Commissioning of the infrared undulator

Part I: Electron beam transport

Oliver Grimm, 30 October 2007

…for the infrared undulator team.

Some results from magnetic tuning

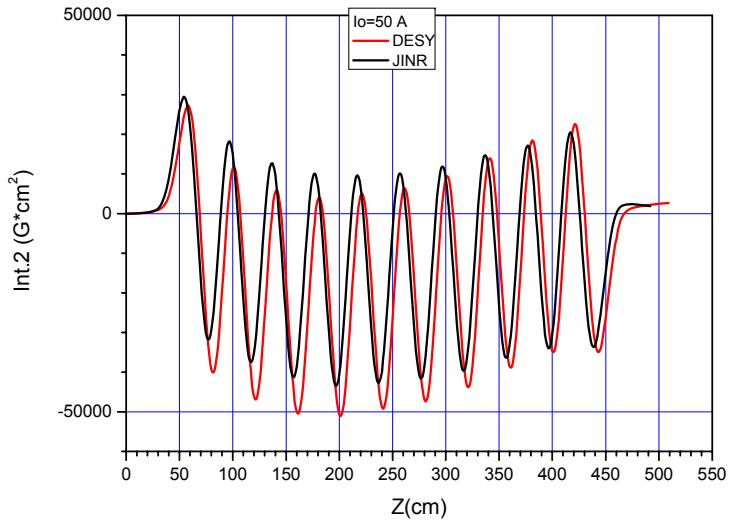
Goal

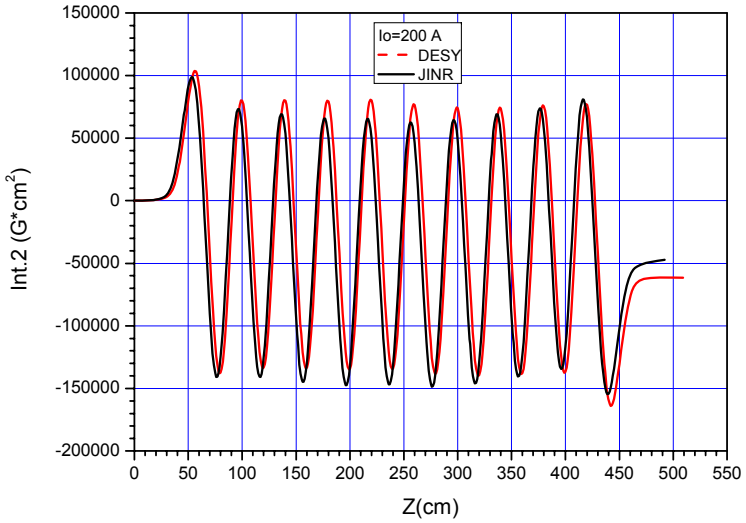
Reduction and flattening of field integrals over full operation range 0 to 435 A

Means

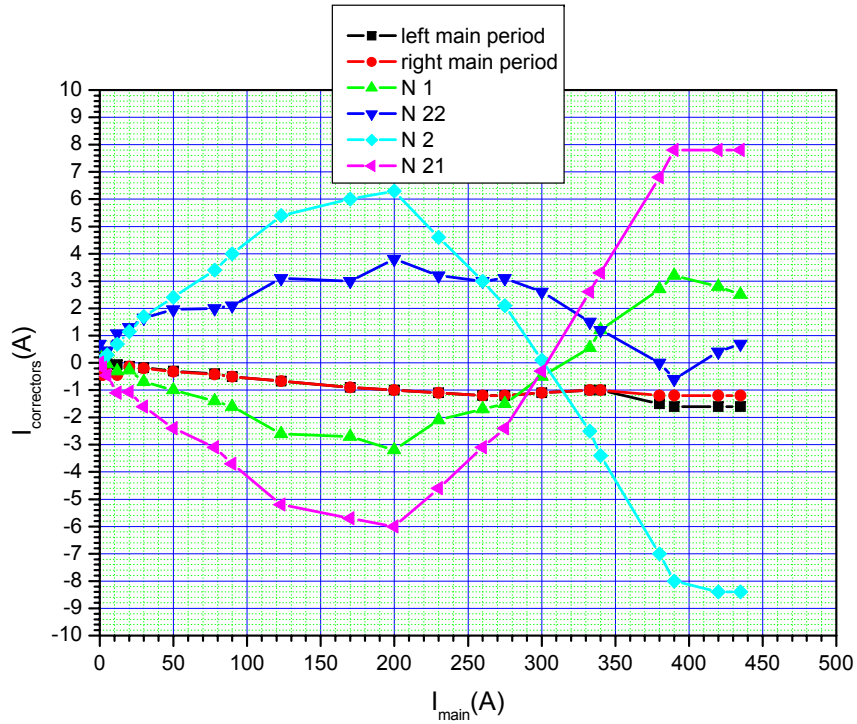
6 power supplies, 40 variable resistors, 80 switches

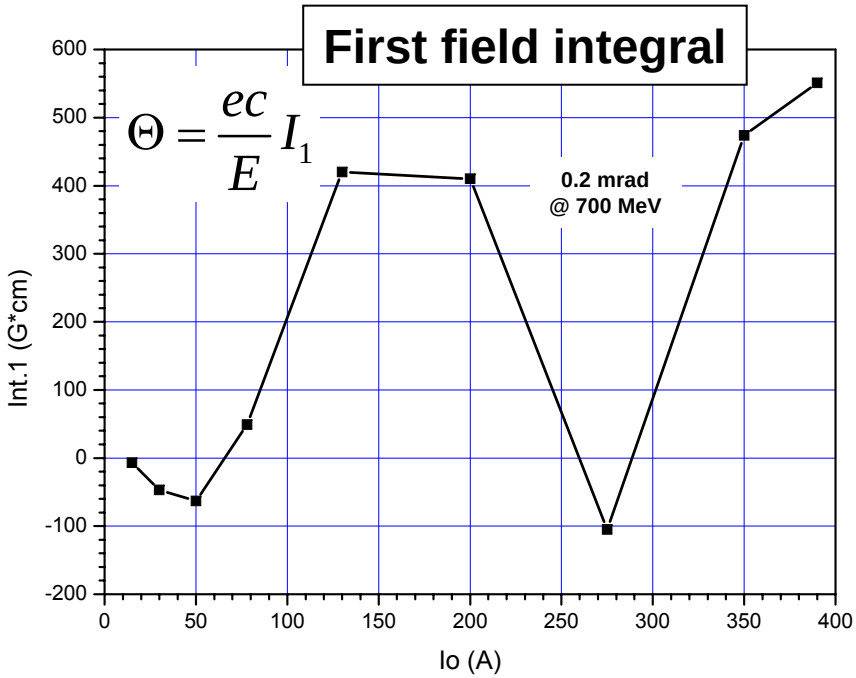
Reproducibility 2nd field integral

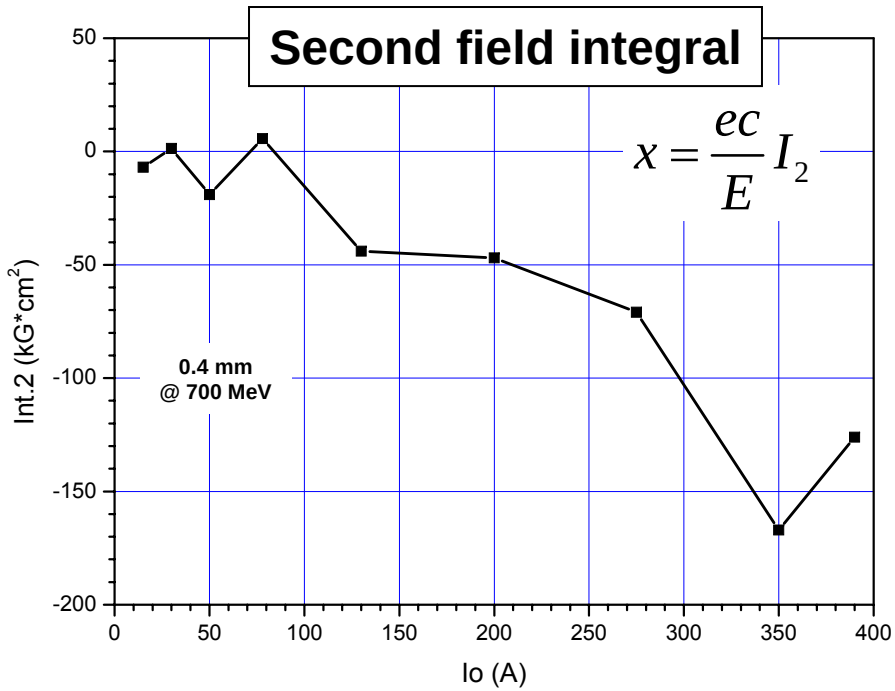


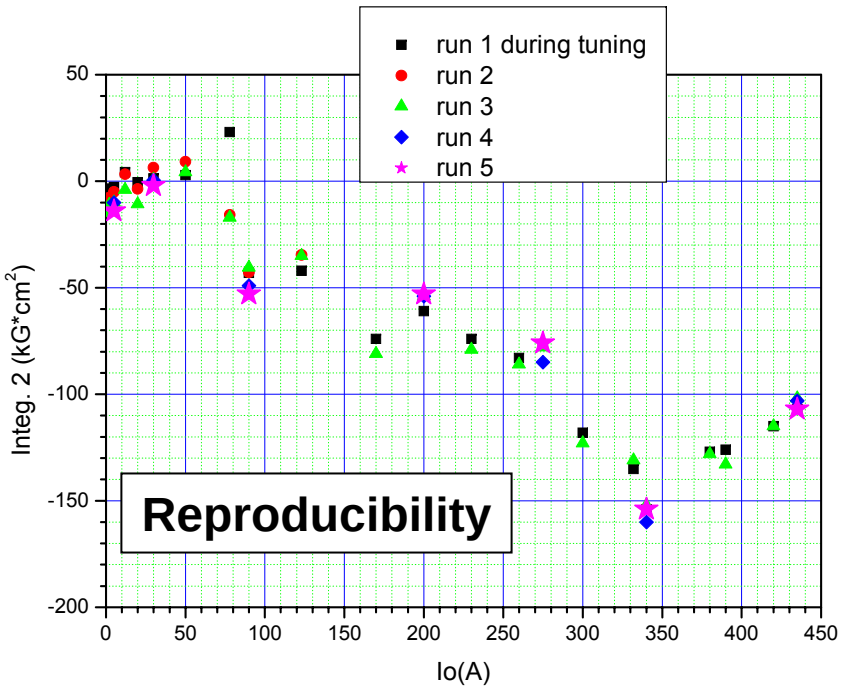


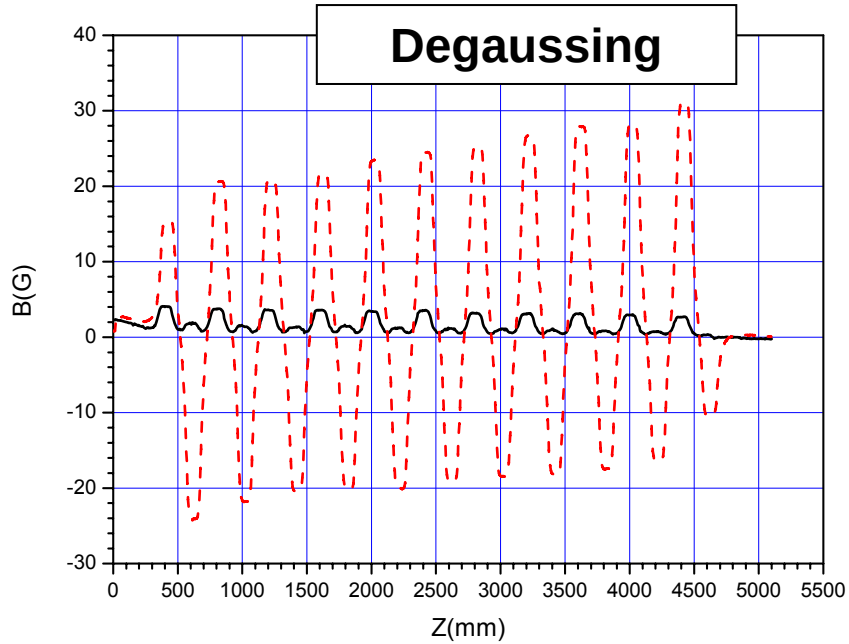
I_{main} (A)	Left period (A)	Right period (A)	N 1 (A)	N 22 (A)	N 2 (A)	N 21 (A)	Int.1 (G·cm)	Int.2 (kG·cm²)
0	0	0	0.53	0.7	0	0	23	-6
2	-0.01	-0.45	0.0	0.18	0.12	-0.18	-63	-3.5
5	-0.03	-0.4	-0.05	0.45	0.29	-0.46	-12	-2.7
12	-0.072	-0.45	-0.30	1.08	0.68	-1.1	-88	4.3
20	-0.12	-0.134	-0.27	1.3	1.14	-1.07	-34	-0.5
30	-0.18	-0.2	-0.7	1.65	1.7	-1.6	-47	-1.3
50	-0.3	-0.32	-1.0	1.95	2.4	-2.4	-58	2.9
78	-0.4	-0.43	-1.4	2	3.4	-3.1	-129	-23
90	-0.5	-0.5	-1.6	2.1	4	-3.7	-73	-43
123.2	-0.67	-0.67	-2.6	3.1	5.4	-5.2	-86	-42
170	-0.9	-0.9	-2.7	3.0	6	-5.7	-81	-74
200	-1	-1	-3.2	3.8	6.3	-6	-52	-61
230	-1.1	-1.1	-2.1	3.2	4.6	-4.6	-52	-74
260	-1.2	-1.2	-1.7	3.0	3	-3.1	23	-83
275	-1.2	-1.2	-1.5	3.1	2.1	-2.4	52	-77
300	-1.1	-1.1	-0.5	2.6	0.1	-0.3	-151	-118
332.7	-1	-1	0.55	1.5	-2.5	2.6	-58	-135
340	-1	-1	1.2	1.2	-3.4	3.3	-146	-154
380	-1.5	-1.2	2.7	0	-7	6.8	-49	-127
390	-1.6	-1.2	3.2	-0.6	-8	7.8	94	-126
420	-1.6	-1.2	2.8	0.4	-8.4	7.8	-46	-115
435	-1.6	-1.2	2.5	0.7	-8.4	7.8	10	-107



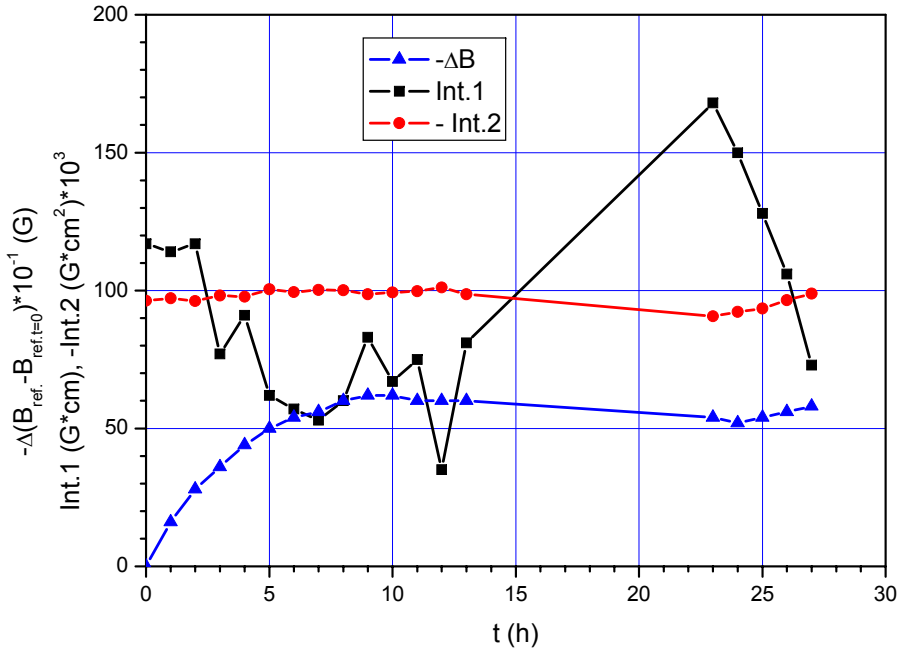

First field integral
$\Theta = \frac{ec}{E} I_1$
0.2 mrad
@ 700 MeV
Int.1 (G*cm)
Io (A)

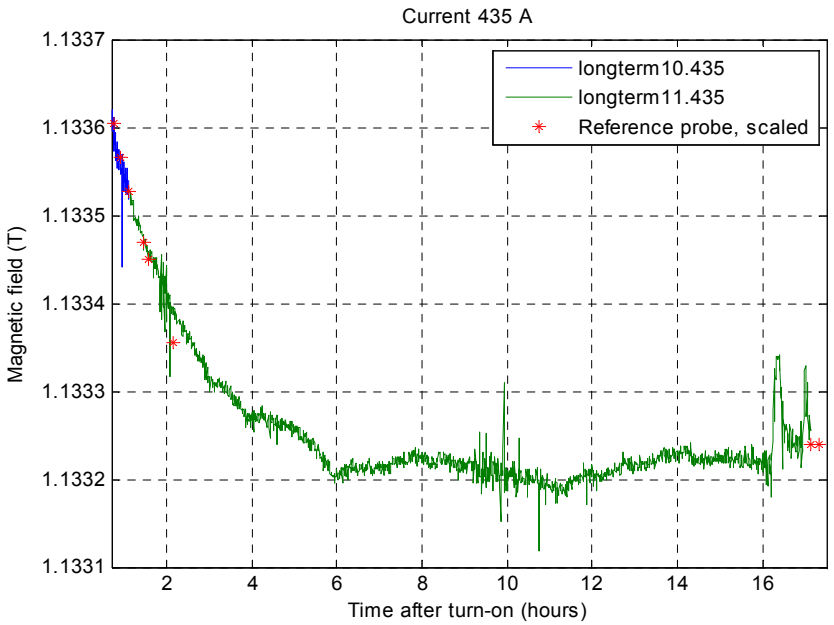

Second field integral
$x = \frac{ec}{E} I_2$
0.4 mm
@ 700 MeV
Int.2 (kG*cm^2)
Io (A)

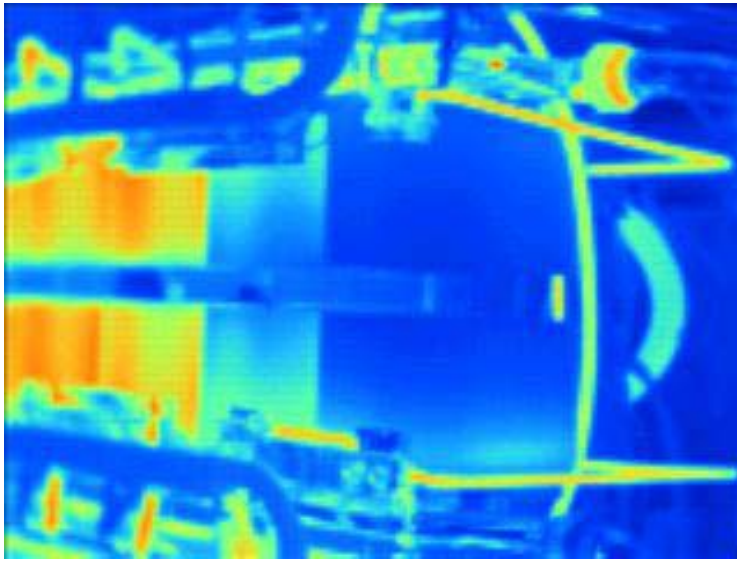

run 1 during tuning
run 2
run 3
run 4
run 5
Reproducibility
Integ. 2 (kG*cm^2)
Io(A)


Degaussing
B(G)
Z(mm)

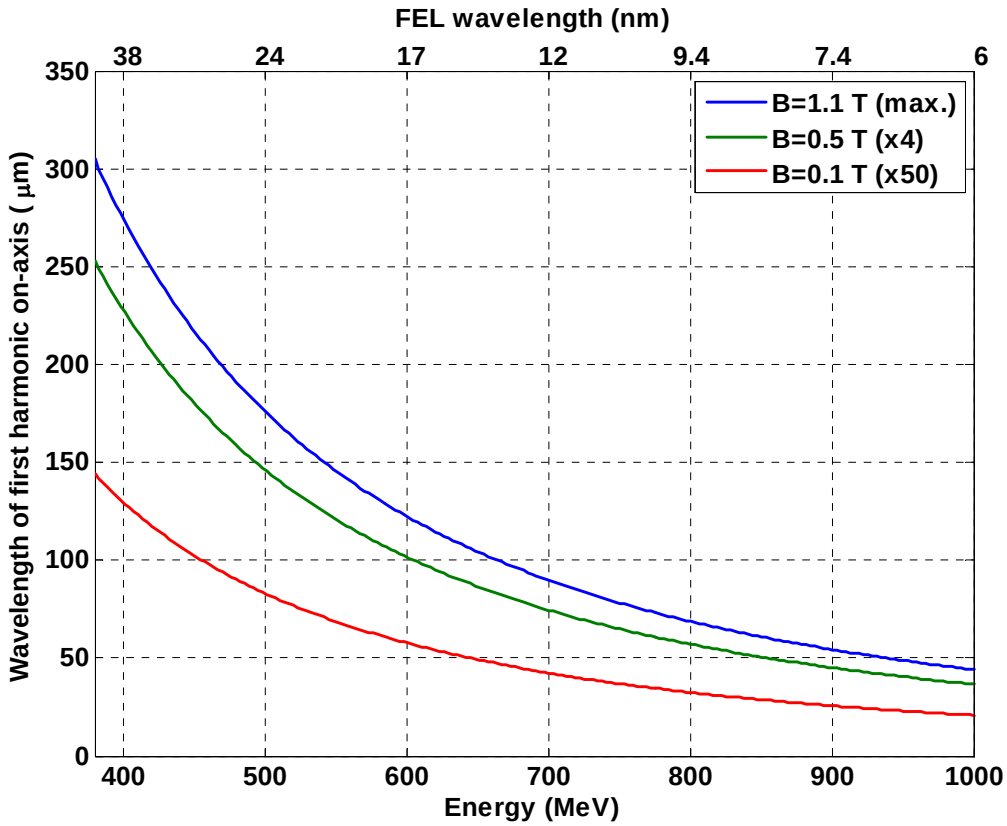
Long term temperature effects

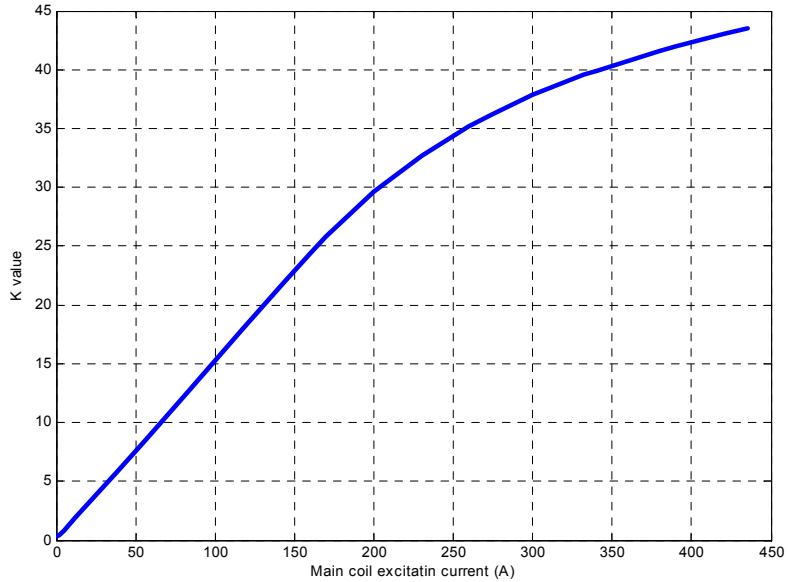


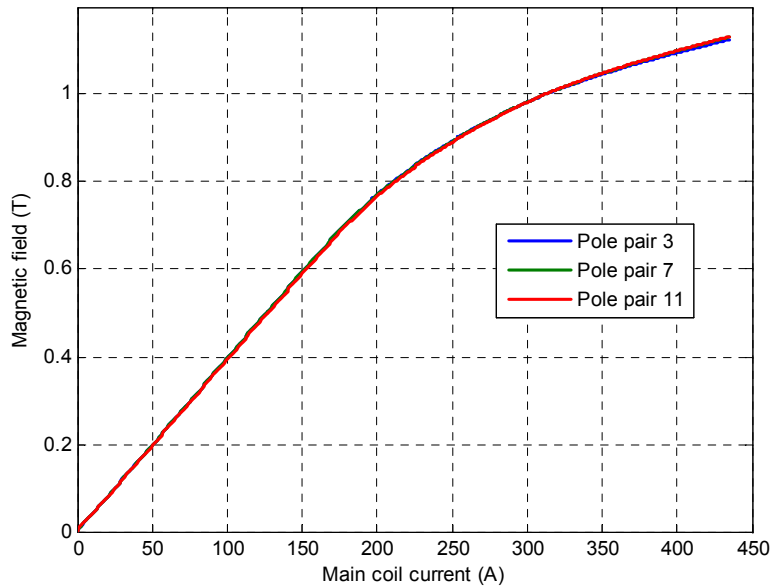




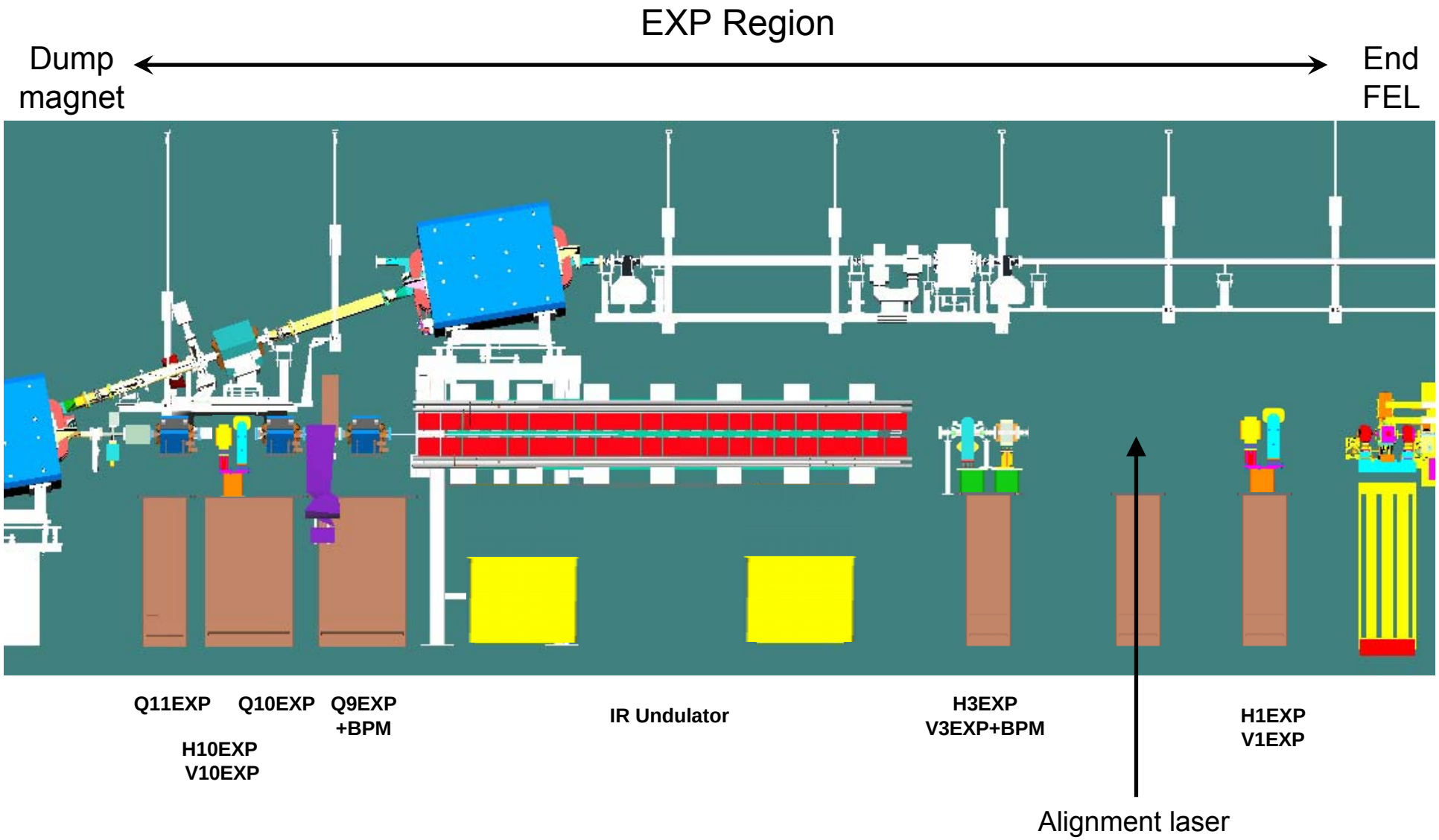
IR undulator first harmonic wavelength



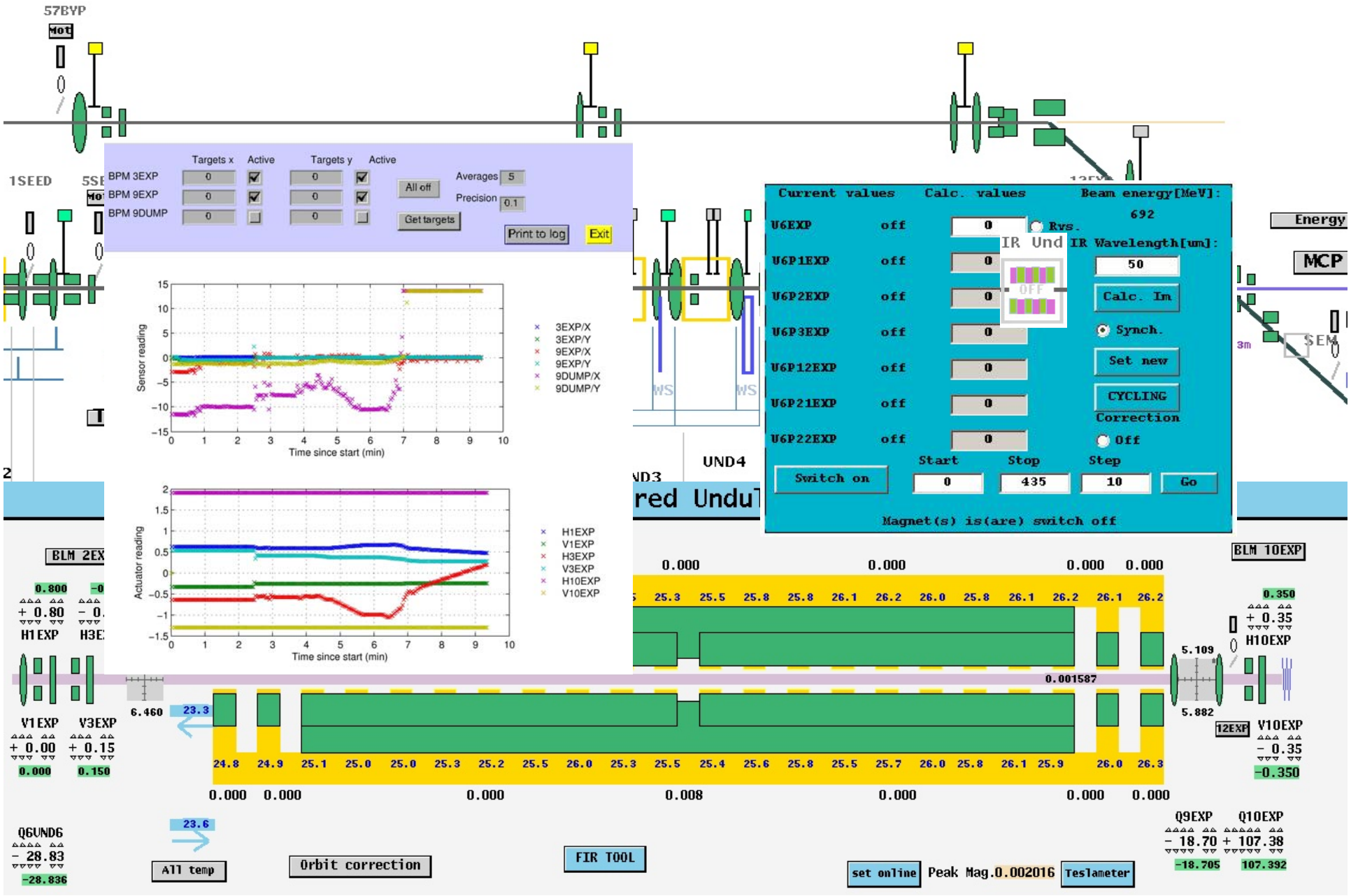




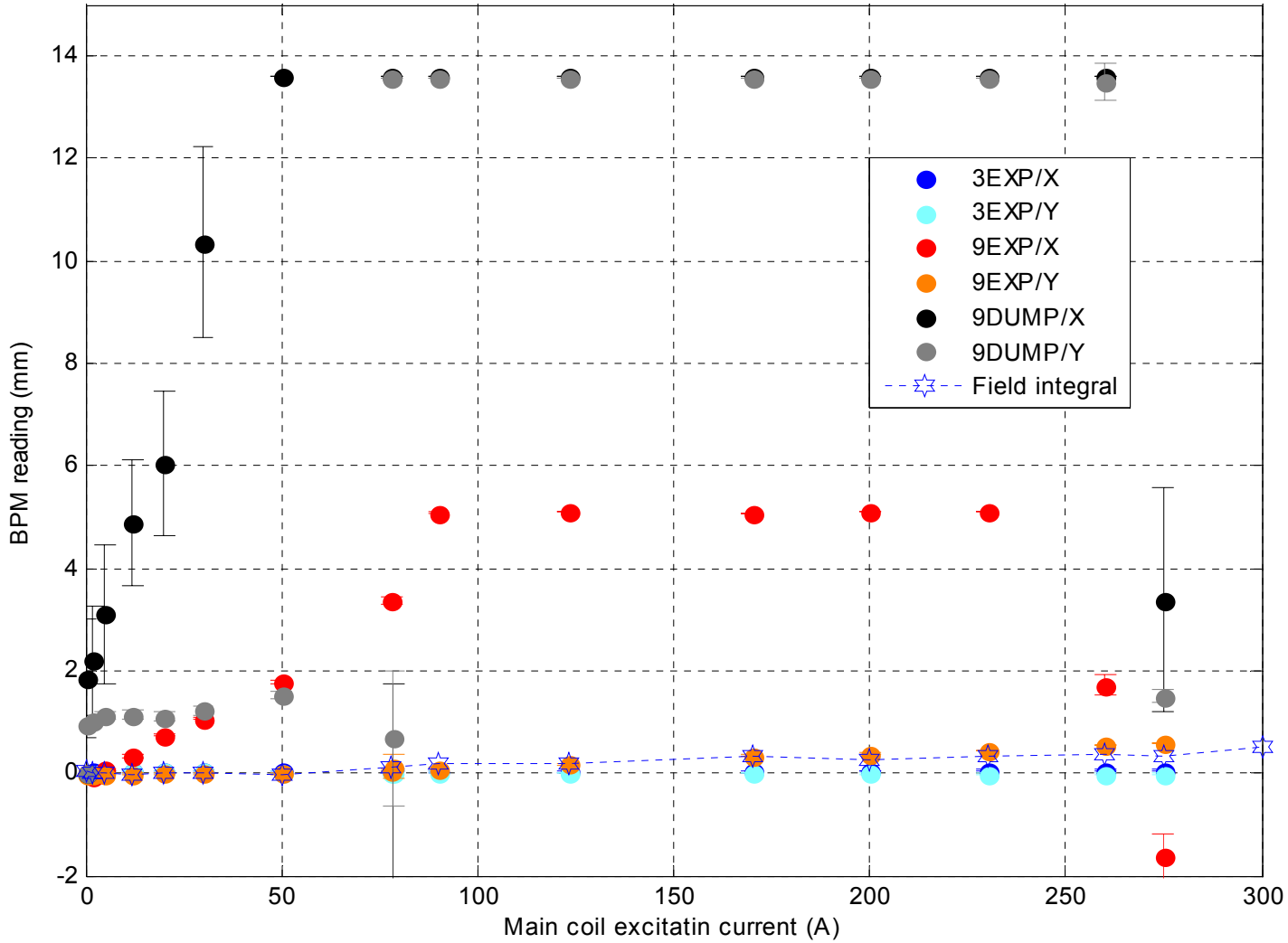
Layout of EXP area



DDD panels


57BYP
1SEED
BPM 3EXP
BPM 9EXP
BPM 9DUMP
Targets x
Active
Targets y
Active
All off
Averages
Precision
Get targets
Print to log
Exit
Sensor reading
Time since start (min)
3EXP/X
3EXP/Y
9EXP/X
9EXP/Y
9DUMP/X
9DUMP/Y
Actuator reading
H1EXP
V1EXP
H3EXP
V3EXP
H10EXP
V10EXP
Current values
Calc. values
Beam energy[MeV]:
692
U6EXP
U6P1EXP
U6P2EXP
U6P3EXP
U6P12EXP
U6P21EXP
U6P22EXP
off
Rvs.
IR Und
OFF
IR Wavelength[um]:
50
Calc. Im
Synch.
Set new
CYCLING
Correction
Off
Start
Stop
Step
Switch on
0
435
10
Go
Magnet(s) is(are) switch off
Energy
MCP
UND4
BLM 2EX
BLM 10EXP
H1EXP
V1EXP
V3EXP
H10EXP
V10EXP
12EXP
Q6UND6
Q9EXP
Q10EXP
All temp
Orbit correction
FIR TOOL
set online
Peak Mag.0.002016
Teslameter

Effect of IR undulator on orbit

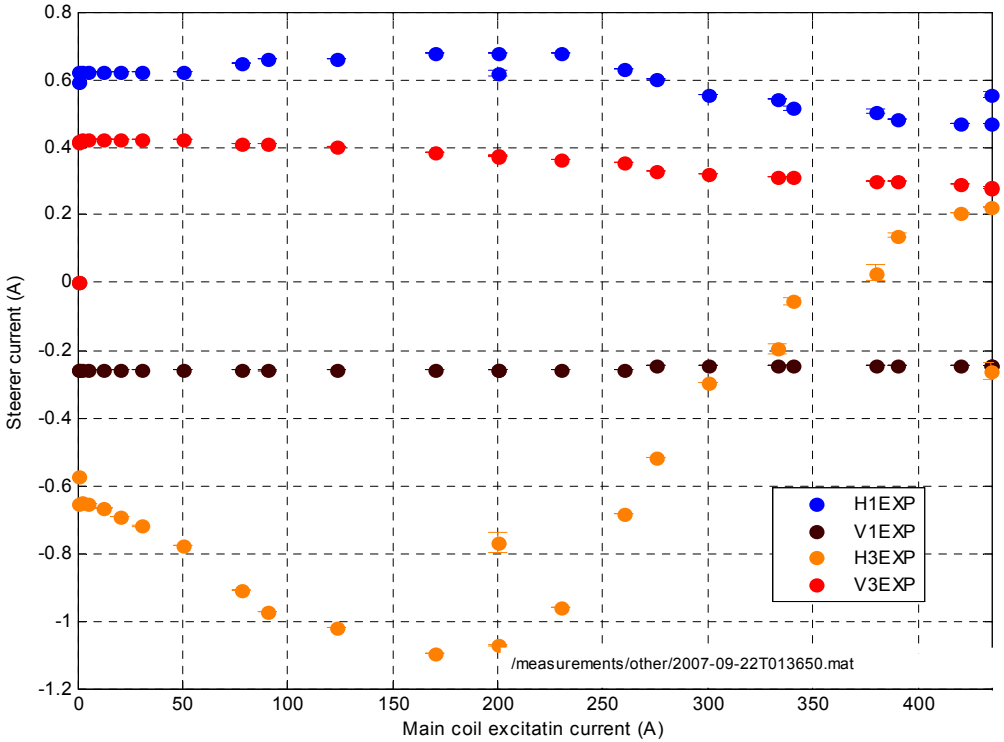


Measurements at 700 MeV, no orbit correction

$$\Delta x = \frac{ec}{E} I_2$$

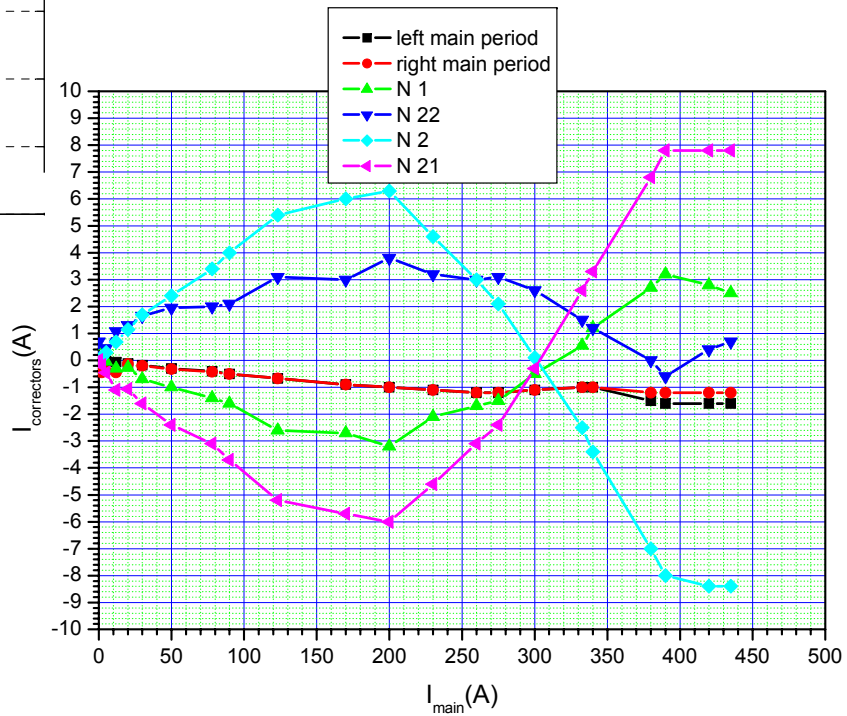
I_2: 2nd field integral

Required steerer currents to fix orbit



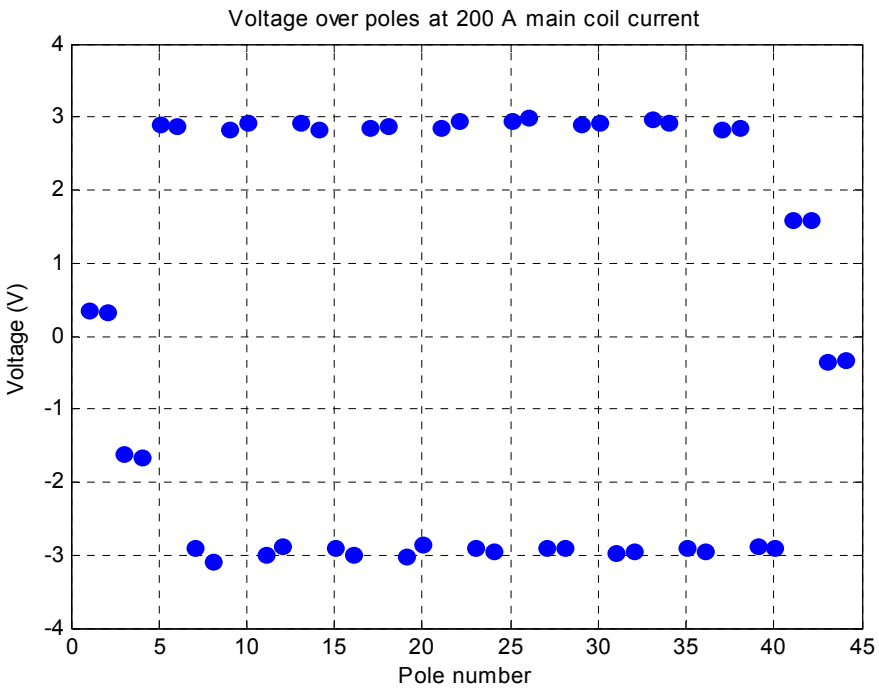
BPMs in front of and after undulator (3EXP and 9EXP) kept at zero reading by orbit feedback.
Undulator correctors as prescribed from tuning.

Currents of undulator correctors as determined from magnetic tuning



Coil measurements

Pole pair	1	2	21	22
Combined resistance (Ω) Voltage at 1 A (V)	1.06 1.07	1.05	1.11	1.07 1.06
Resistance top coil (Ω)	0.52	0.55	0.55	0.55
Resistance bottom coil (Ω)	0.55	0.56	0.53	0.52

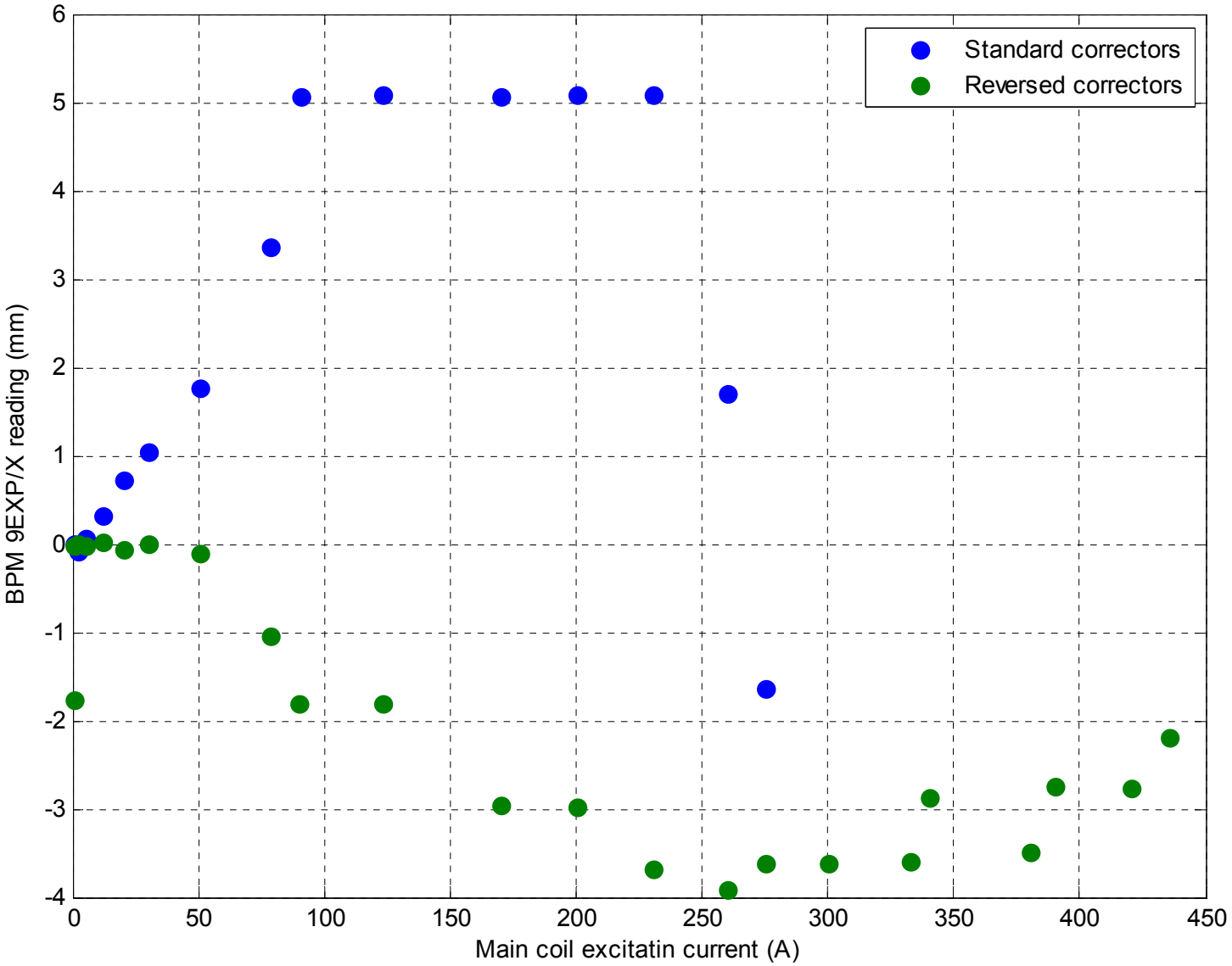


Same fluctuations as measured at JINR.

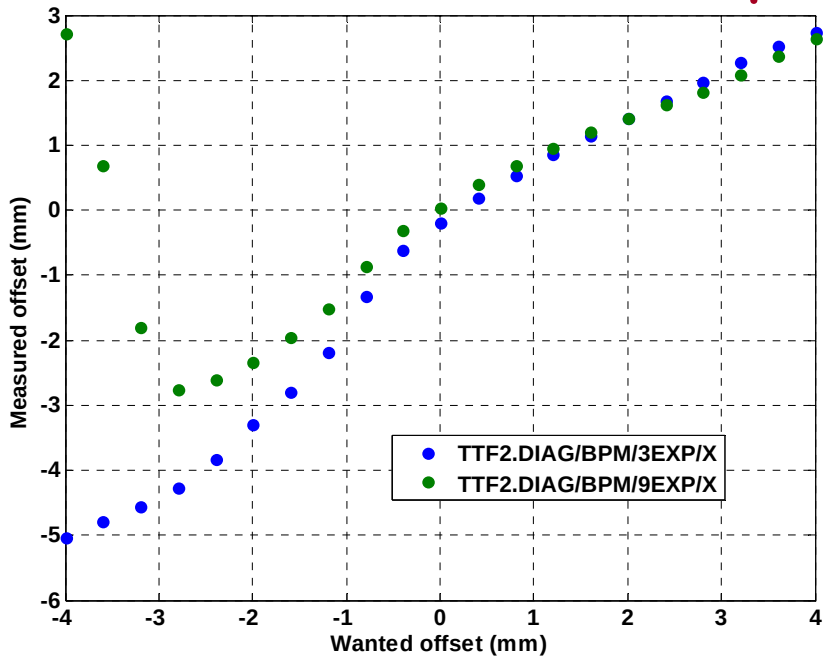
Total voltage U6P3EXP @ -1 A: -15.22 V
U6P12EXP @ -1 A: -20.96 V
@ +1 A: +22.12 V

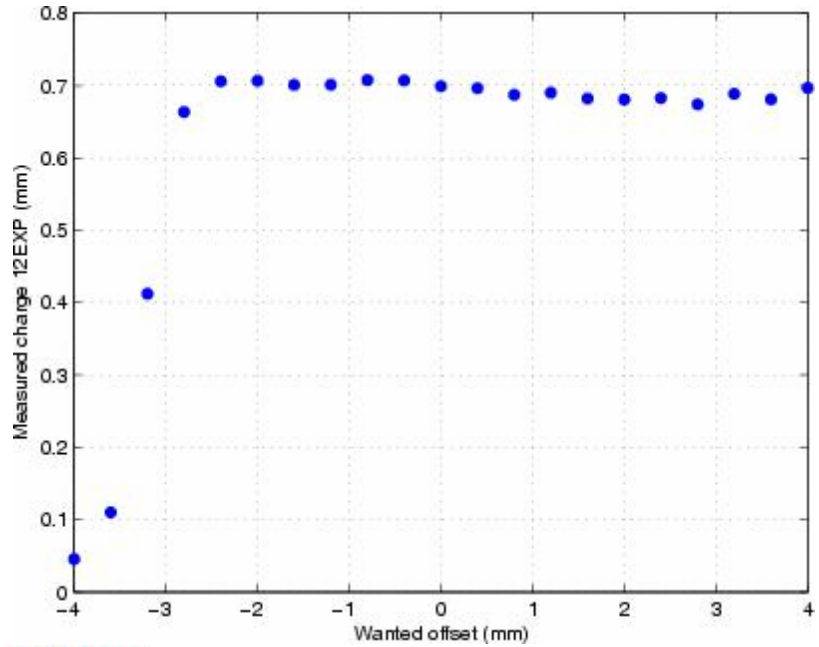
Resistance of 1st corrector coil ≈9 mΩ,
2nd corrector coil ≈15 mΩ,
main coils ≈30 mΩ.

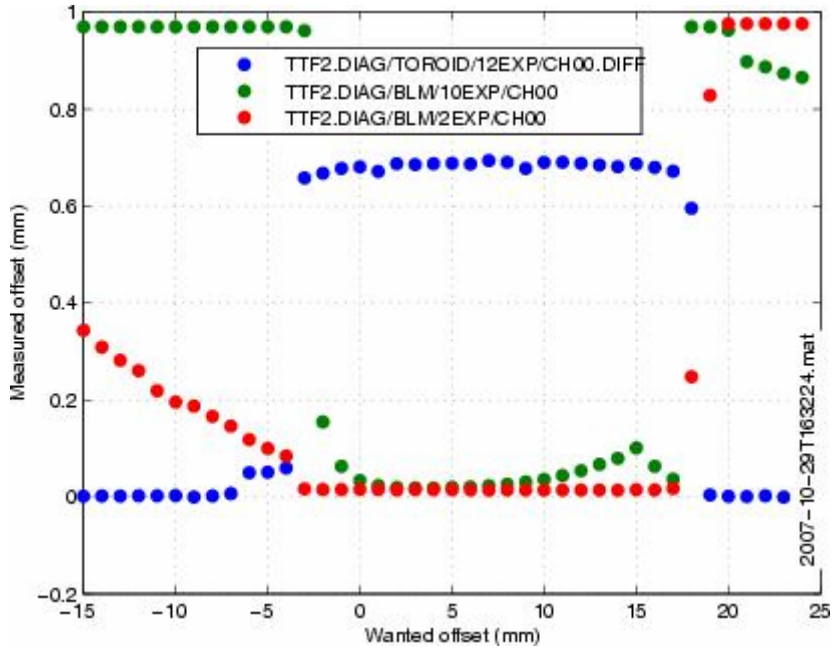
Reversing all correctors helps…



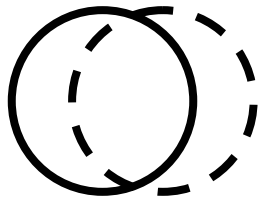
Beam displacement studies



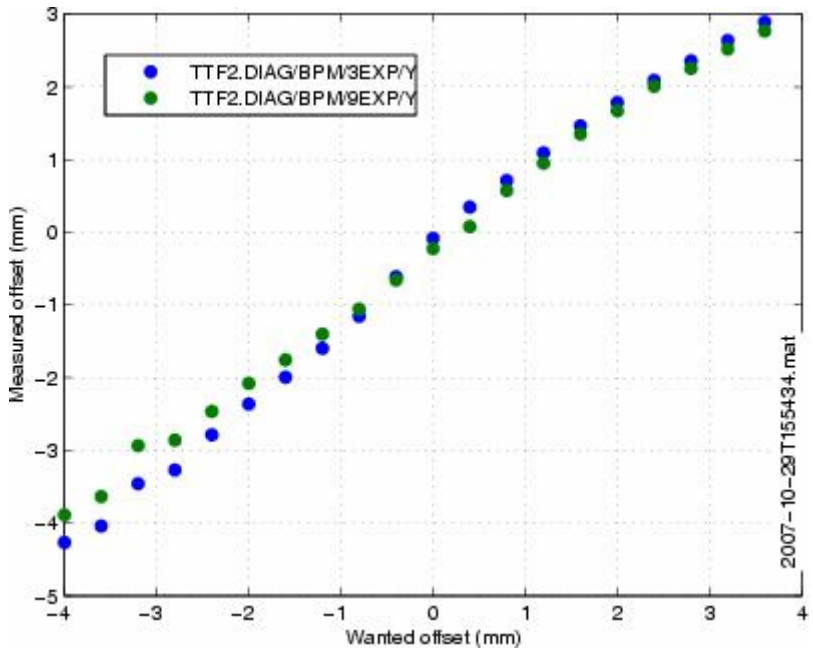




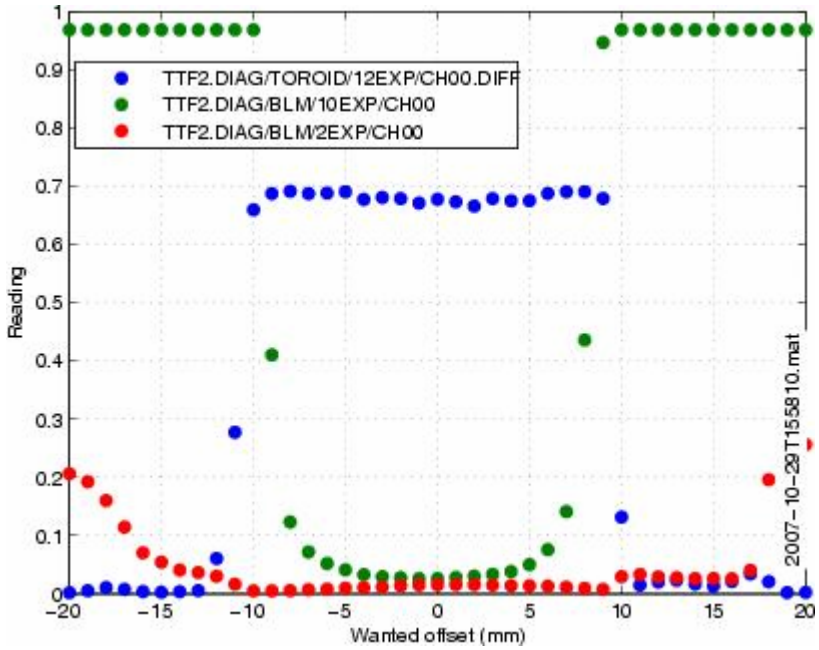
35 mm inner diameter beam pipe



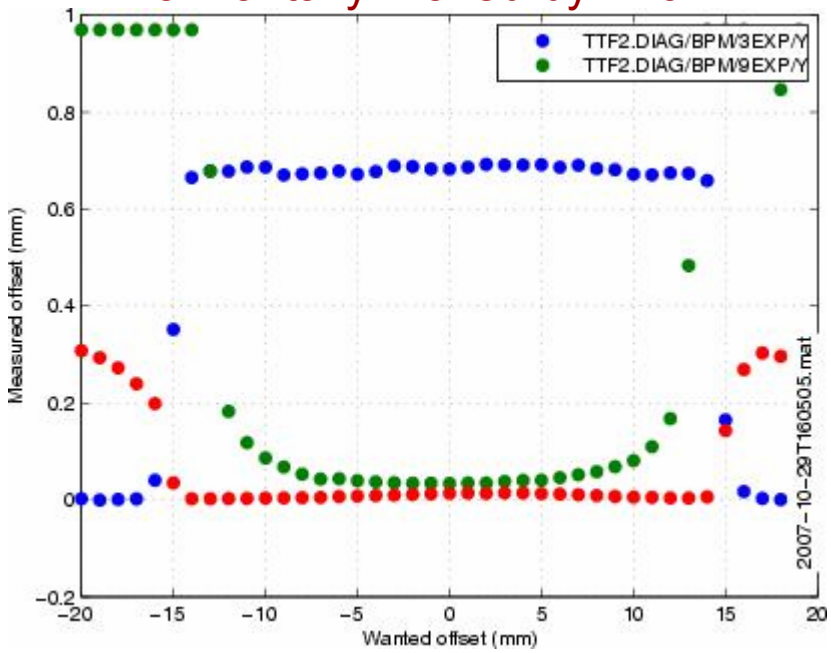
OTR chamber 12EXP indeed horizontal offset by ≈6 mm
… but *after* BPM 9EXP



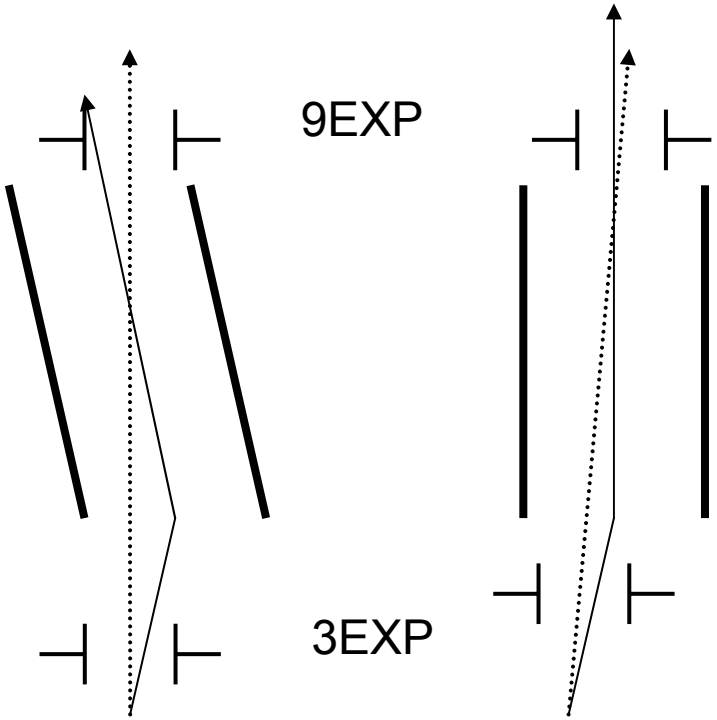
Horizontally centred



Horizontally moved by ≈10 mm

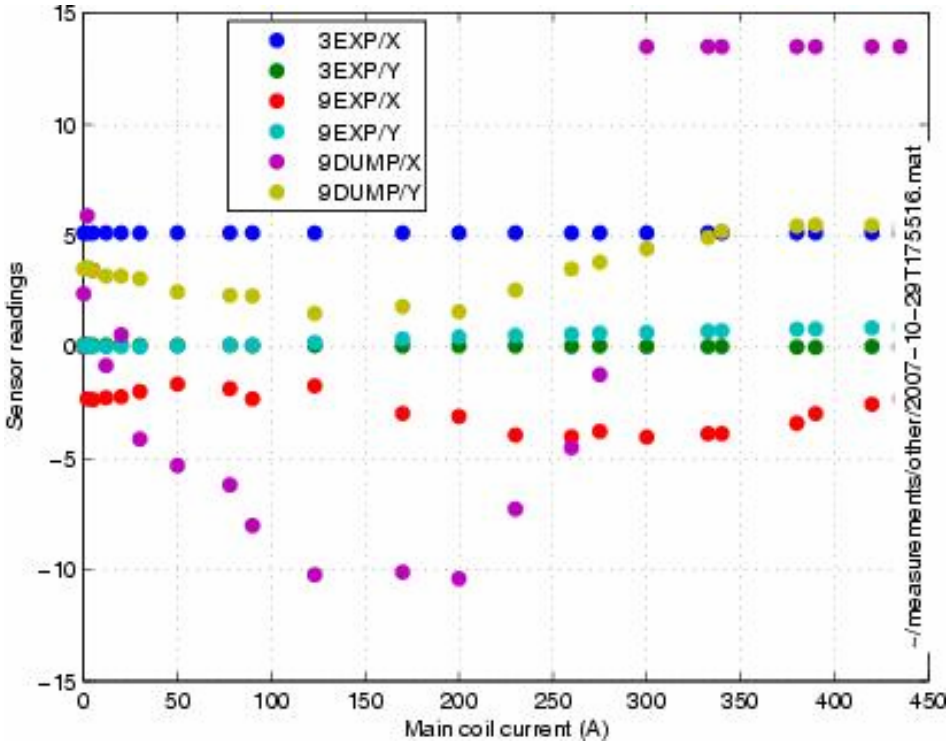


…if undulator would be tilted with respect to BPM zero?



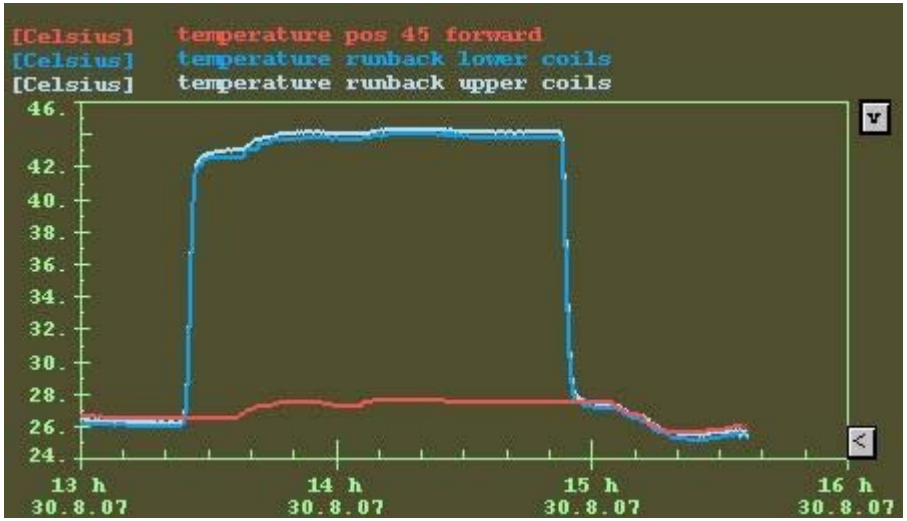
Field integrals valid for
on-axis beam transport

Beam moved horizontally to +10 mm on BPM 3EXP and -2.5 mm on BPM 9EXP. All correctors reversed.

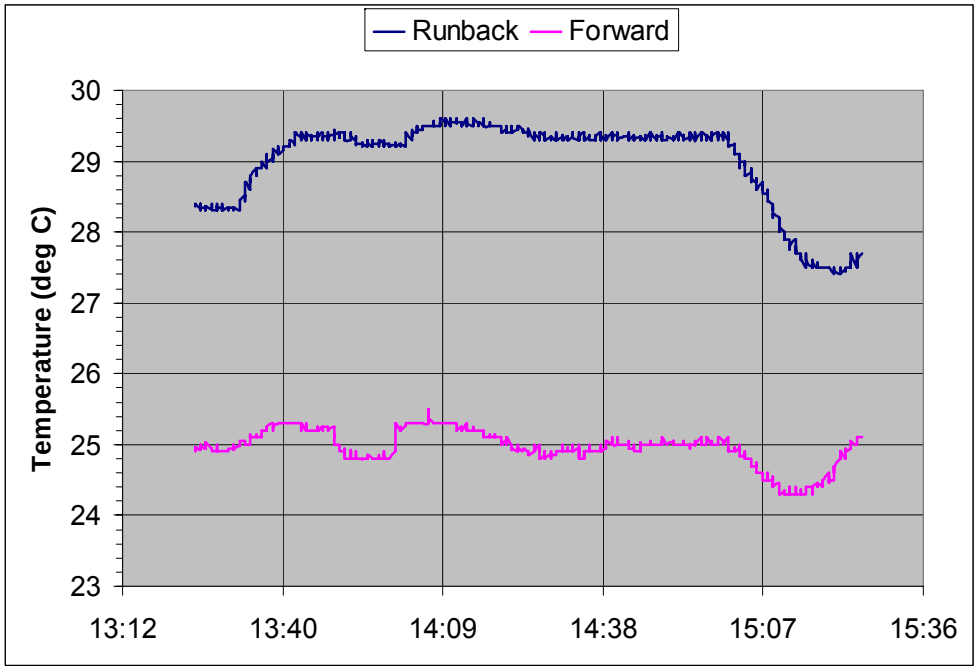


Temperatures

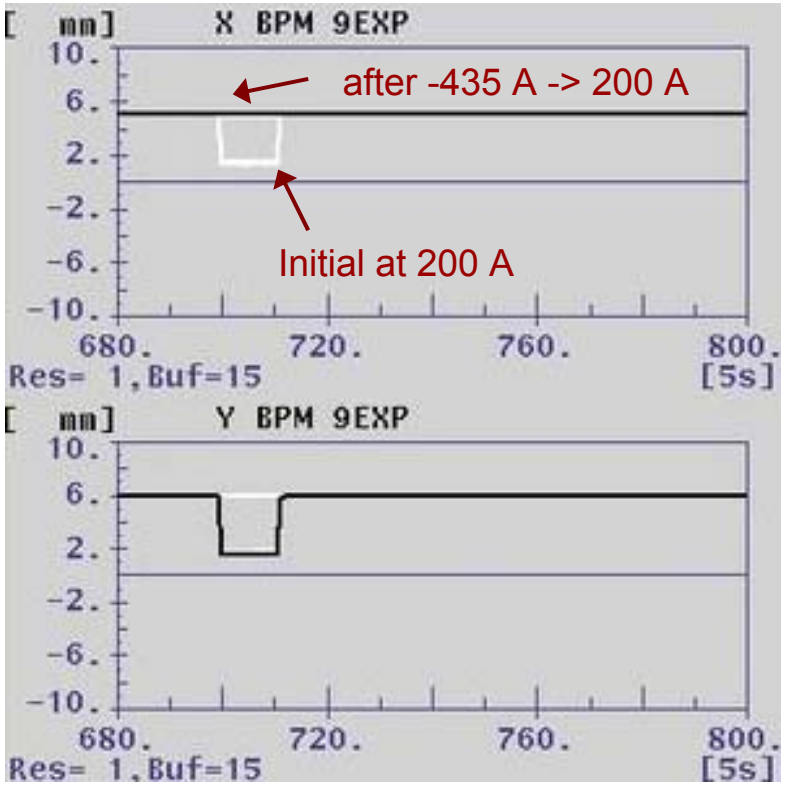
Sensors at undulator

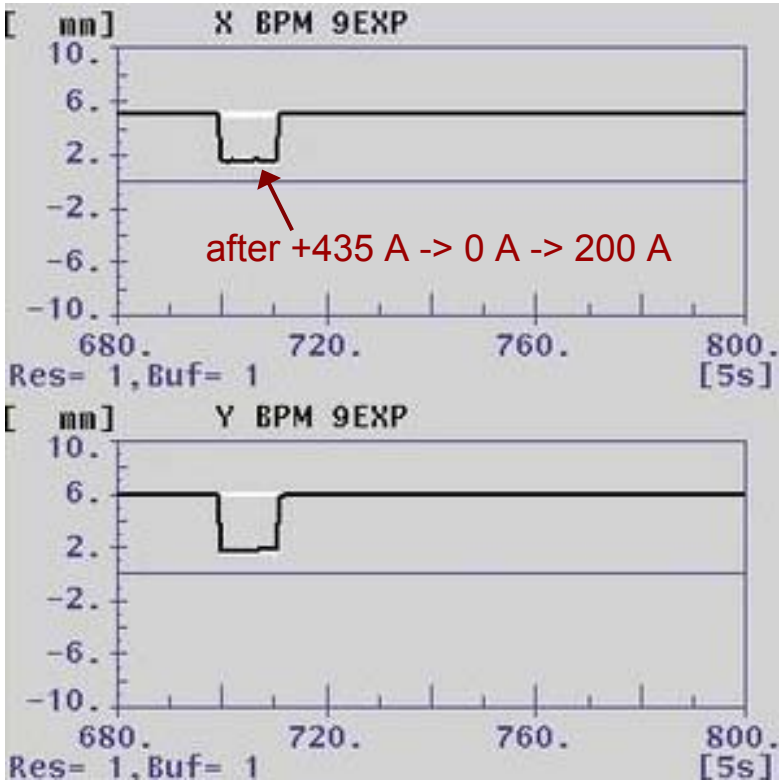


Sensors at cooling tower



Reproducibility after reversing current





Conclusions / Outlook

- Electron beam transported without losses to dump at all undulator settings (using orbit feedback, not yet tried in long-pulse mode)
- Discrepancy between expected and measured orbit displacement
  → critical if this would strongly affect the radiation properties - not seen (yet?)

- Correct aperture problem and strong beam steering effect
  → Again measure/realign EXP section
- Establish fully parasitic operation and/or final protection system
  ("laser" safety)
- Study radiation properties and dependence on undulator settings

- *Use it as source and beam diagnostics tool*