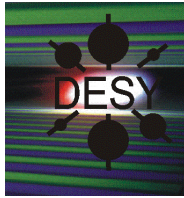
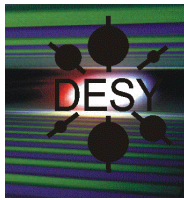


# High-Level Anwendungen (Controls) bei XFEL/FLASH

T. Limberg



- Organisatorisches
- Werkzeuge und Konzepte
- Beispiele

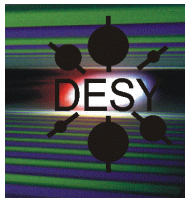


MCS-1  
J. Wilgen

MCS-4  
R. Kammering

MLC verantwortlich  
für HLC: WD, TL

MPY  
S. Meykopff



**FEL Beam Dynamics Group Home Page**

[XFEL lattice files](#)      click in the image to go to the descriptions of the single parts      [List of Components](#)

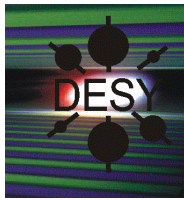
[FLASH lattice files](#)

[view picture to scale](#)

Injector      Bunch Compressor      Main Linac      Collimation Section      Beam Switchyard      Beam Distribution      Beam Distribution

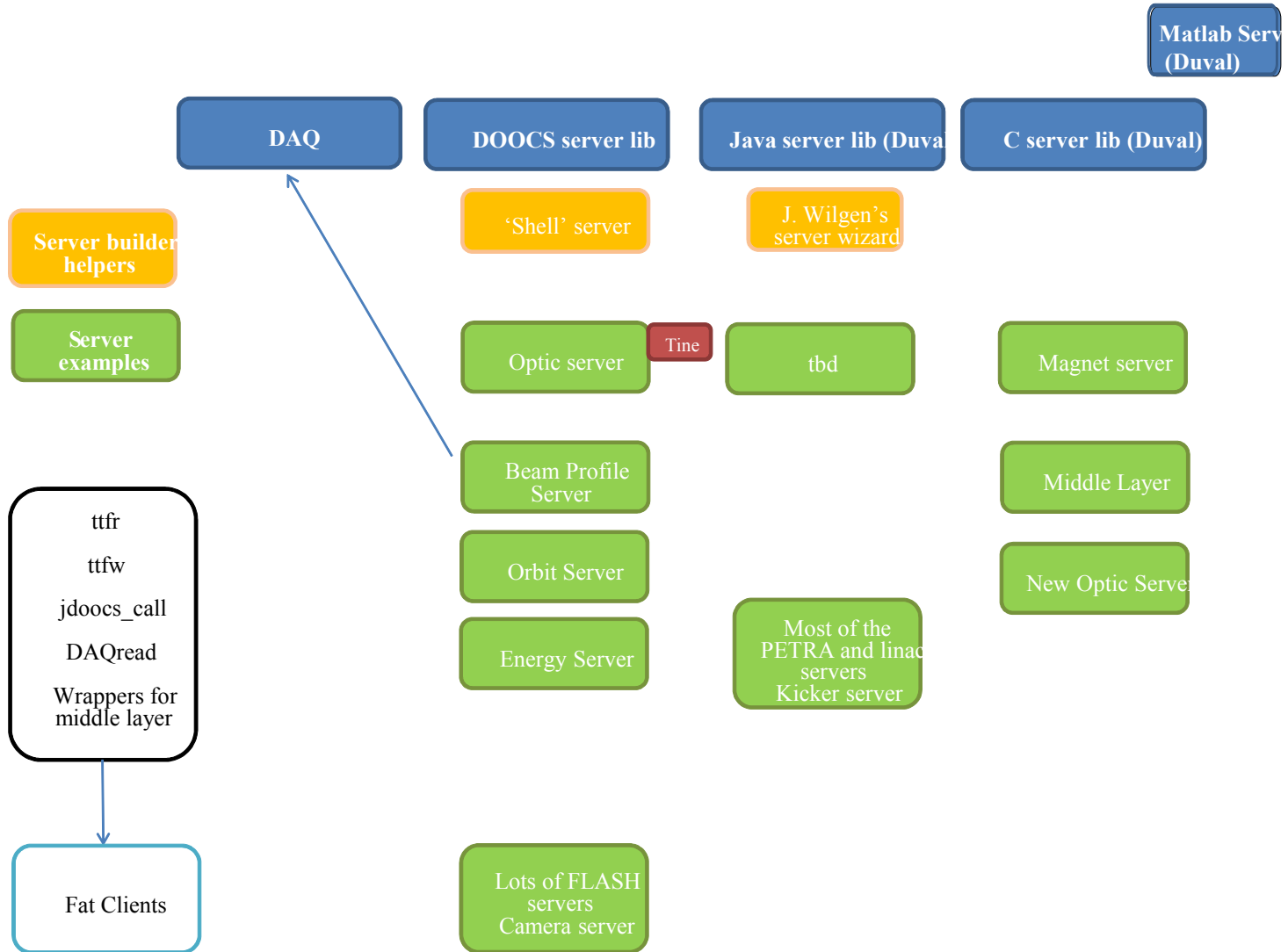
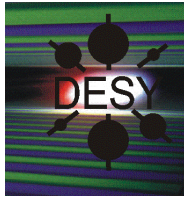
[Talks, Person index, Keyword index](#)      [XFEL WIKI](#)      [Start-to-End Simulations](#)      [Links and Codes](#)      [XFEL Commissioning](#)

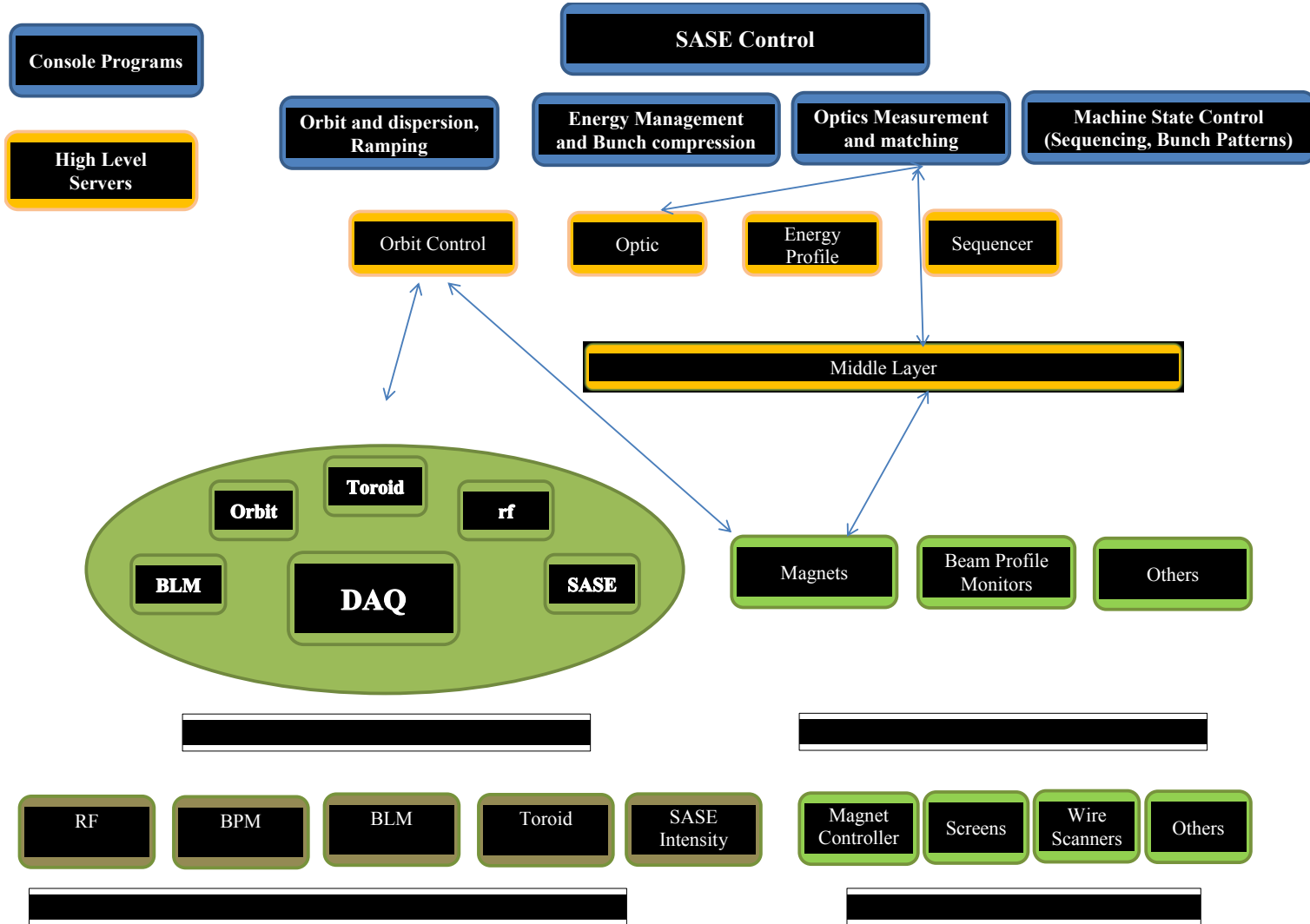
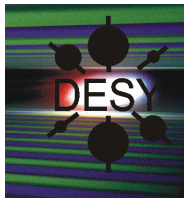
[internal documents](#)

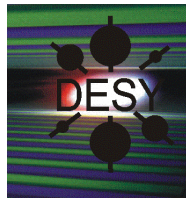


- Oberflächen und Server zur Steuerung von Multikomponenten-Prozessen (z.B. Automatisierte Emittanzmessung)
- Unterstützung automatisierter Maschinenexperimente
- Hi-Level Post-Mortem Analyse

# Was haben wir an Werkzeugen?



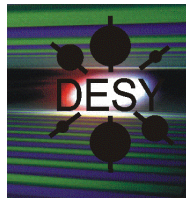




- Produced output data
  - For each BLM and each event, a time series which contains
    - ➔ The current data
    - ➔ A bunch-wise average, RMS, and a peak-hold value over the last N events
  - For each BLM, a summary of the current time series
    - ➔ Average, RMS, maximum and peak-hold of loss rates of bunch current, dark current, and total.
  - For each accelerator section a summary over all contained BLMs
    - ➔ Average, RMS, maximum and peak-hold of loss rates of bunch current, dark current, and total.







**List of Calls:**

- read\_magnets
- set\_magnets
- read\_BPMs
- set\_orbit
- read\_toroids
- read\_BLMs
- get\_beam\_profile
- get\_longitudinal\_profile
- read\_rf
- set\_rf
- set\_energy

**Description of Calls:**

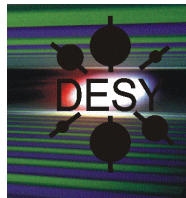
[fields\_and\_currents, status, names, positions, error] =

**read\_magnets (id, further\_specs)**

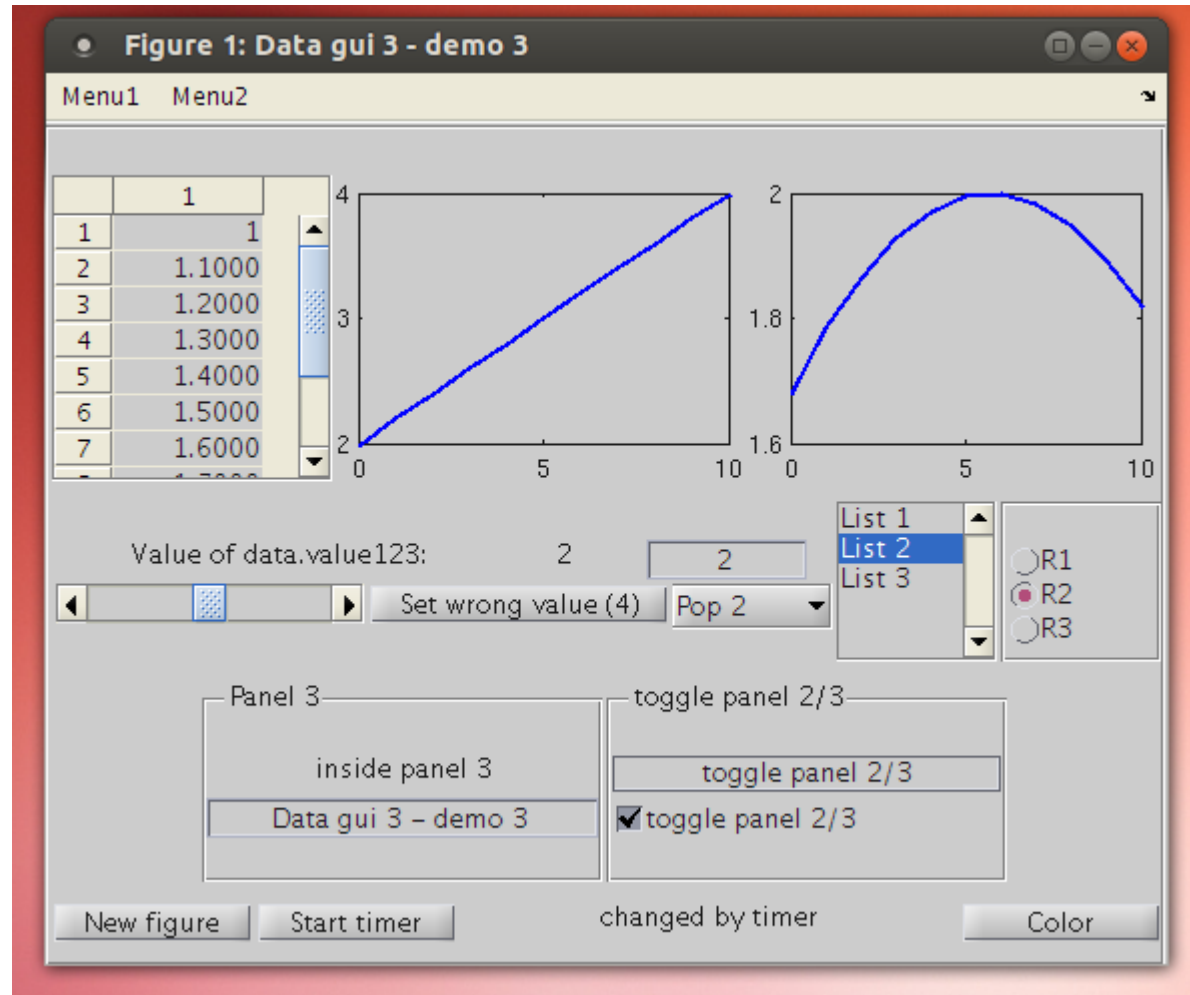
Generic names: 'Quad', 'Bend', 'Sext'

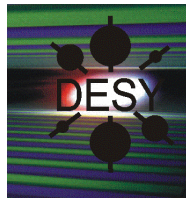
further\_specs:

Name	Type	default	Comment
'ignore_if_off	Logical	1	Does not return switched off magnets



- axes
- checkbox
- edittext
- figure
- listbox
- menuitem
- panel
- popupbox
- pushbutton
- radiogroup
- slider
- statictext
- table
- togglebutton

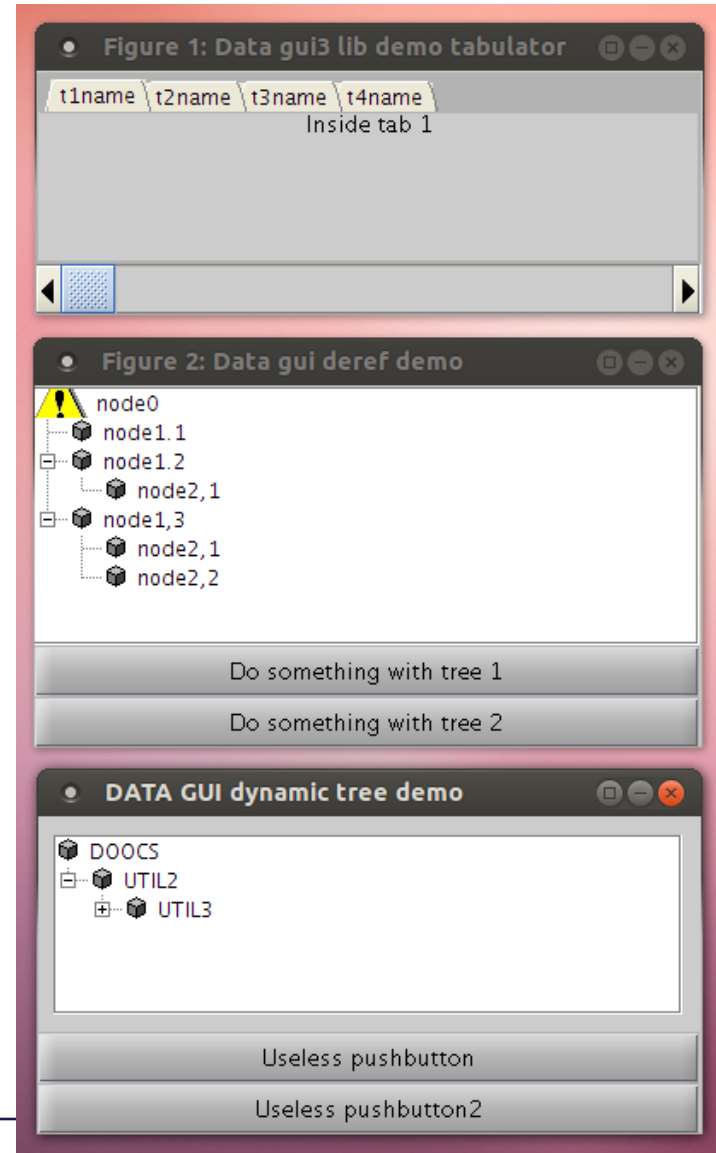




- deref
- timer
- tabgroup
- tree
- treedyn

Special GUI support:

- Continuouse slider
- Mouse wheel /
- Mouse button up/down
- Enter/Leave focus events  
etc.



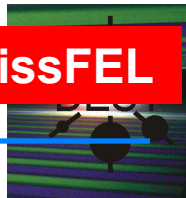


# Matlab Toolbox ADAQA used for Emittance Measurements

*Bolko Beutner, Rasmus Ischebeck*

PSI / DESY / KIT Mini-Workshop on Longitudinal Diagnostics for FELs

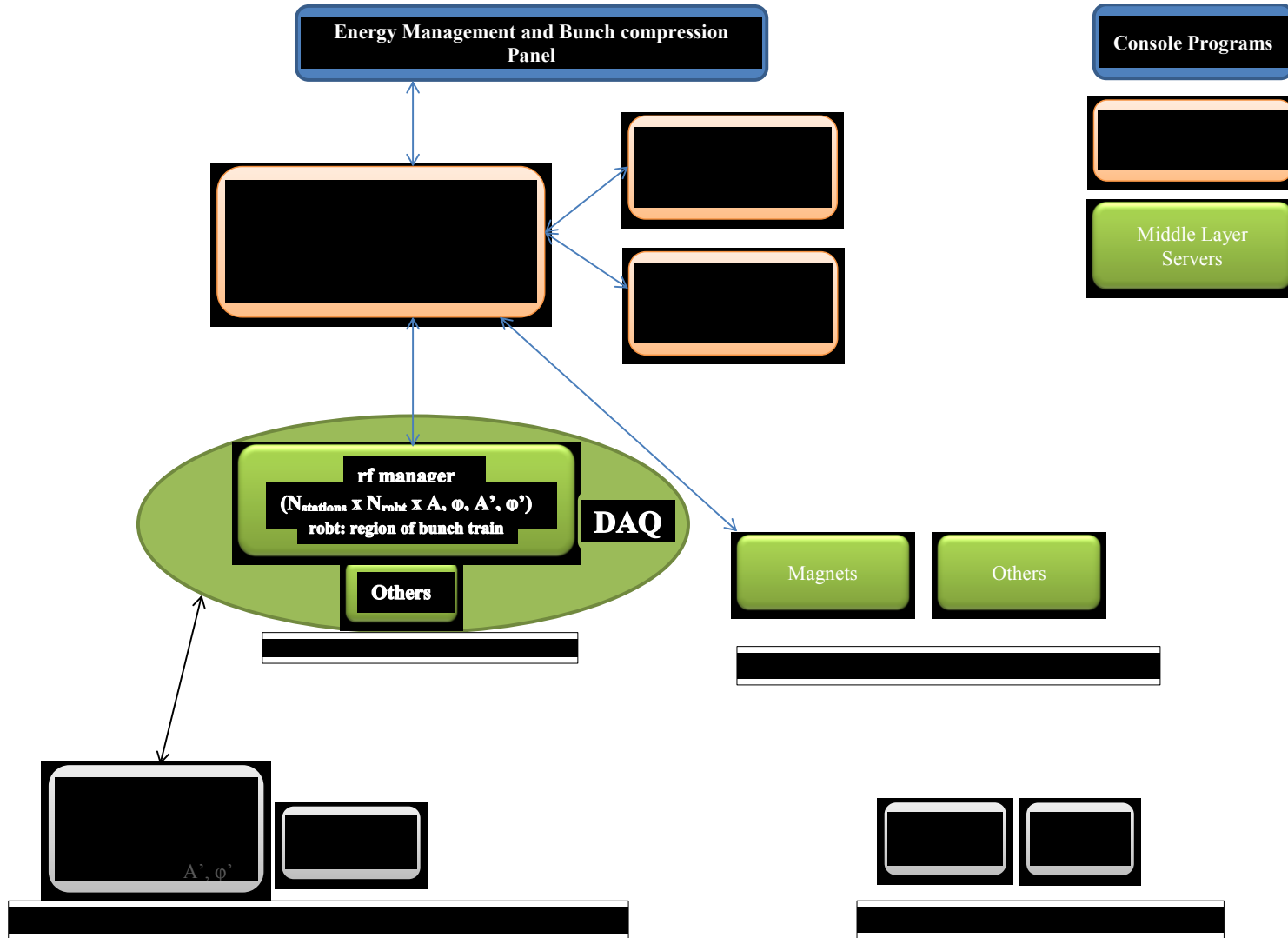
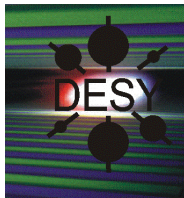
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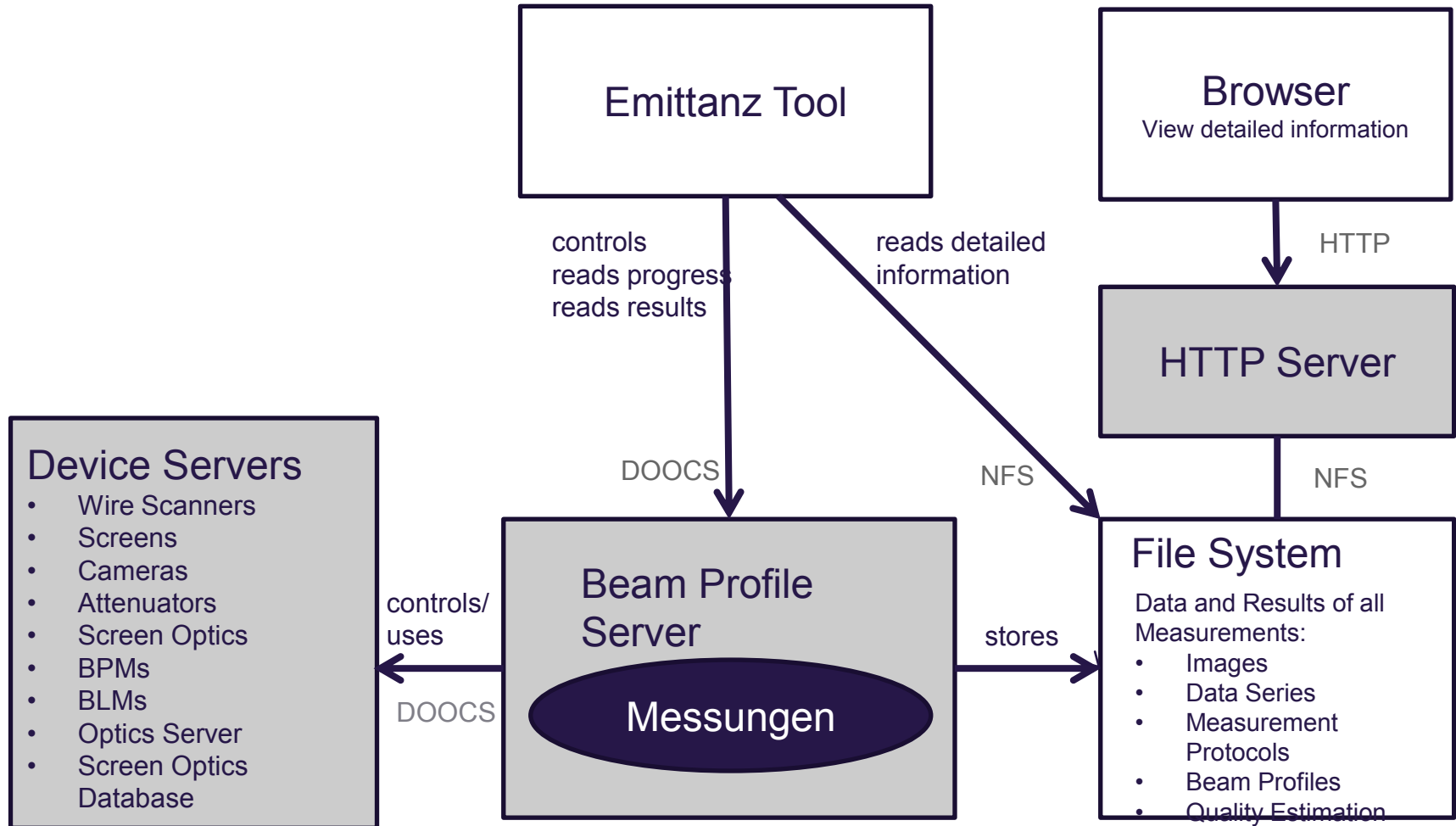
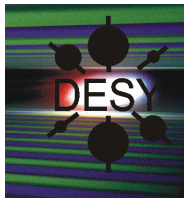


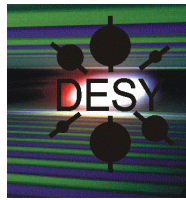
- These measurements need to be automatised for standard operation and commissioning, task are e.g.:
  - moving screens in and out
  - varying quadrupole settings
  - restore initial lattice configuration
- A successful measurement procedure (high level application) needs to be reliable, robust, and usable

**“Always have the operator at the end of the night shift in mind!”**

- Accelerator operation in general relies on data acquisition and parameter scans
- In the various applications the requirements are actually quite similar
  - ⇒ Tasks should be unified and standardised to prevent that every application developer “reinvents the wheel”
  - ⇒ ADAQA - An Accelerator Data Acquisition & Analysis Framework



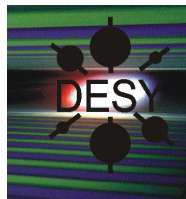




- Das Serverprogram der VME-Creates wurde überarbeitet.
  - Genaue Einmessung von Position und Fahrkurve bei Initialisierung.
  - Dadurch exaktes Anfahren beliebiger Positionen (+- 15um) möglich.
  - Verhalten zuverlässig und reproduzierbar.
  - Erhöhung der Fahrgeschwindigkeit, damit schnelleres Rein- und Rausfahren ermöglicht wird (noch in Arbeit).
  - Erkennbar, wann eine Initialisierung benötigt wird (Flag).
  - Hoffnung: Pro Server-Neustart nur noch einmal initialisieren.
- Bisher gute Erfahrungen/Tests mit neuem Server
  - Zuverlässigkeit wurde deutlich verbessert
  - Kein "Aufhängen" mehr beim Fahren.
  - Kein häufiges Initialisieren mehr nötig
- Einige Probleme werden noch untersucht
  - Einige WS (UND 5 + 6) halten Zielpositionen nicht.
  - Versprochene Max. Fahrgeschwindigkeit nicht erreichbar.
  - Motor bleibt bei vert. Scannern bei Initialisierung manchmal stehen.







Emittance Measurement and Optics Matching (Revision: 48)

View Measurement | New Measurement | Match Optics

	Emittance	alpha	beta	BMAG
horizontal	0.9273	-0.0483	1.7362	2.6123
vertical	0.7250	2.0040	2.9424	1.7575

4DBC2 (66.472um RMS hor)

(69.5465um RMS ver)

6DBC2 (77.2667um RMS hor)

(72.9914um RMS ver)

8DBC2 (127.0973um RMS hor)

(70.1014um RMS ver)

10DBC2 (132.2665um RMS hor)

(111.0323um RMS ver)

hide directory list

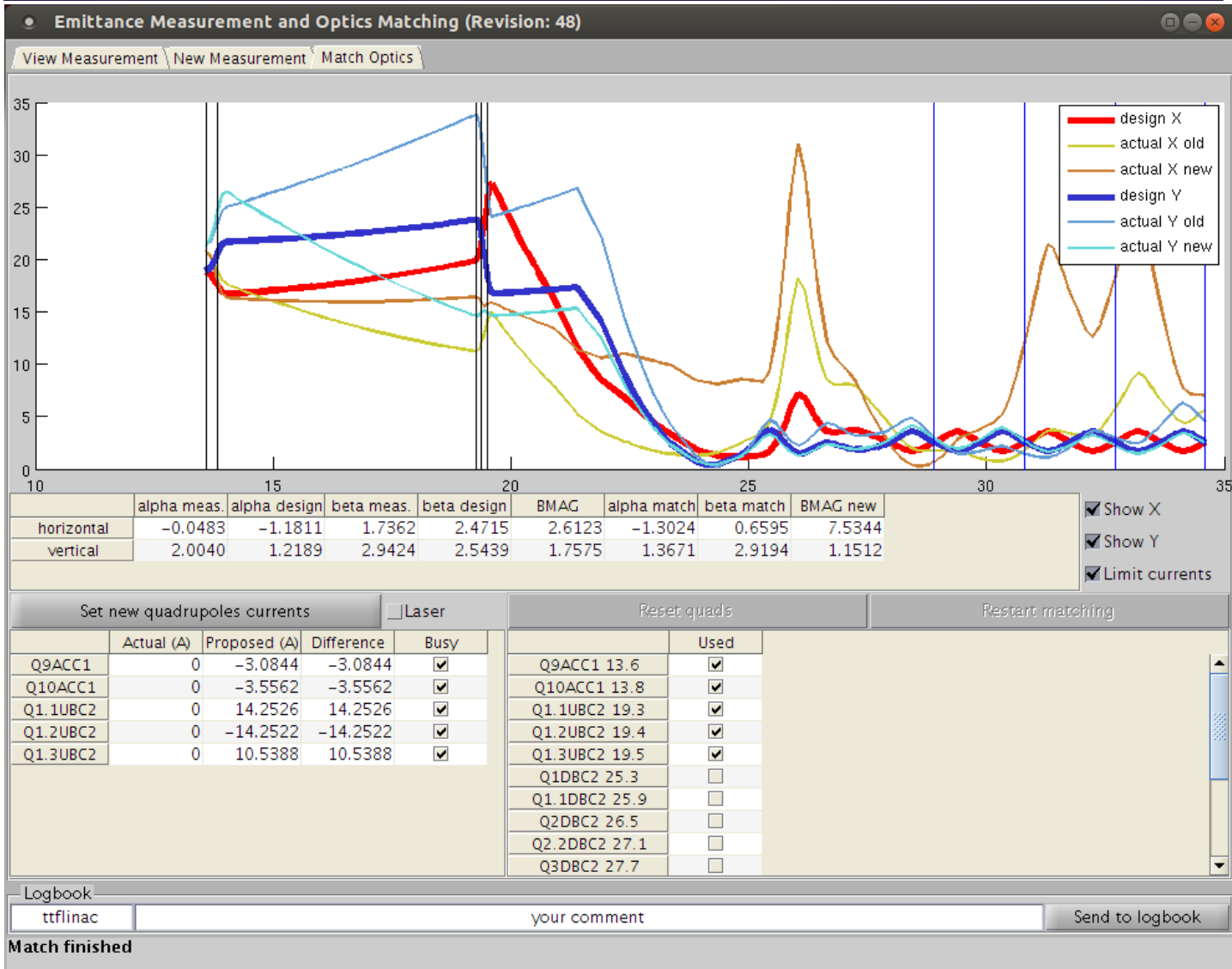
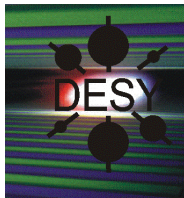
- 2013-03-05T095944-WS.UND2
- 2013-03-05T095911-WS.UND2
- 2013-03-04T160415-WS.VME1
- 2013-03-04T155439-WS.VME1
- 2013-03-04T152900-WS.VME1
- 2013-03-04T145640-WS.VME1
- 2013-03-04T143309-WS.VME1
- 2013-03-04T142228-WS.VME1
- 2013-03-04T131710-WS.VME1
- 2013-03-04T130759-WS.VME1
- 2013-03-04T125301-WS.VME1
- 2013-03-04T123935-WS.VME1
- 2013-03-04T123517-WS.VME1
- 2013-03-04T122753-WS.VME1
- 2013-03-04T122033-WS.VME1
- 2013-01-11T183539-OTR.DBC2
- 2013-01-11T183341-OTR.DBC2
- 2013-01-11T181227-OTR.DBC2
- 2013-01-10T153023-OTR.ORS
- 2013-01-10T152748-OTR.ORS
- 2013-01-10T152541-OTR.ORS
- 2013-01-10T152343-OTR.ORS
- 2013-01-05T120812-WS.SFUND
- 2012-12-21T083111-WS.UND
- 2012-12-21T083037-WS.UND
- 2012-12-04T203127-OTR.SFUND
- 2012-12-04T202517-OTR.SFUND
- 2012-12-04T201938-OTR.SFUND
- 2012-12-04T195644-OTR.SFUND
- 2012-12-04T194748-WS.UND4
- 2012-12-04T194031-WS.UND2
- 2012-12-04T191318-WS.UND1
- 2012-12-04T185457-WS.UND
- 2012-12-04T184351-WS.UND
- 2012-12-04T184244-WS.UND
- 2012-11-28T003050-WS.UND
- 2012-11-28T002239-OTR.DBC2
- 2012-11-27T233323-WS.UND
- 2012-11-27T232550-WS.UND2

Optics Server (TTF2.UTIL/OPTIC/THEOR/)  
med\_sharp\_FEL\_0700

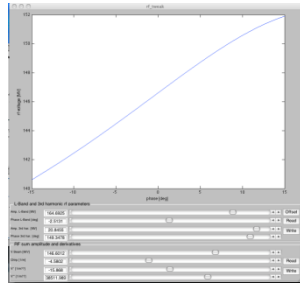
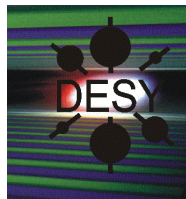
Logbook  
ttflinac      your comment      Send

Using 2013-01-11T183539-OTR.DBC2 with 4 devices; Energy: 693.8823

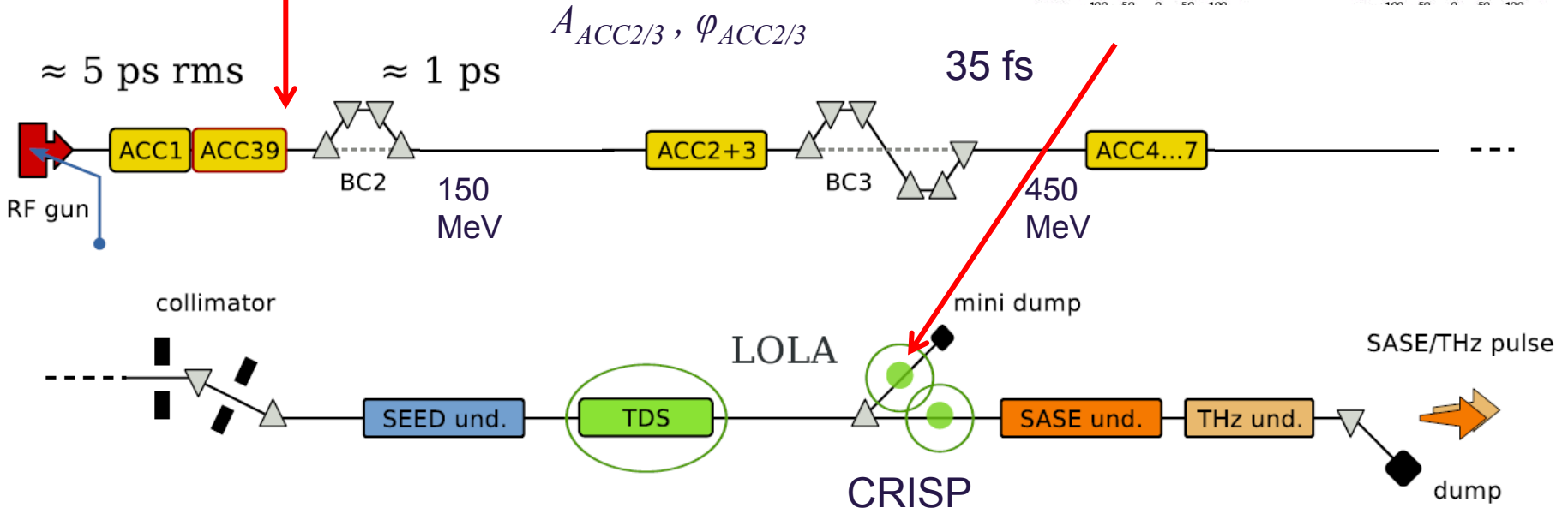
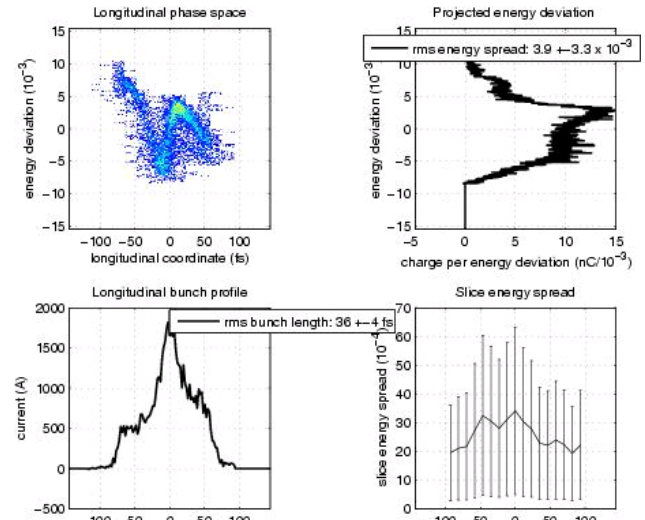
# Emittanzmessung: Optik einstellen

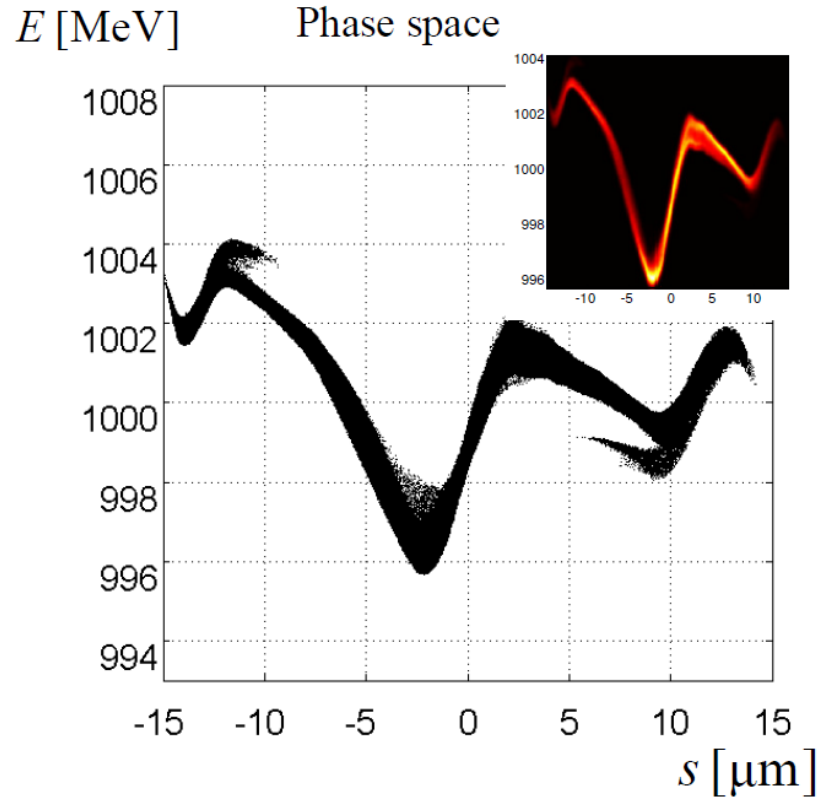
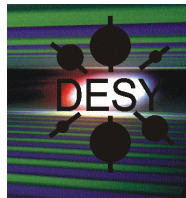


# FLASH Bunch Compression Scheme



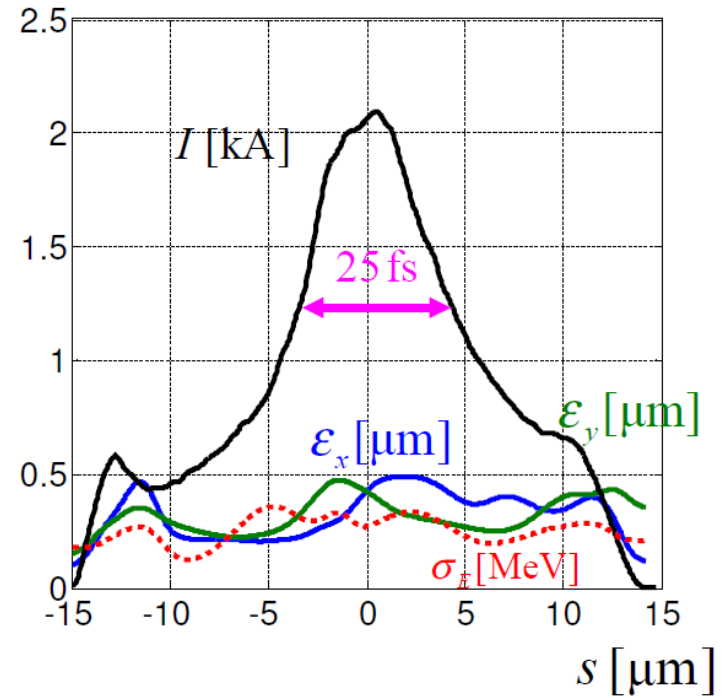
$$\begin{bmatrix} \text{BeamEnergy} \\ \text{Chirp } (V_{sum}^{\prime}) \\ V_{sum}^{\prime\prime} \\ V_{sum}^{\prime\prime\prime} \end{bmatrix} = F(A_{ACC1}, \varphi_{ACC1}, A_{ACC39}, \varphi_{ACC39})$$





bunch head

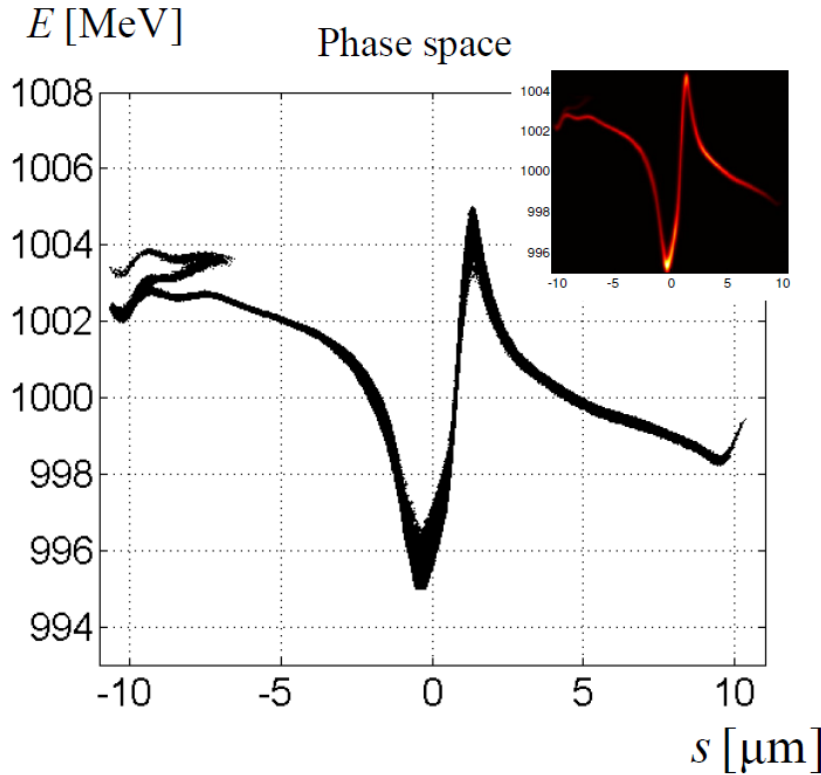
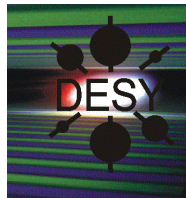
Current, emittance, energy spread



$$\epsilon_x^{proj} = 2 \text{ [}\mu\text{m]}$$

$$\epsilon_y^{proj} = 0.6 \text{ [}\mu\text{m]}$$

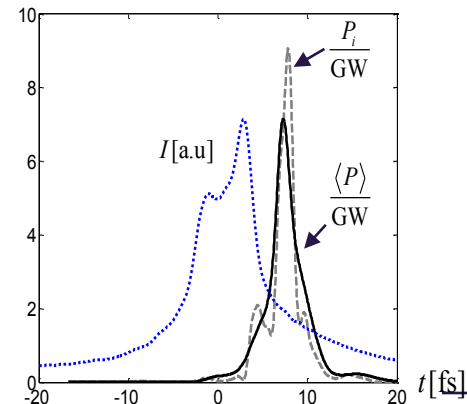
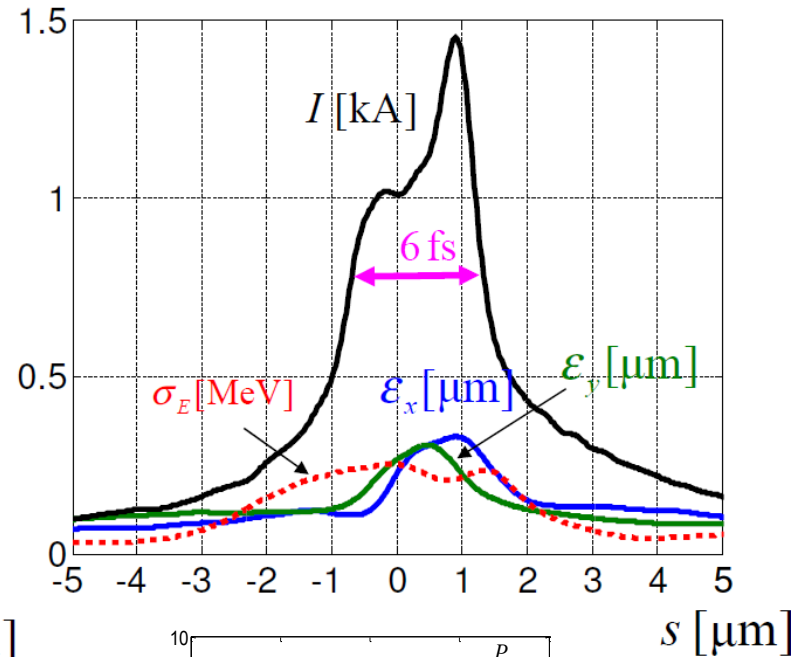
Photon Pulse Length (FWHM) : 7 fs



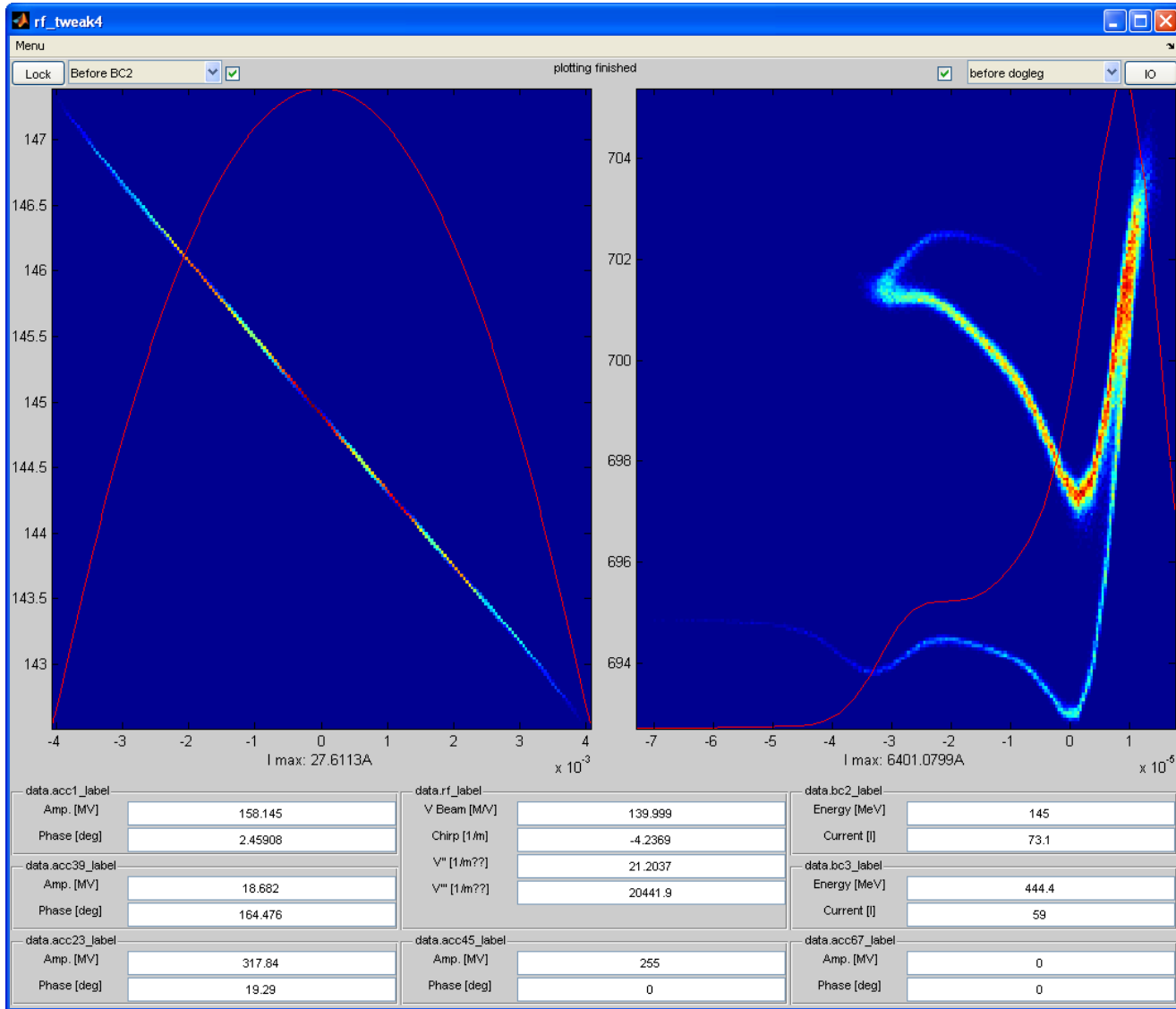
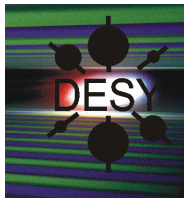
bunch head

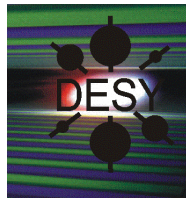
Photon Pulse Length (FWHM) : 2 fs

Current, emittance, energy spread

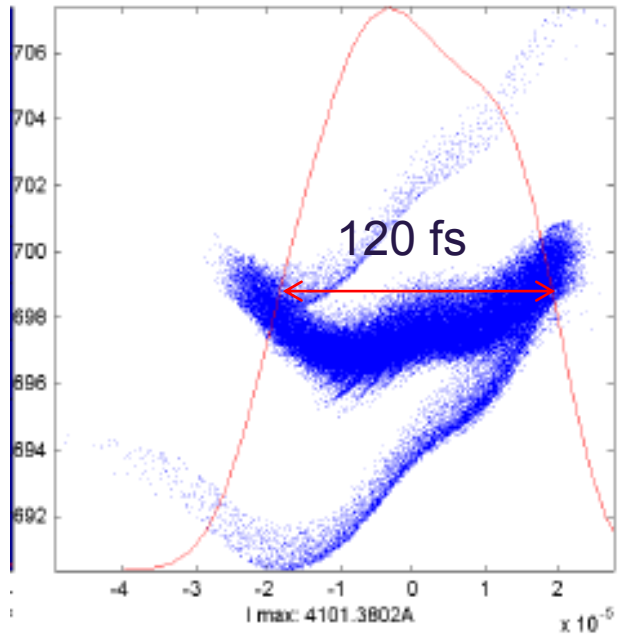


# Fast Model for longitudinal Phase Space

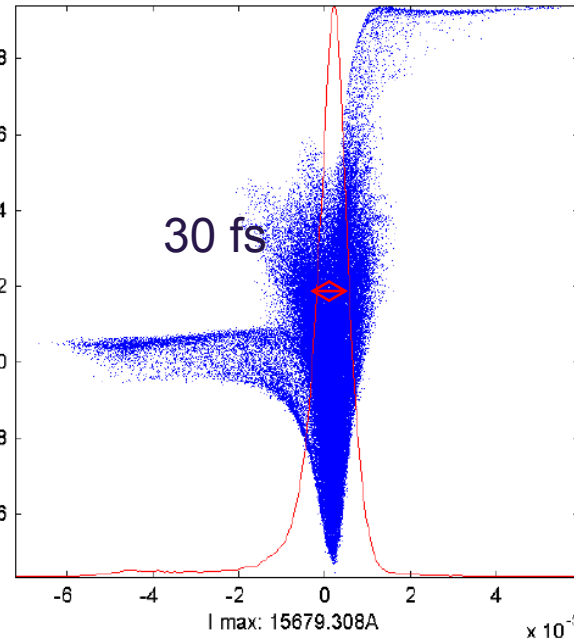




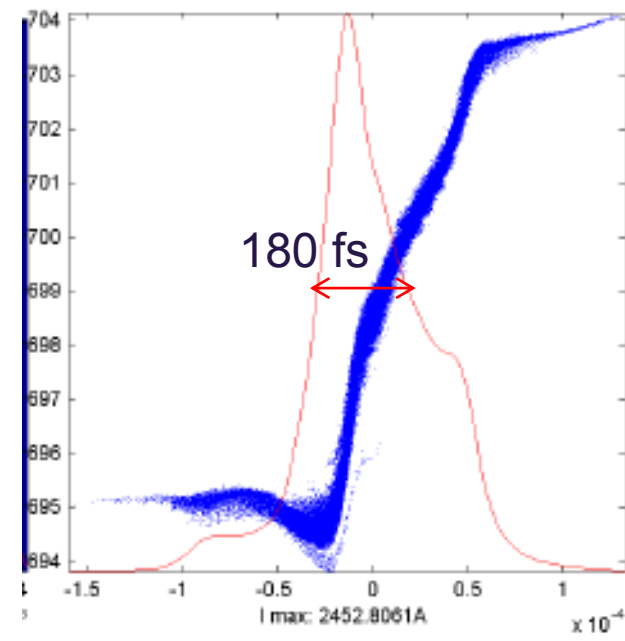
Minimum bunch length limited by non-linearities



ACC1-Phase: 2.51 deg



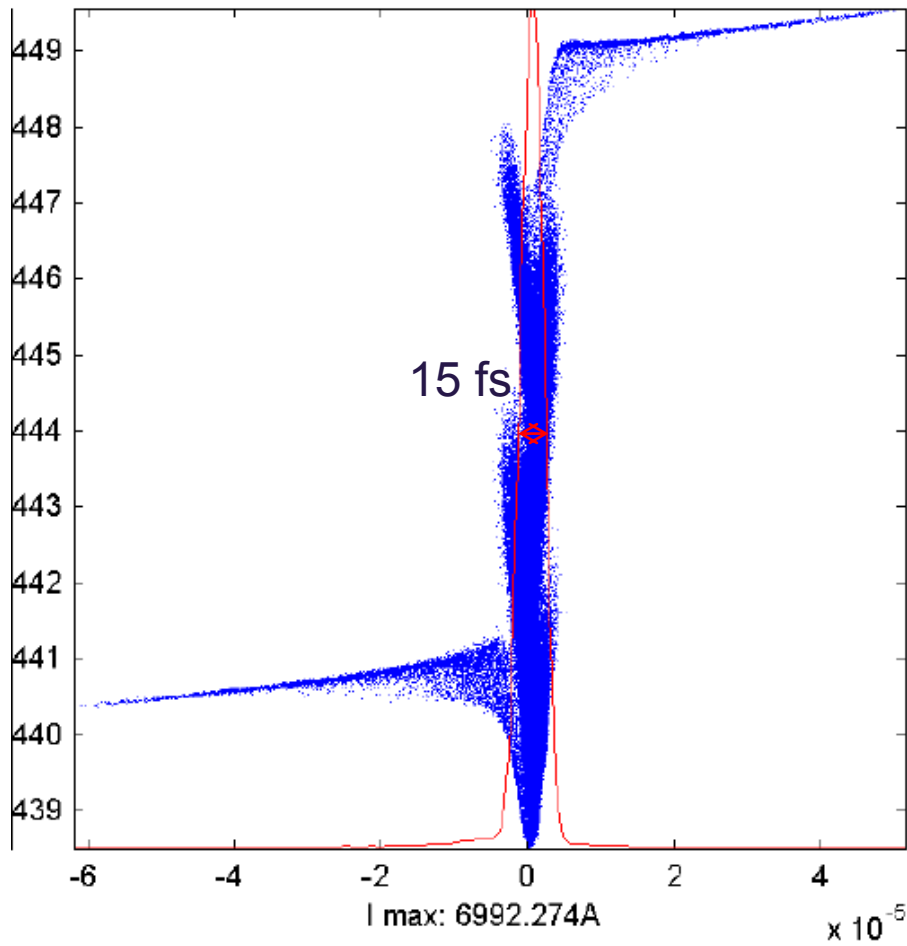
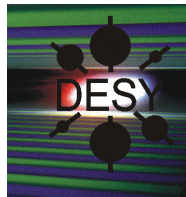
ACC1-Phase: 2.6 deg

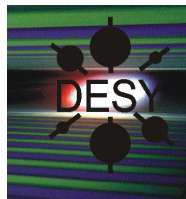


ACC1-Phase: 2.8 deg

Stability and Tuning Issue

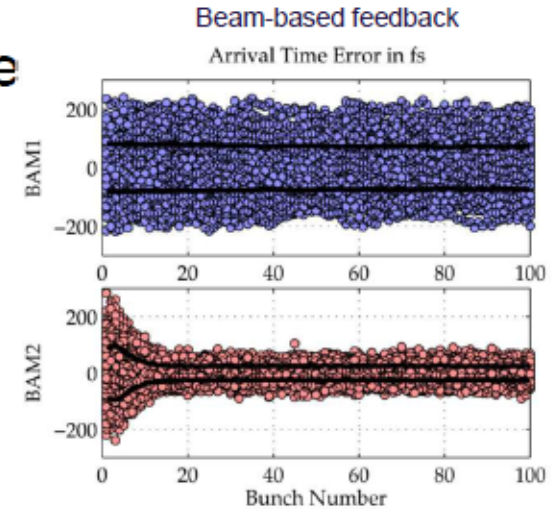
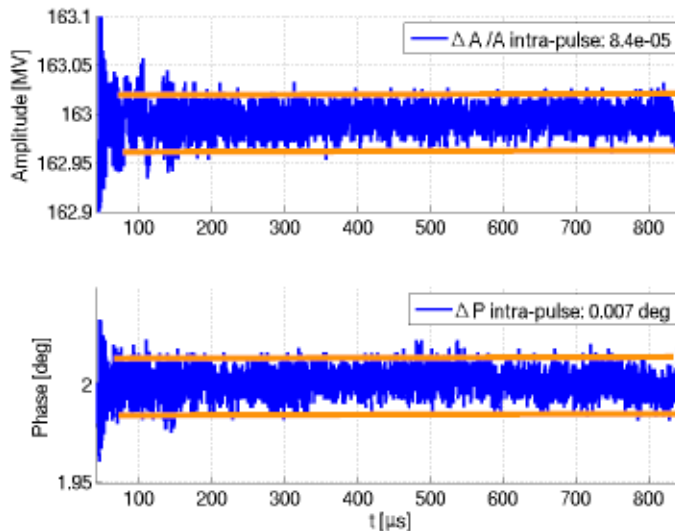


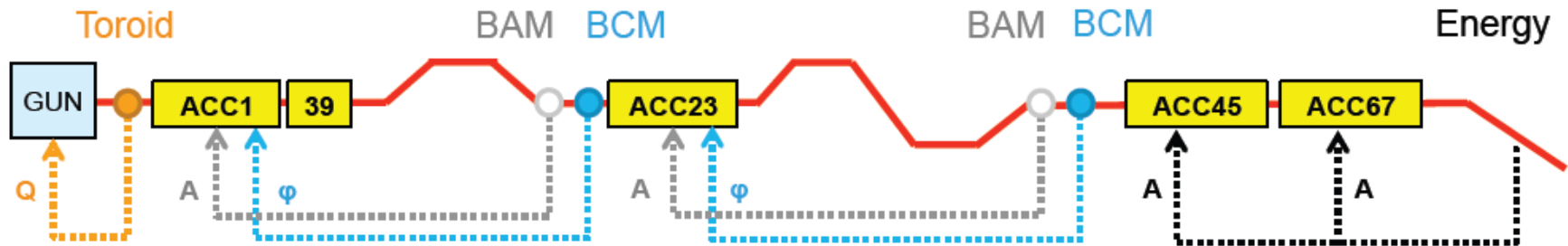
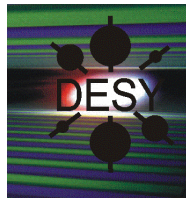




■ Improvement of LLRF control performance

- Beam-based feedback (tested at FLASH)
  - factor of 3 improvement in arrival time jitter
- Cavity fundamental modes (tested at FLASH)
  - detection & filtering of  $8\pi/9$  and  $7\pi/9$  modes
- $\Delta A/A < 9 \times 10^{-5}$  ,  $\Delta\phi < 0.008$  deg. achieved

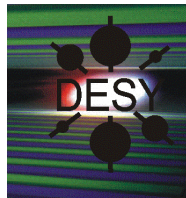




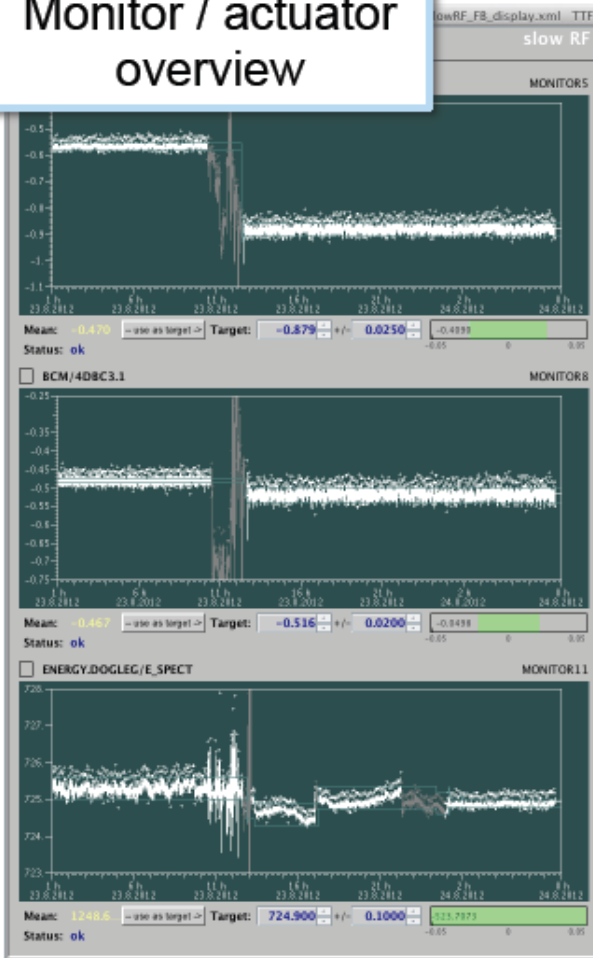
- > PI controller, running up to 10 Hz
- > DAQ attached DOOCS middle layer server
- > Designed to run full coupled RM
- > High flexibility in choice of monitors/actuators
- > Robust operator interface
- > Designed to be well scalable for XFEL needs

$$\begin{pmatrix} SP_{Acc1} \\ SP_{Acc2} \\ SP_{Acc3} \\ SP_{Acc4} \\ SP_{Acc5} \\ SP_{Acc6} \\ SP_{Acc7} \end{pmatrix} = \begin{pmatrix} K_{11} & K_{21} & \dots & \dots & K_{n1} \\ & \ddots & & & \\ & & \ddots & & \\ & & & 0 & \vdots \\ & & & & K_{n0} \\ & & & & K_{n10} \end{pmatrix} \begin{pmatrix} BAM_{Acc1} \\ BAM_{Acc2} \\ BCM_{Acc2} \\ BCM_{Acc3} \\ E_{Dipole} \end{pmatrix}$$





Monitor / actuator  
overview



slow RF Feedback control panel

FB on/off

FB gain: 0.400

BC2\_BCM: Active monitor: 506C2.2 (antenna)

BC2\_EAM: Active monitor: 108C2

BC3\_BCM: Active monitor: 408C3.1 (free)

BC3\_EAM: Active monitor: 408C3

ENERGY: Active actuator: ACC\_45

CHARGE: Active monitor:

Operator panel

slow RF Feedback expert panel

General Server Monitors Actuators RM settings

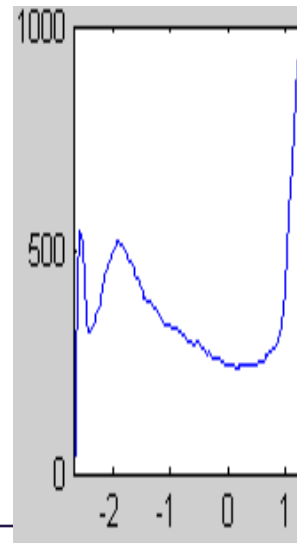
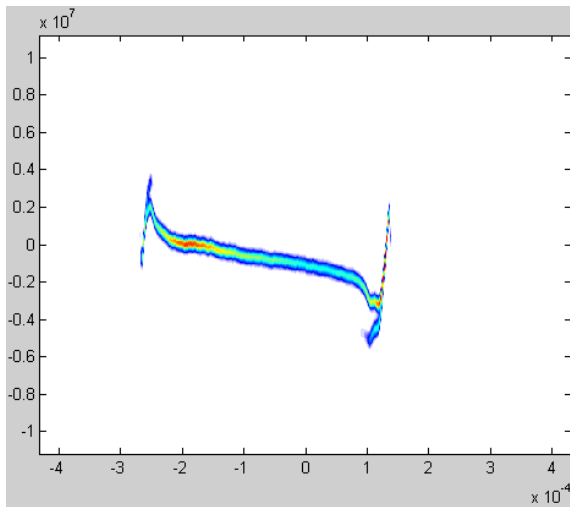
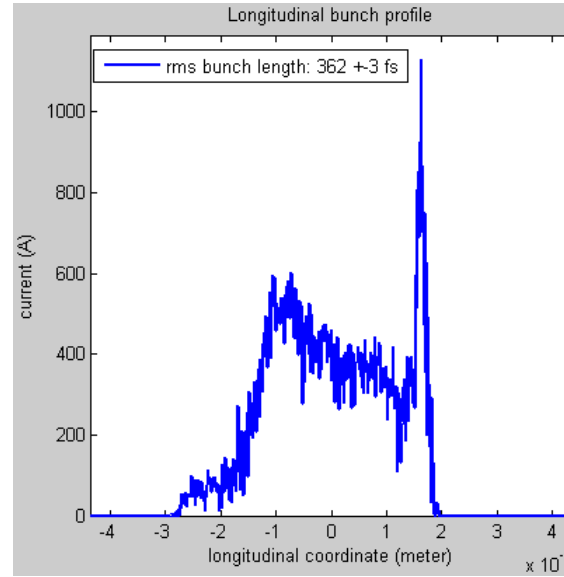
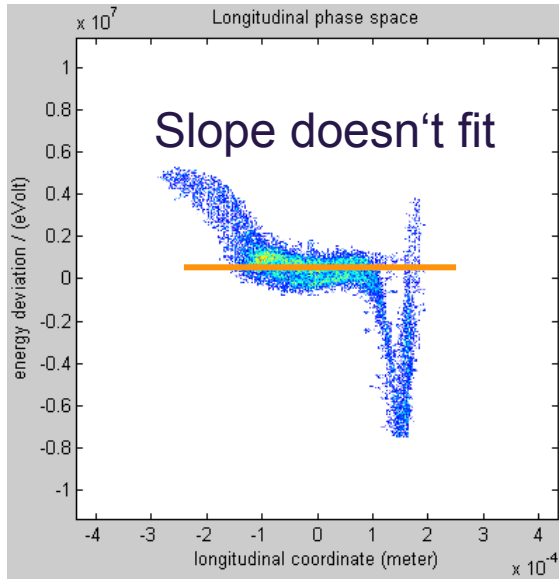
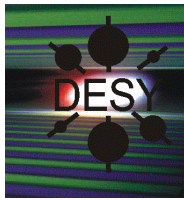
RM file: home/ftf/linac/respMatrix/slowRF\_FB/2013-01-25T214250-SFLASH\_fin\_...  
Last loaded at: 13:21:43 31.01.2013

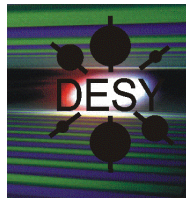
	Laser	F <sub>ACC1</sub>	F <sub>ACC2</sub>	F <sub>ACC3</sub>	F <sub>ACC4</sub>	F <sub>ACC5</sub>	F <sub>ACC6</sub>	F <sub>ACC7</sub>	F <sub>ACC8</sub>	F <sub>ACC9</sub>	F <sub>ACC10</sub>	F <sub>ACC11</sub>	F <sub>ACC12</sub>
I <sub>1</sub>	1.0000E-6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
I <sub>2</sub>	1.0000E-6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BAM10E2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BAM10E3	0.0000	-4.2550	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BCM10E2	0.0000	0.0000	-0.4246	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BCM10E3	0.0000	0.0000	-0.0641	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BAM11A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.4763	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
BAM11B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0373	0.0000	0.0000	0.0000	0.0000	0.0000
BAM11C	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Energy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.1388	0.0000

Expert panel

SVD cut off: 1.00E-14 Used singular values: 6

Expert / configuration panel



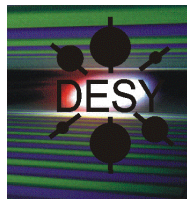


# Tuning and characterization of short electron and FEL radiation pulses at FLASH during shifts 19(a)-21(m).01.2011

E. Schneidmiller and M. Yurkov (SASE & MCP)

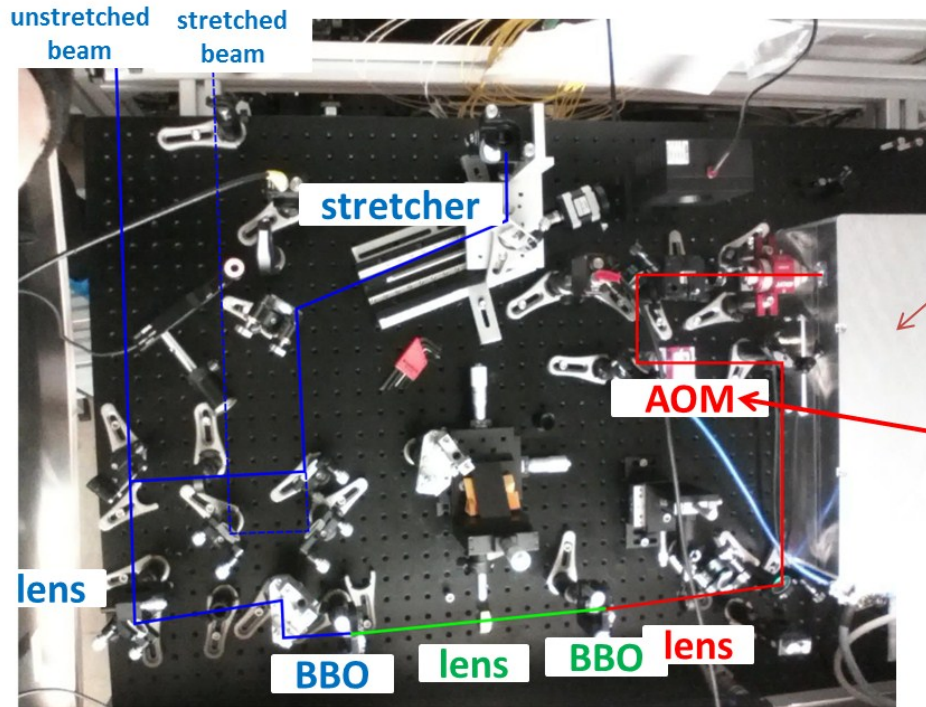
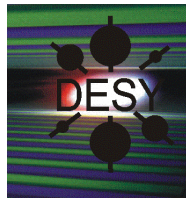
C. Behrens, W. Decking, H. Delsim , T. Limberg, R. Kammering (rf & LOLA)

N. Guerassimova and R. Treusch (PGM & GMD)



	FEL Pulse duration in fs (FWHM)			
	0.5 nC	0.25 nC	0.15 nC	
Statistical method	100		35-40	
THz streak		50 – 70		Preliminary estimate
Spectrometer	100		20	20/-/3-4 spikes
Afterburner	170–200		25-70	FROG resolution 25 fs
	Estimate from electron pulse (FWHM, e <sup>-</sup> length / 2)			
Coherent radiation			50	
LOLA	150	50 – 70	35	

- > In general good agreement for the short pulses - within a factor of 2
- > Larger uncertainties for longer pulses



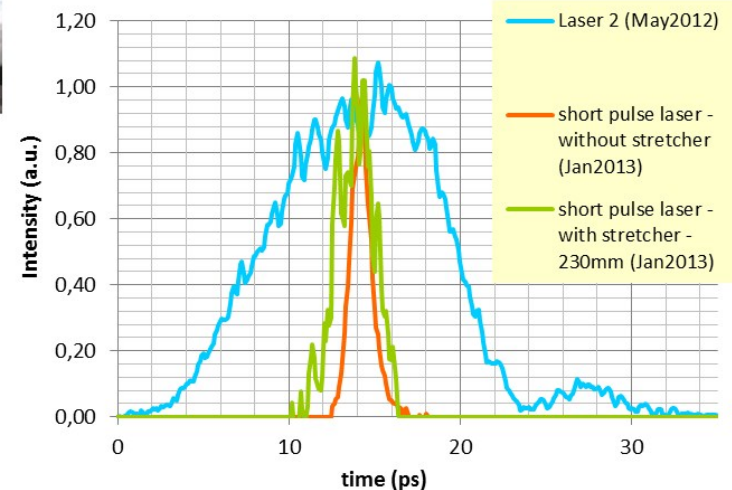
**Amplified Laser System:**

- Seed laser Origami 10 (OneFive)
  - 1030nm, 260mW, 54MHz, 400fs
- 2 stage amplifier (Amphos)
  - 1030nm, 10W, 1MHz, 800fs (10 $\mu$ J)

**AOM pulse picker (1MHz to 10Hz)  
- allows pulse train operation**

- 2 BBOs (forth harmonic)**
- 1030nm -> 257.5nm
  - (10% efficiency @ 10 $\mu$ J) -> 1 $\mu$ J

**Streak camera measurement**

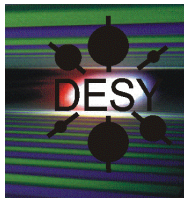


**Supported by BMBF under contract  
05K10GU2 & FS FLASH 301**

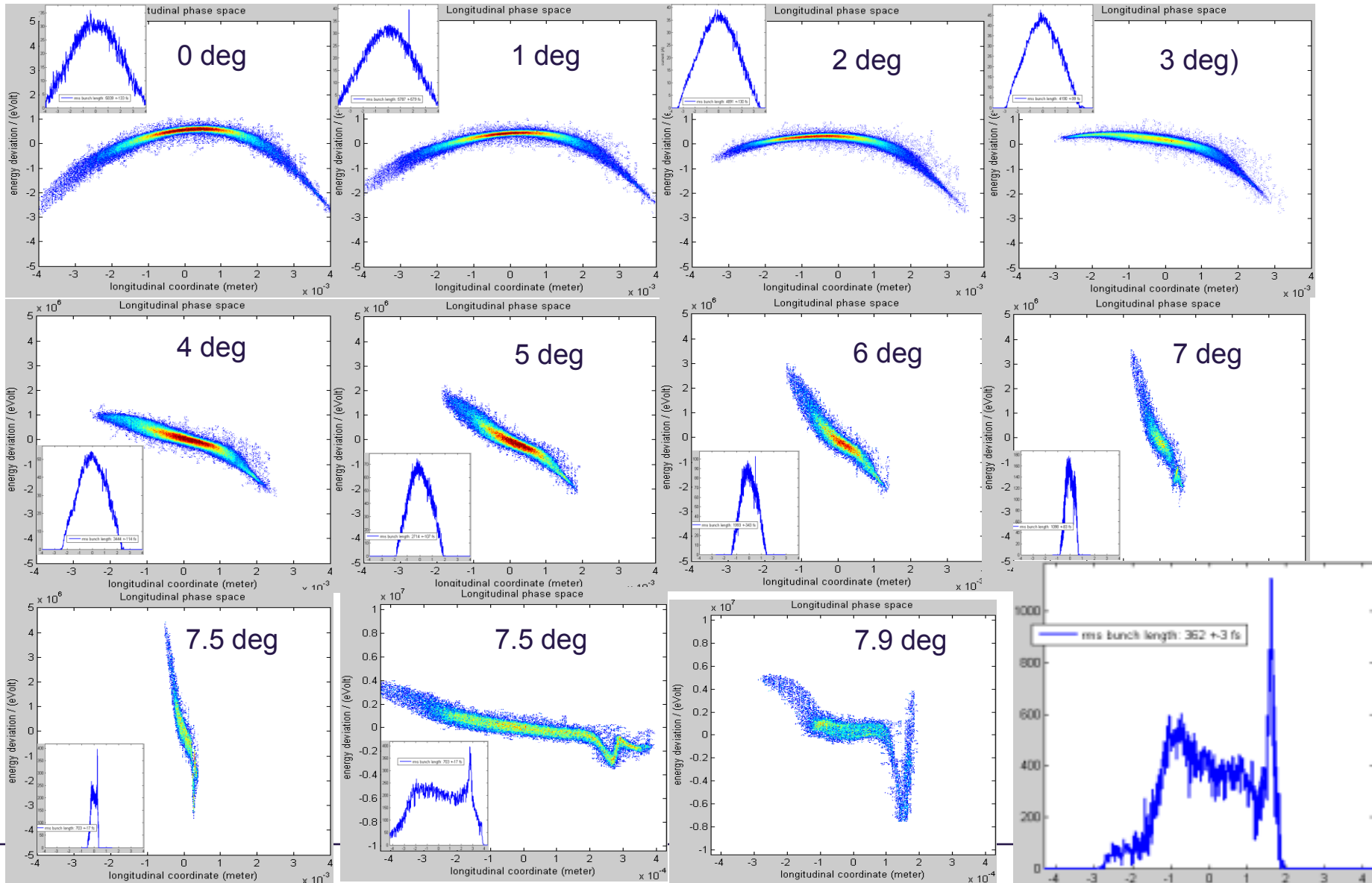
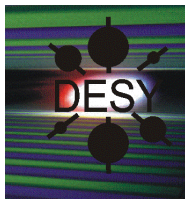


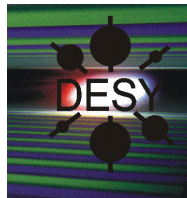
Danke für's Zuhören!





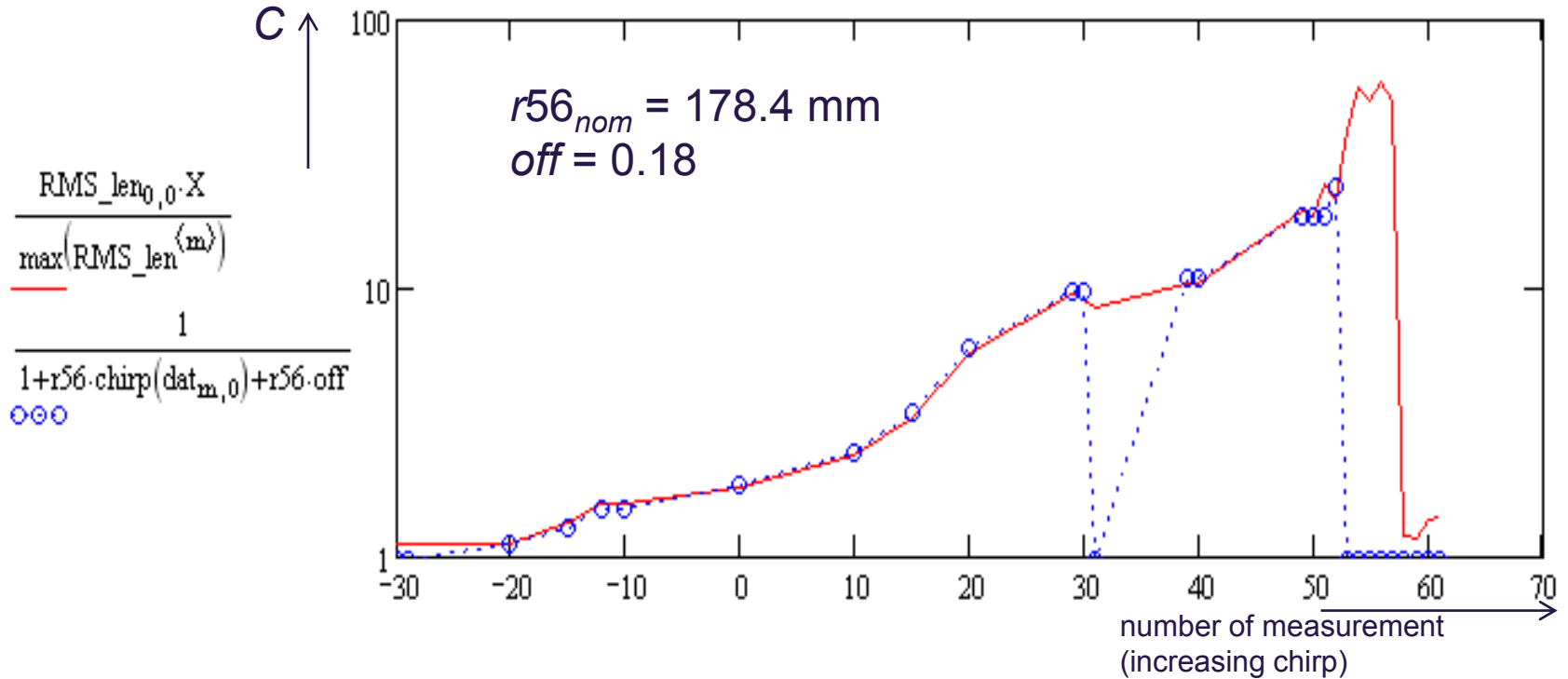
- The tools and methods to tune bunch length exist and have passed first tests
- Extensive feedback from users about photon beam quality is important
- An on-line photon pulse length and pulse shape measurement would be of great help

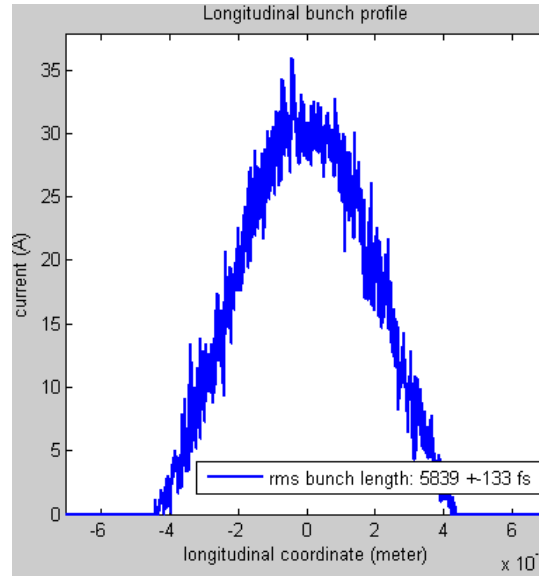
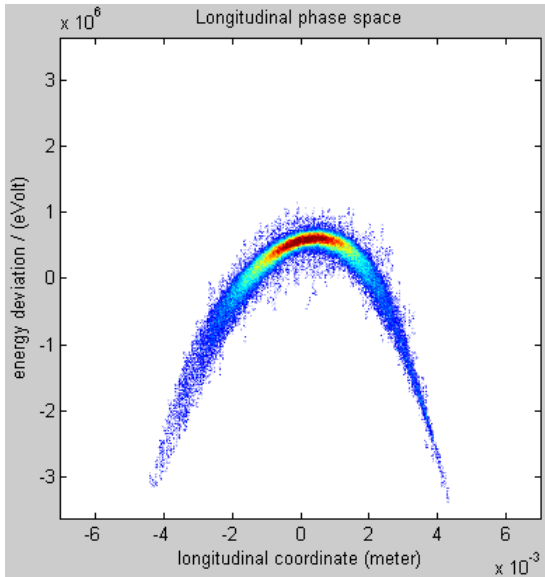
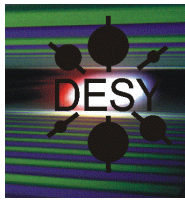




Small additional chirp and 10% correction of LOLA energy calibration:

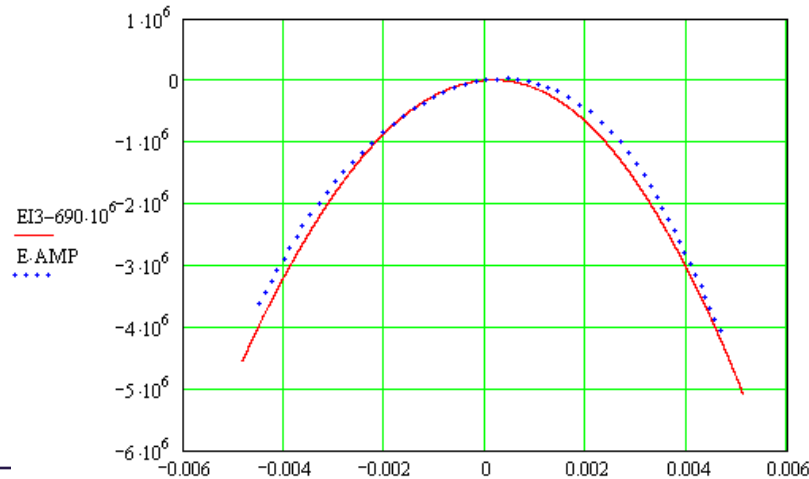
M. Dohlus

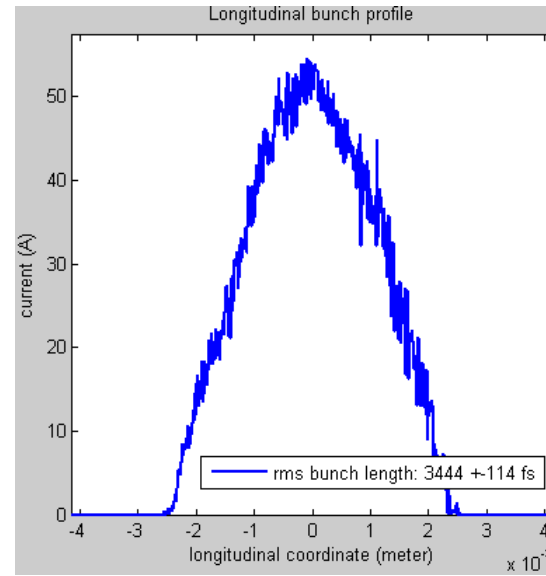
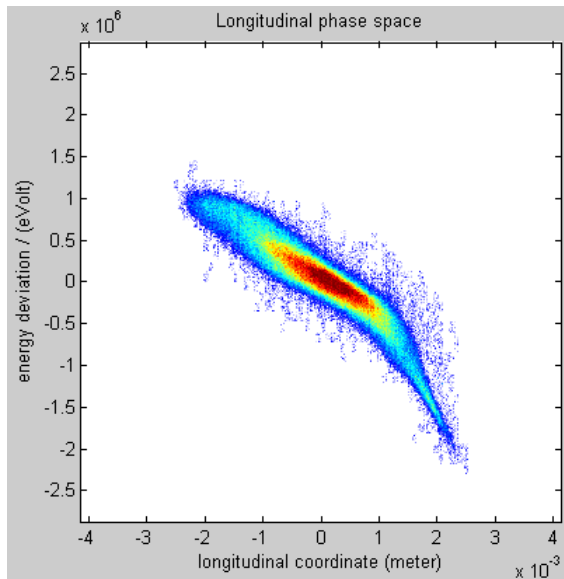
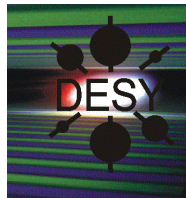




name\_ = "shape\_INI250\_multi\_S\_2p856\_JMD\_07\_loop.dat"

AMP := 1.25      PPP<sub>mess</sub> = -0.1      s\_scale<sub>mess</sub> = 1.146



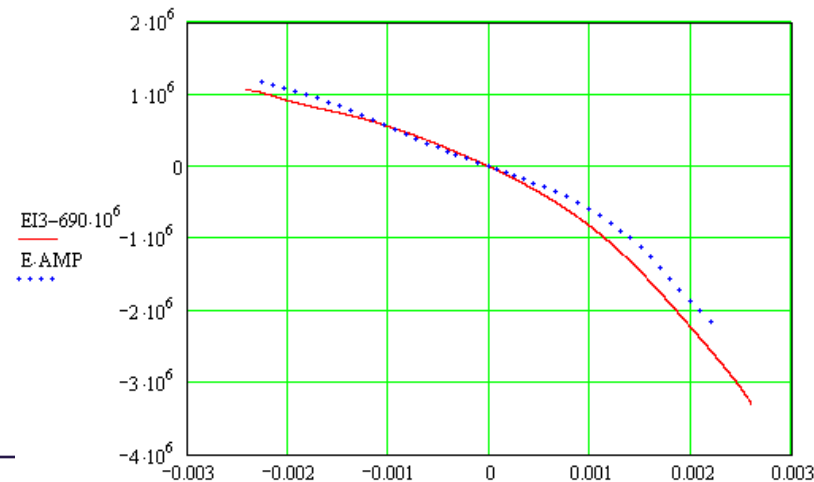


name\_ = "shape\_INI250\_multi\_S\_2p856\_JMD\_07\_loop.dat"

AMP = 1.25

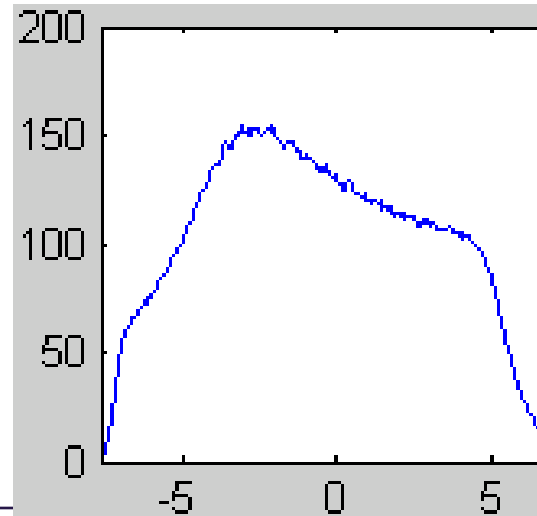
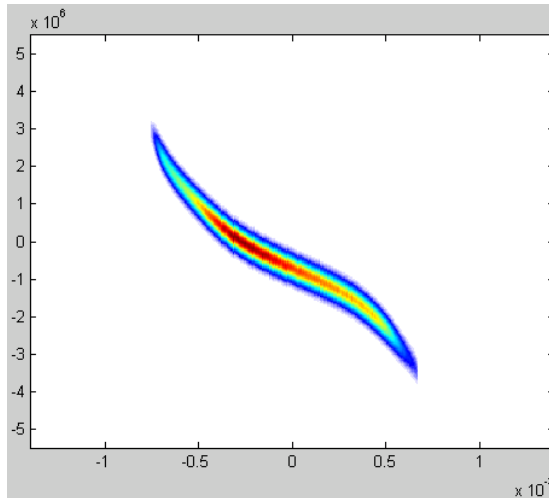
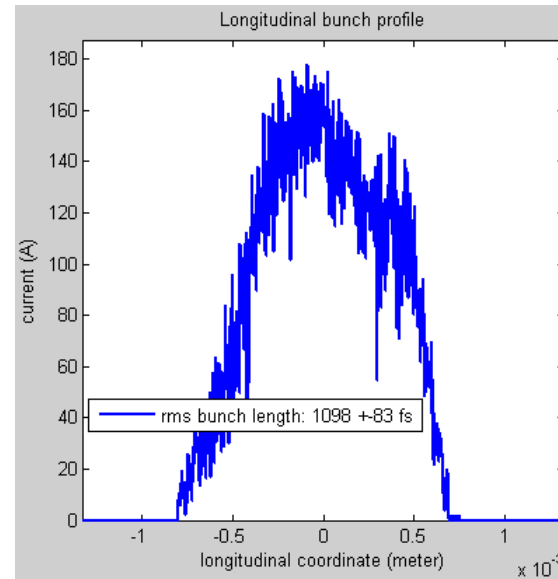
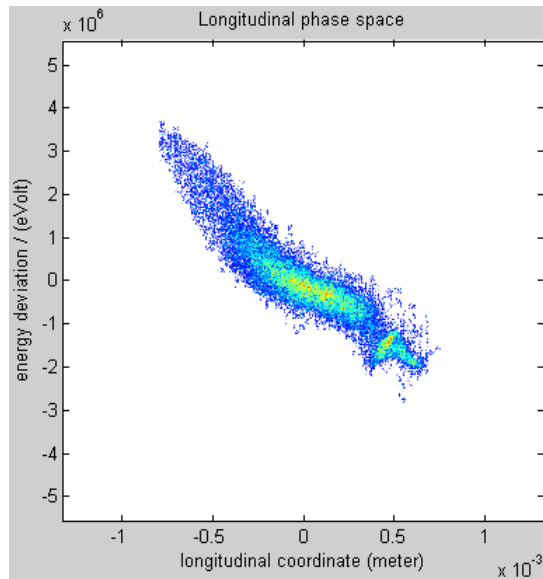
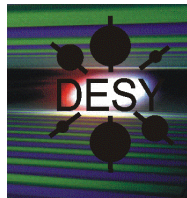
PPP<sub>mess</sub> = -0.1

s\_scale<sub>mess</sub> = 0.979



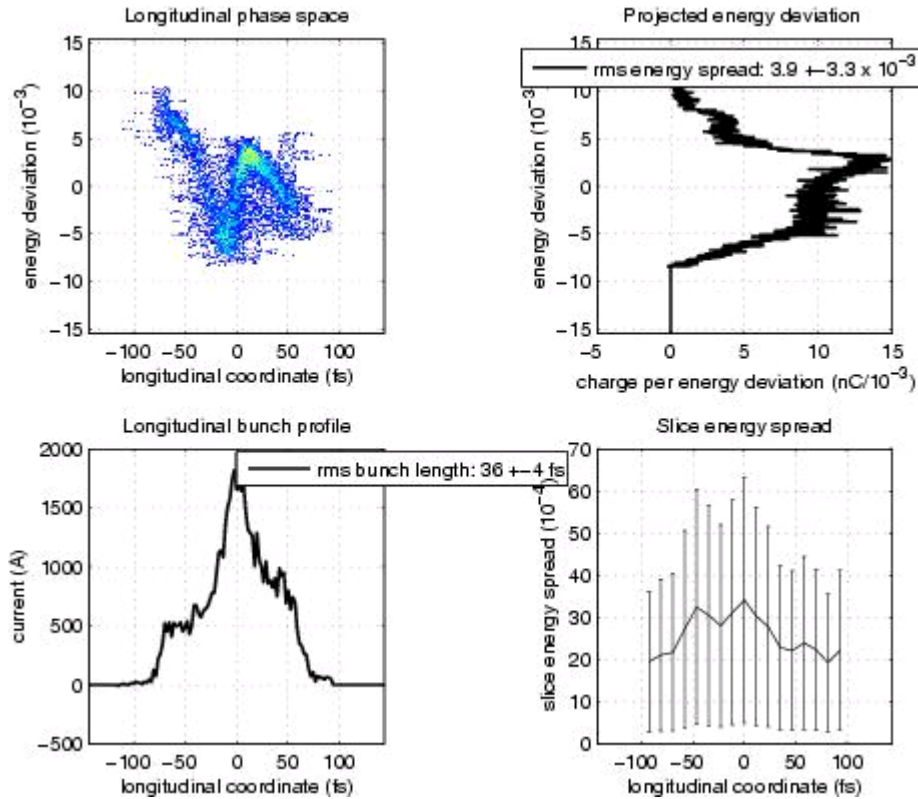
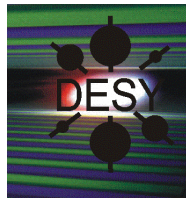
No self-effects

# Compressed to ca. 150 A

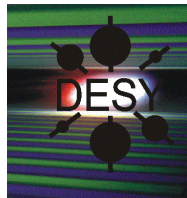


With self-effects

# Bunch-Length-Tuning (differential): 150 pC



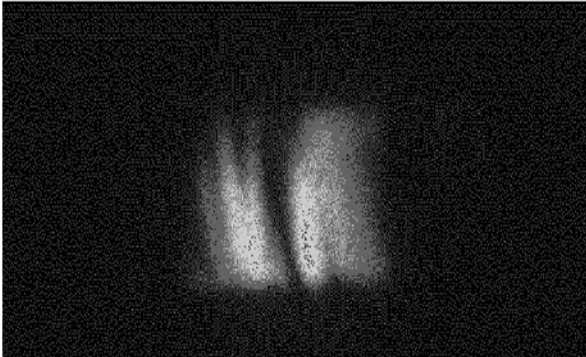




- Statistical measurements agree qualitatively with spectral measurements .
- 150 pC                      sigma = 60%                      M = 2.8                      T\_rad ~ 15 fs (+10 fs + 7 fs)

Info: Online      TCP: disconnected      Camera: 0      **Shutdown**

XYE array length = 4796, X dis. = 4796, Y dis. = 1, X off. = 147840239, Y off. = 0, option = 1



Exposure: 0.02

Gain: 190

X HBIN: 1  
first: 805    last: 1504

Y VBIN: 1  
first: 201    last: 404

SND:  Trigger

Acq: Single Scan  
Trigger: External  
Mode: Image  
CCD ID: DH740\_18nm

Temperature: Set -10    Act.t -8.1    C  
Cooler Stabilized at

Bits per Pixel: 16    Width: 2048    Height: 512    Frame: 448  
Status: OK

Rate [Hz]: 1.65

Toolbox: Calibing, Spect X, Spect Y

Buttons: STOP, out DAQ, ImagePoints, 142800, Tiner

### FLASH photon energy distribution (via DAQ)

XO reference + 1169

X: start +805, end +1504, min +201, max +404

Y: min +201, max +404

Scale px/mm: +51.5

Bckgr.: +540

Energy scale: +10

EO ref: 84.801 eV

Mode: **BEAM**    Beam Fattern

Status: Ok, no DDG operation

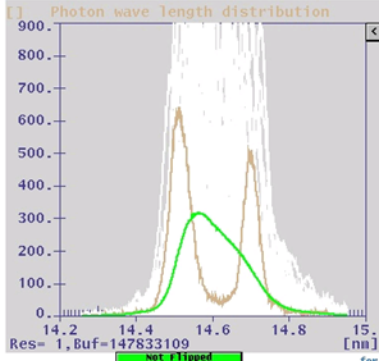
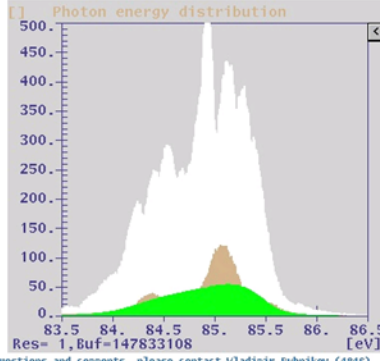
Max 121.6 at 85.06 eV  
Max 709.8 at 14.58 nm

Monochr: +84.8 eV    Expert

Screen: IN    OUT    Cur pos 53.5

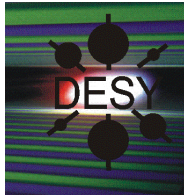
Mean: **STOP**  
Max 54.39 at 85.12 eV  
Max 317.8 at 14.57 nm

Bunch # +1    DDG ps 160000    56160000    On-chip

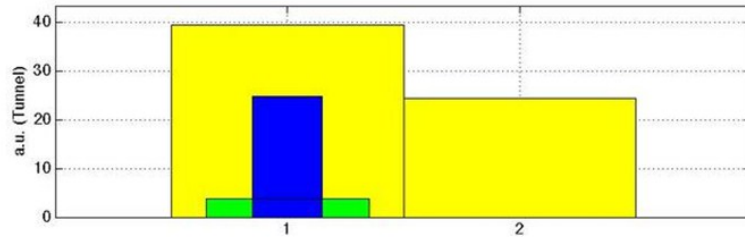
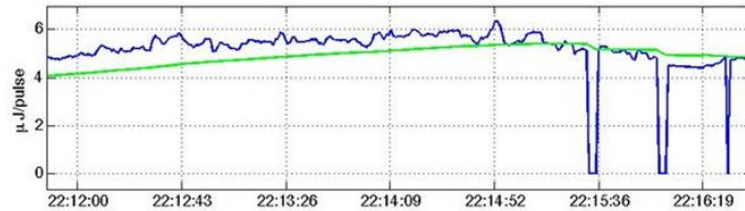
Res= 1, Buf=147833109    Res= 1, Buf=147833108

for questions and comments, please contact Vladimir Rybnikov (4846)

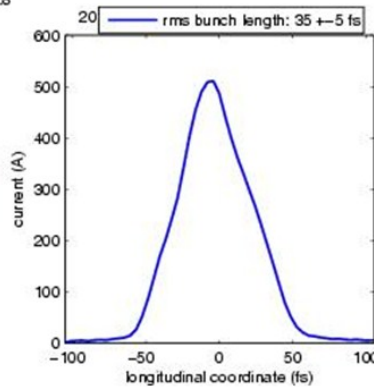
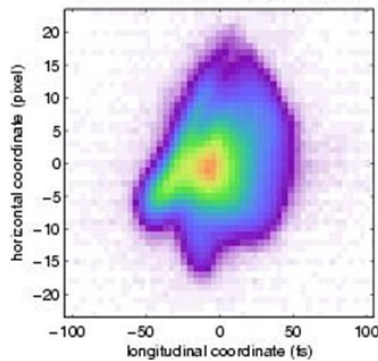


First SASE with short pulse injector laser:

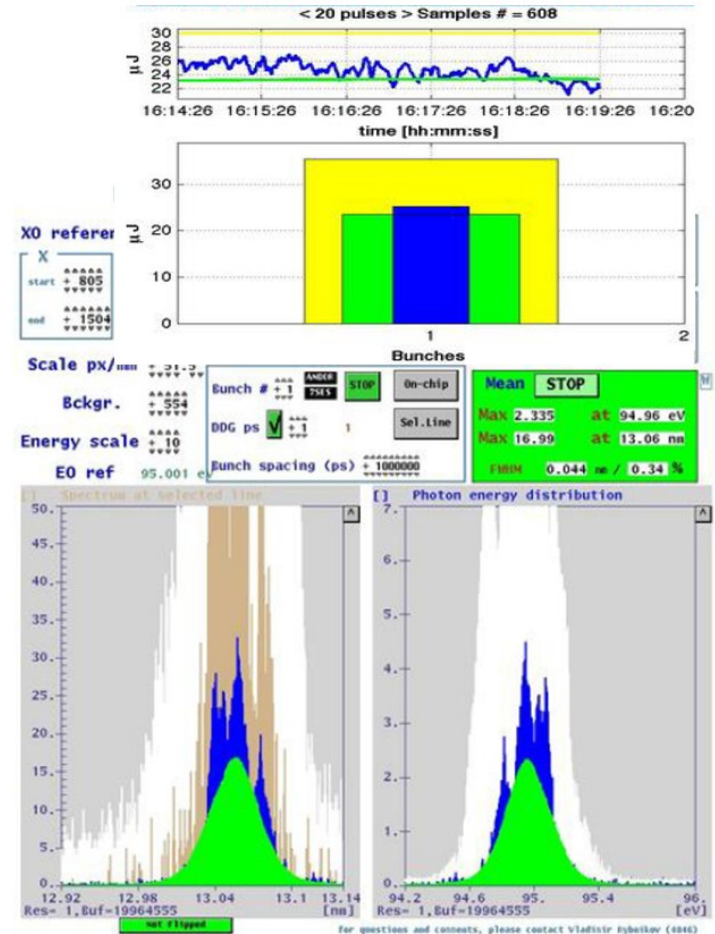
- 9<sup>th</sup> & 11<sup>th</sup> of January 2013
- 5 uJ at 13,5 nm, bunch charge 35 pC



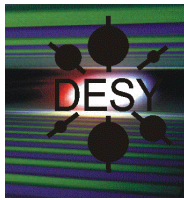
Longitudinal/horizontal bunch profile (LOLA phase) 23.8  
2013-01-09T225505-image-SMATCH



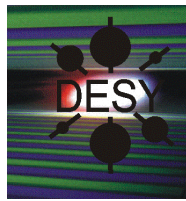
- 25 uJ (GMD-T, 10/10 mm) at 13 nm, bunch charge 80 pC
- PG-measurement: Narrow bandwidth (0.34 % in linear regime, 0.42% at saturation)



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- Longitudinal bunch shape changes with pulse train length, but LOLA can take only one bunch
  - Under study/development: UV Pockels cell
- Uncertainty in absolute rf phases
  - Beam Arrival-time Monitors help
- rf drifts
  - LLRF hardware and software upgrades improved situation significantly
- Instrumentation specified and designed for the original design charge of 1 nC



Charge [pC]	Peak Current [kA] E-Bunch <100 fs FWHM	Peak Current [kA] E-Bunch <50 fs FWHM
1000	8.4	16.8
500	4.2	8.4
250	2.1	4.2
100	0.8	1.6

From S2E: At short bunches, peak currents of 2 kA already increase slice emittance.

From SASE Simulations: Peak currents of 1.5 - 2 kA needed for saturation (at least for the shorter wave lengths)

In the charge regime below 250 pC, SASE intensity and very short bunch length should go together