Karlsruhe Institute of Technology

Current status of data center for cosmic rays based on KCDC

Face-to-face project meeting, Karlsruhe

Victoria Tokareva, Andreas Haungs | October 30, 2018

INSTITUTE FOR NUCLEAR PHYSICS (IKP)

German-Russian Astroparticle Data Life Cycle Initiative*

Karlsruhe Institute of Technology

НИИЯФ МГУ

TAIGA

Karlsruher Institut für Technologie — Institut für Kernphysik

Иркутский государственный университет 1918

RSF Russian Science Foundation

HELMHOLTZ ASSOCIATION

SCC Steinbuch Centre for Computing

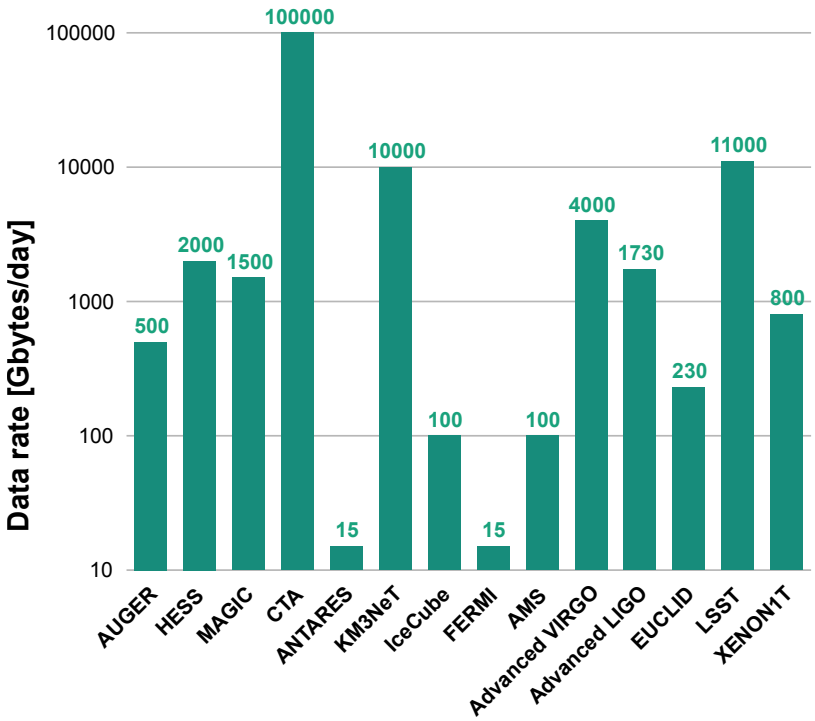
Matrosov Institute for System Dynamics and Control Theory

KASCADE - Grande

KArlsruhe Shower Core and Array DEtector - Grande

*Granted by RSF-Helmholtz Joint Research Groups

Introduction:
The astroparticle physics data rate



Modern astroparticle experiments data rate [Gbytes/day]*

- More than hundred years of cosmic particle measurements;
- Looking at the same sky with different detectors;
- Common data rate for astrophysical experiments all together is a few PBytes/yeary, which is comparable to the current LHC output*
- Big data for deep learning

*Berghöfer T., Agrafioti I. et all. Towards a model for computing in European astroparticle physics, Astroparticle Physics European Coordination committee, 2016

Astroparticle data life cycle features

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- But not too many events of our interest;
  $\Rightarrow$ combined analysis of data from different experiments becomes topical;
- Astronomical Virtual Observatories (Auger & IceCube data).

KASCADE-Grande

- Proposed in 1989—disassembled in 2013;
- Aimed at studying high-evergy (galactic) cosmic rays by observing extensive air showers (EAS);
- Consisted of:
  - scintillators detecting e, γ, μ:
    - KASCADE—256 stations;
    - GRANDE—37 stations;
  - Hadronic callorimeter;
  - Digital radio array LOPES detecting e, e^+;
- Important features of cosmic-ray spectrum have been obtained. The data analysis is ongoing;
- KCDC (**K**ASCADE **C**osmic Ray **D**ata **C**enter, http://kcdc.ikp.kit.edu) is a dedicated portal where all the data collected are available online.

TAIGA

- Started in the mid 90s, is still operating and continiously enhancend

Tunka-133

- 133 photomultipliers
- measures EAS Cherenkov light

Tunka-Rex

- 63 antennas
- measures EAS radio-emission

Tunka-HiSCORE

- 47×4 photomultipliers
- measures EAS Cherenkov light

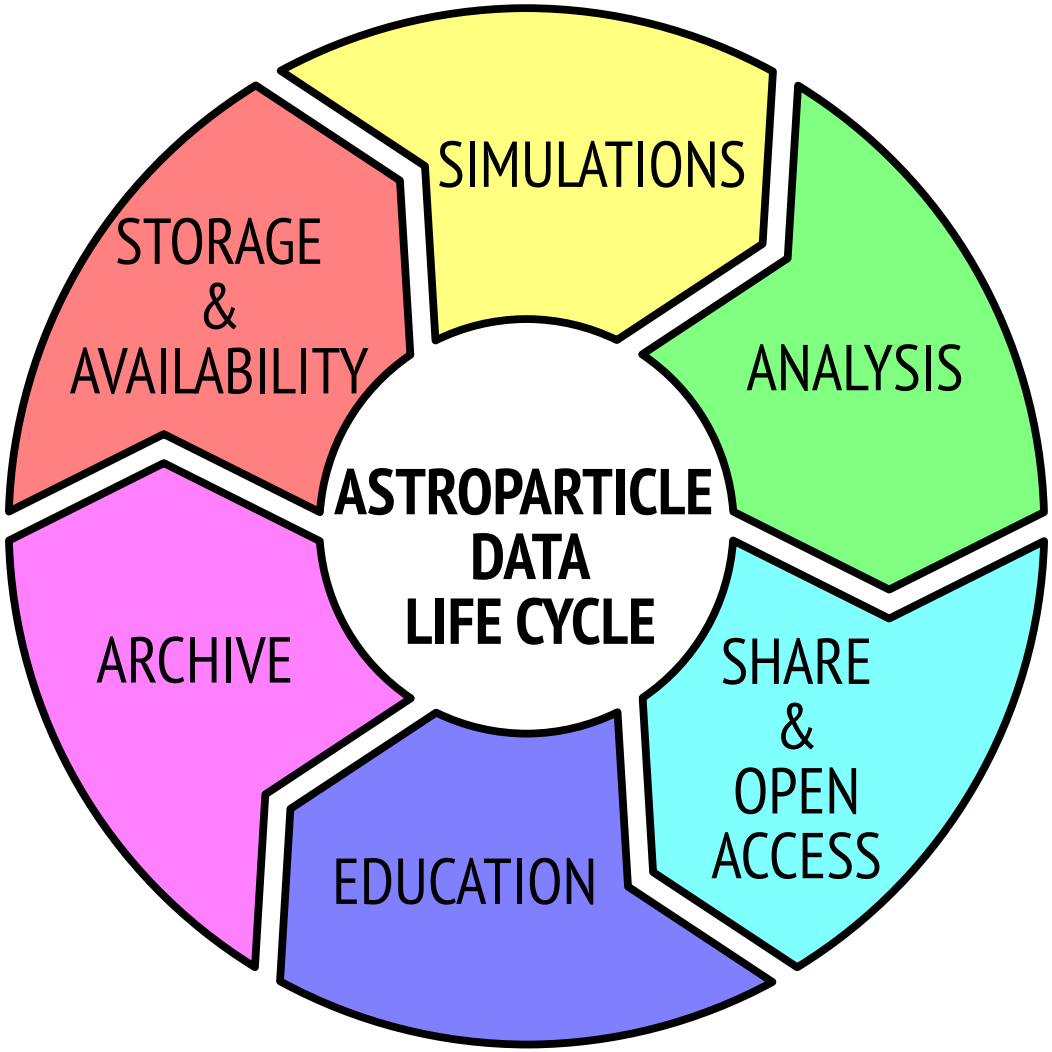
Tunka-Grande

- 380 scintillators 0.64m^2 each
- measures e/μ from EAS

Tunka-IACT

- Imaging Air Cherenkov Telescopes
- is being extended

Data life cycle scheme



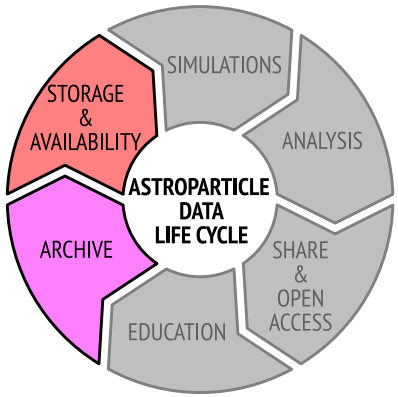
Data-oriented approach

What data do we work with?

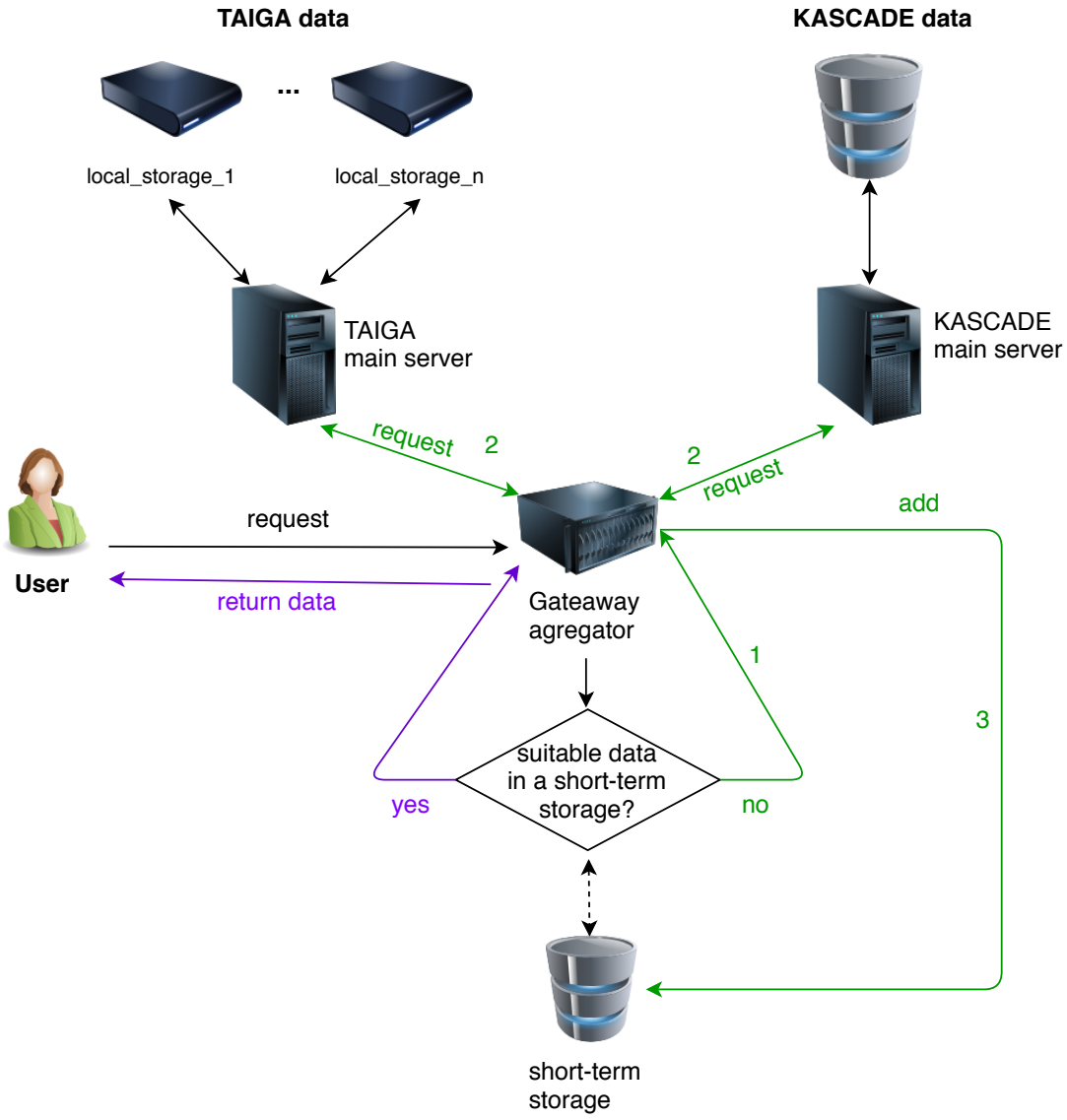
- Data types:
  - Raw detector readouts;
  - Pre-analyzed events;
  - Metadata
- Data structure:
  - Different formats;
  - Different messengers;
  - Common metadata

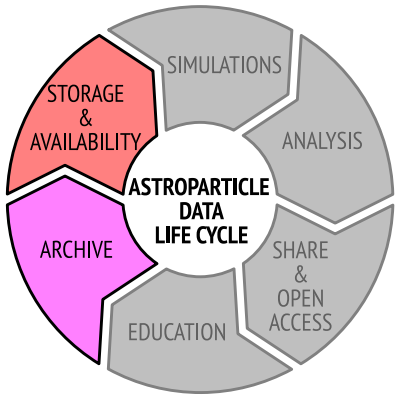
Our approach:

- It is proposed to store unique event id and metadata in the unified database
- With growing data sizes, distribured storage for events could be useful

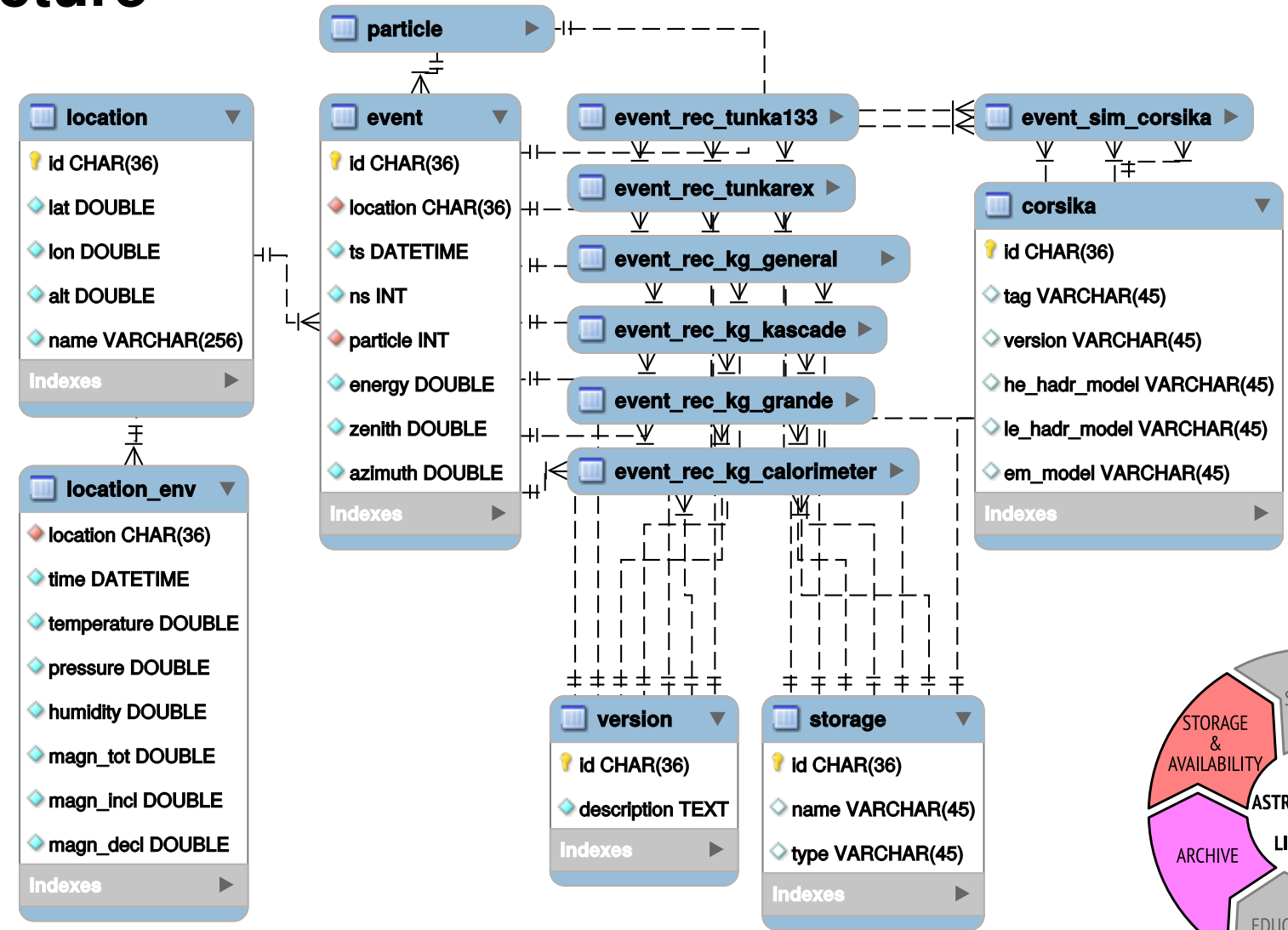


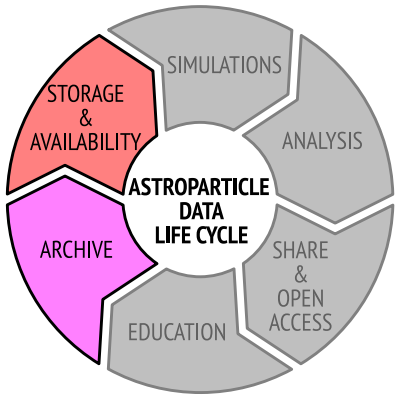
Archiving and storage



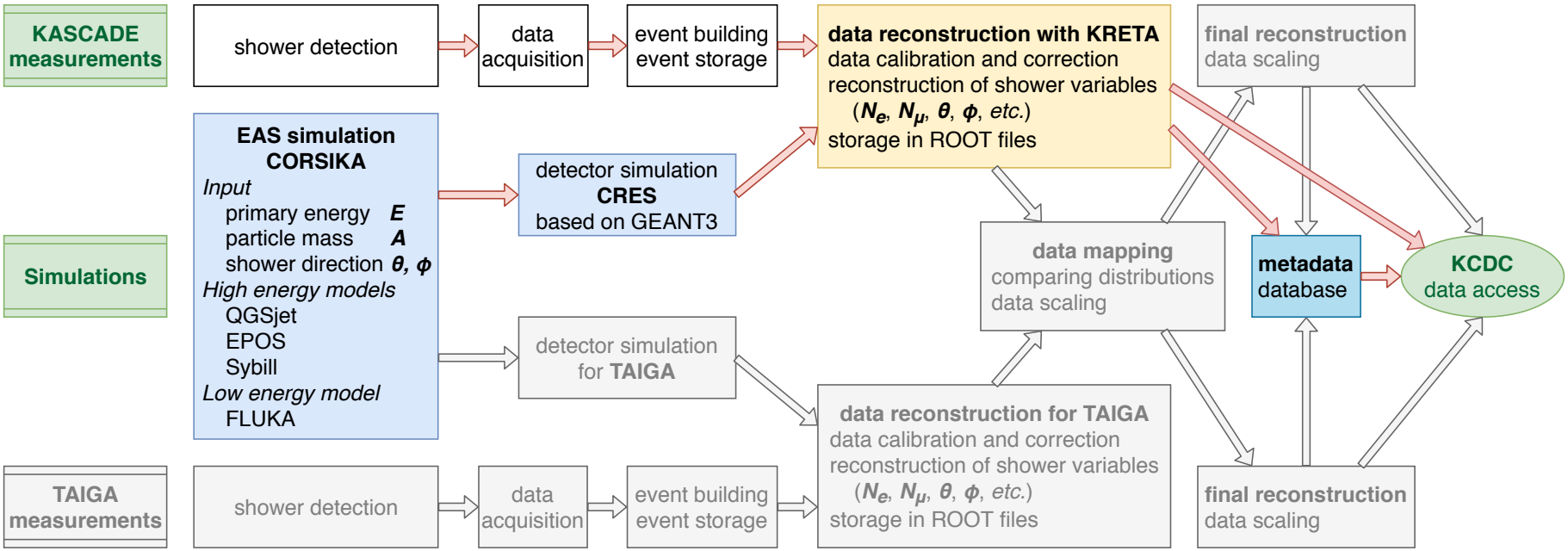


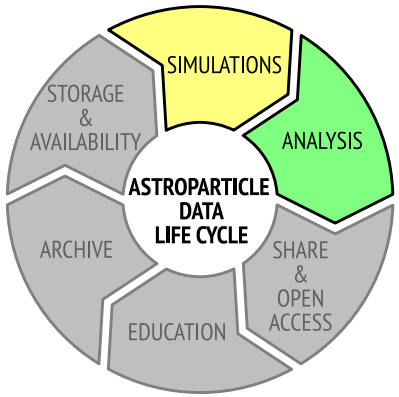
Proposed cosmic-ray metadata structure





Data workflow





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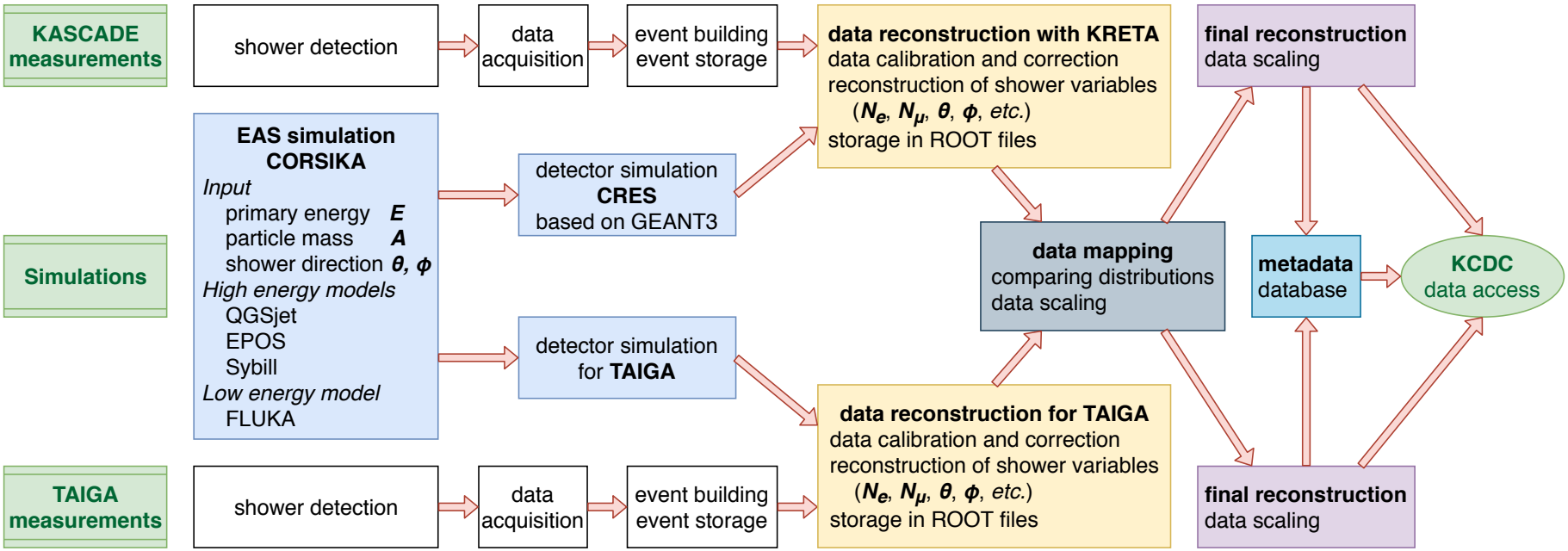
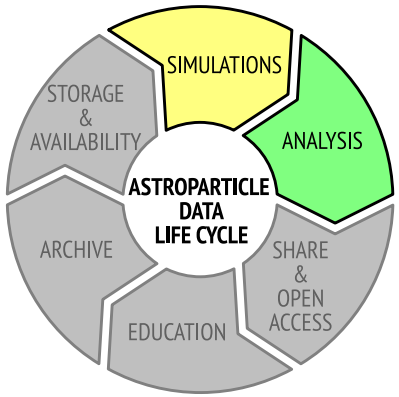
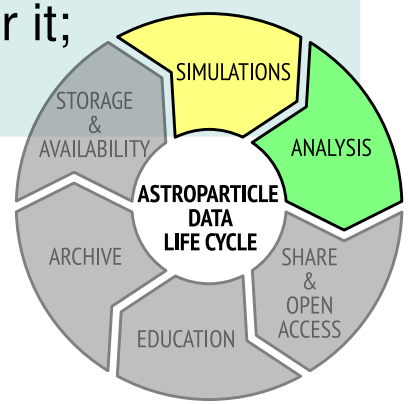




Simulation

Simulation: two steps

1. Simulating EAS:
   - CORSIKA, does not depend on detector features, depends on location ans atmospheric conditions;
   - requires large computing power with a standard environment;
   - a small amount of input data and a large amount of output data;
2. Simulating detector output:
   - depends on detector features;
   - requires dedicated software and special environment for it;
   - large amount of both input and output data;



Analysis

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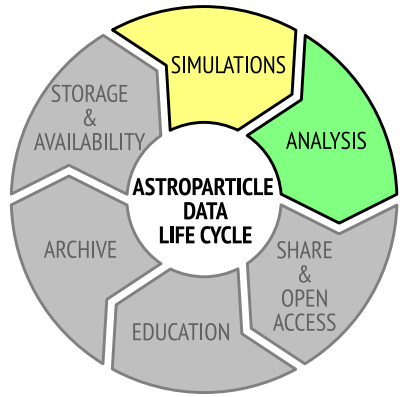
Event building | Data calibration and correction | Preliminary reconstruction | Data mapping and scaling | Reconstruc-tion | Joint data analysis

- Analysis could be either algorithmic or machine learning;
- Machine learning requires large enough statistics in order to work properly.



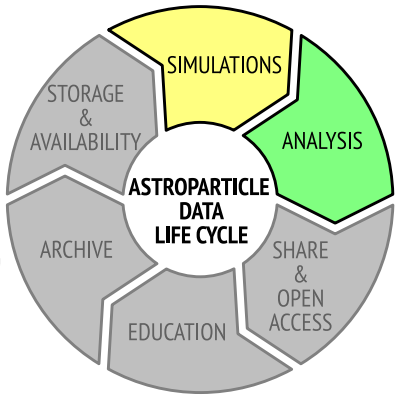
Analysis features

Software for data analysis depends on a particular experiment

- Problem: It may even require dedicated system environment
- **Solution: Virtualization**†

Data analysis requires huge amounts of input data

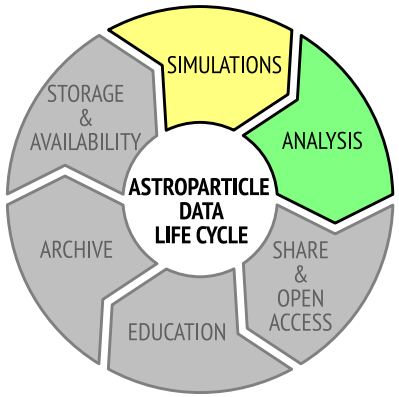
- Problem: It is often more optimal to perform it on the same site the data are stored
- **Solution: Job management**



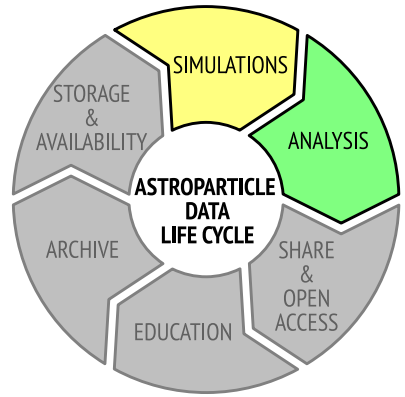
† "The act of creating a virtual (rather than actual) version of something, including virtual computer hardware platforms, storage devices, and computer network resources". © Wikipedia

WMS—workload management system

- The basic idea is to provide a central queue for all users and make all the distributed sites look like local ones;
- Starting from mid 90's are widely used in collider experiments (Dirac, PanDA);
- Dedicated for:
  - Unified usage of the distributed remote data and common data analysis;
  - Conceal various low-level software and provide unified high-level interface;
- Provide the common way to issue tasks to different types of the distibuted sites;
- The same system for the data access, analysis and simulation.

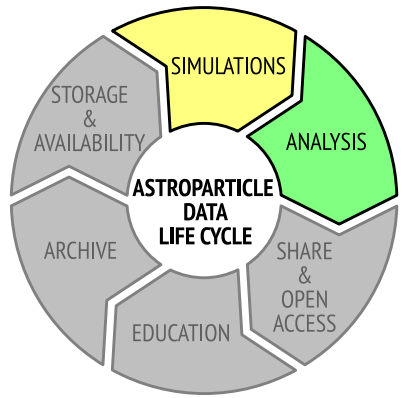


WMS for astroparticle data management



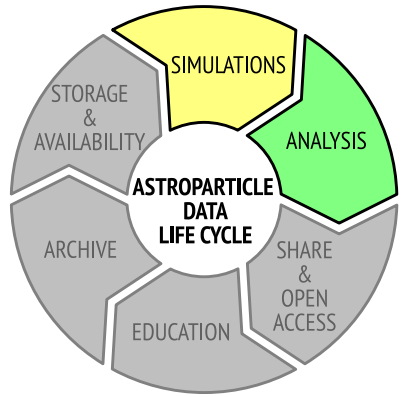
WMS for astroparticle data management

- IceCube ?



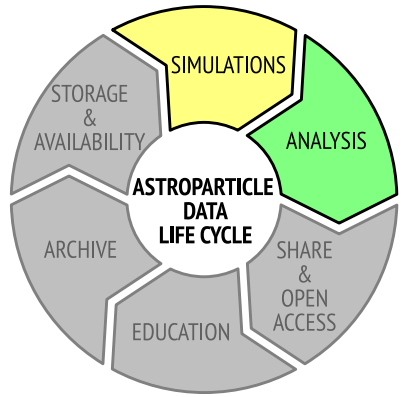
WMS for astroparticle data management

- IceCube ? PanDa



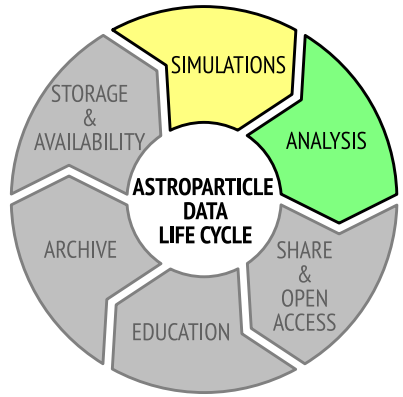
WMS for astroparticle data management

- IceCube ? PanDa
- Auger ?



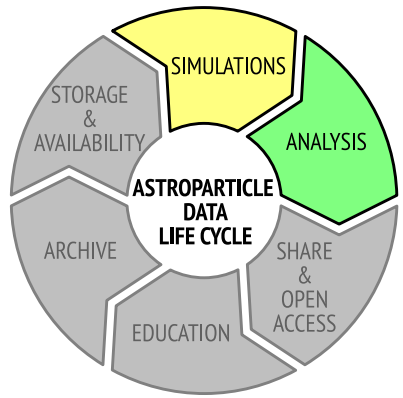
WMS for astroparticle data management

- IceCube ? PanDa
- Auger ? DiRAC



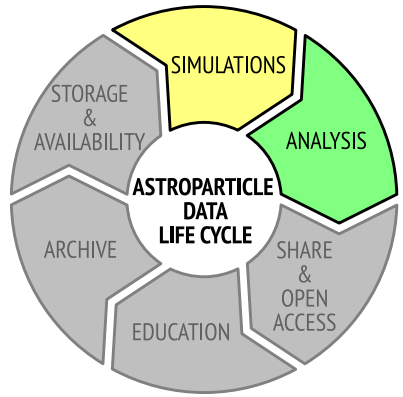
WMS for astroparticle data management

- IceCube ? PanDa
- Auger ? DiRAC
- Other WMS ?



WMS for astroparticle data management

- IceCube ? PanDa
- Auger ? DiRAC
- Other WMS ? VCondor, MyCluster, GWPilot, BigJob, ...



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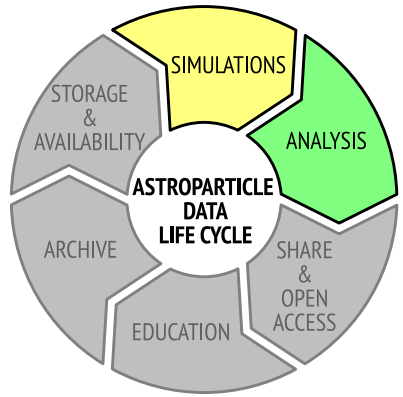
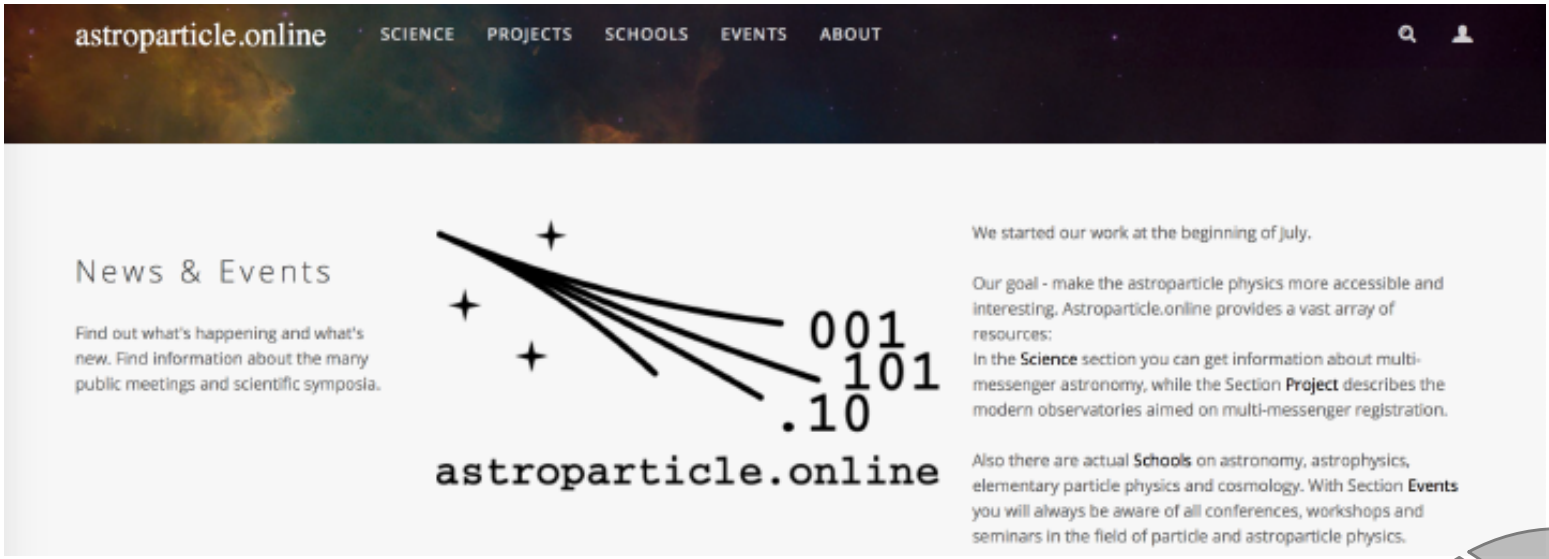
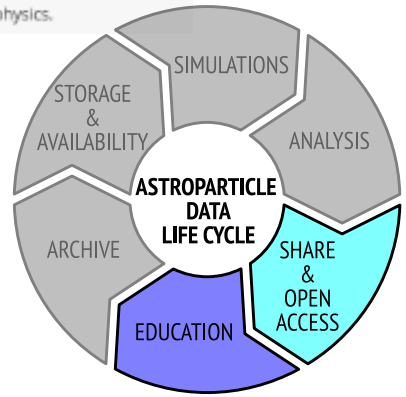
- **APPDC - ?**



Open access and education

- Open access: a dedicated portal planned;
- Education: astroparticle.online.





Summary

- The KASCADE-Grande project has a data center called KCDC, that is planned to serve as the basis for the future common center for data access;
- The differences in the data formats were analyzed and solutions for organizing storage and distributed data processing were proposed;
- A scheme of a relational database for the future data center is designed using a metadata-based approach;
- The possibilities to apply the results of the project to educational and outreach activities are being explored.
- We are developing a new approach to the astroparticle data life cycle for combined analysis of the KASCADE-Grande and TAIGA data;
- The built-up infrastructure will be used to analyze combined data sets with large statistics, allowing to study galactic sources of high-energy γ-rays, which could be a notable step forward in multi-messenger astroparticle physics.

Thank you
for your attention!

The German-Russian Astroparticle Data Life Cycle collaboration I

TAIGA—Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy (see taiga-experiment.info);

KASCADE-Grande—KArlsruhe Shower Core and Array DEtector—Grande (see www-ik.fzk.de/KASCADE_home.html);

KIT-IKP—Institute for Nuclear Physics Karlsruhe Institute of Technology

SCC—Steinbuch Centre for Computing Karlsruhe Institute of Technology

The German-Russian Astroparticle Data Life Cycle collaboration II

SINP MSU—Skobeltsyn Institute Of Nuclear Physics Lomonosov Moscow State University

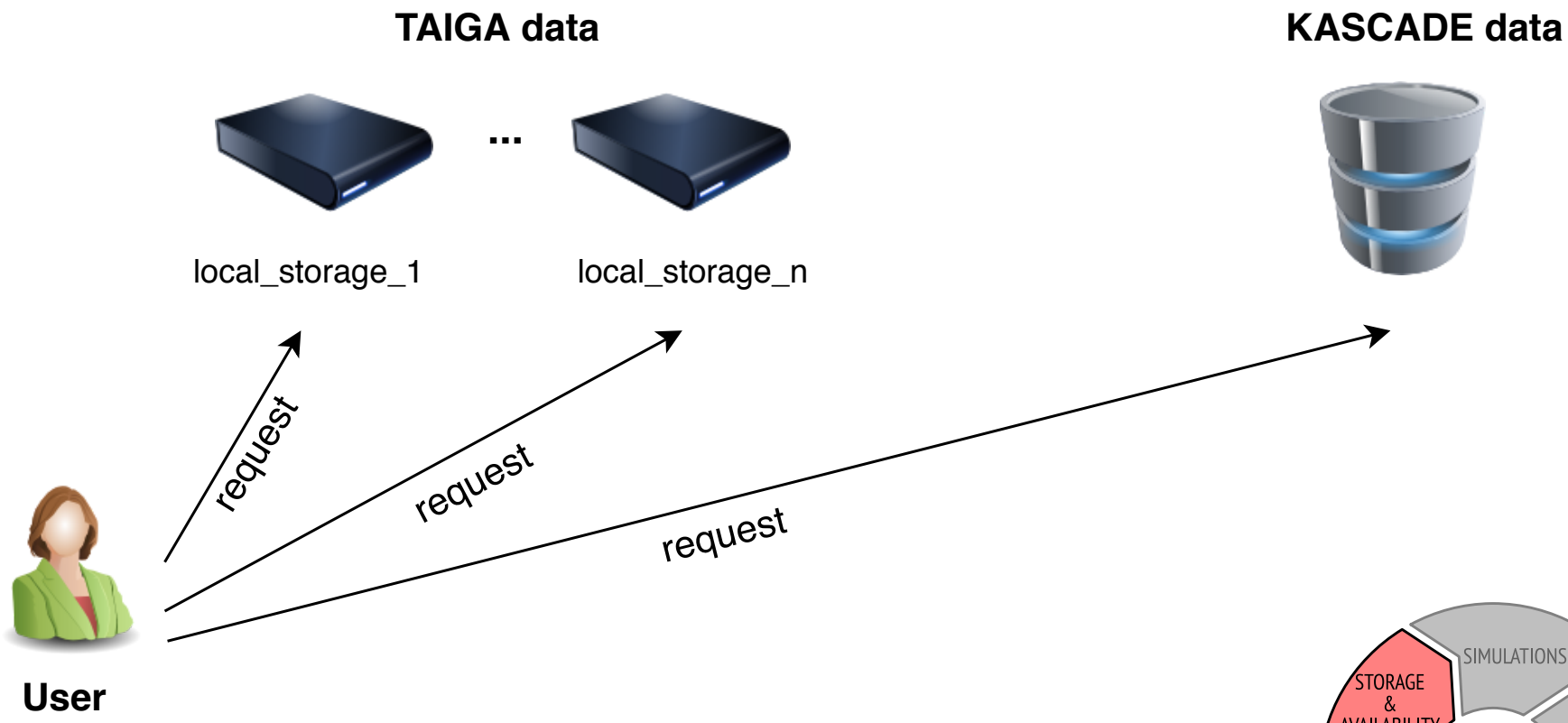
ISU—Irkutsk State University

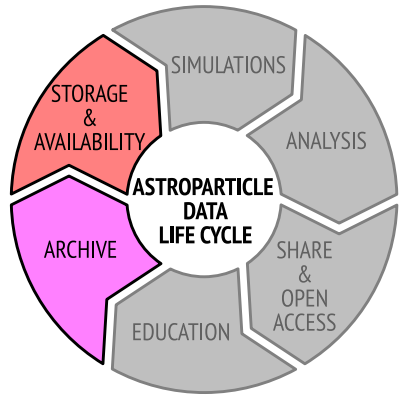
ISDCT—Matrosov Institute for System Dynamics and Control Theory

References

- Berghöfer T., Agrafioti I. *et al.* Towards a model for computing in European astroparticle physics, Astroparticle Physics European Coordination committee, 2016, web-source: `http://appec.org/wp-content/uploads/Documents/Docs-from-old-site/AModelForComputing-2.pdf`;
- KCDC—**K**ASCADE **C**osmic Ray **D**ata **C**enter, web-source: `http://kcdc.ikp.kit.edu`;
- KASCADE-Grande official site, web-source: `http://www-ik.fzk.de/KASCADE_home.html`;
- TAIGA collaboration official site, web-source: `http://taiga-experiment.info`;
- Astroparticle.online—outreach resource, web-source: `http://astroparticle.online`.

Archiving and storage





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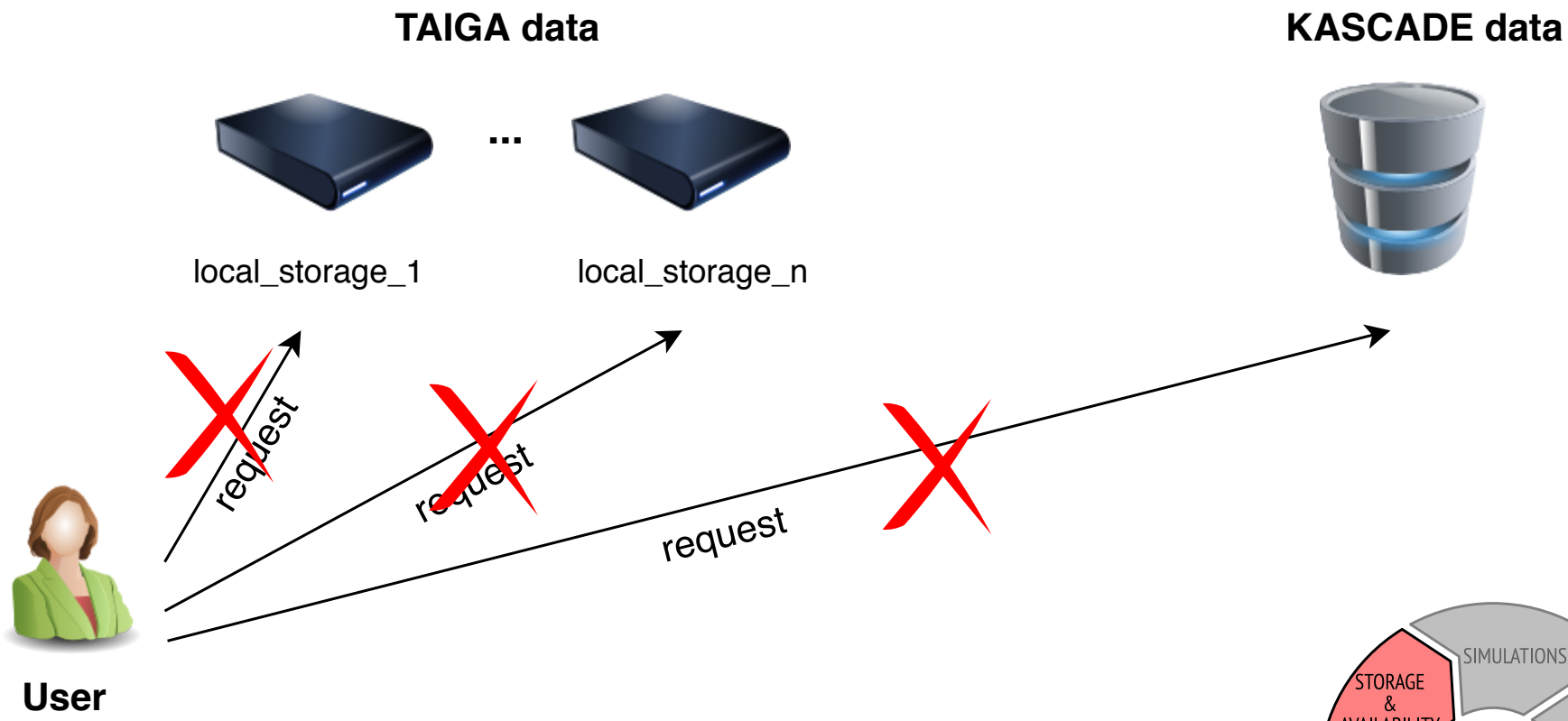

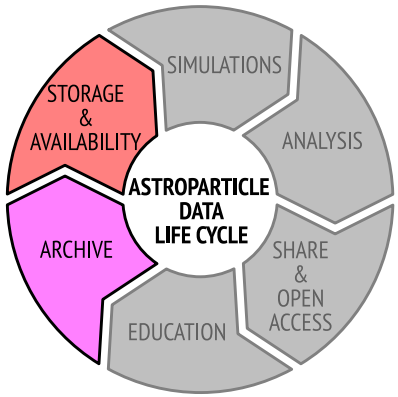

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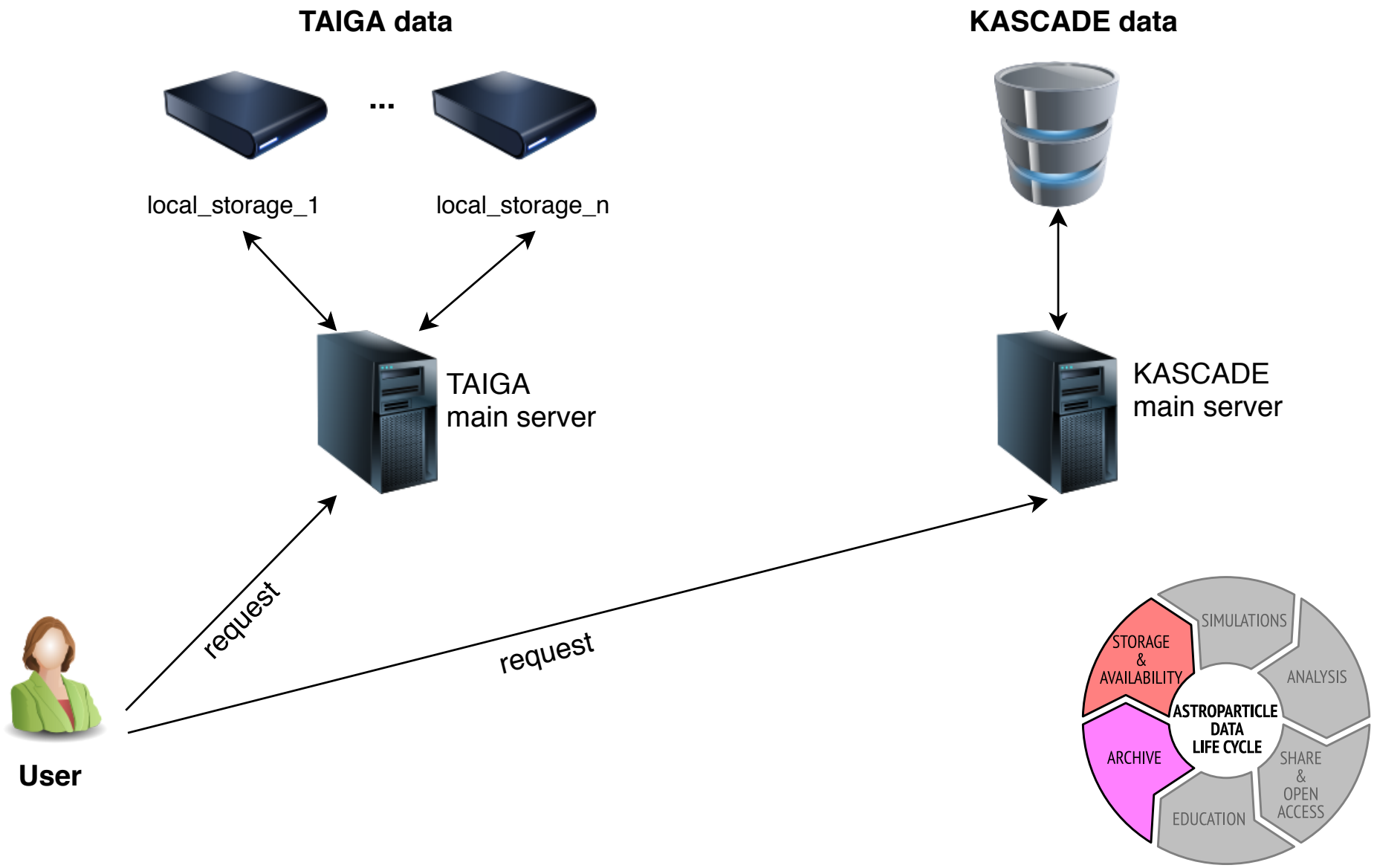

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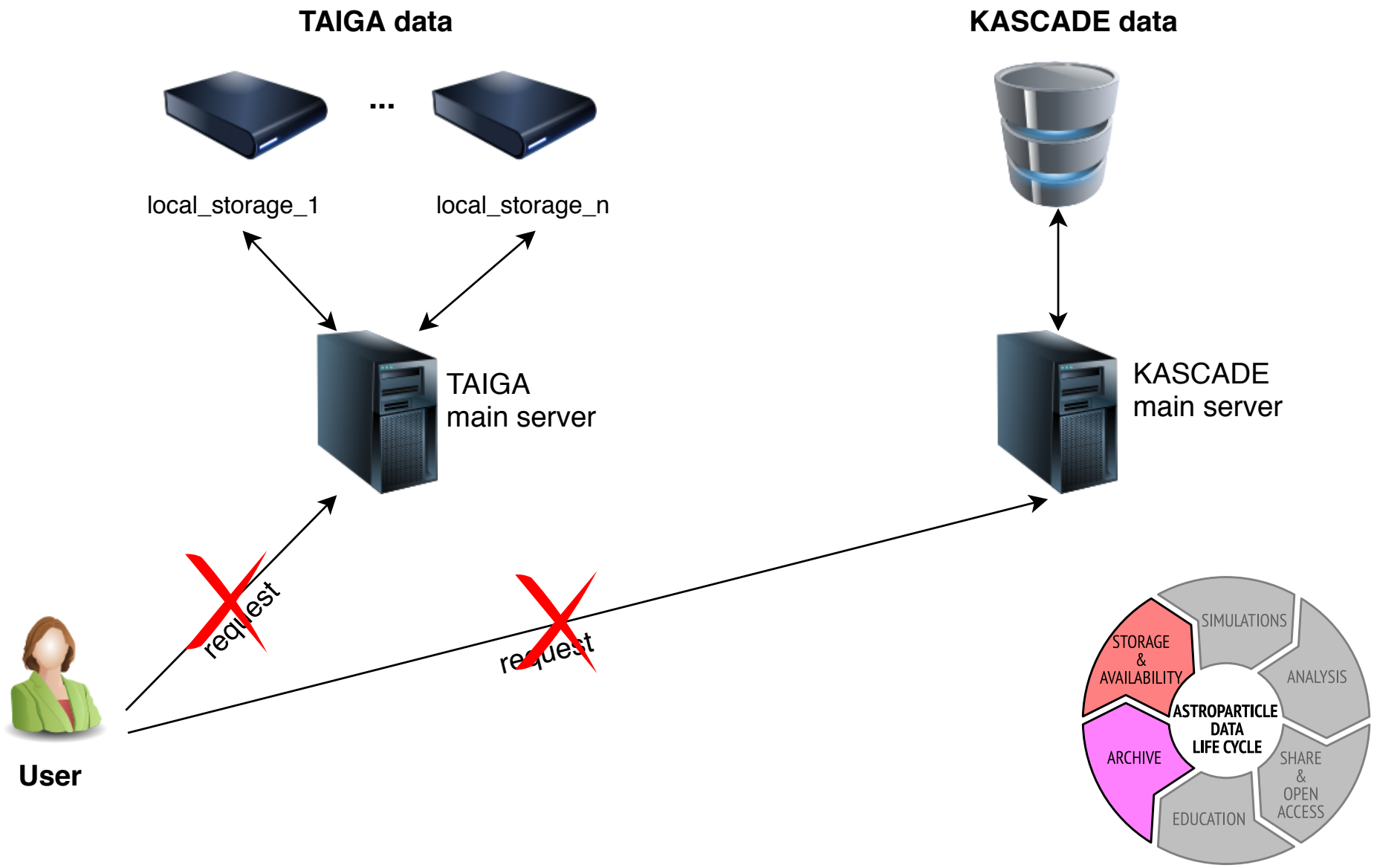

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