INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

LE NUOVE TECNOLOGIE IN INAF

SECONDO FORUM DELLA RICERCA SPERIMENTALE E TECNOLOGICA IN INAF

Bologna, 1-3 Ottobre 2024

CSN5

FOREWORD

Why a «New Technology» session?

Large (natural) interest in new technologies with a clear, direct and immediate impact on astronomical research.

But:

- What about «innovations» with a not so predictable future and/or potential impact?
- What about all the innovative technological activities which are diluted in large programs and projects?
- Are we always able to identify an “innovation”?

“I’ll be happy to give you innovative thinking. What are the guidelines?”

What is a «New Technology»?

- New ideas and tech. developments with high (expected?) impact on A&A research
- New technologies with an important impact on a specific INAF research area
- New ideas/technology for which the real, expected impact on INAF and/or A&A research is not clear
- New methods and techniques applied to data analysis, technology development, etc.

PLEASE DEFINE INNOVATION

How can we identify an innovation?

TLR BASED CLASSIFICATION?

- New **ideas** : 1 ≤ TRL ≤ 3
- New **developments:** 4 ≤ TRL ≤ 6/7
- New **implementations** (e.g. of technologies validated in other research fields): 4 ≤ TRL ≤ 6/7

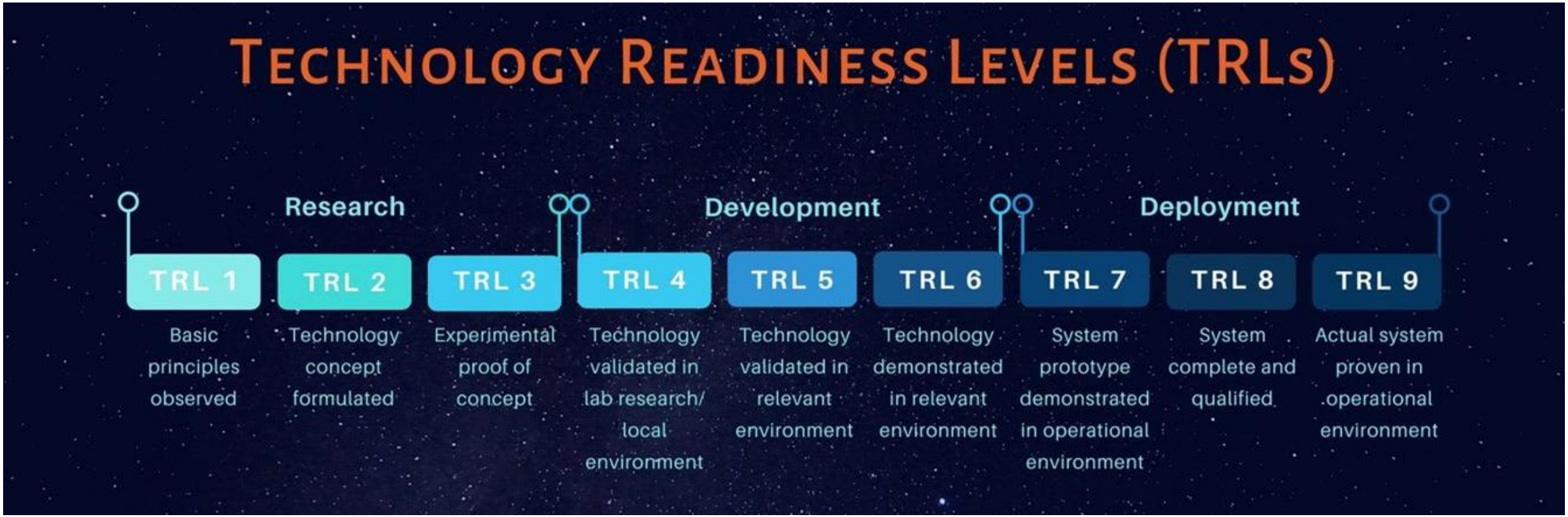
POTENTIAL FUTURE IMPACT ON ASTROPHYSICS?

- Low, medium or high potential impact on the **whole astronomy/astrophysics research**
- Low, medium or high potential impact on a **research area**
- Low, medium or high potential impact on a **specific research activity** or **development**

OPEN QUESTIONS (just a few of them…)

- Is TRL definition applicable to HW, SW and data analysis projects? Are we able to classify SW and data analysis innovation by means of the TRL scale?
- How can we predict (now) the impact of a new technology on INAF or A&A future? Does an objective "forecast" method exist?

TRL



Is TRL definition applicable to both HW and SW/data analysis projects?
Are we able to classify SW and data analysis innovation by means of the TRL scale?

TRL AND HW/SW

TRL		Definition	Hardware Description	Software/Data Analysis Description
Research	1	Basic principles observed	Scientific knowledge generated underpinning hardware technology concepts/applications.	Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation
	2	Technology concept formulated	Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. A tailored solution is defined based on definition of user requirements, specific application, and operating conditions.	Practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations and concepts defined. Basic principles coded. Experiments performed with synthetic or sample data
	3	Experimental proof of concept	Analytical studies place the technology solution in an appropriate context and laboratory demonstrations, controlled field tests, modelling and simulation validate analytical predictions and limitations.	Development of limited functionality to validate critical properties and predictions using non-integrated software components.

TRL		Definition	Hardware Description	Software/Data Analysis Description
Development	4	Technology validated in lab research/local environment	A low fidelity system/component breadboard assembly is built and operated to demonstrate basic functionality in critical test environments. Associated performance predictions are defined relative to the final operating environment.	Key, functionally critical, software components are integrated, and functionally validated, to establish interoperability and begin architecture development. Relevant Environments defined and performance in this environment predicted.
	5	Technology validated in relevant environment	A medium fidelity system/component brassboard assembly is built and operated to demonstrate overall performance in a simulated operational environment with realistic support elements that validates performance of core components. Performance predictions are made for subsequent development phases.	End-to-end software elements implemented and interfaced with existing systems conforming to target environment. End-to-end software system, tested in relevant environment, meeting predicted performance. Operational environment performance predicted. Prototype implementations developed.
	6	Technology demonstrated in relevant environment	A high-fidelity system/component prototype assembly that adequately addresses all core features and key performance metrics is built and operated in relevant environments to demonstrate operation under relevant environmental conditions.	Prototype implementations of the software demonstrated on full-scale realistic problems. Partially integrate with existing hardware/software systems. Limited documentation available. Engineering feasibility fully demonstrated.

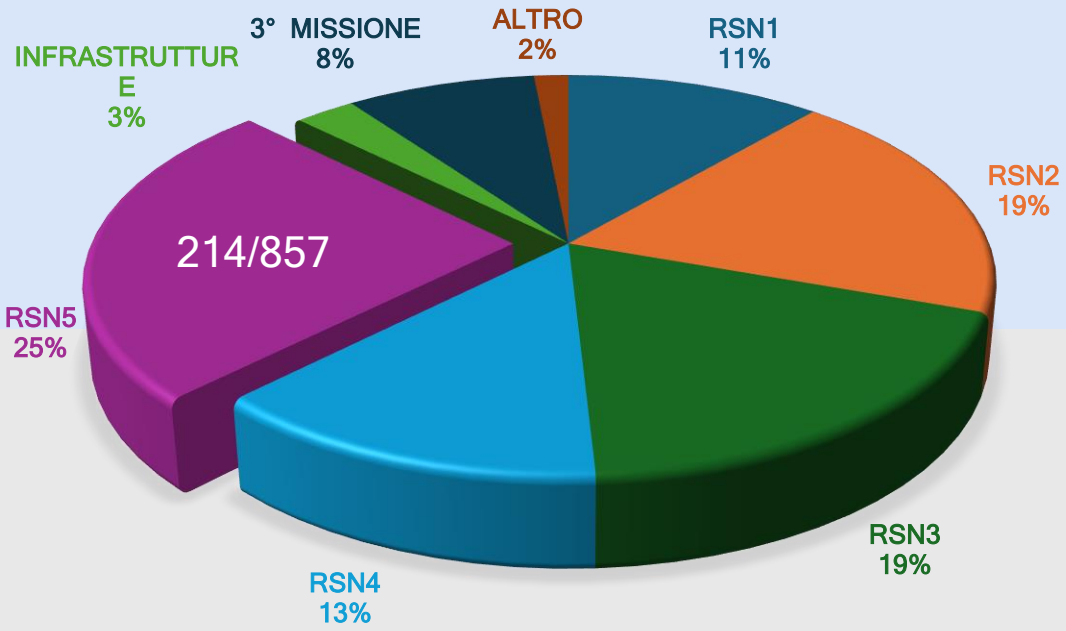
source: https://frontiersi.com.au/trl/

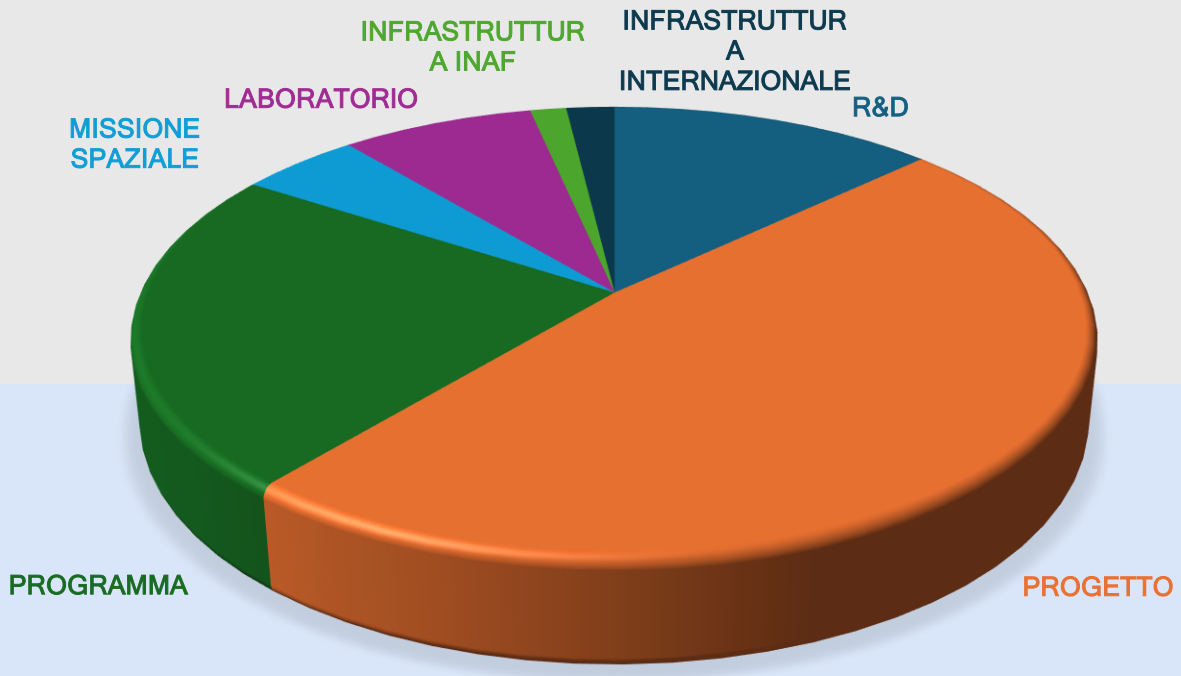
Tentative classification of «New Technology» used for data aggregation

- New **ideas** (TRL≤3) with high (foreseeable?) impact on astronomical and astrophysical research
- New **technological developments** (4≤TLR≤6) with high (expected) impact on astronomical and astrophysical research
- New **methods and techniques** (TLR≤6) applied to **data analysis**
- New **methods and techniques** (TLR≤6) applied to **technology development**
- New **methods and techniques** applied to **technology deployment** (TLR≥6)
- Newly introduced ideas, technologies and methods (1≤TLR≤6) **borrowed from other fields**

DISCALIMER: Due to the complexity and inhomogeneity of analyzed data, and due to the inevitable subjectivity in the analysis process (see Slide #3), the following data analysis is only intended as a discussion starting point. So… no decision should be taken based on this analysis!

AVAILABLE INPUT DATA - *SCHEDE*

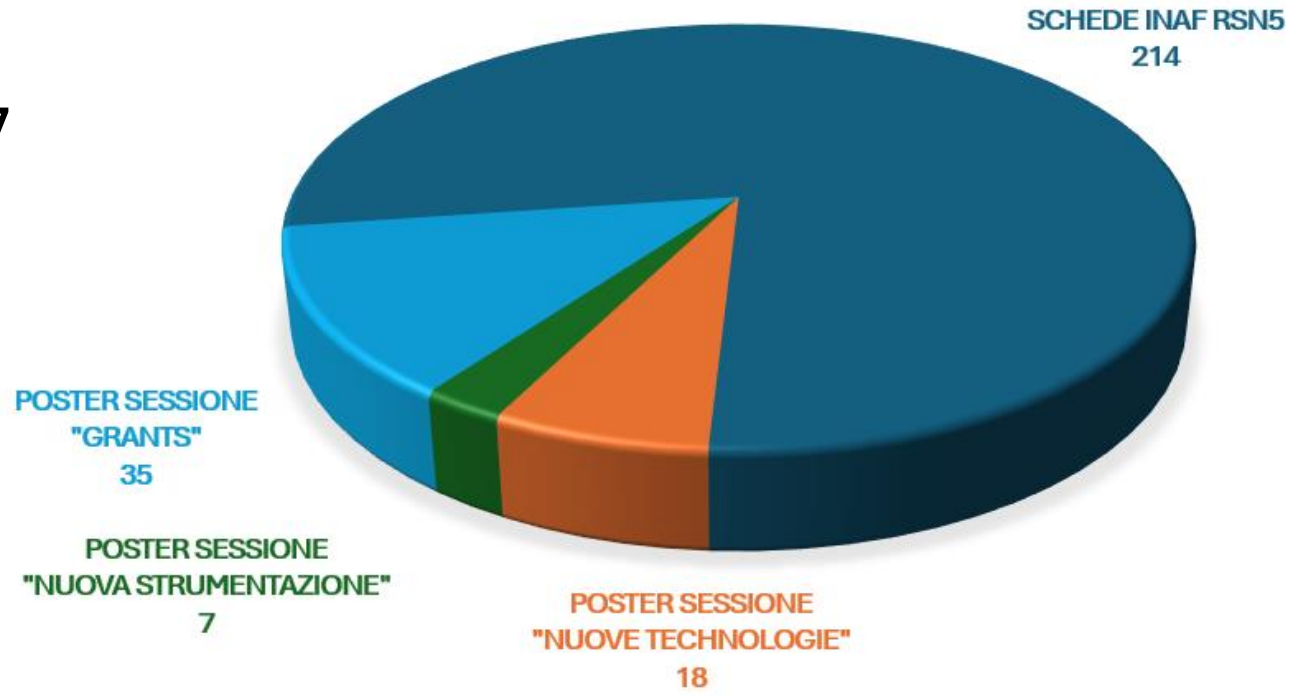




AVAILABLE INPUT DATA - ALL

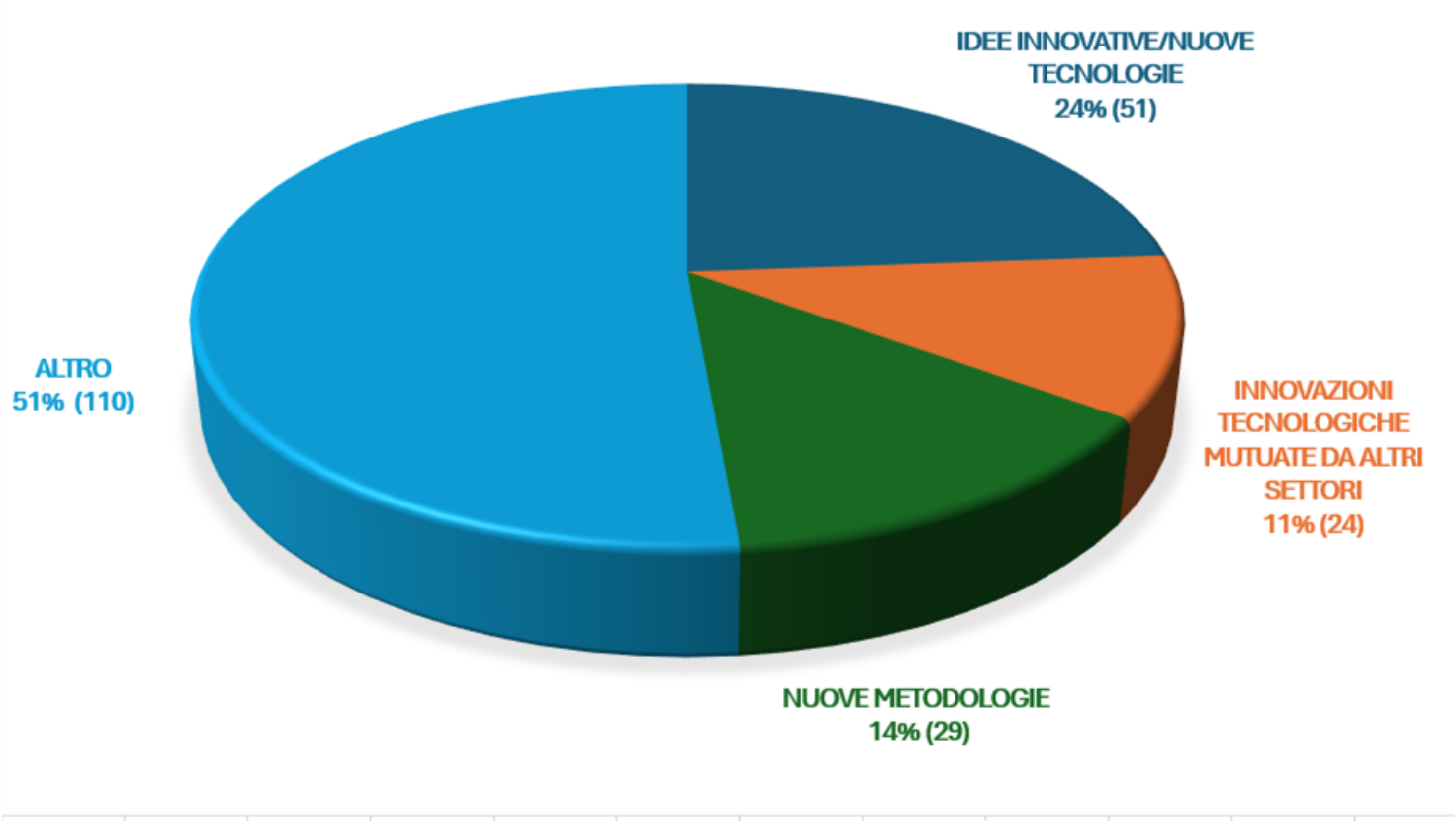
Thanks to the contribution of RSN5 Researchers and Technologists, other inputs are available for the survey:

- Posters: “Nuove Tecnologie” - 18
- Posters: “Proposte Nuova Strumentazione” - 7
- Posters: “Grants Ricerca Fondamentale” - 35



Same info often present in both *schede* and posters. But, strangely enough, this not always happens…

DATA AGGREGATION - *SCHEDE*

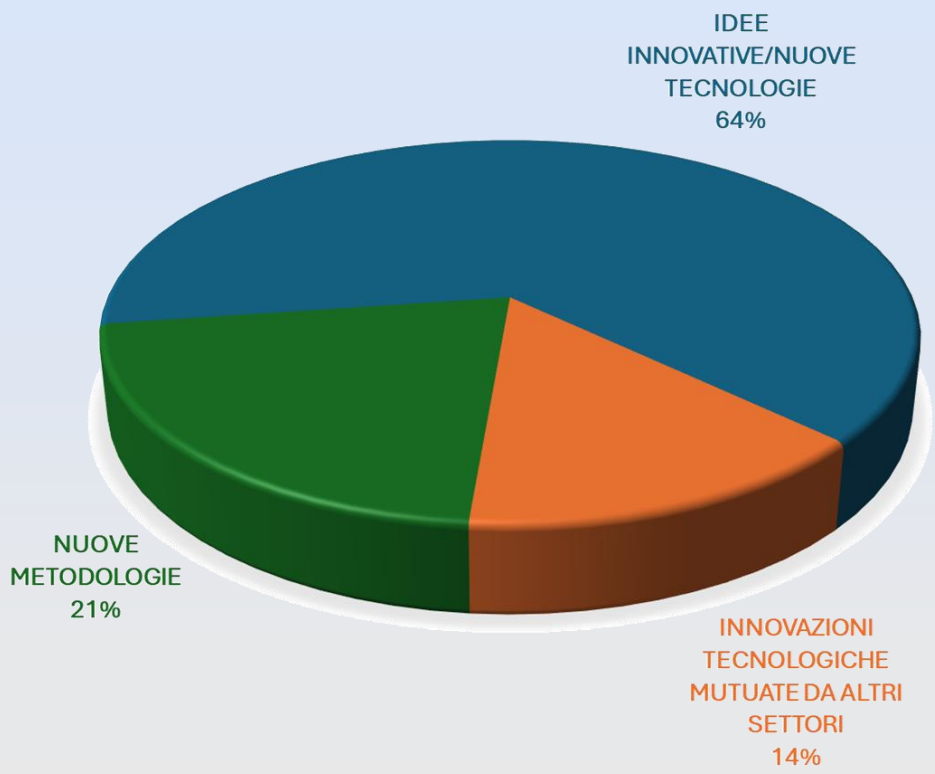


Total of 49%, distributed in:

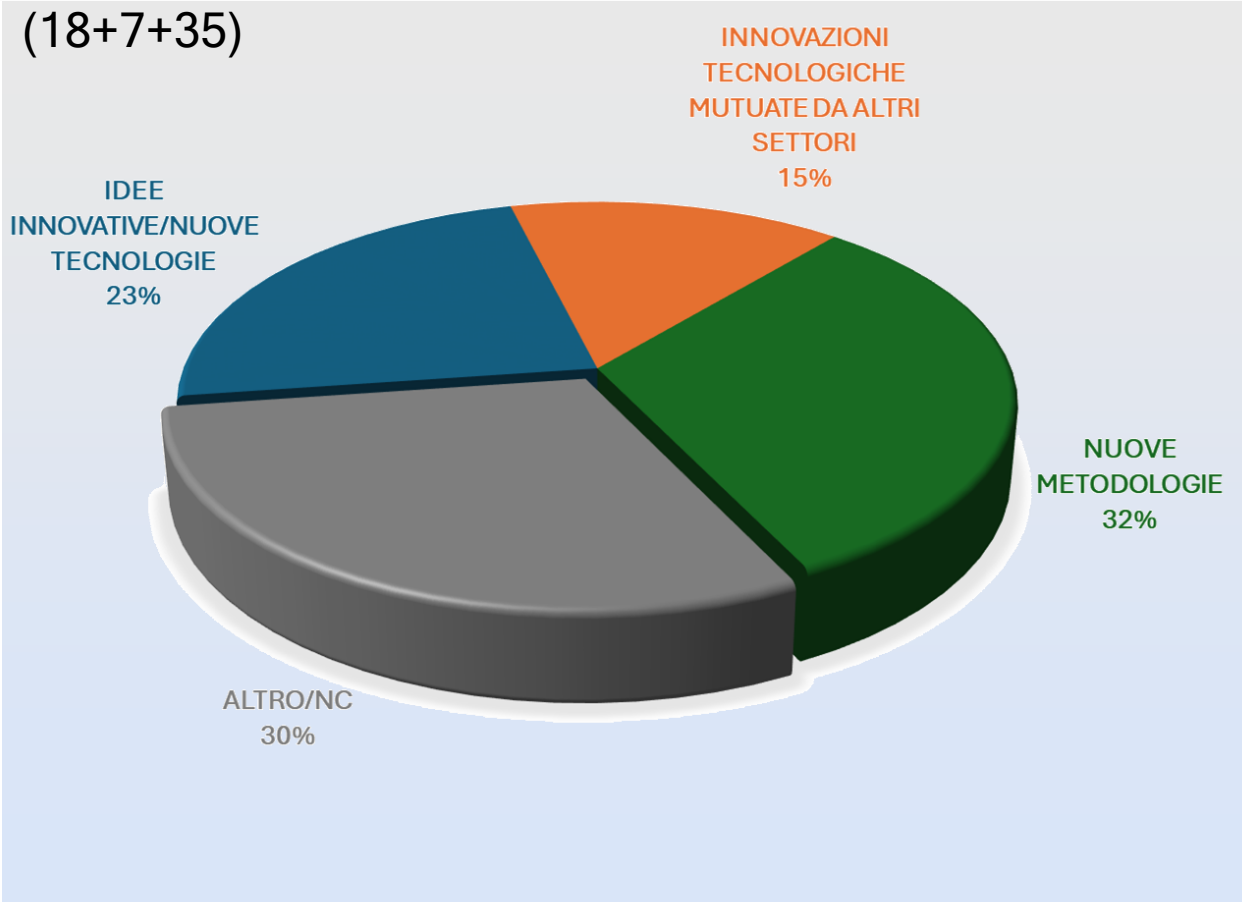
- New ideas/technologies (24%)
- New implementations (11%)
- New development and analysis methods (14%)

DATA AGGREGATION - POSTERS

NEW TECHNOLOGIES (18 POSTERS)

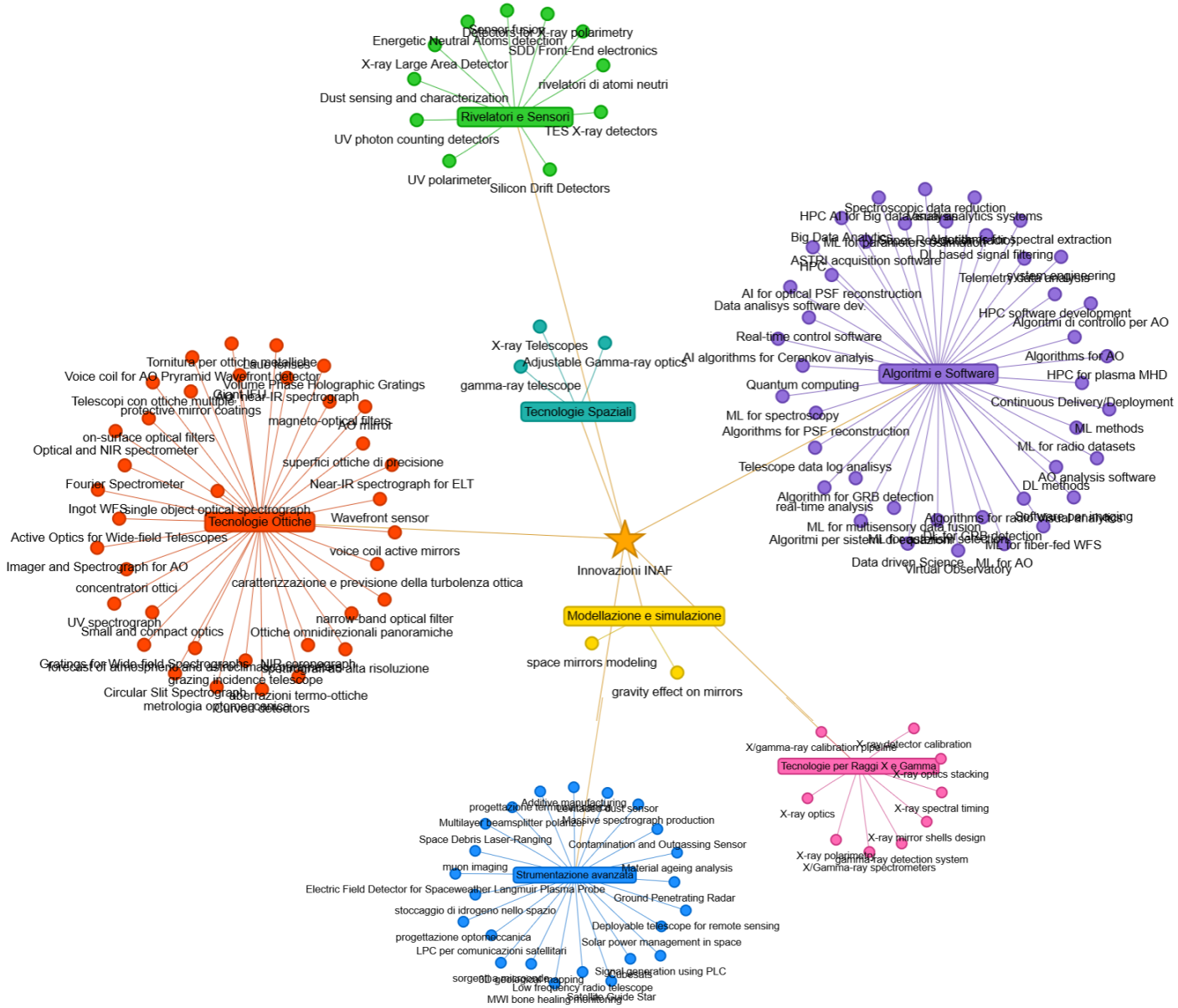


ALL POSTERS (18+7+35)



INNOVATION SECTORS: POSTERS

INNOVATION SECTORS: SCHEDE



OVERALL CONSIDERATIONS

We know this analysis is incomplete

Schede INAF

- not conceived with the aim of providing this kind of information
- large/complex projects descriptions do not (always) emphasize the detail of implemented technologies and/or technological challenges
- Sometimes the same technological development trend appears in several *schede*, thus introducing a bias.

Posters

- Contributed posters give an incomplete view of INAF innovative techs, although the overall picture is impressive

What's missing

A lot of things… E.g. quantum computing, generative A.I., IOD and COTS applicability, etc… (let's fill-up this list all together)

CONCLUDING REMARKS

RSN5 activities show a large number of innovations

- New technologies: **copious**, and in almost all thematic areas
- New implementation or optimization of cutting-edge techs: again **copious**, and in almost all RSN5 activities
- Totally new ideas (TRL1/2): **not so much…**
  - An endangered species?
  - Only presented after the proof of concept (>TRL2/3)?

It is worth noticing that the **optimization** or **adaptation** of already **validated technologies** has equal dignity to the development of new technologies, being clearly **indispensable** for the development of state-of-the-art instrumentation.
But! it also presents an additional criticality: the need to acquire know-how and new skills on technologies that are new for INAF, thus hiring experts in high-tech sectors in competition with the industry

CONCLUDING REMARKS

- New technologies represent a **large** and **dynamic** part of INAF activities.
- Promotion and support of new **ideas**, **developments** and **implementations** seem necessary for growth and competitiveness

"I had phenomenal luck with my garden this year. Not a thing came up."

How to **promote&support** these activities?