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San Francisco, USA

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

Dark Matter Research Cluster based on Computational Science

2016. 10. 10 ~ 14

Kihyeon Cho(KISTI)

Dark Matter Research Cluster

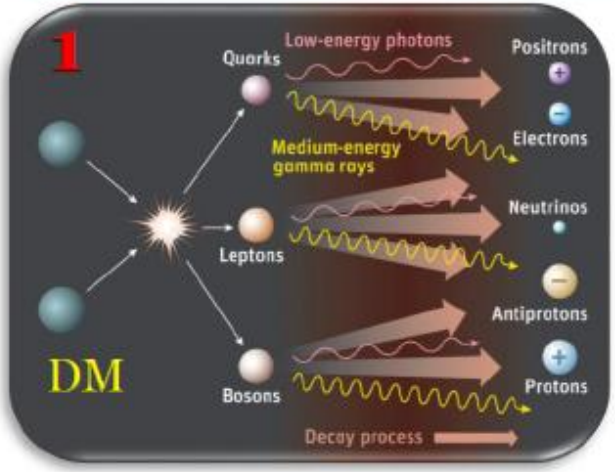
Project

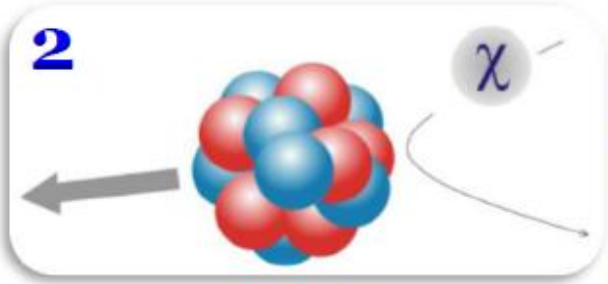
Title	Dark Matter Research Cluster
Leader	Kihyeon Cho
Host Institute	KISTI
Partner Institutes	KASI and 14 Institutes
Fund	50,000,000 won/year * 2years
Period	2015.9.23~2017.9.22
Sponsor	NST (National Council of Science and Technology)

Goal

- To make a national project where most of Korean research community working in the field of dark matter
- To make synergies and collaborations among the participating groups for searching dark matter in experiments and theories
- To study the plausible dark matter candidates and the evolution in the Universe
  - to support and analyze the experiments for its detection

Dark Matter Search

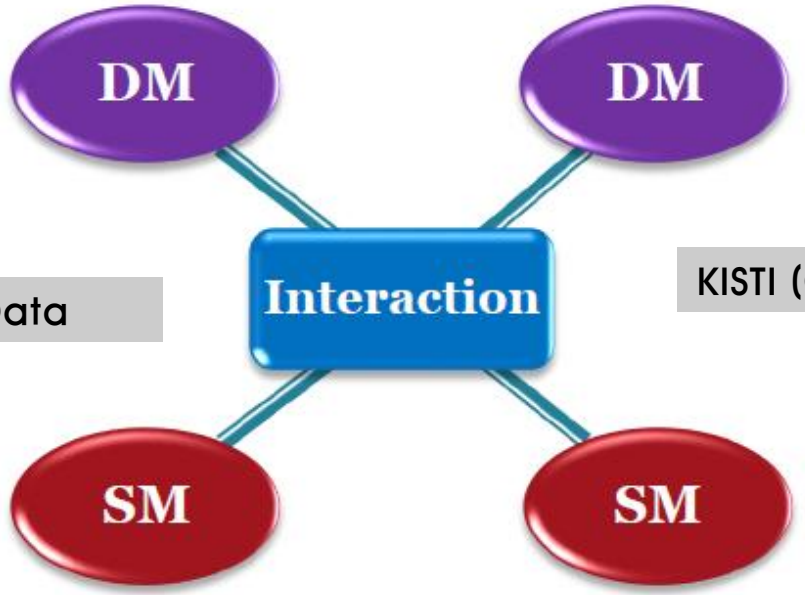




2 Direct

Indirect

KASI ⇒ Astronomical Data



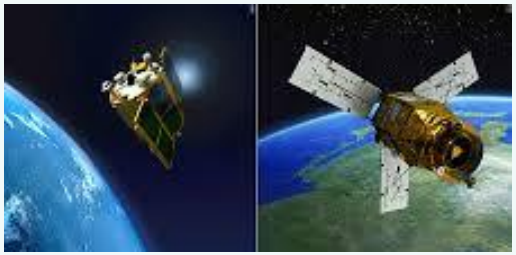
Collider

KISTI (GSDC) ⇒ Collider Data

Prof. J.C. Park

➲ Dark Matter Research Cluster

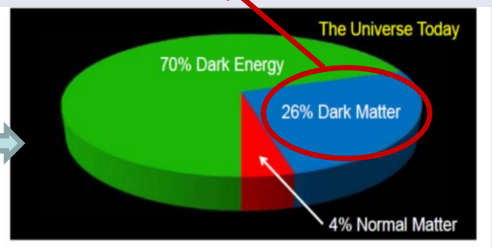
➢ From Collider to Astronomy



KASI ⇒ Astronomical Data

KISTI (GSDC) ⇒ Collider Data

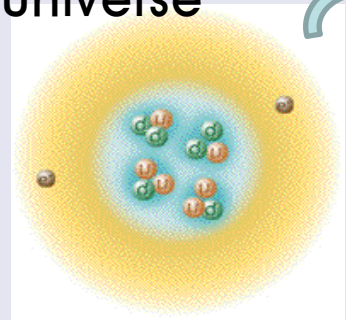
Dark Matter

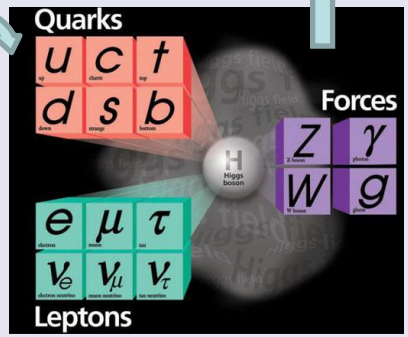


Standard Mode

Evolution of Universe

Components





Origin of Matter

Standard Model

Universities (Students)

Strategy

Goal

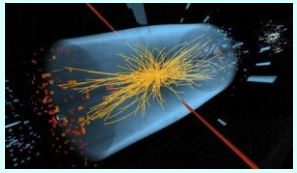
Enabling discovery on Dark Matter

Fusion Research

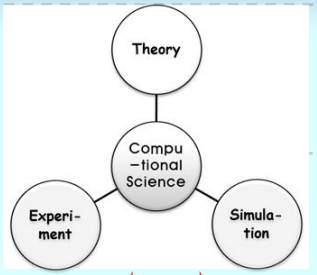
Content

Accelerator

- Experiment
- Theory
- Simulation



KISTI



Universities

Cosmology

- Observation
- Theory
- Simulation

KASI

Computational Science

Big Data

Belle/Belle II Date, MC simulation, Astronomical Data, etc.

Infra-structure (KISTI)

Supercomputer, GSDC, KREONET, GLORIAD

Observatory

Infra-structure (KASI)

What we need for Dark Matter Research

– Computational Science

Computational Science

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

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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

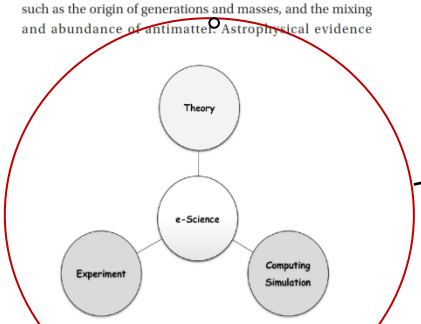

Fig. 1. Paradigm of e-Science in astroparticle physics represented as a unification of experiment, theory, and computing.

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➲ Theory – Experiment – Simulation

=> computational Science

From Experiment

- Person Power:
  - Dedicated team/scientists for DM search for HW/SW
- Networking
  - Networking for both Korea experimentalists in local and international institutions in DM search experiments (in Indirect, Direct and Colliders)
  - Regular workshop including international workshop
  - Enhancement communication between experimental and theoretical community

    ⇒ brain-storming to new ideas
- Computing resources for big data :
  - HPC (High-Performance Computing) for MC
  - Storage for experimental data and theoretical model

Prof. H.D. Yoo & Y. Kwon

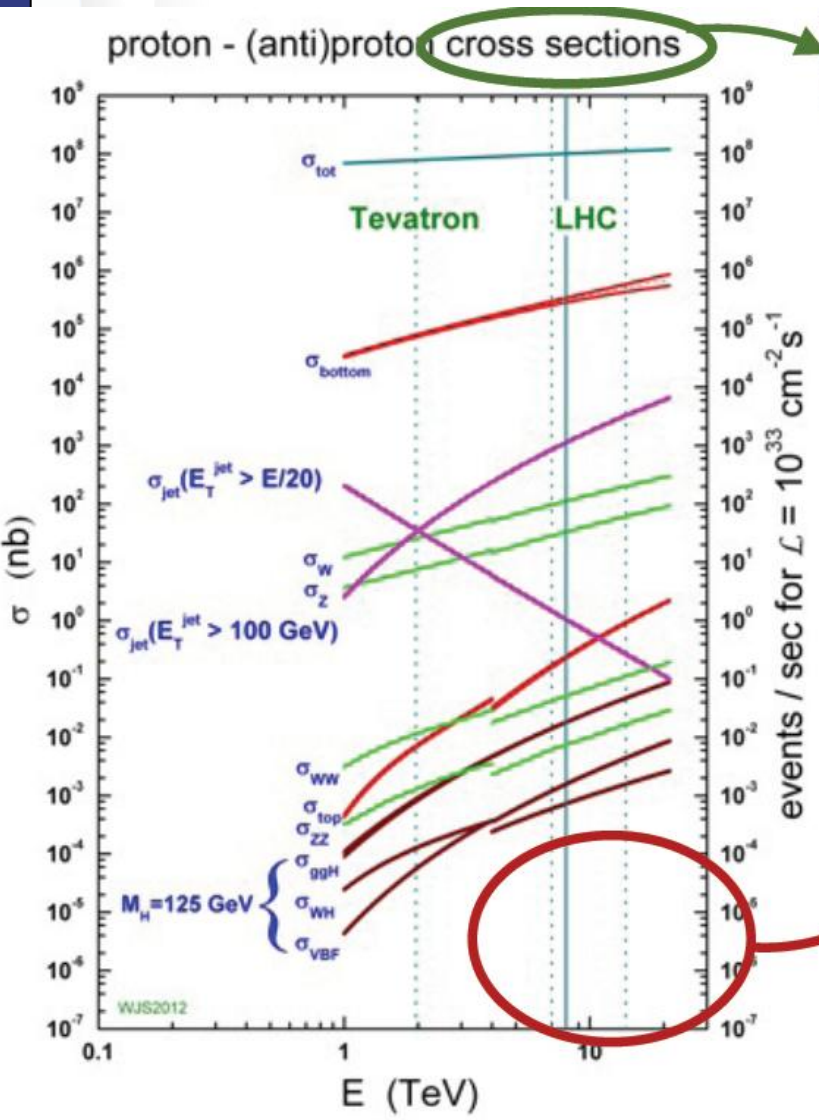
From Theory

- Rapid update & sharing of information
  - Key point summary DB site by specialists
  - Regular meeting, Network Feedback between experimentalists and theorists

  ⇒ Through a (new) center
- Rapid & Easy comparing check of theoretical model
  - Development of new numerical package
  - Computing power and Person power ⇒ new jobs
- Cross check with astrophysics (theoretical model)
  - N– body simulation
  - Discussion with Dark Energy survey group

Prof. J.C. Park

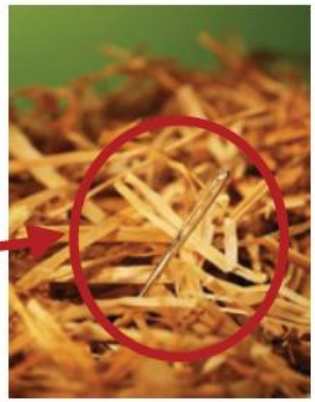
From simulations

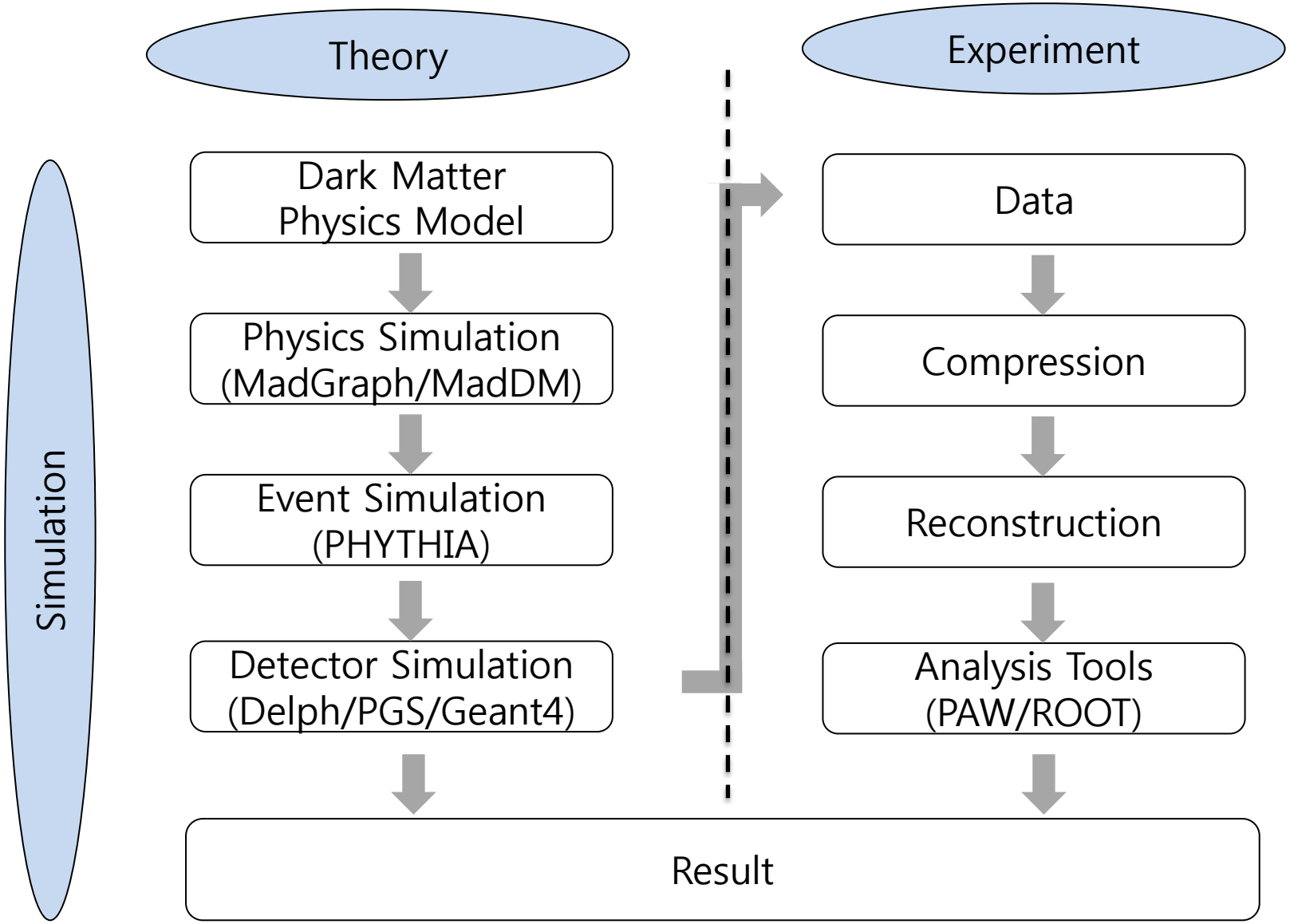


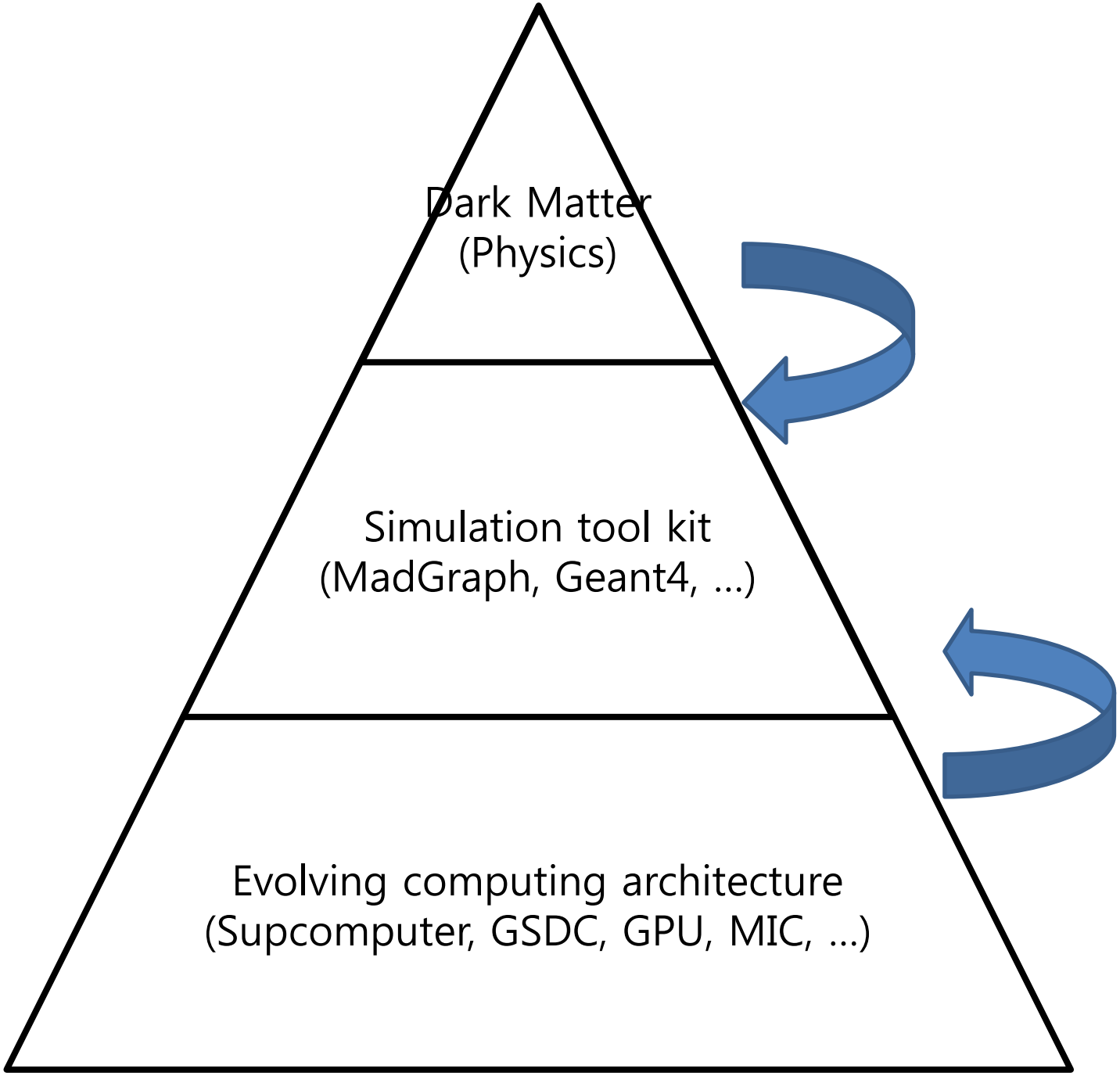
= production rate: to be calculated

- 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

Dark Matter




Theory
Experiment
Simulation
Dark Matter
Physics Model
Physics Simulation
(MadGraph/MadDM)
Event Simulation
(PHYTHIA)
Detector Simulation
(Delph/PGS/Geant4)
Data
Compression
Reconstruction
Analysis Tools
(PAW/ROOT)
Result


Dark Matter
(Physics)
Simulation tool kit
(MadGraph, Geant4, …)
Evolving computing architecture
(Supcomputer, GSDC, GPU, MIC, …)

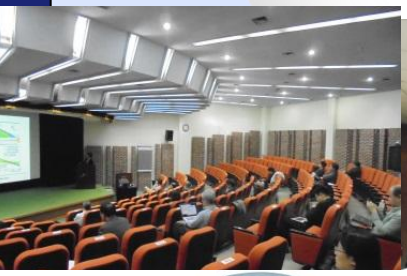
Vision for Dark Matter Simulation

- To have a massively parallelized particle transportation engine
- To comply with different architecture (GPU, MIC and etc.)
- To draw community interests for collateral effort
  - ⇒ Dark Matter Research Cluster

Summary

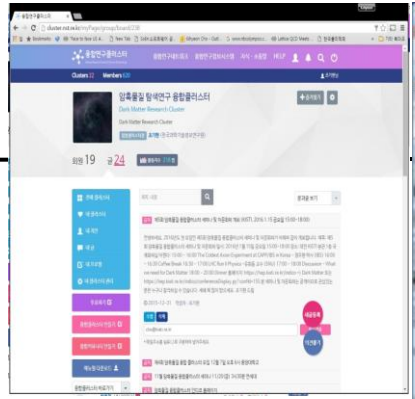
Meetings

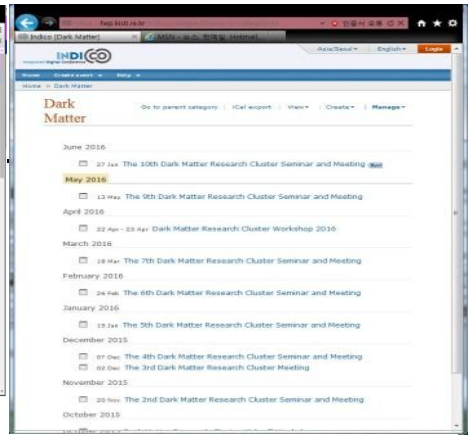
- Seminar and Meeting: once per month
- Dark Matter Research Cluster Kickoff workshop
  - KISTI, October 27, 2015, 2:00–6:00 PM
- 2016 Dark Matter Cluster Workshop
  - KISTI, April 22–23, 2016
  - Yangyang, July 20~21, 2016
- 2016 Joint workshop on France–Korea and France–Japan Particle Physics Workshop
  - KIAS, May 18~20, 2016
  - ~100 persons from France, Japan, China,



Outreach

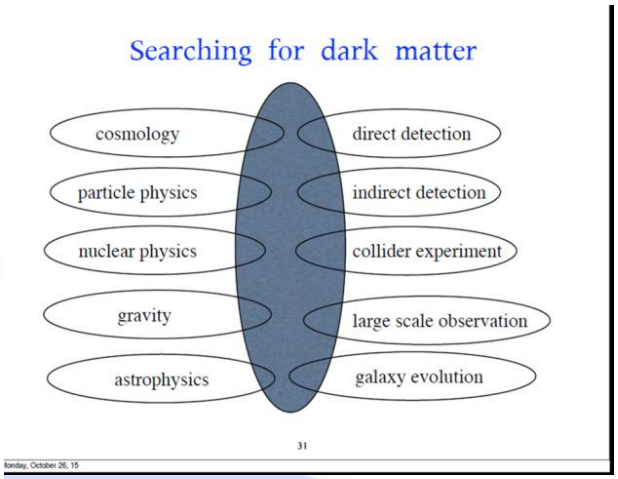
- Home pages
  - http://cluster.nst.re.kr
  - https://hep.kisti.re.kr/indico
    - ⇒ Dark Matter Portal
- Advertisement (panel, conference)
- Dark Matter Research White Paper
  - SCOPUS Journal(KPS) Special Edition
  - 2016. 8.31

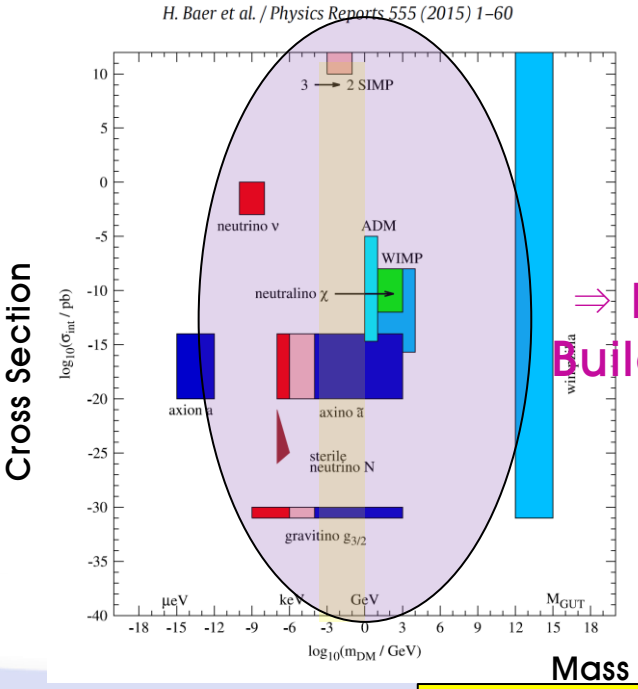




Plan

- White Paper(SCOPUS Journal) ⇒ Proposal (NST)
- Computing Resources ⇒ GSDC
- Koreas Supercomputing Conference (Seoul '16.10.5~7)
  - Dark Matter research cluster Session
- Dark Matter Research Cluster ⇒ National Multi-Dark





⇒ Network Building

Prof. K.Y. Choi