

CLAXSON: a citizen science experiment to make the most of XMM-Newton archives

Hugo TRANIN, Postdoc, ICCUB, University of Barcelona

29 Feb 2024

XMM2ATHENA

XMM-Newton survey legacy for Athena and beyond

26-29 Feb 2024 Toulouse (France)

60

Outline

- 1) Why
- 2) How
- 3) Results



1) Why use citizen science?



Remember yesterday...

- CLAXBOI includes data preparation and value-adding
- Fully probabilistic classification
- Well-behaved on catalog-sized samples
- Both reliable and interpretable
- Samples of known XRB, CV, TDE... are still small



⇒ to enlarge training samples and find anomalies, use citizen science.

⇒ **CLAXSON platform** <https://xmm-ssc.irap.omp.eu/claxson/>

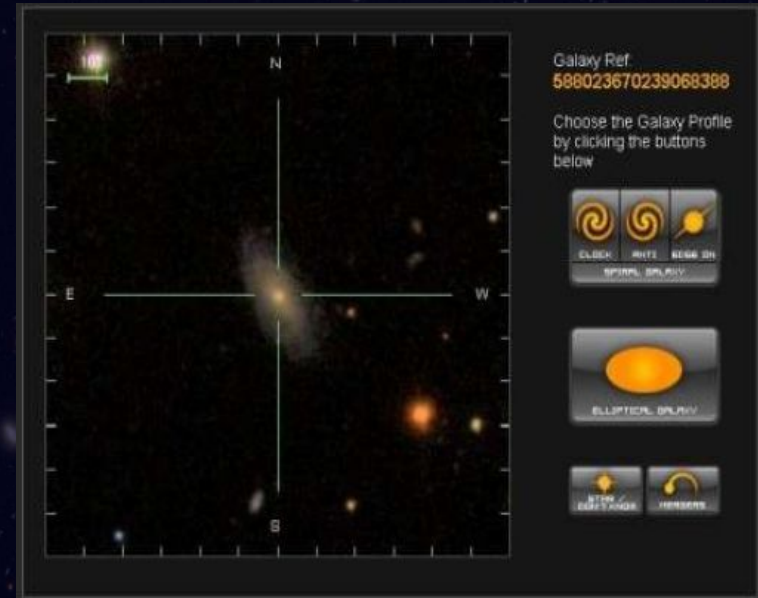


Going further with citizen science

Green Peas discovered by volunteers



- Citizen science is increasingly used for classification tasks
 - **enlarging training samples**
 - **making serendipitous discoveries**
- Example: Galaxy Zoo (2007)
 - 1 million galaxies classified, ~50/galaxy
 - >150 peer-reviewed publications so far



2) How to implement it?



Going further with citizen science

CLAXSON website (CLAssification of X-ray Sources for Novices) <https://xmm-ssc.irap.omp.eu/claxson>

For astronomers | About us | The project | Tutorial | Contact | Log in | Sign up

Welcome to CLAXSON!

(Classification of X-ray Sources for Novices)

CLAXSON is a platform designed to identify new objects observed in the X-ray sky with the European Space Agency X-ray telescope XMM-Newton. Be the first to find new supermassive black holes, stars, galaxies and other exotic objects in observations taken over the last 20 years, and help astronomers unravel the mysteries of the X-ray sky.

Begin!

Name: 4XMM J174702.5-285259
Galactic latitude $b = -0.2^\circ$
loXO = unknown
loXI = 1.3

From what you see, what is the type of this source?

- An AGN
- A star
- An X-ray binary
- Something else
- I don't know

Go to counterparts

Send

I see nothing in the 1st image!

Send a comment

Other wavelengths:

Back to initial zoom

X-rays: Aladin xCAT

UV image

optical image

infrared image

X-ray image

X-ray spectrum

X-ray light curve

Sp.1 Sp.2

LC 1 LC 2

Source spectrum, camera: PN

Luminosity (counts/s/keV)

Energy (keV)

Source light curve, camera: PN

Luminosity (photons/s)

Time (s)

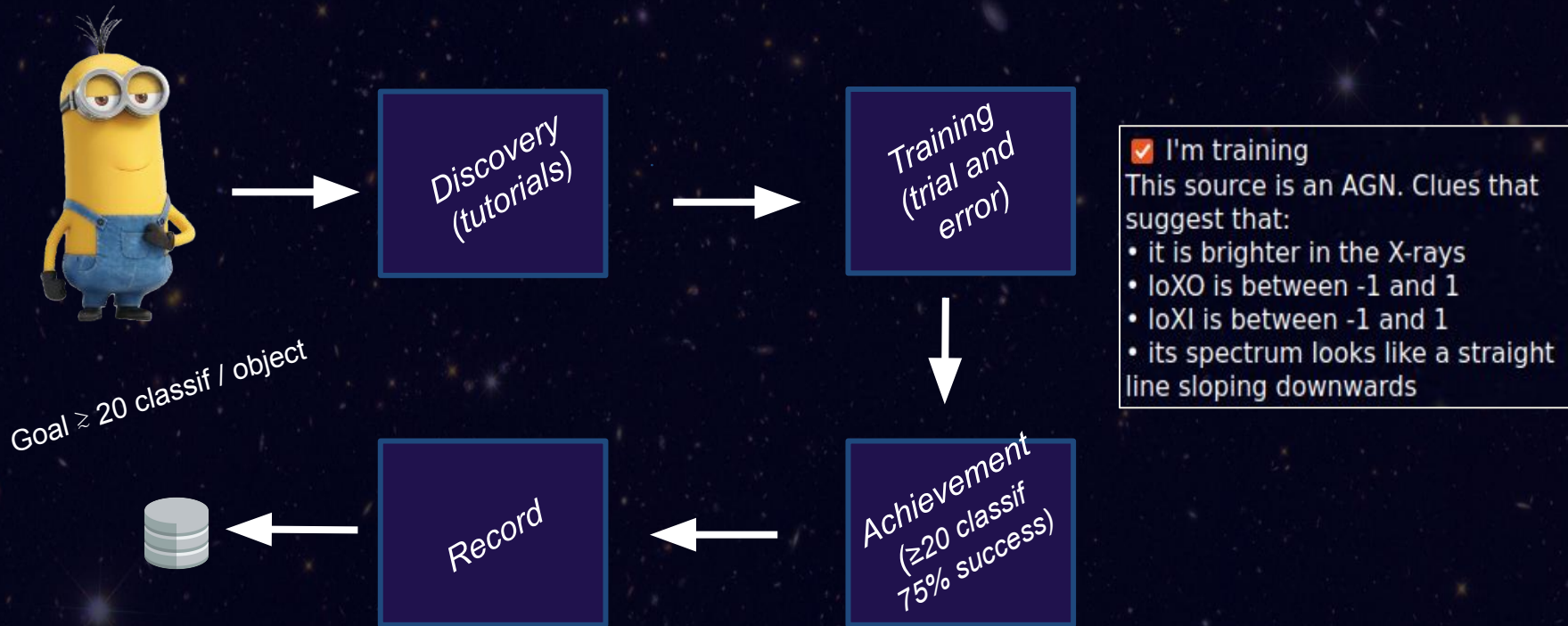
Ultraviolet

Optical

Infrared



“Wisdom of crowds”



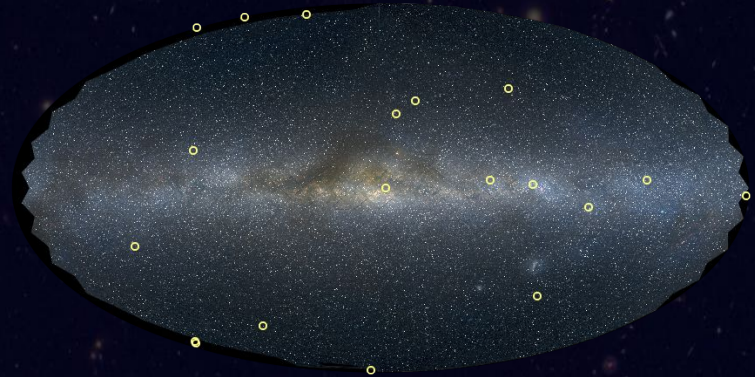
<u>Rank</u>	<u>User</u>	<u>Number of classifications</u>	<u>Success rate</u>
1	chrostek	21561	88.9
2	KrystianBykowski	21272	86
3	algol	15035	92.8
4	Marty_SAP	10000	95.3
5	SimonLeKlaxon	6063	91

Gamification!

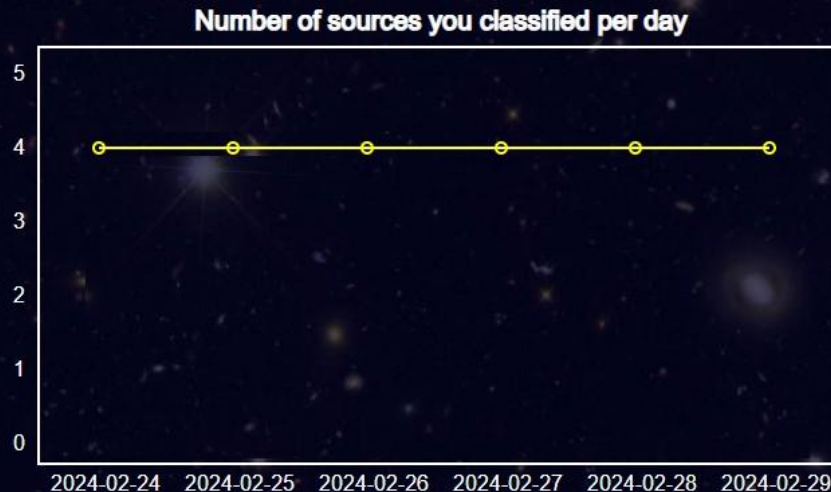
Leaderboard

<u>Rank</u>	<u>User</u>	<u>Number of classifications</u>	<u>Success rate</u>
1	chrostek	21561	88.9
2	KrystianBykowski	21272	86
3	algol	15035	92.8
4	Marty_SAP	10000	95.3
5	SimonLeKlaxon	6063	91

User's classification map



Daily streak



Dynamic weekly ranking

You moved up in the weekly ranking!

Name	Rank	Change
1 4XMMUJ0313.1+58062	5	▲
2 AstroPPR	4	▼
3 chrostek	4	▼

loXI = unknown

From what you see, what is the type of this source ?

3) Results (so far)

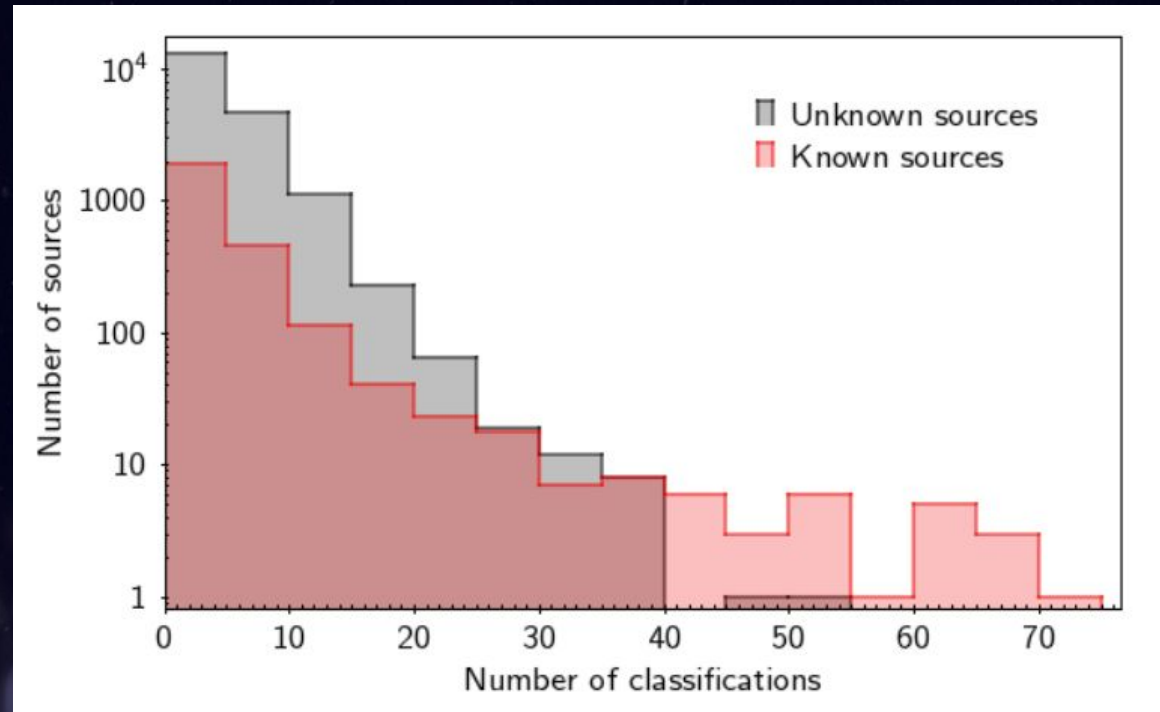


Performance of CLAXSON classification

- So far >200 unknown sources were classified ≥ 20 times
⇒ how reliable are their classifications?

Known sources				
	AGN	Star	XRB	Precision
→AGN	38	0	0	100%
→Star	1	31	1	94%
→XRB	1	0	8	89%
→Other	0	0	1	-
Recall	95%	100%	80%	

Unknown sources				
	AGN	Star	XRB	Precision
→AGN	43	1	8	83%
→Star	5	15	4	62%
→XRB	6	1	9	60%
→Other	0	0	2	-
Recall	80%	88%	39%	



Outperforming machine learning

- So far >200 unknown sources were classified ≥ 20 times
⇒ reliable classifications
- Of these, some ~20% disagreement between CLAXSON and CLAXBOI (especially the case for XRB).

Taken from CLAXBOI

	Unknown sources			
	AGN	Star	XRB	Precision
→AGN	43	1	8	83%
→Star	5	15	4	62%
→XRB	6	1	9	60%
→Other	0	0	2	-
Recall	80%	88%	39%	

⇒ visual inspection

⇒ in most cases the **CLAXSON-based classification is more trustable**

- Also useful to train the human (scientist) in the loop

Anomaly detection (?)

Users can leave comments to discuss each source. Examples:

KrystianBykowski 2024-01-14
23:45:02

[202019018010025](#)

"very old agn? and interesting black hole object on left of the source"

guest 2022-11-16
10:46:39

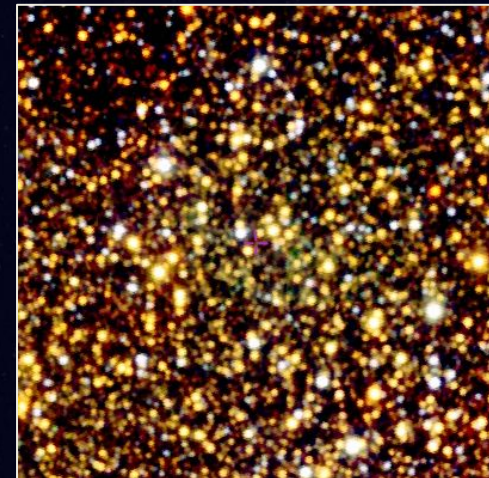
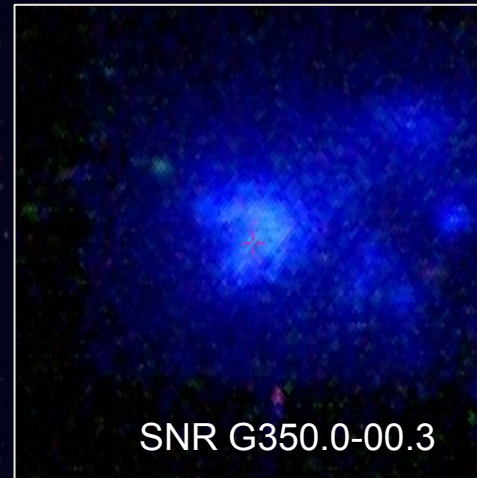
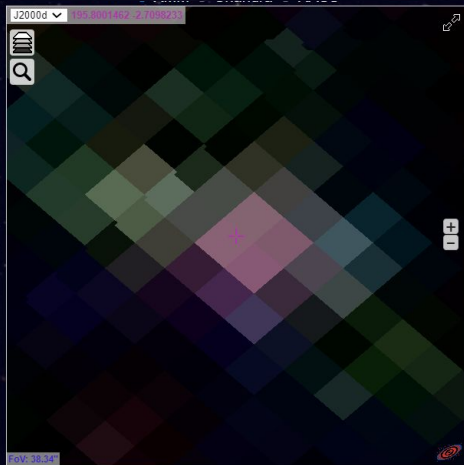
[201123706010010](#)

"It looks lie a star because of loXO, loXI and optical brightness, but the UV and optical images look extended"

KrystianBykowski 2022-09-21
16:56:35

[201130507010022](#)

"massive! :)"



“Challenges”: expert mode for specific science

Experienced users can choose to join “challenges” with sources difficult to classify

First challenge: ULX candidates in nearby galaxies

Name: 4XMM J111813.1+580625

Galactic latitude $b = 55^\circ$
 $l_{OX} = -0.24$
 $l_{OI} = \text{unknown}$

From what you see, what is the type of this source ?

- An AGN
- A star
- A ULX
- A volume of hot gas
- Something else
- I don't know

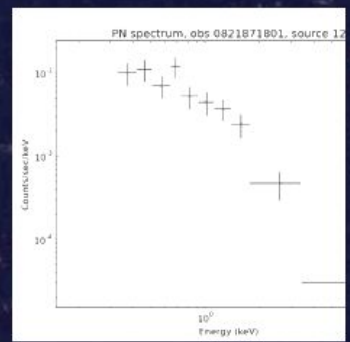
Go to counterparts
Send
I see nothing in the 1st image!
Send a comment

Other wavelengths:
+
-
Back to initial zoom

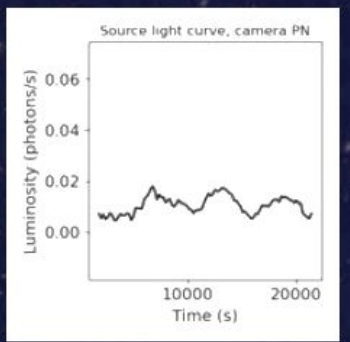
Aladin Chandra



Sp.1



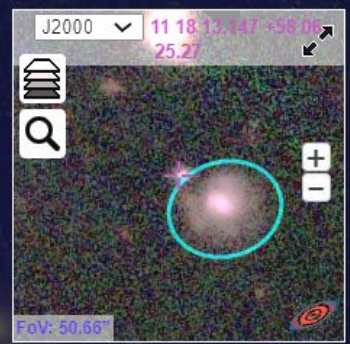
LC 1



Ultraviolet



Optical



Infrared

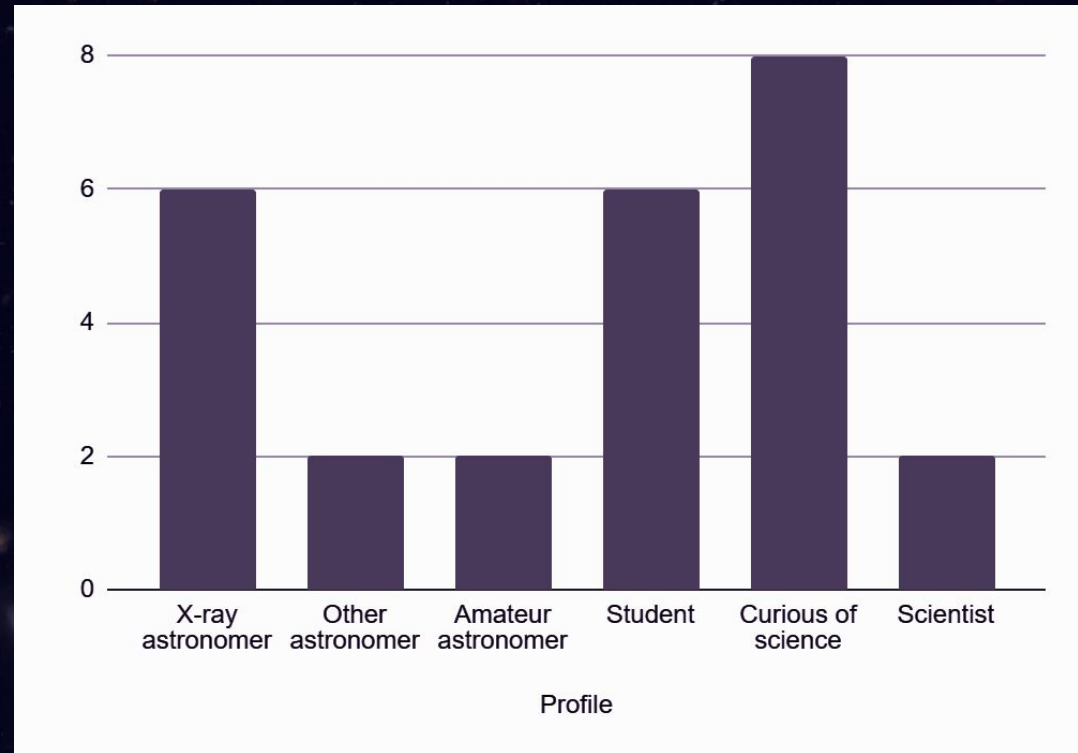
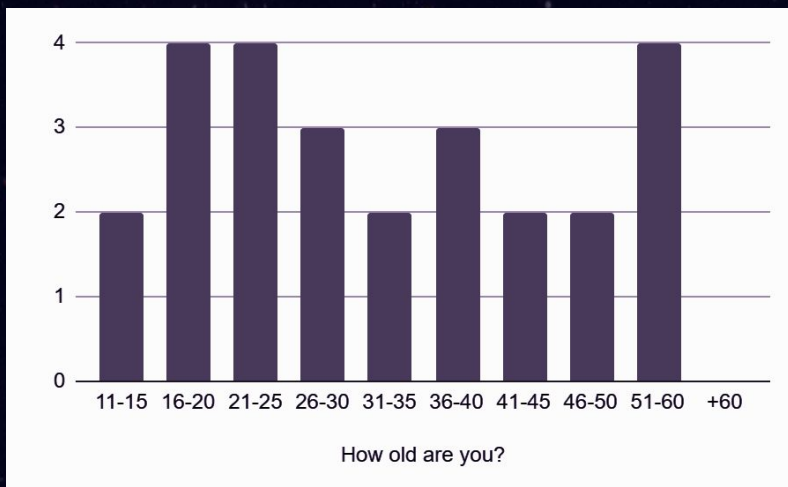
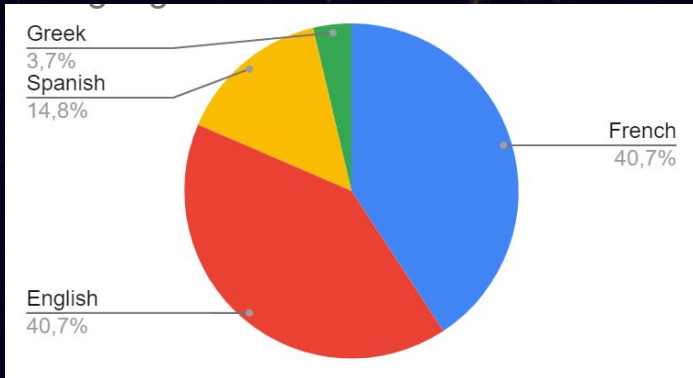


New classes

Impact as an outreach tool

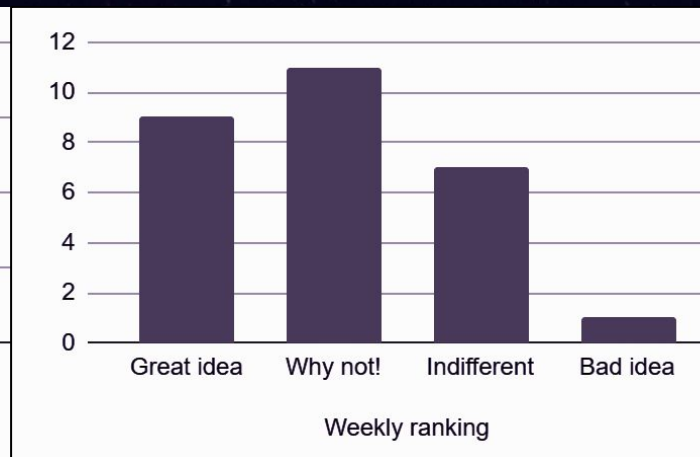
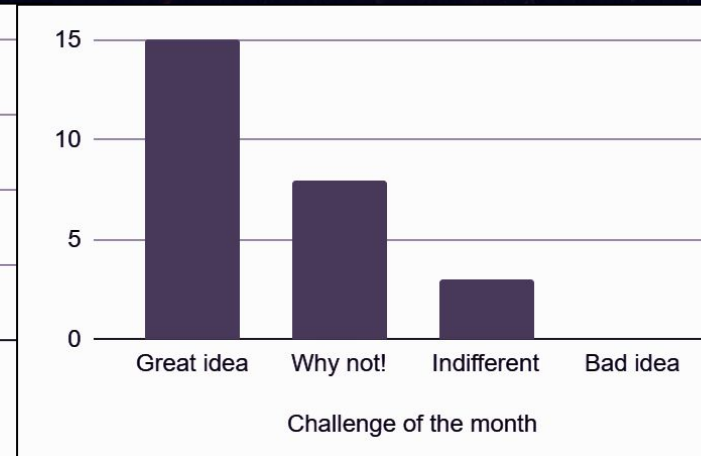
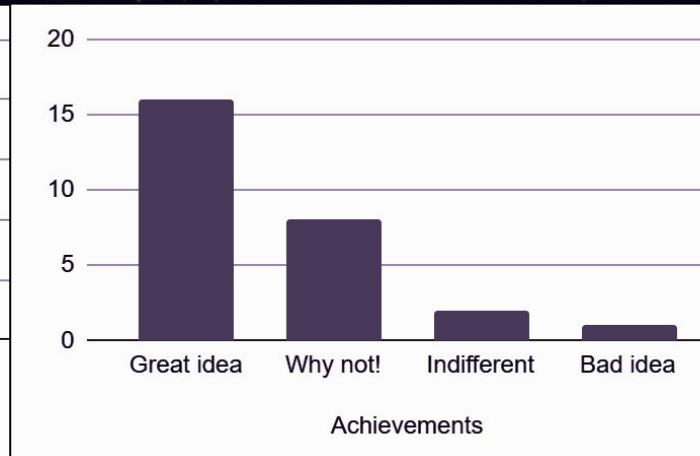
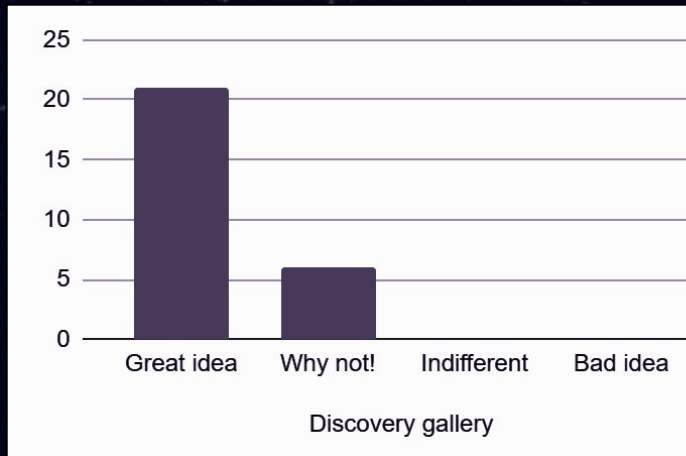
User survey May 2022 (29 answers):
CLAXSON reaches a large variety of user profiles!

2024: >140 experienced (level 2) users



Citizen science close to the people

Users were asked to give their opinions on a bunch of possible future developments. Here is what they replied.



1. Discovery gallery
2. Confidence bar
3. Challenge of the month ✓
4. Achievements
5. Weekly ranking ✓

Conclusion

- ❑ **CLAXSON** is a **citizen science platform** to make the most of current and future XMM-Newton archives
- ❑ Ongoing since 2022 with capabilities to enlarge **training samples** / do **serendipitous discoveries**
- ❑ Scientific impact: **encouraging results** (better than ML) + train the **human in the loop** (+ keep them enthusiast 🙄)
- ❑ Outreach impact: has interested **all kinds of public** to X-ray astronomy. Huge enthusiasm! Some **very active users**.
- ❑ **Give it a try!** Opportunities to **contribute**:
Use it in your teaching, advertise it and help us adding translations 😊

link to CLAXSON:

