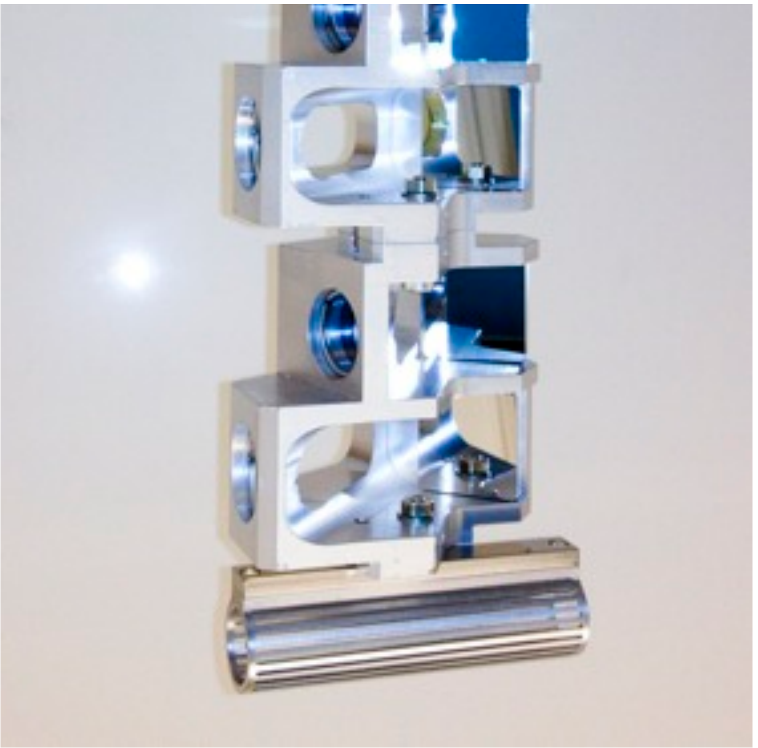
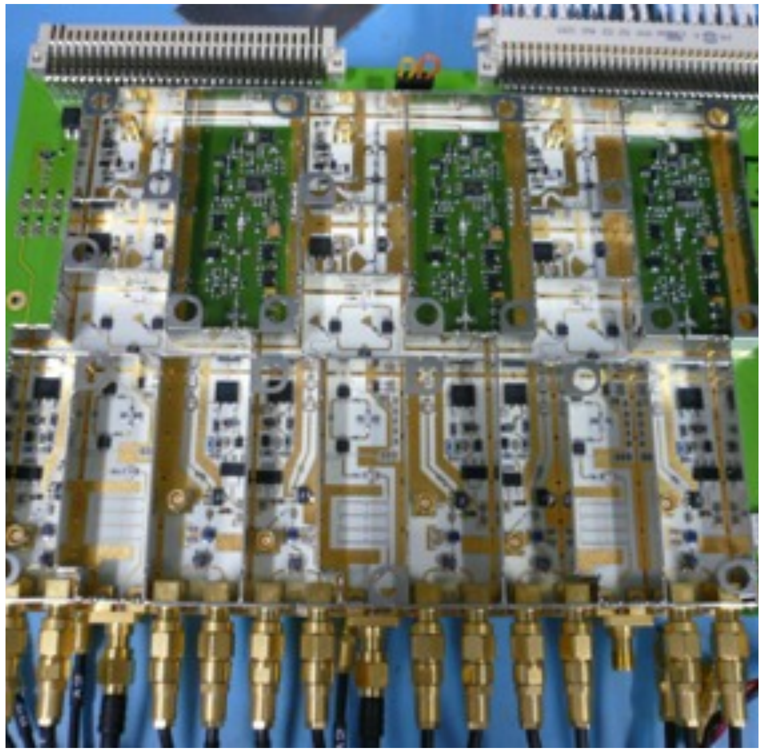
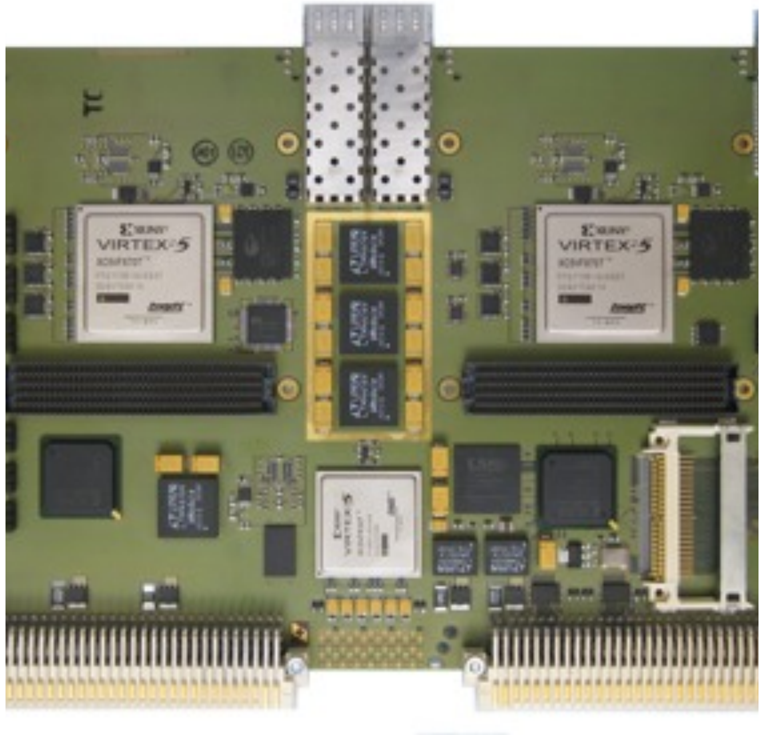
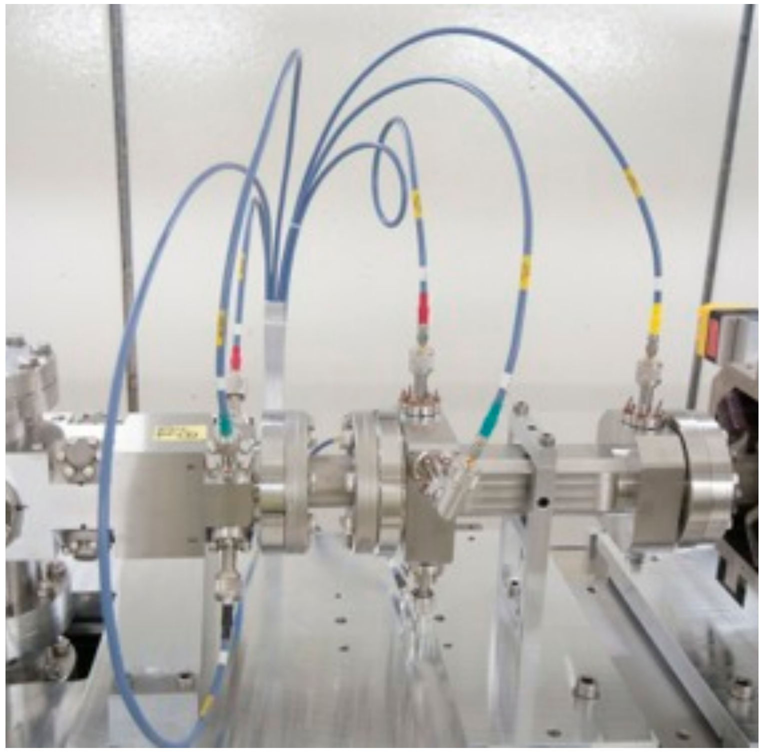
PAUL SCHERRER INSTITUT









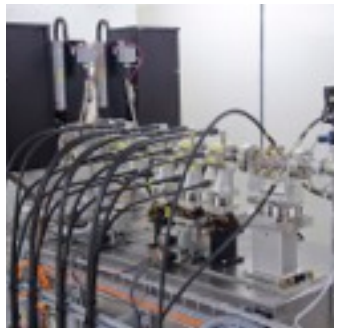
Standard Diagnostics for SwissFEL

Rasmus Ischebeck, for the GFA Diagnostics Section

Standard Diagnostics for SwissFEL

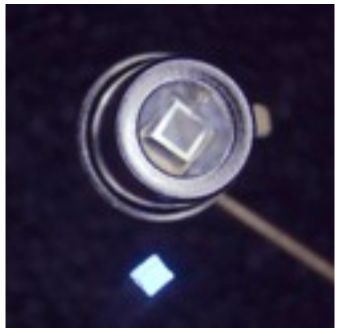
> Transverse profile imager (DSCR)

> Synchrotron radiation imager (DSRM)



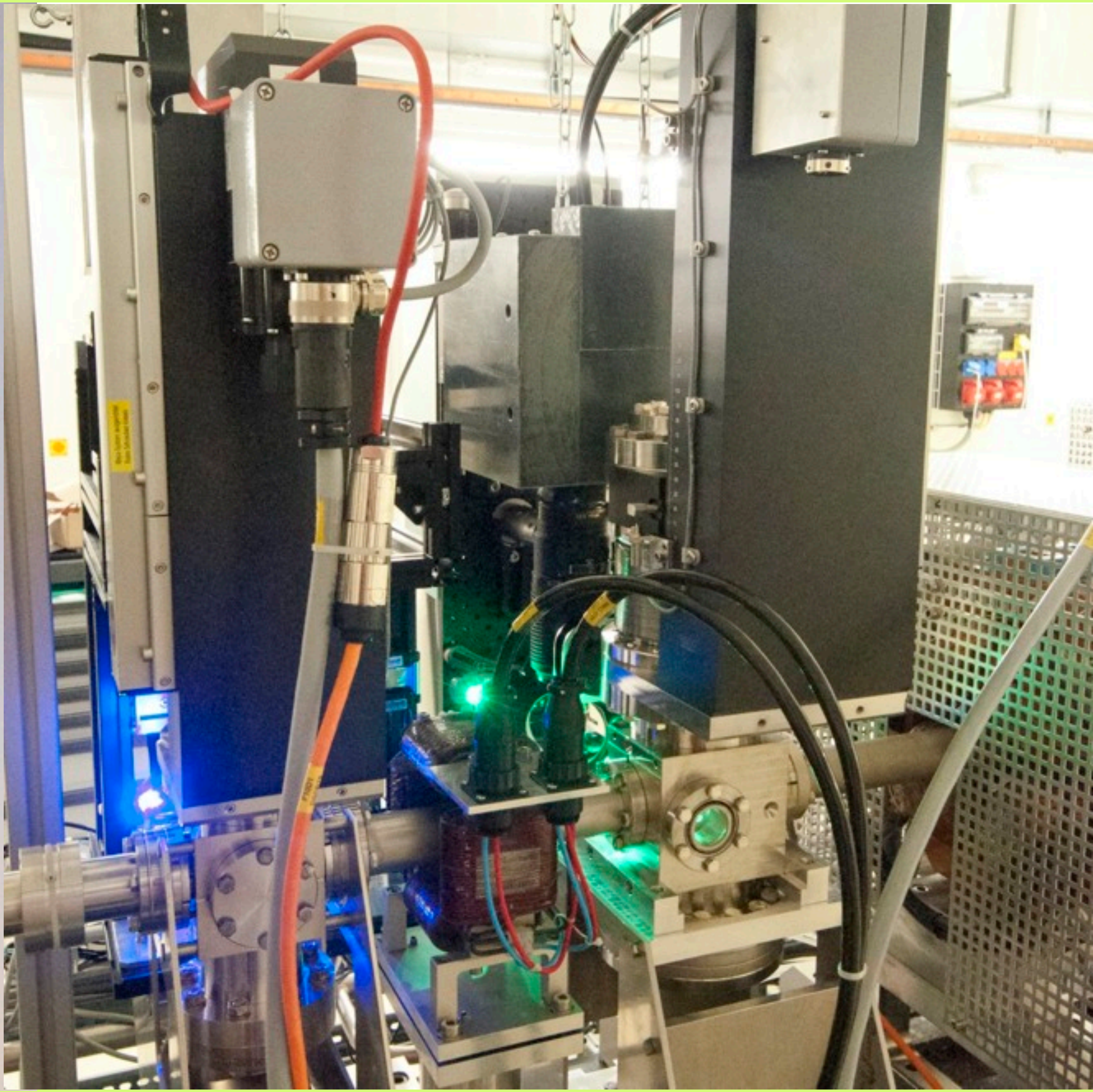
> Electron Beam position monitor (DBPM)

> Electron bunch arrival monitor (DBAM)



> Loss monitor (DBLM)

Transverse Profile Imager (DSCR)



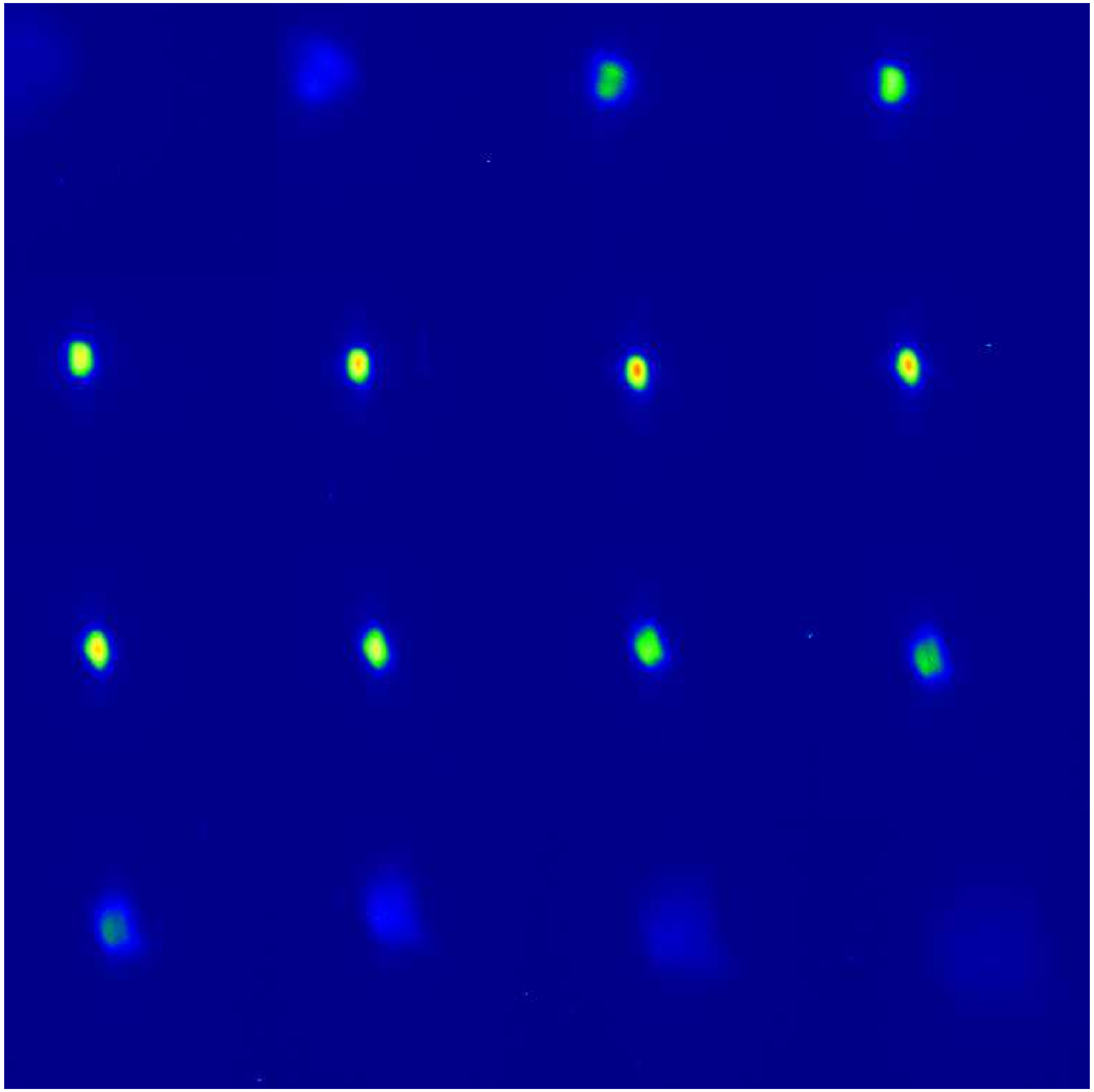
Transverse Profile Imager (DSCR)

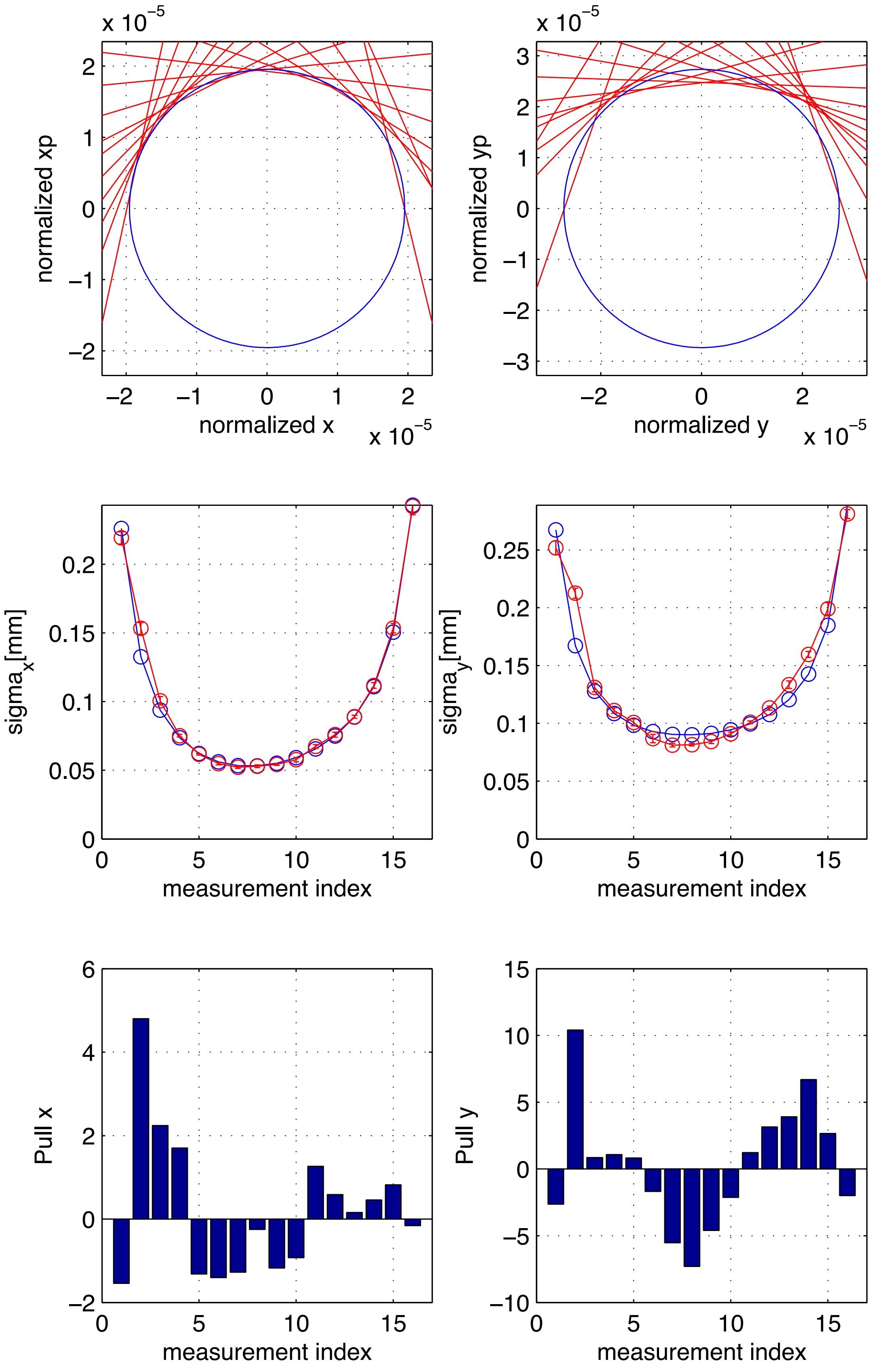
> Specifications

Quantity	“Overview”	“Measurement”
Resolution	10 µm	
Field of view	6 mm (h) × 8 mm (v)	6 mm (h) × 15 mm (v)
Sensitivity	ionizing radiation	
Image frame rate	10 Hz	100 Hz
Length of vacuum chamber	137 mm	
Required space outside of vacuum chamber	tbd.	

Transverse Profile Imager (DSCR)

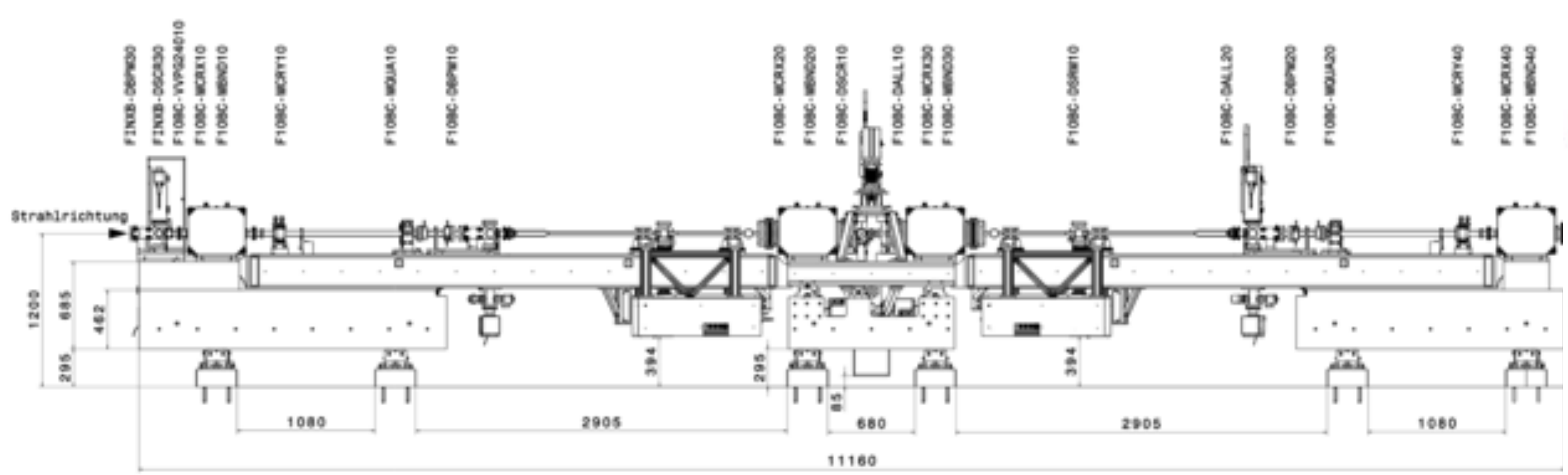
> Emittance Measurement

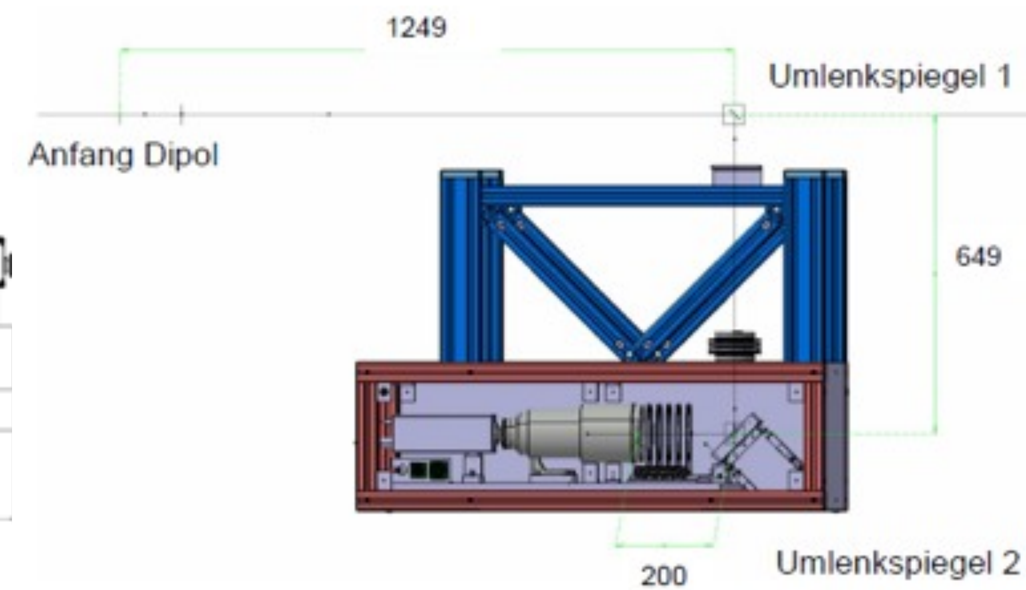


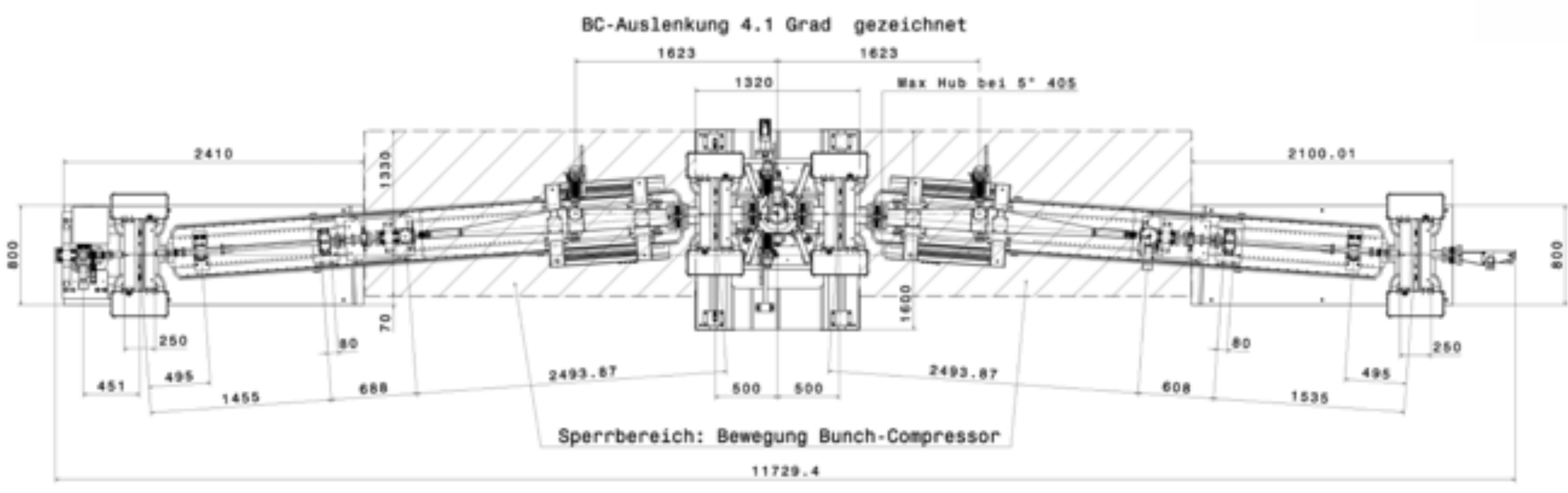


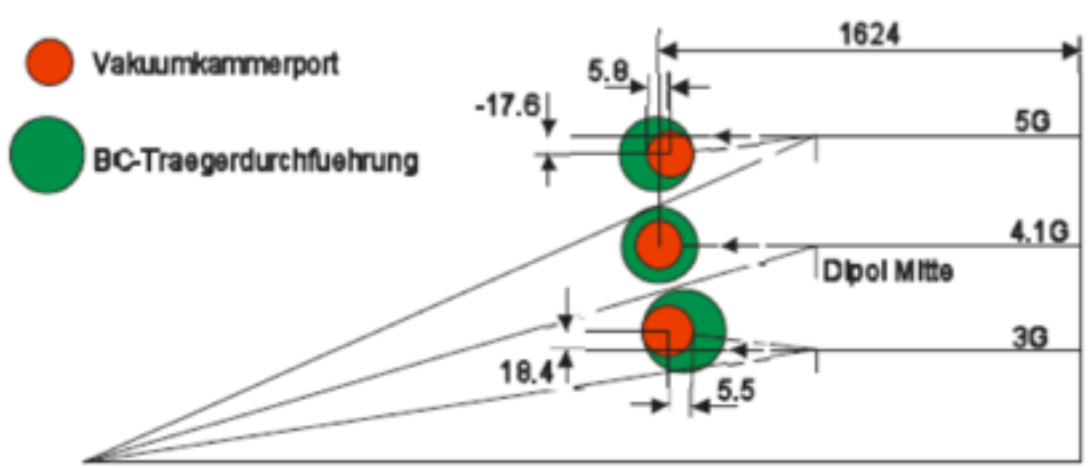
The smallest beam in this measurement is 50 μm rms.
Beams of 10 μm rms have been measured.

Technical Realization-BC 250 MeV Injector Test Facility









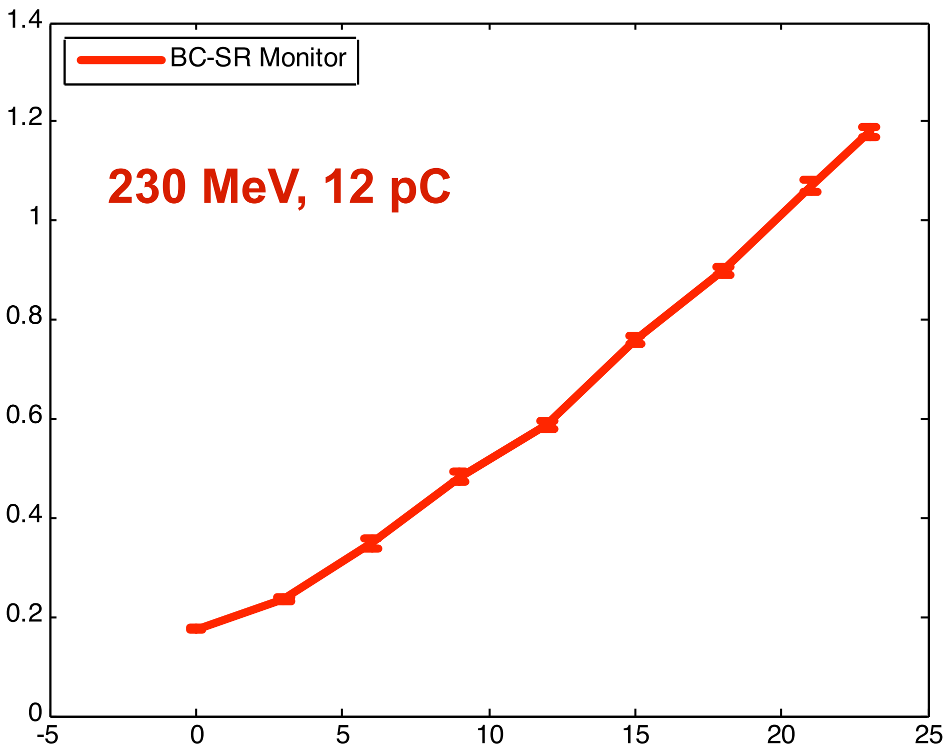
Technical drawings, courtesy L. Schulz, P. Heimgartner

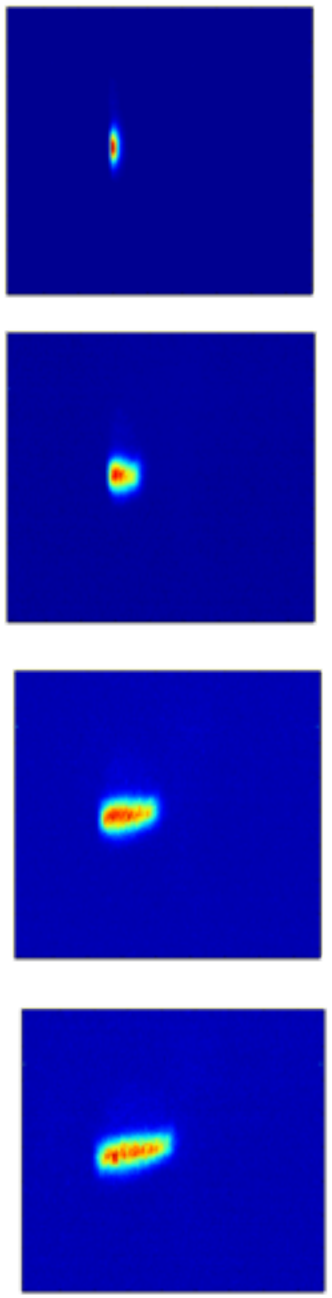
Synchrotron Radiation Imager (DSRM)

Conceptual Design-BC SwissFEL

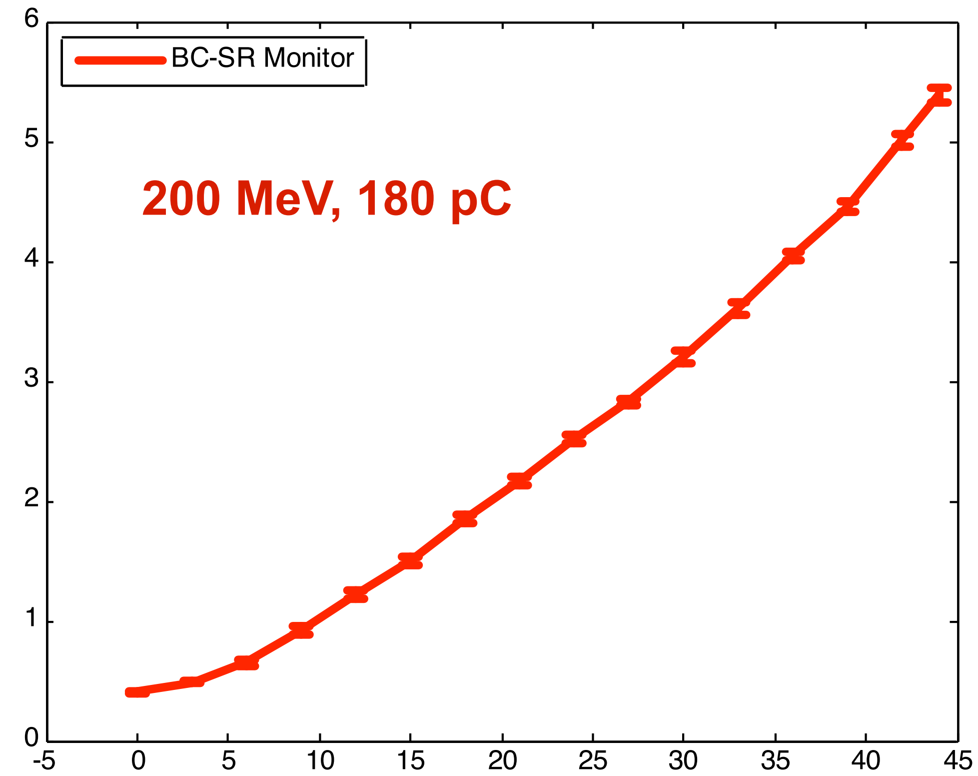
	BC1	BC2
Nominal bending angle θ	3.85 deg	2.15
Mechanical bending angle range	-0.1 ↔ 4.6 deg	-0.1 ↔ 3.8 deg
Operational bending angle	2.85 ↔ 4.6 deg	1.15 ↔ 3.15 deg
Horizontal Dispersion	419.6 mm	281.56
Nominal Beam Energy	350 MeV	2100 MeV
Range for transverse movement	-10 ↔ 500 mm	-10 ↔ 495 mm
Beam Size (rms) at the 3rd dipole	6.0 mm	1.2 mm
Field of View (in-vacuum mirror length=68 mm)	68 mm	68 mm
Projected pixel size	31 μm	38 μm
Relative Energy Spread Resolution	7.0*10^-5	1.4*10^-4
Lens focal length	400 mm	500 mm
Lens diameter	143 mm	125 mm
Camera (PCO.EDGE) pixel size	6.5x6.5 μm^2	6.5x6.5 μm^2
Camera Resolution	hor x ver = 2560x2160	hor x ver = 2560x2160
Camera Frame Rate	100 Hz	100 Hz
Separation in-vacuum mirror edge and central trajectory of the beam	40 mm	61.5 mm

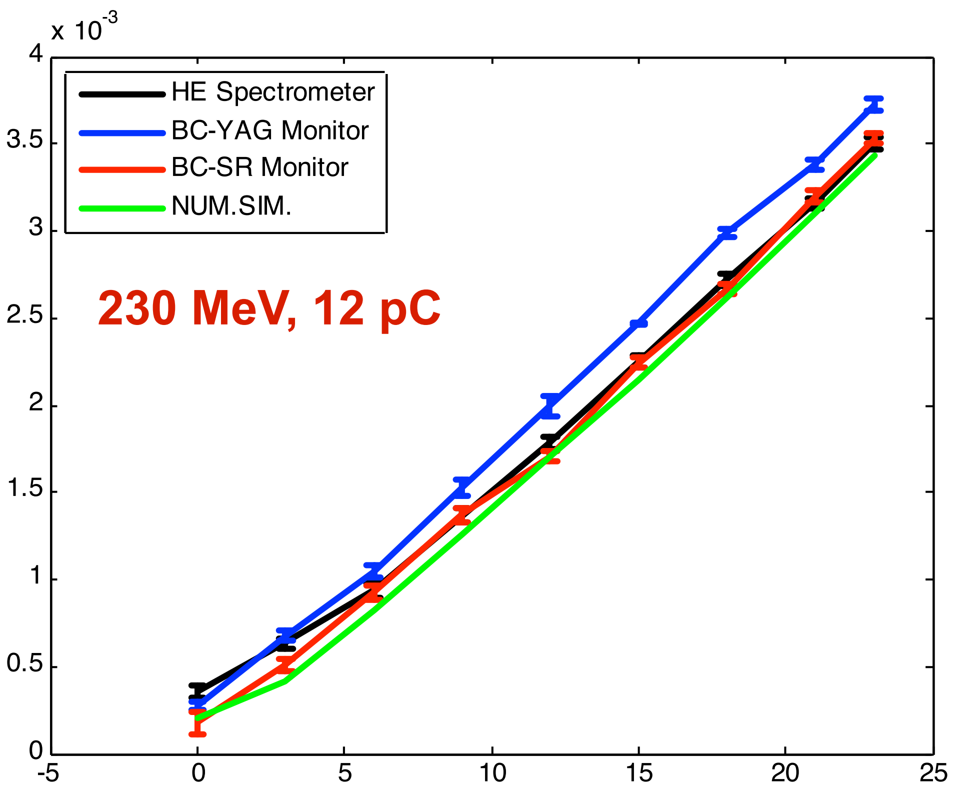
Prototype Results - 250 MeV Injector Test Facility (SITF)

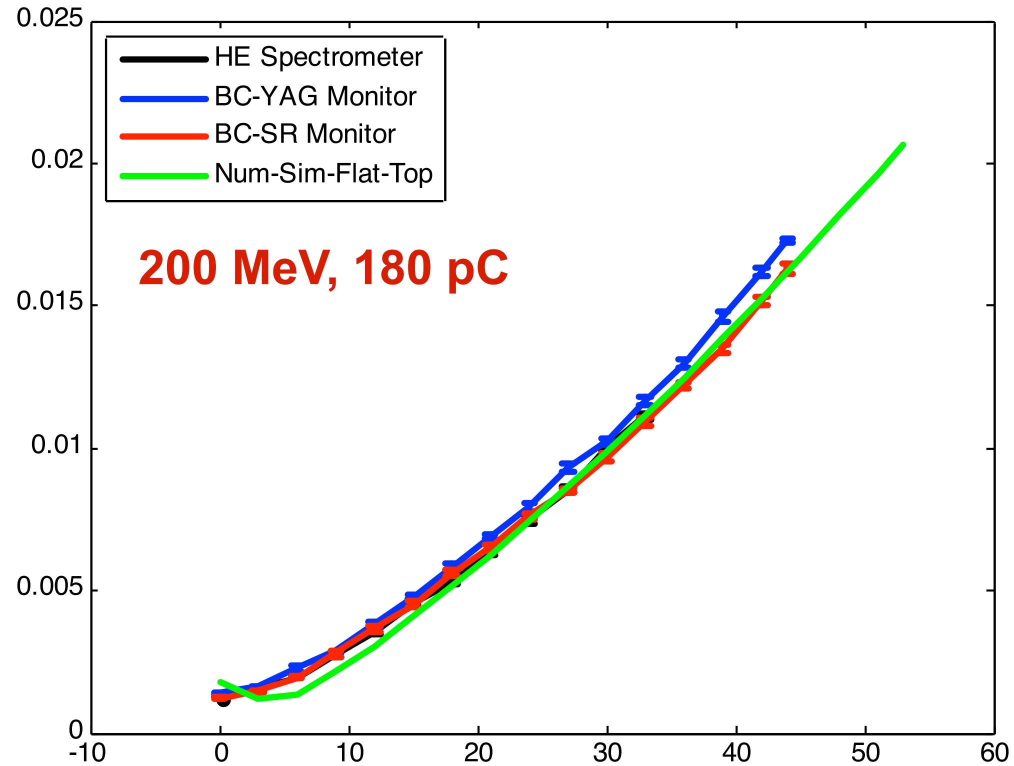




12 pC, SR Monitor images, 0- 23 deg OFF RF Crest





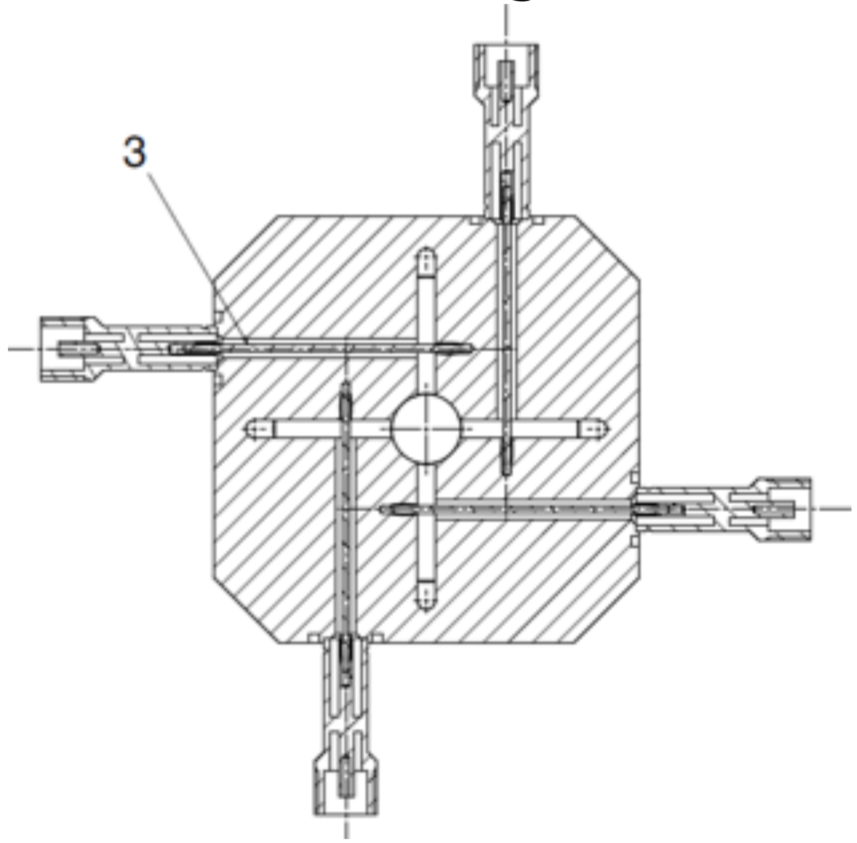


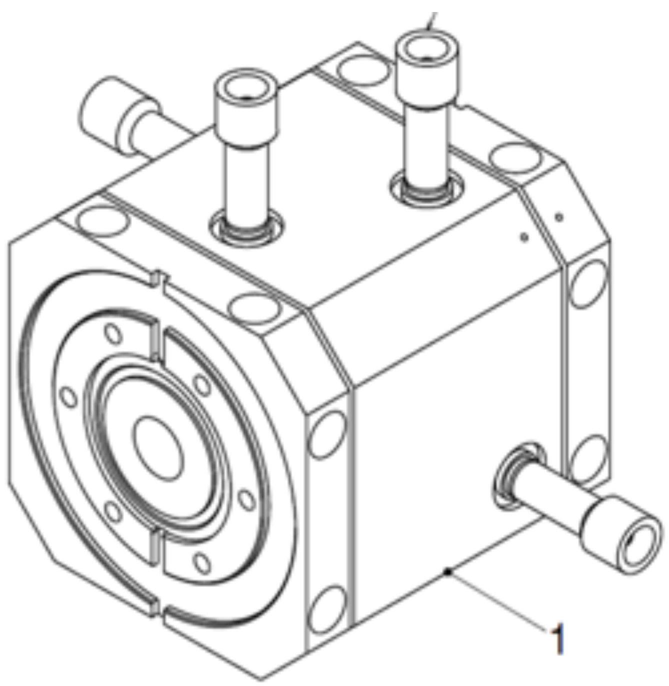
Numerical simulations, thanks to S.Bettoni

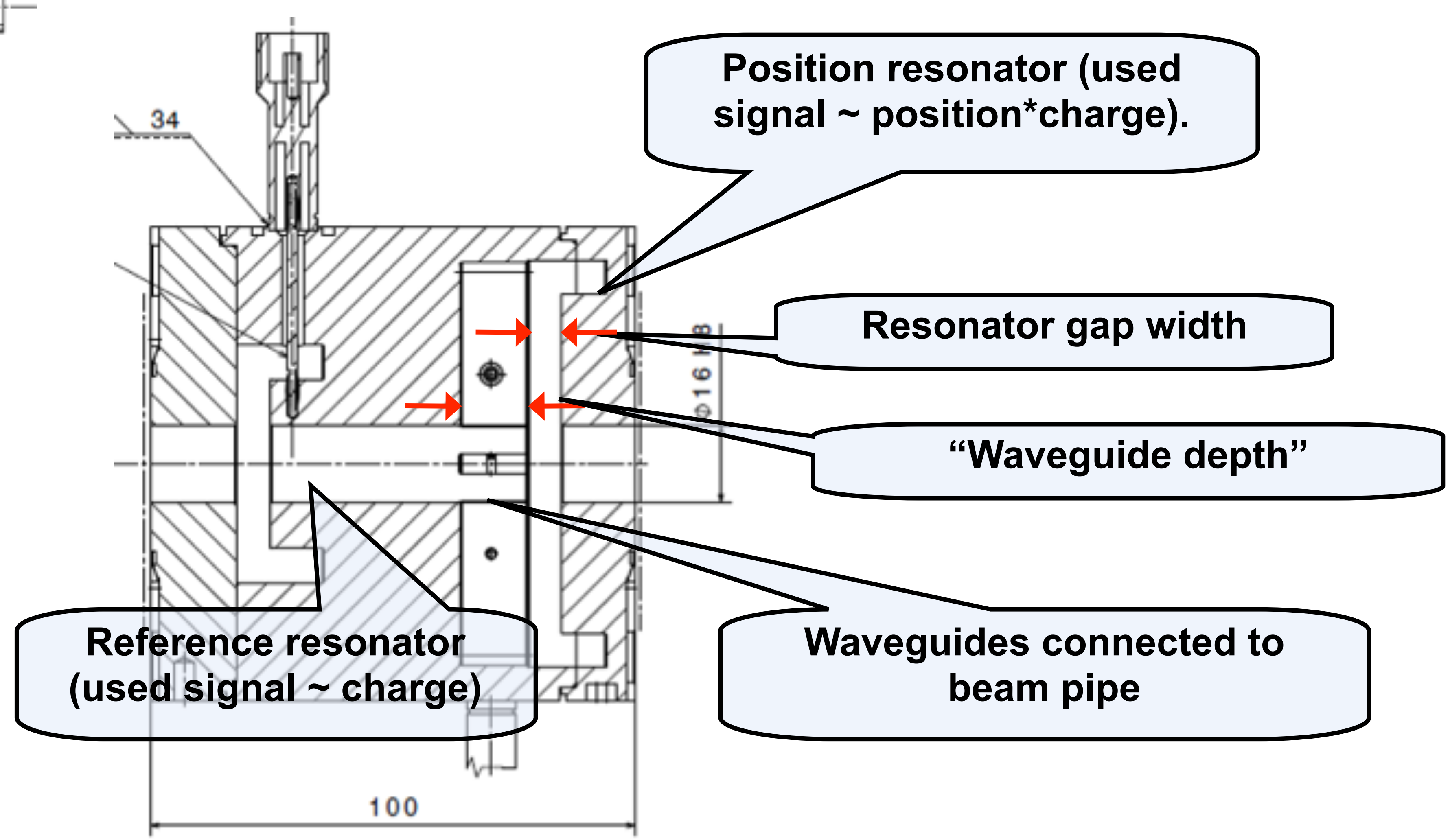
Electron Beam position monitor (DBPM)

> Technical Design: Linac Pickup

- Based on E-XFEL/SACLA design
- Optimized for low charge & low production costs.







Electron Beam position monitor (DBPM)

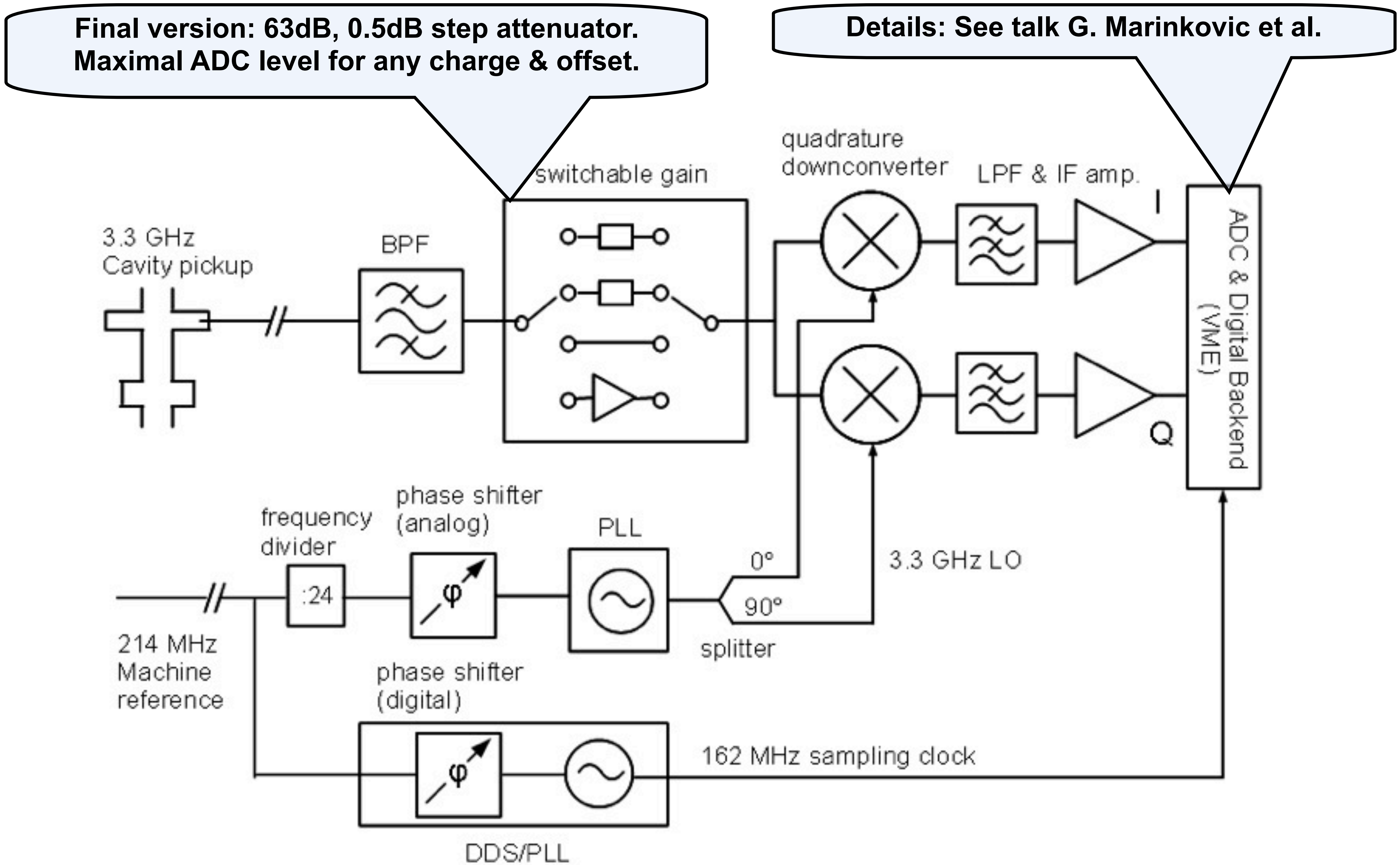
> Technical Design: Parameters

	Injector	Linac	Undulator (Baseline)	Undulator (Alternative Option)
Pickup Type	Cavity (2 Resonators, Mode-Suppressing Couplers)			
Frequency	3.3GHz			4.8GHz
Loaded Q	~40		~70	~100-1000
Material	Stainless Steel			Cu-Coated Steel
Gap Width	TBD	7mm	7mm	TBD
Waveguide Depth	TBD	14mm	25mm	TBD
Signal [V/mm/nC]	TBD	7.1	9.3***	TBD
RFFE	IQ Downconversion*			
IF Frequency	~0Hz			~50MHz
ADC	16-Bit 160MSPS (Linac/Injector: 12-Bit 500MSPS Option)**			

* Undulators (Alternative Option): Single-channel downconversion feasible, to be evaluated.
** Sample rates of available ADCs for European XFEL (E-XFEL) BPM electronics built by PSI
*** E-XFEL Undulator: 2.9 V/mm/nC (Q=70) -> ~3x better low charge resolution for SwissFEL.

Electron Beam position monitor (DBPM)

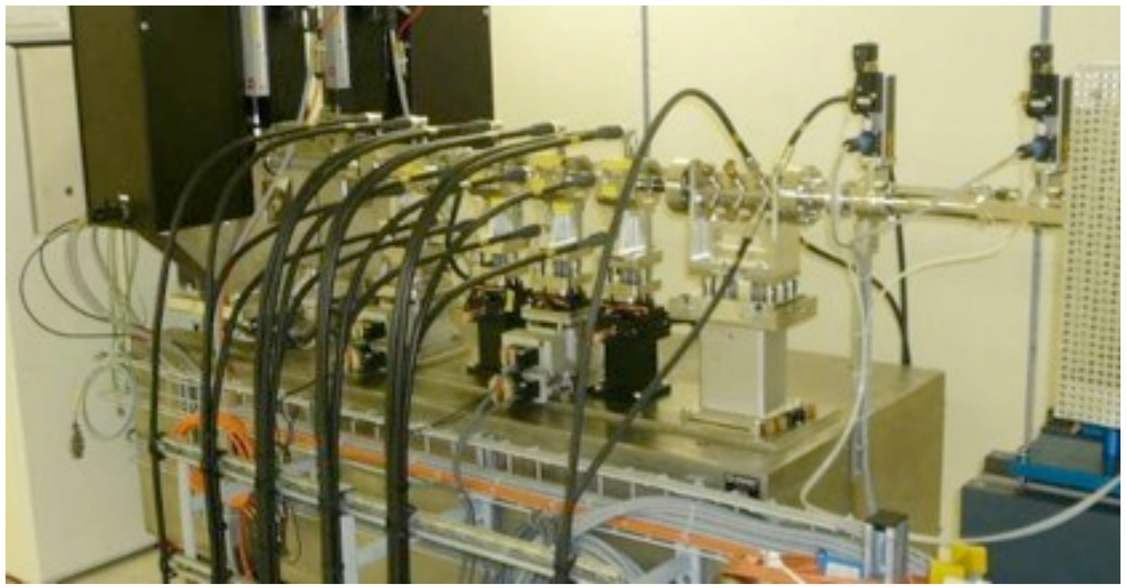
> Technical Design: RF Front-End

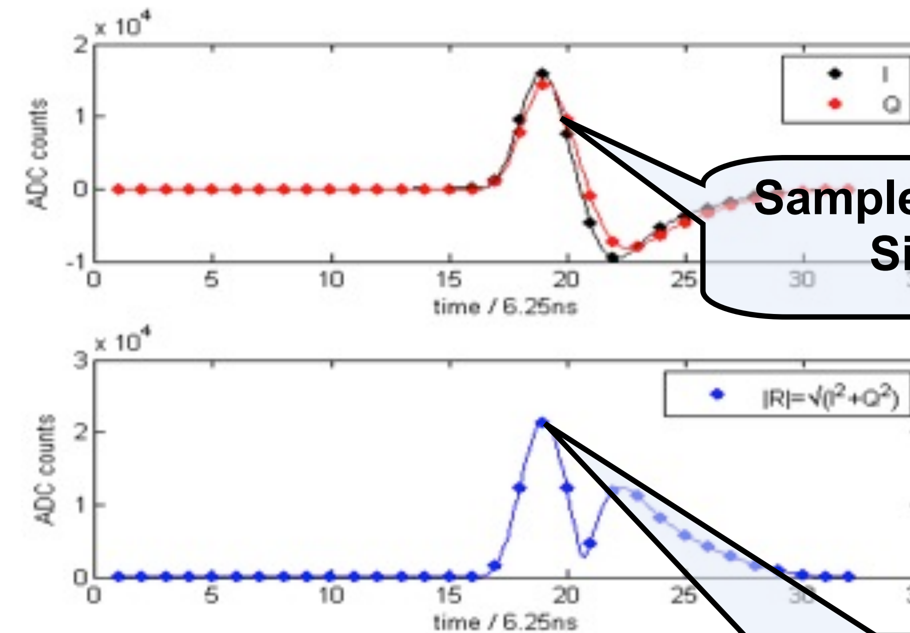


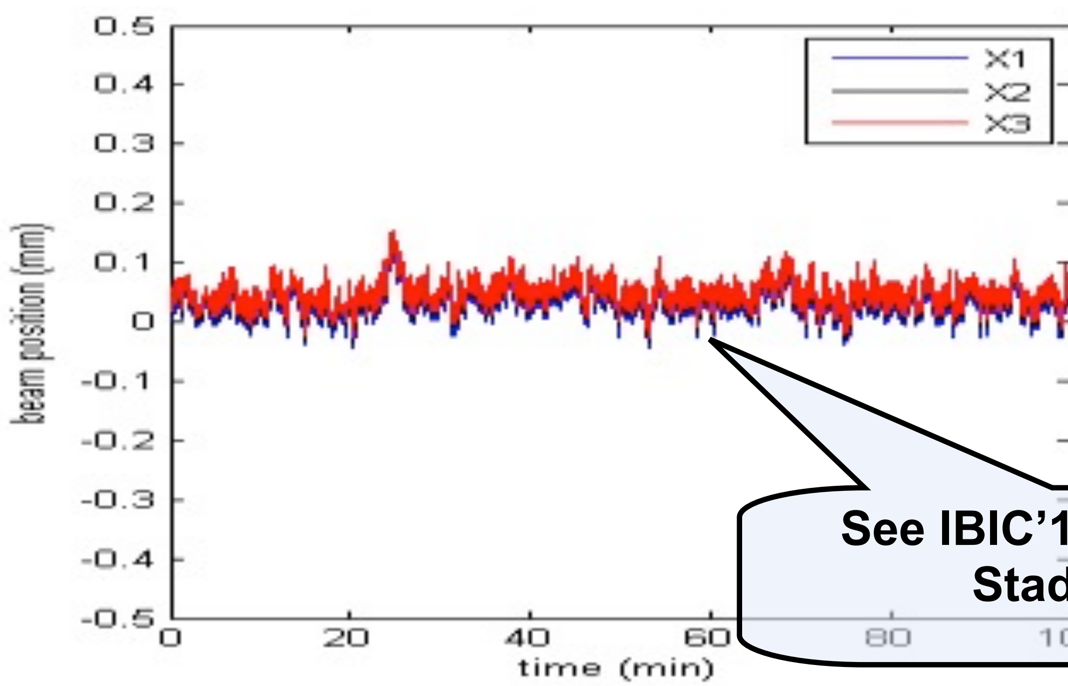
Electron Beam position monitor (DBPM)

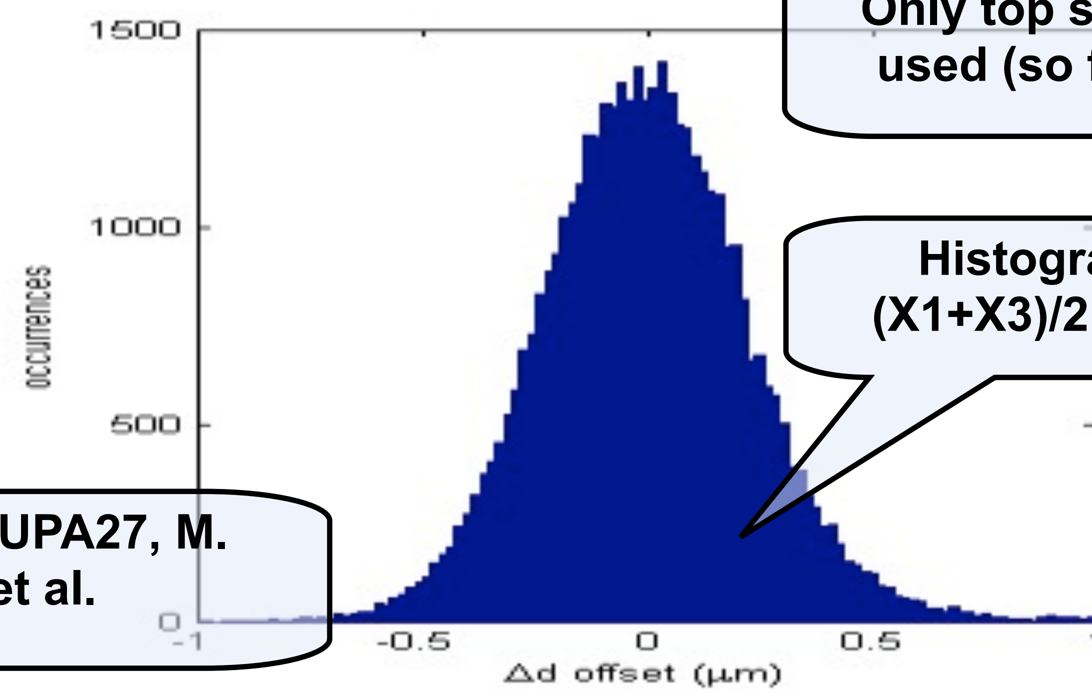
> Results: Prototype Beam Test

Correlation of 3 E-XFEL Undulator Cavity BPMs

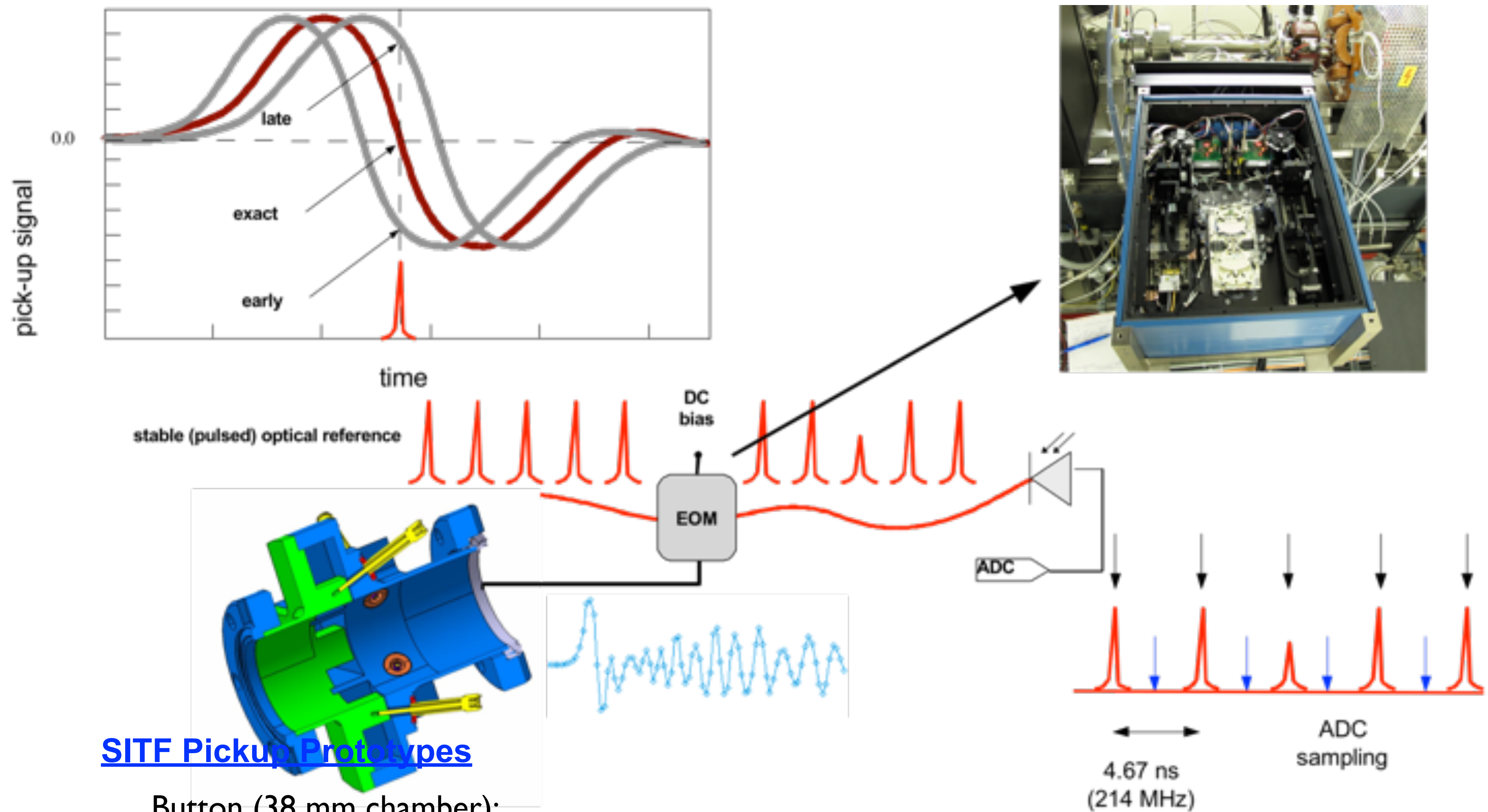








BAM Detection Principle



SITF Pickup Prototypes

I. Button (38 mm chamber):

- 80 GHz design BW,
- Resolution limited by the feedthru, EOM and ADC. For 2 bunch operation needs an upgrade (ringing):

200pc – 60 pc: 20 fs (measured)

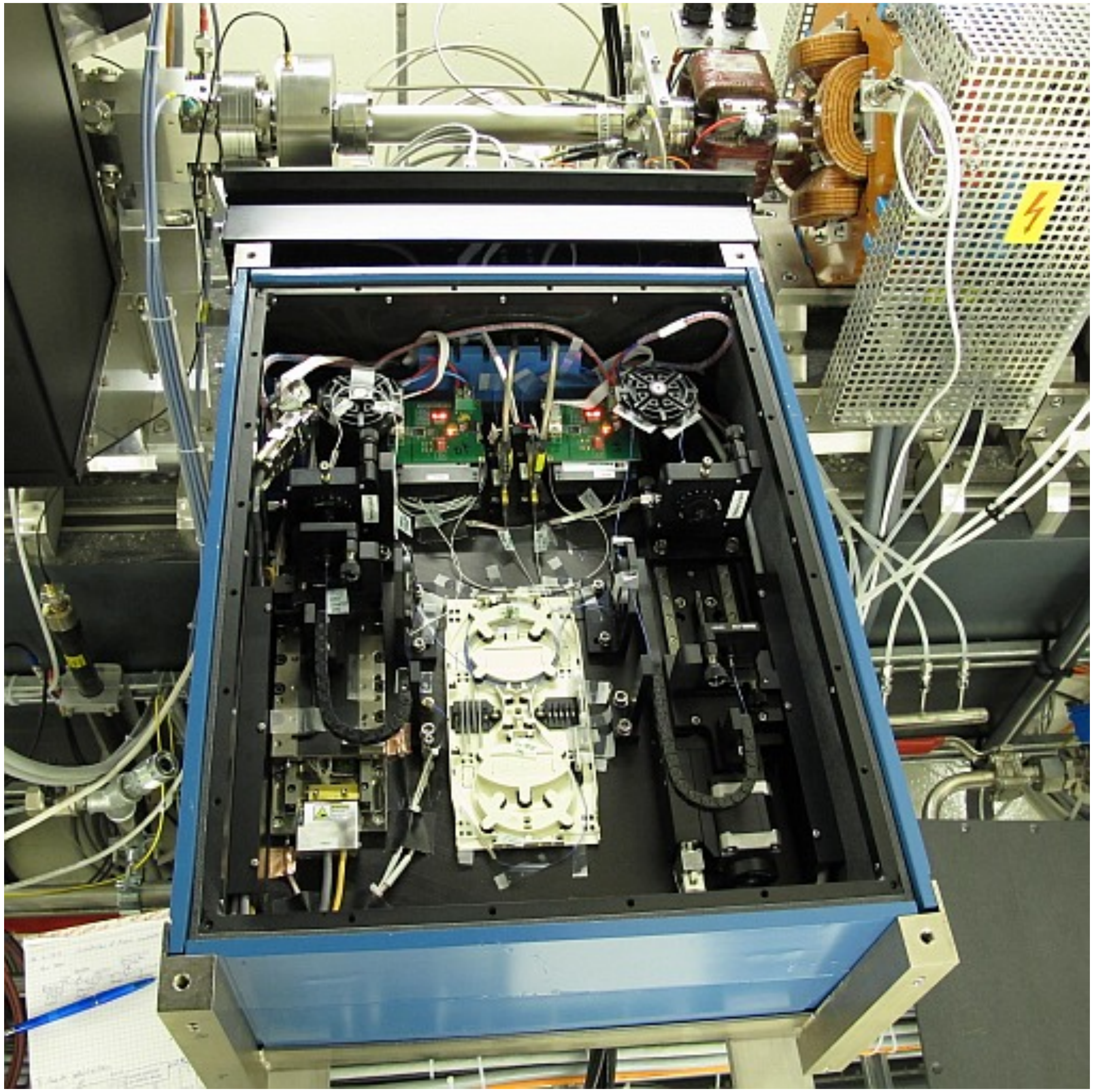
60 pC-10pC: 30fs -170 fs (measured)

II. Ridge waveguide (RWG) (38 mm chamber):
insufficient resolution, non linear behavior, ringing

SITF BAM-Data Acquisition (GPAC ADC12FL)

- The ADC clock is generated by the laser pulses and is shifted simultaneously with them
- The laser pulse amplitude is normalized pulse-to-pulse
- The laser amplitude jitter is monitored online

BAM Front End Design in SITF (BOX Var. 1)



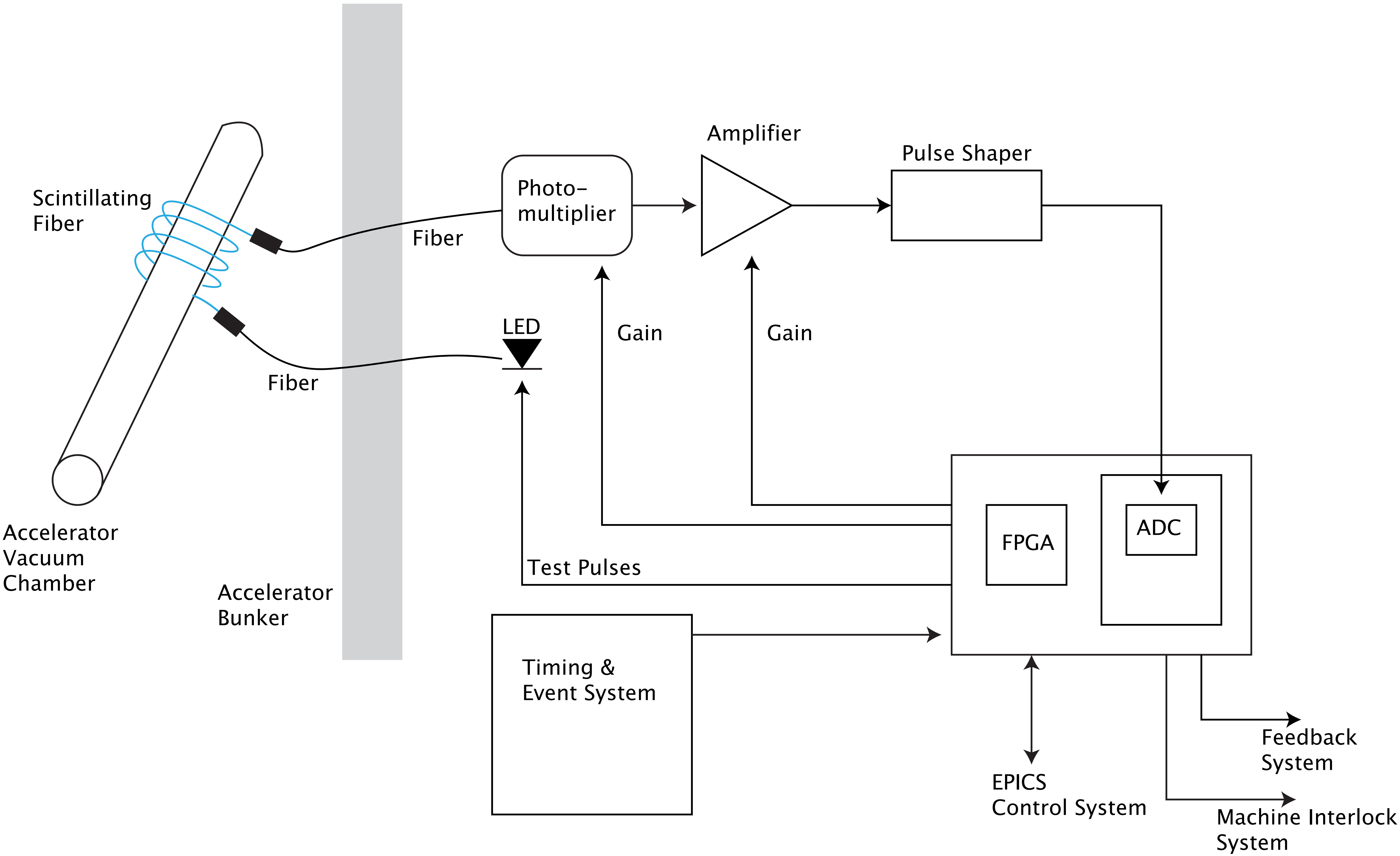
Dimensions (with the shielding):

640x450 mm (cables and cable radii not included)

Basic Components:

- EOMs (current status): 2x12 GHz (Covega) .
- EDFAs with controllers (custom design, Photop, CN)
- linear motor with 10 nm encoder (Parkem)
- linear motor controller
- stepper motor
- T° stabilization of the baseplate ($T_{pk\text{-}pk}$ < 0.05°C)
- T° & RH monitoring
- EPICs control, archiver channels
- EOM bias control and WP setting
- Radiation shielding (sufficient for SITF, insufficient for SwissFEL)
- possibility for channel extension (further EOMs)
- ∃ Box Var. 2 with imporoved thermal management

Loss Monitor (DBLM)



Loss Monitor (DBLM)

- Fiber-based system
  - Compact, low installation costs
- All electronics outside the accelerator tunnel
- We need a large dynamic range
  - Foresee to use vacuum PMTs
- Digitization by fast ADC