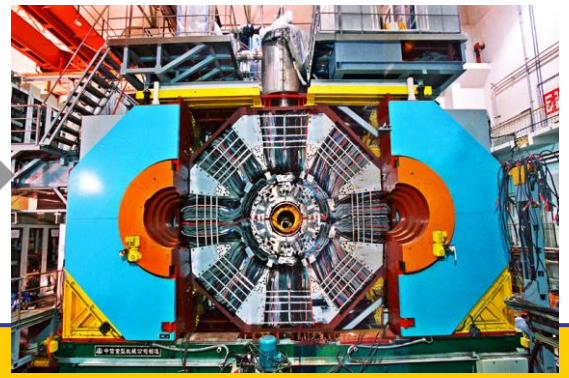
BESIII Data Preservation

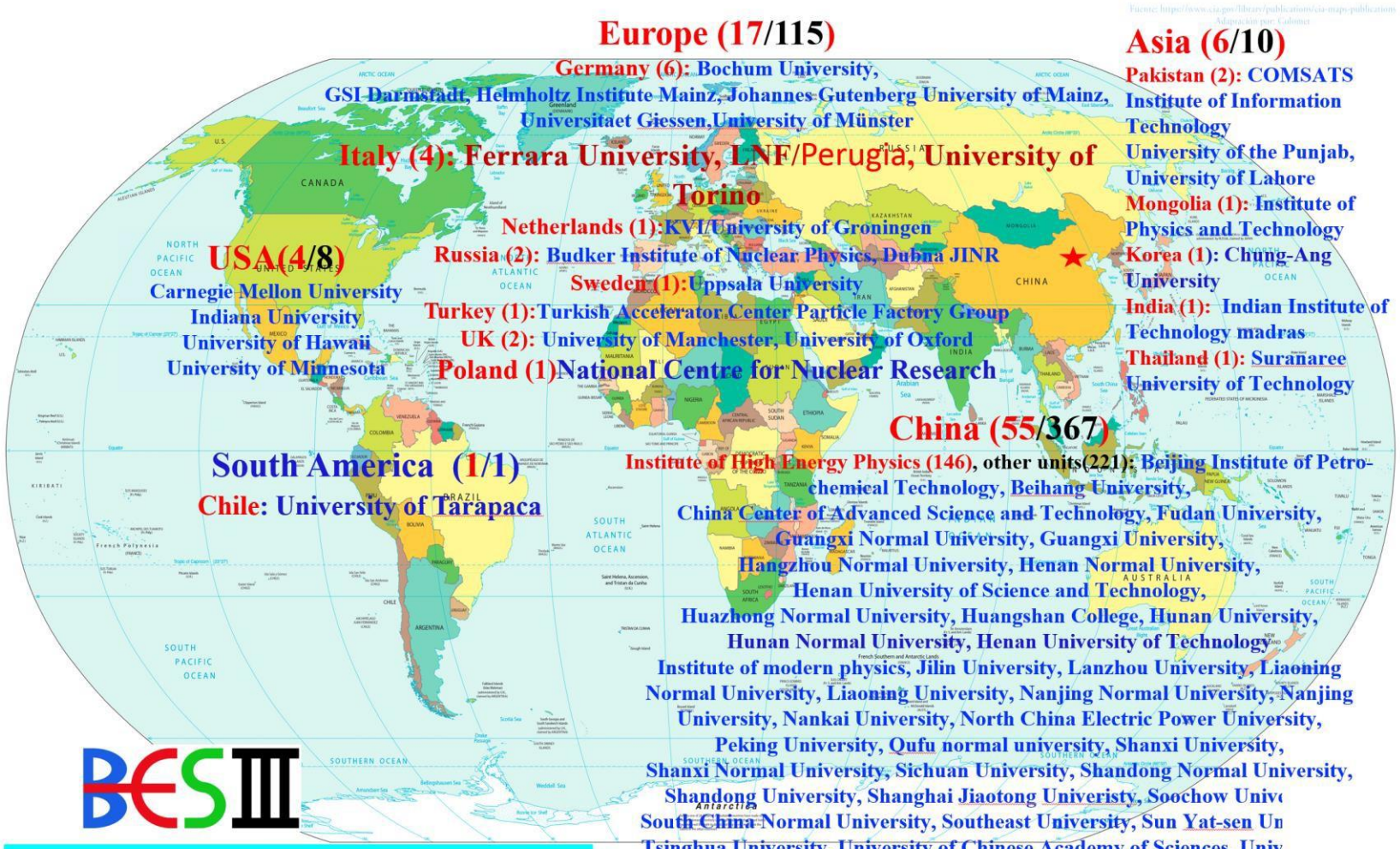
Gang Chen, Beijiang Liu
IHEP

BESIII/BECPII

- BEPC: Beijing Electron Positron Collider
  - Started in 1989, and upgraded to BEPCII in 2004
  - Dual-Ring, 2~5GeV/C
  - Luminosity $(3\sim10)\times10^{32}$ $cm^{-2}s^{-1}$
- BES: Beijing Spectrometer
  - Upgraded to BESIII with BEPCII
  - Data-taking from May 2004
  - Decommission in 2030



BESIII Collaboration



Europe (17/115)

Germany (6): Bochum University, GSI Darmstadt, Helmholtz Institute Mainz, Johannes Gutenberg University of Mainz, Universitaet Giessen,University of Münster

Italy (4): Ferrara University, LNF/Perugia, University of Torino

Netherlands (1):KVI/University of Groningen

Russia (2): Budker Institute of Nuclear Physics, Dubna JINR

Sweden (1):Uppsala University

Turkey (1):Turkish Accelerator Center Particle Factory Group

UK (2): University of Manchester, University of Oxford

Poland (1)National Centre for Nuclear Research

USA(4/8)

Carnegie Mellon University

Indiana University

University of Hawaii

University of Minnesota

South America (1/1)

Chile: University of Tarapaca

Asia (6/10)

Pakistan (2): COMSATS Institute of Information Technology

University of the Punjab, University of Lahore

Mongolia (1): Institute of Physics and Technology

Korea (1): Chung-Ang University

India (1): Indian Institute of Technology madras

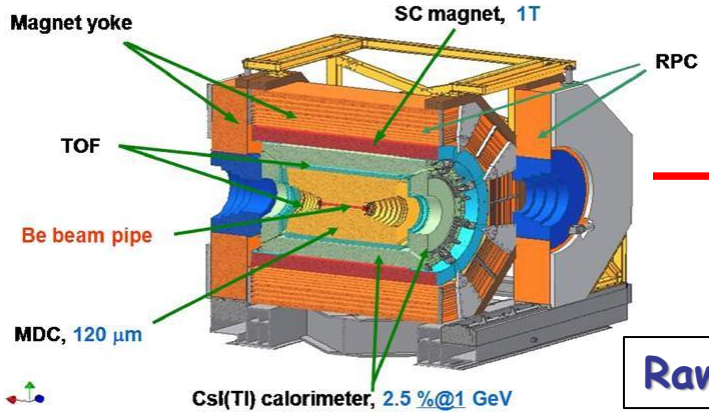
Thailand (1): Suranaree University of Technology

China (55/367)

Institute of High Energy Physics (146), other units(221): Beijing Institute of Petro-chemical Technology, Beihang University, China Center of Advanced Science and Technology, Fudan University, Guangxi Normal University, Guangxi University, Hangzhou Normal University, Henan Normal University, Henan University of Science and Technology, Huazhong Normal University, Huangshan College, Hunan University, Hunan Normal University, Henan University of Technology, Institute of modern physics, Jilin University, Lanzhou University, Liaoning Normal University, Liaoning University, Nanjing Normal University, Nanjing University, Nankai University, North China Electric Power University, Peking University, Qufu normal university, Shanxi University, Shanxi Normal University, Sichuan University, Shandong Normal University, Shandong University, Shanghai Jiaotong Univeristy, Soochow Univ, South China Normal University, Southeast University, Sun Yat-sen Un, Tsinghua University, University of Chinese Academy of Sciences, Univ Jinan, University of Science and Technology of China, University of Science and Technology Liaoning, University of South China, Wuhan University, Xinyang Normal University, Zhejiang University, Zhengzhou University,YunNan University , China University of Geosciences , Yantai University,

~600 members
From 83 institutions in 16 countries

Data Analysis Model



Raw data on disk
(All, Bhabha, Dimu.,
Random trigger …)
.raw

Raw data on tapes

Detector Calibration

Detector Simulation

.rtraw,
ROOT

Offline Reconstruction (DST Production)

.dst,
ROOT

Background Mixing
(with random trigger events)

.raw

Physics Skimming (nprong, DTag, …)

.dst,
ROOT

Reconstruction

.dst,
ROOT

User Analysis

BESIII Data and software

- 1.8 PB raw data collected up to 2023.
- 3.6 PB reconstructed data and MC data correspond to three different versions of BOSS (BESIII Offline Software System).
- BEPCII is being upgraded and the luminosity will be increased.
  750 TB/year of raw data will be collected from 2024.

Data preservation

- BESIII adopts DPHEP Level-4 model
  - The full potential of data
    - RAW, DST (data, incl.MC),
    - metadata (calibration databases, ……),
    - software, documents
  - Adhere to the FAIR principles

DPHEP Collaboration: T. Basaglia, M. Bellis J. Blomer et al.: Data Preservation in High Energy Physics
Eur.Phys.J.C 83 (2023) 9, 795

Level	Model	Use Case
1	Provide additional information	Publication-related information search
2	Preserve the data in simplified form	Outreach, simple training analysis
3	Preserve the analysis-level software and data format	Full scientific analysis based on existing reconstruction
4	Preserve the reconstruction and simulation software and raw data	Full potential of the experimental data

Data preservation (cont.)

Tasks	
Data	• Raw: data • DST: data/ incl. MC
Metadata	• Databases • Bookkeeping
Documents	HN, docdb, webpages, indico, codes, ……
Software	• System • Analysis framework • External libs

Needs

Storage
- With checksum
- Long time

Containers
- Virtualization
- No longer maintenance

To-do

- Define the requirements
- Develop a prototype
  - Storage services
  - Containers with orchestration
  - Verification tools
- Get the resources

However, permanently preserved does not mean practically useable
- Large scale resources for now are not forever (20000 CPU cores, …)
- Lack of expertise with BESIII specific detailed information

Bit preservation

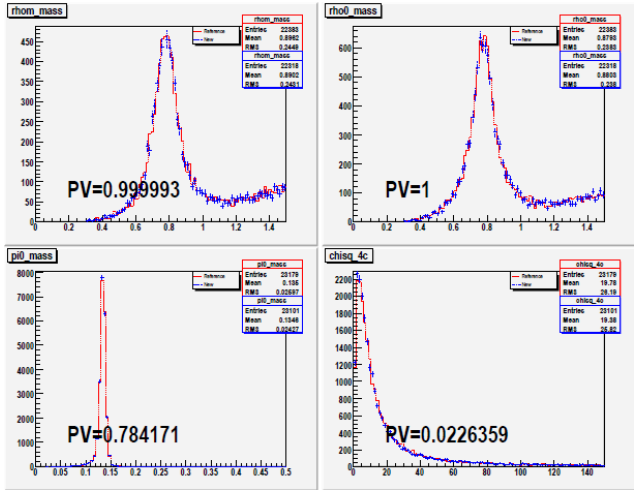
- Media: Tape LTO9, IBM-3584 tape library
- Raw data/Random trigger data:
  - Flows from on-line farm to tape directly,
  - A copy on disk after reconstruction.
- Rec/DST/skimmed DST/tag data :
  - Replicated from disk to tape when a certain software version is stable.
- Condition/document databases:
  - Snapshots are copied to tape routinely
- Integrity check
  - A MD5 integrity check is done when data is copied from disk to tape
- Annual examination of tape library and LTO9 tapes

Software preservation

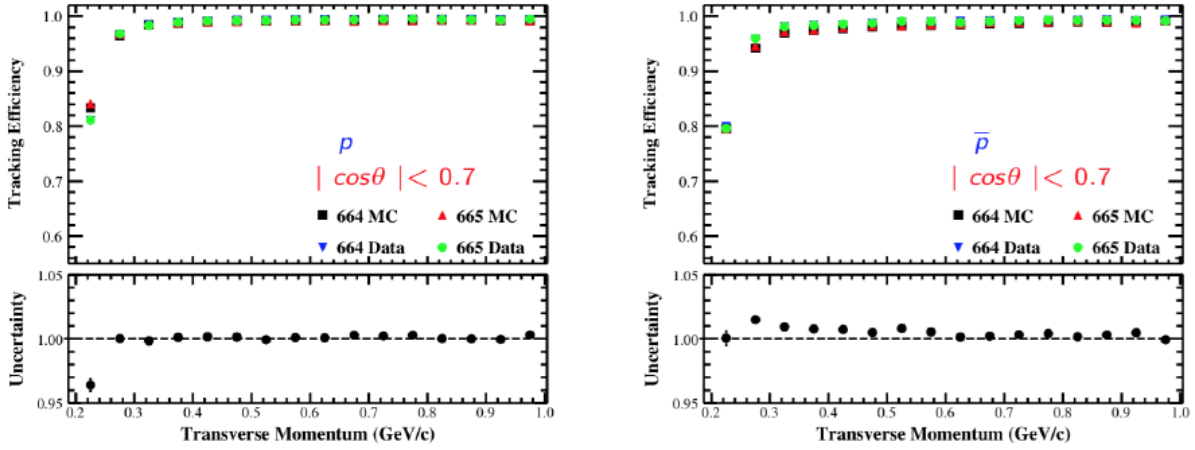
- BOSS is an integrated software package that includes all the blocks required in BESIII data processing.
  - Simulation, reconstruction, calibration, analysis…
  - functions could be preserved all together in a package
- The stable versions of BOSS are preserved following items:
  - A complete package of software,
  - A runnable virtual machine image
  - The puppet template and RPM repository from which a runnable OS is created,
  - Release documents, bookkeeping parameters…
- Functional validation is done according to the standard software release process.

Validation Process

- Several MC data samples are generated to do MC validation
  - For example, Jpsi to Rhopi, KsKpi, ee, mumu, ppbar
- Related data samples are reconstructed to check the consistency between MC and real data

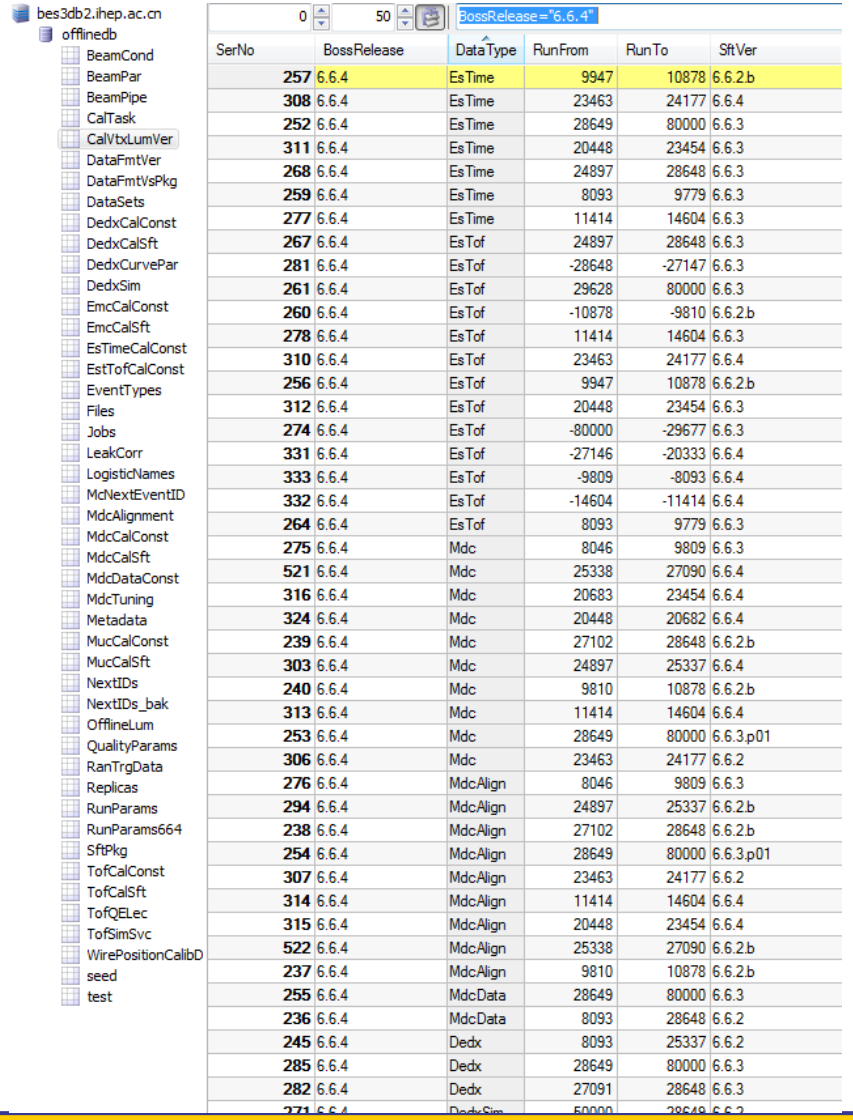


Jpsi to Rhopi



Tracking efficiency between BOSS 6.6.5 and 6.6.4

Bookkeeping for calibration constants



SerNo	BossRelease	DataType	RunFrom	RunTo	SftVer
257	6.6.4	EsTime	9947	10878	6.6.2.b
308	6.6.4	EsTime	23463	24177	6.6.4
252	6.6.4	EsTime	28649	80000	6.6.3
311	6.6.4	EsTime	20448	23454	6.6.3
268	6.6.4	EsTime	24897	28648	6.6.3
259	6.6.4	EsTime	8093	9779	6.6.3
277	6.6.4	EsTime	11414	14604	6.6.3
267	6.6.4	EsTof	24897	28648	6.6.3
281	6.6.4	EsTof	-28648	-27147	6.6.3
261	6.6.4	EsTof	29628	80000	6.6.3
260	6.6.4	EsTof	-10878	-9810	6.6.2.b
278	6.6.4	EsTof	11414	14604	6.6.3
310	6.6.4	EsTof	23463	24177	6.6.4
256	6.6.4	EsTof	9947	10878	6.6.2.b
312	6.6.4	EsTof	20448	23454	6.6.3
274	6.6.4	EsTof	-80000	-29677	6.6.3
331	6.6.4	EsTof	-27146	-20333	6.6.4
333	6.6.4	EsTof	-9809	-8093	6.6.4
332	6.6.4	EsTof	-14604	-11414	6.6.4
264	6.6.4	EsTof	8093	9779	6.6.3
275	6.6.4	Mdc	8046	9809	6.6.3
521	6.6.4	Mdc	25338	27090	6.6.4
316	6.6.4	Mdc	20683	23454	6.6.4
324	6.6.4	Mdc	20448	20682	6.6.4
239	6.6.4	Mdc	27102	28648	6.6.2.b
303	6.6.4	Mdc	24897	25337	6.6.4
240	6.6.4	Mdc	9810	10878	6.6.2.b
313	6.6.4	Mdc	11414	14604	6.6.4
253	6.6.4	Mdc	28649	80000	6.6.3.p01
306	6.6.4	Mdc	23463	24177	6.6.2
276	6.6.4	MdcAlign	8046	9809	6.6.3
294	6.6.4	MdcAlign	24897	25337	6.6.2.b
238	6.6.4	MdcAlign	27102	28648	6.6.2.b
254	6.6.4	MdcAlign	28649	80000	6.6.3.p01
307	6.6.4	MdcAlign	23463	24177	6.6.2
314	6.6.4	MdcAlign	11414	14604	6.6.4
315	6.6.4	MdcAlign	20448	23454	6.6.4
522	6.6.4	MdcAlign	25338	27090	6.6.2.b
237	6.6.4	MdcAlign	9810	10878	6.6.2.b
255	6.6.4	MdcData	28649	80000	6.6.3
236	6.6.4	MdcData	8093	28648	6.6.2
245	6.6.4	Dedx	8093	25337	6.6.2
285	6.6.4	Dedx	28649	80000	6.6.3
282	6.6.4	Dedx	27091	28648	6.6.3
271	6.6.4	DedxSim	50000	28648	6.6.2

- Calibration constants and tuning parameters of each sub-detector are got from database according to run number
- A complete set of calibration constants and tuning parameters are set in a table in database for each BOSS Release, to make sure the production of simulated data and reconstruction are reproducible

Data ecosystem: to use the data

- Core capabilities for data-driven science: storage, access, transfer, process, analysis
  - Build with existing technologies while supporting new tech., e.g. AI
- Long time preservation
- Seamless Data and Compute Infrastructure
  - Flexibility with resources and support of time-critical tasks

Technical Concept

System services
- Containers
- Orchestration
- User APIs

Data services
- Data catalog
- Data management
- Storage interface

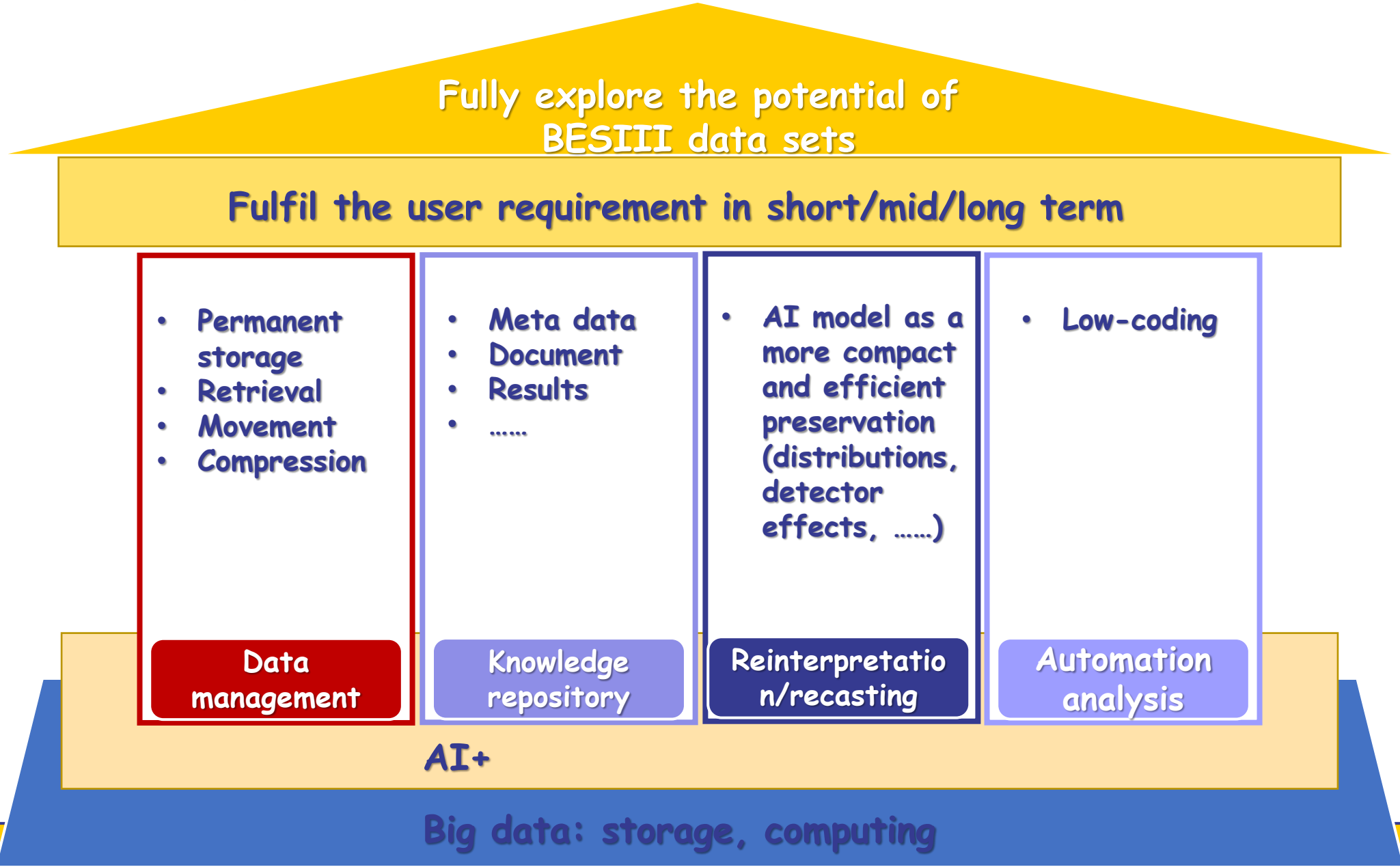
Storage
- Composable
- High-performance/hot data
- Stable/cold data

Computing
- CPU standard units
- GPU standard units
- Dynamical configuration

⇔

Interface to National Data Center
- APIs
- Network
- Infrastructure

AI-empowered data ecosystem for BESIII

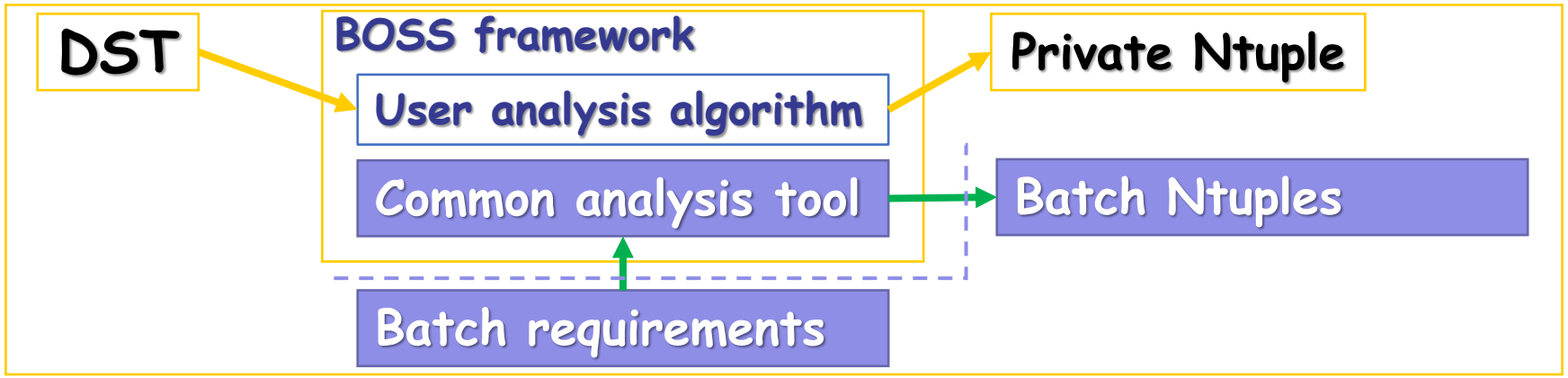


Data ecosystem: to use the data easily

Further development: Common analysis tool

- User-friendly: as a middleware
  - Produce physics information without knowing DST and BOSS
  - Many options. FSFilter can be a good start

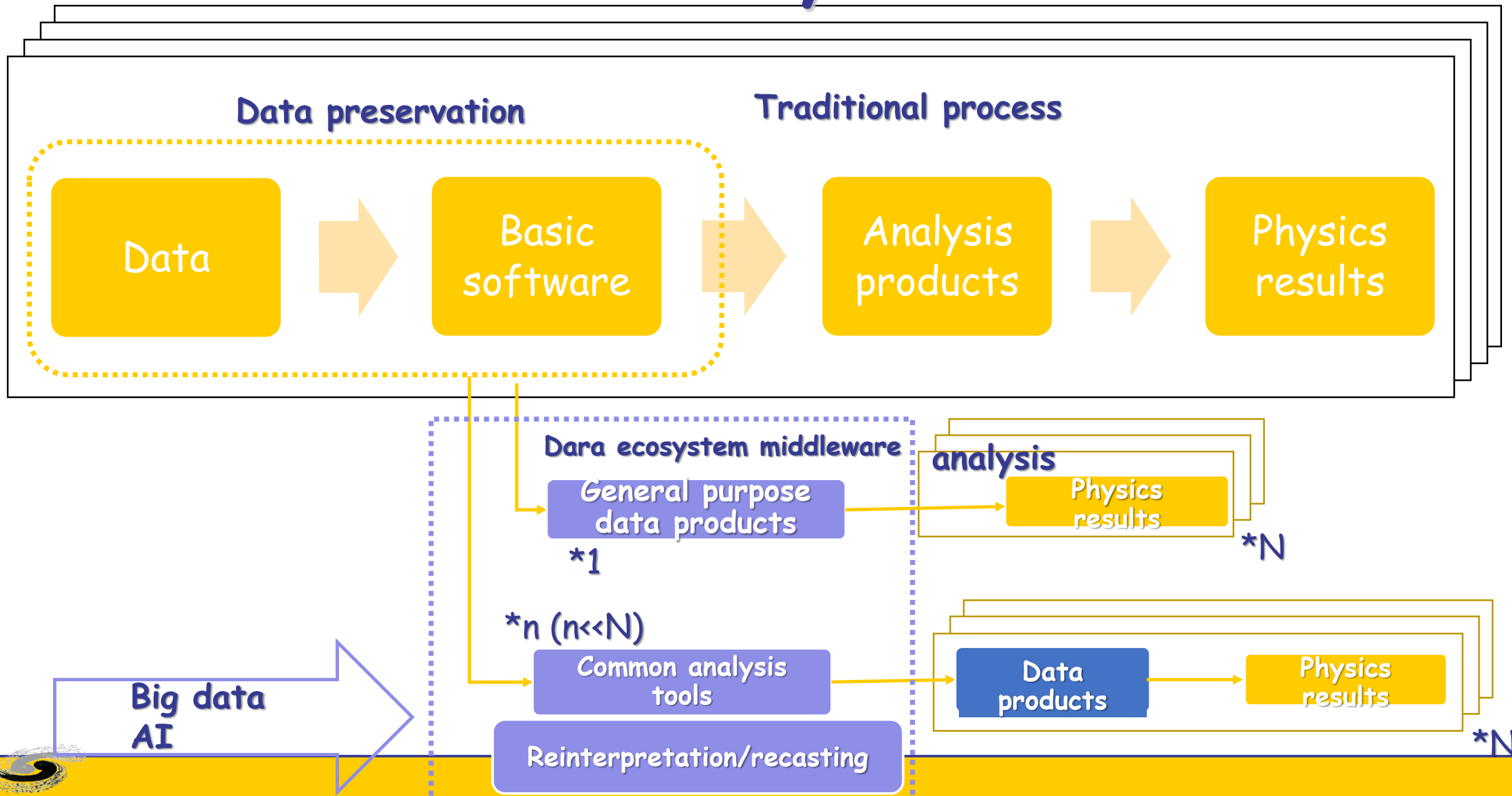
A simple example
(minimum R&D)



- Higher performance: faster I/O, reduced throughput, …
- Possibility for workflow automation

This can be applied to the current analyses

Data ecosystem



Goals and progress

- Goals
  - 1-3 years:
    - develop baseline design for data preservation
    - R&D of the data ecosystem
    - establish costs and get more funds for R&D
  - 3-5 years:
    - develop baseline design for the full data ecosystem
    - Build it, test it and get ready
- Progress
  - Initial discussion with BESIII Publication Committee
  - Formal discussions with the National HEP Data Center (run by IHEP)
  - Started a task force
  - Applied for new funding from IHEP

国家高能物理科学数据中心
National HEP Data Center

Committee for BESIII data ecosystem

- A commitment of data preservation to the collaboration and the community
- Collective intelligence
  - Define the strategy to fulfil the need for the collaboration
  - Expertise to solve key issues
  - Develop the guidelines for data usage after BESIII shutdown
    - Members/global fits/theorists/…
  - Outreach
- Coordinate the resource collaboration-wide (mainly manpower)

Timeline

2024-2030

BESIII data taking

- Data analysis by BESIII collaboration groups
- Current computing resources

- DPHEP level 4
- Research for future data structure

2030-2035

BESIII shutdown

- BESIII groups / Global fit
- Limited resources (local+cloud)

- Fast data search and I/O
- AI-based data compression

2035-

Virtual BESIII

- BESIII groups / Global fit
- Analysis on demand

- AI-based automatic data analysis
- Integrate to large data ecosystem

IHEP will establish a dedicated project to support the BESIII data preservation.
We are also seeking more supports from funding agencies.

Thanks