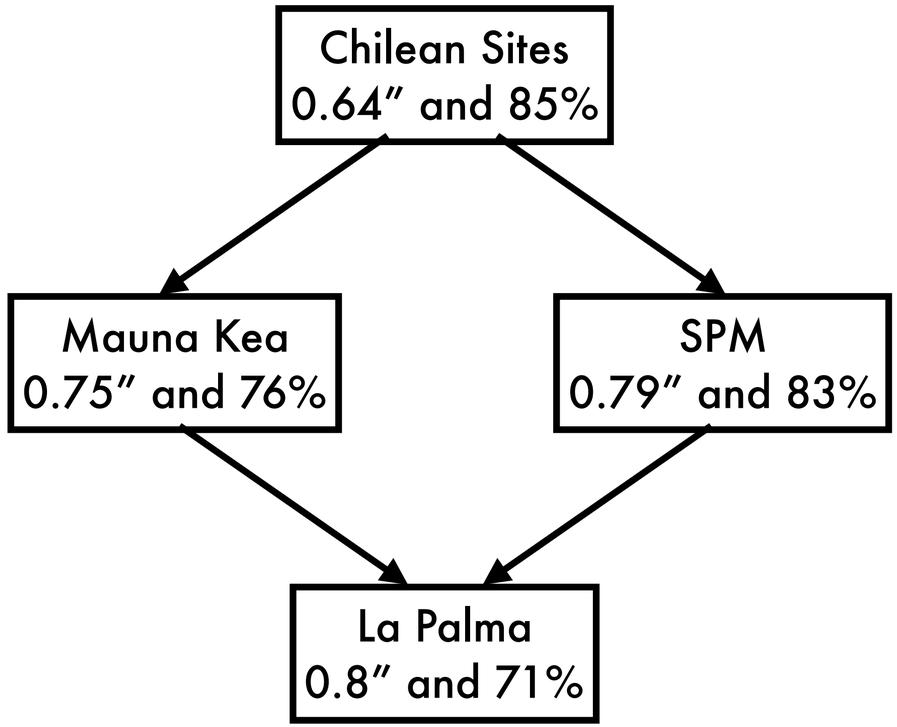
Synergies in Observations of Relativistic Stellar Transients at the OAN/SPM

Alan Watson

Why is the OAN/SPM such a good site for transients?



- Best site, irrespective of hemisphere: **Chile***
- Best northern site for seeing: **Mauna Kea**
- Best northern site for clear skies: **SPM**
- Best northern site for food: **La Palma**

EXTERNAL STUDIES!

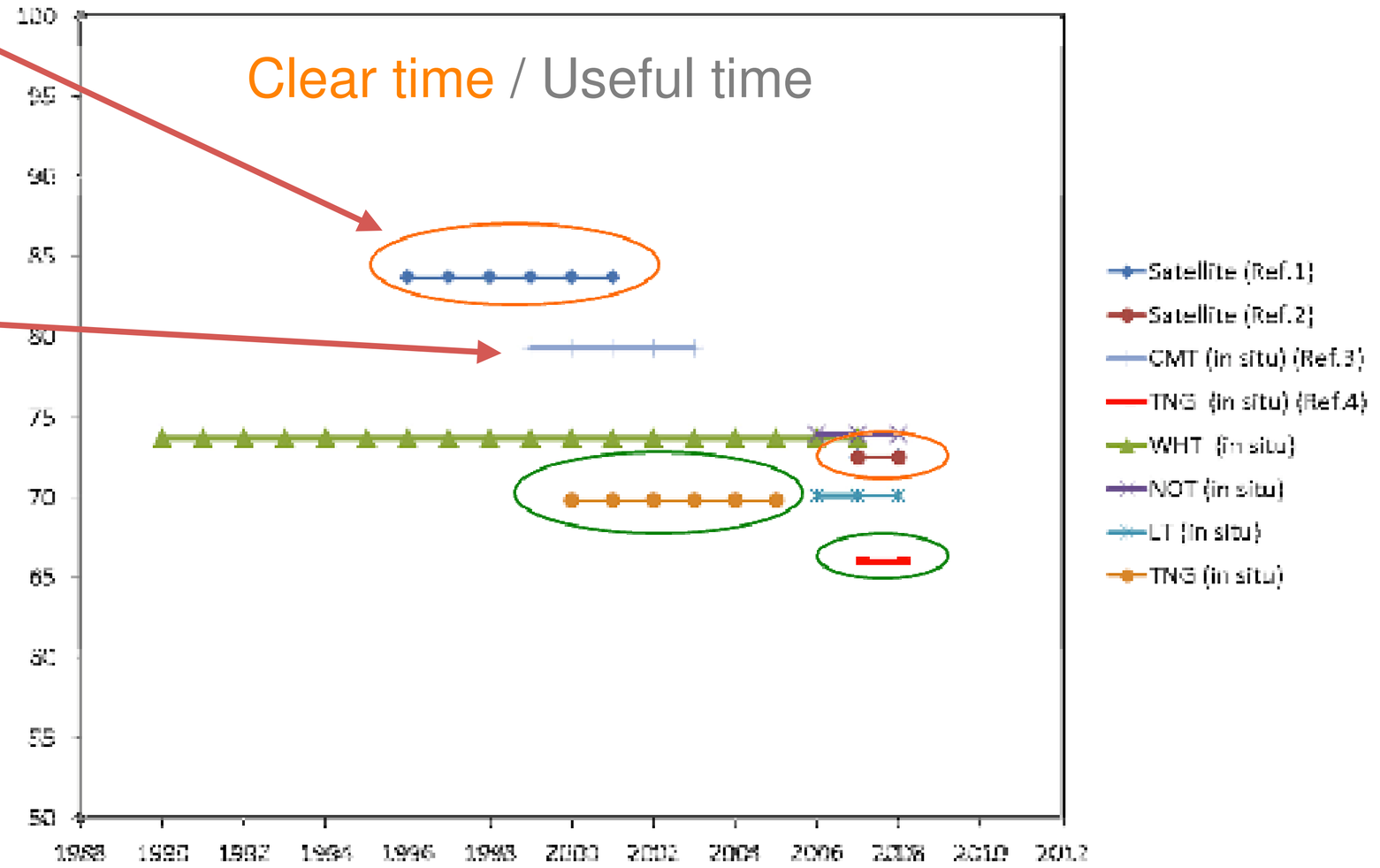
* Turbulence is lower at MK and SPM, so probably better for GLAO and MCAO.

Clear Nights at La Palma

Uncorrected systematic error

Inconsistent with international telescopes

Mean of other results is 71%



Outline

- Many telescopes
  - RATIR
  - COATLI
  - DDOTI
  - COLIBRÍ
- Many collaborators
- (Not going to talk about BOOTES-5)
- Synergies

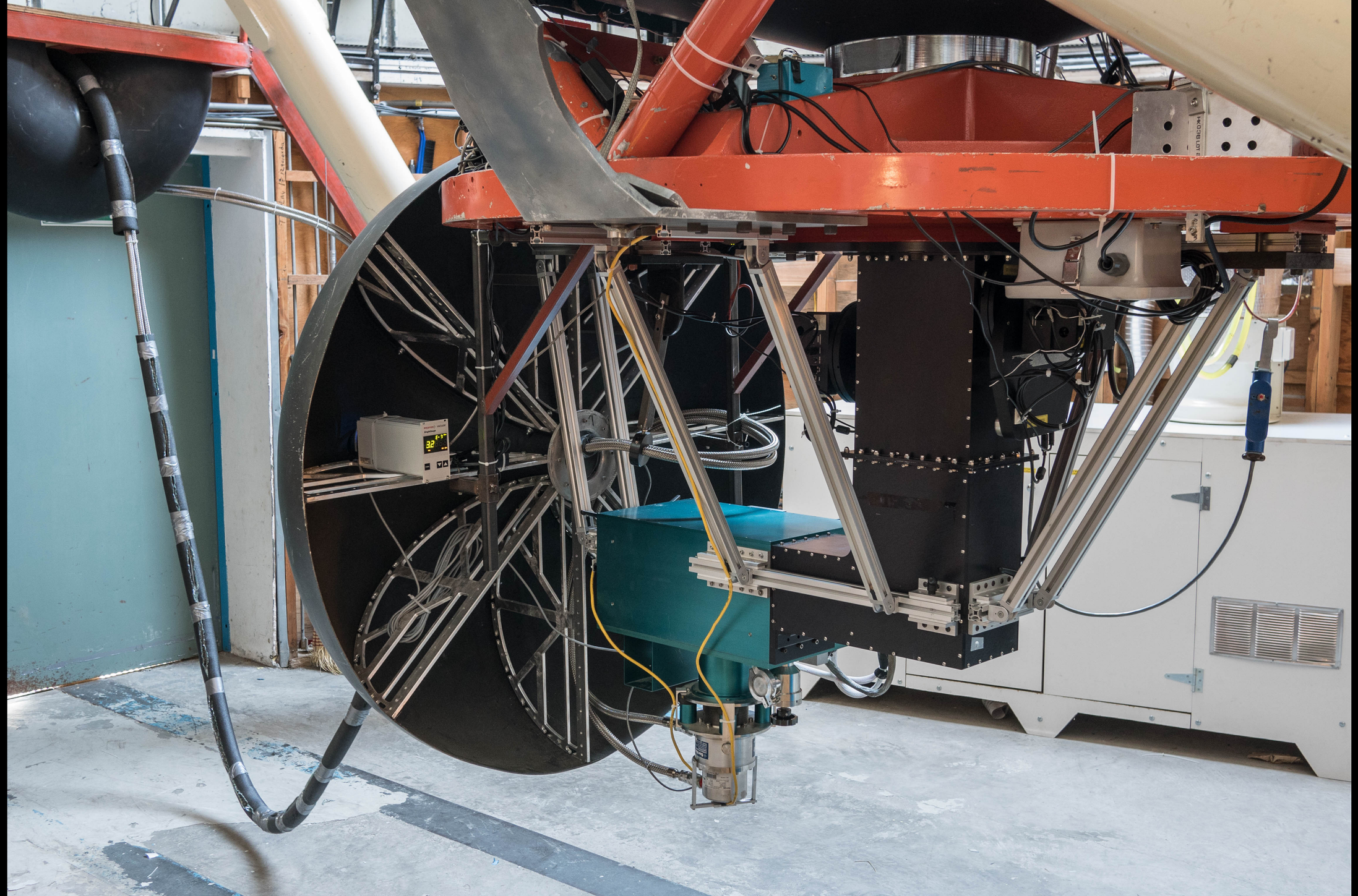

RATIR
84-cm
COATLI
DDOTI
COLIBRÍ
BOOTES-5

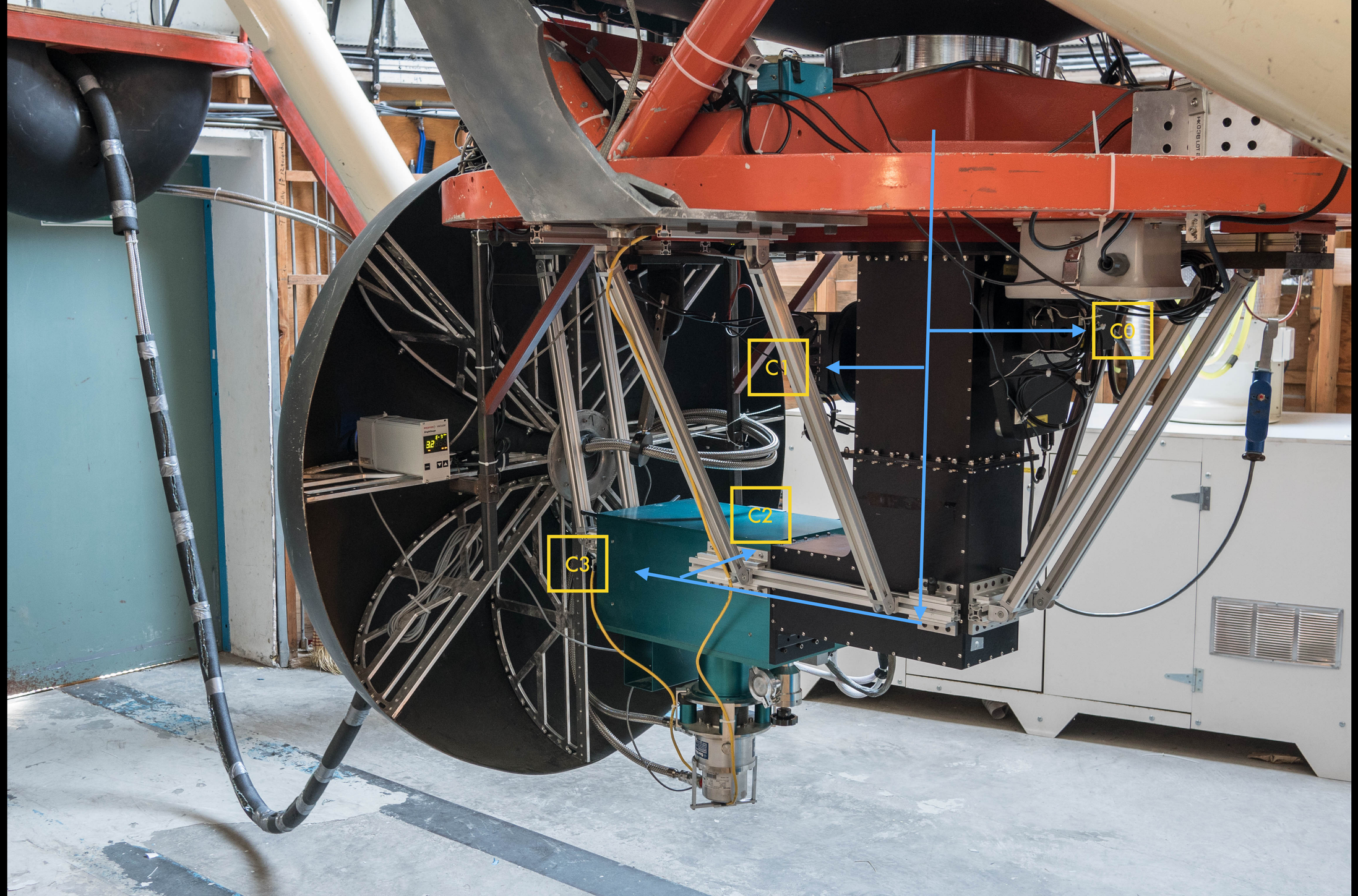
RATIR

2012–2021

ASU/GSFC/UC/UNAM


RATIR
84-cm
COATLI
DDOTI

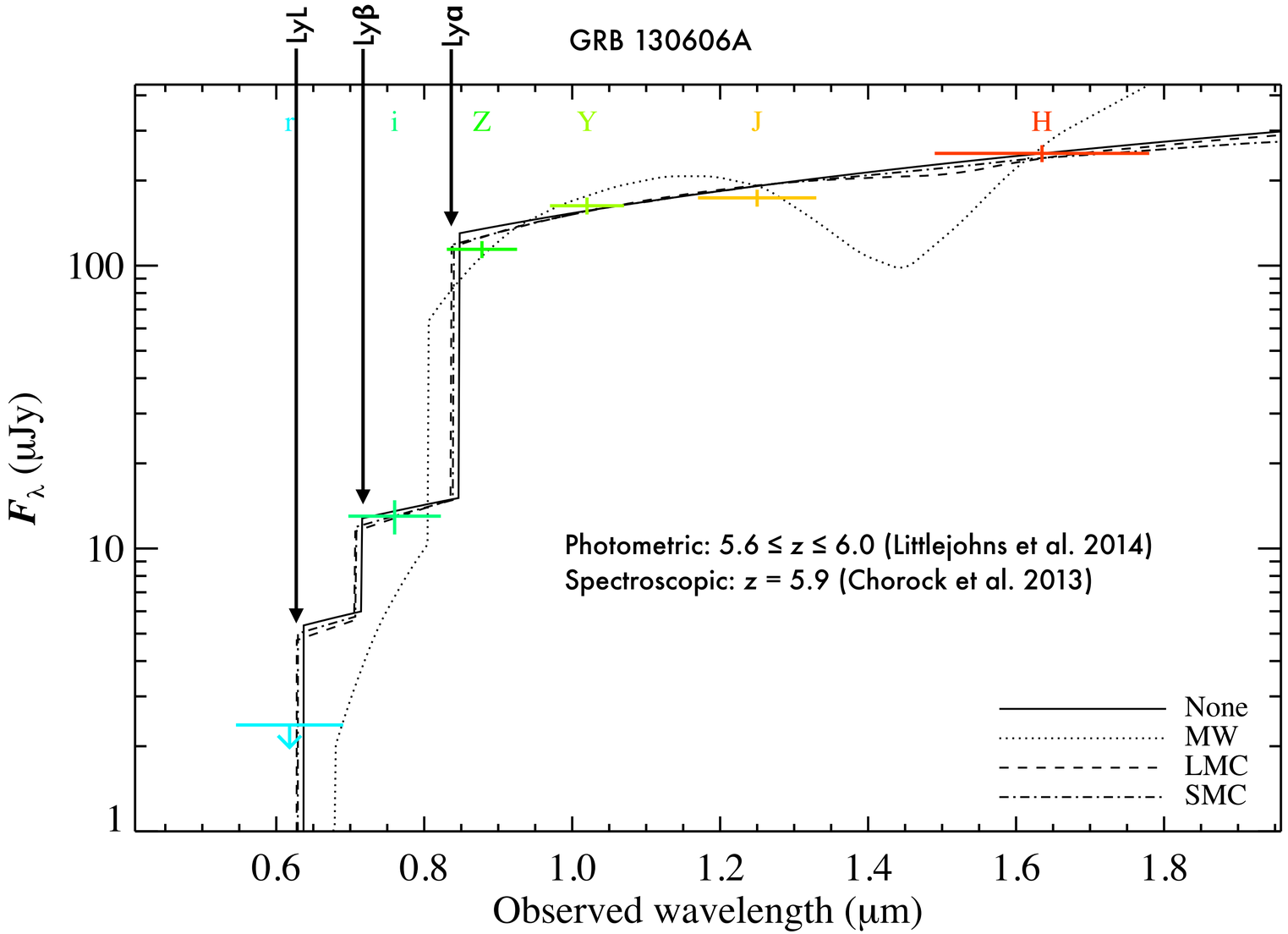



C0
C1
C2
C3

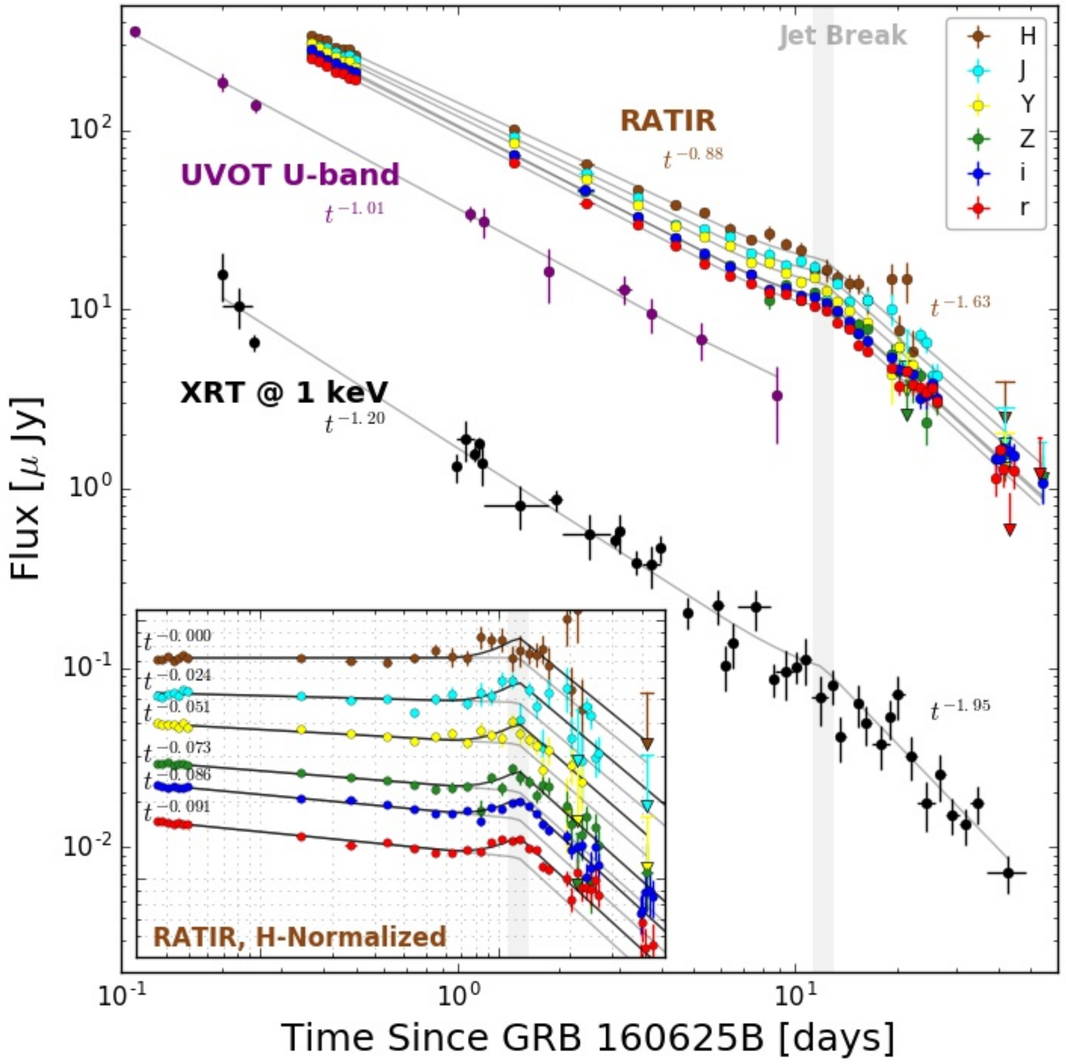
GRB Science

- *riZYJH* over 1 arcmin field
- We follow-up **every** Swift GRB we can, often for **several** nights.
- Colors and photometric redshifts
- OIR magnitudes for spectroscopic follow-up
- Light curves

Photometric Redshifts



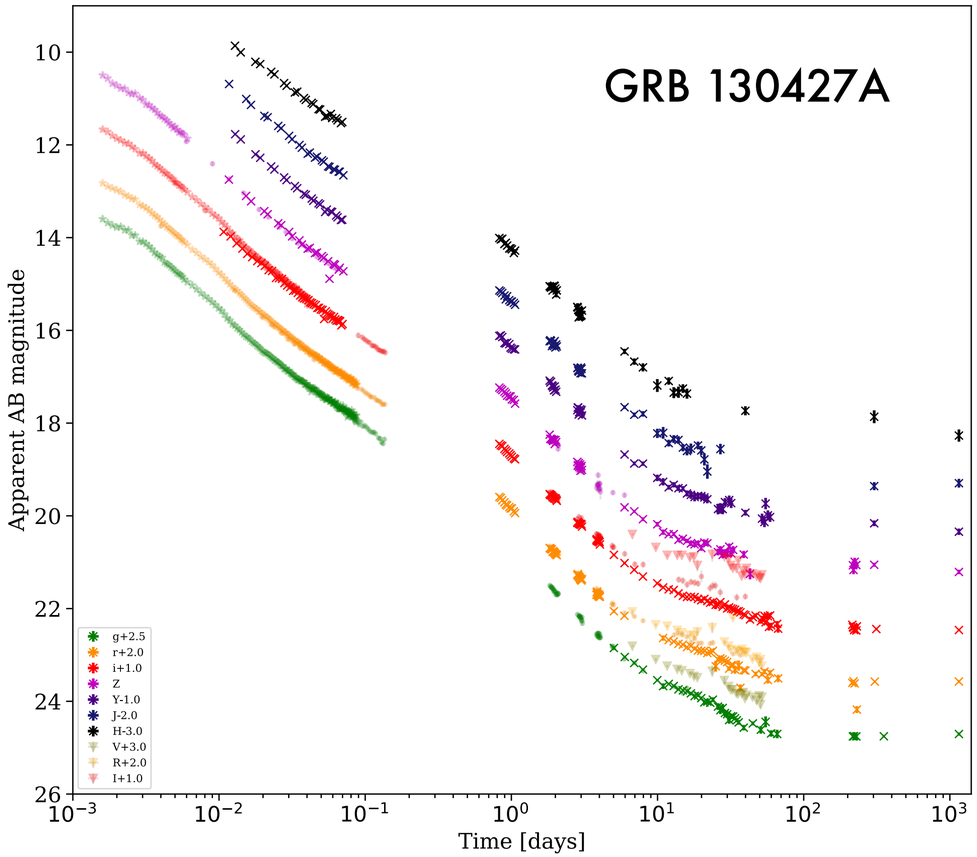
Long-Duration Light Curves

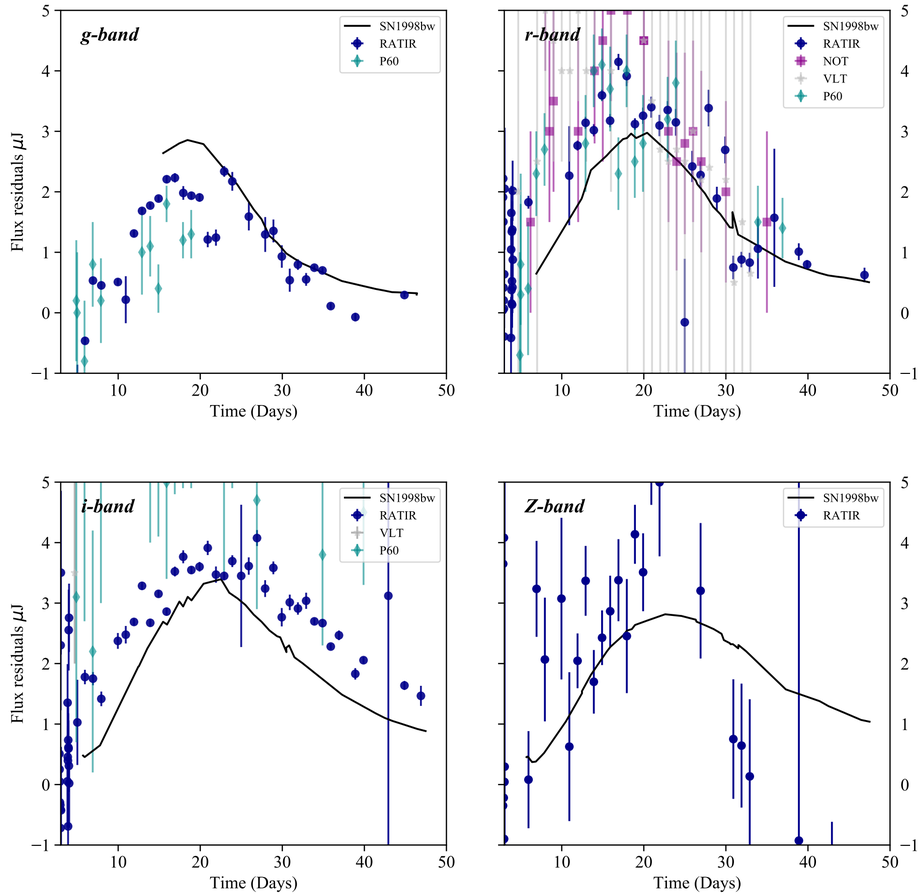


- GRB 160625B:
- 50 nights of data
- Jet break with chromatic edge brightening?

Strausbaugh et al. (2019)

Long-Duration Light Curves





Becerra et al. (2017)

Products 2012–2019

- GCNs: 293 (most productive single terrestrial telescope)
- Refereed publications: 57
- PhD Theses: 6 + 1
- MSc Theses: 1 + 1

RATIR in the Future

- Plan to remove RATIR from the 1.5-meter at end of 2021.

COATLI

2018—

UNAM/ASU

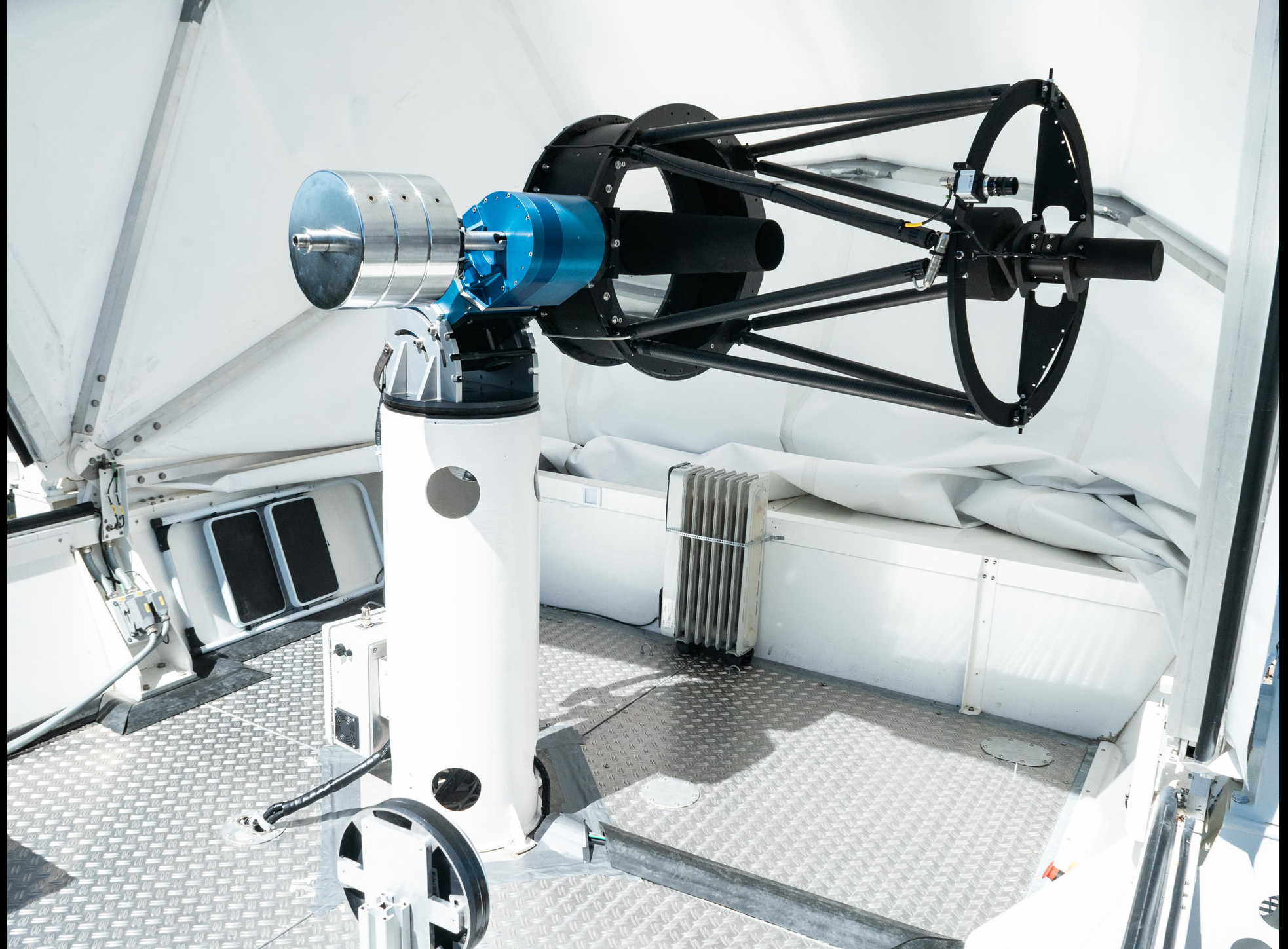

RATIR
84-cm
COATLI
DDOTI

COATLI

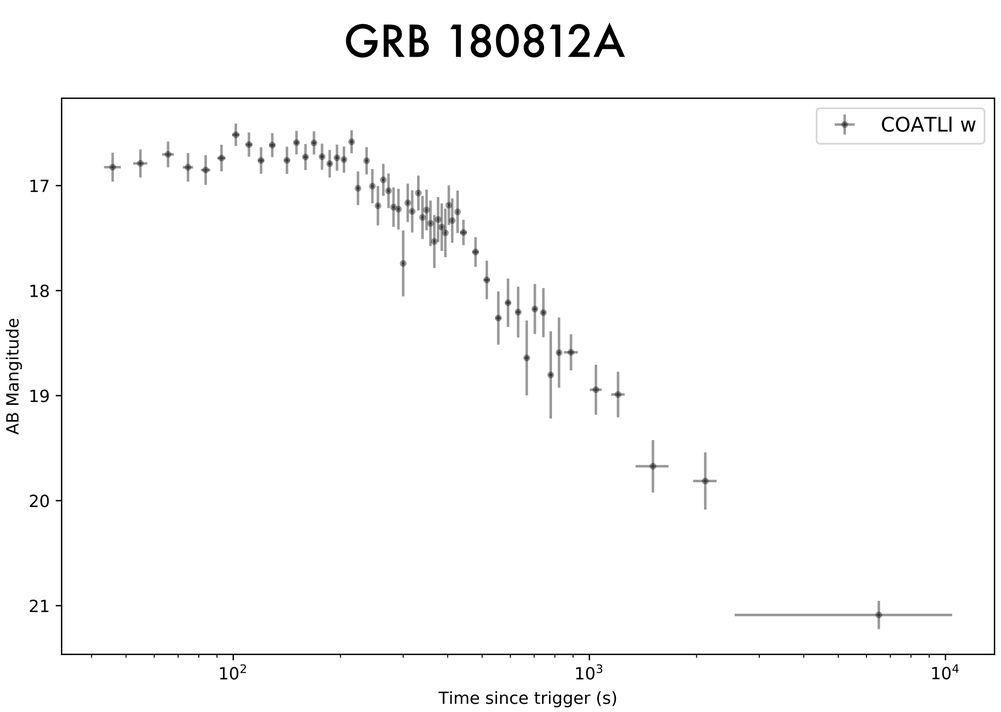
- ASTELCO 50-cm telescope, mount, and folding enclosure installed in 2016

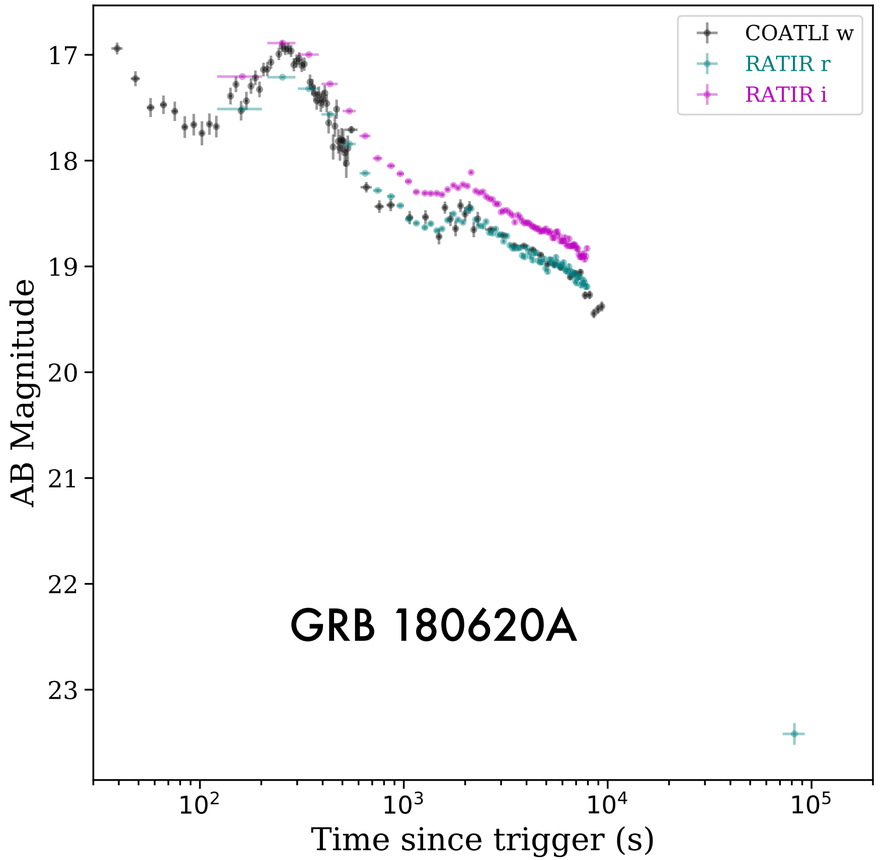
- Plan was to install fast-guiding camera with active-optics system to give 0.3″ FWHM images in *riz*. Currently working with simple interim instrument with a CCD.

- Also happens to have a fast mount — 10 seconds — so can do fast response to Swift GRBs.



COATLI + RATIR
GRB Light Curves





Products 2018–

- GCNs: 25
- Refereed publications: 2 + 1
- PhD Theses: 1

COATLI in the Future?

- Two image quality problems:
  - Wind shake up to 10″. ASTELCO blamed interaction between mount and column. We reinforced the column in August 2018 from 1.8–1.2–0.6 meters to 1.8—1.4—1.4 meters. Waiting (for 8 months and counting) for ASTELCO to come and tune the mount.
  - Poor polish and mirror support limits FWHM to 1.4″ even in still conditions. Waiting (for two years and counting) for ASTELCO to fix this.
- Currently working with a simple CCD imager with 8′ x 12′ field.
- If we can fix the image quality problems, we will build and install the tip-tilt imager. This has an EMCCD channel in *g* (5′) and a CCD channel in *riz*.
- If we can't, we will install the EMCCD (10′) in place of the current CCD.
- Either way we get an 1k x 1k EMCCD. Better early light curves.

DDOTI

2019—

UNAM/ASU/UMD LAM/OHP?


RATIR
84-cm
COATLI
DDOTI

DDOTI Basic Imager

- Celestron RASA
  - 11-inch (28 cm) f/2.2
  - Prime-focus Schmidt astrograph
- FLI Microline with Kodak KAF-50100
  - 8k x 6k
  - 49 × 37 mm
  - 6 µm pixels = 2.0 arcsec
  - 10-15 electron read noise with 3 second read time
  - 60% peak QE
- Starlight Instruments focuser
- Three-point static adjustment of CCD
- 20 kg
- Mainly commercial components
- US$21,000

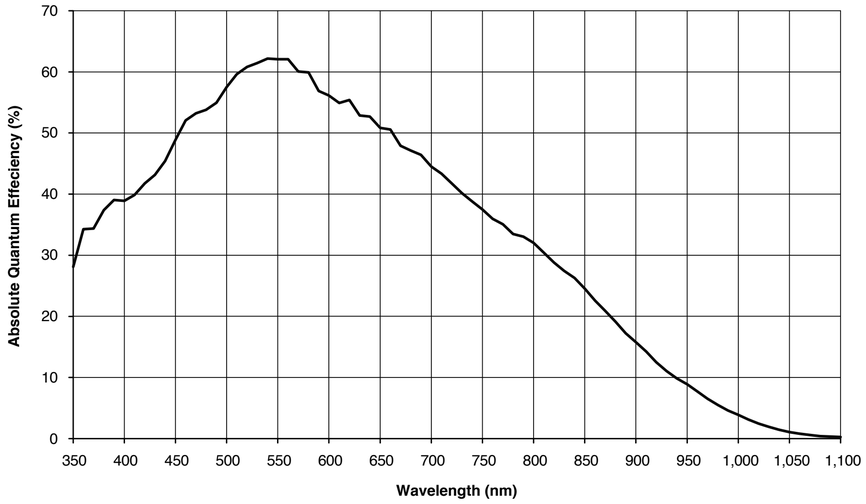
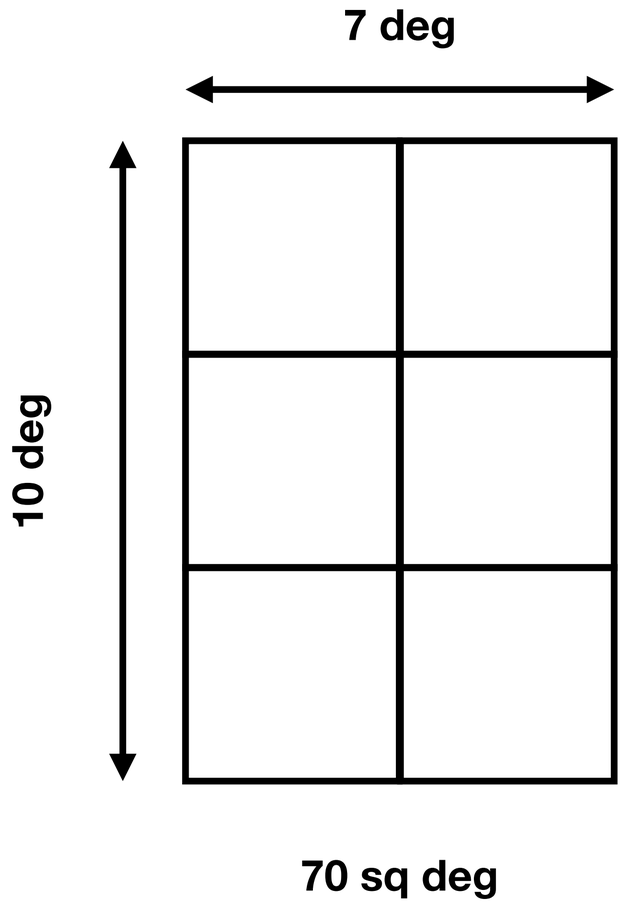


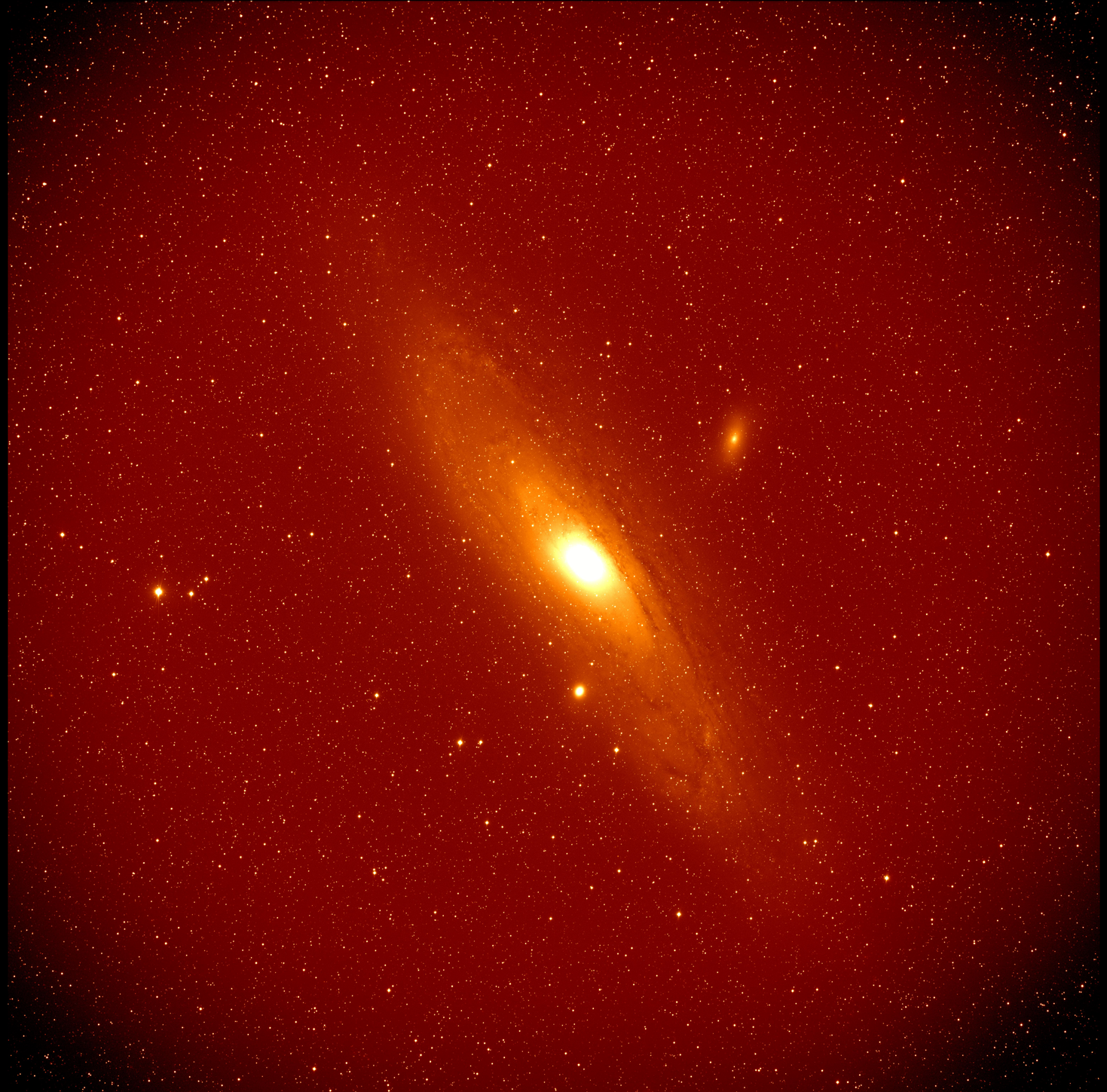
Figure 9. Spectral Response (KAF–50100–ABA Version)

DDOTI

- Enclosure, mount, and infrastructure are identical to COATLI
- 2 tubes (UNAM) in 2017
- 4 tubes (UMD) in early 2019
- 70 sq deg – designed for GWs and Fermi/GBM GRBs
- Commissioning:
  - Mount needs tuning
  - Some focuser problems
  - Need to align CCDs with mount
- In 2000 seconds, the10-sigma limiting magnitude is 19.5.




C1
C0
C2
C5
C4
FLI
CELESTRON
ROWE-ACKERMANN
F/2.2 SCHMIDT ASTROGRAPH



6k x 6k = 36 Mpx

3.4 x 3.4 deg = 11.5 sq deg

12k x 18k = 216 Mpx

7 x 10 deg = 70 sq deg

Products 2018–

- GCNs: 5

COLIBRÍ/DDRAGO/CAGIRE

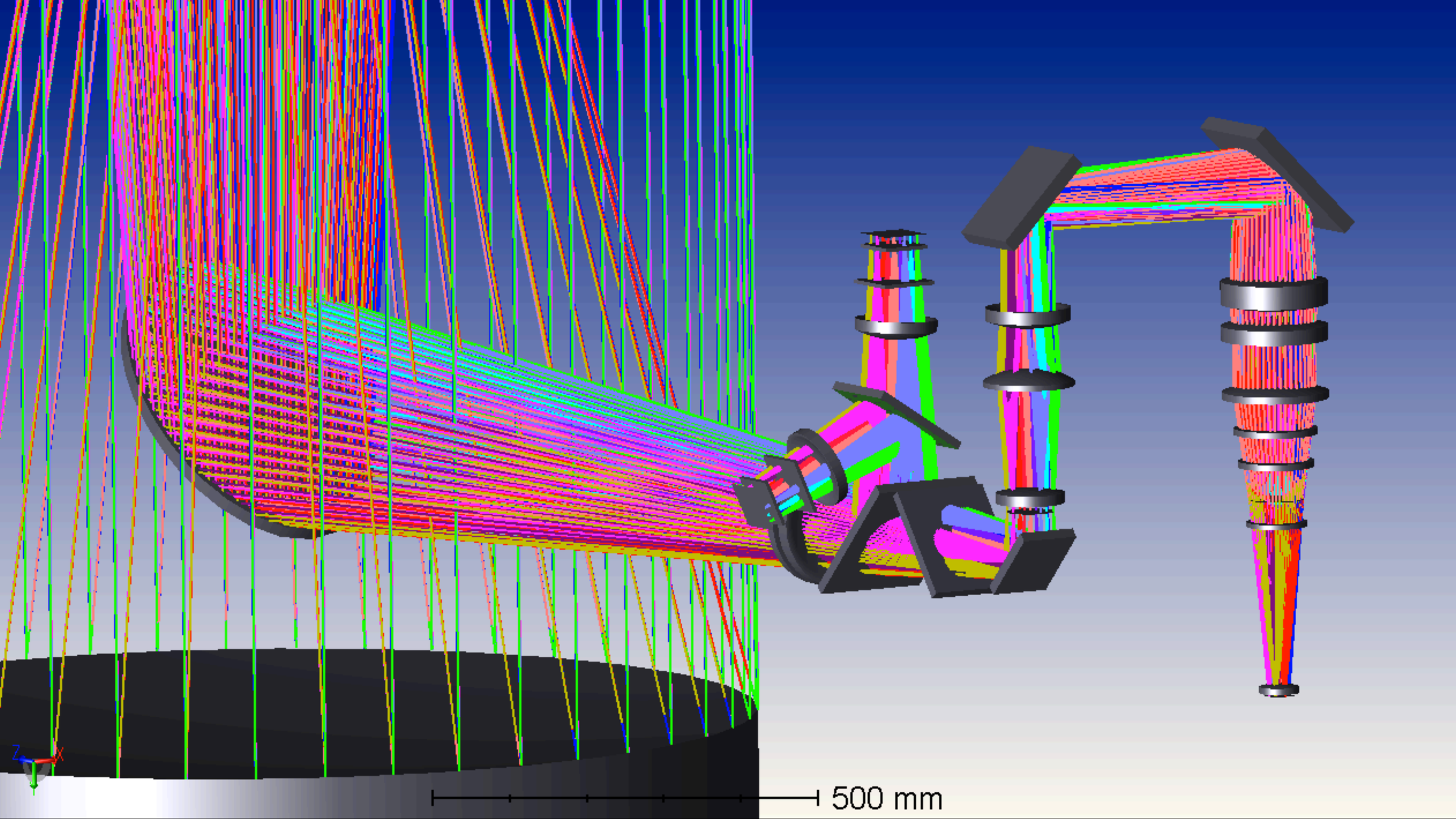
2020—

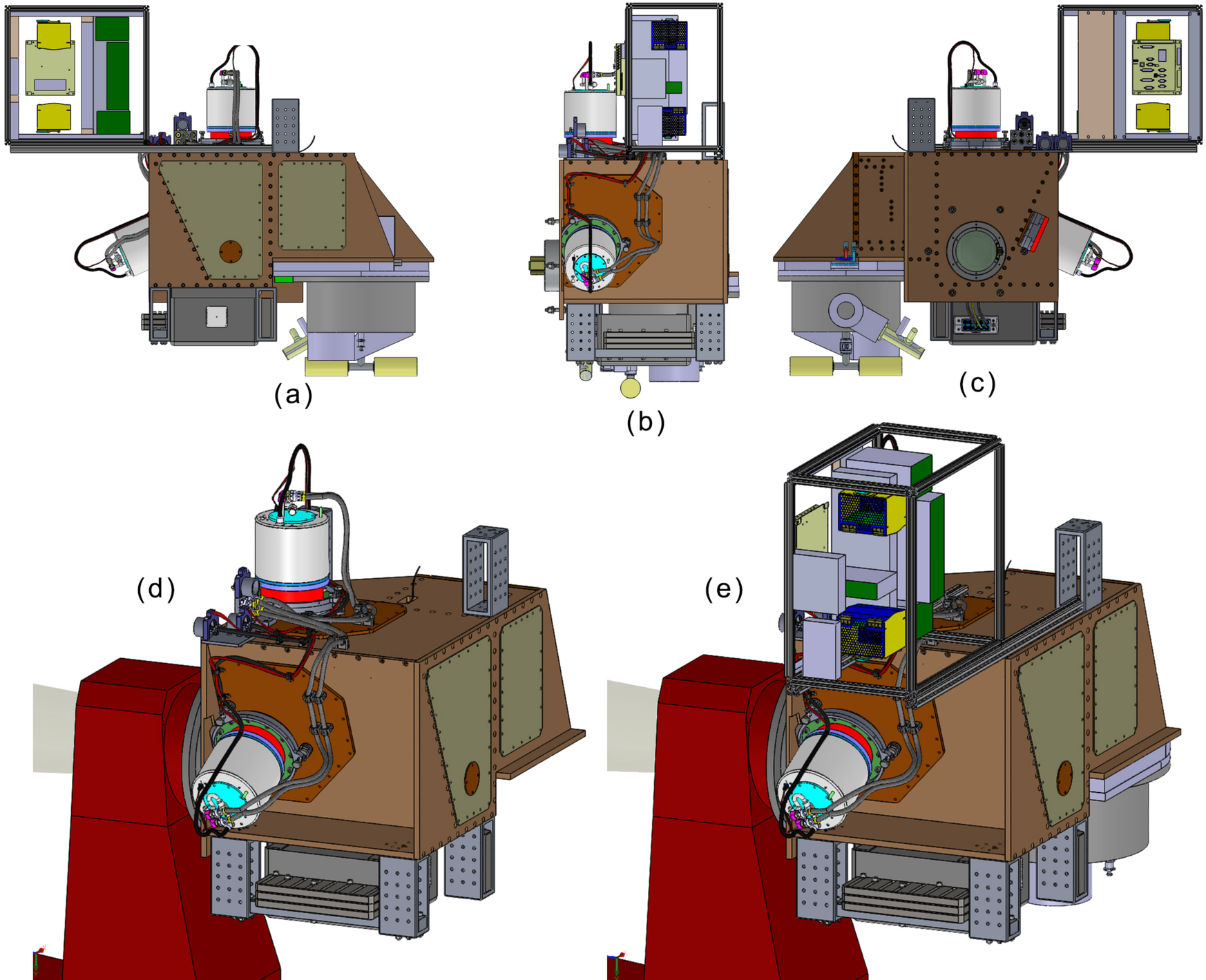
LAM/IRAP/CPPM/OHP/CEA/UNAM/ASU


RATIR
84-cm
COATLI
DDOTI
BOOTES-5
COLIBRÍ

COLIBRÍ/DDRAGO/CAGIRE

- COLIBRÍ
  - 1.3-meter fast alt-az
  - Median FWHM = 0.9 arcsec
  - Fast – 20 seconds
- DDRAGO
  - Two-channel imager: *gri* and *zy*
  - 4k x 4k CCD
  - 0.38 arcsec pixel and 26′ field
- CAGIRE
  - One-channel imager: *JH*
  - 2k x 2k SOFRADIR
  - 0.63 arcsec pixel and 22′ field


Z
X
500 mm


(a)
(b)
(c)
(d)
(e)

COLIBRÍ/DDRAGO/CAGIRE

- Identification of SVOM/ECLAIRs GRBs
- Photometric redshifts of SVOM/ECLAIRs, Swift/BAT, and Fermi/LAT GRBs
- Light curves of SVOM/ECLAIRs, Swift/BAT, and Fermi/LAT GRBs

COLIBRÍ in the Future

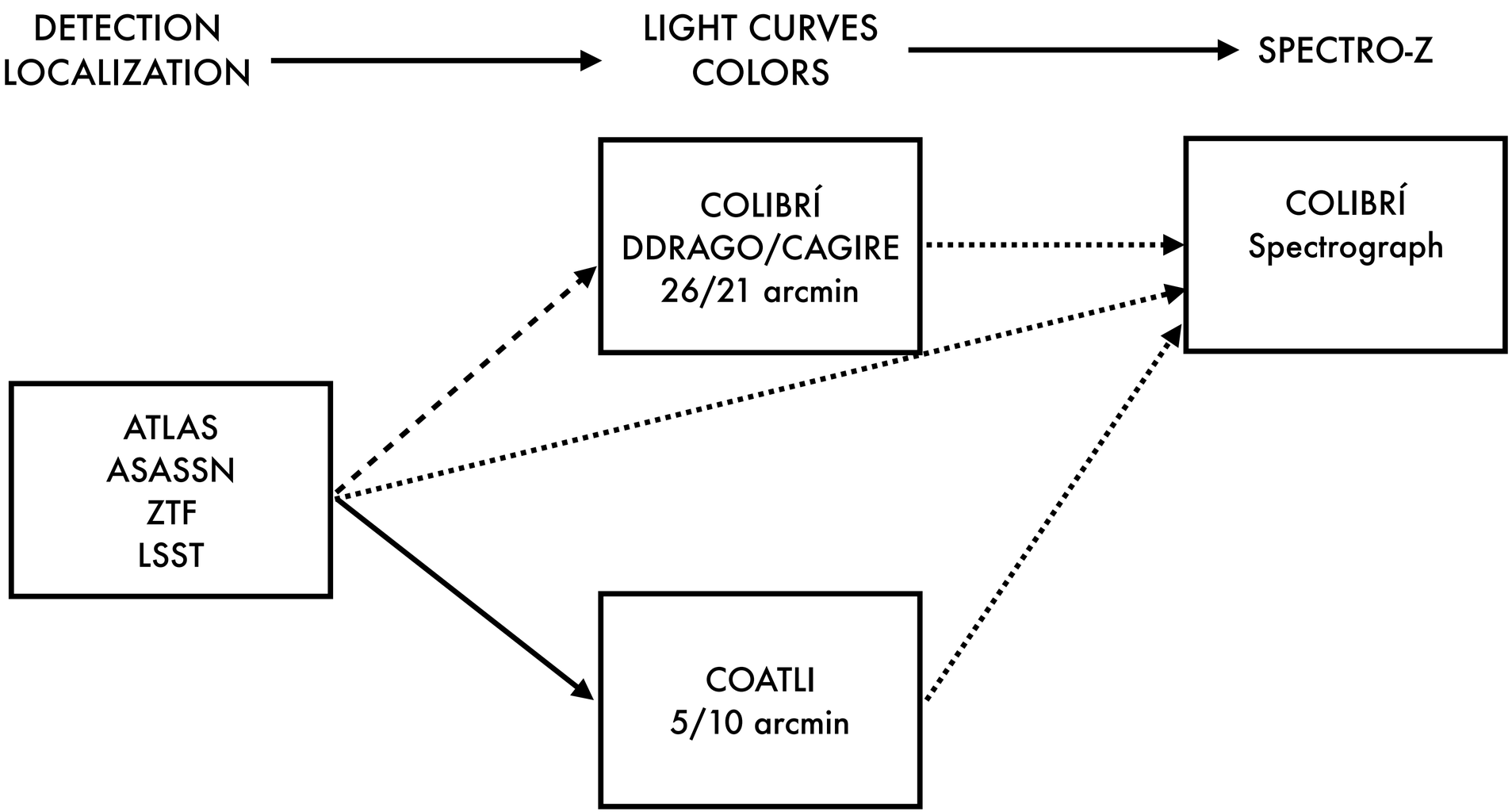
- Low-resolution spectrograph?

Synergies for Transient Astronomy

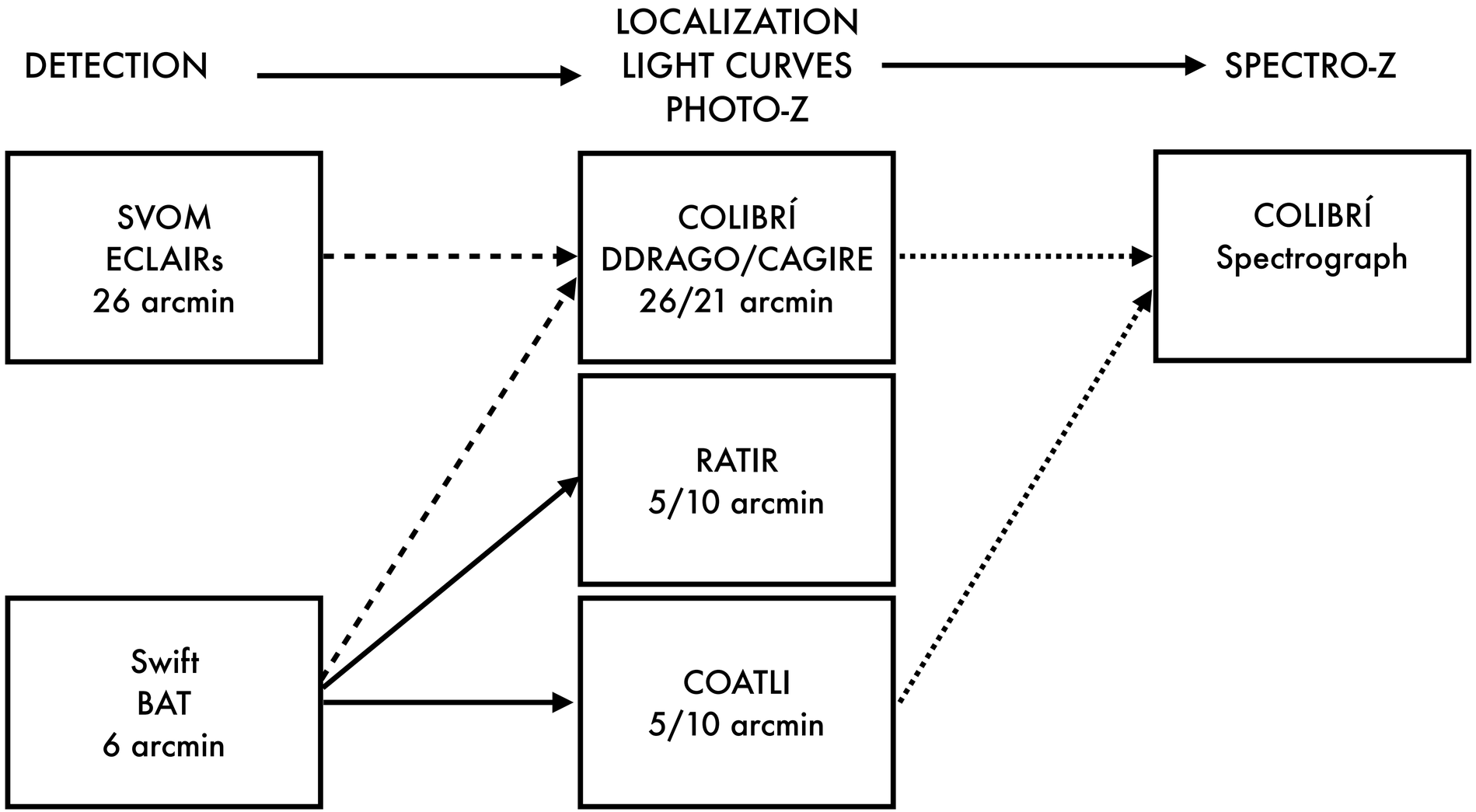
Common Control System

- RATIR, COATLI, DDOTI, and COLIBRÍ all use
  - UNAM robotic control system
  - ASU data pipeline
- This makes it (relatively) easy the data-pipeline automatically or semi-automatically request observations
- Automated? Identifying the best candidates is hard.
- Semi-automated? A “go” button for each interesting source in the data-pipeline results page. The combination of a data-pipeline and eyes with experience is difficult to beat.
- Combination? Do the best you can do with an automated response, but let an experienced observer tweak the results.

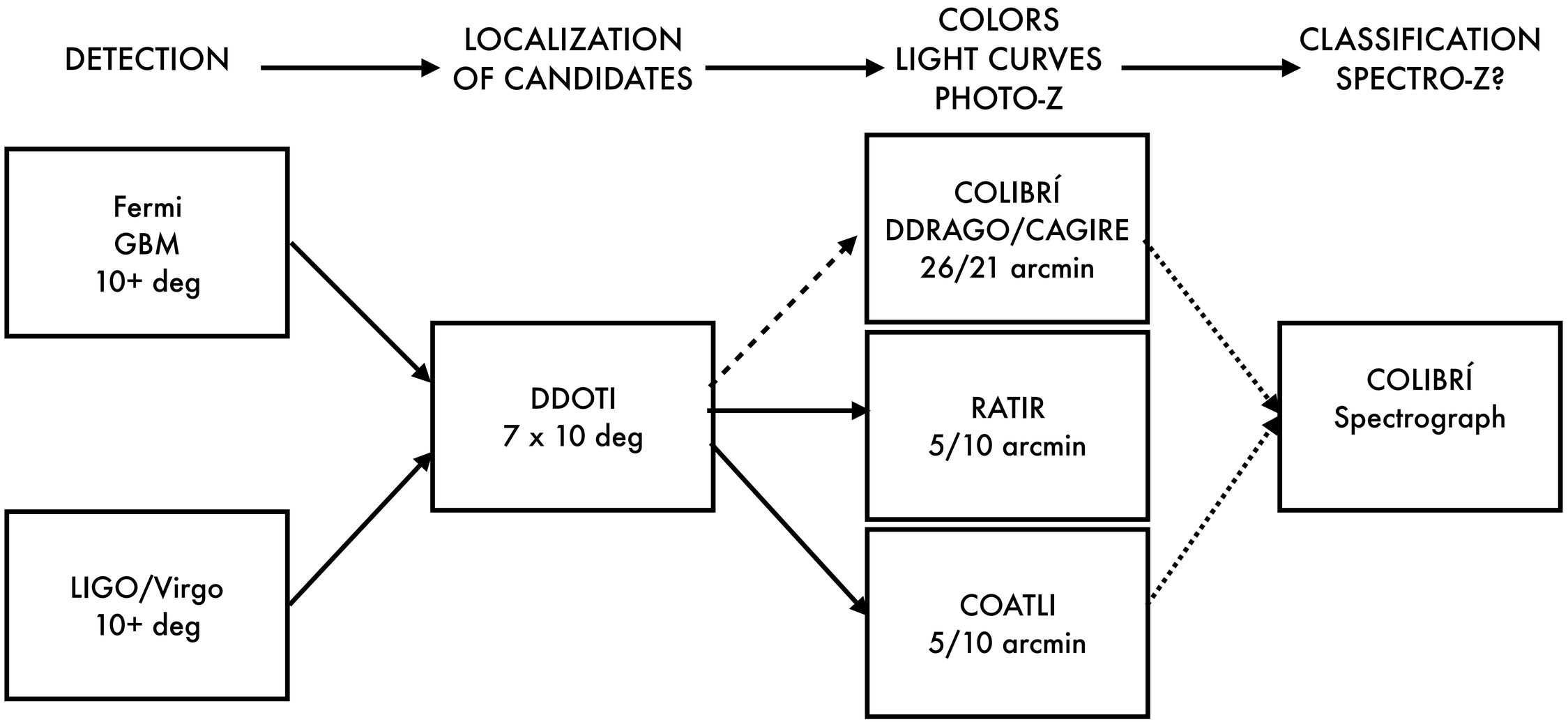
EXCELLENT LOCALIZATIONS



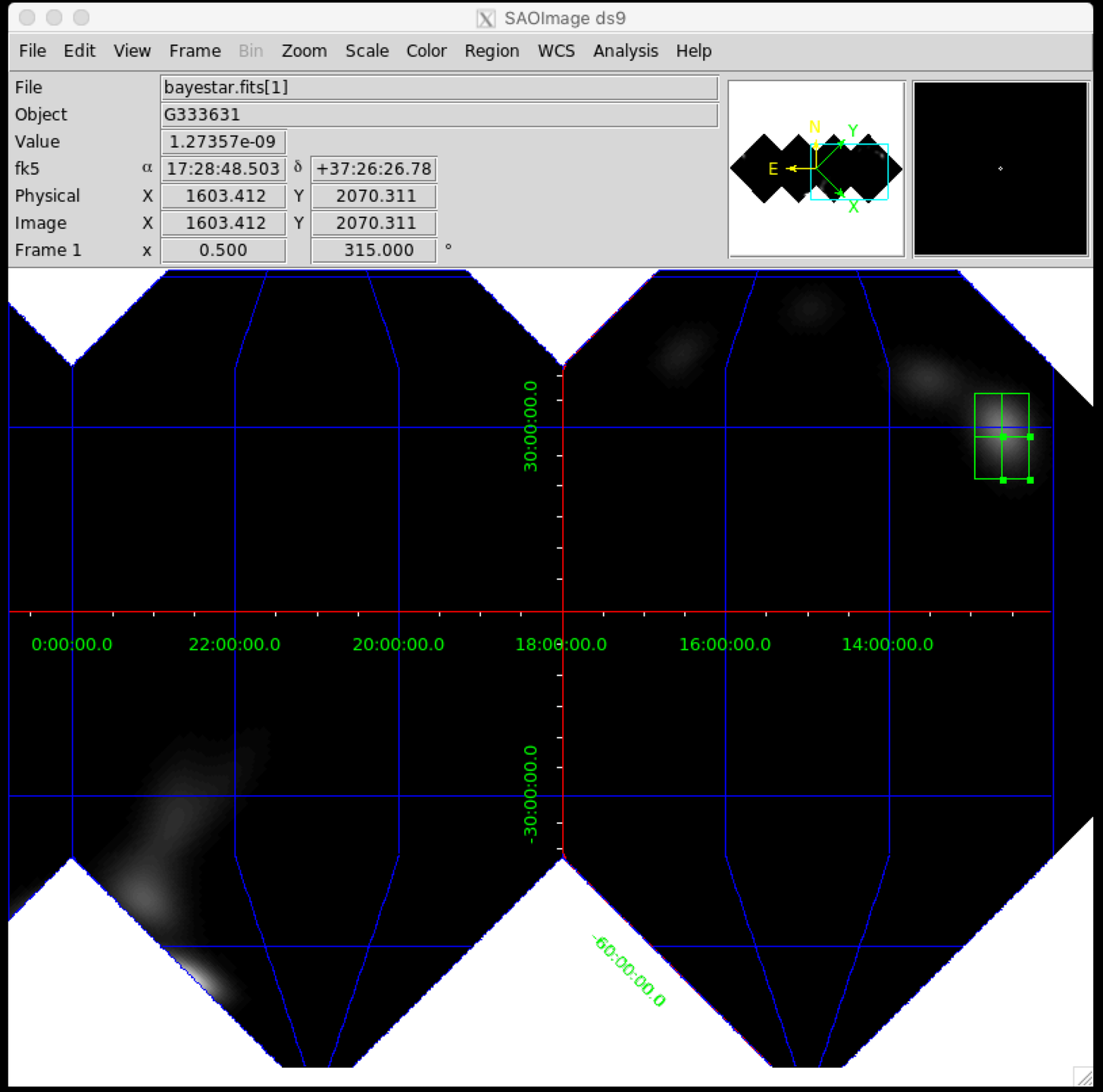
GOOD LOCALIZATIONS



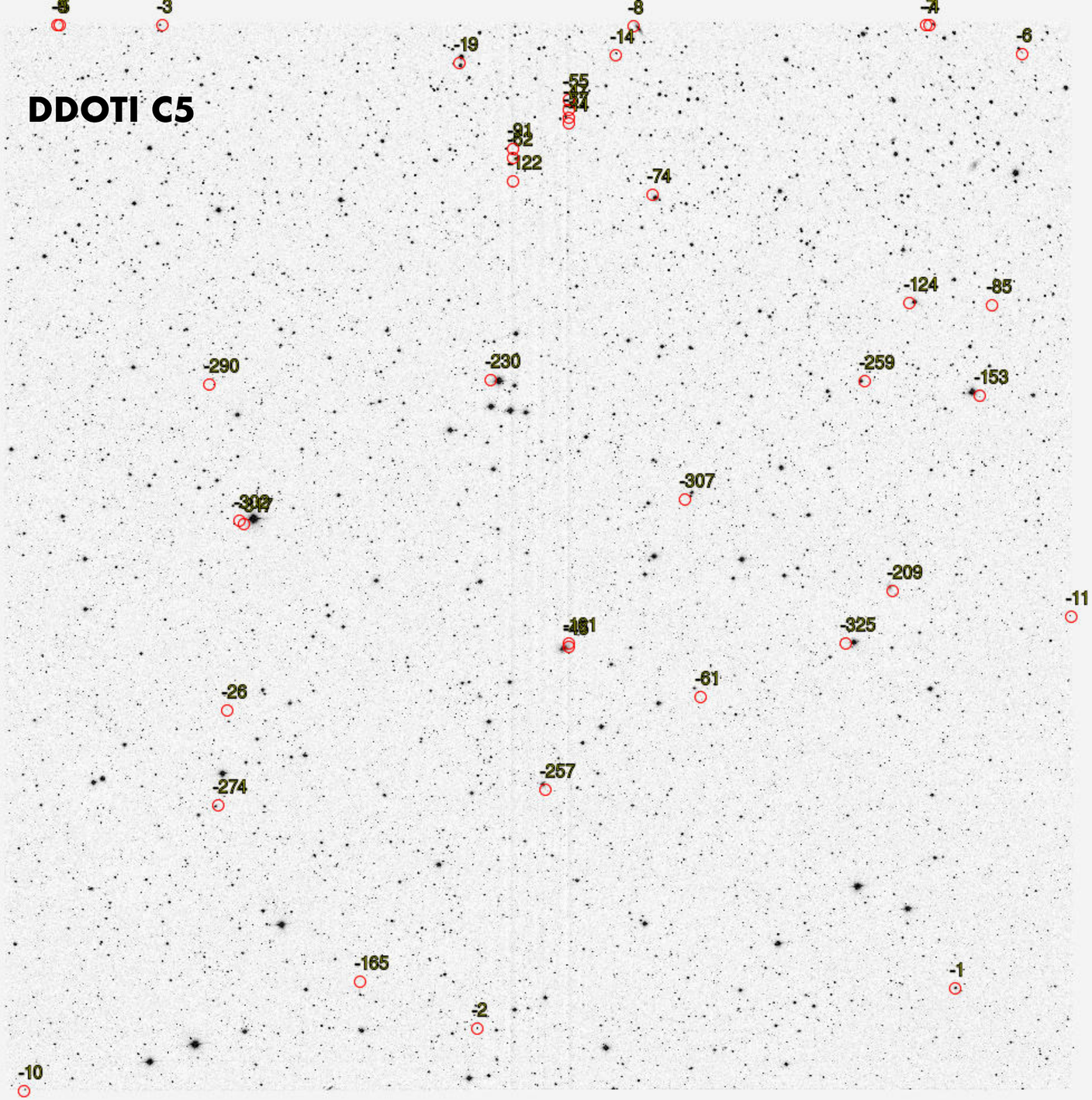
POOR LOCALIZATIONS

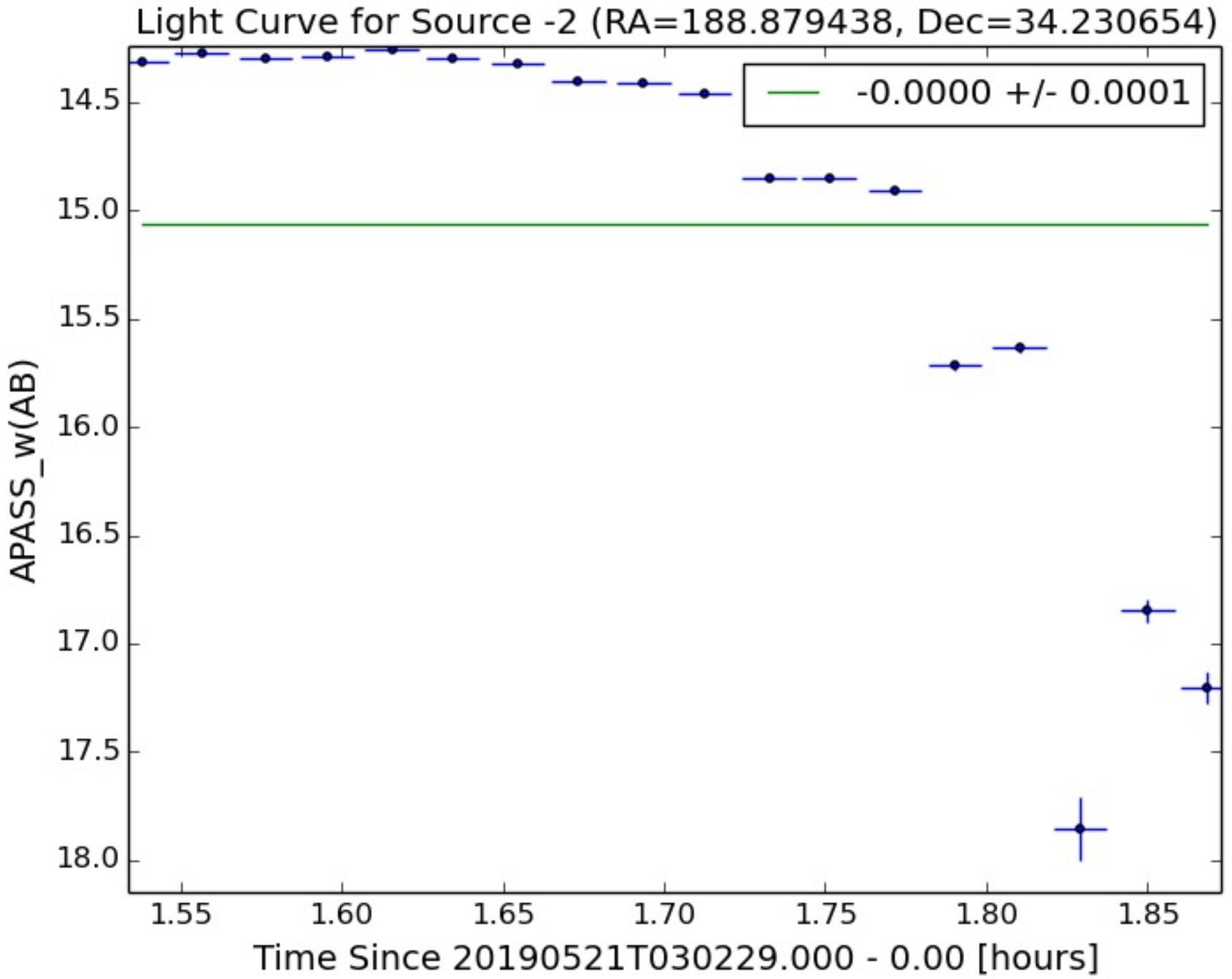


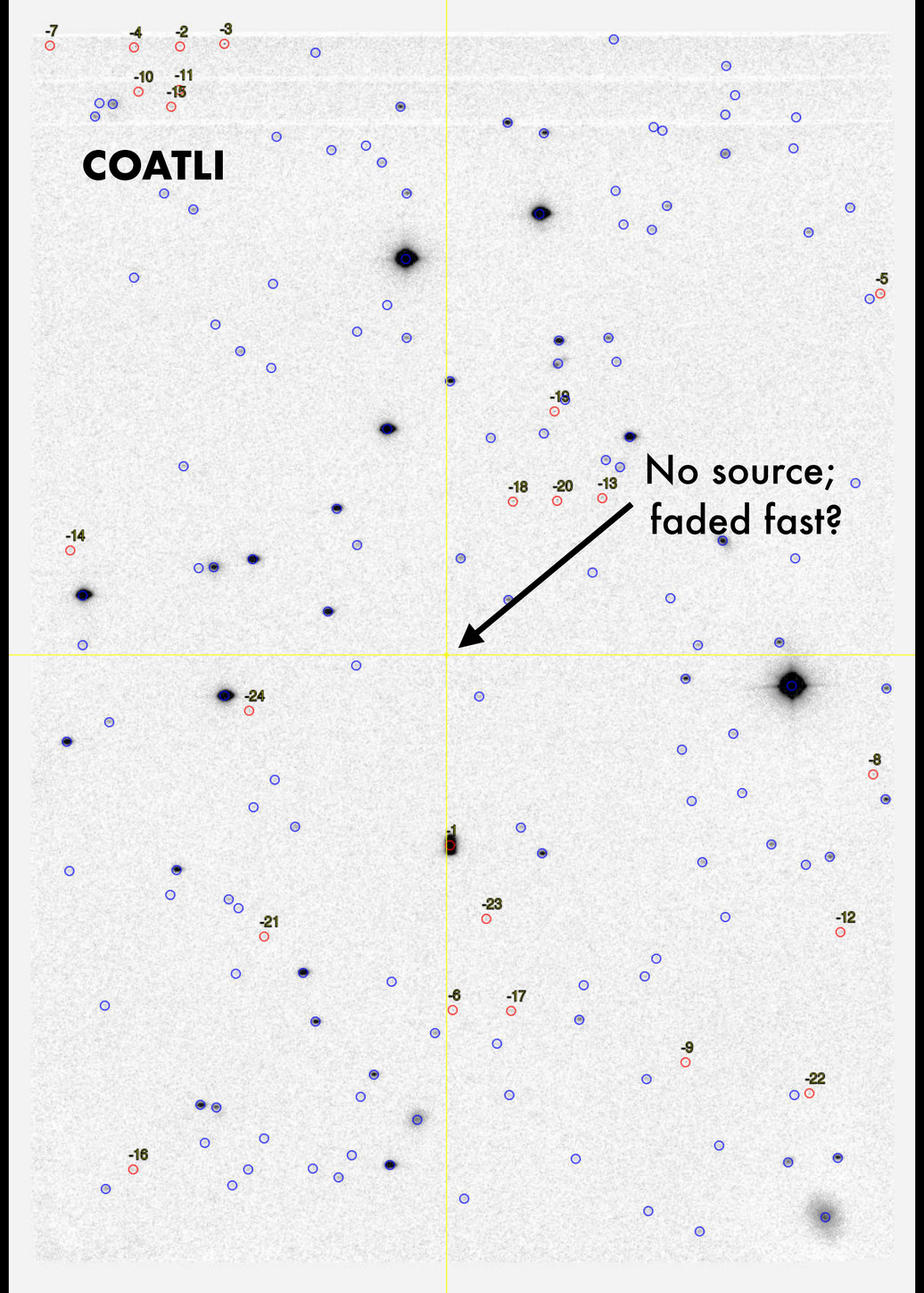
Example: S190521g

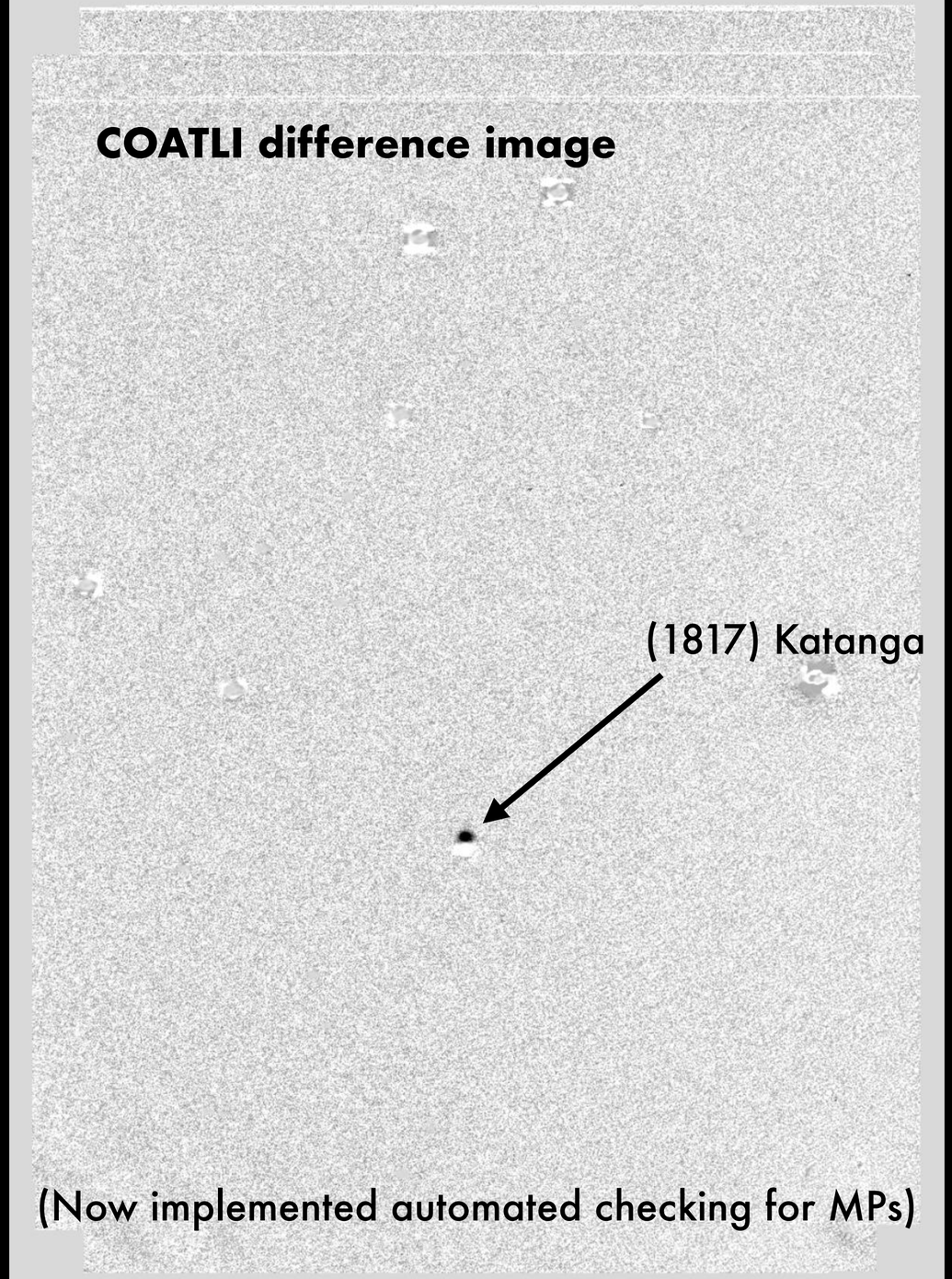


S190521g: manually programmed 4 pointings


DDOTI C5
-5
-3
-8
-4
-19
-14
-6
-55
-91
-82
-122
-74
-124
-85
-290
-230
-259
-153
-307
-209
-11
-325
-26
-61
-257
-274
-165
-1
-2
-10


Light Curve for Source -2 (RA=188.879438, Dec=34.230654)
-0.0000 +/- 0.0001
APASS_w(AB)
14.5
15.0
15.5
16.0
16.5
17.0
17.5
18.0
1.55
1.60
1.65
1.70
1.75
1.80
1.85
Time Since 20190521T030229.000 - 0.00 [hours]


COATLI
No source;
faded fast?
-7
-4
-2
-3
-10
-11
-15
-5
-19
-18
-20
-13
-14
-24
-8
-1
-23
-12
-21
-6
-17
-9
-22
-16


COATLI difference image
(1817) Katanga
(Now implemented automated checking for MPs)

Summary

- We hand and will have great telescopes and instruments for observing relativistic stellar transients.
- Getting the most out of our telescopes requires **automated** or **semi-automated** (go/no-go) coordination
- Pass DDOTI candidates to RATIR/COATLI/COLIBRÍ for photometry
- Pass COLIBRÍ/COATLI imaging candidates to the COLIBRÍ spectrograph
- Still need eyes looking at results of the data pipeline. The geographic diversity in our team is almost perfect: Mexico/US take start of night and France takes over for the second half of night.