

한미 고에너지물리 국제공동연구 현황

양운기

서울대학교 물리천문학부

KSHEP Fall 2023, 동신대, 2023.11.23~25

Yes, we can do it!

Fearless Koreans at Fermilab

This was 15 years ago



고에너지물리 국제공동연구

1970

1980

1990

2000

2010

2020

Europe



USA



Japan



➤ 5-decade effort from 3 different continents



In 1970s

There was Benjamin Lee

(이휘소)

- Renormalization of the weak interaction (infinity problem)

1999



G. 't Hooft



M.J.G. Veltman

- Search for Charm (Aug. 1974: Rev. Mod. Phys.)
- $m_c < 1.5$ GeV

1976

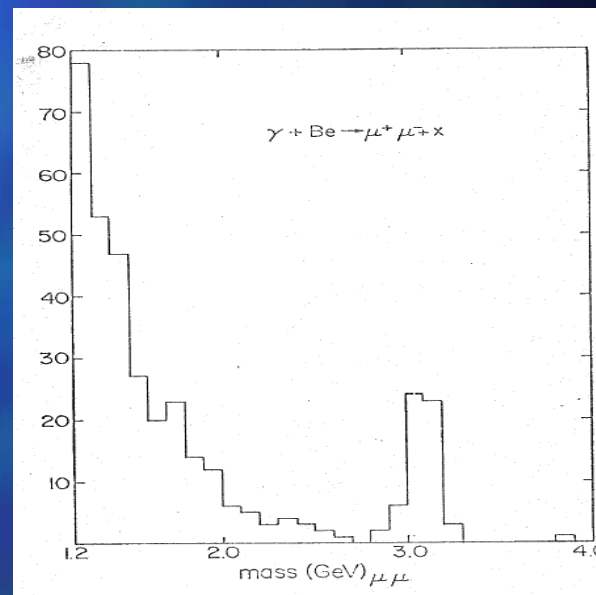




And 이원용 (Columbia)

- Pioneer for charm physics at Fermilab in 1970s (E89)
- Pioneering role for Korean HEP at Fermilab
 - 1980s: 김종오(고려대), 송진섭(경상대)
 - E687 / FOCUS: 강주상 (고려대)

E89: $\gamma + \text{Be} \rightarrow u^+ u^- X$



Observation of narrow resonance
(PRL, Feb 1975)

➤ **1970s: 이휘소 and 이원용 (E89)**

- Leading figures in World HEP
- Pioneering role for Korean HEP

➤ **1980s: 김종오(고려대), 송진섭(경상대)**

- Charm/beauty studies using 600/800 GeV π/p beams to Emulsion targets (E653): established a big emulsion group

➤ **1990s**

- 강주상 그룹 (고려대): E687/FOCUS (photo-production), Beginning of active research at Fermilab by Korean Institutes



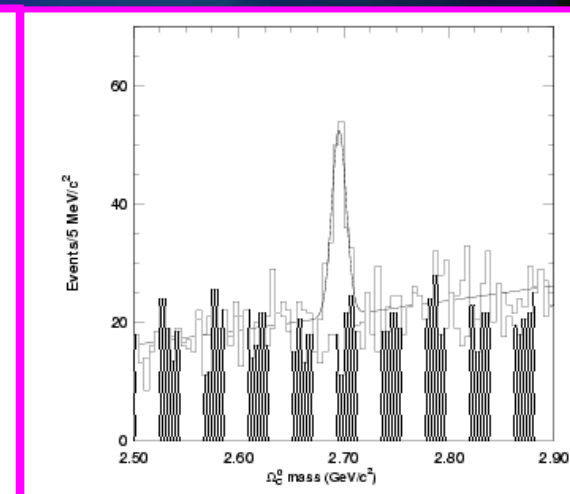
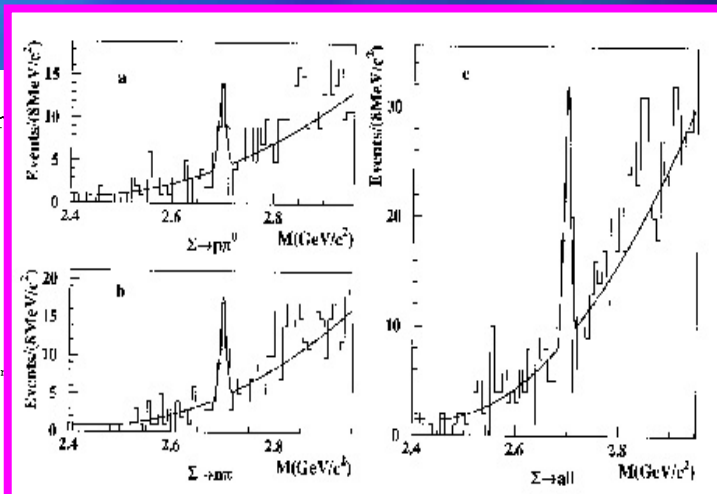
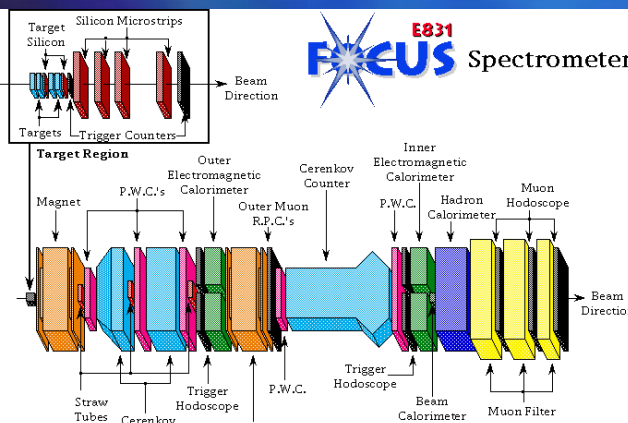
In early 1990s, 강주상(고려대)

➤ Join E687/FOCUS in 1991

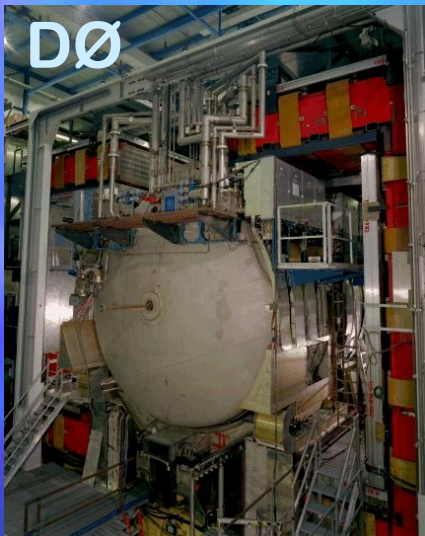
- 1991: E687 students (김귀용, 천병구)
- 1993: FOCUS students (이경범, 정연세)
- Later 광정원, 고병록

➤ Many significant contributions to calorimeter, trigger and charm studies (6 PhDs)

➤ Established an active Korean Institute at Fermilab



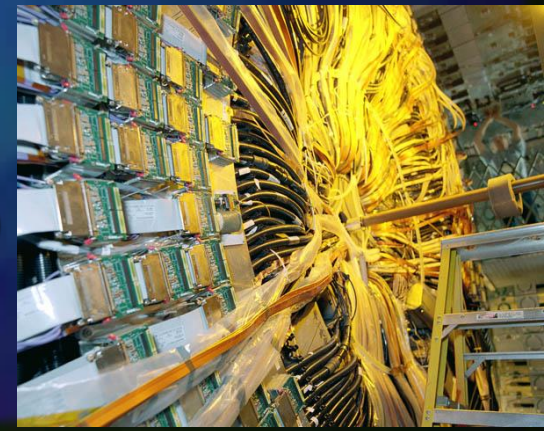
Tevatron: High Energy Frontier (early 1990s)



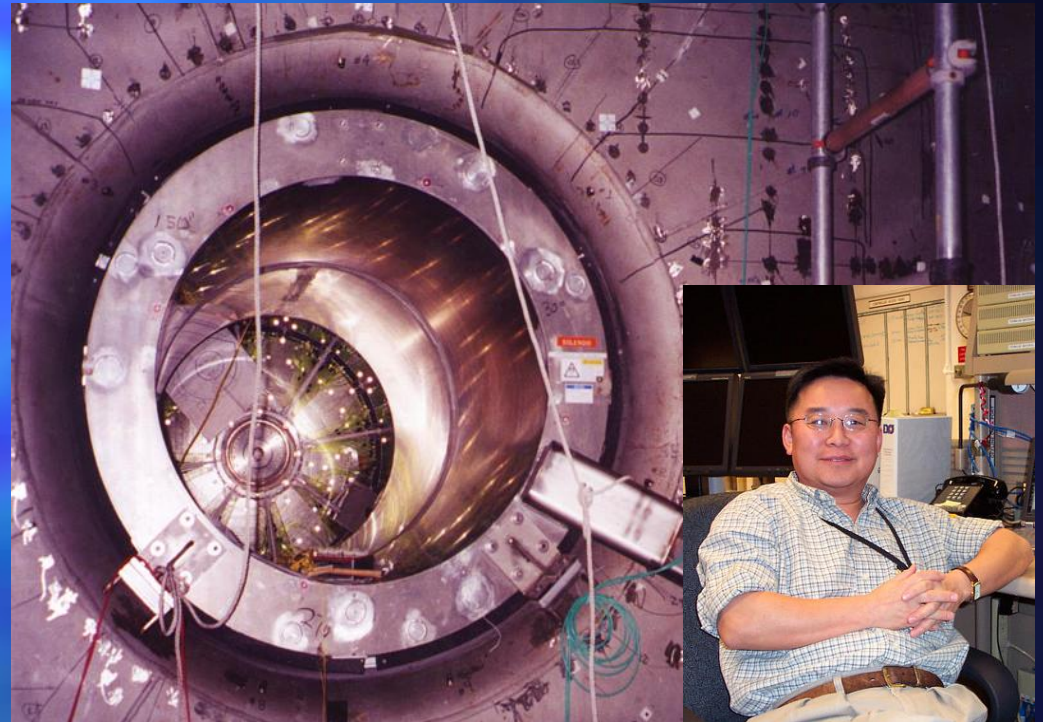
Post-TRISTAN

- New particle search
- Precision tests on the SM

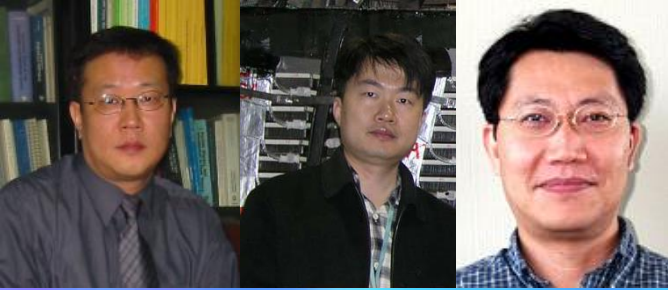
- DØ (1994): 고려대 (강주상), 서울대 (김선기), 경성대(박영목)
 - Fiber tracker (VLPC chip)
 - Top (최수용), QCD pomeron physics
- CDF(1999): KHCL (Korean Hadron Collider Lab)
서울대(김수봉), 성균관(유인태), 경북대(김동희)
- SRC fund -



Run II CDF/D0 Commissioning

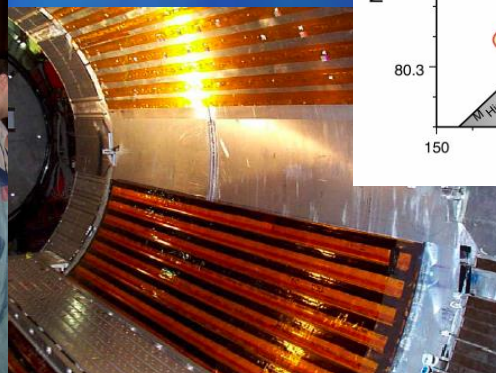
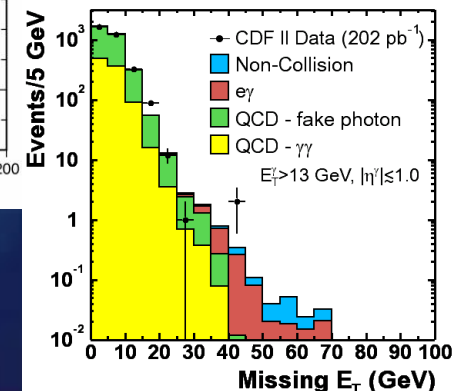
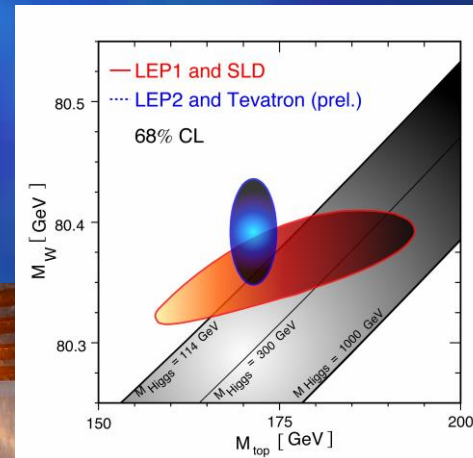


- By two great leaders (commissioner):2000-2001
 - D0: 유재훈 (FNAL)
 - CDF: 김영기 (Chicago)

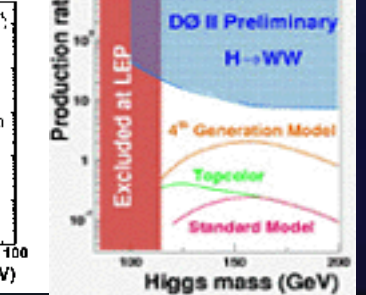
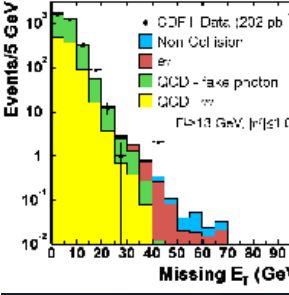
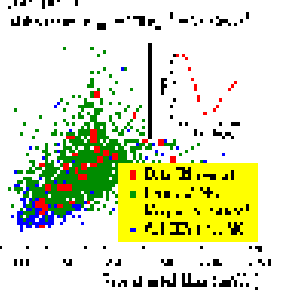
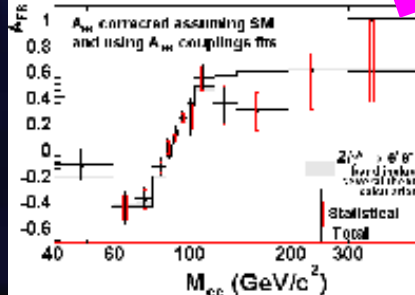
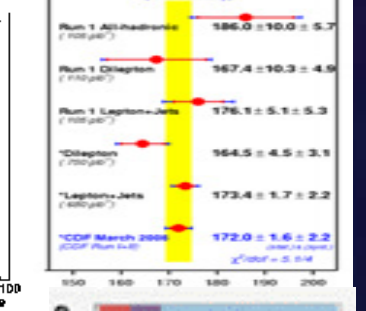
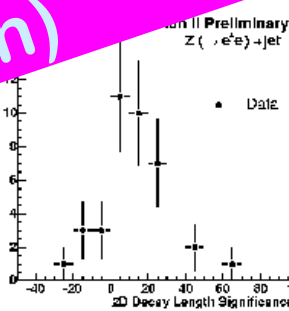
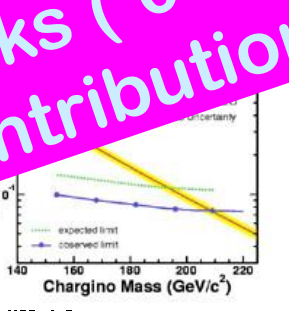
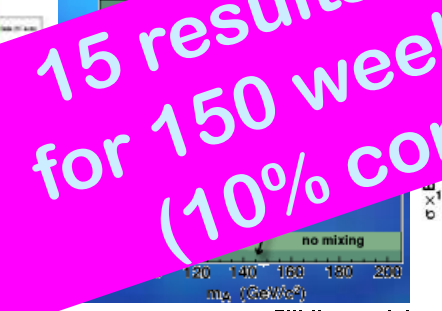
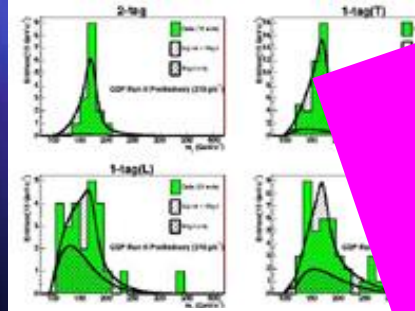
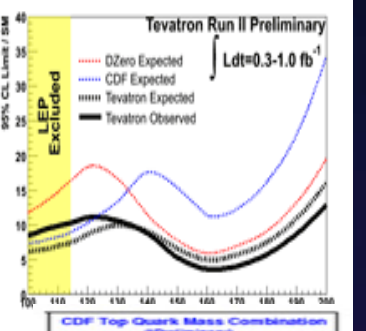
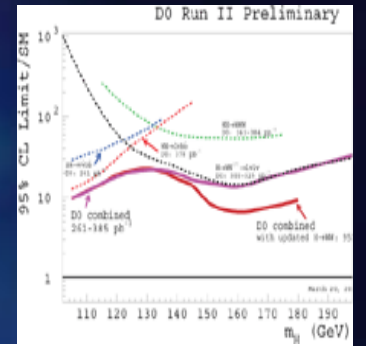
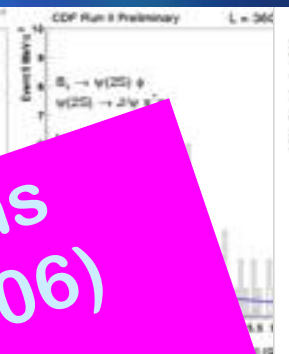
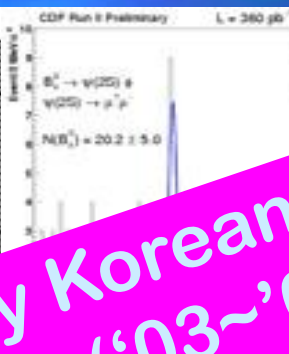
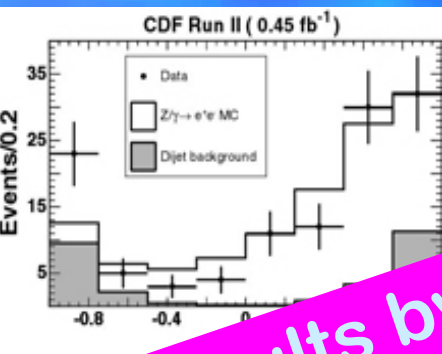
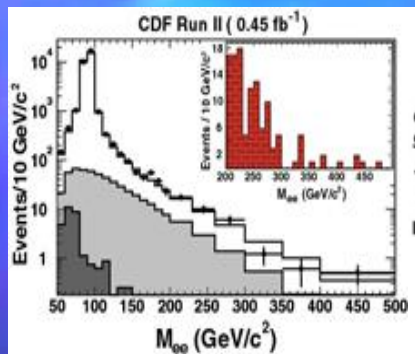


KHCL Activities at CDF (SRC)

- TOF: PMT test and construction
- KoCAF (central analysis farm: toward GRID)
- Calorimeter, trigger, and calibrations
- Contributed to top, B, new physics searches
- 서울대(김수봉), 성균관(유인태), 경북대(김동희)



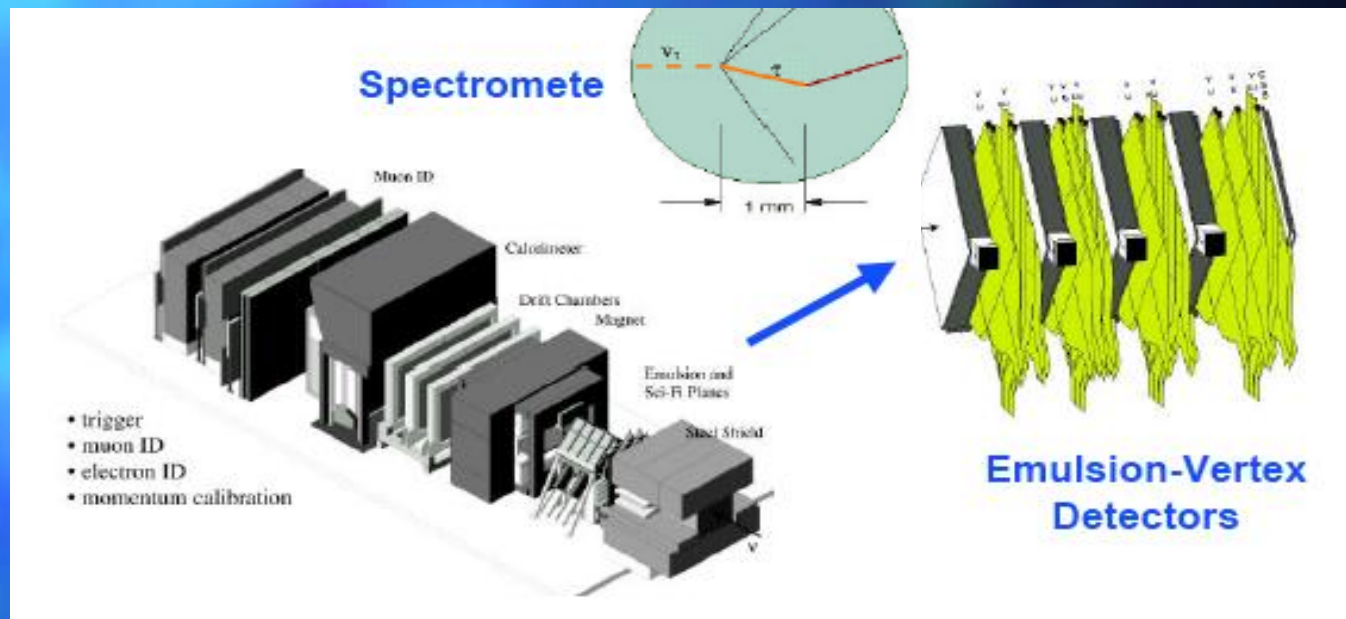
Fermilab Results of the Week



15 results by Koreans for 150 weeks ('03~'06) (10% contribution)

Discovery of the Tau neutrino

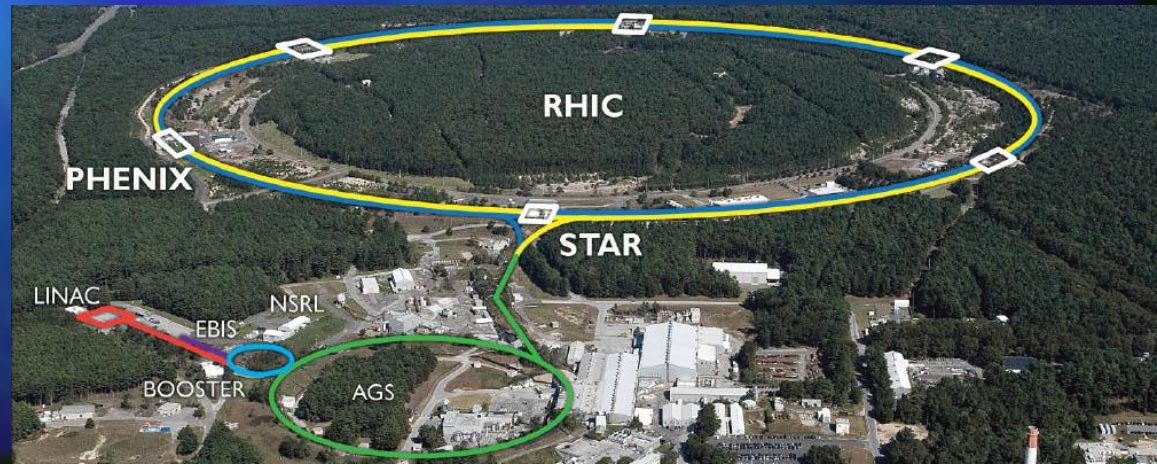
DONUT



- July 21, 2000: 4 EvtS (0.41 exp. bkgd)
- Emulsion target: search for a kink
- Korean Institutes (inherited from E653):
경상대(송진섭) , 건국대(이준택)

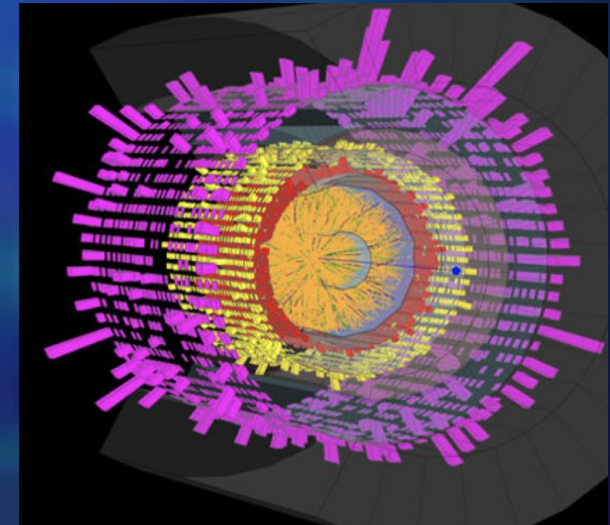
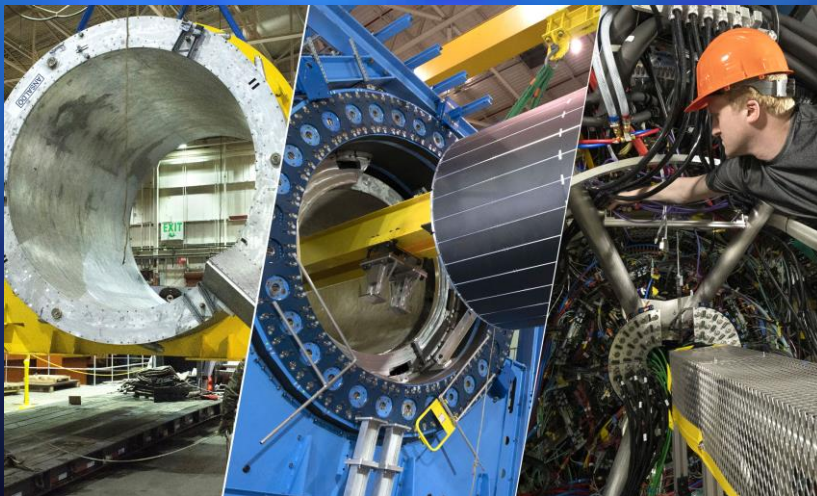
Korean Activities at Brookhaven

- RHIC: Au+Au @ 200 GeV: quark gluon plasma 탐색
polarized p+p: spin physics
- 주요 참여 실험: PHENIX(1995~), STAR (2004~), RHICf
- PHENIX의 endcap RPC를 제작함
- 참여기관
 - 인하대 (권민정)
 - 연세대 (강주환, 권영일)
 - 세종대 (김용선, 오새한슬)
 - 전북대 (김은주)
 - 성균관대 (채종서)
 - 이화여대 (한인식 前)
 - 고려대 (홍병식)
 - 서울대 (K. Tanida 前)
 - 부산대 (유인권, 임상훈)



sPHENIX

- The upgrade of the PHENIX: enhanced capability to capture snapshots of 15 kHz collisions for QGP studies
- EIC 가동 전의 마지막 RHIC 실험: 2023년 테스트 완료하고, 2024년 physics run
- 참여대학: 부산대 (임상훈), 연세대 (권영일), 고려대 (홍병식), 세종대 (김용선), 한양대 (김용균)
 - 실리콘 검출기인 INTT와 MVTX 개발에 참여

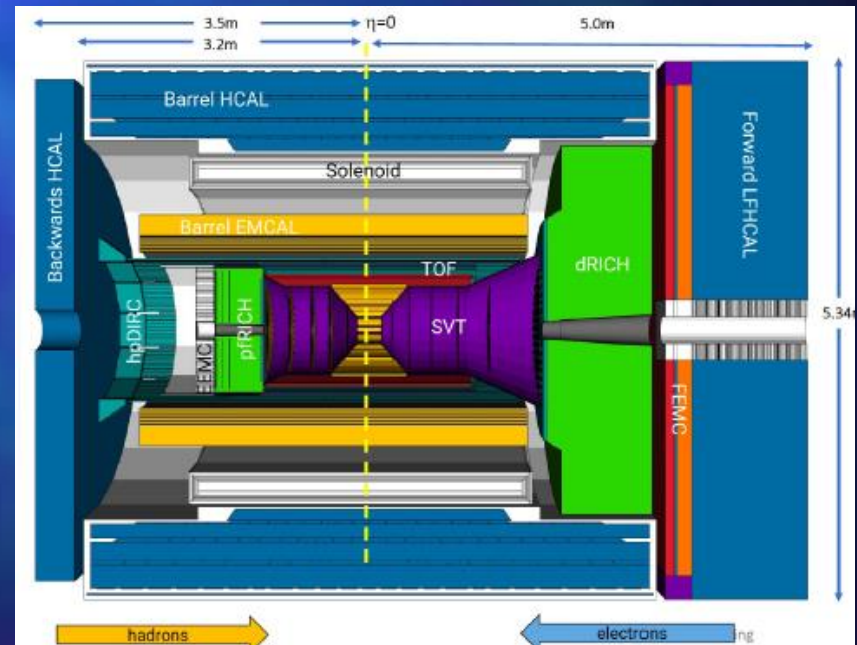
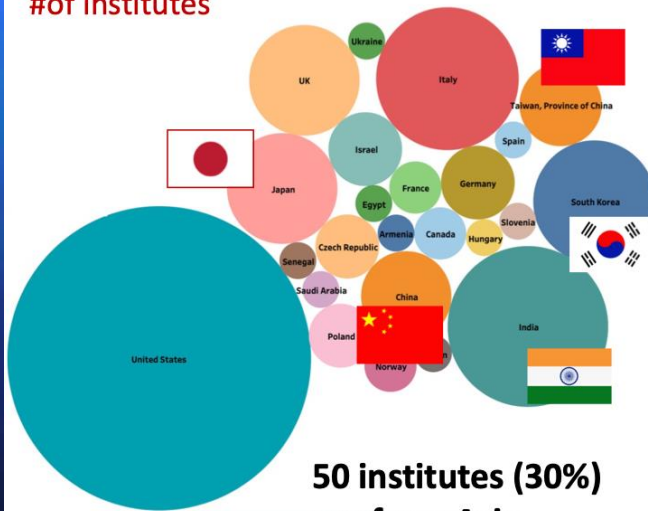


Electron Ion Collider (EIC)

- Polarized e+P & e+A collider
 - Construction & Installation by 2029
 - Commissioning by 2032, and data taking from 2034

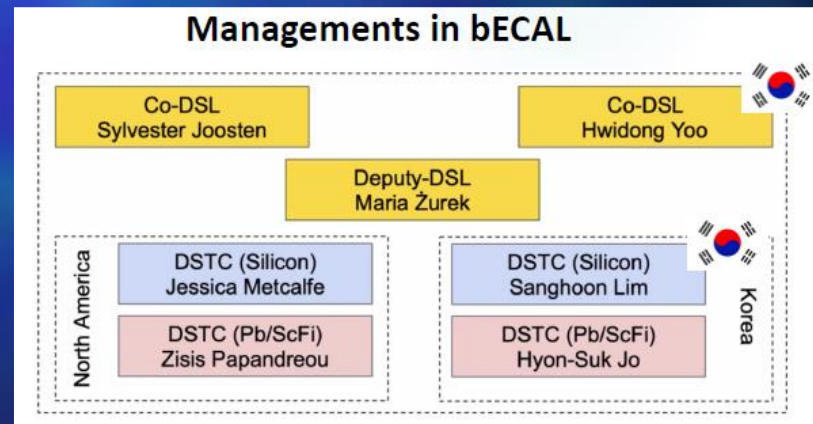
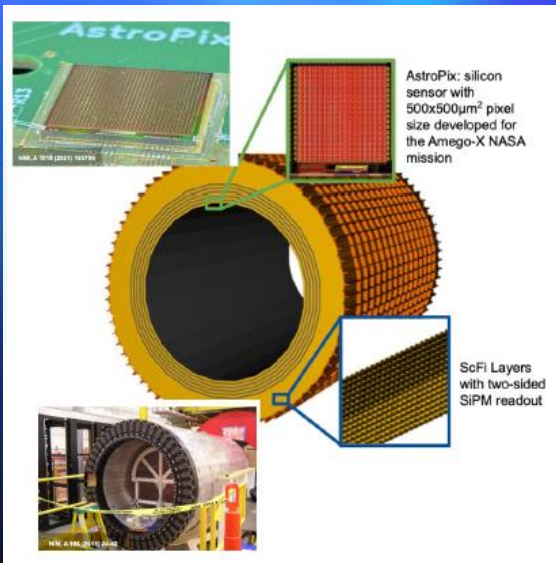
▶ ePIC experiment is the 1st international collaboration at the EIC

#of institutes



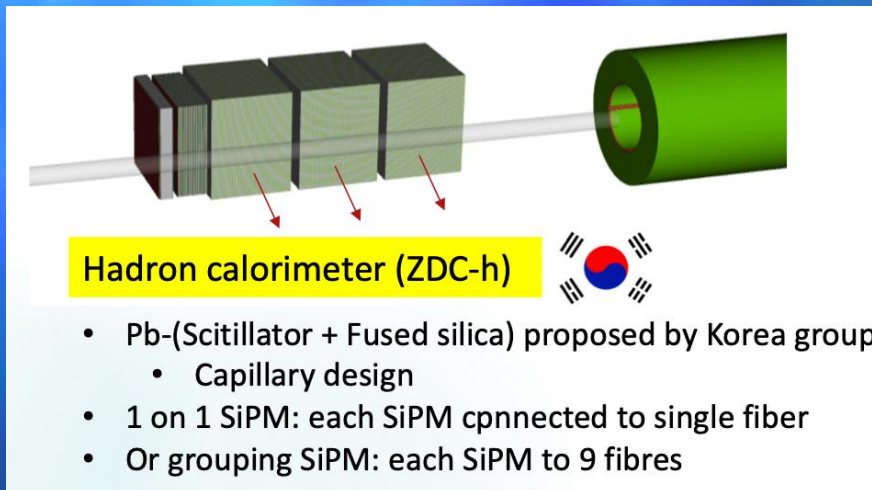
Barrel Calorimeter (bECAL)

- Silicon detector와 Calorimeter를 결합한 Hybrid detector
- 한국이 절반을 (\$14M) 개발하는 것을 목표로 하며 Argonne Lab과 공동연구
- 참여: 연세대 (유휘동), 경북대, 시립대, 부산대, 고려대, 성균관대, 한양대, 강릉원주대



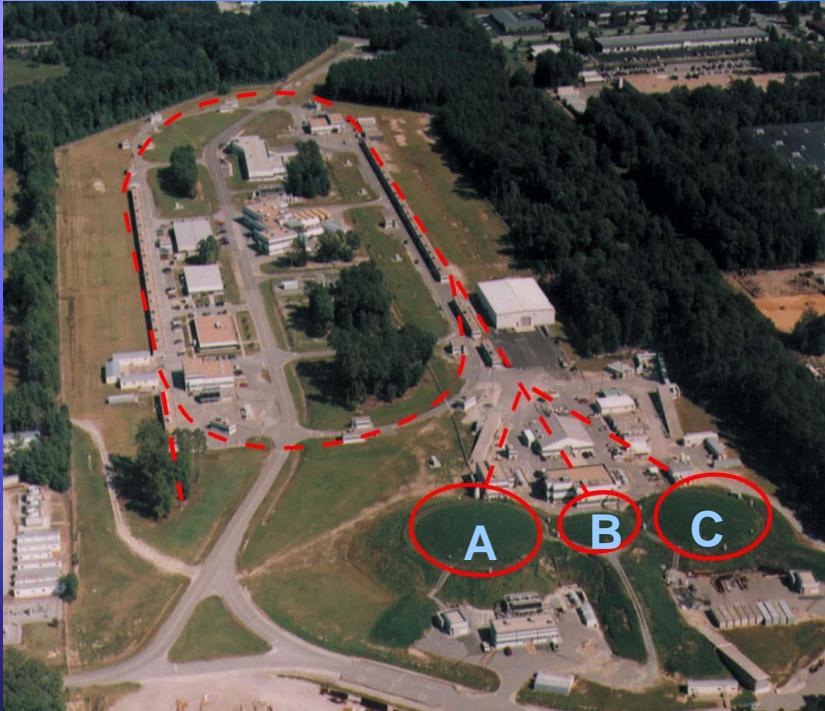
Zero Degree Calorimeter (ZDC)

- ZDC의 hadronic sector 개발을 한국이 주도하는 것을 목표로 미국 BNL, 일본 RIKEN 과의 공동연구 진행 (radiation hardness)
- 참여: 세종대, 고려대



- 추가로, ALICE의 IT3기술을 이용하여 Endcap Silicon Disk 제작을 제안 (연세대: 권영일)

Activities at Jefferson Lab



- CEBAF with 6 GeV e beam
 - Nuclear/spin structure
- Upgrade to 12 GeV e beam
 - Develop a unified description of hadron structure

- Three experimental Halls
 - Hall-A: 2 High Resolution Spectrometer (HRS)
 - Hall-B: Large Acceptance Spectrometer (CLAS)
 - Hall-C: High Momentum Spectrometer (HMS) and Short Orbit Spectrometer (SOS)

한국의 JLab 참여상황

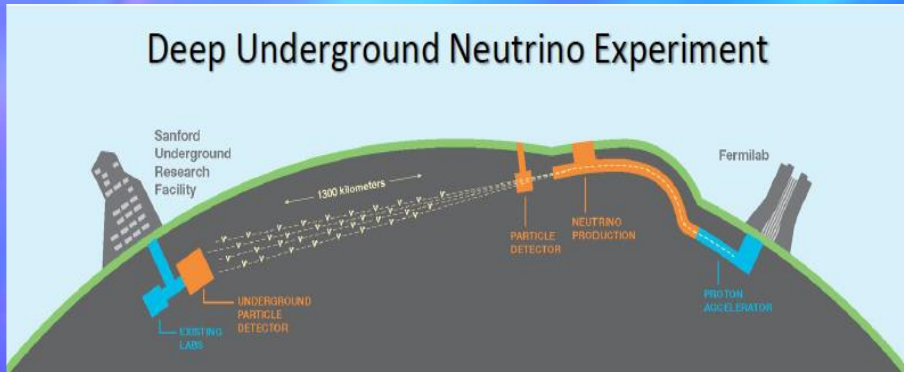
➤ 실험

- 서울대학교 (최선호)
 - Spin structure of the nucleons
 - Polarized neutron (^3He) target: Hall-A
 - Polarized proton target: Hall-B & C
- 경북대학교 (김우영, 조현석)
 - Nucleon and nuclei structure with the CLAS12 detector: Hall-B
 - Spin structure of the nucleons: Hall-A & C

➤ 이론

- 경북대학교 (오용석, 최호명)
- 인하대학교 (김현철)
 - Structure of exotic hadrons

Deep Underground Neutrino Exp. (DUNE)



Fermilab and CAU: 공동연구센터 설립 (2018)

- ν beam (1~20 GeV)
 - CPV & mass hierarchy
 - BSM physics
- Low energy (~100 MeV)
 - Solar ν , supernova bursts
 - BSM sterile ν , light DM

Moses Chung (UNIST) 2019 Accelerator and Neutrino interphase	Kim Siyeon (CAU) 2016 Neutrino interaction, Sim/Rec, Oscillation Analysis
Mehedi Masud (CAU) BSM Search	Seodong Shin (JBNU), 2019 Kihyeon Cho (KISTI) BSM, DM Search

- Contributions to protoDune, 3-D Scintillation tracker for ND, neutron studies

한미 국제공동 연구

➤ Fermi National Lab

- 1990s: E687/ FOCUS (Fermilab support)
- 2000s: D0, CDF (SRC @ KHCL + 개인과제)
- 2010s~now:
 - ✓ DUNE (개인 + what* ?)
 - ✓ IBS CUP (Korean project by IBS)

➤ Brookhaven National Lab.

- 1990s: PHENIX (개인)
- 2000s~now: PHENIX, STAR (개인)
- 2020s~now: EIC ePIC (개인 + what* ?)

- **What*** : 한미 국제협력 사업 (~한선사업)
Global Research Int. fund?

Yes, Korean can lead HEP

It is time to support KSHEP

Fearless Koreans at Fermilab



Yes, Korean can lead HEP

It is time to support KSHEP





➤ *Prof. Kang's Interview by Fermilab*

*“Many good physicists have been produced,
individuals are being recognized”*

*“It is time for country to be recognized:
National Center for High Energy Physics”
envisioned by Prof. Kang: Symmetry Vol 3 2006*