Data & analysis preservation at CERN
intro and IT aspects
Software & Computing Round Table
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Preserving the Deduction Chain & Preserving the Investment

- Preservation - what and why?
  - data (measured or simulated) provides the opportunity to obtain scientific information via analysis
- Analysis steps: need to adhere to scientific quality standards
  - reproducible, repeatable
  - by other people, on different hardware, at a later time
- Scrutiny requires to preserve used data and analysis
  - benefits the originating project and science community as whole
- General data preservation
  - data is (re-)produced with a significant public investment
  - data/method reuse for a different purpose in the future
  - benefit original producers - but only in future
  - benefit an external community - Open Data
Community Context - DPHEP

• ICFA Study Group on Data Preservation and Long Term Analysis in High Energy Physics

• Includes

  • many accelerator sites
  • experiments at different stages of their lifecycle

• Built foundation and structured discussion across the HEP community
Data Abstraction Hierarchy

1. Provision of additional documentation for the published results

2. Simplified data formats for analysis in outreach and training exercises

3. Reconstructed data and simulations as well as the analysis level software to allow a full scientific analysis

4. Basic raw level data (if not yet covered as level 3 data) and their associated software which allows access to the full potential of the experimental data

Four data levels for capture, preservation and opening

adapted from slide by Tibor Simko
Some milestones... (tombstones?)

- **2012**: DPHEP Blueprint published
- **2013**: CERN assumes role of DPHEP MGR
  - Many events & w/s in [https://indico.cern.ch/category/4458/](https://indico.cern.ch/category/4458/)
- **2014**: DPHEP Collaboration Agreement signed by CERN and other labs / FAs
- **2016**: CERN services for LTDP@iPRES (Bern)
  - Covers all areas proposed to 2012/13 ESPPU: bit preservation, s/w preservation, documentation
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- **2017**: DPHEP w/s on FAIR data, TDRs
  - TDR = Trustworthy Digital Repository (ISO 16363, CoreTrustSeal, DPC RAM, ...)
  - Self audit of CERN (ISO 16363) completed, discussion with T1s in ESCAPE to complete audit as well
- **2018**: Science Europe Guidelines on Research Data Management (“domain protocols”)
- **2019**: Workshop on Sustainable Software: LEP+CERNLIB experience
Focus on LHC experiments

• Driving current infrastructure and software developments

• Active collaborations are most exposed to the central resource conflict that needs to be addressed

• Assumption: a solution for large active collaborations
  
  • can be extended/adapted to other projects
  
  • prevents further unmanaged knowledge decay - that may already have taken place in older projects
Data & Analysis Preservation Workshop

• LHC experiment focus (profiting from RHIC participation)

• Experts and management from experiments, WLCG and IT

• All experiment presentations and discussion notes at

  • https://indico.cern.ch/event/858039/

• Target: collect consolidated experiment input to policy and funding discussion
Four domains of best practices

- Analysis preservation can be adopted step-by-step
- Synergies between the domains
REusable ANAlysis

- Plan to use REANA
  - Data: open data
  - Use input from CAP
  - Software: CVMFS
  - Environment: LEGO trains
- Can be used for:
  - Rerun the train
  - Plot production with local macros
- **Procedure** is available on the REANA main page:
  - to run a lego train in a AliPhysics specific container
  - use as input the intermediate files of the lego system, not yet any pre-saved JSON configuration file
- In addition, simple ALICE analysis demonstrator submitted to the CERN Open Data portal works with ALICE Open Data VM, now available in REANA with docker container

26/11/2019

*Slide: Stefano Piano - Data & Analysis Preservation workshop*
Technology Support

• Bit-preservation is performed routinely and independently by storage infrastructures
  • media replacement and disk failure tracking/prediction
  • eg @CERN: EOS with Castor/CTA as archive layer

• S/W and environment preservation
  • containers and GIT are used by all experiments

• Technology problems are largely solved in a common way
  • current industry standard -> migration path can be expected
Reproducible Analysis

- **Reproducible analysis** provides an immediate scientific benefit
  - as a principle: essential for quality science
  - as a tool (eg ReANA) **helps**
    - analyst productivity via automated re-execution
    - consolidated input to **publishing review** process
    - preservation by making analyst knowledge **explicit**
      early (input data, s/w, environment, meta-data)
REANA Reproducible Analyses

**Status:** pilot

**Purpose:** run containerised scientific workflows on diverse compute clouds (Kubernetes, Condor, Slurm)

**Usage:** data + code + environment + workflow = reproducibility

**Community:** pilot examples with ALICE, ATLAS, CMS, FCC, LHCb; synergies with astronomy, life sciences, machine learning

**Notes:** focus on “preproduibility” of analysis during its active phase; structure analysis in a reproducible way to facilitate its future “preservation”

**Resources:** shared Ceph storage and Kubernetes cluster; need for proper experiment accounting

[http://www.reana.io](http://www.reana.io)
Computational workflows

Serial

Yadage

CWL

Slide: Tibor Simko
REANA: NSF collaboration

Ongoing collaboration with NSF SCAILFIN project (NYU, Notre Dame University, etc) to deploy REANA using VC3 on HPC centers in the US

Reproducible Open Benchmarks for Data Analysis Platform (ROB)

Exploratory work for enabling such community benchmarks.

Outline of ROB usage
1. Benchmark workflow defined by coordinator along with inputs/outputs
2. Users provide Docker containers that satisfy workflow specifications
3. Back-end processes envs, validates metrics (powering reproducibility)
4. Front-end displays results.

Benchmark Workflow Example:
1. Common input data set used for benchmarks (defined by coordinator)
2. Preprocessing stage (code provided by user)
3. Prediction stage (code provided by user)
4. Evaluate metrics, update tables & plots (defined by benchmark)

SCAILFIN Project Activities

- SCAILFIN Deployment and Application Development
  - Establish shared REANA deployment cluster at NYU
  - Implement new tool applications (e.g. MadMiner) with robust logging in REANA
  - Study Matrix Element Method acceleration using deep neural networks
- Parallel Integration
  - Build, analyze python functions to enable to run in parallel on laptops, OSG, supercomputers, clouds, or a combination without otherwise changing the original python program and developing capability to exploit workflow in DSS
  - Use and maintain ParStar, REANA, incomparable - options
  - Use Python’s libraries to deploy jobs into resources
  - Export workflow to various other workflow specifications (e.g. yadage or CWL)
  - Run HEP workflows within P스트로리티로 이어짐

HPC Integration
- Employ infrastructure (e.g. VC3) to configure and set-up edge services for ND cluster and Blue Waters
- Batch-gather using HI/Condor

Progress
- Successfully deployed MadMiner use cases on the NDS Labs REANA cluster
  - With CI to update Docker images to the latest MadMiner changes
- First deployment outside the reana development team
  - New insights and feedback on the user side of REANA (which was translated into new user-friendly features)
CERN Analysis Preservation (CAP)

Responds to two parallel demands regarding data re-use and reproducibility:

- **Internal**: high complexity of experiments create major challenges in capturing and preserving analyses and related knowledge

- **External**: Funder policies that require comprehensive solutions for comprehensive data management and knowledge preservation

Accordingly the goals of this effort are:

- Capture all the elements needed to understand and rerun an analysis and link them together persistently

- Make analysis components easily discoverable, shareable and re-useable

- Flexible to respond to diverse needs of research teams
CAP Features:

- Flexible data models (JSON-Schemas)
- FAIR practices [more info]
- Versioning of metadata and files
- Integration with related scientific services and universal identifiers (i.e. Github, Gitlab, Zenodo, ORCID, ROR, etc.)
- Ongoing integration with services that support remote execution and reuse (e.g. REANA) of computational workflows
- Piloted in collaboration with all the major LHC experiments at CERN
Open data policy

DOI: 10.7483/OPENDATA.LHCb.HKJW.TWSZ

• Adopted by the LHCb Collaboration Board on Feb 27th 2013
• Open data for Outreach and education:
  • »... LHCb already participates in outreach activities and will continue to do so. [...] The data are provided for educational purposes only, and are not considered suitable for publication. Only a limited fraction of the complete LHCb data-set may be used. »
• Open data for Research:
  • «... access will be granted to portions of the DST data five years after data is taken. The portion of the data which LHCb would normally make available is 50% after 5 years, rising to 100% after 10 years. All requests will be considered by the CB and the period and proportion may be varied for specific requests.»
• Big caveat
  • «... LHCb is extremely resource limited at present. Therefore whilst this policy expresses a spirit of intent, we cannot commit to implementation of any capability on any specific timescale. Specifically in respect of open access we will not be able to undertake any significant development to support this without injection of additional resources. »
CERN Open Data
http://opendata.cern.ch

OpERA neutrino-induced charmed hadron event 10270021561
This OpERA detector event is a muon neutrino interaction with the lead target where a charmed hadron was reconstructed in the final state. The event data consist of Electronic Detector files (such as ...)

OpERA neutrino-induced charmed hadron event 222274169
This OpERA detector event is a muon neutrino interaction with the lead target where a charmed hadron was reconstructed in the final state. The event data consist of Electronic Detector files (such as ...
CERN Open Data

Status: production (since November 2014)

Size: 7K records, 800K files, 2 PB size

Purpose: “big data” sharing of event-level particle physics data and accompanying code for both education and research purposes

Content: raw samples, collision & simulated & derived datasets, docs, configs, software tools, example analyses, VMs, event display

Community: ALICE, ATLAS, CMS, LHCb, OPERA (coming: JADE, Data Science)

Notes: independent expert curation; batch ingestion workflows with Collaborations

Slide: Tibor Simko  http://opendata.cern.ch
Integration Options with Existing Infrastructures

• Open Data access patterns seem well matched to the existing archive infrastructure at CERN or the distributed archive in WLCG

• potentially: include also cloud based back-end storage eg funded via CPU purchases of external OD users

• balance between cost distribution and long term availability

• Expectation: Open Data is findable and available, but not in all cases without access latency

• caching techniques together with lower cost archive media should allow to steer media costs

• closer integration with experiment data management should enable to further reduce duplication between open data and experiment resources
Common Technical Activities

- All experiments focus on similar model and same tools

- Production: CERN Open Data Portal (COP)

- Evaluation: ReANA, CERN Analysis Portal (CAP)
  - Insure resource coverage to complete evaluation by significant part of the analysis user community
  - Setup effective communication channels to facilitate technical exchange between experiments and service teams
  - Use HSF/WLCG workshops to discuss and facilitate the adoption of common data preservation and reproducible analysis services and their integration with existing production
Data Management Plans

• All experiments anticipate the requirement of formal Data Management Plans (DMPs)

• integrated with existing services at hostlab and WLCG

• potentially without additional resources, unless a demonstration of value for additional investment can be given

• Proposal:

• Task experiment computing management, IT and WLCG to prepare an agreed DMP skeleton - to be used to derive concrete experiment DMPs
Towards a Common Policy

• A common Open Data Access Statement between CERN and LHC experiments could provide leadership

• Frame for common activities such as defining a resource reporting & review process for open / preservation data

  • profit from policy review several experiments are currently undertaking

• Towards FAs: clarification of potential hostlab responsibilities wrt open data and preservation

• Dedicated discussion via experiment spokespersons and directorate has been initiated

• WG has been actively working towards a CERN Open Data Policy draft
Open Science, Open Data & Data Preservation

- **Open Science, Open Data** and **Data Preservation** are closely related
  - obligation to return the full potential of a **public** investment to the public
  - on the scale of LHC experiments this is a complex goal requiring patience to develop a shared strategy resulting in quality science

- **Open Data** and **Data Preservation** require a **policy/funding incentive**
  - to resolve their likely **resource conflict** with more **immediate priorities** of scientific collaborations

- Goal: find a pragmatic **balance** for the **collaborations, science community** and **public**
  - between **decaying analysis knowledge** and **decreasing storage prices**
  - within **external** budget and policy **constraints**
Summary

• All LHC experiments made significant investments in open data activities and data & analysis preservation.

• Supporting services (COD, CAP, ReANA) exist and are evaluated by all LHC experiments. Their adoption by the analysis community at large should be discussed regularly eg at WLCG/HSF workshops.

• At this point Run1 Open Data releases have absorbed the initial ad-hoc resources. Without clarification on policy/funding incentives further releases would likely be suppressed by immediate priorities.

• A common Open Data Statement between LHC experiment and CERN management is currently being prepared

• Expect to continue discussion on Data Management Plans and impact of data privacy regulations locally and via DPHEP
Thank you.