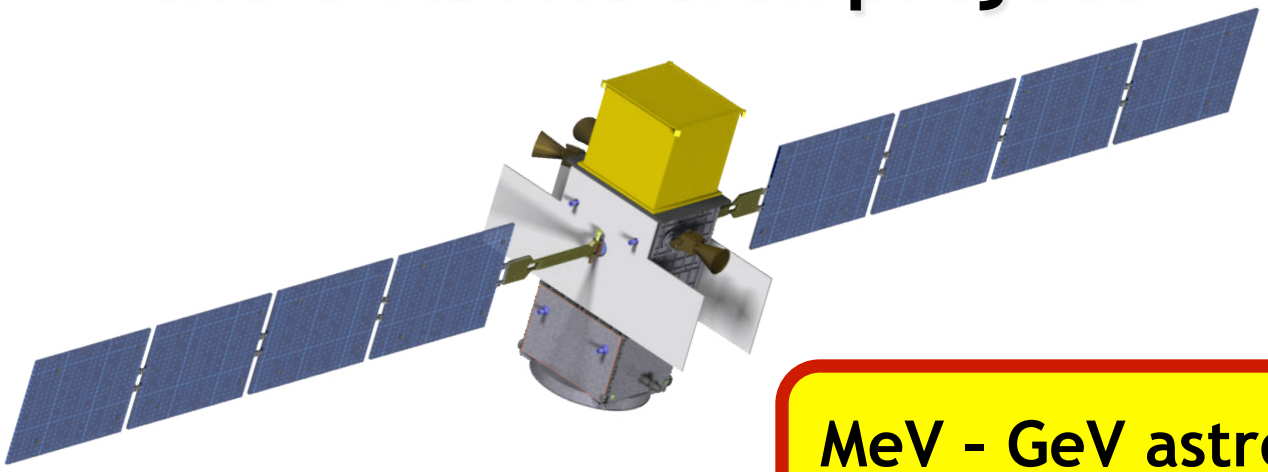
The next gamma-ray MeV-GeV mission: the e-ASTROGAM project



MeV - GeV astrophysics
MeV - GeV community

Proposed for the ESA M4 call; currently under study for enhancement and reconfiguration for the ESA M5 call. e-ASTROGAM is focused on gamma-ray astrophysics in the range 0.3-100 MeV with excellent capability up to GeV energies.

History and heritage

heritage	M1/M2 (2007)	M3 (2010)	S1 (2012)	M4
CLAIRE, NCT	GRI	DUAL	AstroMeV	ASTROGAM
COMPTEL	GRIPS I	CAPSITT, GRIPS II		
FERMI / AGILE			Gamma-Light	

Collaboration

INAF, INFN, University of Rome 2

CSNSM, IRAP, APC, CEA, LUPM, IPNO

ICE (CSIC-IEEC), IMB-CNM (CSIC)

University College Dublin

MPI, Universität Mainz

DTU

University of Geneva

KTH

University of Tokyo

Ioffe Institute

NASA GSFC, NRL, Clemson Un., UC at Berkeley

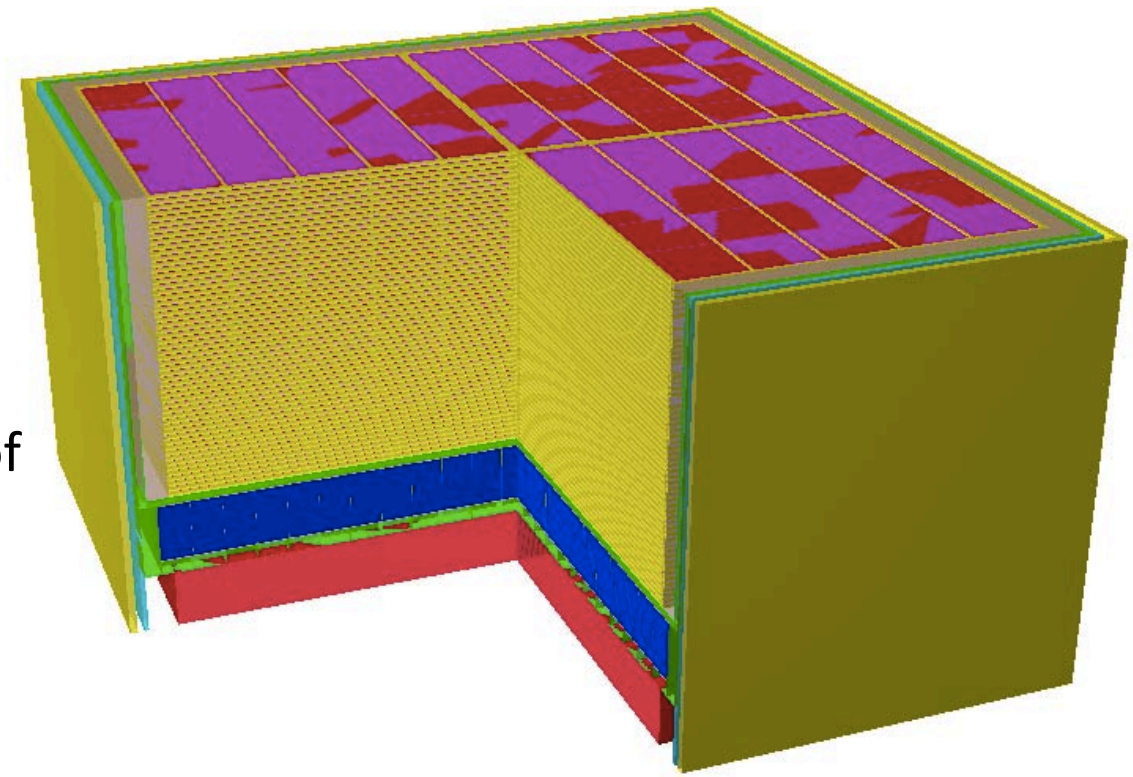
- **A new window for Galactic, extragalactic & and multi-messenger science.**

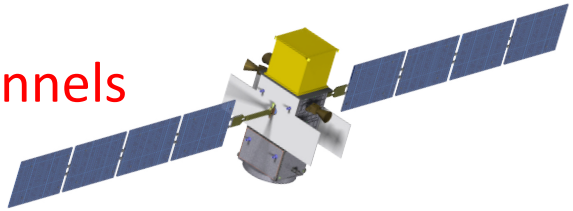
- **Broad band (0.3 MeV – 3 GeV), focused on the mostly unexplored energy range (0.3-100 MeV). Continuum & line detection, polarization measurements.**

e-ASTROGAM Sensitivity (M5)

- **4 towers**
- **50 layers** of 5×5 double sided Si strip detectors
- Each DSSD has a total area of 9.5×9.5 cm^2, a thickness of 400 (500) μm, readout pitch of 240 μm (384 strips per side), and a guard ring of 1.5 mm
- Spacing of the Si layers: 7.5 mm
- The DSSDs are wire bonded strip to strip to form 2-D ladders

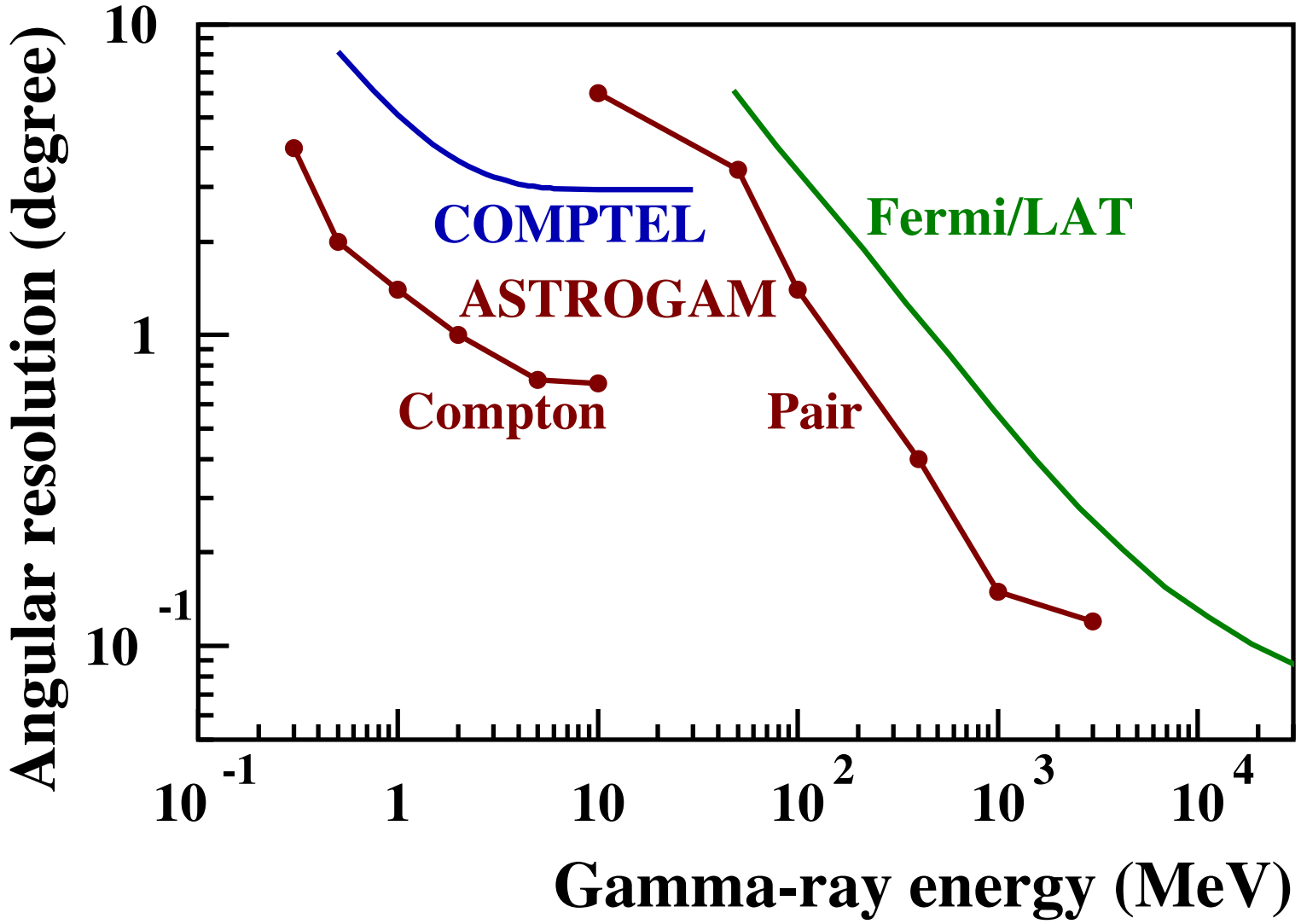
⇒ 900.000 electronic channels

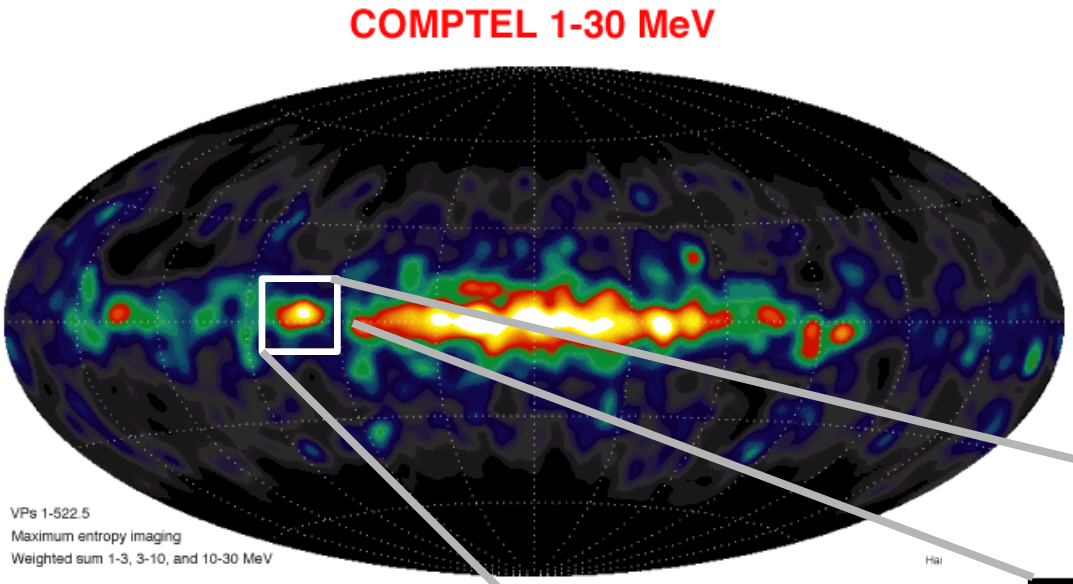




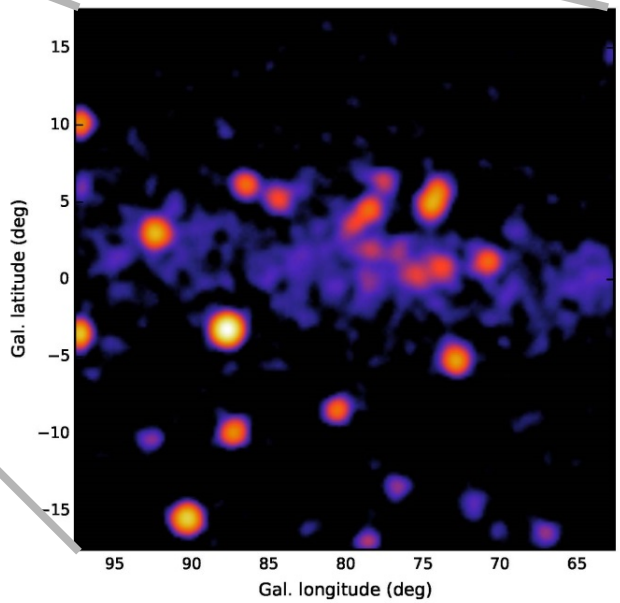
LEO orbit of altitude 520-550 km
2.5 – 3 sr FoV
Launch 2029 – 2030
3-yr mission

Angular resolution





- **ASTROGAM will have unprecedented angular resolution in the MeV domain.**
- **a large fraction of the Galactic source and diffuse components will be resolved.**



Simulated 1-3 MeV sky of the Cygnus region assuming 3FGL source and diffuse extrapolations to MeV energies.

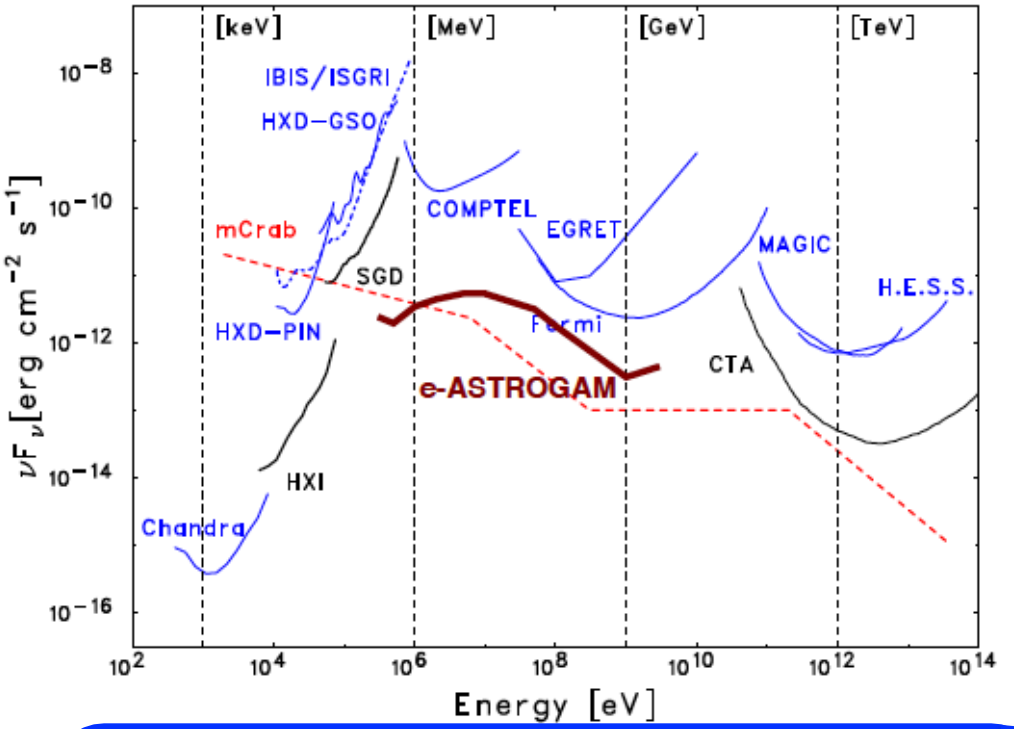
The e-ASTROGAM core science

- **Extreme phenomena in the era of new astronomy**
  Gravitational waves ……

- **The mysteries of the GC and Inner Galaxy**
  Central BH, compact objects, anti-matter

- **Supernovae, nucleosynthesis, and Galactic chemical evolution**

e-ASTROGAM Sensitivity (M5)



Adapted from Takahashi et al. (2013)

- **ASTRO-H/SGD**: S(3σ) for 100 ks exposure of an isolated point source
- **COMPTEL** and **EGRET**: sensitivities accumulated during the whole duration of the CGRO mission (9 years)
- **Fermi/LAT**: 5σ sensitivity for a high Galactic latitude source and after 1 year observation in survey mode
- **ASTROGAM** − 3σ/5σ sensitivity for a 1-year effective exposure of a high Galactic latitude source

Table 1. e-ASTROGAM line sensitivity (3σ in 10^6 s) compared to that of *INTEGRAL*/SPI

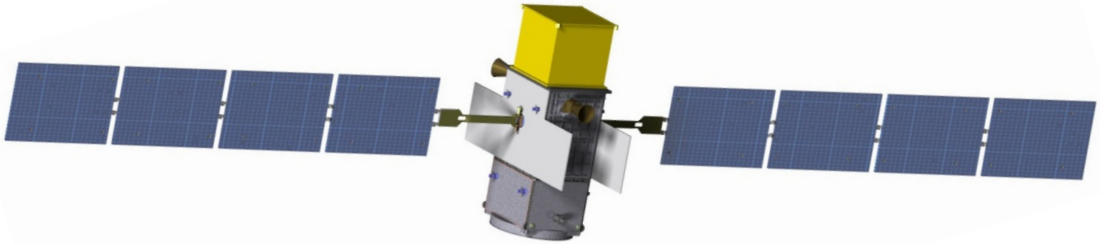
E (keV)	FWHM (keV)	Origin	SPI sensitivity (ph cm^{-2} s^{-1})	e-ASTROGAM sens. (ph cm^{-2} s^{-1})	Improvement factor
511	1.3	Narrow line component of the e+/e- annihilation radiation from the Galactic center region	5.2×10^{-5}	4.1×10^{-6}	13
847	35	^{56}Co line from thermonuclear supernovae	2.3×10^{-4}	3.5×10^{-6}	66
1157	15	^{44}Ti line from core-collapse supernova remnants	9.6×10^{-5}	3.6×10^{-6}	27
1275	20	^{22}Na line from classical novae of the ONe type	1.1×10^{-4}	3.8×10^{-6}	29
2223	20	Neutron capture line from accreting neutron stars	1.1×10^{-4}	2.1×10^{-6}	52
4438	100	^{12}C line produced by low-energy cosmic rays in the inner Galaxy	1.1×10^{-4}	1.7×10^{-6}	65

e-ASTROGAM will gain a factor 10−60 in line sensitivity compared to INTEGRAL/SPI

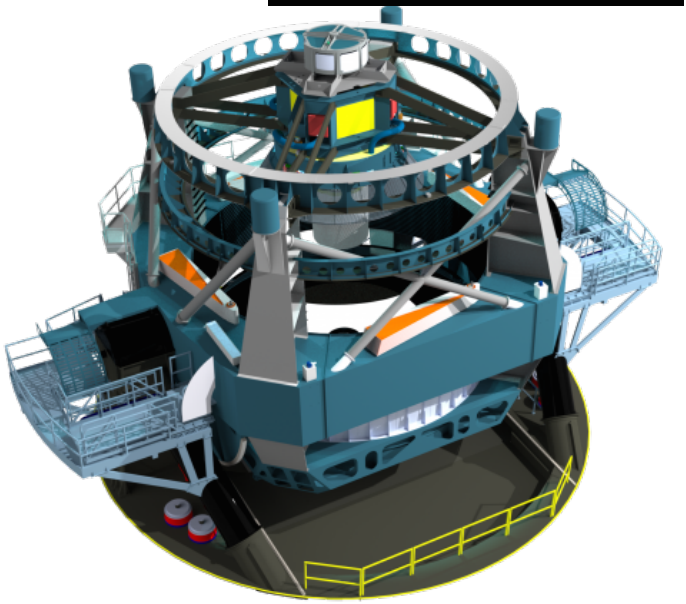
Discovery potential

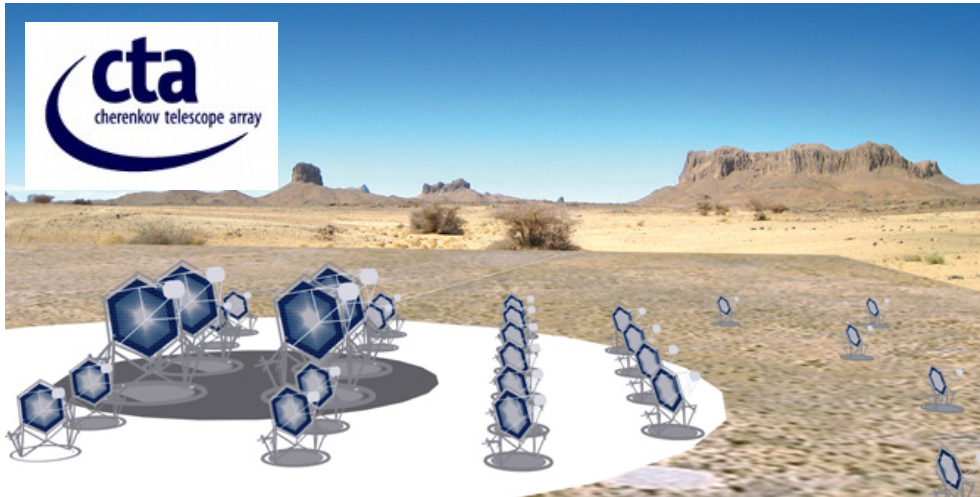
- **Sources and phenomena not accessible by Fermi-LAT and X-ray detectors**
  - **Galactic sources:**
    - accreting with MeV tails
    - pulsars with 1-10 MeV cutoffs
    - microquasars going from thermal to non-thermal, jet launching, hadronic vs. leptonic
    - Nuclear lines
  - **AGNs**
    - MeV blazars (high-z blazars)
    - Tidal disruptions in supermassive BHs at their peak energy
    - Radio galaxies in the MeV range
  - **Extragalactic MeV background**
  - **GRBs**
    - Polarization and broad band spectroscopy

e-ASTROGAM Time domain astronomy



- A wide-field γ-ray observatory operating at the same time as facilities like LSST and SKA will give a more coherent picture of the transient sky.
- CTA science related to variable sources will need a coverage of the γ-ray sky at lower energies to trigger Target-of-Opportunity observations.





Observatory

- **an Observatory open to the community**
  - **Program based on Key Pointings (2)**
  - **ToO observations performed with fast reaction**
- **most open & fast use of the data**
  - **Quicklook results, fast alerts for transient sources**
  - **Standard products in friendly format**
- **a very large community involved (from radio to TeV)**

Multifrequency, multimessenger

- **Multifrequency**
  - **Radio (SKA, ALMA, VLA)**
  - **Optical telescopes (e.g., LSST)**
  - **X-rays (Athena)**
  - **TeV (CTA, HAWK).**

- **Multimessenger**
  - **gravitational waves**
  - **neutrinos**

- **Very large communities and potential users in Europe, and across the world.**