HELMHOLTZ ZENTRUM BERLIN für Materialien und Energie

Status of FLASH II

DESY

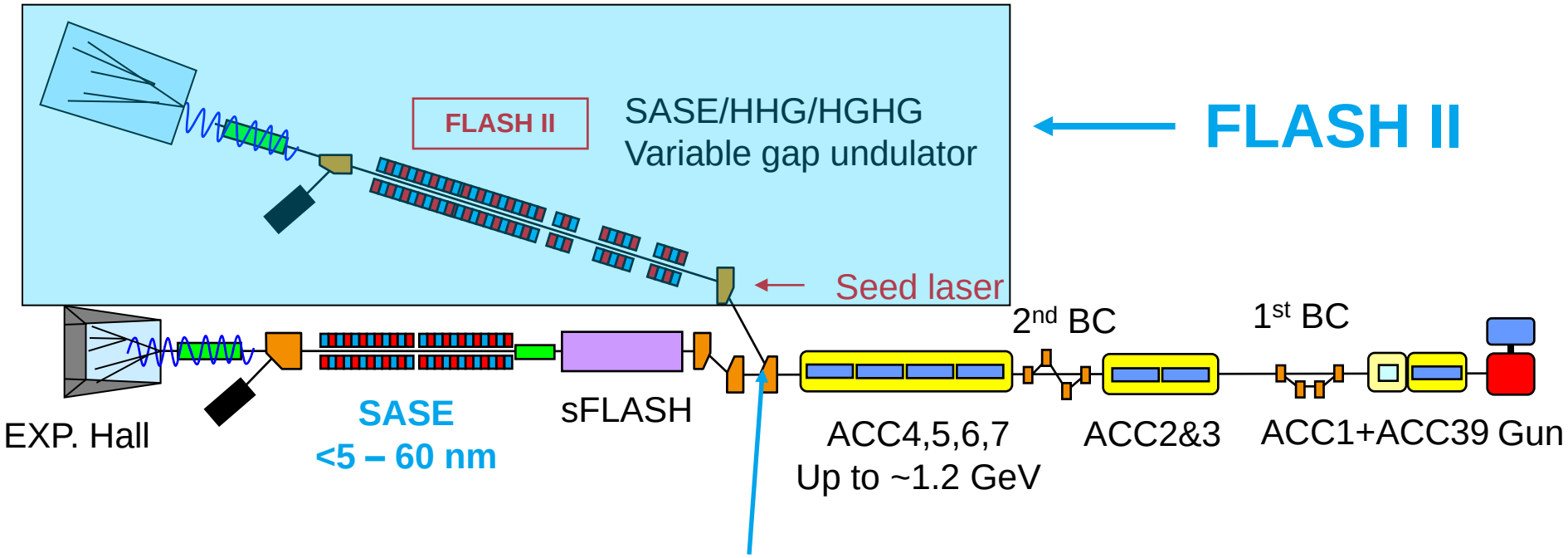
1. Layout.
2. Operation modes: Parameters.
3. Separation/Extraction.
4. Components.

FLASH II is a combined proposal of HZB and DESY with participation of PSI.
It is in its preparation phase until approval in Summer: detailed planning and redesigning.

Bart Faatz
Status of FLASH II
Hamburg, February 16, 2010

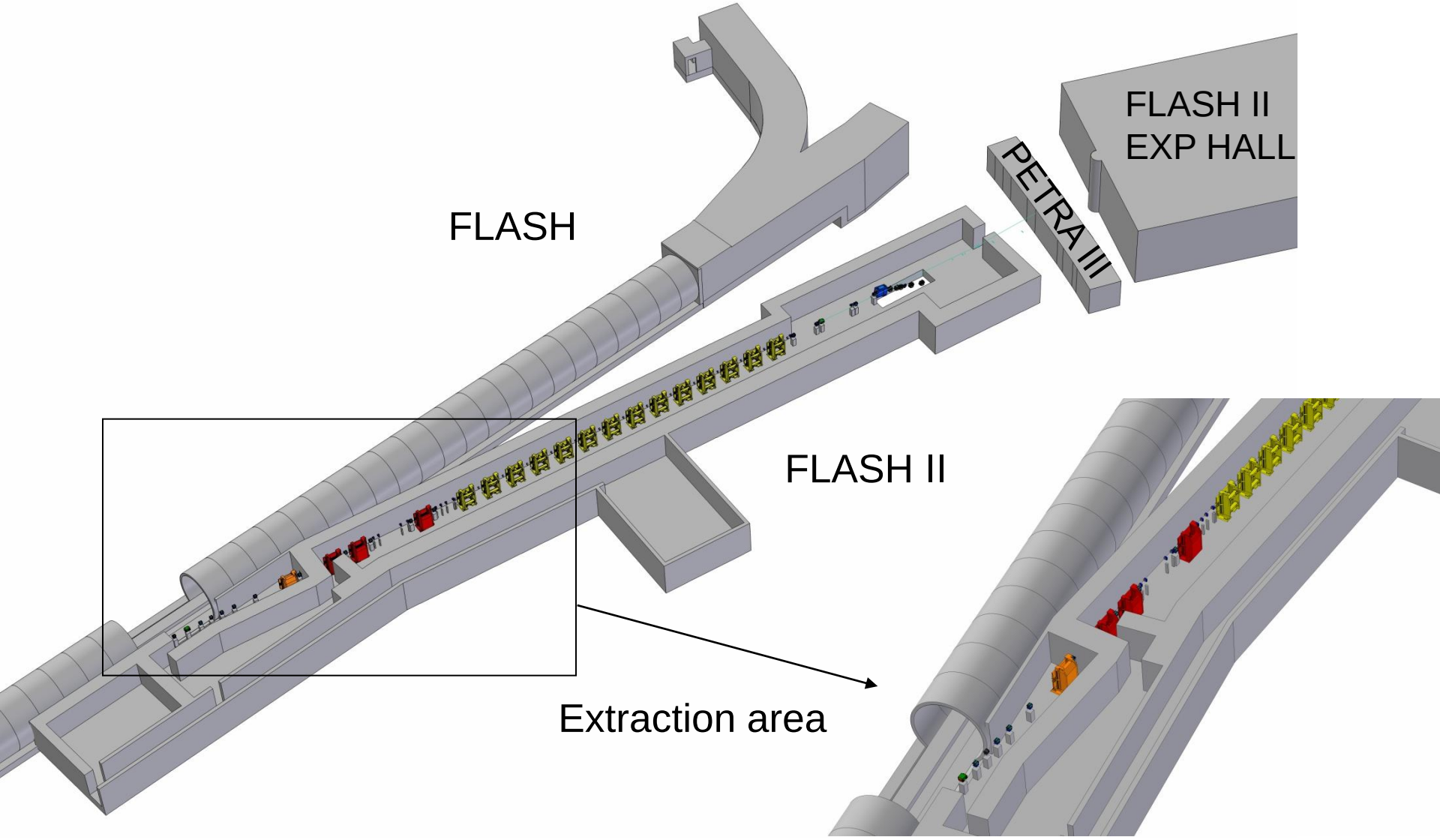
HELMHOLTZ ASSOCIATION

Upgrade: layout after upgrade FLASH II.

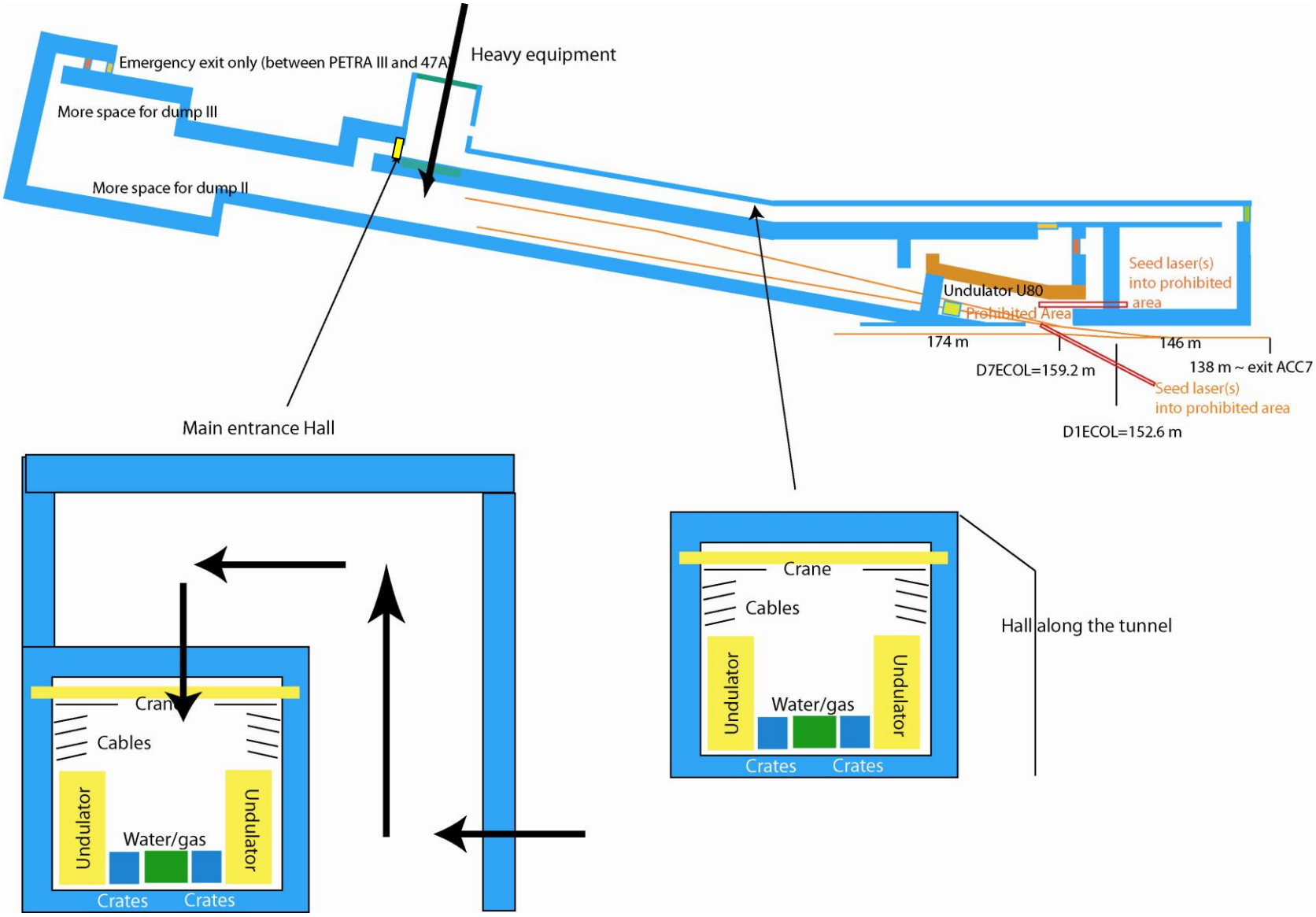


- Separation FLASH and FLASH II behind last accelerator module
- Tunability of FLASH II by undulator gap change
- Extend user capacity with SASE and HHG/HGHG seeding
- Use of existing infrastructure up to last accelerating module

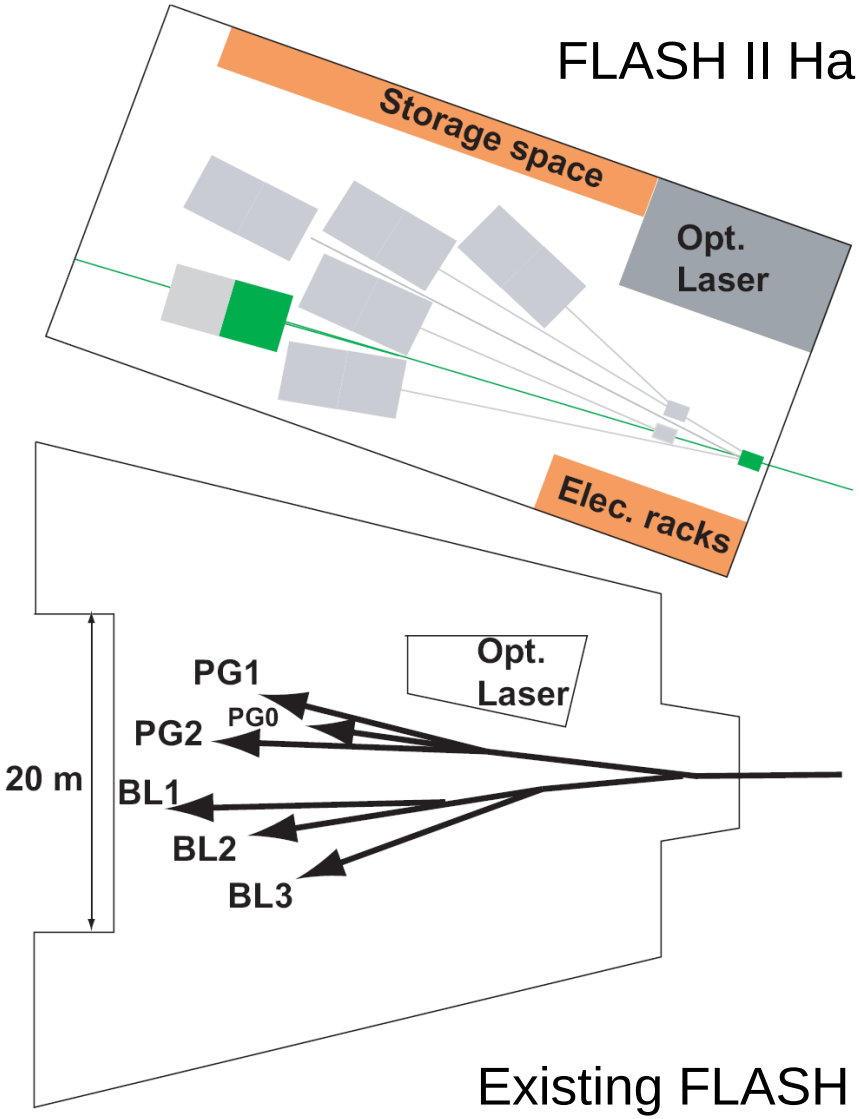
Upgrade: layout after upgrade FLASH II.



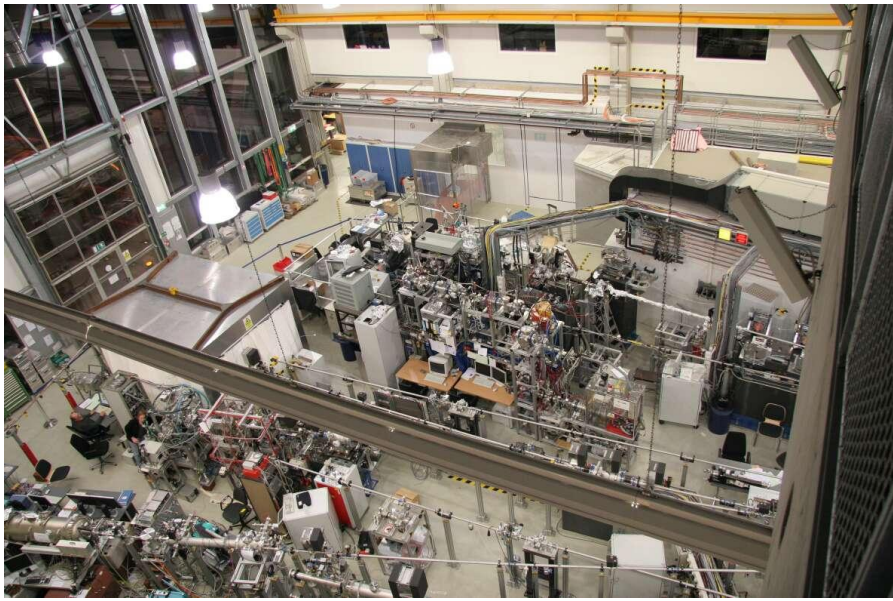
FLASH II Layout, next iteration.



Layout experimental Hall.



More space for experiments
Two experiments in a row
Less mirrors to experiment
....



FLASH II: foreseen operation modes.

Self Amplified Spontaneous Emission mode: Start from fluctuation in electron density
spiky, but at full rep.rate and short and long pulses possible.

SEEDING SCHEMES: Amplification of an external laser

High Gain Harmonic Generation mode:

Amplify a long wavelength seed and apply frequency multiplication in FEL process.

Only short pulses (up to ~5-30 fs), but close to single mode.

High Harmonic Generation mode (see also sFLASH):

Amplify an external, frequency multiplied seed laser.

Only short pulses (up to ~5-30 fs), but close to single mode down to ~10 nm.

Hybrid mode: HGHG with HHG source

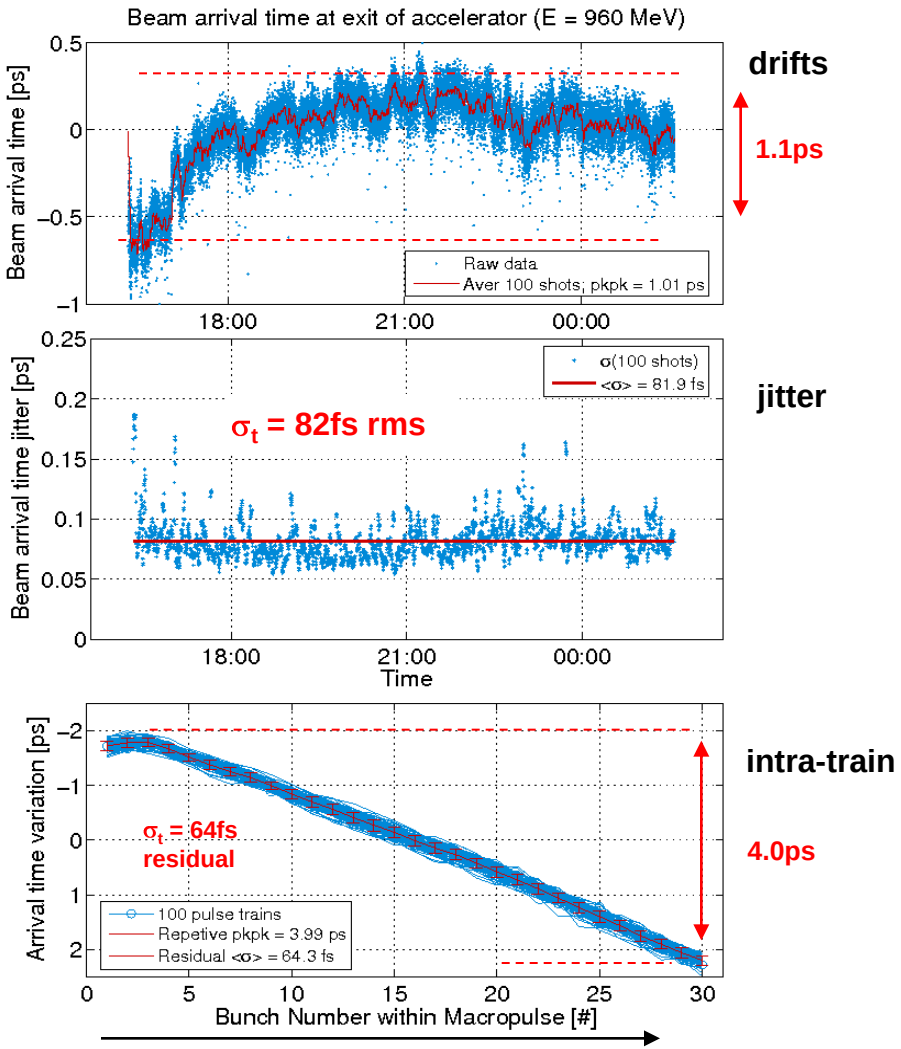
SASE operation with S2E simulations (Igor Zagorodnov).

	with harmonic module					without*
Bunch charge, nC	1	0.5	0.25	0.1	0.02	0.5-1
Wavelength, nm	6.5					6
Beam energy, MeV	1000					1000
Peak current, kA	**2.5**	**2**	**1.7**	**2.6**	**2.5**	1.3-2.2
Slice emmitance,mm-mrad	**1-1.5**	**0.7-1.5**	**0.5-1.2**	**0.5-1**	**0.5-0.7**	1.5-3.5
Saturation length, m	**13-15**					22-32
Energy in the rad. pulse, μJ	700-1200	400	200	30	3	50-150
Radiation pulse duration FWHM, fs	**100-200**	**35-150**	**25-100**	**3-5**	**2-3**	15-50
Averaged peak power, GW	3-5				1	2-4
Spectrum width, %	0.4-0.5			0.3-0.4		0.4-0.6
Coherence time, fs	4-5			-	-	-

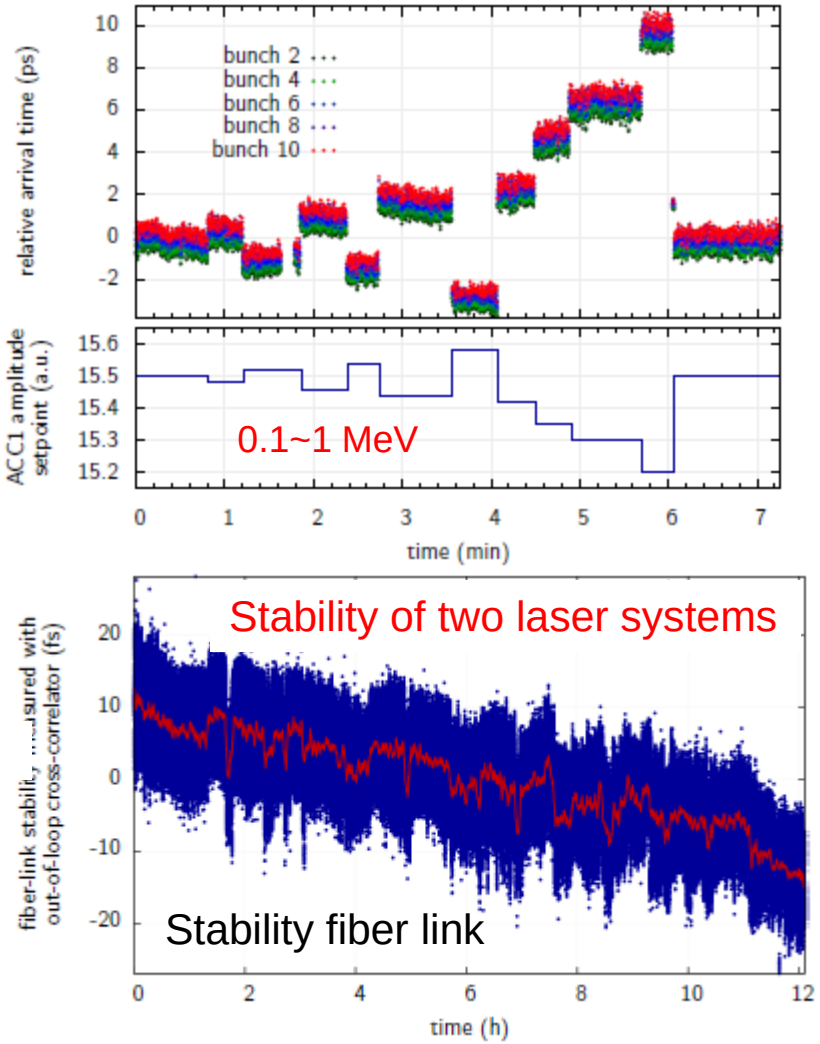
*) E.L.Saldin at al, Expected properties of the radiation from VUV-FEL at DESY, TESLA FEL 2004-06, 2004.

Why seeding (Pump-Probe jitter smaller than pulse length)?

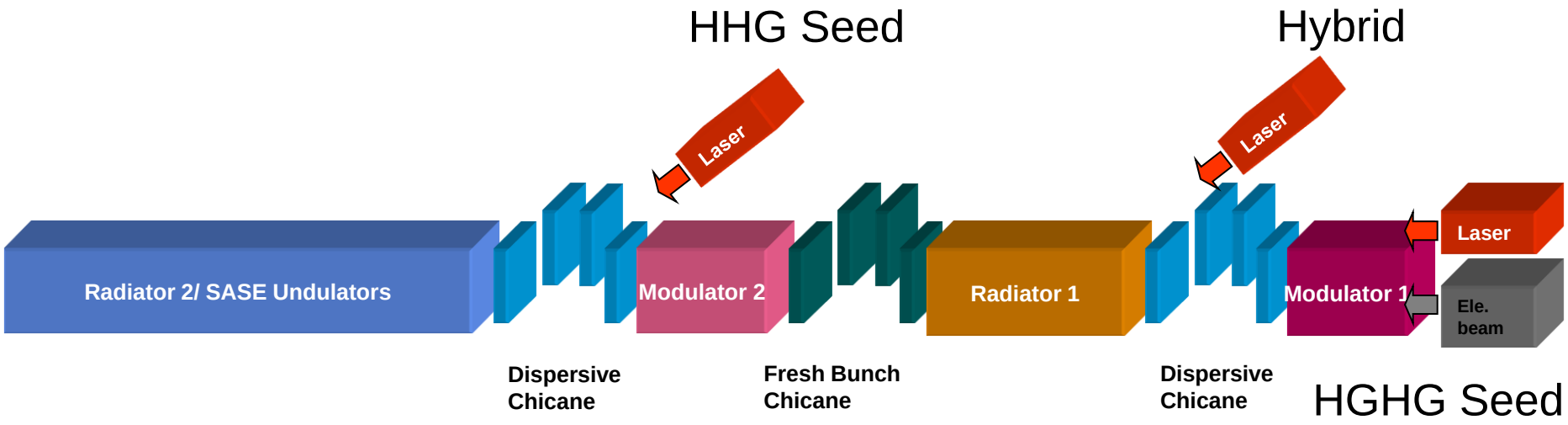
August 2009 user run (courtesy Schlarb)



Arrival time with ACC1 (courtesy Loehl)



General Layout.



Structure given by cascaded HGHG

HHG seed at entrance of SASE undulators=radiator 2

HHG seed at entrance of radiator 1 combined with 1 HGHG stage

SASE Mode (baseline design).

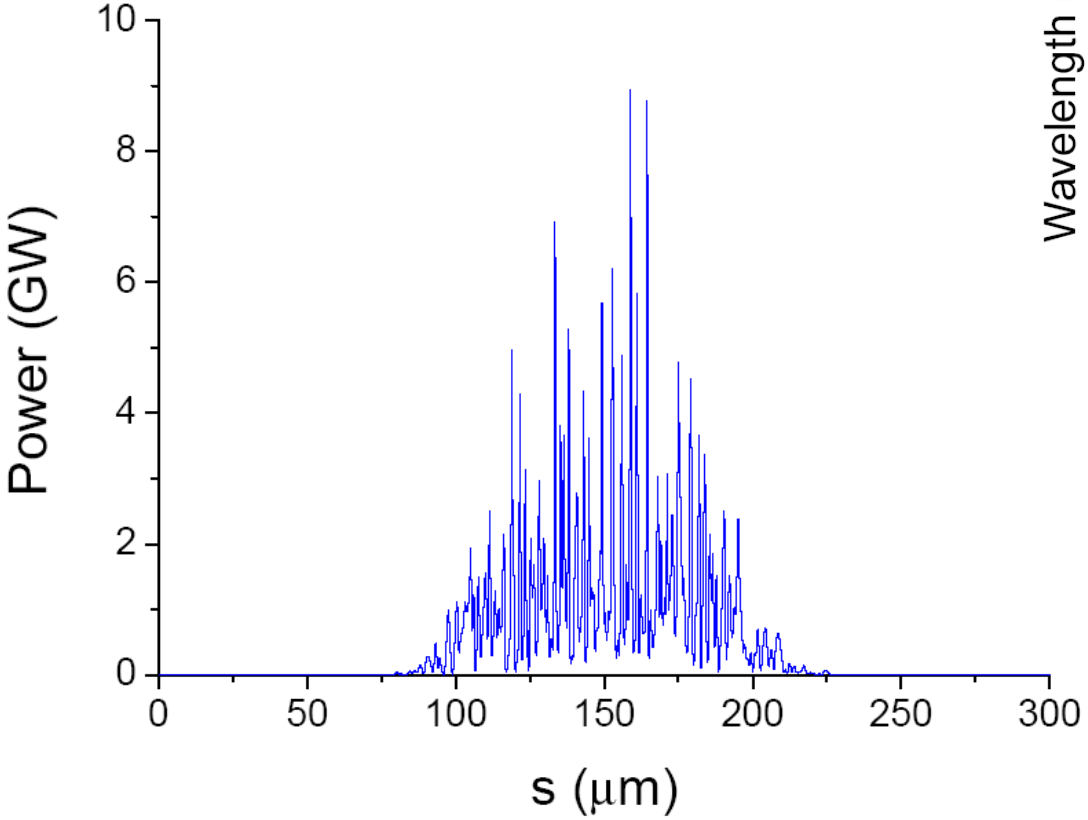
Picosecond-mode*	
Wavelength	4.5-60 nm
Peak power	2-5 GW
Pulse energy	200-1000 μJ
Photons per pulse	10^{13} - 10^{14}
Pulse length (FWHM)	~200 fs
Bandwidth (FWHM)	~0.3 – 1.5 %
# Pulses / s	<=800x10**

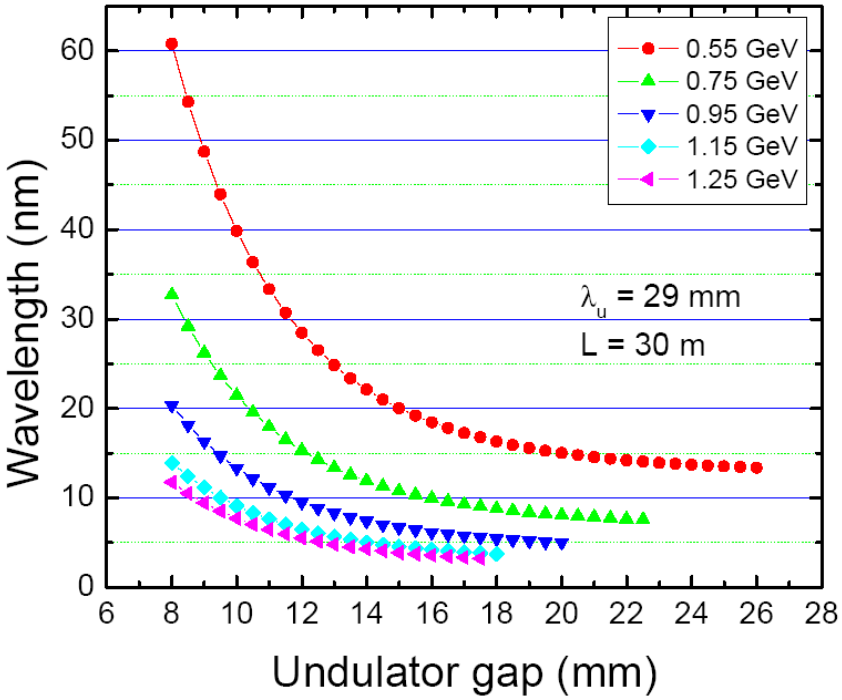
femtosecond-mode*	
Wavelength	6-60 nm
Peak power	1-5 GW
Pulse energy	10-100 μJ
Photons per pulse	10^{12} - 10^{13}
Pulse length (FWHM)	~10 - 50 fs
Bandwidth (FWHM)	~0.5 – 1.5 %
# Pulses / s	<=800x10**

**radiation parameters depend on wavelength and exact machine settings, simulations by I. Zagorodnov*
***Maximum number of bunches depends on operation of FLASH I*

SASE simulation results (picosecond mode).

Using gap tunability





HGHG Seeding Mode.

Picosecond-mode*

-

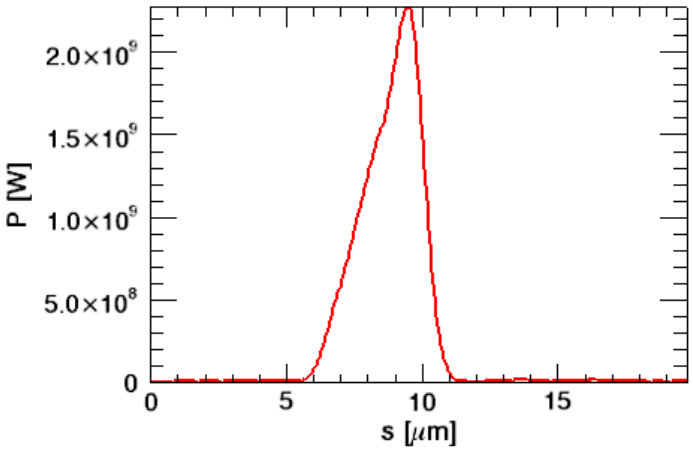
femtosecond-mode*

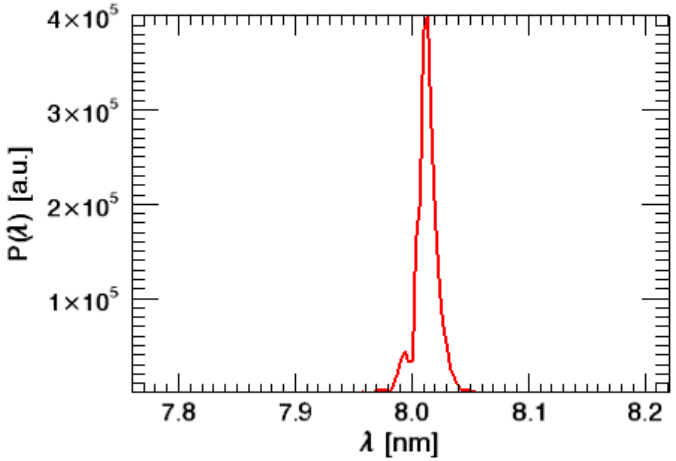
Wavelength	4-60 nm
Peak power	0.2-5 GW**
Pulse energy	1-100 μJ**
Photons per pulse	10^{11} – 10^{13}**
Pulse length (FWHM)	~5 - 30 fs
Bandwidth (FWHM)	Fourier limited
# Pulses / s	10 or 80x10***

**Because of limited seed power, long seed pulses with sufficient power is not yet possible.*
***4 nm only at reduced power, longer than 8 nm at GW powers*
****Depending on ongoing development of seed lasers*

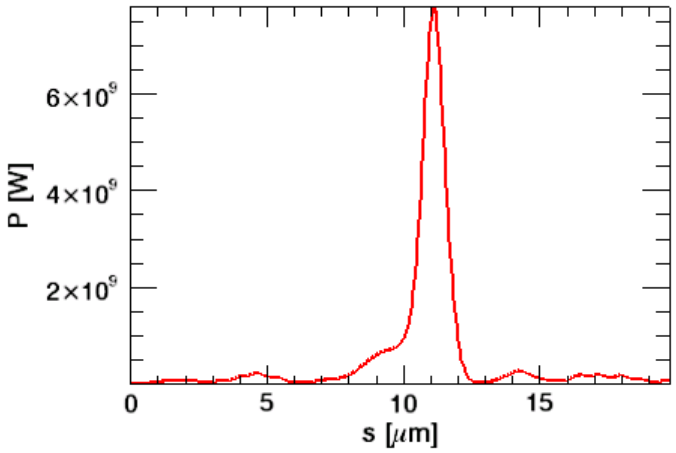
HGHG simulation results.

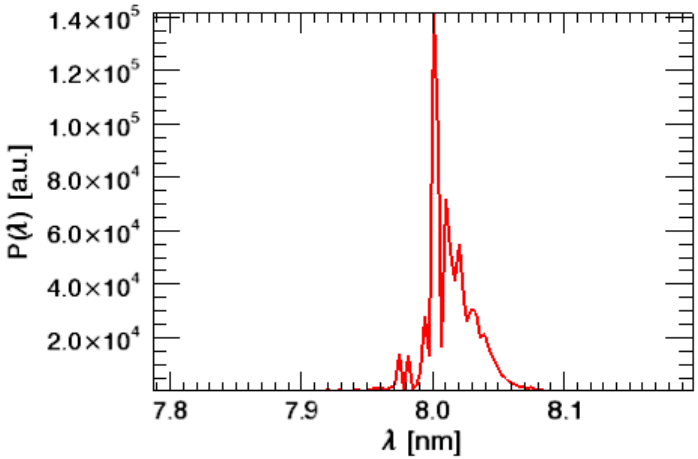
200MW-seed peak power, at z=8m





200MW-seed peak power, at z=13.8m





HHG Seeding Mode.

Picosecond-mode*

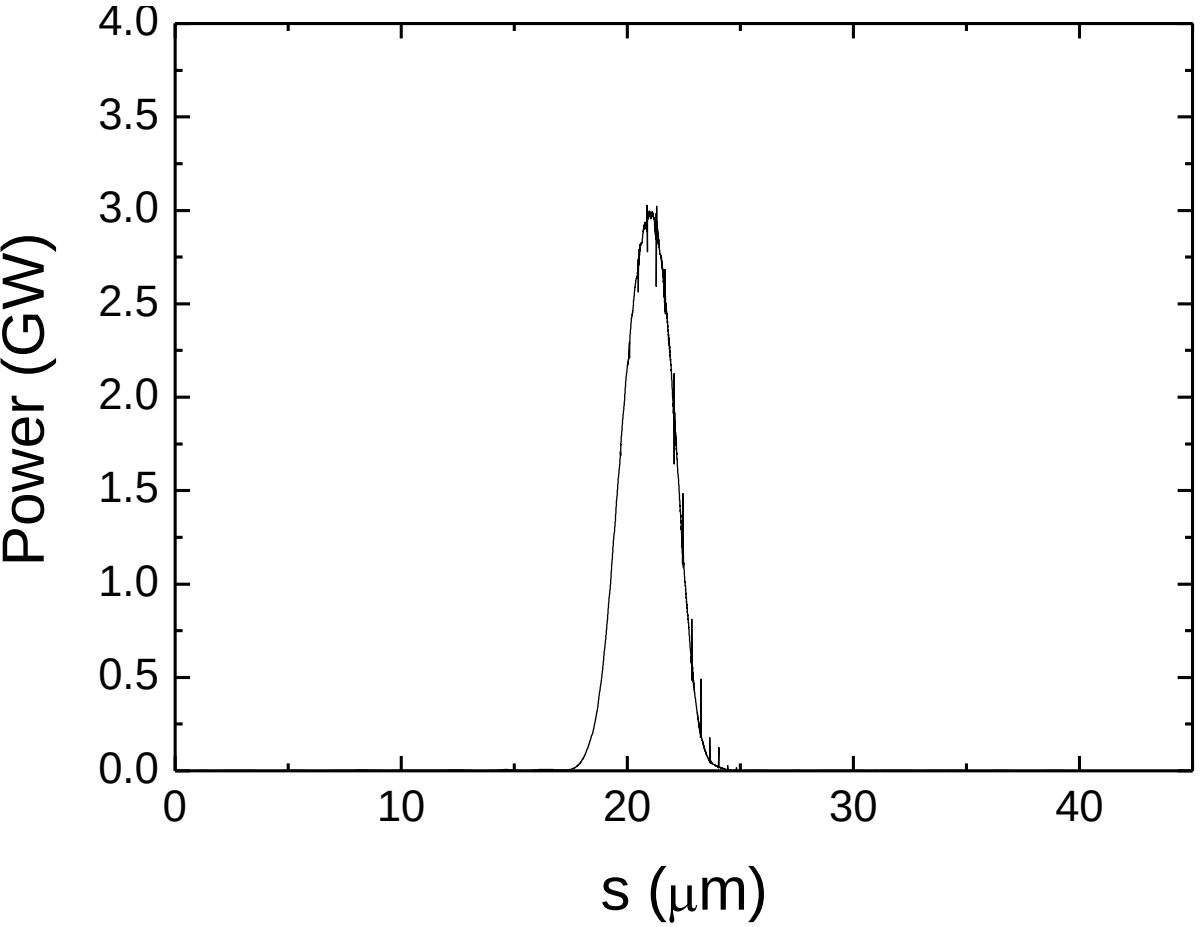
-

femtosecond-mode*

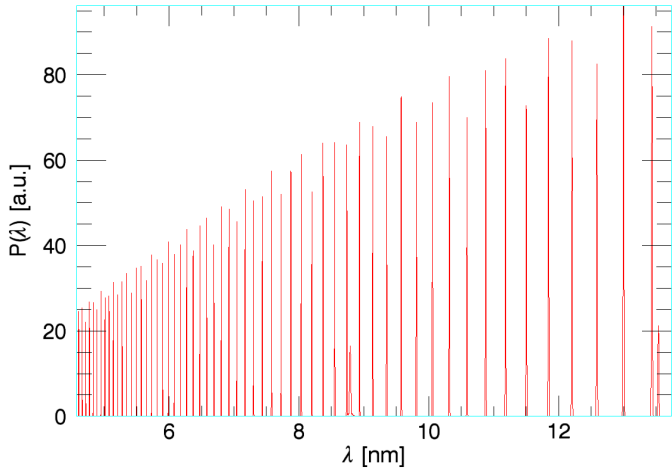
Wavelength	10-40 nm***
Peak power	1-5 GW
Pulse energy	10-100 μJ
Photons per pulse	10^{12} - 10^{13}
Pulse length (FWHM)	~5 - 30 fs
Bandwidth (FWHM)	Fourier limited
# Pulses / s	<=80x10**

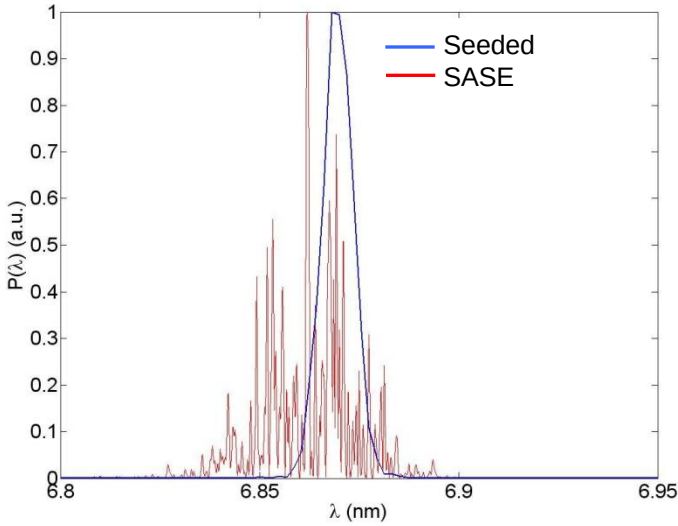
**Because of limited seed power, long seed pulses with sufficient power is not yet possible.*
***Future developments to reach full repetition rates are underway.*
****SHORTER WAVELENGTH ACHIEVED WITH QUASI PHASE MATCHING*

HHG simulation results.



HHG input

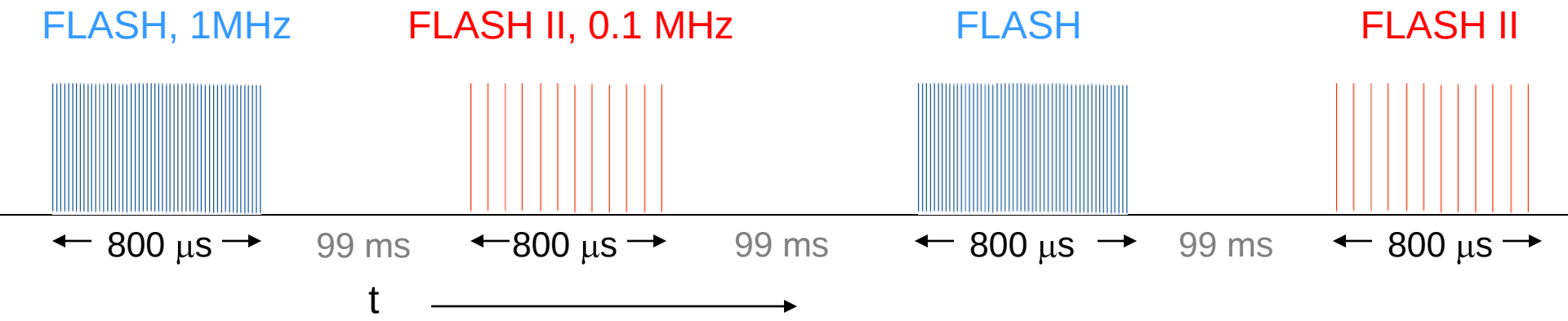




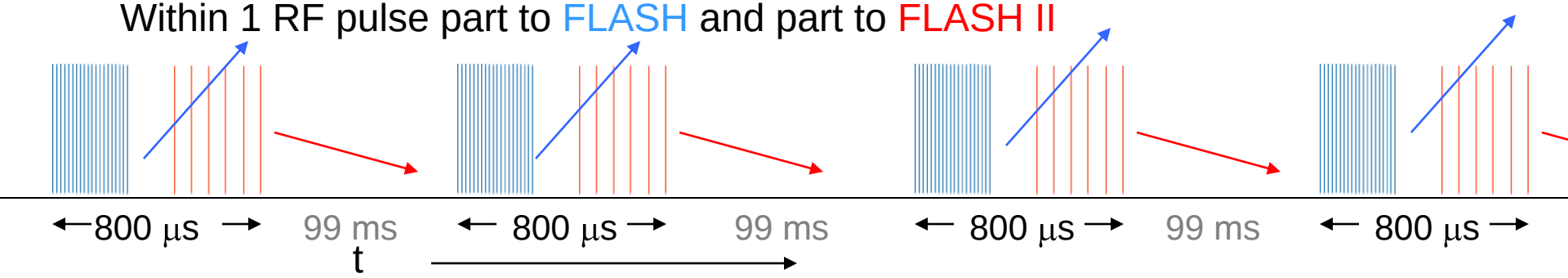
POSSIBLY AT **LOW** REP RATE

Beamline switching.

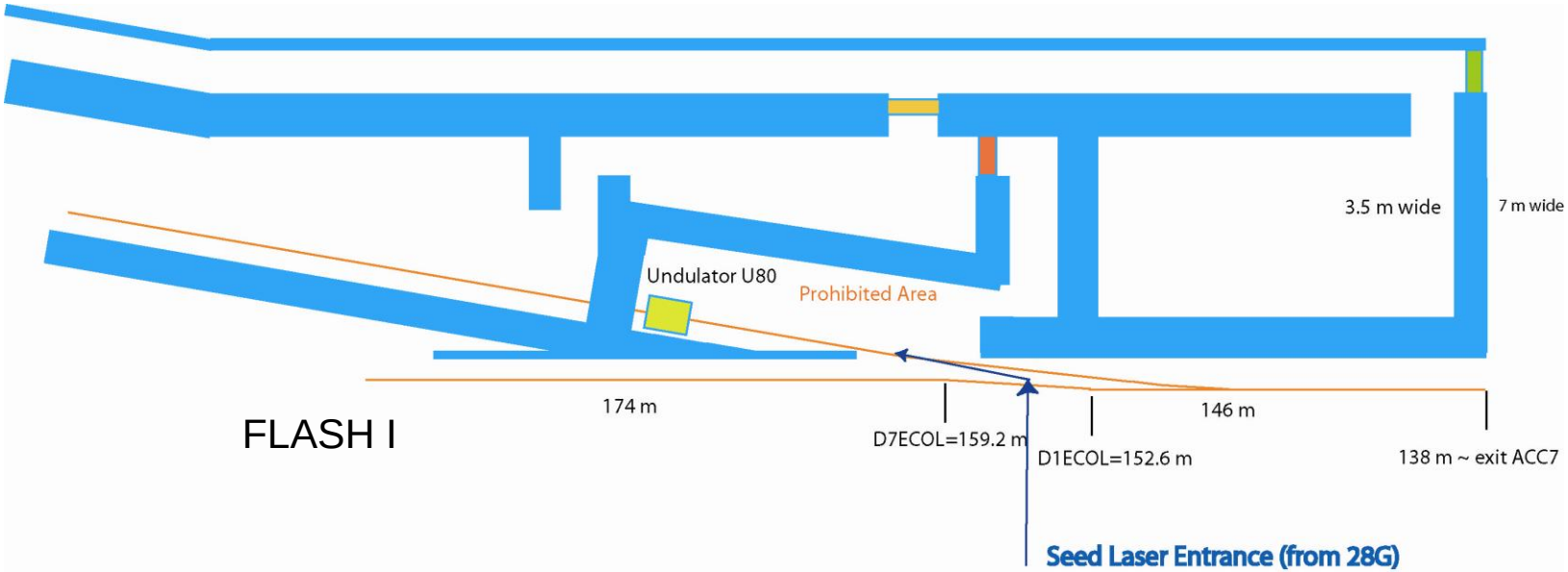
From pulse to pulse to FLASH or FLASH II



Within 1 RF pulse part to FLASH and part to FLASH II



Incoupling of seed laser.

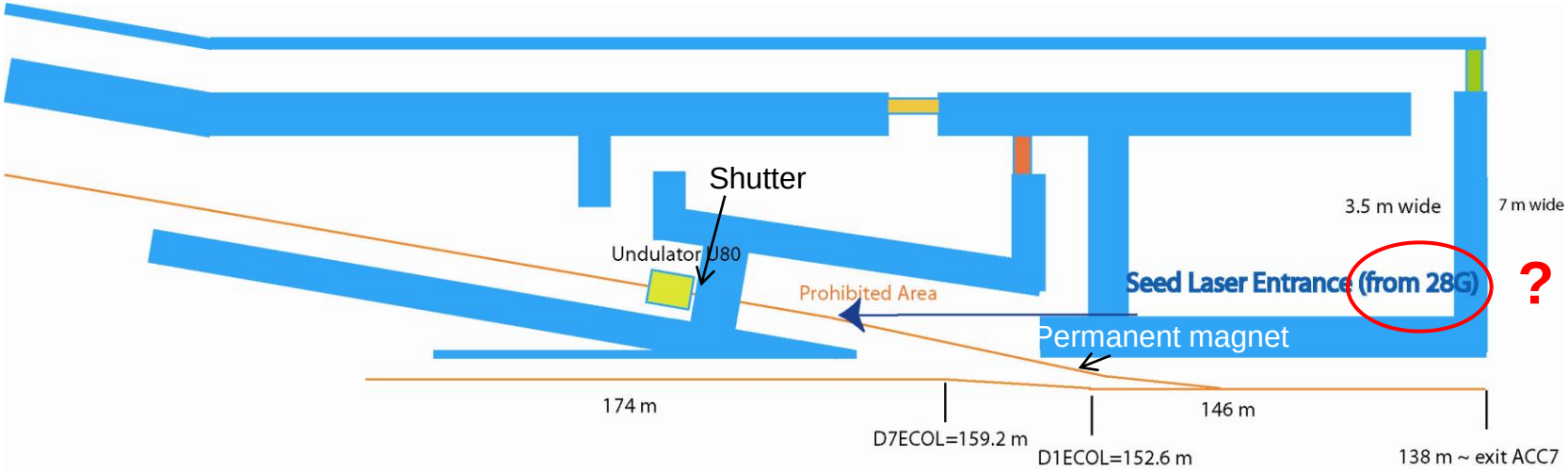


OLD

Laser seed entrance (=optical element) from FLASH I (prohibited)
What about difference HGHG/HHG seed?
U80 Undulator inside prohibited area (without crane?)
Small angle of extraction → smaller CSR effects

Incoupling of seed laser.

Laser seed entrance from FLASH II (freely accessible?)
HHG/HGHG SEED separation is transverse offset
U80 Undulator outside prohibited area (which is much smaller)
Larger angle of extraction → larger CSR effects (still seems to be OK)



NEW

In both cases (old/new) HHG seed details are unclear (but will be in one of the HGHG chicanes)
Safety issues need to be clarified, but shutter and space for “permanent” magnet needed

Components (preliminary).

Extraction area (~25 m long, includes matching).
Button type BPMs: resolution 10-50 um, 40 mm vacuum pipe (XFEL type).
Quadrupoles: TQA (36 mm diameter, geometrical step-wakes seem acceptable).
For matching 4 OTR/WS combinations.

HGHG area (~20 m long).
Cavity type BPMs: resolution 1 um, 10 mm vacuum pipe (XFEL type).
Quadrupoles: TQG (15 mm diameter, 10 mm vacuum pipe).
1xU80, 3x U62 Undulators.
2x dispersive chicanes for bunching (?).
1x fresh bunch chicane (probably including phase monitor?).
1xphase shifter: unknown geometry, etc.
Diagnostics for transverse overlap Seed/beam.

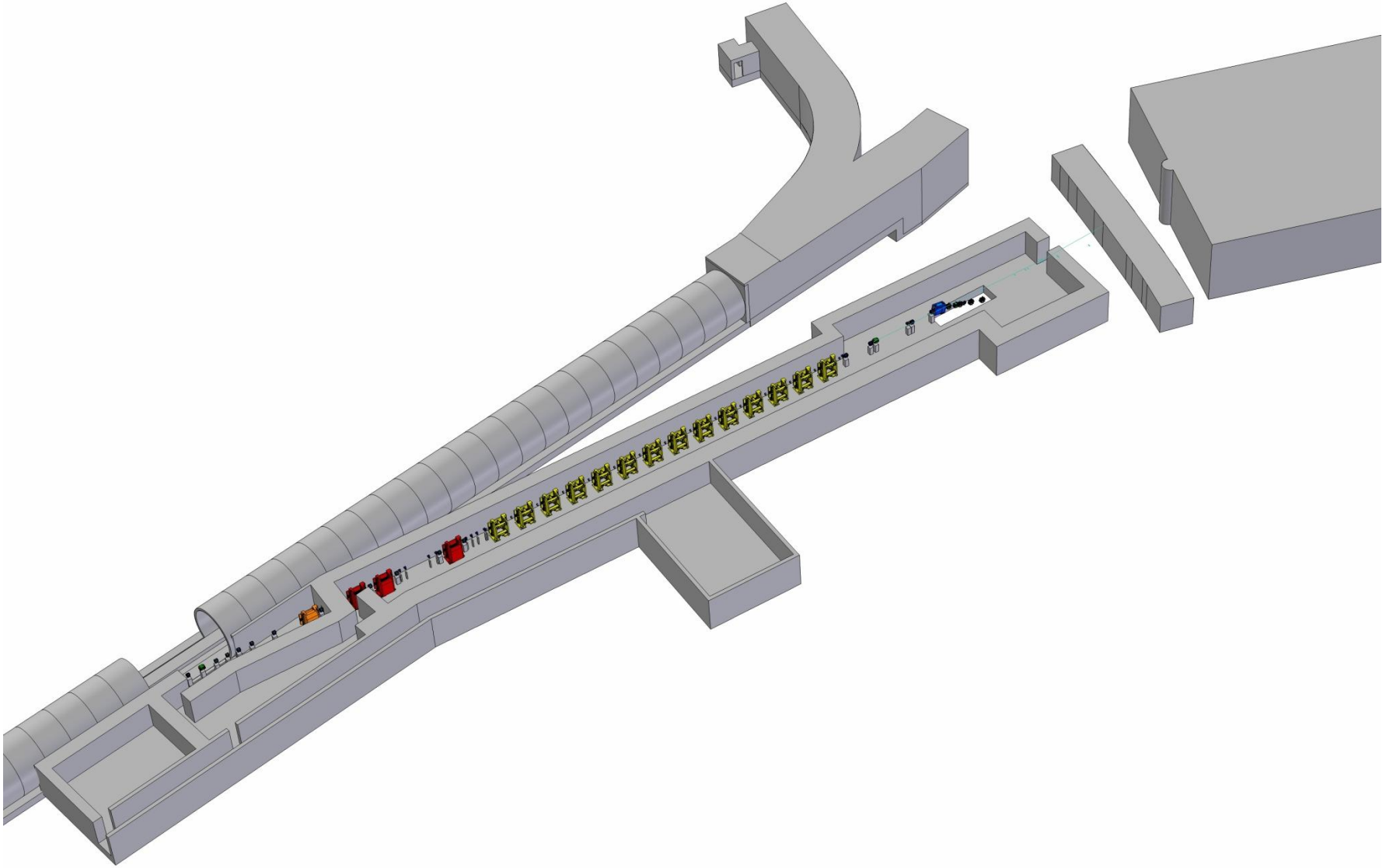
SASE area (~40 m long).
Cavity type BPMs: resolution 1 um, 10 mm vacuum pipe (XFEL type).
Quadrupoles: TQG (15 mm diameter, 8 mm vacuum pipe, wakes not checked).
Either 10xU29 or 6xU29 + 2xAPPLE Undulators.
10x or 8x phase shifter: probably sFLASH type.

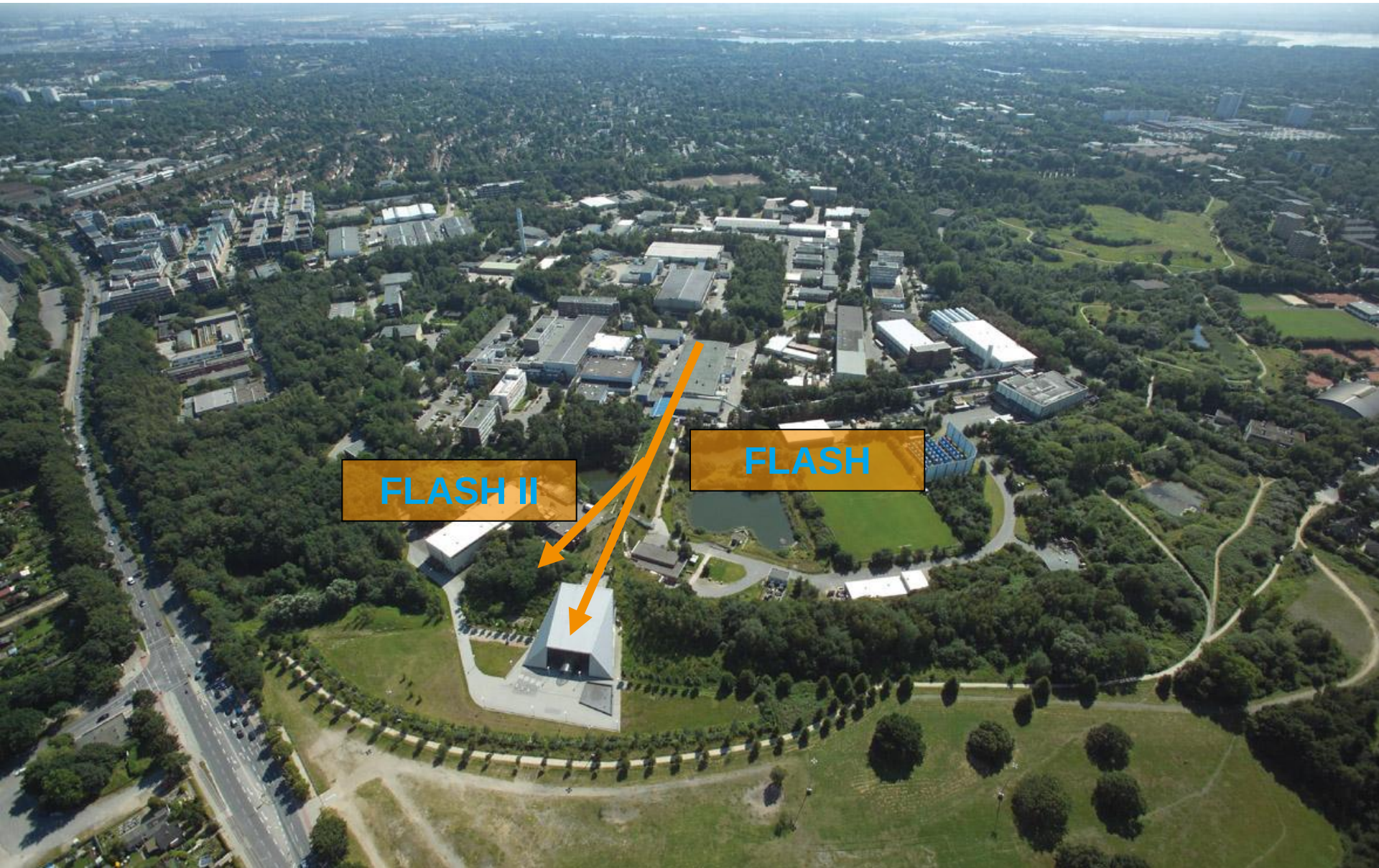
Components (preliminary).

EXP area (~12 m long).
Stripline BPM from BYPASS: resolution 10-50 um, 40 mm vacuum pipe.
Quadrupoles: TQB (50 mm diameter from BYPASS).

DUMP area (~10 m long).
DUMP Dipole from BYPASS.
Button type BPMs: resolution 10-50 um, 100 mm vacuum pipe (XFEL type).
Quadrupoles: ??? (100 mm diameter).
DUMP diagnostics as in FLASH I?

Photon Diagnostics area (~15 m long).
GMD based Intensity monitor/online spectrometer/BPMs.
YAG screen.
Set of Apertures.
First Deflecting mirror inside tunnel.
Absorber/Shutter.




FLASH II
FLASH