PHOTOINJECTOR DRIVE LASER TEMPORAL SHAPING FOR SHAGNHAI SOFT X RAY FREE ELECTRON LASER

TUPAB121

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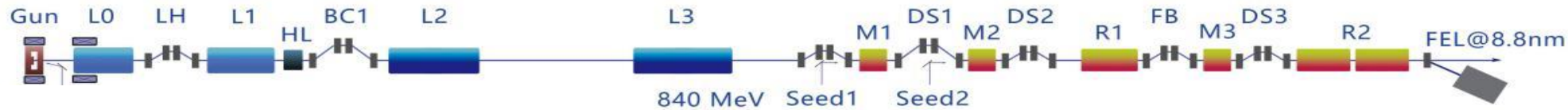
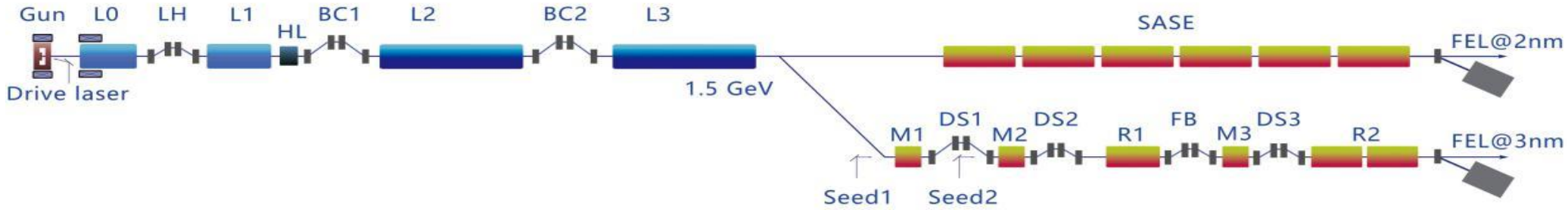
OUTLINE

- **PHOTOINJECTOR LASER TEMPORAL SHAPING**
  - **α - BBO pulse stacking**
  - **UV grating pair stretcher**
  - **Cross correlation diagnostic**
- **Conclusions**



Drive laser

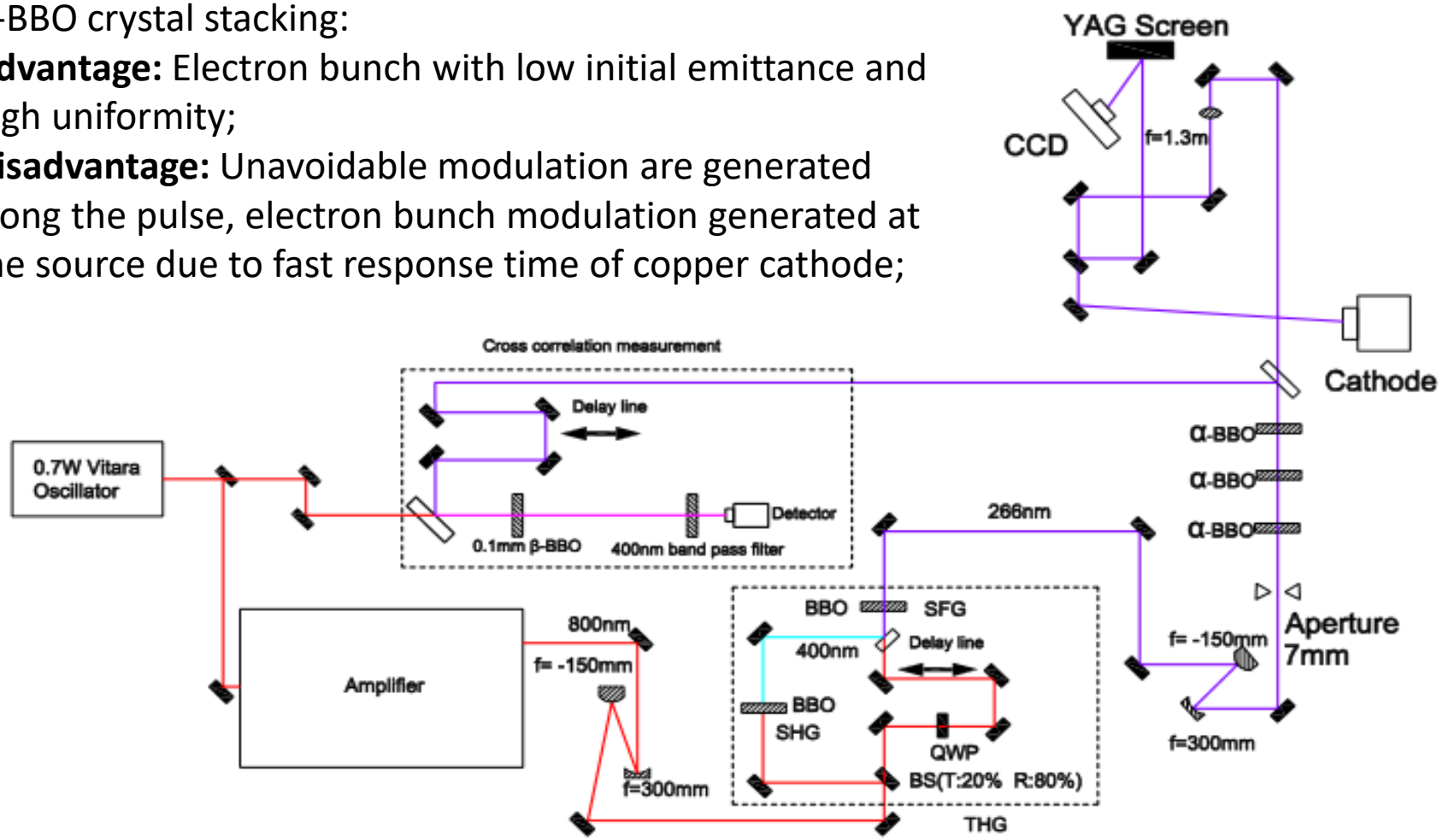


Test facility and user facility of Shanghai Soft X ray Free electron laser (SXFEL)

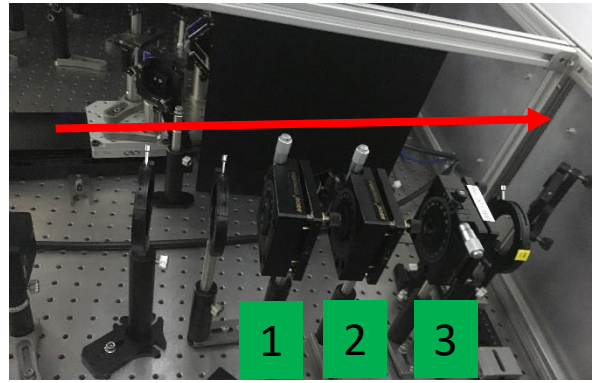
α-BBO crystal stacking:

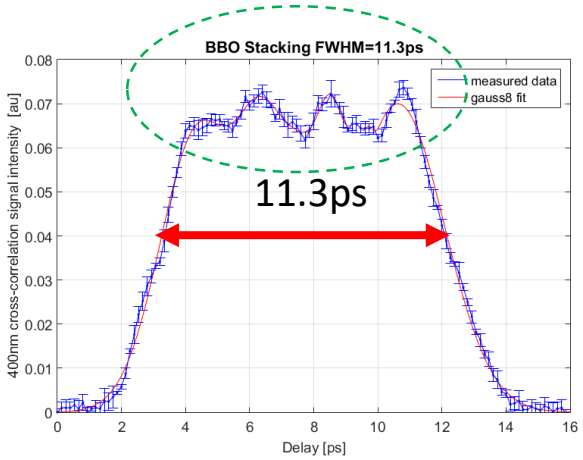
Advantage: Electron bunch with low initial emittance and high uniformity;

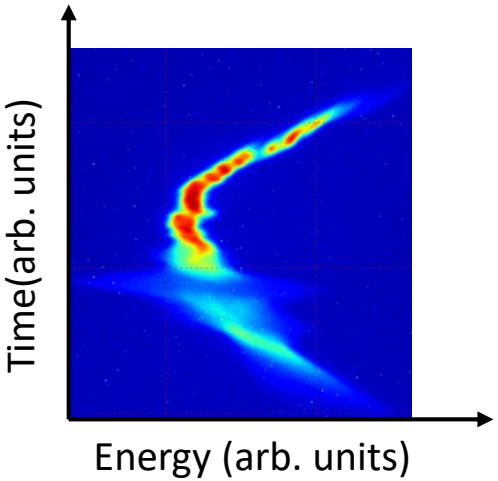
Disadvantage: Unavoidable modulation are generated along the pulse, electron bunch modulation generated at the source due to fast response time of copper cathode;



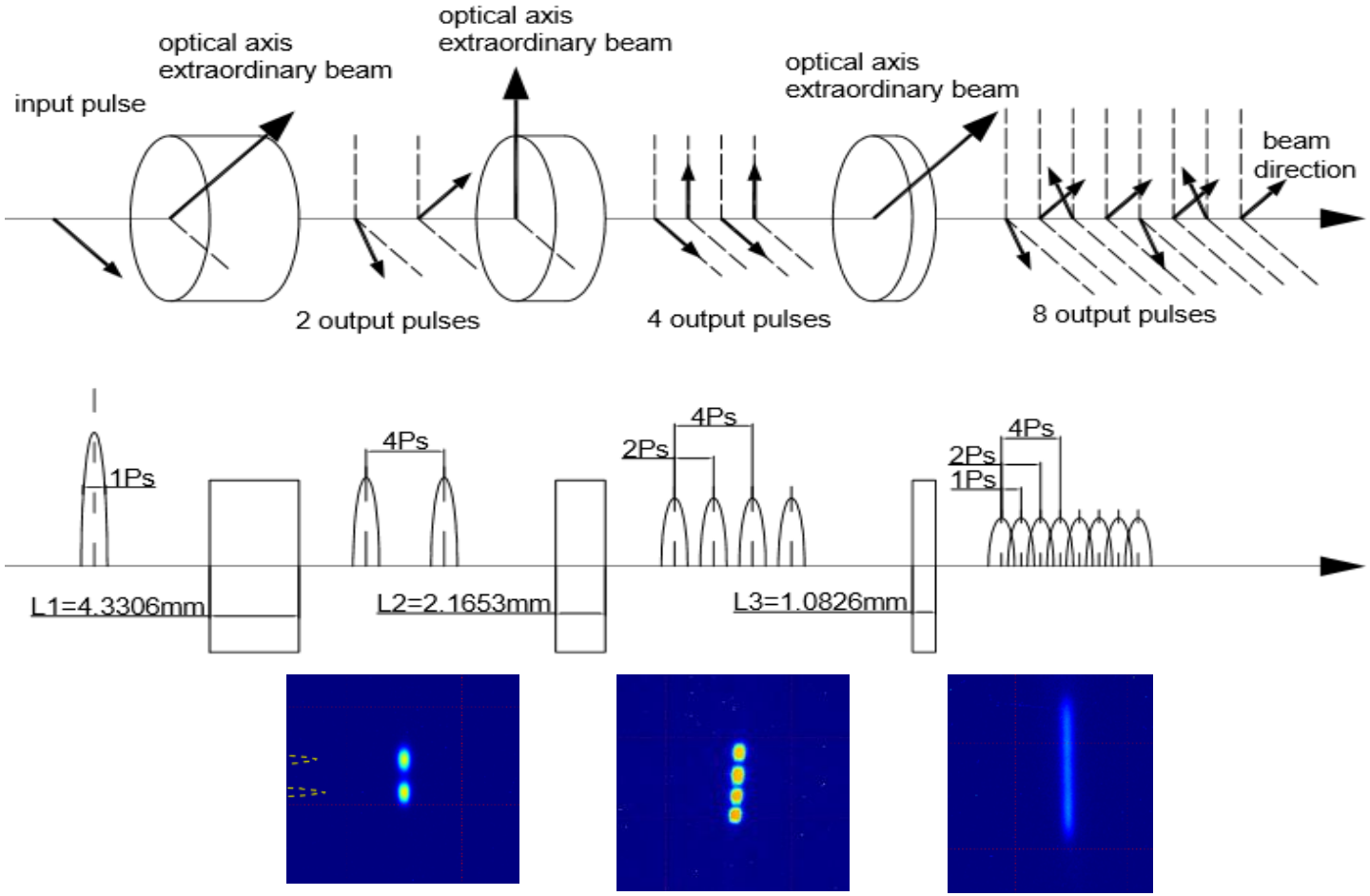
Schematic of SXFEL drive laser system





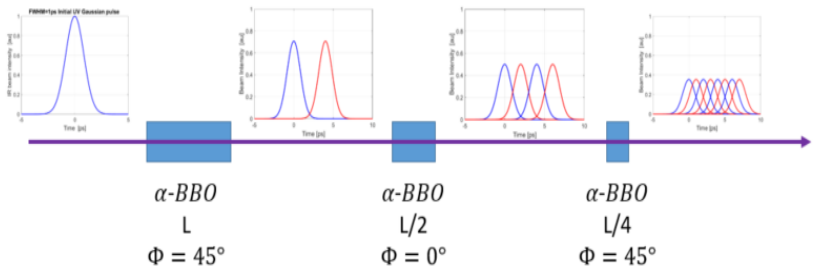


1. 8 pulses stacking measured by cross correlation；
2. Electron beam longitudinal profile measured by transverse deflecting cavity；



Schematic of α-BBO crystal stacking process

λ =266nm, n_{go}=2.09, n_{ge}=1.81,GVM=0.935 ps/mm



Sellmeier equations for $n_o(\lambda)$ and $n_e(\lambda)$:

$$n_o(\lambda) = \sqrt{2.7471 + \frac{0.01878}{\lambda^2 - 0.01822} - 0.01354\lambda^2}$$

$$n_e(\lambda) = \sqrt{2.3174 + \frac{0.01224}{\lambda^2 - 0.01667} - 0.01516\lambda^2}$$

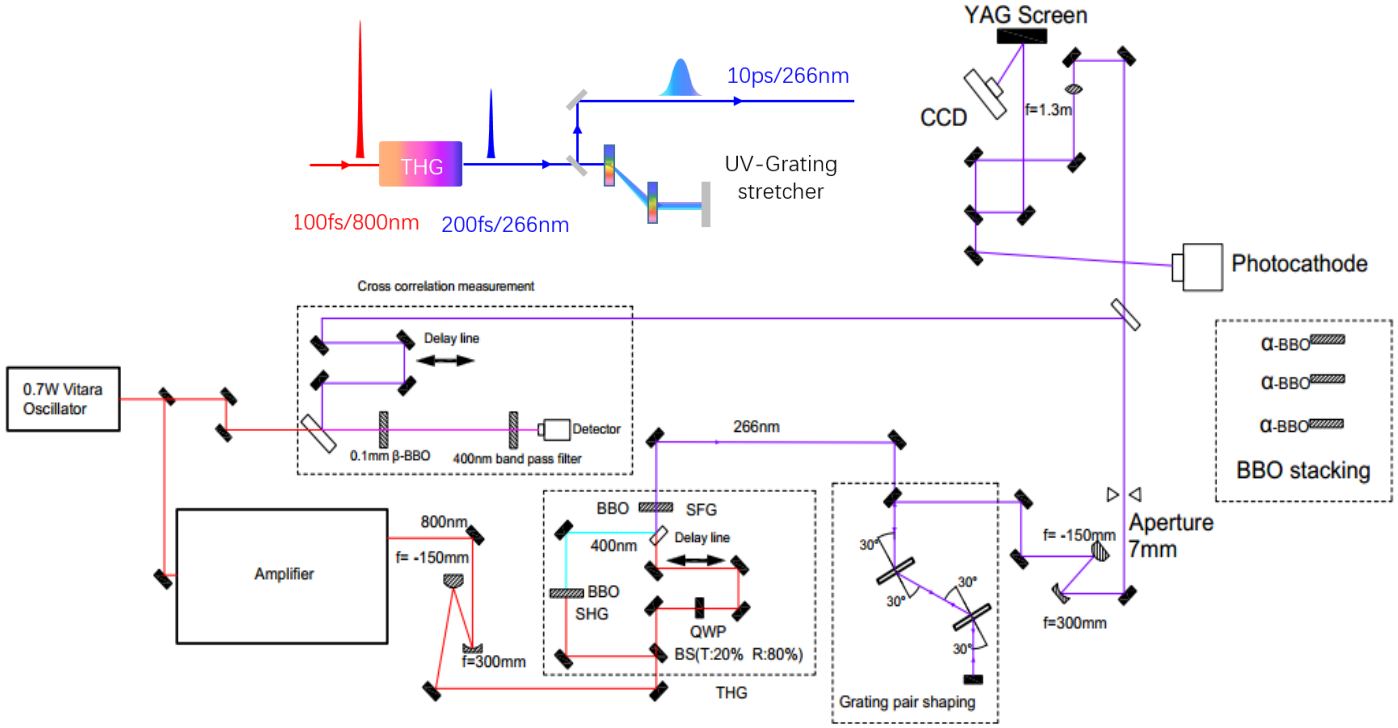
The temporal separation (Δt) between *o* beam and *e* beam when they propagate through the BBO birefringence crystal:

$$\Delta t = L * GVM$$

Group velocity mismatch (GVM):

$$GVM = \frac{1}{V_{ge}} - \frac{1}{V_{go}}$$

$$v_g = \frac{c}{n}\left(1 + \frac{\lambda}{n}\frac{dn}{d\lambda}\right)$$



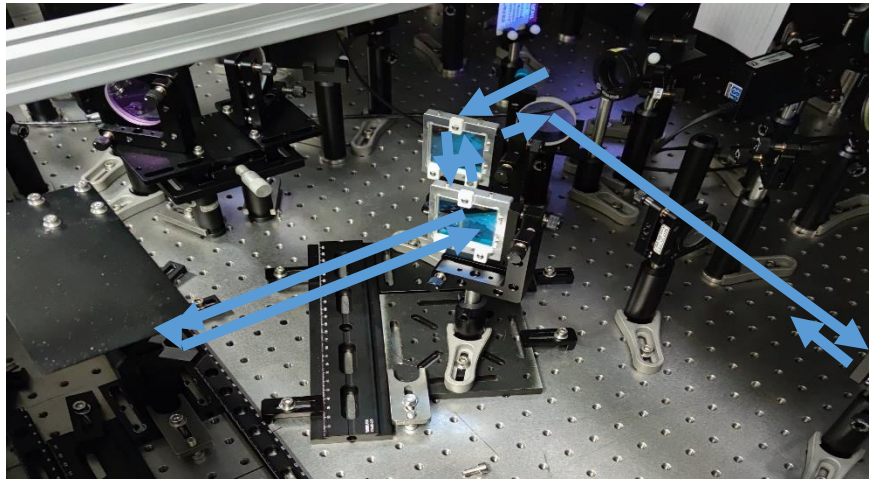
UV grating pair parameters	
Grating lines/mm	3846
Incident angle	30°
Input pulse duration	175fs
Output pulse duration	10ps
Grating separation	400mm
Material	Fused silica

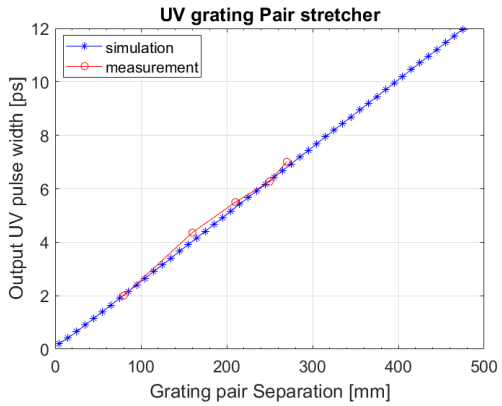
Group delay dispersion (GDD) introduced by the grating pair stretcher

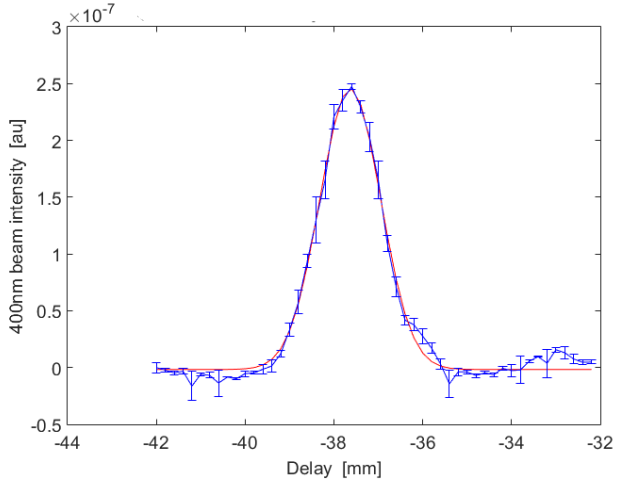
$$\mathrm{GDD} = \frac{d^2\phi}{d\omega^2} = \frac{m^2\lambda^3 L_g}{2\pi c^2} \times \left[1 - \left(-m\frac{\lambda}{\Lambda} - sin\theta_i\right)^2\right]^{-3/2}$$

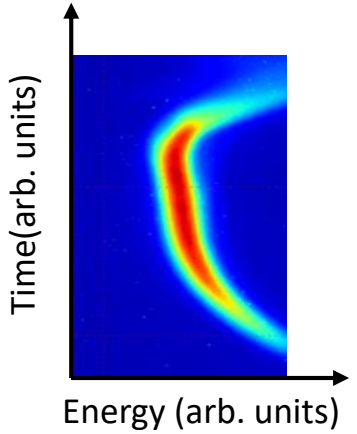
For given GGD, disperse pulse length τ is related to the initial pulse lengthτ_0

$$\tau = \tau_0 \sqrt{1 + \left(\frac{GDD \cdot 4\ln(2)}{\tau_0^2}\right)^2}$$

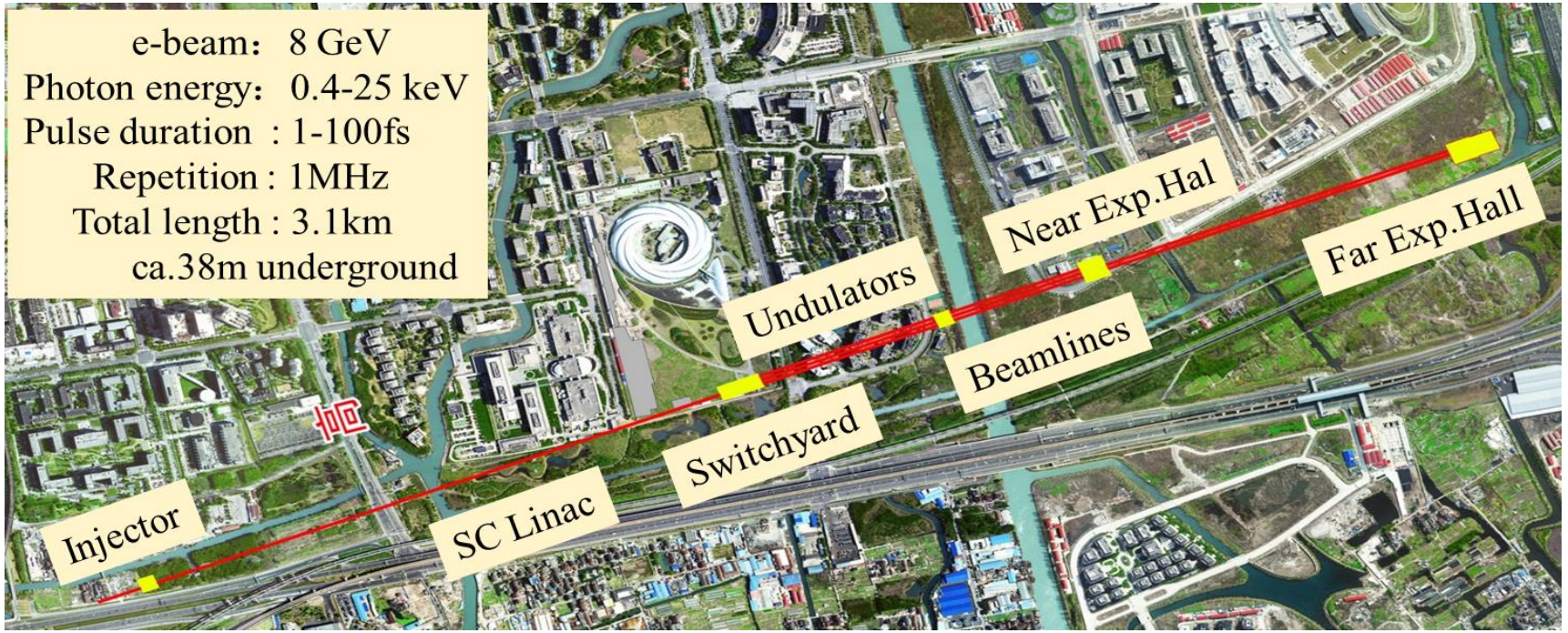




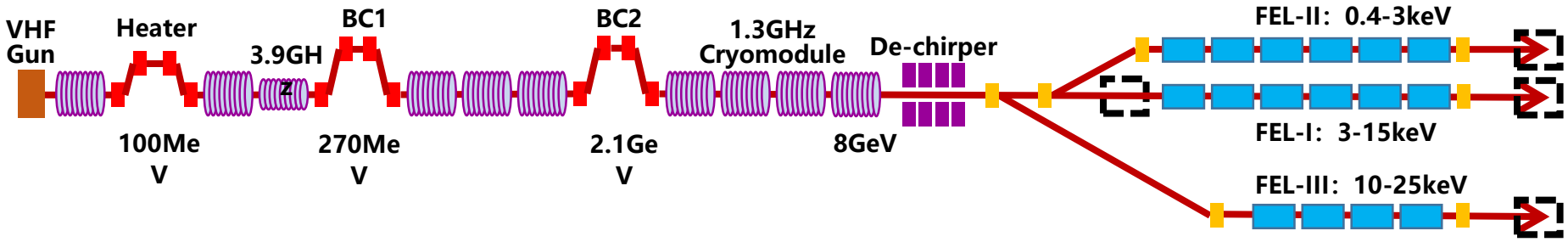


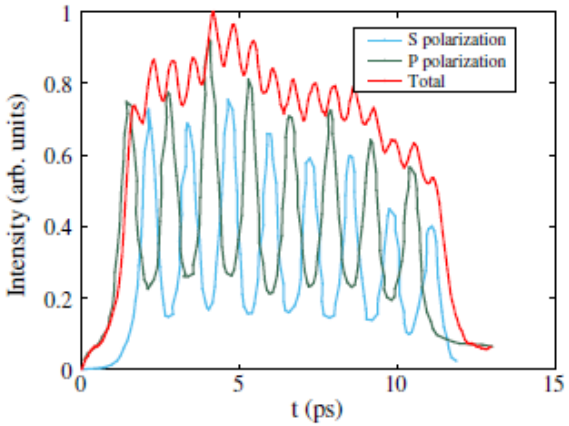


Electron beam longitudinal profile

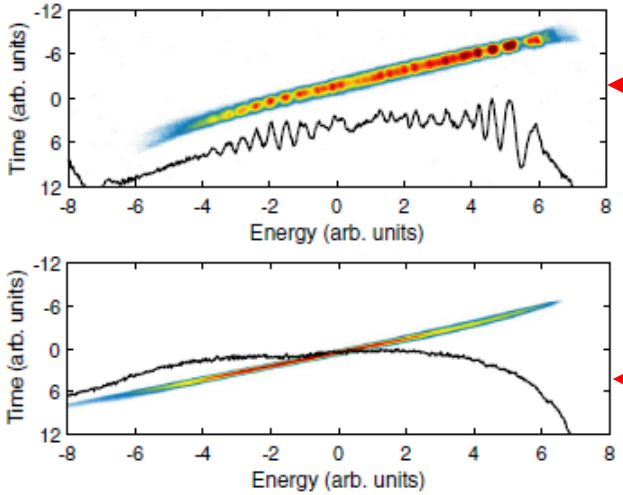


Shanghai high repetition rate XFEL and extreme light facility (SHINE)





16 stacked pulses



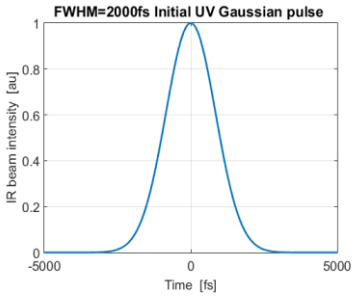
Copper Cathode

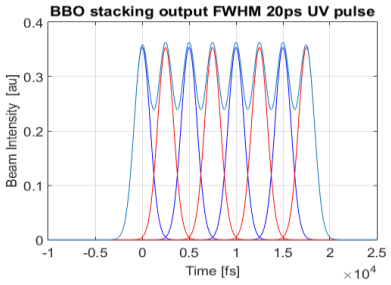
Response time is a few tens of fs

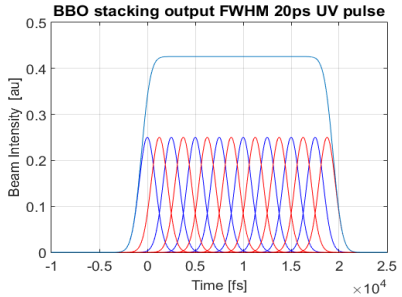
Cs_2Te Cathode

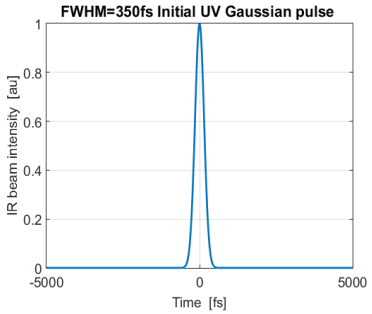
Response time a few hundreds of fs to 1 ps

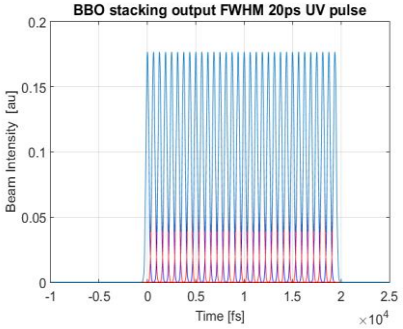
Measured longitudinal phase space distribution of an electron bunch[**SwissFEL**]

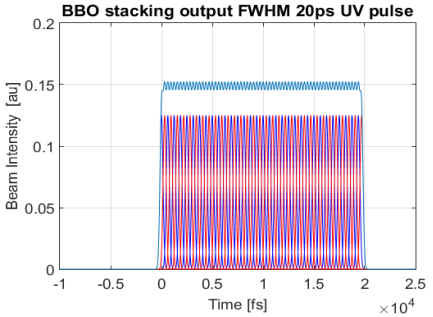












Crystal Stacking for **SHINE** injector test platform **Input:** 2ps or 350fs **Output:** 20ps

S. Bettoni, M. Csatari Divall, R. Ganter et al., Physical Review Accelerators and Beams, 2020

Conclusion

- Stretched Gaussian pulse for SXFEL with copper cathode
- BBO pulses stacking for SHINE photoinjector test platform
- Cross correlation for temporal diagnostic

ACKNOWLEDGEMENTS

- SXFEL team.
- M.B. Danailov from FERMI and Guorong Wu for his valuable suggestions and fruitful discussion.
- This work was supported by National Key Research and Development Program of China (No. 2016YFA0401901) and Shanghai Sailing Program (18YF1428700).