CTA - Operating and Controlling more than 100 Cherenkov telescopes

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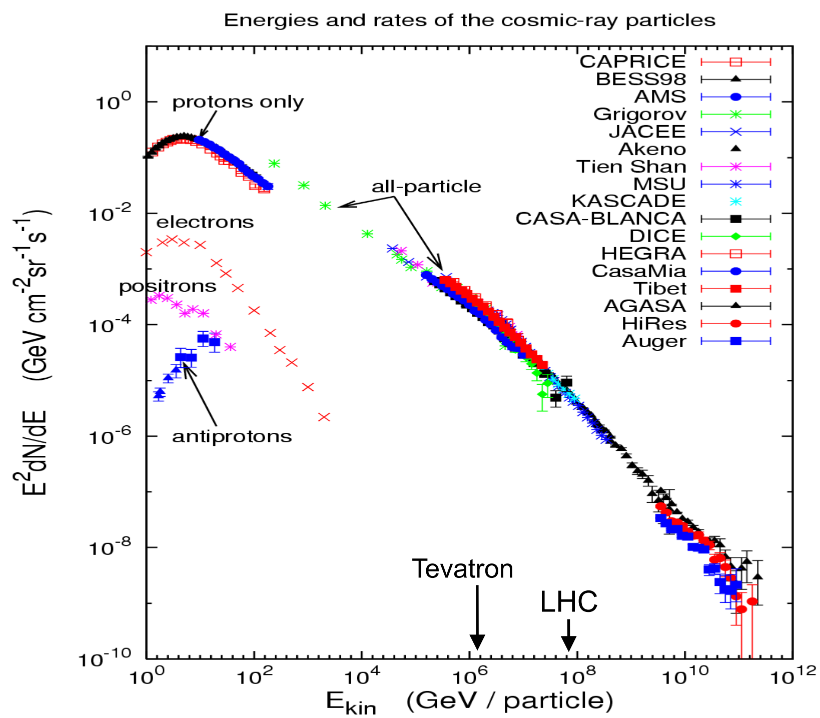
Austin, August 7th, 2012

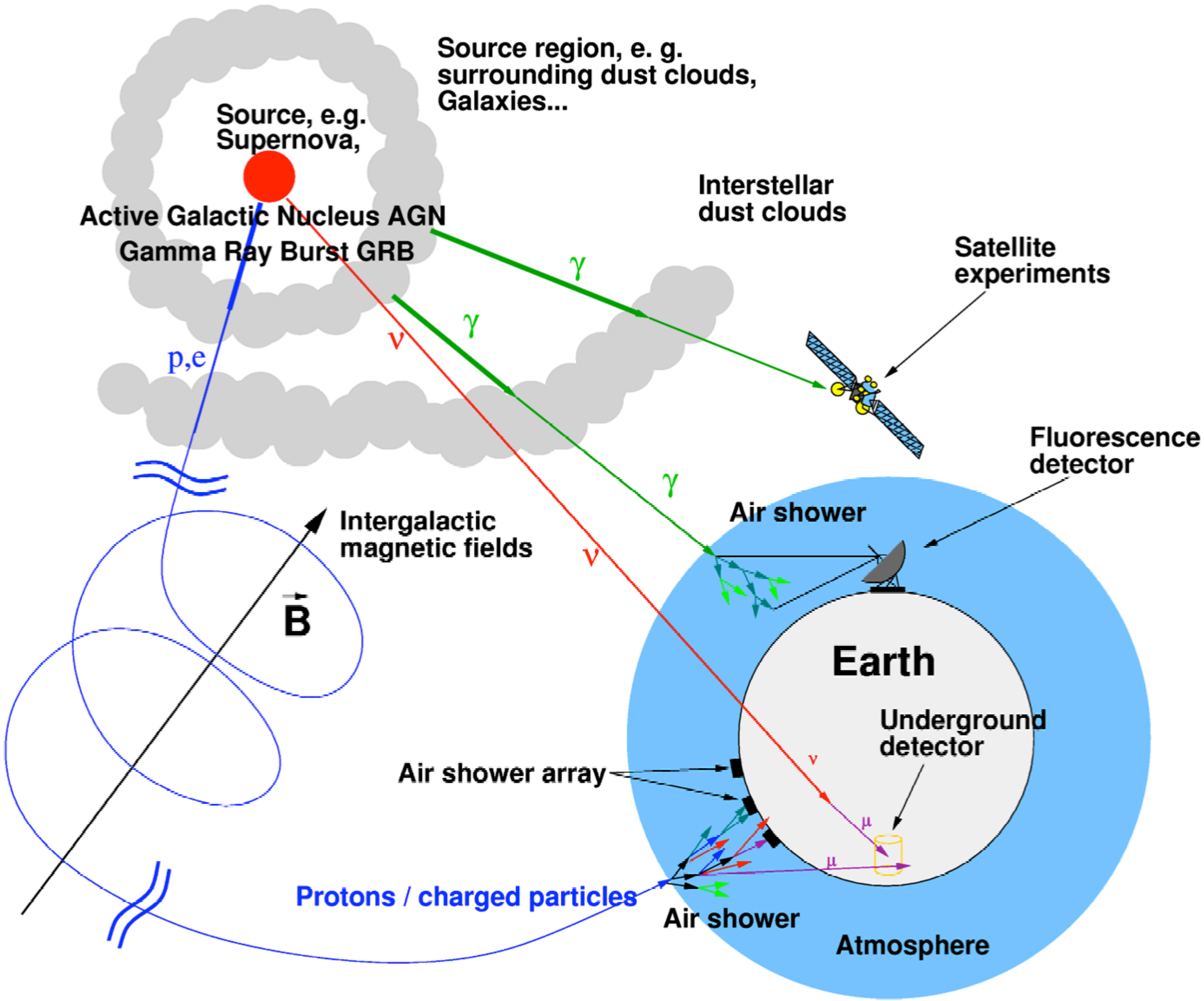
Cosmic rays



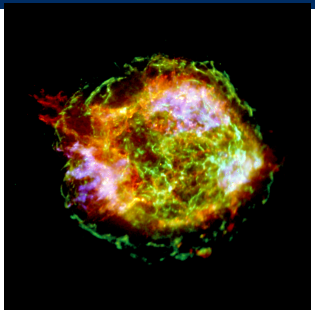
Victor F. Hess 1912
(Nobel Prize 1936)

Ionisation [J]

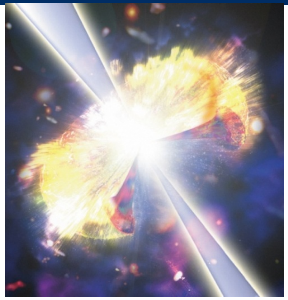
Origin of cosmic particles



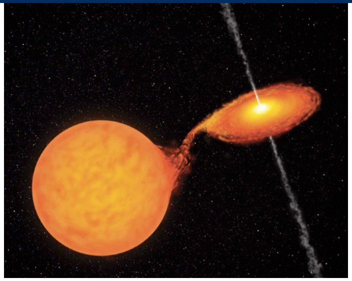
CTA Physics



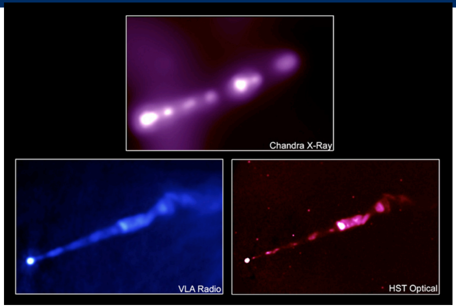
SNR
Supernova Remnants



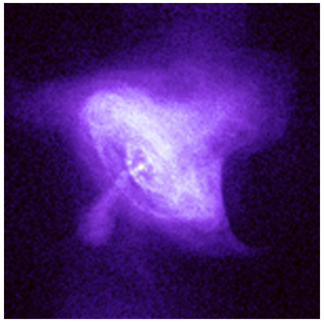
GRB
Gamma Ray Bursts



Micro quasars



AGN
Active Galactic Nuclei

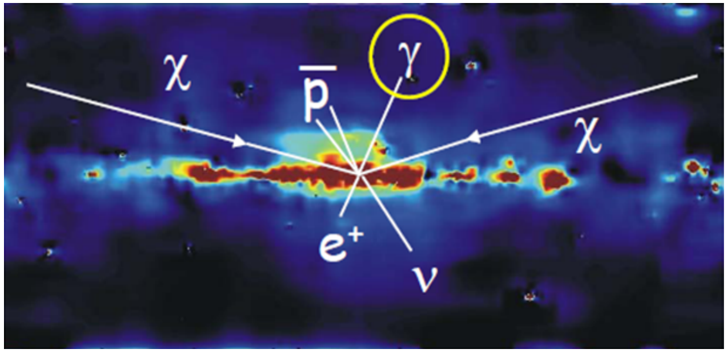


Pulsar, PWN
Pulsar Wind Nebula

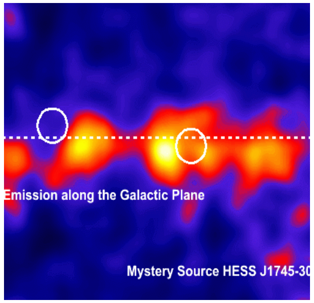
Understanding of cosmic ray sources

Detailed study of cosmic particle accelerators in and beyond our galaxy

Starburst Galaxies

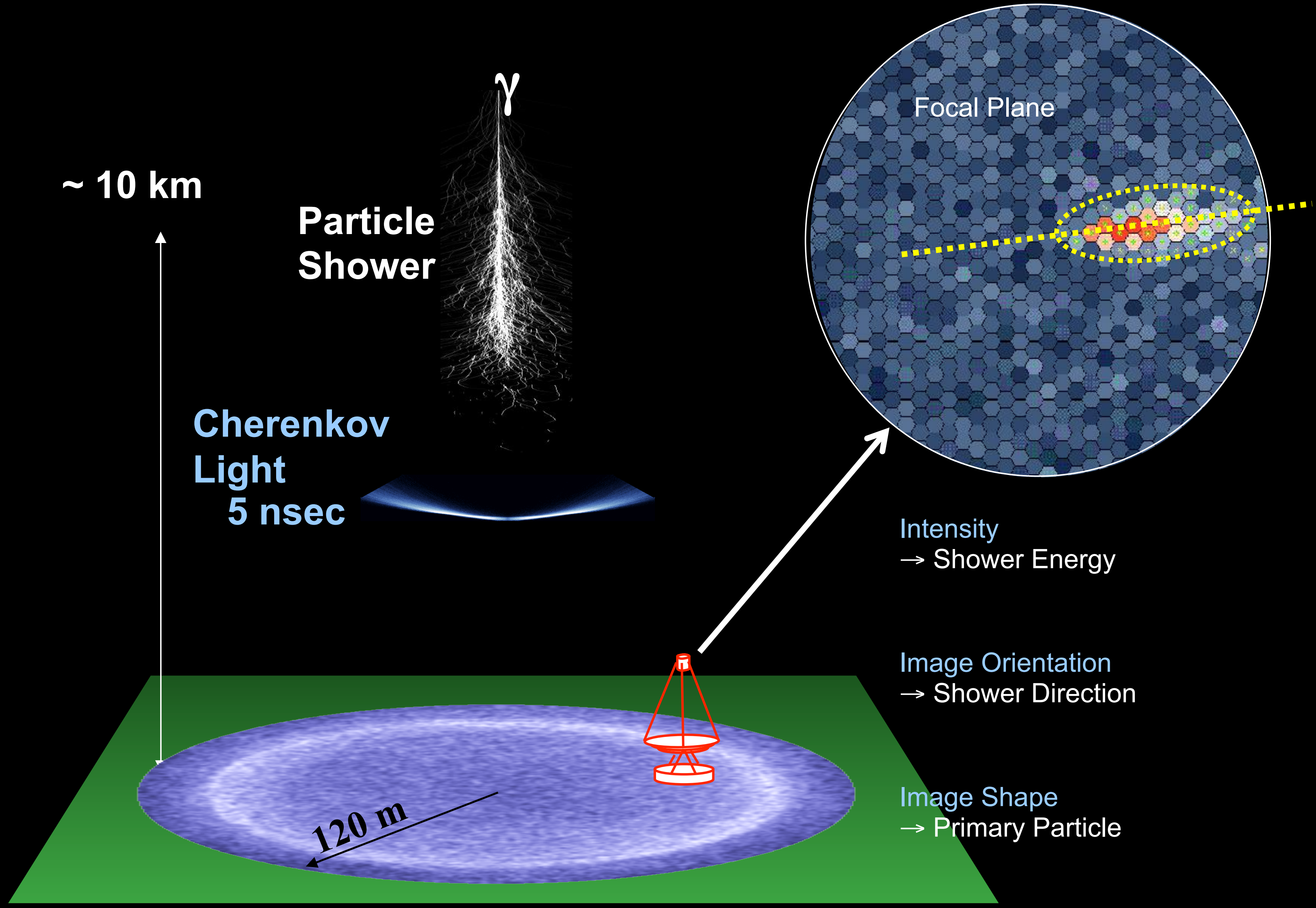


Dark matter

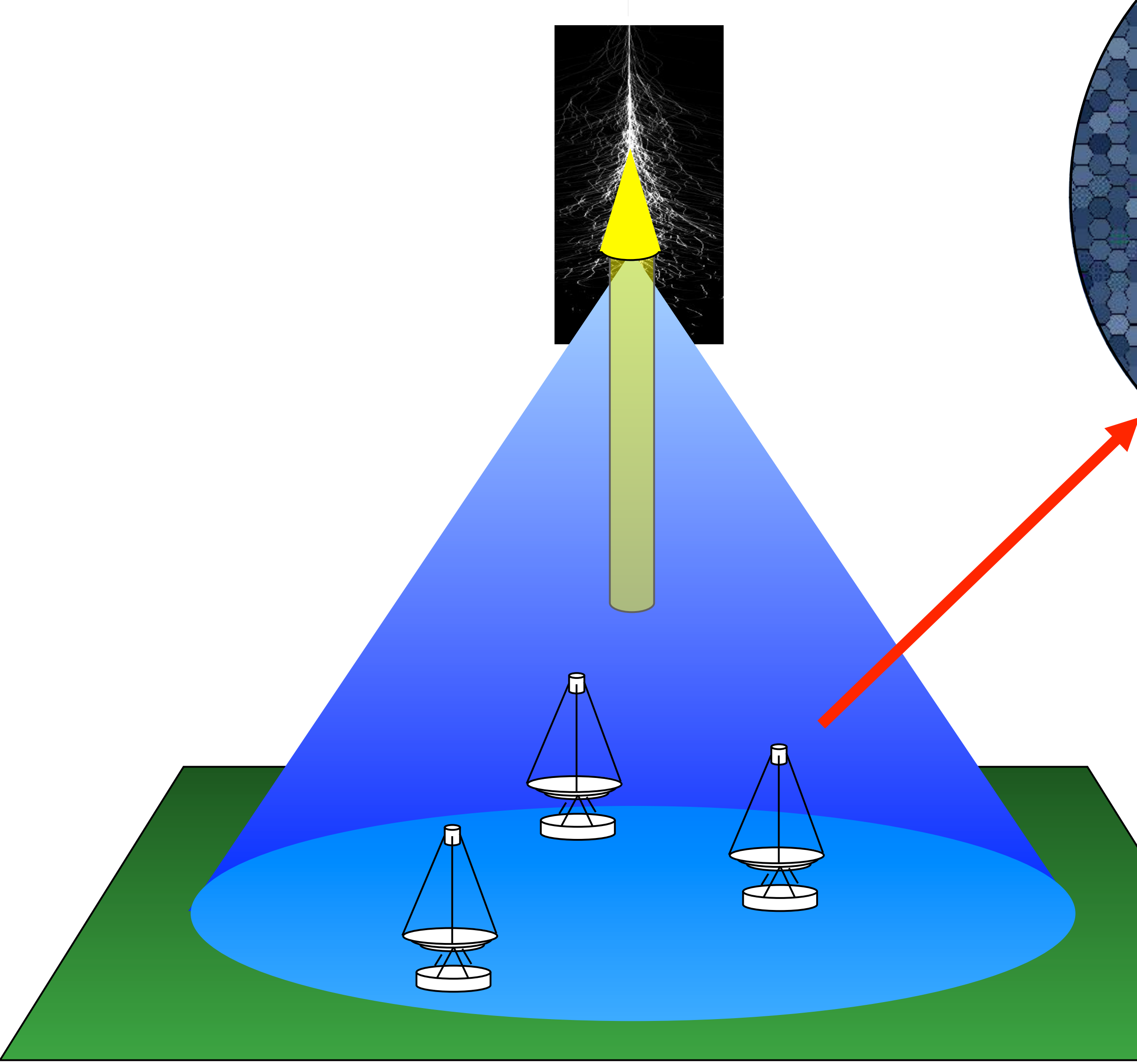


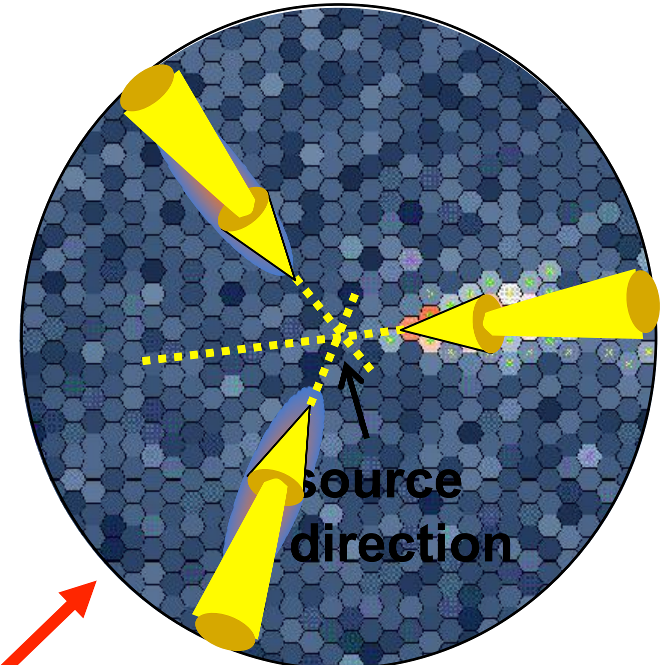
Unknown Sources

Detection of Cosmic Rays and Gamma Rays



Stereoscopic Observation Technique

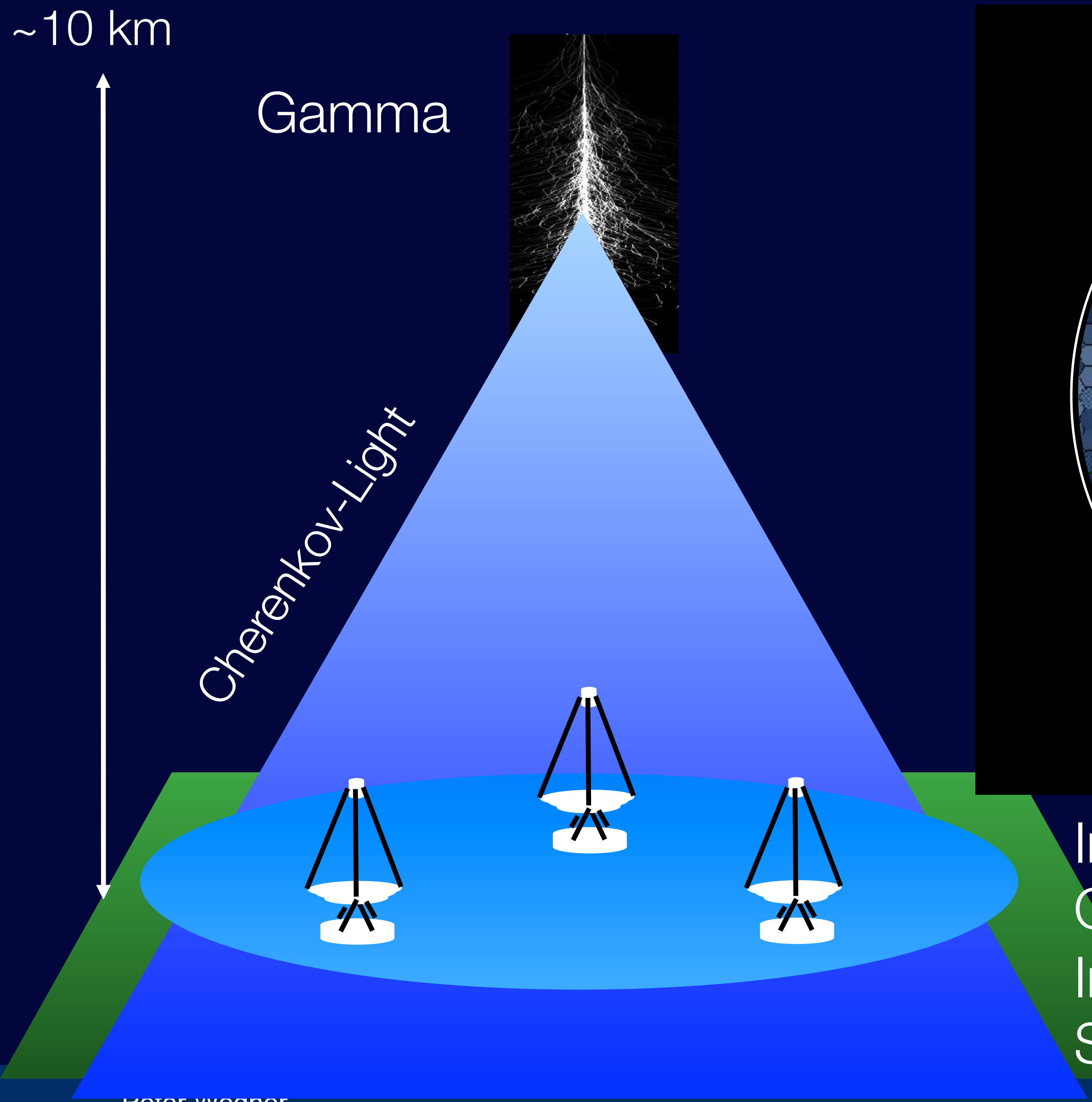


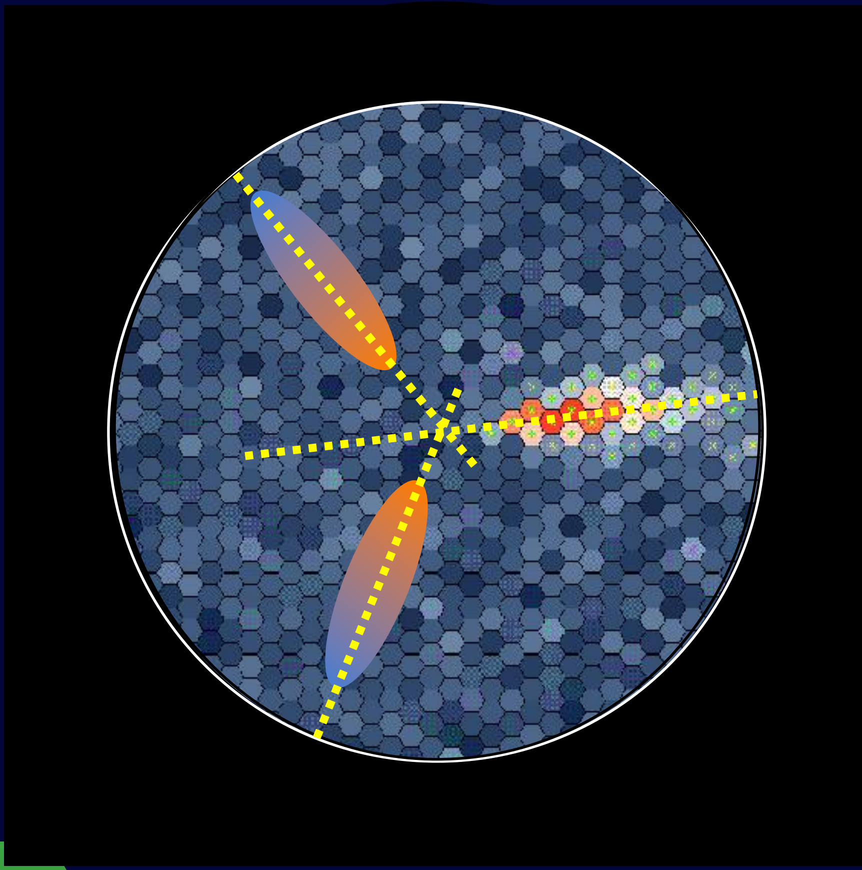


source image is on image axis ⇒

several viewing
angles for precise
event-by-event
source location!

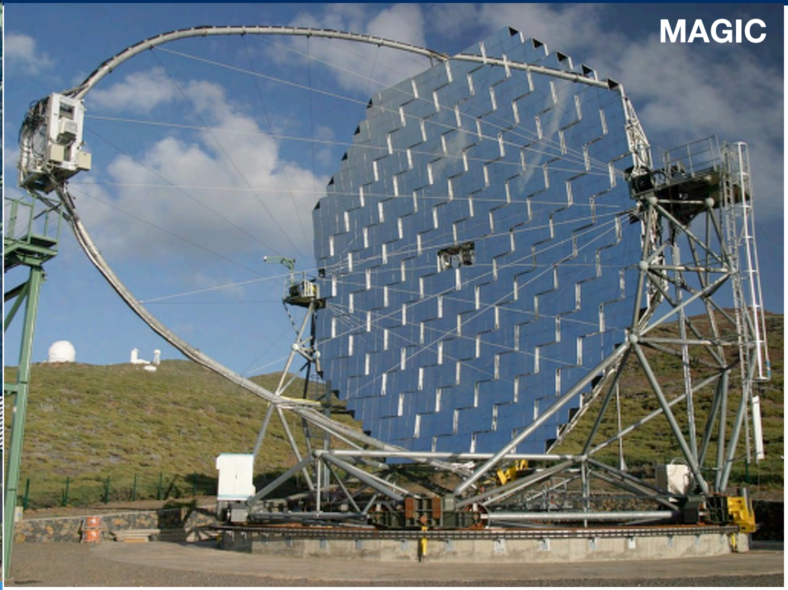
Gamma ray detection

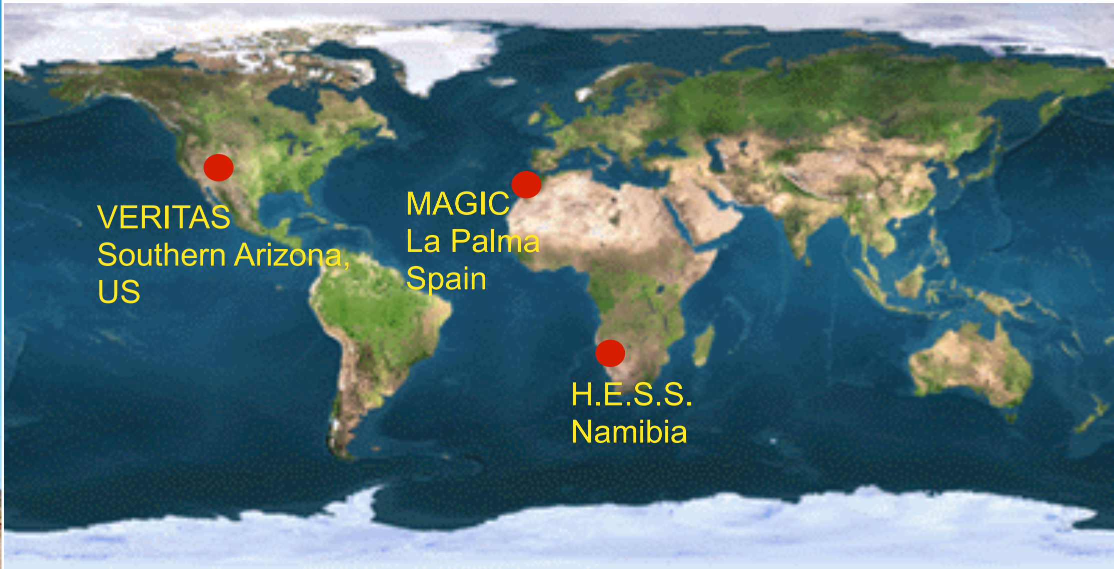




Intensity → Energy
Orientation → Direction
Image Shape → Particle
Stereo View → Source

Cherenkov telescope projects

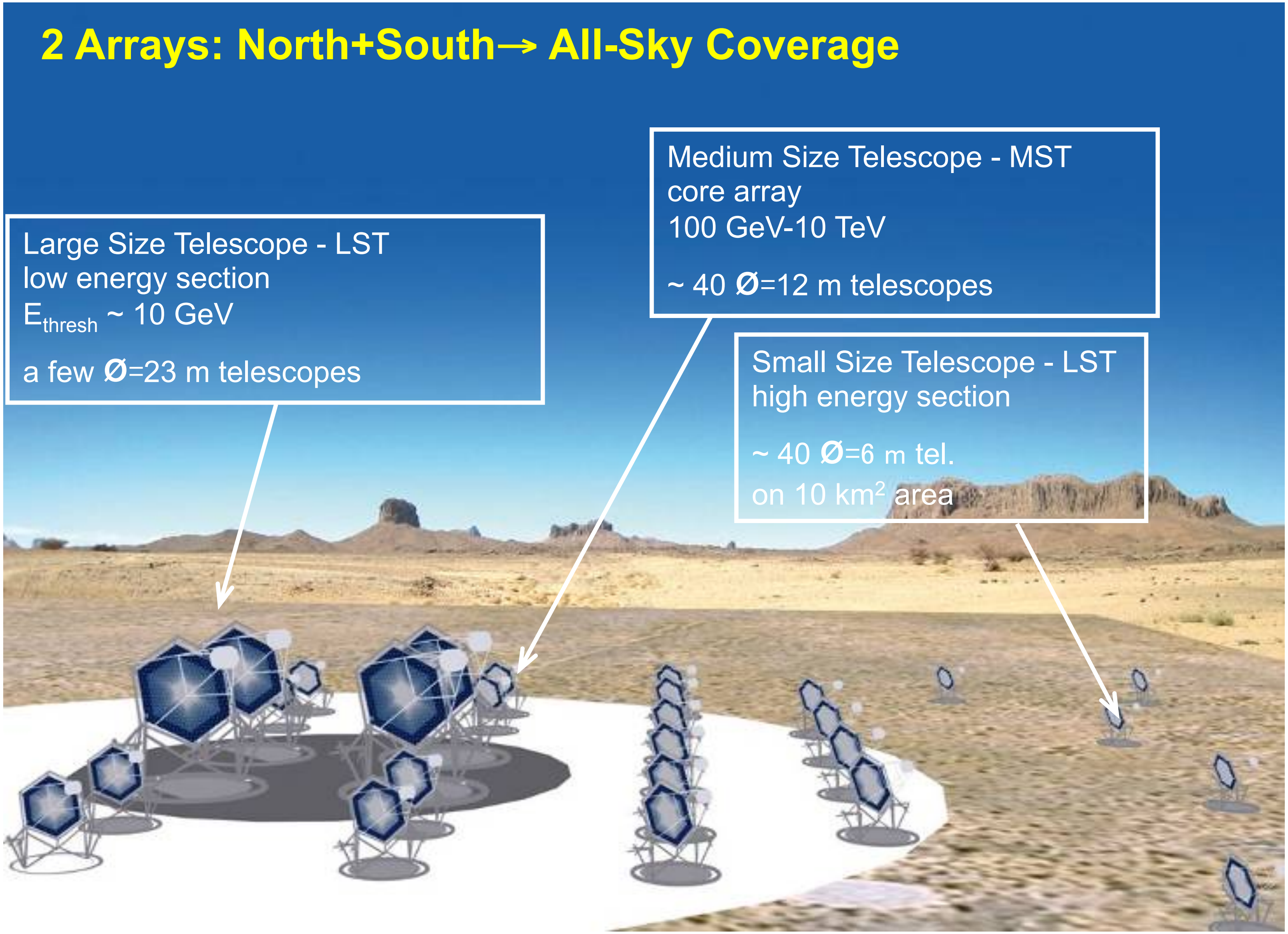




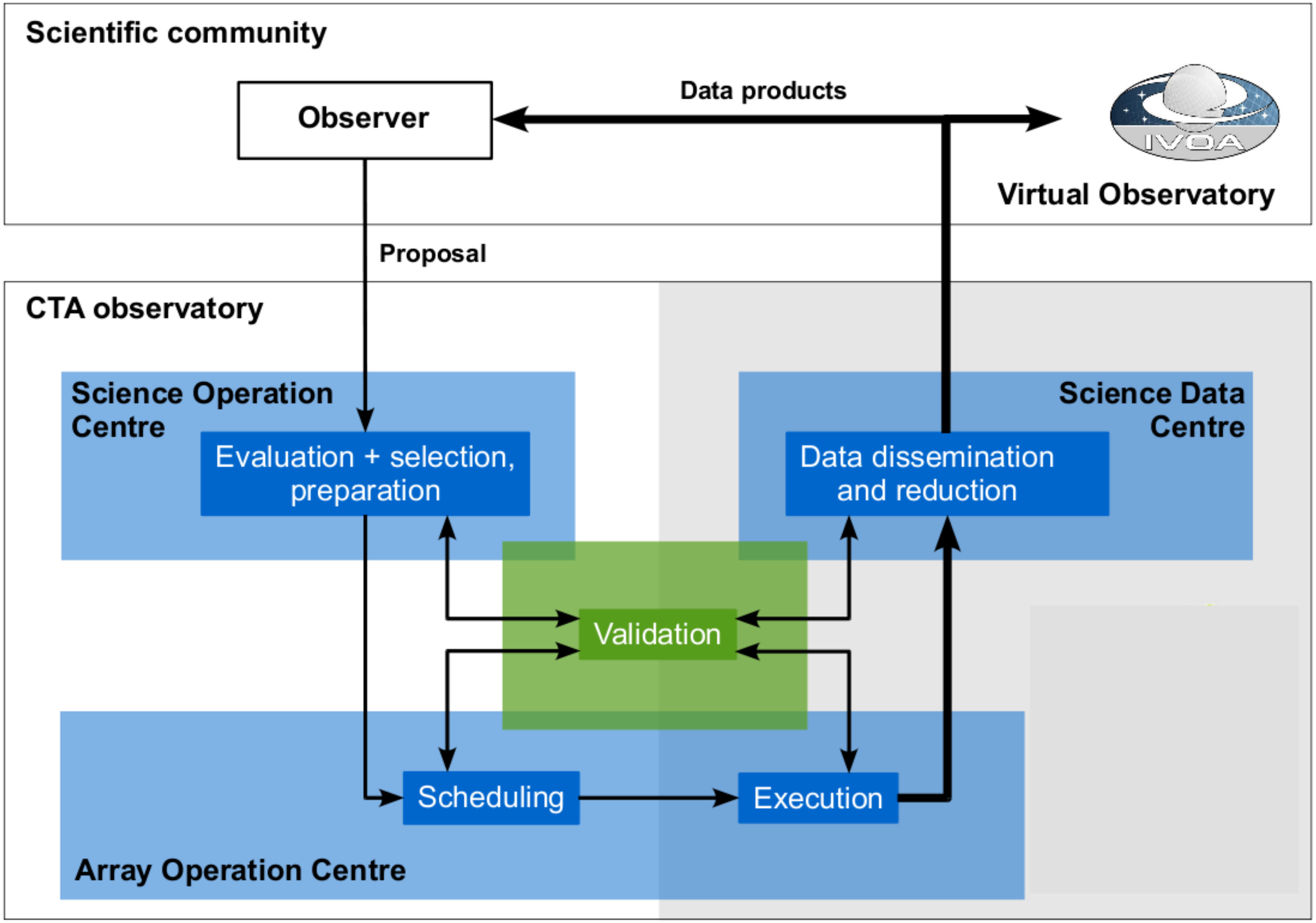
Cherenkov Telescope Array

cherenkov telescope array

2 Arrays: North+South→ All-Sky Coverage



CTA – Open obvervatory



CTA – DAQ and Array Control (ACTL)

- **Design Hardware and Software Systems, control/DAQ**
  - **Hardware components and hardware standards**
  - **Data streams, Data structures**
  - **Interfaces, Protocols**
  - **Software Systems**
  - **Safety implications**

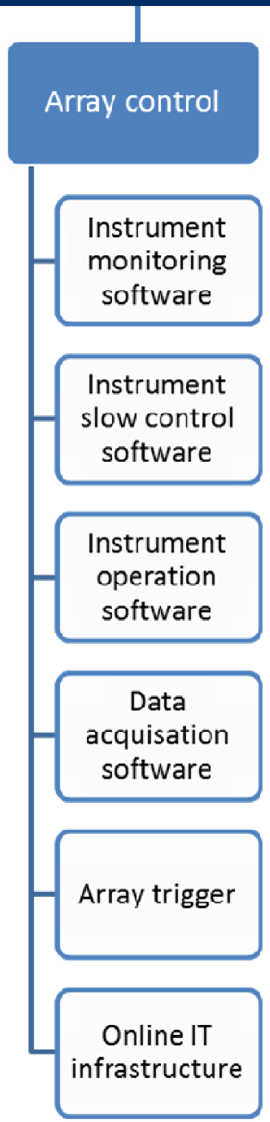
  - **Online Computing/IT infrastructure**
  - **Array Trigger**
  - **Test beds / Demonstrators**

MST prototype telescope used as a test environment

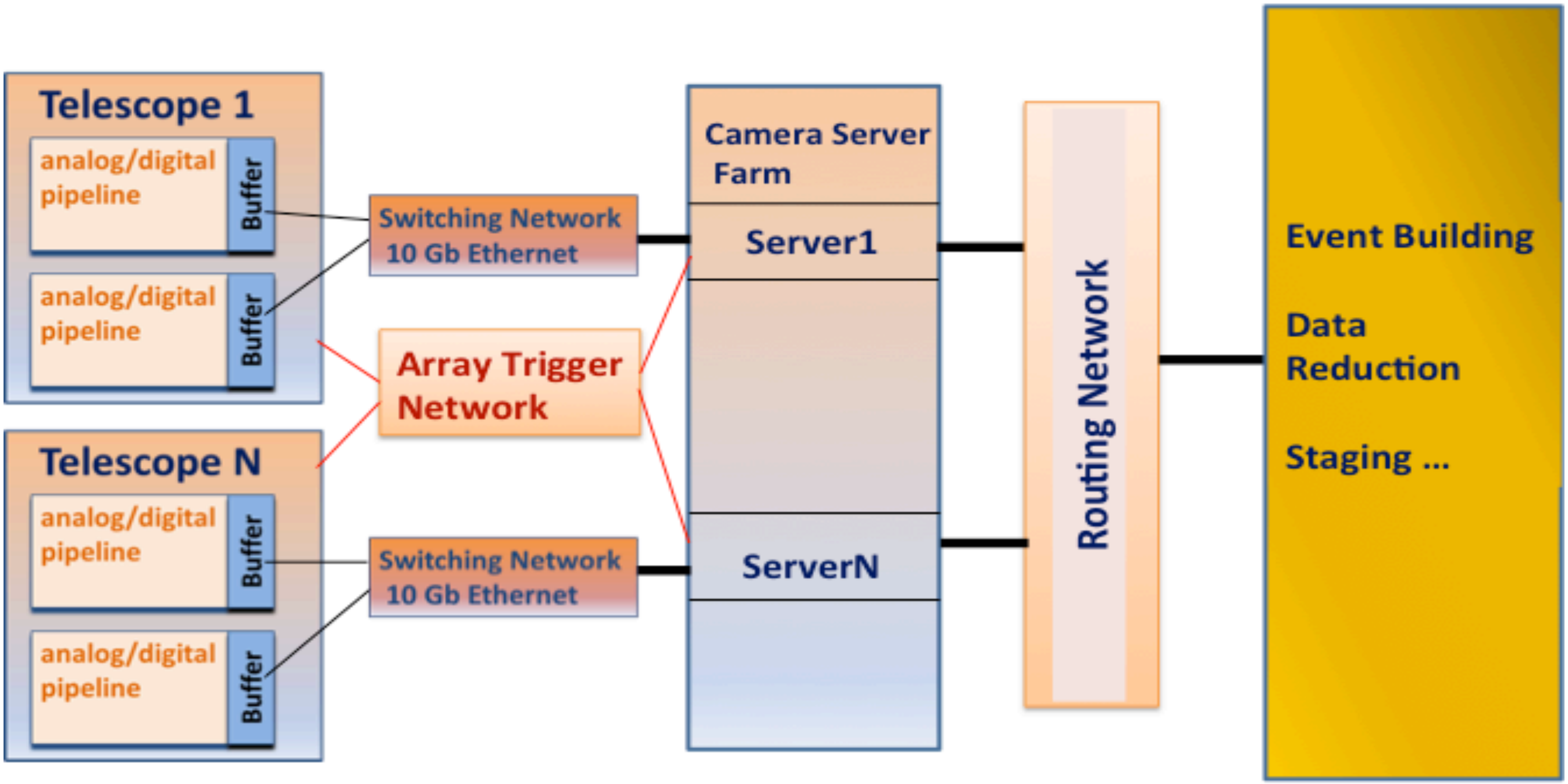
- **Readout/monitoring/control of various hardware**

  drives, devices, camera simulation – camera dummy

  Benefit from existing software packages and industrial standards wherever possible



DAQ/ACTL Networking Infrastructure



CTA Array Control – Layers, Key Technologies

cta
cherenkov telescope array

Interfaces

Application Layer

Control Layer

Data Transfer Layer

Device Layer

ACS

Alma Common Software (Alma, ESO)

DDS

Data Distribution Service for Real-time Systems

OPC UA

OPC Unified Architecture

ACS Framework (under investigation)

ACS – the common middleware for the ALMA software development, runs under Scientific Linux (RedHat Enterprise based distr. – Fermilab, CERN)

provides an XML configuration database (CDB)

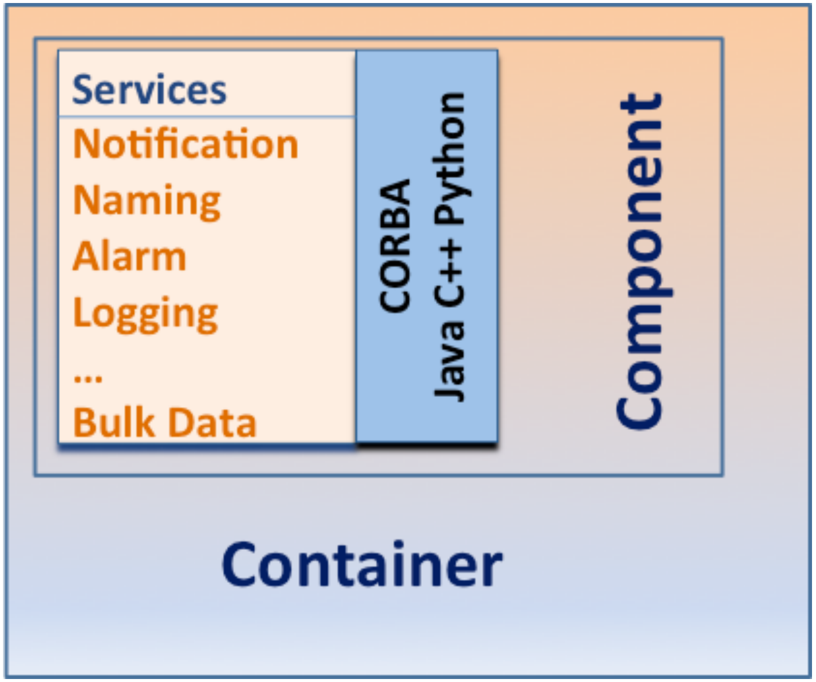
- **Containers, Components, Manager**

Employs several standard CORBA services

- **Notification service**
- **Naming service**
- **Interface repository**

Provides generic GUIs and tools for

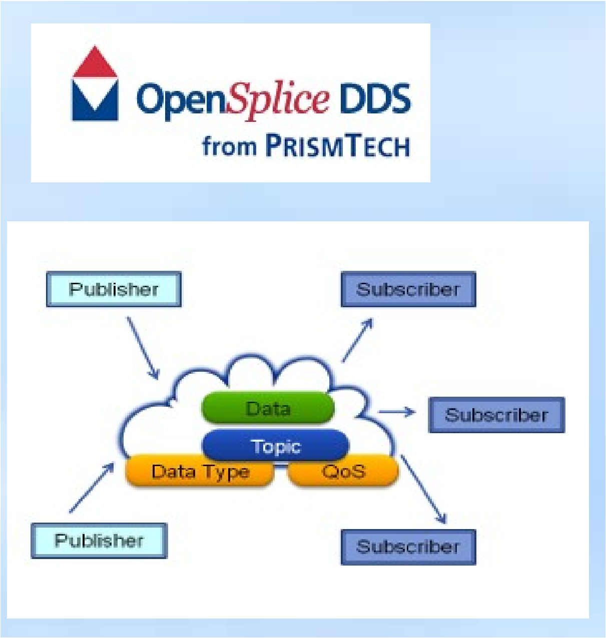
- **ACS Command Center,**
- **Logs Displayer, Object Explorer**
- **CDB Explorer, Alarm Display System**
- **…**



DAQ/ACTL DDS

Data Distribution Service for Real-time Systems (DDS) is a specification of a publish/ subscribe middleware for distributed systems created in response to the need to standardize a data-centric publish-subscribe programming model for distributed systems.

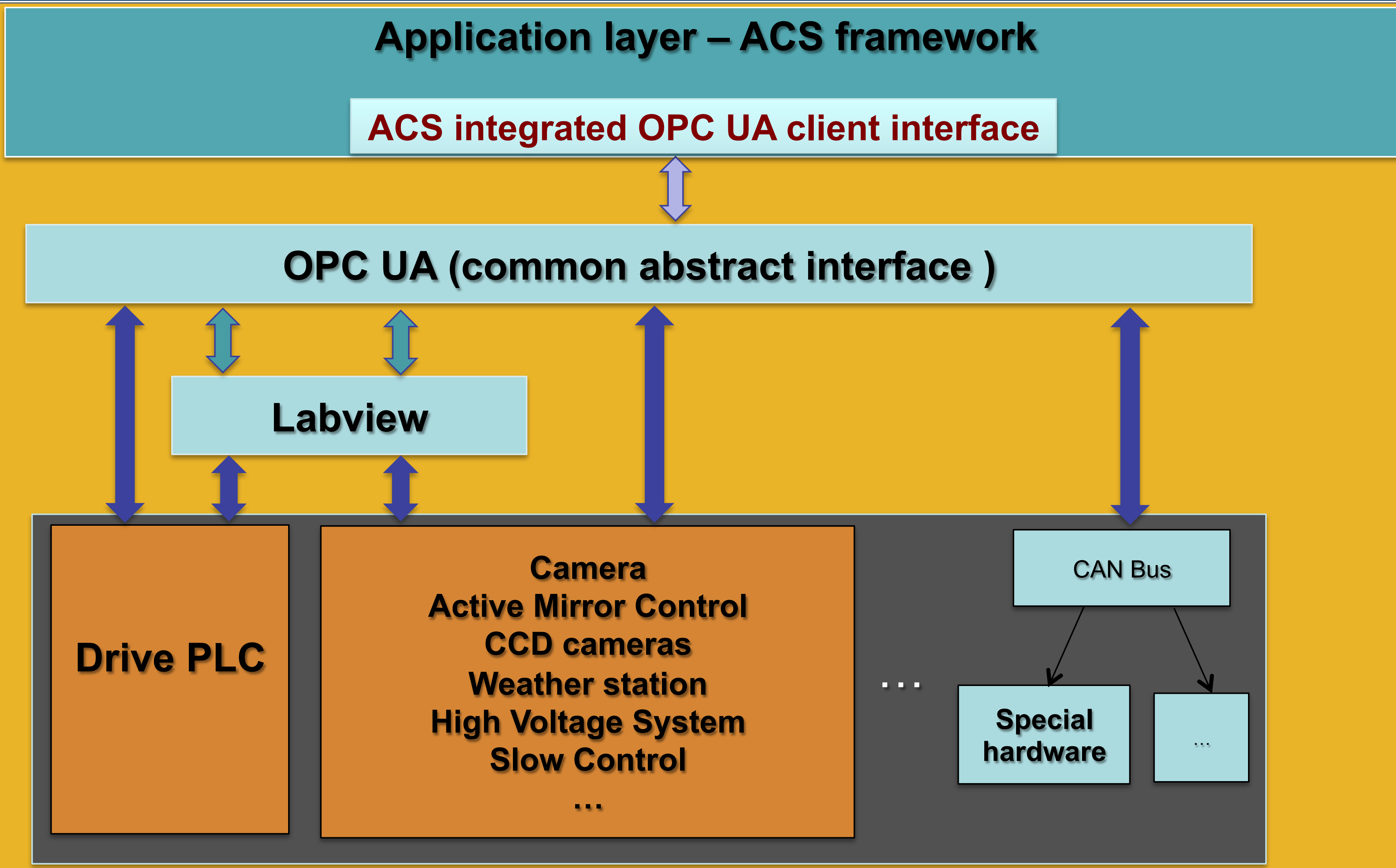
DDS is/will be integrated into ACS



RTI DDS

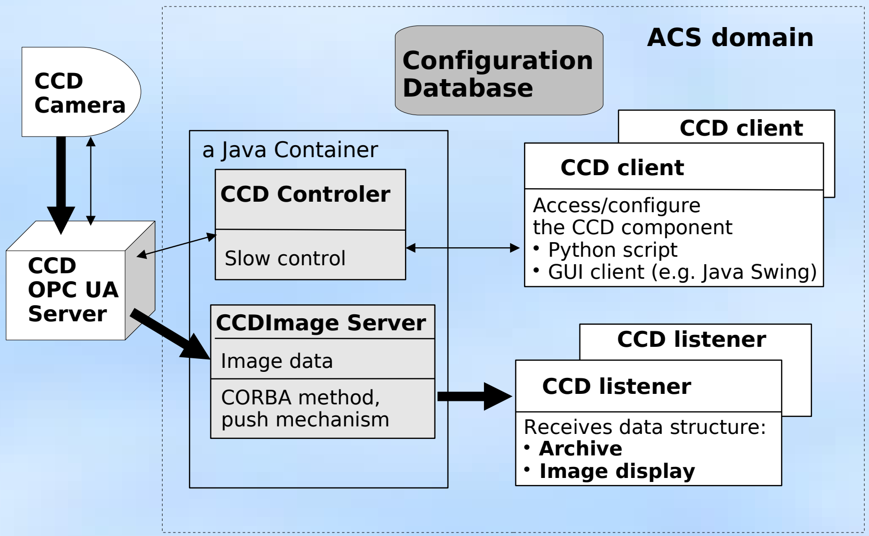
- Commercial DDS API
  - Latest release renamed as RTI Connext DDS
    - Not evaluated yet
- Widely used by the industry
  - 500 products using this middle-ware
  - 350 research and university projects
- OMG DDS compliant

OPC UA – Device level abstraction

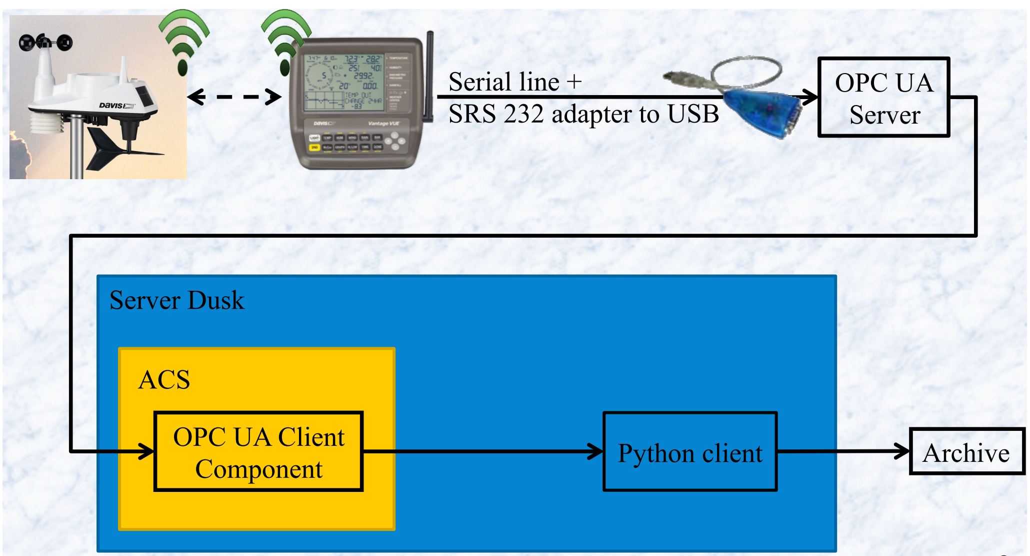


MST Prototype – ACS / OPC UA Implementation CCD cameras / Weather Station

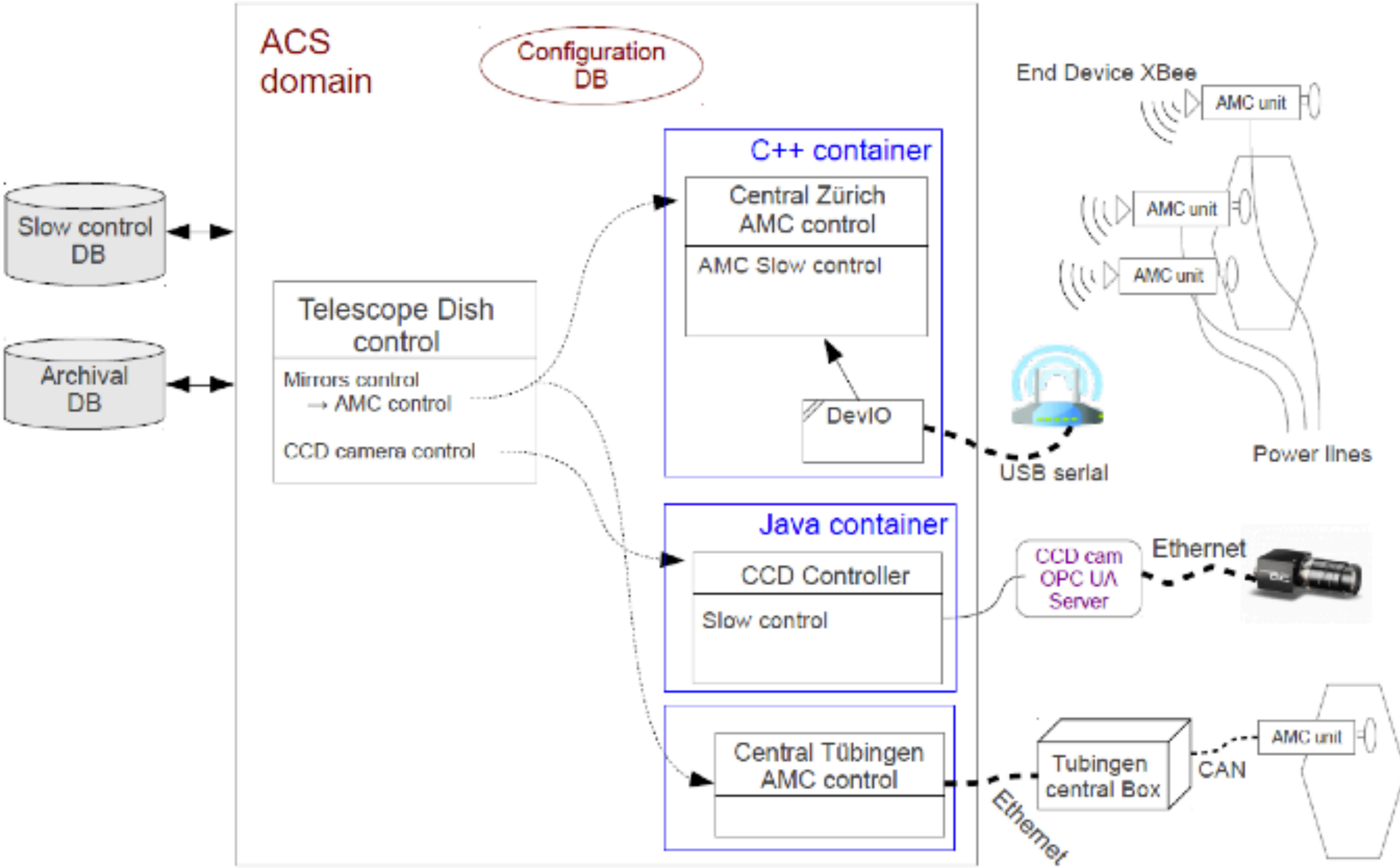
- 5 CCDs
- Max 10 Hz
- OPC UA+ACS
- Java impl
- Image Data to doc DB
- Slow control to MySql



Calibration of camera movement and pointing.
Mirror adjustment procedures (H.E.S.S. + VERITAS).
PSF measurement.
CCD+WS: Influence of the environment on the hardware.
Requirements for the prototype
Max 10 Hz required
8-12-16 bit precision.
Interleave LEDs On/Off



MST Prototype – ACS / OPC UA Implementation
Active Mirror Control



White Rabbit time synchronization (CERN, GSI)

Technology

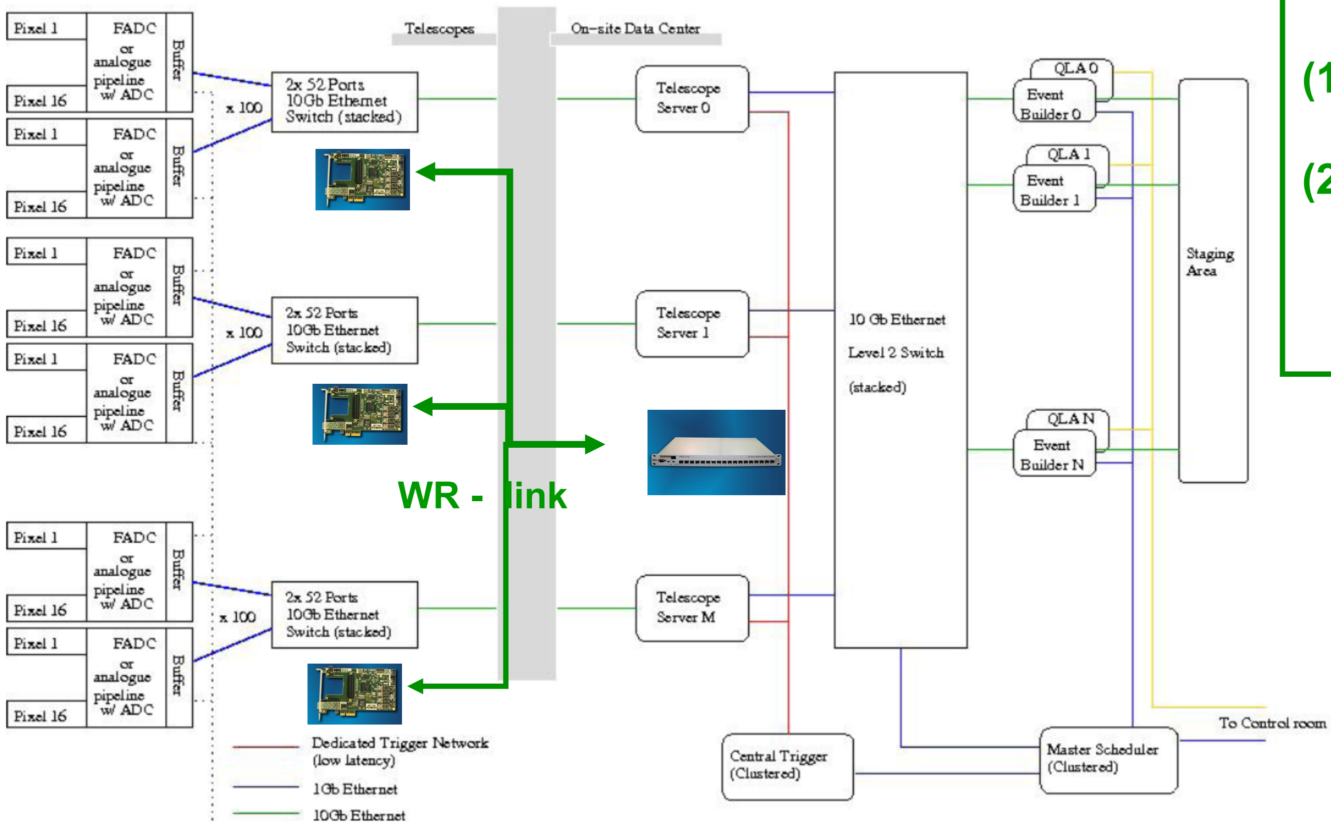
An extension to Ethernet

- **Synchronous mode (Sync-E) - common clock for physical layer in entire network, allowing for precise time and frequency transfer**
- **Deterministic routing latency - a guarantee that packet transmission delay between two stations will never exceed a certain boundary.**
- **Precision Time Protocol (IEEE1588), PTP**
  - ➢ **Synchronizes local clock with the master clock by measuring and compensating the delay introduced by the link.**
  - ➢ **Packet time stamping**
    Link delay is measured by exchanging packets with precise hardware transmit/receipt timestamps

(T. Wlostowski, CERN)

White Rabbit for Timing & ArrayTrigger

DAQ Architecture



Use the WR-link for

(1) nsec-timing cameras

(2) Array-trigger request / confirm messages (1Gbs) with guaranteed latency.

Here, we considered just the baseline functionality: Time-stamping of Camera trigger.
There many are more options, including development of CTA-WR boards;
Which could integrate FE/DAQ components with WR-cores.
E.g.: a WR-Mezzanine with DRS4 (or NecTar). (Ralf Wischnewski, DESY)

Summary

- The Cherenkov Telescope Array – CTA
  - North and South array with in each about 50 Telescopes operating together in full coincidence
  - 10 times more sensitive compared to HESS/MAGIC/ VERITAS, detection of 1000 new sources expected
  - By introducing 3 types of telescopes – extended energy range from 10 GeV to 200 TeV

- Complexity of CTA requires appropriate software frameworks and standard environments
  ACS (ALMA Common Software), OPC UA, and DDS are being evaluated

- First systems for the Berlin MST prototype implemented/tested