CGEM installation aftermath

G. Cibinetto, M. Greco, G. Mezzadri

Installation preparation

- CGEM had the green light for installation on July 4, 2024
- Preparation for installation and detector qualification
- Average noise levels
  - L1X: 2 fC – L1V: 0.5 fC
  - L2X: 1 fC – L2V: 0.5 fC
  - L3X: 1 fC – L3V: 0.8 fC
- Stable running conditions

Shutdown original schedule

No.	tasks	Duration（day）	Start time and stop time	Sub-system involved
1	Removal of equipment of machine		July 1- Aug. 6	Utility, Small angle lum. Detector and ZDD, Beam pipe, slow control
2	Pull-out of EEMC			Utility, EMC, TOF, MDC, MUC
3	Removal of inner chamber（Operate simultaneously on both sides）	51	Aug. 7- Sep.7 Sep.8- Sep. 28	MDC, MDC electronics, Gas, Mechanics, Laser Alignment group, Trigger, DAQ, Slow control
4	Installation of CGEM	44	Sep.29- Nov. 11	CGEM group, MDC, MDC electronics, Gas, Mechanics, Laser Alignment group, Trigger, DAQ, Slow control
5	Recover EEMC		Nov. 12-Dec.30	Utility, EMC, TOF, MDC, MUC
6	Recover equipment of machine			Utility, Small angle lum. Detector, ZDD, Beam pipe, slow control,
total		180 days	July 1- Dec.30	

Other boundary conditions

- Beijing is about 8000 km from Italy
- INFN technicians are shared with other experiments and have much less flexibility in their schedule w.r.t. researchers

  - Sudden change in the schedule or planned activities are not easy to address and can have a large impact on other tasks

  - INFN people did more than **72 months at IHEP** between June 2023 and January this year working on CGEM

CGEM mechanical insertion

- **Mechanical insertion of the CGEM was successful and on time**
- CGEM insertion was completed on October 5th 2024
- All the testing done before the shutdown guaranteed a smooth and safe installation

Cable routing issue

- Cable routing and electronics installation was quite a trouble
- The endcap flux return doors couldn’t be fully opened and cables could not be routed in the conduits as planned
- Decision of **routing the cables through the EMC endcap hole**, and attached to the final focus support has been made
  - The length of the cables was already fixed; therefore, we had to relocate the electronics; for this we had to wait the production of two platforms
  - No cable holders available: we had to design and produce them
  - Interference between cables and operations for final focus, EMC and flux return closing; CGEM cables have been moved several times
- Knowing that in advance could have helped to have a better plan, better infrastructure, less last-minute schedule modification, better cable and board protection, better control and stability of the system

Cabling

Cabling was completed on October 18th 2024 on schedule

Interference with other activities, miscommunications and being in a rush

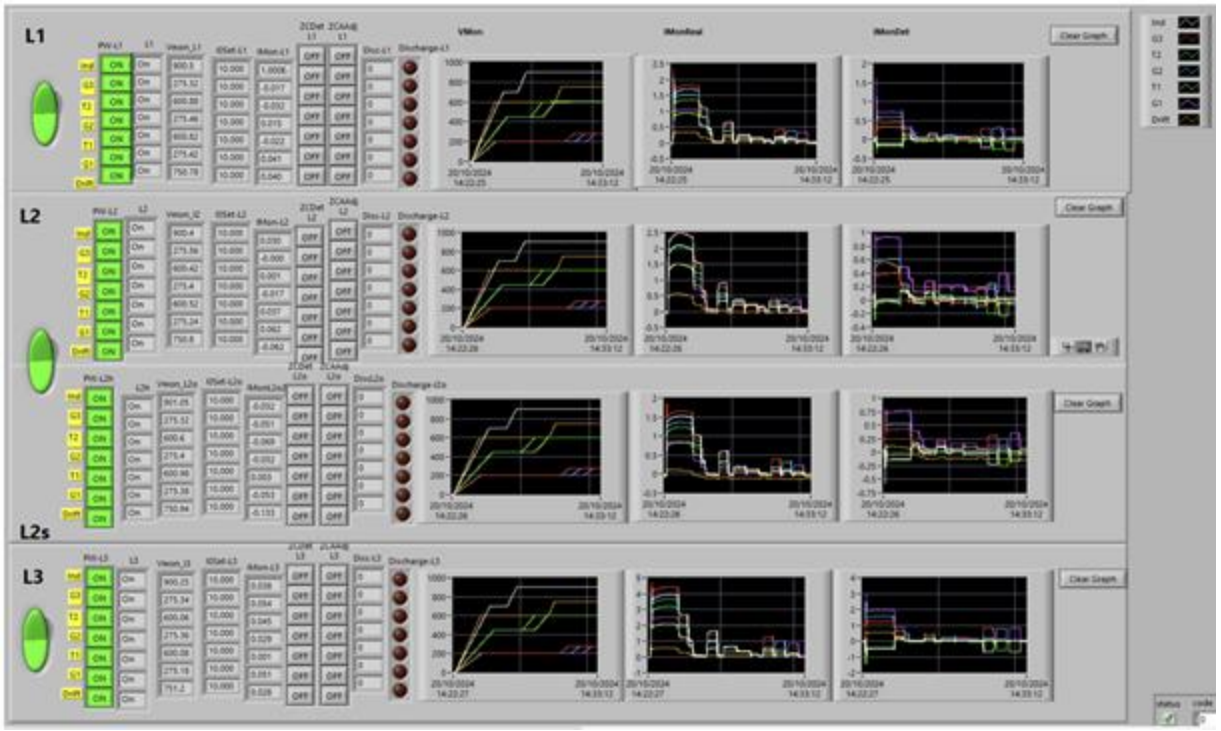
- Several times we have not been notified about work close to our cables, patch cards or electronics

- Sometimes we found people working close to our patch cards while they were unprotected and without any notifications, sometimes we found cables disconnected…

- Often justified by “being in a hurry”

First power on and first noise data

- The entire CGEM-IT was firstly powered on at nominal value on October 19th



- HV ok
- Noise compatible with the situation in lab 106

The MDC noise issue (I)

- After about 20 days from CGEM power on, the MDC electronics have been turned on for the first time after the CGEM cabling
- A large noise was found on all the step layers of the MDC
- The noise was induced by the CGEM digital transmission where CGEM patch cards and cables are close to the MDC preamps
- The identified solution was to implement a double shielding around the CGEM and MDC boards

The MDC noise issue (II)

- During the review, a joint test to check for any EM interference between the two systems was requested by one the referees
  - CGEM took data in 2019 with MDC electronics nearby, and no issues was found on our side
  - The CGEM was taking cosmics in lab 106 for months but no one from MDC performed the required test
  - That could have spared more than one month of work, but mainly a better shielding strategy could have been planned
- More people had to travel from Italy last-minute to join the effort
- More than one month of unplanned work has been needed for testing, designing, uncabling, shielding, cabling and re-testing
- This delay was not due to CGEM

Second power on

- After re-cabling, the CGEM-IT has been powered on on Dec 19th,two months after the first power on
  - HV ok
  - Noise conditions similar to first power on

The rush for closing the detector

- Due to the pressure for restarting the machine, a tight schedule for interaction region reassembly was followed
- During Christmas holiday, for few days we had no people around
- Despite we explicitly asked for stopping the activities involving our cables or close to our electronics the work continued as planned
- Once we arrived, the beampipe was installed and we found some disconnected cables

Layer 1 noise and HV issue on layer 3

- Most probably, during the beampipe installation some cables have been pulled, touched or moved since their path is toward the beam direction

- The patch card system was designed to hold cables that were supposed to be routed safely and tight in the cable conduits, not hanging on the endcap calorimeter; a lot of extra attention was needed and that's why we requested our supervision during all the operations around there

- After we got back at the end of December 2024 the **noise level in layer 1 was largely increased**

- At the beginning of January 2025 during the operations for the endcap EMC repositioning we started having some HV issues on **L3 requiring the induction field to be operated at a voltage 10% lower** than the other layers

Early January operations

- We requested more time to investigate the issues, about 10 days have been granted while continuing with other operations
- It was not clear whether the noise issue was caused by the beam pipe itself or to some grounding cables disconnected; some unshielding and uncabling was needed to investigate with the few people we had at IHEP at that moment
- There was no more time for testing, and it has been decided to continue without any check
- **The issues described in the previous slide have not been fixed yet**

Continuous patching

- The installation and commissioning phases have been a continuous patch work, with very little planning and a huge amount of improvisation and adaptation

- Miscommunications started way before the installation and continued as if very few people listened what we have been saying or presenting in our CGEM workshops and meetings over the years
  - That includes other parts of the system (e.g. DAQ, gas system, ….)

Installation management and coordination

- Most of the coordination has been entrusted to a single person with very limited help. We thanks all the people actively involved in the daily operations

- A larger presence of the BESIII management and technical coordination could have helped in setting priorities and taking difficult decisions

Aftermath of the CGEM installation

- About 10 years of preparation with delays due to
  - Mechanical issues with transport
  - Covid-19

- Between 30-40 persons involved in mechanics, electronics, services, software

- More than 72 person/month (six years) between May 2023 and Jan 2025 at IHEP; maximum occupancy during mechanical installation and cabling (10-15 people)

- The inner tracker upgrade was a task of a high level of complexity, a better integration and involvement of more experienced people would have been needed