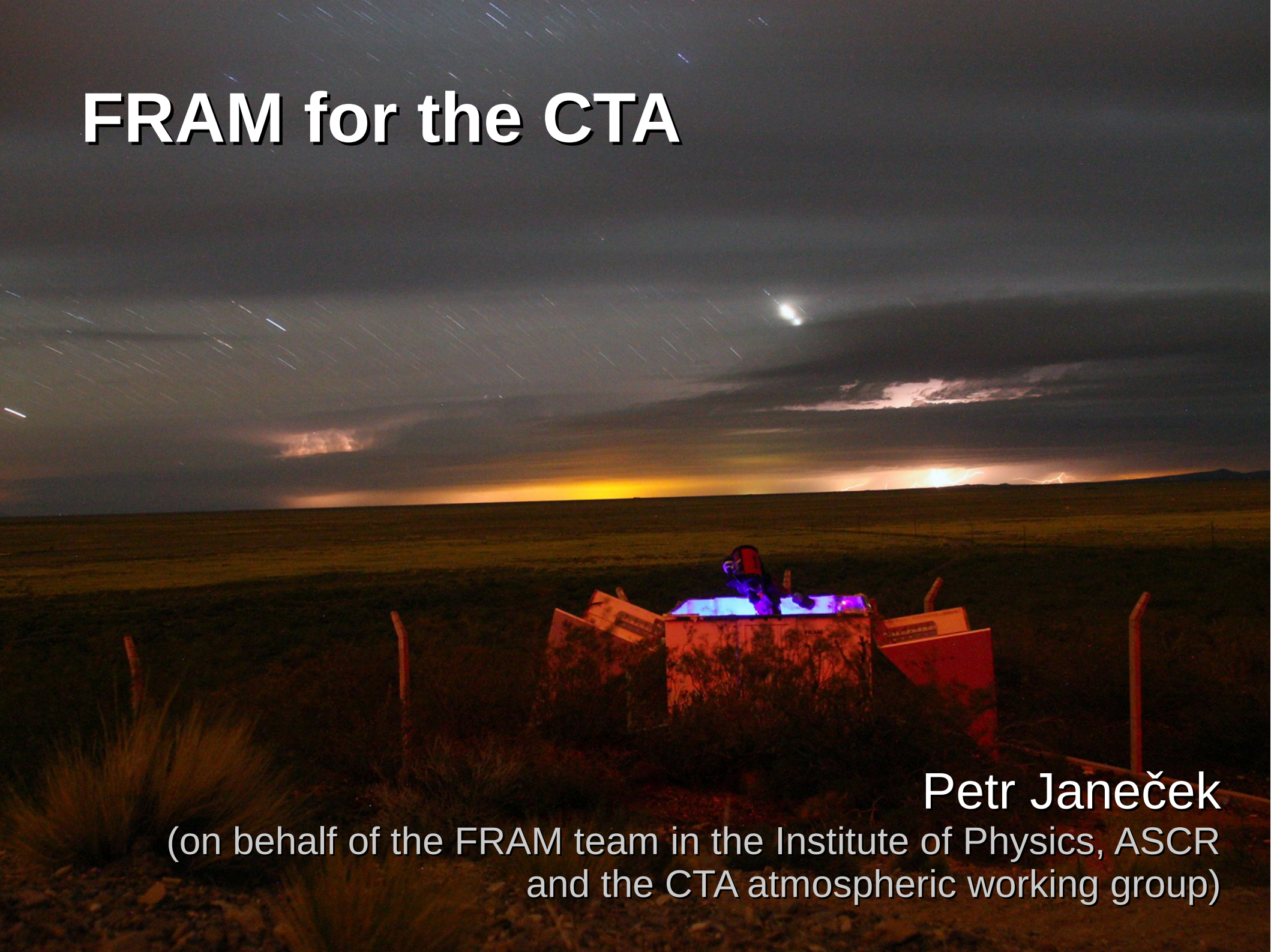
FRAM for the CTA



Petr Janeček
(on behalf of the FRAM team in the Institute of Physics, ASCR
and the CTA atmospheric working group)

Outline

- FRAM – F(Ph)otometric Atmospheric Robotic Monitor
- What it is
- What it does
- Where does it fit in the CTA atmospheric monitoring
- Realization – hardware and software

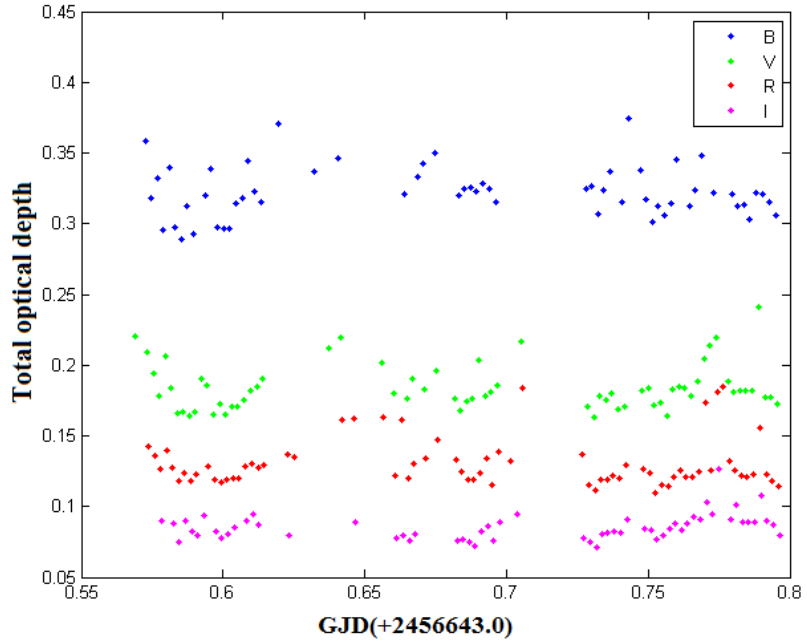
Concept of the FRAM

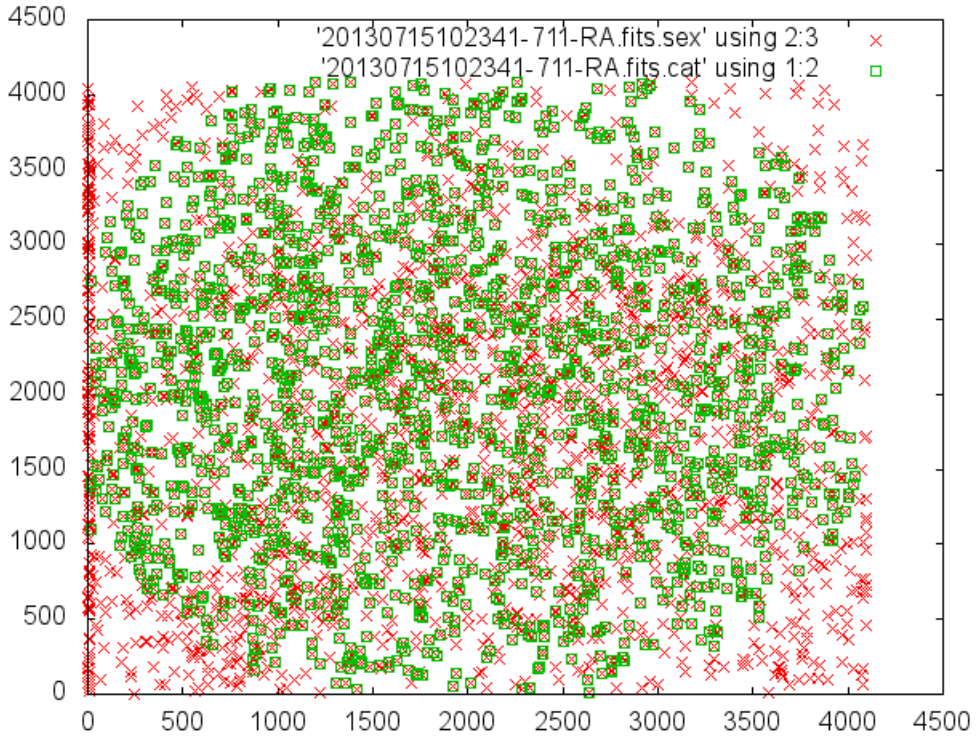
- Atmospheric extinction in the FOV through stellar photometry
- Non-invasive method for the determination of the aerosol content in the atmosphere with high time and spatial resolution

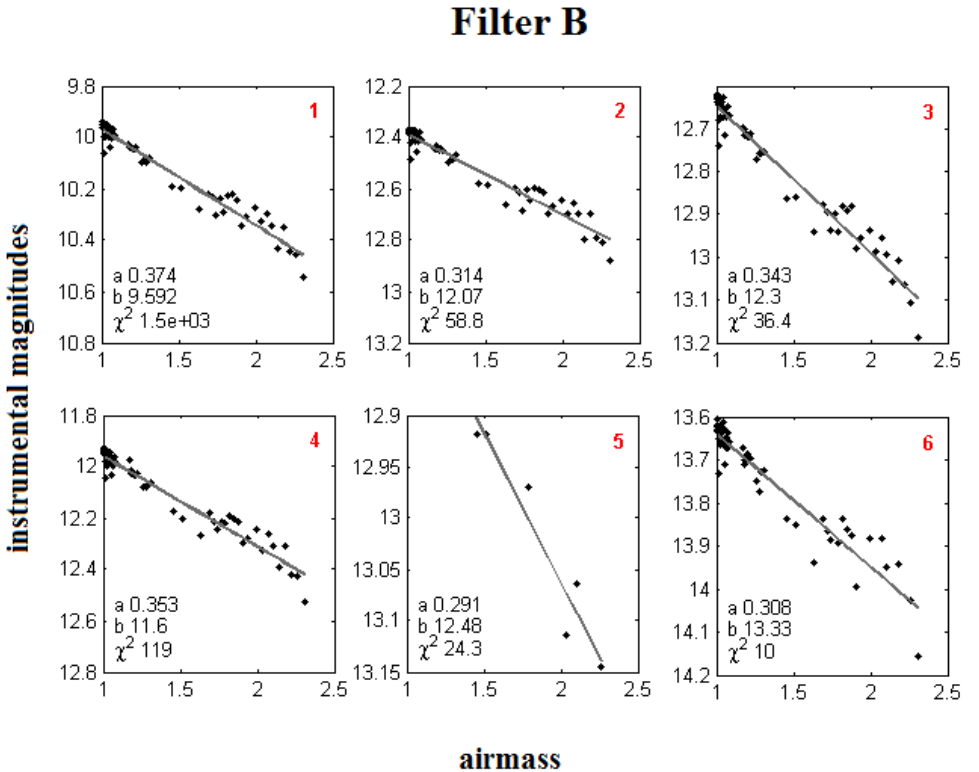
- Implemented since 2006 at the Pierre Auger Observatory in Malargüe, Argentina → experience with hardware (has undergone several changes), software and data processing
- Truly remote operation: Los Leones, ~30 minutes from Auger HQ, no staff on site
- Remote power switches for everything, webcam
- Fully automated day-to-day operation

Data analysis

- Star identification in the catalog, comparison
- Careful consideration of effects of uneven field of view, color of the star, long-term development of sensitivity. . .
- Immediate extinction, spatial distribution in the FOV
- Use of the zenith angle dependency – does not depend on the catalog and on the absolute sensitivity ⇒ self-calibration every night





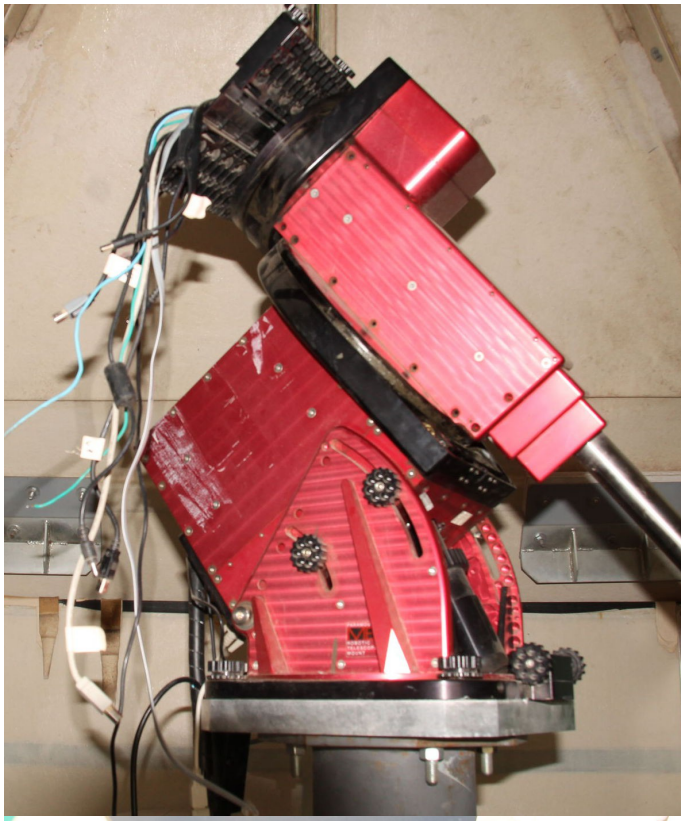


FRAM on the Cherenkov Telescope Array

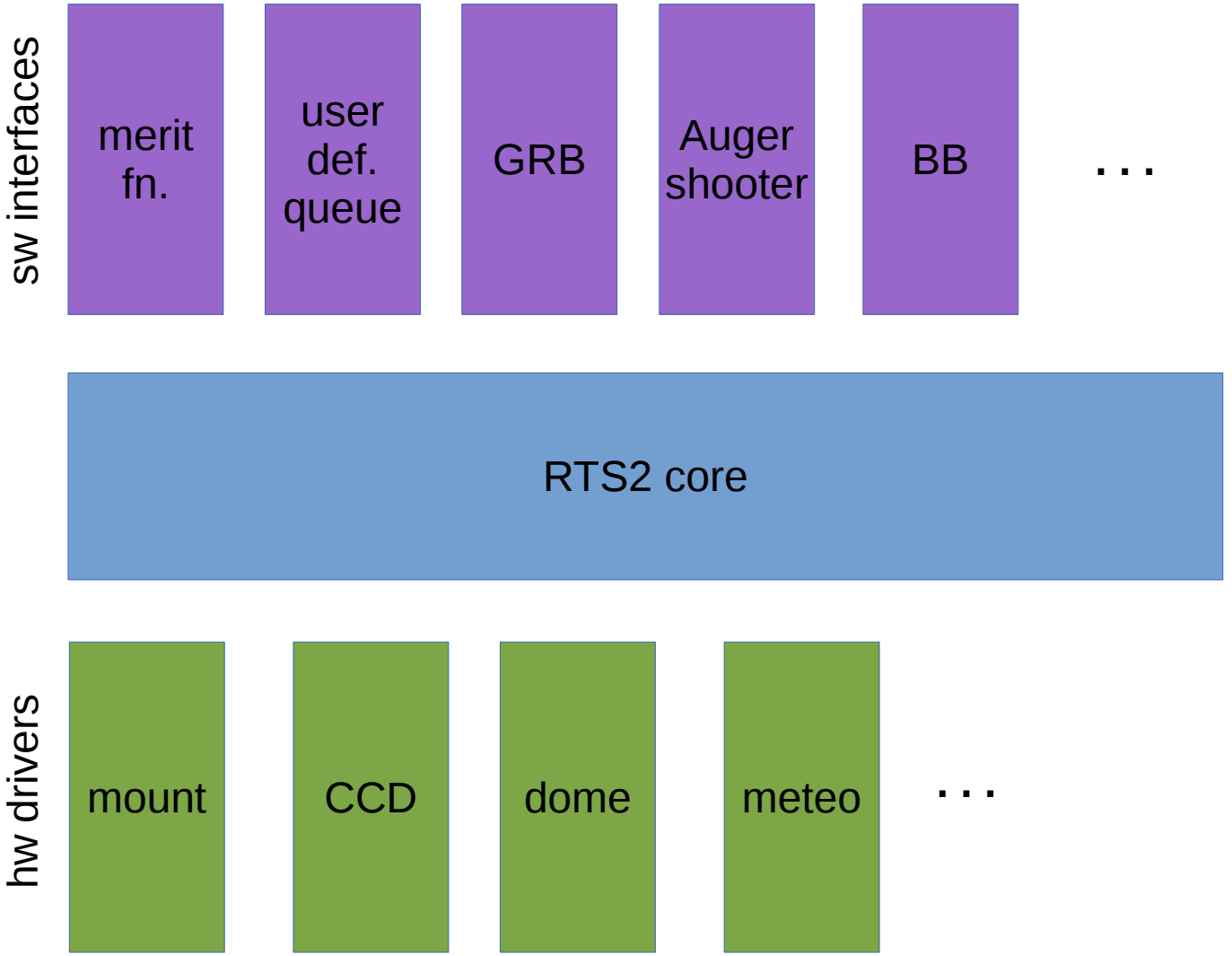
- Strict requirements on the precision of physical parameters (energy flux) → Cherenkov light intensity: required error < 8%, aim ~5% → error budget for aerosol content ratio 2%
- Effective use of observation time: take only “good” data, automatic corrections in imperfect conditions
- Broad range of devices for atmospheric monitoring: weather forecast / alerts, online smart scheduling, data selection, data correction
- Weather stations, ASC, ceilometer, Lidar, UVscope. . .
- Aerosol content: Lidar the most precise and gives altitude profile, but lidar powerful enough to do full atmosphere profile cannot shoot in the direction of the observation → limited number of time windows
- FRAM: passive → can work continuously
- Only integral profile to the top of the atmosphere (but can certify clear conditions)

Hardware

- Equatorial mount Bisque Paramount MX
- CCD camera G4 16000, 4096x4096 pixels, 36.8x36.8mm
- External BVRI filter wheel
- 135mm F/2.0 lens – angle of view 15°
- Up to mag 13 single shot
- Dome: Astelco 2m foldable enclosure
- Industrial PC with redundant PS, disks, UPS, etc.

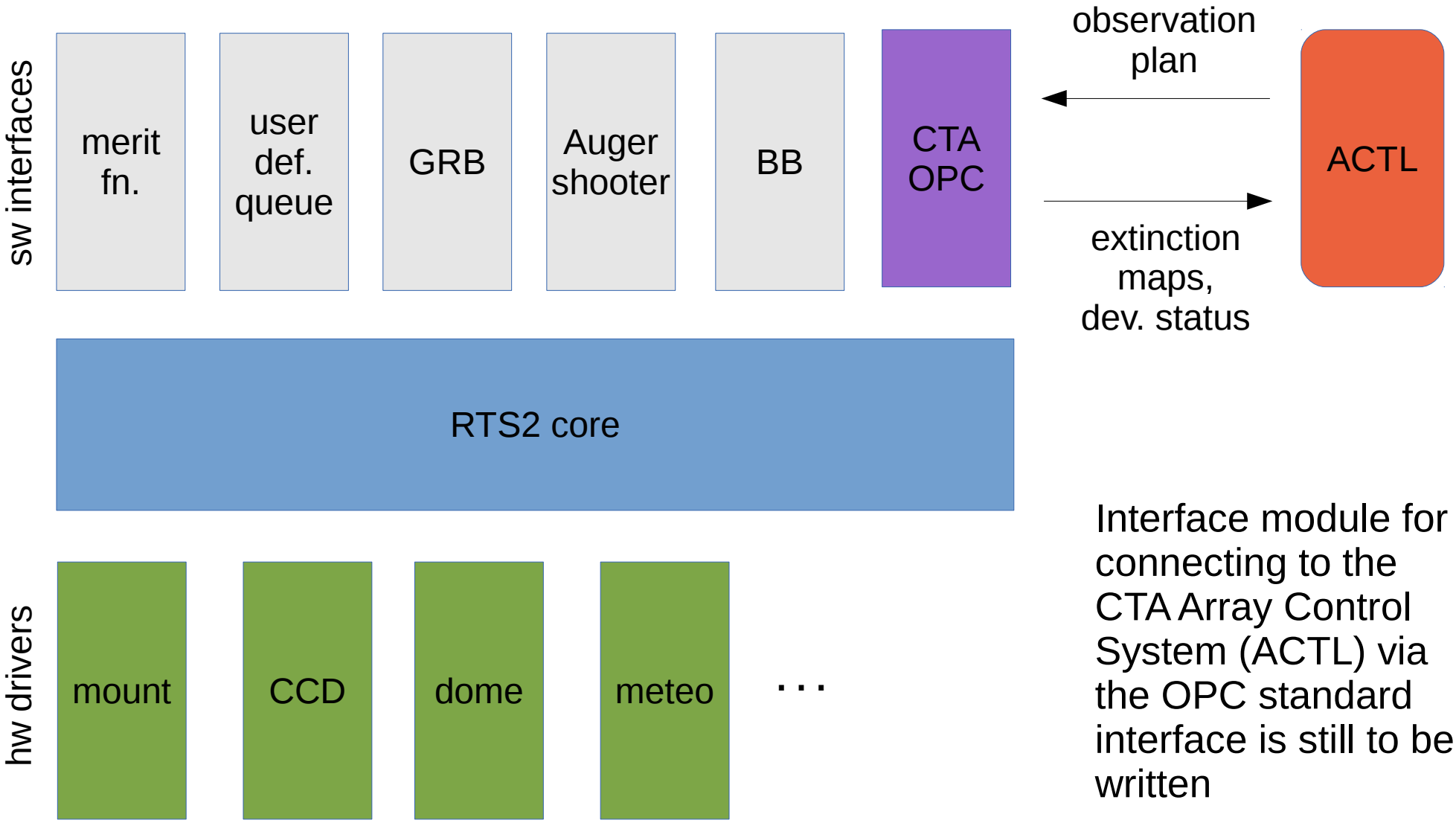


Software: RTS2



- Complete system for robotic observatories
- Developed by Petr Kubánek since 1999
- Free / open source
- Originally for the rapid GRB (gamma ray burst) followups – reaction time critical
- Expanded for general astronomical use (~20 telescopes worldwide)
- Uses astrometry.net

Software: RTS2



Interface module for connecting to the CTA Array Control System (ACTL) via the OPC standard interface is still to be written

Conclusions

- FRAM provides non-invasive method for determination of aerosol content in the atmosphere with high time and spatial resolution
- Extinction maps acquired during observation by the CTA telescopes will help achieve its observation time and low systematic errors goals
- Hardware: already proven in similar conditions
- Software: development should present no big surprises