

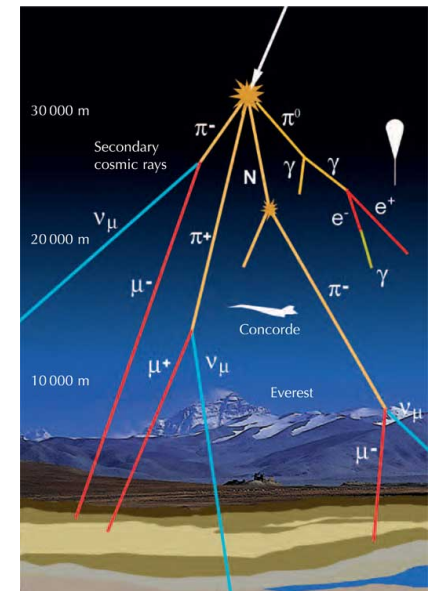
# Preventivi 2020 CSN2

## INFN Roma Tor Vergata

*R. Sparvoli*

*(coordinatore CSN2 @ TOV)*

*Roma, 19 Luglio 2019*

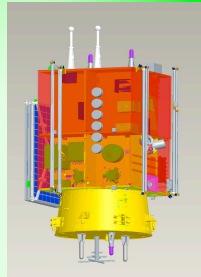




# Linea 2 → 15 sigle aperte (2 nuove e 2 già note) 1 sigla chiusa (Gamma-MeV)

## Esperimenti con responsabile Nazionale (4)

DAMA



LIMADOU

SATOR\_G

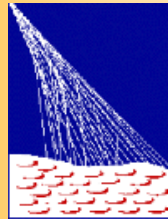


VIRGO



## Altri esperimenti (11)

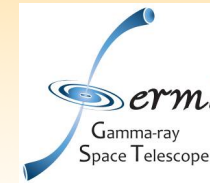
AUGER



CTA-RD



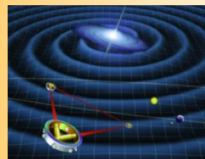
FERMI



QUBIC



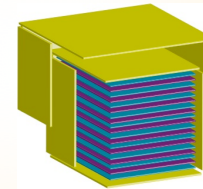
LISA



LSPE



GAPS



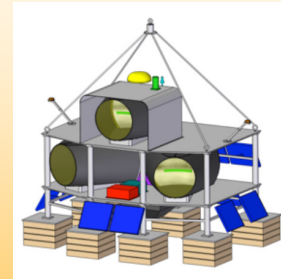
ET-ITALIA



AMS-02



SPB-2



NUCLEUS



# Suddivisione in linee della CSN2

- 1. Neutrino Physics** (solar neutrinos, oscillation experiments, hierarchy and mass, Majorana vs Dirac mass term)
- 2. Radiation from the Universe** (low – CMB - and high energy photons, cosmic rays from space and at ground, neutrino astronomy)
- 3. Gravitation** (interferometers at ground and from space, tests of general relativity, quantum mechanics, QED and fundamentals)
- 4. The Dark Universe** (direct and indirect DM searches, dark energy)

Esperimenti in sezione

**NUCLEUS**

**AUGER, CTA, FERMI, GAPS, LIMADOU, LSPE, SPB-2, AMS-02**

**LISA, VIRGO, SATOR-G, ET-ITALIA**

**DAMA, QUBIC**

# Assegnazioni bilancio CSN2 INFN

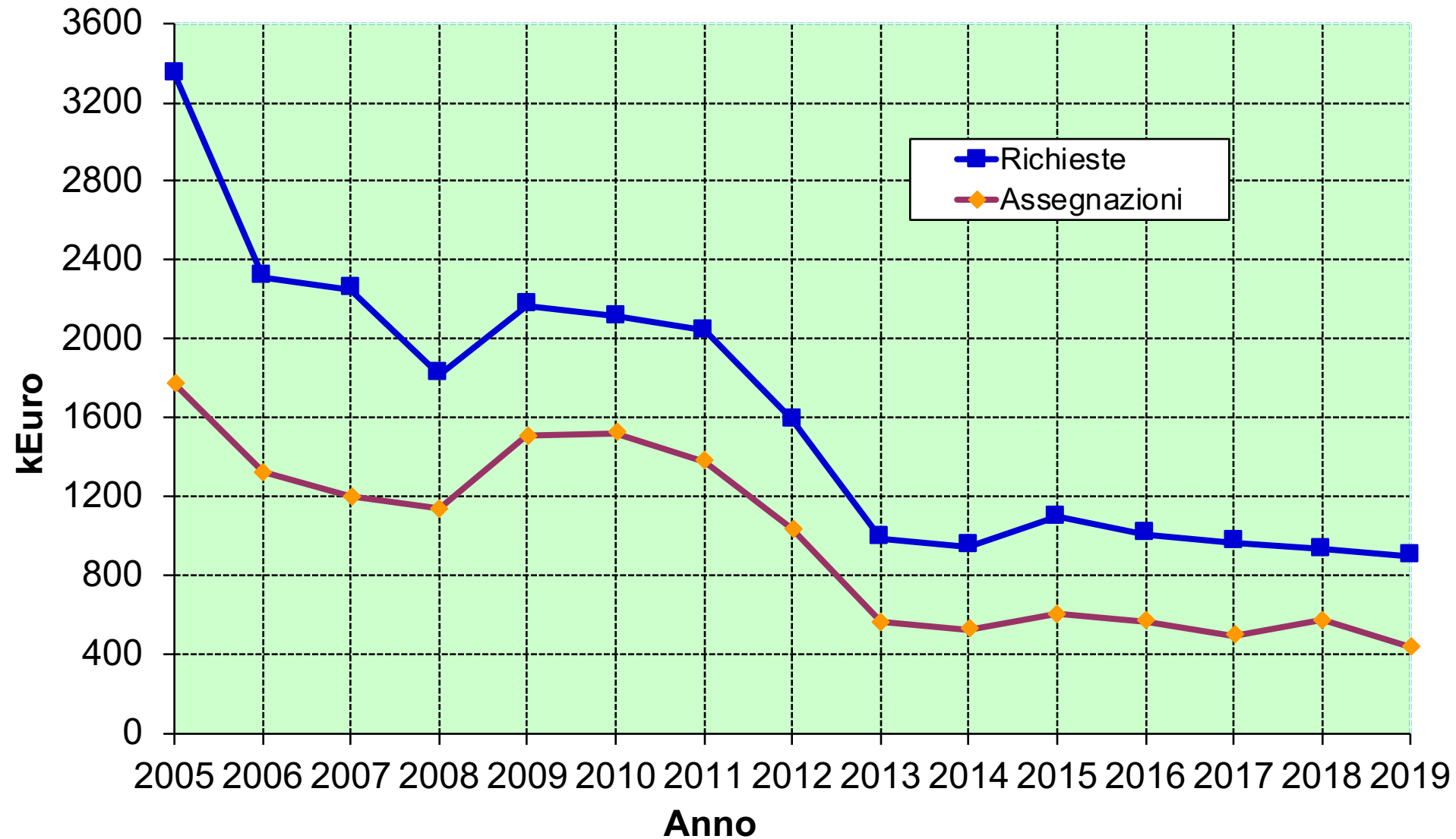
CSN2 – INFN, tutte le sezioni e laboratori

	Richieste (M€)	Assegnato (M€)	%
2005:	45.5	21.0	46
2006:	32.2	14.4	45
2007:	38.2	14.5	38
2008:	28.3	12.3	43
2009:	24.9	11.8	47
2010:	25.0	11.0	44
2011:	23.0	10.4	45
2012:	21.2	12.4	58
2013:	27.1	11.4	42
2014:	26.2	11.6	44
2015:	30.6	11.5	38
2016:	24.4	12.2	50
2017:	27,4	14.7	54
2018:	28,1	13.5	48
<b>2019:</b>	<b>26.6</b>	<b>13.6</b>	<b>51</b>

MISS:	4700	<b>34.6%</b>
CON:	2148	<b>15.8%</b>
ALTRI CONS:	539	<b>4.0%</b>
TRA:	225	<b>1.7%</b>
MAN:	153	<b>1.1%</b>
INV:	1152	<b>8.5%</b>
APP:	3173	<b>23.3%</b>
LIC.SW:	56	<b>0.4%</b>
SPSERVIZI:	797	<b>5.4%</b>
SEM:	27.0	<b>0.2%</b>
PUB	13.5	<b>0.1%</b>

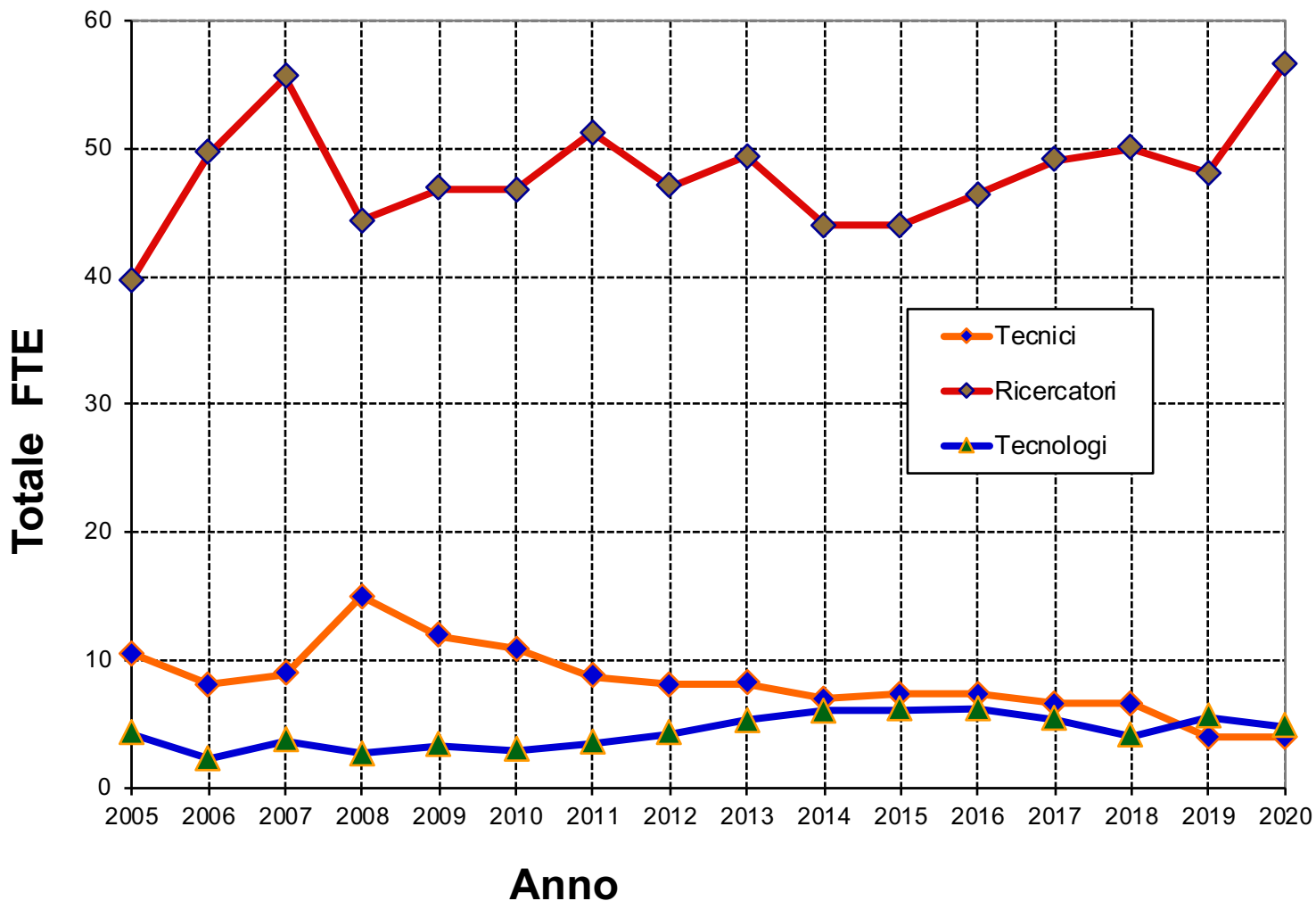


## Assegnazioni INFN Tor Vergata Gruppo 2



# ANAGRAFICA – INFN Tor Vergata – Gruppo II

Importante crescita di FTE ricercatori grazie alle stabilizzazioni e all'apertura di nuove sigle



# AUGER

3000 km<sup>2</sup> – Malargue (Argentina)  
membri collaborazione ~ 500

Responsabilità: G. Salina leader del *Calibration Analysis task*

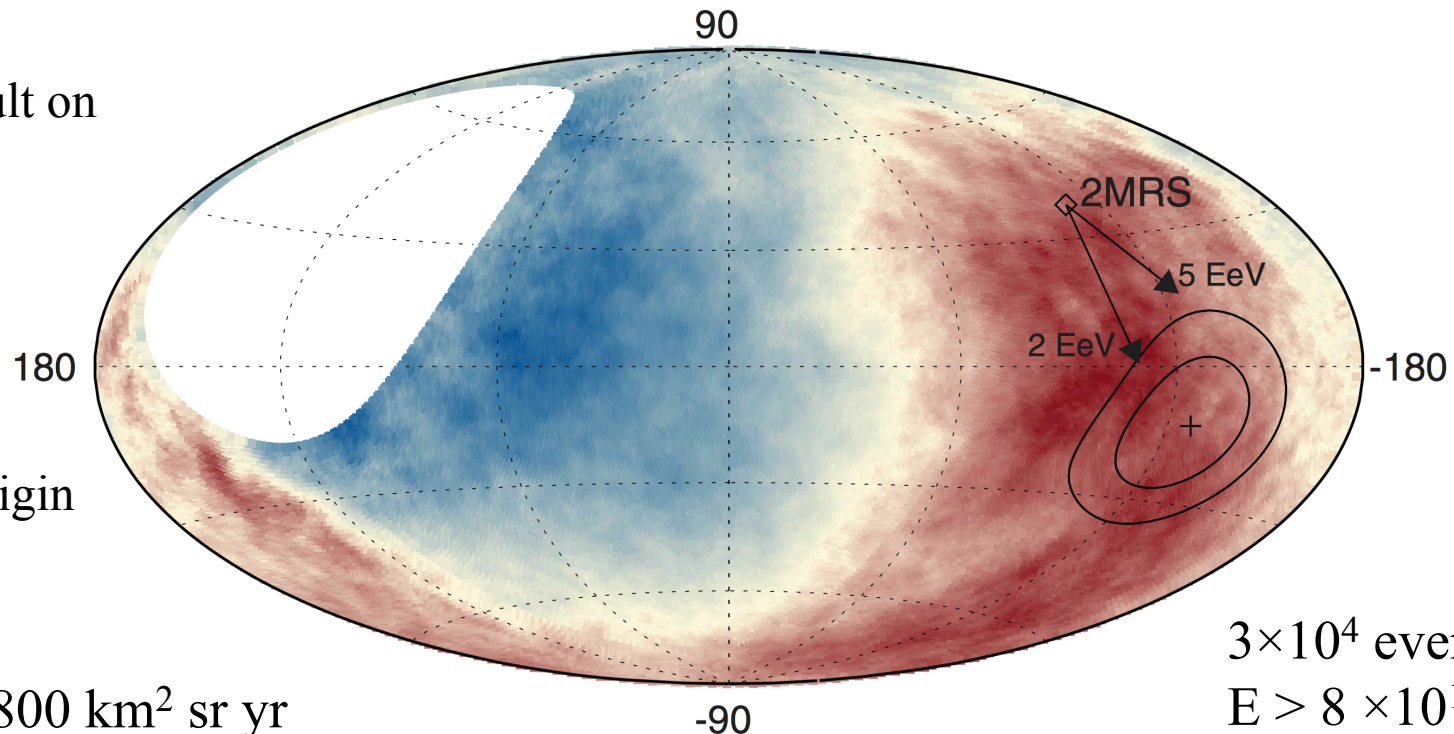
V. Verzi leader del *Energy Spectrum task*  
e *Fluorescence Detector analysis task*

Auger papers: 3 nel 2018, 2 nel 2019 (+ 4 sottomessi)

Observation of a Large-scale Anisotropy ... Science 357 (2017) 1266-1270

first  $> 5 \sigma$  result on  
this field

→ evidence of  
extragalactic origin

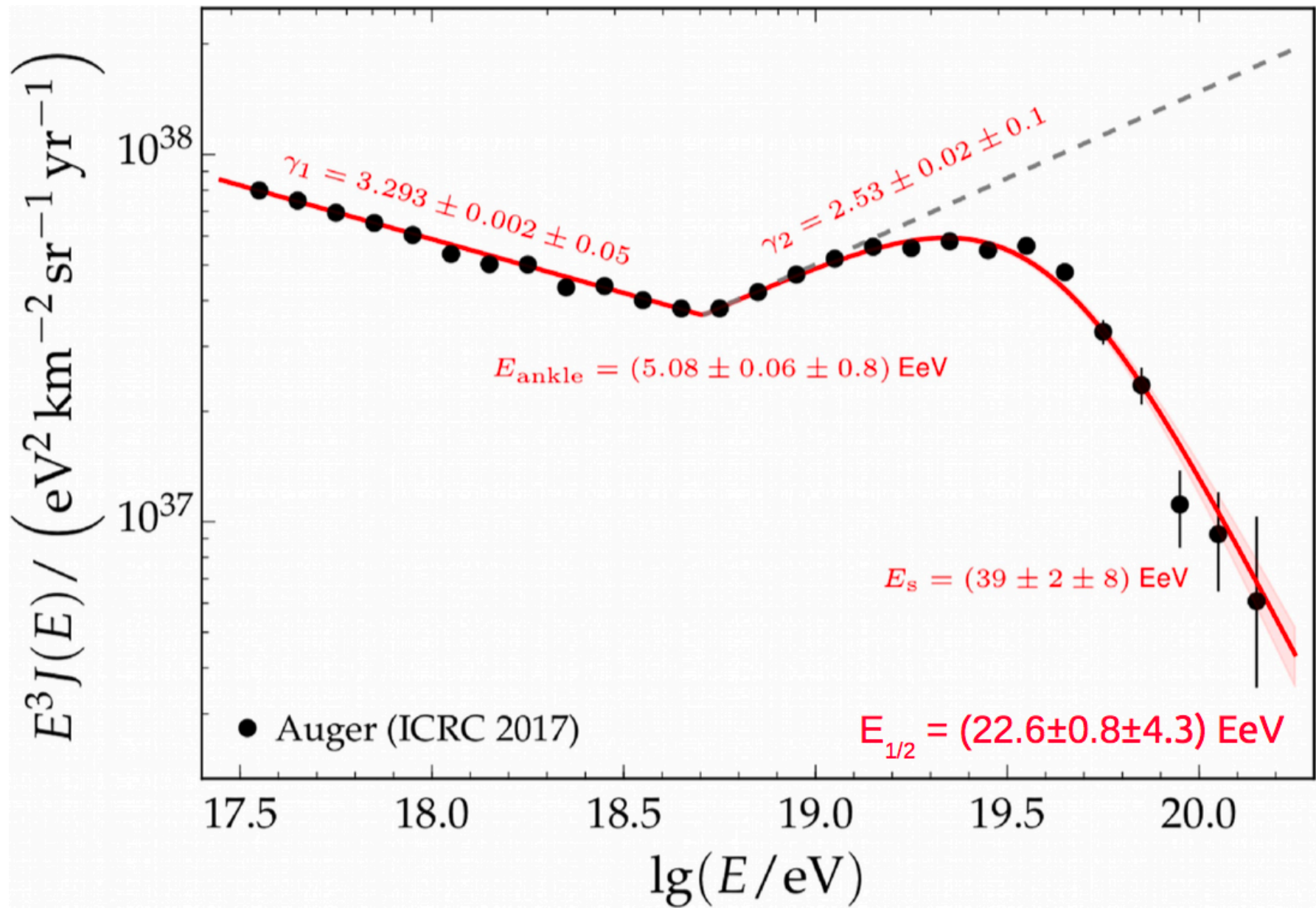


exposure 76800 km<sup>2</sup> sr yr

$3 \times 10^4$  events  
 $E > 8 \times 10^{18}$  eV



# ICRC 2019: spectrum extended up to $10^{16.5}$ EeV



# Richieste finanziarie

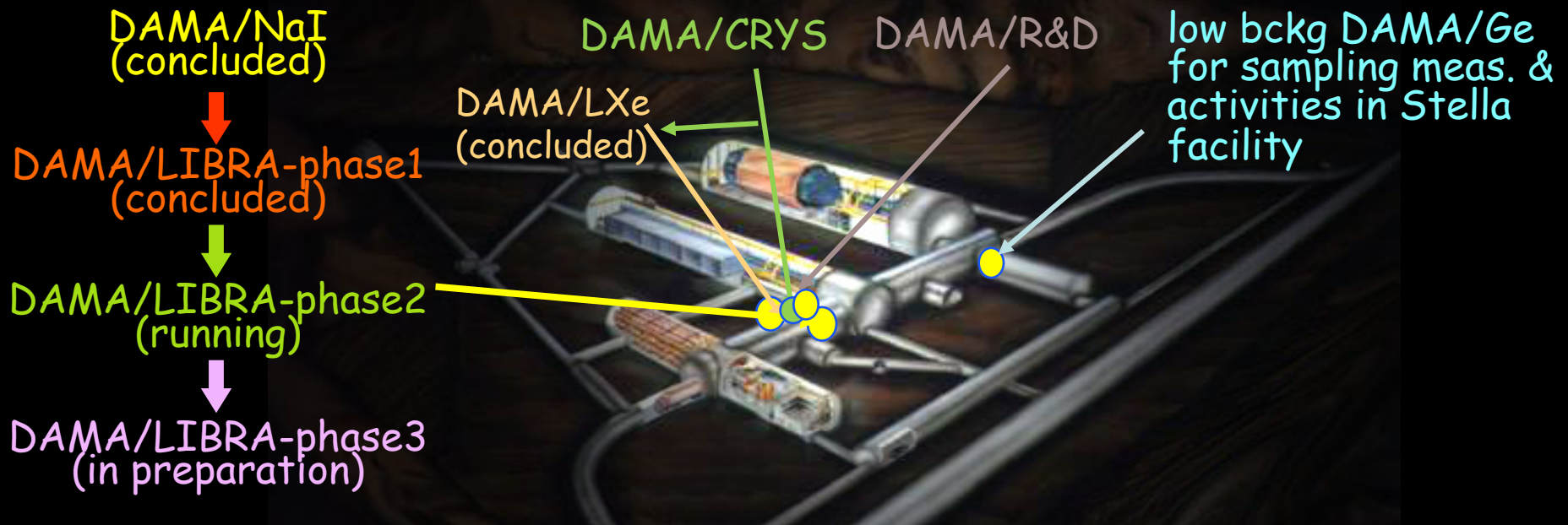
V. Verzi	Ricercatore INFN	80%
G. Salina	Primo Ricercatore INFN	50%
M. Feroci	Dirigente di Ricerca INAF	30%
G. Matthiae	Prof. ordinario	0%
E. Reali	Tecnico categoria B	40%
G. Vitali	Tecnico categoria C	20%

**1.6 FTE**

		k€
Partecipazione a conferenze per i task leader	Missioni (total 26.0 k€)	4
Meeting Malargue		6
Meeting collaborazione Auger in Australia		6
1 meeting per il coordinamento delle attività sullo spettro Auger e Telescope Array		3
1 turno presa dati FD		4
partecipazione responsabile gruppo a incontro con referee e incontri stituzionali		1
meeting della collaborazione italiana (2 persone)		2
Metabolismo & trasporti su sito Auger	consumo	3
TOT.		29

# DAMA

an observatory for rare processes @ LNGS



## Collaboration:

Roma Tor Vergata, Roma La Sapienza, LNGS, IHEP/Beijing  
+ by-products and small scale expts.: INR-Kiev + other institutions  
+ neutron meas.: ENEA-Frascati, ENEA-Casaccia  
+ in some studies on  $\beta\beta$  decays (DST-MAE and Inter-Universities project): IIT Kharagpur and Ropar, India

web site: <http://people.roma2.infn.it/dama>

June 2018 – July 2019:

- 20 publications on int. reviews & int. reviews/volumes of Proc.
- 26 talks at conf. and seminars



# DAMA/LIBRA: Main activities from June 2018 to July 2019

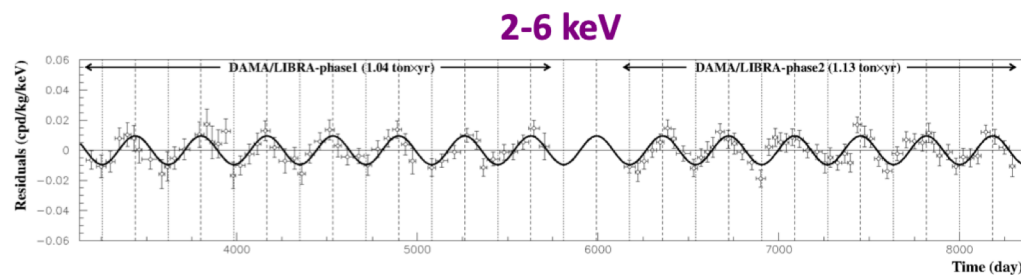
- 1) DAMA/LIBRA-phase2 results of the first 6 full annual cycles have been published and presented at conferences/seminars.
- 2) In September 2018 DAMA/LIBRA-phase2 has concluded the data taking of a 7th annual cycle, and started the 8th annual cycle.
- 3) Model dependent corollary analyses in various scenarios for DM particles in the light also of the new DAMA/LIBRA-phase2 results have been concluded.
- 4) The development of some new electronic modules for further implementation of the apparatus for low energy studies has been progressed.
- 5) Studies towards DAMA/LIBRA-phase3 have been successfully progressed (new metallic PMTs developed by HAMAMATSU: R11065-20MOD)
- 6) The new system voltage divider with preamplifier on the same base has been designed and applied. Tests are ongoing.
- 7) Studies on other DM features or second order effects, and other rare processes (also with dedicated data taking) are in progress.



**DAMA/LIBRA-phase1 + DAMA/LIBRA-phase2 (2.17 ton×yr)**

Universe 4 (2018) 116; NPAE 19 (2018) 207

**Single-hit residuals rate vs time in 2-6 keV**



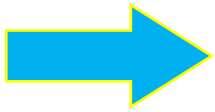
continuous line:  $t_0 = 152.5$  d,  $T = 1.0$  y

$A = (0.0095 \pm 0.0008)$  cpd/kg/keV  
 $\chi^2/\text{dof} = 71.8/101$  11.9  $\sigma$  C.L.

Absence of modulation? No  
 $\chi^2/\text{dof} = 199.3/102$   $P(A=0) = 2.9 \times 10^{-8}$

Fit with all the parameters free:  
 $A = (0.0096 \pm 0.0008)$  cpd/kg/keV  
 $t_0 = (145 \pm 5)$  d -  $T = (0.9987 \pm 0.0008)$  y

# Future perspectives: toward DAMA/LIBRA-phase3

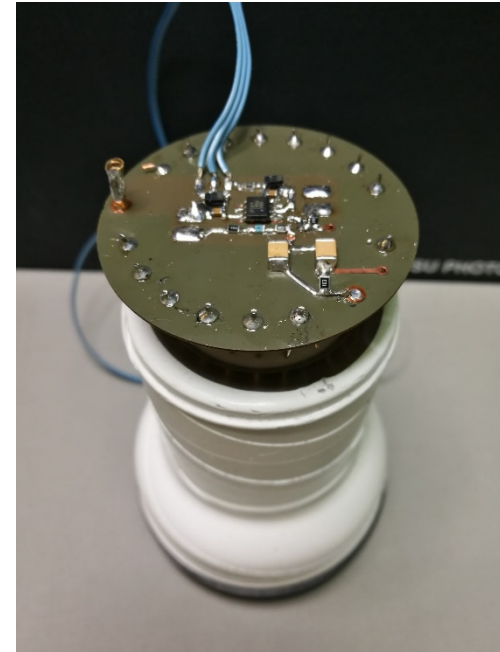


updating hardware to lower software  
energy threshold below 1 keV

new miniaturized low background **pre-amps** directly installed  
on the low-background supports of the **voltage dividers** of the  
new lower background and slightly higher Q.E. **PMTs**.

The presently-reached metallic PMTs features:

- Q.E. around 35-40% @ 420 nm (NaI(Tl) light)
- Radio-purity at level of 5 mBq/PMT ( $^{40}\text{K}$ ), 3-4 mBq/PMT ( $^{232}\text{Th}$ ),  
3-4 mBq/PMT ( $^{238}\text{U}$ ), 1 mBq/PMT ( $^{226}\text{Ra}$ ), 2 mBq/PMT ( $^{60}\text{Co}$ ).



High exposure and lower energy threshold can allow to deeper investigate e.g.:

1. **astrophysical models:** investigation of the DM halo features, solar focusing and DM streams by studying the phase of the annual modulation
2. **possible diurnal effects on the sidereal time:** increasing the sensitivity to observe the DM diurnal modulation effect
3. **nature of the DM candidates:** constraining the nature of DM candidate measuring with high precision the modulation amplitudes below 1 keV

At data taking completion detectors on surface for final characterization before final result

# Recent $\beta\beta$ decay and rare processes in DAMA/R&D

Final results of **AURORA** experiment on  $2\beta$  decay in  $^{116}\text{Cd}$  with two  $^{116}\text{CdWO}_4$  crystal scintillators enriched at 82% in  $^{116}\text{Cd}$  published:

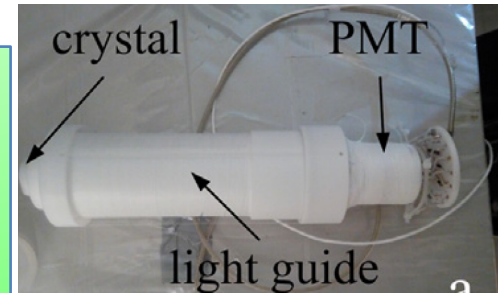
- ✓  $T_{1/2}(2\nu 2\beta) = 2.63^{+0.11}_{-0.12} \times 10^{19}$  yr (the **most accurate** value)
- ✓  $T_{1/2}(0\nu 2\beta) \geq 2.2 \times 10^{23}$  yr (the **strongest** limit)  $\Rightarrow \langle m_\nu \rangle < (1.0 - 1.7)$  eV

Investigation for radio-purer  $^{116}\text{CdWO}_4$  detectors for a new stage of the search is in progress

## R&D of radiopure $\text{ZnWO}_4$ anisotropic scintillation crystals in progress

interests in studies on DM directionality and  $\beta\beta$  decay of Zn and W isotopes

1. Results on the radioactive contaminations of 6  $\text{ZnWO}_4$  crystals, produced by the low-thermal-gradient Czochralski technique by 1 and 2 crystallization processes, and by one crystallization with additionally purified tungsten, have been published
2. Measurements on two new  $\text{ZnWO}_4$  crystal scintillators, produced by double-crystallization from top parts of crystals grown from additionally purified tungsten, starting.
3. Other activities on  $\text{Gd}_2\text{SiO}_5(\text{Ce})$ ,  $\text{CdWO}_4$  depleted in  $^{113}\text{Cd}$ , **barium** containing crystals in progress



## and in DAMA/CRYSTAL

- 1)  $\beta\beta$  decay of  $^{106}\text{Cd}$  investigation with  $^{106}\text{CdWO}_4$  scintillator (enriched in  $^{106}\text{Cd}$  at 66%) in coincidence with two large  $\text{CdWO}_4$  detectors in closed geometry **continues its data taking**  
After **15123 h**, the sensitivity to  $2\nu\epsilon\beta^+$  is at level of  **$T_{1/2} > 4 \times 10^{21}$  yr** (theoretical predictions:  $10^{21}$  -  $10^{22}$  y).

2) R&D of higher quality  $^{\text{arch}}\text{PbWO}_4$  light guide by double crystallization from highly purified archaeological lead on-going

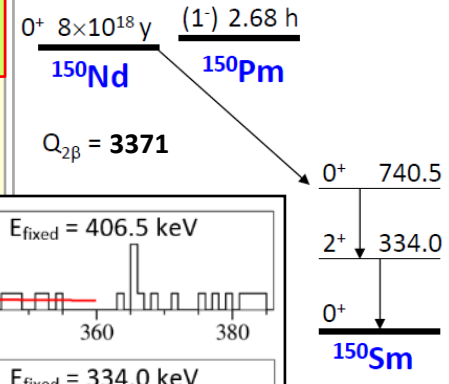
- 3) At completion of the present rearrangement, the DAMA/CRYSTAL setup moved in the ground floor of DAMA/LXe (dismounted in 2018) site in order to:
  - operate it more suitably
  - install the already built cryogenic part



# and in DAMA/Ge and STELLA facility@LNGS

## GeMulti (4 HPGe ~220 cm<sup>3</sup> each)

**PRELIMINARY**



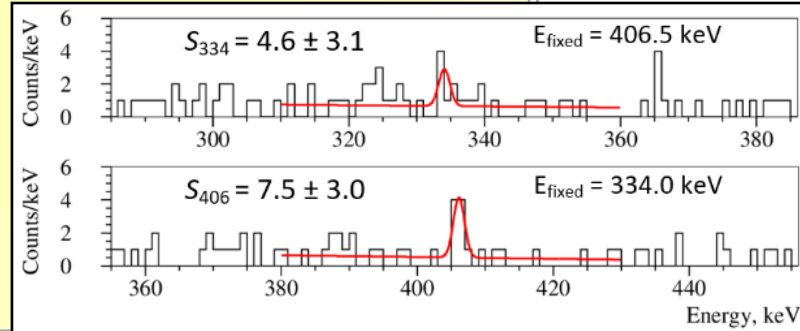
An experiment with highly purified Nd<sub>2</sub>O<sub>3</sub> sample (2.38 kg) to investigate the 2β decay of <sup>150</sup>Nd to the first 0<sup>+</sup> 740.5 keV excited level of <sup>150</sup>Sm is running from **25947 h**

⇒ Gamma quanta with energies **334.0 keV** and **406.5 keV** **are observed** in the data collected in coincidences between two HPGe detectors;

⇒ The half-life:  $T_{1/2} = [6.9^{+4.0}_{-1.9}(\text{stat}) \pm 1.1(\text{syst.})] \times 10^{19} \text{ yr}$  is in agreement with previous results.

A paper describing preliminary results was **published**

The experiment **is running** to improve  $T_{1/2}$  accuracy



**BEGe:** Experiment with 118g of ultrapure osmium to study rare α decay of <sup>184</sup>Os and <sup>186</sup>Os to the first excited levels of daughter nuclei, and ββ decays of <sup>184</sup>Os and <sup>192</sup>Os **is in progress**

⇒ A first paper is under completion;

⇒ The experiment is now running with the osmium sample placed directly inside the cryostat of the BEGe detector to improve the detection efficiency and sensitivity.

**GEMPI3:** Radioactive contaminations of a BaWO<sub>4</sub> crystal scintillator have been measured and the results **published**.

**GeCris:** Measurements of highly purified erbium, ytterbium and samarium oxide samples have been prepared/carried out to search for ββ decays in Er, Yb and Sm isotopes

- First results on the search for ββ decays of <sup>162</sup>Er and <sup>170</sup>Er were **published**;
- A first paper on results obtained with Yb sample **accepted for publication**.

## and other activities

- Preliminary results on half-life measurements of <sup>212</sup>Po with thorium-loaded liquid scintillator **published**; in progress
- R&D of SrI<sub>2</sub>(Eu) scintillators to search for 2β decay of Sr in progress
- Further measurements of anisotropy for low energy nuclear recoils in ZnWO<sub>4</sub> on-going; preliminary data at conf.

## Preventivi 2020 - Roma Tor Vergata

Addazi A.	Prof. straniero	40%	
Belli P.	Dirig. di Ric.	100%	
Bernabei R.	P.O.	100%	
Cerulli R.	Ric.	70%	Resp. Locale
Di Marco A.	doc.	100%	
Ferrari N.	dott.	100%	
Ghorui S. K.	ric. straniero	100%	
Merlo V.	RU	80%	
Montecchia F.	E.P.	100%	

**FTE: 7.9**

Bussolotti A.	Coll. Tec.	100%
Genovese P.	Tecn. C	30%
Iannilli M.	Tecn. B	30%

**FTE: 1.6**

**FTE/TOT=0.9**

	parziale	totale
<b>Missioni:</b> <ul style="list-style-type: none"> <li>Missioni a LNGS; contatti scientifici, conferenze, contatti con ditte nazionali ed estere, riunioni con collaboratori stranieri, ...</li> </ul>	50	50
<b>Consumo:</b> <ul style="list-style-type: none"> <li>Metabolismo apparati</li> <li>--phase3 30 partitori di bassa radiattività con pre-amp x PMT Hamamatsu R11065-20 MOD</li> <li>--phase3 cavi di bassa radioattività, connessioni e cablaggi per phase3</li> </ul>	18 25 15	58
<b>Altro Consumo:</b> <ul style="list-style-type: none"> <li>Gas N2 IP</li> <li>Crescita cristalli di varia natura a bassa radioattività intrinseca, processi di ricristallizzazione e isotopi arricchiti per campioni e per cristalli</li> </ul>	28 22	50
<b>Manutenzione:</b> <ul style="list-style-type: none"> <li>Manutenzione server per calcolo e primo storage, manutenzione cpu daq, manutenzione ups e condizionatori siti sperimentali</li> </ul>	6	6
<b>Inventario:</b> <ul style="list-style-type: none"> <li>2 Moduli alimentazione lineare per premp.</li> <li>--phase3 8 ULB PMT Hamamatsu R11065-20 MOD di nuova concezione da RD</li> <li>--phase3 1 digitizzatore CAEN VME VX1730</li> </ul>	5 56 16	77
<b>Totale</b>		<b>241</b>

### Lista delle voci di inventario

- 1 digitizzatore VX1730B - 16 Ch. 14 bit 500 MS/s 5.12MS/ch : 12.4 k€ +IVA
- 1 DPP-ZLE - Digital Pulse Processing Zero Length Encoding for (16ch x 730) : 1050 € + IVA

### Nota:

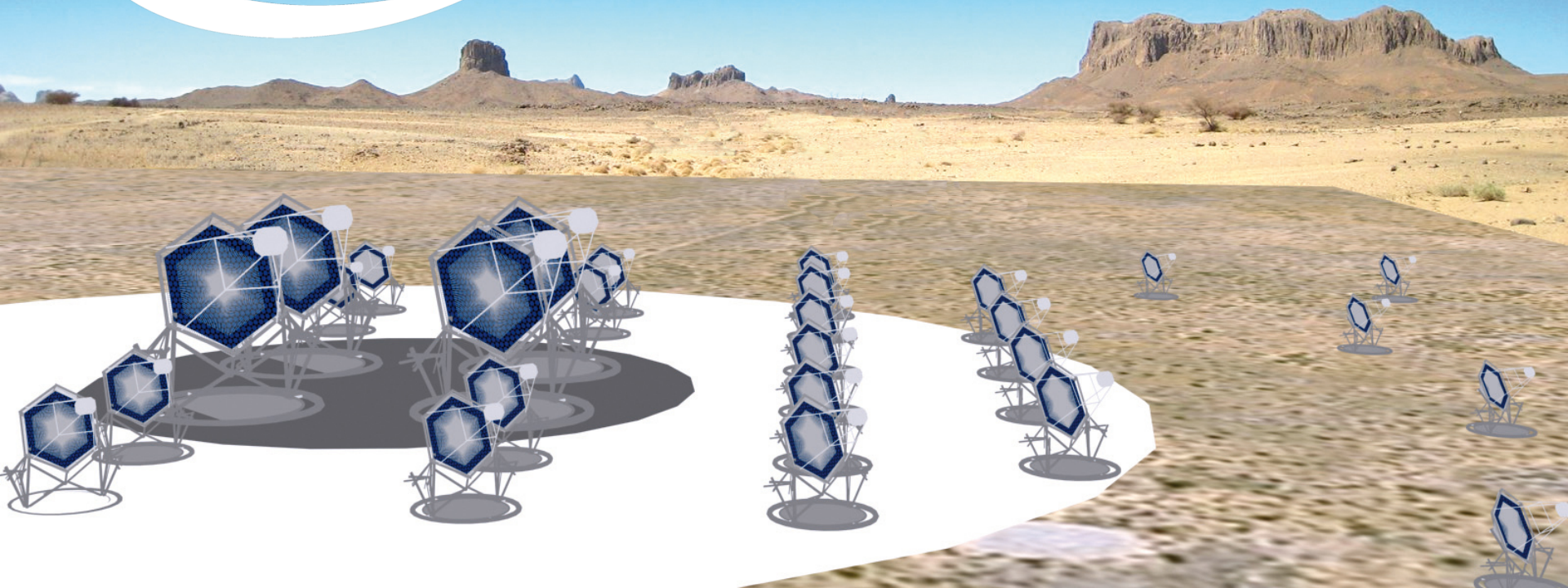
- maintenance: 129 k€
- phase3: 112 k€

# CTA Cherenkov Telescope Array Roma Tor Vergata

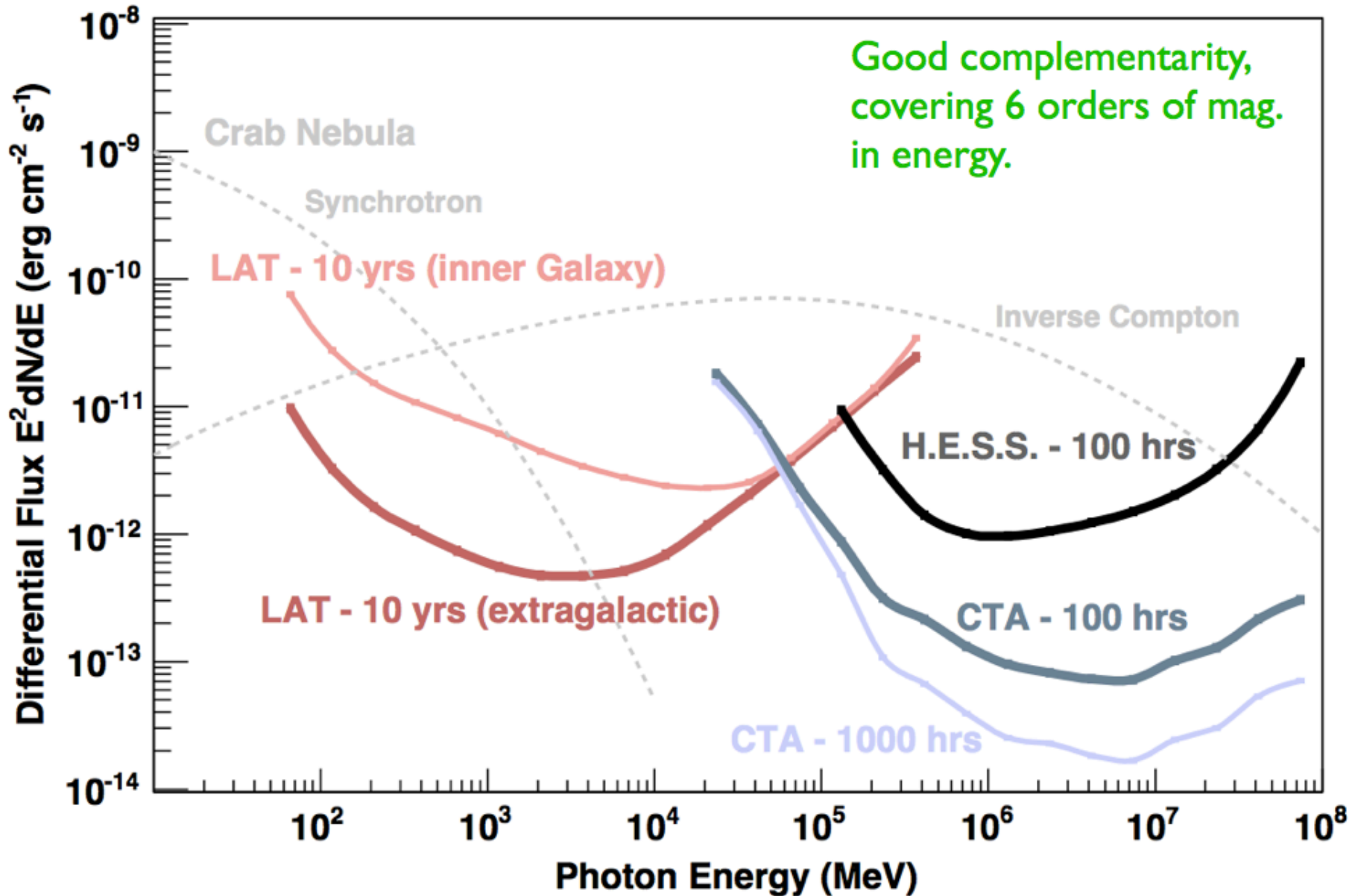
The future in  
VHE gamma ray  
astrophysics:



World-wide Collaboration  
31 countries  
132 institutes  
>1000 scientists



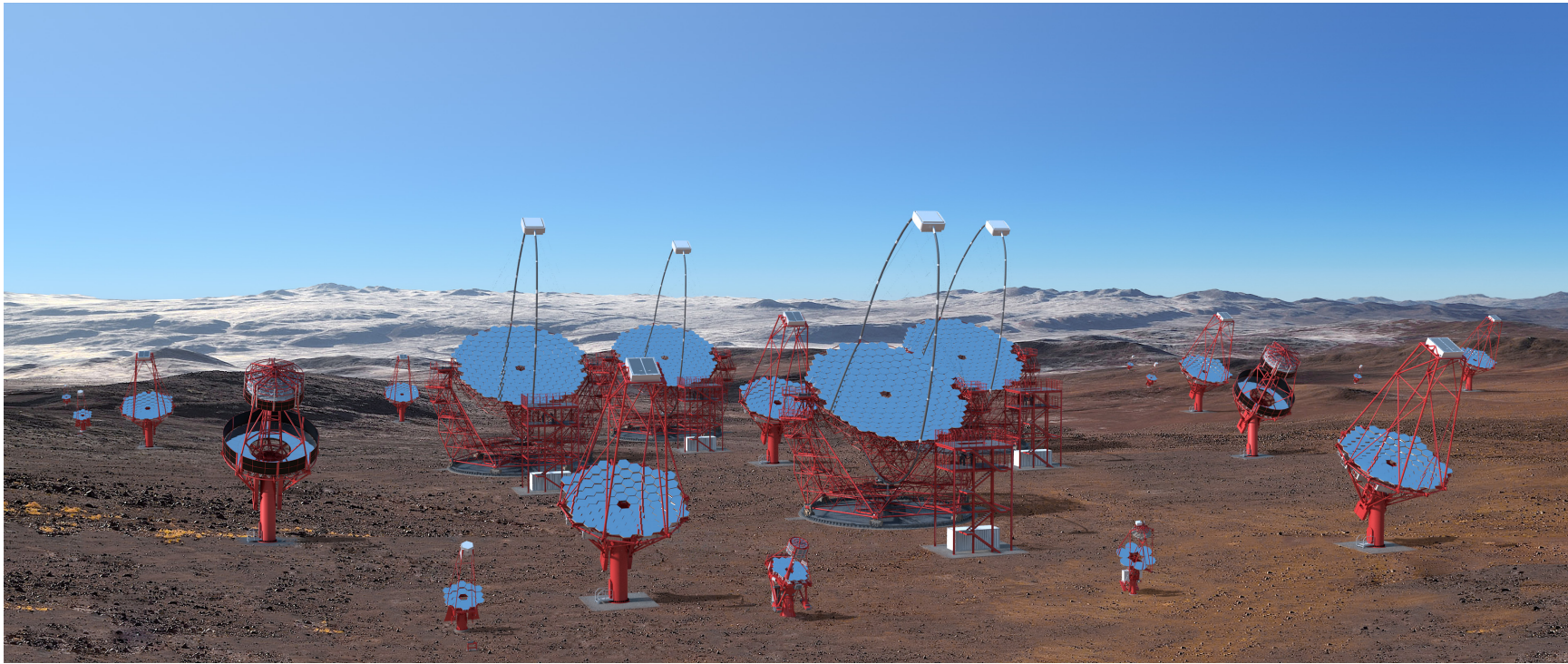
# CTA and Fermi





# Final Agreements Signed for CTA's Southern Hemisphere Site in Chile

Santiago, Chile – On 19 December 2018, the Cherenkov Telescope Array Observatory (CTAO) and the European Southern Observatory (ESO) signed the final agreements needed for CTA's [southern hemisphere array](#) to be hosted near ESO's Paranal Observatory in Chile. Construction on both the northern and southern arrays is expected to begin in 2020.



Rendering of the South Site



inaugurazione del primo Large Area Telescope (LST) di CTA il 10 Oct.2018 a La Palma





# Alcune pubblicazioni nel 2018-2019

- **Monte Carlo studies for the optimisation of the Cherenkov Telescope Array layout**  
the CTA Consortium, [Astroparticle Physics 111 \(Sept.2019\) pp.35-53 \[arXiv:1904.01426\]](#)
- **Science with the Cherenkov Telescope Array**  
the CTA Consortium, [World Scientific, https://doi.org/10.1142/10986 \[arXiv:1709.07997\]](#)
- **Search for annihilating Dark Matter towards dwarf galaxies with the Cherenkov Telescope Array**  
the CTA Consortium, in preparation, contact authors:A. Morselli, G. Rodríguez, M.Doro, G.Saturni

[talks:](#)

## **The Dark Matter Programme of the Cherenkov Telescope Array**

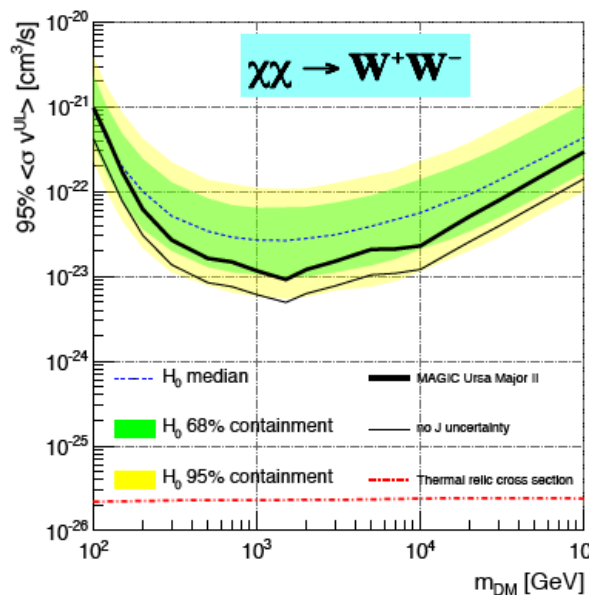
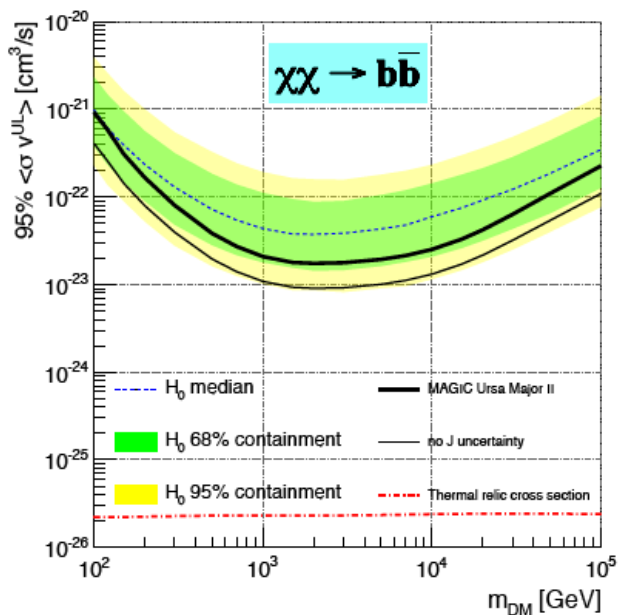
A. Morselli, MAGIC Dark Matter Workshop 16-17 January 2019 Barcelona

## **Gamma-rays signature of dark matter in the CTA era: status and prospects**

A. Morselli, 2nd World Summit: Exploring the Dark Side of the Universe, 25-29 June 2018

# DM Search with MAGIC

- Dwarf Spheroidal galaxies: most Dark Matter dominated structures in the Universe
- Reduced gamma-ray contamination of astrophysical origin (no star formation)
- Ideal for Dark Matter Annihilation searches
- Study of different astrophysical sources to minimize uncertainty in the J-factors
- multi-year project for the Dark Matter search from Dwarf Spheroidal Galaxies
- 2019 observation of current target (undisclosed) completed
- Data analysis ongoing
- Results soon ..



Results of the observation of Ursa Majoris II one of the target of the multi-year observational project, published as JCAP 03 (2018) 009

## Attivita' a Roma Tor Vergata nel 2019

- Sviluppo di software d'analisi basato su gammalib per ottenere la sensitivity di CTA alla dark matter attesa nelle dwarf spheroidal galaxies.
- Partecipazione ai gruppi di simulazione e dei key project di fisica
- Test di varie schede White Rabbit:
  - CTA Zen sviluppata da Grappa, Amsterdam
  - Ticks sviluppata da APC, Parigi.
  - FMC Cards & Zen Board della Seven Solution
- Sviluppo software per monitorare lo stato di sincronizzazione delle schede white rabbit.
- Modifiche del software SWAT per trasmettere i package UDP delle schede APC di sincronizzazione di tempo.

## Attivita' previste a Roma Tor Vergata per il 2020

- Partecipazione ai gruppi di simulazione e dei key project di fisica ( in particolare sulla Materia Oscura,)
- Sviluppo software usando il framework gammalib e gammapy per lo studio della dark matter nelle dwarf spheroidal galaxies.
- Studio del sistema multitrigger e sincronizzazione tramite la stazione di test White Rabbit installata a Tor Vergata per CTA in collaborazione con INAF. Varie schede White Rabbit in test:  
(CTA Zen sviluppata da Grappa, Amsterdam, Ticks sviluppata da APC,Parigi, FMC Cards & Zen Board della Seven Solution)
- Shift di Commissioning di LST
- Sviluppo del software di data reduction e data analysis per LST
- Attivita' su MAGIC Ricerca di Materia Oscura con MAGIC
- Follow up di Neutrini e GRB con MAGIC

# Preventivo locale di spesa CTA-Rd Roma Tor Vergata per l'anno 2020

Riunioni collaborazione	7
partecipazione ai meeting analisi italiani MC, Dark Matter	3.5
partecipazioni ai working group internazionali su MC, Dark Matter	2
partecipazioni al working group internazionale sul trigger multitelescopi	3
Partecipazione a Conferenze internazionali	3.5
Turno presa dati LST 2 settimane	2.5
	_____ Tot MI 21.5
consumo	
materiale di consumo da utilizzare per la continuazione del montaggio della stazione di test per il White Rabbit e simulatore della camera	
	_____ Tot Consumo 2
Inventario	
5 White Rabbit Zen board	2.5+ IVA
	_____ Tot Inventario 12.5
	<b>tot. 36.0</b>

# Preventivi CTA Italia 2020

## Composizione del Gruppo Roma Tor Vergata

Rappresentante Nazionale : N. Giglietto

Responsabile Locale : A.Morselli

Componenti del gruppo di ricerca

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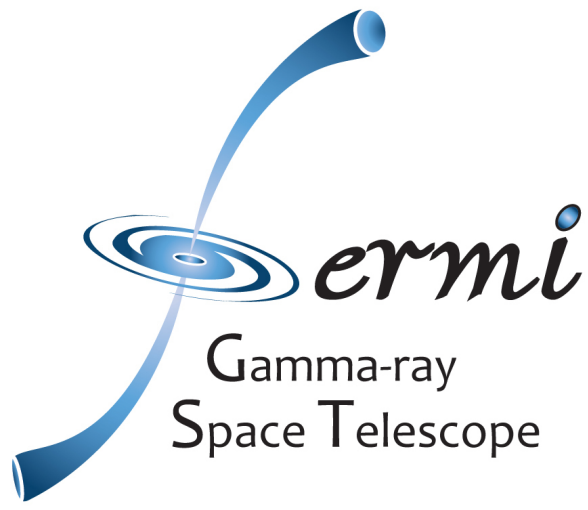
Morselli Aldo	I Ric.	50
Ammendola Roberto	Ric.	30
Antonelli Lucio Angelo	Ric.	40
Bigongiari Ciro	Ric.	40
Feroci Marco	DirRic.	30
Gasparrini Dario	Ric.	20
Lombardi Saverio	Ric.	40
Pittori Carlotta	Ric.	50
Salina Gaetano	I Ric.	20
Stamerra Antonio	Ric.	60
Vagnetti Fausto	P.A.	50
Verzi Valerio	Ric.	20
Vitale Vincenzo	Ric.	80

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Tot.Ric. **13** tot.FTE **5.3**

**FTE/Ric= 0.41**



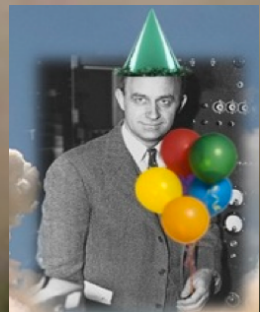


Responsabile Nazionale: Luca Latronico  
Responsabile Locale: Aldo Morselli



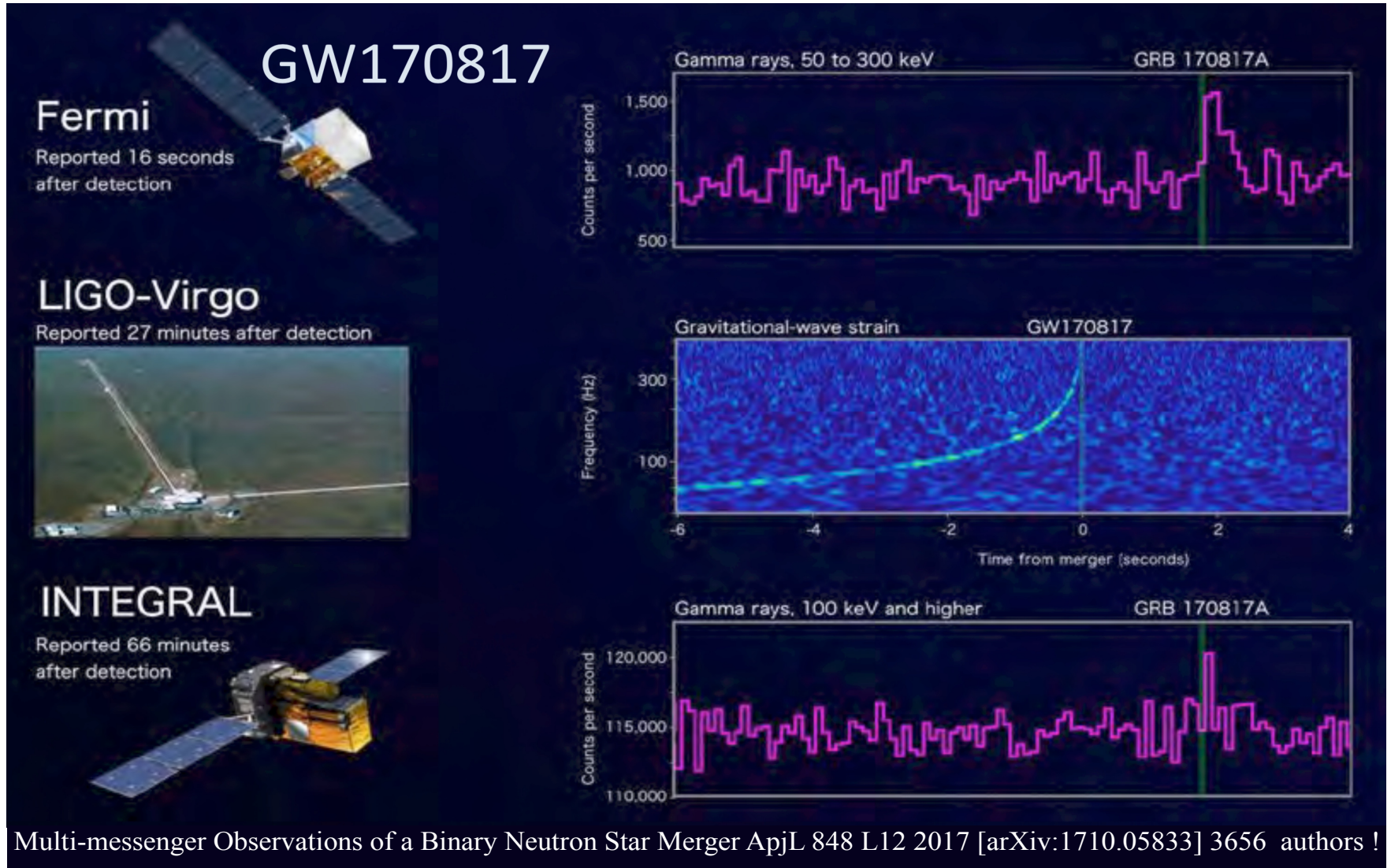
• **Happy 11<sup>th</sup> Birthday Fermi**

11 June 2008



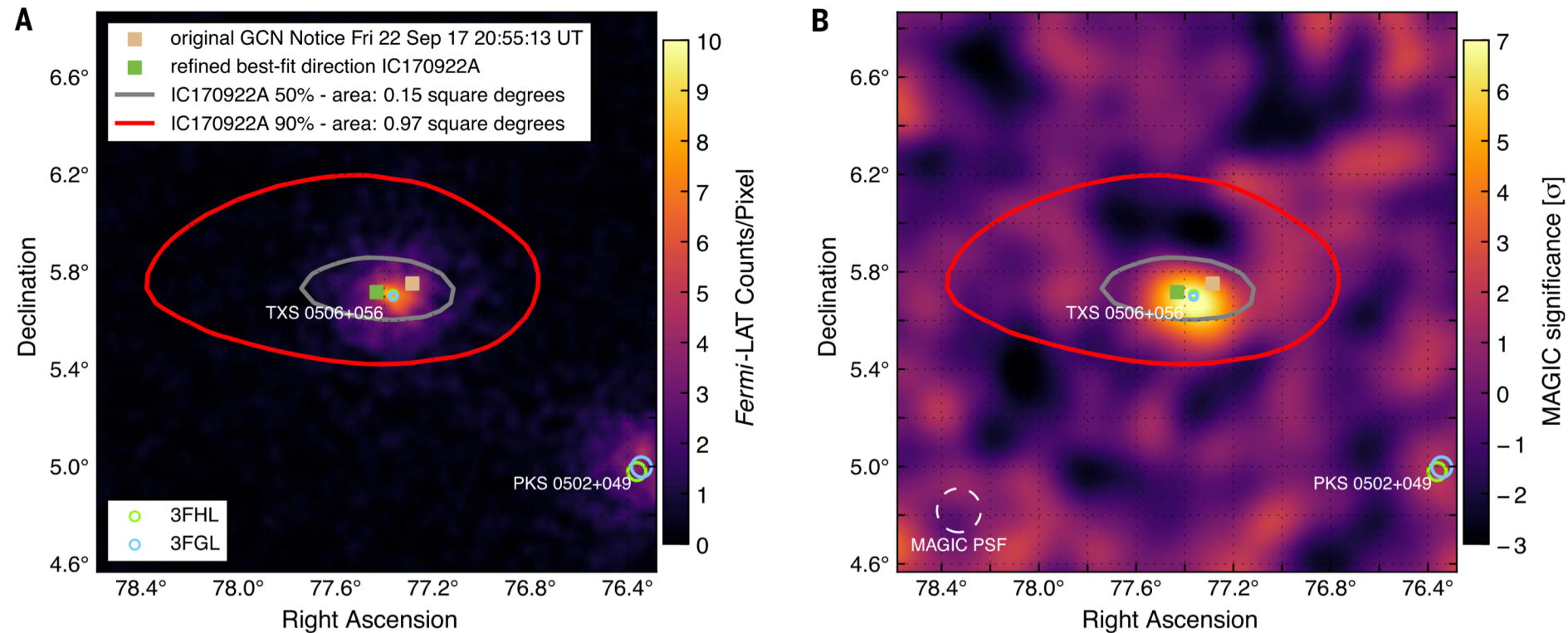
# Periodo estremamente interessante per Fermi

1) la rivelazione in gamma della controparte elettromagnetica delle onde gravitazionali



# Periodo estremamente interessante per Fermi

2) La rivelazione di gamma da una galassia Blazar in connessione con un neutrino di IceCube

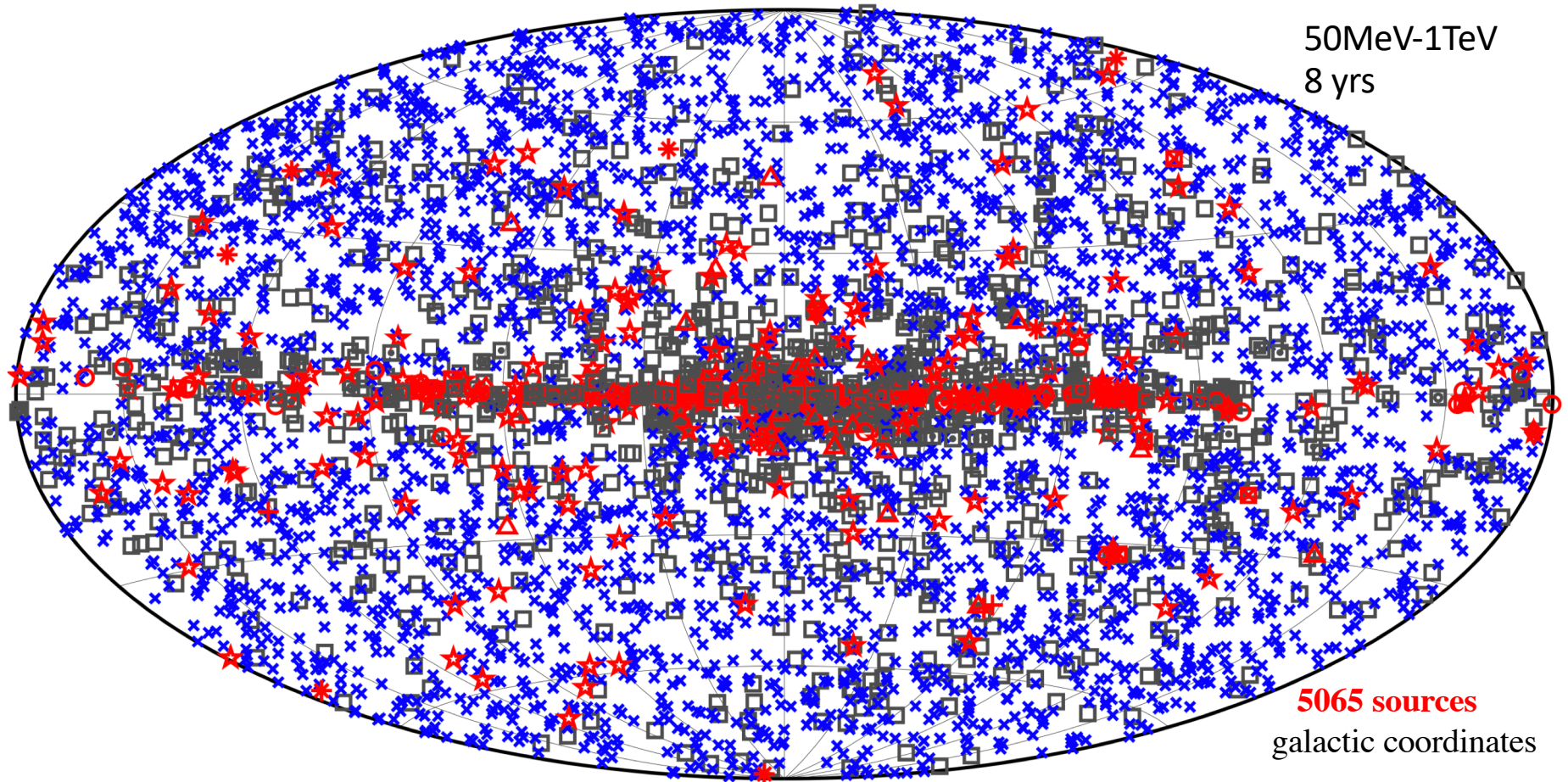


## Fermi-LAT and MAGIC observations of IceCube-170922A's location.

Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A  
The IceCube Collaboration, Fermi-LAT, MAGIC, AGILE, ASAS-SN, HAWC, H.E.S.S, INTEGRAL, Kanata, Kiso, Kapteyn, Liverpool Telescope, Subaru, Swift/NuSTAR, VERITAS, and VLA/17B-403 teams  
**Science 361, eaat1378 (2018) 12 July**

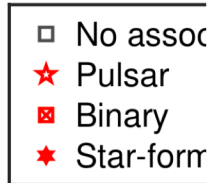
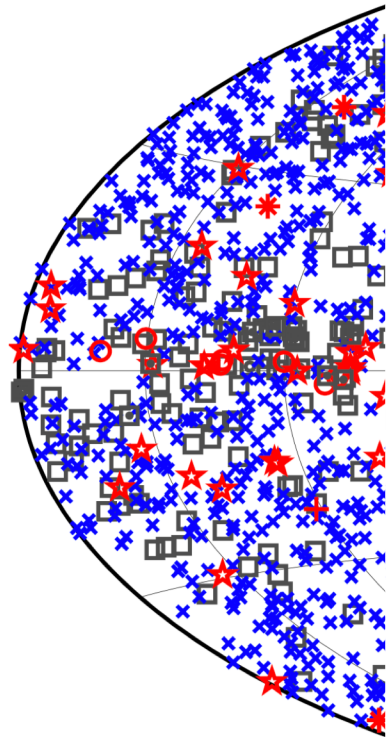


# Il quarto catalogo delle sorgenti di Fermi in arrivo



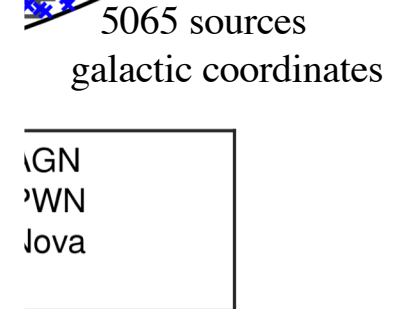
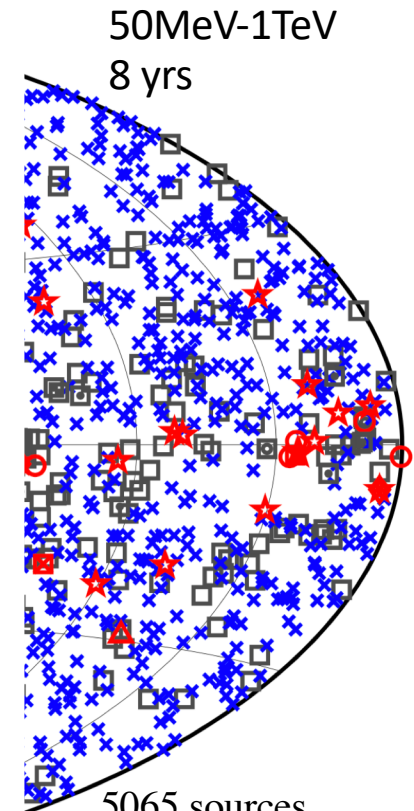
□ No association	▣ Possible association with SNR or PWN	× AGN
★ Pulsar	△ Globular cluster	* Starburst Galaxy
▣ Binary	+ Galaxy	○ SNR
★ Star-forming region	▣ Unclassified source	◆ PWN
		⊛ Nova

# The sky in gamma-rays 4<sup>th</sup> source catalog



Description	Identified		Associated	
	Designator	Number	Designator	Number
Pulsar, identified by pulsations	PSR	229	...	...
Pulsar, no pulsations seen in LAT yet	...	...	psr	10
Pulsar wind nebula	PWN	12	pwn	6
Supernova remnant	SNR	24	snr	16
Supernova remnant / Pulsar wind nebula	SPP	0	spp	90
Globular cluster	GLC	0	glc	30
Star-forming region	SFR	3	sfr	0
High-mass binary	HMB	5	hmb	3
Low-mass binary	LMB	1	lmb	1
Binary	BIN	1	bin	0
Nova	NOV	1	nov	0
BL Lac type of blazar	BLL	22	bll	1094
FSRQ type of blazar	FSRQ	42	fsrq	644
Radio galaxy	RDG	6	rdg	36
Non-blazar active galaxy	AGN	1	agn	17
Steep spectrum radio quasar	SSRQ	0	ssrq	2
Compact Steep Spectrum radio source	CSS	0	css	5
Blazar candidate of uncertain type	BCU	3	bcu	1327
Narrow line Seyfert 1	NLSY1	4	nlsy1	5
Seyfert galaxy	SEY	0	sey	1
Starburst galaxy	SBG	0	sbg	7
Normal galaxy (or part)	GAL	2	gal	2
Unknown	UNK	0	unk	92
Total	...	356	...	3388
Unassociated	...	...	...	1323

NOTE—The designation ‘spp’ indicates potential association with SNR or PWN. Designations shown in capital letters are firm identifications; lower case letters indicate associations.



50MeV-1TeV  
8 yrs

5065 sources  
galactic coordinates



# Altri risultati scientifici nel 2019

- A decade of Gamma-Ray Bursts observed by Fermi-LAT  
[The Astrophysical Journal, 878:52 2019 \[arXiv:1906.11403\]](#)
- MAGIC and Fermi-LAT gamma-ray results on unassociated HAWC sources  
[MNRAS 2018 485, Issue 1, 1 May 2019 \[arXiv:1901.03982\]](#)
- The Search for Spatial Extension in High-latitude Sources Detected by the Fermi Large Area Telescope  
[The Astrophysical Journal Supplement Series, 237, 32, \(2018\) \[arXiv:1804.08035\]](#)
- Investigating the Nature of Late-time High-energy GRB Emission through Joint Fermi/Swift Observations  
[The Astrophysical Journal 863:138 2018 \[arXiv:1808.01683\]](#)
- Unresolved gamma-ray sky through its angular power spectrum  
[Phys. Rev. Lett. 121, 241101 \(2018\) \[arXiv:1812.02079\]](#)
- Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A  
[Science 361, eaat1378 \(2018\)](#)

(Tutte le pubblicazioni su : [http://people.roma2.infn.it/~glast/Glast\\_Pub.html](http://people.roma2.infn.it/~glast/Glast_Pub.html) )

# ATTIVITA' PREVISTA PER L'ANNO 2020

- **Dark Matter:**

- update analisi Dwarf Spheroidal Galaxy con nuovi target
- DM Catalog

- **Transienti**

- Turni settimanali Flare Advocate Gamma-ray Sky Watcher (FA-GSW) e Data Quality Monitor (DQM).
- Partecipazione a updates e sviluppo software per attività di follow-up sui dati Fermi LAT relativi agli alert di rivelazione di VHE (TeV, PeV) neutrini cosmici rilevati da IceCube e Antares.

- **AGN**

- Aggiornamento del catalogo Fermi 4th LAT AGN Catalog (4LAC) ed implementazione pagine web e tabelle interattiva del catalogo presso SSDC-ASI
- Aggiornamento del metodo statistico (likelihood ratio method) di associazione di controparti radio, ottiche e X-ray (survey all-sky) per sorgenti gamma di tipo extragalattico
- Mantenimento e aggiornamento del tool Fermi Online Data Analysis (FODA)

- **Multimessenger**

organizzazione campagne osservative Fermi e multi-frequenza

# Preventivi Fermi 2019

# Componenti del gruppo di ricerca

Rappresentante Nazionale : L.Latronico%

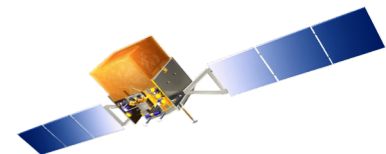
Responsabile Locale : A.Morselli

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Morselli Aldo	I Ric.	II	50
Angioni Roberto	Ass.Ric.	II	100 (da Ottobre 2019)
Antonelli Lucio Angelo	Ric.	II	40
Ciprini Stefano	Ric.	II	50
Gasparrini Dario	Ric.	II	50
Pittori Carlotta	Ric.	II	50
Vagnetti Fausto	P.A.	II	50

---

**Tot.Ric. 7   tot FTE 3.9   FTE/Ric= 0.56**



# Preventivo locale di spesa Fermi Roma Tor Vergata per l'anno 2019

2 riunioni di collaborazione internazionale USA	6	
Meeting analisi USA	6	
Meeting analisi italia	2	
riunioni gruppo Dark Matter	2	
Partecipazione a Conferenze internazionali	5	
<hr/>		Tot MI 21
consumo		
riparazione Workstation	1	
		Tot Consumo 1
Inventario		
2 Workstation per due nuovi ricercatori	5	
		Tot Inventario 5

**tot. 21.5 KE**



# GAPS: General AntiParticle Spectrometer

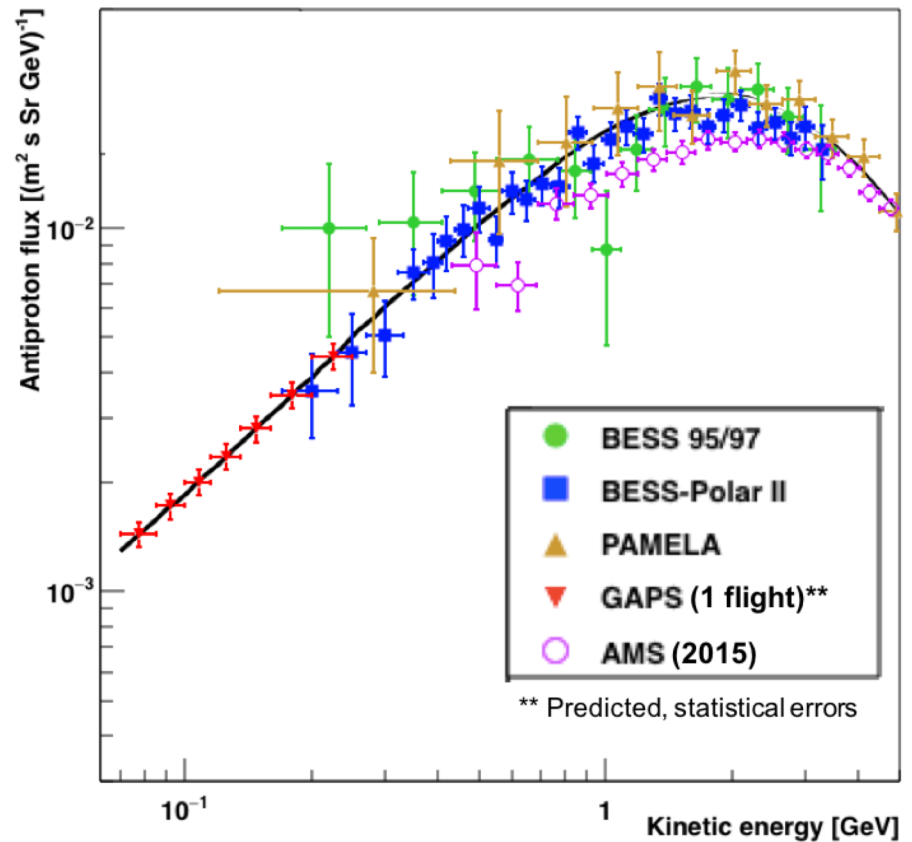
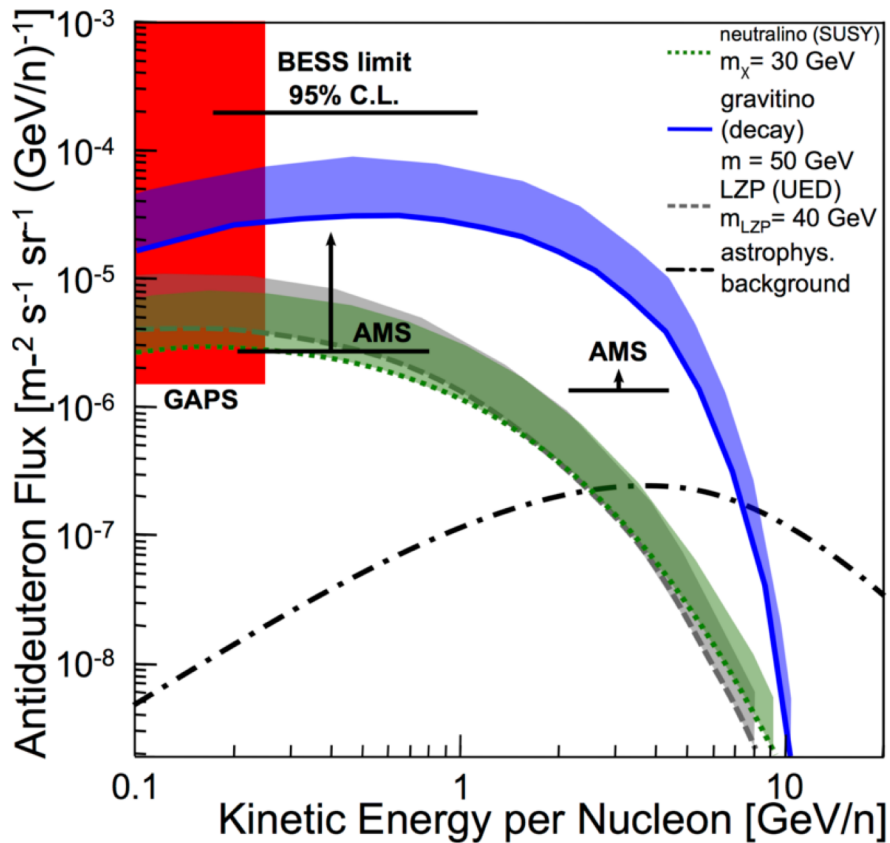
R. Sparvoli



# Obiettivi scientifici

- L'esperimento GAPS (General AntiParticle Spectrometer) è stato progettato per studiare la **componente di antiparticelle nei raggi cosmici con un focus specifico su antiprotoni ed antideuterio (ed antielio) di bassa energia (< 0.25 GeV/n)**.
- L'identificazione per la prima volta di antideuterio nei raggi cosmici sarebbe **un segnale quasi certo di nuova fisica** esplorando tutta una gamma di modelli teorici di materia oscura.
- Questo perché la produzione secondaria di antideuterio (ed antielio) da interazione di raggi cosmici col mezzo interstellare è **significativamente soppressa alle basse energie (sotto circa 1 GeV/n)** rispetto a quanto previsto da molti modelli plausibili di materia oscura.

# Sensibilità all'anti deuterio e all'antiprotone



35-day GAPS flights and five years of AMS-02 operation

# GAPS science summary

- **Antideuterons as DM signatures**
  - **no astrophysical background** at low energy
  - **complementary** to direct/indirect searches and collider experiments
  - search for: **light DM**, heavy DM, gravitino DM,  
LZP in extra-dimensions theories, (evaporating PBH)
- **Antiprotons as DM and PBH signatures**
  - precision flux measurement at ultra-low energy ( $E < 0.25$  GeV)
  - **complimentary** to direct/indirect searches and collider experiments
  - **~ 10 times more statistics @ 0.2 GeV**, compared to BESS/PAMELA
  - search for: **light DM** gravitino DM,  
LZP in extra-dimensions theories, evaporating PBH
- *Expected to launch from Antarctica in* **2021-22**

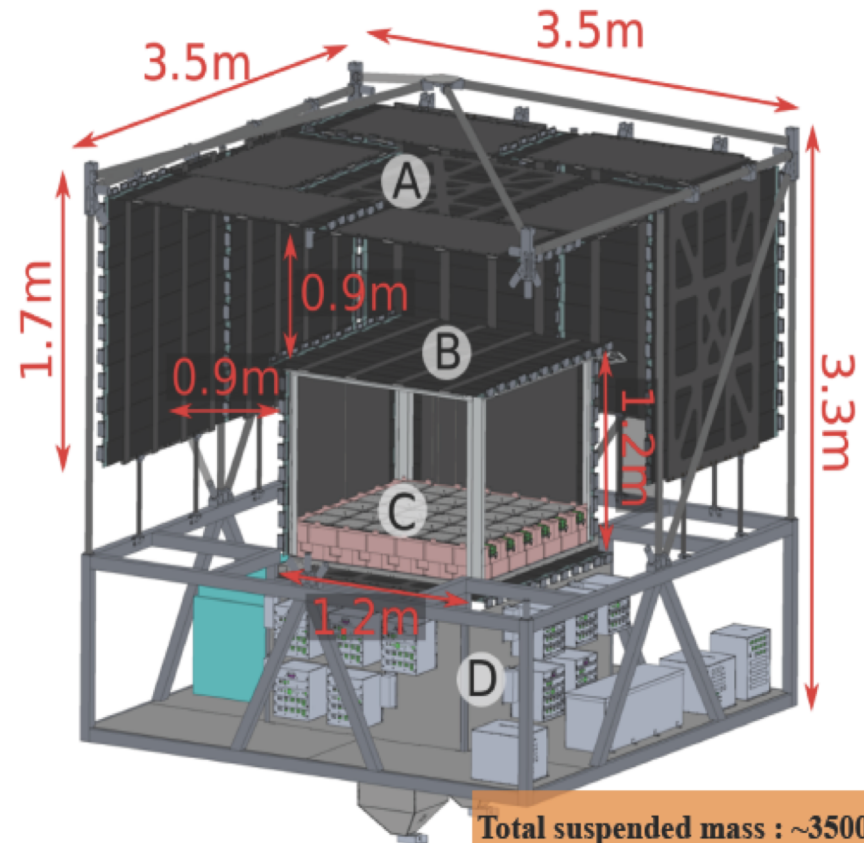
- **1 LDB flight (~35 days) -> precision antiproton flux measurement**  
~1500 antiprotons in GAPS  $E < 0.25$  GeV, while 30 for BESS, 7 for PAMELA at  $E \sim 0.25$  GeV
- **2 LDB flights (~70 days) -> improved antideuteron statistics**  
Antideuteron sensitivity:  $\sim 3.0 \times 10^{-6} [m^{-2} s^{-1} sr^{-1} (GeV/n)^{-1}]$  at  $E < 0.25$  GeV
- **3 LDB flights (~105 days) -> Antideuteron sensitivity:  $\sim 2.0 \times 10^{-6} [m^{-2} s^{-1} sr^{-1} (GeV/n)^{-1}]$  at  $E < 0.25$  GeV**

❑ The detector consists of 2 instruments.

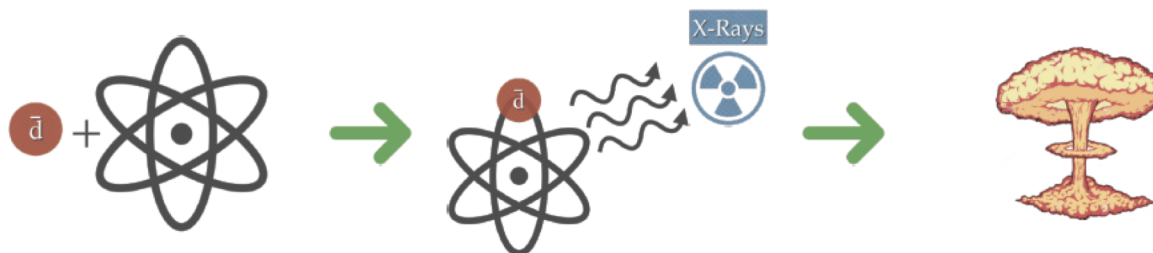
- Si(Li) Tracker (C):
  - 10 layers of 144 10 cm-diameter Si(Li) detectors.
  - Stops primary, detects X-rays, tracks secondaries
- Time-Of-Flight (A, B):
  - Two layers of plastic scintillator paddles providing near 100% coverage.
  - Characterizes primary, counts secondaries, provides trigger

❑ In addition:

- Cooling, power & thermal insulation (not shown)
- Support systems (D)



Total suspended mass : ~3500 kg  
Total power generated : ~1.5 kW



# Collaborazione INFN

- La collaborazione GAPS ha chiesto la partecipazione INFN in quanto ritiene che aumenti sia la credibilità scientifica (impatto internazionale dell'INFN ed il nostro successo con PAMELA) che finanziaria (nel loro budget manpower specializzato, come ingegneri elettronici, conta molto).
- L'INFN contribuisce alla realizzazione degli ASIC per il DAQ dei rivelatori al silicio. A questa attività partecipano INFN TS e Università Bergamo. Napoli contribuisce all'HV.
- L'INFN partecipa allo sviluppo del software di simulazione e di analisi dei dati così pure all'interpretazione degli stessi: INFN TS e INFN FI, Università di Torino e di **Tor Vergata**.

Iniziato un contratto ASI-INFN, di circa € 2.2 Keuro. La partecipazione italiana cresce:

- ASIC di volo
- HV
- Contributo ad analisi dati e MC



# Analysis and Reconstruction



GEANT4 simulations for calculation of sensitivity and algorithm development.

Extensive testing of GEANT4 has identified a couple of improvements in the handling of antinuclei.

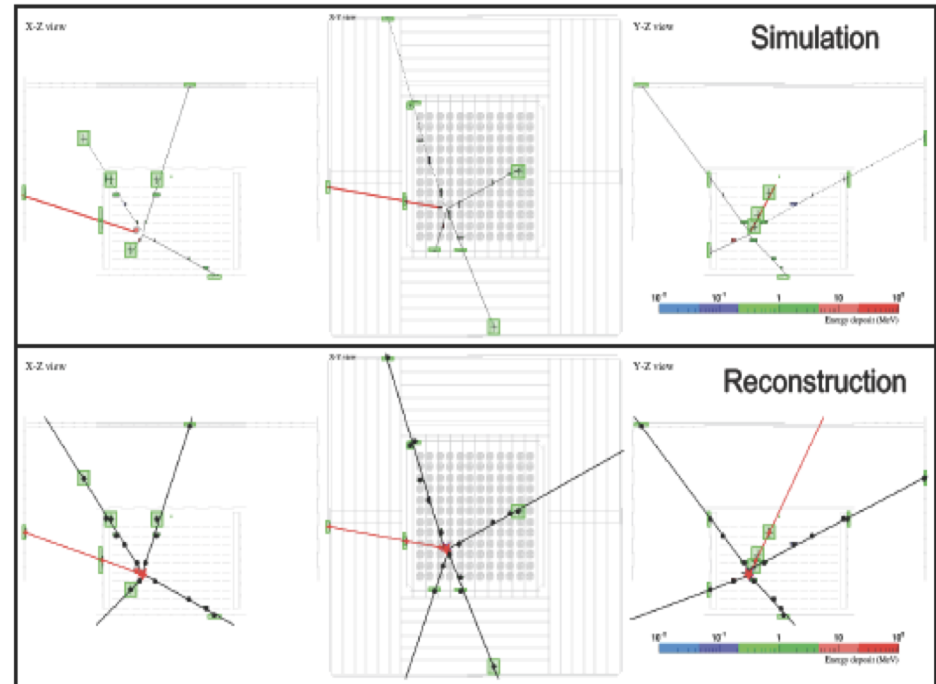
Results cross checked against beam test data (KEK 2004, *Aramaki+13*).

Analysis will require very high proton/antiproton, antiproton/antideuteron rejections.

Existing methods employing using only measured variables (number of TOF/tracker hits,  $dE/dx$ , ...) can reach antiproton/antideuteron rejection of  $10^5$ .

Additional variables from reconstruction and improved techniques will see further improvement.

Antideuteron,  $\beta = 0.54$



Reconstruction requires identification of tracks with unknown vertex.

Multiple techniques being developed to characterize primary and secondary tracks.

At  $> 60\%$  reconstruction efficiency, error on reconstructed position  $< 70\text{mm}$  (68% containment)

# Richieste finanziarie GAPS-TOV e anagrafica 2019

Missioni	15 k€
Totale	15 k€

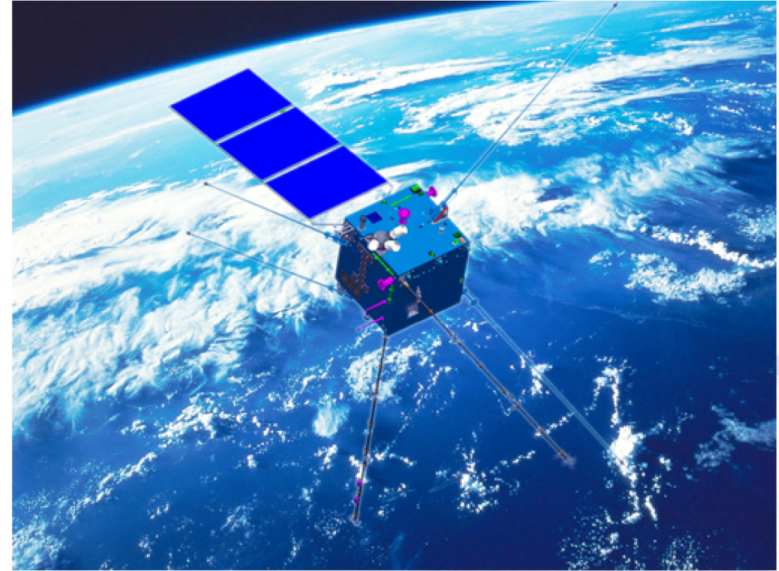
Ricercatori					
	Nome	Età	Contratto	Qualifica	%
1	<a href="#">Carfora Luca</a>		Associato	Dottorando	50
2	<a href="#">Marcelli Nadir</a>		Associato	Dottorando	100
3	<a href="#">Martucci Matteo</a>		Dipendente	Assegno di Ricerca	50
4	<a href="#">Merge' Matteo</a>		Associato	Assegnista	30
5	<a href="#">Sparvoli Roberta</a>		Associato	Prof. Associato	30
<b>Numero Totale Ricercatori</b>				5	FTE: 2.6



# L'esperimento CSES/LIMADOU

**Partecipazione italiana al satellite CSES (China Seismo Electromagnetic Satellite): sviluppo di strumentazione innovativa per la misura - dallo spazio - di perturbazioni magnetosferiche e la loro correlazione con fenomeni sismici.**

Finanziato da un progetto premiale ASI e da successivi contratti per l'avanzamento della missione.



Il contributo dell'Italia riguarda la realizzazione di uno tra gli strumenti scientifici più importanti a bordo di CSES: **un rivelatore di particelle energetiche, detto HEPD (High Energy Particle Detector).**

Ulteriore contributo è lo sviluppo del modello ingegneristico delle quattro sonde per la misura del campo elettrico (EFD), montate su appositi boom dispiegabili.

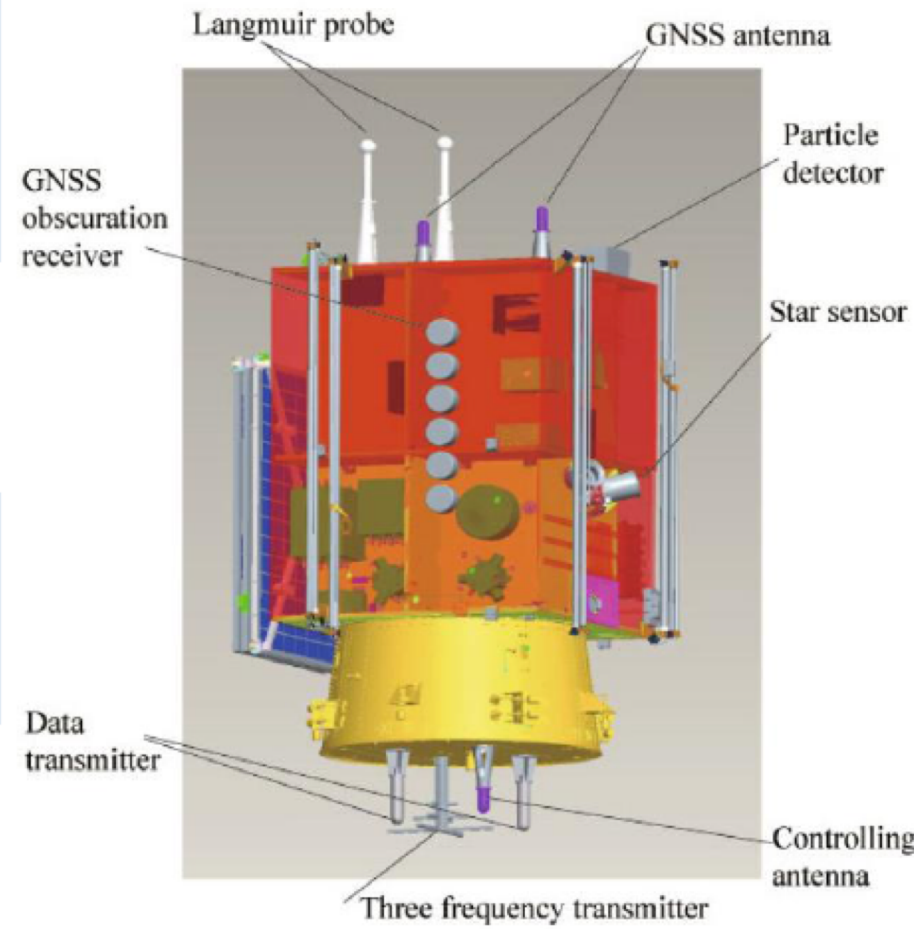
L'interesse della collaborazione italiana alla missione consiste nella **possibilità di sfruttare il volo di CSES per la misura di raggi cosmici di bassa energia (pochi MeV → centinaia di MeV), proseguendo un'indagine dei raggi cosmici che è iniziata 25 anni fa.**

# Instruments onboard CSES

## Measurements

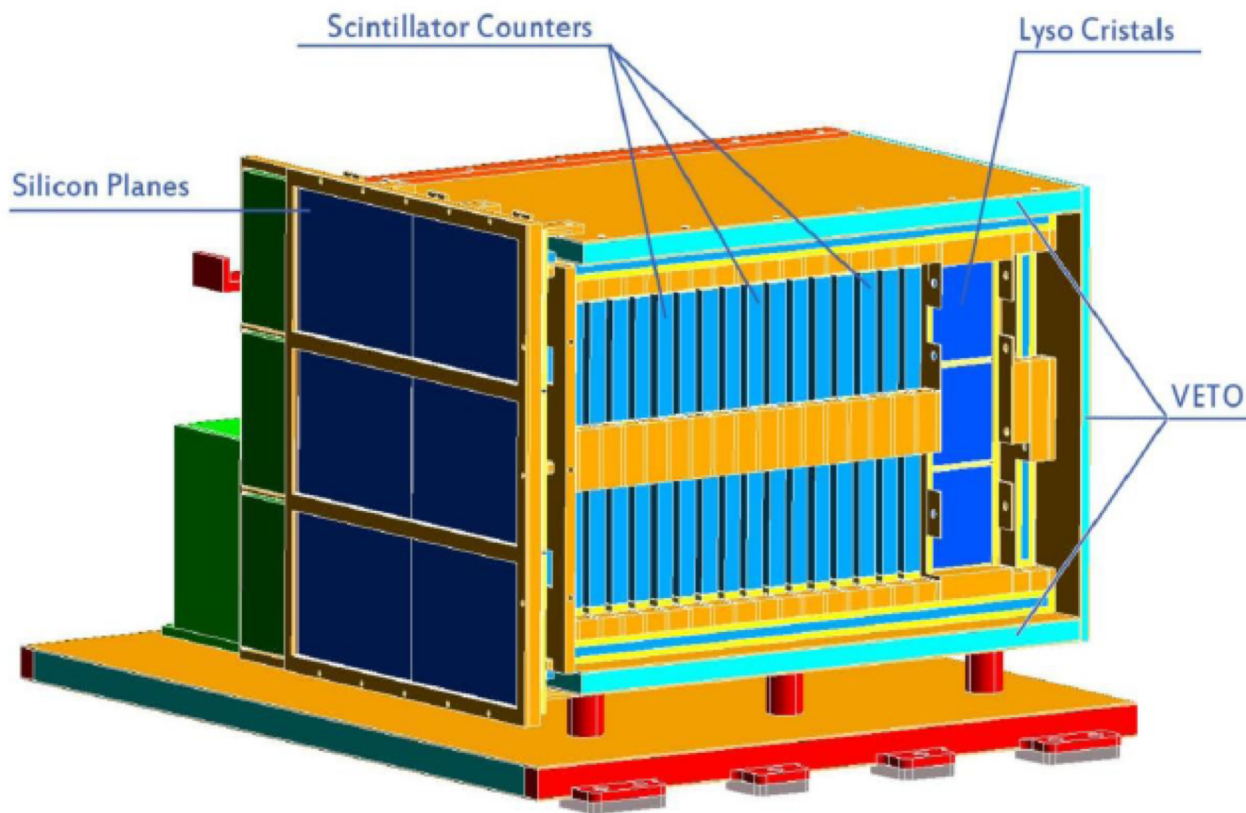
## Instruments

<p><b>S</b> Electrical and magnetic fields and their perturbations in ionosphere</p>	<p>Search-Coil magnetometer (<b>SCM</b>)                  Fluxgate magnetometer                  Electrical field detector (<b>EFD</b>)</p>
<p>Disturbance of plasma in ionosphere</p>	<p>Plasma analyzer (<b>PAP</b>)                  Langmuir probe (<b>LAP</b>)</p>
<p>Flux and energy spectrum of the particles in the radiation belts</p>	<p>High Energy Particle Package (<b>HEPP</b>)                  High Energy Particle Detector (<b>HEPD</b>)                  GPS occultation receiver (<b>GNSS-RO</b>)</p>
<p>Profile of electronic content</p>	<p>Tri-frequency transmitter (<b>TBB</b>)</p>



# The HEPD detector

7



**Silicon tracker:** two planes of double-side silicon micro-strip detectors placed on the top of the HEPD in order to provide the direction of the incident particle  
(213mm × 213mm × 0.3mm)

**Trigger:** a layer of thin plastic scintillator divided into six segments  
(200mm × 30mm × 5mm each)

**Calorimeter:** a tower of 16 layers of 1 cm thick plastic scintillator planes followed by a 3x3 matrix of inorganic scintillator (LYSO)

The calorimeter volume is surrounded by 5mm thick plastic scintillator planes: **VETO**

All the scintillator detectors (trigger, calorimeter and VETO) are read out by photomultiplier tubes (PMT R9880-210 from Hamamatsu)

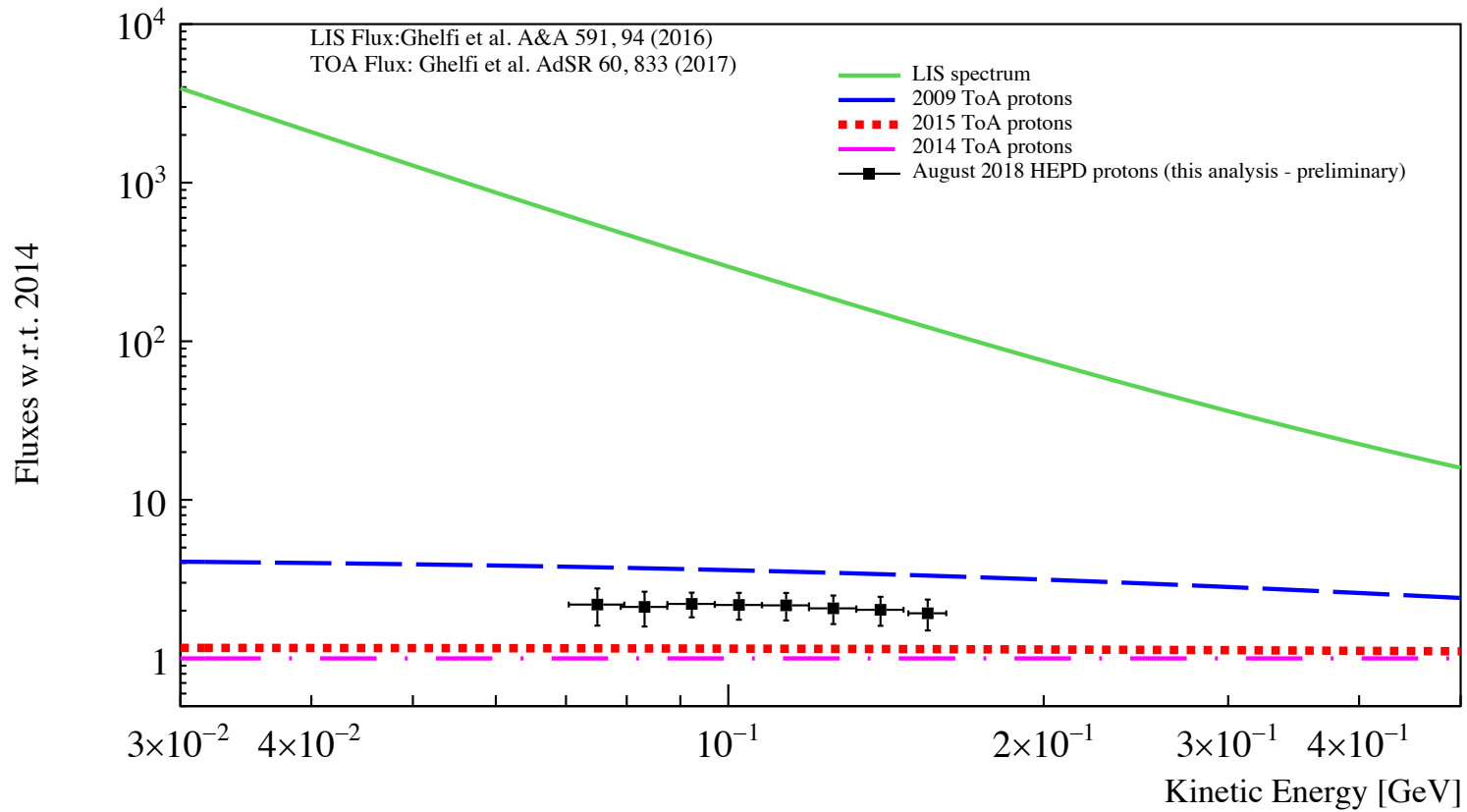


# LIMADOU: cose fatte nel 2018/19

On February 2<sup>nd</sup> 2018 at 3:15 pm (Beijing time, GMT+8) the CSES Satellite was successfully launched from Chinese base “Jiuquan Satellite Launch Center”, located in the Gobi desert in Inner Mongolia.



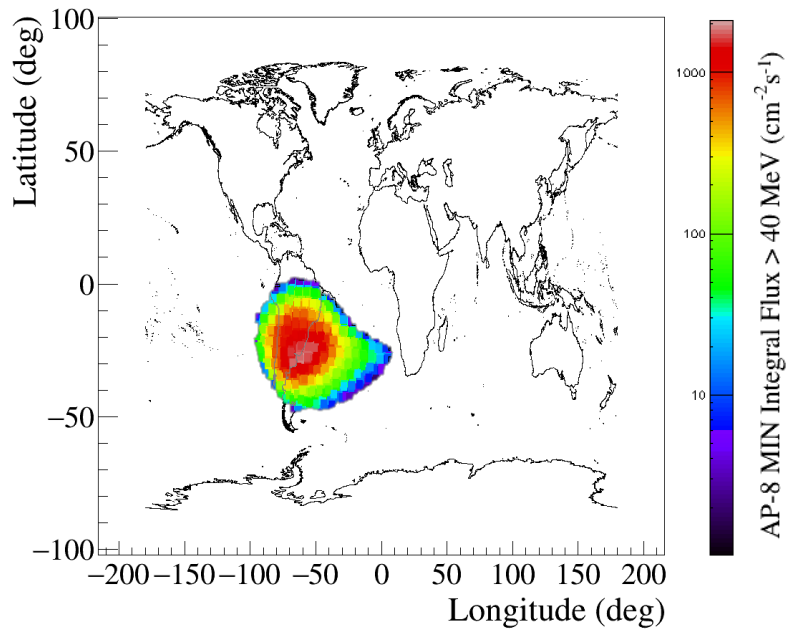
# Flusso preliminare di protoni galattici



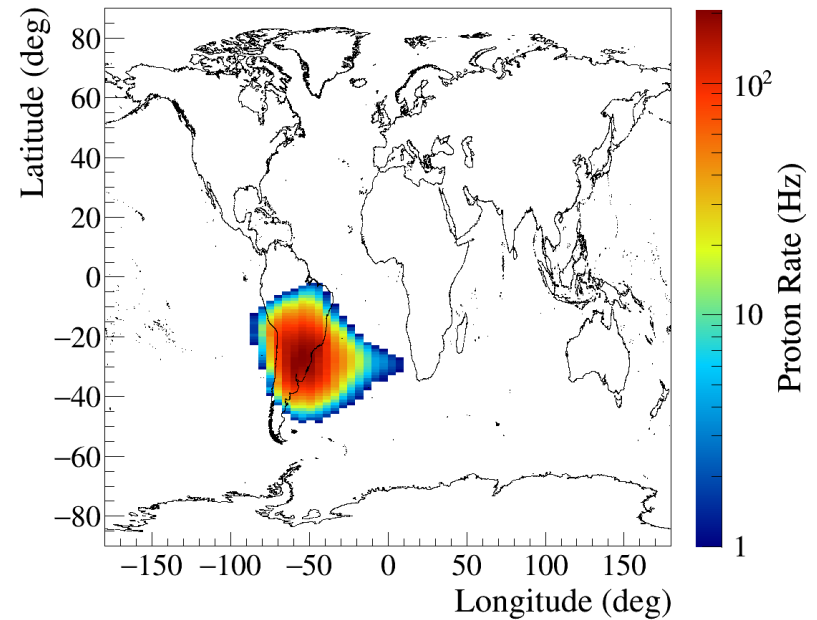


# Mappa di protoni intrappolati

SPENVIS Model



HEPD Data



# LIMADOU: cose FATTE nel 2018/19

- **Studio degli eventi di fisica di CSES-1 e beam test:**
  - Fase di **commissioning dopo lancio conclusa (Luglio 2018);**
  - **Prima analisi dei dati**
  - **1a importante pubblicazione su ApJS “In-orbit performance of the HEPD detector on board CSES”**
- **Studio di fattibilità di CSES-02**
  - Un primo contratto ASI iniziato;
  - Modifiche ed upgrade al calorimetro, al tracciatore, all’elettronica;
  - **MoU tra ASI e CSNA firmato → 24 LUGLIO TAVOLO NEGOZIALE ASI-INFN**

# LIMADOU: da fare nel 2019/20

- **Studio degli eventi di fisica di CSES-1 :**
  - Proseguire **l'analisi dei dati di HEPD**
  - Aumentare i contatti con i colleghi cinesi per analisi congiunte dei rivelatori italiani e cinesi.
  - Pubblicazioni e disseminazione a conferenze
- **Realizzazione di HEPD e EFD per CSES-02**
  - Modifiche ed upgrade al calorimetro, al tracciatore, all'elettronica;
  - Test su fascio dei prototipi;
  - Realizzazione del QM.

# Composizione del gruppo

## LIMADOU a ToV nel 2020 = 13.7 FTE

Ricercatori					
	Nome	Età	Contratto	Qualifica	%
1	Bartocci Simona		Dipendente	Collaboratore	100
2	Berrilli Francesco		Associato	Prof. Associato	30
3	Carfora Luca		Associato	Dottorando	50
4	Casolino Marco		Dipendente	Primo Ricercatore	20
5	Conti Livio		Associato	Ricercatore Universitario	30
6	De Donato Cinzia		Dipendente	Ricercatore	70
7	De Santis Cristian		Dipendente	Tecnologo	80
8	Fornaro Claudio		Associato	Ricercatore Universitario	30
9	Marcelli Laura		Dipendente	Tecnologo	70
10	Martucci Matteo		Dipendente	Assegno di Ricerca	50
11	Merge' Matteo		Associato	Assegnista	70
12	Palma Francesco		Associato	Borsista Post doct.	100
13	Parmentier Alexandra		Dipendente	Ricercatore	100
14	Picozza Piergiorgio		Associato	Prof. Ordinario	0
15	Piersanti Mirko		Dipendente	Ricercatore	100
16	Sotgiu Alessandro		Dipendente	Assegno di Ricerca	100
17	Sparvoli Roberta		Associato	Prof. Associato	60
18	Vitale Vincenzo		Dipendente	Ricercatore	20
<b>Numero Totale Ricercatori</b>				18	FTE: 10.8

Tecnologi					
	Nome	Età	Contratto	Qualifica	%
1	Badoni Davide		Dipendente	Tecnologo	50
2	Carpentiero Rita		Associato	Primo Tecnologo	100
3	De Persio Fulvio		Dipendente	Tecnologo	70
4	Masciantonio Giuseppe		Dipendente	Tecnologo	70
<b>Numero Totale Tecnologi</b>				4	FTE: 2.9

Tecnici					
	Nome	Età	Contratto	Qualifica	%
1	Cipollone Piero		Dipendente	Collaboratore Tecnico E.R.	60
<b>Numero Totale Tecnici</b>				1	FTE: 0.6



# Preventivi 2020 – LIMADOU TOV

Capitolo	Descrizione	Richiesta (Keuro)
MISSIONI	1. Riunioni analisi dati internazionale CSES-1	15
	2. Riunioni di analisi dati nazionali CSES-02	10
	3. Test del QM CSES-02 presso acceleratori	3
CONSUMO	1. Materiale di supporto per test su fascio	2
	2. Sviluppo tecnologico CSES-2	40
		<b>70 keuro</b>

# GRUPPO LISA

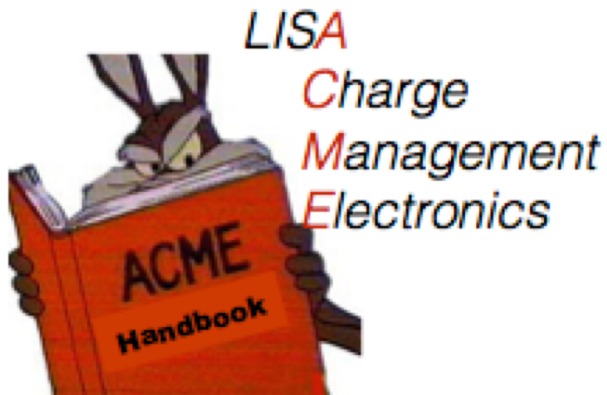


M.Bassan, F.De Persio, G.Masciantonio, Y. Minenkov  
P.Cipollone, E. Reali,

Stato dell'arte:

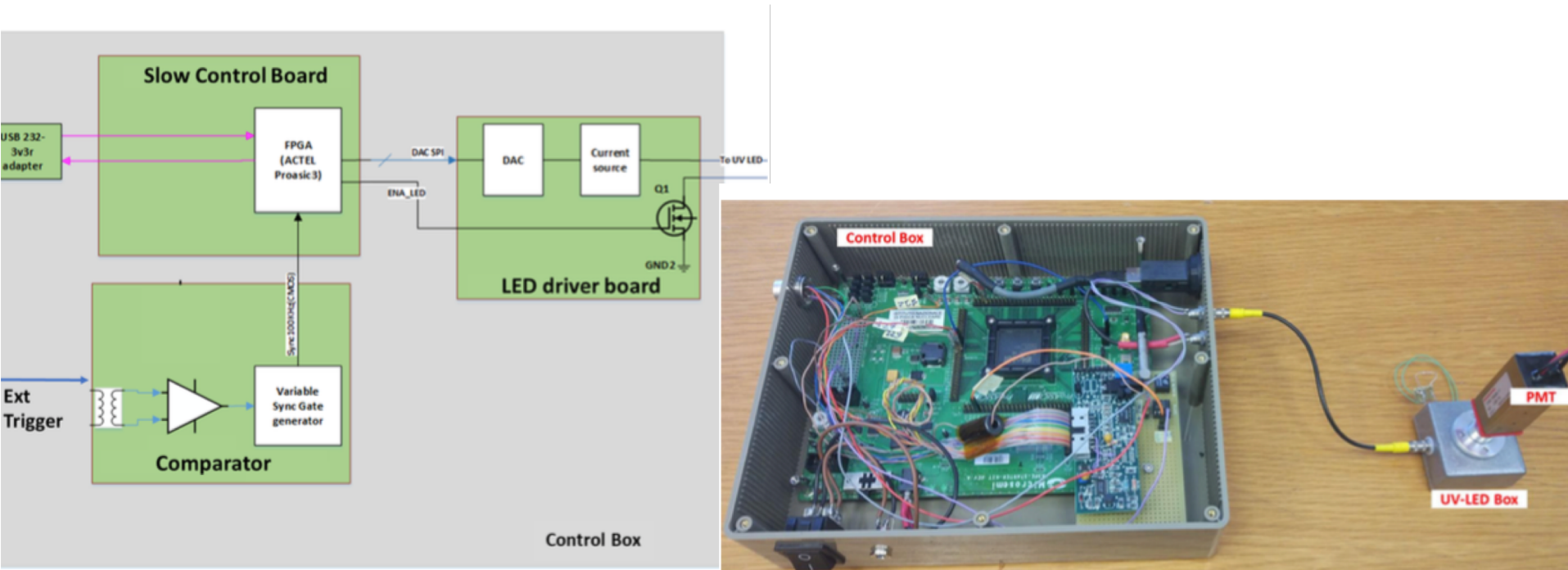
- Il gruppo TOV è FULL MEMBER del LISA Consortium Internazionale
- La Collaborazione LISA-Italia comprende Trento – TOV – Urbino
- TOV è parte del Charge Management System WG, insieme a Trento, Univ. Florida, ESA, ETHZ, Airbus, NASA
- TASK del CMS WG: scarica delle Test Mass di LISA mediante effetto fotoelettrico con luce UV da LED.
- Task del gruppo Tor Vergata: Design, costruzione e test di un elettronica di controllo per l'accensione pulsata di UV-LED :

ACME



# Risultati dei primi 12 mesi di lavoro:

- Acquisita la strumentazione (UV LEDs, fototubi, schede di valutazione, fibre UV, passanti da vuoto...)
- Disegnati, costruiti testati due prototipi di scheda di controllo
- Provata la scheda sui due modelli esistenti di UV LED con emissione a  $\sim 250$  nm
- Calibrate le curve Power vs  $I_{\text{bias}}$  dei due UV LED
- Una scheda è a Trento, dove viene utilizzata per test critici sulla scarica della Test Mass di un pendolo (in preparazione articolo congiunto)
- Continua lo sviluppo del prototipo per perfezionarne le prestazioni
- Un nostro poster all'Amaldi Conference ha sollevato notevole interesse



# Richieste 2020

Caratteri rimanenti: 200

MISSIONI

LISA Consortium, LISA Instrument Group, Charge Management System WG, LISA Symposium

Note:

7.00

0.00

Set

-

Caratteri rimanenti: 192

Missioni a Trento per riunioni di collaborazione, presa dati, messa a punto apparato

Note:

3.50

0.00

Set

-

Caratteri rimanenti: 194

10.50 0.00

-- Nuova voce --

Note:

Caratteri rimanenti: 280

+

CONSUMO

Componenti meccaniche + lavorazioni in officina

Note:

2.50

0.00

Set

-

Caratteri rimanenti: 231

Componenti elettroniche, ottiche (fibre) e UV

Note:

5.00

0.00

Set

-

Caratteri rimanenti: 233

Materiale di laboratorio, consumabili

Note:

2.00

0.00

Set

-

Caratteri rimanenti: 241

Layout e produzione del Master della nuova scheda

Note:

7.00

0.00

Set

-

Caratteri rimanenti: 229

UV LED - secondo batch

Note:

5.50

0.00

Set

-

Caratteri rimanenti: 256

22.00 0.00

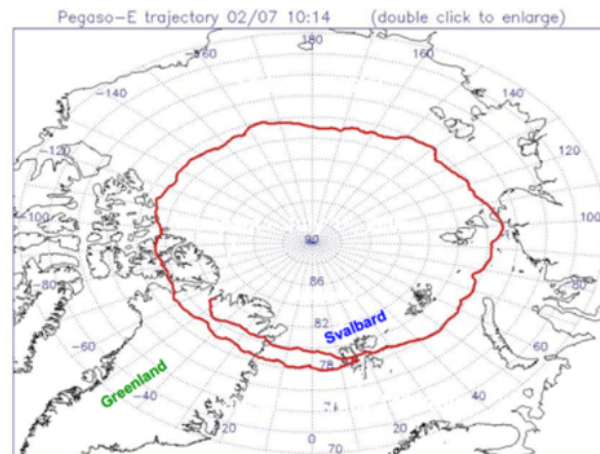
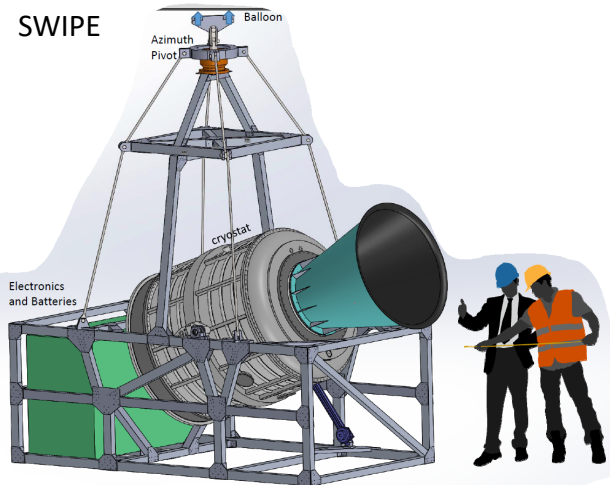
TRASPORTI										
	Spedizioni da e per Trento, da e per University of Florida									
	Note:			1.00	0.00				Set	-
	Caratteri rimanenti:	219							1.00	0.00
MANUTENZIONE										
	-- Nuova voce --									
	Note:								+	
	Caratteri rimanenti:	280								
INVENTARIO										
	-- Nuova voce --									
	Note:								+	
	Caratteri rimanenti:	280								
	Alimentatore da banco Aim-TTi MX100Q, 4 uscite, Vout 70V, Iout 6A									
	Note:			2.00	0.00				Set	-
	Caratteri rimanenti:	212								
	Generatore di funzioni Keysight Technologies 33522B 30MHz, sweep, mod. FM									
	Note:			4.00	0.00				Set	-
	Caratteri rimanenti:	204								
	Nuova Scheda di valutazione FPGA Kintek-7									
	Note:			2.00	0.00				Set	-
	Caratteri rimanenti:	237							8.00	0.00

**Per:** Completamento del prototipo e realizzazione di ACME 2, scheda fully integrated e space compatible

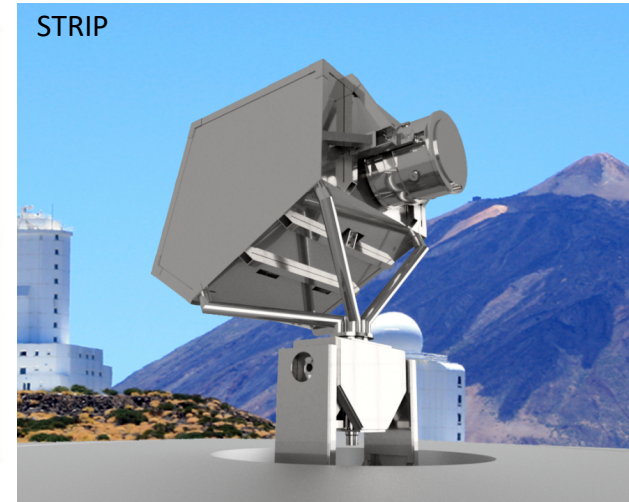


- The Large-Scale Polarization Explorer aims at measuring the CMB polarization at large angular scales;
- Two instruments looking at the same sky region, but at different frequency ranges for optimal foreground rejection:
  - STRIP: low frequency (43, 90 GHz), ground based in Teide Observatory (Tenerife, Spain) – **installazione prevista nel 2021**;
  - SWIPE: high frequency (140, 220, 240 GHz), stratospheric balloon flight from Svalbard Islands/Kiruna (**decisione ASI pending su località e anno di lancio - 2022**);
- Sezioni INFN coinvolte: Fe, Ge (Resp. Naz. F. Gatti), Mi, Pi, Roma1, Roma 2;
- **Il 2020 è l'ultimo anno di richiesta fondi all'INFN.**

SWIPE



STRIP



# Attività Roma Tor Vergata

- **SWIPE:** Assemblaggio e test del criostato di volo e test criogenici delle principali componenti (cryo-harness, filtri ottici, cavi criogenici...). Partecipazione al lancio.



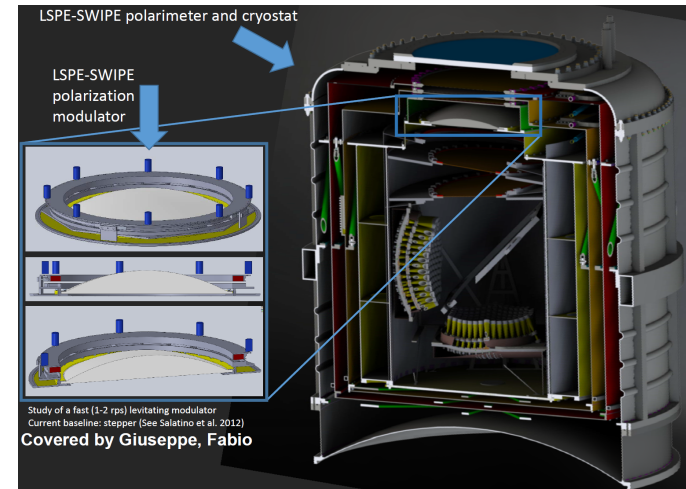
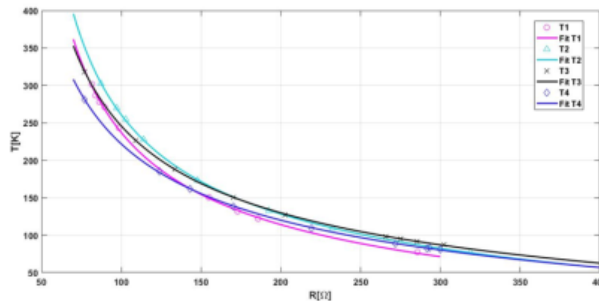
Leak test at room temperature



SWIPE: criostato di volo

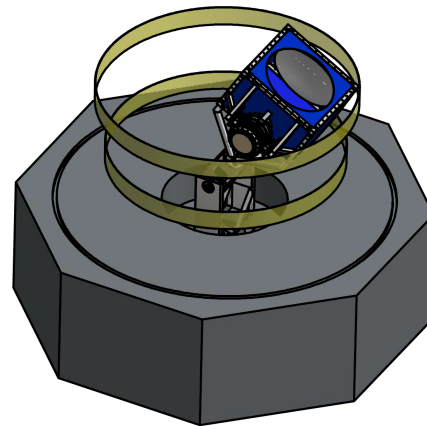


Calibration of temperature sensors

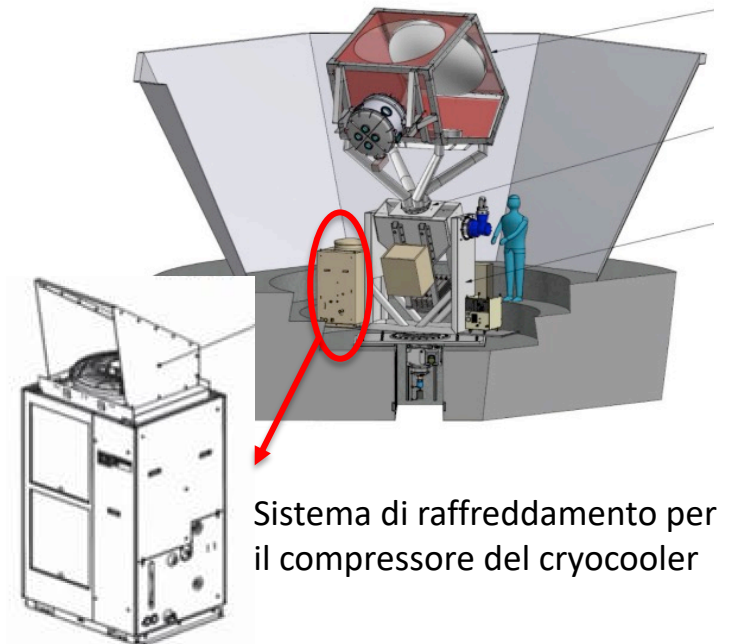


# Attività Roma Tor Vergata

- **STRIP:** lavori di preparazione del sito (definizione dei requirement del basamento e della copertura), analisi termiche e strutturali dello strumento. Partecipazione all'installazione e al commissioning a Tenerife.
- **Analisi dati (SWIPE+STRIP):** sviluppo e costruzione di diversi stadi della pipeline per l'analisi dei dati; simulazioni dello strumento; metodi di calibrazione; map-making; stime di spettri angolari, stima parametri cosmologici...



STRIP: simulazione 3D del moto del telescopio



Sistema di raffreddamento per il compressore del cryocooler

# Richieste finanziarie e anagrafica 2018

Missioni (Tenerife [prep. sito] + Meet. Coll.)	15 k€
Altro Consumo (LHe e LN2)	10 k€
Consumo (Materiali e lavorazioni)	4 k€
Inventario (Chiller per tubo pulsato – anticipi 2019)	9 k€
Licenze software (Ansys)	2 k€
Apparati (Chiller per compressore cryocooler STRIP)	16 k€
<b>Totale</b>	<b>56 k€</b>

(ancora in fase di definizione)

Nominativo	Qualifica	FTE
Coccia Eugenio	PO	0,20
De Gasperis Giancarlo	Ricercatore Univ.	0,30
Fafone Viviana	PO	0,20
Lorenzini Matteo	Ricercatore INFN (GSSI)	0,40
Migliaccio Marina	RTDa	0,50 - TBC
Alessio Rocchi	Primo Ricercatore INFN (Resp. Loc)	0,40
Nicola Vittorio	PO	0,30 - TBC
<b>Totale FTE</b>		<b>2,3</b>



# QUBIC

the **Q** and **U** Bolometric Interferometer for **C**osmology





# The QUBIC Collaboration



SAPIENZA  
UNIVERSITÀ DI ROMA



BROWN



APC Paris, France

IAS Orsay, France

CSNSM Orsay, France

IRAP Toulouse, France

Maynooth University, Ireland

Università di Milano-Bicocca & INFN, Italy

Università degli studi, Milano & INFN, Italy

Università La Sapienza, Roma & INFN, Italy

Università Tor Vergata, Roma & INFN, Italy

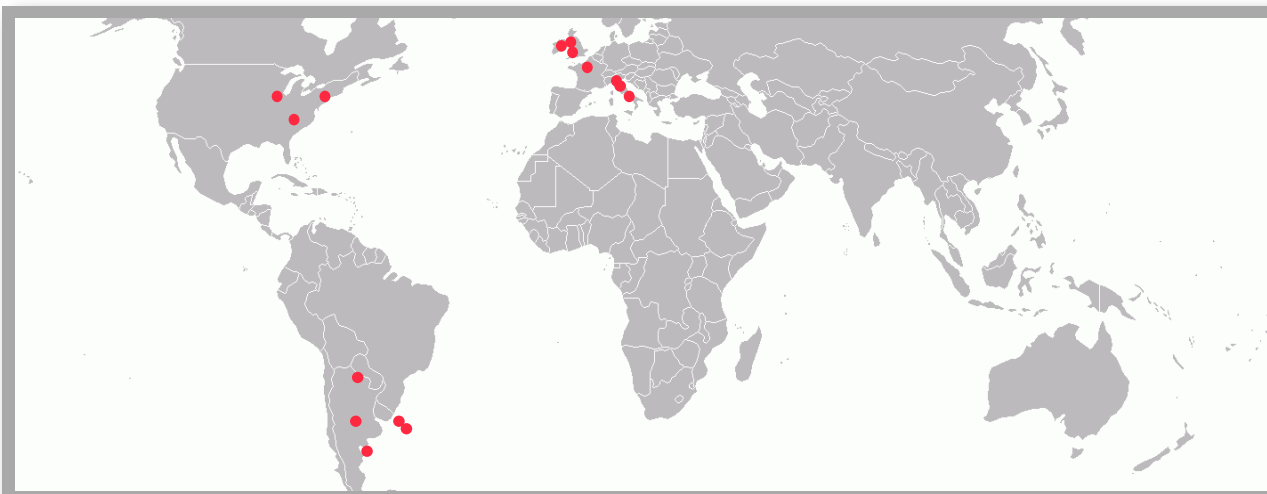
University of Manchester, UK

Cardiff University, UK

Richmond University, USA

Brown University, USA

University of Wisconsin, USA



## White Paper:

arXiv:1010.0645

Astroparticle Physics

34 (2011) 705–71

**QUBIC TDR on arXiv  
this week...**

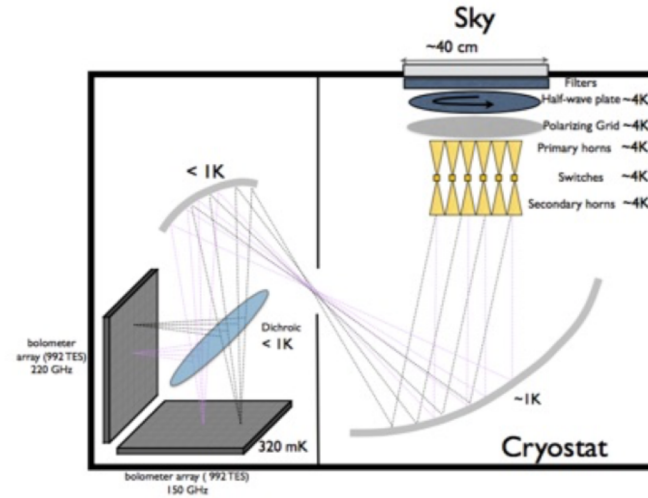
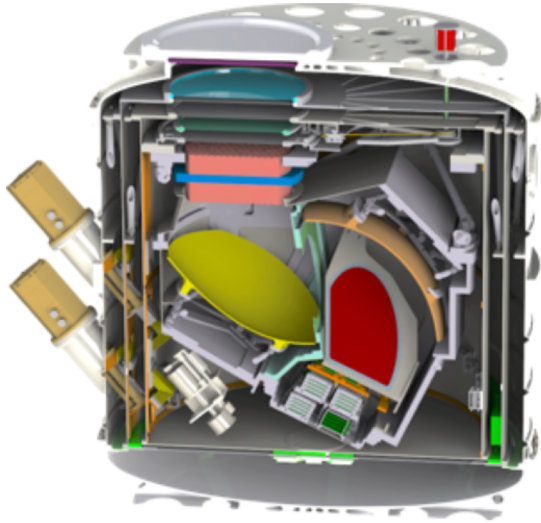
J. Aumont<sup>7</sup>, S. Banfi<sup>13</sup>, P. Battaglia<sup>14</sup>, E.S. Battistelli<sup>17</sup>, A. Baù<sup>13</sup>, B. Bélier<sup>8</sup>, D. Bennett<sup>15</sup>, L. Bergé<sup>6</sup>, J.Ph. Bernard<sup>9</sup>, M. Bersanelli<sup>14</sup>, M.A. Bigot-Sazy<sup>1</sup>, N. Bleurvacq<sup>1</sup>, G. Bordier<sup>1</sup>, J. Brossard<sup>1</sup>, E.F. Bunn<sup>16</sup>, D. Buzi<sup>17</sup>, D. Cammilleri<sup>1</sup>, F. Cavaliere<sup>14</sup>, P. Chanial<sup>1</sup>, C. Chapron<sup>1</sup>, G. Coppi<sup>12</sup>, A. Coppolecchia<sup>17</sup>, F. Couchot<sup>11</sup>, G. D'Alessandro<sup>17</sup>, P. De Bernardis<sup>17</sup>, M. de Petris<sup>17</sup>, T. Decourcelle<sup>1</sup>, F. Del Torto<sup>14</sup>, L. Dumoulin<sup>5</sup>, C. Franceschet<sup>13</sup>, A. Etchegoyen<sup>10</sup>, B. Garcia<sup>10</sup>, A. Gault<sup>18</sup>, D. Gayer<sup>15</sup>, M. Gervasi<sup>13</sup>, A. Ghribi<sup>1</sup>, M. Giard<sup>9</sup>, Y. Giraud-Héraud<sup>1</sup>, M. Gradziel<sup>15</sup>, L. Grandsire<sup>1</sup>, J.Ch. Hamilton<sup>1</sup>, D. Harari<sup>19</sup>, V. Haynes<sup>12</sup>, S. Henrot-Versillé<sup>11</sup>, N. Holtzer<sup>5</sup>, J. Kaplan<sup>1</sup>, A. Korotkov<sup>2</sup>, J. Lande<sup>5</sup>, S. Loucatos<sup>1</sup>, A. Lowitz<sup>18</sup>, B. Maffei<sup>7</sup>, S. Marnieros<sup>5</sup>, J. Martino<sup>7</sup>, S. Masi<sup>17</sup>, C. Medina<sup>6</sup>, M. McCulloch<sup>12</sup>, A. May<sup>12</sup>, S. Melhuish<sup>12</sup>, A. Mennella<sup>14</sup>, L. Montier<sup>9</sup>, A. Murphy<sup>15</sup>, D.Néel<sup>5</sup>, M.W. Ng<sup>12</sup>, C. O'Sullivan<sup>15</sup>, F.Pajot<sup>9</sup>, A. Passerini<sup>13</sup>, C. Perbost<sup>1</sup>, O. Perdureau<sup>11</sup>, F. Piacentini<sup>17</sup>, M. Piat<sup>1</sup>, L. Piccirillo<sup>12</sup>, G. Pisano<sup>4</sup>, D. Prêle<sup>1</sup>, R. Puddu<sup>17</sup>, D. Rambaud<sup>9</sup>, O. Rigaut<sup>5</sup>, G. Romero<sup>6</sup>, M. Salatino<sup>17</sup>, A. Schillaci<sup>17</sup>, S. Scully<sup>15</sup>, M. Stolpovskiy<sup>1</sup>, A. Tartari<sup>1</sup>, P. Timbie<sup>18</sup>, M. Tristram<sup>11</sup>, G. Tucker<sup>2</sup>, D. Viganò<sup>14</sup>, F. Voisin<sup>1</sup>, B. Watson<sup>12</sup> and M. Zannoni<sup>13</sup>

91 Collaborators

19 Institutes

6 countries

# Lo strumento



The QUBIC instrument is made of a cryostat cooled down to 4K using pulse-tubes. The cryostat is open to the sky with a 45 cm diameter window made of high-density polyethylene (HDPE) providing an excellent transmission and mechanical stiffness. Right after the window, filters ensure a low thermal load inside the cryostat and a rotating Half-Wave-Plate (HWP) modulates the polarization. Then, a polarizing grid selects one of the two polarization angles w.r.t the instrument. An array of 400 corrugated horns (called « primary horns » designed to be efficient throughout the 150 and 220 GHz bands with a  $\approx 13$  degrees FWHM at 150 GHz) selects the baselines observed by QUBIC. These primary horns are immediately followed by back-horns re-emitting the signal inside the cryostat towards an « optical combiner » which is simply a telescope that combines on the focal plane the images of each of the secondary horns in order to form interference fringes. Before the focal plane, a dichroic plate splits the signal into its 150 and 220 GHz components that are each imaged on a focal plane equipped with 1024 Transition-Edge-Sensors (TES) from which 992 are exposed to the sky radiation (blind ones are used for systematics studies) cooled down to 320 mK and read using a multiplexed cryogenic readout system based on SQUIDs and SiGe ASIC operating at 4K.

# Schedula

## BRAIN Pathfinder

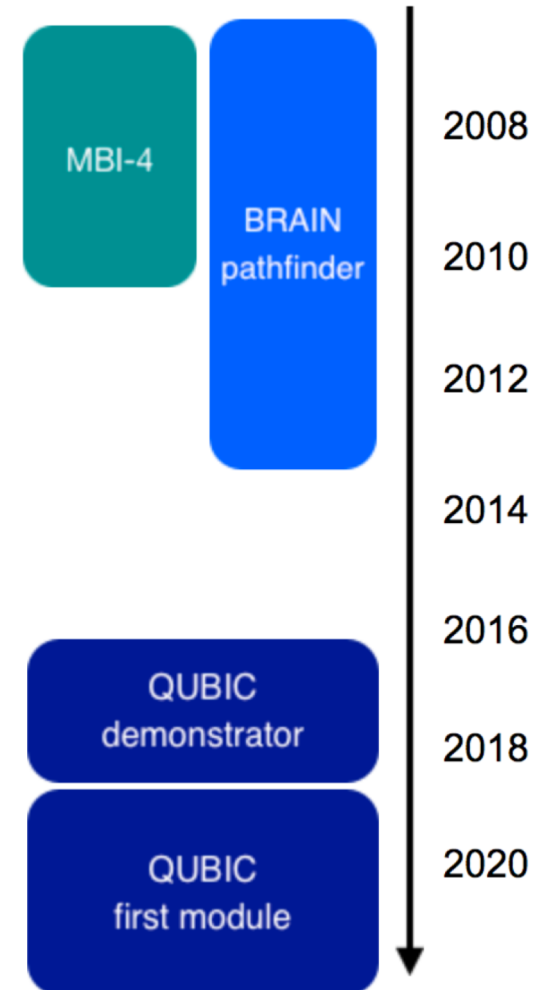
- Site testing, logistics
- Atmosphere characterization at Dome C (effective temperature, polarization ...)
- 3 campaigns, January 2006, 2007, 2011

## MBI-4 Prototype

- 4 horns bolometric interferometer
- Worked in Wisconsin (2008 and 2009)
- Fringes observed !

## QUBIC

- Search for primordial B-modes ( $50 < l < 150$ )
- 20x20 horns/switches
- 2048 TES in 2 focal planes (150 and 220 GHz)
- 25% Bandwidth
- technical demonstrator in lab 2018 (only 8x8 horns, 256 TES)
- Observation site: Alto Chorillos (Argentina)
- Target :  $r \sim 0.01$  in 2 years of data





# QUBIC - Preventivi 2020



## Attività RM2

- Studio delle caratteristiche del rumore dei detector (**Tor Vergata**);
- Ottimizzazione del codice di map-making nella pipeline esistente (**Tor Vergata – APC Paris**):
  - Ottimizzazione del codice iterativo della pipeline esistente con i corretti preconditionatori (validati su precedenti esperimenti, già testati su simulazioni di LSPE/SWIPE e dati scientifici dei due voli di PILOT);
- Integrazione del trattamento del rumore correlato e cross-correlato nella pipeline di map-making (**APC**);
- Caratterizzazione delle proprietà di correlazione del rumore pixel-pixel nelle mappe finali (**APC**);
- Determinazione degli effetti del rumore sulle stime di spettro angolare (**Tor Vergata – APC**).

**(Sede prevista)**



# QUBIC - Preventivi 2020



## Richieste RM2

Persone	Missioni	Giorni/missione	Descrizione	Spese Viaggio	Hotel etc.	Totali
1	2	10	2 meeting di lavoro a Parigi per lo studio degli effetti e caratteristiche del rumore strumentale sulle timeline e sulle mappe; integrazione nella pipeline di analisi dati; Studio e caratterizzazione delle mappe finali.	600€	3400€	4000€

**stime provvisorie!**



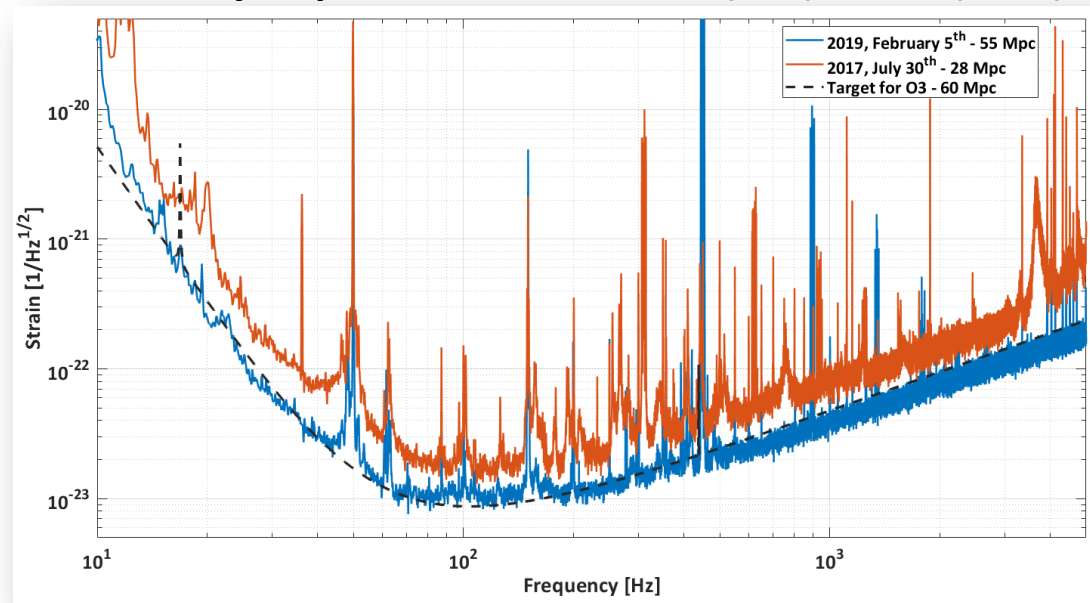
# Virgo ed ET @ Roma Tor Vergata Preventivi 2020

- After the end of the second observing run (O2) in August 2017, the interferometer underwent a deep upgrade (6 months for the installation of new hardware)
- The commissioning (A. Rocchi commissioning coordinator) took 14 months and O3 started on April 1<sup>st</sup>.

**O2 range for BNS: 26 Mpc**  
**O3 range for BNS: 51 Mpc**

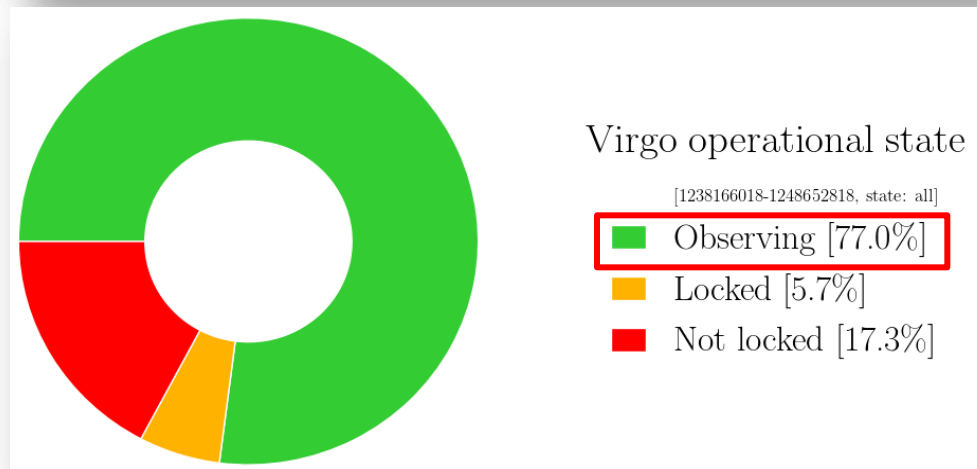
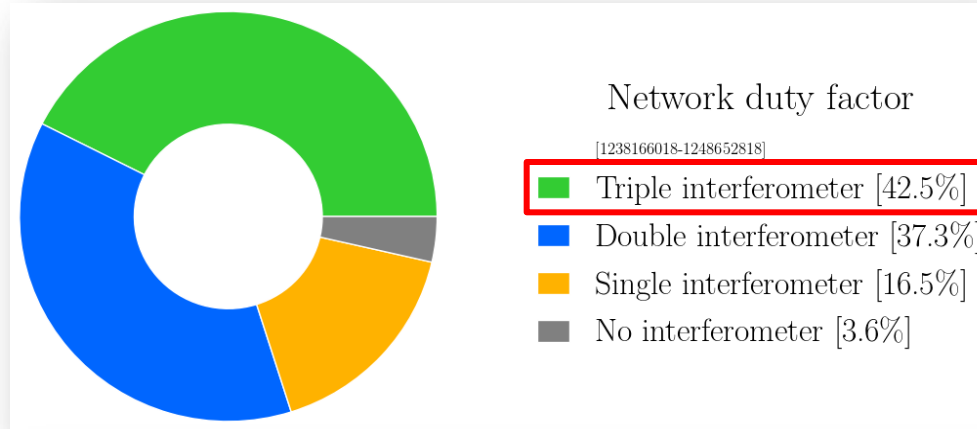
Improvement wrt O2  
Virgo x 2 better  
LL x 1.4 better  
LH x 1.4 better

**Sensitivity improvement from O2 (red) to O3 (blue)**



# O3 status

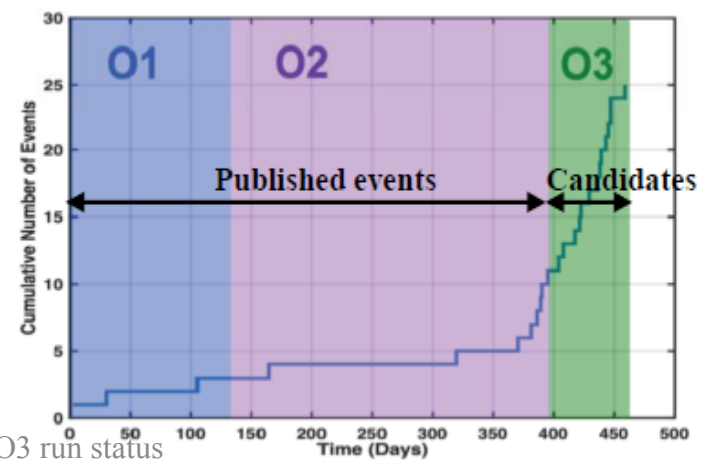
- Very good (~80%) Virgo duty cycle in science mode;



# Public alerts

- Events list (with sky map and distance) publicly available @ <https://gracedb.ligo.org/latest/>

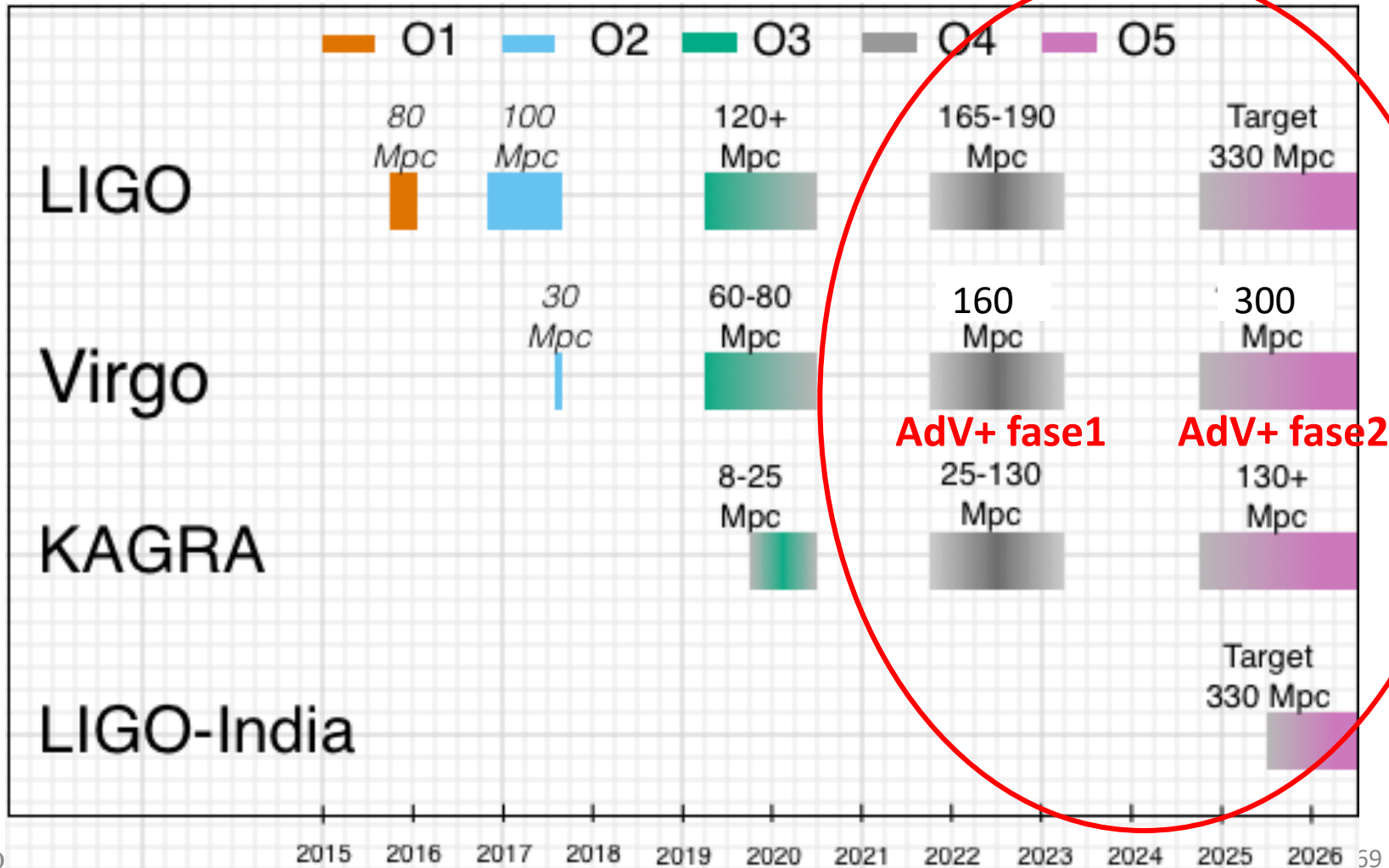
UID	Labels	t_start	t_0	t_end	FAR (Hz)	UTC Created
<a href="#">S190707g</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1246527223.118398	1246527224.181226	1246527225.284180	5.265e-12	2019-07-07 09:33:44 UTC
<a href="#">S190706ai</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1246487218.321541	1246487219.344727	1246487220.585938	1.901e-09	2019-07-06 22:26:57 UTC
<a href="#">S190701ah</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1246048403.576563	1246048404.577637	1246048405.814941	1.916e-08	2019-07-01 20:33:24 UTC
<a href="#">S190630ag</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1245955942.175325	1245955943.179550	1245955944.183184	1.435e-13	2019-06-30 18:52:28 UTC
<a href="#">S190602aq</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1243533584.081266	1243533585.089355	1243533586.346191	1.901e-09	2019-06-02 17:59:51 UTC
<a href="#">S190524g</a>	ADVNO SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1242708743.678669	1242708744.678669	1242708746.133301	6.971e-09	2019-05-24 04:52:30 UTC
<a href="#">S190521r</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1242459856.453418	1242459857.460739	1242459858.642090	3.168e-10	2019-05-21 07:44:22 UTC
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<a href="#">S190519bj</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1242315361.378873	1242315362.655762	1242315363.676270	5.702e-09	2019-05-19 15:36:04 UTC
<a href="#">S190518bb</a>	ADVNO SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1242242376.474609	1242242377.474609	1242242380.922655	1.004e-08	2019-05-18 19:19:39 UTC
<a href="#">S190517h</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1242107478.819517	1242107479.994141	1242107480.994141	2.373e-09	2019-05-17 05:51:23 UTC
<a href="#">S190513bm</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT	1241816085.736106	1241816086.869141	1241816087.869141	3.734e-13	2019-05-13 20:54:48 UTC
<a href="#">S190512at</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT					2019-05-12 18:07:42 UTC
<a href="#">S190510g</a>	ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT					2019-05-10 03:00:03 UTC
<a href="#">S190503bf</a>	ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT					2019-05-03 18:54:26 UTC
<a href="#">S190426c</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT					2019-04-26 15:22:15 UTC
<a href="#">S190425z</a>	ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK					2019-04-25 08:18:26 UTC
<a href="#">S190421ar</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT					2019-04-21 21:39:16 UTC
<a href="#">S190412m</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT					2019-04-12 05:31:03 UTC
<a href="#">S190408an</a>	PE_READY ADVOK SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK GCN_PRELIM_SENT					2019-04-08 18:18:27 UTC
<a href="#">S190405ar</a>	ADVNO SKYMAP_READY EMBRIGHT_READY PASTRO_READY DQOK					2019-04-05 16:01:56 UTC



20 public triggers as of July 16th, 2019

# Planning

- O3 will stop in April 2020
- Major upgrade planned toward Advanced Virgo+



# Virgo @ Roma Tor Vergata

## Principali responsabilità gruppo Virgo Tor Vergata nella Collaborazione Virgo

- V. Fafone
  - Responsabile nazionale
  - Chair del Virgo Editorial Board
- A. Rocchi
  - Commissioning Coordinator
  - Chair del LIGO-VIRGO Joint Run Planning Committee
- E. Cesarini
  - Responsabile del work package “Metrology” per lo sviluppo di coating innovativi

## Attività 2020 gruppo Virgo Tor Vergata

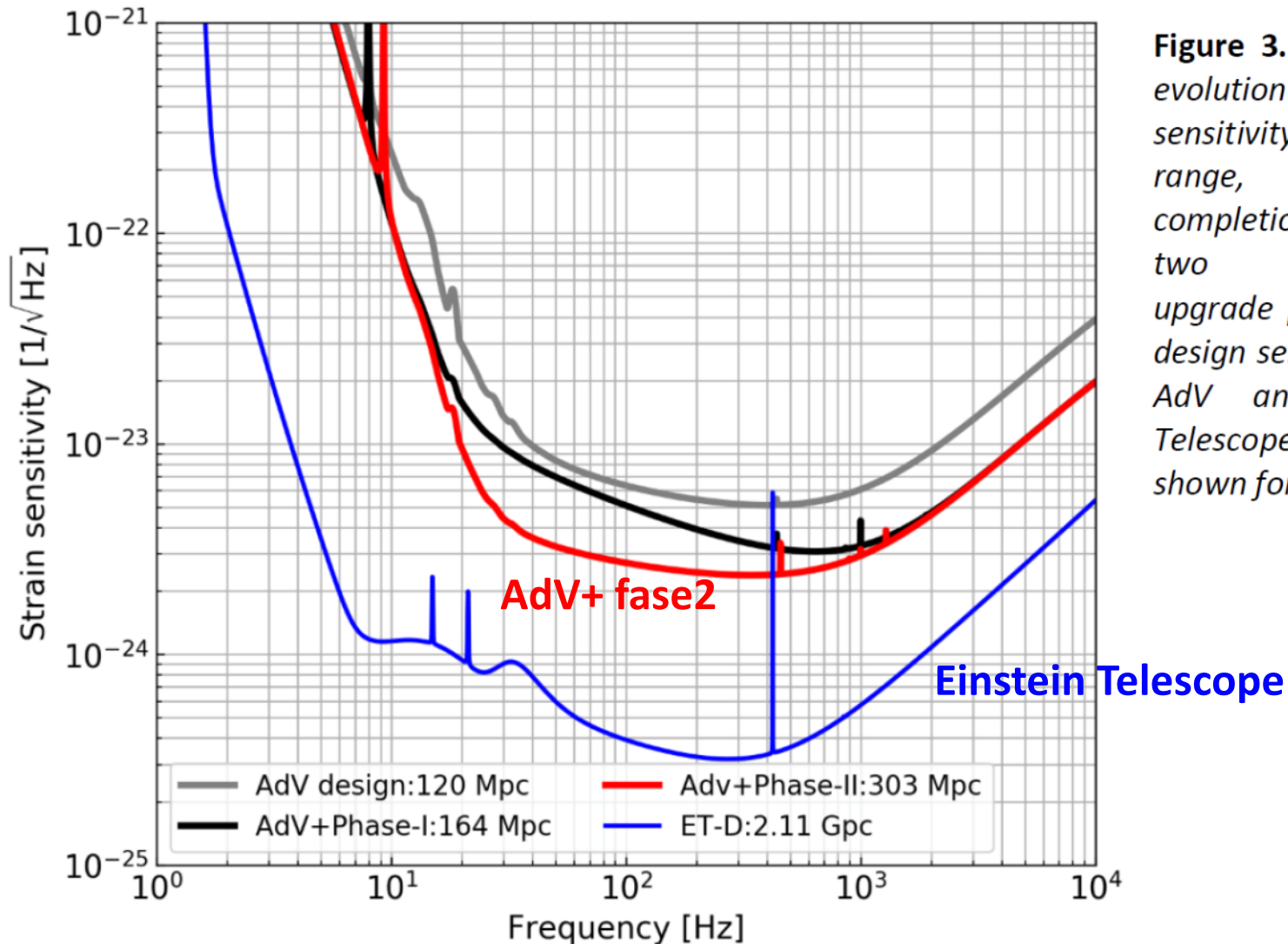
- Preparazione AdV+ fase 1 e fase 2:
  - Sviluppo sistemi avanzati di controllo delle aberrazioni sia negli specchi dell’interferometro che per minimizzare le perdite nel sistema di luce squeezed per l’abbattimento del rumore quantistico
  - caratterizzazione di coating innovativi per l’abbattimento del rumore termico
  - Attività di analisi dati:
    - Ricerca di segnali continui emessi da NS in rotazione
    - Analisi multimessenger: segnali gravitazionali in coincidenza con  $\nu$  e con segnali e.m. (GRB, X, radio, ottico)





# The longer term path to E.T.

- Planned sensitivity improvements



**Figure 3.1:** Expected evolution of the Virgo sensitivity, and BNS range, after the completion of the two proposed upgrade phases. The design sensitivities of AdV and Einstein Telescope are also shown for reference.

# THE GLOBAL SCENARIO

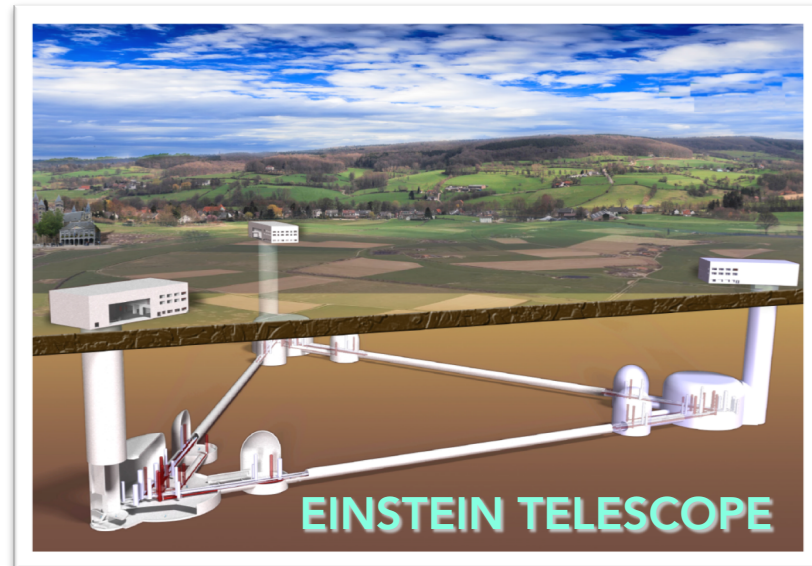


# ET-Italia

- Grande competizione a livello europeo per la definizione del sito: Sardegna (area Sulcis), Ungheria, Germania-Belgio-Olanda
- Grande supporto da parte del MIUR: finanziamento dedicato agli upgrade a breve termine di Virgo (AdV+) e alla qualificazione del sito + R&D su item di punta per ET

## Contributi del gruppo Tor Vergata:

- Controllo delle aberrazioni negli specchi
- Ricerca di nuovi materiali per i coating degli specchi
- Analisi dati



- ❑ 6 interferometri collocati
- ❑ Bracci lunghi 10 km
- ❑ Sotterraneo e criogenico

# Anagrafica 2020

## Virgo

Responsabile Locale : V. Fafone

Arciprete Fabrizio	P.A.	10
Casentini Claudio	A.R.	40
Cesarini Elisabetta	Ricercatore	80
De Matteis Fabio	Ricercatore	40
Fafone Viviana	P.O.	60
Iess Alberto	Dott	100
Lumaca Diana	Dott	100
Nardecchia Ilaria	A.R.	90
Proposito Paolo	Ricercatore	40
Rocchi Alessio	Ricercatore	50
		Tot FTE 6,1
Tecnologi		
D'Antonio Sabrina	Tecnologo	100
Minenkov Yury	Primo tecnologo	50
		Tot FTE 1.5

## ET-Italia

(su DTZ gruppo2)

Cesarini Elisabetta	Ricercatore.	20
De Gasperis Giancarlo	Ricercatore	10
Fafone Viviana	P.O.	20
Nardecchia Ilaria	A.R.	10
Rocchi Alessio	Ricercatore	10
		Tot FTE 0.7
Tecnologi		
Minenkov Yury	Primo tecnologo	10
		Tot FTE 0.1

DRAFT

Preventivi in fase di definizione

Richieste servizi: servizio elettronica 4 M.U. / officina meccanica 4 M.U.

