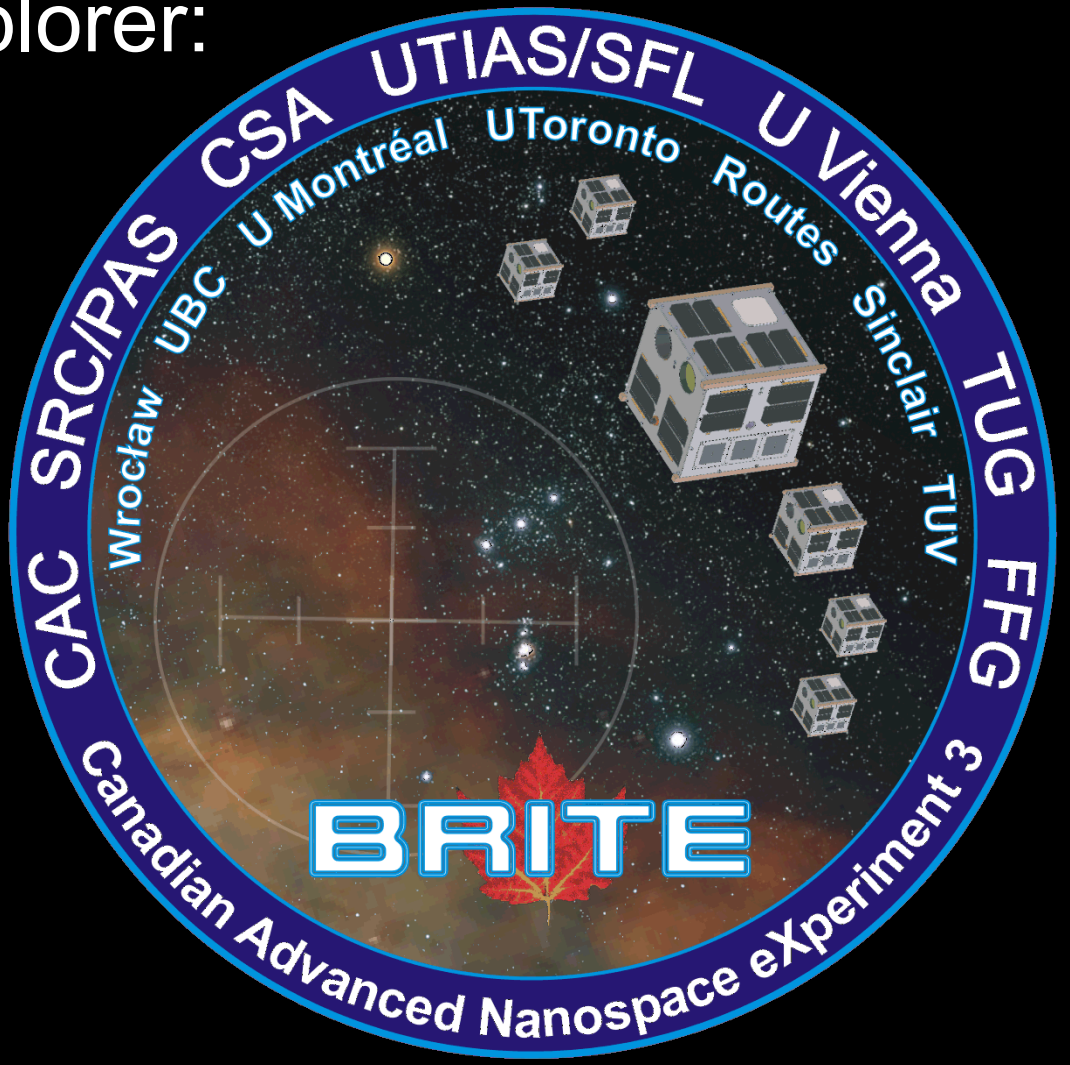
BRIght Target Explorer: a Constellation of 6 nanosatellites 3 countries

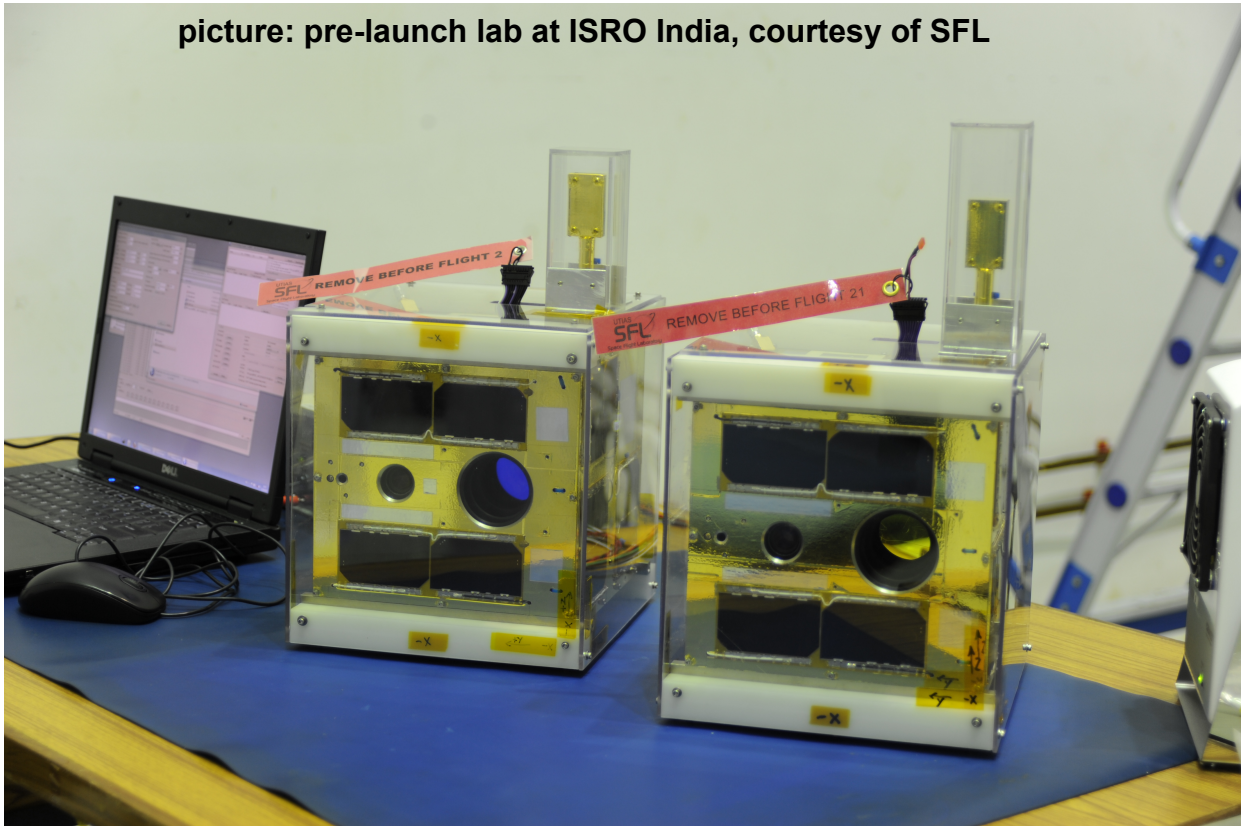
AUSTRIA

CANADA

POLAND



BRITE-Constellation: operating five nano-satellites to serve one mission



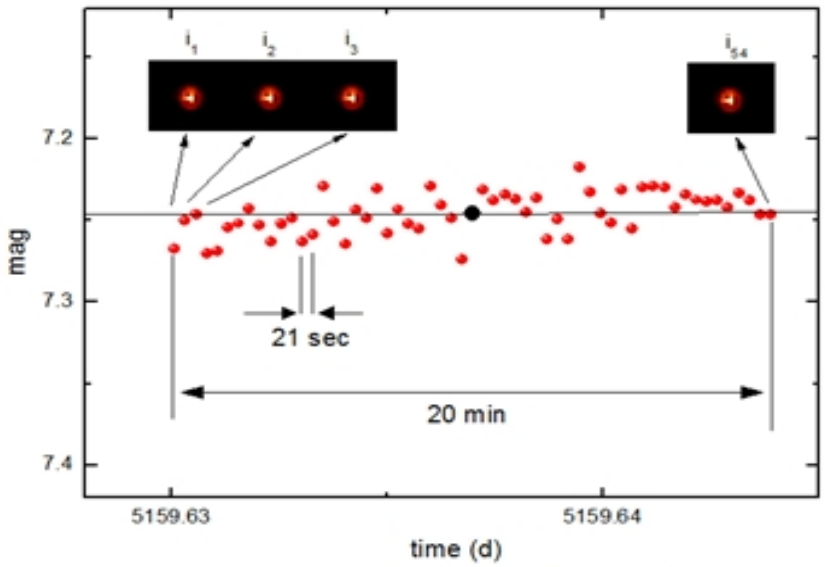
picture: pre-launch lab at ISRO India, courtesy of SFL

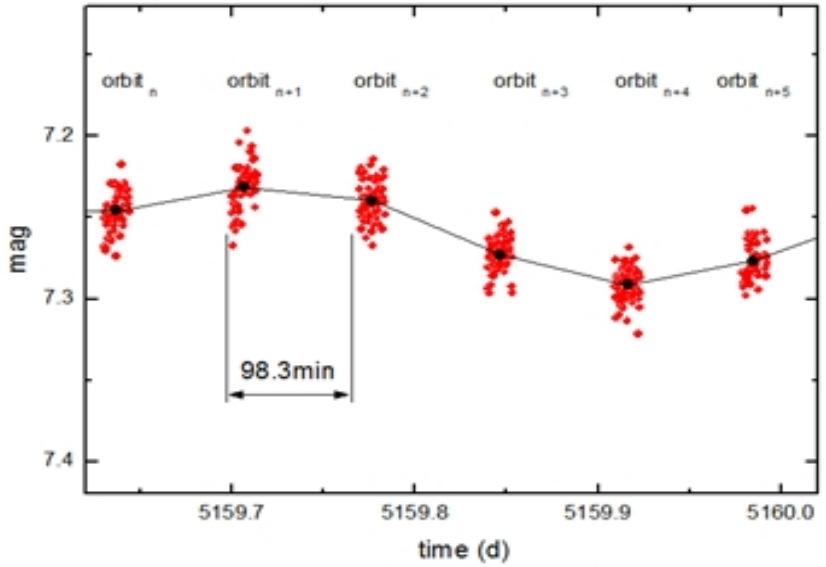
Rainer Kuschnig – *University of Technology Graz / University Vienna*

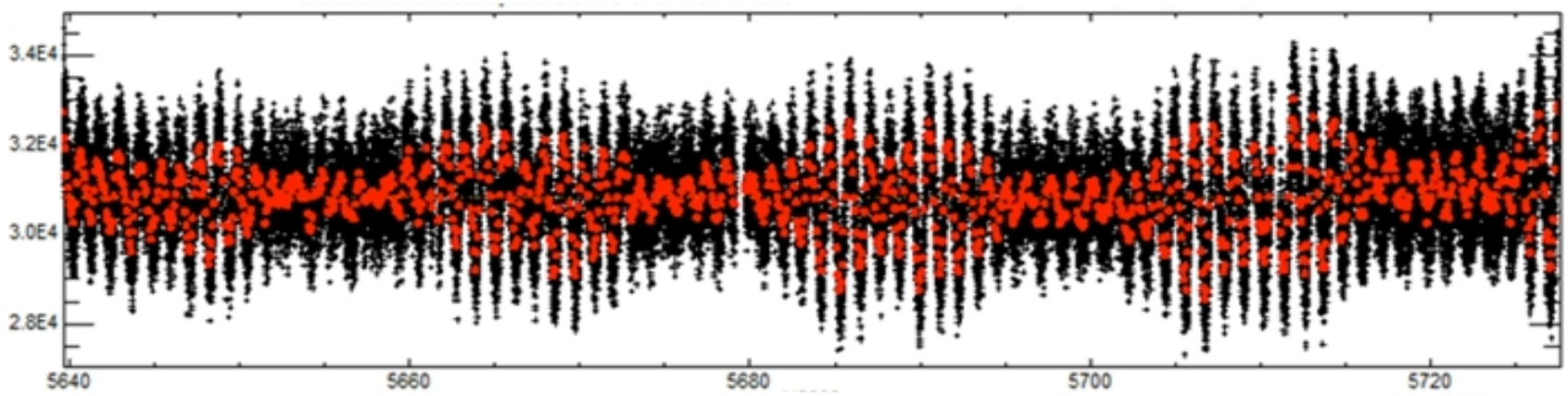
Why BRITE Constellation ?

- Collect time series **photometry** for some of the **brightest stars** in the sky, mag(V)<4(..6) with high precision ~0.1-0.5% (mmag)/orbit mean
- ~ **15-30 stars** per observing field at once **15min/orbit**
- Measurements in **two colors**: red and blue (two wavelength well separated ranges)
- Time bases of **up to 180 days** for a single observing campaign

BRITE-Constellation: Data sampling







BRITE - Constellation

3 countries – 6(5) satellites – ONE MISSION

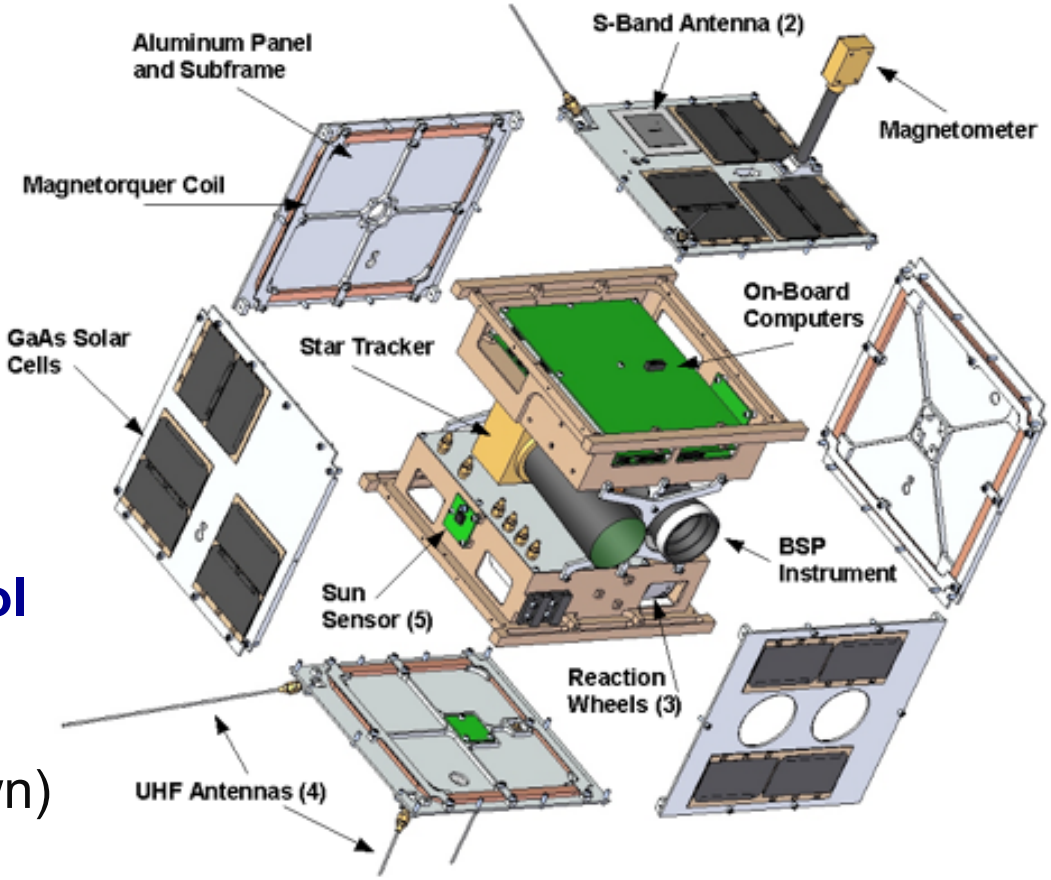
Country	Satellite Name	ID	Launch	Orbit-P(min)	Filter
AUT	UniBRITE	UBr	2013-02-25	100.37	red
AUT	BRITE-Austria 'TUG-SAT-1'	BAb	2013-02-25	100.36	blue
POL	BRITE-PL2 'Heweliusz'	BHr	2014-08-19	97.10	red
POL	BRITE-PL1 'Lem'	BLb	2013-11-21	99.57	blue
CAN	BRITE-CA1 'Toronto'	BTr	2014-06-19	98.24	red
CAN	*BRITE-CA2 'Montreal'*	*BMb*	*2014-06-19*	*n/a*	*blue*

BRITE-CA2 “Montreal” was launched with the same rocket as BRITE-CA1 “Toronto”, but did not separate from the upper stage **83%**

5 satellites collect science data

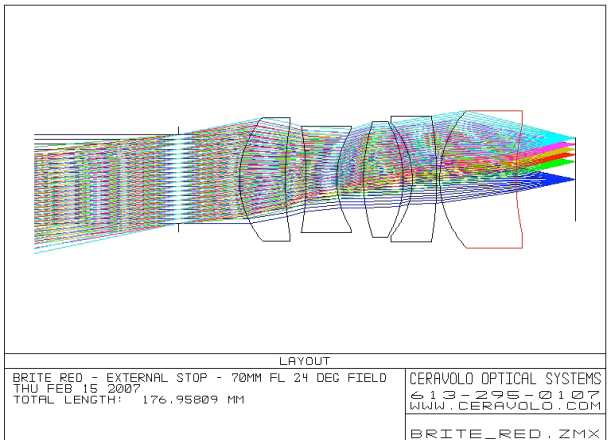
Satellite Design – BRITE nano satellites

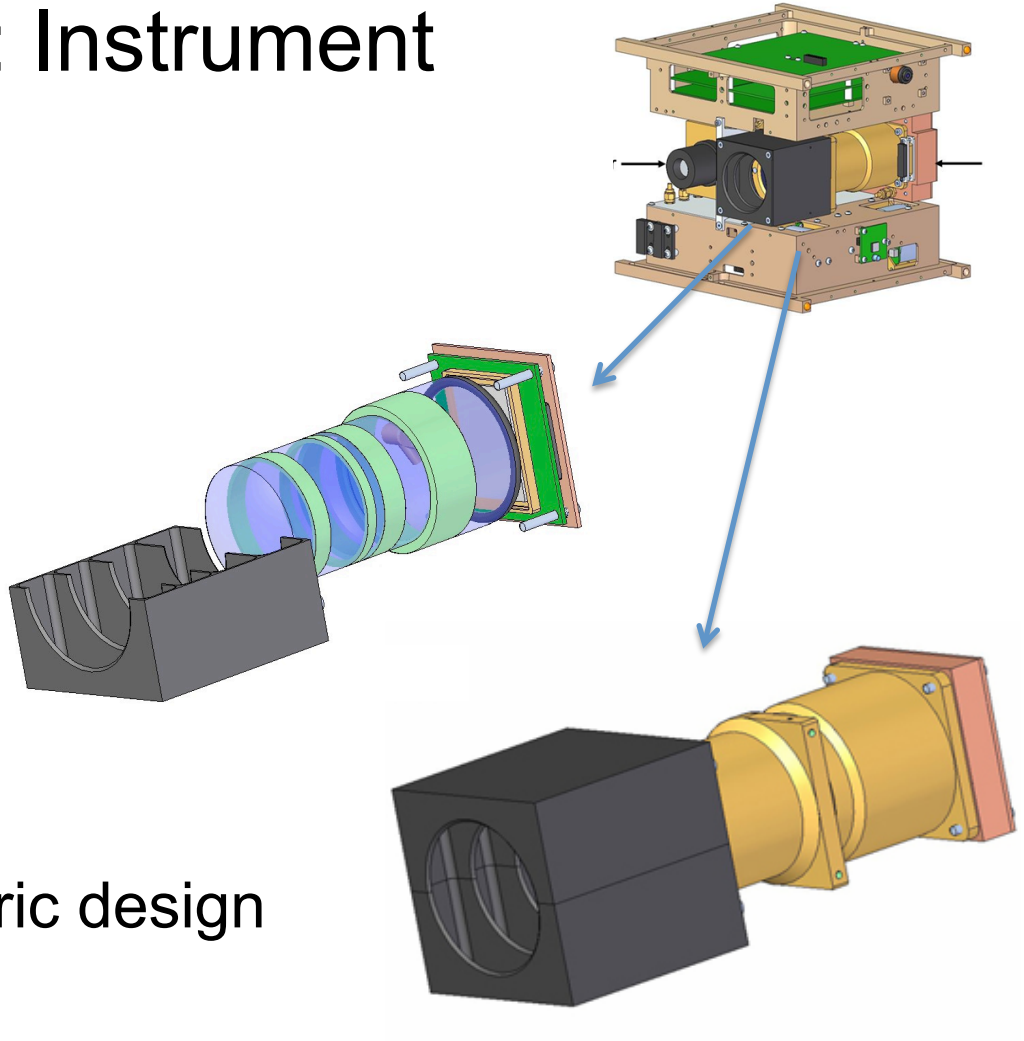
- **20cm cubes mass ~ 7kg**
- Pre-deployed antennas and booms
- Power (peak) 7 Watts
- Star tracker
- **Three-axis attitude control** (~1.5 arcminute stability)
- UHF (up) and S-Band (down) communication



all BRITE satellite have the same design except instrument and star tracker

Satellite Design: Instrument

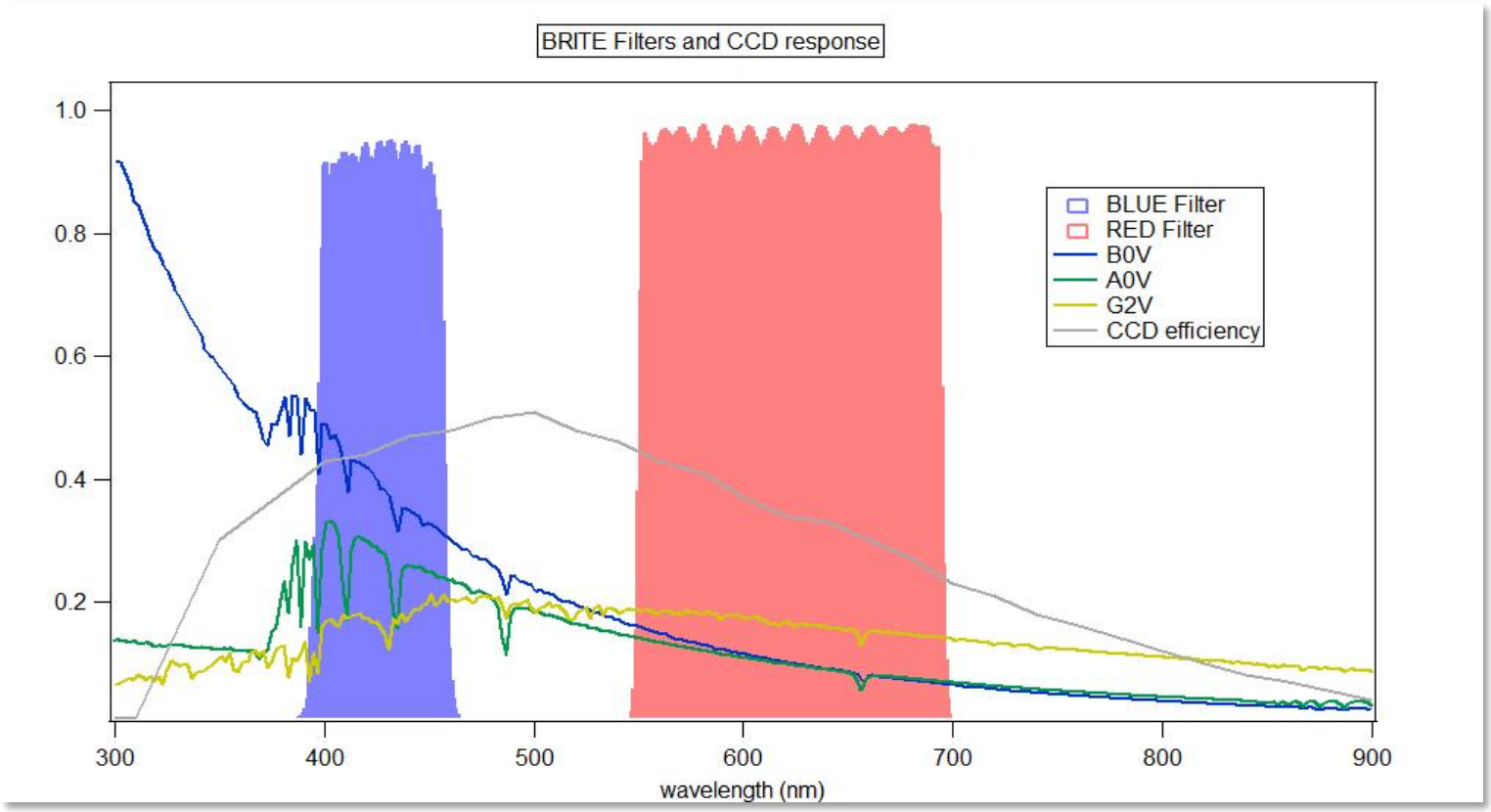




- 3 cm aperture
- 5 lenses telecentric design
- baffle + filter

the optical design of the red and the blue telescope is slightly different

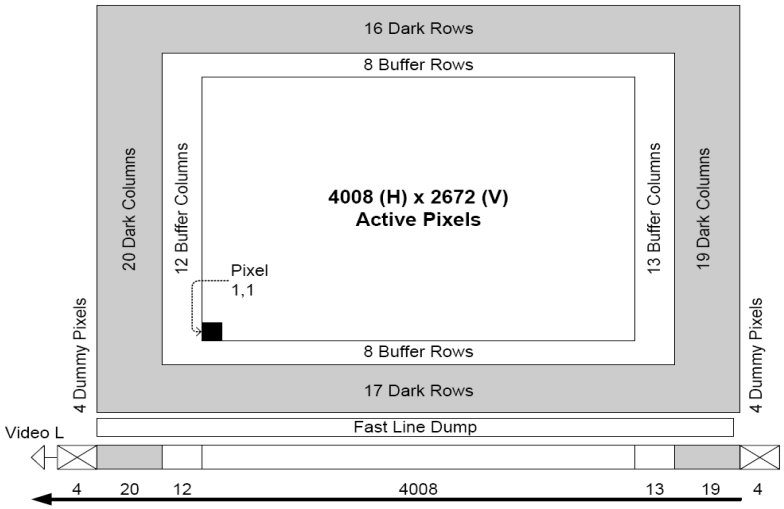
Satellite Design: Instrument Filters

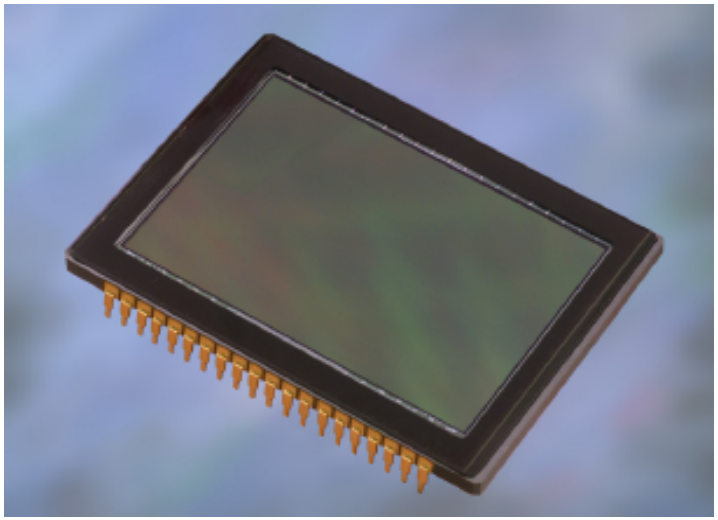


- BLUE 400-450 nm • RED 550-700 nm

Satellite Design: Instrument Detector

CCD : KODAK KA11002

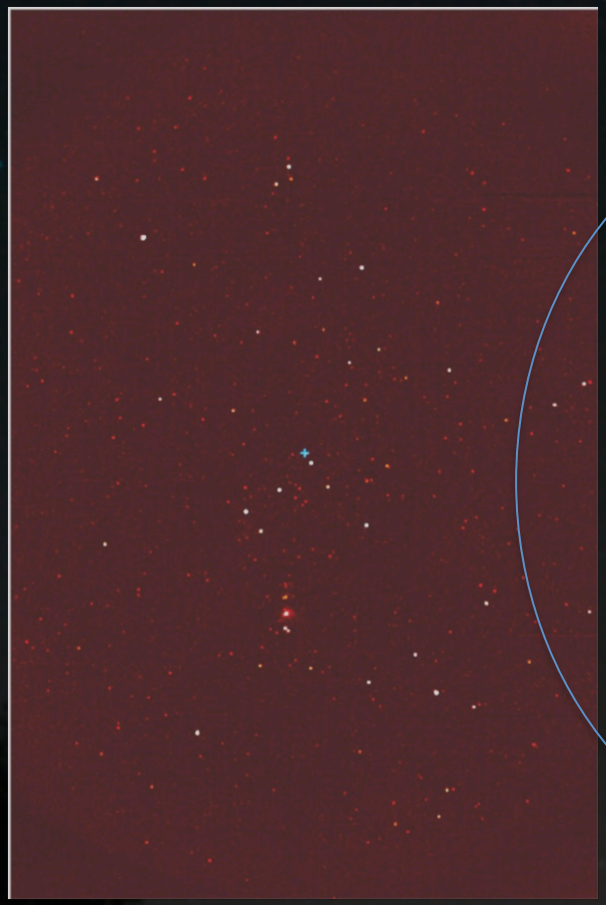




\+ good performance at high temperature (+10 to +30C)
no cooling system is required, low power consumption
very reasonable price

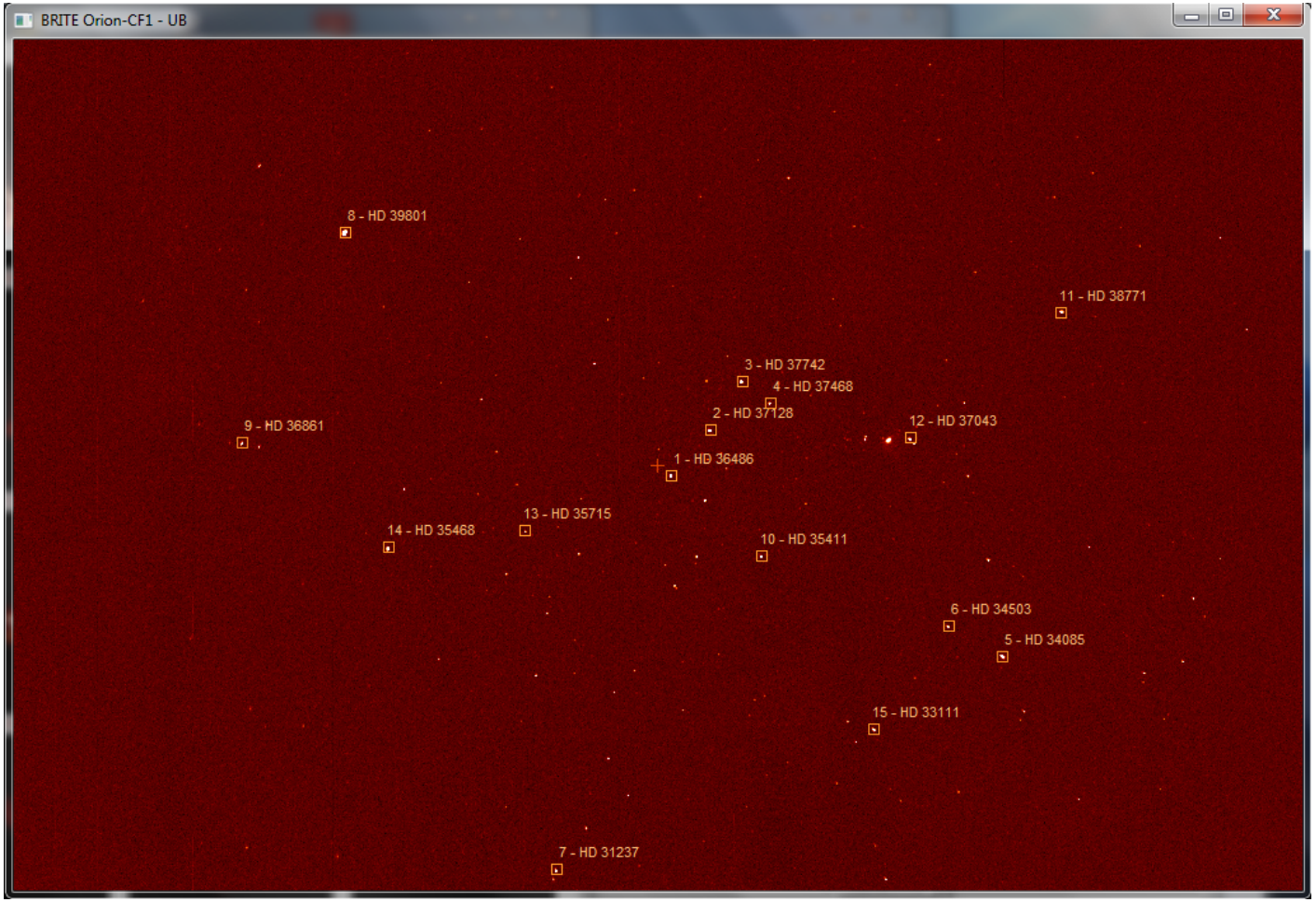
− **does not “like” low earth orbit radiation environment!**

Field of View
~ 24 deg



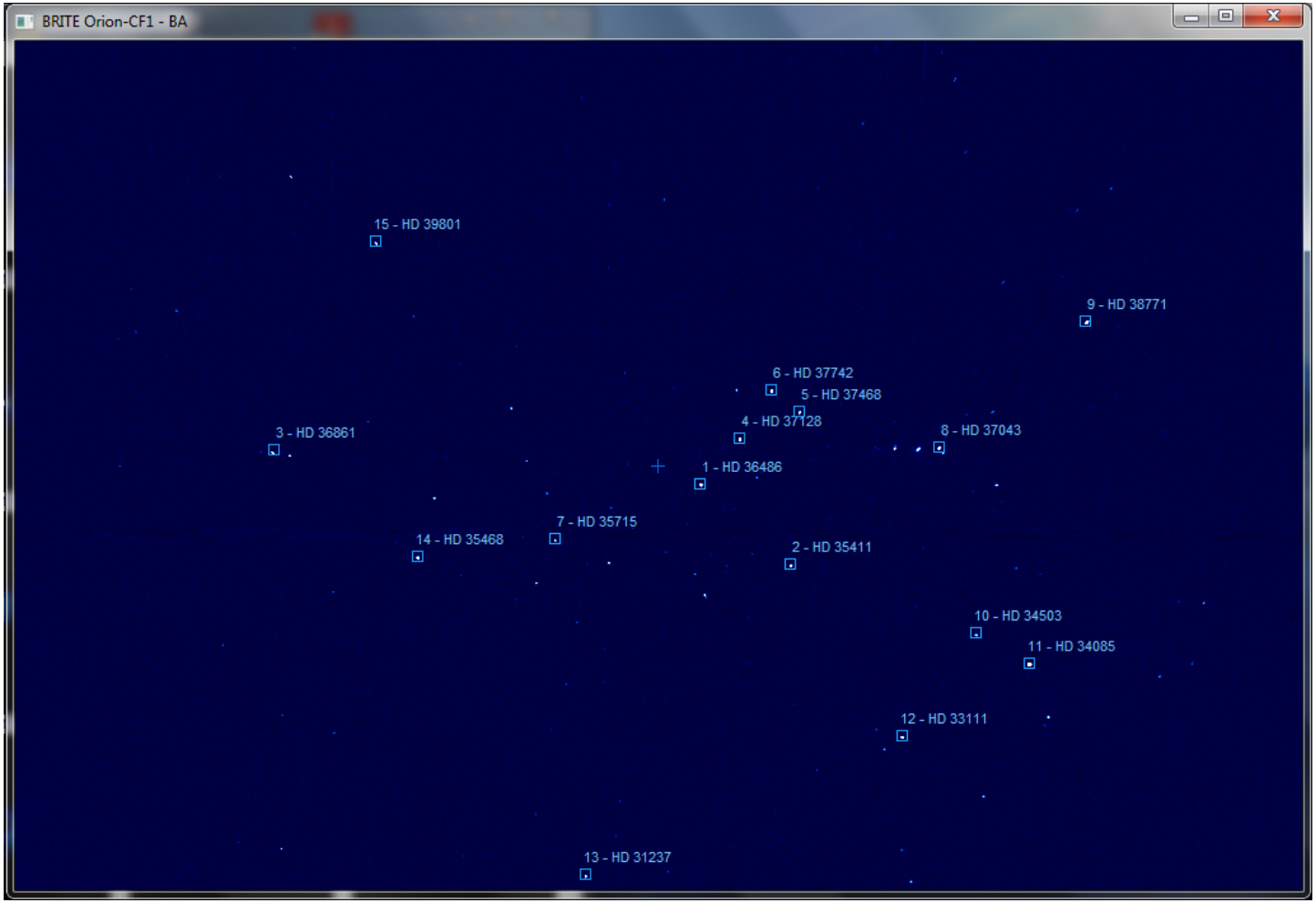
Satellite Design: Instrument Field of View

Orion red

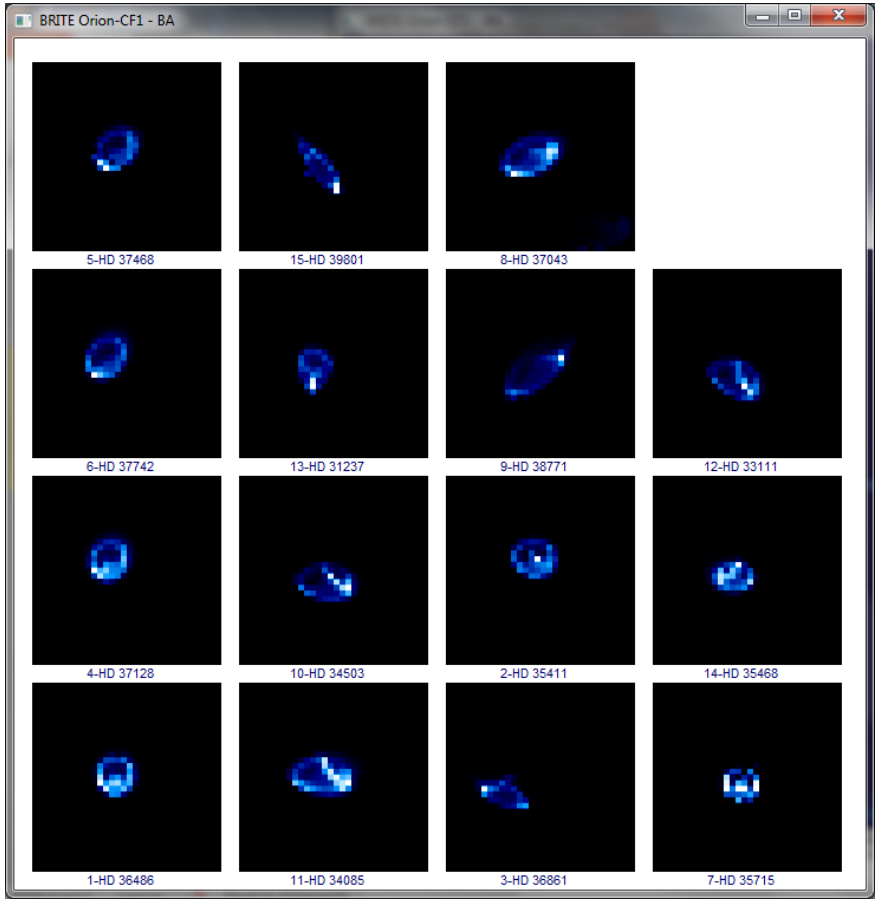


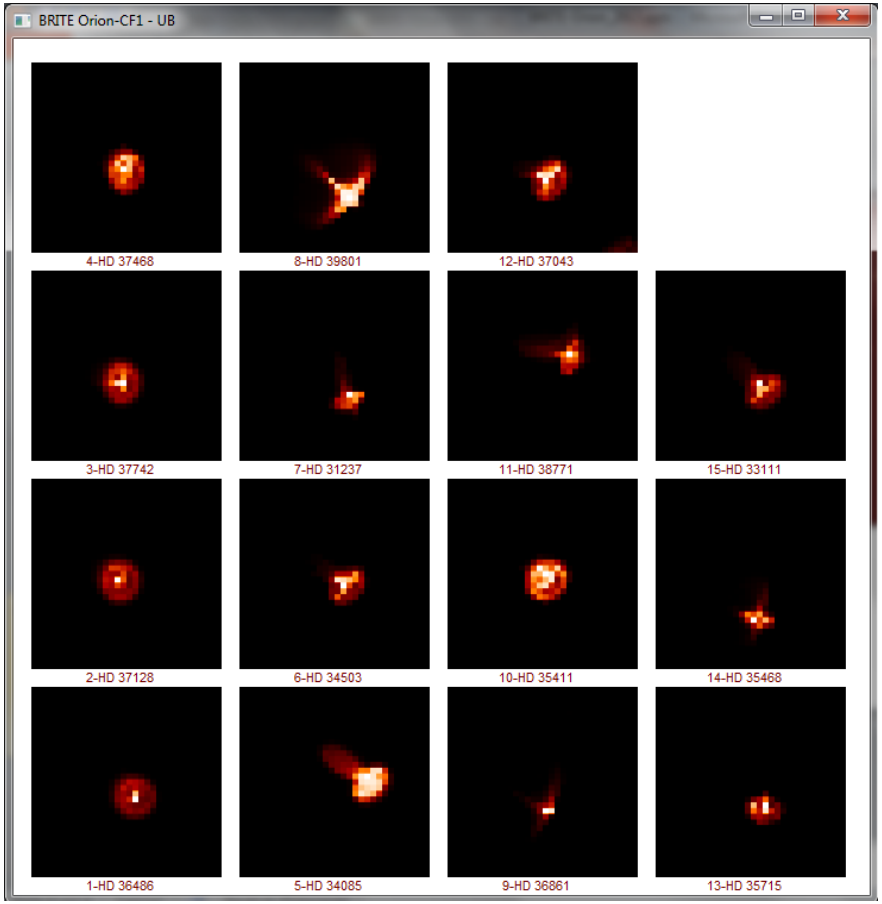
Satellite Design: Instrument Field of View

Orion blue



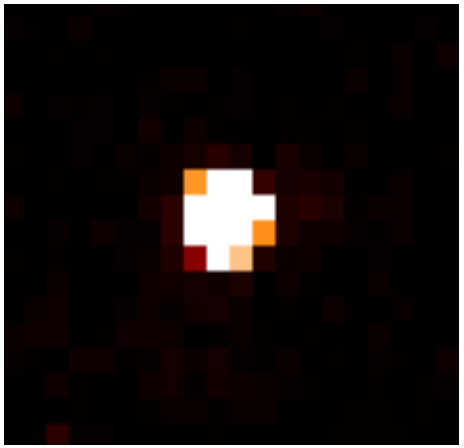
Satellite Design: Instrument Imaging

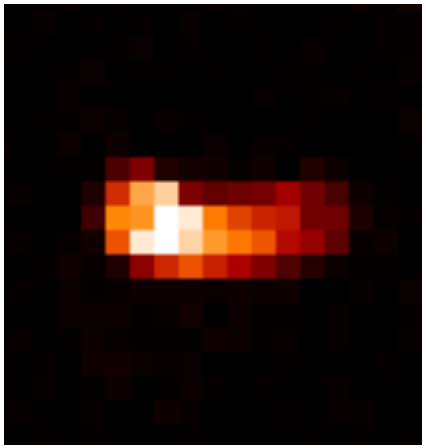




Satellite Design: Attitude Control System

- is the most important subsystem and only if that works to required limits then the measurement can be of scientific quality
- we need to keep the instruments while observing looking at the same orientation on the sky at the level 1.5 arcmin (rms) – 1 pixel ~ 30 arcsec

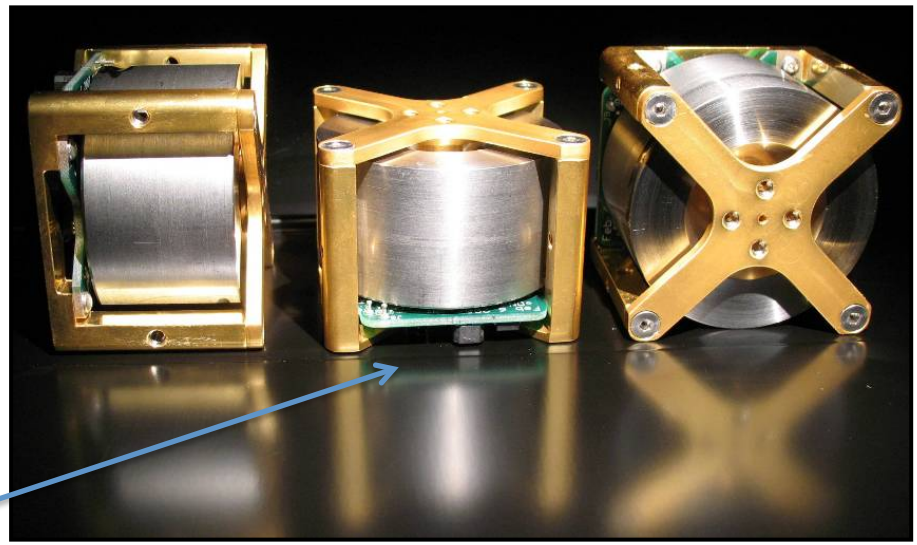




Satellite Design: Attitude Control System

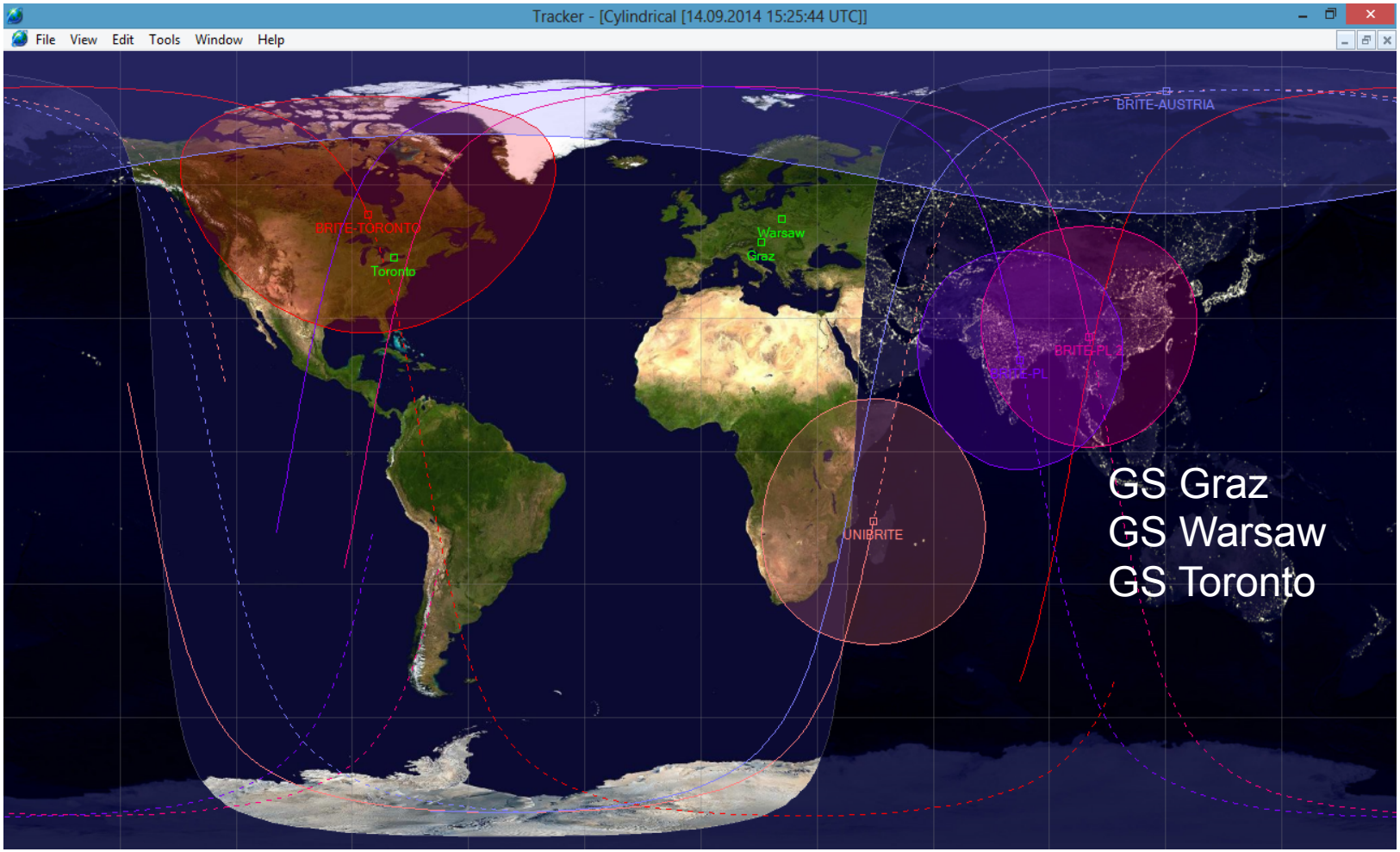
- Sunsensors
- Magnetometers
- Startracker

- Magnetorquers
- Reactionwheels

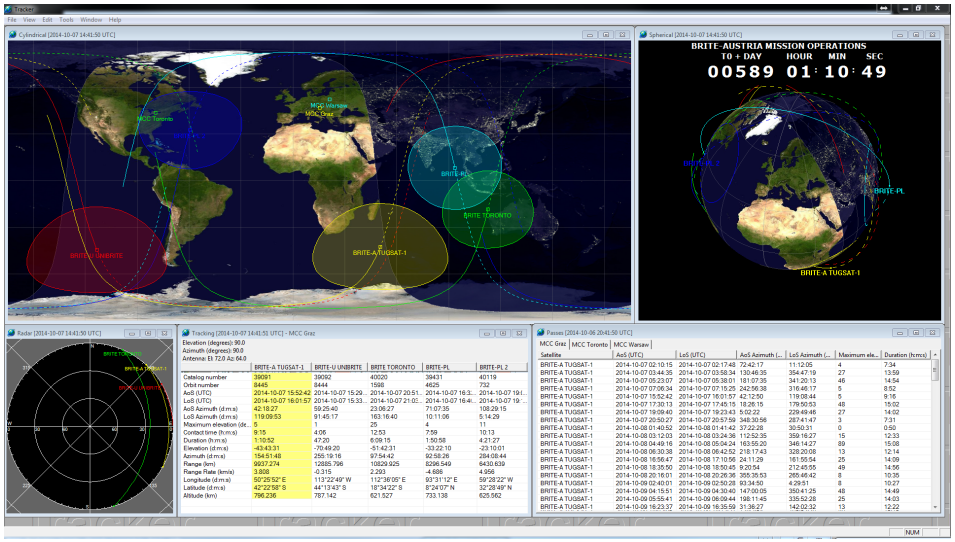


+ Computer and Control Software

Satellites Orbits: 98 -100min Period ~27,000 km/h



BRITE-Austria Ground Station @ TU Graz

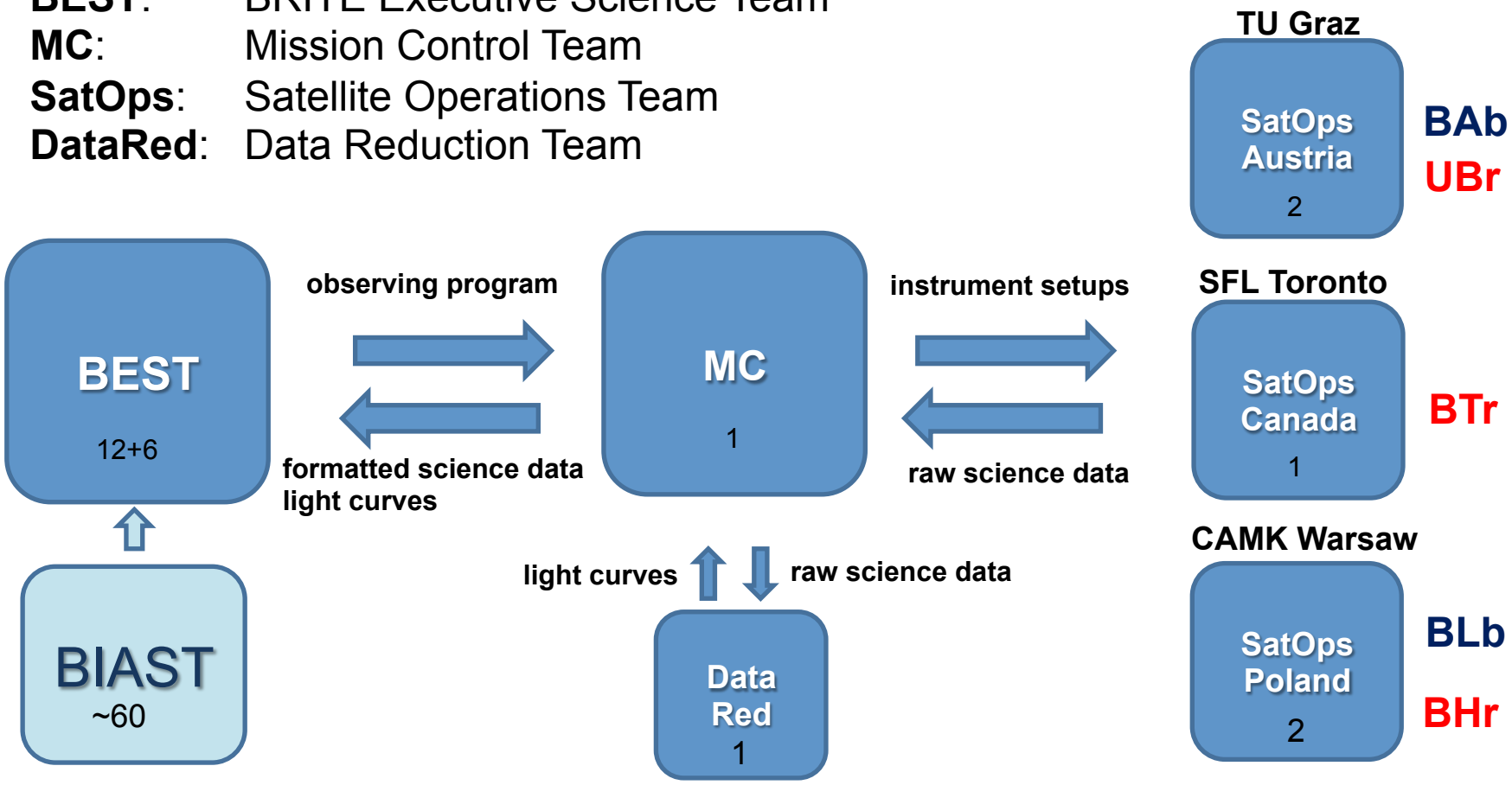


BRITE Ground Station Requirements

- Professional ground segment approach
- Integration in a ground station network
- Tracking (LEO), 6 contacts/day of 10-15min/each
- High performance for nanosatellites
  - 2-10 Mbyte / day .... typical between16-20 Mbyte / day
  - Data rate: 32 kbit/s
- High reliability
  - Data integrity and raw data storage

Mission Organization

BEST: BRITE Executive Science Team
MC: Mission Control Team
SatOps: Satellite Operations Team
DataRed: Data Reduction Team



BIAST: BRITE International Advisory Science Team

BRITE: Target Stars – Observing Field Selection

BEST/BIAST

- 58 proposals have been submitted
- 26 PI's and their teams from 16 countries

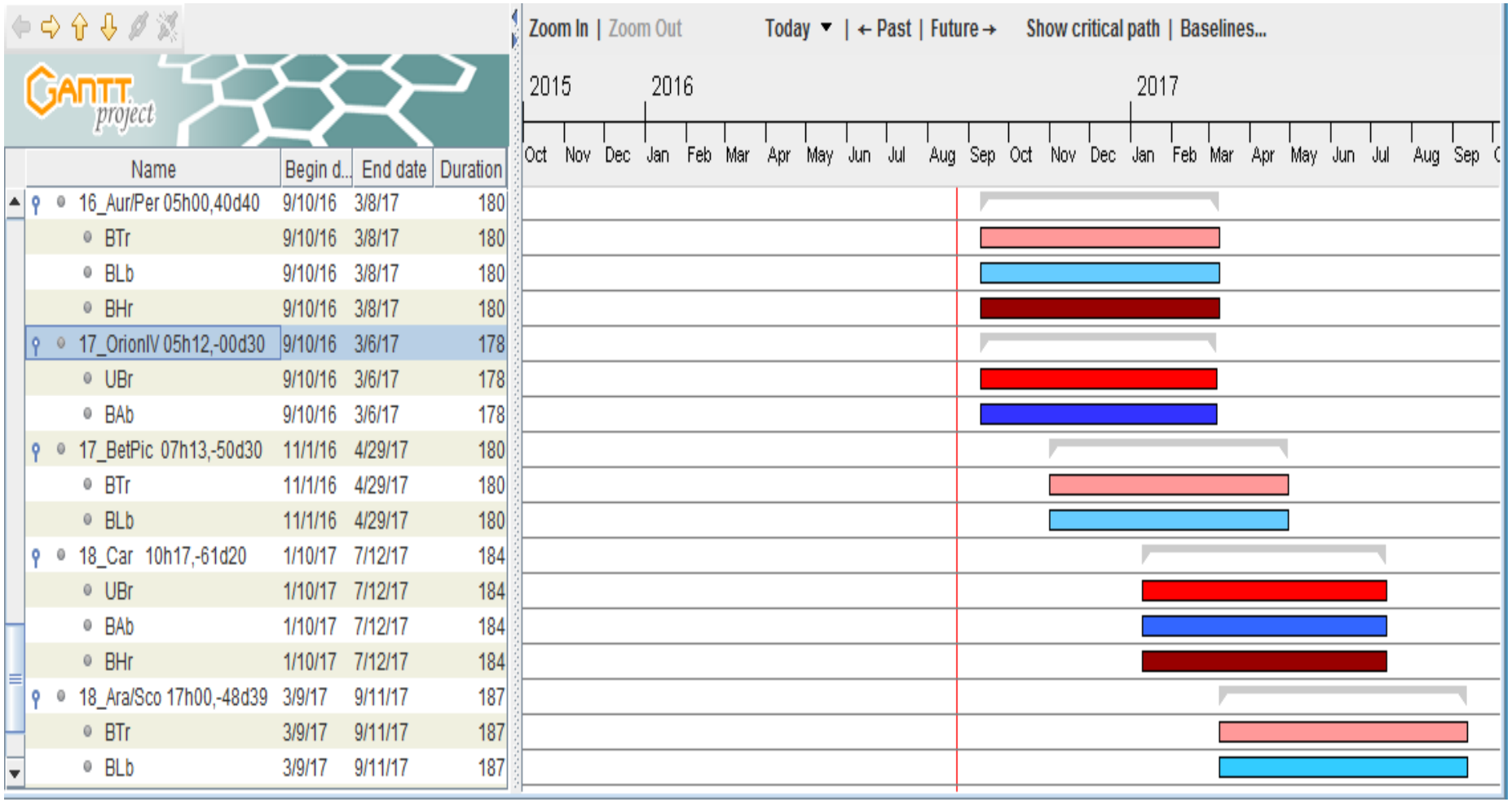
BRITE TARGET STAR CATALOG: 6654 entries

- <= 6 mag(V) with a priority targets <= 4.5 mag(V)
- many multiple nominations up 7 PI for one star

BEST desides which fields are observed about 12 month before the observations are scheduled (GB support)

OBSERVING PLAN posted on WIKI Site

BRITE Constellation Observing Schedule



OBSERVING PLAN posted on WIKI Site

field name

Vel/Pup

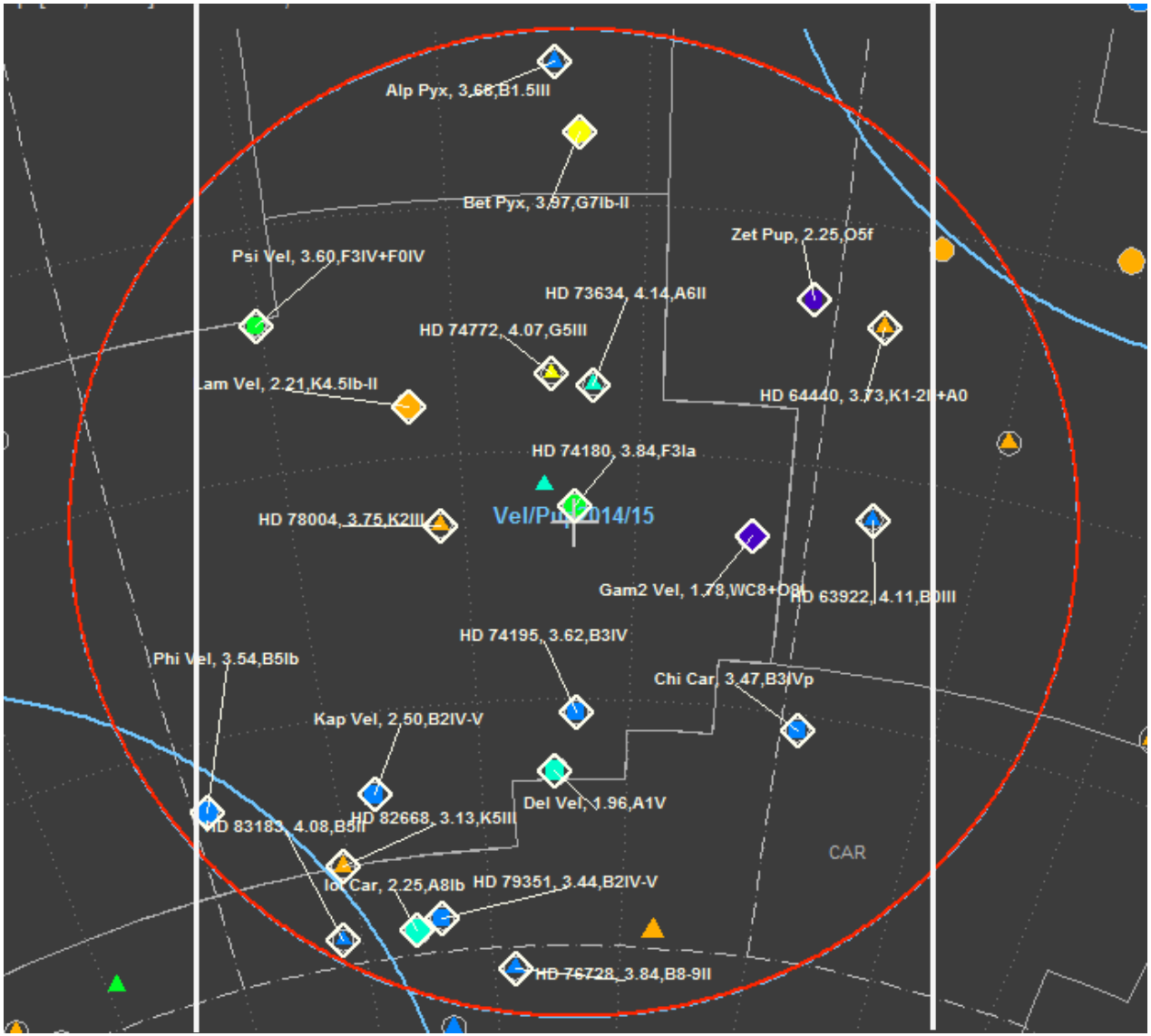
centre coordinates, roll angle

RA 08 40 00 DEC -47 30 00 Roll 0

dates/ status/ sats

1 Dec 2014 - 28 May 2015
planned/BTr-BAb

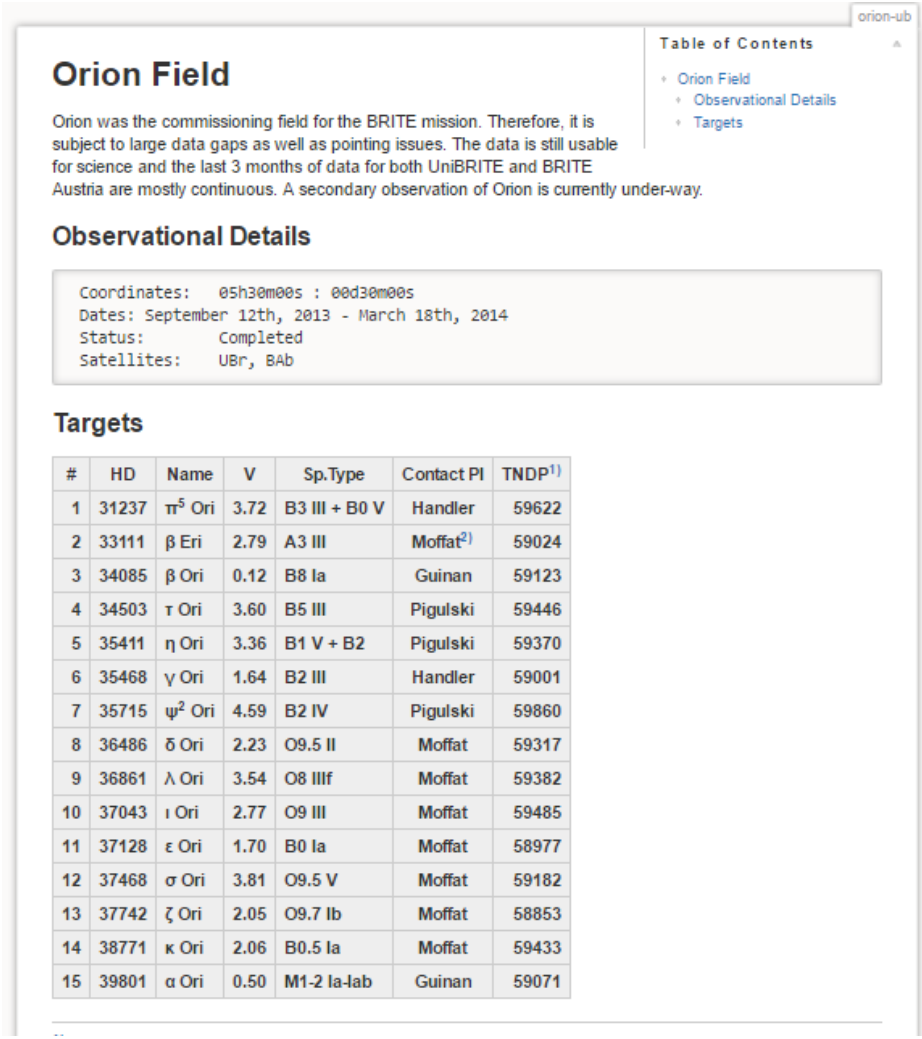
sky view / CCD fov



stars 22

HD#	ID	V	Sp	nP
HD 76728		3.84	B8-9II	2
HD 79351		3.44	B2IV-V	3
HD 80404	Iot Car	2.25	A8Ib	1
HD 83183		4.08	B5II	2
HD 82668		3.13	K5III	2
HD 81188	Kap Vel	2.5	B2IV-V	4
HD 86440	Phi Vel	3.54	B5Ib	3
HD 74956	Del Vel	1.96	A1V	1
HD 65575	Chi Car	3.47	B3IVp	4
HD 74195		3.62	B3IV	3
HD 68273	Gam2 Vel	1.78	WC8+O9I	2
HD 63922		4.11	B0III	3
HD 64440		3.73	K1-2II+A0	1
HD 66811	Zet Pup	2.25	O5f	4
HD 74180		3.84	F3Ia	1
HD 73634		4.14	A6II	1
HD 74772		4.07	G5III	1
HD 78004		3.75	K2III	1
HD 78647	Lam Vel	2.21	K4.5Ib-II	1
HD 82434	Psi Vel	3.6	F3IV+F0IV	2
HD 74006	Bet Pyx	3.97	G7Ib-II	2
HD 74575	Alp Pyx	3.68	B1.5III	3

BRITE Post/Present/Pre-Observation Info:



orion-ub

Orion Field

Table of Contents
- Orion Field
  - Observational Details
  - Targets

Orion was the commissioning field for the BRITE mission. Therefore, it is subject to large data gaps as well as pointing issues. The data is still usable for science and the last 3 months of data for both UniBRITE and BRITE Austria are mostly continuous. A secondary observation of Orion is currently under-way.

Observational Details

```
Coordinates:   05h30m00s : 00d30m00s
Dates: September 12th, 2013 - March 18th, 2014
Status:        Completed
Satellites:    UBr, BAb
```

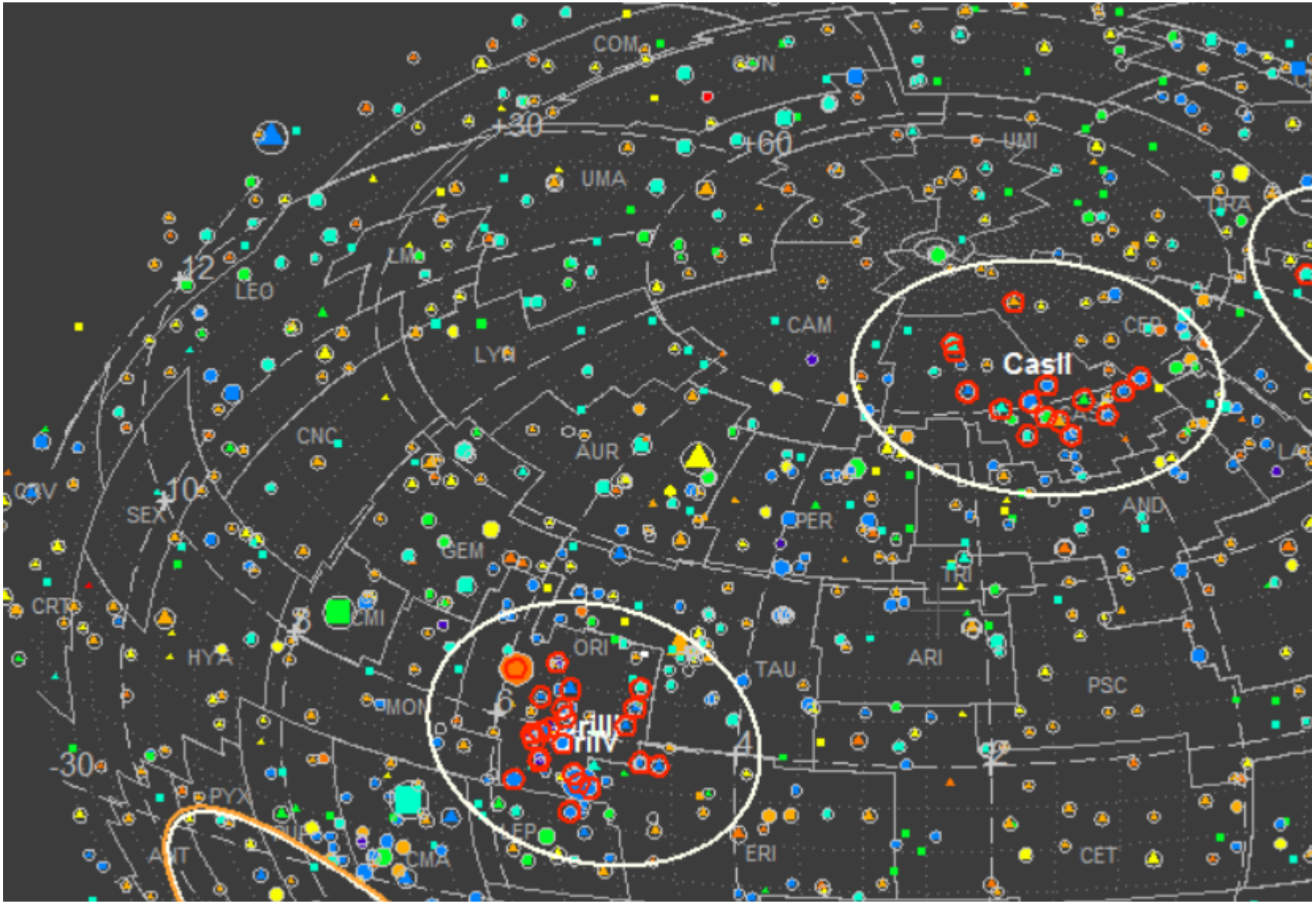
Targets

#	HD	Name	V	Sp.Type	Contact PI	TNDP[1)]
1	31237	π^5 Ori	3.72	B3 III + B0 V	Handler	59622
2	33111	β Eri	2.79	A3 III	Moffat[2)]	59024
3	34085	β Ori	0.12	B8 Ia	Guinan	59123
4	34503	τ Ori	3.60	B5 III	Pigulski	59446
5	35411	η Ori	3.36	B1 V + B2	Pigulski	59370
6	35468	γ Ori	1.64	B2 III	Handler	59001
7	35715	ψ^2 Ori	4.59	B2 IV	Pigulski	59860
8	36486	δ Ori	2.23	O9.5 II	Moffat	59317
9	36861	λ Ori	3.54	O8 IIIf	Moffat	59382
10	37043	ι Ori	2.77	O9 III	Moffat	59485
11	37128	ε Ori	1.70	B0 Ia	Moffat	58977
12	37468	σ Ori	3.81	O9.5 V	Moffat	59182
13	37742	ζ Ori	2.05	O9.7 Ib	Moffat	58853
14	38771	κ Ori	2.06	B0.5 Ia	Moffat	59433
15	39801	α Ori	0.50	M1-2 Ia-Iab	Guinan	59071

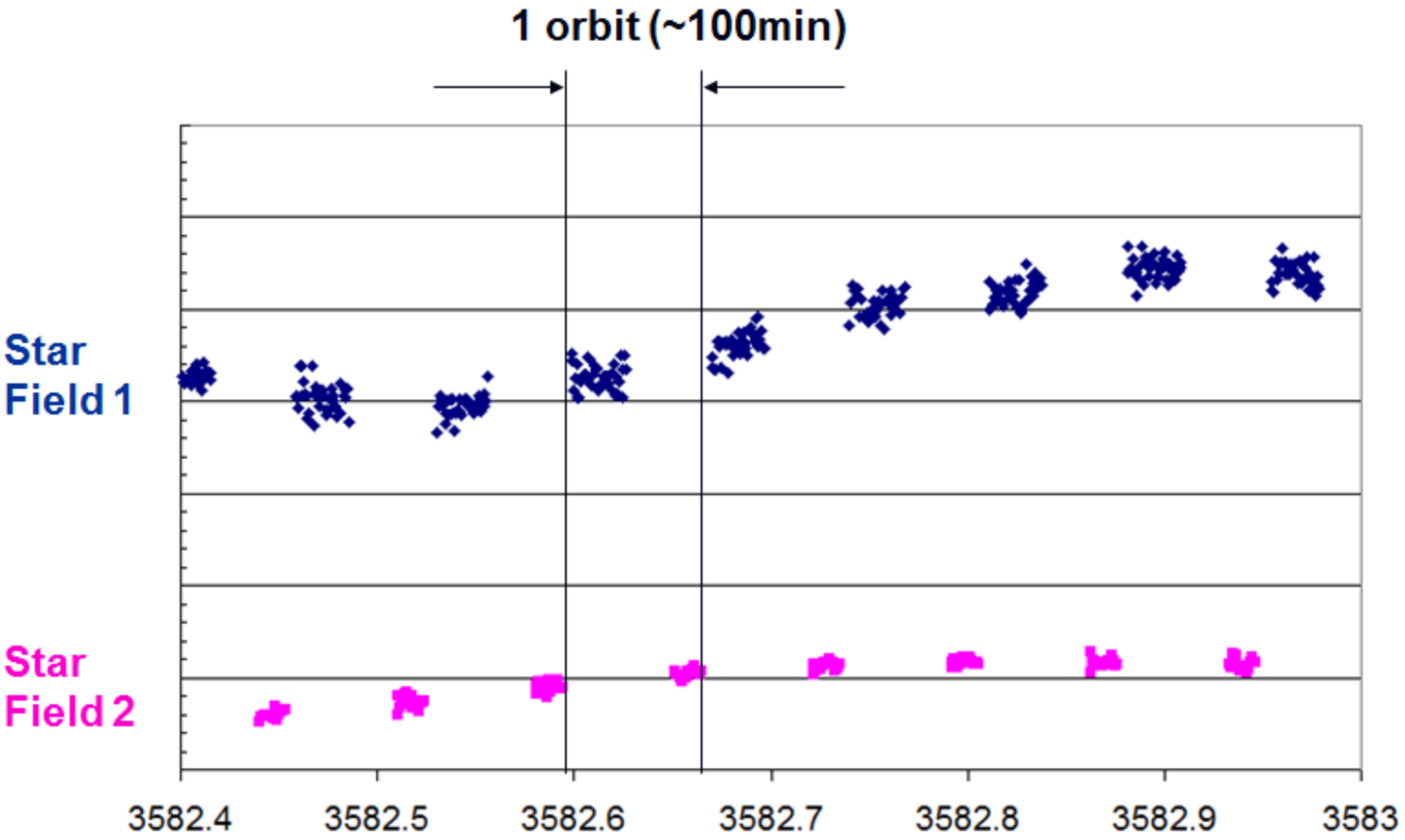
details on WIKI site:
http://brite.craq-astro.ca/doku.php

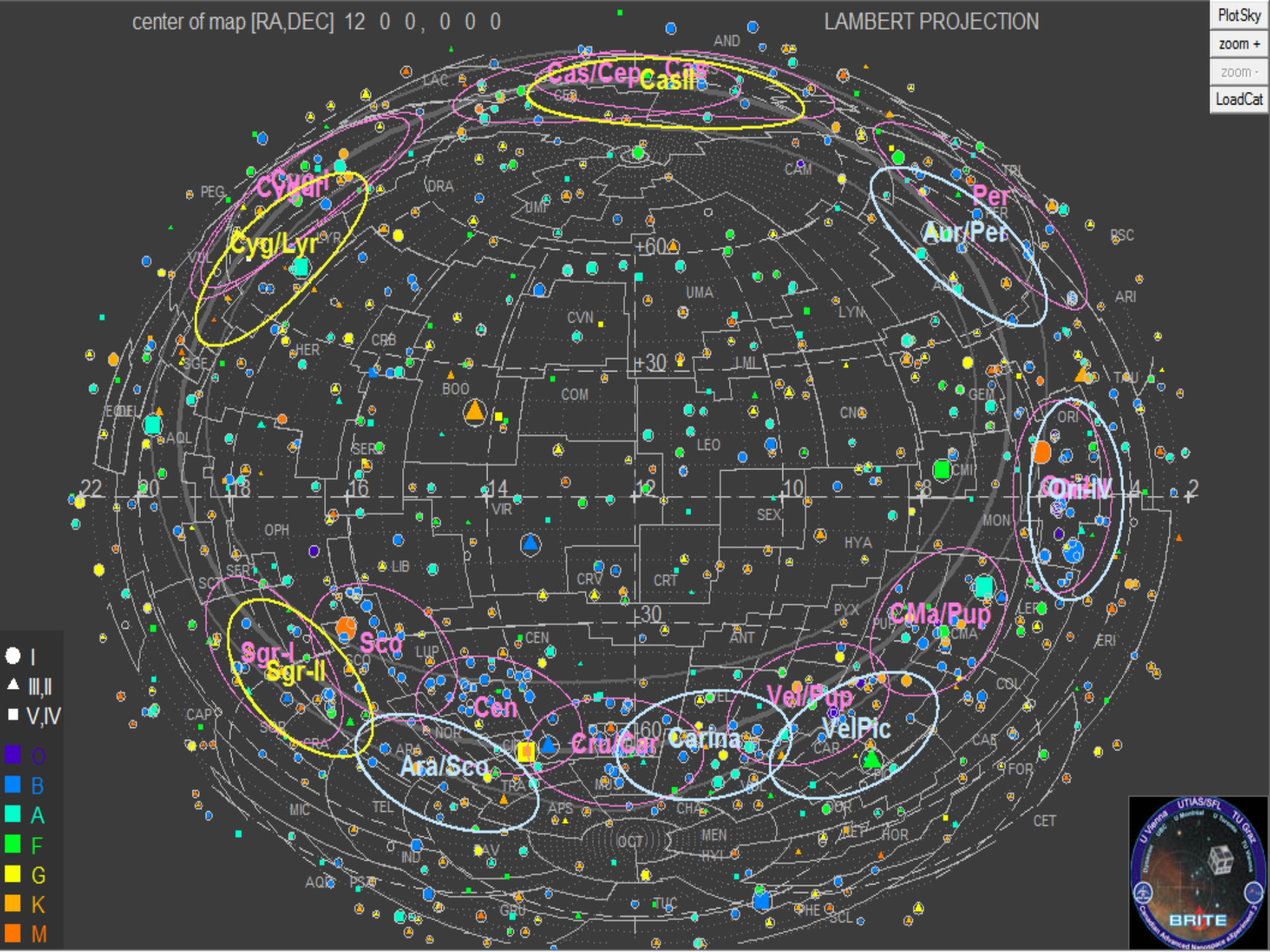
- **observation period**
- **field centre coordinates**
- **stars information**
- **assigned satellites**
- **Principle Investigator(s)**
- **contact PI (if yet elected)**

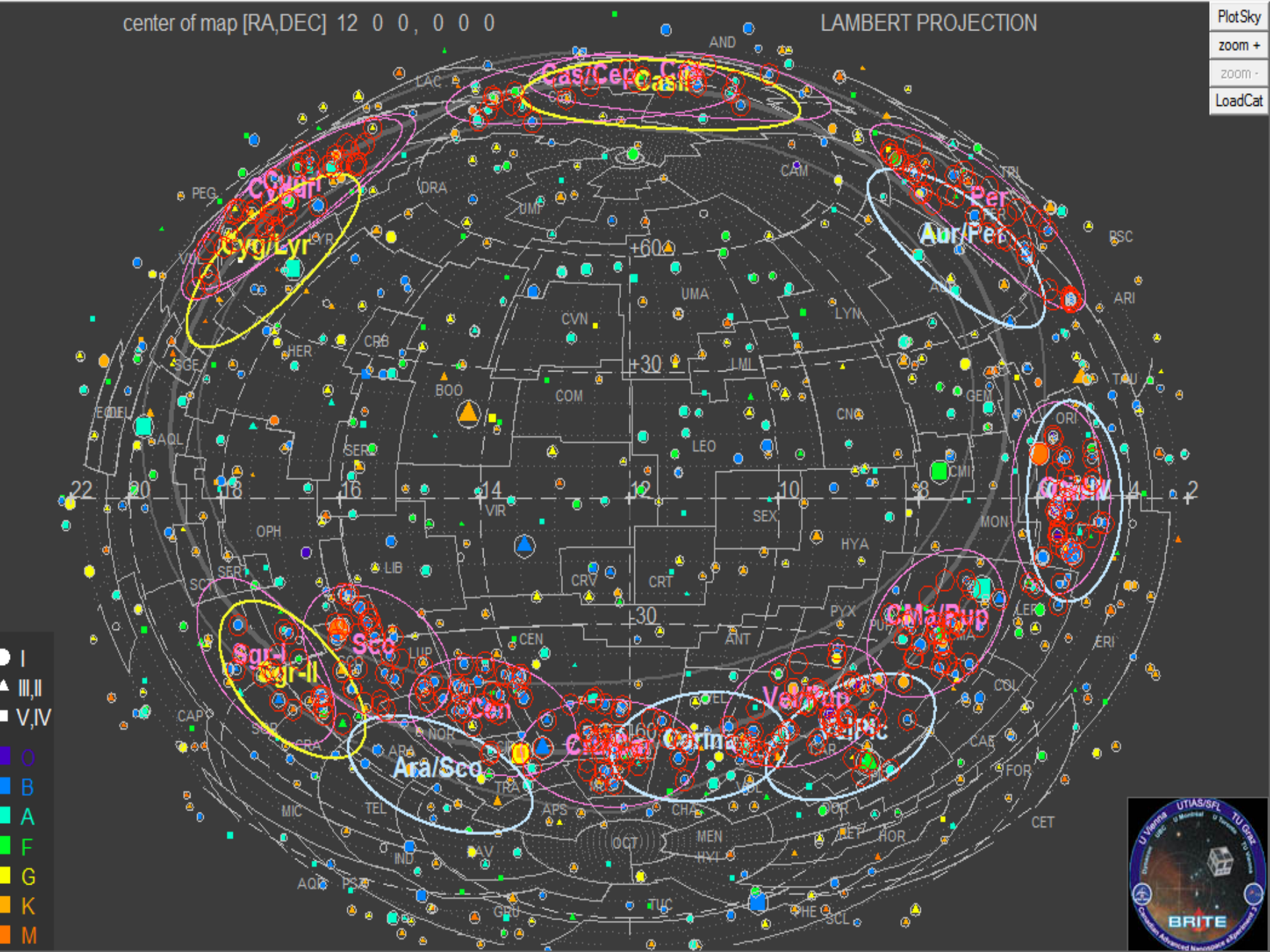
BRITE increasing efficiency: COMBINING TWO FIELDS



BRITE increasing efficiency: COMBINING TWO FIELDS




center of map [RA,DEC] 12 0 0 , 0 0 0
LAMBERT PROJECTION
PlotSky
zoom +
zoom -
LoadCat
Cas/Cep
Cas II
Cyg I
Cyg/Lyr
Per
Aur/Pet
Ori I
Ori IV
CMa/Pup
Vel/Pup
Vel Pic
Carina
Cru/Car
Cen
Ara/Sco
Sco
Sgr-I
Sgr-II
I
III,II
V,IV
O
B
A
F
G
K
M
BRITE


center of map [RA,DEC] 12 0 0 , 0 0 0
LAMBERT PROJECTION
Plot Sky
zoom +
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Cas/Cep
Cyg/Lyr
Per
Aur/Peg
Sgr-I
Sgr-II
Sco
Ara/Sco
Carina
Vel/Pup
CMa/Pup
Orion
+60
+30
-30
22
20
18
16
14
12
10
8
6
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III,II
V,IV
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K
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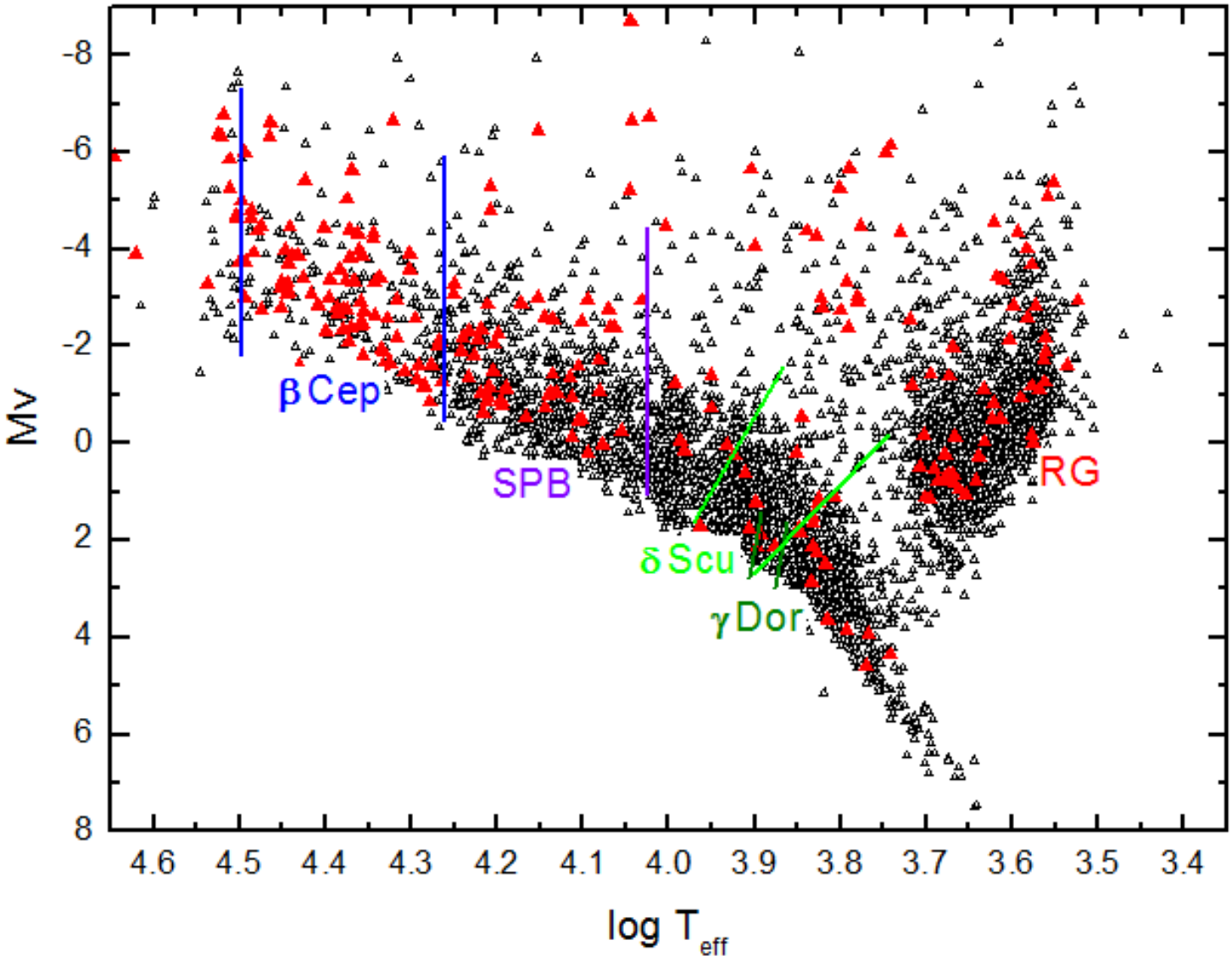
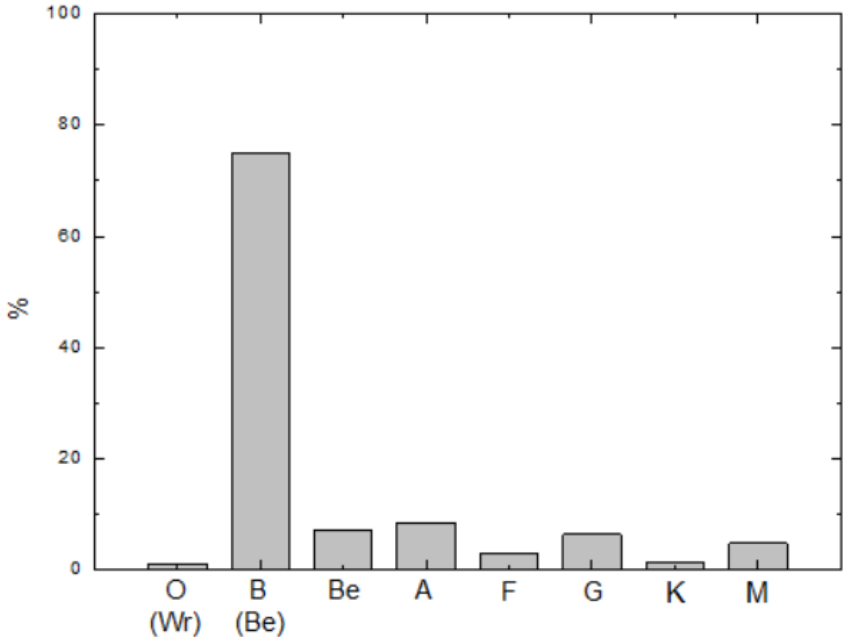
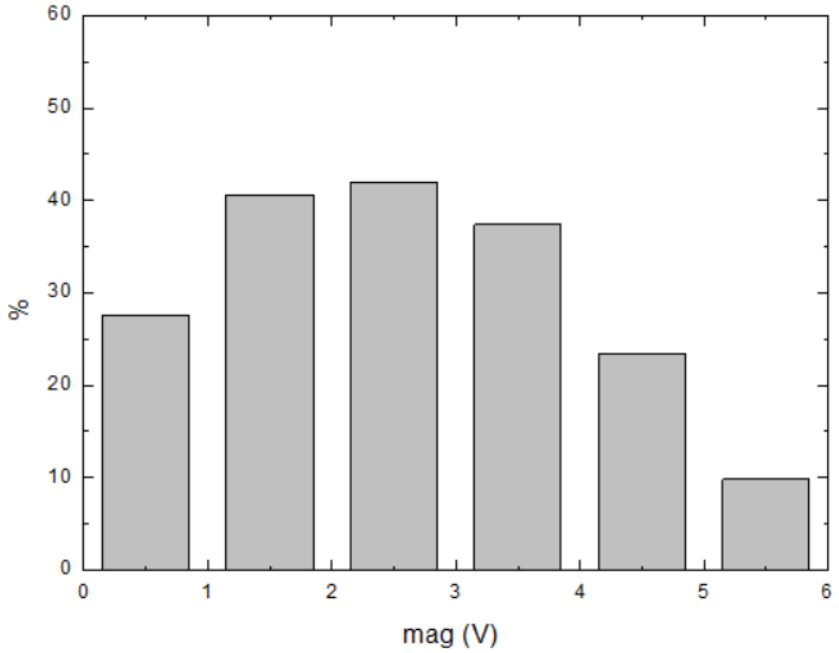
BRITE

BRITE HRD Coverage To Date



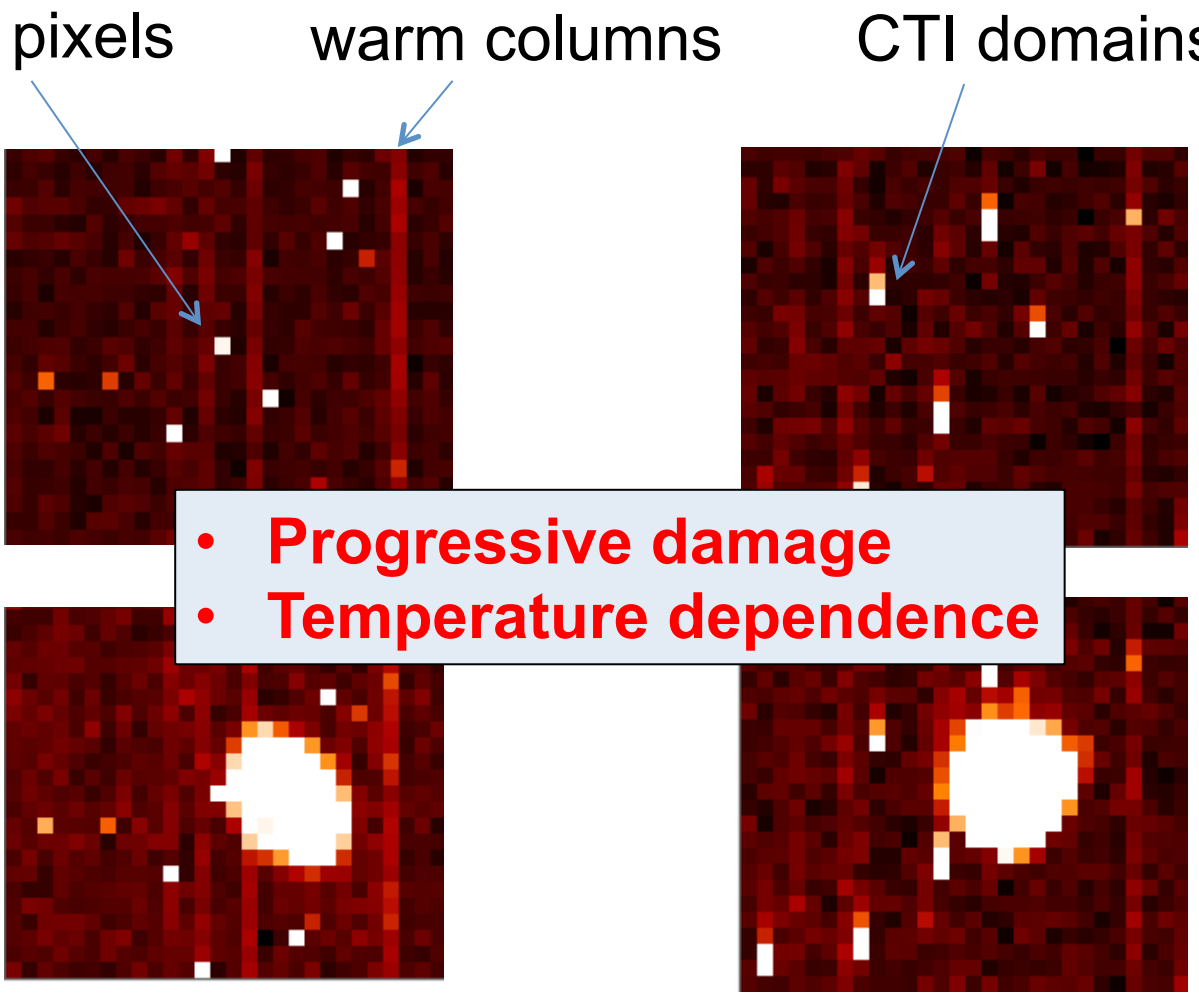
BRITE target stars statistics



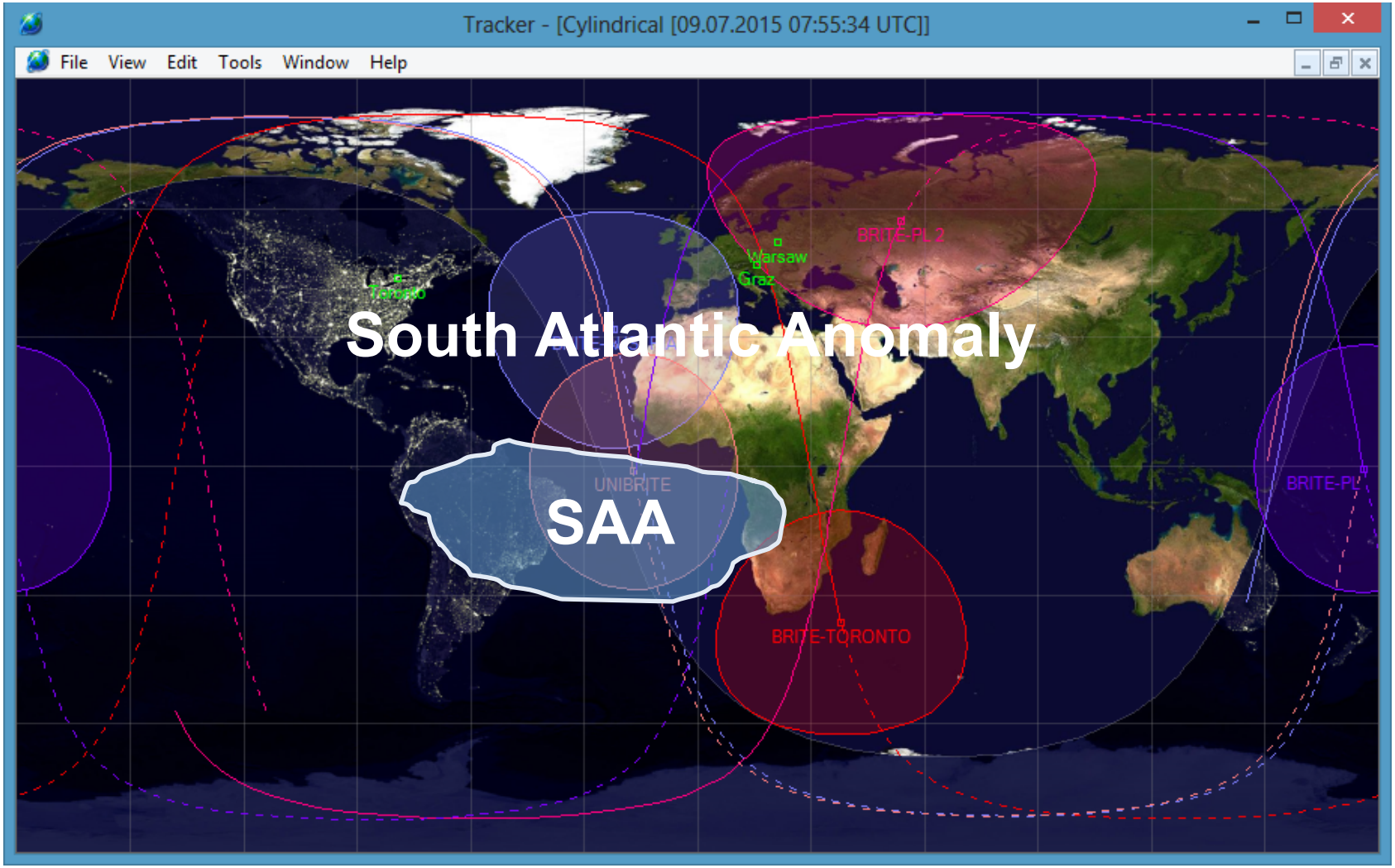


> 500 stars have been observed some 60 multiple times

Main Issue: Radiation Damage

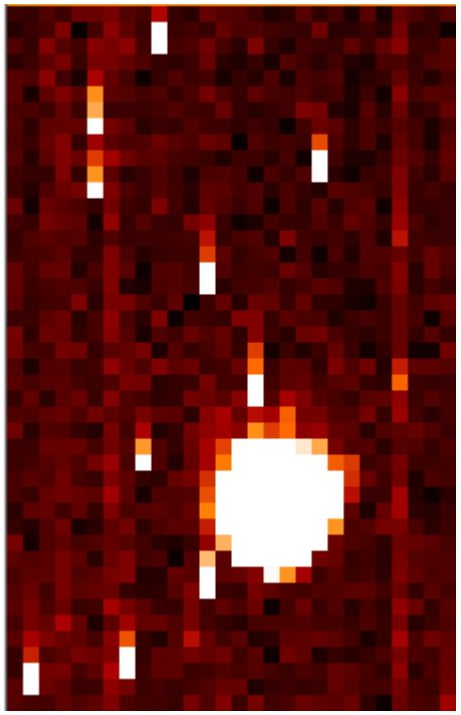


Main Issue: Radiation Damage - SAA



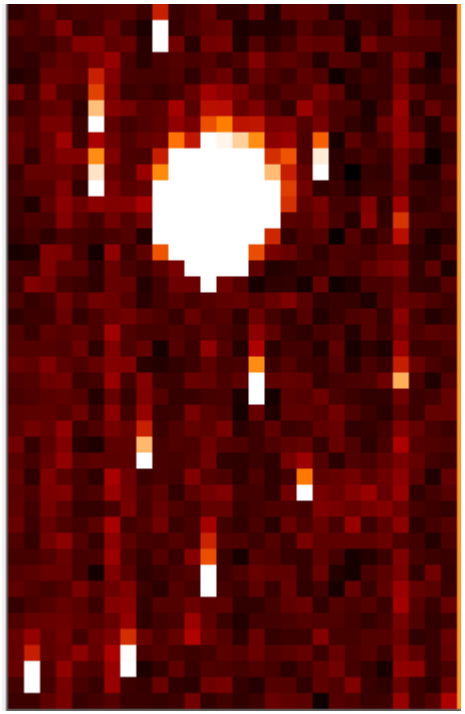
Observing Strategy (since fall 2014) “Chopping”
CTI effects were mitigated with longer charge transfer time

“image n”

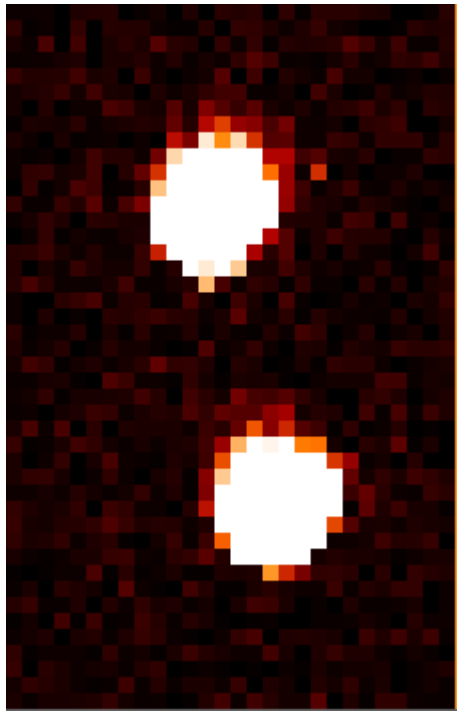


0.15 °

“ image n+1”

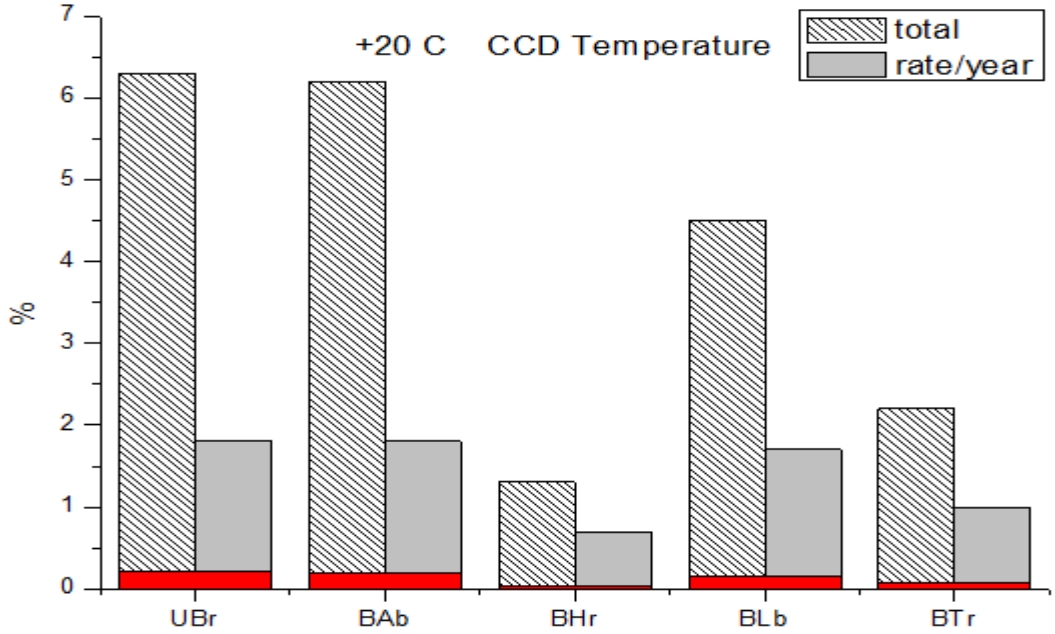


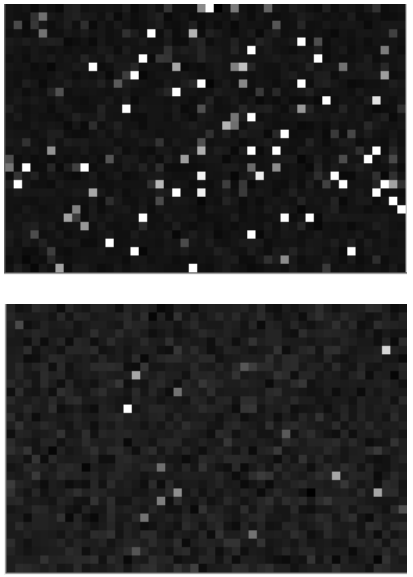
“abs((n+1)-n)”



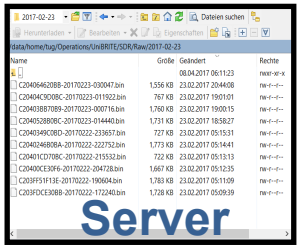
Satellite Hot Pixel Stats

Country	Satellite Name	ID	in orbit[y]	sci ops[y]	hpix[%]	hpix/y[%]	rpix/chop[%]
AUT	UniBRITE	UBr	3.5	2.7	6.3	1.8	0.21
AUT	BRITE-Austria	BAb	3.5	2.7	6.2	1.8	0.20
POL	Heweliusz	BHr	2.0	1.8	1.3	0.7	0.04
POL	Lem	BLb	2.7	2.2	4.5	1.7	0.15
CAN	Toronto	BTr	2.2	2.2	2.2	1.0	0.07





BRITE Data Processing: RAW DATA – PHOTOMETRIC DATA



sftp

WOD Sience Data

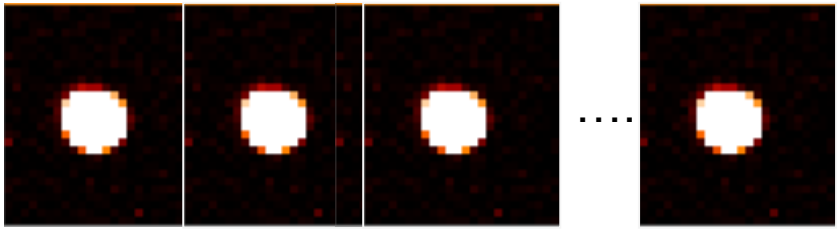
BRITE_Chop

Sience Data Record

BRITE_Data

images/stars

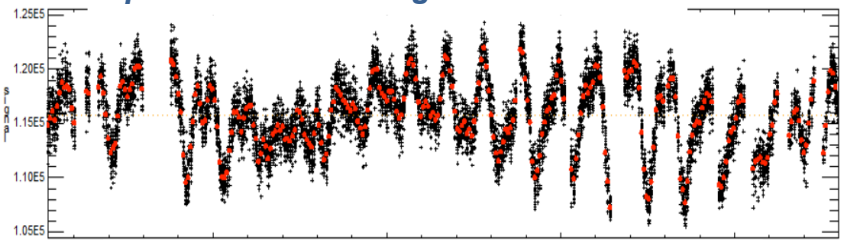
FITS Files



BRITE_Analysis

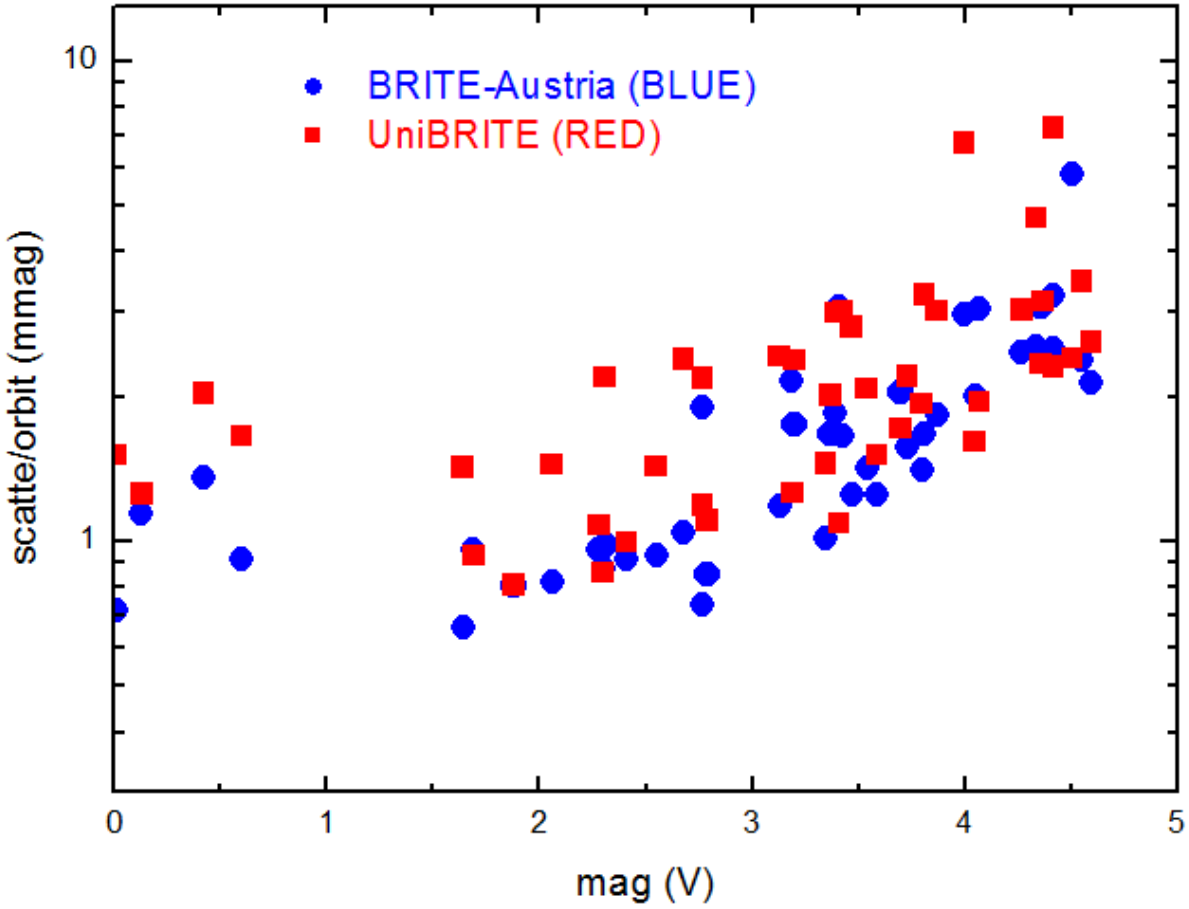
photometric data/light curves

Light Curves

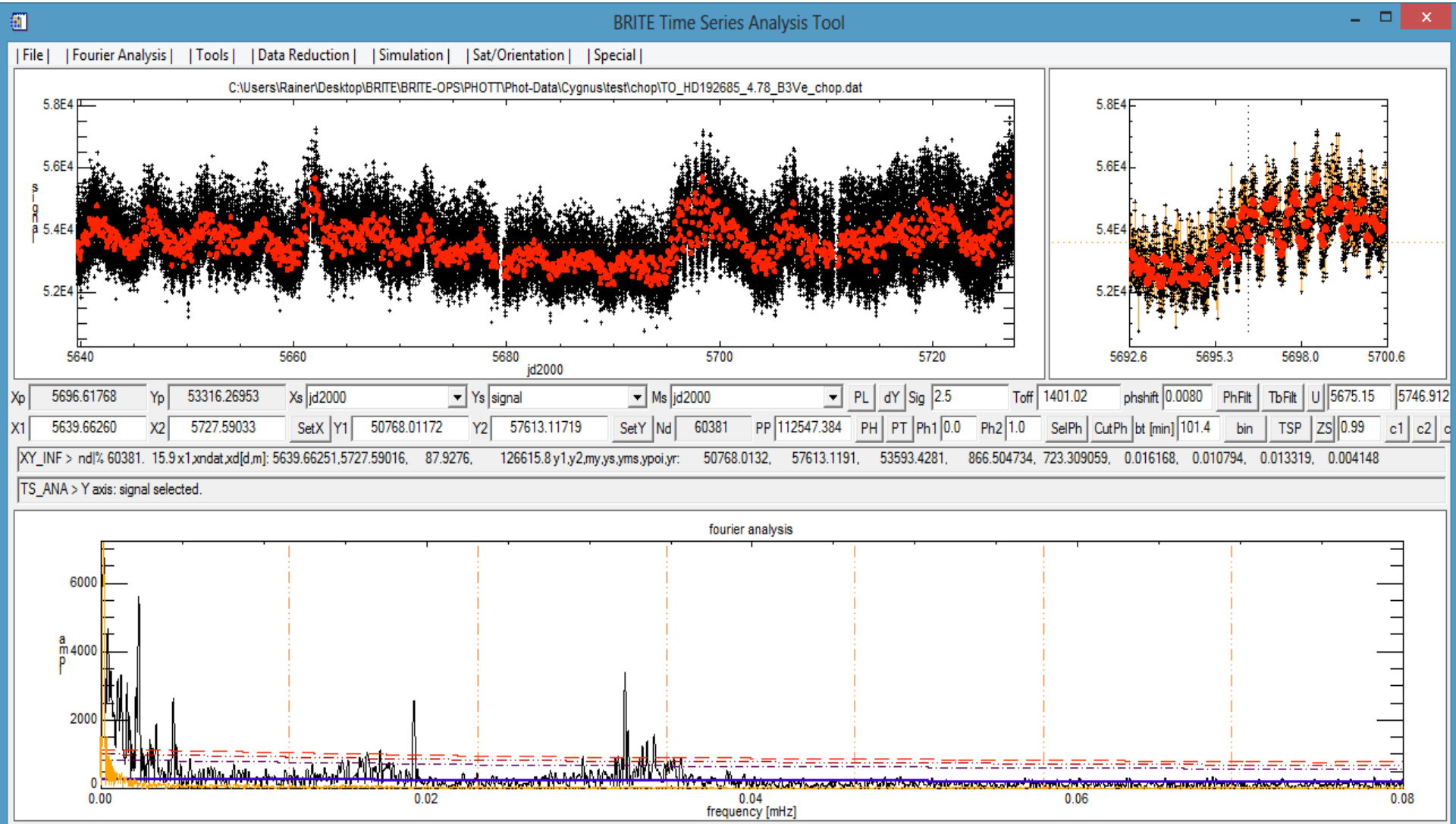


x: time, y: brightness

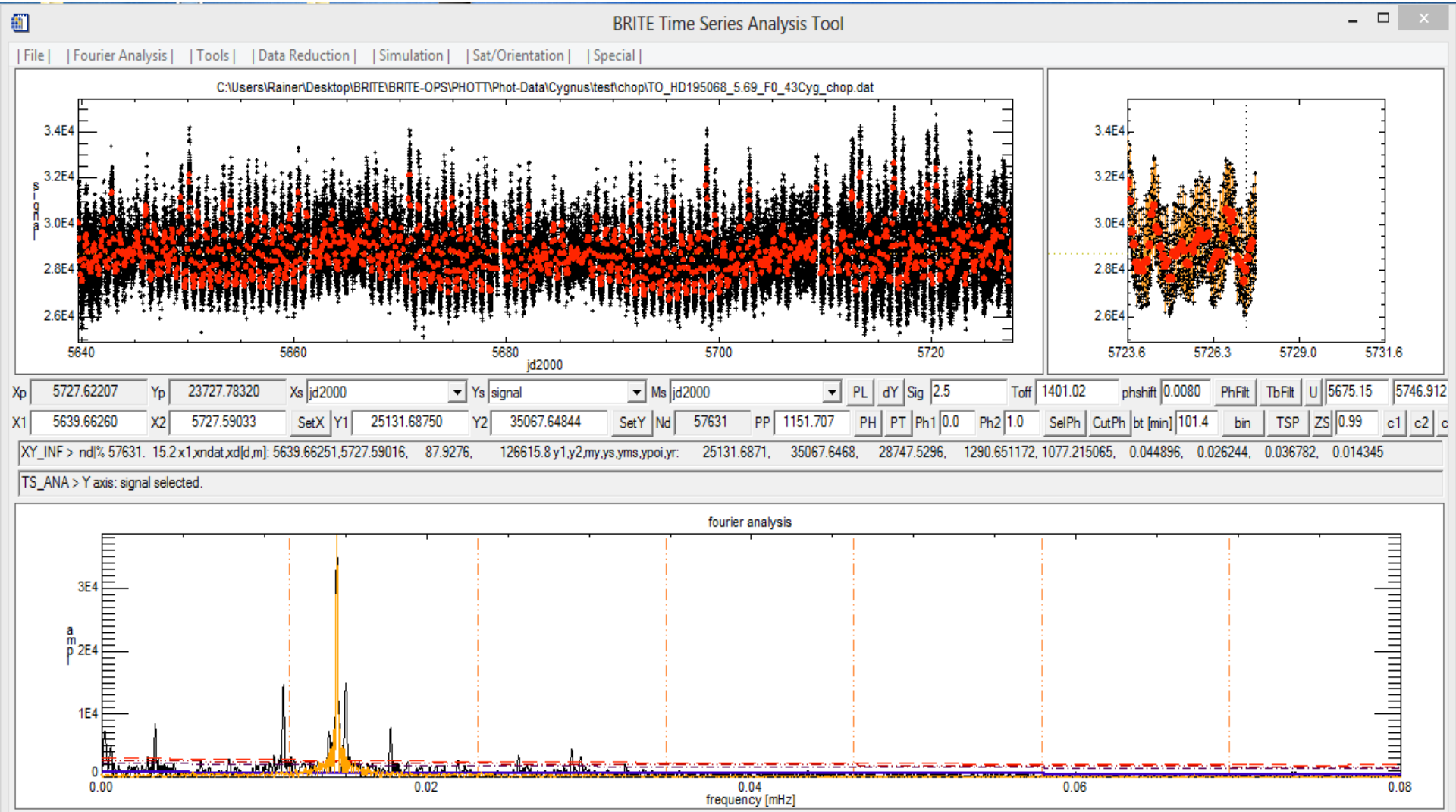
BRITE Photometry Performance



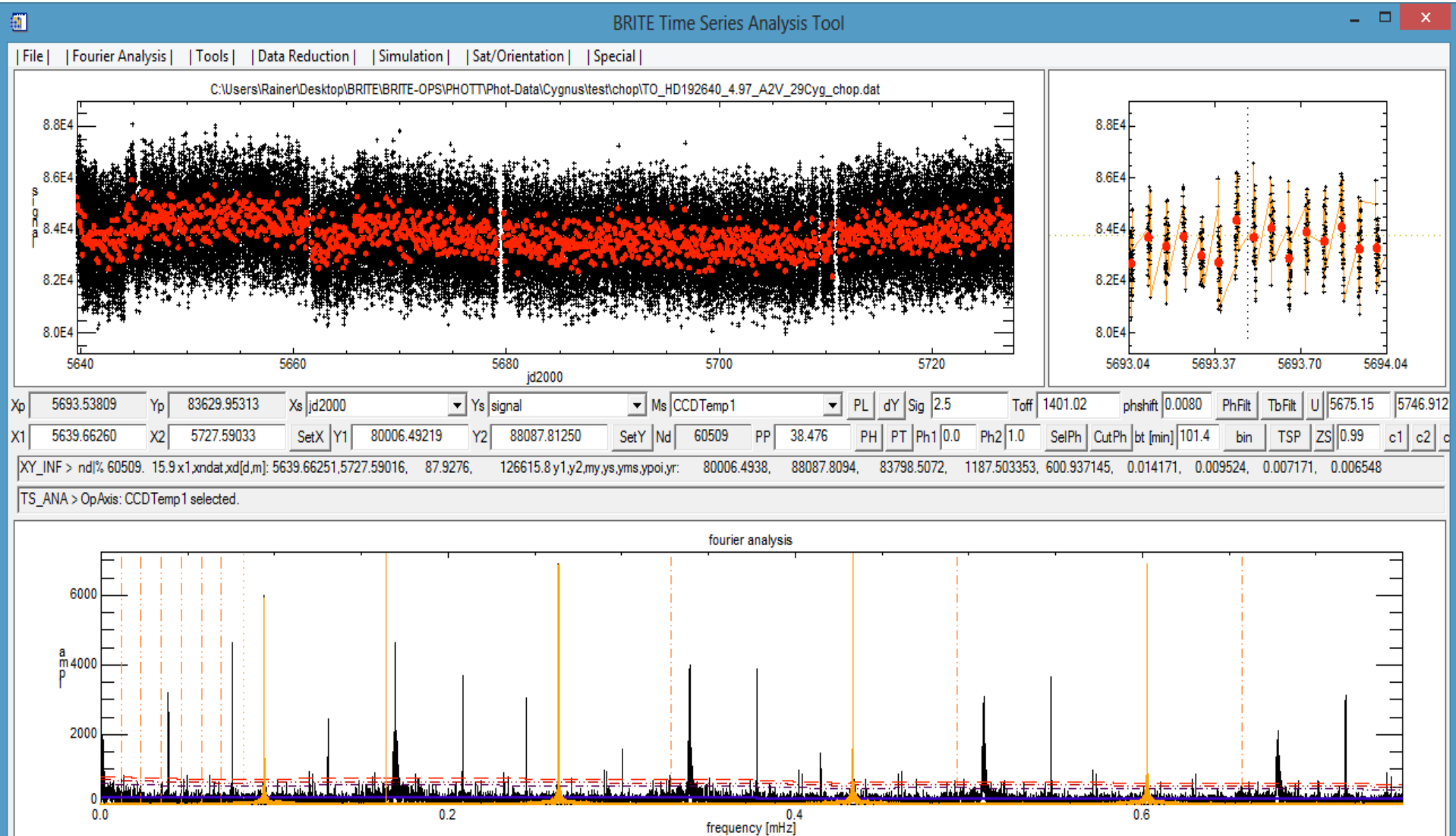
HD192685 mag(V)=4.78 B3Ve



43 Cyg mag(V)=5.69 F0



29 Cyg mag(V)=4.97 A2V

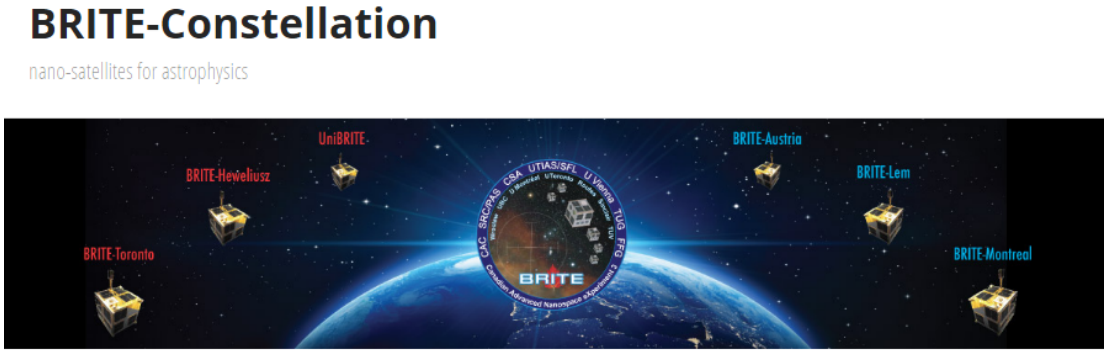


Status Summary and Outlook

- BRITE-Constellation is operating since Feb. 2013
- 5 satellites are collecting data every day
- >500 stars in 23 campaigns almost 3 million images have been collected ... and counting
- data reduction and de-correlation is a complex task
- chopping technique mitigates radiation degradation
- **expect at least 2 more years of quality data**

BRITE Constellation Main Information Sites

General info at: http://www.brite-constellation.at/



Detailed info about observing program on **WIKI** site: **http://brite.craq-astro.ca/doku.php**