Image credit:
NASA/JPL-Caltech

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

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Outline

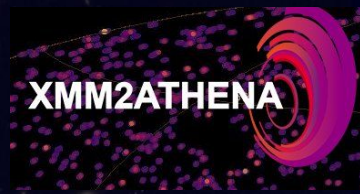
1) Why
2) How
3) Results

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 traning samples and find anomalies, use citizen science.
⇒ **CLAXSON platform** https://xmm-ssc.irap.omp.eu/claxson/

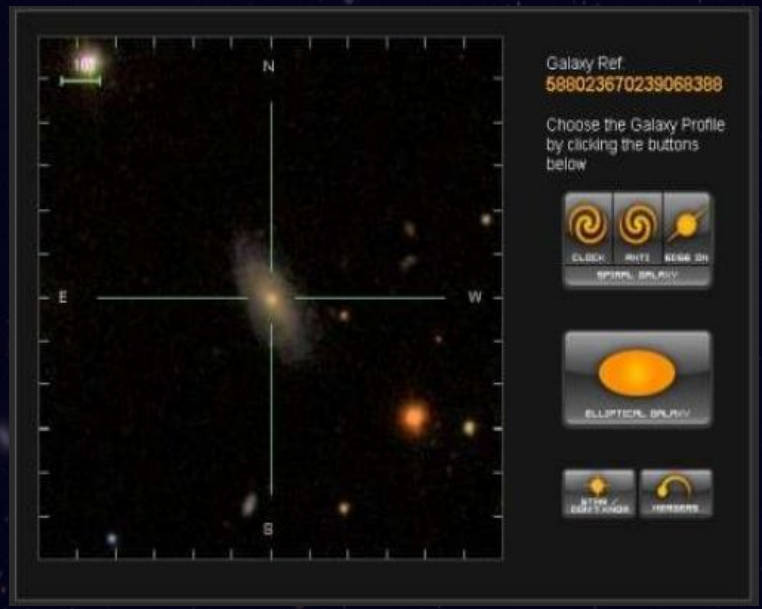


Going further with citizen science

- 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

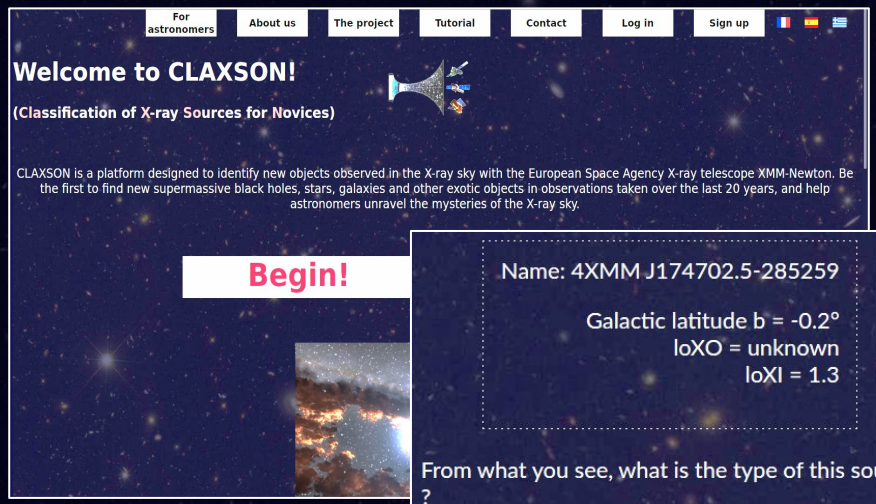
Green Peas discovered by volunteers

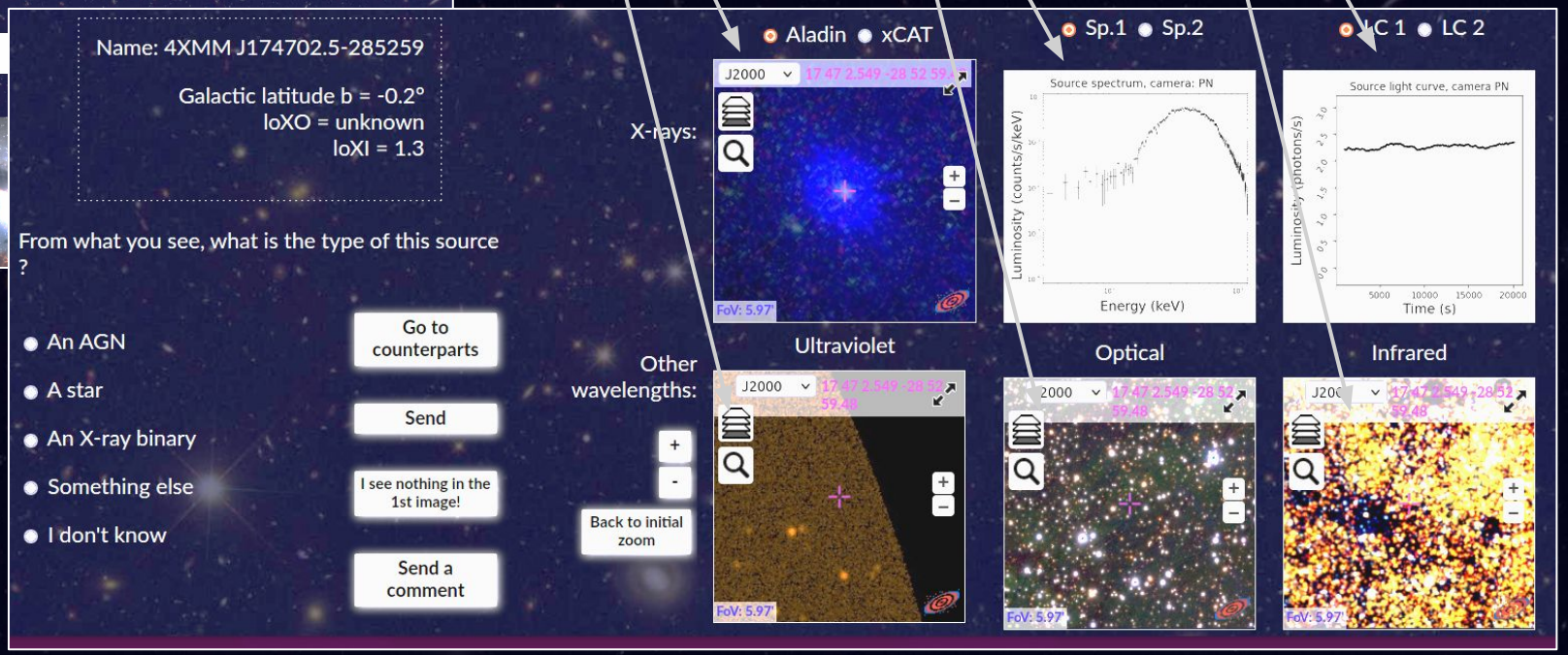


2) How to implement it?

Going further with citizen science

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





“Wisdom of crowds”

Goal ≳ 20 classif / object

Discovery (tutorials) → Training (trial and error) → Achievement (≥20 classif 75% success) → Record

I'm training
This source is an AGN. Clues that suggest that:
- it is brighter in the X-rays
- loXO is between -1 and 1
- loXI is between -1 and 1
- its spectrum looks like a straight line sloping downwards

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

https://xmm-ssc.irap.omp.eu/claxson

Gamification!

Leaderboard

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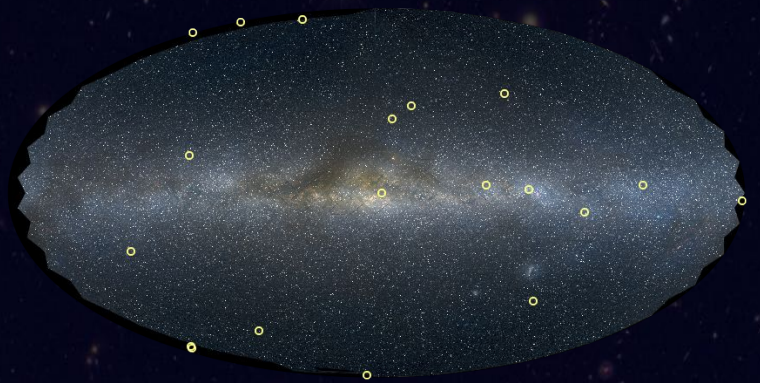
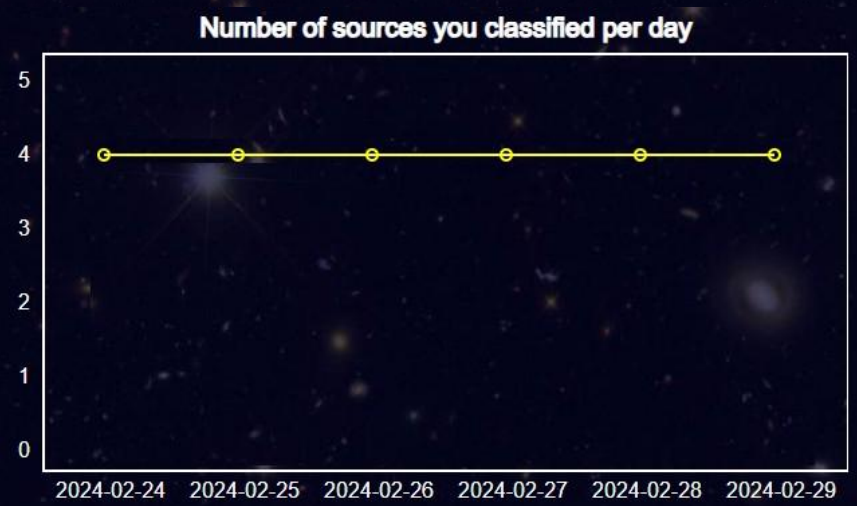
User's classification map



Daily streak



Dynamic weekly ranking

https://xmm-ssc.irap.omp.eu/claxson

3) Results (so far)

Performance of CLAXSON classification

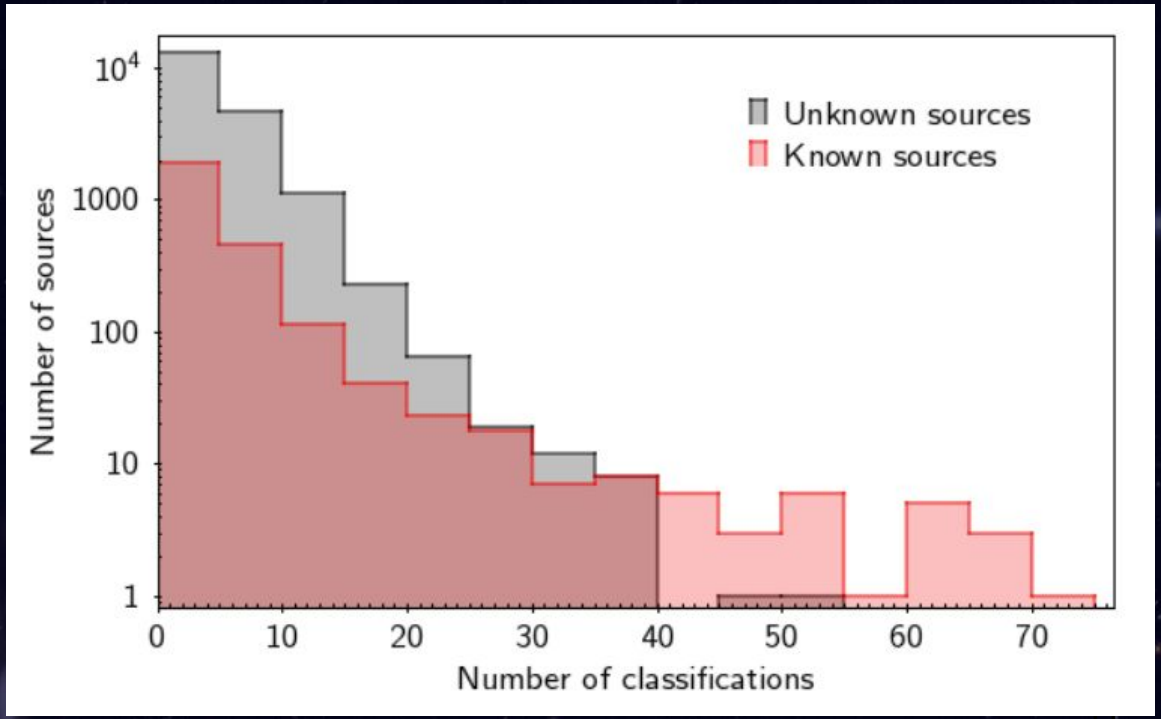
- So far >200 unknown sources were classified ≥ 20 times
  ⇒ how reliable are their classifications?

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%	

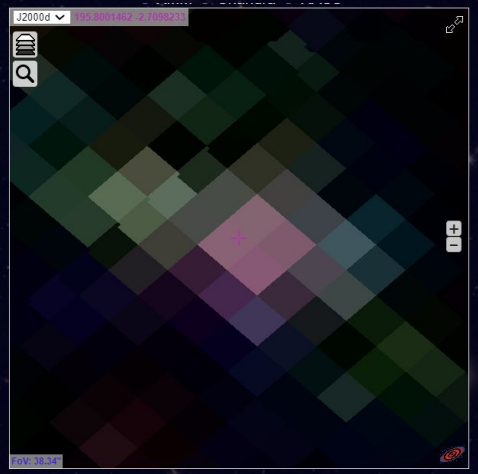
⇒ visual inspection
⇒ in most cases **the CLAXSON-based classification is more trustable**

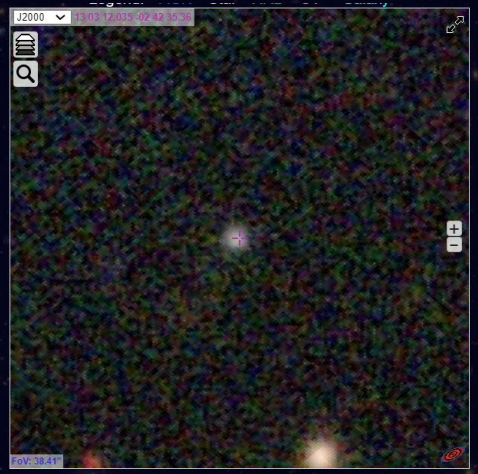
- Also useful to train the human (scientist) in the loop

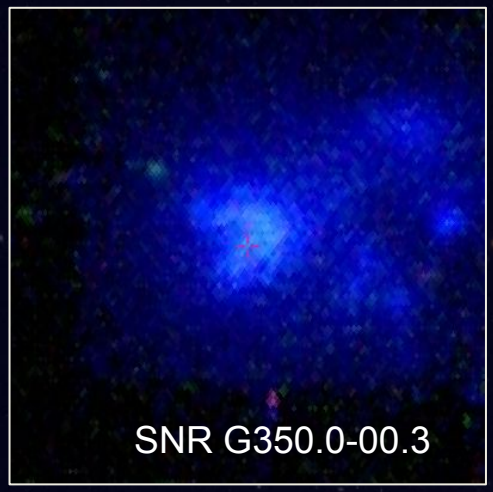
Anomaly detection (?)

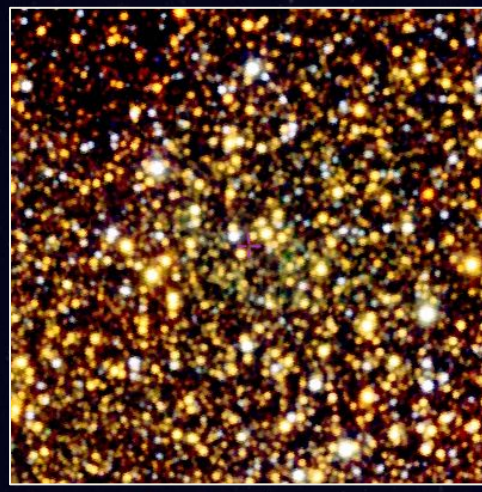
Users can leave comments to discuss each source. Examples:

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! :)





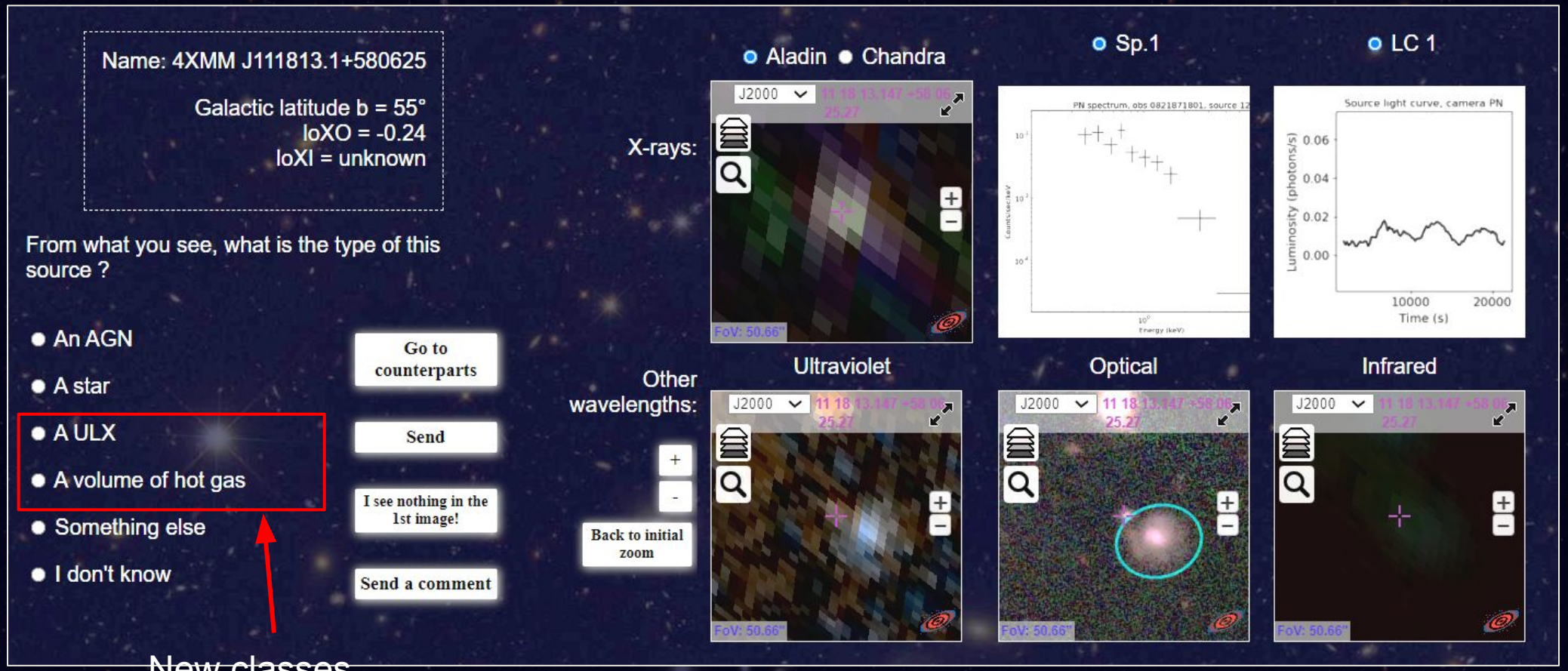




“Challenges”: expert mode for specific science

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

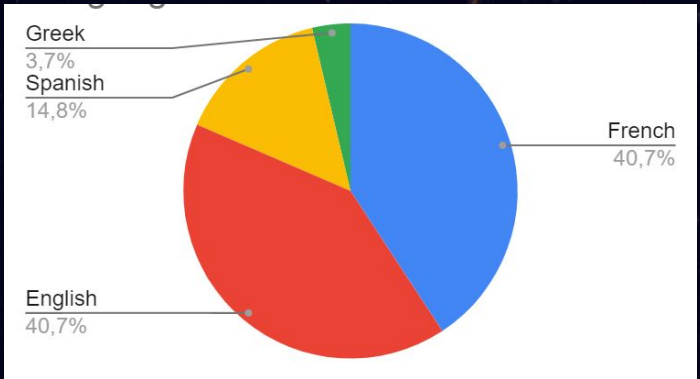
First challenge: ULX candidates in nearby galaxies

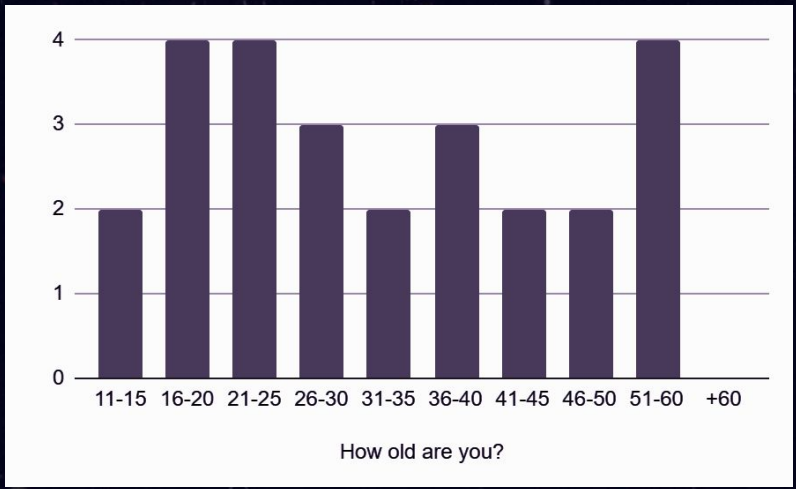


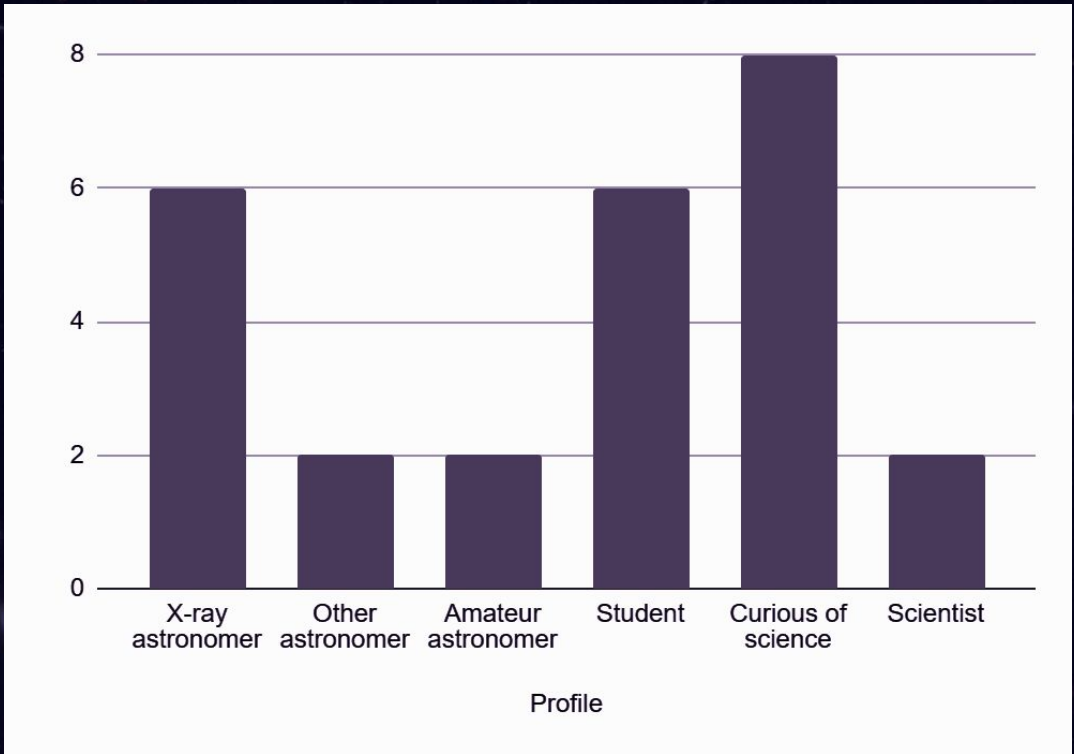
Impact as an outreach tool

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

2024: >140 experienced (level 2) users

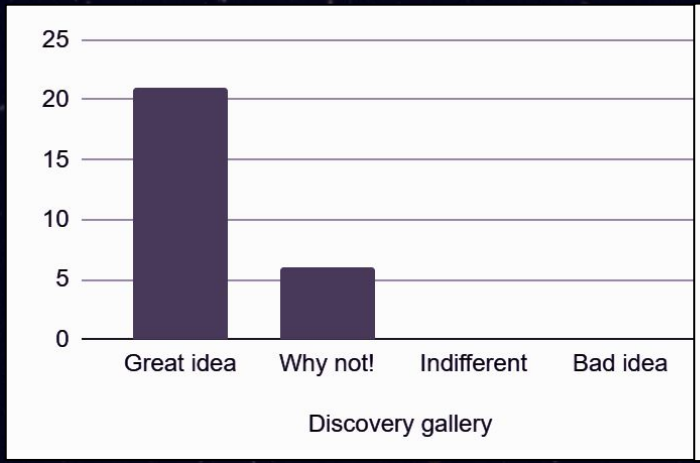


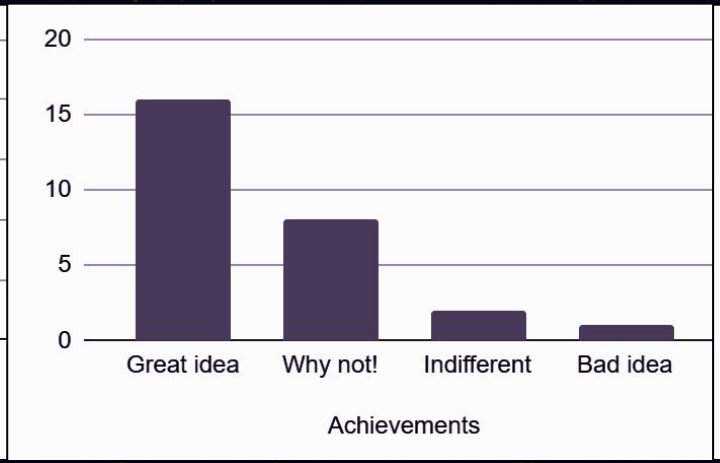


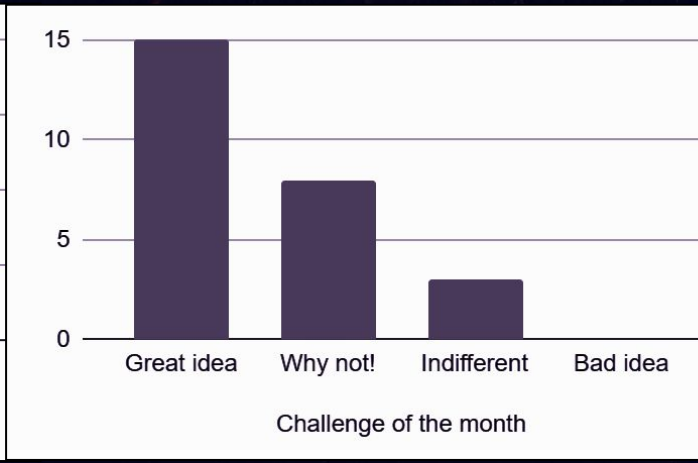


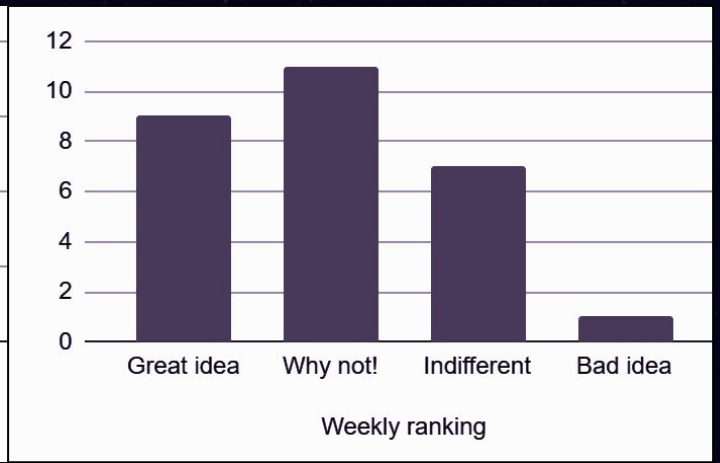
Citizen science close to the people

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**.

link to CLAXSON:

- **Give it a try**! Opportunities to **contribute**:
  Use it in your teaching, advertise it and help us adding translations 🙂

XMM2ATHENA