STATUS OF THE ACS-BASED CONTROL SYSTEM OF THE MID-SIZED TELESCOPE PROTOTYPE FOR THE CHERENKOV TELESCOPE ARRAY (CTA)

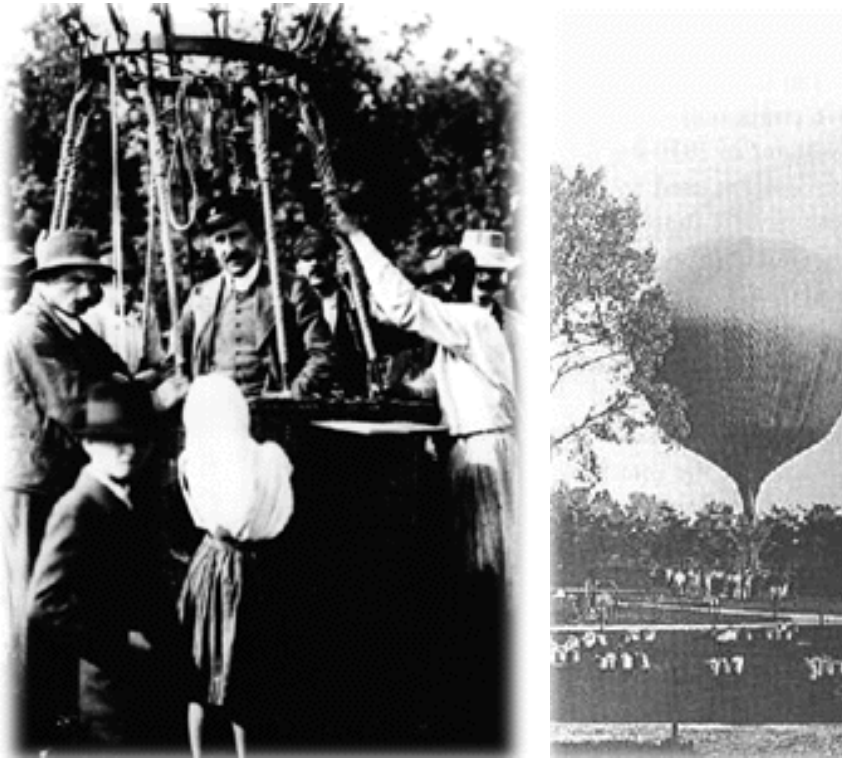
Peter Wegner

ICALEPCS 2013, San Francisco, Oct. 09th, 2013

Cosmic rays

Victor F. Hess 1912
(Nobel Prize 1936)

Cosmic rays



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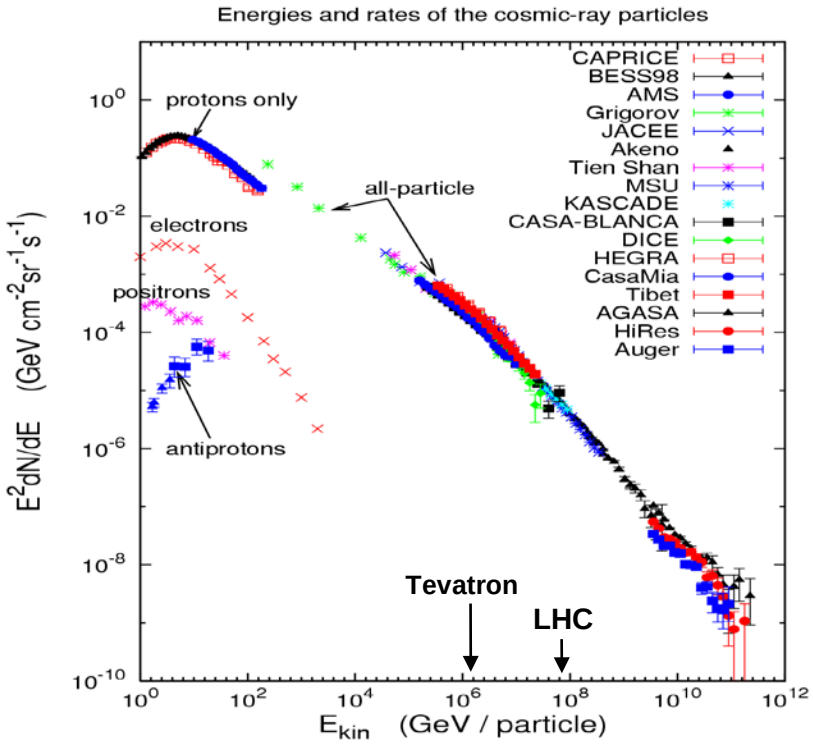
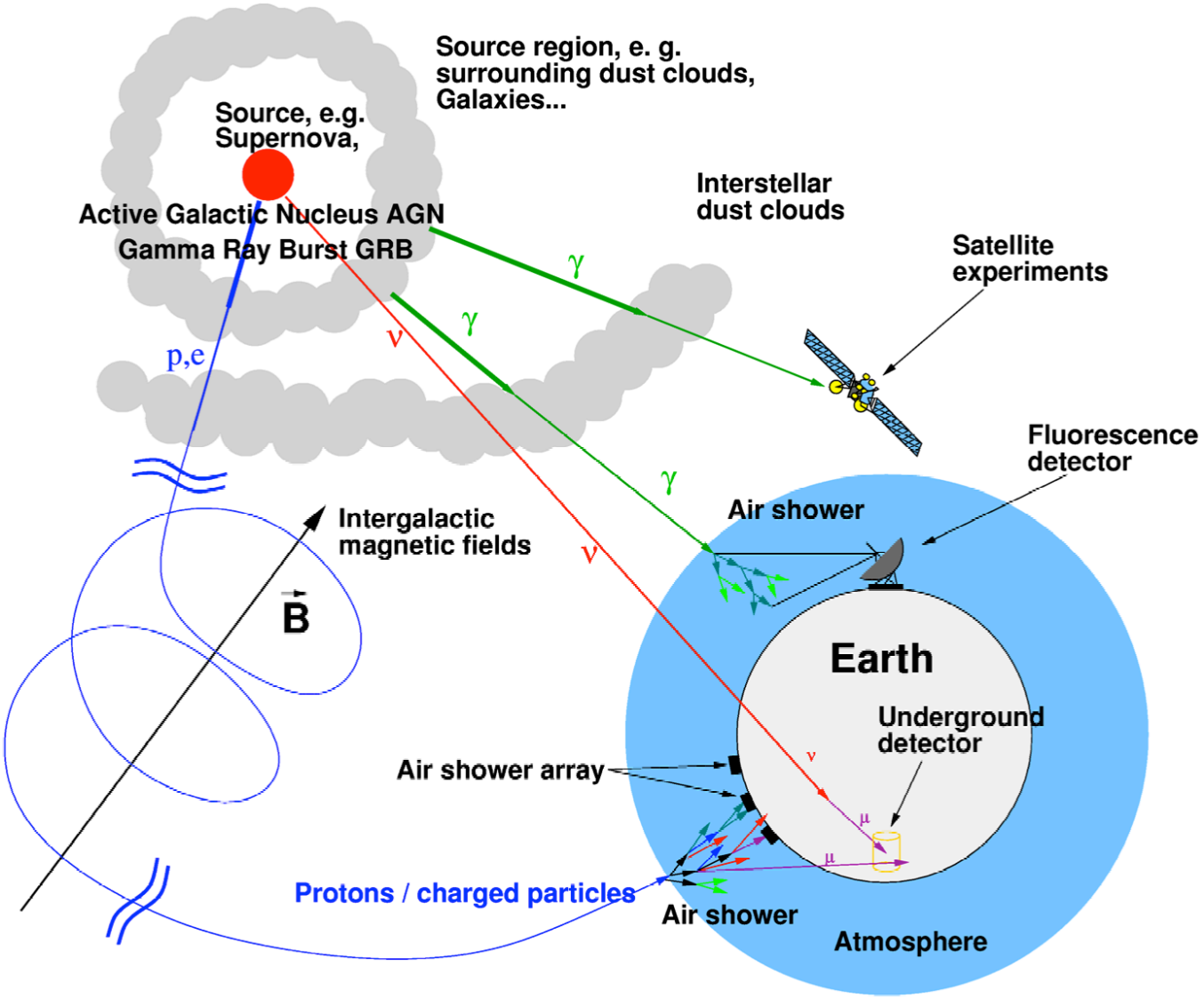
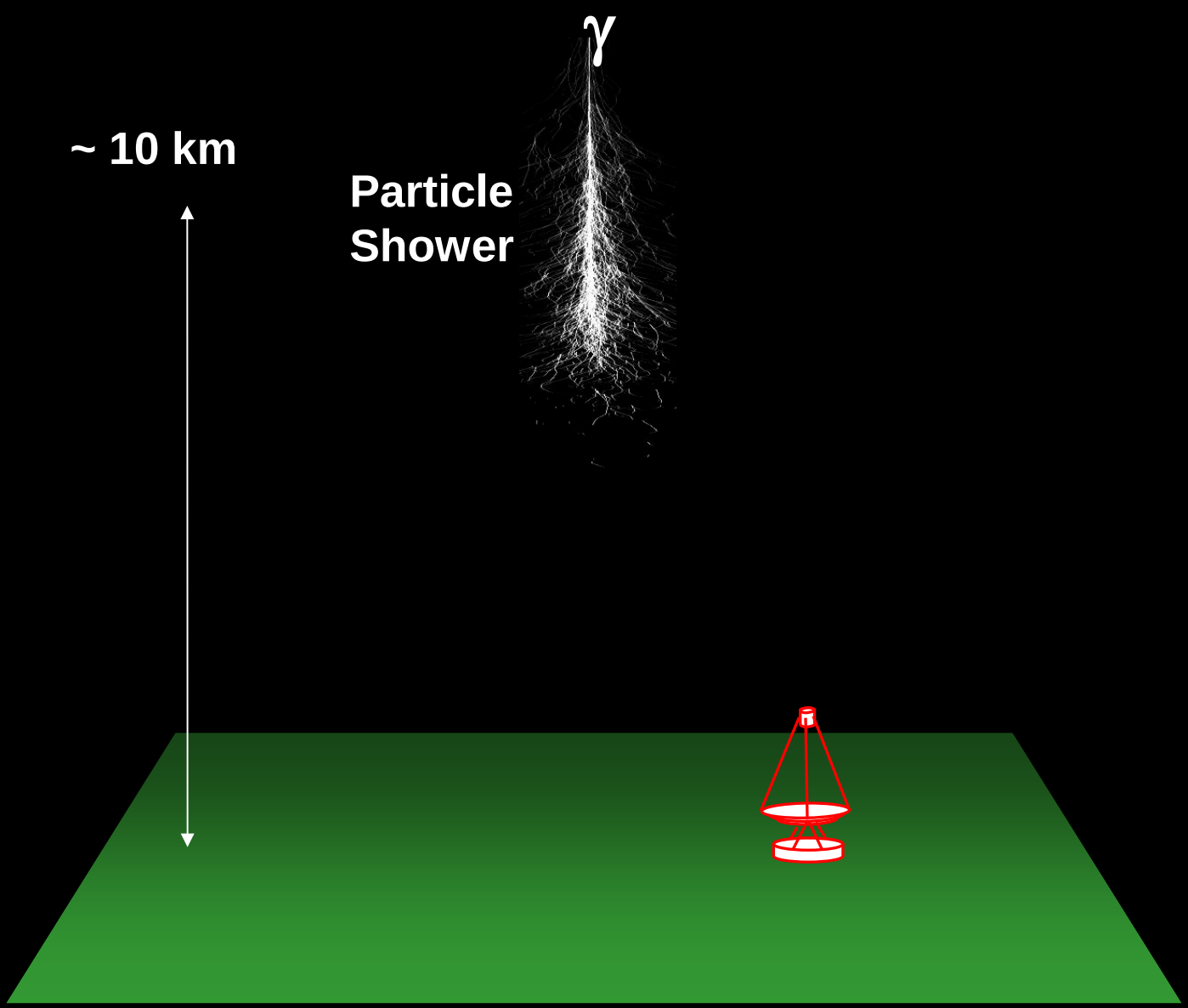


Origin of cosmic particles



Detection of Cosmic Rays and Gamma Rays



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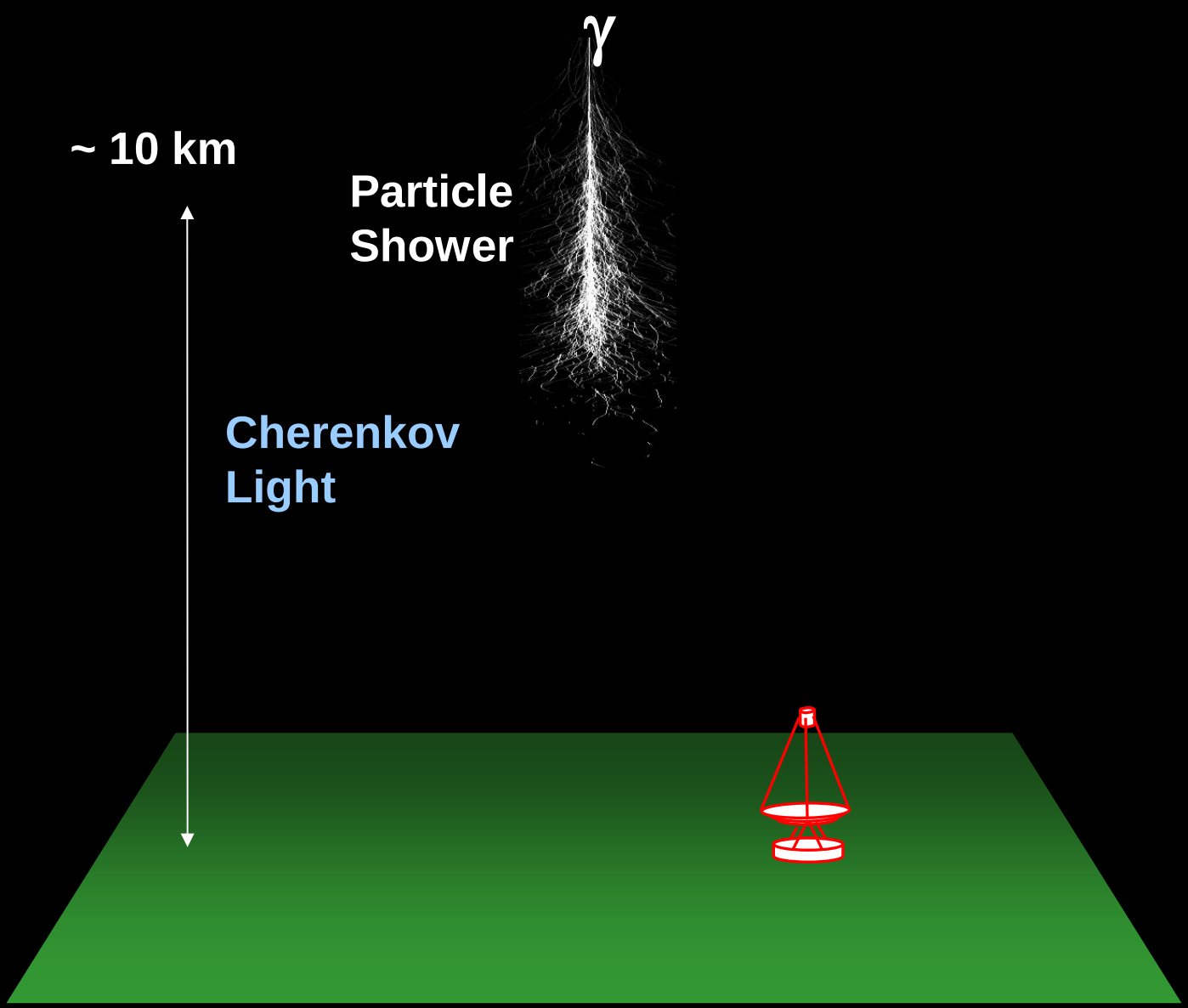

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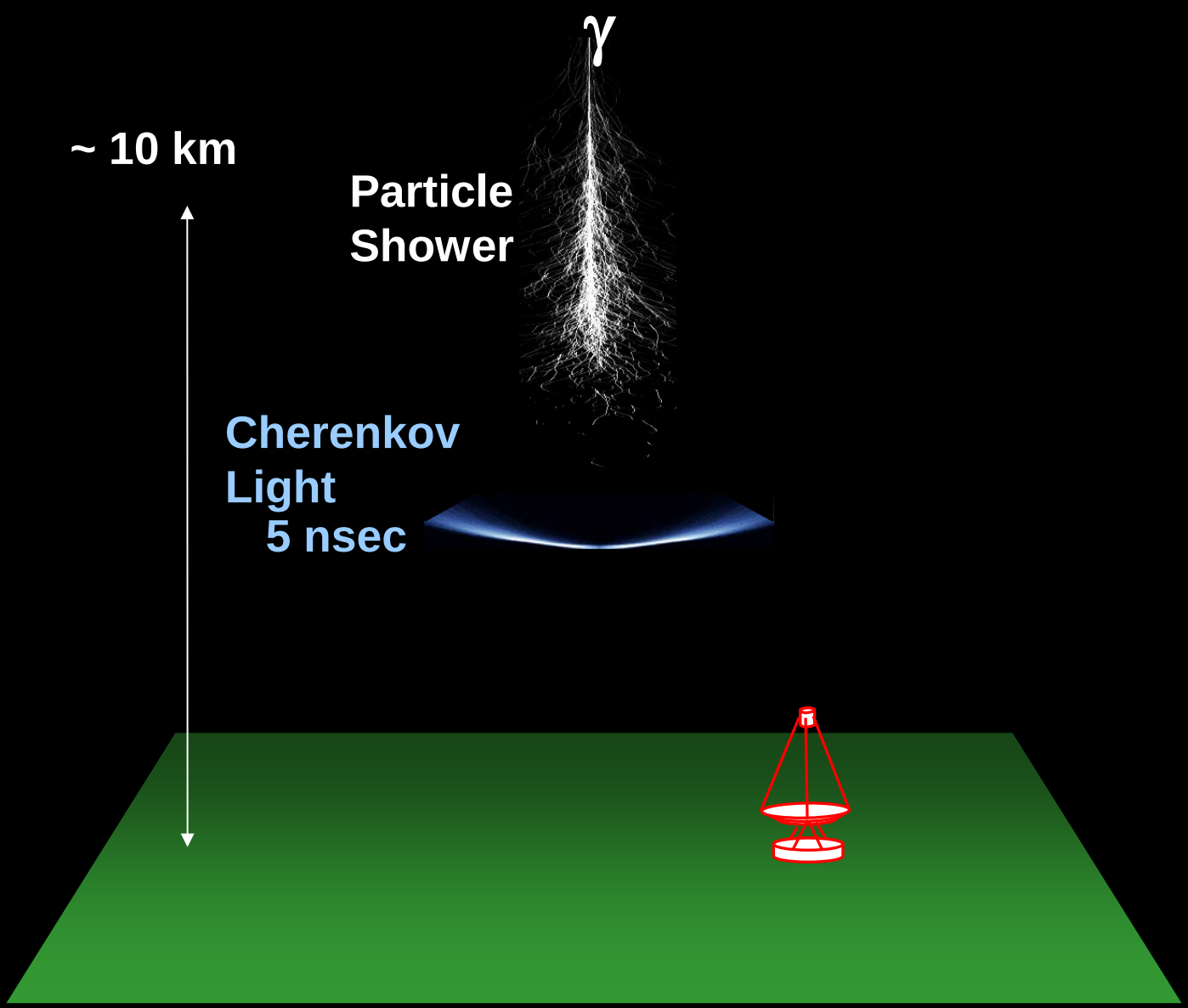

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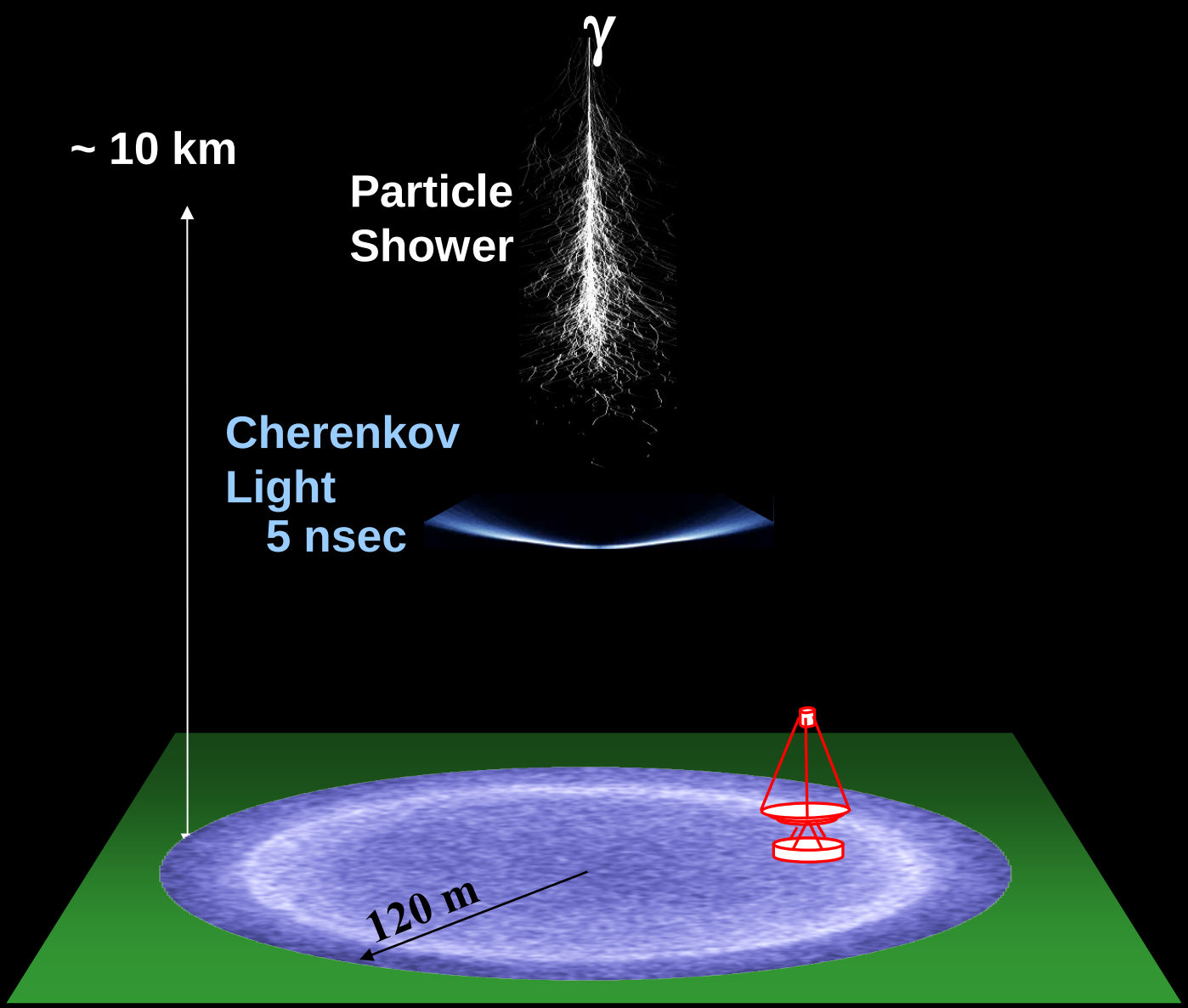

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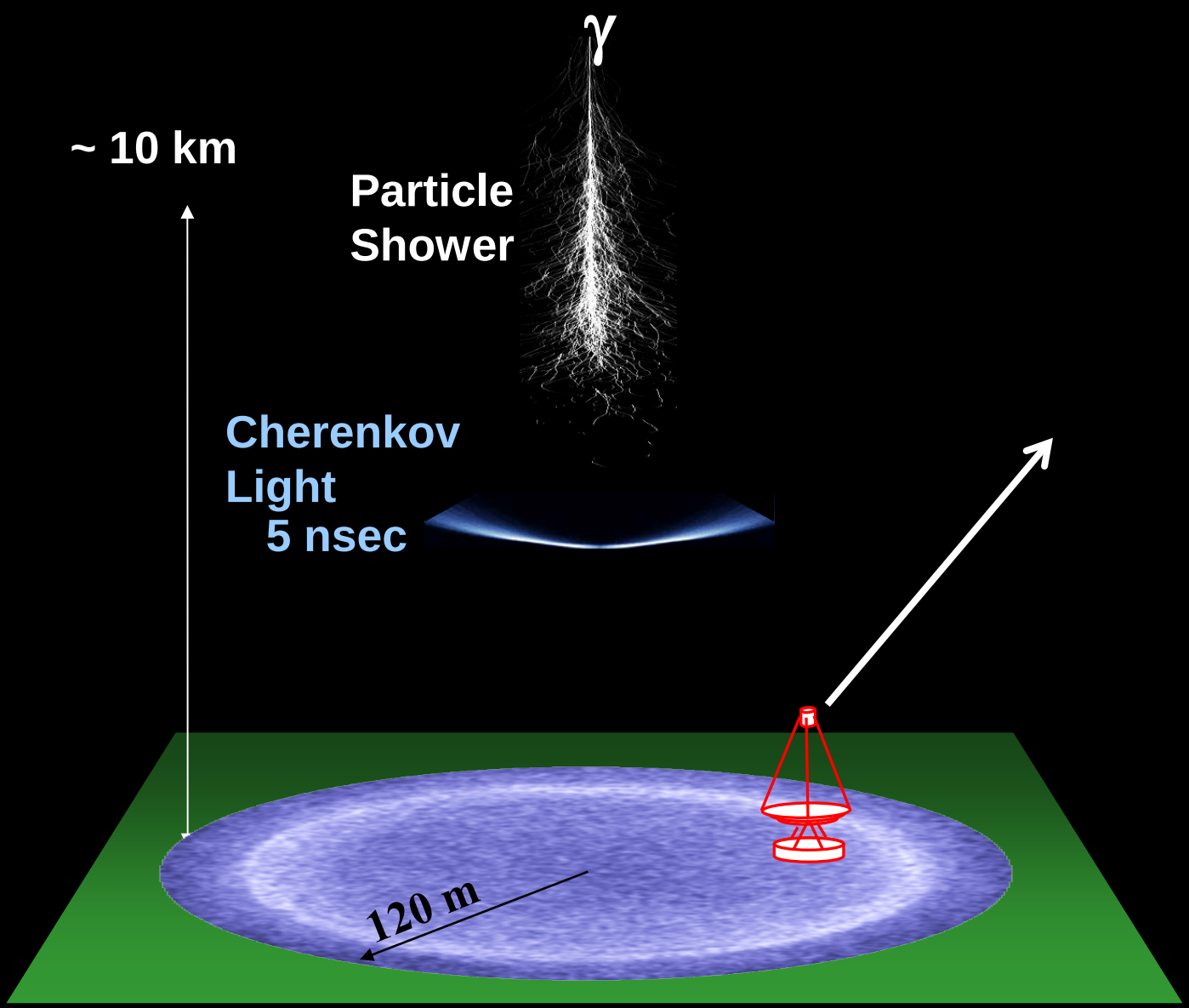

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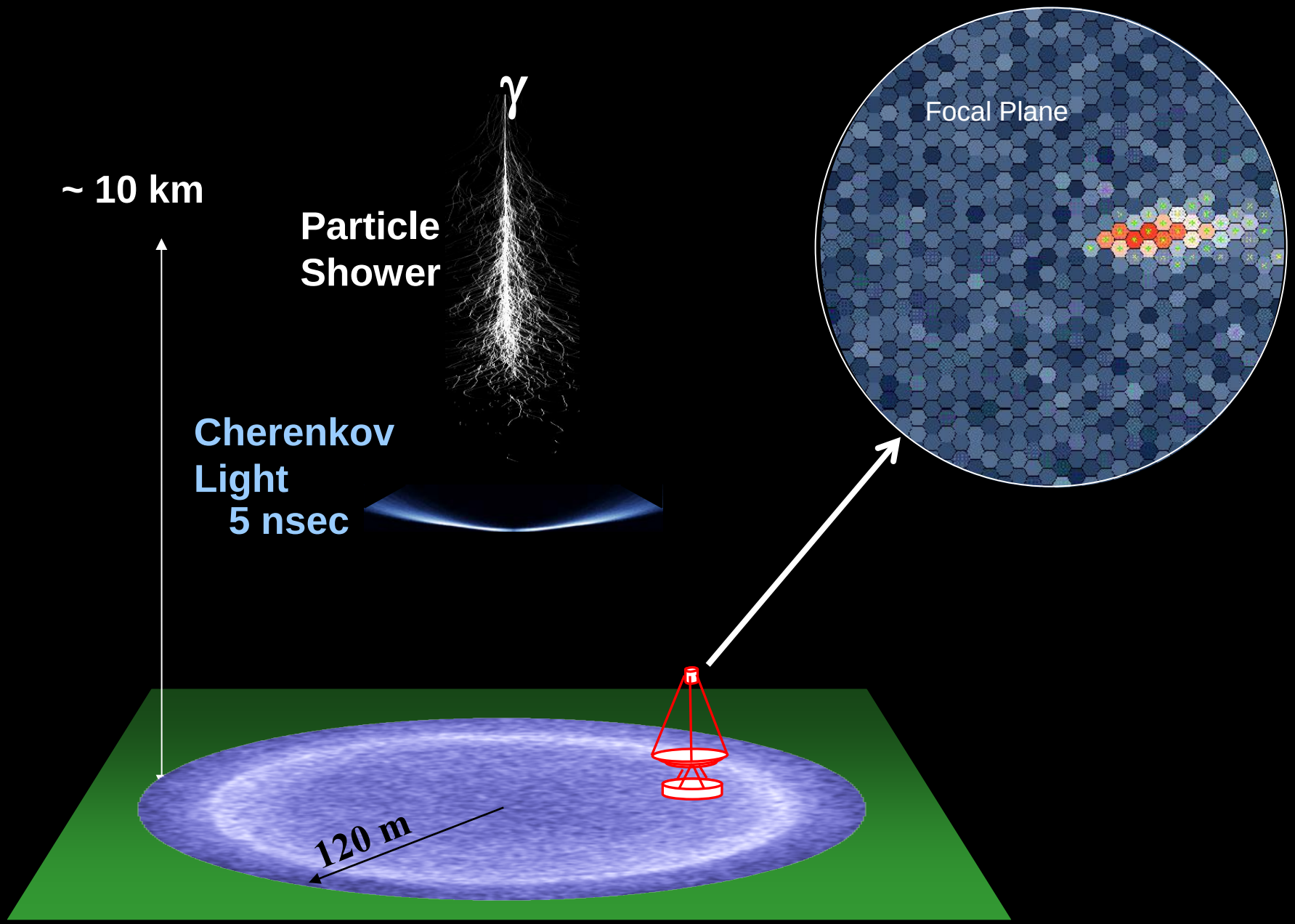

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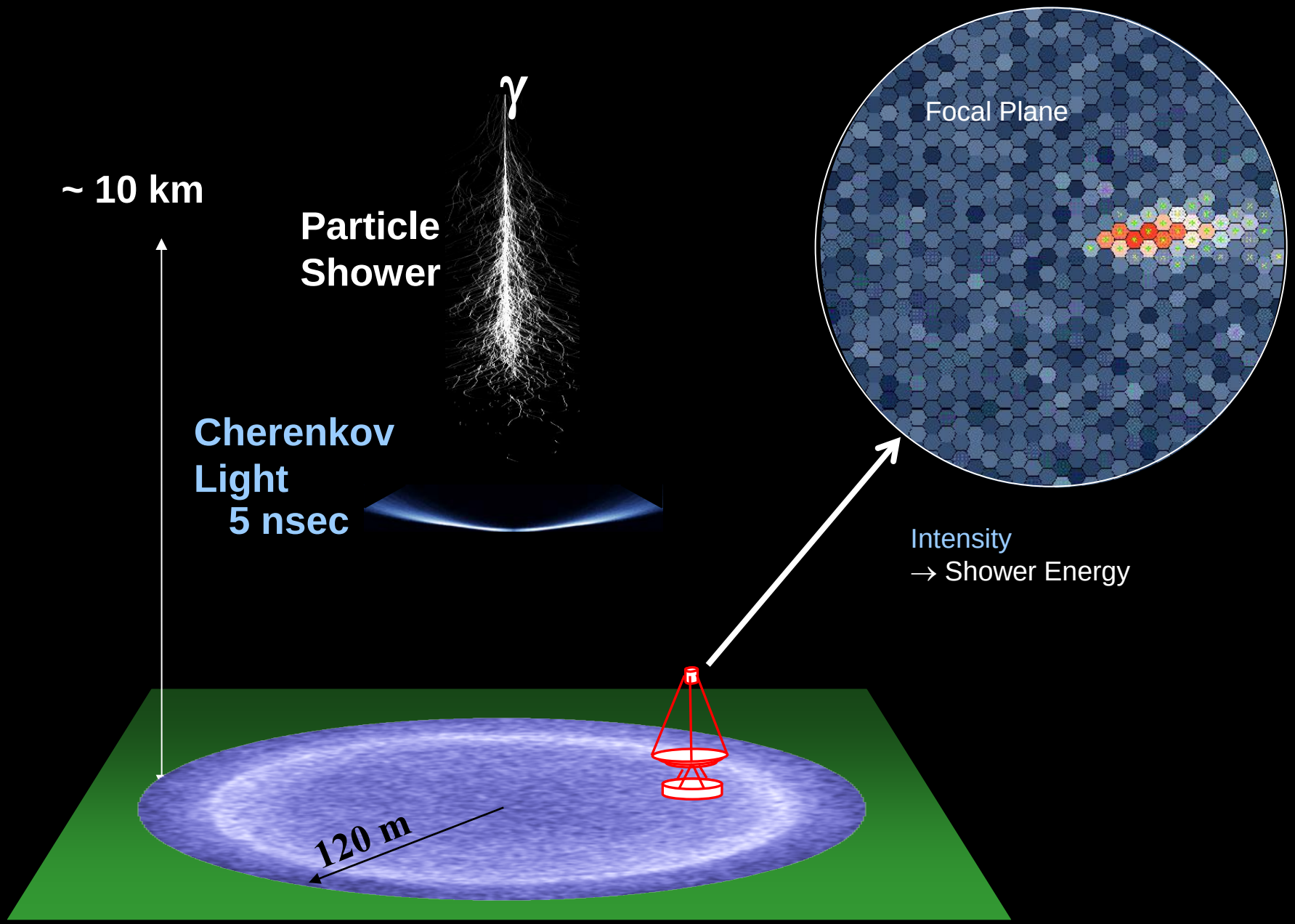

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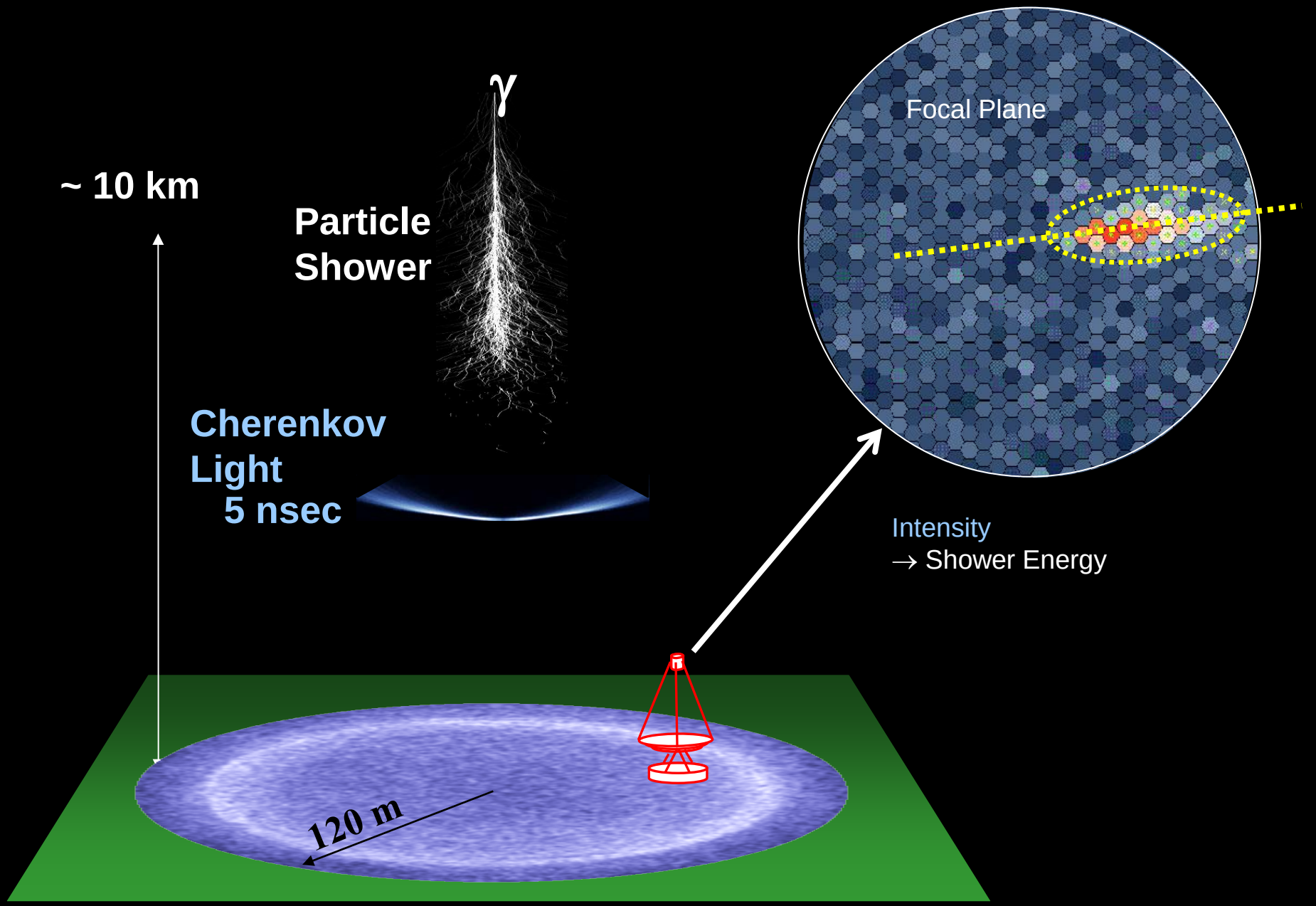

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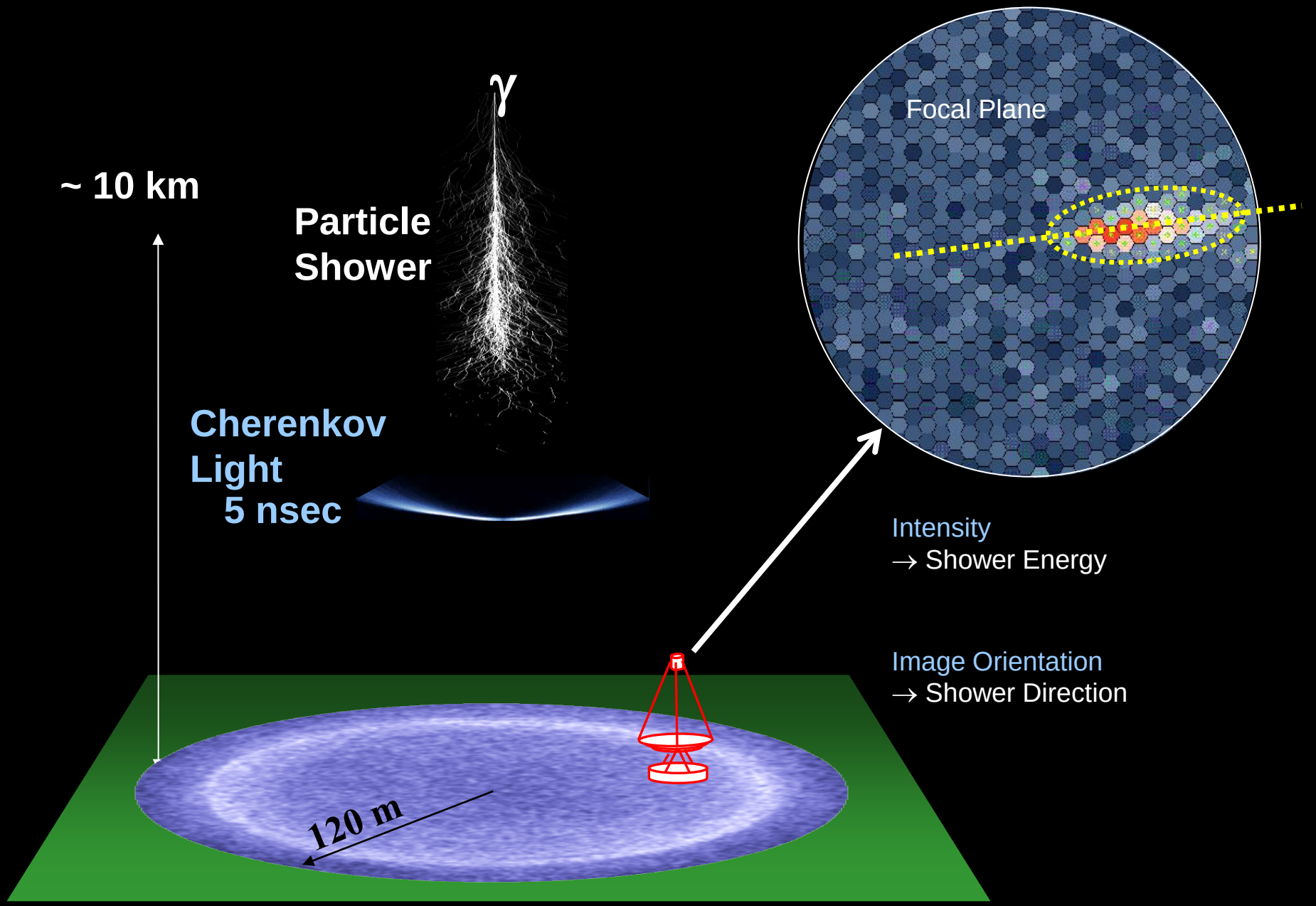

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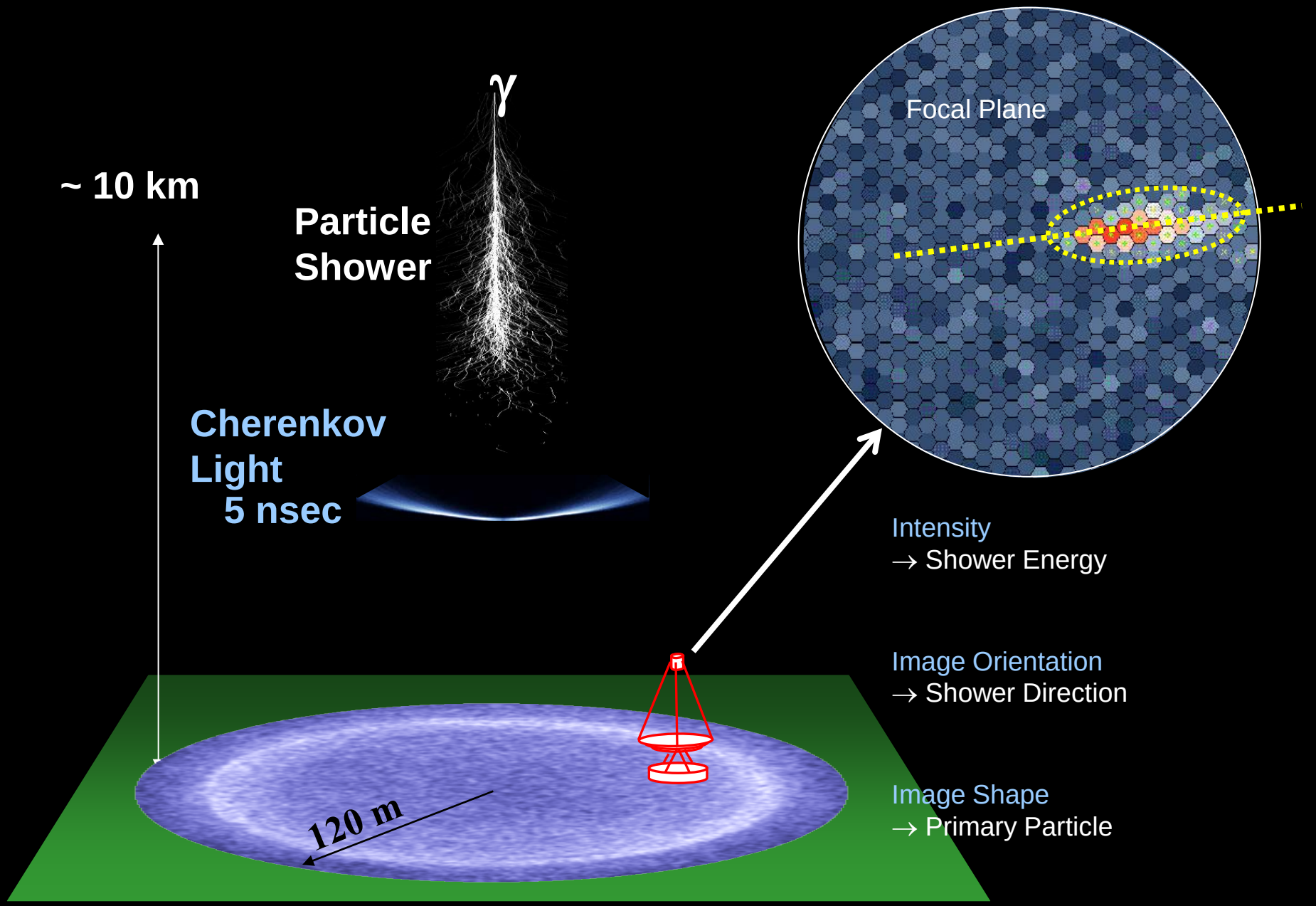
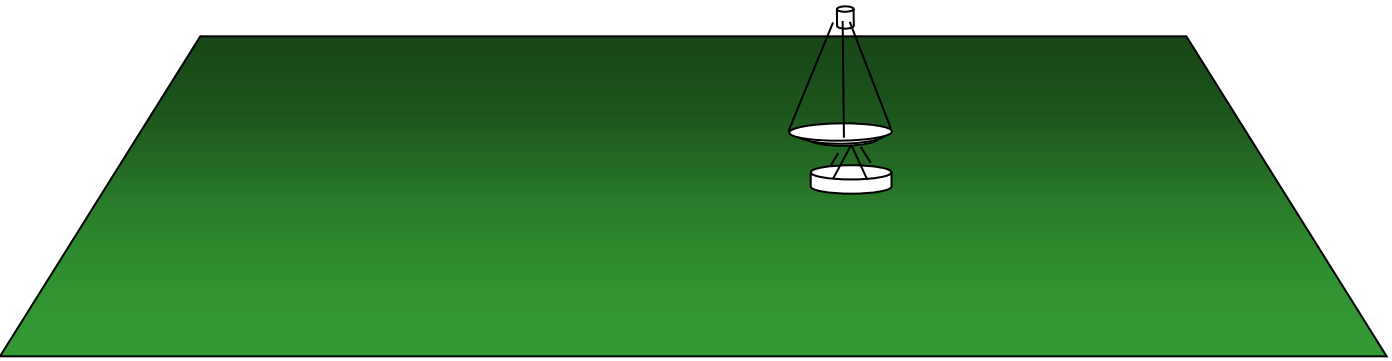
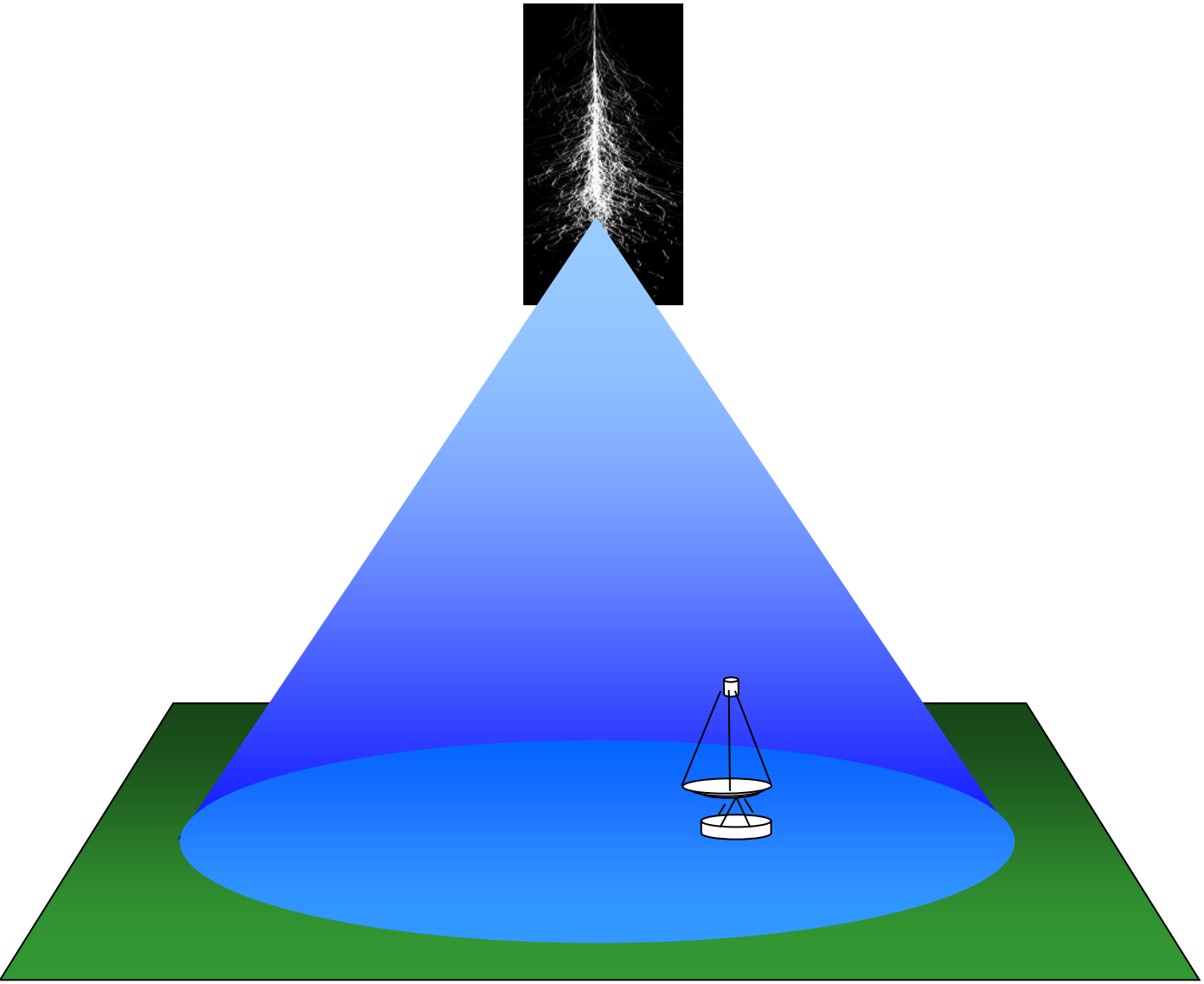


Stereoscopic Observation Technique



Stereoscopic Observation Technique



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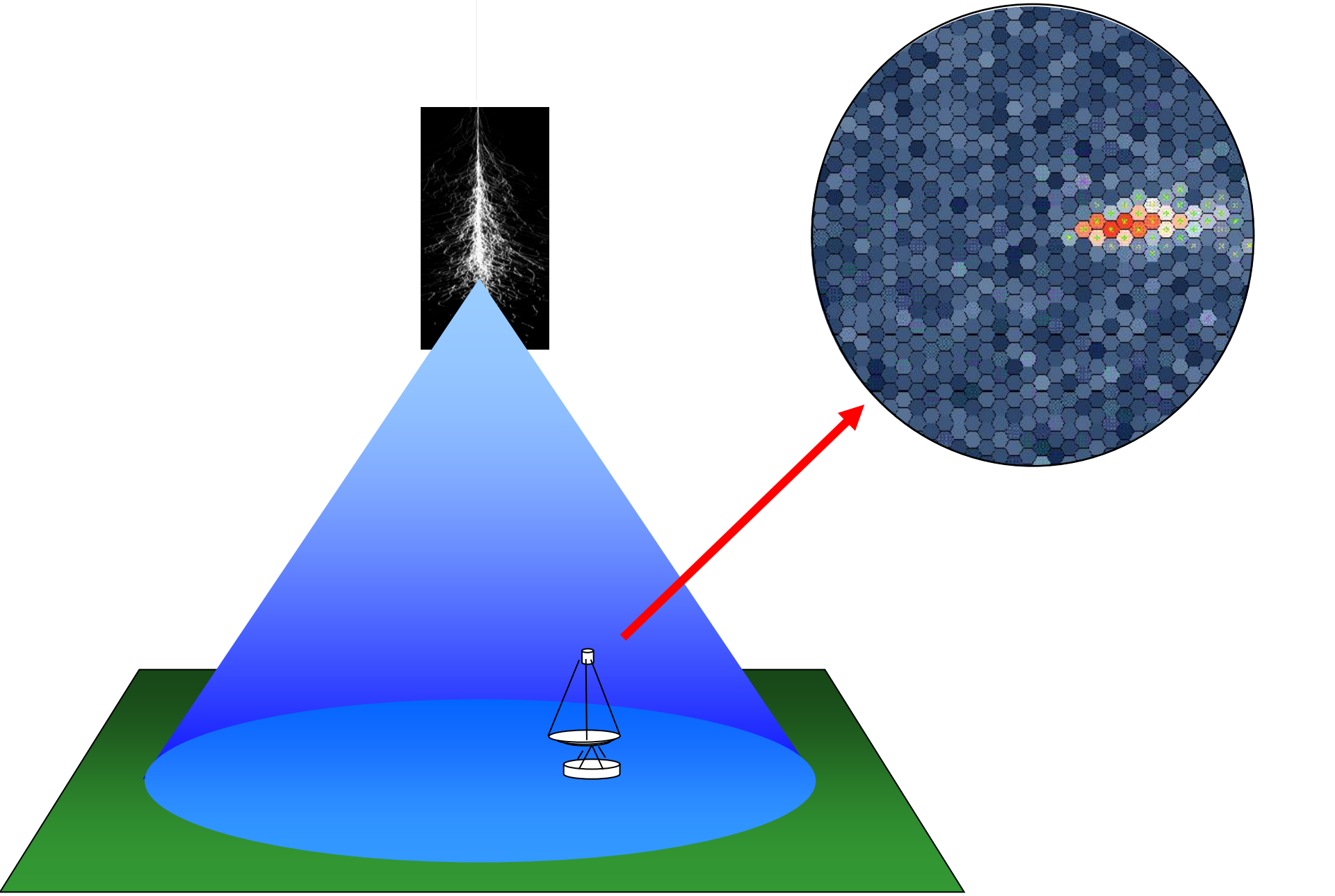

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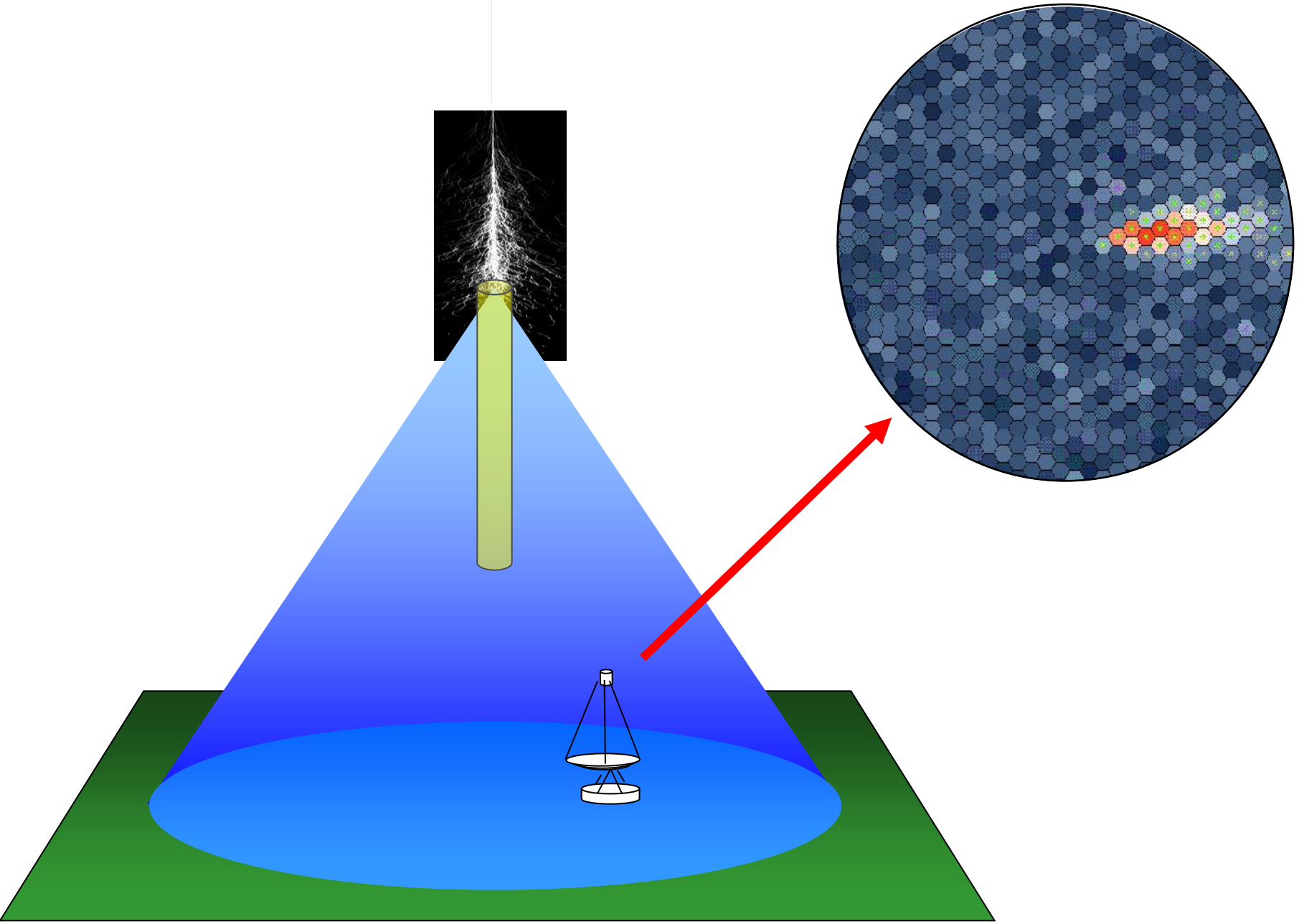

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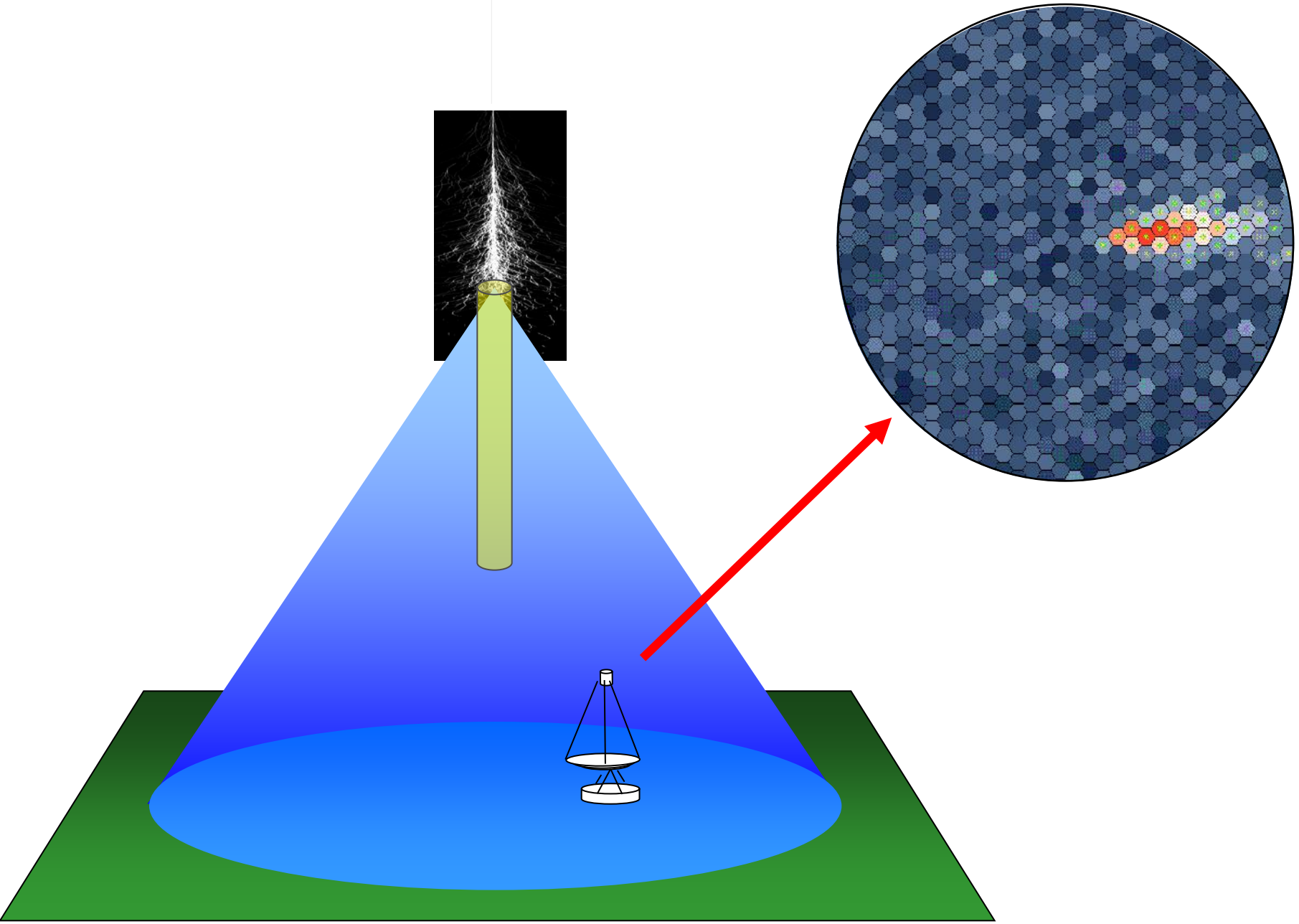

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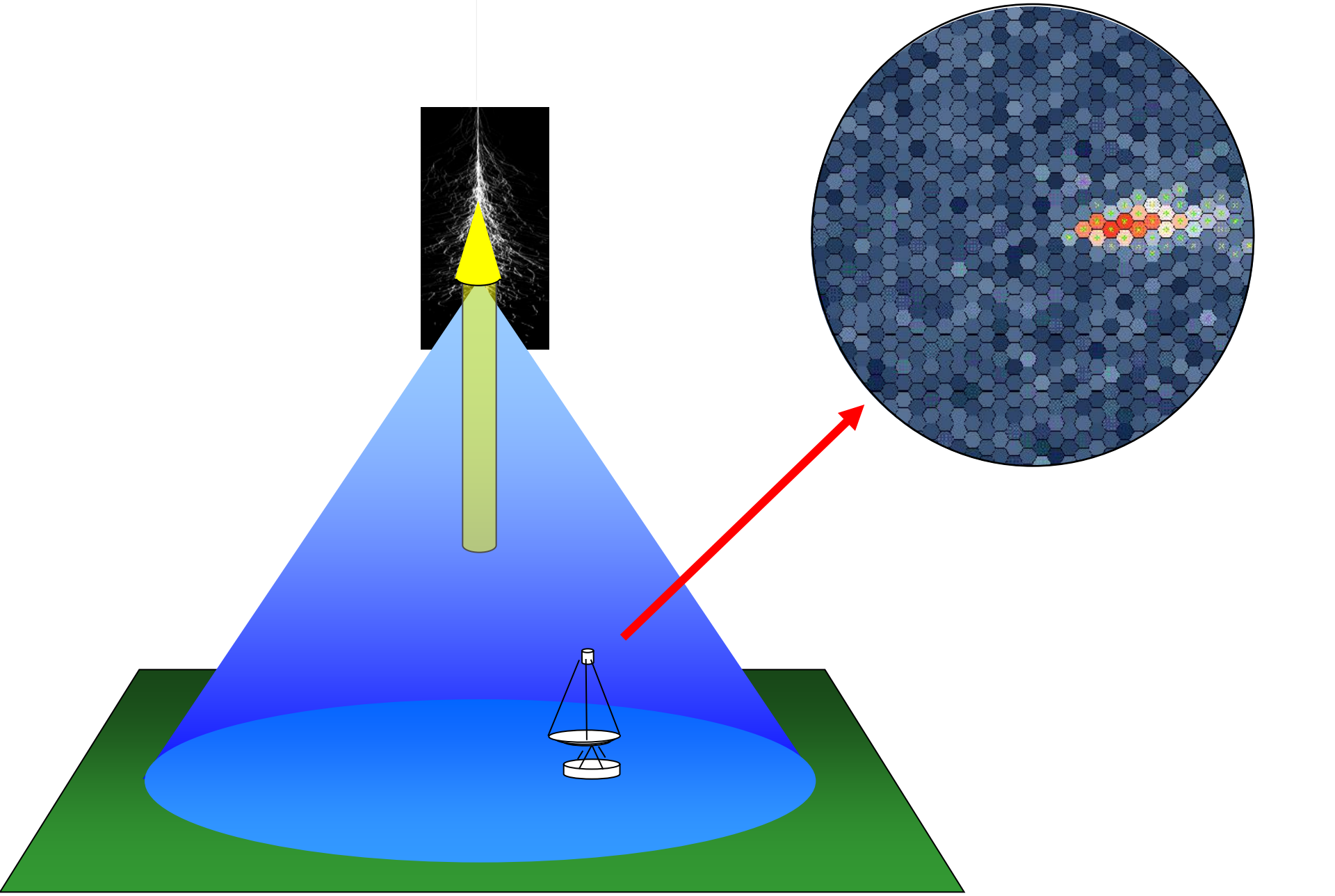

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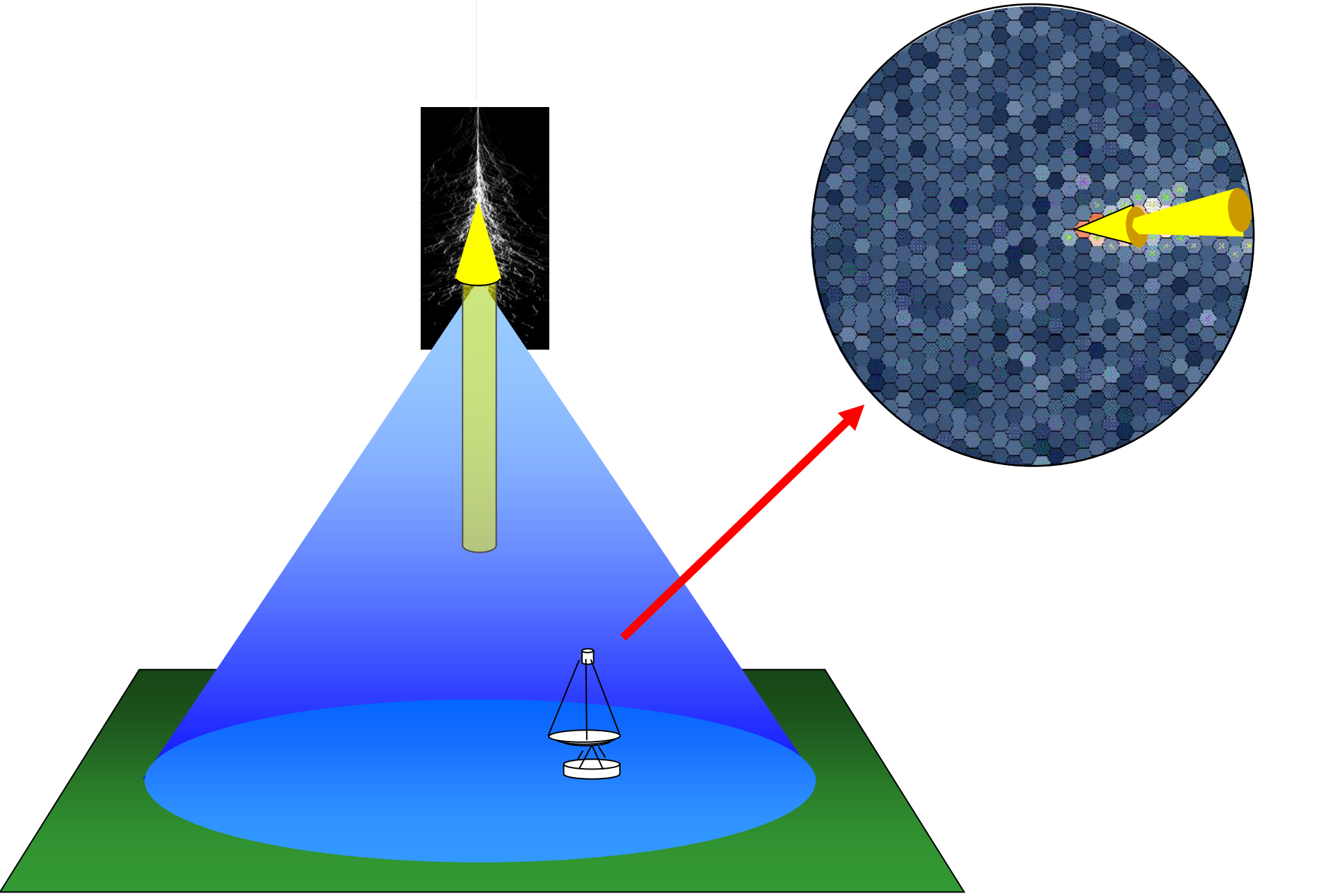

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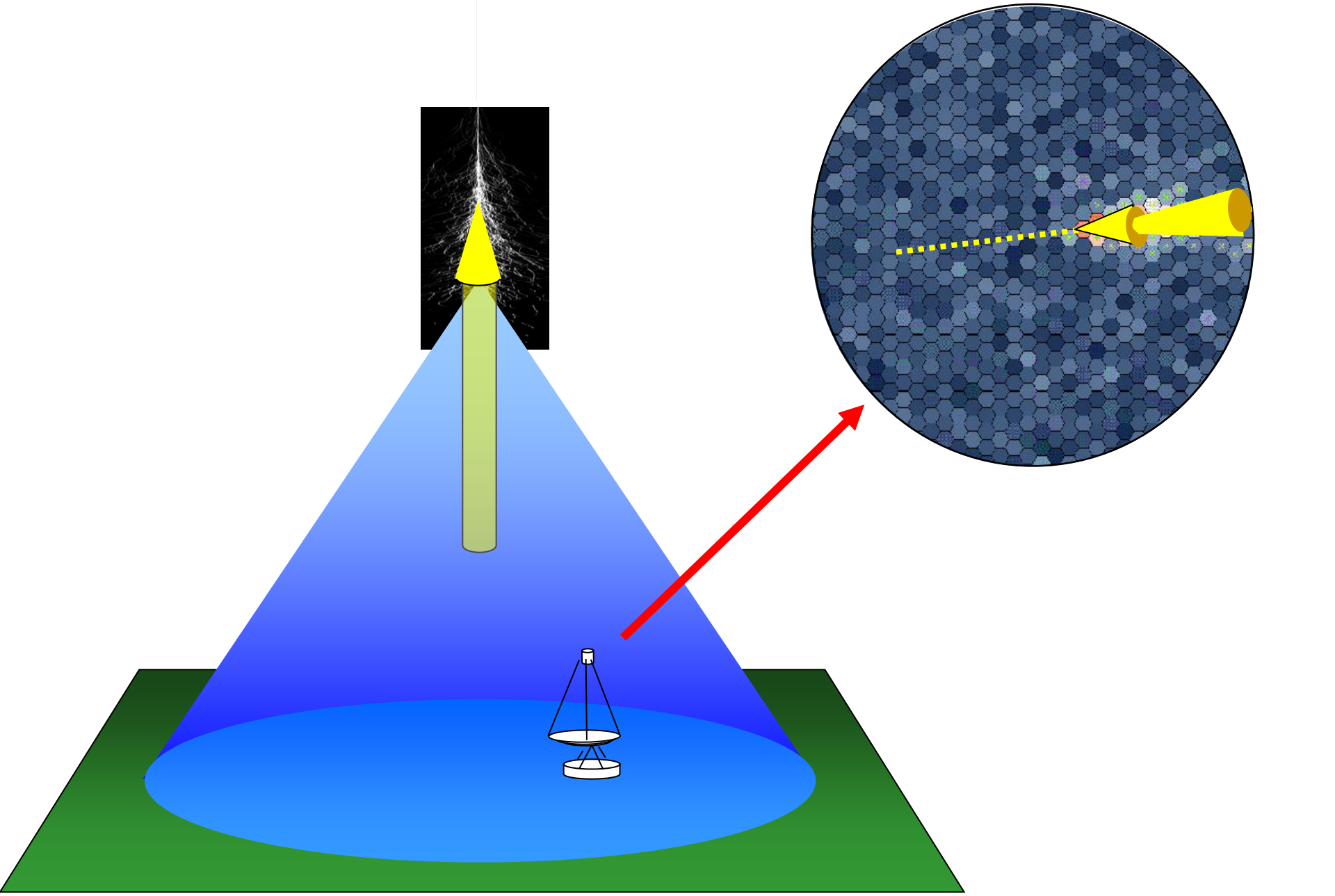

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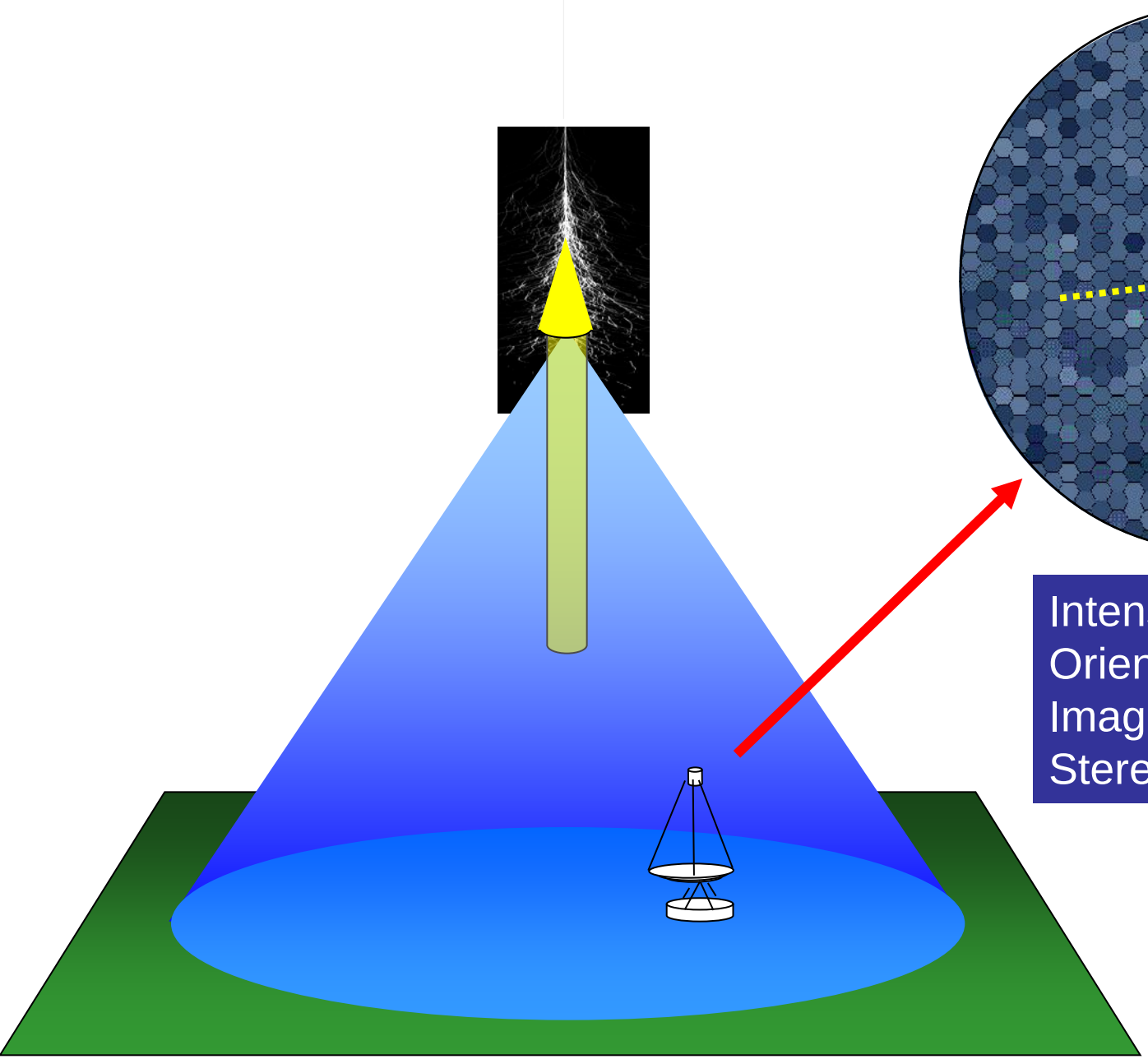

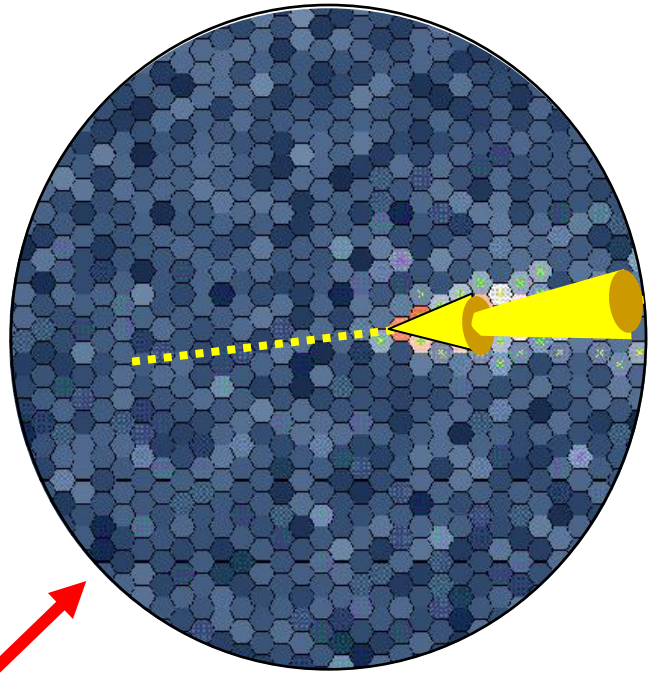

Intensity → Energy
Orientation → Direction
Image Shape → Particle
Stereo View → Source

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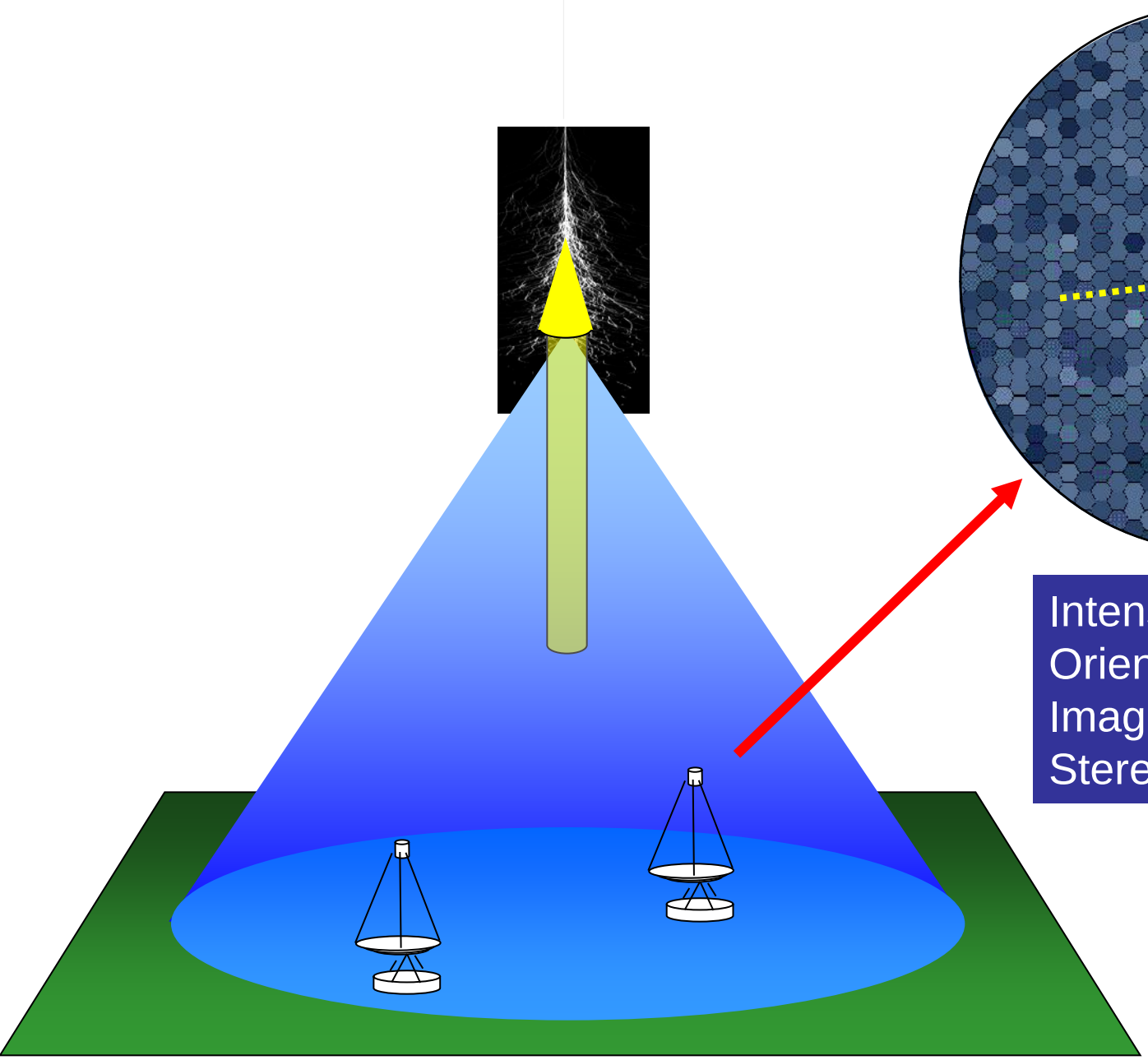

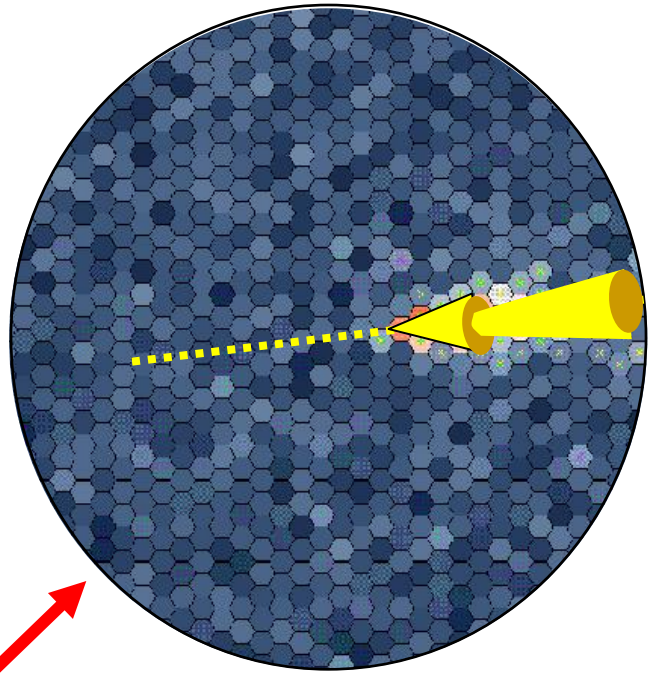

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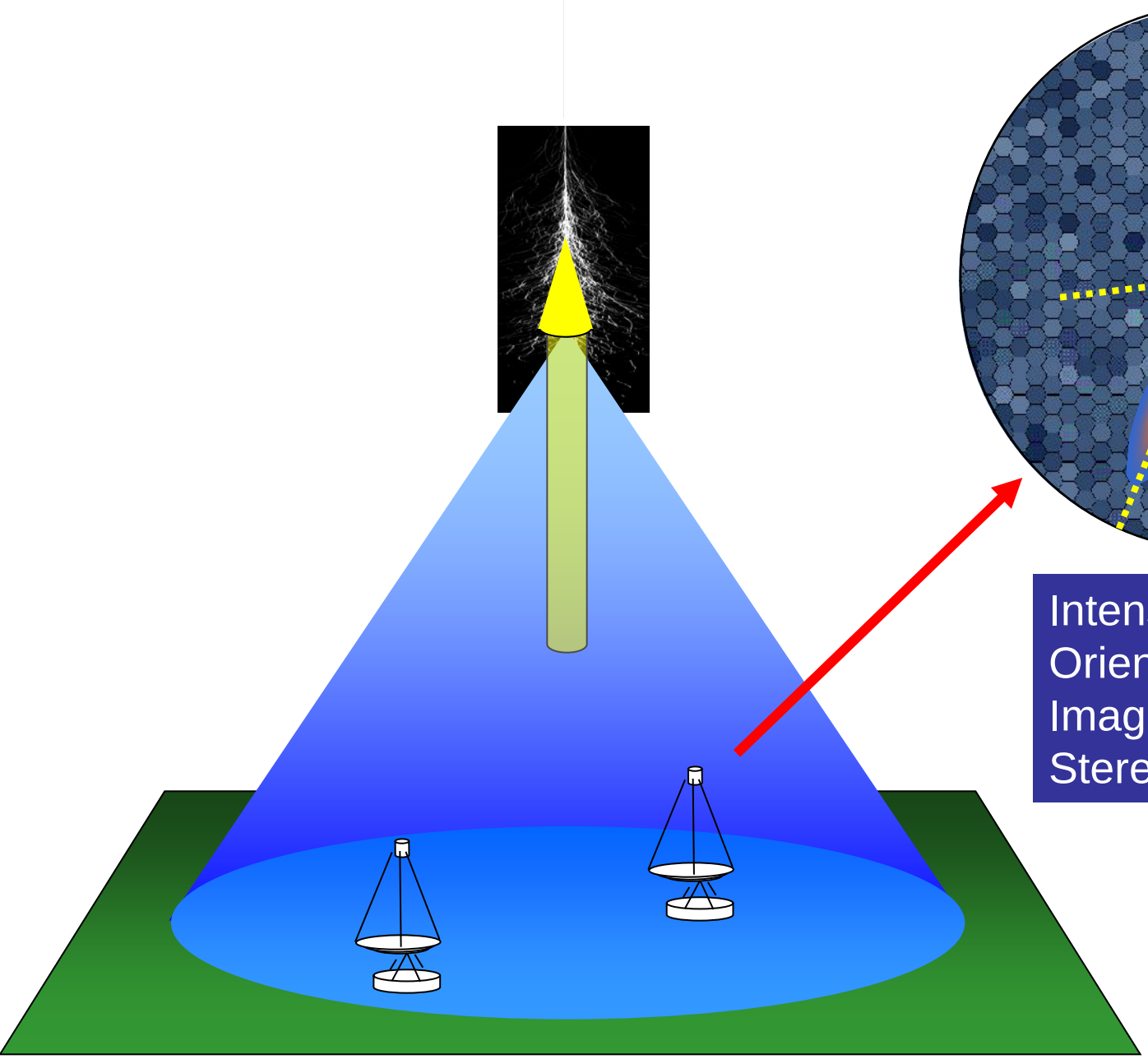

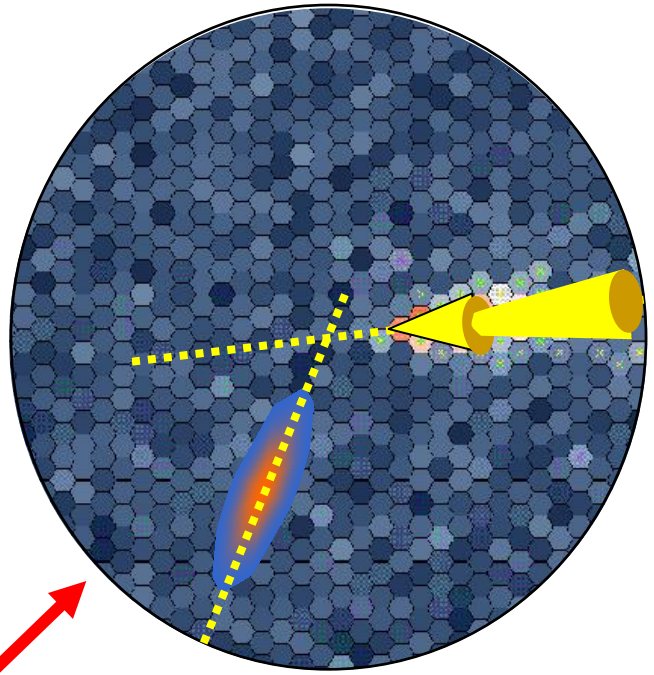

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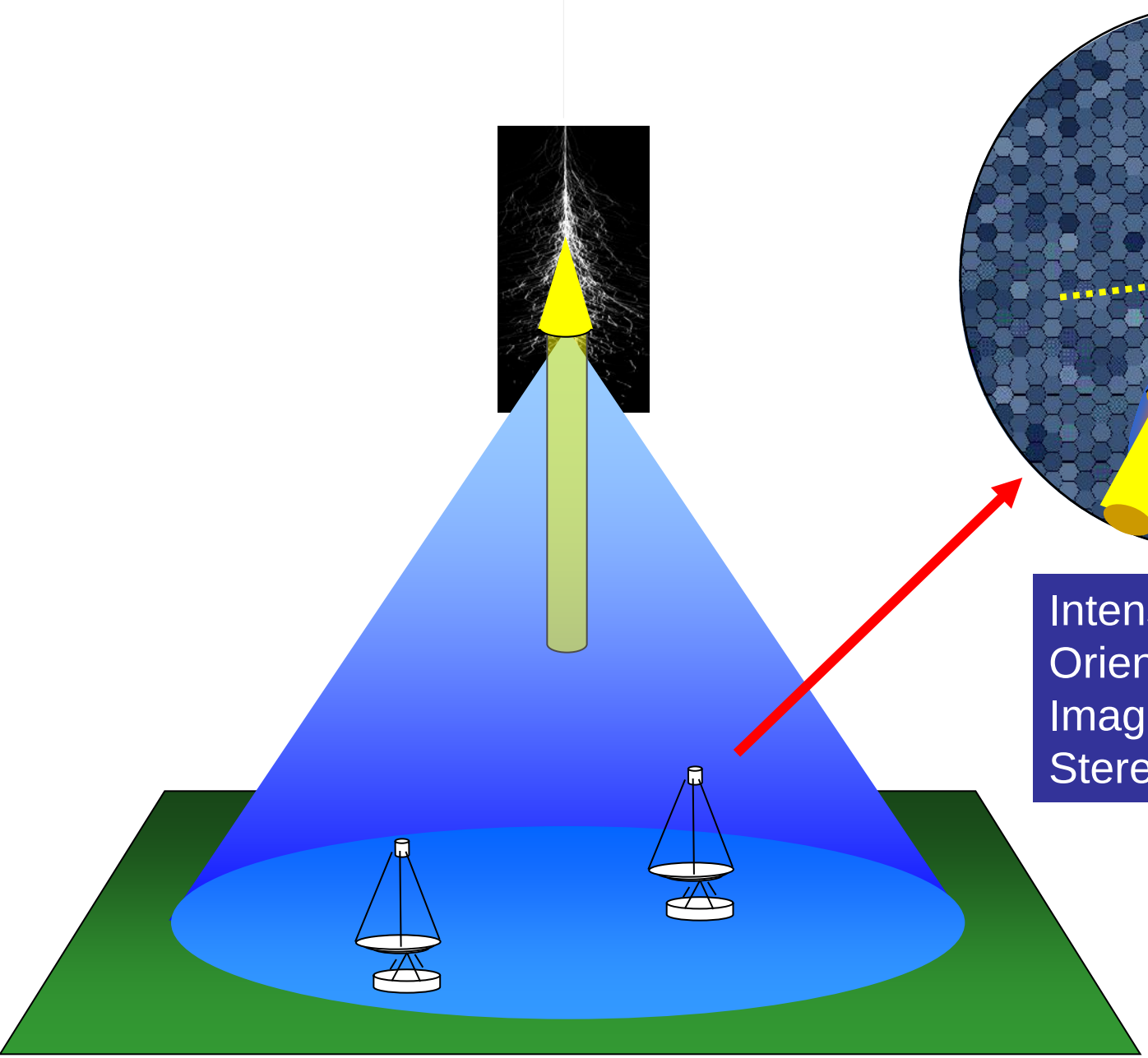

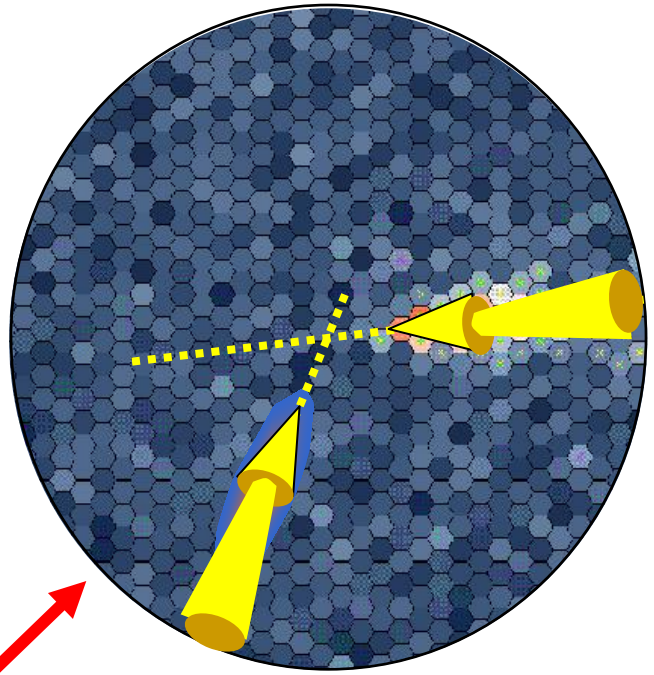

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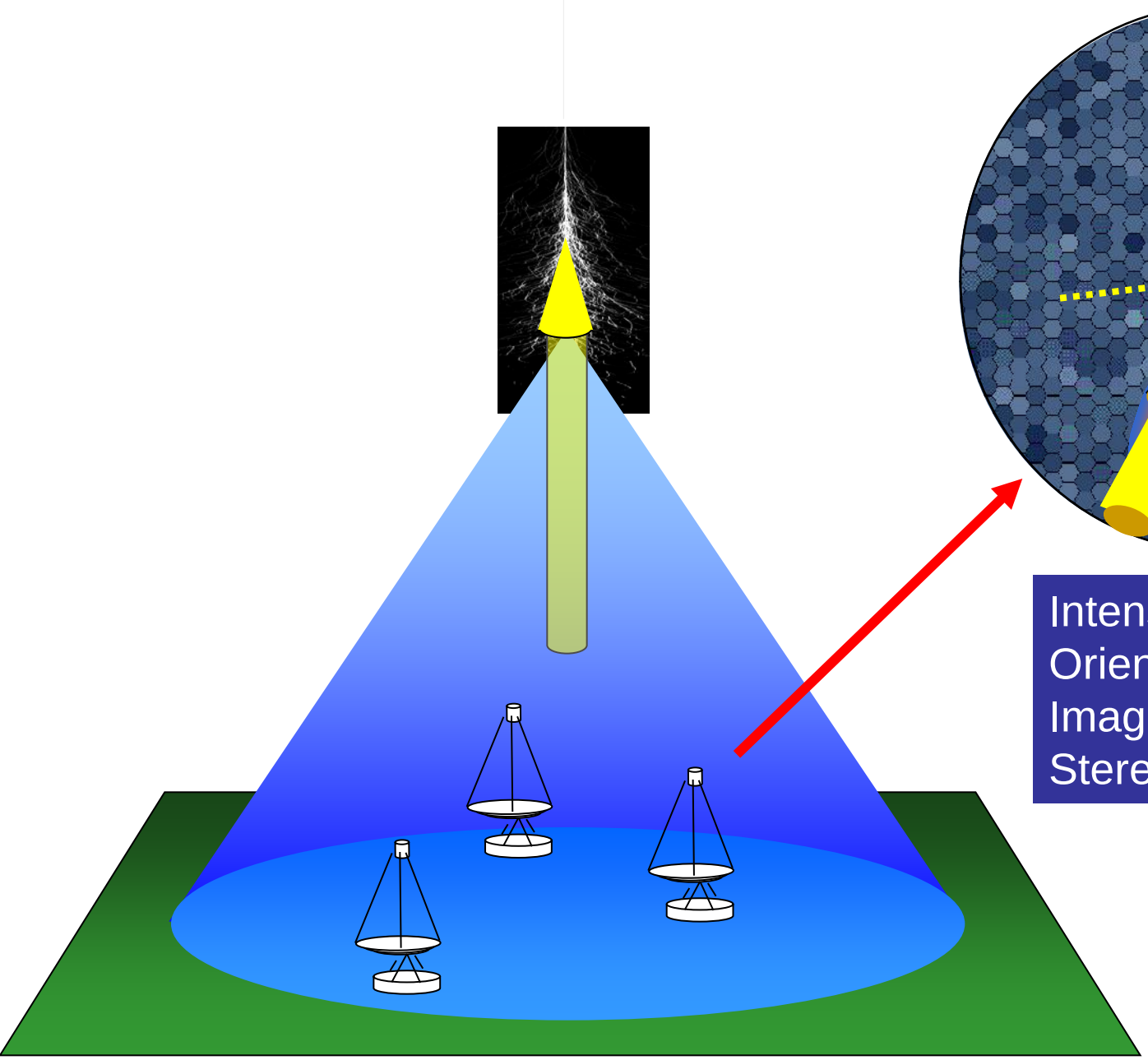

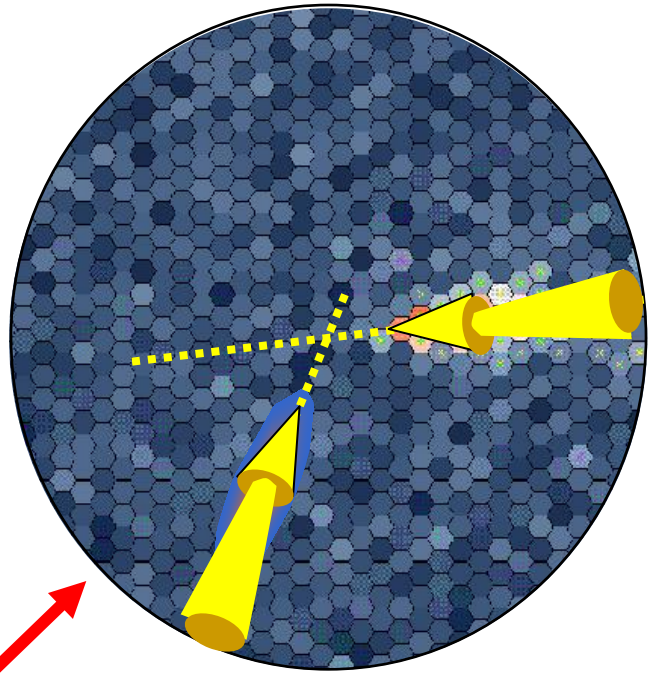

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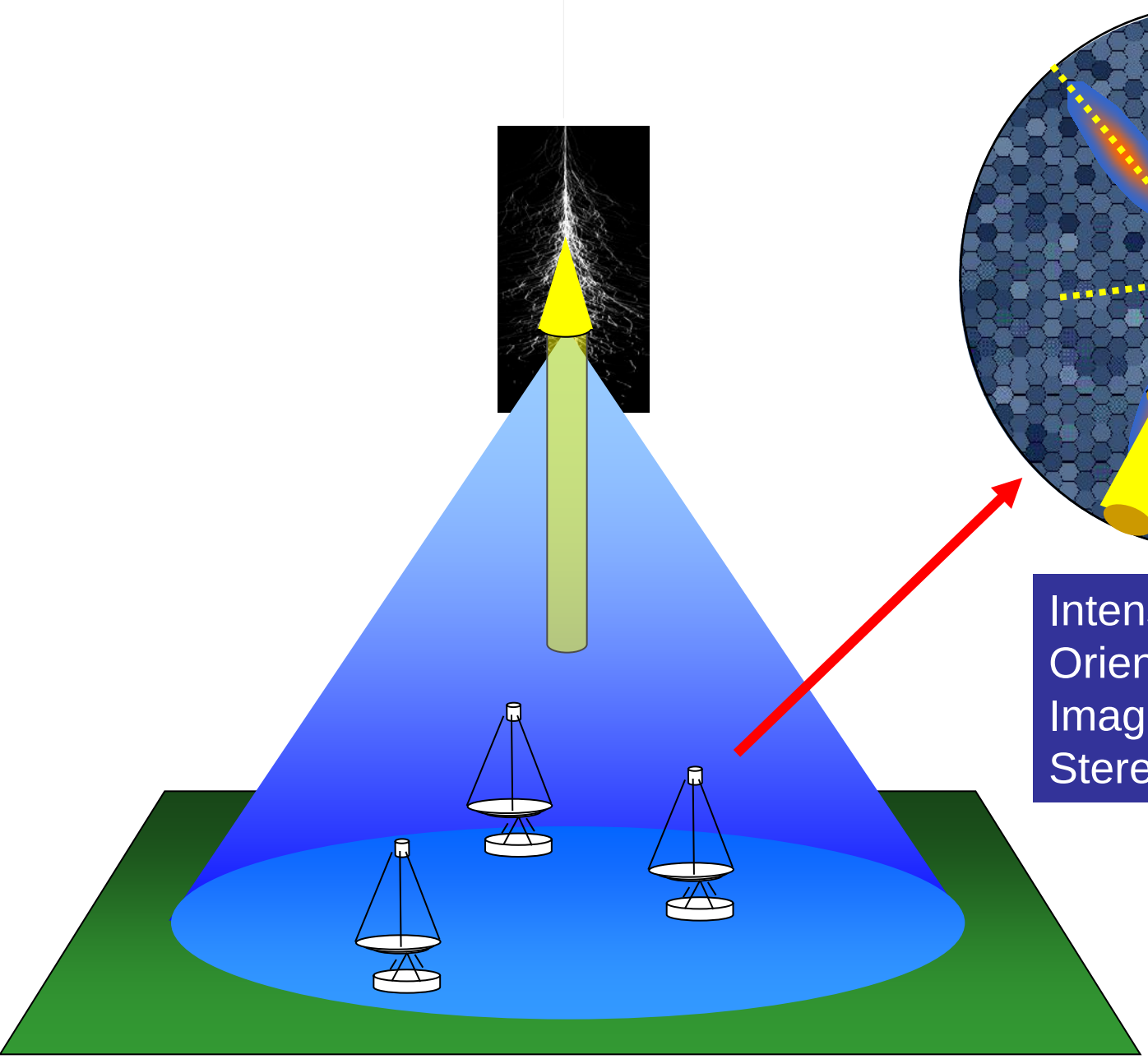

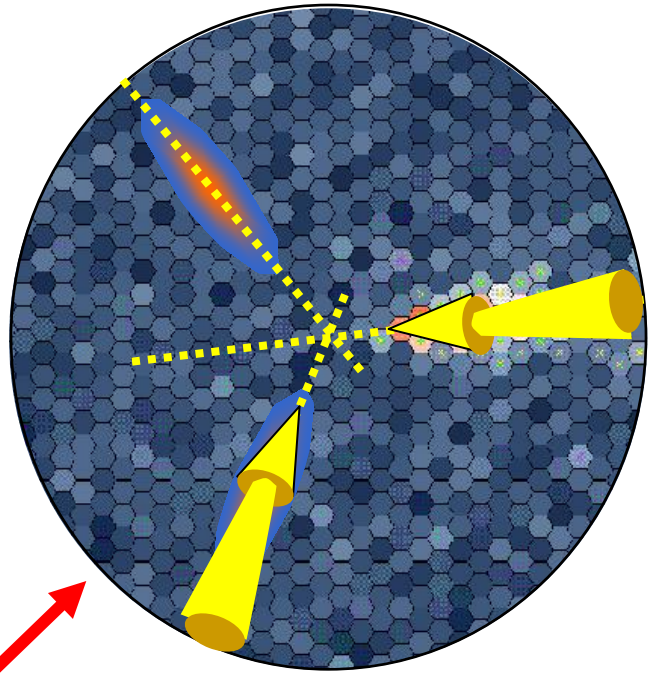

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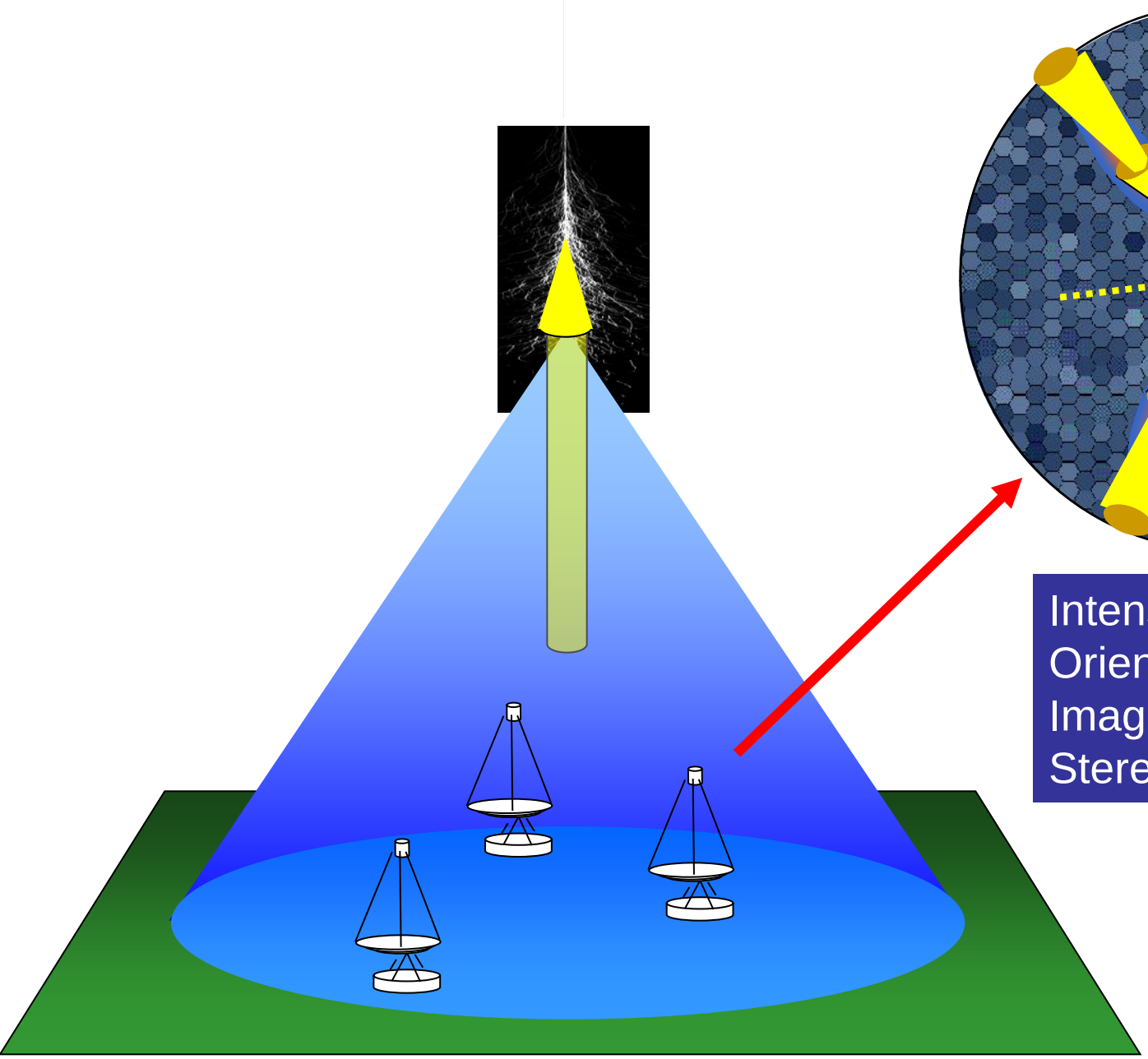

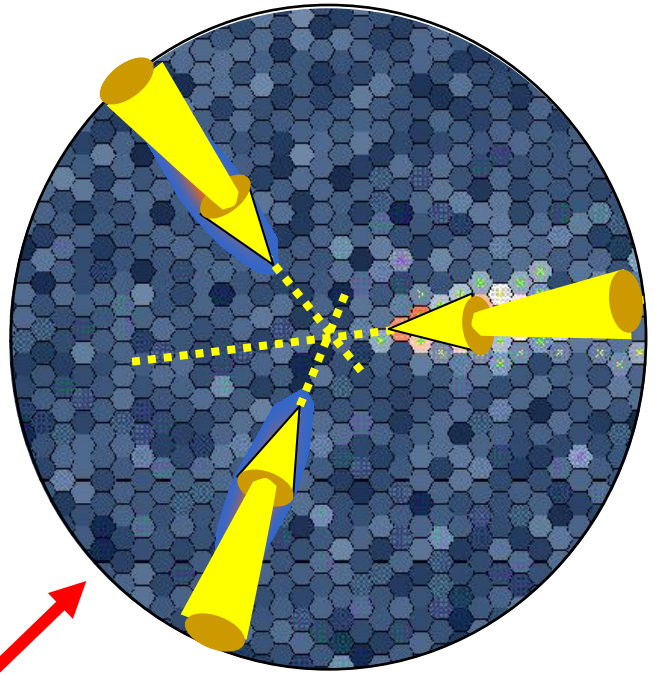

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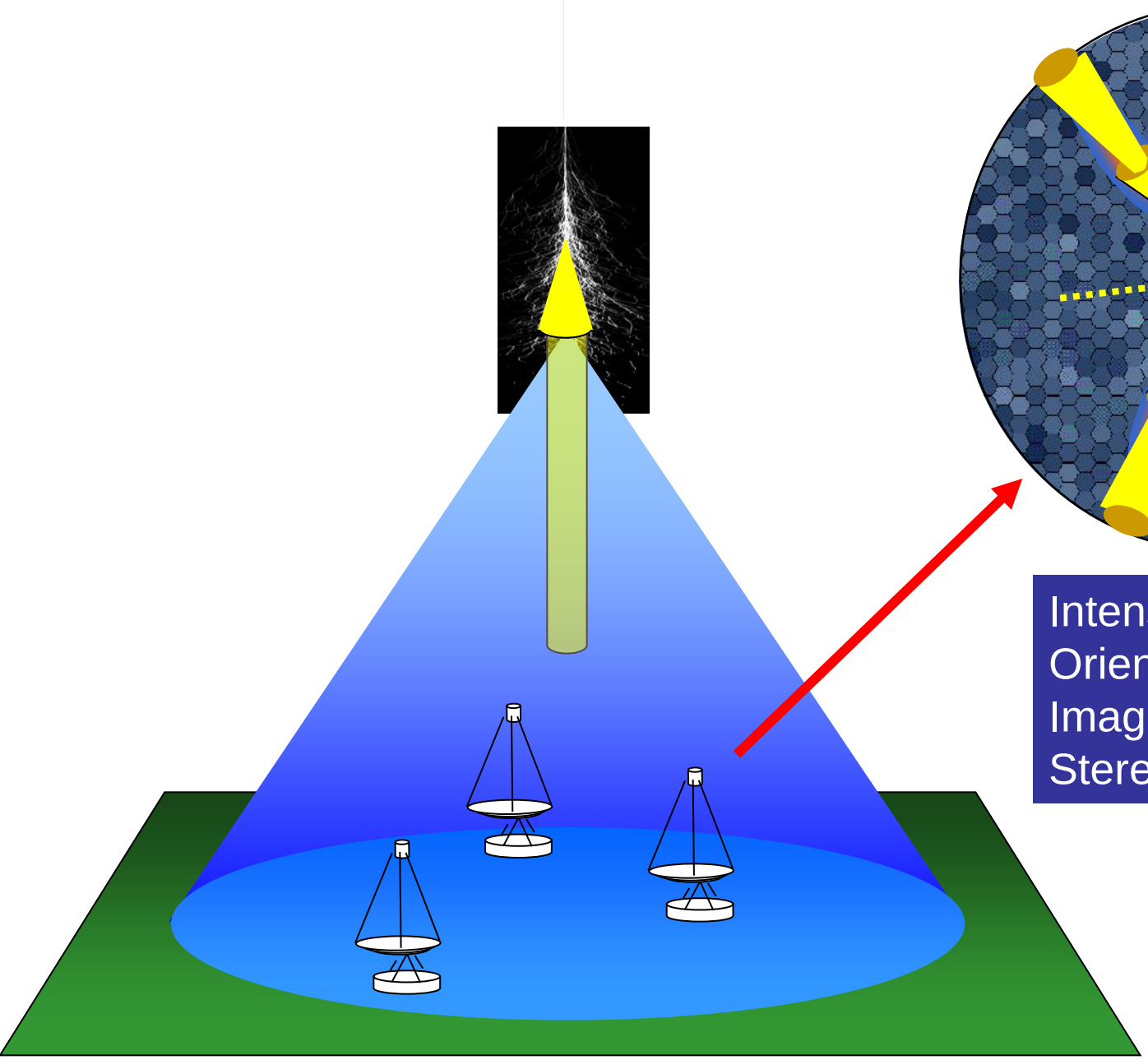

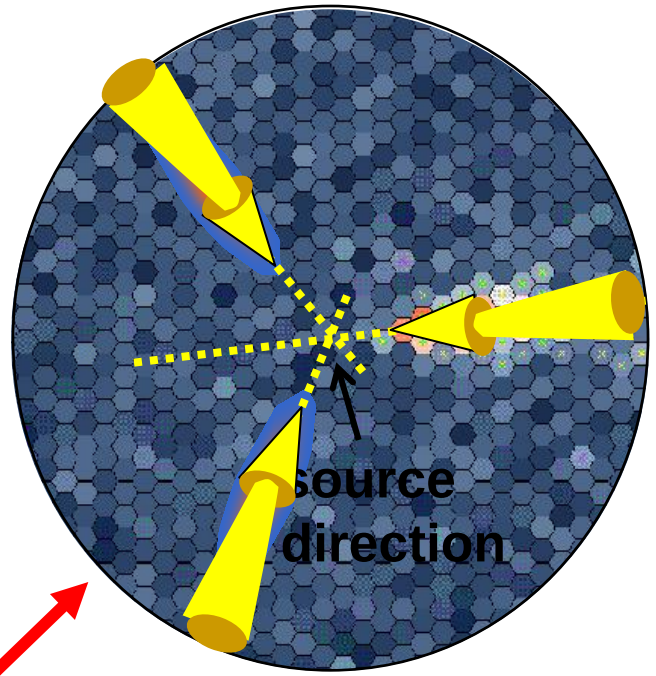

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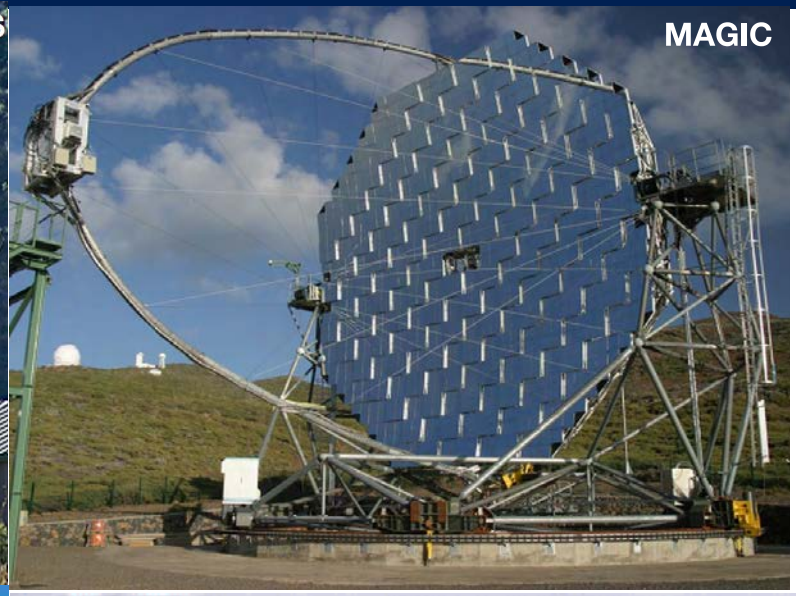
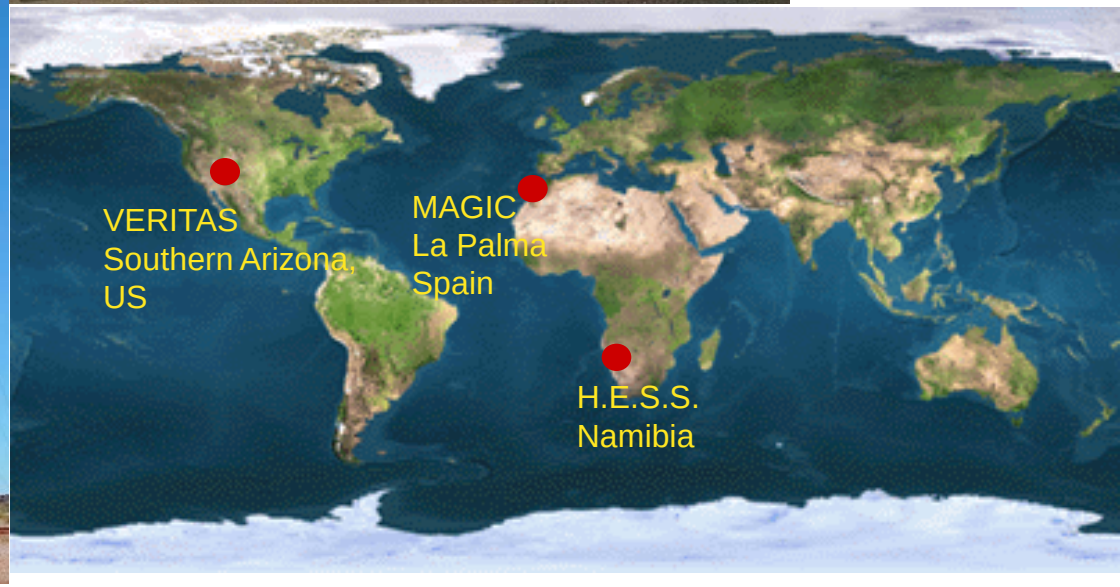
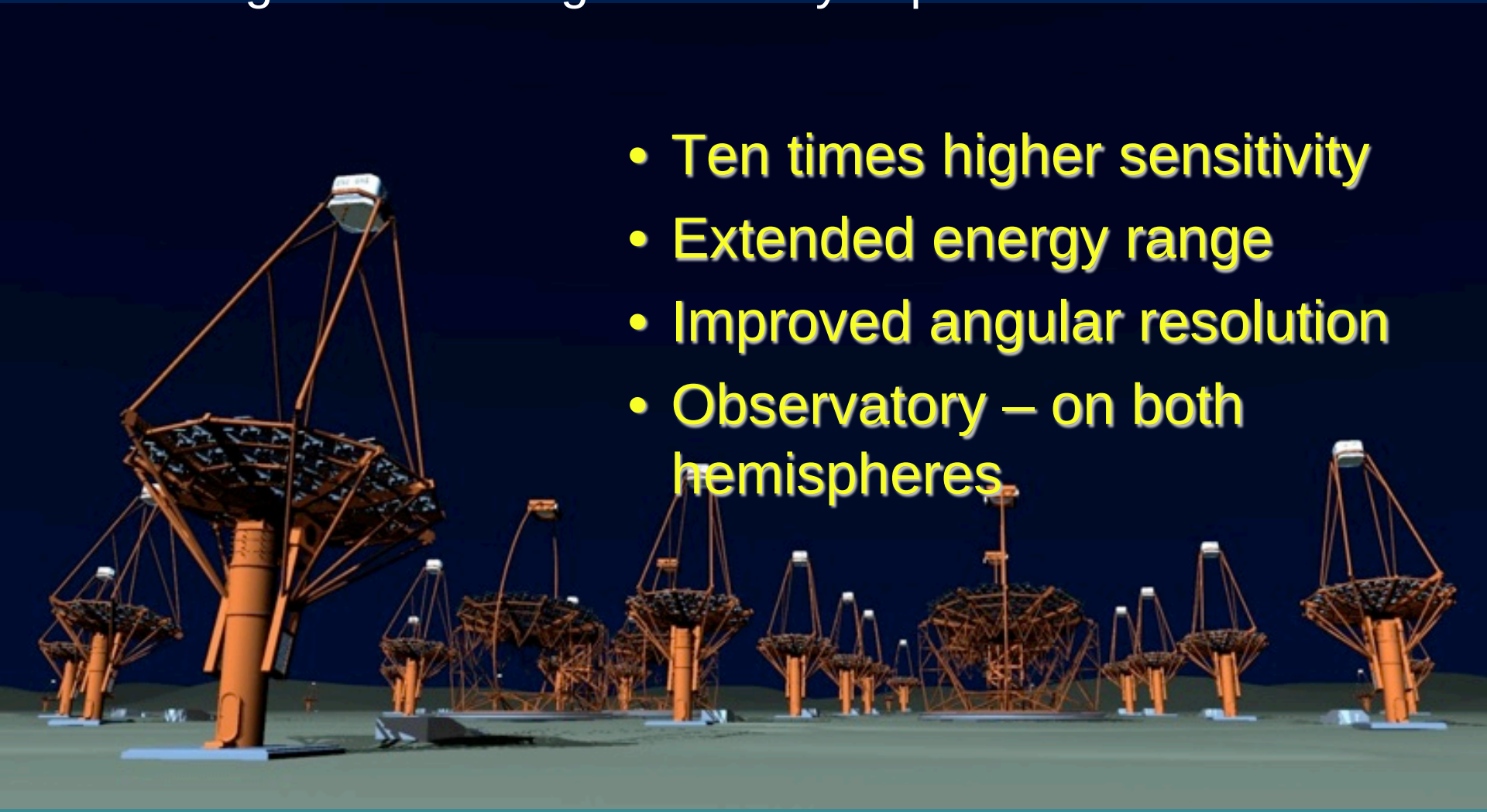
Cherenkov telescope projects





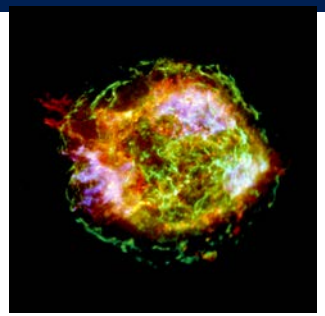
Cherenkov Telescope Array - **CTA**
The next generation of gamma-Ray experiments



- Ten times higher sensitivity
- Extended energy range
- Improved angular resolution
- Observatory – on both hemispheres

CTA consortium: 1100 authors from 27 countries from Europe, the Americas, Africa, Asia, Australia

CTA Physics

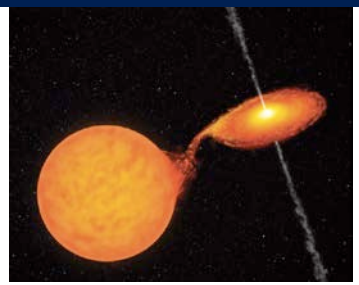


SNR

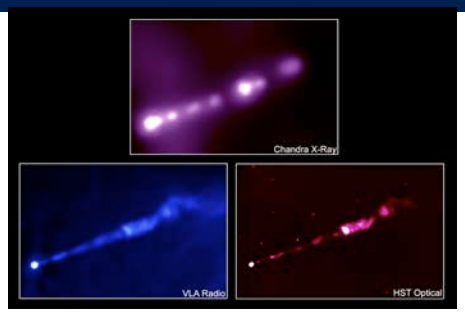
Supernova Remnants

GRB

Gamma Ray Bursts



Micro quasars



AGN

Active Galactic Nuclei

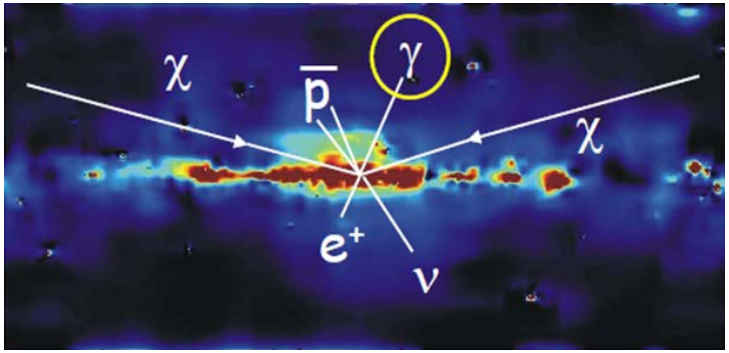
Pulsar, PWN

Pulsar Wind Nebula

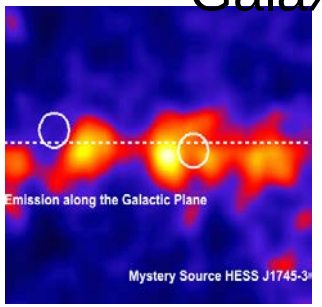
Understanding of cosmic ray sources

Detailed study of cosmic particle accelerators in and beyond our galaxy

Starburst Galaxies



Dark matter



Unknown Sources

CTA – Telescope Arrays

2 Arrays: North+South→ All-Sky Coverage

Large-Sized Telescope - LST
low energy section
E_{thresh} ~ 10 GeV

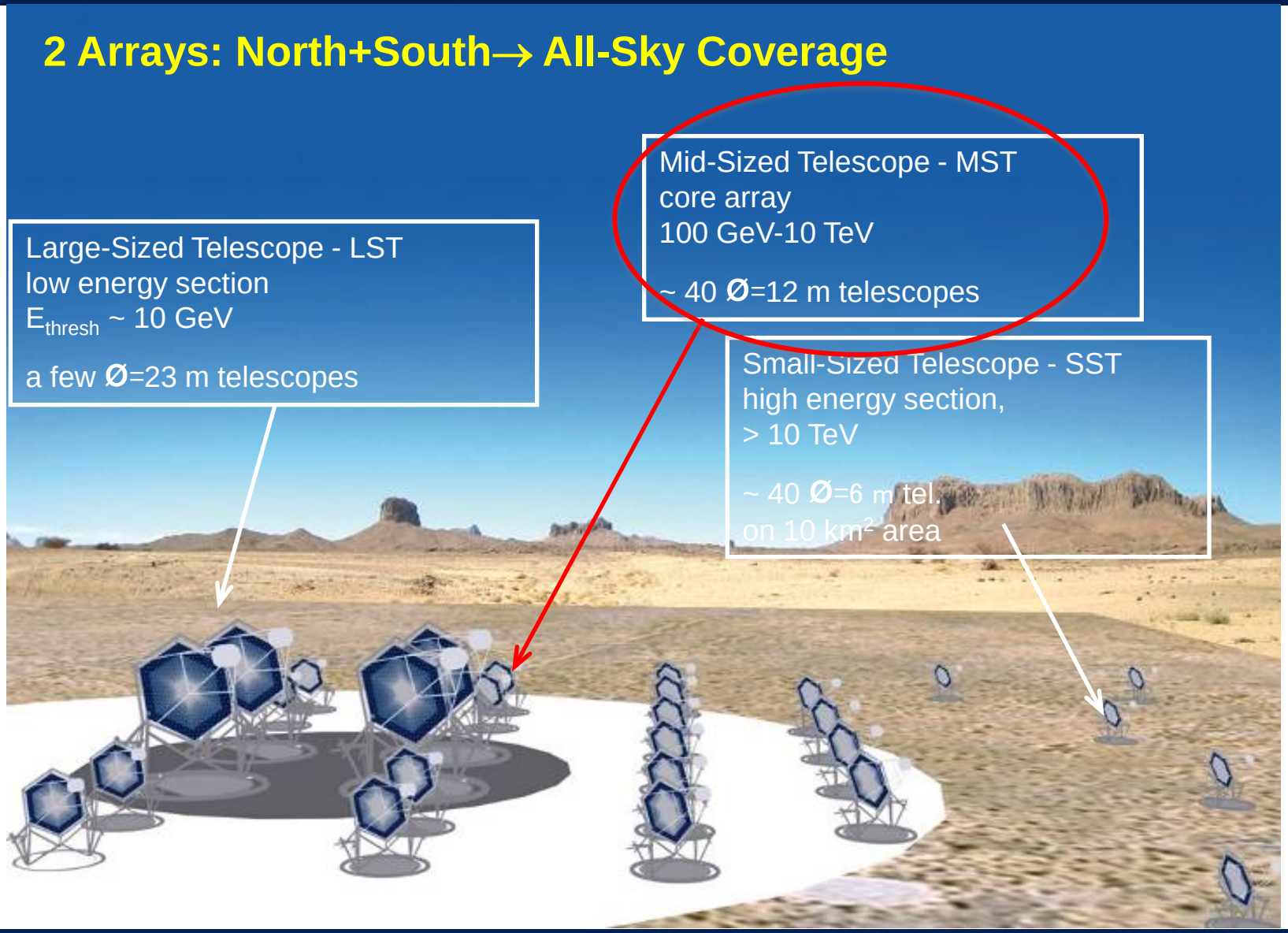
a few Ø=23 m telescopes

Mid-Sized Telescope - MST
core array
100 GeV-10 TeV

~ 40 Ø=12 m telescopes

Small-Sized Telescope - SST
high energy section,
> 10 TeV

~ 40 Ø=6 m tel.
on 10 km^2 area



Mid-Sized Telescope – MST- Prototype

Mid-sized prototype in Berlin – Adlershof, operational since May 2013
(DESY, Humboldt University Berlin, University of Potsdam)

Test and verification of basic hardware technologies:
Drive system, CCD cameras for monitoring/pointing, Active Mirror Control (AMC), Weather Station, Condition Monitoring, ….

Implementation and test of CTA Array Control and Data Acquisition software (ACTL) :
Commissioning of components for:
•Control of drive system, AMC, CCD, camera dummy, weather station, ..
•Alarm and logging system
•Data transfer mechanisms
•Database tests: For slow control and measurements storage and analysis.
Scaling test for CTA array level usage.

CTA ACTL basic software technologies

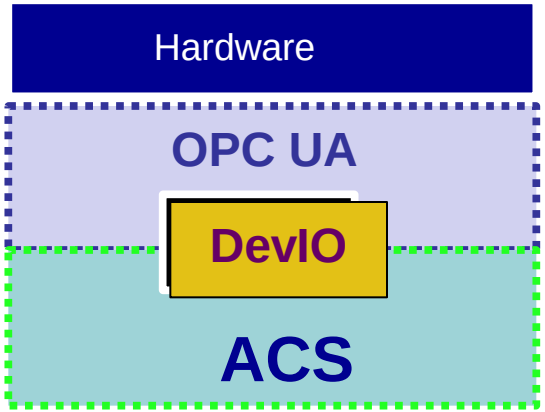
ALAMA Common Software - ACS:

- Framework for distributed applications used for control systems, esp. of the ALMA array, one of the largest astronomical projects, similar in many aspects to CTA
- C++, Java and Python implementations
- Uses Container/Component Model
- CORBA communication

OPC UA:

- OPC Specification from the OPC Foundation
- A cross-platform service-oriented architecture for process control
- Multi-platform implementation, including portable ANSI C, C++, Java and .NET implementations
- High scalability: from smart sensors and actuators to mainframes and servers on embedded systems

DevIO: *is an ACS simple and generic abstraction of hardware monitor and control point, based on the Bridge design pattern.*



ACS Framework

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)

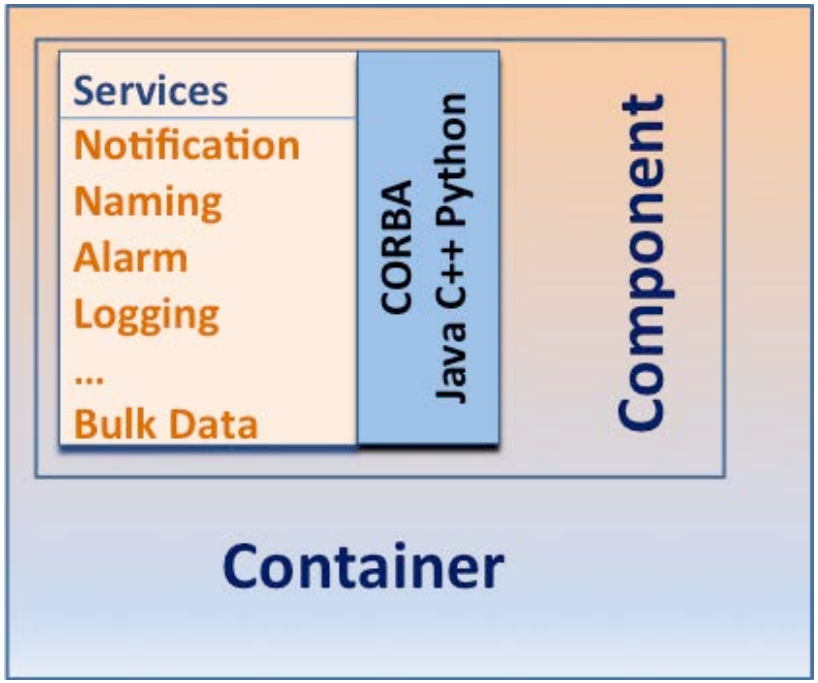
- **Containers, Components, Manager**

Employs several standard CORBA services

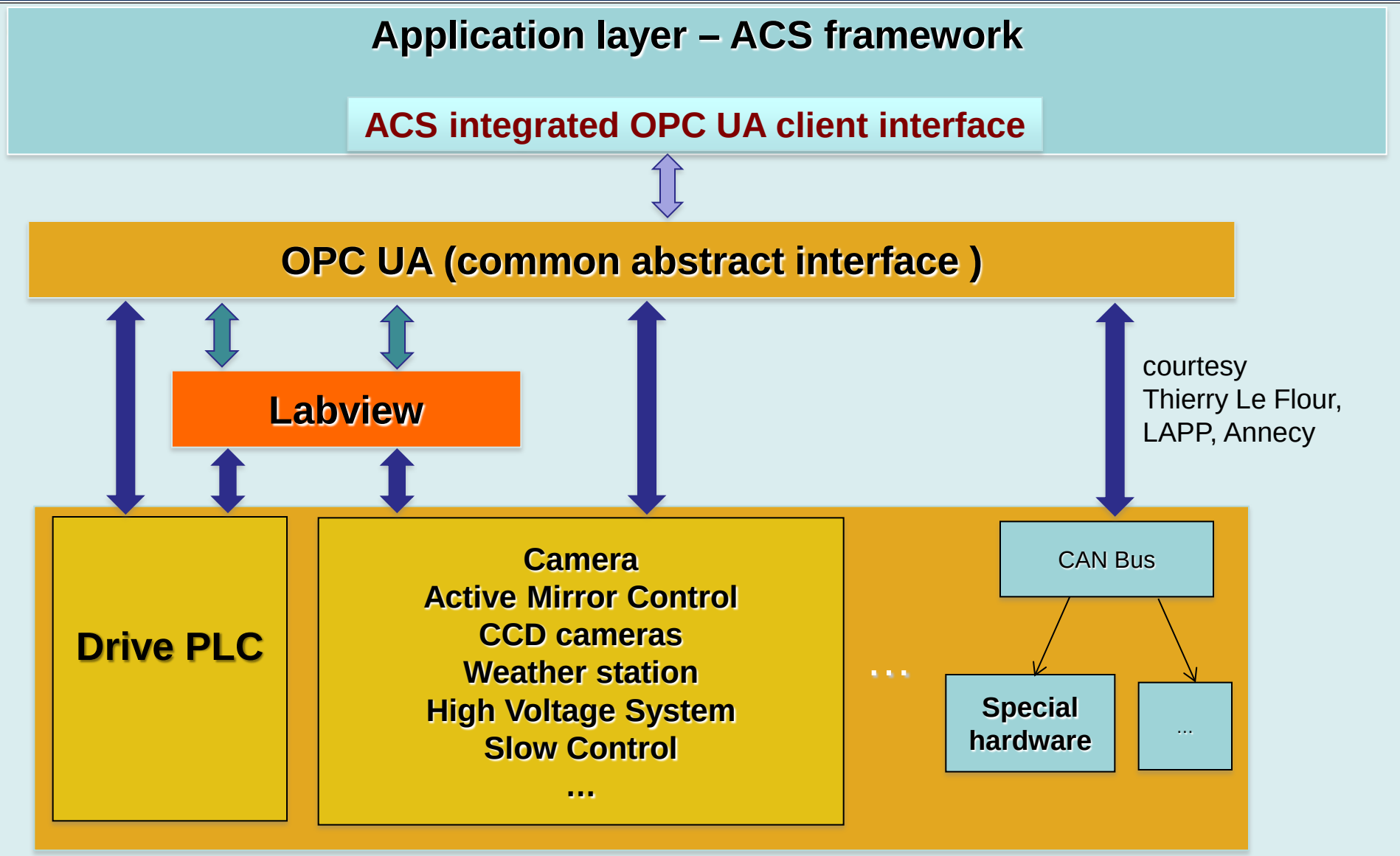
- **Notification service**
- **Naming service**
- **Interface repository**

Provides generic GUIs and tools for

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

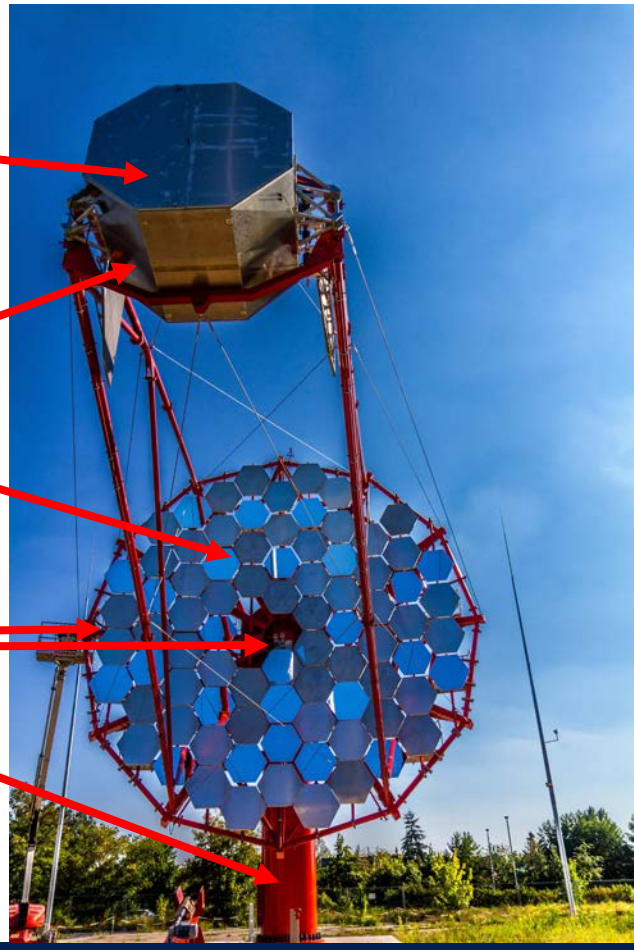


OPC UA – Device level abstraction



MST Prototype Instrumentation and ACTL

Telescope Control server
Dell PowerEdgeR720xd
2 CPUs (12 CPU cores)
128GB main memory
6TB local disk space.
Scientific Linux 6.4



MST Prototype Instrumentation and ACTL

Weather station
OPC UA server
Java ACS component

Telescope Control server
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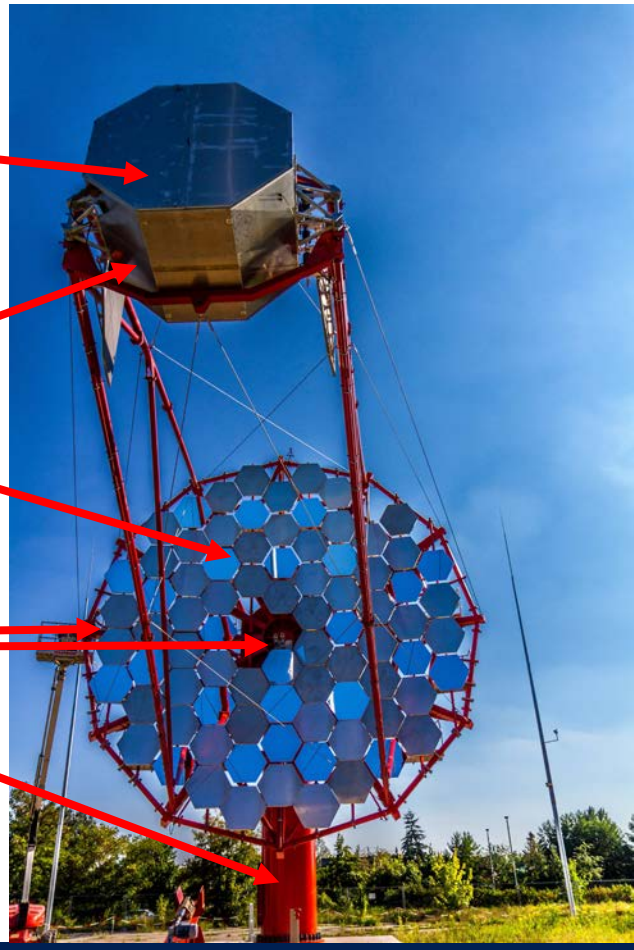
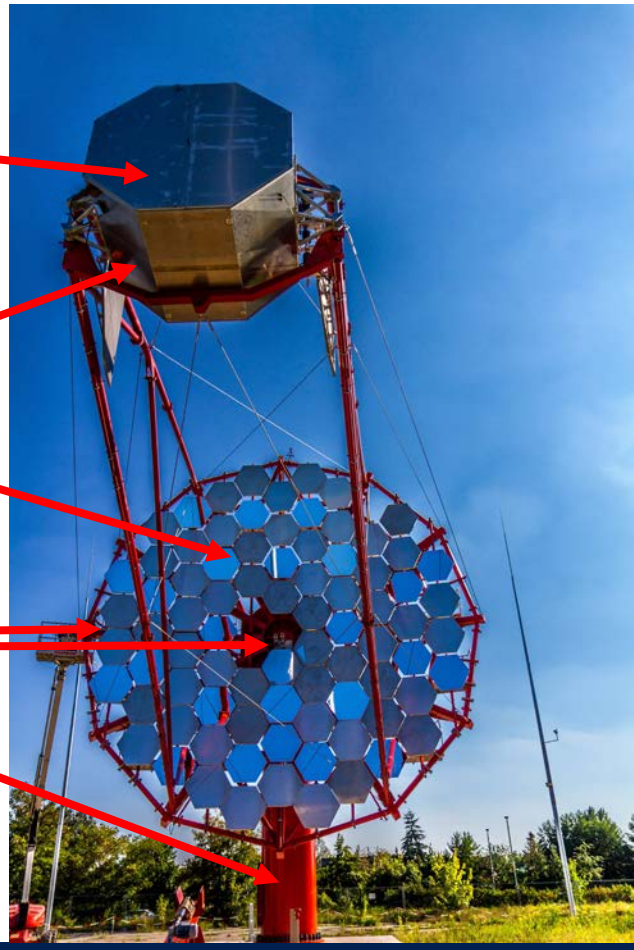


MST Prototype Instrumentation and ACTL

Weather station
OPC UA server
Java ACS component

Camera dummy
OPC UA server
Java ACS component

Telescope Control server
Dell PowerEdgeR720xd
2 CPUs (12 CPU cores)
128GB main memory
6TB local disk space.
Scientific Linux 6.4



MST Prototype Instrumentation and ACTL

Weather station
OPC UA server
Java ACS component

Camera dummy
OPC UA server
Java ACS component

Active mirror control
Different designs:
- Xbee wireless
- CAN-bus

ACS components, common interface

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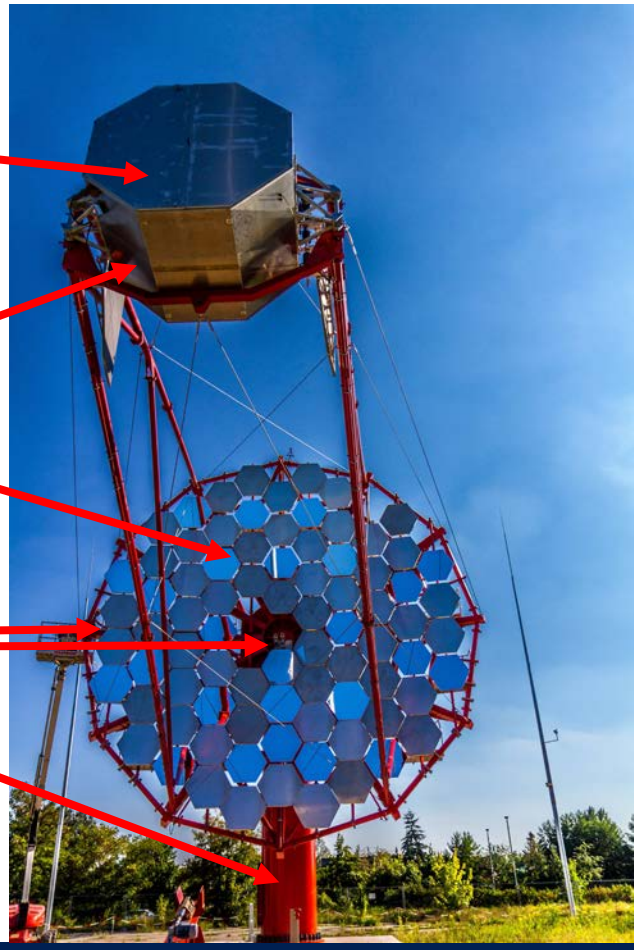

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Video display application
Document oriented database

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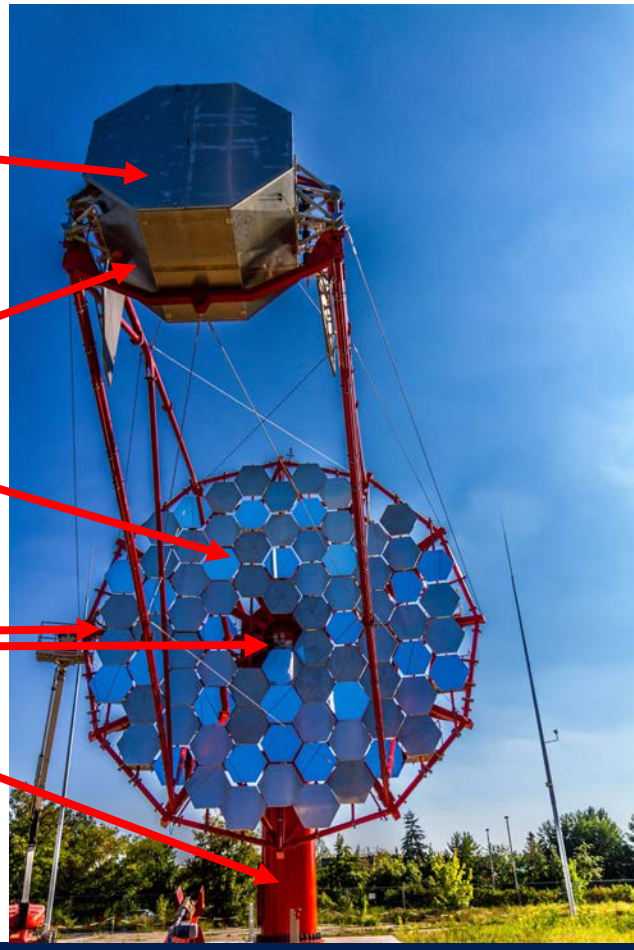

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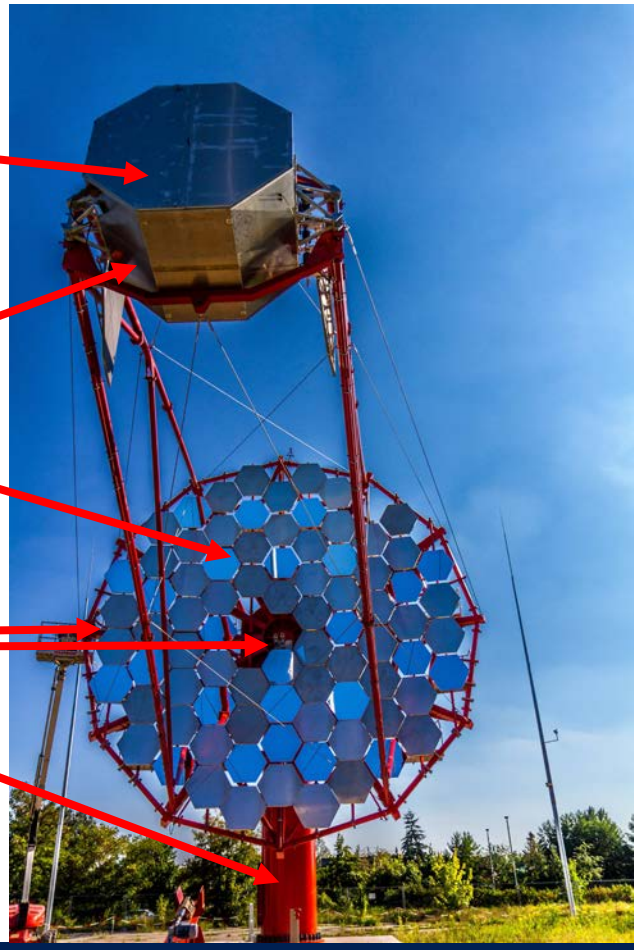
Drive System
PLC with native
OPC UA server
ACS component



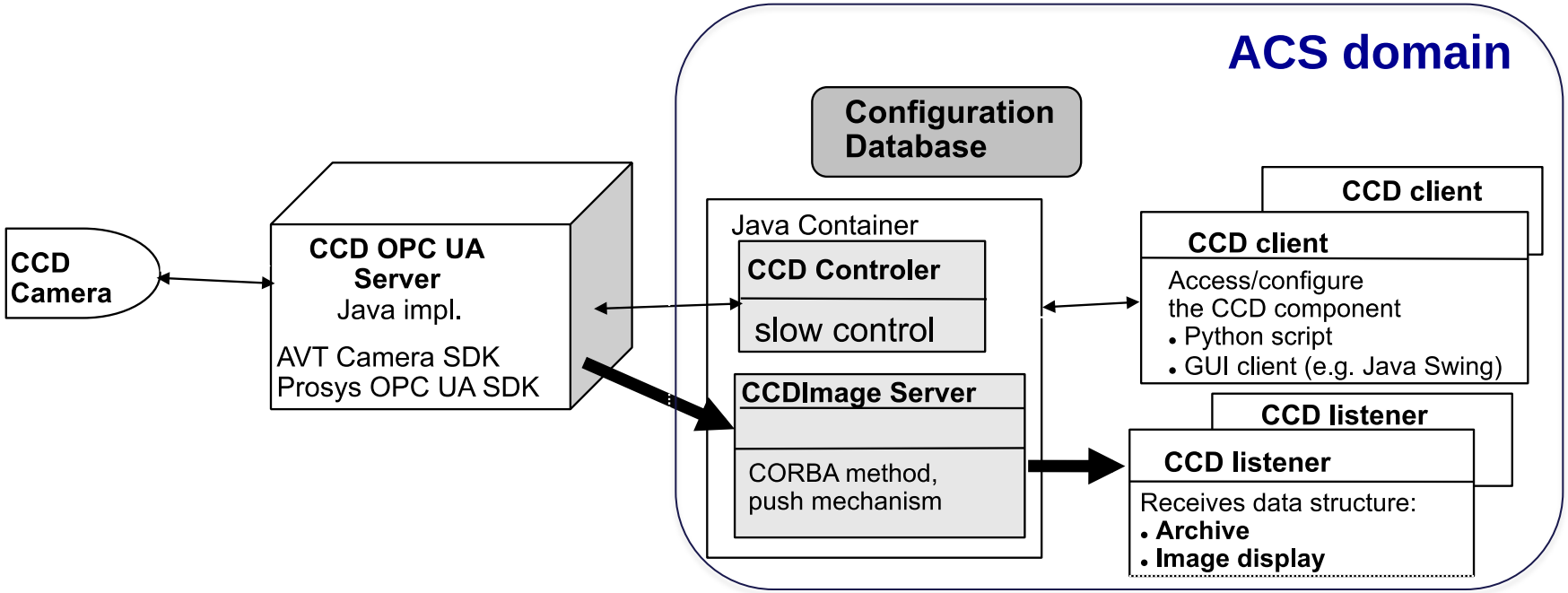
MST – CCD camera readout & control

OPC UA server provides the camera information model (Data&State Model + Basic functions), uses the SDKs from the CCD camera manufacturer for hardware accessing

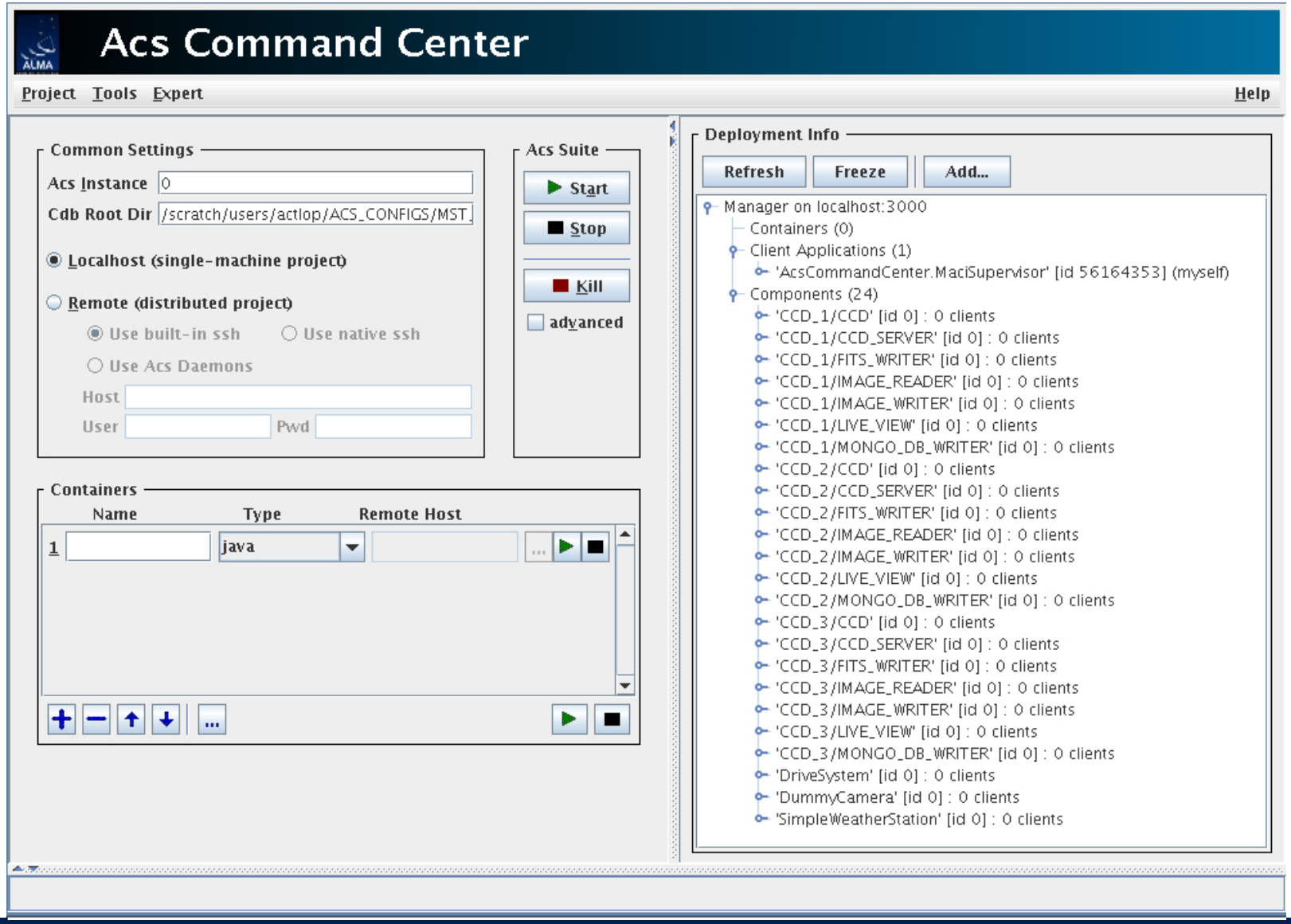
Java DevIO and Prosys Java SDKs for OPC UA and ACS communication.

Image data transferred (*push*) by a CORBA method call on one or more “listeners” (ACS components or CORBA objects). idea to test several other data transfer technologies.

For integration test, each ACS component includes an equivalent simulation component. (True also for OPC UA servers)

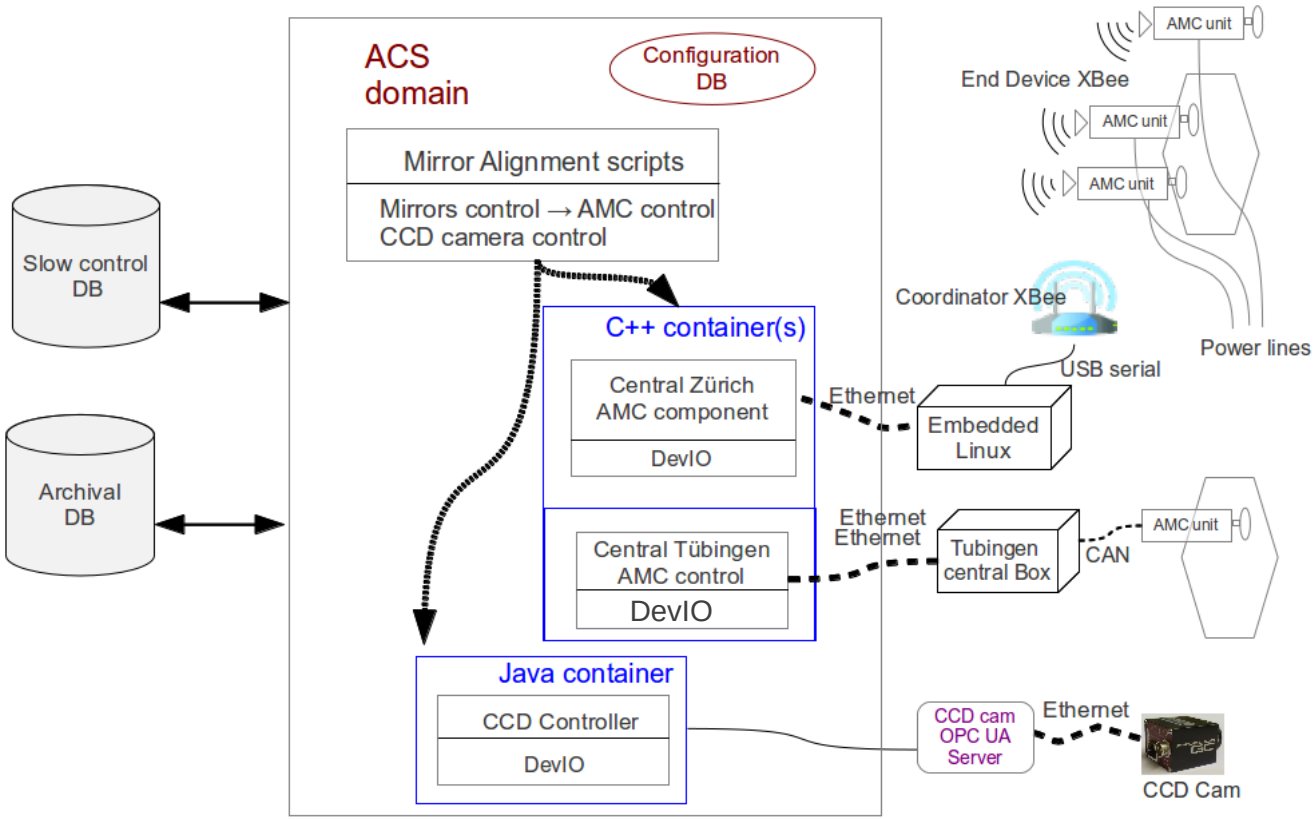


CCD camera – ACS GUI



Active Mirror Control (AMC) ACS interface

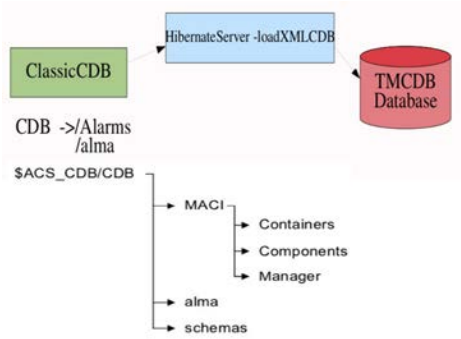
Direct access from Active Mirror Control to ACS DevIO device abstraction layer



MST - Data persistence and archives

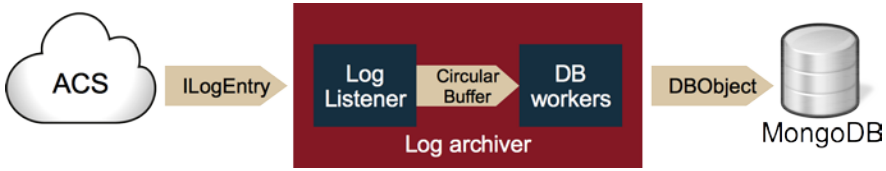
Configuration database (CDB)

- Device configuration and default values
- Front End: ACS TMCDB
- Backend: MySQL



Logging/alarms storage

- Front-End: ACD logging and alarm providers
- Backend: MongoBD



CCD Data storage

- Store the CCD images and headers in the same database
- Front-End: CCD camera readout
- Back-End: MongoDB, images in GridFS

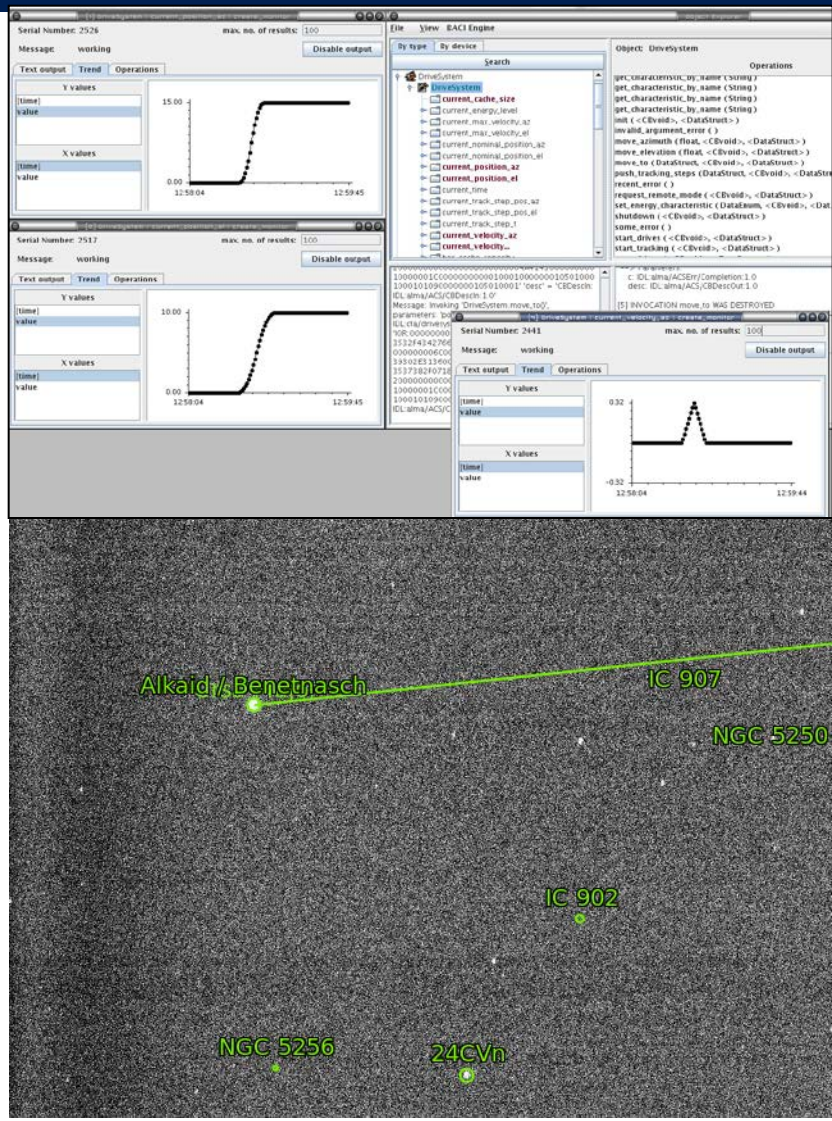
Monitoring storage:

“Property Recorder”

- Monitoring points in device properties
- Periodic and/or value change monitors
- Front-End: Python ACS applications
- Back-End: MongoDB and MySQL

First MST System test under full ACTL control

- CCD night sky data taking with MST prototype (Sep 13th, 2013) under ACTL control
- Took three 10 minutes runs:
  - Select a star from the star catalogue
  - Input RA/DEC coordinates to ACS drive system component and let telescope track star
  - Continuously readout CCD images with 5 seconds exposure
  - Images automatically stored in GridFS with metadata linked in mongoDB (NoSQL database)
  - Extract images from mongoDB
  - Analyse images with astronomy.net
- ACS alarm and logging system running
- Weather Station running



(picture - courtesy Louise Oakes)

MST Prototype – On site server and remote control

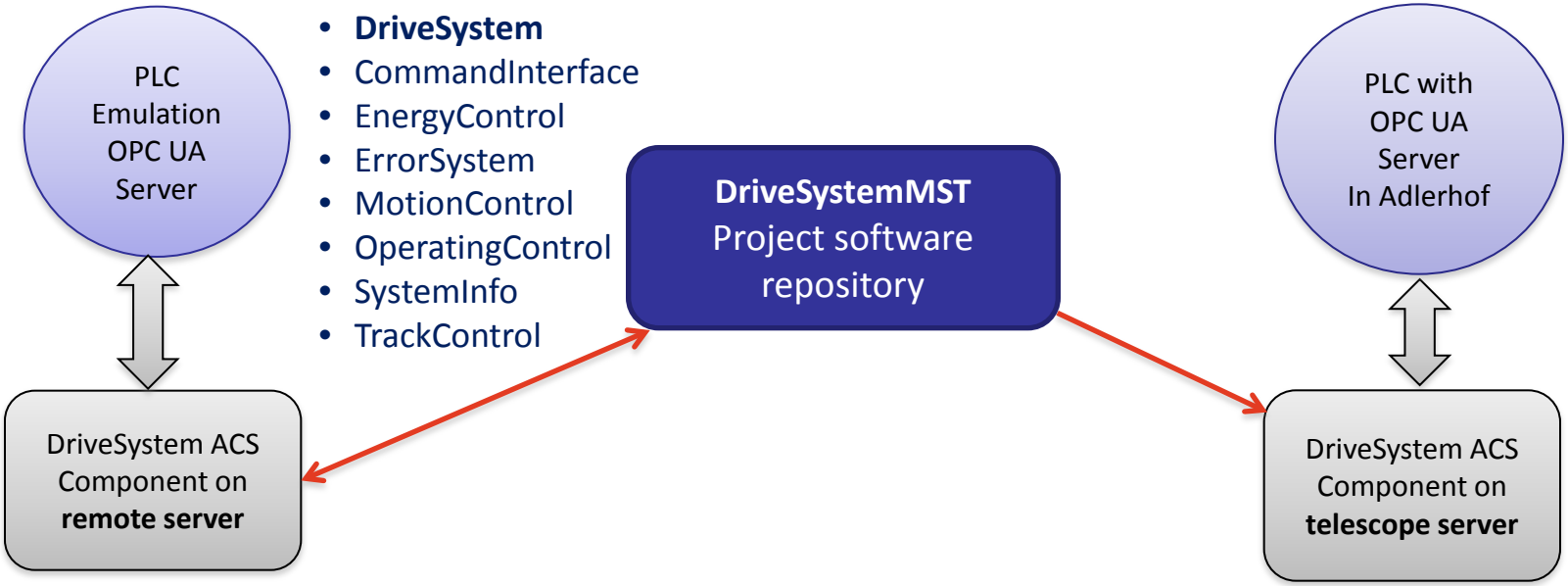
DESY Zeuthen

Remote Control server
2xDell PowerEdgeR510
each
2 CPUs (12 CPU cores)
128GB main memory
5TB local disk space.
Scientific Linux 6.4

Berlin-Adlershof

Telescope Control server
Dell PowerEdgeR720xd
2 CPUs (12 CPU cores)
128GB main memory
6TB local disk space.
Scientific Linux 6.4

Software development/deployment for the MST – Drive system example



Summary - next steps

Brief summary

- First experience with ALMA Common Software positive
- OPC UA server development for various devices feasible
- Using new approaches for control data storage (NOSQL data bases) promising

Next

- Integrate Dummy camera and Active Mirror Control
- Add non-optical sensors (condition monitoring)
- Automatize operations
  - Use script-base operation
  - Central array control GUI
- Central Array Control Prototype
  - Simulate ~100 telescopes and components (data, error handling)
  - Integrate an expert system for error/alarm handling