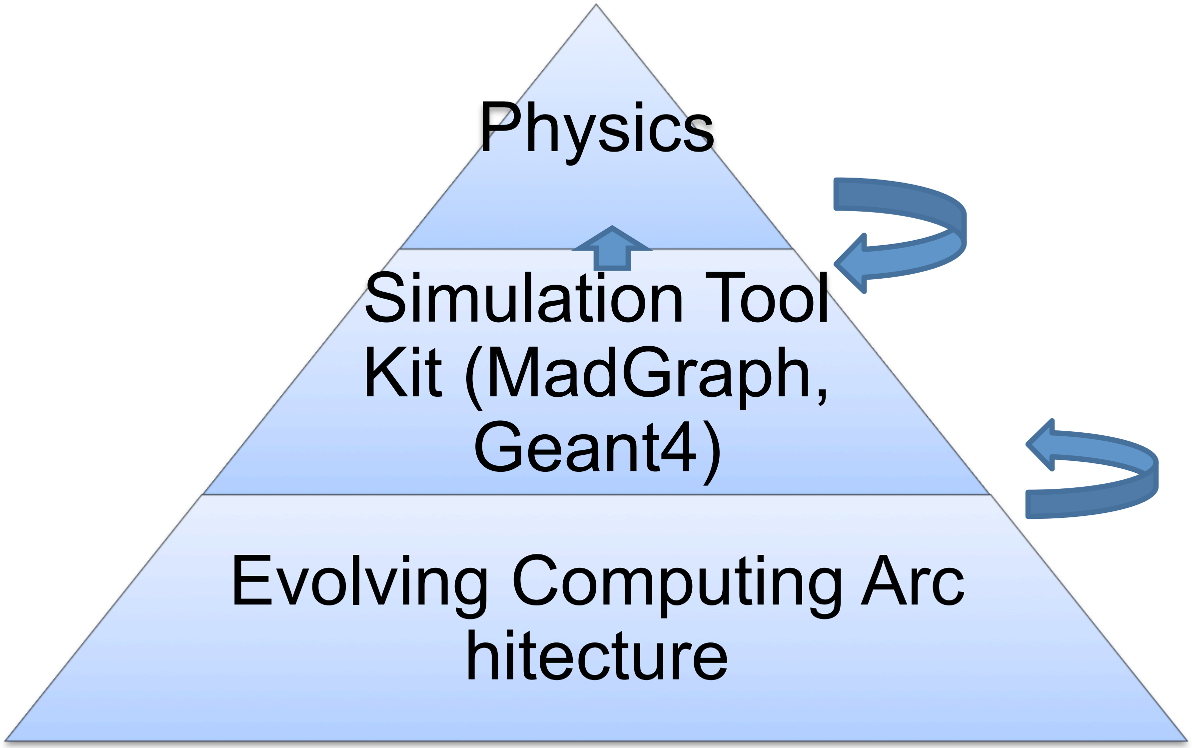
NTSE-2018 (International Conference on Nuclear Theory in the Supercomputing Era)
IBS, Daejeon, Korea
October 29 ~ November 2, 2018

Nuclear Theory in the 5th Supercomputing Era

Kihyeon CHO
(KISTI)

Contents

- KISTI
- Evolving Computing Architecture
- Simulation
- Physics
- Summary



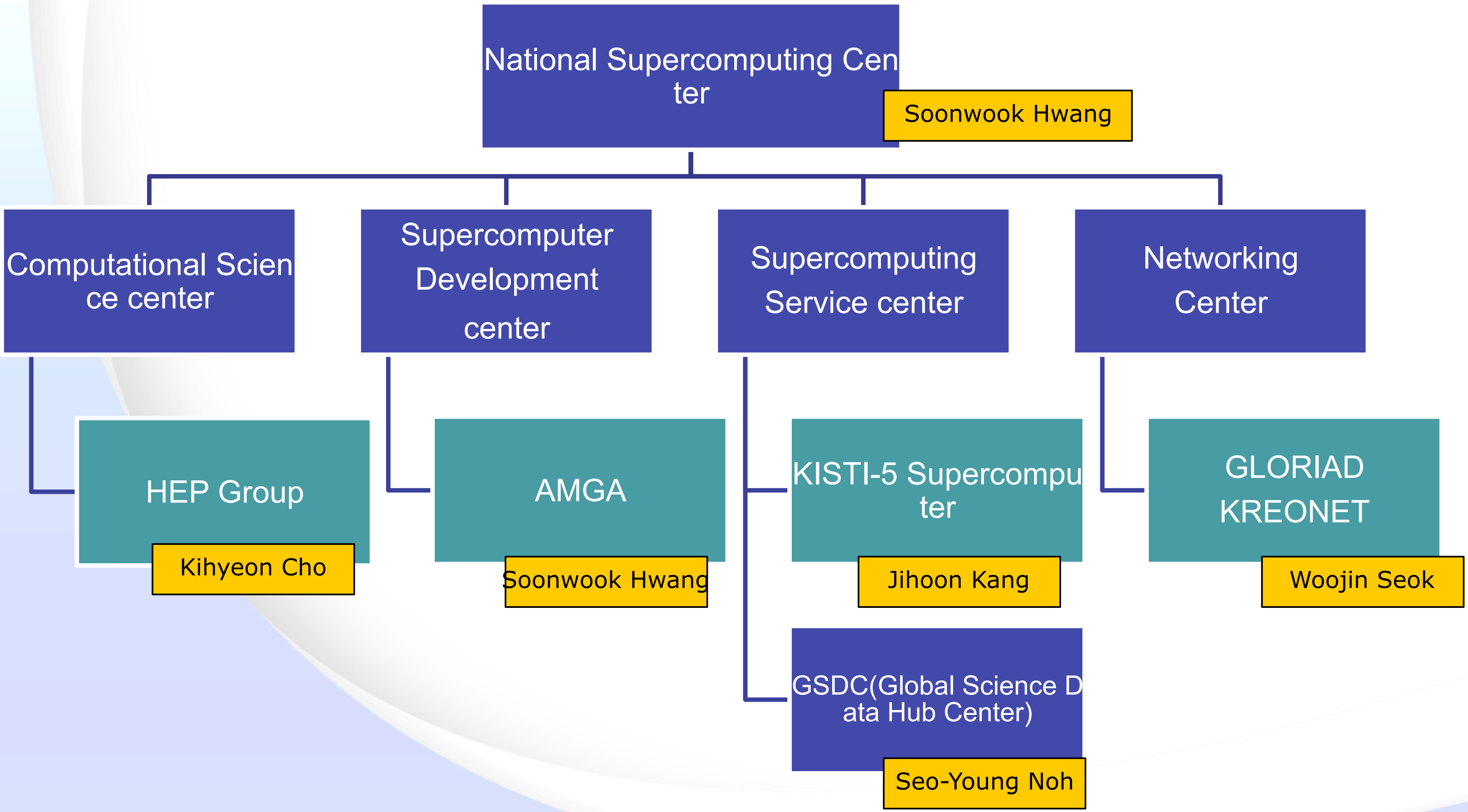
KISTI


국가슈퍼컴퓨팅센터


KiSTi
한국과학기술정보연구원
www.kisti.re.kr
Korea Institute of Science and Technology Information

KISTI Organization

* KISTI has the only national supercomputing center in Korea.



⋆ Describe HEP related departments only♪

Community
(Dark Matter Research Cluster)

KISTI
Supercomputing Ce
nter

Contact person (Kihyeon Cho)

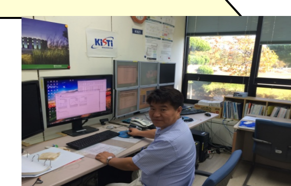
Physics
- HEP Group (Kihyeon Cho)

Software/Middleware
-AMGA, Grid CA(KISTI CA)

Evolving Computing Architecture
-5th Supercomputer (KISTI-5),
-GSDC(ALICE T1, CMS T2, Belle2, LIGO Farm) -
GLORIAD, KREONET



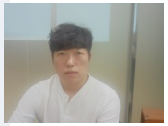




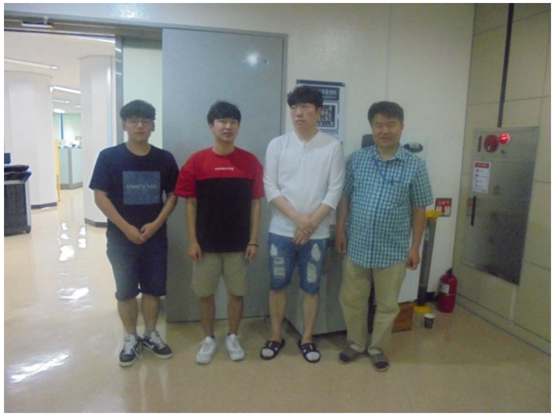
HEP Group @ KISTI

- Who are we?

Name	Ph.D.	Experiences
Prof. Kihyeon Cho	Charm/B @ CLEO ('96, U. of Colorado)	Charm @ FOCUS ('96-06, U. of Tennessee & KNU), B @ CDF ('01- , KNU & KISTI)
Dr. Inseong Yeo	RENO ('17, JNU)	Belle('17- , KISTI)
Dr. Myeong Hwan Mun	Nuclear Theory ('15, KNU)	KAERI('15-18), UNIST('18)



- Looking for M.S. and Ph.D students
- Intern for undergraduate student



Vision @ HEP Group

Technical Paper
J. Astron. Space Sci. 33(1), 63-67 (2016)
http://dx.doi.org/10.5140/JASS.2016.33.1.63

JASS Journal of Astronomy and Space Sciences

e-Science Paradigm for Astroparticle Physics at KISTI

Kihyeon Cho†
Korea Institute of Science and Technology Information, Daejeon 34141, Korea

The Korea Institute of Science and Technology Information (KISTI) has been studying the e-Science paradigm. With its successful application to particle physics, we consider the application of the paradigm to astroparticle physics. The Standard Model of particle physics is still not considered perfect even though the Higgs boson has recently been discovered. Astrophysical evidence shows that dark matter exists in the universe, hinting at new physics beyond the Standard Model. Therefore, there are efforts to search for dark matter candidates using direct detection, indirect detection, and collider detection. There are also efforts to build theoretical models for dark matter. Current astroparticle physics involves big investments in theories and computing along with experiments. The complexity of such an area of research is explained within the framework of the e-Science paradigm. The idea of the e-Science paradigm is to unify experiment, theory, and computing. The purpose is to study astroparticle physics anytime and anywhere. In this paper, an example of the application of the paradigm to astrophysics is presented.

Keywords: e-Science, astroparticle physics, dark matter

1. INTRODUCTION

Current research can be analyzed by big data in the framework of the e-Science paradigm. The e-Science paradigm unifies experiments, theories, and computing simulations that are related to big data (Lin & Yen 2009). Hey explained that a few thousands of years ago, science was described by experiments (Hey 2006). In the last few hundred years, science was described by theories and in the last few decades, science was described by computing simulations (Hey 2006). Today, science is described by big data through the unification of experiments, theories, and computing simulations (Cho et al. 2011).

We introduce the e-Science paradigm in the search for new physics beyond the Standard Model, as shown in Fig. 1. It is not a mere set of experiments, theories, and computing, but an efficient method of unifying researches. In this paper, we show an application of the e-Science paradigm to astroparticle physics.

Dark matter is one of three major principal constituents of the universe. The precision measurements in flavor physics have confirmed the Cabibbo-Kobayashi-Maskawa (CKM) theory (Kobayashi & Maskawa 1973). However, the Standard Model leaves many unanswered questions in particle physics such as the origin of generations and masses, and the mixing and abundance of antimatter. Astrophysical evidence

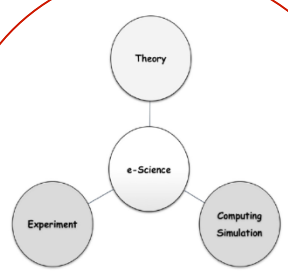


Fig. 1. Paradigm of e-Science in astroparticle physics represented as a unification of experiment, theory, and computing.

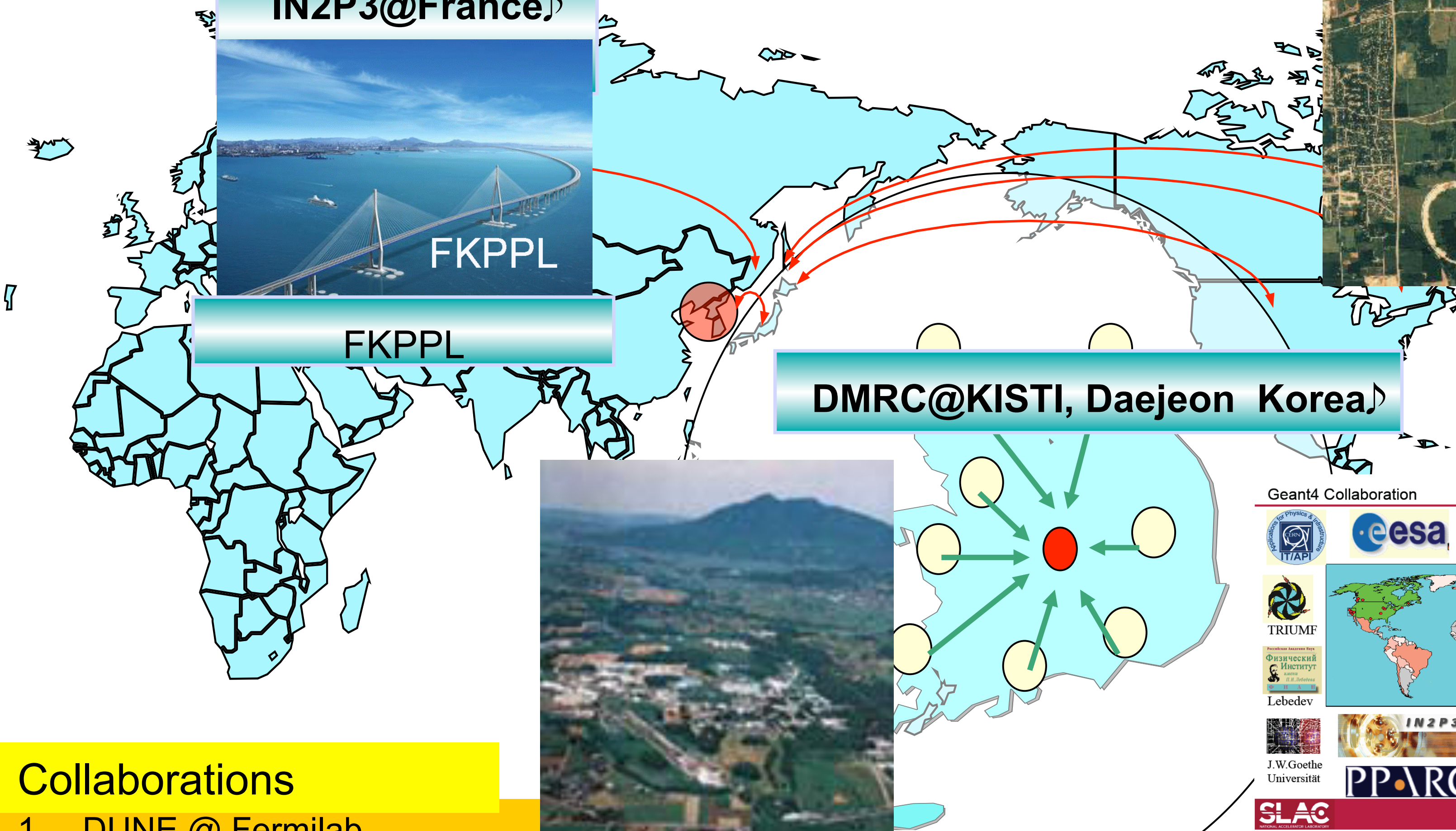
Received Feb 9, 2016 **Revised** Mar 5, 2016 **Accepted** Mar 7, 2016
†**Corresponding Author**
E-mail: cho@kisti.re.kr, ORCID: 0000-0003-1705-7399
Tel: +82-42-869-0722, Fax: +82-42-869-0799

  http://janss.kr pISSN: 2093-5587 eISSN: 2093-1409

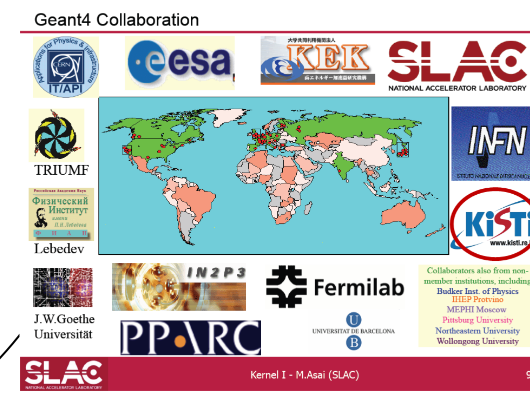
- Theory-Experiment -Simulation

⇒ Computational Science

KISTI HEP Group activities



Belle*/Belle II*
@ KEK, Japan

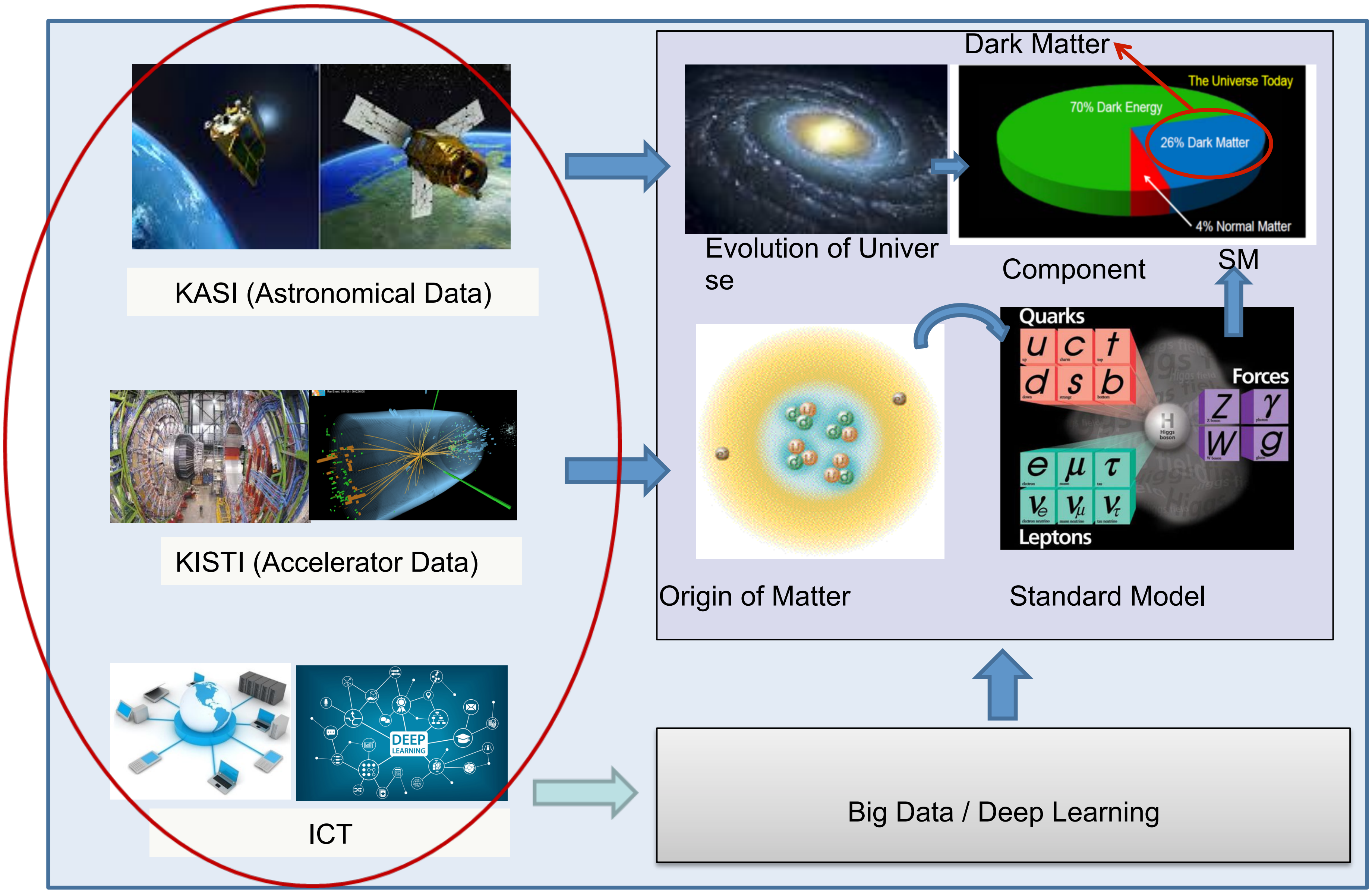


* Official Collaborations

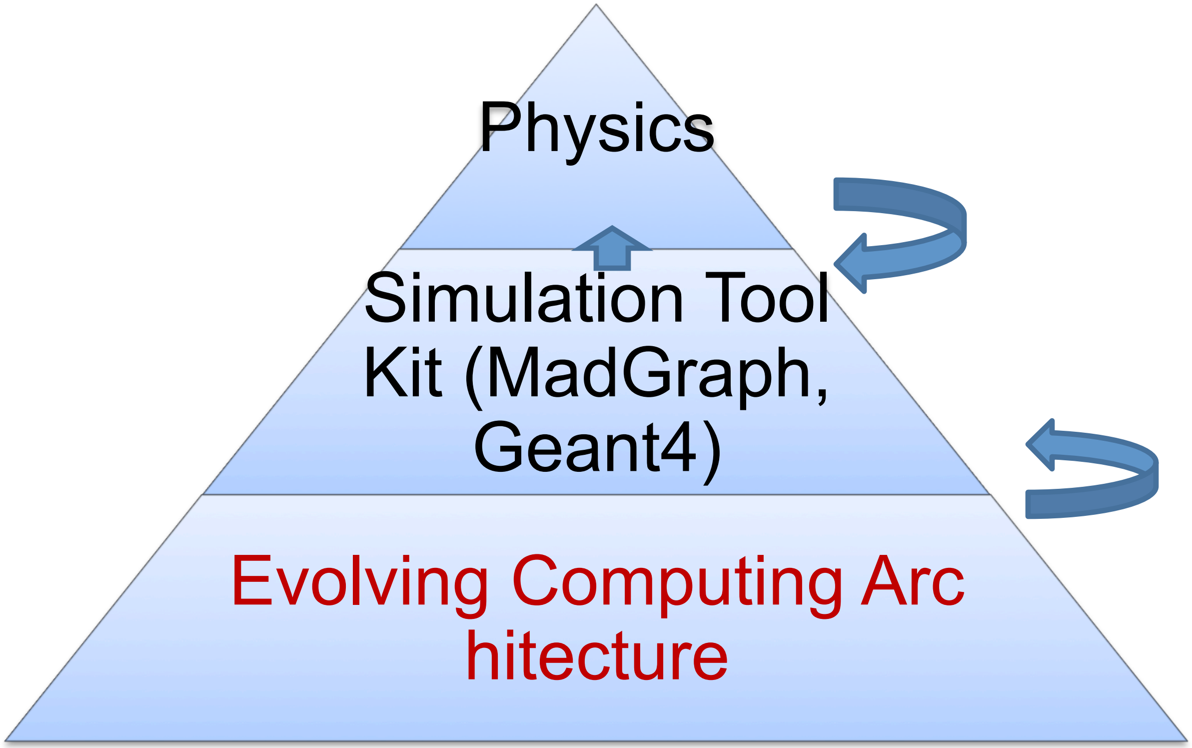
Collaborations

1. DUNE @ Fermilab
2. Belle/Belle II @KEK
3. Geant4 Collaboration
4. FKPPL(France Korea Particle
   ry) Beam Simulation
5. Dark Matter Research Cluster @ KISTI

Dark Matter Research Cluster

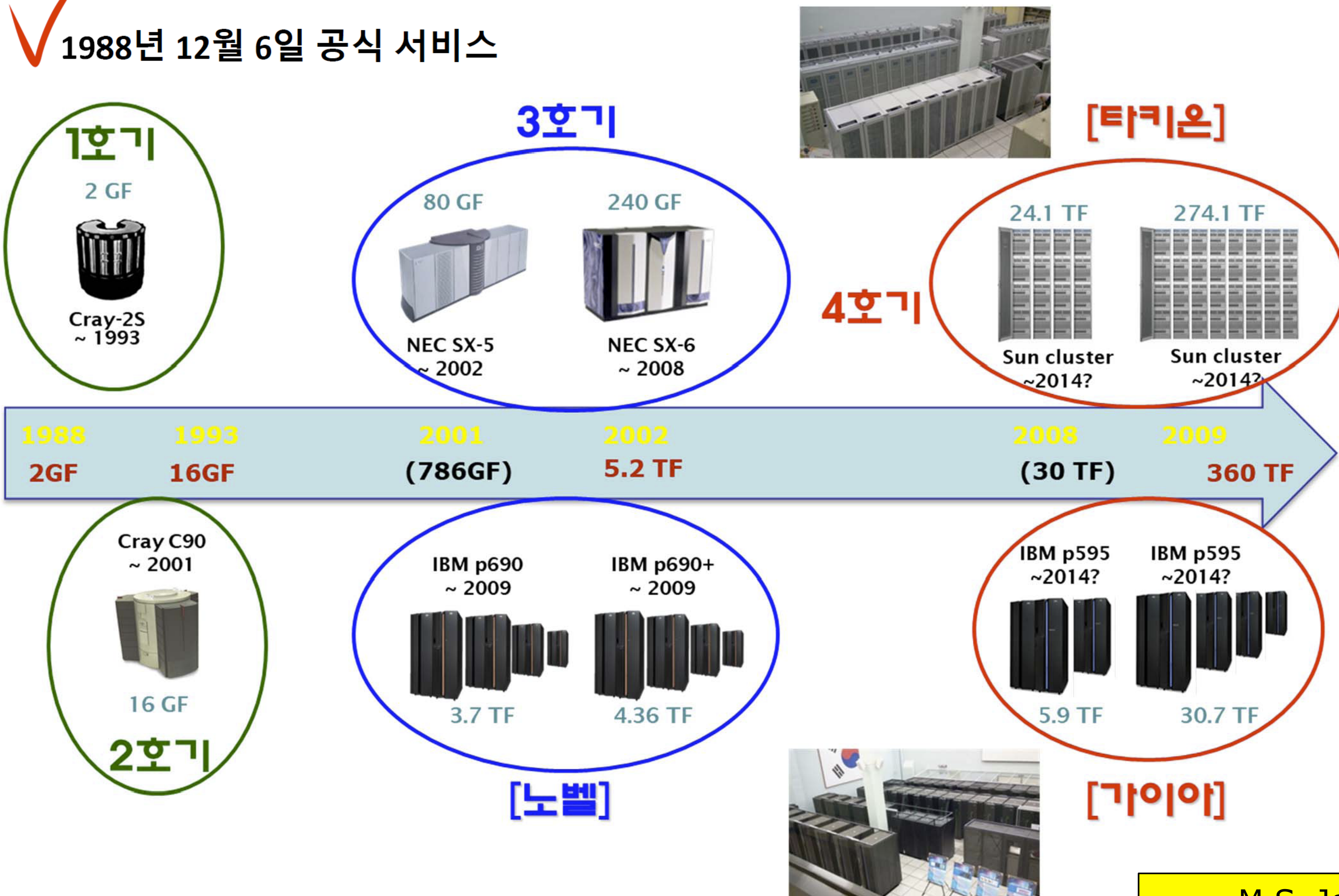


Evolving Computing Architecture



From KISTI-1 to KISTI-4 supercomputer

1988년 12월 6일 공식 서비스



M.S. Joh

KISTI-5 supercomputer (5th supercomputer)

M.S. Joh

KISTI-5 supercomputer building

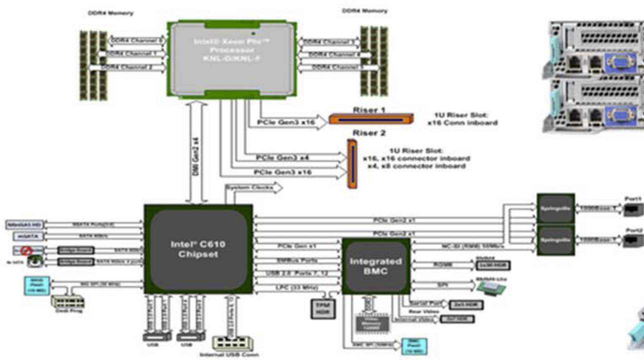
M.S. Joh

KISTI-5 supercomputer

Compute node

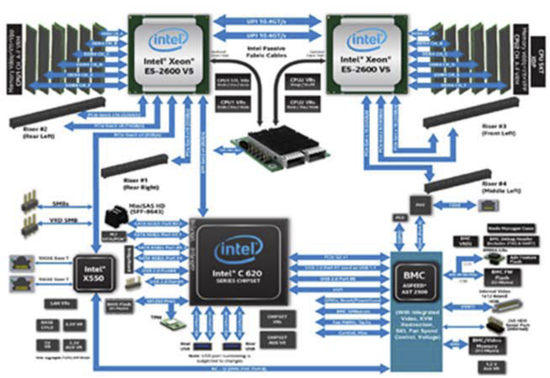
계산노드 Cray 3112-AA000T(2U enclosure), KNL 기반 계산 노드 (8,305개) — 25.3PF

- 1x Intel Xeon Phi KNL 7250 processor
- 68 Cores per Processor
- 96GB (6x 16GB) DDR4-2400 RAM
- 1x Single-port 100Gbps OPA HFI card
- 1x On-board GigE (RJ45) port



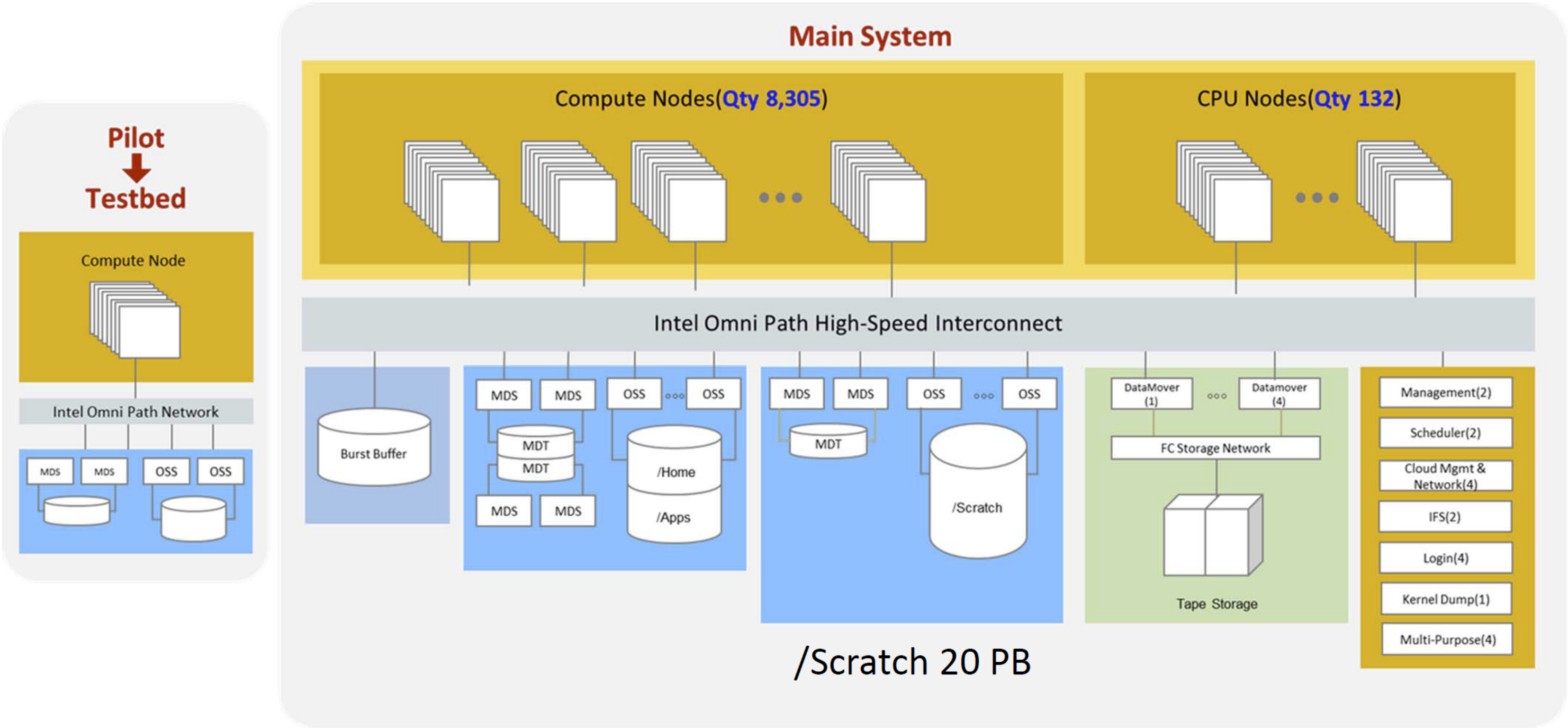
CPU–only Cray 3111-BA000T(2U enclosure), Skylake 기반 계산 노드 (132개) — 0.4PF

- 2x Intel Xeon SKL 6148 (2.4 GHz) processors
- 20 Cores per processor (total 40 Cores)
- 192GB (12x 16GB) DDR4-2666 RAM–6CH
- 1x Single-port 100Gbps OPA HFI card
- 1x On-board GigE (RJ45) port



M.S. Joh

KISTI-5 supercomputer



/Scratch 20 PB

/Home 0.5 PB /Apps 0.5 PB

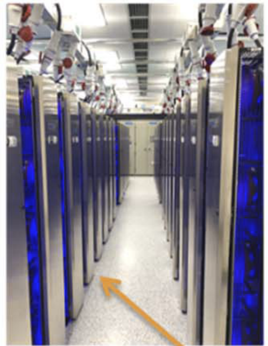
Burst Buffer 0.8 PB

Tape Storage 10 PB

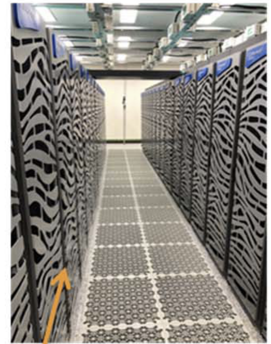
M.S. Joh

8열, 126랙

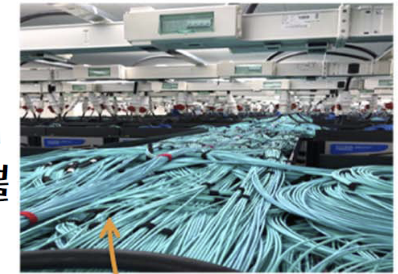
후면
냉각
도어

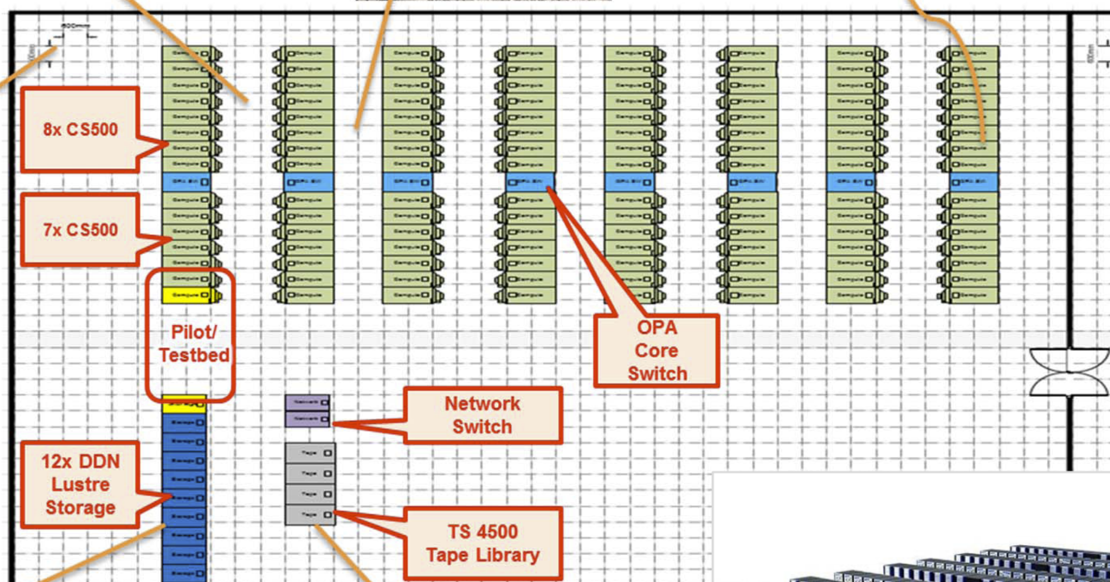


정면



상부
OPA
케이블





디스크
스토리지
(21PB)

테이프
스토리지
(10PB)

KISTI-5 Opening Ceremony

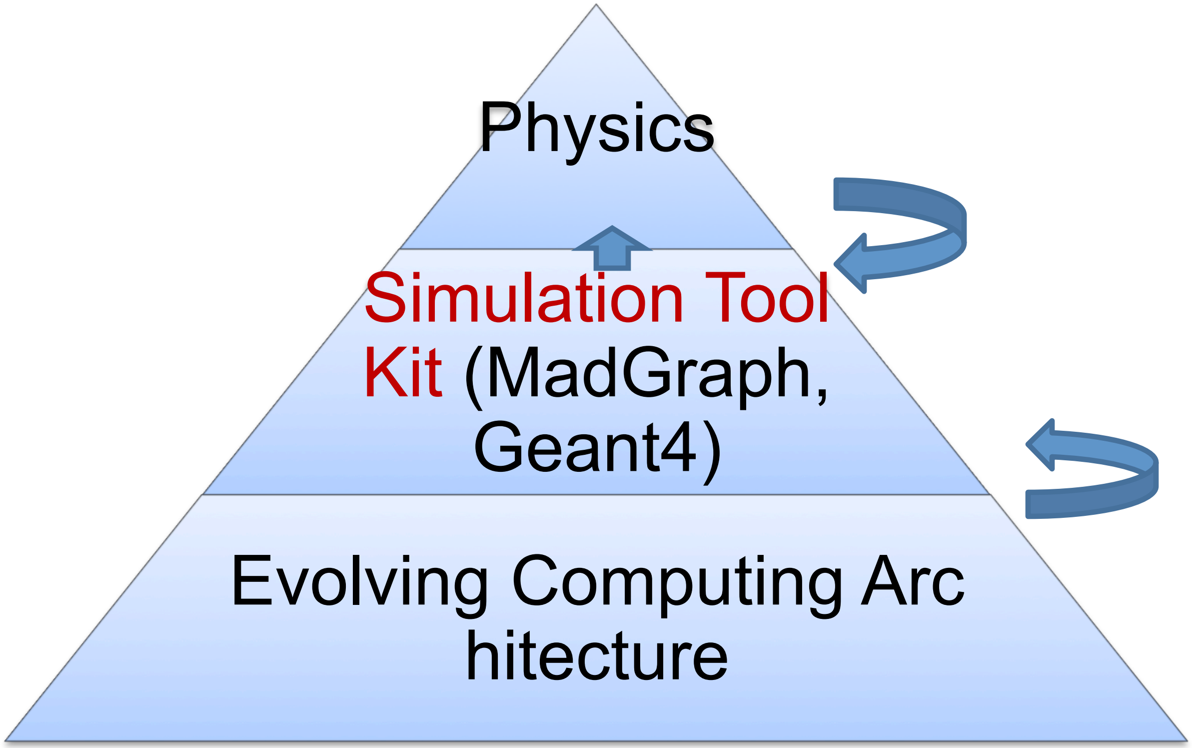
국제 워크숍

International workshop
Date: 2018. 11.7 13:50-17:30
Place: KISTI, Daejeon

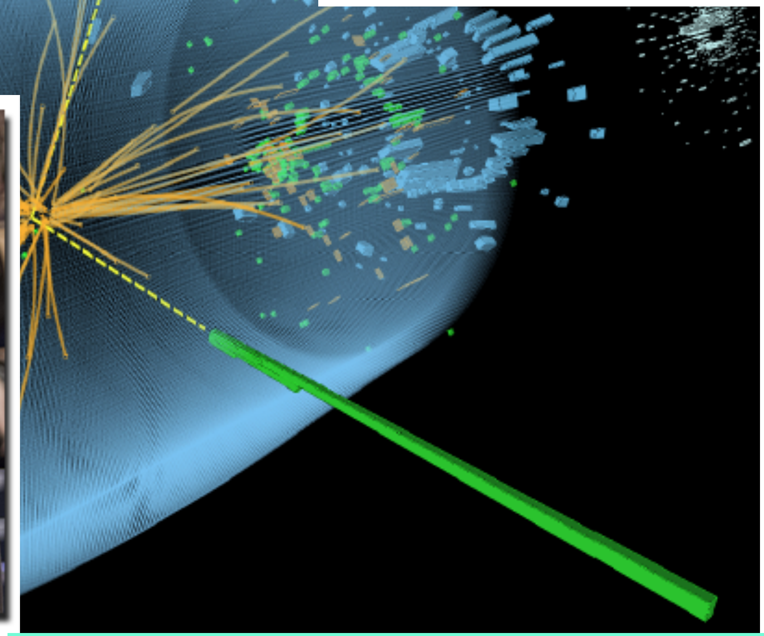
시간		제목/발표자
0 ~ 14:00	(10')	**Welcome Speech** Dr. Hee-yoon Choi (President of KISTI)
		Keynote Speech Session
14:00 ~ 14:30	(30')	**The Direction and Policies of Exascale Computing, AI, Big Data in the US** Prof. Daniel Reed (Chairs of Department of Energy's Advanced Computing Advisory Committee, SVP of University of Utah)
14:30 ~ 15:00	(30')	**The ABCI Project and its AI Usage in Japan** Dr. Satoshi Sekiguchi (Vice Director of AIST)
15:00 ~ 15:30	(30')	Coffee Break
		The World Top KNL Supercomputers Session
15:30 ~ 15:50	(20')	**The successful experiences in OakForest-PACS system in Japan** speaker : Prof. Taisuke Boku (University of Tsukuba)
15:50 ~ 16:10	(20')	**The successful experiences in Cori System in USA** speaker : Dr. Richard Gerber (HPC Department Head, NERSC)
16:10 ~ 16:30	(20')	**The successful experiences in Stampede-2 system in USA** speaker : Dr. Todd Evans (TACC)
16:30 ~ 16:50	(20')	**The usage of KISTI-5 system in Korea** speaker : Dr. Min Sun Yeom(KISTI)
16:50 ~ 17:30	(40')	**Discussion** Dr. Soonwook Hwang (General Director of KISTI)

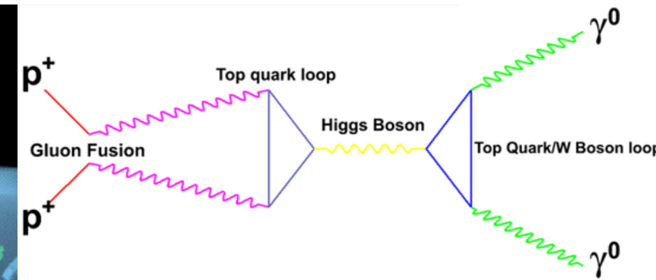
You are welcome to join.

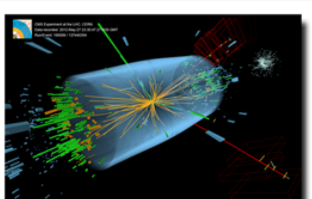
Simulation

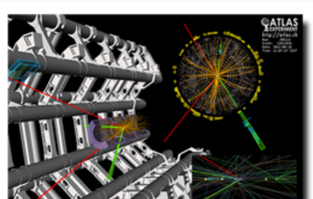

Physics
Simulation Tool Kit (MadGraph, Geant4)
Evolving Computing Arc hitecture

Higgs Discovery (July 4, 2012)





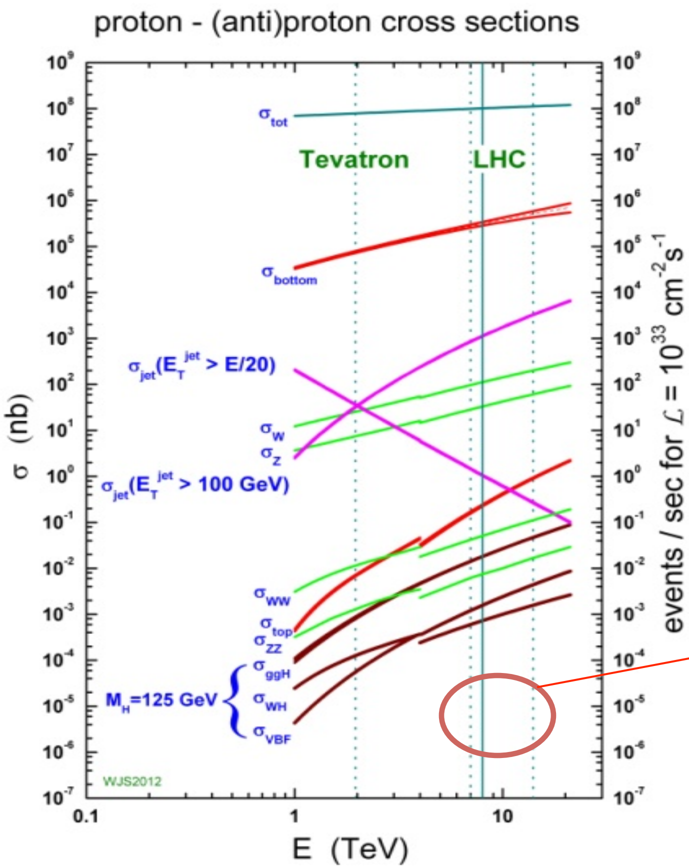


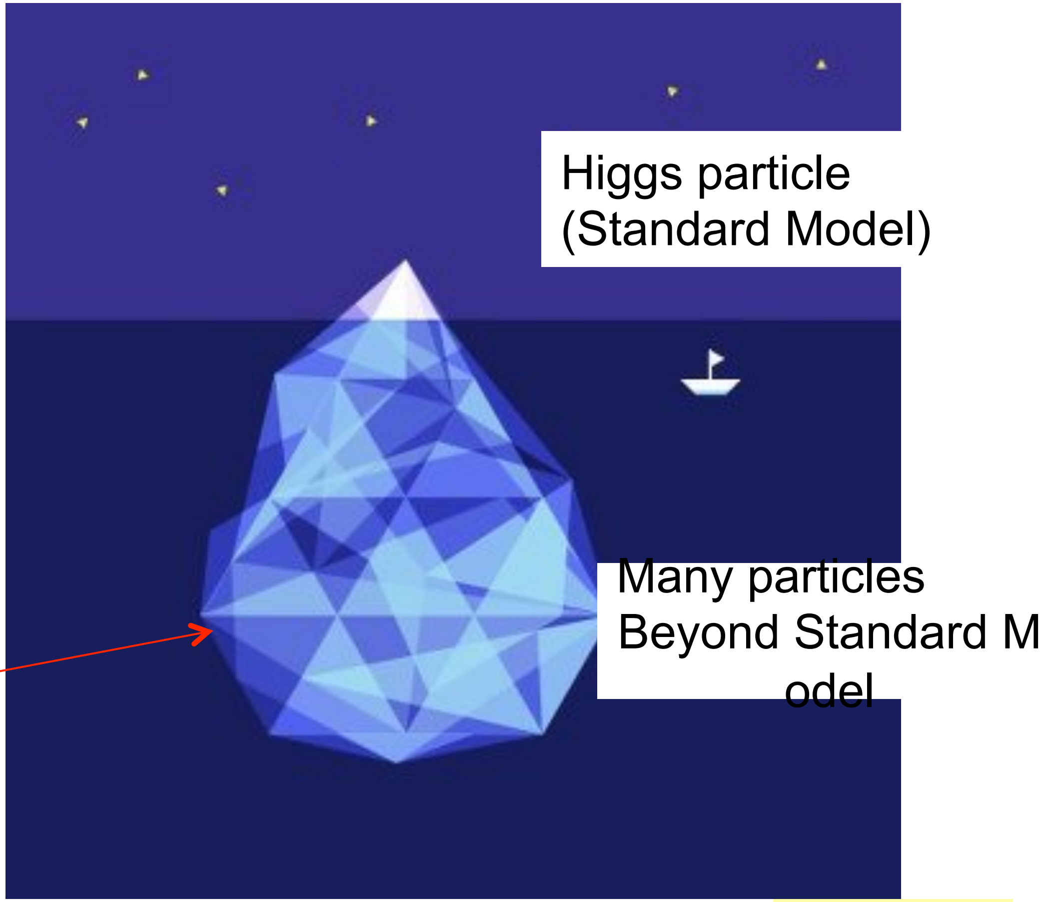


The SM is now complete?

⇒ What is next?

Beyond the Standard Model

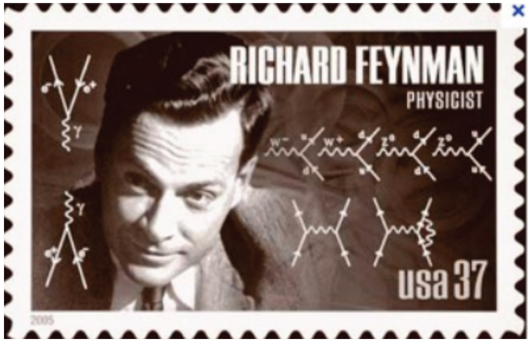


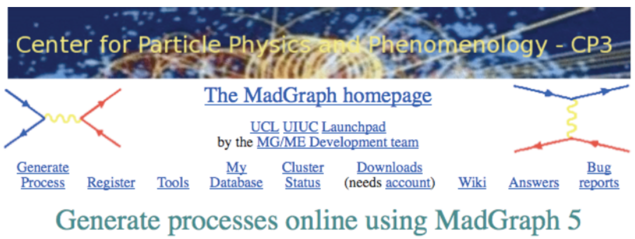


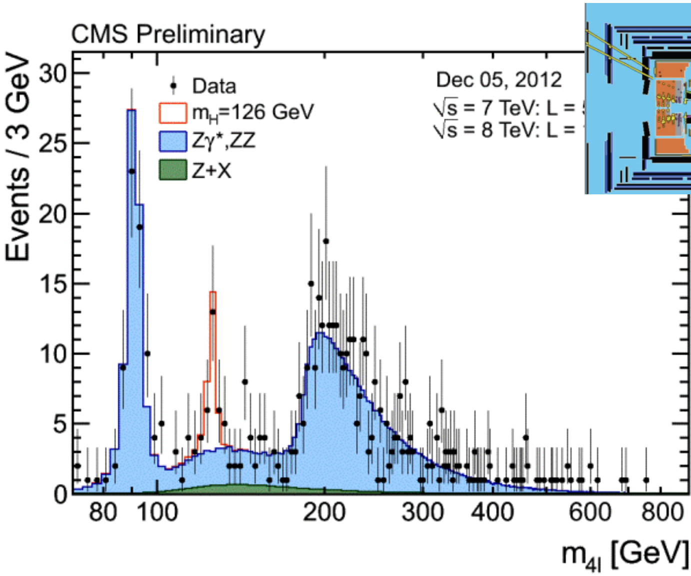
Adam Martin

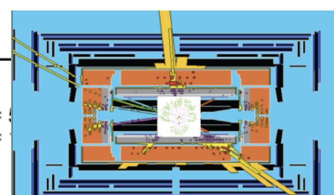
⇒ BSM needs 1000 more Higgs events.

HEP Simulation









New Physics Model

⇓ ⇒ Feynman rules calculation

FeynRules

⇓ ⇒ Model implementation

MadGraph/CalcHEP

⇓ ⇒ Process creation

PYTHIA

⇓ ⇒ Event generation (physics)

PGS/Delphes/Geant4

⇓ ⇒ Detector simulation

MadAnalysis/ROOT/Mathematica

We focus on MadGraph & Geant4

Geant4 Collaboration

- Geant4 is the most successful model in HEP.
- HEP user community – BaBar(2001), LHC(2003), Belle II
- Prof. Kihyeon Cho is the contact person in Korea.

HEP Simulation

- Why profiling?
  - Diversity of physics applications
  - Evolving Computing

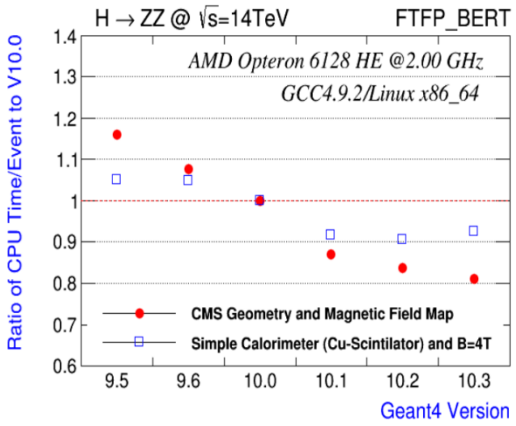
  ⇒ S/W development

  ⇒ Profiling tools

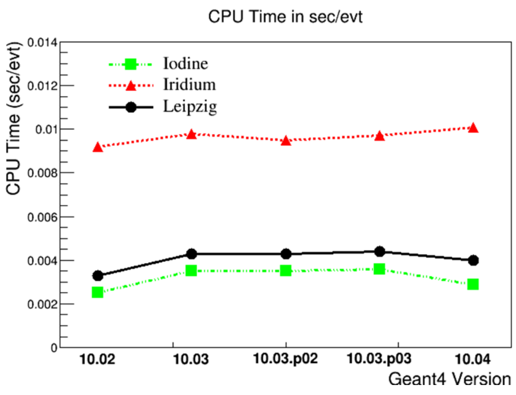
  ⇒To draw community interests for collateral effort

Profiling system

- Current status
  - High energy physics profiling (Fermilab)
    - SimpliCarlo (Sequential)
    - CMSExp (Multi-Thread)

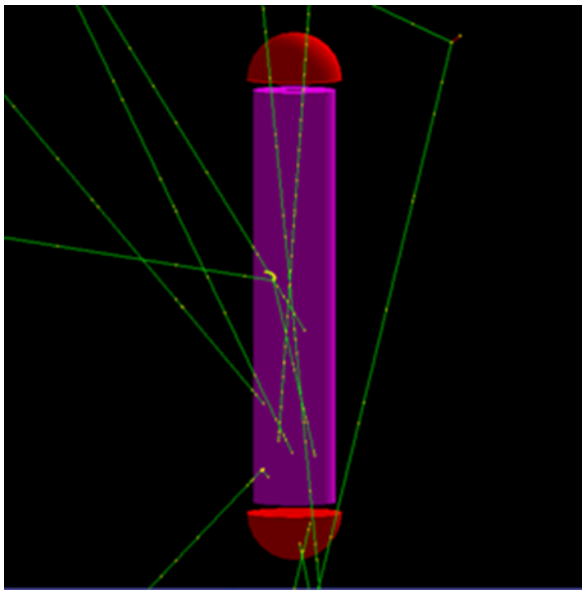


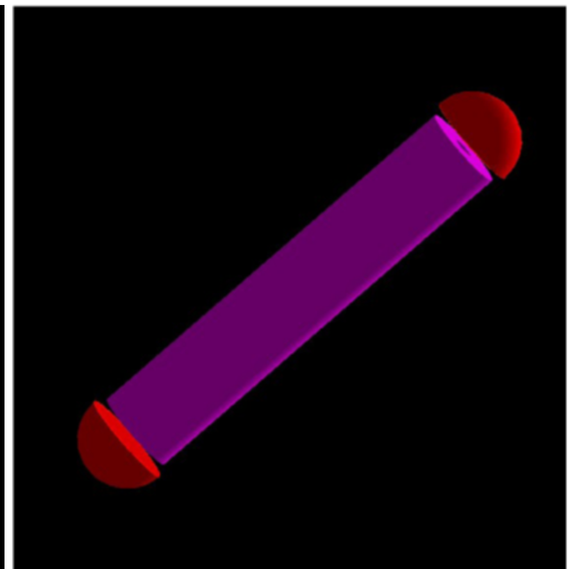
  - Low energy physics profiling (KISTI)
    - Using Brachytherapy code

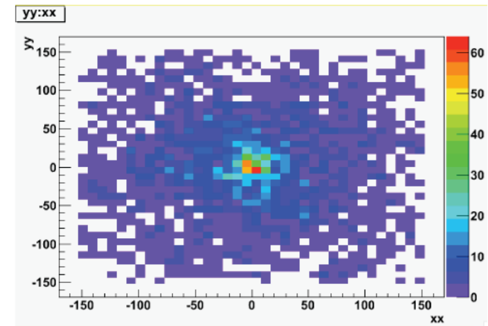


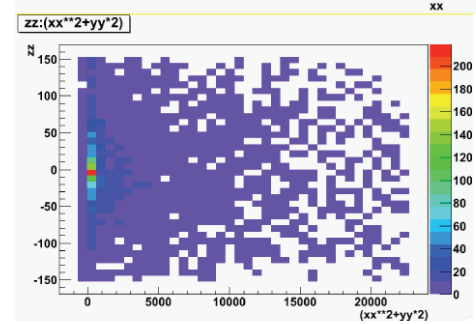
1. Profiling for low energy physics

- Profiling system using brachytheray simulation (Low energy physics)
- \- cf. Brachytherapy(MeV) vs. SimplifiedCarlo(TeV)









- Results (Brachytherapy v.10.02 & Geant4 v.10.04)

1) CPU
2) Memory size
3) Version dependency
4) Event number dependency
5) KISTI-4 machine dependency

Computer Physics Communications 226 (2018) 180–186

Contents lists available at ScienceDirect

Computer Physics Communications

journal homepage: www.elsevier.com/locate/cpc

Performance profiling for brachytherapy applications

Wonqook Choi [a], Kihyeon Cho [a,b,*], Insung Yeo [a]

[a] National Institute of Computing and Networking, Korean Institute of Science and Technology Information, Daejeon 34141, Republic of Korea
[b] University of Science and Technology, Daejeon 34113, Republic of Korea

ARTICLE INFO

Article history:
Received 21 November 2016
Received in revised form 9 August 2017
Accepted 22 December 2017
Available online 31 January 2018

Keywords:
Medical physics
Particle physics
Computational physics
Geant4
Profiling

ABSTRACT

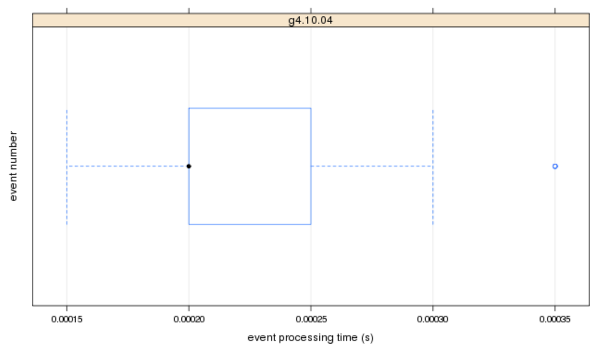
In many physics applications, a significant amount of software (e.g. R, ROOT and Geant4) is developed on novel computing architectures, and much effort is expended to ensure the software is efficient in terms of central processing unit (CPU) time and memory usage. Profiling tools are used during the evaluation process to evaluate the efficiency; however, few such tools are able to accommodate low-energy physics regions. To address this limitation, we developed a low-energy physics profiling system in Geant4 to profile the CPU time and memory of software applications in brachytherapy applications. This paper describes and evaluates specific models that are applied to brachytherapy applications in Geant4, such as QGSP_BIC_LIV, QGSP_BIC_EMZ, and QGSP_BIC_EMY. The physics range in this tool allows it to be used to generate low energy profiles in brachytherapy applications. This was a limitation in previous studies, which caused us to develop a new profiling tool that supports profiling in the MeV range, in contrast to the TeV range that is supported by existing high-energy profiling tools. In order to easily compare the profiling results between low-energy and high-energy modes, we employed the same software architecture as that in the SimpliCarlo tool developed at the Fermilab National Accelerator Laboratory (FNAL) for the Large Hadron Collider (LHC). The results show that the newly developed profiling system for low-energy physics (less than MeV) complements the current profiling system used for high-energy physics (greater than TeV) applications.

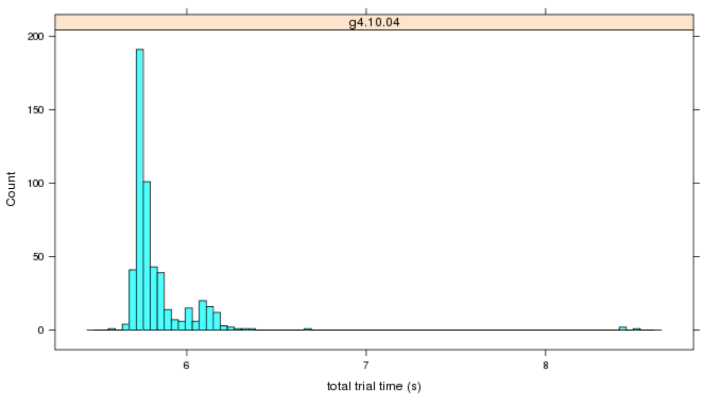
1) CPU time

CPU Time in seconds/event

Geant4.10.04 Brachy 01

Sample	Physics List	Energy	Process
Iodine	QGSP_BIC_EMY	35 KeV	0.0029
	QGSP_BIC_EMZ	35 KeV	0.0029
Iridium	QGSP_BIC_EMY	356 KeV	0.0102
	QGSP_BIC_EMZ	356 KeV	0.0101
Leipzig	QGSP_BIC_EMY	356 KeV	0.0040
	QGSP_BIC_EMZ	356 KeV	0.0040





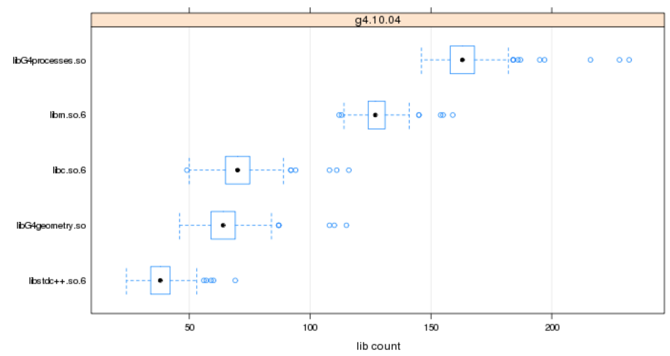
QGSP_BIC_EMY

2) Memory size

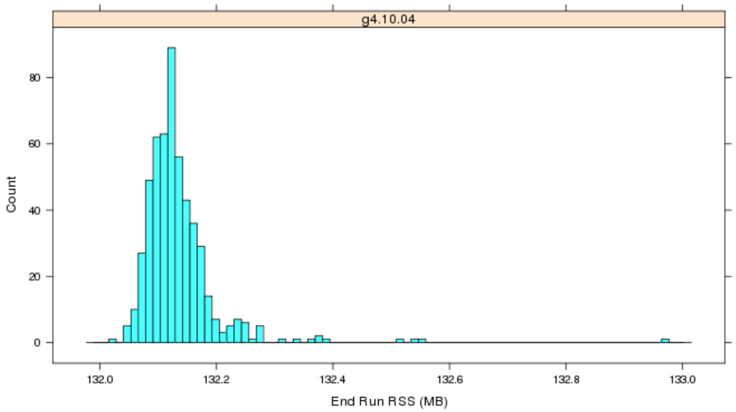
Total Memory in Counts/10,000

Geant4.10.04 Brachy 01

Sample	Physics List	Energy	Process	
			First Event	Last Event
Iodine	QGSP_BIC_EMY	35 KeV	143.372	205.959
	QGSP_BIC_EMZ	35 KeV	143.372	205.968
Iridium	QGSP_BIC_EMY	356 KeV	174.434	233.229
	QGSP_BIC_EMZ	356 KeV	174.434	233.229
Leipzig	QGSP_BIC_EMY	356 KeV	184.667	256.539
	QGSP_BIC_EMZ	356 KeV	184.667	256.529



QGSP_BIC_EMY

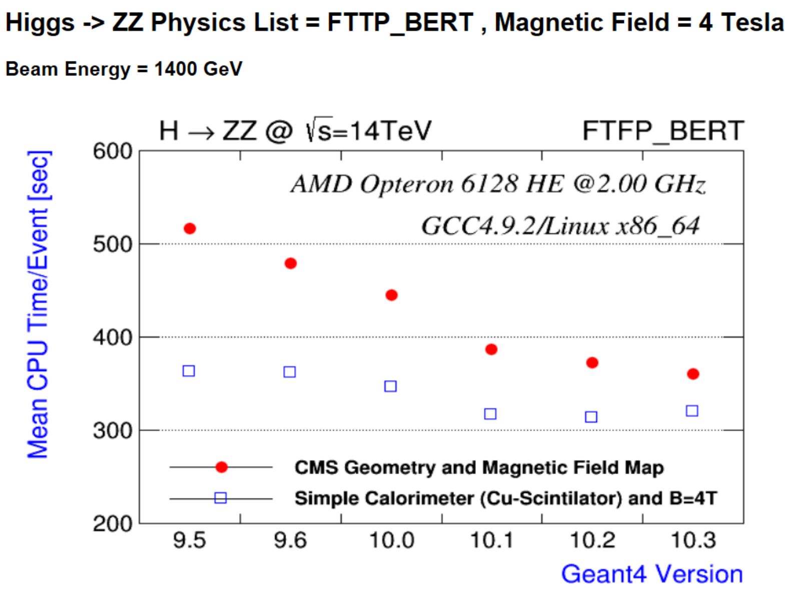


3) Version dependency

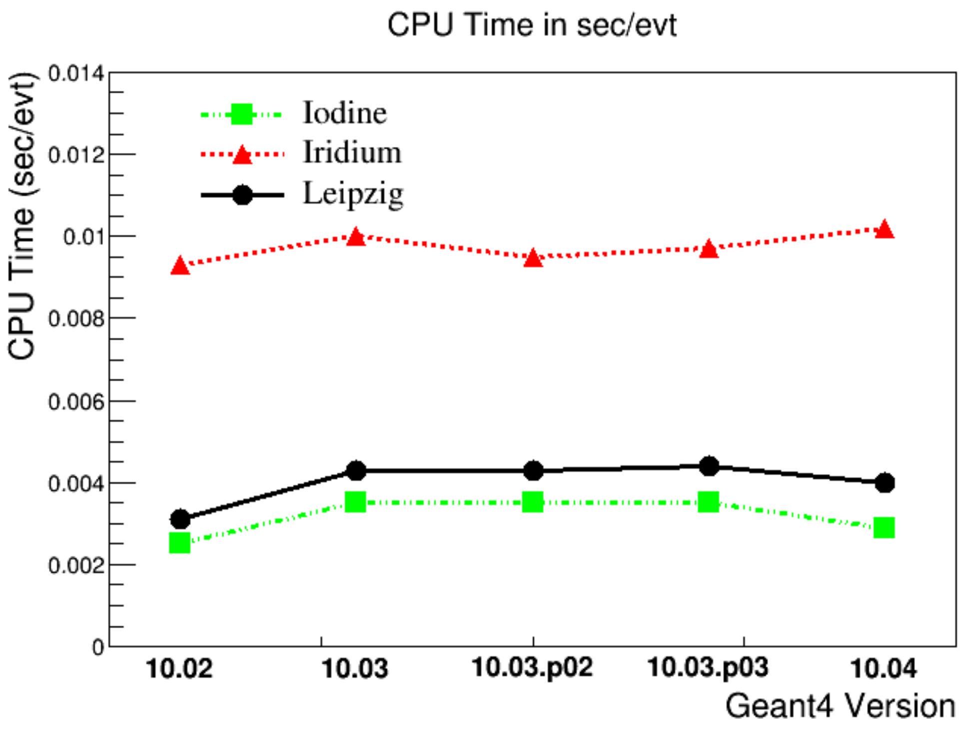
Content	Profiling				
Geant4 Version	10.02	10.03	10.03p02	10.03p03	10.04
Brachy version	10.02				

- Trial time: 528
- Macro file
  - IodiumSourceMacro.mac (endocavitary brachytherapy)
  - IridiumSourceMacro.mac (interstitial brachytherapy)
  - LeipzigSourceMacro.mac (superficial brachytherapy)
- Physics list
  - QGSP_BIC_LIV
  - QGSP_BIC_EMZ
  - QGSP_BIC_EMY

QGSP BIC EMY

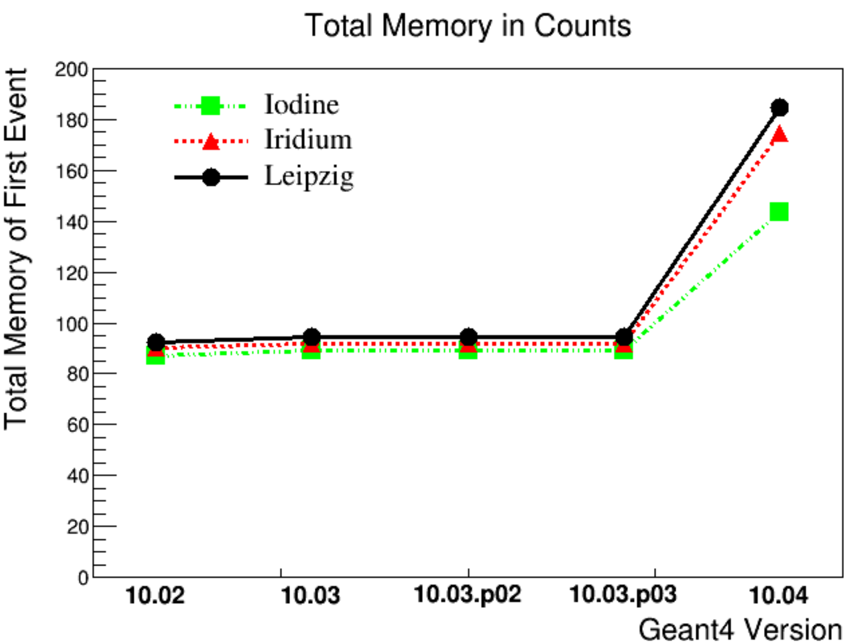


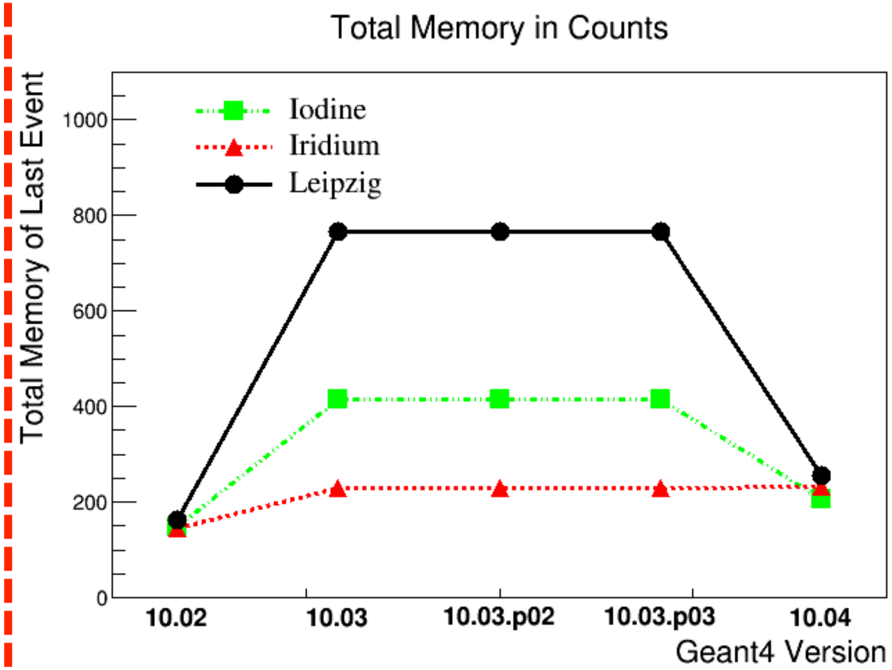
Higgs -> ZZ Physics List = FTTP_BERT , Magnetic Field = 4 Tesla
Beam Energy = 1400 GeV
H → ZZ @ √s=14TeV
FTFP_BERT
AMD Opteron 6128 HE @2.00 GHz
GCC4.9.2/Linux x86_64
Mean CPU Time/Event [sec]
600
500
400
300
200
CMS Geometry and Magnetic Field Map
Simple Calorimeter (Cu-Scintilator) and B=4T
9.5
9.6
10.0
10.1
10.2
10.3
Geant4 Version



CPU Time in sec/evt
CPU Time (sec/evt)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Iodine
Iridium
Leipzig
10.02
10.03
10.03.p02
10.03.p03
10.04
Geant4 Version

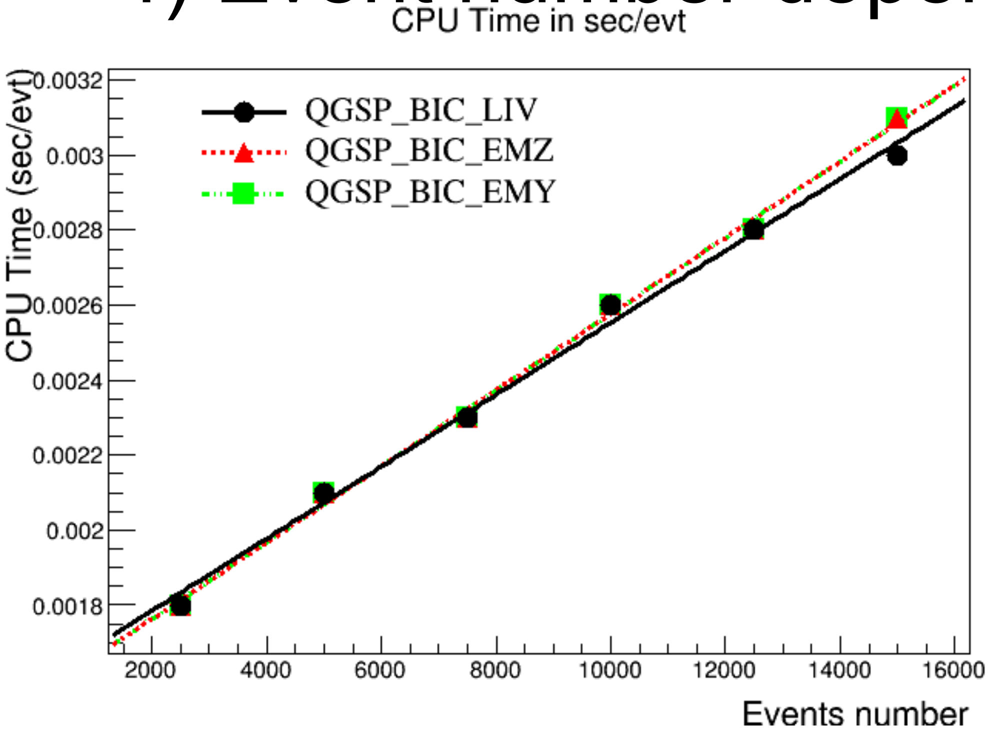
Iodine
QGSP BIC EMY





Iodine

4) Event number dependency



QGSP BIC EMY

Chi2	=	3.42857e-09
NDf	=	4
p0	=	0.00156 +/- 2.72554e-05
p1	=	1.01714e-07 +/- 2.79942e-09

QGSP BIC EMZ

Chi2	=	3.42857e-09
NDf	=	4
p0	=	0.00156 +/- 2.72554e-05
p1	=	1.01714e-07 +/- 2.79942e-09

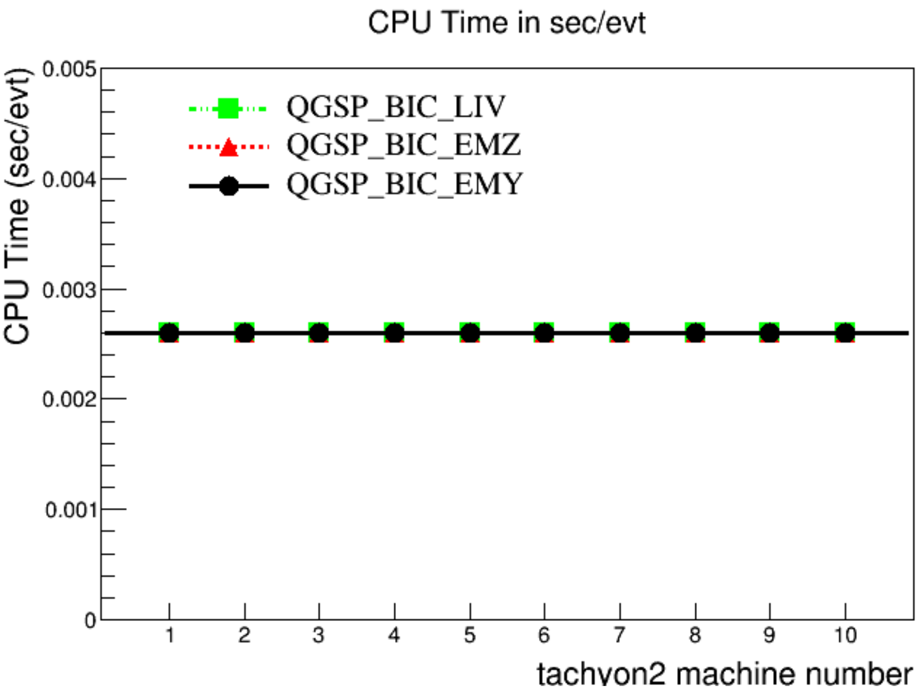
QGSP BIC LIV

Chi2	=	5.33333e-09
NDf	=	4
p0	=	0.00159333 +/- 3.39935e-05
p1	=	9.6e-08 +/- 3.49149e-09

- There is linearity on event number.

Iodine

5) KISTI-4 machine dependency



QGSP BIC EMY

Chi2 = 1.88079e-36
NDf = 9
p0 = 0.0026 +/- 1.4456e-19

****

QGSP BIC EMZ

Chi2 = 1.88079e-36
NDf = 9
p0 = 0.0026 +/- 1.4456e-19

****

QGSP BIC LIV

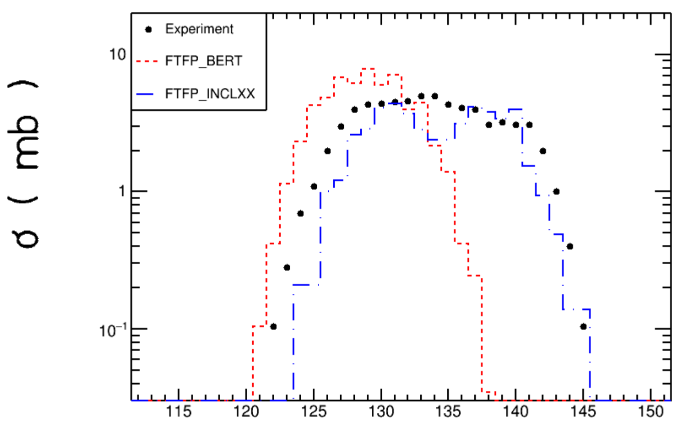
Chi2 = 1.88079e-36
NDf = 9
p0 = 0.0026 +/- 1.4456e-19

- There no machine dependency on KISTI-4 supercomputer.
- To check KISTI-5 supercomputer machine dependency

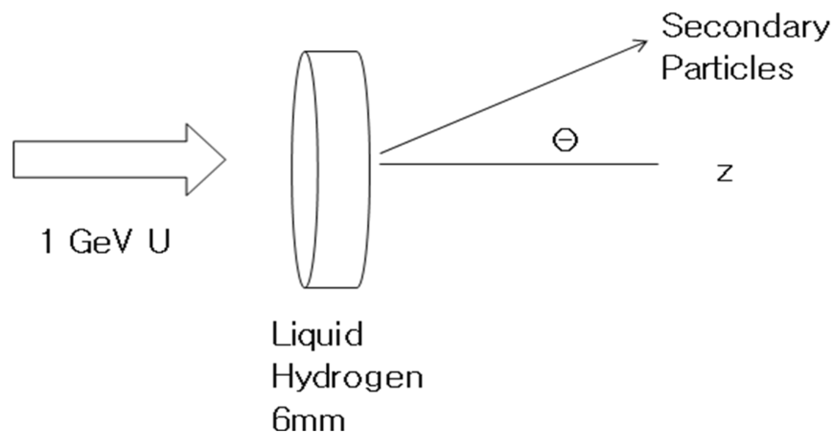
2. Beam Simulations (1/2)

➢Reliability of Geant4 models in producing spallation fragmentation species

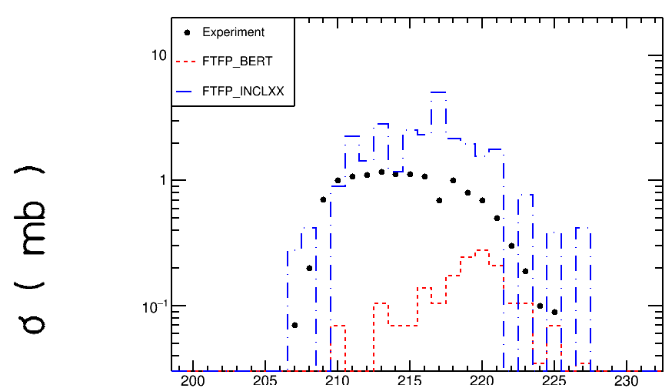
Cesium Isotopes *M. Bernas et al. / Nuclear Physics A 725 (2003) 213–253*



Number of mass



Francium Isotopes *J. Taïeb et al. / Nuclear Physics A 724 (2003) 413–430*



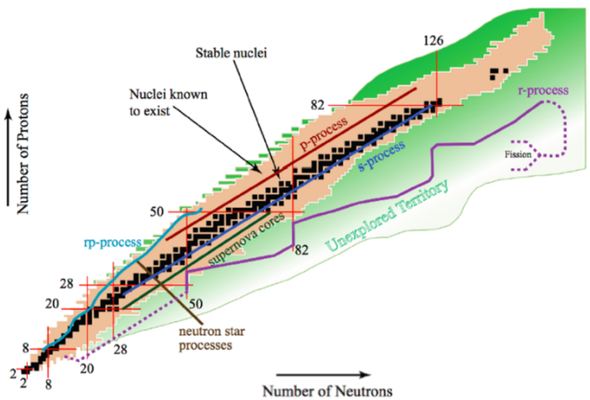
Number of mass

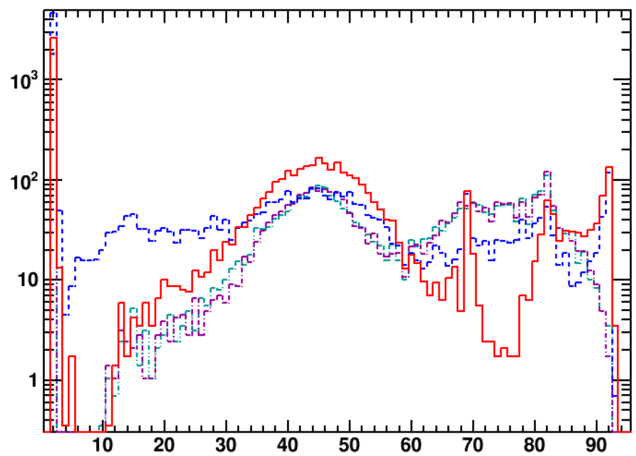
FTFP_BERT	
FTFP_BERT_HP	FTFP_INCLXX
QGSP_BERT	FTFP_INCLXX_HP
QGSP_BERT_HP	QGSP_INCLXX
QGSP_BIC	QGSP_INCLXX_HP
QGSP_BIC_HP	

=> Selected FTFP_INCLXX

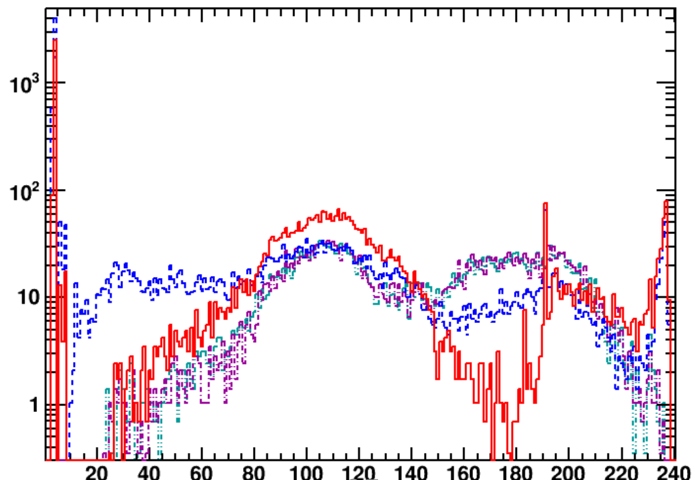
Beam Simulations (2/2)

- Application in astrophysics, nuclear imaging, …





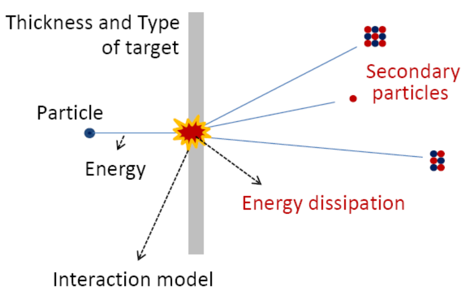
Atomic number(Z)



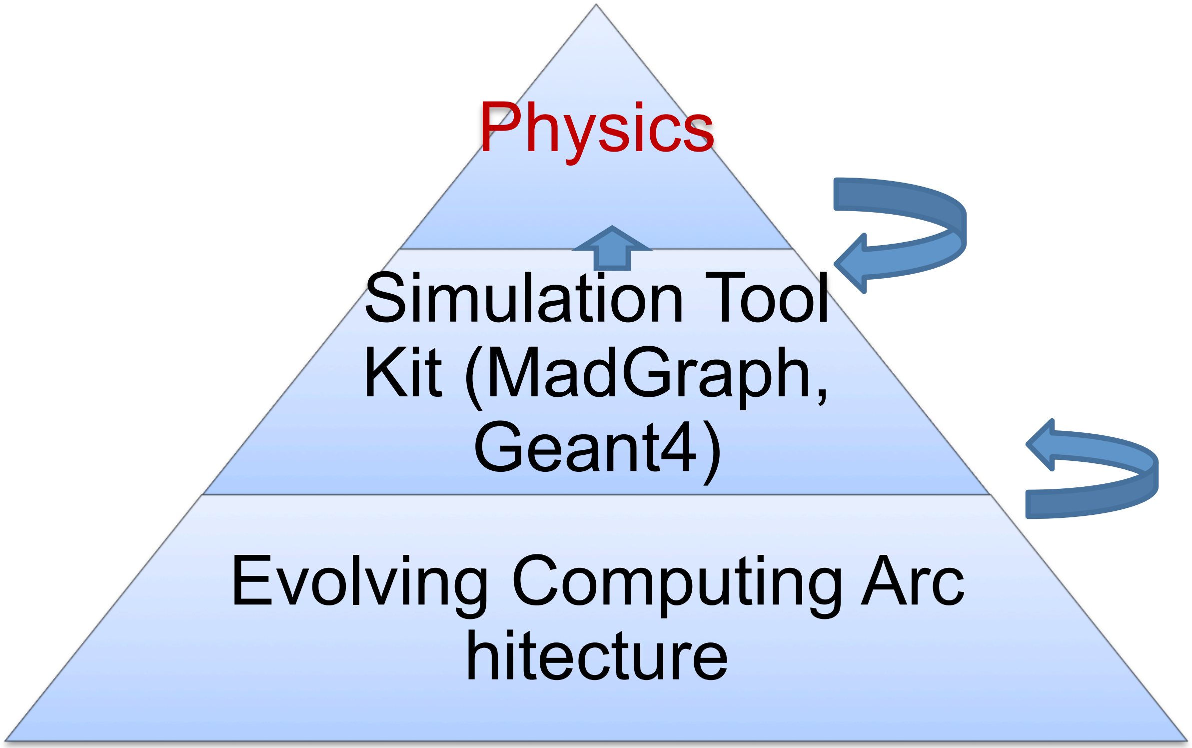
Atomic mass(A)

Proton beam with U Target

- 1000 GeV
- 100 GeV
- 10 GeV
- 1 GeV



Physics


Physics
Simulation Tool Kit (MadGraph, Geant4)
Evolving Computing Arc hitecture

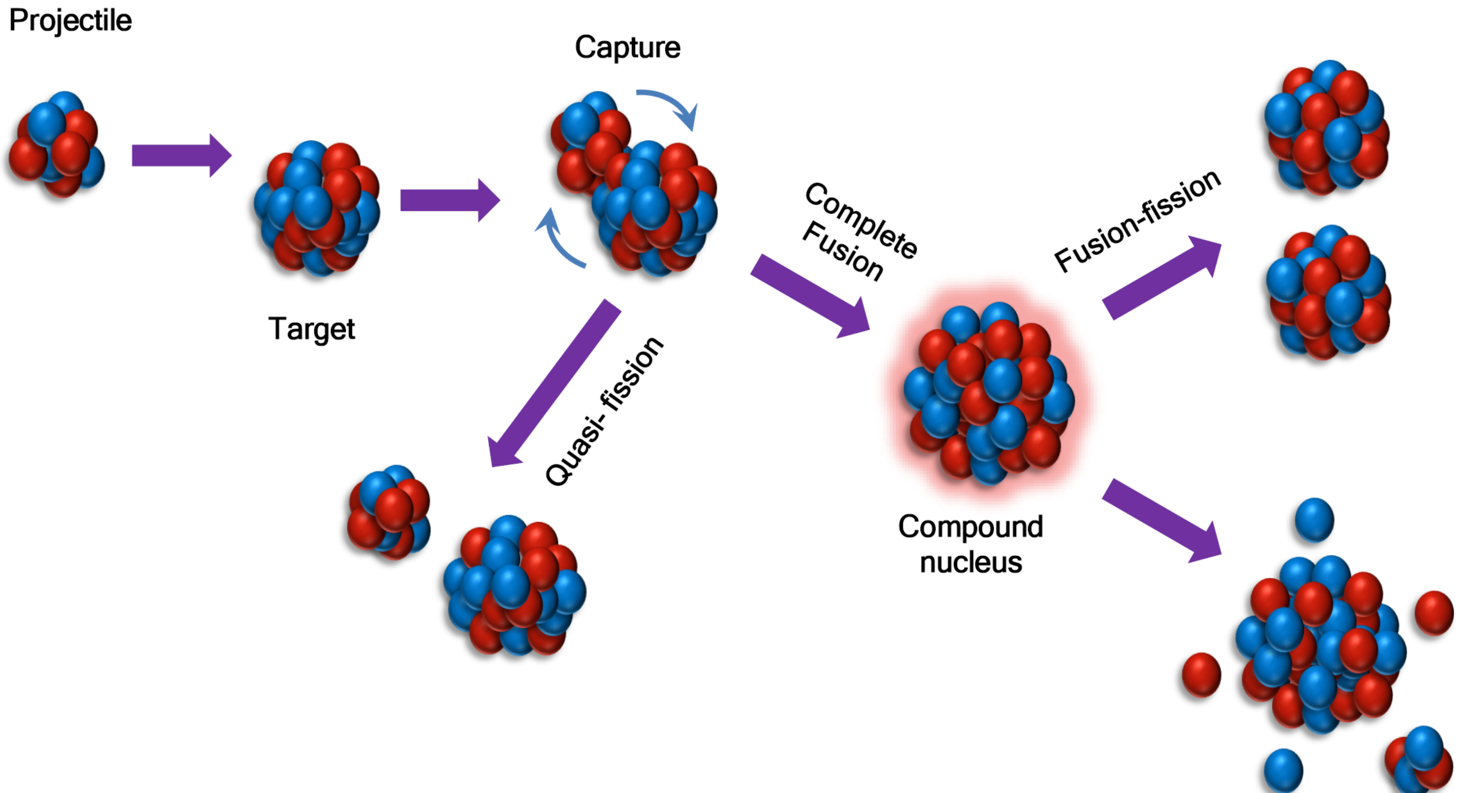
Physics

1. Production of exotic nuclei and heavy elements

2. Nuclear Structure and reactions from first principles

1. Production of exotic nuclei and heavy elements

Nuclear reactions at low energies (< 10 MeV/n)



M.H. Mun

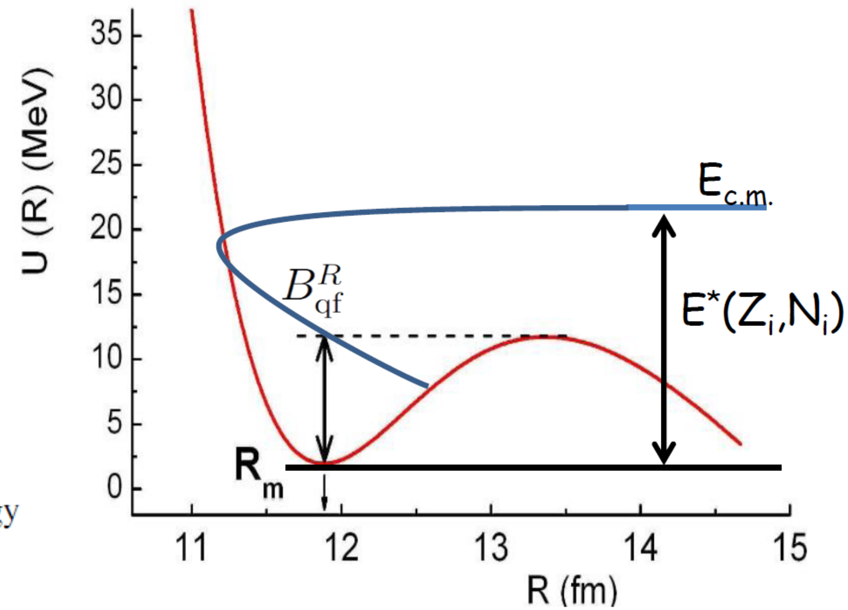
Production cross section

$$\sigma_{Z_i,N} = \sigma_{cap} \cdot Y_{Z_i,N}$$

Capture cross-section

$$\sigma_{cap} = \frac{\pi\hbar^2}{2\mu E_{cm}} J_{cap}(J_{cap}+1)$$

J_{cap} : the value of angular momentum
$J_{cap} = 90$: $E_{c.m.}$ is 20 % larger than the Coulomb barrier energy
$J_{cap} = 30 \sim 40$: $E_{c.m.}$ is similar the Coulomb barrier energy

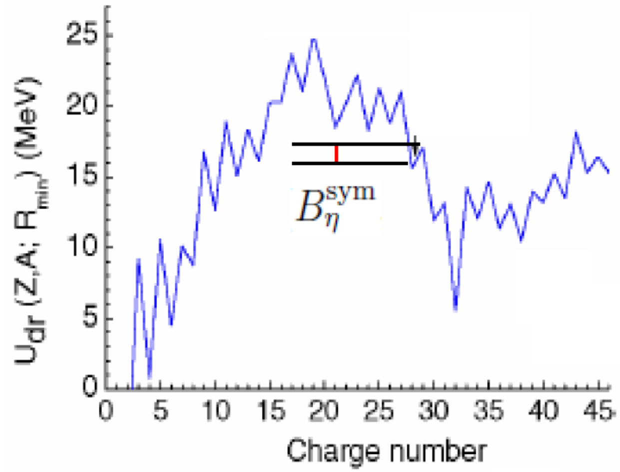


Formation-decay probability

$$Y_{Z_i,N} \approx 0.5 \exp\left[-\frac{B_R(Z_i,N) - B_{qf}(Z_i,N_i)}{\Theta(Z_i,N_i)}\right]$$

$$B_R(Z,N) = U(R_b(Z,N),Z,N,J) - U(R_m(Z,N_e),Z,N_e,J)$$

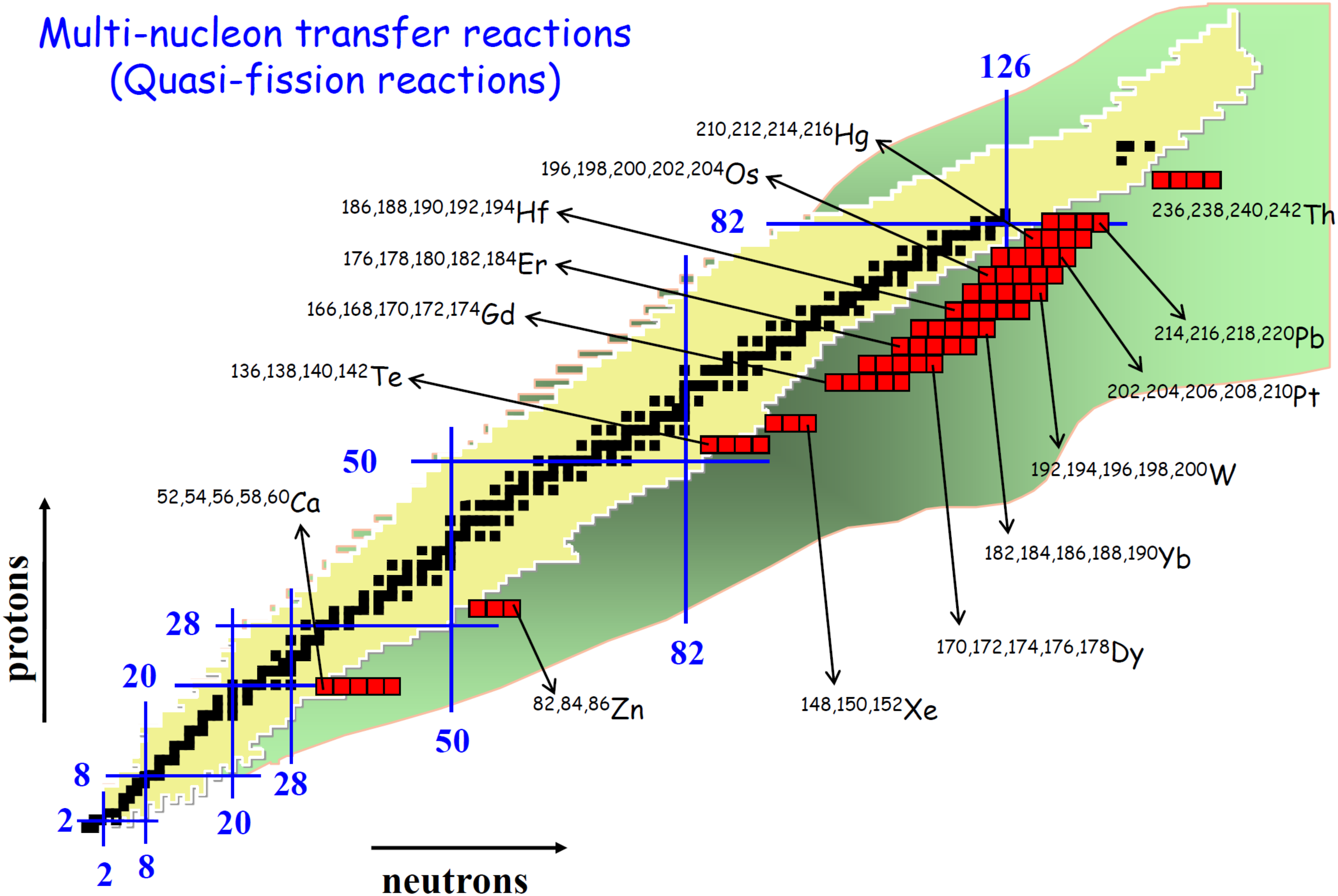
$$B_{qf} = \min(B^{sym}_\eta, B^R_{qf}) \quad \Theta = \sqrt{E^*(Z_i,N_i)/a}. \quad a = A_{tot}/12 \text{ MeV}^{-1}$$



Yu.E. Penionzhkevich et al., *Phys. Lett. B* **621** 119 (2005).
M.H. Mun et al., *Phys. Rev. C* **89**, 034622 (2014).

M.H. Mun

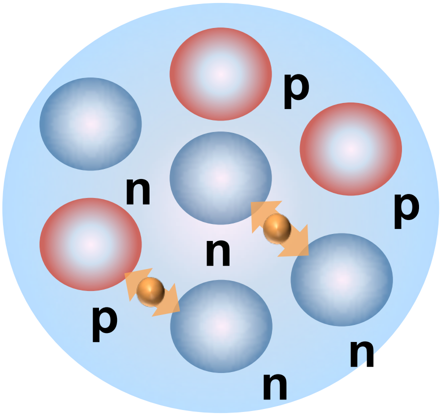
Multi-nucleon transfer reactions
(Quasi-fission reactions)



M.H. Mun

2. Nuclear Structure and reactions from first principles

- Ab initio: nuclei from first principles using fundamental interactions without uncontrolled approximations.
- No core: all nucleons are active, no inert core.
- Shell model: harmonic oscillator basis
- Point nucleons



Y. Kim

- A-nucleon Schrödinger equation

$$\hat{H}\,\Psi(r_1,\cdots,r_A) = E\,\Psi(r_1,\cdots,r_A)$$

- Hamiltonian with $NN(+NNN)$ interactions

$$\hat{H} = \frac{1}{A}\sum_{i<j}\frac{(\vec{p_i}-\vec{p_j})^2}{2m} + \sum_{i<j}V_{ij} + \sum_{i<j<k}V_{ijk} + \cdots$$

- Wave functions are expanded in basis states

$$\Psi(r_1,\cdots,r_A) = \sum a_i\Phi_i(r_1,\cdots,r_A)$$

basis states Φ_i : Slater determinants of single particle states

Requested resources @KISTI-5 supercomputer	**Total core time**	**1,500,000 node time** **- node/job: 4,000 node** **- Core time/job: 1 hours** **- Number of Total job: more than 20 /nuclide**
	Memory	500 TB
	Hard disk	10 GB

Y. Kim

Summary

- Computing needs solutions for the evolving architecture (KISTI-5).
- To fulfill the gap between physics and computing, we also need to focus on simulation R&D.

$\Rightarrow$ Physics goes beyond discovery.

Acknowledgement

- Insung Yeo
- Myeong Hwan Mun
- Soon Yung Jun
- Youngman Kim

Thank you.

cho@kisti.re.kr

Backup

KISTI GSDC

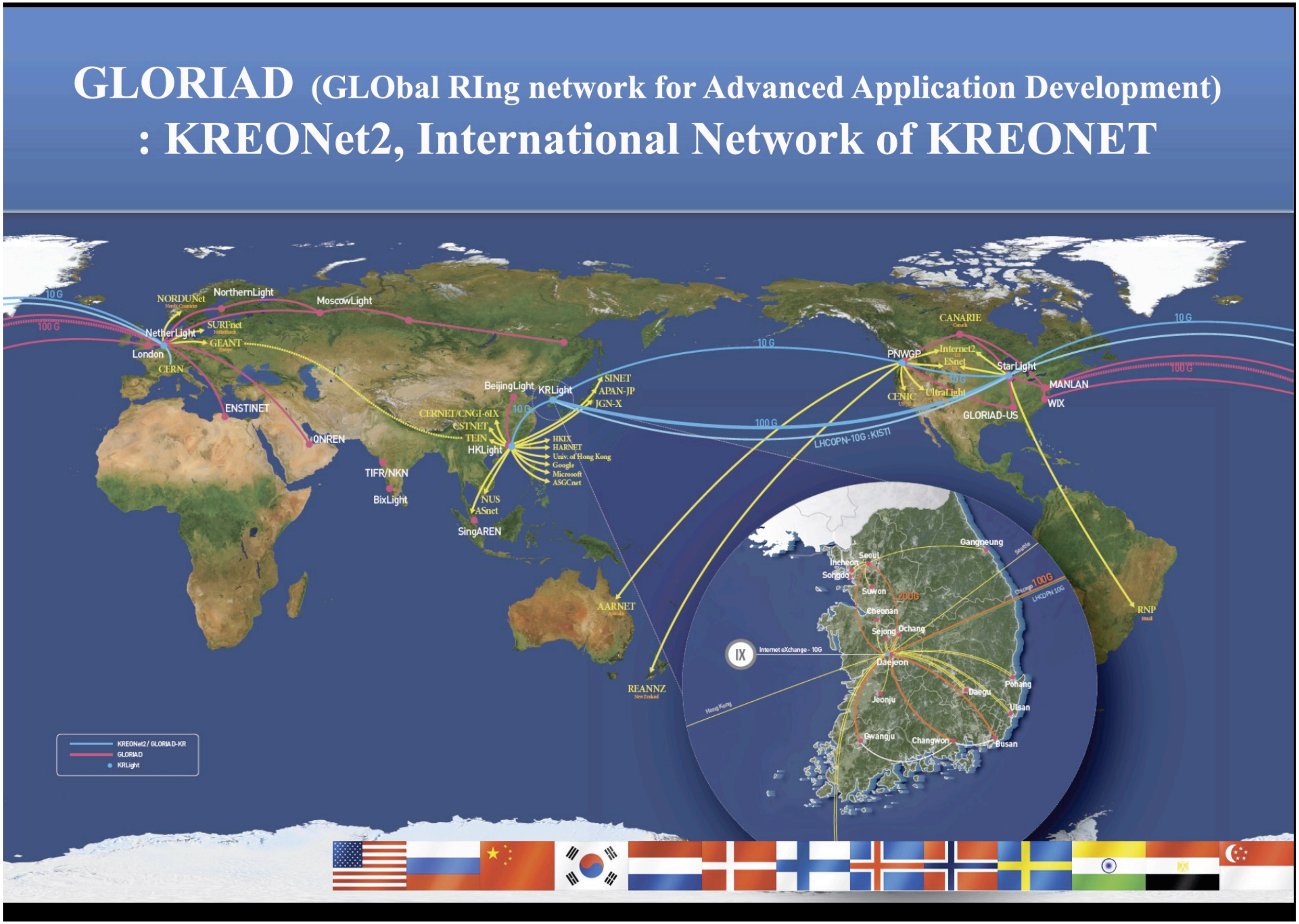
Expanding to other Scientific Domains

Experience on WLCG Tier-1 operation and service has given many benefits to expand its service availability to other scientific domains in Korea

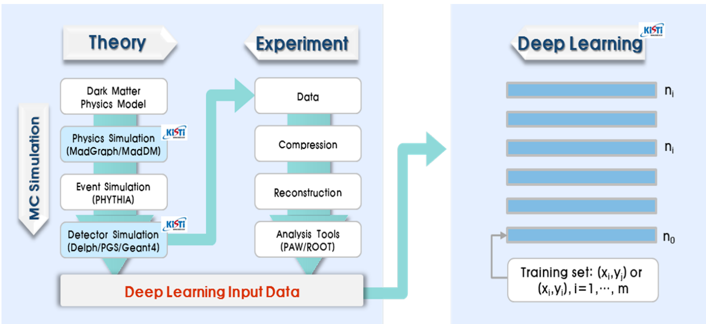
and it is still expanding to many other research areas.

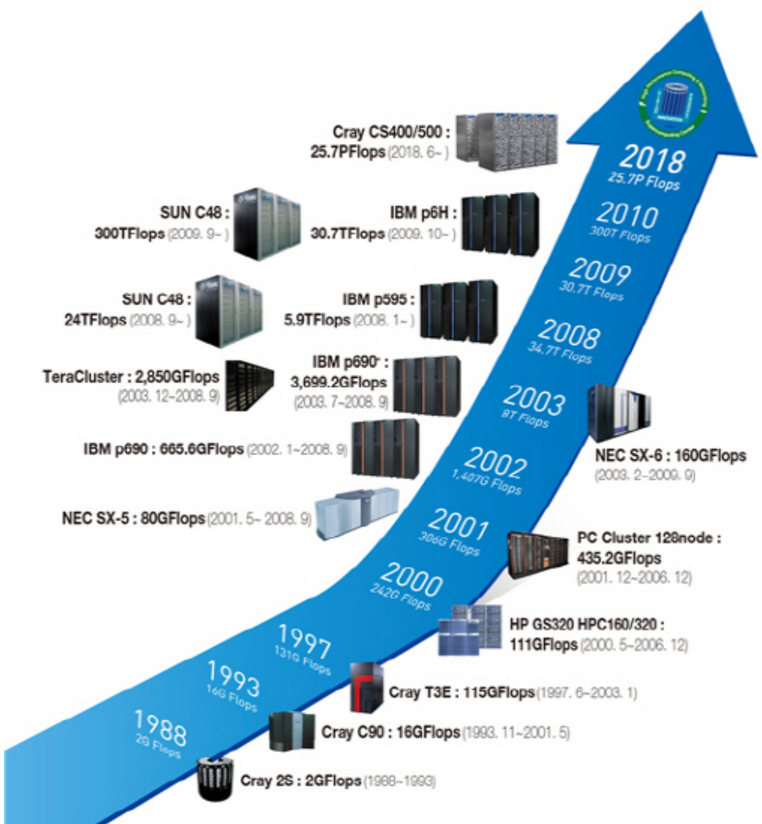
Service for additional domestic experiments is under preparation.

Network


GLORIAD (GLObal RIng network for Advanced Application Development)
: KREONet2, International Network of KREONET
NORDUNet
NorthernLight
MoscowLight
NetherLight
SURFnet
GEANT
London
CERN
ENSTINET
QNREN
TIFR/NKN
BixLight
BeijingLight
KRLight
SINET
APAN-JP
JGN-X
CERNET/CNGI-6IX
CSTNET
TEIN
HKLight
HKIX
HARNET
Univ. of Hong Kong
Google
Microsoft
ASGCnet
NUS
ASnet
SingAREN
AARNET
REANNZ
PNWGP
CANARIE
Internet2
ESnet
StarLight
MANLAN
WIX
CENIC
UltraLight
GLORIAD-US
LHCOPN-10G : KISTI
RNP
10 G
100 G
IX
Internet eXchange - 10G
Seoul
Incheon
Songdo
Suwon
Cheonan
Sejong
Ochang
Daejeon
Gangneung
Jeonju
Gwangju
Changwon
Daegu
Pohang
Ulsan
Busan
KREONet2 / GLORIAD-KR
GLORIAD
KRLight

KISTI Supercomputing





- 5th Supercomputer (KISTI-5)
  - Processing: 25.7PF
    - Heterogonous: 25.3PF CS400 w/KNL
    - CPU: 0.4PF CS500 w/SKL
  - Storage
    - 20PB SPS
    - 10PB Archive
  - Schedule
    - Installing now
    - Service (2Q, 2018)

CDF Remote Control Room

CDF Operation Center

KISTI Remote Control Room

We take shifts at KISTI even if we are not at Fermilab.

Belle II Data Handling system

KOREA, 우주 기원 밝히는 '국제 거대실험' 주도

한국과학자, 세계 3대 가속기 이용 실험 '그룹장 역할 톡톡'

조기현 KISTI 박사, 'Belle II' 데이터 핸들링 그룹장 수행

▲ 고에너지물리 데이터 핸들링 분야 국가대표 연구팀. 문지혜 인턴연구원·남수현·조기현·김정현 박사(왼쪽부터)

©2010 HelloDD.com

특히 KISTI 기반기술개발실의 황순욱 박사가 개발한 데이터 핸들링 소프트웨어 'AMGA'를 응용, 안선일 박사(기반기술개발실)와 김정현 박사(고에너지물리연구팀)가 공동으로 Belle II에 적용될 새로운 개념의 데이터 핸들링 소프트웨어를 개발중이다. 지속적으로 성능을 입증할 경우 큰 무리 없이 600페타바이트(Petabyte) 데이터 용량을 다루는 Belle II 실험에 채택될 예정이다. 연구진에 따르면 600페타바이트는 슈퍼컴퓨터를 건물로 수백층 쌓아도 처리될까 말까한 수준이다. 10페타바이트가 CD를 2만km 쌓아올린 데이터 크기니, 600페타바이트면 120만km의 CD를 쌓아올린 용량과 맞먹는다.

파이낸셜뉴스

KISTI, 거대가속기 '데이터 핸들링'

YAHOO! KOREA 미디어

KISTI, 데이터 핸들링 시스

연간 10페타바이트 처리 능력… 국제

KISTI, 거대가속기 데이터 핸들링 시스템 개발

서울경제

디지털타임스

KISTI, 데이터 핸들링 시스템 개발

연간 10페타바이트 처리 능력… 국제 공동연구서 핵심역할 기대

사회 KISTI, 거대가속기 데이터 핸들링 시스템 개발

우주의 기원 밝히는 거대실험 주도

항공우주뉴스

[읽을꺼리들] KISTI, 거대가속기 데이터 핸들링 시스템개발

아시아경제

중앙일보 경제

KISTI, 거대가속기 데이터 핸들링 시스템 개발

KISTI-5 supercomputer

누리온
NURION

온 국민이
다 함께 누리는
슈퍼컴퓨터

KISTI-5 supercomputer

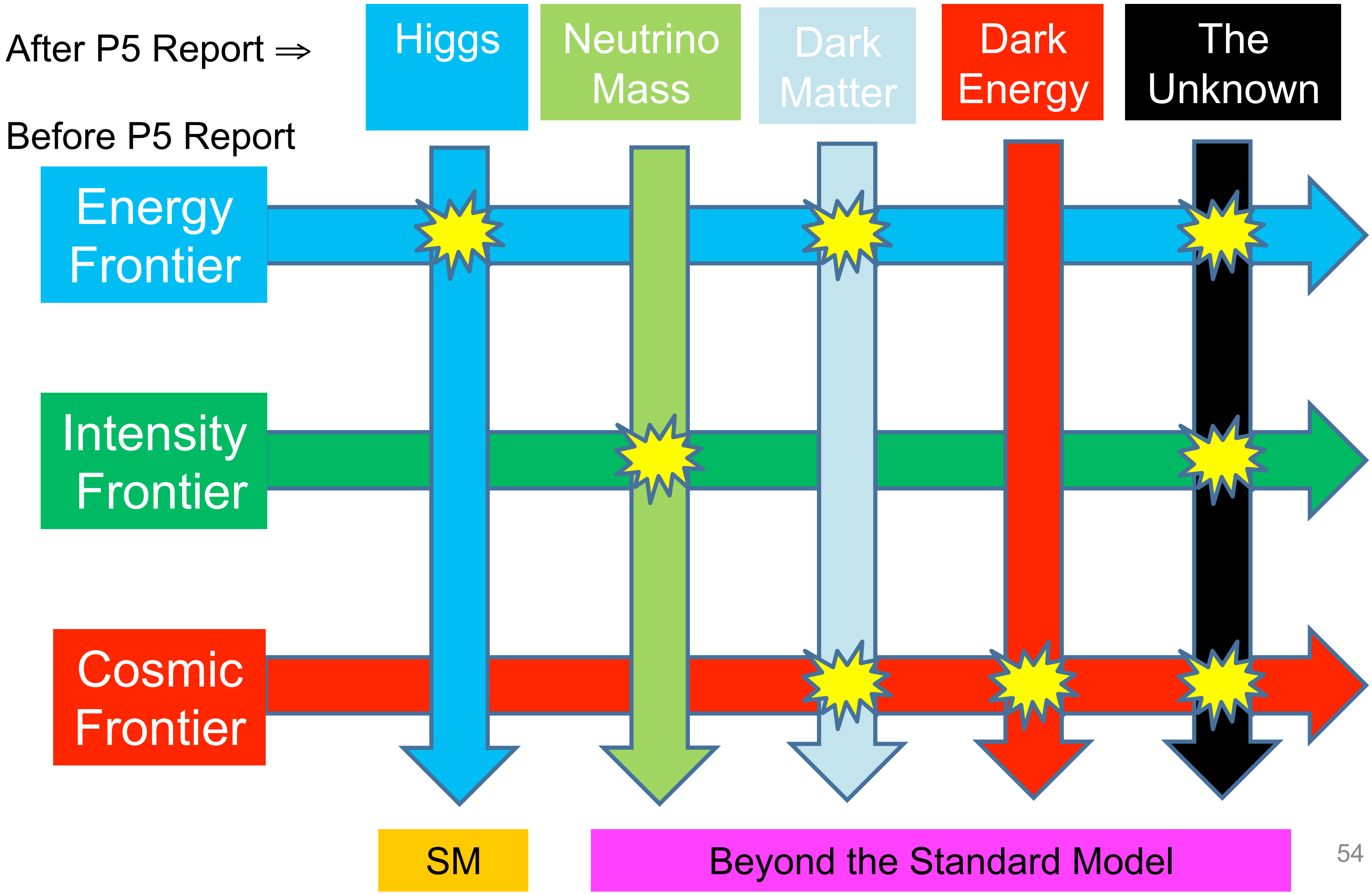
구분	소구분	계산노드	CPU-only 노드
모델명	시스템 모델명	Cray CS400	Cray CS500
	노드수	8,304 +1	132
	랙수	116	2
성능	이론성능	25.297306 PFLOPS	0.405504 PFLOPS
CPU (또는 가속기)	모델명	Intel Xeon Phi 7250 (KNL)	Intel Xeon 6148 (Skylake)
	CPU 이론 성능	3.0464 TFLOPS	1.536 TFLOPS
	CPU당 코어수	68	20
	노드당 CPU수	1	2
	on-package 메모리	16 GB, 490 GB/s	-
HCA	모델명	Intel 100HFA016LS	Intel 100HFA016LS
메인 메모리 (off-package)	메모리 모델	16 GB DDR4-2400	8 GB DDR4-2666
	메모리 구성	16GB x6, 6ch per CPU	8GB x12, 6ch per CPU
	노드 당 메모리 크기(GB)	96 GB	96 GB
	CPU와 메모리 간 대역폭	115.2 GB/s	128 GB/s
	전체 메모리 용량	778.50 TB	12.38 TB
로컬디스크	모델 및 노드당 용량	N/A	N/A
고성능 인터커넥트	토폴로지	FatTree	
	Blocking Ratio	50% Blocking	
	네트워크스위치	274x 48-port OPA edge switches 8x 768-port OPA core switches	
	포트당 단방향 대역폭	12.3 GB/sec	
	Bisectional Bandwidth	27,060 GB/sec	
Burst Buffer (BB)	서버수	DDN IME240서버 40대	
	노드 구성안(NVRAM, SSD)	NVMe SSD	
	전체 용량	0.8PB usable	
	서버당 대역폭	서버당 20 GB/sec, 전체는 0.8TB/s	
대용량 스토리지	**Scratch MDS**	DDN SFA7700X 1대, MDS 2대	
	Home/Apps MDS	DDN SFA7700X 1대, MDS 4대	
	Scratch OSS	DDN ES14KX 9대(각360 x 8TB장착)	
	Home/Apps OSS	DDN ES14KX 1대(각400 x 4TB 장착)	
	전체용량	20PB usable, RAID6 (8D+2P)	
	전체대역폭	0.3TB/s	

KISTI
www.kisti.re.kr
한국과학기술정보연구원

√ 멀티코어프로세서인 인텔 제온(Xeon) 스카이레이크(Skylake) 프로세서를 장착한 CPU 노드 — 0.4 PF

√ 매니코어프로세서인 인텔 제온 파이(xeon Phi) 나이츠랜딩(Knights Landing) 프로세서를 장착한 가속기 노드 — 25.3 PF

P5 Report (May 22, 2015)



HEP Simulation

Physics Model

⇩

Physics Simulation
(Ex. MadGraph)

⇩

Event Simulation
(Ex. PHYTHIA)

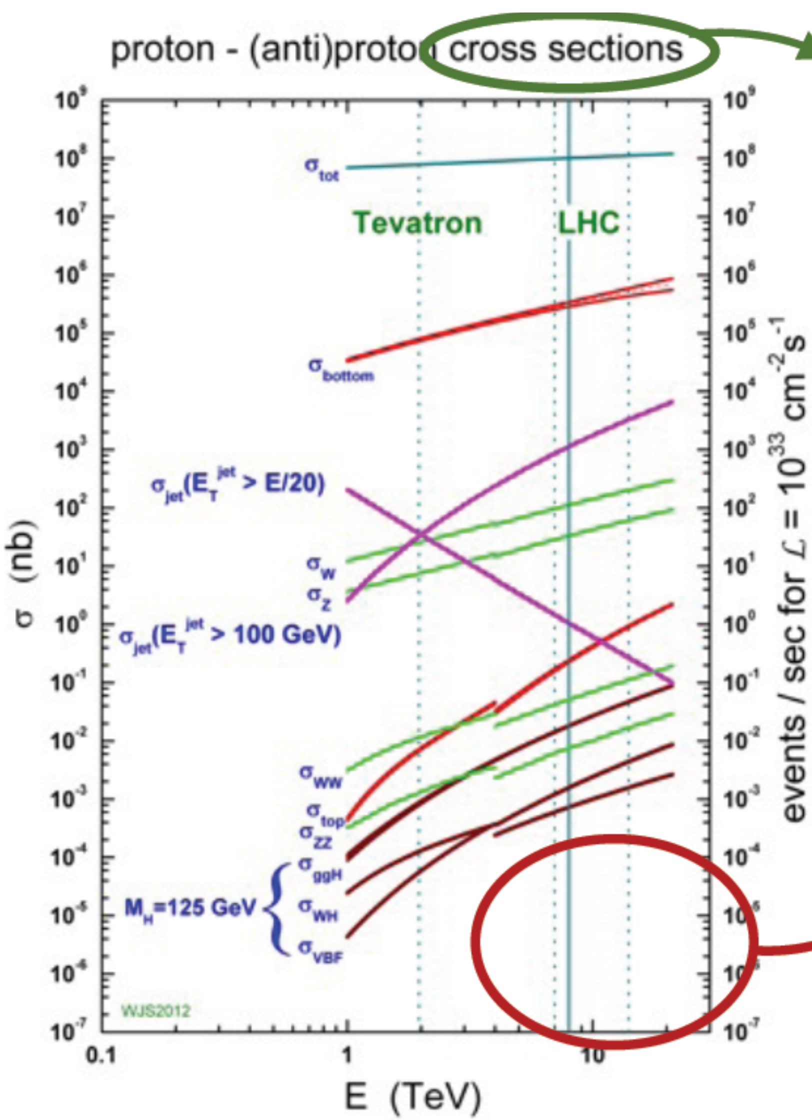
⇩

Detector Simulation
(Ex. Geant4)

⇩

Analysis Tool
(Ex. ROOT)

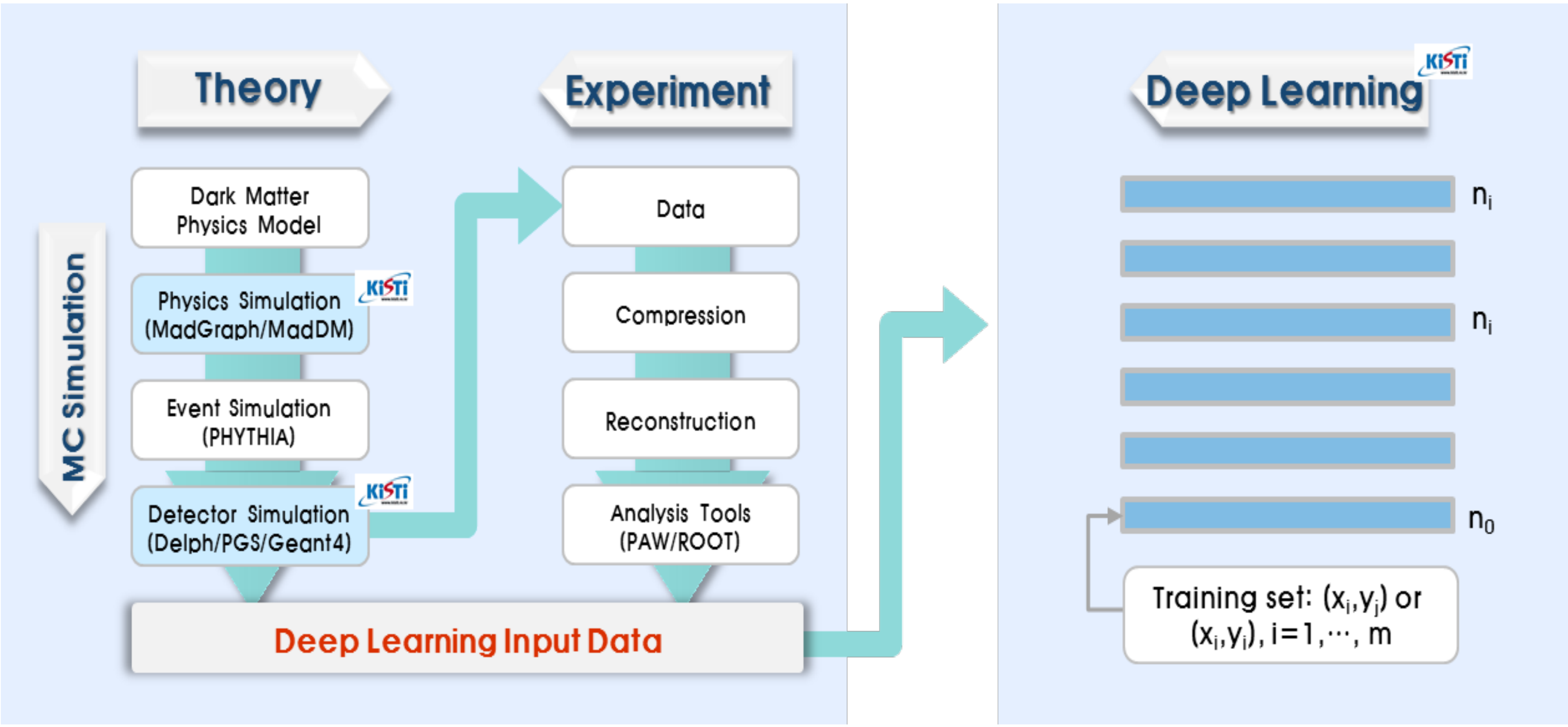
Beyond the Standard Model



= production rate: to be calculated

- This is where any new phenomenon would hide
  - Supersymmetry
  - Extra-dimensions
  - Grand-Unified Theories
  - *etc.*
- Cross sections = production rate
  - 1 possible new physics event (if any)
  - 1.000 Higgs events
  - 1.000.000.000.000 Standard Model events

Deep Learning



Thank you.

cho@kisti.re.kr