Test Facilities World Tour

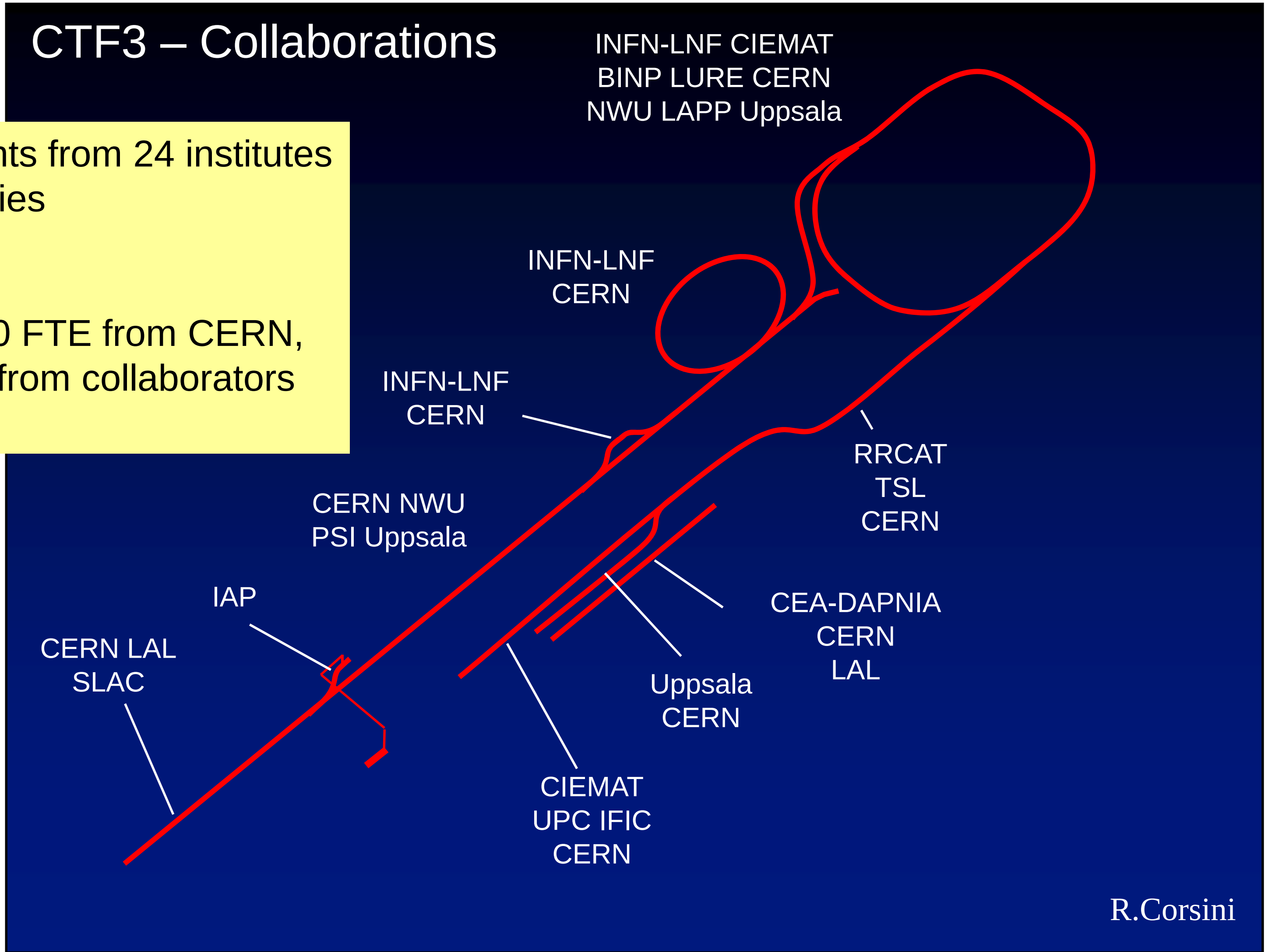
Nobu Toge (KEK)

Backup Slides

CTF3 - Participants

Participants from 24 institutes
16 countries

In 2008:
About 30 FTE from CERN,
21 FTE from collaborators



NLCTA – Evolution

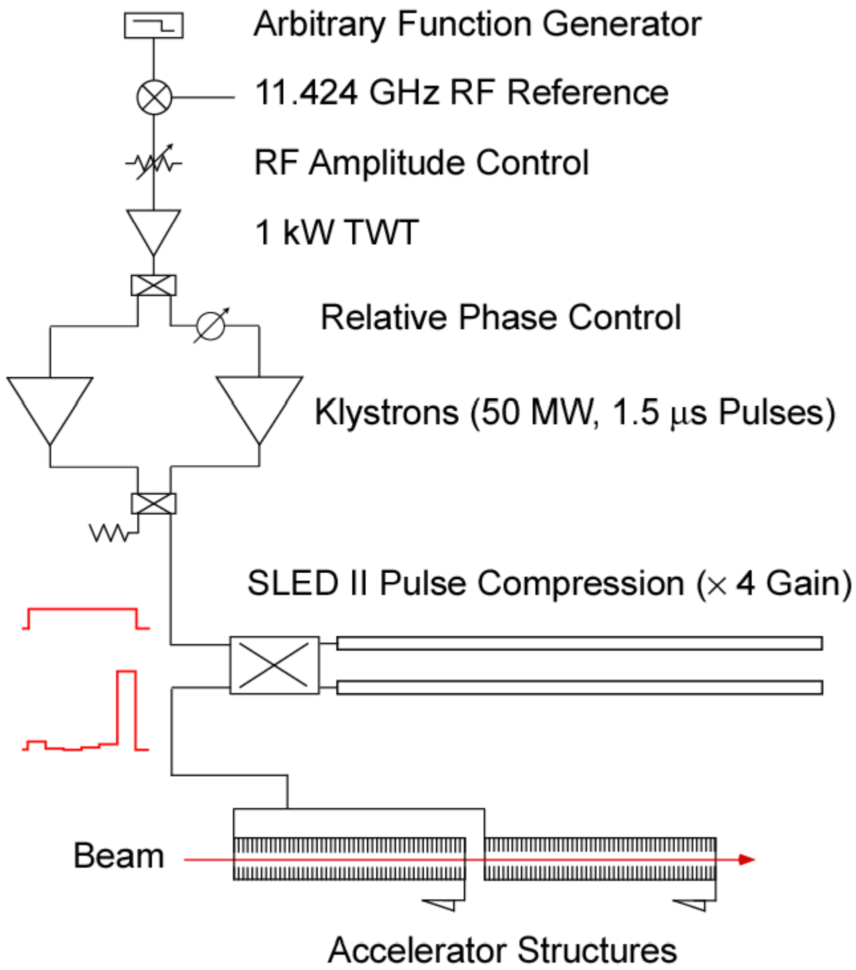
In 1993, construction began using first generation X-Band components.

In 1997, demonstrated 17% beam loading compensation in four, 1.8 m structures at ~ 40 MV/m.

In 1998-99, added second klystron to each linac rf station.

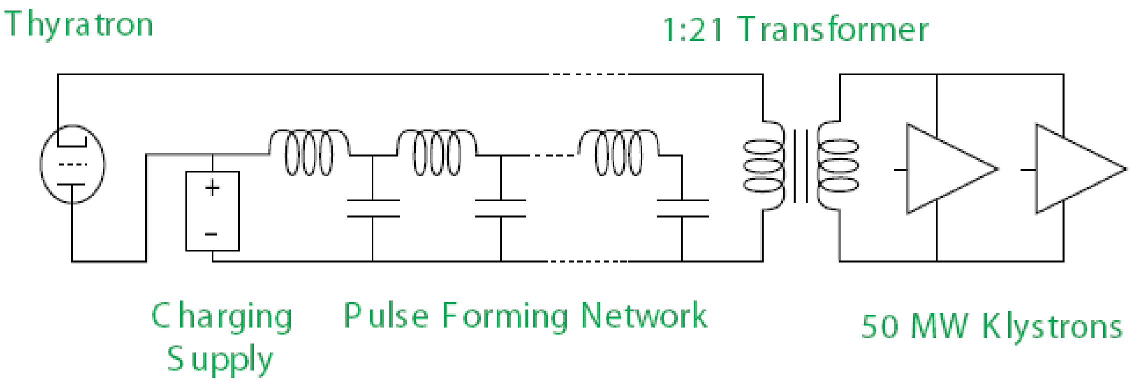
In 2000-present, used for high gradient studies.

NLCTA Linac RF Station (One of Two)



NLCTA – Klystron Modulators

Conventional Line-Type Modulators



400 KV

300 A per Klystron

1.5 µs Flattop

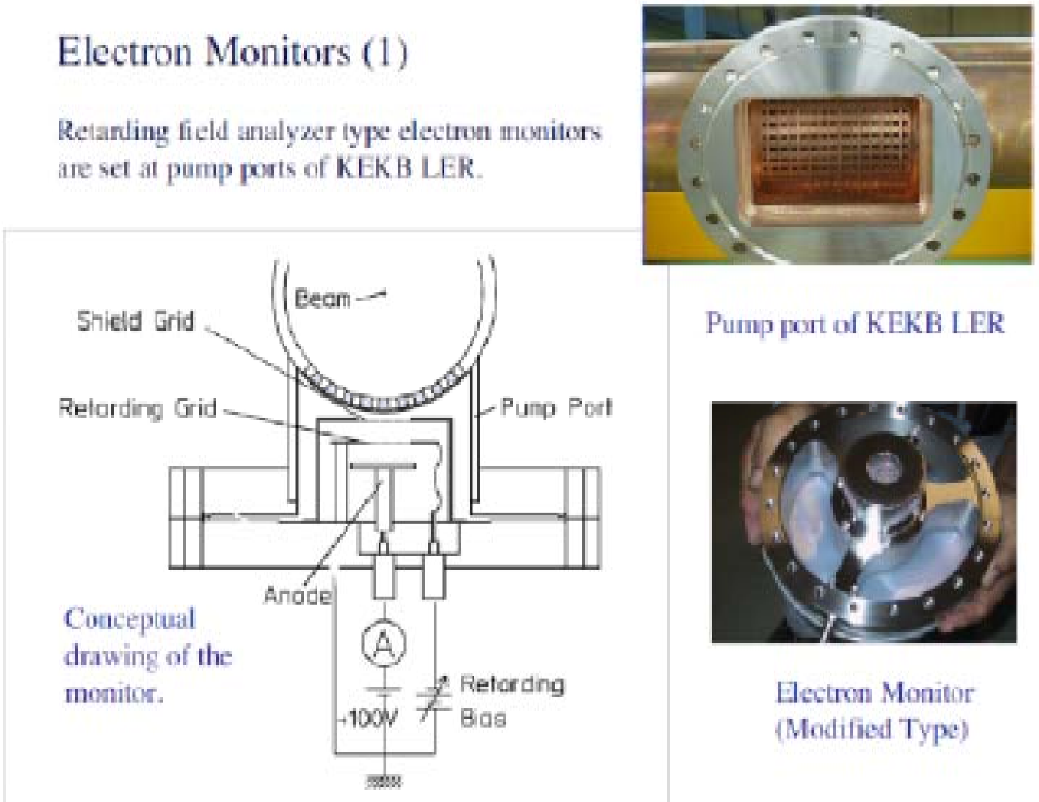
60 Hz Pulse Rate

CesrTA – Relevance to LCs

- "Electron Cloud" Issue at Positron Damping Rings (e+ DR)
  - Synchrotron radiation → Inner wall of vacuum chamber → secondary electrons → "Electron cloud" → Beam instabilities / Emittance growth
- CesrTA
  - Can use positrons.
  - Vehecle for the ILCDR R&D on the timescale of the ILC TDP
  - Internat'l collaboration was formed, centered around Cornell.
  - Reconfiguration of CESR is in progress.
    - Probe species dependent effects
  - Deliver design inputs for the ILC Technical Design Phase

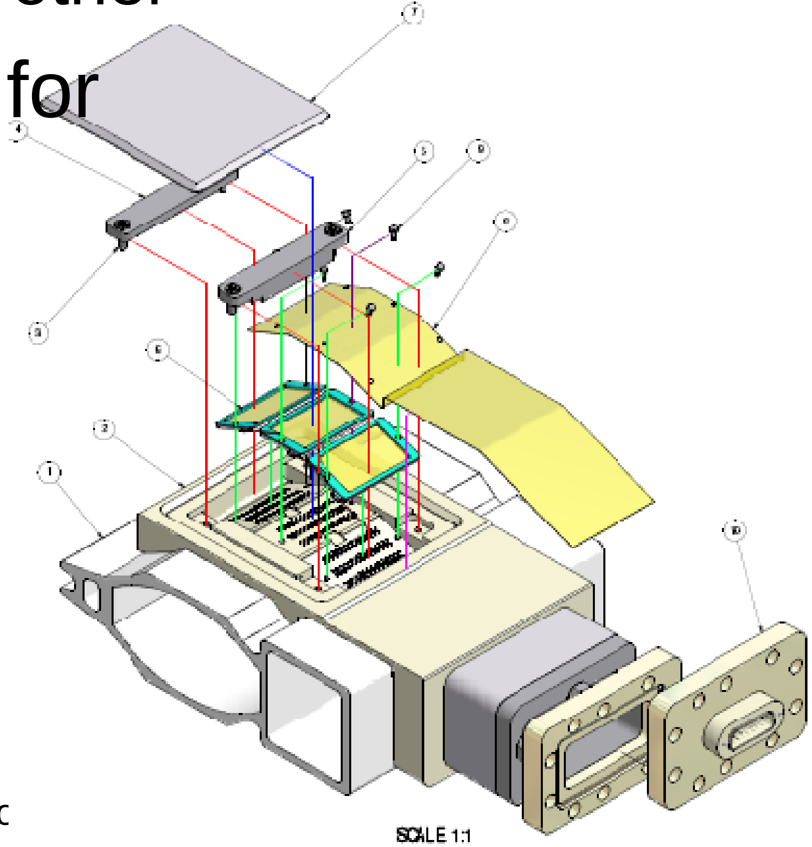
Measurement of Electron Cloud

- RFA (Retarding Field Analyzer) type electron detectors with Faraday cup or MCP or multi-strip anode are installed to KEKB LER.



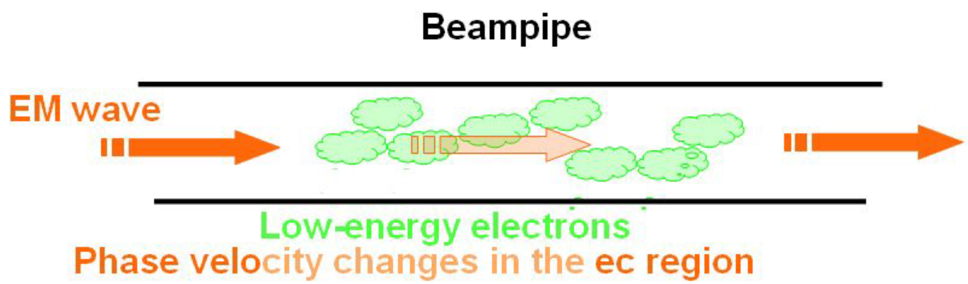
Measurement (Greenwald)

- Comparison between Cornell-type thin RFA and APS-type
  - Almost consistent each other
- Newly developed RFA for CESR-TA
  - Dipole Chamber RFA

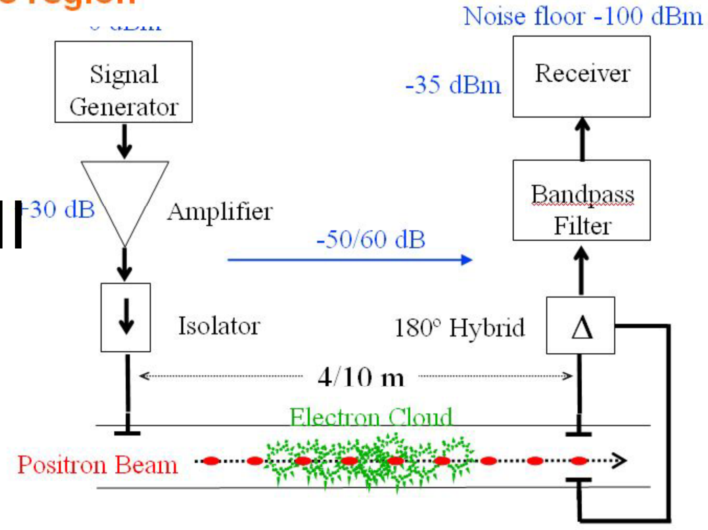


Measurement (Santis)

- Electron density can be estimated by measuring the phase shift of transmitting microwave

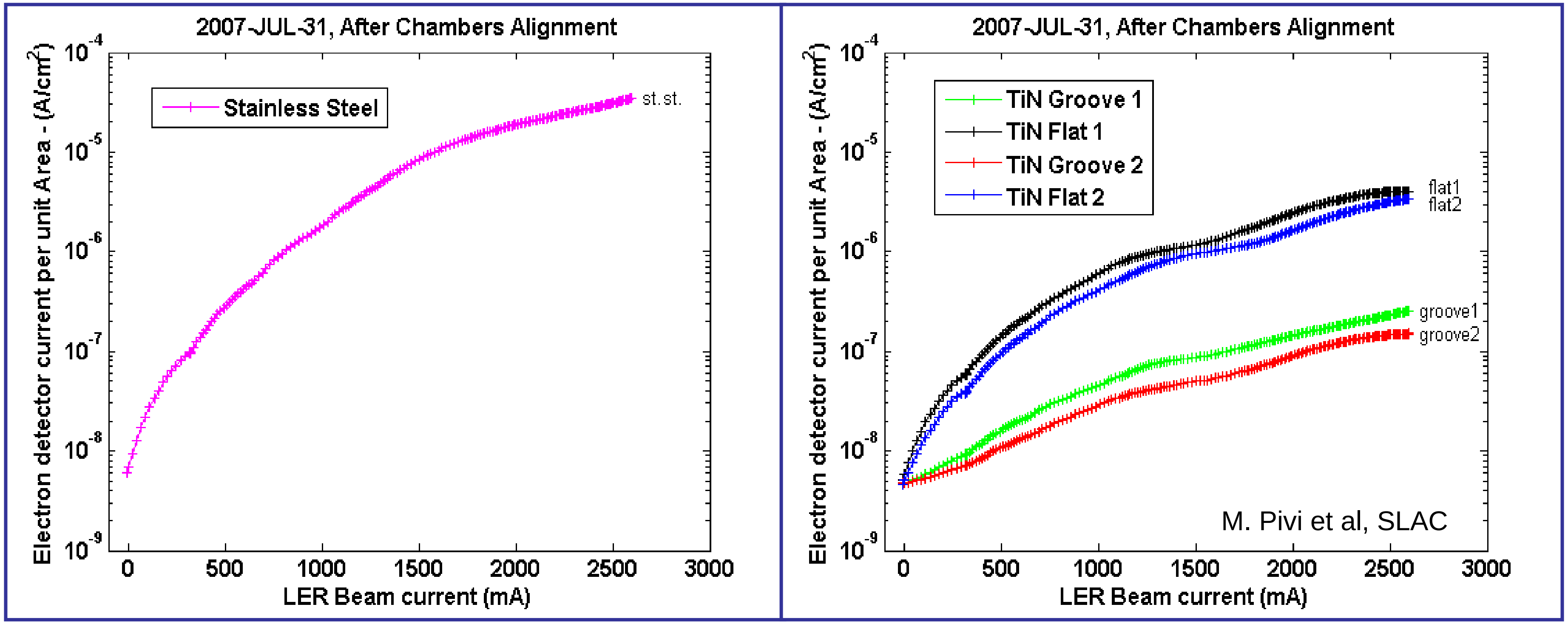


- Instruments were set up for CESR-TA, following PEP-II



CesrTA dipole/ex-wiggler

ECLOUD2 – Grooved Chambers Performance: M. Pivi



Electron cloud signal in stainless steel chamber.

Electron cloud signal in two smooth (flat) TiN-chambers and two grooved TiN-chambers installed in PEP-II.

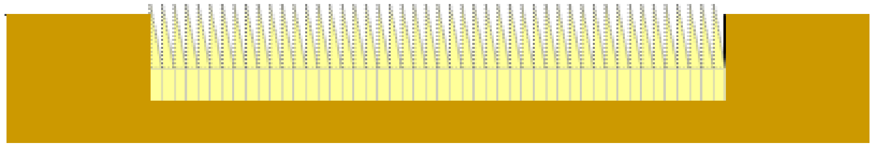
Mitigation tests in Cesr TA: M. Palmer, Cornell

(M. Pivi)

Cornell University
Laboratory for Elementary-Particle Physics

Mitigation Techniques

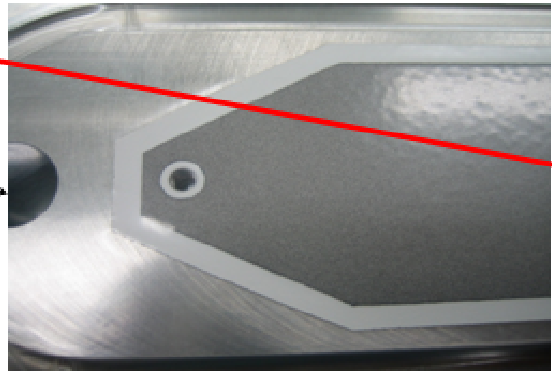
- Wiggler extrusion split into top/bottom halves ⇨ provides exposed vacuum chamber surface for modifications
  - Possibility of adding grooved surface
  - Tungsten Electrode (hot spray) on alumina – see talk by Suetsugu



Propose to pursue this option next

For feed-through →

Looking at options for low impact feedthroughs



July 10, 2008 ILCDR08 - Cornell University 8

Recommendation for mitigation as input for DR design: Discussion All

(M. Pivi)

DR element	% ring	Antechamber	Coating	Additional Mitigation	Remarks
DRIFT in STRAIGHT	33	No	NEG	Solenoid	Groove if necessary
DRIFT in ARC	56	Downstream of BEND only	NEG	Solenoid	Groove if necessary
BEND	7	Yes	TiN	Grooves and Electrodes	
WIGG	3	Yes	TiN	Electrodes and Grooves	
QUAD	1	Downstream BEND / WIGG	TiN	Grooves and Electrodes	

Preliminary table to be completed as input for Technical Design Phase. Goal is to turn all Red colors to Green in the next two years.

Other mitigations under development! (ex: Carbon coating CERN)

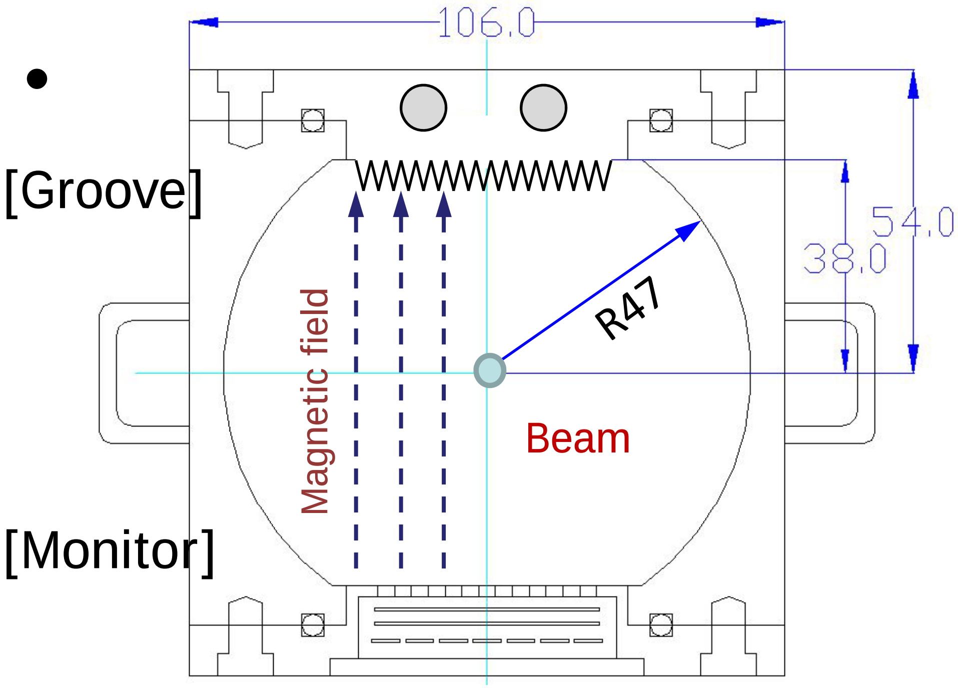
Experimental Plan at KEKB Positron Ring
Grooved Surface, and Clearing Electrode Ver.2

Y. Suetsugu, H. Fukuma, KEK
M. Pivi and W. Lanfa, SLAC

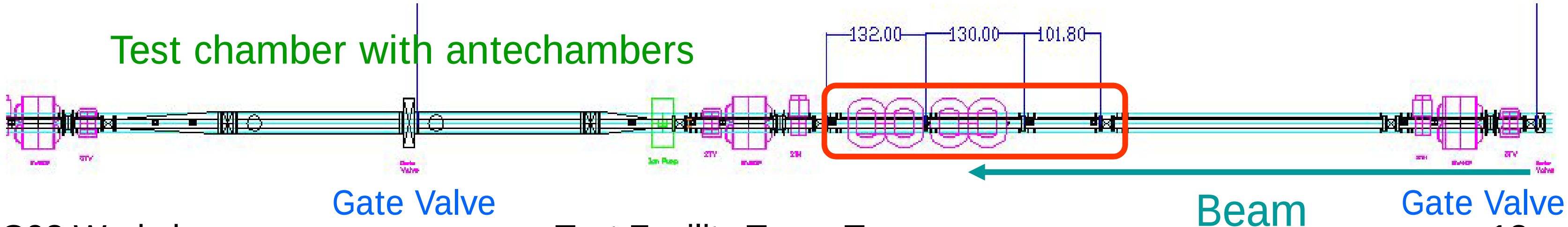
Experimental Setup

(G. Dugan)

•



Wiggler magnets
B = 0.75 T

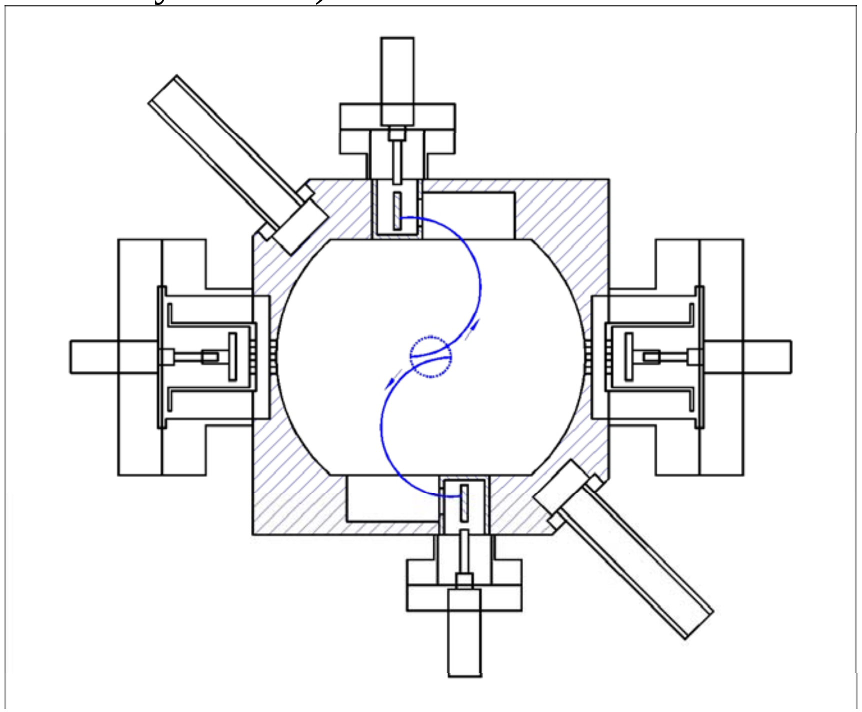


Plan of measuring cloud density in the solenoid field and in the quadrupole field

K. Kanazawa (KEK) (G. Dugan)

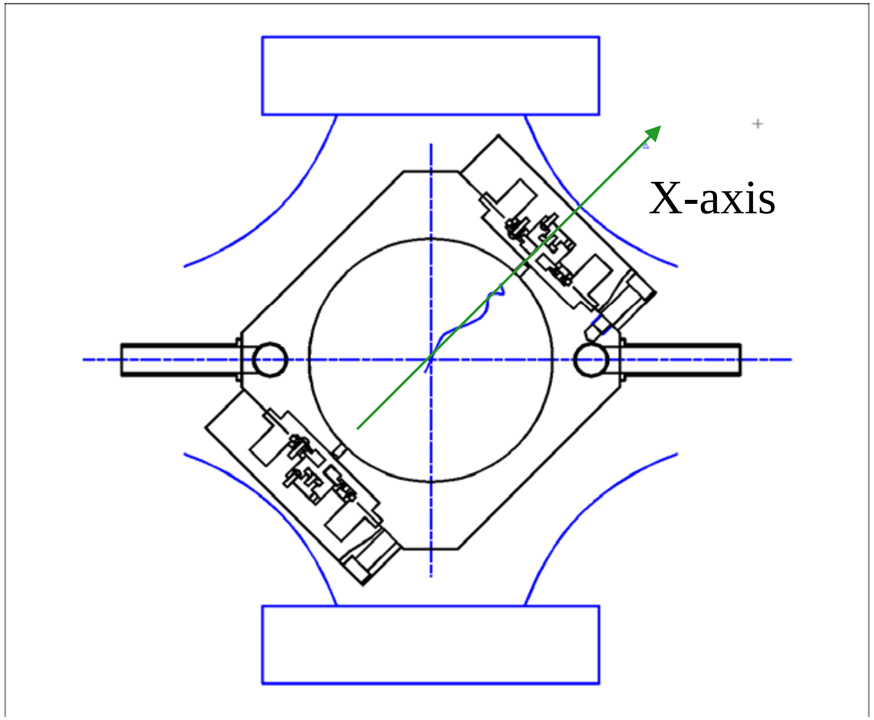
SOLENOID

• Given a solenoid field and the position of detection, the energy of measured electrons is automatically selected (=the volume is automatically defined).

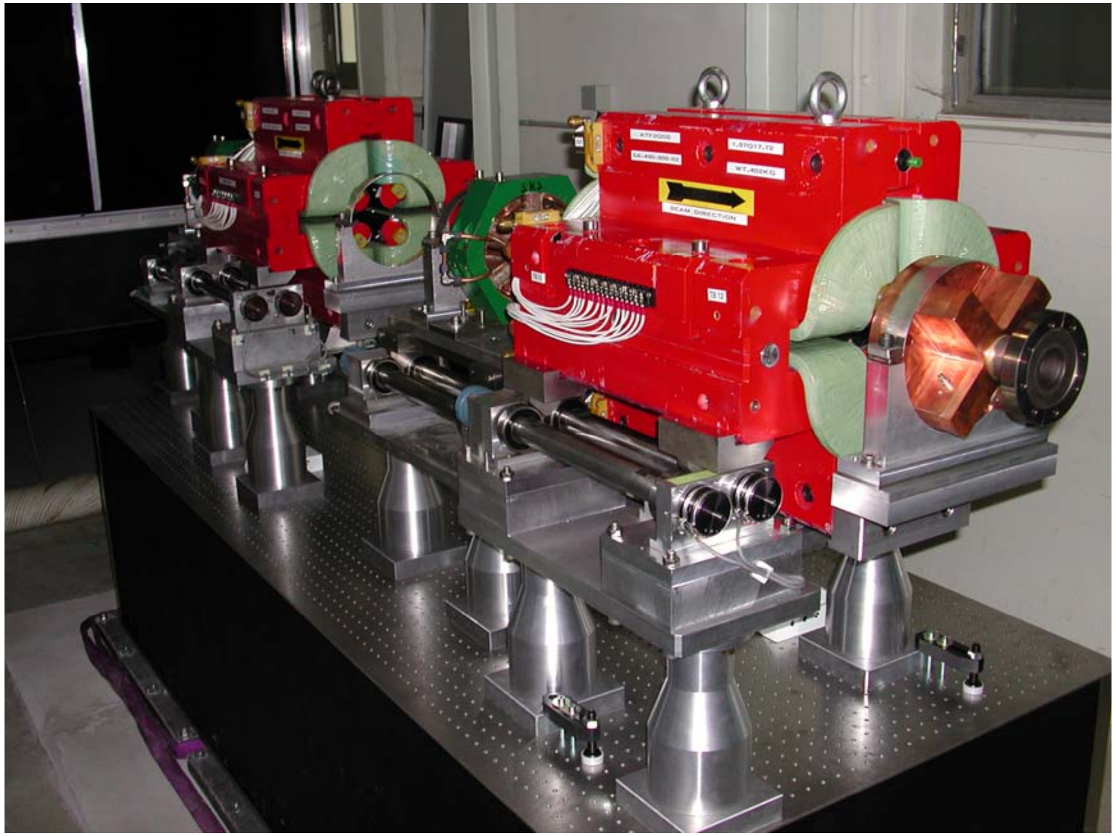


QUADRUPOLE

Electrons accelerated by a bunch along X-axis reach the detector.



Final Doublet System at LAPP



Installation will be started from Sep. 16th by LAPP and KEK.

DR-BPM Upgrade (FNAL/SLAC/KEK)

Goal:

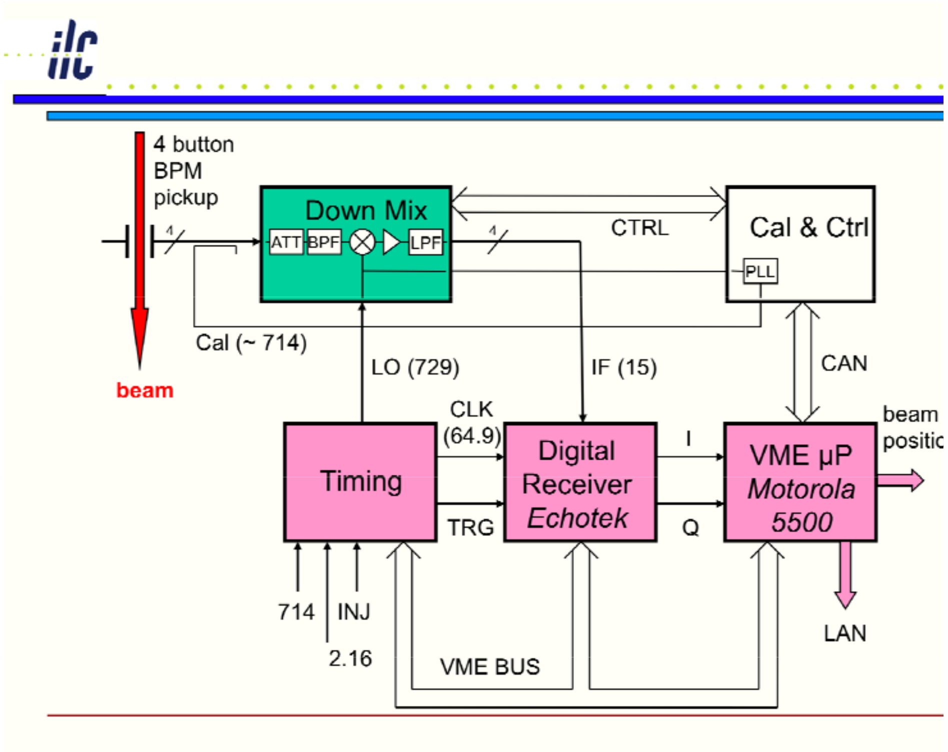
Generation and extraction of

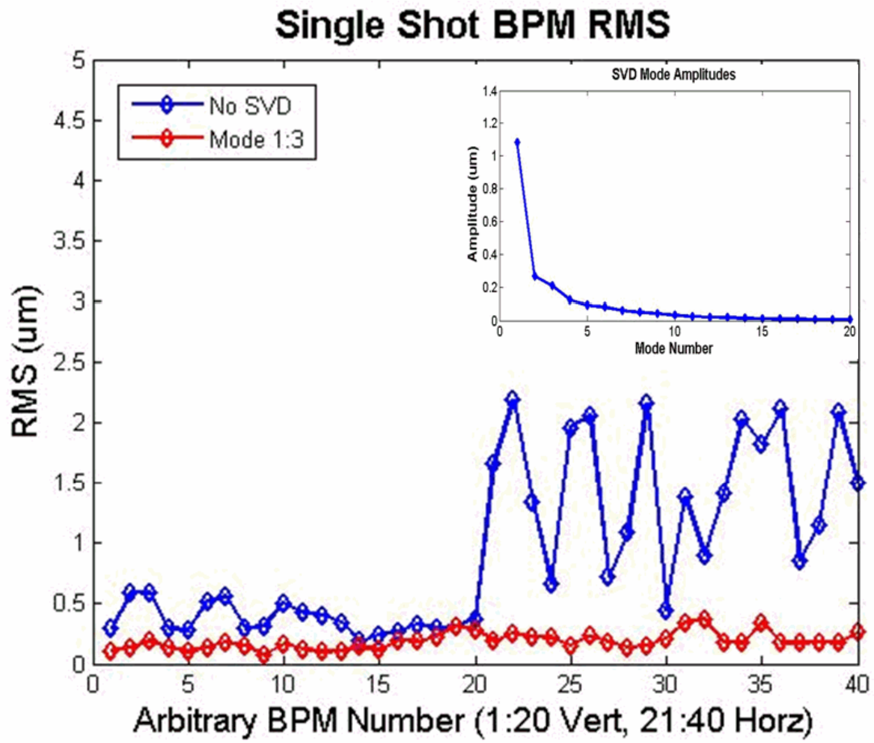
low emittance beam (ε_y < 2 pm)

at the nominal ILC bunch charge

- A major tool for low emittance corrections:
  a high resolution BPM system
  - Optimization of the closed-orbit, beam-based alignment (BBA) studies to investigate BPM offsets and calibration.
  - Correction of non-linear field effects, i.e. coupling, chromaticity,…
  - Necessary: a state-or-the-art BPM system, utilizing
    - a broadband turn-by-turn mode (< 10 µm resolution)
    - a narrowband mode with high resolution (~ 100 nm range)

BPM Hardware Overview

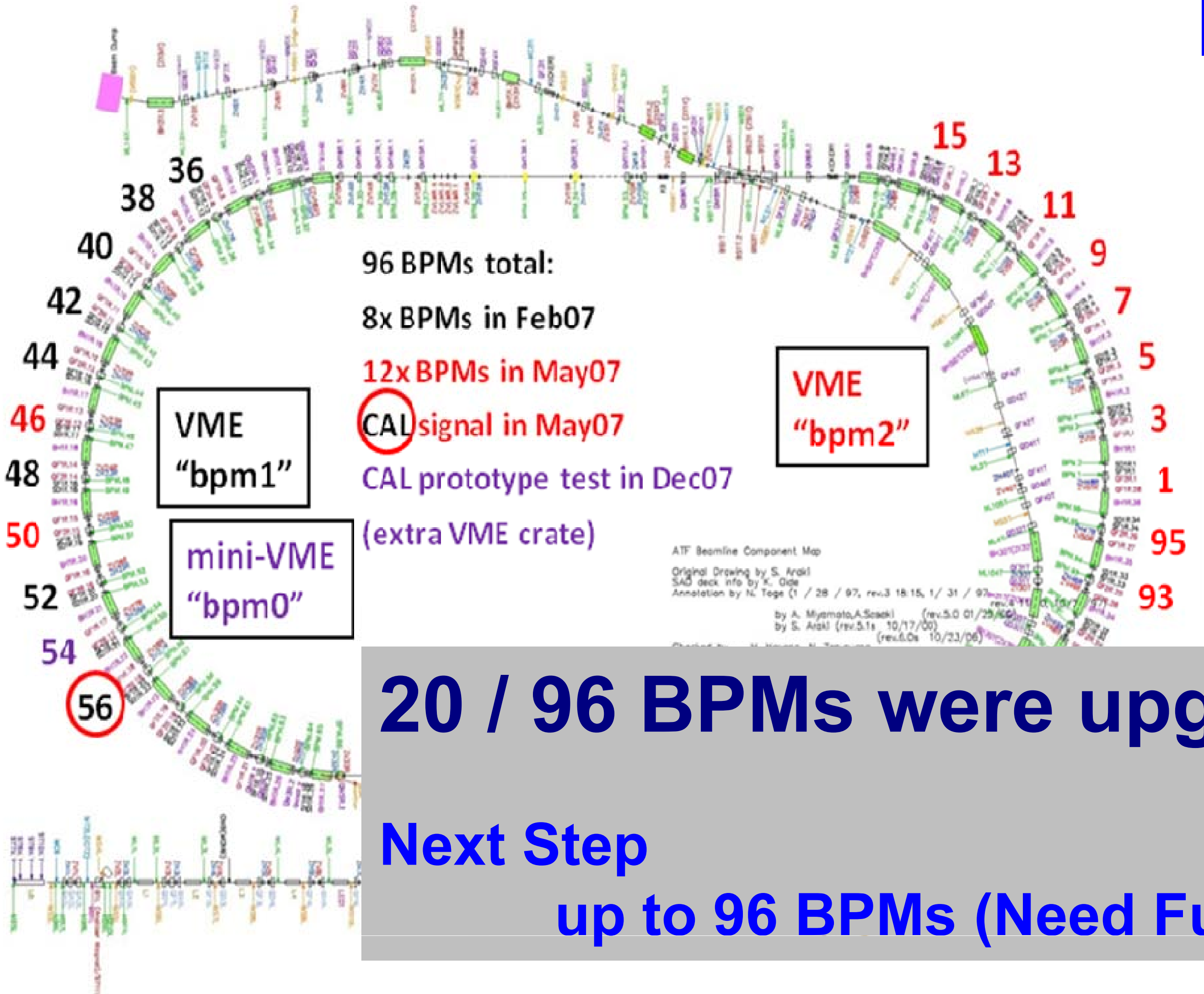




Narrowband Mode Resolution

- Triggered at turn #500,000
- ~200 ms position data per shot (1280 narrowband mode BPM measurements).
- 126 tap box car filter to reject 50 Hz: ~ 800 nm resolution
- SVD analysis, removing modes with hor./ vert. correlation: **~200 nm resolution**

The ATF Damping Ring



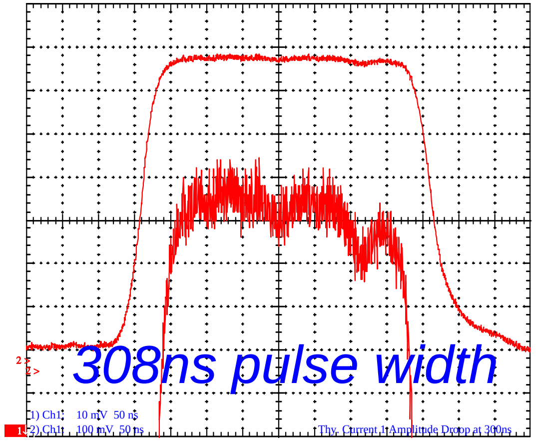
20 / 96 BPMs were upgraded.

Next Step

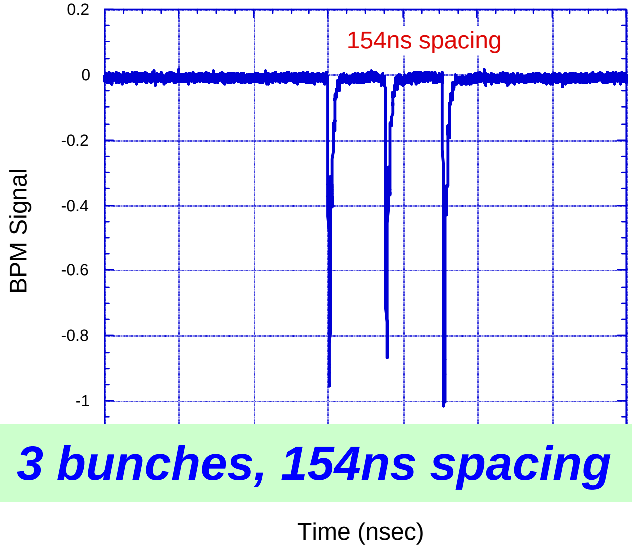
up to 96 BPMs (Need Funds!)

Multi-bunch beam in ATF2

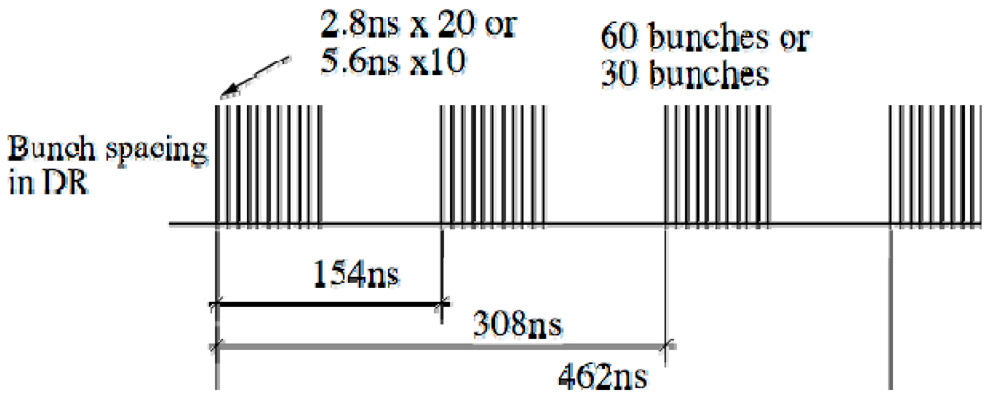
ATF kicker
(Pulse magnet kicker system)

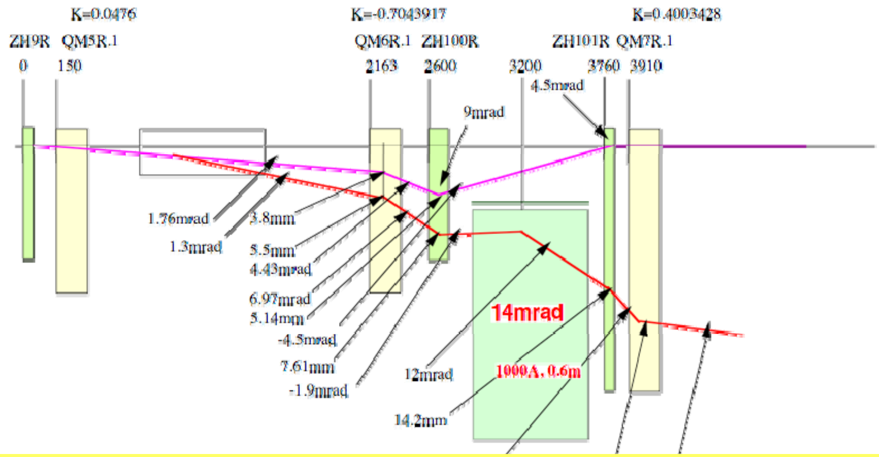


(Single bunch) x 3 Train Extraction



3 bunches, 154ns spacing

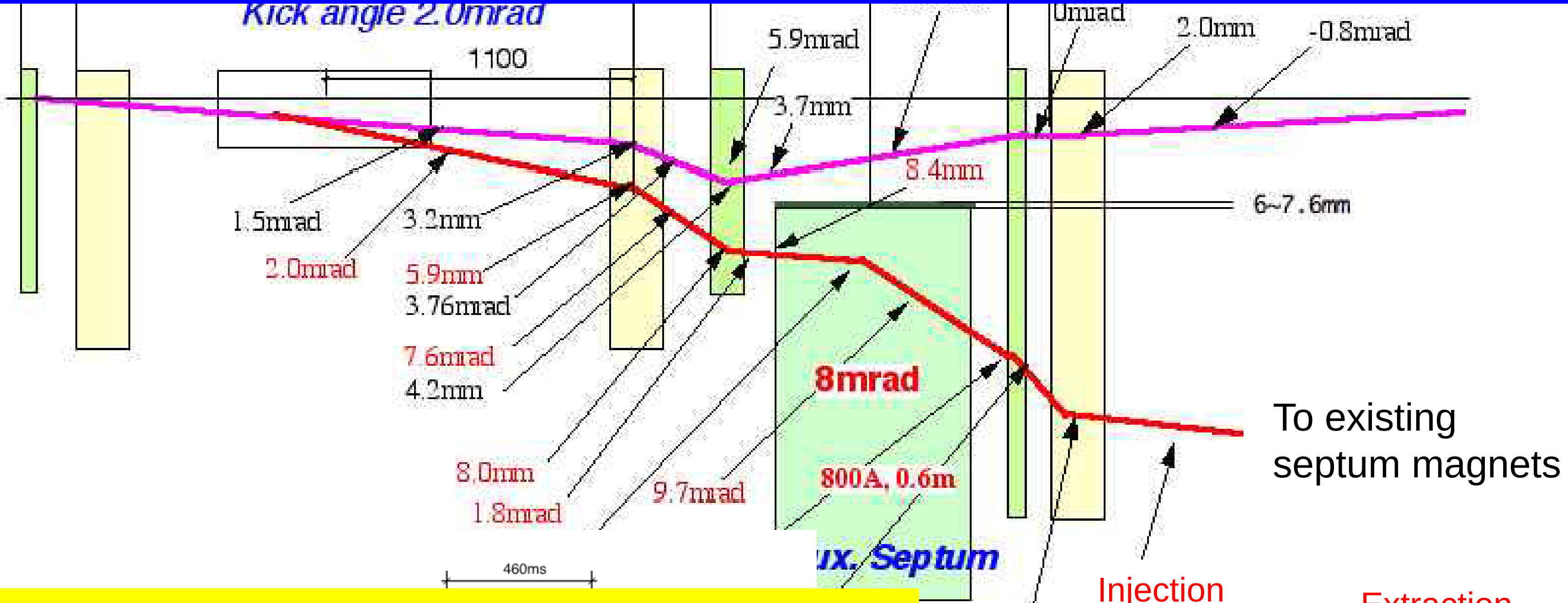




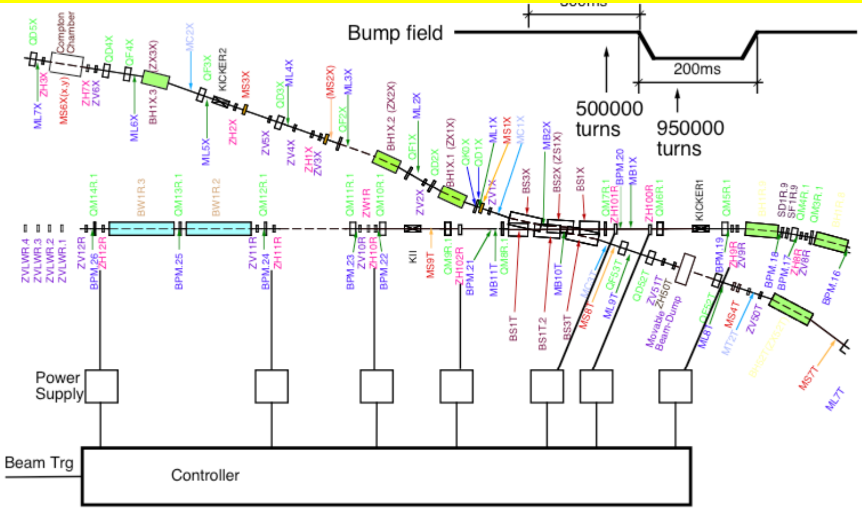
Test

Multi-bunch in ATF2 by fast kicker
30 bunches with 308 ns spacing

Beam extraction orbit by using Strip-line Kicker



Power Supply Control for Pulse Bump orbit



Injection

Extraction

Beam Injection

Bump orbit start

Current control

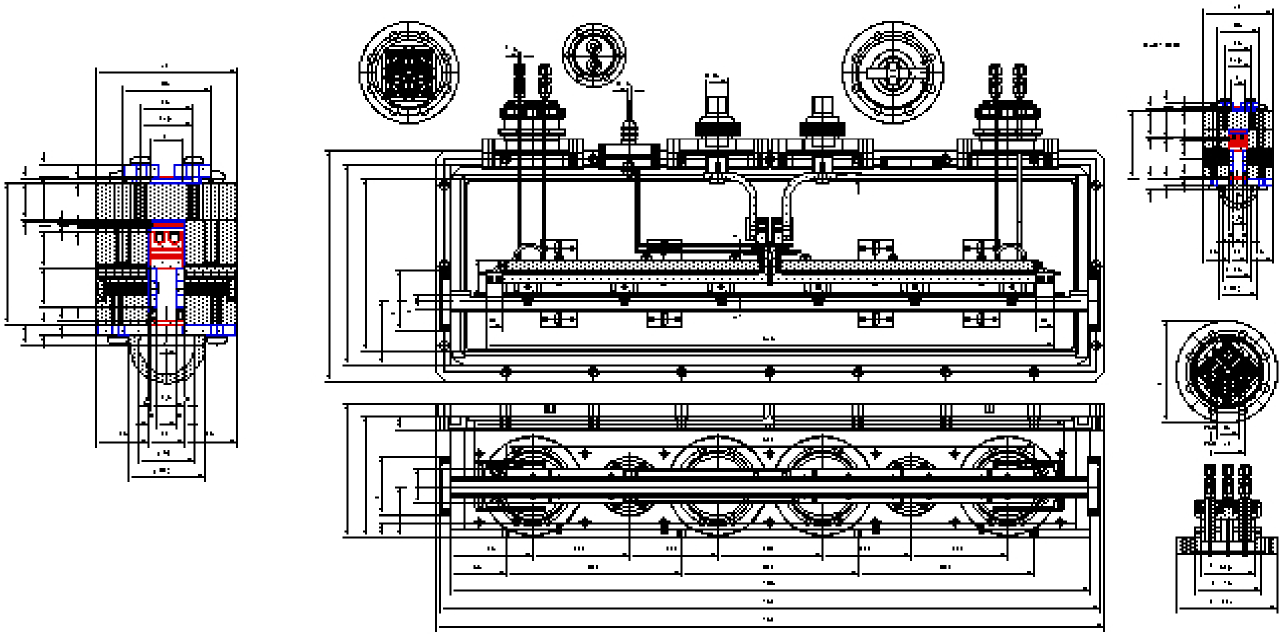
Magnet current

100ms/div

Fast Kicker hardware and Plan

Strip-line kicker

Auxiliary Septum



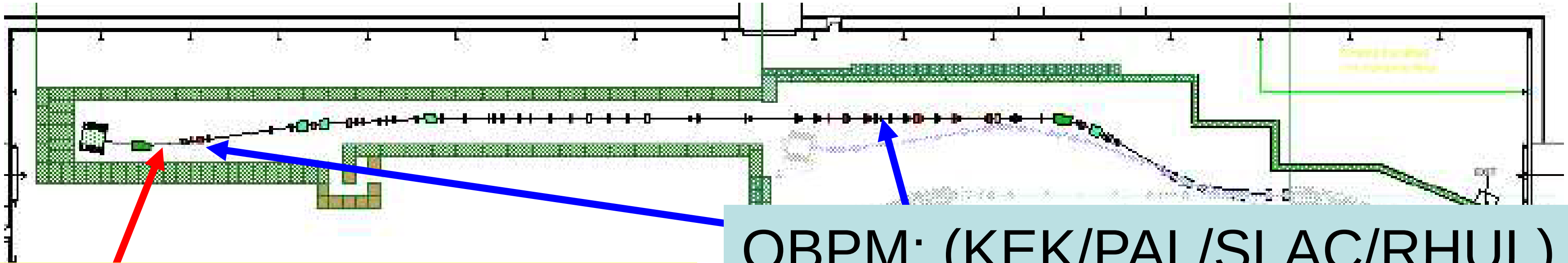
Plan of beam extraction

2008 December
Installation

2009 January
First trial (2 weeks)

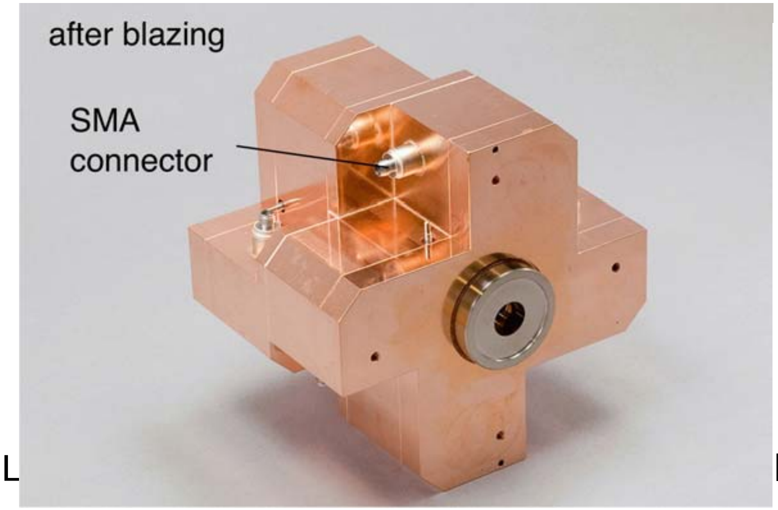
2009 February
Recover the ATF kicker

ATF2 beamline with Cavity BPM



IP-BPM: (KEK/KNU/RHUL)
- Target resolution: 2nm
- Achieved resolution: 8.7nm
- 1 or 2 units

QBPM: (KEK/PAL/SLAC/RHUL)
- Target resolution: 100nm
- Achieved resolution: 17nm
- **Total 38 units**
  - C-band 34、S-band 4

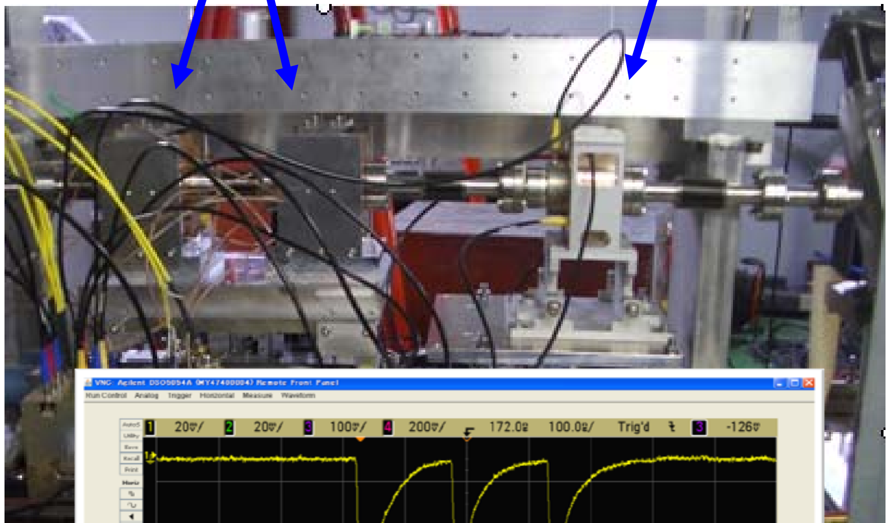


KNU Low Q IP-BPM

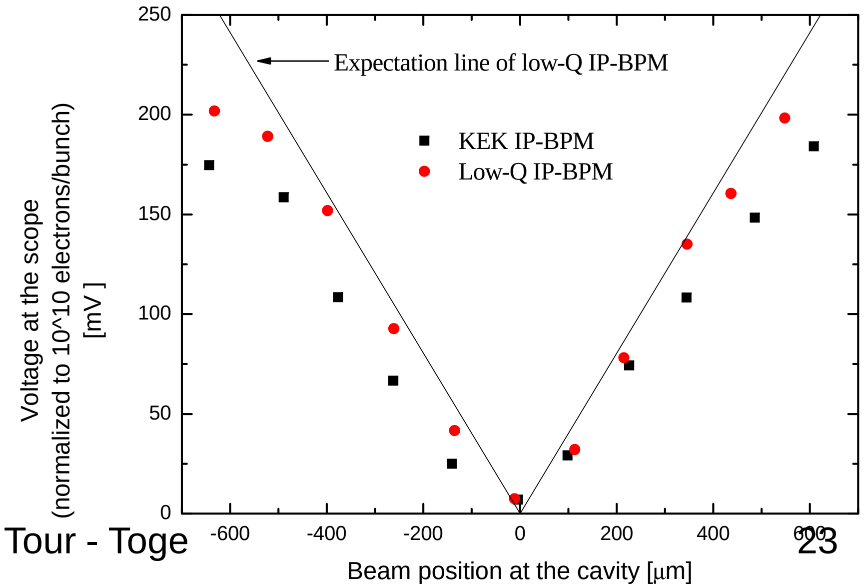
Fast signal decay for multiple bunch operation

KEK IP-BPM

Low Q IP-BPM



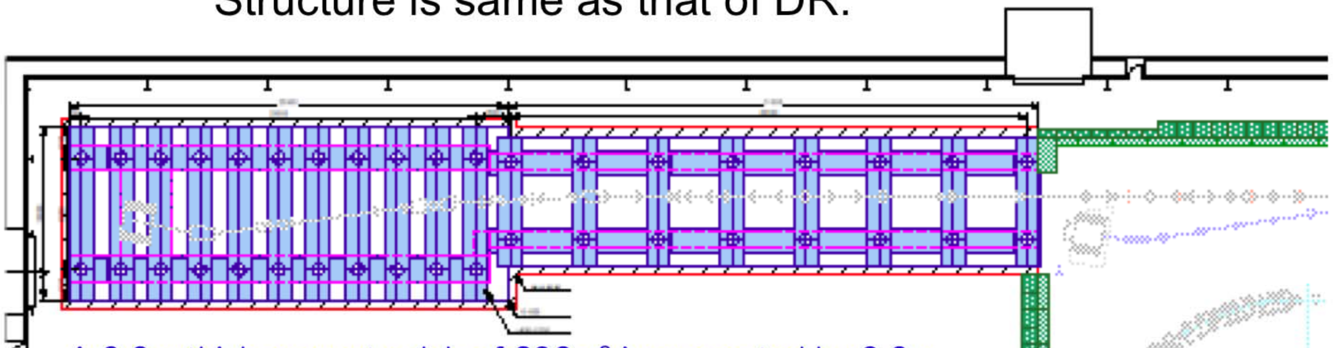
- Position sensitivity test performed, consistent with expectation
- **Bunch separation achieved in 154 ns interval**



Floor structure for ATF2 beam line

Refurbishment from Jun to Sep 2007

Structure is same as that of DR.



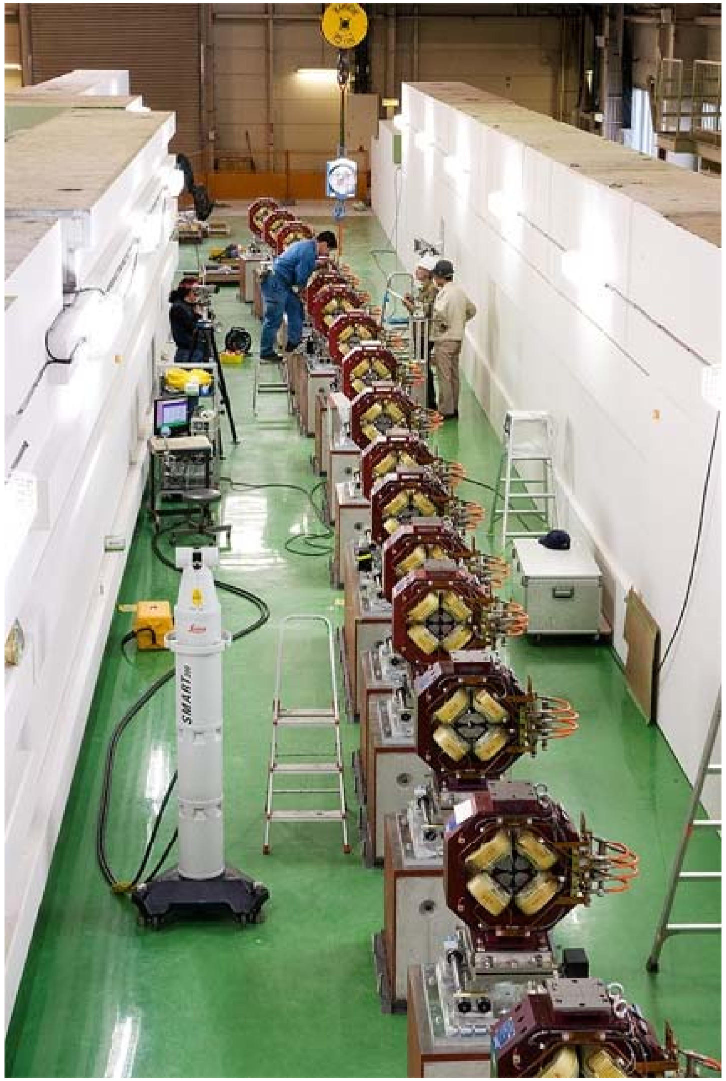
A 0.6m thick concrete slab of $396m^3$ is supported by 0.6m thick beams and 38 piles with 0.7m diameter and 13m height.

Floor Refurbishment

ATF2 construction

2007/9

ATF2 construction



2008/2

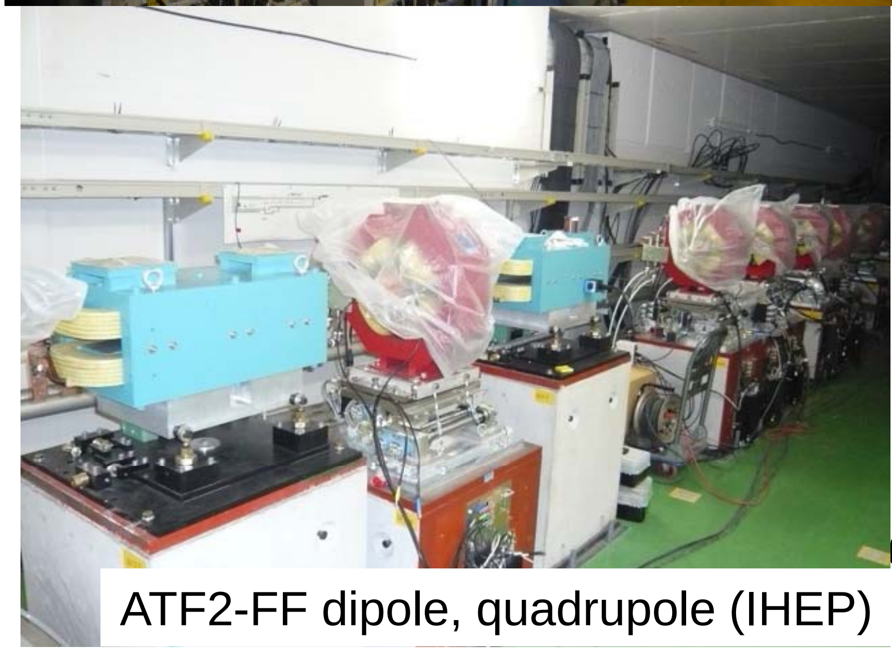
2008/5

2008/9: new EXT

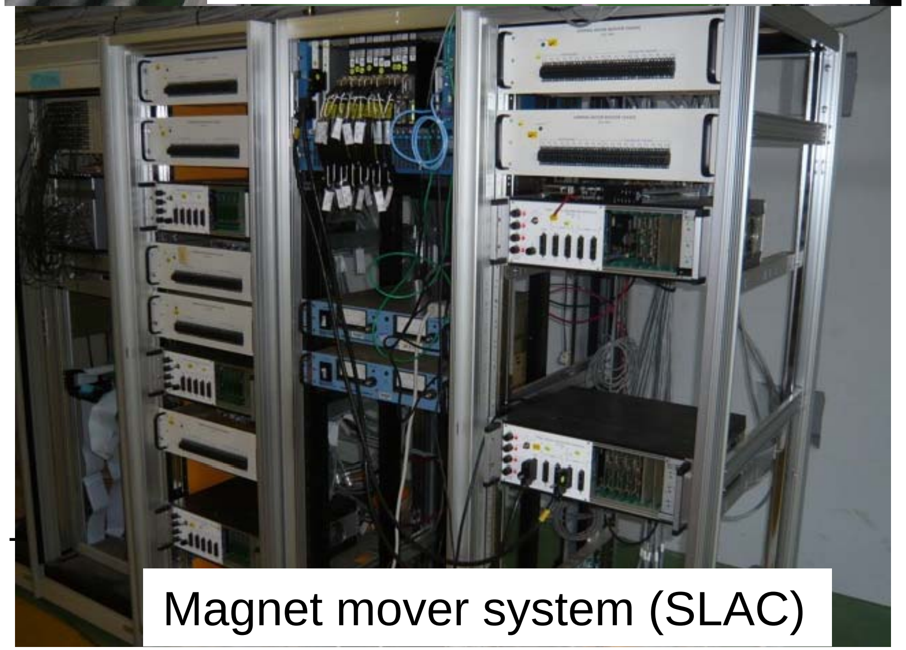
International contribution (2)

High Availability PS (SLAC)

Cooling Water, Cables (KEK)



ATF2-FF dipole, quadrupole (IHEP)



Magnet mover system (SLAC)

Status of ATF2 construction

Remaining works

Installation

- Vacuum system (chambers, pumps,...),
- Final Doublet system,
- R&D devices; Laser wire, FONT.

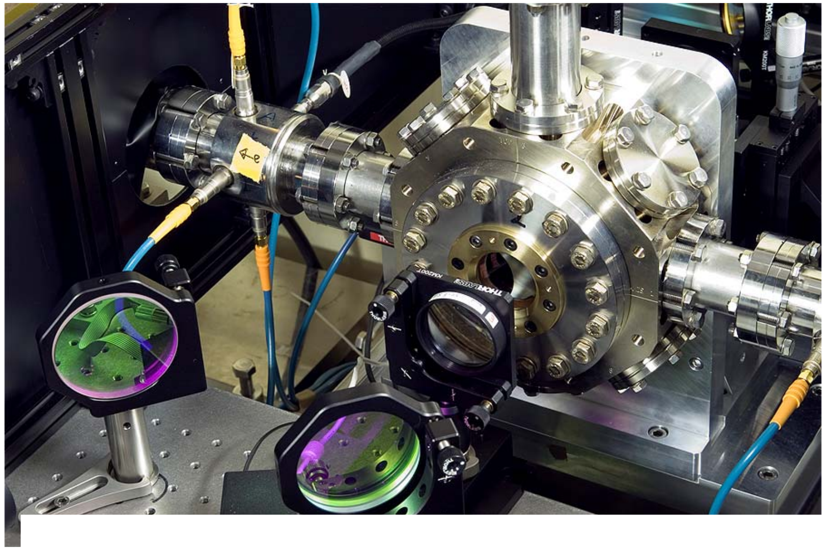
Commissioning

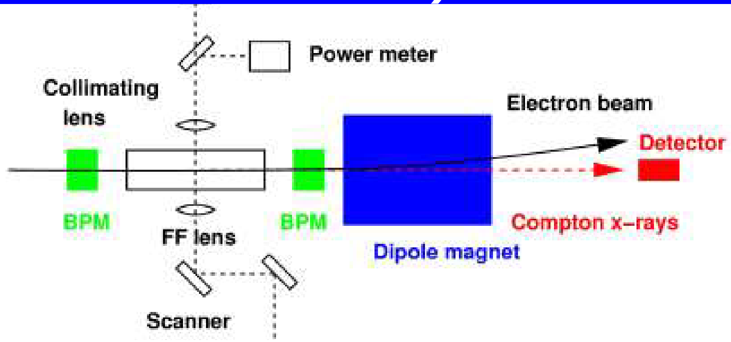
- Cavity BPM read-out system,
- Magnet Power supplies
- Integration of ATF/ATF2 control system

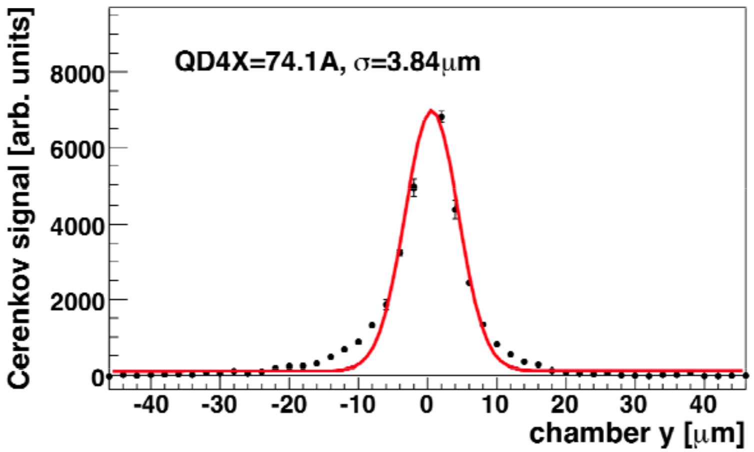
Beam Commissioning will be started on November 2008.

→ Next review by Tauchi-san

Pulsed Laser Wire R&D
(RHUL, Oxford, KEK)







ILC design requirement:

< 1 um laser wire scanner

2007/Jan

σ~8um

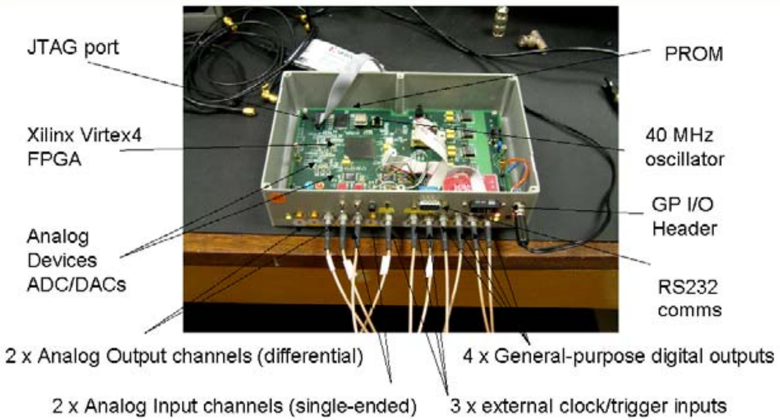
2008/May

σ~3.8um

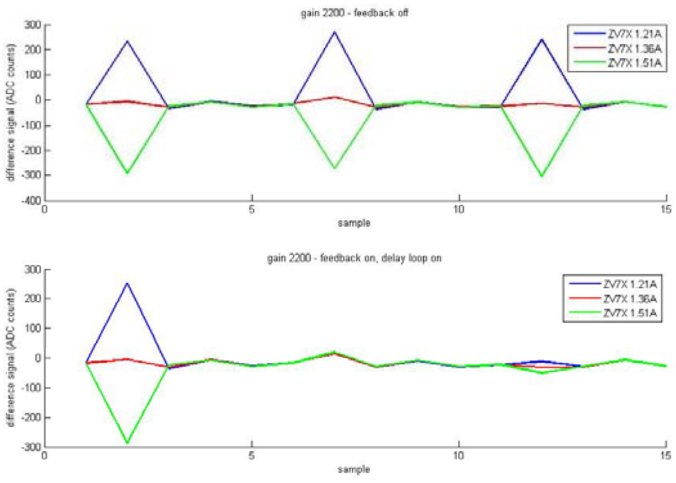
Realize the 1 um beam size scanning in FY2008, by implementing improvements in the electron beam optics and improved laser diagnostics.

FONT
(Oxford, KEK)

Digital Feedback Board



Philip Burrows 15 *ATF Technical Board, Warsaw 11/06/08*

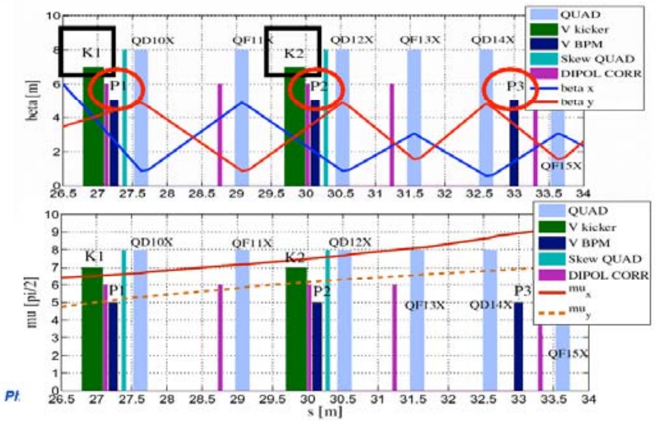


Preliminary Observations

- Bunch train not straight!
  sagitta ~ 100 um
  much worse than in 2007
  not much shift time spent on beam tuning
- Bunch-bunch jitter: within train, and train-to-train
- Feedback works exactly as expected
  (but results limited by train sagitta)
  latency c. 140 ns
- Detailed study of data in progress – stay tuned

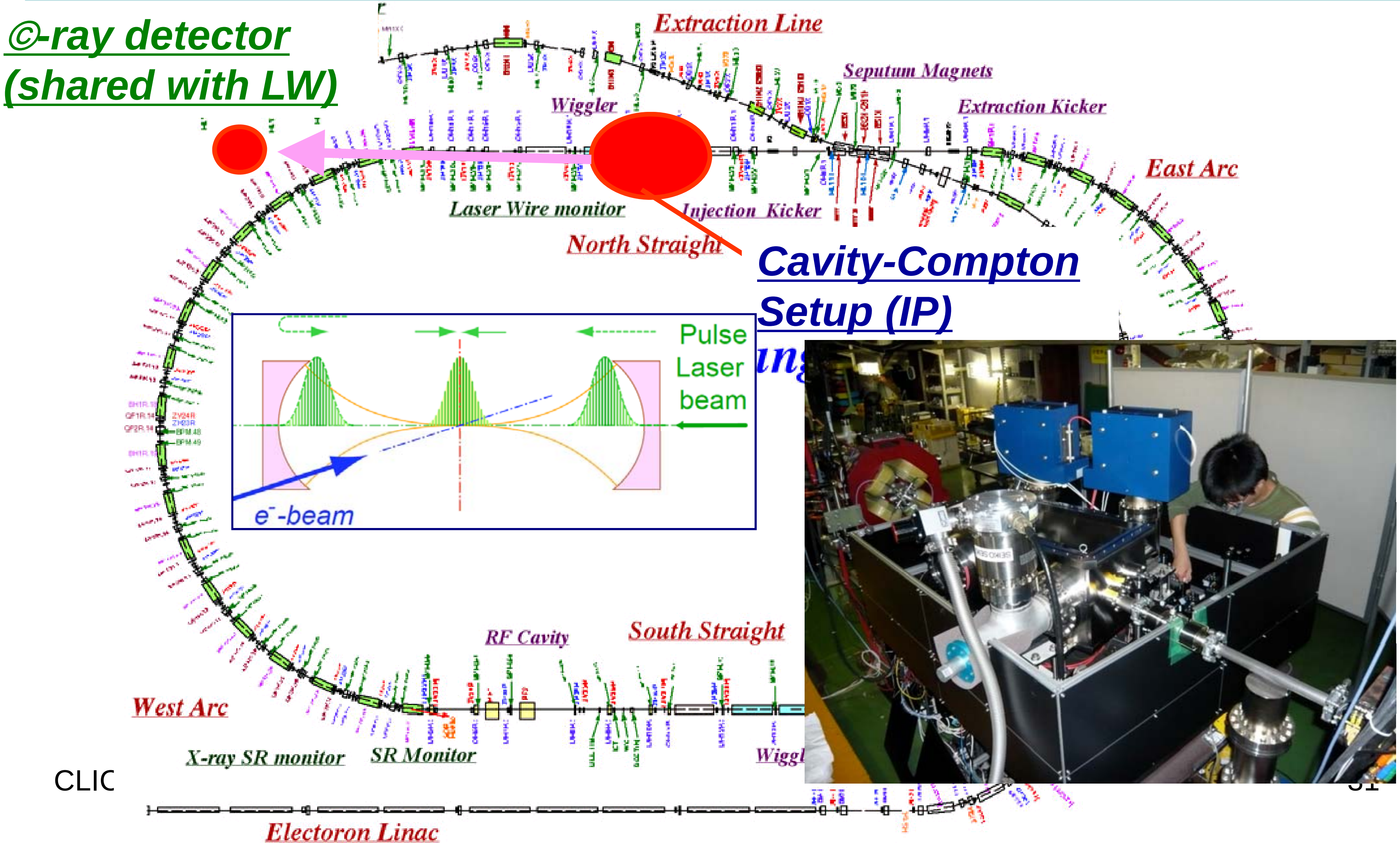
Philip Burrows 36 *ATF Technical Board, Warsaw 11/06/08*

Layout of FB/FF components at ATF2
(FONT group – Resta Lopez)



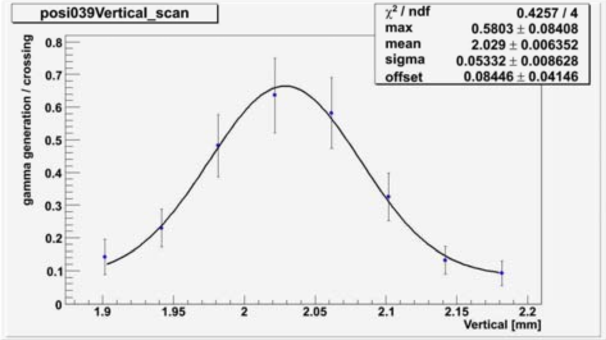
Cavity Compton (R&D for pol.e$^+$)

All equipments are installed into the DR on 12th Sep. 2007.
The first signal has found on 30th Jan. 2008.



Cavity Compton Status

- *Collision Point Scan (V and H) with Mover Table*
- *Collision Timing Scan*
- *Collision with Cavity Length Feed-Back*
- *Phase Lock Loop Stability Test*
- *Signal Intensity Check with Local Bump*



Collision Point Scan in V-direction

of gamma / collision;(λ)

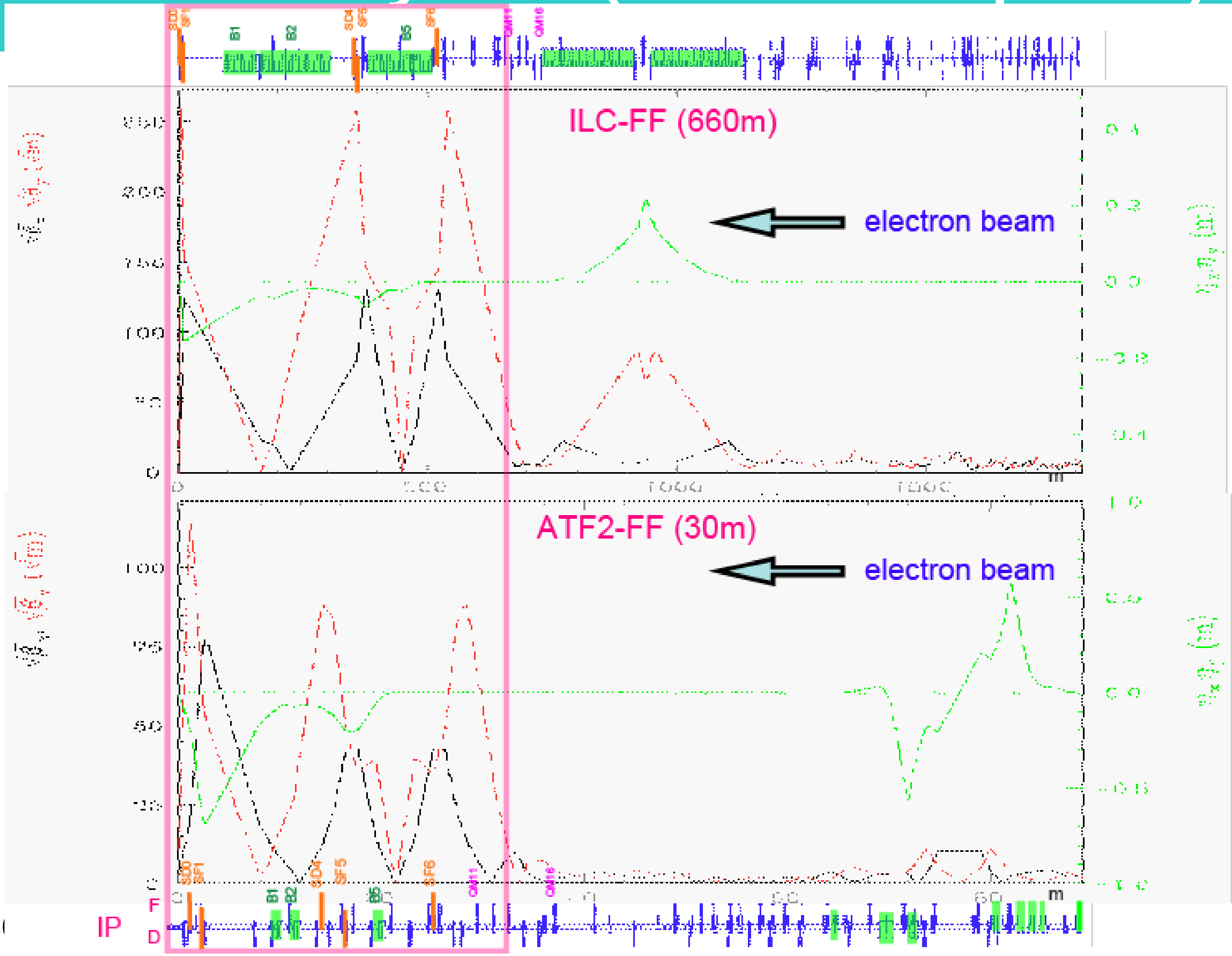
λ [Observed]	λ [Simulated with CAIN]	*Used Bunch #*
3.1	20	20-bunch
3.27	4.5	1-bunch

In next autumn ATF operation,

1) Confirm single bunch mode consistency more precisely.

2) Try to understand the “multi-bunch mode gap” experimentally.

ATF2 Layout (cont. – optics)



ATF2 – Relevance to LC

- Close approximation of ILC FFs
  - Near real-life flight simulator for ILC-FF.
    - Same number of magnets as the ILC-FF.
    - Similar magnet layout → similar steering devices → similar knobs → similar tuning methodology
    - Beam instrumentation has been developed with the ILC specs in mind BPMs, BSMs, movers, magnet support, laserwires, HA power supplies, FONT-feedback system etc..
- Human aspects
  - While ATF started as a more-or-less domestic, in-house project at KEK, ATF2 portion of the program, from start-up is operating as an international collaborative program.
  - Training of younger generation;
  - Beam operation in a setting of an active international collaboration (mini-LC).

ATF2 Research Program (2)

- Additional, somewhat futuristic topics.
- Beam handling and control
  - Use of ILC-like beam 30 (or 60) bunches with 300 (or 150) ns spacing
  - Fast extraction kicker (~2007)
  - Intra-pulse feedback (FONT, Oxford)
- Final-focus quads with alternative designs (2012-2014)
  - SC (BNL)
  - Permanent Mag (Kyoto)
- Photon-Linear Collider (2015-2019)
  - Laser and optical cavities
- Experiments with QED
  - Non-linear QED with laser intensity in excess of 10^{10} W/cm^2

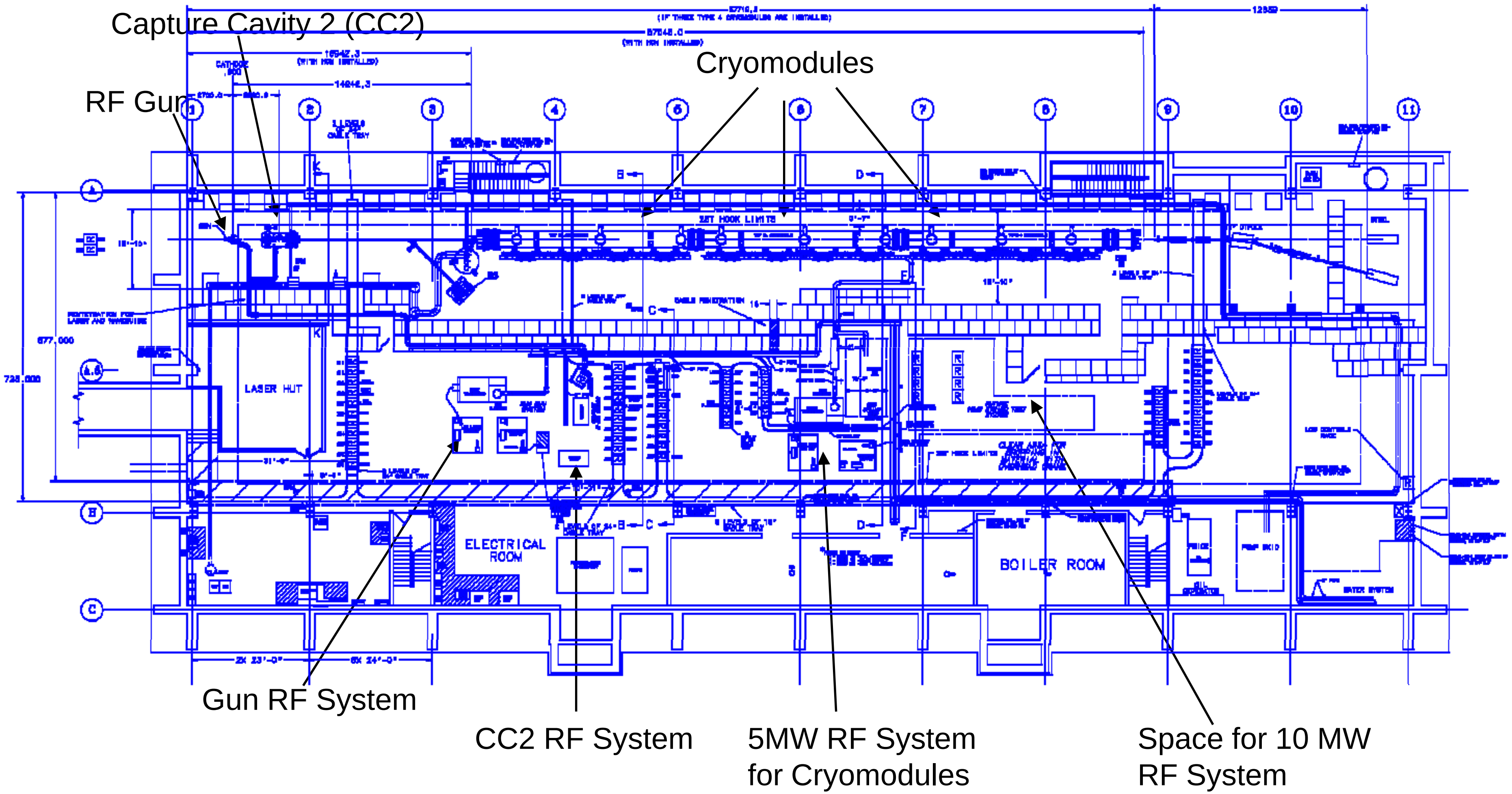
ATF2 – Ref. Information

- Collaboration:
  – 110 institutes (110 authors) have signed up/
- References :
  – ATF2 Proposal, KEK Report 2005-2
  – ATF2 Proposal Vol.2, KEK Report 2005-9
- Web site : http://atf.kek.jp/collab/ap/projects/ATF2/index.php

FNAL NML - Plans

- Overall Plan
  - Build an RF Unit Test Facility at New Muon Lab Building (NML)
    - One RF Unit (3 ILC-like Cryomodules)
    - 10-MW RF System
    - Beam of same Average Current as ILC
- Phase-1 (FY07 - FY09)
  - Prepare Facility for Testing of First Cryomodule (CM1) without Beam
    - Infrastructure, RF Power, Cryogenics (Refrigerator #1)
    - Install First Cryomodule (CM1), Cooldown, and RF Test
- Phase-2 (FY09 - FY10)
  - Prepare for First Beam
    - Install Gun, Injector, Test Beamlines, Second Cryomodule (CM2)
    - Generate First Beam
- Phase-3 (FY11 - FY13)
  - Complete RF Unit
    - Upgrade RF System to 10 MW, Install Third Cryomodule (CM3)
    - Operate Full RF Unit with Beam

NML - Layout


Capture Cavity 2 (CC2)
RF Gun
Cryomodules
LASER HUT
ELECTRICAL ROOM
BOILER ROOM
Gun RF System
CC2 RF System
5MW RF System for Cryomodules
Space for 10 MW RF System

NML – Schedule (1)

- Refrigerator #1 Operational (8/07)
- Begin Civil Design of Build. Extension (8/07)
- Commission Refrig. #1 (Liquify Helium) (9/07)
- Move RF Systems to NML (5MW & CC2) (10/07)
- Install CM Support Girders (4/08)
- 1st Cryomodule Delivery to NML (8/08)
- Delivery of Waveguide from SLAC (9/08)
- Cryo System Component Delivery (10/08)
- Move CC2 to NML (10/08)
- Begin 1st Cryomodule RF Tests (Warm) (11/08)
- Commission Cryo Distrib. Sys. (CC2) (12/08)
- CM1 Ready for Cooldown (12/08)

NML - Schedule (2)

Begin Operation of CC2	(2/09)
Cold RF Testing of CM1	(2/09)
Refrigerator #2 Operational	(4/09)
Install Gun & Injector	(7/09)
2nd Cryomodule Delivery to NML	(1/10)
First Beam	(7/10)
3rd Cryomodule Delivery to NML	(3/11)
Beam Through Full RF Unit	(2012)
Full RF Unit Operations	(2012)
CDR for Extension Complete	(on-hold)
Approval of GPP Extension Project	(on-hold)
Begin Construction of Build. Exten.	(on-hold)
Begin Move of A0 Injector to NML	(on-hold)
Order Cryoplant	(on-hold)
Building Extension Complete	(on-hold)

NML – Current Status (2)

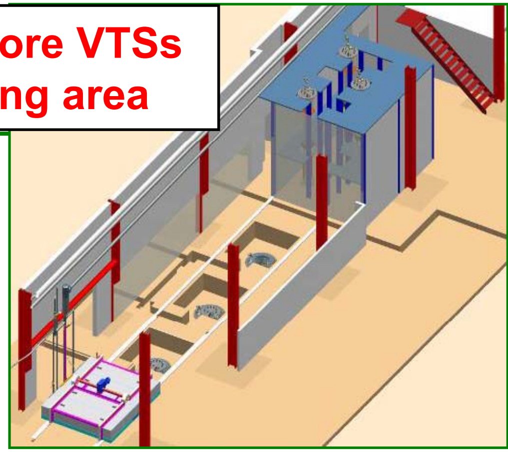
NML Injector/Accel./Test Beamline

- Injector
  - New Injector Lattice Being Worked on
- Accelerator
  - Cryo. Girder/CM Suppo
  - First Cryomodule Insta
- Test Beamline
  - New Lattice Being Wor

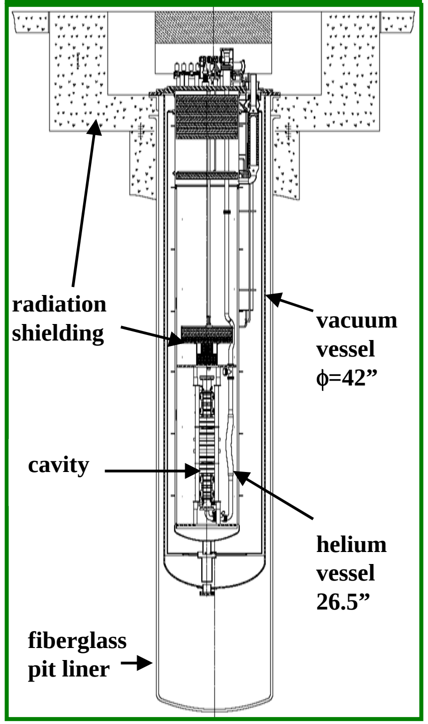
FNAL VTS

- Vertical Cavity Test Facility with one Vertical Test Stand operational since Jul.07
  - 17 test cycles in FY08 of ILC 1-cell and 9-cell elliptical cavities and HINS single-spoke cavity
  - Current capacity limited to ~50 test cycles/year
- Available cavity diagnostic instrumentation
  - Dedicated fast thermometry system for quench location fully functional
  - Variable RF input coupler commissioned
  - 9-cell thermometry for ILC cavities in progress – comprehensive grid measuring all 9 cells at once (10000 diode sensors)
- Planned upgrades
  - Based on considerable experience from Fermilab Magnet Test Facility, and cavity test operations information from other labs
  - Cryogenic system and infrastructure upgrades to reduce interference with magnet test program and improve cryogenic system reliability
  - Two additional VTS cryostats
  - Ultimate capacity ~250 test cycles/yr

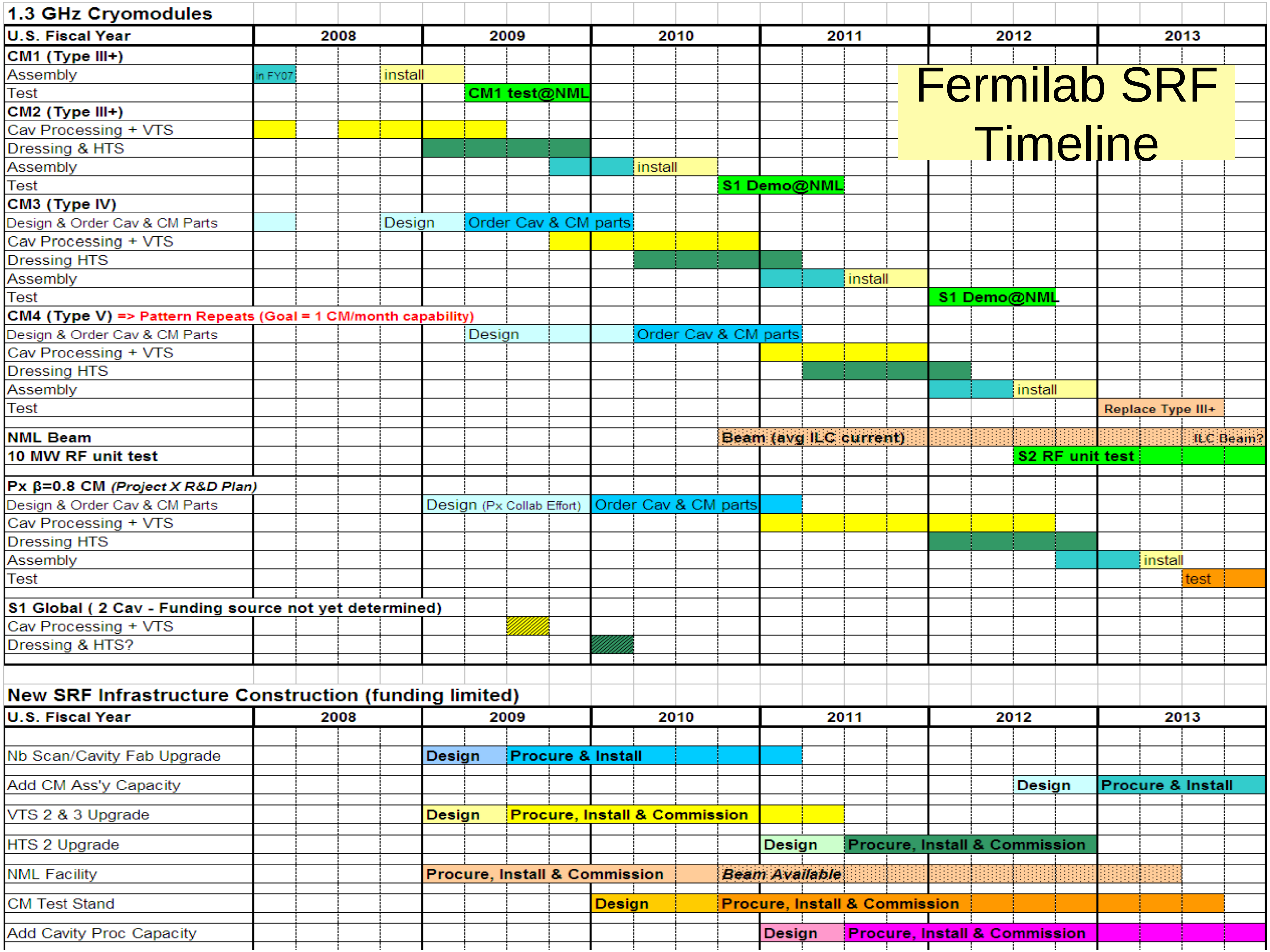
Plan 2 more VTSs & staging area



FNAL VTS



- One Vertical Test Stand (VTS) in Industrial Building 1 (IB1)
  - Measure Q vs. T (T_{min}~1.5 K)
  - Measure Q vs. E_{acc} at 2 K
  - Study cavity quench and field emission behavior
- RF design parameter: 250 W (CW) max power at cavity
  - For ILC cavities: $Q>5x10^9$ and Eacc<35 MV/m
    or generally: $P_d = (1.04 \times 10^{-3})^* E_{acc}^2/Q < 250$ W
- Use existing IB1 cryogenic capacity ~125 W at 2 K
  - 250 W for short periods without excessive helium bath temperature increase
- Magnetically shielded cryostat
  - Ambient field in IB1 pit measured consistent with Earth’s field ~0.5 G
  - External (room-temperature) Amumetal® (80% Ni alloy) and internal Cryoperm 10® magnetic shield attenuate field to <0.01 G at cavity
- Radiation shielding to maintain IB1 “Controlled Area” status
  - < 5 mrem in an hour immediately outside the shielding
  - <0.25 mrem/hr in normal working areas



Fermilab SRF Timeline
1.3 GHz Cryomodules
U.S. Fiscal Year
2008
2009
2010
2011
2012
2013
CM1 (Type III+)
Assembly
in FY07
install
Test
CM1 test@NML
CM2 (Type III+)
Cav Processing + VTS
Dressing & HTS
Assembly
install
Test
S1 Demo@NML
CM3 (Type IV)
Design & Order Cav & CM Parts
Design
Order Cav & CM parts
Cav Processing + VTS
Dressing HTS
Assembly
install
Test
S1 Demo@NML
CM4 (Type V) => Pattern Repeats (Goal = 1 CM/month capability)
Design & Order Cav & CM Parts
Design
Order Cav & CM parts
Cav Processing + VTS
Dressing HTS
Assembly
install
Test
Replace Type III+
NML Beam
Beam (avg ILC current)
ILC Beam?
10 MW RF unit test
S2 RF unit test
Px β=0.8 CM (Project X R&D Plan)
Design & Order Cav & CM Parts
Design (Px Collab Effort)
Order Cav & CM parts
Cav Processing + VTS
Dressing HTS
Assembly
install
Test
test
S1 Global (2 Cav - Funding source not yet determined)
Cav Processing + VTS
Dressing & HTS?
New SRF Infrastructure Construction (funding limited)
U.S. Fiscal Year
2008
2009
2010
2011
2012
2013
Nb Scan/Cavity Fab Upgrade
Design
Procure & Install
Add CM Ass'y Capacity
Design
Procure & Install
VTS 2 & 3 Upgrade
Design
Procure, Install & Commission
HTS 2 Upgrade
Design
Procure, Install & Commission
NML Facility
Procure, Install & Commission
Beam Available
CM Test Stand
Design
Procure, Install & Commission
Add Cavity Proc Capacity
Design
Procure, Install & Commission