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
• 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. Kroprek, 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

- 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

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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
• 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.Kosed, 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)
  – Stability 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
- 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 measurements 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 through 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
- 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

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Beam position monitors (BPM)

- Coordinator: Nicoleta Baboi
- 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 alignments (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)

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• **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)
• **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**

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

**SASE**

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

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<table>
<thead>
<tr>
<th>Week 10</th>
<th>Mon 06.03</th>
<th>Tue 07.03</th>
<th>Wed 08.03</th>
<th>Thu 09.03</th>
<th>Fri 10.03</th>
<th>Sat 11.03</th>
<th>Sun 12.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning 07-15</td>
<td>Laser double pulse</td>
<td>Maintenance (tunnel open)</td>
<td>LLRF: SIMCON @ ACC1</td>
<td>LLRF: RF-gun</td>
<td>BPM</td>
<td>THz/EOS</td>
<td>LLRF: SIMCON @ ACC1 RF-gun</td>
</tr>
<tr>
<td>Afternoon 15-23</td>
<td>Cold BPM</td>
<td>Start-up</td>
<td>ODR</td>
<td>ODR</td>
<td>ODR</td>
<td>ODR</td>
<td>ODR or LLRF develop.</td>
</tr>
<tr>
<td>Evening 23-07</td>
<td>HOM</td>
<td>HOM</td>
<td>HOM</td>
<td>LLRF develop.</td>
<td>LLRF develop.</td>
<td>LLRF develop: single bunch transients</td>
<td>LLRF develop.</td>
</tr>
</tbody>
</table>

**FEL mode**

**By-pass mode**

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## Week 11

### Long bunch trains

<table>
<thead>
<tr>
<th>Week 11</th>
<th>Mon 13.03</th>
<th>Tue 14.03</th>
<th>Wed 15.03</th>
<th>Thu 16.03</th>
<th>Fri 17.03</th>
<th>Sat 18.03</th>
<th>Sun 19.03</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning 07-15</strong></td>
<td>ZZ for ODR Preparation for long pulses: LLRF, Personnel safety, BIS-BIC</td>
<td>Maintenance (ZZ only)</td>
<td>Toroid protection system</td>
<td>Toroid protection system</td>
<td>Toroid protection system</td>
<td>LLRF: beam load comp.</td>
<td>LLRF develop: Multi bunch transients</td>
</tr>
</tbody>
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**By-pass mode**

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## Week 12

### High gradient / high beam energy

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

**By-pass or FEL mode mode**

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

**By-pass mode, max beam energy (600 MeV ?)**
## Week 14

### Emittance (projected + slice)

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

**FEL-mode (no SASE)**

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