# THE STRATEGIC VISION OF INAF 2015-2024

## Scientific Council

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# Scientific challenges in the 21th century

- Our parent star, the Sun, and its planetary system
- The exoplanets
- The building blocks of the universe:the stars
- History of the formation and evolution of the Milky Way and nearby galaxies
- Formation and evolution of galaxies and cosmic structures
- Geometry of the universe
- High energy and relativistic Astrophysics
- New Physics and multi-messenger Astronomy

# Main scientific questions in the next decade

- Our parent star: the Sun
- Which mechanisms drive the quasi-periodic 11-year cycle of solar activity?
- Why is the solar corona so hot (million degrees) ?
- What accelerates the solar wind, coronal mass ejections and other phenomena influencing the interplanetary space and Earth's environment?
- SOLAR ORBITER, SOLAR-C and SOLAR PROBE PLUS, EST will answer these questions

# Main scientific questions in the next decade

- The Sun planetary system

- How was the planetary system formed? Did the planets form where they are now? Were they different in the past?

- What is the composition of the Martian soil below surface?When and why Mars has lost most of its atmosphere? How much water is present in the Jupiter atmosphere?

- Do conditions exist that may have led to the emergence of habitable environments in the Jovian icy satellites, Ganimede, Europa and Callisto?

- EXO-MARS, BEPICOLOMBO, JUNO, JUCE, ROSETTA can answer these and many more question

# Main scientific questions in the next decade

- The exoplanets
- Is there life in other planets?
- Starting from the study of the solar system we will understand the internal structure and the atmospheres of exoplanets
- The Italian community will take advantage of HARPS-N and GIANO on TNG, VLT (ESPRESSO, SPHERE), as well as GAIA, TESS, PLATO, CHEOPS, E-ELT, JWST, ATHENA, ALMA, SKA

# Main scientific questions in the next decade

- **The building blocks of the universe: the stars**
- How do stars form?
- Is the IMF universal? Is the SFR the same in different galaxies?
- Are SNe Ia reliable standard candles? Which are their progenitors?
- How precise are the predictions on the stellar evolution and nucleosynthesis?
- How and when the multiple stellar populations found in GCs formed?
- Answers will come from ALMA, SKA, E-ELT , LBT, JWST, GAIA, EUCLID, VLT, LSST

# Main scientific questions in the next decade

- History of the formation and evolution of the Milky Way and nearby galaxies

- How did the Galactic halo form? Did the stars form in situ or were accreted? What was the IMF of the first stars? Are the local dwarfs the building block?

- How did the bulge form? How did the thick-disk form?

- How did the thin-disk form? Inside-out? How did the abundance gradients form and evolve in time?

- Which is the role of gas inflow, outflow and stellar migration?

- Ongoing and planned large surveys (RAVE, OGLE,APOGEE, HERMES, GES, LAMOST, PanSTARSS, WEAVE,SDSSIV) and telescopes such as GAIA, VLT, JWST, Euclid, E-ELT, ALMA, VISTA, VST, LSST will help in answering these questions

# Main scientific questions in the next decade

- Formation and evolution of galaxies and cosmic structures
- When and how the universe was reionized?
- What is the chemical enrichment history of the universe? How does it depend on galaxy type and mass?
- What is the origin of the Hubble sequence? How important and effective is the environment in the galaxy formation processes
- E-ELT, ,JWST, EUCLID, SKA , VST, VISTA, ALMA, ATHENA will be devoted to answer these questions

# Main scientific questions in the next decade

- Geometry of the universe
- What is the nature of dark matter and dark energy?
- Do we understand gravity at large scales?
- Can we probe fundamental physics with cosmological observations (neutrino masses, violation of fundamental laws of physics)?
- Where are the baryons in the low redshift universe?
- Can we trace the physical and chemical properties of the baryons from high to low redshift?
- EUCLID, ATHENA, CTA, SKA will be fundamental to answer these questions

# Main scientific questions in the next decade

- High energy and relativistic Astrophysics
- How do black holes form and grow? Will event horizon existence be unequivocally proved?
- Does the matter orbiting close to the event horizon follow the prescriptions of general relativity
- How is energy extracted from compact objects (X-ray binaries, GRB, AGN) to power their radiation output'
- How and which stars will end their lives as SNe and GRBs? Which is the connection between the two?
- How does particle acceleration in (ultra)-relativistic flows occur?
- eROSITA survey, SKA, CTA, ATHENA, PAMELA, will help answering these questions

# Main scientific questions for the next decade

- New Physics and multi-messenger Astronomy
- Are we able to detect gravitational waves?
- Are gravitational waves and neutrinos emitted as expected from theory?
- What is the true rate of short GRBs, SNe or any GW source?
- Advanced Virgo, advanced LIGO and LISA (if launched)

# Italian contributions to Astronomy
## Method: ADS by affiliation
## http//adsabs.harvard.edu/mightysearch.html (Gratton)

* Italy is 5th according to the impact parameter
* Impact parameter is defined as number of citations (country of first author)/(world total)

| Rank | Country | 2001-2003 | 2004-2006 | 2007-2009 | 2010-12 | Average | trend |
|---|---|---|---|---|---|---|---|
| 1 | United States | 0.354 | 0.342 | 0.346 | 0.346 | 0.346 | -0.004 |
| 2 | Germany | 0.110 | 0.118 | 0.114 | 0.114 | 0.114 | +0.002 |
| 3 | United Kingdom | 0.093 | 0.092 | 0.088 | 0.080 | 0.090 | -0.086 |
| 4 | France | 0.065 | 0.068 | 0.067 | 0.068 | 0.067 | +0.012 |
| ***5*** | ***Italy*** | ***0.065*** | ***0.062*** | ***0.061*** | ***0.059*** | ***0.062*** | ***-0.060*** |
| 6 | Canada | 0.039 | 0.033 | 0.046 | 0.050 | 0.041 | +0.329 |
| 7 | Japan | 0.037 | 0.036 | 0.033 | 0.030 | 0.035 | -0.121 |
| 8 | Spain | 0.030 | 0.033 | 0.035 | 0.045 | 0.034 | +0.284 |
| 9 | Netherland | 0.035 | 0.030 | 0.024 | 0.028 | 0.029 | -0.203 |
| 10 | Australia | 0.027 | 0.022 | 0.021 | 0.021 | 0.023 | -0.136 |

# Italian contribution to Astronomy

* First 15 nations for ratio between impact in Astronomy and GDP (Gross Domestic Product)

| Rank | Country | Impact in astronomy/GDP |
|---|---|---|
| 1 | Chile | 4.33 |
| 2 | United Kingdom | 2.19 |
| 3 | Netherland | 2.09 |
| 4 | Germany | 1.88 |
| 5 | Israel | 1.77 |
| ***6*** | ***Italy*** | ***1.68*** |
| 7 | Switzerland | 1.67 |
| 8 | France | 1.43 |
| 9 | Canada | 1.39 |
| 10 | Spain | 1.38 |
| 11 | United States | 1.37 |
| 12 | Denmark | 1.25 |
| 13 | Portugal | 1.24 |
| 14 | South Africa | 1.23 |
| 15 | Sweden | 1.00 |

# Italian contributions to Astronomy per Macroarea

Table 6. Impact of different macroareas on the respective fields of competence (2010-12 and for reference 2005-2007)

| Area | | 2010-2012 | | | | 2005-2007 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Average Ranking | Impact | | | Average Ranking | Impact | | |
| | | | Italy/ World | INAF/ Italy | INAF/ World | | Italy/ World | INAF/ Italy | INAF/ World |
| General | | 5.1 | 0.058 | 0.59 | 0.034 | 5.1 | 0.061 | 0.59 | 0.036 |
| MA1 | Galaxies | 4.5 | 0.064 | 0.65 | 0.042 | 4.7 | 0.062 | 0.62 | 0.039 |
| | Cosmology | 5.5 | 0.049 | 0.49 | 0.024 | 5.3 | 0.062 | 0.45 | 0.028 |
| MA2 | Stars | 5.2 | 0.064 | 0.71 | 0.045 | 5.2 | 0.065 | 0.70 | 0.045 |
| | ISM | 6.0 | 0.058 | 0.56 | 0.032 | 5.0 | 0.055 | 0.69 | 0.038 |
| MA3 | Sun | 9.6 | 0.029 | 0.54 | 0.016 | 8.9 | 0.030 | 0.54 | 0.017 |
| | Solar System | 8.2 | 0.033 | 0.58 | 0.019 | 5.3 | 0.040 | 0.63 | 0.025 |
| MA4 | High energy | 3.8 | 0.083 | 0.51 | 0.042 | 3.8 | 0.096 | 0.56 | 0.054 |
| | Relativity | 4.0 | 0.058 | 0.38 | 0.022 | 3.0 | 0.093 | 0.40 | 0.037 |
| MA5 | Instrumentation | 4.5 | 0.062 | 0.83 | 0.052 | 5.4 | 0.066 | 0.80 | 0.052 |

Table 7 and Table 8 list the top ten keywords according to impact for Italy and INAF, respectively.

# Italian contributions to Astronomy

Table 7. Top ten keywords of Italian astronomy (2010-2012)

| Keyword | Total cit | Cit/ paper | Int | Rank Italy | Italy/ World | INAF/ World | INAF/ Italy | University/ Italy | INFN/ Italy |
|---|---|---|---|---|---|---|---|---|---|
| GRB | 14190 | 11.6 | 3.07 | 2 | 0.095 | 0.048 | 0.51 | 0.37 | 0.12 |
| Stars - clusters | 19231 | 10.1 | 2.28 | 3 | 0.095 | 0.056 | 0.59 | 0.39 | 0.02 |
| Stars - abundances | 9987 | 11.6 | 2.86 | 3 | 0.095 | 0.068 | 0.72 | 0.23 | 0.05 |
| High energy | 16794 | 11.5 | 3.99 | 3 | 0.093 | 0.042 | 0.45 | 0.39 | 0.16 |
| Cosmic rays | 12657 | 11.7 | 3.27 | 3 | 0.088 | 0.030 | 0.34 | 0.38 | 0.29 |
| Galaxies – active | 22156 | 11.9 | 3.34 | 3 | 0.087 | 0.055 | 0.63 | 0.33 | 0.04 |
| Radiative processes | 15410 | 11.4 | 3.45 | 4 | 0.086 | 0.044 | 0.51 | 0.39 | 0.10 |
| gamma-ray | 82907 | 11.1 | 3.16 | 4 | 0.083 | 0.041 | 0.49 | 0.38 | 0.13 |
| AGN | 24280 | 12.2 | 3.17 | 4 | 0.083 | 0.048 | 0.58 | 0.38 | 0.04 |
| Galaxies – clusters | 23297 | 13.4 | 2.84 | 3 | 0.080 | 0.045 | 0.56 | 0.26 | 0.17 |

Table 8 Top ten keywords of INAF (2010-2012)

| Keyword | Total cit | Cit/ paper | Int | Rank Italy | Italy/ World | INAF/ World | INAF/ Italy | University/ Italy | INFN/ Italy |
|---|---|---|---|---|---|---|---|---|---|
| Stars - abundances | 9987 | 11.6 | 2.86 | 3 | 0.095 | 0.068 | 0.72 | 0.23 | 0.05 |
| Stars - clusters | 19231 | 10.1 | 2.28 | 3 | 0.095 | 0.056 | 0.59 | 0.39 | 0.02 |
| Galaxies – active | 22156 | 11.9 | 3.34 | 3 | 0.087 | 0.055 | 0.63 | 0.33 | 0.04 |
| Stars - populations | 20007 | 13.8 | 2.87 | 3 | 0.080 | 0.054 | 0.68 | 0.28 | 0.04 |
| GRB | 14190 | 11.6 | 3.07 | 2 | 0.095 | 0.048 | 0.51 | 0.37 | 0.12 |
| AGN | 24280 | 12.2 | 3.17 | 4 | 0.083 | 0.048 | 0.58 | 0.38 | 0.04 |
| Stars - atmosphere | 9518 | 13.0 | 2.16 | 6 | 0.057 | 0.047 | 0.82 | 0.17 | 0.01 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Supernovae | 42139 | 15.5 | 2.58 | 4 | 0.072 | 0.046 | 0.64 | 0.23 | 0.12 |
| Galaxies - individual | 13152 | 8.9 | 2.81 | 5 | 0.060 | 0.046 | 0.77 | 0.20 | 0.04 |
| Galaxies – clusters | 23297 | 13.4 | 2.84 | 3 | 0.080 | 0.045 | 0.56 | 0.26 | 0.17 |

# Italian contributions to Astronomy in the world

* Italy is second behind USA in Gamma Ray Bursts. It is third (behind USA and Germany) in High Energy, Stars : clusters,  Stars:abundances, Cosmic Rays and Galaxies: active, Galaxies: clusters, Stars: populations, Galaxies: halos

# Italian contributions to fashionable Astronomy

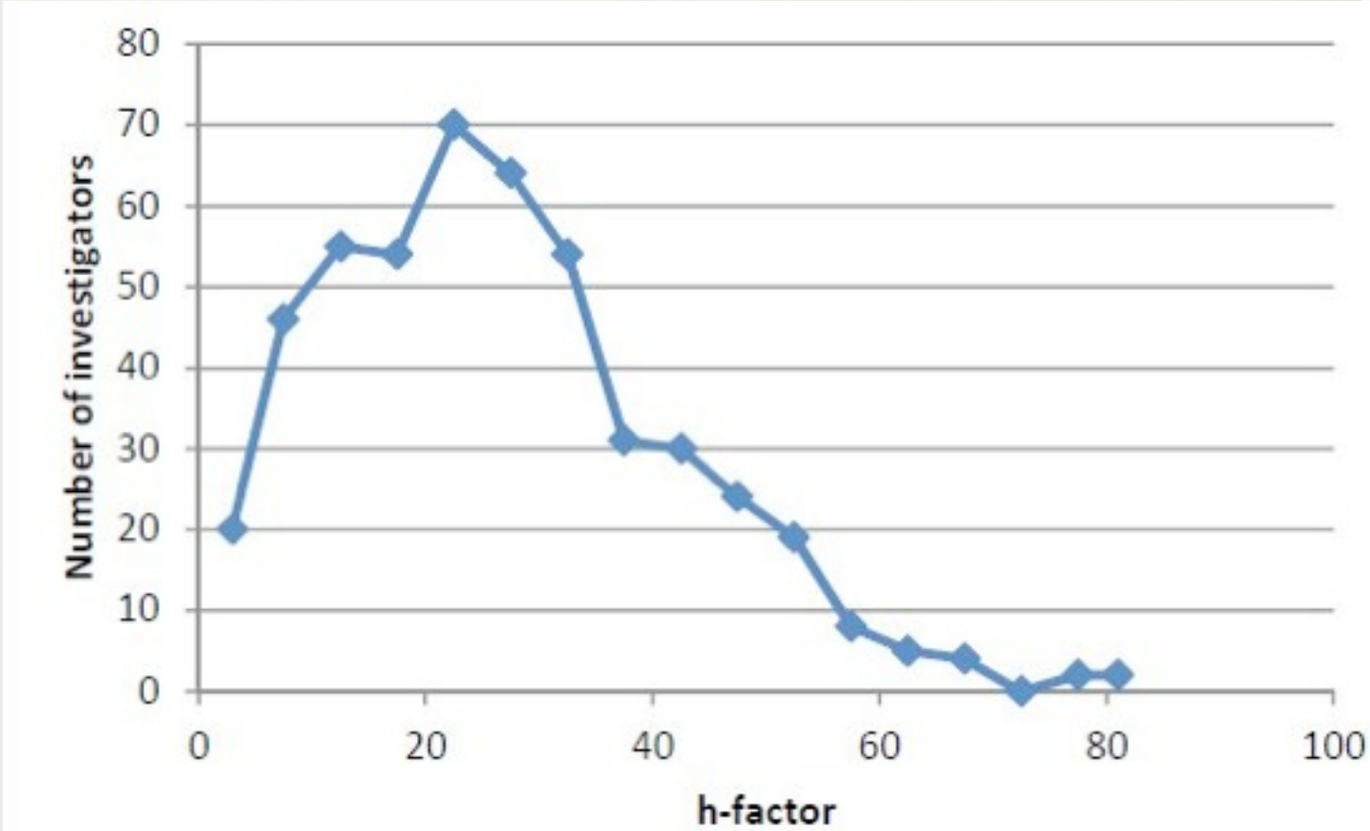
* Italian Astronomy has good results for Cosmic Rays, Galaxies: star formation and Galaxies: high redshift

Table 9. Impact of Italian astronomy in the ten most fashionable keywords

| Keyword | World citations | Fashion Index | 2010-2012 | | 2005-2007 | |
|---|---|---|---|---|---|---|
| | | | Rank Italy | Italy/World | Rank Italy | Italy/World |
| Galaxies: high redshifts | 20345 | 0.56 | 5 | 0.068 | 5 | 0.063 |
| Hydrodynamics | 27813 | 0.54 | 6 | 0.046 | 3 | 0.069 |
| Cosmic Rays | 12657 | 0.51 | 3 | 0.086 | 6 | 0.066 |
| Dark Matter | 52680 | 0.50 | 5 | 0.060 | 5 | 0.064 |
| Sun: structure | 5085 | 0.49 | 11 | 0.040 | 11 | 0.016 |
| Extrasolar planets | 30577 | 0.47 | 10 | 0.029 | 8 | 0.038 |
| Radiative transfer | 10820 | 0.47 | 7 | 0.034 | 7 | 0.046 |
| Galaxies: star formation | 14023 | 0.46 | 4 | 0.067 | 5 | 0.067 |
| Early Universe | 21277 | 0.44 | 6 | 0.039 | 5 | 0.059 |
| Synchrotron, Compton, Radiative processes | 15410 | 0.43 | 4 | 0.085 | 5 | 0.102 |
| *Weighted Average* | | | *5.9* | *0.054* | *5.5* | *0.061* |

# Italian contributions to Astronomy

* The h_index distribution
* Data from a total of 506 researchers from ADS
* The average h_index is 26.8 and the median value is 25
* There are 43 researchers with h>50
* If we comapare these values with Abt (2012) who gives average h values for IAU member countries: France (21.1),Germany (24.2), UK(23.5), USA(24.5)



# Women in Italian Astronomy (M+G)

- About 32% of all INAF research staff are women
- About 27% of the Italian IAU members are women
- This makes Italy the third country for number of women among countries with > 100 IAU members, after Argentina and Ukraine but before France (24.6%), Spain (20.6%), China (15.3%), UK (14.1%), USA and Canada (13.5%), Netherland (13.1%), Sweden (12.6%), Germany (10%), Japan (6.4%). Source http://www.iau.org/administration/membership/individual/distribution/)

# Women in Italian Astronomy

- Women are still a few in scientific Academies: at the Accademia dei Lincei women are 6% in the section of Sciences with only two women in Astronomy. Margherita Hack was the first woman astronomer at Lincei and the first woman full professor in Astronomy

- Women are still a few in high positions (dirigente di ricerca/full professor): 13% in INAF and 8% in the University. More effort is required to improve the situation

# Women per Macroarea

Table 2. Women presence among different INAF Macroareas

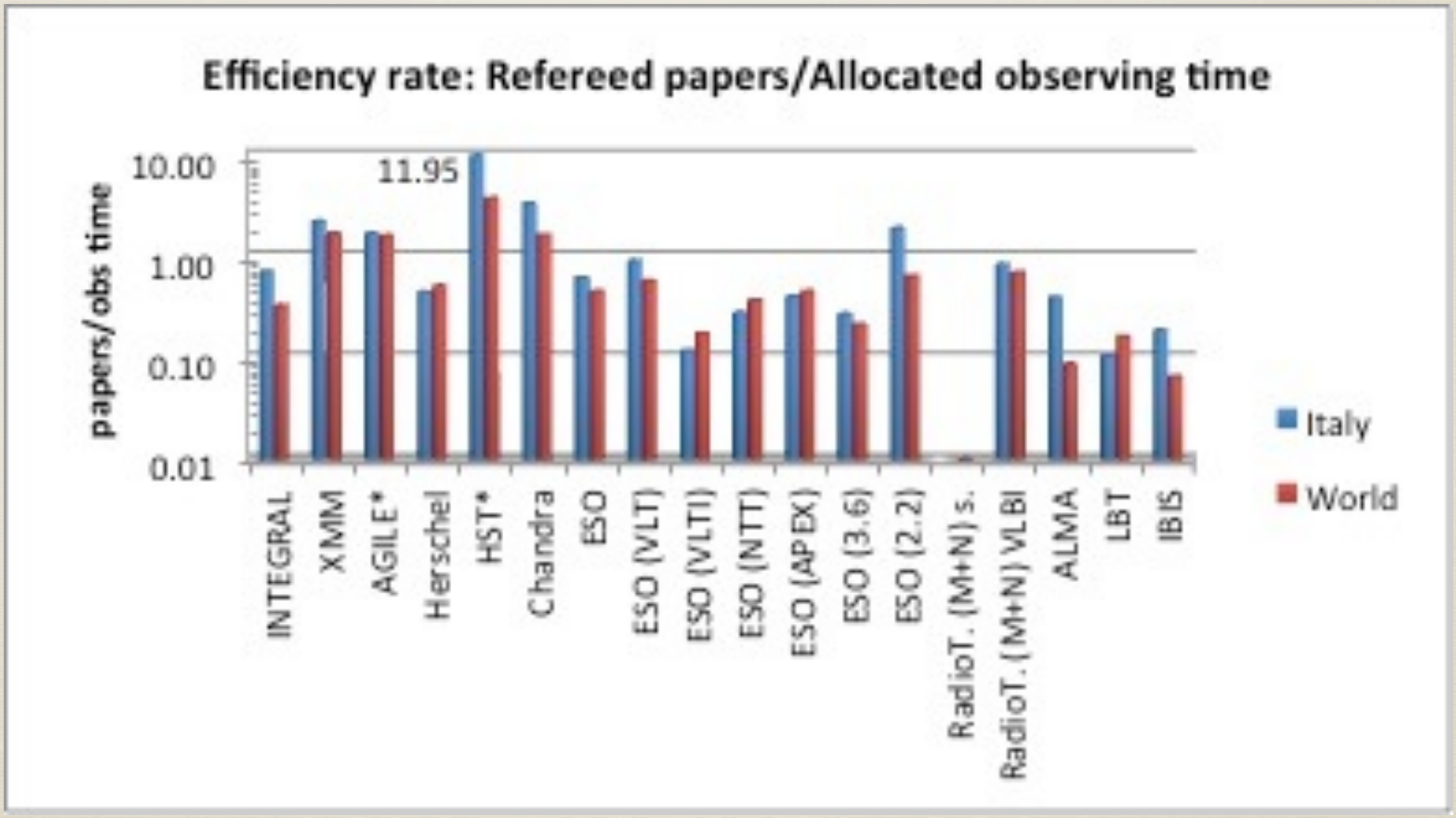
| Macroarea | Total | Women | Fraction |
|---|---|---|---|
| 1. Galaxies and Cosmology | 182 | 63 | 0.35 |
| 2. Stars and Interstellar Medium | 163 | 58 | 0.36 |
| 3. The Sun and the Solar System | 133 | 40 | 0.30 |
| 4. High Energy and Relativity | 136 | 46 | 0.34 |
| 5. Technology | 179 | 30 | 0.17 |

# Impact of the Italian astronomical community on the ground and space observational facilities

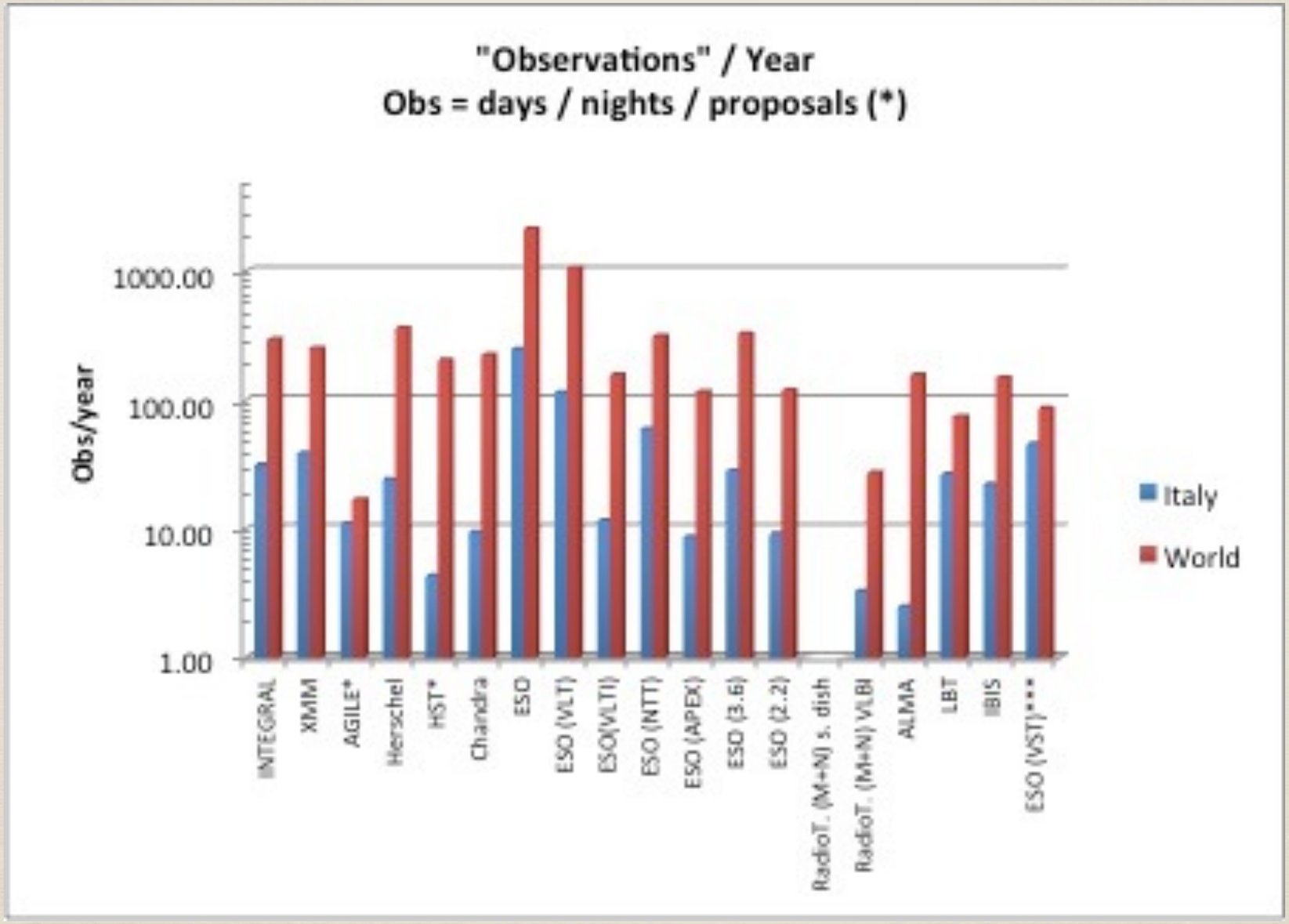
* We looked at the number of papers published using each observational facility, the fraction of papers with first author italian and the amount of observational time allocated per year and fraction allocated to italian PIs.

* These quantities were averaged, when possible, over the last 4-5 years

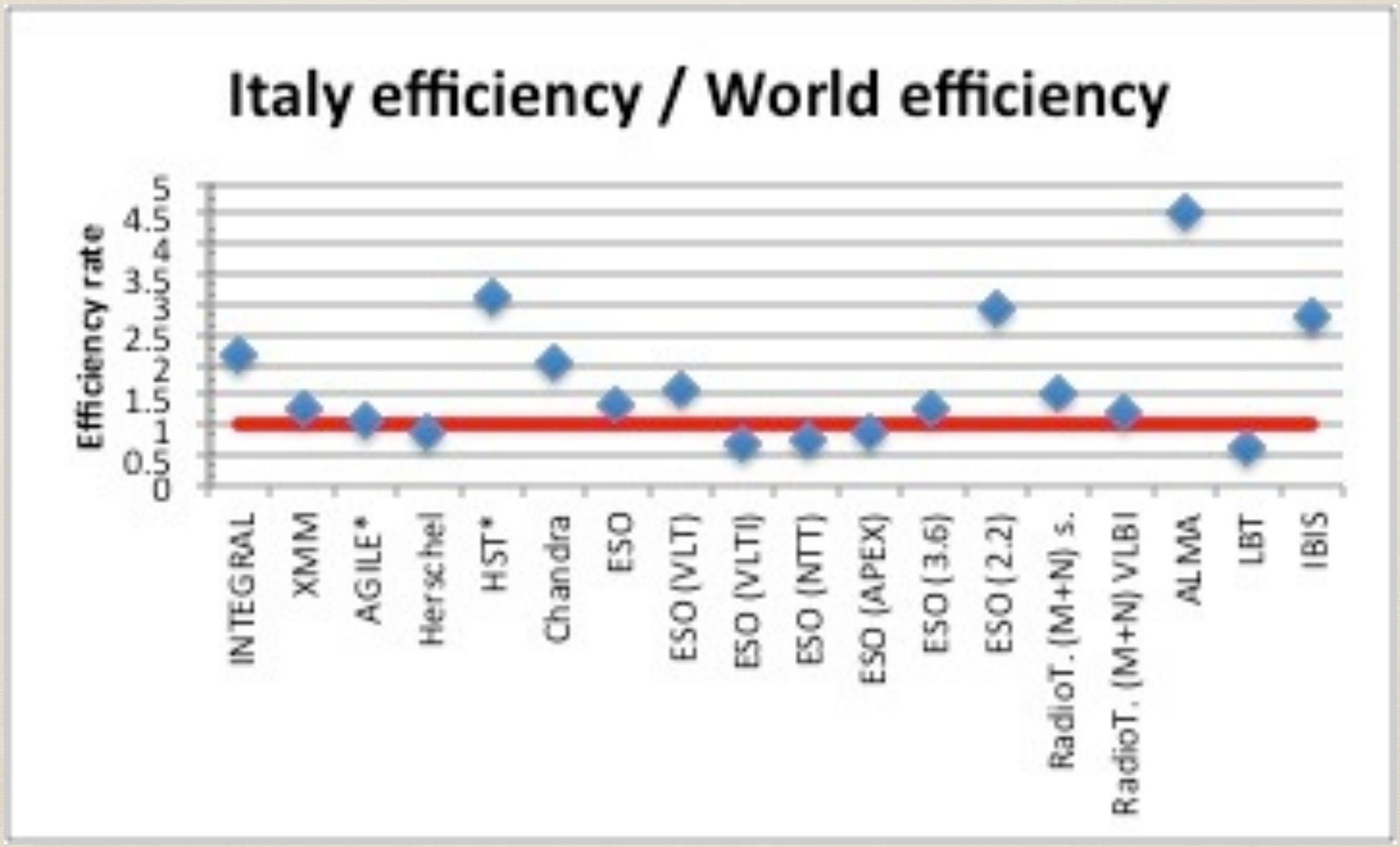
# Impact of the Italian astronomical community on ground and space observational facilities



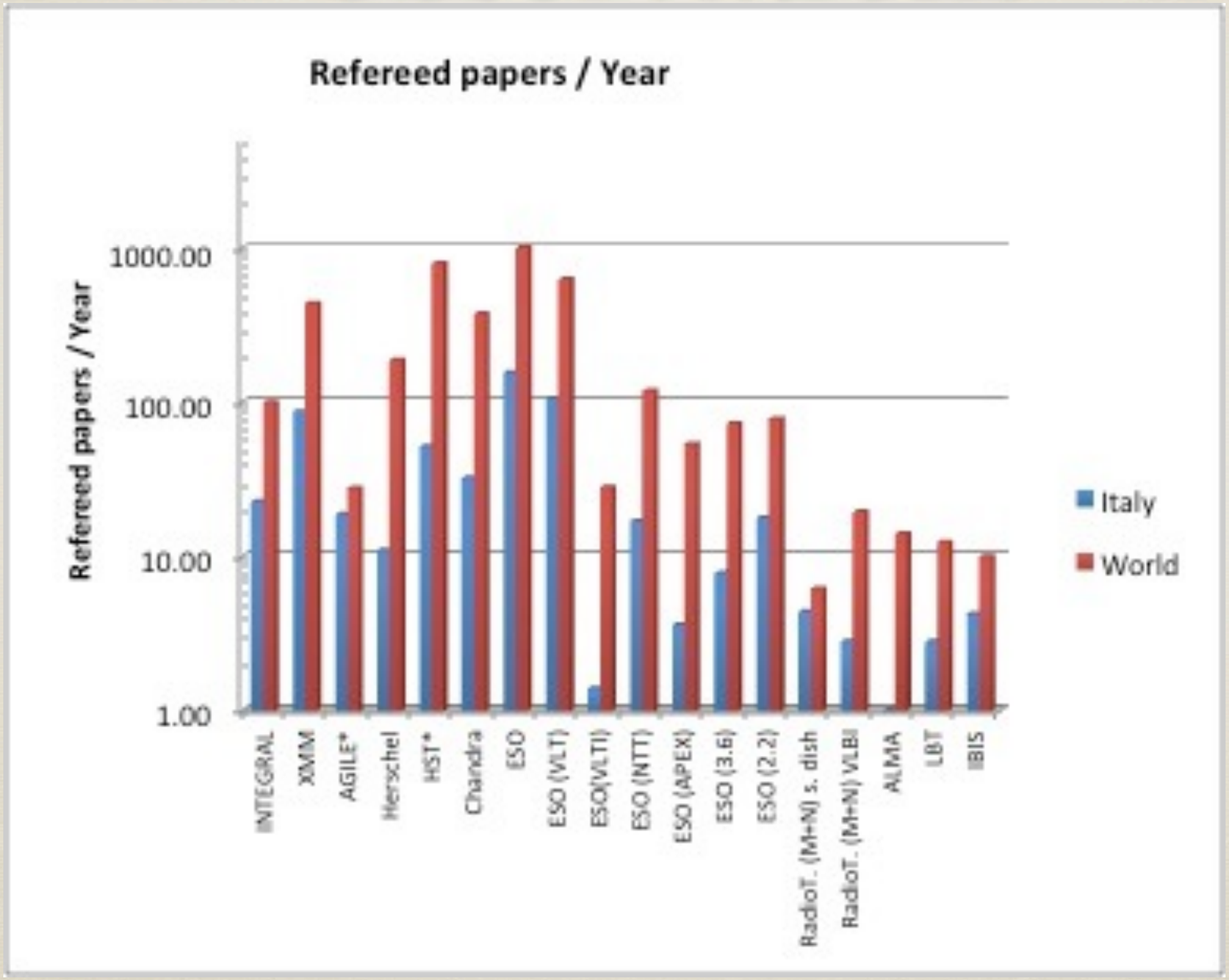
# Allocated observing time



# Italian efficiency vs. the rest of the world



# Refereed papers from observations



# Conclusions on the impact of Italian Astronomy on observational facilities

- The results show a clear excellence of Italian astronomers in leading successful research when compared to the overall international use of the examined observational facilities

- In particular, Italian astronomers are more efficient in publishing scientific results obtained from their observing time almost for all the space and ground facilities

# Strategies for the future

- The INAF Scientific Council would like to conclude by suggesting that the strategic plan of INAF in the next decade should give first priority to support fundamental research, which will be necessarily connected to the realization of future maximum priority projects such as E-ELT, CTA, ATHENA, SKA and JUICE

- Maximum attention should be payed to solve the highly worrying situation of the “precari” INAF who represent the young forces and the future of INAF, as well as the career progressions