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

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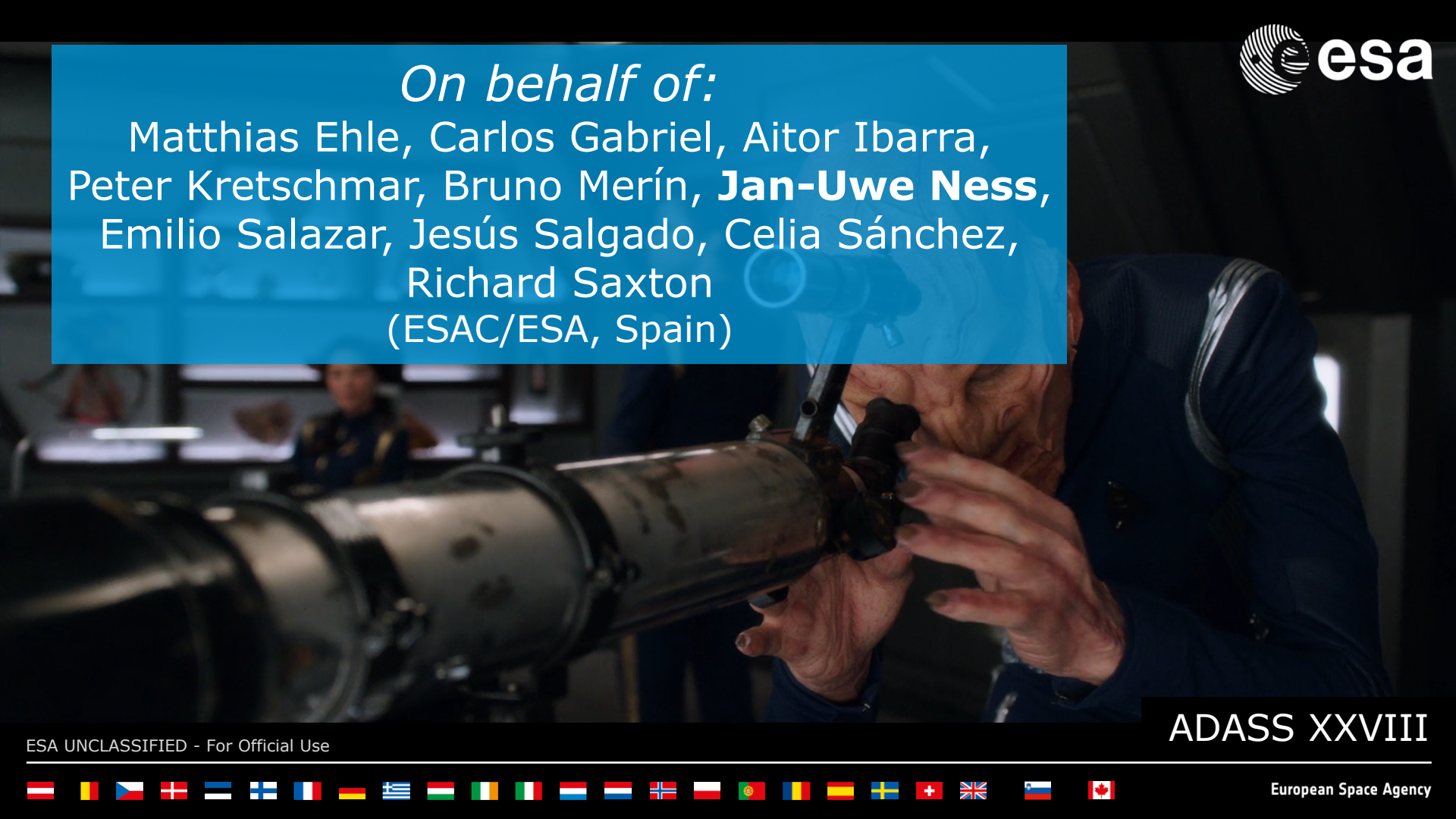
ADASS XXVIII



On behalf of:

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

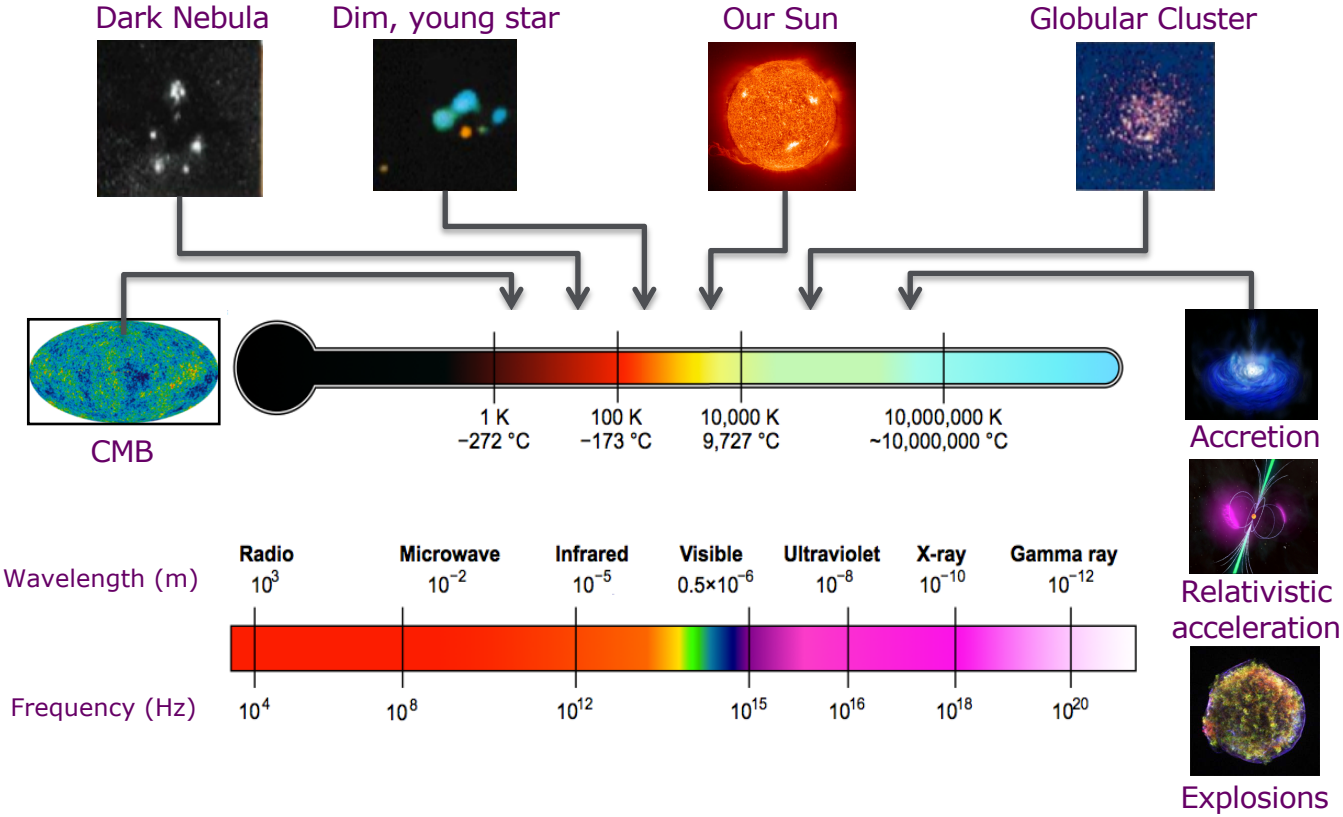
(ESAC/ESA, Spain)

November 13, 2018. A Tuesday….

Presentation outline:

- *Multi-wavelength astronomy*
- *Time-domain astronomy*
- *Coordinating observations: the old way*
- *Time-domain multi-messenger (astro)physics*
- *Observing schedules & visibility info*
- *Standardisation → VO*
- *Coordinating observations: the new way*
- *Conclusions*

The electro-magnetic (EM) universe



Why multi-wavelength?

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That’s why!

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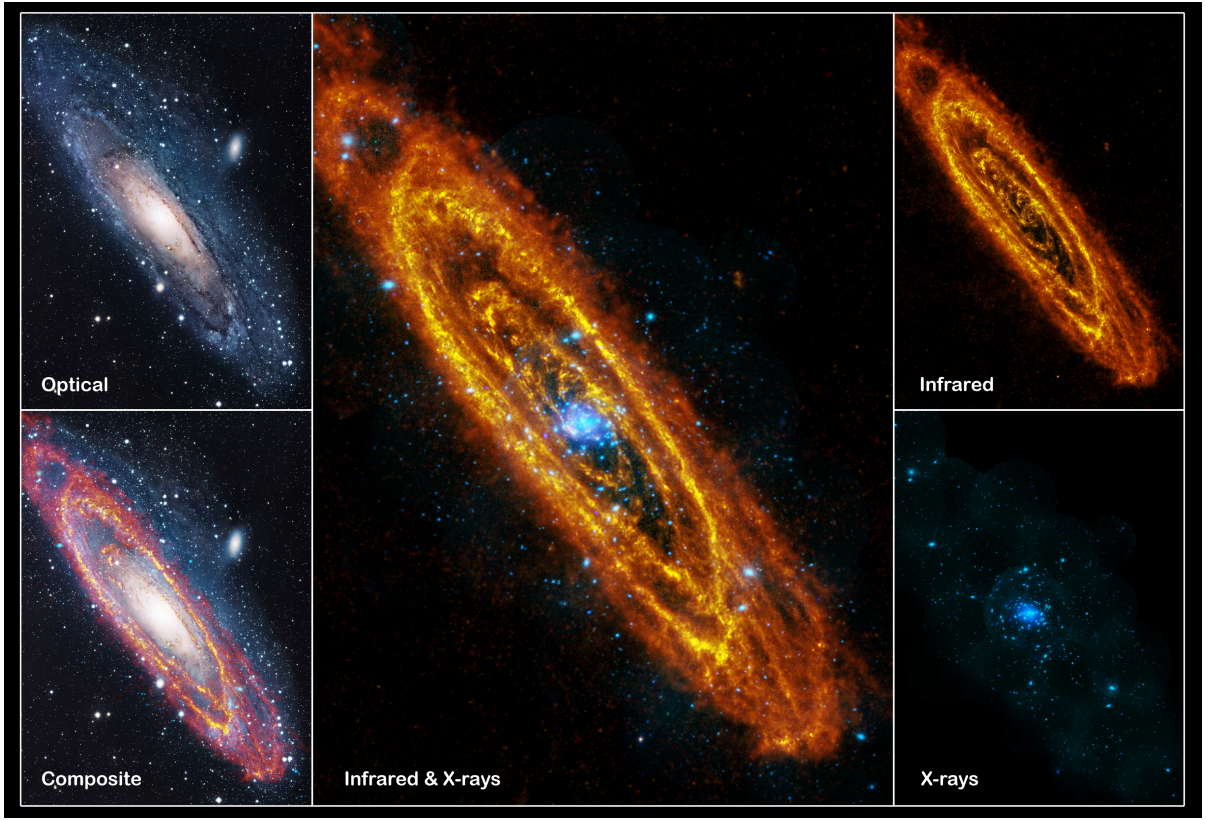
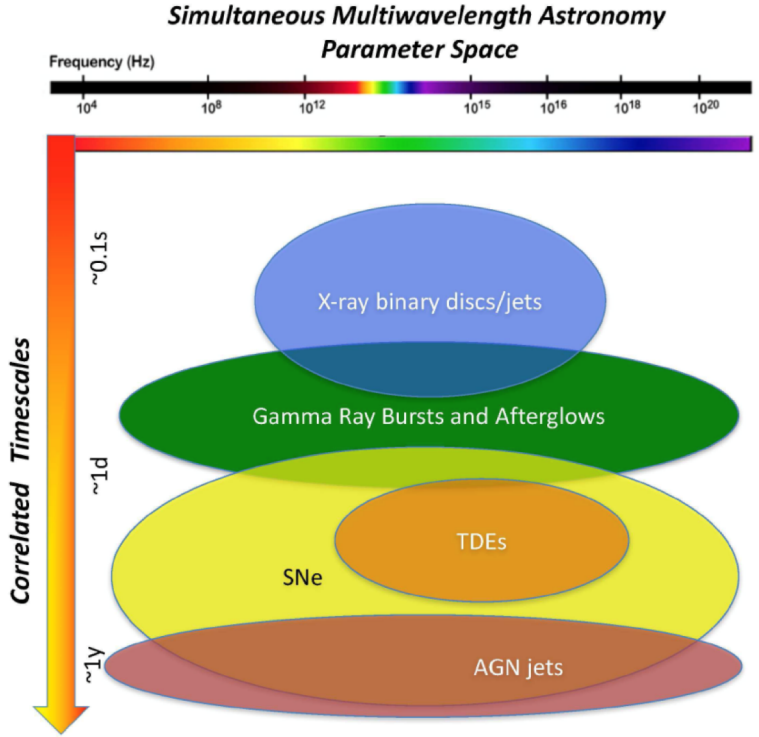


Andromeda – M31

Time-Domain multi-wavelength (EM) astronomy



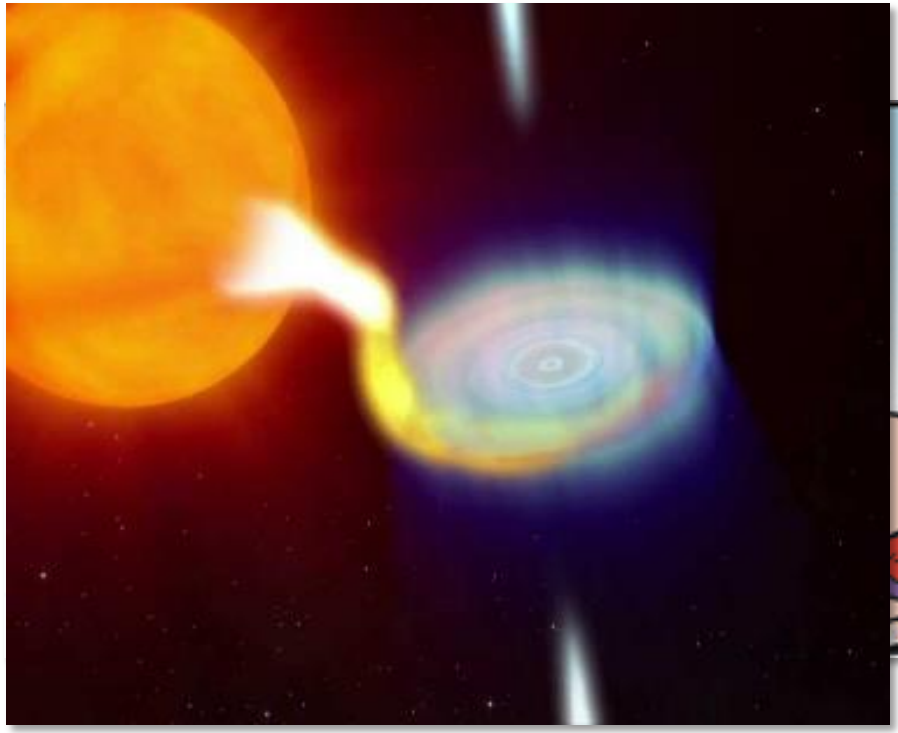
e.g., Middleton *et al.* 2017, New Astronomy Reviews

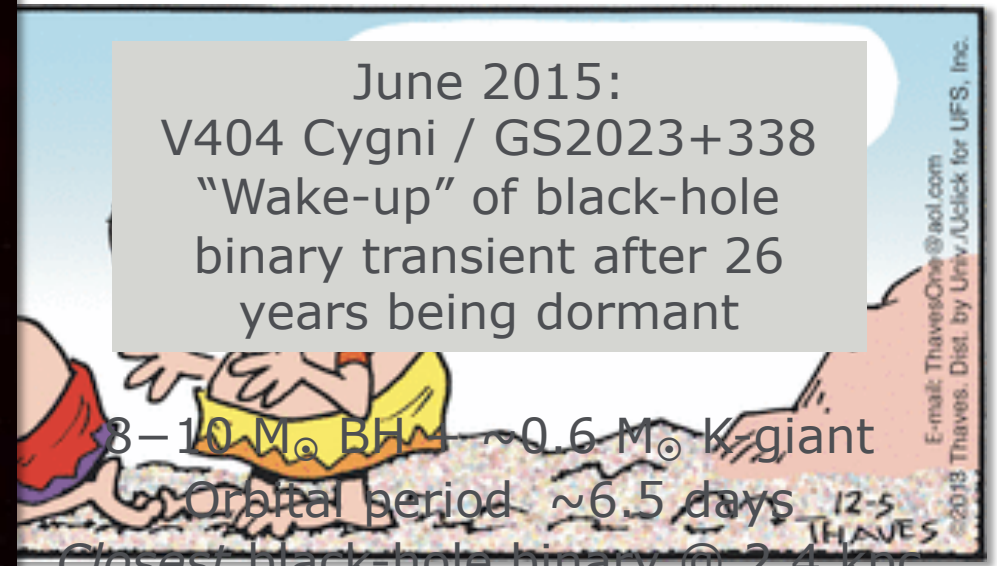
Increasing interest to <u>simultaneously</u> observe same target at different wavelengths at various <u>time scales</u>

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

Time-domain multi-wavelength? Need coordination!

Coordination in the old days - example





June 2015:
V404 Cygni / GS2023+338
"Wake-up" of black-hole binary transient after 26 years being dormant

8–10 $M_\odot$ BH + ~0.6 $M_\odot$ K-giant
Orbital period ~6.5 days
Closest black-hole binary @ 2.4 kpc

Coordination in the old days - example

>> Subject: Re: V404 Cyg -- coordinating multi-w
>> 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.Altamiranc
>> <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@scior
>> <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-D
>> 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:jo
>> Nick Higginbottom
>> <nick_higginbottom@fastmail.fm><mailto:nick_hi
>> Bird A.J. <A.J.Bird@soton.ac.uk><mailto:A.J.Bird@s
>> Sivakoff <sivakoff@ualberta.ca><mailto:sivakoff@u
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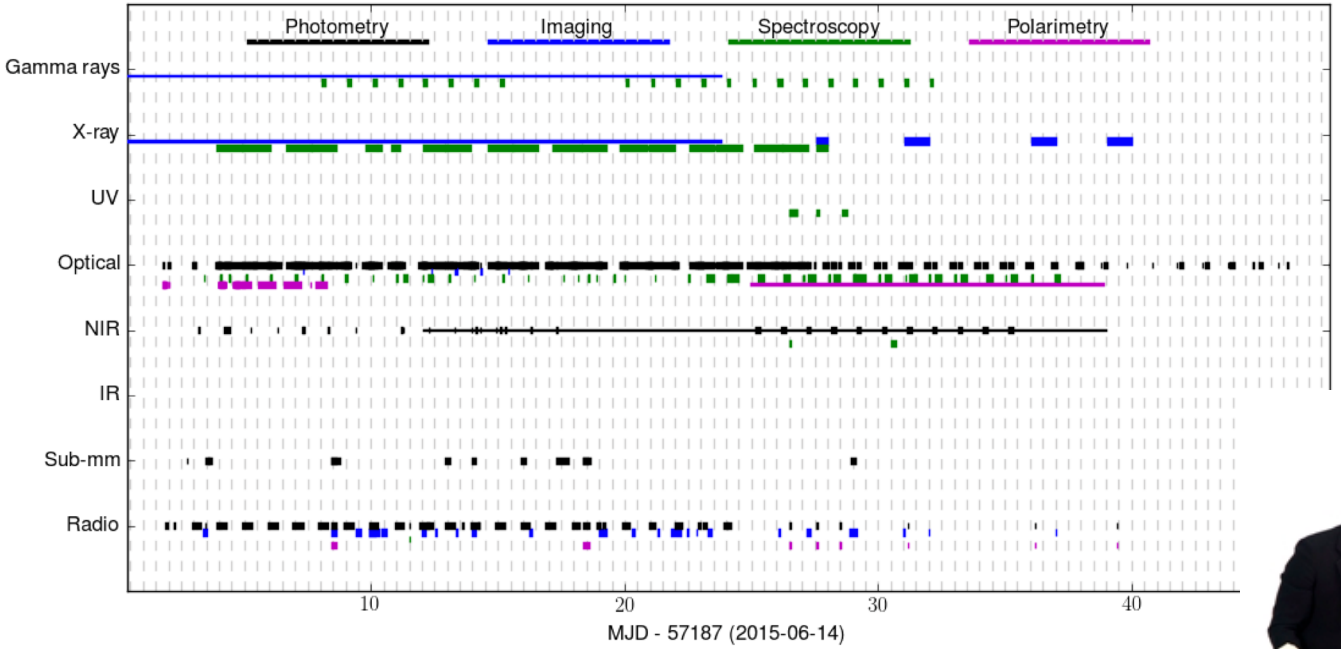
>> <john.r.thorstensen@dartmouth.edu><mailto:johr
>> James Miller-Jones
>> <james.miller-jones@curtin.edu.au><mailto:james
>> Boris Gaensicke
>> <Boris.Gaensicke@warwick.ac.uk><mailto:Boris.Ga
>> Danny Steeghs
>> <dsteeghs@cfa.harvard.edu><mailto:dsteeghs@cf
>> Dhillon
>> <vik.dhillon@sheffield.ac.uk><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,
>>

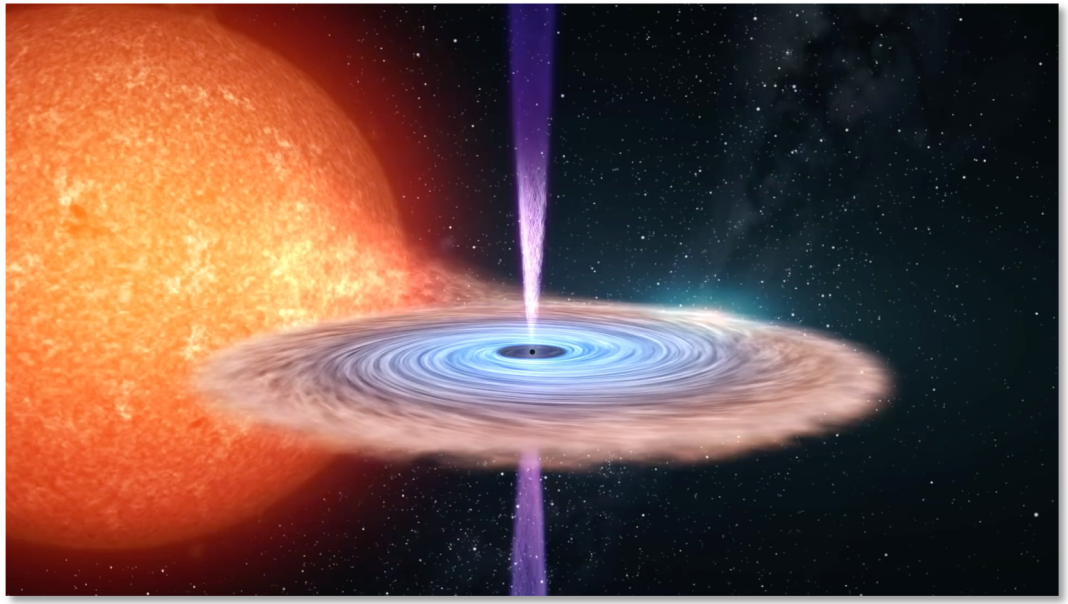
Coordination in the old days - example

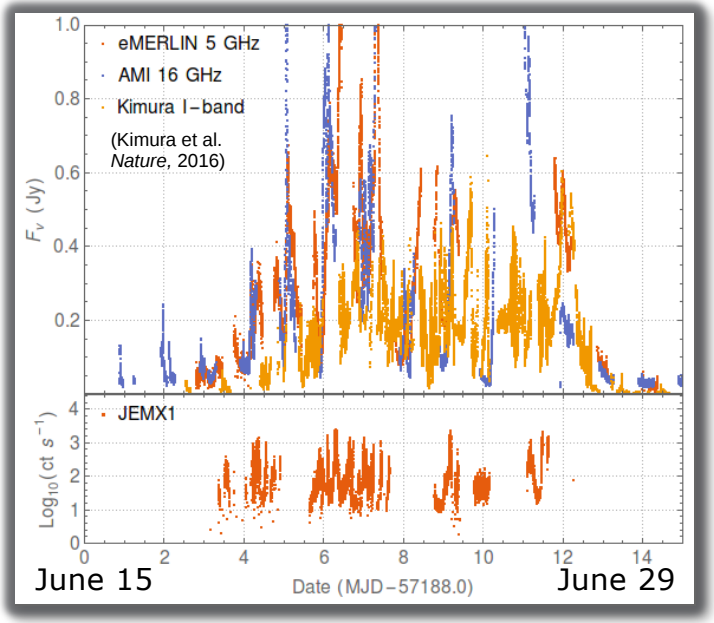


(Credit: Tom Marsh, University of Warwick, UK)

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

Coordination in the old days - example

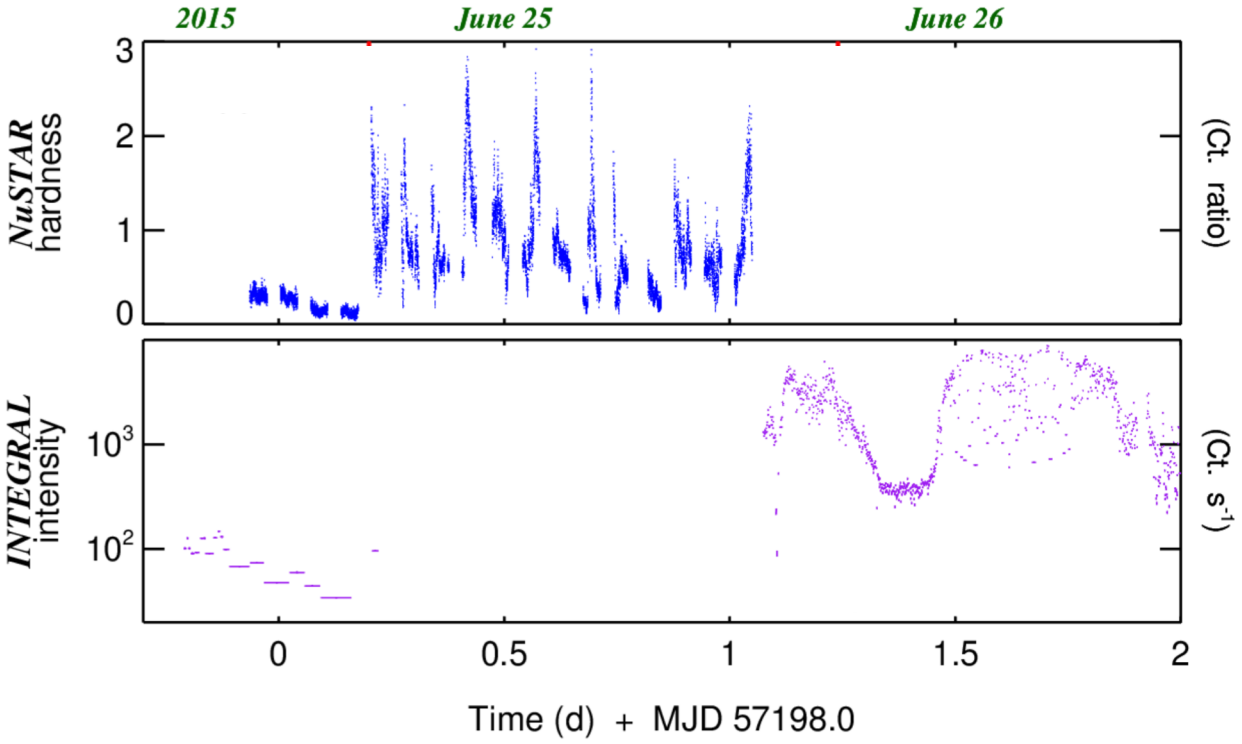




2015

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

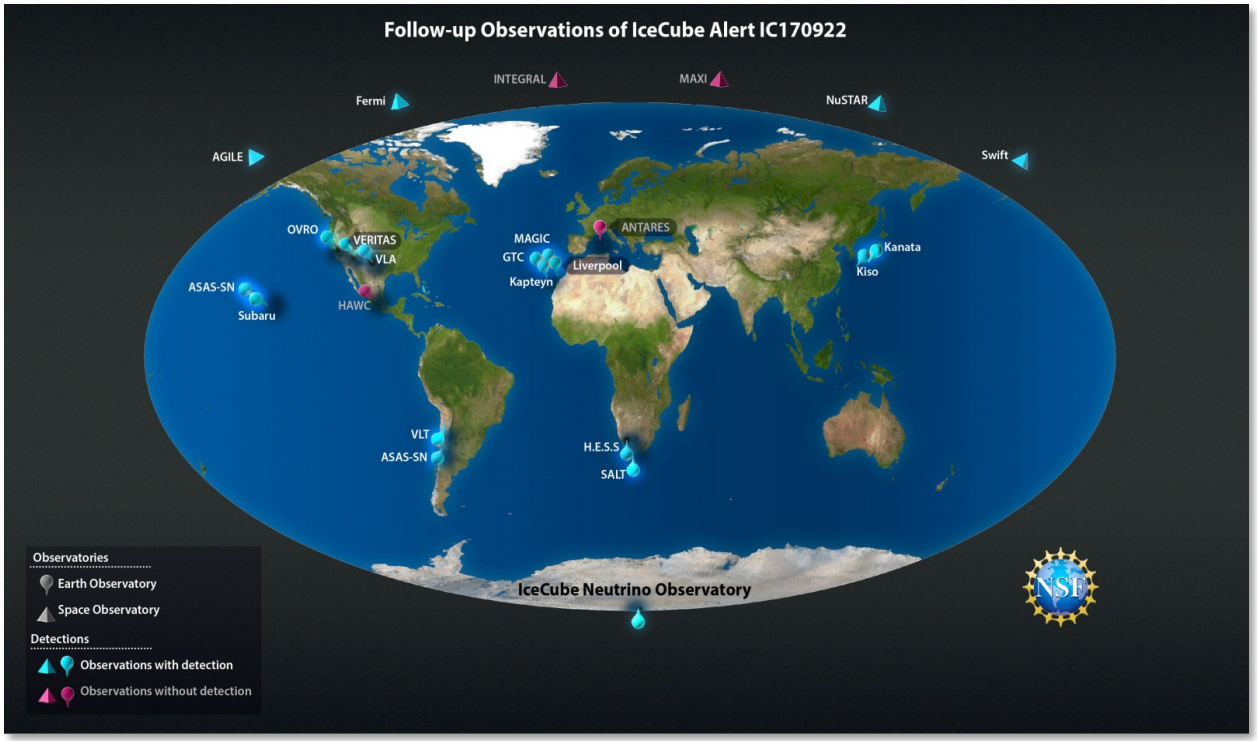
Coordination in the old days - example



uh-oh...

Gandhi *et al.* 2017, Nature Astronomy

1010 scientists working together…



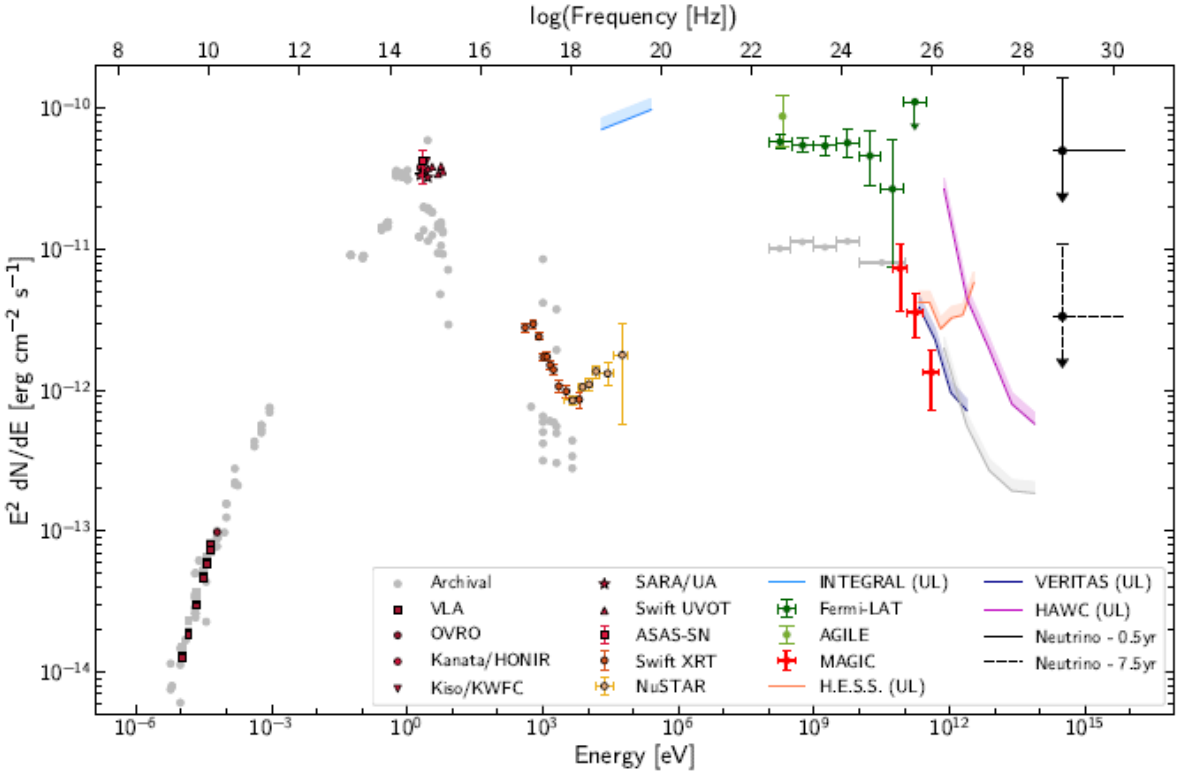
22 September 2017

IceCube high-energy neutrino event:

IceCube-170922A

- **~20 ground- and space-based observatories**

1010 scientists working together…



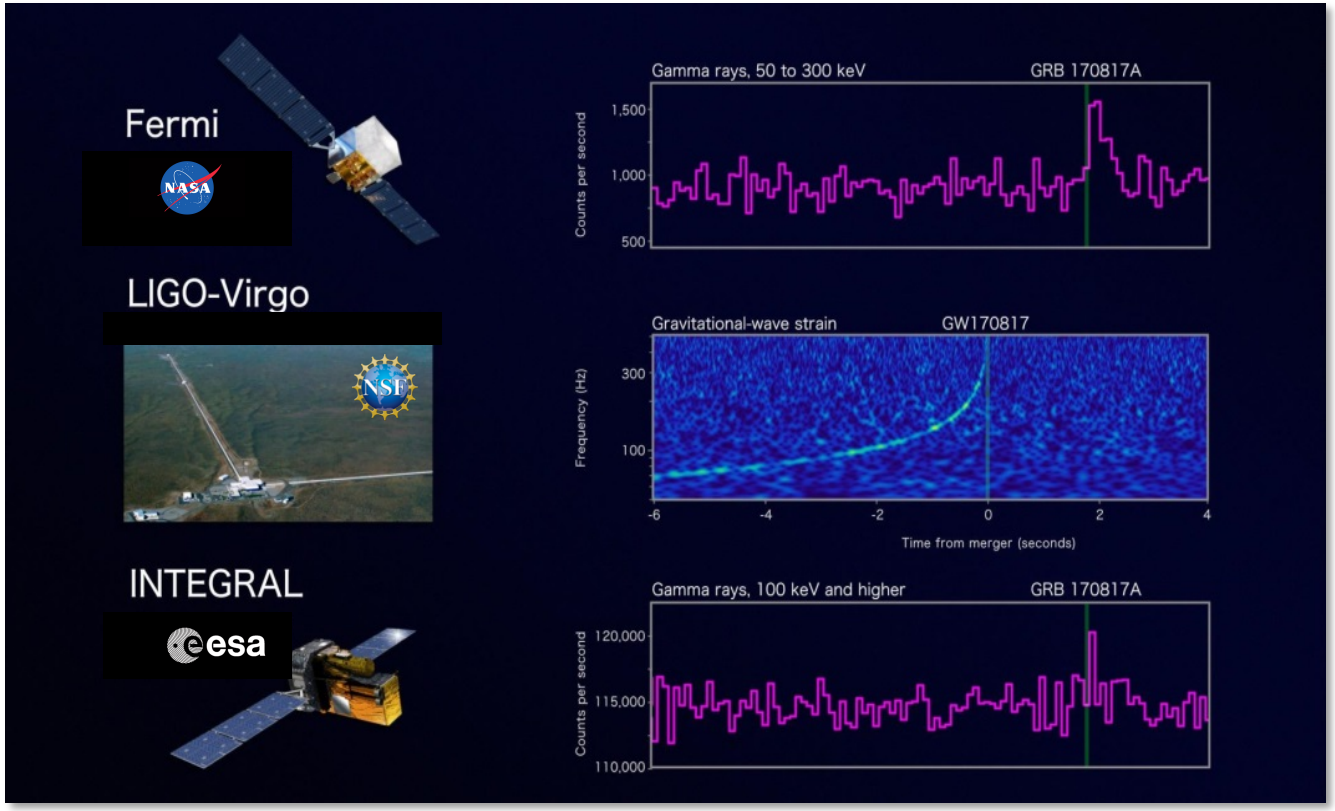
Aartsen *et al.* 2018, Science

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…

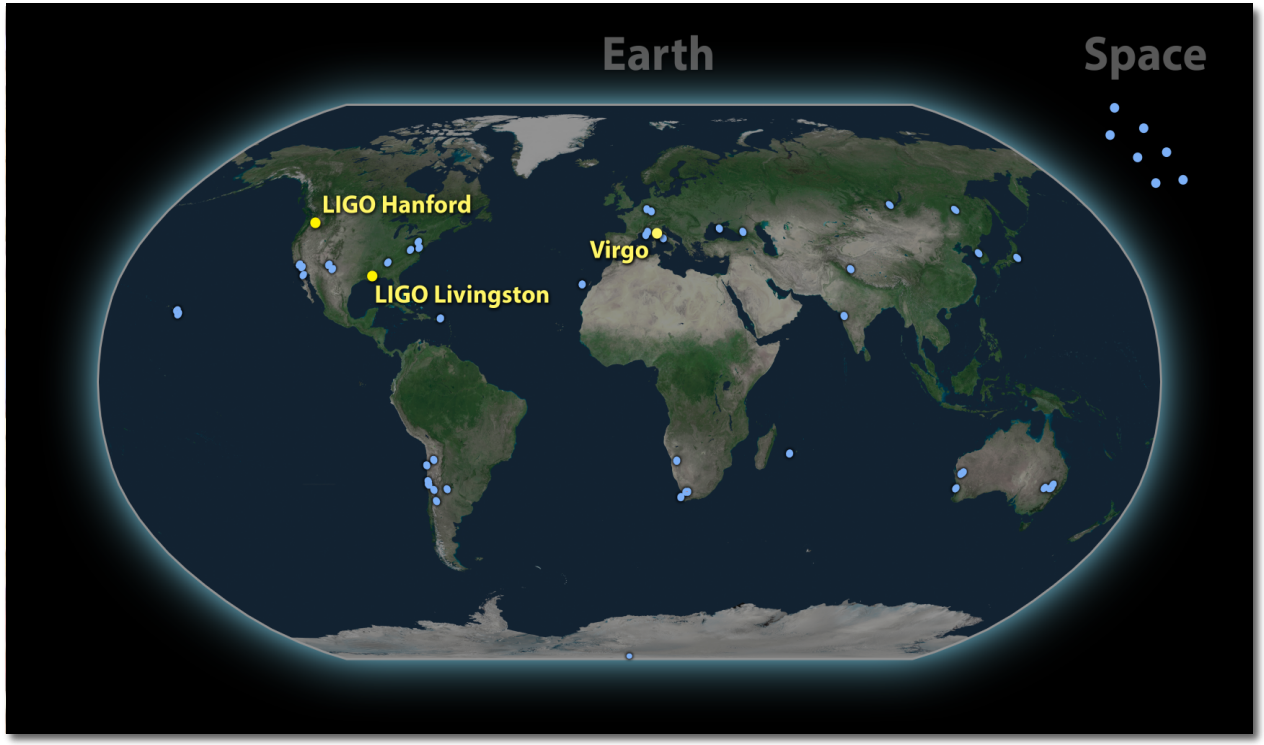


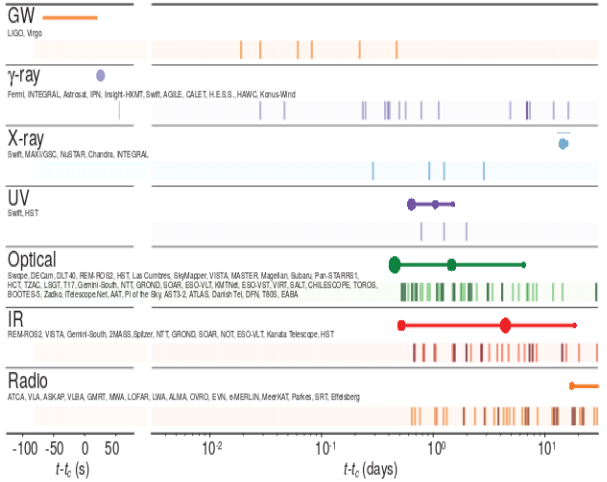
17 August 2017:

GW170817

GRB180817A

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**

Buzzword…

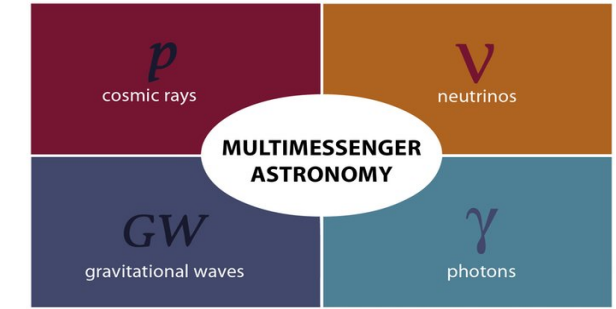
Wikipedia

Buzzword

A buzzword is a word or phrase, new or already existing, that becomes very popular for a period of time. Buzzwords often derive from technical terms yet often have much of the original technical meaning removed thr…

time-domain

+



=

time-domain multi-messenger (astro)physics

Requires improved coordination!

Coordination starts with basic needs…

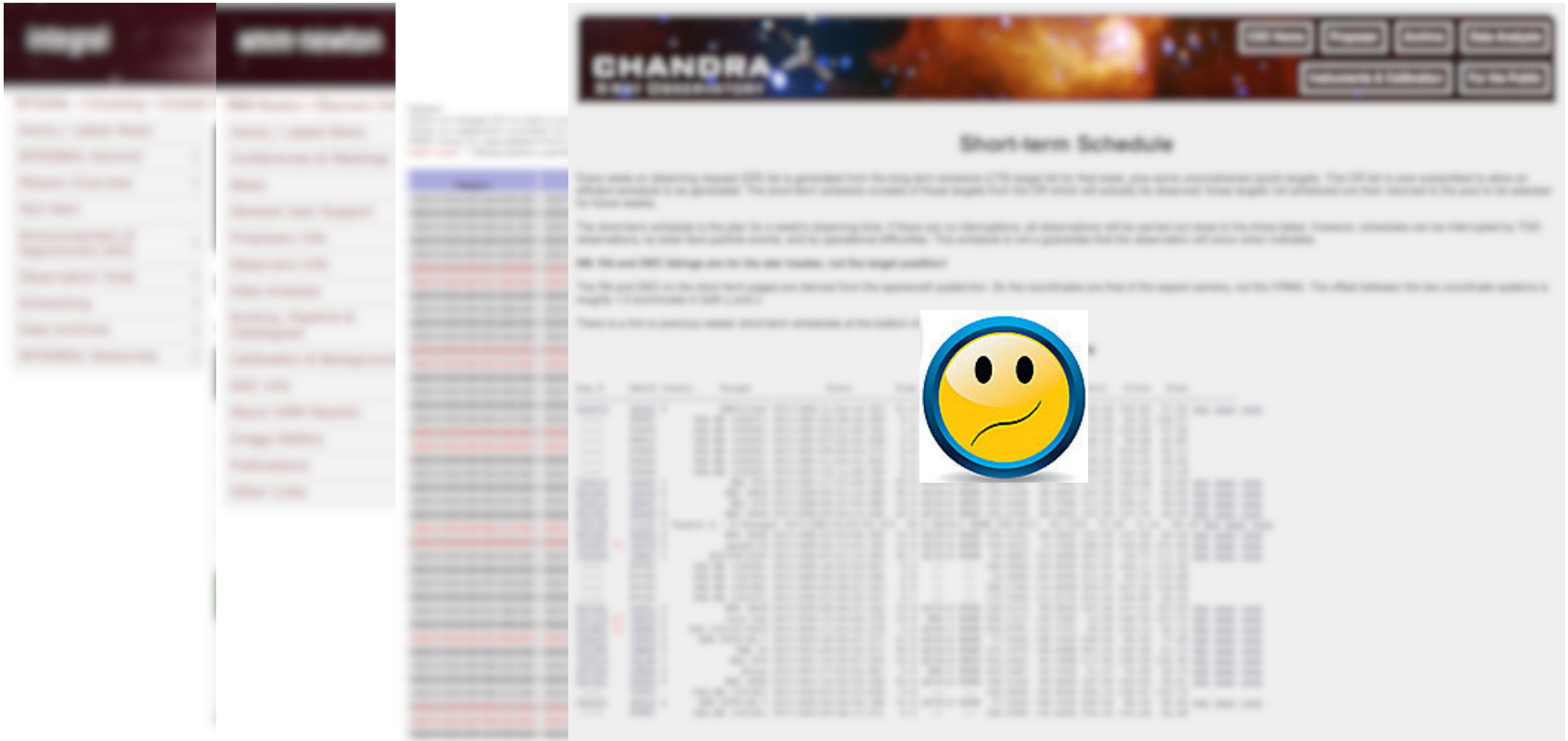
Observing schedule (past, current, future):
Facility/instrument – time period – target

Target visibility:
Target – facility/instrument – time period

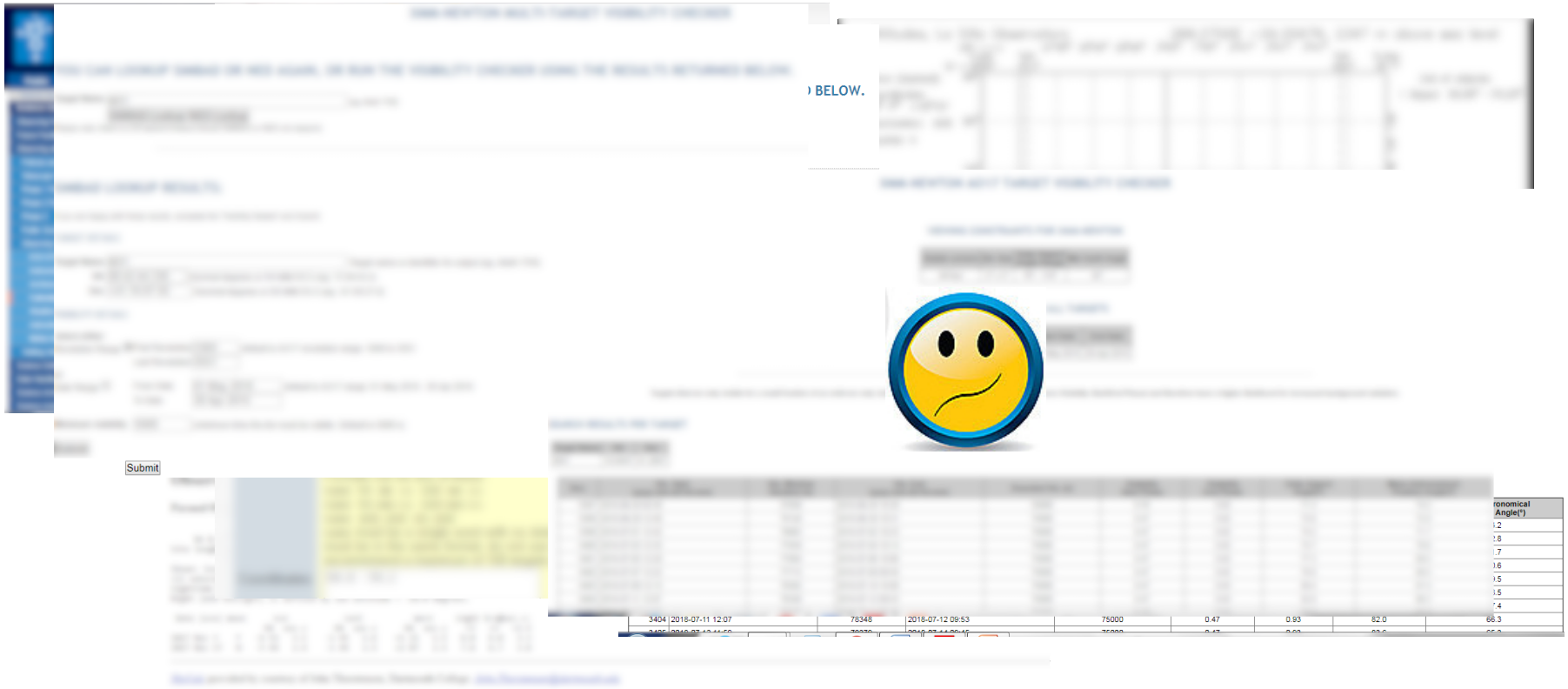
- Nowadays, many ground- and space based observatories provide tools + web info

… but …

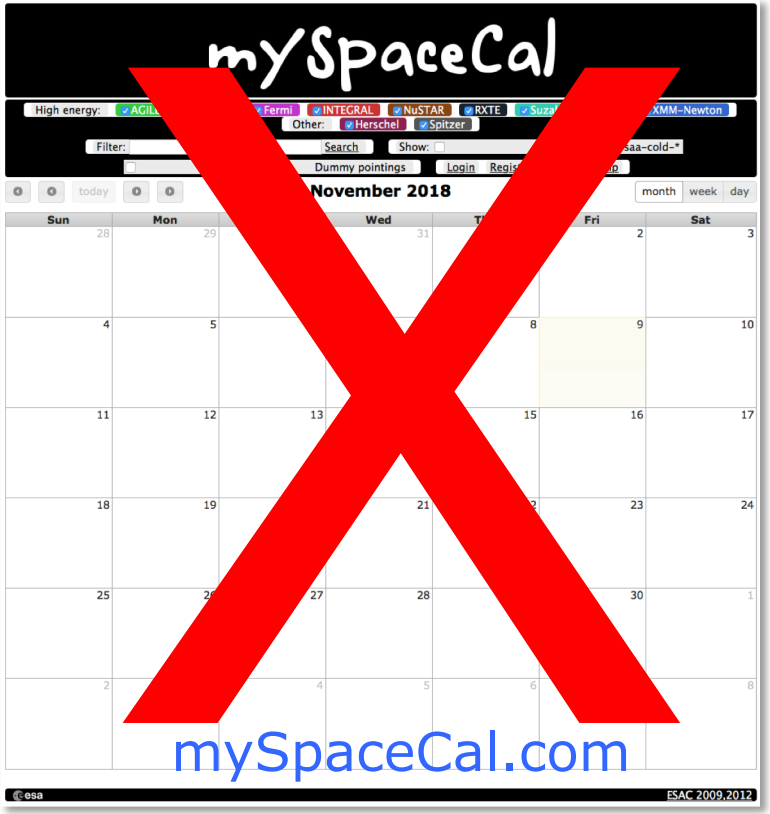
Observing schedule today - examples



Target visibility today - examples



~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 better?

- **Yes, we can**

1. All observatories provide observing schedules (also?) in *standard format*
2. Same for target visibilities
3. [Collaborative tools to share information efficiently]

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

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

- ObjVisSAP - http://www.ivoa.net/documents/ObjVisSAP/
- ObsLocTAP - http://www.ivoa.net/documents/ObsLocTAP/

Object Visibility Simple Access Protocol

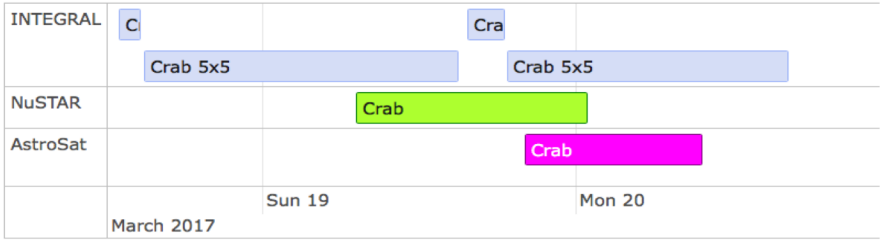
Observation Locator Table Access Protocol

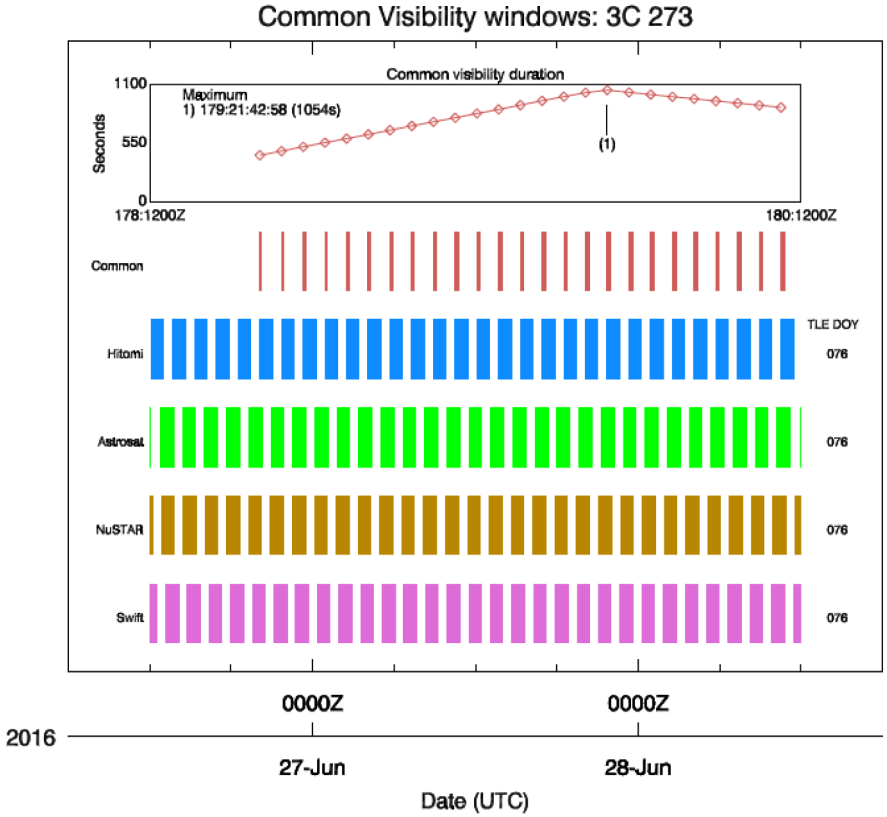
Currently under consideration by VO consortium

Yes, we can

→ User: build tool to compile and display

Coordinated Crab Observations

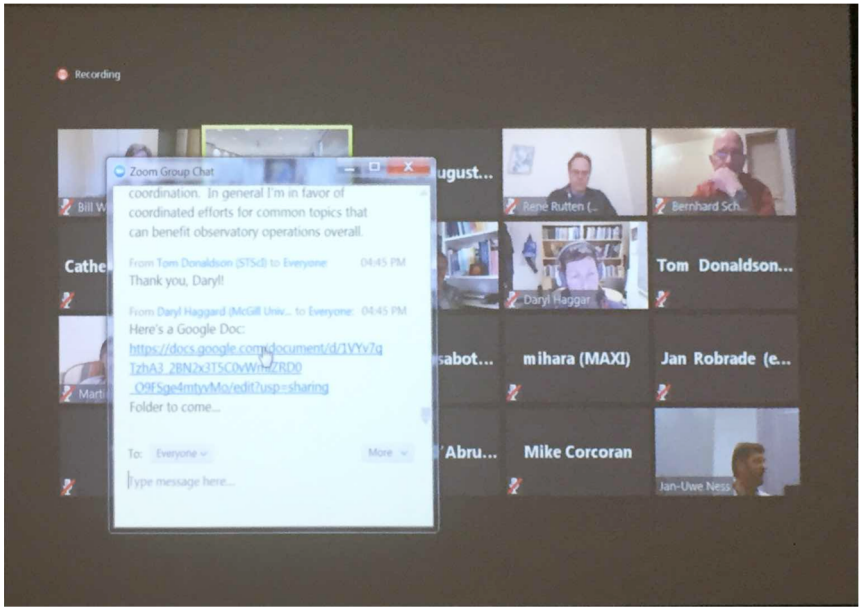




Hello world - VOVisObs Workshop

- 21 September 2018 @ ESA/ESAC, Spain:

Discuss details VO protocols & prototypes & operational services



- 29 participants @ ESAC
- 35 participants by video

Can we do even more better?

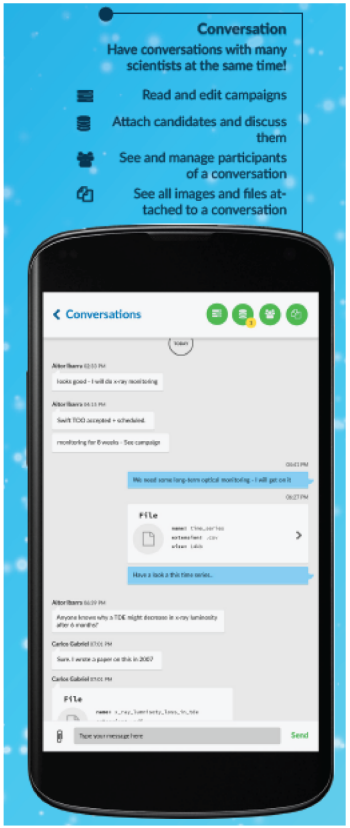
➢ Yes, we can… we may need a new forum?

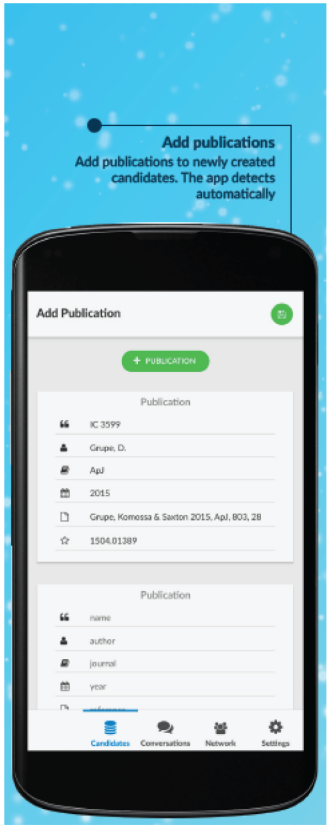
- SciApp: a collaboration application, based on web mobile technologies, designed to facilitate management of observation campaigns, writing of articles and general exchange of knowledge in a specific area – beta developed at ESA/ESAC

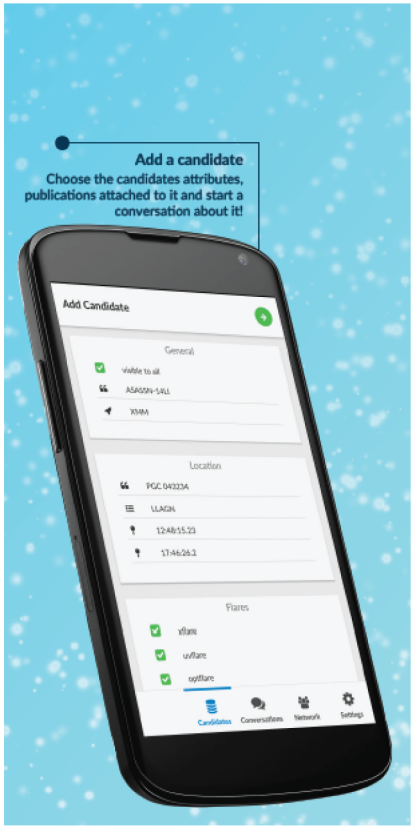
  - Simple, intuitive, easy-to-read interface
  - Target visibility checks
  - Visibility checker
  - Image and data storage and exchange
  - Real-time access to alerts
  - Basic data visualization, e.g., light curves
  - Virtual Observatory compliant
  - Easy access to database results, e.g,., Vizier, 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

Conclusions

- **One format fits all?**
  - Short-term (+ mid- & long-term) schedules in standard format
  - Visibility (output) in standard format
  - Interface with explicitly machine readable information

In order to work: need ground- and space based facilities onboard!

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

Needs further development/maintenance… Volunteers?


SOMETIMES THE UNIVERSE ALLOWS FOR THE MAKING OF UNEXPECTED MEMORIES.
PHILIPPA GEORGIOU
MAGICALQUOTE
esa
Thank you
ADASS XXVIII
European Space Agency