FLASH Seminar

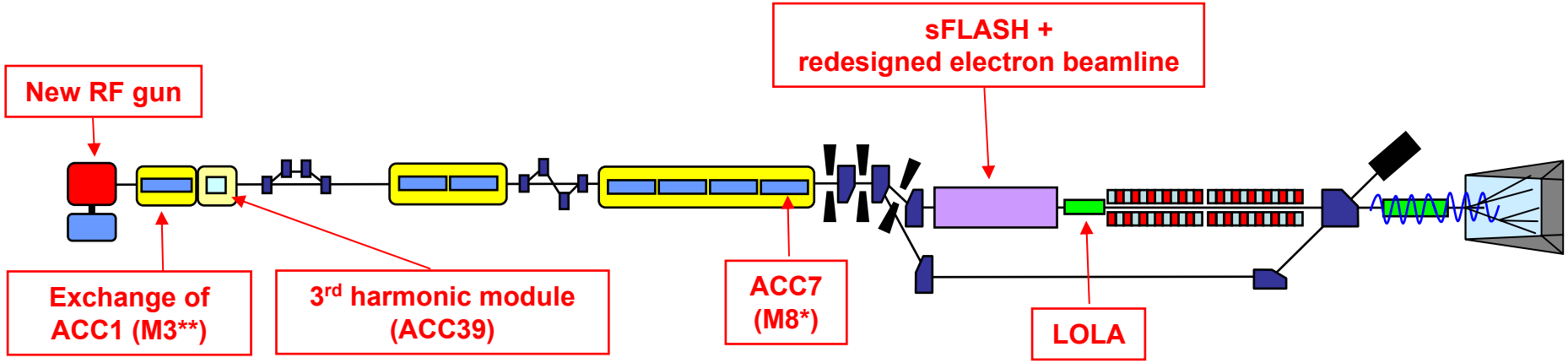
March-31, 2009

FLASH
Free-Electron Laser in Hamburg

FLASH Upgrade 2009

Katja Honkavaara

- new installations and upgrades
- tentative time schedule
- coordination



HELMHOLTZ GEMEINSCHAFT

New installations 2009

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- new
  - 3rd harmonic (3.9 GHz) accelerating module (ACC39)
  - 7th accelerating module (ACC7)
    - transverse deflection cavity LOLA moved downstream
  - sFLASH: seeding experiment
    - replacement of complete electron beam line between collimators and SASE undulators (~ 40 meters)
- upgrades
  - exchange 1st accelerating module
  - exchange RF gun
  - upgrades of RF stations 2 and 3
    - new modulators
  - optimize RF waveguide distribution

Linac layout

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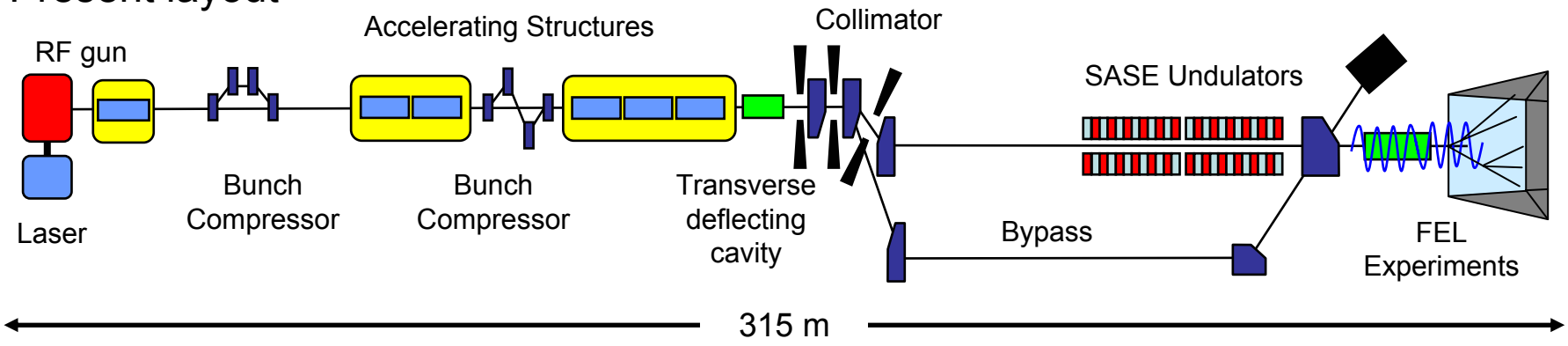
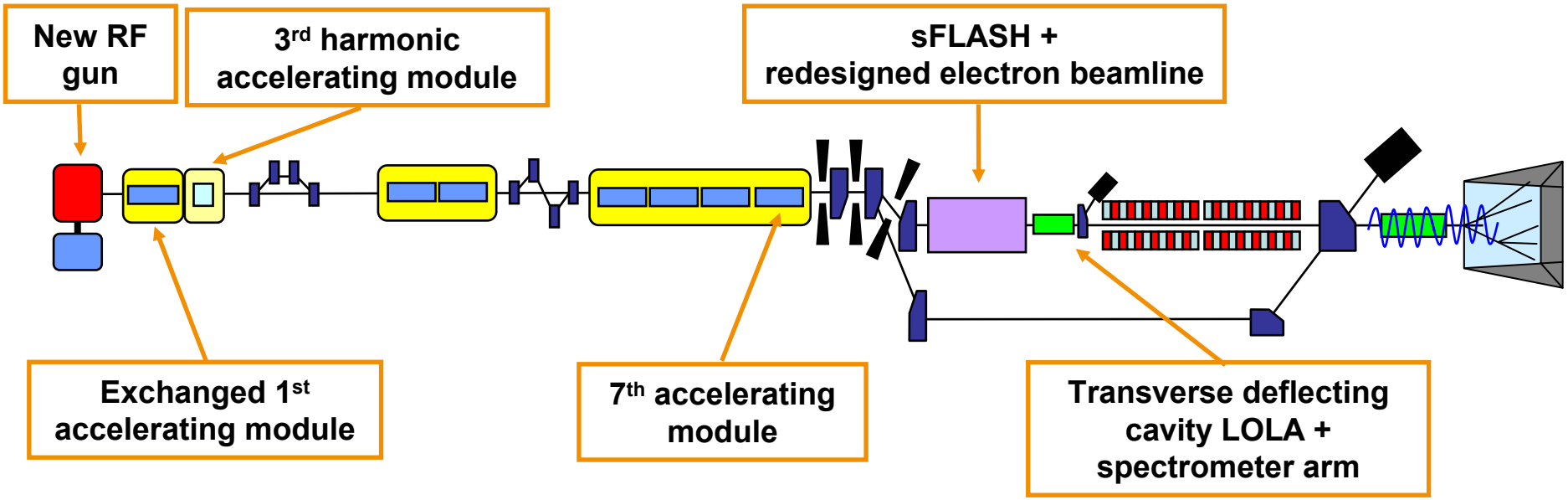
Present layout



New layout



Exchange of RF gun

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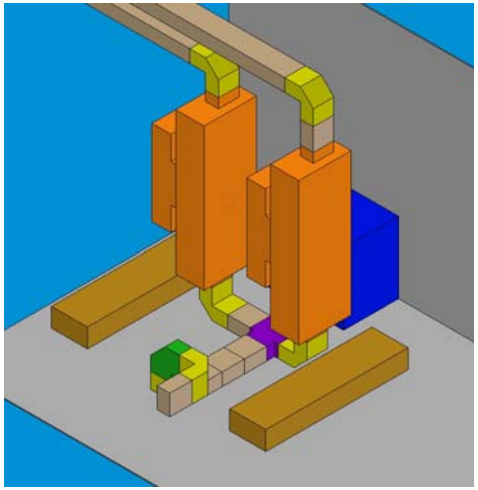
- motivations:
  - RF gun in continuous operation last ~ 5 years
    → aging effects, high dark current
  - installations allowing a 10 MW operation
- a new CO_2 cleaned RF gun
  - conditioned and operated at PITZ
- two waveguide arms and two circulators + directional couplers will be installed to the tunnel to be prepared for a 10 MW operation



Exchange of ACC1

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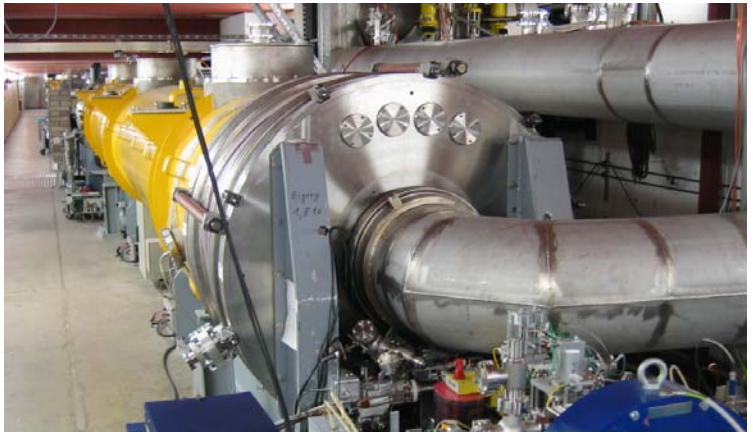
- 1st accelerating module will be replaced
  - cryo-module 3* with new cavities
- motivations:
  - increased gradient of the last four cavities
    - electron beam energy increased to compensate the energy loss due to the 3.9 GHz module (ACC39)
  - reduced dark current
    - presently cavity 7 has a high field emission and therefore attenuated
  - piezo tuners for each cavity
    - to improve performance with long bunch trains



3.9 GHz (3rd harmonic) module ACC39

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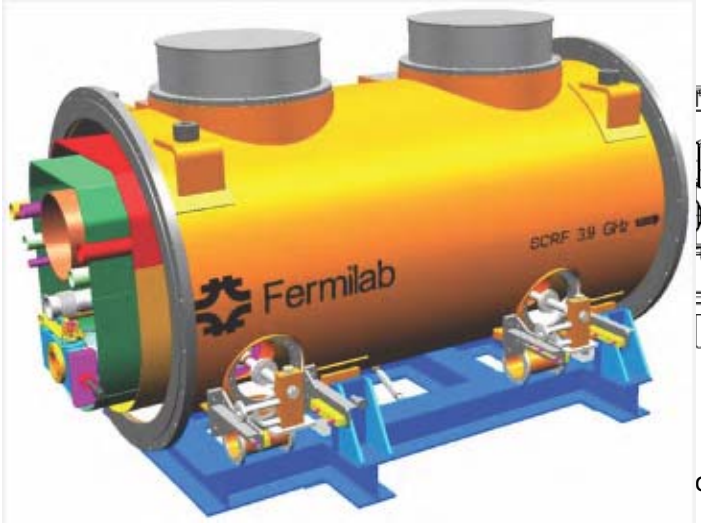
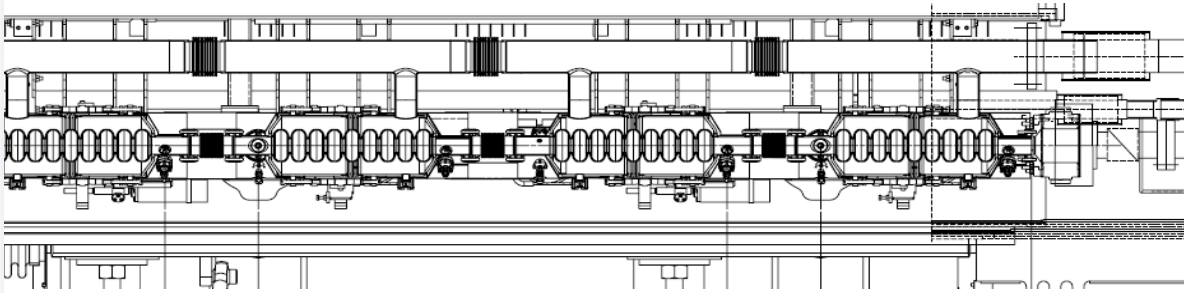
- 4 nine-cell superconducting 3.9 GHz cavities
- collaboration FNAL / DESY
- to be installed after the first accelerating module
- includes RF-system (klystron, modulator), waveguides, and LLRF regulation





Longitudinal phase space

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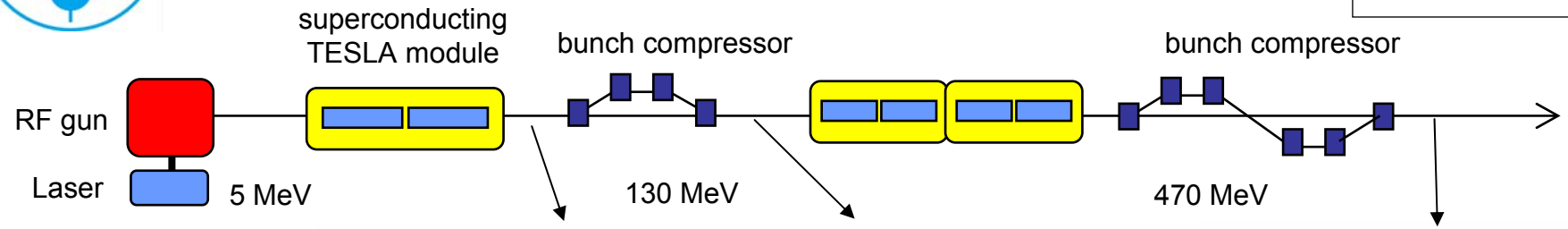

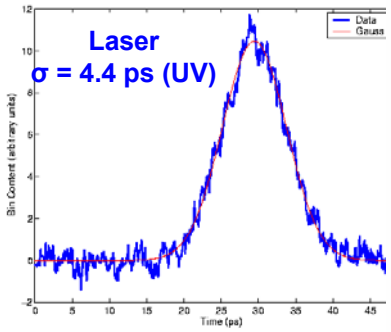

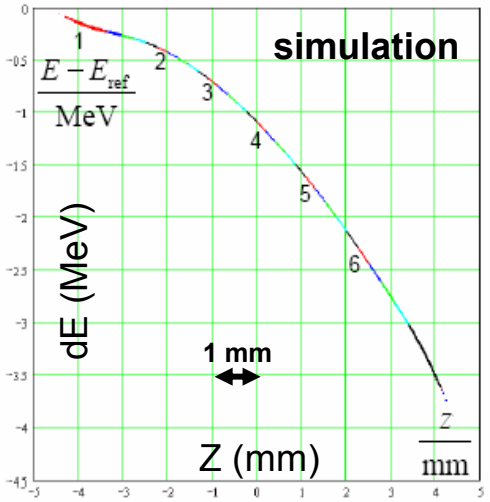

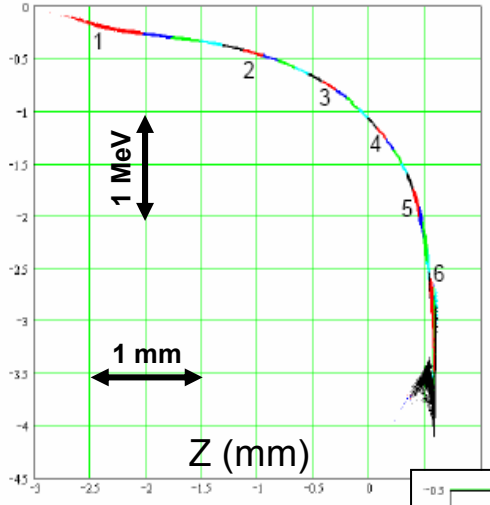

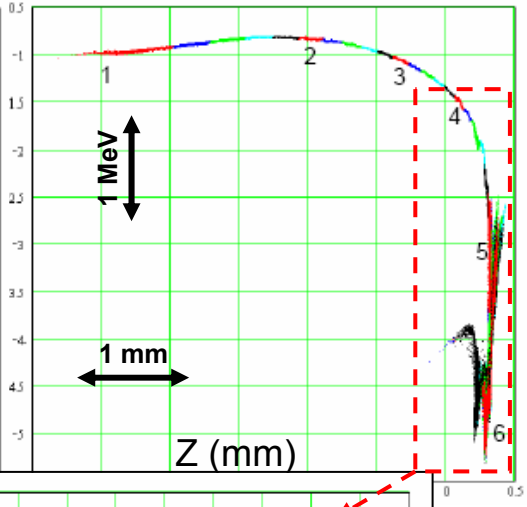

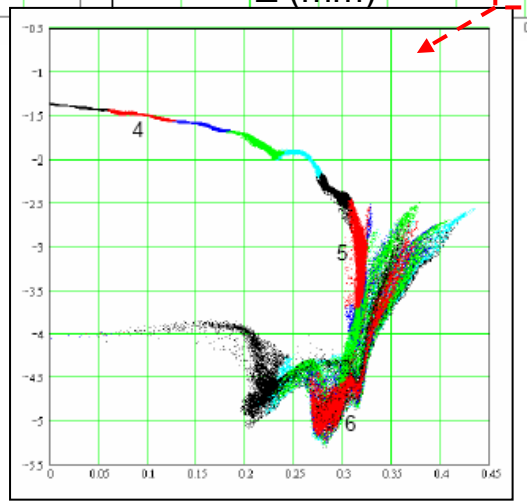

- long initial electron bunch (~ 2 mm) and sinusoidal accelerating field of the first accelerating module

→ off-crest acceleration leads to a curvature in the longitudinal phase space

→ non-linear longitudinal bunch compression

Longitudinal bunch shape

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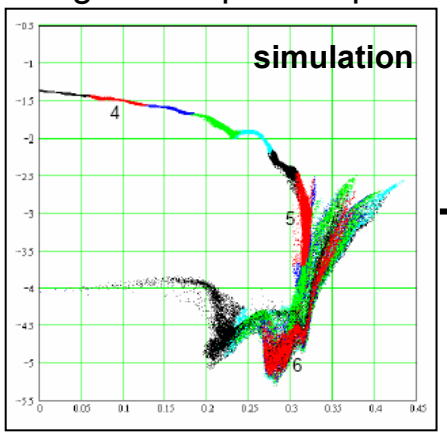
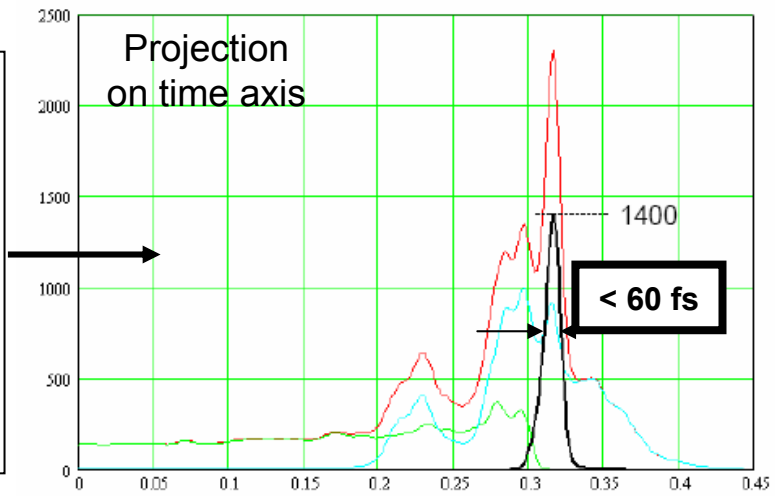
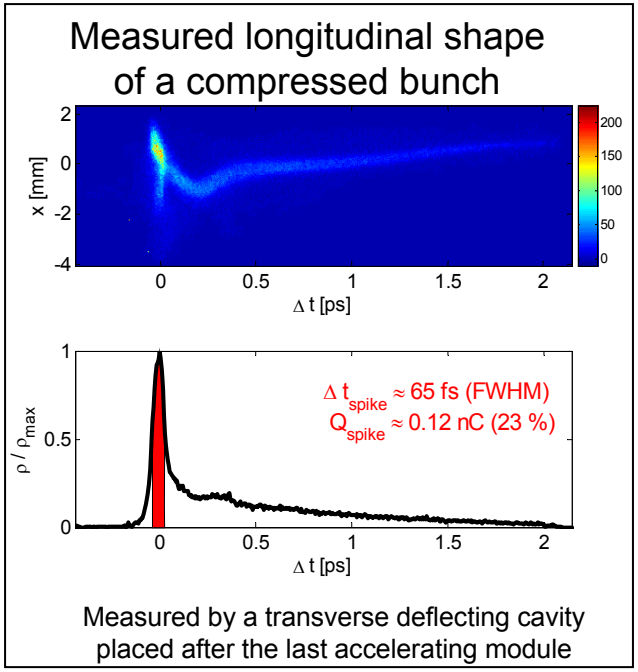
Longitudinal phase space







- ultra-short bunch spikes created (< 60 fs fwhm)
  → femtosecond operation mode
- difficult to measure relevant beam parameters
  → standard diagnostics measures projected parameters
  → empirical tuning needed to achieve good SASE performance

Expected performance with ACC39

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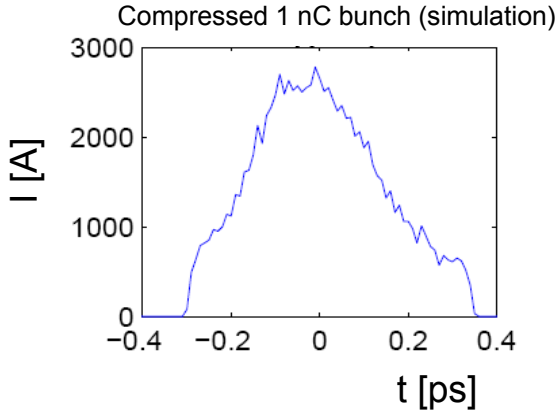
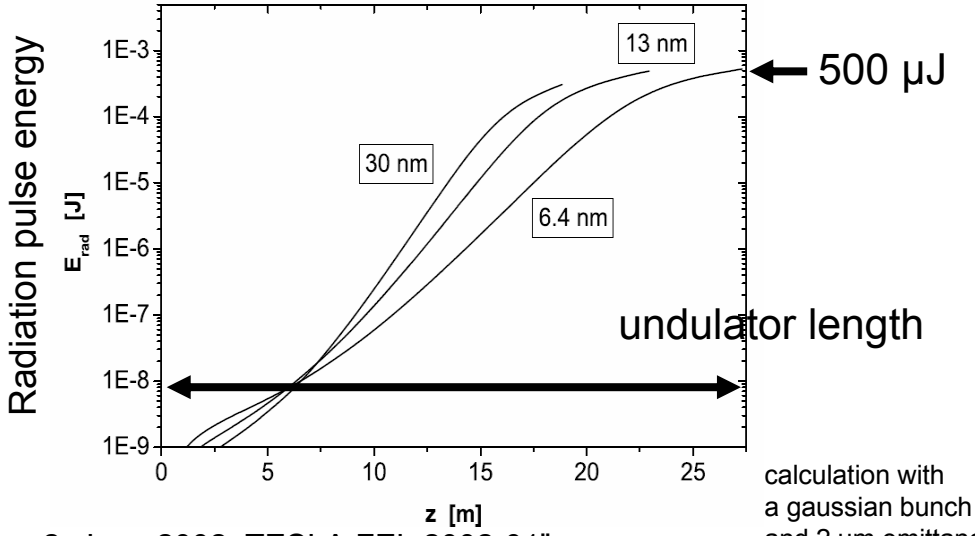
- flattening of the longitudinal phase space with 3rd harmonic (3.9 GHz) module ACC39 → more regular shape of the compressed bunch
- present femtosecond mode
  - only a fraction of the bunch contributes to lasing: slice with a high peak current and a small emittance
- with ACC39: a more regular bunch shape
  - entire 1 nC bunch contributes to lasing





calculation with a gaussian bunch and 2 um emittance

from "SASE FEL at the TESLA Facility, Phase 2, June 2002, TESLA FEL 2002-01"

New simulations on-going (Igor Zagorodnov)

Currently under study

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- operational modes
  - long pulse mode (a few hundred fs) with ACC39
    - lasing of an entire bunch of ~1 nC
  - femtosecond modes
    - ACC39 off: leading lasing peak and a long tail (as presently)
    - with ACC39: lasing of an entire low charge bunch
      - length and peak current of the low charge bunch similar to the present leading spike
  - intermediate modes
- phase stability issues
- coupler kicks and their effect on the emittance (long pulse mode only)
- to be studied in simulation (on-going) and experimentally
- we expect a relative long commissioning time

Energy upgrade

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- 7th accelerating module (ACC7): Module 8*
  - goal: increase electron beam energy up to ~ 1.2 GeV
- expected wavelength after upgrade: below 5 nm
- SASE performance depends on achievable beam parameters
  - saturation below 6 nm not guaranteed with the present undulator length
  - if required, a seventh undulator module can be installed later

THz set-up (ACC7 section)

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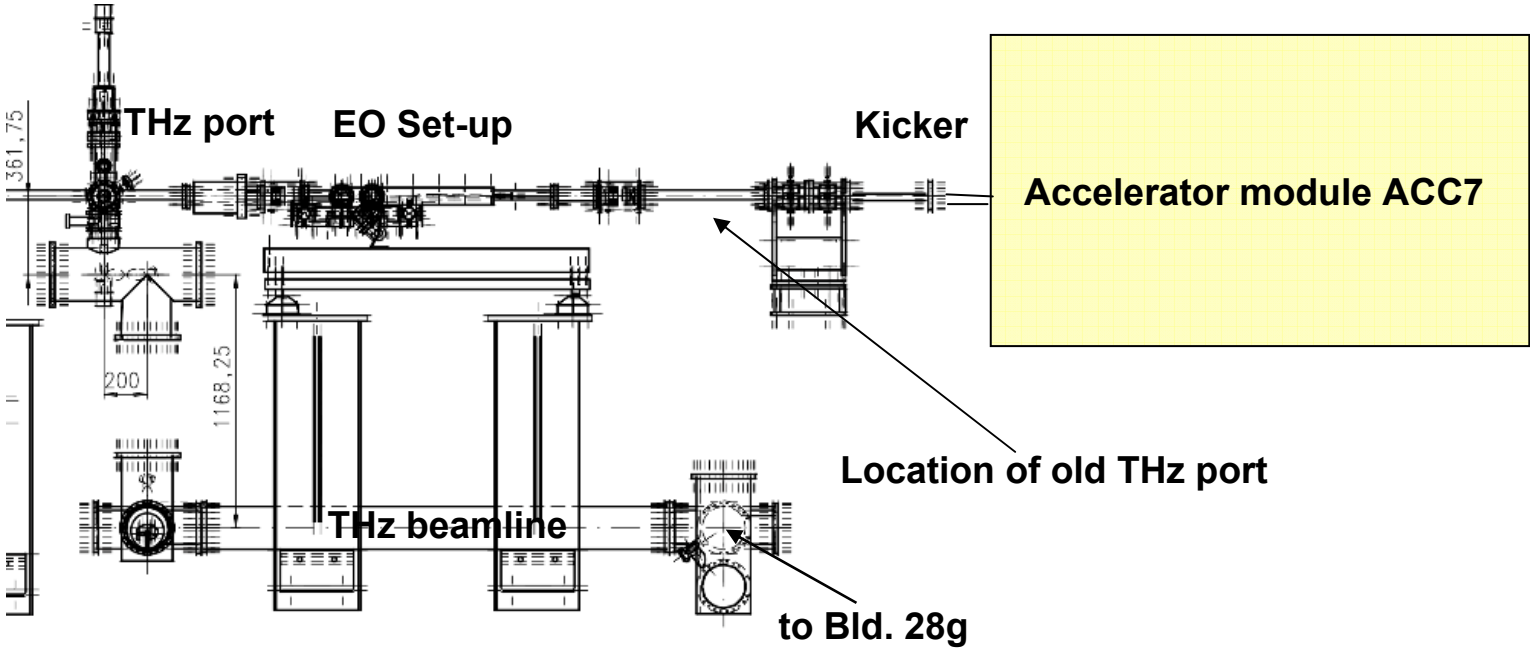
- due to installation of 7th accelerating module, layout of THz experiment at ~140 m must be modified
  - THz port (screen) will be moved downstream of EO set-up → longer THz beam line required
  - new kicker



sFLASH

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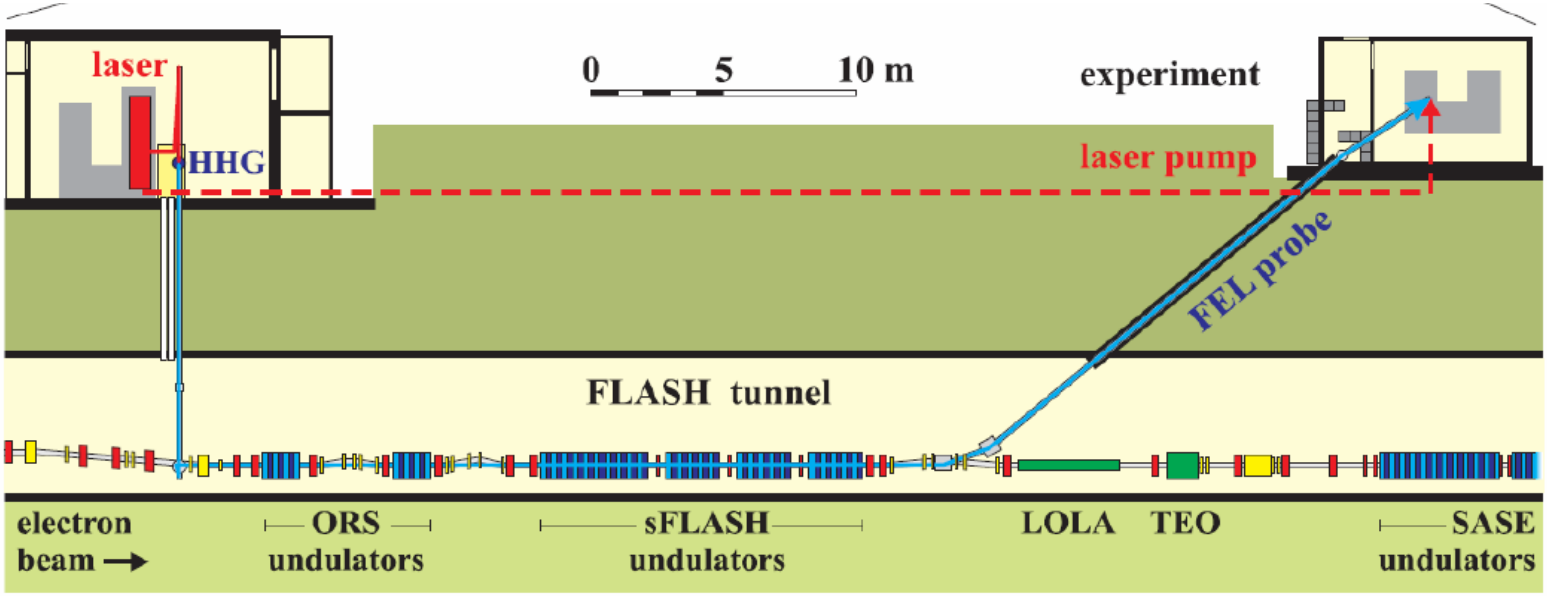
- seeded SASE-FEL experiment
- undulators and other components to be installed between the collimator and SASE undulators
  → new electron beamline with a length of ~ 40 m



More details in FLASH seminar in April-28, 2009
V. Miltchev : Final Layout of sFLASH

Effect of sFLASH on FLASH operation

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- new electron beamline between collimators and SASE undulators
  - magnets moved to other locations → new beam optics and steering
  - electron beam diagnostics devices in new locations
  - new hardware related to sFLASH
    - 4 undulators (variable gap)
    - mirror chambers
    - diagnostics devices
- establishment of SASE operation with the modified electron beamline
  - standard SASE operation is taken into account in the sFLASH design, in case of conflicts SASE operation has the priority
  - operational experience need to be gathered → commissioning with beam
- parasitic operation of SASE and sFLASH is aimed for, however it may be very difficult to realize
  - dedicated beamtime required for sFLASH, at least during commissioning

LOLA

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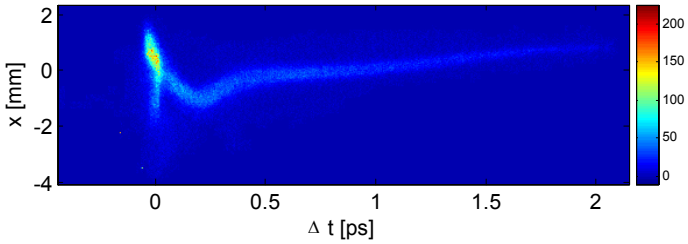
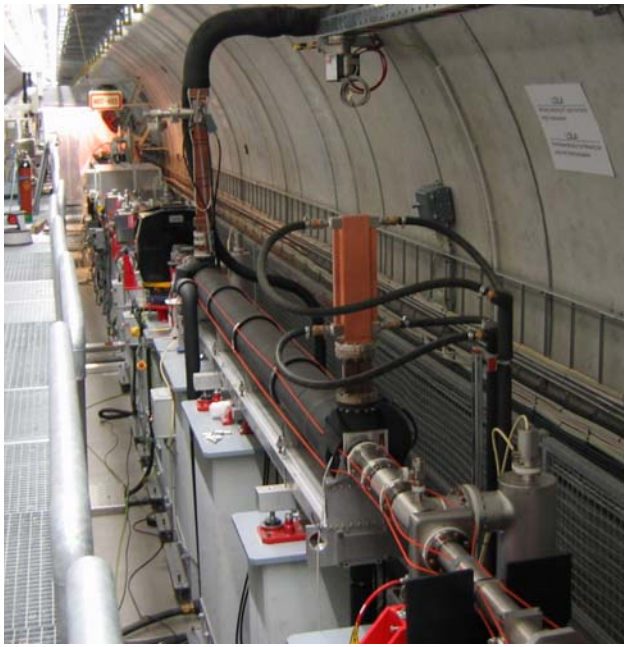
- LOLA (transverse deflecting cavity) is an important tool to measure the longitudinal bunch structure
  → commissioning of ACC39
- presently located at the place of ACC7
  → must move downstream
  → new place: just before the SASE undulators
- move with LOLA:
  waveguide extension, cabling, diagnostics (screen + camera), kicker
- with a dispersive section to complete phase space information





Layout of new LOLA section (SMATCH)

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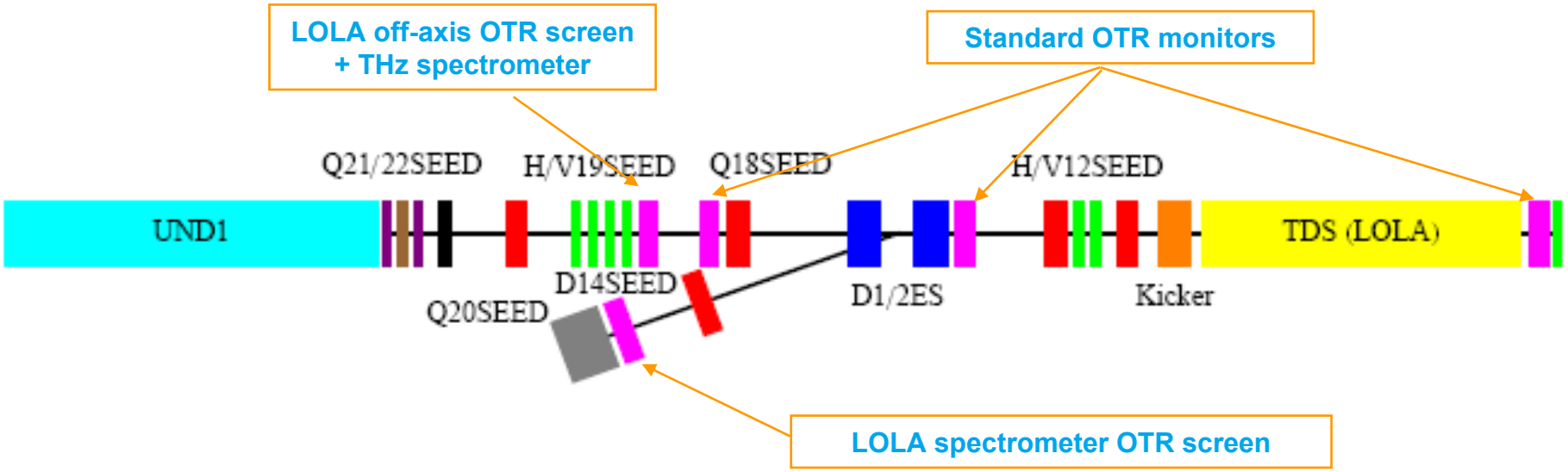
- dispersive section (spectrometer arm)
  - two dipoles to deflect electron beam by 10 deg
- goal:
  - on-line bunch profile measurements parasitic to SASE operation
  - precise measurement of the longitudinal phase space



Other scheduled work

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- replace a resistive current monitor at DBC2 (z= 31.9 m) by a dark current monitor
- THz spectrometer at DBC3 (no vacuum work)
- move XFEL BPM test set-up to a new location downstream of SASE undulators (EXP section)
  - presently mounted just upstream of SASE undulators
- work on photon beam lines and photon diagnostics (in tunnel)
  - no work announced yet

Upgrade of RF stations

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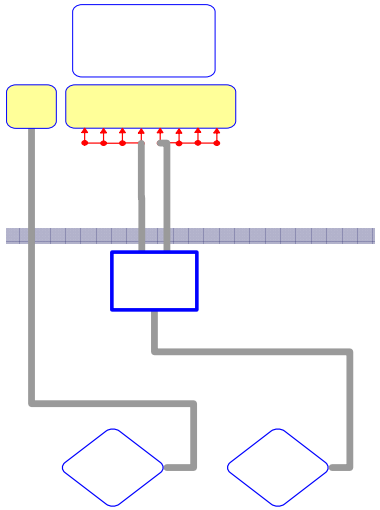
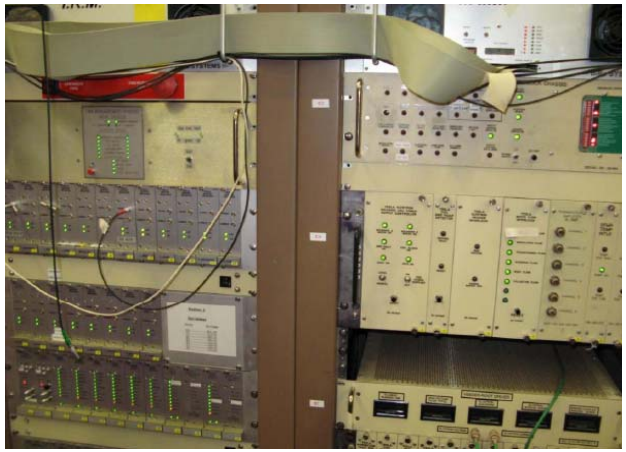
- upgrades of RF stations 2 and 3 (ACC1 and RF gun)
  - old Fermilab modulators (in operation already ~ 10 years) will be replaced by new ones

    → reliability, easier operation and maintenance
  - preparation for RF gun operation with a 10 MW klystron





Upgrade of waveguide system

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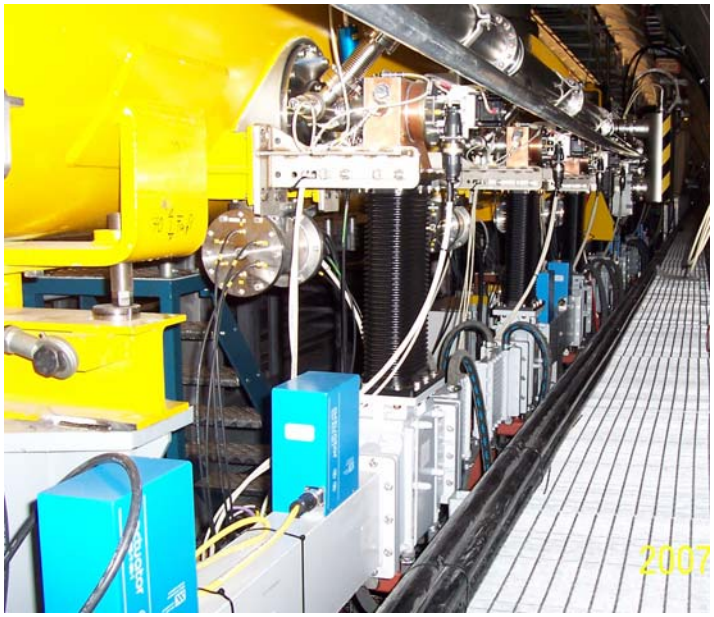
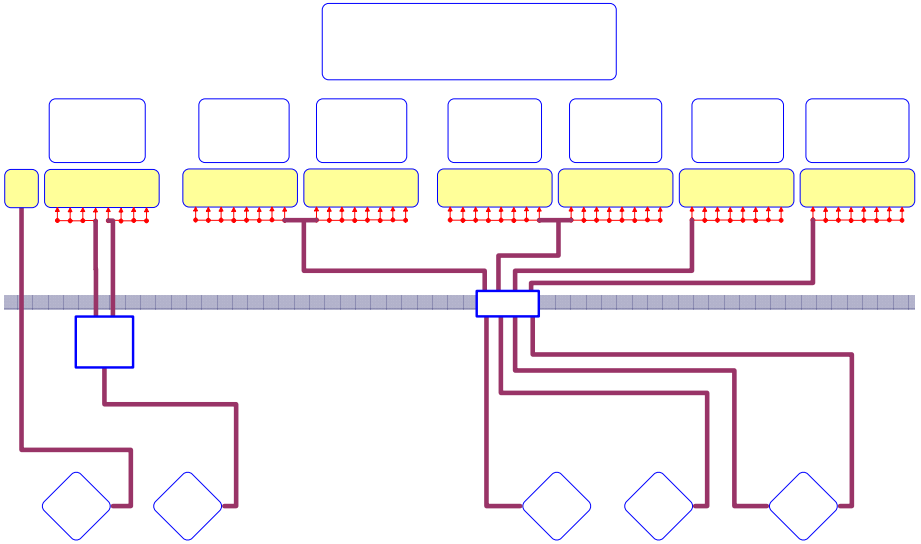
- optimized waveguide system for the accelerating modules
  - an additional RF-station is needed for the operation with the 7th module
    - modulator 6 used now for waveguide tests
  - optimized waveguide distribution for ACC7 to achieve the highest possible beam energy (power for each cavity adjusted individually)
  - XFEL type waveguide distribution like already used for ACC6





Responsible persons

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- each subsystem has one responsible person
  - Accelerating modules: Kay Jensch
  - ACC39: Elmar Vogel
  - sFLASH: Jörg Roßbach
  - RF gun: Klaus Flöttmann
  - RF stations 2 and 3: Frank Eints
  - Waveguides: Valery Katalev
  - LLRF
    - RF-gun, Modules: Valeri Ayvazyan
    - ACC39: Markus Hoffmann
  - LOLA: Christopher Behrens (student, help from Christopher Gerth)
  - RF-stations and waveguides for ACC39 and LOLA: Markus Hüning
  - THz experiments: Bernhard Schmid

Naming convention

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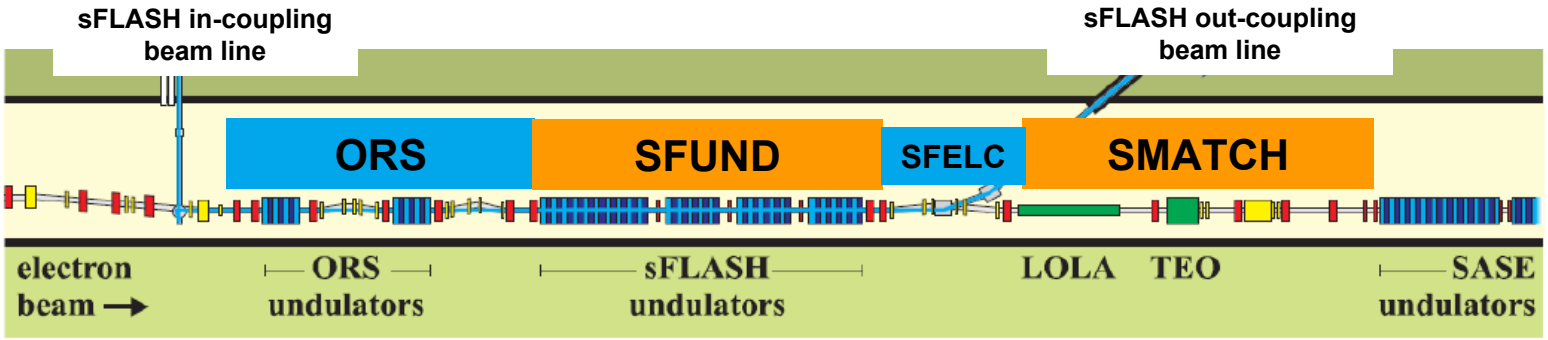
- new names for electron beam line sections between collimators and SASE undulators
  - ORS: z = 159. 4 – 171.2 m
    - optical replica synthesizer
  - SFUND1/2/3/4: z = 171.2 – 184.2 m
    - sFLASH undulators
  - SFELC: z = 184.2 – 189.4 m
    - sFLASH out-coupling mirror chamber + chicane
  - SMATCH: z = 189.4 – 203.4 m
    - LOLA + matching to SASE undulators



FLASH schedule until shutdown

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- FEL user period 2 ends Aug-17, 2009 at 7 am
- repair of electron beam dump line:
  Aug-17 to Sep-6, 2009
  - interruption of the linac beam operation to repair the dump line for 9 mA run,
    NOT a general maintenance or shutdown
  - NO work allowed on the electron beam line or infrastructure (cables, water, etc.)
    → contact K. Honkavaara, if you wish to do anything inside or outside of the tunnel
  - survey of the complete linac by MEA 2
  - nights and weekends: preparation of the 9 mA experiment (tunnel closed)
    - LLRF w/o beam
    - RF gun pulse length increased to 800 us
    - beam in GUN mode
- 9 mA experiment: Sep- 7 to Sep-20, 2009
  - electron beam operation with long bunch trains of high charge: up to 2400 bunches of 3 nC

Shutdown start: September-21, 2009

April	14	30.Mar - 5.Apr	1	User Run
	15	6.Apr - 12.Apr	1	
	16	13.Apr - 19.Apr	1	
	17	20.Apr - 26.Apr	1	
May	18	27.Apr - 3.May	2	FEL studies
	19	4.May - 10.May	3	
	20	11.May - 17.May	1	User Run
	21	18.May - 24.May	1	
	22	25.May - 31.May	1	
June	23	1.Jun - 7.Jun	1	
	24	8.Jun - 14.Jun	2	FEL studies
	25	15.Jun - 21.Jun	3	
	26	22.Jun - 28.Jun	1	User Run
July	27	29.Jun - 5.Jul	1	
	28	6.Jul - 12.Jul	1	
	29	13.Jul - 19.Jul	2	FEL studies
	30	20.Jul - 26.Jul	3	
August	31	27.Jul - 2.Aug	1	User Run
	32	3.Aug - 9.Aug	1	
	33	10.Aug - 16.Aug	1	
	34	17.Aug - 23.Aug	5	Repair of electron beam dump line
	35	24.Aug - 30.Aug	5	
September	36	31.Aug - 6.Sep	5	
	37	7.Sep - 13.Sep	4	9 mA experiment (BEAM!)
	38	14.Sep - 20.Sep	4	
	39	21.Sep -	6	Shutdown for Upgrade Work

Tentative schedule Sep-2009

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- shutdown start: September-21, 2009
- first week of shutdown (Sep-21 to Sep-27):
  preparation work in ACC7 and sFLASH sections
  - disconnect magnets (power cable, water, piloterms)
  - disconnect cables of beam diagnostics and other components: BPMs, toroids, OTR monitors, LOLA, kickers, etc.
  - remove OTR optical set-ups and all components on ORS and TEO tables
  - vent vacuum, install clean rooms
- vacuum work starting Sep-28
  - remove electron beam line in ACC7 section
  - remove electron beam line between collimators and SASE undulators
    - starting from the entrance of SASE undulators and working upstream

Tentative schedule Oct-2009

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- preparation of ACC1 + ACC39 installations
  - transport ACC1 out of the tunnel
  - prepare place and supports for ACC1 + ACC39
  - cryo-endcap to a new location
- preparation of ACC7 installation
  - remove electron beam line and LOLA cavity
  - supports for ACC7
  - cryo-endcap to a new location
- sFLASH section
  - remove electron beam line
  - stones and other support structures (e.g. sFLASH undulator girders, optical tables) to their new locations
  - finish sFLASH in-coupling beam line installation work

Tentative schedule Nov-Dec-2009

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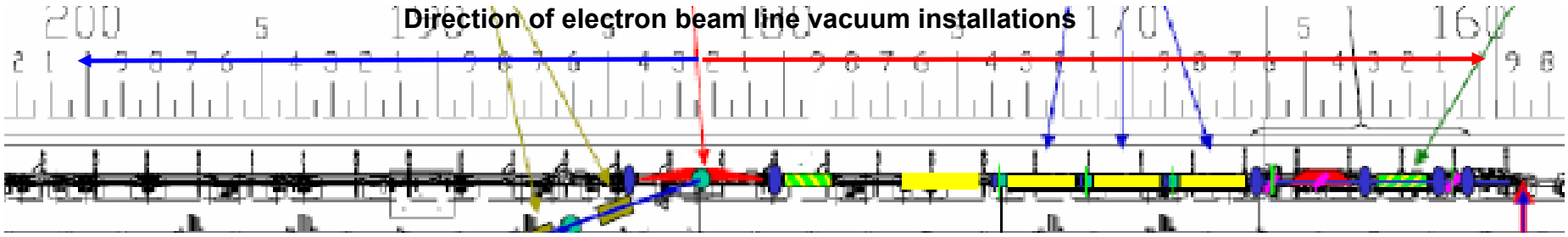
- transport and mount module ACC7
  - vacuum and cryo connections
  - installations of waveguides, couplers, technical interlocks, etc.
- transport and mount modules ACC1 + ACC39
  - vacuum and cryo connections
- THz experiment (ACC7 section)
  - installation of electron beam line and THz line
- sFLASH section
  - installation of electron beam line
    - starting from SFELC/SFUND section and working upstream
    - when vacuum work finished in ORS section, start installation in SMATCH section
  - transport and mount sFLASH undulators
    - as soon as vacuum installation in SFUND section finished



Tentative schedule Jan-2010

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- exchange of RF-gun
- prepare laser and laser beam line
- ACC1 + ACC39
  - cryo connections, waveguides, technical interlocks, ACC39 subsystems
- finish work on ACC7
- sFLASH section (ORS+SFUND+SFELC)
  - commissioning of sFLASH undulators
  - installation and commissioning sFLASH and ORS diagnostics components: screens, optical set-ups, streak camera, etc.
  - commissioning of standard electron beam diagnostics: BPMs, OTR screens, optical set-ups + cameras, wire scanners, etc.
  - installation of out-coupling sFLASH beam line
- SMATCH section
  - finish vacuum work (including dispersive section)
  - connection and commissioning of standard electron beam diagnostics: BPMs, OTR screens, optical set-ups + cameras, wire scanners, etc.
  - commissioning of LOLA and its subsystems (screens, kicker, etc.)

Tentative schedule Feb-2010

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- work in the tunnel finished by Feb-14, 2010
  - laser and laser beam line ready for beam operation
  - RF gun and all accelerating modules (incl. ACC39) ready for RF operation
  - magnets connected and ready for commissioning
  - standard electron beam diagnostics ready for beam operation
  - sFLASH and LOLA installations finished
- magnet commissioning: Feb-15 to Feb-28, 2010
  - tunnel closed
- RF stations and waveguides ready for RF operation: Feb-28, 2010
- cryo shutdown finished by Feb-28, 2010

Commissioning March-2010 →

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- goal: beam through linac by middle of April-2010
  - interlock tests
  - warm coupler conditioning
  - cool down accelerator modules
  - conditioning of RF-gun
  - beam in GUN mode, beam based solenoid alignment
  - cavity tuning of modules after cool down
  - LLRF phase adjustments
  - beam transport to dump (by-pass + FEL mode)
- followed by
  - demonstration of maximum electron beam energy
  - SASE recovery
  - ACC39 commissioning
  - sFLASH commissioning
- FEL user period 3 starts in Summer 2010 (July? → tbd)

Shutdown coordination

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- overall coordination: Katja Honkavaara
- coordination of technical work: Karsten Klose, Peter Hopf, Ben Polzin
- time schedules: Armin Brand
- meetings Mondays (10h30, 200 / 24)
  - every subsystem has presented its plans and current status
  - minutes and presentations available in web: flash.desy.de/upgrade_2009
- mailing-list: flash-upgrade09@desy.de
- detailed time schedule will be presented in the upgrade meeting of Monday April-20, 2009
  - after that the time schedule will be available in the FLASH upgrade webpage as a project file, and will be updated regularly

Summary

FLASH
Free-Electron Laser in Hamburg

- several new installations and upgrades
- shutdown starts September-21, 2009
- work in tunnel finished by middle of February, 2010
  - followed by magnet commissioning (tunnel closed)
- RF stations, waveguides, and cryogenics ready by end of February, 2010
- commissioning starts March-1, 2010
  - beam through linac by middle of April 2010
- FEL user period 3 starts in July 2010 (tentative, tbd)