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Design of an Integrated Control System for Automated Operation of Large Array of Imaging Atmospheric Cherenkov Telescope

Si Ma[1], Huang Li[1,2], and the LACT Collaboration[1]

[1] Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
[2] Tianfu Cosmic Ray Research Center, Chengdu, Sichuan, China

Distributed Architecture | TANGO Framework | Automated Workflow | AI-ready Operation | Unified Web Portal

1 About LACT

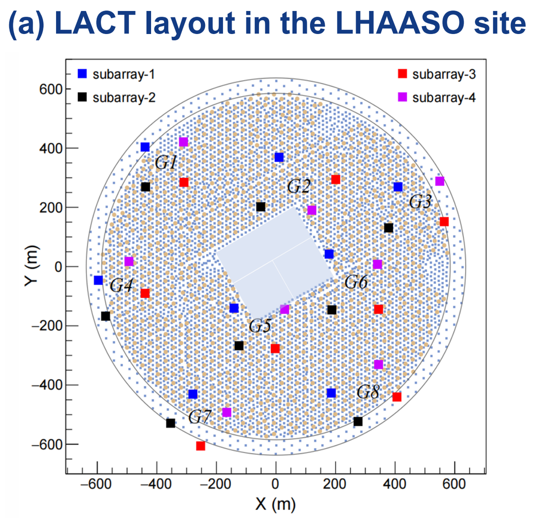
32 + Telescopes	<0.05° Resolution @ >10 TeV
6 m Reflector Diameter	LHAASO Co-located Array Site

Scientific role

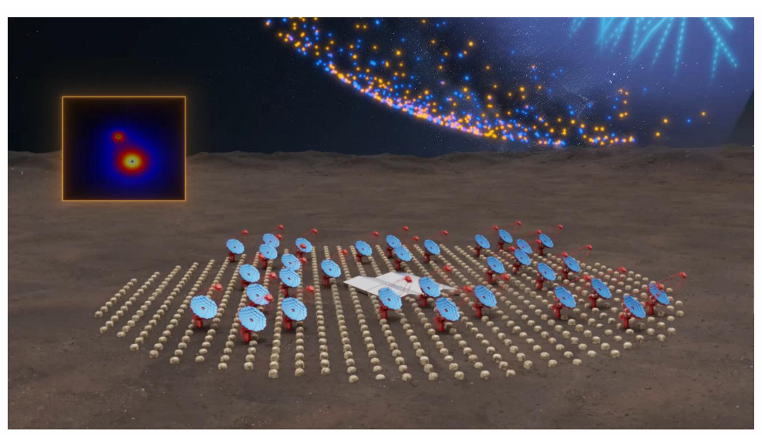
LHAASO (All-sky survey) → Need (Fine source morphology) → LACT (Stereo follow-up)

Array layout and conceptual site illustration

(a) LACT layout in the LHAASO site



(b) Conceptual illustration of the LACT site



2 Motivation and Automation Challenges

Why automation matters

- Many heterogeneous subsystems
- Nightly operation requires tight coordination
- Manual operation is inefficient and hard to scale
- Automation improves reliability, response, and maintainability

International benchmark

CTA
Array-level
ACADA / SCADA
scheduler + RTA

H.E.S.S.
Autonomous
To follow-up
alert → DAQ → RTA

Control challenge for a large telescope array

Telescope mount | Camera electronics | DAQ hardware | Power supplies | Calibration sources | Weather sensors → **Workflow & Resource Orchestration**: Safety / interlocks; Telemetry / health; Scheduling; Run configuration

Core automation challenges for LACT

1. Scale — Telescopes and devices must behave as one array.

2. Heterogeneity — Drive, camera, DAQ, Power and sensors

3. Synchronization — Observation, calibration and DAQ workflows must align.

4. Safety — Weather, interlocks and safe parking.

5. Data flow — High-rate status, logs and DAQ metrics need archiving.

6. Fault recovery — Robust restart, operation and diagnostics.

7. Quality control — Online checks for pointing, calibration and data integrity.

LACT strategy — Unified TANGO model + workflow automation.

3 Control System of 'Wangxi'

The first LACT telescope

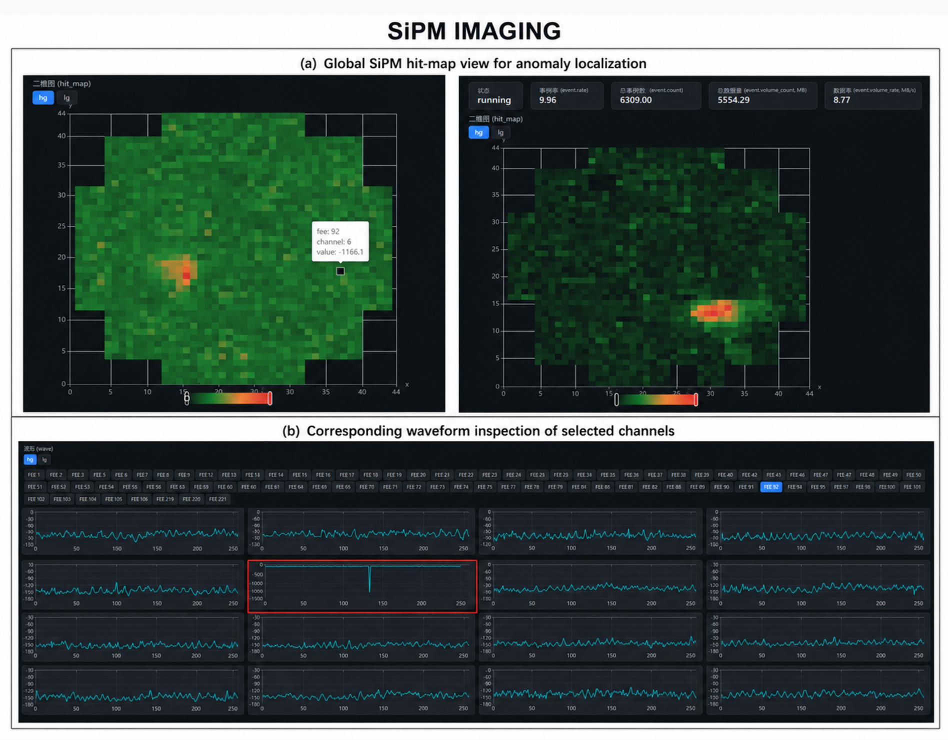
Integrated control frontend highlights

- **1 portal** — login + permissions
- **full-chain** — ACDC / DCDC / LED / DAQ
- **real-time** — waveforms+rates+counts

Validated architecture for unified telescope control

Unified frontend (login, permissions monitoring, configuration) → API Gateway (REST / WebSocket MCP-ready access) → Containerized Tango core (Tango DB, Device Servers service coordination) → Device services (ACU, DAQ, FEE Power, LED)

Integrated SiPM imaging view for online monitoring & anomaly localization



Frontend workflow

- View global 2D SiPM hit maps
- Identify hotspots or abnormal channels
- Inspect selected channel waveforms
- Cross-check rate, count and volume
- Read event rate and event count online
- Read parameters and set operation modes
- Timed DAQ / power operation support
- Basis for Telescope #2 standardization

4 Contributions and Outlook

Unified architecture

- Tango-based abstraction
- Hardware + DAQ + software
- API Gateway and containers

First-telescope validation

- Integrated control + DAQ
- Monitoring and diagnosis

Scalable deployment

- Wangxi to Telescope #2
- Then 8 telescopes
- 32+ array scale

AI-ready operation

- Online analysis
- AI scheduling and diagnosis
- Joint-trigger coordination

Roadmap toward array-scale operation

#1 Wangxi (stable operation) → #2 upgrade (new DAQ + PLC interface) → 8 telescopes (reproducible deployment) → 32+ array scale (automated intelligent O&M)

LACT is evolving from automated observation to intelligent observation, integrating coordinated triggering, multi-messenger response, and AI-driven operations to become an intelligent science node in the global observatory network.