The ATLAS Online Luminosity Software
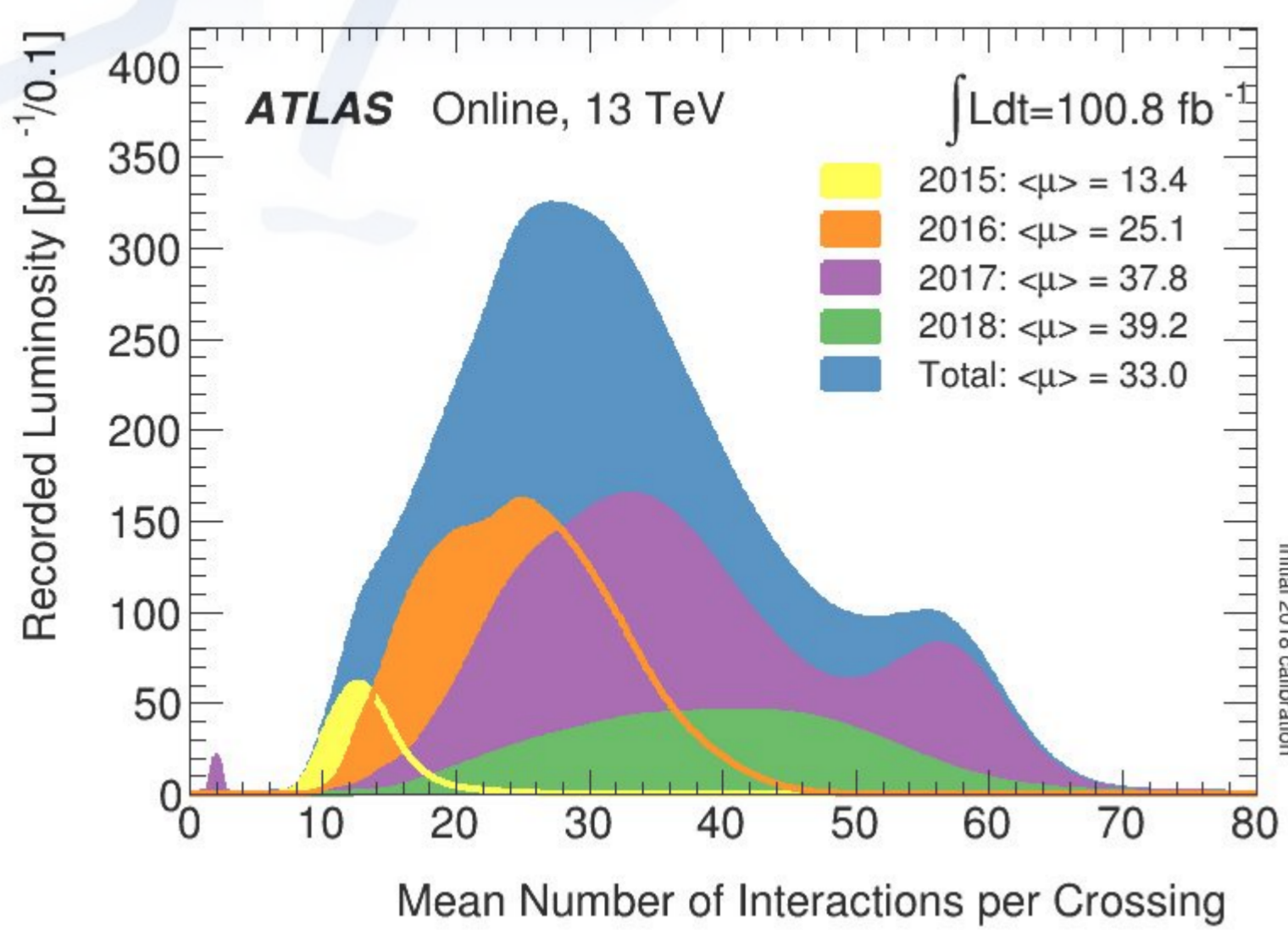
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for the ATLAS collaboration

At a collider the **luminosity** is a measurement of the **interaction rate** at a collision point. For a given process, with a certain cross-section, the event rate is the product of the luminosity and the cross-section.

Real-time luminosity determination is important for both ATLAS and the Large Hadron Collider (LHC). This has led to the development of software tools responsible for reading and calibrating inputs from luminometers, publishing the information in the control room as well as archiving the data for offline analysis.

Scan Controller — 2018

The `Scan Controller` is responsible for automatically steering beam scans in ATLAS.

Upon LHC request, the `Scan Controller` **automatically** prepares ATLAS for a scan:
- Adjust **trigger** (only for emittance scans).
- Aligns LBs with the **LHC magnets movements**.
- Increase number of data files in local storage.

Once done, the `Scan Controller` signals **readiness** for scans and LHC operators **vary the beam separation** in **steps** with a 10 s pause per step so ATLAS can **acquire data**.

The luminosity data during the scans are sent to the LHC online.

At the end of a scan ATLAS is brought back to **nominal physics** configuration.
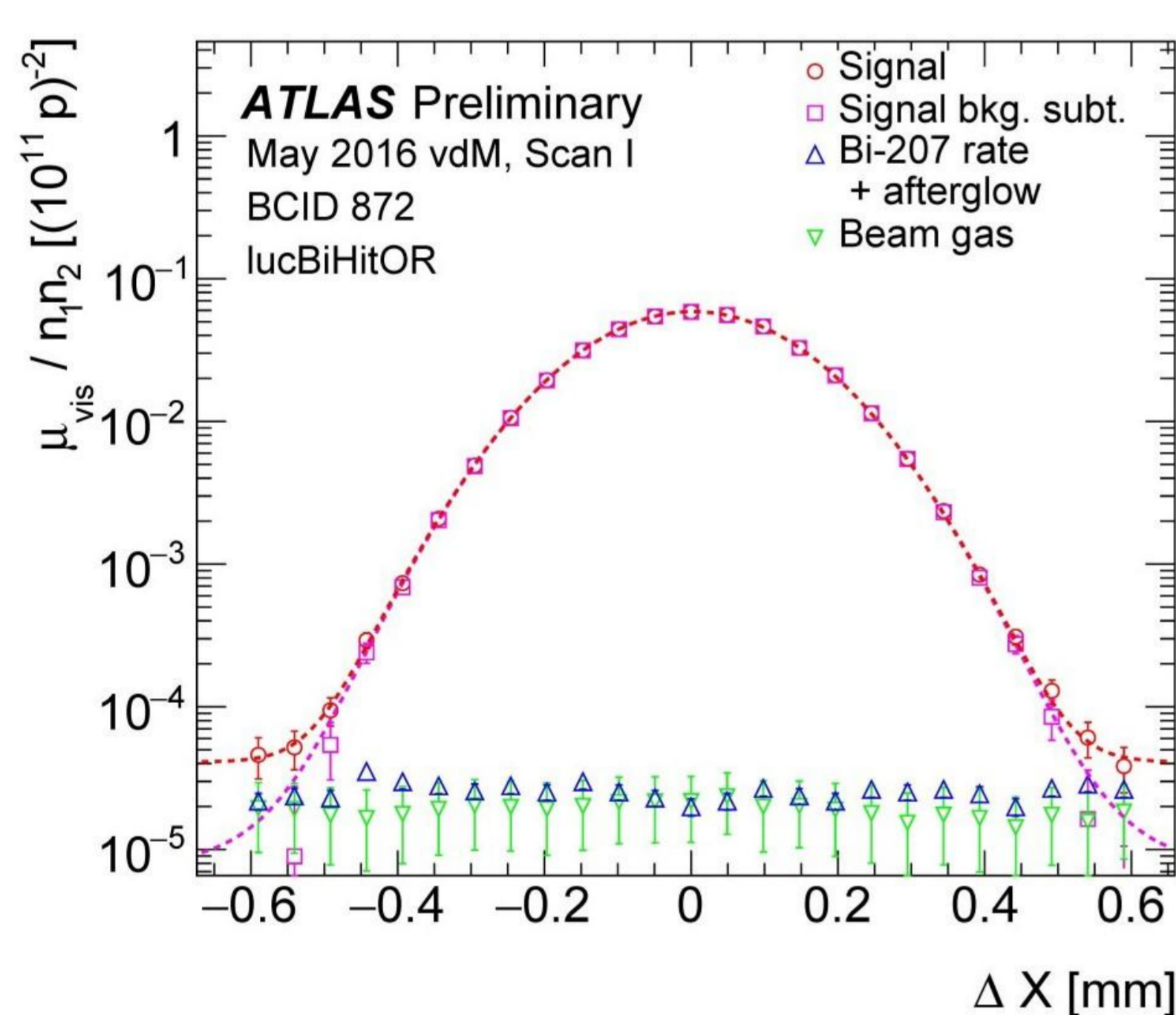
*Luminosity as a function of beam separation, example from the first 2016 Van der Meer scan*

Online Luminosity Calculator — 2017

The ATLAS luminometers deliver inputs for $\mathcal{O}(70)$ luminosity algorithms:
- averaged over all LHC bunches every $\mathcal{O}(1\ s)$.
- per-bunch data for every ATLAS luminosity block (LB*) on a timescale of $\mathcal{O}(1\ minute)$.

The `Online Luminosity Calculator` (OLC) **reads** the data, **calibrates** and **publishes** it online in the control room. It was re-designed with a **multithreaded architecture** and updated for the LHC Run-II, with the goal of improving reliability and reducing latency in providing the luminosity data.
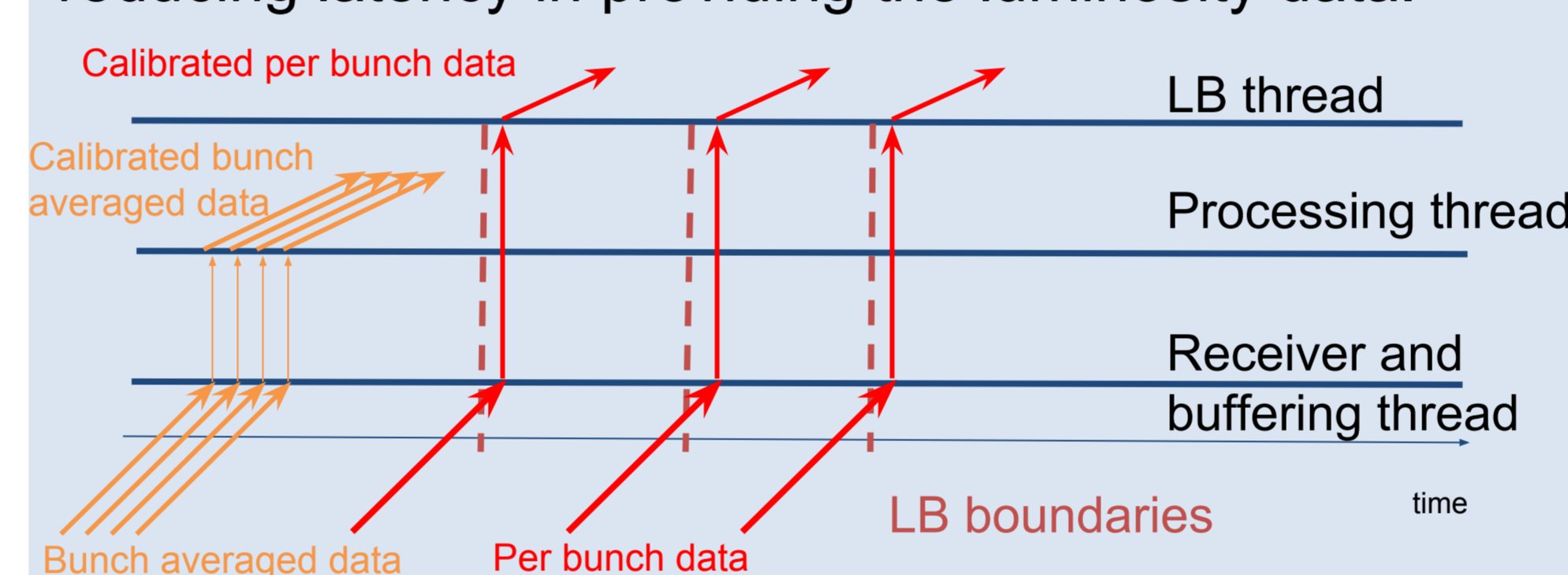

*: LB = a period of time for which conditions are considered constant and for which the average luminosity is computed.

OLC2COOL — 2016

Archiving of luminosity and accelerator data from the OLC is done by the `OLC2COOL` application, redesigned for Run-II. Luminosity information is archived for every LB. When archiving the **optimal online luminosity** is also produced as well as a measure of the **integrated luminosity**.

A crucial deliverable is ensuring that in rapidly changing conditions all data are archived. This was achieved with a **multithreaded architecture** where data reading and calculations are performed independently in separate threads.
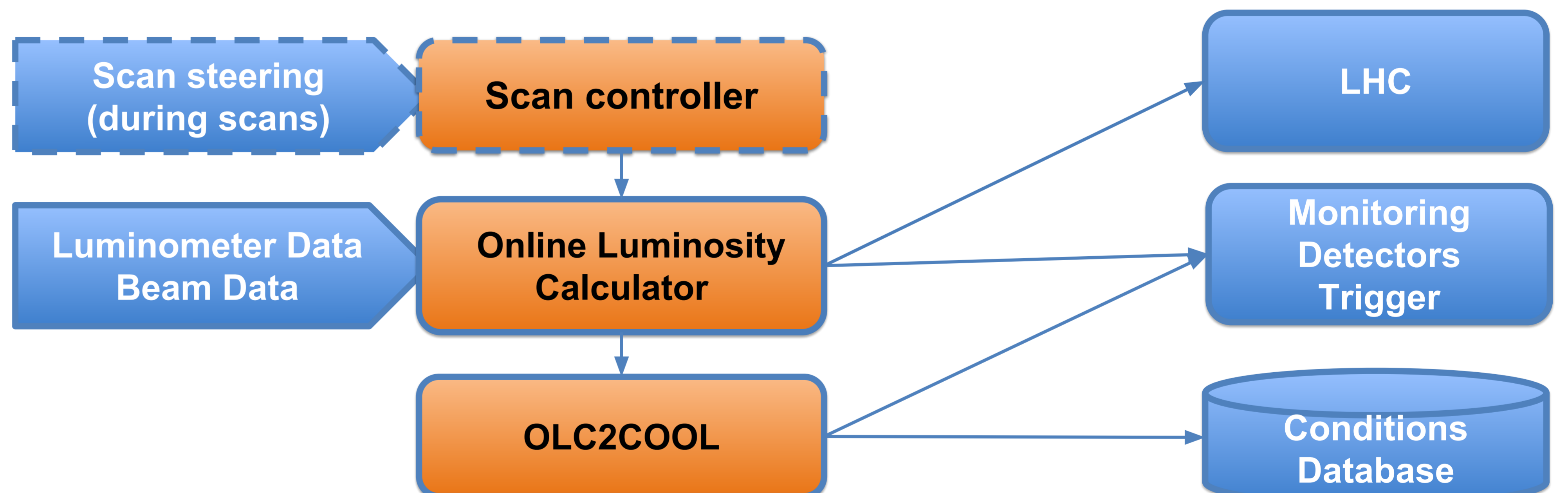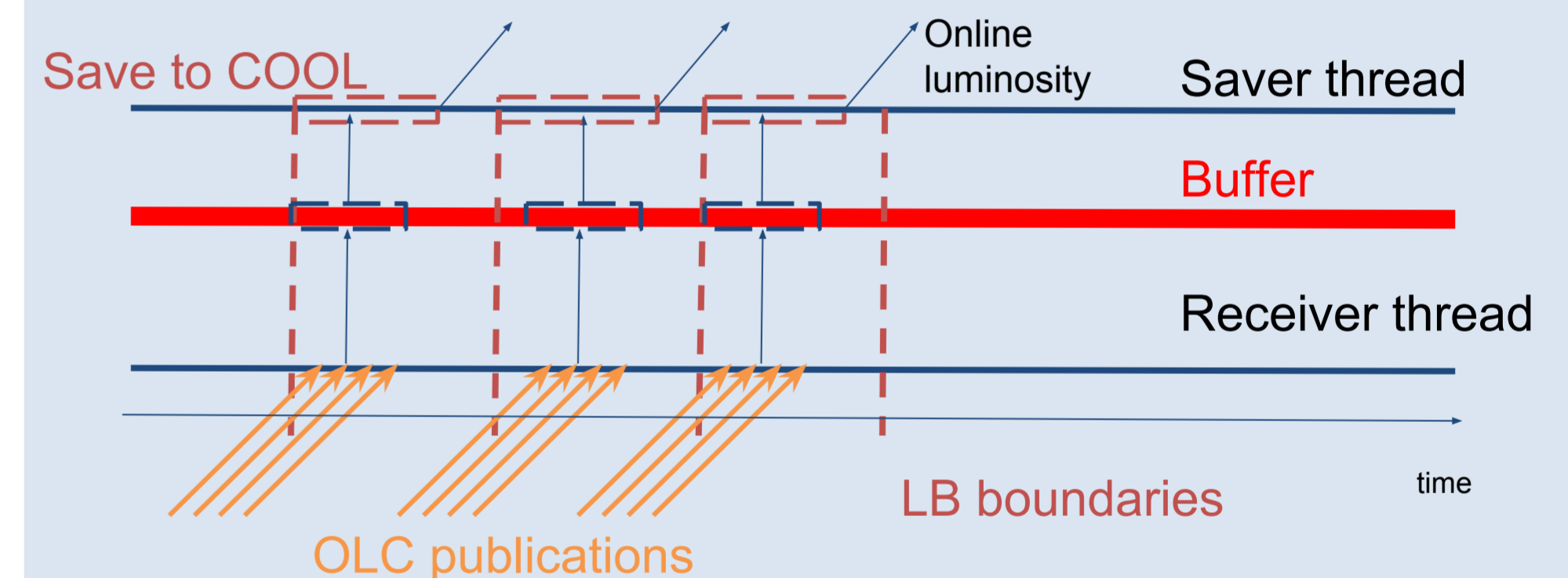
Beam Scans

Van der Meer scans are used to measure the calibration constant for absolute luminosity of a given luminometer. They occur typically twice per year in specialised fills.

Emittance scans are short (~ 5 minutes) Van der Meer-like scans performed during physics fills (separating over $\pm2.5\ \sigma_{beam}$).

They provide an important tool to monitor the ATLAS luminometers response and the calibration stability in time.
- Emittance scans were made possible thanks to the new online luminosity software architecture.
- The automation has proven successful, allowing scans to be performed every second fill with minimal overhead and no human intervention required.

Feedback and Monitoring

The luminosity output is used for many purposes:
- Provide feedback on **accelerator performance**.
- **Optimise** collisions at ATLAS interaction point.
- **"Level luminosity",** keep the luminosity at ATLAS interaction point at a steady value.
- Used by the detectors and high level trigger to correct for **luminosity dependent** effects.

Multiple systems are used to **monitor** the luminosity:
- The Detector Control System provides a **real time** view as well as evolution with time.
- Summary web pages show the current status in a user-friendly manner for **overview.**
- **Alerts** provide feedback to the operators in case of serious problems.

Summary

The new ATLAS luminosity software for Run-II has proven successful and a reliable and flexible system:
- Greater stability and lower latency in delivering information online → all data read and archived.
- Improved configuration flexibility → an asset given the exceptional LHC performance.
- Possibility to change configuration on the fly.

Both accelerator and experiment conditions can change rapidly, robust monitoring proven to be crucial:
- Multiple tools giving a complete picture.
- Faster feedback to operators with respect to Run-I.

The *Scan Controller* allows performing emittance scans regularly during physics fills:
- A new capability for ATLAS in 2018.
- Successfully automated.

ATLAS EXPERIMENT