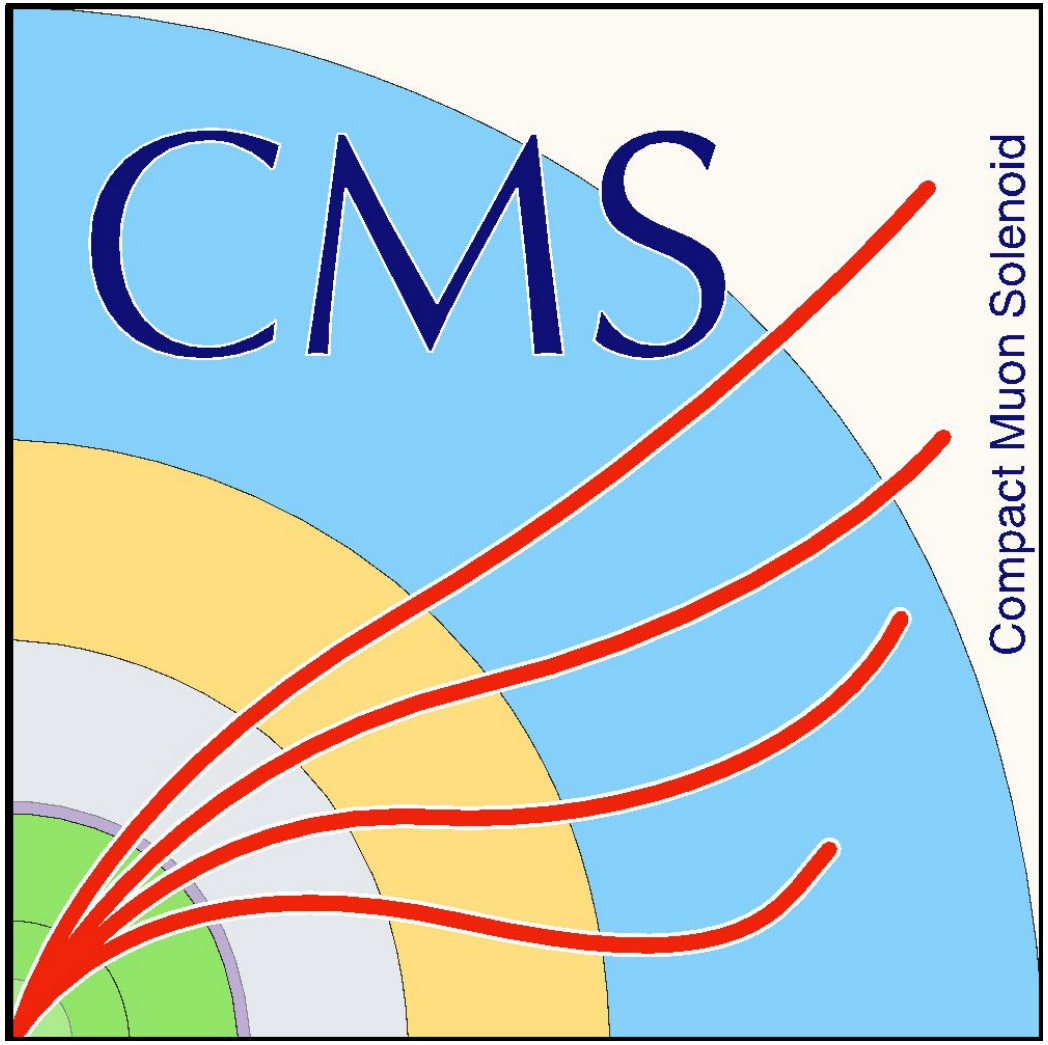
DIPARTIMENTO INTERATENEO DI FISICA

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

INFN
Istituto Nazionale di Fisica Nucleare



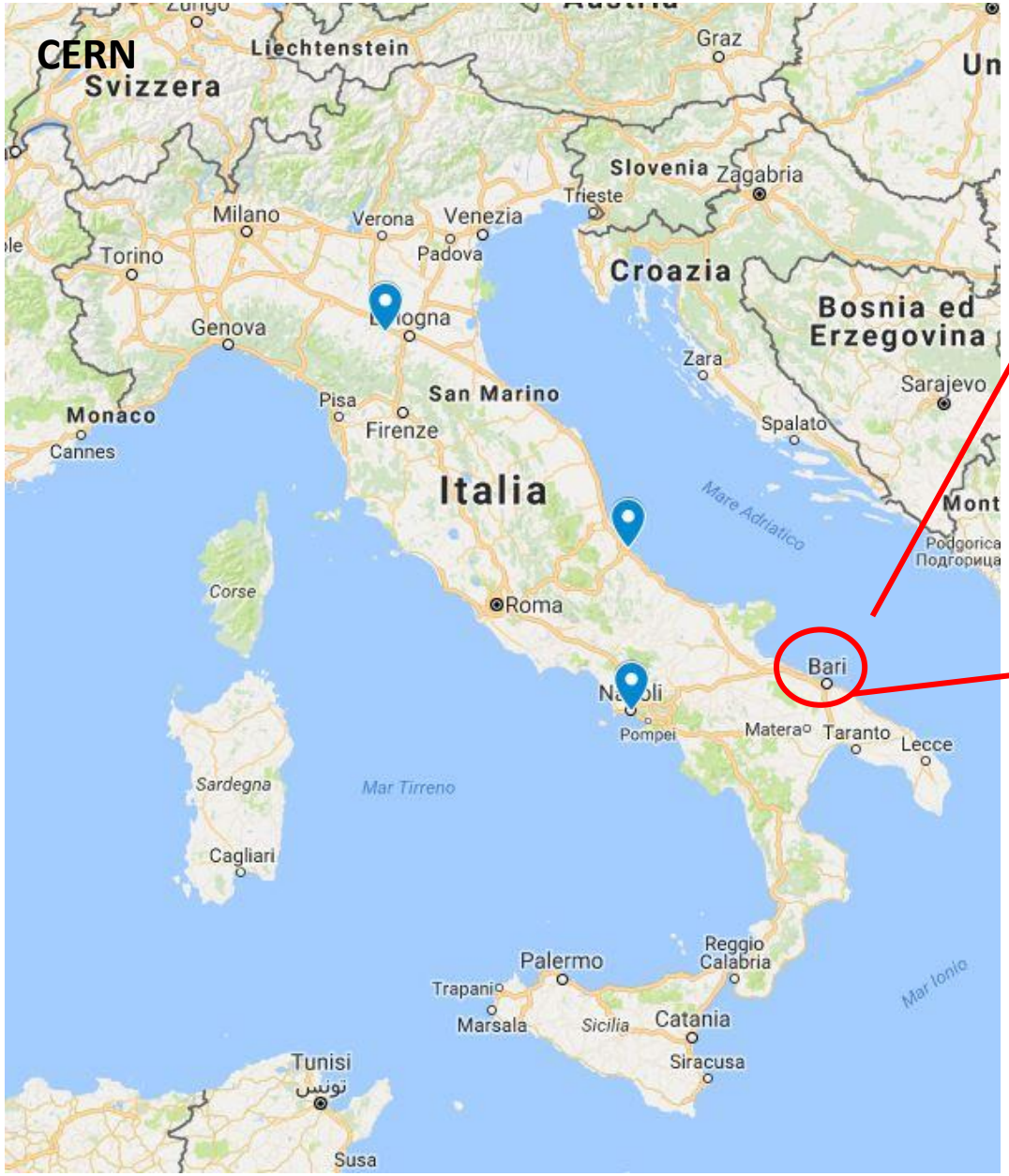
CMS Bari Overview

Rosamaria Venditti
Team Leader

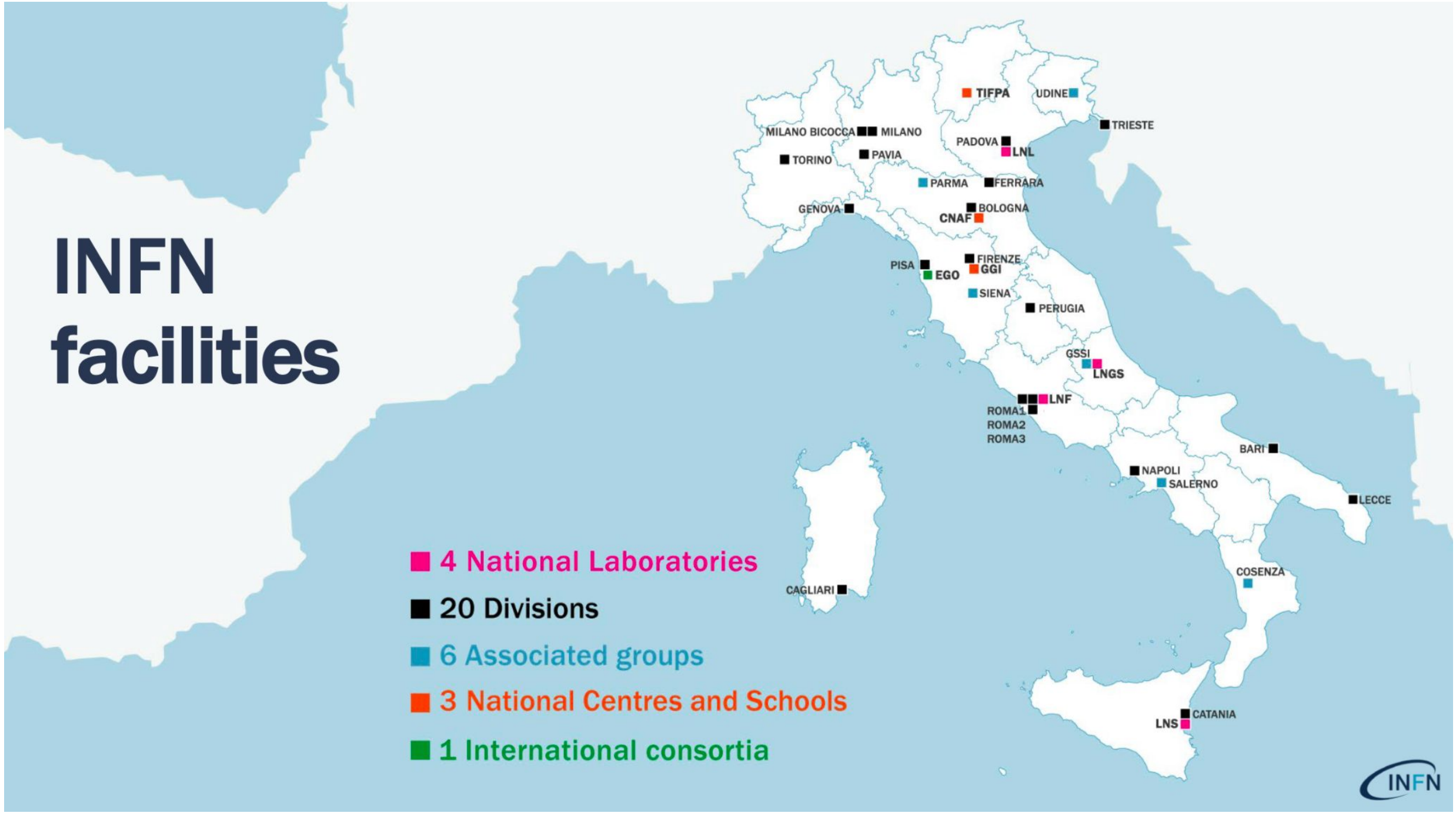
Bari University and INFN

On behalf of the CMS Bari group

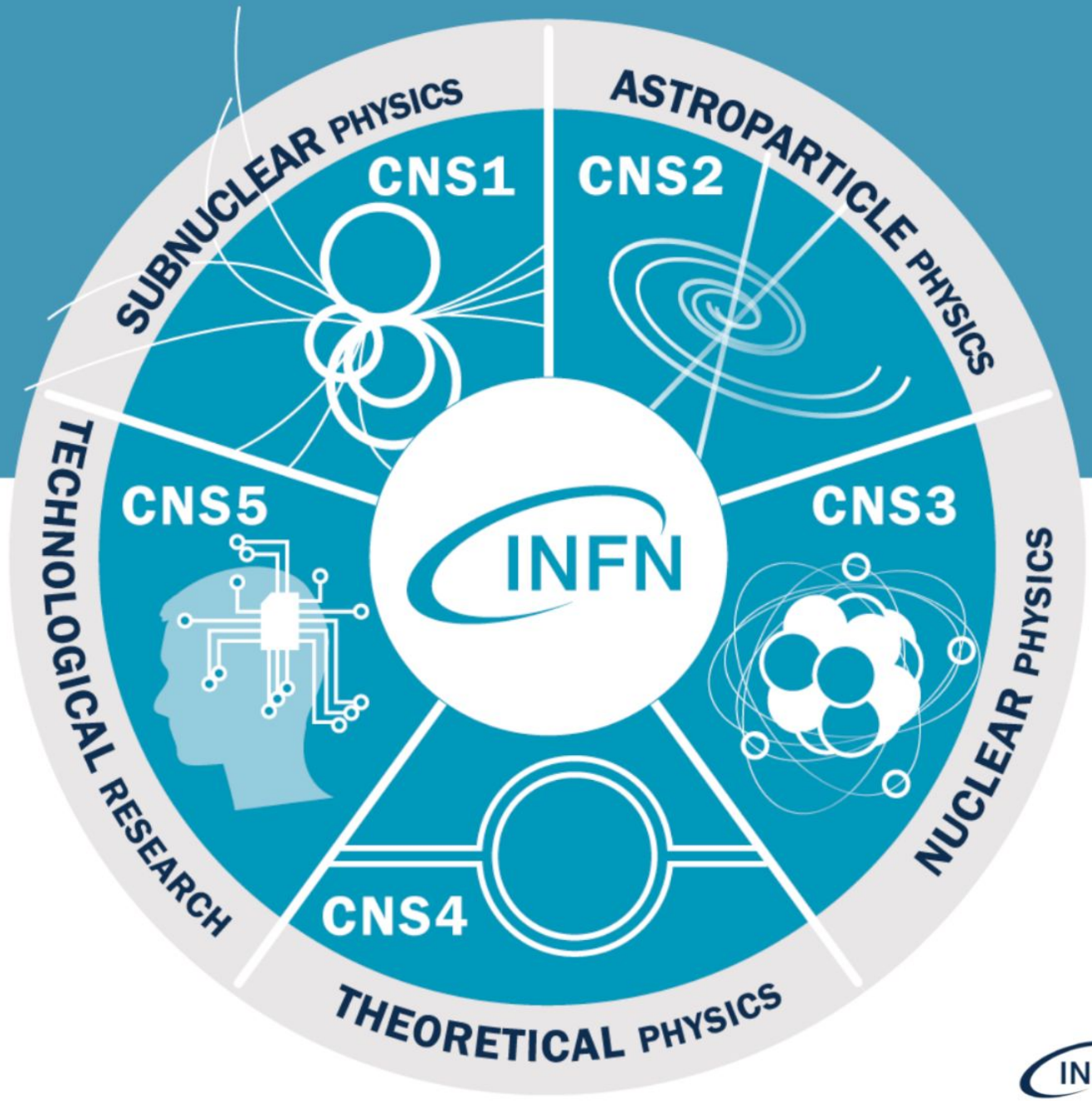
Welcome to Bari University and INFN



INFN facilities



The **5 research lines**
and the National Scientific Committees



A unique scientific organization in the world:

- Each Scientific Committee is composed by representatives of all the INFN facilities, chosen by local elections.
- The representatives (coordinators) vote their president.
- Scientific Committees approve new experiments and evaluate and referee the running ones based on peer review.

INFN

CMS Bari - The group

~40 people for a total of ~25 FTE
(45% staff, 30% PhD, 13% technologist, 13% postdoc)

In CMS since 1995

CMS Bari group: PhD

Muhammad Ali

GEM

Marco Buonsante

GEM

Felice Nenna GEM

Nicola Ferrara RPC

Lisa Generoso GEM

Umit Sözbilir

Analysis

Donato Troiano

GEM but migrating to Tracker

CMS Bari group: Post Doc

Walaa Elmetenawee
Analysis

Magdy Louka Analysis

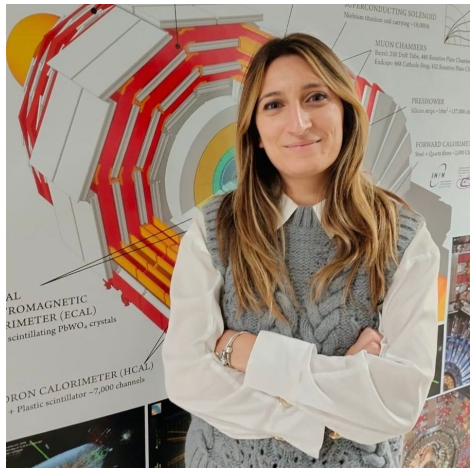
Vincenzo Mastrapasqua
Analysis

Ilirjan Margjeka Tracker

Antonello Pellecchia GEM

Anna Stamerra GEM

Dayron Ramos RPC



Angela Zaza GEM

CMS Bari group

Lucia Silvestris

Gabriella Pugliese

Anna Colaleo

Salvatore My

Donato Creanza

Marcello Abbrescia

Nicola De Filippis

Francesco Cafagna

Giuseppe Iaselli

Giorgio Maggi

CMS Bari group

Marcello Maggi

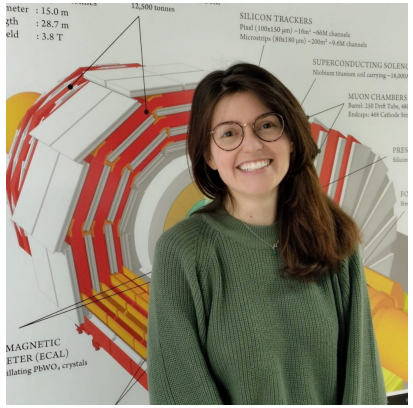
Pompili Alexis

Piet Verwilligen

Luigi Longo

Raffaella Radogna

Rosamaria Venditti



Federica Simone

Luigi Fiore

Salvatore Nuzzo

Mauro de Palma

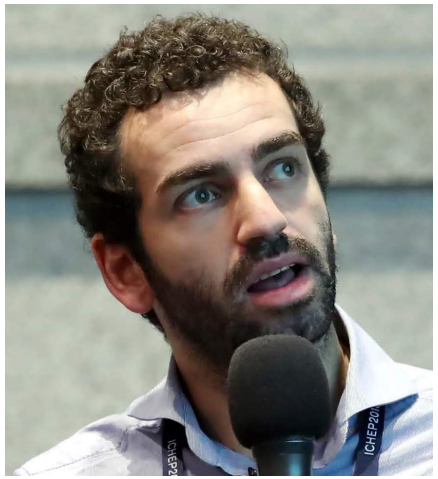
Technologists

De Robertis Giuseppe

Loddo Flavio

Licciulli Francesco

Donvito Giacinto

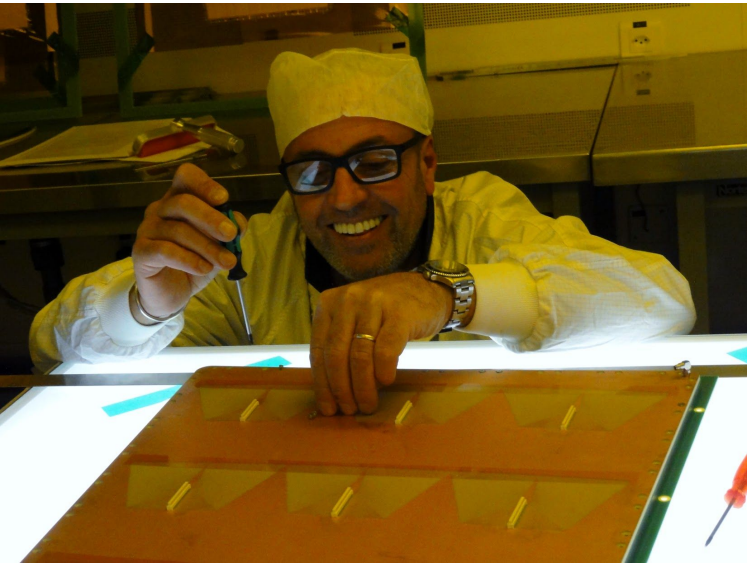


Cristella Leonardo

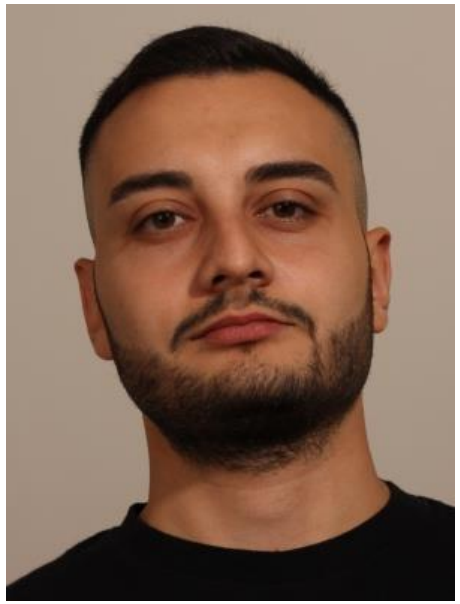
Electronics Service

Computing

Technicians



Michele Franco
Mechanical Workshop



Sabino Martiradonna
Clean Room

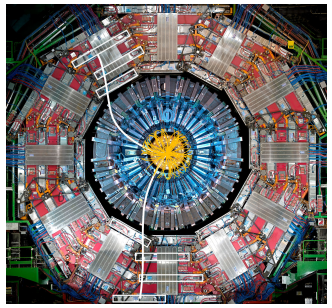
Francesco Maiorano
Electronics Service

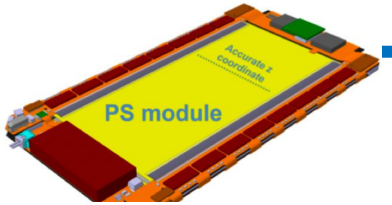
Giuliano Sala
Clean Room

Activity summary

Run3 Operations

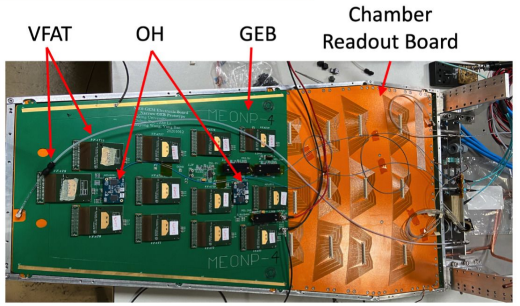
- RPC
- GE1/1
- CT-PPS
- GE2/1, iRPC demonstrators





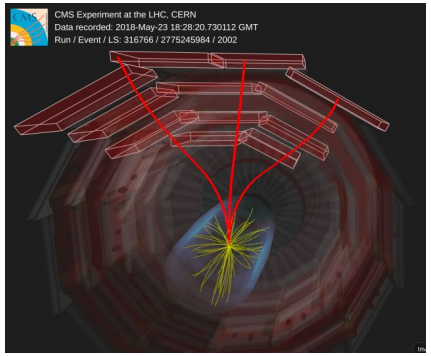
Phase II Upgrade

- Outer Tracker
- ME0



Data Analysis

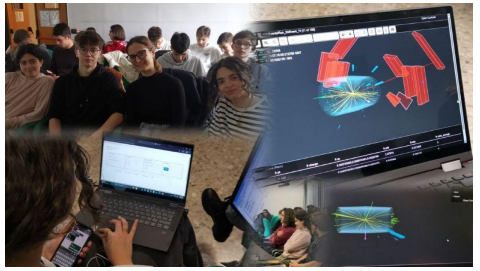
- Higgs, B-Physics
- Muon reconstruction
- Jet Flavor tagging
- Tracking at HLT



Computing

Bari T2 maintenance and operations

Outreach



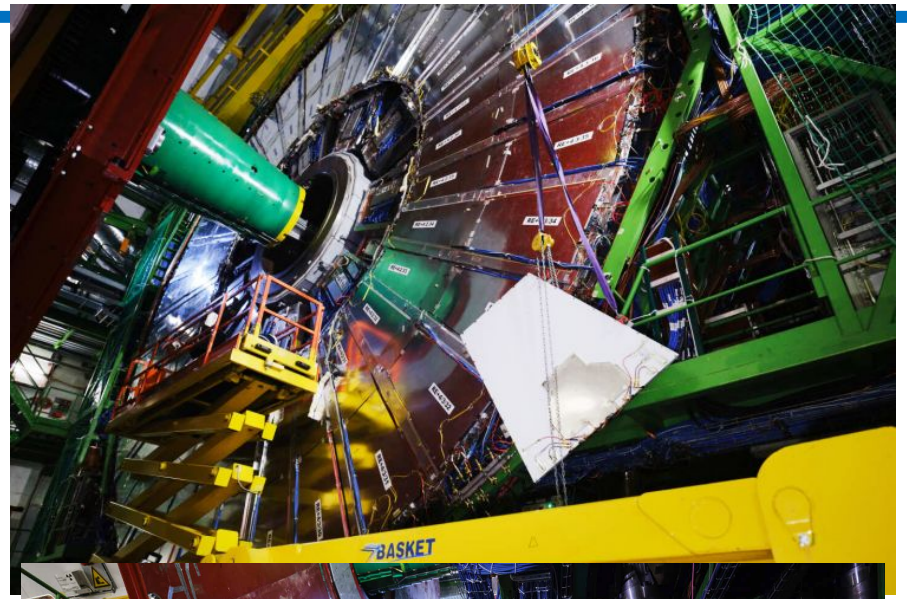
https://www.liceoscacchibari.it/gli-studenti-eee-esplorano-il-cuore-dellesperimento-cms/

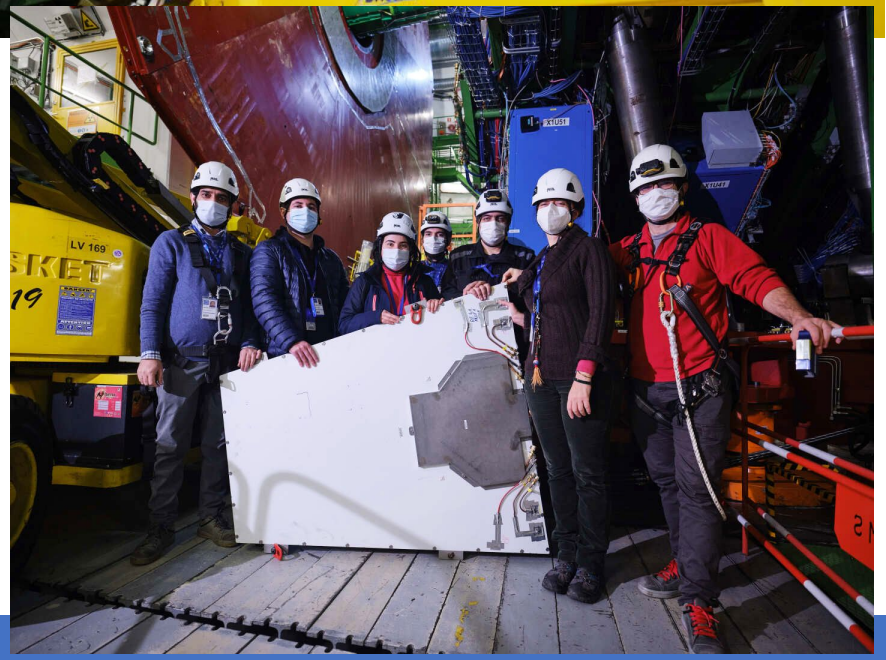
CMS Muon system

G. Pugliese (MUON System Manager L1)

Installation of CMS RPC (2004)

Installation of a new prototype of CMS RPC (2022)





RPC *some history*

Bari group involved in CMS double gap RPC since the CMS construction (several RPC Project Managers from Bari)

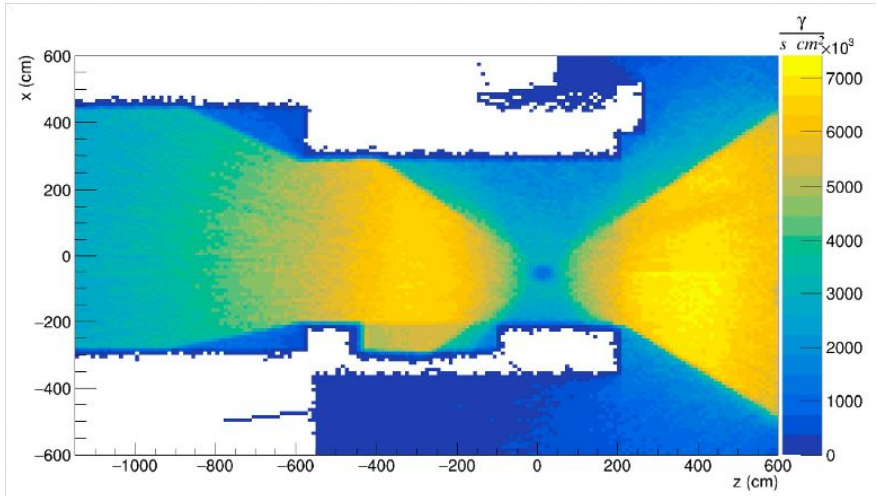
- RPC design, front-end installation and final test
- Test at ISR, installation in CMS, Operations, Online monitoring, performance

Muon Barrel RPC

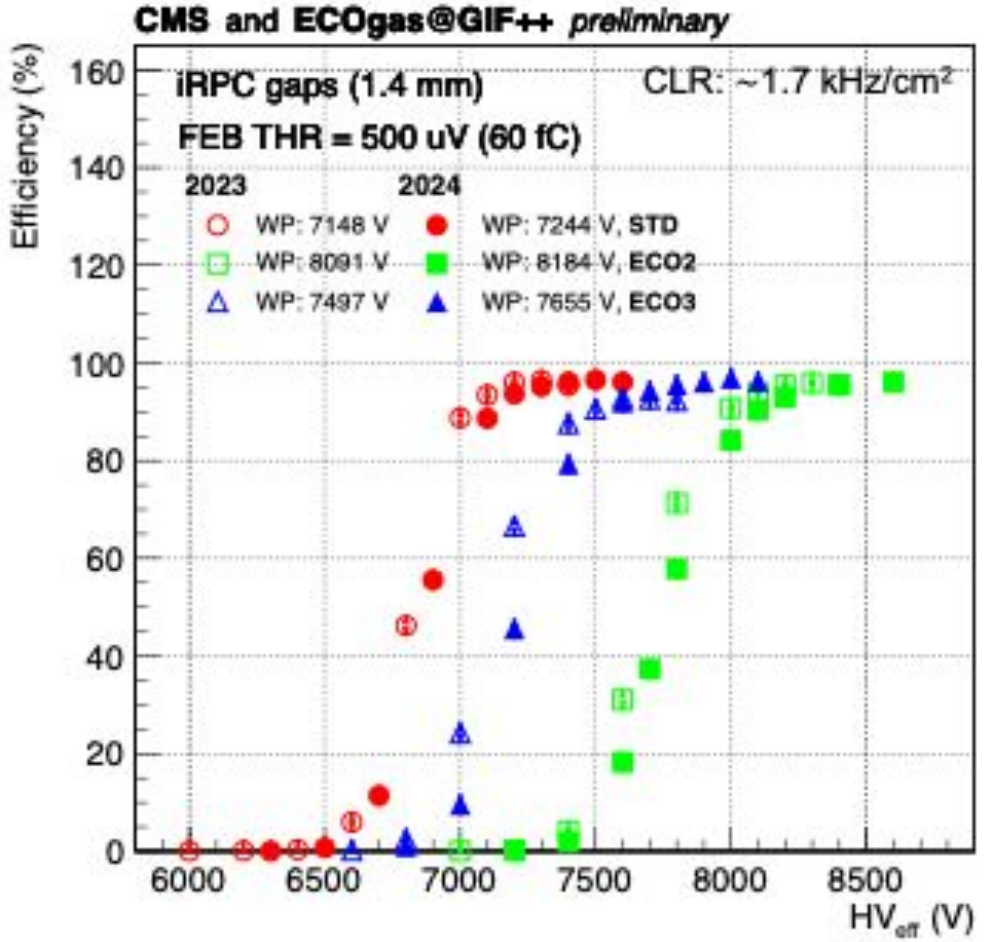
- 70% tested in Bari
- 30% built in Bari

RPC *ongoing activities*

- The Bari technicians were strongly involved in the development of the technique used for RPC leak repairs.
- R&D on new eco-friendly gaseous mixtures for RPC operation (beam tests at GIF++)
- Irradiation campaign for ageing studies of
  - legacy RPC with HFO
  - iRPC with CO2 .
- Monte Carlo simulations of radiation dose at GIF++



Photon flux simulation at GIF++

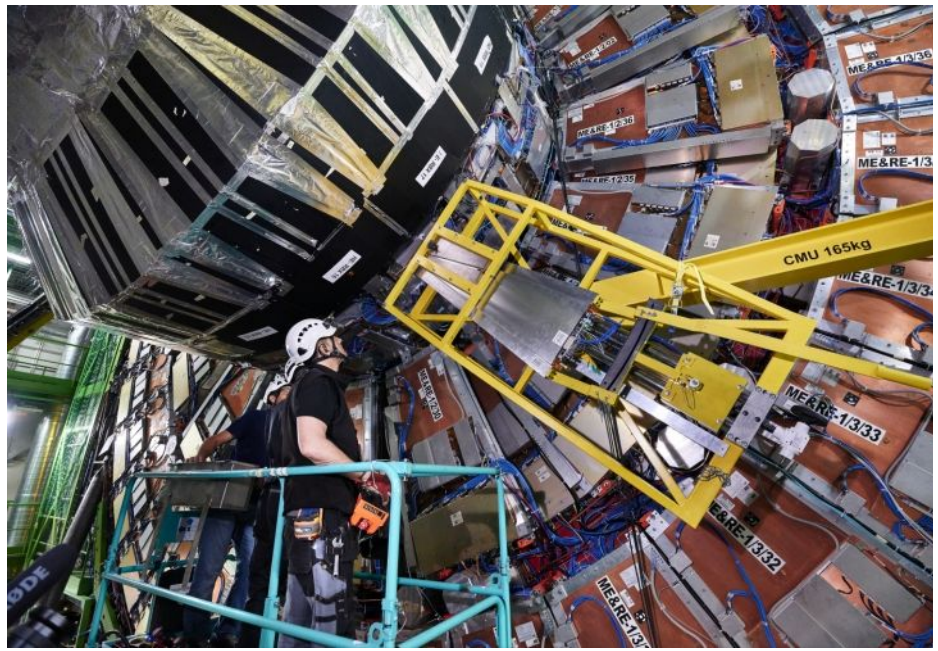


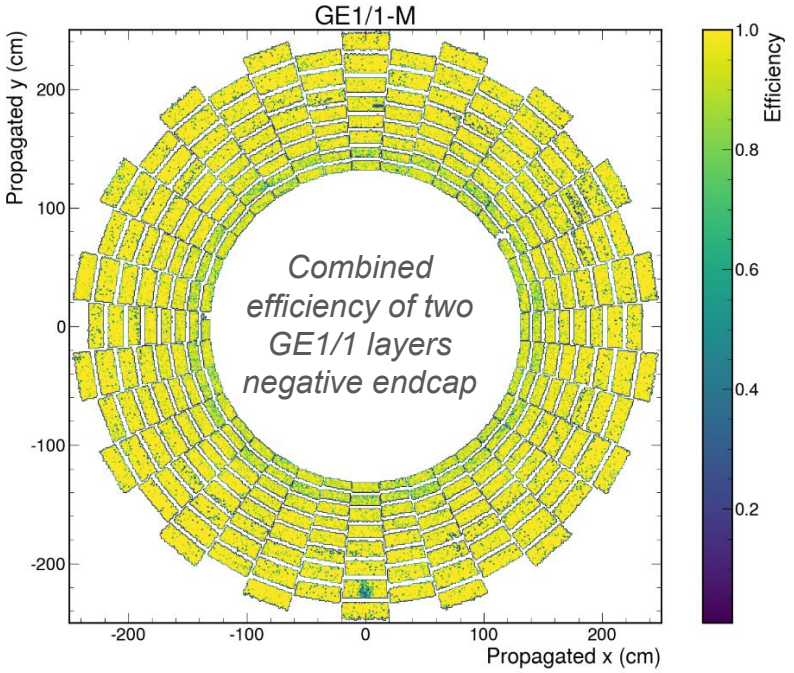
iRPC efficiency for several gas mixtures

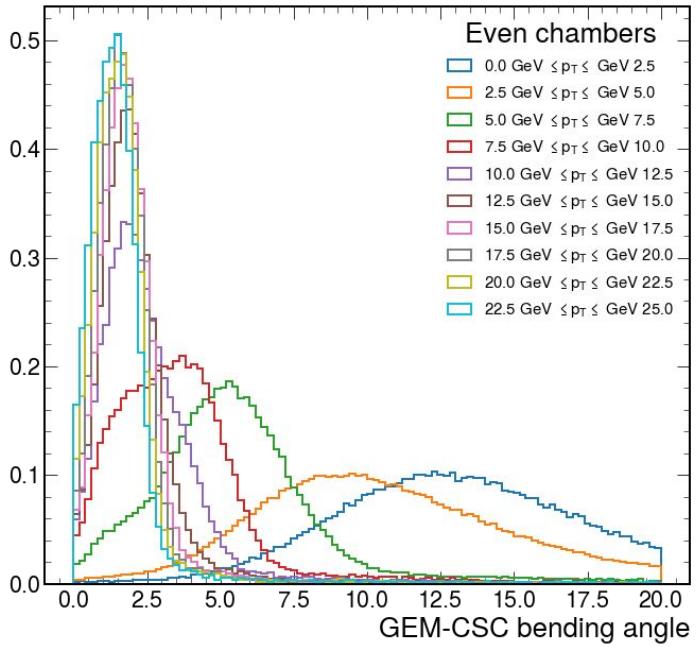
GE1/1 *past and present activities*

Bari group involved in CMS-GEM project since the beginning

- GE1/1: TDR, prototyping, mass production (18 GE1/1 chambers produced and tested), installation, operations, performance, trigger integration
- VFAT3 readout electronics development and testing
- Significant contribution in terms of DOCs





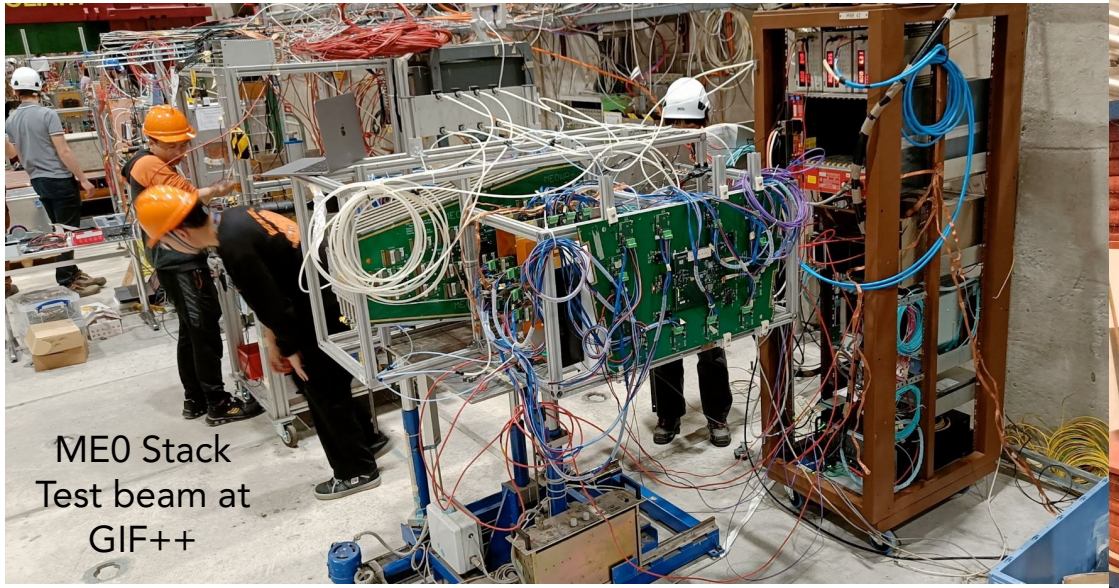


A.Pellecchia GEM Run Coordinator
F. Licciulli GEM Electronics Coordinator

ME0

L. Longo Hardware coordinator (L2)
P. Verwilligen Upgrade Coordinator (L2)

Involved in ME0 project since the beginning (TDR, prototyping, test beam, production)



ME0 Stack
Test beam at
GIF++

- Measurement of segment timing, rate capability with a 6-layer stack at GIF++
- Discharge rate in magnetic field
- In Bari: 50 ME0 modules to be produced and tested by the end of 2026
  - Dedicated and fully equipped clean room an lab
- At CERN: construction of ME0 stack, electronics dressing and test at cosmic ray stand

ME0 module production

ME0 module production

- 1 day for assembly: 3physicists (or 2physicists + 1 technician)

- 1 week for full Quality controls before shipping to CERN

More details in Antonello and Anna's Talk

CMS Tracker*some history*

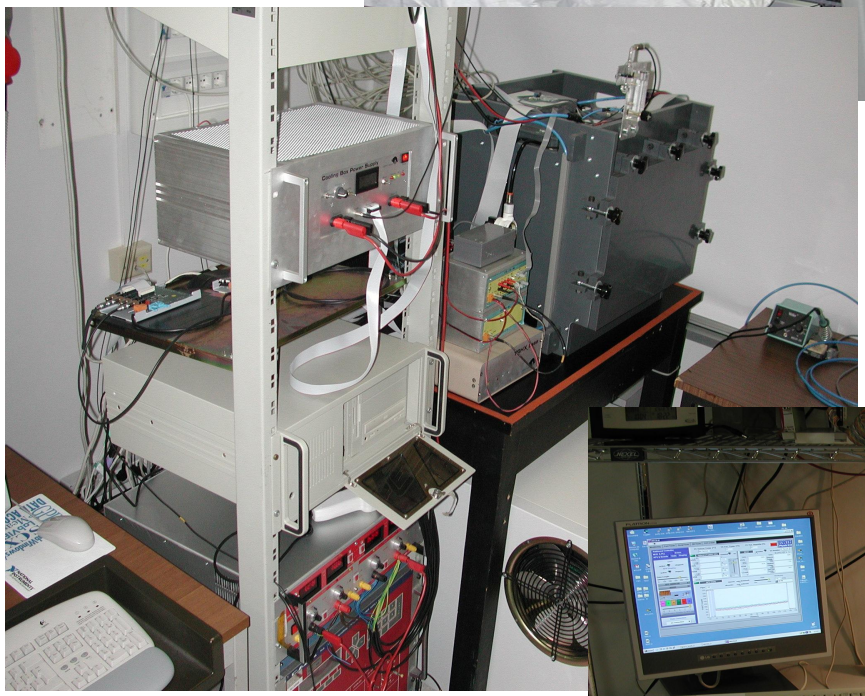
Involved in the silicon module production since CMS construction

- Production: 1926 TIB/TID and 429 TEC modules
- Bonding and test of 414 TIB/TID modules
- Production: BPIX Phase1 Upgrade 300 modules
- TIB/TID integration and Tracker display

Wire-bonding

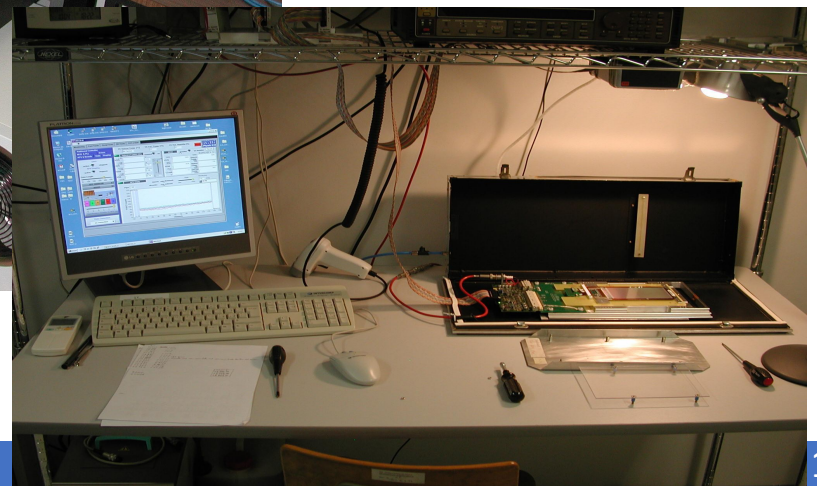
Electronic service:

- Design and prototyping of module bias kapton circuits, Mother Cable, "medusa" cables
- Production of 4000 TIB/TID bias circuits, 886 Mother Cables of 21 different design, 530 " medusa" cables



Thermal cycling test

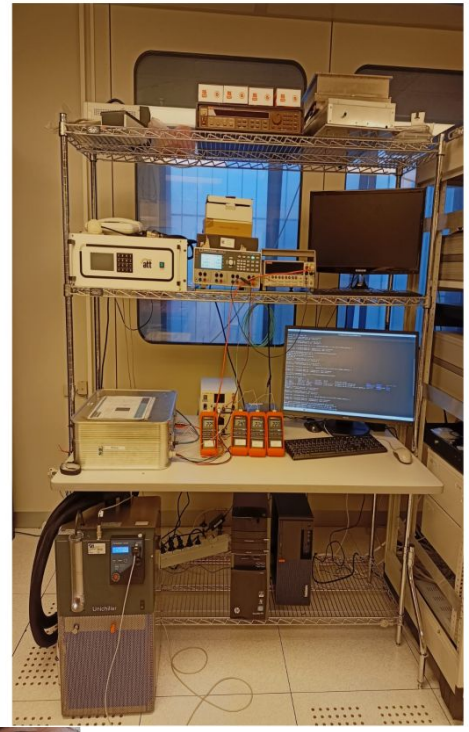
Module ARC test

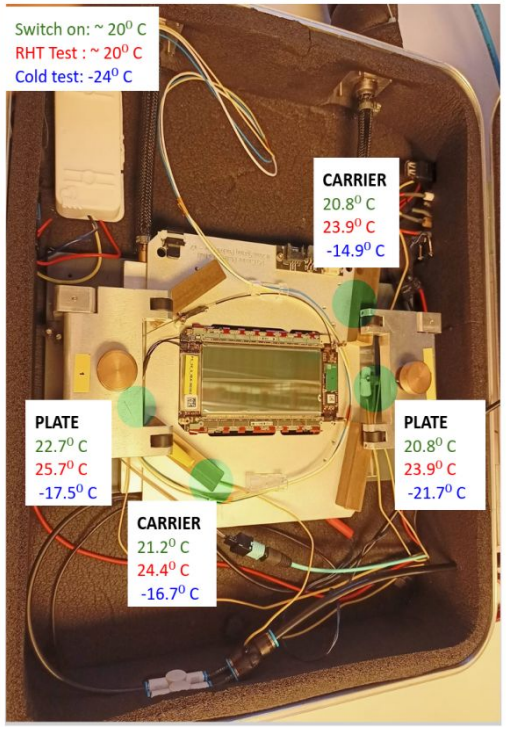


CMS Tracker - PS modules

Set-up test at room and low temperatures (up to ~ –24°C)

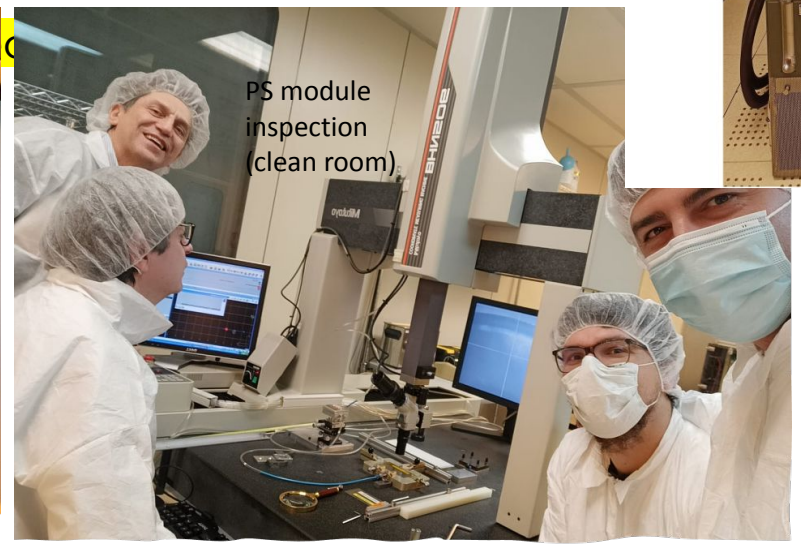
- Fully equipped and dedicated clean room
- Qualification visit to Bari PS production center successfully pass in 2024





Now ongoing

- Outer tracker Pixel-Stip modules production started
- Pipeline test to validate the full production workflow (ongoing i these days)
- 30 modules to be produced by the end of the 2025



1000 modules to be produced by the end of 2027

PS modules production - the team

4 modules/day - 10 days to build a module
- 3 technicians for glueing
- 1 technician wire bonding (+1 for backup)
- 1 physicist: coordination
- 2/3 physicist: metrology and test

More details in Ilirjan's Talk

DAY9: P4 - MITUTOYO	DAY9: P2 - NORDSON	DAY9: P3 - MANUALE	DAY9: P5 - Probe Station	DAY9: P6 - CAPPA??	DAY9: P7 - DELVOTEC G5	DAY9: P1 - Test Station
				Mod 1+2* su Bonding Jig **Strip**		Accensione Chiller
	TC-437 Preparation	TC-437 Preparation		Mod 1+2* su Bonding Jig **Strip**		
	Hibrid Gluing BM 1 + 2** (**Mod 1+2**)	Spacers to MaPSA 1+2+3+4 Gluing + Preparazione Colla Rapida		Mod su jig Lato Strip Contingency	Bond HV Tail	Cold Test Mod 1****
	Hibrid Gluing BM 3 + 4** (**Mod 3+4**)	Colla Rapida Curing			Bond Mod1* **Strip**	
Metro su Bare Sensor 1 + 2	Hibrid Gluing Contingency + Coffee Break	PS* to MaPSA 1+2+3+4 Gluing (**Sandwich**)		Mod1* su Bonding Jig **Pixel**	Bond Mod2* **Strip**	
Metro su Bare Sensor 3 + 4	EP-601-LV Preparation	Rework + Contingency + Coffee Break		Mod2* su Bonding Jig **Pixel**	Bond Mod3* **Strip**	
	Kapton to Baseplate 1+2* Gluing	EP-601-LV Preparation	IV Sensore 1	Mod3* su Bonding Jig **Pixel**	Bond Mod4* **Strip**	Electrical Test After Incapsul Mod 1*
	Kapton to Baseplate 3+4* Gluing	HV Tail to PS 1+2+3+4 Gluing	IV Sensore 2	Mod4* su Bonding Jig **Pixel**	Rework + Contingency + Coffee Break	Electrical Test After Incapsul Mod 2*
Metro Inserti su BP 1 + 2*?	Sandwich 1 + 2* su BP con Kapton* (**BM 1+2**)	Inserti to Baseplate 1+2+3+4	IV Sensore 3		Bond Mod1* **Pixel**	Electrical Test After Incapsul Mod 3*
Metro Inserti su BP 3 + 4*?	Sandwich 3 + 4* su BP con Kapton* (**BM 3+4**)		IV Sensore 4			Electrical Test After Incapsul Mod 4*
Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo
Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo
Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo	Pausa Pranzo
	Preparazione Sylgard	Preparazione Sylgard + Incaps **HV Tail** 1234			Bond Mod2* Pixel	
Metro Bare Module 1	Incapsulamento **Strip** Mod 1 + Mod2 **		IV Sens + HV Tail 1		Bond Mod3* Pixel	Electrical Test After Bonding Mod 1
Metro Bare Module 2	Incapsulamento **Strip** Mod 3 + Mod4 **		IV Sens + HV Tail 2		Bond Mod4* Pixel	Electrical Test After Bonding Mod 2
Metro Bare Module 3	Preparazione Sylgard		IV Sens + HV Tail 3		Rework + Contingency + Coffee Break	Electrical Test After Bonding Mod 3
Metro Bare Module 4	Incapsulamento **Pixel** Mod 1 + Mod2 ***		IV Sens + HV Tail 4			Electrical Test After Bonding Mod 4
	Incapsulamento **Pixel** Mod 3 + Mod4 ***					Inserimento e cabling Mod 1*** in Cold Box

CMS Phase II Pixel Readout

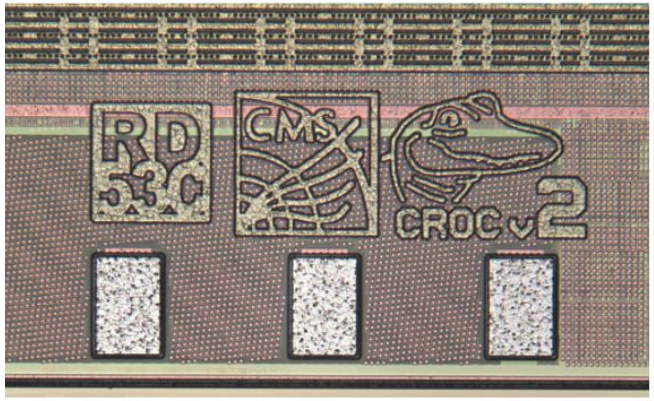
Pixel readout development for HL-LHC

Design activity

- RD53 Project coordination (F. Loddo)
- Chip floorplanning
- Rad-hard 10 bit DAC
- Analog bias network
- Power distribution
- Scan chain architecture
- Sign off verifications for easier production testing

The final chips were successfully submitted to foundry in 2023 and are currently under mass production

Significant contribution from Bari (F.Loddo, G. De Robertis)

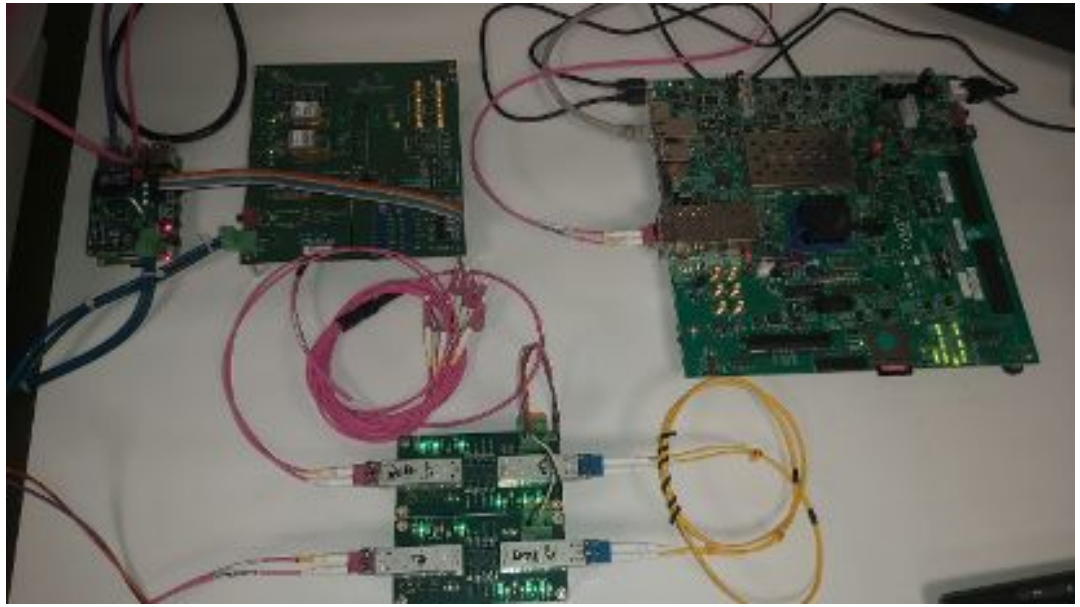


CT-PPS

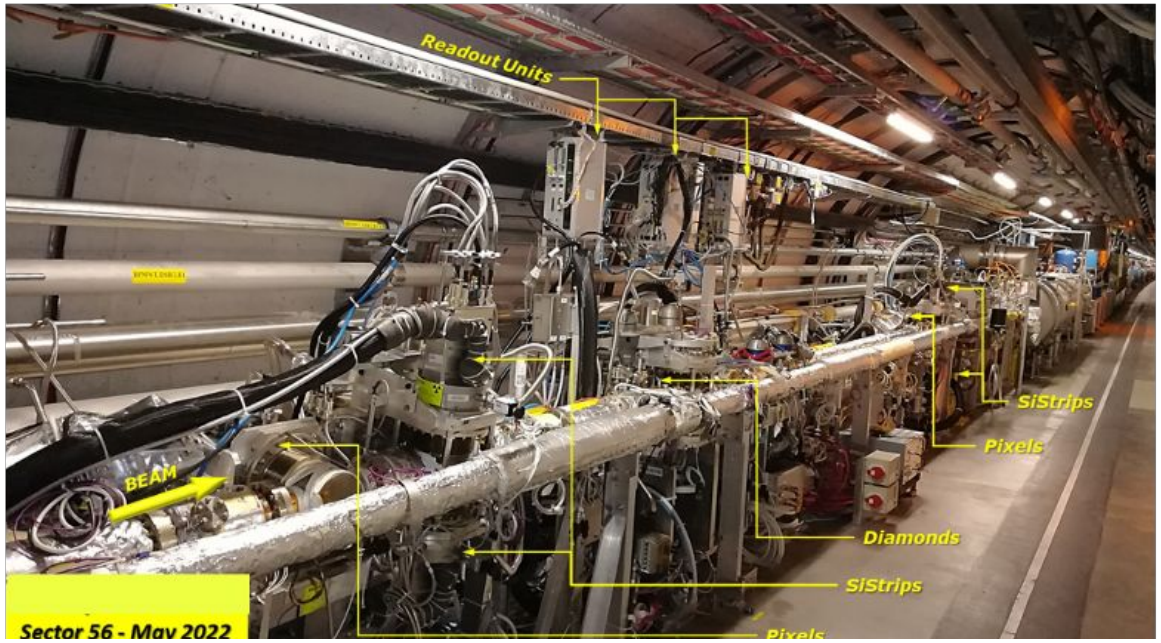
- Support for TOTEM decommissioning and analysis (CMS TOTEM or CT-PPS analysis).
- Online coordination:
  - DAQ;
  - Online software;
  - Precision clock.

F. Cafagna PPS Online Coordinator

- Participation to PPS2 DAQ development.



RP layout in sector 56



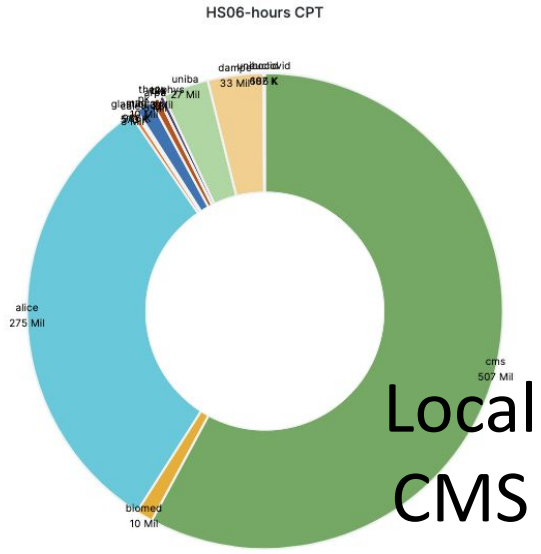
- PPS2: *3D pixels read out by the CROC for tracking and LGADs read out by the ETROC for the timing.*
  - Contribution to the DAQ for both detectors readout.

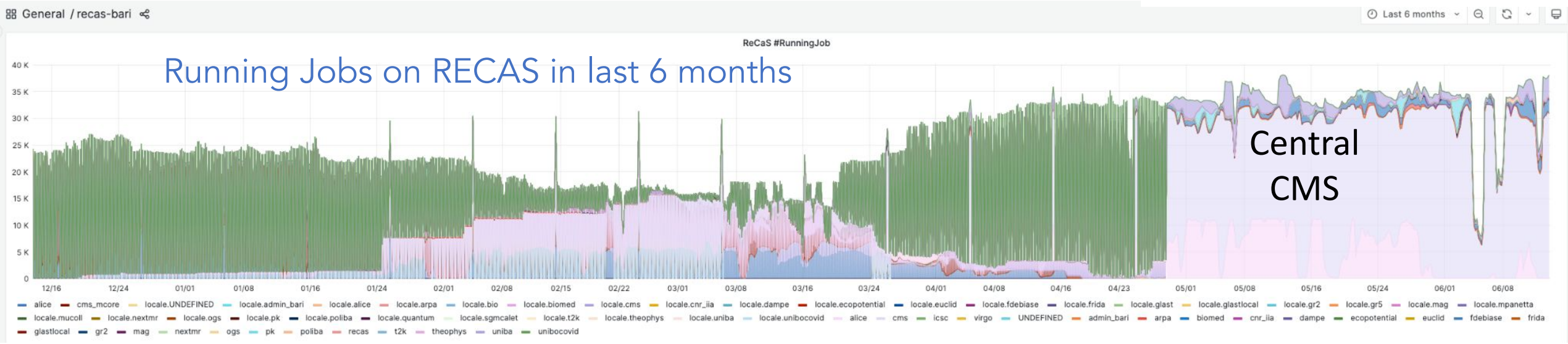
lpGBT and VTRX+ tunnel link testbench for PPS2

Bari T2

Bari hosts a T2 in the computing center Recas, managed by INFN and University

- Around 40’000 cores distributed over 450 nodes
- 16’000 TB of shared disk space on Lustre file system
- HPC cluster: 20 servers, interconnected by Infiniband network
  - 256-392 cores + 4 GPU NVIDIA V100/H100/ server

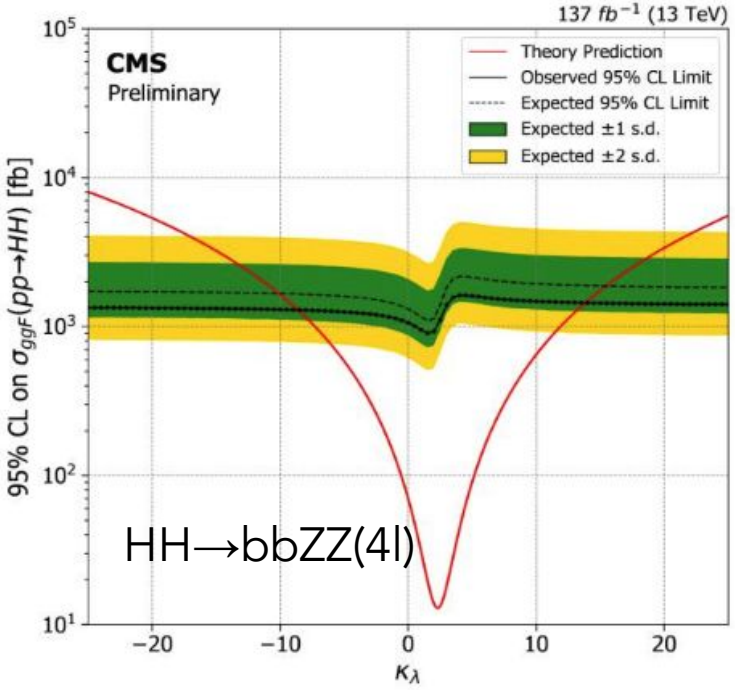




Higgs Searches

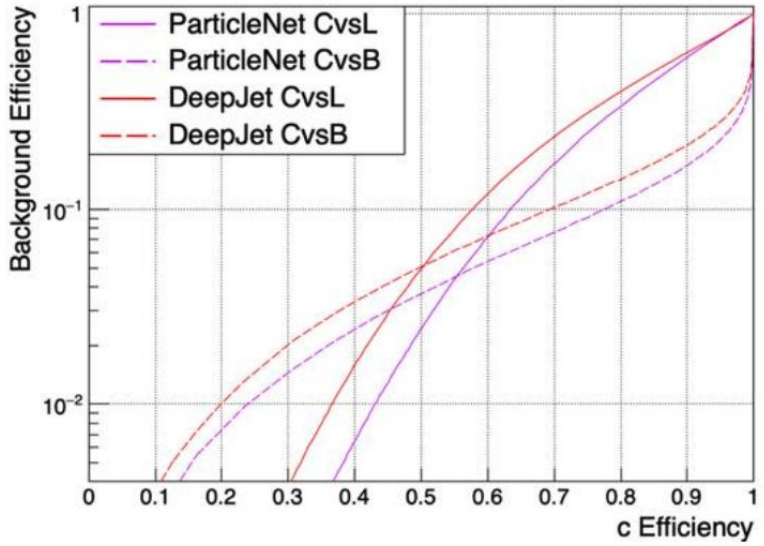
Double Higgs searches

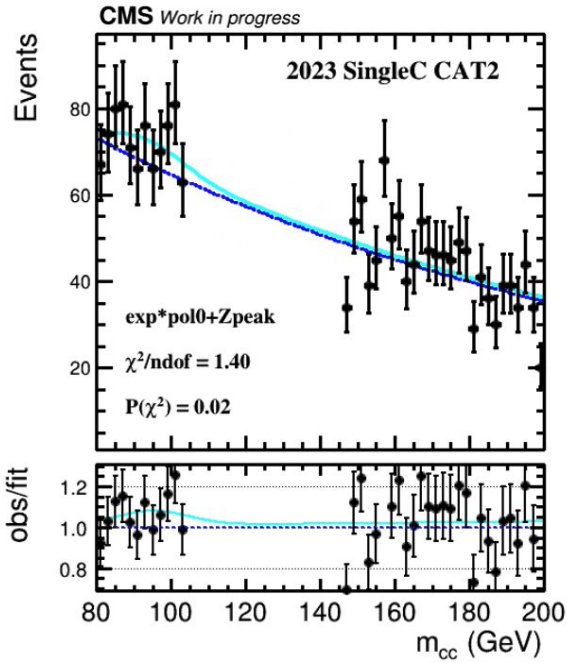
- HH→bbμμ: [PhD thesis, B. D'Anzi]
- HH→bbZZ(4ℓ) res and non-res: [PhD thesis, M. Louka]
- Differential cross section (res and non-res)



Higgs decays: VBF H→cc

- 2023 dataset, first HLT path with PNet [2024 PhD thesis: A. Zaza] → Upper limit on μ ~ 30
  - Sensitivity comparable with ttH, VH
- 2024-2025, VBF parking dataset [PhD thesis: L. Generoso] → analysis ongoing





B-Physics: rare decays and spectroscopy

Rare decays

- LFV τ →3μ (HF channel): [past PhD thesis F. Simone, C. Aruta]
  - Run2: Upper limit BR(τ →3μ) published on PLB
  - Run3: preapproval of 2022+2023 (combined expected UL compatible with Belle)
  - HL-LHC: muon acceptance and ID with ME0 [phD thesis Felice Nenna]
    Contribution to the ESPP document

- Bs→4μ and Eta' →4μ [PhD thesis, M. Buonsante]
  - 2022-2024 inclusive double muon triggers
  - 30% improvement of the current world-best upper limit on the B0s(B0)→ 4μ
  - Evidence of Eta' → 4μ

F.M. Simone: BPH Rare decays Coordinator

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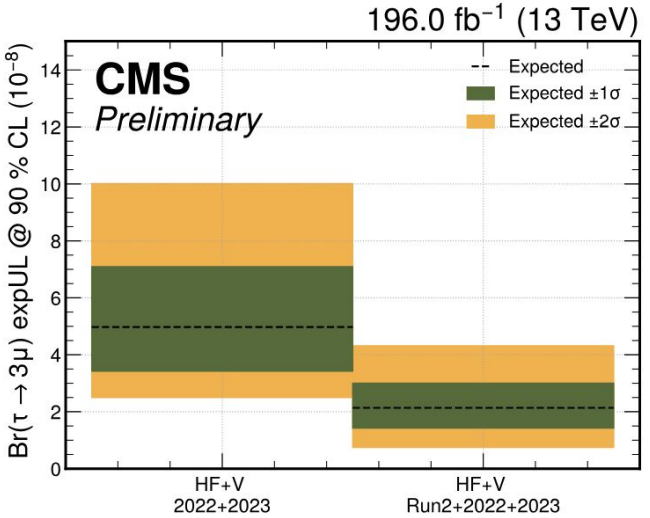
journal homepage: www.elsevier.com/locate/physletb

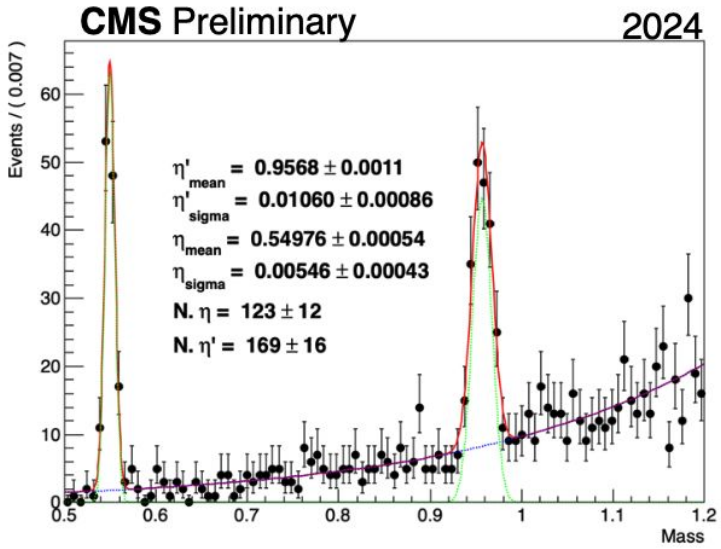
Letter

Search for the lepton flavor violating $\tau \to 3\mu$ decay in proton-proton collisions at $\sqrt{s} = 13$ TeV

The CMS Collaboration *

CERN, Geneva, Switzerland





Bottomonium Spectroscopy

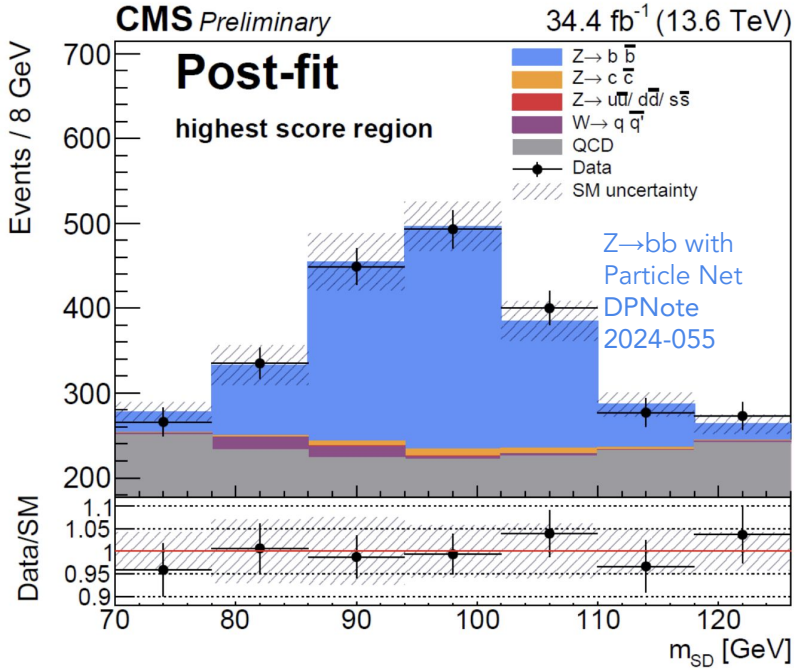
[PhD thesis V. Mastrapasqua]

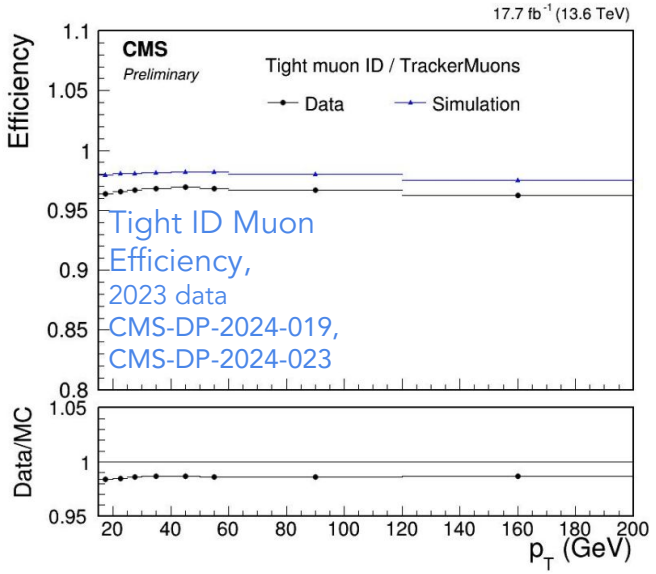
- Bc lifetime [PhD thesis,U. Solibzir]

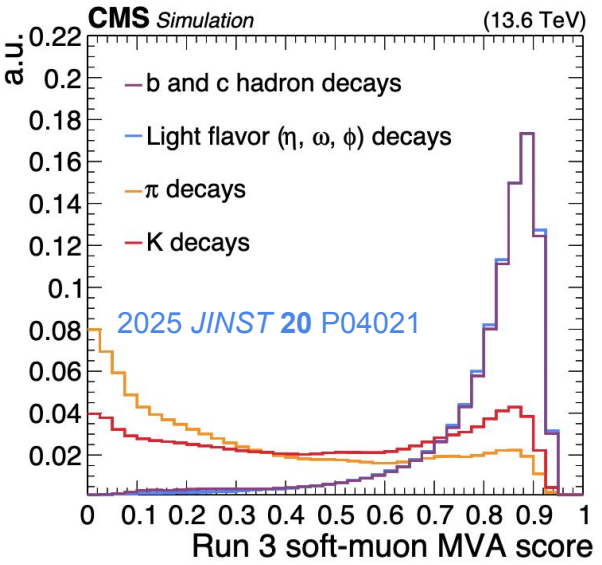
Object reconstruction

- Offline: Muon identification, Jet flavor tagging [PhD thesis ongoing, D. Troiano], Tracking efficiency

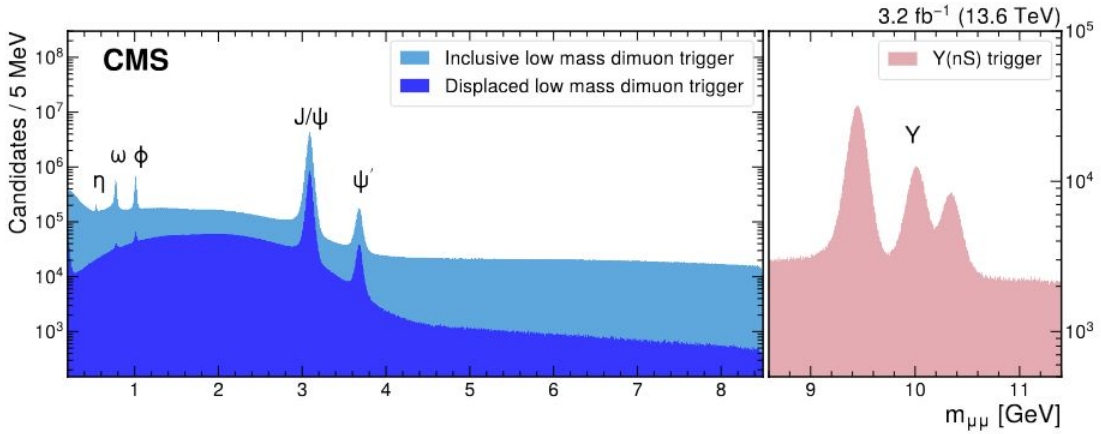
R. Radogna: Muon POG Selection and Identification Coordinator





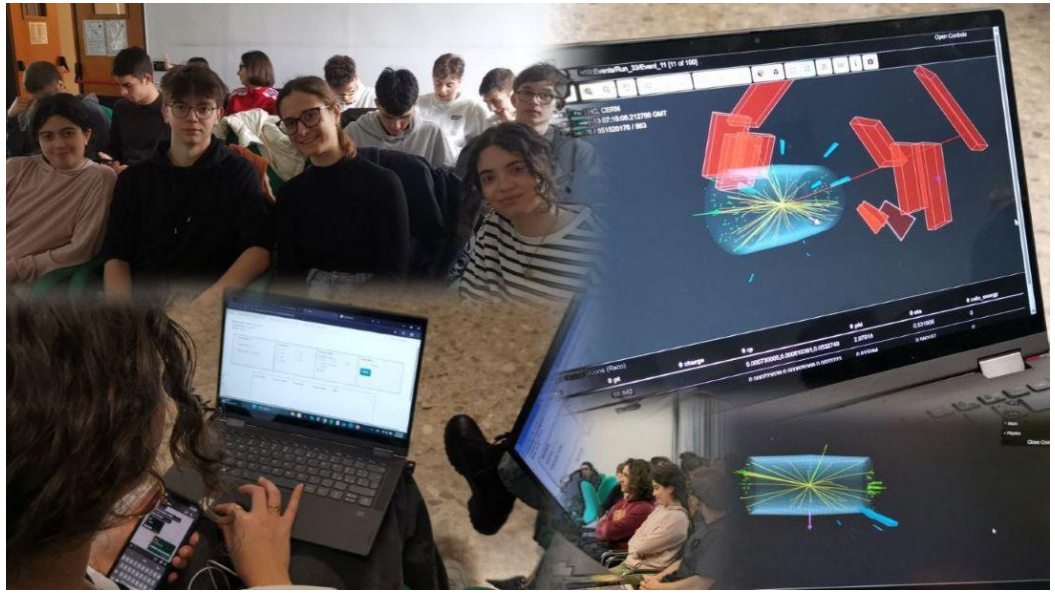


- Trigger performance:
  - Tracking
  - B-Physics
  - B-tagging

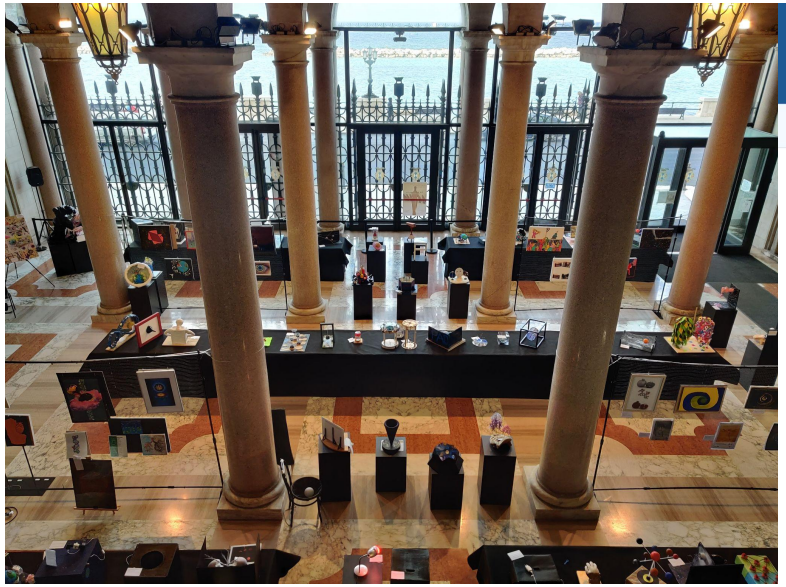


Run3 Trigger Performance, link to arxive

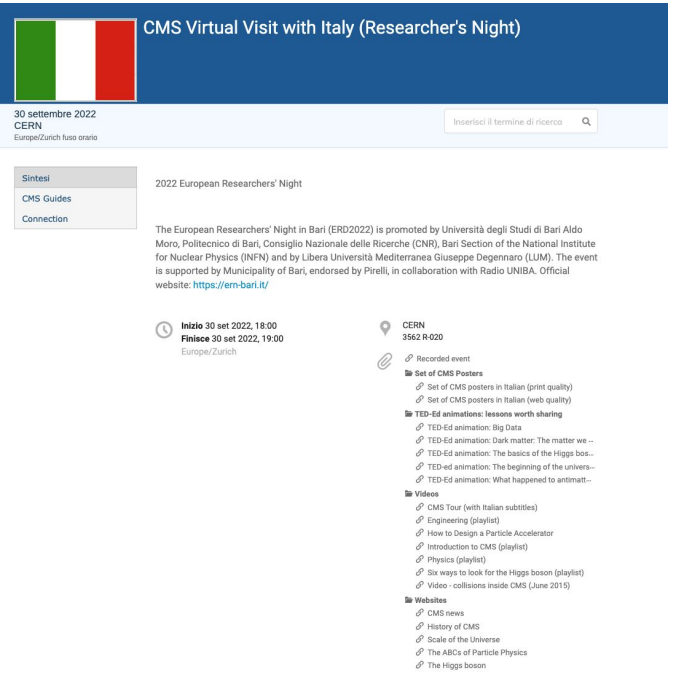
Outreach



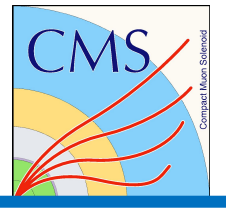
CMS Masterclass
8 schools, 50 students



Art and science across Italy
~10 schools, 300 students

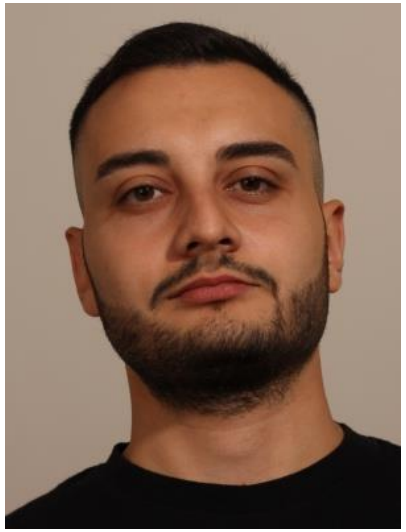


European Researchers Night


CMS
Compact Muon Solenoid

CMS-Bari TK: Technicians and non staff people

Pasquale*



Sabino

Giuliano

Pasquale Cariola* assembly, bonding (just retired)
Vito Porcelli assembly (Fellowship)
Sabino Martiradonna assembly, bonding
Maurizio Mongelli CAD design
Giuliano Sala assembly, bonding
Donato Troiano metrology, Module Test (Post-doc)