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Belle II Conditions Database

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Pacific Northwest National Laboratory

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Purpose of a Conditions Database

- Holds conditions data – status of detectors
  - Calibration, alignment, geometry, environmental parameters
  - Types/values can be simple or complex
- Uses include reprocessing of raw data, MC production, possibly user analysis?
- Different than a…
  - *Configuration* DB that holds settings for the detector
  - *Logging* DB that records time-dependent information from the detector
  - *File system/metadata* DB that keeps tracks of experiments, runs, files, etc.
- *But* almost always will interact with those in some way!

Database Schema

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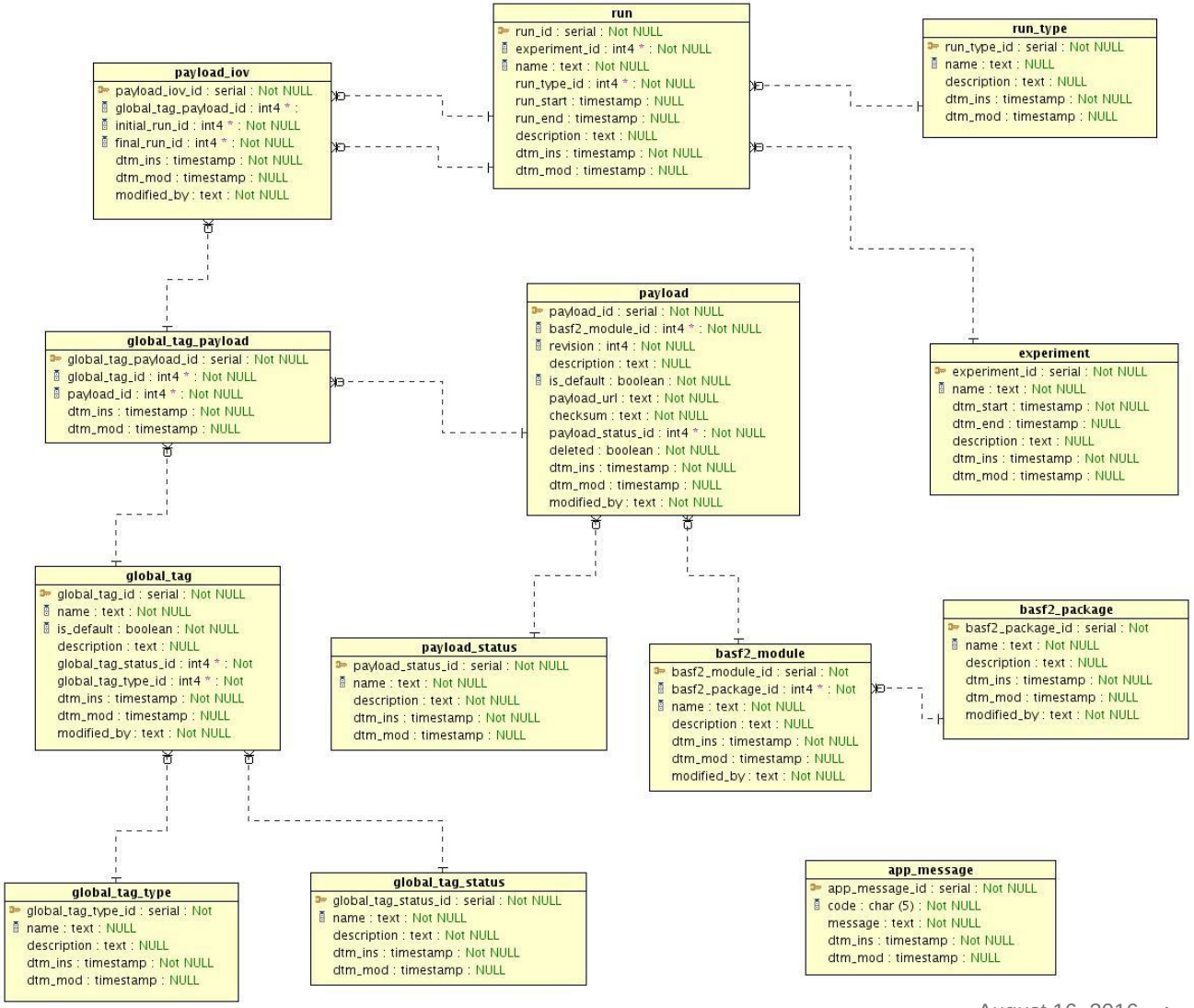
- A DB schema defines the types of entries in the DB and their relationships to each other



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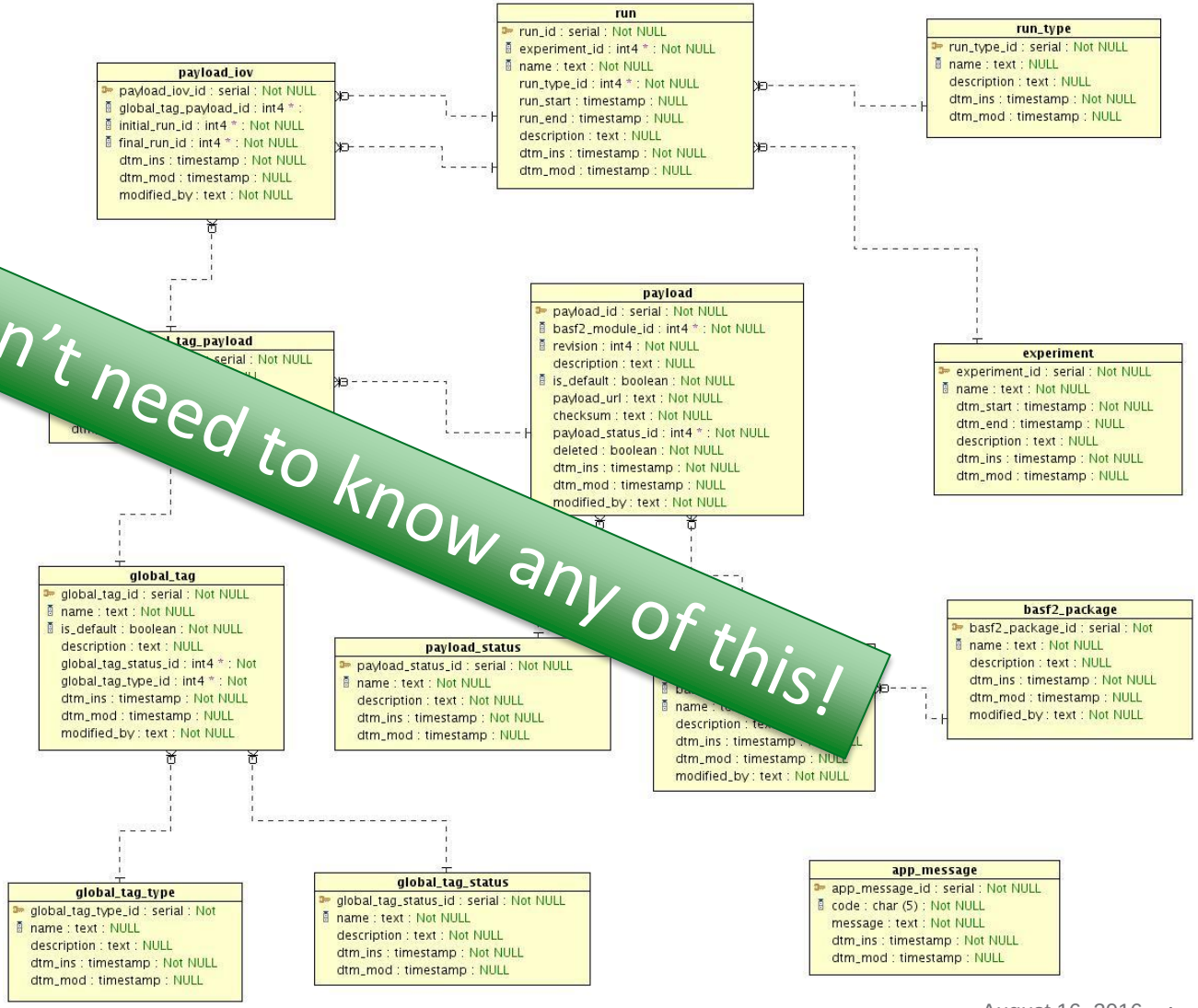

Structured Query Language (SQL)

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- SQL is a standard computer language for relational DB management and data manipulation. It is used to query, insert, update, and modify data.

- Examples:

```
SELECT Orders.OrderID, Customers.CustomerName, Orders.OrderDate
FROM Orders
INNER JOIN Customers
ON Orders.CustomerID=Customers.CustomerID;
```

```
SELECT * FROM Customers
WHERE Country='Mexico';
```

```
SELECT STREAM *
FROM (
  SELECT STREAM '"Orders"' as type, orderId FROM Orders
  UNION ALL
  SELECT STREAM 'SHIPMENT' as type, orderId FROM Shipments
)
```

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- Examp

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REST API

- The Belle II conditions DB is access via a “REST” interface, basically just HTML accesses to a server
  - This is very common in industry, and makes the database easier to scale and maintain

Example: **get /v1/globalTag/{gtName}/globalTagPayloads**

- Data is returned in either JSON or XML format:


```
[
 {
  "globalTagPayloadId": 0,
  "globalTag": {
   "globalTagId": 0,
   "description": "string",
   "isDefault": false,
...
```

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…
```

You don’t need to know any of this!*

*(unless you’re trying something tricky, and even then this is MUCH easier than schemas and SQL…)

What the Conditions DB Server Looks Like Now…

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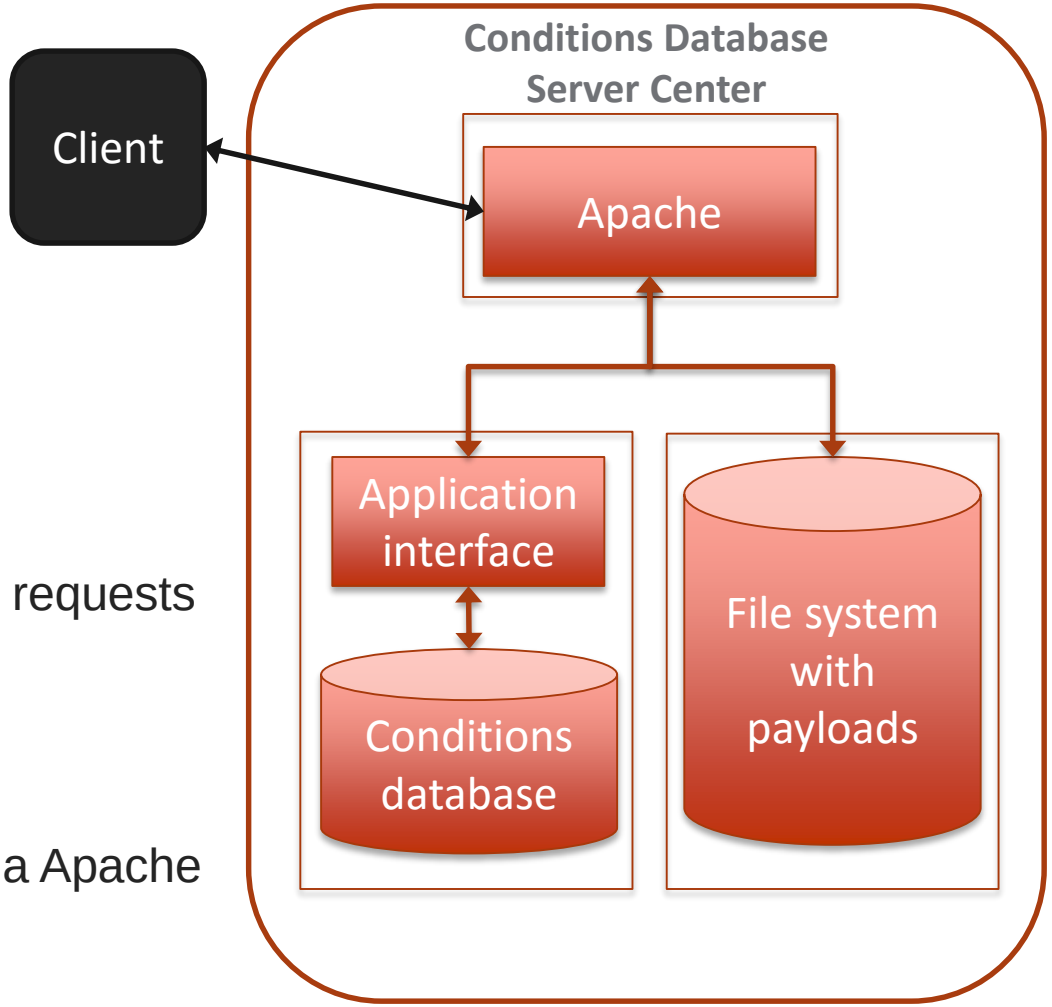
- **HTTP server**
  - Apache, etc.
- **Database**
  - PostgreSQL
- **Application interface**
  - Translates the REST (HTTP) requests into SQL
- **File system**
  - Simplest option: on server via Apache



You don't need to know any of this!

What We Are Working Towards

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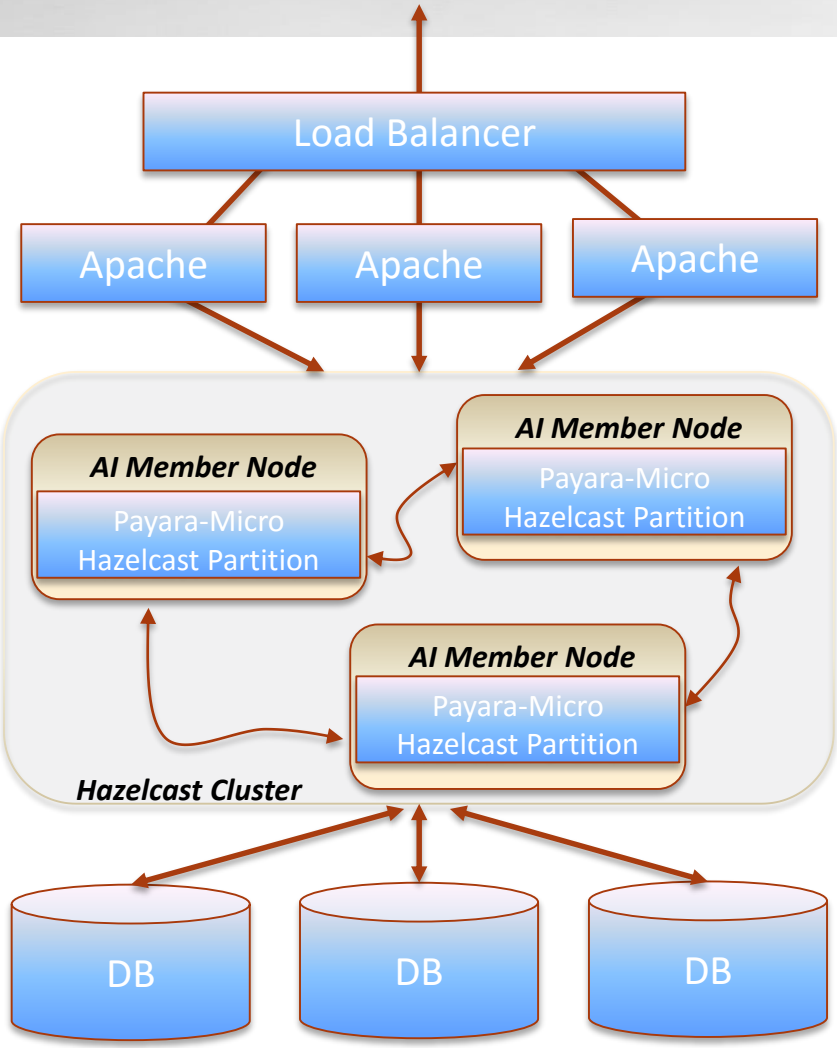
- Database loading will be significant when data reprocessing is underway
- Goal: make all components reliable and scalable



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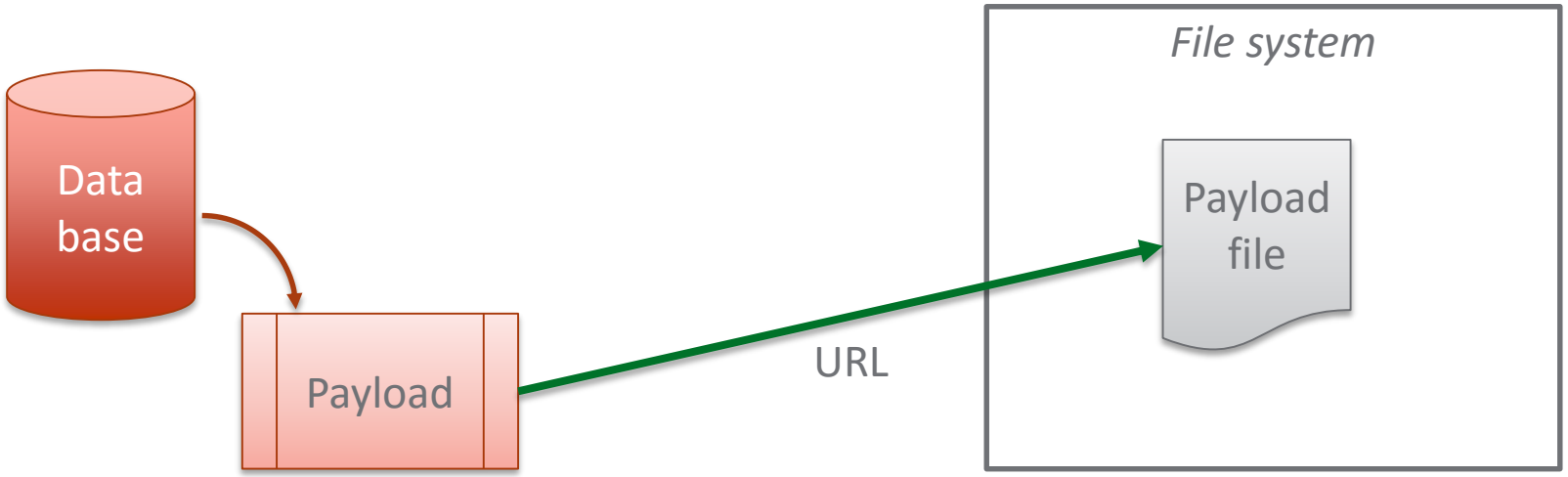
What You Need to Know

- The components that the Belle II Conditions DB is designed with:
  - Payloads (and payload files)
  - Intervals of Validity (IOV)
  - Global tags
- How the conditions DB is accessed from Basf2
- Upcoming changes

Payloads and Payload Files

- A **payload** is a piece of conditions data
  - (Belle II assumes ROOT objects, but the DB technically doesn't care)

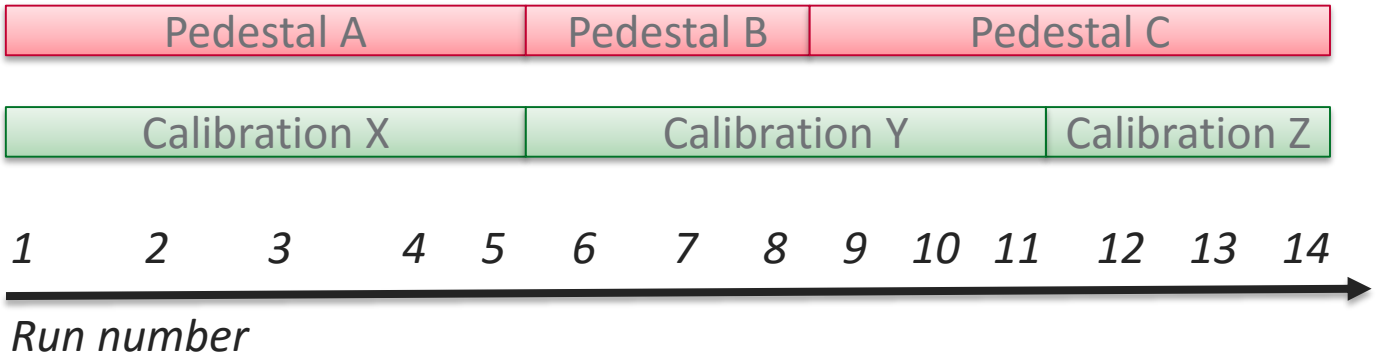
- In the Belle II database, the payloads are stored <u>outside</u> the DB itself
  - The DB only contains references (URLs) to the **payload files**
  - Designed this way for multiple reasons: keeps DB itself small, allows separation of DB server and file server, etc.



Intervals of Validity (IOV)

- Each payload is valid for a certain period of time that needs to be identified in the database
  - In Belle II, current granularity is a “run” (~hours)
  - An IOV contains a start run and a stop run (or -1 for “forever”)

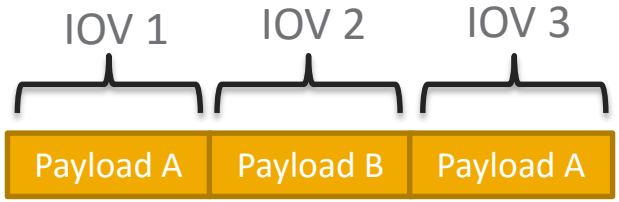
- Each type of payload may (will) have different IOVs, depending on when conditions change

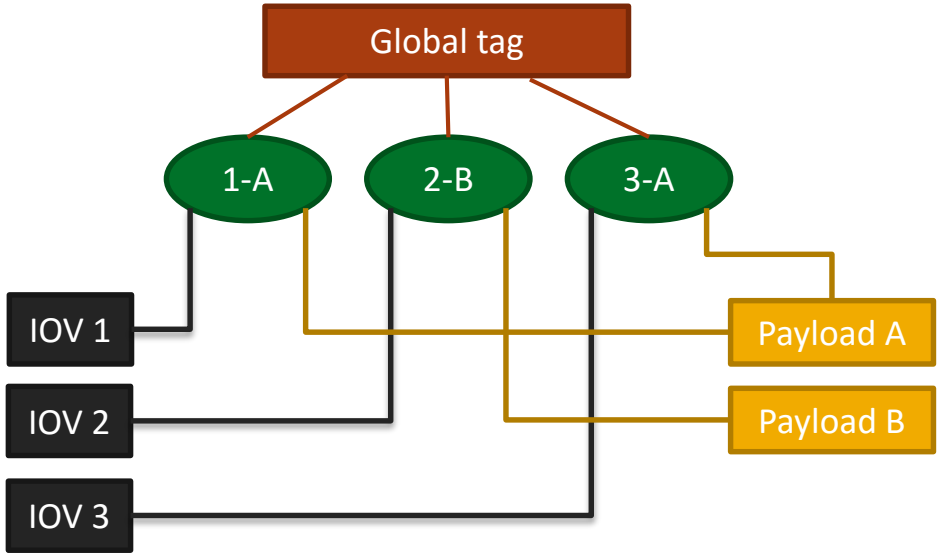


Global Tags

- There will be many payloads valid over many different IOVs, so we need a way to keep track of all of all the “good” ones

- This is a **global tag**: contains a list of IOV-payload relationships
  - Note that separation of IOVs and payloads allows payload reuse in different IOVs





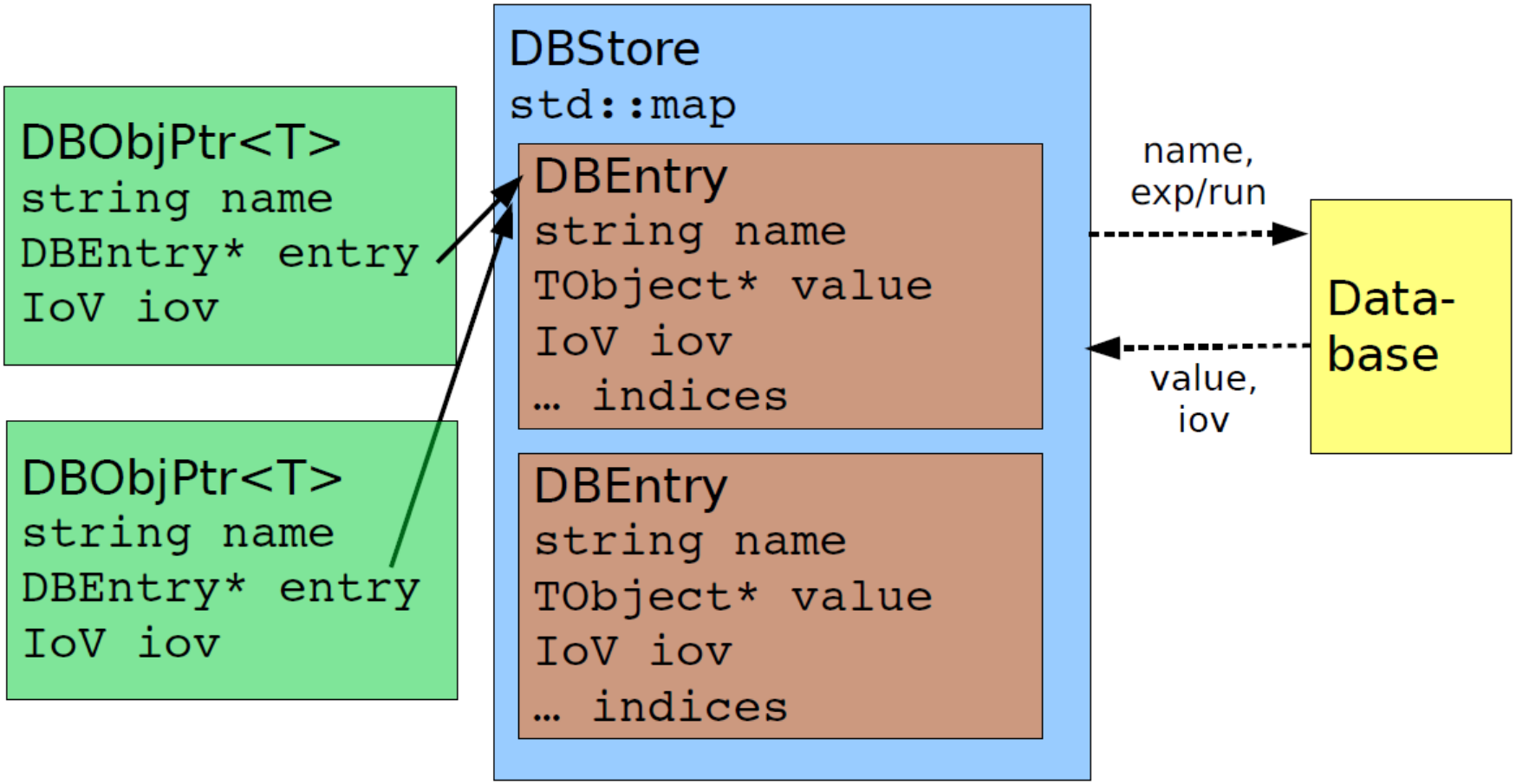
Global Tag Management

- Three levels of control are planned (but not yet present):
  - ***User*** Read access to database
  - ***Developer*** Can add payloads, IOVs, global tags
  - ***Coordinator*** Can change global tag status
- Global tags have three states: "**new**", "**invalid**", or "**published**"
- Concept of a "Global tag coordinator" (GTC) was discussed at the Software/Computing Workshop in May 2016
  - Would coordinate creation and validation of global tags for reprocessing
- For development work, everyone creates their own global tags
  - **Naming convention will be published soon!**

Database Interface in Basf2

- Similar to the successful Basf2 “DataStore” concept
- Encapsulates low-level interface(s) – no SQL, REST, etc. required!
- Handles many things automatically:
  - Experiment and run number
  - Memory management
  - Caching (only accesses DB if new data is needed)
  - Run dependency
    → **automatically get the correct payload** (like DataStore)
- Hooks available to handle data changes, accessing array elements by index, etc.

Basf2 DBStore



DB Read Access

- Reading from database is straightforward:

```
DBObjPtr<BeamParameters> beams("superkekb/beams");
beams->getHEREnergy();
```

- Sequence:
  - *(global tag is identified in steering script before analysis starts)*
  - Asks DBStore about object with name "superkekb/beams"
  - If no DBEntry with this name, creates on and accesses the DB
  - Fills the IOV and value
  - Returns a pointer to the DBEntry

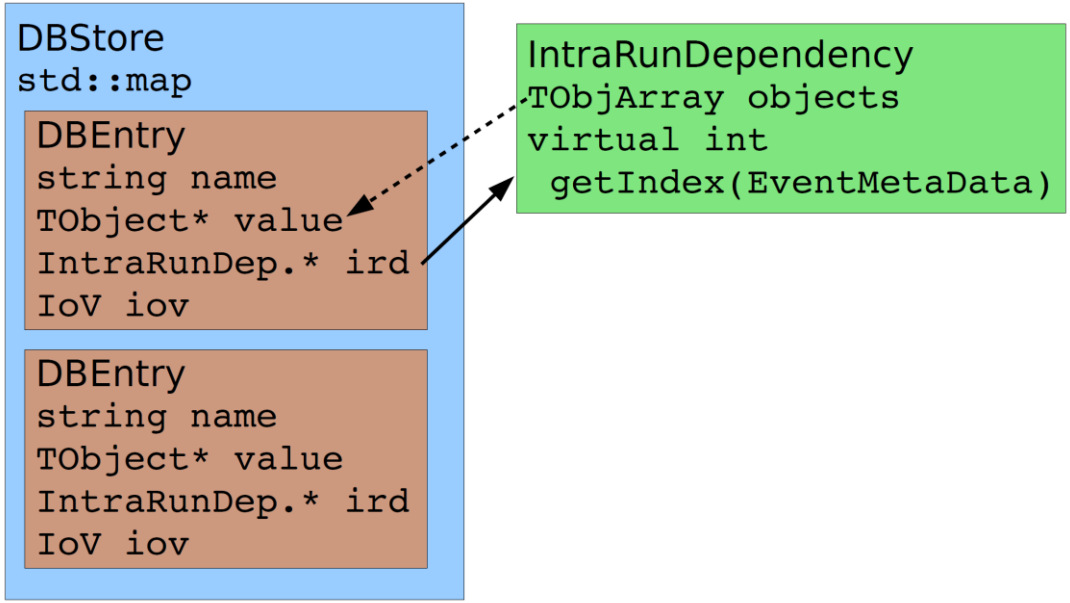
- There is a similar class "DBArray" for arrays
  - Similar naming convention as DataStore (add "s" to arrays)

Automatic Updates

- When a new run is accessed:
  - Checks all DBEntries
  - If the new experiment/run is outside of a current IOV, the DBStore gets the next IOV and value for that payload
- DB access is done as a bulk request (not individual ones)
- Possible to add callback
  - Example: parameter calculated from conditions data needs to be recalculated if the input values change

Intra-Run Dependency

- What if conditions data changes **more frequently** than run-level granularity?
- "Intra-run dependency" support for storing multiple values in a single payload



- Current granularity: event number within a run
- DBStore automatically identifies these when loaded from the database
- Also checks for changes at event level as well as run level

Local Databases

- Possible to use local DB instead of official DB
  - Useful for testing, storage of payloads during development, etc.

- Database represented as text file with IOV assignments
- Payload files are identical (but located on local machine)

- Better still, the Basf2 DBStore already creates a local copy of all the payload files when they are downloaded
  - Also creates a “dbcache.txt” file that can be used as a local database

  → **Local DB automatically generated from global DB**

Database Chaining

- Possible to create a list of databases
  - Each one is searched in turn until a payload is found
  - Can combine local and global (remote) DBs
- Configured by the steering file; default sequence is:
  - Local database in “localdb” directory
  - Global database global tag “production”
  - Local database in “data/framework” (fallback with default payloads)
- Can be overridden/added to by user’s steering script

DB Write Access

- Somewhat more complicated; need to deal with global tags and IOVs
  - See examples in ARICH source code

```
TClonesArray agelConstants("Belle2::ARICHAerogelInfo");
// fill agelConstants here…

// global tag identified previously (in steering script)
IntervalOfValidity iov(0, 0, -1 ,-1);   // from expt 0, run 0 to forever

// store under user-defined name
// Database::Instance().storeData("testAerogel", &agelConstants, iov);
// store under standard name
Database::Instance().storeData(&agelConstants, iov);
```

Code Examples

- ARICH was the first detector to use the Conditions DB en-masse by moving all their XML-based data into the DB (hooray!)

- Code examples in **software/arich**:
  - dobjects/include/* ← object (payload) definitions
  - dobjects/src/*
  - examples/ArichDatabaseInstructions.txt ← how to use the scripts
  - examples/ArichDatabaseImporter_export.py
  - examples/ArichDatabaseImporter_import.py

- From the framework:
  - framework/tests/database.cc ← test suite for DB
  - framework/tests/upload_localdatabase ← transfers local DB to global

Continued Conditions DB Development

- **Schema change in progress**
  - Experiment/run are currently "objects" in DB; adds complexity but not values
    → changing them to simple numbers
  - Will move all (valuable) data from original format to new schema
- Second, more robust server up and running at PNNL; will be used for stress-testing
- **<u>All subdetector groups</u>** are supposed to stop using XML files for conditions data by Nov 2016…
  - All groups have made progress, but lots of work still to do!

“Documentation”

- In confluence:
  - https://confluence.desy.de/display/BI/Software+DatabaseInterface
- REST API:
  - http://belle2db.hep.pnnl.gov/b2s/api/
- Mailing list:
  - database-conditions@belle2.org
- Meetings:
  - Typically Tuesdays every ~3 weeks or so
  - https://confluence.desy.de/display/BI/Software+DBMeetingPage