ILC Status

- Time line
- SCRF status
- Test Facilities
- Design Improvement
- Summary

Kaoru Yokoya
IPAC2010
May.26.2009, Kyoto

RDR (Reference Design Report)

- RDR published in summer 2007
  - **First cost estimation**
  - **Accelerator 4.79BILCU(=US$2007)**
  - **Civil engineering 1.83**
  - **Explicit labor 14.2 kperson-year**

Exec Summary

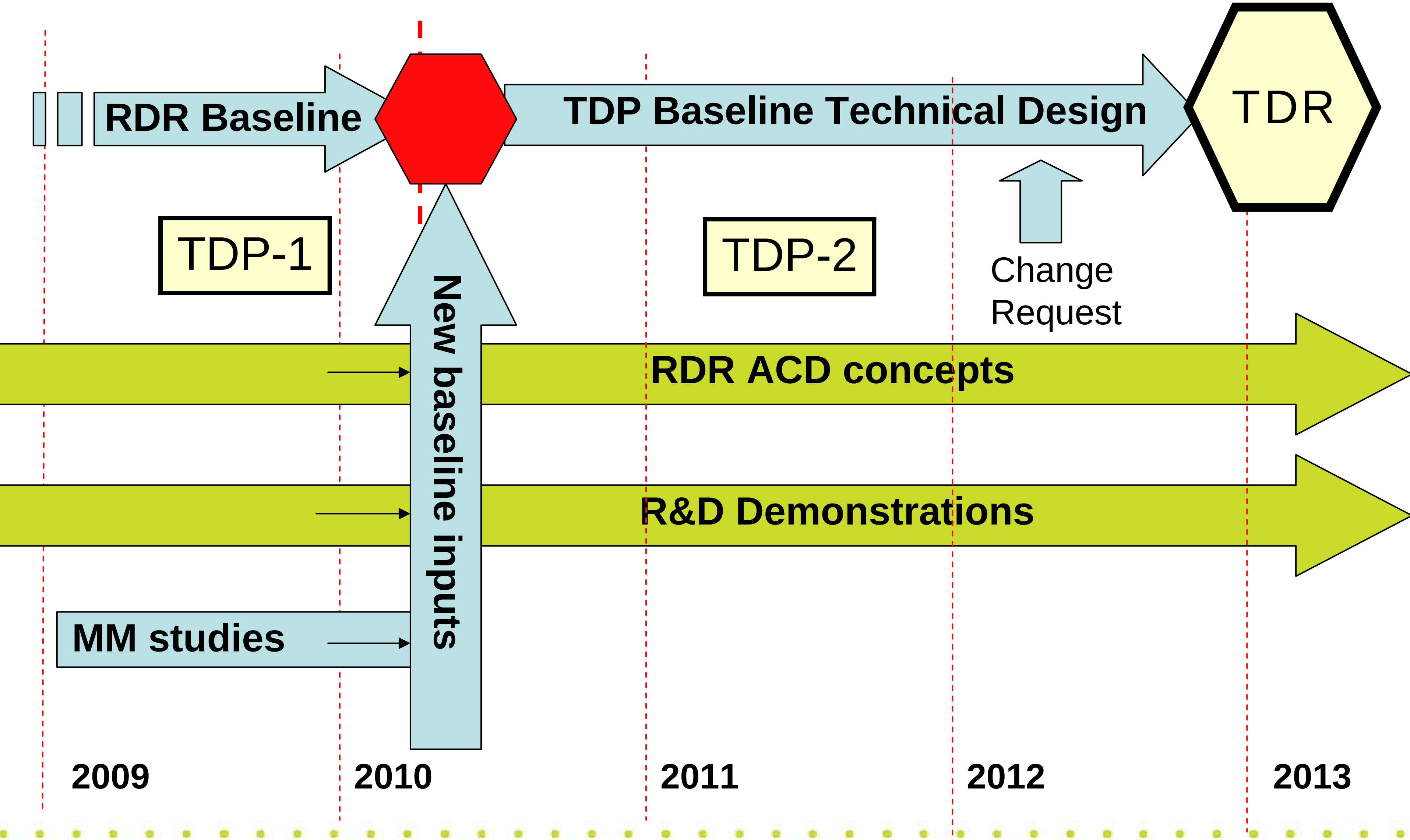
Physics

Accelerator

Detectors

- GDE re-structured since then for the next milestone
  - **3 Project Managers**

ILC/GDE Timeline



Technical Design Phase

- Technical Design Report
  - **It will be a detailed technical report**
    - Sufficient to give reliable estimate of the total cost
    - Ready for construction proposal to governments
  - **But will not be a complete engineering document**
  - **Planned to be completed by the end of 2012**
- Technical Design Phase
  - **TDP1 till Jul.2010 (ICHEP at Paris)**
    - Critical R&D
      - Risk mitigation
      - Cost reduction
    - New baseline
  - **TDP2 till end of 2012**
    - Technical design
    - Project implementation plan

GDE SCRF Plan

- SC(Superconducting)RF technology is the key to ILC
- SCRF issues
  - **S0: cavity**
  - **S1: Cryomodule**
  - **S2: Module string**
  - **Industrialization**

Calendar Year	2007	2008	2009	2010	2011	2012
Technical Design Phase		TDP-1			TDP-2	
Cavity Gradient R&D to reach 35 MV/m			Process Yield > 50%		Production Yield >90%	
Cavity-string test: with 1 cryomodule			**Global collab.** **For** <31.5 MV/m>			
System Test with beam 1 RF-unit (3-module)		FLASH (DESY)			STF2 (KEK) NML (FNAL)	

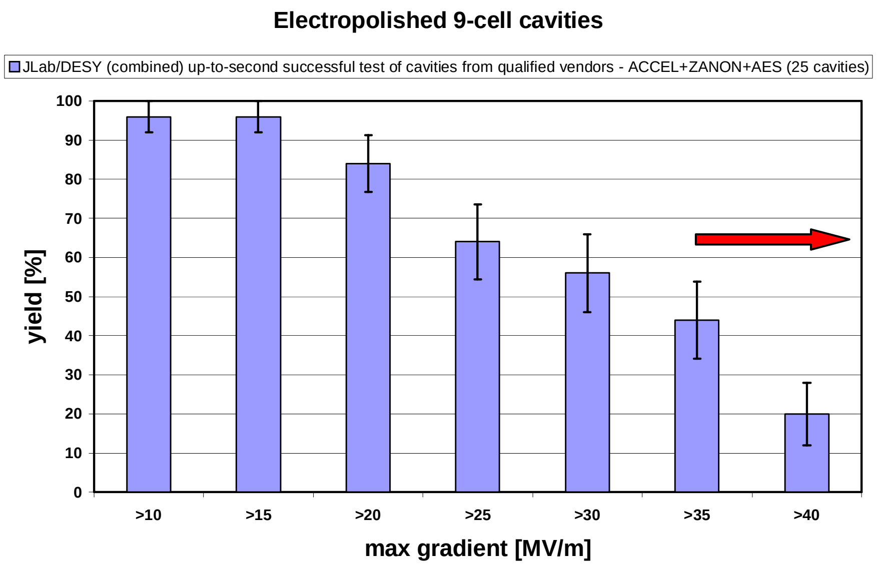
S0: Cavity Gradient

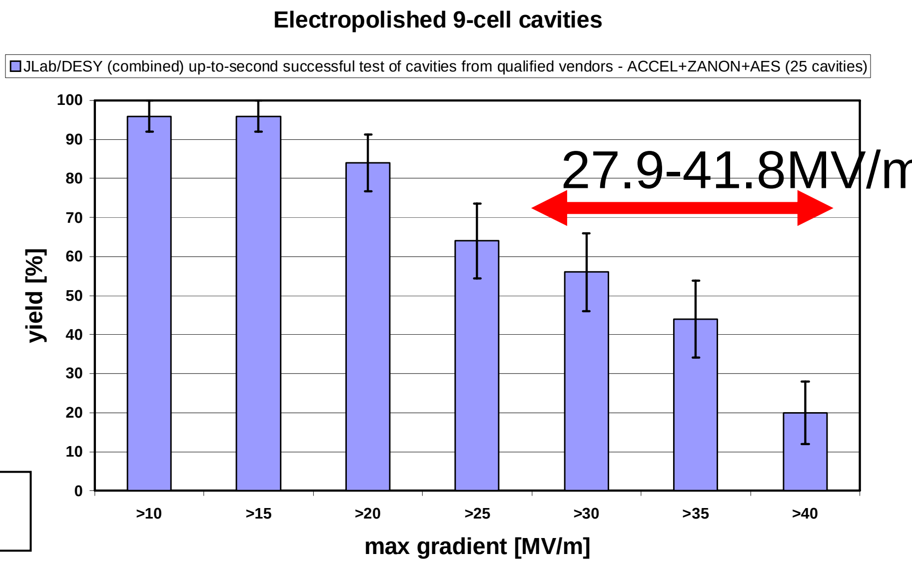
- Cavity gradient is a big, single cost-driver
- RDR assumes >35MV/m ($Q_0 > 1x10^{10}$) in vertical test
- Target of cavity yield during TDP
  - **Yield > 50% in TDP1**
  - **Yield > 90% in TDP2**
  - **Should be revisited in Rebaseline**
- **Cavity Global Database Team** established last summer
  - **Uniform, well-controlled database**
  - **Definition of the standard cavity processing**
  - **`Production Yield'   = (# of)/(# of produced cavities)**
  - **Up to 2nd pass**
  - **Cavities to be included in the statistics**
    - `Established vendor'
    - No R&D cavities such as Large Grain
  - **Condition of X-ray should be added soon**

Present Production Yield

- Simple criterion >35MV/m → 44% yield
- Improved HLRF system can accept cavity gradient spread ~20% → 64% yield (27.9-41.8MV/m, average 36.5MV/m)
- TDP1 target satisfied

Only `established' vendors included



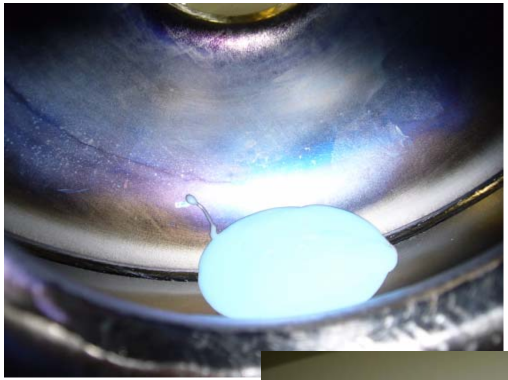


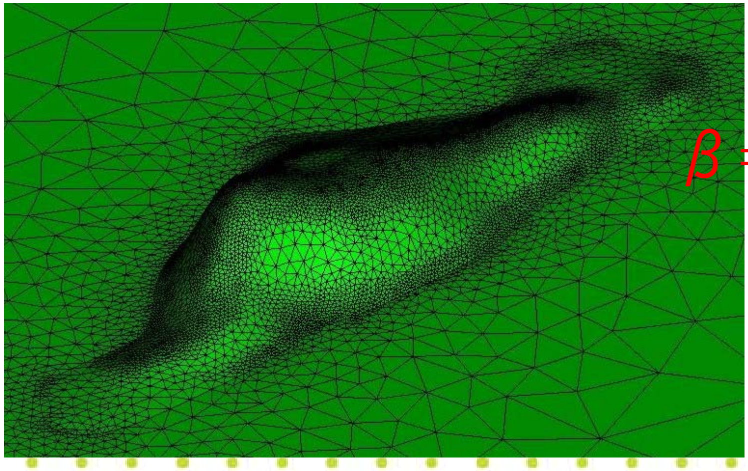
Locating the Defects

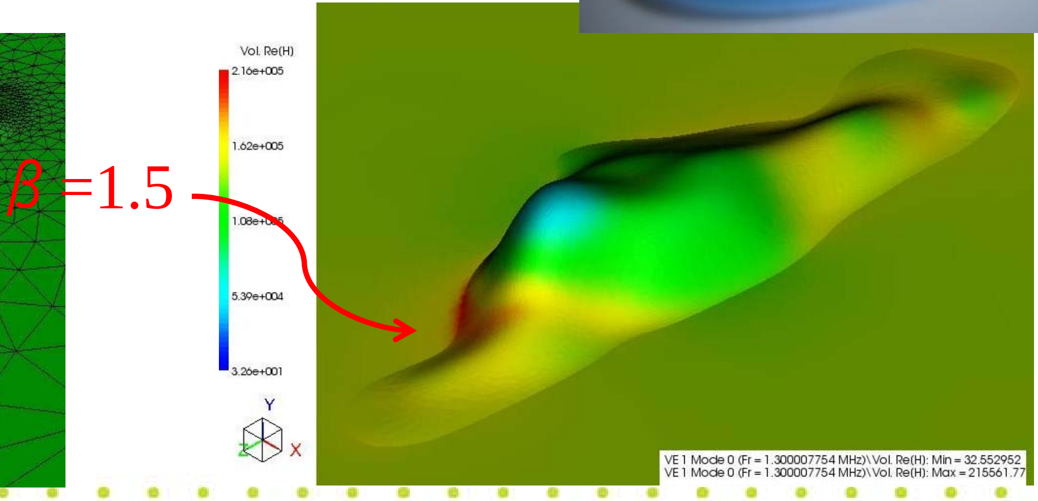
- Techniques to locate the defects inside cavities are by now common in the world
  - **Pass-band mode measurement**
  - **Temperature map**
  - **Optical inspection**
- Try&error → science

Detailed Surface Analysis

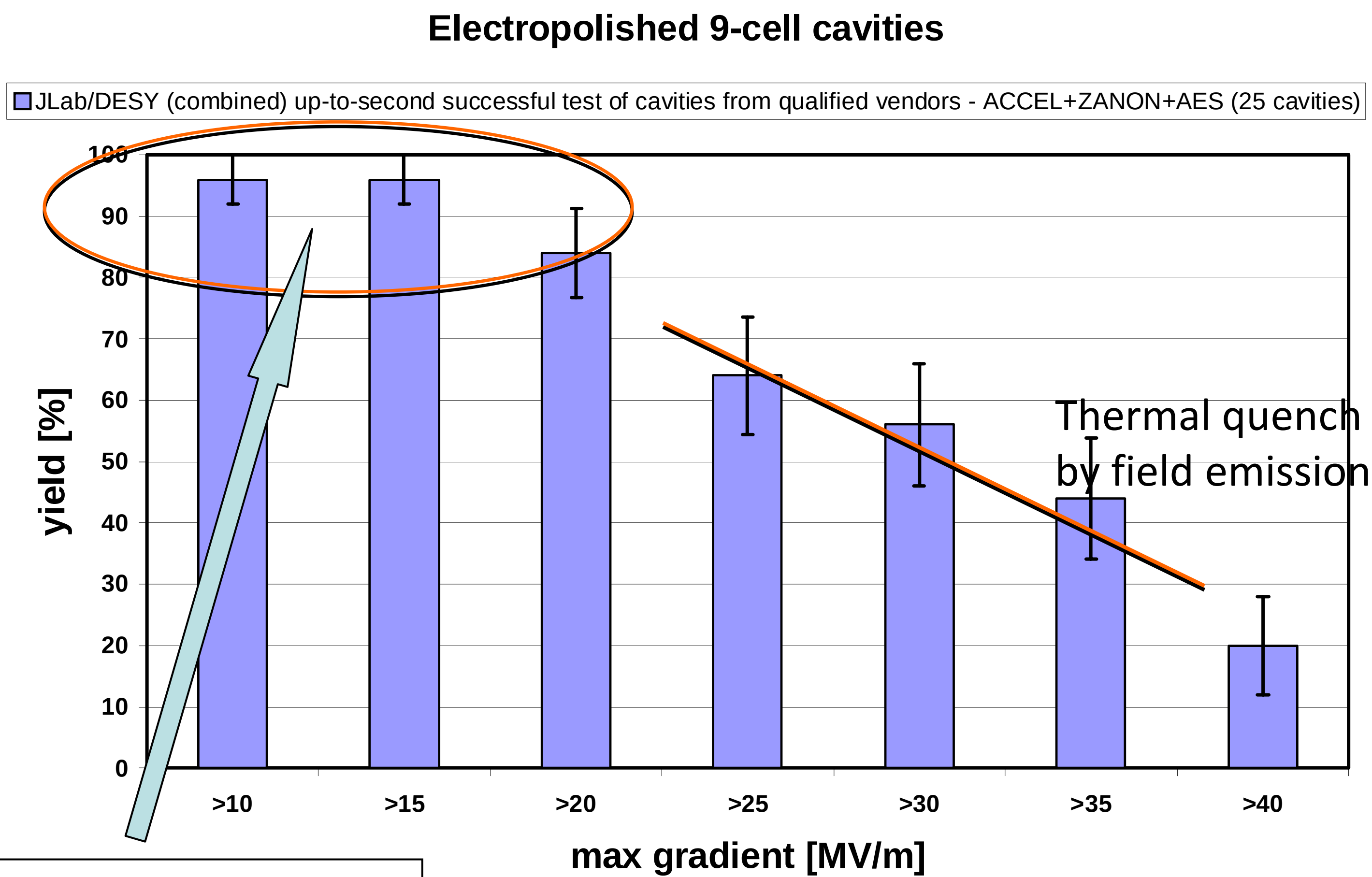
- Make a replica
- Accurate measurement of the shape
- Computer simulation of the field enhancement







Cause of Gradient Limitation

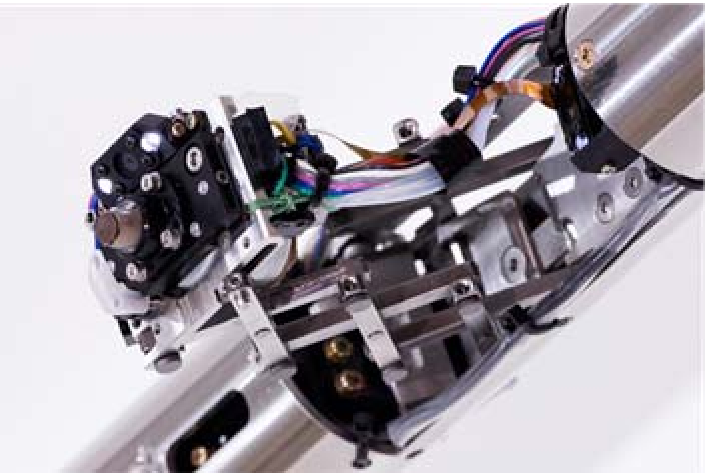


Likely to be large surface defect > O(100mm)

Hayano 2010.Jan

Local Repair: Grinding

Grinder for equator



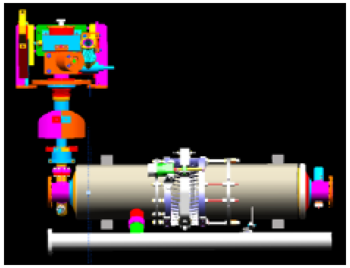
Grinder for slope surface

Labs	Method	Cavity name	Results
DESY	Local Grinding (KEK)	AC71	26MV/m (string???) -> 30 MV/m
FNAL	Local Grinding (KEK)	AES-03	20 MV/m (Bump, scratch) -> 34 MV/m
JLAB	Local Grinding (KEK)	JLAB LG-01	30 MV/m (Pit) -> will be tested.
KEK	Local Grinding(KEK)	MHI-08	16 MV/m (Pit) -> 27 MV/m

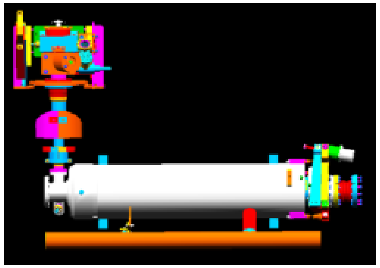
S1-Global

- Goals
  - **Try average gradient > 31.5 MV/m**
  - **Demonstrate plug-compatibility**
- Assemble cavities from DESY-FNAL-KEK in KEK-STF
  - **All cavities and cryostat (1 from INFN) sent to KEK. Now assembling.**
- Operation to finish by the end of 2010

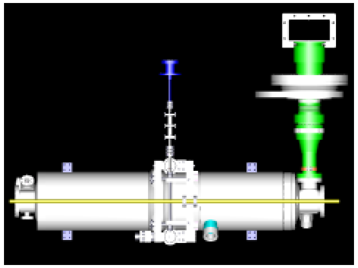
FNAL



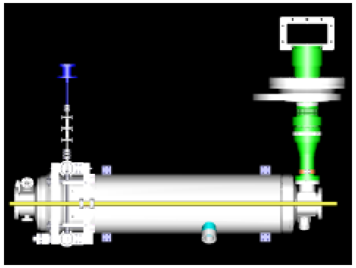
DESY

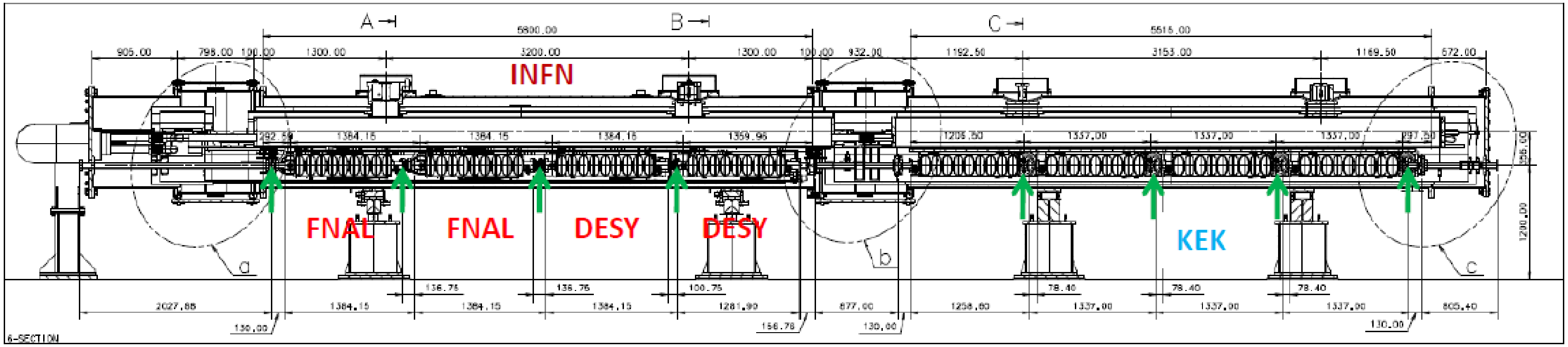


KEK-a



KEK-b



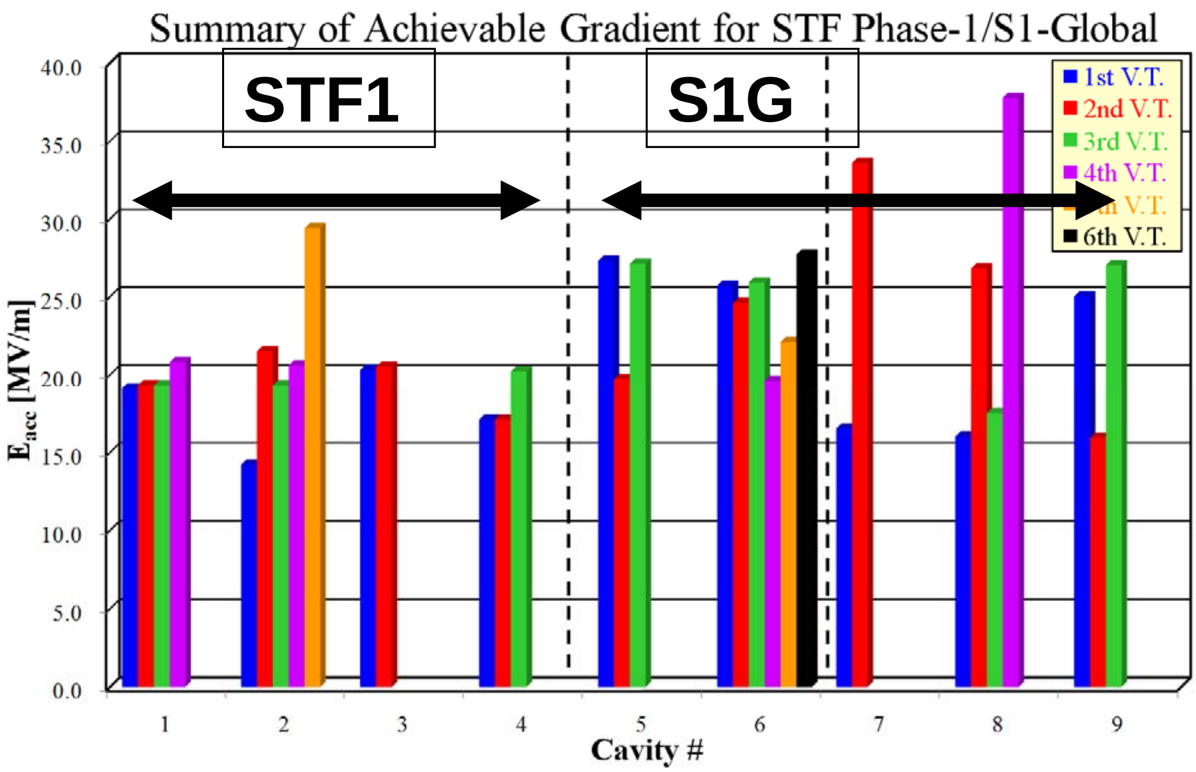


Cryogenic system   Module C   Module A

8 Cavities for S1-Global

- Module C MV/m
  - **AES002 32.8**
  - **ACCEL8 30.6**
  - **Zanon108 31.3**
  - **Zanon109 30.7**
- Module A
  - **MHI005 27.1**
  - **MHI006 27.7**
  - **MHI007 33.6**
  - **MHI009 30.6**
- Average 30.5

KEK cavities



S1-Global Module C (DESY, FNAL cavities)

S1-Global Test Plan

Month	Subjects	Participation
5	Assembly to be complete	
6	**Cool-down,** Low Power Test	IHEP
7	**Low Power Test & Tuner Function Test** Preliminary Cryog. Performance test	INFN, FNAL
8	Input coupler conditioning	
9	Re-cool-down **High Power Test for Cryomodule C**	FNAL, SLAC,
10	**High Power test for Cryomodule A** **Cryogenic Performance Test**	FNAL,
11	Control, LLRF, total-system dynamic loss Cryomodule heat loads at 2K DRFS preparation,	
12	DRFS test using S1-Global setup	

S2: String Test

- System test with
  - **high-gradient, fully beam-loaded, full LLRF control, high rep rate**
- Necessary in each region (Asia, Europe, Americas)
- Europe
  - **FLASH**
  - **XFEL**
- US
  - **FNAL-NML**
- Japan
  - **KEK-STF2**

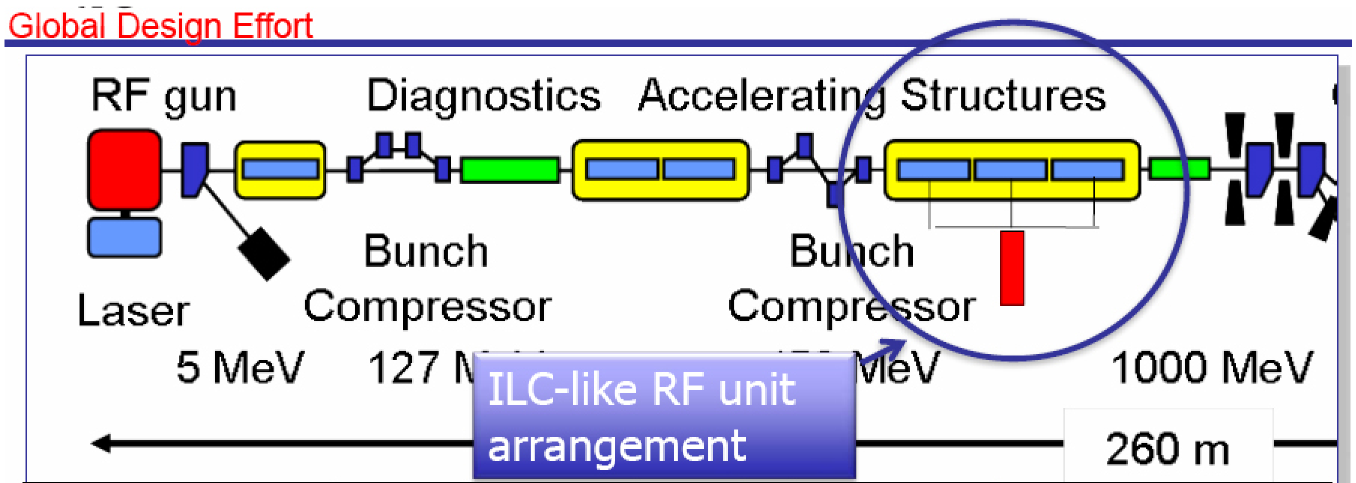
FLASH 9mA Experiment

- Fully beam-loaded, high gradient, LLRF-controlled experiment

•Successful long-time (>10hr) operation at 3mA

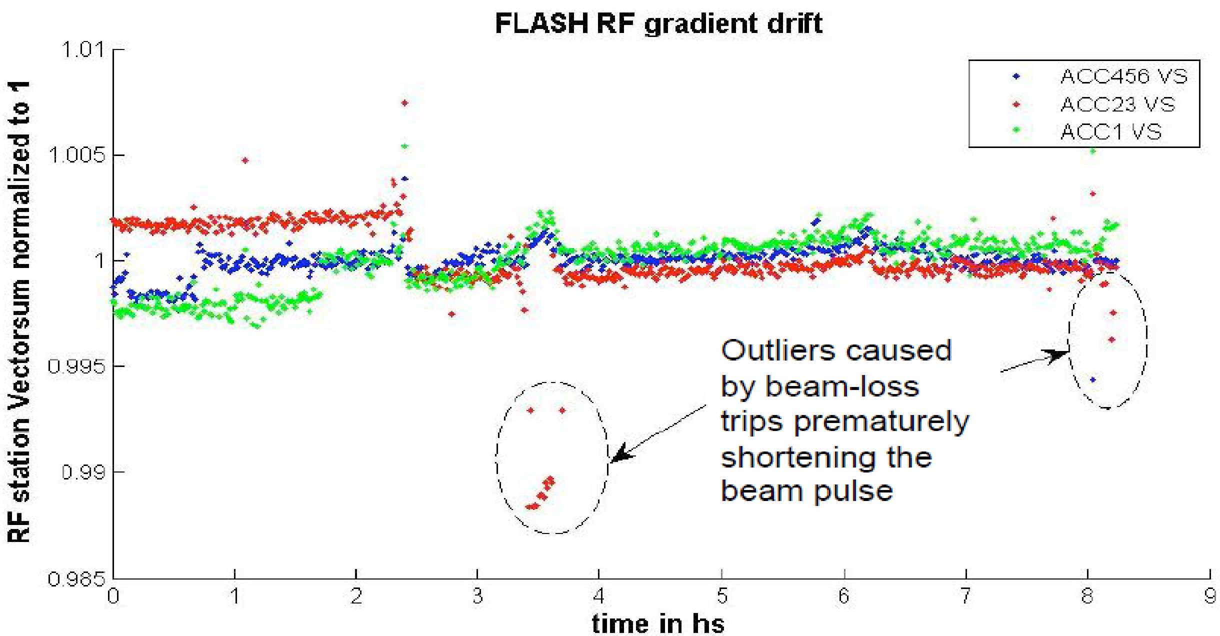
•Short time at >6mA

•Almost satisfies S2

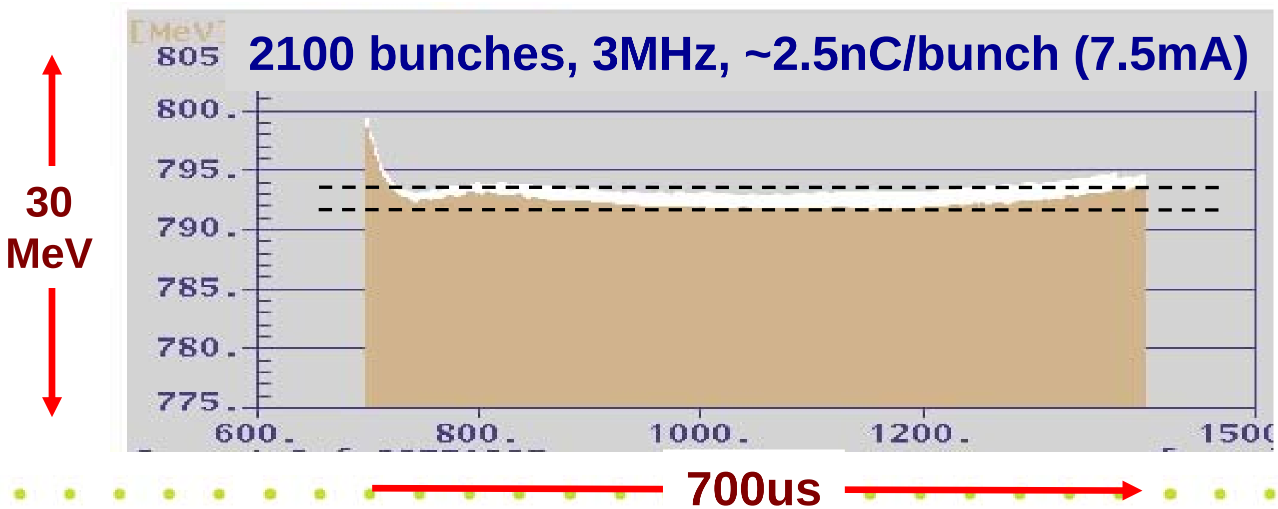


		XFEL X-Ray Free-Electron Laser	ilc	FLASH design	FLASH experiment
Bunch charge	nC	1	3.2	1	3
# bunches		3250*	2625	7200*	2400
Pulse length	μs	650	970	800	800
Current	mA	5	9	9	9

Energy Stability (examples)



Pulse-pulse

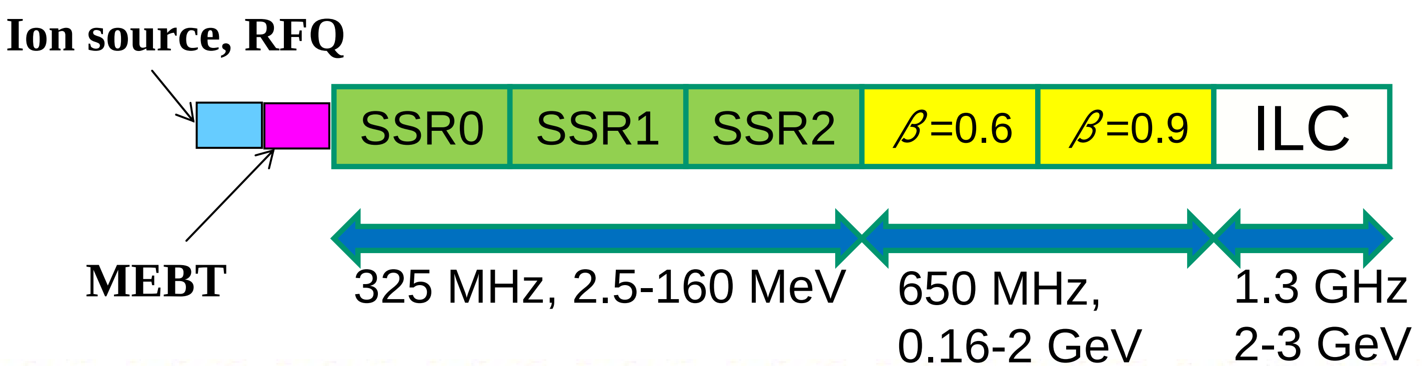


Along pulse

Along pulse: 0.5% p-p
Pulse-pulse: 0.13% RMS

FNAL-NML (New Muon Lab)

- Synergy with Project-X
- First module
  - **Fabricated at DESY (TTF type III+)**
  - **Assembled in FNAL**
  - **Cooling test is going to start**
- 2^{nd} module
  - **US cavities**
  - **To be built in 2010**
- CM3-CM6



Cryomodule activities at FNAL

CM1 String Assembly

MP9 Clean Room

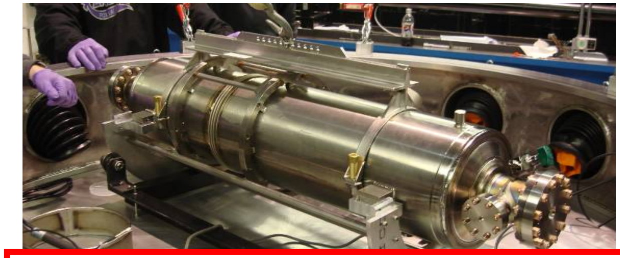
Final Assembly

Kephart, Kyoto 2010

CM1

Move to NML

CM1 installed



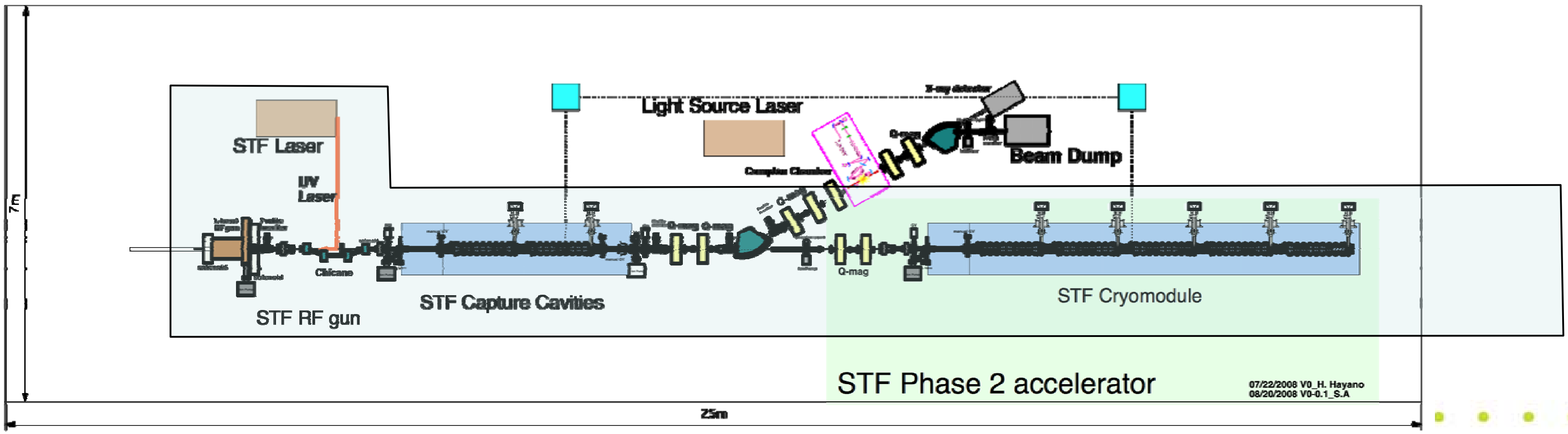
Dressing cavities for CM2

FNAL S1 global Cavities @ KEK

KEK-STF2

- First module test (STF1) completed in 2008
  - **Half size (4 cavities)**
  - **Max gradient ~30MV/m (1 cavity)**
  - **Measurement successful**
- STF2
  - **Injector 2011 to early 2012 (with beam)**
  - **1st 9 cavity module to be completed by end of 2012**

Compact Light Source accelerator in STF Phase 2



Industrialization

- Success of S2 does not mean ready for production
- Scale of projects

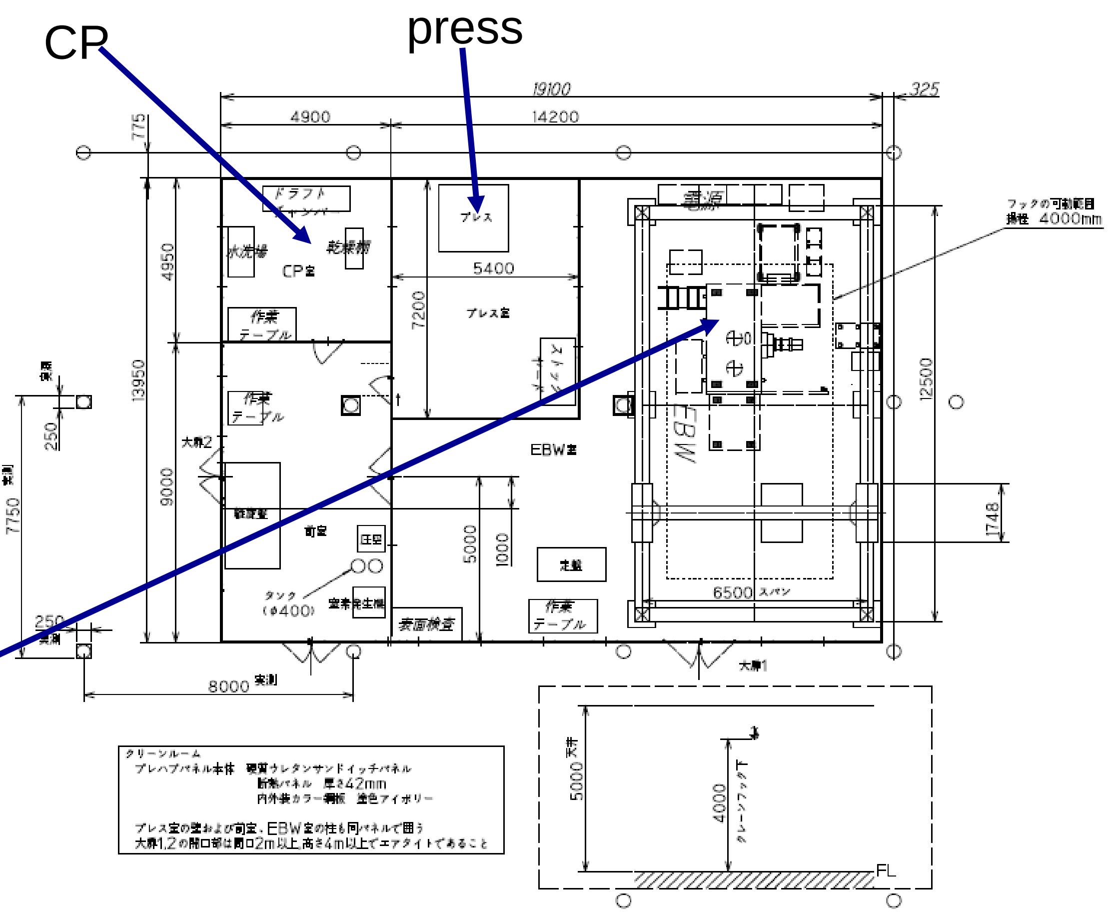
	# of cavs	period	production rate
Euro-XFEL	800	2yr	1 cav/day
Project-X	400	~3yr	2 cavs/week
ILC	16000	~4yr	7 cavs/day (3 regions)

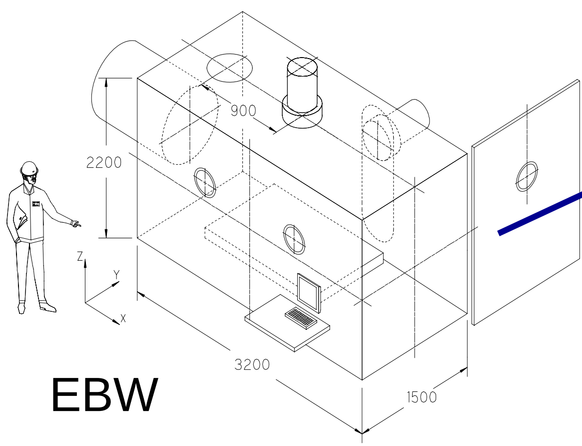
- Exceeds the present capacity of any company
- Multiple vendors in each region desired
- Must consider: quality control, mass-production, cost reduction
- Industry session last Sunday at Kyoto

	vendors	laboratories
Europe	**RI (ACCEL)** **Zanon**	DESY, LAL(Orsay), CEA(Saclay), INFN
Americas	**AES**, Niowave, PAVAC	FNAL, ANL, Cornell, JLAB
Asia	MHI (HITACHI, Toshiba)	KEK, IHEP, PKU, RRCAT, IUAC

Cavity Pilot Plant at KEK

- Prototype for the future production line
- Main part is EBW facility
- Cost reduction
- Need more companies to join
- EBW to be delivered Mar.2011





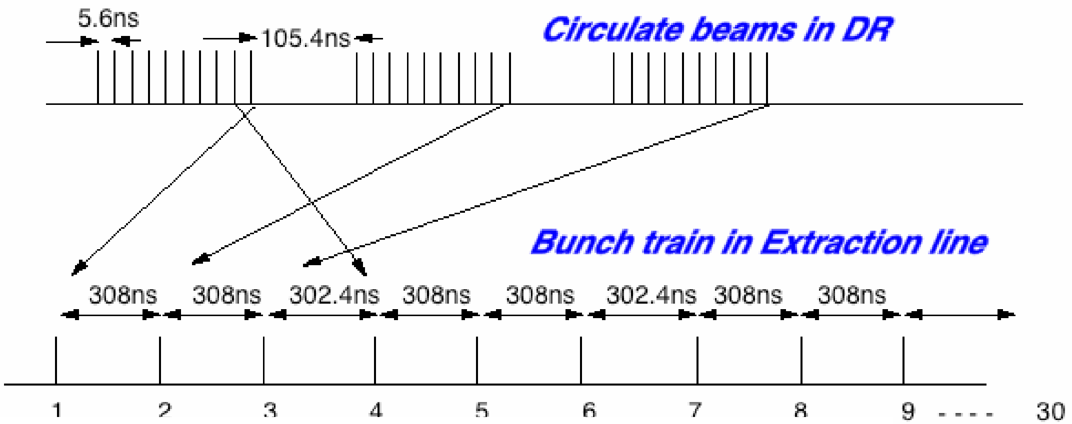
EBW

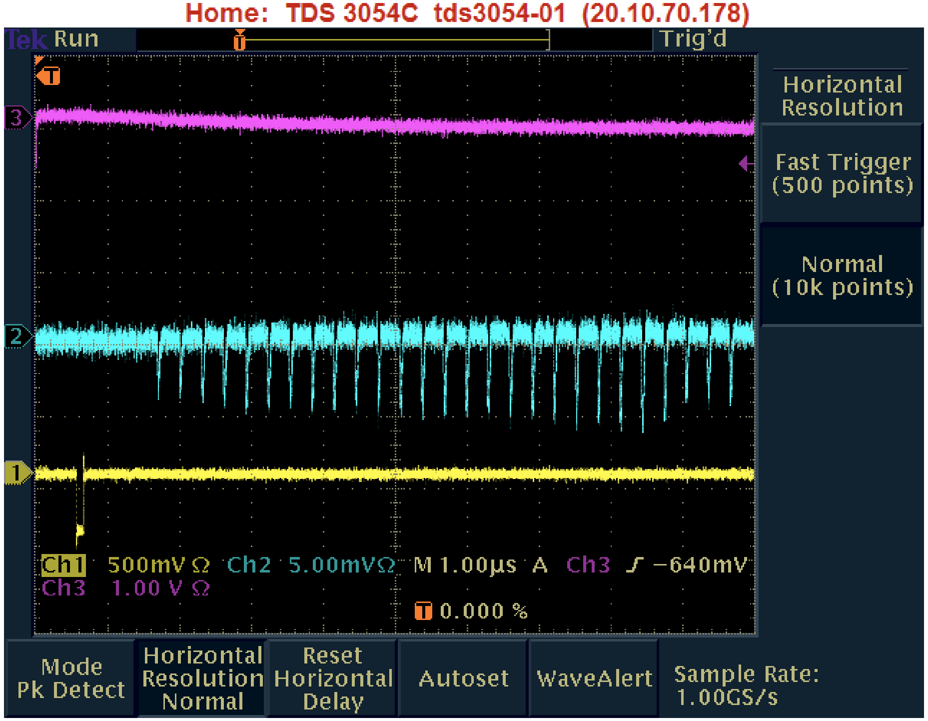
Damping Rings

- Critical issues
  - **Emittance tuning**
    → KEK-ATF, CESR-TA
  - **Fast injection/extraction kickers**
    - Bunch-by-bunch extraction needed
    - Rise/fall time < 6ns required
    - → test at KEK-ATF
  - **Electron cloud**
    → CESR-TA

Multibunch Extraction from ATF by Fast Kicker

T.Naito, WEOBMH02





in DR:

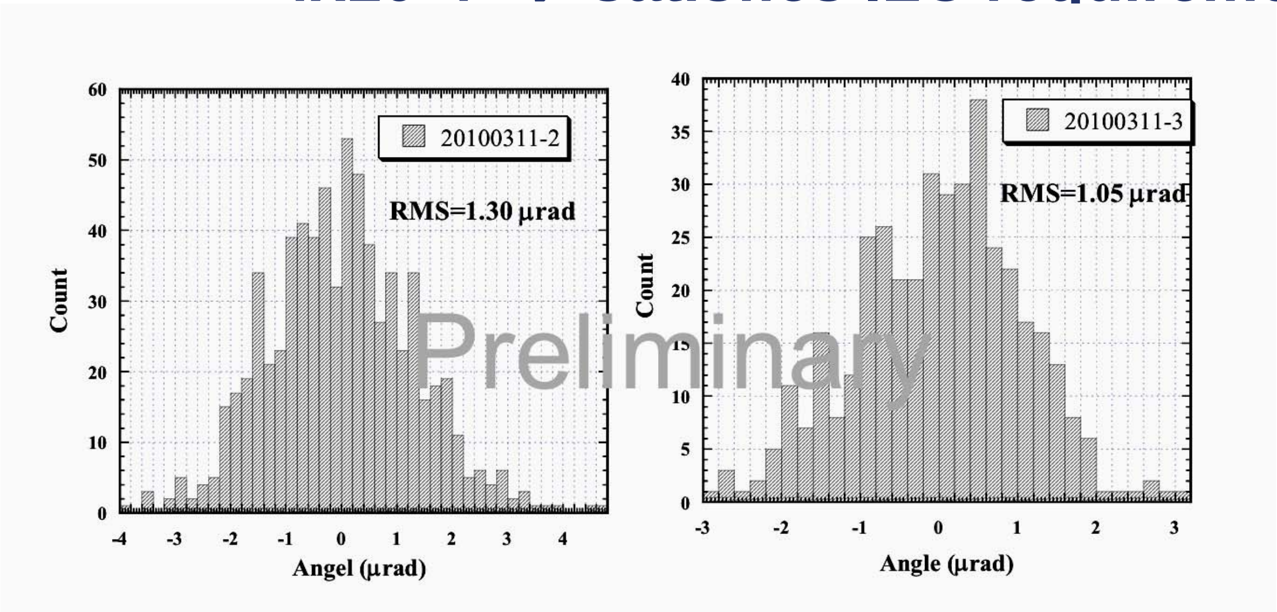
- 3 Trains,
- 9(max 10) bunches/train with 5.6 ns spacing

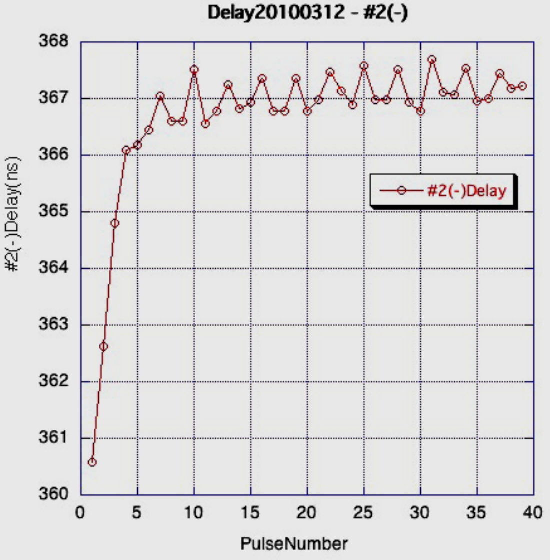
Extracted:

- 27(max 30) bunches with 308 ns spacing
- bunch-by-bunch profile follows that in the DR.
- bunches were extracted from the last bunch to the first bunch.

Kicker Stability

- Kick angle jitter
  - **~4x10-4 → satisfies ILC requirement**





- Remaining problem
  - **Pulse-to-pulse timing jitter**
- Next study in June

1ns/div

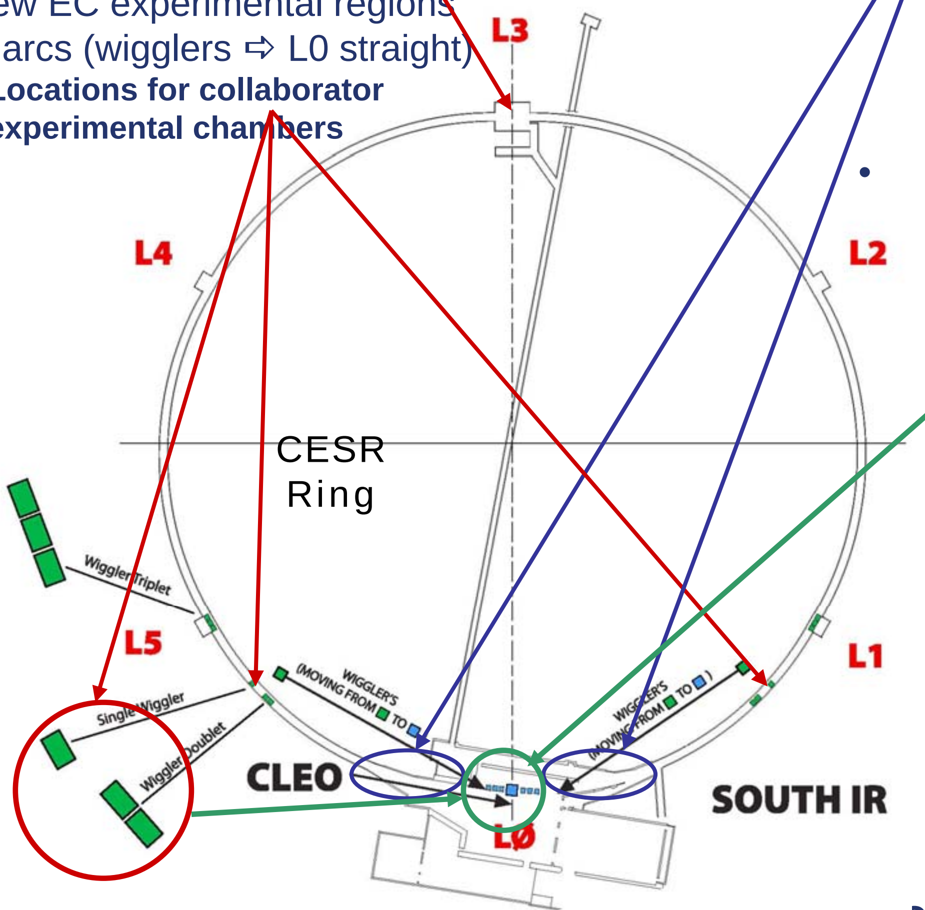
CESR-TA

- Electron cloud is one of the highest risk factor for ILC
- Study at CESR started in 2008
  - **Evolution of electron clouds under various cloud-mitigation techniques**
    - chamber coatings (TiN, alpha carbon)
    - clearing electrodes
    - grooved chambers

    can be monitored in various magnetic fields: drift, dipole, quadrupole, wiggler
- Reconfiguration of CESR needed
- Beam parameters are not identical to ILC
  - **Extrapolation with computer simulation is needed**

CESR Reconfiguration

- L3 EC experimental region
  - **PEP-II EC Hardware: Chicane, upgraded SEY station (coming on line in May)**
  - **Drift and Quadrupole diagnostic chambers**
- New EC experimental regions in arcs (wigglers ⇨ L0 straight)
  - **Locations for collaborator experimental chambers**



- CHESS C-line & D-line Upgrades
  - **Windowless (all vacuum) x-ray line upgrade**
  - **Dedicated optics box at start of each line**
  - **Detectors share space in CHESS user hutches**
- L0 region reconfigured as a wiggler straight
  - **CLEO detector sub-systems removed**
  - **6 wigglers moved from CESR arcs to zero dispersion straight**
  - **Region instrumented with EC diagnostics and mitigation**
  - **Wiggler chambers with retarding field analyzers and various EC mitigation methods (fabricated at LBNL in CU/SLAC/KEK/LBNL collaboration)**

CESR-TA Status

- Reconfiguration complete
  - **BPM upgrade, xBSM, 4ns feedback**
  - **new EC chambers (electrodes, grooves, a-C coating, RFA detectors,**
  - **Solenoid windings**
- Status
  - **Emittance ε_y~20pm**
  - **EC mitigation comparisons progress**
  - **EC simulations**
- Future plans
  - **~70 machine development days scheduled in 2010 – May, July, September and December experimental periods. Will focus on:**
  - **LET effort to reach a target emittance of ey≤ 20pm**
  - **Continued EC mitigation studies**
  - **Detailed characterization of instabilities and sources of emittance dilution in the ultra low emittance regime**
  - **Application of our results to the damping rings design effort**
  - **An extension to the R&D program has been proposed…**
  - **ILC DR Electron Cloud Working Group in Oct.2010**

From M.Palmer, PAC, May2010

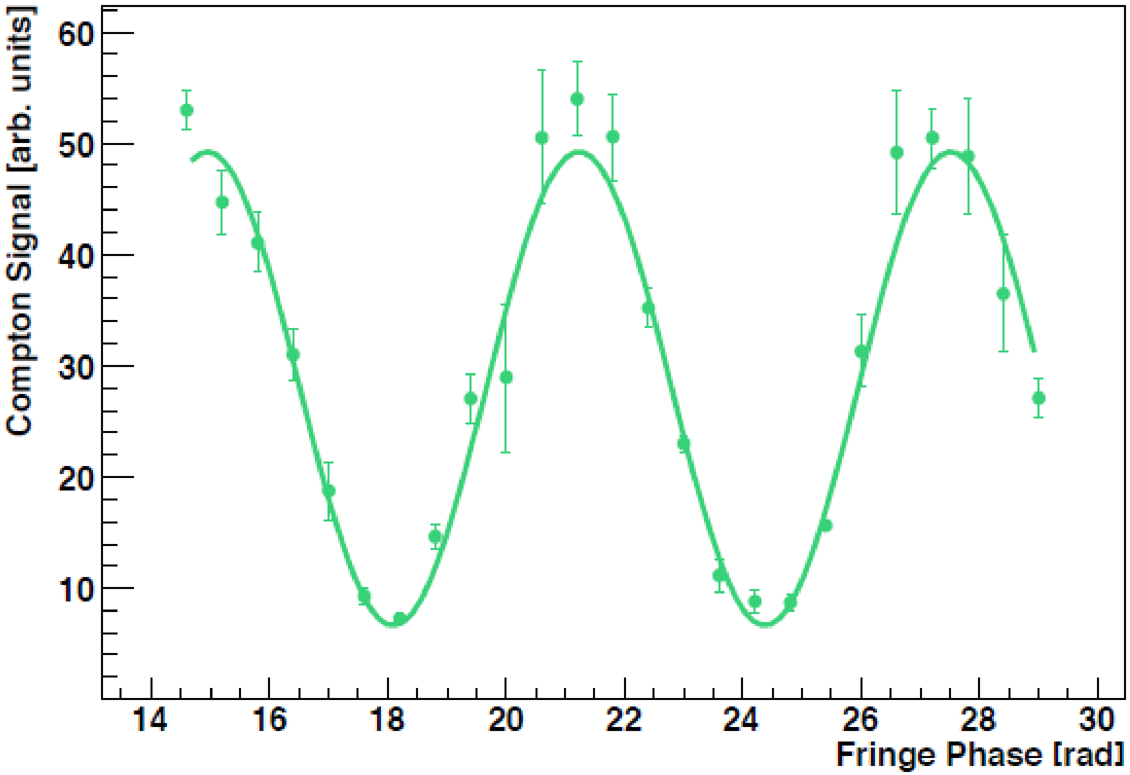
ATF2

- Miniature of ILC Final Focus
  - **Same optics system as ILC**
  - **Tolerances similar to ILC**
  - **International project**
    - Funding
    - manpower
- Goals
  - **1st step: Beam size < 35nm**
    - IP BSM (beamsize monitor) needed
  - **2nd step: Stability of the beam centroid < 2nm**
    - IP BPM (beam position monitor) (<2nm) needed
    - IP feedback system
    - ILC format beam from ATF
- Beam line construction started in 2005 and completed in December 2008

ATF2 Status

- Goal 1
  - **Beam size reached ~300nm**
  - **Target: 37nm by end of 2010**
- Goal 2
  - **IPBPM being tested upstream**
  - **Laser wire tested in Apr.**
  - **FONT5 showing progress**

Fringe Scan



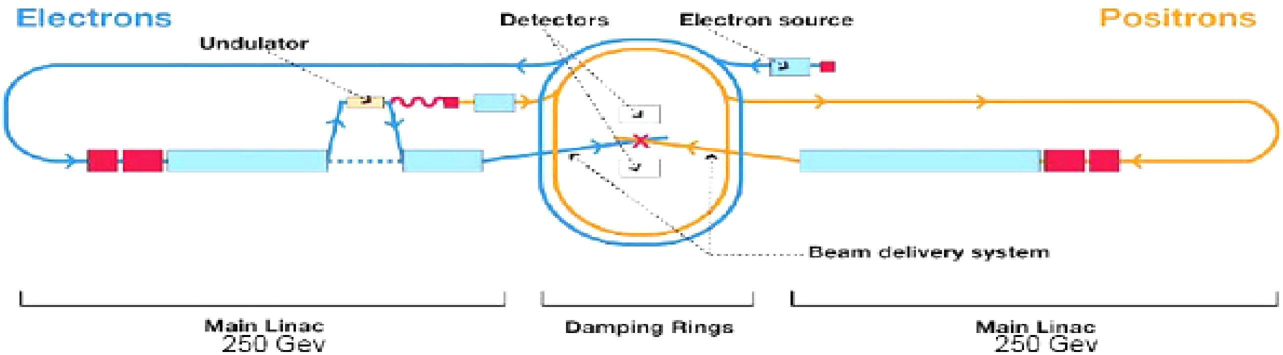
Crossing angle :4.12 [deg]
Average of 4 bunches/point
Scan range 13.2[rad]
with a step of 600mrad

Fringe Pitch 7.4um

Modulation = 0.767± 0.020
σy = 855 ± 42 nm

As of Apr.10

Design Improvement



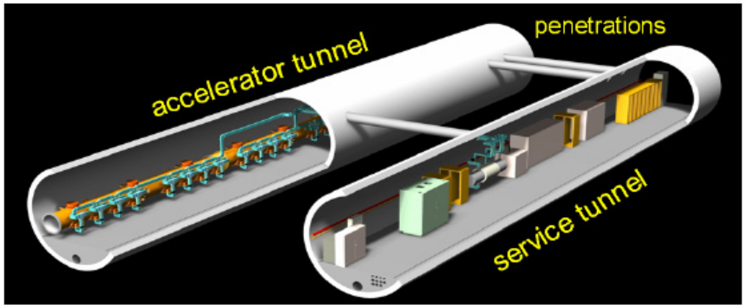
- Revisit the baseline design
  - **Cost optimization**
  - **Balance of cost and risk/performance**
- Cost is an important issue for big projects
  - **Should not exceed the cost estimation in RDR**
  - **Should prepare for the possible cost increase, e.g., cryomodule, cavity gradient, etc.**
    (waiting for info of XFEL cavity cost)

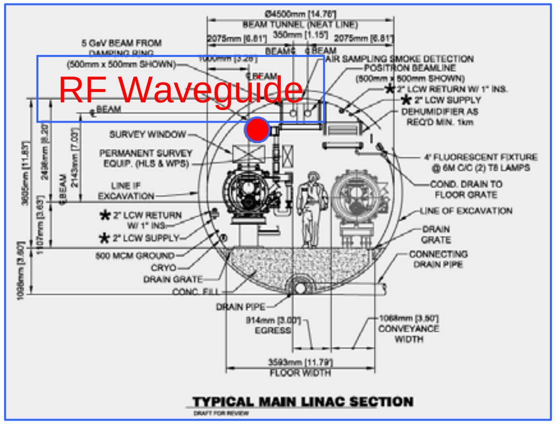
SB2009

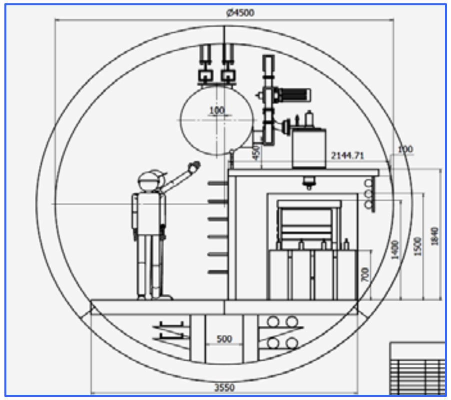
- **Single tunnel** with new RF distribution system:
  - **KCS (Klystron Cluster System)**
  - **DRFS (Distributed RF System)**
- **Half number of bunches** (1312) with same pulse length (1ms) → reduce RF system to half
- **Half circumference of DR**
  (same bunch interval in DR)
- Single-stage bunch compressor (minimum bunch length 300μm)
- Positron
  - **undulator at linac end**
  - **Use QWT (Quarter Wave transformer) in capture section**
- Traveling focus
- Layout of central region with shorter tunnel length
- **Expected total cost reduction ~13%**

Single Tunnel

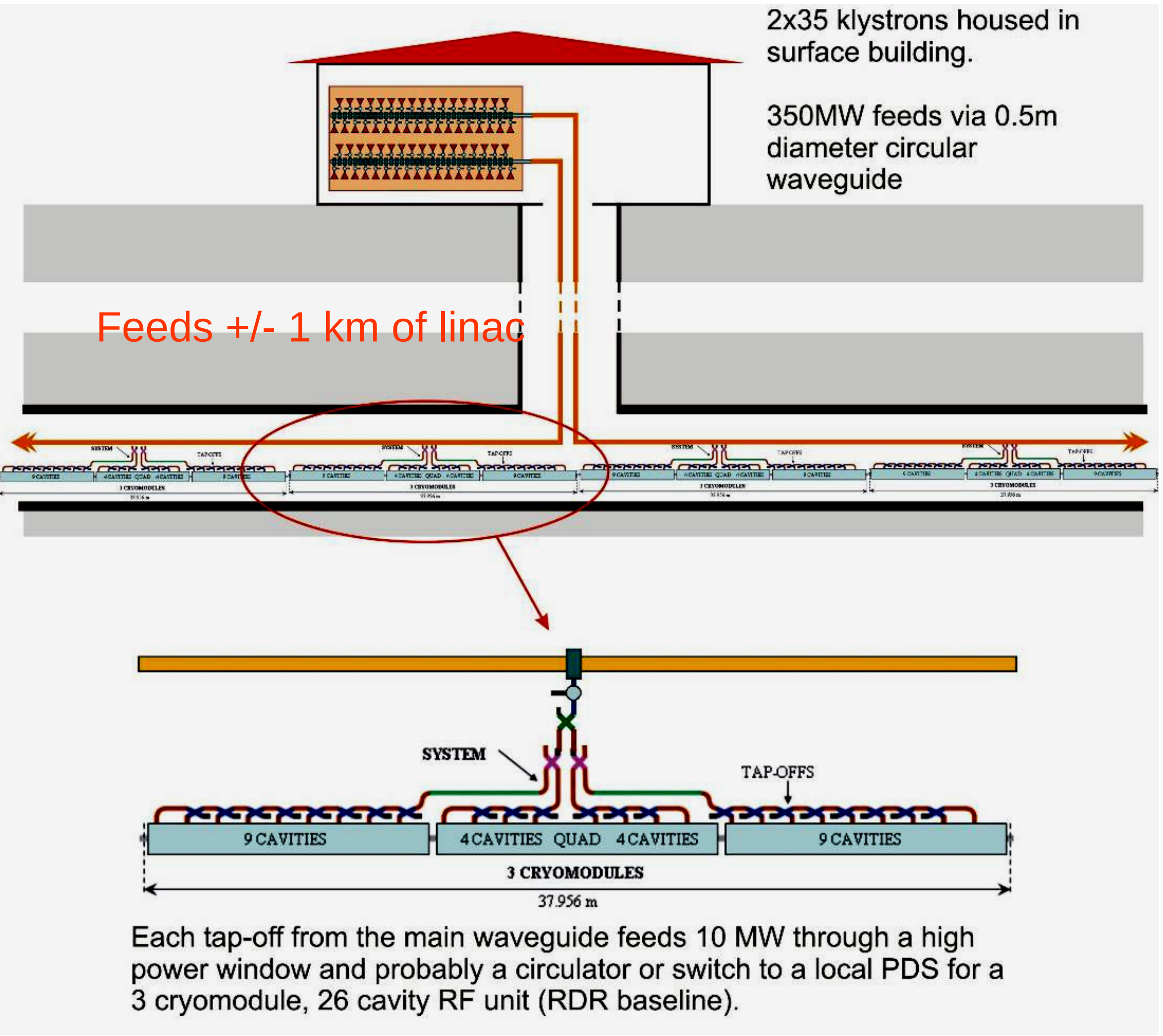
- Packing all component in RDR in single tunnel will cause significant increase of machine down time (XFEL adopts single tunnel but modulators are on the surface)
- Revision of RF distribution system is needed
  - **KCS (Klystron Cluster System)**
  - **DRFS (Distributed RF system)**







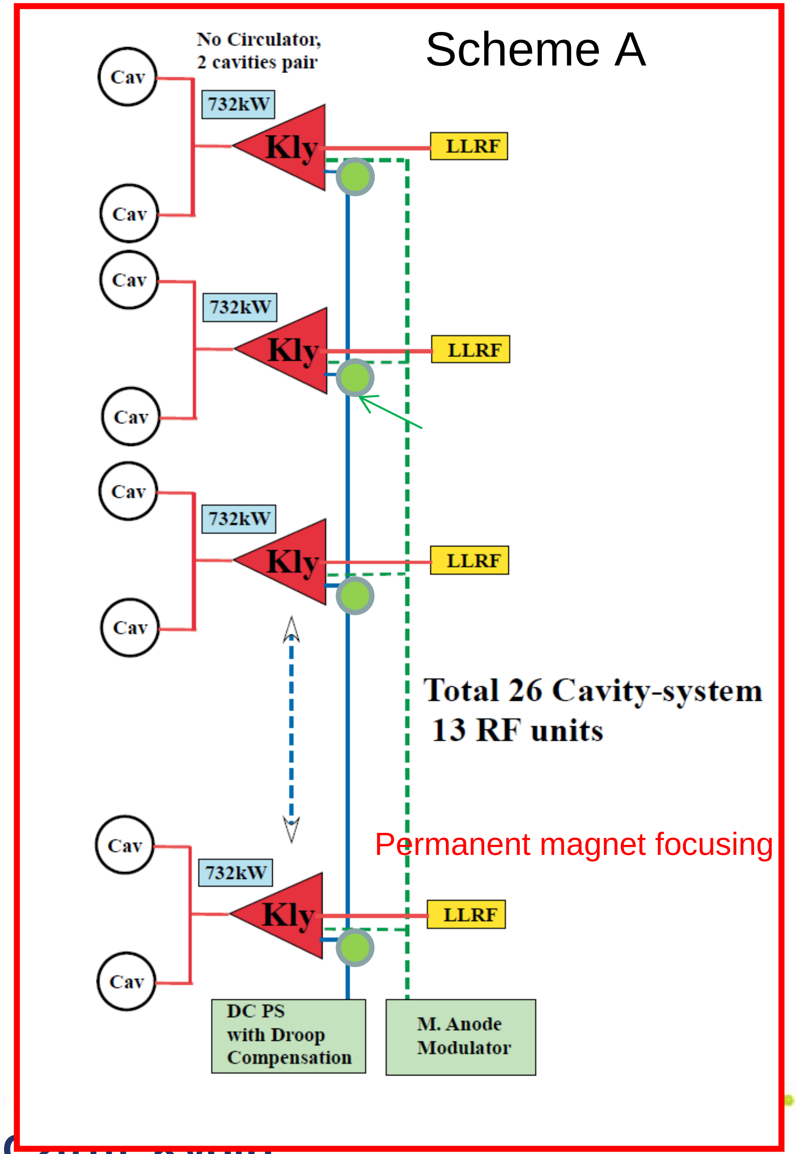
Klystron Cluster System



- Power station on surface every 2km
- ~30 klystrons (10MW MBK) in a station
- Output microwave combined (~300MW) and sent to underground by overmoded wave guide (~48cm)
- Distributed to modules by coaxial tap-offs.
- Need R&D of high power system
- Developed at SLAC

DRFS

- Feed 2 (or 4) cavities by a klystron (~750kW)
- Present scenario
  - **1 klystron for 4 cavities (SB2009)**
  - **1 modulator for 26 cavities with back up**
- Flexible distribution
- Issues are maintenance and cost
- Being developed at KEK
  - **First test planned at the end of S1-Global**
  - **Capture cavities for STF2**
  - **STF2 will be driven by DRFS**

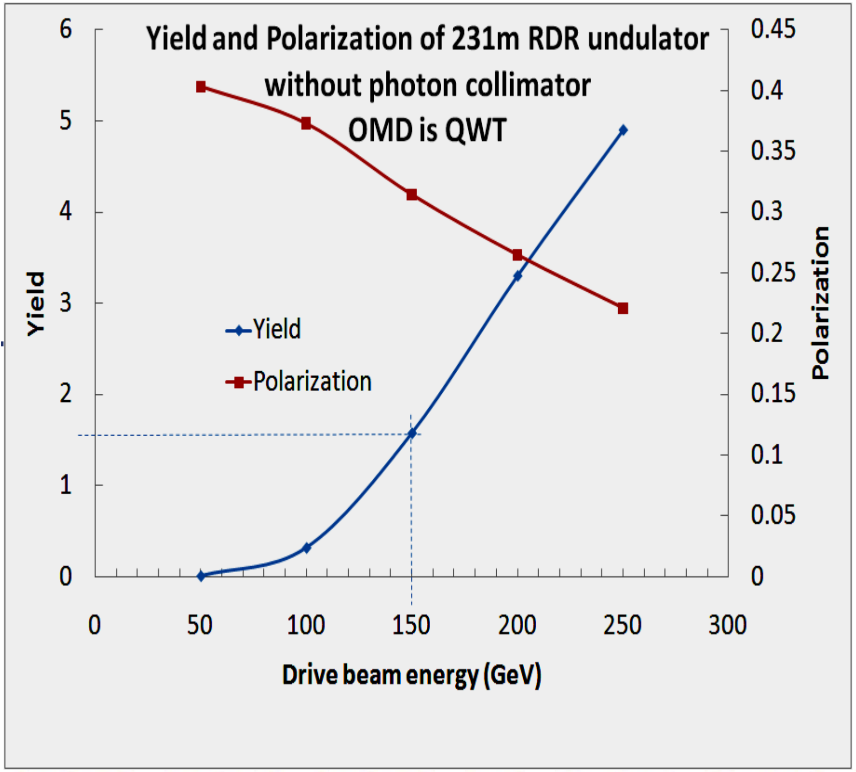


Reduced Number of Bunches

- Number of bunches 2600→1300 with same pulse length (~1ms)
  → half current in linac
  → RF system half
- Allows half size damping rings (same bunch interval in the ring)
  → ~6km → ~3km
  - **Electron-cloud : almost the same**
  - **Update to ~2600 bunches is harder**
    - Experience of e-cloud needed
    - Fast kicker
- Need to squeeze more the beam at IP for the same luminosity

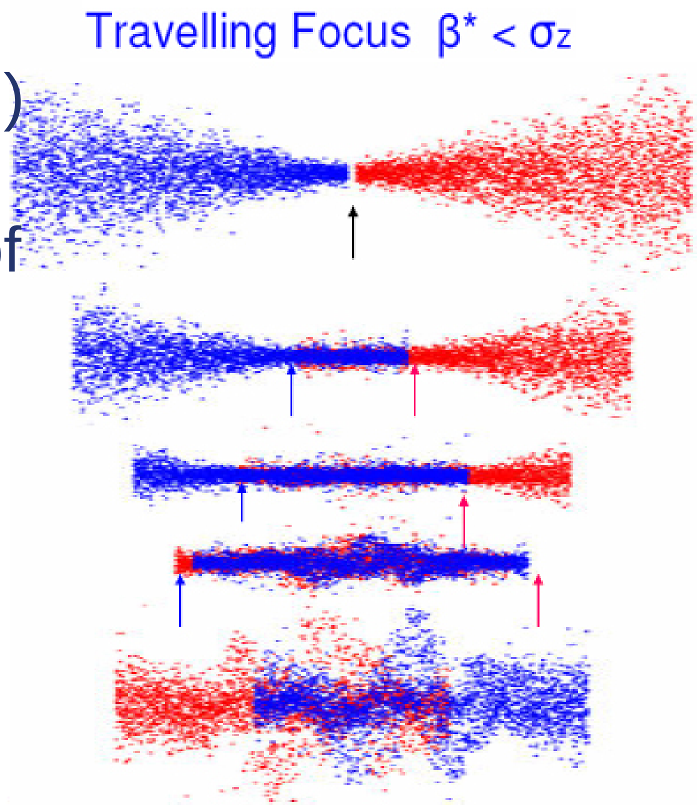
New Design of Positron Source

- Replace flux concentrator with Quarter Wave Transformer (less efficient but safer)
  → longer undulator (=230m), higher target load → target R&D
  - **Continue R&D of flux concentrator**
- Place undulator at linac end (250GeV point)
  - **Simpler machine protection system**
  - **Complex systems concentrated in the central region**
  - **Allows low acceleration gradient of linac at low energies**
  - **No deceleration**
  - **Higher positron yield at high energy (>300GeV CM)**
  - But poor yield below 300GeV CM (~half at 250GeV)



Luminosity

- Bunch number reduction would cause factor 2 reduction of luminosity → squeeze more tightly
- Further reduction at low energies due to the new location of undulator (factor 2 at 250GeV CM)
- Can be cured in principle by `traveling focus' (at the expense of higher sensitivity on collision offset), but it does not work at low energies due to larger geometric emittance
- → factor of 3-4 reduction from RDR value at 250GeV CM.



Recovery of Luminosity at Low Energies

- At low energies the machine repetition rate (5Hz) can be raised owing to the low site power consumption
  - **Requires stronger wigglers in damping rings but this seems to be feasible**
  - **Must revisit entire system**
- The final focus quadrupoles can be modified for low energy collision to make traveling focus effective
  - **Shorter magnet can focus the beam**
  - **Detailed design needed**

Towards Re-baseline

- New baseline must be decided by early 2011 to be in time for TDR
- Four major issues
  A) Accelerating gradient
  B) Single tunnel (with new RF distribution)
  C) Half number of bunches
  D) Undulator
- BAW (Baseline Assessment Workshop)
  - **BAW1 Sep.2010 @KEK A&B**
  - **BWA2 Jan.2011 @??? C&D**

Collaboration with CLIC

- Collaboration of the two linear colliders groups, ILC and CLIC, is desirable with respect to synergies and saving resources
- Collaboration is going on in several fields
  - **General Issues**
  - **CFS (Conventional Facility & Siting)**
  - **Positron Source**
  - **Damping Ring**
  - **BDS (Beam Delivery System)**
  - **Cost Estimation**
  - **Detectors**

Governance

- Discussion launched among the management levels of ICFA, ILCSC, and GDE.
- What sort of organization needed for ILC Lab
  - **Models (CERN, ITER, XFEL,…..)**
  - **Budget model**
    - In-kind contribution
    - Common fund
- Site selection procedure

Beyond TDR

- Technical issues
  - **Possible remaining R&D issues**
    - RF distribution, positron
  - **System tests (most important: S2)**
  - **Industrialization**
    - Cost reduction
    - Mass-production
  - **Engineering design**
- Project implementation plan
  - **Governance**
  - **Siting**

Summary

- GDE is on the track to TDR in 2012
- Progress in SCRF technology and evaluation of cavity yield
- Efforts for industrialization growing
- Test facilities, CESR-TA, ATF/ATF2, FLASH, etc, contributing to risk mitigation
- Re-baseline is being planned through BAW (Baseline Assessment Workshops) by early 2011.