MAX-PLANCK-INSTITUT
FÜR KERNPHYSIK
HEIDELBERG

cta
cherenkov
telescope
array

Francesco Conte

# CHEC-S

## A Compact High-Energy Camera for the Cherenkov Telescope Array in the 1-300 TeV range

# Overview

1. Ground-based VHE astrophysics: a completely different logic!
2. CTA and the Small-Sized Telescope [SST]
3. The Small-Sized Telescope and CHEC-S
    1. Telescope optical needs and requirements
    2. Camera requirements
4. Triggering CHEC-S: the TARGET module
5. On-site testing: the ASTRI campaign
6. Conclusions

1. **Ground-based VHE astrophysics**
2. CTA and the SST
3. The SST and CHEC-S
    1. Telescope optical needs and requirements
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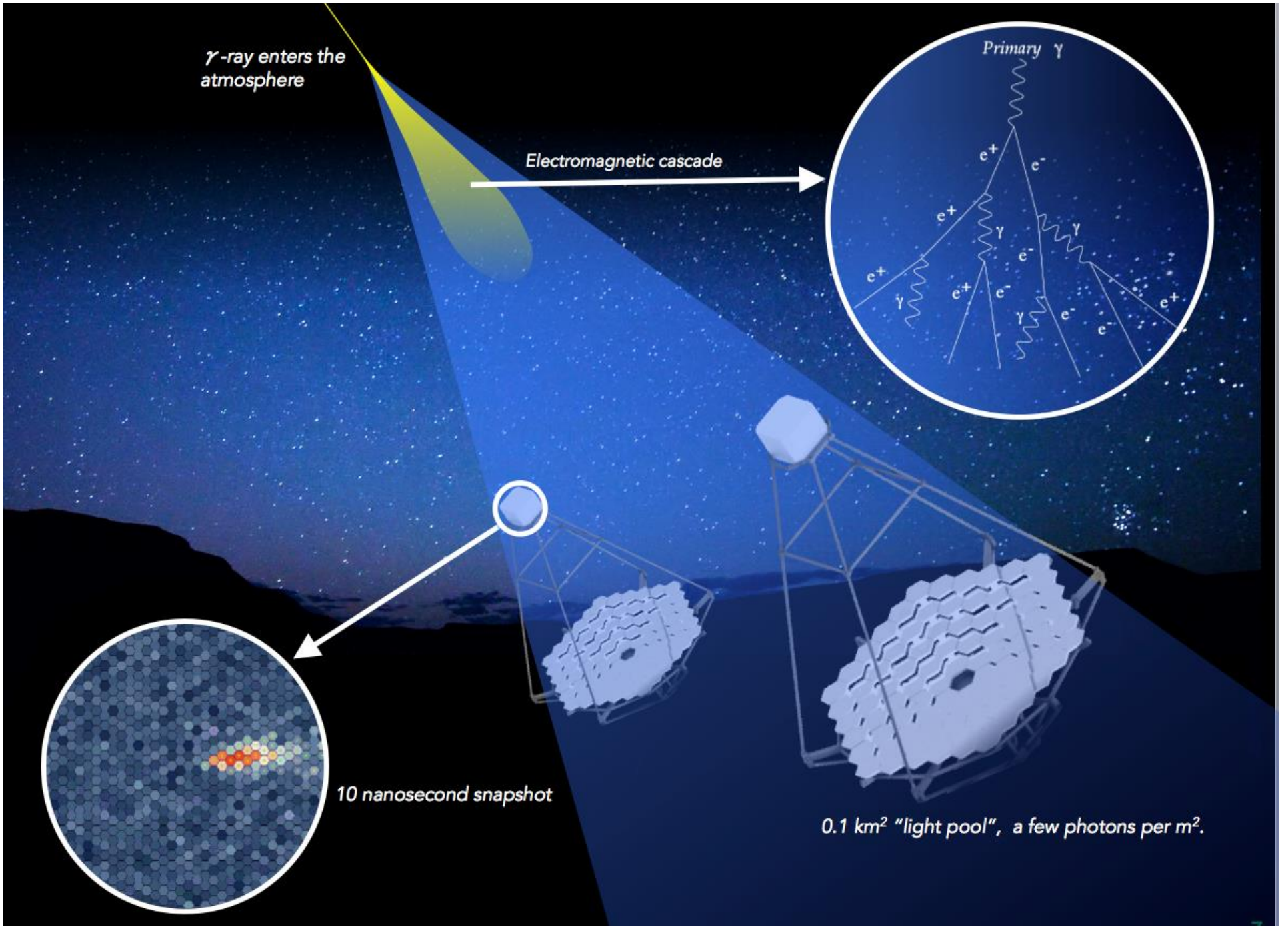
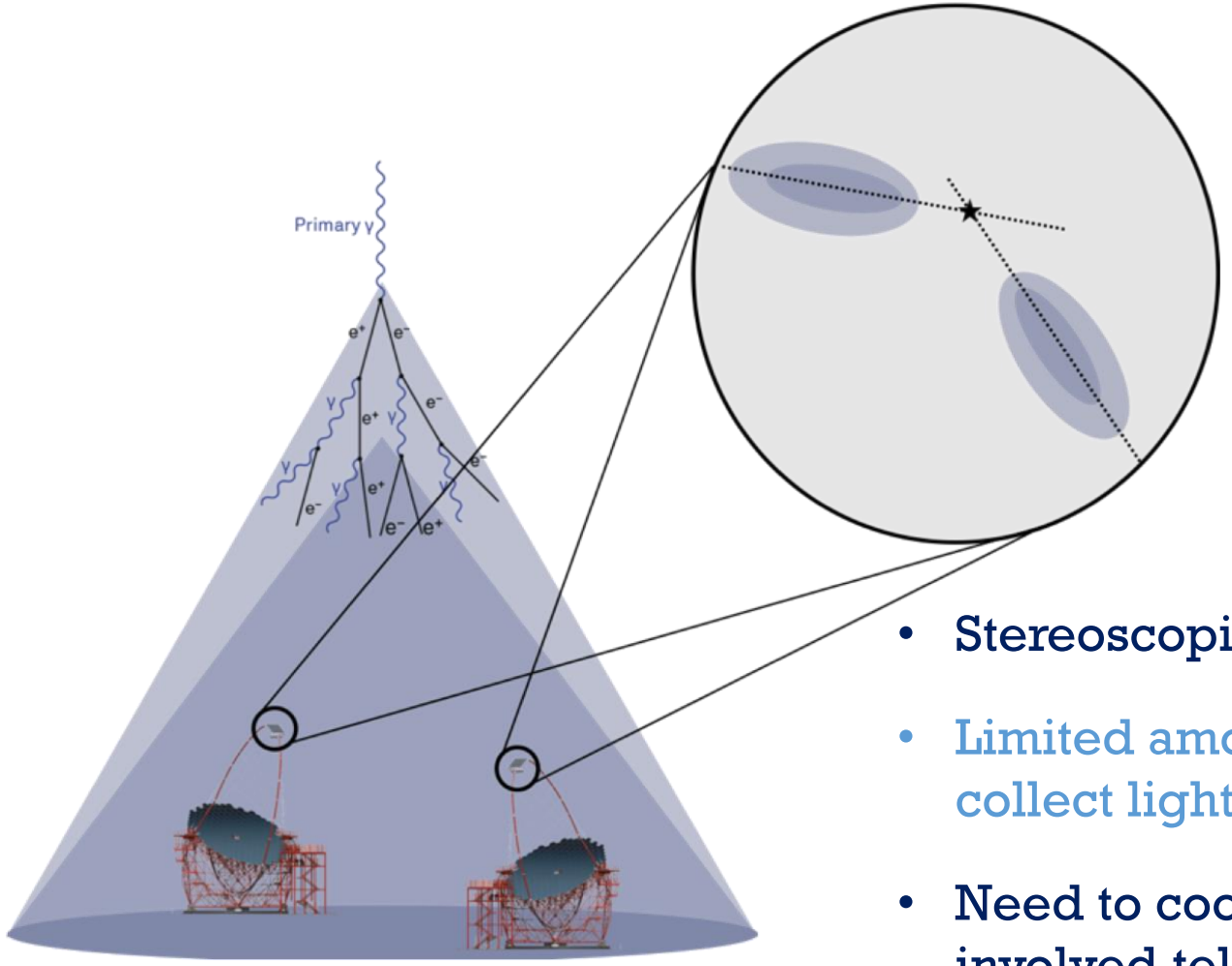


# A completely different logic!

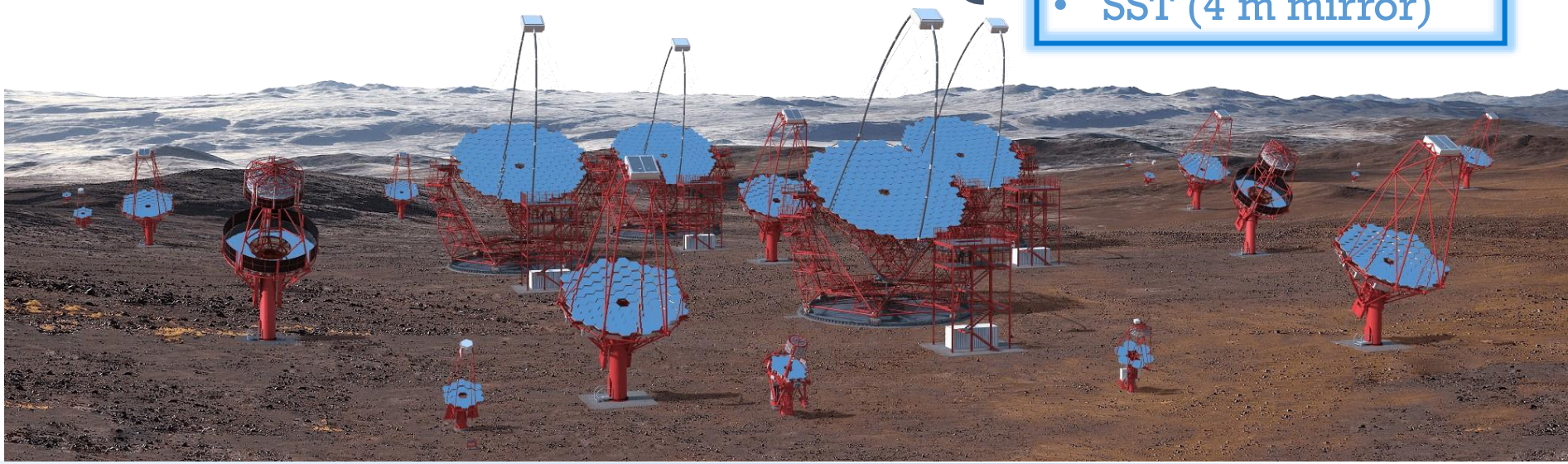





- Stereoscopic reconstruction
- Limited amount of time to collect light
- Need to coordinate all the involved telescopes with precision of ~ nanosecond

# CTA – the next generation Cherenkov Telescope

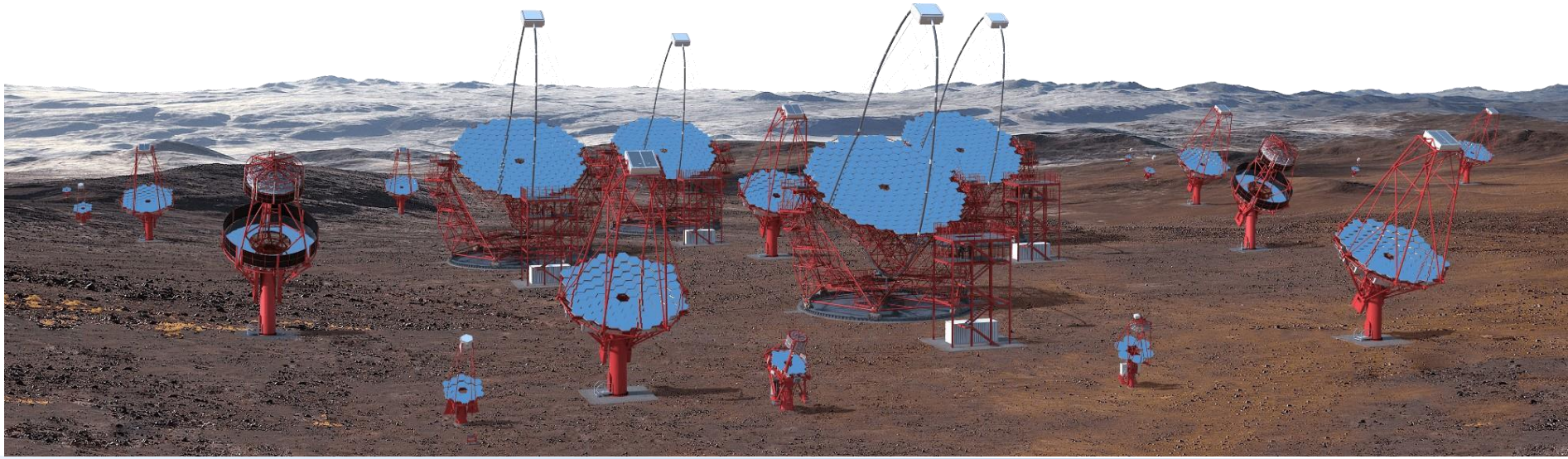
- Two sites in the northern and in the southern hemisphere
- ~100 telescopes just in the Southern site, covering a huge area
- Telescopes of 3 different sizes:
  - LST (23 m mirror)
  - MST (12 m mirror)
  - SST (4 m mirror)



# The Small-Sized Telescope – Optical requirements

## Constraints on the optical system to observe at 100+ TeV:

- Mirror area
- Field of view
- Pixel size and number



# The Small-Sized Telescope – Optical requirements

## Constraints on the optical system to observe at 100+ TeV:

- Mirror area → Small
- Field of view → Large

} Small focal ratio required!

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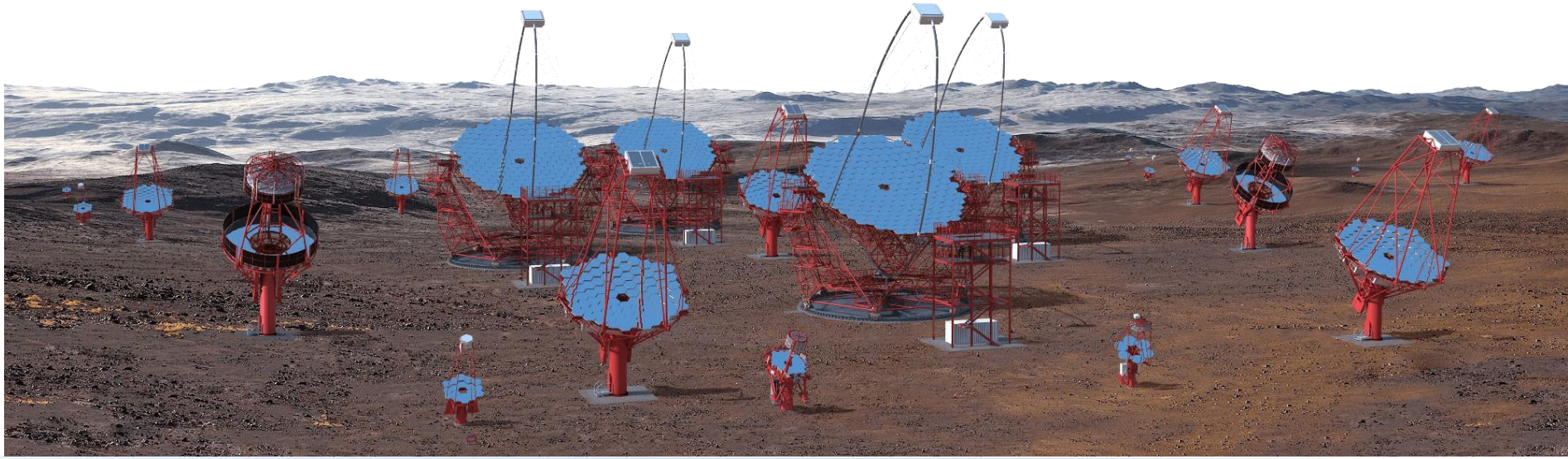

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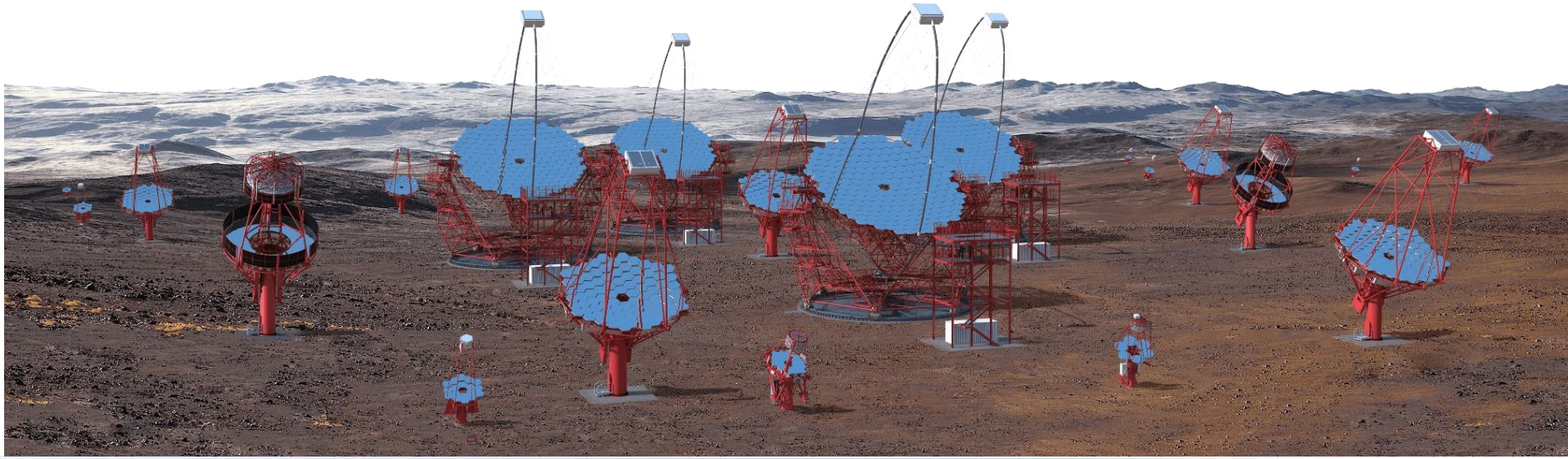

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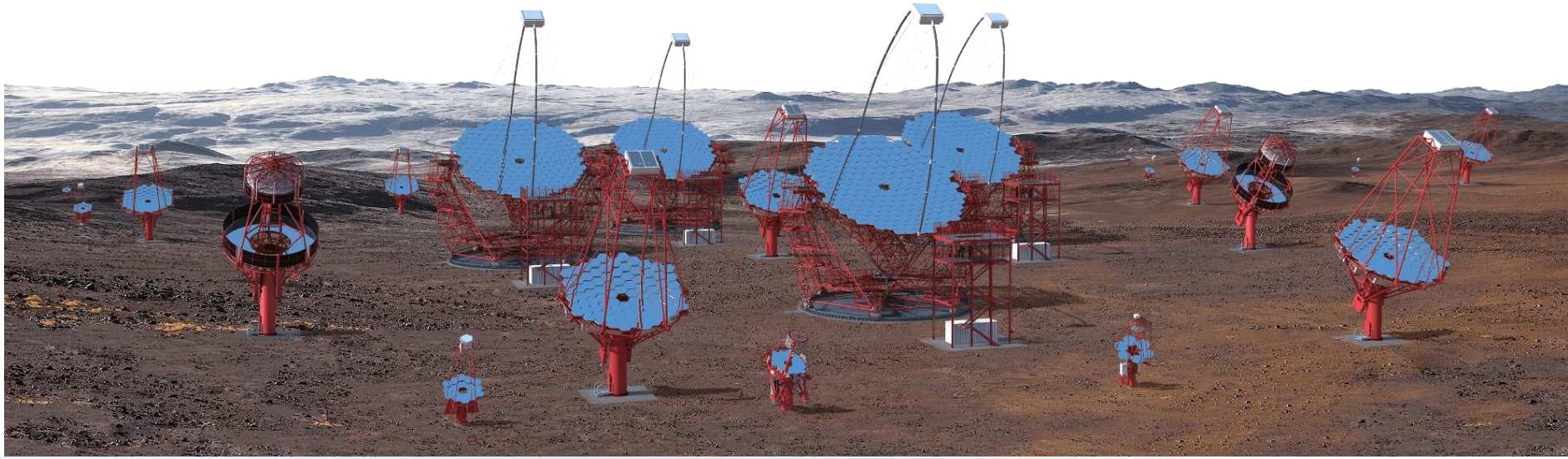

# The Small-Sized Telescope – Optical requirements

## The optical system Point Spread Function affects the pixels

- Aberrations: power laws of the inverse of the focal ratio
  - Spherical
  - Coma
  - Astigmatism
  - Distortion
  - Field curvature
  - …

Smaller PSF → Higher f/#

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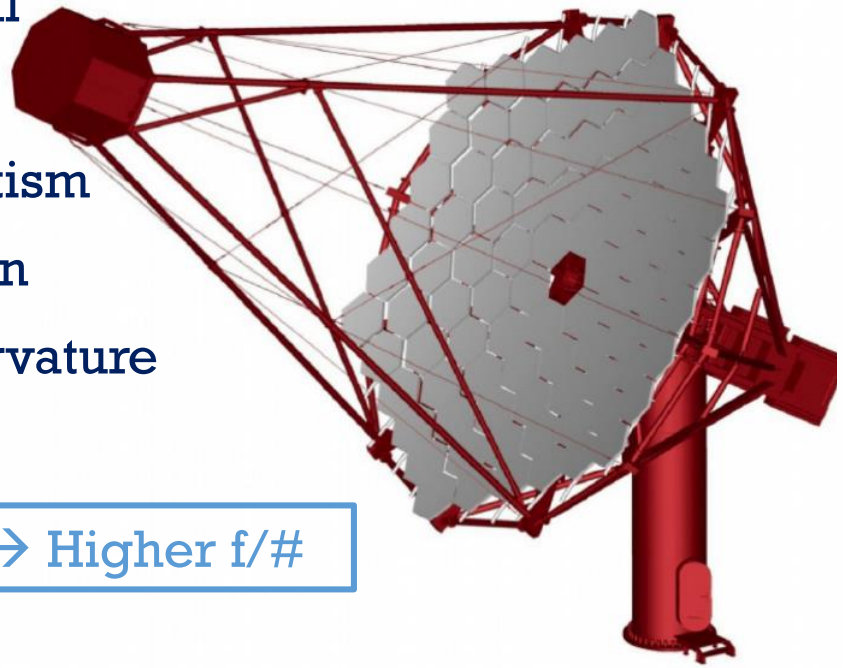
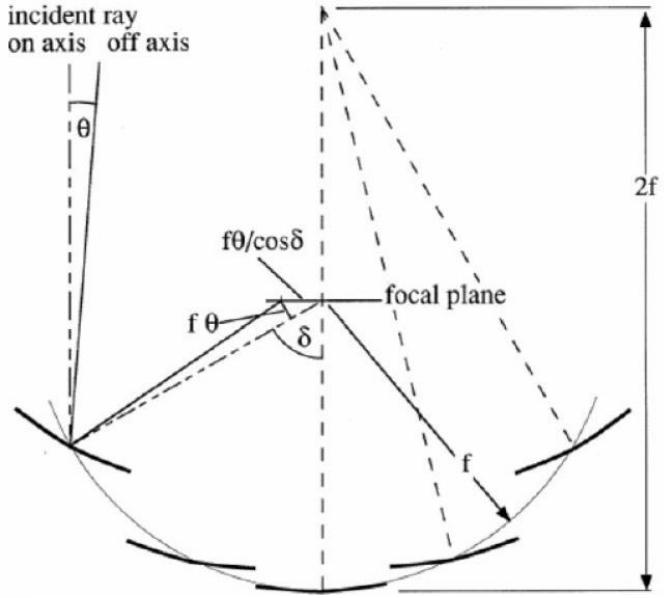





Smaller PSF → Higher f/#

Davies-Cotton: paraboloid, but with spherical facets

# The Small-Sized Telescope – Optical requirements

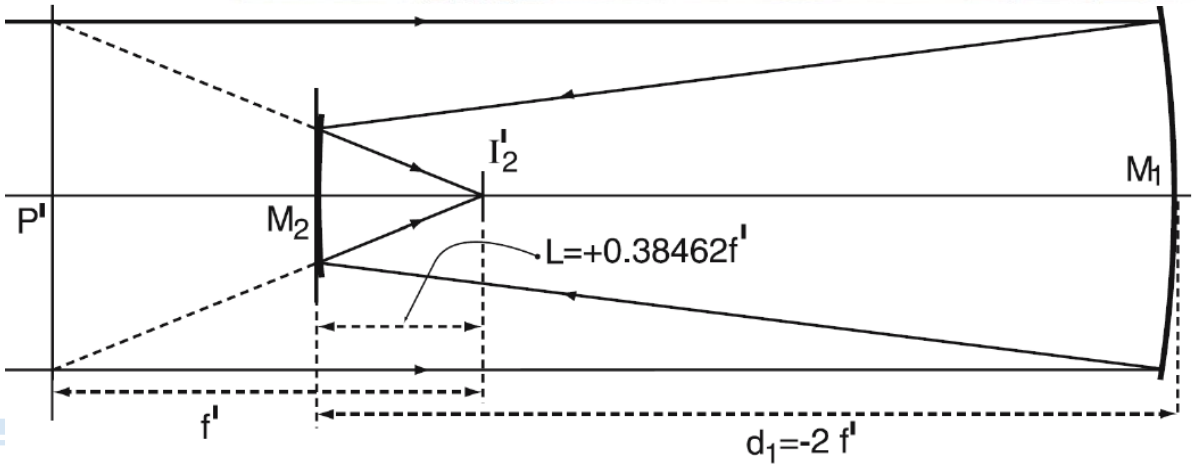


Schwarzschild-Couder: two-mirror, aplanatic telescope

- Slow primary iperboloid, fast secondary ellipsoid
- Uses the secondary to REDUCE the effective focal length!
- High distortion and curvature
- High obscuration of M1
- Camera "looking" at the source

"The Couder telescope will remain an important theoretical limit case but will rarely be utilized in practice"

R. Wilson, 1970



# The Small-Sized Telescope – Camera requirements

Fov ~ 8°
Pixel angular size ~ 10 arcmin (0.17°)
} 48 pixels in a row

6mm x 6mm pixels → camera 30 cm long

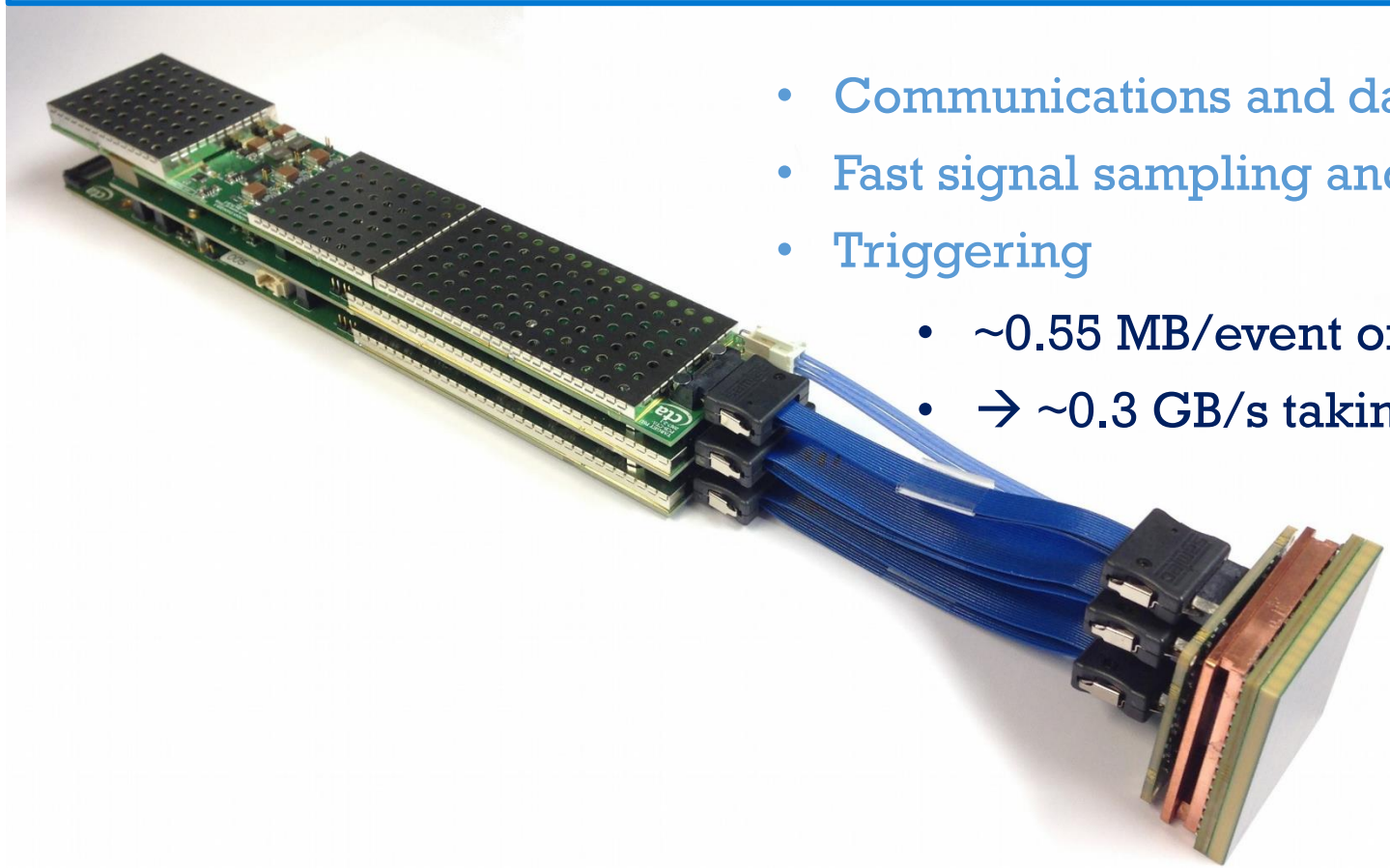
Plate scale S = 10 arcmin/6mm = 1.67 arcmin/mm
[but S = 3.44 arcmin/ $f_{eff}$ (in mm)] → $f_{eff}$ = 2.2m

Using a 4m mirror → f/# = 0.55

Diffuse flux @1 TeV: 0.27 $m^2$/s/sr/TeV
Effective area for 1 TeV photon: $10^5$ $m^2$
Fov = 8° (0.017 sr)
} 450 Hz event rate

Timing sensitivity → 1 ns

# CHEC-S – The TARGET module



- Communications and data handling
- Fast signal sampling and digitization
- Triggering
  - ~0.55 MB/event on raw file
  - → ~0.3 GB/s taking data at 600 Hz

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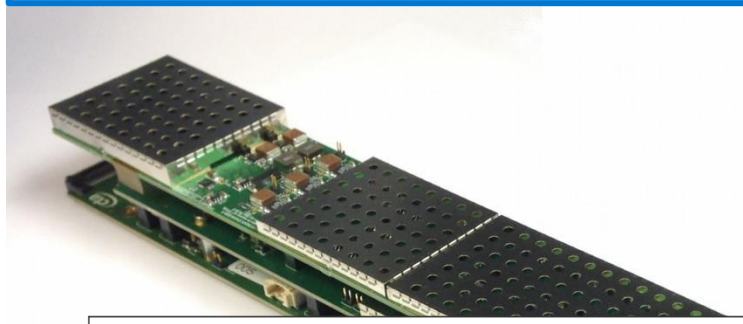

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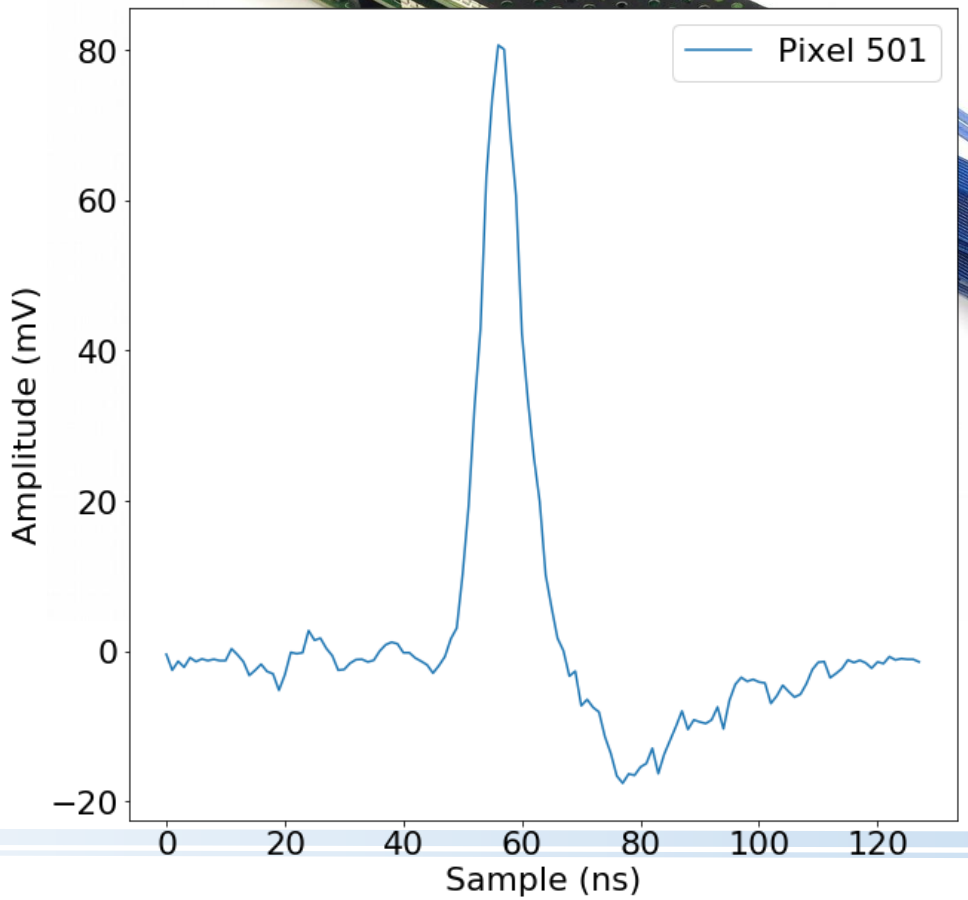


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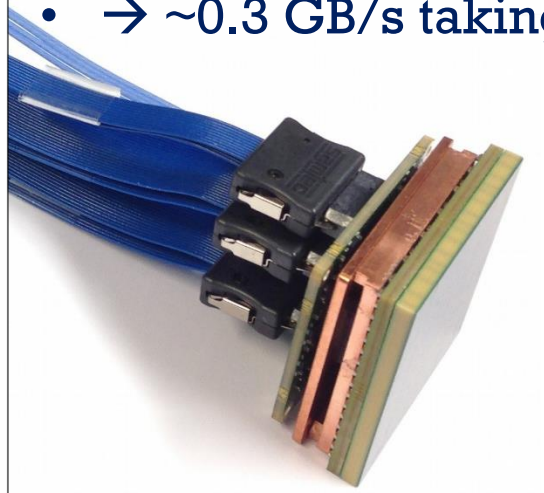

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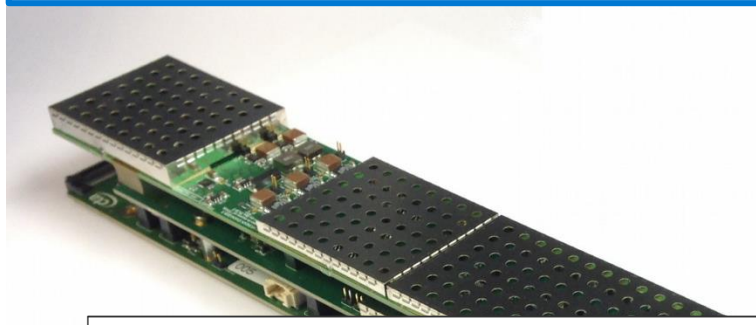

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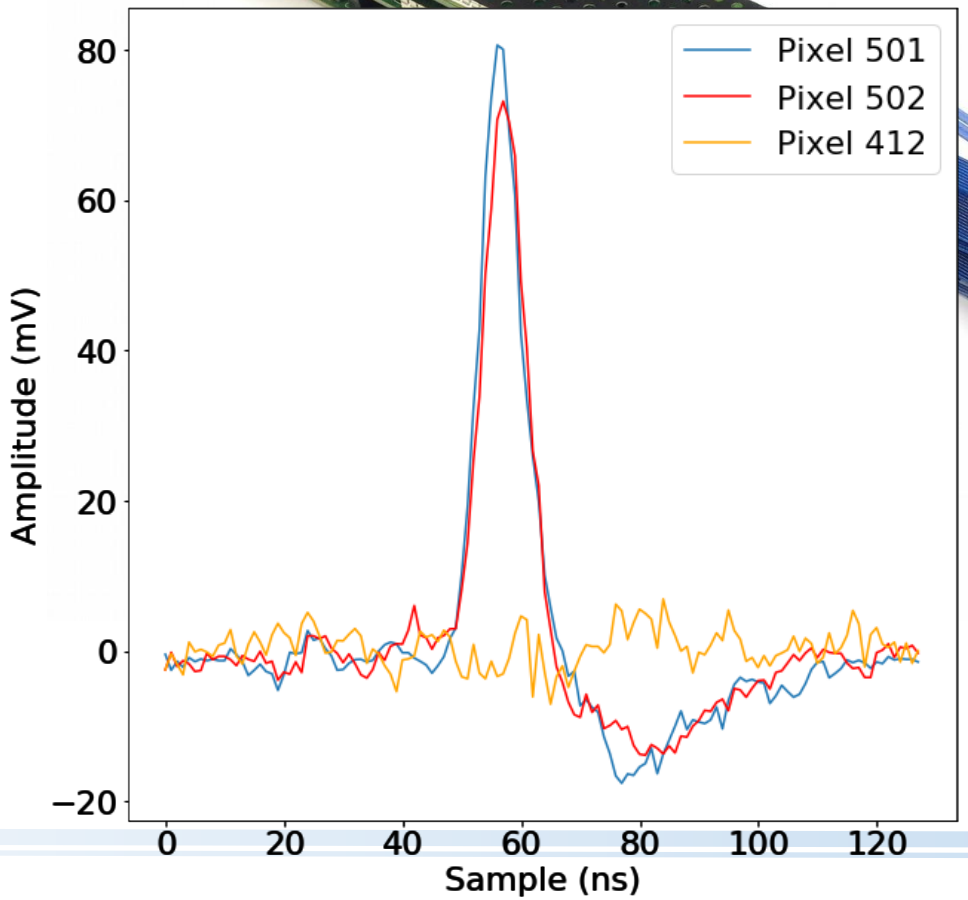


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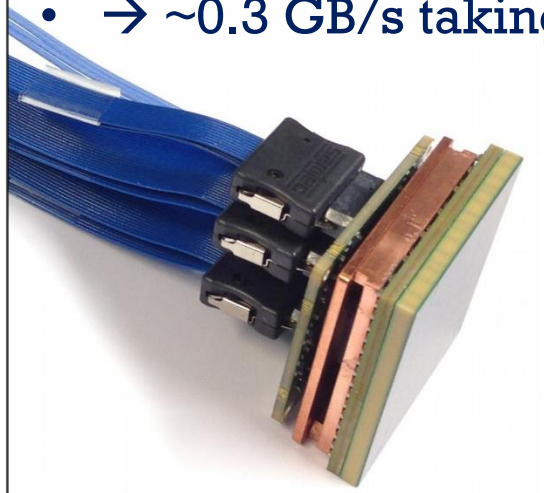

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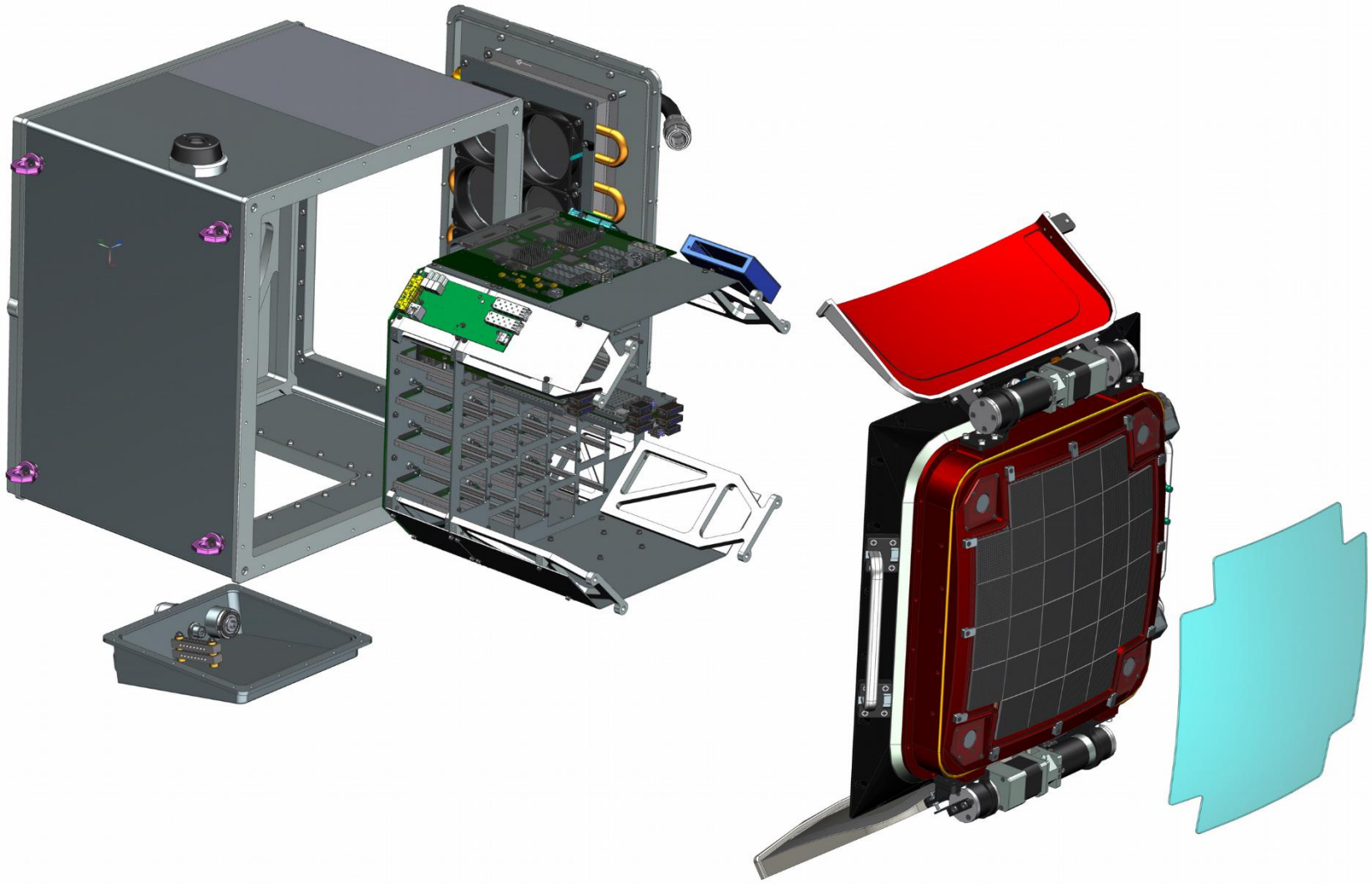
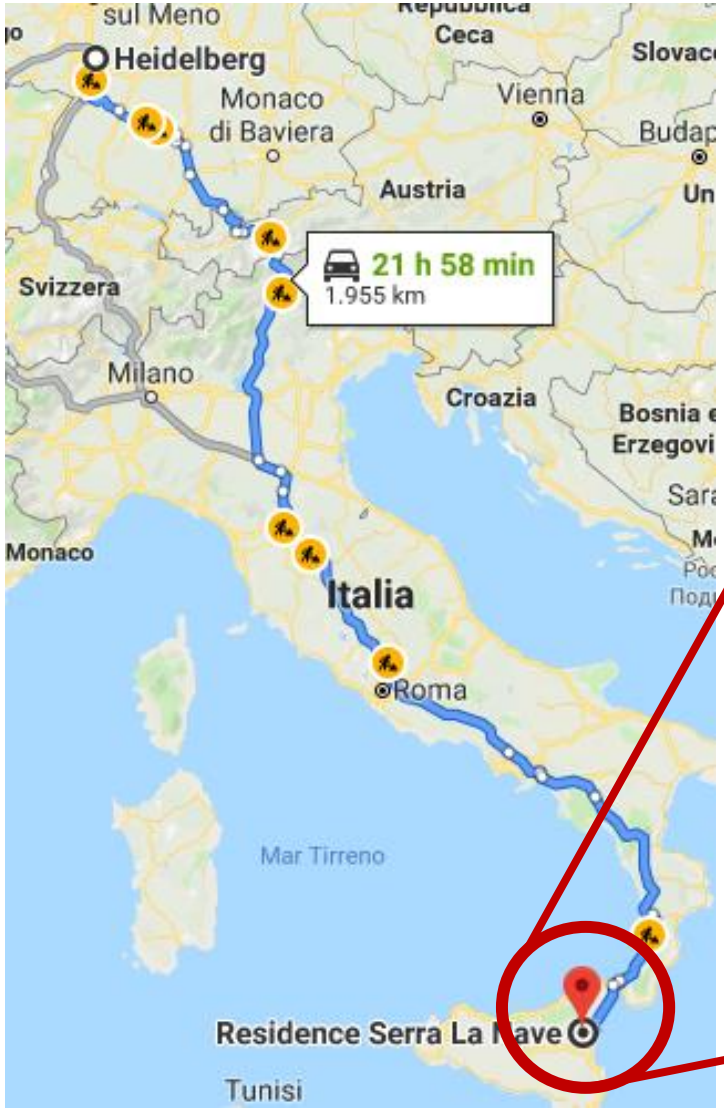


# On-site testing: the ASTRI campaign (3 weeks ago!)



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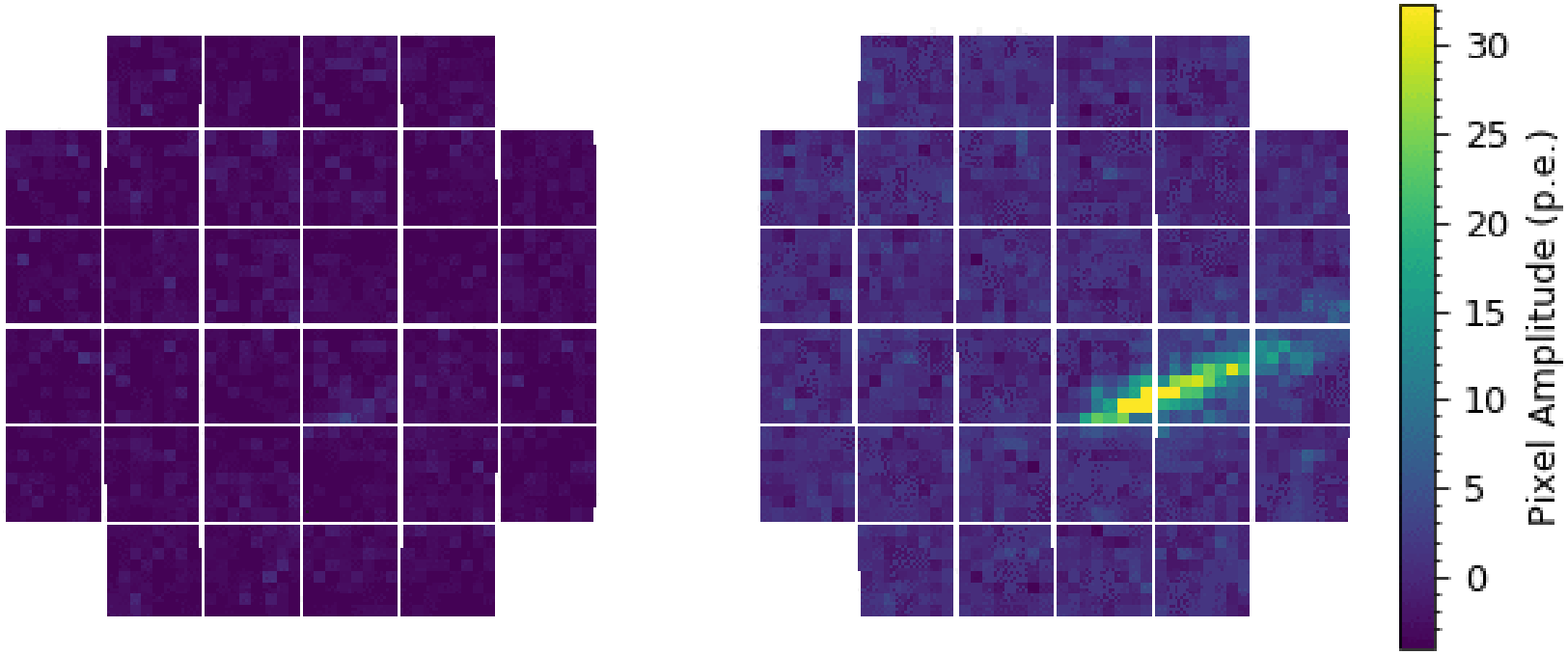
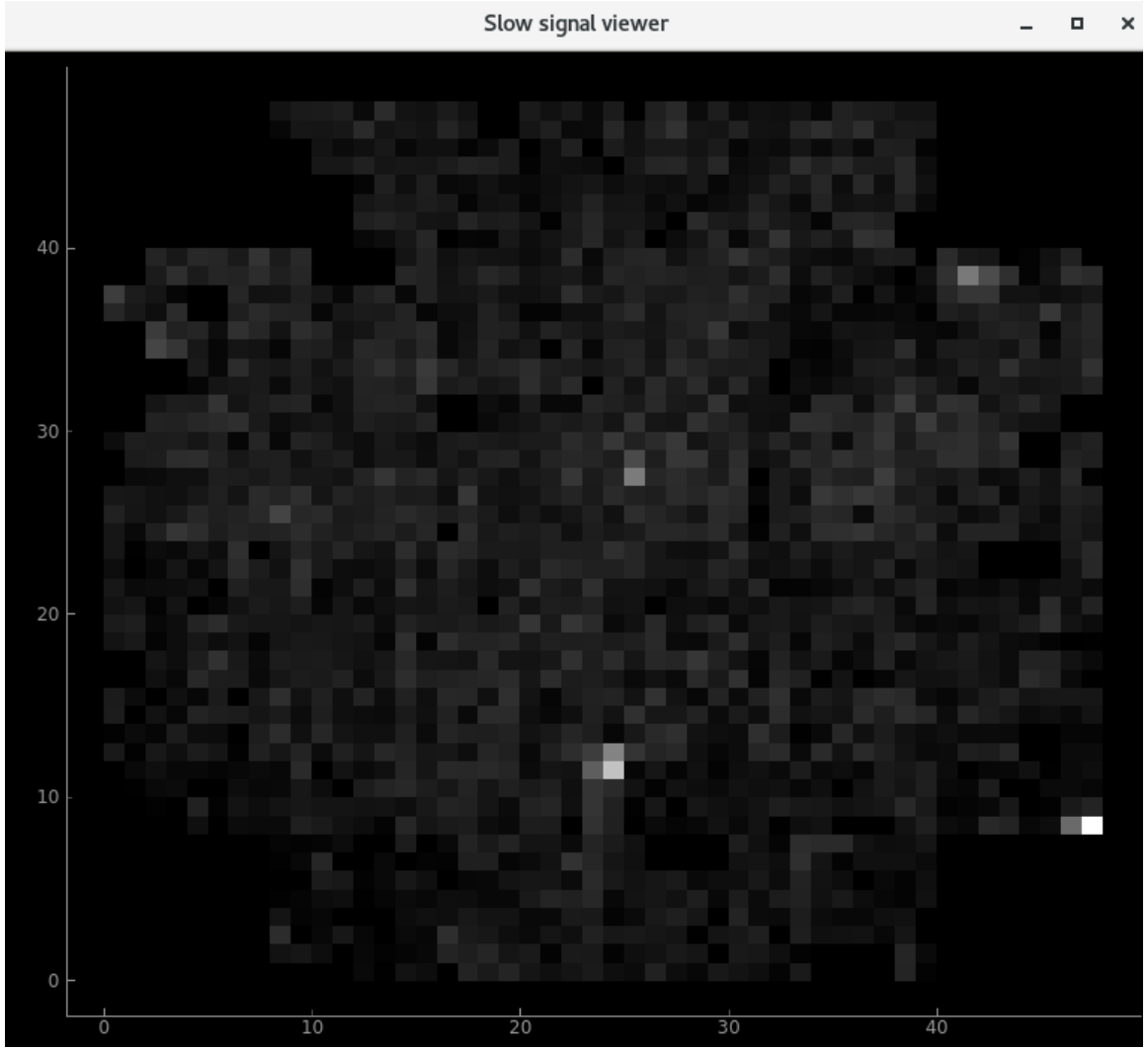



See the press release at:

https://www.cta-observatory.org/chec-achieves-first-light-on-astri/

# On-site testing: Slow signal





# Conclusions



# Conclusions (seriously)

✓ Many sources pointed:
- Mrk421
- Mrk501
- PG 1553+113

✓ Many functionalities proven:
- Pointing & Slow Signal
- Feasibility of absolute calibration via LED flashers
- Trigger patterns

✓ Many dependencies under investigation:
- Temperature & Humidity
- NSB

- Hot topics
  - Muons
  - NSB variability
  - Charge reconstruction and saturation
  - SPE
  - Noise & Calibration
  - Low amplitude events
  - …

# Thank you for your attention!

## (and patience!)

(really!)