ATLAS TDAQ **Controls** and **Configuration** software: Evolution from Run 2 to Run 3

Andrei Kazarov / NRC “Kurchatov Institute” – Petersburg NPI

on behalf of ATLAS TDAQ Controls and Configuration team

virtual CHEP 2021 May 17-21

Content / Overview

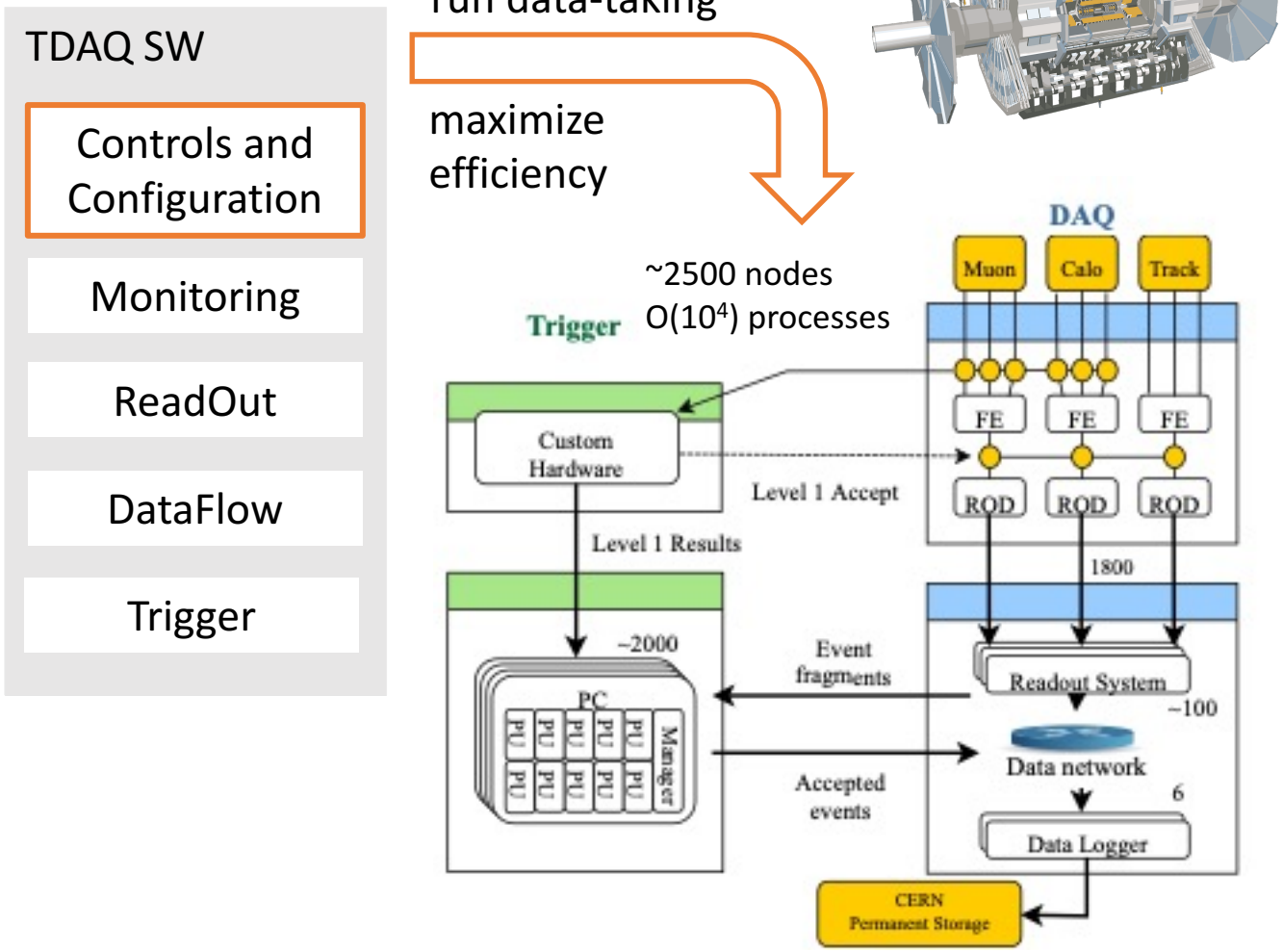
- Controls and Configuration software in context of ATLAS TDAQ
- Software evolution and challenges
- Run-2 to Run-3 evolution (in few selected examples)
  - Configuration database backend: *upgrade of technology*
  - TDAQ Run Control in a web browser: *new requirements, new package*
  - Expert System: *performance upgrade*
  - Electronic LogBook: *re-vamp of the package*

introduction

details

C&C s/w as part of ATLAS Trigger-DAQ

- Controls and Configuration (C&C) s/w packages are part of a bigger **TDAQ s/w**, including also Monitoring, DataFlow, ReadOut, Trigger steering and algorithms
- C&C components essentially provide a **glue** for all other TDAQ s/w components including Detector readout s/w, Detector Control
  - **Configuration** service
  - Run **Control** framework
  - Knowledge-base tools
  - Web applications for TDAQ operations
- TDAQ s/w is organized in packages (200+), regularly released in form of stable binary distributions



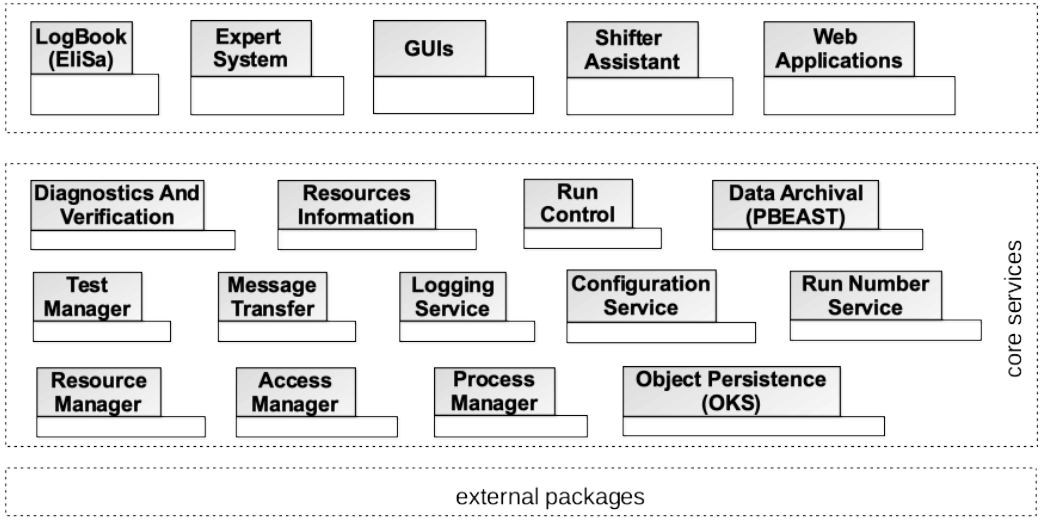
Evolution and challenges

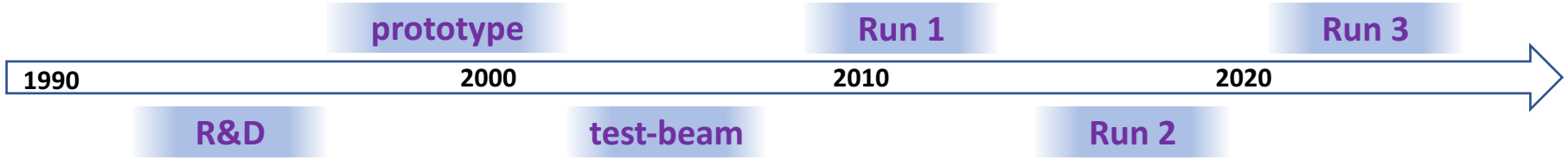
- Modular, loosely-coupled package-based design, well-established APIs: allows long-term development, evolution and maintenance by a small and non-stable team of developers
- Some architectural and design ideas persist since late ‘90th
- Must follow LHC run/shutdown cycles, maintaining **gradual evolution** in 1-2 years of shutdown and **stable operations** in 2-3 years of Run periods
- Must follow and profit from emerging software technologies, standards and 3rd party s/w
- In every cycle, a few packages undergo a major re-implementation, new packages added, some are dropped/replaced
- Aiming for **simplification** and **modernization** of code, implementation of **new requirements**

[MOR97] G. Mornacchi et al, "The ATLAS DAQ and event filter prototype "-1" project", 10th IEEE Real Time Conference, Beaune, France, 1997

[JON97] Robert Jones at al., “The OKS in-memory persistent object manager”, *IEEE Transactions on Nuclear Science, Vol.45, no.4, August 1998*, pp 1958-1964

A high-level architecture of C&C software (see backup)

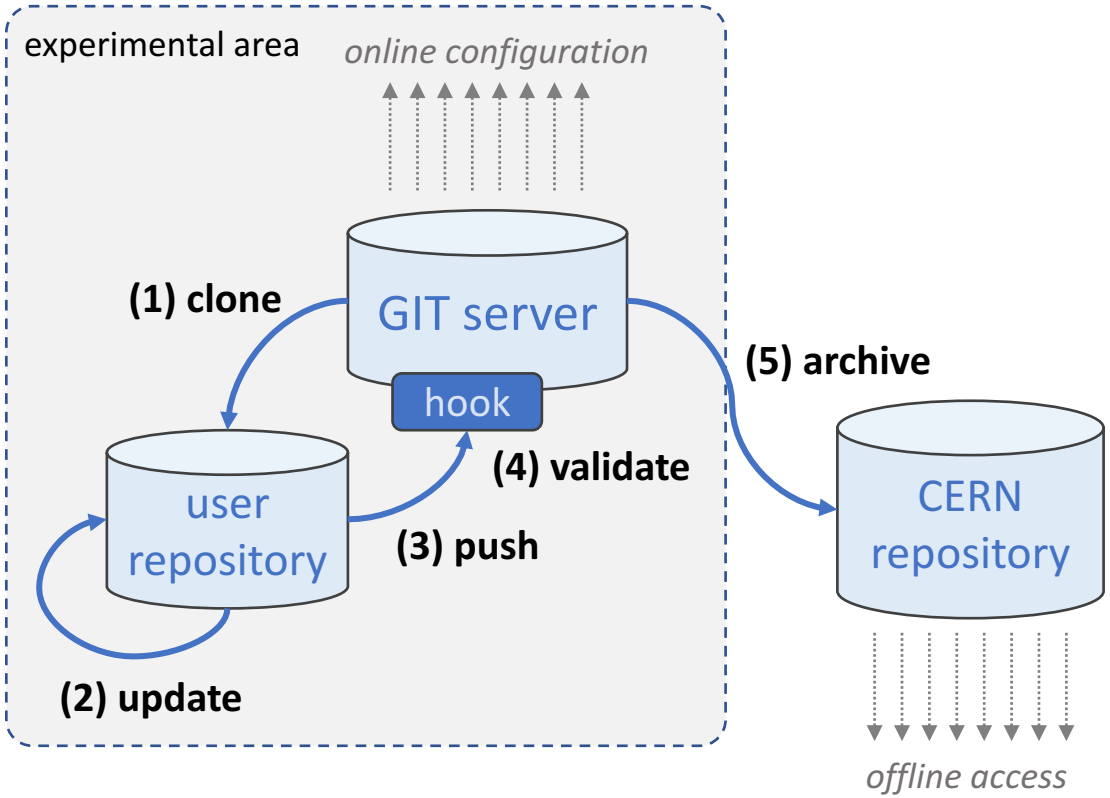




Run1->Run2 evolution in more details: *A. Kazarov, I. Aleksandrov, G. Avolio, M. Caprini, A. Chitan, A.C. Radu, A. Kazymov, G.L. Miotto, M. Mineev, A. Santos et al.,* Journal of Physics: Conference Series 1525, 012036 (2020) https://doi.org/10.1088/1742-6596/1525/1/012036

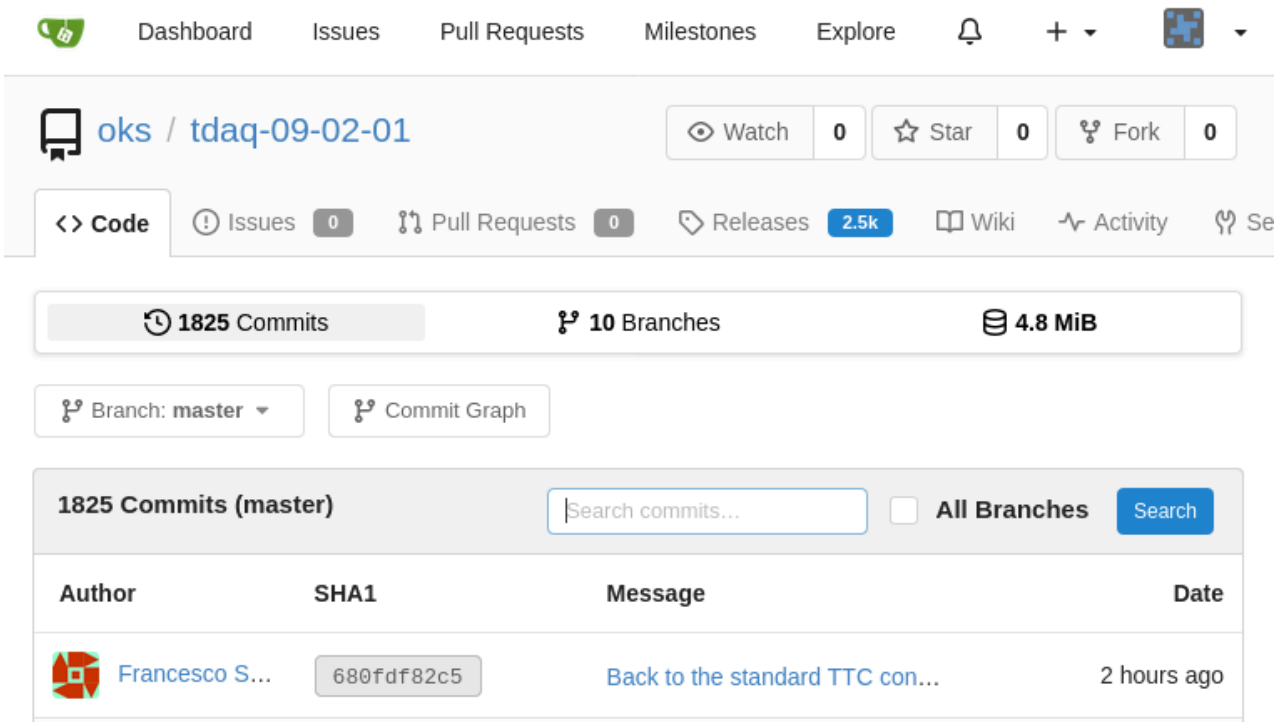
Configuration service: CVS to GIT migration

- TDAQ configuration data is stored in +1000 nested XML files updated by many experts
- **CVS** was used to keep the files in a consistent state during Runs 1&2
  - not supported for many years, misses important security and interface improvements
- Replaced by **GIT** solving several issues and keeping design mostly unchanged:
  - Validation of changes on update in server hook: check consistency and access permissions using role-based Access Manager
  - preserve and archive a data-taking configuration by a commit hash
  - expose GIT interface directly to users, including web editing capabilities



OKS GIT implementation details

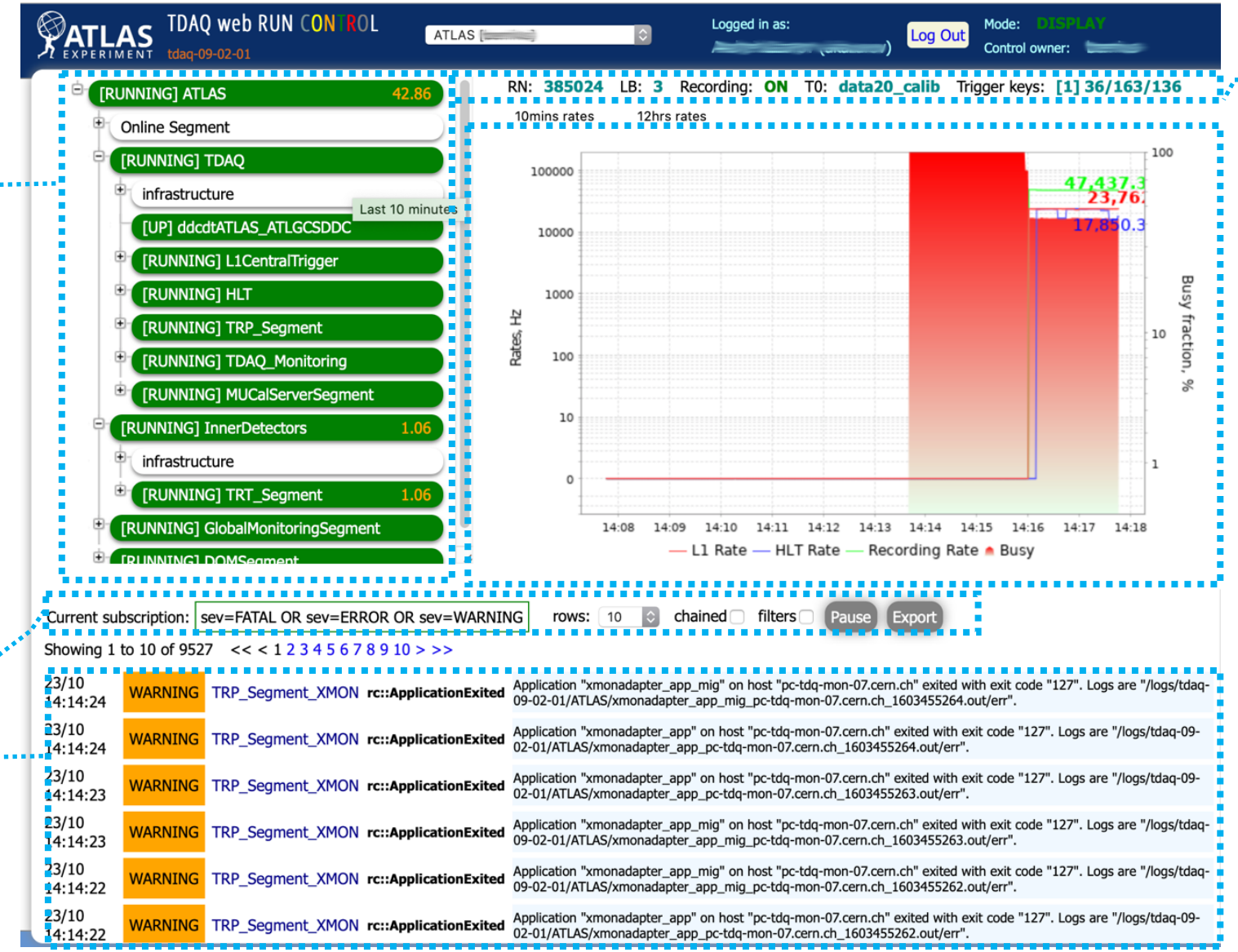
- **gitea** (GIT) server on a VM
  - more than 3K user accounts
  - web interface (browse, edit, merge)
  - 5 seconds per commit (including validation)
  - synchronized with central CERN Git service (gitlab) for archiving and world-wide read access
- A configuration **update** integrated with data TDAQ taking session tools:
  - show available **changes as commits** with details to the Operator
- Implemented a workflow on top of GIT merge/pull requests to facilitate scheduled configuration changes during TDAQ operations



Web-based Run Control

- Motivation: provide web-based access to the functionality of Integrated GUI: a standalone application integrating interfaces to C&C services for controlling and supervising ATLAS data-taking sessions
- The required functionality
  - connecting to a TDAQ session for control or monitoring
  - presenting hierarchical TDAQ applications tree (see next slide), dynamically updating states of individual items
  - sending RC commands to applications
  - connecting to Error Messaging service to provide real-time error monitoring
  - log files browsing
- Requirements for the technology:
  - its backend part needs to be tightly integrated with main TDAQ services like Run Control, Information Service and Error Reporting
  - the frontend part should offer a rich set of widgets
  - provide good scalability and conservative resource usage, allowing connections for many (O(10)) users and serving multiple running TDAQ sessions in parallel
  - support of dynamic and interactive web features like Ajax or Web Sockets
- **Apache WICKET** was chosen for the implementation: a Java-only powerful backend and simple frontend

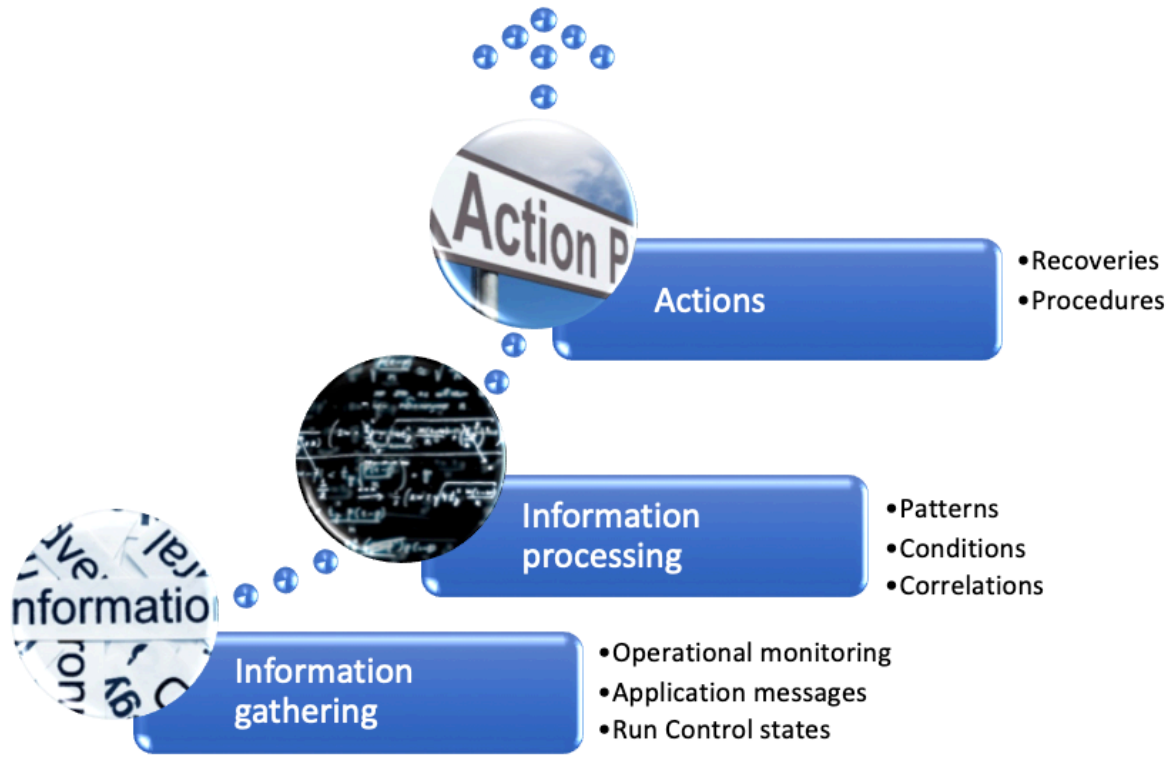
Web Run Control in action



An Expert System (CHIP)

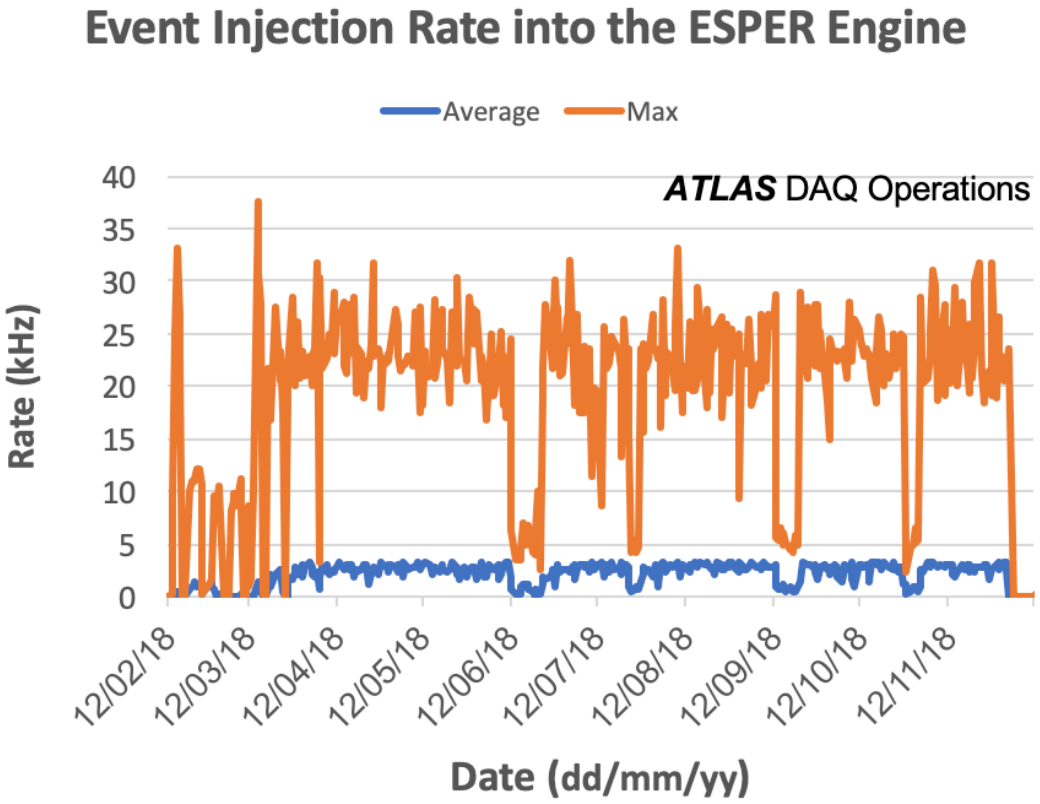
TDAQ system largely deterministic → Possible to identify "signatures" and react properly

- CHIP: The **C**entral **H**int and **I**nformation **P**rocessor (aka Expert System)
- An "*intelligent*" application having a global view of the TDAQ system and **taking operational decisions**
  - Handles abnormal conditions (correctly disabling a failing readout channel)
  - Automates complex procedures (reacts on "Stable Beam" condition)
  - Performs advanced recoveries (restarting a Trigger PU)
- CHIP embeds the Java-based ESPER **Complex Event Processing** (CEP) engine
- Large Knowledge Base (KB)
  - More than **300** detection "rules" or "directives" expressed and stored in EPL



CHIP performance

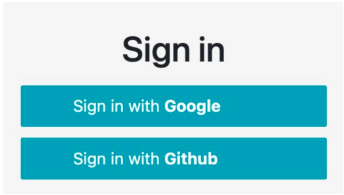
- Performance in Run 2
  - Single CHIP instance adequate to monitor the whole TDAQ system
  - Data injection peaks into the ESPER engine up to **40 kHz**
  - Average execution time of KB rules of about 2 µs*
- From Run 2 to Run 3
  - Extension of the KB (13% increase in number of rules)
    - Including new scenarios and integrating new TDAQ components and systems, e.g.
      - Integration of the new readout system SWROD (including stop-less removal and recovery)
      - Restarting of the RootController (egg/chicken problem)
  - Move to Esper 8
    - Knowledge base compiled in Java bit code
    - Evaluation of rules reduced up to **40%**



** Running on dual-socket Intel Xeon E5-2680 V3 - 64 GB RAM*

Electronic logbook (ELisA) re-vamp for Run 3

- for Run 2 we developed a complete s/w suite to cover an electronic logbook services: web interface, REST API, user authentication, database storage of messages and configuration, client API libraries and utilities, configurable email notification, mailer client
- Reasons for a change:
  - SW updates: the code was ~8 years old
  - Maintenance improvements: two different applications handling web interface and REST API requests, and separate Tomcat web server
  - Deployment improvements: more clients interested to set up their own standalone logbook
  - Requests for new features
- Getting ready for Run 3:
  - Simplification and refactoring: merged the web interface and REST API applications, + embedded web server
  - The application packed and distributed as an RPM, and managed automatically as a service. Custom client configuration is preserved.
  - Support for MySQL backend in addition to Oracle
  - Social login



- The solution is spreading: currently ELisA is used by 14 different clients, half of them beyond ATLAS

Conclusions

- We provide a stable stack of software for smooth steering of the TDAQ data-taking, for all ATLAS development and operational periods started in early 2000, ranging from core system-level services to web-based applications
- Complexity of the system and need in high data-taking efficiency requires s/w solutions which can implement a high level of operational automation
- Maintaining the high quality of s/w through 20-30 years of the experiment life-time requires its permanent and gradual evolution, including use of new s/w technologies and partial re-development of the components

Backup

Run 2 – Run 3 evolution

- Configuration database backend: from CVS to GIT
- Web-base Run Control: full remote control of data-taking in a browser window
- Expert System: focus on performance
- Electronic LogBook: re-vamp
- Evaluation of a time-series DB for a persistency backend for operational monitoring archival
- Dismiss a very old package CLIPS, replaced by in-house rules engine