

***Coordinating observations
among ground and space-
based telescopes in
the multi-messenger era***

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MM Asterics2020

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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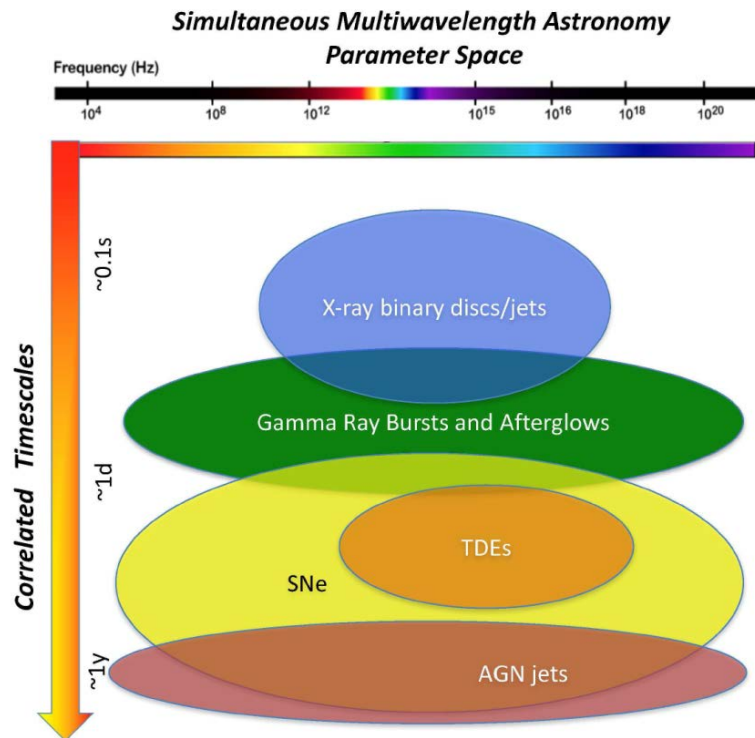
27 March, 2019. A Wednesday....

Presentation outline:

- *Coordinating observations: the old way*
- *Observing schedules & visibility info*
- *Standardisation → VO*
- *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

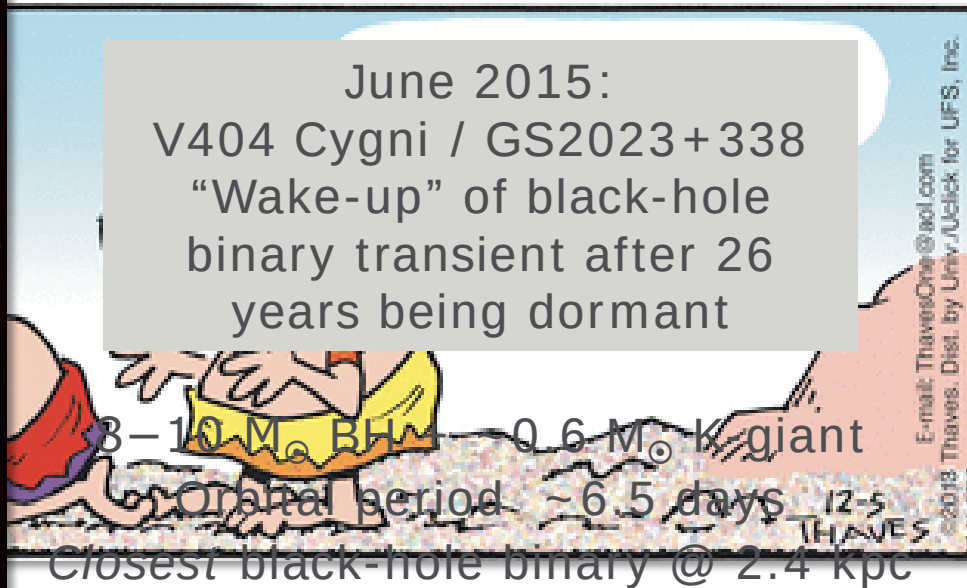
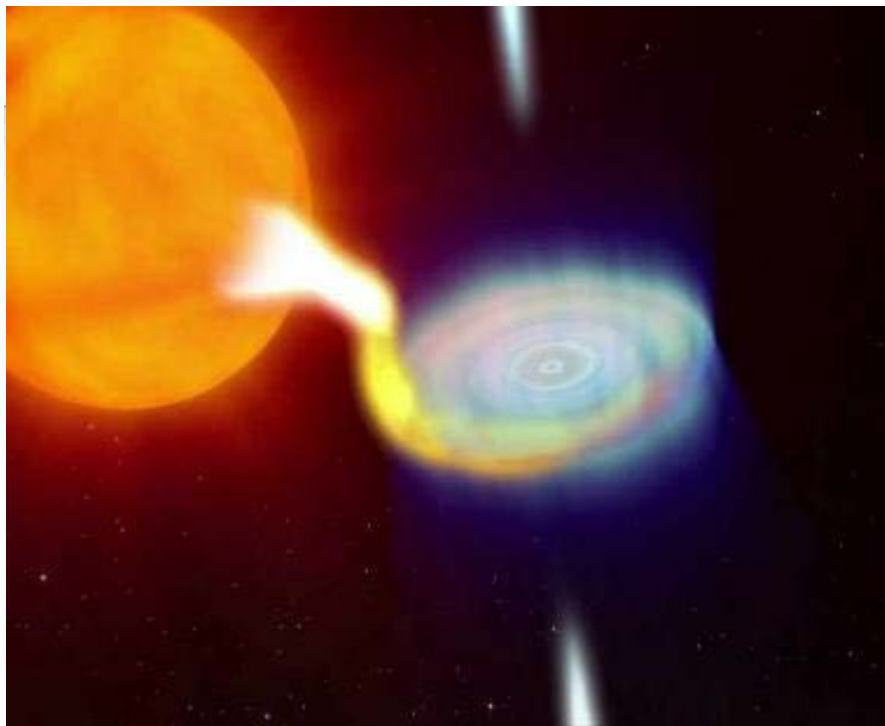
Increasing interest to
simultaneously observe
same target at
different wavelengths at
various time scales

➤ Some numbers:

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



Coordination 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@astro.ox.ac.uk>>
>> To: Altamirano D.
>> <D.Altamirano@soton.ac.uk> <<mailto:D.Altamirano@soton.ac.uk>>
>> <C.Knigge@soton.ac.uk> <<mailto:C.Knigge@soton.ac.uk>>
>> CC: Shaw A. <A.Shaw@soton.ac.uk> <<mailto:A.Shaw@soton.ac.uk>>
>> Hernandez Santisteban J.V.
>> <J.V.Hernandez@soton.ac.uk> <<mailto:J.V.Hernandez@soton.ac.uk>>
>> Pretorius
>> <retha.pretorius@astro.ox.ac.uk> <<mailto:retha.pretorius@astro.ox.ac.uk>>
>> <ekuulker@sciops.esa.int> <<mailto:ekuulker@sciops.esa.int>>
>> <ekuulker@sciops.esa.int> <<mailto:ekuulker@sciops.esa.int>>
>> <P.Gandhi@soton.ac.uk> <<mailto:P.Gandhi@soton.ac.uk>>
>> <rih@phys.lsu.edu> <<mailto:rih@phys.lsu.edu>>, Jo
>> <jorge.casares@iac.es> <<mailto:jorge.casares@iac.es>>
>> <Teo.Munoz-Darias@iac.es> <<mailto:Teo.Munoz-Darias@iac.es>>
>> P.A. <P.A.Charles@soton.ac.uk> <<mailto:P.A.Charles@soton.ac.uk>>
>> <Erik.Kuulkers@sciops.esa.int> <<mailto:Erik.Kuulkers@sciops.esa.int>>
>> <erik.kuulkers@sciops.esa.int> <<mailto:erik.kuulkers@sciops.esa.int>>
>> matthews j. (jm8g08) <jm8g08@soton.ac.uk> <<mailto:jm8g08@soton.ac.uk>>
>> Joe Patterson <jop@astro.columbia.edu> <<mailto:jop@astro.columbia.edu>>
>> Nick Higginbottom
>> <nick_higginbottom@fastmail.fm> <mailto:nick_higginbottom@fastmail.fm>
>> Bird A.J. <A.J.Bird@soton.ac.uk> <<mailto:A.J.Bird@soton.ac.uk>>
>> Sivakoff <sivakoff@ualberta.ca> <<mailto:sivakoff@ualberta.ca>>
>> Thorstensen
>> <john.r.thorstensen@dartmouth.edu> <<mailto:john.r.thorstensen@dartmouth.edu>>
>> James Miller-Jones
>> <james.miller-jones@curtin.edu.au> <<mailto:james.miller-jones@curtin.edu.au>>
>> Boris Gaensicke
>> <Boris.Gaensicke@warwick.ac.uk> <<mailto:Boris.Gaensicke@warwick.ac.uk>>
>> Danny Steeghs
>> <dsteeghs@cfa.harvard.edu> <<mailto:dsteeghs@cfa.harvard.edu>>
>> Dhillon
>> <vik.dhillon@sheffield.ac.uk> <<mailto:vik.dhillon@sheffield.ac.uk>>
>> Marsh <t.r.marsh@warwick.ac.uk> <<mailto:t.r.marsh@warwick.ac.uk>>
>>

>> 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)

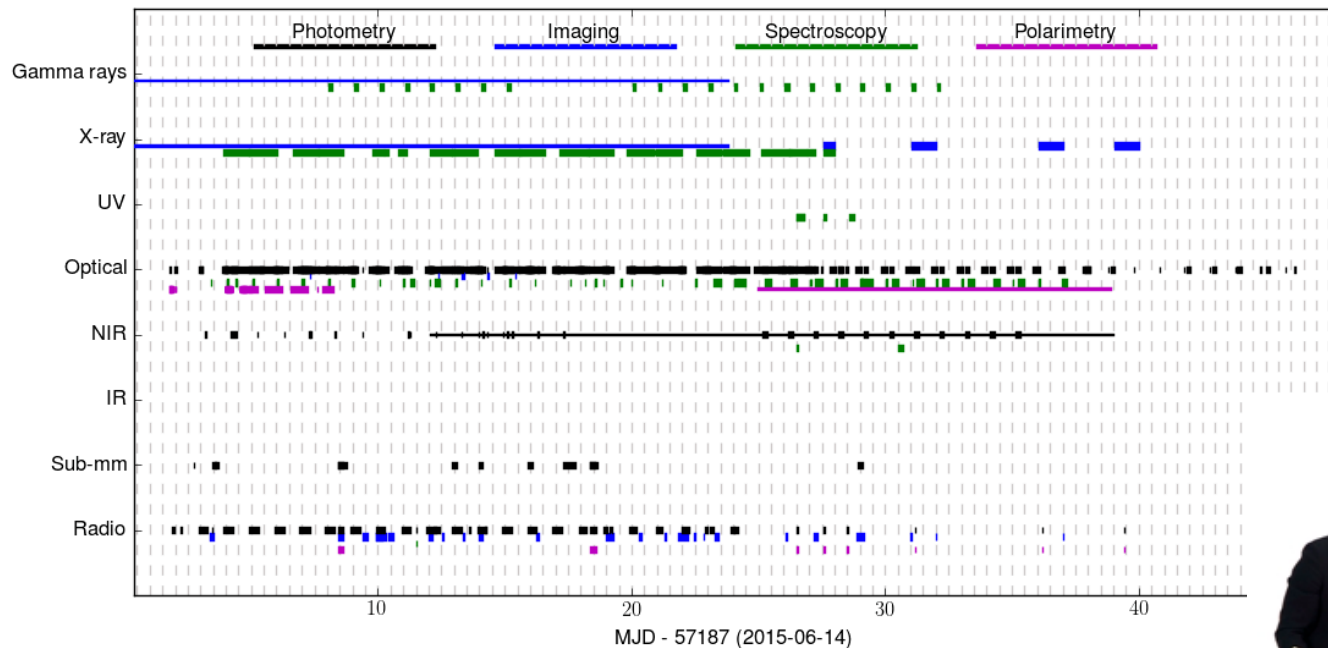
>> -- X-ray --> Swift [Chandra, XMM]
>> -- UV photometry --> Swift/UVOT
>> -- UV spectroscopy --> [HST]
>> -- Time-resolved optical spectroscopy --> WHT, INT, TNG, NOT, CA3.5,
>> CA2.2
>> -- optical photometry --> ptm5, WHT (Ultracam), IAC-80, Mercator, INT,
>> IAC-80, TNG, NOT, CA2.2
>> -- Time-resolved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

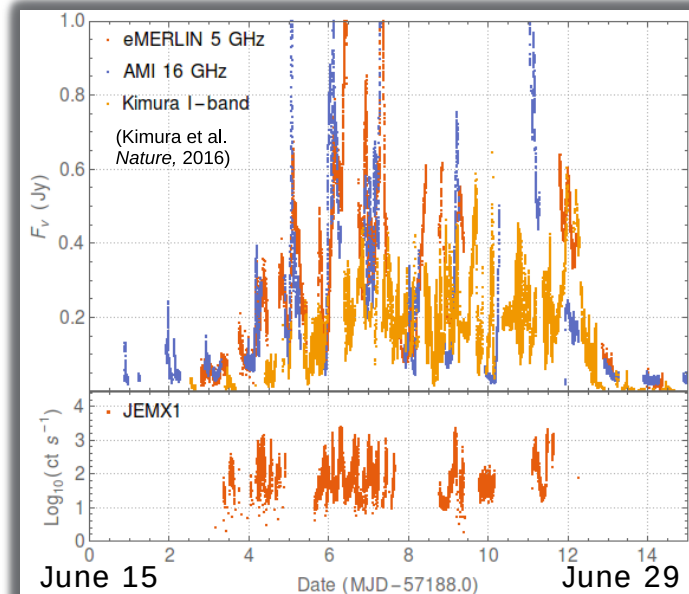
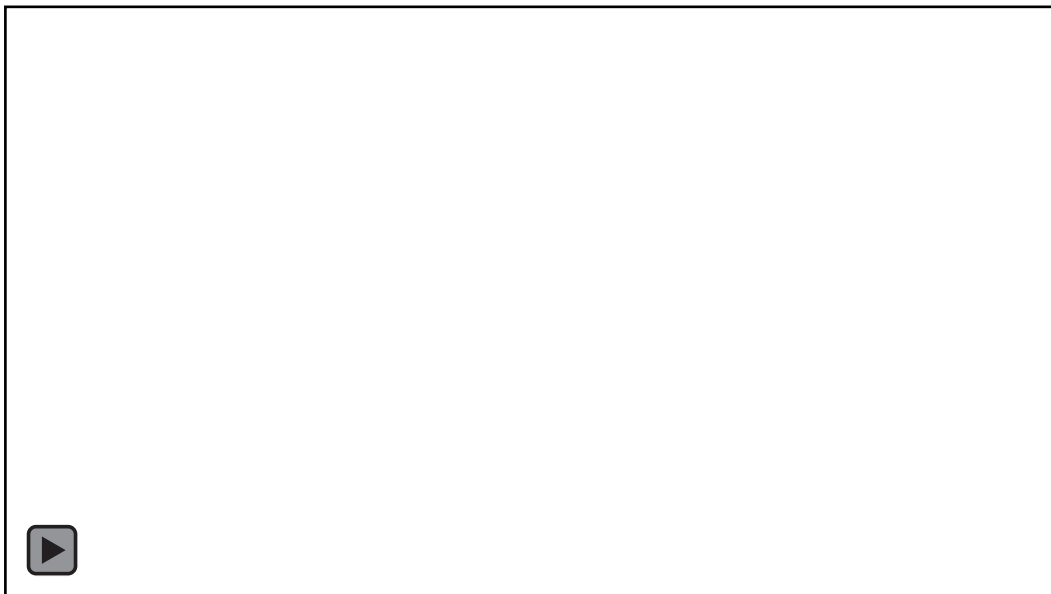


(Credit: Tom Marsh,
University of Warwick, UK)

Ad-hoc, *manual*, multi-wavelength coordination campaign
during the 2015 outburst of V404 Cygni



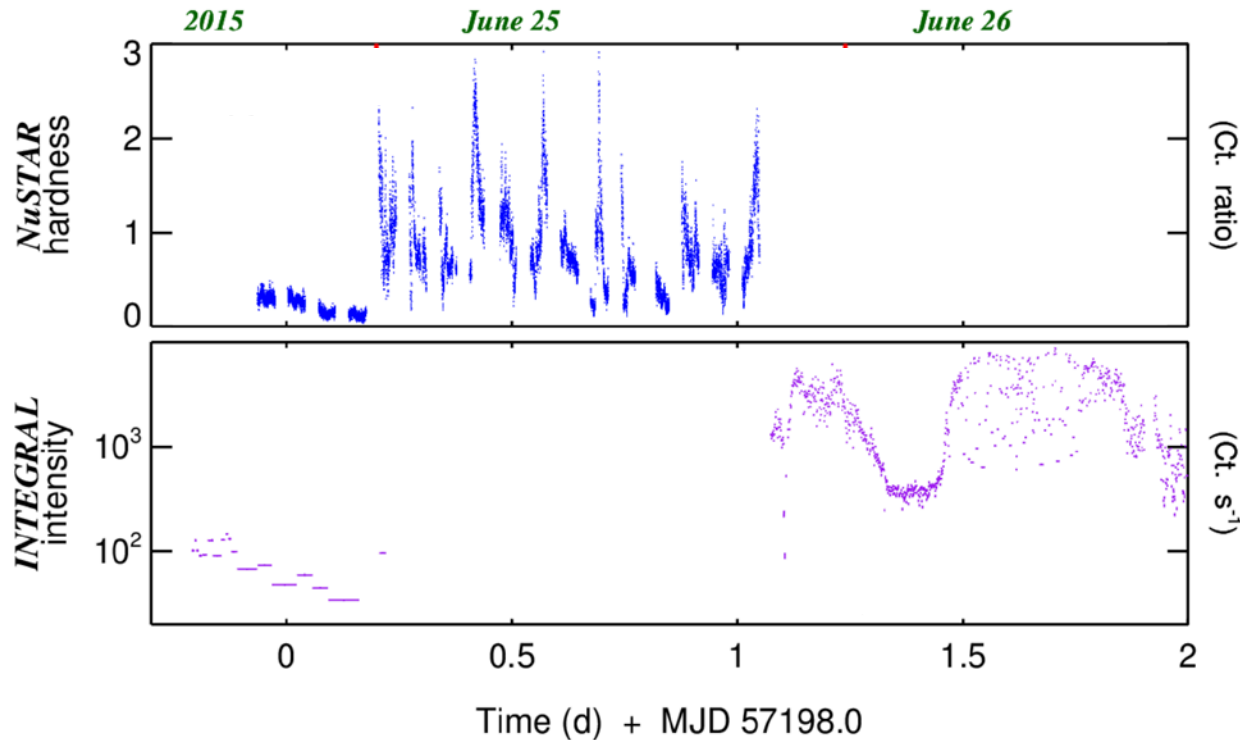
Coordination in the old days – example result



2015

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

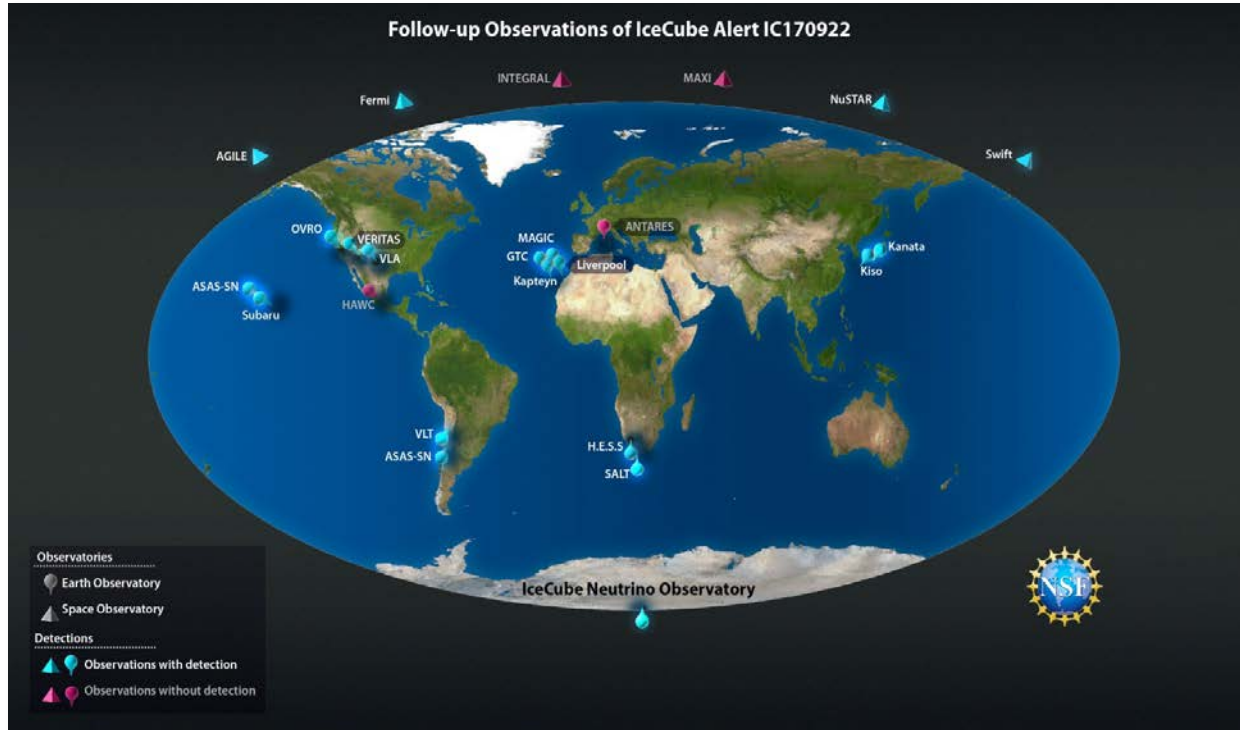
Coordination in the old days – example result



uh-oh...

Gandhi *et al.* 2017, Nature Astronomy

1010 scientists working together...



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

➤ ~20 ground- and space-based observatories

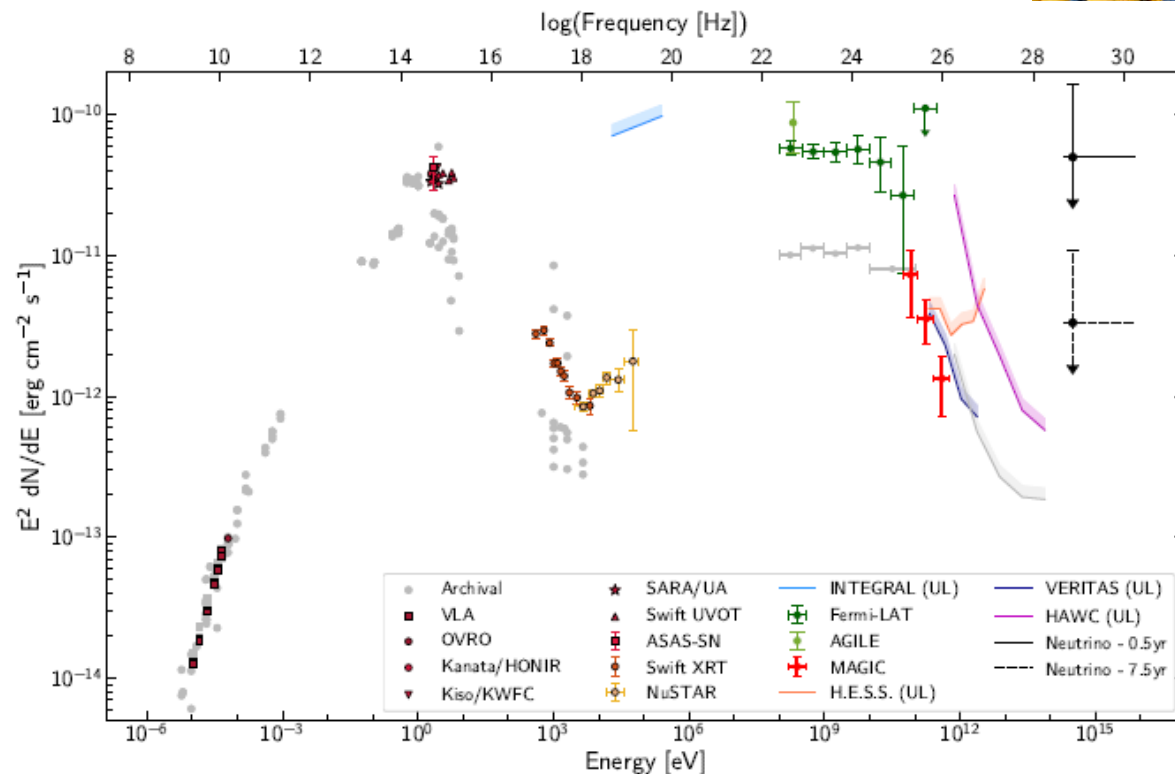
ESA UNCLASSIFIED - For Official Use

MM Asterics 2020 | Erik Kuulkers | Groningen, NL | 25-29 Mar 2019 | Slide 11



European Space Agency

1010 scientists working together...



Aartsen *et al.* 2018, Science

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

Gravitational waves and gamma-rays...

17 August 2017:
GW170817
GRB170817A

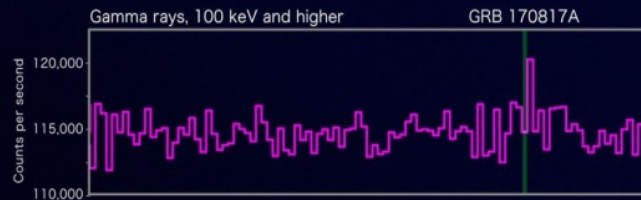
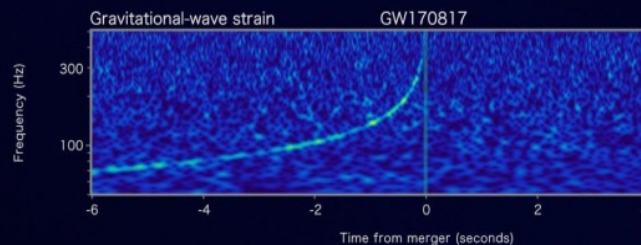
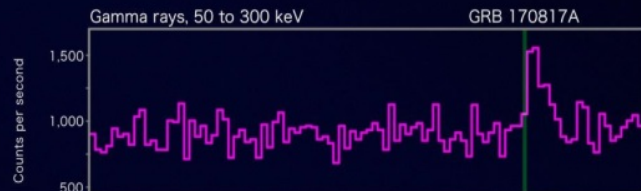
Fermi



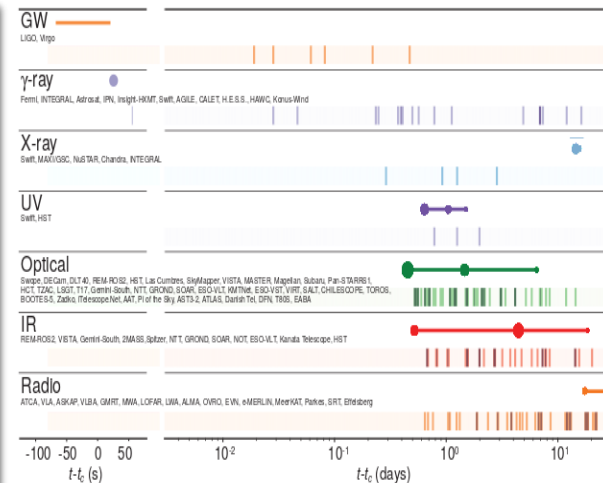
LIGO-Virgo



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

Time-domain multi-messenger (astro)physics...

Requires improved coordination!



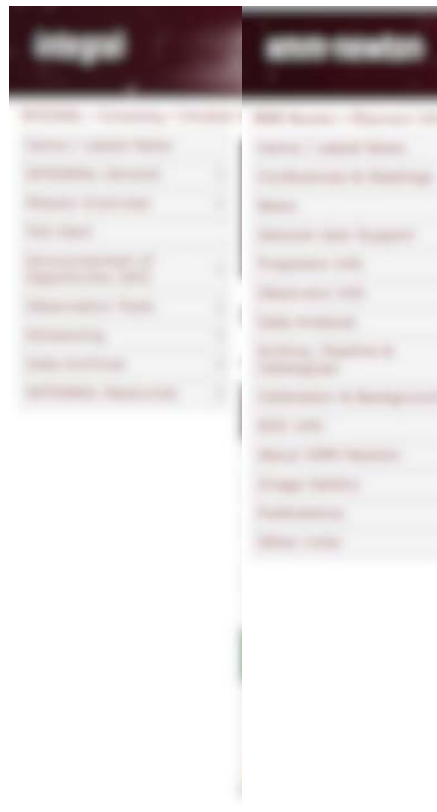
Observing schedule (past, current, future):
Facility/instrument – time period – target

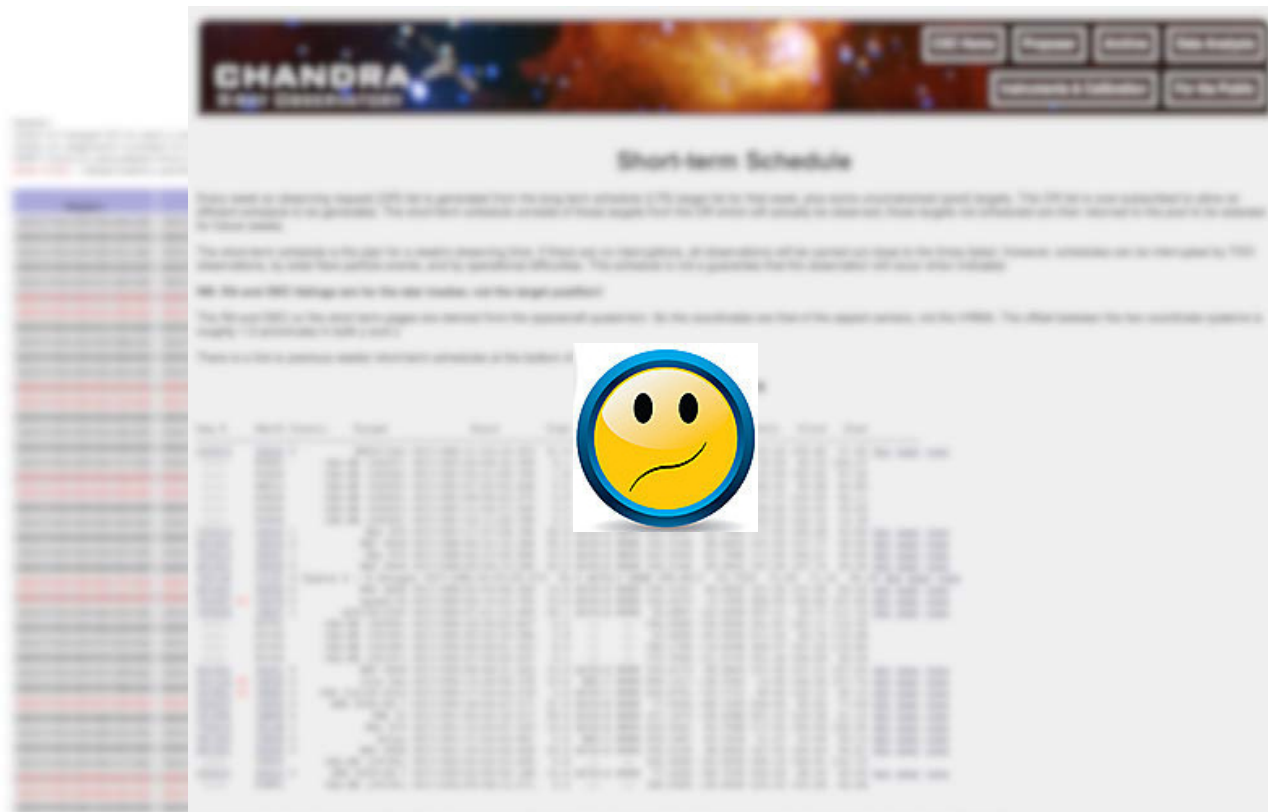
Target visibility:
Target – facility/instrument – time period

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

... but ...

Observing schedule today - examples









Cry out for a standard...



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



Yes, we can

- Standardise the input parameter
- Standardise the output information and format



Virtual Observatory
protocols



Use ObsTap as existing standard



International
Virtual
Observatory
Alliance

Observation Data Model Core Components
and its Implementation in the Table Access
Protocol

➤ **ObjVisSAP** [Object Visibility Simple Access Protocol]

<http://www.ivoa.net/documents/ObjVisSAP/> v0.5 (22 Mar 2019)

➤ **ObsLocTAP** [Observation Locator Table Access Protocol]

<http://www.ivoa.net/documents/ObsLocTAP/> v0.4 (27 Feb 2019)



International
Virtual
Observatory
Alliance

Object Visibility Simple Access Protocol



International
Virtual
Observatory
Alliance

Observation Locator Table Access
Protocol

Currently under consideration by VO consortium



Yes, we can



→ Example service for visibility info (using INTEGRAL):

Q: When is the Galactic Center visible by INTEGRAL this week?

Input (URL):

```
http://integral.esa.int/isocweb/tvp.html?startDate=24-03-2019&endDate=31-03-2019
&coordinates=equatorial&ra=266.417&dec=-29.008
&duration=12.600&dither=R&action=predict&format=json
```

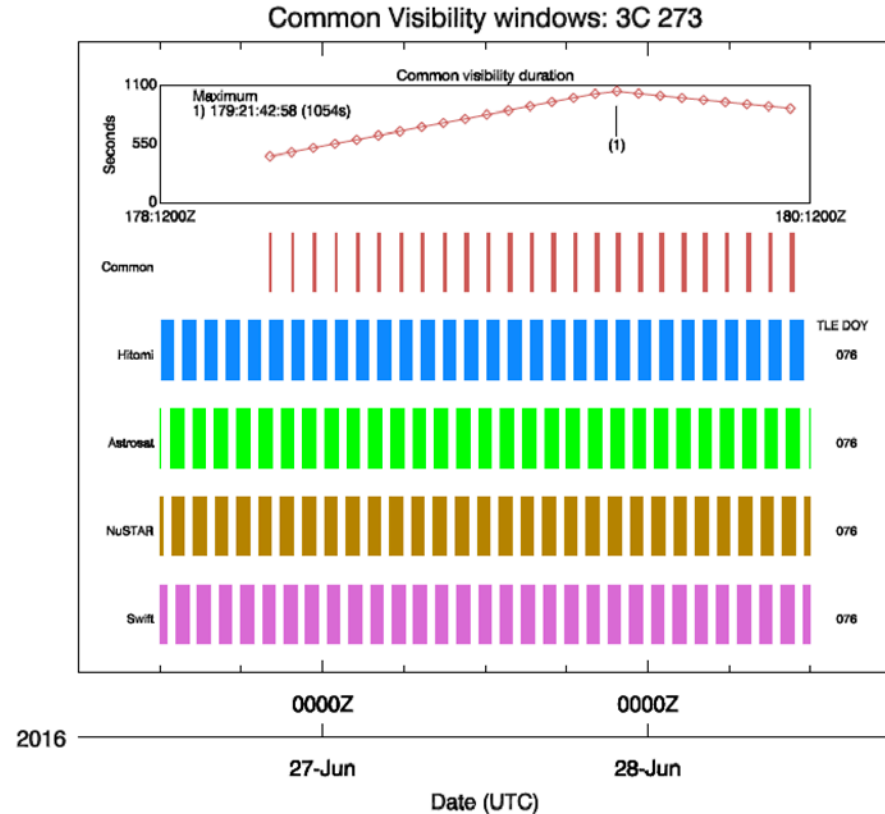
Output (JSON):

```
{ "RA": "266.417", "RAHMS": "17:45:40.08", "DEC": "-29.008", "DECHMS": "-29:00:28.8",
  "START_DATE": "2019-03-24", "END_DATE": "2019-03-31", "DITHER_PATTERN": "Raster",
  "MINIMUM_DURATION": "12.6", "TOTAL_DURATION": "375994", "INTERVALS":
  [ { "revolution": "2071", "start": "2019-03-23 16:18:43 GMT", "end": "2019-03-25 20:31:43 GMT",
    "duration": "187980" },
    { "revolution": "2073", "start": "2019-03-28 23:56:02 GMT", "end": "2019-03-31 04:09:36 GMT", "duration":
    "188014" } ] }
```

Yes, we can!

→ Simple example of client for visibility info:

User builds tool to compile info and display



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:

- ➔ Get VO protocols ObjVisSAP & ObsLocTAP certified by IVOA
- ➔ Need (all) ground- and space based facilities onboard!

Contact



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[@ekuulkers](https://twitter.com/ekuulkers)

Want more info? Read

[arXiv:1901.05390](https://arxiv.org/abs/1901.05390)

[arXiv:1903.10732](https://arxiv.org/abs/1903.10732)



WE NEED YOU!

“

SOMETIMES THE
UNIVERSE ALLOWS
FOR THE MAKING
OF UNEXPECTED
MEMORIES.

PHILIPPA GEORGIU

Thank you

MM Asterics2020

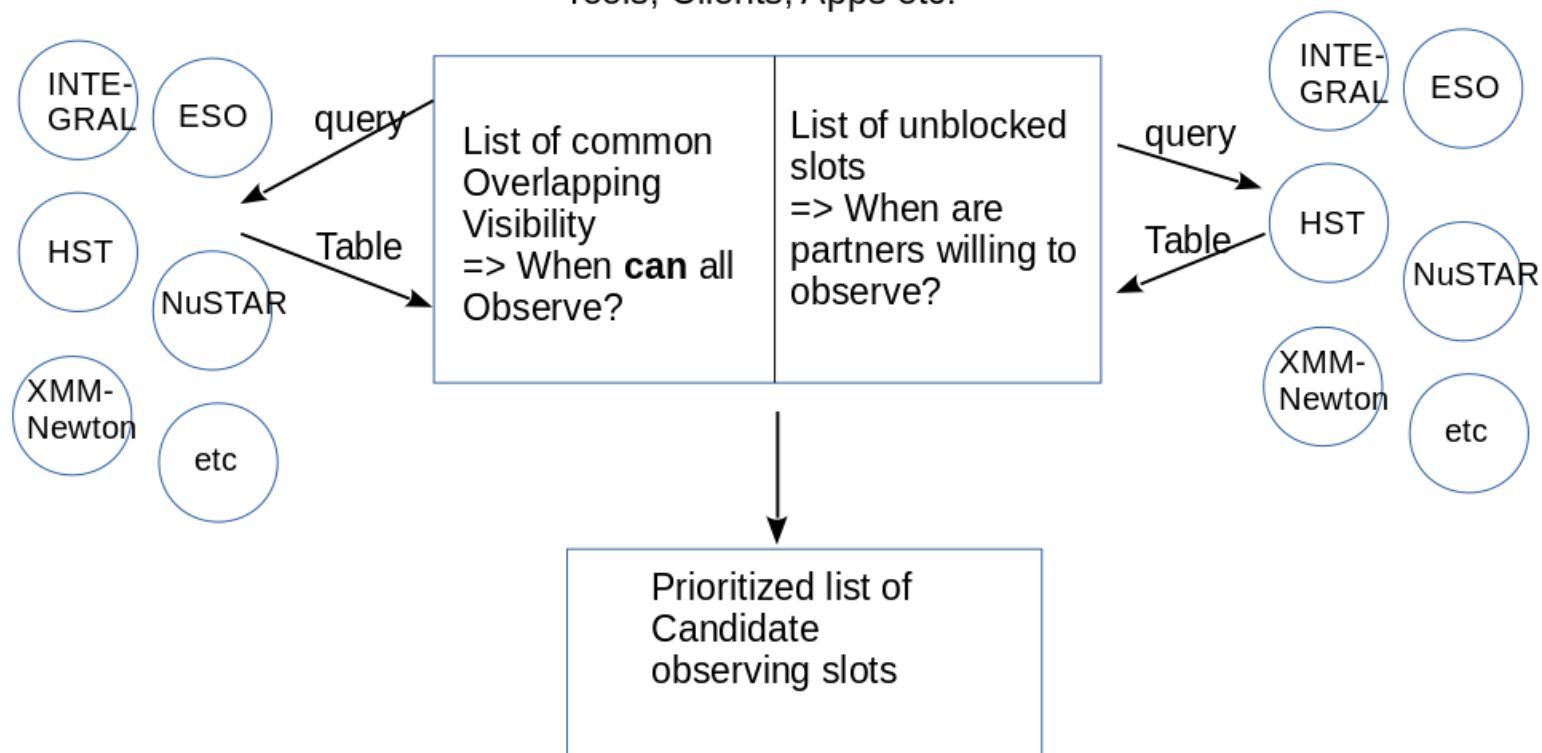
Back-up...



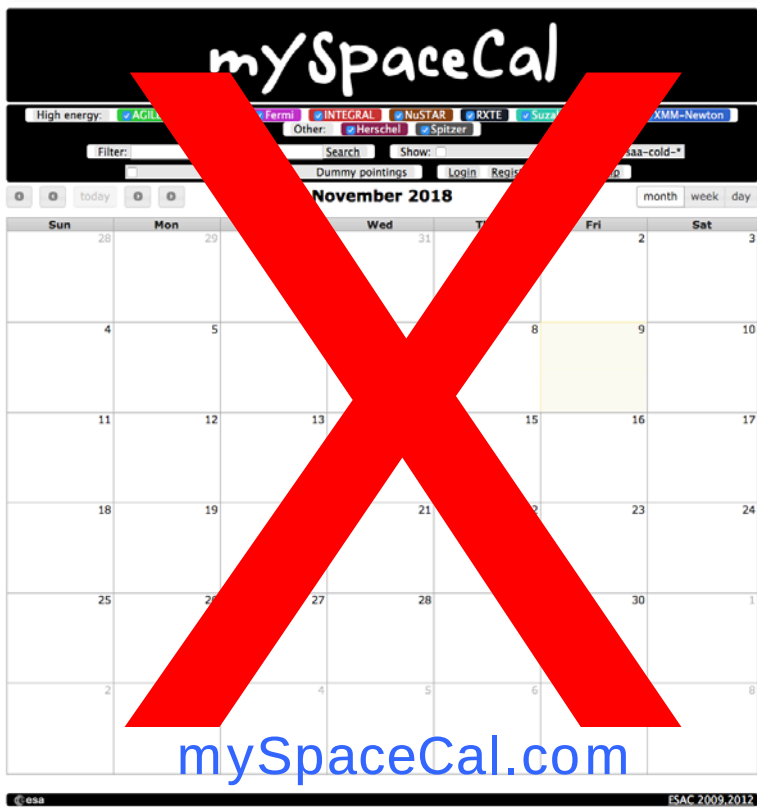
- Implementation status:
 - INTEGRAL: public test version (see examples)
 - XMM-Newton: almost ready (waiting for hardware replacements)
 - Chandra, NuSTAR: Advanced state of implementation
- Applications:
 - ASTERICS: Working on Multimessenger Platform
 - Visualization of Observing Plans and visibility in Sky.esa.int

Always happy to welcome new collaborators!

You can help us to convince observing facilities to implement VO services



~10 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 even more better?

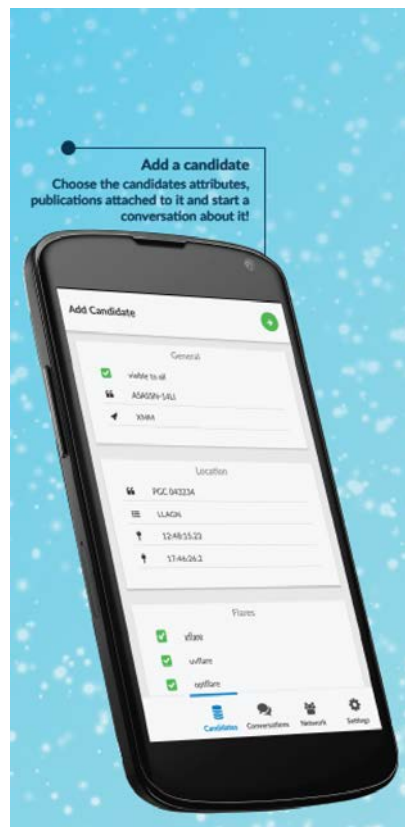
➤ Yes, we can... we may need a new forum?

- SciApp: a 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>



Collaboration application - SciApp



WATCH THE VIDEO



Hello world - VOVisObs Workshop



- 21 September 2018 @ ESA/ESAC, Spain:
Discuss details VO protocols & prototypes & operational services



- 29 participants @ ESAC
- 35 participants by video

