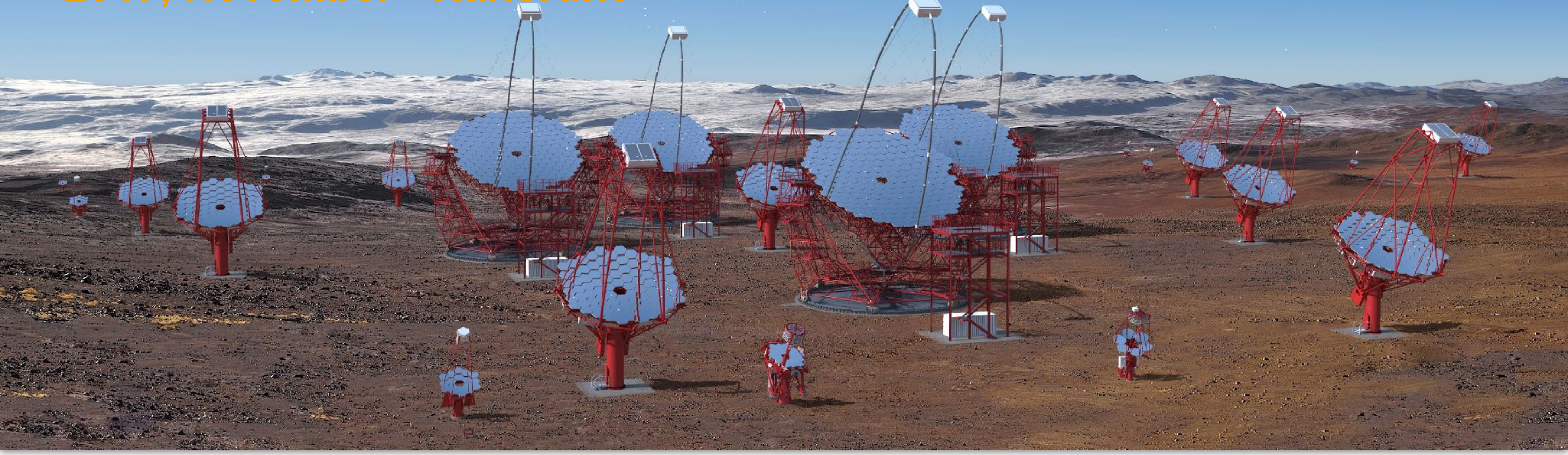
The Cherenkov Telescope Array

Computing and Data Handling - status and plans

Initiative for a Data and Analysis Centre for Astroparticle Physics

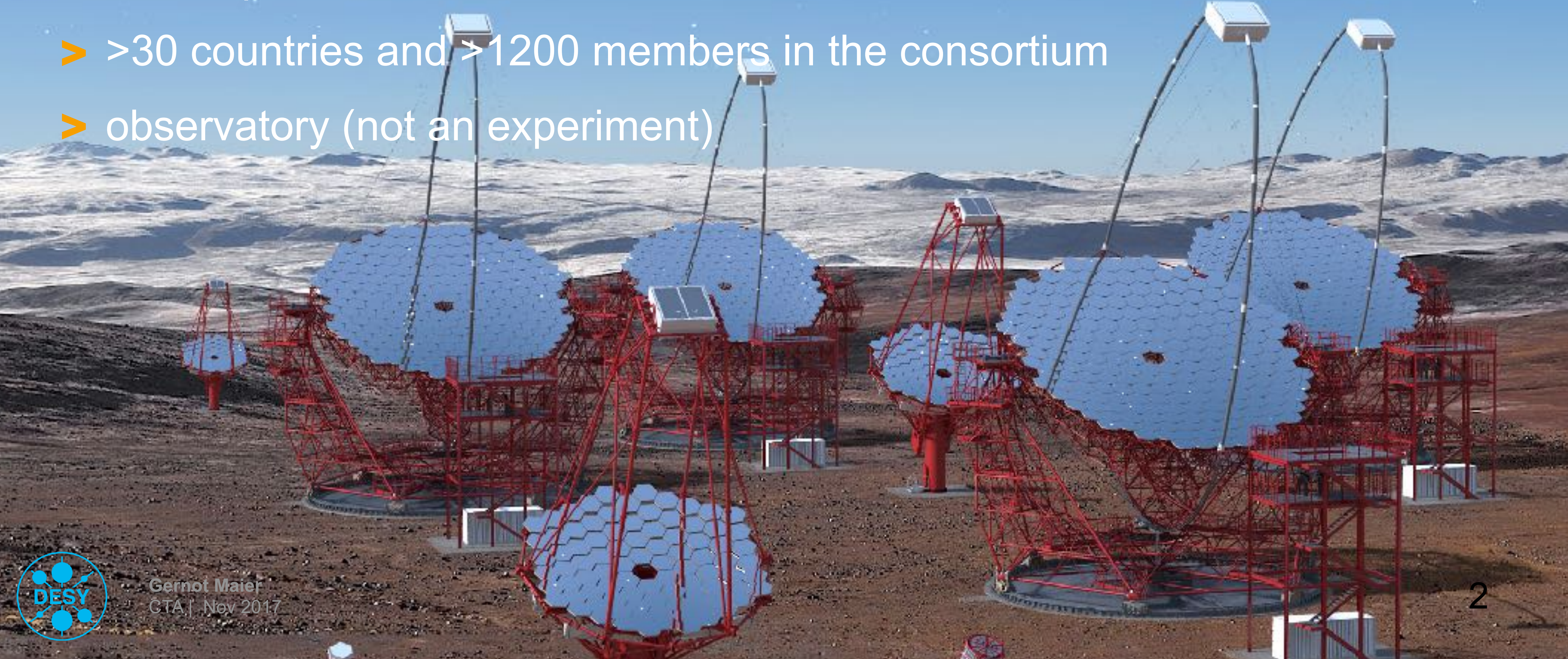
2017, November - Karlsruhe



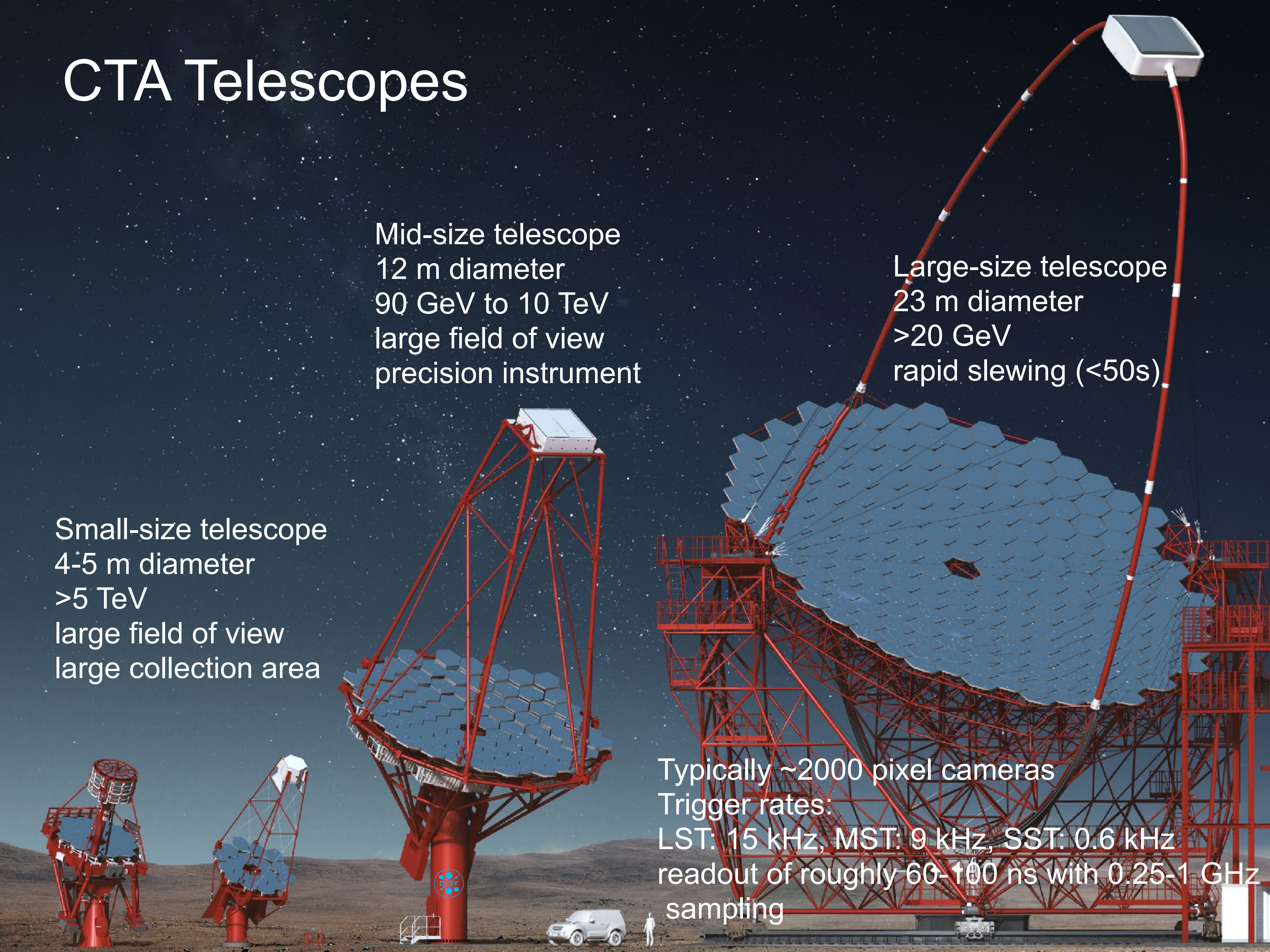
Gernot Maier

The Cherenkov Telescope Array (CTA)

- next-generation gamma-ray observatory
  - order of magnitude increased sensitivity, significantly improved angular and energy resolution, broadened energy range, increased field of view
- Two observatories:
  South (Chile) with 99 telescopes and North (La Palma) with 19 telescopes
- >30 countries and >1200 members in the consortium
- observatory (not an experiment)



CTA Telescopes



Mid-size telescope
12 m diameter
90 GeV to 10 TeV
large field of view
precision instrument

Large-size telescope
23 m diameter
>20 GeV
rapid slewing (<50s)

Small-size telescope
4-5 m diameter
>5 TeV
large field of view
large collection area

Typically ~2000 pixel cameras
Trigger rates:
LST: 15 kHz, MST: 9 kHz, SST: 0.6 kHz
readout of roughly 60-100 ns with 0.25-1 GHz sampling

Prototypes

Prototype of a CTA mid-size telescope
Berlin Adlershof

Dual-mirror mid-size telescope
(Arizona)

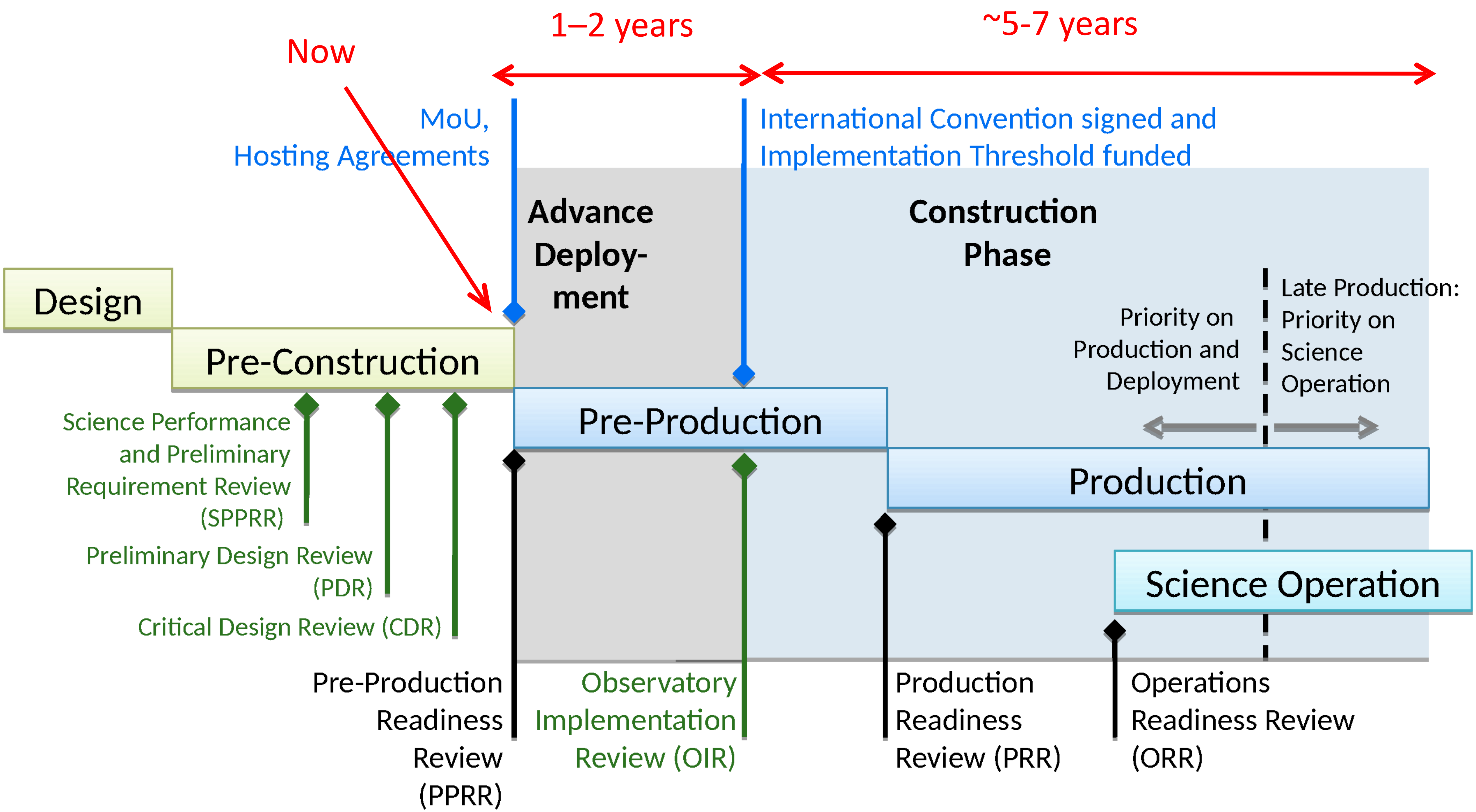
Small-size telescope
(Meudon)

Small-size telescope
(Krakow)

Small-size telescope
(Sicily)

CTA Timeline

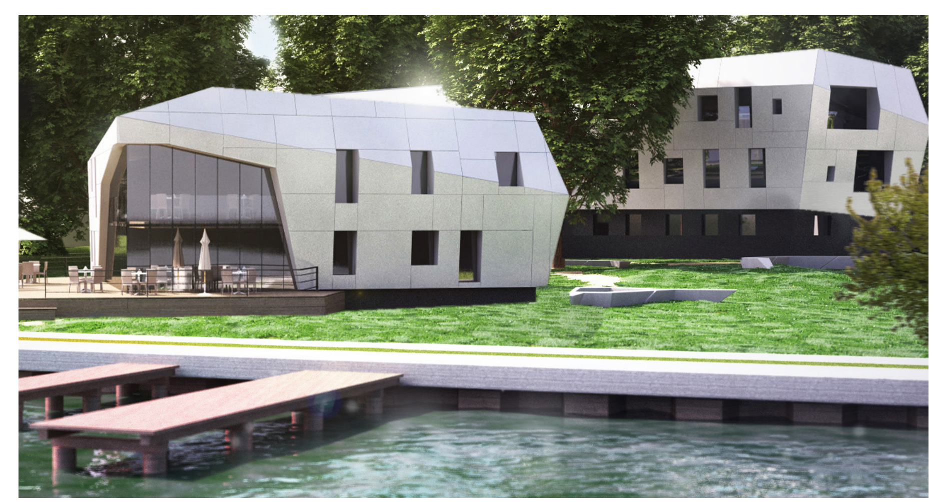
Release of official CTA Integrated Project Schedule in summer 2017



The CTA Observatory

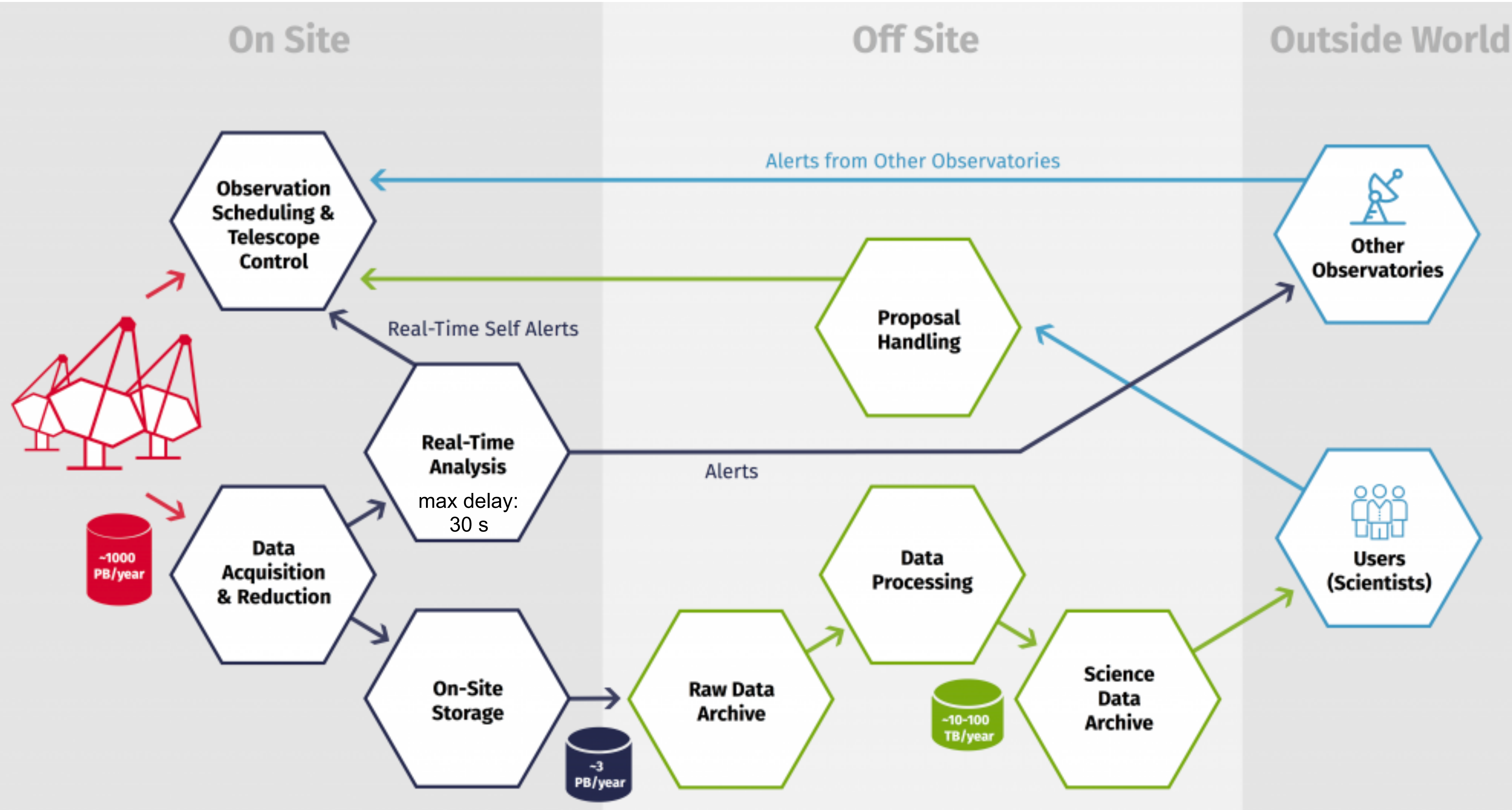
- legal entity that will operate the instrument during 30 years
- announcement of opportunity for observation proposal collection
- responsible for science user support
  - science tools (images, spectra, light curves, …)
  - high-level science data (event data plus instrument response functions and technical data)
- operates outreach gateway
- different categories of users
  - guest observers, consortium, observatory users
- all data will be public after predefined proprietary period
  - archive will ensure data access in line
  - open data formats
- Virtual Observatory compatibility

CTA Headquarters Bologna



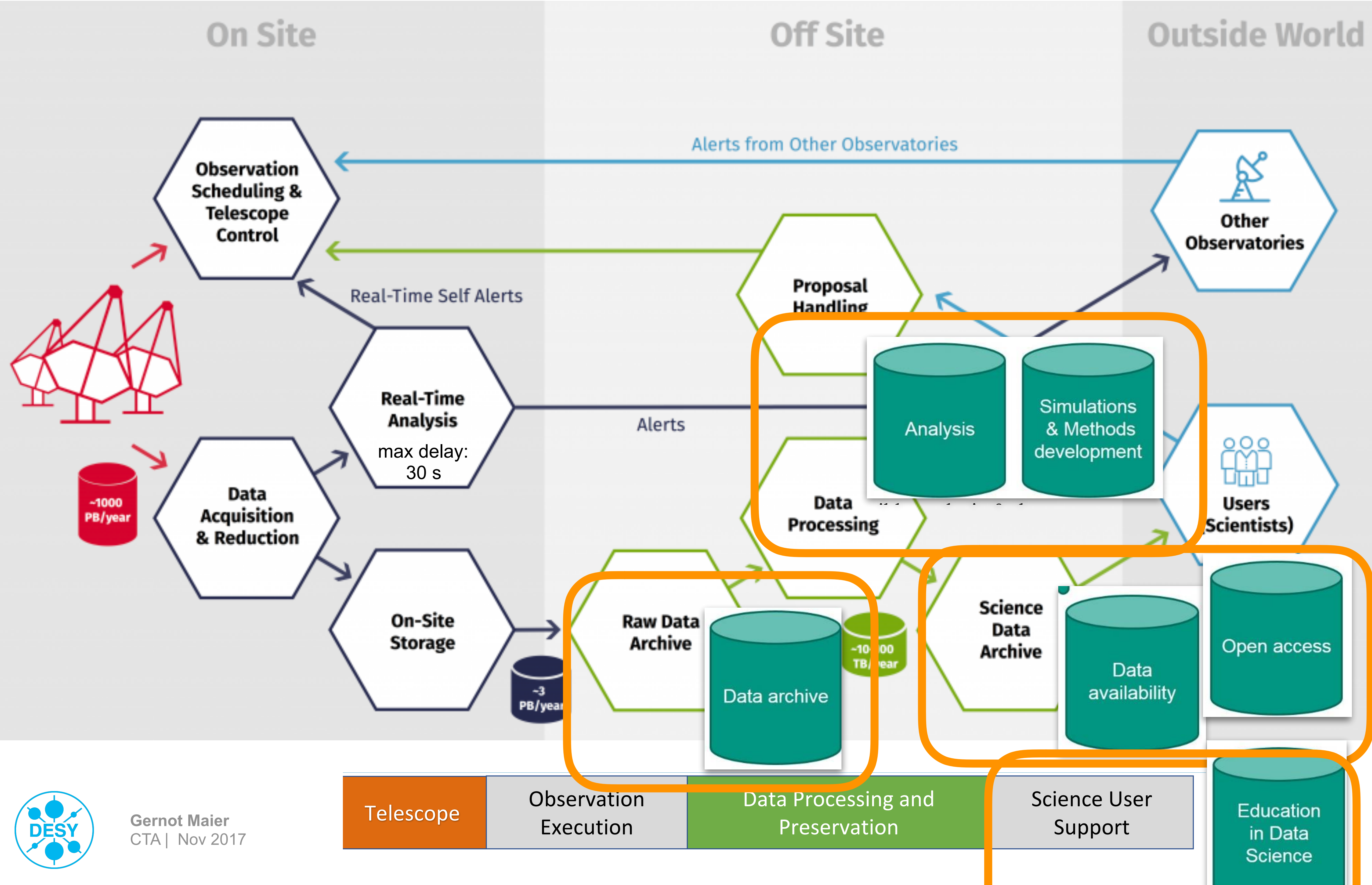
CTA Science Data Management Center Zeuthen

CTA Observatory: Operations, Processing, Users



Telescope	Observation Execution	Data Processing and Preservation	Science User Support

CTA Observatory: Operations, Processing, Users



CTA Data Rates - example Southern site

"massive computing in the desert"

Telescope	Data rate	Data rate (Central Trigger)
LST	110Gb/s	40Gb/s
MST	450Gb/s	150Gb/s
SST	60Gb/s	30Gb/s
Total	610Gb/s	220Gb/s

Central Trigger

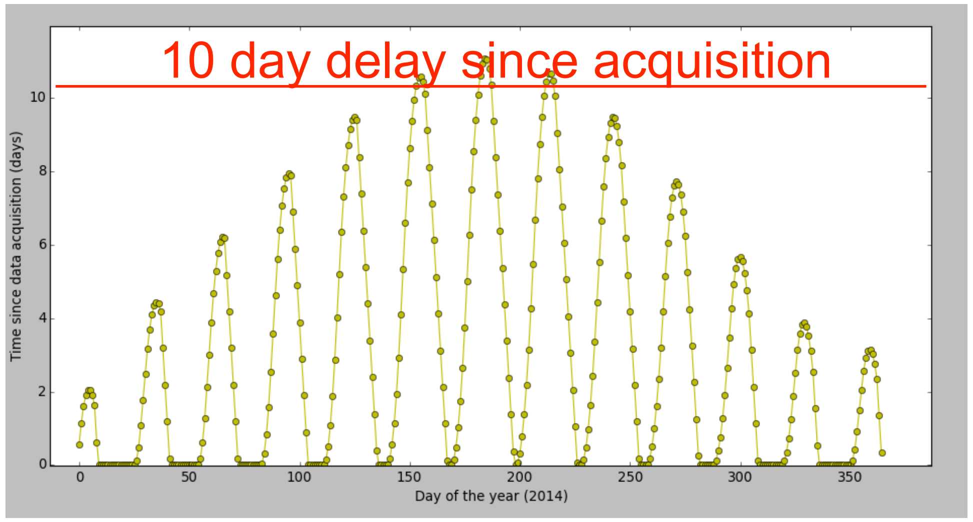
Full waveform signal from photodetectors (Total 1314h):
130 PB/year

Zero suppression, trace integration: 36 Gb/s (21 PB/year)

- Resulting data rates (assuming 1300 h of observing per year):
  - CTA South: 5.4 Gb/s
  - CTA North: 3.2 Gb/s

⇒ 40 PB/year (max 370 TB/day)

- Constrains
  - limited overall and network bandwidth of 1GB/s
  - transfer data in less than 10 days
- **Challenge: compression / event selection**



Daily data transfer duration/ Day of the year

⇒ 4 PB/year (max 370 TB/day)

CTA Data Rates - example Southern site

"massive computing in the desert"

Telescope	Data rate	Data rate (Central Trigger)
LST	110Gb/s	40Gb/s
MST	450Gb/s	150Gb/s
SST	60Gb/s	30Gb/s
Total	610Gb/s	220Gb/s

Central Trigger

Full waveform signal m photodetectors (Tota 314h):
130 PB/year

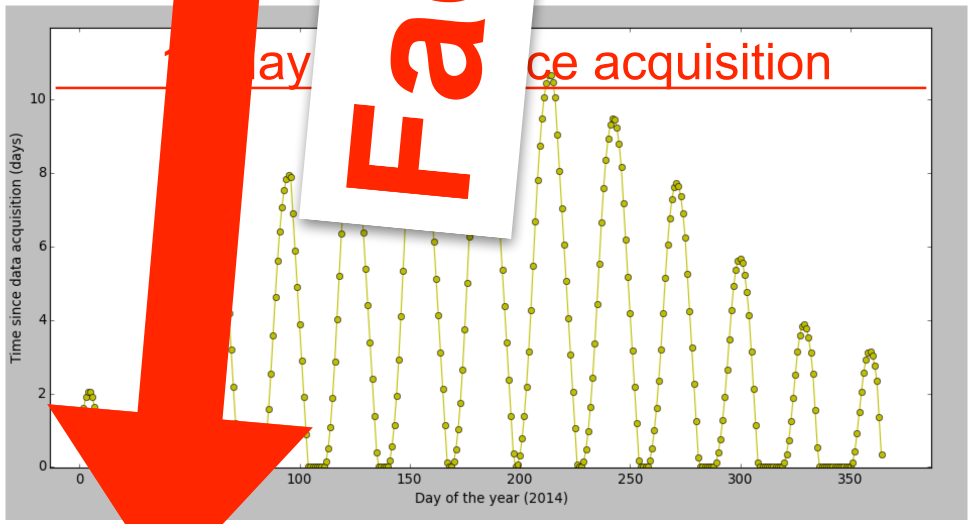
Zero suppression rac ration:
36 Gb/s (21 PB/y)

Factor 70

- Resulting data rates (assuming 1300 h of observing er
  - CTA South: 5.4 Gb/s
  - CTA North: 3.2 Gb/s

⇒ 40 PB/year (max 37 TE

- Constrains
  - limited overall and network bandwidth of 1GB/s
  - transfer data in less than 10 days
- **Challenge: compression / event selection**



Daily ata transfer duration/ Day of the year

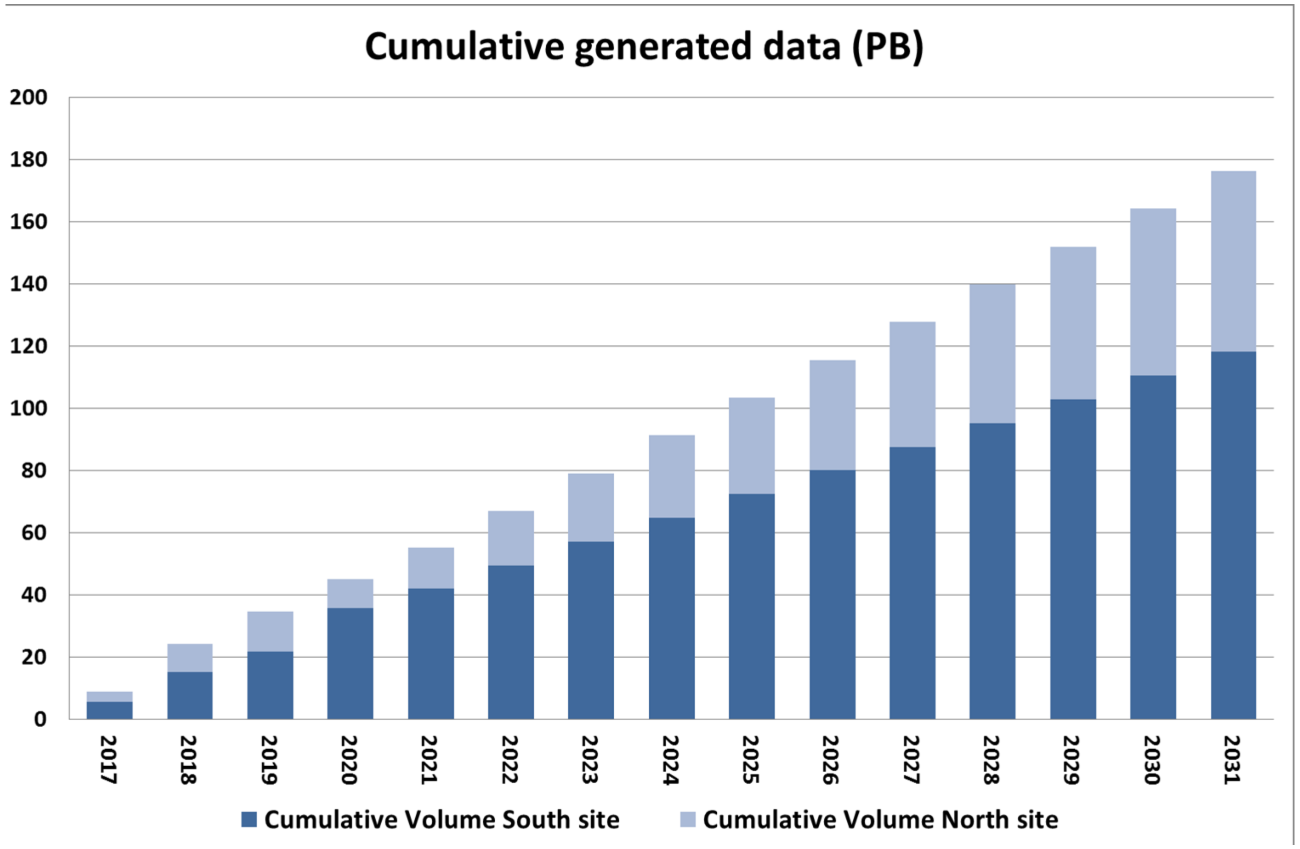
⇒ 4 PB/year (max 370 TB/day)

CTA Data Volume & Computing

"massive computing in Europe"

Data calibration, reconstruction, analysis, MC production

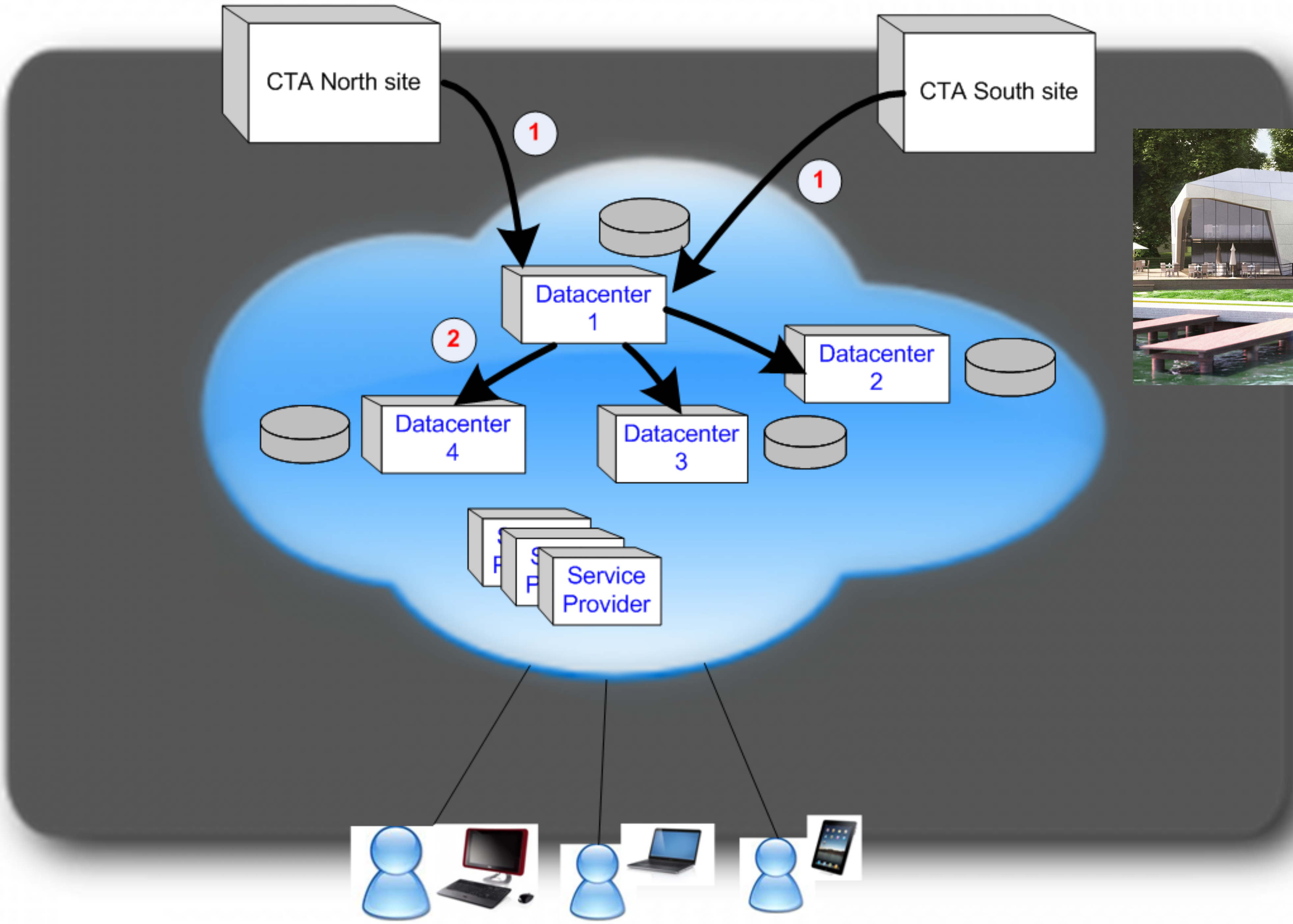
- data be archived for 30 years of operations + 10 years
- one reprocessing per year
- resulting data per year:
  - raw data: 4PB/y
  - processed data: 4PB/y (x2)
  - Monte Carlo: 20 PB/year

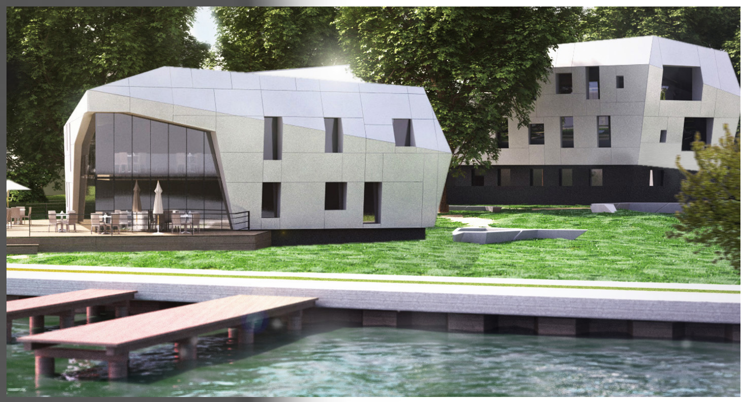


Computing Operation Phase (in HS06):

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cumulative raw data volume(PB)	23	27	31	35	39	43	47	51	55	59
Cumulative event data volume(PB)	47	59	71	83	96	108	120	132	144	156
Monte-Carlo data volume(PB)	20	20	20	20	20	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)	**67**	**79**	**92**	**104**	**116**	**128**	**141**	**153**	**165**	**177**

CTA Distributed Computing Model (Grid/Cloud)





CTA Challenges

> **Data Rates:**
  - large data rates taken at a remote site and transfer to Europe

> **Archive and open access:**
  - provision of guaranteed long-term access to the data products

> **Alerts:**
  - results and alerts to the astronomical community from transients in near real-time (latency < 30 s)
  - Multi-messenger interfaces - integration into available solutions from astronomical community

> **Simulations:**
  - sufficiently accurate instrument response functions to guarantee small systematic uncertainties. Period(run)-wise Monte Carlo simulations
  - CORSIKA & the next 30 years
  - modern computing architecture (GPUs, ARMs)

> **Analysis:**
  - likelihood minimisation problems
  - gamma selection methods (hadron+electron suppression); machine learning methods

> **User Support & Training:**
  - service and support for a scientific community

Common themes

- astroparticle analysis facility
  - dedicated computing / data access for German astroparticle groups
- common tools
  - most importantly CORSIKA
- methods development
  - machine learning, imaging, likelihood methods, …
- high-throughput computing in remote places
  - efficiency, data compression, data transmission, …