A new data format for the commissioning phase of the ATLAS detector

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Abstract. In the commissioning phase of the ATLAS experiment, low–level Event Summary Data (ESD) are analyzed to evaluate the performance of the individual subdetectors, the performance of the reconstruction and particle identification algorithms, and to obtain calibration coefficients. In the grid model of distributed analysis, these data must be transferred to Tier-1 and Tier-2 sites before they can be analyzed. However, the large size of ESD ($\approx 1$ MByte/event) constrains the amount of data that can be distributed on the grid and is available on disks. In order to overcome this constraint and make the data fully available, new data sets — collectively known as Derived Physics Data (DPD) — have been designed. Each DPD set contains a subset of the ESD data, tailored to specific needs of the subdetector and object reconstruction and identification performance groups. Filtering algorithms perform a selection based on physics contents and trigger response, further reducing the data volume. Thanks to these techniques, the total volume of DPD to be distributed on the grid amounts to 20% of the initial ESD data. An evolution of the tools developed in this context serves to produce another set of DPDs that are specifically tailored for physics analysis. All selection criteria and other relevant information is stored inside these DPDs as meta-data and a connection to external databases is also established.

1. Introduction

The ATLAS experiment [1] is one of four experiments situated at an interaction point of the Large Hadron Collider (LHC) [2, 3, 4] at CERN, the European Organization for Nuclear Research situated near Geneva, Switzerland. The first collisions of the two proton beams at a center-of-momentum (c.m.) energy of 10 TeV are scheduled to take place towards the end of 2009. Later on in the long-lasting LHC programme, the c.m. energy will be increased to the full design energy of 14 TeV.

The physics goals of the ATLAS experiment contain, e.g., precision measurements of the $W$ and $Z$ boson, the top quark, and other Standard Model (SM) processes, as well as the search for the Higgs boson, for Supersymmetry, for Large Extra Dimensions, or any other so far unmeasured physics processes [1].

The volume of data that will be produced by the ATLAS experiment will exceed everything currently existing. About 1 Pbytes/yr will be recorded. This enormous amount of data is going to get analyzed by about 2000 members of the ATLAS collaboration. This grand challenge requires new ways of organizing, distributing, and analyzing data. The new concept of distributed computing over the LHC computing grid [5] is designed to cope with these challenges (see Sec. 2).
One of the biggest challenges is the problem that hundreds of users may try to access the same set of data files at the same time. This can lead to access problems, even in the model of distributed grid analysis, see Sec. 3. An introduction of datasets that are specialized to certain tasks mitigate this problem because a given dataset is only interesting for a sub-group of the ATLAS collaboration and not to the whole collaboration any more. This path is chosen by introducing the new Derived Physics Datasets (DPD), see Sec. 4.

Also, the level of detail of a given collision event that is needed to analyze certain aspects will vary. Different requirements are given for the already recorded cosmic data, the early collision data that will mostly focus on understanding the detector as well as the reconstruction algorithms, and the steady-state physics analysis. For these three different classes of analysis, three different types of DPDs have been designed, using a common set of tools (see Sec. 4.1).

The DPDs designed for analysis of the cosmic data select events based on the type of cosmic event at hand, e.g., whether a track was reconstructed that went through the innermost part of the ATLAS detector or an electromagnetic cluster has been found in the event. These DPDs are described in more detail in Sec. 4.2.

The calibration of the ATLAS detector and improving the understanding of the reconstruction algorithms will have the highest priority during the initial colliding-beam phase of the LHC. The DPDs designed for this purpose select events based on, e.g., the presence of a loosely identified muon. Another approach is also taken for these DPDs. Not all information of a given event is always retained. Instead, e.g., for the DPD aimed at studying the electromagnetic calorimeter and the reconstruction performance of electrons and photons contains only the calorimeter cells nearby a reconstructed electron or photon to save on the per-event size. Section 4.3 describes the details of these performance DPDs.

The third class of DPDs is meant to support physics analysis. Here, events are either selected based on specific triggers or based on the combination of several loosely identified objects in the event, e.g., the event must contain one electron and one muon in order to be selected. The per-event size in these DPDs is much smaller compared to the other two classes of DPDs described above. Only information that is needed for the final physics analysis is retained. In case the analyst finds a problem with some specific events where more information is needed, she can navigate back to the full event content in the appropriate parent file. These physics DPDs are described in Sec. 4.4.

The DPDs described here are also being integrated into the ATLAS tag database which allows for fast searching through all events using database technology.

The integration of the new DPDs into the ATLAS data production and distribution model is described in Sec. 4.5 and an extension of the idea of DPDs to users and user groups is discussed in Sec. 4.6. Finally, a summary of this article is given in Sec. 5.

2. The ATLAS distributed analysis model
At the full design luminosity of the LHC of $10^{34}$ cm$^{-2}$s$^{-1}$, the beam collision rate will be 40 MHz and the event rate will be about 1 GHz. This is due to about 25 proton–proton interactions occurring on average per beam crossing. The three–level trigger system of the ATLAS experiment reduces this rate to a maximum of about 200 Hz. Since the average size of a single event is about 1.6 Mbytes, this amounts to a constant data rate of over 300 Mbyte/s which corresponds to more than 1 Phytes/yr.

In order to process this unprecedented large amount of data and make it available to the world–wide community of ATLAS physicists, a tree-like structure with several layers, or Tiers, was adopted by the ATLAS collaboration, the ATLAS part of the LHC computing grid [6].
2.1. The first processing of the data
The ATLAS trigger system splits the events up into several inclusive trigger streams (electron, muon, jet, etc) based on the actual trigger decision for a given event. This means that an event that passed an electron trigger and a muon trigger will be transferred both to the electron and muon trigger streams. This trigger streaming is designed such that the event overlap amongst different trigger streams is at the level of about 10%.

The recorded data will be transferred separated in these trigger streams from the ATLAS experiment situated at the LHC interaction point 1 (Point 1) to the central Tier 0 computing center at CERN. The specialized ATLAS reconstruction software is run over the raw data at the Tier 0 within 24 hours to reconstruct the physical objects which interacted with the ATLAS detector, such as electrons, photons, muons, jets, etc. The result of this reconstruction is the Event Summary Data (ESD) which contains all the reconstructed objects, but not any more all the raw data. Its average per–event size is approximately 700 kbytes and it is produced for all events from all trigger streams. A subsequent processing step, also at the Tier 0, is producing the Analysis Object Data (AOD) from the ESD. The AOD is a size–reduced data set that contains less detail than the ESD, e.g., most of the individual calorimeter cells are not stored any more.

The AOD was originally meant to be the primary data format for the final physics analysis with an average per–event size of about 150 kbytes. As for the ESD, the AOD is produced for all events from all trigger streams. Both the ESD and the AOD are stored in the same format, the POOL format [7].

The TAG database is also filled during this last processing step. This database contains information about the event content. For example information about the presence of well–identified electrons or muons above a certain minimum transverse momentum is stored. The TAG database size is only about 1 kbyte per event. And its storage using database technology allows for very fast access and event selection. The TAG database is very efficient in cases where rather simple selection criteria are used to select only very few events, i.e., when a lot of the actual AOD files that the TAG database is linking to are not touched because the TAG database query determined that no interesting events are contained within these files.

All the above listed processing happens at the Tier 0 during the first 24 hours of data taking. When the processing of a given dataset is completed, all associated files will be transferred to about 10 regional Tier 1s distributed all over the globe. Due to the large overall size of the raw data, only two copies of the raw data are stored, distributed between the Tier 0 and the Tier 1s. All data files are copied to magnetic tape storage and only a very small fraction of the ESD and an even smaller fraction of the raw data will be also kept on magnetic disk drives for random access. This small fraction, together with all AOD files are then distributed to the next layer of the LHC computing grid, the Tier 2s, where they will reside on magnetic disk drives available for usage by all users of the ATLAS collaboration. Each of the several Tier 2s associated to one Tier 1 can only receive or request data that is already stored on that associated Tier 1. In general, one full copy of the total AOD is residing on disk drive storage distributed over all Tier 2s associated to one Tier 1.

2.2. Reprocessing of data
The ATLAS reconstruction software is continuously being improved. This can come from the implementation of new or improvements of existing algorithms, a better understanding of the detector geometry and response and thus determination of more precise calibration constants, and many other things. This continuous change of the ATLAS software makes it necessary to reprocess the raw data with the improved version of the algorithms and calibration constants.

The ATLAS collaboration is planning to reprocess the raw data every few months, depending on the needs and available computing and storage capacity. The data reprocessing will happen at the Tier 1s where each Tier 1 will only reprocess the fraction of the raw data that is stored
there. The newly produced ESD files will mostly remain at the Tier 1s and are transferred to magnetic tape storage. The AOD data files will be distributed to disk storage at the Tier 2s, such that again one full copy of the AOD is residing distributed at the Tier 2s associated to a given Tier 1. This will allow all users within the ATLAS collaboration to have full access to the newest available version of the AOD.

3. Shortcomings of the ATLAS distributed analysis model
The detailed understanding of the physics response of the ATLAS detector will be one of the most important tasks during the startup phase of the LHC. In addition, the performance evaluation and improvements of the ATLAS reconstruction and identification software will be very important. Very detailed detector information will be needed for these kind of studies, information that is not usually available at the level of the AOD, but is available in the ESD. This poses a problem since the users of the ATLAS collaboration have only full access to data stored on disk storage at the Tier 2s, i.e., to the AOD and a very small subset of the ESD.

To partially avoid this problem, the ESD will be also stored at the Tier 2s, but only for the first weeks or so (depending on disk storage capacity limitations) after the startup of the LHC. After this short initial time, the ESD will only be available during the scheduled reprocessing campaigns described in Sec. 2.2. Thus, users do not have full access to, in some cases vital, detailed detector data contained in the ESD.

Another possible issue is the case when new data from the ATLAS detector is just arriving at the Tier 2s and possibly hundreds of users are trying to access and process these new AODs all within a very short time period. This can lead to large backlog and even failure to access the requested data at the Tier 2s.

4. New specialized derived physics datasets
In order to circumvent the possible issues mentioned in the previous section, a new class of datasets has been designed, the so-called Derived Physics Datasets (DPDs). These DPDs are stored in the same POOL format [7] as are the ESDs and AODs in order to simplify the actual data processing for the user.

The individual user is usually only interested in a small fraction of the total data volume since this user will only do one or two types of analysis. Most of the possible data analysis task that users intend to do can be grouped into a few categories. For example, there will be users interested in the commissioning of the ATLAS muon detector system, or users trying to understand and optimize the electron reconstruction algorithms, or users who are searching for the Higgs boson in a very specific decay channel. Three distinct classes of data analysis have been identified and for each of these three classes a special set of DPDs has been designed.

The first class of data analysis is focusing on the commissioning of the ATLAS detector using mostly cosmic muon events taken while the LHC is not operational and also data events from single-beam LHC operation. The commissioning DPDs designed for these commissioning tasks are described in Sec. 4.2.

During the first year of colliding-beam LHC operations, another class of data analysis is the most important, namely determining and understanding the performance of the ATLAS detector and reconstruction software. For these performance studies, the performance DPDs described in Sec. 4.3 have been designed.

The third category of data analysis is comprised by the actual final physics analyses. The physics DPDs tailored for these types of analyses are described in Sec. 4.4. However, it is expected that most analyses will utilize the performance DPDs during the first year of data taking because more detailed information will be necessary to understand the new experiment. Thus, these physics DPDs have a rather long-term goal unlike the other two DPD categories.
4.1. Tools for the DPD production

A few DPDs of each of the three categories mentioned above are produced with the specific analysis goals in mind from each of the several ATLAS trigger streams. This design reduces the user load on an individual dataset since usually only one dataset type is useful for a given user. To be able to produce several DPDs from a given ATLAS trigger stream, a new framework within the ATLAS software has been utilized that allows to produce several output streams from a single input stream. Each of the configured output streams can schedule its own computation and selection algorithms and tools. This design permits the production of very different output DPDs in a single processing job.

In order to be able to make the DPDs readily available to all users of the ATLAS collaboration, they have to be stored on disk storage systems at the Tier 2s. However, these disk storage systems have a limited capacity. To fit all DPDs within this storage capacity constraint, the total DPD size is restricted to be about the same size as the total AOD size. This is achieved by employing several size reduction techniques.

- **Skimming.** This is a basic event selection. Only events that are interesting for the specific types of analysis that are envisioned to be done with the DPD at hand are kept. For example only events that contain at least two well reconstructed and identified electrons above a certain transverse energy threshold are kept. This DPD can then be used to study, e.g., \( Z \rightarrow e^+e^- \) events or high-mass resonance searches. This reduces the average per-event size.

- **Trimming.** Here, all objects of a certain type are removed. One can, e.g., remove all calorimeter cells from every event. One example is a DPD designed for track reconstruction performance studies where the calorimeter cells are not needed any more. This reduces the size of each individual event.

- **Thinning.** Only selected objects of a given type are removed. One example is given by a DPD that is designed to evaluate and optimize the performance of electron and photon reconstruction. Only calorimeter cells in the vicinity of interesting electrons or photons can be kept while all other calorimeter cells far away can be removed. This again reduces the size of each individual event. The precise size reduction depends however on the content of the event at hand.

- **Slimming.** Some parts of an individual object are removed. For example one can remove redundant error matrices from a reconstructed track. This is used when some very detailed information about an object is not needed any more in the final analysis. This also reduces the size of each event.

Since most DPDs do not contain all events any more, the information of how many events were actually processed from the input data needs to be stored. An event counter is run during the DPD production job and the total number of events and the number of selected events is stored in each output DPD. If this information is already found in the input file, as in case of subsequent processing steps, the total event count is simply added from all processed input files and the updated numbers are written into the output DPD. Also, the information about the instantaneous luminosity of the LHC is transferred correctly to each DPD, even if no event from the input file was selected.

In addition to this, the user needs to know why a given event was actually selected. For most DPDs, there are several distinct event filtering algorithms defined and an event can be accepted by either of these. The information which of the possible several event filtering algorithms actually accepted the event at hand is stored inside the DPD for each individual event.
4.2. *The commissioning DPDs*
Commissioning of the ATLAS detector using cosmic muon events and LHC single–beam data is already ongoing for some time now. The studies performed with these cosmic muon events are, *e.g.*, detector alignment studies using the muon tracks, measurements of the energy deposits of a cosmic muon inside the ATLAS calorimeters, cosmic muon trigger studies, and related tasks. For these types of studies, the event content of the ESD is the most suitable data set.

So far, about 294 million cosmic muon events have been recorded, comprising a total size of about 600 Tbytes of ESD files. For most analysis tasks, only a small subset of these events are needed, usually about 500 k events. These are events where, *e.g.*, a sufficient localized energy deposition in the electromagnetic calorimeter was found, or events where a track close to the nominal interaction point was found that left a sufficient number of hits in the ATLAS silicon pixel detector. Eleven different categories have been identified and thus, eleven distinct commissioning DPDs have been implemented. All of these have different event selection criteria but keep the full ESD event content. Each of the resulting commissioning DPDs has a total size of only 1 Tbyte or less. Therefore, they are easily stored on disk storage systems at the Tier 2s and are thus readily available to the whole ATLAS collaboration.

These commissioning DPDs were produced successfully at the Tier 0 for the first time in December 2008. A new reprocessing and thus new production of all the commissioning DPDs took successfully place in March 2009 and another reprocessing is going to start soon.

4.3. *The performance DPDs*
Once the LHC will collide both proton beams, the most important analysis tasks will be related to improving the understanding of the detector performance and also understanding and improving the performance of the reconstruction and identification algorithms of the ATLAS software. Very detailed information is needed in order to allow these studies, information that is available in the ESD, but not necessarily in the AOD. Thus, the performance DPDs are produced from the ESDs. At the time of the first data processing, the performance DPDs will be produced at the Tier 0, after the reconstruction jobs produced the ESDs, thus minimizing possible time delays.

The performance DPDs will then be distributed to disk storage at the Tier 2s, making them easily available to the whole ATLAS collaboration for analysis. This will give users access to ESD–level information, something which is not possible using the too large ESDs directly since they are saved on tape storage systems at the Tier 1s. The overall size restriction for all performance DPDs combined amounts to the same overall size as all AODs combined.

Nine distinct performance DPDs have been defined and implemented. Each of these nine performance DPDs is produced from the ESDs of only one trigger stream. This scheme is chosen because a specific performance analysis uses in most cases events from only one trigger stream. In case an analysis requires events from several trigger streams, several performance DPDs have to be processed.

Four of these nine performance DPDs keep the full ESD event content. In order to reduce the overall size to the required limit, only very specific events are selected. One example is the DPD produced from the minimum bias trigger stream. Here, an event is kept if either an isolated track is found (to perform early tracking studies) or a simple pre-scale accepts the event (to have an unbiased sub-sample), that is every 50th event is kept independent of finding an isolated track. Another example is a DPD designed for studying jet reconstruction algorithms and calibrating jets using a recoiling jet against either a photon or a *Z* boson decaying into two electrons. Here, the event is selected if either a very well reconstructed and identified photon with large transverse energy is found or a loosely reconstructed $Z \rightarrow e^+e^-$ event is found.

Another four performance DPDs employ a somewhat looser event selection and reduce in addition the event size. Two of these reduce the per–event size by dropping all objects of a
Table 1. Overview of the available performance DPDs.

| DPD        | Trigger stream | Event selection            | Content                      | Main purpose                  |
|------------|----------------|----------------------------|------------------------------|-------------------------------|
| MinBias    | minimum bias   | Isolated track or pre-scale| Full ESD                     | Calibration, missing $E_T$   |
| PhotonJet  | electron, photon| Clean high–$E_T$ photon or $Z \to e^+e^-$ | Full ESD                     | Jet calibration              |
| SingleEl   | electron, photon| One low–$E_T$, well identified electron | Full ESD                     | Electron, tau, missing $E_T$ |
| SingleMu   | muon           | One low–$p_T$ isolated muon | Full ESD                     | Muon, tau, missing $E_T$     |
| CaloJet    | jet, missing $E_T$ | Jet trigger selection with $E_T$ dependent pre–scale | Calorimeter cells and basic tracks | Jet                           |
| Tracking   | jet, missing $E_T$ | Jet trigger selection with $E_T$ dependent pre–scale | ESD–level tracking information | Tracking and $b$–tagging     |
| LargeMet   | jet, missing $E_T$ | Large missing $E_T$ or medium missing $E_T$ with one high–$E_T$ hadronic $\tau$ decay | ESD objects near taus plus AOD | Tau                           |
| Muon       | muon           | High–$p_T$ muon or $J/\psi \to \mu^+\mu^-$ or $Z(t) \to \mu^+\mu^-$ candidate | ESD objects near muons plus AOD | Muon                          |
| EGamma     | electron, photon| All events                 | ESD objects near $e/\gamma$ plus AOD | Electron and photon          |

given type, i.e., the events are trimmed (see Sec. 4.1). In one case, the DPD is tailored towards studying calorimeter seeded jets. Here, the full tracking information is removed and only basic tracks are retained, in addition to the full calorimeter information. In the other case, the DPD is designed to study the tracking performance and thus, the calorimeter cells can be safely removed. The other two DPDs with a loose event selection utilize the possibility to remove individual objects of a given type, i.e., a given object category is thinned (see Sec. 4.1). One example is a DPD produced from the muon trigger stream where events are kept that contain either at least one muon with large transverse momentum, at least one $J/\psi \to \mu^+\mu^-$ candidate, or at least one $Z(t) \to \mu^+\mu^-$ candidate. In addition to these event selection criteria, a simple pre-scale is sampling the events as well to obtain an unbiased subset of events. When an event is selected, only the calorimeter cells and the detailed information of the ATLAS inner tracking detector are kept which are nearby a reconstructed muon.

The one performance DPD that is keeping all events during the initial LHC running period is designed for understanding and optimizing the performance of the electron and photon reconstruction and identification software algorithms. It is only produced from the electron/photon trigger stream. The concepts of trimming and thinning are heavily used to meet the overall size requirements (see Sec. 4.1). All detailed ESD level information that is not relevant for electrons or photons is removed. Also, only the calorimeter cells and the detailed information of the ATLAS inner tracking detector are kept which are nearby a reconstructed electron or photon, or near an accepted electromagnetic level 1 trigger object.

An overview of the available performance DPDs is shown in Table 1.

The performance DPDs will be produced right from the start of the LHC running with colliding beams. The current event selection criteria are however optimized with simulated
events only. Thus, there may be the need to change the DPD event selection criteria rapidly to adjust for event rates and thus total dataset sizes different from expectations. This will be possible because the event selection criteria for each of the performance DPDs are fully configurable on the command line. Thus, no rebuilding of a new release of the DPD making packages or even the whole ATLAS software will be needed. The full job configuration is stored in an ATLAS database for future reference.

4.4. The physics DPDs

Once the detector performance is reasonably well understood, physics analyses can be performed using information that is stored in the AOD, without the need to also use more detailed information from the ESD. Physics analysis have in general very specific final states. Thus, more than a dozen physics DPDs have been designed that select only certain types of events from the AOD. Each of these physics DPDs will have a total size of about 1% of the total AOD size. In order to achieve this, two different schemes have been chosen.

The first scheme selects events based on the trigger decision. In addition, several object types that are not needed are removed, i.e., trimmed from the selected events. In addition, removal of parts of certain objects has been used, i.e., some objects are slimmed (see Sec. 4.1). One example for this is the case of tracks. Each track stored in the AOD has three full error matrices associated with it, one calculated for the perigee, one for the first detector hit, and one for the last detector hit. The slimming algorithms used for these type of physics DPDs retains only the track error matrix at the track perigee, thus reducing the size of each track object by a factor of more than two.

The second type of physics DPDs retains for each kept event the whole AOD content. In order to meet the size requirement a rather stringent event selection is used. From the physics analysis point of view, the event selections are usually quite loose though. The event selection is based on loosely reconstructed and identified objects. For example events that contain two good electrons with a certain minimum transverse energy are kept for one DPD. For another DPD, events that contain both a loosely identified electron and muon are kept. The former example will be only produced for the electron/photon trigger stream whereas the later example will be produced for both the electron/photon trigger stream and the muon trigger stream.

Physics analyses will benefit greatly from either of the above mentioned physics DPD types. This is due to the large reduction in the DPD size which will increase the physics analysis processing speed by a factor of about 100. These physics DPDs will be produced at all the Tier 1s and then copied to disk storage at the Tier 2s for physics analyses.

4.5. Integration of the DPDs into the ATLAS data production

All DPDs mentioned in the previous sections are so-called primary DPDs. These primary DPDs are produced centrally by the ATLAS data production team and contain only information that is also available in the ESD or AOD.

Right after recording the raw data and the reconstruction of the events at the Tier 0 (see Sec. 2.1), the primary performance DPDs (see Sec. 4.3) are produced from the ESD, also at the Tier 0. They are then distributed to disk storage systems at the Tier 2s such that users can access them at any time. The primary physics DPDs (see Sec. 4.4) are produced from the AODs at the Tier 1s, also shortly after the AODs are available there. When a scheduled reprocessing takes place at the Tier 1s (see Sec. 2.2), the primary performance and physics DPDs are also recreated and subsequently distributed to the Tier 2s for user access. This processing scheme is illustrated in Fig. 1.
Figure 1. The prompt ATLAS data processing scheme. Shown is the path the data takes, starting at the top at the ATLAS experiment at the LHC interaction point 1. The trigger system defines several trigger streams for the raw data which are then transferred to the Tier 0 computing center at CERN. Here, the event reconstruction is performed, resulting in the ESDs. Still at the Tier 0, the AOD and performance DPD production is performed. The physics DPDs are then produced at the Tier 1s. All AODs and DPDs are subsequently transferred to disk storage at the Tier 2s. The production of the TAG database is not shown.
4.6. Different levels of DPDs

There is the option that users or user groups produce secondary and even tertiary DPDs. The general concept is that several secondary DPDs are produced from one primary DPD and that one or several tertiary DPDs are produced from one secondary DPD, thus building a tree-like data hierarchy. However, this hierarchy is not enforced. Users or user groups can also decide to produce a secondary or tertiary DPD directly from the AOD. But the concept is that each further layer of datasets is more specialized to a certain analysis. Also, the size reduction techniques described in Sec. 4.1 have to be applied more and more stringently the more a DPD is specialized for a small number of users. The secondary DPDs are restricted to be of the same data format as the ESDs, AODs, and primary DPDs. They can however store additional information which the user can compute during the production, e.g., Z boson candidates can be stored for each event. The tertiary DPDs can be completely defined by the user, but the files should be saved in the ROOT format [8].

5. Summary

Before the introduction of DPDs, there were potential problems for users to access the needed information. These problems can come from too many users trying to access the same (new) datasets on the grid within a short time period and thus producing a backlog. Another issue was that detailed detector information is not distributed to disk storage systems at the Tier 2s due to size limitations. The concept of the DPDs mitigates these issues due to a creation of several distinct and more specialized datasets that are useful for only a certain class of analysis and also the possibility to specifically select only certain quantities from an input dataset. Several tools that allow the creation of these specialized DPDs have been developed and integrated into the ATLAS software framework, including automatic bookkeeping tools.

Three different classes of primary DPDs have been identified. The first class is used only for cosmic muon and single-beam events. Here all the information in on event is kept, but only very specific events are kept. The second class is designed for evaluating the performance of the ATLAS detector and the reconstruction software. Here, only the needed parts of an event, including very detailed detector information, can be stored. Also, only interesting events are kept for each of these primary performance DPDs. The primary physics DPDs comprise the third class of DPDs. These DPDs are used for the final physics analyses and are intended for the longer term when not every physics analysis will need detailed detector information.

The introduction of the DPDs has thus mitigated some possible issues and also improved the analysis speed due to the specialized content and event selection. The DPDs are expected to considerably improve the user access to the required data and advance the analysis speed.

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