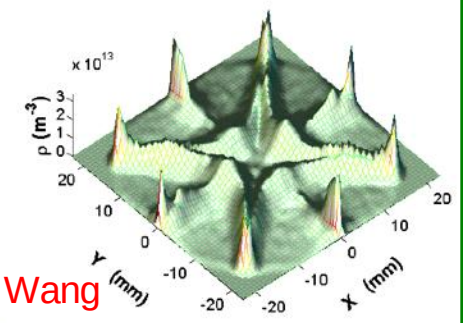
Electron cloud density (e/m$^3$) | Electron energies (eV)



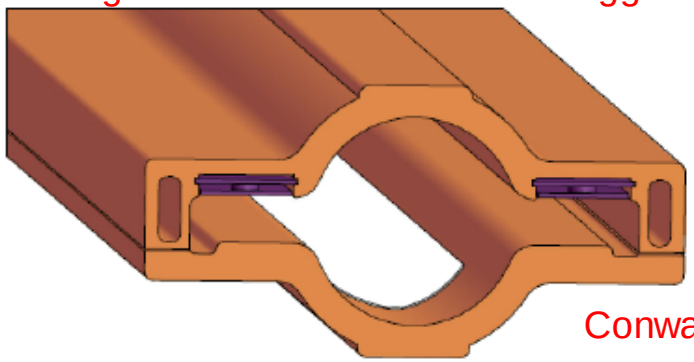

Crittenden




Wang

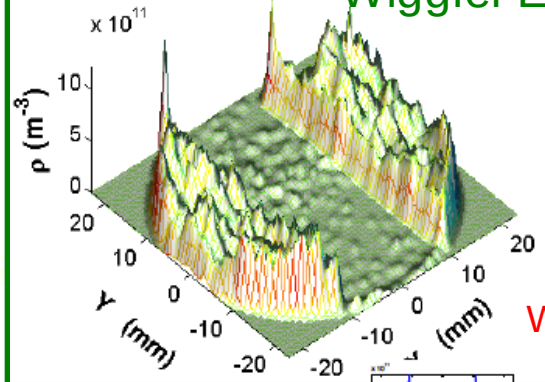
DR Wiggler chamber concept with thermal spray clearing electrode – 1 VC for each wiggler pair.



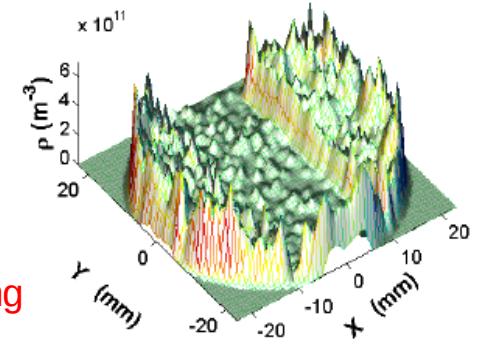
Conway/Li

## EC Suppression by Wiggler Electrode

+400V

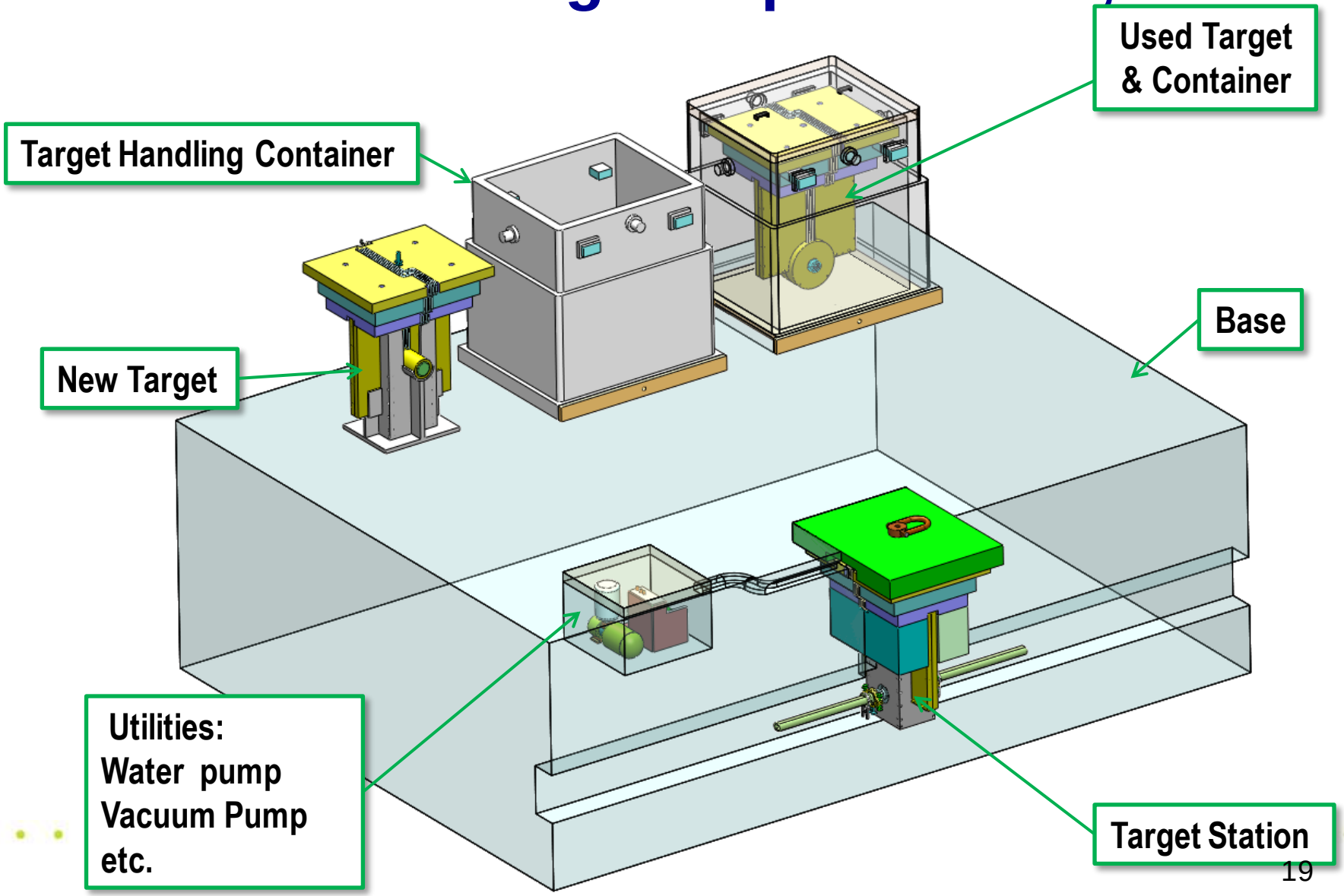



+100V

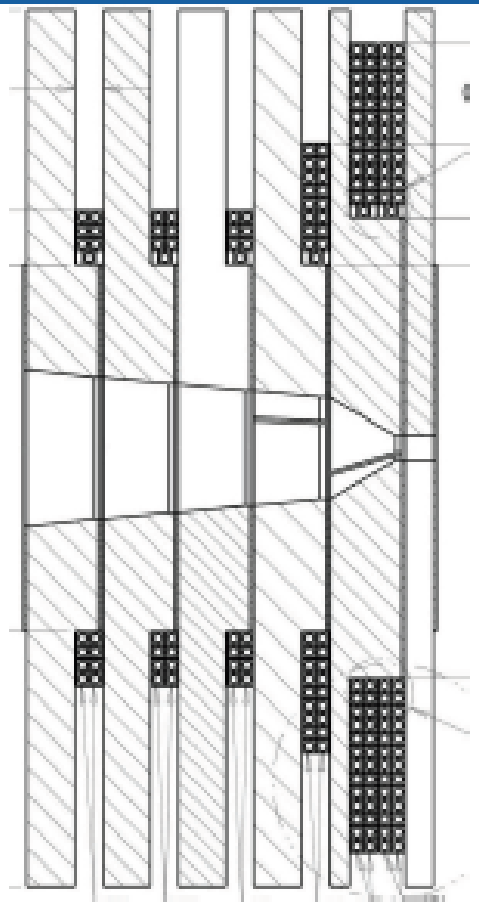



Wang

# New General Layout for Remote Target Replacement , Jia IHEP



# Water cooling and room temperature greatly simplifies the design



- Device sits in the vacuum
- All power and cooling connections move to the rim
  - Coils are kapton wound, hollow copper, water cooled
  - Plates are OFHC copper with water cooling pipes soldered in
  - Only metal in the high radiation areas
- Plates and coils stack and bolt together

**New OMD design,, Jeff Gronberg, LLNL**

# RTML & ML Beam Dynamics

- **RTML** design (A.Vivoli, N.Solyak, V.Kapin, Fermilab)
- **Main Linac lattice** design (V.Kapin, N.Solyak, Fermilab)
  - **(Almost) Complete.**
  - **No Problem**
- Comments to Main Linac Design from Beam Dynamics (K.Kubo KEK)
  - **Confirm present lattice choice is the best.**
  - **Remind requirements from beam dynamics.**
  - **No Objection**
- Status of RTML writing for TDR (prepared by N.Solyak but could not be presented)
  - **No Problem**

# ILC-TDR: Baseline Parameters

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

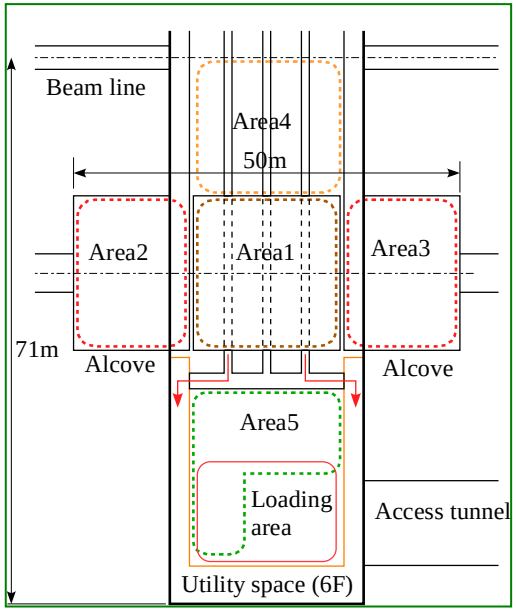
| Centre-of-mass energy | $E_{CM}$ | GeV | 200 | 230 | 250 | 350 | 500 |
|---|---|---|---|---|---|---|---|
| Luminosity pulse repetition rate | | Hz | 5 | 5 | 5 | 5 | 5 |
| Positron production mode | | | 10 Hz | 10 Hz | 10 Hz | nom. | nom. |
| Bunch population | $N$ | $\times 10^{10}$ | 2 | 2 | 2 | 2 | 2 |
| Number of bunches | $n_b$ | | 1312 | 1312 | 1312 | 1312 | 1312 |
| Linac bunch interval | $\Delta t_b$ | ns | 554 | 554 | 554 | 554 | 554 |
| RMS bunch length | $\sigma_z$ | $\mu m$ | 300 | 300 | 300 | 300 | 300 |
| Normalized horizontal emittance at IP | $\gamma\epsilon_x$ | $\mu$m | 10 | 10 | 10 | 10 | 10 |
| Normalized vertical emittance at IP | $\gamma\epsilon_y$ | nm | 35 | 35 | 35 | 35 | 35 |
| Horizontal beta function at IP | $\beta_x^*$ | mm | 16 | 14 | 13 | 16 | 11 |
| Horizontal beta function at IP | $\beta_y^*$ | mm | 0.34 | 0.38 | 0.41 | 0.34 | 0.48 |
| RMS horizontal beam size at IP | $\sigma_x^*$ | nm | 904 | 789 | 729 | 684 | 474 |
| RMS horizontal beam size at IP | $\sigma_y^*$ | 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 | $\delta_{BS}$ | % | 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 |

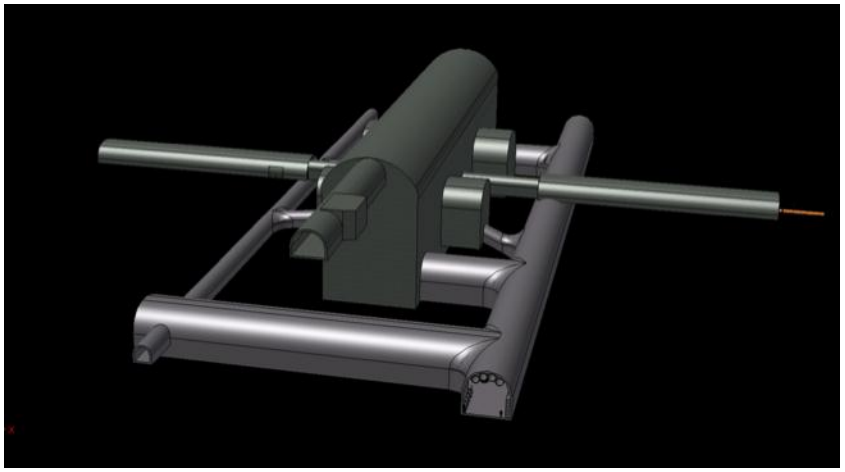
# Progress in CFS

- **Design and Costing for TDR nearly finished**
  - Asia and Americas
  - (Europe design / cost due in late May)
- **Completely new, more mature design than RDR**
- **Excellent Cost performance / Saving**

- **Adaptation to Japanese candidate sites started**
- **Draft TDR content reviewed**

# 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.**

# Technical Design Report

2007 2011 2013*

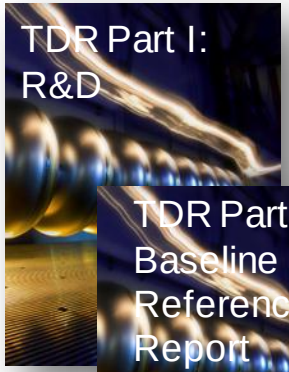

ILC Technical Progress Report
(“*interim report*”)


Reference Design Report

AD&I

**Technical Design Report**

~250 pages




The two parts are inherently linked


~300 pages


~50 pages

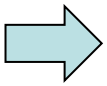

~25 pages

* 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)

# 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 |

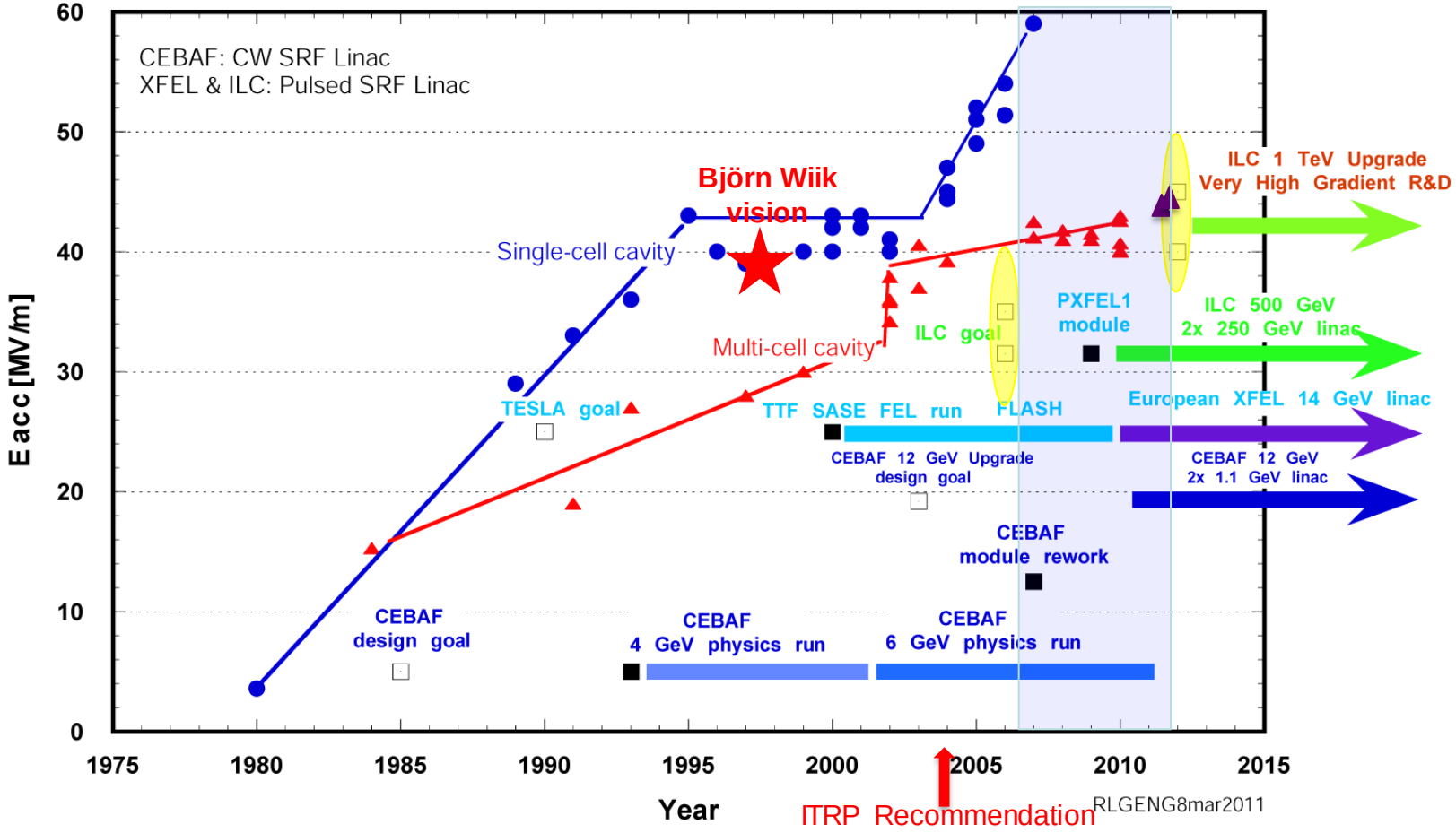
In parallel, EXFEL experience kindly informed by DESY, INDFN, CES/Saclay

# 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

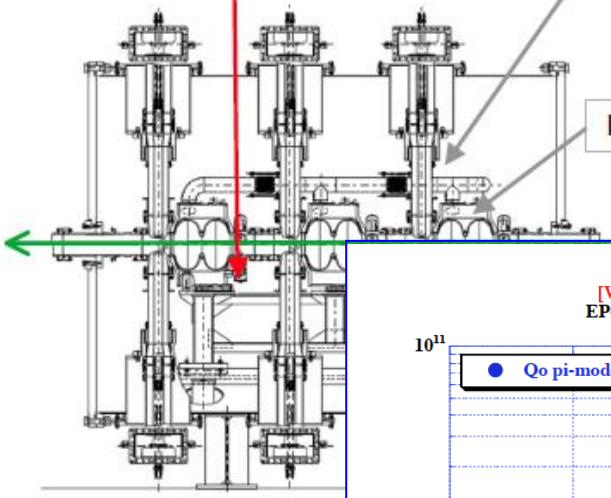
* 15 MV/m / cavity at CW

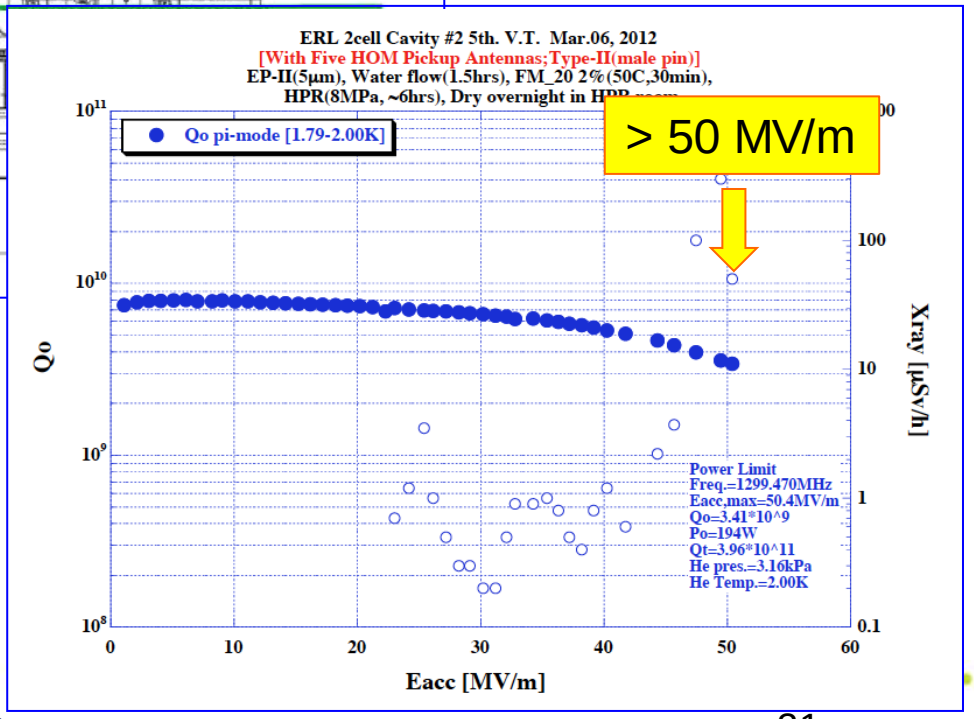
Cavity : 3 x 2-cell cavities
Slide-Jack tuner and piezo tuner

5 coaxial HOM couplers for one cavity

Input coupler (double feed) 167kW/coupler

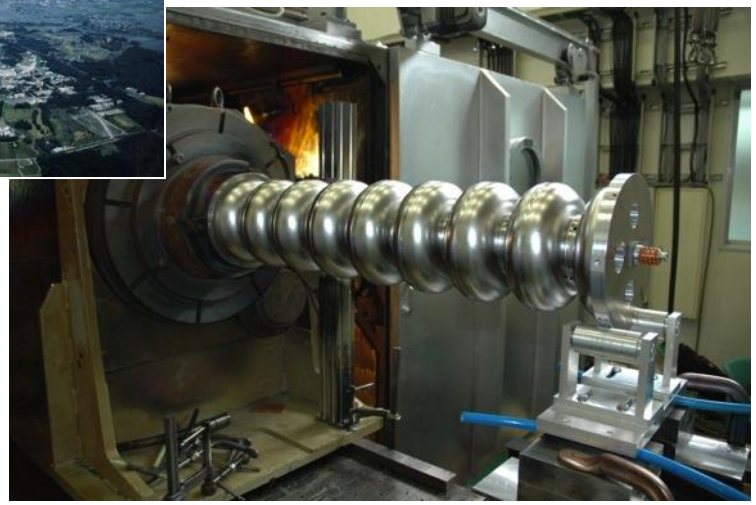
liq. He

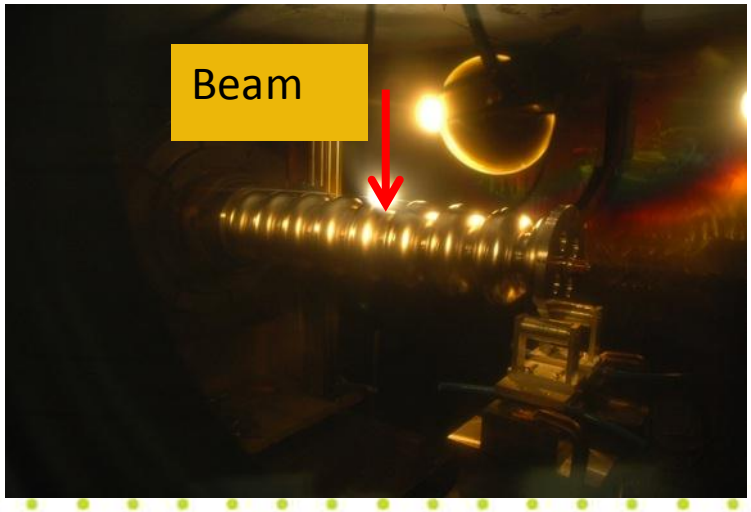





To be installed in
KEK cERL injection beam line

# Cavity Fabrication at KEK is coming






# Summary

- **ILC accelerator technology**
  - SCRF cavity gradient progressing toward 35 MV/m,
  - Beam test facility functioning to demonstrate the ILC accelerator requirements,
- **Technical Design Report (TDR)**
  - Contents being settled w/ flat and mountainous cases,
  - Draft being submitted by each author,
  - Final draft due LCWS-12, Oct., 2012
- **Further work beyond TDR**
  - Advanced R&D for 1 TeV upgrade capability,
  - Further study to be readh for various energy operation

- *Many thanks for the KILC12 organizer*

# Logistics

| Ch | Sect | Heading | Pages | Primary |
|---|---|---|---|---|
| | | **PART I: ILC R&D in the Technical Design Phase** | 280 | |
| 1 | | Introduction | 10 | Walker |
| 2 | | Evolution of the ILC design in the Technical Design Pha | 10 | Walker |
| 3 | | Superconducting RF technology | 95 | Yamomoto |
| 4 | | Beam Test Facilities | 70 | *[Editor]* |
| 5 | | Accelerator Systems R&D | 70 | *[Editor]* |
| 6 | | Conventional Facilities and Siting Studies | 10 | Kuckler |
| 7 | | Post-TDR R&D | 10 | Ross |
| 8 | | Summary | 5 | Walker |
| | | **Part II: The ILC Baseline Reference** | 338 | |
| 1 | | Introduction and overview | 5 | Paterson |
| 2 | | General parameters and layout | 15 | *[Editor]* |
| 3 | | SCRF Main Linacs | 50 | Yamomoto |
| 4 | | Electron source | 10 | Sheppard |
| 5 | | Positron source | 20 | Gai |
| 6 | | Damping Rings | 25 | Guiducci |
| 7 | | RTML | 20 | Solyak |
| 8 | | Beam Delivery System and MDI | 25 | Seryi |
| 9 | | Global Technical Systems | 26 | |
| 10 | | Commissioning, Operations, and Availability | 15 | Ross |
| 11 | | Conventional Facilities and Siting | 42 | Kuchler |
| 12 | | Upgrade options | 20 | *[Editor]* |
| 13 | | Scope of post-TDR engineeting (tech. risk assessment) | 20 | Ross |
| 14 | | Project Implementation Planning | 20 | Harrison |
| 15 | | Cost and Schedule | 20 | Dugan |
| 16 | | Summary | 5 | Walker |

There are too many chapters to spend 3hrs on each, so we will need to prioritize

Which authors are going to the meeting?

# Communication with Industry

## SC Cavity Manufacturers

| | Date | Company | Place | Technical sbject |
|---|---|---|---|---|
| 1 | 2/8, 2011 | Hitachi | Tokyo (JP) | Cavity/Cryomodule |
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| 16 | 11/11 | SST | Maisach (DE) | Electron Beam Welder |

# Progress in CFS

- **By Marc and Vic**
  - Design progress in FLAT and Mountaineous category
- **To be provided by Marc and Toshiaki**
  - Detector hall review

# TDR Deadlines

| | |
|---|---|
| First-draft sections | * 22 April, - 4 days* |
| Complete edited draft | 22 October (ILCWS 12) |
| Final draft (for PAC) | 15 November |
| PAC review | 13-14 December |

Drop-dead deadline

**203 Days (29 Weeks) …. AND COUNTING !!**
**~ 20% submission, as of 26, April**