



# Hyperloop – The ALICE analysis train system for Run 3

ALICE

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## ALICE from Run 2/LEGO trains to Run 3/Hyperloop trains

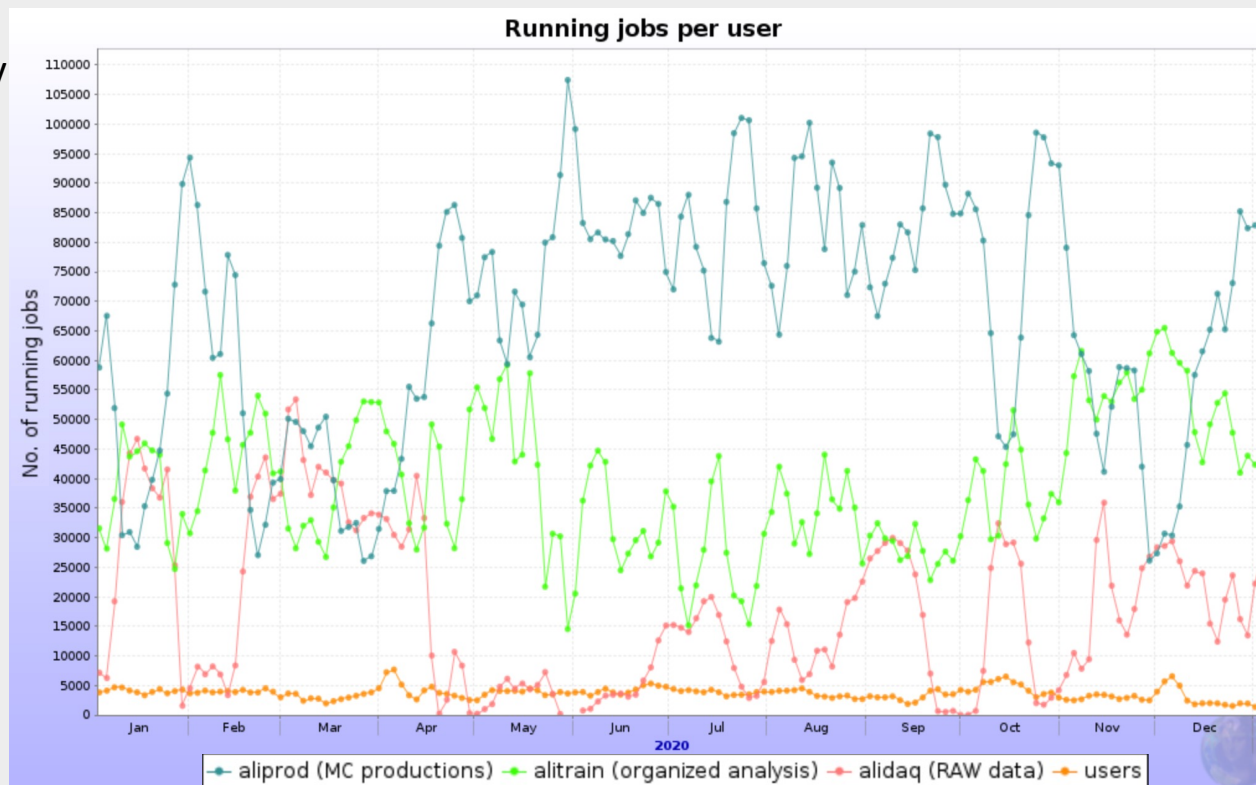
The ALICE analysis framework allows the creation and submission of analysis jobs to the Grid. These jobs are monitored and resubmitted using MonALISA. In Run 1 and 2, ALICE developed a system of analysis trains to optimize the usage of computing resources.

### LEGO trains

- Tool to run and manage analysis trains on AliEn providing a friendly user interface
  - Analysis code is contained in an AliEn package, **AliPhysics**
  - Analysis tasks (wagons) using the same dataset are run together
  - Main workhorse for Run 2 analysis
- 2020:** 16 000 trains, 172 million Grid jobs, 39 000 average job slots

### Long-term plan

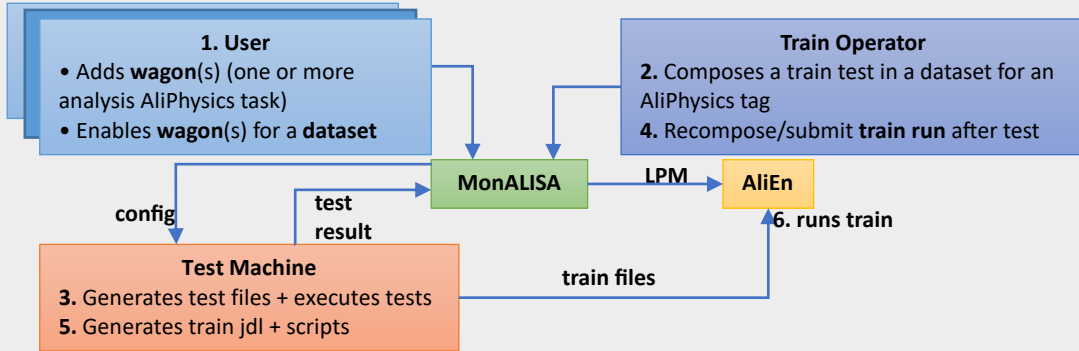
- During LS2, ALICE went through upgrades allowing to collect in Run 3 roughly 2 orders of magnitude more data than in Run 2
- Run 3 data analysis uses **ALICE Online-Offline (O<sup>2</sup>)** framework
- Run 2 data converted to Run 3 format, analysis moves to **O<sup>2</sup>**
- **Hyperloop trains** have been developed based on the solid LEGO trains concept and integrated in the **O<sup>2</sup> workflow**
- LEGO trains phased out and replaced by **Hyperloop trains** 



# LEGO trains



- Analysis train framework for Run 2
- Database: PostgreSQL, backend: MonALISA, frontend: static HTML
- Trains are divided per Physics Working Group (PWG), data type and collision system (87 active)
- Same user interface for all users and train operators
- Requires train operators (per PWG) to test, compose and submit train runs



### Wagon configuration

Editing wagon `LegCoef_an_xexe_`

**Basic settings**

Wagon name: `LegCoef_an_xexe_root6`  
 Wagon owner: `raquishp`  
 Wagon group: `Default`  
 Macro path: `PWGCF/EBVE/LongAsymmetry/macros/AddTaskLegendreCoef.C`  
 Macro parameters: `K`  
 Macro customization: `_R_ADDT; TFile* file = TList* histlist; if(histlist) Note: you g Do not forf Example: ...`  
 Libraries: `Note: separ Example: C`

**Advanced settings**

**Subwagon configuration**

**Testing statistics**

Dataset: `LHC17n_pass1` [Update]

Graph showing CPU Usage (red), resident memory (blue), and virtual memory (green) over time. The x-axis is labeled 'run' with values 9,650 and 9,675. The left y-axis is CPU (ms/evft) from -0.2 to 1.1. The right y-axis is (GB) / (numevt) from -150 to 50.

### Train run result

Train Run (PWG train overview)

Status: Running triggered on 01 May 2021 02:57 (11d 11:52 ago)  
**Train finished, masterjobs submitted: 1, last run: 280234**

Files: Files copied to the Grid successfully | file copying log | train files in FC

Processing: processing progress  
 60 total, 59 done, 1 error, 0 active, 0 waiting

Merging: merging progress: 1 total, 1 done, 0 error, 0 active, 0 waiting  
 intermediate merging: stage1 (3/3/0/0/0) stage2 (0/0/0/0/0) stage3 (0/0/0/0/0) stage4 (0/0/0/0/0)

Final Merging: Runlist 1: Status of final merging job (stage 5) | merged files in FC  
 AliEn Output dir: /alice/cern.ch/user/a/alltrain/PWGCF/CF\_PbPb/9682\_20210430-2057/merge

Train run finished at: 01 May 2021 23:22 (train duration: 20:25)  
 Totals: running time: 3d 0:29 | output size: 24.01 MB  
 Files/job (for done jobs): min: 1, max: 130, average: 28.2, standard deviation: 40.2  
 Running time/job (for done jobs): min: 6s, max: 7:28, average: 1:14, standard deviation: 1:49, 95% done after 4:38

**Running time per job**

Bar chart showing the number of jobs (log scale) versus time per job in minutes. The x-axis ranges from 0 to 750 minutes. The y-axis ranges from 0 to 40 jobs.

**Input files per job**

Bar chart showing the number of jobs versus input files per job. The x-axis is labeled 'files/job' and the y-axis is 'Number of jobs'.

**Job Overview**

State	Jobs #	%	Files #	%	Input size	Files/job min	Files/job max	Files/job avg
DONE	59	98.3%	1664	99.9%	2.09 TB	1	130	28.2
ERROR_V	1	1.7%	1	0.1%	1.128 GB	1	1	1
ERROR_E (TTL)	0	0.0%	0	0.0%	0 B	0	0	0
ERROR_E (mem)	0	0.0%	0	0.0%	0 B	0	0	0
ERROR_E (disk)	0	0.0%	0	0.0%	0 B	0	0	0
ERROR_EW	0	0.0%	0	0.0%	0 B	0	0	0
Other	0	0.0%	0	0.0%	0 B	0	0	0

Legend: DONE (green), ERROR\_V (blue), ERROR\_E (TTL) (red), ERROR\_E (mem) (cyan), ERROR\_E (disk) (magenta), ERROR\_EW (yellow), Other (black)

# Hyperloop trains



- Analysis train framework for Run 3
- Database: PostgreSQL, backend: MonALISA + java-based model, frontend: **React.js**
- Unified trains throughout PWGs
- Personalized user and operator interfaces, saves page configuration
- **Analysis** defined in **JIRA**, wagons are defined per analysis
- Wagons ( $O^2$  workflow) can be enabled for an available  $O^2$  tag or **pull request**
- Immediate and **automatic wagon test** ⌚ → ⌚ → (🌟, !, 💣)
- Wagon and dataset **bookkeeping**, allows wagons and train runs comparison

The screenshot shows the Hyperloop trains web interface. It includes a **Correlations** window with tabs for Wagon settings, Configuration, Derived data, and Test Statistics. A **History** panel shows a list of wagon updates with details like Name, Analysis, Workflow, and Dependencies. Below this, there are **Datasets** and **Performance graphs**. The graphs show PSS Memory, CPU Time, Wall Time, and Throughput over time. A yellow box highlights the text: "Responsive and interactive performance graphs".



# Hyperloop trains

- Most train operations are automatic based on available target memory and wagon configuration compatibility
- Requires less and **global train operators**

Dataset definition

LHC15o\_dev (RUN2)  
child1 only Edit dataset

Activated  Run final merging over all runs in this dataset

AF staging:

Automatic Composition

Automatic composition: Scheduled    Composition CPU max: -1    Composition max trains per analysis: 14

Composition schedule: Monday - 9:00 Tuesday - 11:00 Wednesday - 9:00 Thursday - 9:00 Friday - 9:00 Saturday - 9:00 Sunday - 9:00

Productions (1) Expand All

+/- Train run 170 /

Train submission

Wagon	Analysis	User	Package tag	Package type	Enabled	Test Status	PSS Memory	Private Memory	Compose
<input type="text" value="Search 7 records..."/>	<input type="text" value="Search 7 rec"/>	<input type="text" value="Search 7 r"/>	<input type="text" value="Search 7 records..."/>	All	<input type="checkbox"/>	All			
SpectraTPCTiny	Hyperloop ...	grosseo	nightly-20210512-1	newer	1 day ago	<span style="color: green;">✔</span>	2.8 GB	1.9 GB	<input checked="" type="checkbox"/>
SpectraTPCPiKP	O2 Integra...	alhyperloop	nightly-20210514-1	fixed	6 hours ago	<span style="color: red;">✘</span>	2.5 GB	1.9 GB	<input type="checkbox"/>
SpectraTPCTiny	O2 Integra...	alhyperloop	nightly-20210514-1	fixed	6 hours ago	<span style="color: red;">✘</span>	2.8 GB	1.9 GB	<input type="checkbox"/>
Correlations	O2 Integra...	alhyperloop	nightly-20210514-1	fixed	6 hours ago	<span style="color: red;">✘</span>	2.9 GB	1.9 GB	<input type="checkbox"/>
SpectraTPCPiKP	Hyperloop ...	grosseo	nightly-20210512-1	newer	6 hours ago	<span style="color: red;">✘</span>	3.1 GB	2.1 GB	<input type="checkbox"/>
SpectraTPC	Hyperloop ...	grosseo	nightly-20210512-1	newer	6 hours ago	<span style="color: red;">✘</span>	3.1 GB	2.3 GB	<input type="checkbox"/>
HistogramsFull	O2 Integra...	eulisse	nightly-20210514-1	newer	6 hours ago	<span style="color: green;">✔</span>	0	0	<input type="checkbox"/>

Target: Grid - Single core    Tag: nightly-20210512-1    Total PSS: 2.9 GB    Total private: 1.8 GB    1 wagons selected

slow train     derived data     automatic submission     Select compatible wagons    Compose

Train run result

General    **Test Results**    Test Graphs    Submitted jobs    Grid Statistics    Merged Output    Clone

Package tag: nightly-20210527-1  
Dataset: LHC15o\_dev  
Operator: alhyperloop  
Settings:  slow train  derived data  automatic submission  
Test status: Done ⚠ (test output)  
Target: Grid - Single core  
Train status: Done  
Train created: 27 May 2021, 02:01:02  
Train submitting: 27 May 2021, 02:04:39  
All jobs submitted: 27 May 2021, 02:04:51  
Train finished: 27 May 2021, 09:43:45  
Train duration: 7h 38m 53.1s  
Job status: Total:95, Done:91, Active:0, Wait:0, Error:4

Wagons

- HistogramsFull
- SpectraTPCPiKP
- EventSelection
- PIDTPCFull
- TimestampCreator
- TrackExtension
- TrackSelection

Wagon	PSS Memory	Private Memory	CPU Time	CCDB
	Max	Max		Calls    Transfer size
Reader	1.6 GB	1.1 GB	1m 51s	
EventSelection	308.7 MB	120.5 MB	3s	
HistogramsFull	25.7 MB	9.6 MB	2s	
PIDTPCFull	226.3 MB	158.3 MB	38s	
SpectraTPCPiKP	165.4 MB	90.5 MB	3s	
TimestampCreator	182.4 MB	71.7 MB	1s	

cpuUsedAbsolute  Per Device

PID    Run no.    Output directory

PID	Run no.	Output directory	Total	Done	Active	Wait	Error	Merging
2272622805	246392	/alice/data/2015/LHC15o/000246392/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8456	20	18	0	0	2	Done
2272622803	246391	/alice/data/2015/LHC15o/000246391/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8455	16	15	0	0	1	Done
2272622802	245068	/alice/data/2015/LHC15o/000245068/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8454	5	5	0	0	0	Done
2272622800	245066	/alice/data/2015/LHC15o/000245066/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8453	6	6	0	0	0	Done
2272622797	245064	/alice/data/2015/LHC15o/000245064/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8452	20	19	0	0	1	Done
2272622795	244983	/alice/data/2015/LHC15o/000244983/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8451	5	5	0	0	0	Done
2272622793	244982	/alice/data/2015/LHC15o/000244982/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8450	8	8	0	0	0	Done
2272622790	244980	/alice/data/2015/LHC15o/000244980/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8449	5	5	0	0	0	Done
2272622786	244975	/alice/data/2015/LHC15o/000244975/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8448	4	4	0	0	0	Done
2272622784	244918	/alice/data/2015/LHC15o/000244918/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8447	5	5	0	0	0	Done
2272622782	244917	/alice/data/2015/LHC15o/000244917/pass5_lowR/PWGZZ/Run3_Conversion/170_20210506-0955_child_1/hy_8446	1	1	0	0	0	Done

## Summary

- Based on the organized analysis trains (LEGO) success, a modern and reactive train framework (Hyperloop) was built which supports the Run 3 software suite
- The Hyperloop train framework has been used during the **ALICE Analysis Challenge** since June 2020
- More than 600 trains successfully submitted to the Grid and Analysis Facilities
- Factor 3-10 higher event throughput, currently being optimized