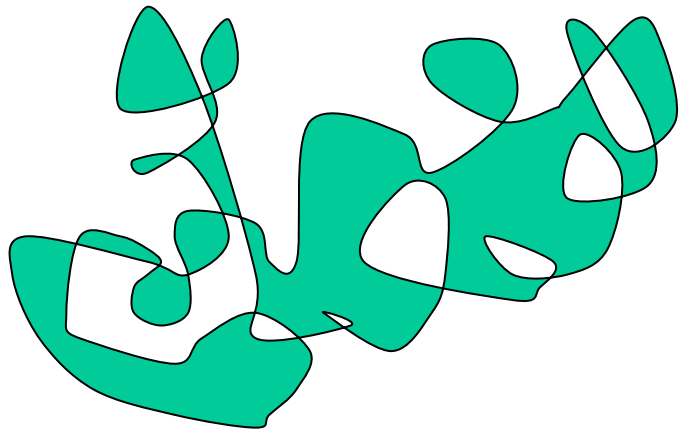
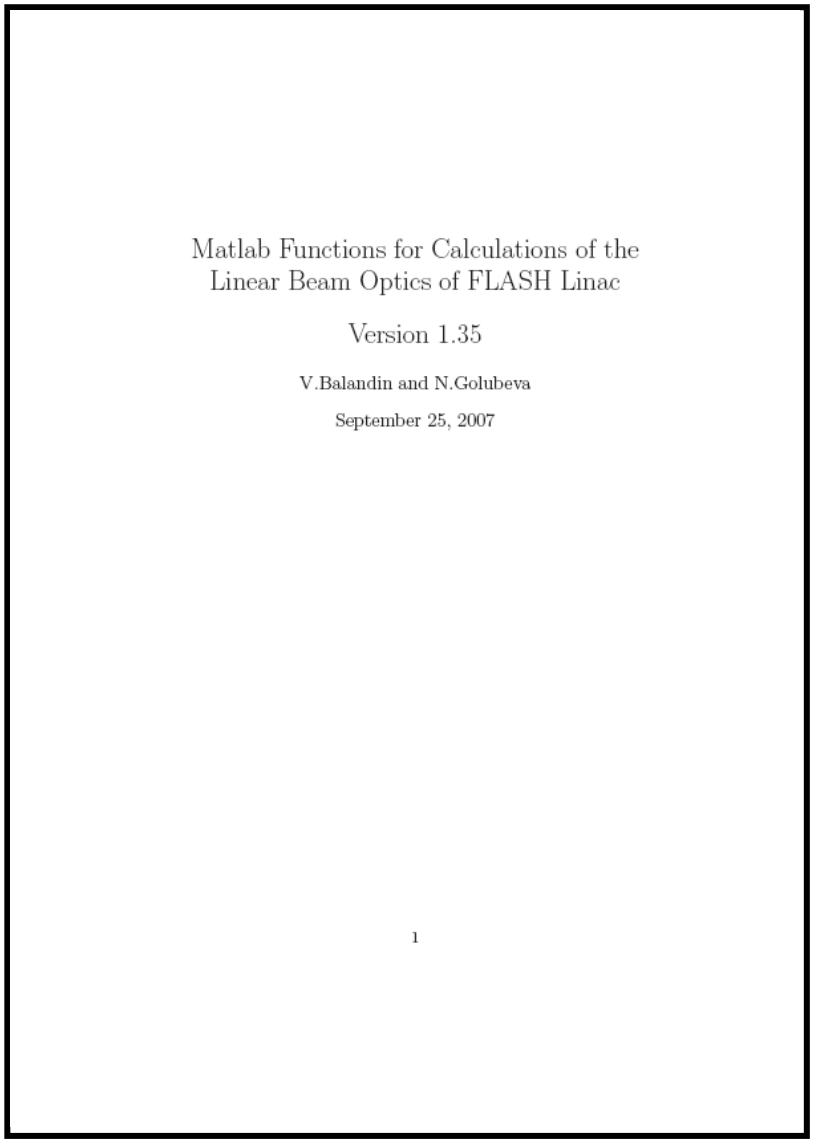
Current Status of the Online MatLab Toolbox for the FLASH Optics

Vladimir Balandin and Nina Golubeva

XFEL Beam Dynamics Group Meeting, 29 October 2007



MatLab Based Online Toolbox for FLASH Optics



Matlab Functions for Calculations of the
Linear Beam Optics of FLASH Linac

Version 1.35

V.Balandin and N.Golubeva

September 25, 2007

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(6 + 2)D motion is implemented, including rf-focusing (based on usage of on-axis accelerating field profile) and natural undulator focusing (based on usage of measured undulator field).

+2)D means dynamics of reference energy and reference time of flight (although time of flight is not in usage yet).

Version 1.0 - July 28, 2006
Version 1.1 - October 20, 2006
Version 1.2 - December 11, 2006
Version 1.3 - July 18, 2007
Version 1.35 - September 25, 2007
Version 1.4 - coming soon

Manual (120 pages for current version)
in FLASH-eLogBook: doc/Physics/Optics

Optics Toolbox consists from three equally important components: optics calculation engine + optical model of the FLASH facility + model for transfer between power supply currents and magnetic fields. All parts are subject of permanent improvement.

Outlook

- New Features in Versions 1.3 and 1.35
- Recent experiments with beam optics using Toolbox Version 1.35
  - Manipulations with beam in ACC1-DBC2 section
    - Matching to the BC2 entrance using 5 upstream quadrupoles
    - Switching BC2 on and off and compensating difference in focusing using 5 downstream to BC2 quadrupoles
    - Moving ACC1 phase off-crest and measuring changes in incoming beam parameters (with BC2 on and off)
  - Four optics installations from scratch
- Expected new possibilities in Version 1.4

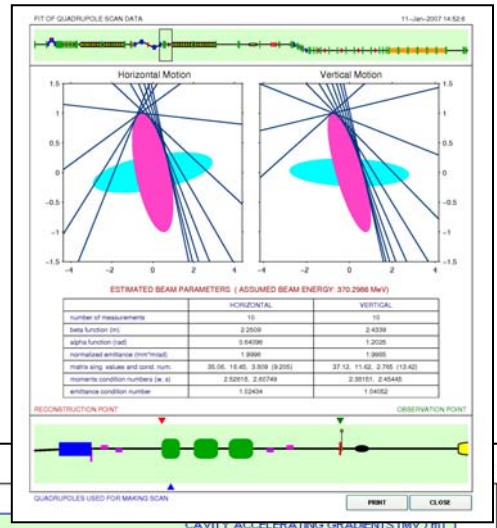
New Features in Versions 1.3 and 1.35

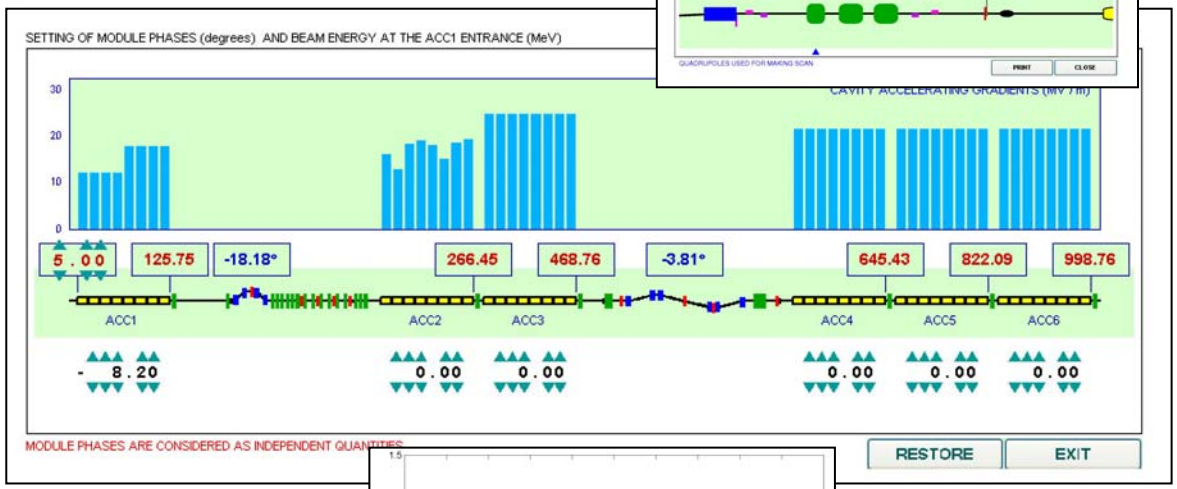
2.4 Version 1.3: 18 July 2007

2.4.1 Updates of Beam Dynamical Model

The main changes of the beam dynamical model in this version are connected with the accelerator upgrade during shutdown 2007. Note that the program update is not finalized yet, and some additional modifications will be introduced into this code version as soon as needed for them information will become available.

Besides that the ACC1 module and upstream steerers were included into the program with the result that the functions *SetEnergyACC1* and *ShowEnergyACC1* are not available anymore and one has to use the new functions *SetEnergyGUN* and *ShowEnergyGUN* instead them.



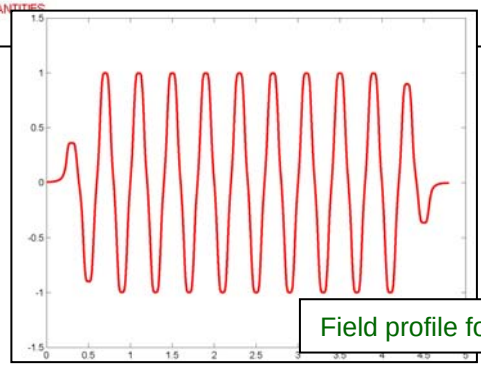


2.4.2 New Functions

- *SetEnergyGUN*
- *ShowEnergyGUN*
- *GetPeriodicBetas*
- *GetMultiProfileMatr*
- *FitMultiProfileData*
- *SetSextupShiftM*
- *UiSetPhases*

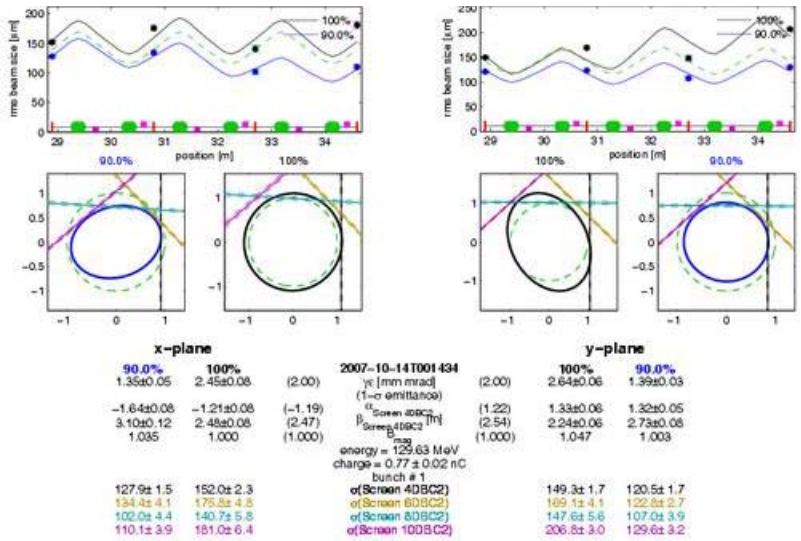
2.5 Version 1.35: 25 September 2007

This version replaces the version 1.3. It includes two new functions (*SetMaxFieldEmUnd* and *GetFieldEmUnd*) which allow to take into account focusing produced by optical replica and FIR undulators. Besides that preliminary transfer coefficients between power supply currents and beam deflection angles were introduced for the steerers in the gun section.



Field profile for the FIR undulator

13 October 2007: manipulations with beam in ACC1 – DBC2 section



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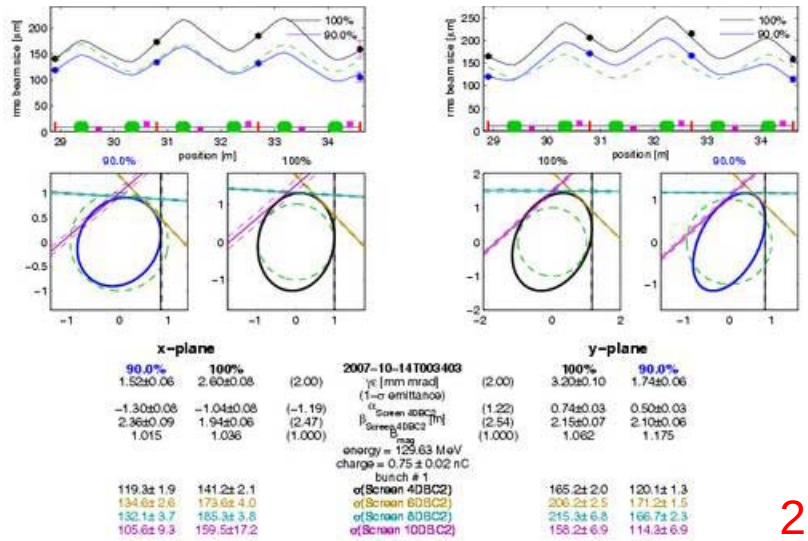
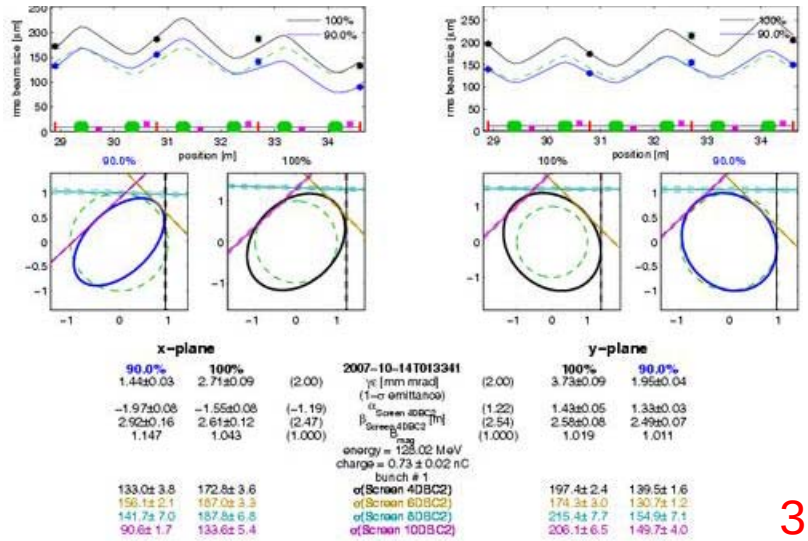


2

1. **BC2 on. ACC1 on crest. Matching to the BC2 entrance using 5 upstream quadrupoles.**

2. **BC2 is switched off and 5 downstream quadrupoles are set to their theoretical currents required to compensate difference in focusing. Nothing else was touched.**

3. **BC2 off. ACC1 is moved to -10 degree off-crest.**



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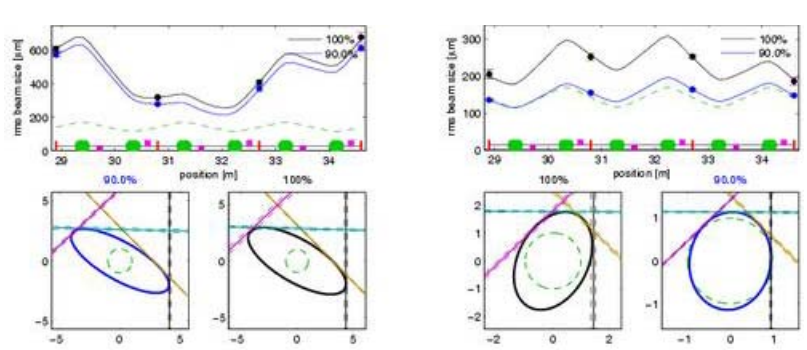
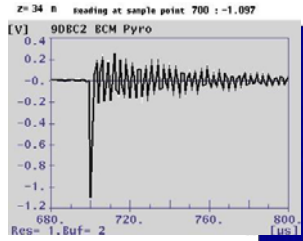
13 October 2007: manipulations with beam in ACC1 – DBC2 section

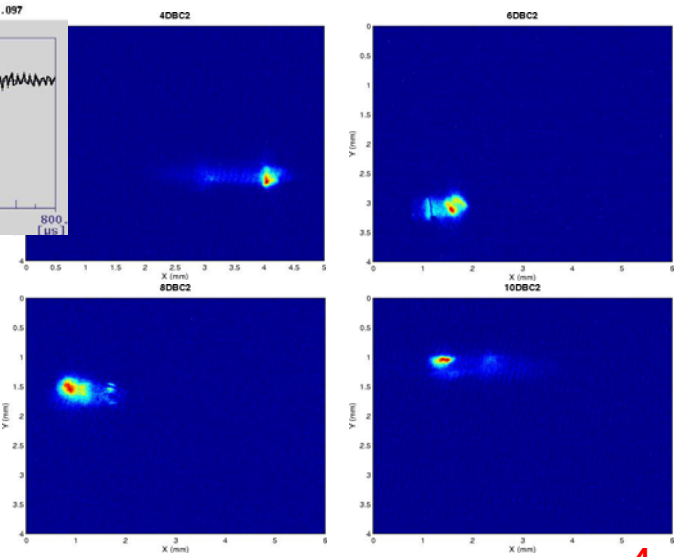


x-plane

90.0%	100%		2007-10-14T020843		100%	90.0%
14.50±0.84	18.69±0.82	(2.00)	γε [mm mrad] (1-σ emittance)	(2.00)	4.65±0.26	2.19±0.05
−1.60±0.16	−1.45±0.11	(−1.19)	$\alpha_{Screen\ 6DBC2}$	(1.22)	0.69±0.08	0.95±0.05
5.61±0.46	5.00±0.35	(2.47)	$\beta_{Screen\ 6DBC2}$ [m]	(2.54)	2.14±0.13	2.12±0.06
1.624	1.485	(1.000)	B_{max}	(1.000)	1.080	1.018
			energy = 128.02 MeV			
			charge = 0.71 ± 0.02 nC			
			bunch # 1			
573.7±13.3	607.4±17.4		σ(Screen 4DBC2)		205.8±12.1	136.0± 3.1
278.4± 5.3	316.7± 8.1		σ(Screen 6DBC2)		253.2± 9.6	155.6± 5.4
370.8±18.4	408.5±15.0		σ(Screen 8DBC2)		253.5± 5.8	164.5± 3.2
611.6±17.2	675.8±30.9		σ(Screen 10DBC2)		186.9±10.4	148.0± 3.1

y-plane





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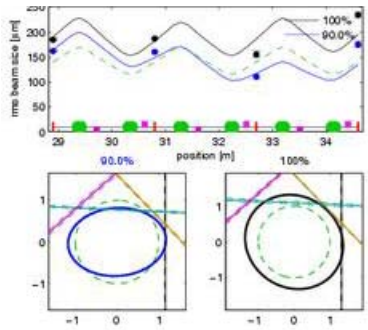
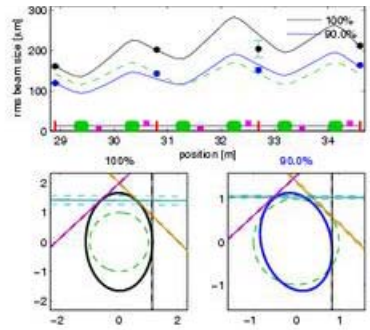
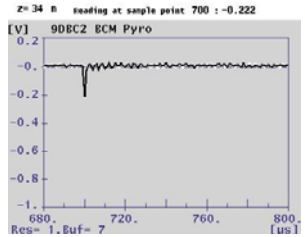
4. BC2 is switched on again and 5 downstream quadrupoles are returned to their initial setting. Nothing else was touched.

5. BC2 on. ACC1 is moved to -7 degree off-crest.







x-plane

90.0%	100%		2007-10-14T023036		100%	90.0%
1.93±0.06	3.58±0.09	(2.00)	γε [mm mrad] (1-σ emittance)	(2.00)	3.77±0.08	1.89±0.05
−1.76±0.09	−1.15±0.05	(−1.19)	$\alpha_{Screen\ 6DBC2}$	(1.22)	0.84±0.04	1.10±0.07
3.54±0.11	2.57±0.07	(2.47)	$\beta_{Screen\ 6DBC2}$ [m]	(2.54)	1.73±0.05	1.90±0.05
1.067	1.005	(1.000)	B_{max}	(1.000)	1.074	1.066
			energy = 128.92 MeV			
			charge = 0.70 ± 0.02 nC			
			bunch # 1			
162.2± 1.8	185.0± 2.7		σ(Screen 4DBC2)		160.6± 2.6	118.9± 1.2
160.4± 3.6	187.2± 2.2		σ(Screen 6DBC2)		202.0± 3.8	142.6± 5.1
110.6± 3.5	155.4± 6.6		σ(Screen 8DBC2)		204.0±21.2	151.3± 5.2
175.4± 6.4	234.6± 5.7		σ(Screen 10DBC2)		211.3± 4.0	163.2± 2.9

y-plane

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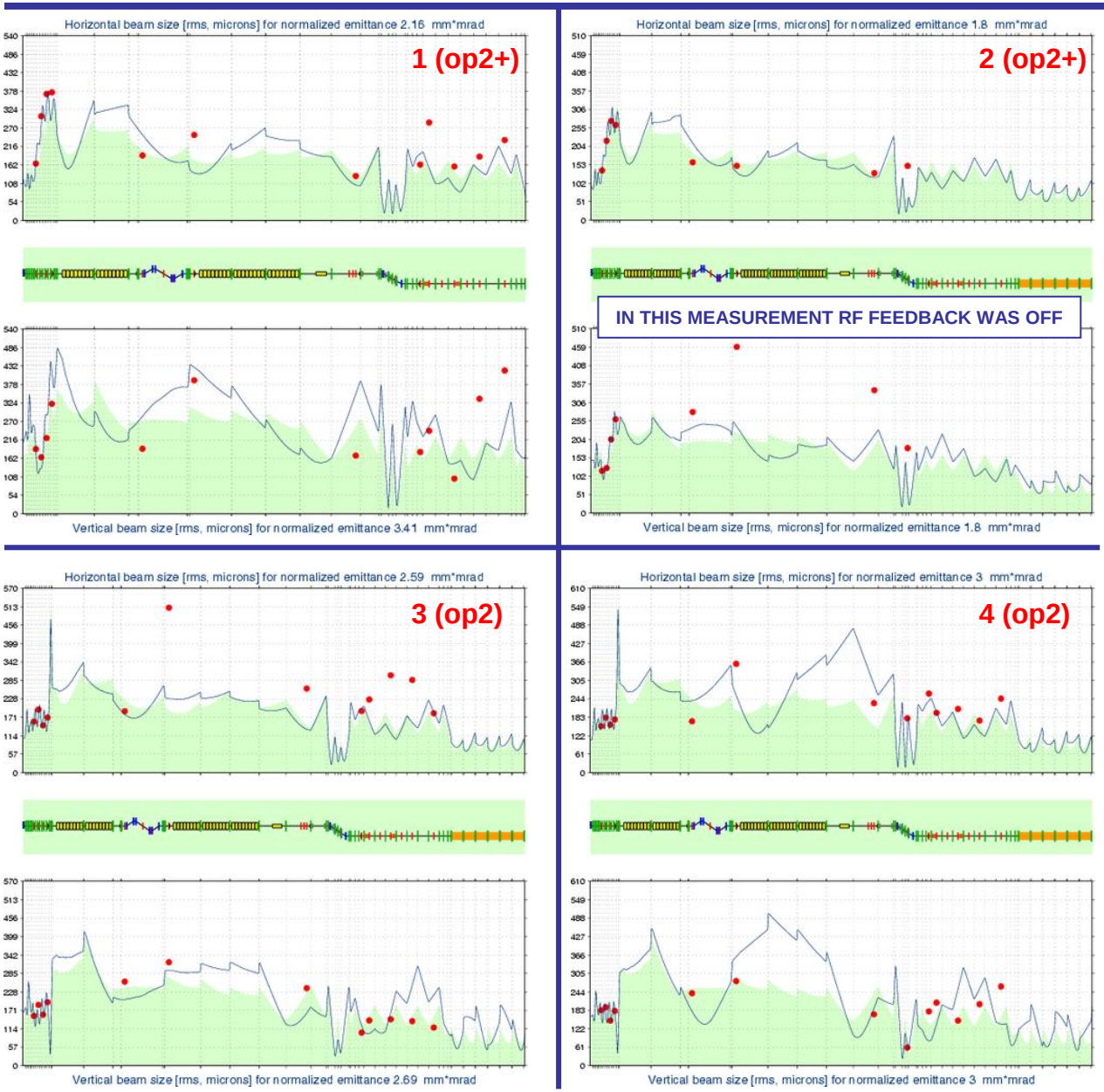
Measured beam sizes along the linac (OTR screens, red dots) compared with theoretical prediction (green areas) and with beam sizes reconstructed using measurements in DBC2 section (blue lines).



Four optics installations (from scratch)

1. **12 October 2007, Afternoon**
2. **13 October 2007, Night**
3. **14 October 2007, Morning**
4. **15 October 2007, Afternoon**

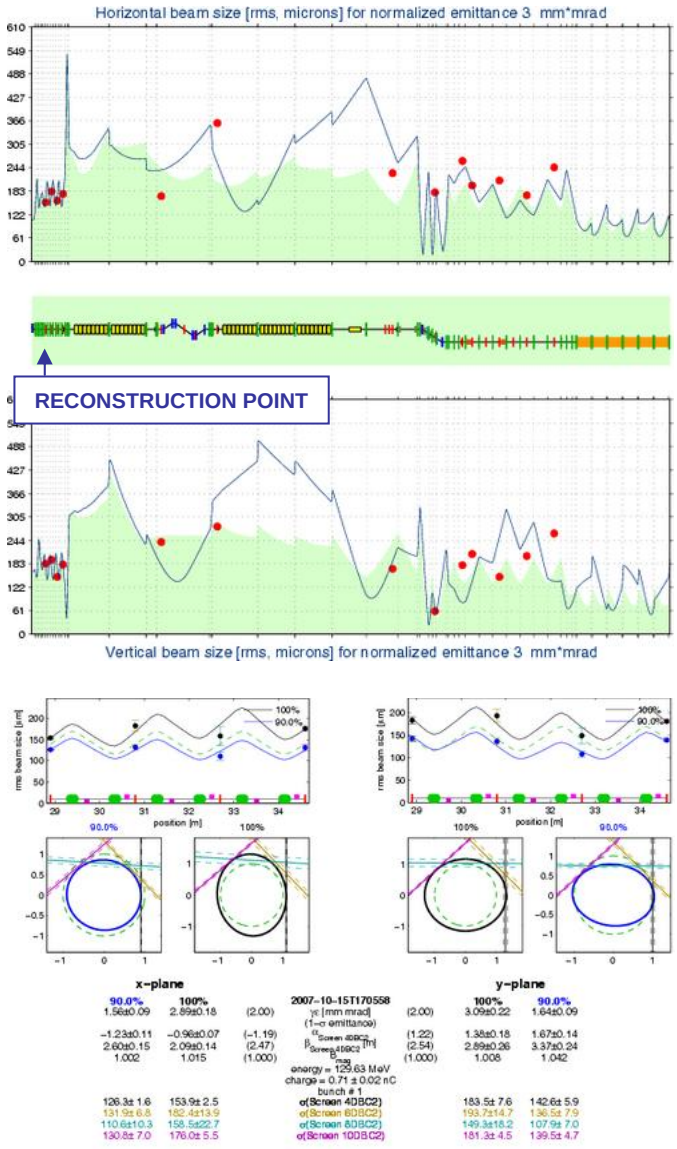
In the beginning of every new installation of the transverse focusing energy profile along the linac was different with about the same final energy (~685 MeV).

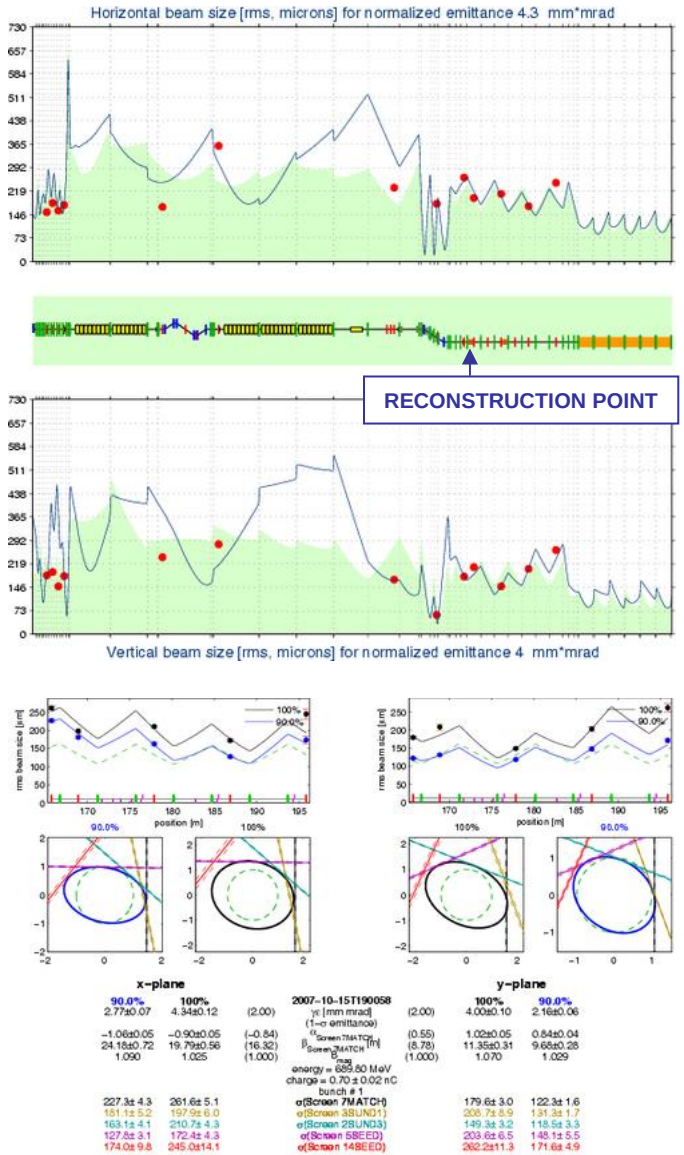
Procedure:

Matching to the BC2 entrance and, after that, loading of theoretical quadrupole currents calculated by Optics Toolbox for all downstream quadrupoles.

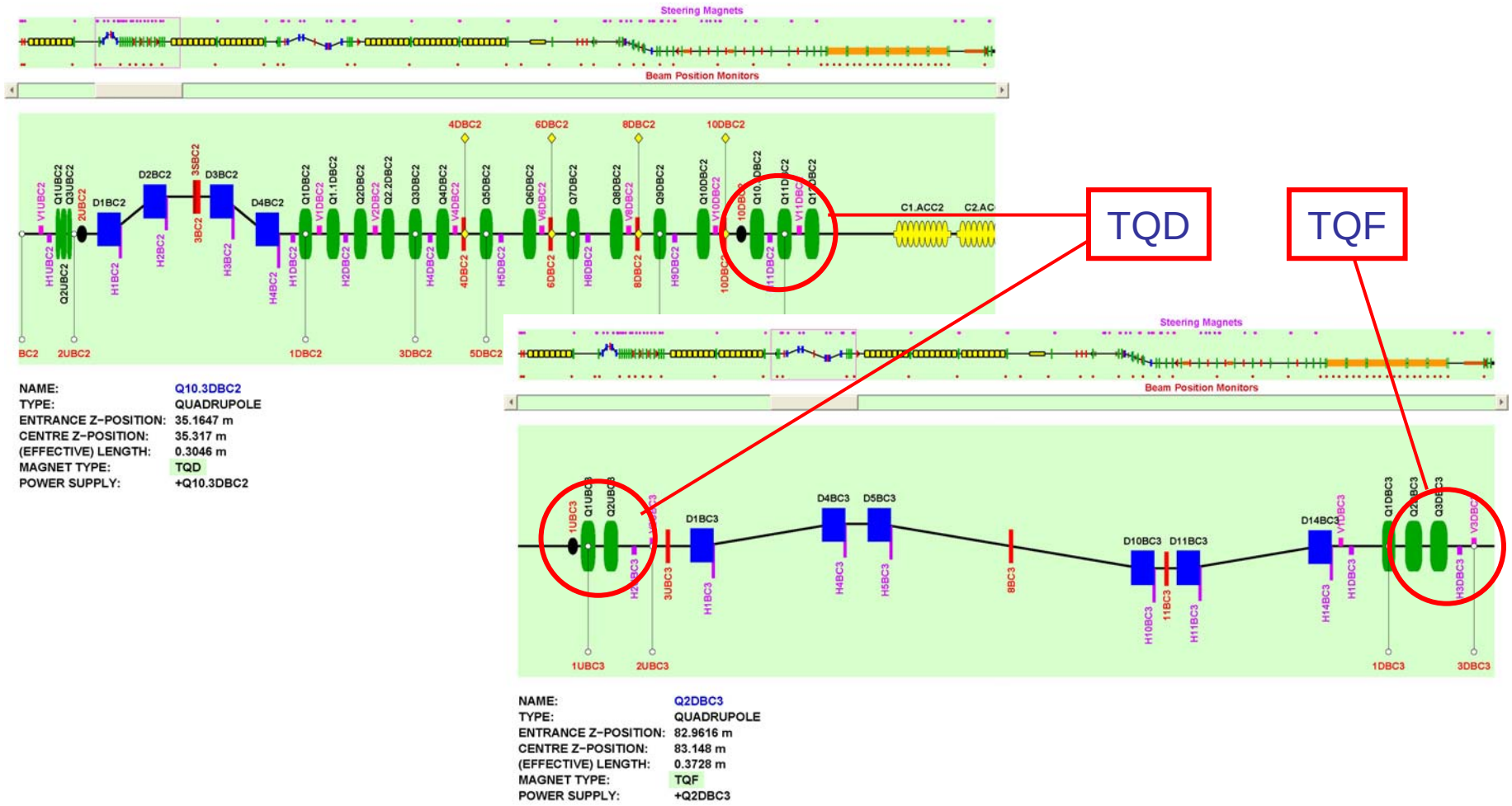
Measurements were done after some steering and without touching quadrupoles (except for the variant 4, where quadrupoles in ACC3 and ACC5 were slightly tuned and beam was matched in the SEED section, because this optics was then used for establishing SASE operation).

15 October 2007: measured beam sizes along the linac (OTR screens, red dots) compared with theoretical prediction (green areas) and with beam sizes reconstructed using measurements in DBC2 and SEED sections (forward and backward tracking, blue lines).





Some disagreement between theoretical and measured beam sizes is observed in BC3 area



Unfortunately, for these quadrupoles we do not have measured or calculated field profiles yet !

Expected new possibilities in Version 1.4

The main new feature:
inclusion of the dump line and bypass description into Optics Toolbox and, therefore, inclusion of the possibility to deal with coupled linear motion.

All other suggestions are welcome !