TOF status report

- Hardware status and detector consolidation
- Participation to the ALICE data-taking
- TOF performance in Run3
- Status of TRM2
- TOF transitional management plan
- Milestones
- Requests for 2026

Meeting with the INFN CSN3 referees
Rome, 9-10 July 2025

F. Bellini (U. Bologna e INFN-Bo)

TOF current status [after TS1, status at 07/07/2025]

72/72 crates in readout

91.6% TOF channels in readout (140118/152928 chs)

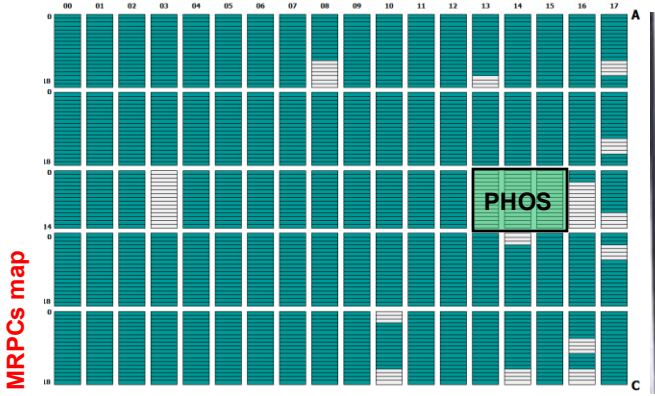
- [3.7%] 38 TRMs OFF (5610 chs OFF)
- [4.7%] 75 MRPCs OFF (7200 chs OFF)

95.3% MRPCs in data taking (1518/1593)

- 73 MPRCs switched off before LS2: broken HV connector in the module side (inaccessible)
- 3 MRPCs switched off in 2024 due to broken HV connectors (same reason)

Interventions at the latest LHC Technical Stop (TS1):

- DRM-08 replaced → **1920 chs back**
- 8 TRMs back ON after restoring (at least partially) a proper cooling-water circulation → **1728 chs back**



Running performance in 2024

pp at $\sqrt{s}$ = 13.6 TeV 2024
TOF in readout in 99% of the ALICE running time corresponding to **687 runs** for Physics (~1880 hours)

Missing difference (downtime of about 24 hours) mainly due to the failure of CAEN Main Frames (see dedicated slide) in two separate occasions:

- May 15th (alitofhv2 lost) - about 19 hours of data taking lost
- July 8th (alitofhv1 lost) - about 2 hours of data taking lost

End-of-Run reasons due to TOF (2% of all EoR reasons):

- ❑ x4 orbit mismatch
- ❑ x2 HV main frame failure (see above)
- ❑ x1 LV main frame failure (alitoflv1 lost)
- ❑ x1 SOR failure
- ❑ x4 others

Pb-Pb at $\sqrt{s_{NN}}$ = 5.36 TeV 2024
TOF in readout in 99.5% of the ALICE Pb-Pb running time corresponding to **204 runs** for Physics out of 205

- 3 EoR reasons due to TOF (1.5% of all EoR reasons).

YETS 2024/2025

List of interventions during the latest YETS:

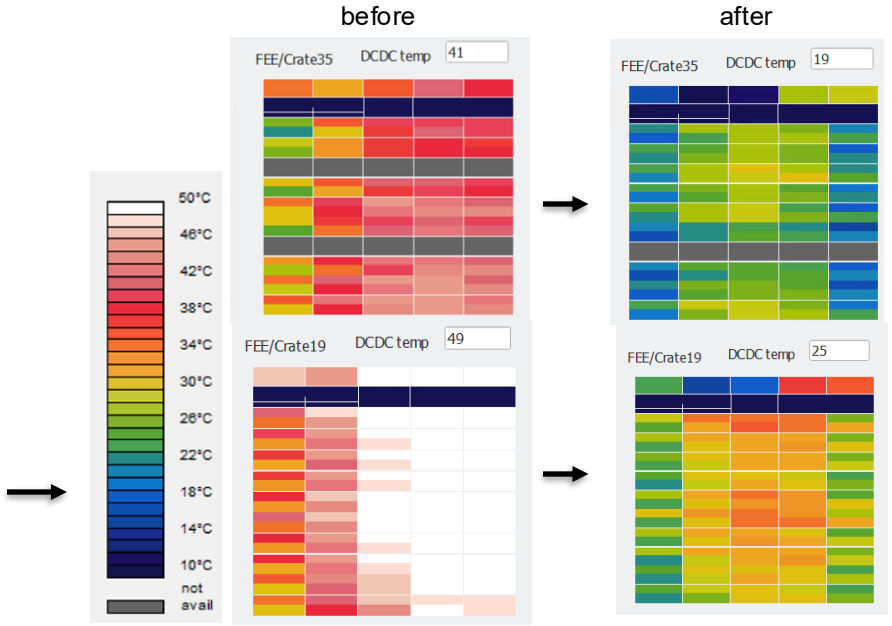
- **2 CAEN DC/DC converters** replaced on crates 21, 65 (5 V in Undervoltage)
  → **+2.9%** TOF channels back in readout

- **2 Data Readout Module DRM2** replaced on crates 39, 70 (data congestion)
  → **+2.9%** TOF channels back in readout

- **1 HV board** replaced (channel tripping at about 5 kV)
  → **+0.2%** TOF channels back in readout

- **2 Crates** (19, 35) unclogged using phosphoric acid left to act for some hours
  → **+0.8%** TOF channels back in readout

- **New DRM2 firmware deployed** to avoid losing data taking efficiency in high-rate Pb-Pb runs (foreseen in Nov. 2025) → currently installed and tested with beams on A side, to be installed on C side



Detector consolidation (HV)

On May 15th and July 13th 2024 we lost two CAEN SY1527 Main Frames, each powering half of TOF MRPCs.

In the meeting with CSN3 referees on July 18th 2024 we asked the funding for three new CAEN Main Frames, model SY4527, for detector consolidation.

The two new SY4527 units have been installed in January 2025 and are in operation, with the third new unit as spare unit.

Old SY1527

New SY4527

TOF running stability in 2025

Milestone 2025

In 2025, **TOF was in readout in 99% (74/75) of the global runs for Physics** in pp at √s = 13.6 TeV (before TS1) → One run missed for persisting issues with an orbit mismatch

10 EOR reasons due to TOF (13.5% of the total EoR reasons)

- ❑ x1 DCS SoR error
- ❑ x1 QC task crash → optional feature (currently disabled, work in progress)
- ❑ x8 orbit mismatch → wrong orbit number coming from TOF link 65
  → Protection added in the latest TOF FEE firmware (installed on June 16th)

TOF was always (100%) in readout in special p-O (last week)

2 fills, 8/10 runs for Physics + 2/10 VdM scans

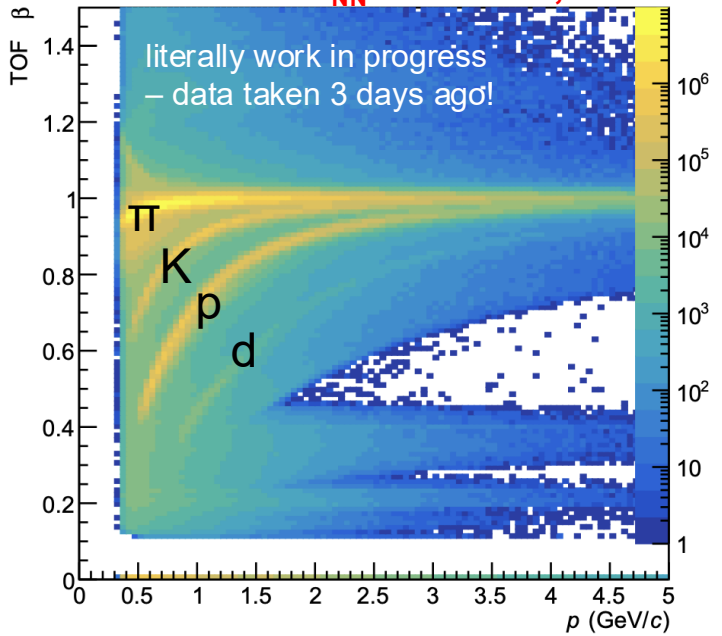
- Total data taking time: 33h, 28m, 49s
- Physics data taking at 18kHz(INEL) (0.04 Hz/μb)
- 1/8 EoR for TOF-orbit mismatch

... and O-O runs (this week)

6 fills, 11/12 runs for Physics + 1 VdM scan

- Total data taking time: 43h, 19m, 30s
- Physics data taking at 45kHz(INEL) (0.034 Hz/μb)
- 1/11 EoR for TOF-orbit mismatch

NEW: O-O $\sqrt{s_{NN}}$ = 5.36 TeV, 2025



TOF technical paper in Run 3

Milestone 2025

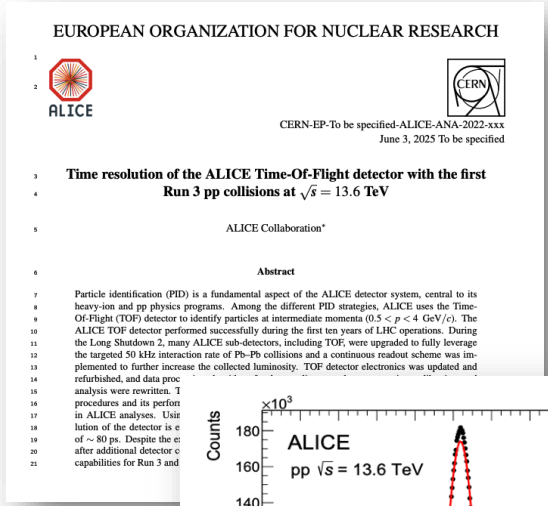
A **technical paper** on TOF performance is in preparation based on the first 2022 pp data and calibrations when we reached the nominal requirement for TOF resolution of 80ps and validated the calibration scheme (sync + async)

- we are currently past the first Collaboration round of review

The achievements presented in this paper **confirm the capability of ALICE** to maintain **reliable particle identification** in the continuous readout mode of **Run 3.**

Following the ongoing effort to improve further the resolution in 2026 (*see next slide*), we will consider to prepare a more extensive paper as done in Run 2 focusing on:

- Best and final time resolution achieved
- Reconstruction performance and MC comparison (e.g. efficiency)
- Event time characterization (in collaboration with FT0)
- Impact on PID


EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ALICE

CERN

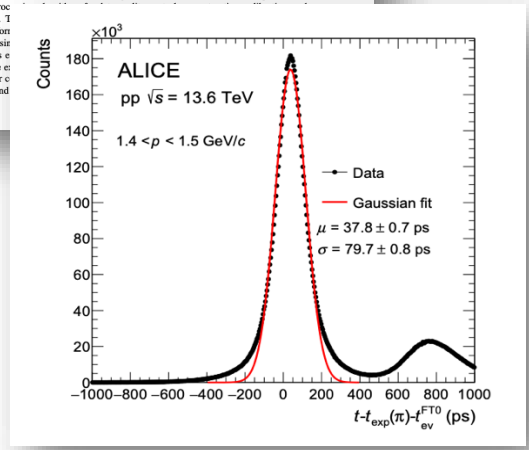
CERN-EP-To be specified-ALICE-ANA-2022-xxx
June 3, 2025 To be specified

Time resolution of the ALICE Time-Of-Flight detector with the first Run 3 pp collisions at $\sqrt{s} = 13.6$ TeV

ALICE Collaboration*

Abstract

Particle identification (PID) is a fundamental aspect of the ALICE detector system, central to its heavy-ion and pp physics programs. Among the different PID strategies, ALICE uses the Time-Of-Flight (TOF) detector to identify particles at intermediate momenta ($0.5 < p < 4$ GeV/c). The ALICE TOF detector performed successfully during the first ten years of LHC operations. During the Long Shutdown 2, many ALICE sub-detectors, including TOF, were upgraded to fully leverage the targeted 50 kHz interaction rate of Pb–Pb collisions and a continuous readout scheme was implemented to further increase the collected luminosity. TOF detector electronics was updated and refurbished, and data proc
analysis were rewritten. T
procedures and its perfor
in ALICE analyses. Usir
lution of the detector is e
of ~ 80 ps. Despite the e
after additional detector c
capabilities for Run 3 and

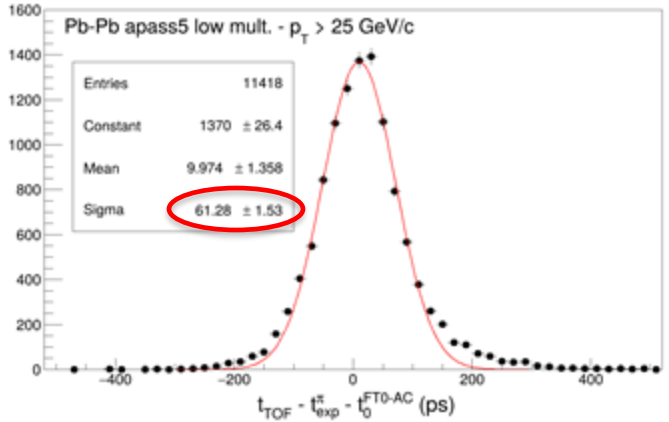


TOF performance

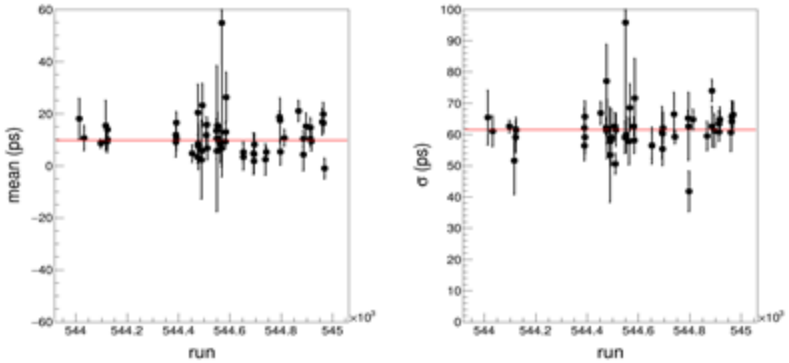
Milestone 2026

A new asynchronous reconstruction pass of Pb-Pb is currently running

- new refinement of TOF calibrations, both for 2023 and 2024 data, was performed
- 2023 data already fully reprocessed and validated, 2024 data ongoing



Stability of calibration and time resolution over time (run n.)



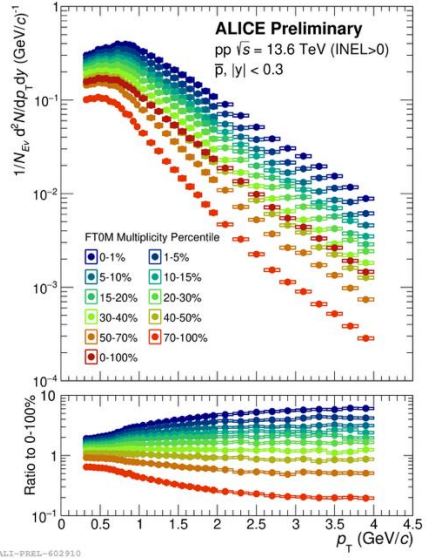
Currently available statistics allows us to look at very high momenta where all hadrons arrive at the “same” time (where we cannot do PID but we do have a clean way to measure the resolution).

TOF performance in Run 3 Pb-Pb reached the same quality as in Run 2: **σ~60 ps**
Next: achieve a similar resolution also in pp collisions

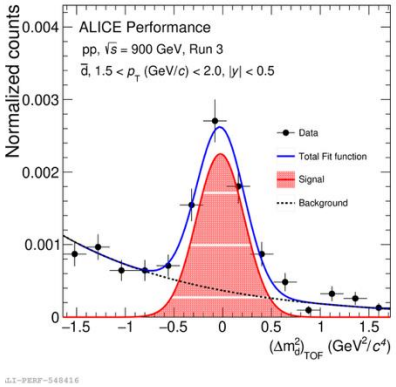
Physics with TOF: recent highlights

TOF is employed for identification of light hadrons as well as of light (anti)nuclei in many analyses across ALICE and several PWGs.

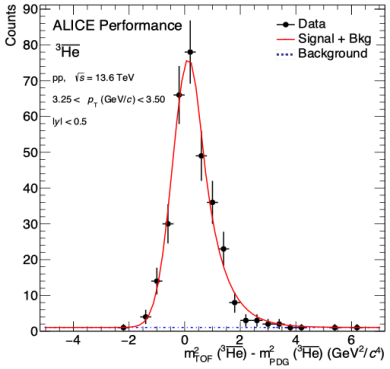
$\bar{p}$ in pp 13.6 TeV (+π,K...) [QM25 preliminary]



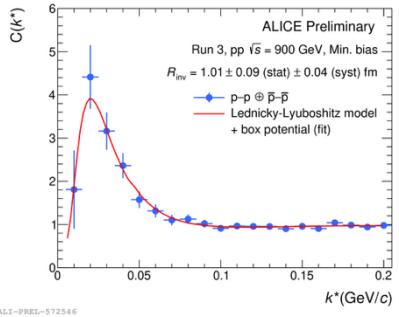
Anti-deuteron in pp $\sqrt{s}$ = 900 GeV [paper proposal approved by PB]



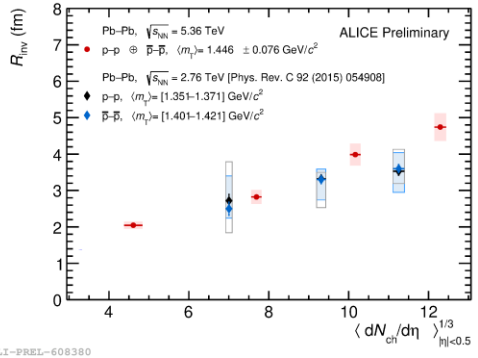
Anti-^{3}He in pp 13.6 TeV [QM23, ongoing analysis]



Proton source radius via femtoscopy in pp $\sqrt{s}$ = 900 GeV – 1° measurement [paper proposal approved by PB]



Proton source radius via femtoscopy in Run 3 Pb-Pb [preliminary at ICHEP24]

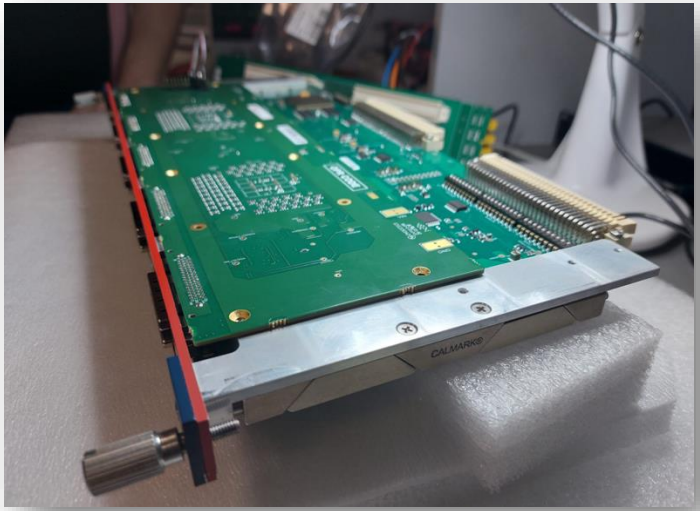


Milestones (physics) : = 2026, = in progress, = completed

Status of TRM2/TOF (1/5)

Reminder: long term project to replace part of TOF TDC Readout Modules (TRMs) damaged with a new TDC card based on PicoTDC (instead of HPTDC).

- prototypes not delivered by end 2024 → 350 kEU (budget 2024) postponed to 2025 (via GE) informed P. Giubellino (6/XI)
- joint work with CAEN (11-12 March) on prototypes
- a prototype since March 2025 then in Bologna



Progress:

- all “geometrical” back-compatibility verified
- power up, FPGA and uC programming done
- porting of remote programming via ARM A1500 (“DirectC”)
- several minor mistakes found on PCBs (→ need of a Rev. 1)
- TRM VME interface (Firmware) ported on PolarFire
- I^2C interface for picoTDC validated on VME: all picoTDC programmed

Status of TRM2/TOF (2/5)

Currently:

working on firmware readout porting (TRM1 → TRM2)

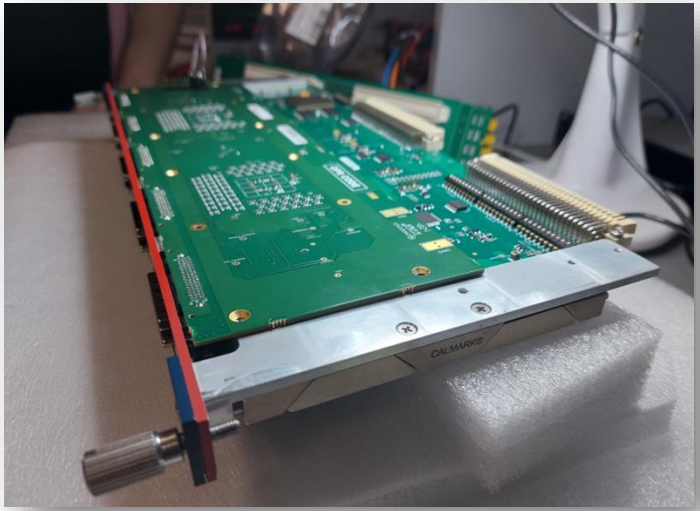
Next steps:

- readout validation
- resolution checks on picoTDC
- […] (a lot of other checks like temperature sensors readout, uC protection against SEL…)

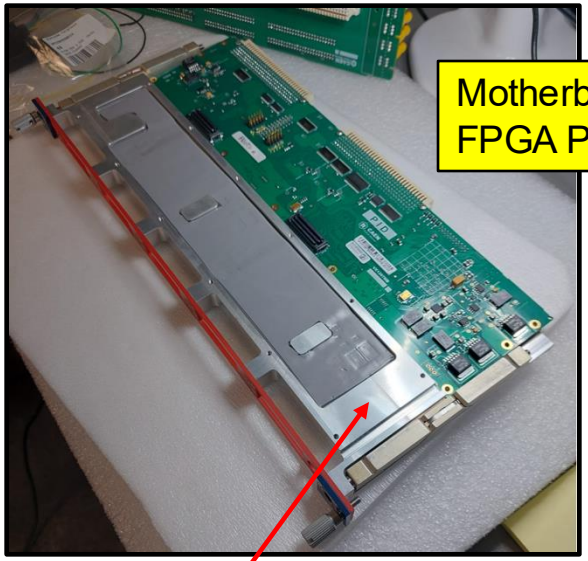
→ we now foresee preparing an order in September 2025
(350 kEU/2024 + 210 kEU/2025)

→ final bunch and order in 2026 (140 kEU) and production completion

→ given Run 3 extension in 2026, and LS3 updated timeline (2027-2029): large time contingency



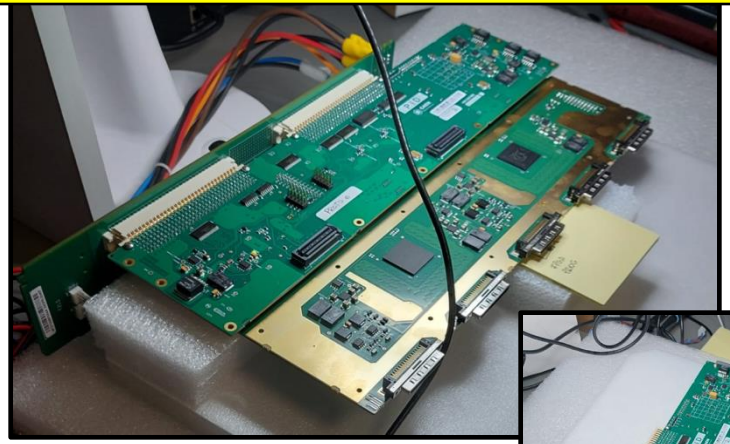
Status of TRM2/TOF (3/5)



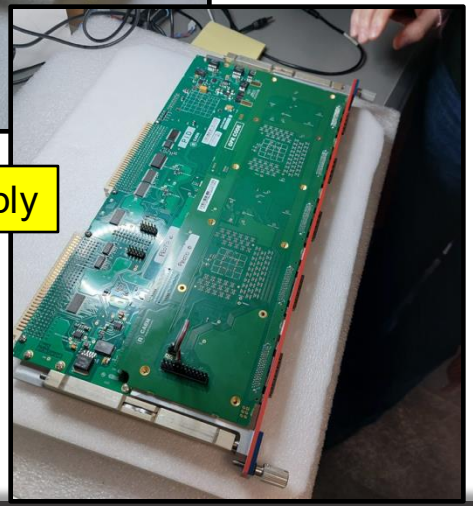
Motherboard with FPGA Polarfire

aluminium block + rubber for heat dissipation

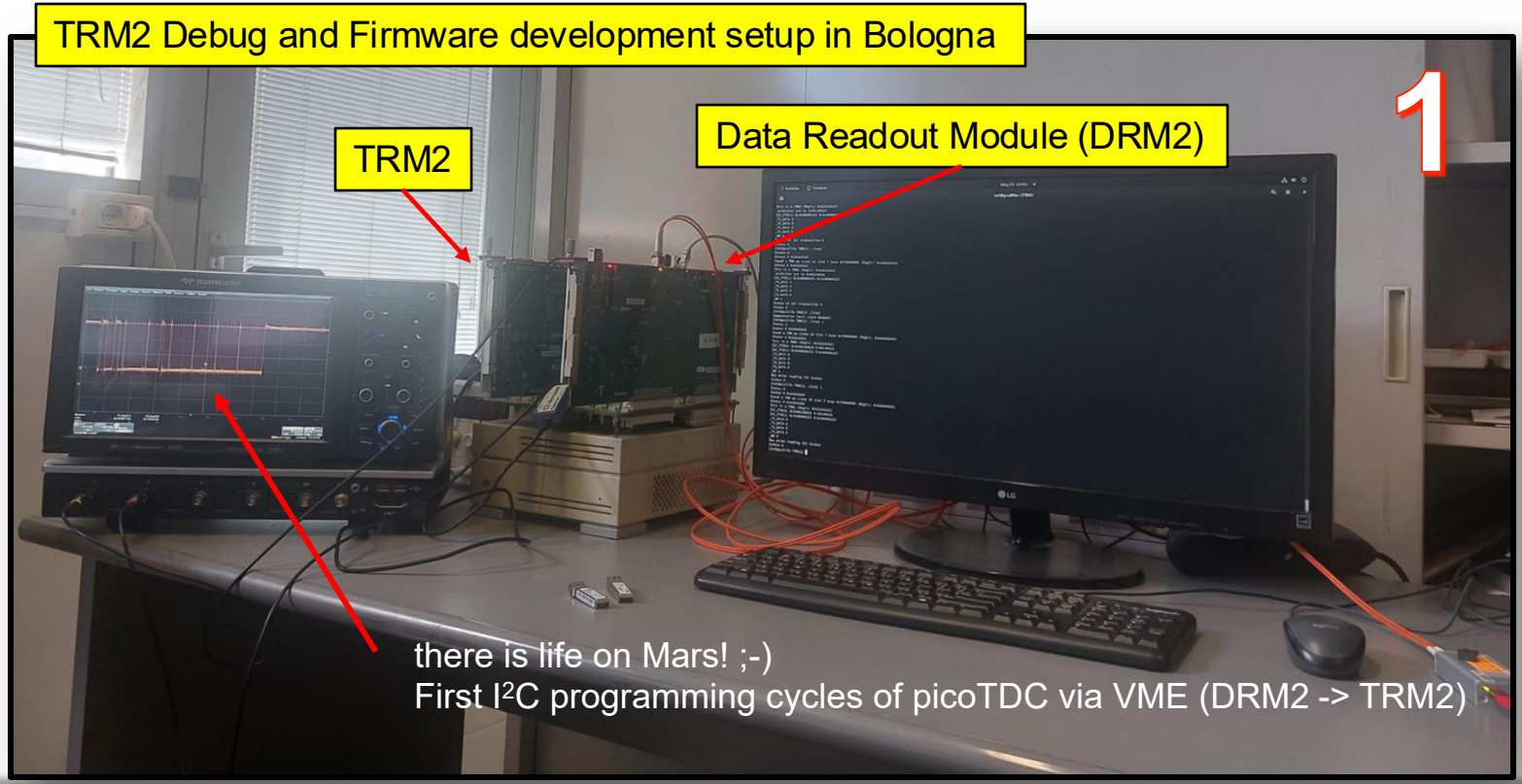
Motherboard + 1piggy back plugged (2 picoTDC)



Full assembly

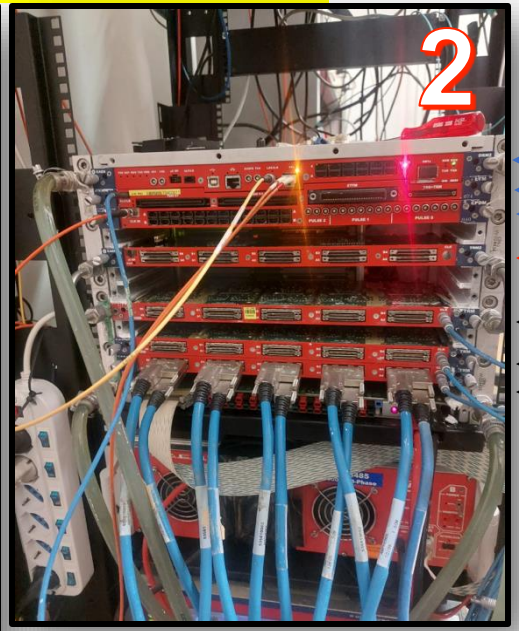


Status of TRM2/TOF (4/5)



Status of TRM2/TOF (5/5)

TRM2 Debug/Integration tests using μTOF@Bologna



- ✓ mechanical integration checks
- ✓ cooling tests
- ✓ TRM2-TRM1 coexistence

TOF transitional management plan

Context: need to move responsibilities to next generations
→ >5 generations of TOFers so far: new leadership is ALICE native!!

As anticipated at last year's meeting with the INFN referees, we are ready to appoint a new (and only one) PL in the foreseen timeline:

Project Leader: P. Antonioli, L.Cifarelli → **A. Alici**
to be endorsed by ALICE MB 17 July

In addition:
INFN-Bo (RL): A. Alici → **F. Bellini** (since 01.07.2025, also TL@CERN from Jan. 2026)

Note:
INFN BO and Uni., INFN SA and Uni. are the TOF Institutions
ITEP (Moscow) and GWNU (Seoul) left TOF

Milestone

2024

- Produzione e test prototipi schede di readout TRM2 in crate ALICE-TOF
  Completamento al 31.12.2024 → 50% - Gli schematici sono stati terminati, ma i prototipi al 31/12/2024 non erano ancora stati consegnati
  Completamento al 30.06.2025 → 80% - Tests to be completed by Sept. 2025

2025

- Partecipazione con alta efficienza alla presa dati durante tutti i periodi di fascio
  Completamento al 30.06.2025 → 50% - Partecipazione a tutti i periodi di RUN fin qui svolti.
- Pubblicazione su rivista internazionale del paper su performance del rivelatore TOF in collisioni pp a 13.6 TeV (Run 3)
  Completamento al 30.06.2025 → 70% - Bozza dell'articolo in fase di revisione da parte della Collaborazione (post-CR1).

2026

- Preparazione firmware/software TRM2 per deployment in ALICE TOF
- Risoluzione a la Run-2 del TOF (< 65 ps) in Pb-Pb e pp (approved performance figure)
- Partecipazione con alta efficienza alla presa dati durante tutti i periodi di fascio

Richieste 2026

Missioni

- missioni per data taking/mobilita' generale/responsabilità (basate su M&O-A, FTE e responsabilità come da tabelle/librone) - **129 k€**
- missioni per interventi di manutenzione su cavi/connettori/box di distribuzione HV (1 tecnico x 2 settimane) e su pipe cooling (2 tecnici per 1 settimana) - **5 k€**
- missioni per sessioni di lavoro in sede CAEN - **2 k€**
- missioni per test beam (ALICE3) - **23.5 k€**

Apparati

- produzione TRM2 - **140 k€**

Inventario

- Acquisto CAEN R6060 Easy Branch Controller - **6 k€**

Consumo – 2 k€

Licenze software

- 1 licenza Microchip Libero (ex Microsemi) – **1.5 k€**