

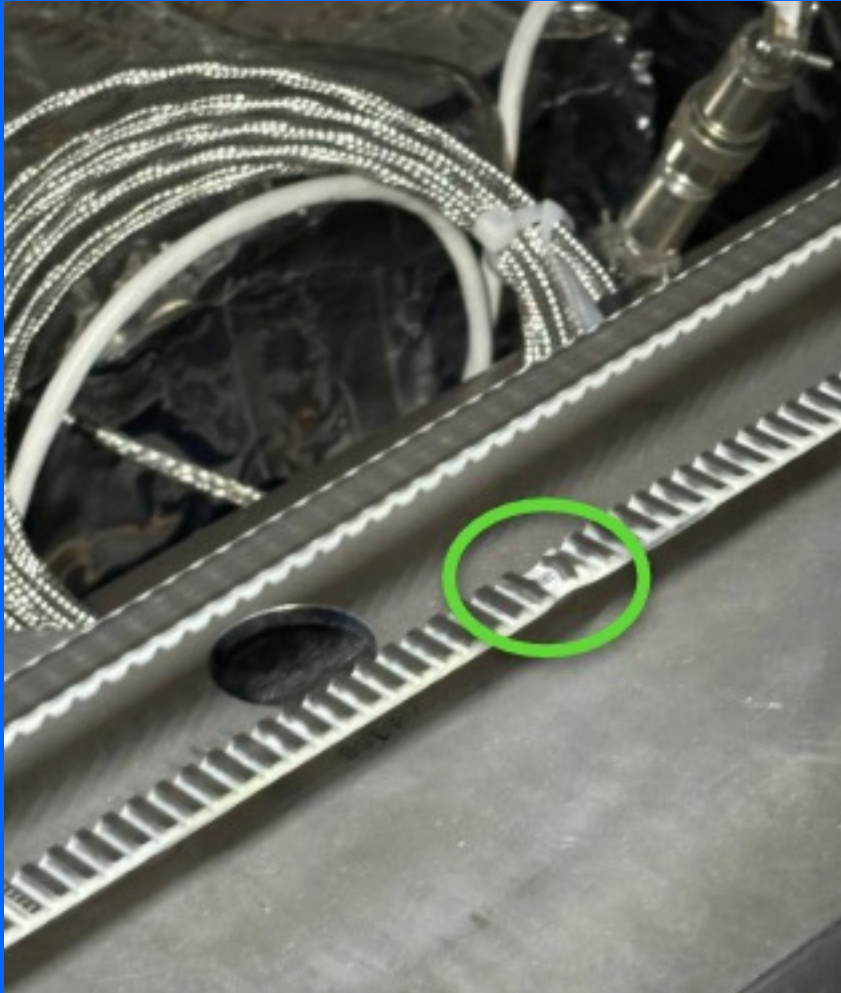
*LNF-CS1 meeting*

*25 September 2024*

# *LHCb*

*Barbara Sciascia  
(INFN)*

*on behalf of Frascati LHCb group*



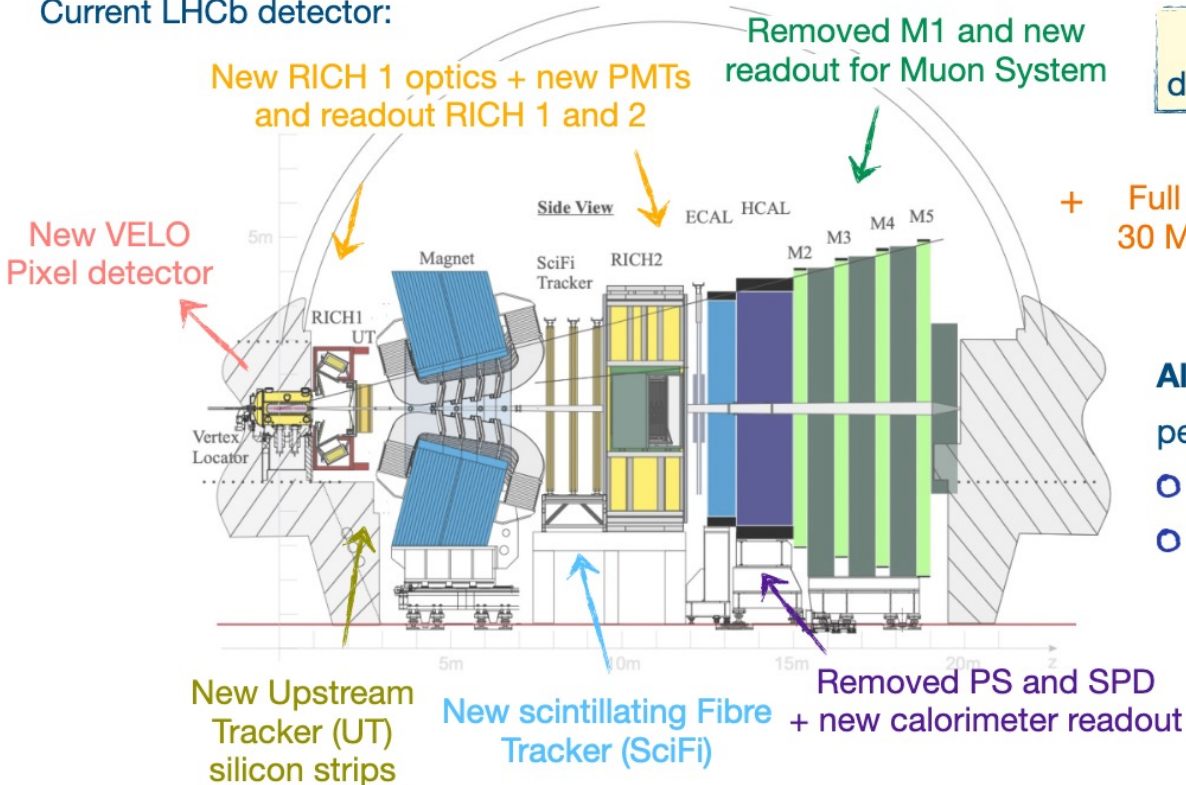
## Presentazione LHCb da parte di G. Punzi (Responsabile Nazionale)

[<https://agenda.infn.it/event/42177/contributions/236298/attachments/124896/183984/LHCB@CSN1-Sep2024.pdf>]

## LHCC, sessione aperta di settembre 2024, I. Bachiller

[[https://indico.cern.ch/event/1444045/contributions/6077846/attachments/2925300/5135181/LHCC\\_LHCb\\_OpenSession.pdf](https://indico.cern.ch/event/1444045/contributions/6077846/attachments/2925300/5135181/LHCC_LHCb_OpenSession.pdf)]

Current LHCb detector:



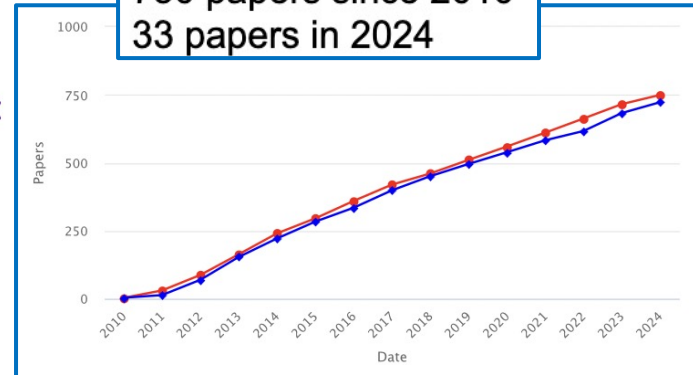
Improved physics performance, despite the more challenging environment.

+ Full software Trigger  
30 MHz processing

All sub-detectors are showing excellent performance. Two milestones in 2024:

- VELO at nominal closed position
- UT stable running in global

750 papers since 2010  
33 papers in 2024



The LHCb Upgrade I [arXiv:2305.10515](https://arxiv.org/abs/2305.10515)

JINST 19P05065

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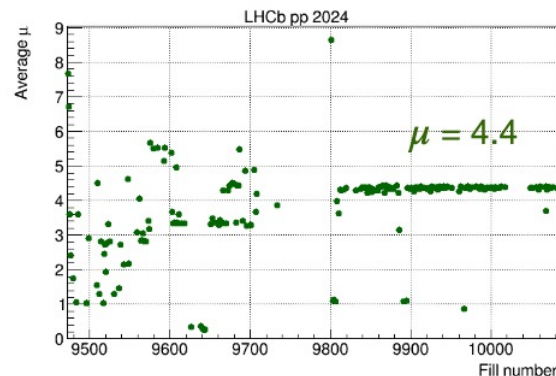
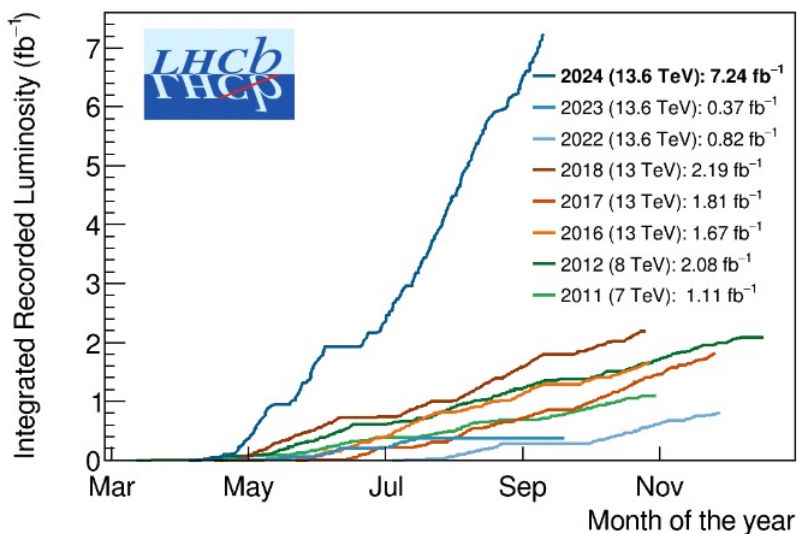
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[[https://indico.cern.ch/event/1444045/contributions/6077846/attachments/2925300/5135181/LHCC\\_LHCb\\_OpenSession.pdf](https://indico.cern.ch/event/1444045/contributions/6077846/attachments/2925300/5135181/LHCC_LHCb_OpenSession.pdf)]

Recorded luminosity of  $7.24 \text{ fb}^{-1}$  in 2024  
(as of beginning of September)  
More than in the whole of Run 2!

### The LHCb Upgrade I final realisation:

- First opportunity for LHCb to run at nominal conditions.
- VELO sub-detector fully closed.
- The UT sub-detector now part of the data taking chain.
- Increased processing capacity with a 3<sup>rd</sup> GPU/event builder.
- Rich physics program and different beam conditions (SMOG2).
- Highest stable number of visible interactions per bunch crossing ( $\mu$ ).
- Good data taking efficiency  $\sim 95\%$ .
- Good data quality efficiency for physics.



## Presentazione LHCb da parte di G. Punzi (Responsabile Nazionale)

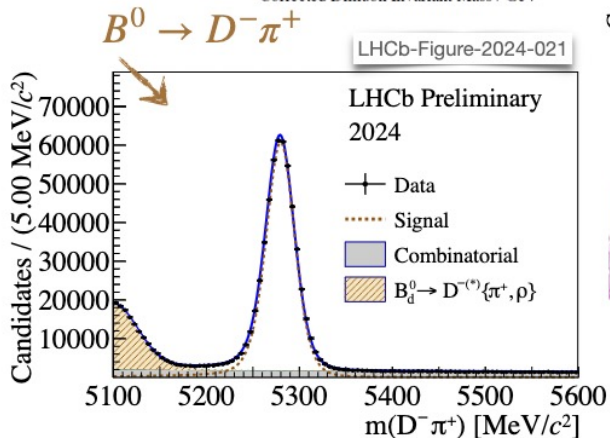
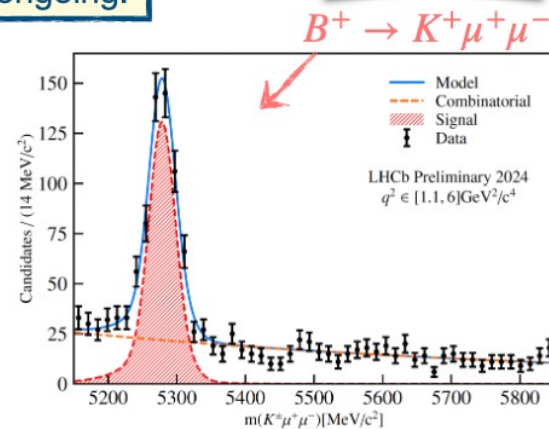
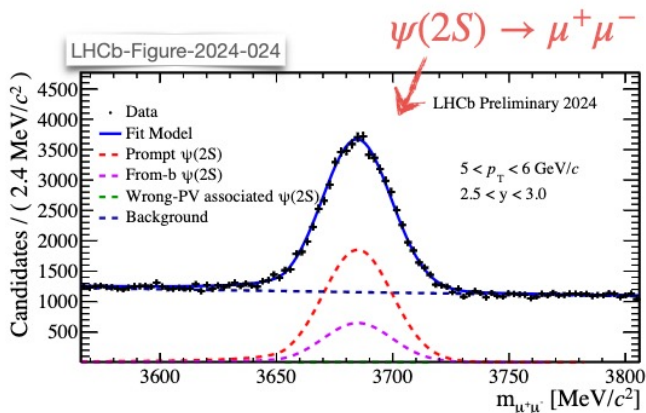
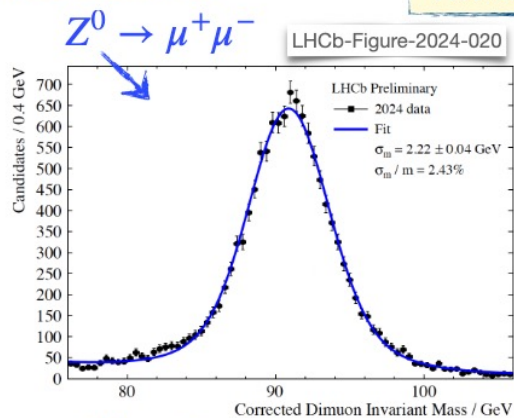
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## LHCC, sessione aperta di settembre 2024, I. Bachiller

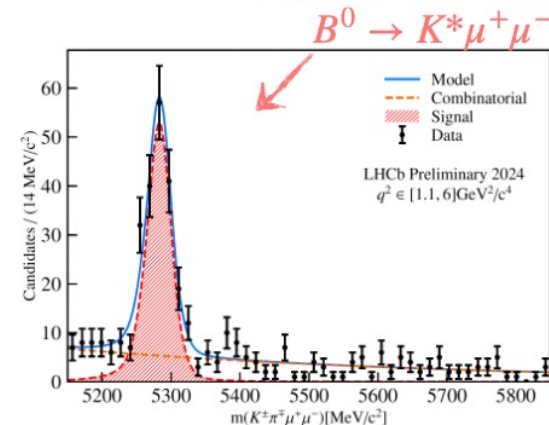
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Partial datasets:

The analysis of the large 2024 data sample is already ongoing.



Total yields in 2024  $\sim [1-2] \times$  Run 1 and 2  
[channel dependent]



And many others...

## Presentazione LHCb da parte di G. Punzi (Responsabile Nazionale)

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### Scoping Document ready to start LHCC review

Solid plan developed compatible with the LHC present schedule:

Run 3			LS3				Run 4					LS4		Run 5				LS5	Run 6	
2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041			
TDR phase			Construction phase						Installation		Exploitation									

TDR phase within 2026, construction phase 6 years, to be fully ready at LS4.

Three detector scenarios are described in the scoping document:

Scenarios	Baseline	Middle	Low
$L_{\text{peak}} (10^{34} \text{ cm}^{-2}\text{s}^{-1})$	1.5	1.0	1.0

Different

- Physics potential
- Cost
- Complexity

### Important experience gained from Upgrade I:

Start early, guarantee enough infrastructure/person-power support, and reduce complexity where possible.

*Companion document, specifying INFN participation, is in preparation*  
*Next step is producing the TDRs (within 2026)*

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)



CERN-LHCC-2024-010  
LHCb-TDR-026  
July 26, 2024

## LHCb Upgrade II Scoping Document

LHCb collaboration

### Abstract

A second major upgrade of the LHCb detector is necessary to allow full exploitation of the LHC for flavour physics. The new detector is proposed for installation during the long-shutdown 4 (LS4), and will operate at a maximum luminosity of  $1.5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ . By upgrading all subdetectors and adding new detection capability it will be possible to accumulate a sample of  $300 \text{ fb}^{-1}$  of high energy  $pp$  collision data, giving unprecedented and unique discovery potential in heavy flavour physics and other areas. The baseline LHCb Upgrade II detector has been presented in a Framework Technical Design Report in 2022. Here, updated and additional scoping options with reduced detection capability and different choice of operational luminosity are presented. The costs and physics performance of each scenario are discussed, and an overview of the project management plans is presented.

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- IGNITE
- AIDAINNOVA
- PRIN\_2022N4W8WR
- PNRR\_ROMETECHS5

Sigle sinergiche

# Anagrafica 2025 - LHCb@LNF

Italia: 135.7 FTE, in lieve crescita rispetto allo scorso anno (131.7)

Cognome	Nome	Ricercatore	Tecnologo	MOF A	Autore	FTE Ricercatori			FTE Tecnologi			Persone	FTE/Per	Job	Qualifica
						LHCb	Altro	Totale	LHCb	Altro	Totale				
Albicocco	Pietro	0	1	1	1				60	10	70			tecn	Tecn
Antonelli	Antonella	1	0	0	0	10		10						staff	Dir Ric
Bencivenni	Giovanni	1	0	1	1	60	10	70						staff	I Ric
Campana	Pierluigi	1	0	0	1	50		50						Pens	Dir Ric
Chulikov	Vladimir	1	0	0	1	100		100						dott	Ass Ric
Ciabrone	Paolo	0	1	1	1				60	20	80			tecn	I Tecn
De Lucia	Erika	1	0	1	1	60	10	70						staff	Ric
De Simone	Patrizia	1	0	1	1	95	5	100						staff	I Ric
Di Nezza	Pasquale	1	0	1	1	80	20	100						staff	I Ric
Felici	Giulietto	0	1	0	0				30		30			Pens	Dir Tecn
Giovannetti	Matteo	1	0	1	1	100		100						pdoc	Ass Ric
Lanfranchi	Gaia	1	0	1	1	70		70						staff	I Ric
Martellotti	Silvia	1	0	0	0	20		20						staff	Ric
Minucci	Elisa	1	0	1	1	100		100						pdoc	Ass Ric
Morello	Gianfranco	1	0	1	1	70	10	80						staff	Ric
Moulson	Matteo	1	0	0	0	10	20	30						staff	I Ric
Palutan	Matteo	1	0	1	1	100		100						staff	I Ric
Pepe Altarelli	Monica	1	0	0	1	100		100						Pens	PA
Poli Lener	Marco	0	1	1	1				60	10	70			tecn	Tecn
Rotondo	Marcello	1	0	1	1	80	10	90						staff	I Ric
Santimaria	Marco	1	0	1	1	100	0	100						staff	Ric
Sciascia	Barbara	1	0	1	1	95	5	100						staff	I Ric
Spadaro	Tommaso	1	0	0	0	20		20						staff	I Ric
Tinti	Gemma	1	0	0	0	10	10	20						staff	Ric
		20	4	15	18	13.30	1.00	14.30	2.10	0.40	2.50	24	0.70		

## Frascati:

- 16.8 FTE (era 13.1)
- 24 persone con 0.70 FTE/persona (era 16, con 0.82)
- prevalentemente effetto cancellazione HIKE

## Diverse responsabilità:

- Barbara Sciascia: **MUON Project Leader (L1)**
- Monica Pepe Altarelli: **Membership Committee Chair (L1)**
- Pasquale Di Nezza: **SMOG2 Project Leader (L2a)**
- Patrizia De Simone: **Software coordinator MUON (L2b)**
- Erika De Lucia: **Convener WP4 Simulation**
- Paolo Ciabrone: **Electronics for Muon@U2 (L2b)**
- Erika De Lucia: **Data analysis for Muon@U2 (L2b)**
- Marco Poli Lener: **Detector for Muon@U2 (L2b)**

## Operations

- TELL40 fw firmware updated to manage the re-sync on the fly (PAUSE\_CONTINUE\_RUN)
- HV tuning for  $\mu > 4.5$  for internal regions ongoing

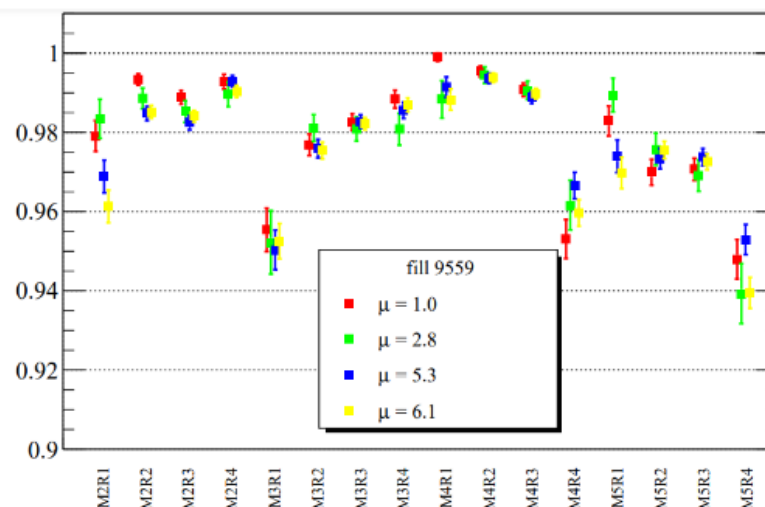
## Detector status

- replaced a few HV boards
- 3 chambers (2 sparks in gap, 1 shorted gap) need to be replaced in the YETS
- few FE channels in M2 and M3 disabled (1 problem in nODE, 1 in FE board, 1 being investigated)

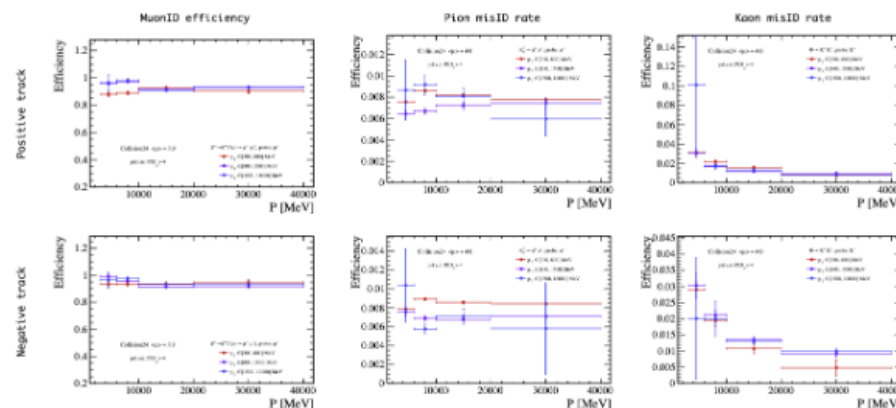
## Performance tuning

- adjustments to time alignment applied in Aug (improvements mostly in M4R4 and M5R1)
- ongoing analysis of muon hit efficiency: current estimate  $> 94\%$  (further improvements expected from latest time alignment)
- approaching nominal muonID efficiency: fine tuning ongoing
- work ongoing on Low Energy Background parametrisation to improve detector modelling in simulation

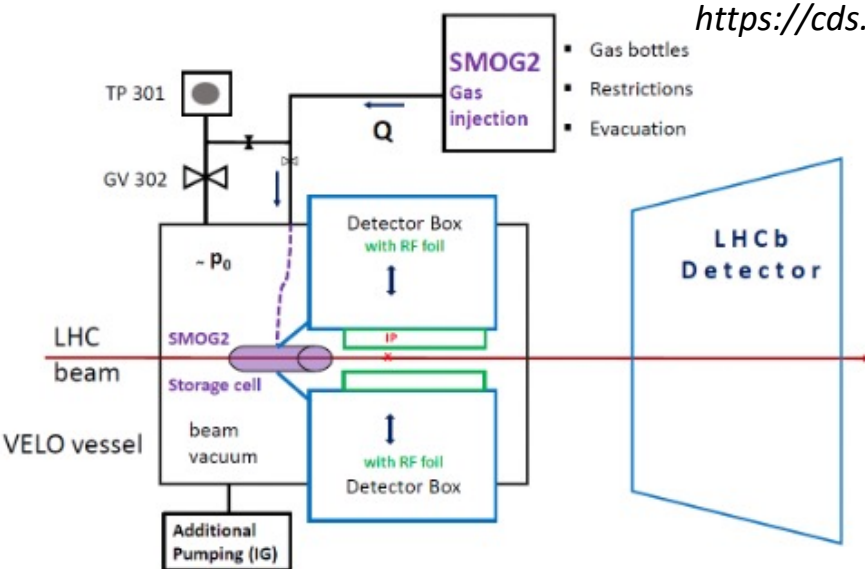
muon hit efficiency



muonID efficiency and misID



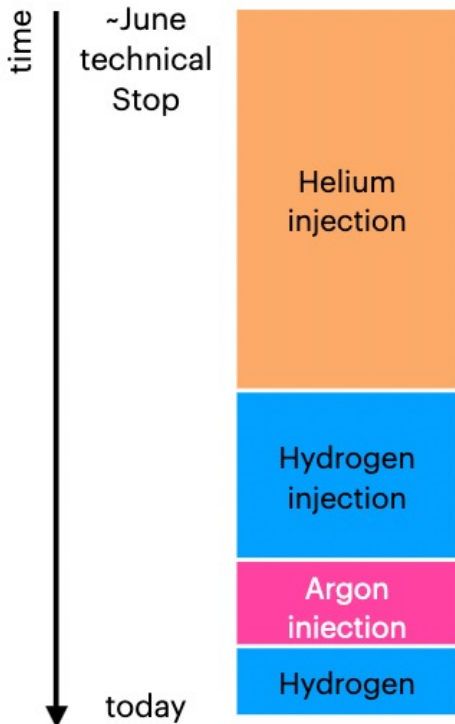
Smooth commissioning and operation. Still recovering from the end of Russia-CERN agreement: most of Muon activities in Run 3 rely on Frascati group



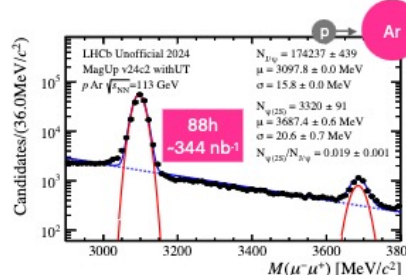
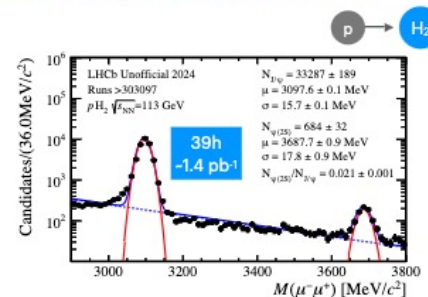
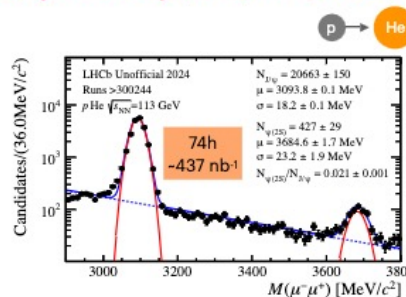
Only experiment capable of inject gases in the LHC through SMOG and acquire proton-gas and lead-gas data (gas in 2024, with protons: He, H, Ar)

**Ready to Heavy Ion data taking in November**; wrt 2023:

- Increase PbPb luminosity with magnet polarity inversion by 20%.
- Increase PbPb number of colliding bunches by 40% [at the price of ~5% less for ALICE, ATLAS, and CMS]



## J/ψ and ψ(2S) in pHe, pH<sub>2</sub> and pAr collisions



- pHe data was taken before the new major alignment update in August
- pH<sub>2</sub> and pAr data is after the major August alignment update
- > Significant improvement seen in agreement with PDG mass and in mass resolution



## Muon system:

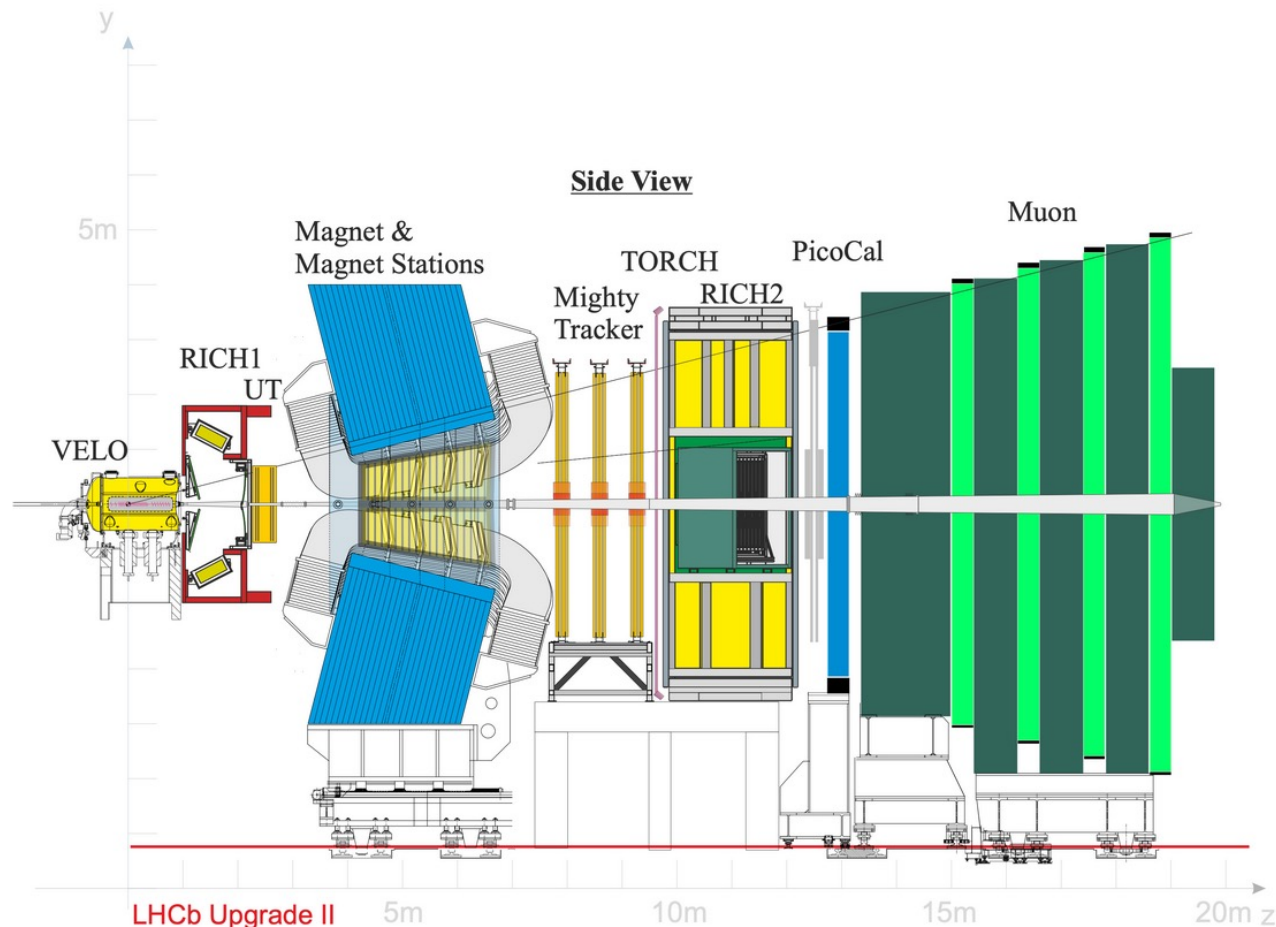
- inner regions: muRwell
- outer regions: MWPC
- electronics
- shielding and infrastructure

- **creation of the Institution Board** (Bari, LNF, Roma 1, Roma 2), lead by M. Palutan: key tool to involve other institutes/countries in the project

## Polarised target

## PicoCal

- contribution from “ex NA62/HIKE”



Relazione del collegio dei referee

A, Braghieri, A, Negri, M, Panareo, E, Robutti, U, Tamponi, T Boccali

[<https://agenda.infn.it/event/42177/contributions/236299/attachments/124898/184030/Referee-LHCB-LS3E+U2.pdf>]

## **LHCB**

## **LS3 Enhancement e Upgrade 2**

### **Criteri di assegnazione**



la CSN1 non può finanziare le richieste LS3E e U2 tout court, prima che i progetti siano stati completamente definiti, insieme allo share di compiti e costi tra i vari membri della LHCB Collaboration (MoU). E prima che gli organi direttivi e scientifici dell'INFN abbiano approvato e deciso la forma di finanziamento.

Pertanto le richieste del gruppo italiano sono state esaminate in questa ottica, valutate e oggetto di una proposta di assegnazione.

- **LS3E**. Valutazione e proposta di assegnazione SJ a review dell'INFN
- **U2, richieste nell'ambito di RD\_FLAVOUR e associate a DRD**: valutazione e formulazione di un finanziamento ritenuto idoneo. **L'assegnazione è costituita dal 50%** di questa cifra **e viene posta sub judice** alle decisioni dell'INFN in merito ai DRD.

# Estratti da CSN1 - 09/2024 - LHCB Upgrades

<https://agenda.infn.it/event/42177/>

Relazione del collegio dei referee

A, Braghieri, A, Negri, M, Panareo, E, Robutti, U, Tamponi, T Boccali

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Sistema	LS3E				U2			
	Rich	Rich SJ	Ass	Ass SJ	Rich	Rich SJ	Ass	Ass SJ 50%
MUON					121.0			56.0
PLUME								
SMOG	20.0			8.0				
RICH	183.0	290.0		83.0	128.0		16.0	36.0
ECAL		150.0		0?	8.0			4.0
RTA	85.0	46.0		127.0				
VELO					51.0		5.0	10.0
UT								
<b>Totali</b>	<b>288.0</b>	<b>486.0</b>		<b>218.0</b>	<b>308.0</b>		<b>21.0</b>	<b>106.0</b>

*Un po'  
meno  
del 50%*

# Requests for 2025: consumo/inventario

Richieste principali sono per muRwell; richieste aggiuntive per MWPC e eco-miscele

## Muon inner regions:

- Sviluppo FATIC **77.0 kEUR** (Bari)  
FATIC3 (in 2024): mainly a bug fixing plus some features integration with respect to FATIC2  
FATIC4 (in 2025), performance improvements: lower dead time ( $\sim 2\mu\text{s} \rightarrow \sim 100\text{ns}$ ), chip's digital features closer to LHCb needs  
+ main requests: 200 chips, 50 FE boards [128chs]
- Rivelatori muRwell **37.0 kEUR** (LNF)  
M2R1 prototype: produced and tested with FATIC3 in 2024 (X-ray characterisation; test-beam)  
M2R2-M5R2 produced and tested with FATIC4 in 2025  
+ main requests: M5R2 prototypes

## Muon outer regions:

- Gas per test con MWPC **2.0 kEUR** (Roma 2)

## Studio miscele eco-sostenibili:

- **3.0 kEUR** (Bari, consumo)
- **2.0 kEUR** (Bari, inventariabile)

## ASSEGNATI

## Muon inner regions:

- Sviluppo FATIC **37.5 kEUR SJ** (Bari)
- Rivelatori muRwell **18.5 kEUR SJ** (LNF)

## Muon outer regions:

- Gas per test con MWPC **0.0 kEUR** (Roma 2)

## Studio miscele eco-sostenibili:

- **0.0 kEUR** (Bari, consumo)
- **0.0 kEUR** (Bari, inventariabile)

# Conclusions

High involvement of the group in the ongoing data taking (Central shifts, Muon and SMOG piquet shifts, Performance evaluation, YETS activities)

## Increasing involvement of LNF for Upgrade II

- Muon, inner regions: DDG group on muRwell
- Muon, outer regions: resuming old memories
- Muon electronics
- Polarised Target (SMOG)
- Calo: just started

## Not forgetting physics

- Ion and Fixed Target [P. Di Nezza, M. Santimaria]
- Bsmm on Run 3 data [V. Chulikov, M. Palutan, M. Santimaria, B. Sciascia]
- B semileptonic decays [P. De Simone, E. Minucci, M. Rotondo]
- Long Lived Particles [G. Lanfranchi]



# *Spare*

# Anagrafica 2024 LHCB-LNF

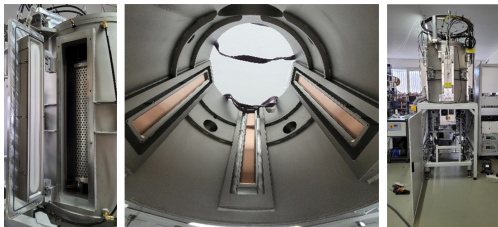
Cognome	Nome	Ricercatore	Tecnologo	MOF A	Autore	LHCB	Altro	Totale	LHCB	Altro	Totale	Persone	FTE/Pers.	Job	Qualifica
Albicocco	Pietro	0	1	1	1				60	10	70			tecn	Tecn
Bencivenni	Giovanni	1	0	1	1	60	10	70						staff	I Ric
Campana	Pierluigi	1	0	1	1	50		50						staff	Dir Ric
Ciambrone	Paolo	0	1	1	0				60	20	80			tecn	I Tecn
De Lucia	Erika	1	0	1	1	60	10	70						staff	Ric
De Simone	Patrizia	1	0	1	1	90		90						staff	I Ric
Di Nezza	Pasquale	1	0	1	1	100		100						staff	I Ric
Felici	Giulietto	0	1	0	0				30		30			tecn	Dir Tecn
Giovannetti	Matteo	1	0	0	1	0	100	100						dott	Dott
Morello	Gianfranco	1	0	1	1	80	10	90						staff	Ric
Palutan	Matteo	1	0	1	1	100		100						staff	I Ric
Pepe Altarelli	Monica	1	0	1	1	100		100						staff	I Ric
Poli Lener	Marco	0	1	1	1				60	10	70			tecn	Tecn
Rotondo	Marcello	1	0	1	1	90		90						staff	Ric
Santimaria	Marco	1	0	1	1	100	0	100						pdoc	Ass Ric
Sciascia	Barbara	1	0	1	1	100		100						staff	Ric
		12	4	14	14	9.30	1.30	10.60	2.10	0.40	2.50	16	0.82		

# Anagrafica 2025 LHCB - Italia

**Totale Italia 135.7 FTE** (includere sigle sinergiche); in lieve crescita rispetto allo scorso anno (131.7)

Sezione	People			Ricercatori			Tecnologi		
	Pers.	FTE	FTE/Pers	Ricercatori	FTE	FTE/Pers	Tecnologi	FTE	FTE/Pers
BA	10	7.2	0.72	8	6.7	0.84	2	0.5	0.25
BO	15	11.4	0.76	14	10.4	0.74	1	1.0	1.00
CA	20	13.4	0.67	15	10.4	0.69	5	3.0	0.60
FE	23	16.9	0.73	17	13.6	0.80	6	3.3	0.54
FI	8	6.9	0.86	8	6.9	0.86	0	0.0	0.00
GE	10	6.9	0.69	9	6.8	0.76	1	0.1	0.10
LNF	24	16.8	0.70	20	14.3	0.72	4	2.5	0.63
MI	16	12.3	0.77	14	11.9	0.85	2	0.4	0.20
MIB	14	10.6	0.76	12	10.1	0.84	2	0.5	0.25
PD	11	6.1	0.55	8	5.1	0.64	3	1.0	0.33
PI	17	14.3	0.84	17	14.3	0.84	0	0.0	0.00
RM1	6	3.5	0.58	5	3.4	0.68	1	0.1	0.10
RM2	5	4.1	0.82	5	4.1	0.82	0	0.0	0.00
PG	8	4.1	0.51	7	4.0	0.57	1	0.1	0.10
NA	4	1.3	0.33	4	1.3	0.33	0	0.0	0.00
<b>Totale</b>	<b>191</b>	<b>135.7</b>	<b>0.71</b>	<b>163</b>	<b>123</b>	<b>11</b>	<b>28</b>	<b>12.5</b>	<b>0.44</b>





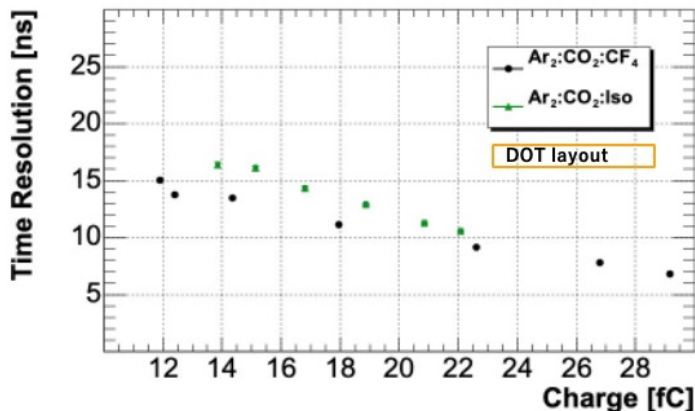
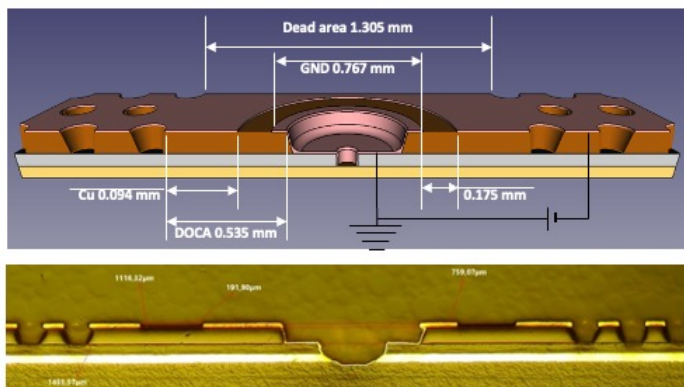
The **CID (CERN-INFN-DLC) sputtering machine**, a joint project between CERN and INFN, is used for preparing the **base material of the detector**. LNF involved on the tuning of the machine: in the 2024 focus on the sputtering of large foils.

## PEP-Dot layout:

- DLC grounding through conductive dots connecting the DLC with a conductive grid on the readout PCB [Pad R/O = 9x9mm<sup>2</sup>; Grounding: Dot pitch = 9mm, dot rim = 1.3 mm] → 97% geometric acceptance

- Results from 2023 Test Beam (H8C) with a preliminary version of the FATIC chip (Bari)

- New Test Beam (Nov 2024) with an updated version of the FATIC aiming at reduce the FEE thr down to 3-3.5 fC.

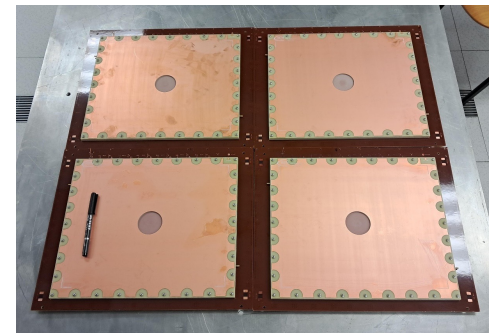


## Prototypes and tests:

- **M2R1 (4)**: funded 2023, delivered Jun 2024: X-ray characterization (Jul 24) then Test Beam with FATIC3 (Nov 24)

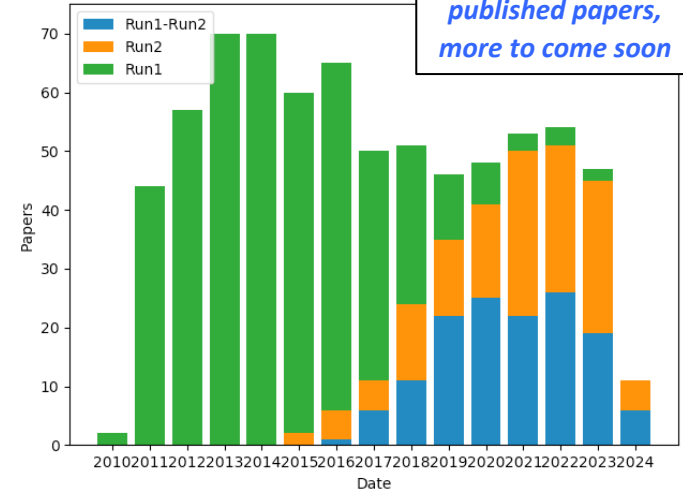
- **M2R2 (2)**: funded in 2024, tentative delivery Apr 25; high rate test (PSI) with FATIC4 in Autum 25

- **M5R2 (2)**: required for 2025



LNF activities  
in green

More than 700  
published papers,  
more to come soon



[For details on all results, see:  
[http://lhcbproject.web.cern.ch/lhcbproject/Publications/LHCbProjectPublic/Summary\\_all.html](http://lhcbproject.web.cern.ch/lhcbproject/Publications/LHCbProjectPublic/Summary_all.html)]

**Physics results: analysis of Run 1+2 data + attaching also Run 3 data**

- Ongoing analyses of Semileptonic, Rare B-decays, Fixed Target

**U1: Major upgrade of all SDs completed on-budget, L= 5×Run 2**

- **2024 data taking:** LHCb followed the LHC intensity ramp up and took data until TS1 (14 June) with all SD in global but UT; after TS1, taking data with all SDs with a good DAQ efficiency (>90%). Now focussing on HLT optimization.

- **MUON:** focussing on DAQ and MuonID performance
- **SMOG2:** Commissioning + Heavy Ion data taking
- **Strong involvement in LHCb organization**

**U2 (\*): U1 will not saturate precision in many key observables; U2 will fully realise the flavour-physics potential of the HL-LHC. U2 is a major change of the detector during LS4: to sustain  $L_{peak}$  up to  $1.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  ( $L= 10 \times \text{Run 4}$ ) aiming at  $\sim 300/\text{fb}$  in Run 5 and Run 6 of LHC. Scoping document in preparation.**

- **MUON:** goal maintain current performance. Solutions proposed, currently under scrutiny:
  - R1-R2 (rates up to  $1 \text{ MHz/cm}^2$ ):  $\mu$ -Rwell detectors with small pads
  - R3-R4 (rates  $\lesssim 50 \text{ kHz/cm}^2$ ): keep most of the present MWPC and read them at their full granularity
- **SMOG3:** polarised target

\* **U2 Frame TDR:** <https://cds.cern.ch/record/2776420/>

# Estratti da CSN1 - 09/2024 - LHCB Upgrades

<https://agenda.infn.it/event/42177/>

Relazione del collegio dei referee

A, Braghieri, A, Negri, M, Panareo, E, Robutti, U, Tamponi, T Boccali

[<https://agenda.infn.it/event/42177/contributions/236299/attachments/124898/184030/Referee-LHCB-LS3E+U2.pdf>]

Sezione	LS3E				U2				MISS (LS3+U2)			
	Rich	Rich SJ	Ass	Ass SJ	Rich	Rich SJ	Ass	Ass SJ 50%	Rich	Rich SJ	Ass	Ass SJ
BA					82.0			37.5	4.0		4.0	
BO									11.5		7.5	
CA	25.0			25.0								
FE	132.0	190.0	29.0						7.5			5.0
FI					6.0			3.0	4.0		0.0	
GE	45.0	100.0	45.0		105.0			27.5	9.0			5.0
LNF	8.0			4.0	37.0			18.5	15.0		15.0	
MI					45.0			2.5				
MIB		150.0		150.0	5.0			2.5	11.0		7.5	
NA												
PD					26.0			13.0				
PG	18.0			18.0					8.0		2.0	5.0
PI	60.0	46.0		106.0								
RM1												
RM2					2.0				4.0			4.0
<b>Totali</b>	<b>288.0</b>	<b>486.0</b>	<b>74.0</b>	<b>303.0</b>	<b>308.0</b>			<b>104.5</b>	<b>74.0</b>	<b>0.0</b>	<b>36.0</b>	<b>19.0</b>

# Requests for 2025: missioni

## Muon@U2: richiesti

### Support per Test Beam:

- 4.0 kEUR (Bari)
- 6.0 kEUR (LNF)
- 4.0 kEUR (Roma 2)

### Turni DLC machine (CERN):

- 12.0 kEUR (LNF)

### Trasferimento Tecnologico (ELTOS):

- 3.0 kEUR (LNF)

## Muon@U2: assegnati

### Support per Test Beam:

- 4.0 kEUR (Bari) --> **Ok**
- 6.0 kEUR (LNF)
- 4.0 kEUR (Roma 2) --> **Ok, SJ**

### Turni DLC machine (CERN):

- 12.0 kEUR (LNF) --> **Ok**

### Trasferimento Tecnologico (ELTOS):

- 3.0 kEUR (LNF) --> **Ok**