The Belle II experiment at CNAF

Fabrizio Bianchi[2, 3], Silvio Pardi[1] on behalf of the Belle II Italia
[1] INFN, Napoli, IT
[2] INFN, Torino, IT
[3] Università di Torino, IT

E-mail: spardi@na.infn.it

Abstract. The Belle II is a new generation B-Factory that aims at revealing new physics beyond the standard model, while making precision measurements of other already known phenomena. The Experiment plan to accumulate ~50ab-1 that will result in over 100PB of RAW data. The Italian sites and CNAF in particular are playing a relevant role in the data storage, processing, and analysis for the whole collaboration.

1. Introduction

In the last decades the B-Factory experiments, Belle and BaBar have established the existence of large matter-antimatter asymmetry (CP violation) in the b-quark system as predicted by the Cabibbo-Kobayashi-Maskawa theory. However, the size of CP violation observed up to now is not enough to explain the present-day matter–antimatter imbalance. This suggest the existence of additional sources of CP violation and of new physics beyond the standard model.

Belle II is an international collaboration devoted to the study of Flavor Physics using the data collected at the SuperKEKB e+e- collider at the KEK laboratory located in Tsukuba (Japan) [1]. Today Belle II involves 113 Institutes spread over 26 countries for a total of 856 scientists involved in different aspects of the experiment.

Belle II will search for new physics beyond the Standard Model by accumulating 50 times more data (~50ab-1) then is predecessor Belle which have operated at the KEKB accelerator, from 1999 to 2010. SuperKEKB has ressumed operation on March 11th, 2019 and Belle II has started the Phase 3 data taking with a fully quipped detector. The luminosity is expected to increase in time and to reach the nominal luminosity of 8×10^{35} cm^{-2} s^{-1}

The amount of produced raw data per year will increase with time and is expected to be of the order of 12 PB/year at nominal luminosity.

In addition, large sample of Monte Carlo events are needed to validate the physics studies.

To store, process, and analyse such large samples of data in a timely manner, about 100.000 cores and 200PB of storage (included data replicas) will be needed. These resources are organized in a distributed computing infrastructure in which CNAF play a key role together with the other Italian Computing Centres.

---

[1]   INFN-Napoli Campus of M.S. Angelo – Via Cintia Napoli – 80126 Napoli - Italy

2. Belle II Computing Model

The Belle II Computing model [2] is designed to accomplish several tasks over a distributed computing infrastructure, among them we have to do: RAW data processing, Monte Carlo Production, Physics analysis and Data Storage and Data Archiving.

From the storage point of view, we consider two main classes of data to deal with: RAW data, produced at KEK and the mDST data, obtained by processing the RAW data, saving the reconstruction object. The mDST can be obtained from detector data or from Monte Carlo simulation. For each data class we want to have two full copies spread over different Computing Centres geographically distributed (Figure 1).

In order to support do all those activities we distinguish three main class of computing sites:

- RAW Data Centre: Sites who store a fraction of the RAW data produced at KEK and responsible for the data processing and reprocessing. They participate at MC production.
- Regional Data Centre: Sites which store the processed data (mDST format) from raw data reconstructions and from MC and in which skimming is done. Regional Data Centres participate at MC production as well.
- MC production Centre: Site who provides computing power for Monte Carlo Production.

In particular the second copy of Raw Data will be stored in USA up to 2020, then since 2021 will be distributed in different countries with the following ratio USA (30%), Italy (20%), Germany (20%), Canada(15%) and France (15%). In this context CNAF will play a key role as the Italian Raw Data Center.
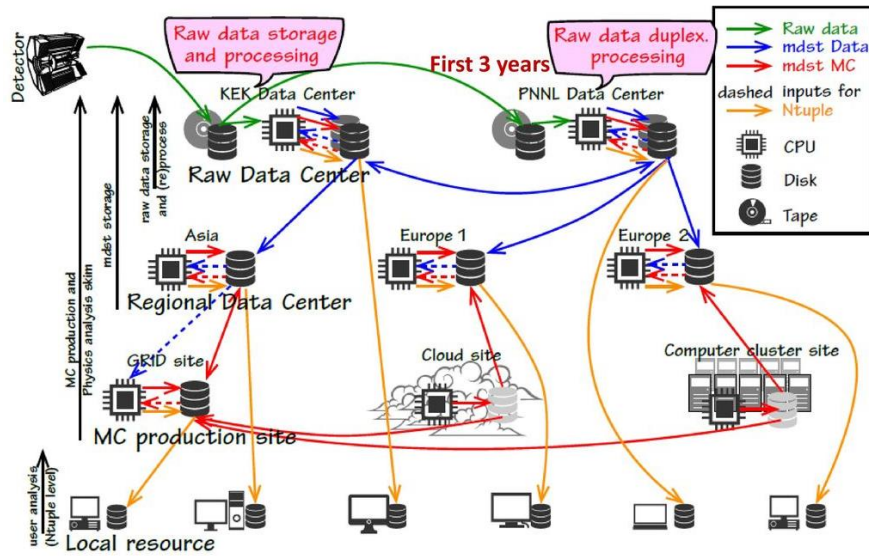

Figure 1. The picture shows synthetically the different Data flows and Computing activities in different Data Centres

The Belle II Distributed Computing Infrastructure is based on DIRAC Framework [3] empowered with BelleDIRAC extensions, created to support the specific Belle II workflows. The main DIRAC servers are run at KEK while a set of slave machines are distributed in different countries included Italy. The system integrates heterogeneous resources with different interfaces as GRID resources, Cloud VM, or direct attached Batch systems. A DDM module is responsible for data management activities, while LFC [4], AMGA [5] and FTS3 [6] are used respectively as logical file catalogue, metadata catalogue and data movement tool. Finally, a powerful monitoring system allows to govern the complexity of the whole infrastructure.

3. Belle II activities in 2018 and CNAF support

2018 has been a very exciting year for the experiment, with the first collisions in April and the completion of Phase II data taking at the end of July. From the computing point of view, activities have been dominated by the 9th, 10th and 11th MC Production Campaigns and relative skimming, as well as the user analysis on the first incoming data. The Italian community has largely contributed to these activities offering pledged resources in the sites of CNAF, RECAS-Napoli, Torino and PISA and opportunistic resources in Frascati, Legnaro, RECAS-Cosenza and Roma3. In addition, several initiatives and R&D studies has been carried on, aimed at improving the computing model and the quality of the Network connection between KEK and other Data Centres.

CNAF is playing a key role in the experiment as service provider but even by promoting and participated actively at several initiatives. As follow we highlights some of the main outcomes of 2018.

3.1. Resource Provisioning

As service Centre, CNAF offered computing and storage resources for MC production, Skimming, and User analysis. In 2018 they provided 13 kHS06 and 350 TB of disk storage pledged for Belle II, in they offered the access to a cluster with up 3 kHS06 for opportunistic usage. Storage was increased to 650TB in mid-February 2019.

The resources were back online in June after a major incident which involved the site, however thanks to the large effort and the brilliant recovery solution provided by the CNAF staff, they were able to manage the incident basically with no impact on belle II data. Then resources have been massively used with success (Figure 2), storage is also part of the R&D activity for the usage of http federation.
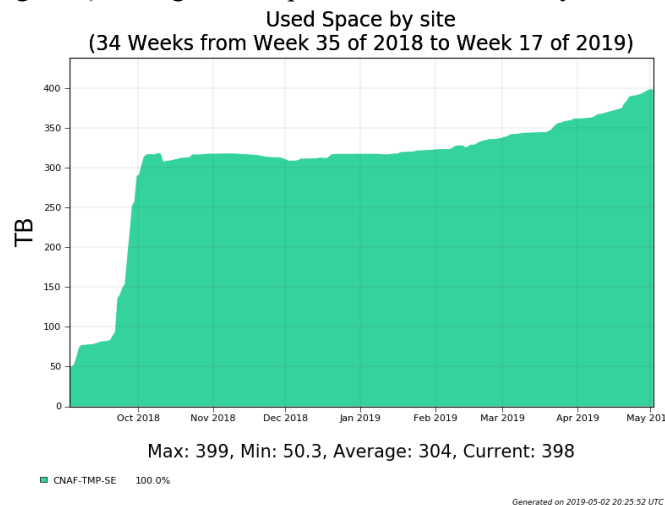

Figure 2. In the picture is showed the trend of the used disk
space at CNAF by Belle II since September 2018

3.2. Network data Challenge

Italy leads the Network activities for Belle II. In autumn the Network Data Challenge 2018 has taken place, with the goal to test the maximum achievable bandwidth storage-to-storage between KEK and all the RAW Data Centres. The activities have been coordinated from Napoli using FTS3 server in BNL. For each site we tested both direction KEK->SiteX and SiteX-> KEK .

Each Test consisted in a set FTS jobs
   ● 100x10GB (1TB total)
   ● 200x10GB (2TB total)

We used different configurations: 25, 50, 100 and 200 concurrent files and from 1 to 16 TCP streams in function of the site.

CNAF has taken part at the Data Challenge, offering to be the first Site among the RAW data centres (Figure 3). The results has been excellent, during the test we was able to saturate the 20Gbps peering between GEANT and SINET which connect Tokyo to London. At the end of DC activities, the CNAF solution (Network and Storage) has demonstrate to be one of the best setup in term of performance and reliability.
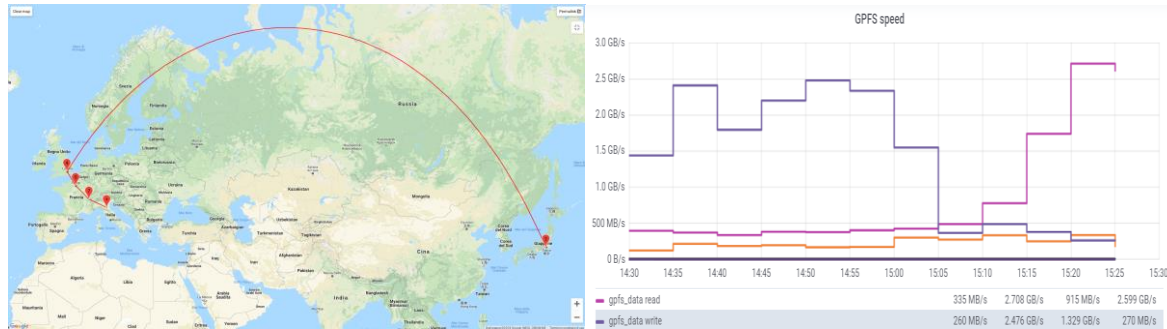

Figure 3. The picture on the left shows of the traceroute from KEK to CNAF, in the right a plot provide by CNAF showing the GPFS speed during the DC session.

3.3. Helix Nebula Science Cloud

CNAF has been one of the proponent of the European Project "Helix Nebula Science Cloud", focused on test the usage of commercial cloud for e-Science applications.

Belle II experiment has taken advantage from the commitment of CNAF to obtain a set of additional computational resources for Montecarlo Production provided by different provider, and integrated in the DIRAC infrastructure through a VCYCLE machinery installed in the site of INFN-Napoli.

The WP5, corresponding to the Scalability phase, has been directly coordinated by CNAF, during this period we as able to scale out up to 1275 cores over the T-System Cloud, reaching the TOP 10 of the most used computing infrastructures of Belle II collaboration in the week of maximum resource availability.
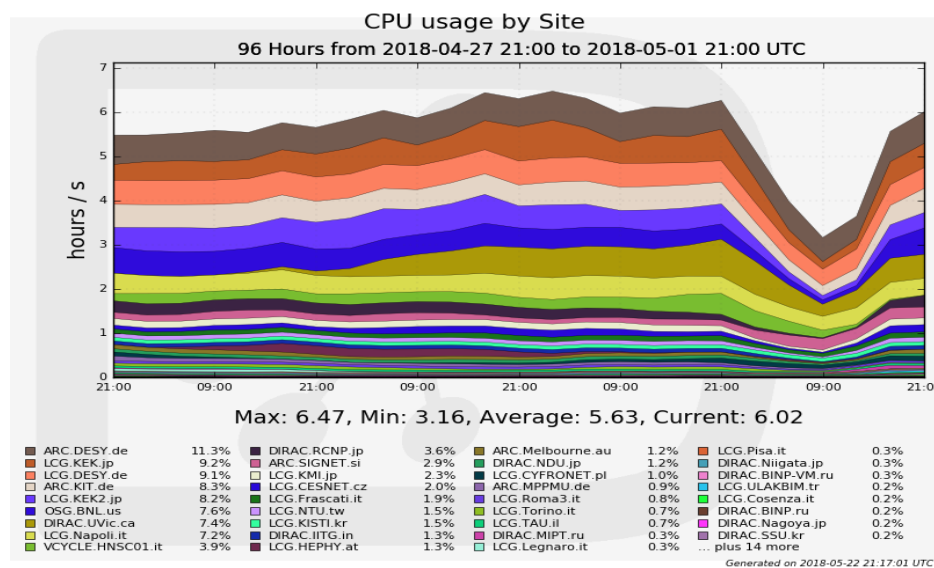

Figure 4. The graph shows the total amount of CPU used by all Belle II sites in the time window 27/04/2018-01/05/2018. The Helix Nebula Science Cloud resources are represented with the site name VCYCLE.HNSC01.

4. Conclusion

Belle II has entered a very exciting phase and the acquisition of large amount of data is foreseen. To successfully store and process those data both computing and human resources are needed. In this context CNAF will play a key role as the Italian Raw Data Centre.

In 2018, CNAF has provided excellent services to Belle II and has totally recovered from the 2017 incident without loss of collaboration data.

5. References

[1] T. Abeet al. [Belle-II Collaboration], arXiv: 1011.0352 [physics.ins-det]
[2] Pardi S et al. "Computing at Belle II" -Belle-II computing Group -Nucl.Part.Phys.Proc. 273-275 (2016) 950-956 -DOI: 10.1016/j.nuclphysbps.2015.09.148
[3] http://diracgrid.org/
[4] https://twiki.cern.ch/twiki/bin/view/LCG/LfcGeneralDescription
[5] J. H. Kwak, et al. "Improvement of AMGA Python Client Library for the Belle II Experiment", J.Phys. Conf. Ser. 664 042041
[6] A. A. Ayllonet al., "FTS3: New Data Movement Service for WLCG", 2014 J. Phys.: Conf. Ser. 513032081
[7] S Pardi and G Russo 2017 J. Phys.: Conf. Ser.898 062037