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Belle II Computing

MALACHI SCHRAM
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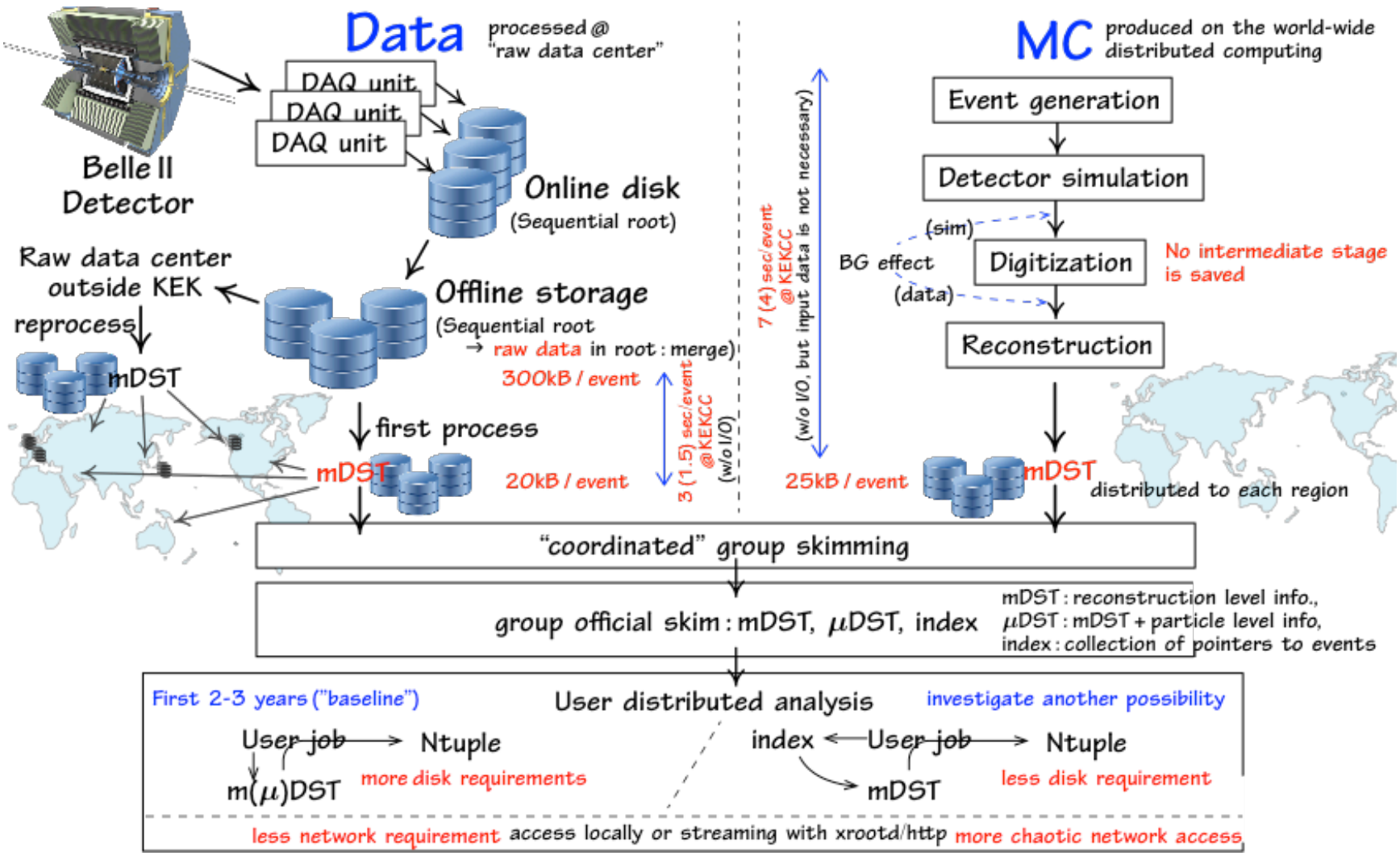
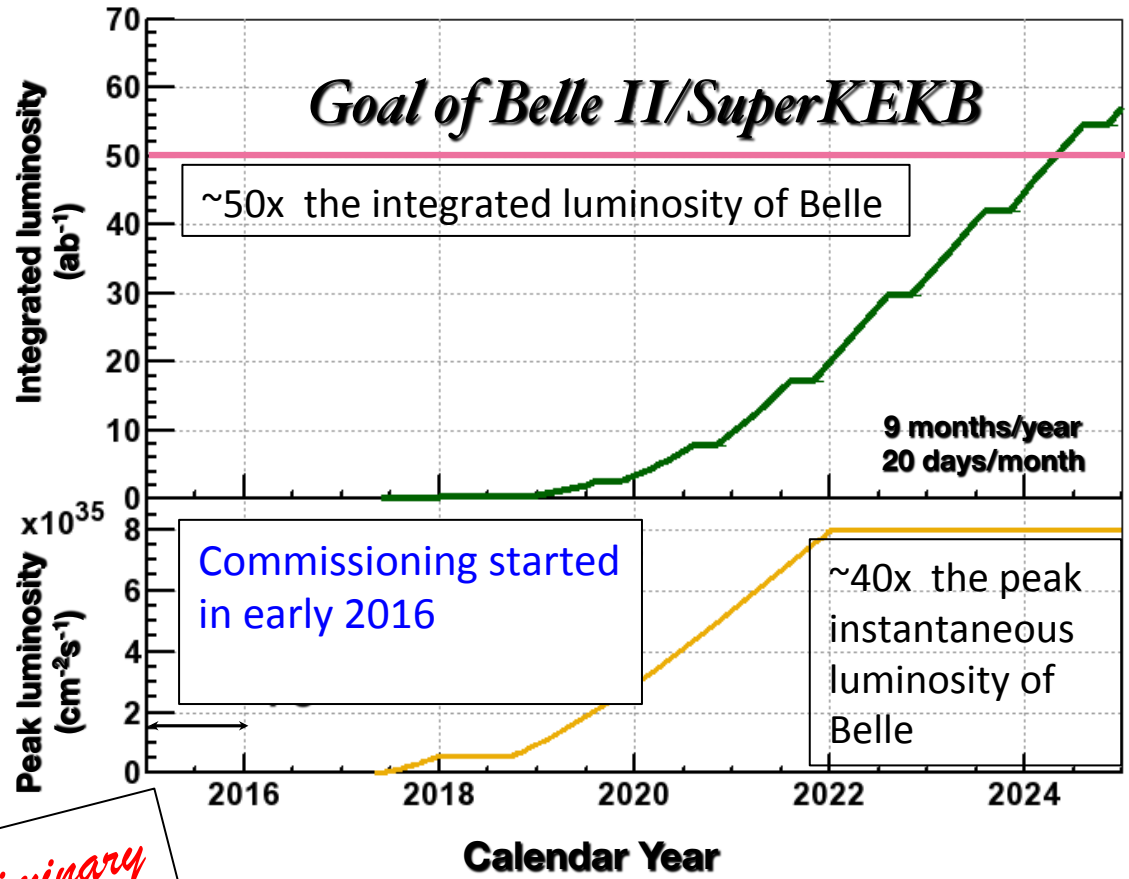
On Behalf of Belle II collaboration

Computing and Software Workflow



Belle II Data Volume & Resources



- The ***Computing Steering Group*** estimates and defines the expected resources contribution for each country
- Contributions are based on fraction of PhD per country
- The US is expected to provide 15%

Preliminary

Year	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total Storage (PB)	3	8	10	22	60	116	190	265	341
Total CPU (kHEPSpec)	240	340	475	610	710	880	1060	1420	1640

~80-160k cores

US Contribution to Computing

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- **Tier-1 Compute and Storage Center**
  - ~4000 cores of compute
  - ~0.5PB of storage
  - Core infrastructure is build using OpenStack and Kubernetes
  - Additional services: VOMS, CVMFS, DIRAC development systems, etc.
  - Investigating using HPC, OSG, University resources
- **Distributed Data Management System and Networking**
  - Coordinator and lead developers (details in slides)
- **Conditions Databases**
  - Coordinator and lead developers (details in slides)

DIRAC (Distributed Infrastructure with Remote Agent Control) **INTERWARE**

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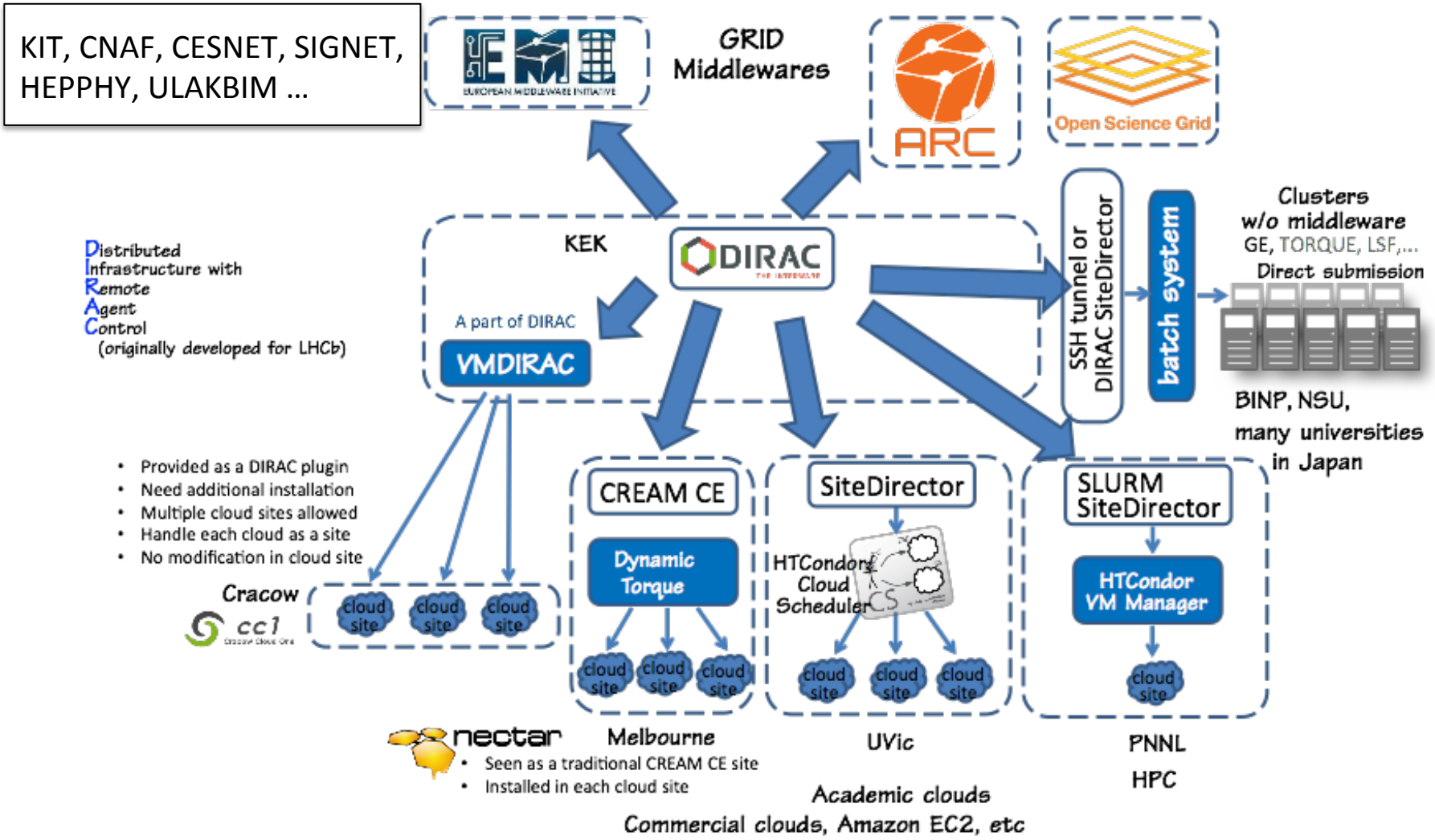
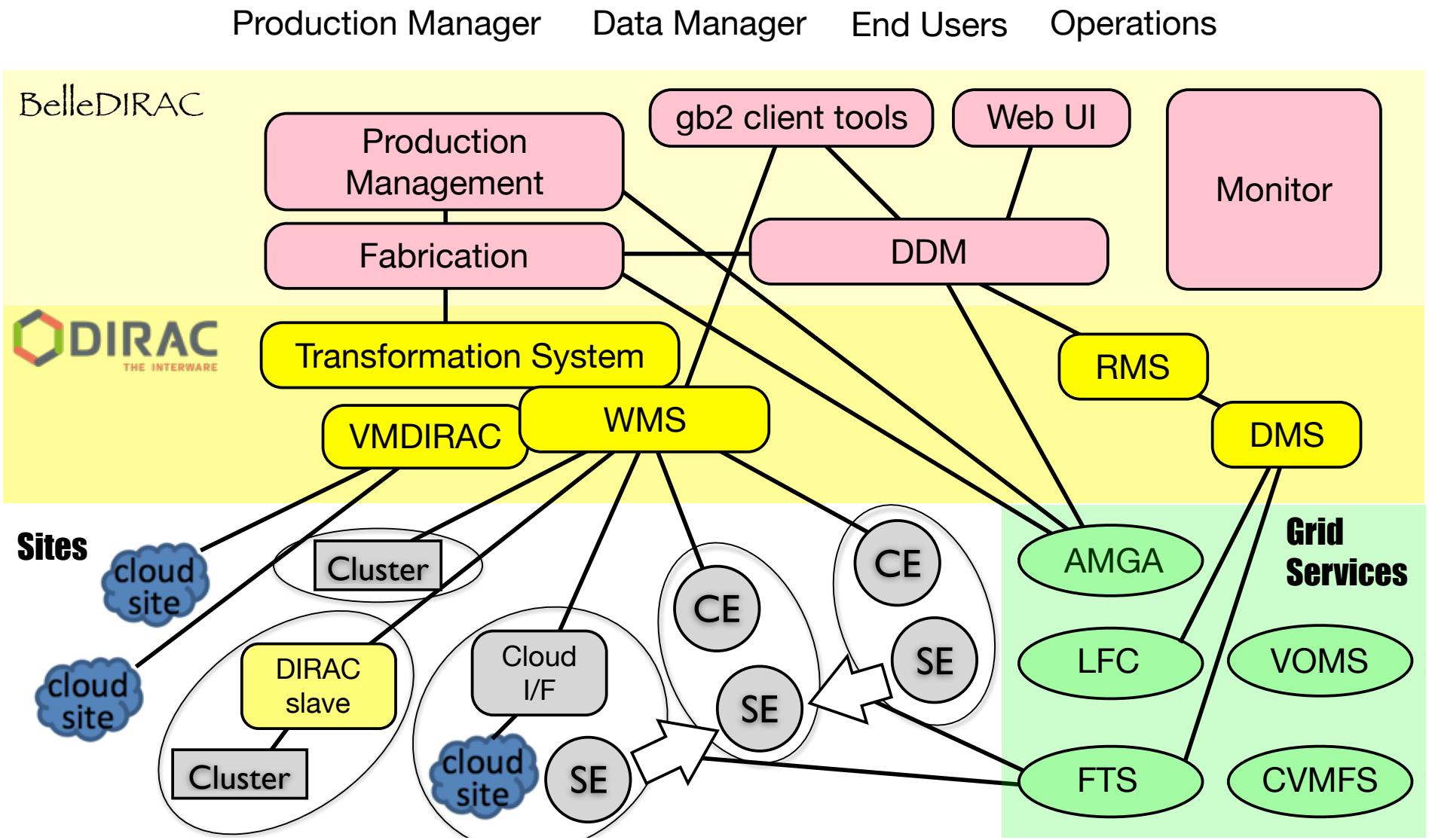
KIT, CNAF, CESNET, SIGNET, HEPPHY, ULAKBIM …



Belle II Distributed Computing Layers



Core BelleDIRAC Extensions

"Production Manager" (human)

- to define a production : sw release, event type, number of events to produce, …
- and put the parameters into Production Management System

Production Management System

- to create Fabrication instance(s) : simulation, reprocess, skim, merge, …
- and chain them as needed

Fabrication System

- to create and look after jobs, replace failed jobs, verify output of successful jobs
  - simulation jobs can run everywhere, merge jobs can run at the sites with "major" SEs.
- to feed output files to Distributed Data Management System

Distributed Data Management System

- to gather output files to "major" SEs in blocks (important for merge)
- to distribute "final" products over the grid (for further processing / analysis)

Distributed Data Management System

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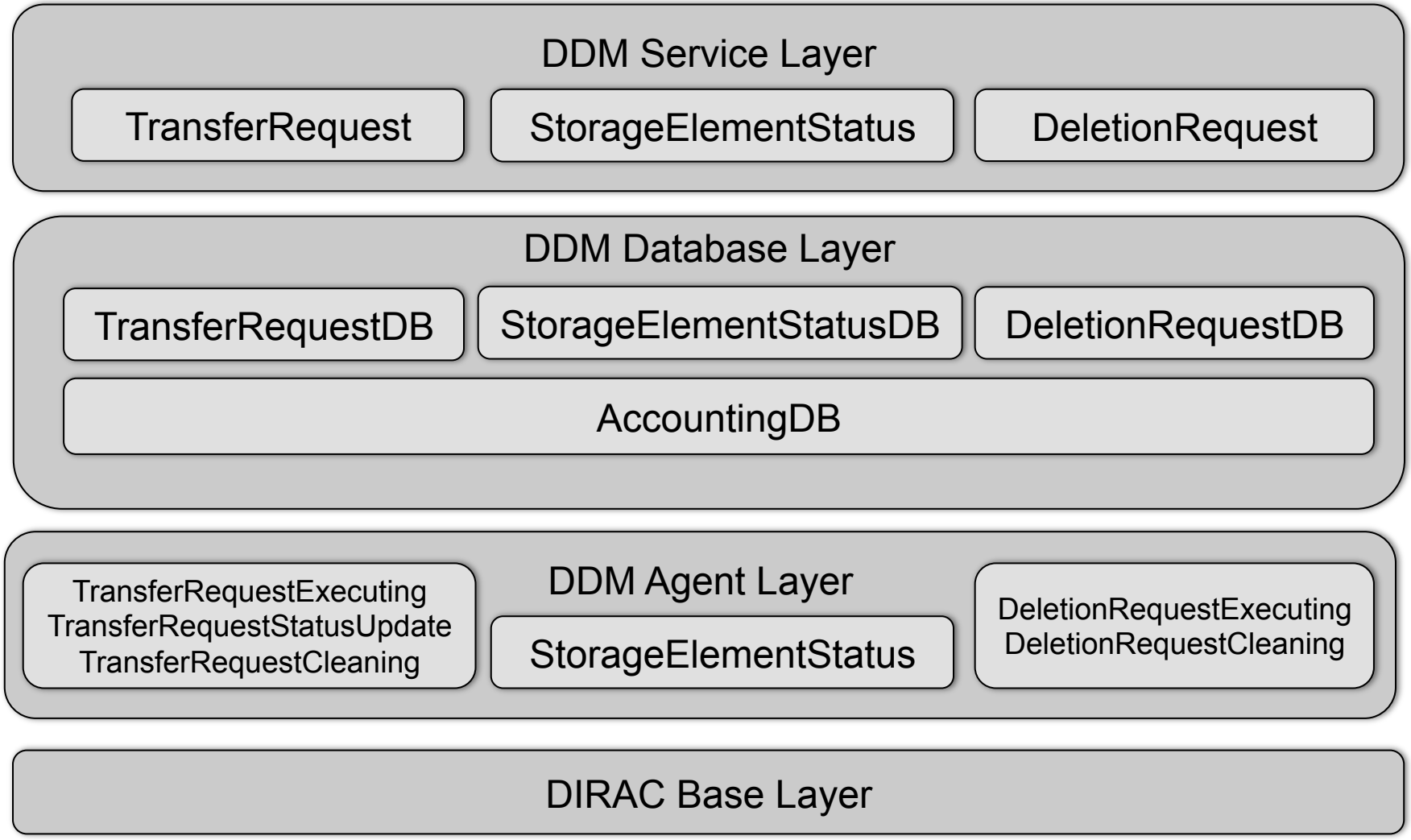
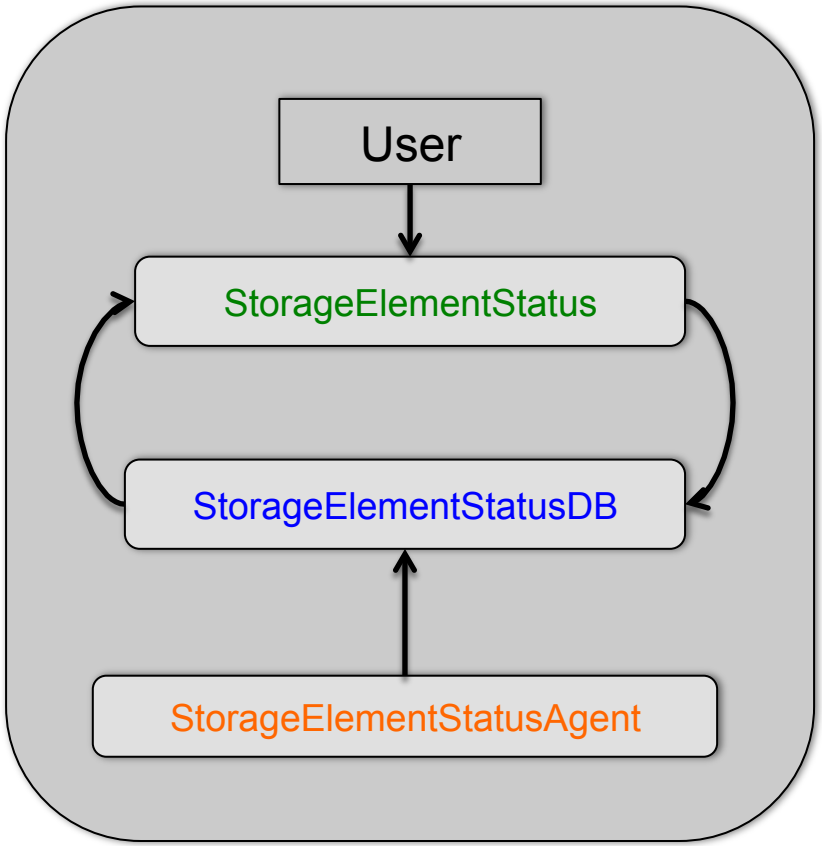
- **Storage element accounting components**
  - Provide health of each registered Storage Element (SE)
  - Overall storage availability at each SE
  - Group and user level accounting
  - Network Monitoring
- **Data transfer components**
  - Provides tools to transfer data between sites
  - Provide tools for users to retrieve their samples
- **Bulk data deletion components**
  - Provides tools to do large scale data deletion
- **Data Integrity**
  - Insures that the physical data is pristine and consistent with the File-Catalogs

Distributed Data Management System



StorageElementStatus Workflow



Purpose:

- Provide near real time SRM storage elements information

Current implementations:

① StorageElementStatus provide API layer for internal and external users.

② StorageElementStatusAgentDB provide persistified information

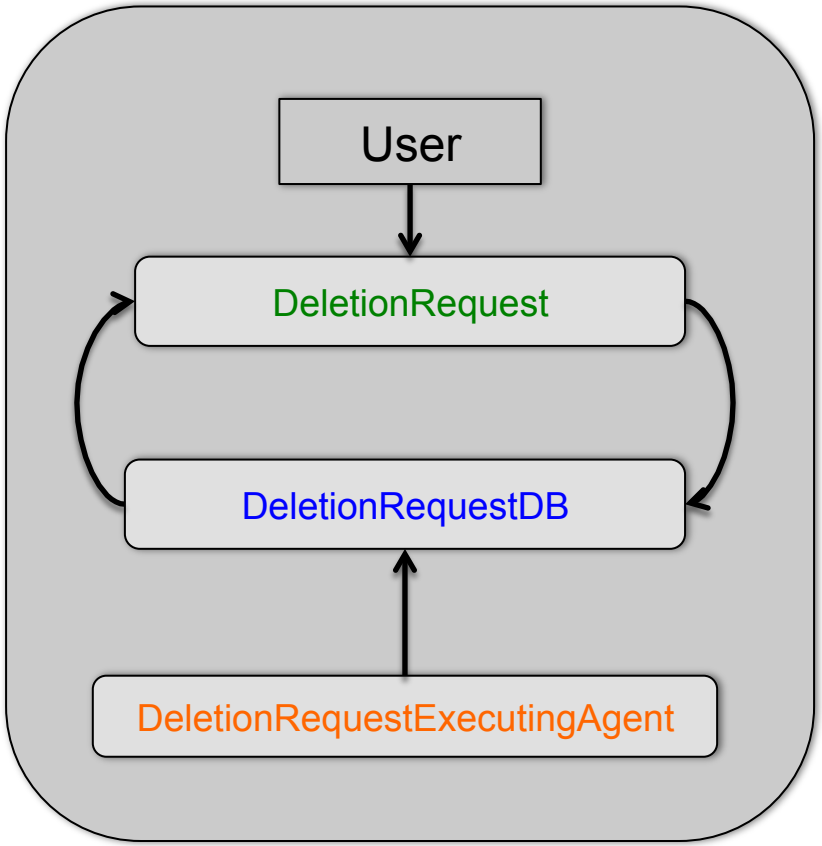
③ StorageElementStatusAgent :

- Available space
- Access rights (w/r) at file and director level
- ADLER32 Checksum

Extra features:

- Include full ACL

DeletionRequest Workflow



Purpose:

- Provide bulk deletion request

Current implementations:

① DeletionRequest provide API layer for internal and external users.

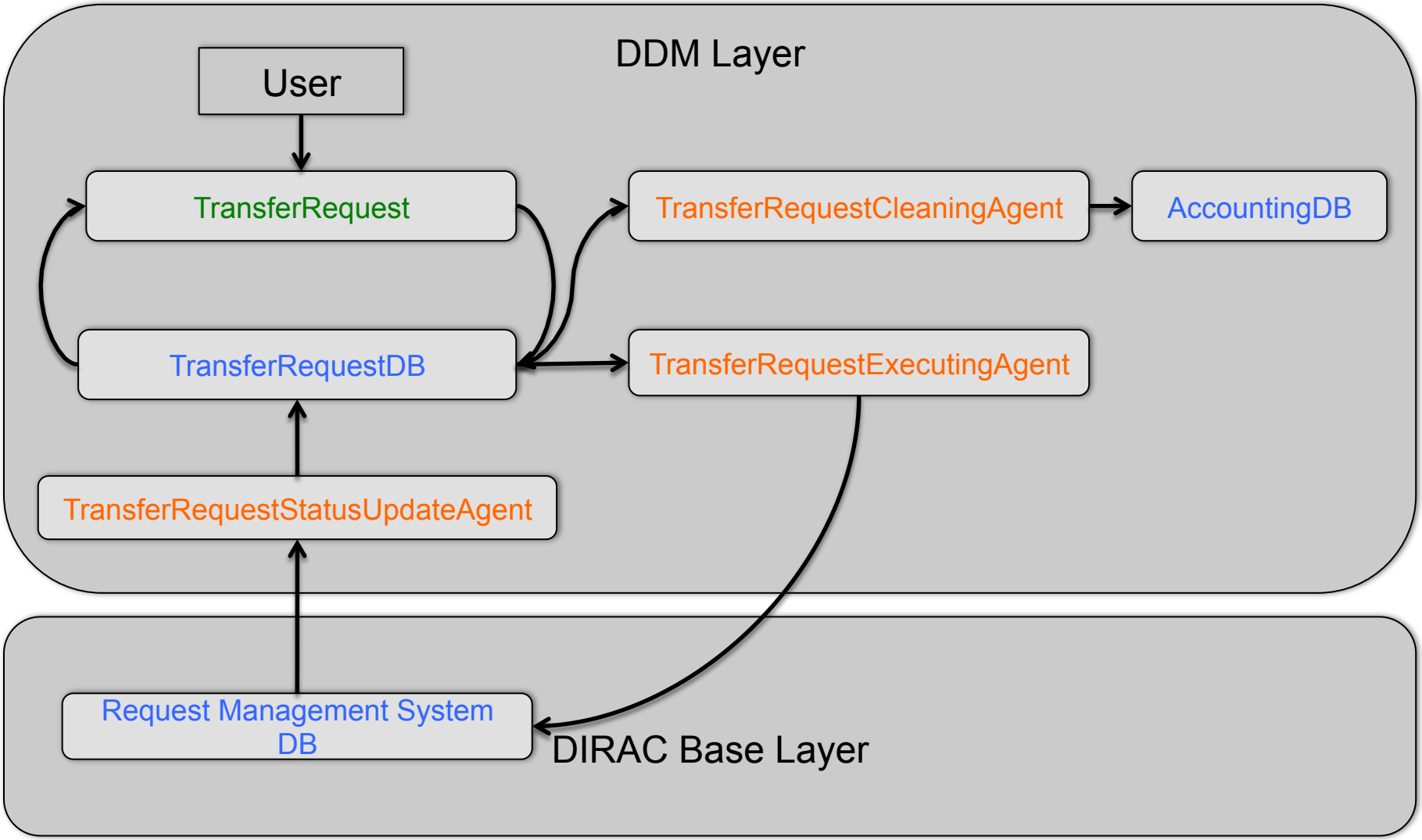
② DeletionRequestAgentDB provide persistified information of requests

③ DeletionRequestExecutingAgent:

Extra features:

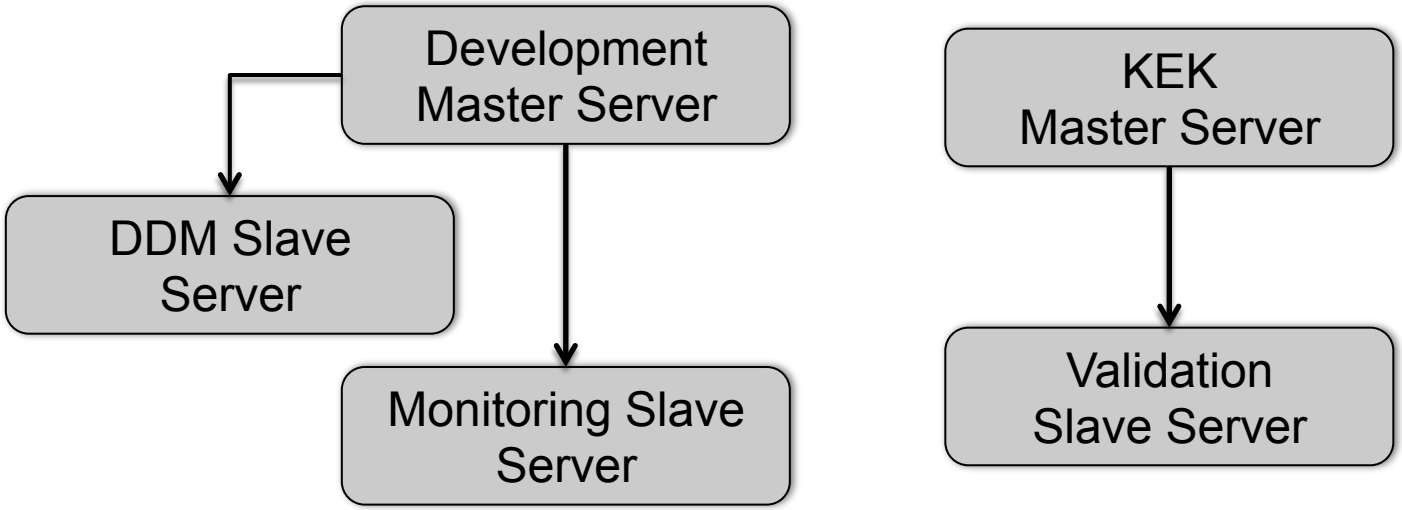
- Priority feature

Transfer Request Workflow



Development Life Cycle

- DDM group work on 3 week development cycle (Agile Sprint)
- Dedicated development DIRAC master server used to configure test setups
  - Runs all systems
  - Common global resources access for development slave servers
- Dedicated DDM slave server for dynamic development
  - PNNL and Melbourne
- Dedicated validation server
  - Runs all systems
  - Uses common global resources for validating development



Cosmic Ray Test and DDM

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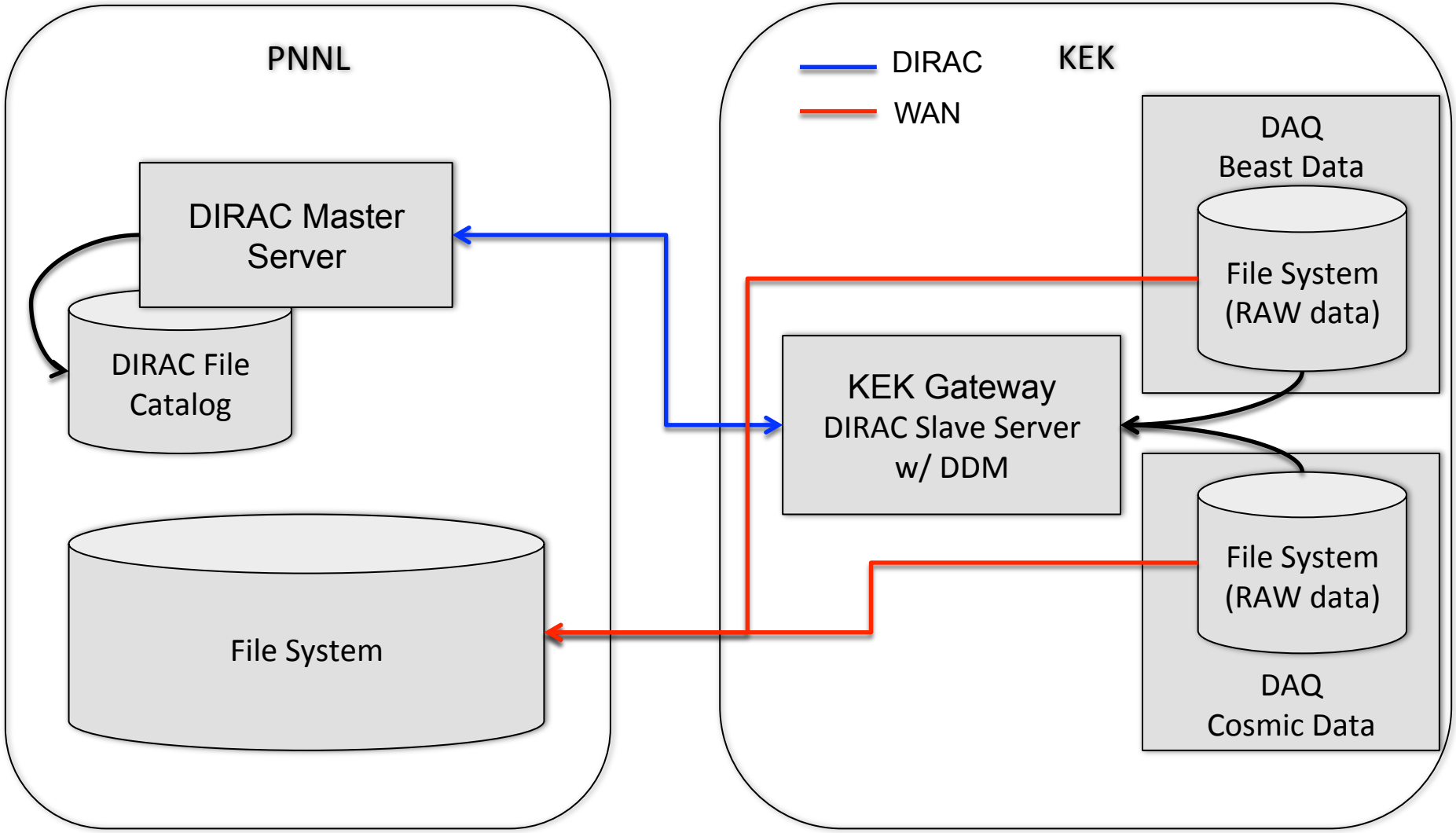
- **Purpose**
  - Transfer raw CRT data from KEK to PNNL
  - Socialization exercise between DAQ and Distributed Computing group
- **Phases 1**
  - Provide access to while KEKCC is down
  - Restricted network between KEK and PNNL
  - No access to KEKCC grid computing
- **Phases 2**
  - Detailed study of network and storage performance
  - Use new KEKCC storage
  - Use LHCONE network

Comic Ray Test: Phase 1



Road to full production system

MC3 (2014 May): no Production System

- 2.5 M jobs: **manual submission** by the **shifters** (with a script)

MC4 (2014 Nov): with "prototype" Fabrication System

- ~5 M jobs: **automatic submission** by the system, controlled by **a single system manager**
- Output files uploaded directly from WNs to "major SEs"

MC5 (2015 Aug — 2016 Feb): with improved "prototype" Fabrication System

- ~10 M jobs: automatic submission by the system, controlled by a single system manager
- Output files **transferred by FTS** from production sites to "major SEs"
- **Monitoring and automatic issue detection** for shift tasks and expert investigation

Cosmic ray data replication (2016 Jun ~):

- An agent to register raw data files as they get available on a storage, and make transfer requests
- **Automatic replication of raw data**

Road to full production system (2)

MC6 (2016 Jun): with Fabrication System and DDM

- O(1) M jobs: automatic submission by the system, controlled by a single system manager
- Output file transfers by FTS **controlled by DDM**
- Monitoring and automatic issue detection for shift tasks and expert investigation

MC7 (2016 Nov ~ 5 months): with the Production Management System

- **The software should be well tested by the software group, validated by a production manager**
- Automatic job submission by the system, **controlled by the system**
- Automatic file transfers by the system, **controlled by the system**
- Monitoring of **production progress**
- **Automatised operations** (eg. ggus tickets, downtime, storage health)
- **Tune and improve the system** during the production and afterwards
- **The system will be ready for workflows** other than MC production (raw dta processing, reprocessing, skim, …)

Road to full production system (3)

Scale Tests (to be repeated as needed in between "production" activities)

- To see if we have any limitation in job or file transfer throughputs beyond the current level
- And address the issues found

Cosmic ray data processing (2017)

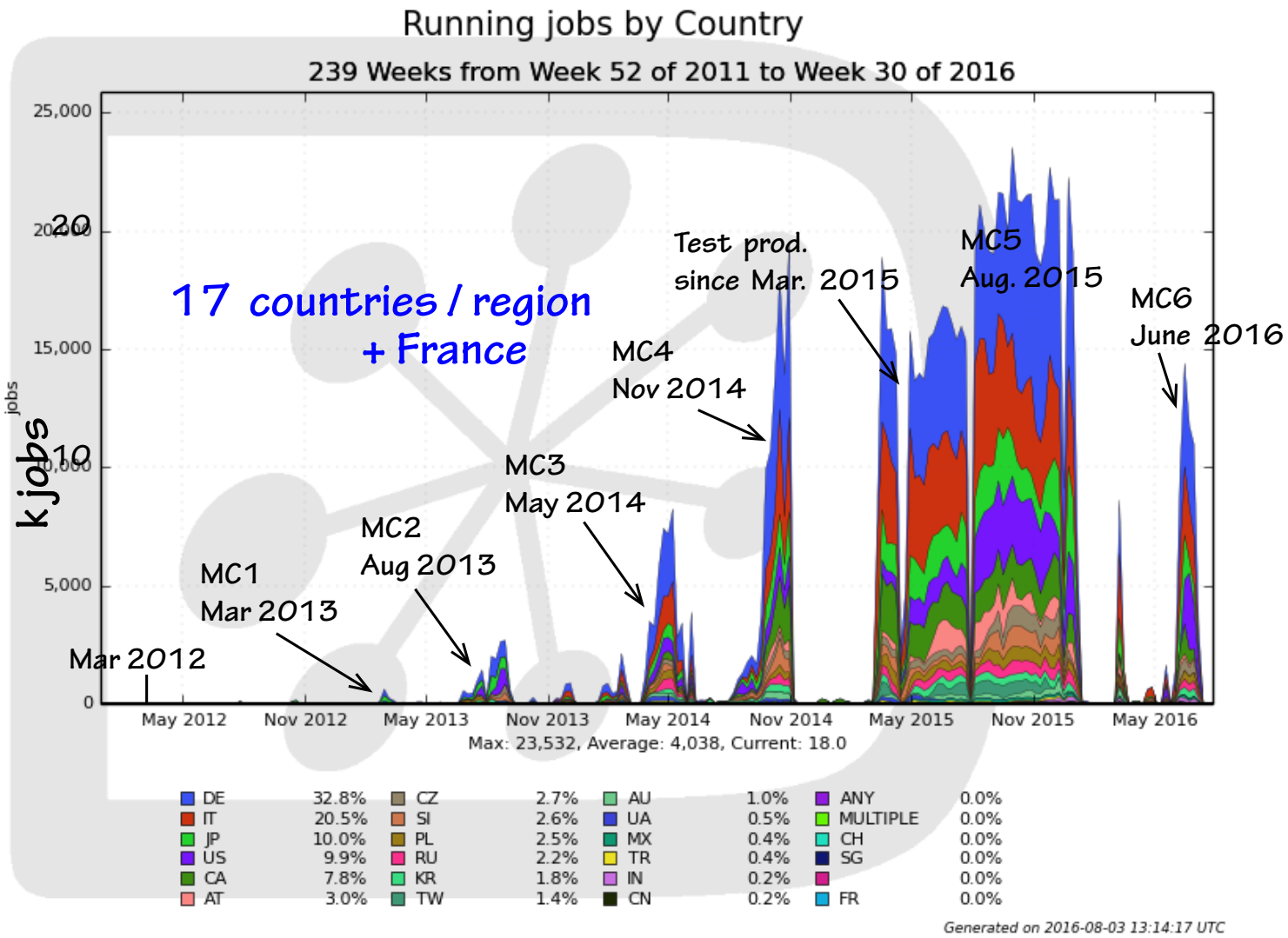
- **Raw data format and reconstruction software need to be ready** and well tested by this time
- **The production system should be ready,** it has been developed not only for MC production, but with other use cases (incl. raw data processing)
- Still, this will be the **first real use case to try raw data processing workflow**

System dress rehearsal (2017): before Phase-2 runs

- To try out the **full chain workflow** from raw data to skim
- Find issues and address them before phase-2 runs

System full dress rehearsal (2018): before Physics runs

Monte Carlo Campaign History



Belle II Networking Requirements

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- In 2014, Belle II was added to the LHCONE network
- International network requirements are based on (*production only*):
  - RAW data
  - mDST from data and Monte Carlo - after data taking and reprocessing
- KEK estimated outgoing (incoming) traffic of 20Gbps (5Gbps) in 2024.
- PNNL estimated maximal incoming (outgoing) traffic 8Gbps (4Gbps)
- European estimated maximal incoming (outgoing) traffic 10Gbps (4Gbps)
- India, Canada and Slovenia will require ~2Gbps traffic
- Other site (Australia) will be interested by a traffic less than 1Gbps

Latest Network Data Challenges

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- DC 1 (2015):
  - KEK ←→PNNL
  - KEK → EU
- DC 2 (2015/2016): LHCONE sites
  - PNNL ←→ EU
  - EU←→ EU
- DC 3 (2016): SINET5 (phase 1)
  - KEK ←→PNNL
  - KEK → EU
- Software stack used:
  - perfSONAR suite
  - SRM storage elements + gridftp servers
  - FTS3 with manual channel configuration

Network Data Challenge Results

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- Results of key sites based on the latest data challenges

Source →	KEK	PNNL	DESY	KIT	CNAF	NAPOLI	SIGNET
KEK	N/A	6.3 Gbps	8 Gbps	7 Gbps	7 Gbps	6.6 Gbps	2.5 Gbps
PNNL	3.9 Gbps	N/A	6.6 Gbps	6 Gbps	9 Gbps	8 Gbps	-
DESY	3 Gbps	6.6 Gbps	N/A	8 Gbps	8 Gbps	8 Gbps*	3 Gbps
KIT	3.2 Gbps	4 Gbps*	8 Gbps	N/A	8 Gbps	6 Gbps	3 Gbps
CNAF	3.8 Gbps	8 Gbps	10 Gbps	6 Gbps	N/A	8 Gbps*	3 Gbps
NAPOLI	3 Gbps	3 Gbps*	3 Gbps*	3 Gbps	3 Gbps*	N/A	3 Gbps*
SIGNET	0.8 Gbps	0.6* Gbps	5 Gbps	2 Gbps	5 Gbps	2 Gbps*	N/A

Networking Status and Plans

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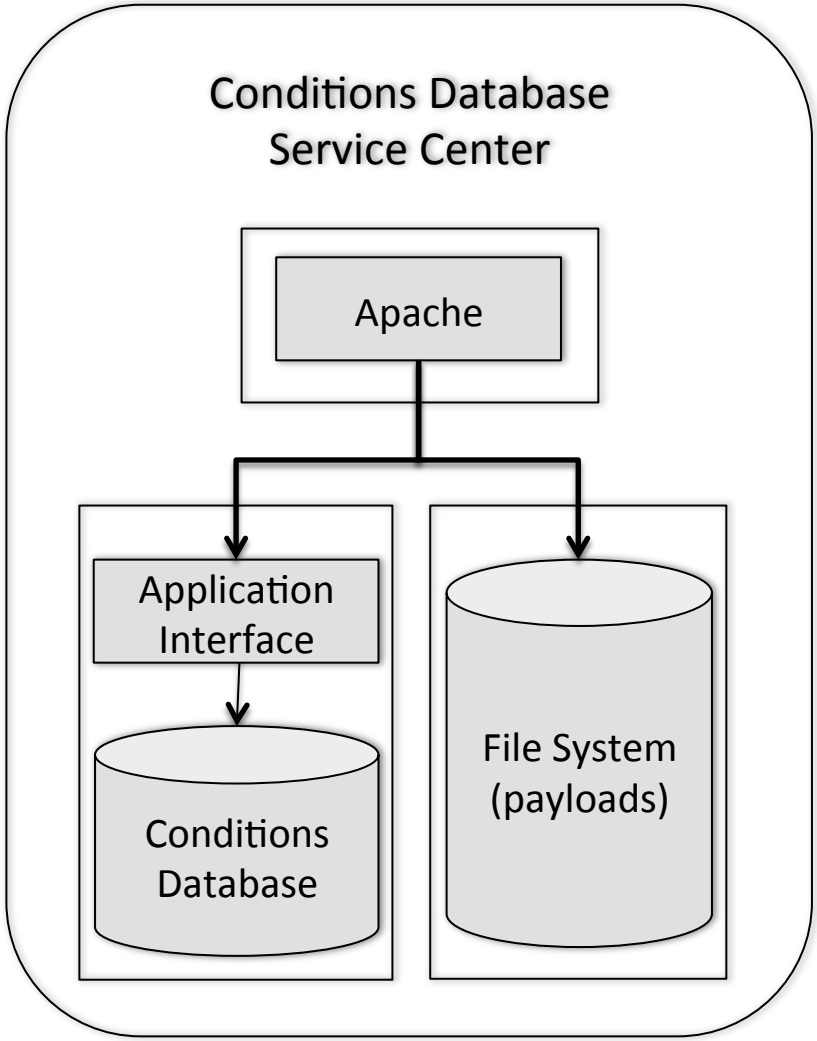
- **Current Status**
  - Network data challenge verify that:
    - KEK→PNNL requirements are satisfied until 2019
    - KEK outgoing traffic appears to be limited to ~3-4Gbps
    - PNNL→EU requirements are satisfied
    - EU ←→ EU requirements are satisfied
  - Next data challenge will test new KEKCC and full LHCONE setup (Fall 2016)

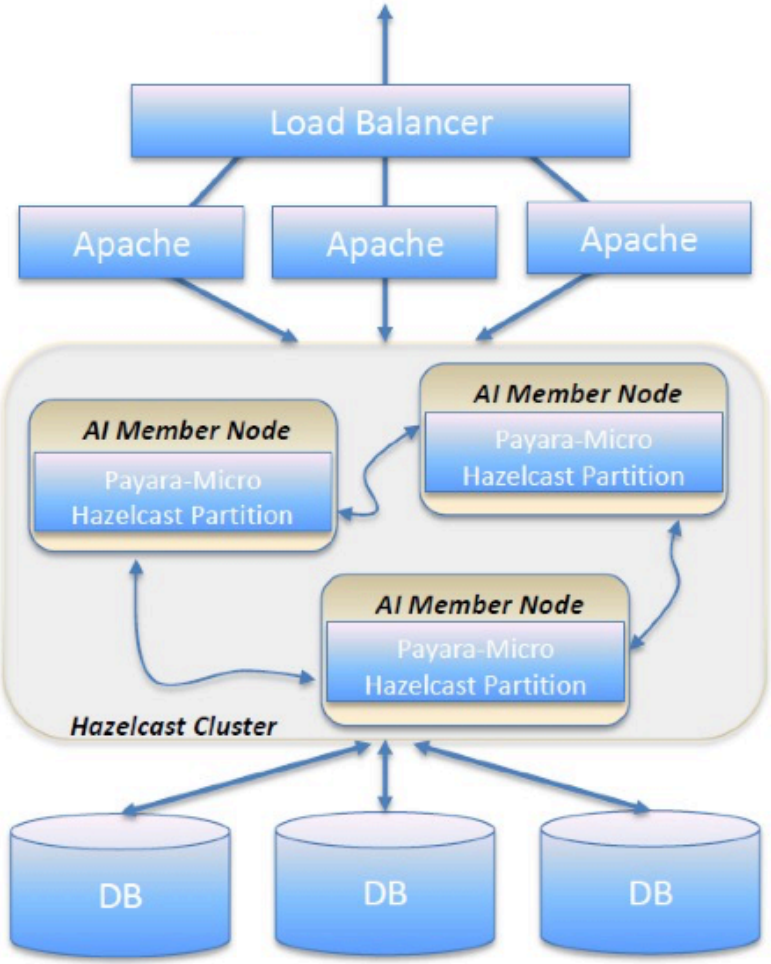
- **Moving Forward (FY16-17):**
  - Integrate networking transfer tools into the Distributed Data Management System
  - Integrate KEK in LHCONE and perform new Data Challenge
  - Update network requirements to include estimation on non-production traffic

Conditions Database Overview



- Provide read/write access to calibration, alignment, geometry, environmental parameters
- Adopted REST API
  - ***Apache*** server
  - Application Interface (***GlassFish***)
  - ***PostgreSQL*** database
  - ***Lustre*** file system
- A global tag is a unique identifier to define a collection of payloads with defined IOVs
- Belle II will use global tags to define processing runs, etc

Scaling the Conditions Database



- Prototype developed using ***OpenStack***
- Use ***Docker*** to develop modular components which allows for quick scaling as needed
- Use ***Swagger*** for automated API documentation
- User ***Payara*** and ***Hazelcast cluster*** for flexible and scalable in-memory data grid solution
- Testing ***OpenStack Trove*** provide redundancy and high availability

Extra Slides

- **Resources**
  - PNNL Tier-1 site
  - Several services are in place at PNNL: CVMFS, VOMS, etc.
  - Investigating increasing the US contribution: Universities, OSG, HPC
  - Conditions Databases in place
  - CRT and BEAST DIRAC setup are available … yes you can analysis TOP data!

- **Computing**
  - Prototype production system is available
  - Working on scalability test of each components and overall system
  - Three separate systems: Develop/Validate/Production
  - Developing automated unit testing

If you're interested join us!!!