Overview of the accelerator studies 27.2-9.4.2006

Katja Honkavaara

- Long electron bunch trains
- High gradient / high beam energy
- LLRF developments
- Emittance studies
- High order mode measurements
- Diagnostics
- Gun studies + QE measurements

Accelerator studies in KW 9-14

- Priority on ILC and XFEL related studies (not VUV-FEL)
  - VUV-FEL benefits directly or indirectly from most of the studies
- Collaborators from outside: SLAC, INFN, CEA-Saclay, FNAL, …
- Machine/beam time available: 6 x 21 shifts = 126 shifts
- Machine time requested for different experiments : ~140 shifts
- Machine/beam time (~ 30 shifts) needed also
  - To set-up different machine conditions / tuning / contingency
  - Maintenance (~ 1 shift / week)
  - Long term stability measurements (long bunch trains, high beam energy)
- Important: continuity from shift to shift

→ Needed to set priorities, cut number of requested shifts, and shift some studies to VUV-FEL study periods and/or next accelerator study period

Organization of scientific program

- Request to submit beam/machine time requests
  - Sent by e-mail in Dec 2005 to ttf2 mailing list (+ collaborators in INFN, SLAC, Saclay, and FNAL); Dead-line Jan 11th, 2006.
- Draft program based on the requests taking into account the priorities in this accelerator study block (e.g. long bunch trains and high beam energy)
  - Presented to the colleagues who have submitted requests
    → Discussions → Final program + detailed schedule
- Final program and detailed schedule sent by e-mail on Jan 31st to ttf2 mailing list
- All the experiments having beam/machine time during the accelerator studies have filled out an experiment description form in TTF/VUV-FEL logbook: ttfinfo.desy.de/TTFelog → Beam request
- After the studies: oral presentations of the results + probably a written report (e.g. DESY Technical Note)

Long bunch trains

- Coordination: Lars Fröhlich
- Long bunch train: > 30 us @ 1 MHz
- Goal: Stable transport of bunch trains of ~100 bunches via by-pass
- Machine protection:
  – Fast switch-off : BLM → BIC → ACC1 RF-inhibit (L.Fröhlich, M.Görler, M.Staack)
  – Toroid protection system (Saclay: A.Hamdi et al.)
- LLRF adjustments
  – RF-gun with SIMCON 3.1 (W. Koprek, P.Pucyk, E.Vogel)
    - Test and adjustment of a fast adaptive feed forward algorithm (FAFF) to keep the RF gradient and RF phase constant along the flat top of the RF pulse
    - Adjustment of the operation mode for long bunch trains (w/wo feedback, w/wo FAFF, etc.)

Long bunch trains (cont.)

- LLRF adjustments (cont.)
  - If ACC1 with SIMCON 3.1 (W.Koprek, P.Pucyk, E.Vogel)
    - Test of FAFF
    - Beam load compensation using FAFF and toroid signals
    - Adjustment of the operation mode for long bunch trains
  - Beam load compensation of modules running with DSP (V.Ayvazyan, G.Petrosyan)
- Personnel safety (A.Leuschner)
- Optics for long bunch trains, especially blow-up before dump
- Stability measurements: charge and energy along the bunch train

High gradient / high beam energy

VUV-FEL
Vacuum-Ultraviolet
Free-Electron Laser

- Coordination: Rolf Lange / NN
- Quench protection
  - ACC2 or ACC3 (no beam)
  - Gradient to quench limit (R.Lange, D.Kostin)
  - LLRF exception handling (V.Ayvazyan, G.Petrosyan, S.Simrock)
- Cryo measurements (R.Lange)
  - Probably delayed, since power of kly4 limited to ~ 2 MW
- High electron beam energy
  - Max possible stable beam energy with kly4 (~ 600 MeV ?)
  - LLRF adjustments (ACC4/5)
  - Optics and transport via by-pass (if time allows, maybe also trough undulator)
  - Beam energy measurements

LLRF developments

- Coordinator: Elmar Vogel
- Controlling of ACC1 with FPGA controller SIMCON 3.1 (W.Koprek, P.Pucyk, S.Bucholc, E.Vogel, W.Jalmuzna)
  - Installation of the hardware
  - Installation and test of DOOCS server
  - Calibrations, tests of FF, FB, and exception handling
  - Tests with beam + stability measurements
  - Permanent installation in VUV-FEL (depends on results)
  - Note: most of scheduled LLRF studies @ ACC1 are based on the use of SIMCON (due to higher available processing)
- Test of AFF in ACC1 (T.Czarski, S.Bulholc, W.Jalmuzna , W.Koprek)
  - Controlling ACC1 by SIMCON 3.1 based on the system parameters identification
  - No beam required

LLRF developments (cont.)

- New developments of SIMCON board (G.Lichtenberg and S.Chughtai (TU-Harburg), A.Brandt)
  - First tests parallel by looking signals
  - Final test with beam (ACC1 running with SIMCON 3.1)

- RF Final State Machine (A.Brandt)
  - Goal of FSM: automation of LLRF control
  - Commissioning of permanently running AFF
  - Commissioning of ZZ procedures
  - Test of a new user interface

- Transient measurements (P.Pawlik)
  - ACC3, 1 cavity
  - Different charges, different phases
  - Low charge single bunch measurements + high charge multibunch measurements
  - Help needed from V.Ayvazyan (detuning cavities) and H.Schlarb (energy)

LLRF developments (cont.)

- Klystron FSM and klystron non-linearities (B.Koseda, W.Cichalewski)
  - Tests of FSM for kly5 and kly4
  - Nonlinearity measurements of the high power chain components of kly5, kly2, kly3, kly4
  - Evaluation of on-line non-linearity measurement tool
  - Evaluation of a Matlab tool for nonlinearity compensation

- Piezo tuner (P.Sekalski)
  - Studies done at ACC1 (only cavity5 at ACC1 has a fast piezo tuner)
  - Influence of piezo detuning offset
  - Fine tuning improvements
  - Influence of different parameters on piezo signal (RF-pulse length, beam, nearest cavities)
  - Stabiltiy of FF algorithm, test with FPGA (SIMCON)

- Calibration of SPARM based passive neutron dosimeter (B.Mukharjee, D.Rybka, K.Korzunowics)
  - ZZ to install the detector, beam parallel to other studies, ZZ to remove the detector

Emittance measurements

- Coordinator: Katja Honkavaara / Michael Röhrs
- Emittance (projected + slice) group: Ch.Gerth, K.Honkavaara, M.Hüning, F.Löhl, V.Miltchev, M.Röhrs, H.Schlarb, S.Schreiber, E.Sombrowski
- Main goal: understand emittance in the undulator (both bunch compressors by-passed, all phases on-crest)

- Measurements of projected emittance @ DBC2
  - BC2 by-passed
  - Understand why the measured emittance is larger than before
  - Emittance of longitudinally flat laser pulse (pulse stecker)
  - Emittance measuremets with wire scanners (tests + comparison with OTR measurements)

Emittance measurements (cont.)

- Measurements of projected emittance along the linac
  - BC2 and BC3 by-passed, all phases on-crest
  - DBC2 (4 screen method)
  - OTR/5DBC3 (quad scan)
  - OTR/18ACC7 (quad scan)
  - Seeding section (multi screen method)
  - Undulator (multi wire scanner method)
- Dispersion, when BCs by-passed
- Measurements of slice emittance
  - LOLA + OTR/17ACC7 and/or OTR/18ACC7 + quad scan
  - BC2 and BC2 by-passed
  - Different compression schemes (e.g. BC2 on + BC3 by-passed)
- Measurements of slice energy spread and energy-time correlation
  - LOLA + OTR/5ECOL
  - Different compression schemes

High order mode (HOM)

- Coordinator: Nicoleta Baboi
- HOM group: M.Ross, C.Simon, O.Napoly, R.Paparella, S.Nagaitsev, N.Eddy, N.Baboi
- Main goal: study of dipole signals from ACC4 and ACC5
- Measurement plan:
  - Establish decent, centered trajectory trough ACC4/5
  - Examination of total dipole power emitted from ACC4/5 while beam is close to the center of the cavities
  - Calibrate the HOM dipole response by using a ‘steering-map’ (grid) to eventually use the HOM signal as a BPM
  - Study HOMs from ACC1 (minimization of transverse emittance and improvement of FEL performance)

Optical diffraction radiation (ODR)

- Coordinator: Alessandro Cianchi
- ODR group: A.Cianchi, G.Benedetti, L.Catani, M.Castellano, E.Chiadroni, G. Di Pirro, S.Tazzari (INFN-LNF/Roma2), K.Honkavaara, G.Kube
- Goal: development of a non-intercepting device to measure transverse electron beam size (→ XFEL, ILC)
- Financial support from EU within the CARE project
- Principle: electron beam transfers a slit → optical part of the emitted diffraction radiation is detected → transverse beam size determined
- Hardware (diffraction radiator, special optical set-up) installed in OTR/57BYP in summer/autumn 2005; a highly sensitive CCD camera will be mounted only for measurements
- Requirements: well-optimized beam trough by-pass, beam energy as high as possible

Coherent radiation (THz) + EOS

- Coordinator: Oliver Grimm
- THz/EOS group: O.Grimm, H. Delsim-Hashemi, A.Knabbe, B.Schmidt, B.Steffen
- Information of the longitudinal beam distribution
  - by measuring the radiation spectrum emitted as coherent synchrotron, transition or diffraction radiation (THz measurements)
  - by electro optical methods (electron beam passes close to a crystal)
- Many studies are and will be done parasitically during the user operation and other experiments; however, detailed understanding of the measurements and devices require systematic studies by varying the phases, charge and/or radiator type
- New instruments to measure the coherent spectra: a grating as a dispersive element + detection of the signal either with a single, movable detector or an array of the detectors
- One important goal of the developments: improve existing bunch compressor monitors to allow complex, single-shot bunch shape feedbacks

Beam position monitors (BPM)

- Coordinator: Nicoleta Baboi
- BPM group: N.Baboi, D.Nölle, J.Lund-Nielsen, J.Kruse, T.Traber
- Work planned:
  - Commissioning of dump BPMs (if not done earlier)
  - BPM characterization (raw data) including XFEL prototype
  - Commissioning BYP BPMs (as needed for machine operation)
  - Calibration of cold BPM 9ACC1 (C.Simon)
  - Improvement of BPM system (non-linearity, dynamic range)

- Measurement of BPM offsets respect to quadrupole magnetic center using beam based aligments (P.Castro)
  - Motivation: beam position has to be carefully corrected in critical places like in bunch compressors and collimators (large offsets in quadrupoles introduce dispersion)

Misc. diagnostics

- Double laser pulses (O.Grimm, K.Klose, E.Plöjens, S.Schreiber)
  - Motivation: Double-pulse generation with the injector laser for pump/probe experiments
  - Goal: transport double electron pulses to the dump and check the effect on the operation of the diagnostics
- Dark current kicker (J.-H.Han, F.Obier, S.Schreiber)
  - Effect to SASE with different kicker parameters (w and w/o BC2 collimator)
  - Dark current measurements with BLMs in undulator section with different kicker parameters
  - Separation of dark current and beam on 3BC2 screen
- Synchrotron radiation monitor (Ch. Gerth)
  - Test of SR monitor in BC2 (different orbit trough BC2 needed)

Misc. diagnostics (cont.)

- Energy server (R.Kammering, H.Schlarb, Ch.Gerth)
  - Goal: test and commissioning the first version of a software for on-line measurements of the electron beam energy with a single bunch resolution
  - Tests take place in the dispersive section between 2TCOL and 3ECOL (“dogleg”)
- Feedback tests (R.Kammering, H.Schlarb)
  - Prove of a general concept of a middle layer based generic skeleton for future feedbacks and other slow controllers
  - Test and commissioning of beam based orbit feedback using the generic feedback monitor in the ACC7 section

Gun studies + QE measurements

- Coordinator: Daniele Sertore / Jang Hui Han
- Study group: J.-H.Han, V.Miltchev, L.Monaco, D.Sertore, S.Schreiber
- Measurement plan
  - Software developments (Matlab tool for QE measurements)
  - QE (quantum efficiency) versus laser energy
  - QE versus gun gradient
  - CW QE using a Hg lamp (can be done during a maintenance day)
  - QE of different cathodes
  - Dark current of different cathodes
  - Long term charge measurements

Week 9

HOM, LLRF, THz+EOS, BPM, Energy server, Feedback, SR monitor

Week 9	Mon 27.02.	Tue 28.02	Wed 01.03	Thu 02.03	Fri 03.03	Sat 04.03	Sun 05.03
Morning 07-15	SASE charact. Energy server	Dark current kicker (SASE)	Maintenance	BPM HOM Cold BPM	HOM Cold BPM	HOM	LLRF develop.
Afternoon 15-23	THz/EOS	Energy server Feedback	BPM	LLRF: SIMCON @ ACC1	HOM Alignment 5DBC3 camera Beam to by-pass?	LLRF: SIMCON @ ACC1 LLRF develop.	HOM
Evening 23-07	LLRF develop. SASE	THz/EOS	BPM offsets	LLRF develop.	Energy server Feedback	LLRF develop.	SR monitor

SASE | **FEL mode (no SASE) or by-pass mode (as required by experiments)**

Week 10

HOM, ODR, LLRF, THz+EOS, BPM

Week 10	Mon 06.03	Tue 07.03	Wed 08.03	Thu 09.03	Fri 10.03	Sat 11.03	Sun 12.03
Morning 07-15	**Laser double pulse**	**Maintenance (tunnel open)**	**LLRF: SIMCON @ ACC1** **BIS-BIC ODR**	**LLRF: RF-gun** **FIR 4BC2 THZ/EOS**	**BPM**	**THz /EOS**	**LLRF: SIMCON@ ACC1** **RF-gun**
Afternoon 15-23	**Cold BPM** **HOM**	**Start-up** **HOM**	**ODR** **HOM**	**ODR**	**ODR**	**ODR**	**ODR or LLRF develop.**
Evening 23-07	**HOM** **Energy server + Feedback**	**HOM** **Beam set-up by-pass**	**HOM** **Beam set-up by-pass**	**LLRF develop.**	**LLRF develop.**	**LLRF develop: single bunch transients**	**LLRF develop.**

FEL mode | **By-pass mode**

Week 11

Long bunch trains

Week 11	Mon 13.03	Tue 14.03	Wed 15.03	Thu 16.03	Fri 17.03	Sat 18.03	Sun 19.03
Morning 07-15	ZZ for ODR Preparation for long pulses: LLRF, Personnel safety, BIS-BIC	Maintenace (ZZ only)	Toroid protection system	Toroid protection system	Toroid protection system	LLRF: beam load comp. Long trains: stability	LLRF develop: Multi bunch transients
Afternoon 15-23	Preparation for long pulses: LLRF, Personnel safety, BIS-BIC	LLRF: beam load comp. Beam set-up by-pass	LLRF: beam load comp. Increase train length	LLRF: beam load comp. Increase train length	LLRF: beam load comp. Increase train length	LLRF: beam load comp. Long trains: stability	Long trains: stability
Evening 23-07	Beam set-up by-pass for long bunch trains	Beam set-up by-pass for long bunch trains	Beam set-up by-pass for long bunch trains	Beam set-up by-pass for bunch trains	Long trains: stability	Long trains: stability	LLRF develop.

By-pass mode

Week 12

High gradient / high beam energy

Week 12	Mon 20.03	Tue 21.03	Wed 22.03	Thu 23.03	Fri 24.03	Sat 25.03	Sun 26.03
Morning 07-15	Quench protection	Maintenance (tunnel open)	Quench protection or cryo	LLRF: preparation for max beam energy	High energy beam: LLRF Optics Transm.	High energy beam: LLRF Optics Transm. Stability	LLRF contingency
Afternoon 15-23	Quench protection	Start – up Preparation of beam energy meas.	Quench protection or cryo	High energy beam: Optics Transm. (by-pass)	High energy beam: Optics Transm. Beam Energy	High energy beam: Optics Transm. Stability	LLRF contingency
Evening 23-07	Beam stability (long pulses?)	Beam stability (long pulses?)	Contingency	High energy beam: Optics Transm. (by-pass)	Beam energy Stability	High energy beam: Optics Transm. Stability	High energy beam: Optics Transm. Stability

By-pass or FEL mode mode

Week 13

ODR, THz+EOS, LLRF, QE+Gun studies

Week 13	Mon 27.03	Tue 28.03	Wed 29.03	Thu 30.03	Fri 31.03	Sat 01.04	Sun 02.04
Morning 07-15	LLRF develop.	Maintenance	ODR	ODR	LLRF develop. Beam set-up by-pass	LLRF develop. Beam set-up by-pass	LLRF contingency
Afternoon 15-23	LLRF develop.	Start-up Beam set-up by-pass (high beam energy) ODR	ODR THz/EOS	ODR Laser double pulse or QE / Gun	ODR	ODR	ODR Feedback
Evening 23-07	High energy beam: Optics Transm. Stability	High energy beam: Optics Transm. Stability	THz/EOS Beam set-up by-pass (high beam energy)	THz / EOS	QE / Gun studies	QE / Gun studies	THz / EOS

By-pass mode, max beam energy (600 MeV ?)

Week 14

Emittance (projected + slice)

Week 14	Mon 03.04.	Tue 04.04	Wed 05.04	Thu 06.04	Fri 07.04	Sat 08.04	Sun 09.04
Morning 07-15	**Maintenance (ZZ only)** **BPM**	**Injector set-up BC2 off** **Emittance DBC2**	**Emittance DBC2** **(flat laser pulse)**	**Projected emittance along linac**	**Parameter scan /** **Undulator emittance**	**Slice emittance + slice energy spread**	**Slice emittance + slice energy spread**
Afternoon 15-23	**Transfer matrix**	**Emittance DBC2** **Machine set-up BC2+BC3 off**	**Emittance** **DBC2** **(flat laser pulse)** **LOLA + slice emit.**	**Projected emittance along linac** **Dispersion Slice emit.**	**Parameter scan /** **Undulator emittance**	**Slice emittance + slice energy spread**	**Slice emittance + slice energy spread**
Evening 23-07	**BPM offsets**	**Machine set-up BC2+BC3 off** **Und. Transfer matrix**	**LOLA + slice emit.**	**Dispersion Slice emit.**	**Beam set-up with different compression scheme**	**Slice emittance + slice energy spread**	**Slice emittance + slice energy spread**

FEL-mode (no SASE)