# Review and optimization of ALICE calibration, reconstruction, and analysis
# The TOF perspective

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on behalf of the TOF Group

# Overview

- How Time of Flight works in ALICE: the TOF, the timeZero, the LHC beam...
- Map the calibration dependencies for TOF
- Status of calibrations/geometry/known problems: where we are with tenders and related....
- 2010: some lessons learned
- What all this tell us for this review?

**Note added during the meeting**: TOF is open to consider emerging pass0 scenario. In principle in following slides you could swap 2 with 1 and 1 with 0, but we need to understand better the quality of output we can get at pass0.

$$\sigma_{PID(TOF)} \neq \sigma_{TOF}$$

A time of flight measurement is always a measurement of a time interval, that is a difference between **two** time measurements.

**In ALICE**: $\Delta t = t_{TOF}$ - timeZero

timeZero is the time of the interaction, measured in ALICE by means of:

- T0 detector OR
- TOF detector itself (if a certain amount of tracks is available) OR
- tzeroFill, that is the average <timeZero> of the LHC fill

**Time of flight** PID uses $\beta$, so we need track length and momentum estimate during its own way to TOF, therefore:

$$\sigma_{PID(TOF)} = \sqrt{\sigma^2_{TOF} + \sigma^2_{timeZero} + \sigma^2_{tracking}}$$

# What we use to discriminate PID usingTOF?

the timeZero for the event (measured/estimated in different ways)

$$\hat{PID}_{TOF} = \frac{(time_{hit} - timeZero) - time_{expected}(p, m, L)}{\sigma_{PID(TOF)}}$$

the time measurement made by the TOF detector

This is computed, during reconstruction by ALICE core central tracking ('integrated times')

$$\sigma_{PID(TOF)} = \sqrt{\sigma^2_{TOF} + \sigma^2_{timeZero} + \sigma^2_{tracking}}$$

# Minimize $\sigma_{TOF}$: TOF calibration

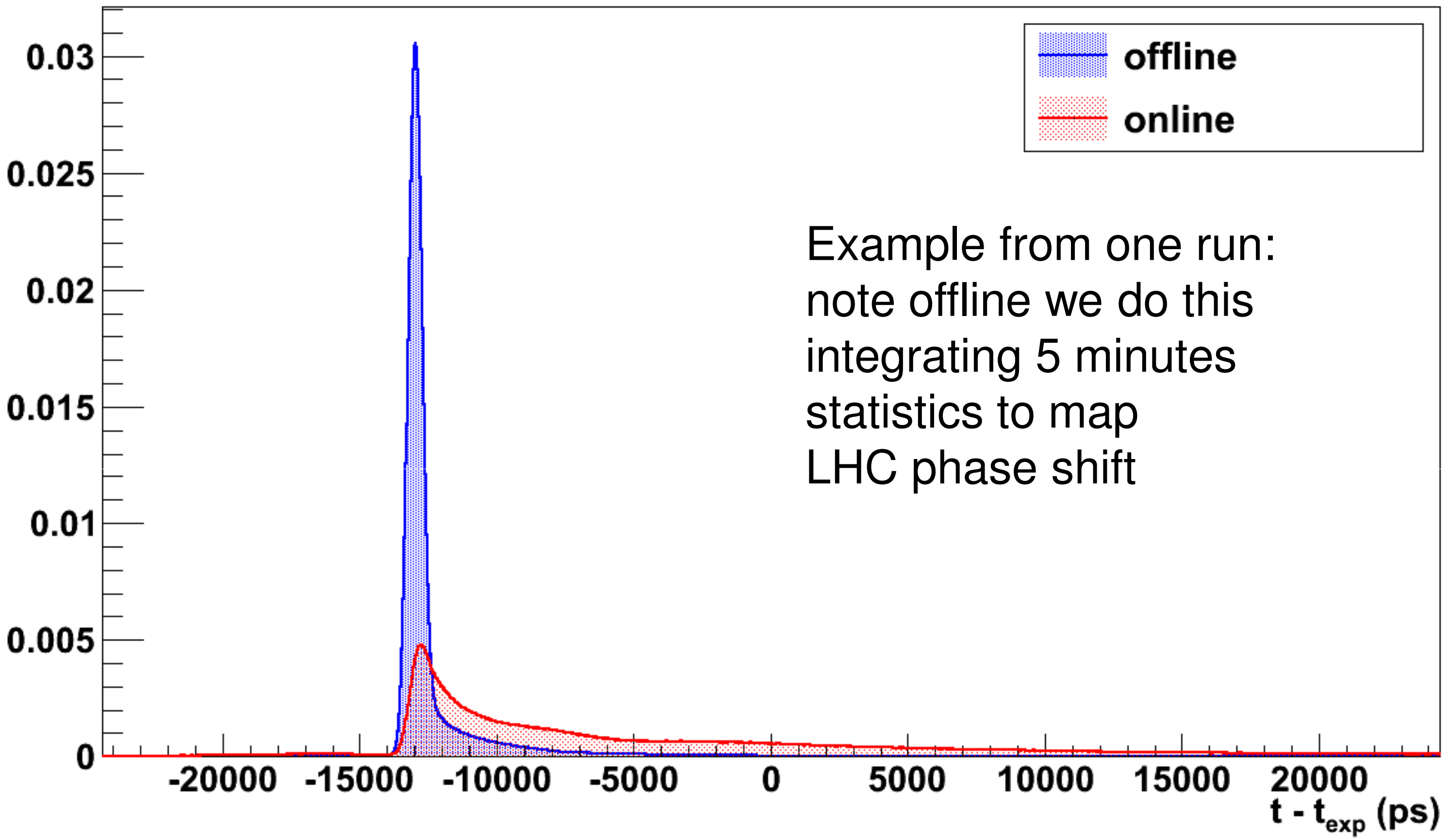
Main “variable part”: find tzeroFill that is the average time of the interactions (phase with respect to LHC clock) in a given LHC fill

Other components: offsets to align channel delays, time-slewing corrections, etc.

**Our strategy**: find tzeroFill from data:

- at online level (Detector Algorithm):
  - no selection: all TOF hits
  - no tracking: all straight relativistic pions
- analysing pass1 data:
  - use tracking (so... TPC) to filter (matching request)
  - use integrated times (so...central tracking, p, material budget...)
- deliver physics at pass2

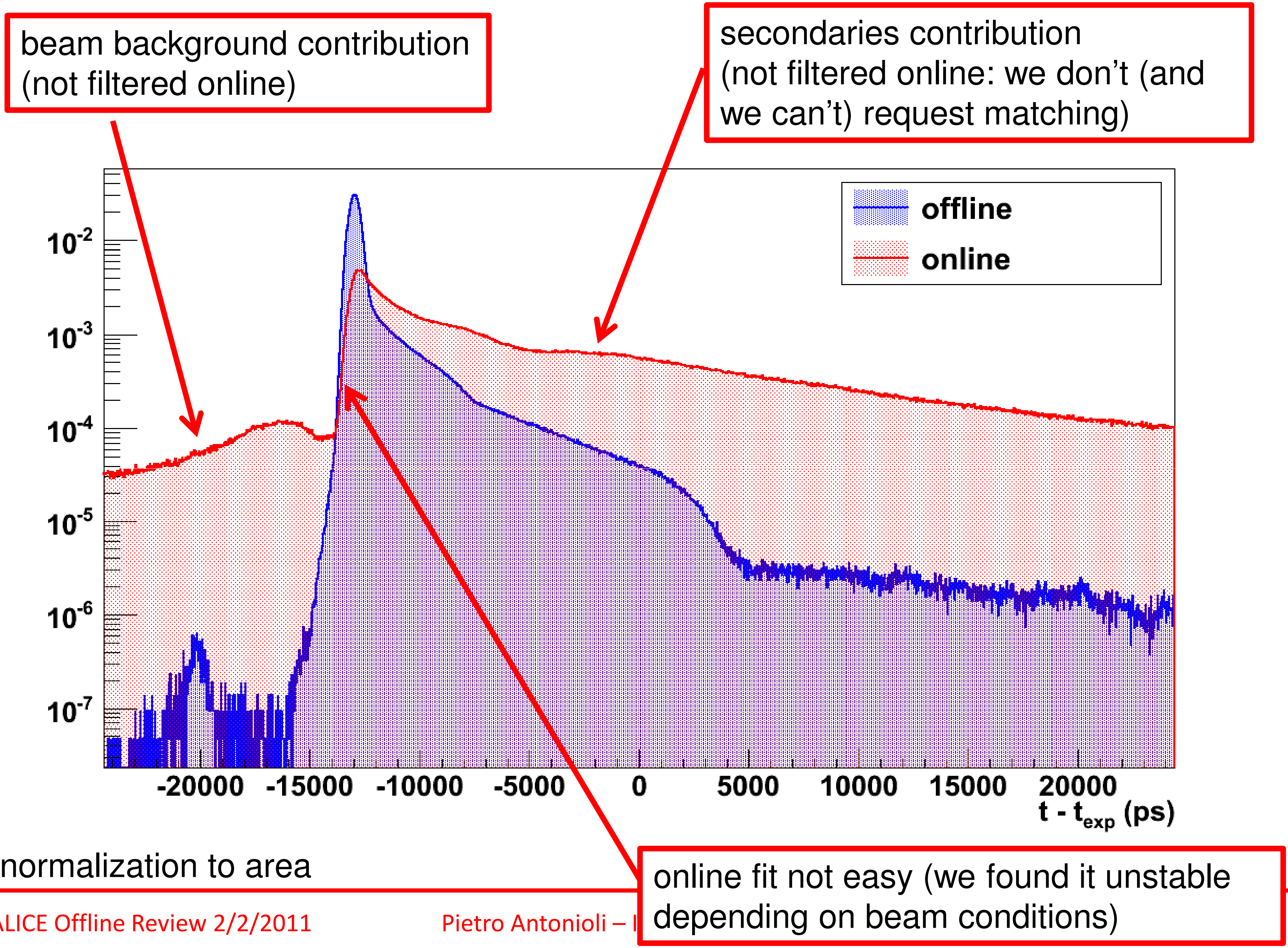
Can we do it online, without introducing any dependencies from “tracking” ?




$t - t_{exp} = t - L(\text{straight line})/c$

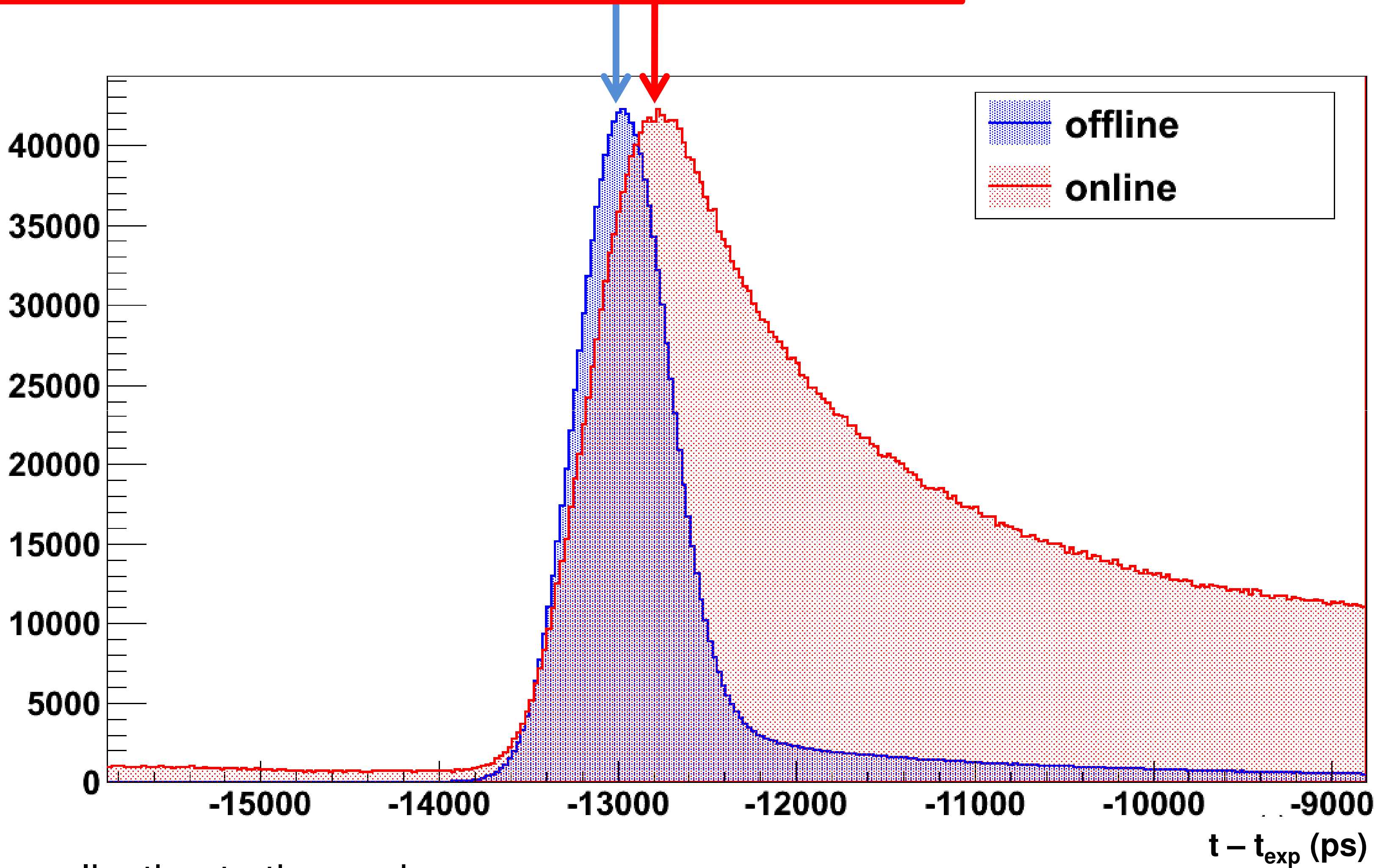
$t - t_{exp} = t - t_{exp}^{\pi}$ (from central tracking)

normalization to area




normalization to area

Note the difference:
what you can fit online is however “wrong” due to v=c and straight line assumptions




normalization to the peak

**Comment 1**: not surprisingly for the resolution and the physics we want to achieve with TOF we need to use ALICE tracking for TOF calibration

**Comment 2:** so let's analyze the dependencies we introduce

# Some definitions

$$C_n^X$$

The set of calibration parameters to be used by detector X while running reconstruction at pass n

# Dependencies on TOF calibration and analysis (I)

$$C_n^{TOF} \quad \text{depends on} \quad C_{n-1}^{TPC}$$

Note:
- calibration at step “n-1” must be ‘good enough’ to provide tracking and matching (so moreover 2nd order dependency on ITS, vertexing, etc)

- central offline tracking (not only TPC!), material budget, energy losses must be ok for integrated times so it is much more correct to say dependency is on

$$C_{n-1}^{tracking}$$

Final quality of TOF pass2 data critically depends on $\delta\left(C_2^{tracking} - C_1^{tracking}\right)$

**Important remark:** the problems can come when δ is an unexpected big Δ! A small improving δ is welcome! ☺

$$\sigma_{PID(TOF)} = \sqrt{\sigma^2_{TOF} + \sigma^2_{timeZero} + \sigma^2_{tracking}}$$

$\sigma_{TOF}$

- portion of $\sigma_{PID(TOF)}$ strictly dependent on TOF detector only
- $\sigma^2_{TOF} = \sigma^2_{MRPC} + \sigma^2_{electronics}$ + (other contributions like clock jitter...)$^2$
- calibration helps to refine it. ESDs of LHC10b, c and d don't make use of best calibrations now available
- **It is not** event by event or track by track dependent

$\sigma_{timeZero}$

- when T0 detector measurement is available , is equal to $\sigma_{T0}$ (event by event it can be different if only T0A or T0C is available)
- if T0 detector is not available but tracks≥2 matches TOF, it can be derived by TOF data itself ("TOF_T0"). In this case $\sigma_{timeZero}$ depends event by event and track by track
- if both methods fail, we just use $\sigma_Z$/c of the LHC fill
- $\sigma_{timeZero}$ **can vary greatly event by event (especially in pp)**

$\sigma_{tracking}$

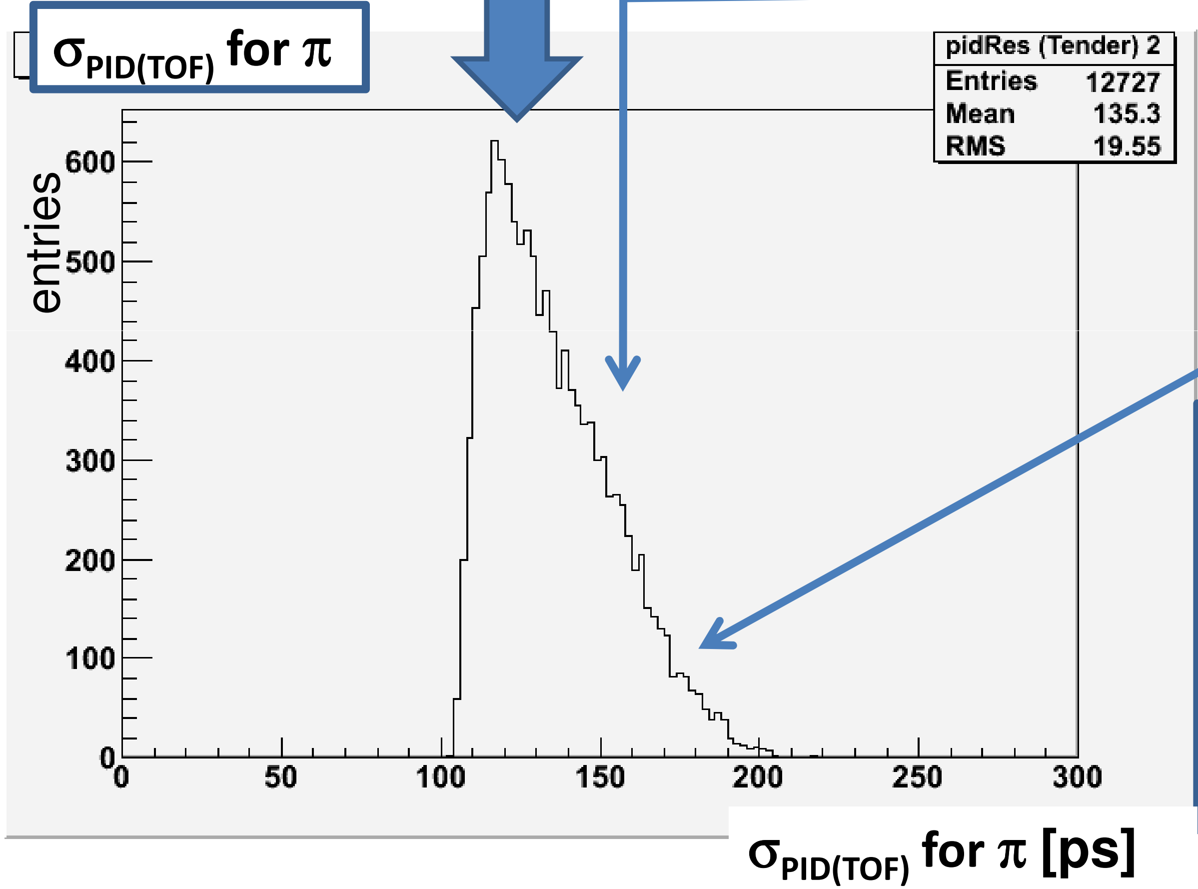
- tracking reconstruction dependent
- It has **momentum and particle mass hypothesis** dependence

# An example of TOF PID @ work (LHC10b)

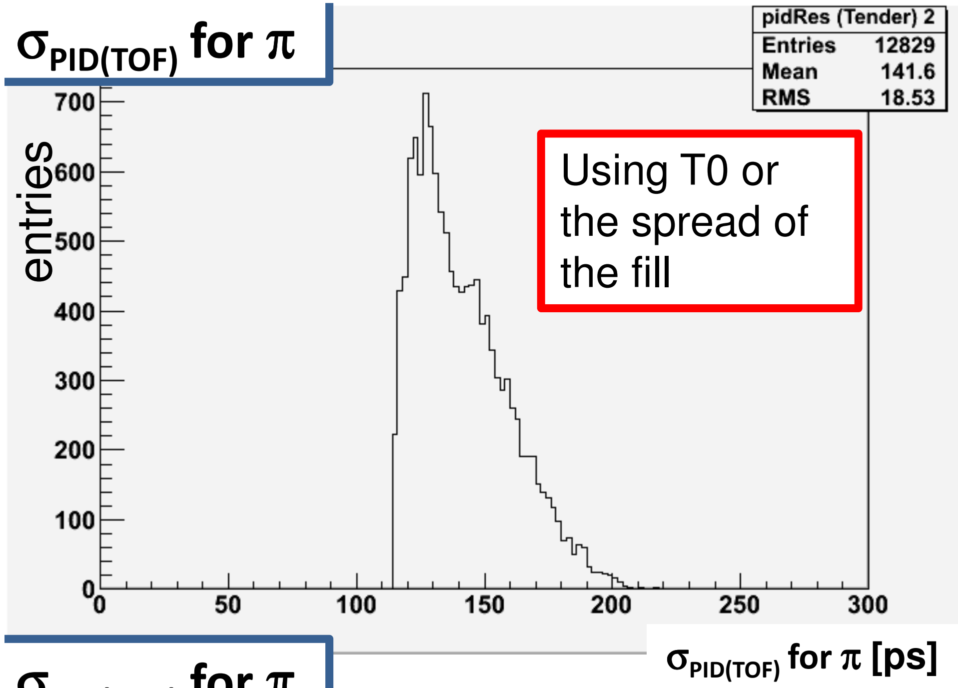
Region where we have for $\sigma_{timeZero}$ 'competing resolutions' amid T0 and TOF_T0

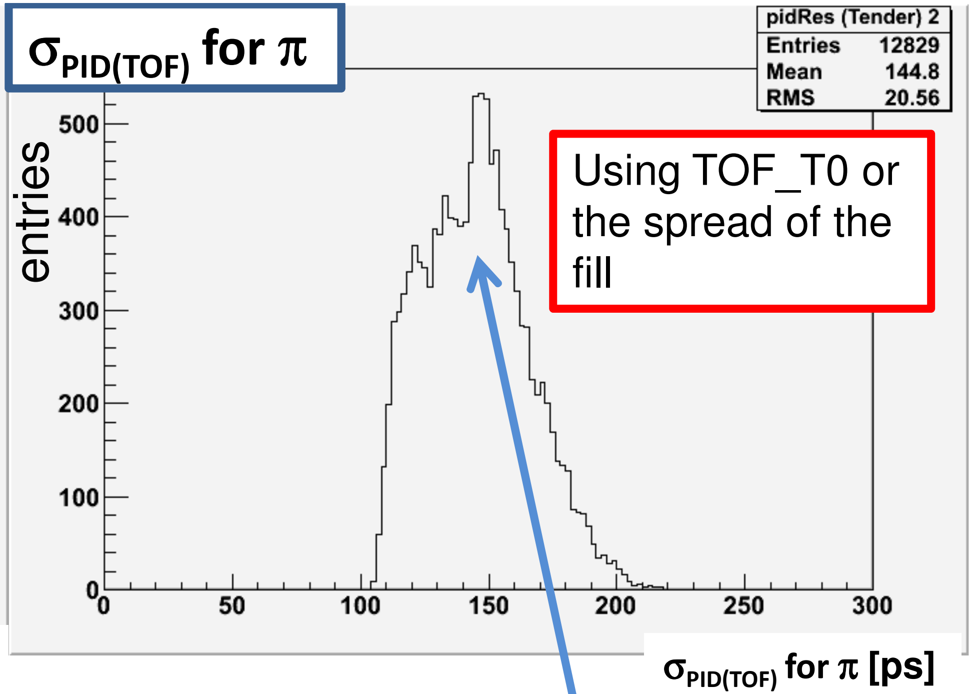
events where we use tzeroSpread ≡ $\sigma_z/c$

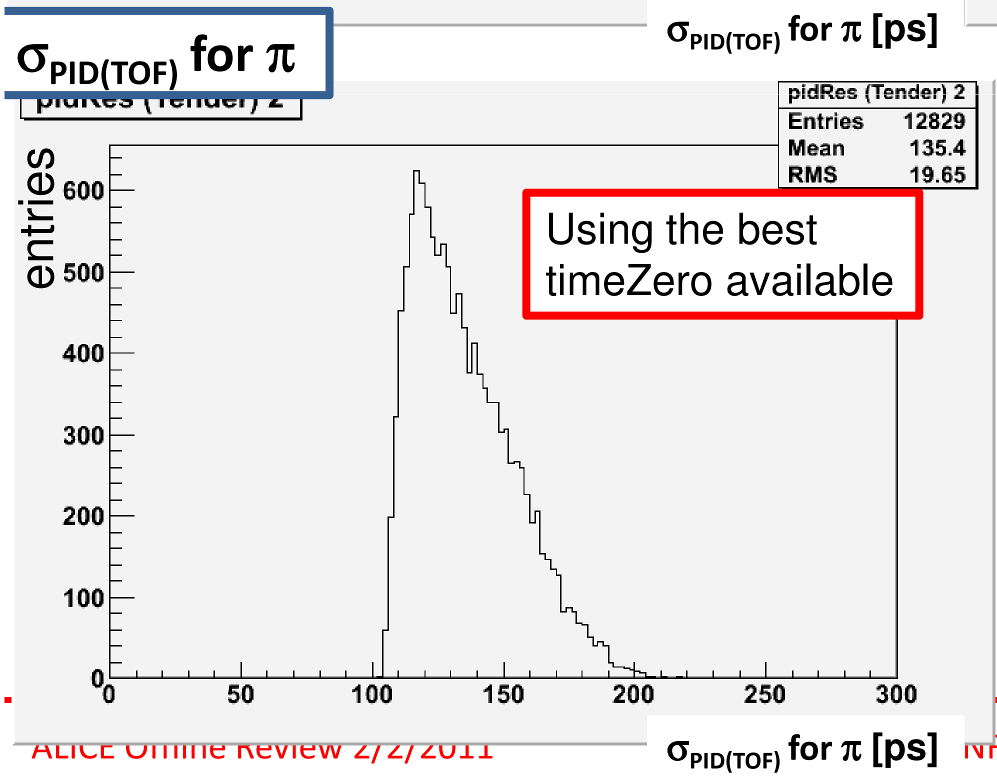
Low energy degradation ($\sigma_{tracking}$ component)




Note:
- tzeroSpread changes with LHC conditions
- 'competition' amid/balance between T0 and T0_TOF changes in PbPb (and use of tzeroSpread decreases a lot!)



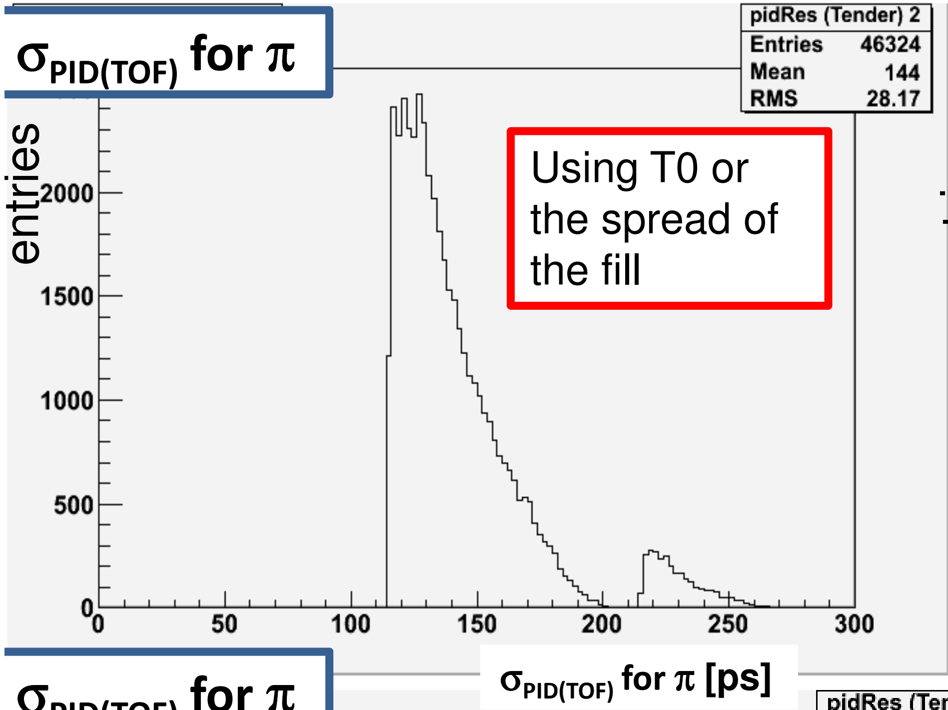



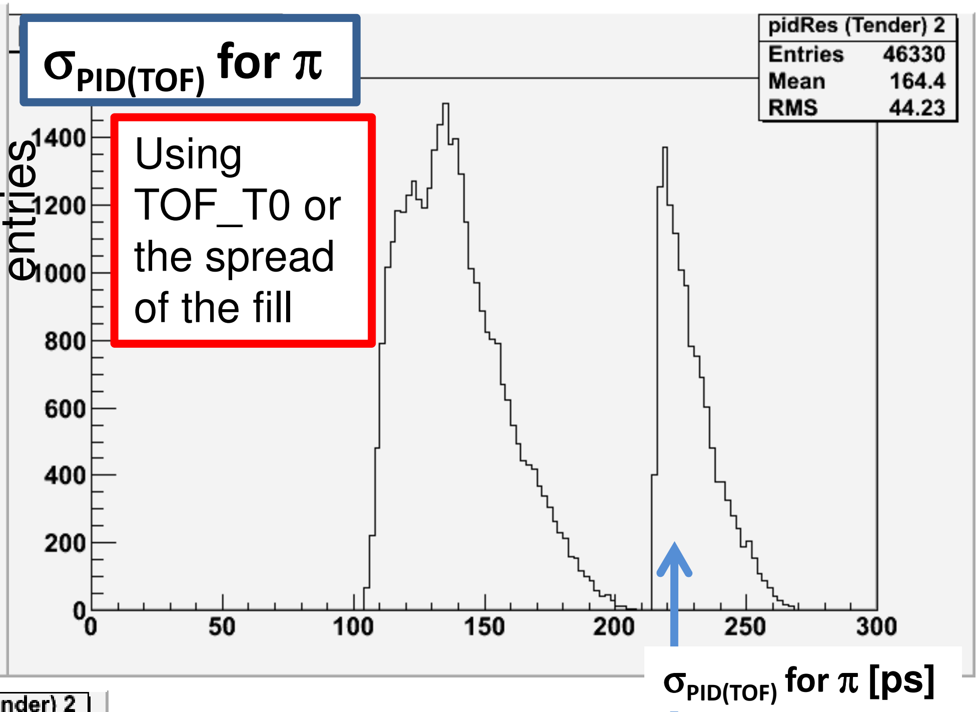

tzeroSpread ‘peak’

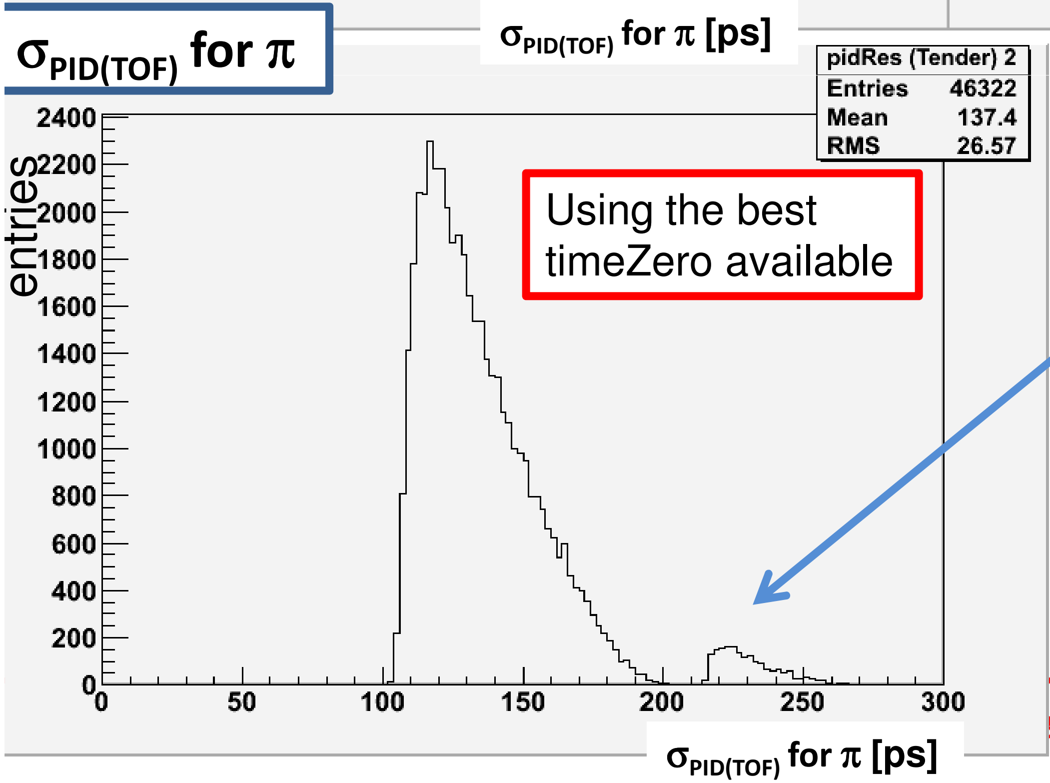
LHC10b:

-the balance between events where we have T0 or TOF_T0 depends on the type of collision

- the tzeroSpread depends only from LHC ($\sigma_z$)




LHC10d:
-the detectors didn’t change! LHC conditions changed!
- using also T0 detector only on 5% events we need to use tzeroFill as timeZero

**Note:** we got calibrations from T0 detector for LHC10d 11 January 2011

# Dependencies on TOF calibration and analysis (II)

$\widehat{PID}_{TOF}$ depends on

$C_n^{TOF}$

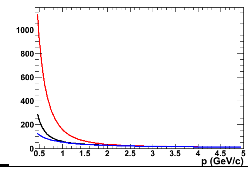
$C_n^{TO}$

$C_{n-1}^{tracking(TPC,...)}$

$C_{n-1}^{vertex(TPC,ITS)}$

Some caveat:
- we need also $\sigma_z$ so ITS must be up and working;
- TRD expected to play increasing role here in future (when back in tracking)
- T0 detector told us can be ready only after pass1 (that is it exists only a $C^{T0}_2$ set)

# A summary of $\sigma_{PID(TOF)} = \sqrt{\sigma^2_{TOF} + \sigma^2_{timeZero} + \sigma^2_{tracking}}$

| PID TOF resolution components | | Typical values (ps) | Dependencies | | | | Calibration Status @1/2/2011 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALICE Tracking | p | mass | # of tracks | b | c | d | e | f | g | h |
| $\sigma_{TOF}$ | | 80-100 | NO | NO | NO | NO | √ | √ | √ | √ | √ | √ | √ |
| $\sigma_{timeZero}$ | $\sigma_{T0}$(AND) | 55 | NO | NO | NO | YES (?) | ? | X | √ | √ | √ | √ | X |
| | $\sigma_{T0}$(OR) | 75(A)-65 (C) | YES | NO | NO | YES (?) | X | X | √ | √ | √ | √ | X |
| | $\sigma_{TOF\_T0}$ | 90(2)-40 (>8) | YES | YES | NO | YES | √ | √ | √ | √ | √ | √ | √ |
| | $\sigma_{tzeroSpread}$ | 90-120 LHC10b<br>200-220 LHC10e | NO | NO | NO | NO | √ | √ | √ | √ | √ | √ | √ |
| $\sigma_{tracking}$ | |  | YES | YES | YES | NO | √ | √ | √ | √ | X | X | √ |

**X T0 detector not available**
**? T0 calibration not fully validated**
**X calibration not yet available**
**√ calibration available, to be validated**
**√ calibration validated**

Tenders currently needed to get the "best" (new calibrations, data stuctures, fix mistakes like geometry, etc....

Not yet TPC good reconstruction at pass1. TOF calibration cannot be validated!

# Improve our definitions

$$C_n^X = R_n^X + A_n^X$$

calibration parameters used during reconstruction, which influence reconstruction output in a irreversible way

calibration parameters used also during reconstruction, but that can be changed during analysis to provide a final better physics output

Examples:
TPC drift velocity
TOF map of ON/OFF/BAD channels

Examples:
TPC: Bethe-Bloch params
TOF: tzeroFill, slewing corr., etc.

**Comment 1**: TOF calibration is by an extremely large part under A type
**Comment 2**: ALICE analysis model seems to consider mainly R type...

# Some considerations / lessons learned some 'case studies'

- Wrong geometry in reconstruction: it looks like we have an uneven level of checks, control systems, man power and money (ex.: coverity checks vs an unchecked wrong geometry insertion) Our system should strengthen checks where the potential physics impact is larger
- Reactiveness: possibility of quick checks would help a lot
- T0 calibration "late": how to 'recover the past'?
- TOF 2010 "learning": we evolved calibration, analysis and data structures inside ESDs: how to 'recover the past'?
- It looks like we don't have a clear policy on **pilot** runs (and checks on them that should be under detectors responsibility): to address the many calibration dependencies we have, this looks fundamental. Current QA efforts could be part of the solution, but we need a clearly physics oriented validation scheme of pilot runs at each pass.

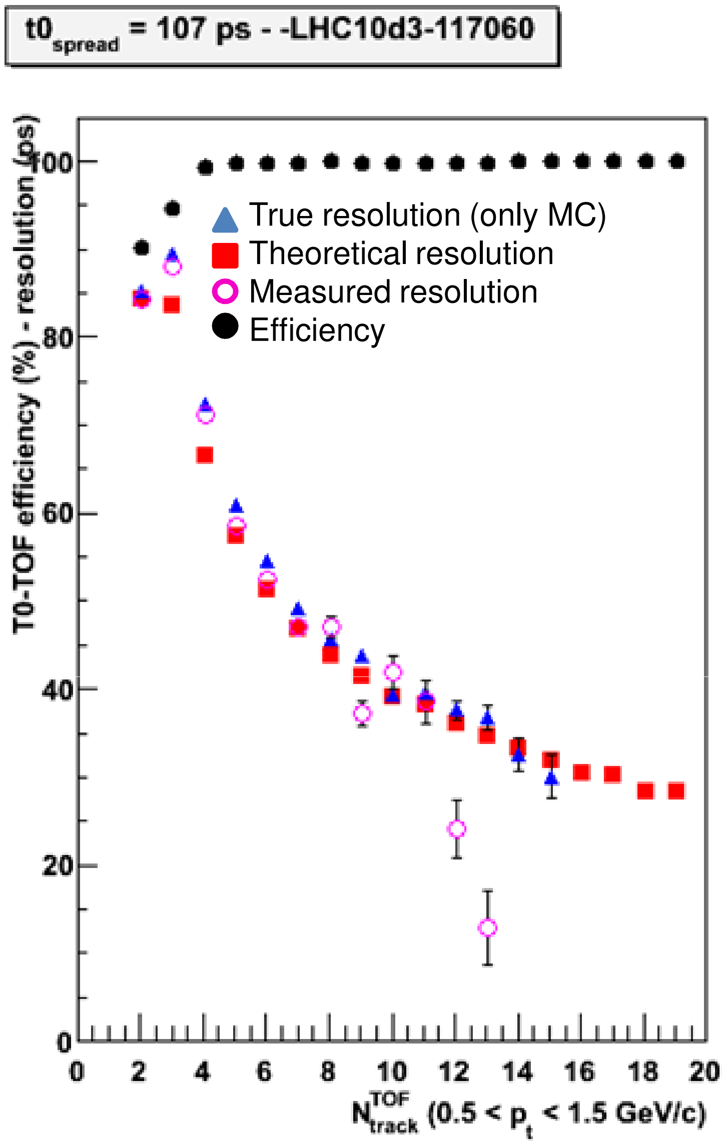
# ‘Recover the past’: some thinking out of the box

- **tenders** (and ad-hoc tasks) work on “A” part of the calibration sets...especially in first year of operation for a complex HE experiment it is normal to have frequent changes on “A” set. Does our current model takes into account this reality properly?
- **tenders are not a bad thing**: they could be the way out to keep back control of the situation (at user level too) and standard way to ‘recover the past’ (at least for A part of calibrations)
- We could consider in some cases a new approach ‘to recover the past’: “**pass2fix**”:
  - don’t re-run reconstruction, but re-write ESD after “loading” all official tenders patches
  - could it work? Resources? Obviously some discipline needed but we would get rid of part of the current anarchy....
  - could be a good alternative to pass3 for LHC10b, LHC10c and (perhaps) LHC10d

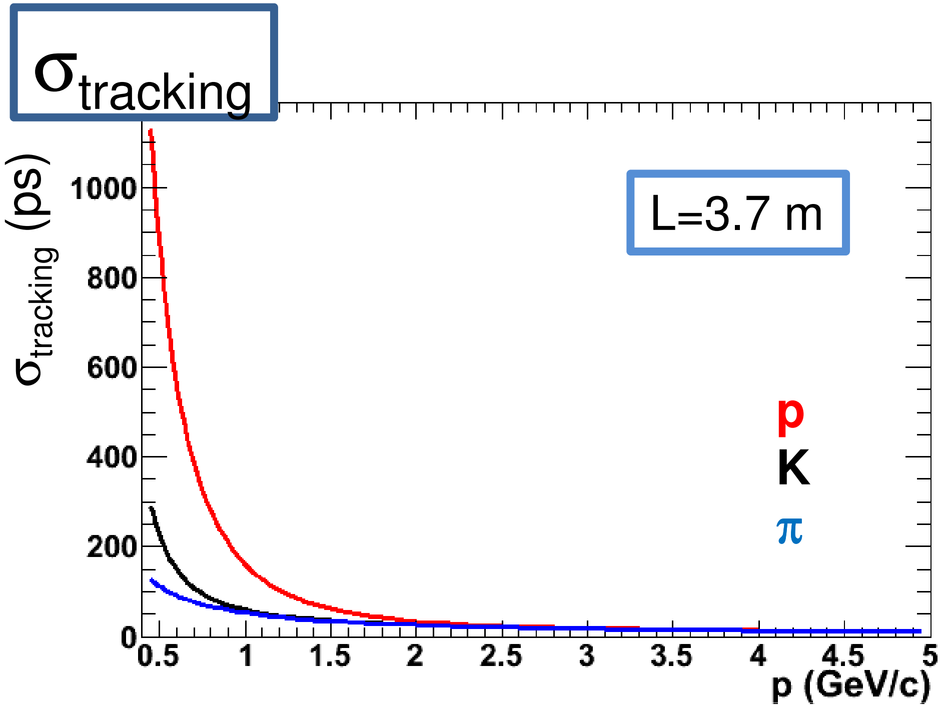
# Some additional ideas/discussions points for ALICE

- we have many **dependencies** of the type: $C_n^X\left(C_{n-1}^Y\right)$ Let's map them!!
- Is the paradigm of 100% consistency between ESDs and AODs really helping us? (R vs A parameters)
- If we change paradigm, we could push much more for **AODs** (and centralize tenders to produce them only if neeeded)
  - but where we are really on AODs? (ex: PWG2 ≠ PWG3)
- Generally speaking centralization obviously important to avoid diverging, but some '**empowering**' of a limited set of detectors experts for quick reconstruction checks could be rewarding

Backup




(see F. Noferini presentation at spectra meeting 16/9/2010)




Notes:

1. Don't be worried by large values at low energies: a proton at 500 MeV/c reaches TOF 9 **ns** after a K and 13 **ns** after a $\pi$!
2. This is semiempirical following what we see in MC... still investigating if we can do better

# Our reactiveness to ‘wrong geometry’

- 14/12/2010 16:06 Bug opened by TOF (anomalous integrated times on LHC10h pass2 ) marked as blocker.
- 17/01/2011 17:00 Offline decides to start LHC10e reconstruction
- 21/01/2011 17:58 Wrong geometry found
- 24/01/2011 17:00 Offline decides to stop LHC10e pass2 with wrong geometry
- 25/01/2011 15:42 TOF requests (with a letter to Karel/Federico) for checks on selected runs on LHC10d, LHC10e, LHC10h to assess impact and check if everything ok)
- 27/01/2011 10:48 Federico agrees
- 31/01/2011 11:23 Formal request (Savannah) posted by TOF of checks on selected runs upon Federico’s request
- 31/01/2011 17:00 Offline approves requests of checks on selected runs
- 31/01/2011 19:06 Reconstruction with correct geometry on run 130795 begins
- 01/02/2011 16:00 Reconstruction on run 130795 reaches enough statistics. TOF finds problem fixed analysing ESDs
- 01/02/2011 18:08 TOF closes the bug

**Main comment:**
Apparently we spent 10 days to agree a check. The check took less than 1 day. What we can learn here?