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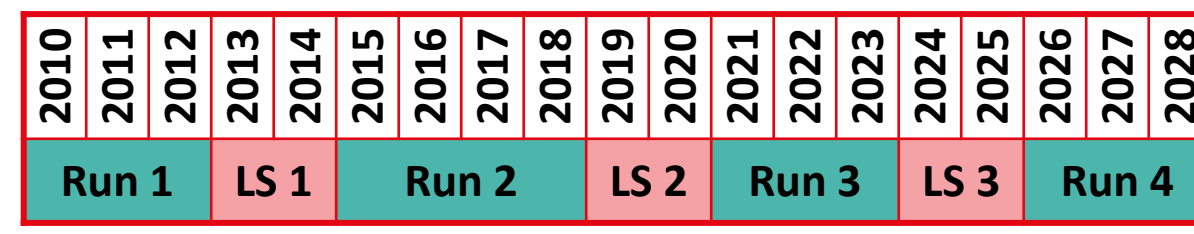
The LHC experiments produce petabytes of data each year, which must be stored, processed and analyzed. This requires a significant amount of storage and computing resources. In addition to that, the requirements to these resources are increasing over the years, at each LHC running period.

In order to predict the resource usage requirements of the ALICE Experiment for a particular LHC Run period, we developed flexible and highly configurable simulation tool, which performs discrete event simulation of ALICE data flow processes by taking into account the LHC running conditions and schedule, data management/removal policies, conferences and other criteria.

The tool provides a Web GUI, which allows entering of all the necessary parameters and to graphically visualize the results of simulations.

## Introduction

Since its beginning, the lifecycle of LHC[1], is composed of the data taking (Run) and upgrade (Long Shutdown, LS) periods. During the data taking periods, the LHC experiments, such as ALICE [2], produce petabytes of data, which handling requires a significant amount of storage and computing resources.



LHC lifecycle by years

Compared to Runs 1 and Run 2, the feature runs of LHC are significantly more challenging for the ALICE online and offline computing system (O2). Building on the experience gained during previous LHC runs, ALICE Computing Model (O2 model) for Run 3 and Run 4 will implement a distributed, parallel and staged data processing model. The purpose of O2 model is to reduce the data volume to the maximum possible extent and to minimize the requirements to the storage and computing resources, necessary for the storage, processing and analysis of the data [3].

With the purpose to estimate the storage and computing resource usage during upcoming Runs of LHC, a special tool is developed, which will perform discrete-event simulations of the ALICE data flow processes during Run3 and Run4. And to validate the results of these simulations, the identical simulations are done for Run 2.

## Input parameters

### General LHC conditions

The time granularity of simulations is a day.

Planned number of collisions (for year) –  $N_{collisions}$

$$CTF\_size\_per\_day = (C_{rate} * E_{size} * Efficiency / 100) * Seconds\_in\_a\_day$$

$C_{rate}$   $E_{size}$   $E_{efficiency}$

Simulation parameters that worth to play with

- $C_{rate}$
- Efficiency

Collision type	Collision Rate (N of collisions/sec)	Data taking efficiency (%)	CTF size per event (kB)
pp	22396.5	50	50
pp-ref	30864	50	50
pPb	108421	50	100
PbPb	11057.5	50	1600

Planned for Run 3

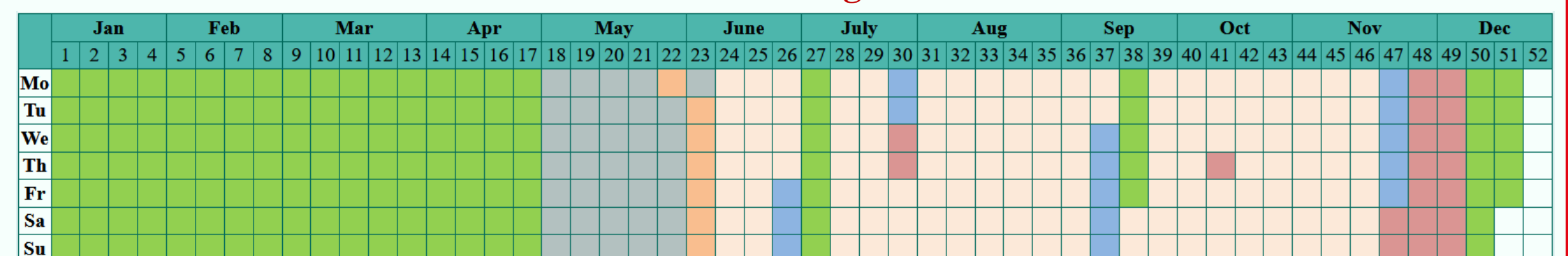
### LHC running schedule

We have  $CTF\_size\_per\_day$  and  $N_{collisions}$ , so we can start simulations, but in order to have more realistic picture, the real LHC running schedule is taken into account. As presently the LHC schedule for Run3/Run4 is not available, we have used LHC running schedule of Run 2 (for 2017).

#### LHC conditions

- Technical stop
- Recommissioning with beam
- Scrubbing
- Machine development
- Physics runs
- Special physics runs

#### LHC running schedule for 2017



### Resource types and their capacities

Here are defined the resource types, which are involved in data storage and processing activities and provided their total CPU and storage capacities.

These numbers serve for the graphical representation of resource thresholds to see the differences between consumed and pledged resources.

Site Type	CPU resources (N of CPU cores)	Storage Resources	Tape resources	
O2	5000	600000	GB 80000	GB 80000
T0	5000	0.000	GB 80000	GB 80000
T1	7000	80000	GB 600000	GB 600000
T2	25000	9.766	TB 0	GB 0
AF	25000	10000	GB 0	GB 0

Example values, on the base of ALICE resources capacities as for 2017

### Job types and their CPU consumption

These parameters are required for the estimation of computing resource usage.

The amount of CPU cores required for the transition of certain data types for a given collision type.

The percentage of CPU of each resource type pledged for the transition of certain data types.

Data type transition	pp	pPb	PbPb	pp-ref	O2	T0	T1	T2	AF
RAW → CTF	0	0	0	100	0	0	0	0	0
CTF → ESD → AOD	300	710	3800	300	67	33	0	0	0
MC → MCAOD	1000	3000	45000	1000	0	0	100	0	0
AOD → HISTO	200	700	3700	200	0	0	0	100	0

Planned for Run 3

### Data management policies

The data replication and removal policies are significantly influence on the resource usage estimation results.

Amount of disk and tape replicas for each data type

The percentage of each type of data kept on each storage resource

The number of days that each type of data is kept on each storage resource, and then moved to tape or removed.

Planned data management policies for Run 3

Data Types	Replication factor	Type	O2	T0	T1	T2	AF	O2	T0	T1	T2	AF
CTF	1	1	66.6	0.0	33.3	0.0	0.0	270	0.0	270	0.0	0.0
ESD	1	0	75.0	0.0	25.0	0.0	0.0	10	15	25	0.0	0.0
AOD	1	1	15	0.0	0.0	1.0	0.0	150	250.0	100	0.0	100
MCAOD	1	1	0	25	75	0.0	1.0	100	100.0	100.1	5.0	100
HISTO	1	0	10.0	5.0	75.0	0.0	10.0	100.0	150.0	0.0	0.0	50.0

### Conferences calendar

Certain conferences (such as Quark Matter) have influence on the simulation and data processing activities. In order to make the simulations more realistic, we take also as an input the calendar of ALICE conferences. This part of the software is currently under discussion stage.

### Conclusion and feature work

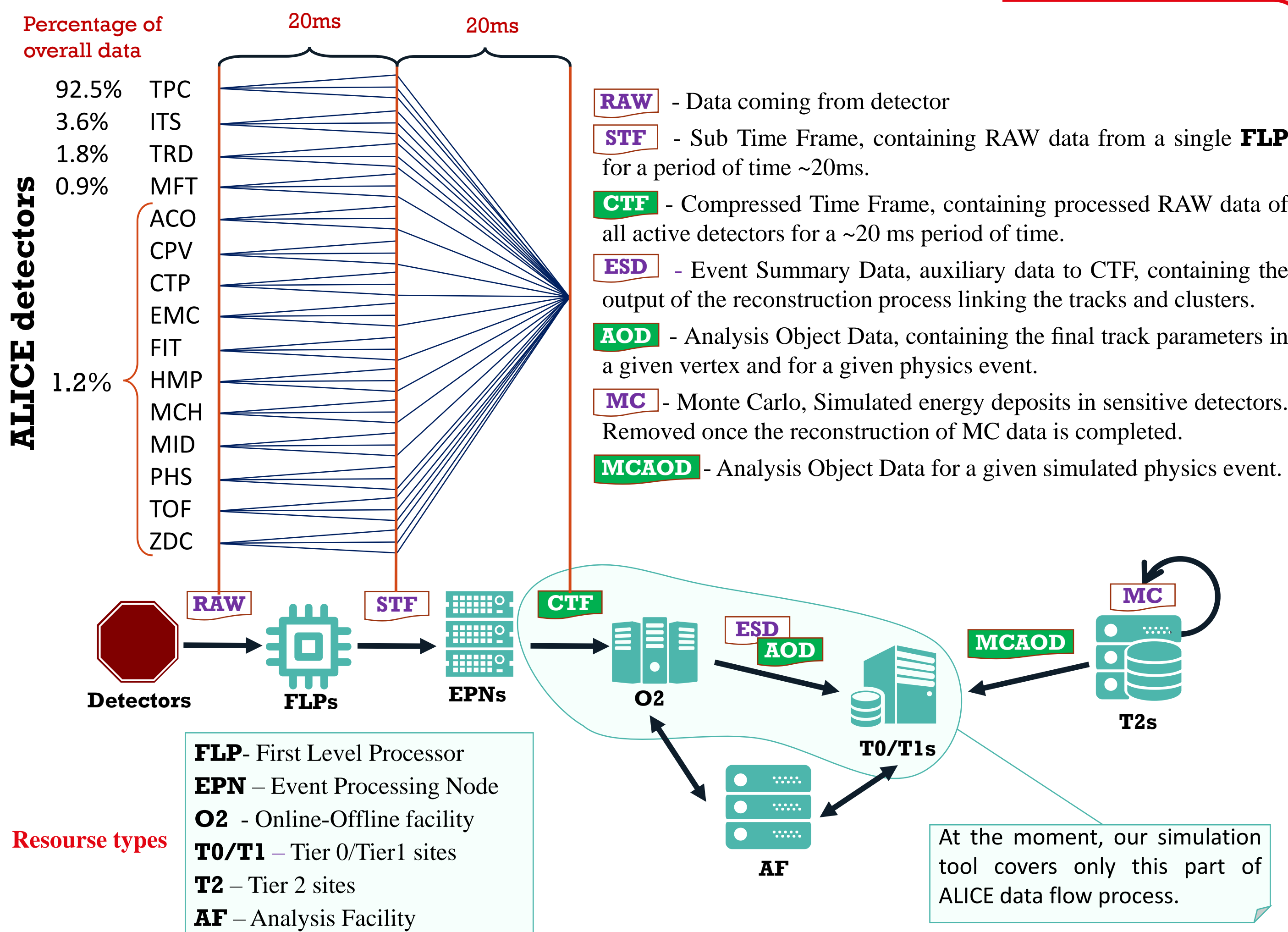
This simulation software is a flexible and highly configurable tool, which presently allows to roughly estimate the volume of storage resources, necessary to store each type of data of ALICE experiment during LHC Run 3 period. The simulations are done by taking into account various input parameters, such as the planned number of collisions for each collision type, LHC running schedule, data management and removal policies and other criteria.

In order to validate the initial results of simulations, another simulation has been done for the storage resource usage during the 2017 year of LHC Run 2, which real results are already known and will be compared with simulated results. The tool is still under development in order make the simulations as realistic as possible, as well as with the vision to make the software universal, that it can be used by the other experiments of LHC.

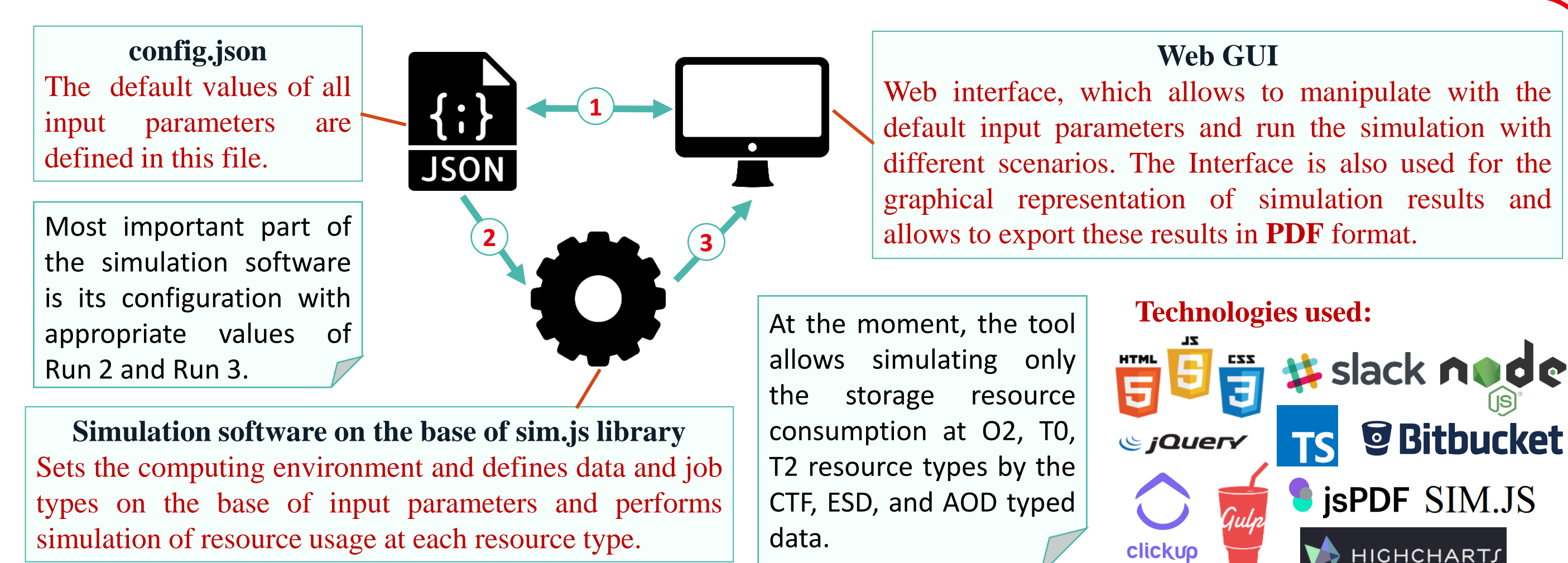
## References

- [1] The LHC (Large Hadron Collider) - <http://home.web.cern.ch/about/accelerators/large-hadron-collider>
- [2] The ALICE experiment - <http://aliweb.cern.ch>
- [3] Alice O2 Upgrade Technical Design Report - <https://cds.cern.ch/record/2011297/files/ALICE-TDR-019.pdf>
- [4] LHC Schedule 2017 - [https://beams.web.cern.ch/sites/beams.web.cern.ch/files/schedules/LHC\\_Schedule\\_2017.pdf](https://beams.web.cern.ch/sites/beams.web.cern.ch/files/schedules/LHC_Schedule_2017.pdf)
- [5] ALICE Computing Resources Usage in 2017-2018 and Resource Requirements for 2018, 2019 and 2020, Page 2 - [https://indico.cern.ch/event/718770/contributions/2954296/attachments/1627208/2591768/Resources\\_review\\_and\\_requirements\\_2017-2020.pdf](https://indico.cern.ch/event/718770/contributions/2954296/attachments/1627208/2591768/Resources_review_and_requirements_2017-2020.pdf)

## ALICE data flow during LHC Run3/Run4



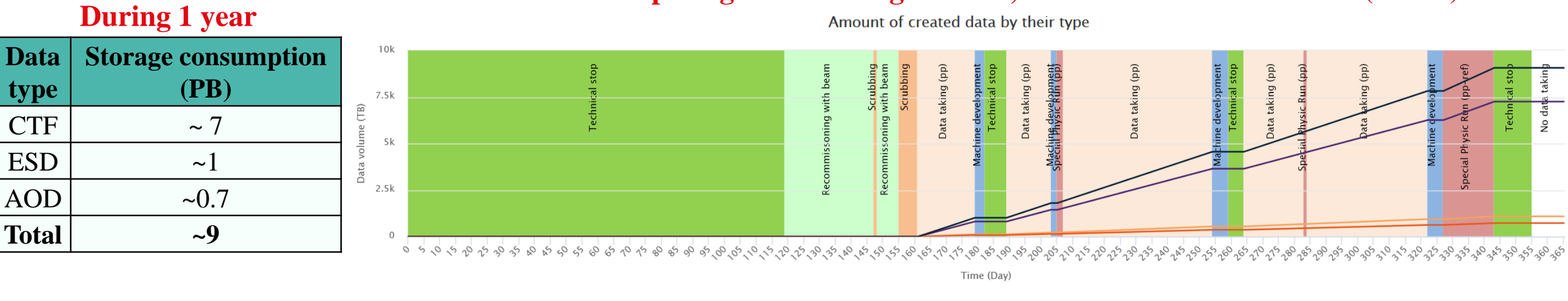
## The simulation tool architecture



## Initial results

Monte Carlo simulation processes are not included in these results.

### With Run 3 computing model configurations, but LHC calendar of 2017 (Run 2)



### With Run 2 computing model configurations and LHC calendar of 2017 (Run 2)

