"Modello di calcolo di CTA e sinergie con le strutture di calcolo dell'INFN (CNAF)"

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Data Management

Objective:

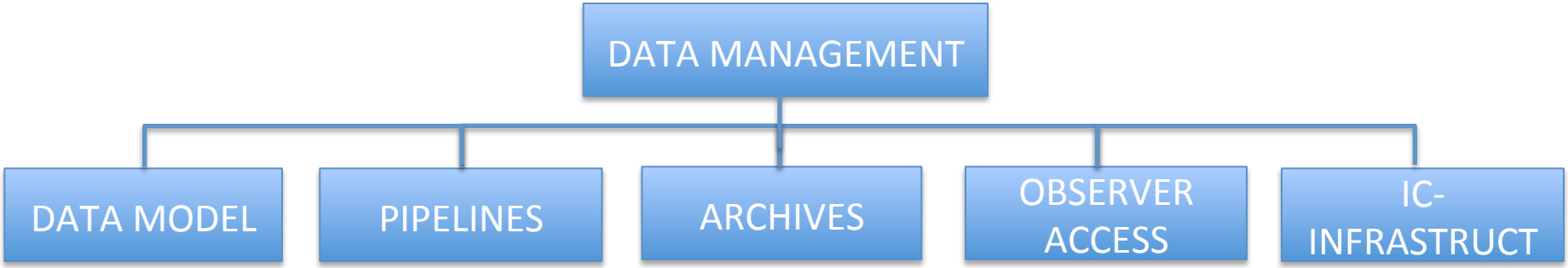
- Design CTA Data Center (data handling, reduction, MC, archive, data distribution)
- On-to off-sites network connection services
- Off-site software and middle-ware service for data distribution
- On-site data reduction, RTA, temporary archive, data quality monitoring

CTA Consortium (CTAC) vs CTA Observatory (CTAO)

- CTAC -> MC, design, physics, algorithms, data challenges and validation
- CTAO -> archive users, guest observers, advanced users

Data Management

- All levels of data model and format, and number of versions to be kept (DATA MODEL)
- Process data flow with associated input/output data (PIPELINES)
- Data access requirements (ARCHIVE), based on use cases
- Tools and support for Observatory data access (OBSERVER ACCESS)
- Off-site Information and Computing (IC) infrastructure: data processing center (s) and Internet Protocol (IP) communication lines.



Performances

- CTA Expected lifetime 30 years (deployment in 4 years), 1314 hours/y
- Data availability <2 months after observation
- 1 month to reprocess 1 year of data
- CTA sites connection able to transfer 1 night of first level rec events in 5 hours
- raw data transfer in less than 10 days
- reprocess 1 year of CTA data in 1 month

List of Data

Data Level	Short Name	Description	Data reduction factor
Level 0 (DL0)	RAW	Data from the Data Acquisition hardware/software.	
Level 1 (DL1)	CALIBRATED	Physical quantities measured in each separate camera: photons, arrival times, etc., and per-telescope parameters derived from those quantities.	1-0.2
Level 2 (DL2)	RECONSTRUCTED	Reconstructed shower parameters (per event, no longer per-telescope) such as energy, direction, particle ID, and related signal discrimination parameters.	10^{-1}
Level 3 (DL3)	REDUCED	Sets of selected (e.g. gamma-ray-candidate) events, along with associated instrumental response characterizations and any housekeeping (technical summary) data needed for science analysis.	10^{-2}
Level 4 (DL4)	SCIENCE	High Level binned data products like spectra, sky maps, or light curves.	10^{-3}
Level 5 (DL5)	OBSERVATORY	Legacy observatory data, such as CTA survey sky maps or the CTA source catalog.	10^{-5} - 10^{-3}

Data Volumes

Assumptions:

- waveform saved only for selected pixels, general information for all of remaining pixels (ev. size 15-40 kB)
- 10Mbytes/s of device monitoring and control data (100TB/year)
- Deployment schedule from 2017-2021: 10%, 30%, 50%, 70%
- Data volume reduction software ratio is 1 the first year, 2 the second year and 10 afterwards.

Data Volumes (2)

Assumptions:

- One full reprocessing per year (2 versions Archived)
- Monte-Carlo data volume is equivalent to the yearly cumulated data volume (Min 5PB, Max 20PB)
- Percentage of volume of reconstructed data and intermediate data is 10% of raw data (prior to any data volume reduction software): DL2, DL3-DL5 (Calibrated data are not archived)

Required storage

	Event Size	Data Access	Disk replicas of each version	Number of versions	Number of Tape Copy
Raw (DL0)	14000 to 41000 bytes depending on camera	Write once, low read rate	10% kept on disk (Tape cache is 10% of the global data volume)	1	1+1 (backup)
Calibrated (DL1)	20% to 100% of RAW prior to any data volume reduction		0	0	0
Reconstructed (DL2)	10% of RAW camera data prior to any data volume reduction	New version per year. Low read rate.	100% kept on disk for the last version, 0% for the old version	2	1+1 (backup for last version only)
Reduced (DL3)	1% of DL2	High read rate	1 (100%)	2	1+1 (backup)
Science (DL4)	0.1% of DL2	High read rate	1 (100%)	2	1+1 (backup)
Observatory (DL5)	0.1% of DL2	High read rate	1 (100%)	2	1+1 (backup)
MC Data	100% of Observation data (Min 5PB, Max 20PB)	Read/Write	100% during commissioning phase (3 years), 1PB afterwards	1	1+1 (backup)

Full independent backup must be provided for all raw data to restore data in case of lost or damaged data files

Data Volume Needs

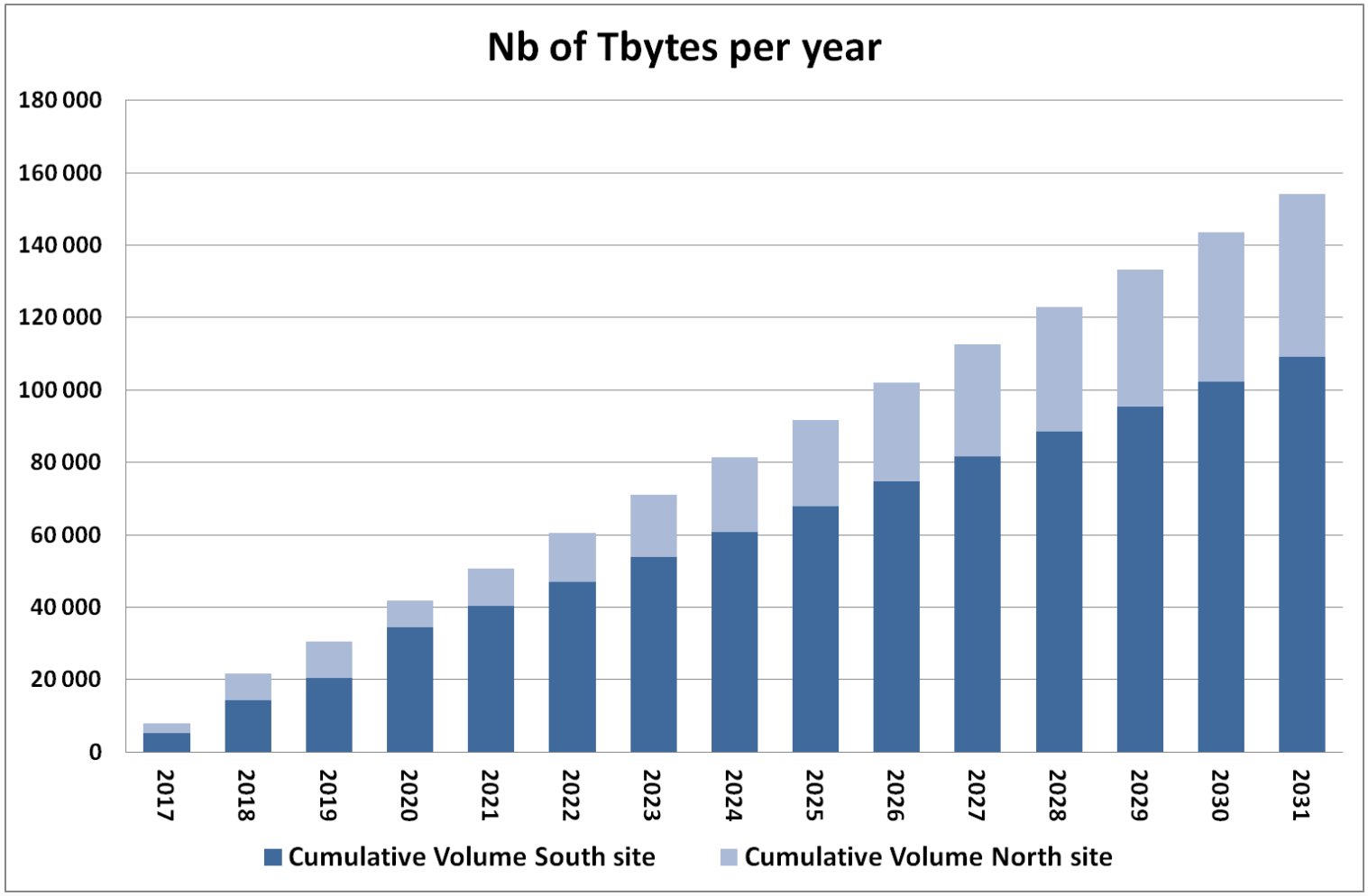
- Expected data rate (CTA fully deployed, reduction 1/10) ~ 3.6 PB/y (DL0)
- Products of reconstruction and analysis pipeline: DL2~3 PB/s and DL3+DL4+DL5=580 TB/y
- New version of data production per year, keeping the n-1 version: twice the DL2-DL5 volume every year ~ 7 PB/y
- 100 TB/y of technical data

+11 PB/y

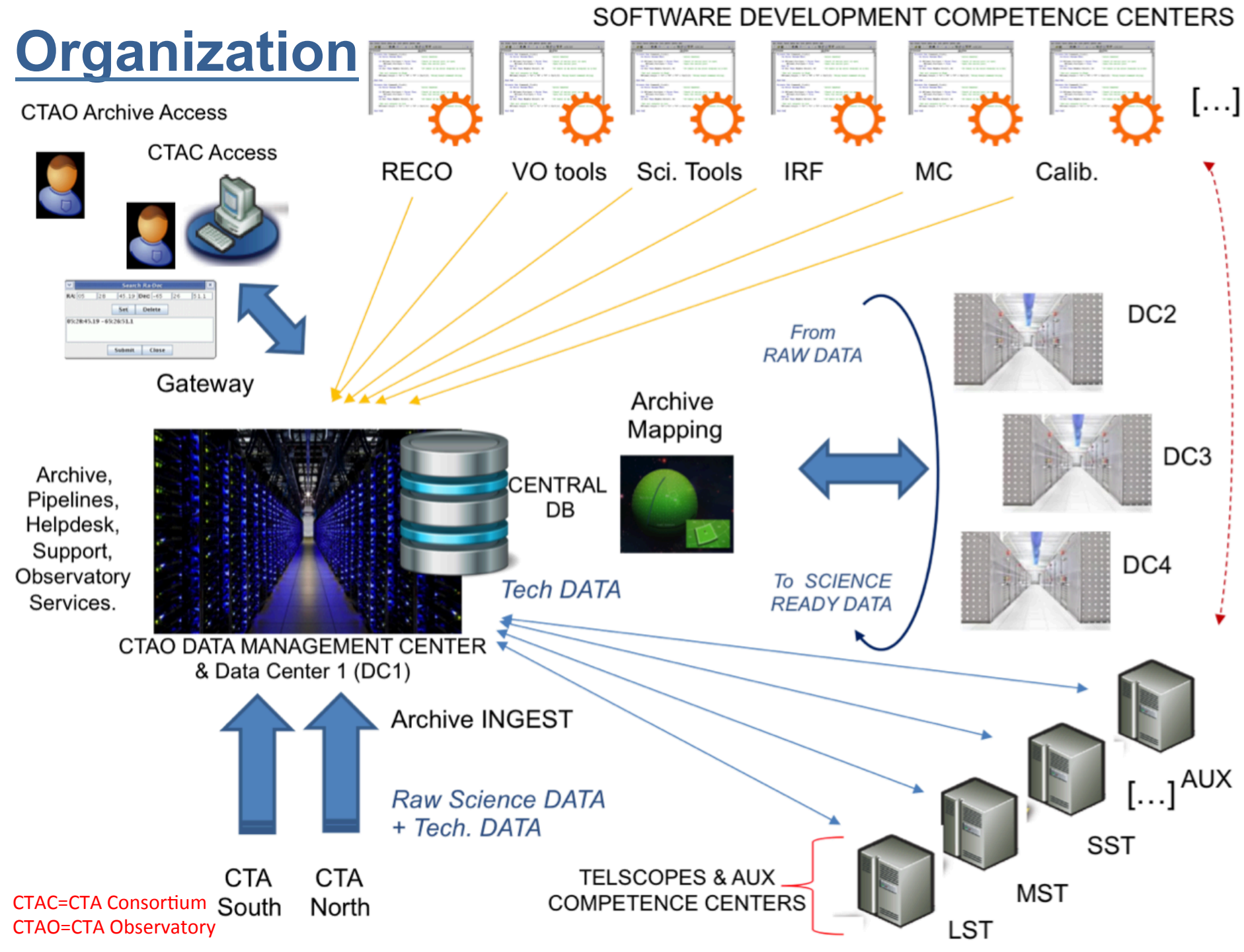
Year	2017	2018	2019	2020	2021
Cumulative raw data volume(PB)	3.6	9	11	13.5	17
Cumulative event data volume(PB)	4	11	16	23	32
Monte-Carlo data volume(PB)	5	11	16	20	20
Technical data volume(PB)	0.01	0.04	0.09	0.16	0.26
Cumulative Data (PB)	**9**	**22**	**31**	**43**	**52**

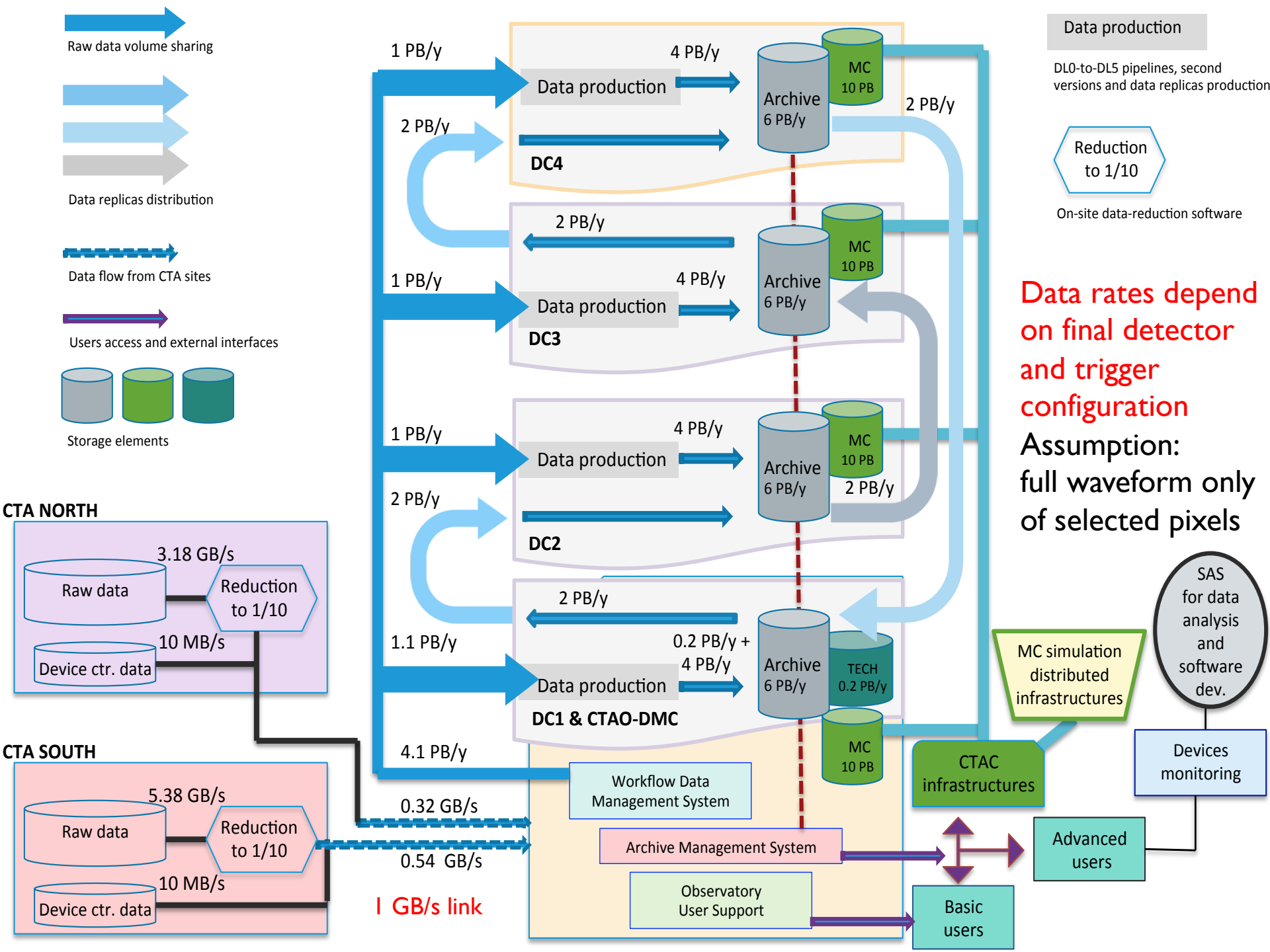
Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cumulative raw data volume(PB)	20	24	28	31	35	39	42	46	50	53
Cumulative event data volume(PB)	42	53	64	75	86	97	108	119	130	141
Monte-Carlo data volume(PB)	20	20	20	20	320	20	20	20	20	20
Technical data volume(PB)	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
Cumulative Data(PB)	**63**	**74**	**85**	**96**	**107**	**118**	**129**	**140**	**151**	**162**

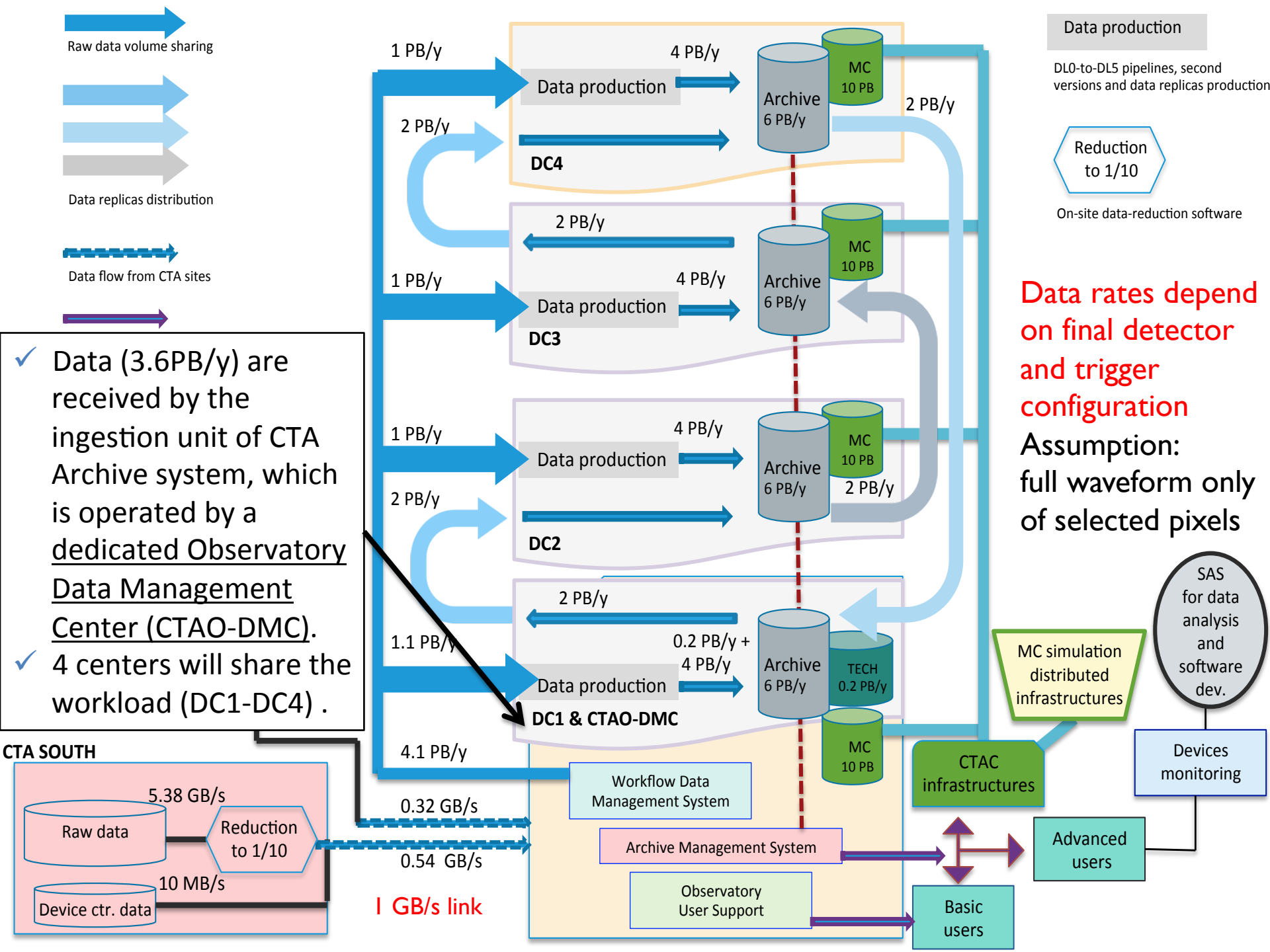
Cumulative Data Volumes



Organization




Raw data volume sharing
Data replicas distribution
Data flow from CTA sites
Users access and external interfaces
Storage elements
Data production
DL0-to-DL5 pipelines, second versions and data replicas production
Reduction to 1/10
On-site data-reduction software
1 PB/y
4 PB/y
Data production
Archive 6 PB/y
MC 10 PB
2 PB/y
DC4
DC3
DC2
1.1 PB/y
0.2 PB/y +
4 PB/y
DC1 & CTAO-DMC
TECH 0.2 PB/y
4.1 PB/y
Data rates depend on final detector and trigger configuration
Assumption: full waveform only of selected pixels
CTA NORTH
3.18 GB/s
Raw data
Reduction to 1/10
10 MB/s
Device ctr. data
CTA SOUTH
5.38 GB/s
0.32 GB/s
0.54 GB/s
1 GB/s link
Workflow Data Management System
Archive Management System
Observatory User Support
MC simulation distributed infrastructures
SAS for data analysis and software dev.
CTAC infrastructures
Devices monitoring
Advanced users
Basic users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1.1 PB/y
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Data rates depend on final detector and trigger configuration
Assumption: full waveform only of selected pixels
✓ Data (3.6PB/y) are received by the ingestion unit of CTA Archive system, which is operated by a dedicated Observatory Data Management Center (CTAO-DMC).
✓ 4 centers will share the workload (DC1-DC4) .
CTA SOUTH
5.38 GB/s
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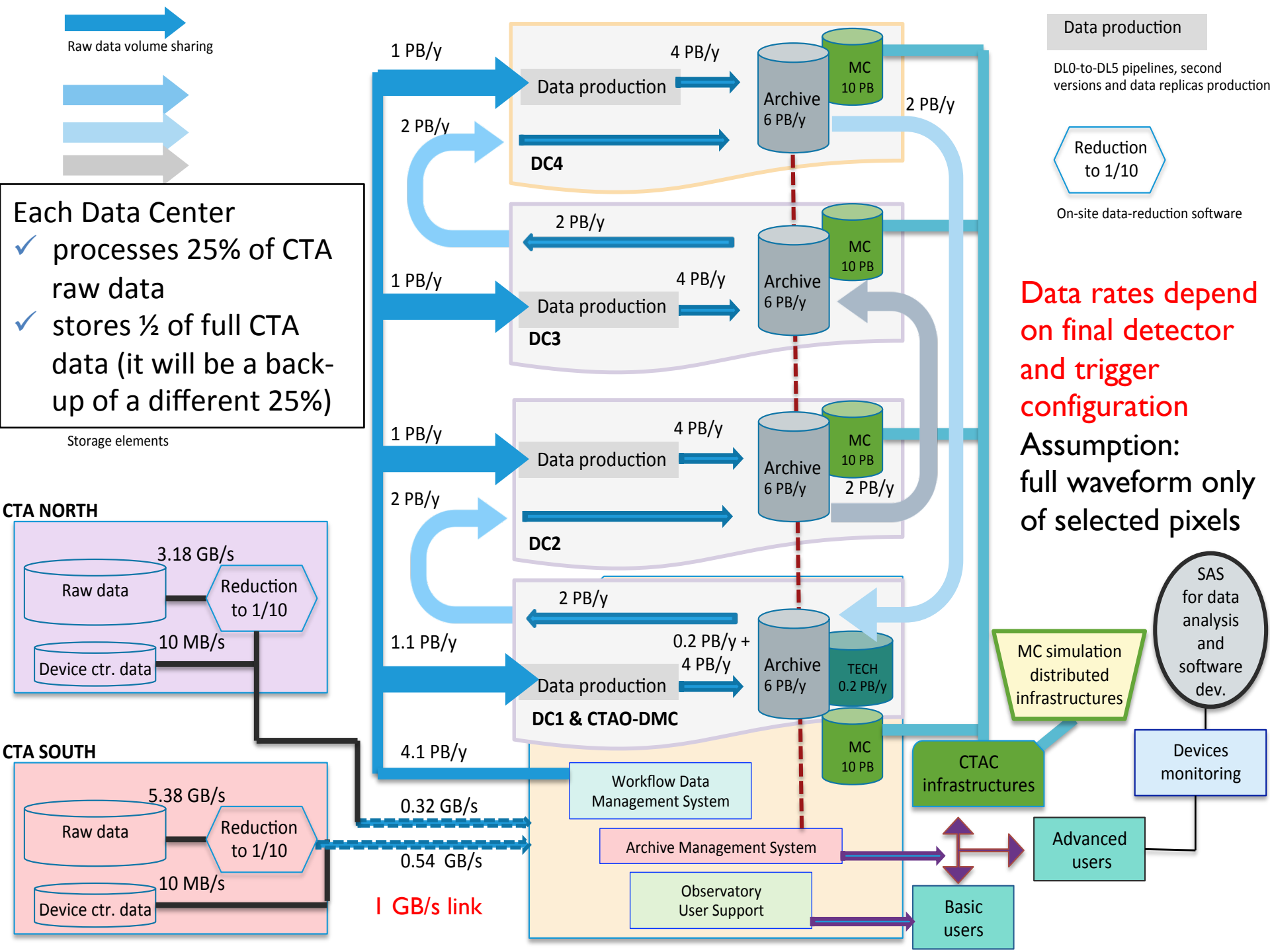
Raw data volume sharing
Each Data Center
✓ processes 25% of CTA raw data
✓ stores ½ of full CTA data (it will be a back-up of a different 25%)
Storage elements
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3.18 GB/s
Raw data
Reduction to 1/10
10 MB/s
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CTA SOUTH
5.38 GB/s
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Data production
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Data production
DC1 & CTAO-DMC
4 PB/y
4 PB/y
4 PB/y
0.2 PB/y + 4 PB/y
Archive 6 PB/y
MC 10 PB
Archive 6 PB/y
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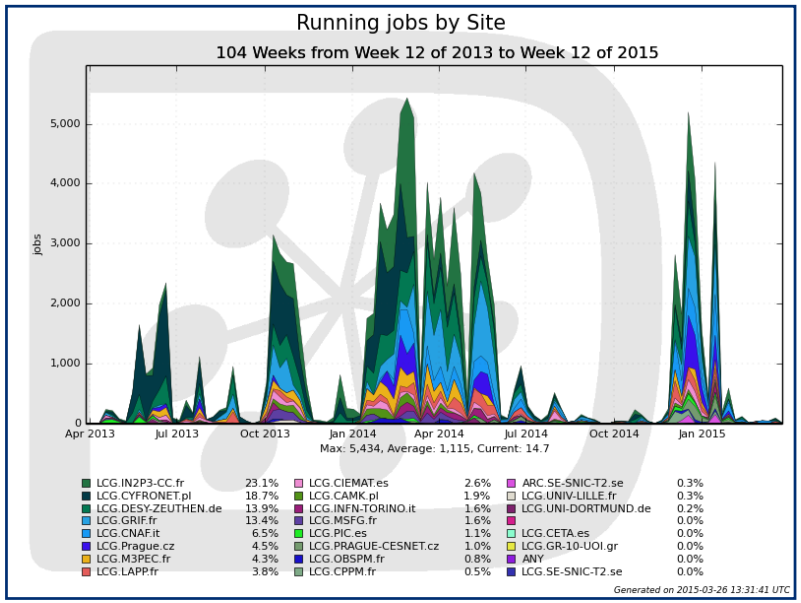
Computing Resources 2014-2015

- **About 20 centres** currently support the CTA VO. They are classified as:
  - ***Production centres*** if they provide CPU only **-> *used for MC production***
  - ***Analysis centres*** if they provide both CPU and storage resources **–> *used for MC production and Data Analysis***

CPU usage by Centre

- **Total used 2014: 94 M HS06**
- **87% CPU for MC production**
- **13% CPU for Users Analysis (7 active users)**
- **(2.6 M executed jobs in 2014)**
- **Total pledged 2015: 143 M HS06**

50% FRANCE; 20% POLAND; 14% GERMANY
8% ITALY; 4% SPAIN; etc.

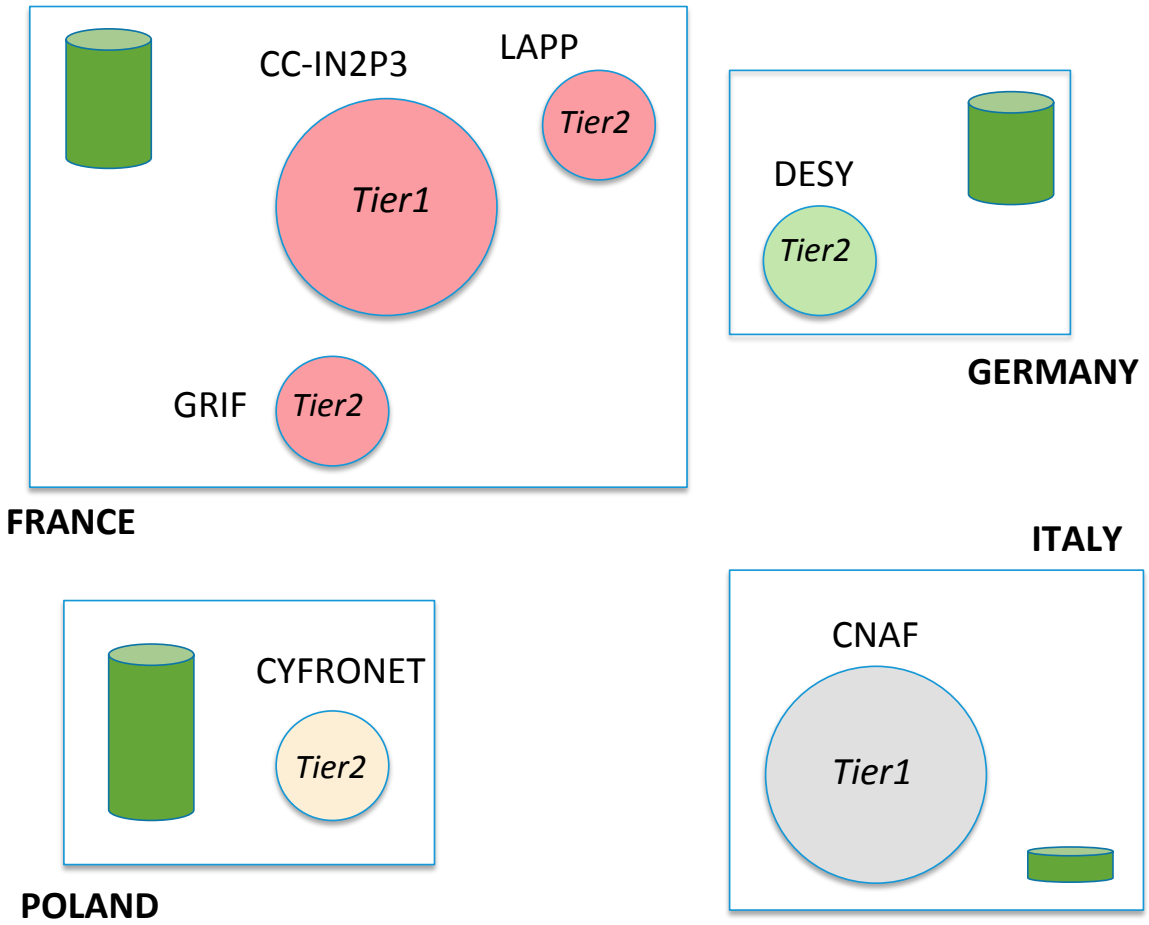


Storage resources at 6 Analysis Centres

- **Total pledged 2015: 1.4 PB**
- **About 400 TB more disk than in 2014**

Centre	Allocated Disk 2014 (TB)	Pledged Disk 2015 (TB)	Used Disk (TB)
CYFRONET-LCG2 (**PL**)	448	600	206
DESY-ZN (**DE**)	336	336	204
IN2P3-CC (**FR**)	190	270	98
GRIF (**FR**)	50	120	61
IN2P3-LAPP (**FR**)	60	100	51
INFN-T1 (**IT**)	30	110	15
Total	**1004**	**1426**	**635**

Current (MC) federated archive



Computing Resources for 2015 @ CNAF

- 3500 HS06
- 140 TB on disk (30 TB in 2014, larger available disk space will allow the CNAF site to be more and more involved in the production activities)
- 120 TB on tape (as in 2014)

Conclusions

- CTA Data model is going to defined. Final design with the first detector prototype
- Pipelines for Data and MC processing are under optimization (test on GPU for Real Time Analysis)
- Archive Structure almost defined based on data level structure

Conclusions

- INFN is supporting CTA activities since Jan 2014
  - ✓ 4th country in terms of cpu and 6th in terms of disk space
- INFN contribution will increase in the next calibration campaign (Prod3) due to the additional resources pledged in 2015
  - ✓ Total cpu: 3500 HS06
  - ✓ Total disk space: 140 TB
- CNAF could be one of DC network for CTA data processing