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Progress of Lattice Design and Physics Studies on the High Energy Photon Source

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Abstract: The High Energy Photon Source (HEPS) is a 34-pm, 1360-m storage ring light source being built in the suburb of Beijing, China. The construction of the HEPS started in mid-2019. While the physics design has been basically determined, modifications on the HEPS accelerator physics design have been made since 2019, in order to deal with challenges emerging from the technical and engineering designs. In this paper, we will introduce the new storage ring lattice and injector design, and also present updated results of related physics issues, including impedance and collective effects, lattice calibration, insertion device effects, injection design studies, etc.

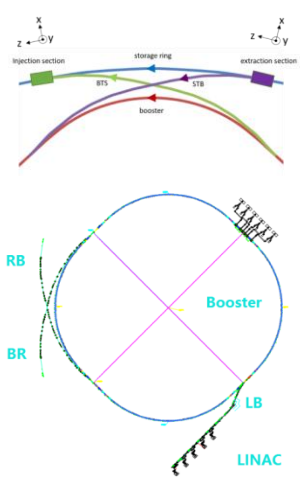
Where are we? Status of HEPS physics design

The **High Energy Photon Source (HEPS)** is a 6-GeV, 1.3-km, ultralow-emittance storage ring light source to be built in Beijing, China. **Construction started in mid-2019.**

The **R&D project** for HEPS, **the HEPS test facility (HEPS-TF)** was started in 2016, and completed in 2018.

Based on the HEPS PDR design (**Y. Jiao et al., "The HEPS project", J. Synchrotron Rad. 25, 1611-1618, 2018**), the main accelerator design was modified and frozen (**Y. Jiao, *Radiat. Detect. Technol. Methods* 2020**. doi: 10.1007/s41605-020-00212-x), with related physics studies based on the latest design being updated & commissioning software work initiated.

Injection and Injector



Injection: On-axis swap-out + high energy accumulation

—injection and extraction design were updated

—injection timing sequences specified, and pre-extraction kicker proposed to protect LSM

Injector modified:

—Linac design upgraded [1] w/ a new bunching system [2], up to 8.5 nC/bunch design

— Modified lattice for transport lines [3] and booster design [4]

— Booster impedance model updated, no limitation by instability

Papers in RDTM, 2020
[1] C. Meng et al., doi:10.1007/s41605-020-00205-w
[2] S. Zhang et al., doi:10.1007/s41605-020-00200-1
[3] Y.Y. Guo et al., doi:10.1007/s41605-020-00209-6
[4] Y.M. Peng et al., doi:10.1007/s41605-020-00752-3

Collective Effects & Error Effects & Others

A more detailed impedance model of the storage ring has been developed. Simulations of impedance driven instabilities will be updated based on V3.0.

- more involved with the engineering designs (N. Wang et al., paper ID: **WEPAB222**)
- CSR impedance evaluated (H.S. Xu et al., paper ID: **MOPAB102**)
- Simulation code developed for beam ion effects (C. Li et al., PRAB 2020） doi:10.1103/PhysRevAccelBeams.23.074401

Simulations on the error effects, lattice calibration and first-turn around, repeated based on the V3.0 lattice.

- first-turn around w/ practical conditions (B. Wang et al., paper ID: **TUPAB008**)
- Simulation for initial injection commissioning under way

Different Models of combined function dipoles investigated (Y.Y. Guo et al., **MOPAB089**)

Storage Ring Lattice

Lattice modified

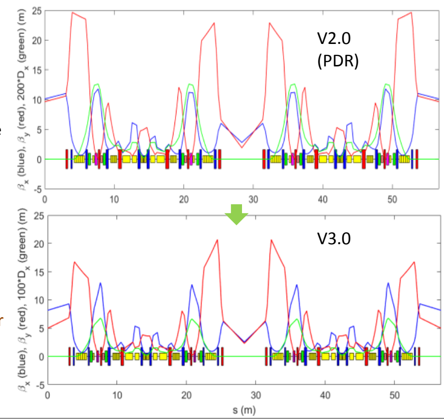
1, Upper limit of all quad. gradients set to ~80 T/m

2, Magnetic fields of middle three dipoles in each 7BA were reduced

3, Distance between adjacent magnets enlarged for hardware elements

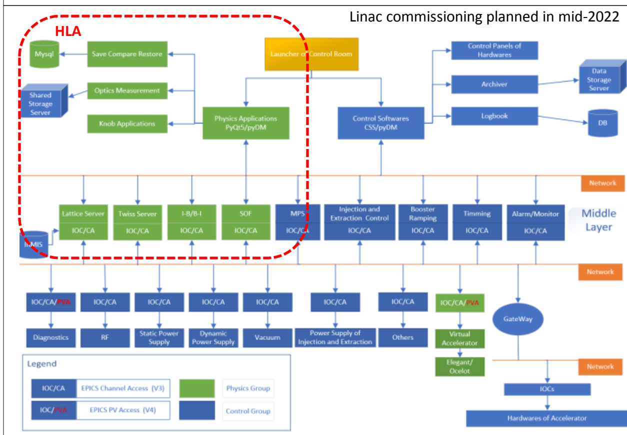
Emittance remains
Smaller acceptance
→ Re-design booster for injection

Y. Jiao et al., RDTM, 2020
doi:10.1007/s41605-020-00189-7



Commissioning Software Work Launched

Linac commissioning planned in mid-2022



Insertion Devices & Beam stability study

14 beam lines to be constructed in phase I of the HEPS

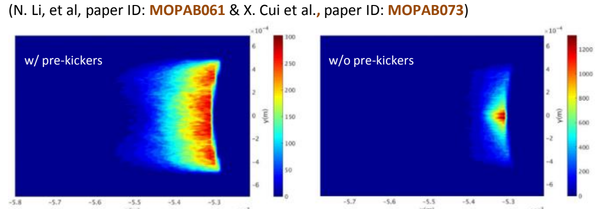
- ID types and parameters basically determined (X.Y. Li et al., paper ID: **MOPAB090**)
- APPLE-KNOT undulator affects dynamics if at high-beta section. Effect can be avoid by putting it to low-beta section.

Beam orbit stability requires the rms position and angular motion of the electron beam less than 10% of the beam size and divergence

- Calculate the orbit motion induced by two major sources: ground vibration and power supply ripples (X.Y. Huang et al., paper ID: **TUPAB304**)
- FOFB proposed with an effective bandwidth up to 500 Hz. Simulations are under way

Beam loss & Collimation

Simulation based on V3.0: Lattice errors also considered.
Collimator parameters fixed: 4 collimators, moveable in vertical (±1 mm), nominal radius 4mm
Collimator used as beam dumps in case of machine protection, w/ two pre-dump kickers
(N. Li, et al, paper ID: **MOPAB061** & X. Cui et al., paper ID: **MOPAB073**)



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