Calibration and Cryogenic Instrumentation

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Database Workshop

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LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS

Summary

- Calibration (Cal)
    - Introduction to the calibration systems
    - Database use cases
    - Data volume estimates
    - Database access
- Cryogenic Instrumentation (CI)
    - Introduction to CI systems
    - Database use cases
    - Notes on access

Disclaimers

- Slow Controls are not covered in these notes
  - Moving from CISC to DAQ
  - Both CAL and CI feed into slow control DBs
    - Slow changing data
- Discussion on some of these details is still ongoing
  - Where possible and unclear, conservative estimates are provided
- In these notes there are references to multiple “databases”
  - These are not necessarily different physical databases but rather “different classes of data” that differ in origin, purpose and/or use

Calibration systems

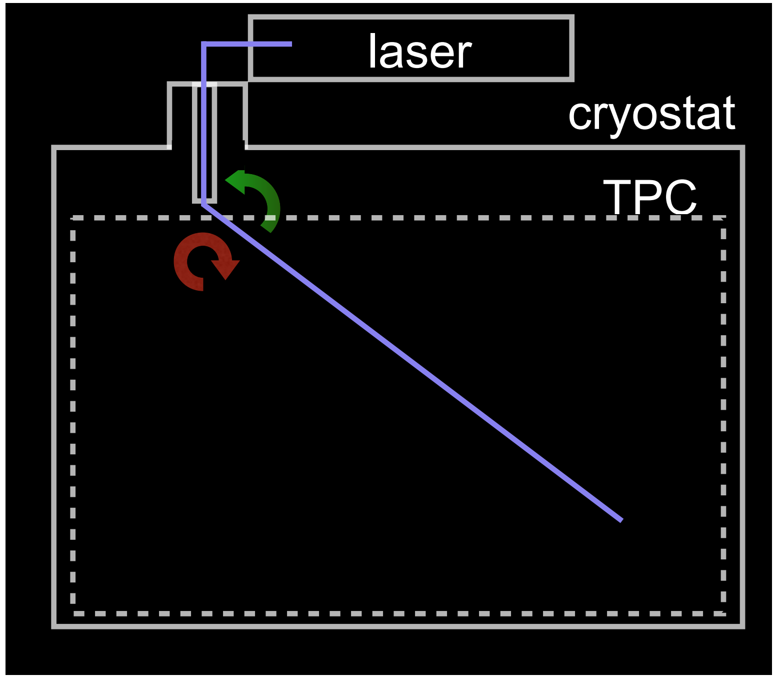
Calibration systems

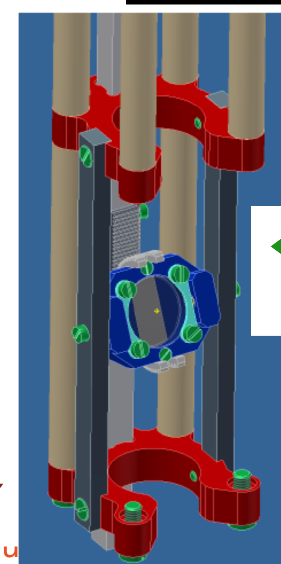
- **Ionisation laser**
  - High intensity laser, to ionise argon along tracks
  - Measure E field map, possibly electron lifetime
- **Pulsed neutron source (PNS)**
  - Neutron capture events
- **Radioactive Source**
  - Single 9 MeV gamma from Cf/Ni source
  - Deployed outside field cage (mechanical movement)
- Photoelectron laser
- Laser beam location system (LBLS)

Ionisation laser

266 nm Nd:Yag laser

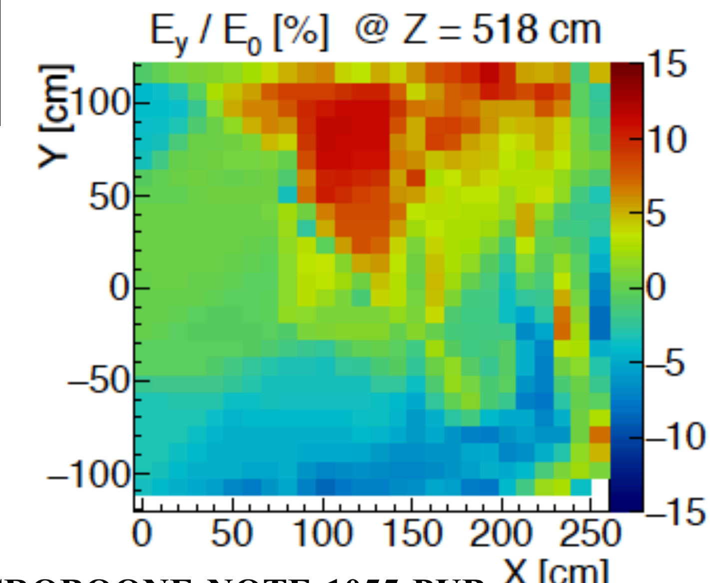
MicroBoone CAD design





steerable mirror

Goal: track E field distortions to 1%



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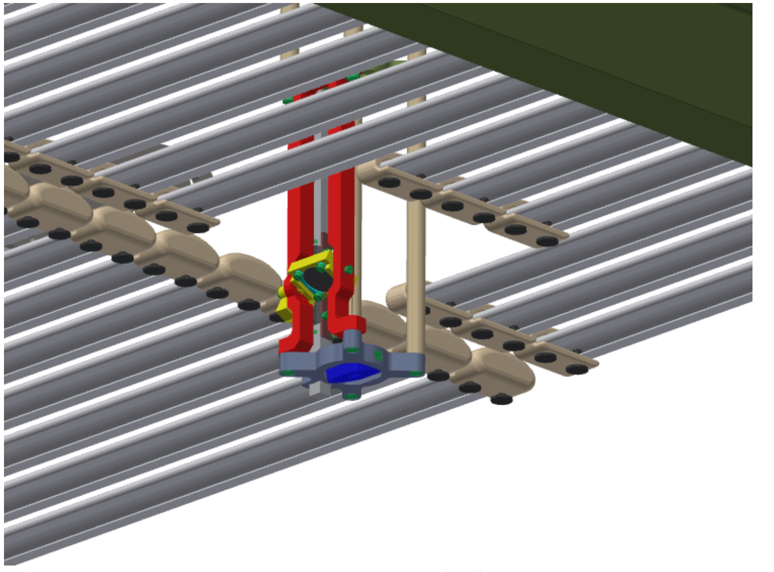
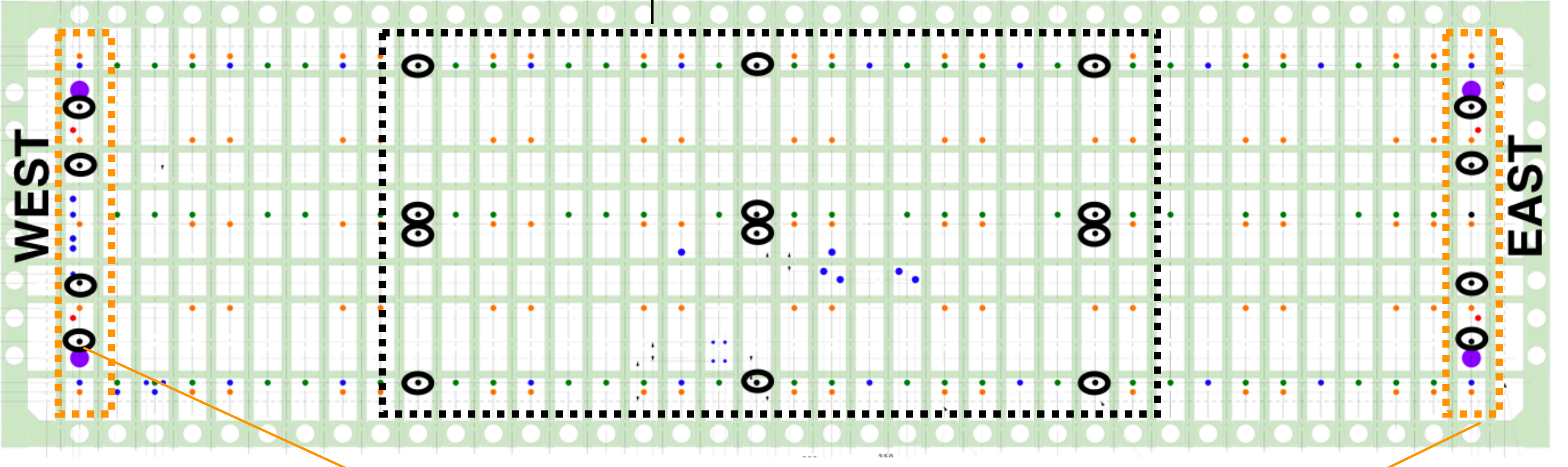
Laser Ionisation System

- 9 lasers, 12 periscopes;

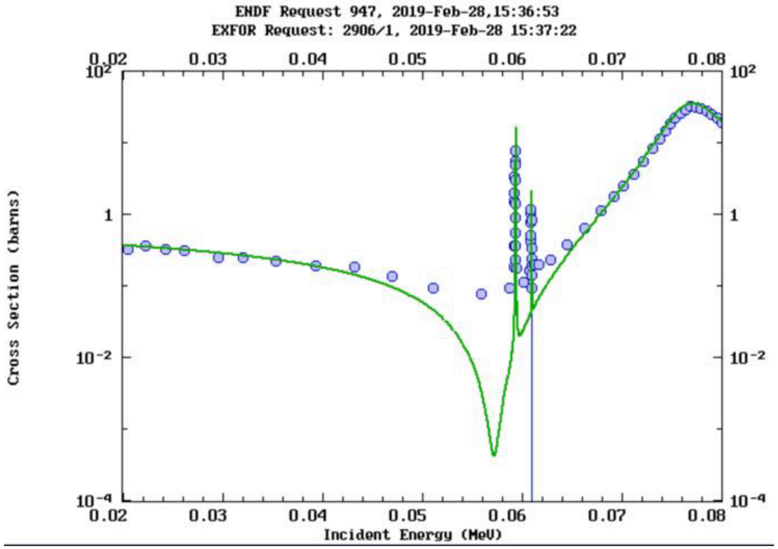


Design 1 (SBND design)
FC penetration — **baseline design**

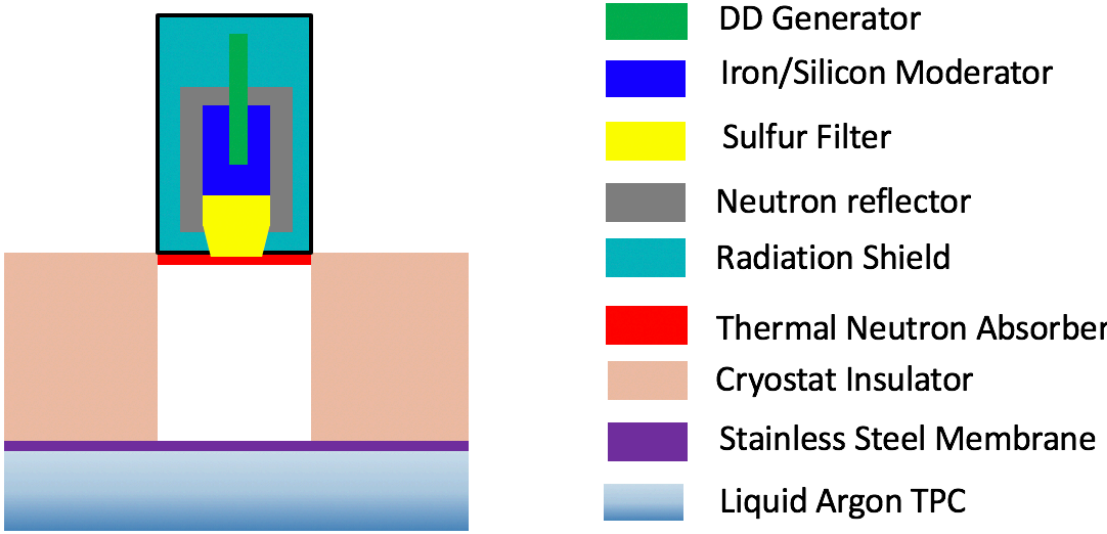


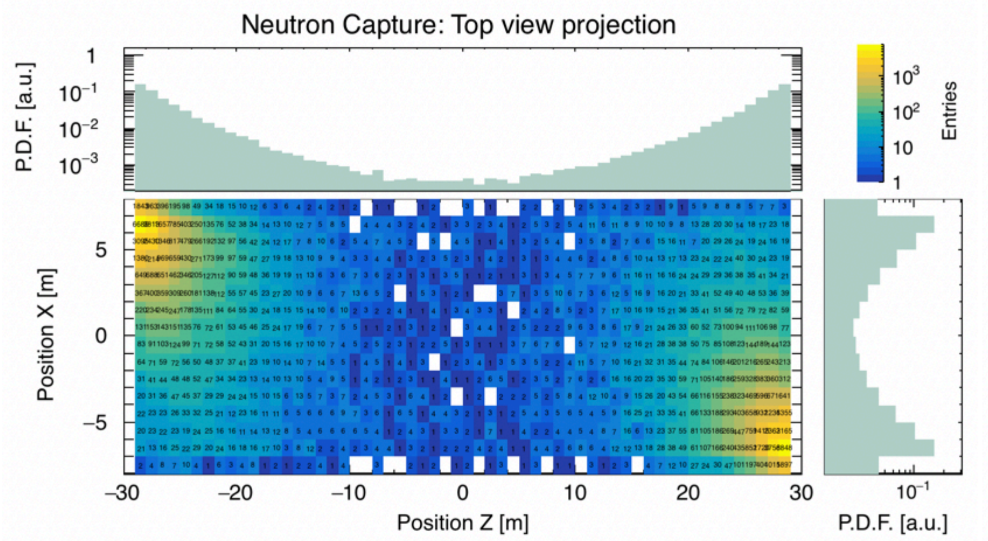
Design 2 (eccentric dual-rotary system, developed from the SBND design);
No FC penetration — **alternative**

Pulsed Neutron Source



Anti-resonance @ 57 keV ?

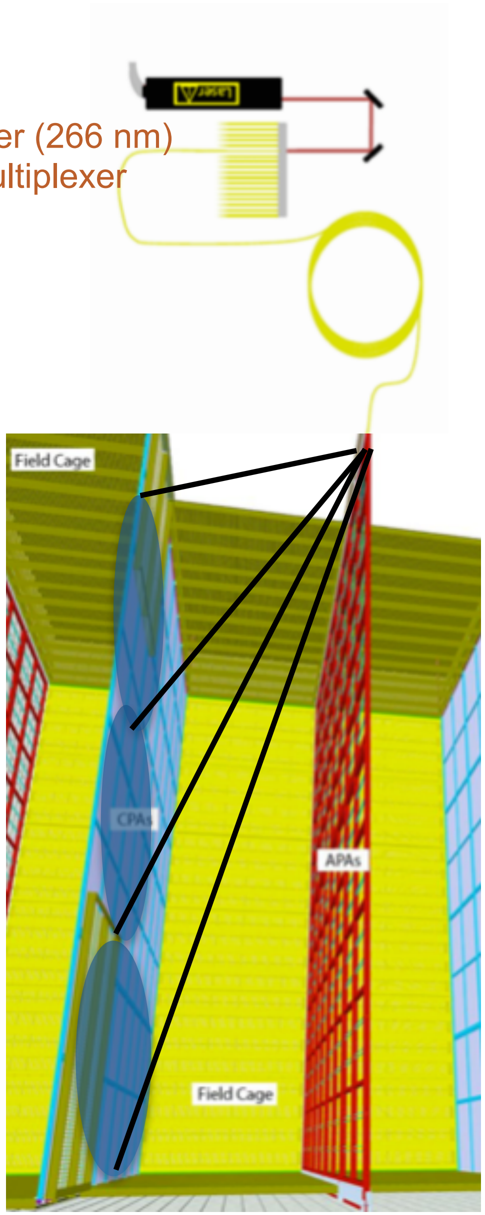




Baseline design for DUNE in 2 human access ports coverage in center requires additional source/port

Photo-Electron Laser

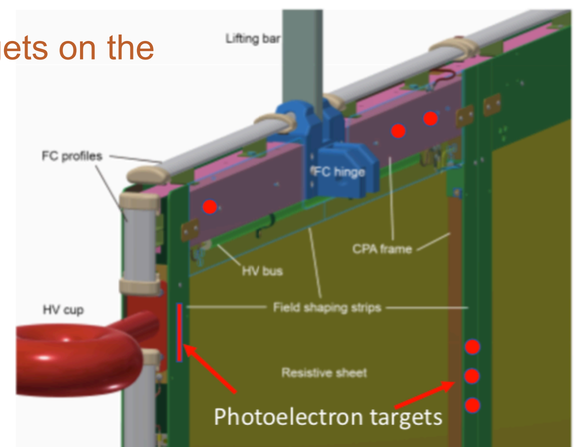
UV laser (266 nm)
and multiplexer



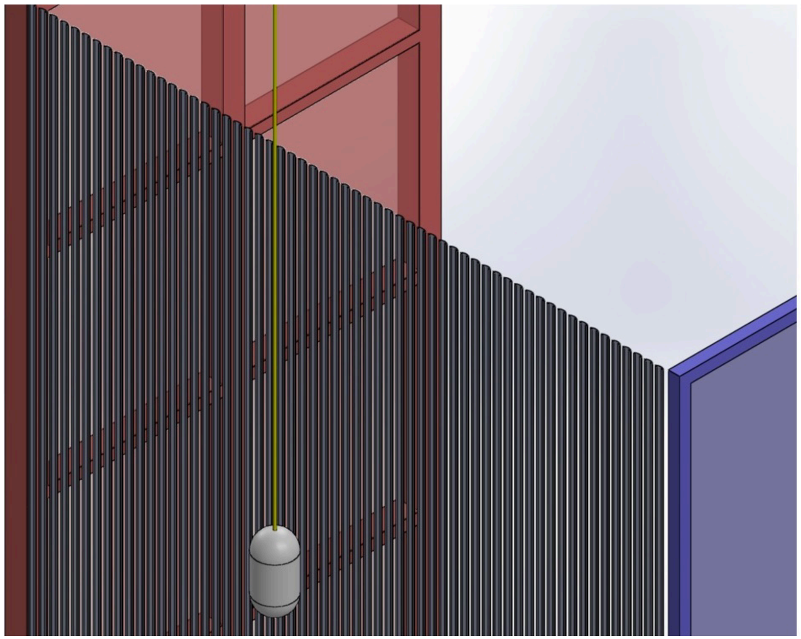
- Bring in 266 nm light via optic fibers to the APA and illuminate photocathode (Al) tabs on the CPA.

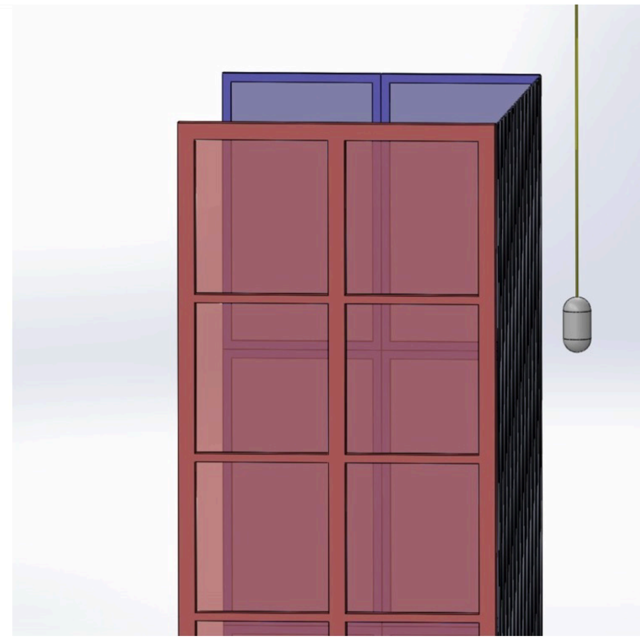
- Precise estimation of electron drift time
- Diagnosis: check if detector is awake
- Measure drift velocity and field distortions
- Vertex reconstruction on CPA

PE targets on the
CPA



Radioactive source





- 9 MeV single gamma, untagged, deployable close to end-walls
- Low energy response with no pile-up

Types of Databases

- **HardwareDB**
  - (Mostly) Static information about the hardware during construction
- **ConfigurationDB**
  - Run specific configuration information — things that are relevant and attached to specific runs
- **CalibrationDB**
  - Calibration specific data. Timestamped, can have data stored outside of a run
- **DUNE DB**
  - Calibration outputs used for analysis: calibration constants
- **Slow Controls DB (covered by the DAQ group)**
  - Slow changing operational information (temperature, HV, etc)
-

Hardware DB

- **Static information of calibration hardware components**
  - Position, identifiers, relative locations
    - If parts are barcode tagged, include ID
  - Should have a timestamp or a version+timestamp
  - Should also accommodate references/attachments of any relevant documents
  - At each point in time, a single object should be valid
    - If a new version is uploaded, it becomes the up-to-date information from then on (until a newer version)
    - Versions should not change unless a major change in hardware disposition occurs (upgrades, remapping, re-routing, removal, etc)
  - **DB population rate:** once at construction
    - Occasionally afterwards with significant hardware changes

Configuration DB

- **Run based information of calibration hardware configuration**
  - Which systems are on
  - Which systems are to be used
  - List of source configurations within a run
    - Source positions (radioactive source)
    - Laser directions (laser)
  - **DB population rate:** 1/run
- Essentially, all configuration information that is passed to the calibration system/DAQ during a calibration run
- The exact schema

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Configuration DB

- **Data structure**
  - Moderately complex structure.
  - Needs to account for hardware configuration for the whole run
    - For example, the laser system is expected to fire over various predefined directions during a single run.
    - Schema needs further internal discussion.
  - Requires iteration with DAQ group about flow of information

- **Expected data volume**
  - **Light.** ~ MB /calibration run

Calibration DB

- **Calibration analysis specific information (only pertinent to the calibration analyses)**
  - Data schema and storage granularity depends on the specific system
  - **Laser system**
    - Part ID
    - Timestamp (requested + served)
    - Part state
      - Encoder position, filter position, diode intensity
  - **PNS**
    - intensity/integrated charge
    - Time (requested+served)
  - **Radioactive source**
    - Source position (motor steps/encoder position)

- **DB population rate:** 5 - 10 Hz, when operating some calibration systems

- **This information needs to be stored also outside a DAQ run**
  - **We can for example do alignment checks during a short shutdown**

Calibration DB

- **Data structure**
  - Relatively simple (in principle could be common to all systems)
    - Part ID
    - Timestamp (requested + served)
    - Part state
      - Encoder position, filter position, diode intensity

- **Note the cross-reference with the hardware/construction database (part ID)**

Calibration DB

- **Rough estimation of data volume**
  - A very conservative, worst (best) case estimate
  - Sampling of 10 Hz with
    - T_{req} (64 bit); T_{serve} (64 bit); Part ID (32 bit); Part state (32 bit)
  - 24 byte words —> 240 B/s / channel
  - 4 channels / feedthrough —> 960 B/s
  - 10 feedthroughs —> assuming we could actually fire all 10 at the same time
    - 9.375 MB/s
  - Running over a live week per year (3 live days per scan/2 scans per year)
    - 5.40 TB/year

- 3 day scan assumed sequential laser firing. There is almost an order of magnitude of room to work, if parallelisation possible (TBD)
- PE laser system will have similar requirements (also aimed sampling of 10 Hz)

DUNE DB

- **Calibration constants (ConditionsDB?)**
  - **Structure will depend on type of calibration**
  - Laser (10 parameters)
    - 3 coordinates of electric field and drift velocity
    - 1 electron lifetime
    - 3 parameters of recombination
  - PNS (4 parameters)
  - PE laser
    - Laser intensity, photocathode properties
    - Possibly other quantities (evaluation ongoing)

  - Data should be valid over run periods/timestamps
    - These could change (to allow re-analysis of data)
    - It would be good to have versioning, but the latest version should always be the default

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DUNE DB

- **Data volumes (rough estimate)**
  - **Laser (worst case)**
    - 10^7 voxels of 10x10x10 cm (highest granularity)
      - May decide on lower number of voxels
    - 10 float parameters —> ~400 MB / scan (two scans per year)
  - **PNS**
    - Much larger voxels (~10k voxels)
    - Possibly 4 floats per voxel —> ~40 MB / scan

Database Access

- **Depends on the type of database**
- **Hardware DB**
  - Browsable based on timestamp (default now())
  - Query based in timestamp
- **Configuration DB**
  - Browsable based on run
  - Access necessary from physics calibration analysis algorithms
- **Calibration DB**
  - Browsable based on timestamp
  - In future may set up automated data quality control
- **DUNE DB**
  - Accessible from physics analysis jobs (should be default)
  - (optionally) Browsable from outside analysis code

Database Access

- **Possibility to implement access through provided APIs**
  - If possible APIs from the analysis framework and outside
  - Not necessarily within the analysis framework
  - For example, one could be interested to run data quality in a standalone system
- **Examples for use of each database system**
  - Scripts/small programs that would show how to get the information about a particular system, for a specified period of time
  - Show how to do this both from inside the overall analysis framework and outside

Cryogenic Instrumentation

Cryogenic Instrumentation

- Purity Monitors
- Thermometers (individual sensors & long movable thermometers) in liquid
- Thermometer in gas
- Gas analyzers
- Cameras & associated light systems
- Level Meters
- Pressure meters
- Cryogenics Recirculation system

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Database use cases

- Assuming/need same structure of 4 distinct databases, as in the calibration

- **Hardware DB:**
  - Same use cases as calibration (and likely most other systems)
  - Possibility to have timestamped versioning would be useful, for the case of upgrades, replacements, etc
  - CI may have some components (cameras) that may be moved from place to place in a ~month timescale — new versions

Configuration DB

- **Configurations of the different instrumentations**
  - Eg.: Configuration of the gas analyser
    - Not expected to change more than 1/day during commissioning and 1/week during operation
  - Purity monitors
    - Could change even within a run (e.g: Xe flash lamp intensity)
  - Movable thermometer systems
  - Cameras
    - Moving them to point into a different direction during operation

Calibration DB

- **Unlike Calibration systems, most CI systems run continuously**
  - Could follow a data structure similar to the proposed Calibration systems
  - Still need to assess granularity of data input and estimate data volumes
  -

DUNE DB

- **Information from CI relevant as input to calibration analyses, data quality and operations**
  - LAr purity values from purity monitors
  - Extrapolated purity values
  - Liquid argon level

- **Formats change widely depending on the system**
  - Most consist of arrays single values
    - Each system provides a single number, but there are multiple units of the same system
  - Others of quite complex structure
    - eg.: images from cameras to be used for data quality assessment