中国科学院高能物理研究所

Institute of High Energy Physics, Chinese Academy of Sciences

Lithium vapour

Wakefield acceleration

Plasma electrons

Ion channel

Pulse electrons

Plasma Test Facility at IHEP

Dr. Dazhang Li

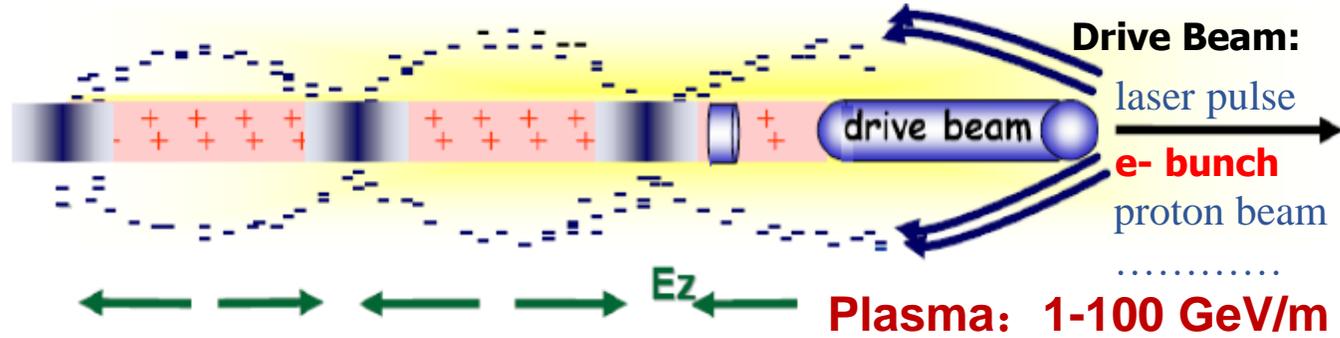Institute of High Energy Physics

On behalf of on IHEP-THU-BNU Team

- **PWFA and CEPC plasma injector (CPI)**

- **Current status of IHEP PBA TF**

- **Summaries and prospects**

Plasma Based Acceleration (PBA): > 1000 $E_{acc.}$

RF cavity：< 100MeV/m
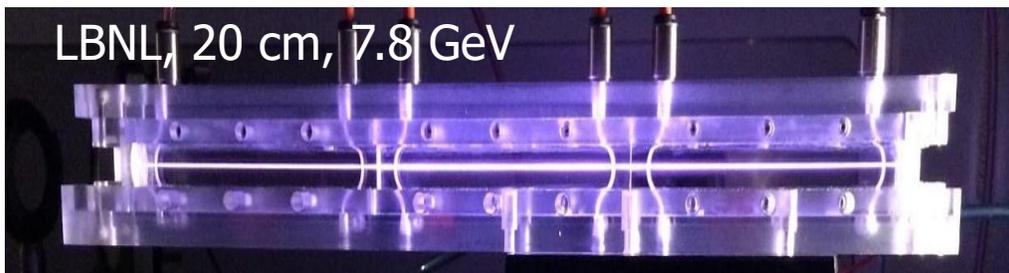
Drive Beam:
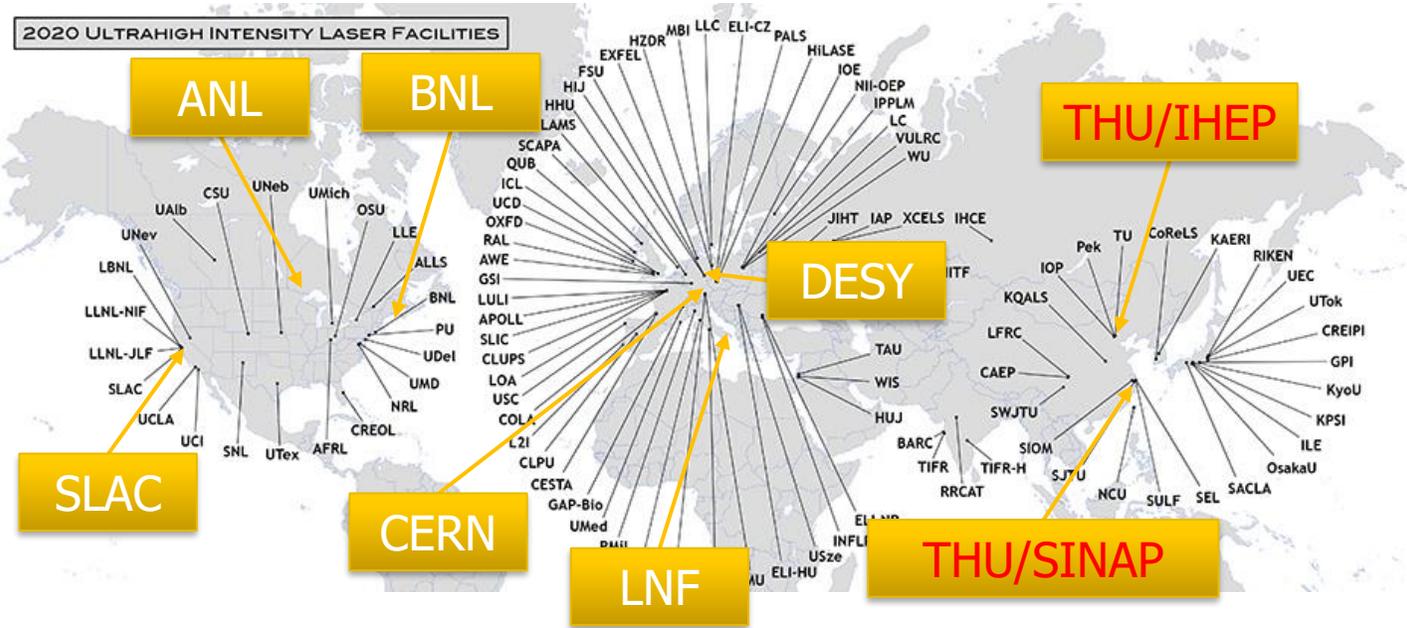laser pulse
e- bunch
proton beam
…………
Plasma：1-100 GeV/m

Table-top X/γ sources

High Energy colliders

HEDP platforms

SACLA, 750 m, 8 GeV

LBNL, 20 cm, 7.8 GeV

2020 ULTRAHIGH INTENSITY LASER FACILITIES
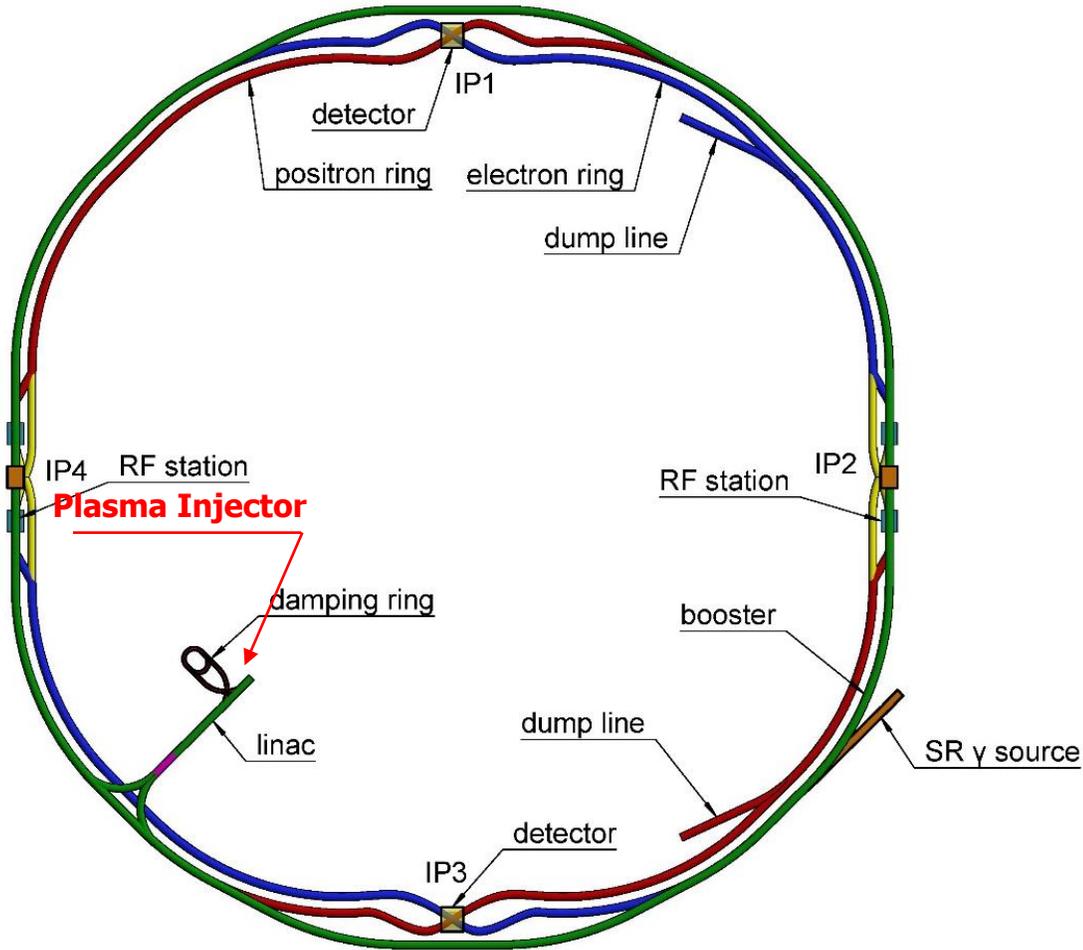
ANL BNL THU/IHEP

SLAC DESY CERN LNF THU/SINAP

Affiliations/institutes on PWFA Study

CEPC Plasma Injector (CPI) since 2017

10 GeV e-/e+ beam in a 100 km ring
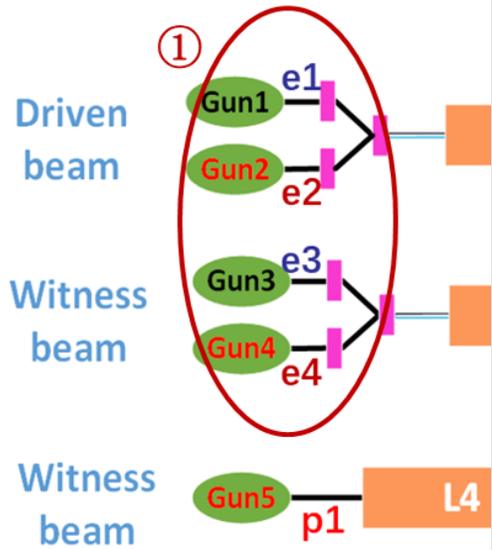
- Minimum magnetic field = 28 Gs
- Field error < 28 Gs*0.1% = 0.028 Gs
- Field reproducibility < 29 Gs*0.05% = 0.014 Gs
- The Earth field ~ 0.2-0.5 Gs, the remnant field of silicon steel lamination ~ 4-6 Gs.

10 GeV Linac → **100 km Booster** → **Collider Rings**

10 GeV linac + CT coil magnet, or 30 GeV linac + iron-core magnet ? Both lead to significant cost rise ~ 1 B RMB

① Driven beam
Gun1 e1
Gun2 e2

Witness beam
Gun3 e3
Gun4 e4

Witness beam
Gun5 p1 L4

Key issues for conventi

① High charge lo
② High current b
③ Low emittance
④ Final focus sys

IHEP-CEPC-DR-2023-01

IHEP-AC-2023-01

CEPC
Technical Design Report

Accelerator

The CEPC Study Group
December 2023

Outlines

- PWFA and CEPC plasma injector (CPI)

- **Current status of IHEP PBA TF**

- **Summaries and prospects**

中 国 科 学 院

2023.10-2028.09

中国科学院关于基础与交叉前沿科研先导专项"束流驱动新加速原理与应用研究"立项的通知

中国科学院高能物理研究所：

经 2023 年第 8 次院长办公会议审议通过，院基础与交叉前沿科研先导专项"束流驱动新加速原理与应用研究"正式立项。现将有关事项通知如下。

一、专项名称和依托单位

专项名称为"束流驱动新加速原理与应用研究"，依托单位为中国科学院高能物理研究所。

二、首席科学家

专项首席科学家为中国科学院高能物理研究所鲁巍研究员。

三、专项实施周期和经费概算

¥ 90M ➔ ¥ 88.32M

专项实施周期为 2023 年 10 月至 2028 年 9 月。经费概算共 9000 万元，全部由院财政支持。

四、相关要求

你单位要认真贯彻落实《中国科学院战略性先导科技专项管理办法》及其实施细则，全面履行依托单位法人责任，认真履行任务书合同条款，建立健全内部管理制度，做好专项组织实施和支撑保障工作。在专项实施过程中，要切实发挥首席科学家作用，加强专项各任务的衔接与协调；既要注重"导出"国家重大科技任务，也要进一步加强与重点实验室体系重组、人才队伍培养等重要改革举措的衔接，注重形成合力，推动科研布局调整优化，促进出成果、出人才；要立足专项特点，建立健全有利于领军人才和青年人才成长的举措和机制，激发创新人才活力；要做好资金管理使用工作，确保资金专款专用，提高资金使用效益；要加强知识产权和成果管理，履行科研诚信建设主体责任，强化专项科研绩效管理，确保专项按期高质量实现预期目标。

附件：基础与交叉前沿科研先导专项"束流驱动新加速原理与应用研究"专项（项目）清单

2024 年 2 月 23 日

（此件依申请公开）
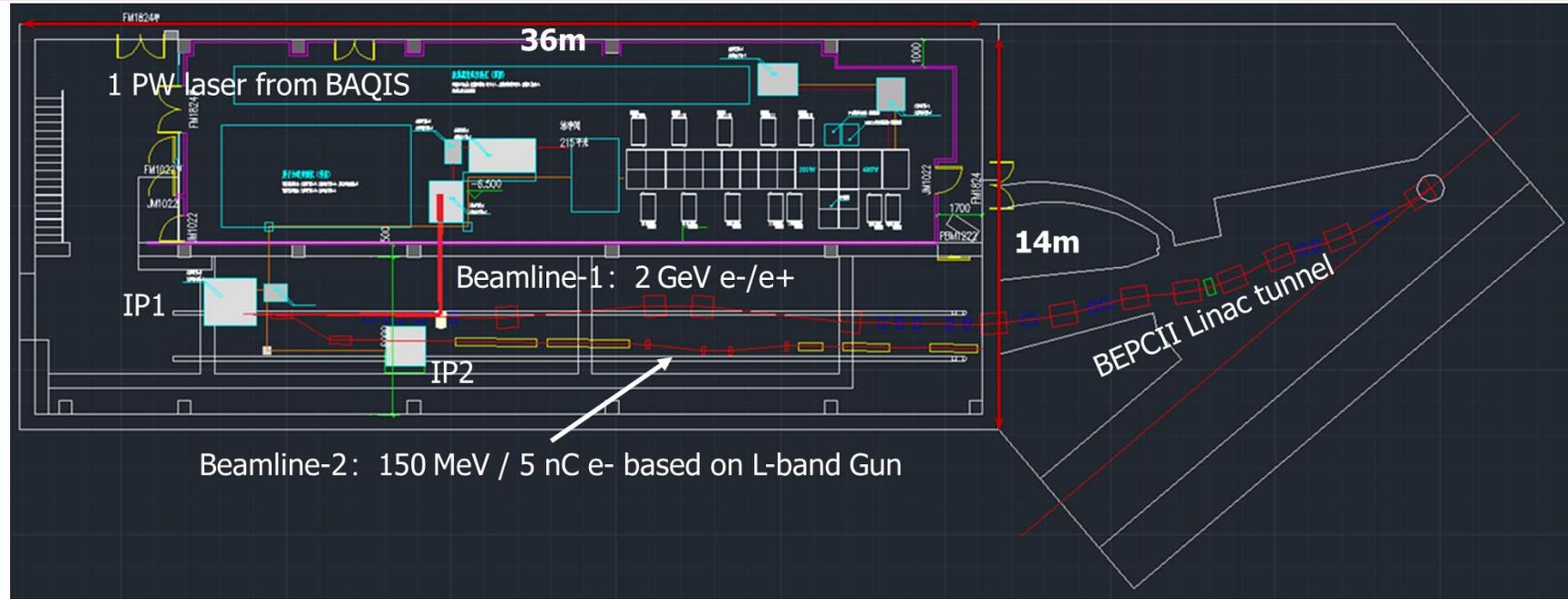
抄送：办公厅、前沿科学与基础研究局（筹）、财务与资产管理局（筹）、人事人才局（筹）、科技基础能力局（筹）、监督审计局。

— 2 —

2023.9.20

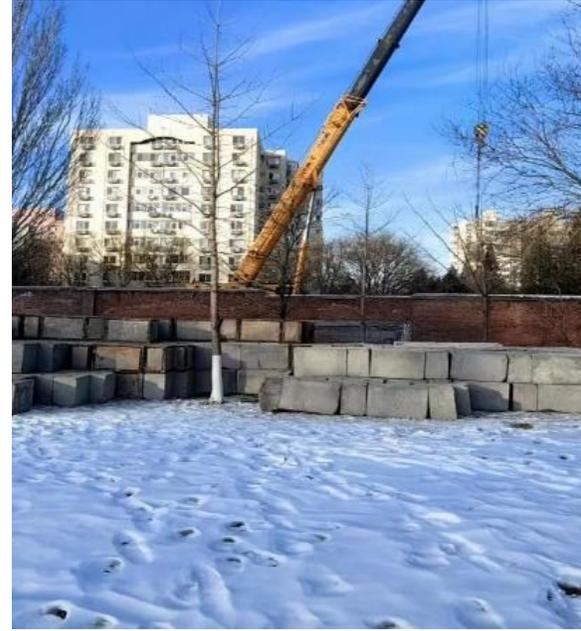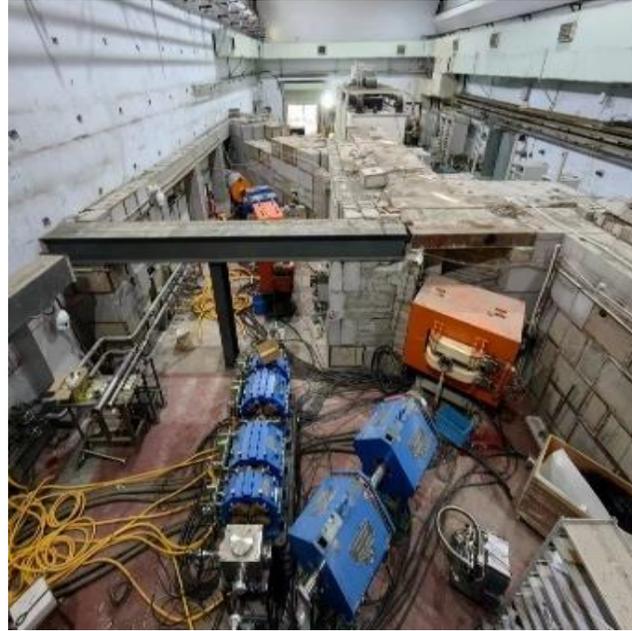专项**概预算**通过**条财局**组织的第三方机构预算评审

2023.9.28

2023年第8次"**院长办公会**"审议通过

Hall #10 @ IHEP was used for detector calibration

1 PW laser from BAQIS

36m

14m

Beamline-1: 2 GeV e-/e+

IP1

IP2

BEPCII Linac tunnel

Beamline-2: 150 MeV / 5 nC e- based on L-band Gun

More than 1400 concrete blocks

~ 2026.04

~ 2026.05

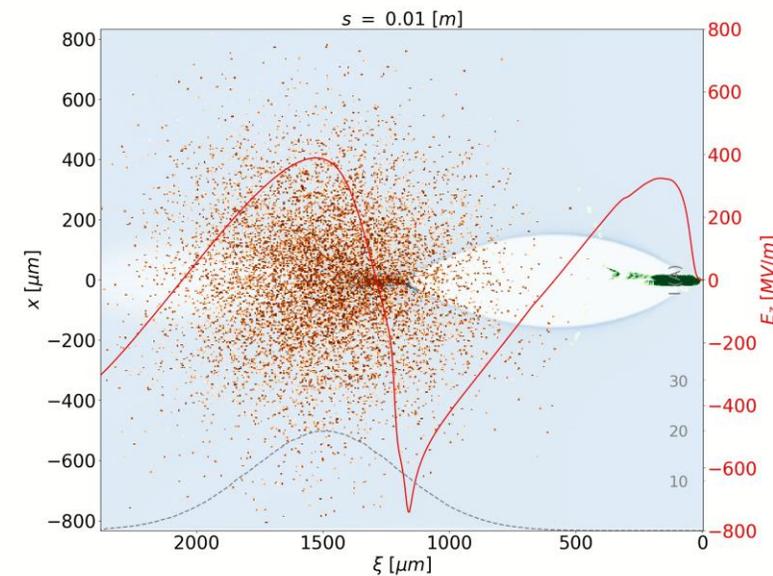Shiyu Zhou, Wei Lu, *et al.*, *Research*. (Accepted)
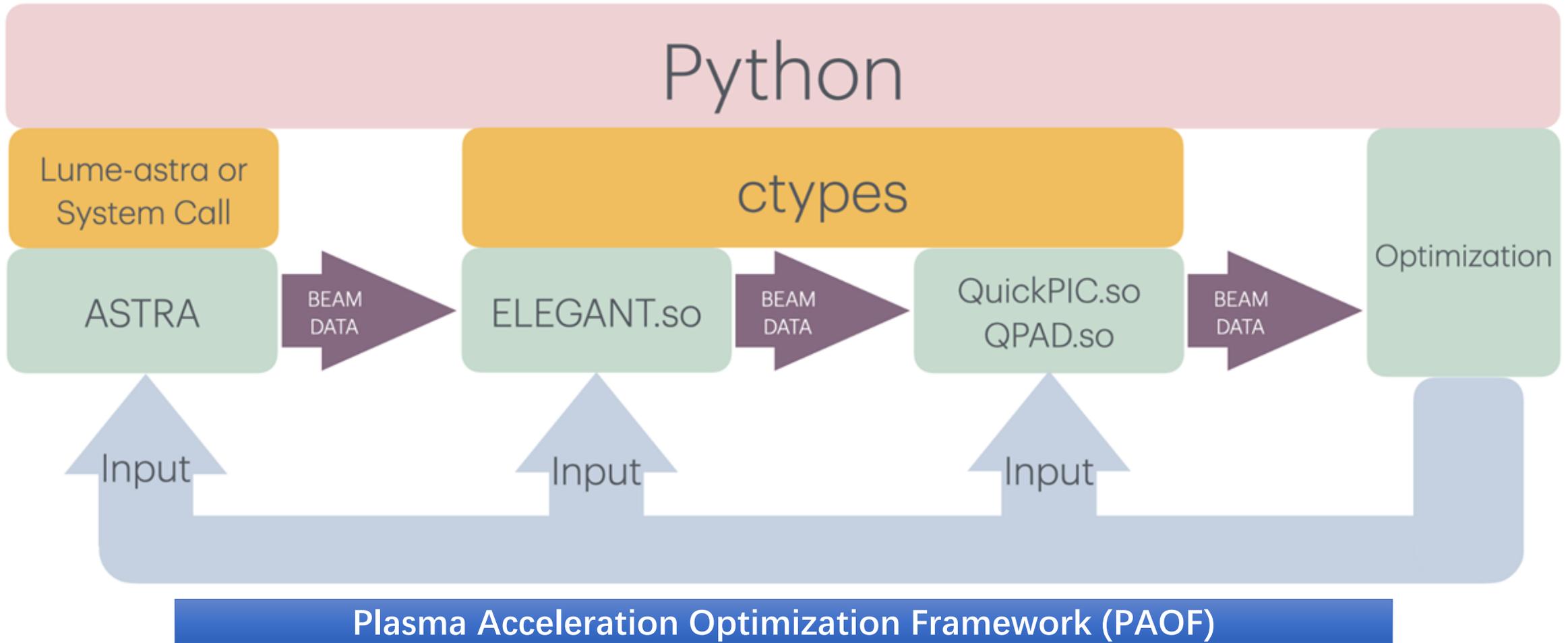
hollow channel plasma   finite-width channel   uniform plasma

Use BL2 e- as driver, and e+ from BL1 as trailer

Try different schemes for better capture efficiency and beam quality

Plasma Acceleration Optimization Framework (PAOF)

Git repository for PAOF already on code.ihep.ac.cn

名称	4阶拉盖尔高斯光	16阶拉盖尔高斯光	0阶贝塞尔光
实物			
图纸			
光强分布 (1mm*1mm区域内)			

Recent progress on IHEP PBA studies – L-band RF Gun

参数	设计值
频率(MHz)	1299.48
腔数	1.55
轴线归一化场平坦度	0.98
无载品质因数	24291
阴极表面加速梯度(MV/m)	60@6.3MW/稳态
模式间隔(MHz)	7.1
最大表面场强/阴极加速梯度	0.936(盘片处)
修正坡印廷矢量(W/um²)	0.65
脉冲加热(℃)	29
重复频率(Hz)	10
射频脉宽(us)	10
耦合系数	1.07

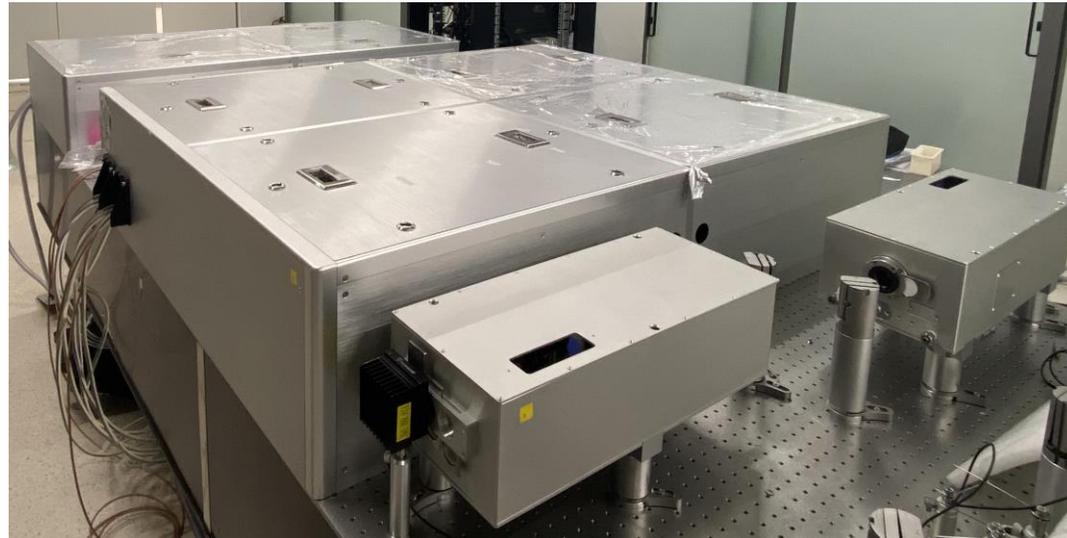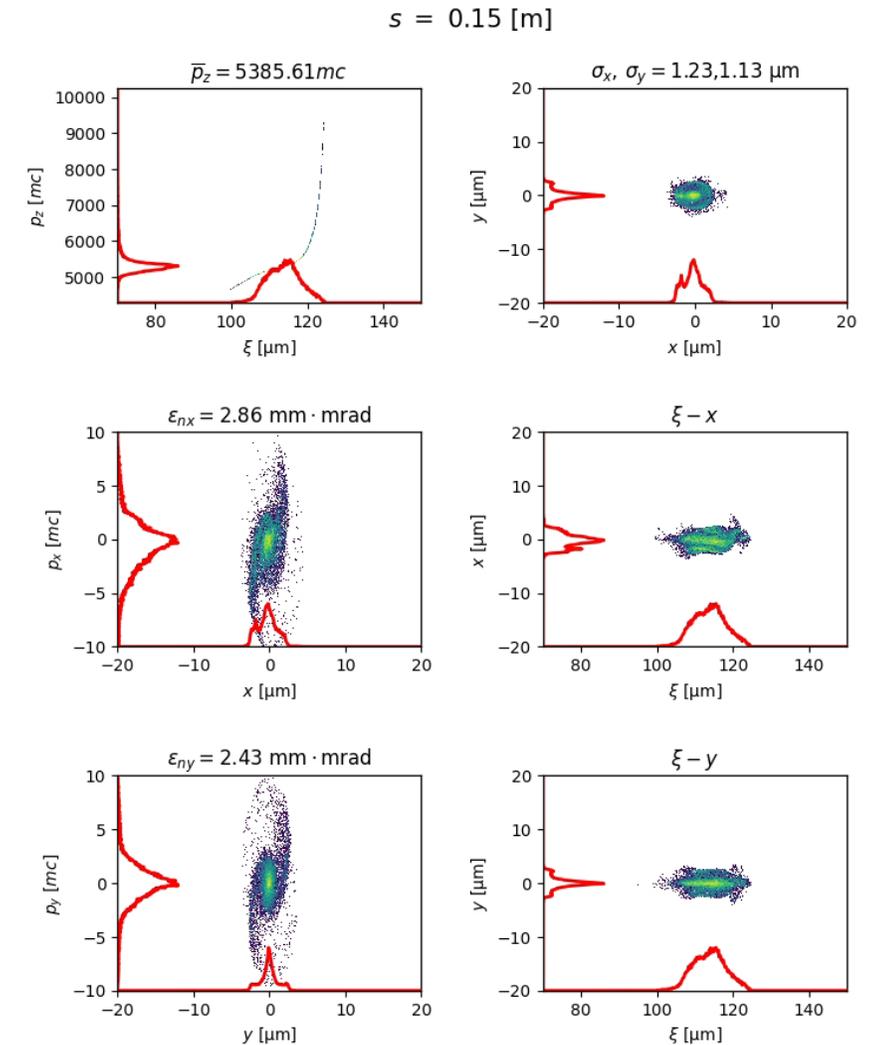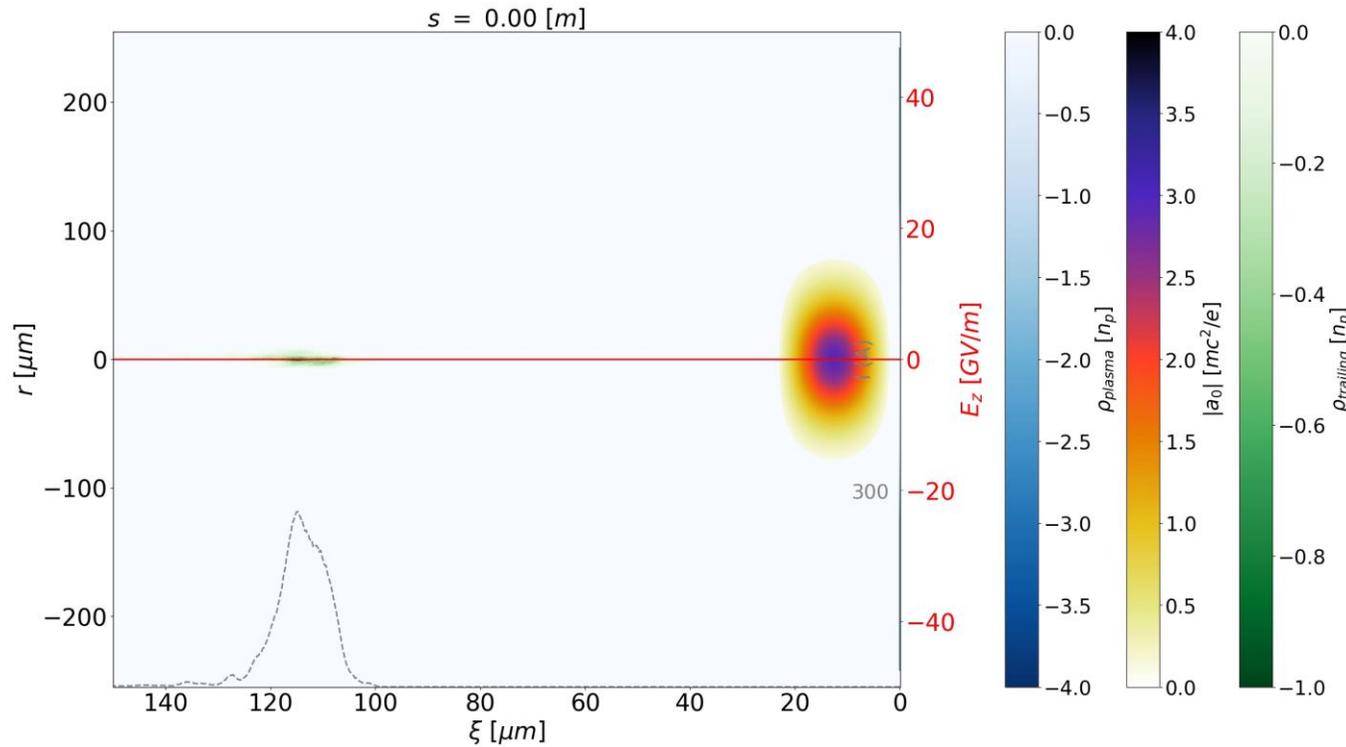| Parameters	Unit	BL-I e- (AM3)	BL-I e- (IP1)	BL-I e+ (AM3)	BL-I e+ (IP1)	BL-I e- (IP1, block)	BL-I e+ (IP1, block)	BL-II e- (IP2)	BL-II e- (IP1)
Energy	GeV	2	2	2	2	2	2	0.15	0.15
Charge	pC	2000	2000	100	100	9.4	0.2	5000	1000
bunch length	ps	10	1	10	1	~1	~1	0.7	1
Geo. emittance	mm·mrad	0.1/0.1	0.1/0.1	0.4/0.4	0.4/0.4	0.011/0.005	0.04/0.02		
RMS beam size	μm	-	150/150	-	300/300	30/40	54/76	35/22	100/50

Stage 1: PWFA @ IP2

L-band e- gun generate 2 bunches
Trailer is accelerated from 150 MeV to 170MeV

Stage 2: PWFA @ IP1

Use 2 GeV e- bunch from BEPCII linac as driver
Trailer is accelerated from 170 MeV to 310 MeV

PW Laser + BL2 e- (9.45 pC)

E~16.6 GeV, rms energy spread ~ 7.7%

Outlines

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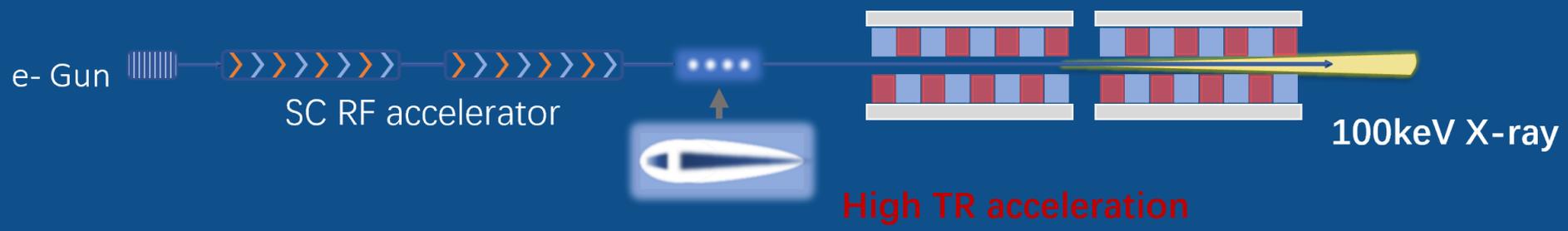
- **Summaries and prospects**

PATH: Plasma Accelerator towards TeV Horizon

- ➢ PATH is a China initiated effort towards future light source and collider

- ➢ PBA TF is only the starting point for this effort.

  - ➢ The new TF is NOT only for PBA, but also for conventional accelerator R&D

  - ➢ The PATH is NOT only for CPI, but also for a real plasma-based accelerators

- ➢ Hope to start PBA experiments this year

- ➢ We'll focus on addressing the fundamental unsolved key issues, and clear the "path" of future plasma colliders
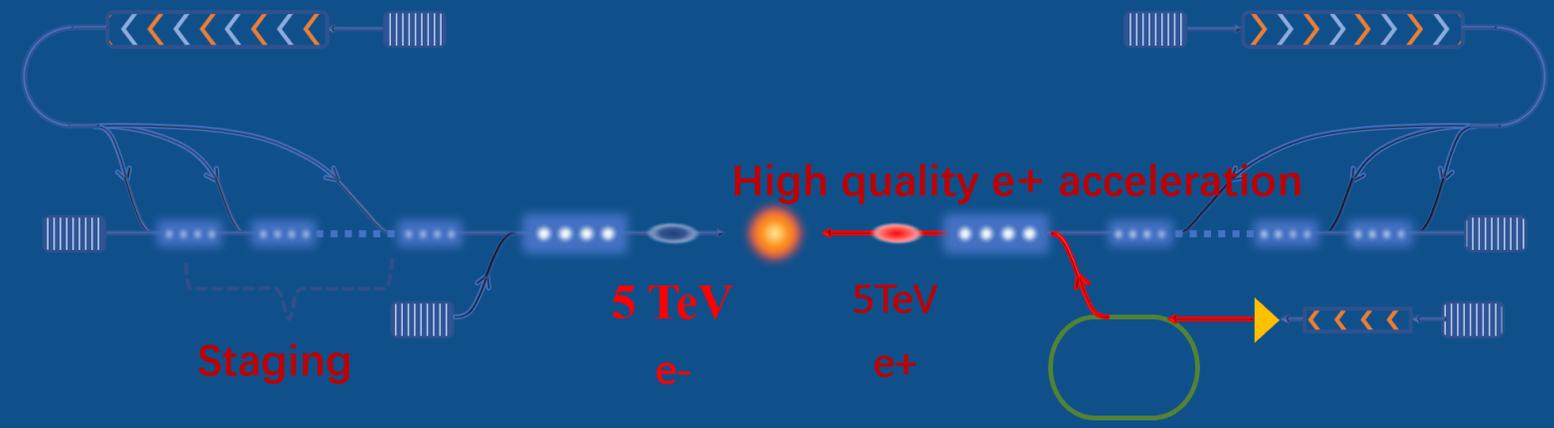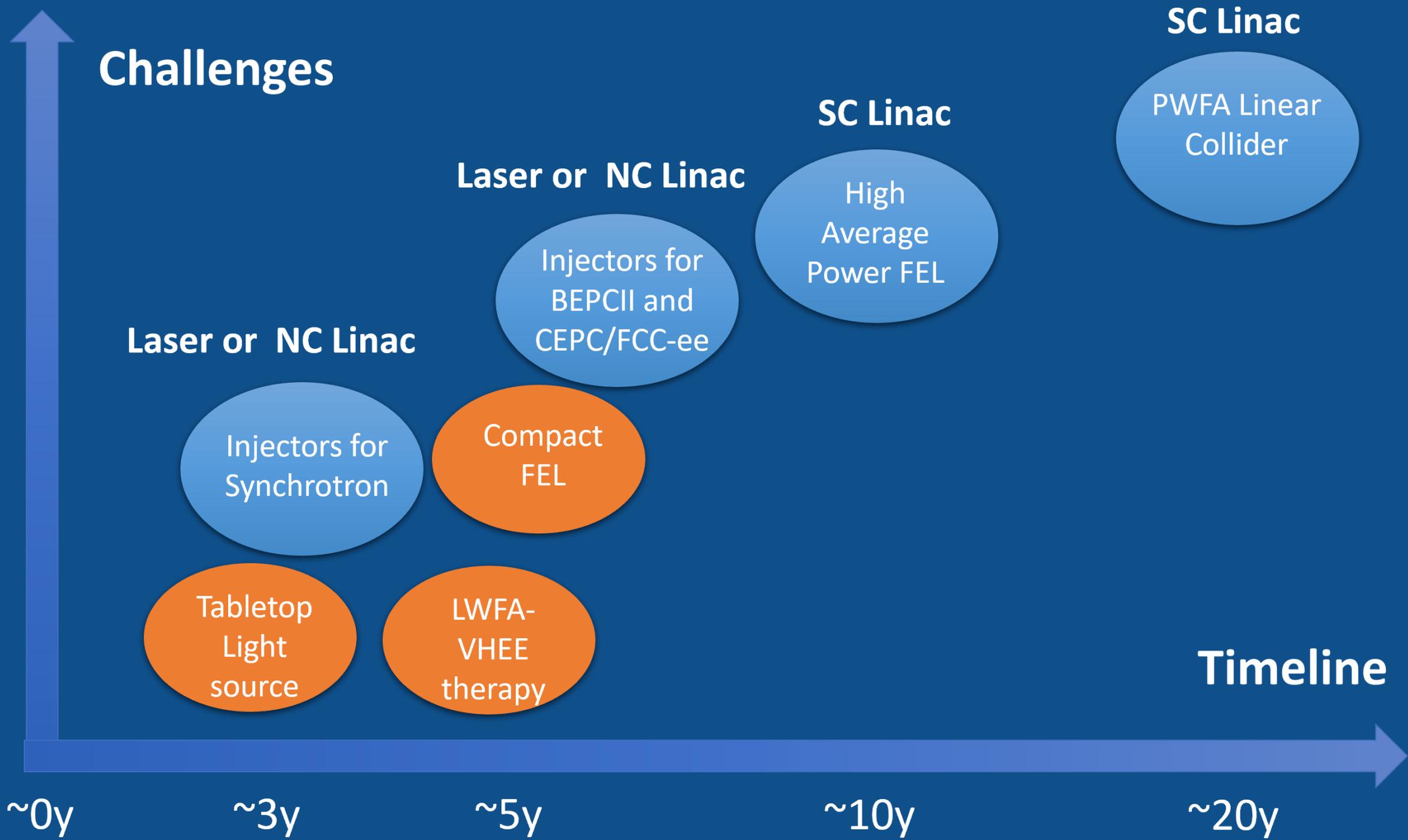
Future high average power PWFA

100s keV X-ray FEL 5km → 1km

e- Gun

SC RF accelerator

High TR acceleration

100keV X-ray

1-10 TeV e-/e+ Linear Collider 300km→ 20km

High quality e+ acceleration

Staging

5 TeV

e-

5TeV

e+

Thank you and welcome to IHEP