



中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences



环形正负电子对撞机
Circular Electron Positron Collider

粒子物理前沿卓越中心 2018年度考评报告 2017.10-2018.10

孟才

中科院高能所

2018-11-23

- 2005-2009** 东南大学物理系 本科
- 2009-2014** 中国科学院大学 粒子物理与原子核物理 博士
期间在CERN交流研究6个月 (SPL、LINAC4)
- 2014-至今** 中国科学院高能物理研究所 副研究员 (2016年12月至今)
- 2014至2017年参与**ADS**注入器束流调试及主加速器设计, 高能所2015-2017年度优秀党员
- 2014年开始参与**MOMENT**, **负责**靶区废弃质子束分离设计
- 2016.4开始参与**CEPC**, **负责**直线加速器物理设计及正电子源物理设计
- 2017年开始参与**HEPS**, **负责**直线加速器物理设计、增强器误差分析等工作

CEPC直线加速器物理设计

- 根据CEPC Booster对直线加速器提出的参数要求，完成方案设计
- 在设计之初便提出了设计原则，并予以设计考虑
 - **高可用性** → 高积分亮度
 - 具备升级潜力，以应对高要求（高电荷量、小发射度）

Parameter	Symbol	Unit	Value
e ⁻ /e ⁺ beam energy	E_{e^-}/E_{e^+}	GeV	10
Repetition rate	f_{rep}	Hz	100
e ⁻ /e ⁺ bunch population	N_{e^-}/N_{e^+}		$>9.4 \times 10^9$
		nC	>1.5
Energy spread (e ⁻ /e ⁺)	σ_E		$<2 \times 10^{-3}$
Emittance (e ⁻ /e ⁺)	ϵ_r	nm	<120
e ⁻ beam energy on Target		GeV	4
e ⁻ bunch charge on Target		nC	10

$$L_{int} = \int_0^T L(t) dt$$

$$= \langle L \rangle \cdot T_s \cdot \eta$$

Top-up **Availability**

CEPC直线加速器物理设计

完成并确定布局方案 (2018.1)

- 正电子源靶

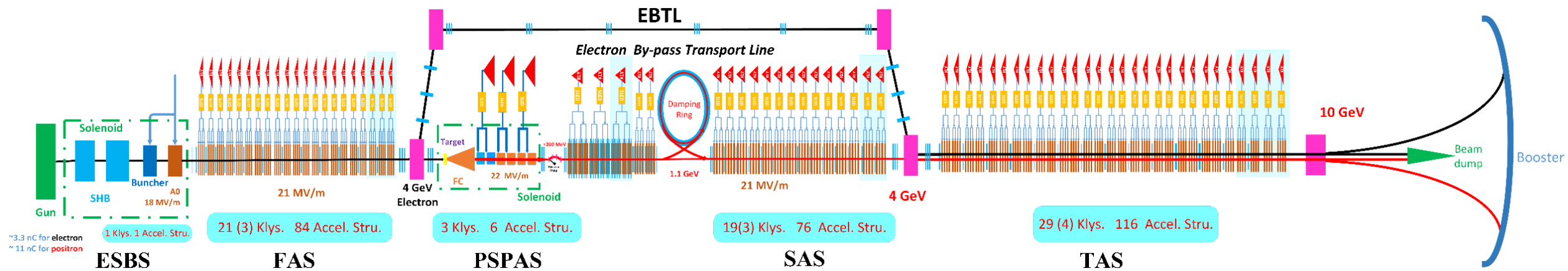
- ✓ 移动靶, 类似于BEPcII、SLC, 考虑top-up及高可靠性、高可用性, 不采用

- ✓ 固定靶

- 采用By-pass方案, 比较简单, 隧道加宽, 增加少量磁铁

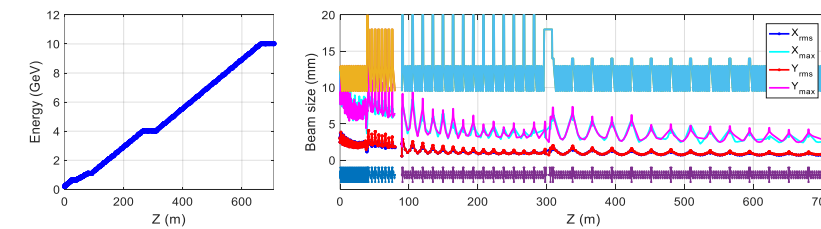
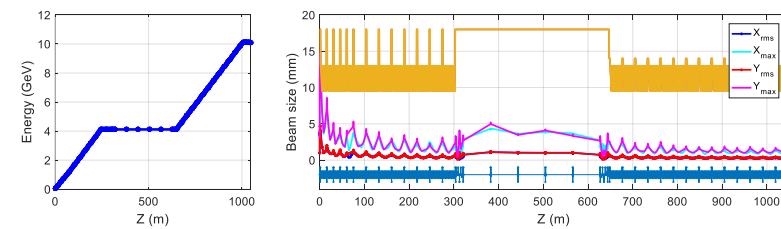
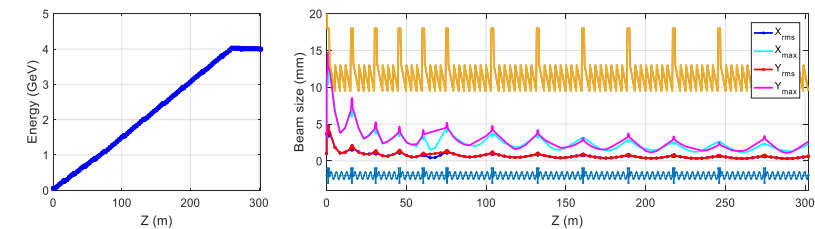
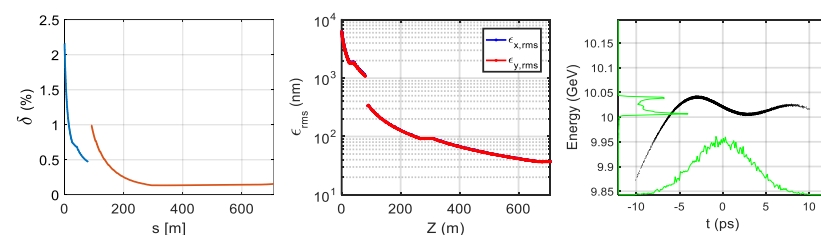
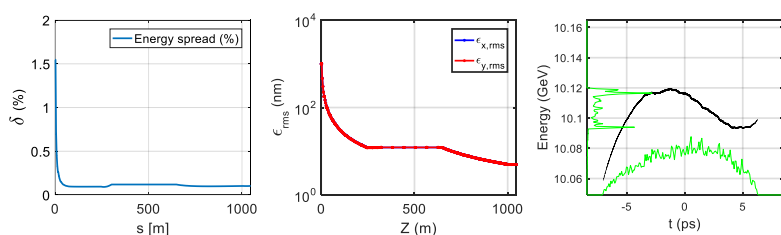
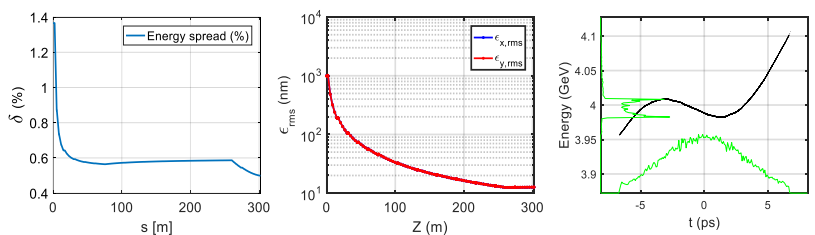
- 类似于SuperKEKB方案, 调试难度大, 采用脉冲磁铁, 与KEK专家讨论, 建议By-pass方案

- 增加Damping Ring



CEPC直线加速器物理设计

- 完成各加速段、功能段物理设计
- Lattice中包括加速原件、聚焦元件、BPM、校正子、PR、部分真空元件等，并初步预留了安装空间，提供survey数据
- 完成电子加速器、正电子加速器End-to-end动力学模拟
- 模拟结果满足设计要求



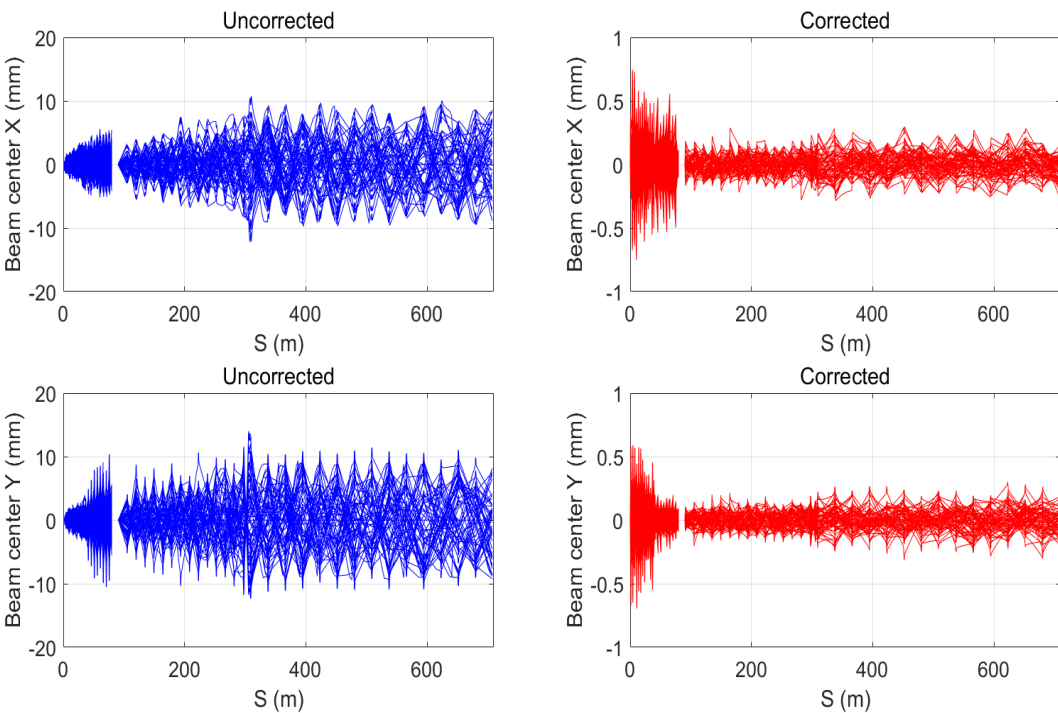
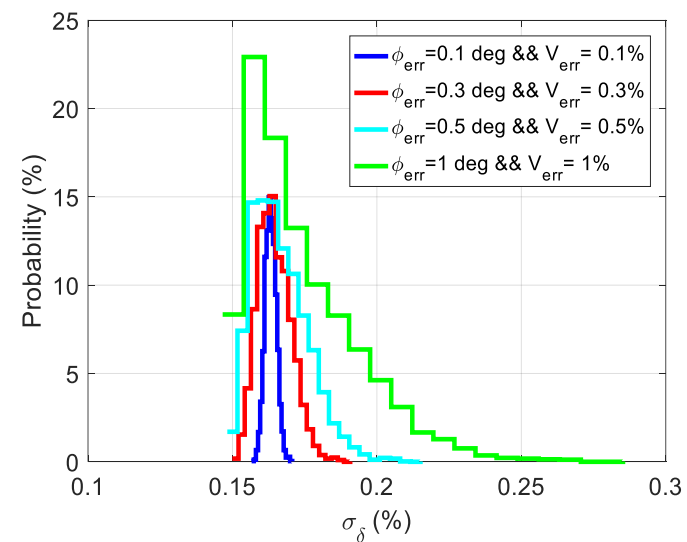
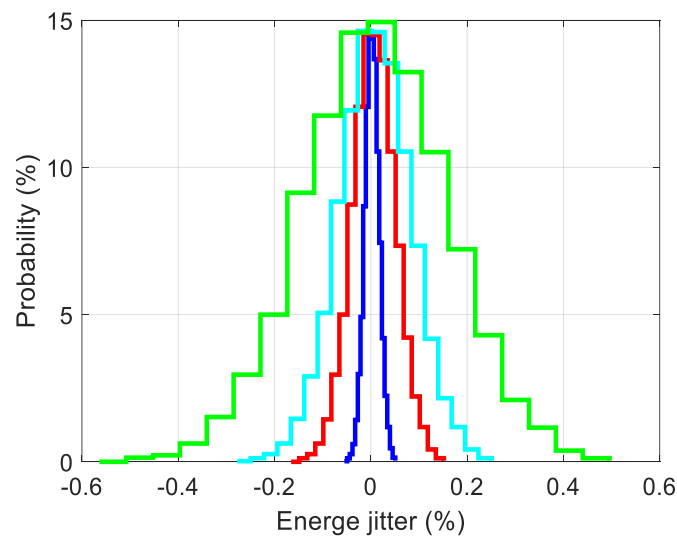
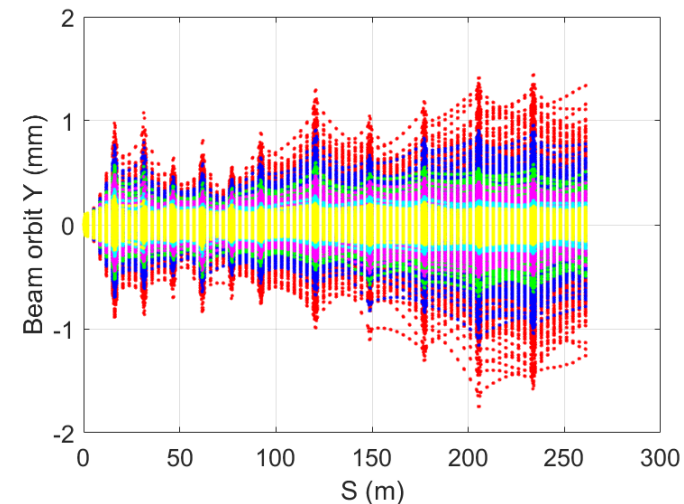
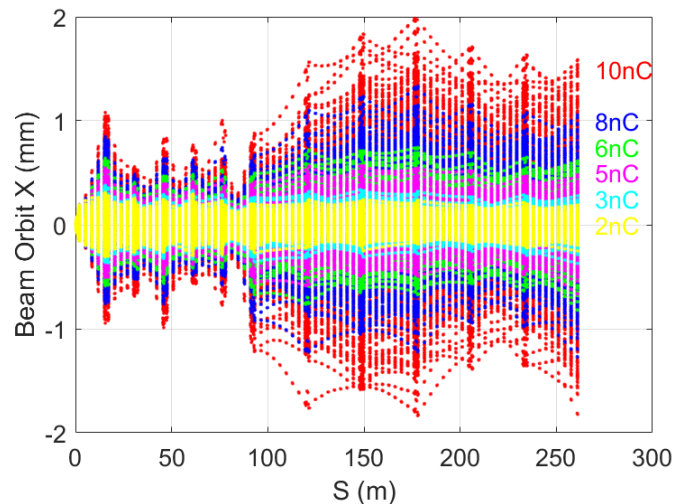
打靶电子加速器动力学模拟

电子加速器动力学模拟

正电子加速器动力学模拟

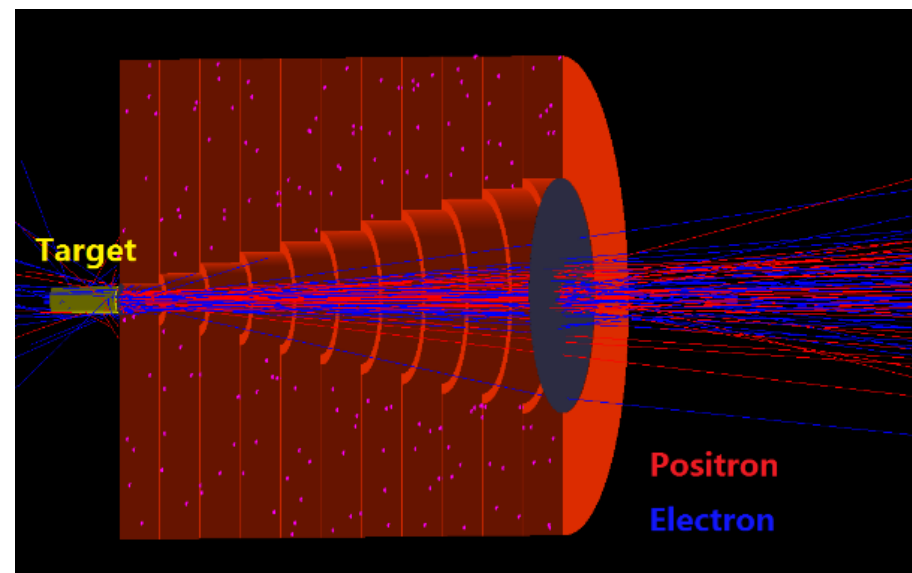
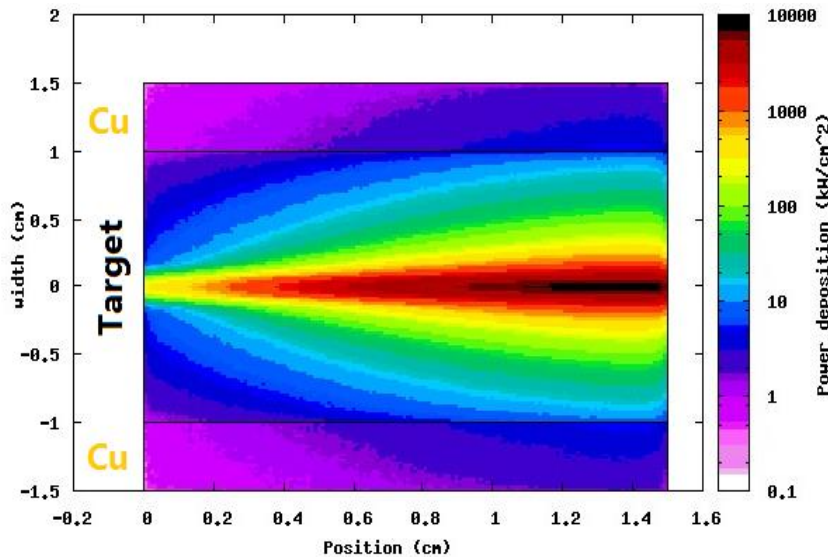
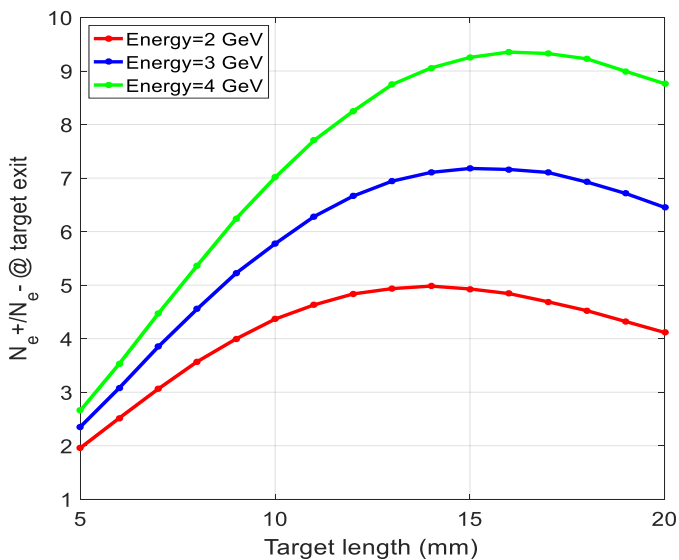
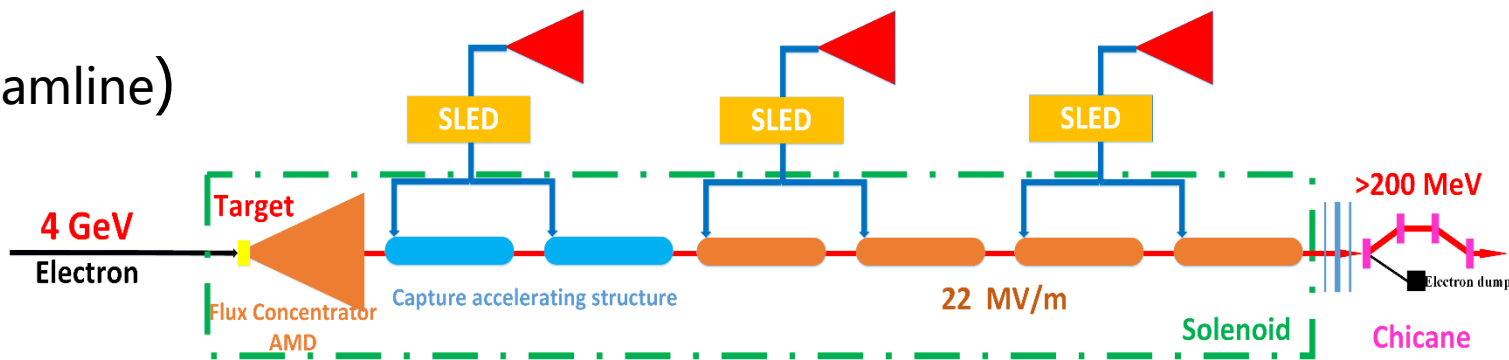
➤初步完成误差分析

- 准直误差及轨道校正
- 加速管梯度及相位误差



➤ 正电子源方案设计

- 完成电子打靶模拟(FLUKA/G4beamline)
 - ✓ 正电子产额
 - ✓ 能量沉积及PEDD
- 完成正电子收集模拟
 - ✓ AMD模型建立及模拟



CEPC正电子源物理设计



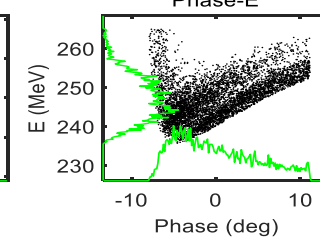
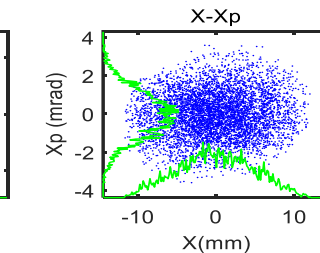
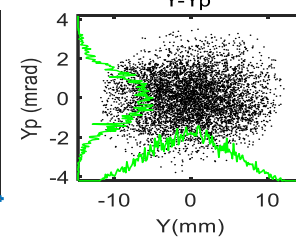
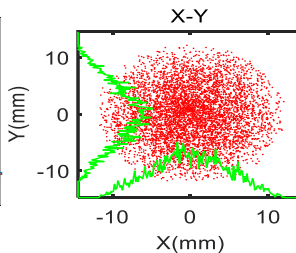
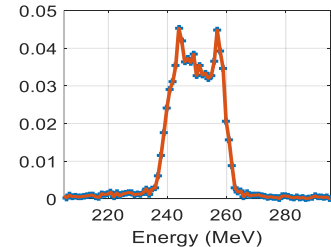
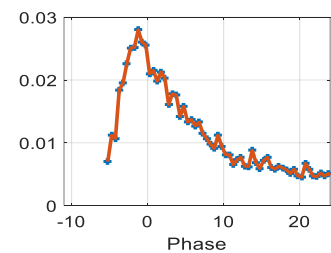
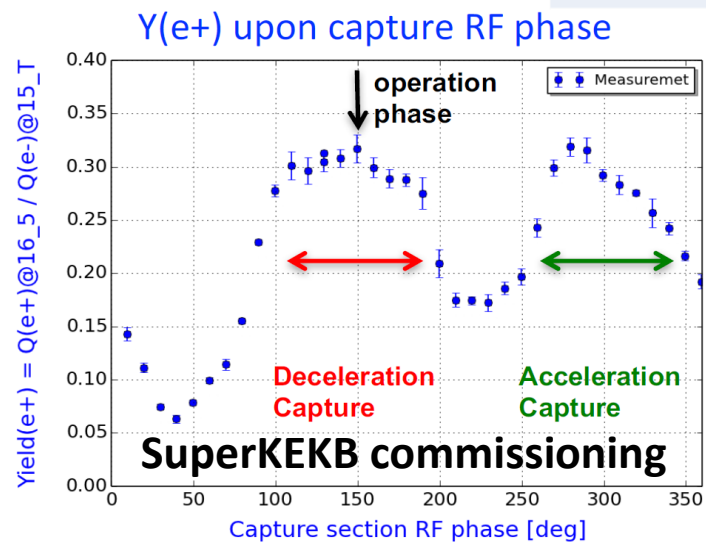
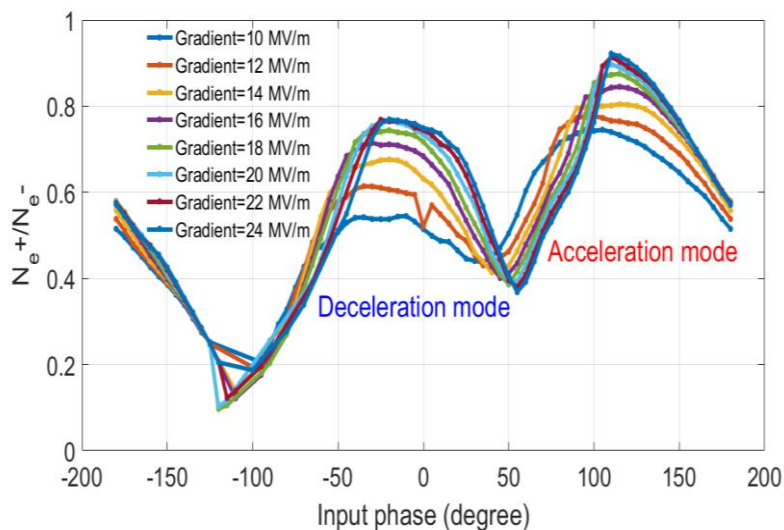
完成正电子预加速模拟

- 加速模式模拟及选择
- Start-to-end动力学模拟

正电子源预加速段出口束流参数

- 归一化RMS发射度~2400 mm-mrad
- 能量>200MeV
- 正电子产额 $N_{e^+}/N_{e^-} > 0.55$ @ cutoff condition

Parameters	SLC	LEP (LIL)	KEKB/SUPER KEKB	FCC-ee	CEPC
Incident e- beam energy (GeV)	33	0.2	3.3/3.3	4.46	4
e-/bunch [10^{10}]	3-5	0.5 - 30 (20 ns pulse)	6.25/6.25	5.53	6.25
Bunch/pulse	1	1	2/2	2	1
Rep. rate (Hz)	120	100	50/50	200	100
Incident Beam power (kW)	~20	1 (max)	3.3	15	4
Beam size @ target (mm)	0.6 - 0.8	< 2	/>0.7	0.5	0.5
Target thickness	6X0	2X0	/4X0	4.5X0	~4.5X0
Target size (mm)	70	5	14	-	10
Target	Moving	Fixed	Fixed/Fixed	-	Fixed
Deposited power (kW)	4.4	-	/0.6	2.7	0.78
Capture system	AMD	$\lambda/4$ transformer	/AMD	AMD	AMD
Magnetic field (T)	6.8→0.5	1→0.3	/4.5→0.4	7.5→0.5	6→0.5
Aperture of 1st cavity (mm)	18	25/18	/30	20	25
Gradient of 1st cavity (MV/m)	30-40	~10	/10	30	22
length of 1st cavity (m)	1	3	2	3	2
Linac frequency (MHz)	2855.98	2998.55	2855.98	2855.98	2860
e+ yield @ CS exit(e+/e-)	~1.6	~0.003 (linac exit)	/~0.5	~0.7	~0.55 (with cut-off condition)



CEPC LINAC 设计

- 完成CEPC CDR直线加速器设计部分的编写，并向硬件系统提出参数要求
- 参加了CEPC相关国际研讨会及评审会，并做相关报告
- 相关工作多次受邀参加国际会议进行报告

2017-10-25 (周三) 14:49
IAS Program on High Energy Physics <iashep@ust.hk>
 Invitation (Accelerator group) - IAS Program on High Energy Physics 2018 (8 - 26 Jan 2018)
 收件人: gaoj@ihep.ac.cn; chou@fnal.gov; Andrew COHEN; Tao LIU
 抄送: Prudence WONG; Linus See / IAS / HKUST

To potential participants of IAS Program on High Energy Physics 2018 (Accelerator group)

Dear all,

Greetings from Prudence Wong, the Secretary of IAS Program on High Energy Physics (HEP) 2018 <http://iasprogram.ust.hk/hep2018> (8 - 26 Jan 2018). As suggested by our conveners of Accelerator group, Prof. Weiren Zhou (Fermi Lab) and Prof. Jie Gao (HEP, China), our organizing committee would like to invite you to participate in the said program that includes a mini workshop on 18 - 19 Jan 2018 and a 4-day conference on 22 - 25 Jan 2018 to be held at [HKUST Jockey Club Institute for Advanced Study](http://ust.hk/ust-jockey-club-institute-for-advanced-study) at Hong Kong.

The program's objective is to bring theorists, experimentalists and accelerator physicists together, and provide a platform for the participants to promote stimulating discussions. During this program, we plan to address issues on the physics, detectors and colliders with emphasis on the future of high energy physics. We may also organize discussion sessions regarding topical interests, such as gravitational waves, unexpected progress at LHC made before the program, as well as their implications for future research.

Area	Date	Title
Theory	11 - 12 January 2018 (Thu and Fri)	Next steps for particle physics: LHC and beyond
Experiment and Detector	18 - 19 January 2018 (Thu and Fri)	Central calorimeters for high energy e+e- colliders
Accelerator		High temperature superconducting cables and magnets

*Organizing committee of HEP2018/ conveners of each mini workshop will contact participants who intend to give a talk in due course.

An official invitation letter, undersigned by Prof. Andrew Cohen, the Chair of the organizing committee for the program of HEP2018, will be sent to you in a separate email. Interested parties should register by completing an online registration form <http://iasprogram.ust.hk/hep2018/registration>, preferably on or before 3 November 2017. Requests of on-campus accommodation indicated in the registration form, if any, will be handled on first-come, first-served basis.

More information about the Program is available on our website at <http://iasprogram.ust.hk/hep2018> (Schedule for 2018 is being planned. The one for 2017 is linked [here](#) for your reference). If you need further information, please write to Prof. Tao Liu, the Chair of the organizing committee of conference of HEP2018, at taoliu@ust.hk, and me at prudence@ust.hk.

We are looking forward to seeing you soon.

Regards,
 Prudence Wong (Miss)
 Secretary
 IAS Program on High Energy Physics
 HKUST Jockey Club Institute for Advanced Study
 The Hong Kong University of Science and Technology
 Tel: 2358 5061
 Fax: 2343 1538
 Email: prudence@ust.hk

HEP2018

2018-2-15 (周四) 16:58
FCC Week 2018 secretariat <fccw2018.secretariat@cern.ch>
 Notification of abstract acceptance
 收件人: Cai Meng
 Follow up,
 答复此邮件的时间为 2018-2-16 21:47,

Meng Cai (HEP)
 Geneva, 15 February 2018

Our Ref. FCC-ADM-COM-0409
 Your Ref. 4AMS06C

Dear Meng Cai,

The fourth Annual Meeting of the Future Circular Collider study will take place from 9 to 13 April 2018 in Amsterdam. It will bring together scientists and engineers from around the world to exchange information on the design progress and to review the baselines all collider scenarios towards the completion and delivery of the FCC Conceptual Design Report by end 2018.

It is our pleasure to inform you that your proposed contribution entitled "CEPC linac design" has been accepted and scheduled as oral presentation from 11:10 to 11:25 (incl. 5 mins for discussion) in the morning of Thursday 12 April, as part of the "CEPC and others" session.

A confirmation of your availability would be much appreciated.

Further details on the FCC Week 2018 are posted on the meeting website (<http://cern.ch/fccw2018>), where you can also register if you do not yet. Please do not hesitate to contact us with any questions.

Yours sincerely,
 Julie Hadre
 On behalf of the FCC Week Program Committee

FCCWEEK2018

2018-5-4 (周五) 23:22
Dmitri <denisovd@fnal.gov>
 ICHEP abstract 83
 收件人: mengc@ihep.ac.cn
 抄送: RUAN Manqi; Daniel Schulte
 答复此邮件的时间为 2018-5-5 8:54,
 已删除此邮件多余的换行符。

Dear Cai,

as you know your abstract 83 "CEPC injector linac design" has been accepted for presentation at parallel session at ICHEP this year.

Could you, please:

- confirm that you are planning to present this talk at ICHEP.
- provide us with the speaker name or confirm that you are the speaker.

We would like to get this information by May 9, 2018.

We expect that the agenda for the ICHEP parallel sessions will be finalized by early June.

Accelerators group conveners,
 Daniel, Manqi, Dmitri.

ICHEP2018

2018-7-20 (周五) 2:48
Seeman, John <seeman@slac.stanford.edu>
 Talk at eeFACT2018?
 收件人: mengc@ihep.ac.cn
 抄送: Kazuro FURUKAWA
 答复此邮件的时间为 2018-7-23 11:33,

Dear Cai Meng,

As you probably know, there will be an electron-positron collider workshop (eeFACT2018) in Hong Kong September 24-27, 2018. For more details, please see <http://eefact2018.ust.hk/index.php>.

Kazuro Furukawa and I are conveners of Working Group #6 on "Injection and Injectors".

Since you have worked a lot on the CEPC design project, we would like to invite you to give a talk on the "Overall Design of the CEPC Injector". The title and topic can be adjusted somewhat with your suggestion.

Please let us know.

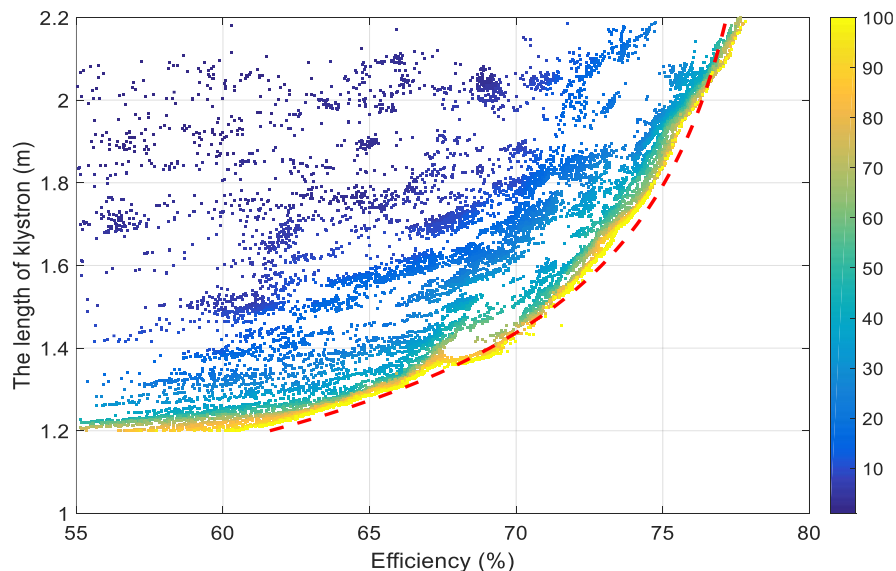
A written paper will be asked for this contribution to be included in a ICFA Workshop proceedings.

Very best regards, John Seeman

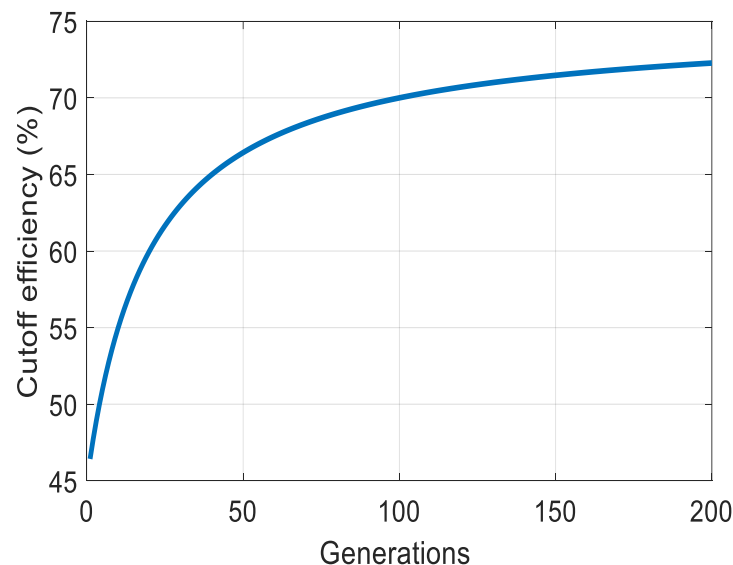
eeFACT2018

速调管多目标优化程序

- **背景**：高效率速调管设计（1D→2D→3D），可变参数较多，追求高效率并控制长度，需要引入优化程序代替人工设置（1D模拟）
- **目标**：基于AJDISK利用MOGA（NSGA-II）完成速调管多目标优化程序编写
- **结果**：实现多参数、多目标程序优化，大大提高了设计效率，同时可讨论最优解，整个过程实现自动化
- **特点**：程序并行计算，可定制优化方向、引入发射电子及带宽限制等条件，设置简单



常规导流系数电子枪+6腔速调管优化（11变量）



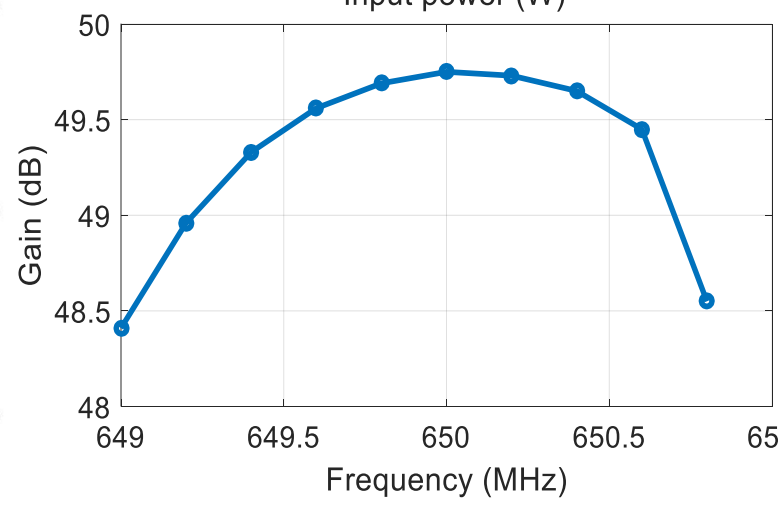
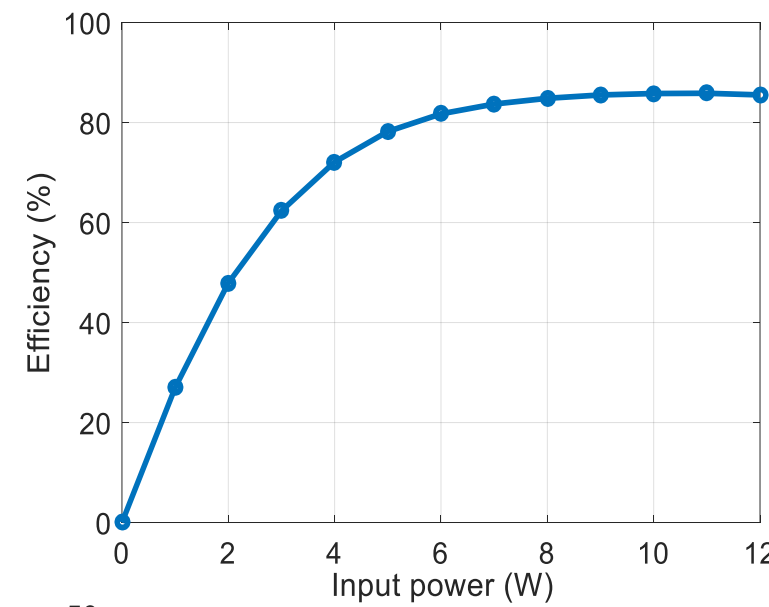
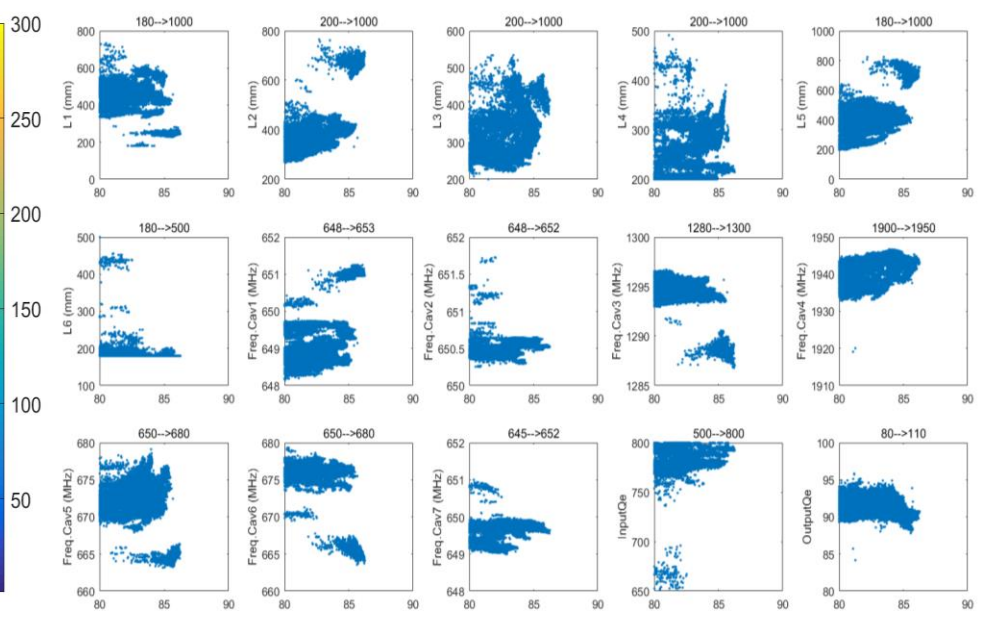
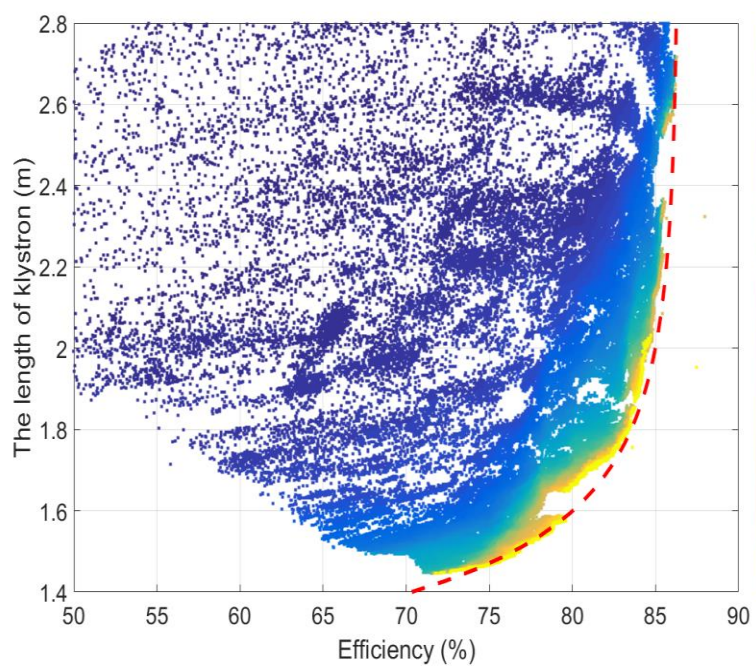
• Cutoff efficiency curve example

- The cut-off condition of the velocity of the slowest electron is ZERO
- The bandwidth cut-off condition is considered

$$D_{gain} = 2G_{f_0} - G_{f_+} - G_{f_-}$$

速调管多目标优化程序

- 可分析优化目标（效率）与各参量的关联性，便于分析优化方向
- 程序已经交付速调管设计人员使用



The evolution results for 7-cavity klystron with low perveance electron gun. [15 variables]

- 作为科技骨干参与CEPC科技部重点研发计划项目（首席：高原宁）——加速器关键技术课题，并负责其中直线加速器及正电子源物理设计；
- 参与并负责HEPS直线加速器物理设计、增强器误差分析等工作，同时完成《可研报告》、《初设报告》相关内容编写

项目名称	类别	角色	经费(万元)	状态
加速器RAMI分析软件开发及应用	青年科学基金项目	负责人	24	在研
超大发射度的高功率次级束流输运线研究	面上项目	主要人员	64	在研
加速器关键技术研究	科技部重点研发计划	科研骨干	960	在研
未来高能前沿正负电子对撞机	院其他任务	主要人员	300	在研
高功率石墨烯束流窗口的研究	青年科学基金项目	主要人员	23	在研

2017年底结题：作为主要参与人，重点项目一项（子任务负责人）、青年科学基金项目一项

- 会议文章第一作者5篇，合作作者9篇，期刊文章合作作者2篇，第一作者2篇已投稿（审稿中）
- 国际会议报告4次、评审会2次
 - CEPC Accelerator CDR mini-review（北京，2017年11月）报告
 - CEPC2017（北京，2017年11月）分会报告
 - IAS HEP2018（香港，2018年1月）分会报告
 - FCCWEEK2018（阿姆斯特丹，2018年4月）分会报告
 - CEPC2018（罗马，2018年5月）分会报告
 - CEPC CDR Review（北京，2018年6月）报告

未来工作计划

- 进一步细化**CEPC**直线加速器物理设计，并配合硬件系统迭代设计
- 完成RAAS程序编写，并基于此完成CEPC直线加速器可用性、可靠性分析，甚至整个CEPC可用性分析
- 细化正电子源物理设计及结构设计，实现数字化设计（TDR）
 - 山东大学马连良教授希望进行合作（ILC/CLIC）
 - 受邀参加SuperKEKB正电子源合作
- 积极参与PWFA相关注入器设计工作
- 其他安排工作

谢谢！