PAUL SCHERRER INSTITUT

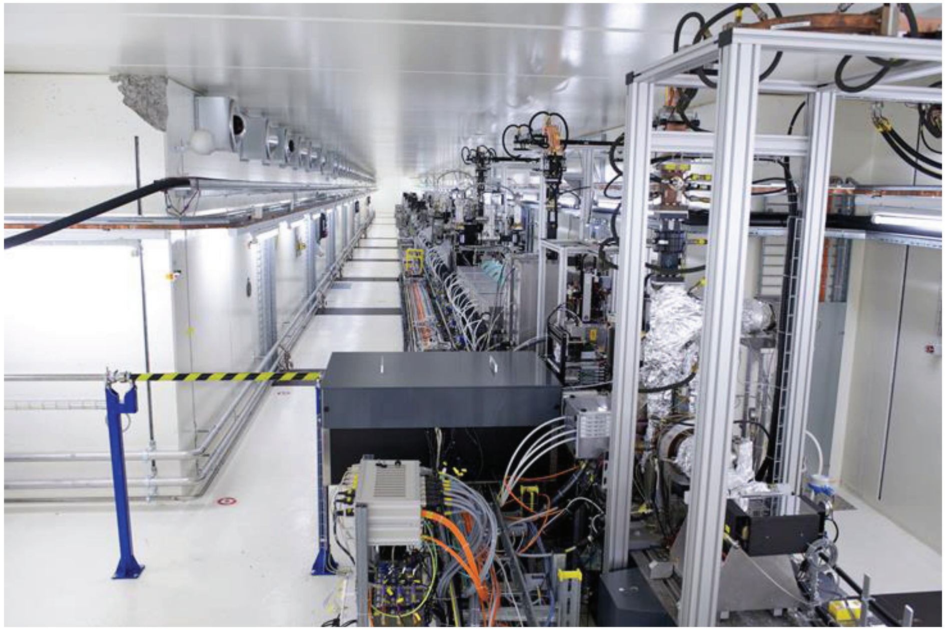
Paul Scherrer Institut

FEL14 – Basel 25.08.14

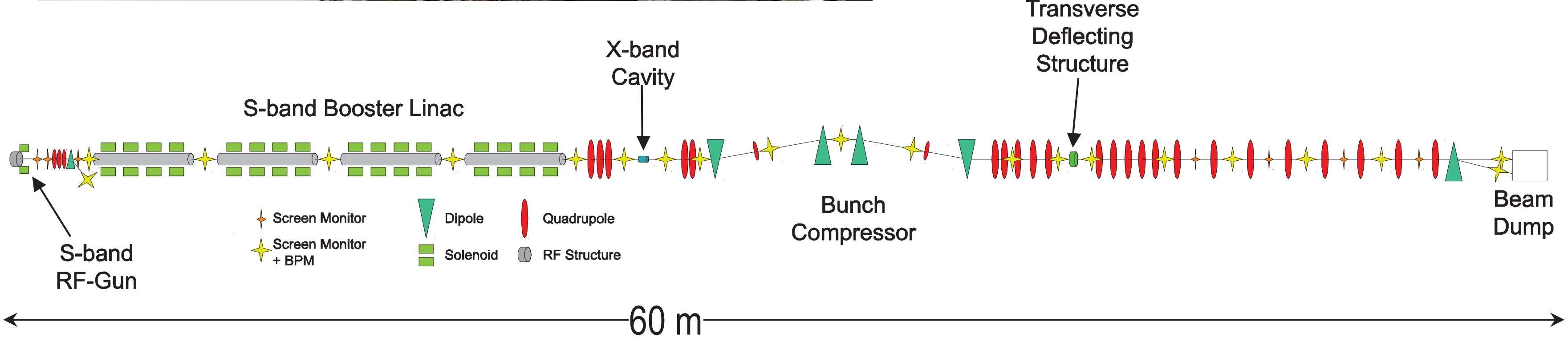
Observation of SASE at the SwissFEL Injector Test Facility

R. Ganter on behalf of the SwissFEL Team

SwissFEL Injector Test Facility



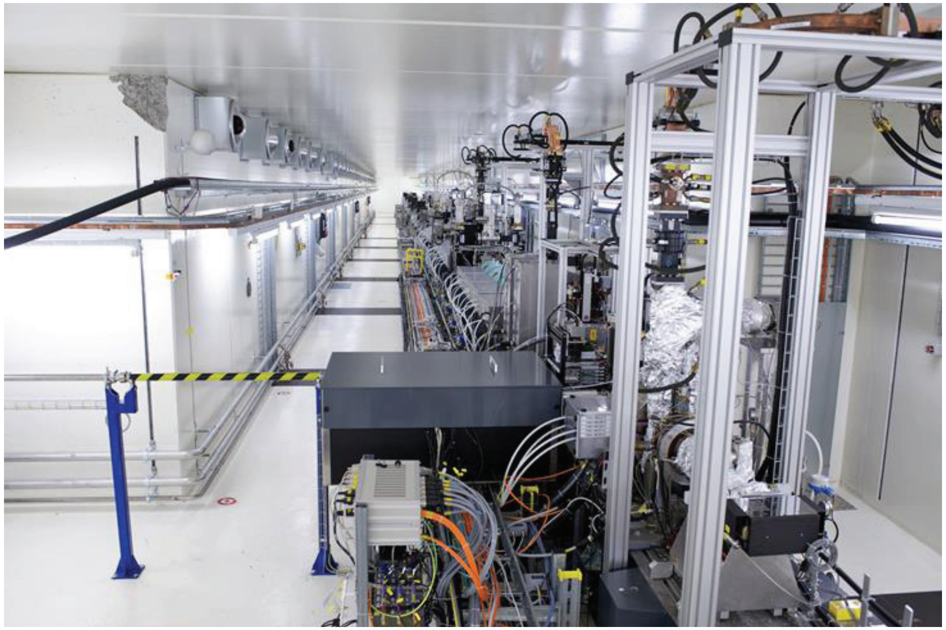
Nominal Parameters:
220 MeV; 10 Hz; 200 pC
$\varepsilon_{n,slice}$=0.3 µm at 100 A



Test facility for SwissFEL components.

Courtesy of M. Pedrozzi

SwissFEL Injector Test Facility



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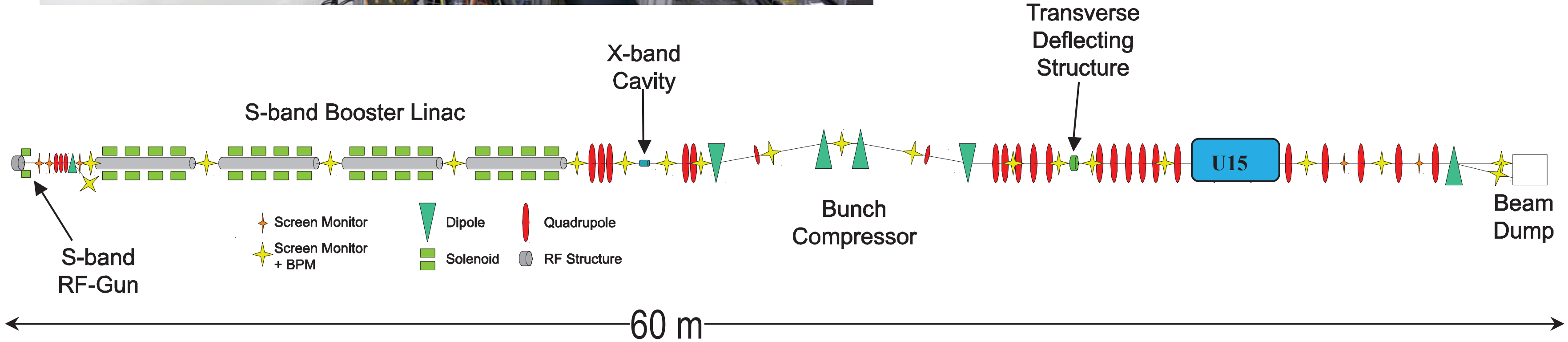
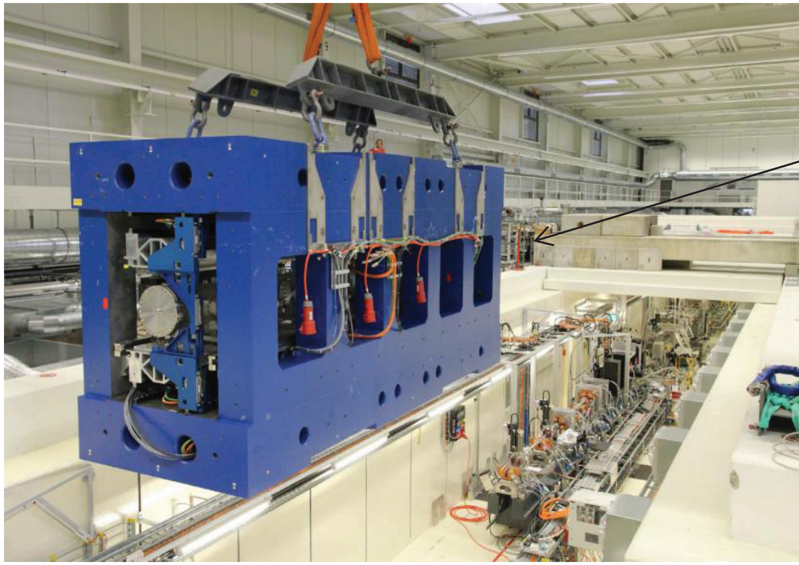


Test facility for SwissFEL components.

Courtesy of M. Pedrozzi

U15 Undulator Installation in Tunnel



December 2013: Installation in Tunnel of the undulator

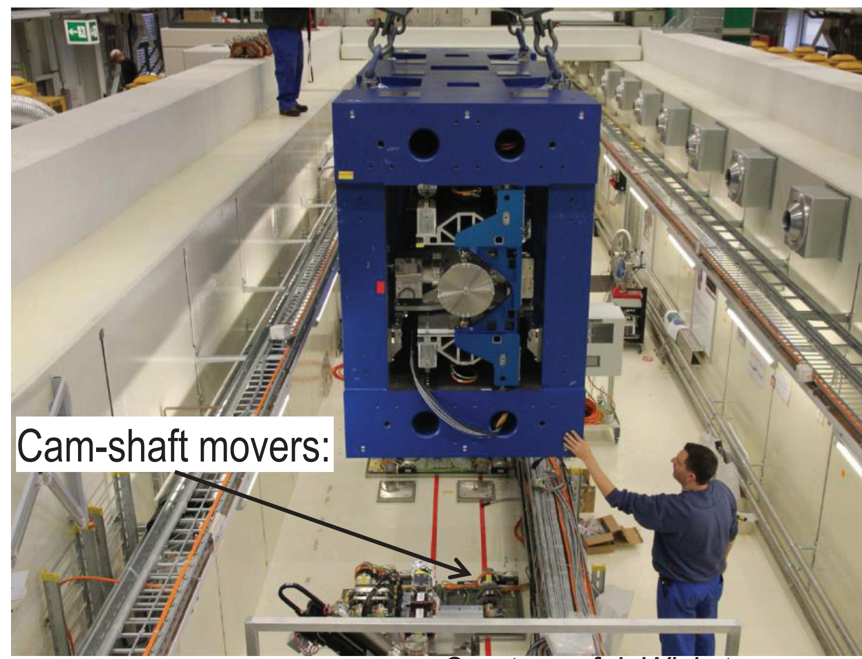
U15 Parameters:

λ_U=15 mm; In vacuum – Hybrid;

1.0 < K < 1.8

4 m long; 17 tons;

266 periods; Nd-Fe-B (Dy)



Courtesy of J. Wickstroem

First SASE FEL at PSI

Operation started on 15th of January:

After a few hours operation and some compression: 1st SASE FEL lasing at PSI.

200 MeV; λ~100 nm
I~ 100 A
gap = 3.8 mm; K=1.48

Electron beam

Photon beam

YAG Screen

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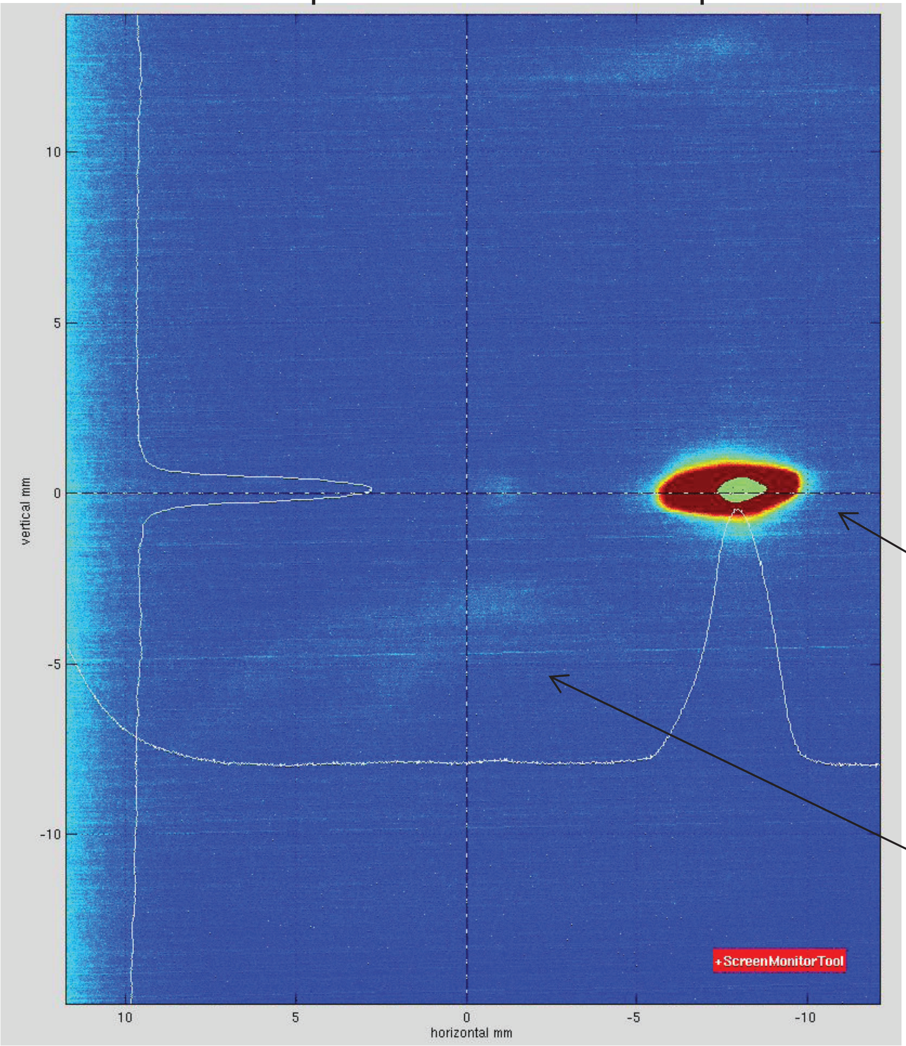

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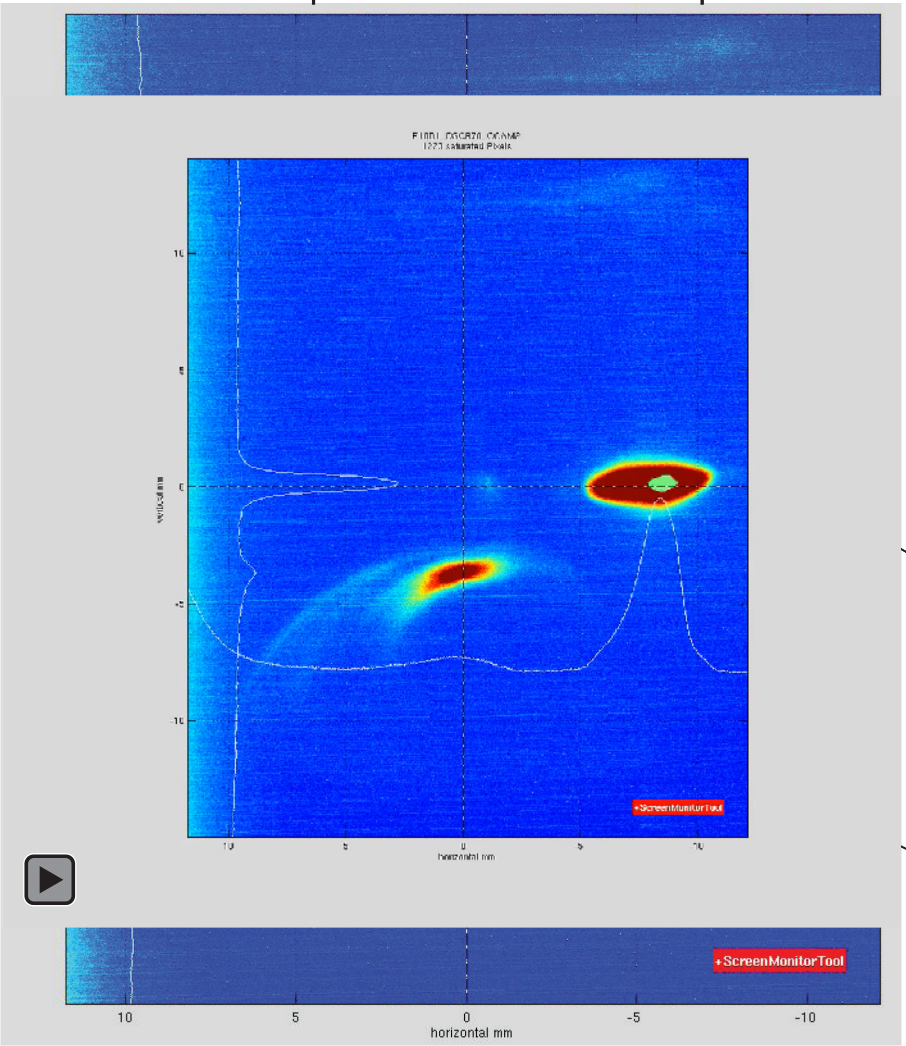

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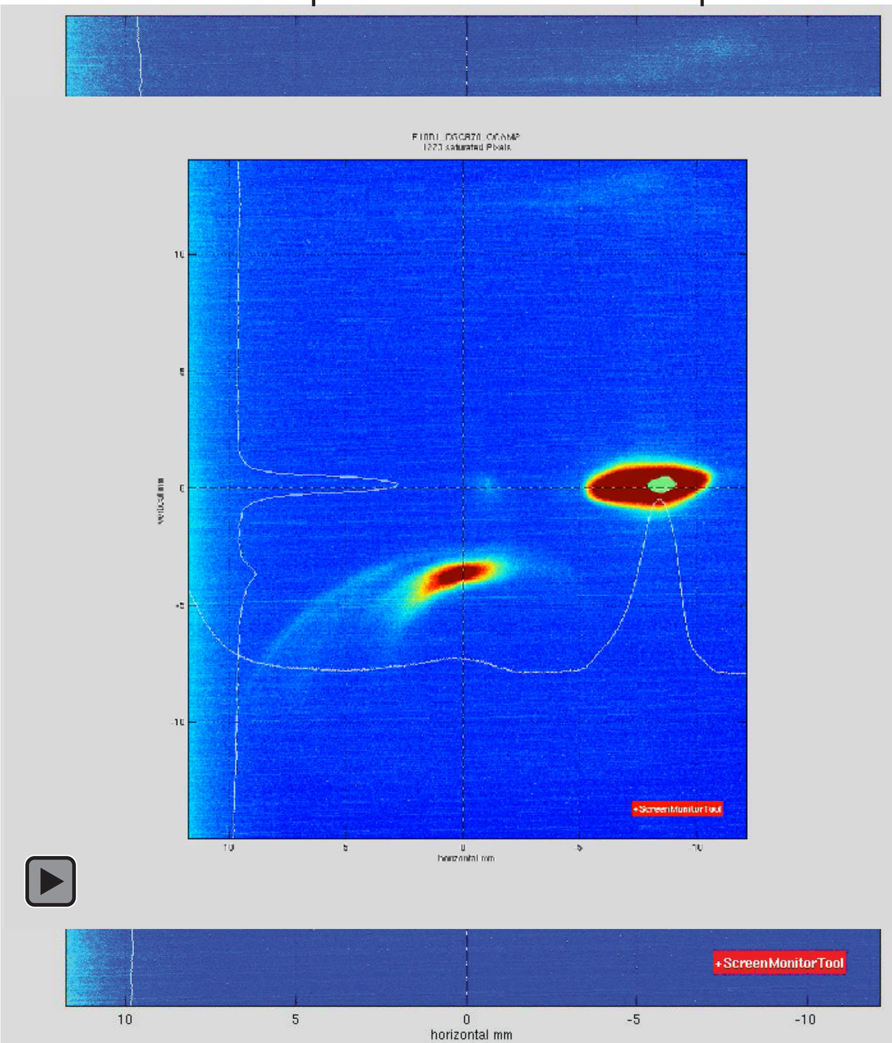


YAG Screen

200 MeV; λ~100 nm
I~ 100 A
gap = 3.8 mm; K=1.48

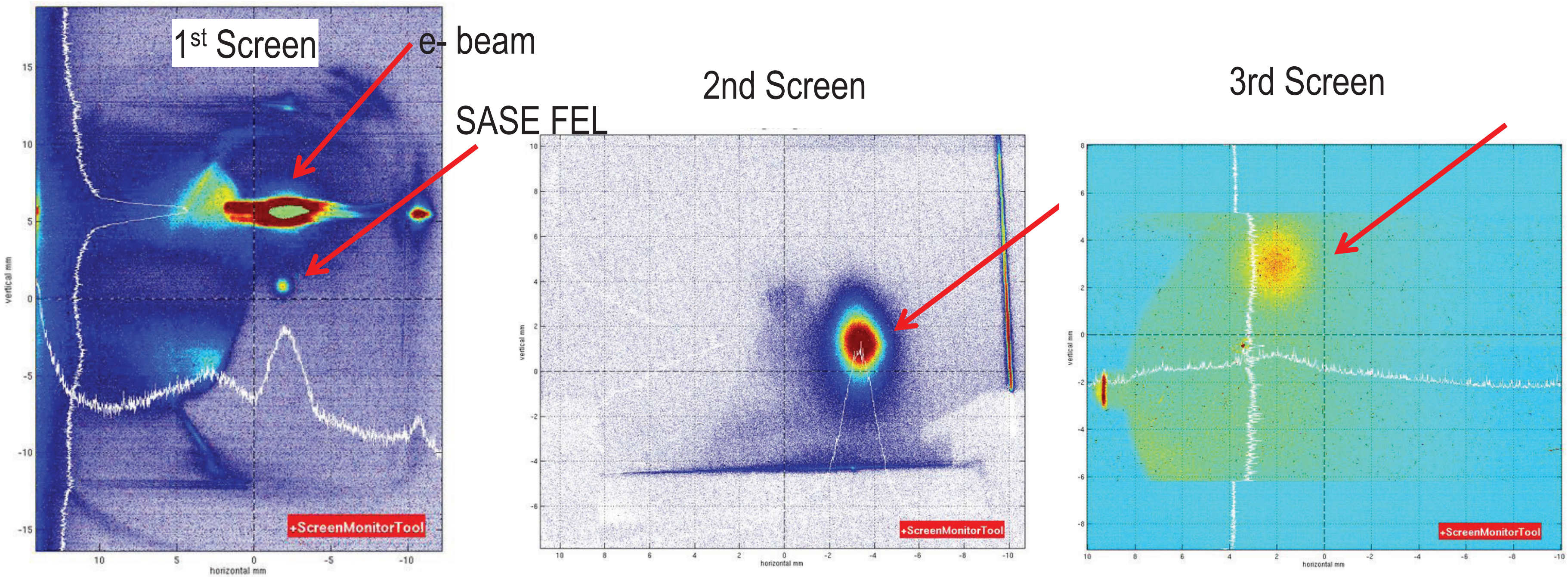
Electron beam

Photon beam

But … SASE beam is not round (reflection) !

Because of undulator vertical dipole kicks !

SASE scintillation on 3 YAG screens



Z=1.1 m
Distance from U15 exit

Z=2.2 m

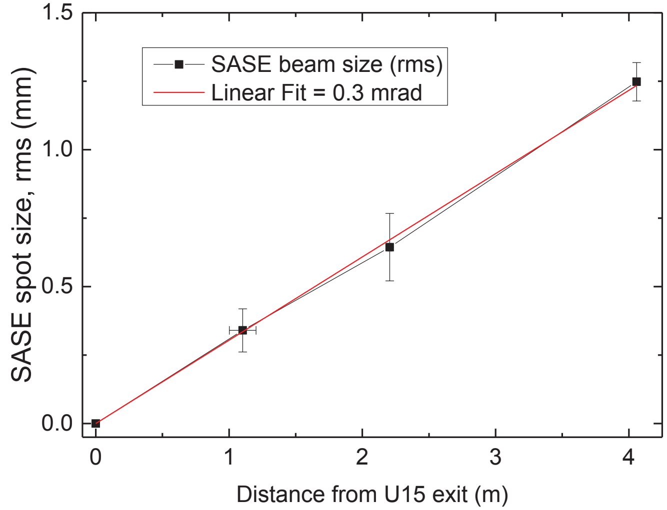
Z=4.0 m

130 MeV; 200 pC
~100 A
K=1.28
λ=210 nm

Measured divergence = 0.3 mrad (-> SASE)

Comparison to Genesis FEL divergence

Measurement:



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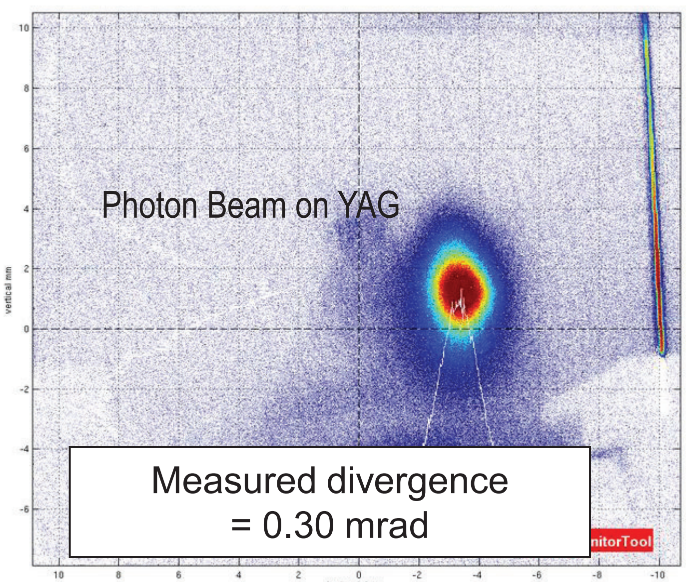
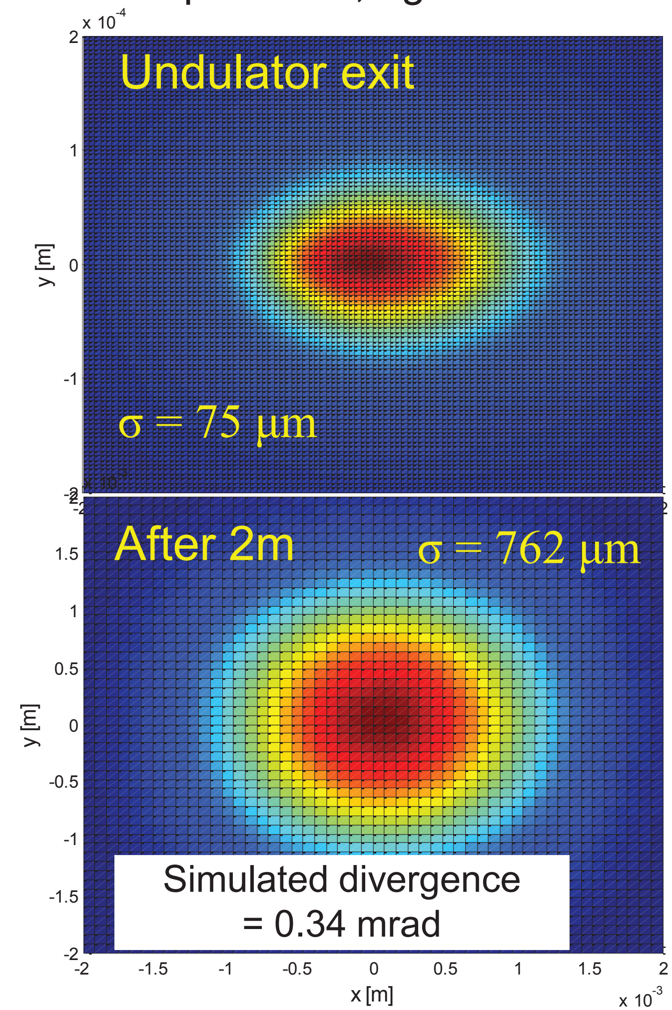


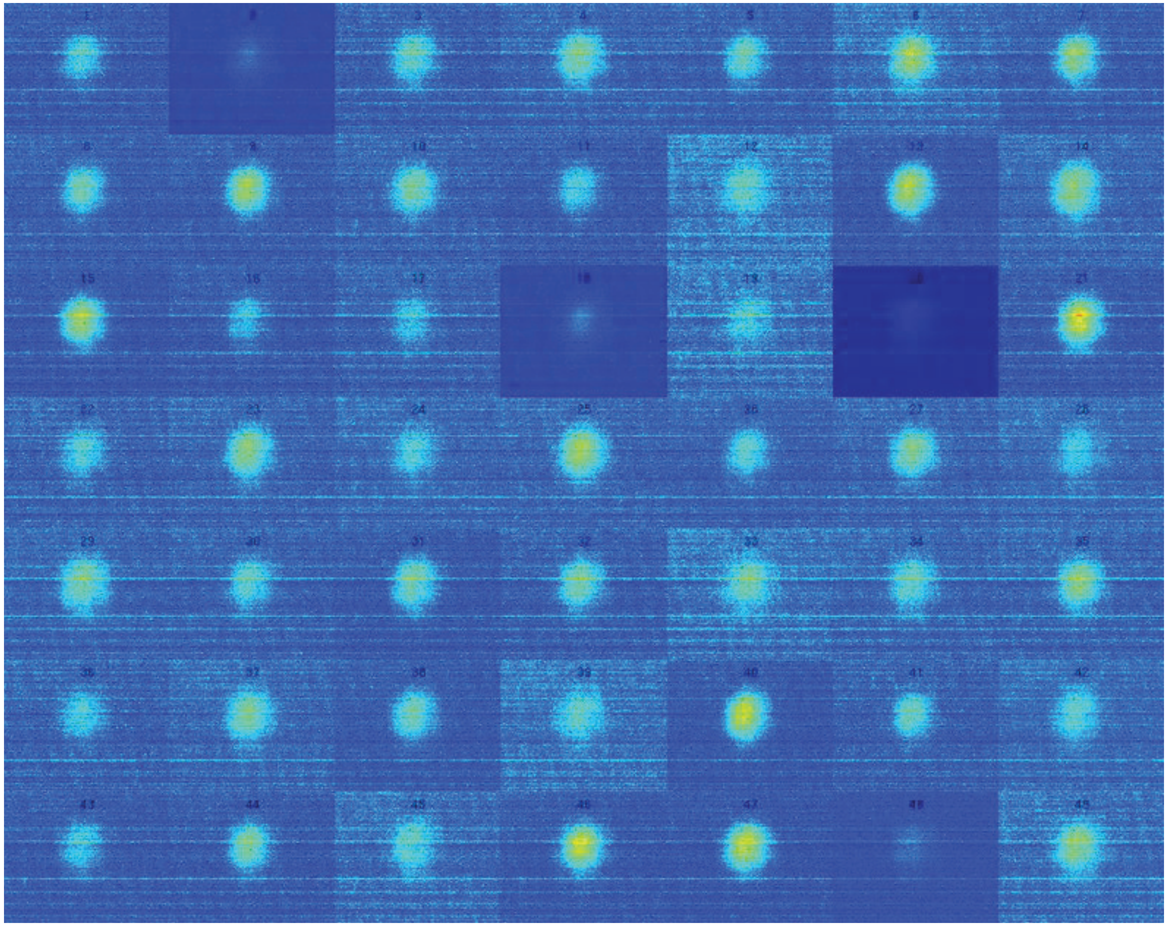
Simulation:

$\varepsilon_{n,slice}$= 0.5 um rms
ρ= 2.e-3 ; Lg= 30 cm



See MOP053

SASE fluctuations



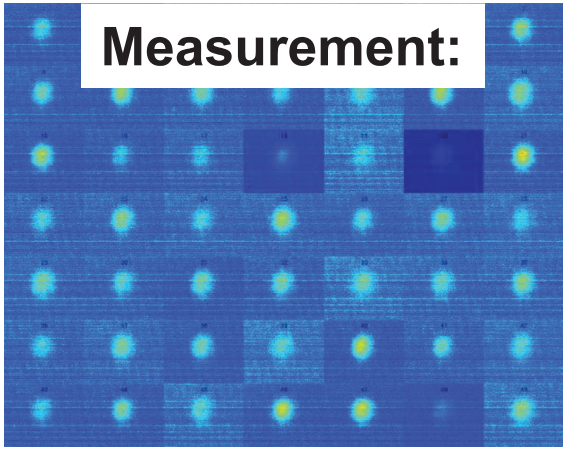
1st Screen
(0.5 m downstream U15)

130 MeV; 200 pC
~100 A
K=1.28
λ=210 nm

This is scintillation on YAG … YAG is not so efficient at 210 nm.

Intensity fluctuations should follow a gamma distribution: $p(E) = \frac{M^M}{\Gamma(M)} \left(\frac{E}{\langle E\rangle}\right)^{M-1} \frac{1}{\langle E\rangle} \exp\left(-M\frac{E}{\langle E\rangle}\right)$

FEL SASE statistics for compressed beam



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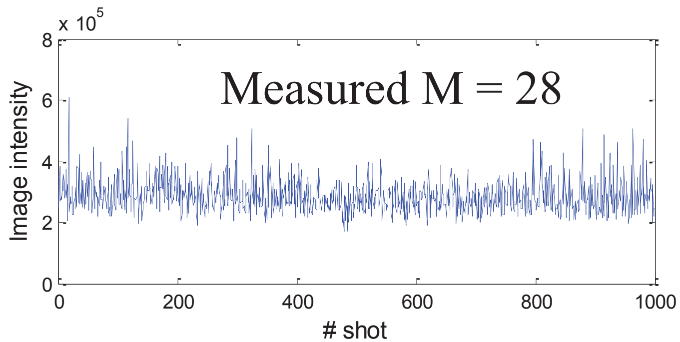
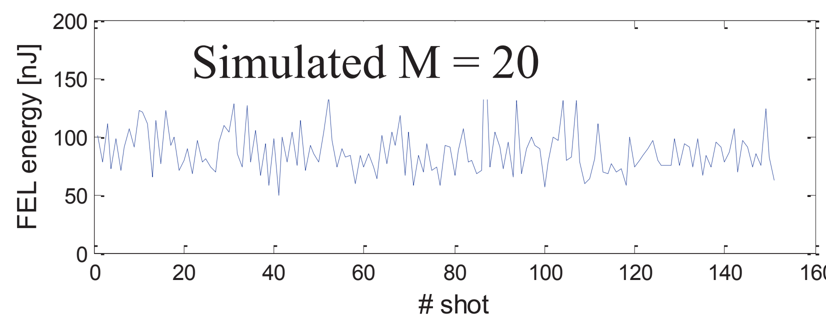
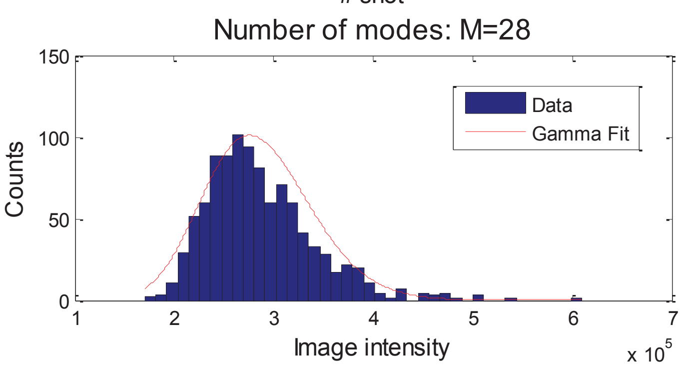
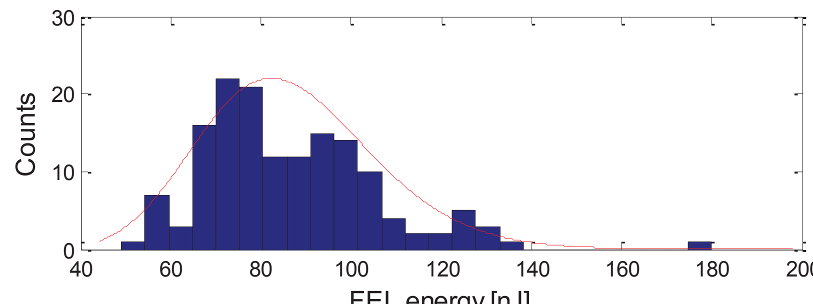
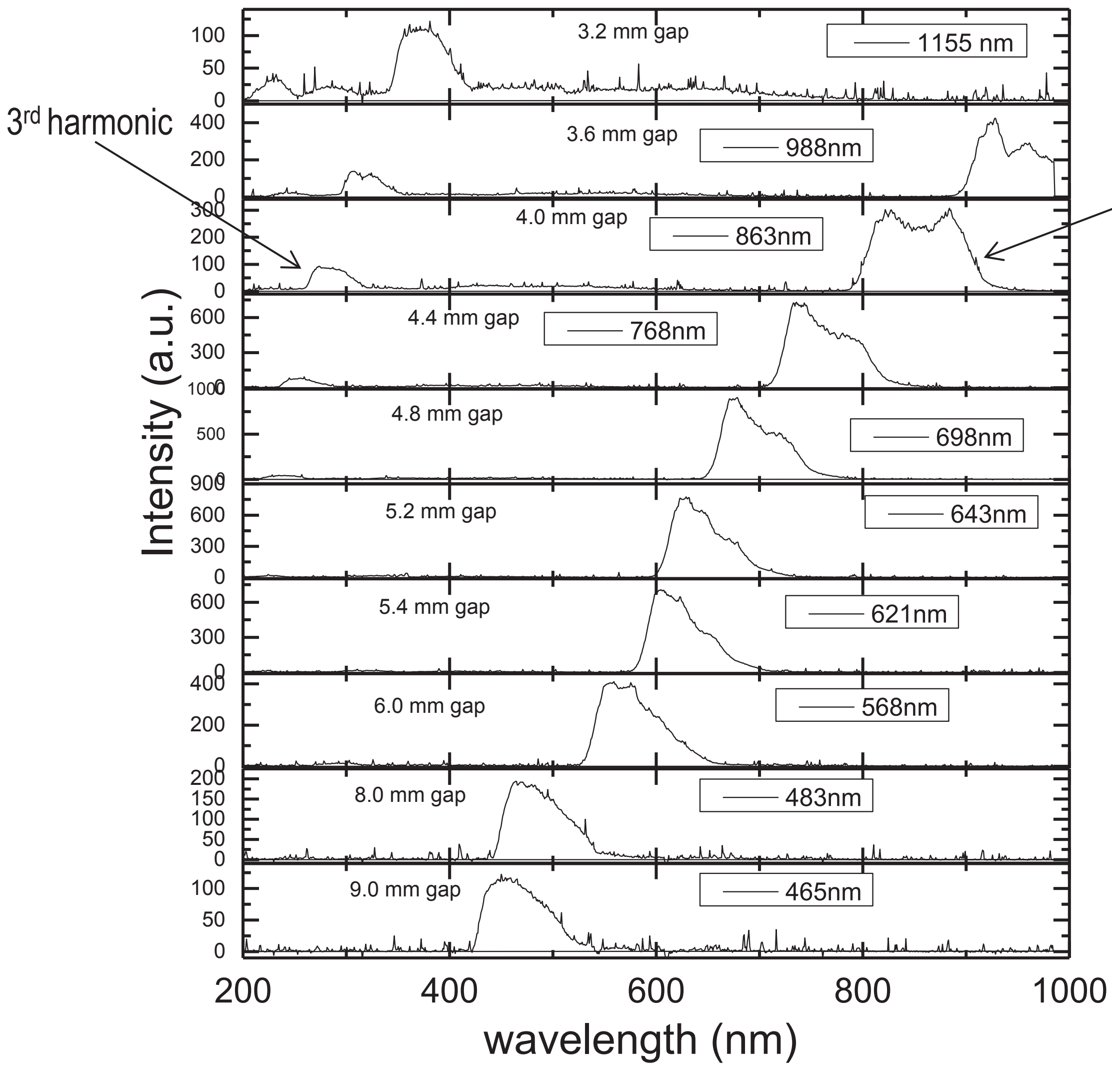








Undulator Tunability



Spectrum width dominated by electron bunch energy spread

Tunability with undulator gap:

3.2 mm to 9 mm

1.8 > K > 0.5

69 MeV; 200 pC; 100 A

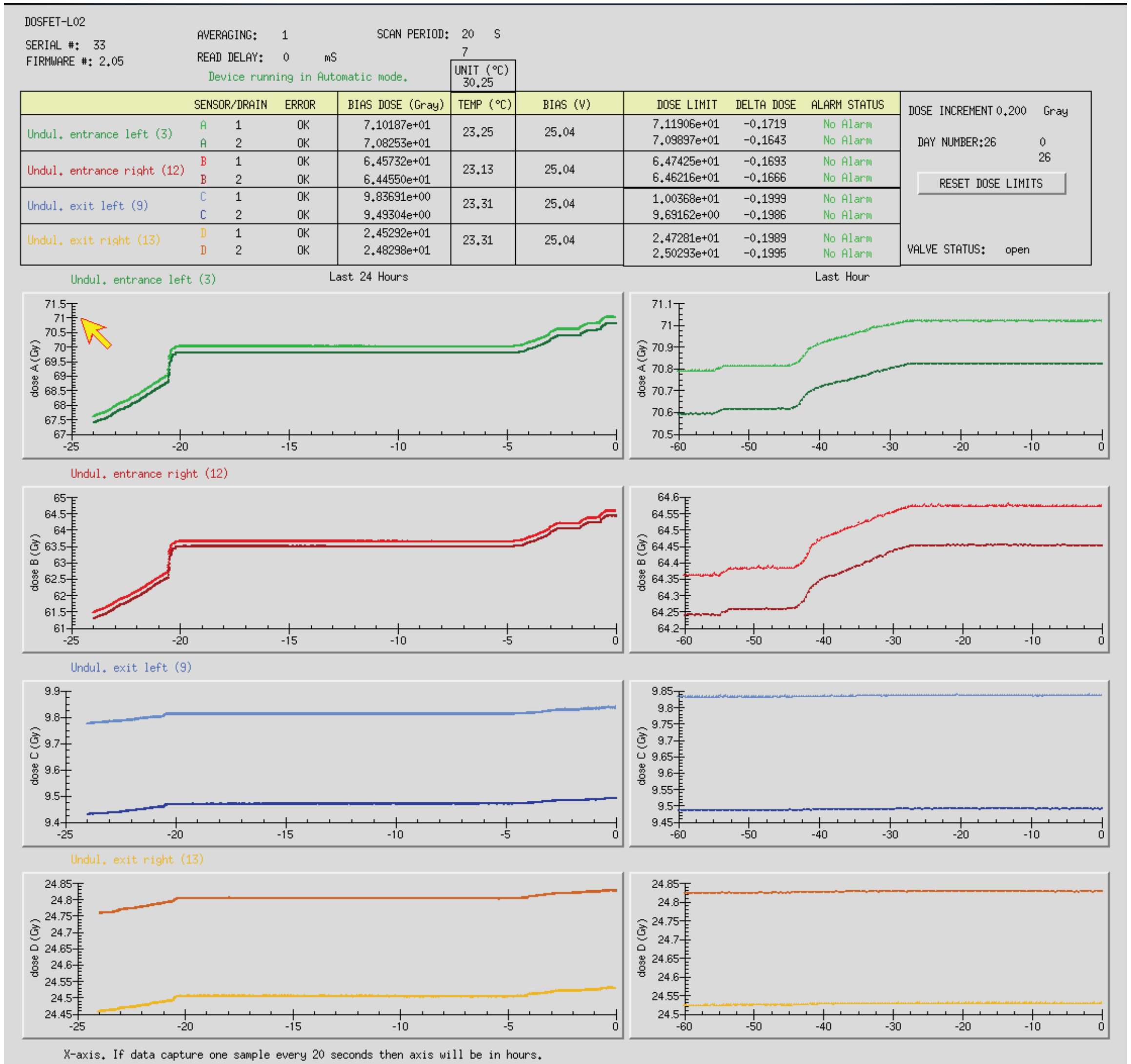
Spectrometer response not calibrated

Conclusions:

- Good preparation for future SwissFEL Commissioning: team integration, …
- Test of Alignment procedure based on “Alignment quadrupoles”: MOP040
- Measurements of undulator kick angles (Vertical plane!): MOP041
- Observation of SASE signal (confirmation of e- beam and U15 quality): MOP053


Many Thanks to PSI Colleagues
Enjoy Switzerland !

Beam Loss Monitors

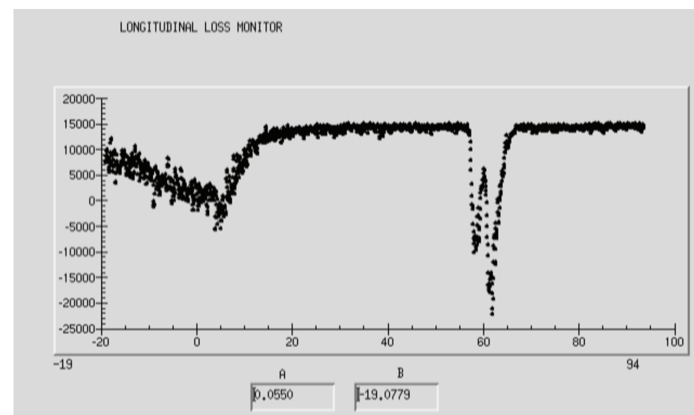


SENSOR/DRAIN			ERROR	BIAS DOSE (Gray)	TEMP (°C)	BIAS (V)	DOSE LIMIT	DELTA DOSE	ALARM STATUS
Undul. entrance left (3)	A	1	OK	7.10187e+01	23.25	25.04	7.11906e+01	-0.1719	No Alarm
	A	2	OK	7.08253e+01			7.09897e+01	-0.1643	No Alarm
Undul. entrance right (12)	B	1	OK	6.45732e+01	23.13	25.04	6.47425e+01	-0.1693	No Alarm
	B	2	OK	6.44550e+01			6.46216e+01	-0.1666	No Alarm
Undul. exit left (9)	C	1	OK	9.83691e+00	23.31	25.04	1.00368e+01	-0.1999	No Alarm
	C	2	OK	9.49304e+00			9.69162e+00	-0.1986	No Alarm
Undul. exit right (13)	D	1	OK	2.45292e+01	23.31	25.04	2.47281e+01	-0.1989	No Alarm
	D	2	OK	2.48298e+01			2.50293e+01	-0.1995	No Alarm

RadFET Panels

90 Gy in 2.5 Months at 10 Hz,
… we will see if any demagnetization can be detected.

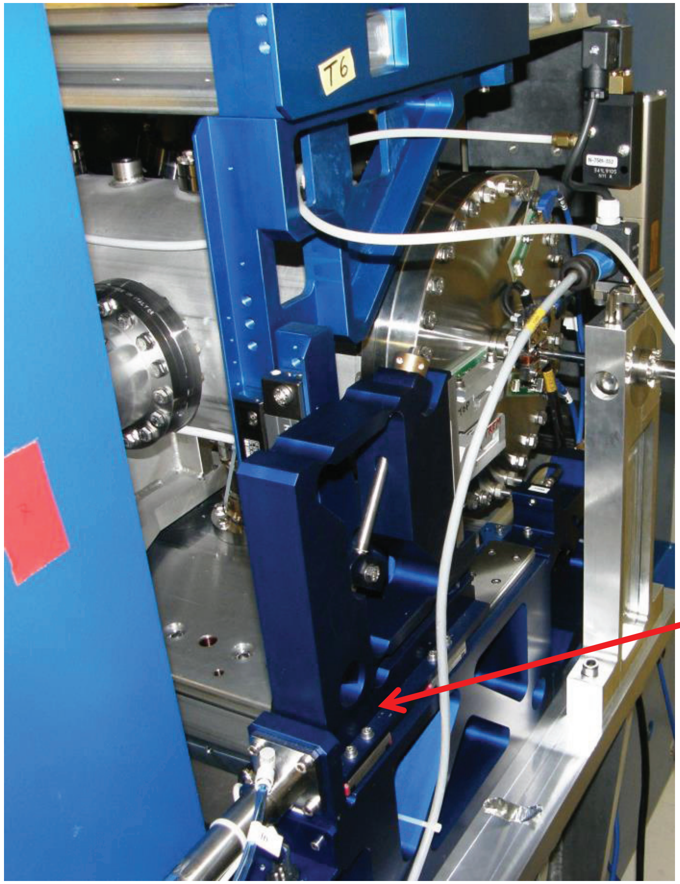
… encoders have survived

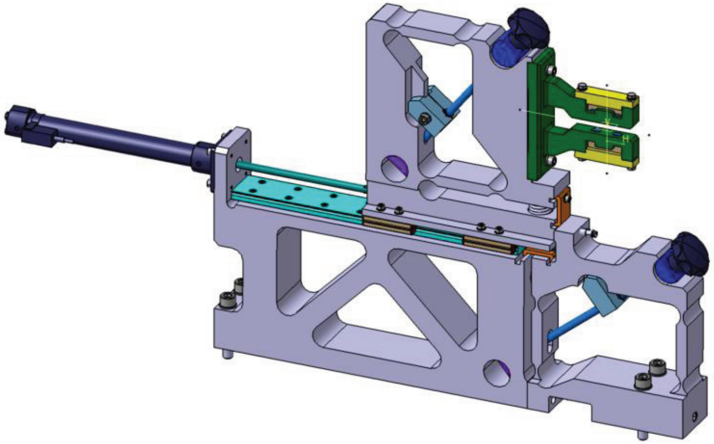


Longitudinal Loss Monitor (along z (m))

Courtesy of Cigdem, Edwin and Florian

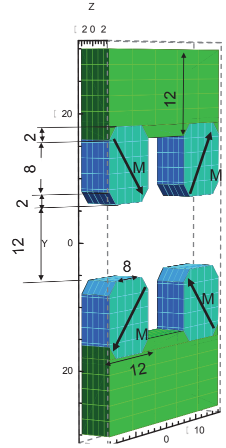
U15 Alignment Quadrupoles





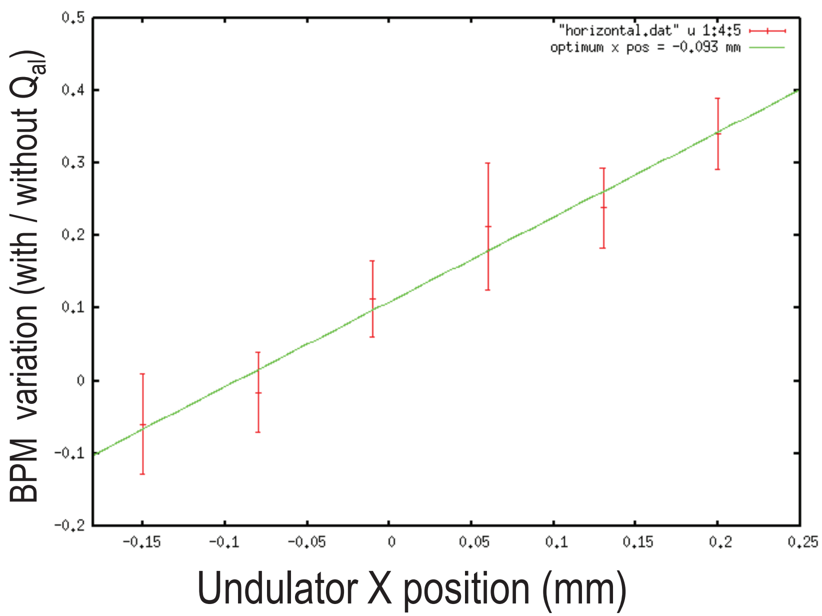
Pneumatic support to drive In and Out the Alignment Quadrupole

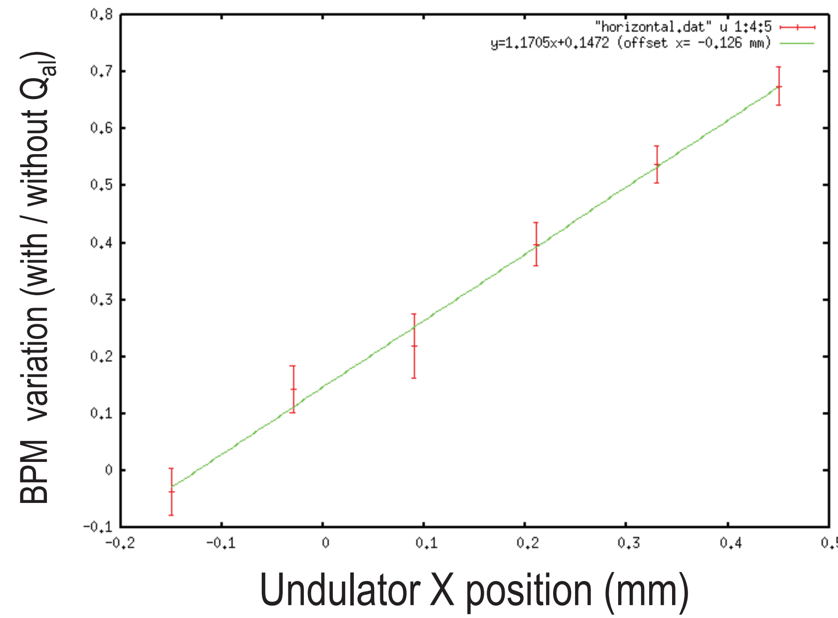
Thickness=5mm
Br=1.1T;
Gap = 12mm
G=28.8 T/m; G.L=0.46 T

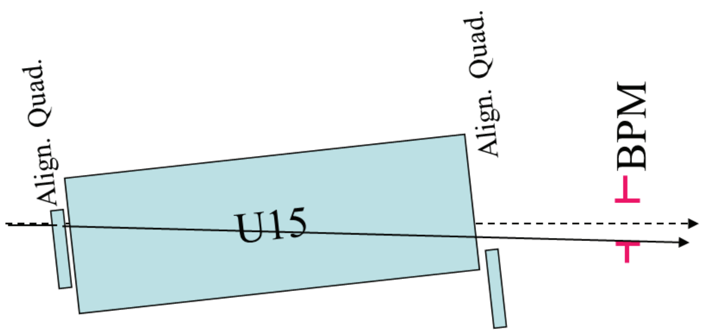


Thickness=5mm

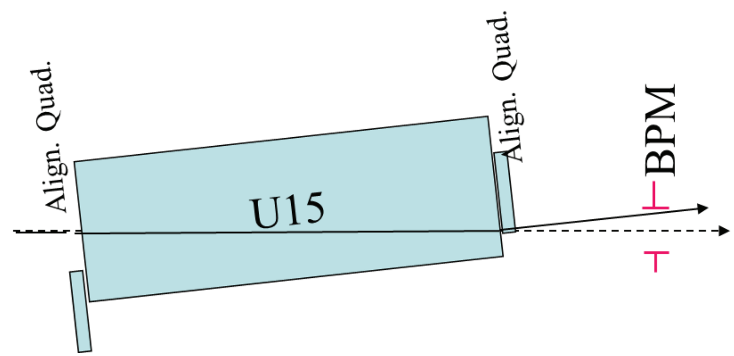
U15 Alignment: horizontal plane







Upstream Q_{Al} ; Gap Closed



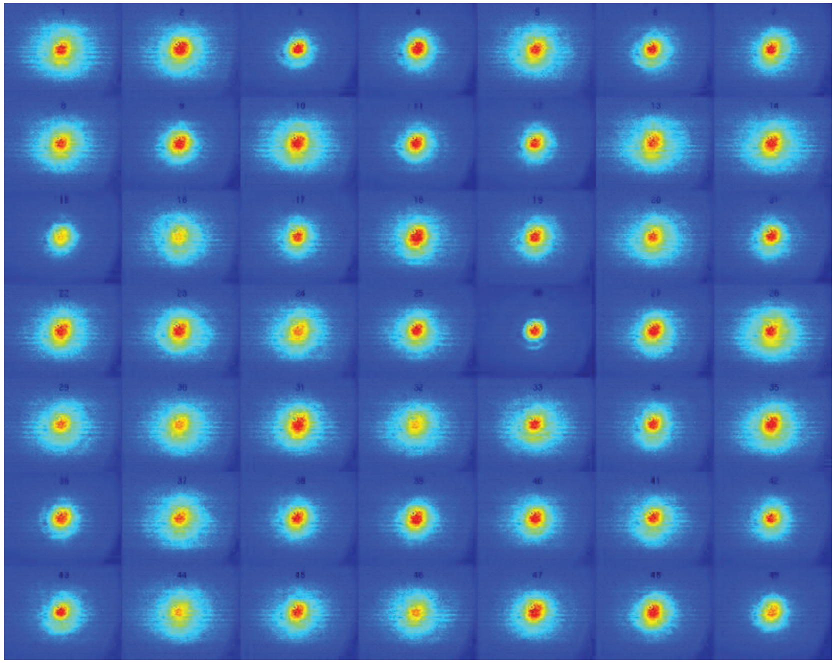
Downstream Q_{Al} ; Gap Open

200 pC; 200 MeV

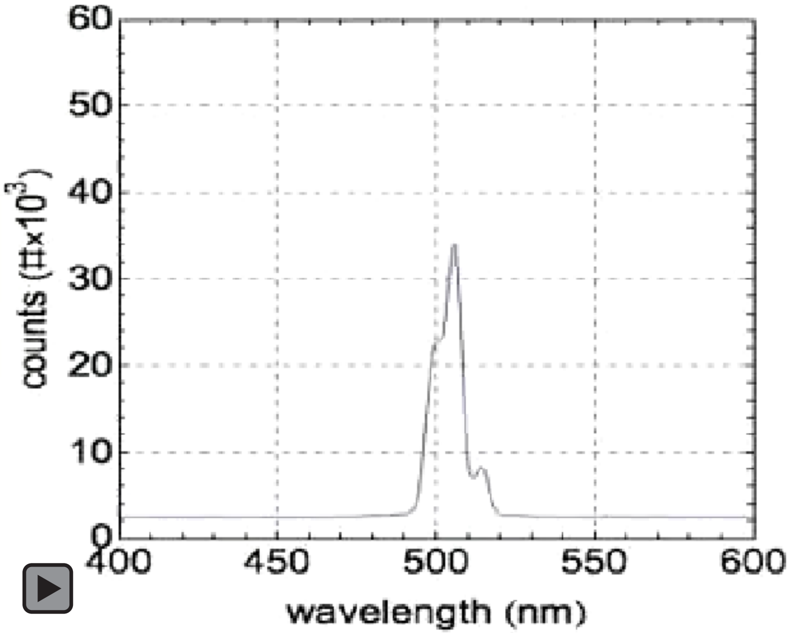
Courtesy of M. Aiba

Light shots with 100 MeV electron

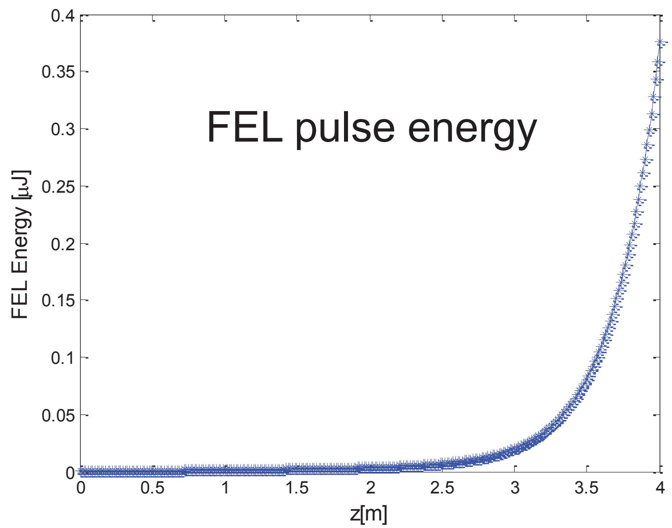
CCD camera

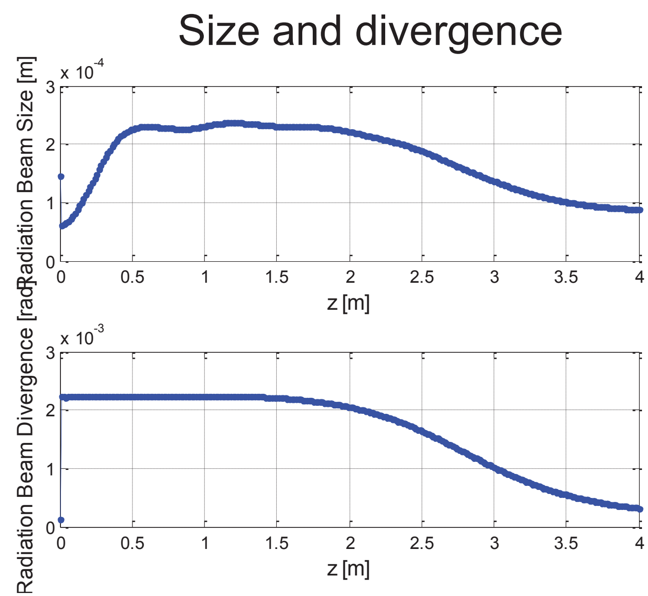


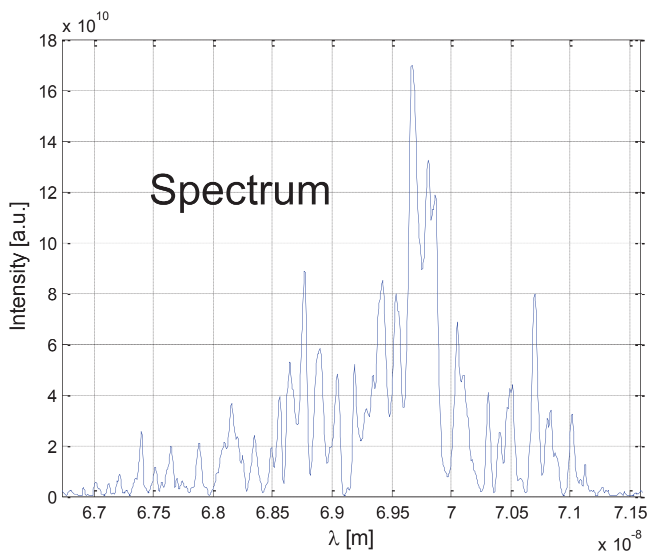
Spectrometer – Single Shot



FEL performance for nominal conditions







- FEL is in linear exponential gain
- Strong reduction of radiation divergence w.r.t. spontaneous radiation
- In the measurements we worked mostly at longer wavelengths (lower E) in exponential mode
- Saturation can only be reached if non-linear compression

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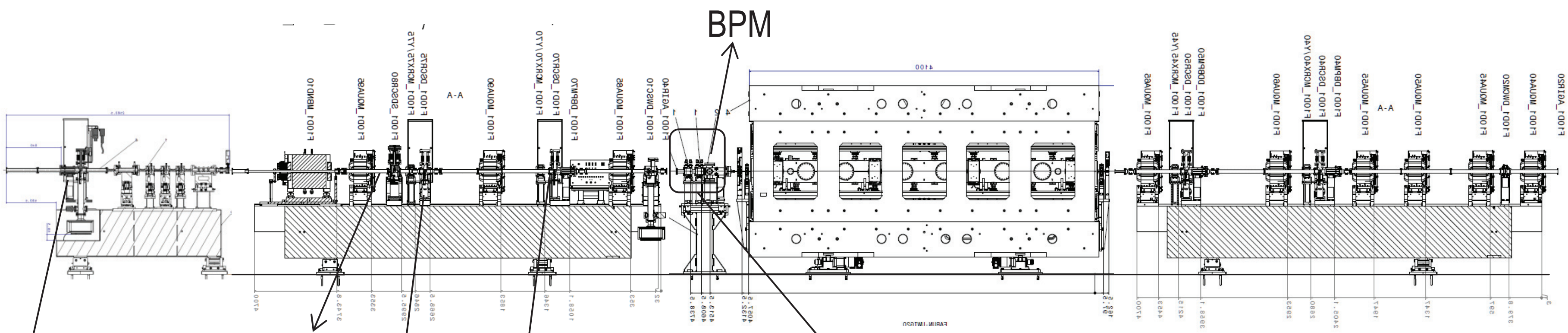
SITF Layout with U15



BPM

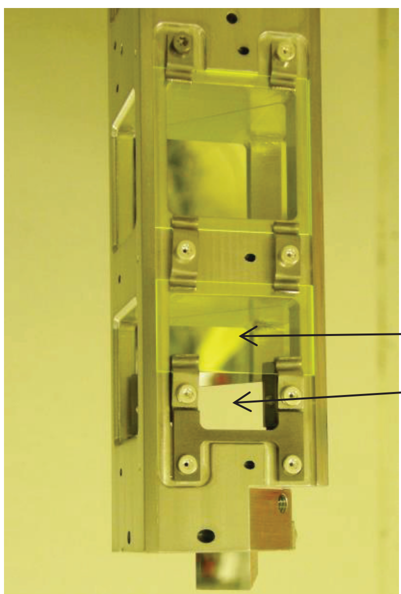
4th Screen

3rd Screen

2nd Screen

1st Screen

2 SFC steerers (1.7 mT.m) to bypass YAG screens (5 mrad at 200 MeV)



YAG

Hole for e-

Undulator side components

Loss Beam
Scintillation paper

Pneumatic
support

Earth magnetic field corrector loop

Alignment
Quadrupole Q_{Al}

Fiber loss monitor
(fast but not calibrated)

Radfet
(Calibrated Loss
Monitor)