



FLASH Seminar

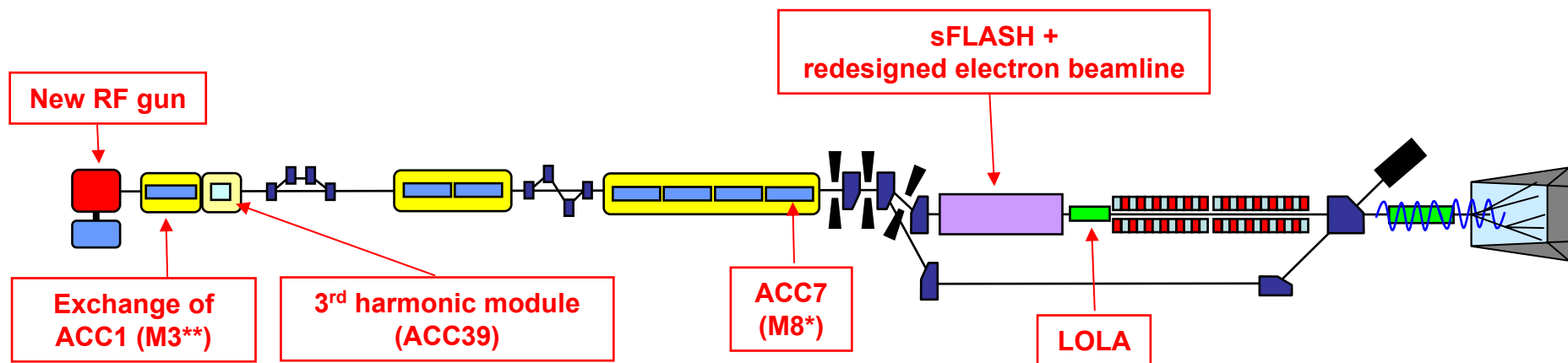
March-31, 2009



FLASH Upgrade 2009

Katja Honkavaara

- new installations and upgrades
- tentative time schedule
- coordination





New installations 2009

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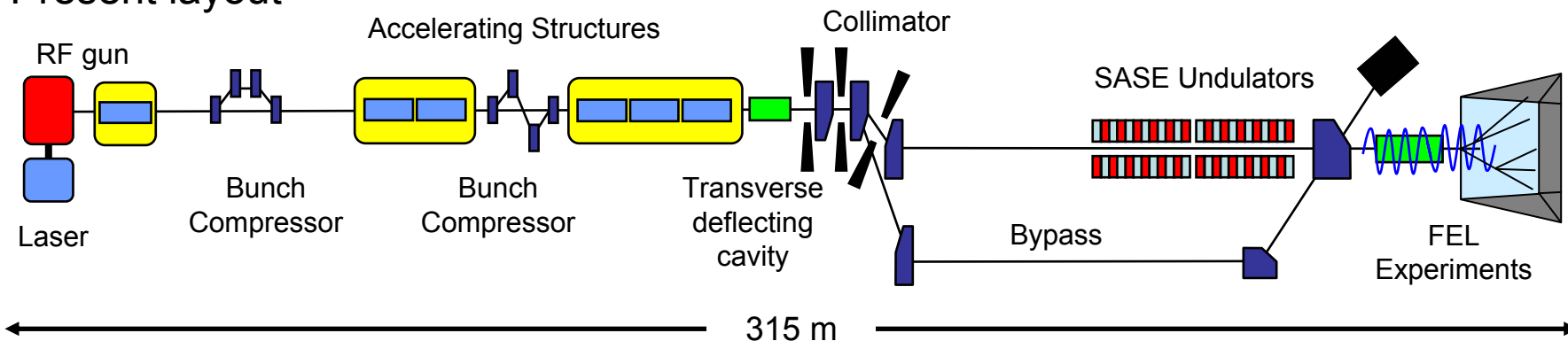
- new
 - 3rd harmonic (3.9 GHz) accelerating module (ACC39)
 - 7th accelerating module (ACC7)
 - transverse deflection cavity LOLA moved downstream
 - sFLASH: seeding experiment
 - replacement of complete electron beam line between collimators and SASE undulators (~ 40 meters)
- upgrades
 - exchange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



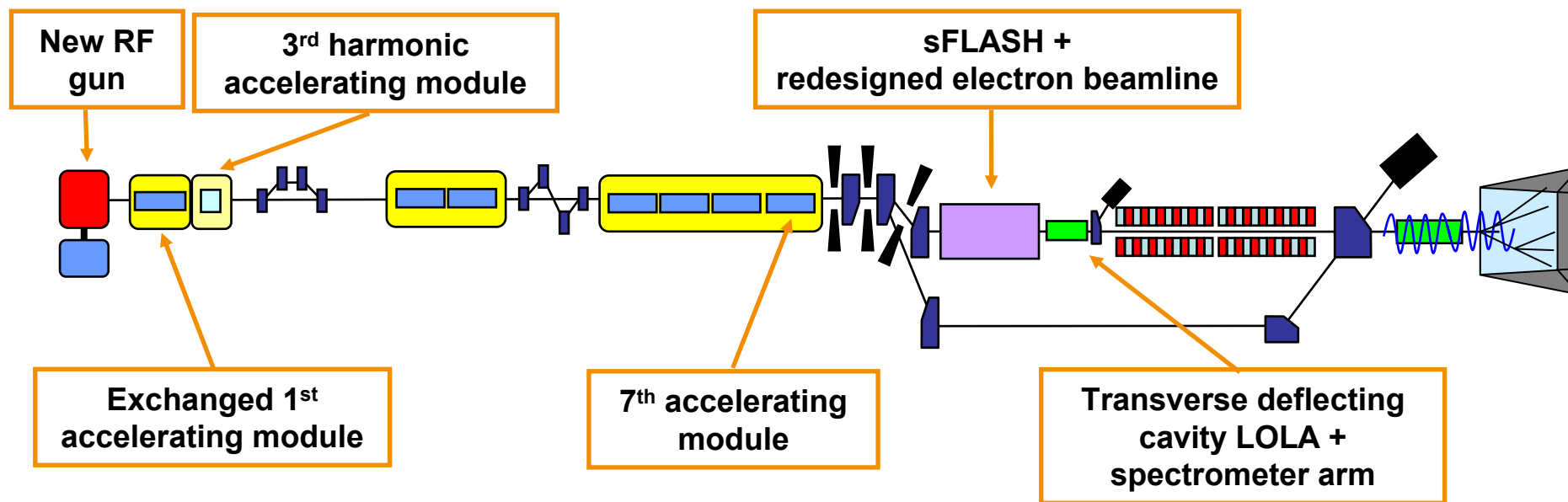
Linac layout

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Present layout



New layout

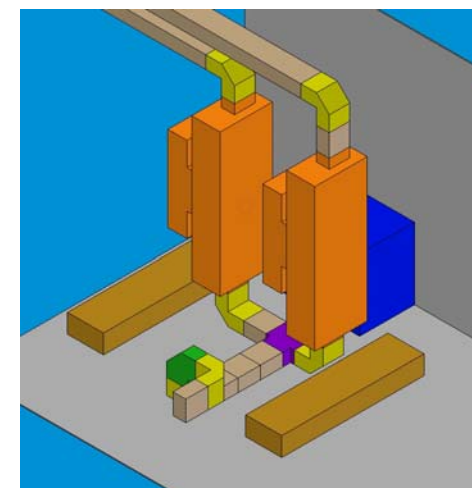




Exchange of RF gun

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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 CO₂ 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

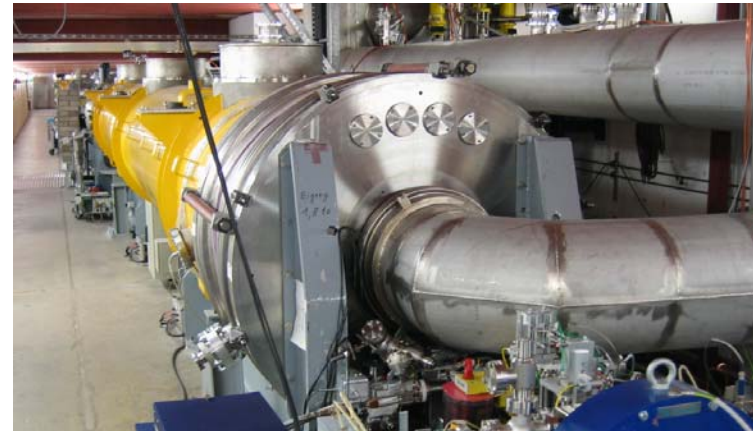




Exchange of ACC1

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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



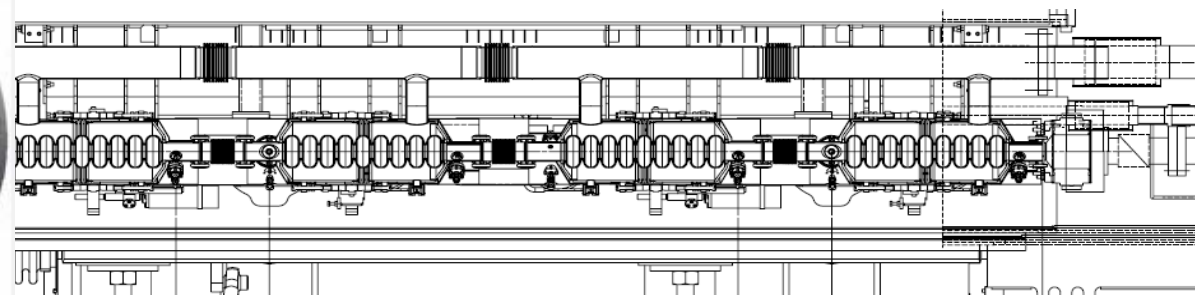
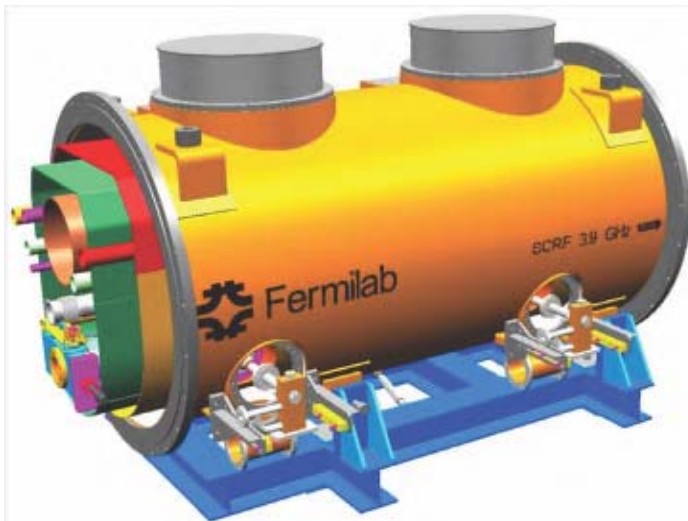
Katja Honkavaara, FLASH Seminar, March-31, 2009



3.9 GHz (3rd harmonic) module ACC39

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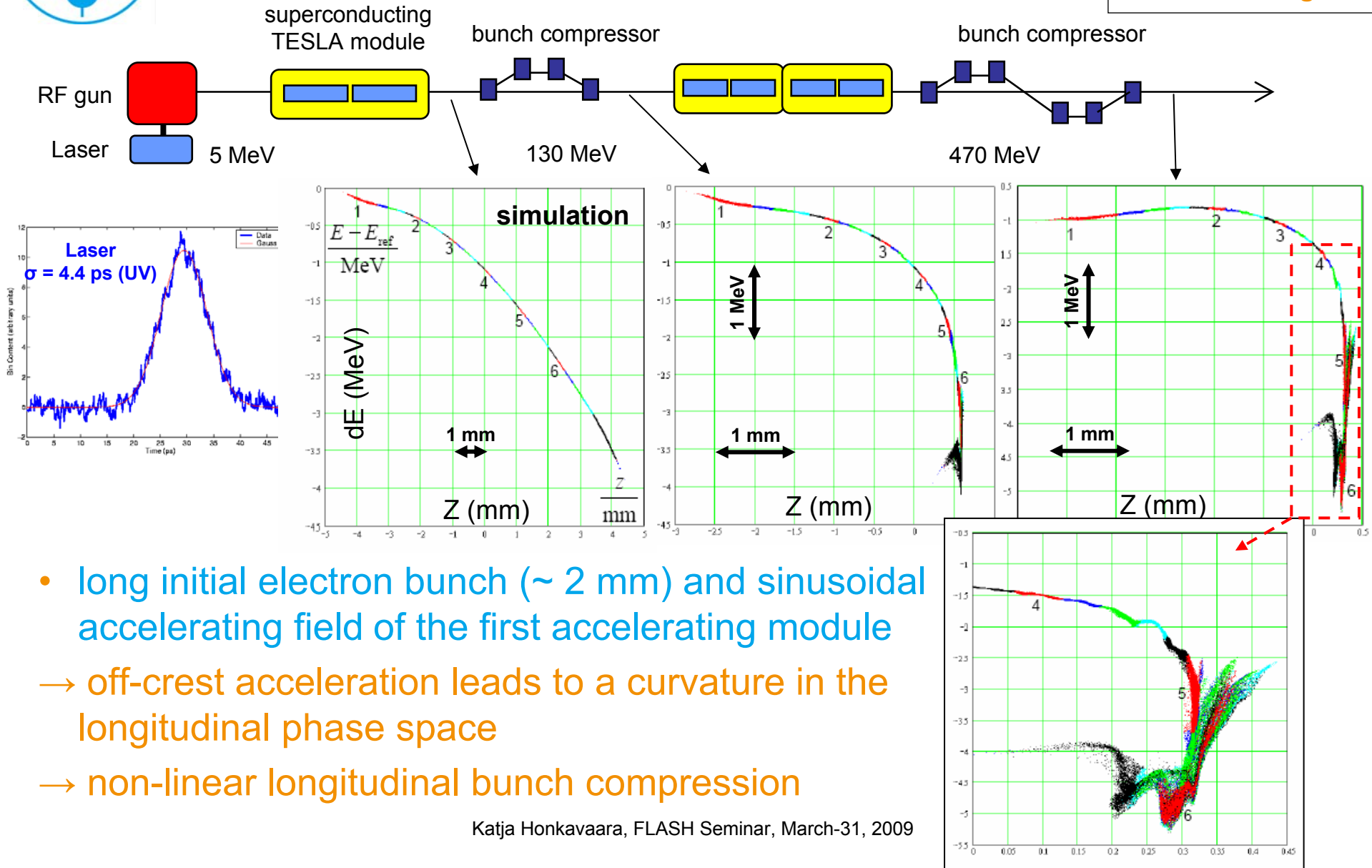
- 4 nine-cell superconducting 3.9 GHz cavities
- collaboration FNAL / DESY
- to be installed after the first accelerating module
- includes RF-system (klystron, modulator), waveguides, and LLRF regulation





Longitudinal phase space

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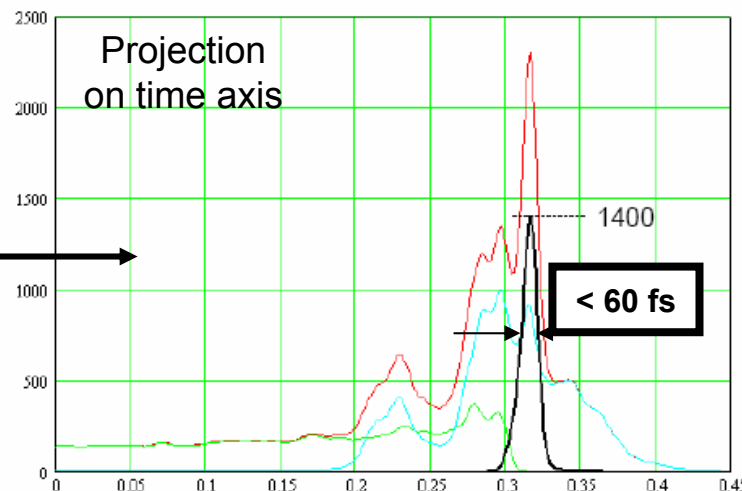
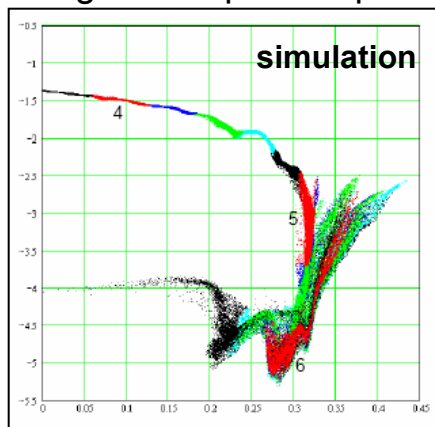
- long initial electron bunch (~ 2 mm) and sinusoidal accelerating field of the first accelerating module
 - off-crest acceleration leads to a curvature in the longitudinal phase space
 - non-linear longitudinal bunch compression



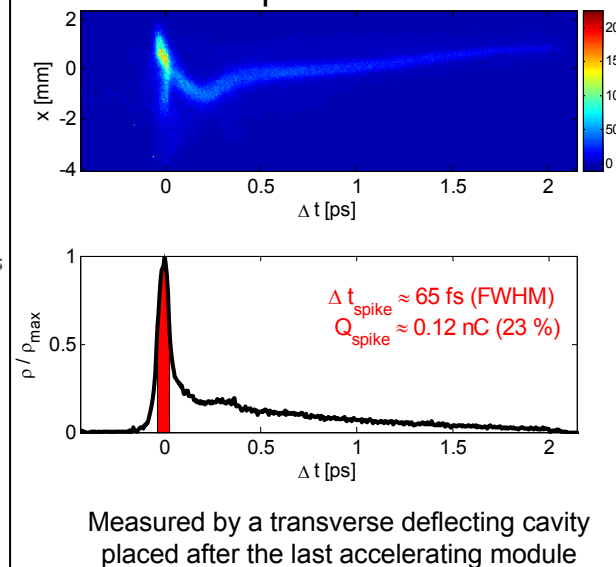
Longitudinal bunch shape

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Longitudinal phase space



Measured longitudinal shape of a compressed bunch



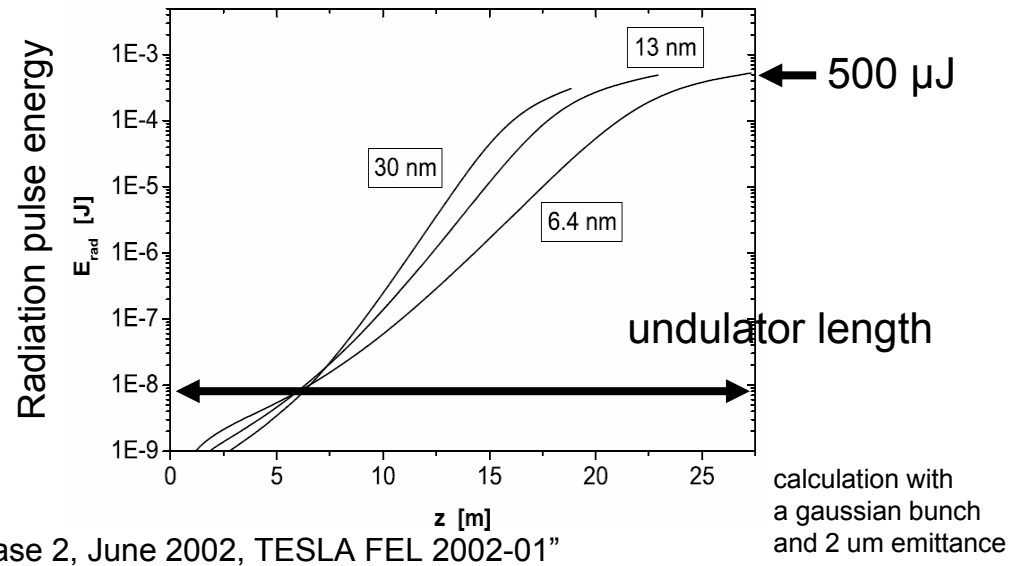
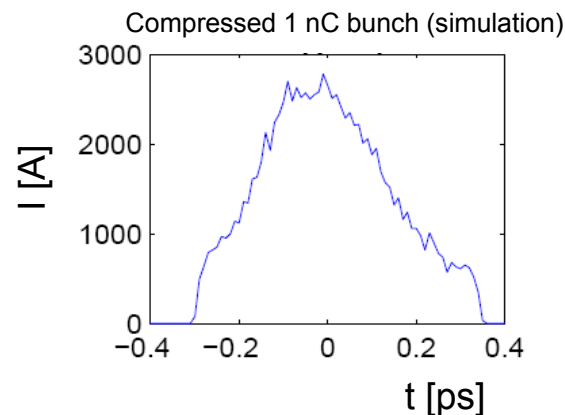
- ultra-short bunch spikes created ($< 60 \text{ fs fwhm}$)
→ femtosecond operation mode
- difficult to measure relevant beam parameters
→ standard diagnostics measures projected parameters
→ empirical tuning needed to achieve good SASE performance



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



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



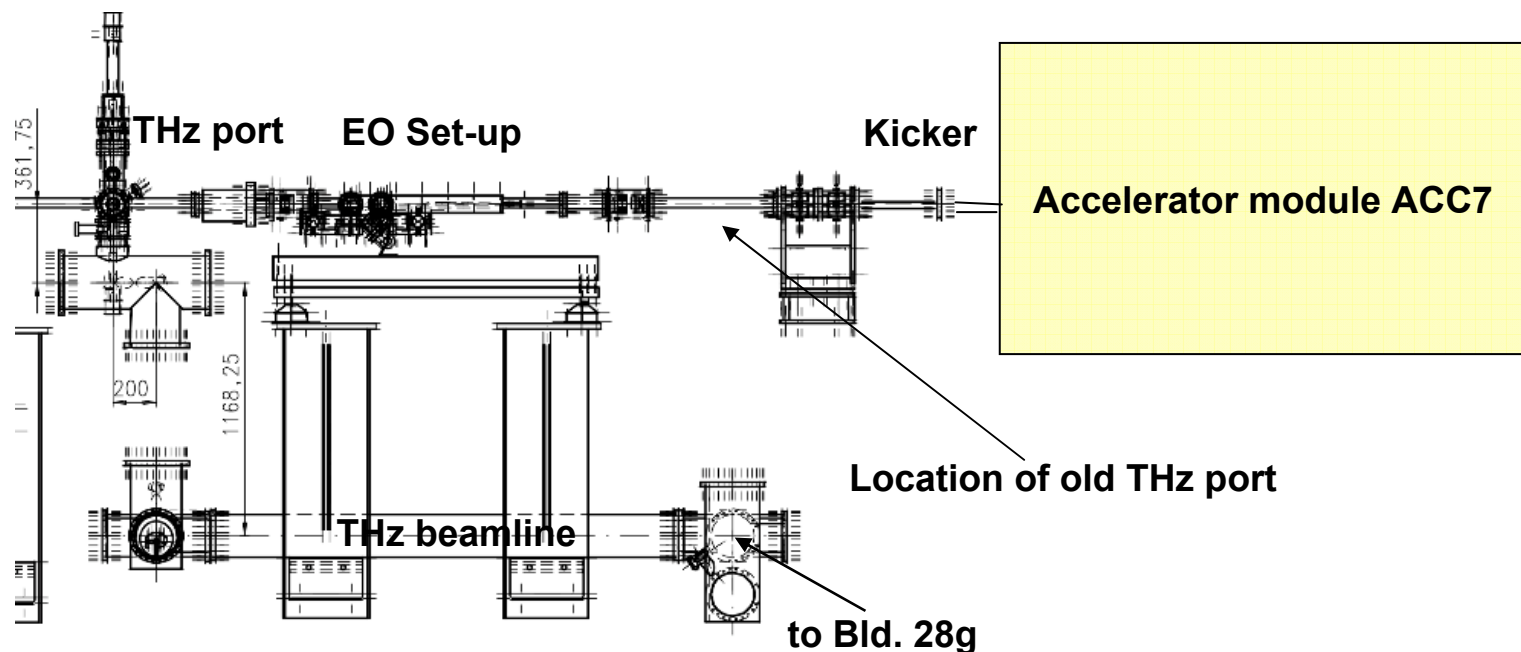
Katja Honkavaara, FLASH Seminar, March-31, 2009



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

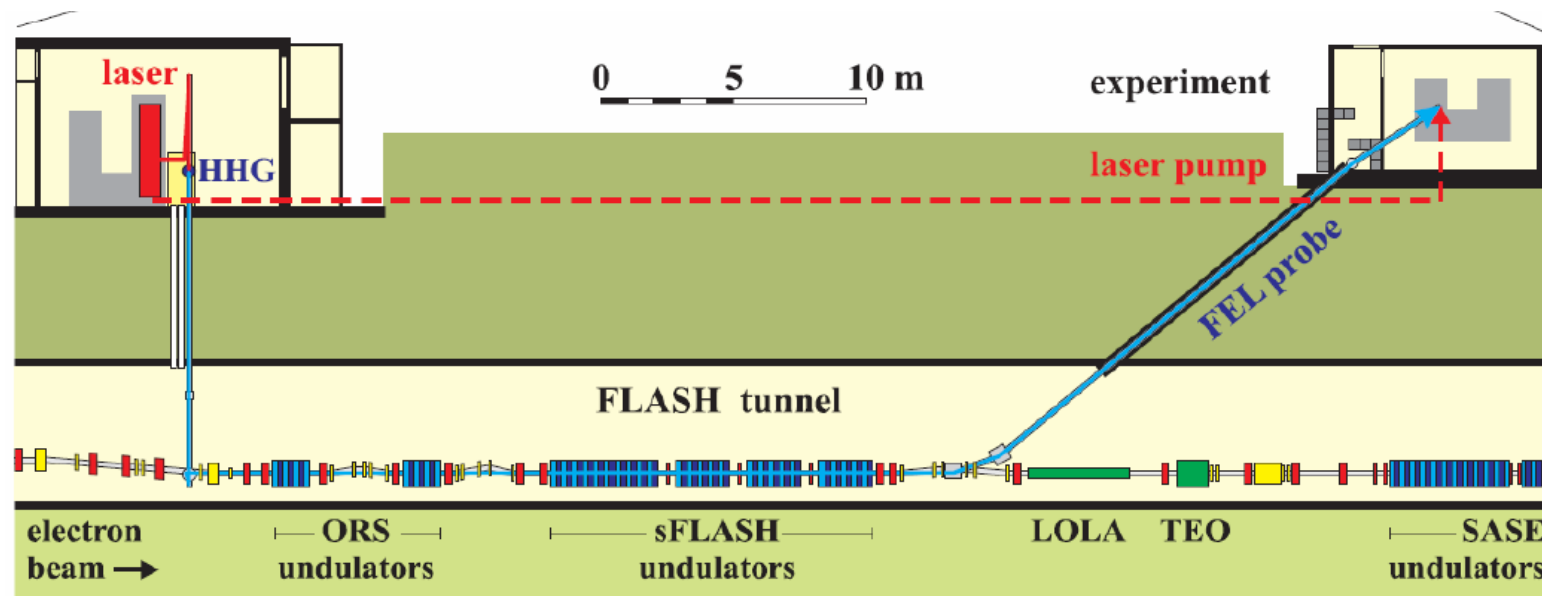




sFLASH

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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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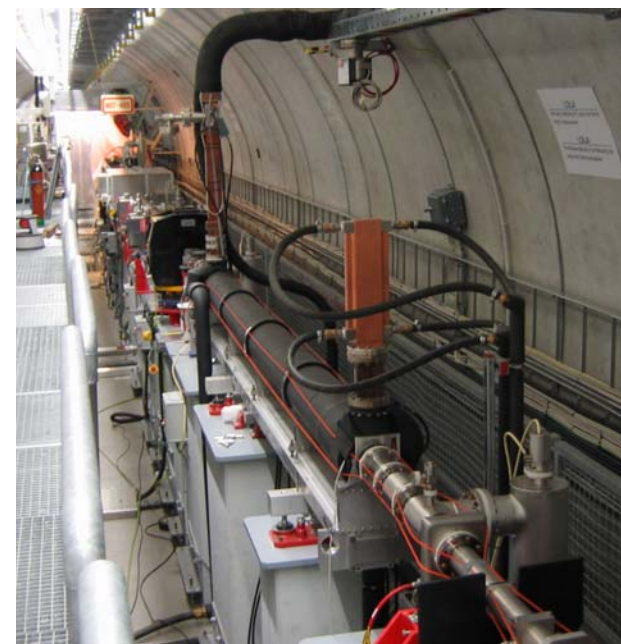
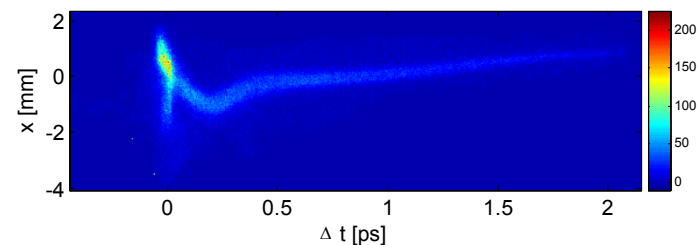
- new electron beamline between collimators and SASE undulators
 - magnets moved to other locations → new beam optics and steering
 - electron beam diagnostics devices in new locations
 - new hardware related to sFLASH
 - 4 undulators (variable gap)
 - mirror chambers
 - diagnostics devices
- establishment 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

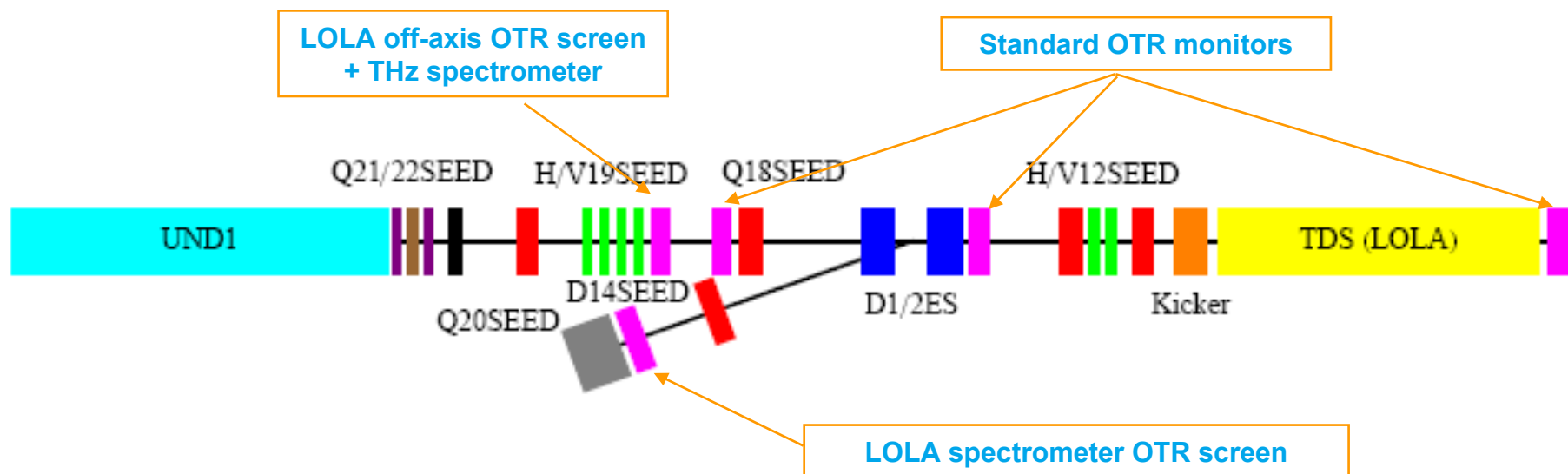




Layout of new LOLA section (SMATCH)

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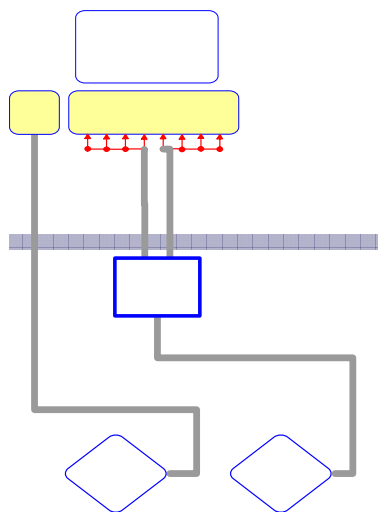
- replace a resistive current monitor at DBC2 ($z = 31.9$ m) by a dark current monitor
- THz spectrometer at DBC3 (no vacuum work)
- move XFEL BPM test set-up to a new location downstream of SASE undulators (EXP section)
 - presently mounted just upstream of SASE undulators
- work on photon beam lines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

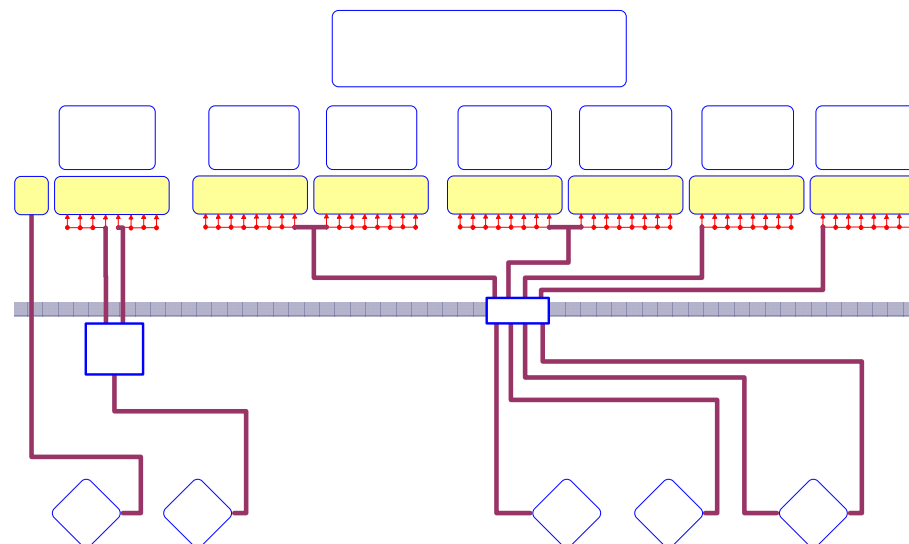
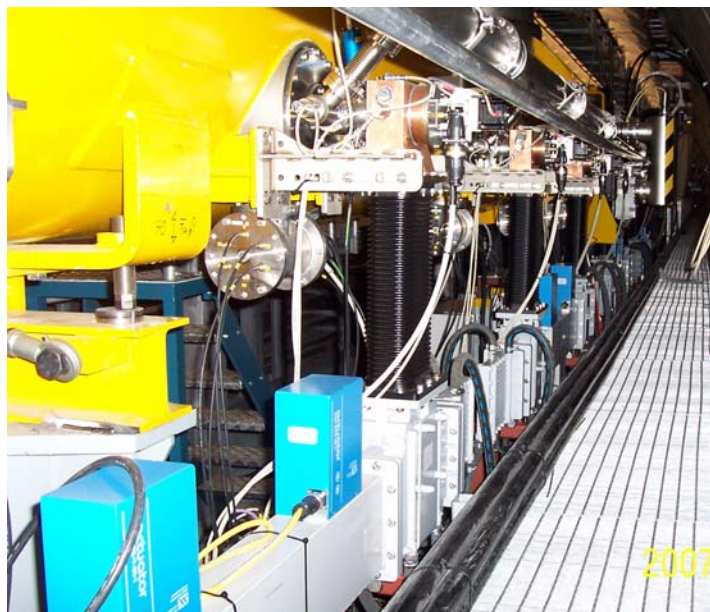




Upgrade of waveguide system

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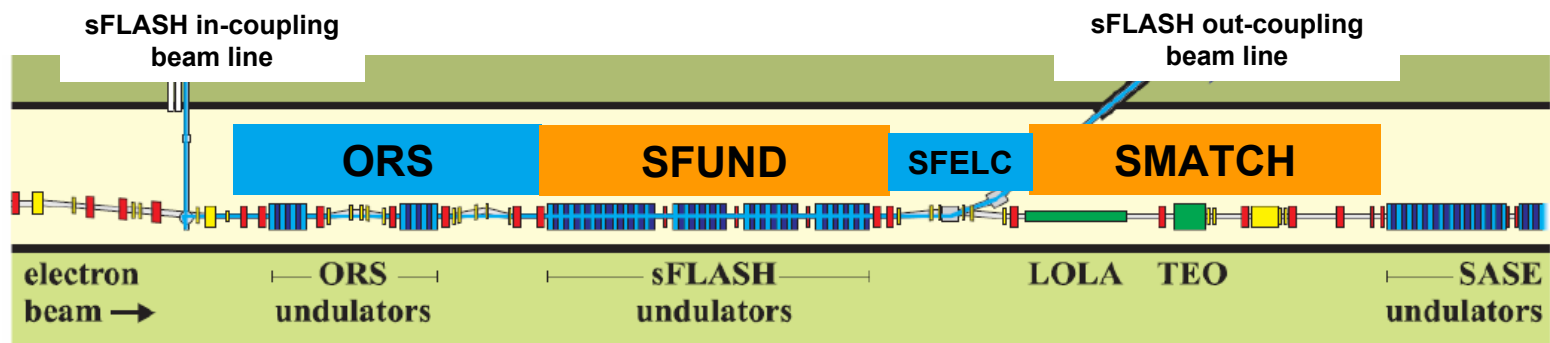
- each subsystem has one responsible person
 - Accelerating modules: Kay Jensch
 - ACC39: Elmar Vogel
 - sFLASH: Jörg Roßbach
 - RF gun: Klaus Flöttmann
 - RF stations 2 and 3: Frank Eints
 - Waveguides: Valery Katalev
 - LLRF
 - RF-gun, Modules: Valeri Ayvazyan
 - ACC39: Markus Hoffmann
 - LOLA: Christopher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



Naming convention



- 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	
	23	1.Jun - 7.Jun	1	
June	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	
	31	27.Jul - 2.Aug	1	User Run
August	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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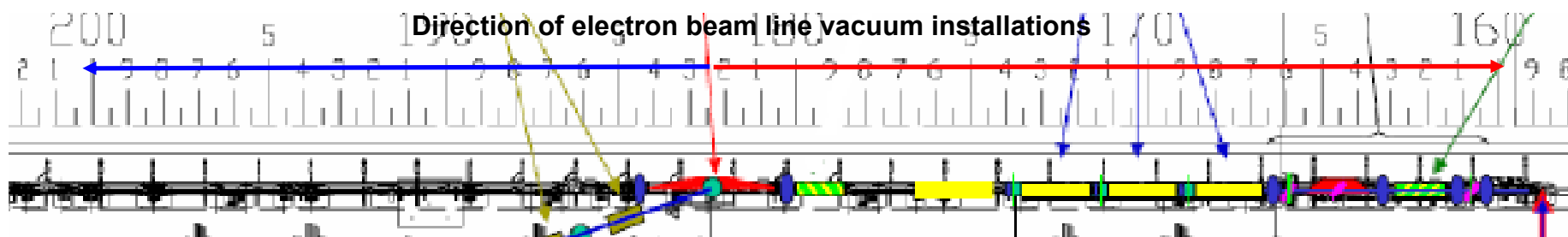
- preparation of ACC1 + ACC39 installations
 - transport ACC1 out of the tunnel
 - prepare place and supports for ACC1 + ACC39
 - cryo-endcap to a new location
- preparation of ACC7 installation
 - remove electron beam line and LOLA cavity
 - supports for ACC7
 - cryo-endcap to a new location
- sFLASH 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

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- 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)