

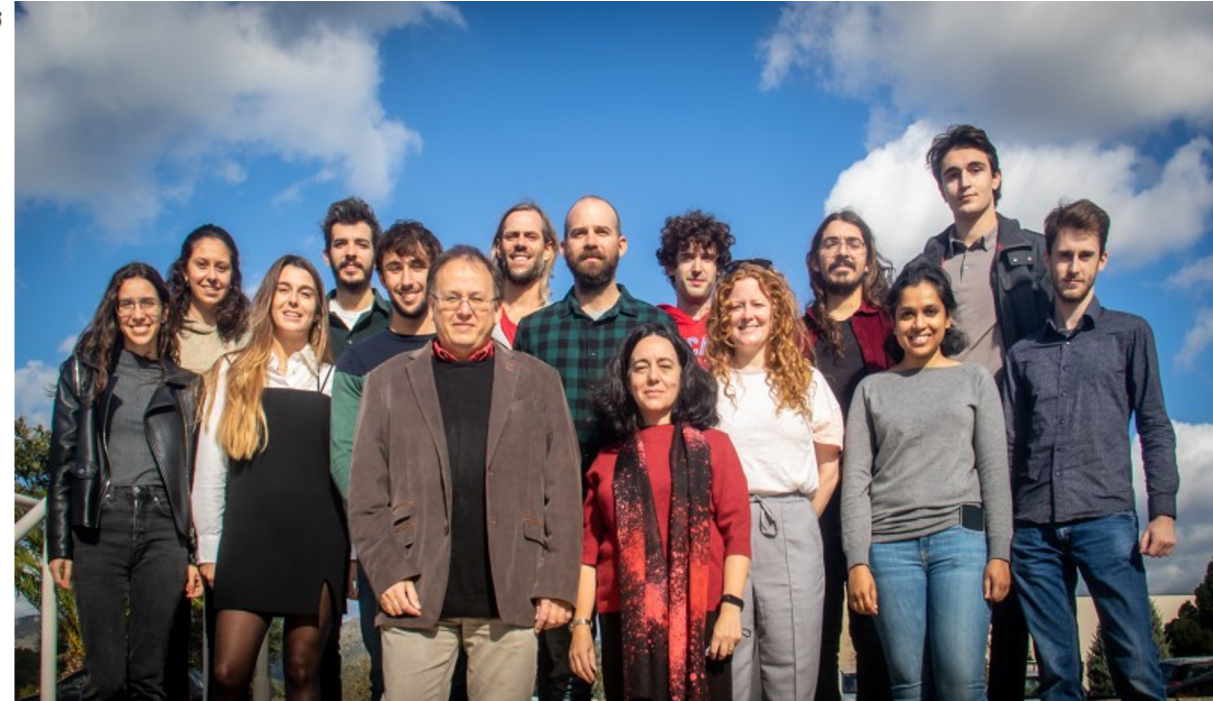
Presentation of the UIB gravitational physics group



Universitat
de les Illes Balears

IAC3 Institute of Applied Computing
& Community Code.

3 faculty (Sintes, Husa, Keitel),
4 post-docs, 6 PhD,
3 master and 4 undergrad students



- Part of LSC, GEO, LISA, ET
(A. Sintes founding member of the LSC in 1997)
- Focus: data analysis for GWs from binary black holes and neutron stars (including continuous waves), and the computational modeling needed to identify them.
- IMRPhenom models used for parameter estimation for all GW events so far, latest generation developed @ UIB: XPHM + TPHM
- Leadership on several LVC/LVK O3 projects: continuous waves, gravitational lensing, tests of GR
- Large allocations on Spanish supercomputing network (RES), past PRACE projects (PI Husa).

Possible contributions to ET Computing

Extend our work on data analysis with HPC/traditional supercomputers
(MareNostrum and others in Spain)

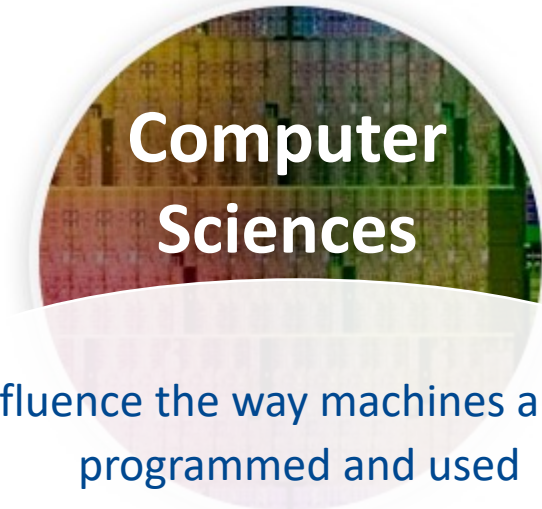
- So far: fast “high resolution” Bayesian parameter estimation of LIGO-Virgo events, GPU-based searches for spinning neutron stars in binaries, gravitational lensing of GWs.
- Primary goal: Develop workflows for data analysis tasks to be carried out on HPC machines, European infrastructure.
- Includes:
 - Continue development of fast(est) waveform models, seek partners for optimisation.
 - Automatization of computing jobs, analysis of performance with ML.
 - Help to interface between source modeling, data analysis strategies, science case, computing performance, and adaptation to European computing infrastructure, special focus on parameter estimation, tests of GR and continuous waves.

Barcelona Supercomputing Center

- Spanish National Supercomputing Center
 - +700 people
 - R&D in Computer Sciences, Earth Sciences, Life Sciences and Engineering Applications
 - Operation of a highly diverse, large-scale Computing and Data research infrastructure



- Peak performance 13,7 Pflop/s
- Large, general-purpose Intel partition
- AMD-based high-memory (1TB) cluster
- IBM Power9+Nvidia V100 cluster
- ARM-based Fujitsu cluster
- +Agora, 130 PB of HSM storage and heavy-duty VMs
- +Nord3, hybrid Cloud-HPC flexible system



To influence the way machines are built,
programmed and used

Programming models, performance tools,
Big Data, Artificial Intelligence, computer
architecture, energy efficiency

Computing and Data Research Infrastructure

- **Competitive Access**
 - Periodic calls for HPC and Data Management services
 - Peer Reviewed
- **Strategic Projects**
 - Dedicated allocations, after scientific assessment
 - Up to 10% of total annual competitive capacity
 - Currently for Spanish contribution to GAIA, LHC and EGA







Coming soon (2022)!!!

MareNostrum5

- anticipated peak performance >200PFlop/s
- heavy-duty GPUs
- Large storage capacity (~200 PB)

Quantum Computing

Possible contributions to ET Computing

Contribution	Previous experience	Who
Co-lead of WP8: Computing and data model	PRACE RI, EUDAT RI FENIX RI, ESFRI H&F SWG eIRG, EuroHPC, RES	Dr. Sergi Girona 
Computing models, workflows, performance and optimization	POP CoE , EPI, MEEP MontBlanc (ARM-based architectures),	Prof. Jesús Labarta 
Data model, data management, Open Science	(Astrophysics projects: MAGIC, Euclid simulations) Gaia Satellite data at BSC EOSC projects Gaia-X, RES data projects	Dr. Nadia Tonello 
Governance and financial aspects (ESFRI)	PRACE RI RES	Dr. Oriol Pineda 

- CC-IN2P3 : French National Computing Centre of IN2P3.
 - Mission : Providing computing resources and services for experiments supported by IN2P3.
 - 85 agents
 - Strong and long term engagement
 - Tier 1 for WLCG (LHC Grid Computing)
 - LSST (50% of the raw data)
- Experiments supported
 - High Energy Physics : ATLAS, CMS, LHCb, ALICE, Belle-II, JUNO, DUNE,...
 - Gravitational waves : **VIRGO**
 - Cosmology : LSST, EUCLID, ...
 - Cosmic rays : KM3NET, AUGER, ...
 - Others : Nuclear experiment, theory,....
- Most of them on international landscape.

- 2 computing rooms for a total of 1500 m²
- Computing Facilities
 - HTC (High Throughput Computing) : ~50 000 slots
 - HPC (High Performance Computing) : ~ 512 physical cores.
 - GPU cluster : 20 K80 GPUs, 72 V100 GPUs
- Storage
 - Tapes : ~ 110 PB
 - HDDs : ~45 PB (different technologies: dCache, XRootD, CEPH...)
- Networks
 - LHCOPN : 100 Gb/s (dedicated to LHC data)
 - LHCONE : 100 Gb/s (LHC, Belle2, Juno,...)
 - Specific link : LSST (40Gb/s), French HPC (100Gb/s)
- Services
 - Mail, github, web, institutional services, cloud infrastructure,.....



Academic Computer Centre Cyfronet AGH

- The biggest Polish Academic **Computer Centre**
 - **Over 45 years of experience** in IT provision
- Legal status: an **autonomous** within AGH University of Science and Technology
- Staff: >150 , ca. 60 in R&D
- Leader of **PLGrid**: Polish Grid and Cloud Infrastructure for Science
- NGI Coordination in **EGI e-Infrastructure**
- Coordination of EuroHPC activities in Poland



HPC

- 10 PFLOPS
- > 100k cores, NVIDIA A100
- 1st HPC system in Poland from 2015 to 2020



Storage

- 70 PB (POSIX / S3)
- hierarchical data management

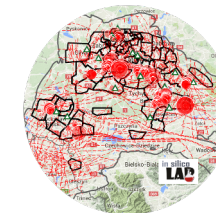
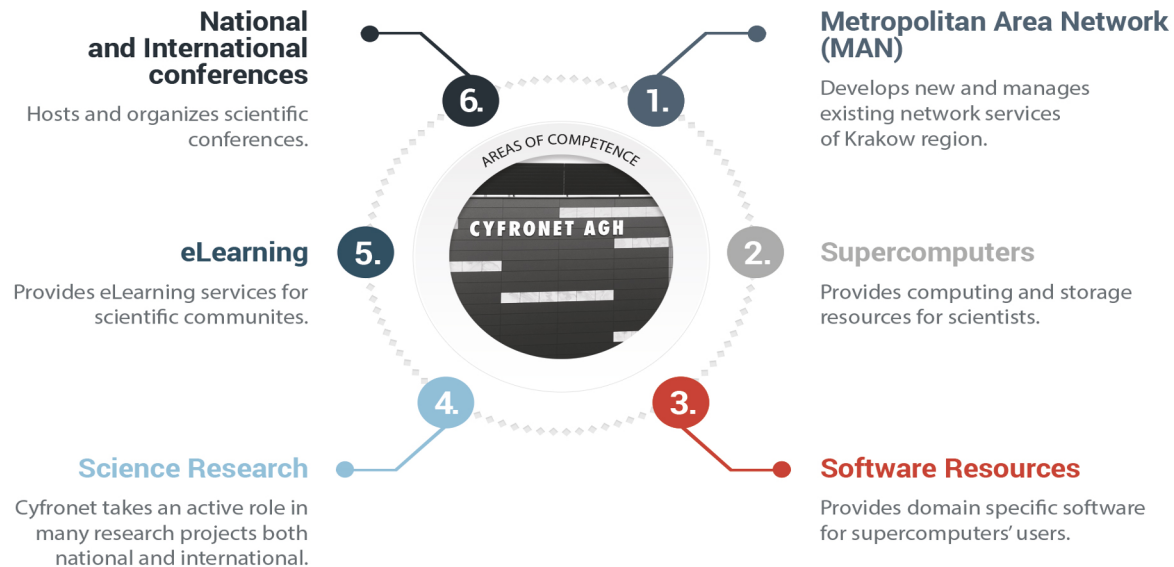
Computing portals and frameworks

- OneData
- PLG-Data
- DataNet
- Rimrock
- InSilicoLab

ONEDATA

in silico
LAB

rimrock



Possible contributions to ET Computing

- HPC/AI/Grid resources
 - GPUs (NVIDIA V100 and A100)
- Cloud computing platform
- Cloud storage (S3 and S3 Glacier)
- E-Infrastructure coordination and operations
- User support services
- AAI integration experience
- EOSC service integration



KIT – Steinbuch Centre for Computing

- KIT basic IT provider + Computational Science and Engineering, Data Intensive Computing
 - >250 people, 13 departments and 5 research groups
- Long standing history of operating facilities and services for HEP and Astro communities
 - GridKa Tier-1 Data and Computing center for LHC (ALICE, ATLAS, CMS, LHCb) + Belle II, Pierre Auger, IceCube, ...
 - Global Grid User Support Portal (GGUS)
- R&D for Research Data Management & Distributed Dynamic Computing
 - [PUNCH4NDFI](#)
 - <https://github.com/MatterMiners>
- Long history of HPC on state and national level
 - National High Performance Computing Center (NHR)
- R&D for AAI
 - [AARC Blueprint](#), [Helmholtz AAI](#), [Watts](#), [Federated User Deployment](#)
- deeply involved in build-up of EOSC (European Open Science Cloud) through several projects and member of EOSC Association

Possible contributions to ET Computing

- Computing Model Design
 - Bit preservation
 - Technical requirements for research data management
- Feedback of ET/GW requirements in national R&D efforts (PUNCH4NFDI)
- AAI
- Community Services
 - Gitlab
 - federated service management

ICCUB: Institute of Cosmos Sciences, University of Barcelona

- Institute of the University of Barcelona focused on **physical cosmology**
 - Astrophysics, high-energy physics, **gravitation**, hadronic, nuclear and atomic physics, quantum theories and technologies...
 - Created in 2006, now with ≈ 175 members
 - Yearly: ≈ 10 PhD theses, ≈ 250 -300 publications (mostly in 1st quartile, several high-impact ones), outreach activities...
- Fundamental questions on the **Universe**:
 - What are its **origin and fate**?
 - Which are its **ultimate constituents**?
 - Why does it have its **present appearance**?
- **Technology Unit**: Electronics, instrumentation, **computing and software engineering**
- Some key projects: LHCb, Gaia, DESI, MAGIC, CTA, Solar Orbiter, LISA, PTA...
 - Strong expertise on data processing pipelines (design + implementation), data analytics and cloud computing
- **Joined Virgo in July 2018**
 - Currently 15 members and ≈ 5 FTEs
 - **Science models**: BBH mergers from clusters, boson stars, neutron star physics (EoS, crust), GW lensing
 - **Data analysis**: new templates (e.g. precession, high eccentricity), pipelines, denoising for burst searches
 - **Instrumentation**: quadrant photodetectors for quantum noise reduction
 - **Computing and software engineering**: computing model, software migration, low-latency support, efficient data handling



ICCUB: Possible contributions to ET Computing



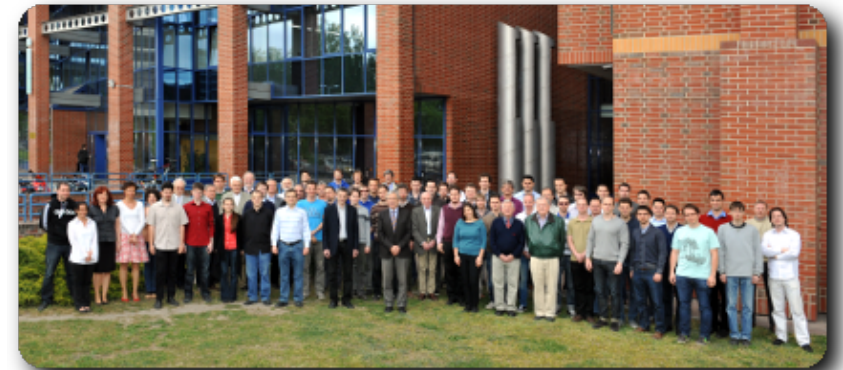
Institut de Ciències del Cosmos
UNIVERSITAT DE BARCELONA

- ICCUB interests on ET: natural extension of our participation in Virgo
 - *Science case* being defined.
Items from the ET Observational Science Board which are specially interesting for ICCUB scientists: Cosmology, Population (esp. astrophys. origin and primordial BHs), Nuclear Physics (esp. NSs), Waveforms
 - *Data analysis:*
Burst searches, denoising techniques
 - *Instrumentation (TBC):*
Capabilities on sensors, low-noise high-speed photodetectors, FPGA programming, ASICs, PCBs...
 - **Computing:**
Contributions to the general computing model and architecture, focusing on efficient data handling.
Contributions to the design and implementation of massive data processing pipelines.
Efficient data models and formats, including high-performance data compression.
Studies on the use of Big Data technologies and cloud computing for ET.
Software engineering manpower.
- No specific commitment yet
- Good perspectives of funding for some initial manpower devoted to ET
 - **We expect ≈1 FTE for ET engineering activities (software, computing, data) starting ≈Q2 2022**
 - Exploratory phase to identify specific activities
 - Initial focus of ICCUB for ET: data analysis and computing

- Budapest University of Technology and Economics
 - Faculty of Electrical Engineering and Informatics
 - Department of Measurement and Information Systems
- Main research fields of the Department
 - Embedded systems (HW + SW)
 - Intelligent Systems
 - Critical Systems
- 50+ Staff and 20+ PhD students
 - 100+ BSc and MSc students on projects
- R&D:
 - Industrial partners
 - Funding by the EU (e.g. H2020) and National bodies (e.g. NKFIH)

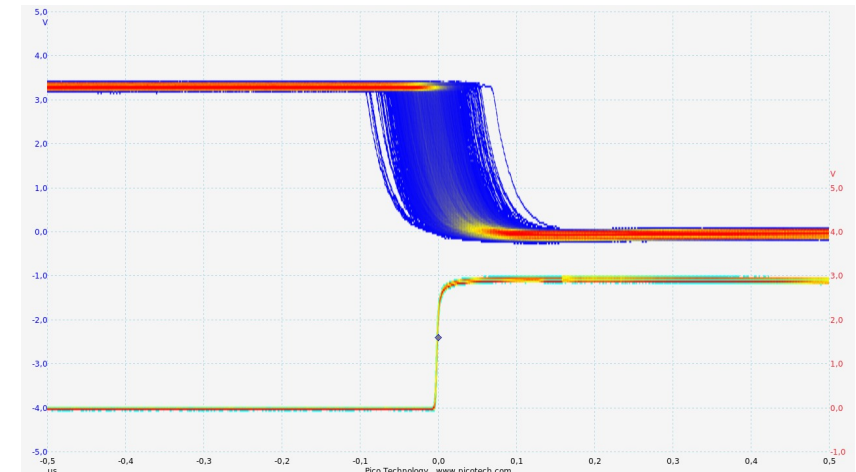
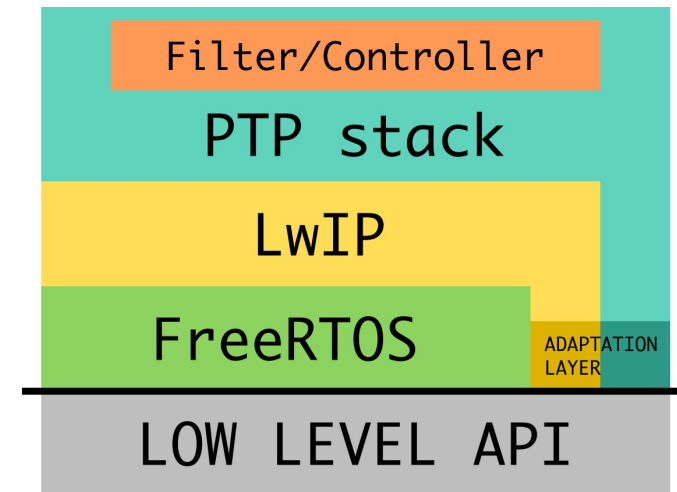


Méréstechnika és
Információs Rendszerek
Tanszék



Real-Time Networked Embedded Systems

- Real-time networked embedded system design and implementation (HW+SW)
 - Precision clock and frequency synchronization
 - IEEE 1588 PTP, White-Rabbit (CERN)
 - Real-time communication
 - Real-time Ethernet, Time Sensitive Networking (TSN)
 - High-speed Electronics and Printed Circuit Board (PCB) Design
 - Field-Programmable Gate Arrays and other Accelerators
 - Embedded Linux and Real-Time Linux SW development
- Measurement and Control Algorithms
 - Digital Signal Processing
 - Active Noise Control
 - Sensor Fusion
 - Artificial Intelligence
 - Machine Learning and Neural Networks



- [Wigner RCP](#)
- [Wigner Datacenter](#)
 - Originally CERN TIER-0 site
 - Atlas TIER-2
 - Academic cloud



- Virgo group since 2008, connection ~96
- 6 members
- IT: Balázs Kacskovics
- Waveform / source models,
- Seismic studies, infrasound measurements
- gravity.wigner.hu

Possible contributions to ET Computing

- Low-latency, offline computing
- Planned setup:
 - ET/VIRGO TIER-2 Cluster
 - 1000 vCPU, 3 TB RAM, 150 TB disc
 - Start at the beginning of next year

Port d'Informació Científica (PIC)

- Collaboration agreement [CIEMAT](#) - [IFAE](#). Founded in 2003. In Barcelona, Spain.
- **Mission:** Participate in the LHC Computing as Tier-1 and leverage experience to support other data-intensive scientific activities.
- **Resources:** 200 Gbps WAN, 10PB disk, 30 PB tape, 10.000 CPU cores cluster w 20 GPUs (HTCondor batch, JupyterHub interactive)
- **PIC staff** 20 people: 50% PhD scientists, 50% CS engineers.
 - Local interdisciplinary teams to provide custom support to experiments.
- **PIC production data services:**
 - Data center for: LHC, MAGIC, CTA, Euclid, PAUsurvey
 - Grid computing node for: VIRGO/LIGO, DUNE
 - Support to local groups in: medical imaging, environmental sciences, biology

Possible contributions to ET Computing

- Participation in the offline computing development and operation
 - Near 20 years experience in WLCG - design and evolution of the architecture
 - Production services for several large experiments
 - Long-term preservation and massive reprocessing responsibilities
 - User analysis services for large distributed communities
- Computing and data model design
 - Experience with several real-life computing model development processes in the fields of astrophysics and particle physics
- Realtime alert and multimessenger analysis (MMA) system
 - Local group with experience in analysis portal for cosmology analyses (<https://cosmohub.pic.es>)
 - Project to extend it into a MMA platform in collaboration with local gamma ray, GW and cosmology groups.

Presentation of the Polish ET consortium

Polish ET consortium: CAMK PAN/AstroCeNT, OA UW, NCBJ (≈ 10 persons)

- Main activities in Virgo
 - Data analysis (Continuous Waves - Time Domain F-statistic), theory
 - Sensors for Newtonian Noise: seismic, infrasound; data analysis
 - Compact objects' astrophysics

- Good collaboration with Cyfronet
 - (multiple successful production runs ending in results in collaboration papers, and experimental/proof-of-concept papers)

Possible contributions to ET Computing

- Users' expertise in
 - HPC, HTC
 - ML, GPU computing
 - QC and QML (AstroCeNT)
 - GW data analysis
 - Interested in semi-online DA pipelines (e.g. CW DA)
 - Interested in active contributions to DetChar
- Links with OSB Div 6, 9 and 10
- Support Cyfronet in securing funds for infrastructure and dedicated staff

- Focus on particle physics, astroparticles, GWs and cosmology.
- ~15 permanent researchers, ~25 postdocs, ~25 PhDs and 3 IT experts.
- Tier 2 computing cluster (~3.5K CPUs, ~3 PB storage).

Support CMS, Na62 and LIGO/Virgo Vos as well as Madgraph cluster (particle collision generator)

- GW group:
 - Analysis: 1 staff, 3 postdocs, 2 PhD
 - Instrumentation: 1.5 staff, 2 postdocs, 1 PhD
 - Computing support: 1 computer scientist (physicist with PhD)
 - Theory: 1 permanent staff, 1 postdoc, 1 PhD

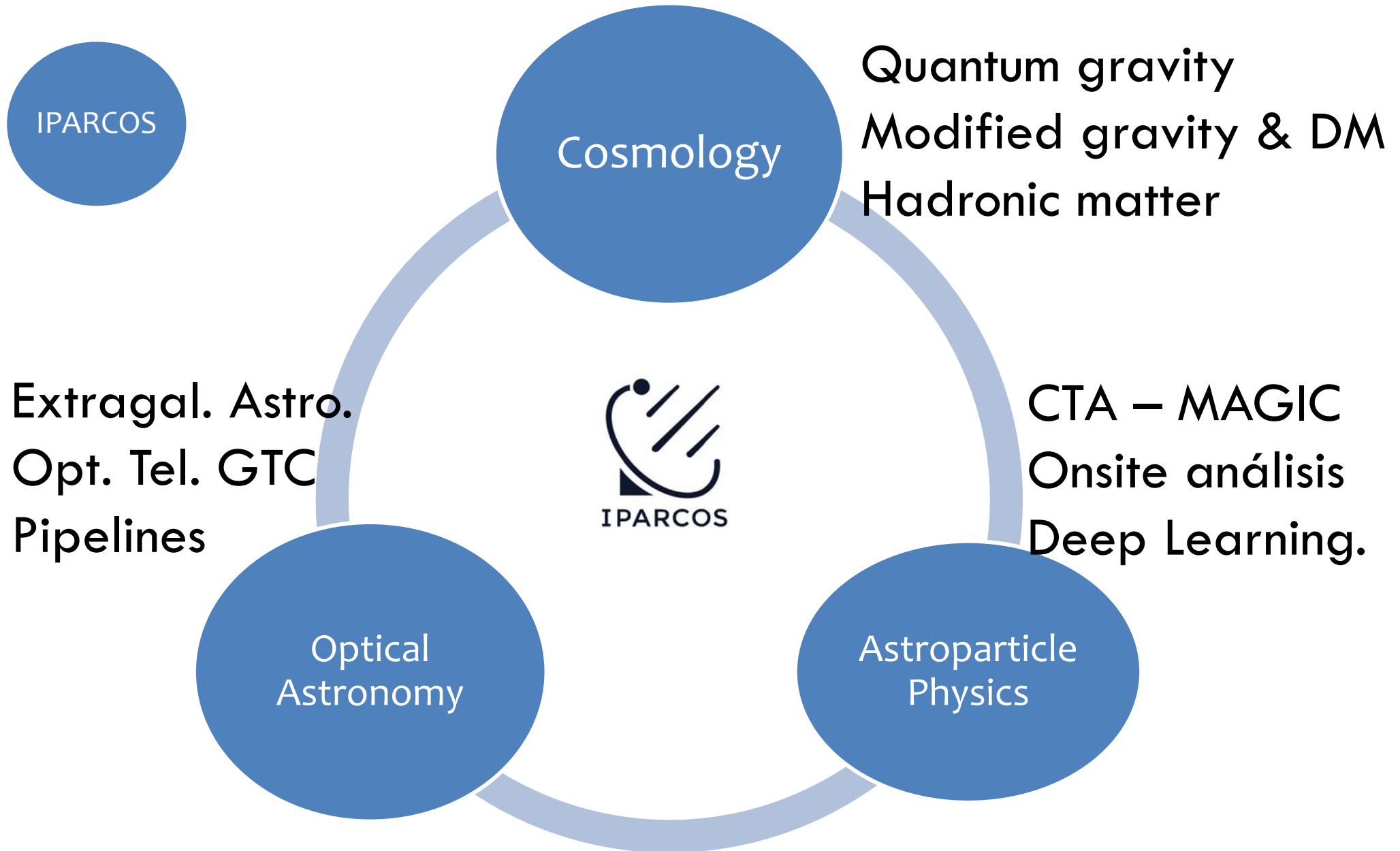
- Most obvious contribution: provide distributed computing resources.
We do it already for CMS, Na62, LIGO/Virgo and Madgraph
- We could also host a dedicated service for offline computing not requiring high availability (we can not ensure immediate action in case of problems).
Ex: We are installing a StashCache Origin server to host Virgo h(t) data.
- Contribute in offline software development (A. Tanasijczuk ~ 0.4 FTE).
More enthusiastic about coding than other computing tasks.

IPARCOS is the Institute of Particle and Cosmos Physics of Universidad Complutense de Madrid (> 50 Senior res.).

Interest in ET arises mainly from the Cosmology group (theory).

Support from the Extragal. Astronomy & Instrument. and the Astroparticle Physics groups (experimental).

We want to explore a possible cooperation in ET-EIB mainly for the experimental groups.



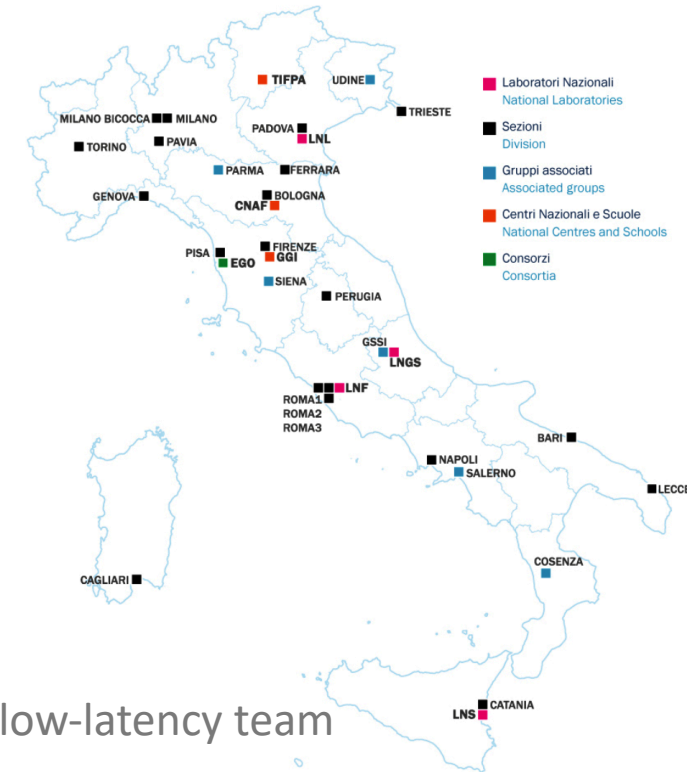
- Jesus Gallego
 - Full professor
 - Extragal Ast. & Instrumentation
 - ELT @ UCM
- José Luis Contreras
 - Associate professor
 - ESCAPE @ UCM
 - MAGIC, CTA
- Daniel Nieto
 - Associate professor
 - ESCAPE @ UCM
 - VERITAS, CTA



- Since 1951, pursues several lines of research: **Particle, Astroparticle, Nuclear and Theoretical physics and interdisciplinary Technology**
- About 2100 employees and 4000 associates
- Counts **4 laboratories**, 20 divisions, **6 related groups**, **3 national centres** and **2 consortia**

EXPRESSION OF INTEREST IN ET COLLABORATION

- **Torino:** S. Bagnasco, L. Gaido, F. Legger, S. Vallero
- **Genova:** L. Rei
- **Bologna:** D. Bonacorsi, C. Grandi
- **Pisa:** M. Razzano and members from the Virgo group at University of Pisa & INFN-Pisa
- **Perugia:** G. Greco → (technologist) financial support from AHEAD project, member of the low-latency team of the Virgo, LIGO and KAGRA collaborations since last 7 years
- **Roma:** P. Astone, S. D'Antonio, S. Frasca, P. Leaci, C. Palomba, O. J. Piccinni, I. La Rosa, L. Pierini and few master students → CW data analysis group of the Rome Virgo group
- **Catania Division:** G. Andronico → presently involved in developing Jiangmen Underground Neutrino Observatory distributed computing infrastructure
- **Catania National Laboratory:** E. Giorgio



Possible contributions to ET Computing

ASSETS:

Bologna

- experience in Computing Model definition/evolution and computing coordination in LHC experiments (CMS)
- experience in data challenges design/coordination/operation in WLCG (e.g. DC'04, WLCG STEP'09 scale test)
- experience with workload management tools (e.g. HTCondor /DAGman)
- experience in Applied Machine Learning /Deep Learning (R&D in HEP/LHC + teaching)
- experience in ultra-low latency Deep Learning inference models on FPGAs (e.g. CMS muon trigger)
- HPC/AI initiatives; "AI and Hard Sciences" scientific unit in the interdepartmental ALMA-AI Centre; new Data Science & Computation PhD

Integrated HW/SW facility for PoC and mock data challenges

- signal detection algorithms performance improvement
- new algorithms design (incl. AI) for better heterogeneous architectures exploitation in different use cases (e.g. event selection, data analysis, predictive maintenance, ...)
- definition of effective methods to better exploit hardware accelerators (GPU, FPGA, possibly Google Cloud TPU's)
- investigation of quantum computing (and quantum machine learning) algorithms on real quantum resources or simulators (via Qiskit, Braket, Pennylane, etc)

ASSETS:

Torino

- decennial experience in distributed computing (WLCG and Virgo): data management, distributed analysis, operations, monitoring and accounting (HTC, HPC, MLaaS)
- LVK low-latency computing
- twenty years experience in participating to European projects on distributed computing (GRID and Cloud) and recent involvement in EOSC projects

INTERESTS

- computing model design
- technology tracking
- analysis pipeline
- distributed computing infrastructure support and operation

ASSETS:

Genova

- LVK distributed computing

INTERESTS

- computing model development

Possible contributions to ET Computing

ASSETS:

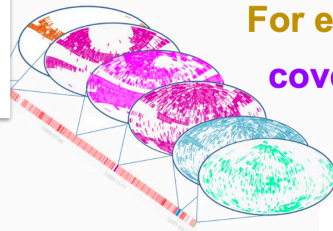
- main activities in the ASTERICS/DADI, ESCAPE/CEVO, AHEAD/wp12: implementation of FAIR principles for ESFRI data through the Virtual Observatory
- development and implementation of IVOA (International Virtual Observatory Alliance) standards to encode and visualize credible regions of gravitational-wave sky localizations

Perugia

Connection between the FAIR principles and ET multimessenger

MOC: Multi-Order Coverage map

Version 2.0
IVOA Working Draft 2021-03-24



For each element of a temporal coverage we list the associated spatial coverage.

2.4 Space and Time MOC: Einstein Telescope and Early Warning Alerts

1. The 2D credible regions of gravitational-wave sky localizations are straightforwardly encoded into a **Space MOC** data structure - see [LIGO and Virgo User Guide](#).
2. **Space and Time MOC**: query in real time the ET localizations in a specific time range to receive the corresponding (and better) sky position.
3. **Space and Time MOC**: filter candidate EM transients adding a proper time window in any ET sky localization.

ASSETS:

- various aspects related to the development of the detector (mostly suspensions)
- data analysis for detector characterization and detection of sources
- expertise on machine learning applied to GW data analysis

Pisa

INTERESTS

- machine learning for fast characterization of noise, including studies on auxiliary channels (also expertise from REINFORCE citizen science project)
- suspension simulations
- advanced machine learning for fast localization of GW events

ASSETS:

- hosting activities in several INFN interest area
- in the past was very active in Grid development and dissemination, supporting a very wide range of applications
- it is hosting a Tier-2 for ALICE experiment
- it was recently part of several projects aimed in developing computing infrastructures for scientific research based on modern technologies
- Catania data centre is presently under renovation thanks to a national project

Catania Division

Possible contributions to ET Computing

ASSETS:

- decennial experience in data analysis

Roma

INTERESTS

- thanks also to our intense experience to handle LIGO-Virgo data sets, we plan to develop search codes (including GPU porting) that we can easily adapt to various environments/interfaces and deeply test them
- as done until now for the LIGO-Virgo detector network, we plan to be involved into detector characterization (data quality and noise budget studies)
- keep the related software updated in centralized repositories

STAFF:



P. Astone



S. D'Antonio



S. Frasca



P. Leaci



C. Palomba

POST-DOC fellows:



O. J. Piccinni

PhD students:



I. La Rosa



L. Pierini

***CW data analysis
group of the Rome
Virgo group***

Fellini fellow from Dec 1st 2021

and a few of master students

- Recently began cross-department effort to increase involvement in GW science
 - Astronomy, particle physics, and theoretical physics departments
 - Mixture of those with past GW experience and new collaborators
 - Interest in ET from at least two PIs per department (6+ groups)
- GW-related experience: simulation, modelling, physical interpretations, etc
 - Long-standing ET involvement by Michele Maggiore (ET OSB co-chair)
- Other experience: computing, electronics, science data centres, triggers, etc
 - Astronomy: ATHENA, CHEOPS, CTA, EUCLID, GAIA, INTEGRAL, etc
 - Particle physics: AMS, ATLAS, CTA, DAMPE, FASER, Hyper-K, T2K, etc
- Benefit from international environment and collaborations, including CERN

- Interested groups have past experience in:
 - Designing, deploying, and operating HPC systems
 - Large-scale data preservation and public distribution
 - Mission-critical computer systems for remote control and operation
 - Custom electronics for low-latency readout and processing+triggering
 - Software triggering and public alert systems for multi-messenger obs.
 - Data analysis, data calibration, data pipeline design, and implementation
- Still investigating exactly how to best contribute to the ET eIB
 - Clear interest in participating, need to identify where is most beneficial
- Open to feedback from the eIB on possible topics for collaboration

Presentation of the institution/group/centre...

UPM: Main Technological University in Spain

✓ Specialized in engineering and architecture

1st

Spanish speaking university in QS ranking (2018)

76th

(world)
Ranking QS (2018)

92nd

(world)
Employability in QS ranking (2019)

✓ UPM Big Science

✓ Strategic areas



+500
R&D&i projects

+120
Tenders for the Large Scientific Facilities

Materials	Instrumentation & Control
Vacuum	Superconductivity
ICT	Remote handling
Detectors	Engineering methodologies
Safety systems	Electrical, electronics and RF systems



Possible contributions to ET Computing

UPM Possible Contributions

INSTRUMENTATION
& CONTROL

- High performance and low latency advanced DAQ.
- Integration of **high-end solutions** using FPGAs and GPUs.
- Development of platforms for accelerating algorithms using **GPUS** (NVIDIA and AMD) and **mainly FPGAs** (IntelFPGA and XILINX) using **OpenCL and High-Level Synthesis technologies**.
- Implementation of **machine learning and deep learning** (the inference part) to detect events.

OPEN SCIENCE
& DATA

- **Laboratory protocols.**
- **Reproducibility of workflows** in Astronomy.
- Ontology-based sensors data integration.
- **Packaging of research objects** for scientific experiments.

DATA
MINING

- **Data collection, analysis and knowledge extraction.**
- **Image processing architectures.**
- **Joint transformations.**

✓ Relevant applications to industry:

- **NDS CORE SOFTWARE SUPPORT FOR CODAC CORE SYSTEM:** development and integration of standard device driver for **ITER** fast controllers in PXIe and MTCA.
 - **ITER UPPER WAVS SENSORS, DATA ACQUISITION ELECTRONIS AND DATA ANALYSIS SOFTWARE PROJECT:** development of advanced image acquisition and processing for **ITER** upper WAVS.
 - **VALIDATION OF FAST INTERLOCK ARCHITECTURE:** development of the validation and verification solution for **ITER** fast interlock platform.
-
- Creation of a common database to **store highly-relevant data on radiation damage** of Reactor Pressure Vessel steels (ENTENTE) for **FAIR**.
 - Contributions to the **European Open Science Cloud**. Membership of the **EOSC Interoperability Framework**, and. **membership of the EOSC FAIR Working Group**.
 - **CABAHLA:** ecosystem for the integration between **HPC and large scale data analysis**.
-
- **ECV Fire Disturbance:** funded by **ESA** inside the **Climate Change Initiative (CCI)**, to realize the full potential of the long-term global Earth Observation archives.
 - **IASIS: integration and analysis of heterogeneous big data** for precision medicine and suggested treatments for different type of patients.