

On the Transients Handler for the Cherenkov Telescope Array Observatory

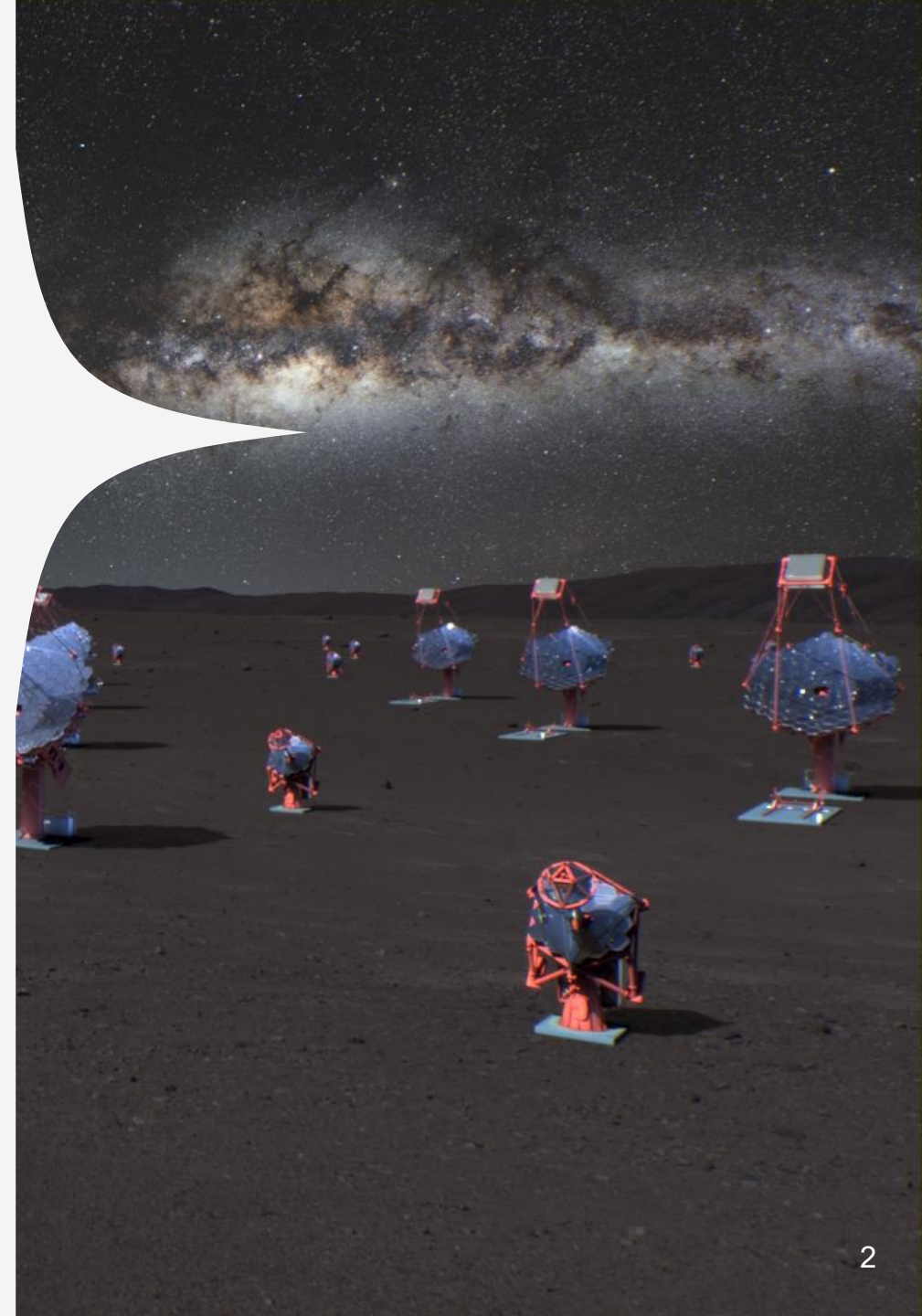
Astro COLIBRI, 2026



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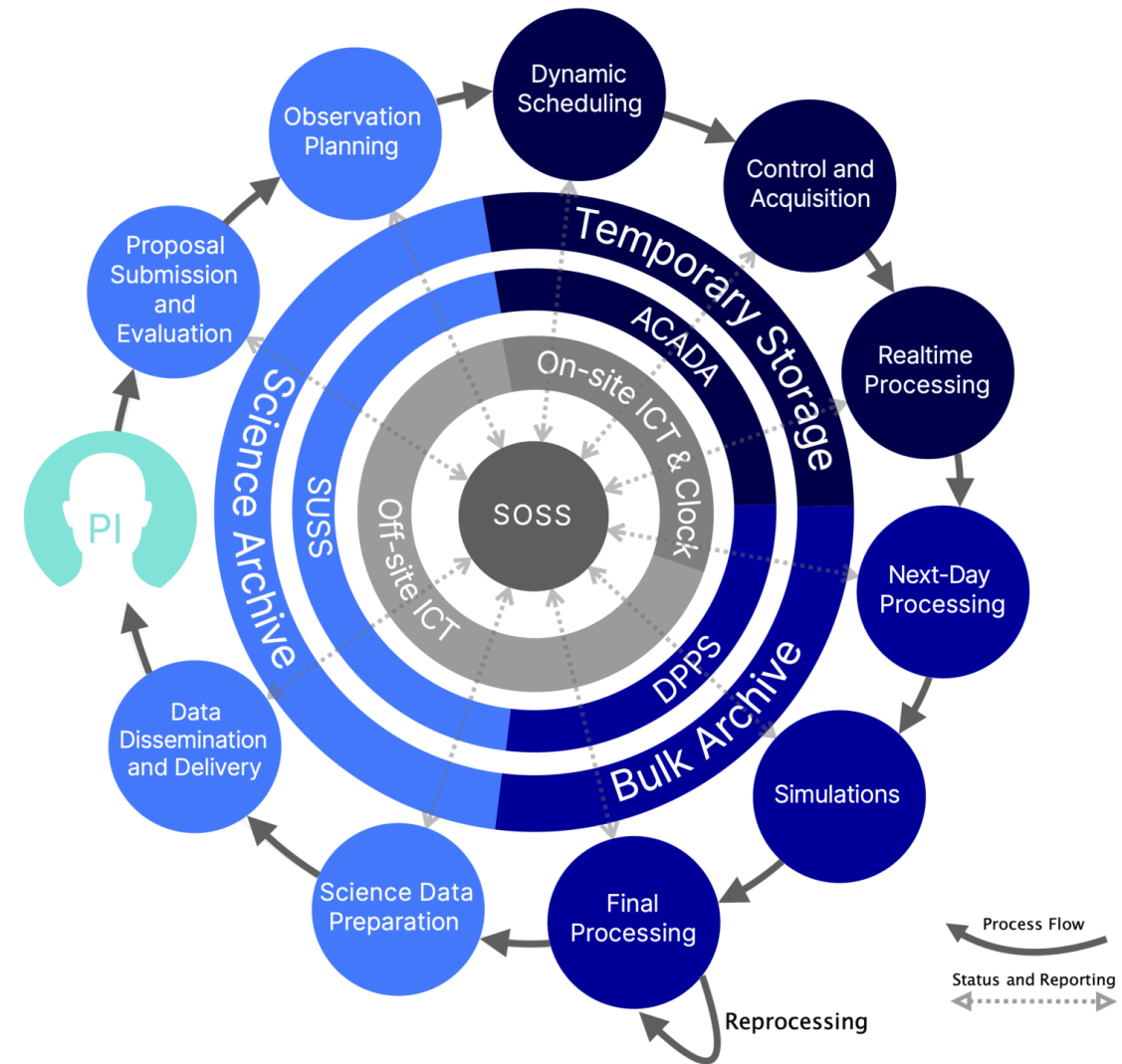
Cherenkov Telescope Array Observatory

- Next generation gamma-ray observatory located in two sites in the Northern (La Palma) and Southern Hemisphere (Chile) consisting of 64 telescopes.
- Three different telescope types covering a broad energy range from 20 GeV to 300 TeV
- In each site, the telescopes can be divided into subarrays to observe multiple parts of the sky simultaneously



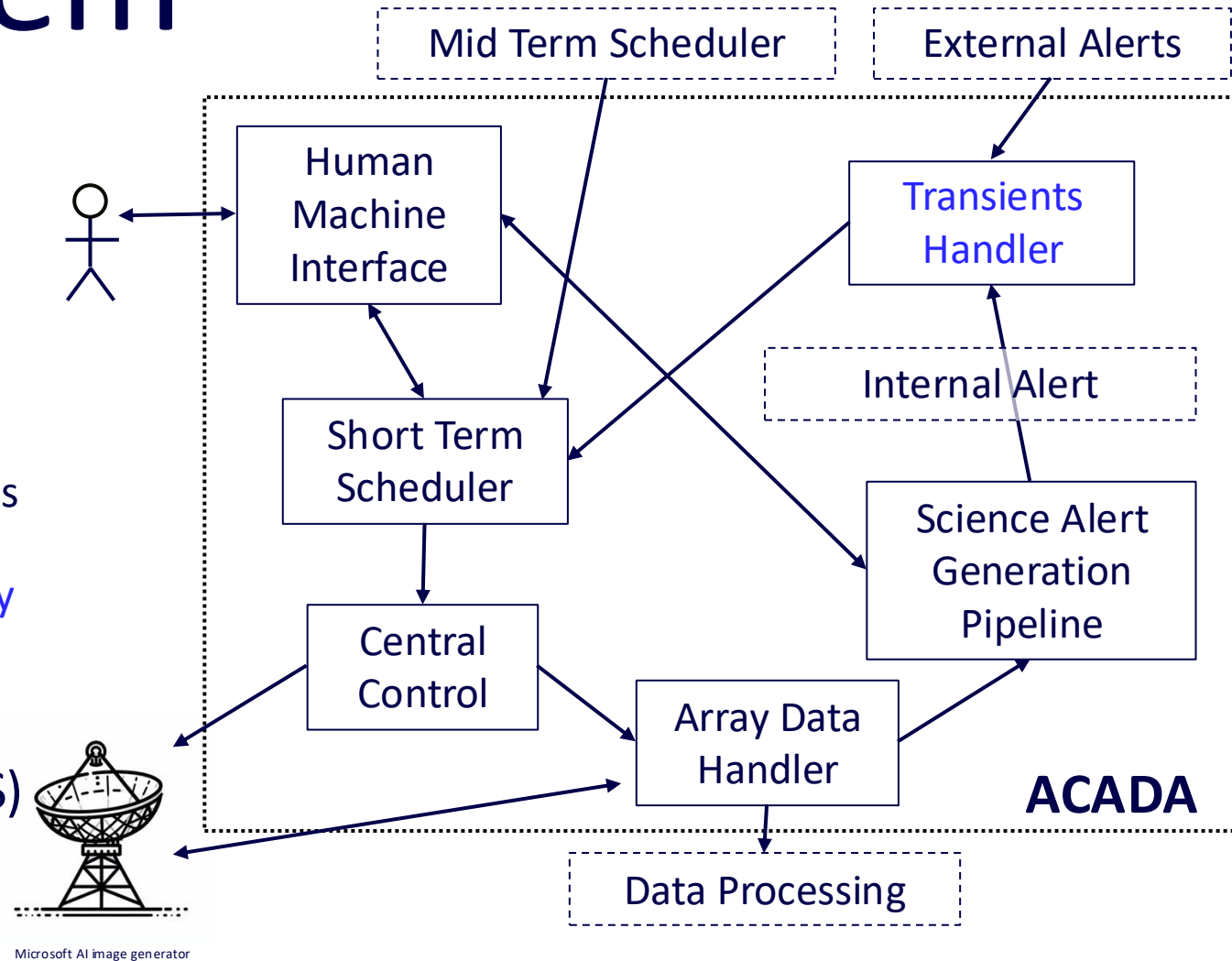
CTAO Software

- CTAO would not work without the software that controls the telescopes, to process and store the data and planning future observations
- Software Systems:
 - Array Control and Data Acquisition System (ACADA)
 - Data Processing and Preservation System (DPPS)
 - Science User Support System (SUSS)
 - Science Operations Support System (SOSS)



Array Control and Data Acquisition System

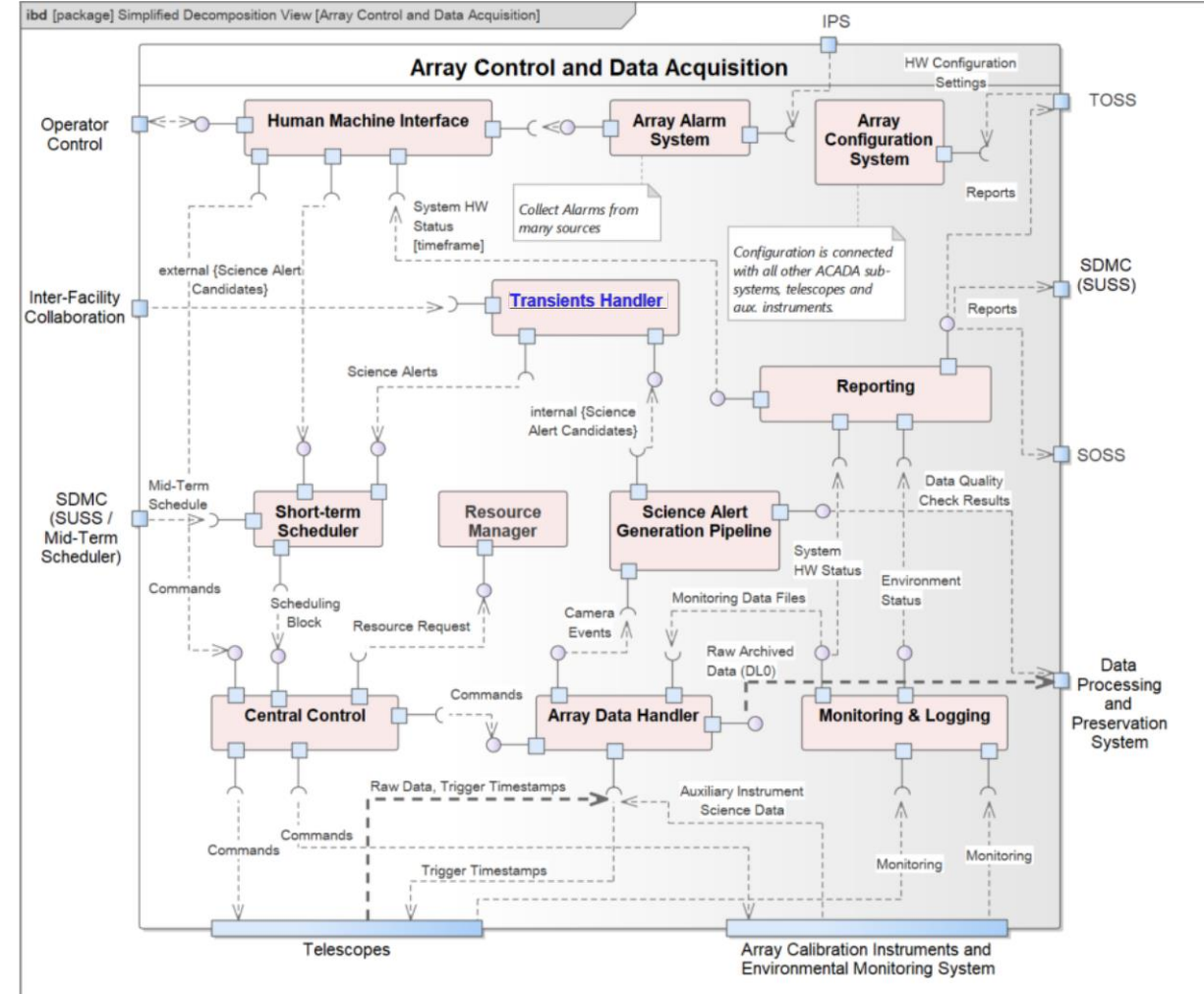
- The software deployed in both the North and South CTAO sites that enables CTAO to:
 - Operate sub-arrays of telescopes simultaneously
 - Schedule observations on short (minutes-hours) time scales
 - Coordinate observations between the two sites
 - React within seconds of receiving external and internal alerts reporting Targets of Opportunity (ToO)
- Consists of many sub-systems
- Based on the ALMA Control Software (ACS) framework*



*CORBA-based Common Software for the ALMA project, 2002, DOI:10.1117/12.461036.

Array Control and Data Acquisition System

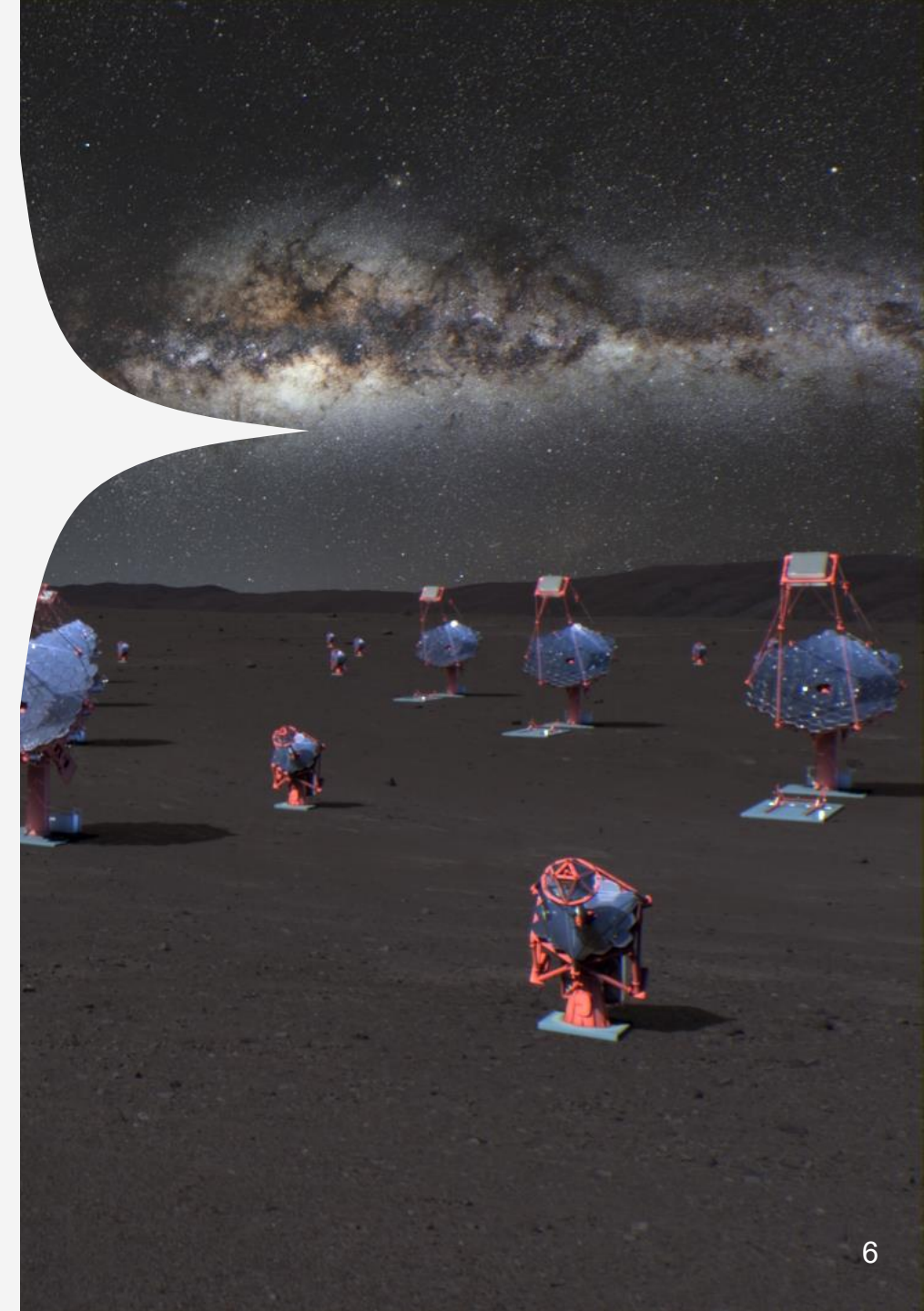
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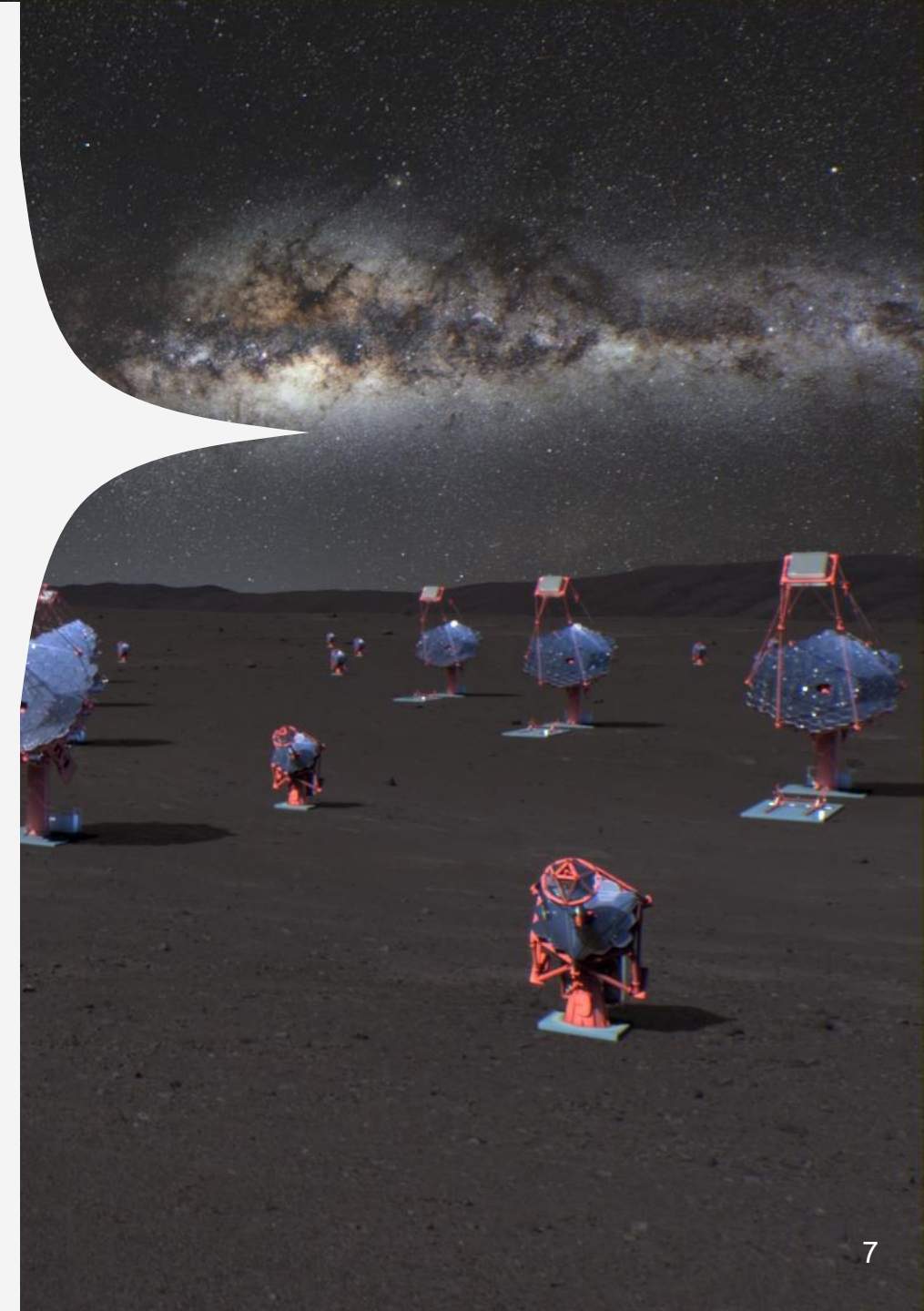
The Transients Handler (TH)

- With a relatively small field of view ($\sim 10^\circ$), CTAO will rely on external alerts (e.g. from IceCUBE, LIGO, Fermi-LAT, HAWC) to follow up on targets of opportunity (ToO)
- CTAO is expected to receive a few thousand alerts per night
- The Transients Handler is expected to process and schedule observations within 4 seconds of receiving an alert
- Relies on Python 3.12.0 with several python packages (e.g. numpy, astropy)

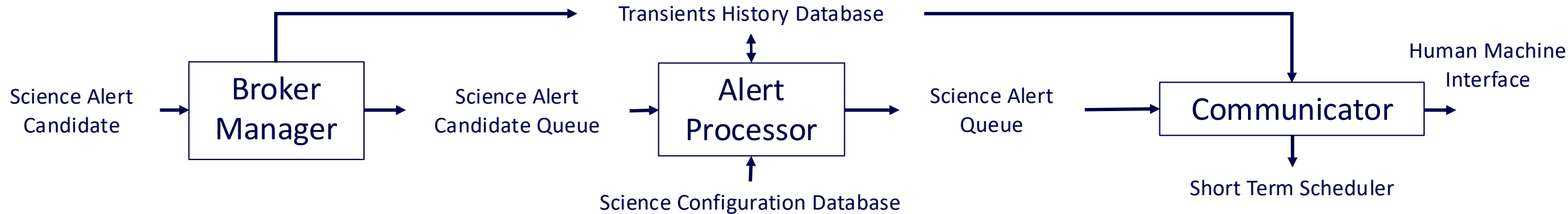


The Transients Handler (TH)

- Three instances of the TH will be deployed in CTAO
 - CTAO southern site
 - CTAO northern site
 - SUSS Transients Handler
- The TH instances onsite will handle alerts coming in during operation
- The SUSS TH will handle observation runs using both sites to follow up observations and how this affects the mid-term schedule of CTAO



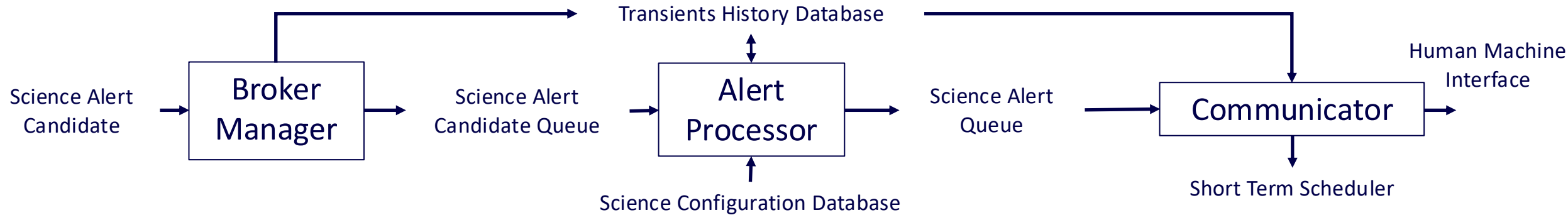
The Transients Handler



The Transients Handler (TH) is responsible for:

- Filtering both internal and external alerts matching to scientific proposals
- Processing of alerts according to the corresponding scientific configuration to determine the optimal observation schedule
- Submission of scheduling blocks to the Short Term Scheduler (STS)
- Broadcasting of events detected by CTAO

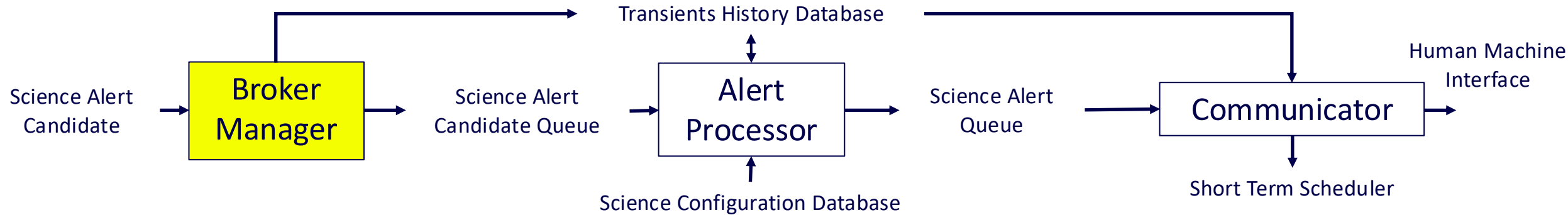
The Transients Handler



The Transients Handler consists of:

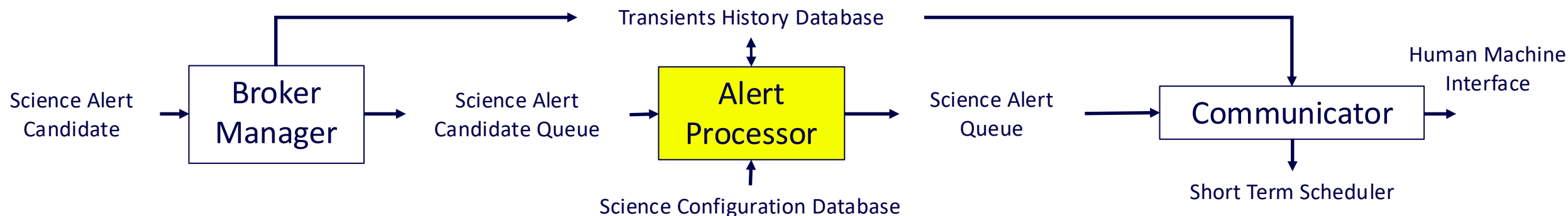
- Three Components (Broker Manager, Alert Processor and the Communicator)
 - The components between the TH and other subsystems communicate through the Alma Common Software (ACS) network
- Two Databases (TH database and the Science Configuration Database)
- Two internal Queues (Science Alert Candidate Queue and the Science Alert Queue)

Broker Manager



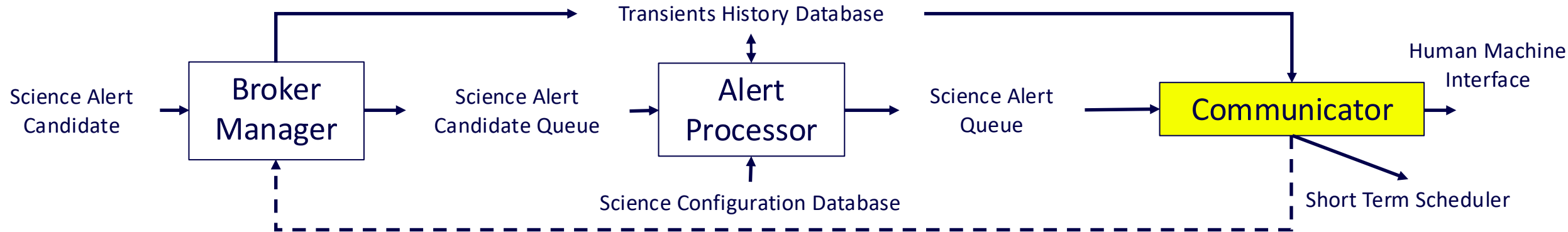
- Manages the internal and external brokers that receive/send science alert candidates (SACs):
 - External brokers receive alerts from external observatories such as the General Coordinates Network (GCN) using VOEvent format
 - Internal brokers receive alerts from the Science Alert Generator (SAG) or the Science User Support System (SUSS)
 - Alert Broadcaster to publish alerts to internal/external brokers
- Basic filtering and archival of alerts to the Transients History database before passing the alert to the SAC queue

Alert Processor



- Reads the alert from the SAC queue
- Matches the alert to a science configuration and processes alert according to the configuration:
 - Calculation of observation windows based on current conditions
 - Download localisation information for (e.g.) GW alerts from the LIGO/Virgo Consortium Data centres
 - Calculation of correlation maps
 - Determining the optimum scanning pattern of telescopes
- Passes the science alert (SA) to the SA queue

Communicator



- Reads alerts from the SA queue
- Communicates alerts to other subsystems of ACADA (e.g. STS) and broadcasts alerts to external observatories via the Broker Manager:
 - Builds/updates/cancels scheduling blocks and passes results to the Short Term Scheduler (STS)
 - Displays information on recent/new science alerts to the Human Machine Interface (HMI)
 - Monitors the state of the TH

Quality Control

- Level C: Transients Handler
 - Unit Tests
 - Requirement Tests
 - Performance Tests
 - Jenkins Pipeline
 - SonarQube

```

#####
b'<?xml version="1.0" ?>\n<voe:VOEvent xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"\nxmlns:voe="http://www.ivoa.net/xml/VOEvent/v2.0"\nxmlns:xsi:schemaLocation="http://www.ivoa.net/xml/VOEvent/v2.0 http://www.ivoa.net/xml/VOEvent-v2.0.xsd"\n version="2.0" role="test" iivorn="ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1">\n  <shortName>cta-th</shortName>\n  <contactName>self.author</contactName>\n  </Author>\n  </Who>\n  </WhereWhen>\n  </ObsDataLocation>\n  <ObservatoryLocation id="GEOSURFACE"/>\n  <ObservationLocation>\n    <Time unit="s">\n      <Position2D unit="deg">\n        <C2>41.777407</C2>\n      </Value2>\n    </Position2D>\n  </ObsDataLocation>\n  </WhereWhen>\n</voe:VOEvent>\n</>
#####
(component_utils.py:54)
2023-10-10 23:00:00 [ WARNING] Found science configurations with the same name more than once. (science_configs.py:125)
2023-10-10 23:00:00 [ WARNING] Found science configuration Swift-GRB-follow-up 2 times. Choosing one based on priority (science_configs.py:132)
2023-10-10 23:00:00 [ INFO] Found 1 matching science configs for science alert 'ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1' (RawAlertManager.py:97)
selection = earliest
2023-10-10 23:00:00 [ INFO] + Tasks report: (pipelines.py:109)
2023-10-10 23:00:00 [ INFO] | ObservationWindow - PASS (pipelines.py:110)
2023-10-10 23:00:00 [ INFO] + Post-action report: (pipelines.py:122)
2023-10-10 23:00:00 [ INFO] | CreateDefaultSchedulingBlock DONE (pipelines.py:131)
2023-10-10 23:00:00 [ INFO] | AddObservationConstraints DONE (pipelines.py:131)
2023-10-10 23:00:00 [ INFO] | FillOBList DONE (pipelines.py:131)
2023-10-10 23:00:00 [ INFO] Processed science alert 'ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1' with science config 'T_UC_130_3_1'. (ExecuteManager.py:63)
2023-10-10 23:00:00 [ INFO] Sending result of science alert 'ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1' with science config 'T_UC_130_3_1' to ResultManager. (ExecuteManager.py:80)
2023-10-10 23:00:00 [ INFO] Entering ResultManager with T_UC_130_3_1 for 'ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1'. (ResultManager.py:48)
2023-10-10 23:00:00 [ INFO] Positive validation of science alert 'ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1' with science config 'T_UC_130_3_1'. Asking for immediate action. (ResultManager.py:79)
2023-10-10 23:00:00 [ INFO] Finished processing of science alert 'ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1'. (ResultManager.py:112)
2023-10-10 23:00:00 [ INFO] Overview of science alert
Processed alert: ivo://ctao.cta.th/test_stream/2023_10_10_23_00_00#T_UC_130_3_1
Observation window (UTC)
from: Tue 10 Oct 2023, 11:01PM
to: Tue 10 Oct 2023, 11:22PM
SB was sent to STS: False
SB ID: 1303110 (Communicator.py:134)
2023-10-10 23:00:00 [ INFO] Stopping the AlertProcessor - New alert candidates will be rejected. Processing of already queued alert candidates will be completed. (AlertProcessor.py:107)
2023-10-10 23:00:00 [ INFO] TH_AlertProcessor has stopped pulling from queue. (component.py:85)
2023-10-10 23:00:00 [ INFO] Successfully stopped the AlertProcessor. The Transients Handler is in OFFLINE MODE now. (AlertProcessor.py:117)
2023-10-10 23:00:00 [ INFO] TH_Communicator has stopped pulling from queue. (component.py:85)
PASSED

```

Quality Control

- Level C: Transients Handler
 - Unit Tests
 - Requirement Tests
 - Performance Tests
 - Jenkins Pipeline
 - SonarQube
- Level B: ACADA Level
 - Use Case Tests

REL2: UC130-1.1 React to an External Science Alert

[Edit](#)

Open Issue created 3 months ago by Arne

Summary and Scope: An external Science Alert is received by ACADA. The TH evaluates the Alert, applying filtering and prioritization methods, and requests to the Support Astronomer an acknowledgment before requiring the STS to modify the current schedule. The CC executes the observations of the Science Alert (target of opportunity). If the Support Astronomer rejects the request, the Alert is not executed.

Quality Control

- Level C: Transients Handler
 - Unit Tests
 - Requirement Tests
 - Performance Tests
 - Jenkins Pipeline
 - SonarQube
- Level B: ACADA Level
 - Use Case Tests
- Level A: On site
 - 3-4 times a year



<https://www.flickr.com/photos/ctao-universe/>

Release 2 of TH

- Released in August 2026
- Inclusion of Neutrino and Gravitational Wave as science cases using Tilepy*
- Move from the GCN classic to the new GCN maintained by NASA
- The inclusion of an internal broker with the ability to receive internal alerts
- Further interfacing with other ACADA subsystems
- Developments for better maintainability and efficiency

*<https://github.com/astro-transients/tilepy>



ACADA Release 3

- Release 3 planning started in August 2026 with the release date in May 2027
- Inclusion of alert updates in the TH pipeline
 - Repositioning of Telescopes
 - Increase/decrease of observation time
 - Retraction of alert
- Speeding up the time it takes to process GW and Neutrino alerts



Summary

- The Transients Handler allows CTAO the means to handle internal and external alerts within four seconds of receipt
- With CTAO expecting a few thousand of alerts per night, the TH filters these alerts and calculates observation windows and scheduling blocks based on dynamically changing circumstances
- Release 2 of the Transients Handler/ACADA was released in August 2026 and included Gravitational Waves and Neutrino alerts as science cases
- Release 3 will occur in May 2027 and will heavily focus on updates to alerts

Author List



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- d) CIEMAT, Avda. Complutense 40, 28040 Madrid, Spain



Backup Slides

Example Science Alert

- Currently in VOEvent format
- Includes information such as
 - Author
 - Time of event
 - Coordinate or event/localisation map
 - Further information about pipeline of instrument
- Migrate to JSON formatting in Release 3

```
<ns0:VOEvent xmlns:ns0="http://www.ivoa.net/xml/VOEvent/v2.0" xmlns:xsi="ht
  <Who>
    <Date>2026-09-22T12:00:04</Date>
    <Author>
      <title>CTA Transients Handler</title>
      <shortName>cta-th</shortName>
      <contactName>voevent.cta.th/GRB_alert_generator</contactName>
    </Author>
  </Who>
  <What>
    <Param name="alert_channel" dataType="string" value="GENERATED" />
  </What>
  <WhereWhen>
    <ObsDataLocation>
      <ObservatoryLocation id="GEOSURFACE" />
      <ObservationLocation>
        <AstroCoordSystem id="UTC-FK5-GE0" />
        <AstroCoords coord_system_id="UTC-FK5-GE0">
          <Time unit="s">
            <TimeInstant>
              <ISOTime>2026-09-22 12:00:04.526529</ISOTime>
            </TimeInstant>
          </Time>
          <Position2D unit="deg">
            <Name1>RA</Name1>
            <Name2>DEC</Name2>
            <Value2>
              <C1>229.368668</C1>
              <C2>87.204854</C2>
            </Value2>
            <Error2Radius>0.100000</Error2Radius>
          </Position2D>
        </AstroCoords>
      </ObservationLocation>
    </ObsDataLocation>
  </WhereWhen>
</ns0:VOEvent>
```

Example Science Configuration

- Will be maintained by SUSS in the future but currently, the TH uses yaml files
- Science Configurations contain a set of instructions that processes alerts to follow up on Targets of Opportunity (ToOs)
- Each science configuration is separated into Tasks and Post Actions:
 - Tasks are the instructions that processes the information from the alert directly and determine whether the alert passes criteria. For example: the calculation of an observation window and check whether this window meets the minimum time duration
 - Post Actions act on the results of the tasks and generates the final information to be used by ACADA. This can include the create of a Scheduling Block and the inclusion of further observational constraints (e.g. use Wobble Mode with two positions with an offset of 0.2°)