Computing in High Energy Physics.

DHEP annual meeting (May 08-09)

Brij Kishor Jashal, Puneet Patel

Disclaimer

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Outline:

1 – Grid computing evolution at TIFR.

2 – LHC plan and future needs.

3 – TIFR HEP Cloud

4 – Software and Computing challenge areas.

5 – New Technologies being adopted at TIFR.

India-CMS Tier 2 LHC grid computing center at TIFR

Recap from Puneet's talk

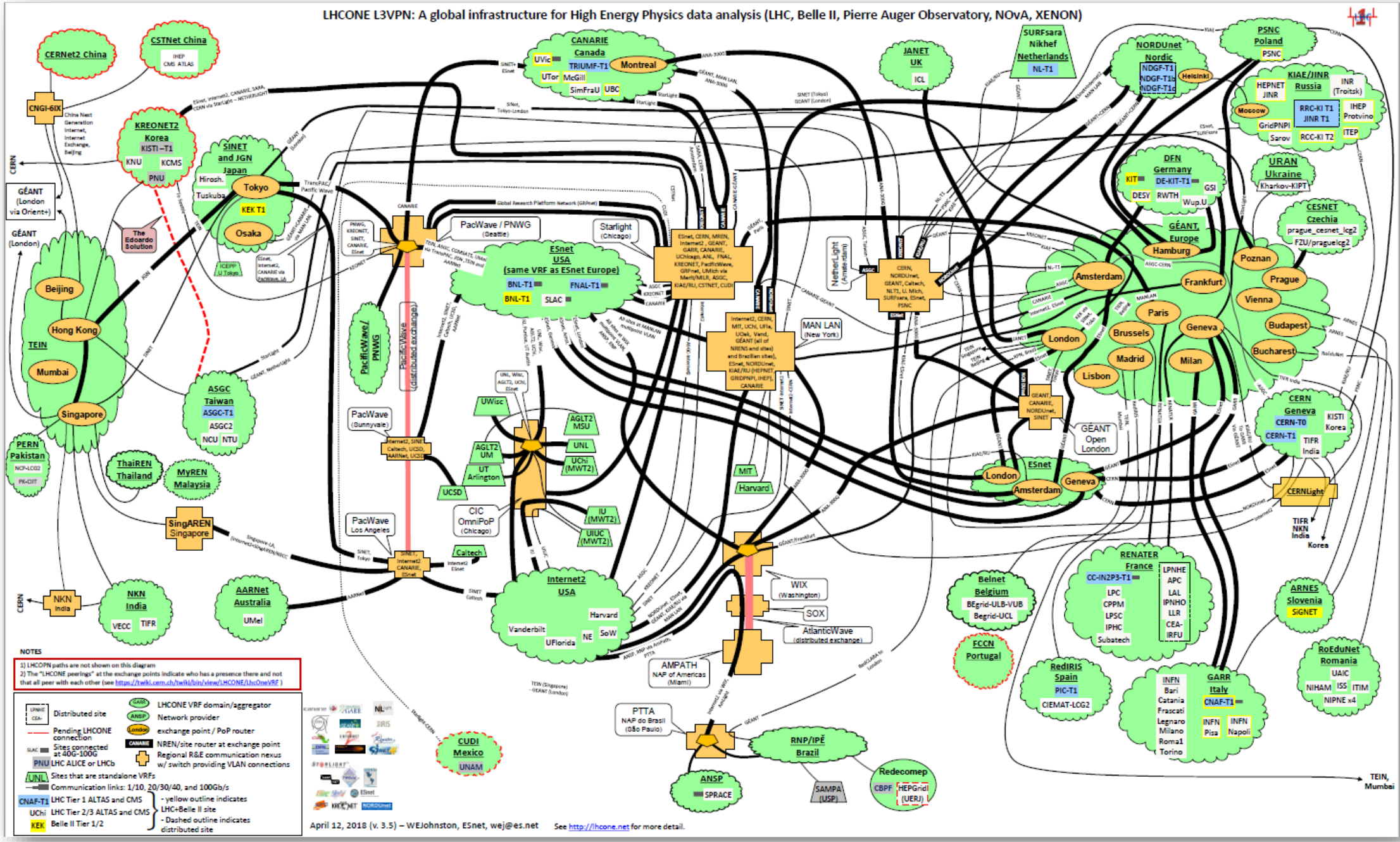
- TIFR has played lead role for Indian participation in CMS experiment at LHC: Hardware, Computing, Physics
- National contribution to CMS international collaboration at LHC
- Average availability and reliability ~ 95%
- One of the largest CMS T2 centre , active since 2008
- Crucial contribution for Higgs discovery in 2012.
- 24x7 operations… sites gets red marked if A/R falls below 90%
- 92 different tests and probes monitoring the health of system..
- Multi agency monitoring and enforcement with GGUS ticketing system.

- Two commissioned sites for CMS central computing (Production and analysis)
  - **T2_IN_TIFR**
    - Part of the global CMS resources.
    - ~ 100 active users from collaborating Indian Institutes
    - 30% of storage for Indian community
  - Dynamic resources site –**TIFR HEP Cloud** since 2017
  - Dedicated resources for T3 for analysis of Indian users.

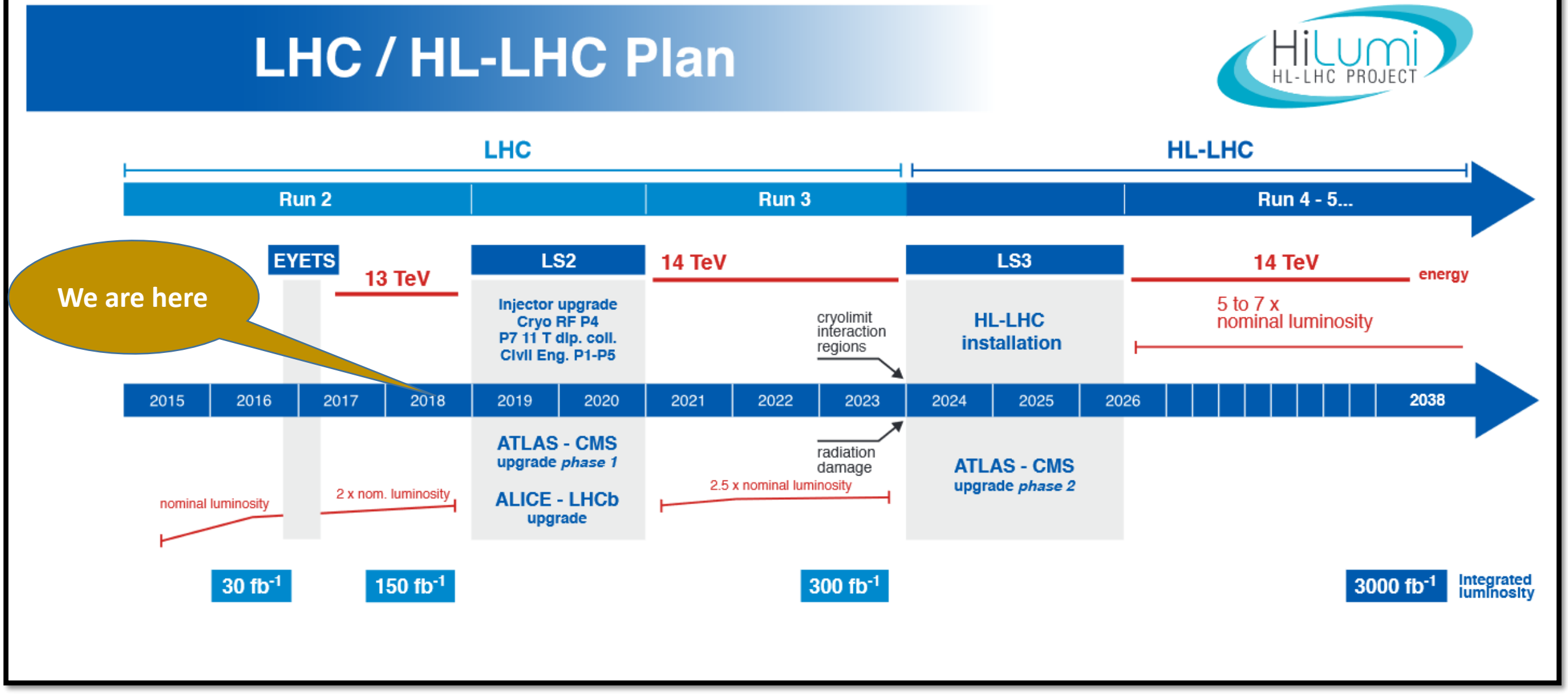
Grid computing at TIFR: Evolution of Network:

- **Major force behind the development of NKN and Indian R&E Network.**
- 1 G dedicated P2P link from TIFR ⇔ CERN (2009)
- Upgraded to 2G in 2012 ➔ Upgraded to 4G in 2014
- Implemented fall-back path using 10G shared TEIN link to Amsterdam. (2015)
- CERN P2P link Upgraded to 8G. (2015)
- Implemented LHCONE peering and L3VRF over NKN, all collaborating Indian institutes. (2015-2016)
- Upgraded to full 10G dedicated circuit till CERN. (2017)
- NKN implemented CERN PoP with 10G link. (2018)
- At present (10G + 10G) active links to LHC network.
- TIFR first institute to have 10G end point.
- Dedicated L3 peering to US West coast via Singapore and Amsterdam (Underway)
- **Network for Run-III => ~40 G International circuit**

Complexity of LHCONE Network



LHC / HL-LHC Plan

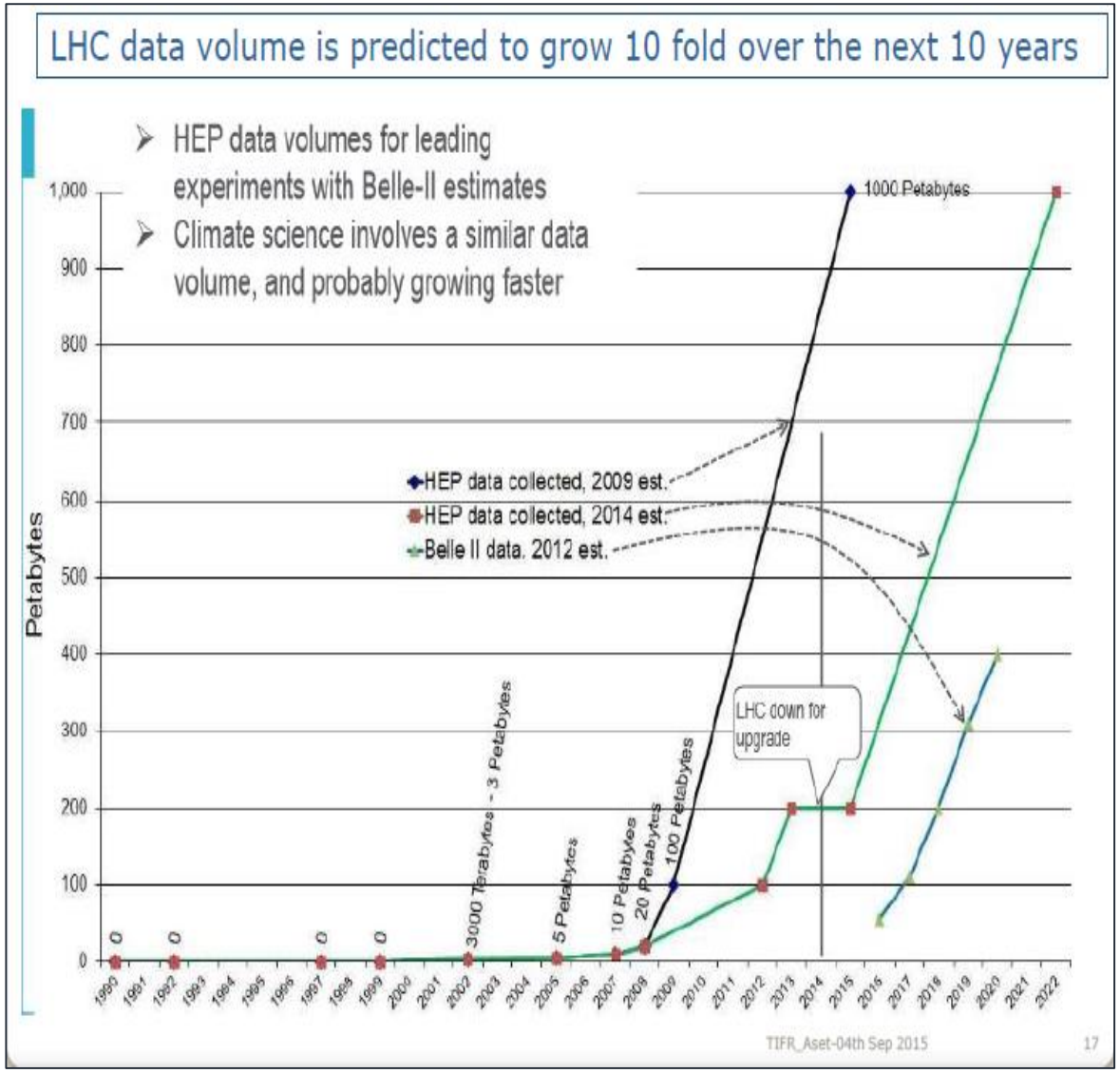


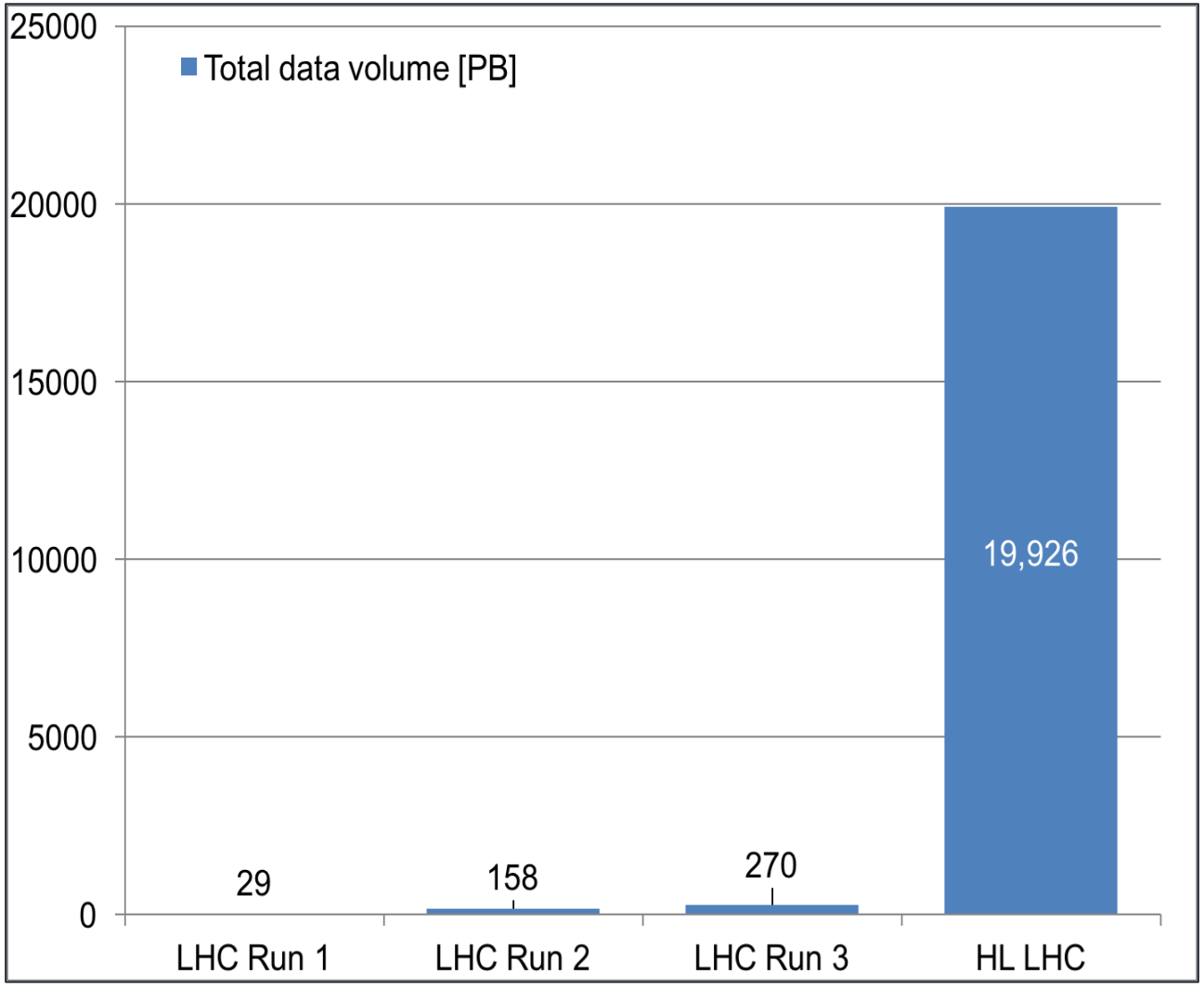
We are in the exabyte era already

brij@cern.ch

Ref:. https://tinyurl.com/ya2r6e8x

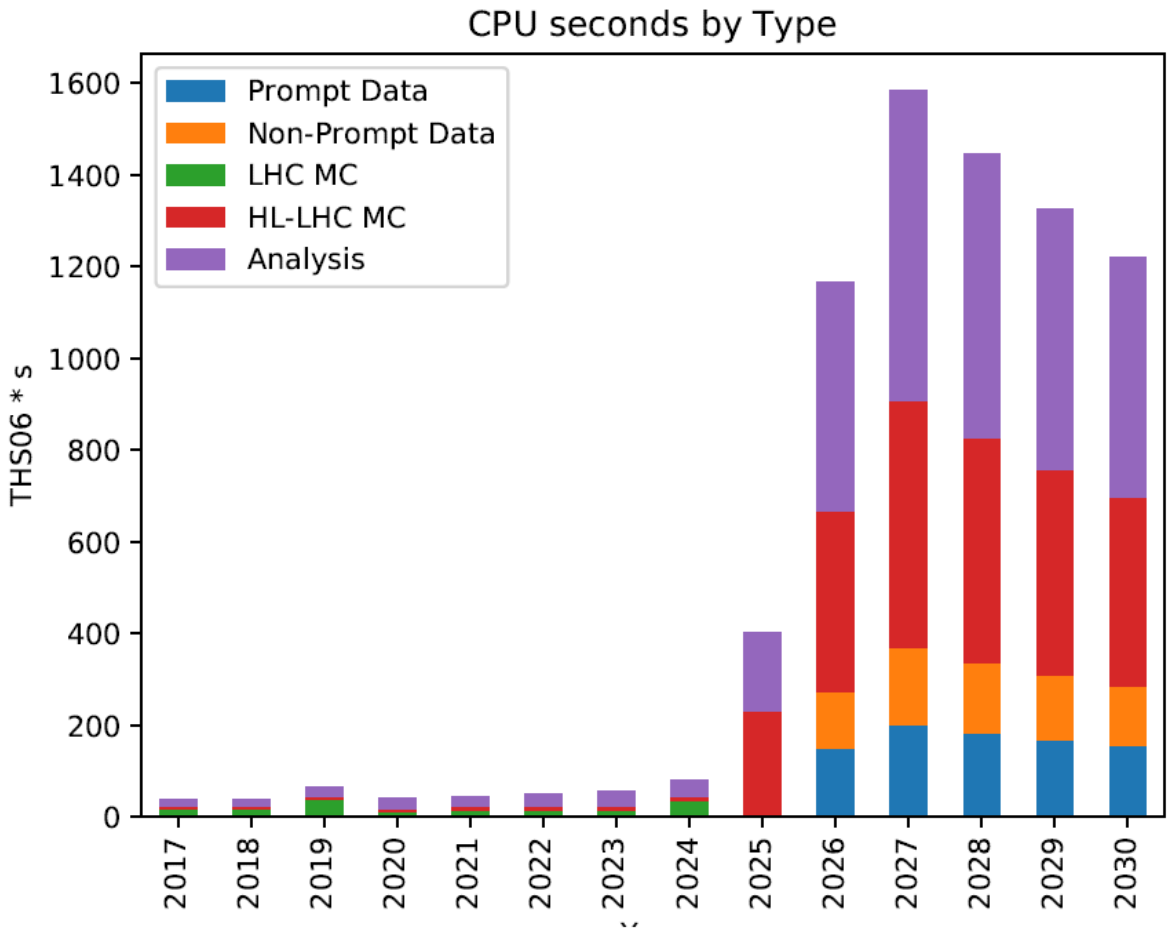
LHC experiments use about 600k CPU cores every hour of every day and have around 400 PB of data stored on disk and 600 PB on tape

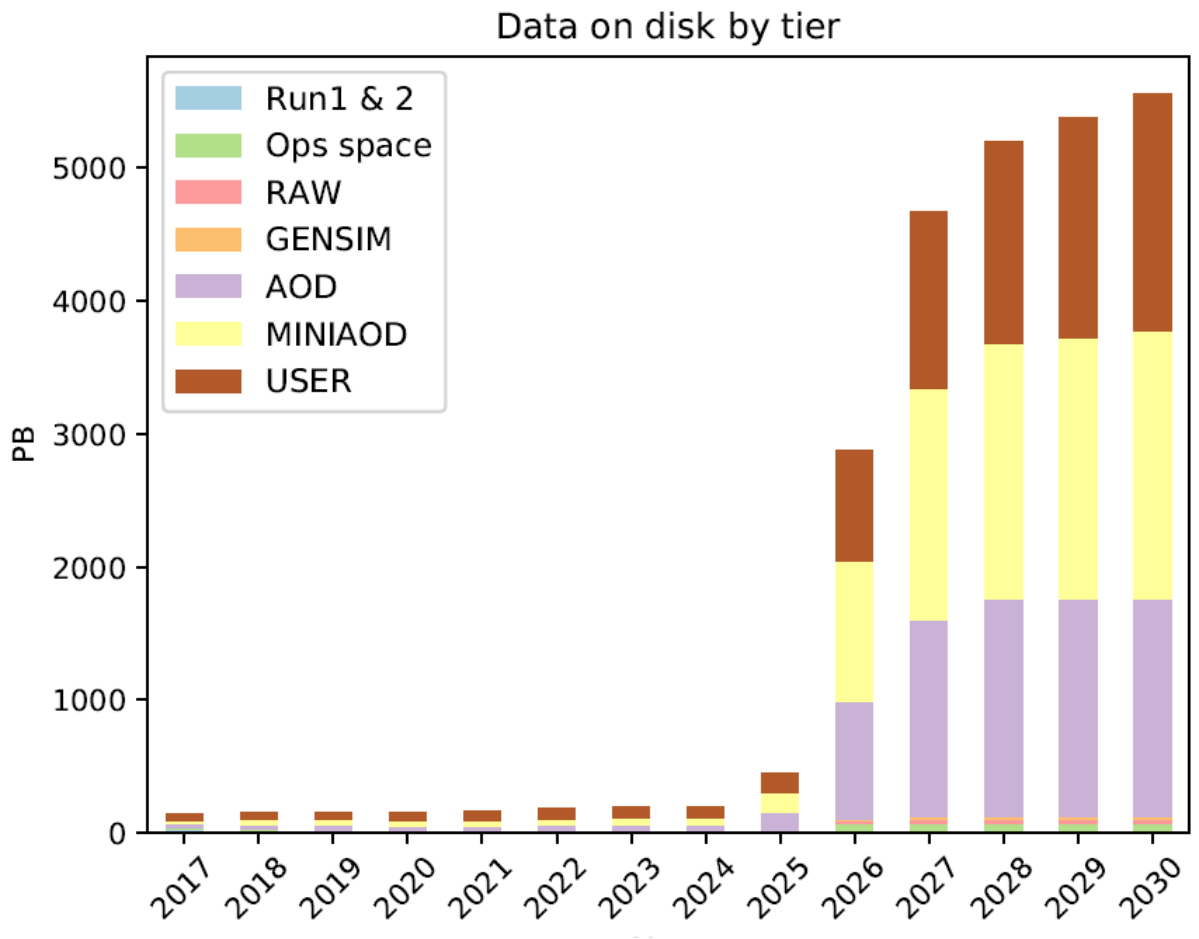




- High Energy Physics computing will need 10-100x current capacity

Planning for the future: Computing resource projection by CMS





CMS estimates for HL-LHC using the current computing model

Near Future:
To remain significant and fulfil the needs of Indian users

Year	CPU: No of HT cores	Pledge: CPU HEP-Spec06	Storage pledge (TB)	Power utilization
2018	2500	25,000 (3%)	3000 (4%)	60 KVA
2019	3500	35,000 (3%)	5000 (4%)	80 KVA
2020	**5000**	**50,000 (2%)**	**7000 (3.5%)**	**100 KVA**

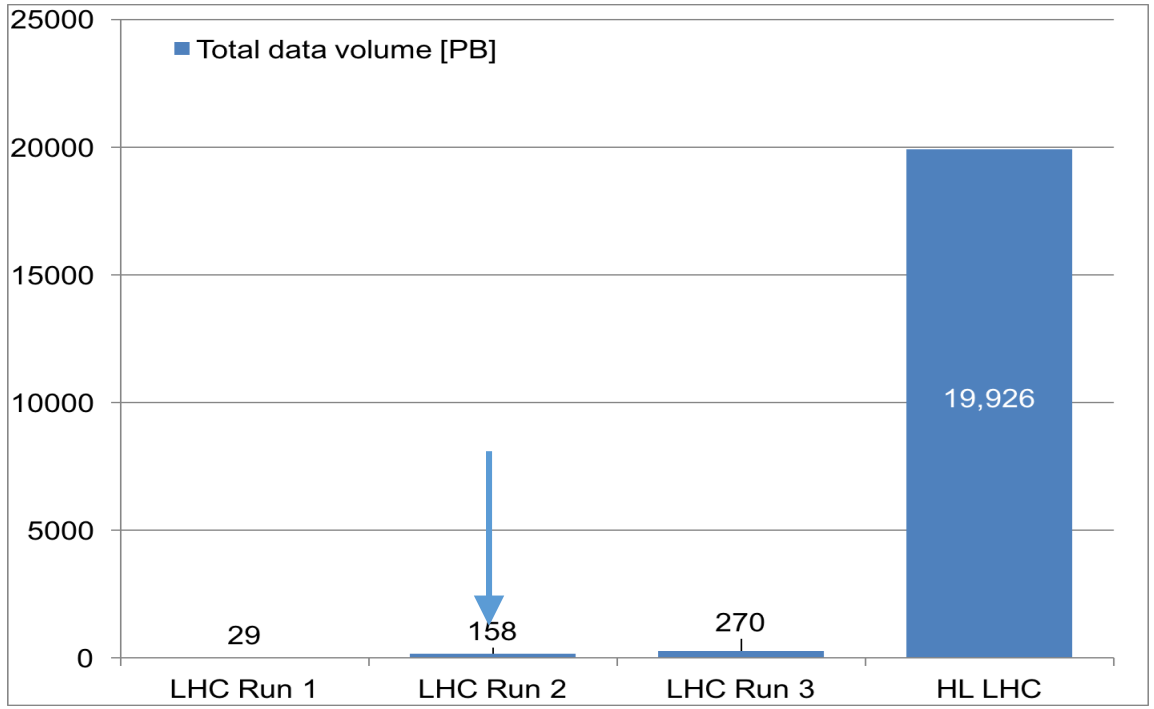
In 2025 for HL-LHC India need to provide 20,000 cores of CPU+GPU cluster and 15 PetaByte of storage.
Total power needed for Grid in TIFR - ~500 KVA.
Dedicated cooling solution for server room essential

In the existing facility it is not possible to go beyond 5000 cores and 7 petabyte of storage. Even with the latest hardware after retiring old hardware.

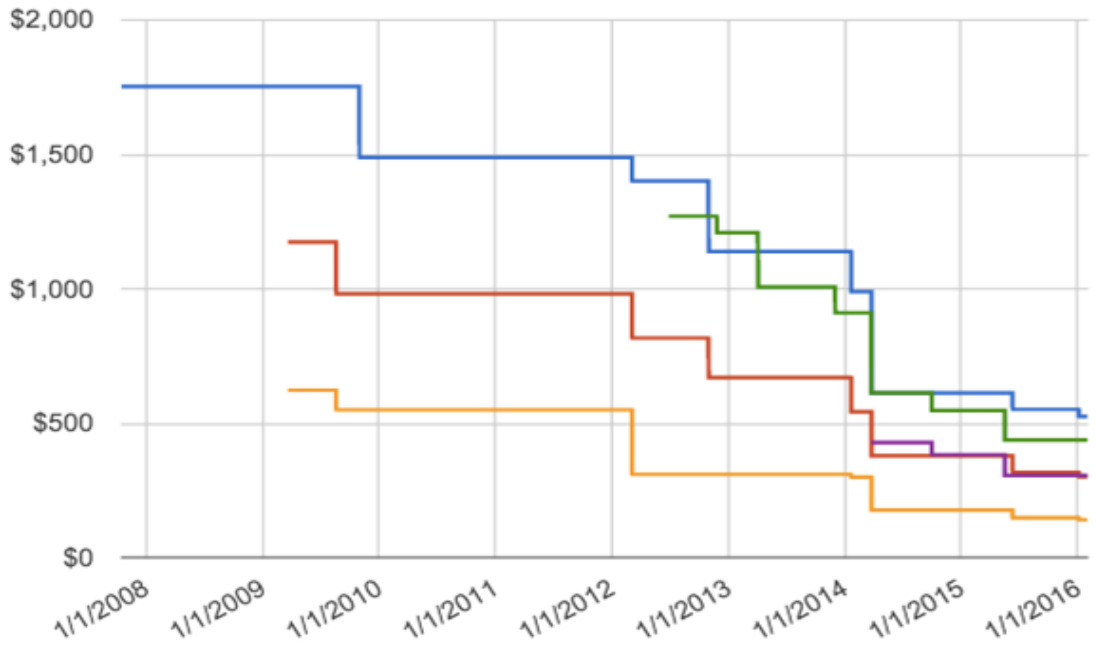
This is a common problem

HEP Computing needs.

- High Energy Physics computing will need 10-100x current capacity



- Scale of industry at or above R&D
  - Commercial clouds offering increased **value** for decreased **cost** compared to the past



System to leverage global cloud infrastructure of big players.

Reference –http://research.cs.wisc.edu/htcondor/HTCondorWeek2017/presentations/WedTimm_GCE.pdf

Dynamic Resources in CMS

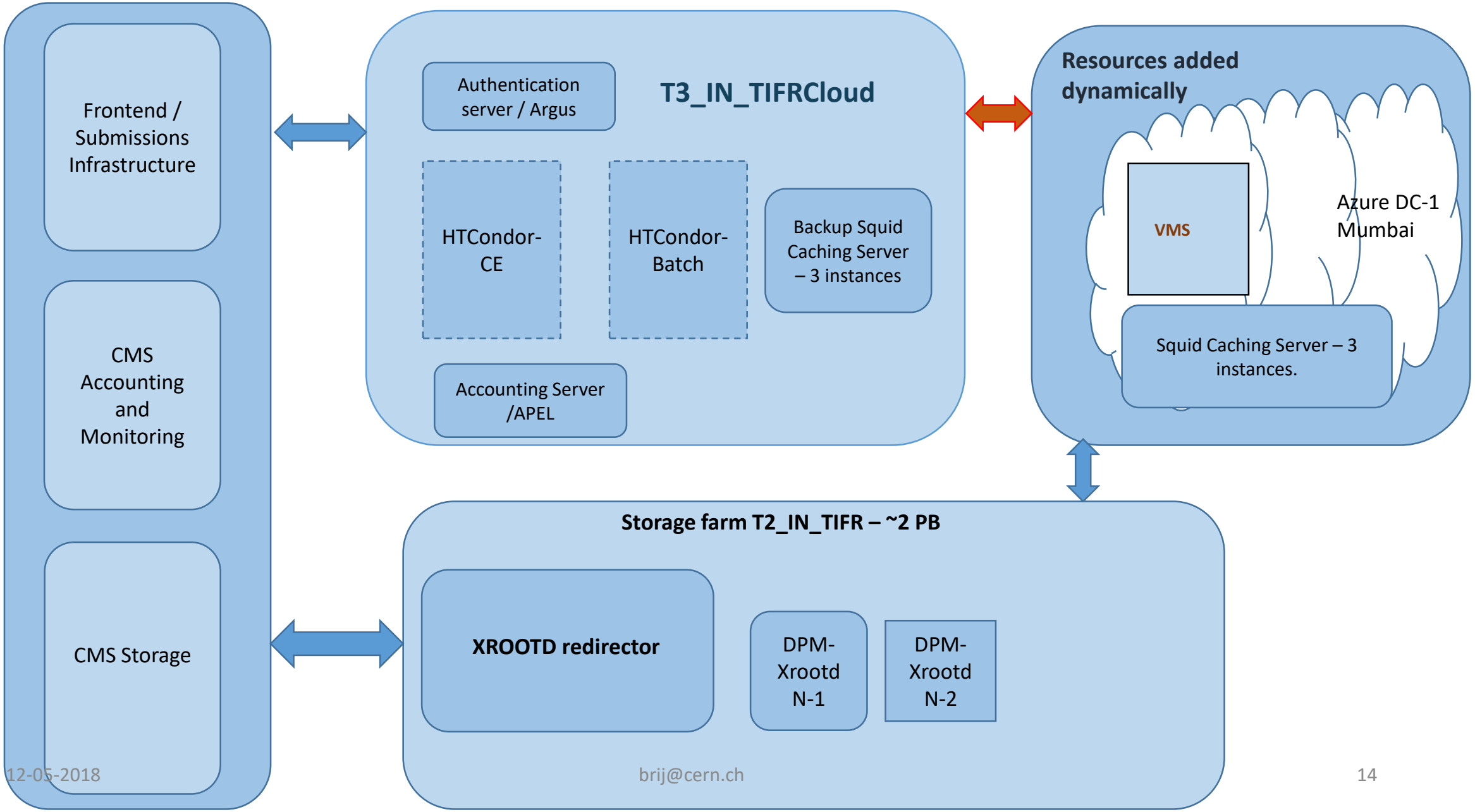
- T0 and HLT (OpenStack)
- HEPCloud (Fermi National Lab)
- Opportunistic OSG (Open Science Grid) (Including ATLAS sites)
- **TIFR HEP cloud**
- CMS@home
- Dynamic Cluster INFN
- HPCs : e.g NERSC (National Energy Research Scientific Computing Centre)

➔ Resources in addition to the regular pledge.

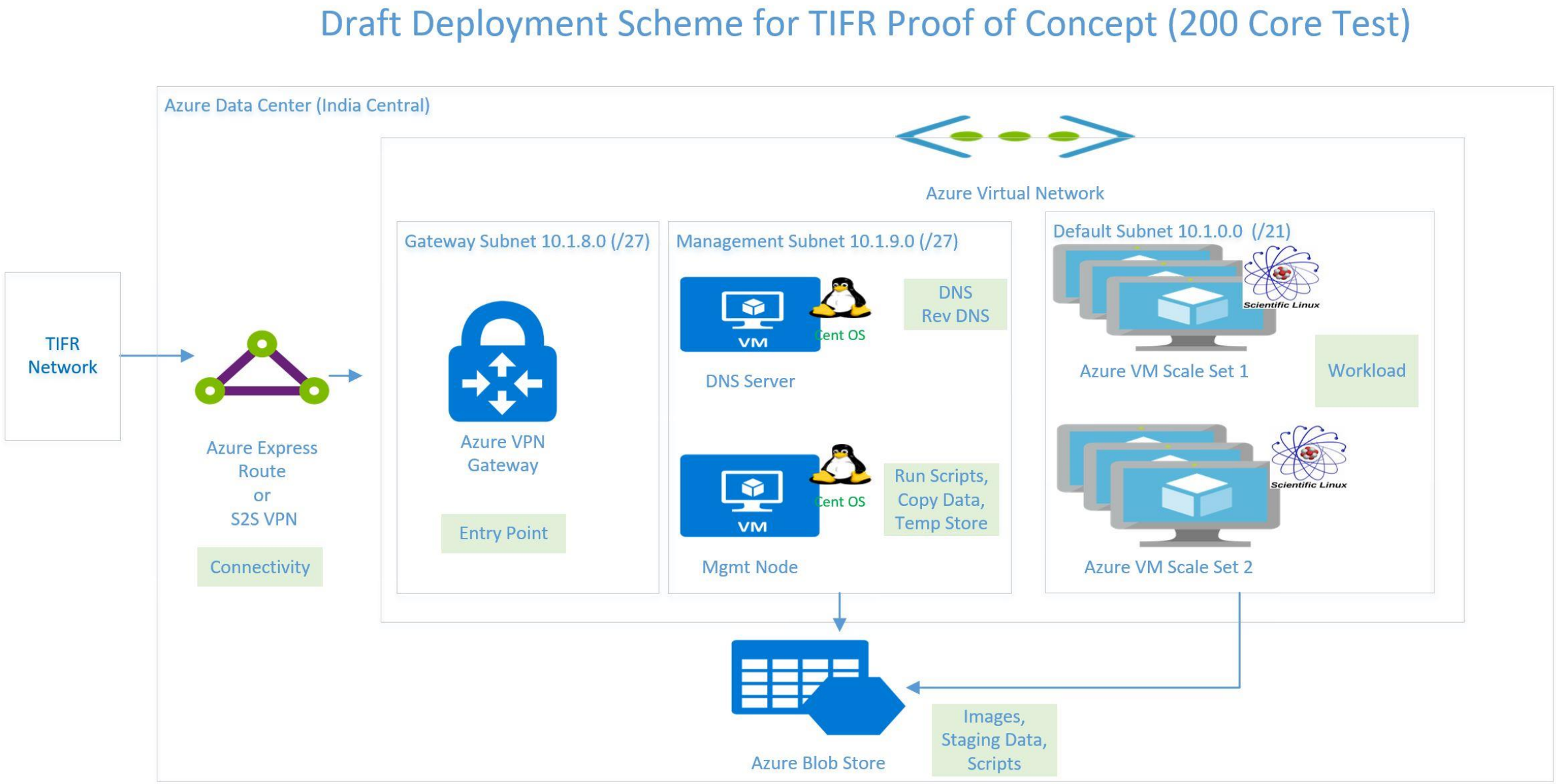
TIFR-HEP Cloud:

- Dynamic Resources for WLCG Commissioned in May-2017.
- Collaboration with Microsoft Azure: Azure infrastructure with Grant of USD $100,000/- in terms of resources.
- MS Cloud Datacentres, three in India (Mumbai, Chennai, Pune)
- Development of tools and technologies for interfacing WLCG Grid with Azure (Grid ASCII Helper Protocol and Condor Annex)
- Successfully processed 1 Billion Physics events in 30 days run.
- TIFR earned additional service credits from CMS
- Resources seamlessly integrated with WLCG
- **Adding 0 to 10K cores in global pool under 10 minutes.**

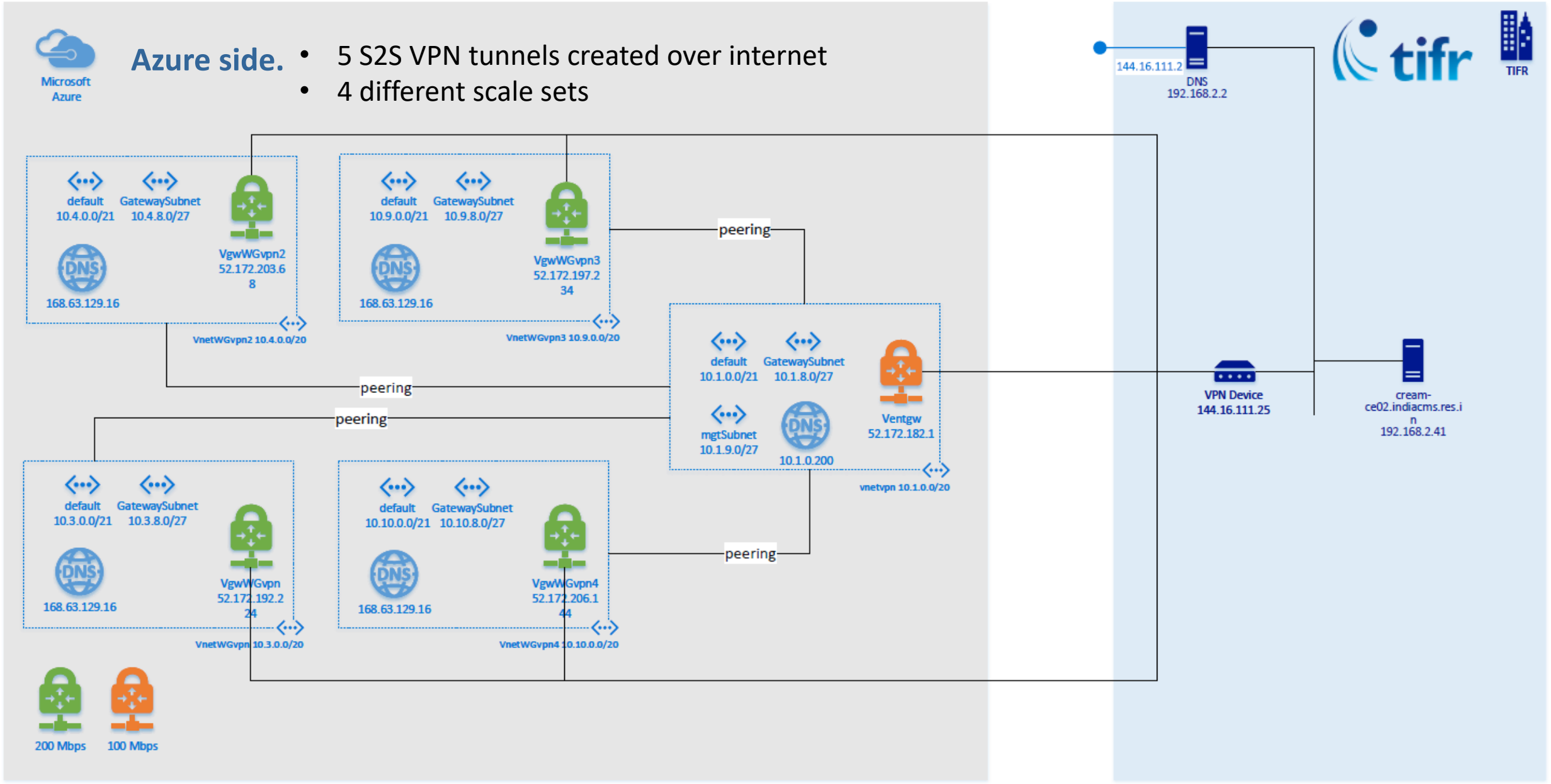
TIFR-HEP Cloud: (2016-2017)



TIFR-HEP Cloud:



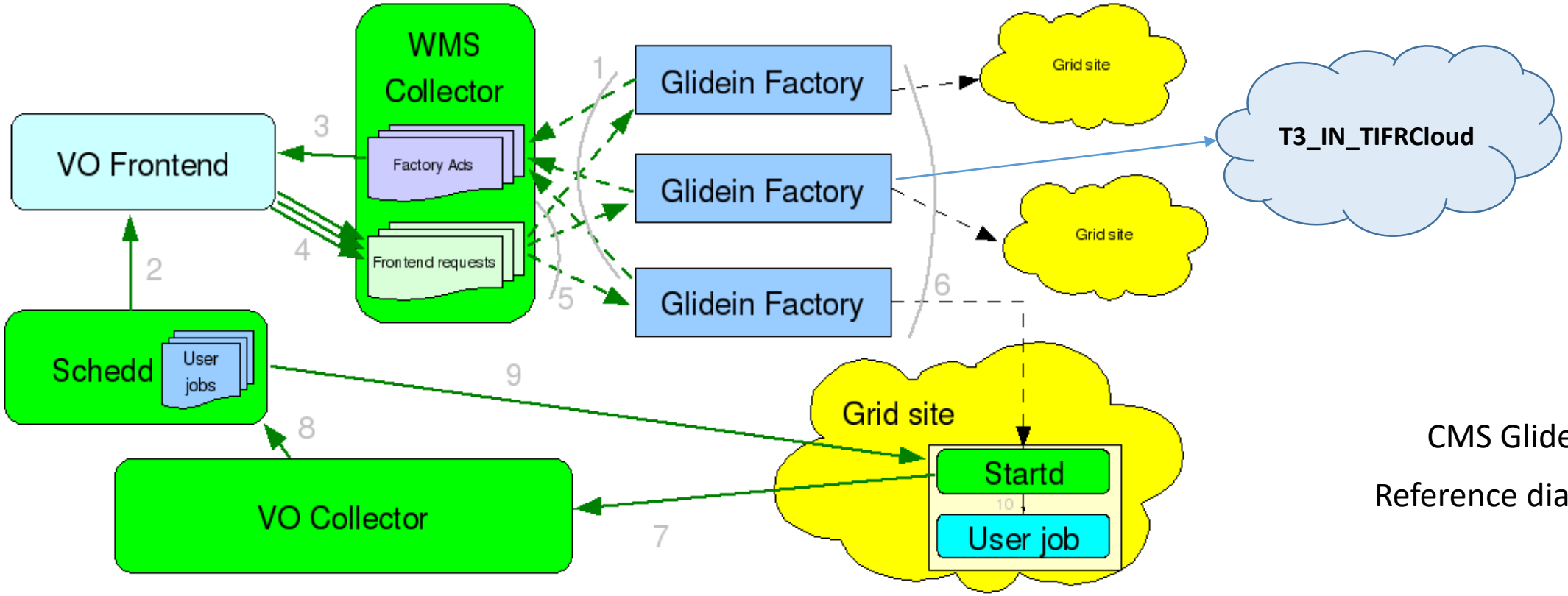
TIFR-HEP Cloud:



Integrating Azure resources in CMS Global pool

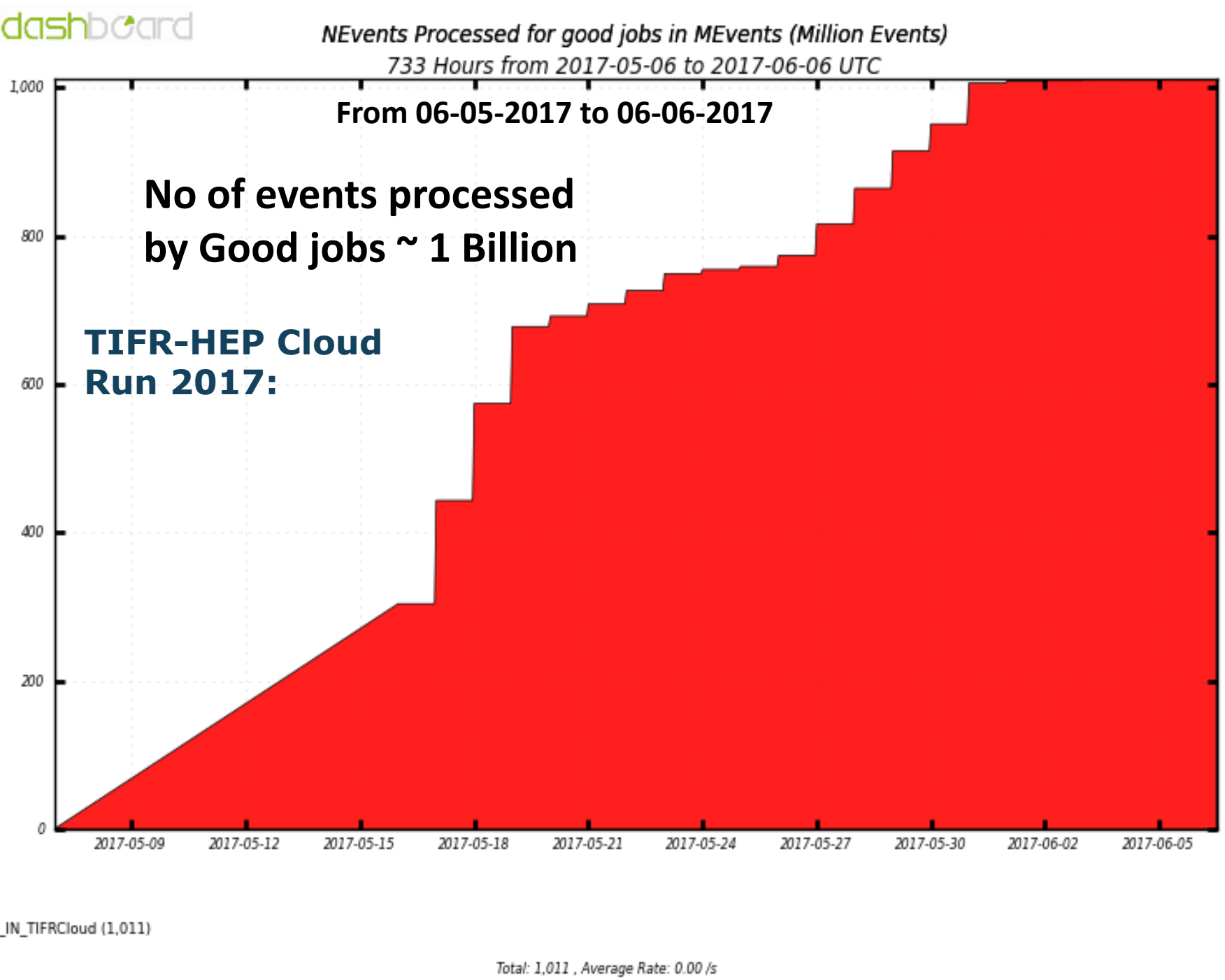
Objectives / Challenges.

- No pre-placement of data
- Diskless site, no cloud storage used
- Stage-in and stage-out directly via TIFR xrootd redirector to any CMS site.
- No special connectivity, communication over internet
- Auto-spinning of VMs based on load queue size
- Auto de-allocation of scale-setup based on queue and idle slots



CMS GlideInWMS entry

Reference diagram : USCMS

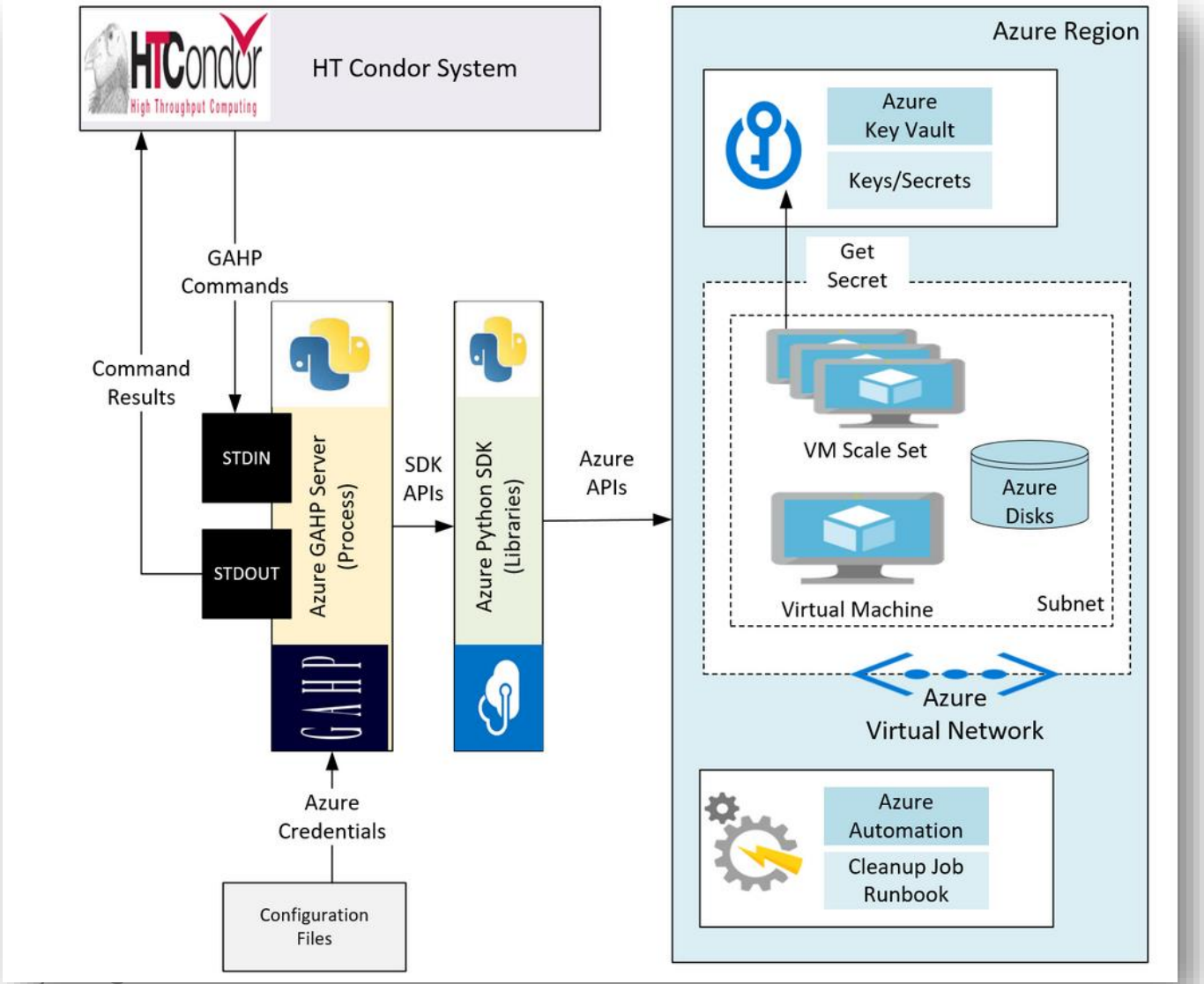

dashboard
NEvents Processed for good jobs in MEvents (Million Events)
733 Hours from 2017-05-06 to 2017-06-06 UTC
From 06-05-2017 to 06-06-2017
No of events processed
by Good jobs ~ 1 Billion
TIFR-HEP Cloud
Run 2017:
1,000
800
600
400
200
0
2017-05-09
2017-05-12
2017-05-15
2017-05-18
2017-05-21
2017-05-24
2017-05-27
2017-05-30
2017-06-02
2017-06-05
T3_IN_TIFRCloud (1,011)
Total: 1,011 , Average Rate: 0.00 /s

AZURE GRID ASCII HELPER PROTOCOL (GAHP)

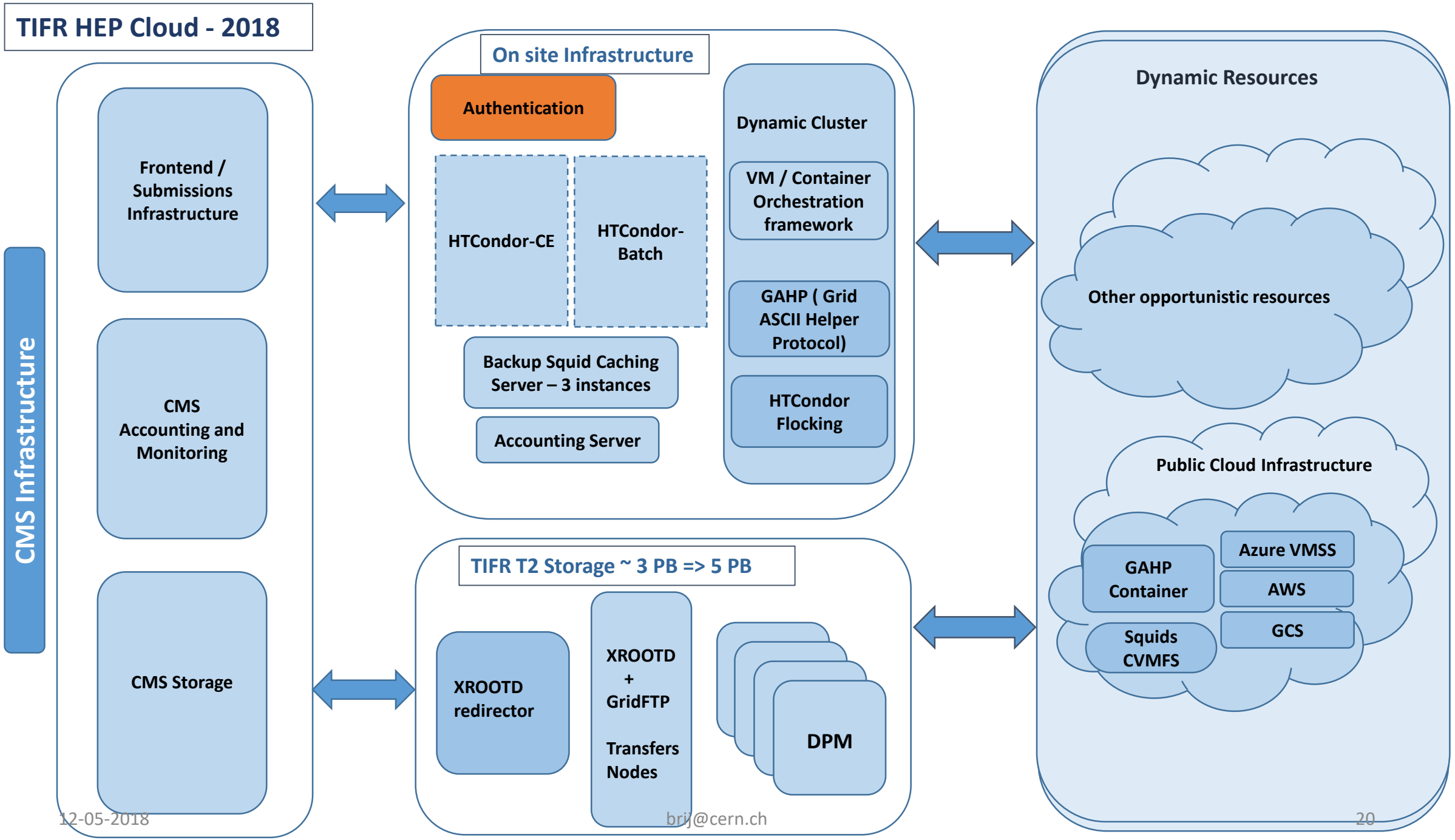
HT-condor team and Microsoft CAT

https://blogs.msdn.microsoft.com/azurecat/2017/09/12/azure-gahp-server-for-htcondor/

- Designed to handle both synchronous (blocking) and asynchronous (no blocking) calls.
- Features for high capacity users
- Integration with Azure scale set
- Security and encryption
- Auto-scaling features



TIFR HEP Cloud - 2018



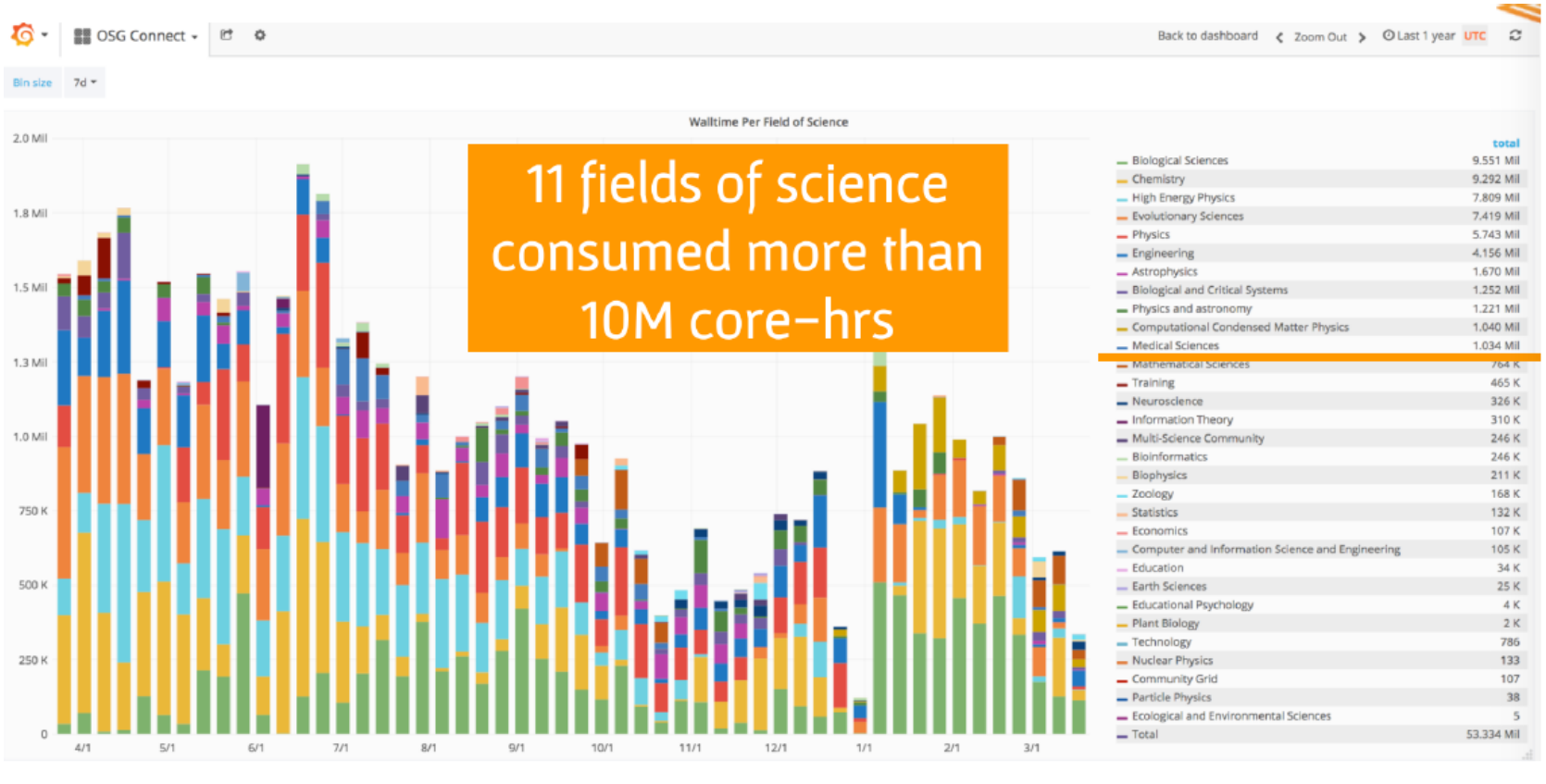
Future directions : TIFR-HEP Cloud expansion

- Joining international efforts like, Dynamic Clusters from INFN (Italy) and integration of Fermi HEP Cloud Decision engine (USA)
- Reaching out to other Indian research and education computing facilities, eg., NSM, IISER, NISER, IITs, IISC, CDAC.. Etc..
- Possibility for spanning HEP Cloud across Indian organizations.
- Automation in provisioning and management.
- Can all the research computing community of India come together?

Sharing Infrastructure:

US Open Science Grid: Shared Infrastructure:

30 VOs at 80 sites. More than 1,000,000 cpu hours are turned into scientific results



ESCAPE

European Science Cluster of Astronomy & Particle physics
ESFRI research infrastructures

ESFRI Science Projects

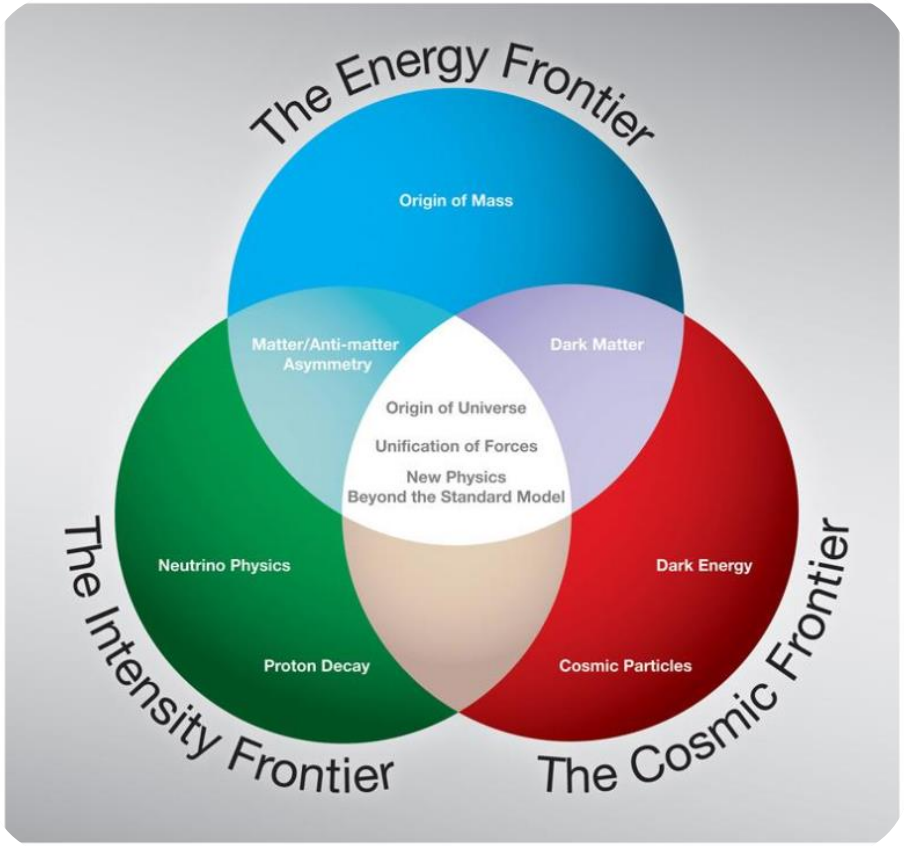
HL-LHC	SKA
FAIR	CTA
KM3Net	JIVE-ERIC
ELT	EST
EURO-VO	EGO-VIRGO
(LSST)	(CERN,ESO)

HEP Software foundation(since 2016)

HSF Vision and goal : http://hepsoftwarefoundation.org/

The HEP Software Foundation facilitates cooperation and common efforts in High Energy Physics software and computing internationally.

- **CWP (Community White Paper)**
  - ⇒ **Final Road Map Paper (https://arxiv.org/pdf/1712.06982.pdf)**
  - ⇒ **We are signatories from TIFR**
- **Description and inventory of community activities and projects**
- **Better cooperation between new projects.**



Ref: - CWP RoadMap Paper, European Strategy for Particle Physics & Particle Physics Project Prioritization Panel, US

Challenge areas and programme of work: branches where TIFR has already initiated efforts:

- **Software Trigger and Event Reconstruction**
  - Huge impact on detector physics:
  - Full software triggers
  - Exploiting new computing architectures, Vectrorization, Machine learning

- **Data Organisation, Management and Access**
  - Organization: Root
  - Management: Universal Catalogues.
  - Access: GridFTP => Xrootd, HTTPS
  - => Subfile granularity
  - => Data Lakes

- **Facilities and Distributed Computing**
  - Experience at TIFR
  - Dynamic resources
  - Software Defined Networks (SDNs)

Challenge areas and programme: branches where TIFR can put efforts in future

- **Physics Event Generators**
  - Development driven by theory community: LHAPDF, HepMC and Rivet
- **Detector Simulation**
  - Geant4 at the core = > Extensive efforts underway in GeantV
- **Data Analysis and Interpretation**
  - ROOT playing central role: main development from CERN. (Key: Time to Insight)
- **Machine Learning (applicable to all the areas)**
  - BDTs, NN used in HEP for long => Coordination with Industry and adoption of frameworks..
- **Data Processing Frameworks**
  - Scaffolding for algorithims (Gaudi, CMSSW)
- **Security**
  - **GSI X509 => SSO and Scientific Tokens**
- **Data, Software and Analysis Preservation for future**
  - Cross-community efforts (e.g., Research Data Alliance forum), CERN Analysis Preservation Portal
- Visualization:
  - Web-based graphics and GUI in root7 (WebGL) , VR_Based event visualization.

The Changing landscape of LHC Grid:

- **Future beyond Globus (Formed the basis of Grid)**

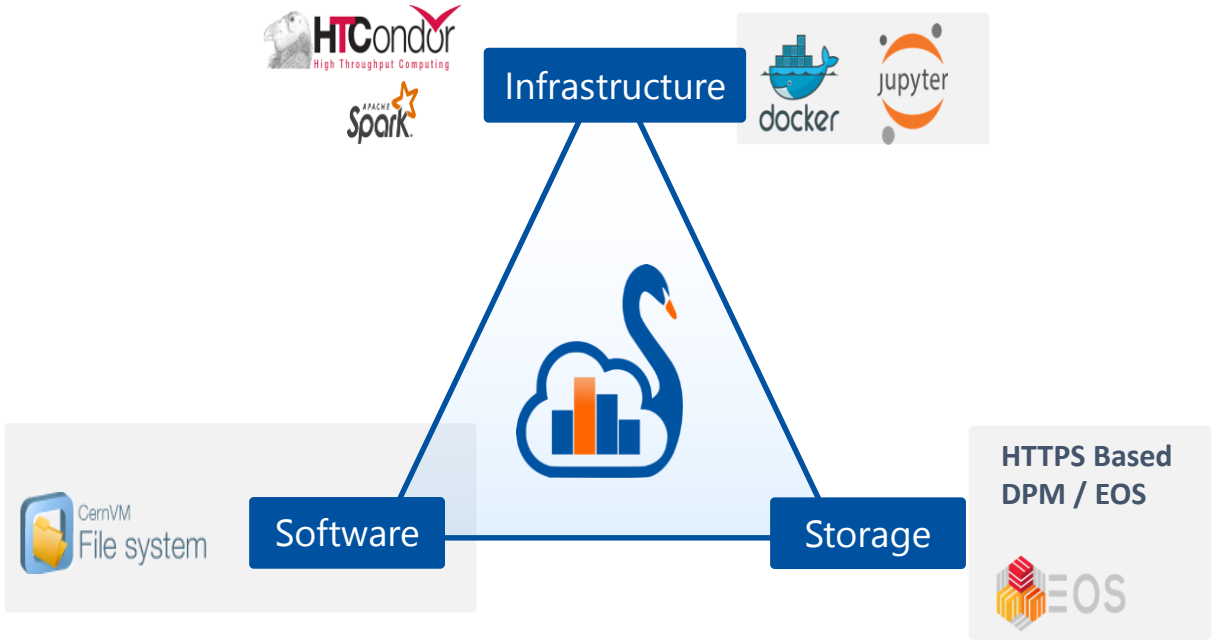
  - Official development and support ends end of this year
  - Community looking for and adopted some alternatives..
  - HTCondor as the core of computing pool of WLCG. (In production at TIFR since 2017)
  - Authentication: GSI .x509 => Token based authentication
  - Data transfer: GridFTP => HTTPS Based
  - Data Lakes and Named data networks. (NDNs)
  - Transfer system: Universal adoption of RUCIO by all the experiments.
  - Data caches (AAA & xrootd)

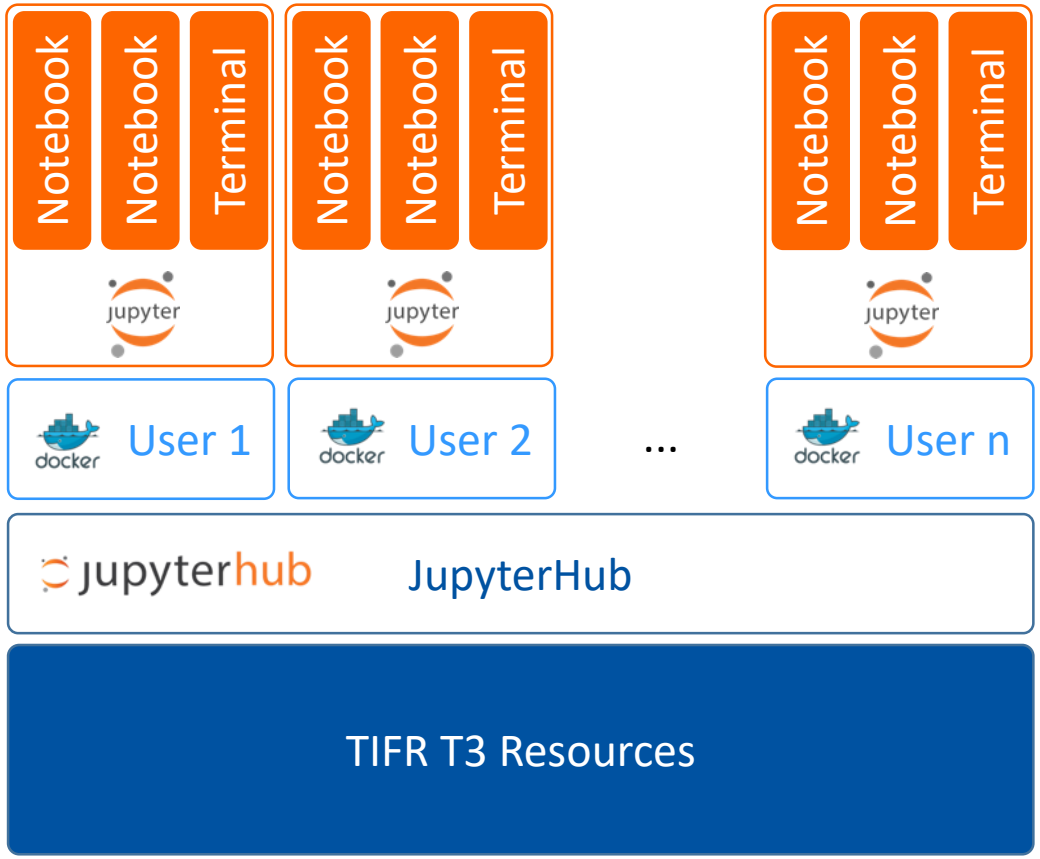
New Technologies being adopted at TIFR.

- New T3 environment and cluster with **JupiterHub** and HTTPs based access to data
- Completely automated orchestration with true un-attended installation and commissioning using **Puppet and Foreman.**
- Moving complete configuration templates and production files on **Git**
- **Docker**: Containerizing everything
- **Kubernetes cluster** for Docker management and virtualization
- **EOS** storage for T3.
- Completing **IPv6** transition

SWAN: Service for web based analysis (swan.indiacms.res.in)

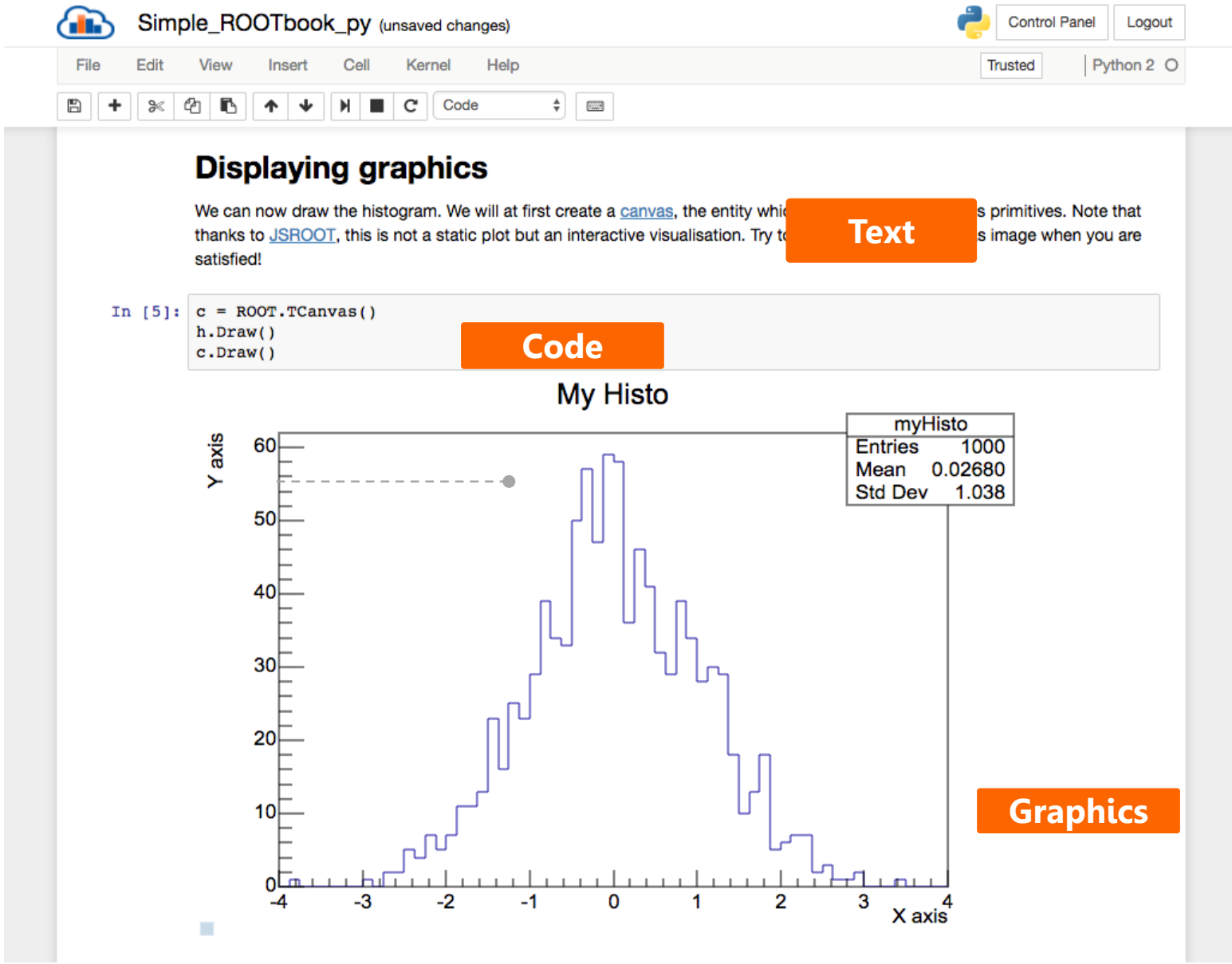
Under testing at TIFR: - Based on CERN SWAN (Boxed)



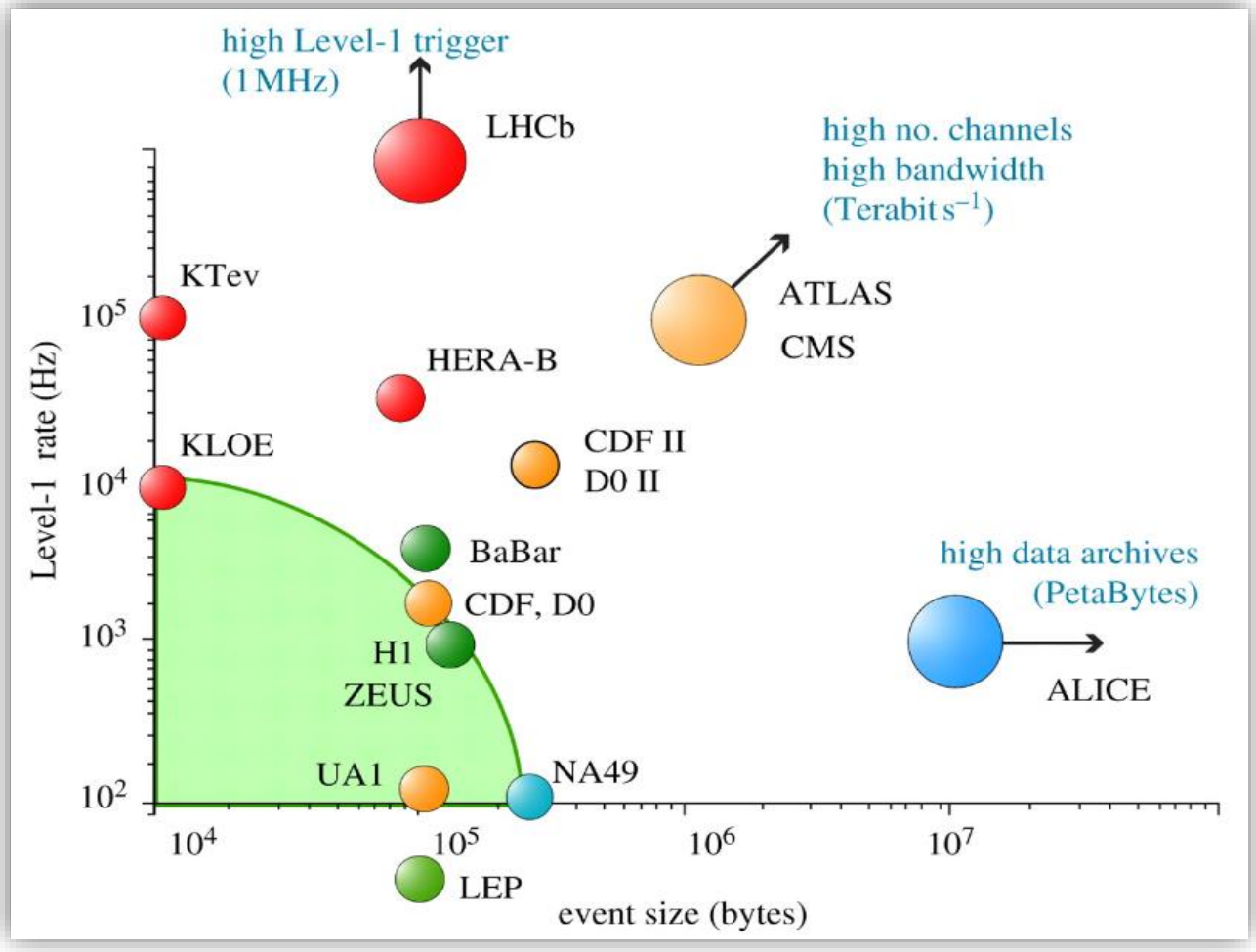


- Jupyterhub to allow multiple Jupyter instances
  - Single instance of Jupyter per user
- User sessions spawned as Docker containers
  - Enforces resource limits per user
  - To isolate users work

- Deployment and maintenance using local **Kubernetes** cluster
- Local instance at TIFR under testing.
- Data analysis only with a web browser
- Easy to use (but powerful): No local installation and configuration needed
- Collaborate and share scientific results (plots, data, code)



Software Trigger, Tracking and Reconstruction:



- Current Phase: Capacity building and exploration
- Understanding the existing code and environment
- Joining the global efforts in development.
- Interest areas.
  - Contributing code at HLT level.
  - Kalman filter implementations on new architectures.

Bilateral Collaborations:

- **TIFR-Caltech** Bilateral collaboration on joint operations and various R&D projects such as
  - Named Data Network / SANDIE
  - Dynamic Resources at Caltech

- **TIFR-ATCF** (Asia Tier Centre Forum) lead by KISTI, Korea
  - Improving network connectivity and building support community in Asia.

Industry collaboration:

- Collaboration with **Public Cloud** ISPs (**Microsoft,** Amazon, Google)
- **TIFR-Intel** collaboration under INTEL University program partnership
- Possible partnership with Indian Software industry and educational Institutes.

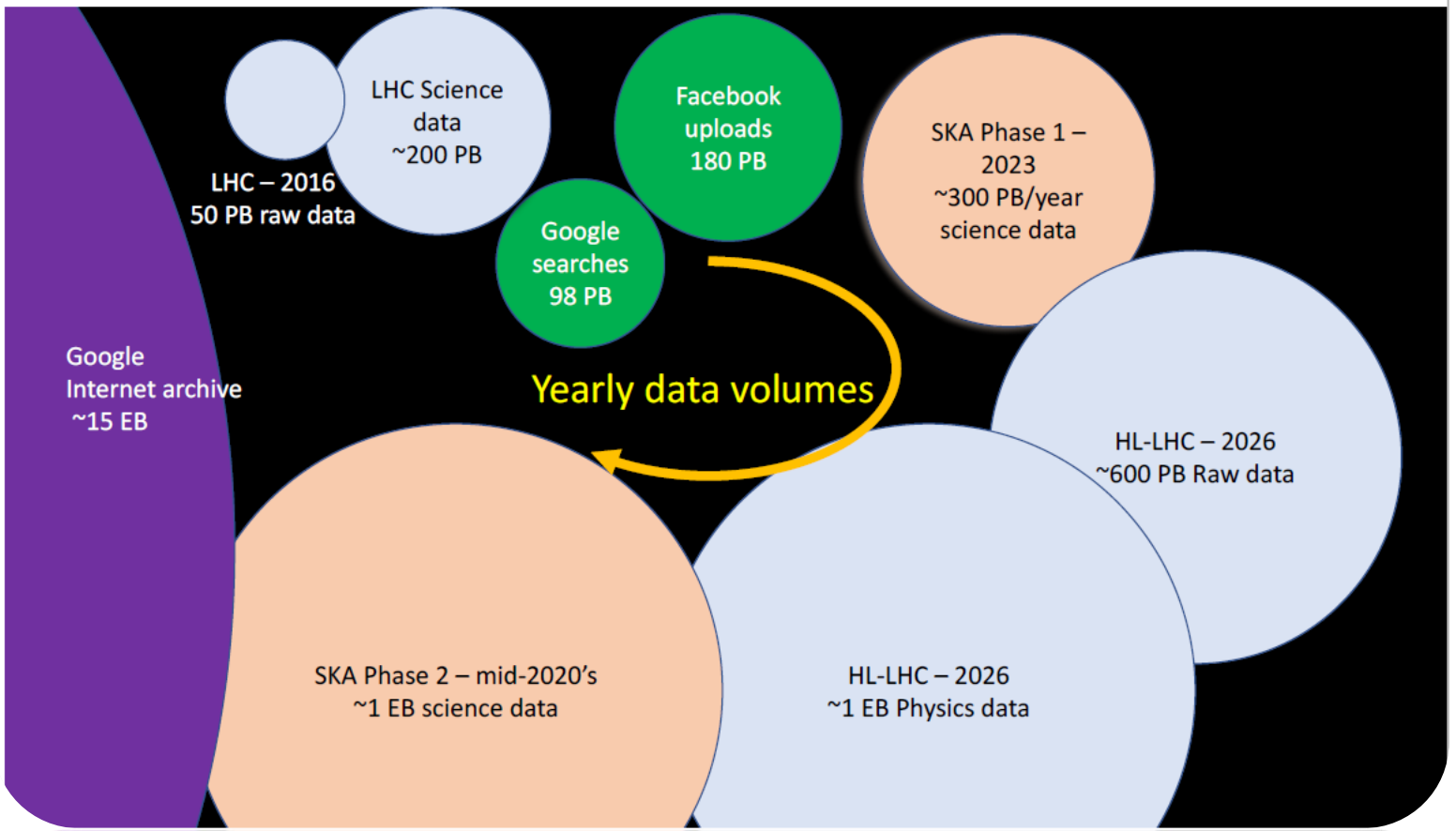
Grid Is evolving…..
Stay tuned…

LHC is the model for large scale international scientific collaboartive effort

Growing collaboration with Major data intensive sciences:

LHC, SKA, DUNE, LIGO, LSST, Climate data etc..

International Data Needs



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Thank you..