CTA 報告 113：Schwarzschild-Couder
光学系を用いた小・中口径望遠鏡の開発

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Cherenkov Telescope Array (CTA)

**Large-Sized Telescope (LST)**
- 4@North + 4@South
- $D = 23$ m
- FOV = 4.5°
- $E = 20$–200 GeV

**Medium-Sized Telescope (MST)**
- 15@N + 25@S
- $D = 12$ m
- FOV = 8°
- $E = 100$ GeV – 10 TeV

**Schwarzschild–Couder Telescope (SCT)**
- 25@S
- $D = 9.6$ m
- FOV = 8°
- $E = 200$ GeV – 10 TeV

**Small-Sized Telescope (SST)**
- GCT (SC) ~35@S
- ASTRI (SC) ~35@S
- Davis–Cotton ~20@S
- $D \sim 4$ m
- FOV ~9°
- $E = 5$ TeV – 300 TeV
Schwarzschild–Couder Telescope (SCT)

At first, proposed as Advanced Gamma-ray Imaging System (AGIS)

Now an extension for the CTA South
- Will improve the sensitivity in 100 GeV – 10 TeV
- Davies–Cotton MST × 25
- Schwarzschild–Couder × 25

Challenges
- High-quality mirrors and fine alignment
- SiPM array and ASIC
- Will realize a large FOV of 8° and fine angular resolution of ~0.06°

Okumura+ (2016)
SCT Advantages

- MC study shows SCTs have better angular resolution of arrival direction by a factor of ~1.5 than Davies–Cotton MSTs
- ~30% better sensitivity for point sources
- Less expensive camera pixel cost

**Angular Resolution**

**Point Source Sensitivity**

Wood+ (2016)
The plate scale of 97.5 mm/deg and FOV of 8° require SiPM or MAPMT camera modules.

- The focal plane is covered with 11,328 SiPM pixels.
- 64 pixels per module are readout by 4 TARGET ASICs.
The SCT Prototype is under Construction

Sep 11, 2016 at the VERITAS site
http://cta-psct.physics.ucla.edu/index.html
Small-Sized Telescope (SST)

- 3 different designs proposed
  - ASTRI
  - 1M-SST (Davies–Cotton)
  - Gamma-ray Cherenkov Telescope (GCT)
- GCT uses similar techniques as in SCT
  - SC optics
  - TARGET modules and SiPMs
  - Backplane board
  - Camera control and DAQ software
- The GCT prototype was inaugurated at the Paris Observatory in Dec 2015
Inauguration of the GCT Prototype (Dec 2015)
The GCT Camera Prototype (with MAPMTs)

- Lid
- Water chiller
- ~40 cm
- LED Flasher
- Camera Module
- FPGA
- TARGET ASIC × 4 (16 ch per ASIC)
- Pre-amp Boards
- Hamamatsu MAPMT

@ Univ. Leicester, UK
64-ch MAPMT × 32
2,048 pixels

@ Paris Observatory, France
The First Cherenkov Light in CTA (Nov 26, 2015)

- Very Preliminary Calibration
- Mirrors are not aligned
- Under the Paris sky

Thu Nov 26 18:53:37 2015 (UTC)
First GCT-M On-Sky Data, Peak values ~275 p.e.
SiPM-based GCT Camera

- 32 MAPMTs will be replaced by SiPMs, and the latest TARGET ASICs will be used
- A prototype with improved camera mechanics will be built in 2017
- Three production telescopes will be at the CTA South in 2018
TARGET ASIC – 16-ch Readout and Trigger

- We have been developing TARGET ASICs since 2009
- The trigger performance was worse than expected in T1, T5, and T7 (TARGET variants)
- Finally satisfactory trigger performance achieved in the latest design (TARGET C & T5TEA)
SiPM Characterization for SCT and SST

- SiPM characterization in various temperature/voltage conditions underway
- Recent SiPMs have lower crosstalk rate and higher PDE compared to ~2010
- PDE ~60% is expected with a lens array
Summary

- We have developed
  - Schwarzschild–Couder telescopes for CTA Medium and Small-Sized Telescopes
  - Cameras with the TARGET ASIC technology and SiPMs
- The prototype of GCT (a Small-Sized Telescope design) was inaugurated at the Paris Observatory Dec 2015
- The first Cherenkov events ever in CTA were recorded
- Further improvements of TARGET, photodetectors, and camera mechanics foreseen