M2Tech:
Technologies for Multi-Messenger Astrophysics

Edwige Tournefier (CNRS-LAPP) on behalf of the M2Tech partners

Swiss CTA day, December 14th, 2022

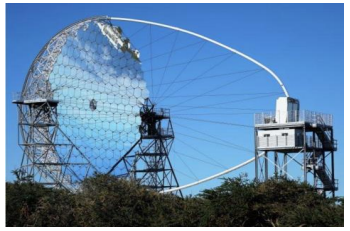
M2Tech was a proposal to answer the HORIZON-INFRA-2022-TECH-01-01 call on

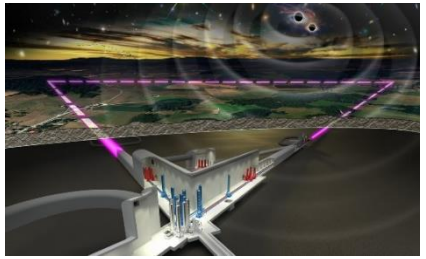
"R&D for the next generation of scientific instrumentation, tools and methods"

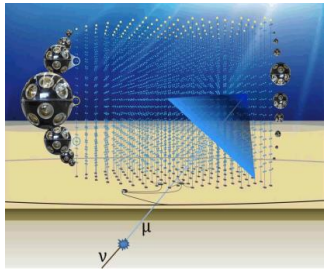
- Scope:
  - The aim of this topic is to deliver **innovative scientific instrumentation, tools and methods**, which advance the state-of-art of European RIs, and show **transformative potential in RIs operation**. **The related developments,** which underpin the provision of improved and advanced services, **should lead research infrastructures to support new areas of research and/or a wider community of users, including industrial users.**
  - Cutting-edge technologies will also enhance the potential of RIs to contribute addressing EU policy objectives and socio-economic challenges.
- Expected outcomes:
  - enhanced **scientific competitiveness of European research infrastructures**
  - foundations for the **development of innovative companies**;
  - **increase of the technological level of industries** through the **co-development of advanced technologies** for research infrastructures and creation of potential new markets
  - **integration of research infrastructures** into local, regional and global innovation systems
- Consortia must be built around a leading core of at least **3 world-class research infrastructures (RIs)**

M2Tech : Technologies for Multi-Messenger Astrophysics

Aim: realisation of a common technological platform for research infrastructures in the multimessenger astrophysics research field





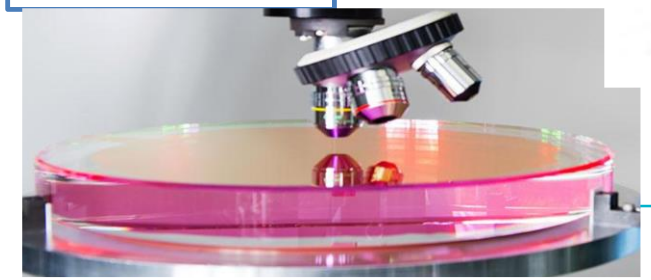


- Involved research infrastructures:
  - **CTAO and MAGIC** for gamma-ray astronomy,
  - **ET** and **Virgo** for gravitational wave interferometry
  - **KM3NeT** for neutrino astronomy
  - **ELI** for high power laser related technology
- Diversity of the *messengers* $\Rightarrow$ heterogeneity of the technologies used in the observatories
- **M2Tech** will:
  - explore the **synergies between these technologies**
  - develop a **common technological platform**, aiming to the **integration of some of the neighbouring technology**,
  - support **the different specialisations**,
  - promote a **cross-fertilisation between the different observatories** and **the connection with industrial partners**
  - fully make use **of the different life stage at which the different RIs are**

M2Tech: Workpackages

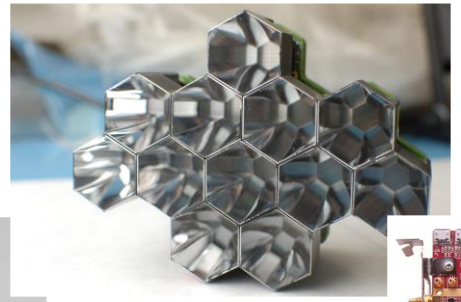
WP1 Project management and coordination

- Technical coordination of the project
- Administrative, legal and financial management
- Internal quality management
- Management of the research data and other research output



WP2 Surface materials and coatings

- High performance optical coatings
- Surface treatments and Environmental durability
- Low defects substrates



WP3 Advanced photosensing

- Silicon based sensors development
- Stellar intensity interferometry
- Photodiodes and real-time cameras

WP4 Advanced electronics

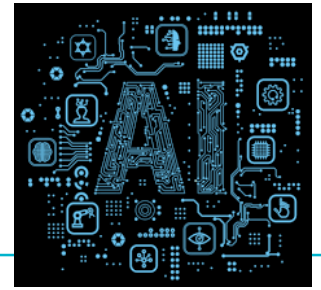
- Flexibal readout for photosensors
- Digitizing, optical links and synchronisation
- Smart processing for image-forming detectors

WP5 Monitoring, control and synchronisation

- Digital Twins
- Noise monitoring, cancellation and optimized controls
- White Rabbit developments and real-time networking infrastructure

WP6 Efficient computing and tools

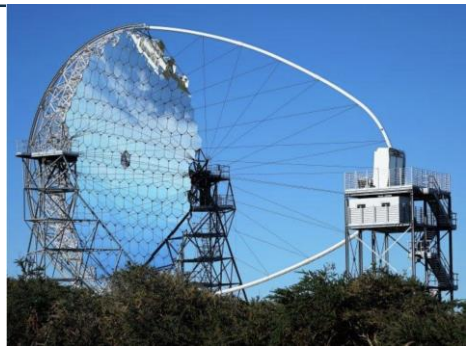
- Sustainable fast data reduction and processing
- Operational intelligence for instrument and data flows management
- Efficient tools for multimessenger alerts



WP7 Technology and knowledge transfer

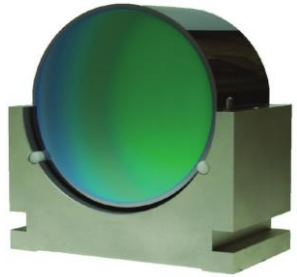
- Identification of M2Tech key exploitable results
- Training activities
- Plan for dissemination, exploitation, and communication
- Communication and outreach activities
- Dissemniation activities

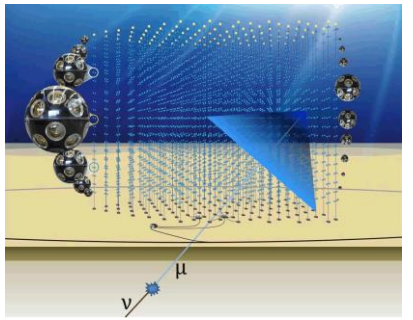
WP leader: Stuart Reid (ET)



Optical elements for light collection / optical cavities

- Gamma ray: high reflectivity in NUV range, resistance to harsh conditions, large area
- Neutrinos: high transmission, resistance to environmental conditions
- GWs: low defects, high uniformity, low thermal noise
- ELI: enhanced laser damage threshold coatings



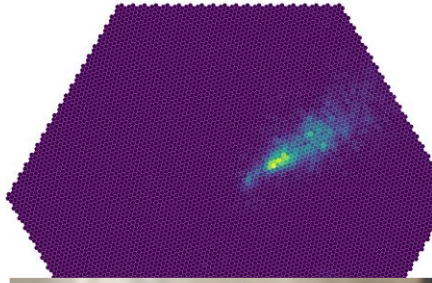


M2Tech aims at developing:

- High quality coatings: enhanced optical performances, low thermal noise
- Methods for high quality surfaces immune to environmental conditions
- Low defects substrates

Making use of facilities and knowhow from all partners, in partnership with industries (Power Photonics, Gooch, Helia, Riber, III-Vlab, Cutting Edge Coatings), fostering industrial developments

WP leader: Teresa Montaruli (CTA, MAGIC)

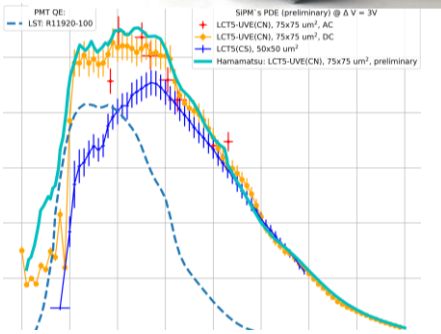


High efficiency light detection

- Gamma rays & neutrinos: HE for NUV, low at NIR, pixelisation, modularity and large area
- GW: new technology to be developed for ET-LF (@1550nm) and enhanced performances for ET-HF (@1064nm)

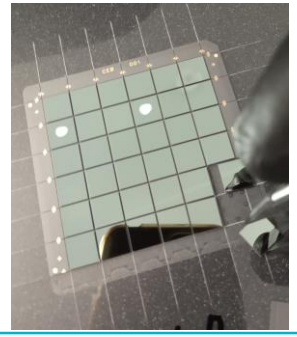
M2Tech aims at developing:

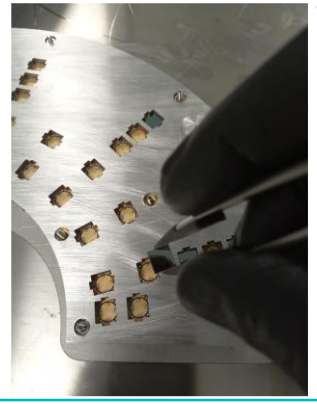
- A plug-and-play modular universal tile of SiPM sensors for large photosensing areas
- A digital photon counter 3D sensor for stellar interferometry
- UHV compatible photosensors for scattered light monitoring
- Pixelated phase camera for mapping the laser field



Patnership with companies FBK, VIGO, Bright Photonics

Connections with WP2 for coating

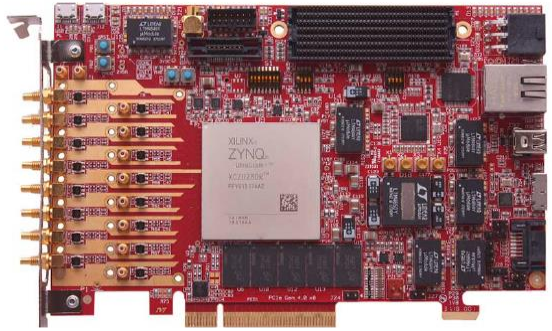




WP leader: David Gascon (CTA, MAGIC)

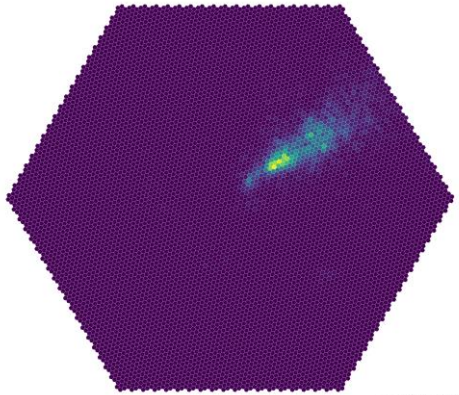
Efficient, low noise, precise, flexible electronics

- Signal readout: Low noise and low power electronics for photosensors
- Data transmission: low noise digitisation and high flux data transfer
- Precise timing
- Image reconstruction



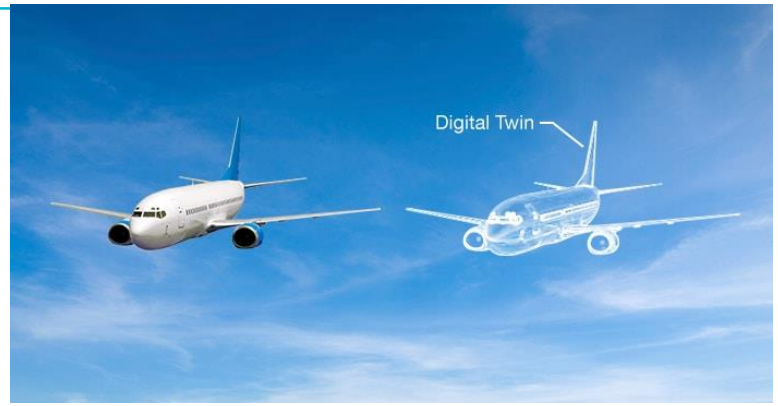
M2Tech aims at developing:

- Flexible readout for SiPM modules
- Low noise, low power digitization and optical links and associated transceivers
- Accurate timing distribution system / local timing generation system
- Smart image processing (triggering)



Involved industries: SCI and CSEM

WP leader: Tommaso Chiarusi (KM3Net)

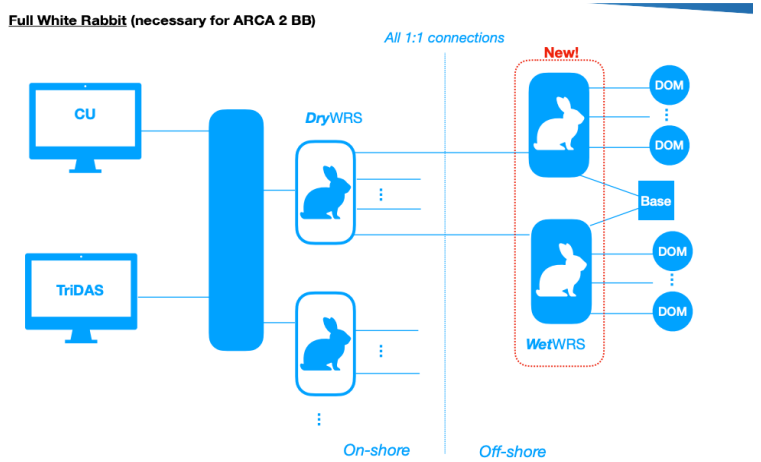


Complex detectors monitoring, control and understanding

- Detector monitoring and control
- Simulation
- Timing and clock distribution

M2Tech aims at developing:

- Digital twins for better detector understanding: coupling of noises, detector behaviour, control system design
- Sensors for noise monitoring, new control methods
- Anomaly detection DNN based
- Real time infrastructure based on White rabbit technology (switches, low phase noise, clock repeater, connectors,...)



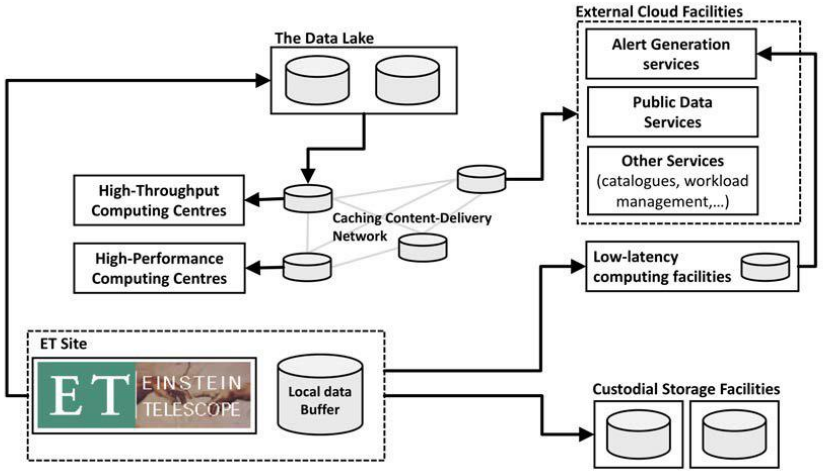
Development of innovative solutions sharables among all RIs

In collaboration with COSYLAB

WP leader: Stefano Bagnasco (ET, Virgo)

MM astronomy from rare to high rate observation

- Large data sample to be analysed at a fast rate / computing power
- Low latency alert release
- Alert management challenges



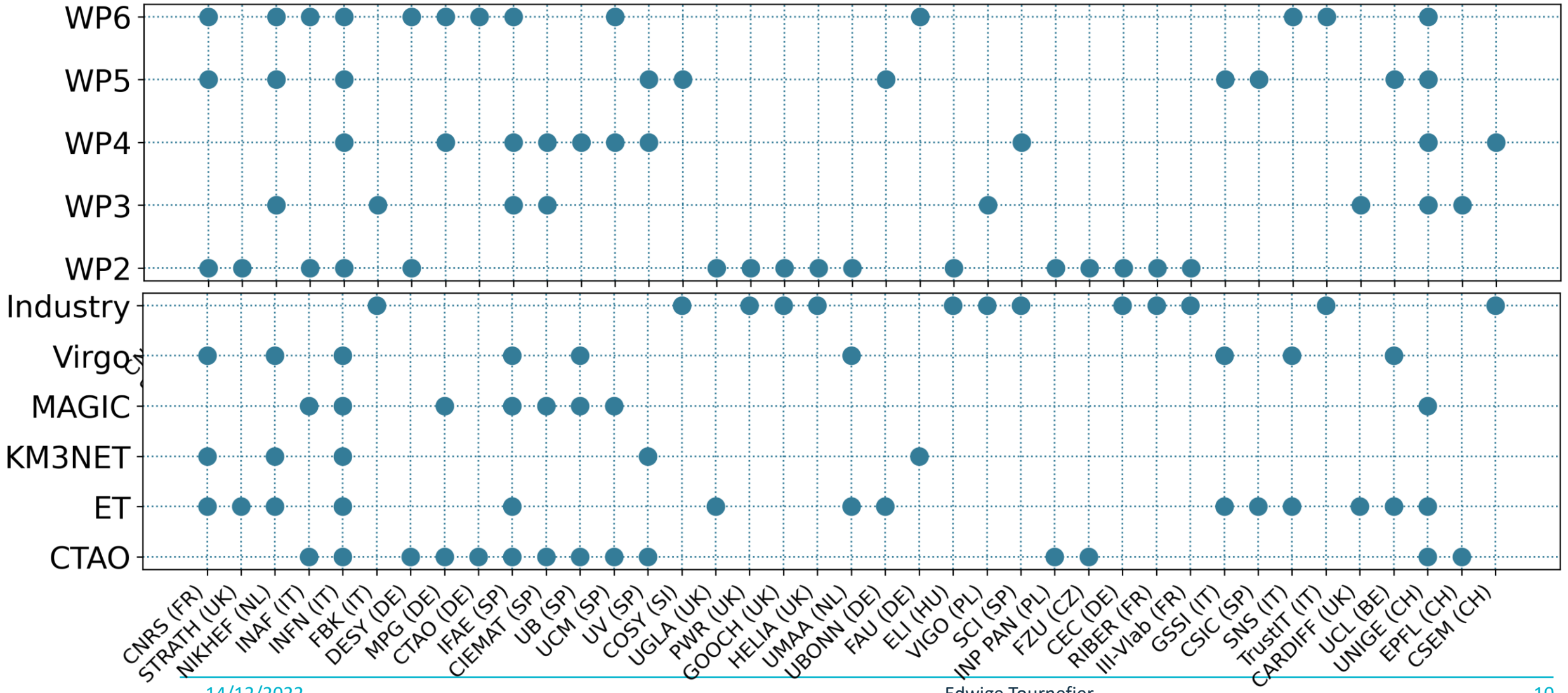
M2Tech aims at developing:

- sustainable fast data reduction and online processing methods (ML based)
- experiment-agnostic ML based and human-machine interface tools for instrument and data flow management
- tools and interfaces for multimessenger alerts (communication, common infrastructure)

Common methods and tools among RIs and sharing of knowhow.

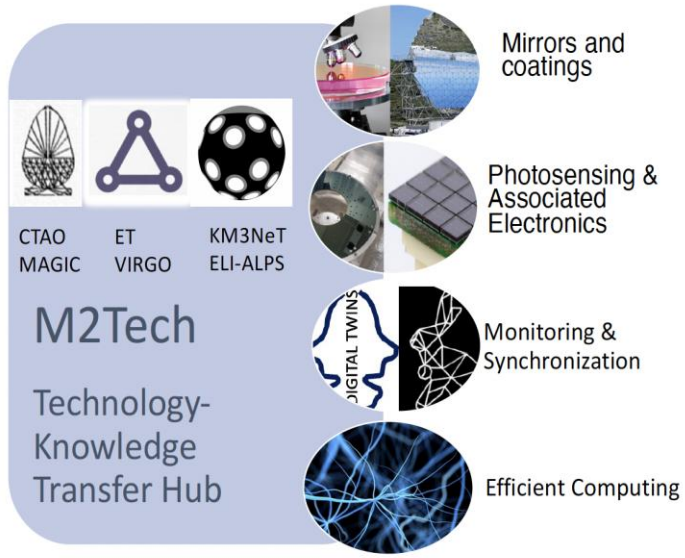
Partnership with industry: Trust-IT

- 39 partners among which 12 industries



- M2Tech 2022 proposal
  - submitted in April 2022 to EU Horizon program
  - Total cost: 11.8ME
  - Duration: 48 months

- 2022 Horizon INTRATECH call outcome
  - Positive review and notation
  - But the M2Tech project was not selected to be funded



- The project is being internally reviewed and improved taking into account the reviewers comments

- The new project will be submitted to the 2024 INFRATECH call "R&D for the next generation of scientific instrumentation, tools, methods, solutions for RIs upgrades"

M2Tech’s future

END