Preliminary simulation of Terahertz superradiation generation at PITZ

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HELMHOLTZ

DESY.

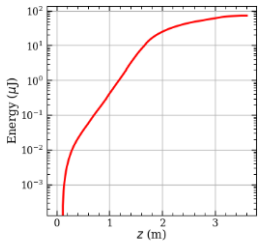
Parameter study for electron bunch at undulator entrance

with ideal 6D Gaussian distribution

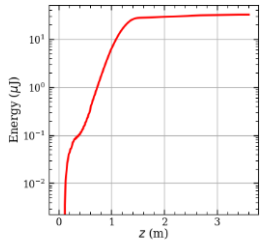
Initial beam parameters:

α_x	10	β_x	17.5 m	$\varepsilon_{x,n}$	2 μm
α_y	9.75	β_y	1.125 m	$\varepsilon_{y,n}$	2 μm
$\sigma_{E,cor}$	-85 keV	$\sigma_{E,uncor}$	8.5 keV	p_z	17 MeV/c

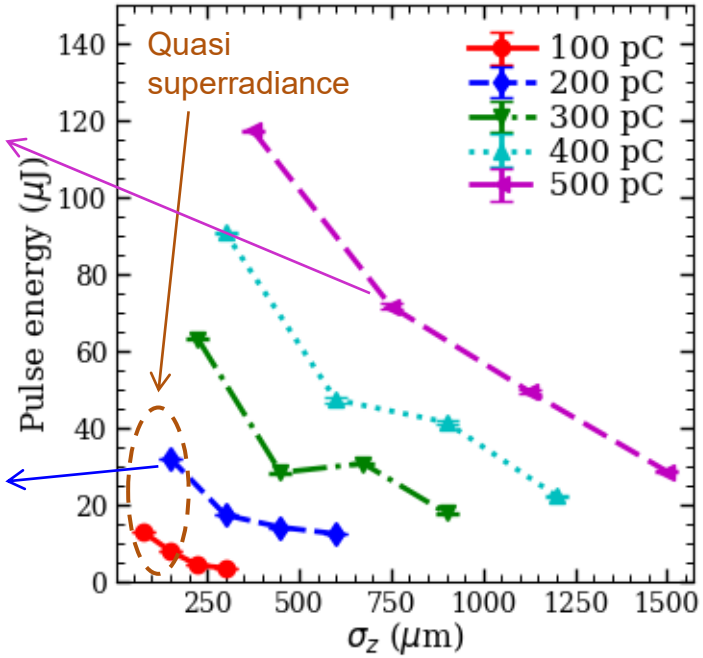
- The shortest rms bunch length was estimated according to previous studies of bunch compression at PITZ

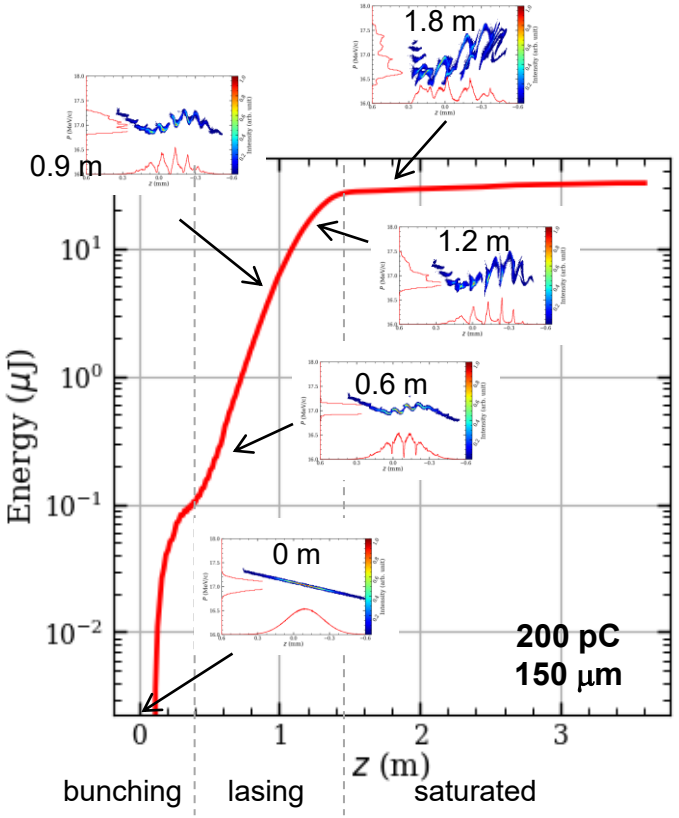


500 pC 750 μm

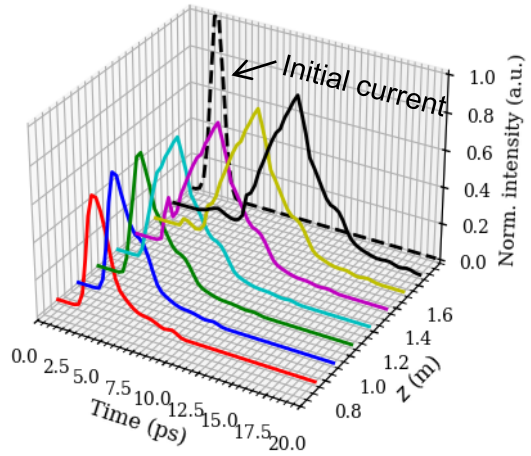


200 pC 150 μm





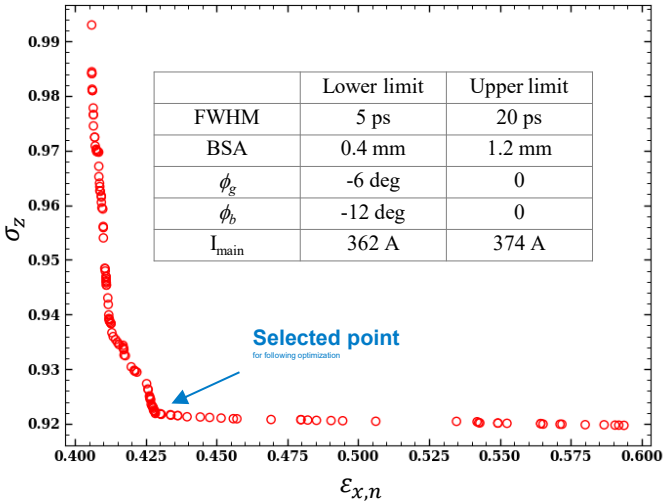
z (m)	FWHM (ps)	z (m)	FWHM (ps)
0.75	1.99	1.35	4.11
0.9	2.78	1.5	4.10
1.05	2.41	1.65	4.10
1.2	3.62		



Temporal profiles

Performance for the 200 pC 150 μm case:
Saturated undulator length **~1.4 m**
Saturated energy **~30 μJ**
THz pulse FWHM **4.1 ps**

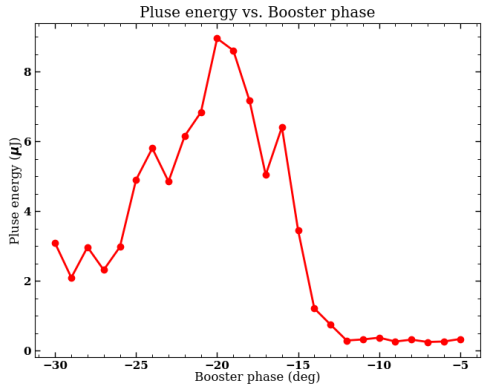
S2E simulation for generating desired electron bunch



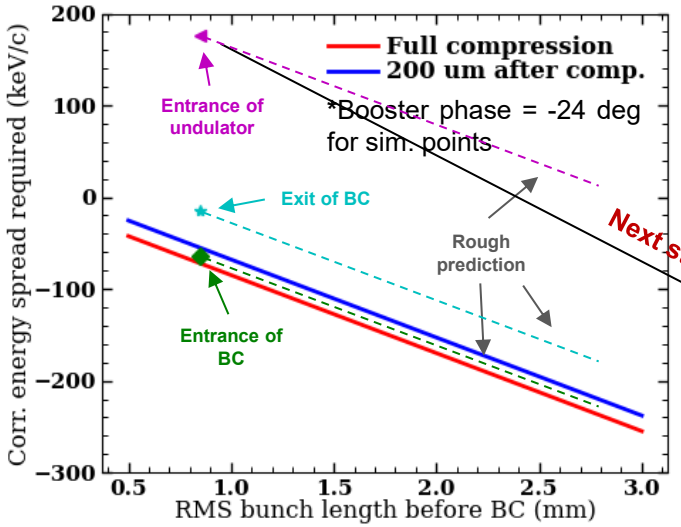
	Lower limit	Upper limit
FWHM	5 ps	20 ps
BSA	0.4 mm	1.2 mm
ϕ_g	-6 deg	0
ϕ_b	-12 deg	0
I_{main}	362 A	374 A

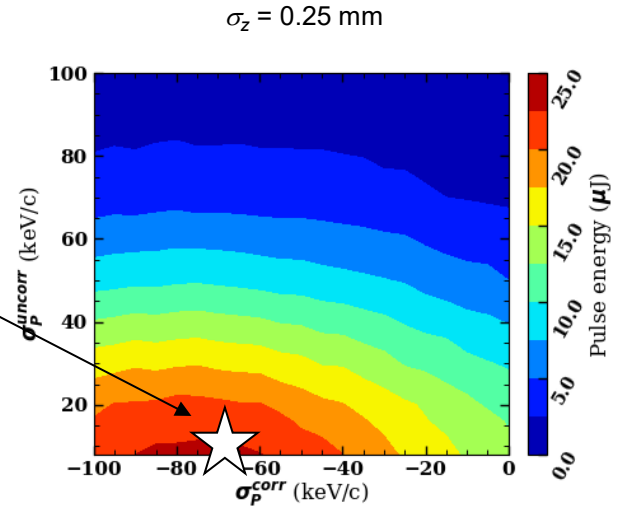
Optimized photoinjector parameters from minimizing bunch length and transversal emittance:

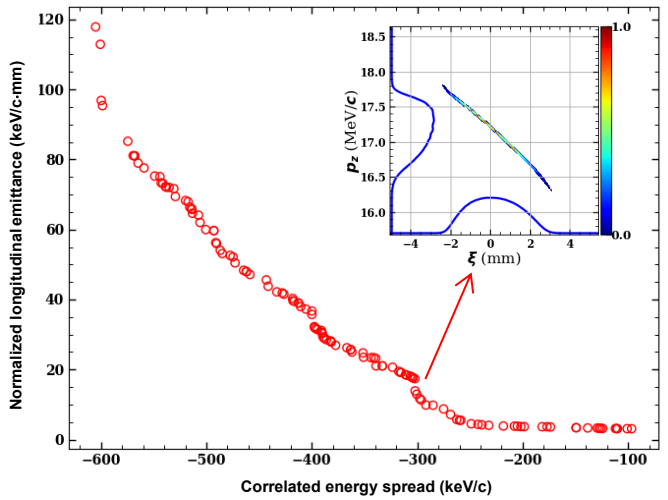
- **FWHM = 5 ps**
- **BSA = 1.2 mm**
- **ϕ_g = -5.73 deg**
- **I_{main} = 366.02 A**



Chirp flipped due to space charge effect -> bad FEL performance







Next steps for current PITZ facility:

1. Increase **laser length** and optimize **longitudinal phase space**;
2. Relax requirement for **target bunch length** step-by-step;
3. Reduce **charge**.

Suggestions for ideal machine design:

1. Increase **operating beam energy** to weaken space charge effect;
2. Shorten **drift space** after BC to prevent chirp flipping.

Thank you

Contact

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