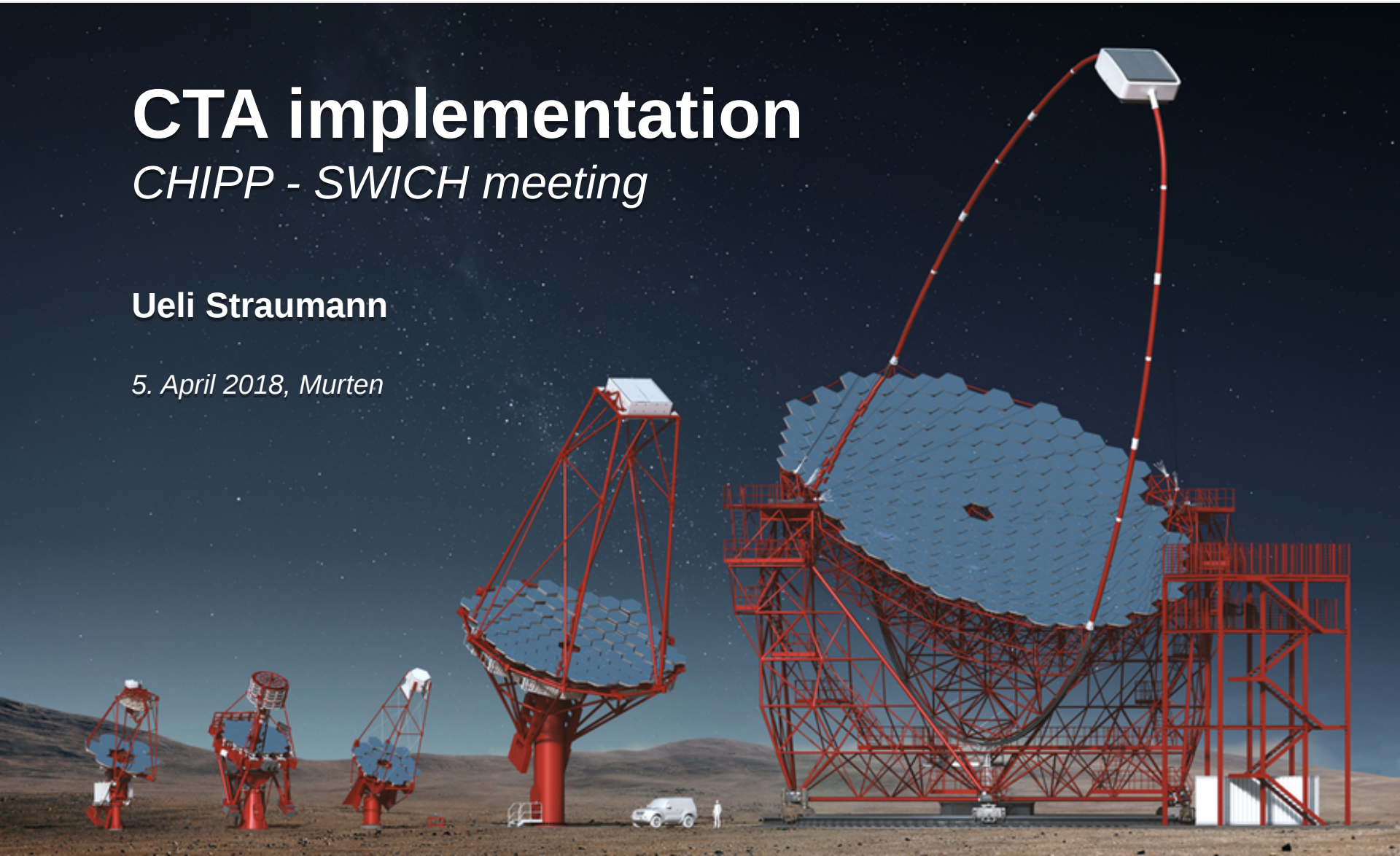
cherenkov telescope array

CTA implementation

CHIPP - SWICH meeting

Ueli Straumann

5. April 2018, Murten



Overview

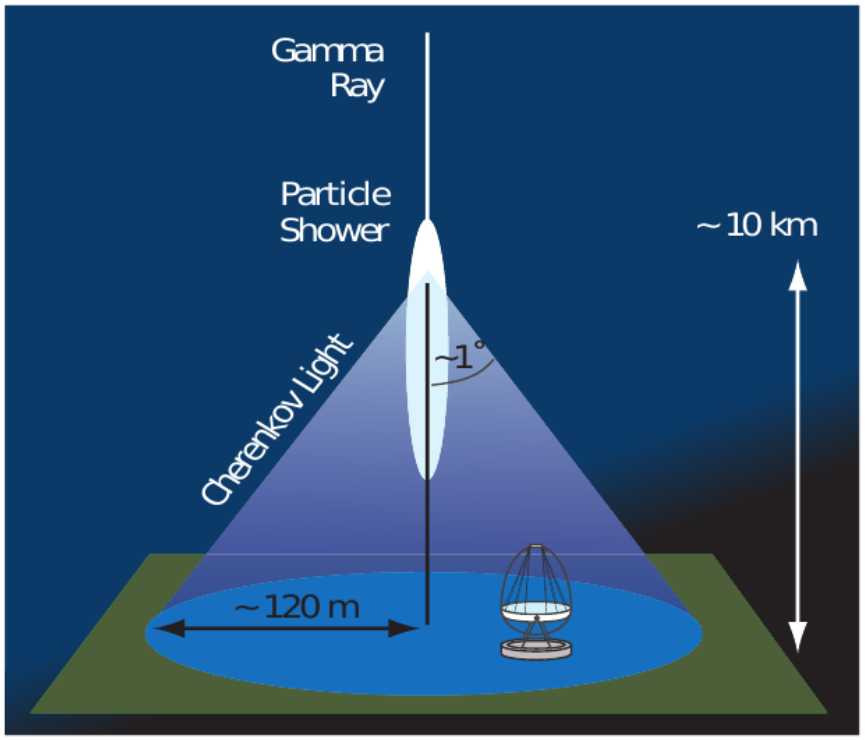
- Motivation, Concept, Requirements
- What did we achieve so far?
  Prototypes, site infrastructure, Swiss contributions
- CTA project government
- Create a final legal entity: ERIC
- Summary and Outlook

Motivation, Concept and Requirements

Detect Highest Energy Gamma Rays

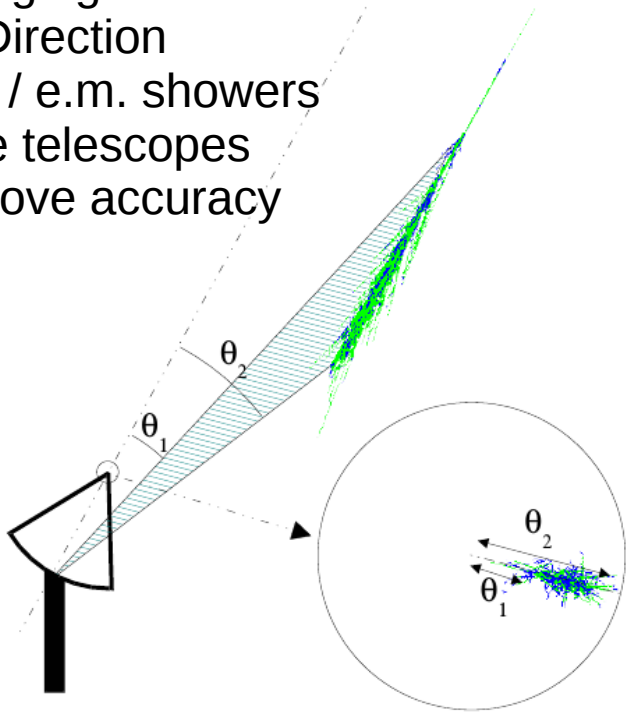
- To learn about the acceleration process of cosmic rays
- To extend photon observation window to a completely new regime of the very highest energies
- To study gamma ray bursts (GRB), the brightest electromagnetic events in the universe
- To contribute to the Multi messenger approach to observe cosmic events with all instruments available (GW event!)
- To study fundamental physics questions:
  Dark matter annihilation, quantum gravity effects …

Cherenkov Telescope



Shower imaging:

- Energy, Direction
- Hadronic / e.m. showers
- 2 or more telescopes
  to improve accuracy



Atmosphere used as a calorimeter.

Presently active telescopes:
MAGIC(LaPalma, 2), HESS(Namibia, 5), VERITAS(USA, 4)

Requirements for CTA

- Highest energy results in very large showers, producing lots of Cherenkov light, but events are extremely rare.
  -> need many, simple and cheap telescopes to cover large area.

- "Low" energy photons produce small showers
  -> need a few very large and sensitive telescopes

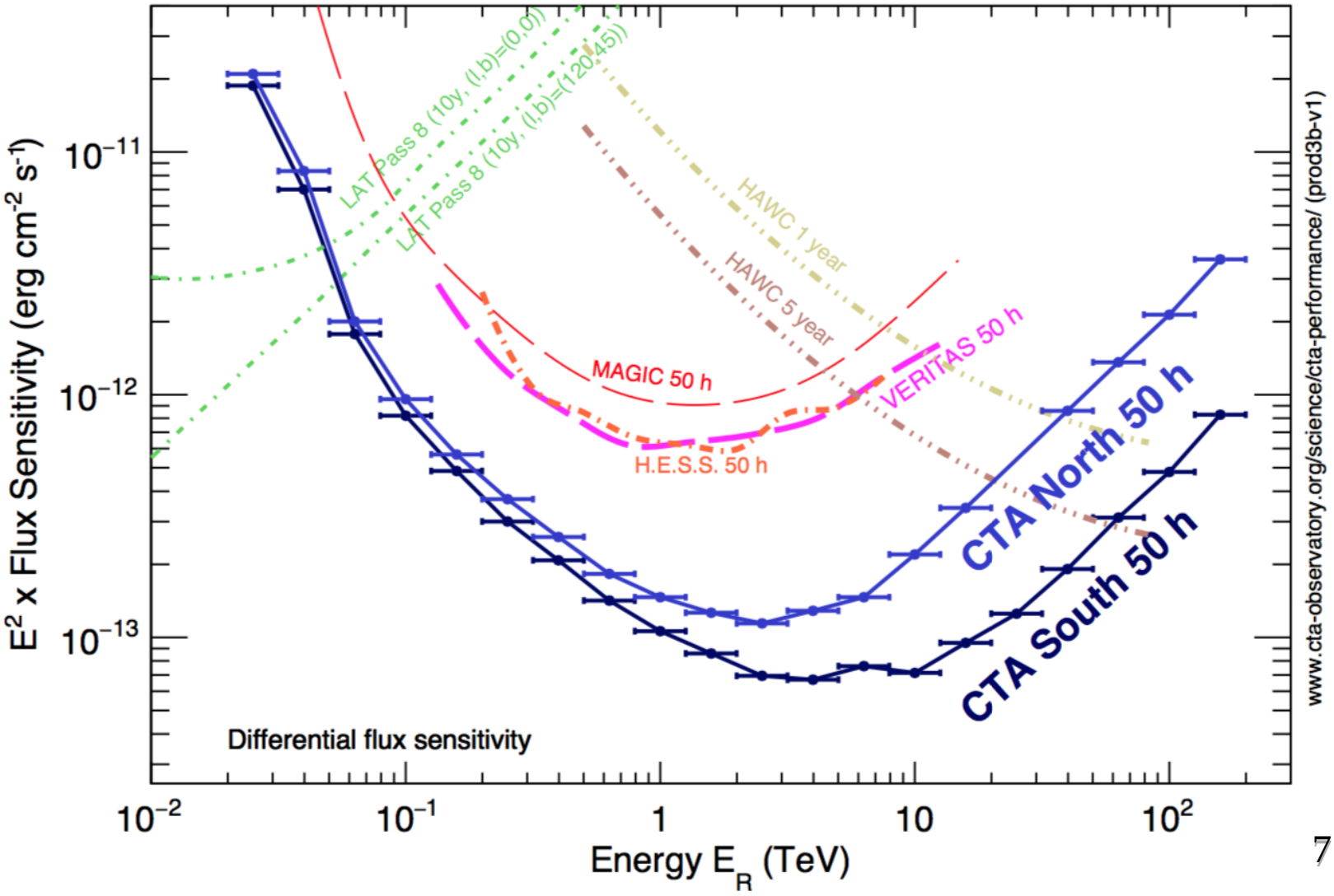
-> use 3 types of telescope 8 LST, 40 MST, 70 SST
To be installed on two sites, one in each hemispheres.

- Sensitivity region: > 30 GeV (beyond existing detector systems)
  < 300 TeV (limited by a realistic size of the array)

- Wide Field of View, to do scans in an efficient way

- Fast reposition time of the telescopes on event alert (20 to 30 sec to any direction)

CTA Performance



Key science projects (KSP)

KSPs will provide legacy data sets and data products;

- Documented in arXiv:1709:07997;
- World Scientific, in press. ca. 200 pages.

Surveys

1. Dark Matter Programme
2. Galactic Centre
3. Galactic Plane Survey
4. Large Magellanic Cloud Survey
5. Extragalactic Survey

Key Objects

6. Transients
7. Cosmic-ray PeVatrons
8. Star-forming Systems
9. Active Galactic Nuclei
10. Cluster of Galaxies
11. Beyond Gamma Rays

CTA Observatory operation

Present, very preliminary view of an operation model:

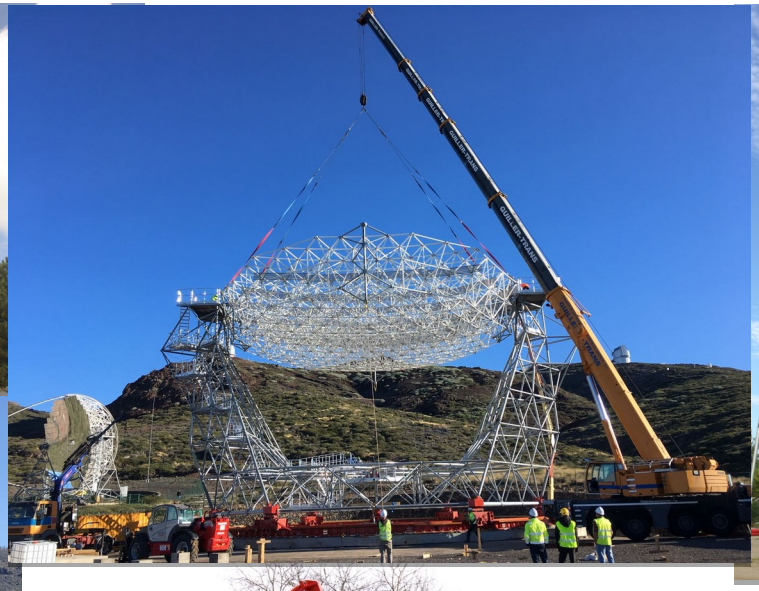
"Guest Observers" (open time): smaller programs 10...100 hours
- Announcement of Opportunity
  - -> proposals by individual (groups) of scientists
    - -> evaluation, ranking
      - -> allocation of time (TAC)
- accessible for member states

"Key Science Program", typically 40% of the time in the first decade
- large programs typically 1000 hour or more,
- will be run by the CTA consortium

Special time reserved for:
- 10% for Chile, 10% for Spain, 10% for ESO, 5% for CCI

What did we achieve so far?

CTA Telescope and Camera prototypes built by potential in-kind contributors.



Infrastructure design and construction

Infrastructure = roads, power lines, data lines,
central clock, trigger, DAQ and on-site IT,
telescope foundations,
service buildings
European Headquarters

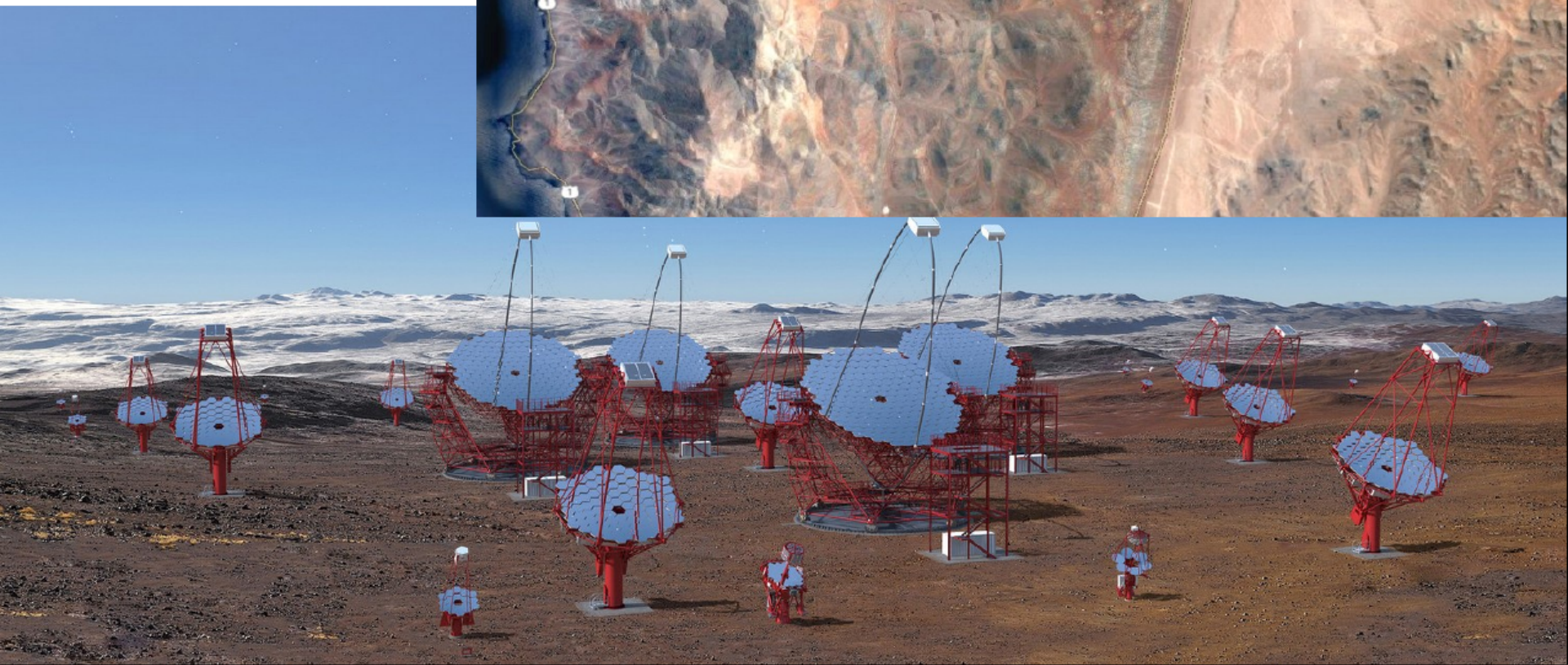
Significant progress in design in recent years, but

- Discussions on hosting agreement with Chilean authorities
- Complicate and slow permission process on La Palma

Estimate >= 2 years until first telescopes can be installed.

CTA South

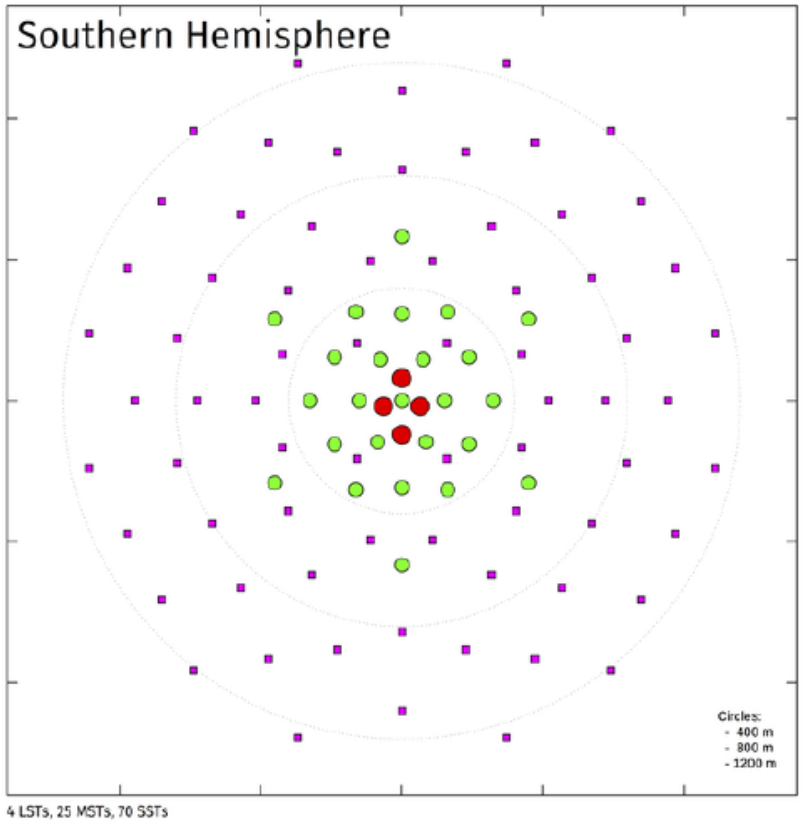
Atacama desert,
ESO site, Chile

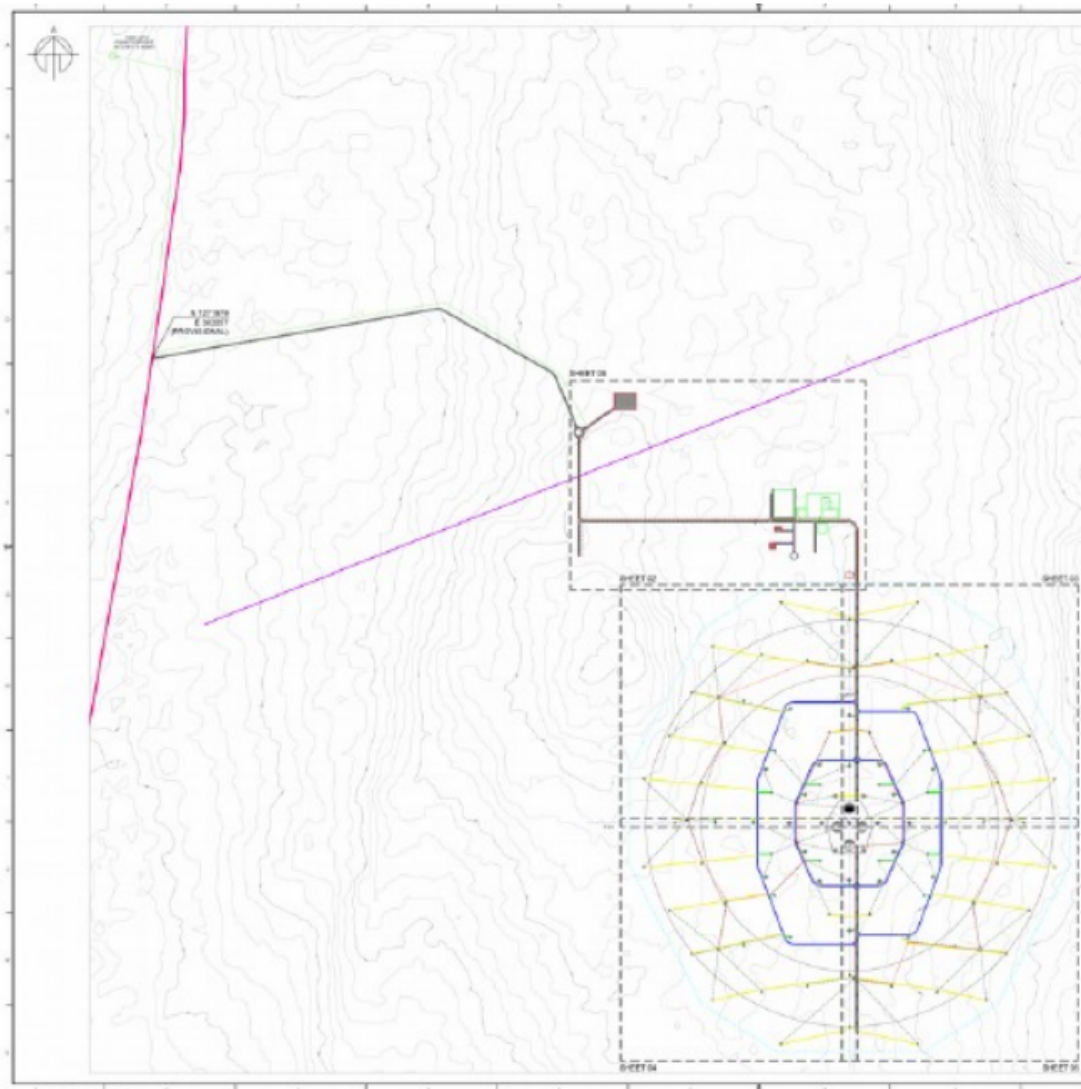



Infrastructure South
Geotechnical Study, May 2017
sondeal

South Layout

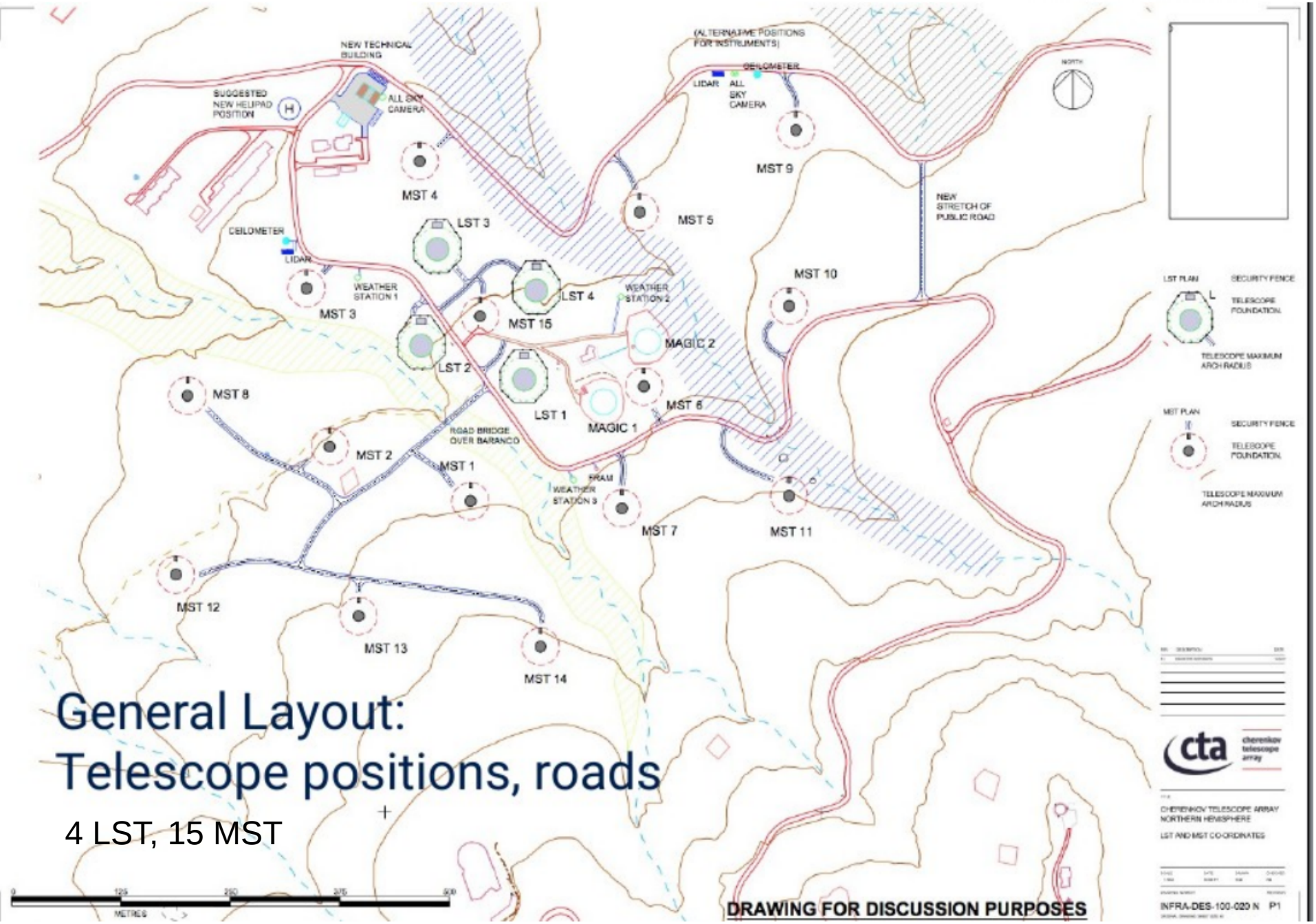
4 LST
25 MST
70 SST





CTA North

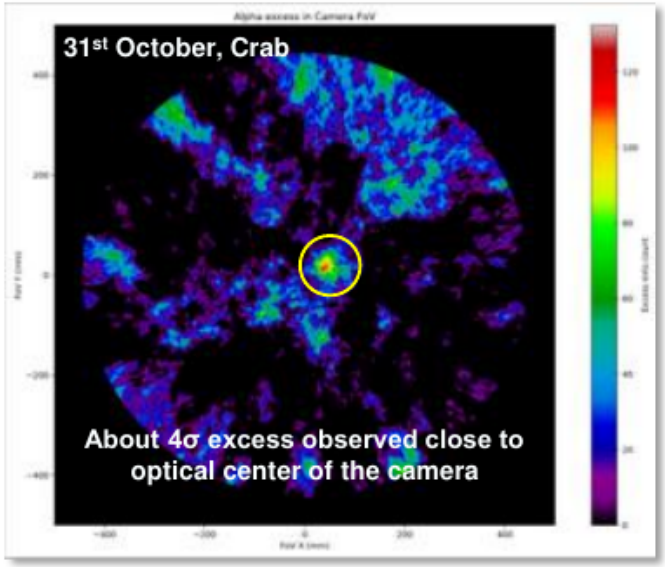
La Palma,
Canary Islands,
IAC site



General Layout: Telescope positions, roads

4 LST, 15 MST

Swiss contributions: UniGe / DPNC
SST-1M telescope prototype



- SST-1M is a project supported by an international consortium (PL,CZ,CH) led by UniGE
- After years of R&D, the telescope has been fully commissioned in Krakow in Aug. 2018 (see Video 1 Video 2)
- Camera is performing extremely well
  - Continuously tested in lab and compared to simulation
  - High Trigger rate (~ kHz) without dead time (CTA requirement ~600 Hz)
  - Camera test on telescope in challenging conditions:
    - pollution ~ 1.2 GHz/pixel
    - bad weather - only 6h of observation in 2 months;
    - gamma-ray showers observed from Crab Nebula.
- SST-1M has already achieved end-to-end commissioning and proven high performance
- SST-1M has high degree of harmonization with MST (Drive, PLC, software, mirror alignment, actuators, pointing system, readout philosophy, engineering GUI). Currently undergoing further harmonization with dual mirror-SSTs.
- **PL /CZ / CH available funds would suffice for 21 SST-1Ms (including spares, for a cost of 530 kCHF (wo contingency on exchange rate variations)/telescope).**
- Geneva has the potential to become a data center for the Astrophysics, which should include CTA as major contributor (~25 Pbyte/year).

Swiss contributions: UniGe / Astro

Obs. Exec. Syst. (OES): software and analysis tools

10 PB/night

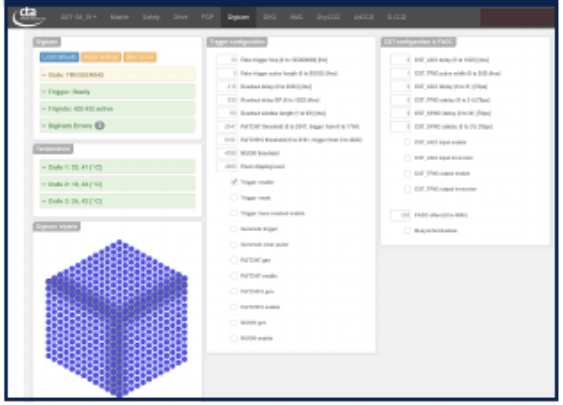
Data Acquisition

12 PB/year

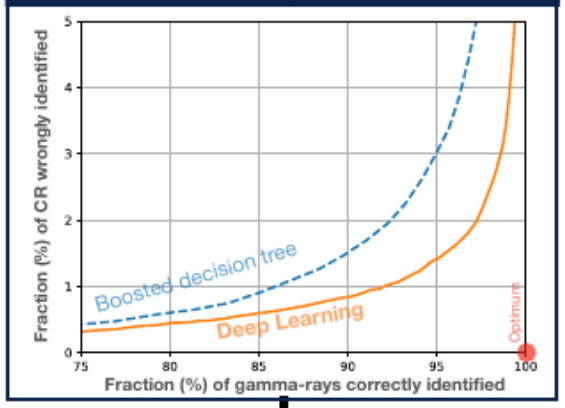
Archive

40 PB/year

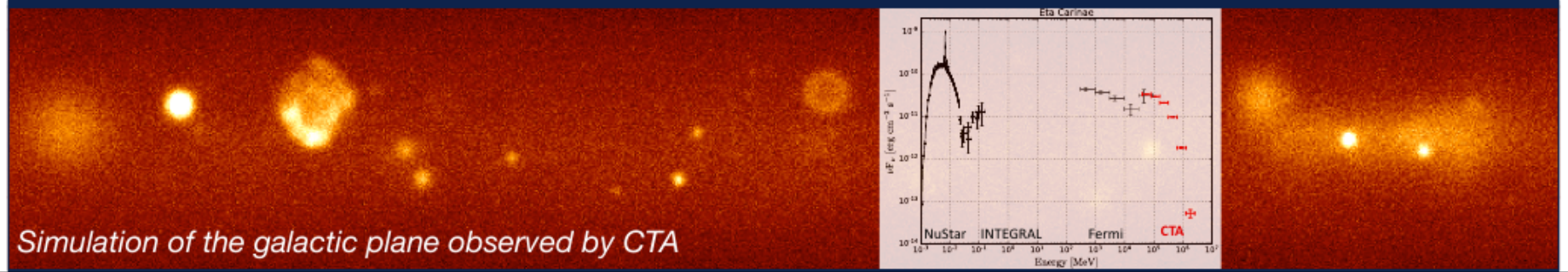
Telescope Control



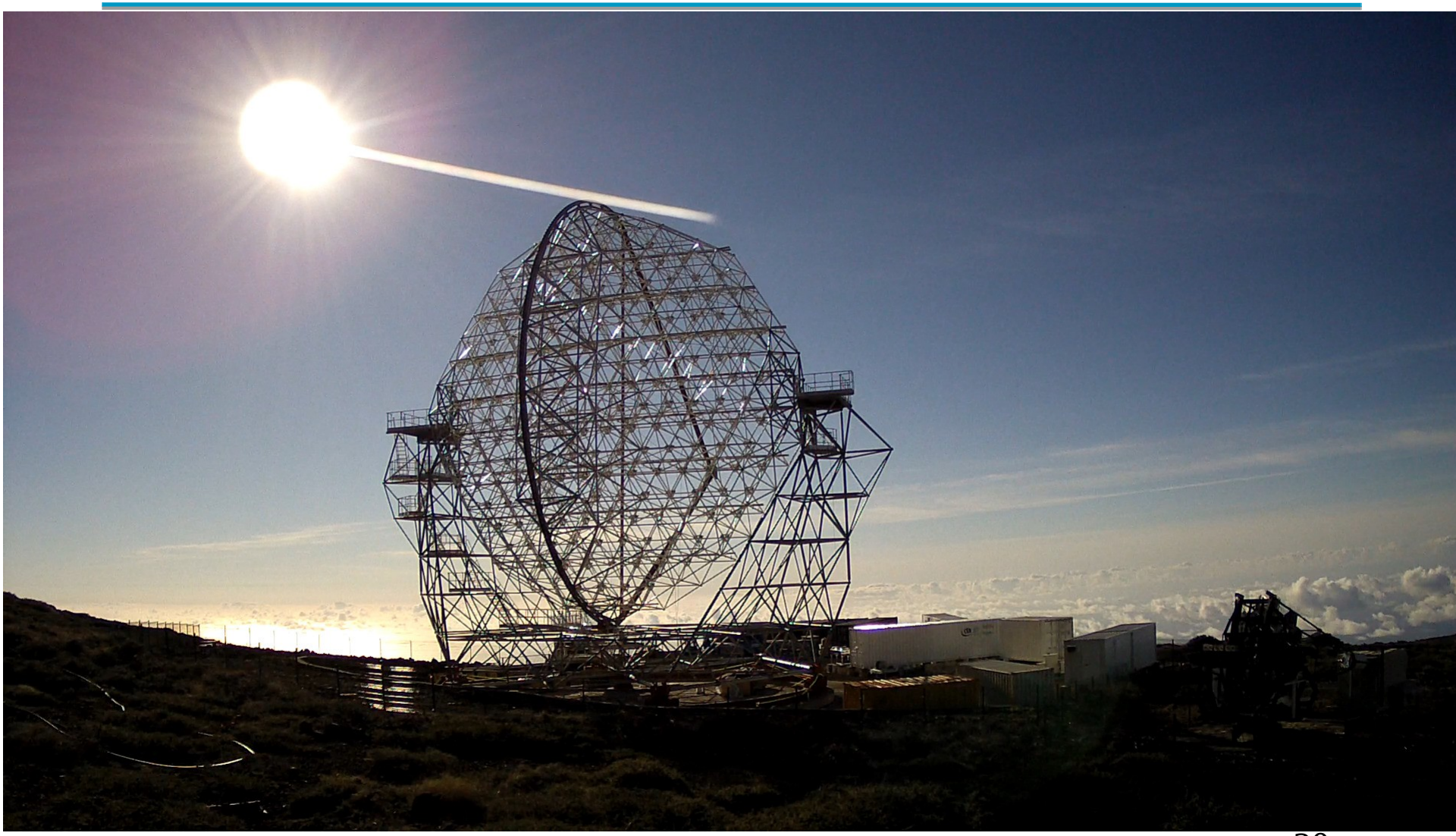
Analysis



Science

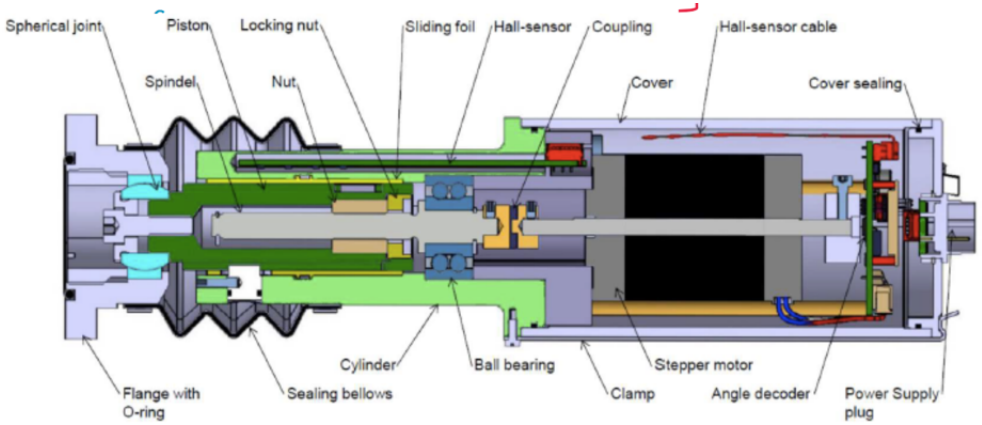


WebCam on La Palma:
LST-1 prototype structure



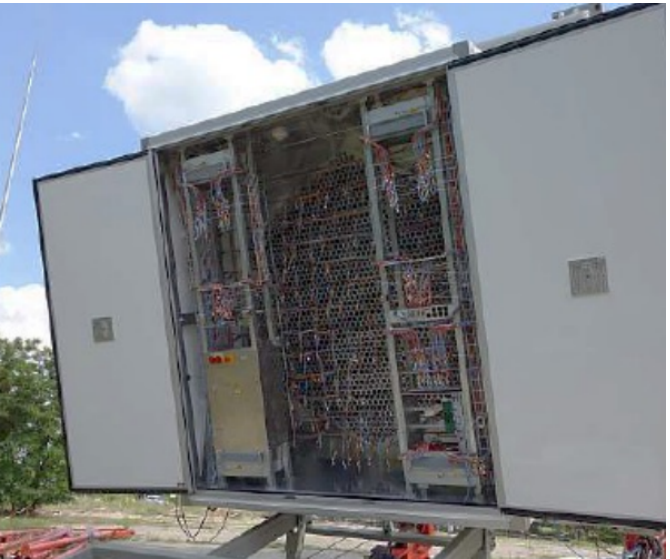
Swiss contributions: UZH

Prototypes for AMC, FlashCam, Central Clock



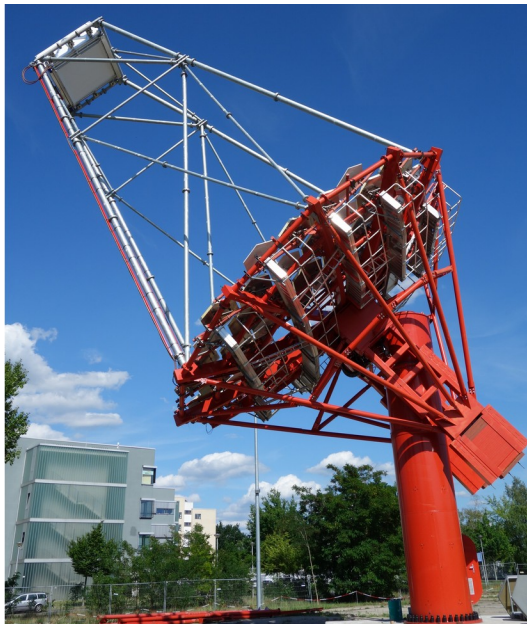
- Mirror segments of LST need to be dynamically adjusted individually (Active Mirror Control, AMC)
- To be used also for MST, SST-1M, ...
- Design started from ETH Magic actuators, redesign, optimized for reliability and price.
- UZH co-operation with local industry

FlashCam mounted on MST,
fully operational, service doors open



FlashCam:

- Fully digital camera,
- Data and trigger path identical
- PMT sensors (or SiPM)
- „Horizontal“ setup
- Designed to fit for MST (South)
- AT-CH-DE co-operation



FlashCam mounted
on MST proto in Berlin

What is missing

On engineering level

more awareness on lifetime cost and operation is needed:

- presently 6 different telescopes and 7 different cameras are proposed
  => need to select, in order to reduce complexity of the system
- 30 years operation time with 20 Meuro / y operation cost = 2 * investments
  => focus on reliability and maintainability over a long period of time.

Further to this we need

- detailed, full system engineering design
- complete definition of interfaces (hardware and software)
- final cost book
- critical design review on technical level
- In-kind contribution agreements, incl. change control and accept. processes

On government level:

- final legal entity
- lots of legal stuff

CTA project government

History: the early days

2006: University and Research Centre groups started cooperation

ESFRI roadmap project since 2008 (presently evaluation is ongoing to become a Landmark)

FP7 funded preparatory phase 2011-2013

Under the leadership of German BMBF a resources board was created in 2011

Declaration of Intent signed in July 2012 by 13 countries (similar as now), Advisory committees: STAC, AFAC, SSC

CTAO gGmbH and MoU C&O

Soon it became clear, that a better organized project government is needed.

→ Interim legal entity CTAO gGmbH according to German law was founded in 2014

Achievements of (or coordinated by) the GmbH include:

- Cost estimate 2014, Technical Design Reports (all options), CDR 2015 (mainly on management issues, technical level missing)
- **Site selection**: summer 2015: ESO, Chile and IAC, La Palma
- IAC La Palma **hosting agreement** signed in summer 2016
- HQ selection 2016: HQ in Bologna, Italy and SDMC in Berlin-Zeuthen
- 2017/18 Long (and not yet finished) discussions about hosting agreement in Chile
- 2017: **Geotechnical studies** on telescope sites, detailed planning of infrast.
- **HQ setup** in Bologna 2017, hiring legal and HR advisor, administrative personnel
- 2016/7: completely new software architecture → interface definitiions.
- 2016/8: lots of work on **in-kind contribution framework** and agreements
- **New project manager** started Sept. 2017

CTAO gGmbH shareholders
(founding members)

Australia	Australia Astronomy Limited	2018
Austria	Leopold Franzens Universität	2016
Czech Republic	Institute of Physics of the Academy of Science	2015
France	Centre national de la recherche scientifique (CNRS)	2016
France	Comm. à l'énergie atomique et aux énergies alt. (CEA)	2016
Germany	Deutsches Elektronen-Synchrotron (DESY)	2014
Germany	Max-Planck-Gesellschaft (MPG)	2016
Italy	Istituto Nazionale di Astrofisica (INAF)	2014
Italy	Istituto Nazionale di Fisica Nucleare (INFN)	2017
Japan	University of Tokyo	2015
Slovenia	University of Nova Gorica	2018
Spain	Instituto de Astrofísica de Canarias (IAC)	2015
Switzerland	Universität Zürich	2014
United Kingdom	The Science and Technology Facilities Council	2015

Associated Members

Netherlands: Netherlands Organisation for Scientific Research (NWO)	2015
South Africa: National Research Foundation	2015

Further interested countries include: Poland, Brazil, India, USA

Present Government: CTAO gGmbH

Council of 14 shareholders from 11 countries

Employees:

- Director
- Project Manager
- Lead System Engineer
- Legal advisor+HR, administration and outreach (8)
- Infrastructure (3.5)
- Science and Engineering (4, plus 6 secondments)

Need much more engineering people

Advisory committees to council:

- Administrative and Finance committee (AFC)
- Scientific and technical advisory committee (STAC)
- In kind contribution review committee (IKRC)

CTAO present office locations

Heidelberg: official seat of the GmbH:

- Site infrastructure planning.
- GmbH finances
- GmbH will be liquidated after ERIC is established

Bologna project office since January 2017:

- Project Management
- Systems engineering / software coordination
- General GmbH administration / legal support

Berlin-Zeuthen: SDMC: to be established.

Distributed organization is very challenging!

MoU for construction and operation of

On the initiative of the German BMBF this MoU was designed in 2016 to allow to express the member countries their interest and their commitment to the funding of the construction and operation of CTA.

- The MoU is signed by ministries or funding agencies
- Signatories have to give an **indication of the amount of funding** they foresee to support the construction of CTA.
- They express their **willingness to support the operation** costs, according to a model to be defined in the final founding agreement.
- At least 25% of each countries contribution shall be paid by cash, rest may be delivered as in-kind contributions according to the IKC agreement.
- The total cost estimate is 400 M€. The construction must not begin before a **threshold value of 250 M€** is reached and a final founding agreement exists.
- The signatories of the MoU shall **prepare the final legal entity.**

MoU is now signed by 7 countries, about 85% of threshold reached.

cherenkov telescope array

Create the final legal entity:

European Research Infrastructure Collaboration

(ERIC)

Why do we need a new legal entity?

When moving the CTAO offices to Bologna we realized

- There is no tax free Italian limited liability company,
  i.e. the gGmbH can not simply be transferred to Italy
- Complex mixture of labour laws of Germany and Italy
- We will have site locations in 3 different EU countries
  (Germany, Italy, Spain) and Chile
- Need to be able to move material and personnel
  between these location, without VAT and customs problems

Further to this we need to (as foreseen in the MoU for C&O)

- fix construction contributions of member countries
- fix operation cost distribution
- create a well defined legal relation to the member countries
- try to achieve flexible and efficient procurement procedures

In short: install what Cern provides for accelerator based experiments.

An ERIC for CTA

From the website of the European Commission … ERIC:

The principal task of ERIC is to establish and operate new or existing research infrastructures on a non-economic basis. ……

The ERIC legal framework provides:

- a European joint-venture (allows also non-European members)
- a legal capacity recognised in all EU Member States
- flexibility to adapt to specific requirements of infrastructure
- a faster process than creating an international organisation
- exemptions from VAT and excise duty

An ERIC may adopt its own procurement rules which have to respect the principles of transparency, non-discrimination and competition.

The members of an ERIC can be Member States, associated countries, third countries and intergovernmental organisations.

Planning:

1st step in autumn 2018, final step early 2019, CTA-ERIC established end of 2019

Note: The members are countries, with council representatives from ministries

Summary and Outlook

Currently in Pre-Construction phase with existing

- prototypes of cameras and telescopes
- software architecture
- prototypes of support equipment
- array layout optimized by simulation
- site studies and infrastructure designs

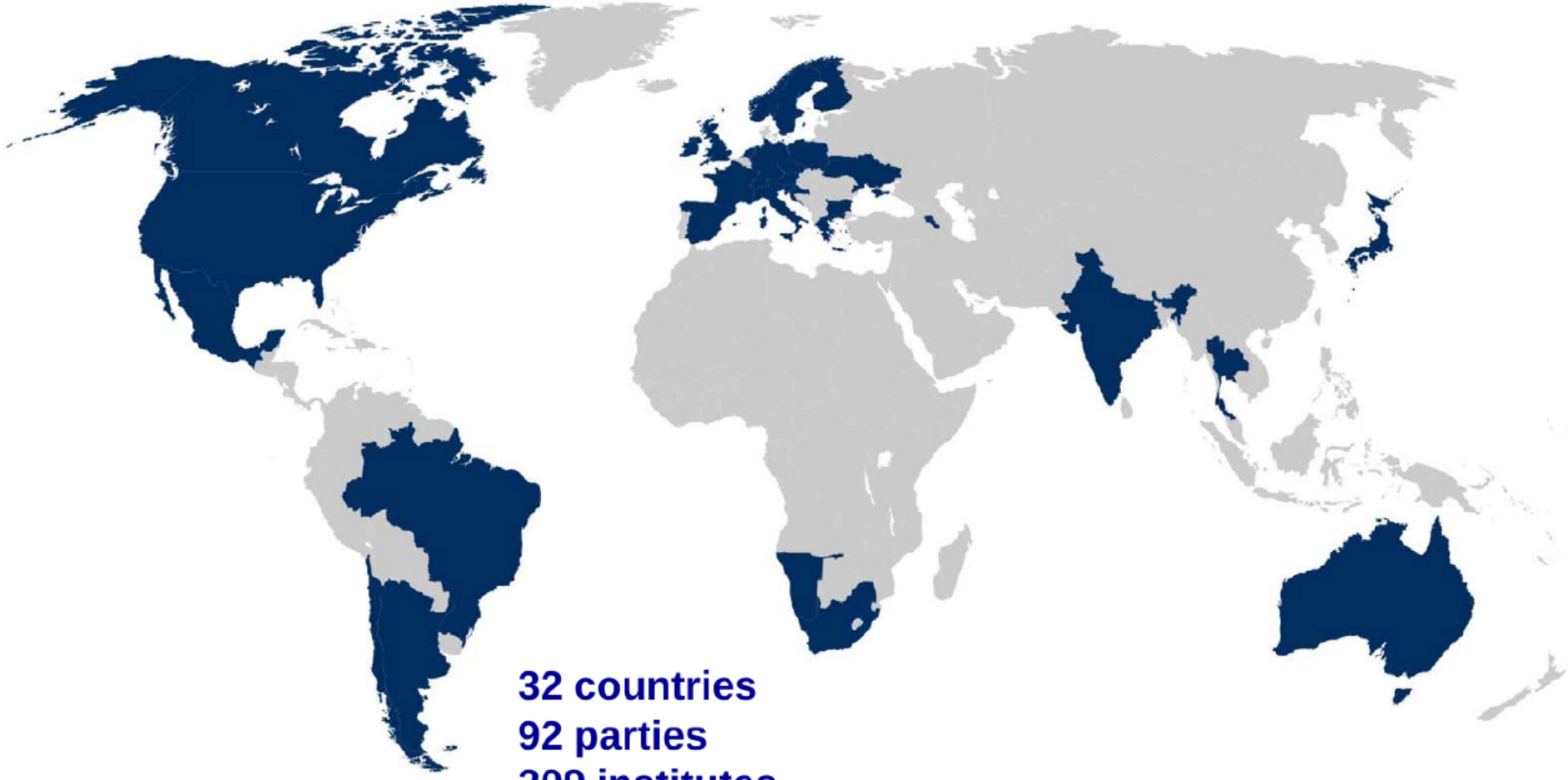
To be done:

- final legal entity ERIC
- define country's financial contributions for construction and operation
- finalize hosting agreements
- define In-kind contributions (incl. selection / harmonization)
- define system engineering and interfaces
- do technical reviews (incl. CDR)

Backup

Bg

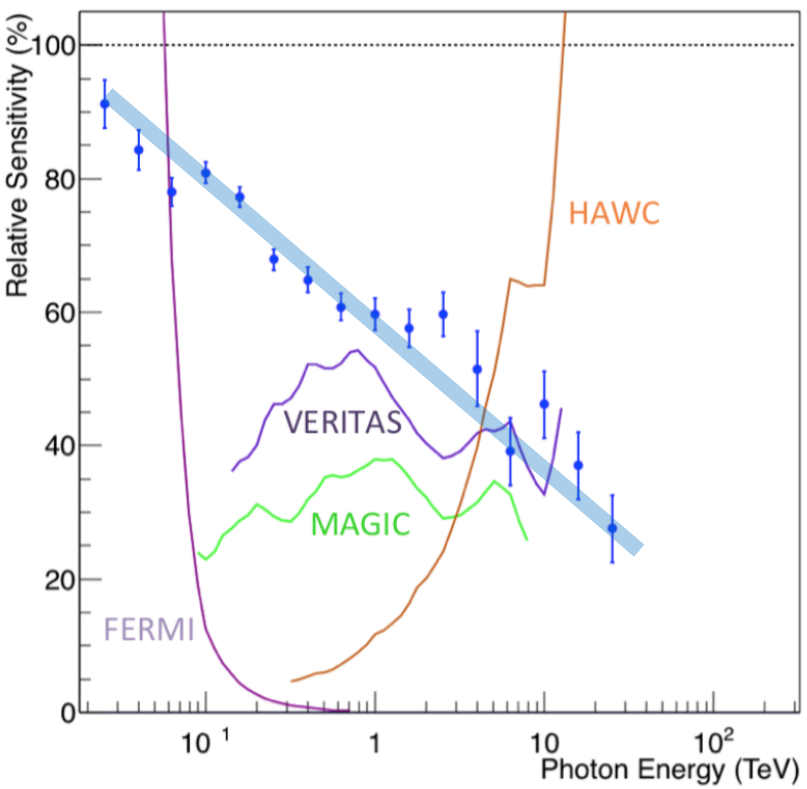
CTA Consortium, growing since 2006



32 countries
92 parties
209 institutes
1346 members (456 FTE)

Threshold /Baseline Performance Ratio

North



South