Time-Of-Flight measurements at FLASH
- Status of the Setup -

Martin Kollewe

MVP/DESY
FLASH Meeting 25.Apr.2006

1) Motivation
2) Setup
3) Measurements
   - Sensitivity tests
   - Applications:
     - On Crest Phase, Dark Current (?), Compression Coefficients
4) Summary
Motivation

3\textsuperscript{rd} harm ON:
- \( z \) smaller
- \( q/z \) higher
- \( q/z \) smoother

To control the compression process:
1. Installation of third harmonic cavity
2. Time-Of-Flight Measurements

Figure 4: Comparison of the charge density profiles, downstream of the bunch compressor, when the 3\textsuperscript{rd} harmonic section is or not operated.

Floettmann et al. / FEL report 2001-06
Principle

Phase Monitor \( \phi_{\text{bun}} \) → Bunch

Analog Electronics

\( \phi_{\text{ref}} \) → Phase shifter

I/Q → DOOCS Front End AD conversion

DOOCS middle layer server

GUI (ddd)

\( \phi_{\text{bun}} - \phi_{\text{ref}} \)

1.3 GHz reference line

TOF-measurements at FLASH, Status of Setup/25.Apr.2006/Kollewe
Example of analog signal

Phase of electron bunch passage w.r.t. reference: $\phi_x = \arctan(I_{x}/Q_{x})$
($x = \text{'B'} \text{ or } \text{'DC'}$)
Instrumentation

Phase Monitors

1UBC2
H1DBC2
3DBC2
2DBC2

ACC1
BC2

6.2 m
5.9 m
1.4 m
1 m
0.2 m
7.1 m

TOF-measurements at FLASH, Status of Setup/25.Apr.2006/Kollewe
Instrumentation

Examples of devices at FLASH

'1UBC2' at z = 19 m

'3DBC2' at z = 28 m

TOF-measurements at FLASH, Status of Setup/25.Apr.2006/Kollewe
Long-term drift
Reference signal was put into both inputs of electronics

'SPhase' at 4DBC3 (z = 85 m) [deg]
Slope \( \sim 2.4^\circ/\text{day} = 0.1^\circ/\text{hour} \)

14.Feb.2005, 12.00h

MSK: \( 1^\circ/(\text{Phase output})/1^\circ\text{C}(\text{Temperature}) \)
Measured in laboratory

TOF-measurements at FLASH, Status of Setup/25.Apr.2006/Kollewe
Dependence on charge per bunch

Phase at 3GUN [°]

Linear fit: $27°/nC$

10 bunches/macropulse

Charge per macropulse at 3GUN [nC]

(17.Nov.2005)
Dependence on beam position

1. Beam steered with steerer H1DBC2

2. Beam position while ACC1 phase scans (chopped beam)

![Graph showing beam position at BPM 3DBC2 vs. phase at 3DBC2](image)

- Phase at 3DBC2: $\theta = 7.7^\circ$
- Beam position at BPM 3DBC2: $x = 3.8$ mm
- Slope: $\theta / x = 2.0^\circ / \text{mm}$
Dark current signal

BC2 collimator out

BC2 collimator in
Modification of electronics '6MATCH'
Dark current kicker varied
BC2 collimator varied
-> no effect in interval between 'bursts'
ACC1 RF phase
Comparison Set Values <-> Measured Values

ACC1 RF phase measured value [deg]
“TTF2.RF/ADC/Cx.ACC1.PROBE/PHASE.TD”

ACC1 RF phase set value [deg]
“TTF2.RF/LLRF.DSP/ACC1.SP_PHASE_REL_BEAM”

Linear fits
Slopes:
- 1.00014 (1.0 nC/bunch)
- 1.00731 (0.8 nC/bunch)
- 1.00200 (1.2 nC/bunch)

- Each symbol: Average of 10 measurements
- Measurements done within 34 min.

1 nC : \( \phi_{\text{set}} = \frac{21.505^\circ - \phi_{\text{meas}}}{1.00014} \)
On crest phase determination
- Dark current -

Dark current phase at '3DBC2' [°]


Maximum at 19.4° (Beam at 25.9°)

ACC1 RF phase [°]

22.Mar.2006:
Very little dark current signal

TOF-measurements at FLASH, Status of Setup/25.Apr.2006/Kollewe
On crest phase determination - Beam -

Toroid '3GUN'

Toroid '10DBC2'

Charge / bunch [nC]

ACC1 RF Phase [°]

Phase at phase mon. [°]

ACC1 RF Phase [°]

ACC1 RF Phase [°]

ACC1 RF Phase [°]

(22.Mar.2006)
On crest phase determination - Beam -

On-crest phase by eye

(minimum energy spread on screen 3DBC2): 31.5°

- Pyro-detector maximum signal ('maximum compression') at 42.5°
Compression coefficients measurement

\[ z = z_0 + R_{56} \delta + T_{566} \delta^2 \]

\[ \delta = \frac{(p - p_0)}{(p_0 + p_{\text{Gun}})} \]

(Design values\(^1\))

\[ R_{56} = -175 \text{ mm} \]
\[ T_{566} = 196 \text{ mm} \]

\(^1\)TESLA-FEL 2002-01
Summary
Purpose, principle and installation reviewed
Influence of different (side-)parameters discussed
Measurements
- On crest determination (beam, dark current)
- Compression coefficients of BC2 measured
- Dark current amount measurements?

Plans
Measurement of accuracy
Improvements (Hardware, DOOCS mid. layer server)
Discussion: what is required?