cherenkov telescope array

DESY

# Status of the Medium Size Telescope for the Cherenkov Telescope Array

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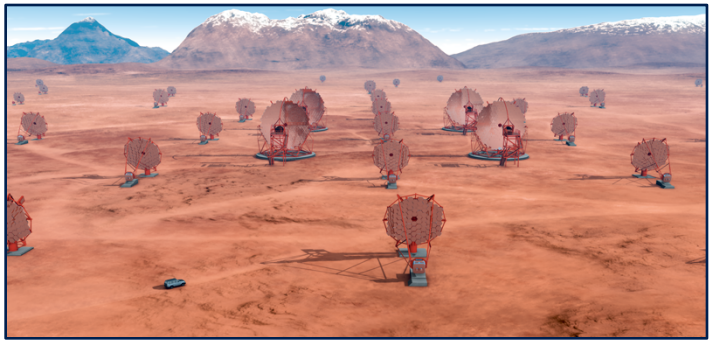
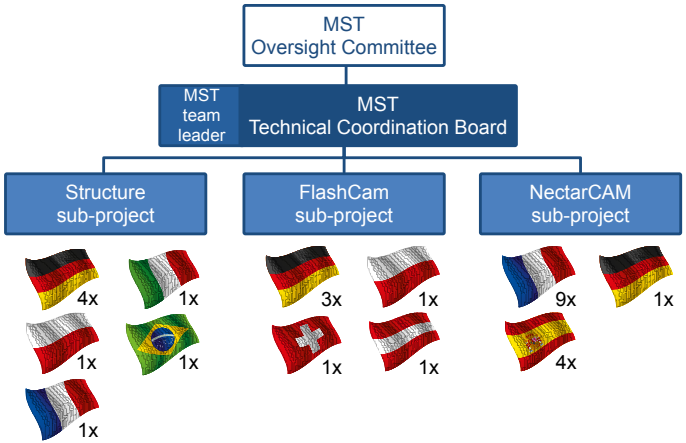
on behalf of the CTA consortium

Cosmic Ray International Seminar 2016 – Ischia – 4.07.2016

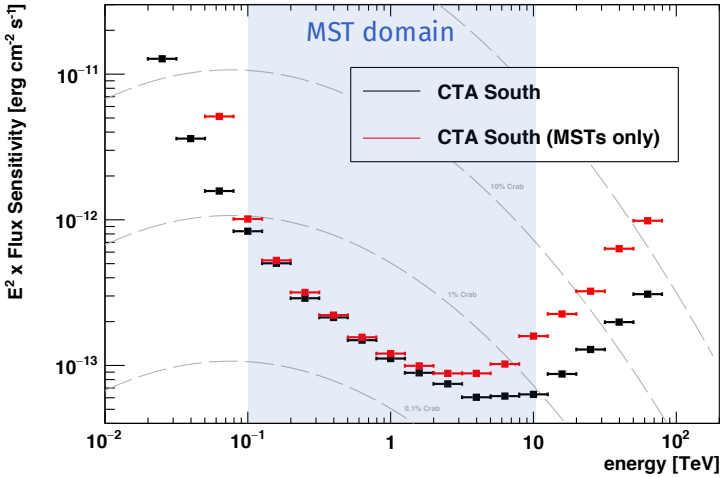
# MST sub-system

- Core energy range: 100 GeV – 10 TeV
- Baseline: 25/15 MSTs in South/North
  Initial stage: 15/5 MSTs in South/North
- Three sub-projects

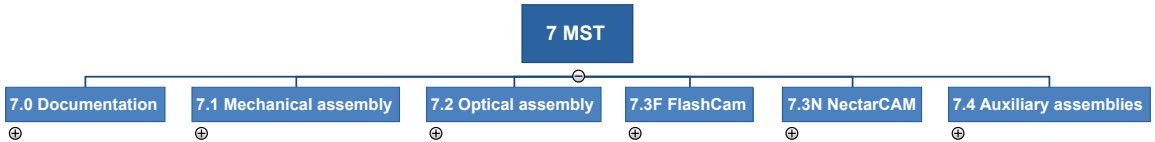





8 countries
27 institutes
125 persons



# Telescope assemblies

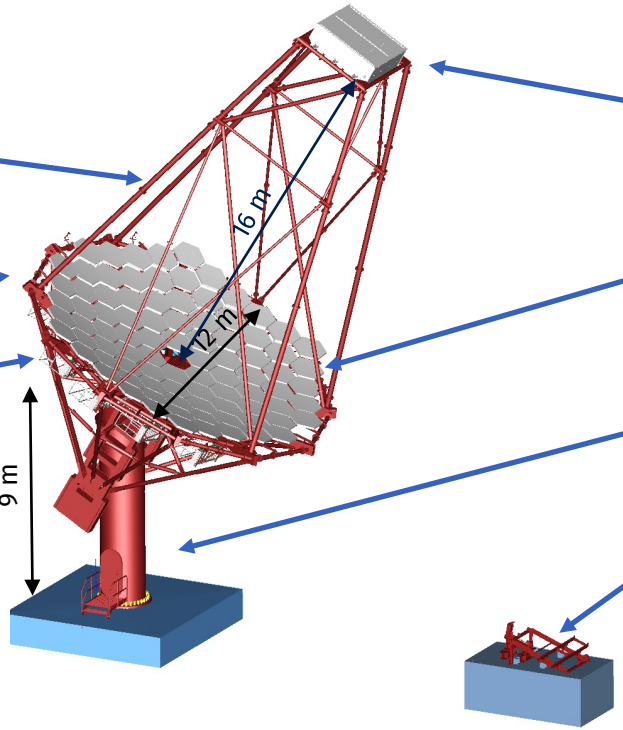



Camera support structure

Optical support structure
- Modified Davies-Cotton

Mirror access platforms

Total weight: ~86 t



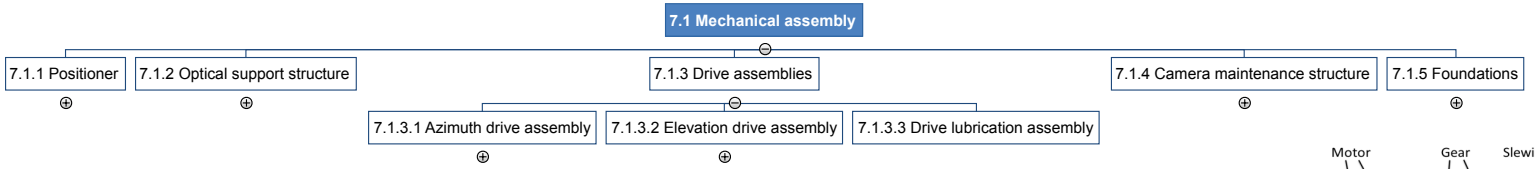

Telescope camera:
- FoV: ~7°
- Pixel size: ~0.18°

Mirrors with active mirror control
- Effective mirror area > 88 $m^2$

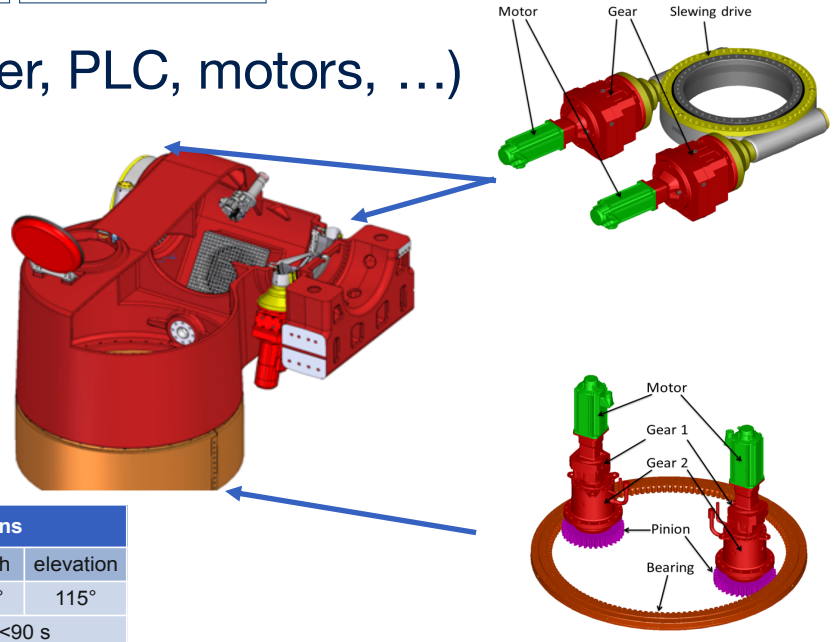
Positioner:
- 3 floors
- Hosts electrical cabinets

Camera maintenance structure

# Drive assemblies



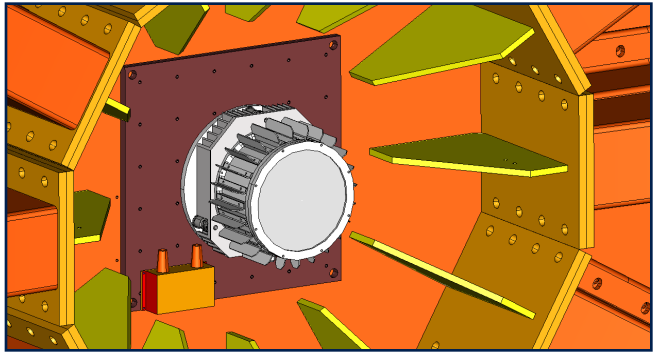

- Redundant critical components (power, PLC, motors, …)
- Gantry axis for elevation drive
- Backlash elimination
- Automatic lubrication
- Active vibration damping
- Drive condition monitoring

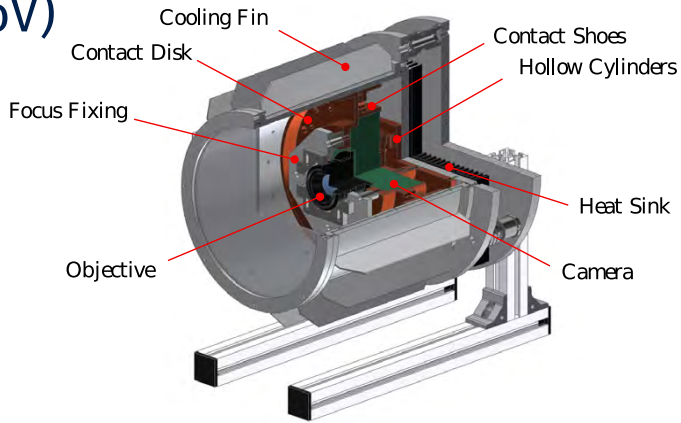



| drive specifications | | |
|---|---|---|
| | azimuth | elevation |
| operation range | ± 270° | 115° |
| repositioning time | <90 s | |
| tracking precision | 0.1° | |
| pointing precision | 7" | |

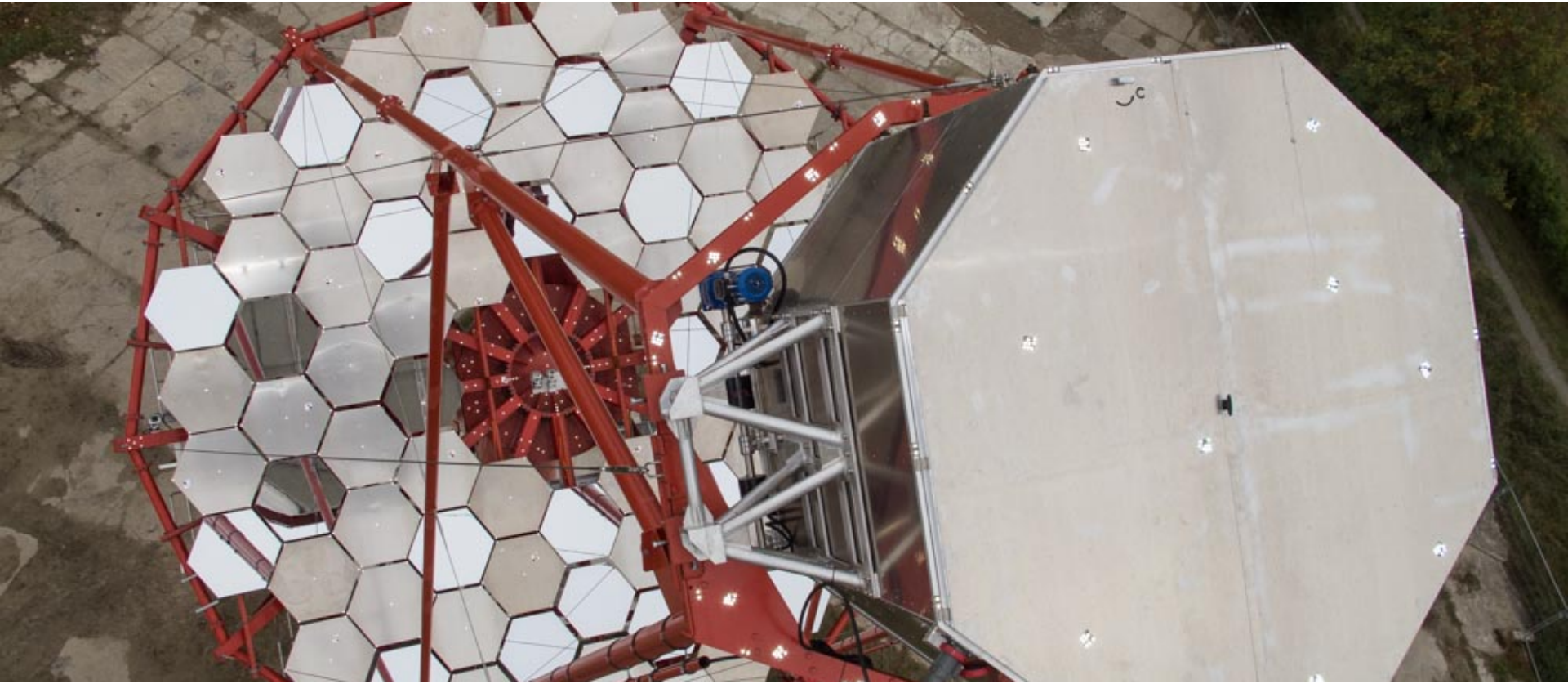
# SingleCCD camera

- Monitoring of the focal plane and star FoV:
  - Design by ECAP based on H.E.S.S.
  - Apogee CG 8300
    - Electronic shutter
    - 3298×2472 pixels with 5.4 µm
    - Nikon Nikkor 50mm f/1.8 lens (20°×15° FoV)
  - Design proven with simulations
  - Tests on prototype ongoing





# MST prototype built in Berlin

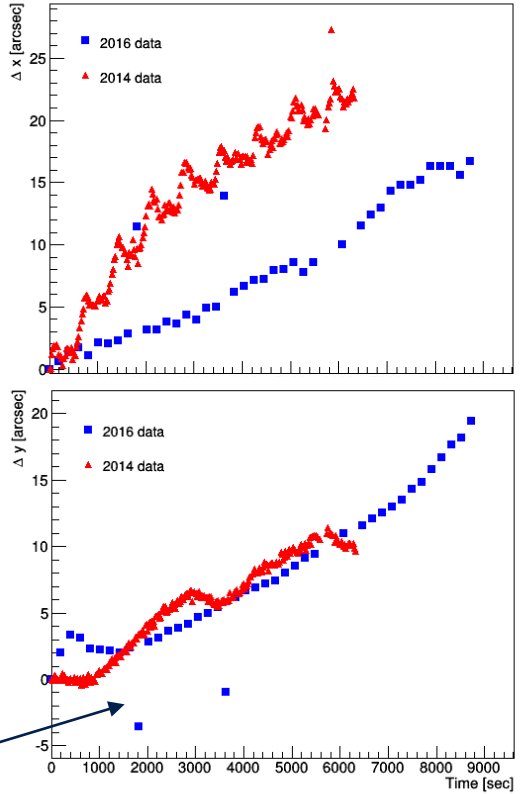


# pSCT positioner deployed in Arizona


Improved design of the positioner → ready for production

# Performance of the drive system

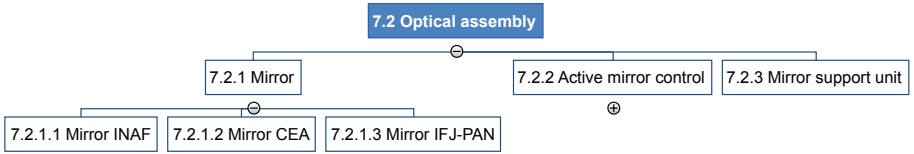
- Continuous remote operation of the telescope
  - Tracking of celestial coordinates
  - Generation of failures
  - Analysis of telescope bending
  - Software development / debugging
- Validation drive/structure monitoring
- Validation of monitoring CCD camera
- Performance tests / requirements validation




Relative star movement in SkyCCD
with simple bending model

# Mirrors

- Hexagonal shape:
  1.2 m width (side/side),
  r = 32.14 m, $R_{300\text{-}550\,nm} > 85\%$
- Three providers:
  - Higher production rate
  - Open / closed structure
- Unified mirror-AMC interface

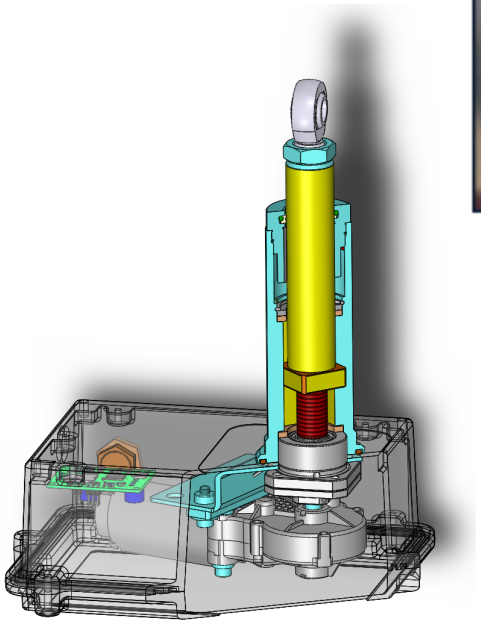



| Mirror technology | Description | Coating (PVD) | Width / Weight | Responsible institution |
|---|---|---|---|---|
| Glass replica mirrors (sandwich structure design) | Two glass sheets, cold slumped, with Al honeycomb in between. Plastic profile to protect the edges and seal the honeycomb structure. | Al+$SiO_2$ | 25mm / 16kg | INAF, Italy |
| | Two glass sheets, cold slumped. Glass side walls. | Al+$SiO_2$ +$HfO_2$ +$SiO_2$ | 40mm / 19kg | CEA, France |
| | Core made of two glass sheets separated by Al tube spacers, open structure (not sealed). Reflective surface made of an pre-coated glass sheet, glued using the cold slumping technique to the core substrate. Glass epoxy layer between the glued surfaces. | Al+$SiO_2$ +$HfO_2$ +$SiO_2$ | 60mm / 33kg | IFJ-PAN, Poland |



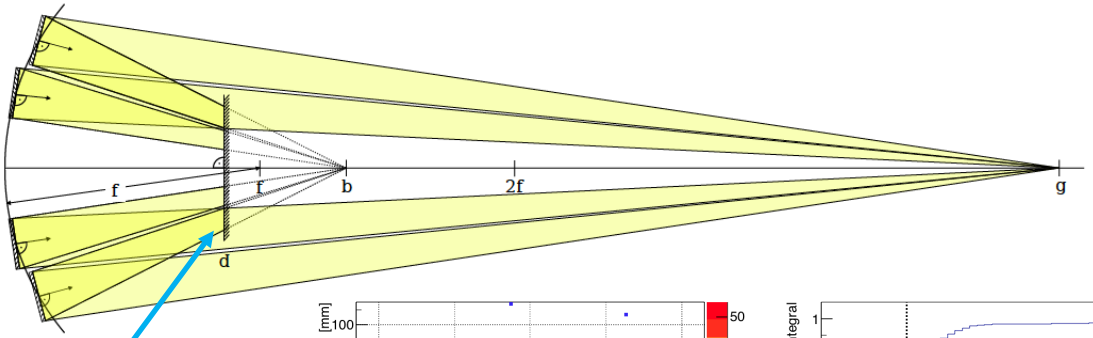
# Active mirror control

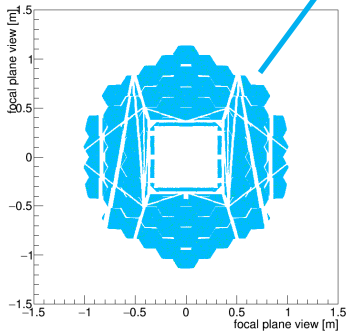
- Used during initial alignment and after mirror recoating
- Advantages: safety, $f_{(ele)}$ , defocus
- Revised H.E.S.S-II concept
  - Commercial servo motor
  - Embedded PC as interface to ACTL (OPC-UA)
- Ongoing actuator consolidation within CTA

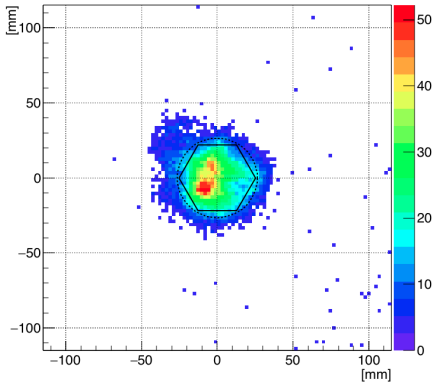


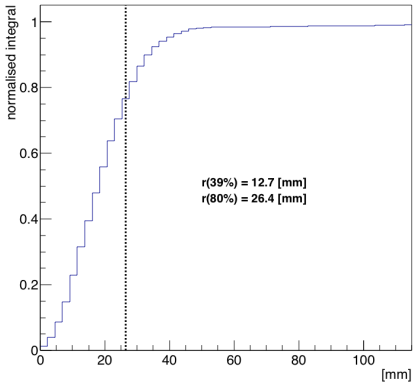
# Mirror alignment

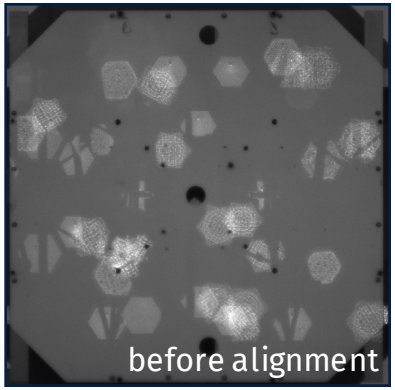
- Pre-alignment using Bokeh-Method
- Fine alignment with stars

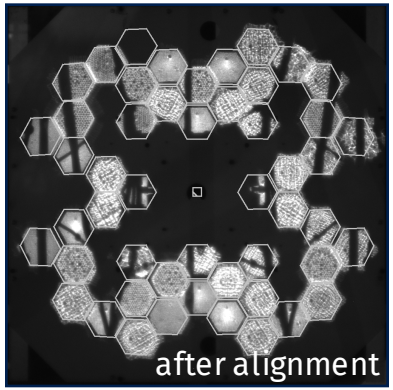


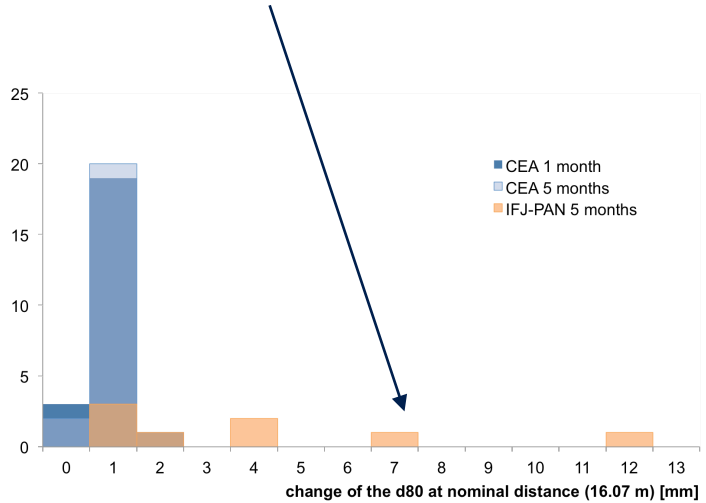



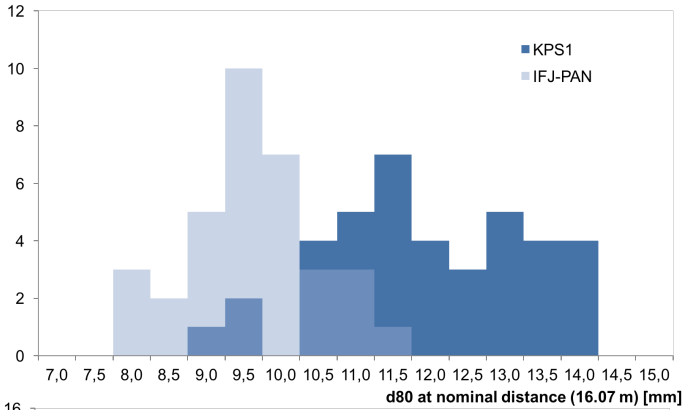



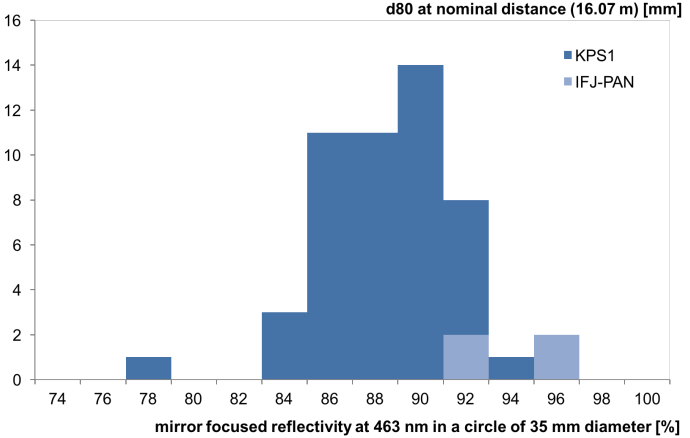
# Mirror tests in climate room

# Mirror characterisation

- Initial characterisation (2f setup / PMD)
- Test on the prototype telescope
- Long term T cycle test in climate room
  - Problem detected & corrected



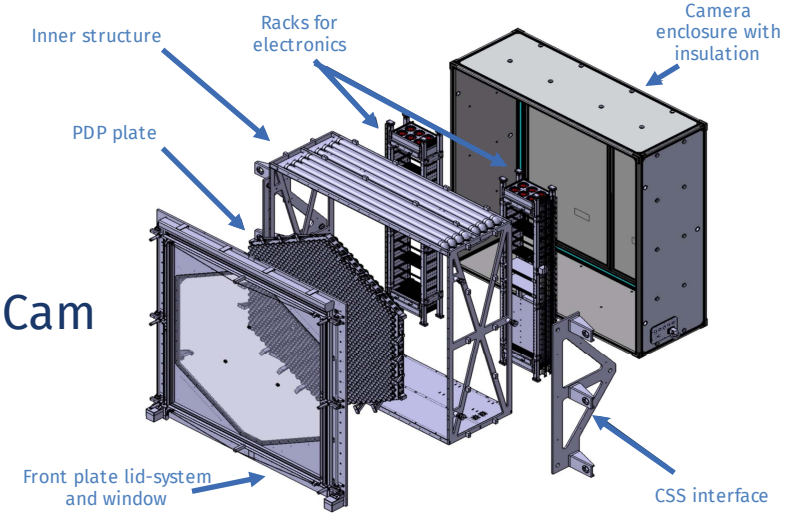



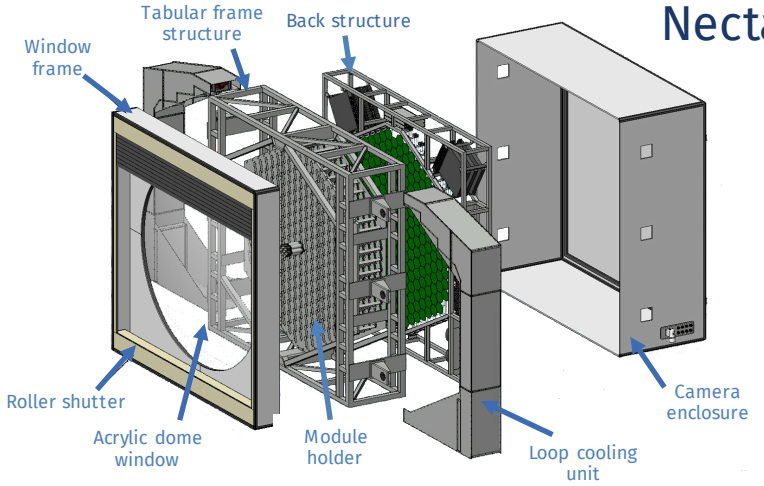
# MST FlashCam & MST NectarCAM

- Two camera designs with different architecture and technology, both fulfilling CTA requirements
- Expertise and resources of both sub-projects combined in MST
- Unified interface to telescope structure, cameras exchangeable

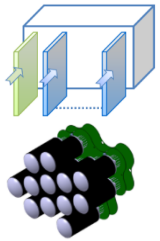
FlashCam




NectarCAM



# FlashCam: Architecture & Specifications

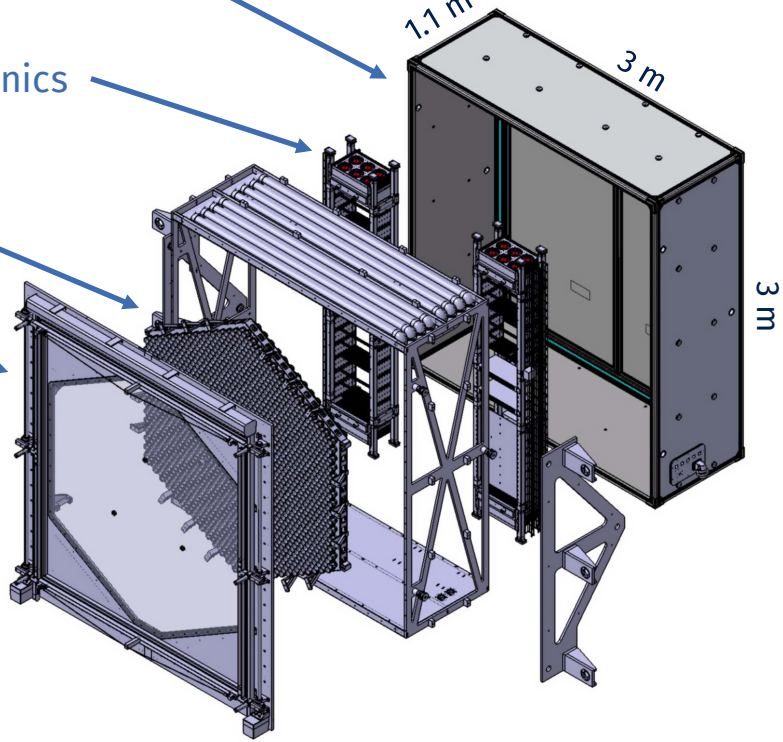



Mechanical structure & thermal insulation

Readout & safety control electronics

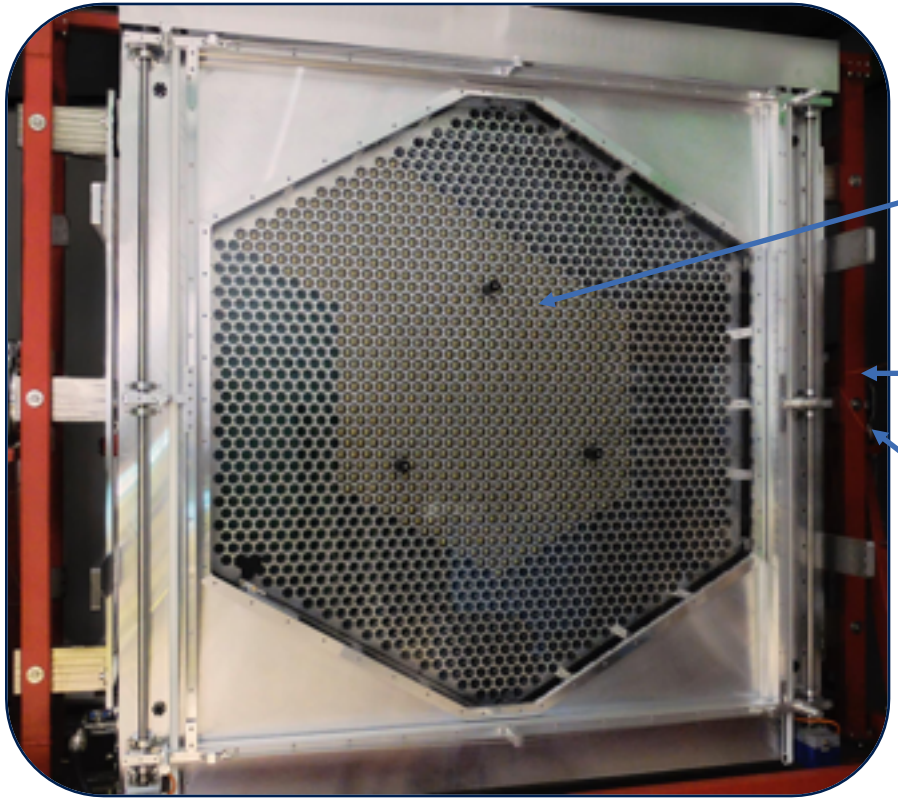
Photon detector plane

Window & shutter




- 1758 pixels (PMTs), 7.7° FoV
- 0.2 … 3000 p.e. dynamic range
- Continuous digitisation with 250 MHz
- Fully digital trigger formation & readout
- >20 kHz dead-time free Ethernet-based DAQ
- <4.5 kW power consumption

# FlashCam prototype



Two types of PMTs installed in PDP:

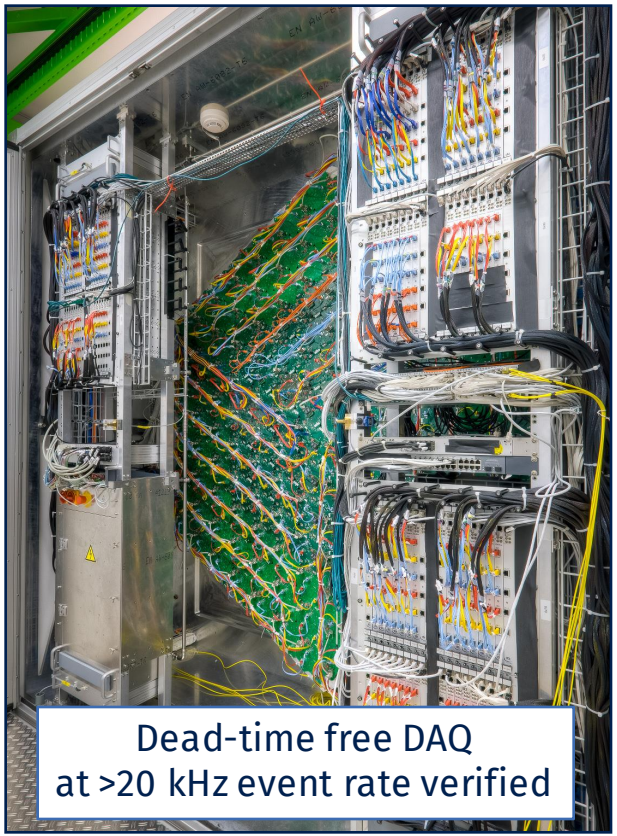
358 Hamamatsu R11920-100 (8 dynodes)
359 Hamamatsu R12992-100 (7 dynodes)

Remaining slots with dummy heater modules

1G fibre (safety /slow)

4x10G fibre bundle, 1km long (data)
to camera server

# Readout, safety & power system, PDP



Dead-time free DAQ
at >20 kHz event rate verified

Readout system complete:

- Readout electronics for up to 2304 channels installed
- Cabling nearly complete (optimising for mass prod.)

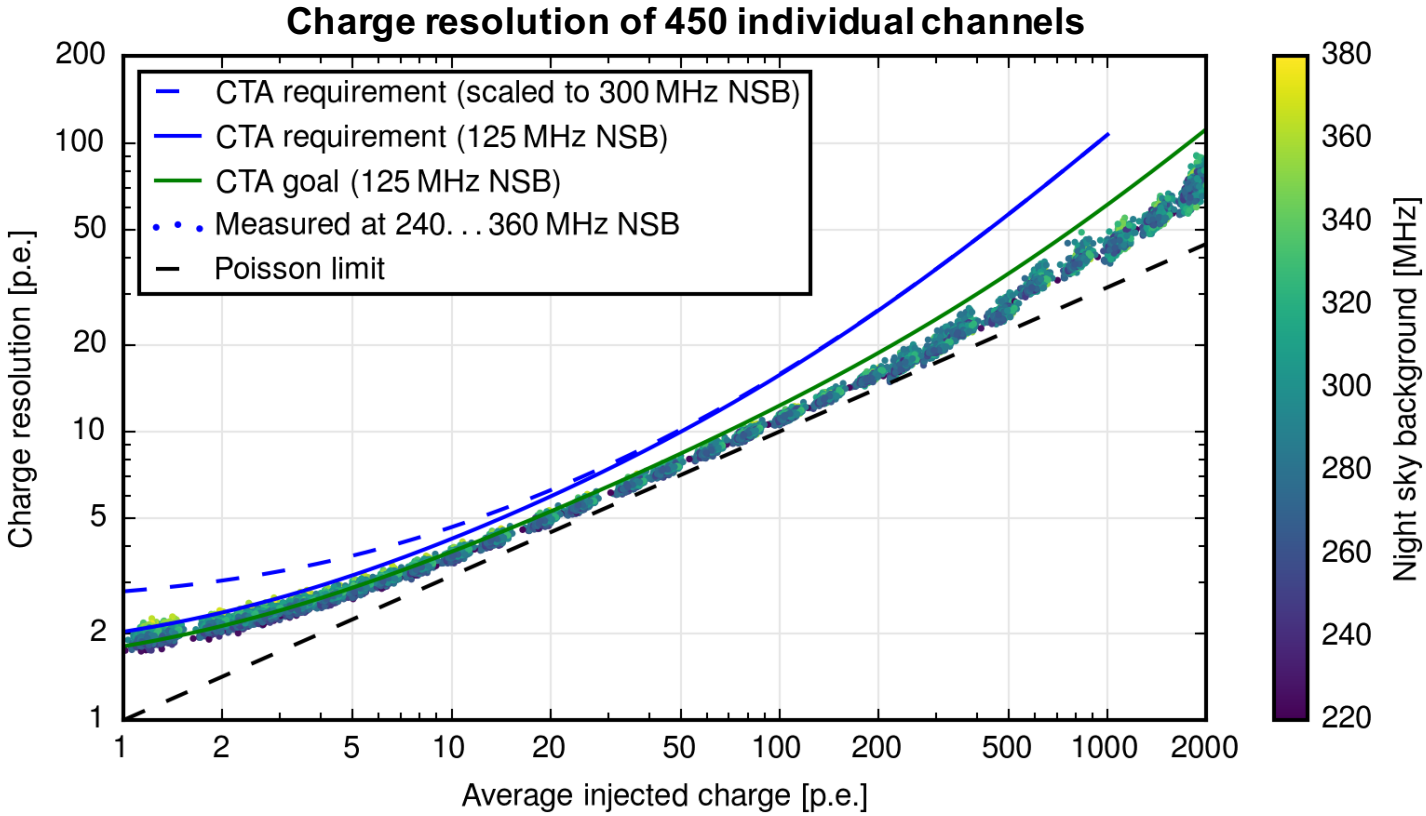
Near final safety, power and mechanics:

- Power consumption of complete system as specified
- Closed-circuit cooling with ~20°C coolant works

Software in good state:

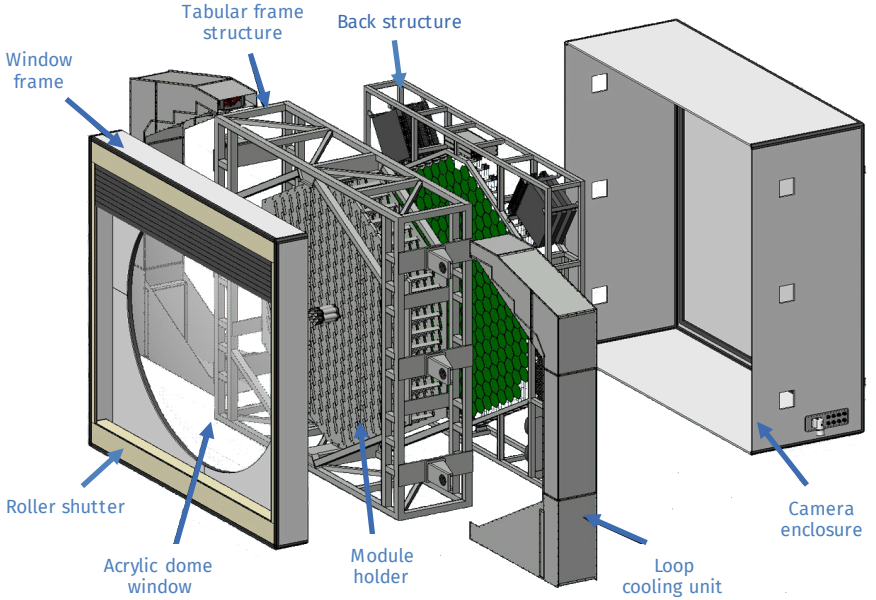
- Remote control of all components works
- DAQ over 1 km 4×10G fibres works out of the box
- Analysis & calibration software evolving

# Charge resolution at expected NSB rates

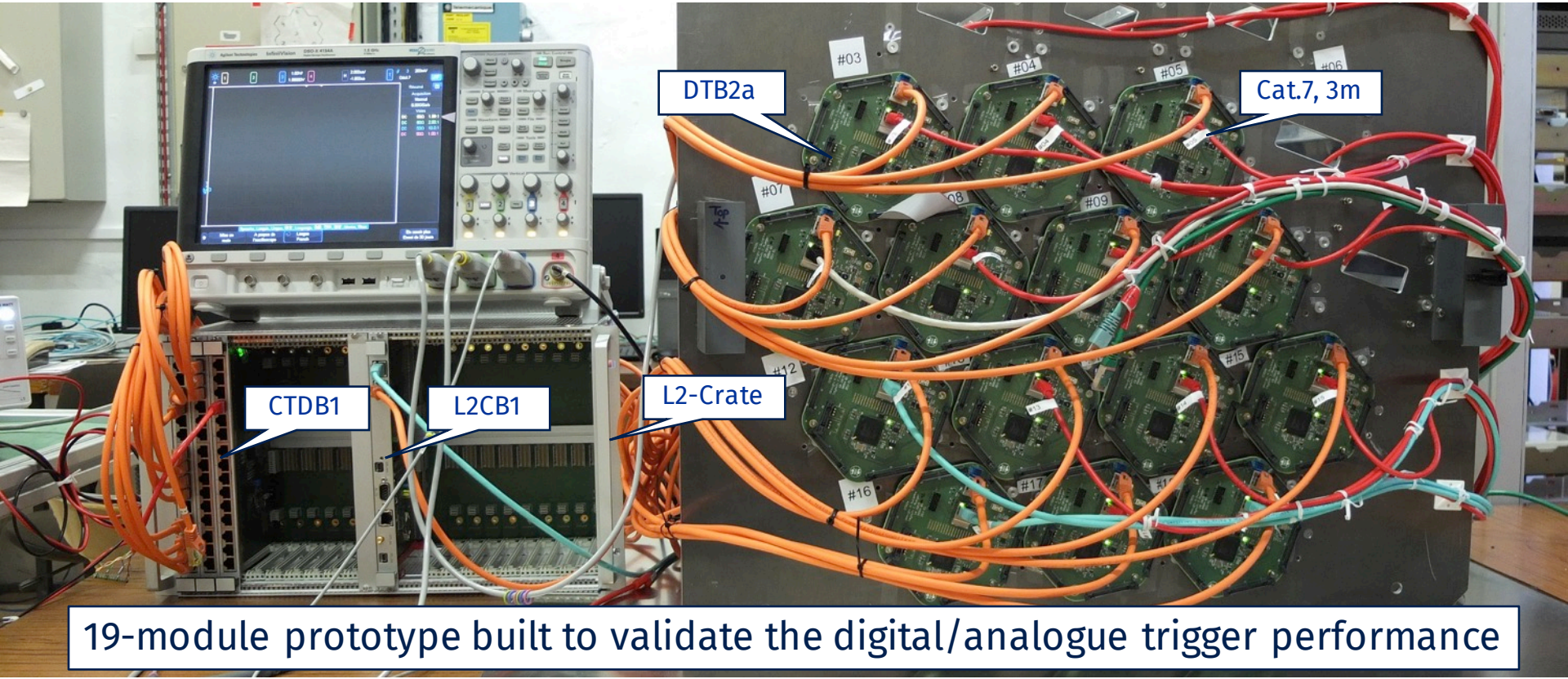


# Basics of NectarCAM

- 1855 pixels (PMTs), 265 modules, 8.0° FoV
- 0.5 ... 2000 p.e. dynamic range
- Nectar chip based (2 gains/channel)
- Digitalization: 0.5 – 2 GHz (1 GHz nominal)
- Dead time <3%
- 2 trigger solutions (digital/analogue)
- Power consumption 7.7 kW
- Design similar to LST camera



# Digital trigger test-setup




19-module prototype built to validate the digital/analogue trigger performance

# NectarCAM prototyping

- Focal plane instrumentation available
- Front-end electronics fully characterized on single modules
- DAQ successfully tested with burst of simulated data
- Slow control hardware/software tested
- Cooling system qualified with demonstrator
- Extensive testing of 19 module mini-camera
- 500 $m^2$ integration facility with dark room

# Next steps

- Structure:
  - Testing of new mirror and AMC prototypes
  - Assembly and test of new dish structure
  - Requirements validation
- FlashCam:
  - Test and characterisation of prototype
  - Production of 2 pre-series cameras in 2017
- NectarCAM:
  - Trigger selection with 19 module camera
  - Start production qualification camera
- 2-3 pre-production MSTs ready in 2017/2018