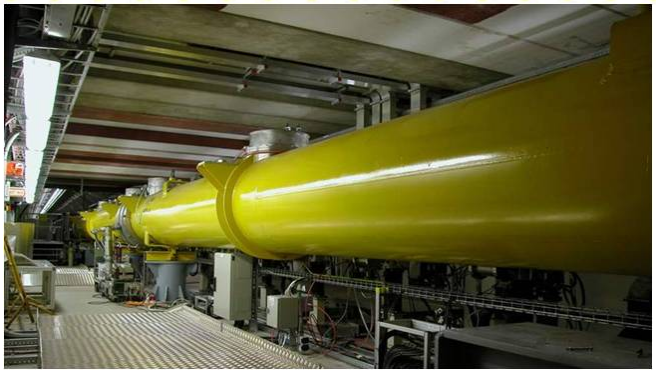
Test Facilities Part 2

Nick Walker

PAC Review – 10.05.2009

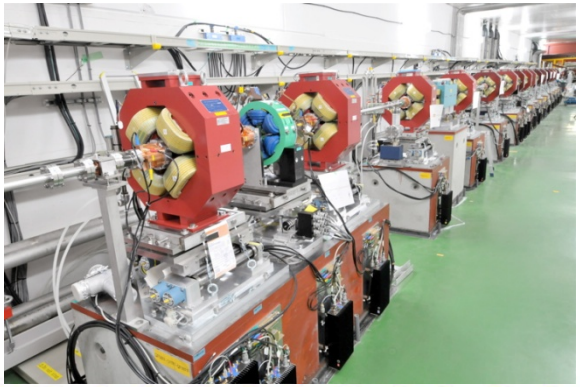
(Other) Test Facilities

- TTF2/FLASH (DESY)
  - **“String Test” SCRF linac technology**
  - **Specifically: 9mA full beam-loading experiment**



- ATF (KEK)
  - **Ultra-low emittance Damping Ring**
  - **Fast (inj/extr) kicker test-bed**
  - **Fast-ion instability studies**
  - **Source for…**

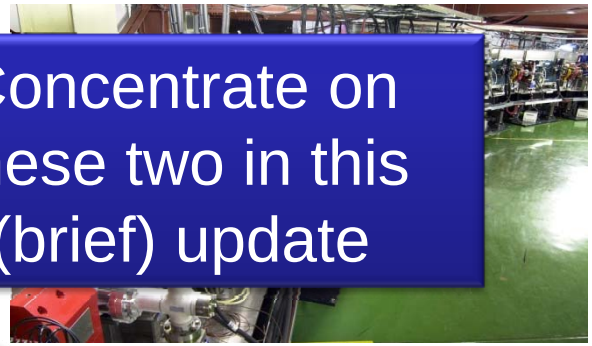
- ATF2 (KEK)
  - **New facility (commissioning since end 2008)**
  - **BDS Final Focus optics (tuning)**
  - **Instrumentation / Diagnostics**



(Other) Test Facilities

- TTF2/FLASH (DESY)
  - **"String Test" SCRF linac technology**
  - **Specifically: 9mA full beam-loading experiment**

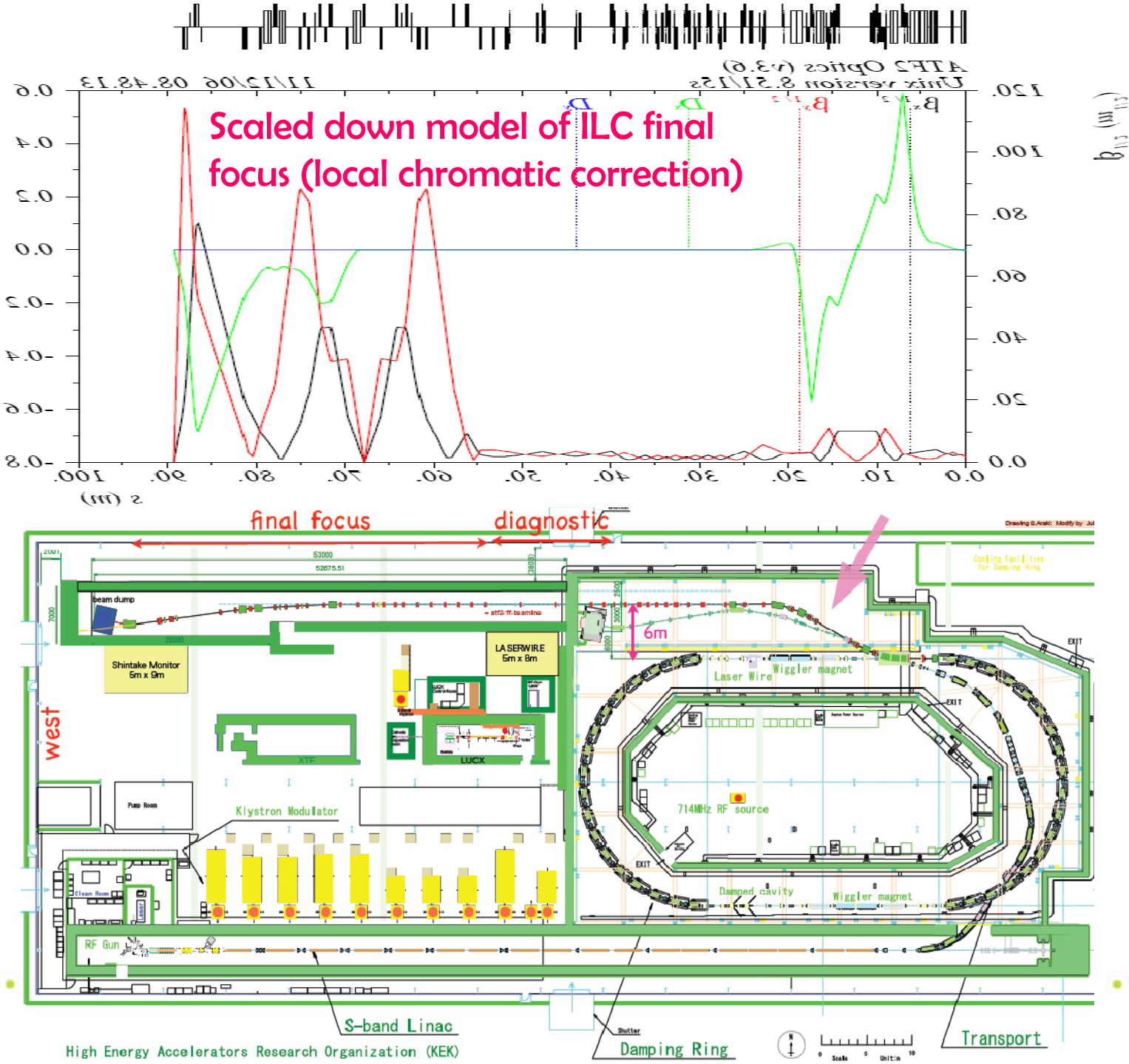
- ATF (KEK)
  - **Ultra-low emittance Damping Ring**
  - **Fast (inj/extr) kicker test-bed**
  - **Source for ...**



Concentrate on these two in this (brief) update

- ATF2 (KEK)
  - **New facility (commissioning since end 2008)**
  - **BDS Final Focus optics (tuning)**
  - **Instrumentation / Diagnostics**

ATF2 – model of ILC BDS

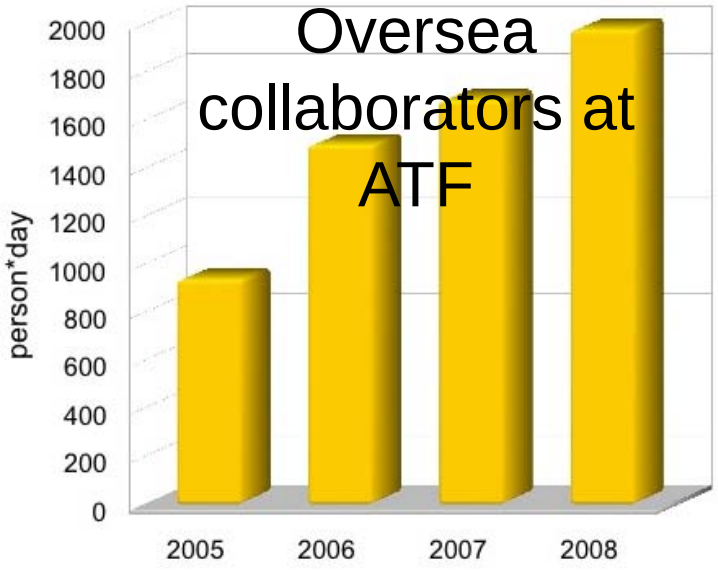


ATF International Collaboration

CERN
DESY
IN2P3
Tomsk Polytechnic Univ.
INFN, Frascati
University College London
Oxford Univ.
Royal Holloway Univ.

KEK
Waseda Univ.
Nagoya Univ.
Tokyo Univ.
Kyoto Univ.
Hiroshima Univ.
PAL (Korea)
IHEP (C...

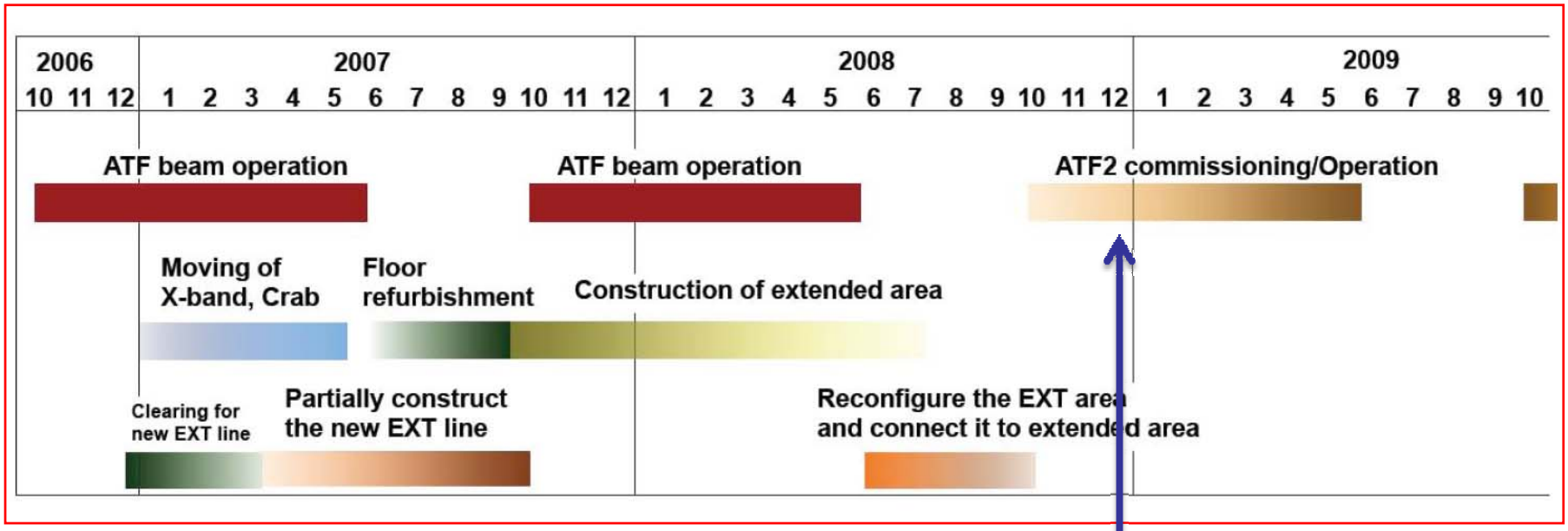
SLAC
LBNL
FNAL
Cornell Univ.



Primary ILC Objectives

- Achieve 35nm vertical beam size at IP (focus) 2010
  - **Demonstration of Raimondi/Seryi compact optics**
  - **Development of beam-based tuning algorithms**
- Demonstration of stability 2012
  - **Maintain 35nm for "long period of time"**
  - **Actively stabilise beam centroid to <2nm**
    - Fast feedback systems
    - Active (mechanical) component stabilisation (laser systems)
- Tests of prototype ILC final-doublet technology 2012
- Rich programme (large international participation)
  - **Laser-based diagnostics**
  - **nm BPM development**
  - **…**

ATF2 schedule



First beam to beam-dump ☺

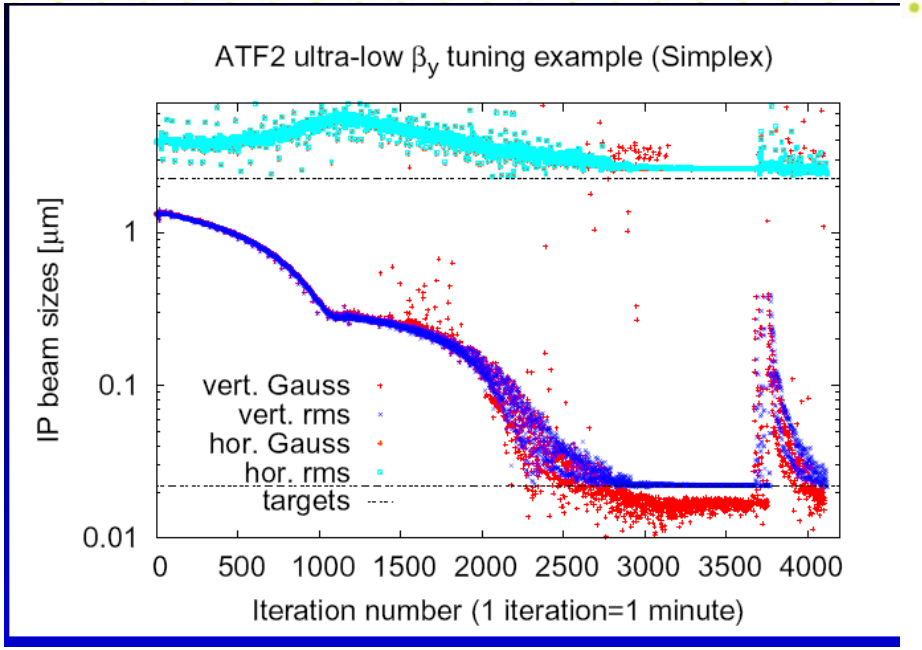
Highlights of recent runs

- December 2008
  - **large IP beta optics, semi-ballistic trajectory**
  - **Establish beam to beam dump, minimize losses, Radiation inspection**
  - **First tests of hardware and tuning software (FS)**
  - **BSM commissioning & background characterization**
- Jan 2009
  - **fast kicker study**
  - **Replace QM7 to one with larger aperture (possible source of EXT ε growth)**
- Feb-Mar 2009
  - **Large (8cm beta*), all magnets ON**
  - **Commission laser wire mode of BSM**
  - **Tuning tools (fp beam size tuning, beam-based alignment…)**
- April 2009 run
  - **Optics verification for ~1um beam (large, 1cm β*) / IP wire scanners**
  - **Commission interferometer mode of BSM**

ILC-CLIC Collaboration

ATF2 is an excellent example of cross-collaboration between ILC and CLIC

Many R&D programmes are equally applicable to both projects

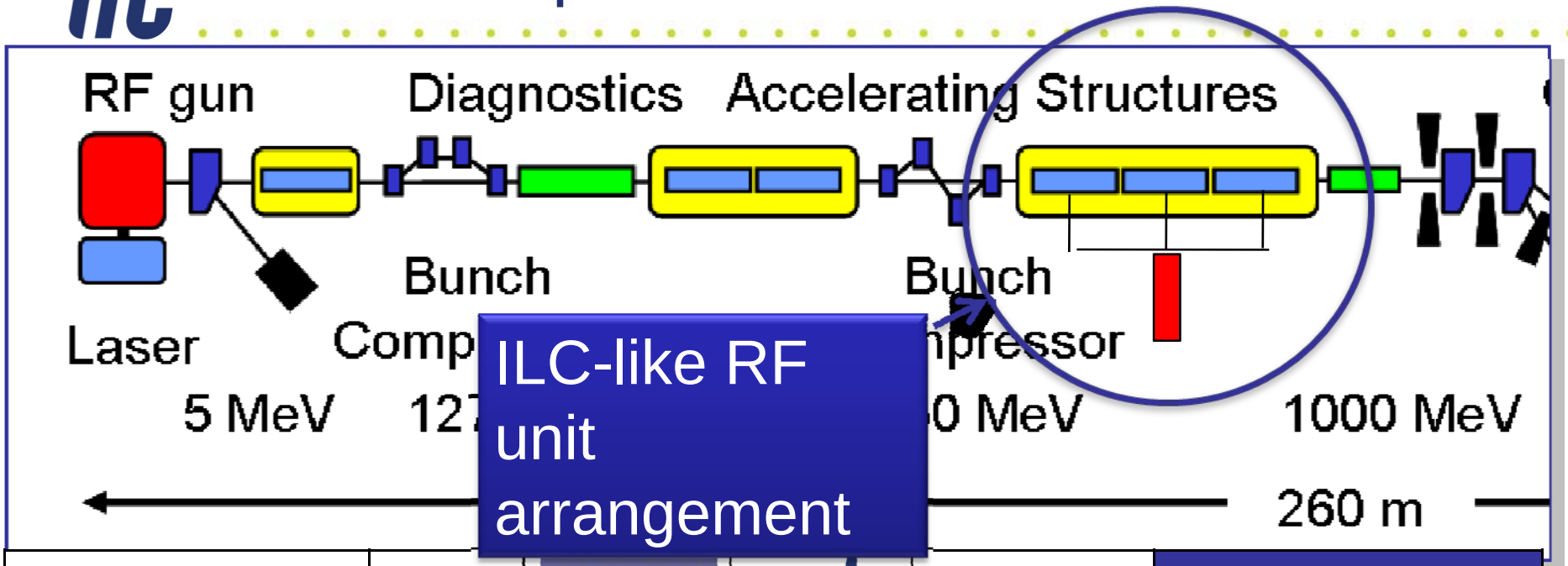


- Low-β proposal
- by CLIC colleagues
  - Rogelio Tomas et al
- Explore & push the limits of optics
- Large aperture QF1 may be necessary

case	Max. tuning time	Success	$\langle\sigma_y\rangle$
β_y=0.1mm	5.5 days	100%	43nm
β_y=0.05mm	8 days	90%	33nm
β_y=0.025mm	10 days	80%	26nm
including multipoles			
β_y=0.025mm	10 days	70%	29nm

TTF2/FLASH
“9mA Experiment”

9mA Experiments in TTF/FLASH



		XFEL	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

The (International) Team

- **FLASH Experts (DESY)**
  - Siggi Schreiber - laser/gun injector set-up
  - Bart Faartz - general set-up
  - Lars Froehlich - TPS installation / commissioning, BLM calibration
  - Florian Loehl - optics matching & emittance
  - Holger Schlarb - optics & steering
  - Nina Golubeva - optics calculations
  - Vladimir Balandin - optics calculations
  - Valeri Ayvazyan - - LLRF set-up and tuning
  - Mariusz Grecki - LLRF set-up and tuning
  - Waldemar Koprek - LLRF set-up and tuning (mostly gun)
  - Jacek Sekutowicz - HOM absorber measurements
  - Stefan Simrock - LLRF (general)
  - Kay Rehlich - controls (DAQ)
  - Kay Wittenburg - diagnostics
  - Dirk Noelle - diagnostics (BPM)
  - Nick Walker - overall coordination
  - Katya Honkavaara - planning
  - Mikhail Krasilnikov - RF gun modelling
- **ANL**
  - John Carwardine - LLRF / overall coordination
  - Xiaowei Dong - data analysis, optics modeling
- **FNAL**
  - Brian Chase - LLRF (experiment & data analysis)
  - Gustavo Cancelo - LLRF (experiment & data analysis)
  - Michael Davidsaver - DAQ applications programming
  - Jinhao Ruan - laser setup
- **KEK**
  - Shinichiro Michizono - LLRF (experiment & data analysis)
  - Toshihiro Matsumoto - LLRF (experiment & data analysis)
- **SLAC**
  - Chris Adolphsen - LLRF (experiment & data analysis)
  - Tom Himel - Planning & scope
  - Shilun Pei - LLRF (experiment & data analysis)
- **SACLAY**
  - Abdallah Hamdi - TPS installation / commissioning

~40 subscribers to ttf9mA mailing list (not all shown here)

RF/LLRF collaborators:
DESY, KEK, FNAL, SLAC

String Test: goals from R&D Plan

Integration Tests

- The highest priority goal is to demonstrate beam phase and energy stability at nominal current

- Important because of their potential cost impact:
  - **demonstrate operation of a nominal section or RF-unit**
  - **determine the required power overhead**
  - **to measure dark current and x-ray emission**
  - **and to check for heating from higher order modes**

- Needed to understand linac subsystem performance:
  - **develop RF fault recognition and recovery procedures**
  - **evaluate cavity quench rates and coupler breakdowns**
  - **test component reliability**
  - **tunnel mock up to explore installation, maintenance, and repair**

Primary objectives of 9mA program

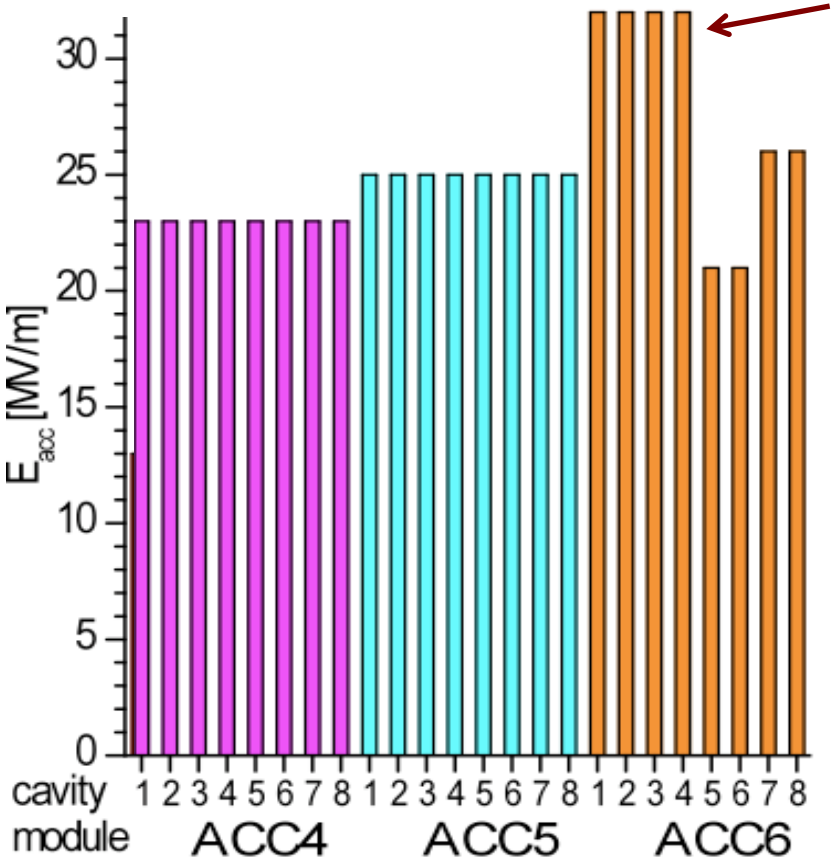
- Long-pulse high beam-loading (9mA) demonstration
  - **800μs pulse with 2400 bunches (3MHz)**
  - **3nC per bunch**
  - **Beam energy 700 MeV ≤ E_{beam} ≤ 1 GeV**

- Primary goals
  - **Demonstration of beam energy stability**
    - Over extended period
  - **Characterisation of energy stability limitations**
    - Operations close to gradient limits
  - **Quantification of control overhead**
    - Minimum required klystron overhead for LLRF control
  - **HOM absorber studies (cryo-load)**
  - **…**

- Major operational challenge for FLASH !
  - **Pushes many current operational limits**

Primarily a LLRF experiment

Extrapolating to ILC gradients



- 1/2 cryomodule could be running close to ILC gradients with ILC beam
- Opportunity to study:
  - **Lorentz-force detuning + piezo compensation near ILC gradients**
  - **rf overhead near ILC gradients**
  - **rf distribution system near ILC cavity powers**

- Broadly, we get information on operating cavities with full beam loading, eg
  - **Piezo compensation of LFD**
  - **Running high gradient cavities close to quench**
  - **Vector Sum field regulation**

Comparison of gradient-related operational issues

	RDR	ACC4-6
Nominal maximum operating gradient over all cavities in RF unit	31.5MV/m	~27MV/m
Spread in nominal maximum operating gradients	31.5MV/m +/-0	21-32MV/m (4 cavities at 32MV/m)
Number of cavities operating at 31.5MV/m or above	26 of 26	4 of 24
Cavity quench limits	All: >33MV/m	Range: 21-35MV/m
LFD compensation with piezos	All cavities	ACC5,6 (16 cavities)
Operate cavities close to quench?	Yes	Yes

Schedule

- 19/05-01/06/08: 1st machine study period
  - **3nC optics via by-pass (good transmission)**

complete

LLRF development & planning for

- 08-28/09/08: 2nd machine study period
  - **By-pass TPS** **(6 shifts)**
  - **Longer bunch trains**

Complete / Aborted!

XFEL✓
FLASH ✓
ILC ✓

- 05-18/01/09: 3rd machine study period
  - **"dress rehearsal"** **(est. 9 shifts *tbc*)**

Low-power or no-beam studies only

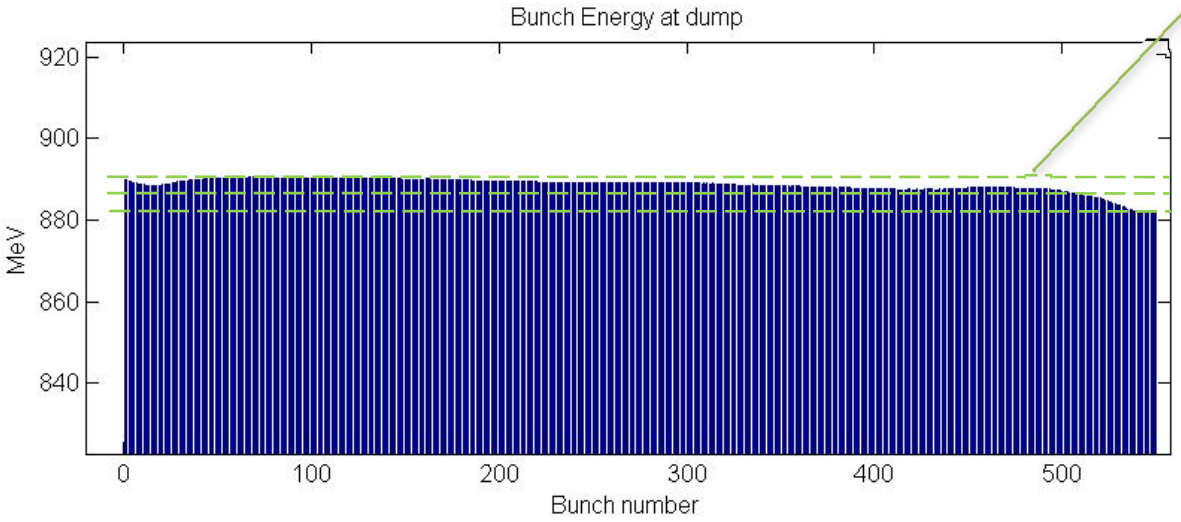
almost 100% synergy

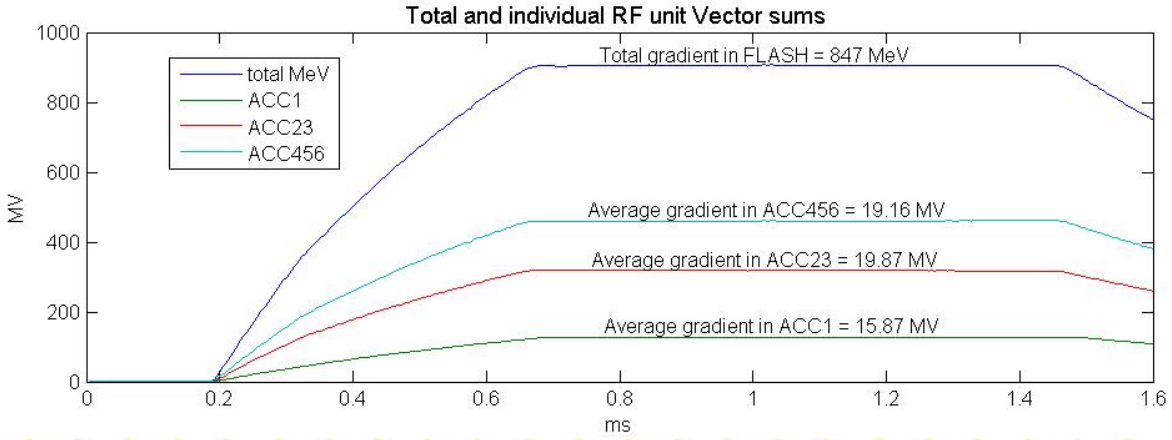
- August 17th 2009: Three week shutdown for vacuum repair

- Two-week dedicated 9mA experiment
  - **2 week run dedicated to 9mA studies**
  - **Detailed experimental programme in planning**

High Beam-Loading Long Pulse Operation

September 2008





10 MeV over 550 bunches (~1%)
(~4 MeV over 1st 500)

- 450 bunches achieved with stable operation
  - **Few hours of archived data**
  - **Currently under analysis**
  - **(vacuum OK)**
- Long bunch trains with ~2.5 nC per bunch:
  - **550 bunches at 1MHz**
  - **300 bunches at 500KHz**
  - **890 MeV linac energy**
- All modules (RF) running with 800us flat-top and 1GeV total gradient
- Increase from 450 to 550 bunches eventually caused vacuum incident
  - **The "straw that broke the camels back!"**

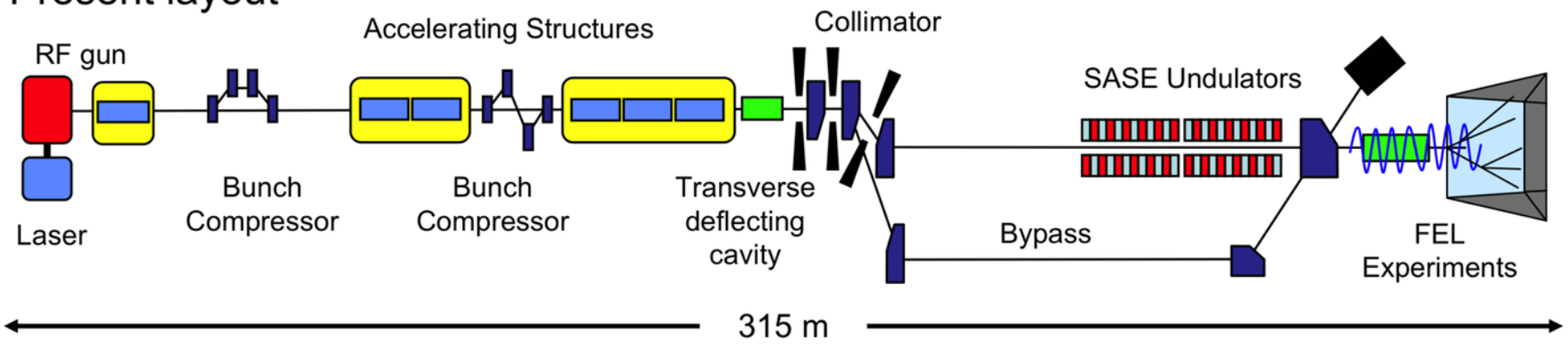
FLASH long-range schedule

- Shutdown for FLASH upgrade: Sept 21 – March 09
- Re-commission + machine & FEL studies: ~ 3months
- Restart operation for photon users: Summer 09
- User operation continues until end 2011
- Shutdown for FLASH-II upgrade: early 2012

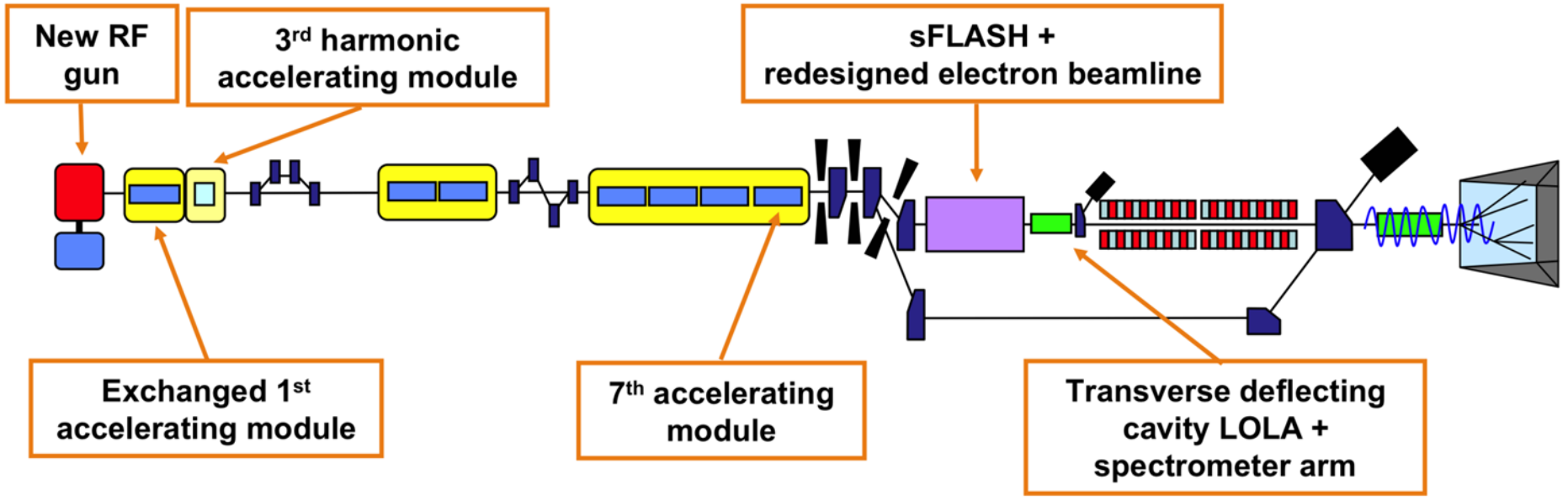
FLASH Upgrade 2009/10

FLASH
Free-Electron Laser in Hamburg

Present layout



New layout



Possible future ILC studies at FLASH

- The new RF distribution system means we no longer have an ILC-like RF unit (now 16 cavities / klystron)
  - **Not a “show stopper” for String Test demo**

- Highly desirable to continue with the major 9mA program topic areas
  - **Add: priority items not covered in 2009 run**
  - **Add: new ILC-related studies, eg RTML**
  - **Add: studies of mutual interest to ILC and XFEL**

Beam test in every region?

- Assuming we accept the necessity of developing infrastructure in all 3 regions for cryomodule construction, development and testing, the question remains if it is necessary to have a beam test facility in all 3 regions
  - **i.e. a linac**

- If we strictly focus ourselves on the ILC, then the answer could be no. In principle, a single test linac somewhere in the world would suffice.

- However, we must include the constraints of the world-wide situation…

Beam test in every region?

- The attractiveness of this accelerator technology, and the desire by regional governments to develop the technology for other applications, mandates a local expertise in the technology as an accelerator system, which clearly includes acceleration and control of the beam
  - **Education & training**

- Much of our ILC-labelled R&D is strongly based on the synergy with these other projects.

- A single ‘beam test facilities’ would require shipping of regional test modules (prototypes) to the region where the TF is located. This is also a cost issue.

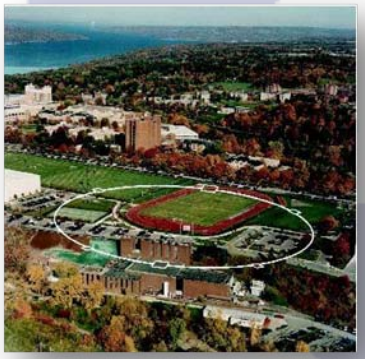
- A decision on “where” a single TF is sited is avoided (political).

Beam Test Facilities (Summary)

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

KEK, Japan

Cornell



DESY

TTF/FLASH
Full-beam loading
HOM…
(S2)

CesrTA (Cornell)
electron cloud
low emittance