Database-driven Status Analysis in Beam Operation at the Heidelberg Ion Therapy Center

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Contents

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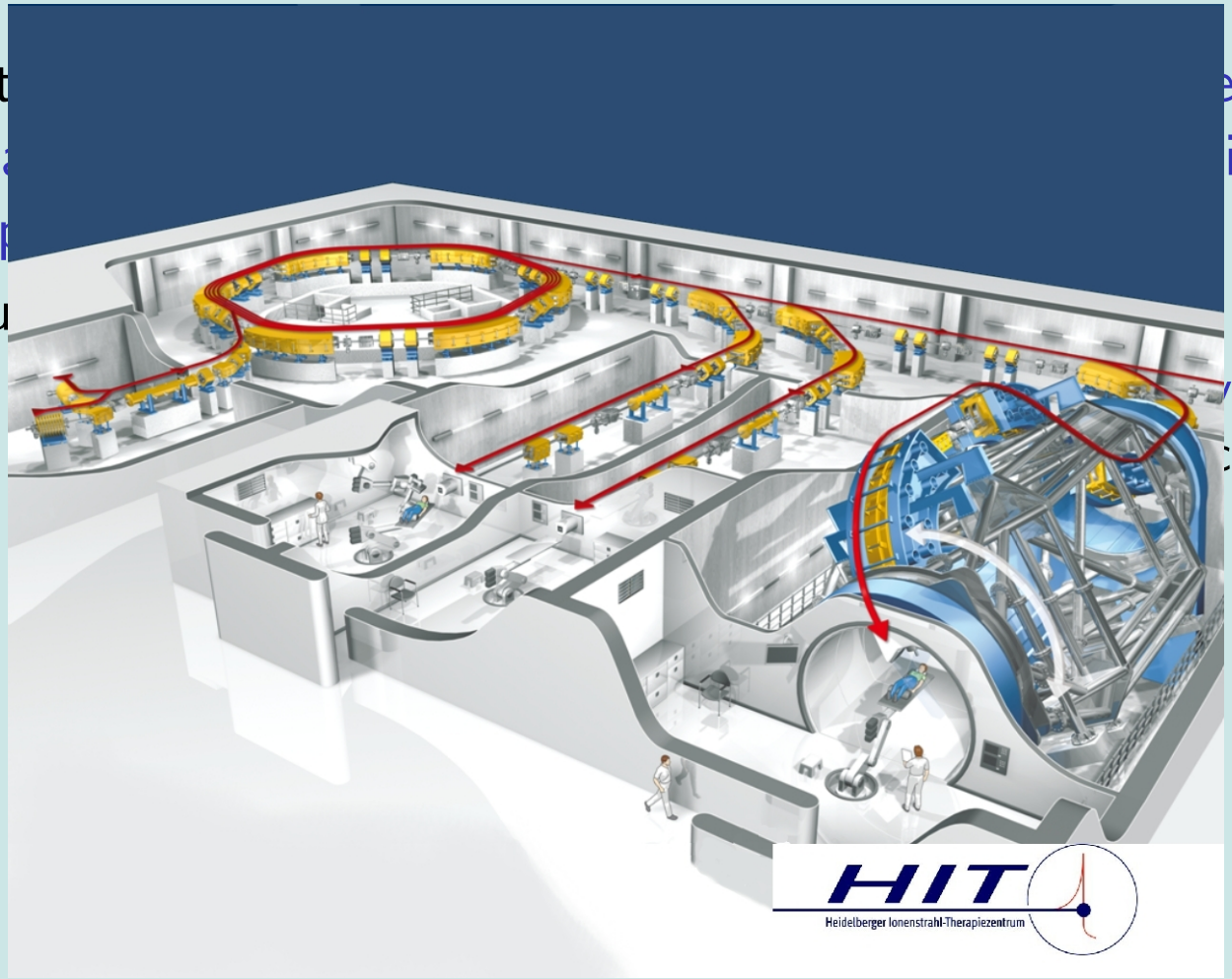

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- Using raster scanning technology for therapy.
- Aim: 1300 patients per year!

Pictures

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Accelerator Control System

- Proprietary Control System supplied by automation company.
- Servers and clients Windows based,
- Oracle database for storing:
  - cycle data,
  - measured values,
  - configuration, device parameters,
  - error logs.

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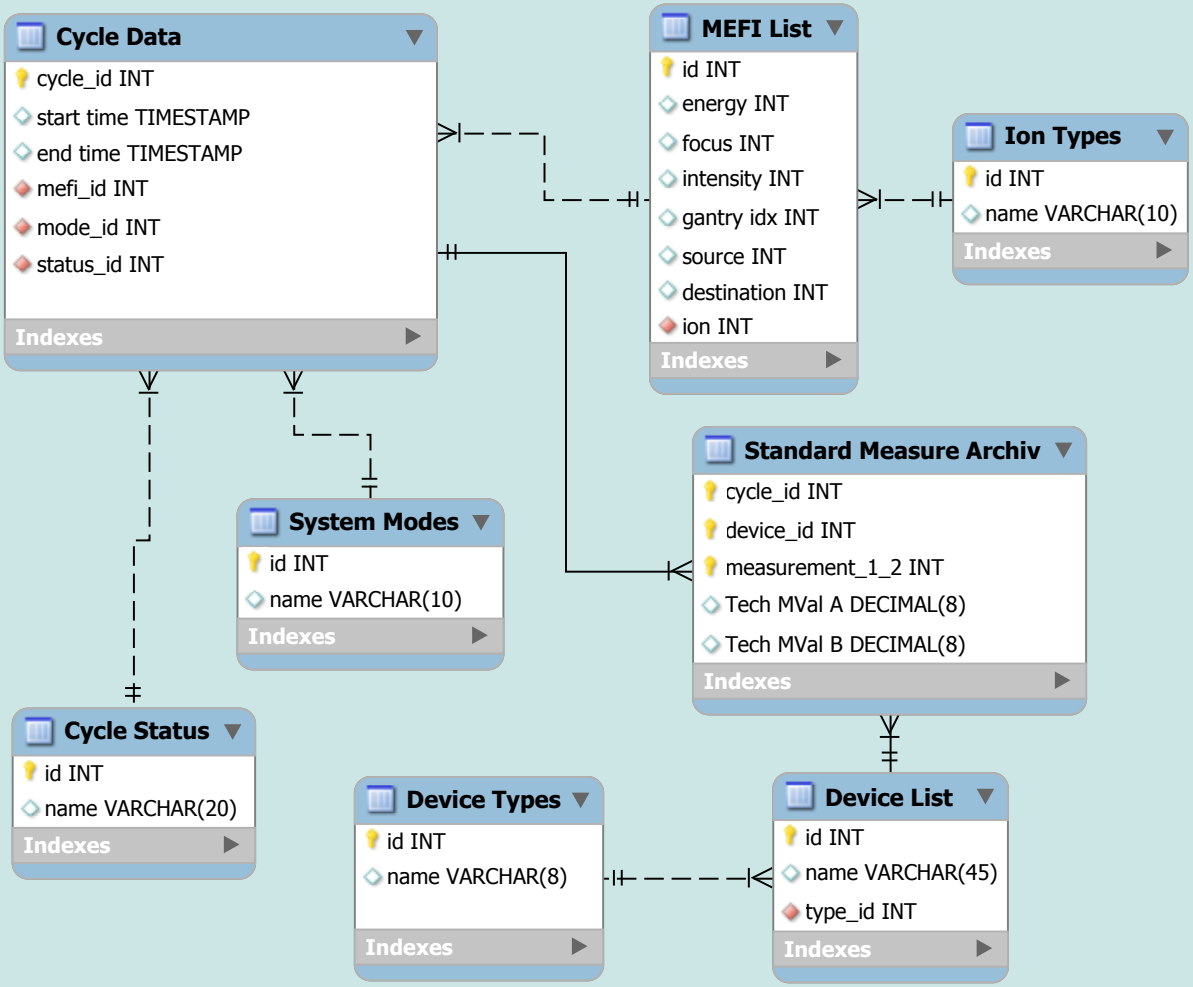
- Supports multiplexed operation:
  - arbitrary source/destination (virtual accelerator),
  - beam properties from MEFI space: 255 Energie values, 6 Focus sizes, 15 Intensity values (plus 36 Gantry angles).

Database Tables



Application Environment

- Python 2.6 with builtin/3rd party modules:
  - cx_Oracle, DB-API 2.0 compliant,
  - csv, reading/writing comma separated values,
  - struct, binary I/O,
  - datetime, date/time functions
- Gnuplot 4.4
- Applications run as GUI on Windows (wxWindows) or by cron demon on Linux.

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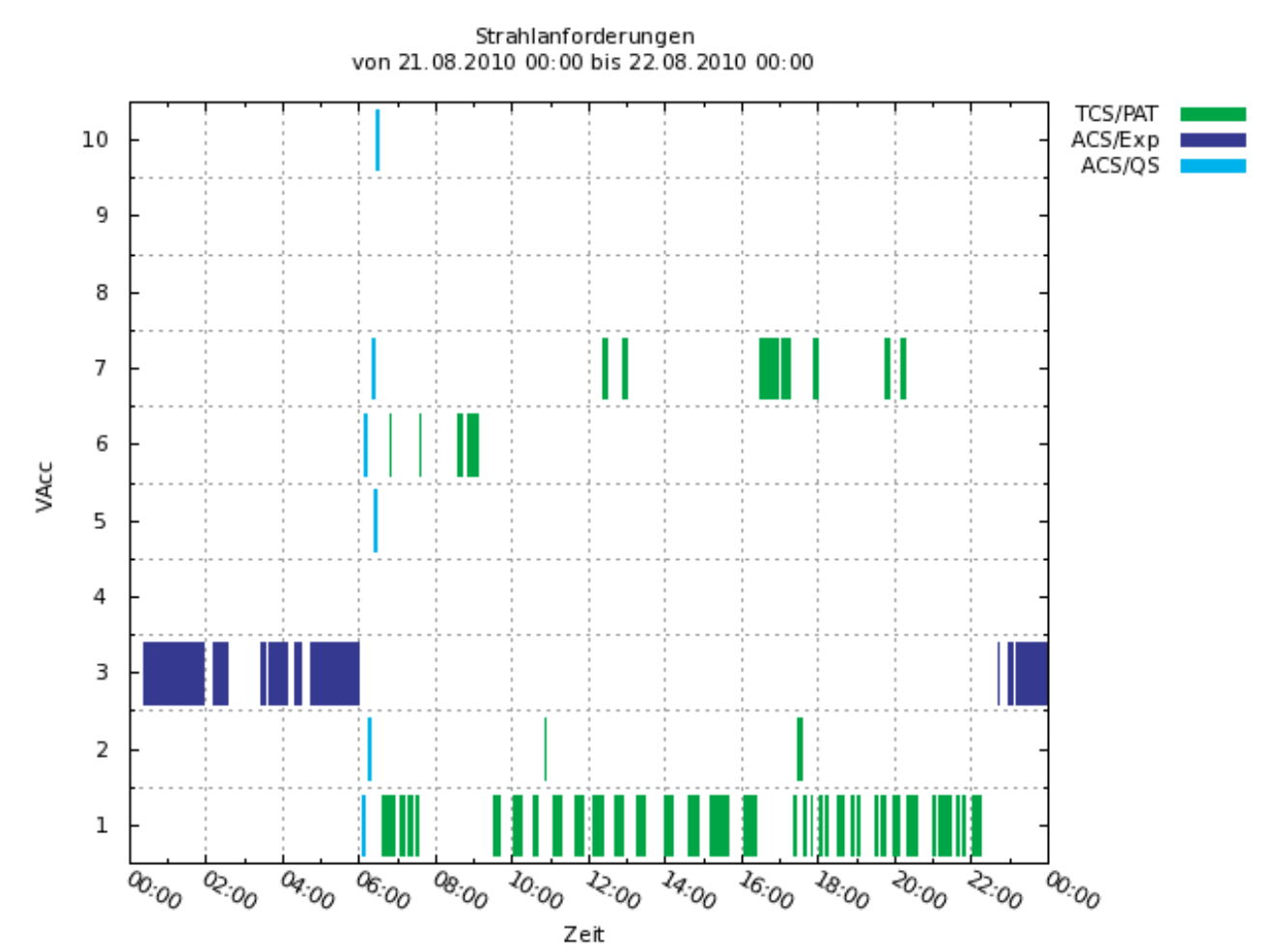
- Backends: HTML, LaTeX.

Analysis Example

	Cycles: Beam Modes				
	All	Carbon		Protons	
	Cycles	Cycles	Particles	Cycles	Particles
Total	3744	3094	1.36×10^{11}	650	1.53×10^{12}
TCS	2369	1778	3.43×10^{10}	591	1.47×10^{12}
ACS/Exp	1257	1257	1.01×10^{11}	0	0.00×10^{00}
ACS/QS	118	59	1.47×10^{09}	59	5.87×10^{10}
	Cycles: Destinations				
H1	1881	1744	3.35×10^{10}	137	3.85×10^{11}
H2	568	74	1.98×10^{09}	494	1.13×10^{12}
Gantry	1257	1257	1.01×10^{11}	0	0.00×10^{00}
QS	0	0	0.00×10^{00}	0	0.00×10^{00}
Dump	38	19	2.68×10^{08}	19	1.07×10^{10}

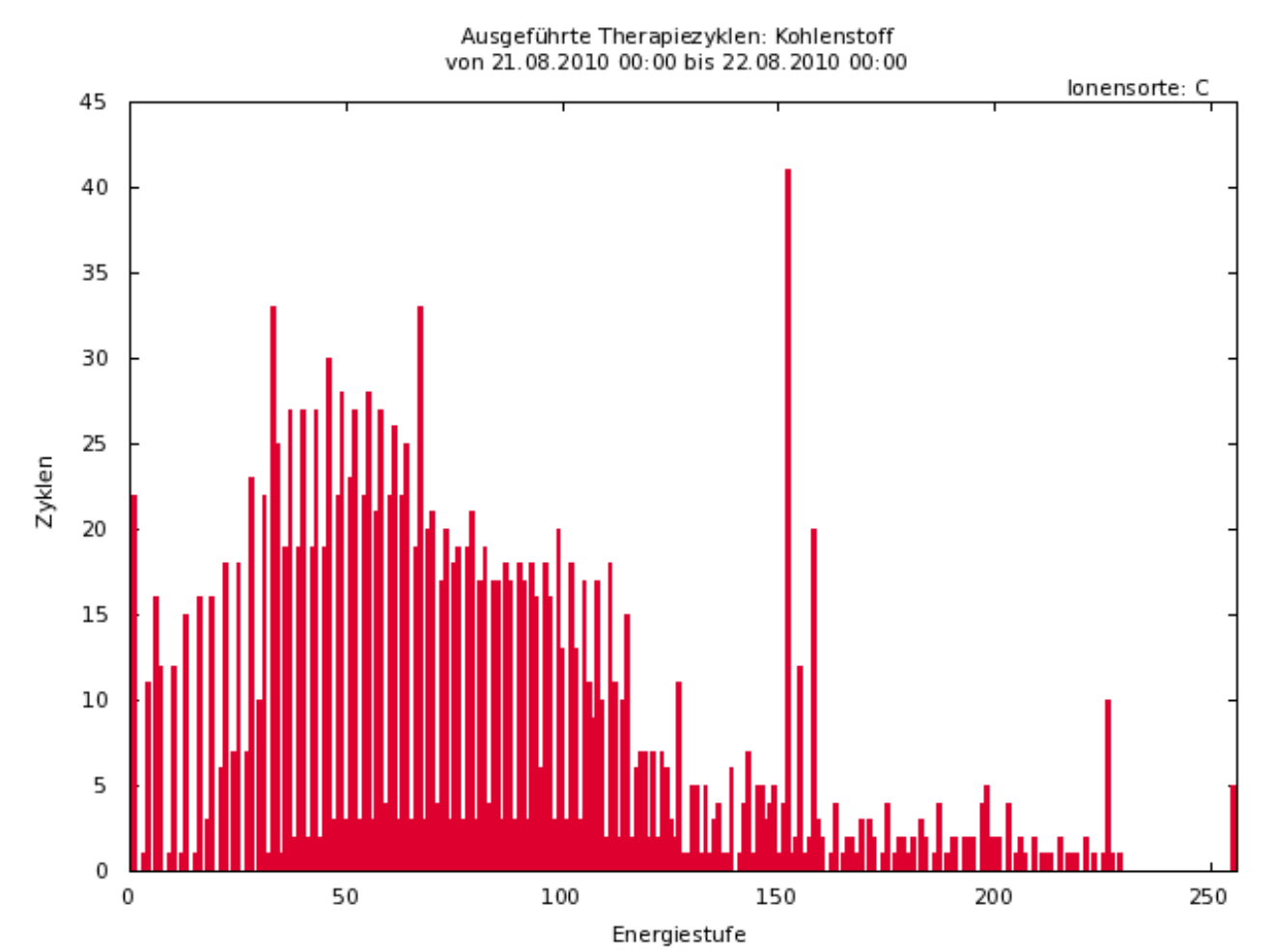
Analysis Example

Plot: Virtual accelerators used during 24 hrs:



Analysis Example

Plot: Distribution of used energy values during a 24 hrs period:



Commissioning Tools

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- Gantry commissioning in progress: Optimizing beam for a set of MEFI parameters as sampling points, interpolation of device settings in between.
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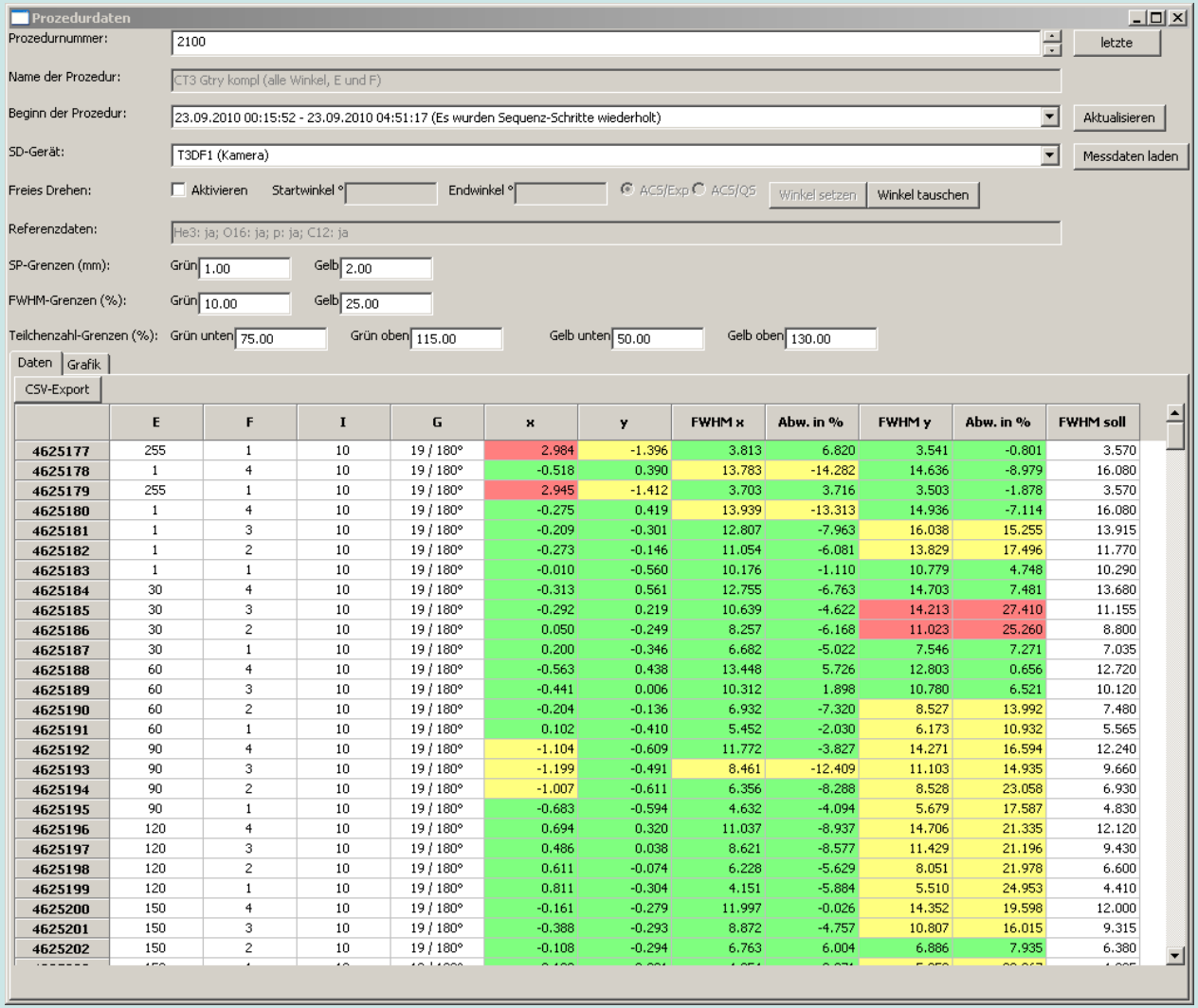
- Previously manual analysis of CSV export within OpenOffice spreadsheet, now reading measured and reference values directly from database, result displayed in GUI within seconds.
- Possibility to plot data slices, i. e. quality as function of E for fixed G and vice versa.

Screenshots



	E	F	I	G	x	y	FWHM x	Abw. in %	FWHM y	Abw. in %	FWHM soll
4625177	255	1	10	19 / 180°	2.984	-1.396	3.813	6.820	3.541	-0.801	3.570
4625178	1	4	10	19 / 180°	-0.518	0.390	13.783	-14.282	14.636	-8.979	16.080
4625179	255	1	10	19 / 180°	2.945	-1.412	3.703	3.716	3.503	-1.878	3.570
4625180	1	4	10	19 / 180°	-0.275	0.419	13.939	-13.313	14.936	-7.114	16.080
4625181	1	3	10	19 / 180°	-0.209	-0.301	12.807	-7.963	16.038	15.255	13.915
4625182	1	2	10	19 / 180°	-0.273	-0.146	11.054	-6.081	13.829	17.496	11.770
4625183	1	1	10	19 / 180°	-0.010	-0.560	10.176	-1.110	10.779	4.748	10.290
4625184	30	4	10	19 / 180°	-0.313	0.561	12.755	-6.763	14.703	7.481	13.680
4625185	30	3	10	19 / 180°	-0.292	0.219	10.639	-4.622	14.213	27.410	11.155
4625186	30	2	10	19 / 180°	0.050	-0.249	8.257	-6.168	11.023	25.260	8.800
4625187	30	1	10	19 / 180°	0.200	-0.346	6.682	-5.022	7.546	7.271	7.035
4625188	60	4	10	19 / 180°	-0.563	0.438	13.448	5.726	12.803	0.656	12.720
4625189	60	3	10	19 / 180°	-0.441	0.006	10.312	1.898	10.780	6.521	10.120
4625190	60	2	10	19 / 180°	-0.204	-0.136	6.932	-7.320	8.527	13.992	7.480
4625191	60	1	10	19 / 180°	0.102	-0.410	5.452	-2.030	6.173	10.932	5.565
4625192	90	4	10	19 / 180°	-1.104	-0.609	11.772	-3.827	14.271	16.594	12.240
4625193	90	3	10	19 / 180°	-1.199	-0.491	8.461	-12.409	11.103	14.935	9.660
4625194	90	2	10	19 / 180°	-1.007	-0.611	6.356	-8.288	8.528	23.058	6.930
4625195	90	1	10	19 / 180°	-0.683	-0.594	4.632	-4.094	5.679	17.587	4.830
4625196	120	4	10	19 / 180°	0.694	0.320	11.037	-8.937	14.706	21.335	12.120
4625197	120	3	10	19 / 180°	0.486	0.038	8.621	-8.577	11.429	21.196	9.430
4625198	120	2	10	19 / 180°	0.611	-0.074	6.228	-5.629	8.051	21.978	6.600
4625199	120	1	10	19 / 180°	0.811	-0.304	4.151	-5.884	5.510	24.953	4.410
4625200	150	4	10	19 / 180°	-0.161	-0.279	11.997	-0.026	14.352	19.598	12.000
4625201	150	3	10	19 / 180°	-0.388	-0.293	8.872	-4.757	10.807	16.015	9.315
4625202	150	2	10	19 / 180°	-0.108	-0.294	6.763	6.004	6.886	7.935	6.380

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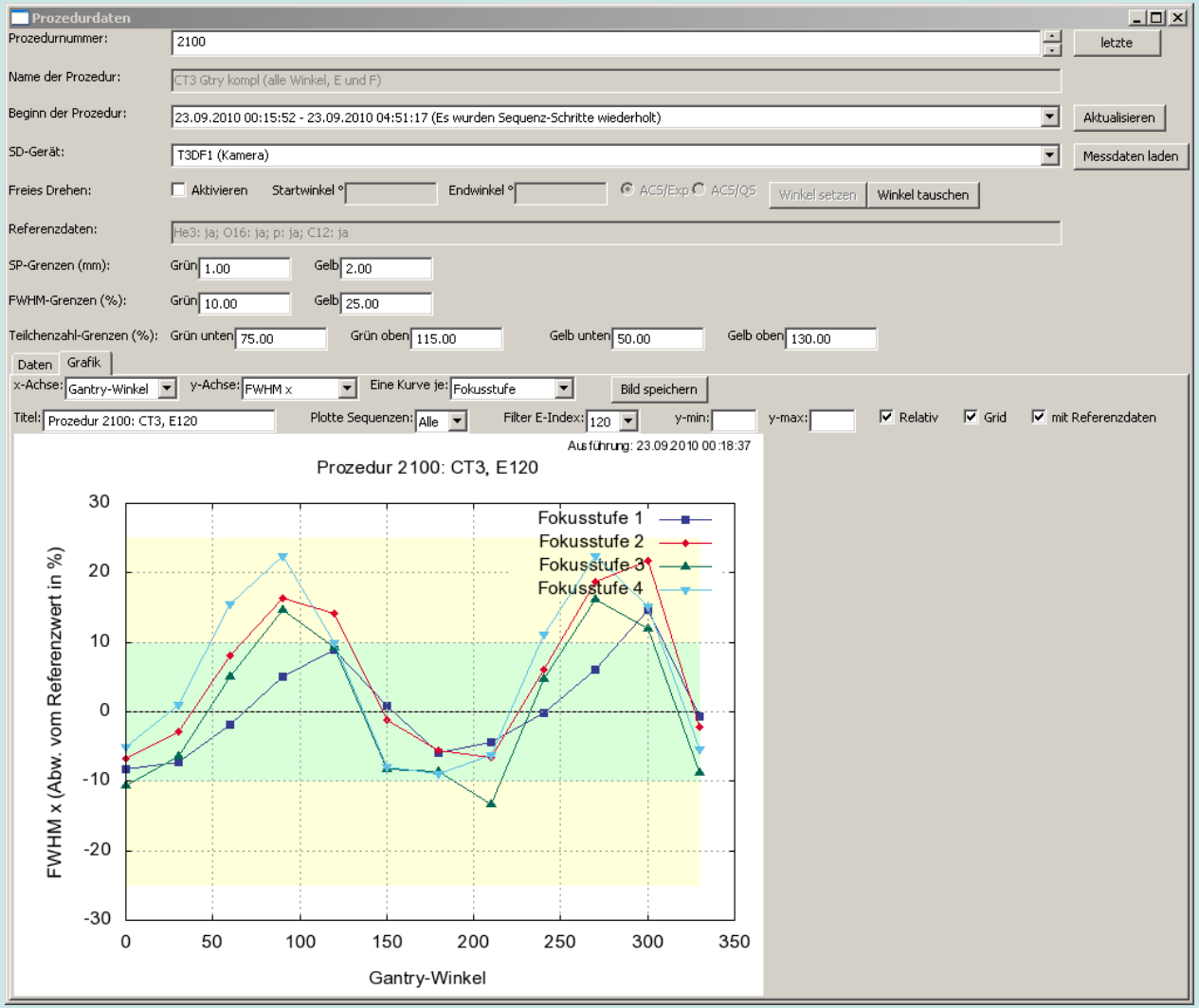

Conclusions

Python proved as powerful tool for flexible and fast development of tools:

- Beam statistics,
- error analysis,
- data analysis,
- fast generation of sequences,
- help in beam intensity optimization: Read particle numbers per second as function of quadrupol field, compare to reference value, propose adjustment value for quadrupol field.