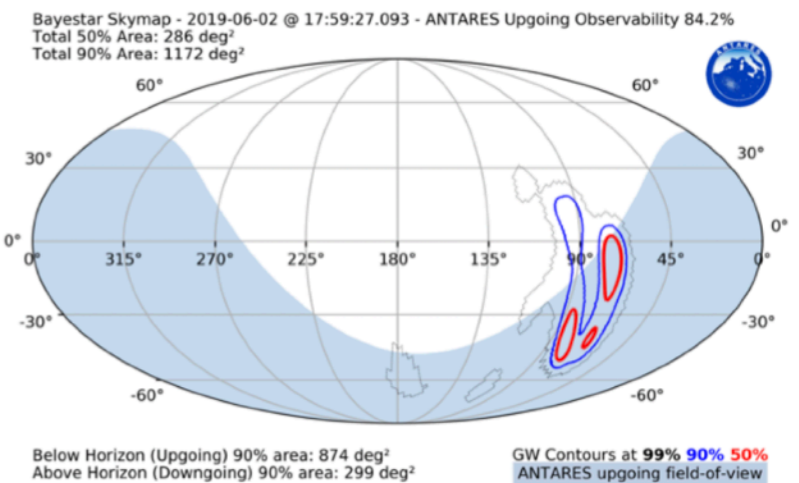
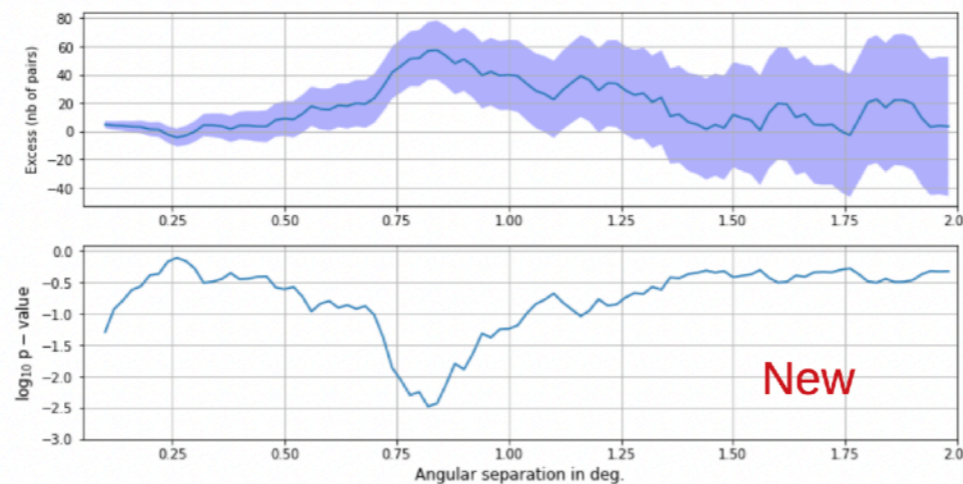
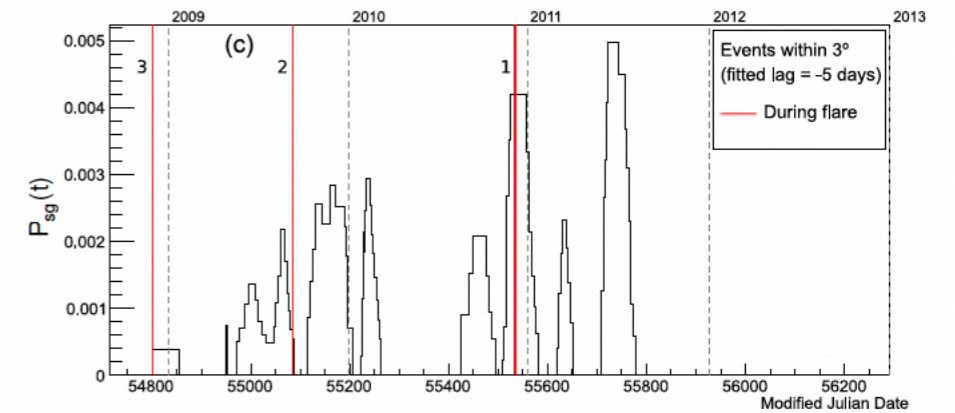
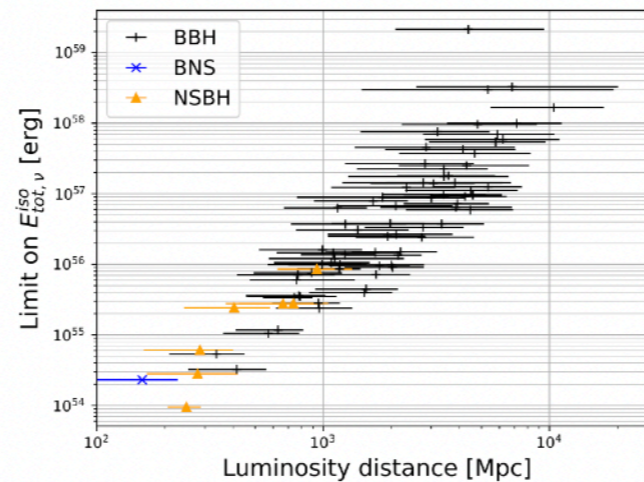
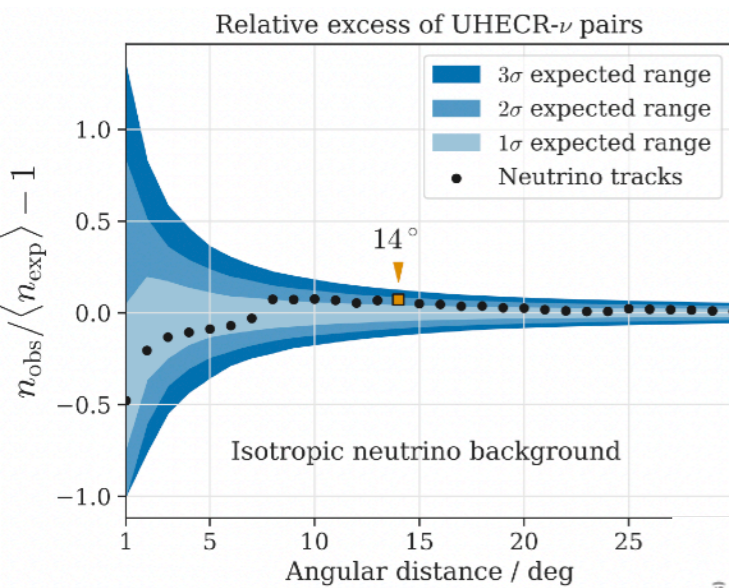
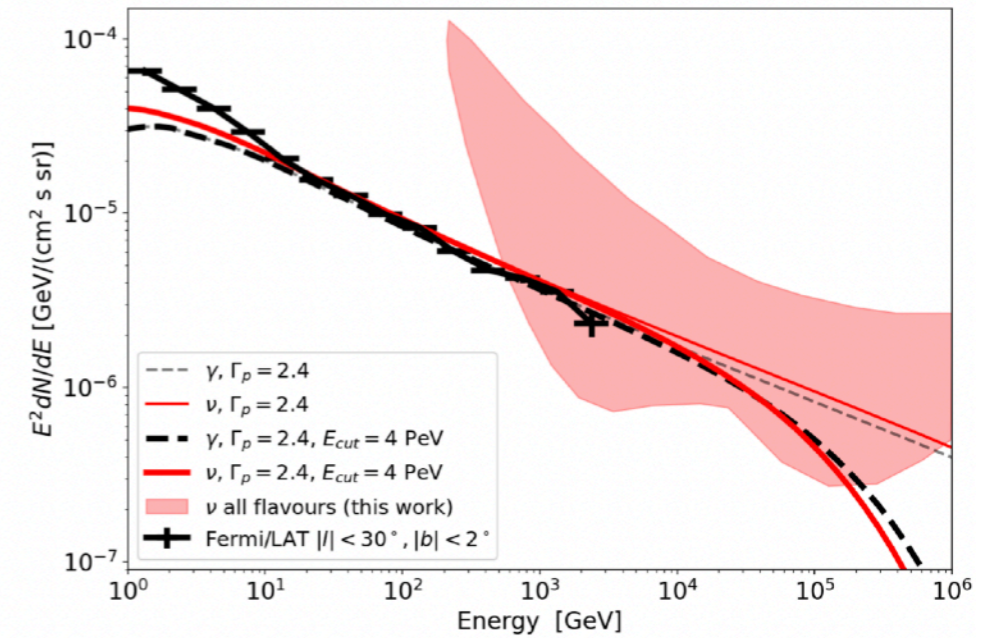


# **Astro WG**

# **French perspectives**

# Reminder of our « specialities » in ANTARES

- GP diffuse flux (APC)
- Stacking analyses (APC)
- UHECR correlation (APC)
- Real-time follow-up (CPPM, APC, IPHC)
- TAToO (CPPM)
- GW offline/sub-th analyses (APC, IPHC)
- Transient sources (CPPM)



# KM3NeT astro WG

Mailing list: ~183 members

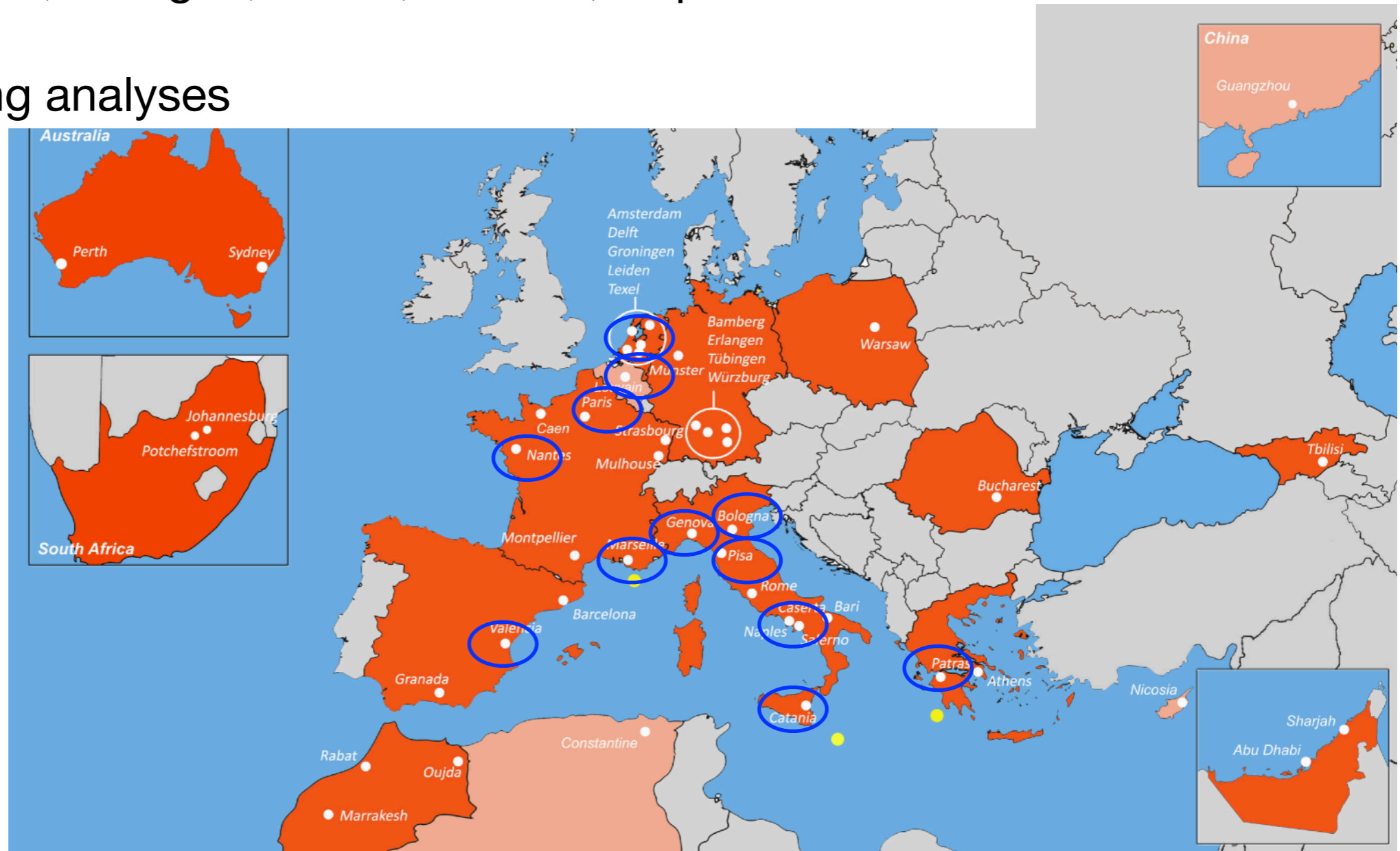
~ 50 active members (~40 participants to each weekly meeting) from mainly 12 Institutes :

Nikhef, IFIC, Demokritos, CP3

CPPM, APC, Subatech

Genova, Bologna, Roma, Catania, Napoli

~28 on-going analyses



# ~ 28 ongoing analyses

Analysis	Contributors	Wiki link	Git Link	Public plots	status
Double bang tau neutrino reconstruction	T. Van Eeden	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	In progress. Last presentation in ICRC2021 <a href="#">link</a> .
Improving shower reconstruction	J. Seneca	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	Finished. Paper in preparation. Last presentation in ICRC2021 <a href="#">link</a> .
Cascade sensitivity	T. Van Eeden	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	Finished. Paper in preparation. Last presentation at Neutrino2022 <a href="#">link</a> .
PS likelihood analysis	R. Muller / A. Heijboer	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	Finished. Last presentation in ICRC2021 <a href="#">link</a> .
Galactic extended source likelihood analysis with full ARCA	B. Caifi / M. Sanguinetti / V. Kulikovskiy	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	Finished. Last presentation in ICRC2021 <a href="#">link</a> .
Diffuse likelihood analysis	A. Garcia / A. Heijboer	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	Finished. Last presentation in ICRC2021 <a href="#">link</a> .
Starburst Diffuse and PS analysis	A. Ambrosone / W. Idrissi Ibsalih / A. Marinelli	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	In progress. Presentation at ICRC2021 <a href="#">link</a> , updated at Neutrino2022 <a href="#">link</a> .
IC diffuse analysis (full ARCA)	M.R. Musone	<a href="#">wiki</a>			started
Combined gamma-ray/neutrino likelihood analysis	L. Mohrmann / T. Unbehaun / S. Funk / J. Hofstadt / T. Gal	<a href="#">wiki</a>	<a href="#">git</a>		Finished. Paper in preparation. Last presentation at Neutrino2022 <a href="#">link</a> .
Quiescent Blazars analysis	B. Nkosi	<a href="#">wiki</a>			In progress
ARCA6+8 PS likelihood analysis	R. Muller	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	Finished. Unblinding asked. Last presentation at Neutrino2022 <a href="#">link</a> .
ARCA6+8+21+ANTARES PS likelihood analysis	B. Caifi / M. Sanguinetti / V. Kulikovskiy				In progress
Diffuse analysis + Galactic ridge ARCA6	A. Sinopoulou / K. Tzamariudaki / F. Filippini	<a href="#">wiki</a>		<a href="#">plots</a>	In progress. Last presentation at Neutrino2022 <a href="#">link</a> .
Stacked point source analysis	J. Majumdar / A. Heijboer	<a href="#">wiki</a>			In progress
IC neutrino alert - blazar's flare associations (PKS0735, PKS1741, PKS 0215...)	R. Muller, J. Palacios, F. Filippini, F. Huang, S. Le Stum, G. Illuminati, D. Dornic	<a href="#">wiki</a>			In progress (last presentation at Neutrino2022 <a href="#">link</a> ).
HAWC template analysis with ARCA data	G. Ferrara	<a href="#">wiki</a>	<a href="#">git</a>		started
GRB likelihood analysis (ORCA)	A. Zegarelli / S. Celli	<a href="#">wiki</a>			started
GRB binned analysis	M. Colomer	<a href="#">wiki</a>			finished
Transient binned analysis	J. Palacios / P. Salesa	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	In progress. Last presentation in ICRC2021 <a href="#">link</a> .
Triggered flaring analysis	E. Pastor				started
Untriggered flaring analysis	F. Carenini				to be started
Transient likelihood analysis (microquasar)	S. Le Stum / D. Dornic	<a href="#">wiki</a>			in progress
Periodic sources (pulsar) in VLE data	R. Gracia-Riuz / M. de Jong / M. Eff	<a href="#">doc</a>			in progress
GW 03 analysis	S. Le Stum, F. Huang, M. Lamoureux, G. de Wasseige, G. Vannoye, DD	<a href="#">wiki</a>		<a href="#">plots</a>	Finished. Paper under review by EB. Last presentation at Neutrino2022 <a href="#">link</a> .
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GeV neutrino analysis (ORCA/ARCA)	G. de Wasseige	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	In progress. Last presentation in VLNT2021 <a href="#">link</a> .
CCSN analysis	M. Colomer / M. Lincetto / V. Kulikovskiy / A. Coleiro / D. Dornic / S. El Hedri / I. Goos / M. Bendahman	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	In progress. Last presentation in ICRC2021 <a href="#">link</a> + <a href="#">paper published</a> )
CCSN analysis (noise studies)	M. Bendahman / G. de Wasseige / S. El Hedri / I. Goos	<a href="#">wiki</a>	<a href="#">git</a>		in progress
CCSN analysis (online)	M. Lincetto / G. Vannoye / D. Dornic	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	In progress. Last presentation in ICRC2021 <a href="#">link</a> + <a href="#">submitted</a> + Neutrino2022 <a href="#">link</a> .
Online ORCA/ARCA analysis	F. Huang / W. Assal / E. Le Guirriec / A. Zegarelli / S. Celli / D. Dornic	<a href="#">wiki</a>	<a href="#">git</a>	<a href="#">plots</a>	In progress. Presentation in ICRC2021 <a href="#">link</a> and Neutrino2022 <a href="#">link</a> .

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## French contributions

# French contributions

## Main active members in the astro WG:

(Regular participation to the weekly meeting, F2F...)

- **APC:** Sonia, Isabel, Meriem, +Theophile
- **Subatech:** Lilian, Richard, Valentin, Felix
- **CPPM:** Damien, Sebastien, Godefroy

Interested: APC: Corinne, Bruny - IPHC: Thierry

## Main French activities

- Data/MC preparation, production, analyses on ORCA (APC+CPPM+Subatech)
- CCSN (APC+CPPM)
- Online analyses (CPPM+APC+Subatech)
- Transient analysis (CPPM+Subatech)
- GW searches (CPPM+APC)

# Different types of searches

**General rule of the WG: standardize the analysis tools as much as possible, 1 data format, few event selections, 2 analysis frameworks (1 binned + 1 unbinned).**

For the online and small detector (custom):

- Binned (on/off cut-and-count), data driven analysis but with MC for optimization of the event selection.

Inside aanet:

- Binned likelihood: early data + PS for fast test
- Unbinned likelihood: final analysis: PS, diffuse, stacking, transient, combined detectors

# Service tasks in the astro WG

## **For both ORCA and ARCA (task force):**

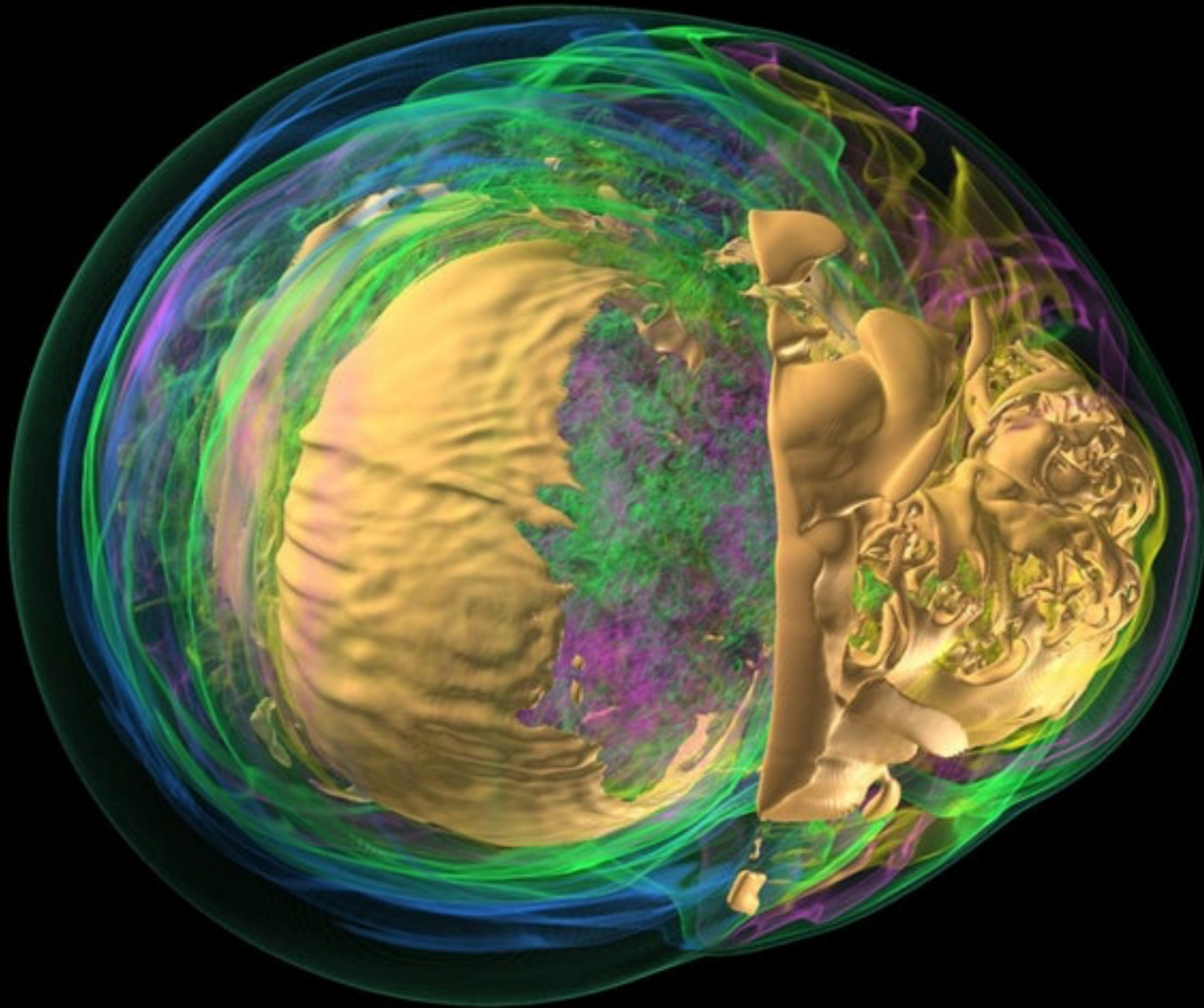
- Data & MC preparation, processing
- MC validation
- Low-level data analyses
- Online analysis and high-level monitoring

## **The French participation is so far only centred on ORCA**

- Huge effort from the astro WG
- Task force ORCA4-6 HE (CPPM)
- Task force ORCA11\* (APC/CPPM/Subatech)
- Control of the PSF and absolute pointing

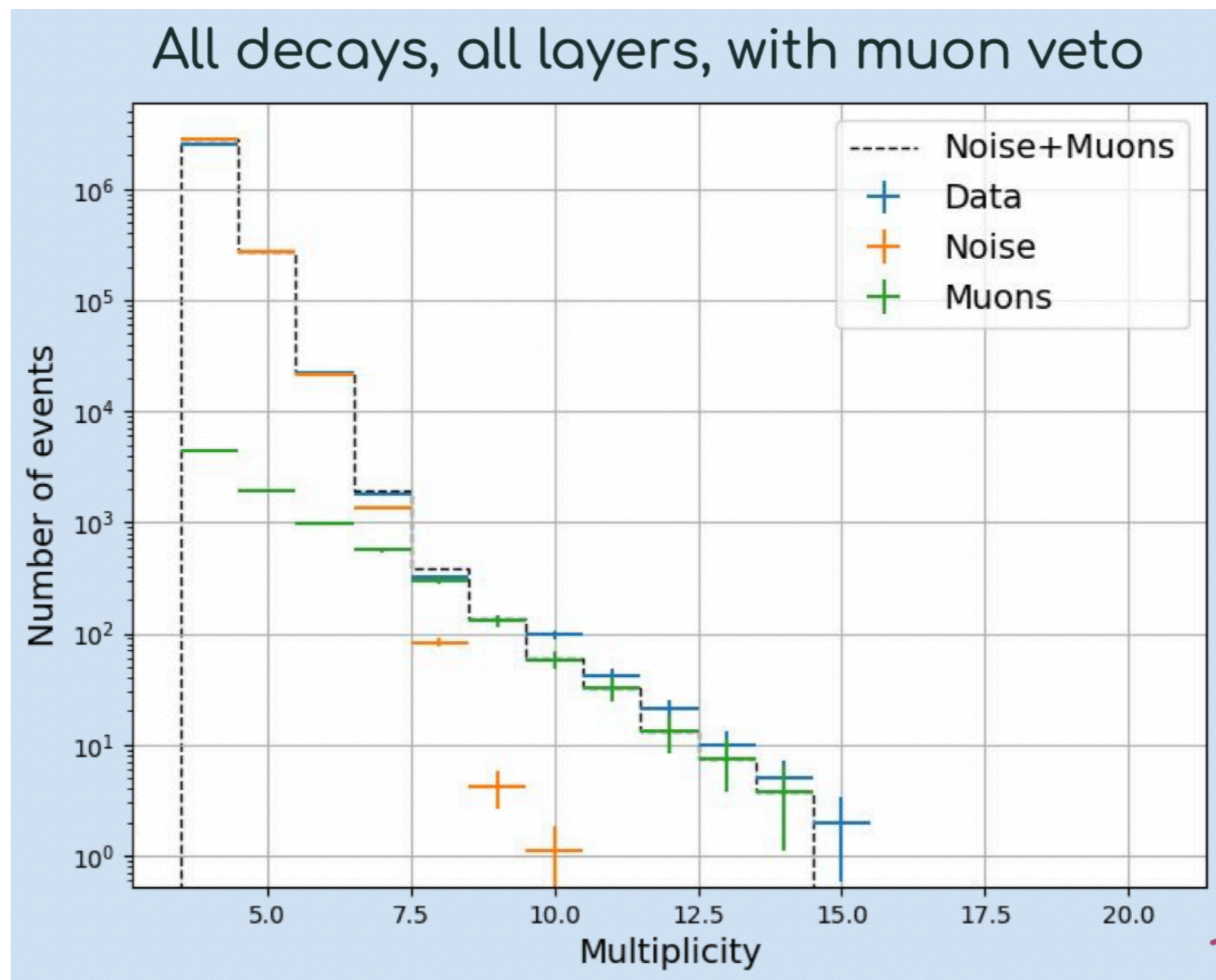


# Neutrinos from core-collapse supernovae



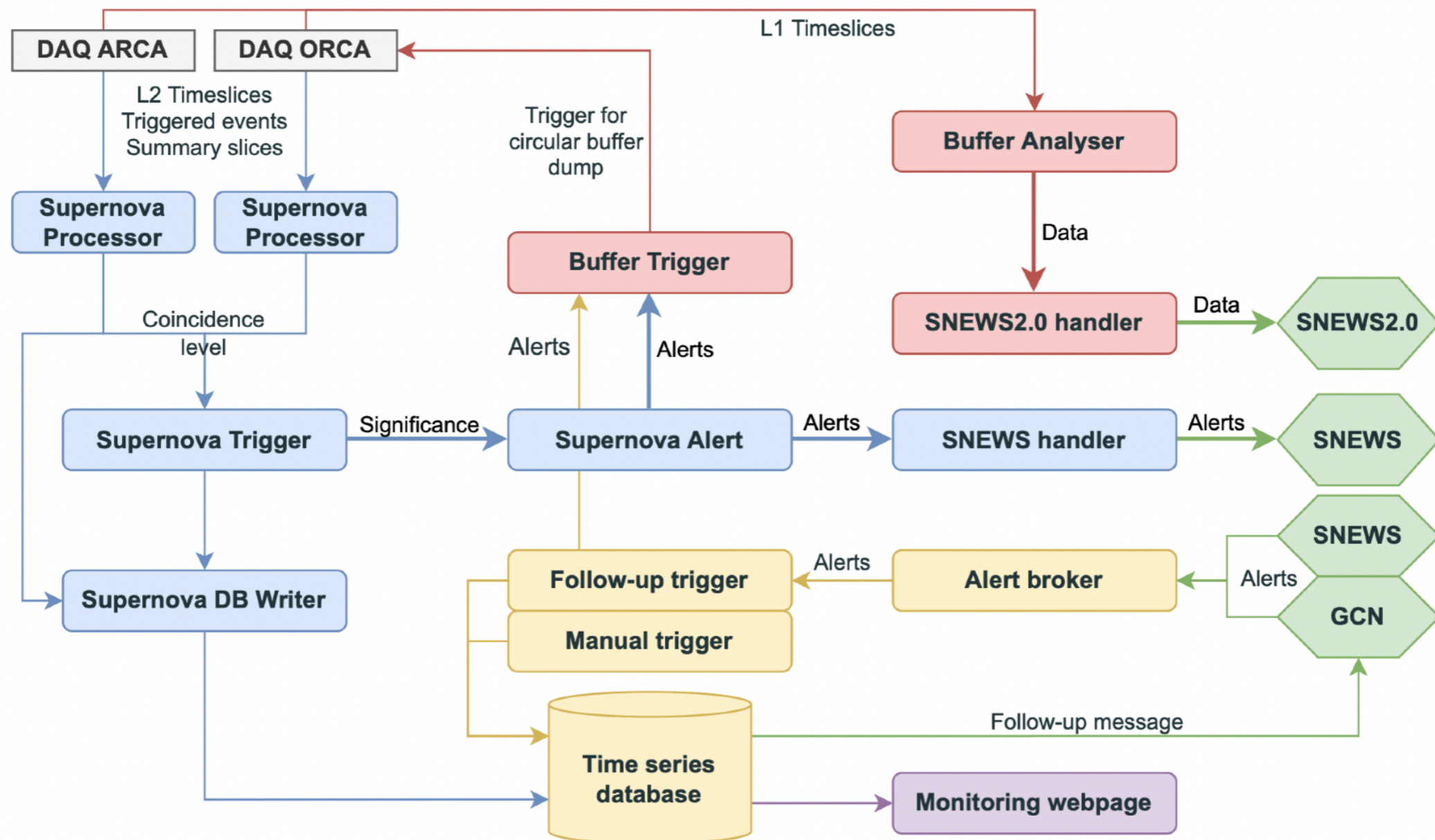
# CCSN

- **Simulation, noise reduction:** Sonia, Isabel, Corinne, Meriem
- **CCSN real-time analyses:** Godefroy, Damien
- **Quasi-online analysis:** Sonia, Isabel, Godefroy, Damien
- **Firedrill:** all
- **SNEWS2.0 interaction:** Godefroy, Damien



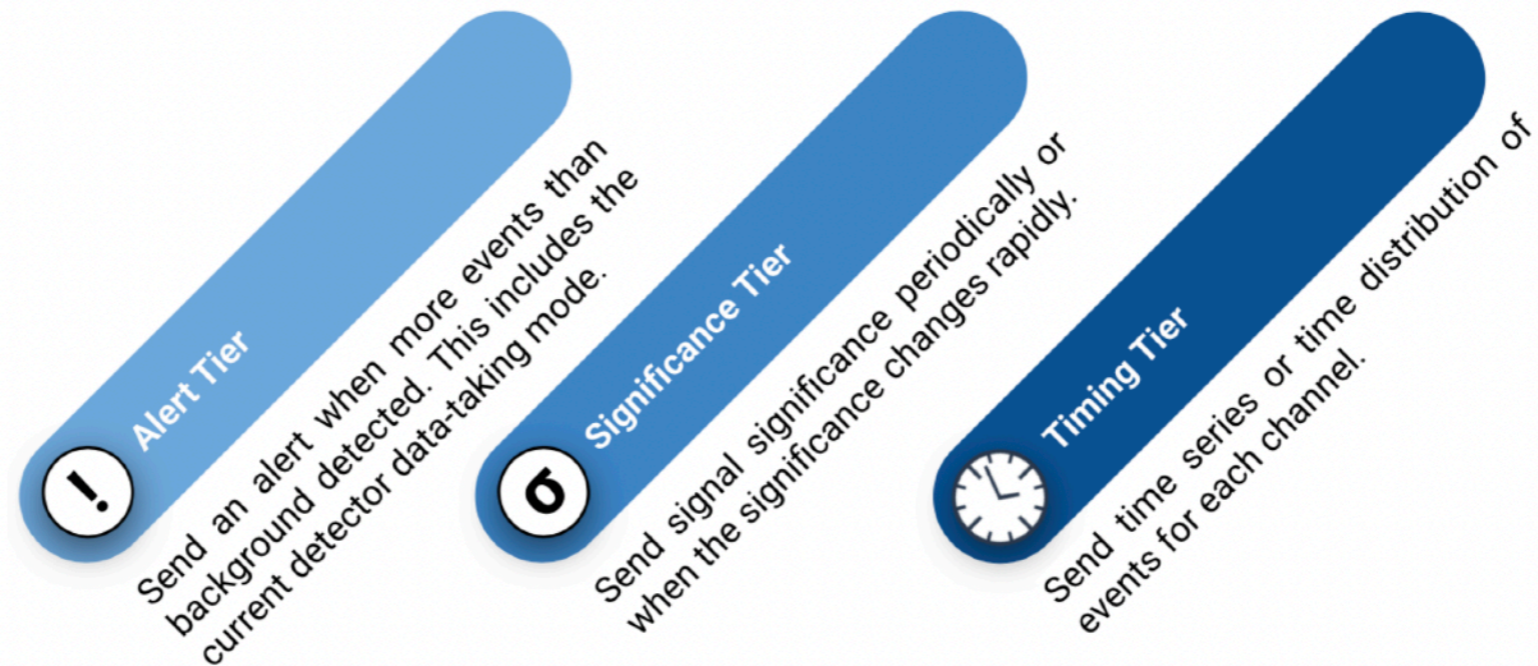
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# CCSN

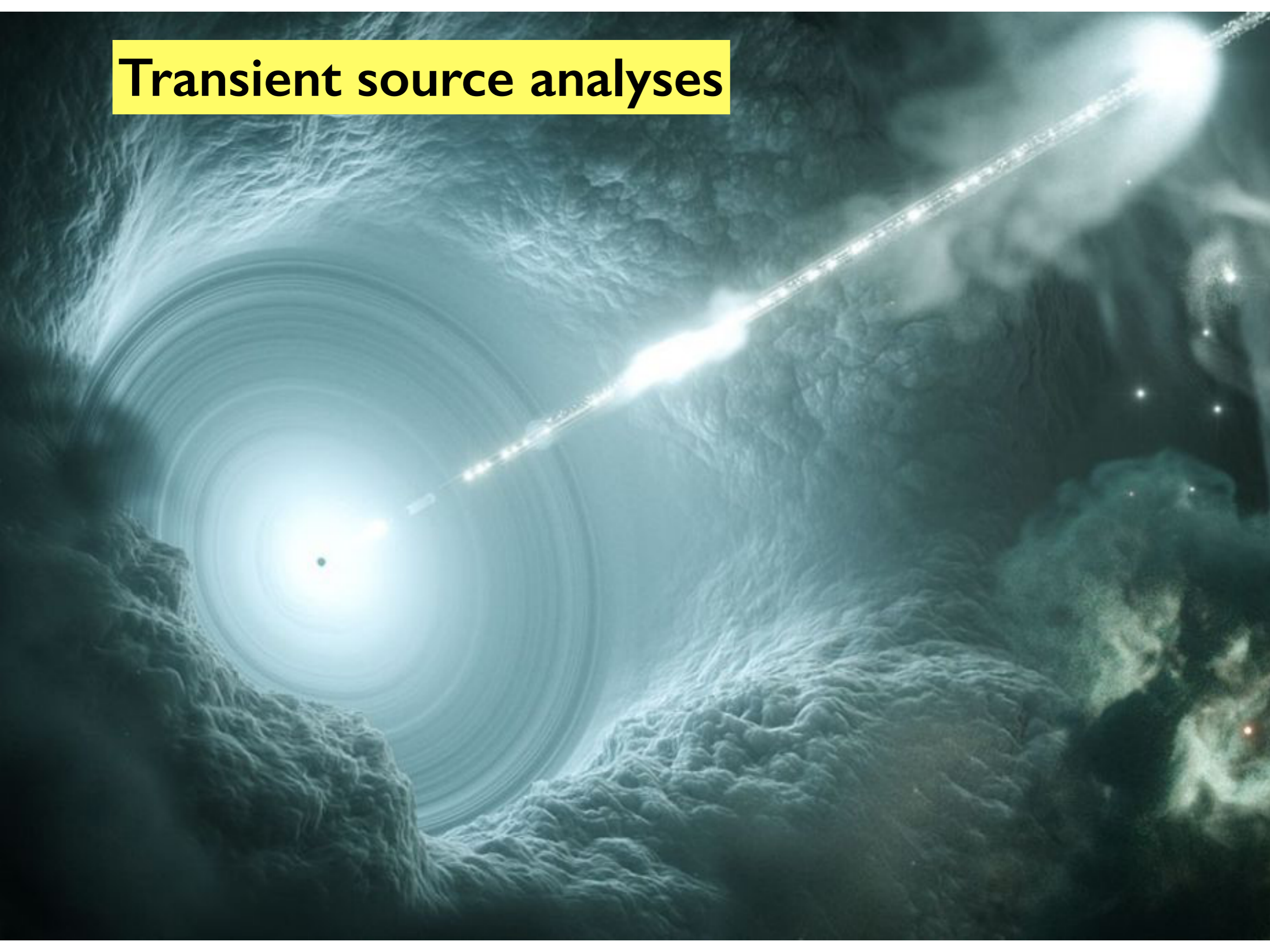
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Effectively  
SNEWS 1.0

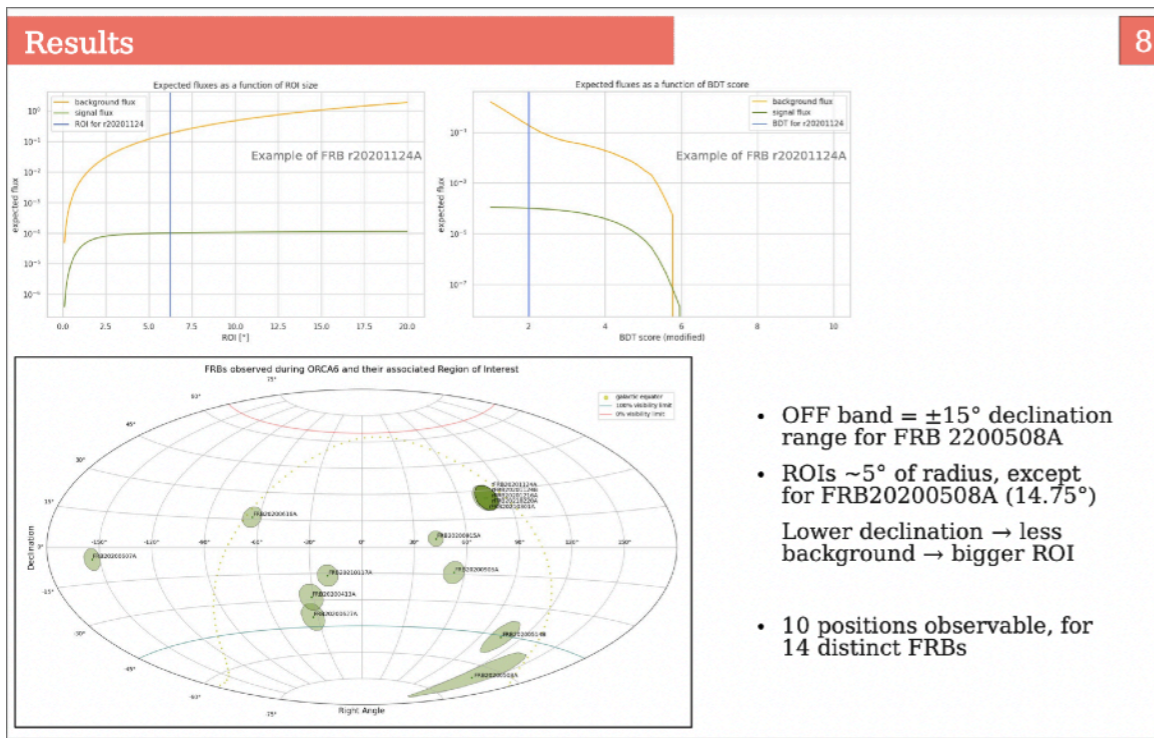
Experiments can share more data  
to enable more new features

# Transient source analyses



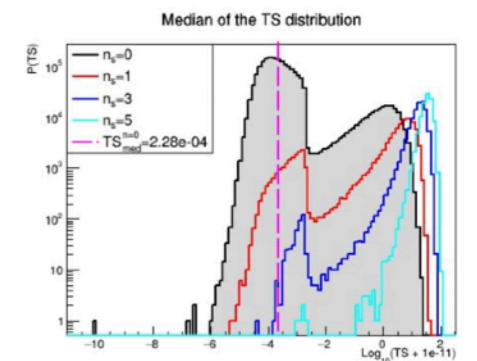
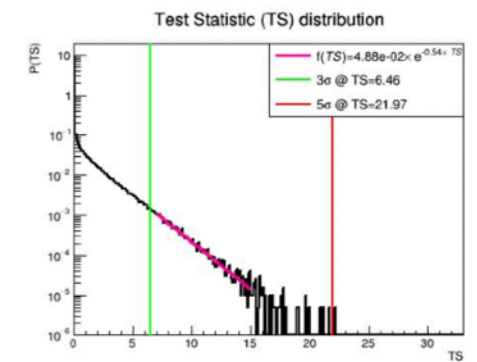
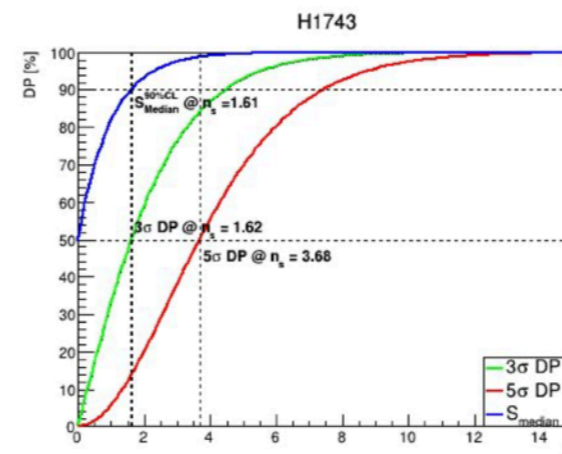
# Transient searches

- **Microquasar:** Sebastien
- **FRB:** Felix
- **GRB special:** Sebastien+Damien + Godefroy
- **AGN:** +Damien



## Pseudo experiments/sensitivity

H1743-322: 368 days of activity

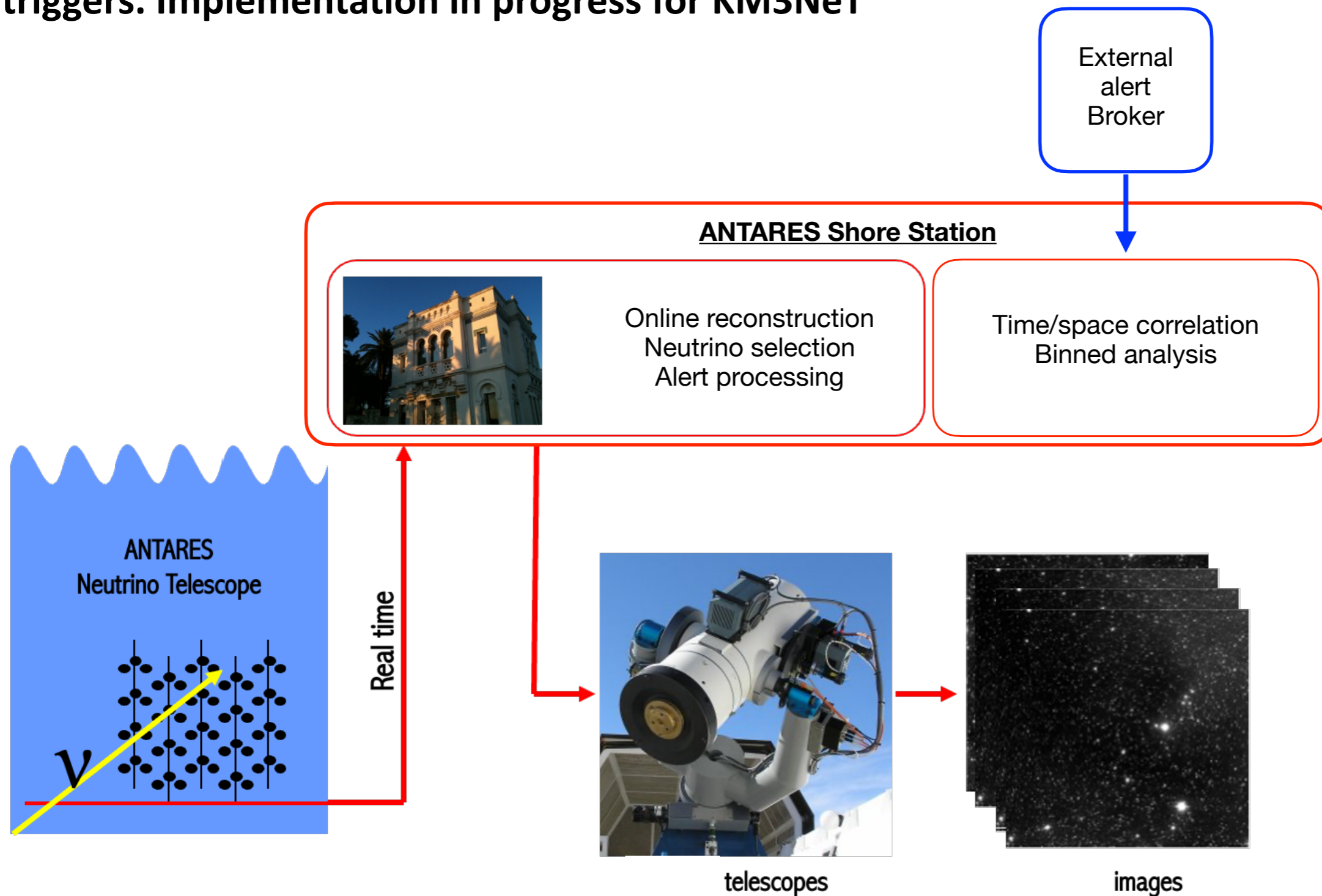


# Real-time analyses



# Real-time analysis platforms

ANTARES and IceCube have implemented in 2008-9 a real-time analysis platform that triggers neutrino alerts and that performs time/space correlation analysis for external triggers. Implementation in progress for KM3NeT





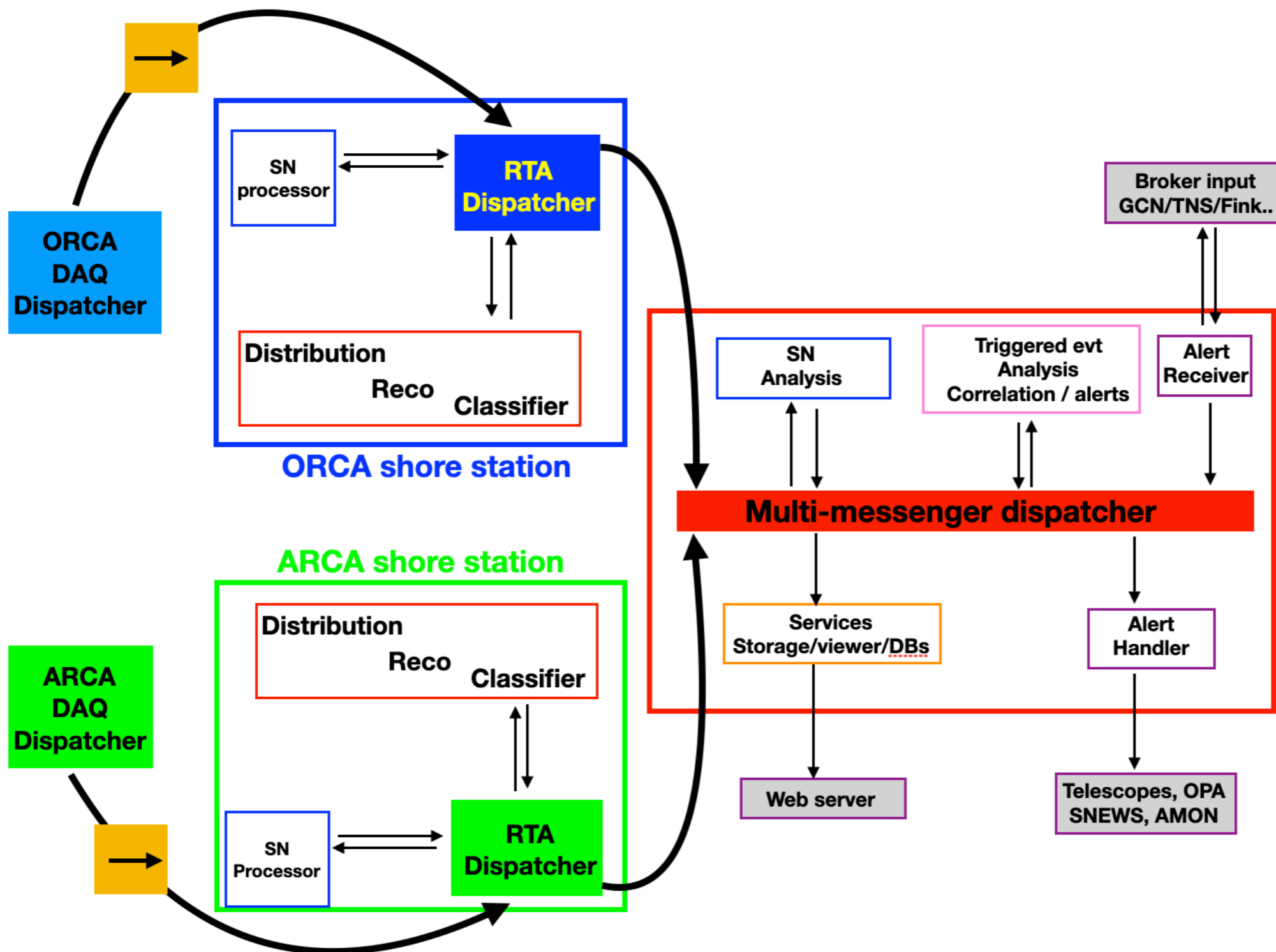
# Online searches

- **Development of the online analysis platform:** Damien, Sebastien, Godefroy, Manu, William
- **CCSN online:** Godefroy, Sonia, Isabel
- **Shift:** all +Valentin

⇒ Very complex infrastructure to host the online analysis platform  
(complex system, a lot of functionalities)

# Online analysis platform

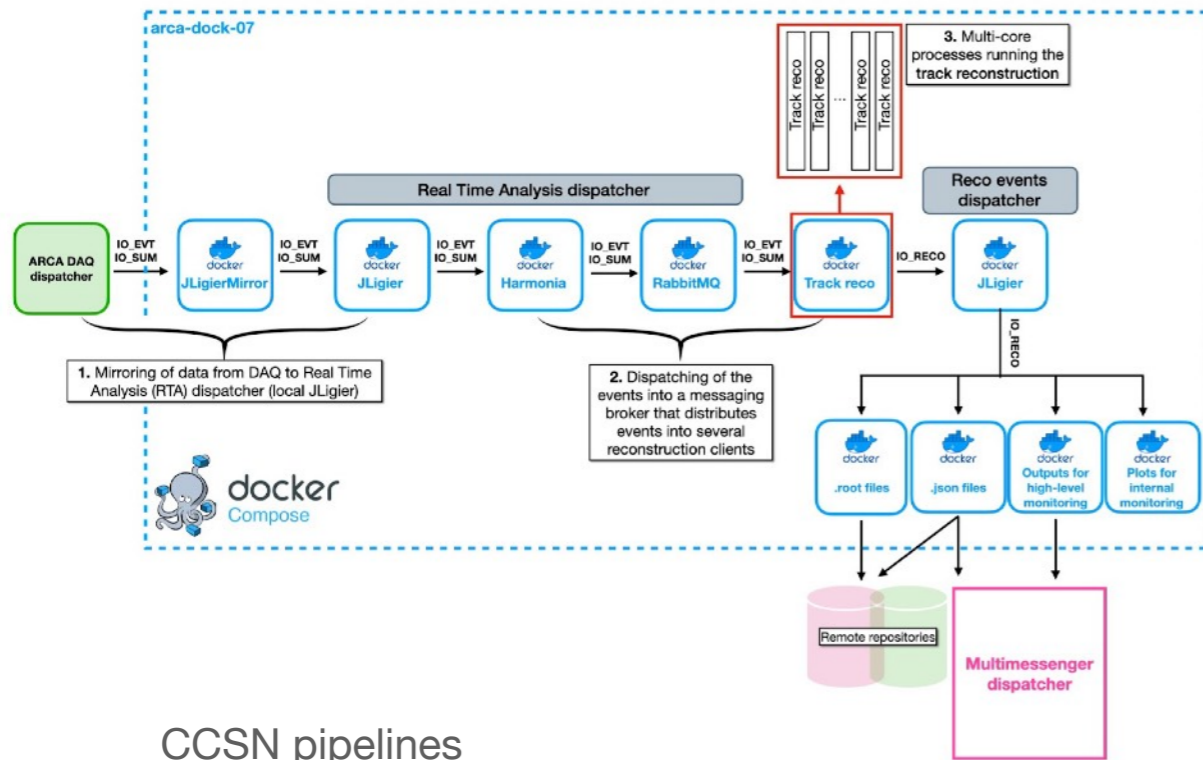
- Very complex infrastructure to host the online analysis platform



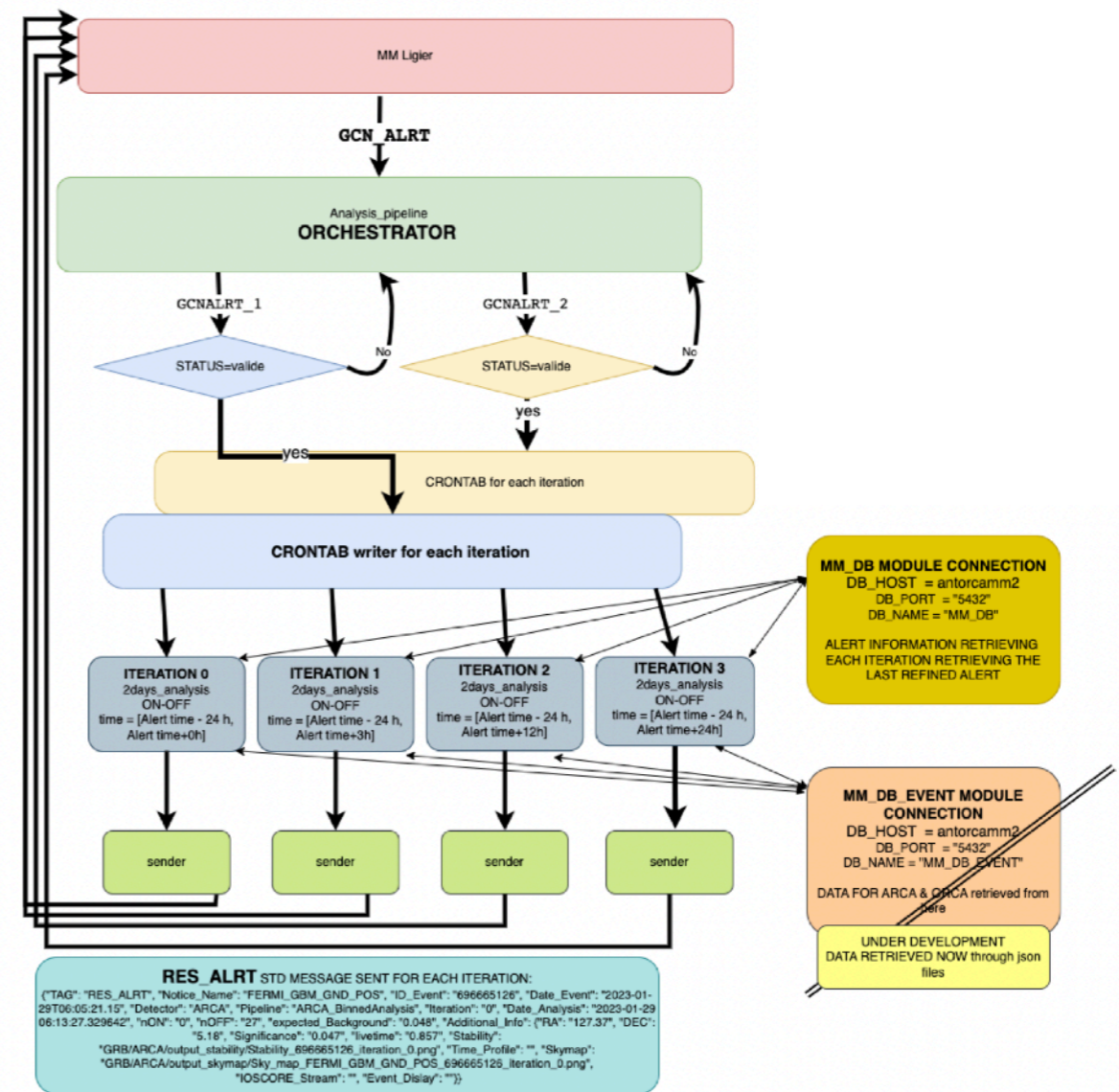
# Online analysis platform

- Very complex infrastructure to host the online analysis platform
- 3 examples: RTA, CCSN & analysis pipeline

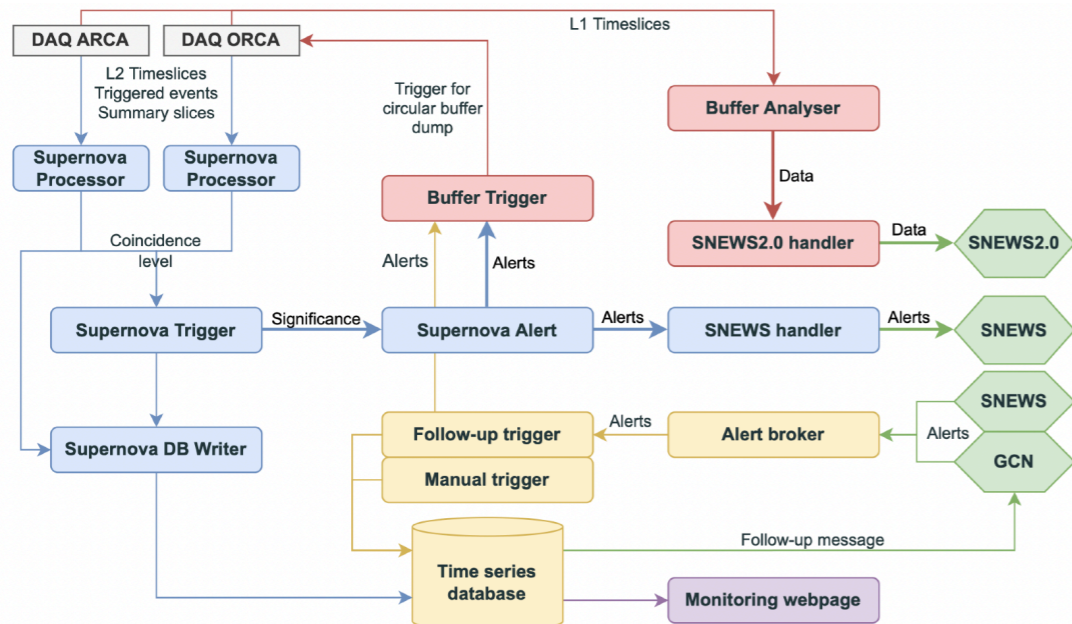
RTA architecture of ARCA



Scheme of the analysis pipeline



CCSN pipelines



# Online physics shift

**KM3NeT Shifter Tools home page**

Status: 10/11 services up

**Common**

- MM mirror and dispatcher: On
- SN applications: On
- GCN applications: On

**ARCA: 4/5 services up**

- Trigger On/Off: Bad data (Detailed dashboard)
- RTA mirror and dispatcher: On
- Services: On
- SN processor: On
- SN mirror to MM: On

**ORCA**

- Trigger On/Off: On
- RTA mirror and dispatcher: On
- Services: On

View status history: ARCA, ORCA. Last update: Wed Feb 08 2023 09:19:34 GMT+0100 (heure normale d'Europe centrale)

- Necessity to develop an efficient shift program to monitor the complexity of the online system and the results of online analyses
- Implementation of the shifter tools webpage to be able to do a shift anywhere
- Core team: CPPM, Roma, Bologna, IFIC

ORCA high-level monitoring

ORCA RTA dashboard

ARCA high-level monitoring

ARCA RTA dashboard

MM dashboard

Analysis dashboard

CCSN monitoring

External triggers **28 new**

Rocket chat

KM3NeT alerts

GCN writer

Manual search

Current shift report

All shift reports

Shifters calendar

- Shifts: 1 week, 2 persons
- Training since oct 4, 2022 (CPPM: 9, APC: 2, Subatech: 1)

Start	End	Sites	MM Online Team Coordinator	Group	MM Online Shift Leader	Group	Where	MM Online Shifter	Group	Where
27/9/2022	4/10/2022	IT,FR								
4/10/2022	11/10/2022	IT,FR			azegarelli	INFN-RM	REMOTE	mmastrodicasa	INFN-RM	REMOTE
11/10/2022	18/10/2022	IT,FR	(ddornic)	CPPM	ffilippini	INFN-BO	REMOTE	jpalaciosgonzalez	IFIC	REMOTE
18/10/2022	25/10/2022	IT,FR	(ddornic)	CPPM	gvannoye	CPPM	REMOTE	slestum	CPPM	REMOTE
25/10/2022	1/11/2022	IT,FR	(ddornic)	CPPM	ffilippini	INFN-BO	REMOTE	slestum	CPPM	REMOTE
1/11/2022	8/11/2022	IT,FR	(ddornic)	CPPM	scelli	INFN-RM	REMOTE	azegarelli	INFN-RM	REMOTE
8/11/2022	15/11/2022	IT,FR	ddornicdel	CPPM	gvannoye	CPPM	REMOTE	jpalaciosgonzalez	IFIC	REMOTE
15/11/2022	22/11/2022	IT,FR	(ddornic)	CPPM	mmastrodicasa	INFN-RM	REMOTE	aveutro	INFN-RM	REMOTE
22/11/2022	29/11/2022	IT,FR	(ddornic)	CPPM	slestum	CPPM	REMOTE	gilluminati	INFN-BO	REMOTE
29/11/2022	6/12/2022	IT,FR	(ddornic)	CPPM	slestum	CPPM	REMOTE	mlamoureux	CP3	REMOTE
6/12/2022	13/12/2022	IT,FR	(ddornic)	CPPM	jpalaciosgonzalez	IFIC	REMOTE	epastor	IFIC	REMOTE
13/12/2022	20/12/2022	IT,FR	(ddornic)	CPPM	ffilippini	INFN-BO	REMOTE	epastor	IFIC	REMOTE
20/12/2022	27/12/2022	IT,FR	(ddornic)	CPPM	gvannoye	CPPM	REMOTE			
27/12/2022	3/1/2023	IT,FR	(ddornic)	CPPM	ffilippini	INFN-BO	REMOTE			
3/1/2023	10/1/2023	IT,FR			mmastrodicasa	INFN-RM	REMOTE	aveutro	INFN-RM	REMOTE
10/1/2023	17/1/2023	IT,FR			slestum	CPPM	REMOTE	ielhedri	UNI-PAR7	REMOTE
17/1/2023	24/1/2023	IT,FR			jpalaciosgonzalez	IFIC	REMOTE	igoos	UNI-PAR7	REMOTE
24/1/2023	31/1/2023	IT,FR			salvesgarre	IFIC	REMOTE	epastor	IFIC	REMOTE
31/1/2023	7/2/2023	IT,FR			gvannoye	CPPM	REMOTE	vdecoene	SUBA	REMOTE
7/2/2023	14/2/2023	IT,FR	add		del jpalaciosgonzalez	IFIC	REMOTE	del fsalesagreus	IFIC	REMOTE
14/2/2023	21/2/2023	IT,FR	add		del scelli	INFN-RM	REMOTE	del azegarelli	INFN-RM	REMOTE
21/2/2023	28/2/2023	IT,FR	add		del ffilippini	INFN-BO	REMOTE	del tvaneeden	NIKHEF	REMOTE
28/2/2023	7/3/2023	IT,FR	add		remote			remote		
7/3/2023	14/3/2023	IT,FR	add		remote			remote		
14/3/2023	21/3/2023	IT,FR	add		remote			del jmajumdar	NIKHEF	REMOTE
21/3/2023	28/3/2023	IT,FR	add		remote			del rconiglione	INFN-LNS	REMOTE
28/3/2023	4/4/2023	IT,FR	add		remote			del lfusco	UNI-SA	REMOTE

# Need to secure access to main follow-up facilities

## Optical telescopes: TAROT, GRANDMA, MASTER, LCOGT, ZTF, LSST...

- Easy access follow-up of large error box
- Characterisation of the potential counterpart with spectroscopy (nature, redshift...)

## X-ray telescopes: Swift, INTEGRAL, SVOM, ATHENA...

- Very clean sky
- Provide transient triggers (GRB, AGN, Novae...)
- ToO program (not so easy access)

## γ-ray telescopes: Fermi-LAT

- All-sky complete monitoring
- Provide transient triggers (GRB, AGN...)

## VHE γ-ray telescopes: HESS, MAGIC, CTA...

- Most natural common science case
- Follow-up (not easy access)

## VHE γ-ray telescopes: HAWC, LHAASO...

- All-sky monitoring
- Provide triggers

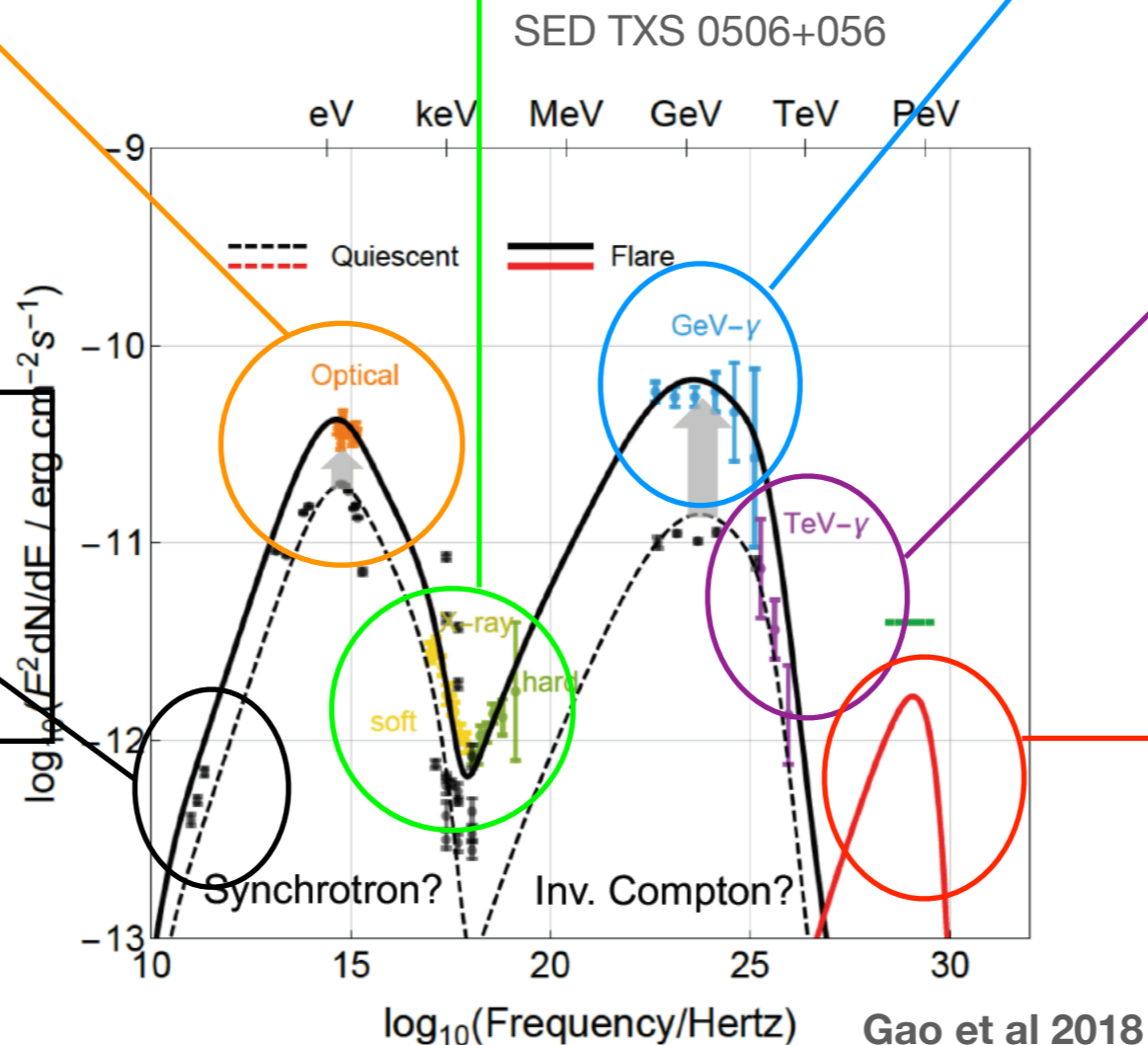
## Neutrino telescopes: ANTARES, IceCube, KM3NeT, GVD...

- Mutual follow-up
- Confirmation of sources, improve significance

## Radio telescopes: Parkes, MWA, Lofar, Nenufar, ASKAP, SKA, VLBI...

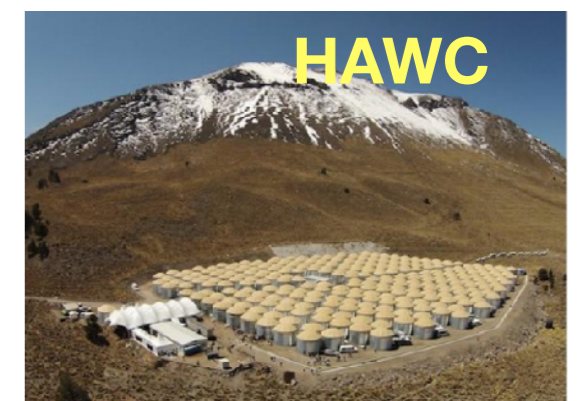
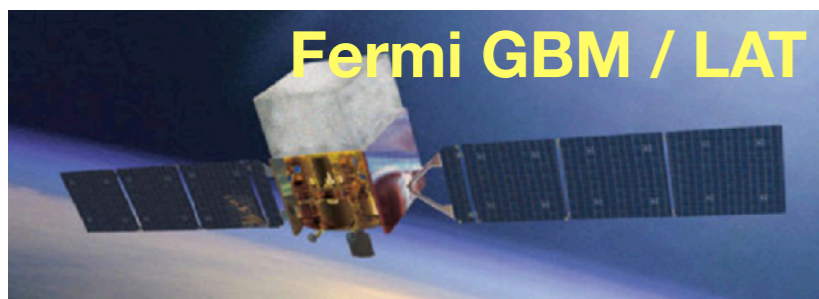
- Provide triggers (FRB...)
- Follow-up

+ link with LIGO/VIRGO  
+ SK, SNEWS



# Need to secure access to main follow-up facilities

- Optical telescopes: **GRANDMA** (Thierry, Damien, Godefroy, Alexis)
- Optical telescope: **COLIBRI** (Damien)
- Optical telescope: **ZTF/LSST** via FINK (Damien, Thierry, Godefroy)
- X/ $\gamma$ -ray satellite: **SVOM** (Alexis, Damien)
- X/ $\gamma$ -ray satellite: **INTEGRAL** (Alexis)
- Radio telescope MHz: **Nenufar** (Richard, Lilian, Valentin)
- Neutrino network: **SNEWS** (Damien, Isabel, Sonia, Alexis, Godefroy)
- Others: **HAWC, LHAASO, HESS**, MoU signed with KM3NeT (?)  
⇒ discussion started with other radio facilities (**VLBI, SKA precursors**)



# Next challenges for the follow-up

**Need to increase the follow-up capabilities**, probably not increasing the number of instruments but more by increasing the access to existing/planned facilities.

For this we should **increase the scientific interest of the astro community**  
⇒ This will help us to have more observing proposals to be accepted by the TACs.

Sending **public alerts** is clearly the way to go.

Having the best angular accuracy for the neutrino alerts is the best but with a **good control of the systematics (absolute pointing)**.

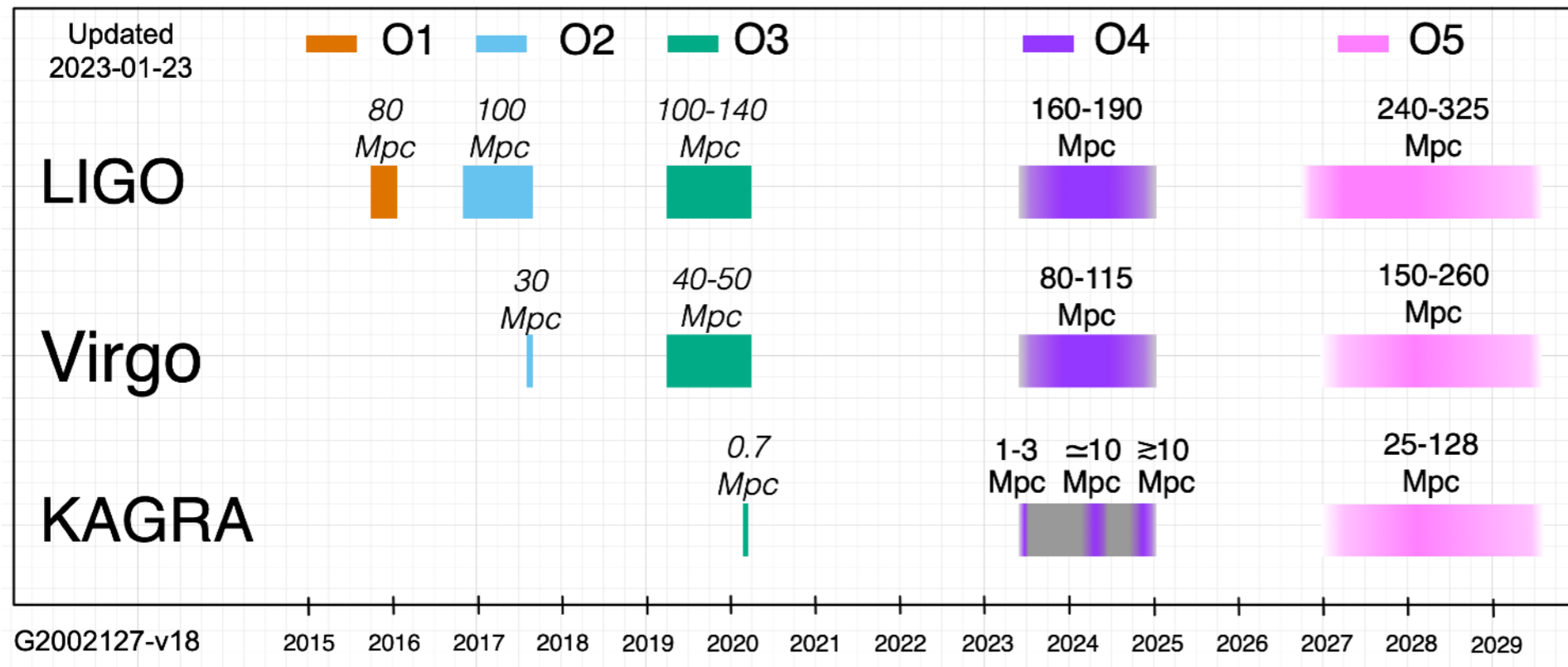
The GW/GRB communities have made this effort to have better organized analysis groups [ENGRAVE, STARGATE...].

# Next challenges for the follow-up

- **Wide-field (ideally all sky) EM counterpart discovery obs.** [ZTF, MASTER, GRANDMA... in visible, Fermi-LAT at high energies]. Rapid dissemination of the information.
- **Complete MWL follow-up from radio to gamma-rays to identify features** [VLBI, X-ray satellites, CTA...]
- **Easy access to large surveys** [ATLAS, Rubin, Euclid, Desi, eRosita...]. In quite a lot of cases, the potential counterpart has already been characterized, without spending new observing time...
- In relatively large error box, **multiple interesting sources** [source confusion, different redshift horizons].
- **Better knowledge of the origin of the different EM/MM components inside the sources.** Going beyond the  $3\sigma$ .
- **Standard way to infer a correlation probability** [need to understand the correlation of the MWL emissions in the sources]
- **Multi-messenger search automatization following FAIR principles** (tools for joint neutrino searches, tools to access to archive observing data)



# KM3NeT organisation for the follow-up of LVC o4



Be ready for  
May 24 for  
18 months

- **Real-time follow-up: online analysis group**

- Pipelines: upgoing track (Seb@ORCA, Ilaria@ARCA), downgoing track (Mathieu@ORCA, Francesco III@ARCA), all-sky shower (CP3@ORCA, ??@ARCA) + VLE (Sonia, Isabel, Godefroy@O/ARCA)
- UL computation + combination: Mathieu
- Follow-up strategy: in discussion

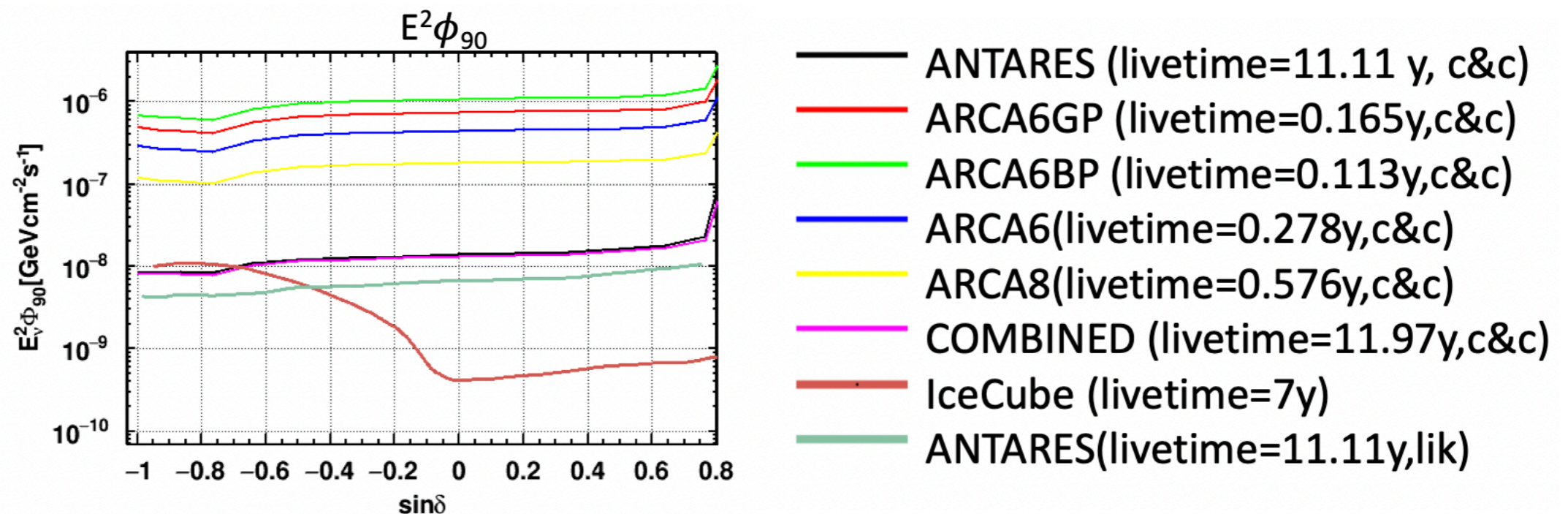
- **Offline search: APC+IPHC ?**

- **Sub-th search: APC+IPHC ?**

# Status main astro analyses

- **Task forces ORCA/ARCA:** almost found the origin of the data/MC discrepancies
  - **Toward an end of the ARCA6+8 and ORCA4-6 astro analyses** (publications ongoing)
    - Review almost finished for the PS ARCA6+8 (ready for combination with ANTARES)
    - Analyses diffuse + Galactic ridge ARCA6+8 almost finished
    - Paper ORCA4-6 GW search in internal review
- ⇒ **Now, moving all the analyses to ARCA19-21, ORCA11-13 data**

- **Finalisation of the full ARCA performances for PS/diffuse +SBG application + tau search**



# Open points for discussions

- ORCA data/MC analyses: task force

We are mainly absent on the event reconstructions whatever the detectors

- So far, nobody in France is doing analysis of ARCA data. I think this is a very weak point in the long term.
- Key analyses where we are not present so far:
  - Stacking analyses (?)
  - Diffuse analyses including Galactic Ridge (Theophile ?)
  - Point-like sources, untriggered search (?)
  - Better organisation of the MWL follow-ups (how to maximise the return of the investment in others facilities (SVOM, Grandma, Nenufar, SNEWS, LVC...))
  - Link to the GW o4 (sub-th analyses ?, offline search ?)
- Common applications ?