Development of Geant4 for Medical and Accelerator physics

Kihyeon Cho

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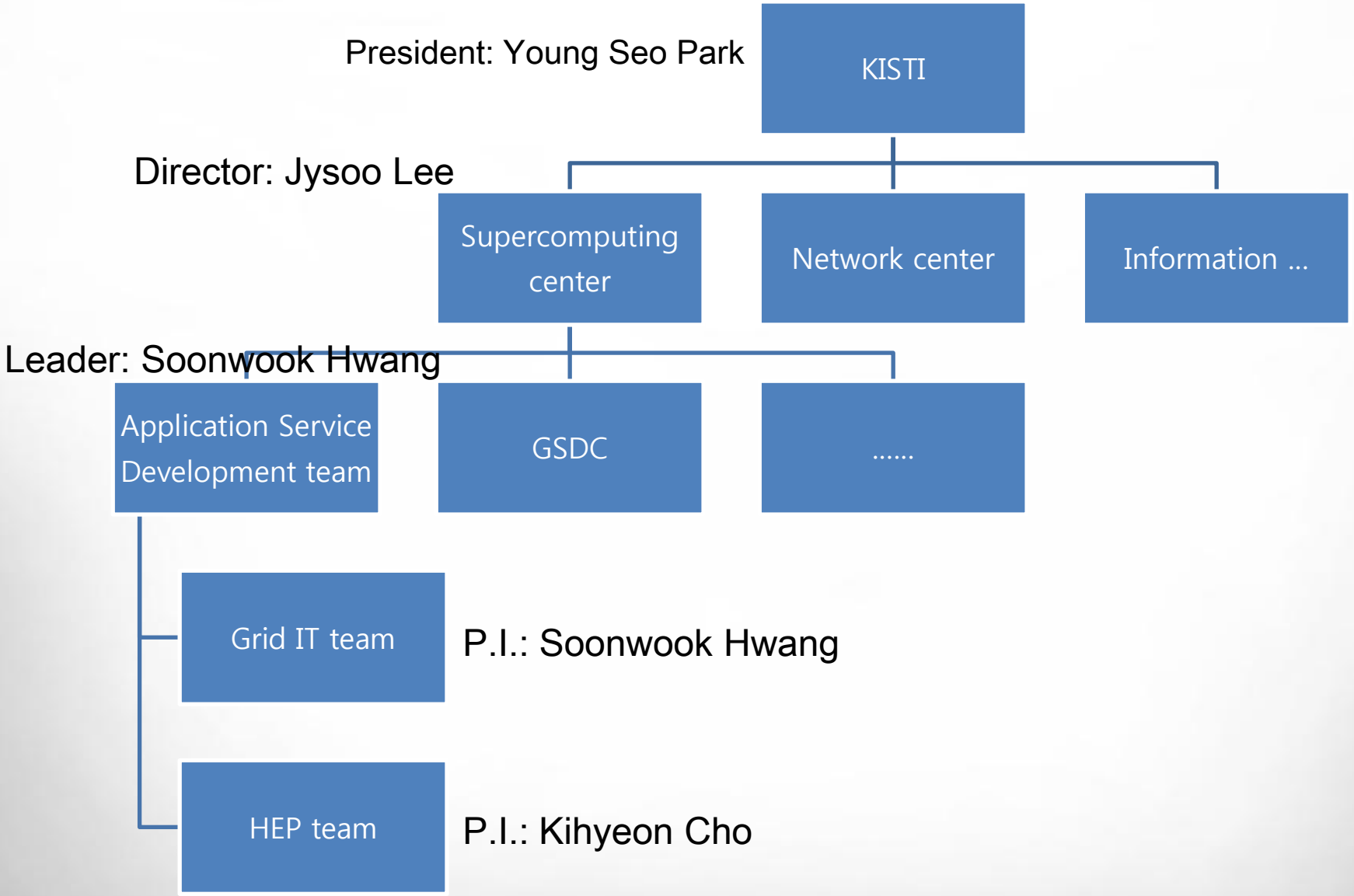
  - KISTI-Fermilab Collaboration
  - Discussions

Organization of KISTI



한국과학기술정보연구원 KiSTi

History of KISTI Supercomputers

[KISTI-1]
Cray 2S

2 GFlops

[KISTI-2S]
Cray T3E

115 GFlops

[KISTI-3]
NEC SX-5/6

320 GFlops

[KISTI-4]
SUN Blade 6048

324 TFlops

1988 2GF
1993 16GF
1997 131GF
2001
2002 5.2 TF
2003
2008
2009 360 TF
2011

[KISTI-2]
Cray C90

16 GFlops

[KISTI-3]
IBM p690

4.4 TFlops

[KISTI-4]
IBM p595

36 TFlops

Supercomputer@KISTI

Hardware Specification : Gaia

- Cluster of SMPs
- Memory intensive Computing System for Massive Parallel Jobs
- Ranked at 393th in top500 in Nov. 2009

	Gaia(IBM)	
	Phase 1	Phase 2
Manufacture	IBM p595	IBM p595
Architecture	SMP	
Process model	POWER5+	POWER6
# of Nodes	10 nodes	24 nodes
# of CPU cores	640 (64 per node)	1,536 (64 per node)
Rpeak (Tflops)	5.9TFlops	30.7TFlops
	36.6TFlops	
Total Memory	2.6TB	9.2TB
Disk Storage	63TB	273TB
Interconnection Network	HPS	IB 4X DDR

Hardware Specification : Tachyon

- Cluster system
- Ranked at 15th in top500 in Nov. 2009

[SUN Blade 6048]

	Tachyon(SUN)	
	Phase 1	Phase 2
Manufacture	SUN Blade 6048	
Architecture	cluster	
Process model	AMD(Barcelona)	Intel (Nehalem)
# of Nodes	188 nodes	3,200 nodes
# of CPU cores	3,008 (16 per node)	25,600 (8 per node)
Rpeak (Tflops)	24	300
	324	
Total Memory	6TB	76TB
Disk Storage	207TB	1.2PB
Tape Storage	422TB	2PB
Interconnection Network	IB 4X DDR	IB 4X QDR

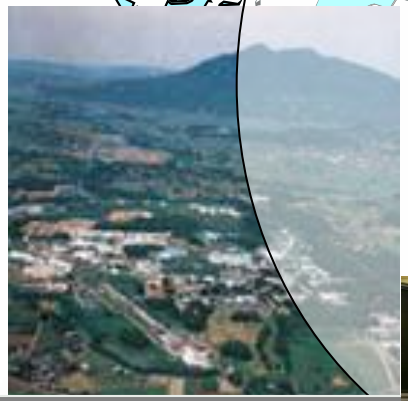
CDF/Geant4
@FNAL, USA

IN2P3@France

Geant4@UCSF, USA

KISTI

FKPPL



Belle*/Belle II*
@ KEK, Japan

* Official Collaborations

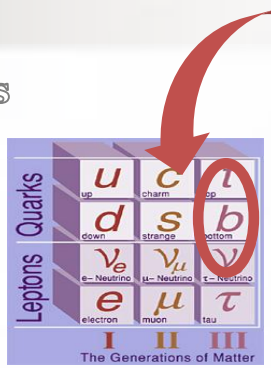
Contents

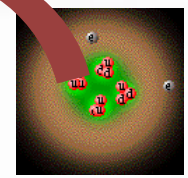
To study B physics both in experiments (Belle & CDF) and theories

High Energy Physics

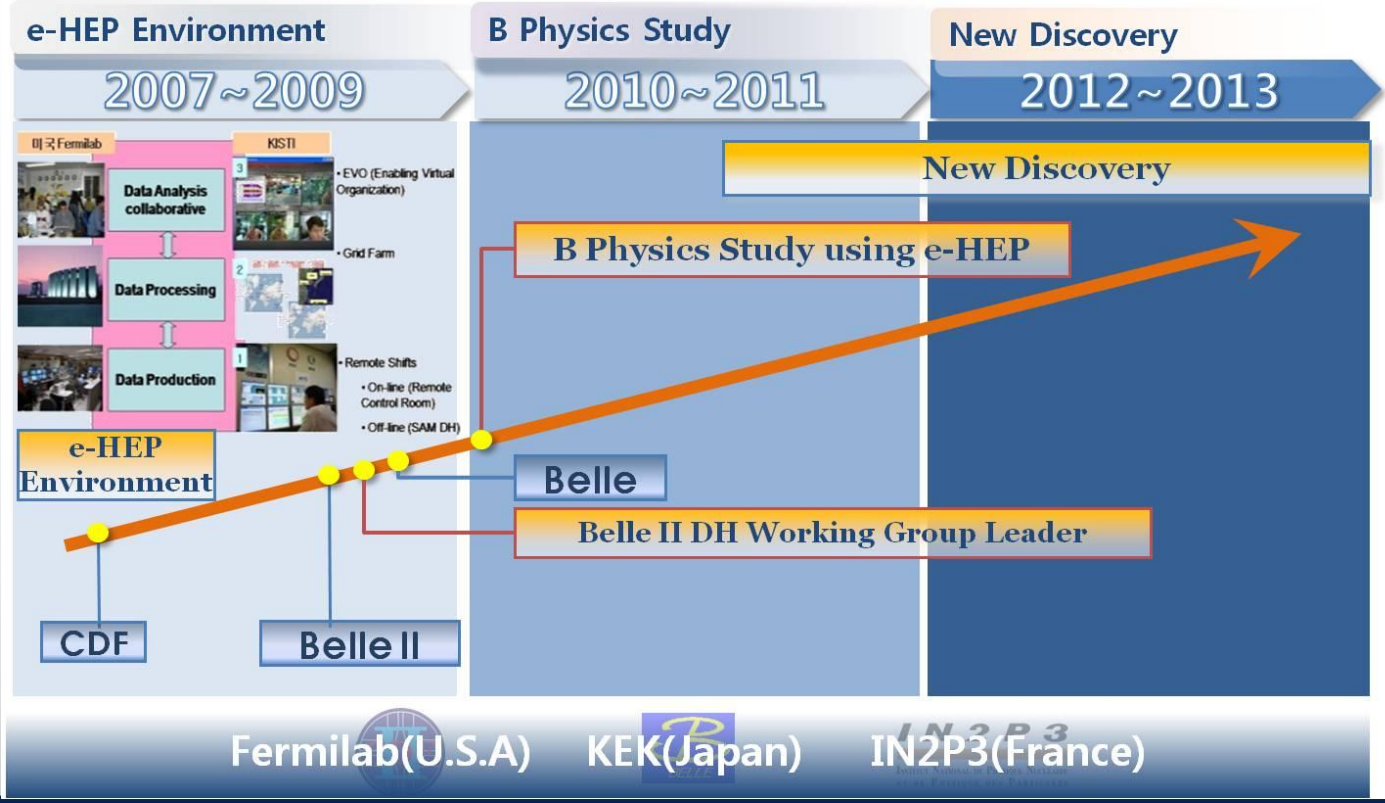
To probe the Standard Model and search for New Physics

⇒ New Discovery





The Standard Model



e-Science for High Energy Physcis

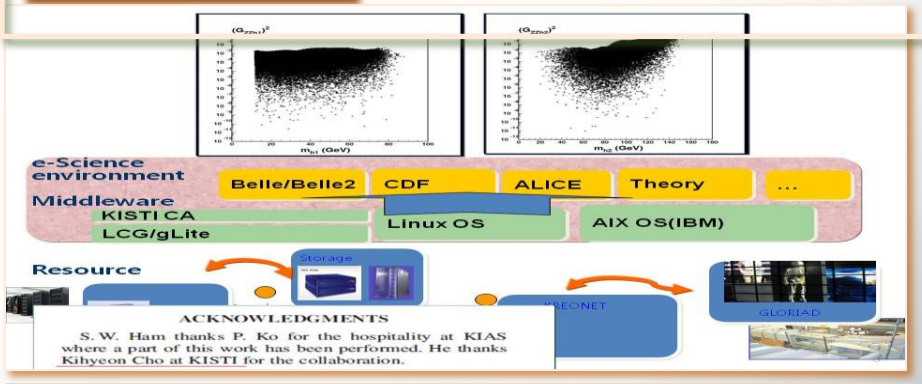
To study high energy physics anytime anywhere even if we are not on-site (accelerator laboratory)

1. Data production
   - CDF Remote Control Room @KISTI

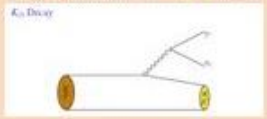
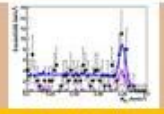
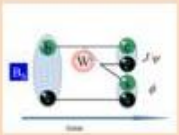
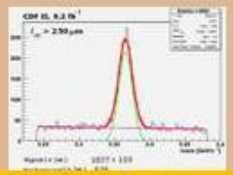
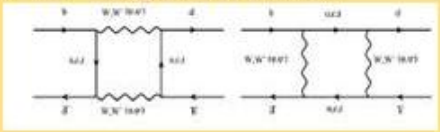
2. Data processing
   - Pacific CAF(CDF Analysis Farm)
   ⇒ North America CAF @KISTI

3. Data Analysis Collaboration
   - EVO servers @KISTI

4. Belle II Data Handling System
   - Working Group Chair (K. Cho)



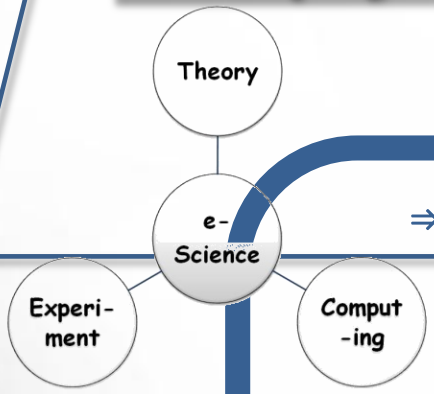
Ex) To study Higgs model using cyberinfrastructure @KISTI

Physics	Experiments	Theories
Kaon Semi−leptonic Form factor 	Belle	LGT using Staggered Fermion T. Bae, Work in progress
Rare B^0 decays	Belle  J.H.Kim, et. al. Belle (2011)	Left−Right models S.-h Nam, Work in progress
Mixing and CPV on Bs → J/ψ Φ 	CDF  Y.J.Kim, K.Cho et.al. CDF (2011)	Left−Right models  S.-h Nam. et.al, PRD 66, 055008 (2002)
Top Forward−backward asymmetry	CDF	Model independent Analysis S.-h Nam. et.al, PLB 691, 238 (2010)
CP violating dimuon charge asymmetry due to B mixing	D0	Left−Right models S.-h Nam, Work in progress

⇒ Feed-back between experiments (Belle & CDF) and theories inside KISTI

Output

B physics using the concepts of e-Science



- To study high energy physics anytime and anywhere
- Fusion research of experiment-computing–theory

⇒ We are applying both concepts to high energy physics. It is a great success!

Publication

B physics

Computer Physics Communications 182 (2011) 1756–1759

Contents lists available at ScienceDirect

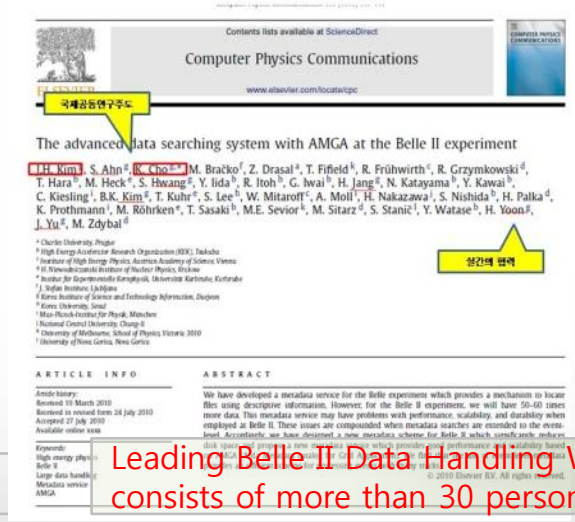
Computer Physics Communications

www.elsevier.com/locate/cpc

Collider physics based on e-Science paradigm of experiment-computing-theory

Kihyeon Cho*, Junghyun Kim, Soo-hyeon Nam

Collider physics using e-Science paradigm of experiment-computing-theory


Contents lists available at ScienceDirect

Computer Physics Communications

www.elsevier.com/locate/cpc

국제공동연구주도

The advanced data searching system with AMGA at the Belle II experiment

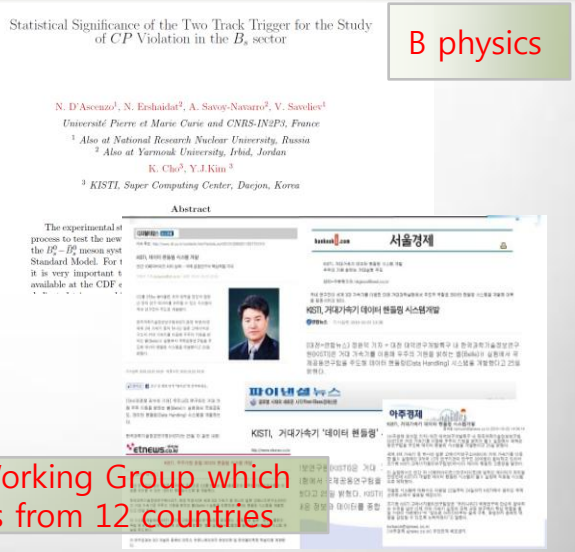
J.H. Kim, S. Ahn, K. Cho, M. Bračko, Z. Drasal, T. Fifield, R. Frühwirth, R. Grzymkowski, T. Hara, M. Heck, S. Hwang, Y. Iida, R. Itoh, G. Iwai, H. Jang, N. Katayama, Y. Kawai, C. Kiesling, B.K. Kim, T. Kuhr, S. Lee, W. Mitaroff, A. Moll, H. Nakazawa, S. Nishida, H. Palka, K. Prothmann, M. Röhrken, T. Sasaki, M.E. Sevior, M. Sitarz, S. Stanič, Y. Watase, H. Yoon, J. Yu, M. Zdybal

설간의 협력

ARTICLE INFO

ABSTRACT

Leading Belle II Data Handling Working Group which consists of more than 30 persons from 12 countries


Statistical Significance of the Two Track Trigger for the Study of CP Violation in the B_s sector

N. D'Ascenzo, N. Ershaidat, A. Savoy-Navarro, V. Savelieva

Université Pierre et Marie Curie and CNRS-IN2P3, France

Also at National Research Nuclear University, Russia

Also at Yarmouk University, Irbid, Jordan

K. Cho, Y.J. Kim

KISTI, Super Computing Center, Daejon, Korea

Abstract

서울경제

KISTI, 거대가속기 '데이터 핸들링' 시스템개발

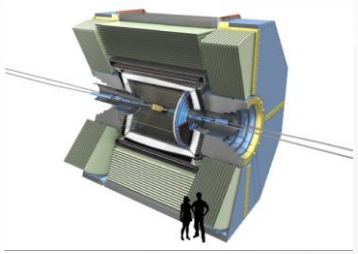
파이낸셜뉴스

KISTI, 거대가속기 '데이터 핸들링'

Development of Geant4 for Medical and Accelerator physics

Project Outline

- **Title: Development of Geant4 for medical physics and High Energy physics**
- **PI: Kihyeon Cho and Soonwook Hwang**
- **Sponsor: Creative project by KISTI**
- **Budget: around half million dollar**
- **Period: Jan. 1, 2012~ Dec. 31, 2012**
  - ❖ Maybe renew
- **Goal:**
  - ❖ Geant4 multi-processing R&D
  - ❖ Porting on Suprecomputing
  - ❖ Profiling and Large-scale test, evaluation and improvement
  - ❖ Simulation for HEP and Medical physics using Geant4
  - ❖ Etc.



Manpower @ KISTI

한국과학기술정보연구원 KiSTi

Name	e.mail	Major (Ph.D.)	Role
Kihyeon Cho	cho@kisti.re.kr	HEP experiment	HEP Application
Soonwook Hwang	hwang@kisti.re.kr	Grid IT	Medical Application
Youngjin Kim	yjkim@kisti.re.kr	HEP experiment	HEP Application
Soo-hyeon Nam	shnam@kisti.re.kr	Phenomenology	HEP Application
Taegil Bae	esrevinu@kisti.re.kr	LQT	Geant4 porting (ParGeant4)
Sangsu Ryu	sangsuryu@kisti.re.kr	HEP experiment	Geant4 porting (Geant4-MT)

HEP Collaboration (outside of KISTI)

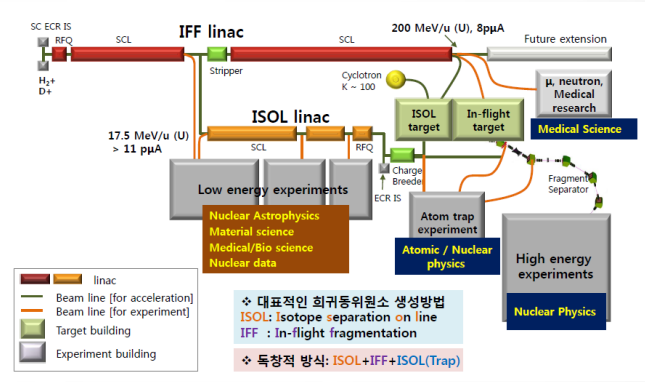
- **Contact person: Kihyeon Cho**
- **Man Power @ Fermilab**
  - ❖ Framework Team
    - Jim Kowalsoki (Enabling Group leader), Marc Paterno
  - ❖ Geant4 re-engineering
    - Pillip Canal, Soon Jun
  - ❖ CERN/SFT riaison and planning
    - Daniel Elvira (Detector Simulation group leader)
  - …….
- **Man Power @ CMU**
  - ❖ Dongwook Jang
- **Man Power @ Yonsei U**
  - ❖ Kyungho Kim
  - ❖ Youngjoon Kwon

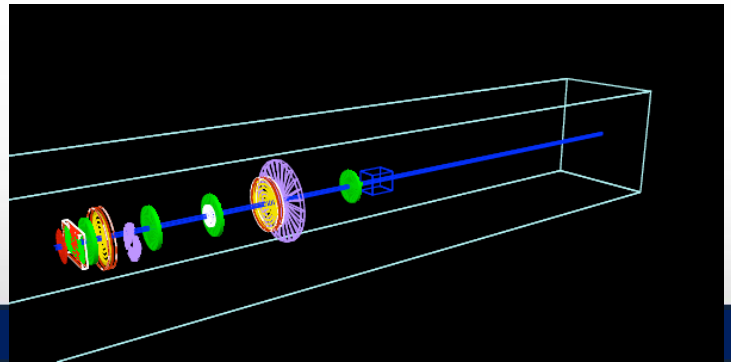
Medical Physics Collaboration (outside of KISTI)

- **Contact person: Dr. Soonwook Hwang**
- **Man Power @UCSF, USA**
  - Jungwook Shin (UCSF)
  - Bruce (UCSF)
  - Joseph (SLAC)
- **Man Power @ NCC, Korea**
  - Se Byeong Lee
  - Jaeik Shin
  - ….

Contents

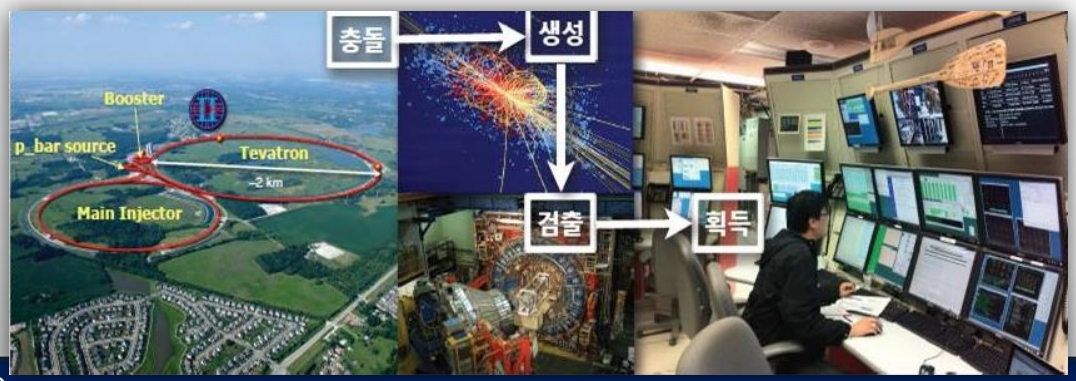
- **Geant4 R&D**
  - ❖ Supercomputing porting
  - ❖ Geant4 parallel processing
  - ❖ Geant4 optimization R & D
- **Geant4 applications for HEP**
  - ❖ KoRIA (Korea Rare Isotope Accelerator) and astro-nuclear physics
  - ❖ Detector R&D
- **Geant4 applications for Medical Physics**
  - ❖ Geant4 application for proton accelerator
  - ❖ Medical physics using Geant4
  - ❖ Geant4 community building

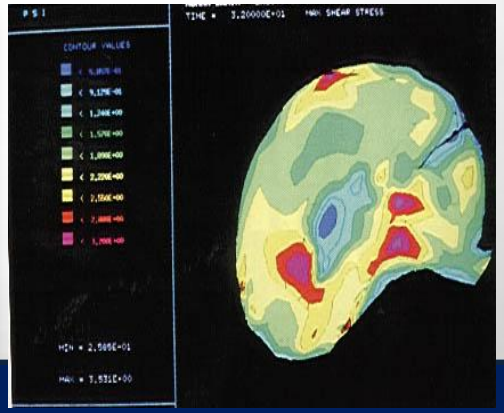


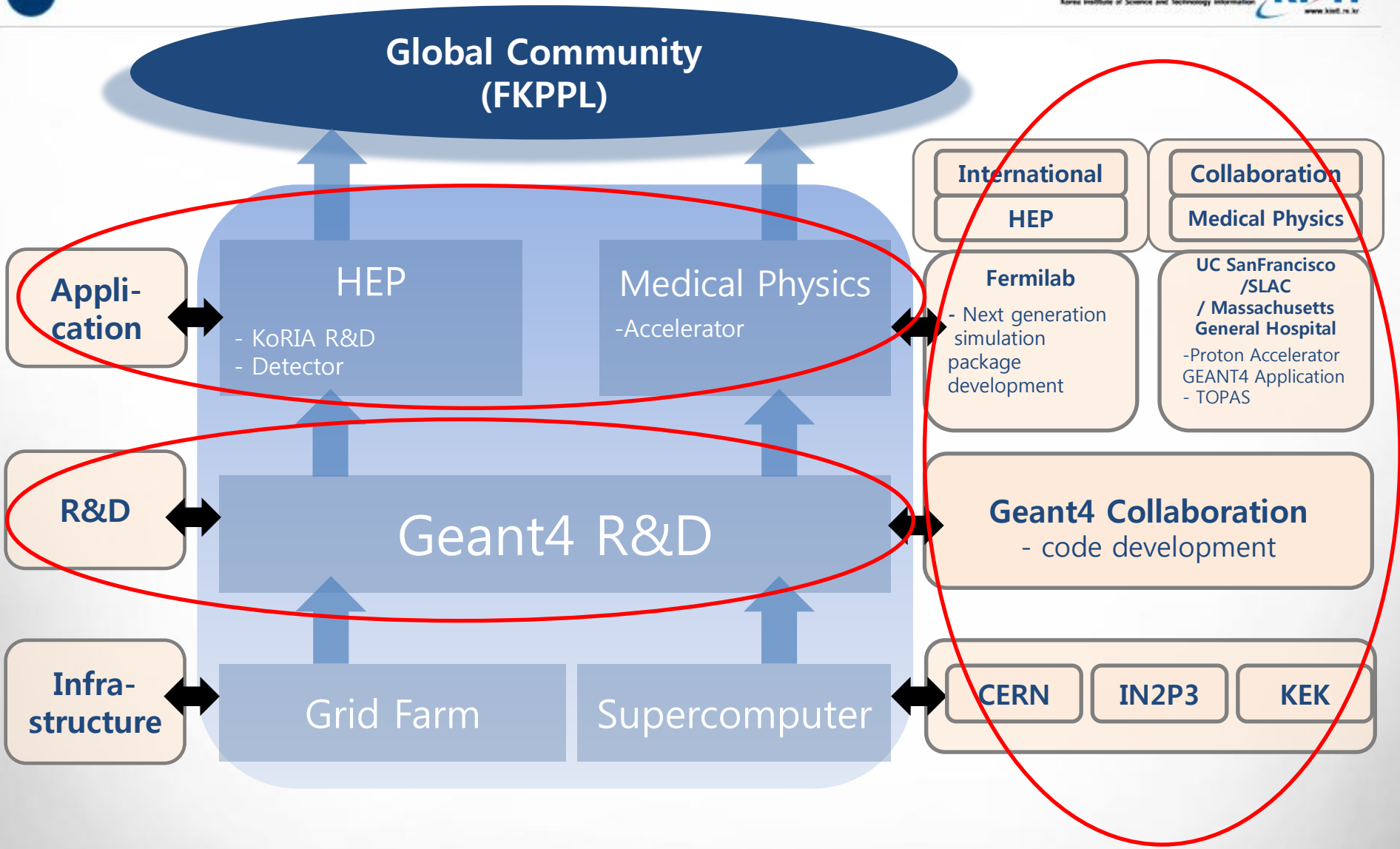


High Energy Physics vs. Medical Physics

	High Energy Physics	Medical Physics
Input data	N/A	50MB (ex, CT data)
Farm	Grid Farm/ Supercomputer	Supercomputer
Porting	Grid Farm	Supercomputer
Application Package	HEP Application	TOPAS, GATE
Community	HEP Application (Belle II, KoRIA)	Accelerator Center
International Collaboration	Fermilab, USA	UCSF/SLAC/MGH, USA
Contents of international Collaboration	Detector simulation package using Multi-thread/parallel computing	Proton Accelerator using Geant4 application






Global Community
(FKPPL)
Appli-
cation
R&D
Infra-
structure
HEP
- KoRIA R&D
- Detector
Medical Physics
-Accelerator
Geant4 R&D
Grid Farm
Supercomputer
International
HEP
Collaboration
Medical Physics
Fermilab
- Next generation simulation package development
UC SanFrancisco /SLAC / Massachusetts General Hospital
-Proton Accelerator GEANT4 Application
- TOPAS
Geant4 Collaboration
- code development
CERN
IN2P3
KEK

Geant4 R&D

❖ Supercomputing Porting

- ➢ SUN Cluster: Tachyon (Sangsu Ryu) => Geant4-MT
- ➢ SUN Cluster: Tachyon (Taegil Bae) => ST(Geant4), MPI(ParGeant4)

1. Single-thread performance measurement and analysis
2. Studies of vectorization or parallelism of Geant4

❖ Parallel Computing Using multi processing (core)

–〉 Fermilab

- ➢ Understanding and Improvement of Single thread
- ➢ Geant4 profiling protocol
- ➢ Studies of vectorization or parallelism of Geant4

Contents	KISTI (SUN Cluster) -Sangsu Ryu	KISTI(SUN Cluster - Taegil Bae	Fermilab Group (Stand-alone cluster)	UCSF Group (Medical)
Geant4 single-thread porting	User support Mandatory	User support Mandatory	Mandatory	TOPAS porting (KISTI) and supporting Korean group
Single-thread performance measurement	Needed	Needed	Needed	Needed
Parallel processing porting	Geant4-MT	Geant4-ST ParGeant4	Needed	Medical physics application using Geant4-MT and Par Geant4
Studies of vectorization or parallelism of Geant4	If possible	If possible	Needed	

HEP application

- Contact person: Kihyeon Cho
- Theory – MadGraph etc.: Soo-hyeon Nam
- KoRIA & Belle II simulatoin: Youngjin Kim

Medical Application

- Contact person: Soonwook Hwang
- Medical physics Group -〉 NCC

Geant4 Home page

- https://hep.kisti.re.kr/geant4

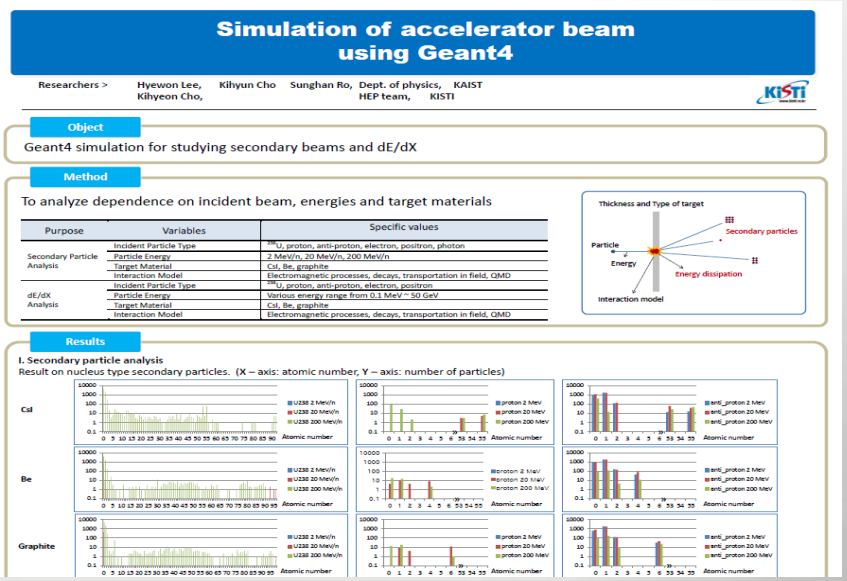
Schedule

- **January**
  - ❖ Kick-off meeting
- **Jan.~Feb.**
  - ❖ Porting on supercomputing
- **Feb.~Sep. International Collaboration**
  - ❖ Fermilab
  - ❖ UCSF
- **March**
  - ❖ Geant4 Workshop
- **October**
  - ❖ Geant4 Tutorial

To join Geant4 Collaboration

Output Quantity

- SCI paper – 2
- International Conference – 1
- Domestic Conferences – 2
- Report Document – 1
- Organizing Conference – 2



Simulation of accelerator beam using Geant4

Researchers > Hyewon Lee, Kihyun Cho Sunghan Ro, Dept. of physics, KAIST
Kihyeon Cho, HEP team, KISTI

Object

Geant4 simulation for studying secondary beams and dE/dX

Method

To analyze dependence on incident beam, energies and target materials

Purpose	Variables	Specific values
Secondary Particle Analysis	Incident Particle Type	^{238}U, proton, anti-proton, electron, positron, photon
	Particle Energy	2 MeV/n, 20 MeV/n, 200 MeV/n
	Target Material	CsI, Be, graphite
	Interaction Model	Electromagnetic processes, decays, transportation in field, QMD
dE/dX Analysis	Incident Particle Type	^{238}U, proton, anti-proton, electron, positron
	Particle Energy	Various energy range from 0.1 MeV ~ 50 GeV
	Target Material	CsI, Be, graphite
	Interaction Model	Electromagnetic processes, decays, transportation in field, QMD

Results

I. Secondary particle analysis

Result on nucleus type secondary particles. (X – axis: atomic number, Y – axis: number of particles)

KISTI-Fermilab Collaboration

	KISTI	Fermilab
Application	KoRIA and Detector R&D	Next generation detector simulation package
R&D	Geant4 R&D	Geant4 Multi-thread or parallel computing optimization
Infrastructure	Supercomputing porting	Performance profiling (Stand-alone cluster)

O Budget for Fermilab Collaboration: 45million won (~40,000$)
- Period: Feb. 1 ~ Sep. 30, 2012
- Item: Stand-alone cluster, travel and so on

O Need a proposal from Fermilab and contract
- Maybe need matching funding such as labor fee
- To send template form and example files

- **Discussion item**
  - physics/computing program that we/you support
  - interest in simulation R&D and high performance computing
  - mission statement and goals in simulation
  - Anything else?
- **Contact person**
  - Fermilab – Soon Jun (?)
  - KISTI – Kihyeon Cho
- **Next Meeting?**
- **Your suggestions are welcome!**

Thanks

KISTI

The Center of 21 Century Knowledge Information !