



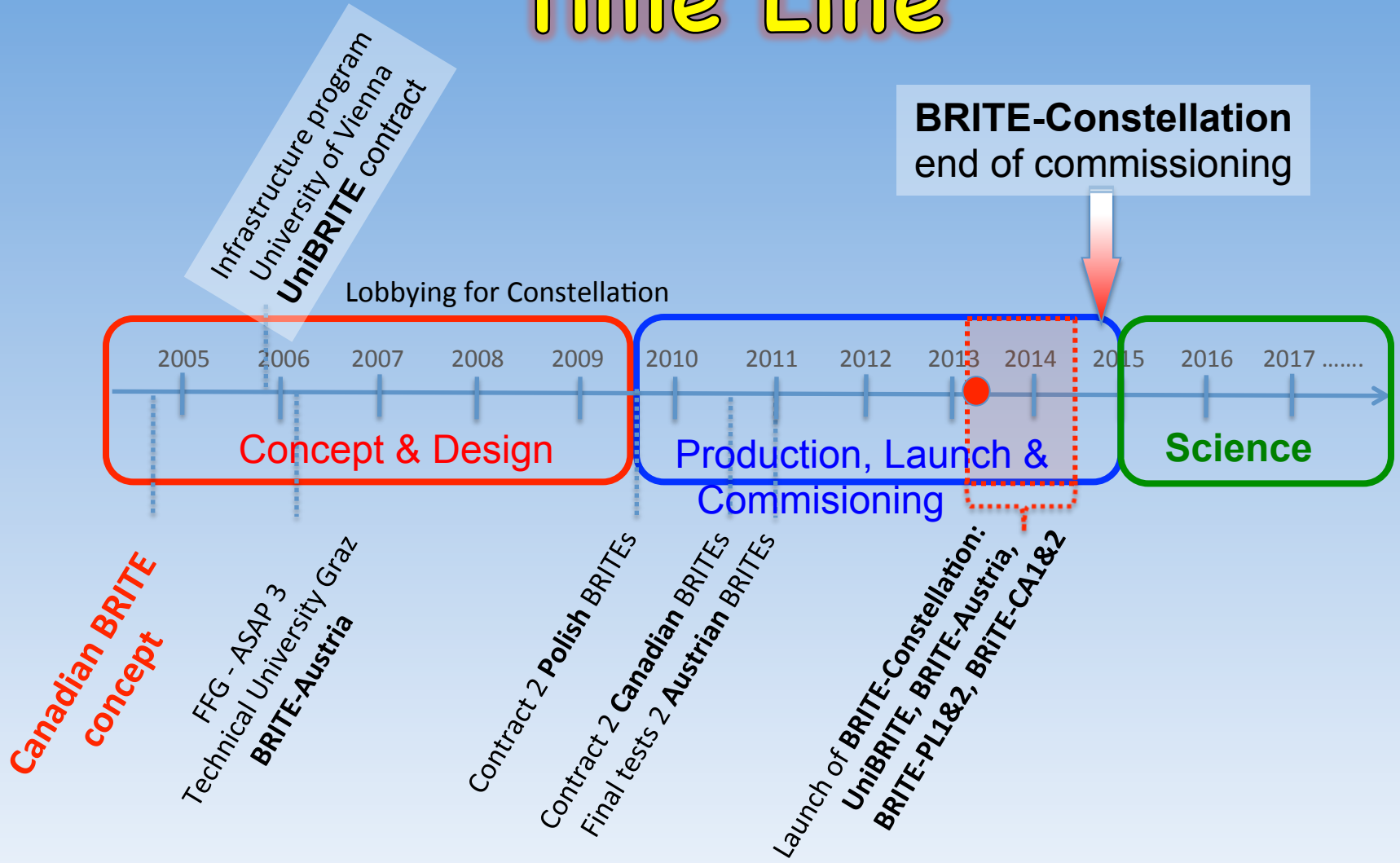
# **BRITE-Constellation:** four successful years and more to come ...

**Werner W. Weiss**

**Rainer Kuschnig**

**BRITE-Consortium Austria, Canada, Poland**

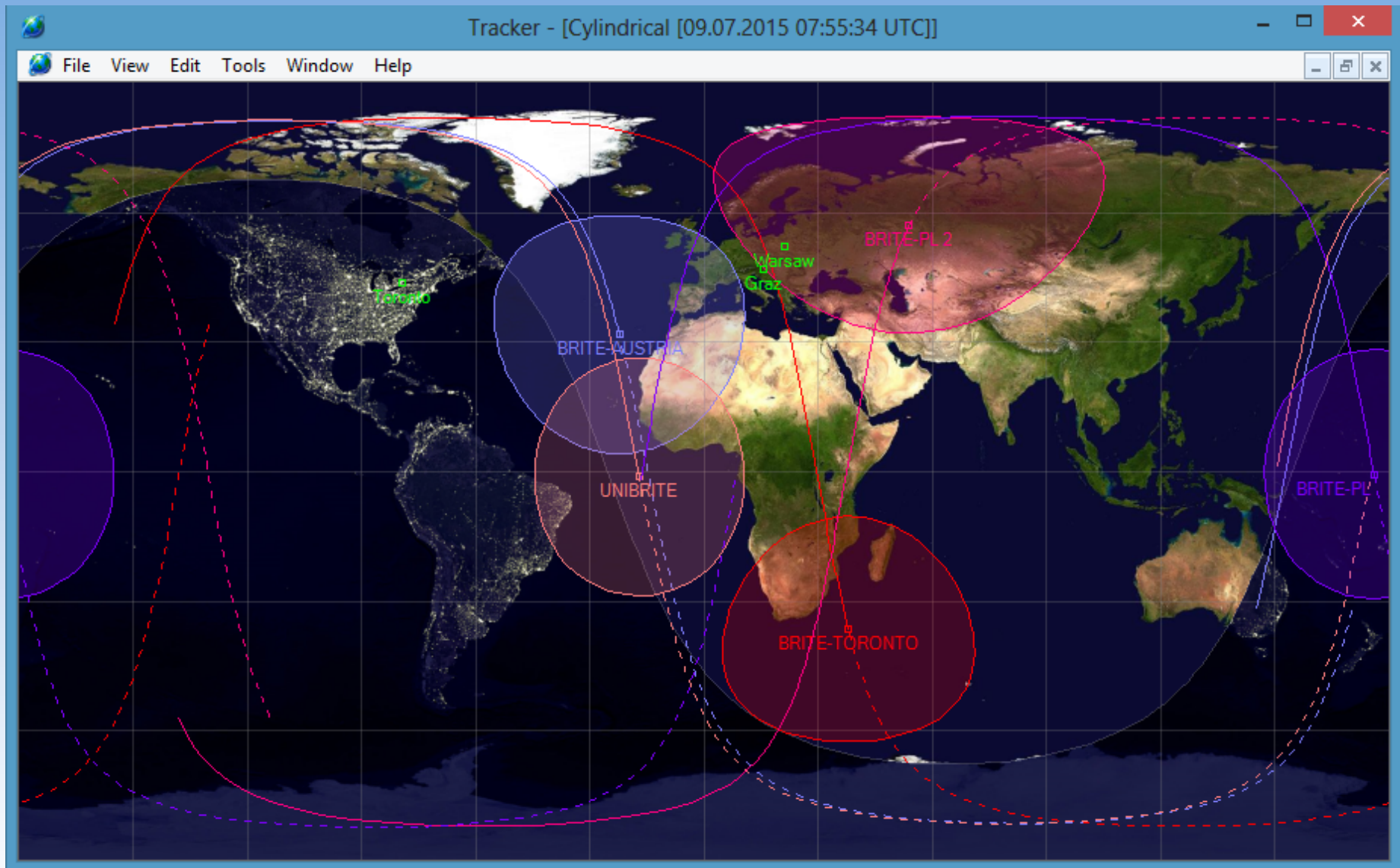
# Time Line



# BRITE Satellites

| ID  | Name            | C | Launch date | Operating Station | Altitude km | i    | Period min |
|-----|-----------------|---|-------------|-------------------|-------------|------|------------|
| UBr | UniBRITE        | R | 2013 Feb 25 | Toronto (SFL)     | 775-790     | 98°6 | 100.4      |
| BAb | BRITE-Austria   | B | 2013 Feb 25 | Graz (TUG)        | 775-790     | 98°6 | 100.4      |
| BLb | BRITE-Lem       | B | 2013 Nov 21 | Warsaw (CAMK)     | 600-890     | 97°7 | 99.6       |
| BTr | BRITE-Toronto   | R | 2014 Jun 19 | Toronto (SFL)     | 620-643     | 97°7 | 98.2       |
| BMb | BRITE-Montreal  | B | 2014 Jun 19 | ...               | ...         | ...  | ...        |
| BHr | BRITE-Heweliusz | R | 2014 Aug 19 | Warsaw (CAMK)     | 612-640     | 98°0 | 97.1       |

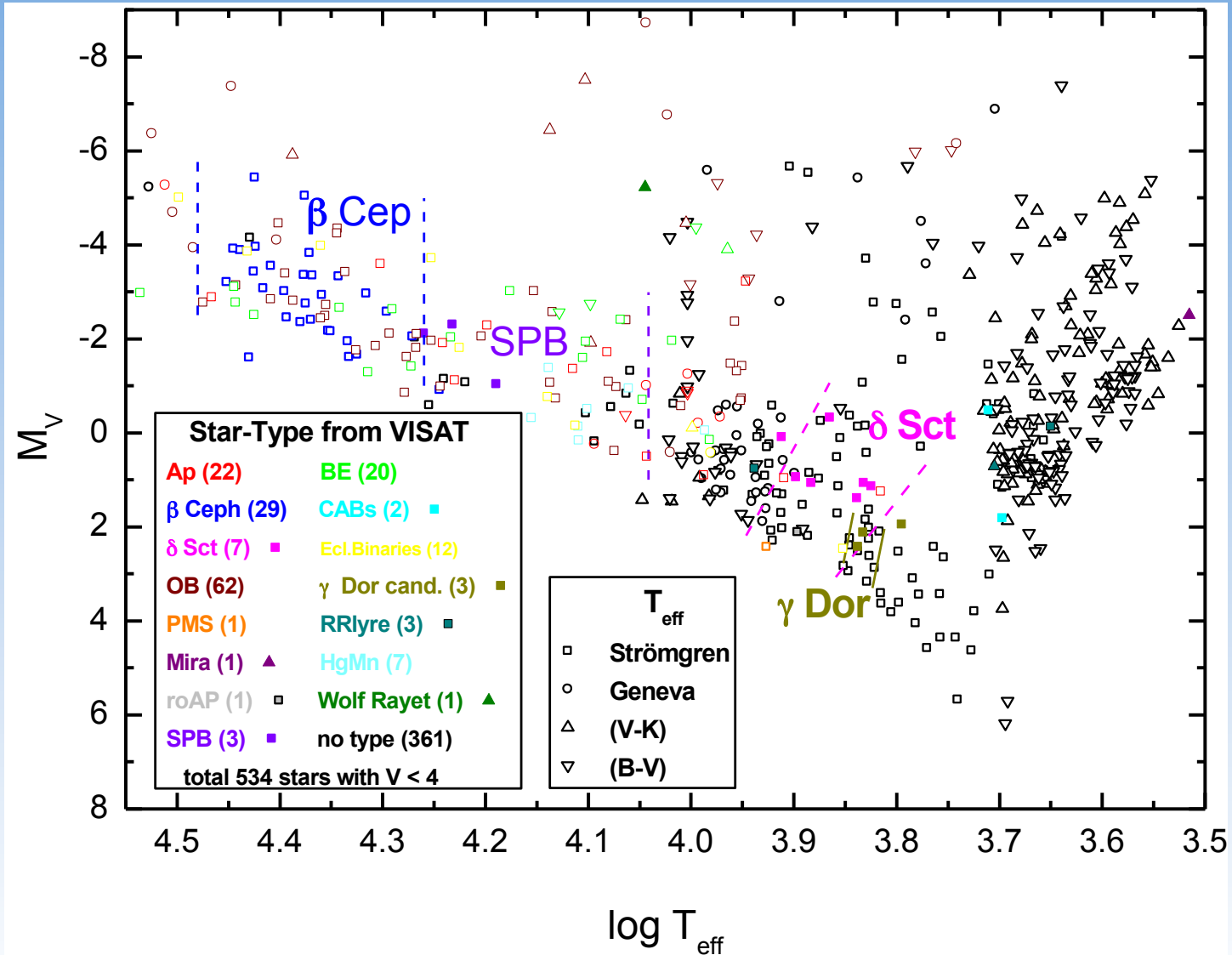
# Orbits



# Science Goals I

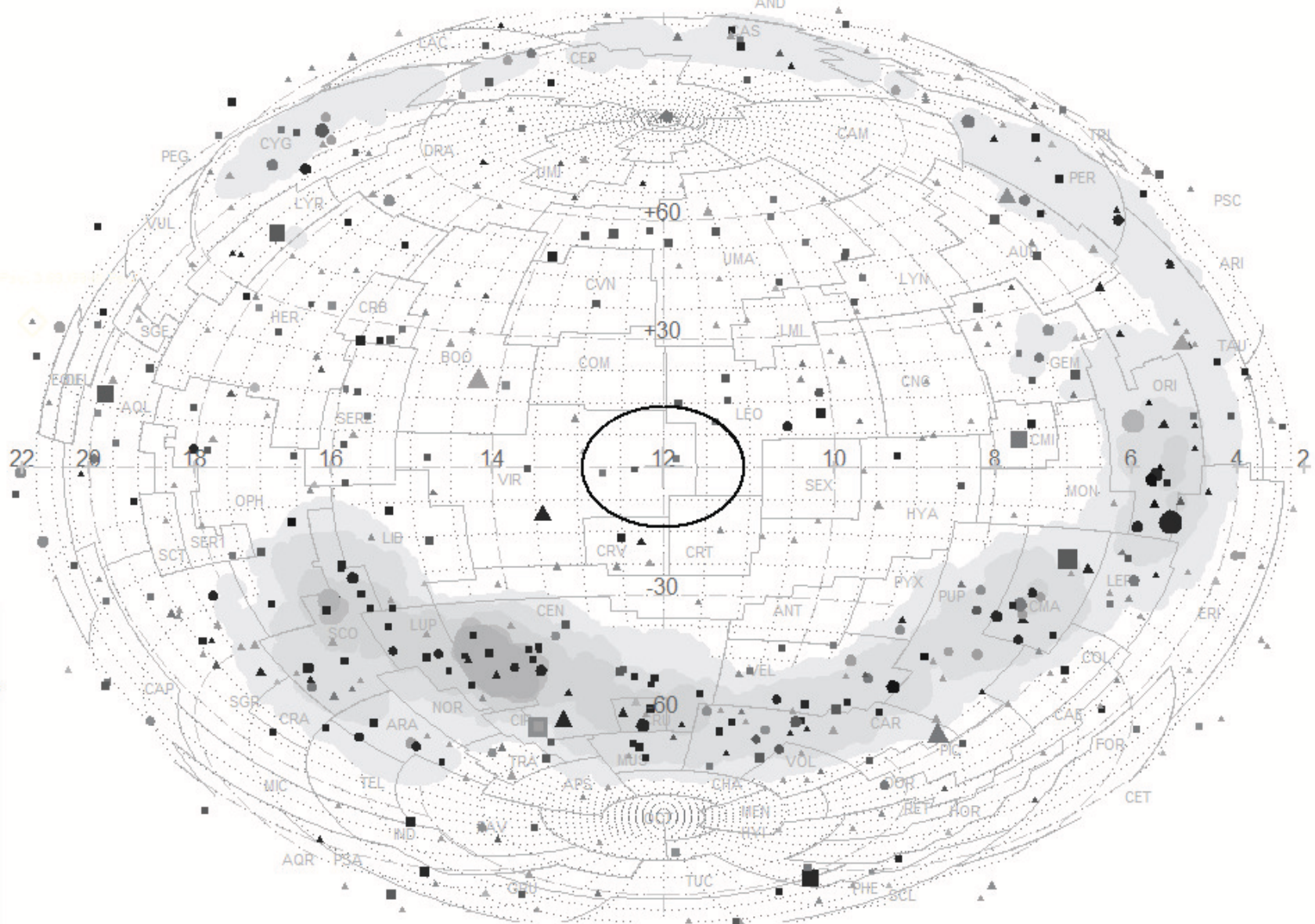
- luminous massive stars in the Milky Way (OB, WR,  $\beta$  Cep, SPB,  $\lambda$  Eri, ...)
- luminous evolved cool stars
- Classical pulsating stars ( $\delta$  Scuti,  $\alpha$  Cen,  $\gamma$  Doradus, RR Lyr, Cepheids, etc.)
- young stars & environment - associations
- interaction of stars with ISM (wind, shell, etc.)
- large parallax stars (improve fundamental parameters)

# Science Goals I



center of map [RA,DEC] 12 0 0, 0 0 0

LAMBERT PROJECTION



# Why small telescopes in space?

- High photometric precision for **bright** stars not realistic from ground
- High duty cycle for many months nearly impossible from ground
- Complementary to

**MOST:** asteroseismology + planets: 0-12 mag(V), 1 colour

**CoRoT:** asteroseismology + planets: 4-14 mag(V), 1 colour

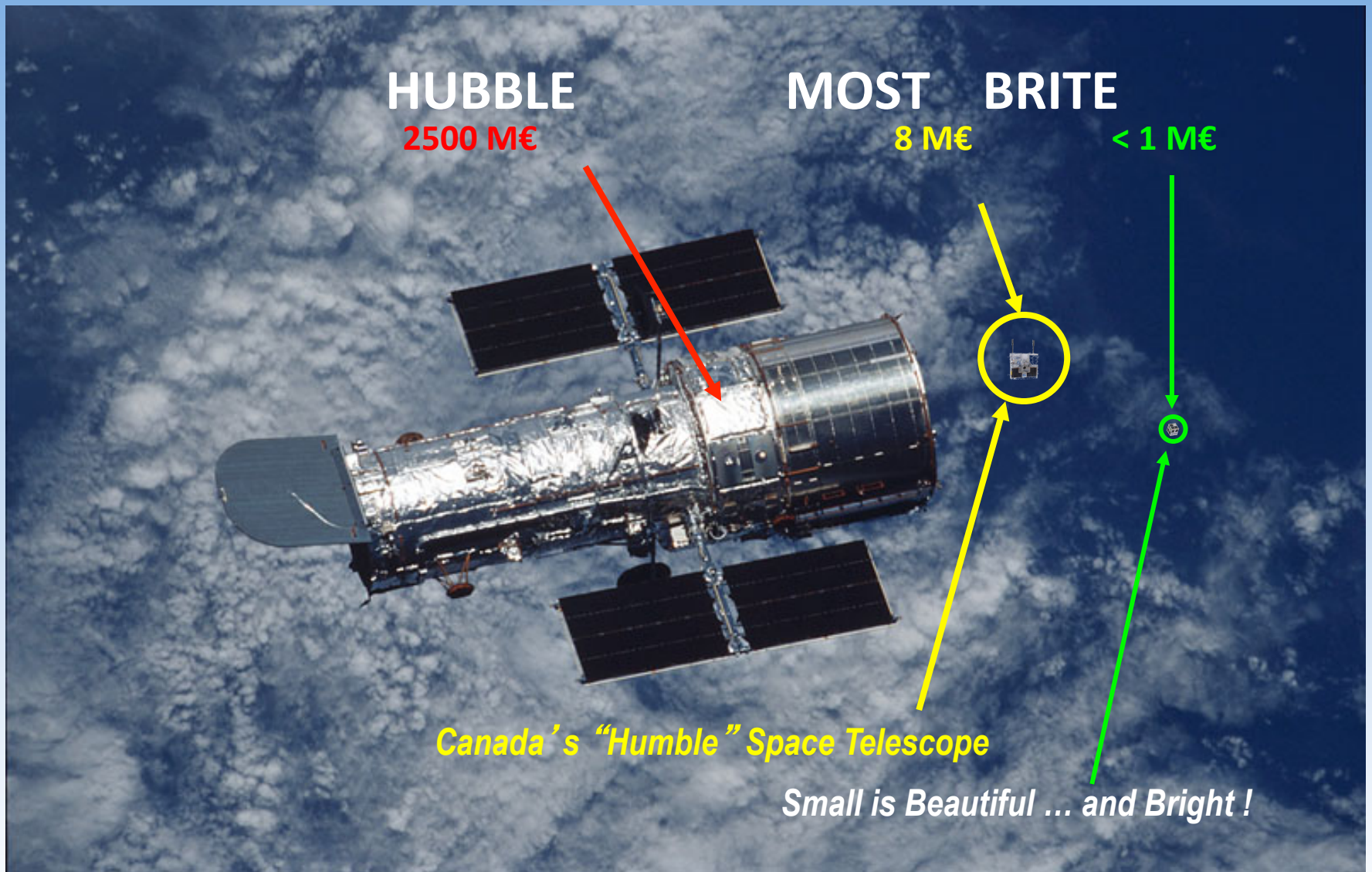
**Kepler:** planets + asteroseismology: 6-16 mag(V), 1 colour



# Science Goals II

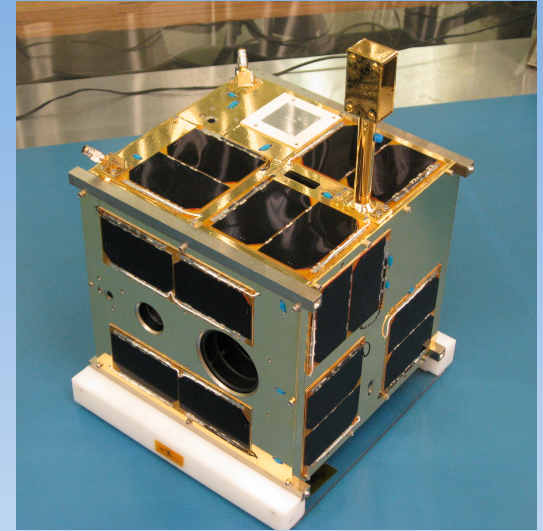
- Collect time series photometry for some of the **brightest, most massive and luminous stars** in the sky, i.e.,  $V < 4 - 5$  mag
- investigate intrinsic brightness variations
- **field-of-view = 24 x 24 deg<sup>2</sup>**
- **15 - 30 stars** per observing field at once
- Photometry in **two colors: red and blue**  
**disentangle geometric & physical effects**
- Time bases of **up to 180 days** for single observing campaign

# Range of Scale

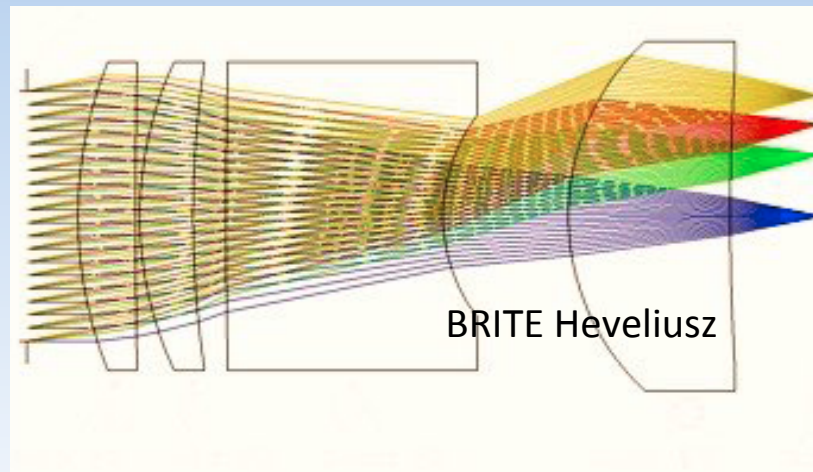
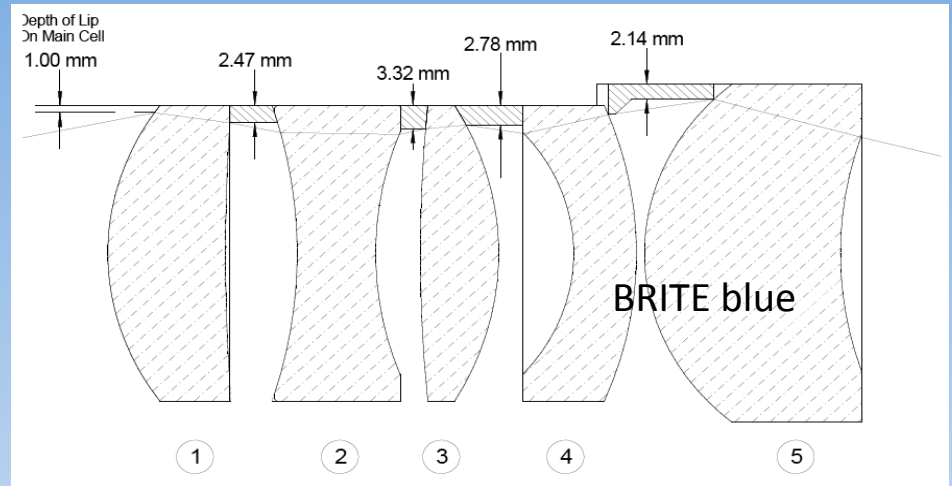
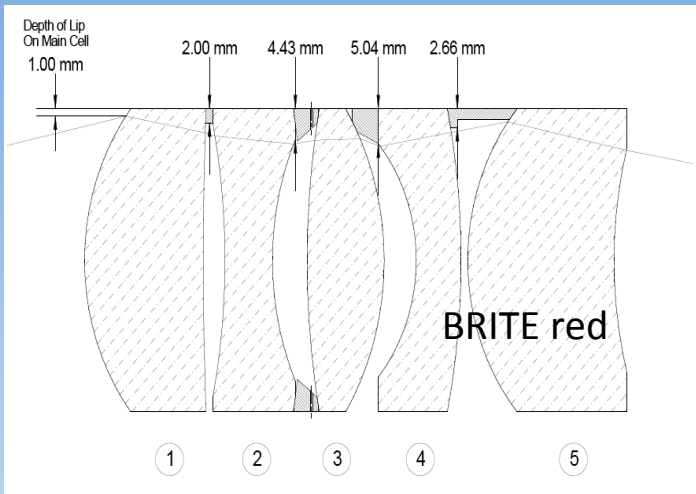


# BRITE Specifications

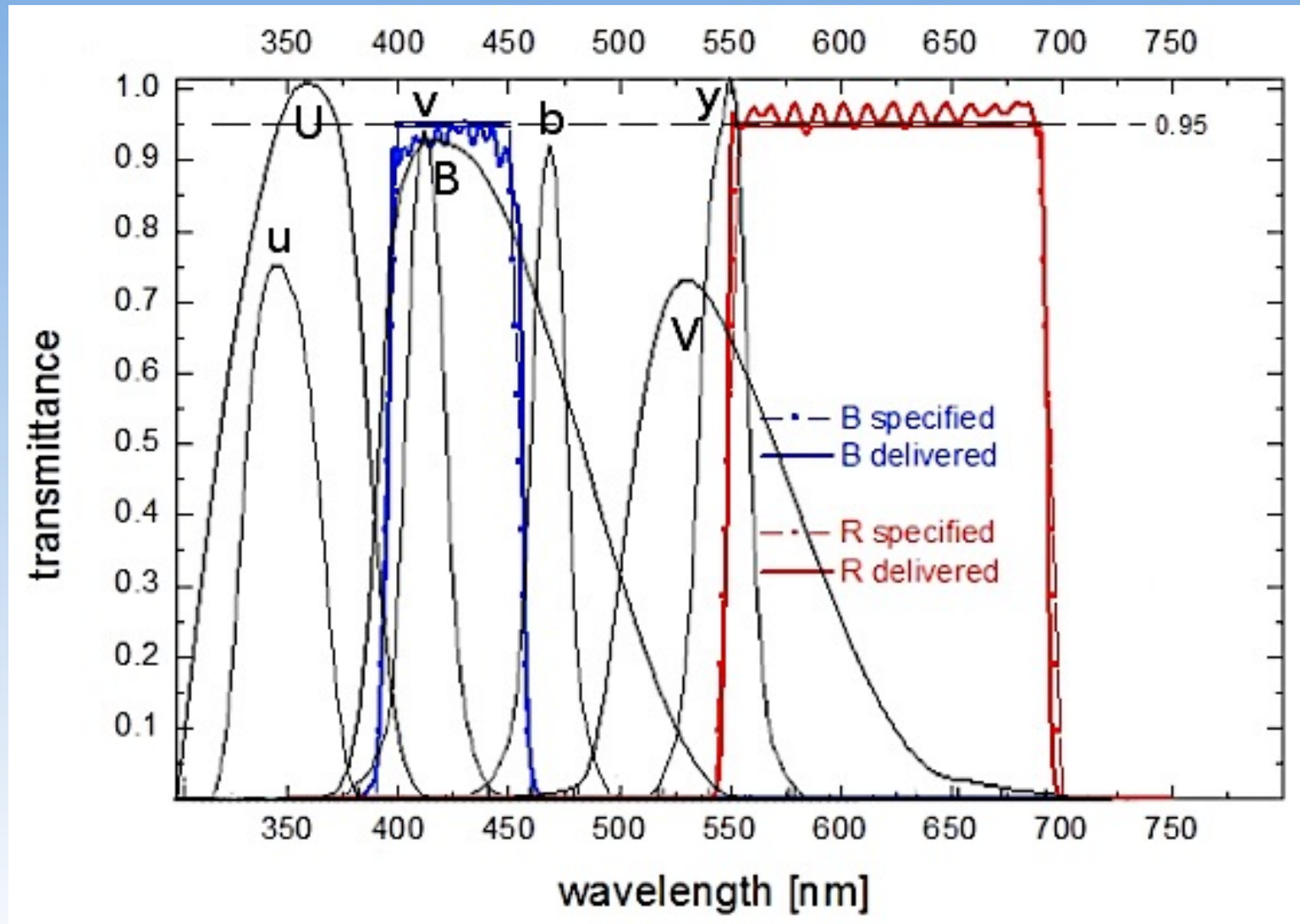
- 20cm cube size, 7kg (nanosatellite)
- 3-axis pointing control ( $\approx 1.5'$  stability)
- Pairs of nanosats - two colors:
  - Red and Blue filter
- 30mm aperture,  $24^\circ \times 20^\circ$  fov
  - Simultaneously 2 to 18 bright stars
- 15+ min per orbit on target
- 3 to 5 data points per minute
- “all” sky access including polar region
- UHF (up) and S-band (down) communication
- LEO sun-synchronous (polar) orbit
- 3 years life time (min. 2 yr)



# Telescopes



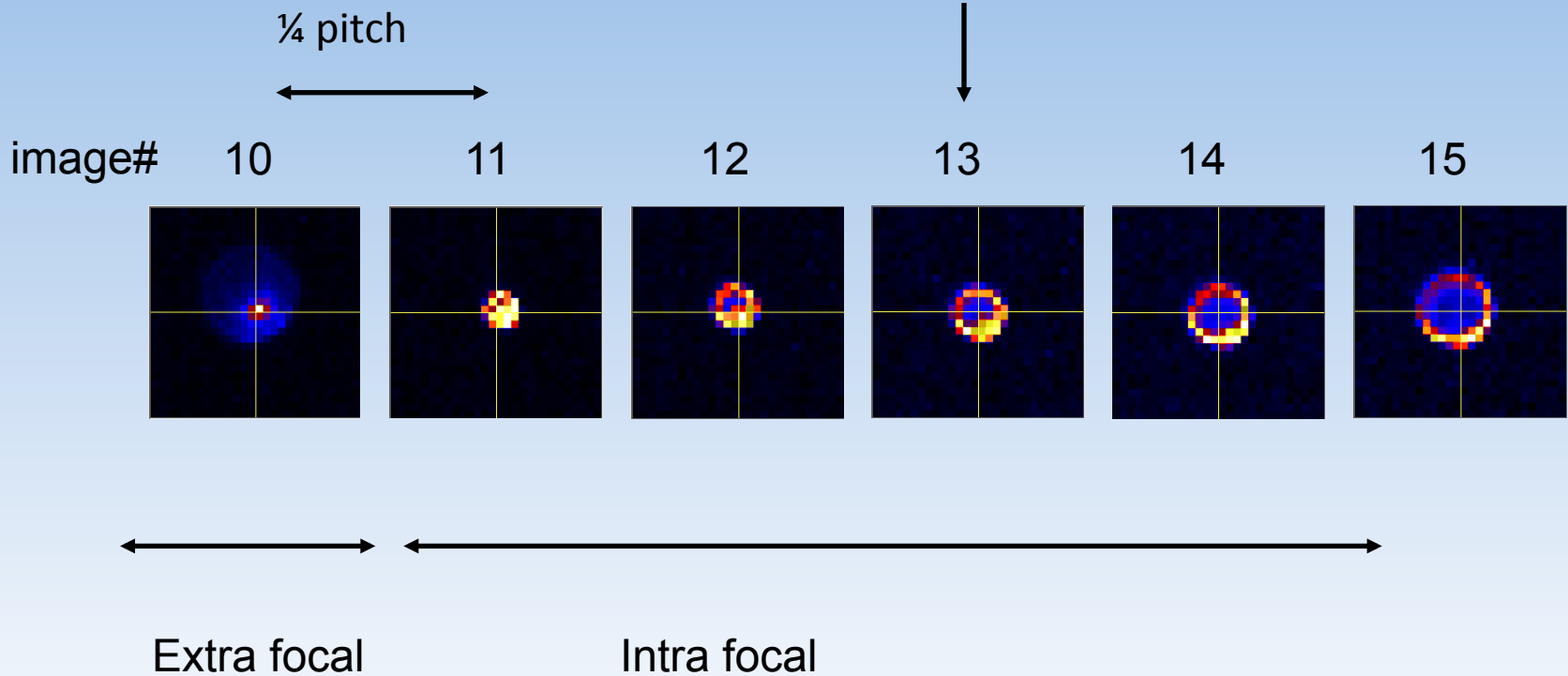
# Filter



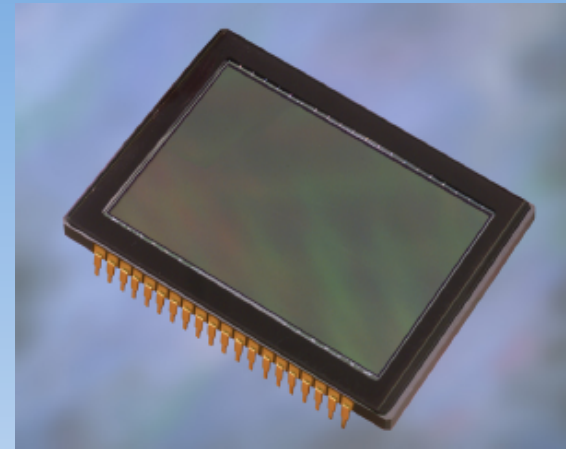
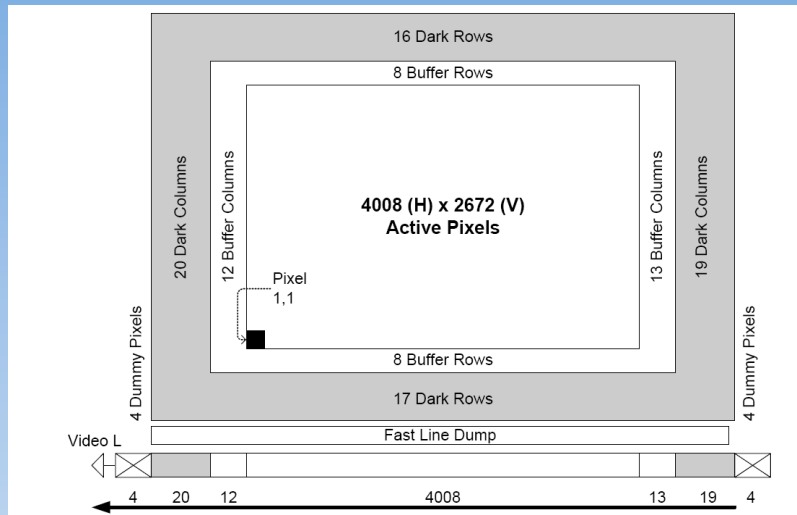
# Out-of-Focus

Focus sequence in the center of the field

set it to this



# Detector



## KODAK KA11002

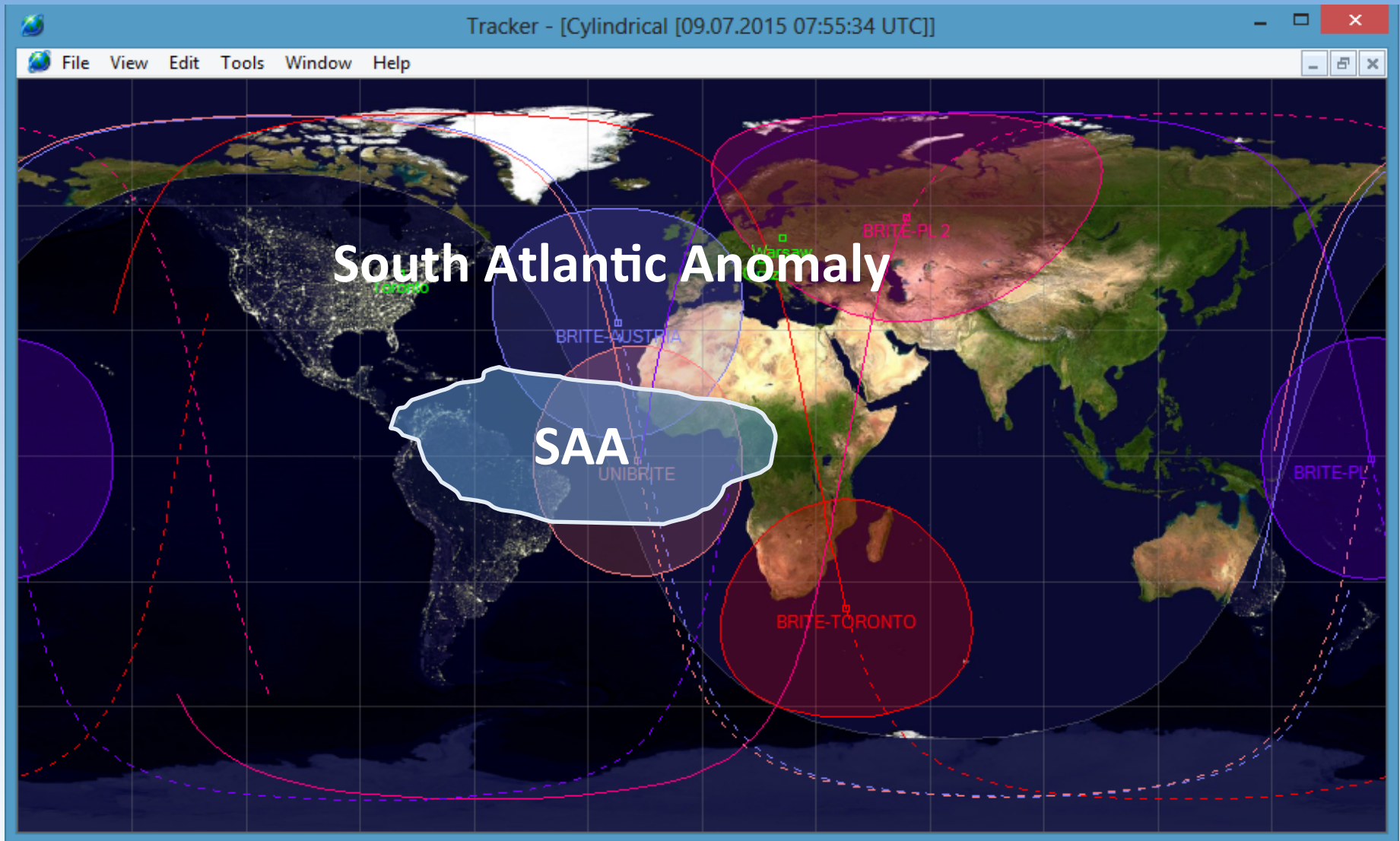
- good performance at high (+20C) temperatures
- low power consumption and reasonable price
- Read-Noise  $\sim 15e$  rms
- 11 Megapixel
- 30 arcsec / pixel
- mission to Mars

# Bus Problem Areas

- Magnetometer Calibration
- ACS (external companies)
- OBC radiation damage (BRITE-Austria)



# SAA



# Bus Problem Areas

- Magnetometer Calibration
- ACS (external companies)
- OBC radiation damage (BRITE-Austria)
- Star Tracker

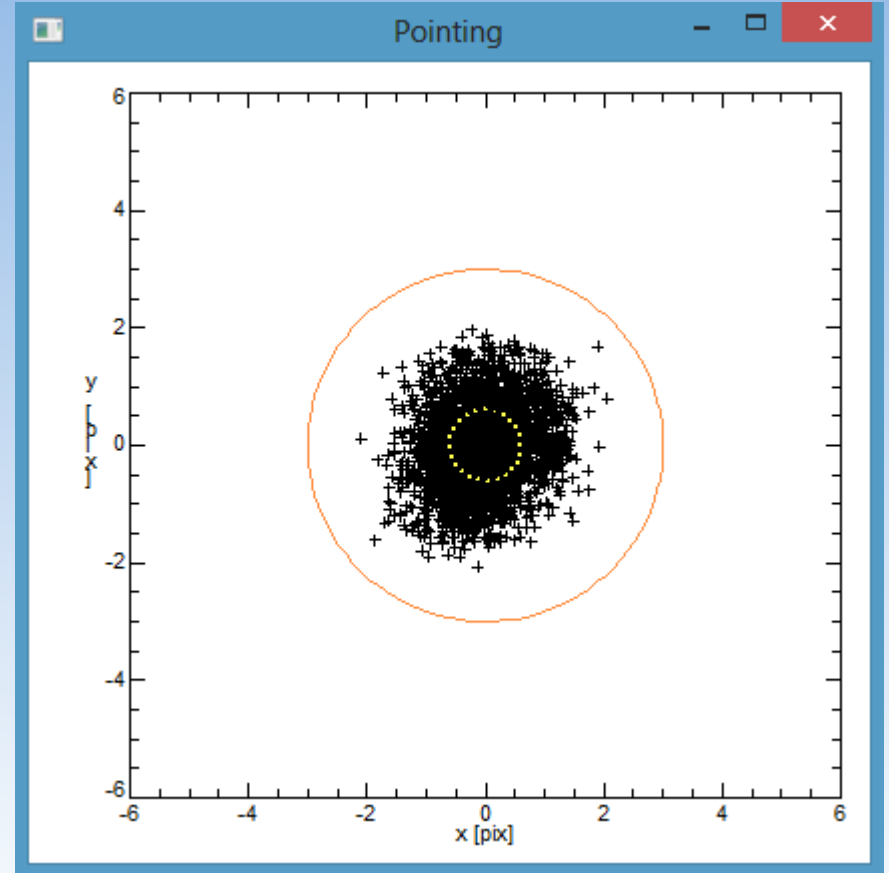
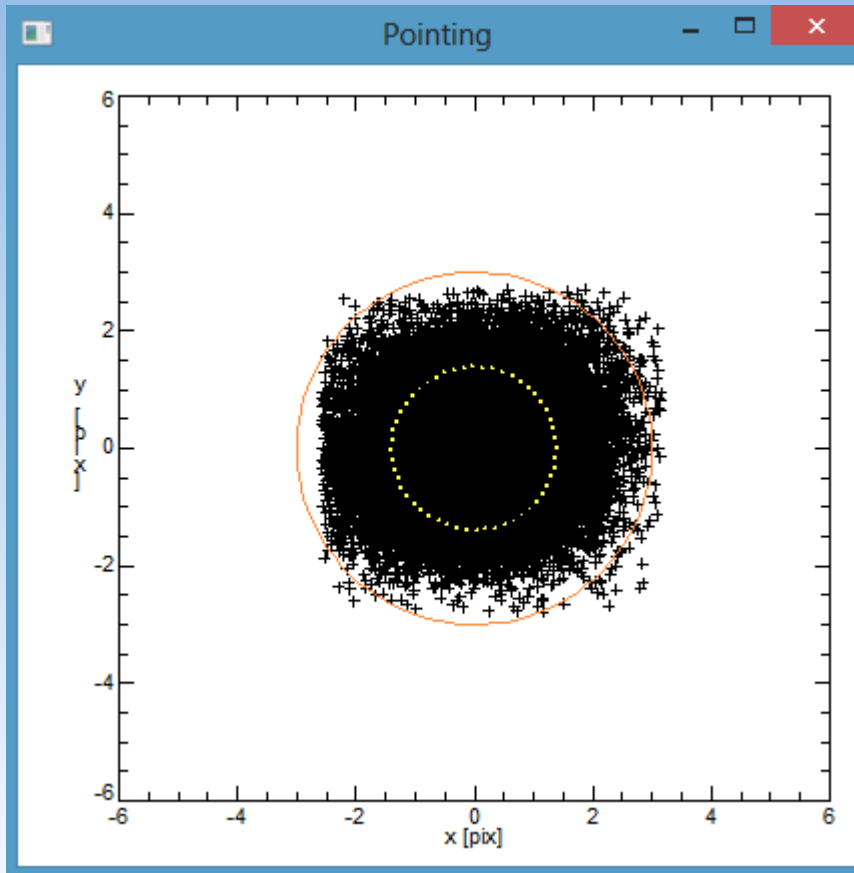
# Star Tracker

**UBr**   **BAb**

Aero Astro Star Tracker

**BTr**   **BLb**   **BHr**

Sinclair Star Tracker

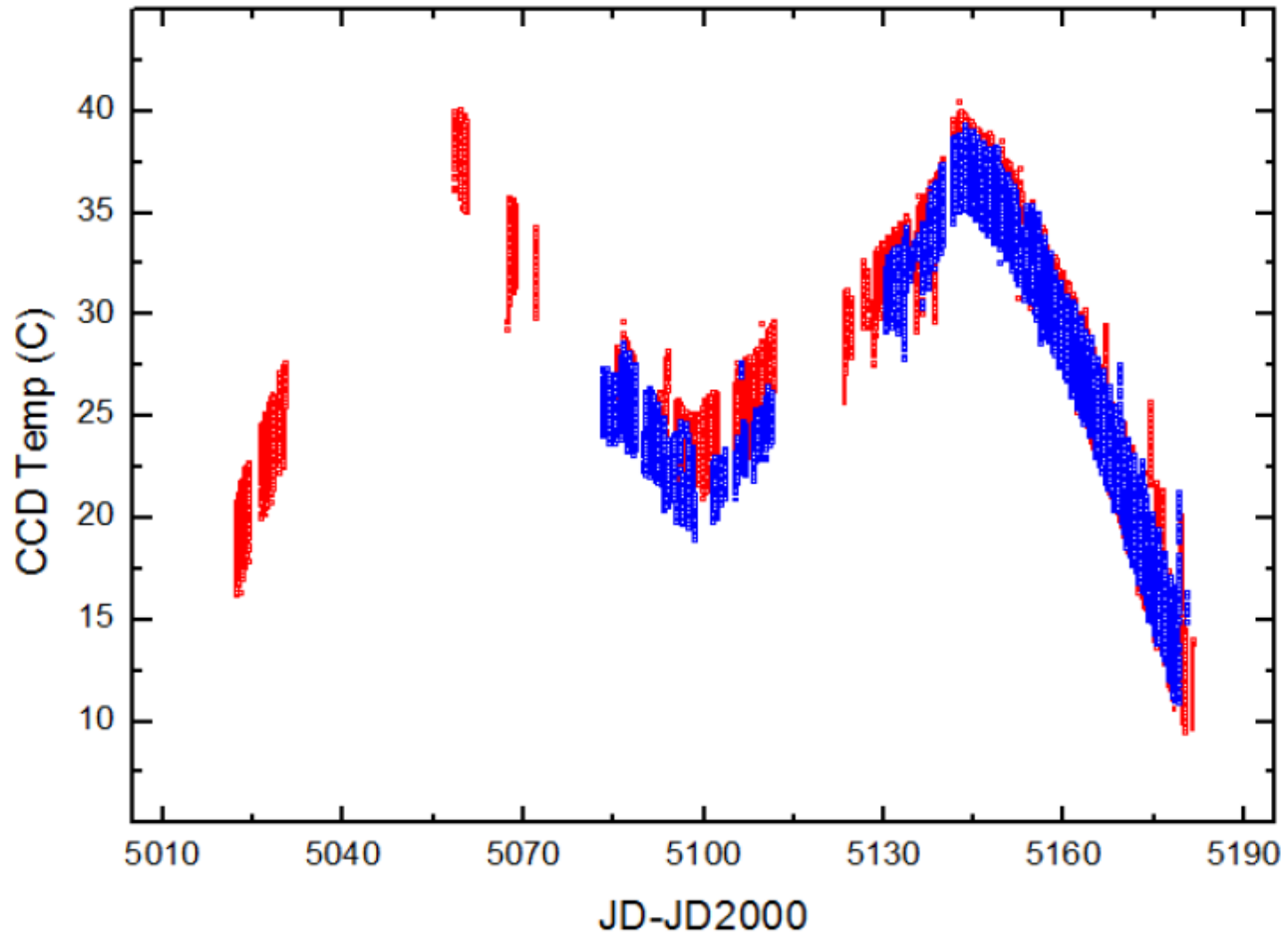


# Bus Problem Areas

- Magnetometer Calibration
- ACS (external companies)
- OBC radiation damage (BRITE-Austria)
- Star Tracker
- Temperature depends on bus-orientation

# CCD Temperature Variations – 5.5 month

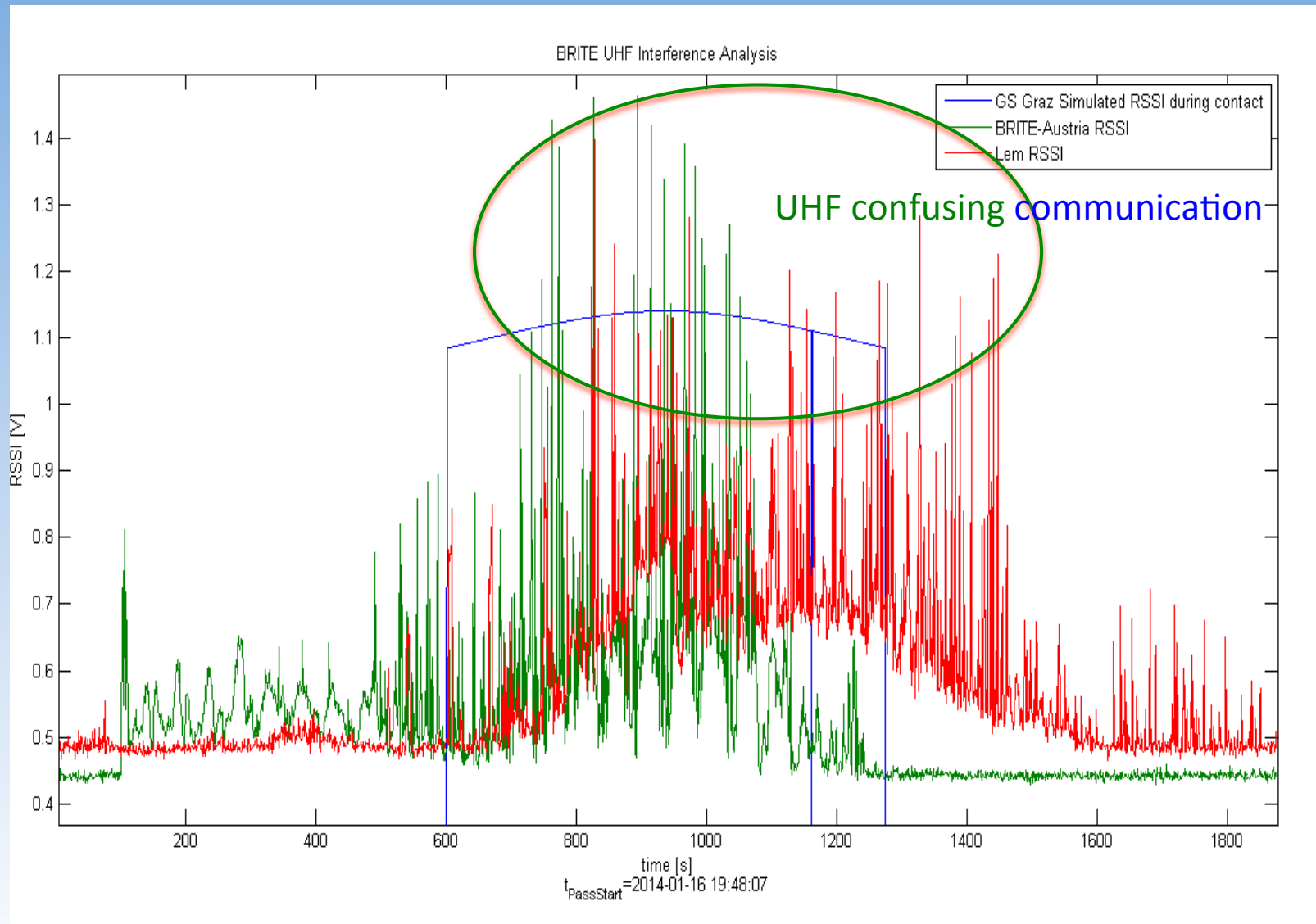
- UniBRITE
- BRITE-Austria



# Bus Problem Areas

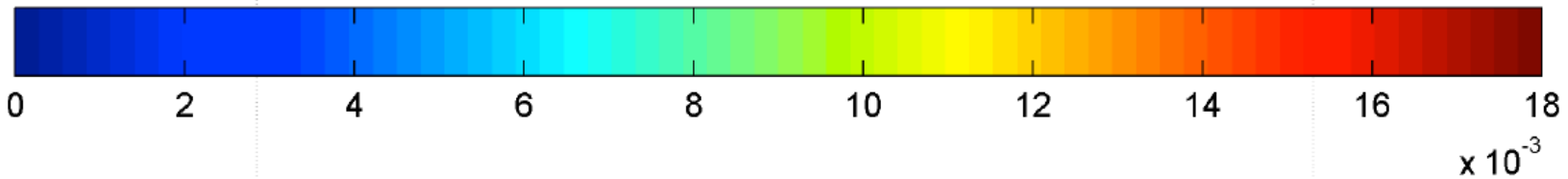
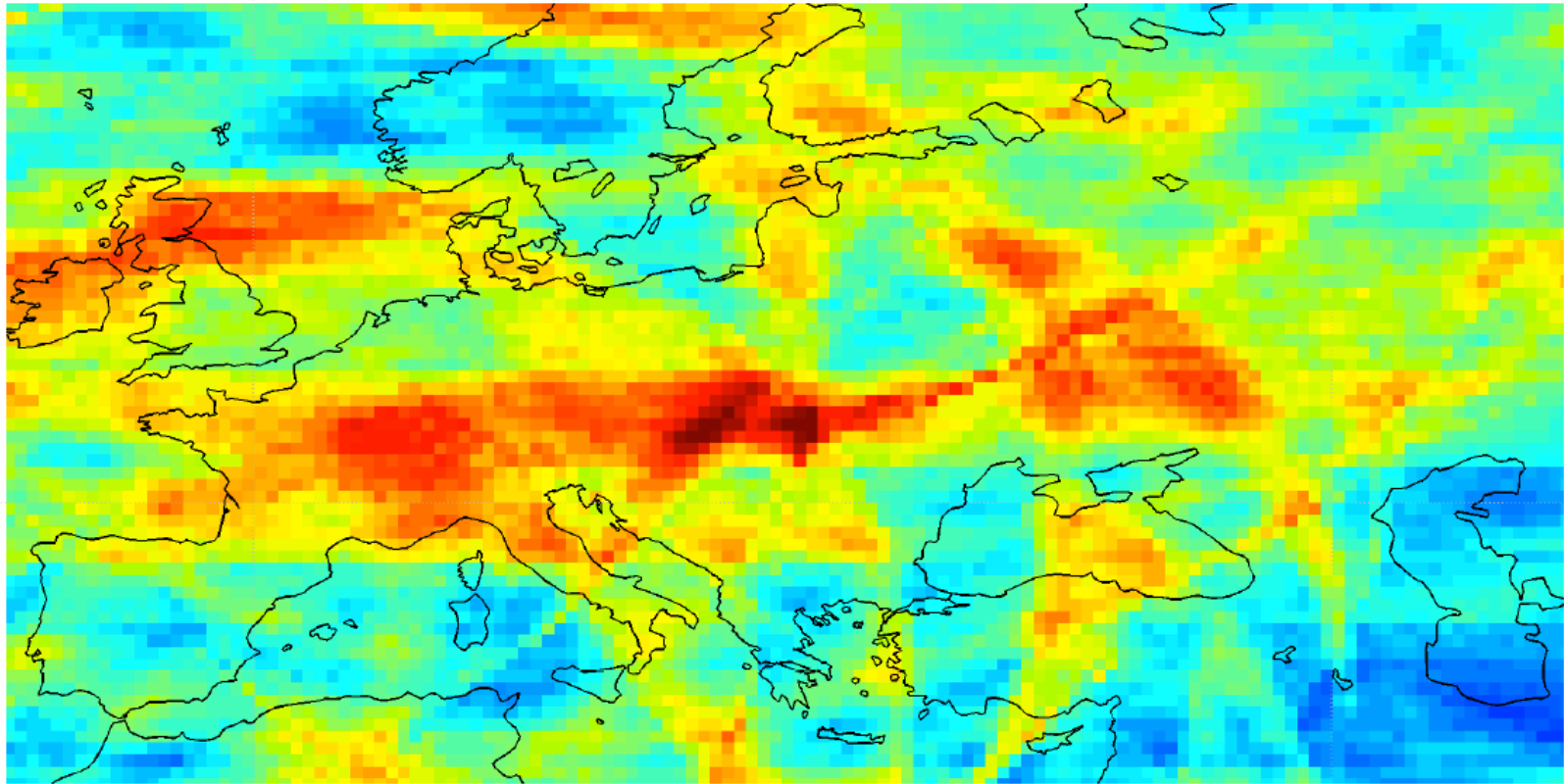
- Magnetometer Calibration
- ACS (external companies)
- OBC radiation damage (BRITE-Austria)
- Star Tracker
- Temperature depends on bus-orientation
- **UHF Interference**

# UHF Interferences



# UHF Sources

DRSSI-13-Jan-2014 00:00:56





Organizations

BRITE-U

TCA Start Date (UTC)

TCA End Date (UTC)

# Space Trash

CDMs

Show 10 entries

Search All Columns:

| CONSTELLATION | MESSAGE ID   | CREATED             | SAT 1 ID  | SAT 1 NAME       | SAT 2 ID   | SAT 2 NAME         | TCA                     | PC           | MIN. RNG |
|---------------|--|---------------------|-----------|------------------|------------|--------------------|-------------------------|--------------|----------|
| BRITE-U       | <a href="#">39092_conj_05755_2017179131925_1770723582155</a> | 2017-06-26 07:11:52 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 13:19:25.661 | 9.663195e-05 | 172      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179131925_1771744312136</a> | 2017-06-26 17:30:11 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 13:19:25.657 | 1.727786e-05 | 199      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179131925_1780816052172</a> | 2017-06-27 07:54:51 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 13:19:25.657 | 1.901819e-05 | 198      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179131925_1781721132124</a> | 2017-06-27 17:02:24 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 13:19:25.661 | 9.94836e-06  | 173      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179131925_1790024062114</a> | 2017-06-28 00:11:47 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 13:19:25.661 | 6.97124e-09  | 201      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179131925_1790836582114</a> | 2017-06-28 08:28:01 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 13:19:25.651 | 0            | 260      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179145950_1761549142092</a> | 2017-06-25 15:32:24 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 14:59:50.536 | 0.0004117631 | 592      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179145950_1770046592126</a> | 2017-06-26 00:37:07 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 14:59:50.532 | 0.0005612626 | 555      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179145950_1770723582156</a> | 2017-06-26 07:11:52 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 14:59:50.525 | 0.0005158318 | 571      |
| BRITE-U       | <a href="#">39092_conj_05755_2017179145950_1771744312137</a> | 2017-06-26 17:30:21 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-28 14:59:50.522 | 2.68507e-06  | 597      |

CONSTELLATION

MESSAGE ID

CREATED

SAT 1

SAT 1 NA

SAT 2

SAT 2 NA

TCA

PC

MIN. I

# OPERATOR PANEL

CDM [Directory](#) [Maneuver](#) [Manage](#) [Help](#)

CDM:

Organizations

BRITE-U

TCA Start Date (UTC)

2017-06-20

TCA End Date (UTC)

2017-06-28

Load CDMs

Show 10 entries

Search All Columns:

| CONSTELLATION | MESSAGE ID   | CREATED             | SAT 1 ID  | SAT 1 NAME       | SAT 2 ID   | SAT 2 NAME         | TCA                     | PC           | MIN. RNG |
|---------------|--|---------------------|-----------|------------------|------------|--------------------|-------------------------|--------------|----------|
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1721605002153</a> | 2017-06-21 15:42:24 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.506 |              | 807      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1730110212142</a> | 2017-06-22 01:03:54 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.506 |              | 807      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1730743542171</a> | 2017-06-22 07:28:45 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.648 |              | 819      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1732151172071</a> | 2017-06-22 21:46:38 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.673 |              | 800      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1740002492112</a> | 2017-06-22 23:50:02 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.679 |              | 809      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1740727162138</a> | 2017-06-23 07:17:14 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.590 |              | 780      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1741455502144</a> | 2017-06-23 14:48:08 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.611 |              | 778      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1750016082097</a> | 2017-06-24 00:06:48 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.613 |              | 778      |
| BRITE-U       | <a href="#">39092_conj_39091_2017175140102_1750654242093</a> | 2017-06-24 06:45:27 | 2013-009G | BRITE-U UNIBRITE | 2013-009F  | BRITE-A TUGSAT-1   | 2017-06-24 14:01:02.617 |              | 765      |
| BRITE-U       | <a href="#">39092_conj_05755_2017178062144_1750654242058</a> | 2017-06-24 06:45:31 | 2013-009G | BRITE-U UNIBRITE | 1969-082JP | THORAD AGENA D DEB | 2017-06-27 06:21:44.412 | 1.105294e-11 | 979      |

CONSTELLATION

MESSAGE ID

CREATED

SAT 1

SAT 1 NAME

SAT 2

SAT 2 NAME

TCA

PC

MIN. F

Showing 1 to 10 of 10 entries

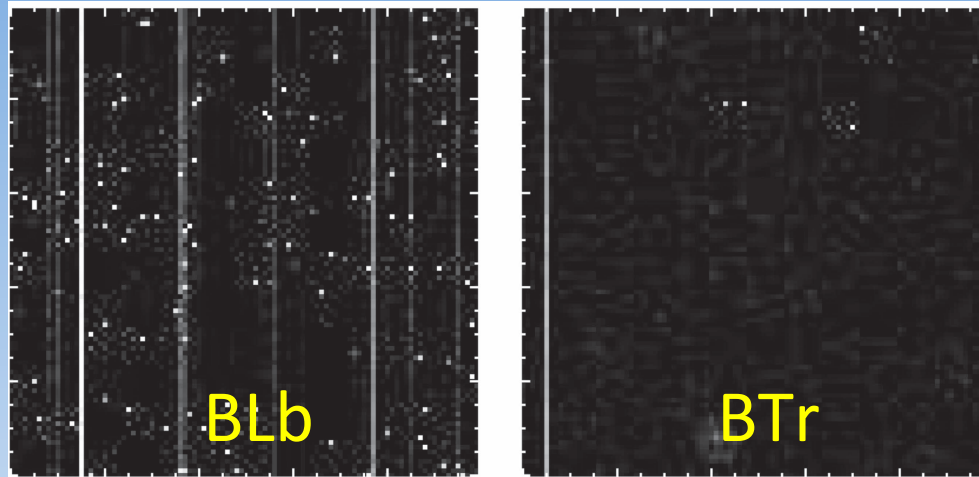
[CDM Guide](#)

First Previous 1 Next Last

# CCD Problem Areas

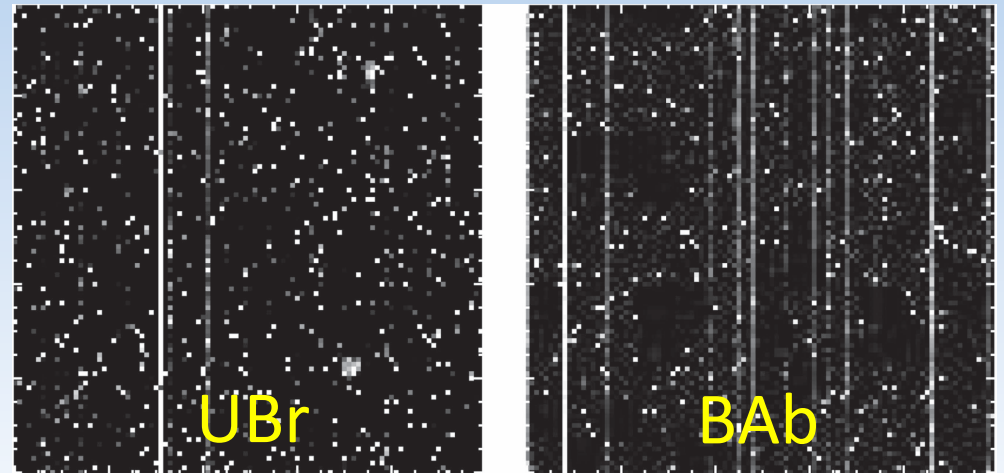
- Radiation damage (BRITE-Austria)
  - Hot / warm pixels

# Warm Pixels



1 week in orbit

4 months in orbit

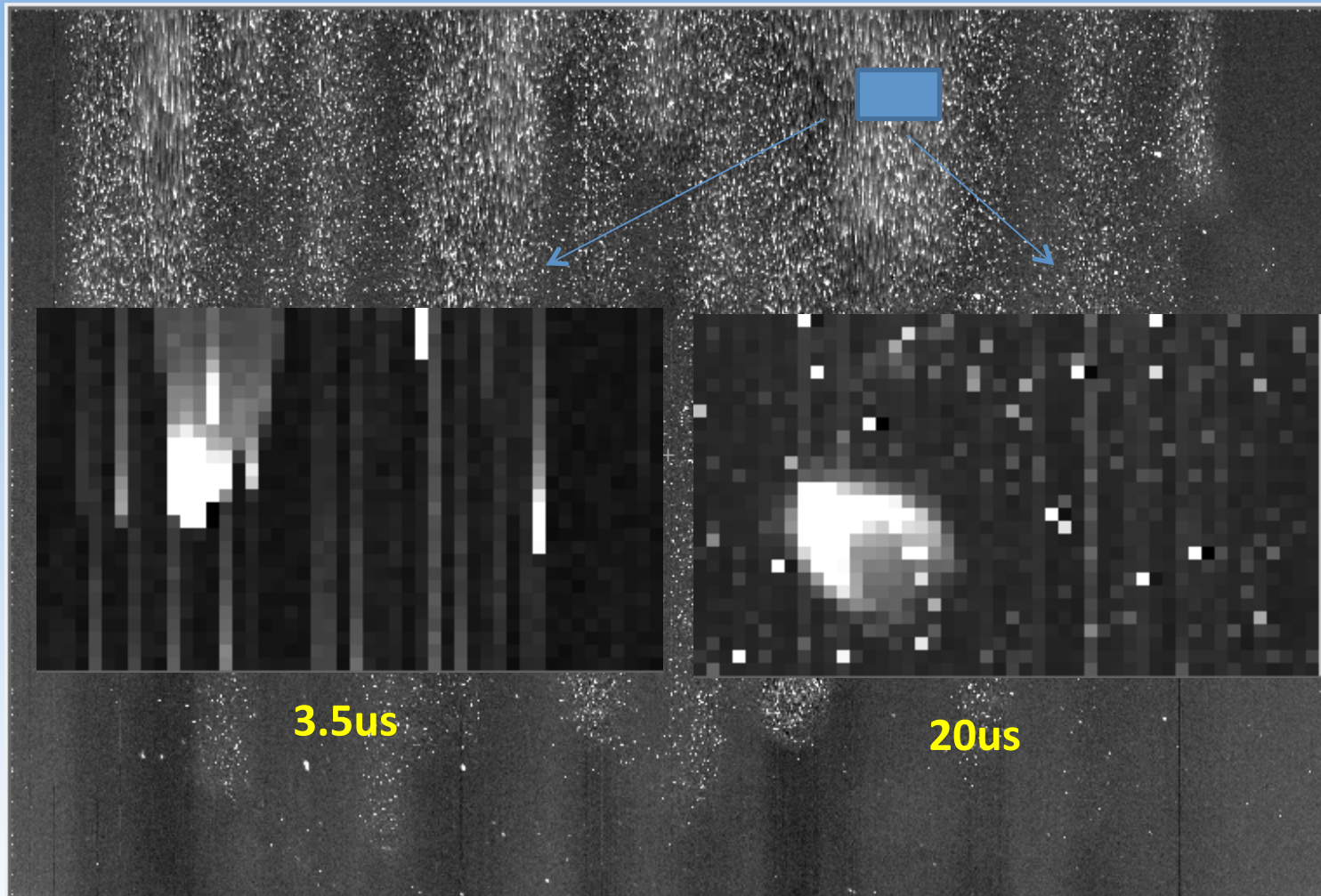


# CCD Problem Areas

- Radiation damage (BRITE-Austria)
  - Hot / warm pixels
  - CTI

# CTI

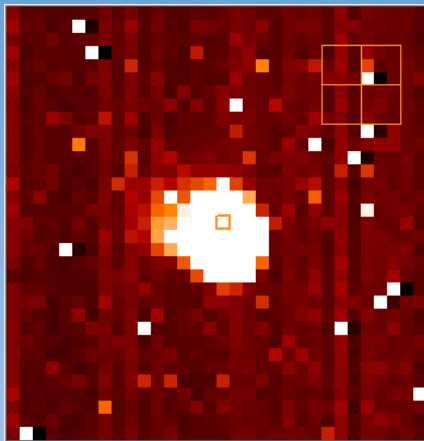
UBr - 2015-07-16 ; +30.5C ; 3.5  $\mu$ sec & 20  $\mu$ sec



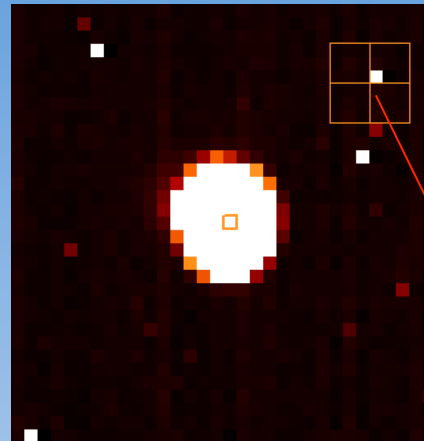
# CCD Problem Areas

- Radiation damage (BRITE-Austria)
  - Hot / warm pixels
  - CTI
- Signal is temperature sensitive

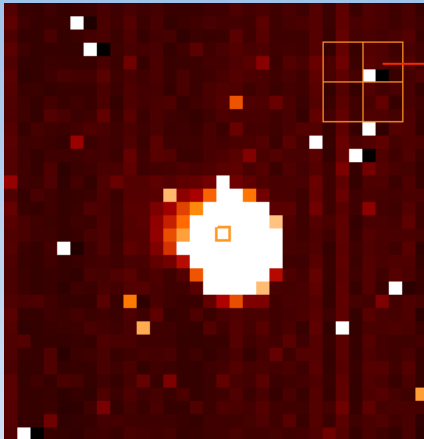
# UB Orion Data



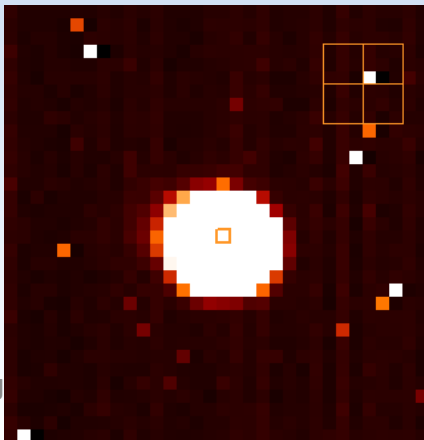
~40C  
Jan-2014



~10C  
Mar-2014, end of run

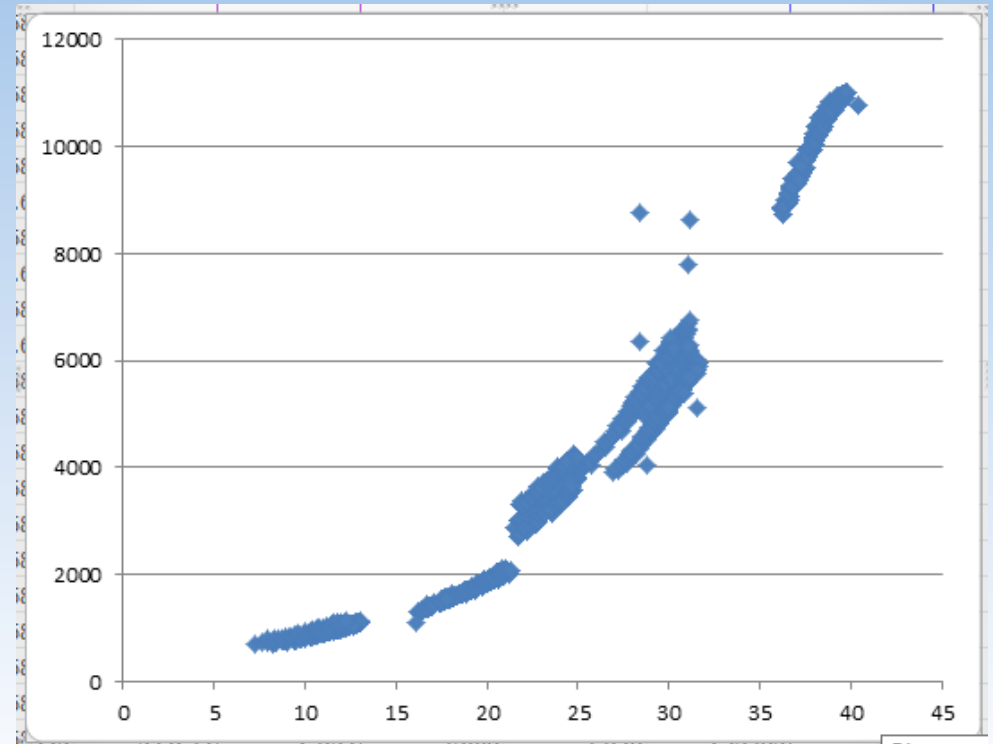


+30C  
Feb-2014



~20C  
Mar-2014

Hotpixel signal – CCD Temp

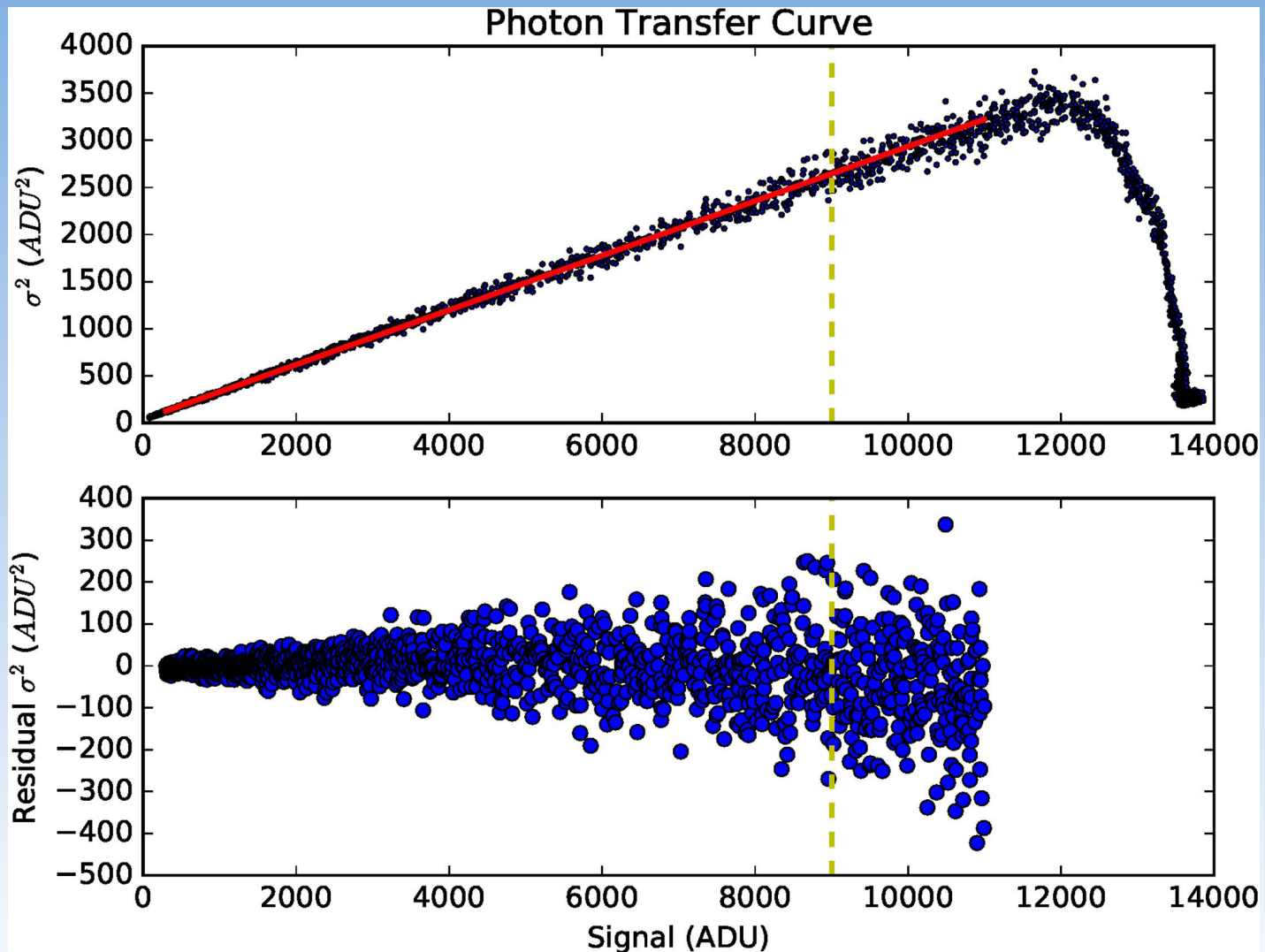




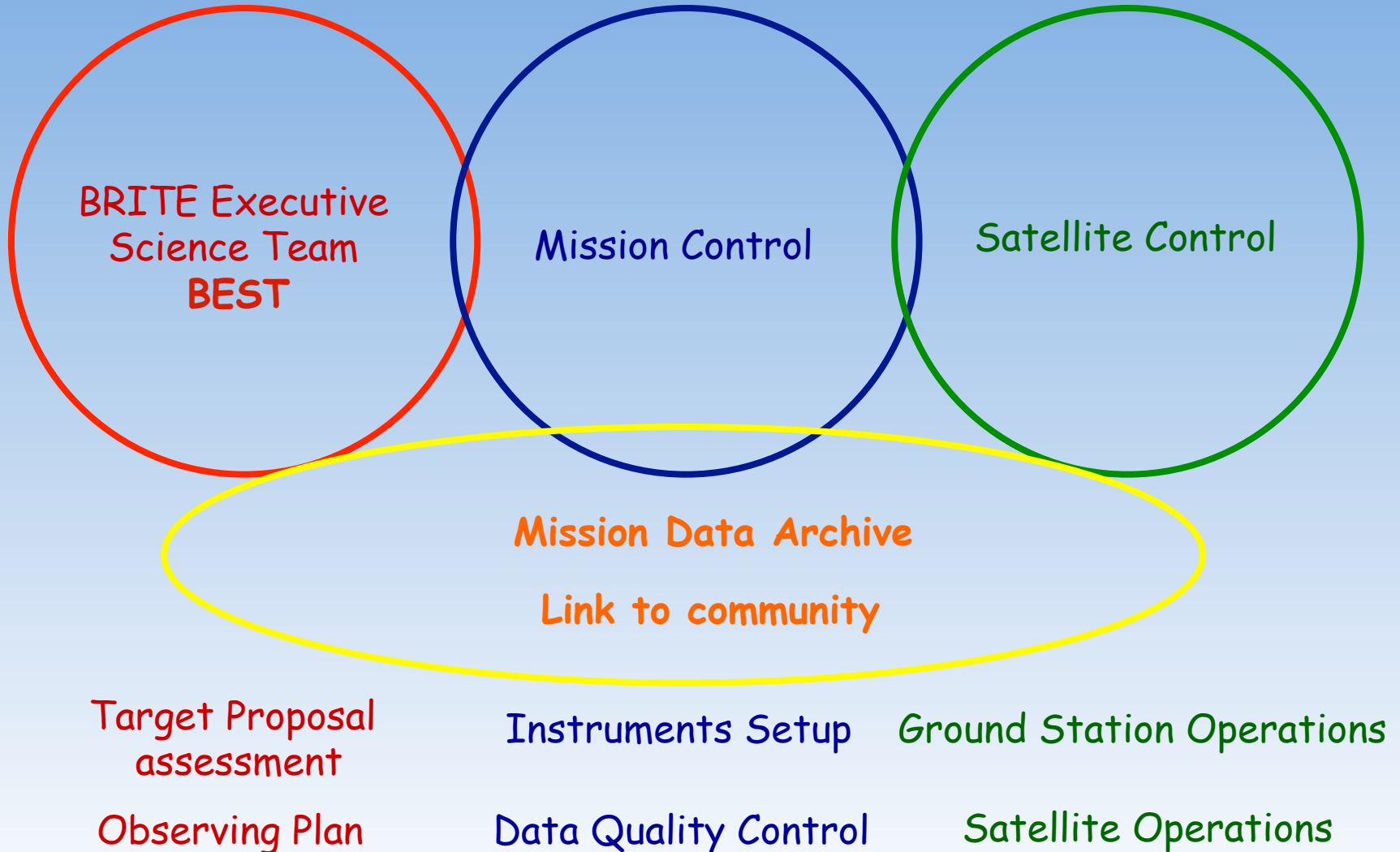
# CCD Problem Areas

- Radiation damage (BRITE-Austria)
  - Hot / warm pixels
  - CTI
- Signal is temperature sensitive
- Limited linearity

# Linearity

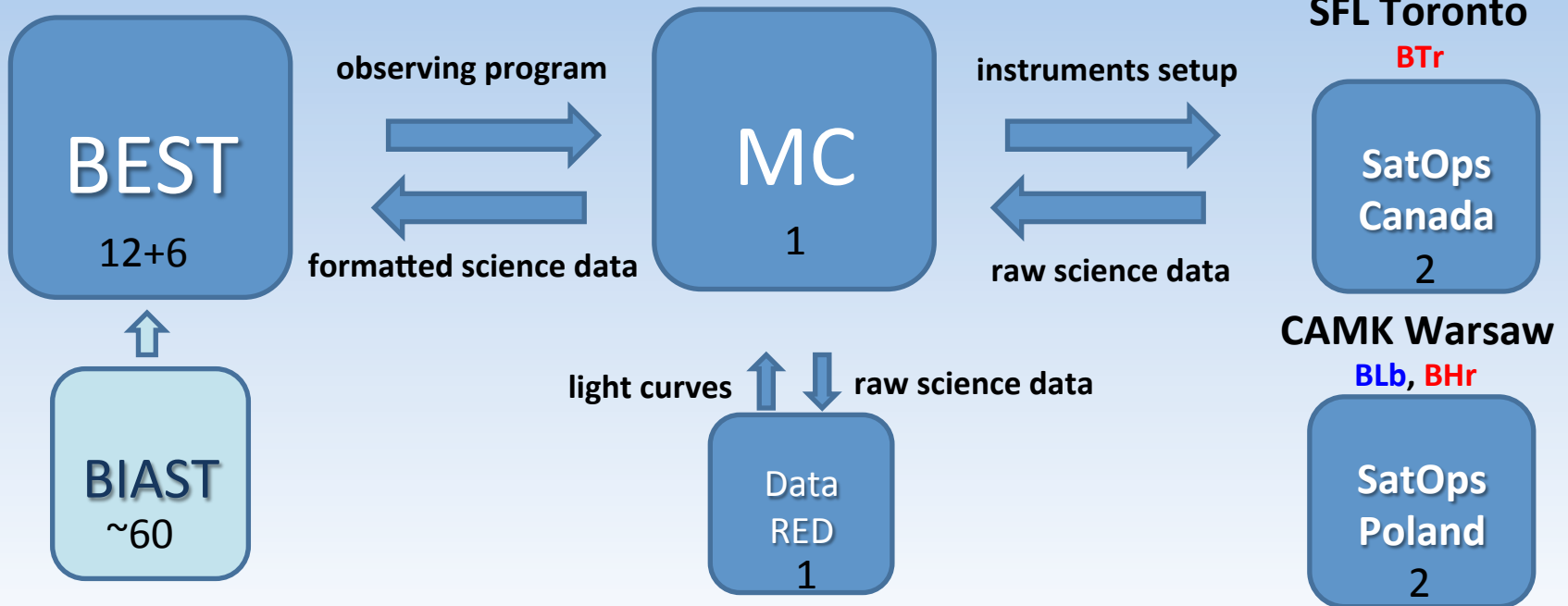


# Management



# Teams

**BEST:** BRITE Executive Science Team  
**BIAST:** BRITE International Advisory Science Team  
**MC:** Mission Control Team  
**SatOps:** Satellite Operations Team



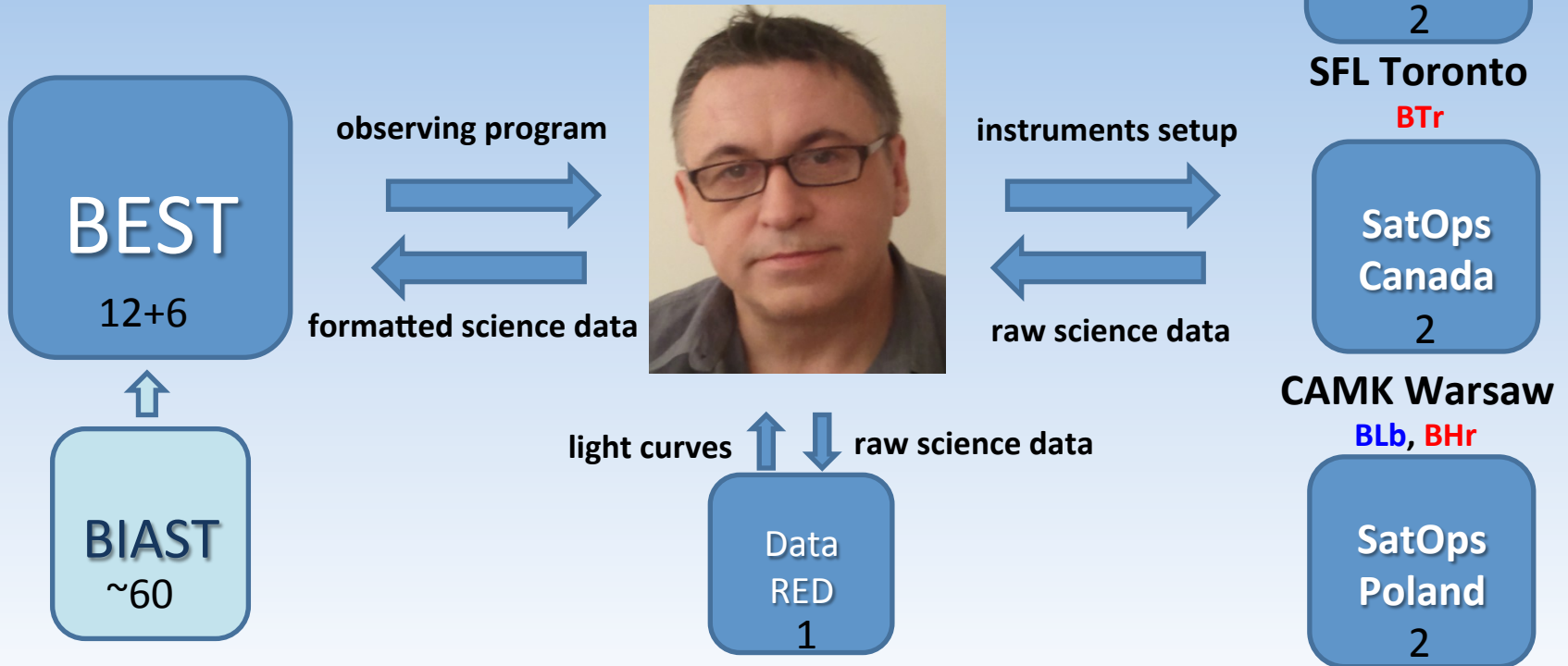
# Teams

**BEST:** BRITE Executive Science Team

**BIAST:** BRITE International Advisory Science Team

**MC:** Mission Control „Team“

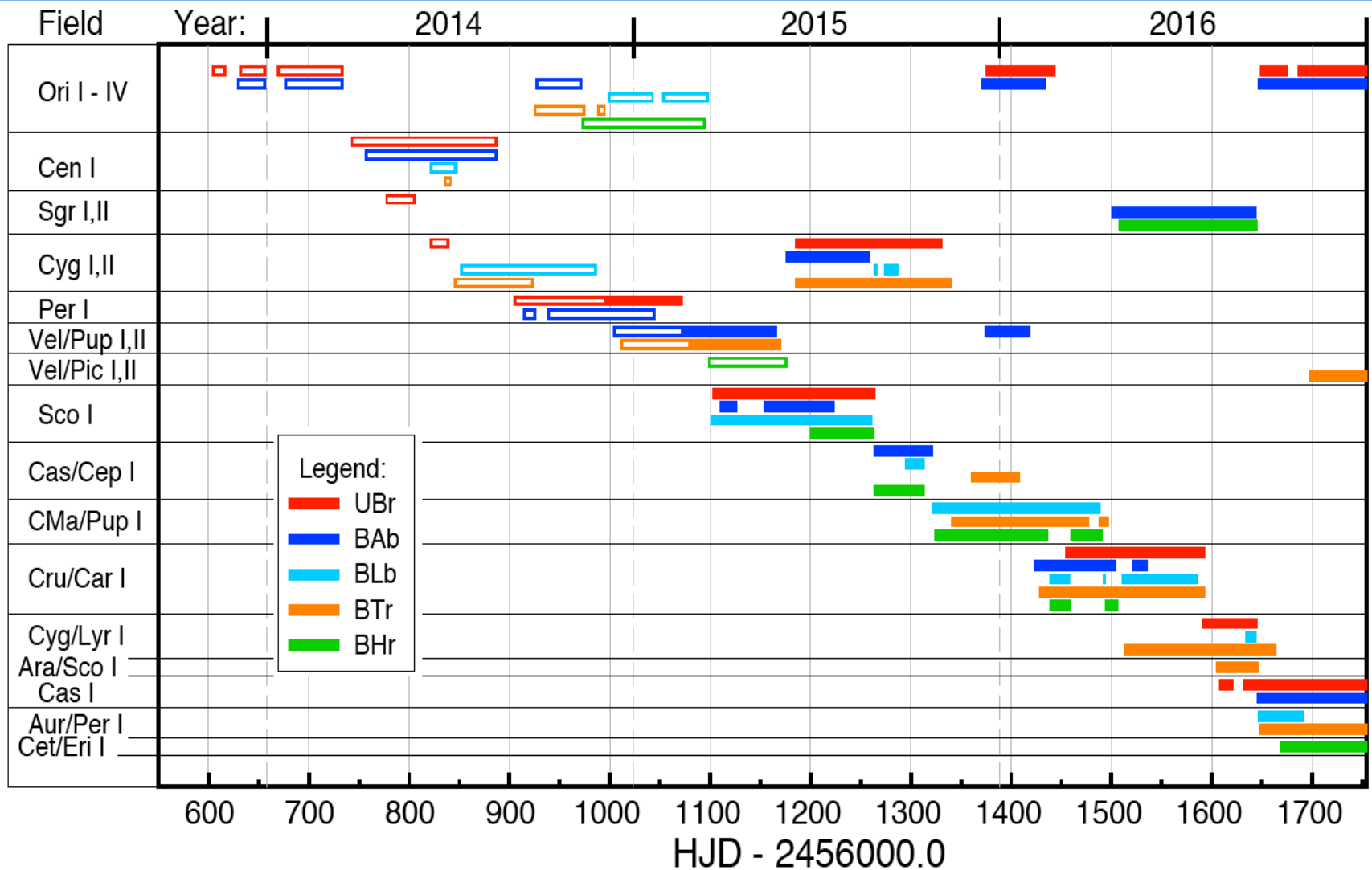
**SatOps:** Satellite Operations Team



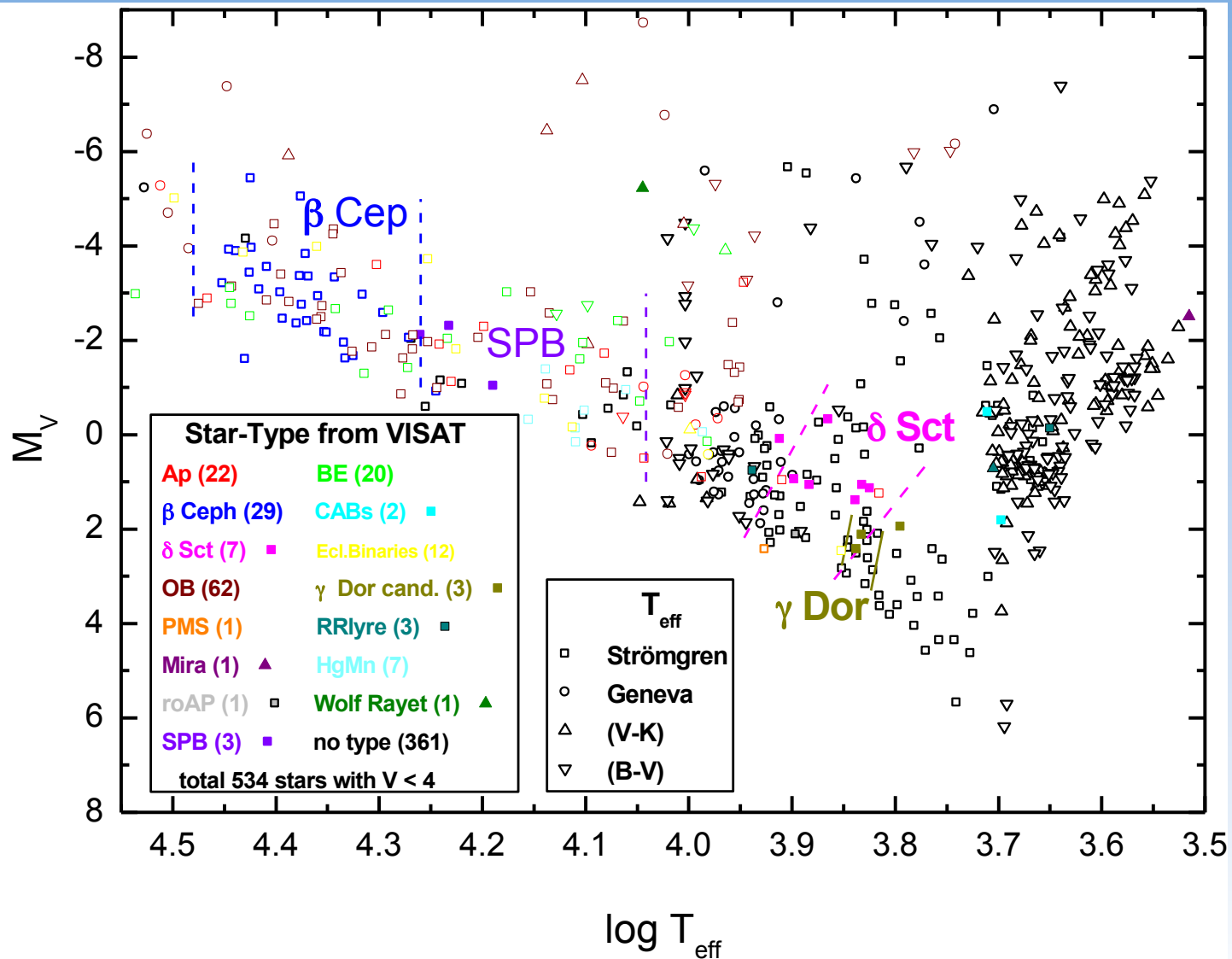
# Access to BRITE-Constellation

- Join BIAST to receive calls for targets  
<http://www.brite-constellation.at>
- ... or contact BEST any time  
[BRITE-BEST-L@lists.queensu.ca](mailto:BRITE-BEST-L@lists.queensu.ca)
- BEST evaluates proposals and optimizes **fields** to be observed and allocates BRITE satellite(s)
- You will be informed about the status of your project, access to data and archive...

# Observed Fields

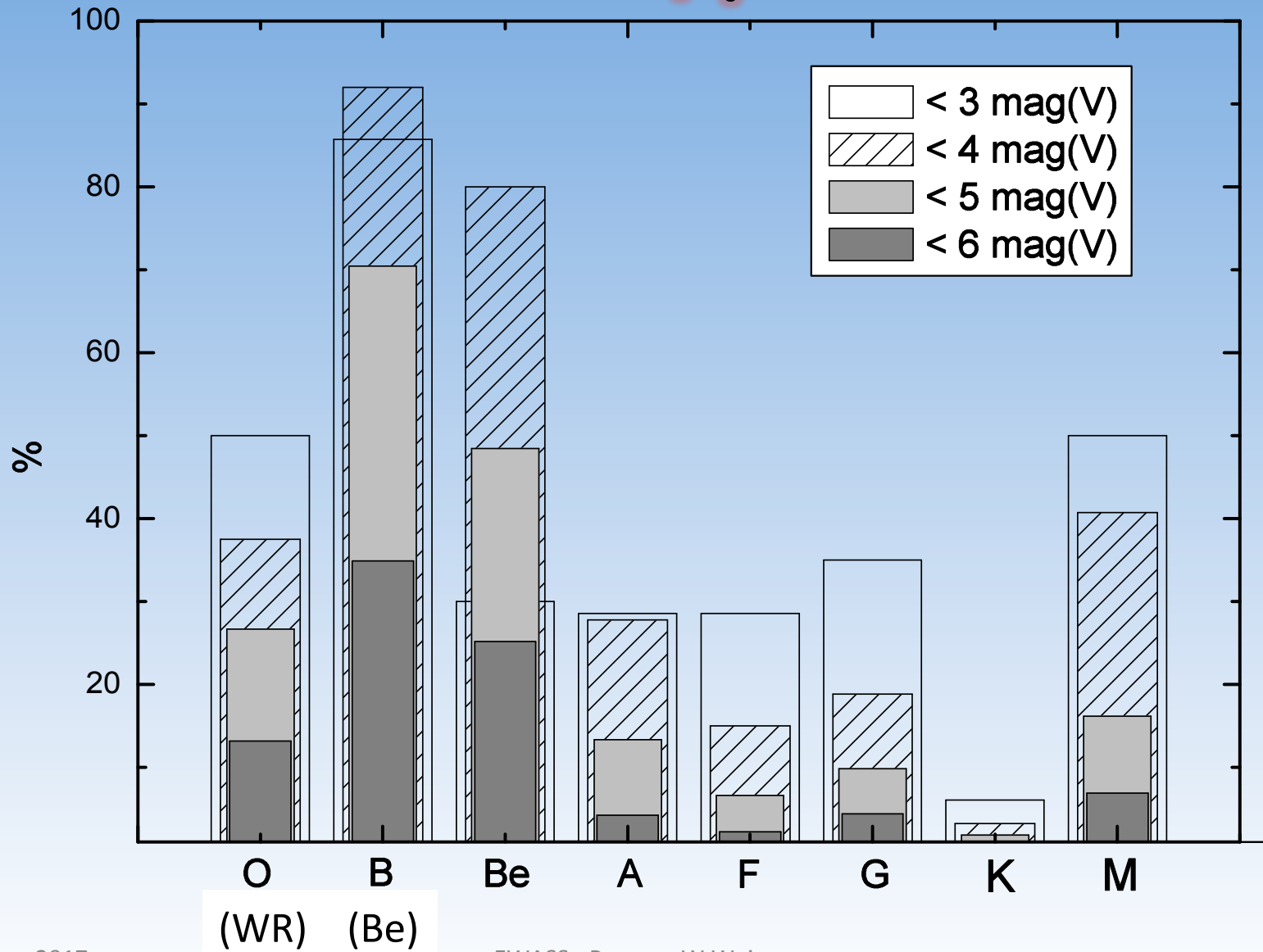


# Science Goals I

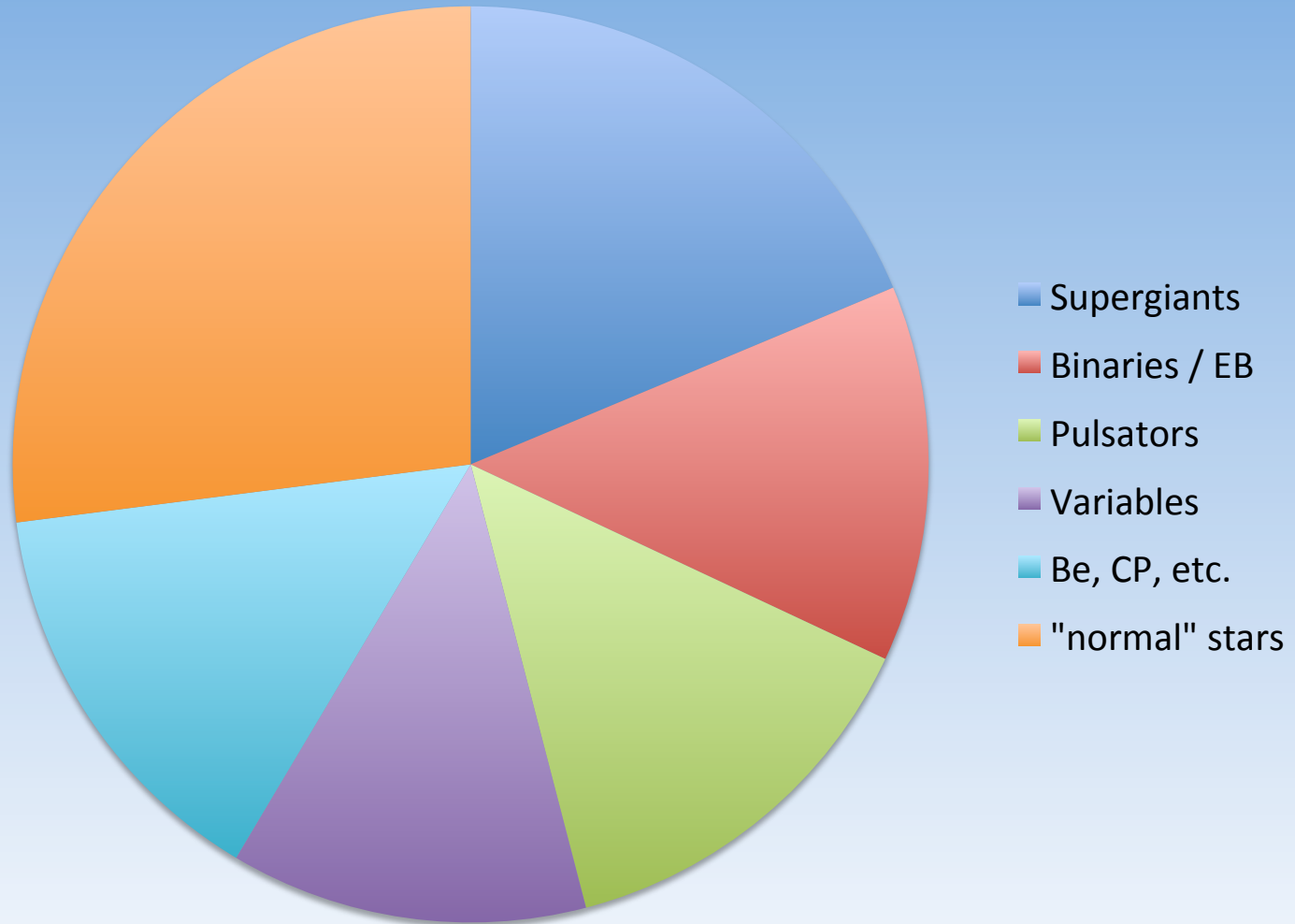




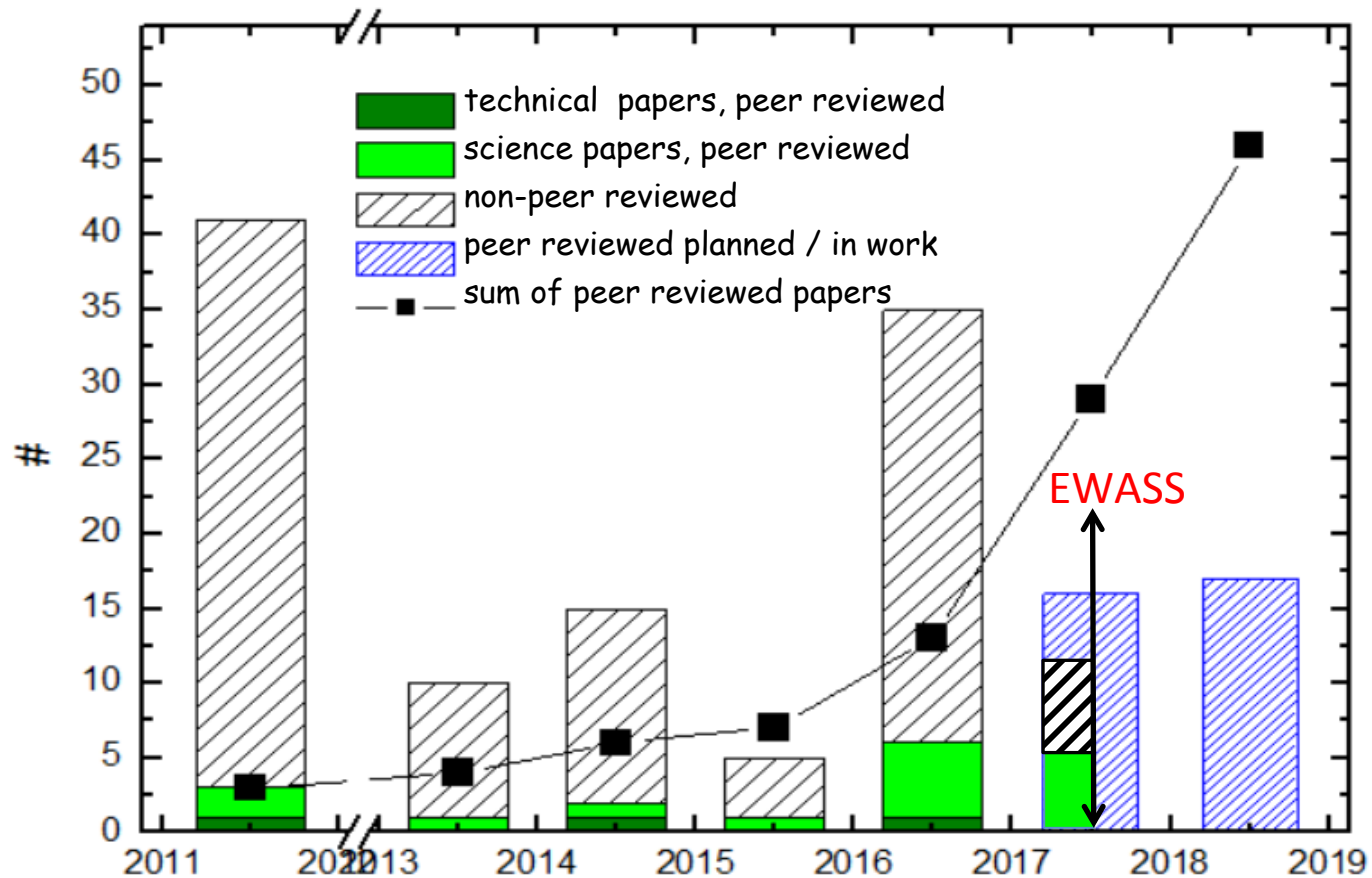
# MKK Types



# Variables



# Publication



Production, Launch & Commissioning

Science

# Bright Star Bonus

- ✓ **Interferometry**
  - angular diameter
- ✓ **Adaptive Optics & Lucky Image**
  - stellar & debris disks
- ✓ **Parallax with high accuracy**
  - linear diameter
- ✓ **Very high spectral resolution spectroscopy**
  - stellar fundamental parameters & atmosphere
  - (Doppler) surface imaging
- ✓ **Time resolved spectroscopy**
  - asteroseismology
- ✓ **Spectropolarimetry**
  - magnetic field structures
- ✓ **Multi-wavelengths options**
- ✓ **“Easy” access to telescope time**
  - of medium size telescopes → GBOT (K.Zwintz, chair)

## ... more to come:

- Rainer **Kuschnig**:  
BRITE-Constellation: operating 5 nanostellites ...
- Edward **Guinan**:  
Unraveling the complex brightness variations of the red supergiant Betelgeuse with the BRITE Constellation Nano-satellites
- Dietrich **Baade**:  
BRITEning up the Be phenomenon
- ... *and afternoon sessions, finishing with:*  
Dietrich **Baade**:  
**BRITE-Constellation: Science Potential**

# BRIght Target Explorer:

a Constellation of  
5 (6) nanosatellites  
3 countries



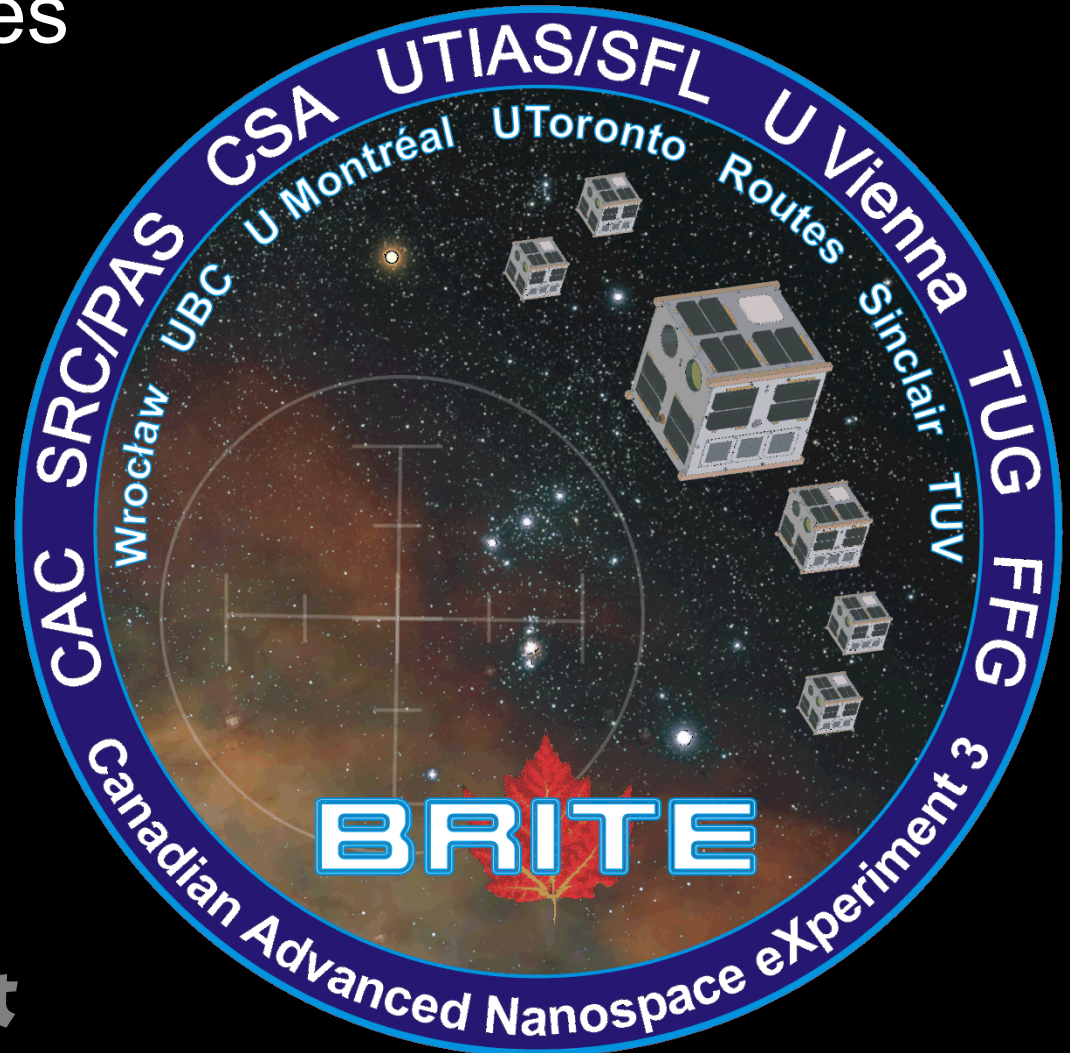
AUSTRIA



CANADA



POLAND



*A world first*

# Filter

