Hardware Activities ATLAS-Bo group
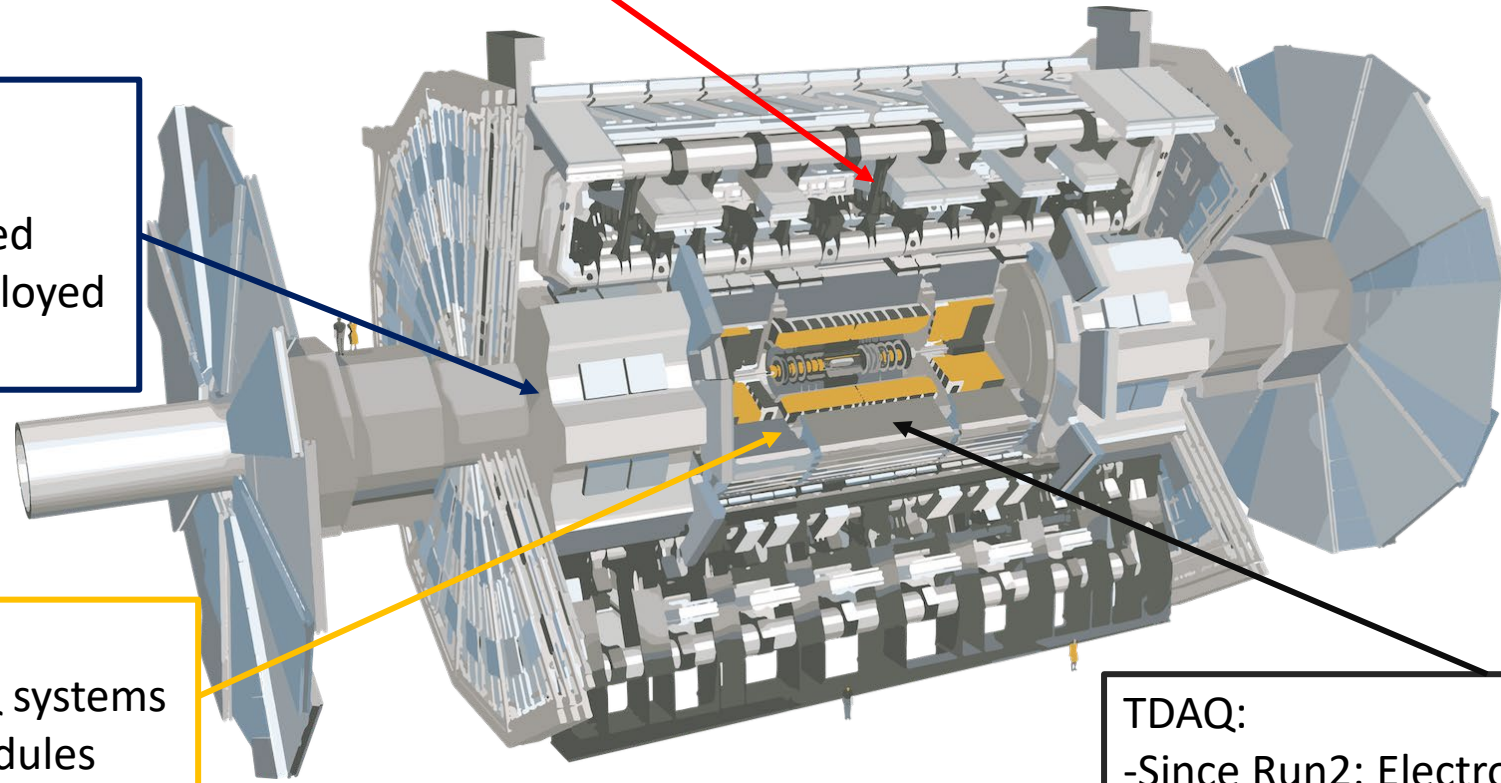
A. Cervelli for the group

Overview

Muon detectors:
-Operation and Amelioration in Run1
-Phase1: BIS 7-8 pilot upgrade project
-Phase2: Muon Barrel upgrade

Computing:
-Support to operations, HPC, MC production

LUCID:
-Operation since Run1
-Phase1: LUCID Upgrade deployed
-Phase2: BMA new detector deployed
-Phase2: New project approved

ITK detectors:
-Phase2: Development of DAQ systems
-Phase2: QC for ITK silicon modules

TDAQ:
-Since Run2: Electronics for IBL
-Phase2: Development of SW or FW based track-trigger

Computing

Personpower:

L. Rinaldi (staff)

M. Negrini (staff

L. Clissa (PhD fino a giugno 2022)

F. Corchia (Laureando Physics con associazione INFN)

F. Semeria (staff, tec)

F. Brasolin (tec)

Activities:

• Supporto alle attività di calcolo distribuito di ATLAS

• Studi su Operational Intelligence per Distributed Data Management and Log Analysis

• Deployment di Analysis Workflows su sistemi HPC

• Sys-admin macchine atlas@P1
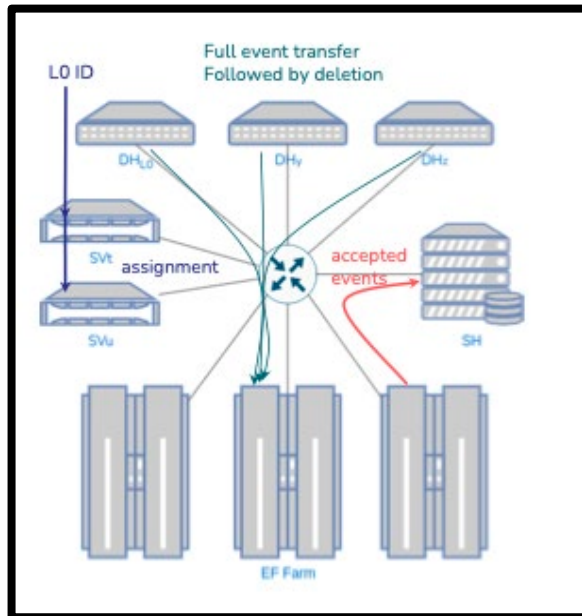
• ATLAS MC Production coordination (M. Negrini)

TDAQ

Hough transform algorithm implementation on FW for ATLAS TDAQ Phase-II Upgrade
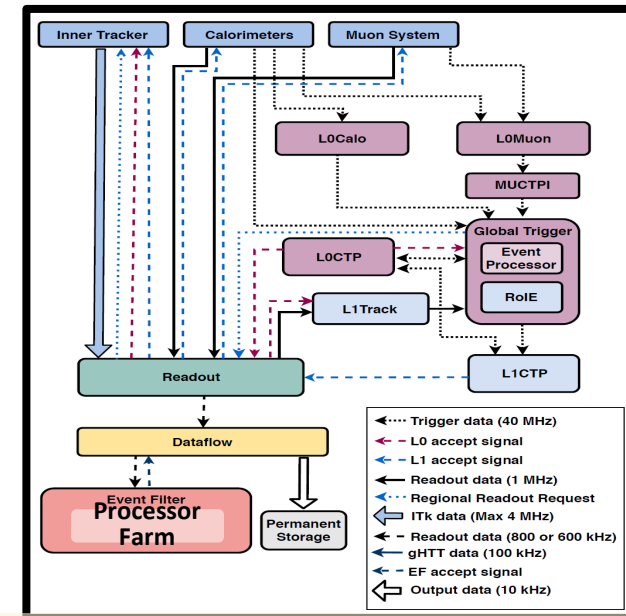
- **Fabrizio Alfonsi** completed his PhD in 2021, started a 2-year PostDoc

  now INFN-Fellow at CERN: specific task t.b.d. about **FELIX integration** or **Event Filter FW design**

- **Francesca Del Corso** just qualified in ATLAS on **test-vector generation** for the HT

- **Alessandro Gabrielli** still involved in the ATLAS TDAQ

  <mark>HT compatible with a reduced regional Track</mark>

- **Giacomo Levrini** new PhD student in Data Science & Computation, started his qualification on <mark>TDAQ networking</mark>: new task for Bologna within ATLAS TDAQ (SW based)

A 2021 ATLAS TDAQ Task Force updated the Phase-II TDR concerning the Event Filter task and now it is SW and commodity HW compliant

- Gabrielli, A.; Alfonsi, F.; Del Corso, F. Hough Transform Proposal and Simulations for Particle Track Recognition for LHC Phase-II Upgrade. *Sensors* **2022**, *22*, 1768. https://doi.org/10.3390/s22051768
- Gabrielli, A.; Alfonsi, F.; Del Corso, F. Simulated Hough Transform Model Optimized for Straight-Line Recognition Using Frontier FPGA Devices. *Electronics* **2022**, *11*, 517. https://doi.org/10.3390/electronics11040517
- Gabrielli, A.; Alfonsi, F.; Annovi, A.; Camplani, A.; Cerri, A. Hardware Implementation Study of Particle Tracking Algorithm on FPGAs. *Electronics* **2021**, *10*, 2546. https://doi.org/10.3390/electronics10202546

Hugh transform implementation in FW

TDAQ

Given a cluster (r, φ) the HT carries out

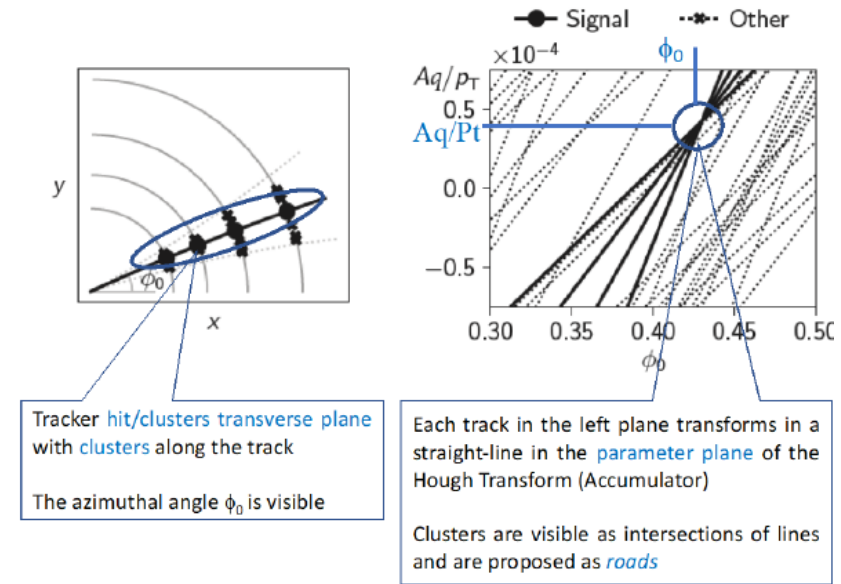$$Aq/Pt = [\sin(\phi_0 - \varphi)]/r \approx (\phi_0 - \varphi)/r$$

with $A=10^{-4}$ GeV c^{-1} mm^{-1} e^{-1}

The use case is for Regions-of-Interests (RoI) of 0.2η x 0.2φ and Pt > 4GeV

The *roads* are the sets of clusters relative to the (Aq/Pt, ϕ_0) values correspondent to the intersection in the parameter space

The current study is to implement the above HT to detect and output the *roads* in real time by matching:
- a total latency less than ≈ 200 ns
- a hardware fit in an individual FPGA
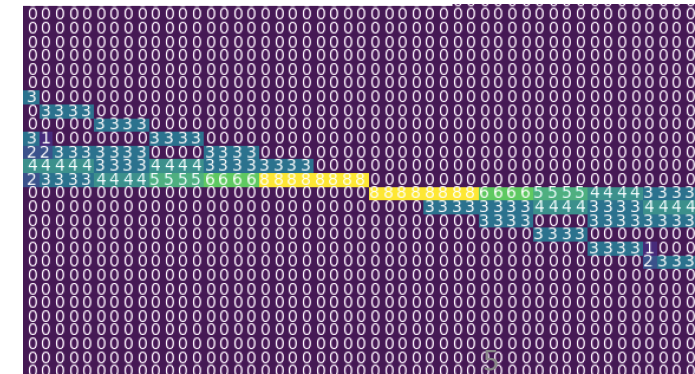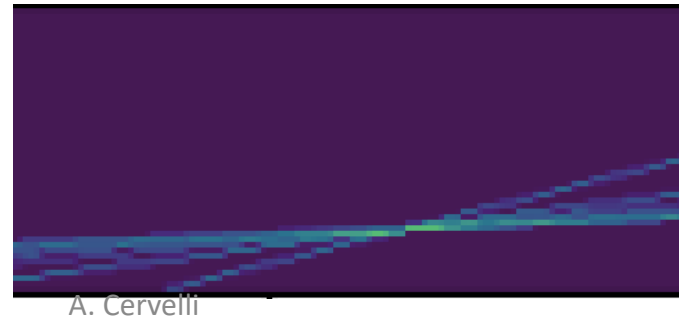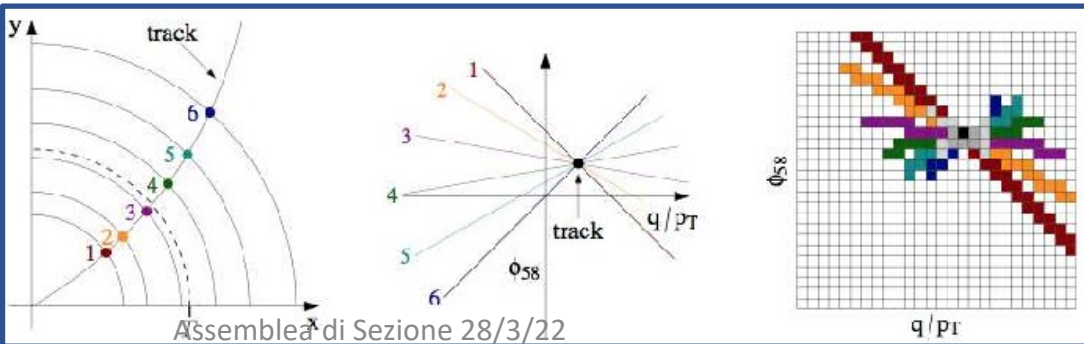- the detection efficiency of the previous studies

Tracker hit/clusters transverse plane with clusters along the track

The azimuthal angle ϕ_0 is visible

Each track in the left plane transforms in a straight-line in the parameter plane of the Hough Transform (Accumulator)

Clusters are visible as intersections of lines and are proposed as *roads*

Phyton-based with Hough space layer counting Bologna

Data to be used shortly to simulate the FPGA-based design

CMS from the WEB

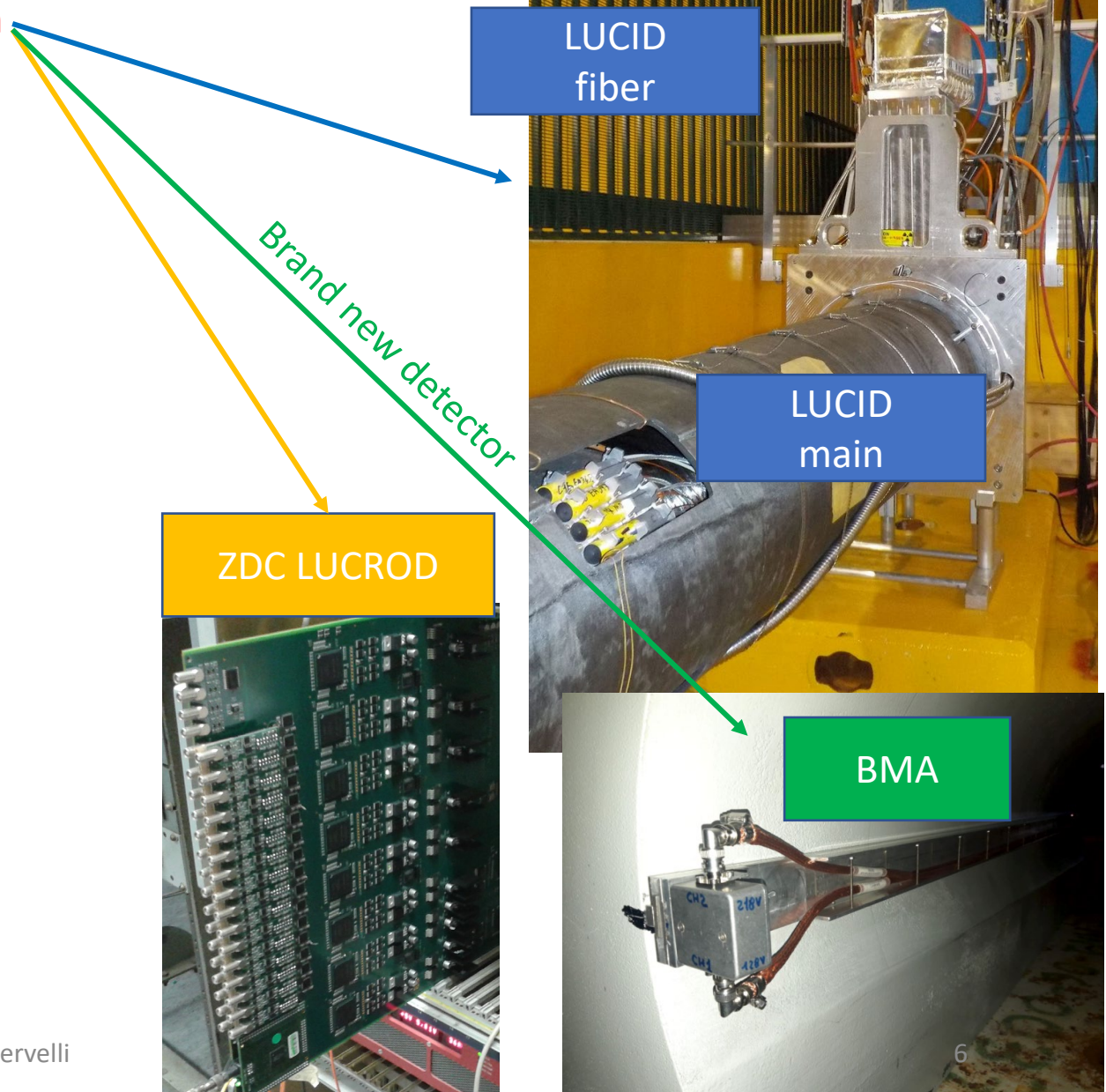Phyton-based Bologna

Assemblea di Sezione 28/3/22

A. Cervelli
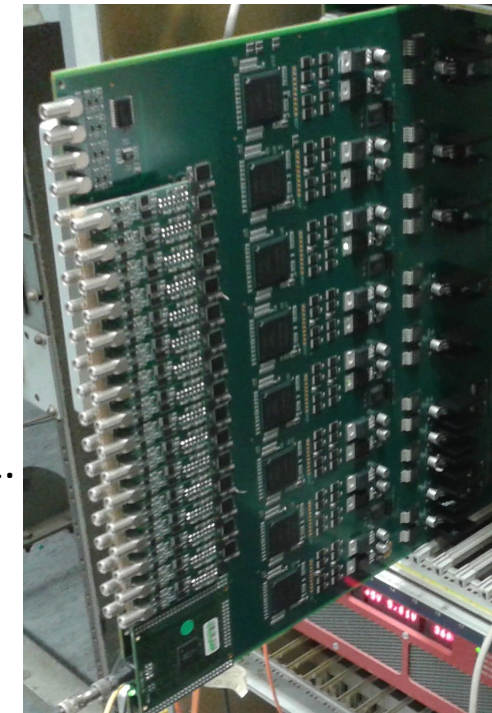
LUCID

Nome	Responsibilities
Laura Fabbri	Responsible for LUCID calibration
Benedetto Giacobbe	LUCID Upgrade Coordinator
	Project leader LUCID3
	ATLAS lumi oversight group deputy coordinator
Federico Lasagni Manghi	LUCID activity coordination Atlas Italia Luminosity coordination Atlas Italia
	LUCID DCS responsible
	LUMAT card responsible
Alessandro Polini	Convenor of the ATLAS Luminosity group
	Coordinator Luminosity group online software and operation
Carla Sbarra	LUCROD card responsible (LUCID & ZDC)
Antonio Sbrizzi	LUCID DAQ Responsible
	Forward Detectors Speakers Committee Chair
	LUCID MC simulation Coordinator
	Luminosity algorithm qualification
Sara Valentinetti	ATLAS Luminosity measurement optimization

LUCID fiber

LUCID main

ZDC LUCROD

Brand new detector

BMA

LUCID & ZDC

- LUCROD for LUCDID and ZDC

- LUCID Readout board LUCROD was used also by Zero Degree Calorimeter (ZDC) → dedicated detector for Heavy Ions run (Run-3) e HL-LHC.

- 9 LUCROD produced by LINK → now testing

- 2 LUCROD Successfully commissioned during LHC pilot beam Oct 2021.

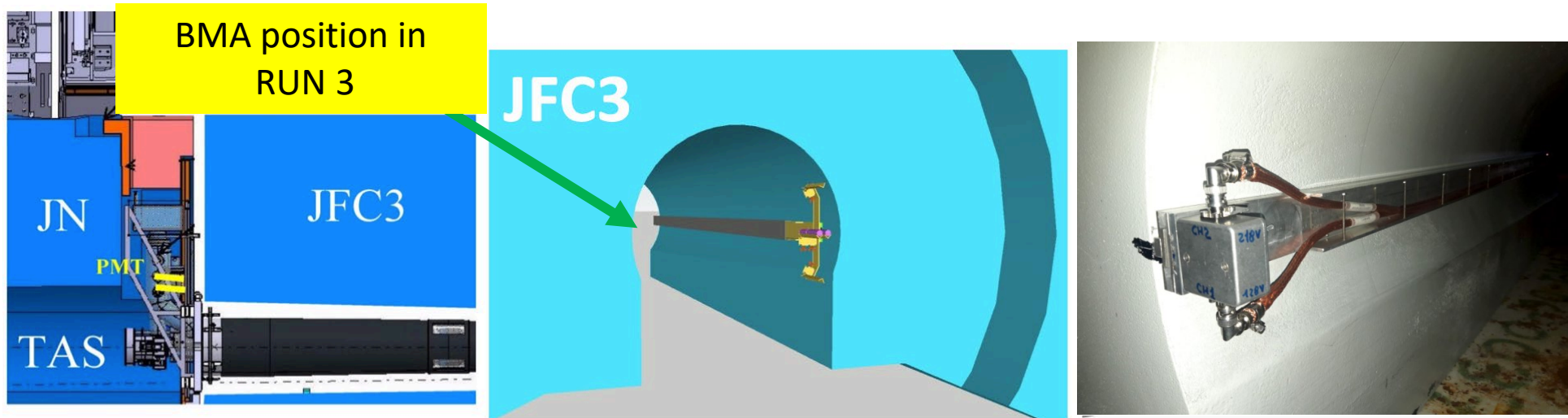- 6 LUCROD (ZDC full readout) tested during ATLAS Milestone week 12.

- Run3 preparation Completed
  - Refurbishment and installation of Run2 prototypes
  - In Bologna: characterization of PMT&fibers *Ongoing*
- DCS &TDAQ software tested and ready for deployment
- Official ATLAS Luminometer: 1.7% precision on measured Lumi
- LUCID 3 IDR approved
- Preliminary Lumi measurement with new setup foreseen in 2022

LUCID: BMA (Beam Monitor for Atlas)

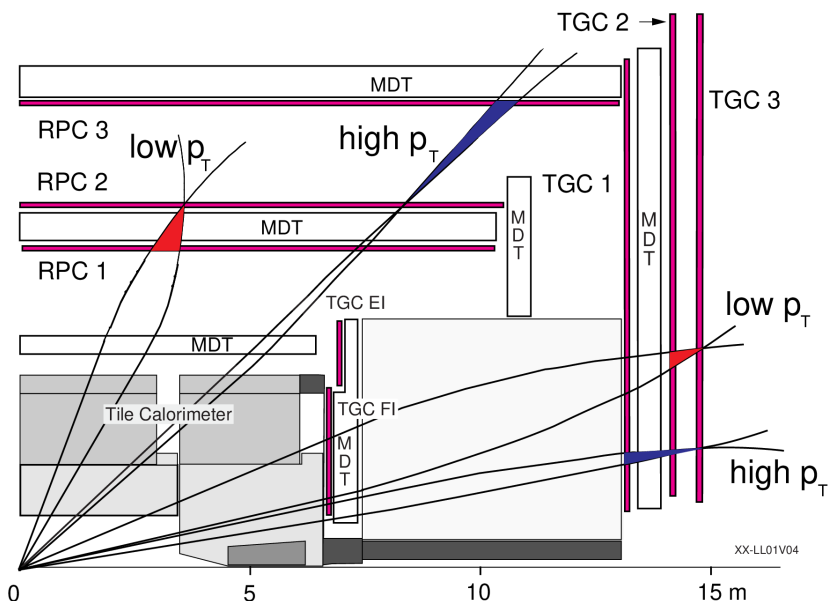G. Avoni, M. Bruschi, A. Sbrizzi

BMA position in RUN 3

- Novel design for Luminosity measurement in Run4

- Detector based on LGAD detectors, feed to a CAEN charge amplifier

- Strong synergy with LUCID development, now readout with LUCROD boards

- 2-channel prototype installed in Feb 2022 inside the ATLAS JFC3 *forward shielding*

- Fully developed by Bologna Group

- A prototype will take data during the full Run3

Muon Detector

- Main involvement RPC detector: muon trigger system in the barrel region
- 3 RPC layers (2 for low pT, 1 for high pT)
- ~4000 gas chambers, ~8000 readout panels, 370k channels
  - INFN Bologna effort since 2005 with RM1, RM2, NA, LE
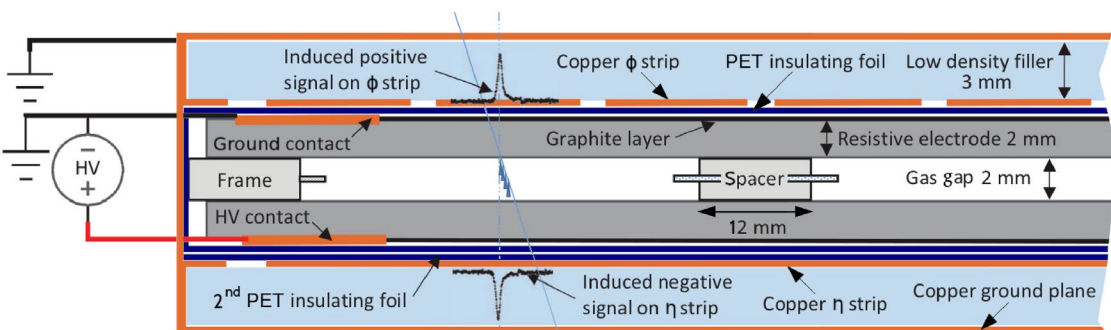 - Barrel Muon: INFN complete responsability of bothdetector (BO,RM2) and trigger (BO, RM1, NA)

Ameliorations and operations in Run2:
- Modified gas systems to reduce leaks. Repaired external gas connectors
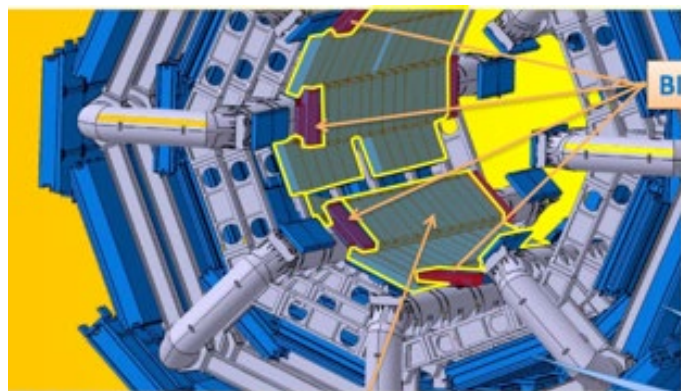- Doubled HV modules for outer barrels

Manpower and responsabilities:
- RPC operations (Boscherini, L2)
- Detector control system(Polini, Romano)
- Data Quality (A.Bruni)
- Expert on call (Romano, Alberghi, Massa)
- Gas leak repair (Chiarini, Gessi)
- Muon Speaker Comm (A.Bruni)
  - Muon Italian coordinator (A. Bruni)
- Student: Gianluca Bianco

Muon Detector: BIS78

BIS7-8 in Phase-1

RPC BIS78 project:
- 16 BIS7 1820 x 1180 mm²
- 16 BIS8 1820 x 440 mm²
- 3 independent layers measuring eta and phi
- Total surface 150 m²

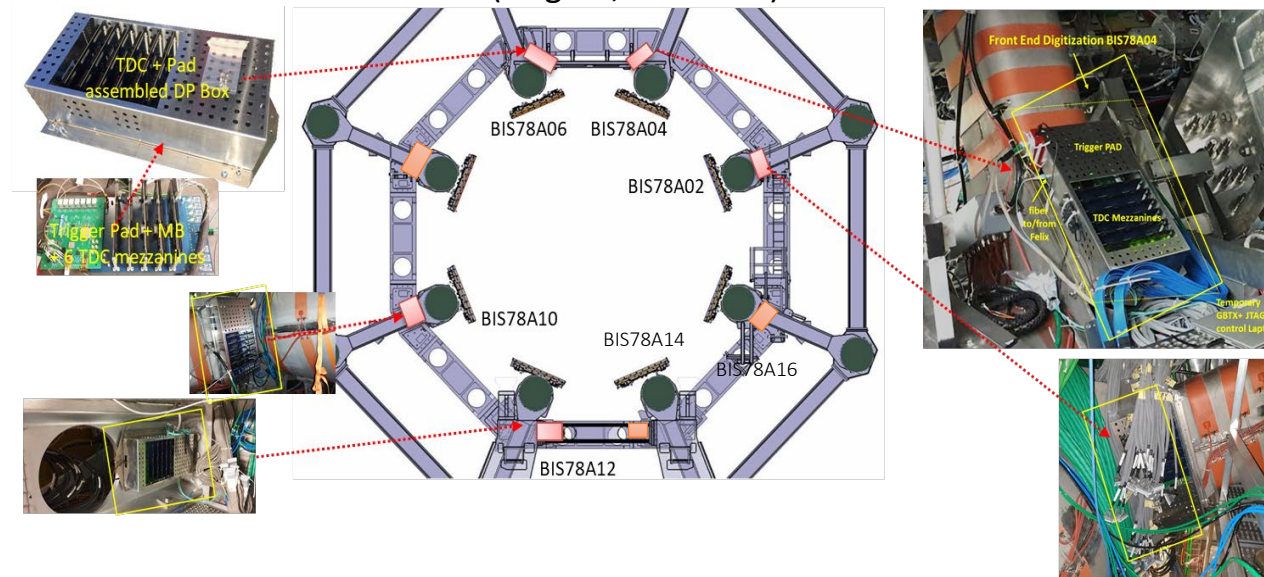**RPC Barrel Outer (confirm)**

RPC Barrel Middle (pivot + confirm)

Full Barrel Inner Layer proposed for Phase-2

RPC BI project:
- 96 BIS 1820 x 916 mm² + 150 BIL 2820 x 1096 mm²
- 3 independent layers measuring eta and phi
- Total surface 1800 m²

- Technical design (Guerzoni, Boscherini)
- Production and commissioning (Massa)
- DCS (Polini, Romano)
- DAQ (Polini, Lasagni)
- services (Avoni), transport and commissioning(Chiarini, Gessi)
- MC simulations (Negrini, Franchini)

Full Upgrade

- New installation of 300 RPCs in the inner barrel
- New MDT and TGD chamber installation
- Partially new FE, readout and trigger for RPC
- New powering system
- BIL chambers built by INFN (Bologna, RM2, CS, RM1)

BIS78:

- Pilot upgrade project currently taking data
- Bologna heavily involved in the upgrade
- 16 new RPC chamber triplet installed in 2020-2021 despite COVID emergency
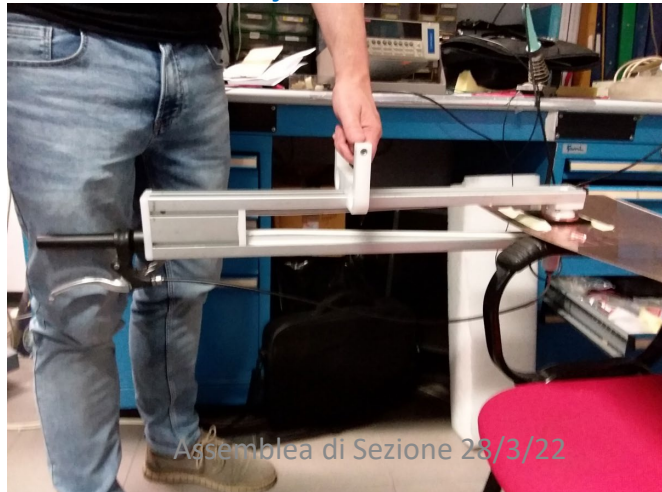
Muon Detector: Phase2
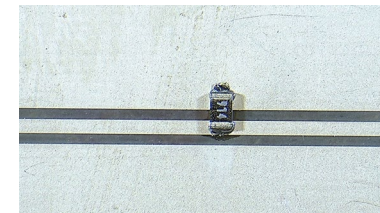
RPC prototypes

Insertion test

Resistivity measurement

Copper lines deployment

Hot-air welding

Current activities:

- Construction and test of protoype gas-gaps and readout panels (Massa, A.Bruni, Romano)
- Design and construction of mechanical machinery for test and production (Serra, Guerzoni, Piazza, A.Bruni)
- Qualification procedure definition and set-up of system tests (A.Bruni and services)
- Internal review and tender preparations (Polini, A.Bruni)
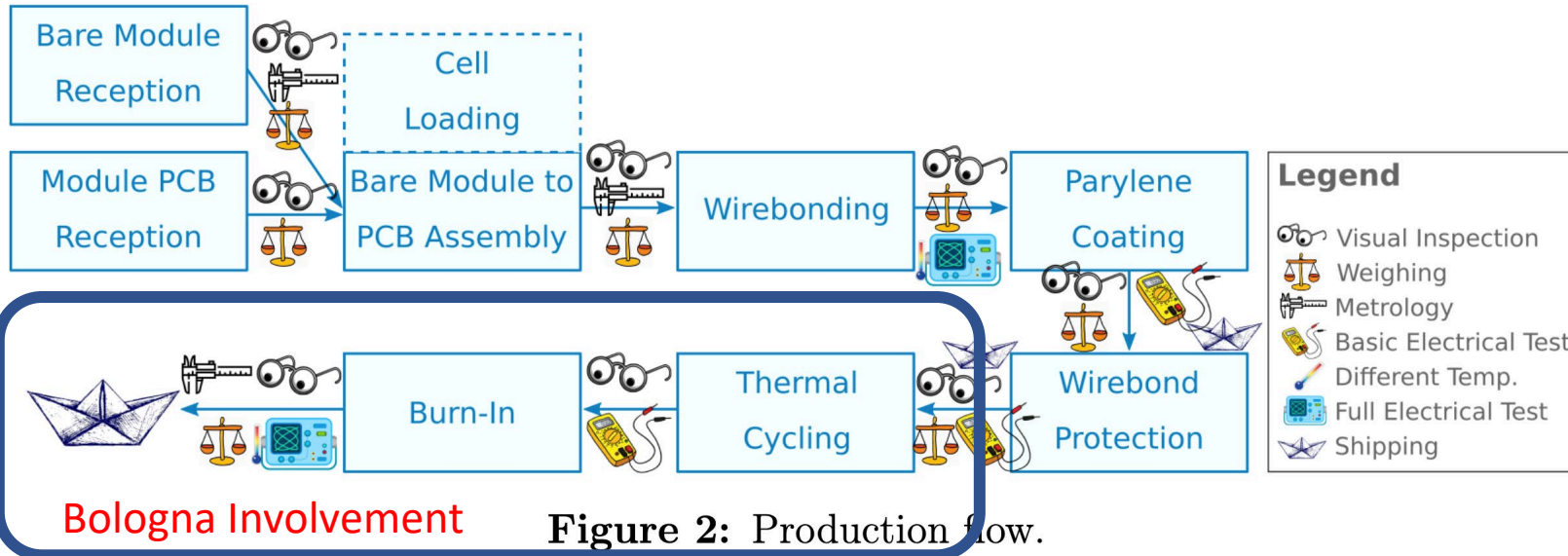- test and simulatons(Negrini, Bellagamba, G.Bruni)

Construction already ongoing!

Responsabilità

- Upgrade Coordinator Muon System: Polini (L1 since May)
- Risk manager: A.Bruni (L2)
- BI project manager: L.Massa

ITK
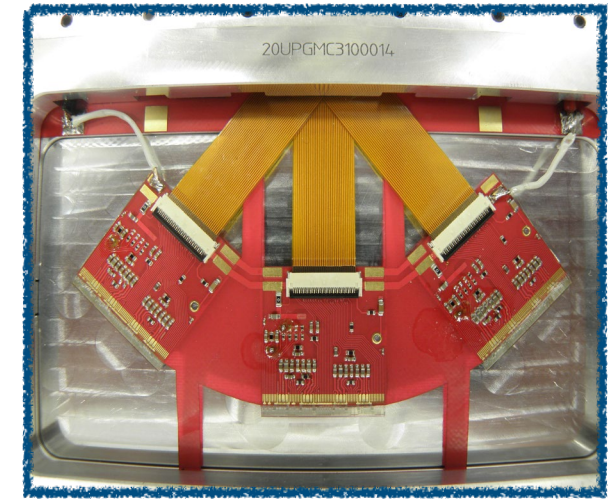
Figure 2: Production flow.

Bologna Involvement

Personpower

G. Carratta (SW and Database development)
A. Cervelli (local responsible)
A. Paladino (Global shipment responsible)
A. Sidoti (Italian DAQ coordinator)
C. Sbarra (Italian QA coordinator)

Other Institutes involved:

- INFN Milano:
  -Triplets and quads assembly
- INFN Genova:
  -Triplets assembly
  -Half Ring Module Loading
- INFN Trento:
  -QC tests on triplets (also with X-Ray)
- INFN Udine:
  -QC tests on quads
- INFN Lecce:
  -Half Ring Module Loading
- INFN Frascati:
  -Final integration
  -Test on the whole end-cap
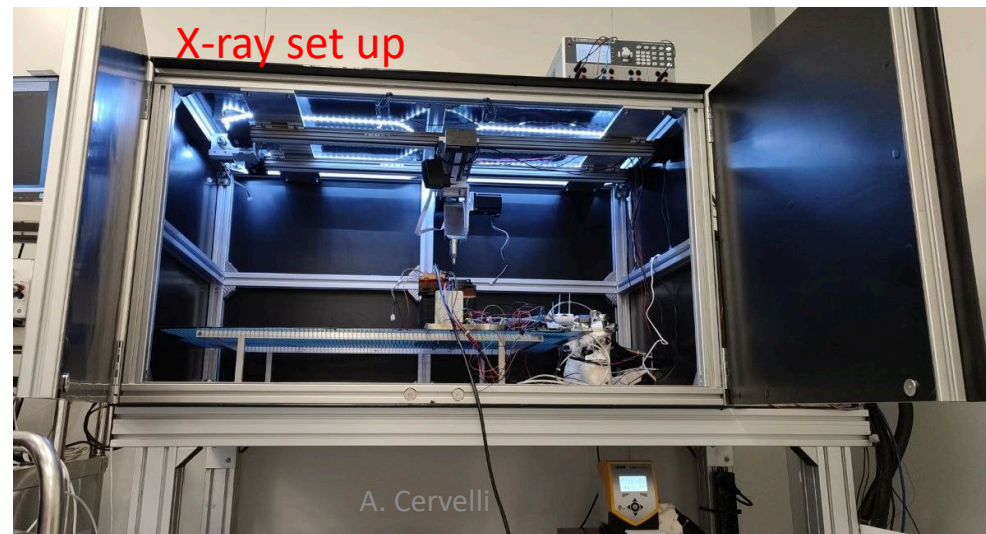
ITK

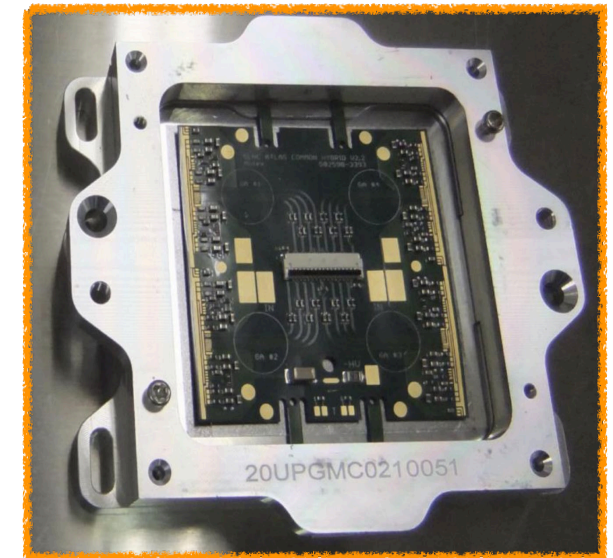Triplet Module

Bologna is in charge of thermal cycles and the testing stage for both triplets and quads

- QC of modules set-up needs:
  - Stable DAQ and logging system for tuning and/or noise measurements
  - Temperature control during operation
- Thermal cycles between -30 and 60 with humidity control
- Functionality test with x-ray irradiation

Clean Room setup

X-ray set up

Quad Module

ITK

Module powered up in cold temperature.

Test infrastructure have been almost completely qualified for production

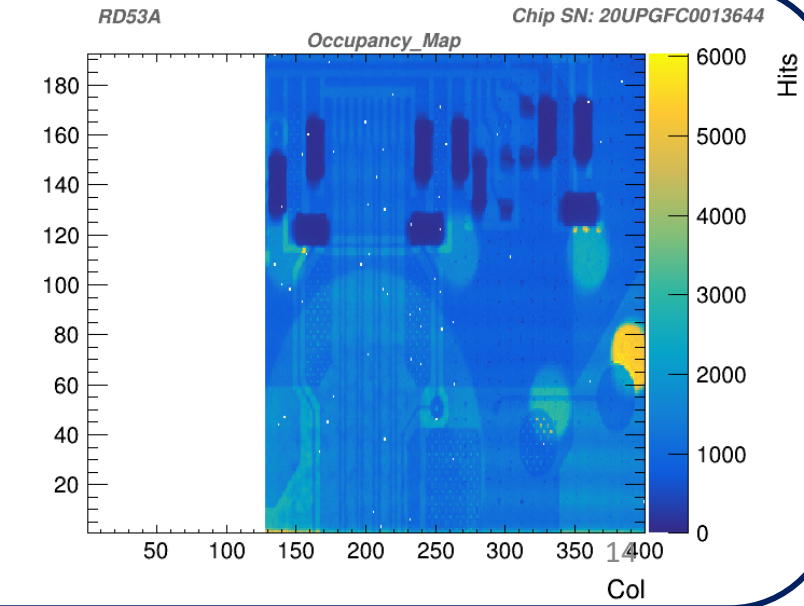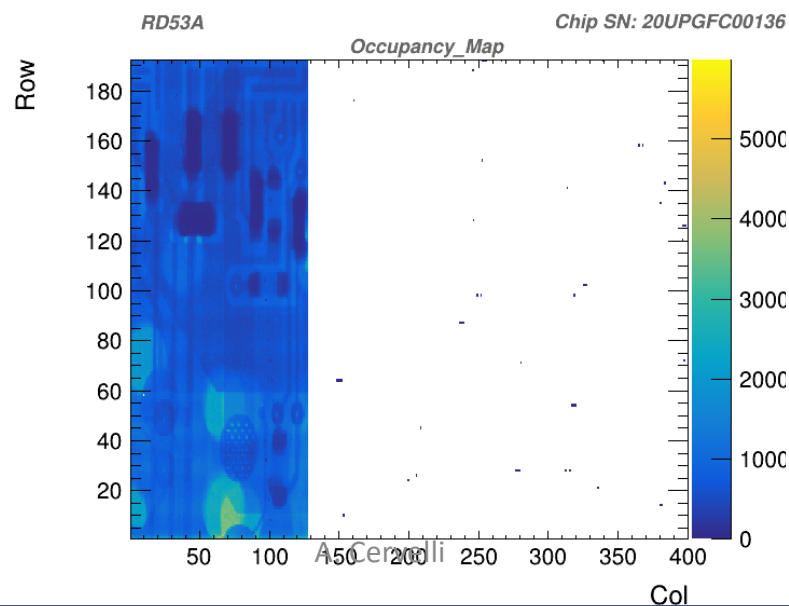Test performed on RD53 modules since december

Source scan on real modules

Complete functionality of modules tested in cold operation with real sources

One of the few sites in the world ready to perform the full array of tests on multiple modules
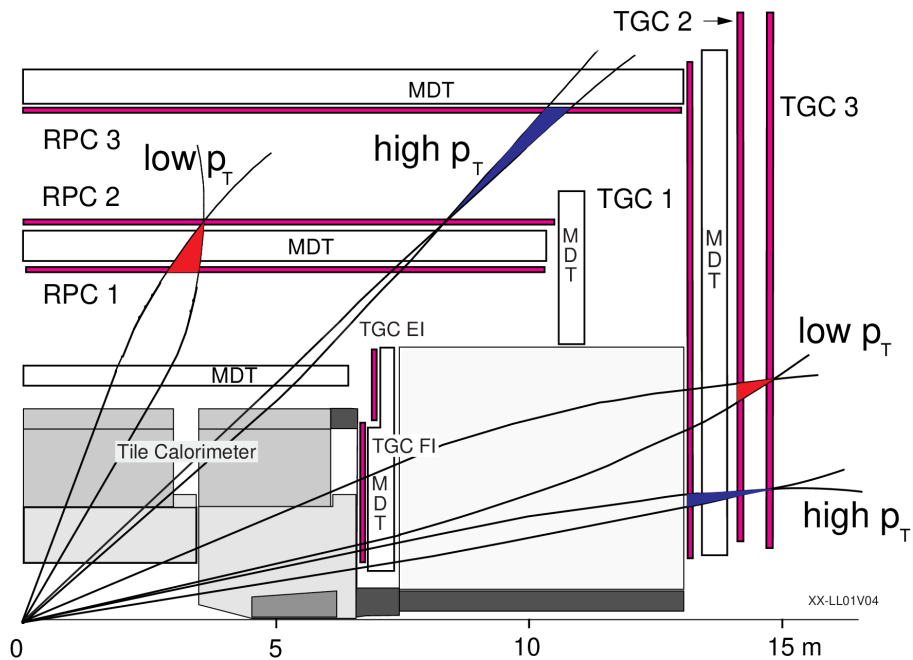
A. Cerrulli

Important note:
All of these activities would've not been possible without the help and the support from the Sezione as a whole

In particular we wish to thank the administration services, the mechanical and electronical workshop and all the technical services of INFN-BO
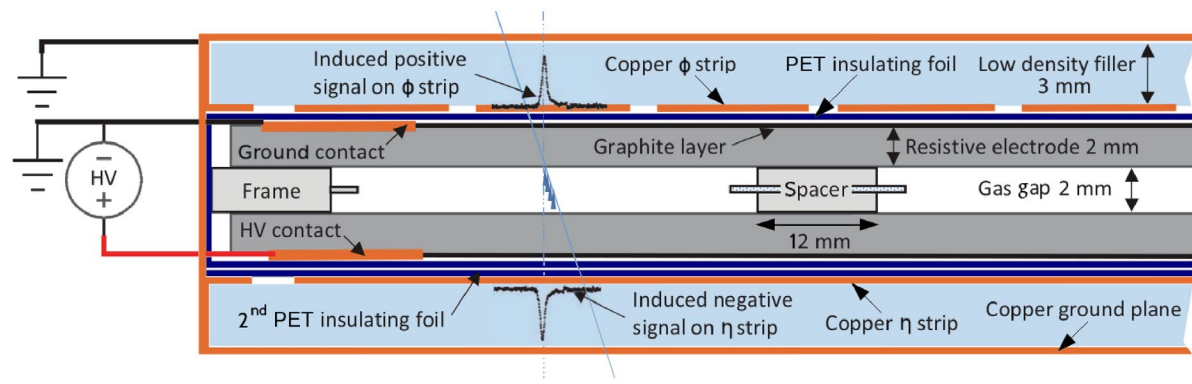
And now unto the analyses!

Muoni - Resistive Plate Chambers

- Nella regione barrel, la ricostruzione è assicurata da rivelatori a fili (MDT) e il trigger dei muoni è assicurato da camere RPC, usate anche per ricostruire la seconda coordinata
- RPC arrangiati in 3 strati (2 per low pT, 1 per high pT), divisi in 16 settori di 12 camere (con eccezioni)
- Ogni camera è composta da 2 strati di rivelatori RPC indipendenti
- ~4000 volumi di gas, ~8000 pannelli di readout, 370k canali
- miscela di gas $C_2H_2F_4$ (94.7%): iso-C_4H_{10} (5%): SF_6(0.3%
- INFN Bologna coinvolta dal 2005, su parere della CNS1 per affiancare RM1, RM2, NA, LE
- Barrel Muon: INFN ha la completa responsabilità. del rivelatore (BO,RM2) e del trigger (BO, RM1, NA)

Muoni - rivelatore barrel di trigger

,

Durante la pausa nella presa dati:
- modificato il sistema di distribuzione del gas, inserite valvole di non ritorno per ridurre perdite di gas
- raddoppiati i moduli HV per camere barrel outer
- controllate/riparate perdite di gas in connettori esterni alle camere, connettori elettrici

Run3 ripartito con turni di 24 h, sistema acceso e funzionante

Attività/Responsabilità:
- responsabilità generale RPC (Boscherini, L2)
- Data Control System (Polini, Romano)
- Data Quality (A.Bruni)
- Expert on call (Romano, Alberghi, Massa)
- Riparazioni perdite di gas, servizi (Chiarini, Gessi)
- Muon Speaker Comm (A.Bruni)
- Studente: Gianluca Bianco

valvole di non ritorno del flusso di gas

ATLAS Muon spectrometer

o Fisica: assicurare trigger e ricostruzione dei muoni, per processi Higgs, W/Z, heavy flavour, ricerca di nuova fisica

o Trigger Muons $|\eta| < 2.5$, camere di percisione fino a $|\eta| < 2.7$ entro campo magnetico generato da toroidi superconduttori

o Risoluzione del 3% per ampio range in pT , scende al 10% per pT ≈1TeV, per $|\eta|$ 2.7

o Coll.di 57 istituti
o INFN coinvolta in MDT, RPC, TDAQ, e i progetti di Upgrade di Fase I: NSW e BIS78