



ALICE



TOF status report

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(INFN Bologna)

Meeting with INFN CSN3 referees
July 18th, 2024

- Hardware status
- Performance in Run3
- Physics with TOF
- TRM2 project status
- TOF transitional management plan
- Milestones and Requests 2025

(credits: part of this presentation based on TOF highlights presentation made by S. Strazzi (TOF SRC) @last ALICE Week, 8th July 2025)

Notch Filters refurbishment

Funded by CSN3 35 k€ (2023 budget "anticipabili")

26 Notch Filter units (CAEN A3000NF) in TOF { filtering the three-phase input (400 V)
supplying TOF 48 V power supplies (CAEN A3485A)

Dec & Jan: **all units were refurbished** in Viareggio ← { some capacitors reached the EOL (End Of Life)
in ATLAS they caused start of fire twice

✓ Replacement of **capacitors at EOL**



CAEN reported that:

- ALICE-TOF: 50% capacitors intact (but degraded), 50% visibly deformed (heat)
- ATLAS (2-3xTOF power): 10% capacitors intact (but degraded), 90% visible deformed

✓ Replacement of **fans** and addition of **overheating protection**

All units were re-installed in the cavern (Jan 26th)

→ **operational** from Jan 27th

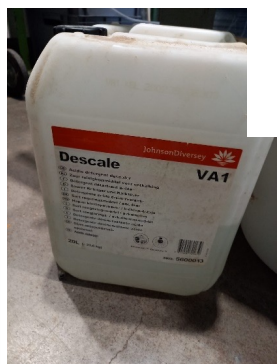
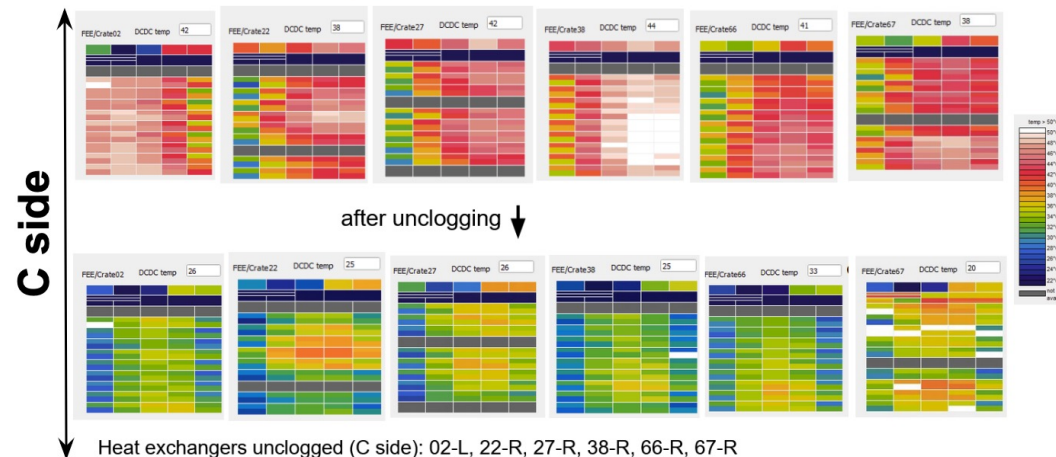
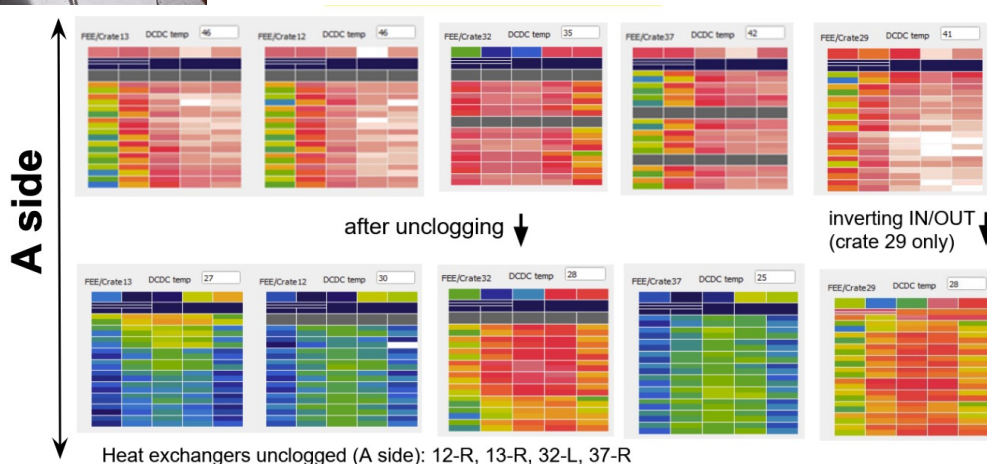


TOF crates heat-exchangers unclogging



11 TOF crates unclogged using phosphoric acid (5-10% conc.) left to act for 1 or 2 days as in the previous YETS (Dec 2022-Feb 2023)

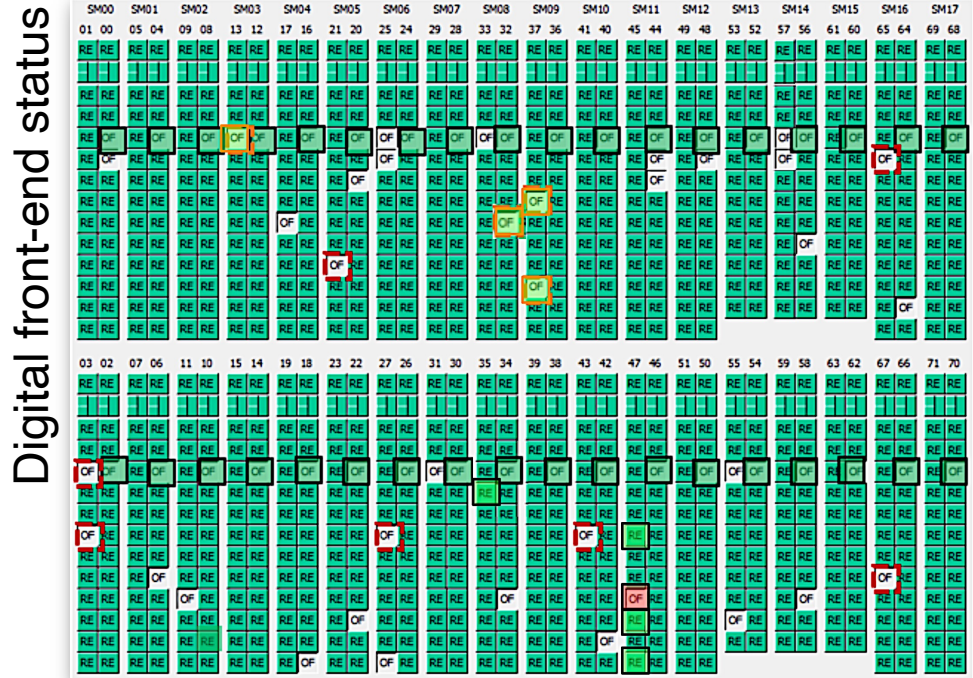
↳ TOF crates are water cooled → **obstruction** in the cooling plates, causing the water flow to stop, **causing overheating of the crate**



Corrosion inhibitor injected in the cooling plant to prevent the galvanic corrosion (Copper and Aluminium). Waiting analysis outcome of TS1 water samples.

mission specific request: 3 k€

TRM replacement campaign



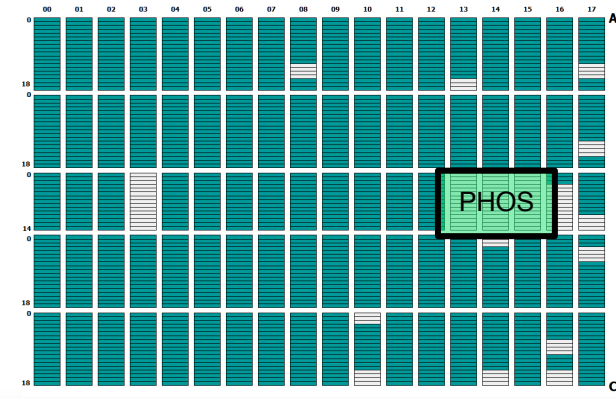
TRMs disabled in 2023:

- 8 TRMs** due to **instabilities**
- 4 TRMs** to limit the **overheating**
 - **back ON after crates unclogg.** (+960 ch)
- **Crates 31, 57** out of data taking
 - **crate 31 back** (+ 2160 ch)

News in 2024:

- TRM 35-4 replaced** (some ch disabled) (+219 ch)
- TRM 47-6-10-11 replaced** → (+720 ch)
- TRM 47-9 replaced**, but issues when HV ON

+4059 ch back in readout (~ 2.7%)



TOF MRPC map

→ **stable since LS2**

One tripolar connector broken 16th July

 HV unipolar cables disconnected (broken connector on the sector side)
→ Partial inefficiency

mission specific request: 1.5 k€

(May – July 2024) HV Main Frames failures

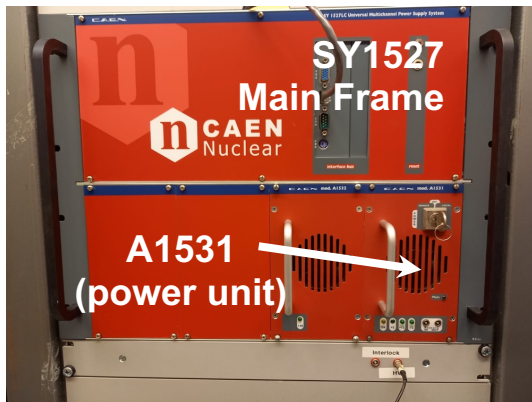
Failures on HV CAEN Main Frames

- May 15th: CAEN SY1527 Main Frame (alitoFHV2) **down**
 - ✓ power unit replaced in the morning but this and other 2 «spares» got burned in the following days
 - ✓ May 17th: Main Frame replaced with one borrowed by CAEN in emergency
- July 8th: CAEN SY1527 Main Frame (alitoFHV1) **down**
 - ✓ manual intervention, rebooted
- July 13th: CAEN SY1527 Main Frame (alitoFHV1) **down** (sent to CAEN for repair)
 - ✓ July 15th: Main Frame replaced with one of our spares (old) (this is one repaired by CAEN in the meantime arrived at CERN...)

Request to CSN3:

replace ASAP SY1527 with new model SY4527
3 (2 + 1 spares) → 22.5 k€

flagged as “anticipabili” and high priority



INTERMEZZO: TOF points of maximal failure and mitigation strategies

What	Impact	Responsibility	Strategy	Year of last buy
Front-end Slow Control central server	100%	INFN	High-end storage/provisioning server, 4 RAID disks/RAID6 on HW controller. Mirror server (night backup) deployed in CR always available. Spare parts bought and stored (ex. fan, SIM, disks,...)	2014
DCS Machines (3)	100%	CERN	Central ALICE DCS takes care	2021
DAQ servers (2)	50%	CERN	Central ALICE DAQ takes care	2020
HV Main Frames (2)	50%	INFN	Replace with a spare	2007
LV Main Frames (2)	25%	INFN	Replace with a spare	2020
[...]				

- **Murphy's law always holds, but...**
- When electronics starts to die, it dies. And this table is very long (1 crate has 1.4% impact, 1 TRM has 0.14% impact....)
- TOF personnel is on call H24 during shifts, SRC is key → highly demanding on INFN BO/SA
- We replaced during LS2 the LV using the used ones as spares for HV... but this paid just for 4 years
- It will be difficult to go up to 2032 (or 2033) [but "difficult" should be a walk in the park for us ;-))]

Stability in 2024 runs

227 Physics runs (any quality)

↳ **225 with TOF** also IN

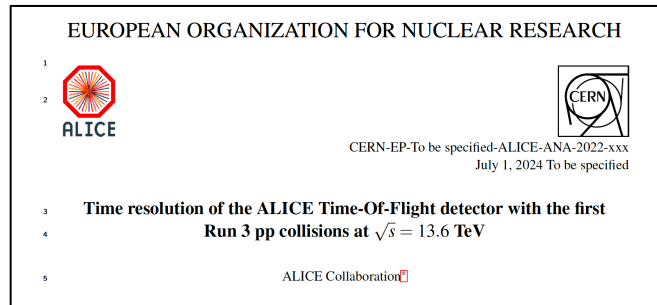
→ So far TOF has been in readout **99.1%** of time

- the 0.9% downtime due to a broken CAEN mainframe (see previous slides)

STATISTICS UPDATED TO 8th JULY

TOF Performance in RUN 3

Paper currently under IRC review



First paper showing the performance of the upgraded detector with the first **Run 3 pp collisions at $\sqrt{s} = 13.6$ TeV**

- **Operation and calibration procedures** of the TOF after the LS2 upgrade (major upgrade of the readout \rightarrow continuous data taking)
- **Time resolution** of TOF *

***The time resolution** of the detector is obtained through **two distinct methods**:

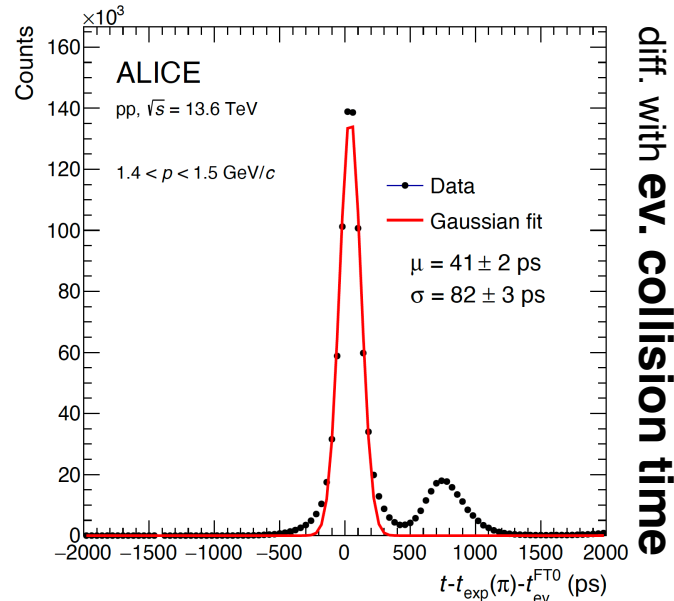
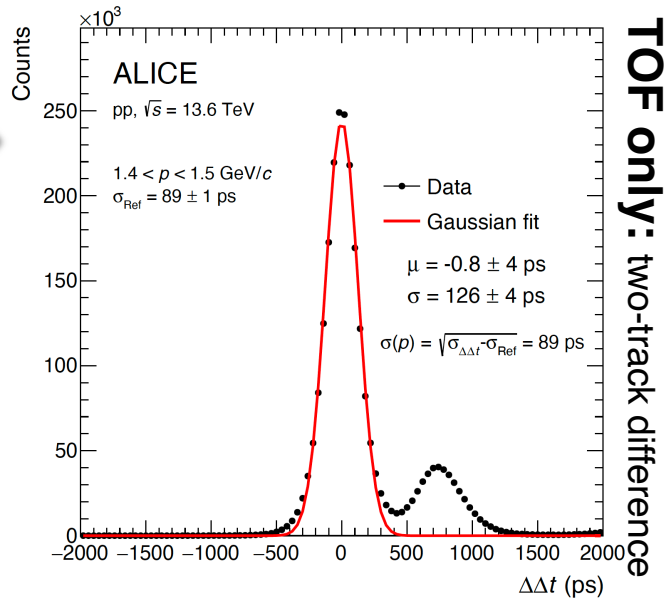
TOF only and FT0+TOF

A measurement of the separation between particle species $t_{\text{TOF}} - t_{\text{exp}} - t_{\text{ev}}^{\text{FT0}}$ generated by using the event times acquired from the TOF and FT0 detectors

TOF only

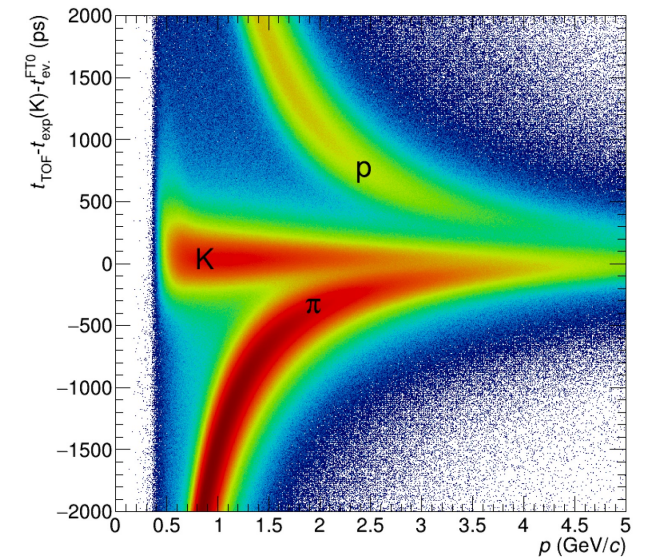
A **self-consistent measurement** by employing $\Delta\Delta t_{\text{TOF}} = (t_{\text{TOF}} - t_{\text{exp}}(\pi))_2 - (t_{\text{TOF}} - t_{\text{exp}}(\pi))_1$ by correlating two tracks matched to TOF in the same event (independent of the definition of collision)

TOF Performance in RUN 3 pp



- Measured TOF resolution with Run3 data using FT0 and a **new standalone method**
 - Consistent results with the two methods: $\sigma_{\text{TOF}} \sim 80 \text{ ps}$
- Stable performance and good for PID

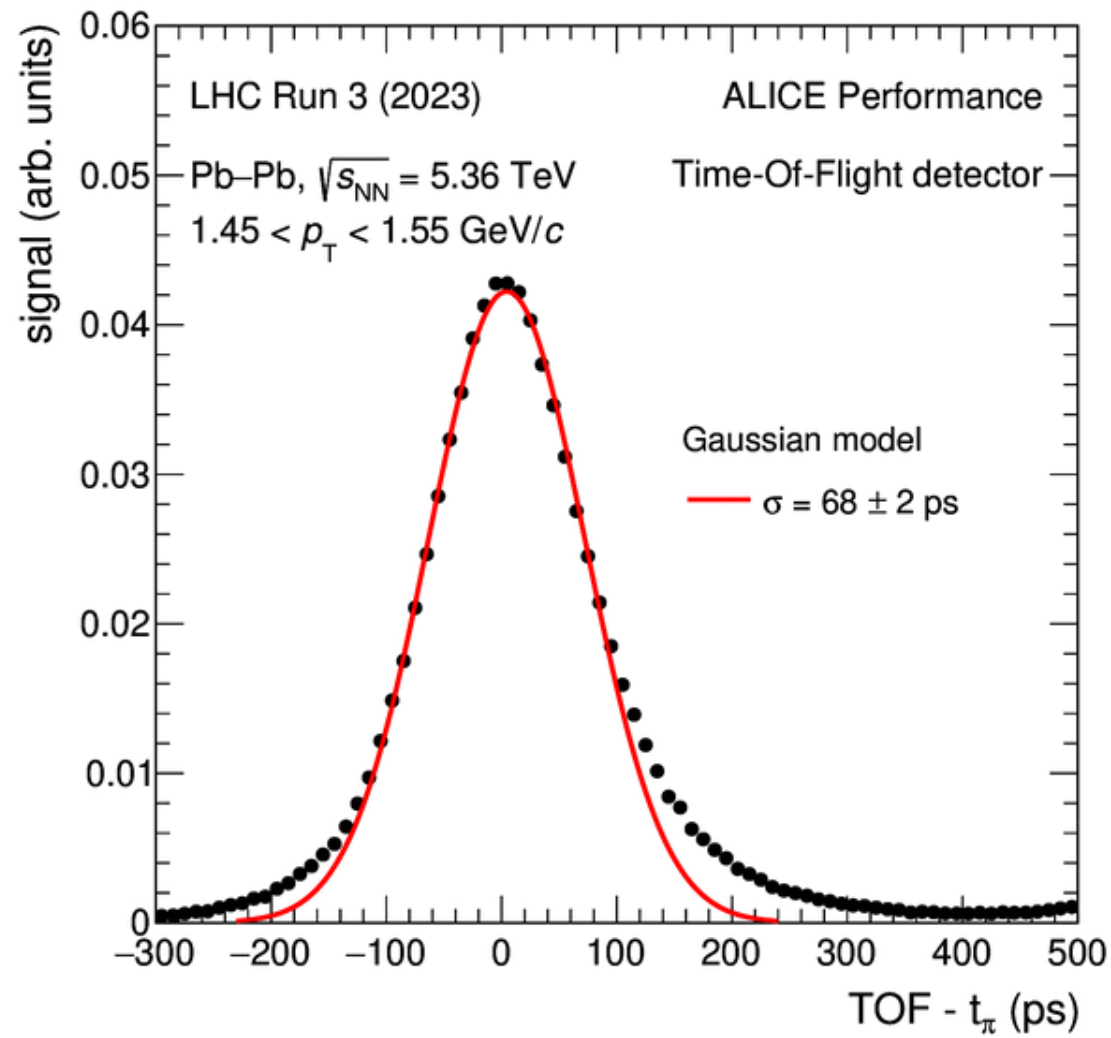
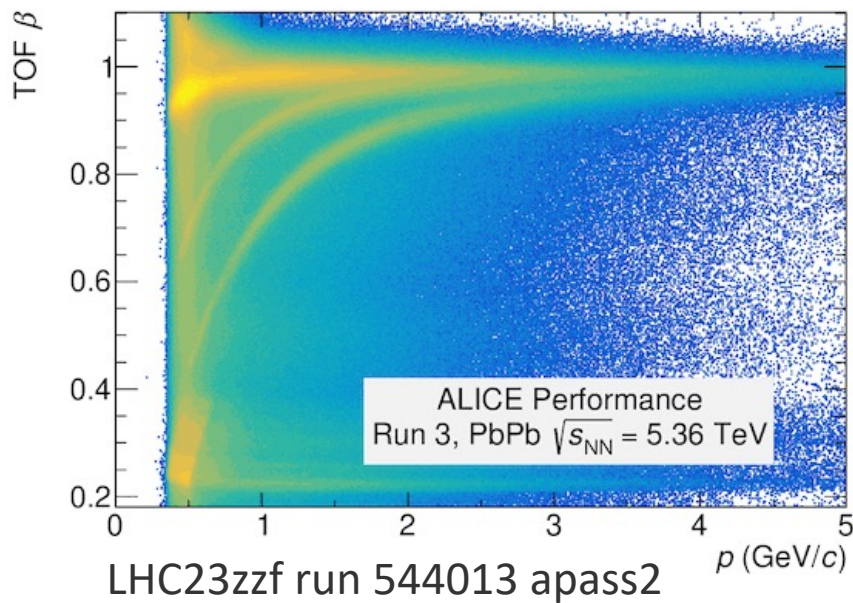
The achievements presented in this paper **confirm the capability of ALICE** to maintain **reliable particle identification** in the continuous readout mode of **Run 3**



The ALICE TOF **operated successfully** since the beginning of LHC operations, **for more than 15 years**

TOF Performance in RUN 3 Pb-Pb

TOF timing performance in
Pb-Pb with refined time-
slewing calibration
 $\sigma_{\text{TOF}} \sim 68 \text{ ps}$



TOF quality in RCT 2024

So far more than **99.3%** of 2024 apass1 runs are **GOOD** for TOF

Bookkeeping ALI FLP Home Log Entries Environments LHC Fills Runs RCT Overview About

Filters **Physics Runs > LHC24af_apass1** Export Runs

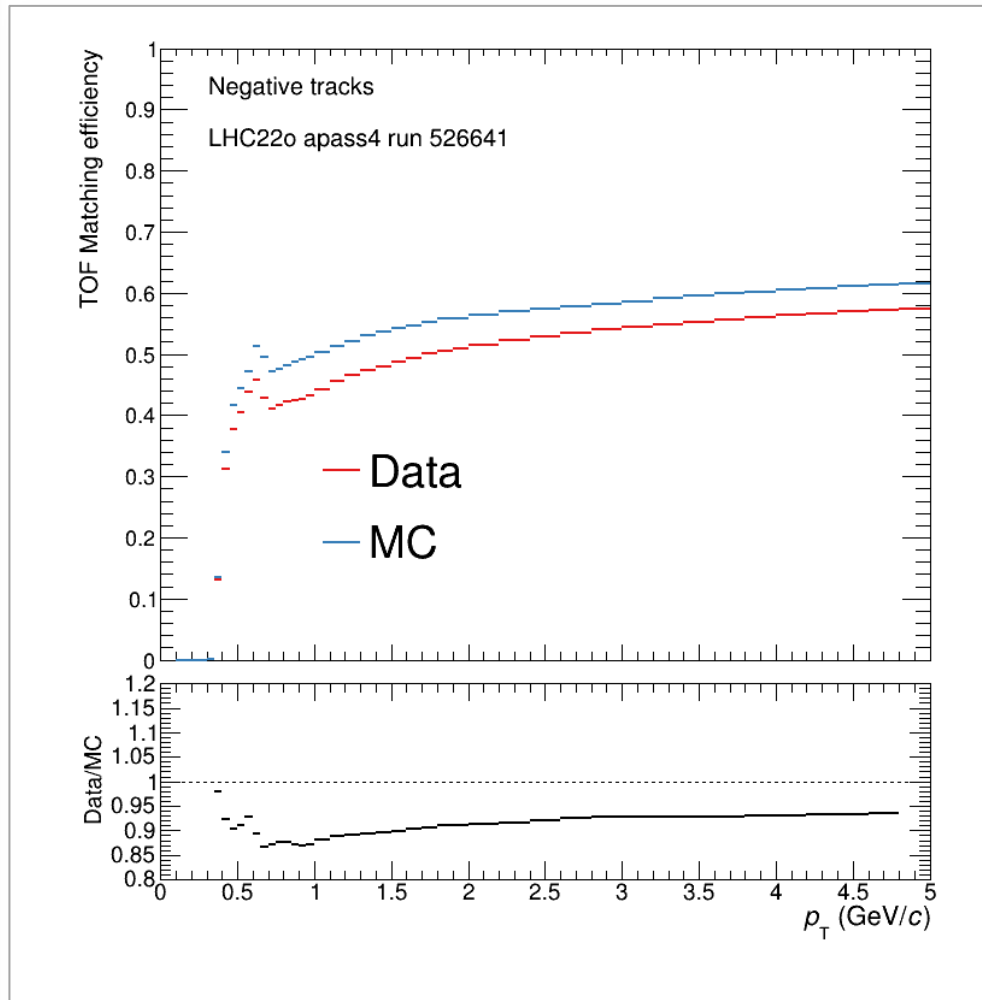
Run	Fill No.	Start	Stop	TRG Start	TRG Stop	L3 (A)	Dipole (A)	μ (INEL)	INEL _{avg} (Hz)	GLO	CPV	EMC	FDD	FTO	FVO	HMP	ITS	MCH	MFT	MID	PHS	TOF	PC	TRD	ZDC	
550916	9579	01/05/2024 19:46:18	01/05/2024 22:17:22	01/05/2024 19:46:18	01/05/2024 22:17:22	-29,999.9	-5,999.96	0.033	743,955	⊙	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	
550889	9575	01/05/2024 00:59:30	01/05/2024 04:31:52	01/05/2024 00:59:30	01/05/2024 04:31:52	-29,999.9	-5,999.96	0.033	751,426	⊙	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550858	9574	30/04/2024 13:04:57	30/04/2024 13:46:25	30/04/2024 13:04:57	30/04/2024 13:46:25	-29,999.9	-5,999.96	0.033	741,619	⊙	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550892	9574	30/04/2024 07:24:27	30/04/2024 12:48:33	30/04/2024 07:24:27	30/04/2024 12:48:33	-29,999.9	-5,999.96	0.033	749,024	⊙	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550848	9574	30/04/2024 05:20:07	30/04/2024 07:12:12	30/04/2024 05:20:07	30/04/2024 07:12:12	-29,999.9	-5,999.96	0.033	753,644	⊙	100%		100%	100%	100%		0	100%	100%	100%	100%	100%	100%	100%	100%	100%
550843	9574	30/04/2024 01:30:52	30/04/2024 05:08:47	30/04/2024 01:30:52	30/04/2024 05:08:47	-29,999.9	-5,999.96	0.033	743,413	⊙	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550824	9573	29/04/2024 16:50:25	29/04/2024 23:21:38	29/04/2024 16:50:25	29/04/2024 23:21:38	-29,999.9	-5,999.96	0.033	749,862	⊙	100%	100%	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550819	9573	29/04/2024 11:46:03	29/04/2024 16:08:31	29/04/2024 11:46:03	29/04/2024 16:08:31	-29,999.9	-5,999.96	0.033	749,020	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550784	9570	28/04/2024 16:39:06	28/04/2024 16:52:44	28/04/2024 16:39:06	28/04/2024 16:52:44	-29,999.8	-5,999.97	0.032	675,413	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550781	9570	28/04/2024 14:31:14	28/04/2024 16:32:00	28/04/2024 14:31:14	28/04/2024 16:32:00	-29,999.8	-5,999.97	0.036	748,673	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550778	9570	28/04/2024 11:36:00	28/04/2024 14:21:04	28/04/2024 11:36:00	28/04/2024 14:21:04	-29,999.8	-5,999.97	0.036	752,356	⊙	100%	0	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550774	9570	28/04/2024 08:26:16	28/04/2024 11:26:57	28/04/2024 08:26:16	28/04/2024 11:26:57	-29,999.8	-5,999.97	0.036	747,710	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550760	9569	28/04/2024 02:51:18	28/04/2024 03:54:39	28/04/2024 02:51:18	28/04/2024 03:54:39	-29,999.8	-5,999.97	0.035	725,756	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550756	9569	28/04/2024 00:19:46	28/04/2024 02:44:02	28/04/2024 00:19:46	28/04/2024 02:44:02	-29,999.8	-5,999.97	0.036	744,088	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550742	9568	27/04/2024 21:28:17	27/04/2024 22:03:06	27/04/2024 21:28:17	27/04/2024 22:03:06	-29,999.8	-5,999.97	0.034	718,768	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550731	9568	27/04/2024 12:20:05	27/04/2024 21:09:33	27/04/2024 12:20:05	27/04/2024 21:09:33	-29,999.8	-5,999.97	0.036	753,260	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550728	9568	27/04/2024 09:25:30	27/04/2024 11:59:03	27/04/2024 09:25:30	27/04/2024 11:59:03	-29,999.8	-5,999.97	0.036	751,002	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550711	9567	27/04/2024 03:41:42	27/04/2024 06:35:12	27/04/2024 03:41:42	27/04/2024 06:35:12	-29,999.8	-5,999.97	0.036	744,227	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550707	9567	27/04/2024 00:49:08	27/04/2024 03:35:01	27/04/2024 00:49:08	27/04/2024 03:35:01	-29,999.8	-5,999.97	0.036	747,627	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550691	9566	26/04/2024 20:06:55	26/04/2024 21:45:33	26/04/2024 20:06:55	26/04/2024 21:45:33	-29,999.8	-5,999.97	0.035	738,232	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550690	9566	26/04/2024 17:08:28	26/04/2024 20:00:14	26/04/2024 17:08:28	26/04/2024 20:00:14	-29,999.8	-5,999.97	0.036	749,692	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
550654	9565	26/04/2024 06:33:15	26/04/2024 13:05:50	26/04/2024 06:33:15	26/04/2024 13:05:50	-29,999.8	-5,999.97	0.041	747,326	⊙	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

TOF

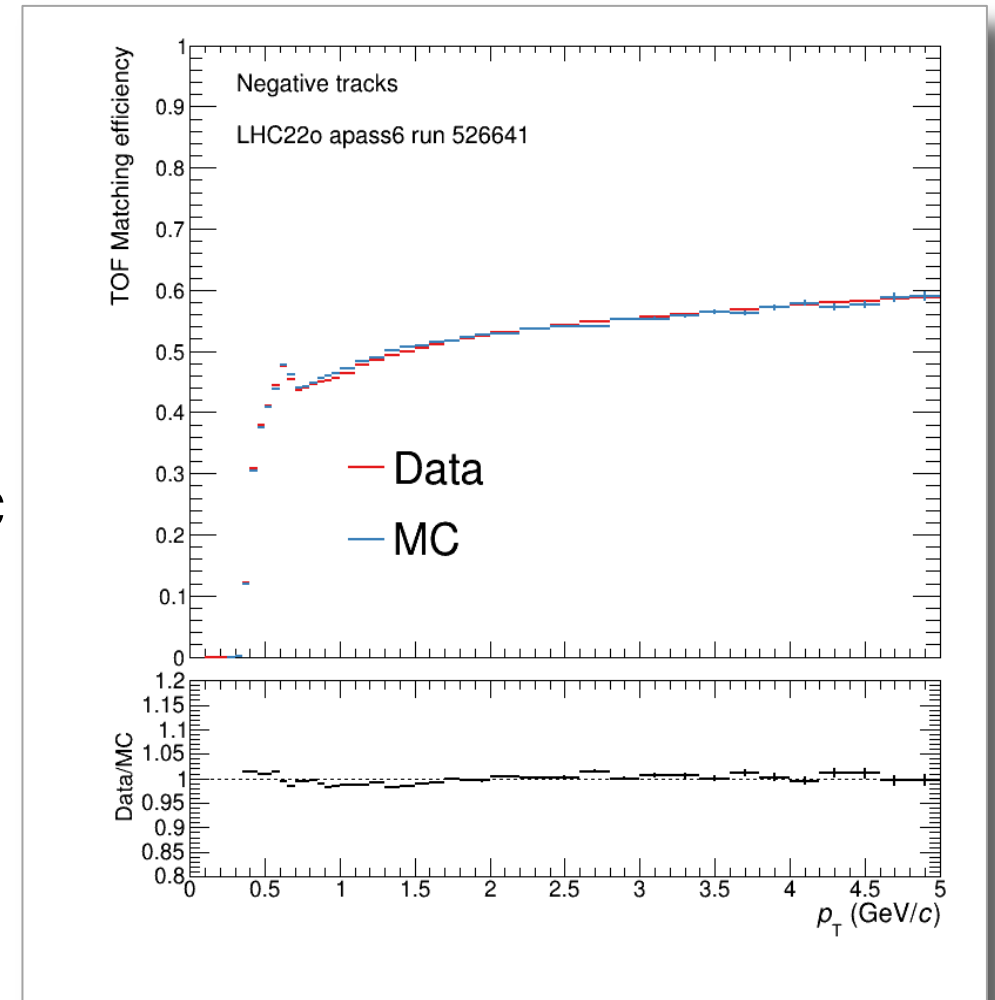
Run condition table

Anchoring quality in MC

Considering in the MC only the enabled channels \rightarrow acceptance comparable to the real one

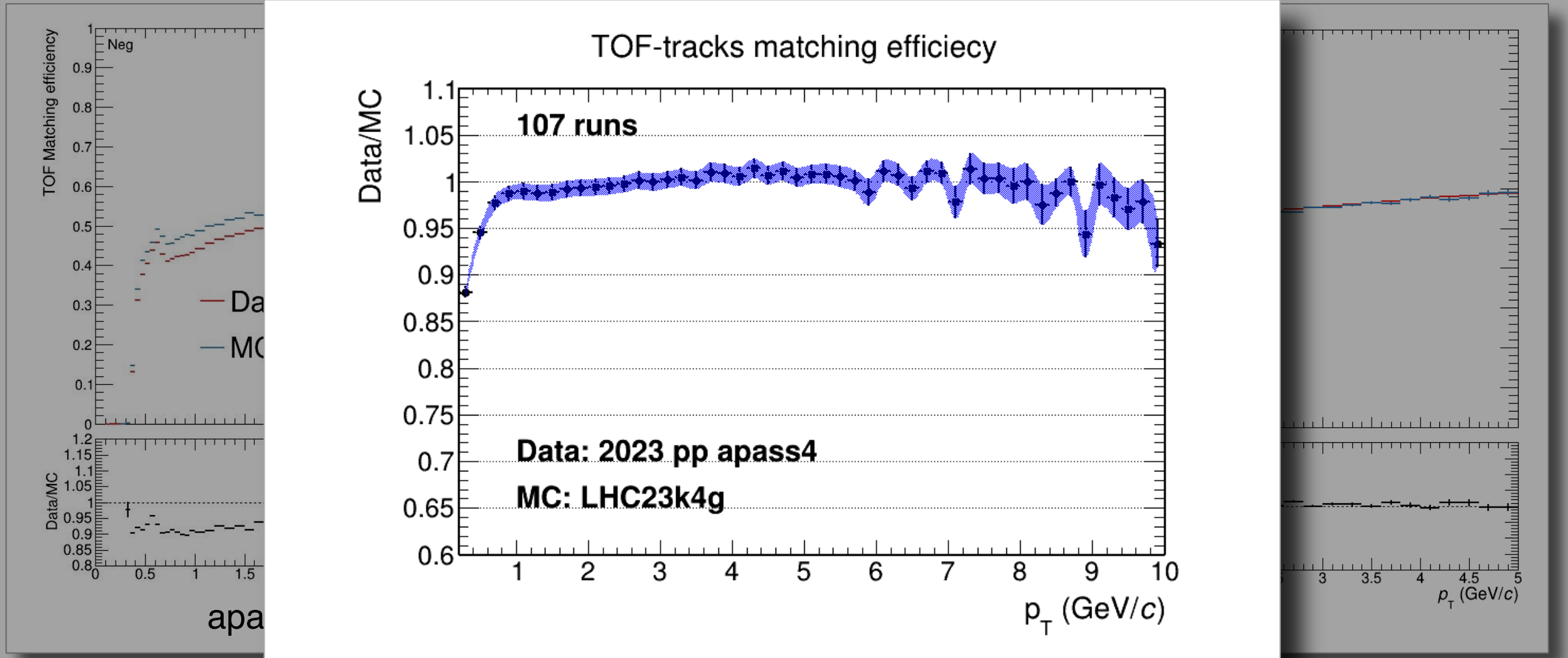


**Improvement
of the data/MC
matching
from aPASS4
to aPASS6**

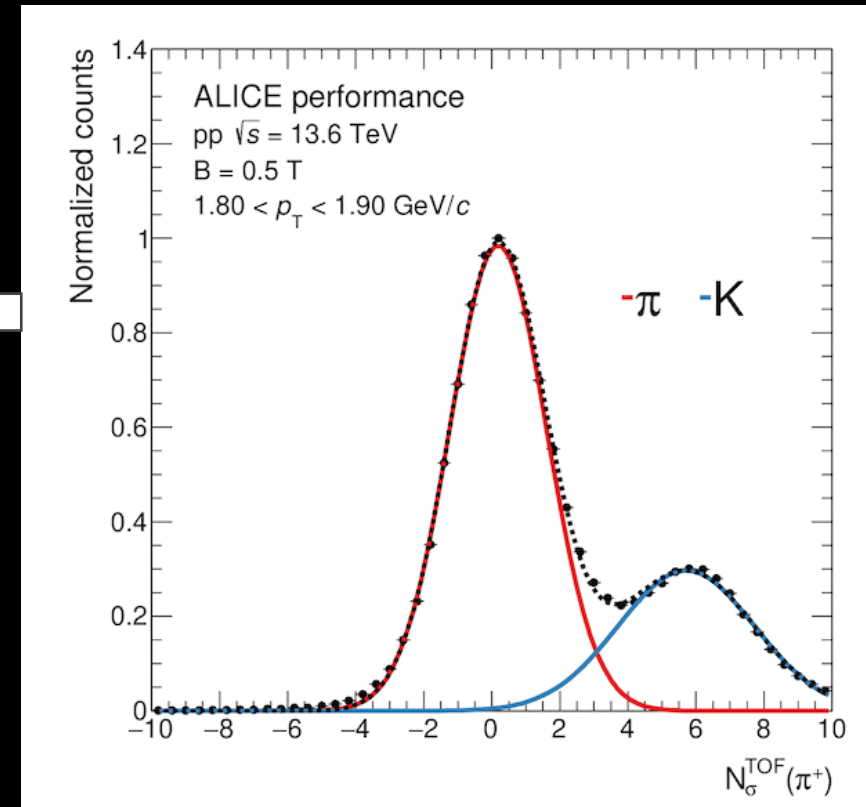
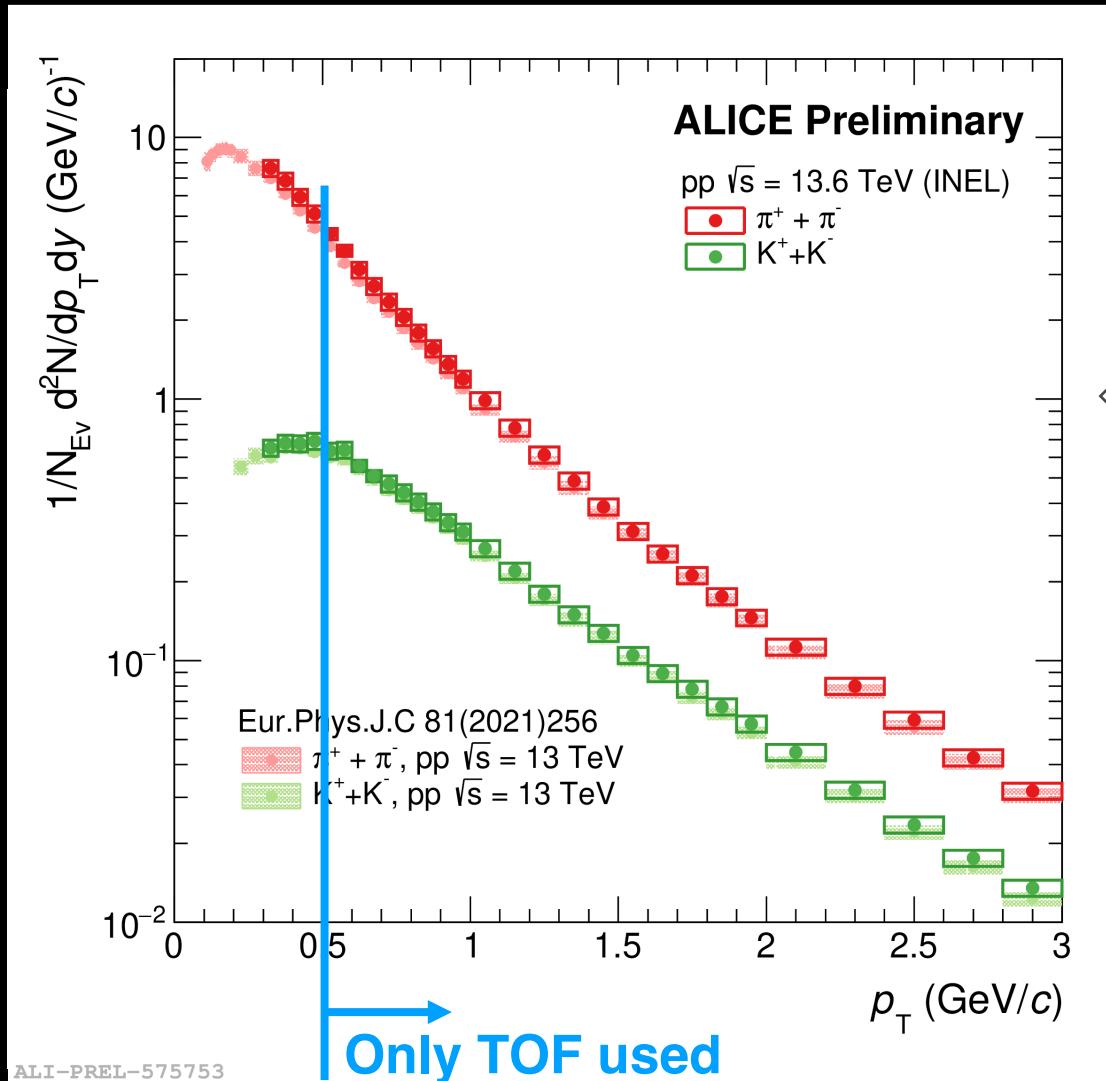


Anchoring quality in MC

Considering in the MC only the enabled channels \rightarrow acceptance comparable to the real one

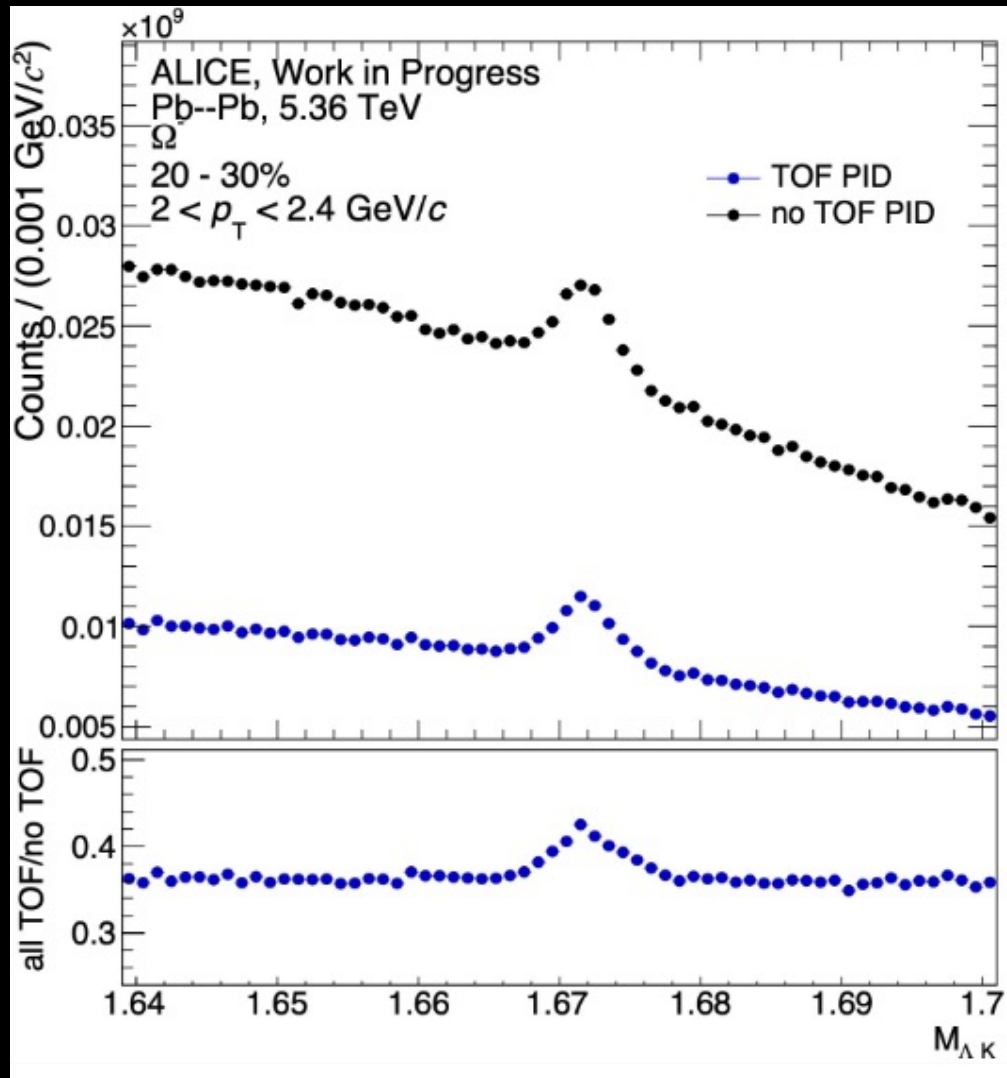


RUN 3 Physics with TOF (pp): spectra



- Spectra in Run 2 and 3 in agreement
- Also extracted VS multiplicity

RUN 3 Physics with TOF (Pb-Pb): LF



Measurement of the Ω mass with and without applying the TOF PID

TOF PID helps to

- **reduce the background shape**
- **increase the purity of cascades in Pb-Pb collisions**

→ TOF PID used in many analyses approved for the Summer conferences

TRM2 project status : financial overview

Long term project to **replace part of TRM damaged with a new TDC card based on PicoTDC** (instead of HPTDC) no longer spares available need to guarantee high efficiency up to end of Run

Plan:

- ✓ produce **100 new TRM2**
- ✓ **replace** during LS3 up to **50 broken TRM**
- ✓ keep 50 TRM2 as spares during RUN4

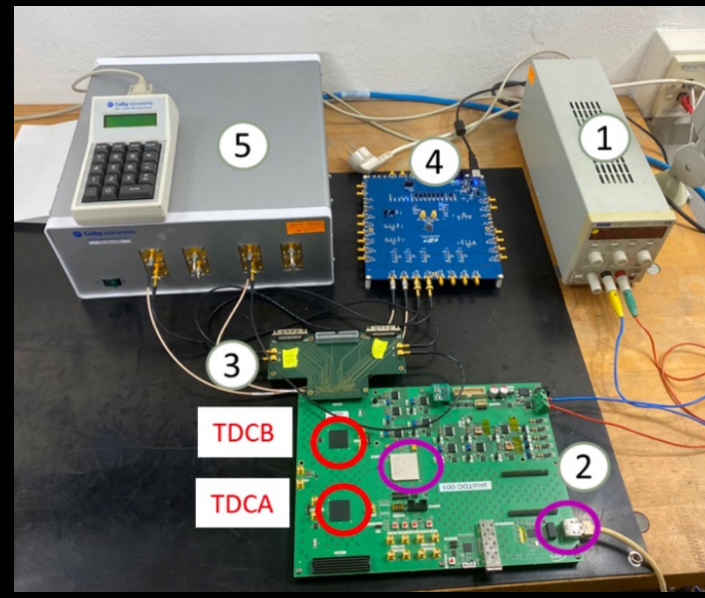
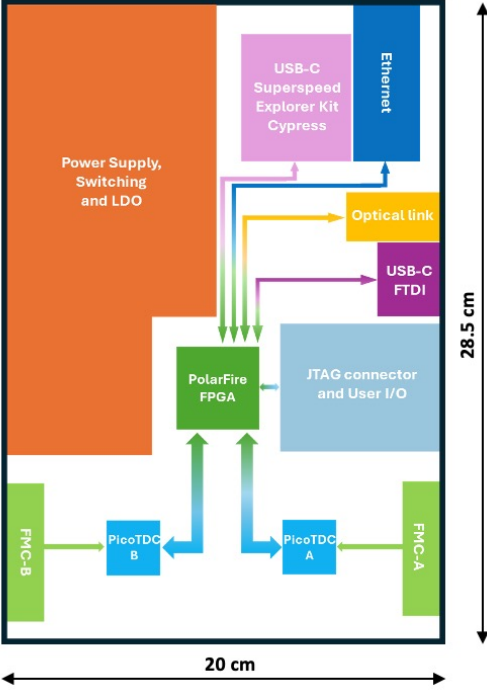
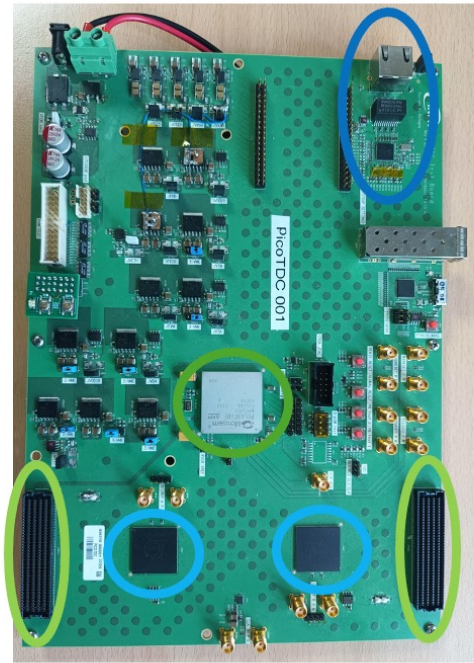
} **800 k€**

Status

- **picoTDC test board (15 k€ budget 2022) fully tested coupled to PolarFire FPGA**
- **picoTDC test board used also in ALICE3-TOF context (test beams)**
- **advanced status of schematics (INFN-BO) and layout (CAEN) for prototypes: first prototypes expected by end of 2024 (100 k€ budget 2023)**
- **50 TRM2 production batch already funded by CSN3 in 2024 budget (350 k€ s.j. → Sep2024)**
- **request of funding for the other 50 expected to be successful in budget 2025 (350 k€ → 2025)**

TRM2 project status: picoTDC board

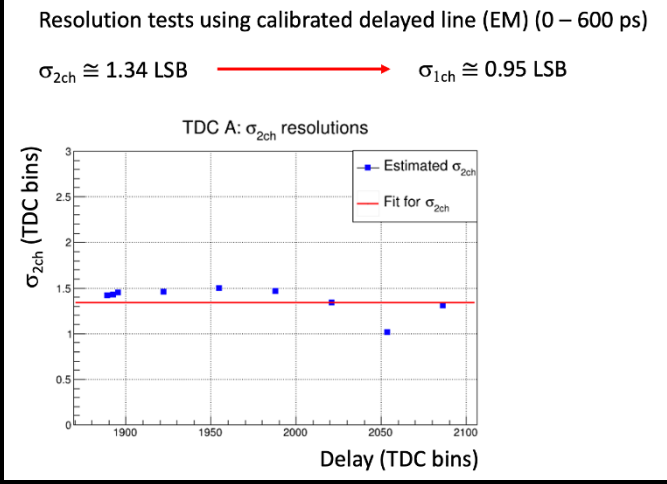
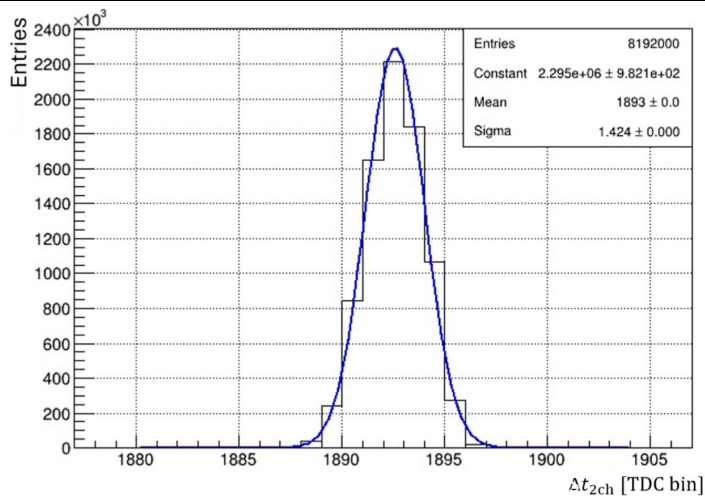
- First step for the TRM2 development.
- A **PolarFire FPGA** and **2 PicoTDCs**, connected to **2 high-density connectors** for plugging different FE boards and sensors.
- External links to the FPGA to control the board through **USB** and **Ethernet** communication protocols (an optical link is also provided).



Resolution tests using calibrated delayed line (EM) (0 – 600 ps)

$\sigma_{2ch} \cong 1.34 \text{ LSB}$ \longrightarrow $\sigma_{1ch} \cong 0.95 \text{ LSB}$

Tests in the lab
 \rightarrow meas. time res. **< 3 ps** per ch.

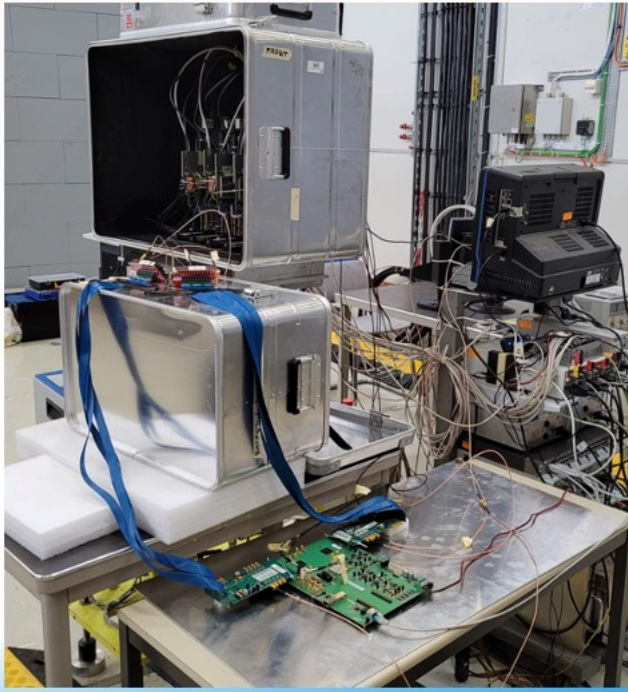


Two master thesis so far@UniBO
 (S. Geminiani defence tomorrow)

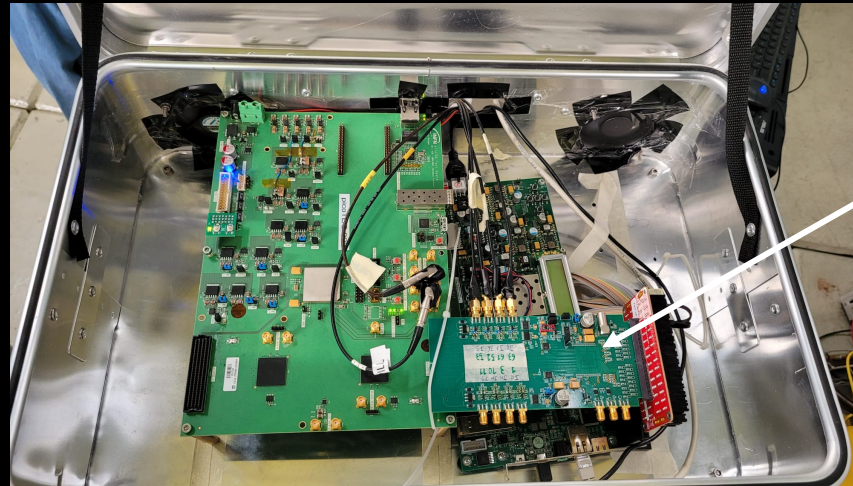
TRM2 project status: picoTDC board @ ALICE3

picoTDC test board now being
used in ALICE 3-TOF Test Beam

→ Readout of
CMOS-LGADs,
LGAD and SiPMs



- interesting "spin-off" of TRM2 project
- see ALICE3 requests @ BO for **PFEB** (picoTDC Front-End Board)
- AIDAInnova funding for part of the project (post-doc)
- now used in the lab for sensor characterization



PFEB-L
using Weeroc LIROC
for SiPM

picoTDC Board: accepted talk @ TWEPP2024

more on ALICE3 presentation

TRM2 project status: designing TRM2

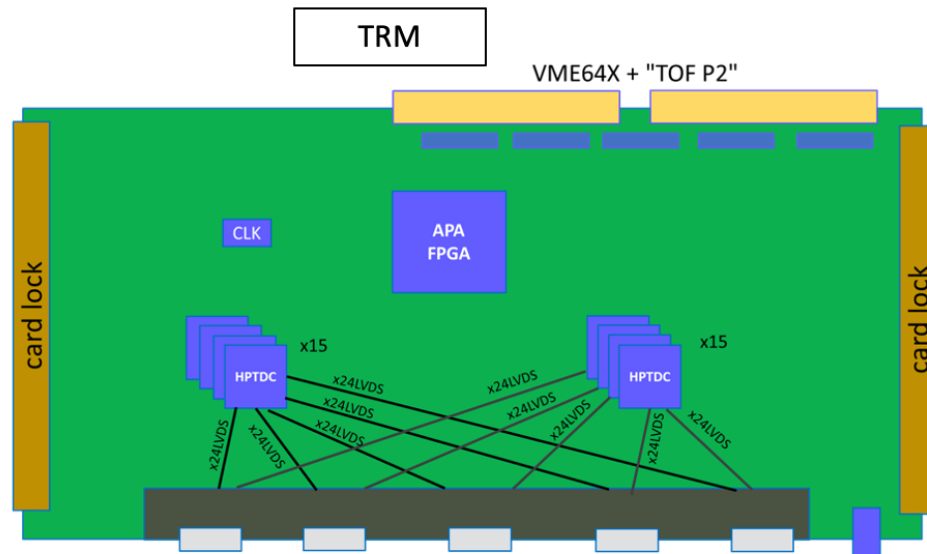
- PO for R&D with CAEN November 2023
- January 2024: INFN-BO/CAEN joint team formed, negotiated responsibilities, shared cloud
 - → INFN-BO: specs, schematics, firmware
 - → CAEN: layout & engineering – production
- July 2024: schematics approval, advanced layout
- 8th August 2024: firmware closure by INFN
- Sep 2024: go for production (5 prototypes)
 - → since Nov. 2024 validation of prototypes etc.



July 7/8 @ CAEN headquarters

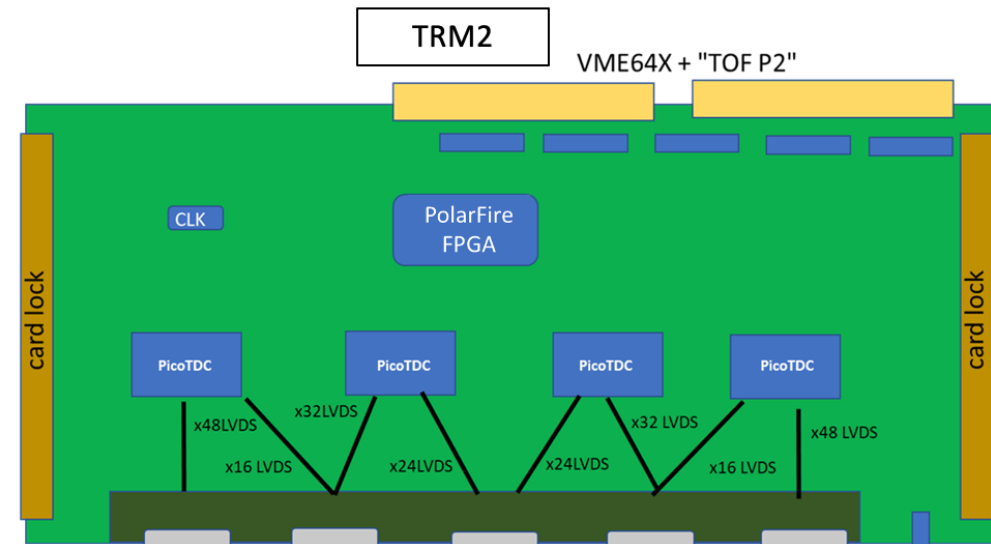
TRM2 project status: from TRM1 to TRM2

From TRM to TRM2 for time measurements in the TOF detector



The **TRM VME** card is the main element of the TOF readout system and it hosts:

- An **Actel ProASIC FPGA** to manage the readout and board operations.
- **30 HPTDC** ASICs (24.4 ps LSB, 8 ch/chip) to provide time measurements.



To replace damaged TRMs during LHC Run 4, a new **TRM2** project began, considering:

- A **PolarFire FPGA** to manage the readout and board operations.
- **4 PicoTDC** ASICs (12.2 ps or 3.05 ps LSB, 64 ch/chip) as successors of the HPTDCs.



TRM2 project status: from TRM1 to TRM2

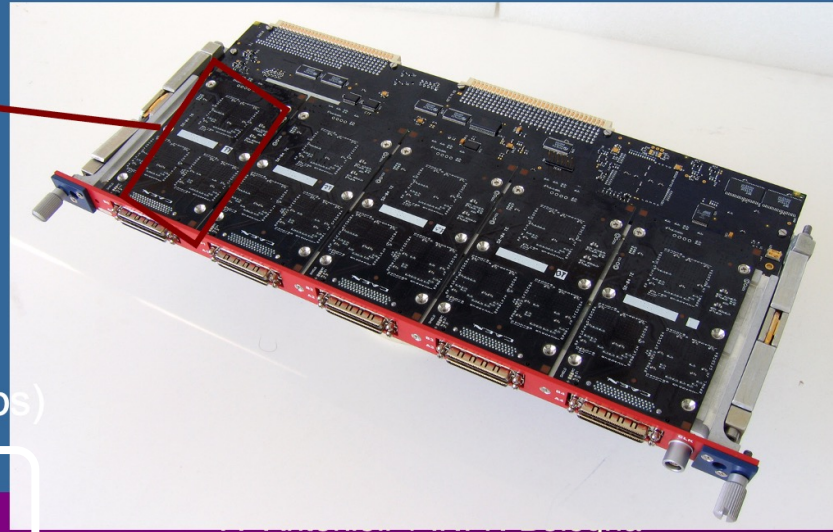
TRM (and HPTDC)



- HPTDC production completed & tested: 82% yield, 16% spare
- TRM production launched and is now ongoing (47 TRMs already delivered)
- 20 ps resolution confirmed



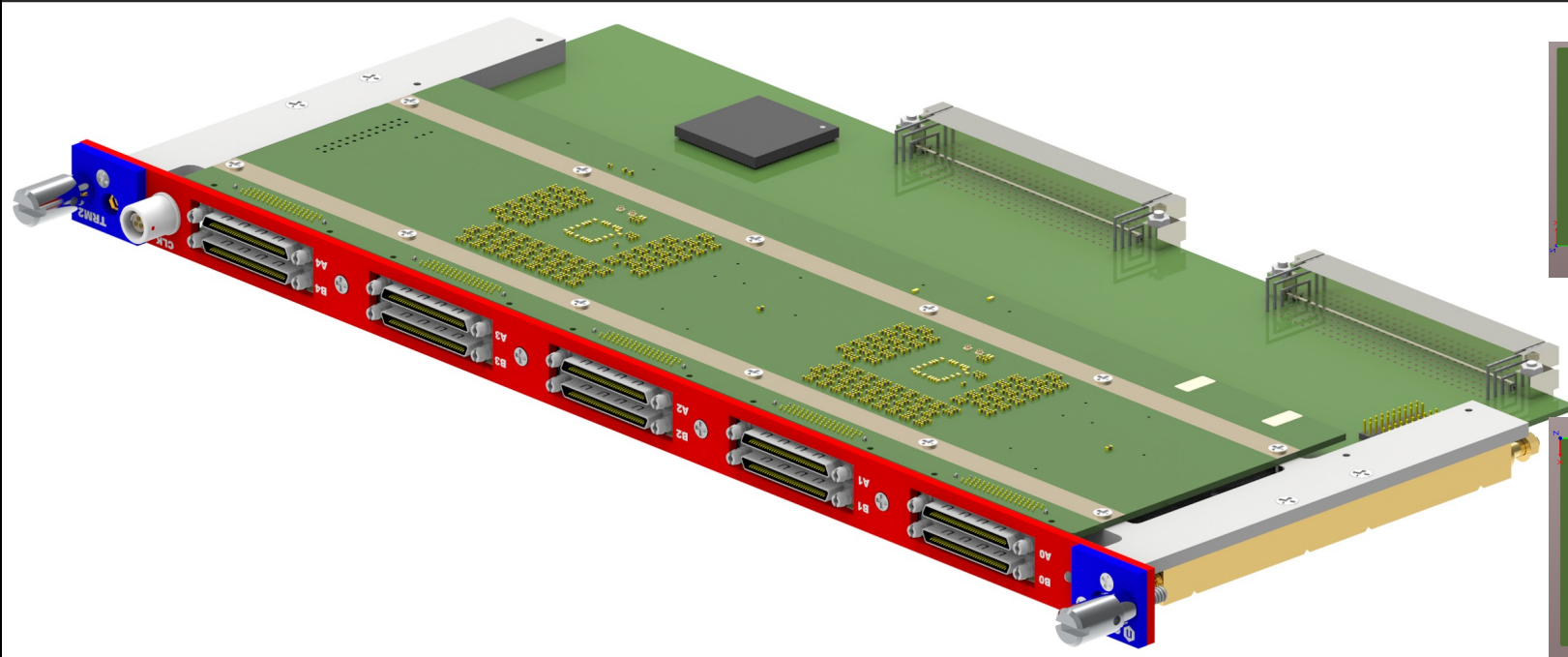
piggy-back card (3 HPTDC chips)



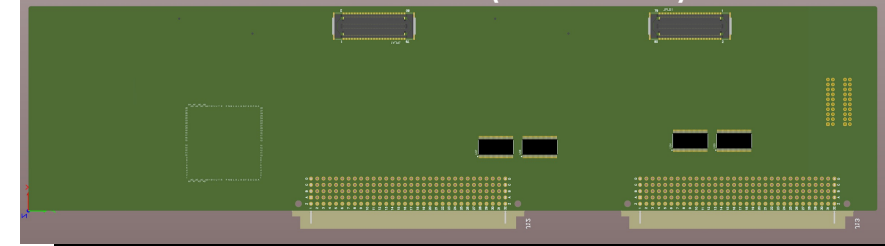
3-4/05/2006 meeting ALICE Italia

A little bit of archeology... first 47 TRM delivered May 2006

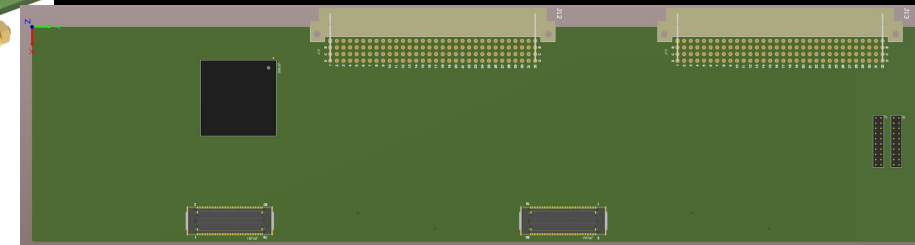
TRM2 project status: TRM2 prototypes



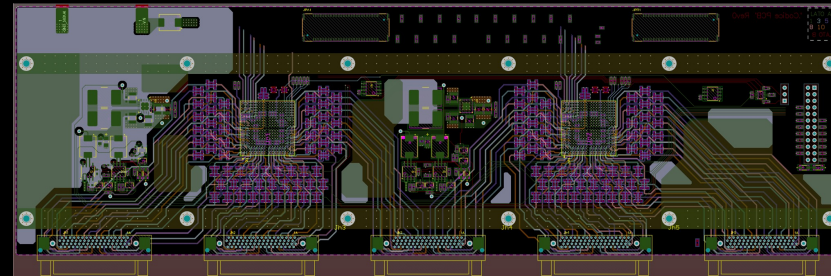
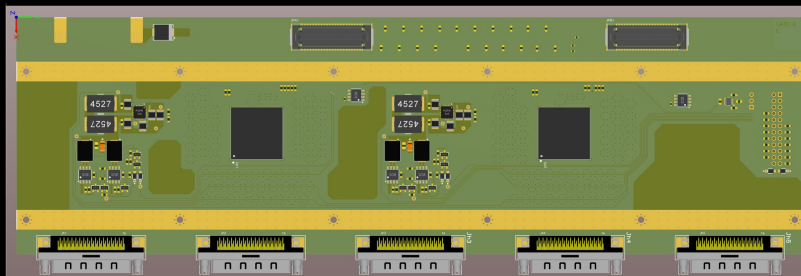
motherboard (bottom)



motherboard (top with FPGA)



2 picoTDC and 5 VHDCI piggy-back: rendering & layout



- central aluminium bar for cooling as in TRM1
- opted for 1 single piggy-back (on both sides)
- LVDS-SubLVDS adaptation
- a lot of tech. stuff learned via picoTDC board

TOF transitional management plan

transitional TOF management plan

context: need to move responsibility to next generations

current situation:

PL: A. Zichichi

Deputy PL: P. Antonioli (representing A. Zichichi in MB), L. Cifarelli

TC: G. Scioli

transitional management plan

PL : P. Antonioli (MB), L. Cifarelli

Deputy PL: A. Alici

TC: G. Scioli

Deputy TC: M. Colocci

(A. Zichichi recognized as PL emeritus on website)

Pietro and Luisa will step down as PL by June 2025, when we will appoint a new (and just one) PL

plan endorsed by ALICE MB 11th July

in addition:

INFN-BO (RL) A. Alici → F. Bellini

Five generations of TOFers in this slide!
Next leader will be ALICE-native

Note:

INFN BO, INFN SA, ITEP (Moscow) and GWNU (Seoul) are TOF Institutions

ITEP Moscow will leave TOF (and ALICE) end of the year as per CERN Council decision

SUMMARY (as given to recent ALICE Week in TOF status talk)

▪ YETS main achievements:

- Notch filters refurbished
- Crate unclogging
- Replacement of disabled TRM
- “periodic” maintenance of several TOF components

**+4059 ch back
in readout**

**Crate 31
back in readout**

▪ Technical Stop:

- Hardware intervention by CAEN

**Crate 35 back
in readout**

- **Performance** shows a time res. of **80 ps** in pp (new standalone method consistent classical one) and **68 ps** in Pb-Pb

**Performance paper
with RUN 3 data under
IRC review**

- **QC improvements implemented** to allow better control of TOF data flow

- Working for **LS3 “upgrade”**

Physics

TOF PID used in plenty of analyses:
nuclei, id-spectra, HF, **CF**

TOF milestones proposal

31/12/2025 Partecipazione a presa dati con collisioni pp e Pb-Pb

31/12/2025 Pubblicazione su rivista internazionale paper su performance del rivelatore TOF in collisioni pp a 13.6 TeV (Run 3)

- in line with major on-going effort (keep detector alive and efficient)
- first performance paper on Run3 data

SUMMARY for CSN3 referees

- TOF is getting older, electronics may require other important financial request during next years
- potential shift of LHC schedule might further stress TOF (end of life in 2033 instead of 2032?)
- Main financial request (TRM2) well on track
- TOF is getting older, new generations are coming

Requests @INFN-BO:

TOF only requests: ALICE3 not listed here

22.5 k€ 3 CAEN SY4527 (new HV Main Frames) [anticipabili] / apparati

350 k€ second batch of TRM2 / apparati

3 k€ manutenzione apparato ("unclogging") /missioni

1.5 k€ manutenzione apparato ("HV connectors reworking") /missioni

3 k€ test e upgrade fw DRM2 / missioni

3 k€ missioni core team @CAEN headquarters (3 x 3 p x 2gg) / missioni

2 k€ licenze Microchip LiberoIDE (IGLOO2/DRM2 – Polarfire/TRM2 + Actel legacy / software

+ 57 k€ usual formula for missioni (shifts/**on-call**/experts) (M&O-A based)

+ 51 k€ M&O-B costs (electronics maintenance)

Requests @INFN-SA:

pro-quota also missions from FTE and responsibilities contribute to TOF life

+ 23 k€ usual formula for missioni (shifts/**on-call**/experts) (M&O-A based)