

*Coordinating observations
among ground and space-
based telescopes*

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SciOps2019

On behalf of:

Matthias Ehle, Carlos Gabriel, Aitor Ibarra,
Peter Kretschmar, Bruno Merín, **Jan-Uwe Ness**,
Emilio Salazar, Jesús Salgado, Celia Sánchez,
Richard Saxton
(ESAC/ESA, Spain)

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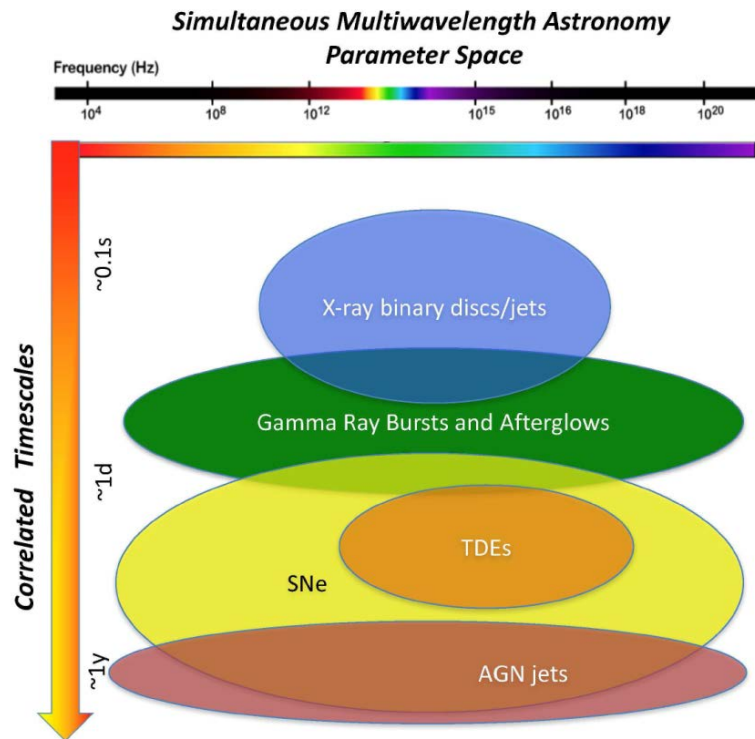
20 November, 2019. A Wednesday....

Presentation outline:

- *Coordinating observations: the old way*
- *Some like it hot: multi-messenger*
- *Coordinating observations: the new way*
- *Conclusions*

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Time-Domain multi-wavelength (EM) astronomy



e.g., Middleton *et al.* 2017, New Astronomy Reviews

*Increasing interest to
simultaneously observe
same target at
different wavelengths at
various time scales*

➤ Some numbers:

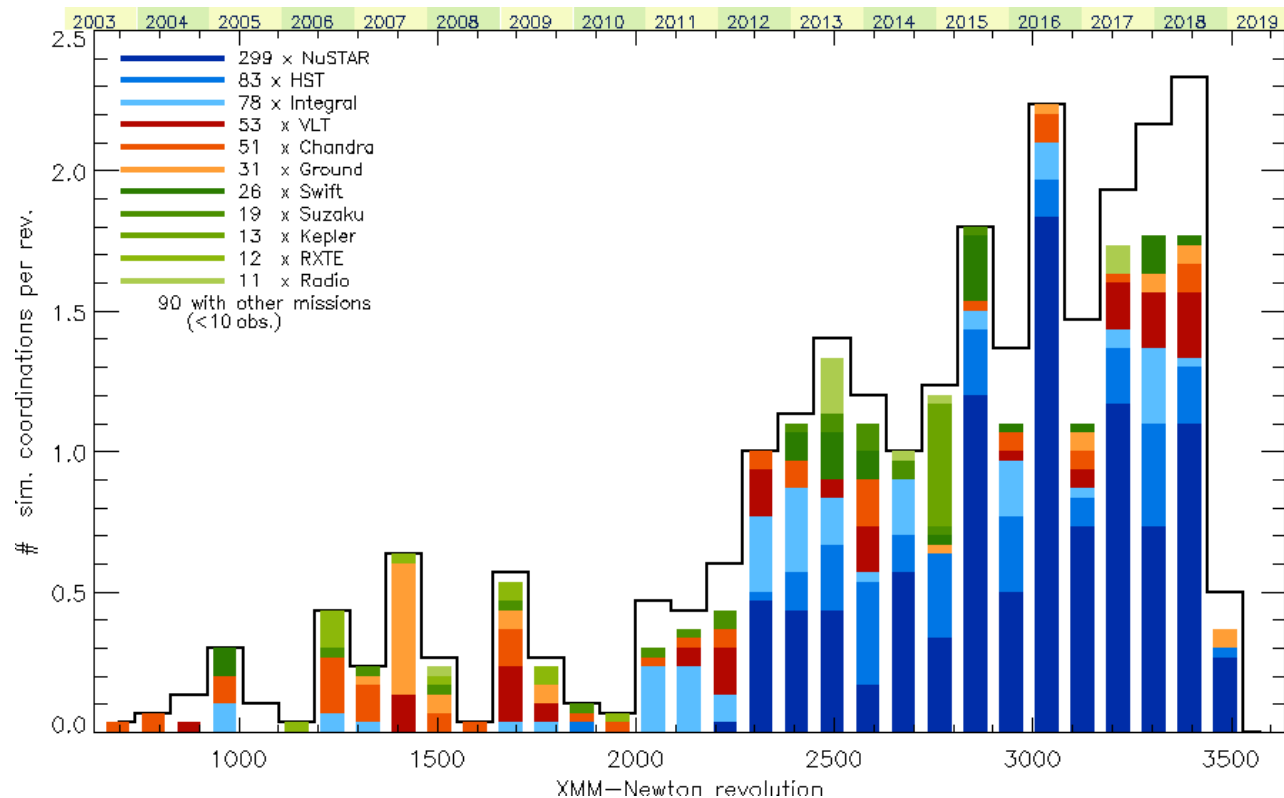
- **XMM-Newton**: ~12% of observations are coordinated with other observatories (e.g., NuSTAR, HST, Chandra, VLT, Swift)
- **INTEGRAL**: ~10%
- **NuSTAR**: ~30%

Coordination: XMM-Newton

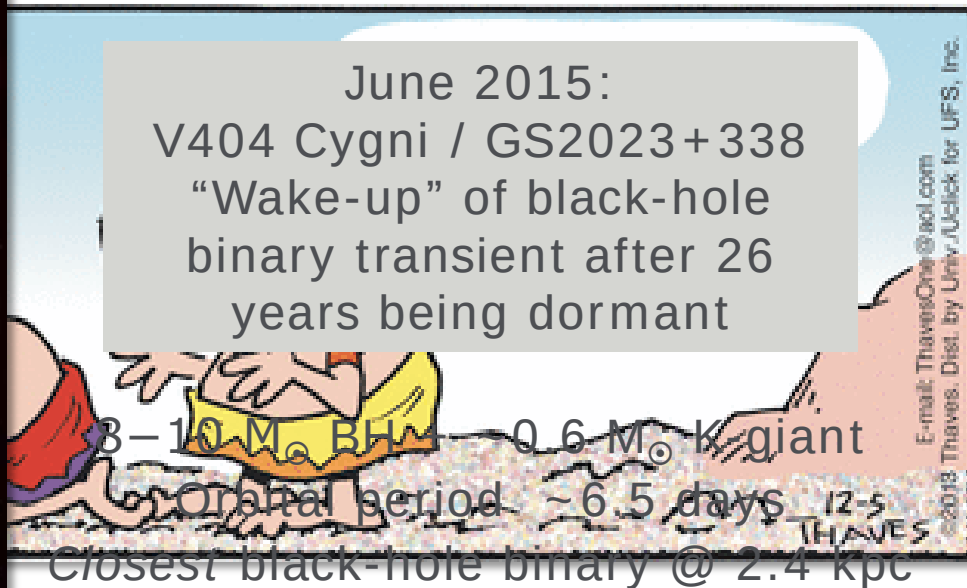
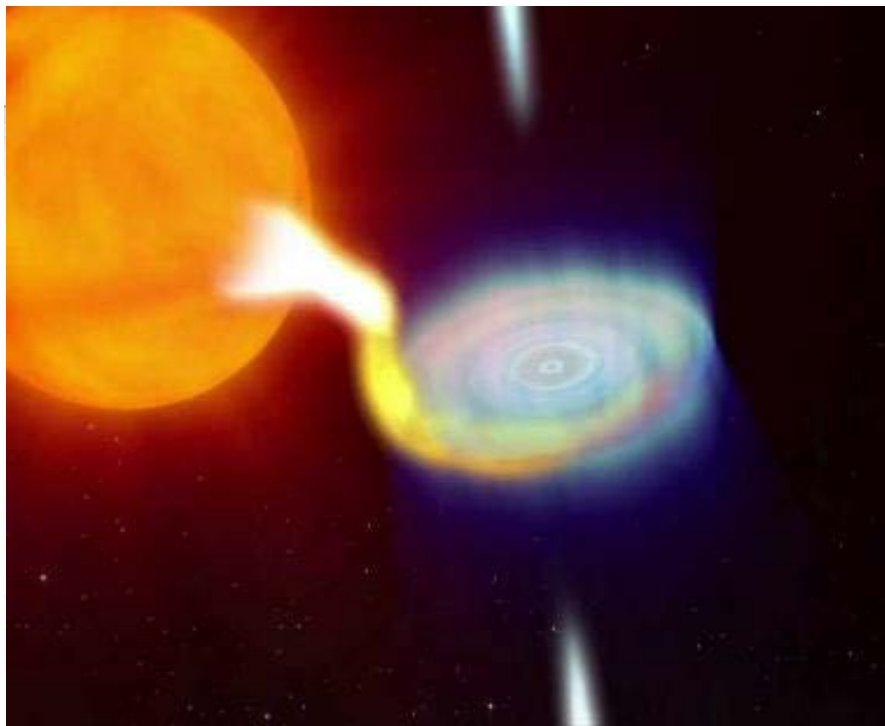


2003

2019



Coordination in the old days - example



Coordination in the old days - example



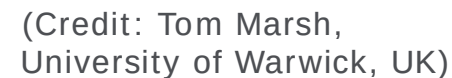
```
>> Subject: Re: V404 Cyg -- coordinating multi-
>> Date: 25/06/15 15:05
>> From: Rob Fender
>> <rob.fender@astro.ox.ac.uk> <mailto:rob.fender@
>> To: Altamirano D.
>> <D.Altamirano@soton.ac.uk> <mailto:D.Altamiran
>> <C.Knigge@soton.ac.uk> <mailto:C.Knigge@soton
>> CC: Shaw A. <A.Shaw@soton.ac.uk> <mailto:A.S
>> Hernandez Santisteban J.V.
>> <J.V.Hernandez@soton.ac.uk> <mailto:J.V.Hernand
>> Pretorius
>> <retha.pretorius@astro.ox.ac.uk> <mailto:retha.pr
>> ekuulker@sciops.esa.int <mailto:ekuulker@sciops.e
>> <ekuulker@sciops.esa.int> <mailto:ekuulker@scioj
>> <P.Gandhi@soton.ac.uk> <mailto:P.Gandhi@soton.
>> <rih@phys.lsu.edu> <mailto:rih@phys.lsu.edu>, Jo
>> <jorge.casares@iac.es> <mailto:jorge.casares@iac.
>> <Teo.Munoz-Darias@iac.es> <mailto:Teo.Munoz-I
>> P.A. <P.A.Charles@soton.ac.uk> <mailto:P.A.Charle
>> Erik.Kuulkers@sciops.esa.int <mailto:Erik.Kuulkers@
>> <erik.kuulkers@sciops.esa.int> <mailto:erik.kuulke
>> matthews.j. (jm8g08) <jm8g08@soton.ac.uk> <ma
>> Joe Patterson <jop@astro.columbia.edu> <mailto:j
>> Nick Higginbottom
>> <nick.higginbottom@fastmail.fm> <mailto:nick.hi
>> Bird A.J. <A.J.Bird@soton.ac.uk> <mailto:A.J.Bird@
>> Sivakoff <sivakoff@ualberta.ca> <mailto:sivakoff@
>> Thorstensen
>> <john.r.thorstensen@dartmouth.edu> <mailto:john
>> James Miller-Jones
>> <james.miller-jones@curtin.edu.au> <mailto:jame
>> Boris Gaensicke
>> <Boris.Gaensicke@warwick.ac.uk> <mailto:Boris.G
>> Danny Steeghs
>> <dsteeghs@cfa.harvard.edu> <mailto:dsteeghs@c
>> Dhillon
>> <vik.dhillon@sheffield.ac.uk> <mailto:vik.dhillon@
>> Marsh <t.r.marsh@warwick.ac.uk> <mailto:t.r.mars
>>
```

```
>> I may not be the best person to actually organize this (or, in fact,
>> organize anything at all), but, just to get the ball rolling, here is
>> the sort of thing I'm thinking of. Ideally, we'd like to get something
>> like this simultaneously (where my observatory suggestions are
>> Euro-centric for now -- apologies)
```

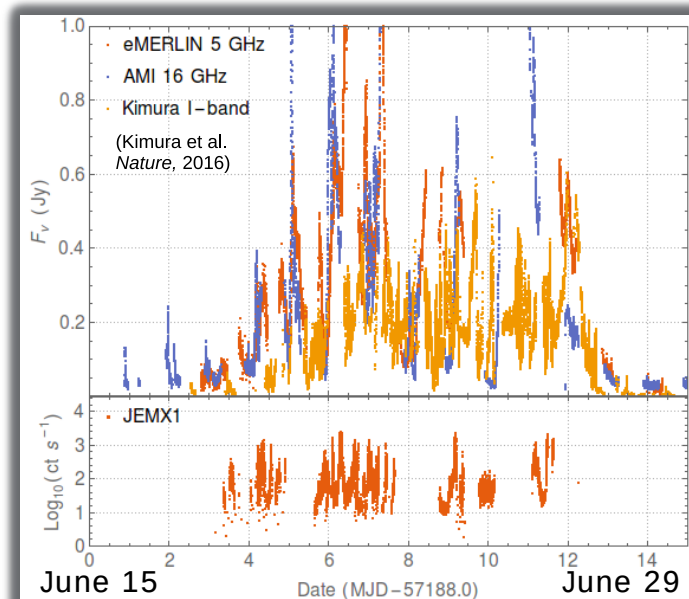
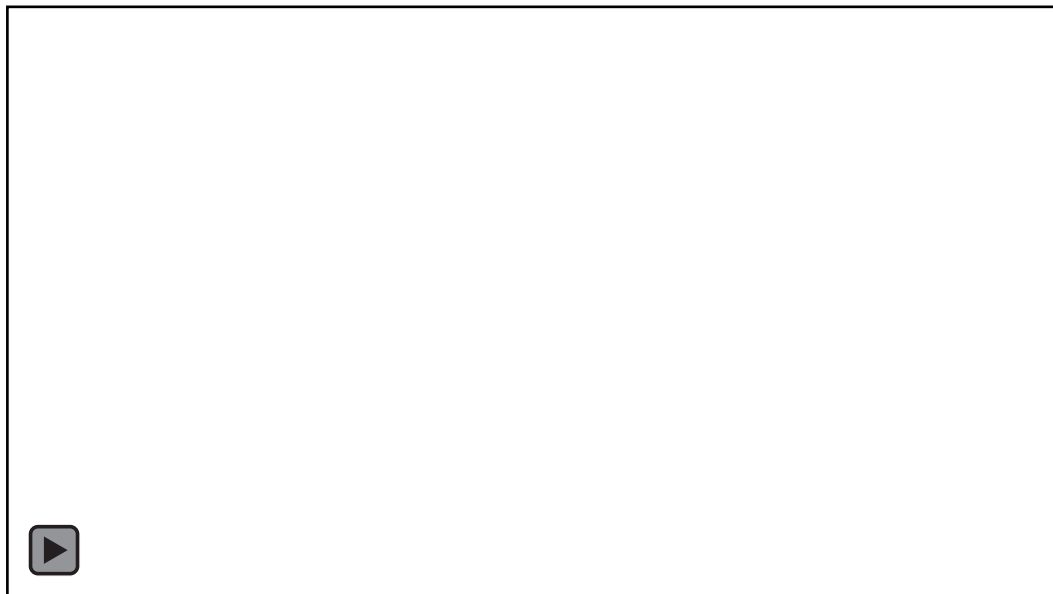
```
-- X-ray --> Swift [Chandra, XMM]
-- UV photometry --> Swift/UVOT
-- UV spectroscopy --> [HST]
-- Time-resolved optical spectroscopy --> WHT, INT, TNG, NOT, CA3.5,
CA2.2
-- optical photometry --> ptm5, WHT (Ultracam), IAC-80, Mercator, INT,
IAC-80, TNG, NOT, CA2.2
-- Time-resolved NIR spectroscopy --> WHT, NOT, CA3.5
-- NIR photometry --> TCS, CA2.2
-- radio -- AMI [VLA, others]
```

```
>> The goal would then be to try and get overlapping data across all these
>> categories during, say, one night within the next few days.
```

```
>> Many of you have more experience than me in putting this sort of
>> campaign together -- I realize that it's tricky, not least because even
>> most ground-based DDT programs usually like to require several weeks of
>> warning, which is impossible. However, I guess what I'm asking is
>> whether we really think there is no hope that we'd be granted a special
>> exception for this once-in-25-years event. In particular, I'm hoping
>> that we might have more clout if we asked *as a consortium* to get, say,
>> 1 or 2 coordinated overrides during which we simultaneously try to look
>> at all different bands, both spectroscopically and photometrically,
```



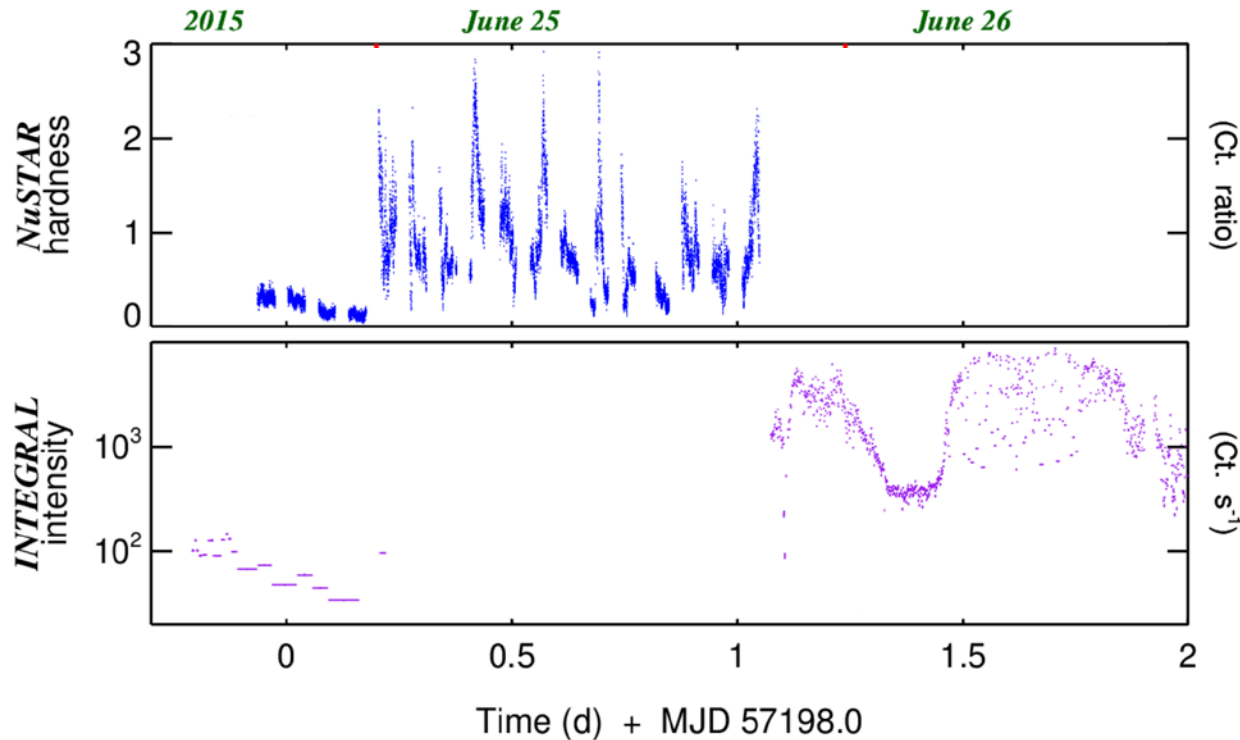
Coordination in the old days – example result



2015

Multi- λ : ~ 19 orders of magnitude
from 150 Mhz to 10 TeV

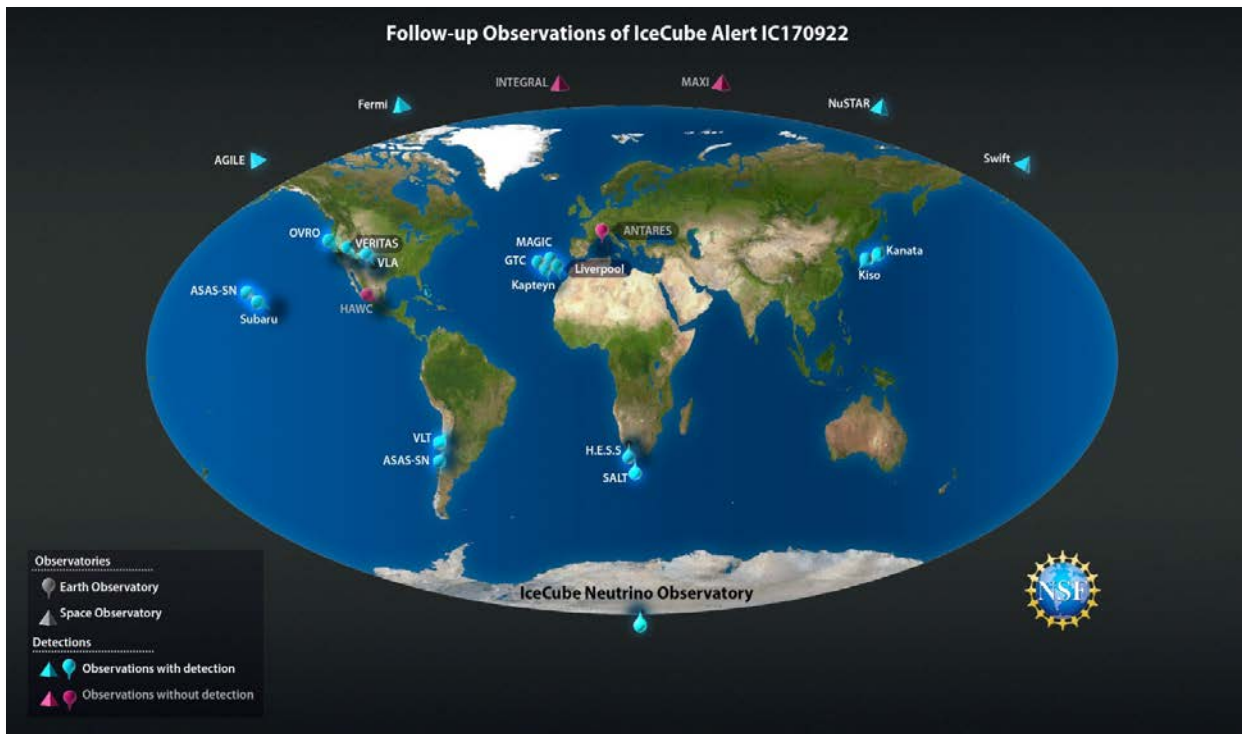
Coordination in the old days – example result



uh-oh...

Gandhi *et al.* 2017, Nature Astronomy

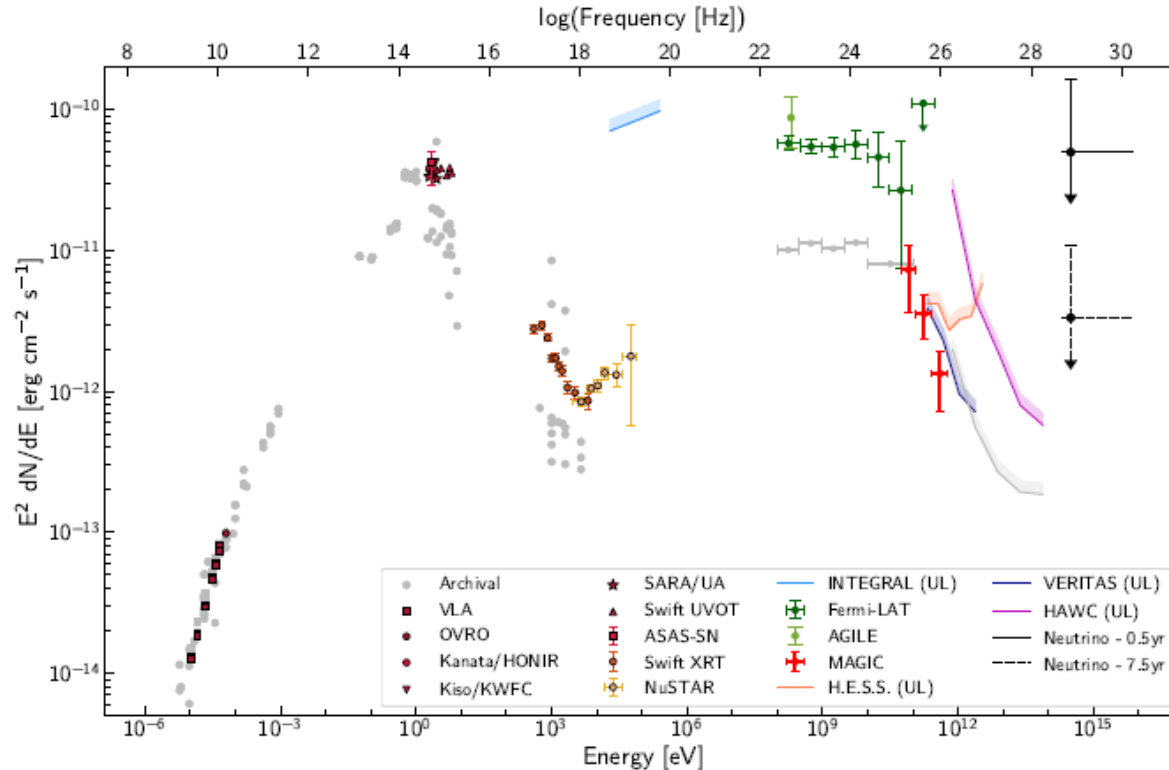
2017: the astrophysical landscape changes...



22 September 2017
IceCube high-energy
neutrino event:
IceCube-170922A

➤ ~20 ground- and space-based observatories

1010 scientists working together...



Aartsen *et al.* 2018, Science

IceCube-170922A
=
flaring γ -ray blazar
TXS 0506+056

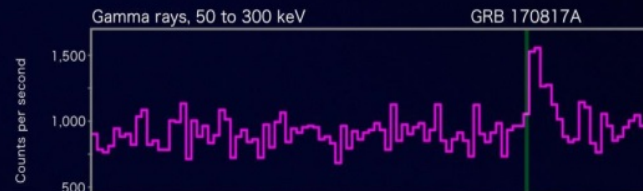
[2018Sci...361.1378I](#)

IceCube Collaboration; Aartsen, M. G.; Ackermann, M.; Adams, J.; Aguilar, J. A.; Ahlers, M.; Ahrens, M.; Al Samarai, I.; Altmann, D.; Andeen, K.; **and 1001 coauthors**

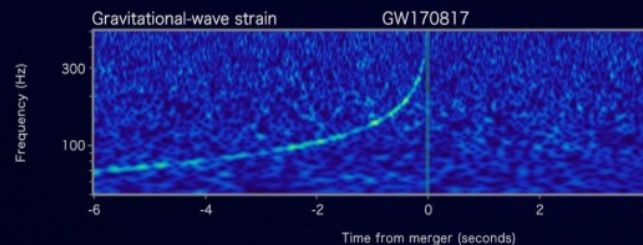
Gravitational waves and gamma-rays...

17 August 2017:
GW170817
GRB170817A

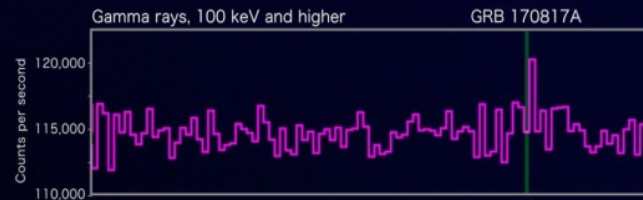
Fermi



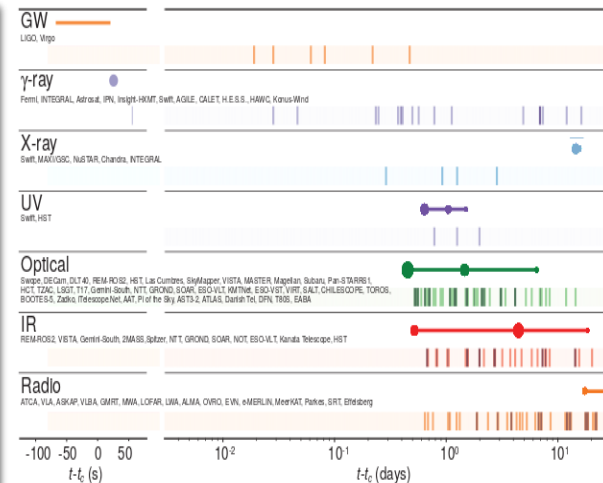
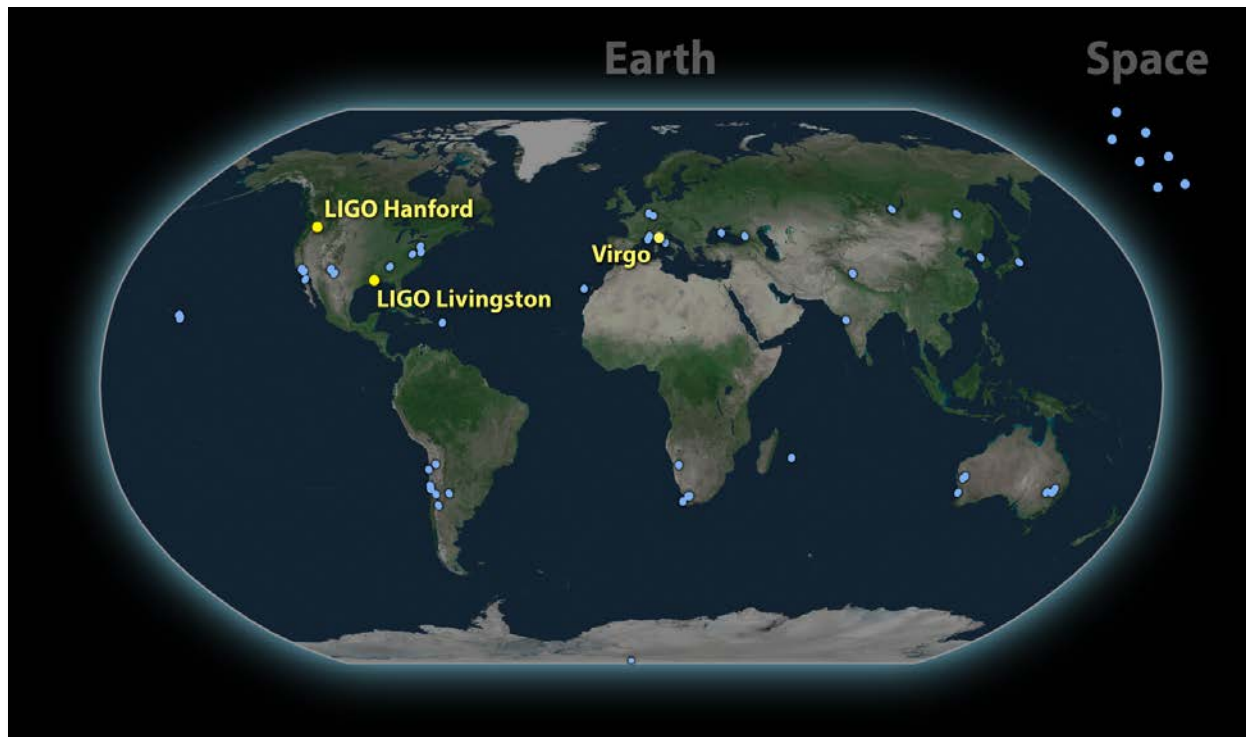
LIGO-Virgo



INTEGRAL



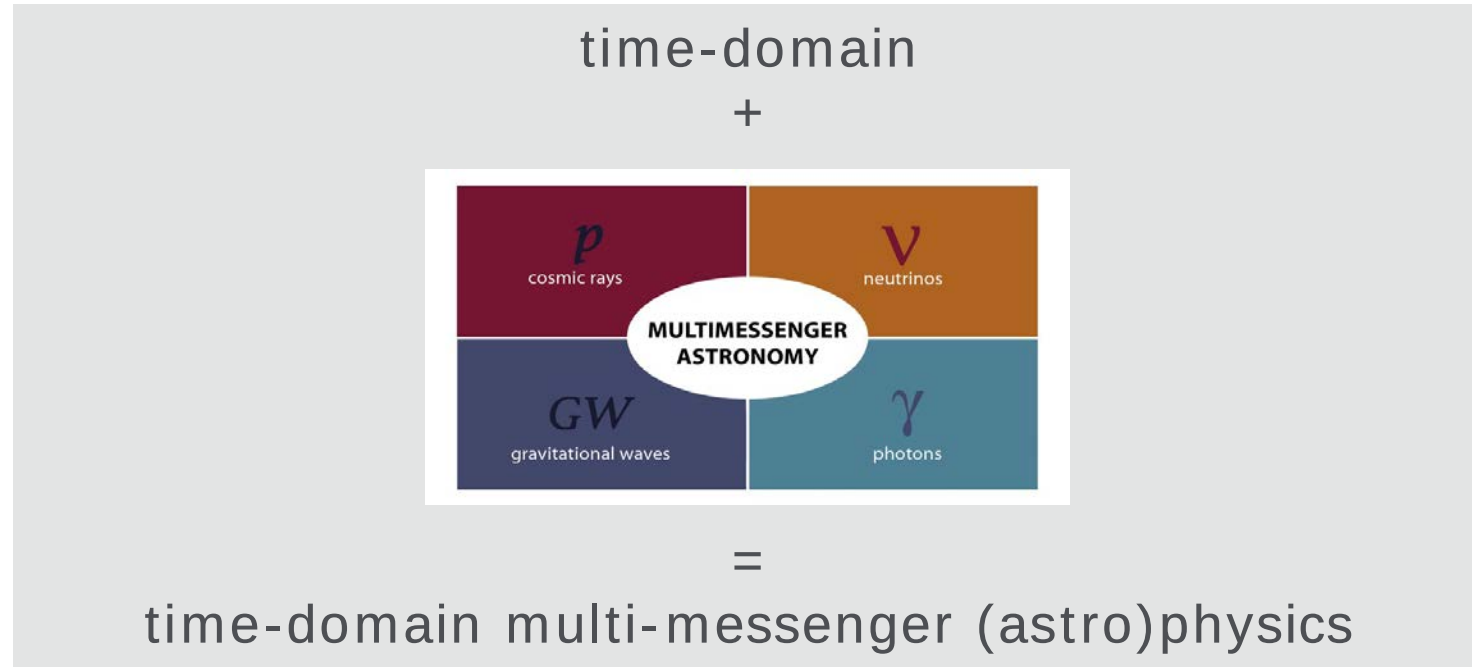
Worse: 3676 scientists working together...



[2017ApJ...848L..12A](#)

Abbott, B. P.; Abbott, R.; Abbott, T. D.;
Acernese, F.; Ackley, K.; Adams, C.; Adams, T.;
Addesso, P.; Adhikari, R. X.; Adya, V. B.; and 3666
coauthors

➤ ~70 ground- and space-based observatories



Multi-Messenger – it's hot...



- Conference on [Multi-Messenger](#) Astronomy in the Era of LIGO-India, 15-18/1/2019
- INTEGRAL looks AHEAD to [Multi-Messenger](#) Astrophysics, 11-15/2/2019
- The New Era of [Multi-Messenger](#) Astrophysics, 25-29/3/2019
- The [Multi-Messenger](#) Physics and Astrophysics of Neutron Stars, 22-26/4/2019
- Enabling [Multi-Messenger](#) Astrophysics in the Big Data Era, 25-26/4/2019
- [Multi-messenger](#) astronomy with SKA precursors and pathfinders. 13-15/5/2019
- Gamma-Ray Bursts and Related Astrophysics in [Multi-Messenger](#) Era, 13-17/5/2019
- Inference for [Multi-Messenger](#) Astrophysics Workshop, 30/5/2019
- EWASS 2019: Cosmology and [Multi-Messenger](#) Astrophysics with Gamma-Ray Bursts, 24-25/6/2019
- IGC@25: [Multi-Messenger](#) Universe, 24-27/6/2019
- Compact Objects and Energetic Phenomena in the [Multi-Messenger](#) Era, 14-16/7/2019
- The New Era of Collaborative Multi-Wavelength and [Multi-Messenger](#) Astronomy, 22-24/10/2019
- [Multi-Messenger](#) Astrophysics in the Gravitational Wave Era, 24-25/10/2019
- ESA/ESO Workshop 2019 “Cross Facilities Collaboration in the [Multi-Messenger](#) Era”, 19-22/11/2019
- [Multi-Messenger](#) and Neutrino Astronomy, 17-19/12/2019
- ...

**Requires improved coordination
& communication!**

**BEE-DO BEE-DO
BEE-DO BEE-DO**



Current efforts... (examples) - I



- AMON – The Astrophysical Multimessenger Observatory Network - www.amon.psu.edu
- Astronomy ESFRI – Research Infrastructure Cluster (ASTERICS) - www.asterics2020.eu
- DWF – Deeper Wider Faster programme - dwfprogram.altevista.org
- Gravitational Wave Treasure Map - treasuremap.space
- SCiMMA– Scalable Cyberinfrastructure to support Multi-messenger Astrophysics - scimma.org
- SmartNet – Simultaneous Multiwavelength Astronomy research in Transients NETWORK - www.isdc.unige.ch/smartnet/
- etc...

Current efforts... (examples) - II



- **AMON** - real-time correlation analysis of high-energy signals across all known astronomical messengers – photons, neutrinos, cosmic rays, & gravitational waves → “triggering” and “follow-up”



- **SmartNet** – Networking platform for astronomers - ease and improve the many multi-wavelength campaigns



- **Gravitational Wave Treasure Map** - coordinate electro-magnetic follow-up of gravitational-wave events → report planned and executed observations & query reports of other observers, in a programmatic way

Swift, Las Cumbres Observatory, SAGUARO (Catalina Sky Survey) & Fermi/GBM



Target visibility:

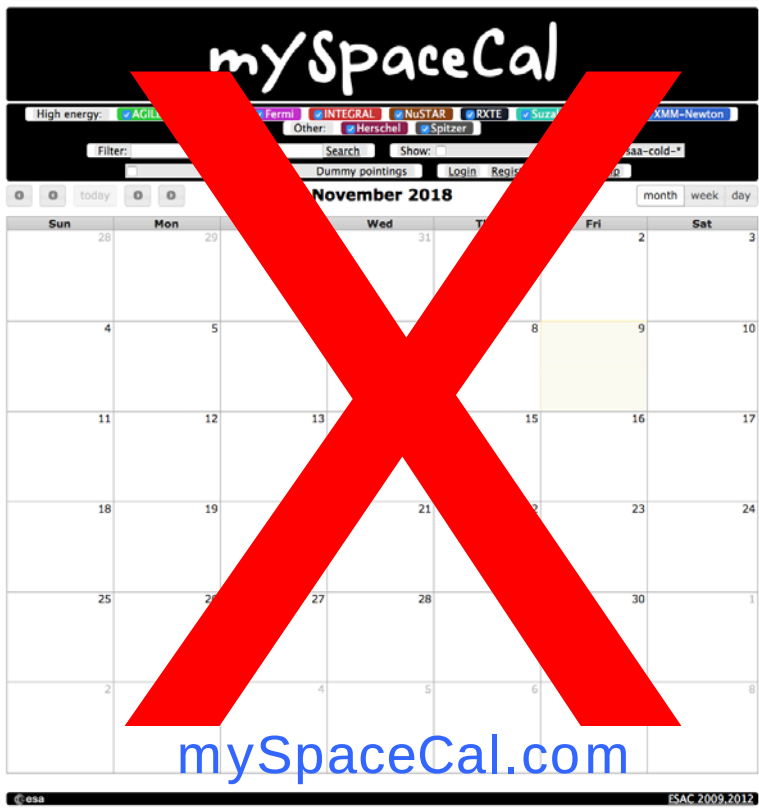
Target – facility/instrument – time period

Observing schedule (past, current, future):

Facility/instrument – time period – target

- Nowadays, many ground- and space based observatories provide tools + web info

~11 years ago, a dream: one calendar – utopia?



But:
Formats change...



Machine parsing of web pages
= tricky and prone to errors
→ can lead to *significant*
maintenance effort
for small changes

Can we do better?

➤ Yes, we can



1. All observatories provide observing schedules (also?) in *standard format*
2. Same for target visibilities

1 & 2 → automatically retrievable: **TOOLS → SERVICES**

- But: need to agree common basic terminology for time stamps, target, coordinates, etc.
- Standardise the input parameter
- Standardise the output information and format



Virtual Observatory
protocols

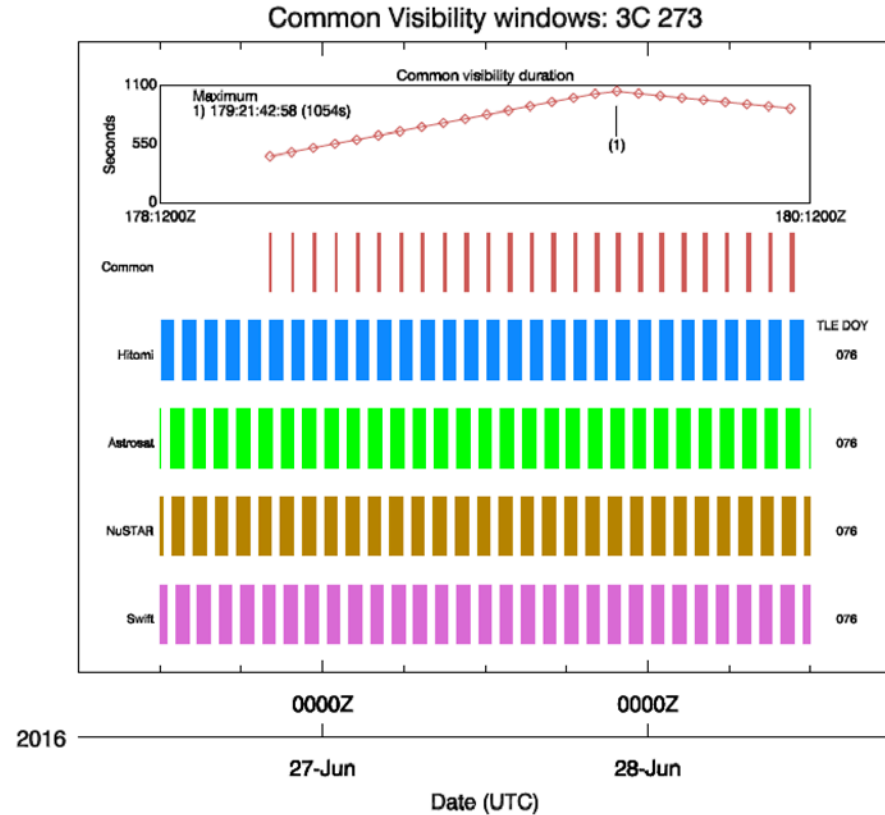


How? See talk **Jan-Uwe Ness** on **Multi-mission coordinations** – Thursday 10:00-10:20

Yes, we can!

→ Simple example of client for visibility info:

User builds tool to compile info and display



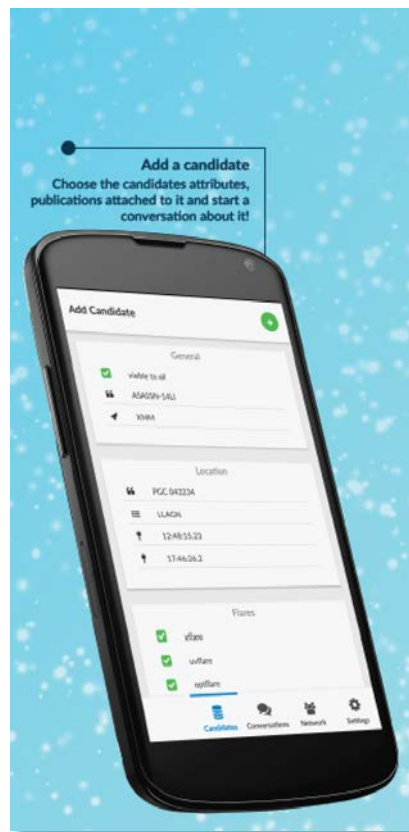
Can we do even more better?

➤ Yes, we can... we may need a new forum?

- SciApp: collaboration application, based on web mobile technologies, designed to facilitate management of observation campaigns, writing of articles and general exchange of knowledge in a specific area – [beta developed at ESA/ESAC](https://sciapp.esac.esa.int)
 - Simple, intuitive, easy-to-read interface
 - Target visibility checks
 - Visibility checker
 - Image and data storage and exchange
 - Real-time access to alerts
 - Basic data visualization, e.g., light curves
 - Virtual Observatory compliant
 - Easy access to database results, e.g., Vizier, NED, SDSS, 6DF, Catalina, ...
 - Database of candidates and publications
 - Skill database of all people registered

<https://sciapp.esac.esa.int>





European Space Agency

Conclusions

➤ One format fits all?

- Short-term (+ mid- & long-term) schedules in standard format (*service*)
 - Visibility (output) in standard format (*service*)
 - Interface with explicitly machine readable information (*clients*)
- In order to work: need ground- and space based facilities onboard!*

➤ Synergy / coordination forum?

- Collaboration application → SciApp?
 - Simple, intuitive, easy-to-read interface
 - Image / data storage & exchange
 - Build-in visibility checker & observation schedules

Needs further development...



WE NEED YOU!

“

SOMETIMES THE
UNIVERSE ALLOWS
FOR THE MAKING
OF UNEXPECTED
MEMORIES.

PHILIPPA GEORGIU

Thank you



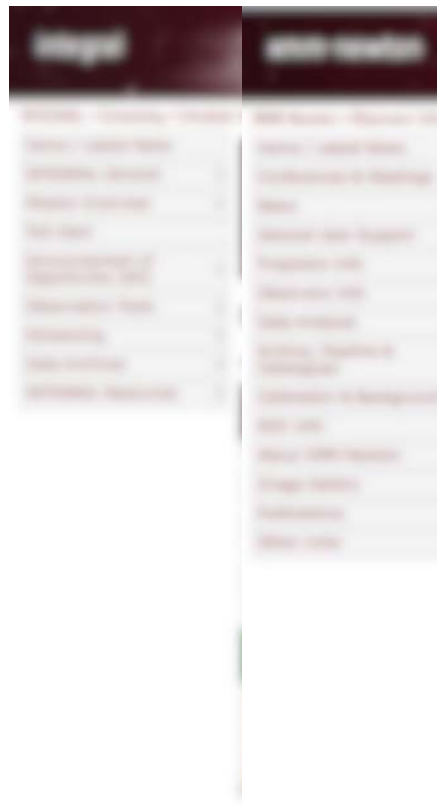
Erik.Kuulkers@esa.int
@ekuulkers

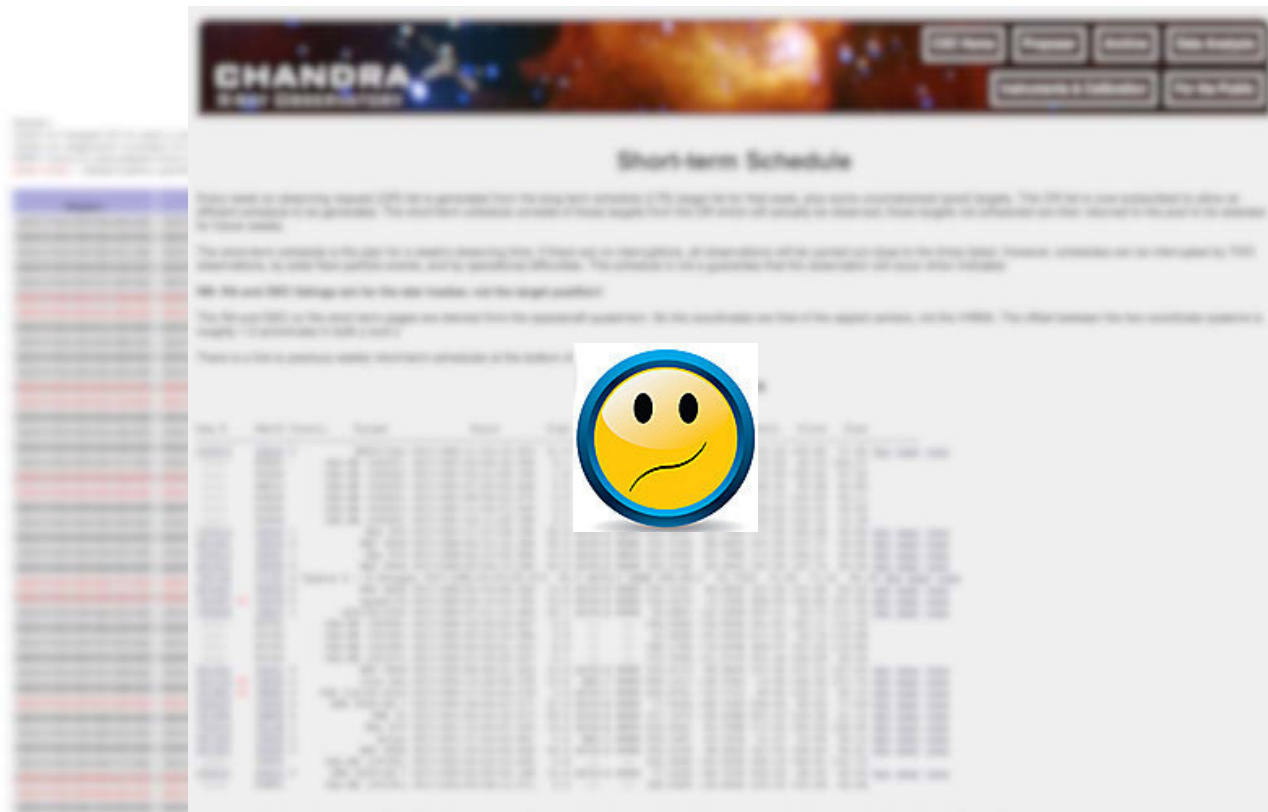
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Back-up...



Observing schedule today - examples







Target visibility today - examples



Target visibility today - examples

BELOW.



Target	RA	Dec	Mag	Parallax	Proper Motion	Distance	Velocity	Age	Notes
2404	1010-07-11 12:07	70245	1010-07-12 09:33	72000	0.47	0.93	52.0	66.3	

Yes, we can!

→ Simple example of a client for visibility & schedule info

User builds tool to compile info & display

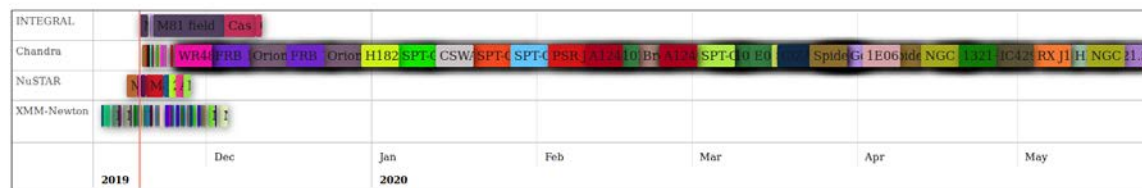
MULTIMISSION VISIBILITY AND SCHEDULE

Source name	
NGC 3227	Look up
Coordinates (RA, DEC) in degrees *	
155.87737	19.86508
Start and End (UTC) *	
2019-11-18T09:14	2020-05-18T08:14
Start and End (MJD)	
58805.385405092	58987.343738425
Calculate	

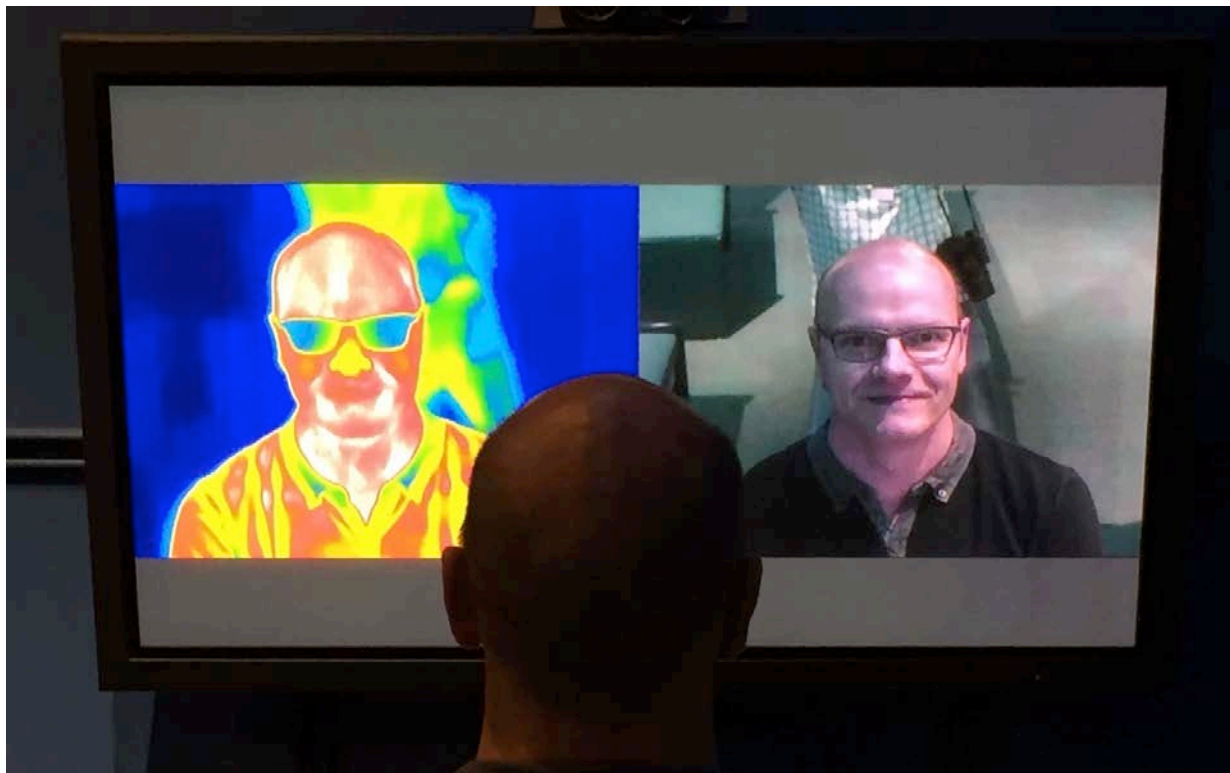
Visibility



Schedule



Why different wavelengths?



Different information at different wavelengths!

