PID performance of the MRPC-based ALICE-TOF detector

XIV Workshop on Resistive Plate Chambers and related detectors
Puerto Vallarta, Jalisco State, MEXICO, 19-23 Feb 2018

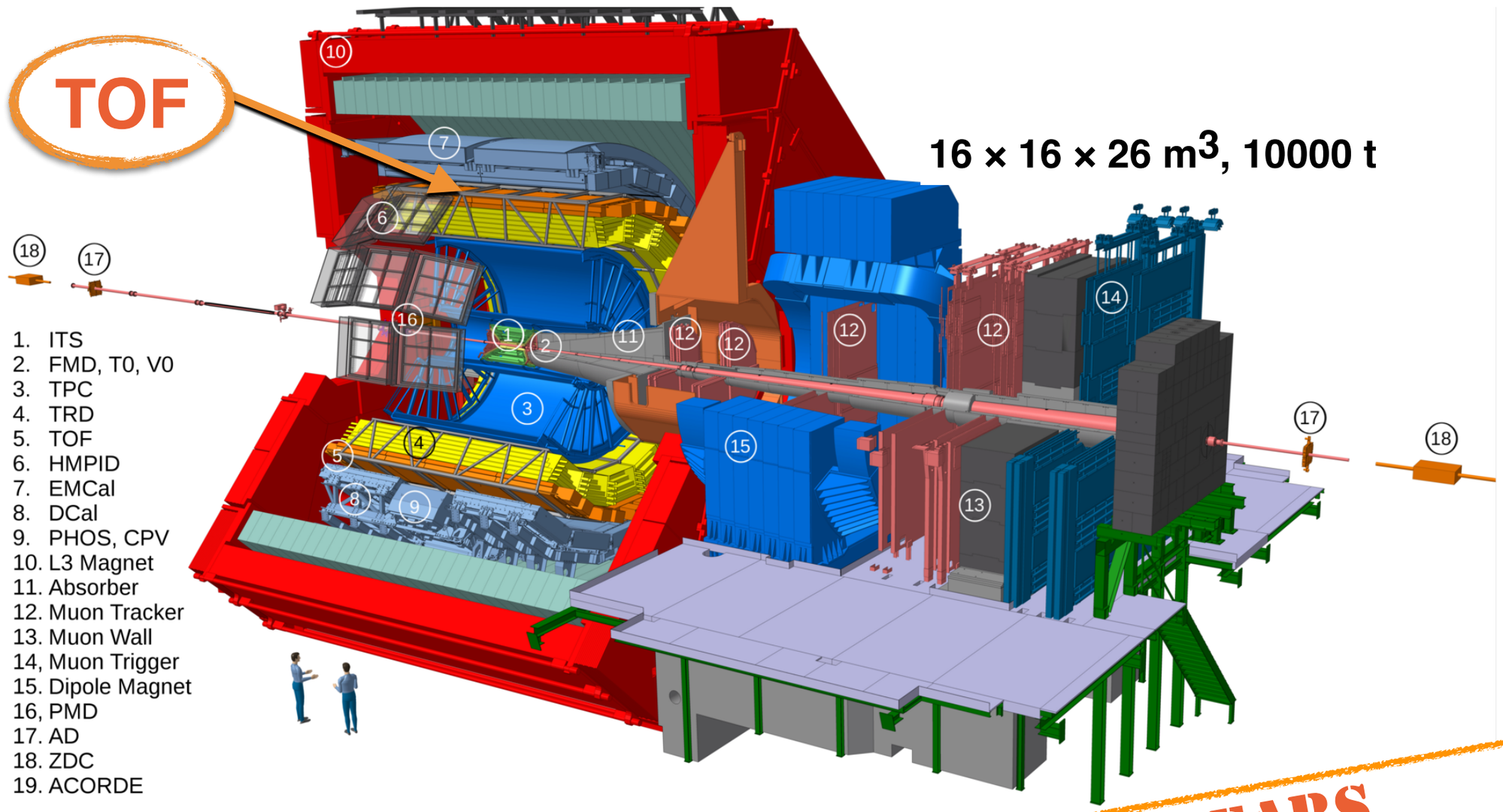
Francesca Carnesecchi
on behalf of the ALICE collaboration

INFN Bologna, Centro Fermi Roma, Italy

ALICE-TOF

ALICE at LHC:

- The experiment devoted to the study of **Q**uak **G**luon **P**lasma
- (0.15 - 20) GeV/*c* • First pp: 2009



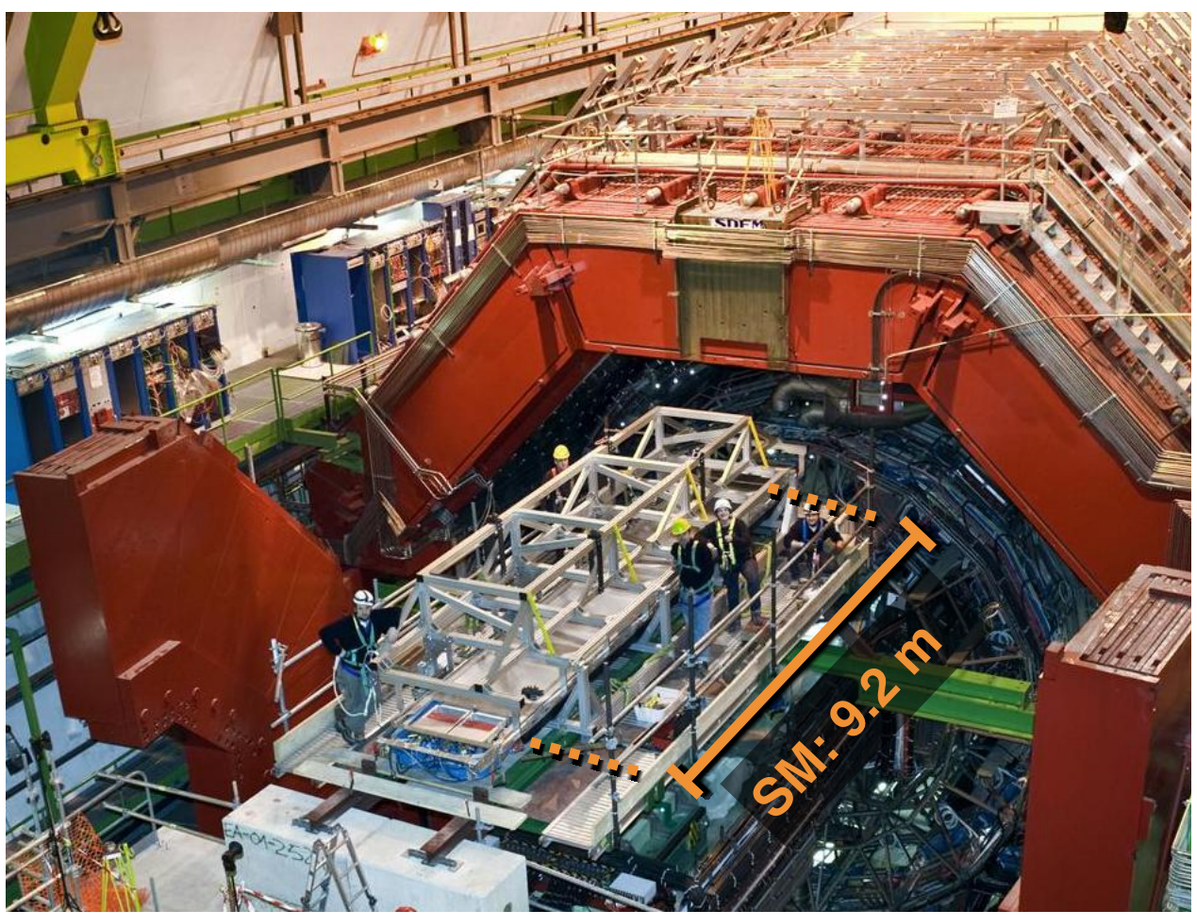
ALICE-TOF:

- Based on **M**ultigap **RPC** technology
- Installed in **2008**
- **PID** from 0.3 GeV/*c*; 3σ up to 2.5 GeV/*c* (π/K) , 4GeV/*c* (p/K)

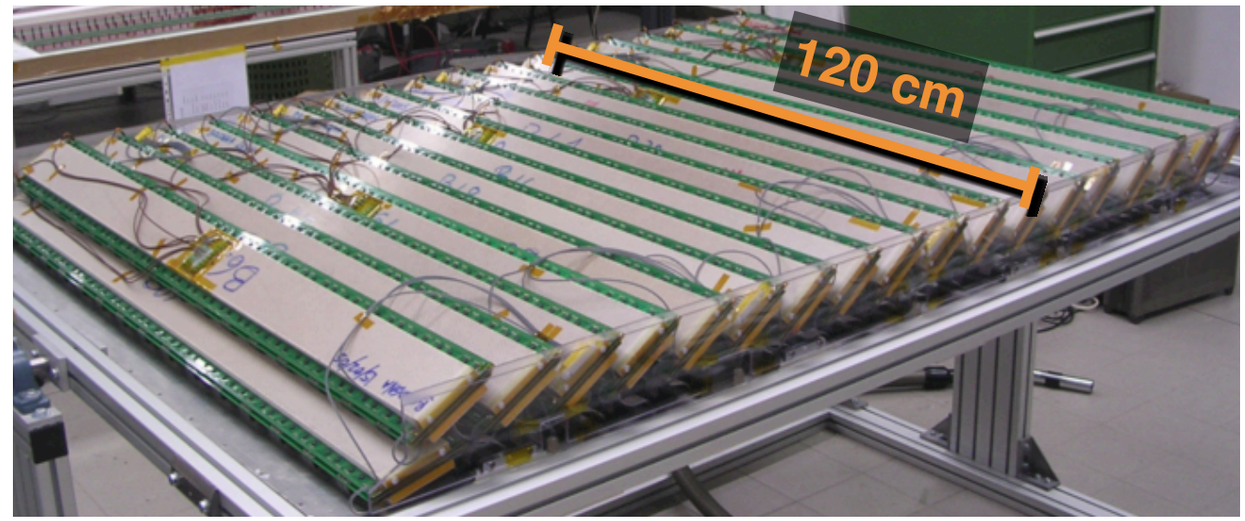
10 YEARS IN OPERATION

ALICE-TOF

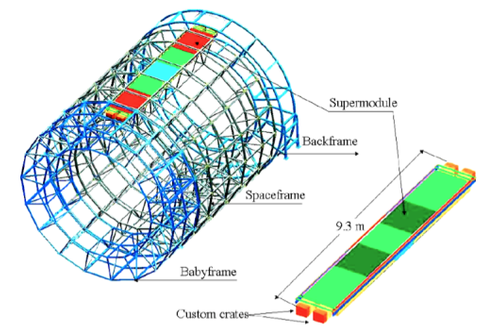
- inner/external radius: 3.7/3.99 m
- active area **141 m²**
- weight 26 tons
- $|\eta| < 0.9$
- full φ —> 18 SuperModules(SM)
- 5 Modules each SM
- 19(15) MRPCs per Modules
- total of **1593 MRPCs**
- **152928** readout **channels**



- 120 × 7.4 cm² active area MRPC



…**wide area** MRPC application!



In **2017**, total of **2116** hours:

- ~**99% total time availability**
- ~**93%** average active **channels**

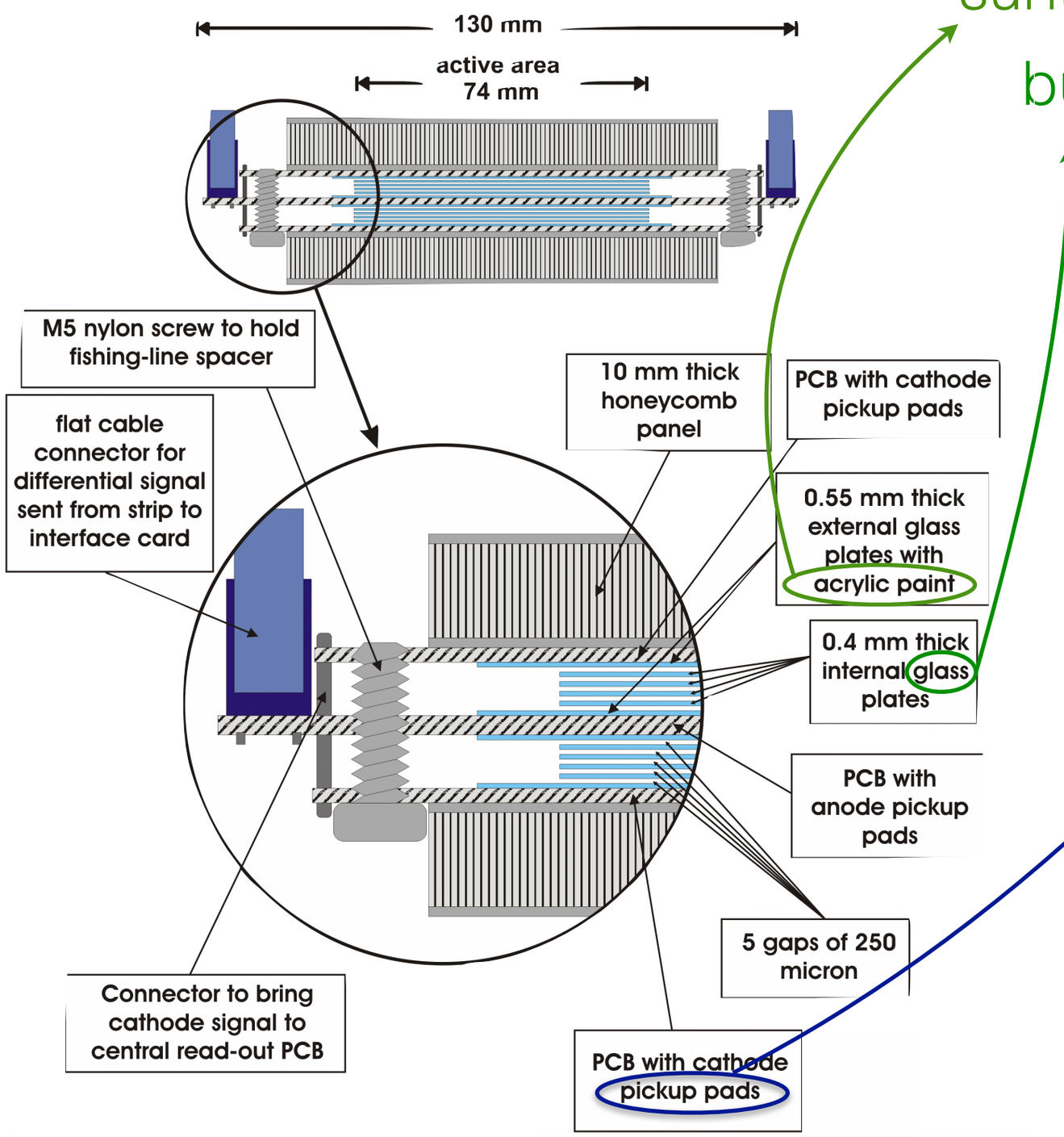
The missing **7%** —>due to **electronics** and **connectors** (**not** to MRPC!)

ALICE-TOF MRPC

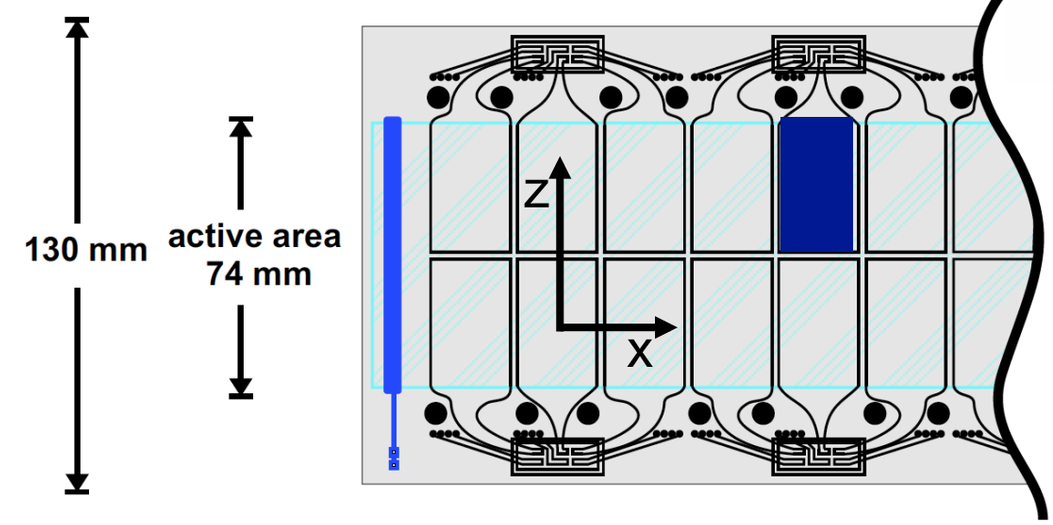
10 gas (93% $C_2H_2F_2$ + 7% SF_6) **gaps**, **250 μm**, **double-stack** design

surface resistivity ~ MΩ/□

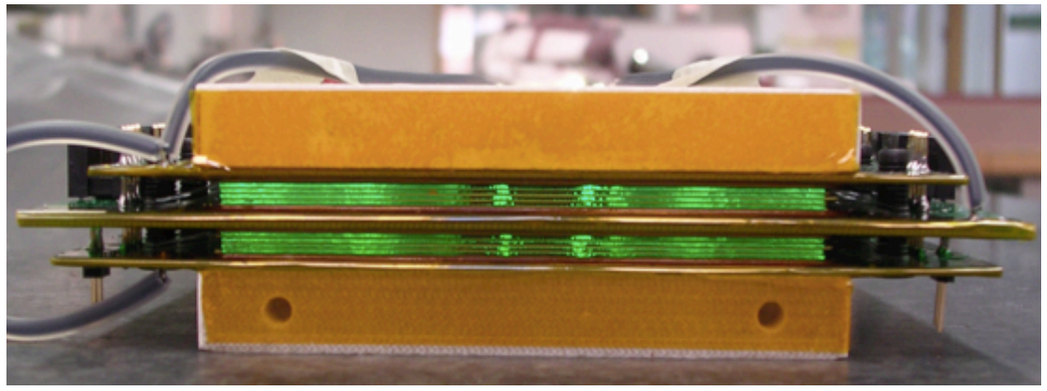
bulk resistivity ~ 5 10^{12} Ωcm



2.5 × 3.5 cm²

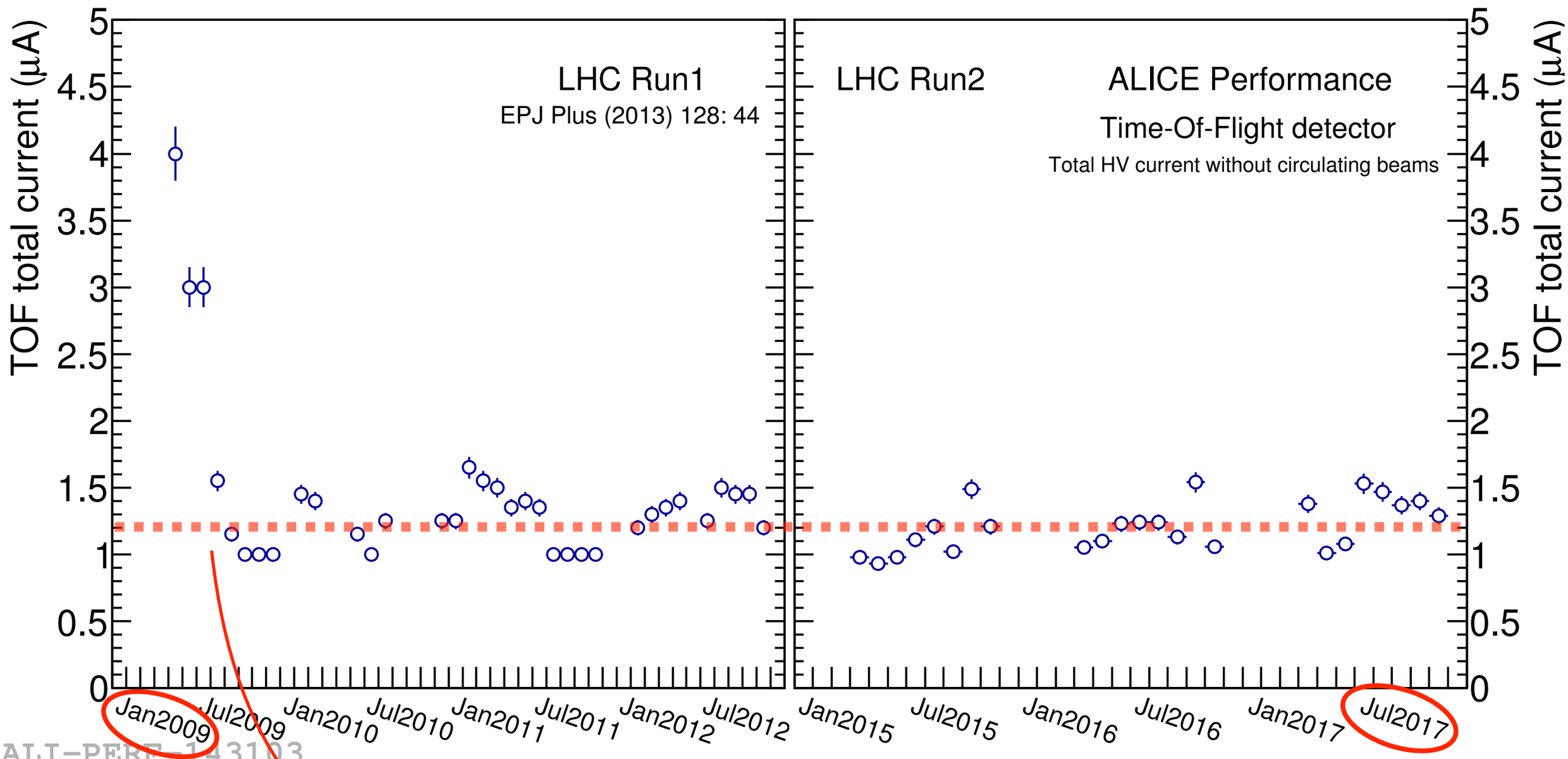


2 rows of **48** pickup **pads**



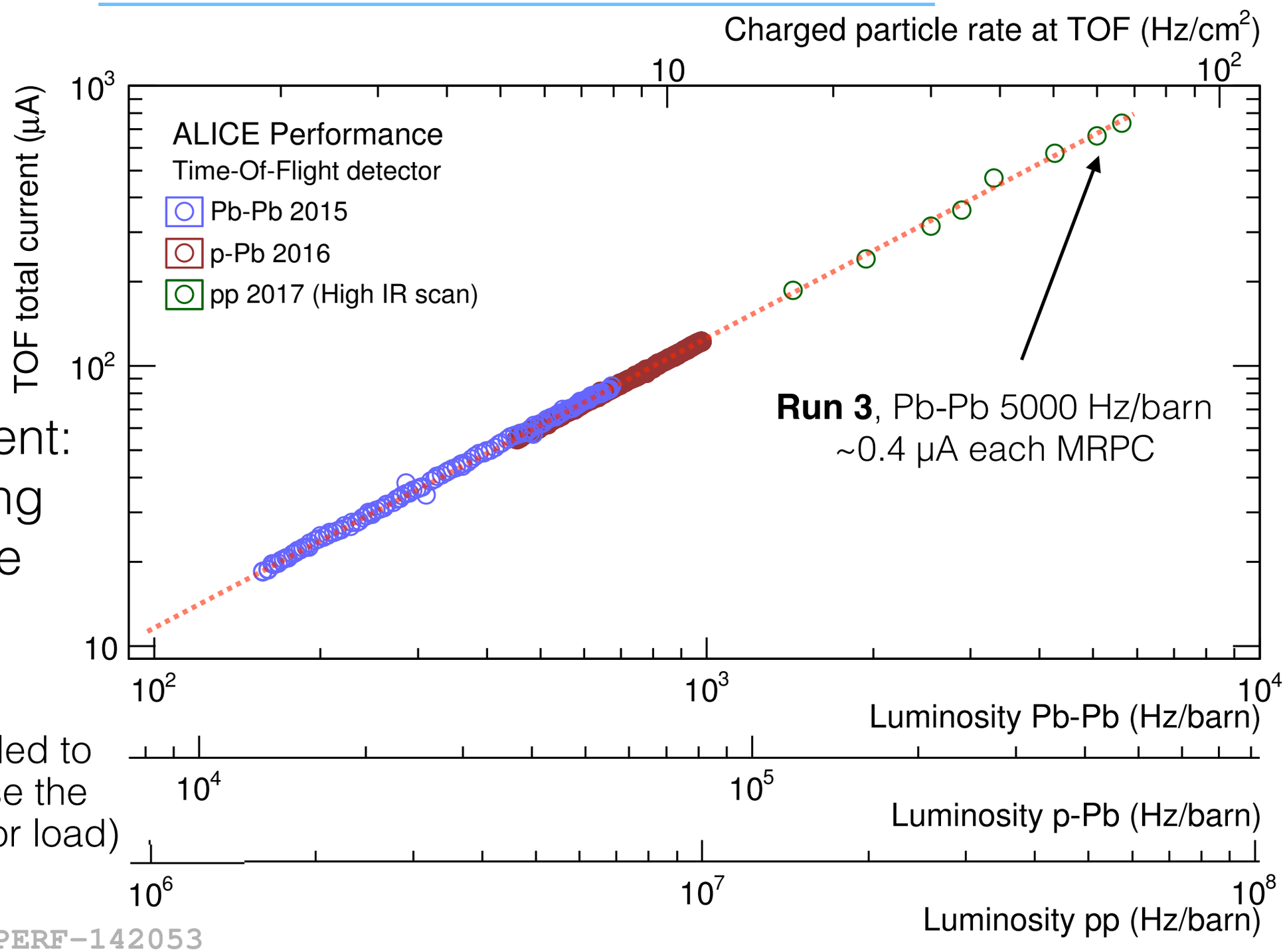
Operation - Current

Total current: overall the 1593 MRPCs (without beam)



stable over the years!

Operation - Current



Small current:

- **no** ageing
- low noise

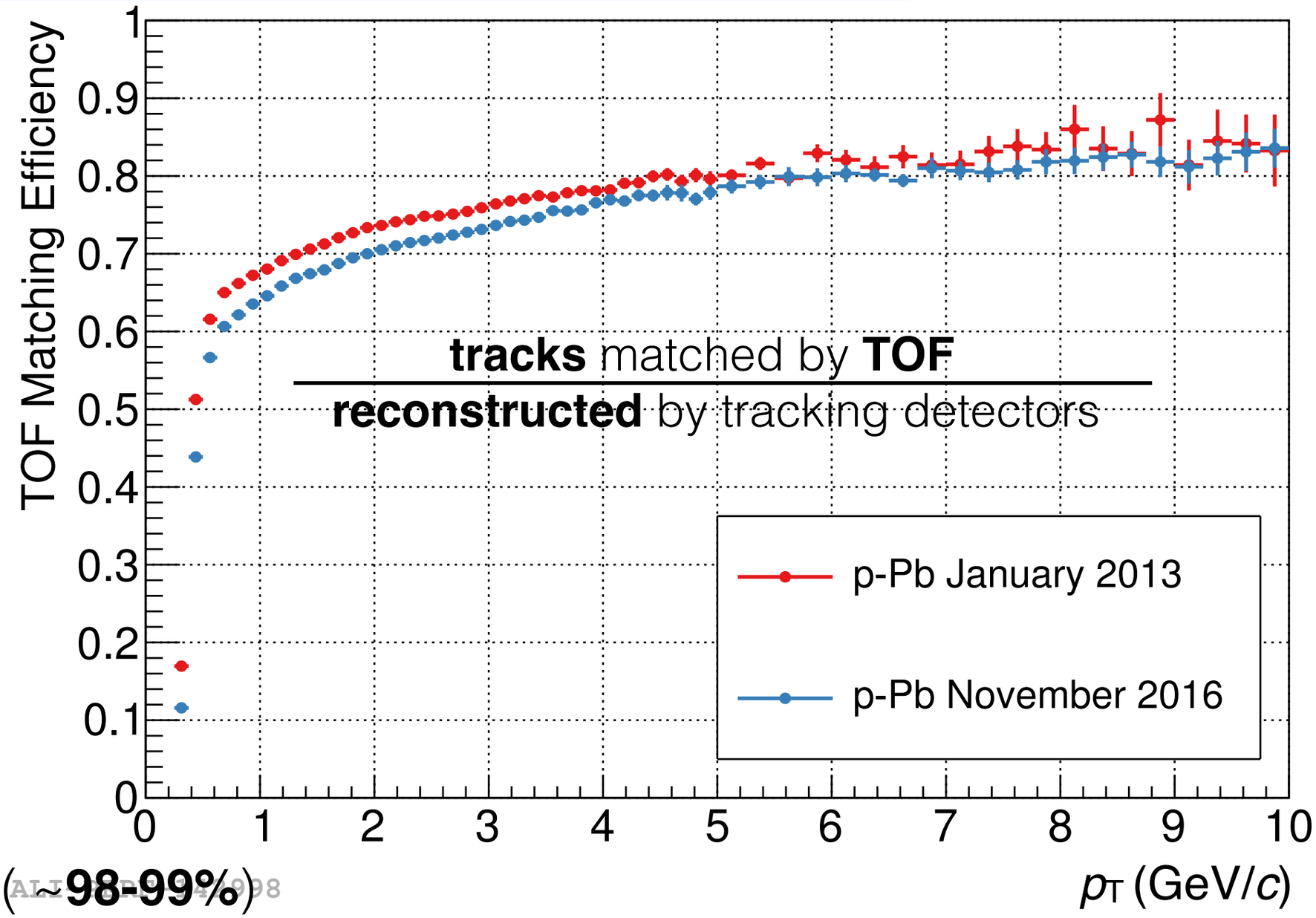
(L: scaled to equalise the detector load)

Total current: increases **linearly** with the **rate** (LHC luminosity)

NO sign of deviations (nor for the expected Pb-Pb Run 3 rate)

Operation - Matching Efficiency

For p_T < 0.3 GeV/c particles do not reach TOF (B=0.5 T)

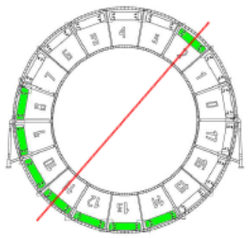


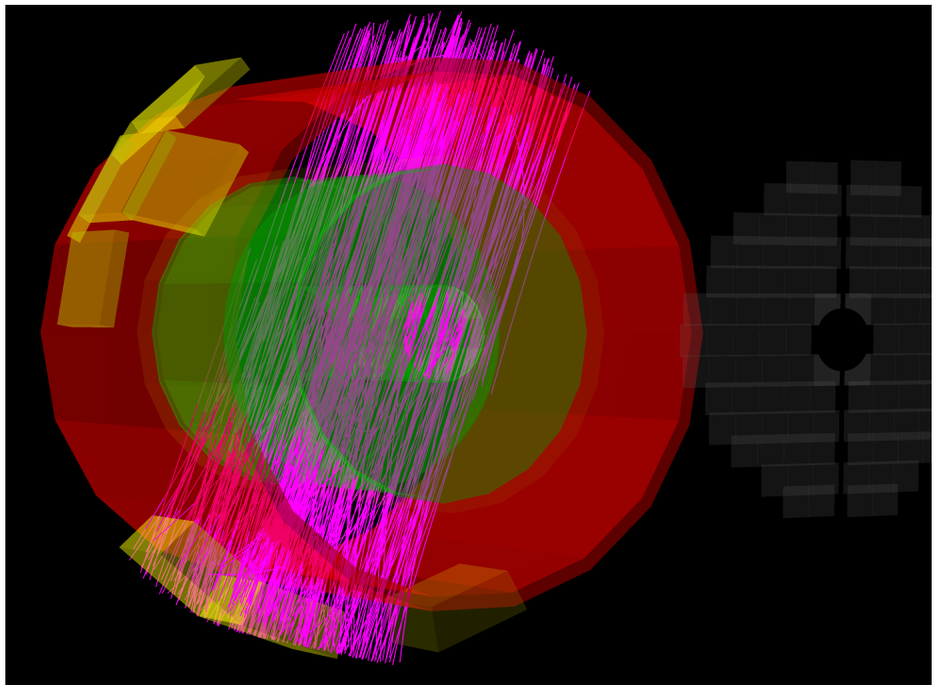
- **MRPC** efficiency (~**98-99%**)
- TOF algorithmic inefficiency
- TOF geometrical acceptance (dead space)
- Budget **material** (in front of TOF)
- **Hardware** data taking **conditions (extern.)**
- **Track extrapolation**

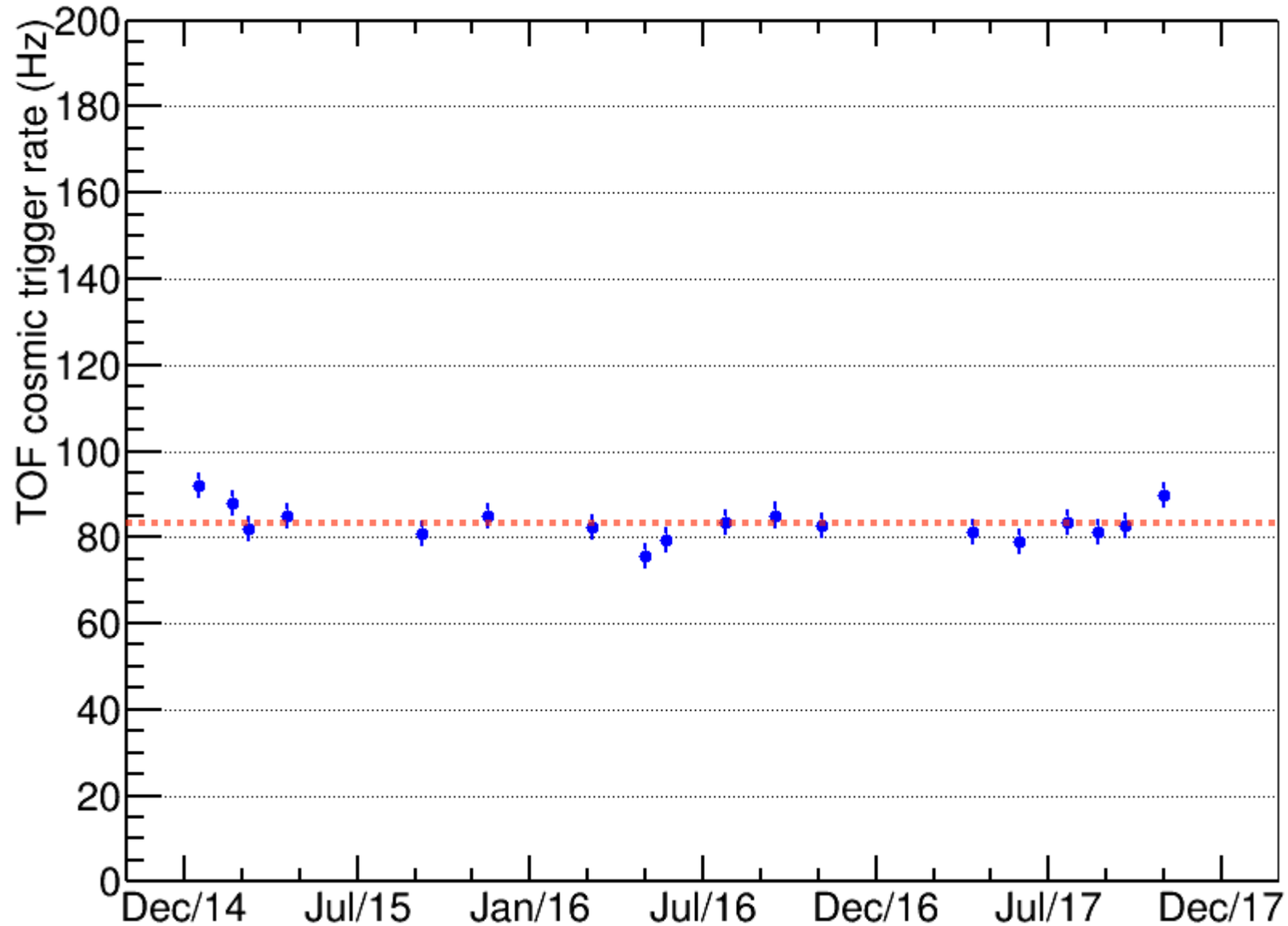
Performance stable during **Run1** and **Run2** (deviations due to)

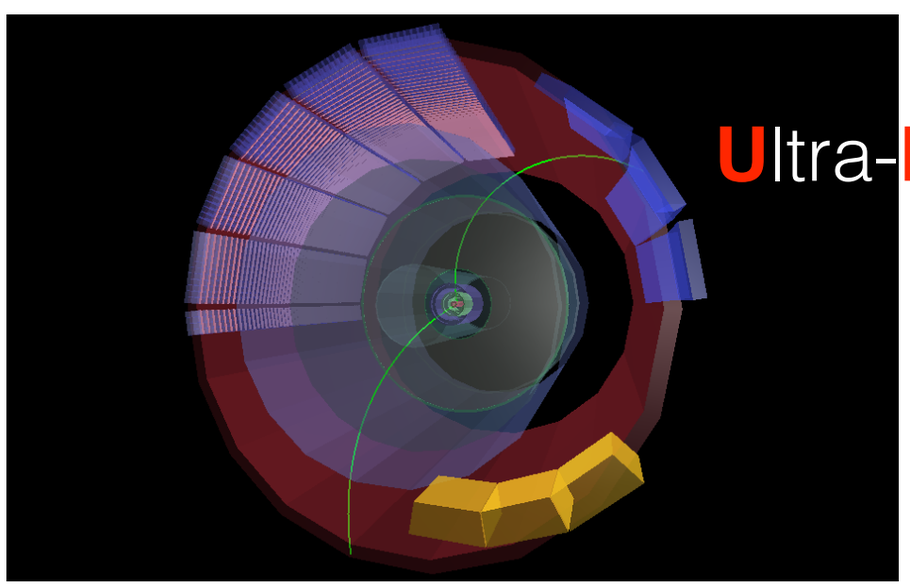
Operation - Trigger

Cosmic ray



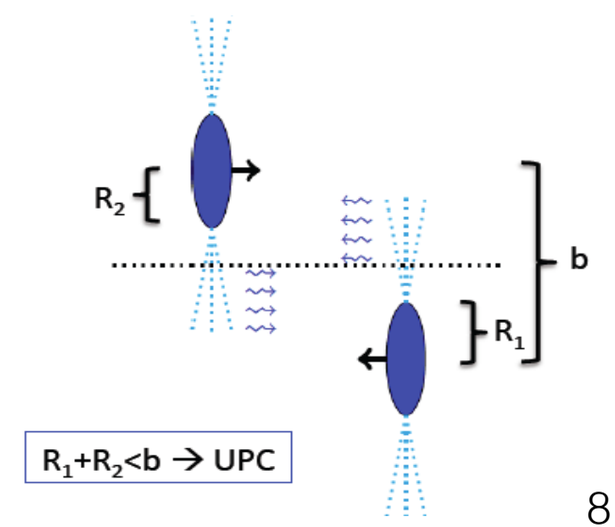






Ultra-Peripheral Collisions

we expect two tracks in the central detectors with forward detectors showing no activity

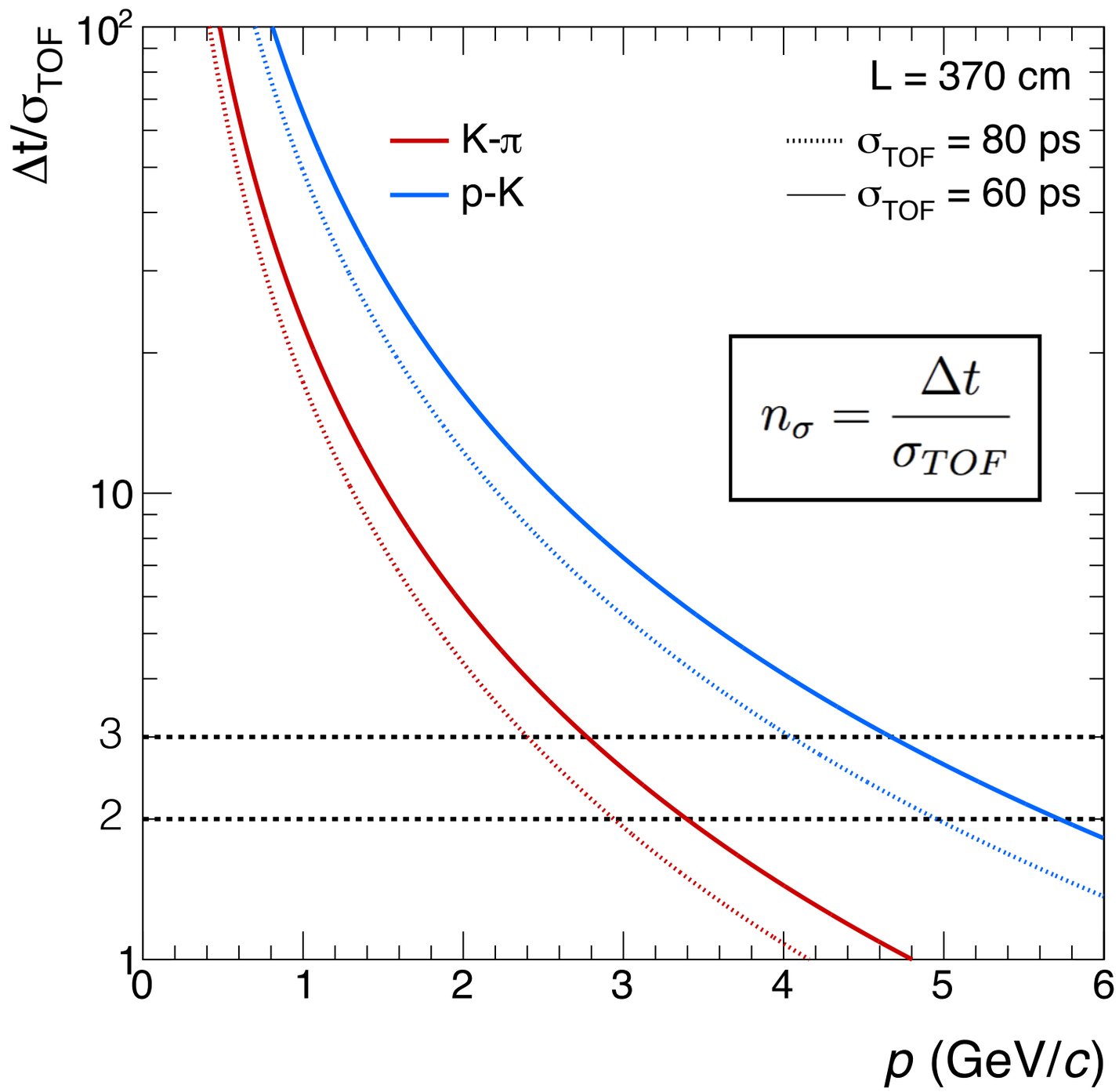


PID with a TOF detector

Dominant term for high momenta

$$m = \frac{p}{c}\sqrt{\frac{c^2t^2}{L^2} - 1}$$

$$\left(\frac{\delta m}{m}\right)^2 = \left(\frac{\delta p}{p}\right)^2 + \left(\gamma^2\frac{\delta L}{L}\right)^2 + \boxed{\left(\gamma^2\frac{\delta t}{t}\right)^2}$$



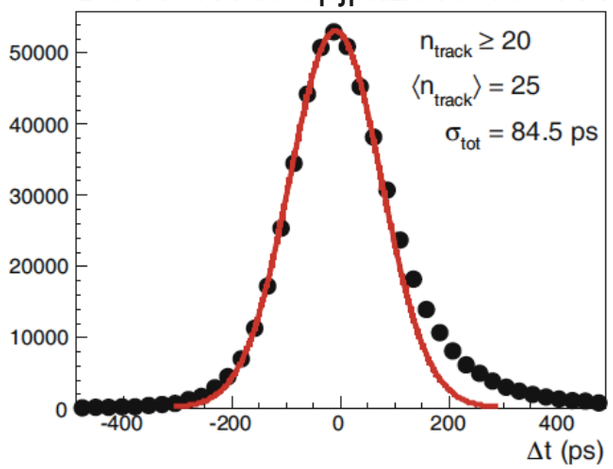
$$\Delta t = t_i - t_j \simeq \frac{Lc}{2p^2}(m_i^2 - m_j^2)$$

← PID capability of a TOF detector

→ **time resolution as low as possible**

Time resolution

DOI 10.1140/epjp/i2013-13044-x



$\sigma \sim 84$ ps

$$\sigma_{TOF}^2 = \sigma_{MRPC}^2 + \sigma_{TDC}^2 + \sigma_{FEE}^2 + \sigma_{Cal}^2$$

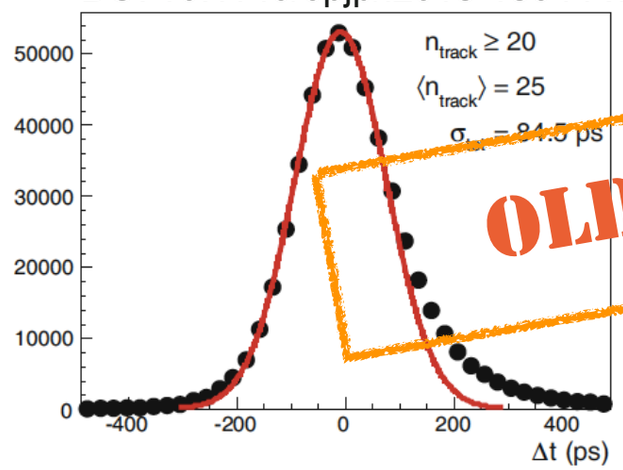
$$t_{TOF} - t_{event} - t_{exp_i}$$

$$\sigma_{TOT}^2 = \sigma_{TOF}^2 + \sigma_{trk}^2 + \sigma_{event}^2$$

(negligible for p> 1 GeV/c)

Time resolution

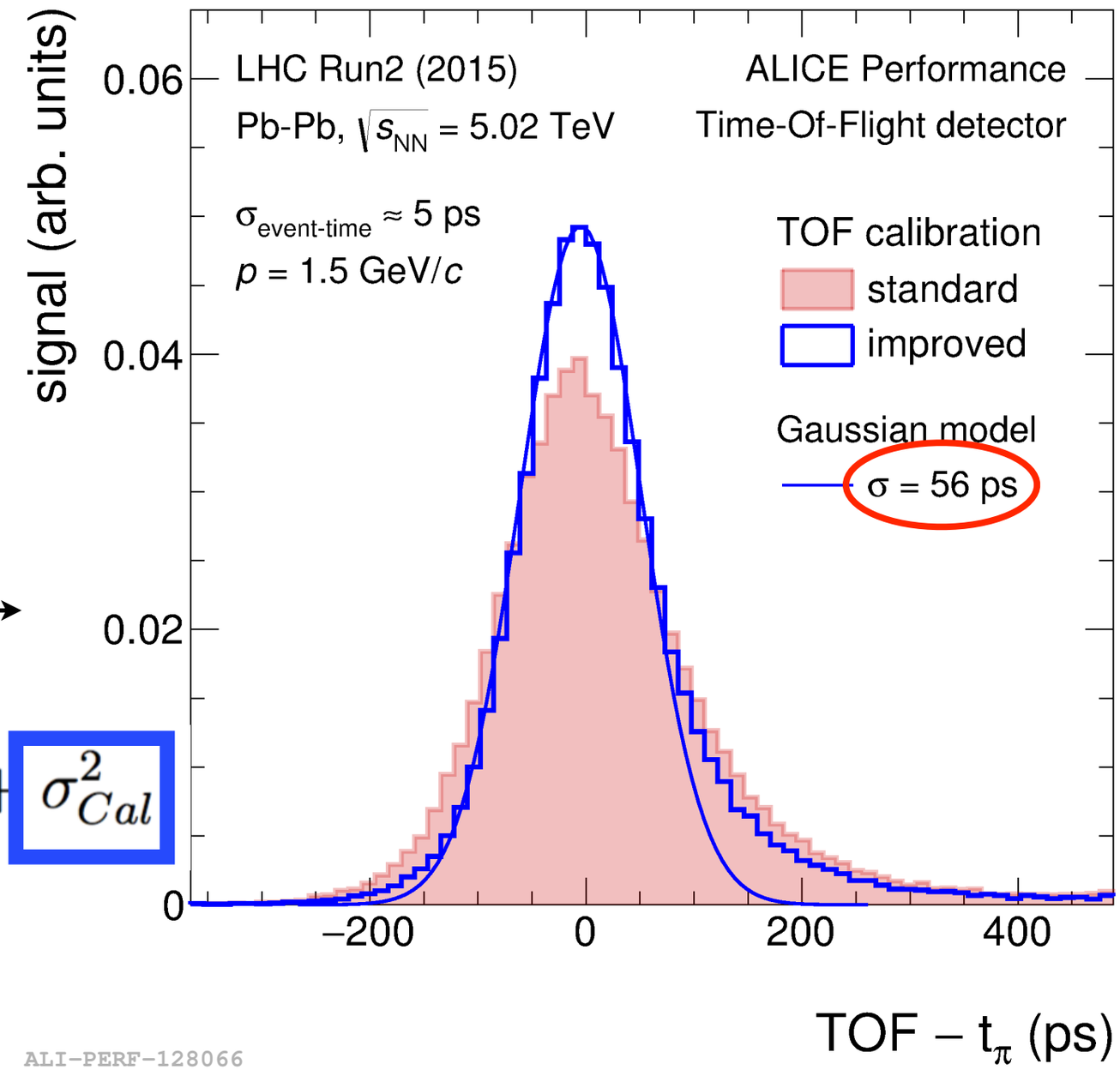
DOI 10.1140/epjp/i2013-13044-x



OLD! $\sigma \sim 84$ ps

…**improved!**

$\sigma \sim 56$ ps



$$\sigma^2_{TOF} = \sigma^2_{MRPC} + \sigma^2_{TDC} + \sigma^2_{FEE} + \sigma^2_{Cal}$$

$$t_{TOF} - t_{event} - t_{exp_i}$$

$$\sigma^2_{TOT} = \sigma^2_{TOF} + \sigma^2_{trk} + \sigma^2_{event}$$

(negligible for p> 1 GeV/c)

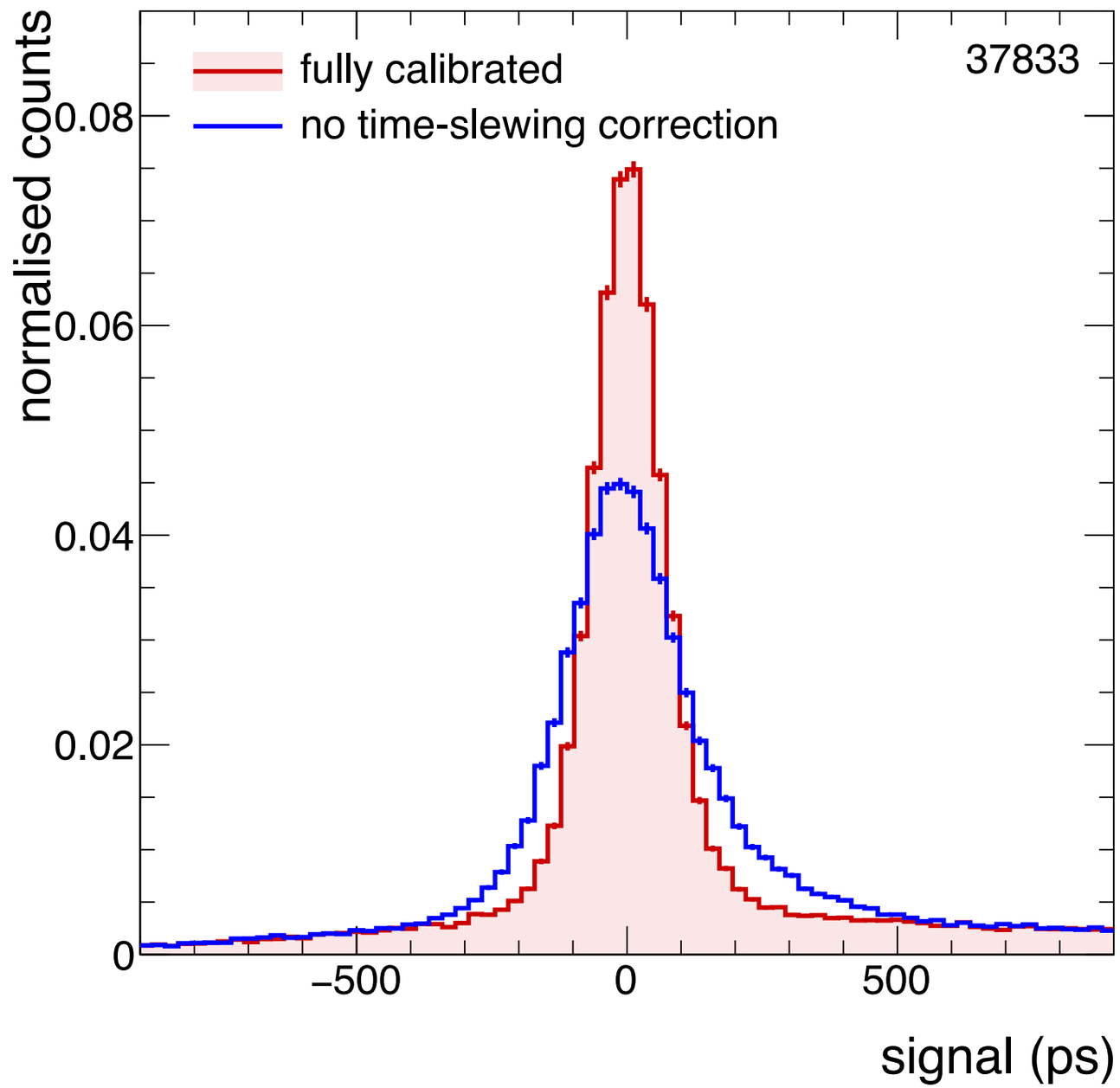
Other factors that can lead to a spoiling of the ALICE-TOF time resolution:

- hit multiplicity (cluster)
- time walk
- asymmetric tails

Time resolution - Time slewing

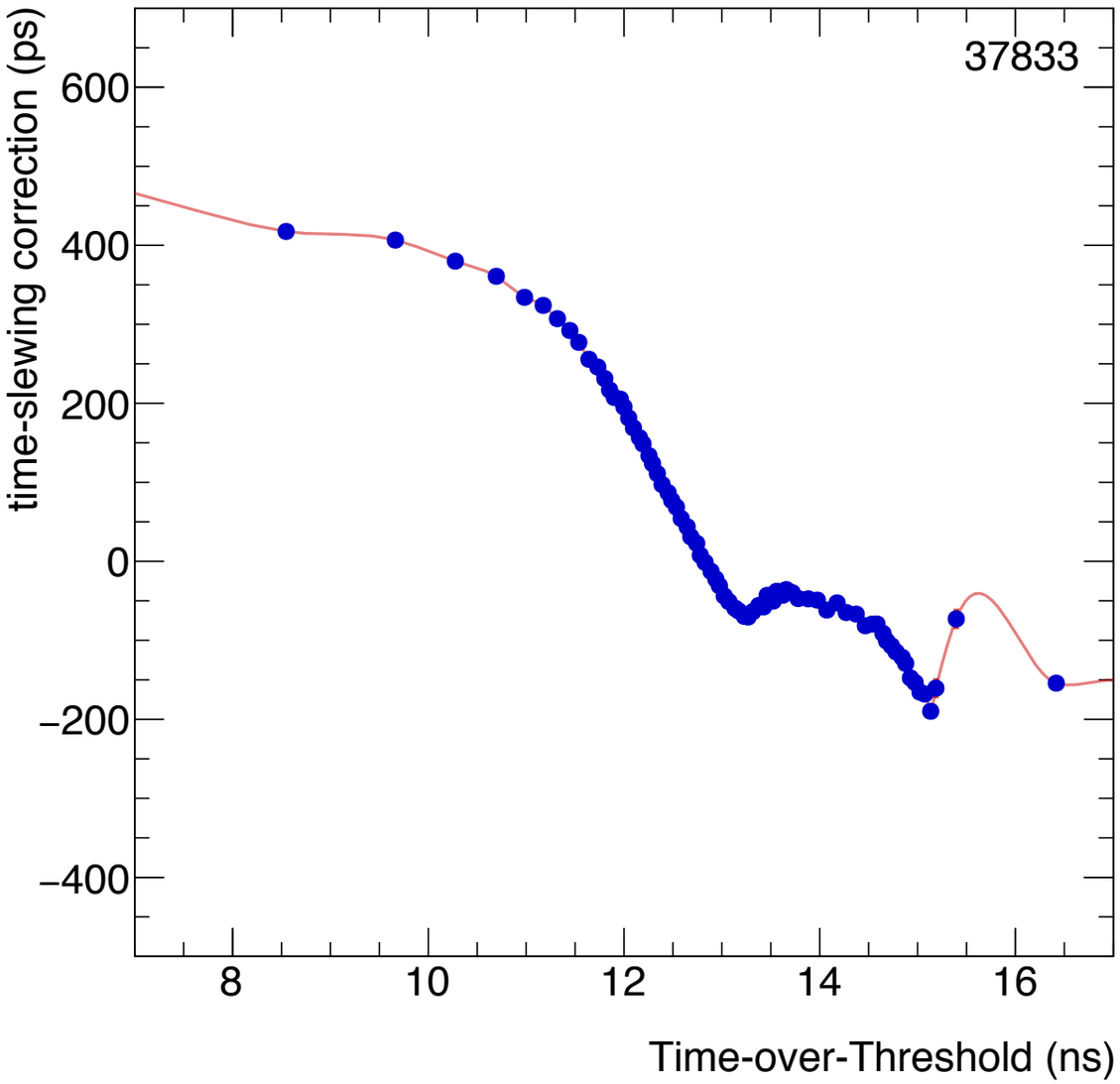
TOF time **calibration** is based on 3 components:

- global offset, common to all channels (clock)
- channel-by-channel offset (cables,…)
- **time-slewing** correction: correlation between the **time** and charge —> TOF system uses **T**ime **O**ver **T**hreshold, as a proxy for the charge



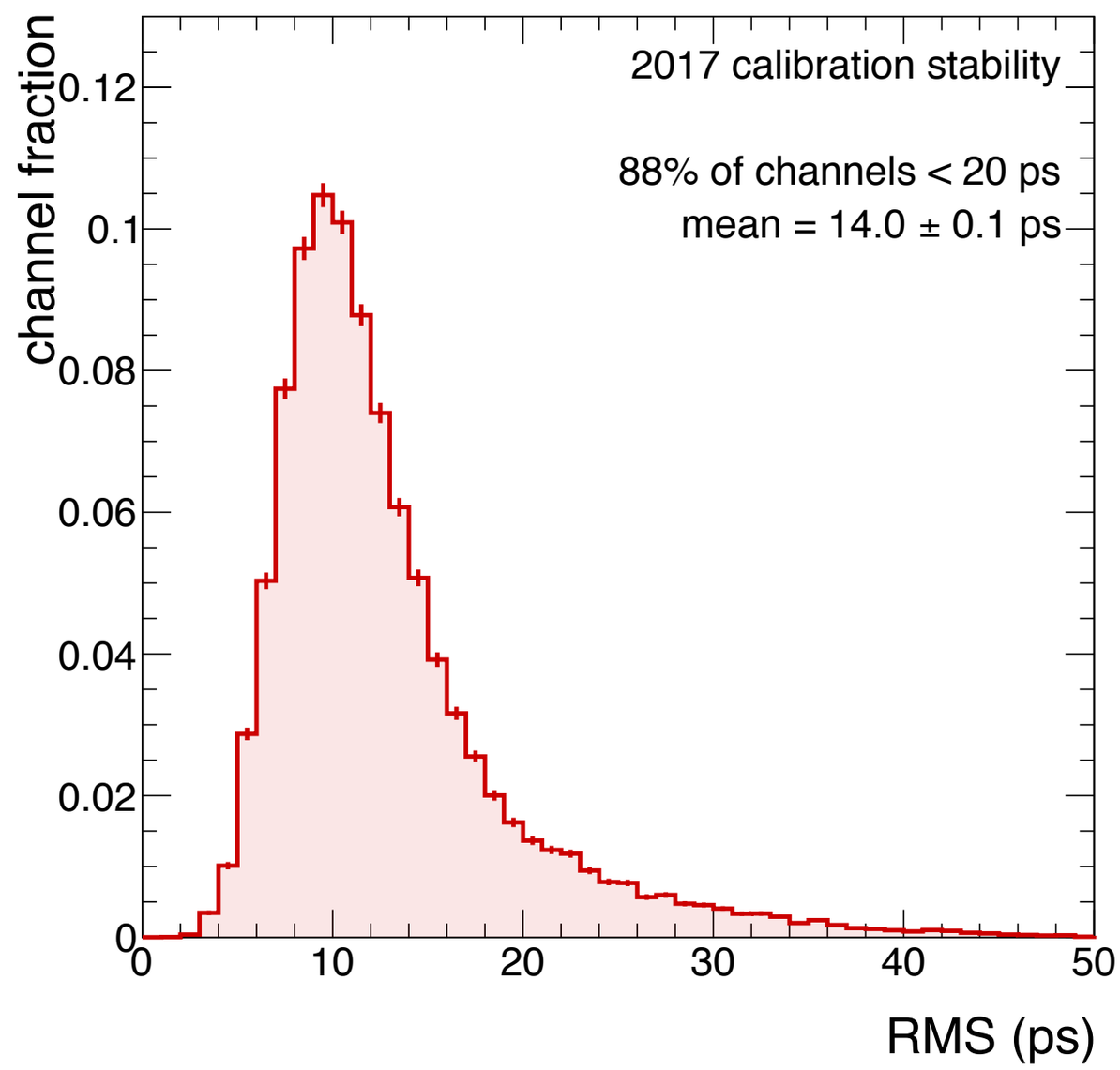
~ 50% improvement
(~110-130 ps in quadrature)

Time resolution - Time slewing



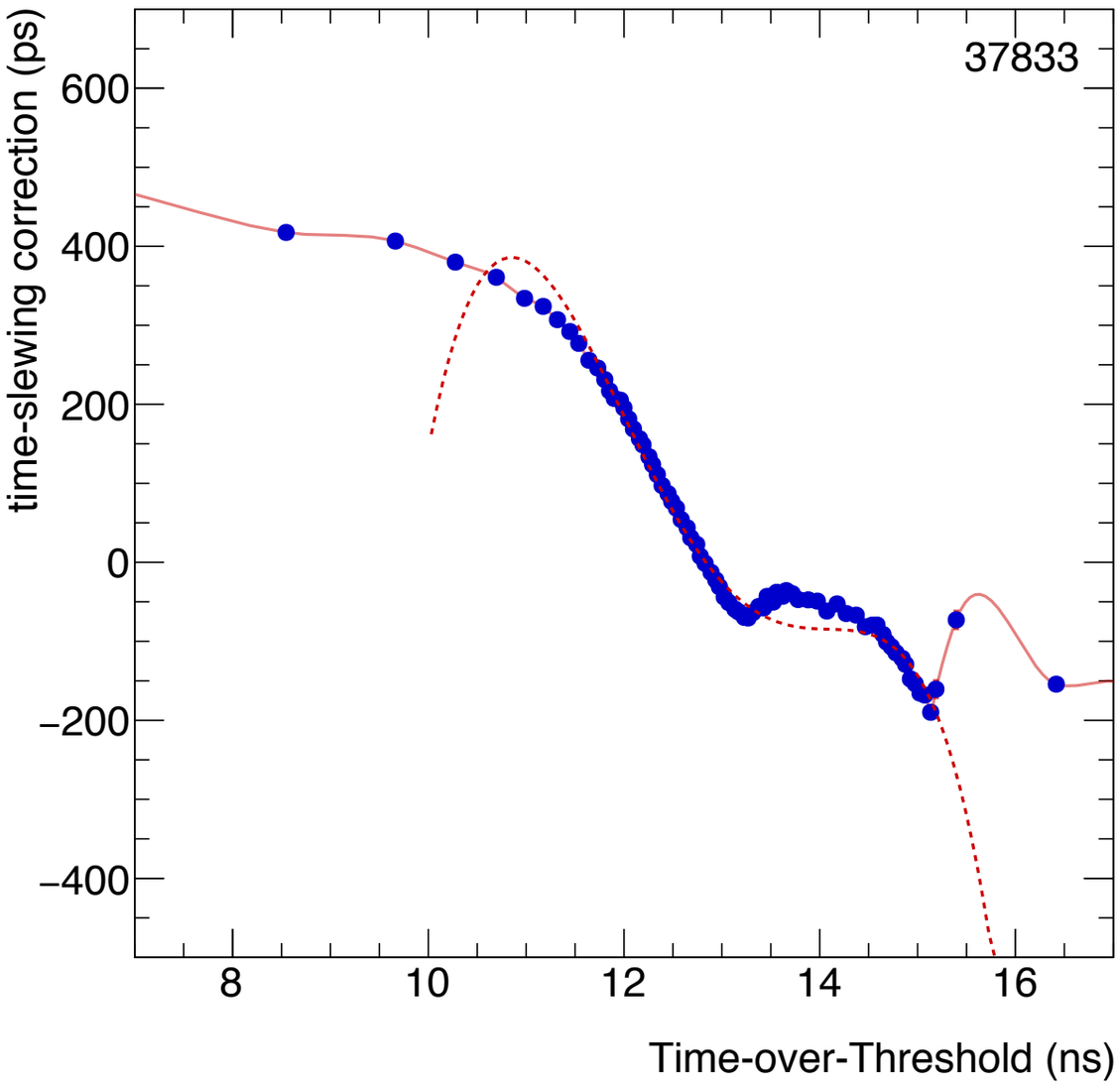
single channel upgraded calibration (2017)

~40000 channels



stable during the year…

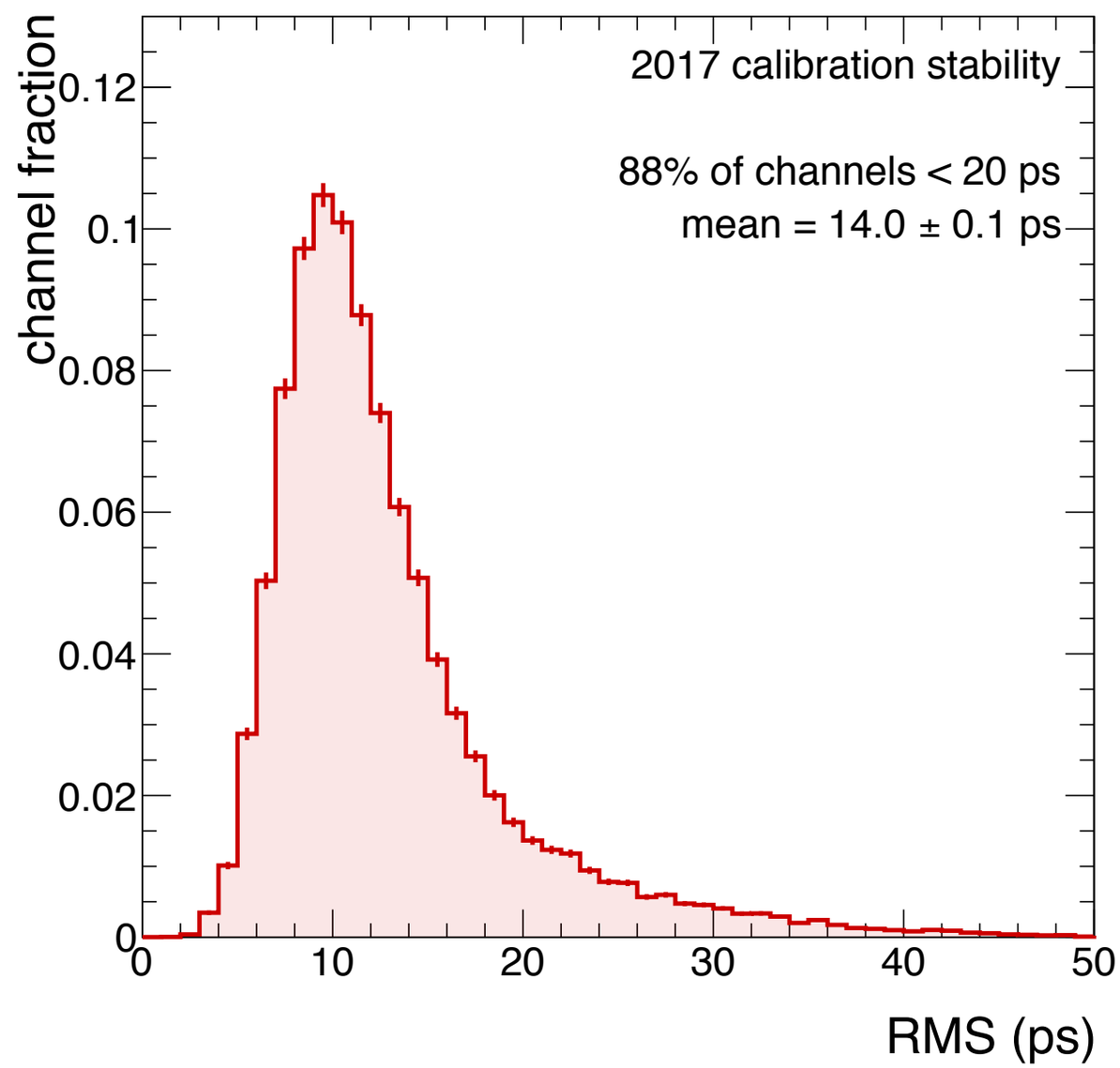
Time resolution - Time slewing



single channel upgraded calibration (2017)

(..... **before**: groups of 8 channels, limited TOT range, polynomial parametrisation)

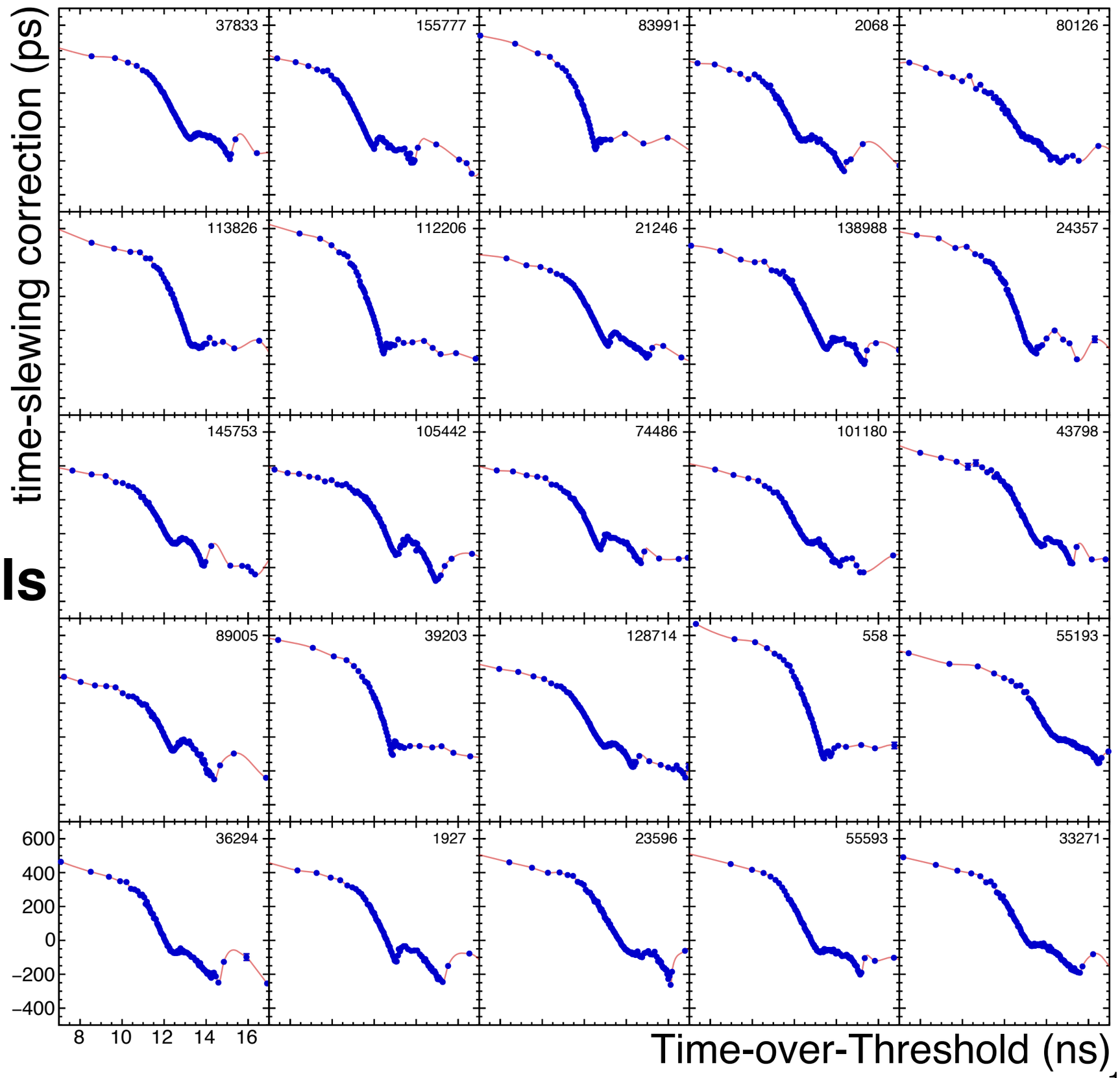
~40000 channels



stable during the year…

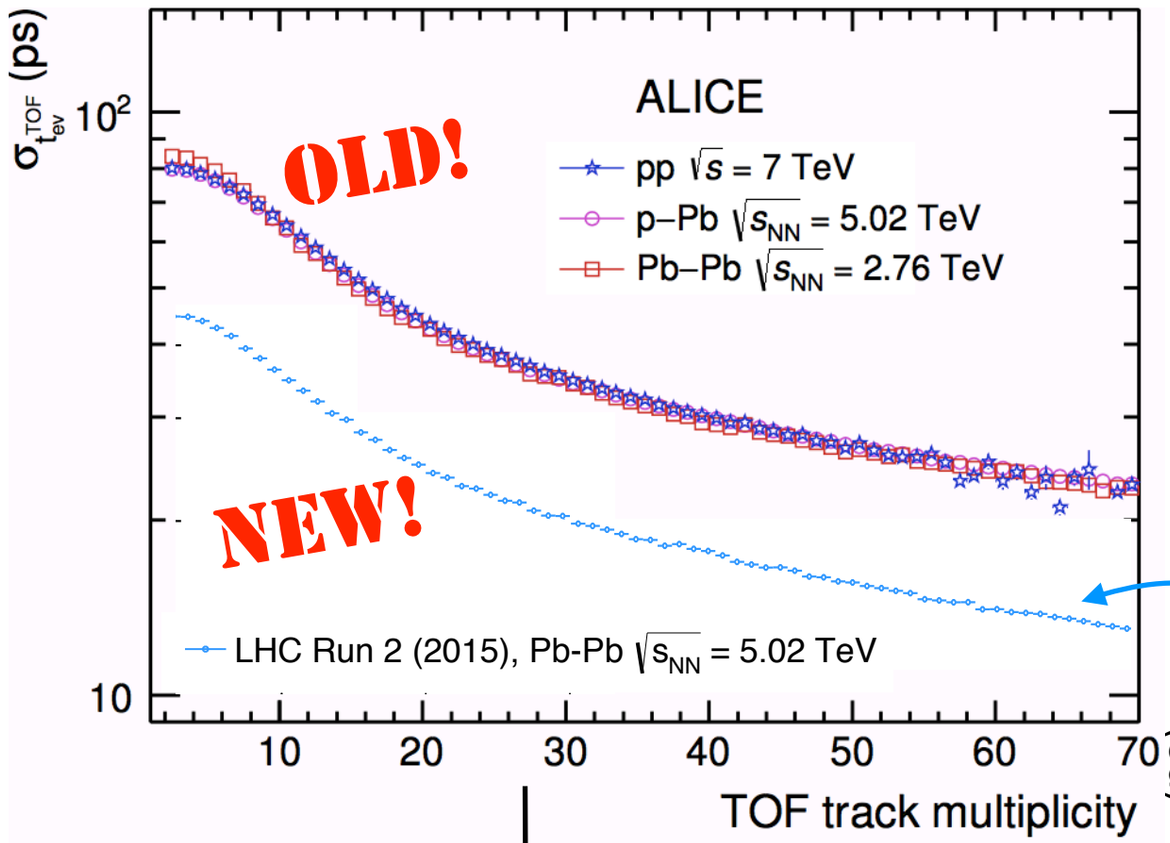
Time resolution - Time slewing

… and **uniform** between **channels**



Time resolution - t_{event}

Eur. Phys. J. Plus (2017) 132: 99



Time event is the event collision time:

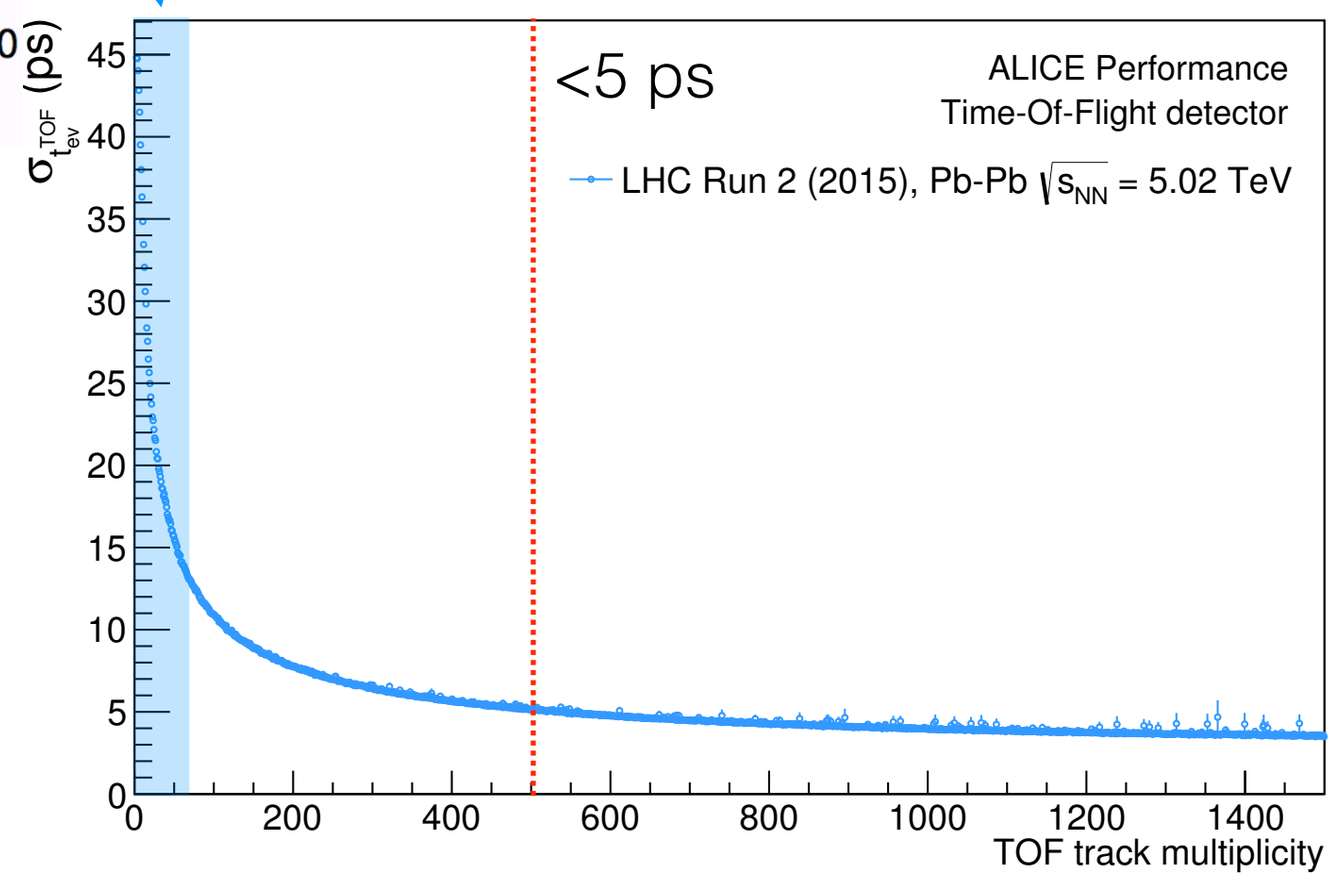
for $N_{track} \geq 2$ →

TOF can measure it independently

Same for different collision systems (**pp, p-Pb, Pb-Pb**) —> depends just on the track multiplicity

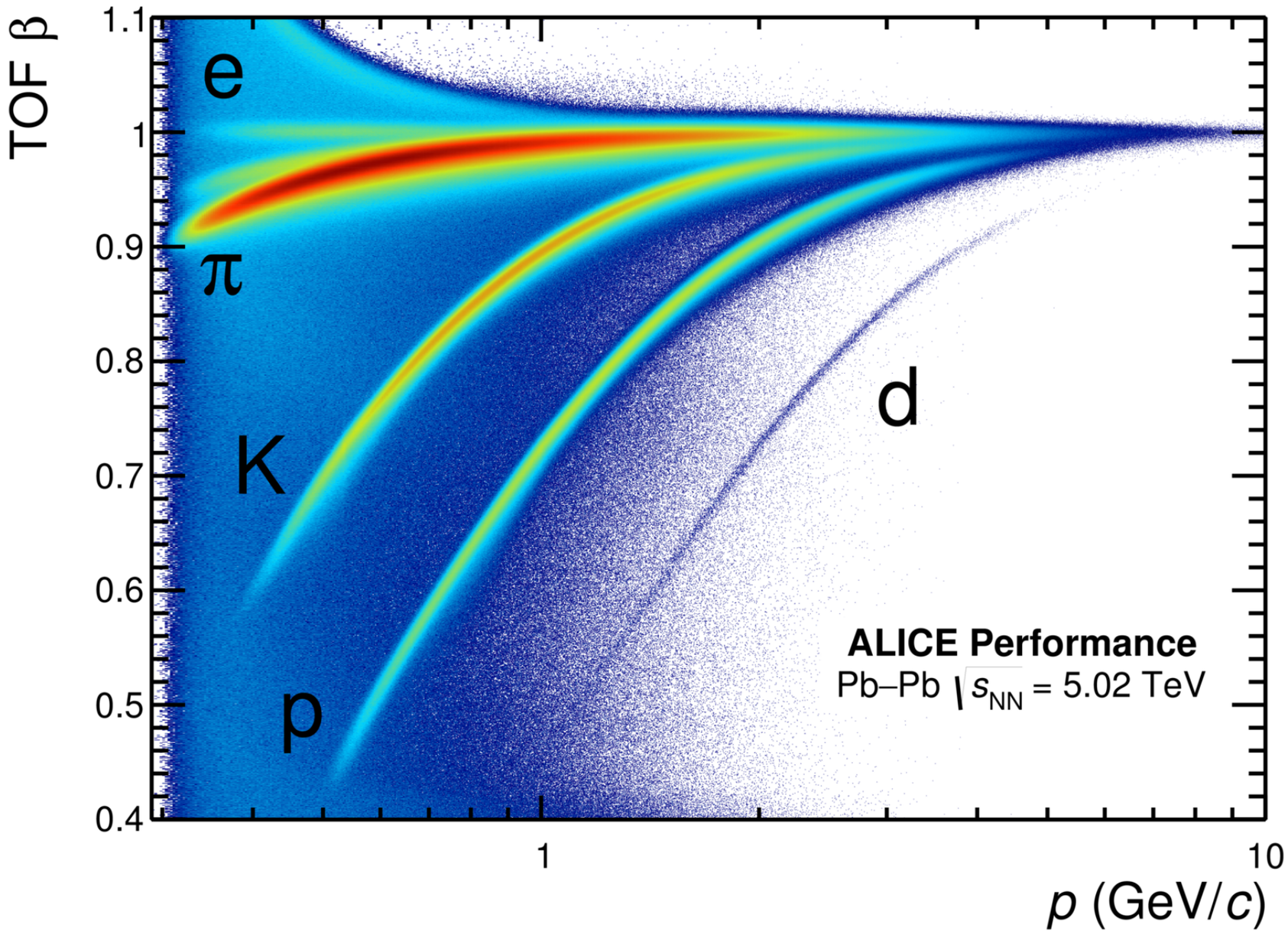
Improvement:

$$\sigma_{t_{ev}} \sim \frac{\sigma_{TOT}}{\sqrt{TOF\ \ track\ \ multiplicity}}$$



PID performance

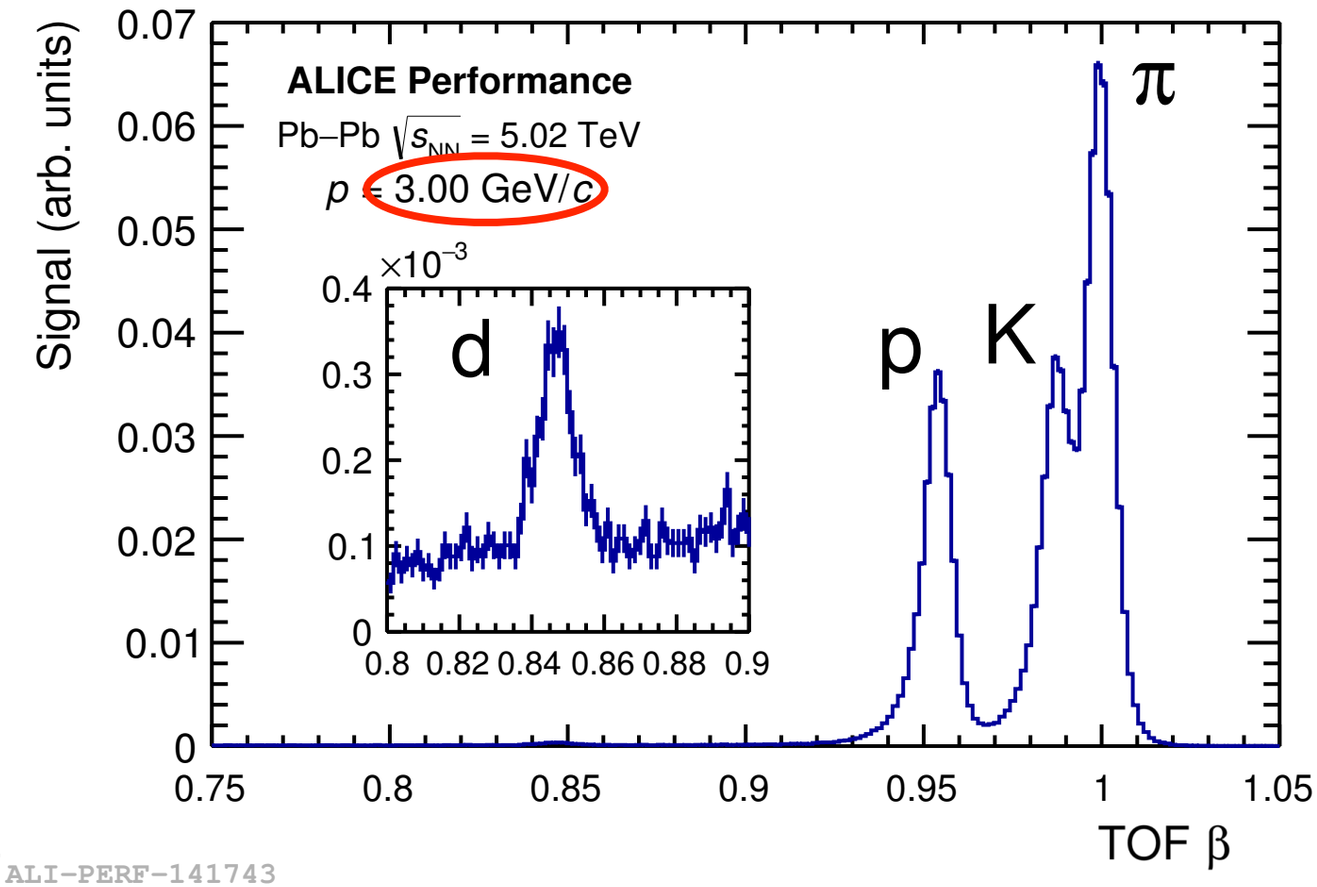
TOF Beta vs momentum (pseudorapidity region |η| < 0.5)



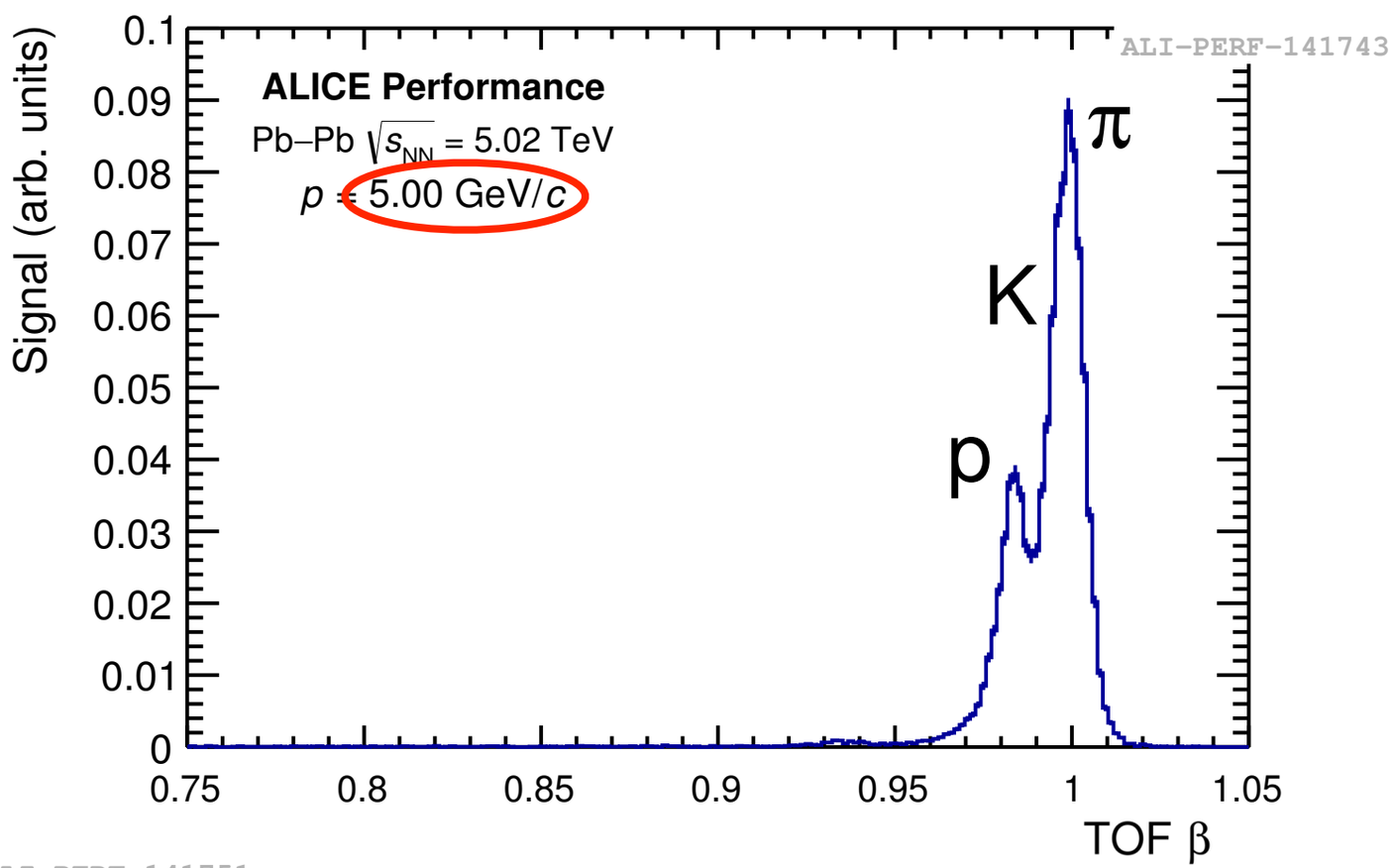
B=0.5 T

ALI-PERF-106336

PID performance



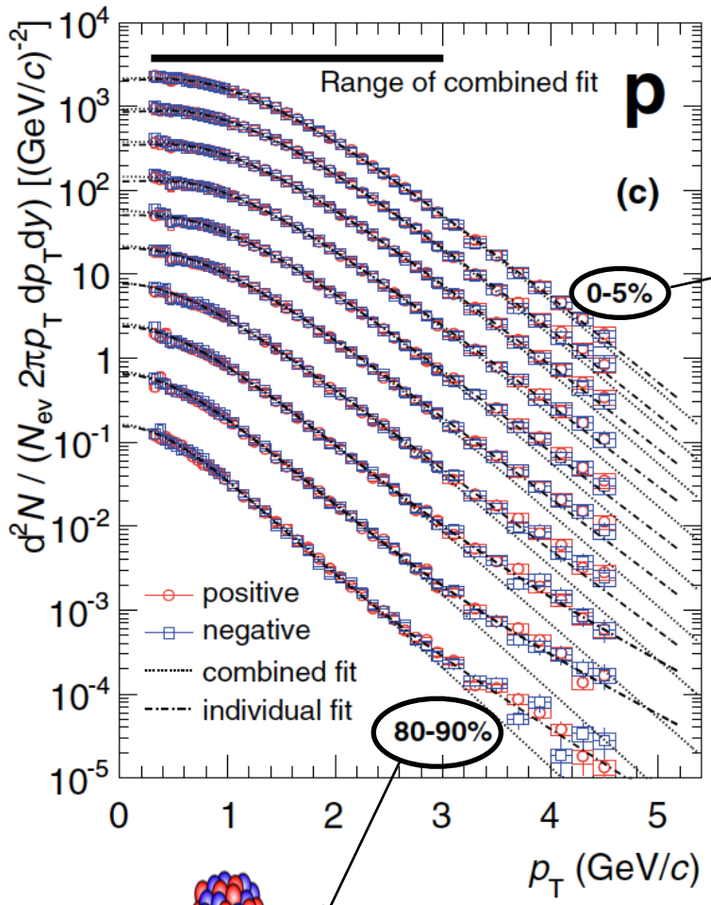
K/π still **separated** ⟵



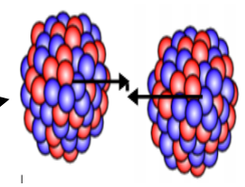
⟶ **p/K** still **separated**

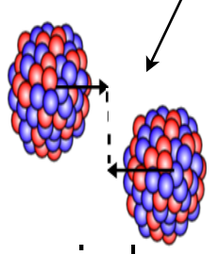
Physics with TOF PID

http://dx.doi.org/10.1103/PhysRevC.88.044910



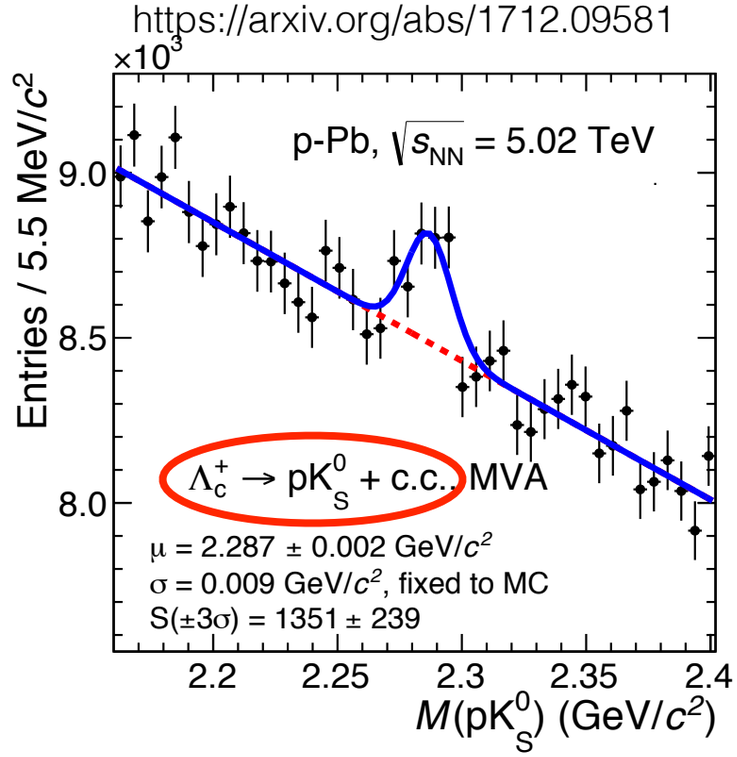
central

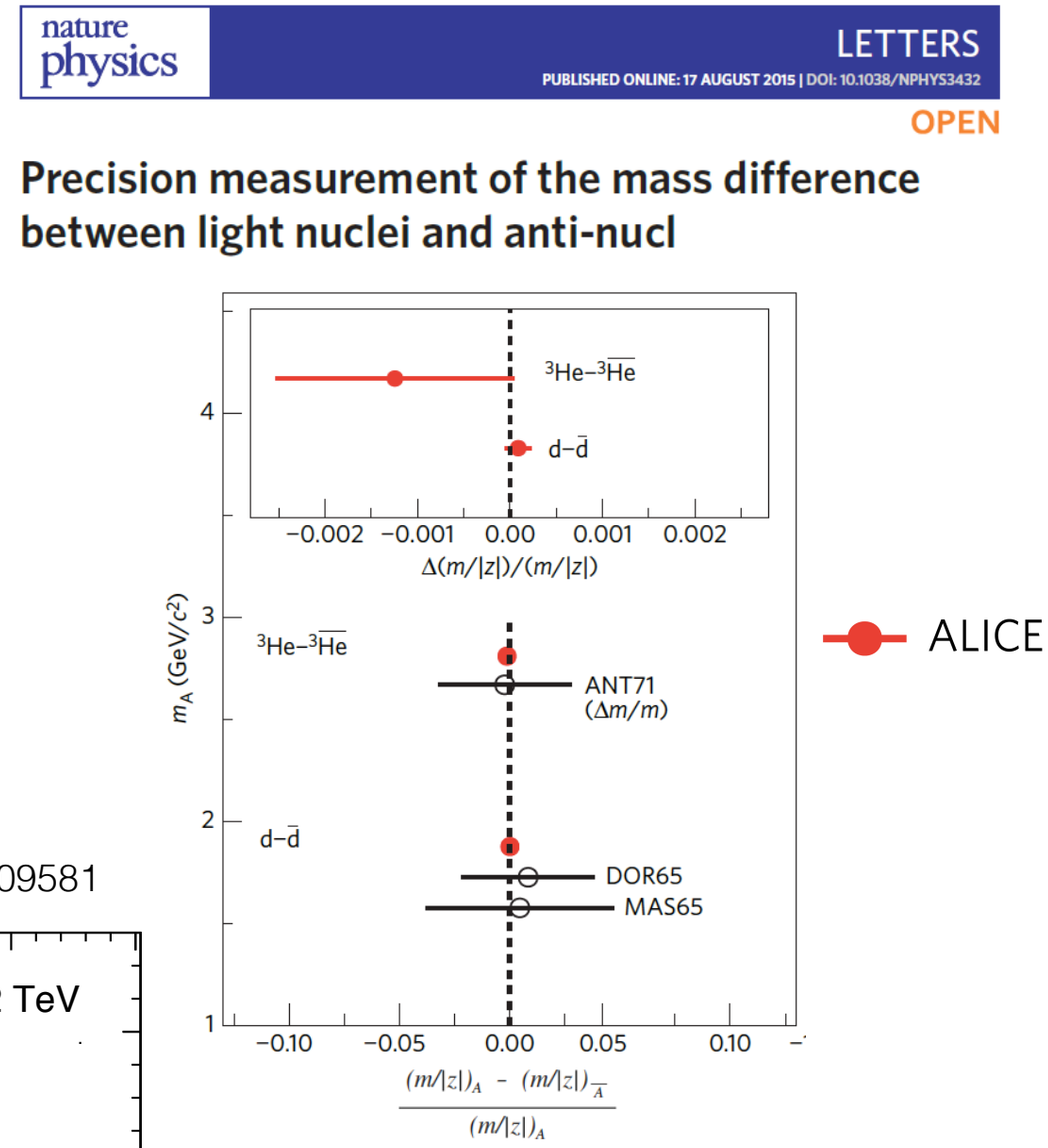




peripheral

https://arxiv.org/abs/1712.09581





Conclusions

- The **ALICE-TOF** detector is a high performance detector based on **MRPC** technology; is a **large** (active area 141 m^2) detector taking data for almost **10 years**

- Since its installation until today:
  - **no** degradation
  - very **stable** detector
  - **no** loss in performance
  - **no changes** in operation expected during **Run 3**

- The **time resolution** is improved thanks to 2017 calibrations (upgraded time slewing corrections): **from ~ 80 ps** to **less** than **60 ps**

- With 2 tracks or more reaching the TOF, t_{event} can be determined by the TOF itself (resolution on **t_{event} below 30 ps** with 10 tracks)

- It provides a **K/π** separation up to **3 GeV/*c*** and a **p/K** separation up to **5 GeV/*c*** (PID)

- The **TOF-PID** is **extensively** and **successfully exploited** in many analyses in **ALICE**