2025 New Year Kick-Off

Center for Accelerator Physics and Engineering (CAPhE)

Moses Chung

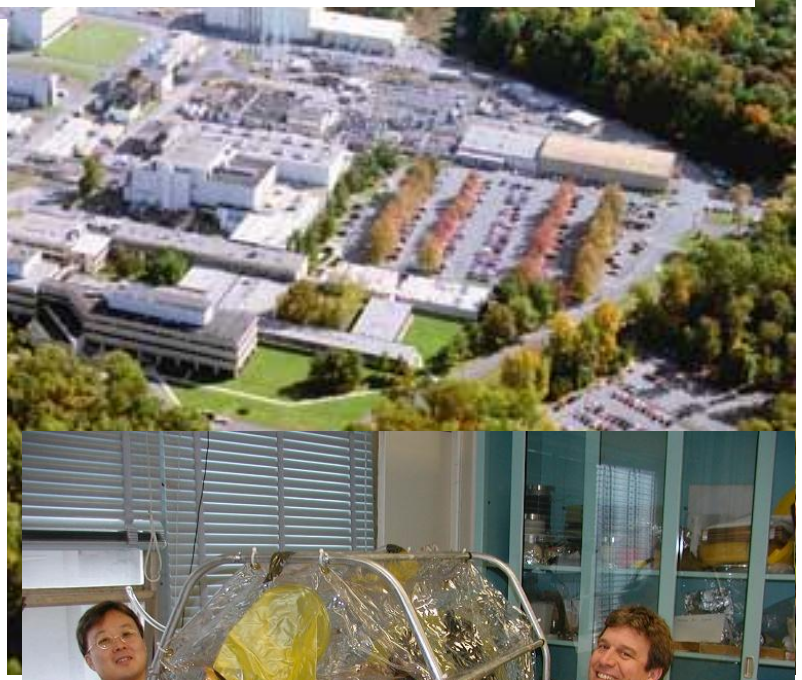
2025. 1. 3.

History of our lab.

2001~2008

PPPL PRINCETON PLASMA PHYSICS LABORATORY

A Collaborative National Center for Fusion & Plasma Research



PRINCETON PLASMA PHYSICS LABORATORY

fact sheet

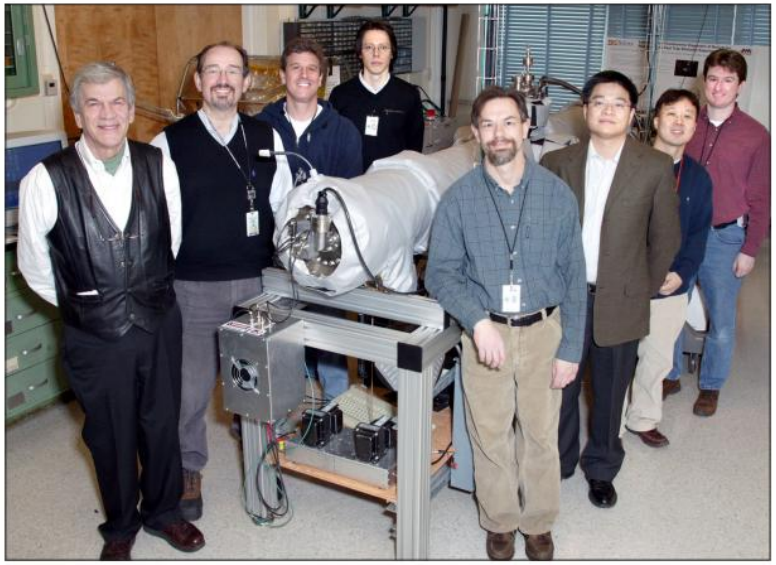
PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

Small is Big for PPPL's Paul Trap

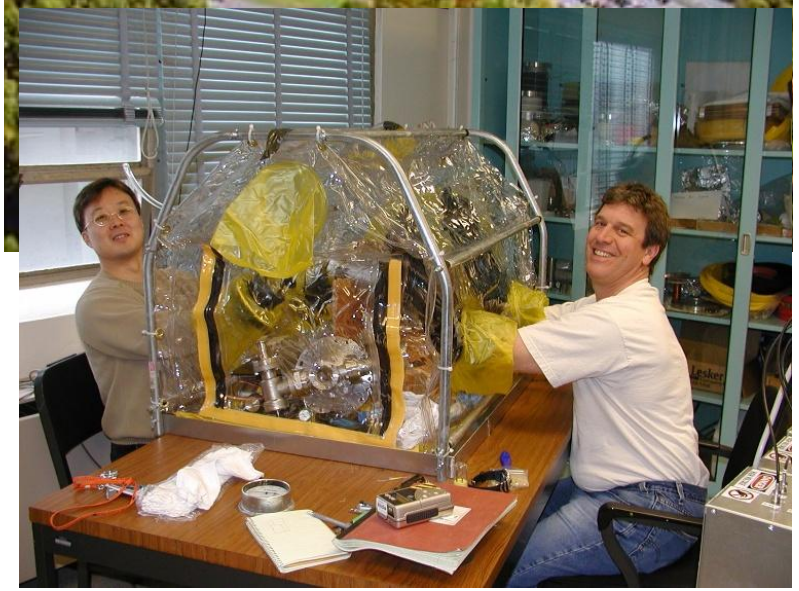
The Paul Trap Simulator Experiment (PTSX) at the U.S. Department of Energy's Princeton Plasma Physics Laboratory doesn't trap people named Paul or simulate the trapping of Pauls. Its mission is much grander.

"We are trying to answer big physics questions that have costly implications in a small, compact relatively inexpensive device," notes PPPL physicist Erik Gilson. Research by Gilson and his colleagues, led by Principal Investigator Ron Davidson, could have a significant impact on several areas of science and technology, including particle physics, heavy ion fusion, nuclear waste transmutation, and high-energy-density physics — wherever charged particle beams are used as tools.



From left at the Paul Trap Simulator Experiment are Ron Davidson, Phil Efthimion, Andy Carpe, Ed Startsev, Dick Majeski, Hong Qin, Moses Chung, and Erik Gilson.

direction perpendicular to the flow of the particles. Gilson likens the beam to a water balloon, which if squished from the sides, will leak out the top and bottom. When pushed



History of our lab.

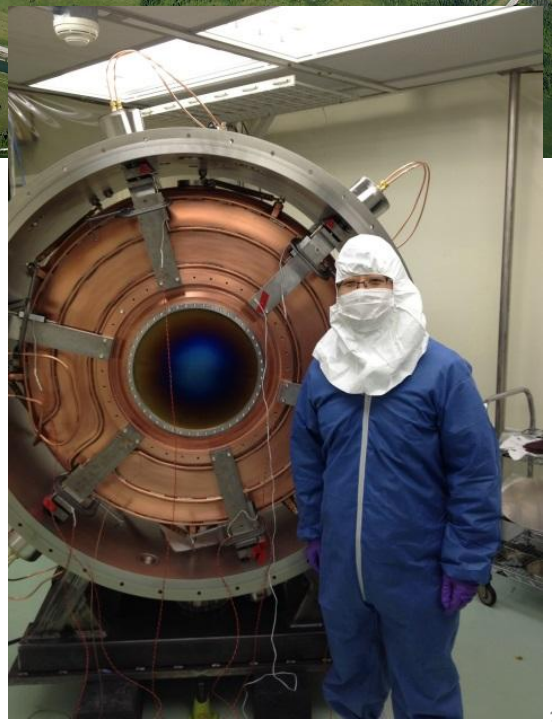
2008~2014

Accelerator Physics Center at Fermilab :

History and Accomplishments (2007-2018)

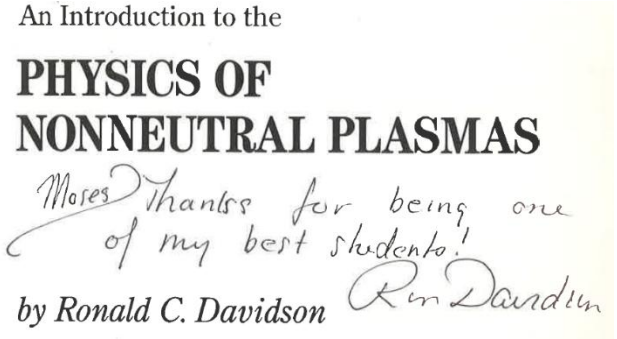
Vladimir Shiltsev

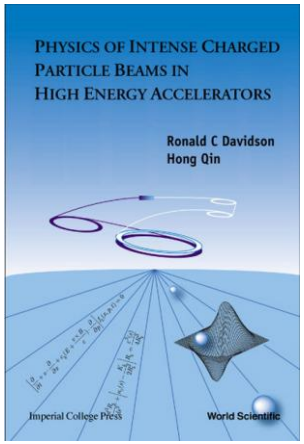
Fermi National Accelerator Laboratory, Batavia, IL, 60510, USA



The late Prof. Ronald C. Davidson:
~6 years at Plasma Physics Lab., Princeton University

The late Dr. Alvin V. Tollestrup:
~5 years at Accelerator Physics Center, Fermilab





"Alvin brought a focus on underlying physical principles and a faith that judicious (현명한) application of **freshman physics** could master any challenge."

"Robert Wilson had some creative people around here, but not guys that understood **freshman physics** very well."

Davidson: 10/7/2014

Beam Envelope Calculations in General Linear Coupled Lattices

Moses Chung,[1] Hong Qin,[2,3] Lars Groening,[4] and Ronald C. Davidson[2]

[1]*Department of Physics, Ulsan National Institute of Science and Technology, Ulsan 689-798, Korea*

[2]*Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08543*

[3]*Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China*

[4]*GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstrasse 1, D-64291 Darmstadt, Germany*

(Dated: October 7, 2014)

Abstract

The envelope equation and Twiss parameters (β and α) provide important bases for the uncoupled linear beam dynamics. For sophisticated beam manipulations, however, coupling elements between two transverse planes are intentionally introduced. The recently developed generalized Courant-Snyder theory offers an effective way of describing the linear beam dynamics in such coupled systems with a remarkably similar mathematical structure to the original Courant-Snyder theory. In this work, we present numerical solutions to the symmetrized matrix envelope equation for β which removes the gauge freedom in the matrix envelope equation for w. Furthermore, we construct the transfer and beam matrices in terms of the generalized Twiss parameters, which enable to calculate the beam envelopes in arbitrary linear coupled systems.

calculation of the

I. INTRODUCTION

The fundamental framework for the design and analysis of an uncoupled quadrupole lattice is the Courant-Snyder (CS) theory [1]. Many standard textbooks on the accelerator and beam physics introduce the CS theory to start discussions on the linear uncoupled beam dynamics [2–4]. Interestingly, one of the recent trends in the beam physics community is to introduce coupling elements between two planes intentionally for sophisticated beam manipulations [5–7]. Several ideas have been proposed to generalize the original CS theory for the systematic beam dynamics description of such coupled systems with as much similarity as possible to the original CS theory [6, 8, 9].

In recent papers [10, 11], the dynamics of charged particles in general linear coupled lattices has been formulated in terms of a generalized CS theory, which extends the original CS theory to fully coupled cases. The generalized CS theory can be applied to systems with quadrupoles, skew-quadrupoles, dipoles, and solenoidal components, as well as torsion of the design orbit and variation of beam energy. Furthermore, the generalized CS theory contains remarkably similar mathematical structure and physical meaning to their counterparts in the original CS theory. The 1D envelope equation is generalized into a matrix envelope equation in higher dimensions, and the phase advance is generalized into a symplectic rotation. Particularly in Ref. [11], the gauge group structure of the generalized CS theory was analyzed using polar decomposition theorem. It has been found that the gauge freedom in the matrix envelope equation for w can be bypassed by solving symmetrized envelope equation for the generalized Twiss parameter β. This gauge fixing makes the numerical algorithms of searching for matched solutions for β and β' more efficient than for matched solutions for w and w'. In the matrix envelope equation for w, in principle, there are infinite numbers of the matched solutions for w and w'.

In this paper, we present more details of the symmetrized envelope equation for β and formulate transfer matrix (M) and beam matrix (Σ) in terms of the generalized Twiss parameters α and β, which turn out to be remarkably consistent with the original CS theory. We also present beam envelope calculations for several linear coupled systems, which indeed demonstrate the validity and usefulness of the generalized CS theory.

begin

include the effects of

the

shown

the adjustment

an

a more detailed analysis in Secs. II and III

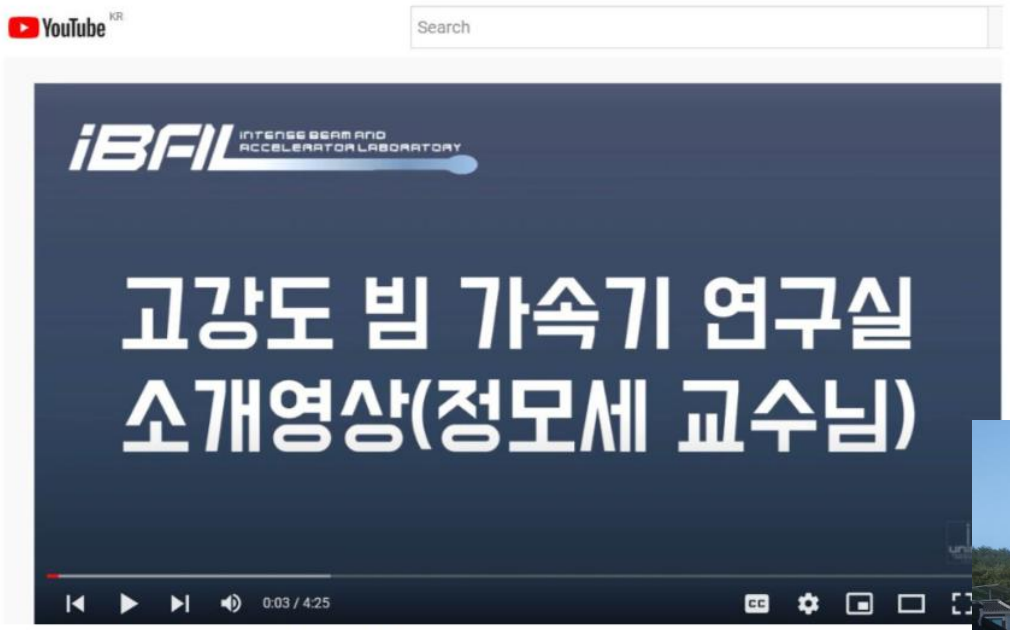
in Sec. IV for

Conclusions are summarized in Sec. V.

History of our lab.

2014~2024.2

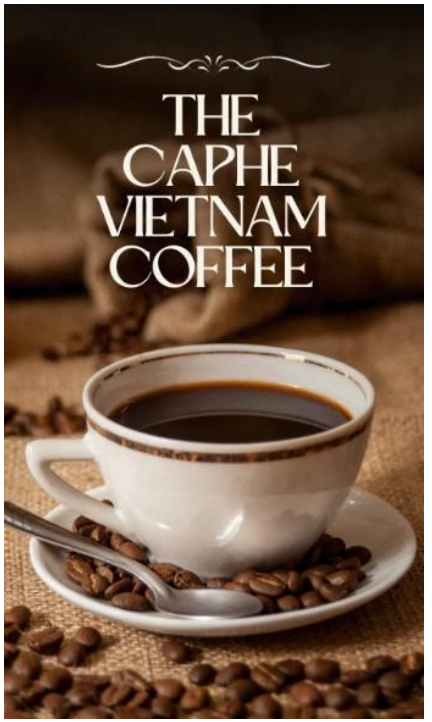
Link to a short video clip: 연구실 소개 동영상 (곽동현 제작)



https://www.youtube.com/watch?v=9RxYB4yXQ3I

History of our lab.

2024.3~



본 연구그룹은 고도화된 빔 물리 이론 및 수치해석 코드 (ML/AI 포함), 첨단 빔 진단 및 제어 장치를 활용하여, 국내외에 건설 또는 운영 중인 대형 가속기의 설계 및 구축, 최적화 및 성능향상에 기여하고, 나아가 지금보다 효율(Brightness, Intensity, Accelerating Gradient 등)이 10~100 배 높은 첨단 가속기 개발에 필요한 물리적-공학적 난제에 도전한다. 이러한 첨단 가속기는 핵융합 재료 연구, 원자력 폐기물 처리, 암 치료, 신소재/신약 개발, 우주의 신비 탐구 등 인류가 당면한 여러 문제를 해결하는 데 필수적인 첨단기술이다.

Coffee, Cafe, Caphe 단어의 뜻과 차이는 다음과 같습니다.

- 영어권 - Coffee / 커피 / 음료
- 영어권 - Cafe / 카페 / 매장
- 프랑스 - Café / 카페 / 음료, 매장
- 베트남 - Càphê / 카페 / 음료, 매장

Benchmark

"Stanford University operates SLAC for the DOE Office of Science."

Budget: $383 milion (2017)
Staff: 1684

"POSTECH operates PAL for the Government of South Korea."

Budget: 580억원 (2021)
Staff: 259명 (2022년 3월 현재)

FACET-II vs eLABs:
→ Advanced Accelerator R&D

SPEAR3 vs PLS-II:
→ Synchrotron Light Source

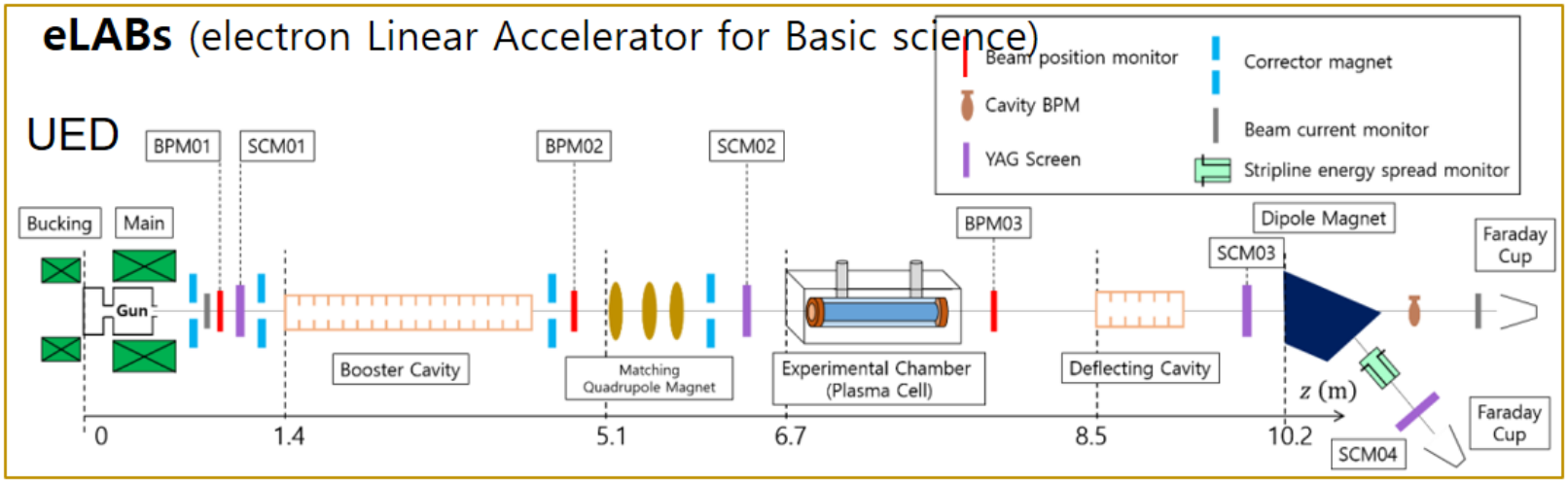
LCLS-II vs PAL-XFEL:
→ Hard X-ray Free Electron Laser

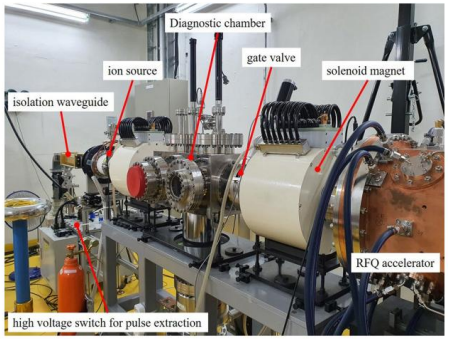
AI/ML → Silicon valley

EUV → Startup (e.g., xLight)

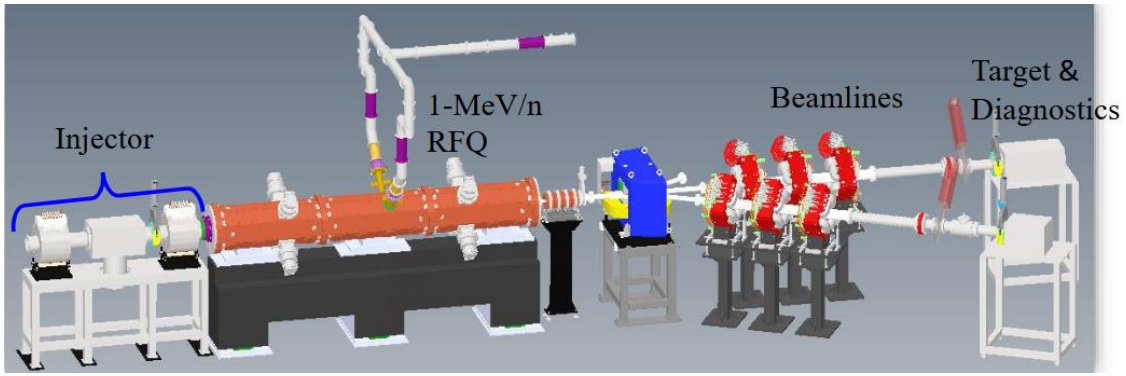
해외에서도
찾아보기 힘든
입지조건!

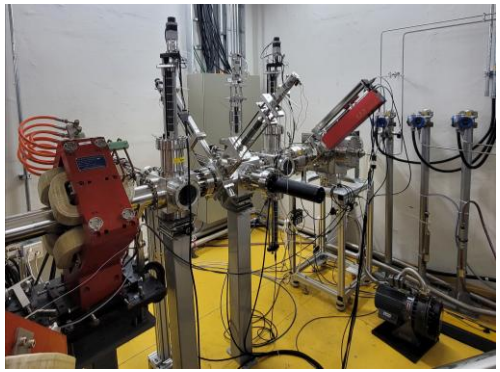
가속기연구소가
우리 실험실!

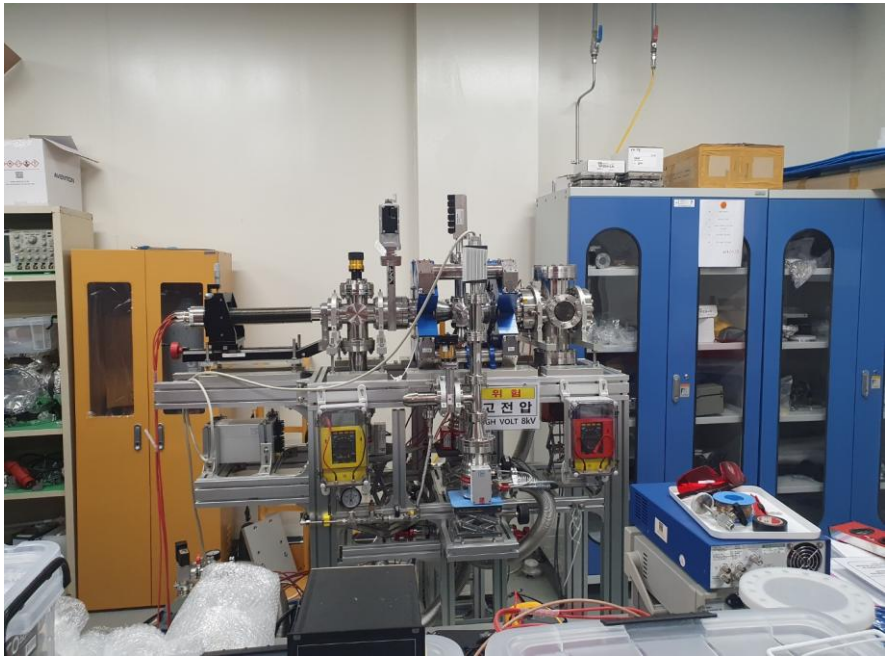




BTS (Beam Test Stand)







→ 우선 순위에서 다소 밀릴 것으로 보임

강의시간: 금요일 12:30~16:45 → 학생들과 협의 하여 13:00부터 로 조정 가능
강의실: 제1실험동(첨단원자력공학부) 302-1호(작은 세미나실) → 실습시에는 장소 변경 가능

→ 1주 : 포항가속기연구소 소개 및 입자가속기의 방사선 환경 (이희석): 강의
→ 2주 : 가속기 자석 1 (한가람): 강의
→ 3주 : 가속기 자석 2 (한가람): 실험/실습/참관
→ 4주 : 가속기 진공 1 (하태균): 강의
→ 5주 : 가속기 진공 2 (하태균): 실험/실습/참관
→ 6주 : eLABs 시설을 이용한 빔운전 및 RF/빔진단 기초 1 (정모세/성창규): 강의
→ 7주 : eLABs 시설을 이용한 빔운전 및 RF/빔진단 기초 2 (정모세/성창규): 실험/실습/참관
→ 8주 : 중간고사 (실험 레포트 작성)
→ 9주 : PLS-II 및 PAL-XFEL의 빔진단 1 (김창범): 강의
→ 10주 : PLS-II 및 PAL-XFEL의 빔진단 2 (김창범): 실험/실습/참관
→ 11주 PLS-II 빔라인 소개 및 X-선 광학계 기초 (김기정): 강의
→ 12주 : PLS-II 4C SAXS II 실험 1 (진경식): 강의
→ 13주 : PLS-II 4C SAXS II 실험 2 (진경식): 실험/실습/참관
→ 14주 : PLS-II 2A MS 실험 1 (김영학): 강의
→ 15주 : PLS-II 2A MS 실험 2 (김영학): 실험/실습/참관
→ 16주 : 기말고사 (실험 레포트 작성)

4GSR
(4th Generation Storage Ring)

PLS II
(Pohang Light Source)

PAL XFEL
(Pohang Accelerator Lab.
X-ray Free Electron Laser)

RAON
(Rare isotope Accelerator complex for ON-line experiments)

SGCC-HITS
(SNUH Gijang Cancer Center of Heavy Ion Therapy and Study)

KOMAC
(Korea Multi-purpose Accelerator Complex)

의료 및 산업에도 기회가 많음

동아사이언스

인간

세브란스병원, 췌장암 · 간암 대상 회전형 중입자치료기 가동

2024.05.28 17:38

금웅섭 연세암병원 방사선종양학과 교수와 의료진이 중입자 치료기 장비를 조정하고 있다. 연세암병원 제공

머니투데이

VIP

뉴스 증권 정치 법률 유니콘팩토리 헬스·바이오 칼럼 연예 이슈 MT리포트 속보 근로기준법 적용 '5인 이상 사업장' 기

40분 단 한번 치료로 암세포 죽인다...송도에 문 연 '이곳' 가보니 [르포]

머니투데이 | 송도(인천)=홍효진 기자

VIEW 5,247 | 2024.08.28 15:06

다원메닥스 '송도 BNCT(붕소중성자포획치료) 의원'
국내 최초 BNCT 의원..."열외중성자 생성, 1회 치료로 암세포 사멸"

신규 고객이라면 누구나 혜택
Temu

네이버에서 머니투데이 뉴스 보기

다음언론사홈에서 머니투데이 구독

연합뉴스 | 최신기사 정치 북한 경제 미켓+ 산업 사회 전국 세계 문화 건강 연예 스포츠 오피니언 사람들 비주얼뉴스 제보

뉴스홈 | 최신기사

중국, 美 제재에 입자가속기 활용한 반도체 노광장비 공장 추진

송고시간 | 2023-09-25 16:30

요약 7

윤고은 기자

홍콩 매체 "칭화대 연구진, 승안지구에 거대한 공장 건설 계획"

[로이터 연합뉴스 자료사진]

핫뉴스

"친애하는 한강님 나와주세요" 노벨상 시상식서 한국어로 호명한다

수원 이어 의왕서도 사슴 나타나… 소방당국 "마취총 포획"

성매매업소 장부에 적힌 '착한 놈'…법원, 현직 경찰 "무죄"

xLight

Technology Team News Contact

Building the world's most powerful lasers

The xLight mission is to commercialize particle accelerator driven Free Electron Lasers (FEL) for critical US economic and national security applications.

RADEXCEL 추진 체계 – 주요 팀원:

방정배, PhD, 총괄책임
라덱셀 이사, CTO
경북대 가속기 물리학
(전) MIT postdoc, 고려대 가속기학과 조교수

주요 국가R&D사업 실적)
[사업화] 100keV 급 이온 주입용 고안정
[사업화] 데이터 기반 자기장-방사선 융
[인력양성] 한국연구재단, 가속기 및 빔

김태순, MD, CEO
(전) AI biotech CEO
경영 총괄

정누리현, MD
방사선종양학 전문의
R&D 총괄

정수현, MBA
경영학
재무, 인사

김성준
기계공학, 의료장비 설계 12년
장비 설계

윤영준, MD
방사선종양학
기술전략, 학술 데이터

남승희, PhD
(전) 포항공대 가속기연구소
방사선 가속기 제어

SK 하이닉스

안현 SK하이닉스 사장

안현 SK하이닉스 N-S 커미티(Committee) 담당이 5일 단행된 SK그룹 인사에서 사장으로 승진했다.

안 사장은 동시에 개발 총괄(CDO)을 맡아 HBM 마켓 리더십을 공고화하고 D램과 낸드, 솔루션 등 기술경쟁력 강화를 진두지휘한다.

안 사장은 미래기술연구원과 경영전략, 솔루션 개발 등 핵심 보직을 거쳤고, 올해 주주총회에서 사내이사에 선임돼 회사의 기술과 전략 관련 주요 의사결정에 참여해왔다.

△1967년생 △서울대 원자핵공학 학사 △서울대 대학원 원자핵공학 석사 △서울대 대학원 원자핵공학 박사 △솔루션개발 담당 겸 N-S 커미티 담당

전통의 미국

Accelerators are critical tools for physical sciences research


Linac Coherent Light Source


Advanced Light Source


Fermilab Accelerator Complex


Advanced Photon Source


National Synchrotron Light Source II


Relativistic Heavy Ion Collider


FACET Beam Test Facility

More than 54%* of SC's nearly 36,000 users perform research at an accelerator-based facility


BNL Accelerator Test Facility


Stanford Synchrotron Radiation Light Source


DIII-D


NSTX-U


Spallation Neutron Source

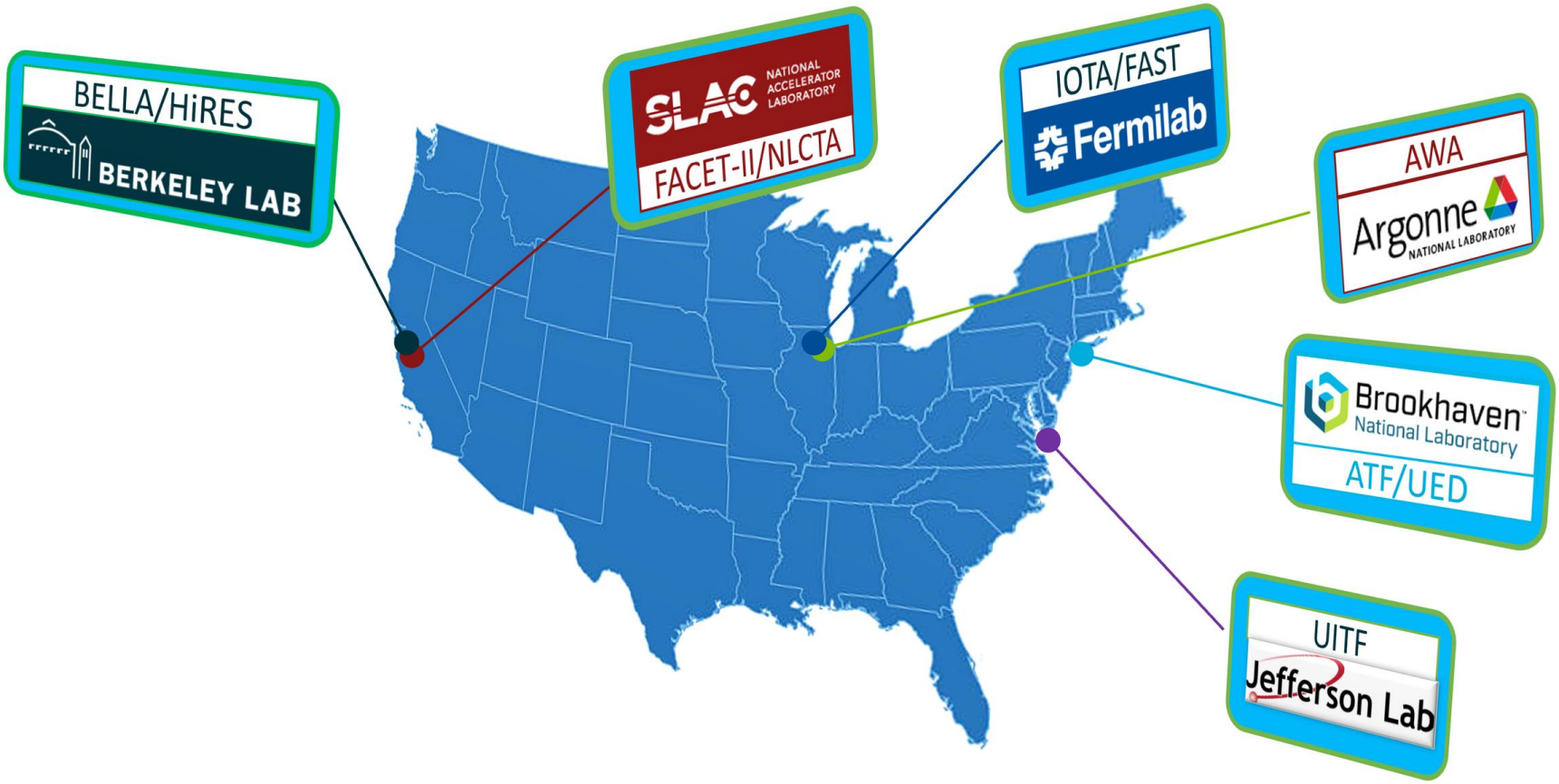

ATLAS


Continuous Electron Beam Accelerator Facility

U.S. DEPARTMENT OF ENERGY | Office of Science

FY 2019: 19,337 users (**54%** of 35,771 total SC users) were at accelerator-based SC facilities.
FY 2020: COVID reduced the number of users coming to physical facilities significantly, down to 47% (15,700) of 33,500 users.

+ FRIB / Cornell CHESS


BELLA/HiRES
BERKELEY LAB
SLAC NATIONAL ACCELERATOR LABORATORY
FACET-II/NLCTA
IOTA/FAST
Fermilab
AWA
Argonne NATIONAL LABORATORY
Brookhaven National Laboratory
ATF/UED
UITF
Jefferson Lab

무서운 중국

	Operation	Construction	Design & R&D	Sum
Collider	**BEPCII** (1.89 GeV, 2 CAV, since 2006)	**BEPCII upgrade** (2.35 GeV, 4 CAV, complete in 2024)	**CEPC** (45.5-180 GeV, 288 ~ 980 CAV) …	**2 circular colliders** tau-charm, Z, W, Higgs, ttbar
Synchrotron Light Source	**BSRF** (2.5 GeV, 2 CAV, since 2006) **SSRF** (3.5 GeV, 3 CAV, since 2009)	**HEPS** (6 GeV, 10 CAV, complete in 2025) **HALF** (2.2 GeV, 1 CAV, complete in 2028)	**SAPS** (3.5 GeV, 4 CAV) …	**5+ light sources** 3rd & 4th generations 2.2 ~ 6 GeV
FEL	**PKU FEL & DC-SRF Gun** (30 MeV, 3 CAV) **CTFEL** (10 MeV, 2 CAV, since 2017)	**SHINE** (8 GeV, 616 CAV, complete in 2027) **S3FEL** (2.5 GeV, 224 CAV, complete in 2031) **CTFEL upgrade** (50 MeV)	**DALS** (1 GeV, 96 CAV) **Pulsed XFEL** (15 GeV) …	**7+ FELs** 2 hard X-ray 1 soft X-ray 1 EUV, 1 IR, 2 THz
Proton & Heavy Ion	**ADS injector I** (10 MeV, 14 CAV, since 2016) **CAFe** (25 MeV, 23 CAV, since 2017)	**CiADS** (0.5 GeV, 151 CAV, complete in 2025) **HIAF** (4.25 GeV/u, 96 CAV) **CSNS-II** (300 MeV, 54 CAV, complete in 2028)	**CSNS-III** (1 GeV) **ADS** (1 GeV) **Pulsed proton linac** (1 GeV) …	**6+ proton & heavy ion SRF accelerators**
Sum	**Operating 6 facilities** **~ 50 cavities**	**Constructing 9 projects** **~ 1200 cavities by 2028** **~ 40 billion CNY**	**Proposing** **6+ projects** **2000+ cavities**	


Operation
Construction
Design and R&D
BEPCII and Upgrade
ADS Injector I
HEPS in Beijing
IHEP PAPS SRF lab
CEPC in China (site to be decided)
IHEP
Beijing
PKU
PKU FEL
DICP
DALS in Dalian
North Korea
South Korea
Japan
IMP
CAFe in Lanzhou
China
HALF in Hefei
USTC
SARI
SSRF and SHINE and large SRF lab in Shanghai
CTFEL in Chengdu
Chongqing
CSNS-II and SAPS and large SRF lab in Dongguan
NSRRC
TPS in Hsinchu
Taiwan
IHEP
IMP
Hong Kong
IASF
Myanmar (Burma)
Laos
S3FEL and SRF lab in Shenzhen
CIADS and HIAF and large SRF lab in Huizhou

연구 방향

- 실험실 차원의 독자적인 가속기 시설 구축은 연구비/인력/공간 등의 제한으로 현실적으로 어려우므로, "빔 물리/시뮬레이션 및 빔 진단/제어 (small footprint), 포항가속기연구소 시설 적극 활용, 국내외 가속기 시설 이용/파견"에 초점을 맞출 예정.

- 이론/시뮬레이션, 장치설계/제작의뢰(주로 업체를 통해서)/설치, 측정실험, 결과해석을 모두 할 수 있는 멀티플레이어 및 문제해결 능력을 갖춘 물리학자/공학자 양성.

How to get a Ph.D?

1. At least 1~2 SCI papers as a first author.

and

2.

- You know your topic better than your advisor.

or

- You can find your job by yourself.

[To do that, you need skill set for the job: Beam physics (various beam dynamics codes) / RF(CST) / Control(EPICS) / Design (CAD) / Diagnostics / Electronics / Magnet / Vacuum / Computation (Python, Matlab, AL/ML) etc.]

Preferred Qualifications:

- Experience with modern programming languages, particularly Python
- Demonstrated ability to communicate research results through reports, publications and presentations.
- Experience in accelerator physics, which may include working in a control room, conducting accelerator-based experiments, and computational modeling

Desired Qualifications

- 2+ years experience with software and hardware for instrument design and calibration
- 2+ years experience with software and hardware methodologies for instrument control and data acquisition.
- 2+ years experience with large-scale scientific or industrial control systems.
- 2+ years experience with programming and scripting languages.
- An understanding of advanced mathematical and scientific software applications as evidenced through educational preparation or professional use.

Target Journals

- Nature/Nature Photonics, Nature Physics, Nature Communications: Nearly lottery. Need to join big collaboration
- Physical Review Letters: Practically the best in our field
- Physical Review - Accelerators and Beams

Need physics results

- Nuclear Instruments and Methods in Physics Research A/B
- Journal of Instrumentation
- Review of Scientific Instruments (RSI)

Related with experimental system

- Korean journals in case of emergency: JKPS(KPS), NET(KNS)

Duties

- Lab. Leader: 송우진 (P) / 정준영 (U)
- IT manager: 박영민 (P) / Emre Cosgun (U)
  - PC purchase/maintenance
  - Server maintenance
  - CST/TraceWin/HFSS/COMSOL/SIMION/Mathematica etc.
- Equipment manger: 김근우 (P) / 정준영(U)
- Project manager and accounting:
  - 조한나 선생님(P): 제2실험동 3층
  - 진주아 선생님(U): 108동 5층

Laboratory rules

- Workhour: Mon ~ Fri., 10 AM ~ 6 PM → But will be flexible → For example, if you are late by 1 hour, then you would stay by 7 PM etc. **다만, 병역특례중인 학생들은 출퇴근 확실하게….**

- Meeting: Just call/email/text me before you come to my office to make sure I'm available.
  - Regular group meeting on every Friday 10: 30 AM (발표는 2~3 주에 한번씩 돌아가도록 지정할 예정)
  - 학위논문 이나 논문투고, 보고서 마감이 다가온 경우에는 일주일에 한번 대면 미팅

- Vacation: Usually, 5 days in summer and 5 days in winter. In case you need to take days off in addition to the regular vacations, just let me know. Things are very flexible.

주요 연구 과제 현황 (책임)

- 과제(책임):
  - Beam-driven Wakefield 과제 → 2020.03.01~2025.02.28
  - 가속기 인력 양성 과제 → 2022.05.01~2027.12.31
  - 포항공대 정착 과제 → 2024.03.01~2027.2.28

2024 상반기 주요 행사

- Winter USPAS (Knoxville, Tennessee): 1월 27일~ 2월 7일
- GEANT4 워크샵 (포항): 2월 3~7일
- 한국물리학회(대전): 4월 23~25일
- 한국원자력학회(제주): 5월 21~23일
- IPAC 2025(타이완): 6월 1~6일
- Summer USPAS (Rohnert Park, California): 7월 28일~ 8월 8일
- 가속기인력양성 공동 여름학교 (포항): 8월 중

Tips / 잔소리

- You need to have good relationship/teamwork with researchers in accelerator laboratories to make the most of facilities or to get a job there.
- English is essential to collaborate with experts worldwide and to write a nice paper. You can make the most of AI tools to improve your English.
- Driver's license
- Insurance/Radiation safety: once per year
- CST/COMSOL/Mathematica etc.: Take education program (mostly on-line these days) when available
- Please read recent papers (e.g., PRL, PRAB, NIM etc.) and don't be afraid of having a meeting with your advisor (i.e, me).

Subtle Items

- 인건비: 과제 상황에 따라 유동성이 있는데, 총액이 석사 ~180만원, 박사 ~220만원/월 전후가 되도록 할 예정. 연차/수업여부 및 타 교수님/박사님 과제 참여 여부에 따라 다소 달라질 수 있음.

과정		현행	개정(안)	납부금액
석사	정규학기	1~4	1~4	전액
	초과학기	5~6	5~6	1/3납부
박사	정규학기	1~6	1~4	전액
	초과학기	7~12	5~12	1/3납부
통합	정규학기	1~10	1~8	전액
	초과학기	11~14	9~14	1/3납부

과정	2024 기준금액(월)				학기(원)	국가연구개발비 최소/최대 한도액(월)	기관계정 /정액(월)
	학기	등록금	생활비	계			
석사	1~4	862,000	638,000	1,500,000	9,000,000	최소10%이상 최대:220만원	440,000
	5~6	287,340		925,340	5,552,040		
박사	1~6	862,000	1,138,000	2,000,000	12,000,000	최소10%이상 최대:300만원	600,000
	7~12	287,340		1,425,340	8,552,040		
통합	1~10	862,000	1,138,000	2,000,000	12,000,000	최소10%이상 최대:300만원	600,000
	11~14	287,340		1,425,340	8,552,040		

- 해외학회/School/파견: 공평하게 기회가 가도록 순차적으로 보낼 예정. 단, 몇 년에 한번 돌아오는 학회/과목/실험이 있을 경우, 순서를 탄력적으로 운영할 생각임.