DPG/AOT – Analysis Objects and Tools: introduction, news, some recommendations

Iouri Belikov, Luca Barioglio, Felix Schlepper, Andrea Ferrero, Mattia Faggin, Igor Altsybeev, Stefano Trogolo, Evgeny Kryshen

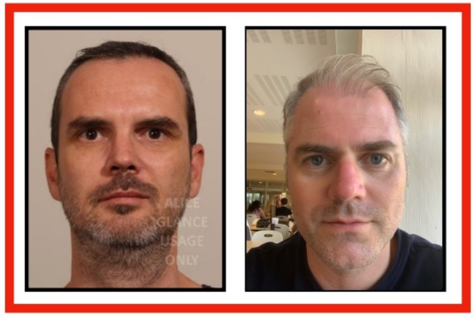
O2 analysis tutorial 5.0

November 10, 2025

Data Preparation Group (DPG): who we are

Catalin Alberto

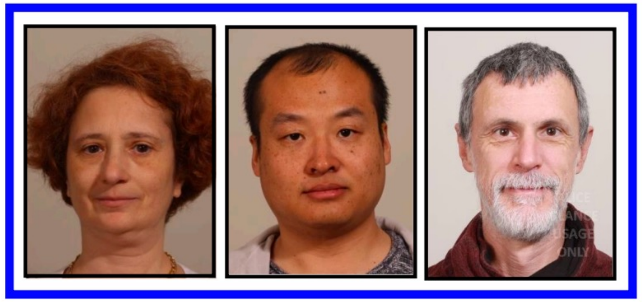
DPG coordinators:



Mesut Michal

Data & MC Productions

Elena Jian Andrea



Async Quality Control

Luca Jouri Felix

AOT-Tracks

Igor Stefano

AOT-Events

- Responsible for **steering and coordinating the reconstruction** of the data collected by ALICE, the preparation and the execution of the **Monte Carlo simulations**, and of organizing the **Quality Assurance** of the reconstructed and simulated data

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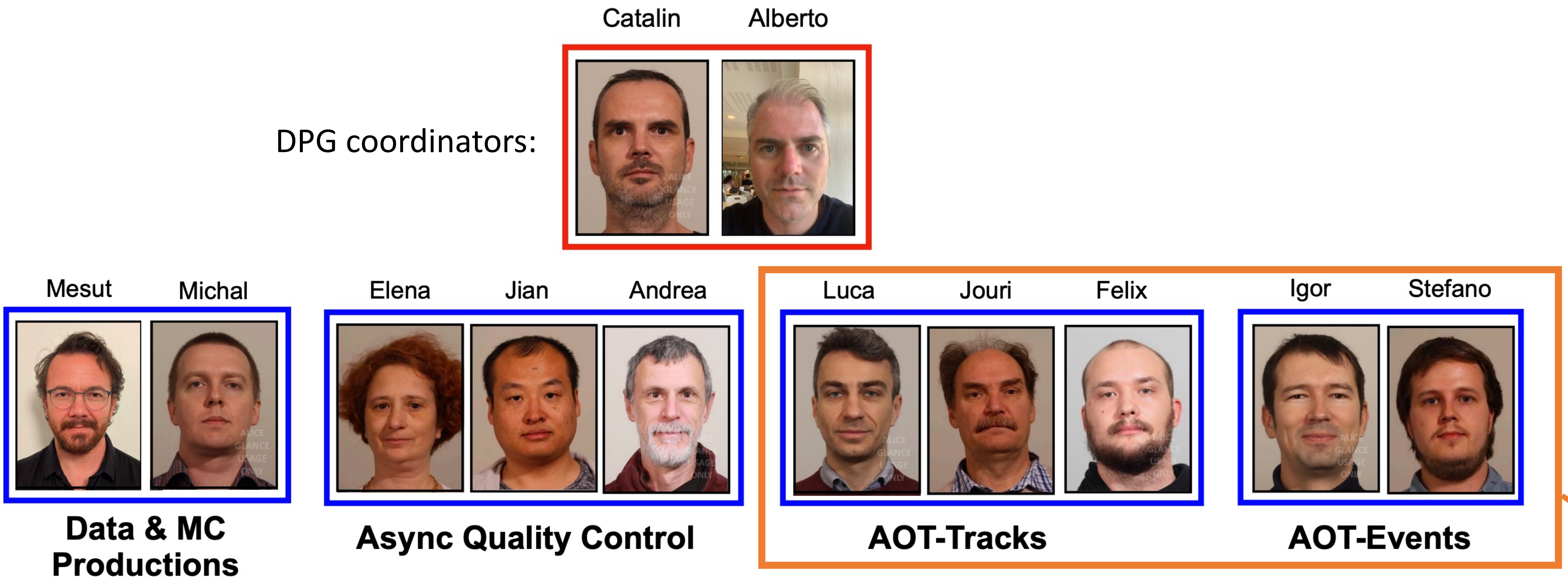

- Responsible for **steering and coordinating the reconstruction** of the data collected by ALICE, the preparation and the execution of the **Monte Carlo simulations**, and of organizing the **Quality Assurance** of the reconstructed and simulated data
- In charge of the **Analysis Objects and Tools** for events and tracks characterization (AOT/Events, AOT/Tracks), which includes the **production, maintenance, Quality Assurance and bookkeeping of the AOD (Analysis Object Data) files**, as well as the **coordination of the groups working on event selections and properties and track selections and properties**

Common utilities for your analysis

AOT = Analysis Objects and Tools

Focus of this talk: common **tools**/utilities for your analysis with O2Physics

AOT/Events

- Event selection
- Event-plane determination
- Multiplicity and centrality calibration

Extra (not a part of DPG)

- Particle Identification (PID)

AOT/Tracks

- Track propagation to the primary vertex
- Track selections
- Track-to-collision association
- Primary-track DCA track smearing in MC (trackTuner)

Common utilities for your analysis

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Focus of this talk: common **tools**/utilities for your analysis with O2Physics

AOT/Events

- Event selection → main focus of this talk
- Event-plane determination
- Multiplicity and centrality calibration

Extra (not a part of DPG)

- Particle Identification (PID)

Tue

09:00 **PID**: Electrons, Hadrons, and Light Nuclei
Speaker: Mr Hirak Kumar Koley (Jadavpur University

09:30 **PID**: Weak Decays and Secondary Vertices
Speaker: Romain Schotter (Austrian Academy of Sciences (AT))

AOT/Tracks

- Track propagation to the primary vertex
- Track selections
- Track-to-collision association
- Primary-track DCA track smearing in MC (trackTuner)

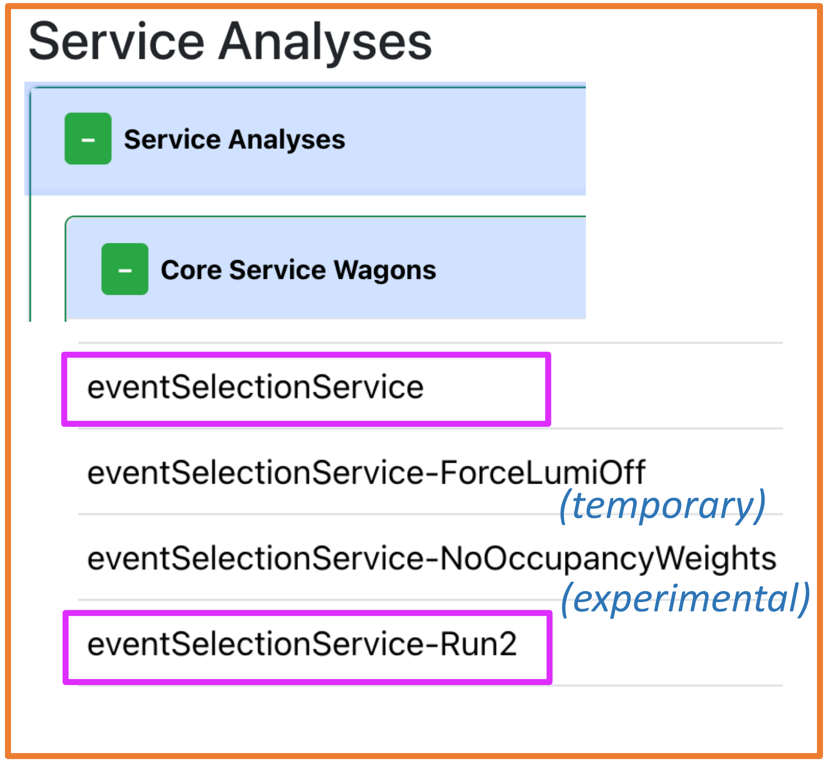
see detailed talk in HF session on Wed:

09:00 **Introduction to the HF O2 framework and general information**
Speaker: Mattia Faggin (CERN)

DPG/AOT-Event

Event selection service

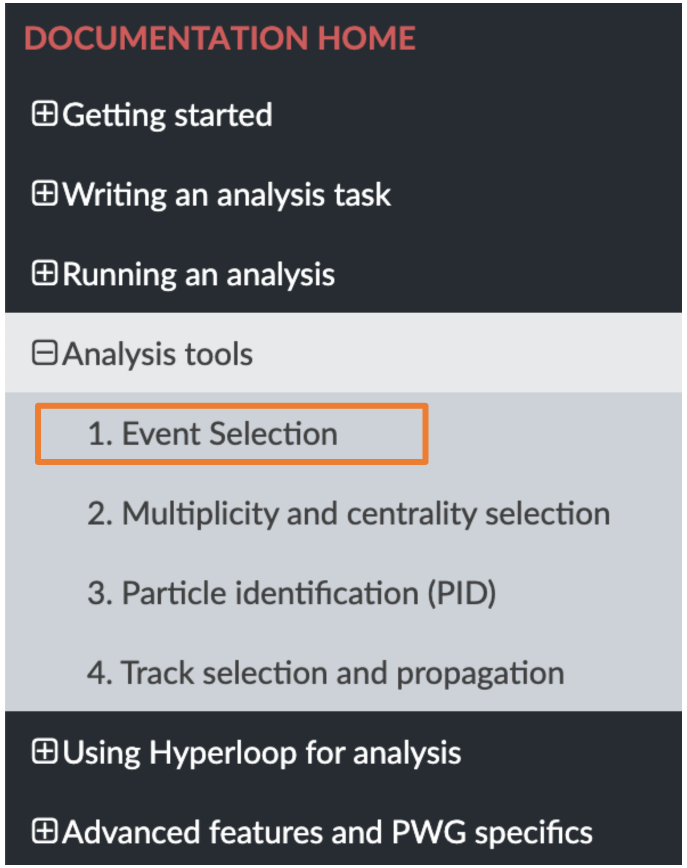
HY service wagons:



o2-analysis-event-selection-service task (see [eventSelectionService.cxx]) integrates several service modules:

- Timestamp module *(creates timestamps corresponding to bunch crossings)*
- **Event selection modules for *bc-based* and *collision-based* analyses**
- Luminosity module

[Event Selection documentation]
(restructured + updated)



Event selection service

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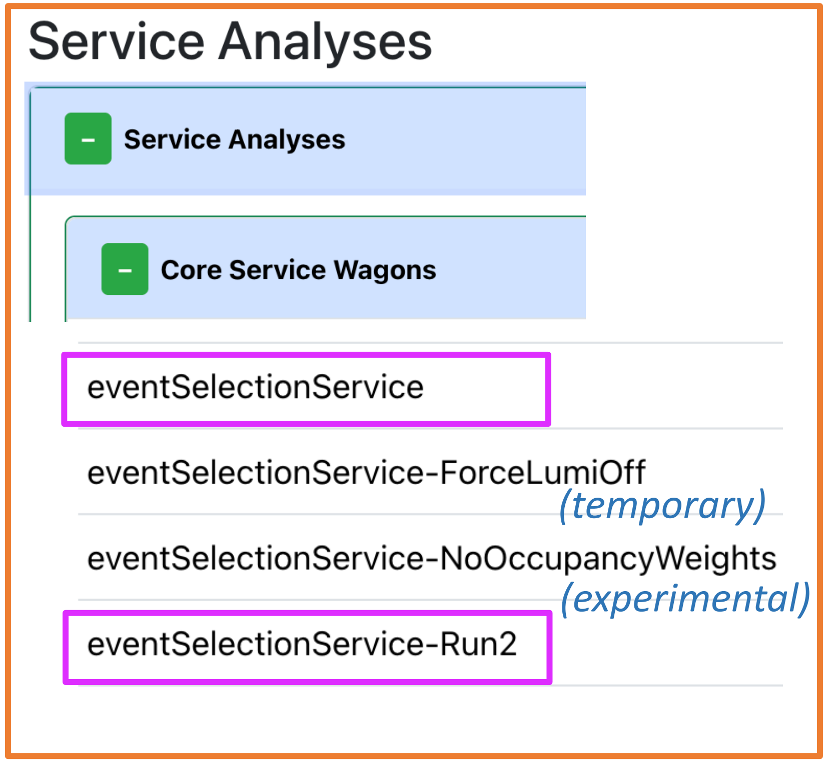

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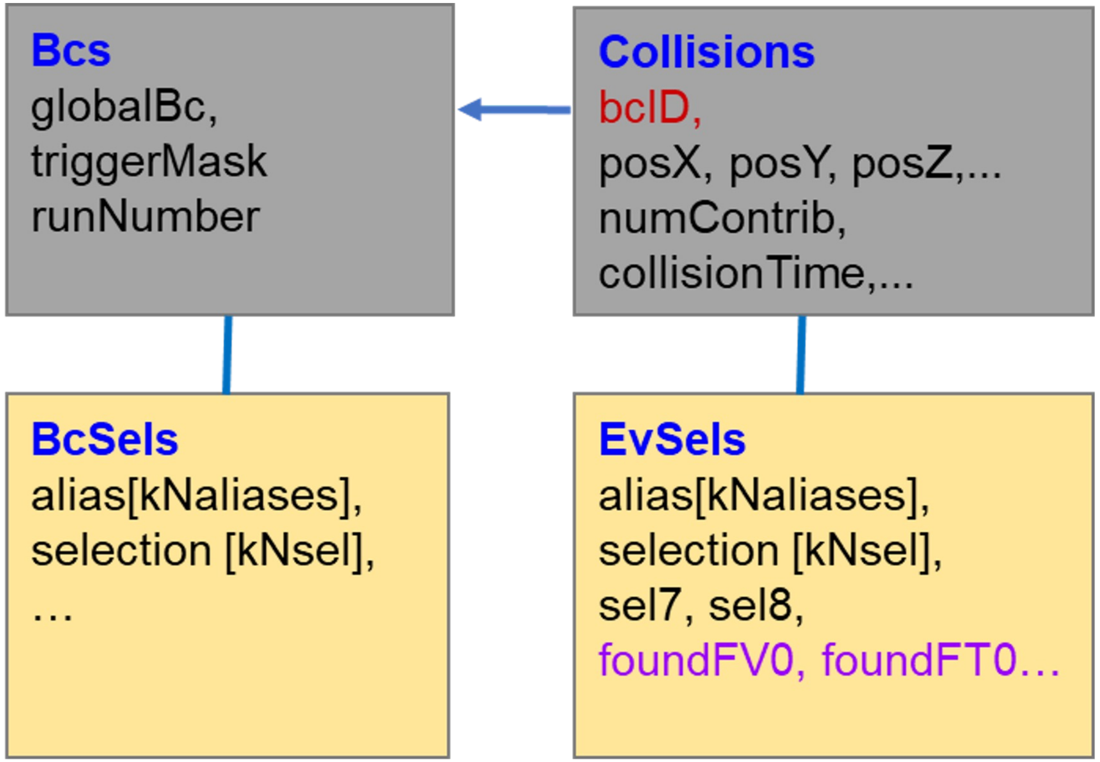
- Luminosity module

NOTE:
Until July 2025, the *timestamp* and *event selection* tables were produced in dedicated timestamp.cxx and eventSelection.cxx tasks.
These tasks are now deprecated and obsolete (and will be removed).
All ongoing developments are being carried out in eventSelectionService.cxx task and corresponding timestampModule.h and EventSelectionModule.h modules.

Event selection in O2: Data Model

- **EvSels** table joinable with **Collisions** table. To be used in analyses based on **loops over Collisions** (primary vertices), i.e. majority of ALICE analyses.
- **BcSels** table joinable with **BCs** table. To be used in analyses based on **loops over BCs** such as muon arm UPCs, luminosity monitoring etc.
- Main contents:
  - aliases[kNaliases]: fired trigger aliases (trigger classes)
  - selection[kNsel]: decisions on single selection criteria
  - sel7, sel8 (historical names): selection decisions = logical AND of several selection criteria
  - foundFV0, foundFT0, foundBC: indices to FV0, FT0 and BC entries matched to current collision

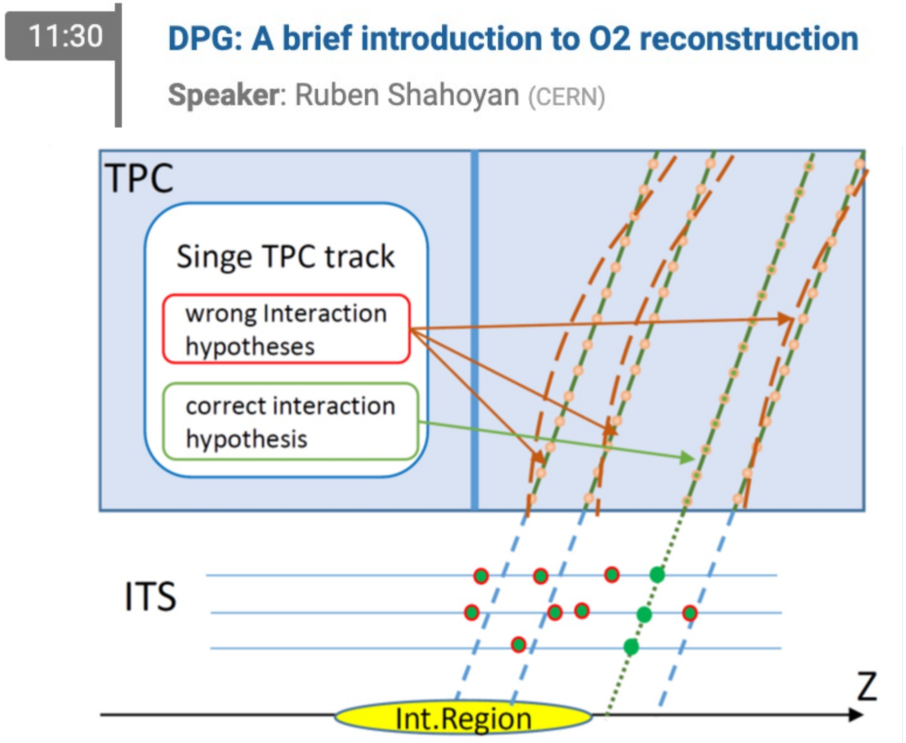
in **EvSels** table only

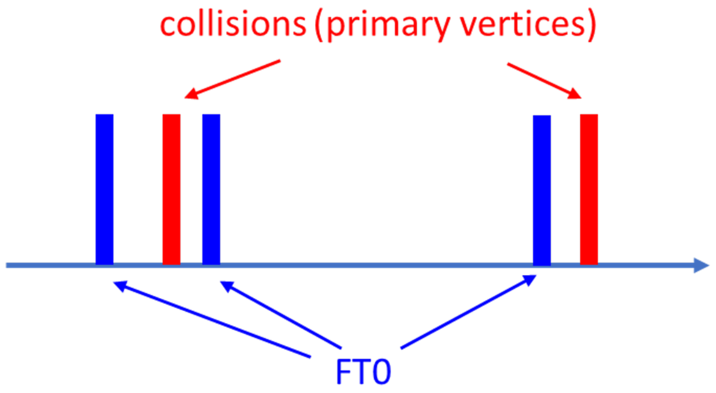


Defenition of event selection tables: [O2Physics/Common/DataModel/EventSelection.h]()

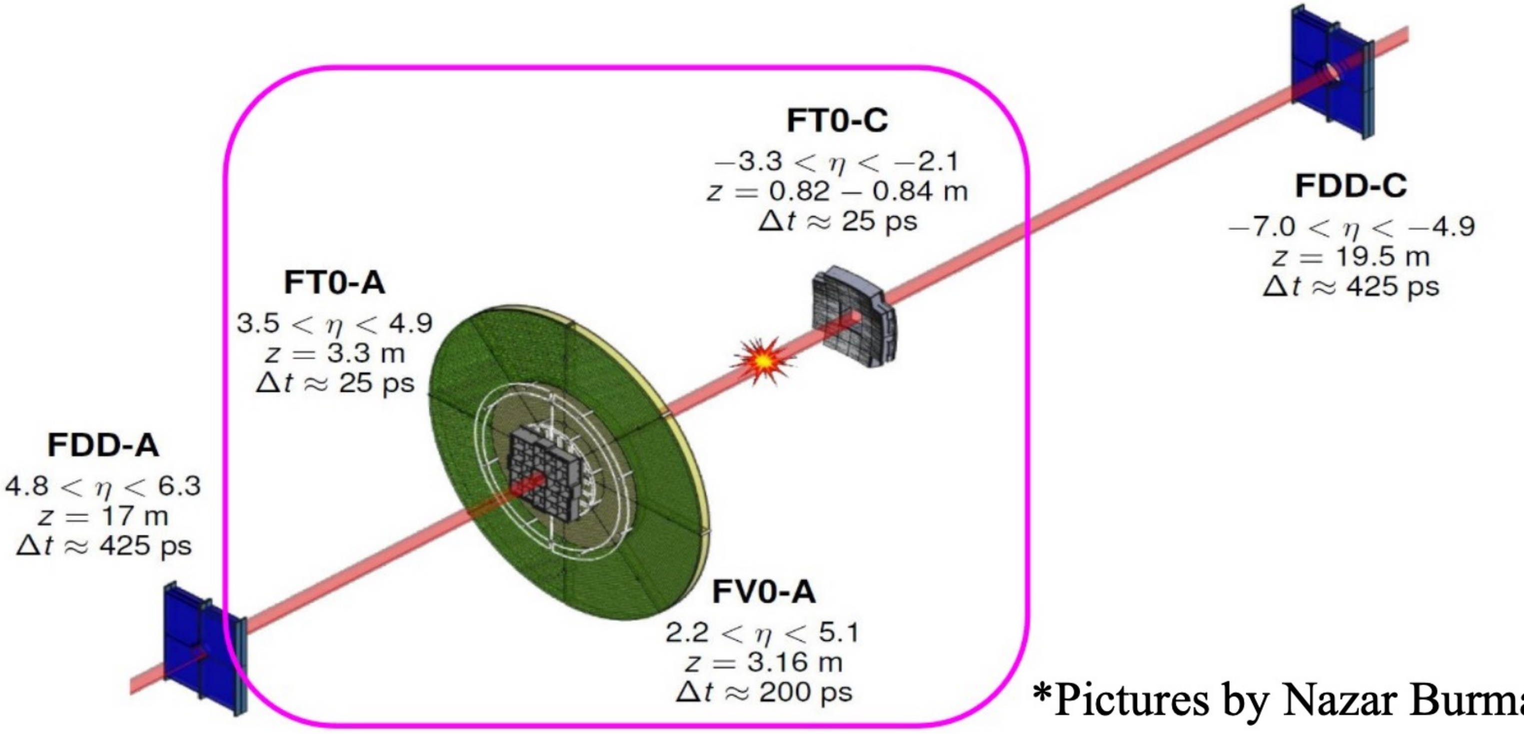
Event selection: challenges

- TPC: tracks are drifting towards endcaps (~100 μs drift time)
  - z-time ambiguity for TPC-only tracks
- ITS integration time ~5 μs in pp (15 μs in Pb–Pb)
  - Several overlapping events (in 650 kHz INEL pp runs)
  - No precise timestamp
- z-time ambiguity for TPC tracks can be resolved via:
  - ITS-TPC matching → ~100 ns resolution
  - TOF matching → precise timing (resolution < 1 ns).
- Collision time uncertainty depends on
  - time resolution of single tracks
  - number of contributors
- Event selection challenge: most probable collision bc is not precise and might be shifted wrt bc with corresponding FIT signals
  - might be a problem in high-rate environment
  - (e.g. typical distance between collisions in high-rate pp ~40 bcs)
- Solution: search for FIT info in neighboring bcs and provide foundBC, foundFT0, foundFV0 indices + flags, trigger aliases and decisions corresponding to foundBC





Event selection: MB event selection in Run 3



*Pictures by Nazar Burmasov

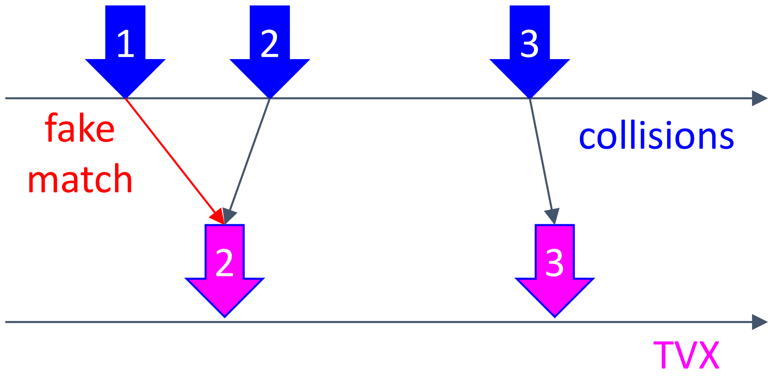
Using T0-vertex signal (TVX) - coincidence of FT0A and FT0C signals + good timing:

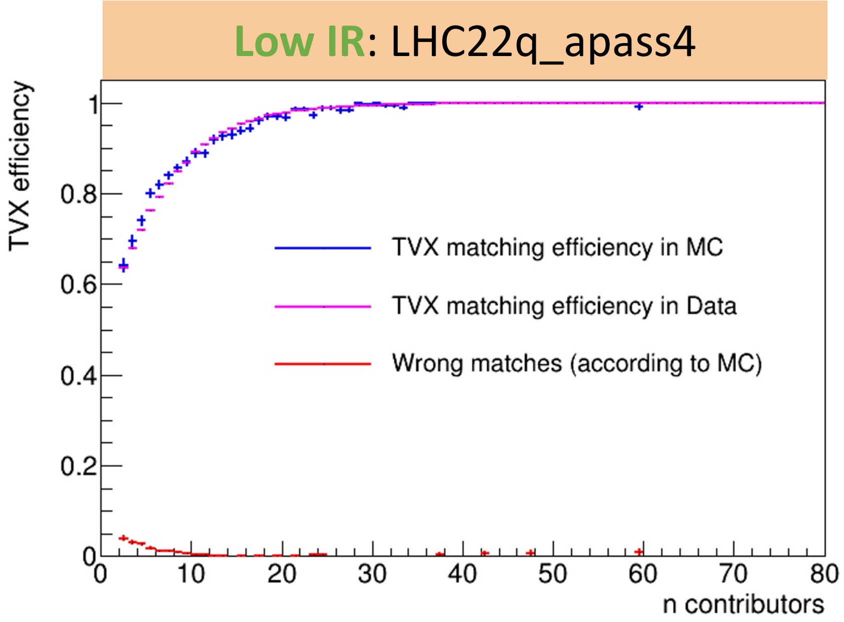
TVX ≈ FT0A & FT0C

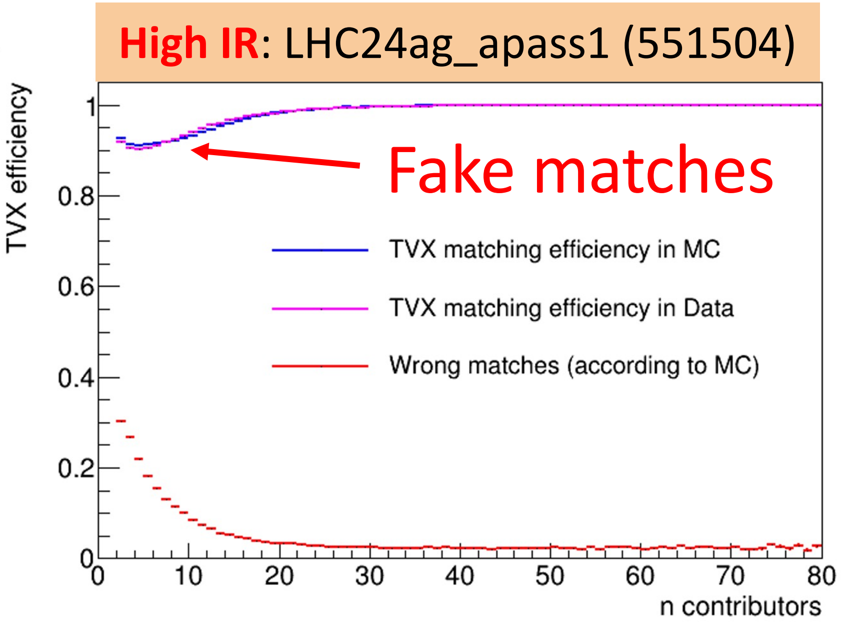
Event selection: collision-to-FT0 matching

`sel8 = kIsTriggerTVX & kNoTimeFrameBorder & kNoITSROFrameBorder` (since April 2024)

- Collision time is not known precisely (up to ~100 bc uncertainties)
- Event selection tries to **find closest bc with TVX** (FT0-vertex activity)
  - works well at low IR ~ 10 kHz (average TVX efficiency ~ 90%)
- BUT: large fraction of fake matches at high IR, especially at low mult…
- Use low IR to cross check results/normalization at high IR!







$$\varepsilon = \frac{\#\,\text{colls}^{\text{matched to TVX}}_{\text{kNoTF \& kNoITSROF}}}{\#\,\text{colls}_{\text{kNoTF \& kNoITSROF}}}$$

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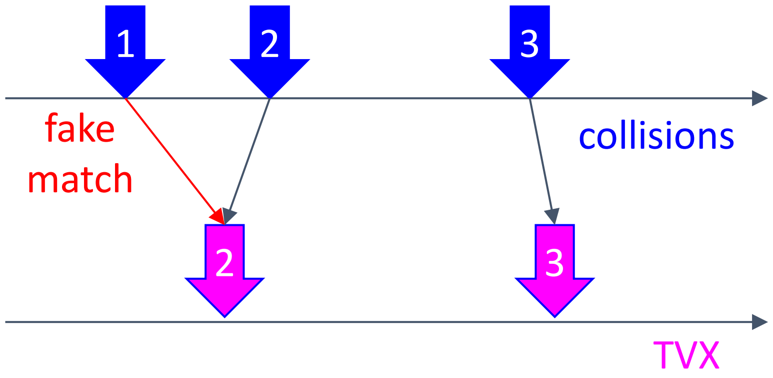
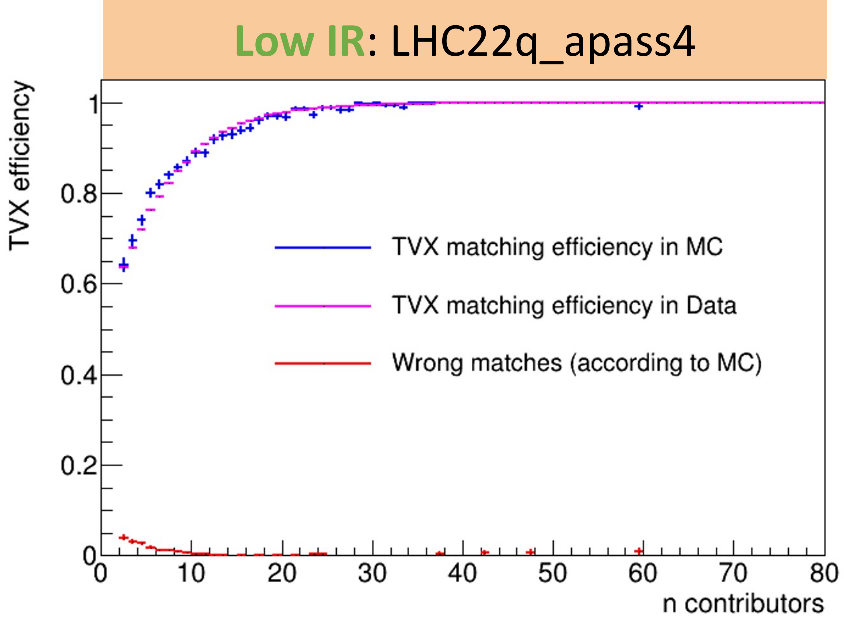
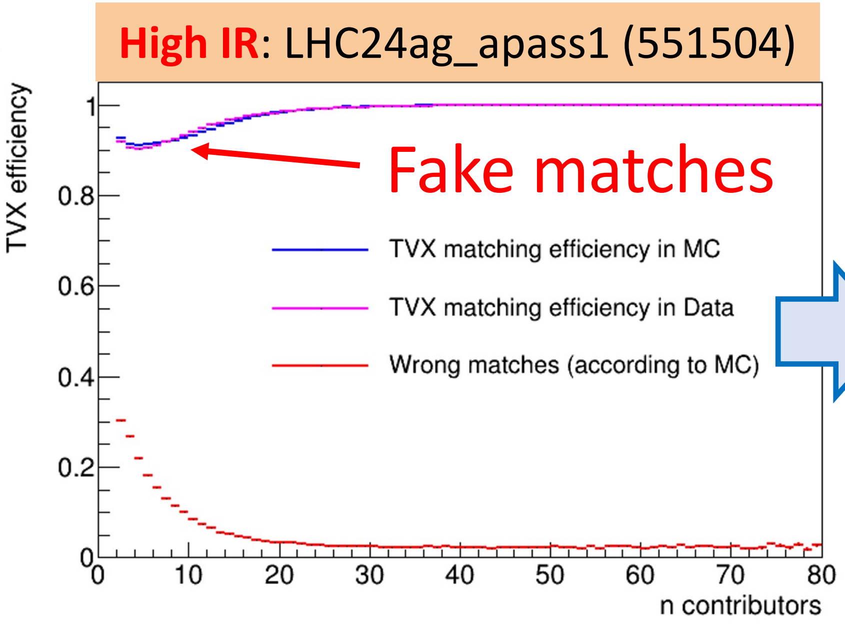
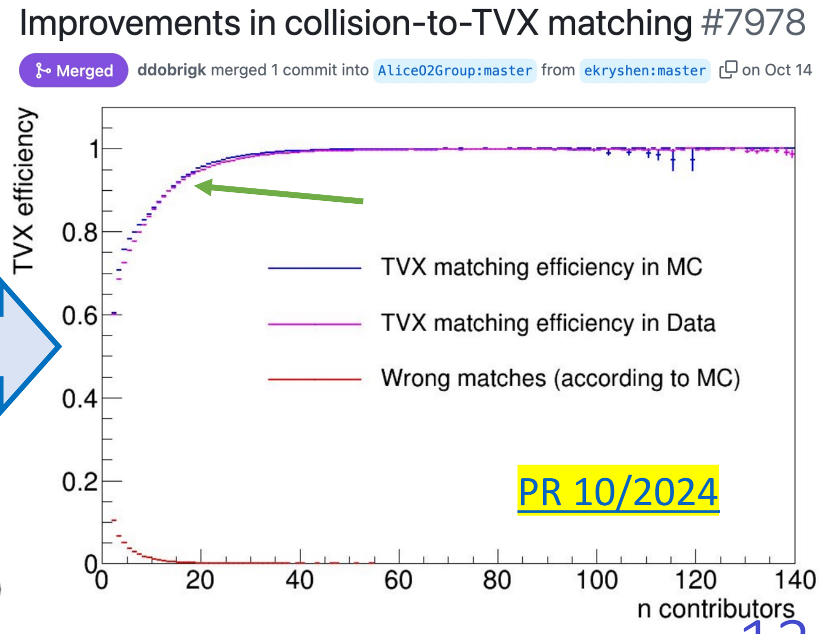




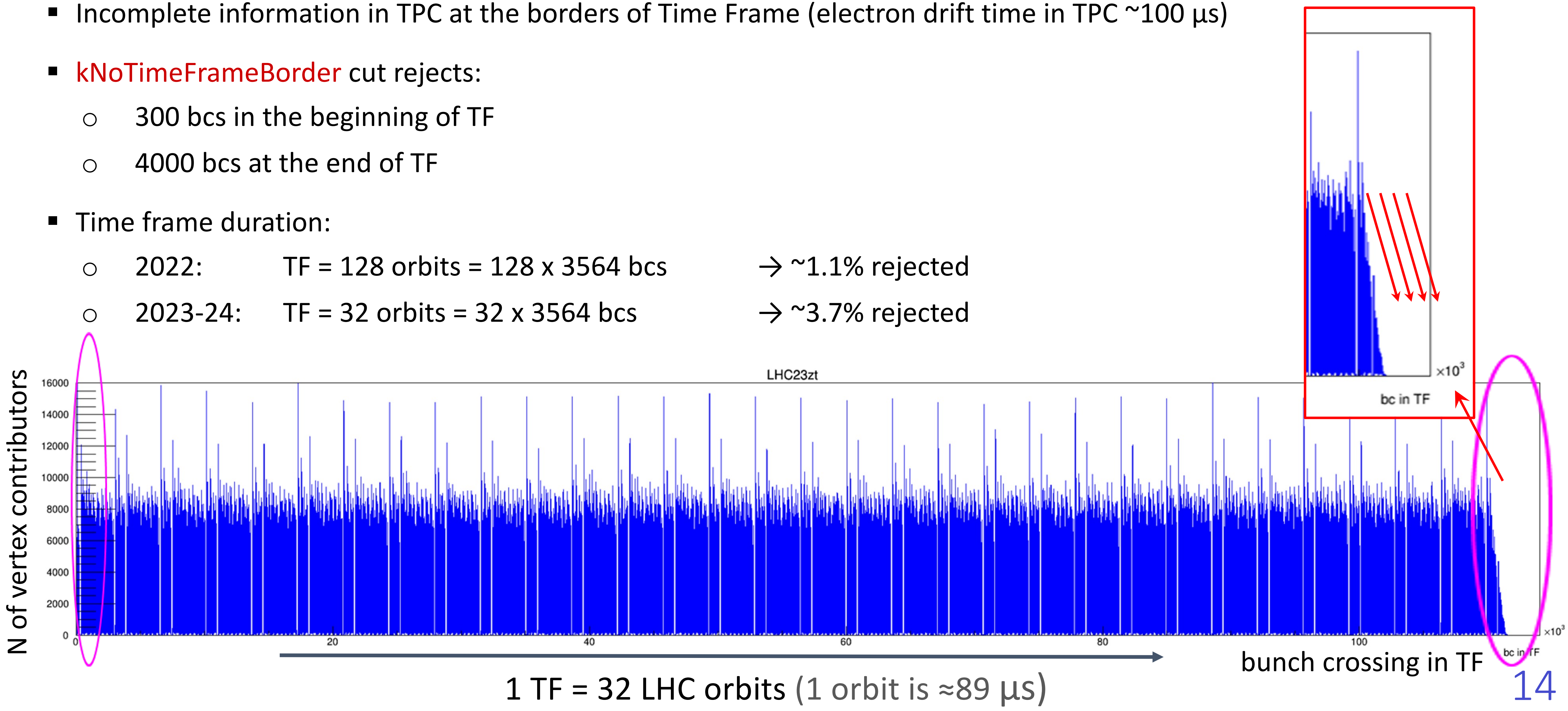




Event selection: kNoTimeFrameBorder

`sel8 = kIsTriggerTVX & kNoTimeFrameBorder & kNoITSROFrameBorder` (since April 2024)

- Incomplete information in TPC at the borders of Time Frame (electron drift time in TPC ~100 μs)
- kNoTimeFrameBorder cut rejects:
  - 300 bcs in the beginning of TF
  - 4000 bcs at the end of TF
- Time frame duration:
  - 2022: TF = 128 orbits = 128 x 3564 bcs → ~1.1% rejected
  - 2023-24: TF = 32 orbits = 32 x 3564 bcs → ~3.7% rejected

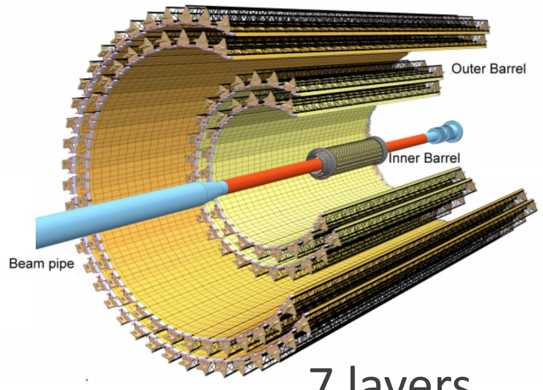


Event selection: kNoITSROFrameBorder

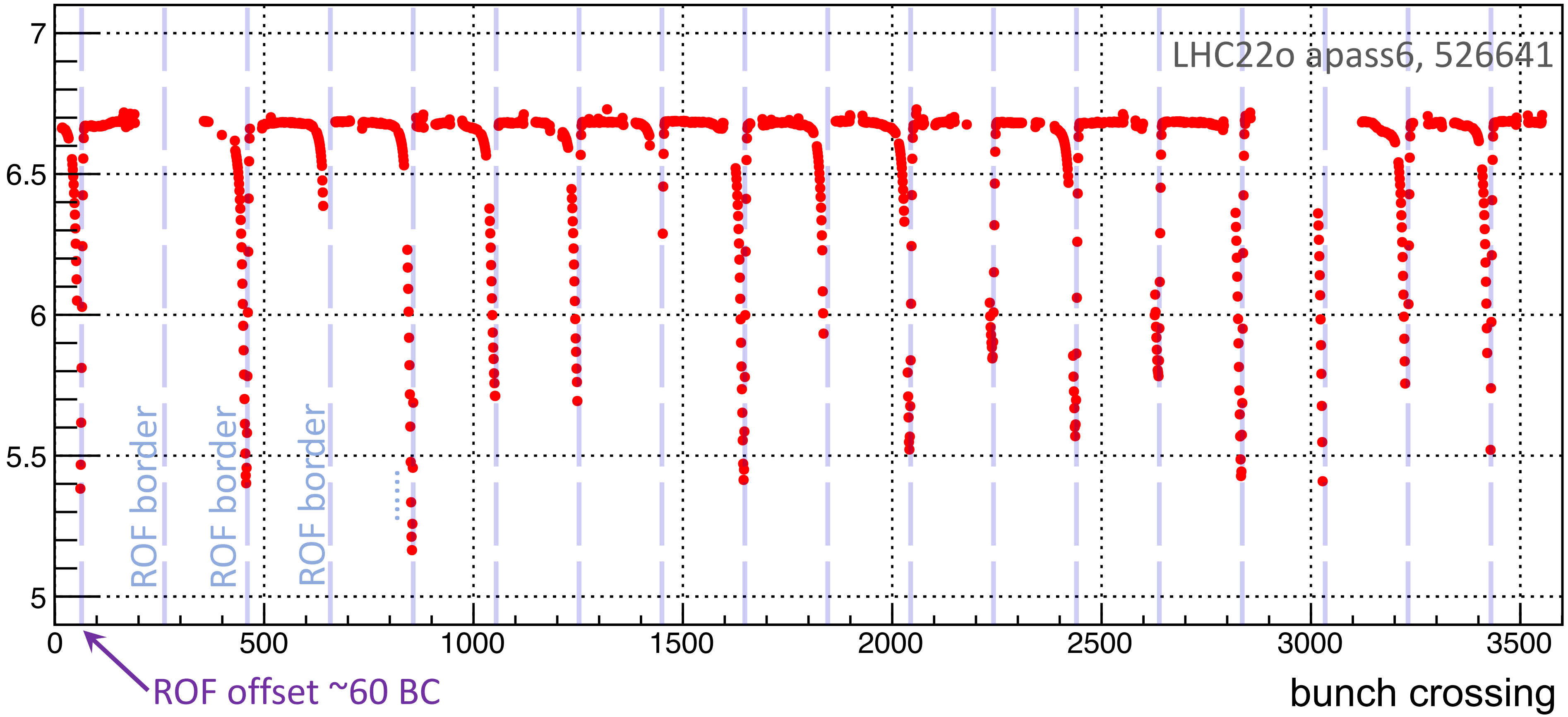
`sel8 = kIsTriggerTVX & kNoTimeFrameBorder &` **`kNoITSROFrameBorder`** (since April 2024)

- ITS cluster loss on the ROF boundary due to the ALPIDE time walk

*in Pb-Pb: 6 ROFs



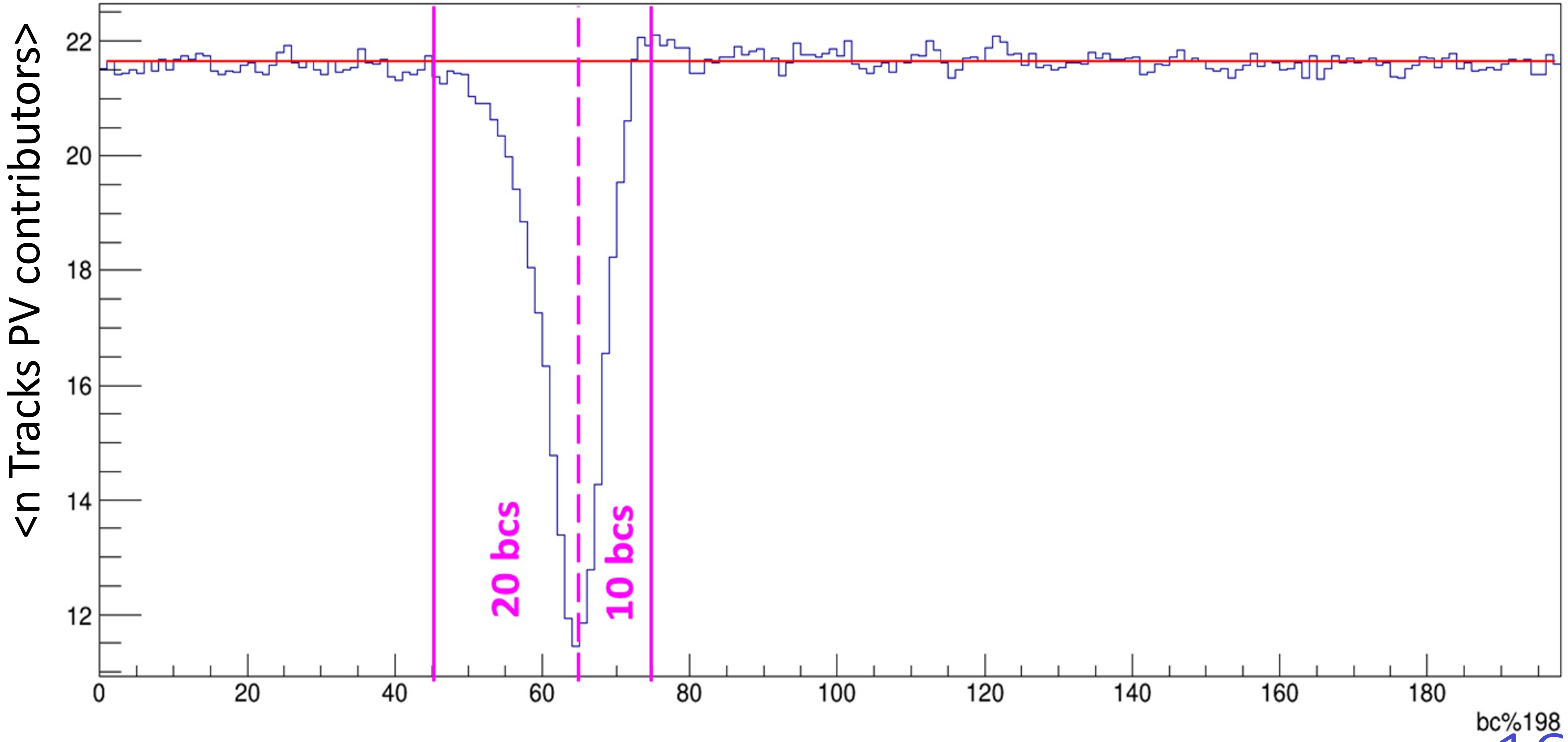
pp collisions: **18 ROFs** per LHC orbit, **each ROF 5 μs** (198 BCs)



Event selection: kNoITSROFrameBorder

`sel8 = kIsTriggerTVX & kNoTimeFrameBorder & kNoITSROFrameBorder` (since April 2024)

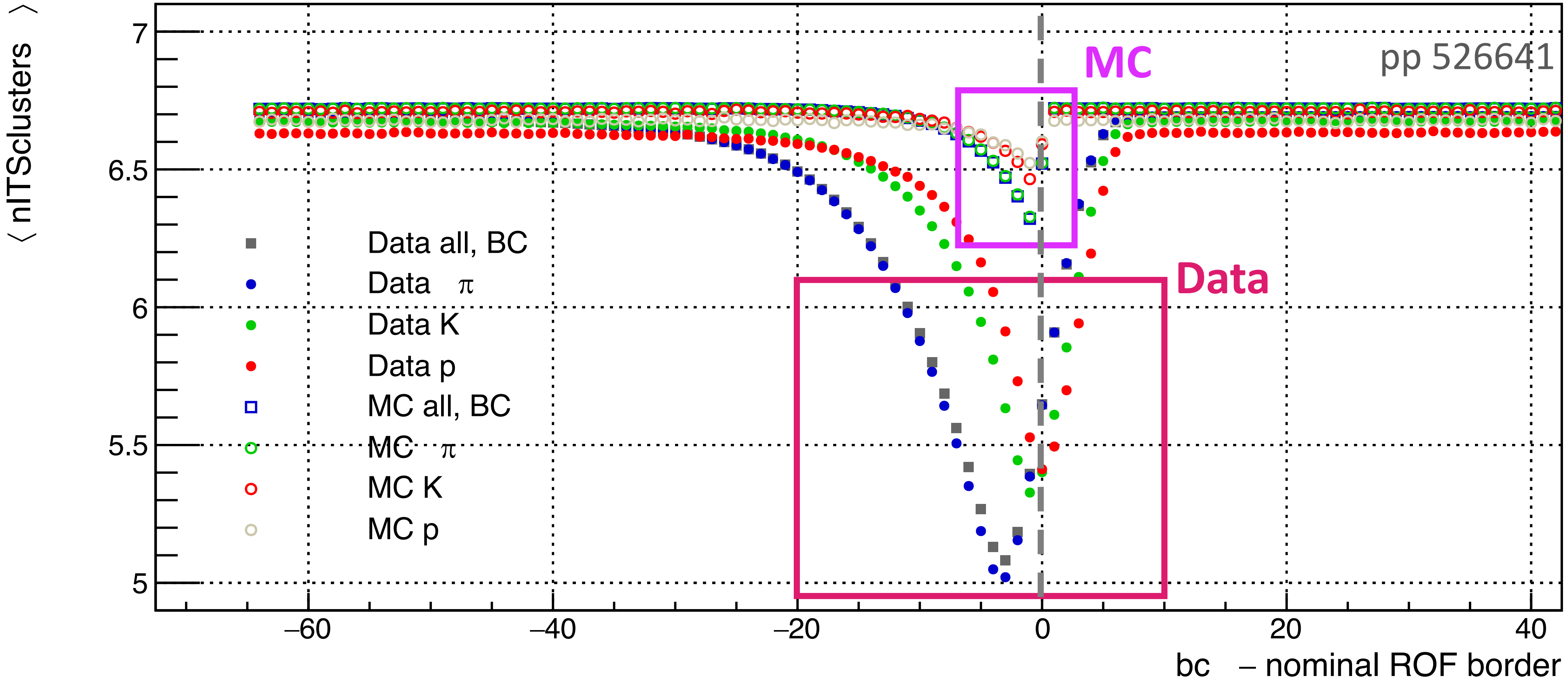
- ITS cluster loss on the ROF boundary due to the ALPIDE time walk
- kNoITSROFrameBorder cut rejects:
  - 20 bcs at the end of ITS RO frame
  - 10 bcs in the beginning of ITS RO frame
- ITS RO frame duration:
  - pp: 198 bcs → ~15% rejected
  - PbPb: 594 bcs → ~5% rejected



Event selection: kNoITSROFrameBorder

`sel8 = kIsTriggerTVX & kNoTimeFrameBorder &` **`kNoITSROFrameBorder`** (since April 2024)

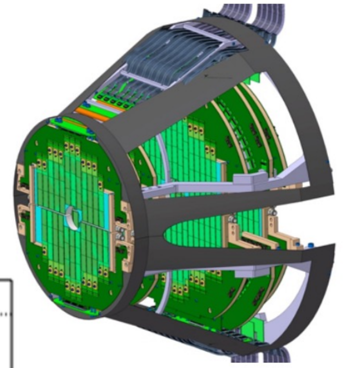
- ITS cluster loss on the ROF boundary due to the ALPIDE time walk
- Simulated also in **MC**, however, effect is smaller, does not fully match **Data**

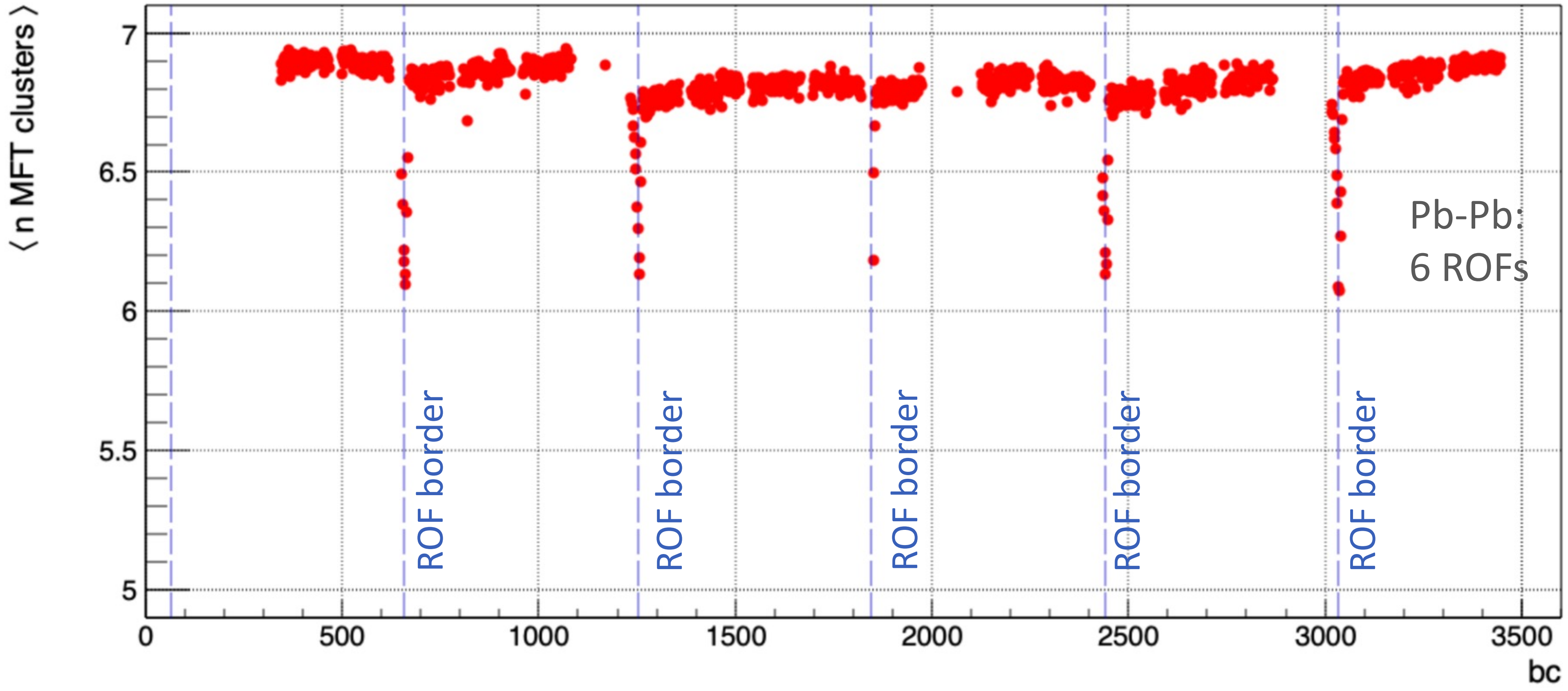


Event selection: kNoITSROFrameBorder

`sel8 = kIsTriggerTVX & kNoTimeFrameBorder &` **`kNoITSROFrameBorder`** (since April 2024)

- ITS cluster loss on the ROF boundary due to the ALPIDE time walk
- MFT also uses ALPIDE chips, and **MFT readout frames are aligned with those of the ITS:**





Event selection: basic usage in user tasks

- add EventSelection.h header:

```
#include "Common/DataModel/EventSelection.h"
```

- join Collisions and EvSels tables and use corresponding iterator as an argument of the process function:

```
void process(soa::Join<aod::Collisions, aod::EvSels>::iterator const& col, ...)
```

- check trigger aliases for Run2 data or triggered Run3 data (EMCAL, PHOS, TRD, HMPID):

```
if (!col.alias()[kINT7]) {
  return;
}
```

(bypass this check for MC or continuous Run 3 data)

- apply offline selection criteria:

Run 2:

```
if (!col.sel7()) {
  return;
}
```

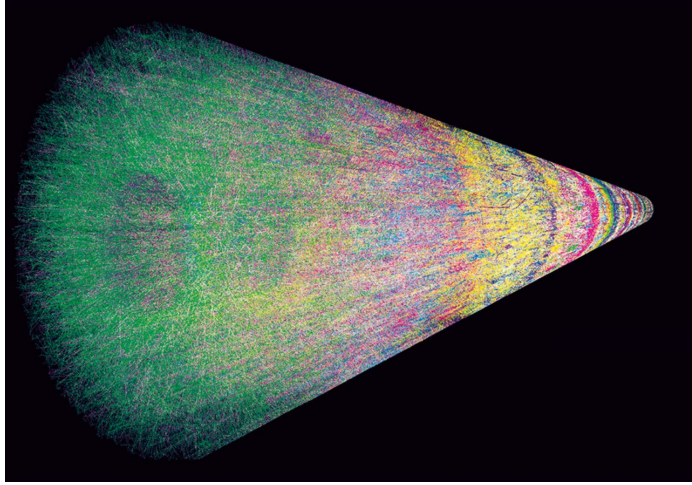
Run 3:

```
if (!col.sel8()) {
  return;
}
```

- run your tasks in stack with timestamp and event-selection tasks:

```
o2-analysis-event-selection-service --aod-file AO2D.root -b | o2-analysis-user-task -b
```

Event selection: Occupancy effects



TPC Occupancy Effects

- overlapping signals from nearby collisions within TPC drift time (~100 µs)
- leads to lower tracking efficiency and worse PID (dE/dx shifts, peak broadening)

Occupancy *estimators* (provided by the event selection routine EventSelectionModule.h):

- sum of **ITS tracks** from nearby collisions within a defined time window

```
int occupancyByTracks = col.trackOccupancyInTimeRange();
```

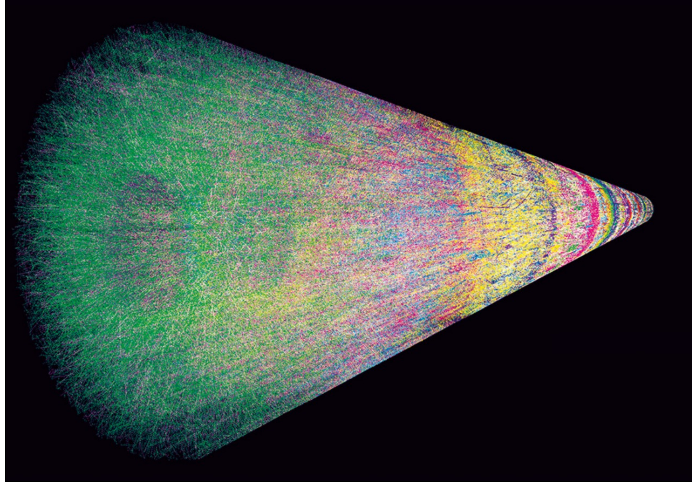
- sum of **FT0C amplitudes** from surrounding collisions

```
float occupancyByFT0C = col.ft0cOccupancyInTimeRange();
```

Multiplicities of nearby collisions are "weighted" according to their time separation from a collision-of-interest.

documentation

Event selection: Occupancy effects



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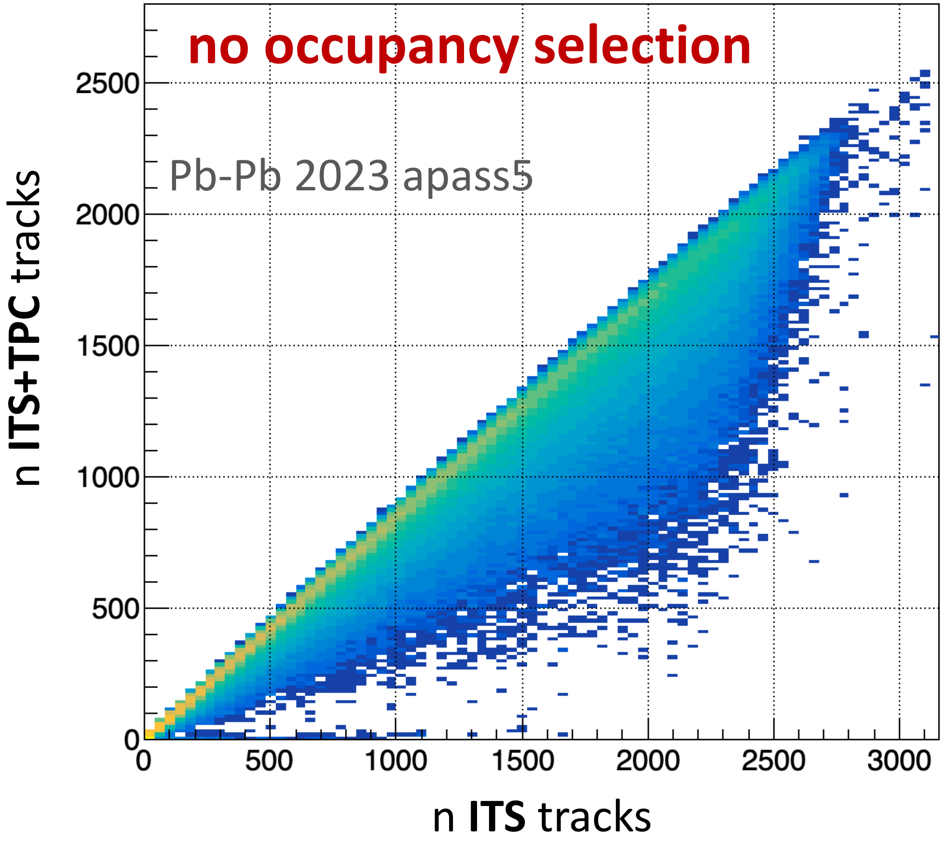
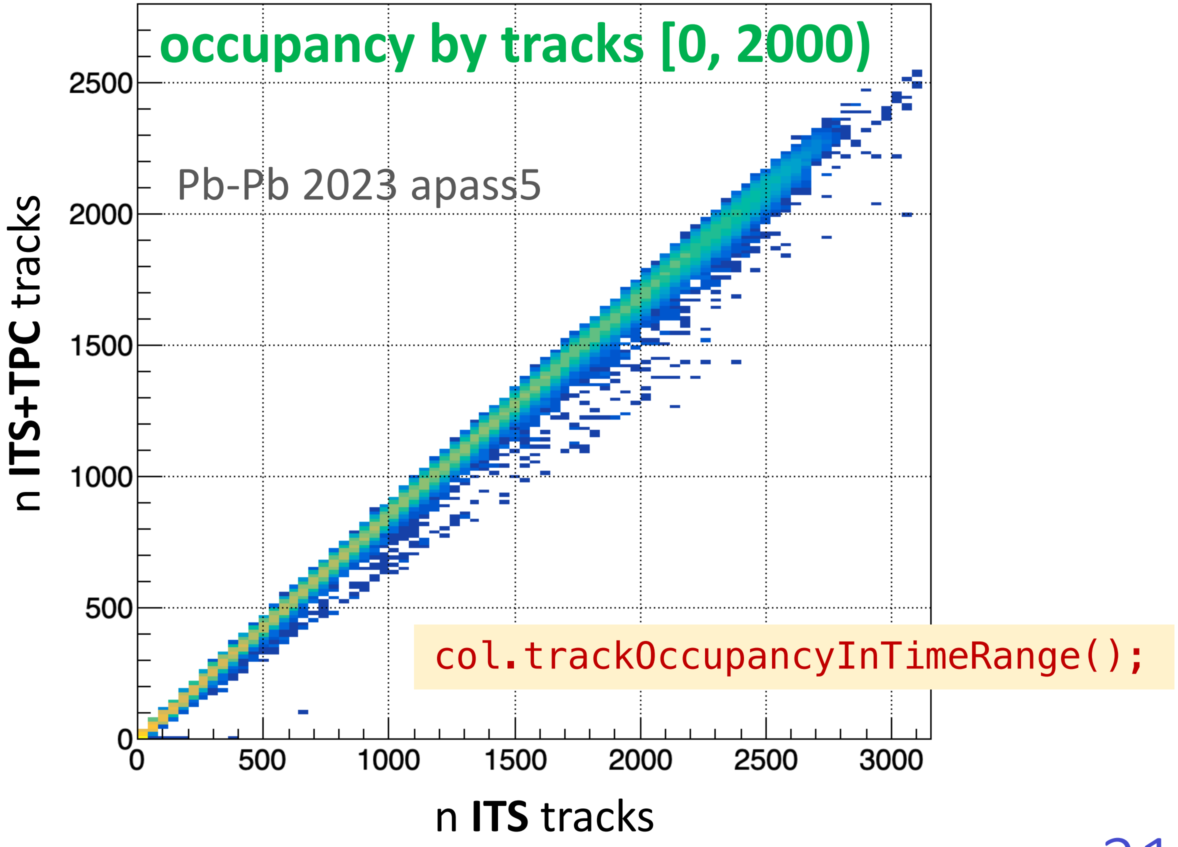




Event selection: Occupancy selection bits

In addition to the occupancy **estimators**, several special **event selection bits** were implemented to better clean up various nearby effects, summarized in the Table:

	Bit	Definition	Strictness	Typical Effect / Event Loss
TPC / TRD / TOF	`kNoCollInTimeRangeNarrow`	Rejects events if another collision within **±0.25 μs**	Narrow veto	Useful to suppress residual BC mis-associations; minimal event loss, ~1-1.5%
	`kNoCollInTimeRangeStandard`	Rejects if: (1) another coll. within ±0.25 μs, or (2) multiplicity of a coll. in dt −4...+2 μs > threshold	Medium	Further suppression of effects from nearby collisions; ~3-7% event loss depending on IR
	`kNoCollInTimeRangeStrict`	Rejects events if another collision is within **±10 μs**	Very strict	Strongly reduces effects from nearby events; large loss of statistics at high IR (can exceed 30–40%)
ITS / MFT ROFs	`kNoCollInRofStrict`	Rejects events if >1 collision in the same **ITS Readout Frame** (~15 μs in Pb-Pb)	Very strict	Removes in-ROF pileup; at 38 kHz Pb–Pb cuts ~35% of events
	`kNoCollInRofStandard`	Allows >1 collision per ROF but rejects if another has multiplicity > threshold (default: FT0C amplitude >5000 a.u. ≈ 500 tracks)	Medium	Retains more stats, but protects against large in-ROF pileup
	`kNoHighMultCollInPrevRof`	Vetoes event if **previous ROF** has high multiplicity (FT0C >5000 a.u.); only for cross-ROF ITS reco	Medium	Removes cases where previous ROF "steals" clusters; few % loss, but improves ITS tracking quality

documentation

Can be checked as:

```
if (col.selection_bit(o2::aod::evsel::kNoCollInTimeRangeStandard)) { /* do analysis */ }
```

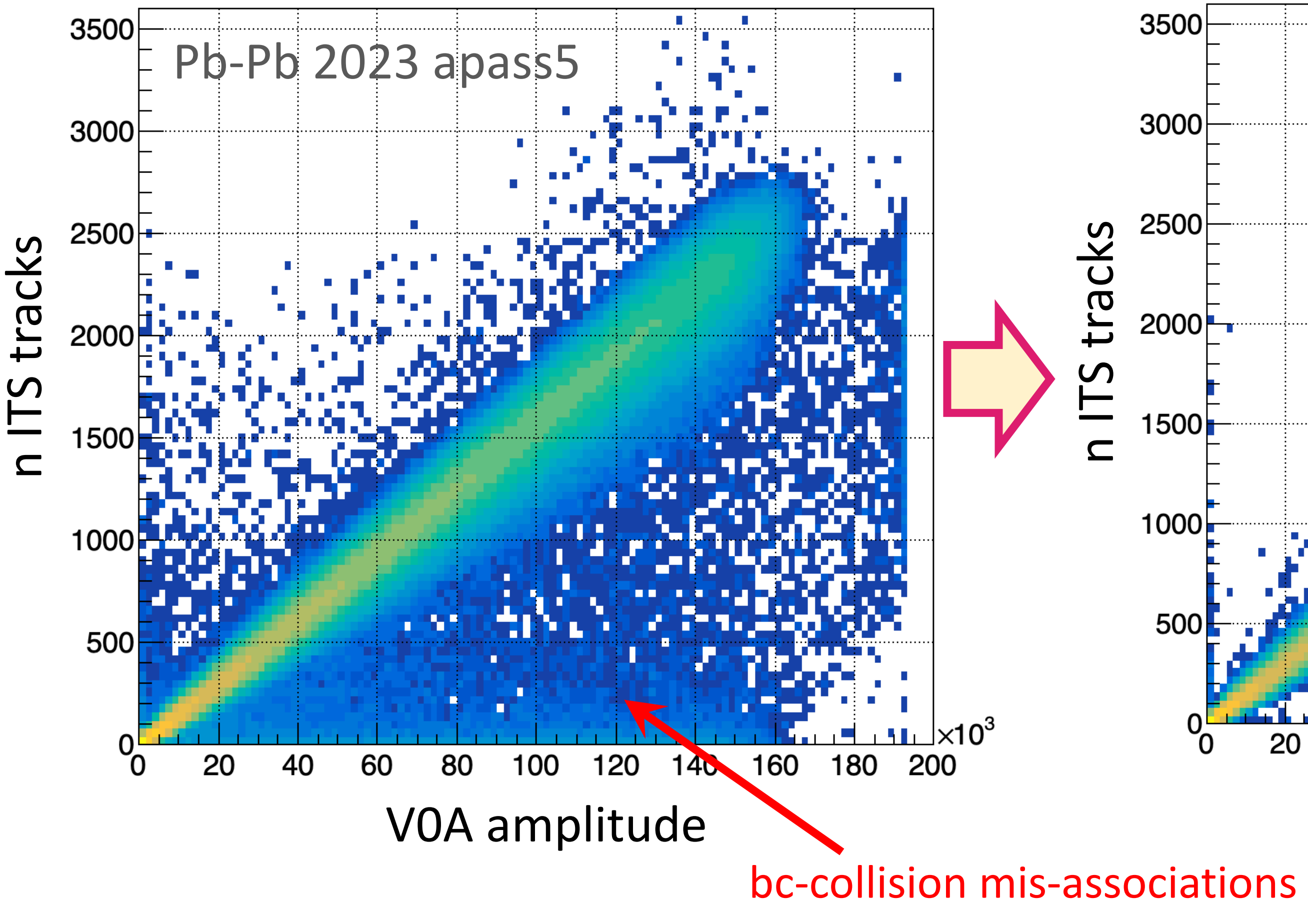
(and similar for other ev.sel. bits)

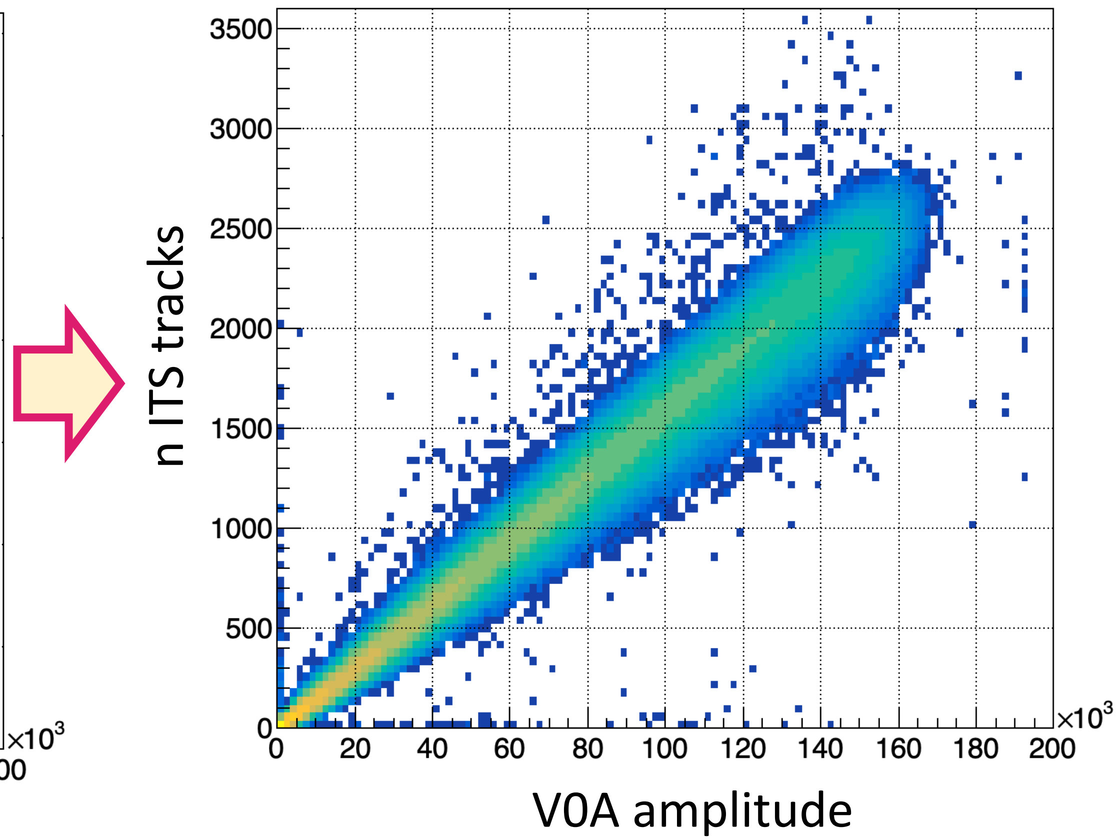
Event selection: Occupancy selection bits

Example:

cleanup of nTracks vs V0A histograms with `kNoCollInTimeRangeStandard`:

(rejects events if (1) another coll. within ±0.25 μs, or (2) multiplicity of a coll. in delta time −4…+2 μs > threshold)





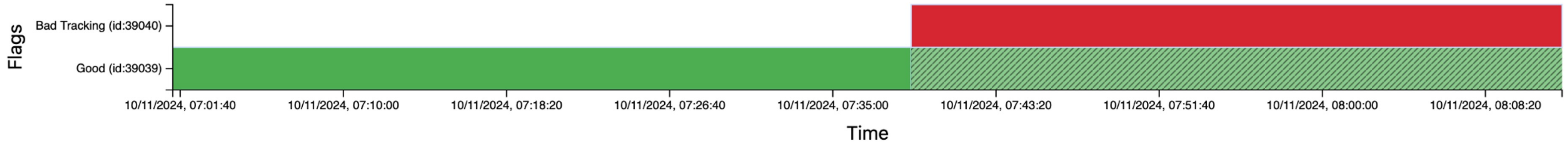
Event selection based on Time-dependent RCT Flags

- Recover events from runs that are only partly GOOD
- Flags stored as CCDB objects upon creation of Run lists and Datasets
- Tutorial shared in several PWGs and RC weekly meetings

Example:

QC › LHC24ar_apass1 › 559783 › MFT

+QC



Id	Type	From	To	Comment	Verified	Deleted	Created by	Created at	Updated at
3904	Bad Tracking	10/11/2024 07:39:00	Until run end	wrong orbit on ...	No	No	Alexian Lejeune	27/12/2024 08:22:51	14/04/2025 08:38:44
3903	Good	Whole run cover...	Whole run cover...	wrong orbit on ...	No	No	Alexian Lejeune	27/12/2024 08:22:35	14/04/2025 08:38:44

RCT Flags: from RCT to CCDB

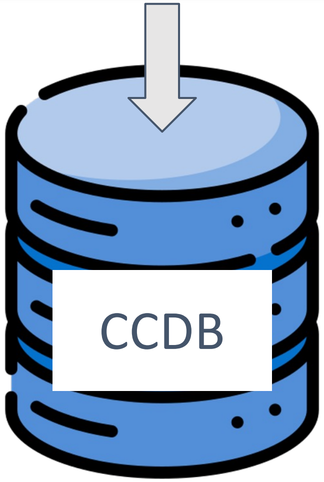
Filters | e.g. 534454, 534455... | **Physics Runs › LHC24ar_apass1** | MC.R as not-bad | Export Runs | Set QC Flags

Run	Fill No.	Start	Stop	TRG Start	TRG Stop	L3 (A)	Dipole (A)	$INEL_{avg}$ (Hz)	$INEL_{start}$ (Hz)	$INEL_{mid}$ (Hz)	$INEL_{end}$ (Hz)	GAQ	CPV	EMC	FDD	FT0	FV0	HMP	ITS	MCH	MFT	MID	PHS	TOF	TPC
559917	10356	12/11/2024 07:53:25	12/11/2024 08:07:44	12/11/2024 07:53:25	12/11/2024 08:07:44	29,999.9	6,000.02	46,427	47,832.2	46,768.6	44,845.7	100	100	100	100	100	100	100	100	100	100	100	100	100	100
559903	10355	12/11/2024 03:26:32	12/11/2024 05:04:52	12/11/2024 03:26:32	12/11/2024 05:04:52	29,999.9	5,999.93	12,328.8	14,147.3	12,294.7	8,777.18	100	100	100	100	100	100	100	100	100	100	100	100	100	100
559902	10355	12/11/2024 02:19:40	12/11/2024 03:17:32	12/11/2024 02:19:40	12/11/2024 03:17:32	29,999.9	5,999.95	16,079.5	17,857.6	16,045.7	14,665.3	40	100	100	100	100	100	100	40	100	100	100	100	100	100
559901	10355	11/11/2024 23:22:09	12/11/2024 02:12:21	11/11/2024 23:22:09	12/11/2024 02:12:21	29,999.9	6,000.11	26,280.1	38,428.6	25,345.8	17,873.9	100	100	100	100	100	100	100	100	100	100	100	100	100	100
559856	10350	11/11/2024 10:01:27	11/11/2024 12:10:19	11/11/2024 10:01:27	11/11/2024 12:10:19	29,999.9	6,000.02	36,092.5	36,872	34,833.3	18,262.4	100	100	100	100	100	100	100	100	100	100	14	100	100	100
559843	10349	11/11/2024 06:20:21	11/11/2024 06:55:14	11/11/2024 06:20:21	11/11/2024 06:55:14	29,999.9	5,999.95	41,505.2	47,468.4	43,752.3	0.001	100	100	100	100	100	100	100	100	100	100	100	100	100	100

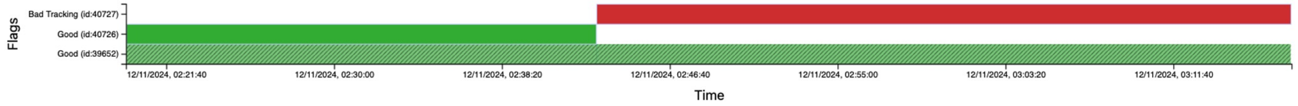
RCT CCDB Object

ITS **Good** from … to …

ITS **Bad Tracking** from … to …



QC › LHC24ar_apass1 › 559902 › ITS +QC



Id	Type	From	To	Comment	Verified	Created by	Created at	Updated at
40727	Bad Tracking	12/11/2024 02:43:01	12/11/2024 03:17:29	L0_00-05 staves (00-...	No	Alessandro Sturniolo	15/01/2025 16:37:35	28/01/2025 12:14:56
40726	Good	12/11/2024 02:19:40	12/11/2024 02:43:00		No	Alessandro Sturniolo	15/01/2025 16:36:57	28/01/2025 12:14:48
39652	Good	12/11/2024 02:19:40	12/11/2024 03:17:29		No	Alessandro Sturniolo	07/01/2025 13:03:40	28/01/2025 12:14:56

Represented as a vector of 32-bit masks, each bit corresponding to one detector flag

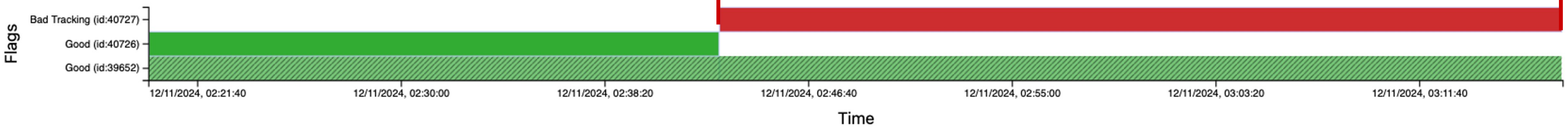
Sub-run granularity of RCT flags

- The DataSets contain all runs for which **at least part of the data is Good or "Limited Acceptance MC Reproducible"**

This part must be skipped in the analysis…

QC › LHC24ar_apass1 › 559902 › ITS

+ QC



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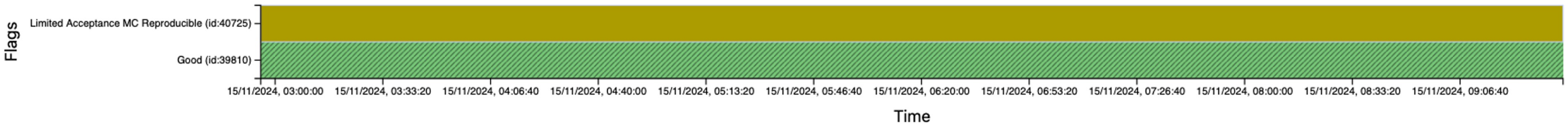
39652	Good	12/11/2024 02:19:40	12/11/2024 03:17:29		No	Alessandro Sturniolo	07/01/2025 13:03:40	28/01/2025 12:14:56

Sub-run granularity of RCT flags

- The DataSets contain all runs for which **at least part of the data is Good or "Limited Acceptance MC Reproducible"**

QC › LHC24ar_apass1 › 560012 › ITS

+ QC



Id	Type	From	To	Comment	Verified	Created by	Created at	Updated at
40725	Limited Acceptance M	15/11/2024 02:55:30	15/11/2024 09:38:32	L5_18 stave went off	No	Alessandro Sturniolo	15/01/2025 16:35:20	15/01/2025 16:35:20
39810	Good	15/11/2024 02:55:30	15/11/2024 09:38:32		No	Alessandro Sturniolo	09/01/2025 16:41:07	09/01/2025 16:41:07

The "Limited Acceptance MC Reproducible" data are also included in the analysis, since the issues are expected to be reproduced in the MC

RCT Flags → to DataSets

- The official DPG DataSets are based on the detector quality flags set in the RCT
- DataSets contain all the runs in which the relevant detectors are good for at least part of the time
- The DataSets include:
  - **Central Barrel Tracking (CBT)**: requiring FT0, ITS, TPC each with quality status Good or Limited Acceptance MC Reproducible
  - **CBT_hadronPID**: FT0, ITS, TPC, TOF each with quality status Good or Limited Acceptance MC Reproducible
  - **CBT_electronPID**: FT0, ITS, TPC TOF, TRD each with quality status Good or Limited Acceptance MC Reproducible
  - **CBT_calo**: FT0, ITS, TPC, EMC each with quality status Good or Limited Acceptance MC Reproducible
  - **CBT_muon**: FT0, ITS, MCH, MID with quality status Good or Limited Acceptance MC Reproducible, TPC Good or Limited Acceptance MC Reproducible or BadPID
  - **CBT_muon_global**: FT0, ITS, MCH, MID, MFT with quality status Good or Limited Acceptance MC Reproducible, TPC Good or Limited Acceptance MC Reproducible or BadPID
- The DataSets provide a granularity of a full run, but in the analysis we can **discard all the collisions where given detectors were Bad** → next slide

Event selection based on RCT Flags: Full Example

- Putting all things together:

```
#include "Framework/runDataProcessing.h"
#include "Framework/AnalysisTask.h"
#include "Common/DataModel/EventSelection.h"

using namespace o2;
using namespace o2::framework;

using namespace o2::aod::rctsel;

struct myExampleTask {
  // initialization with runlist label
  RCTFlagsChecker myChecker{ "CBT_hadronPID" };

  void init(InitContext const&)
  {
    // override initialization with the init() method
    myChecker.init("CBT_hadronPID", true);
  }

  void process(soa::Join<o2::aod::Collisions, o2::aod::EvSels>::iterator const& collision)
  {
    // perform the check on the current collision
    if (myChecker(*collision)) {
      // process this collsion
    }
  }
};
```

RCTSelectionFlags.h is already included in EventSelection.h

Example for *individual* RCT flags:

```
using namespace o2::aod::rctsel;
// ...
col.rct_bit(kITSBad)
// example in O2Physics
```

```
// basically, checks the col.rct_bit(...) for each of the detectors
```

```
// works properly also for anchored MC!
```

Event selection: general recommendations

Apply by default:

- $|v_z|<10$ cm
- col.sel8() = kIsTriggerTVX & kNoTimeFrameBorder & kNoITSROFrameBorder

Check stability of your results using additional selections:

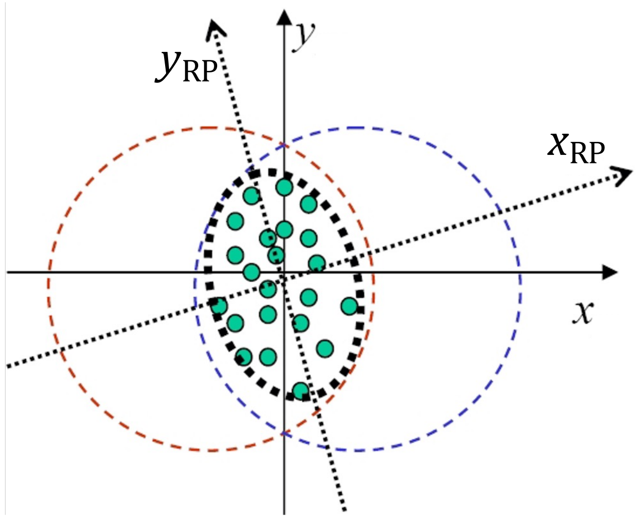
Event Selection documentation

- kNoSameBunchPileup: rejects collisions if more than one reconstructed interaction is associated to the same bunch crossing
- Dependence on TPC **occupancy** (for Pb-Pb analysis):
  - check occupancy bins, e.g. [0,500), [500, 1000), [1000-2000), … (e.g. by track-based estimator)
  - additionally, try cleanup bits kNoCollInTimeRangeNarrow and kNoCollInTimeRangeStandard
- Use time-dependent RCT flags/DataSets to see if some part of data should be excluded from your analysis
- Try rejection of time intervals with dead zones in ITS using kIsGoodITSLayersAll *or* kIsGoodITSLayer0123
- If statistics allows, **check results run-by-run**; compare results from runs taken at **different IRs**

Choice of cuts depends on the type of analysis *and* on quality of reconstruction.

Event plane (Q-vector) framework

Thu: PWG-CF Tutorial: Flow and Event Plane



- **Event Flow Vector "Q_n"** and **Event Plane Angle ψ_n** from the n^{th} harmonics are defined as:

$$Q_{n,x} = \sum_i \omega_i \cos(n\varphi_i) \quad Q_{n,y} = \sum_i \omega_i \sin(n\varphi_i)$$

$$\Psi_n = (1/n) \arctan\left(Q_{n,y}/Q_{n,x}\right)$$

where ω_i is weights and ϕ_i is particle's azimuthal angle

How do we determine EP (Q-vector) in Run 3?

- Use FV0A, FT0A, FT0C, TPCneg, TPCpos, TPCall detectors
- 1st step correction: Gain equalization
- 2nd step correction: Recentering, twisting, rescaling

Provided by DPG-AOT/Event group

How do we handle EP (Q-vector) in Run 3?

- Code: `Common/TableProducer/qVectorsTable.cxx`
- Workflow: `o2-analysis-qvector-table`
- Available in **Core Service Wagons**

Multiplicity/Centrality

calibrations are provided centrally by DPG-AOT/Events-group via central ALICE CCDB

Code: `Common/TableProducer/multiplicityTable.cxx`
`Common/TableProducer/centralityTable.cxx`

HY service wagons:
multCentTable
multCentTableMC

- Add the `o2-analysis-multcenttable` workflow
- If you need the **multiplicity**
  - subscribe to MultiplicityTable → it is possible to subscribe to a table with all estimators
  - as an example

```
using CollisionCandidates = soa::Join<aod::Collisions, aod::EvSels,
aod::FT0MultZeqs, aod::MultZeqs>;

const float multiplicity = collision.multFT0C();
```

multiplicity equalized for the vertex position with the FT0 detector

multiplicity equalized for all estimators

- If you need the **centrality**
  - subscribe to CentralityTable → need to specify the estimators in the table subscription
  - as an example

```
using CollisionCandidates = soa::Join<aod::Collisions, aod::EvSels,
aod::CentFV0As, aod::CentFT0Ms, aod::CentFT0As, aod::CentFT0Cs>;

const float centrality = collision.centFT0M();
```

DPG/AOT-Tracks

Track selection

!!! See detailed presentation in HF session on Wed:

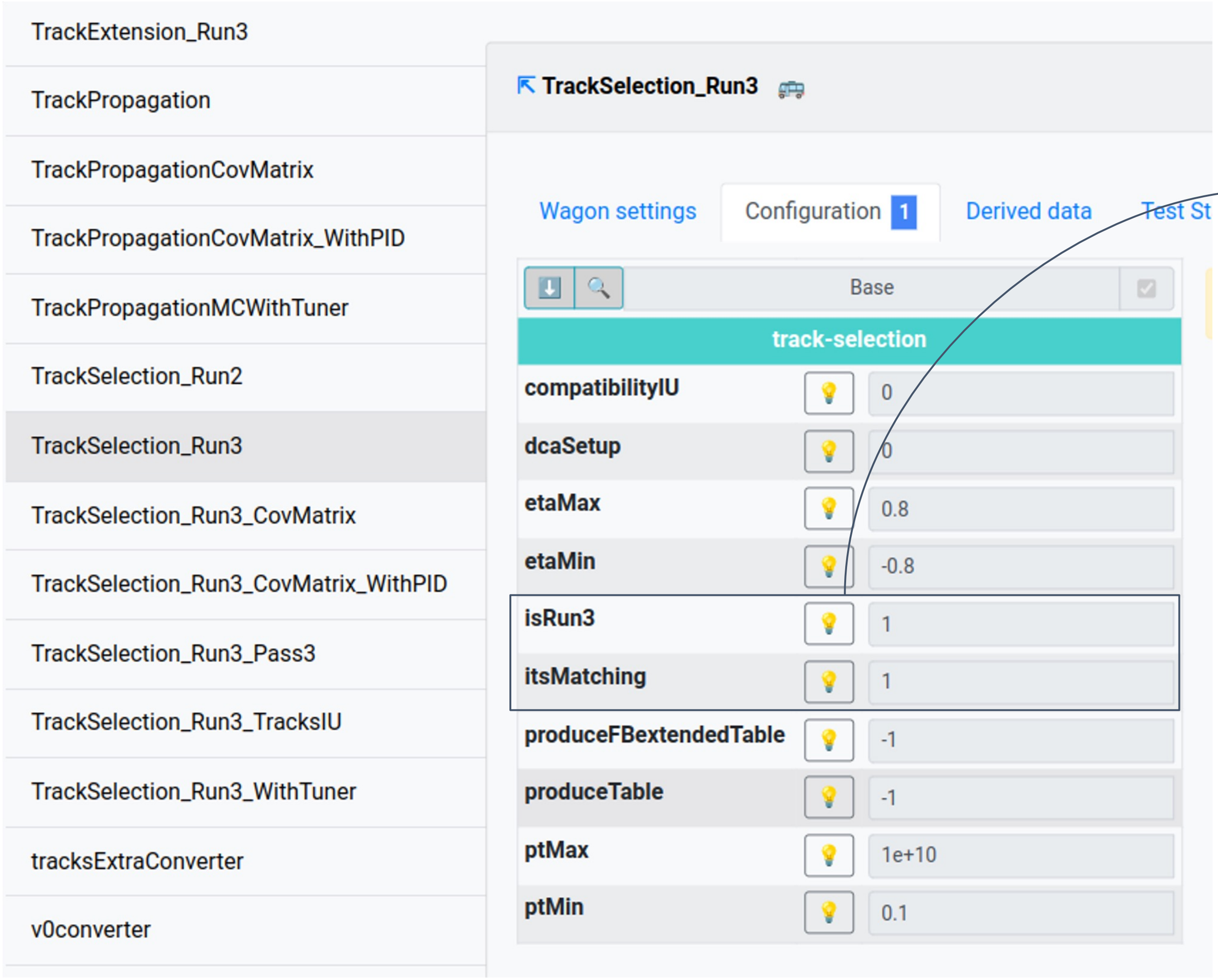
09:00 **Introduction to the HF O2 framework and general information**

Speaker: Mattia Faggin (CERN)

Code: [Common/TableProducer/trackSelection.cxx]

📚 Documentation [here]

[Core Service Wagons/TrackSelection_Run3]



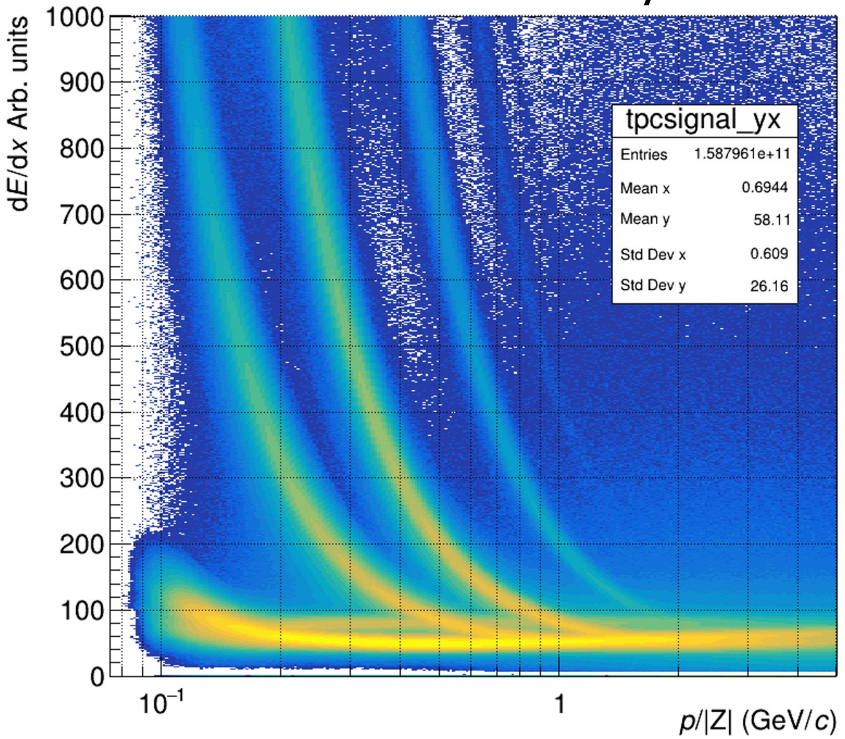
[Common/TableProducer/trackselection.cxx#L85-L91]

```
case 1:
      // Run 3 kAny on 3 IB layers of ITS
      if (isRun3) {
        [...]
        globalTracks =
getGlobalTrackSelectionRun3ITSMatch(TrackSelection::GlobalTrackRun3ITSMatching::Run3ITSibAny,
dcaSetup.value);
        break;
      }
```

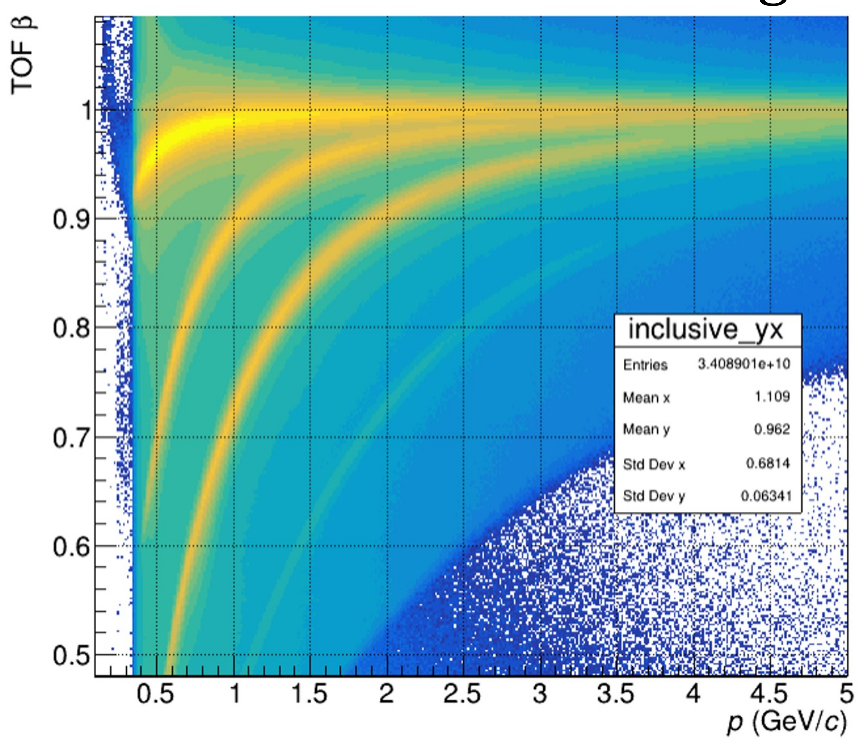
- By default, global track selections defined in [Common/Core/TrackSelectionDefaults.cxx#L27-L45] are enabled (see the documentation for ITS matching)
- Possibility to enable <u>subsets</u> of such cuts via “masks”
- Example of application in [DPG/Tasks/AOTTrack/qaEventTrack.cxx#L134-L141]

Extra - Particle identification (PID) in TPC and TOF

PID in TPC via dE/dx



PID in TOF via time-of-flight



- Different particle species have separate distributions of dE/dx (TPC) and time-of-flight (TOF)
- In analysis: n_σ values are used

TPC

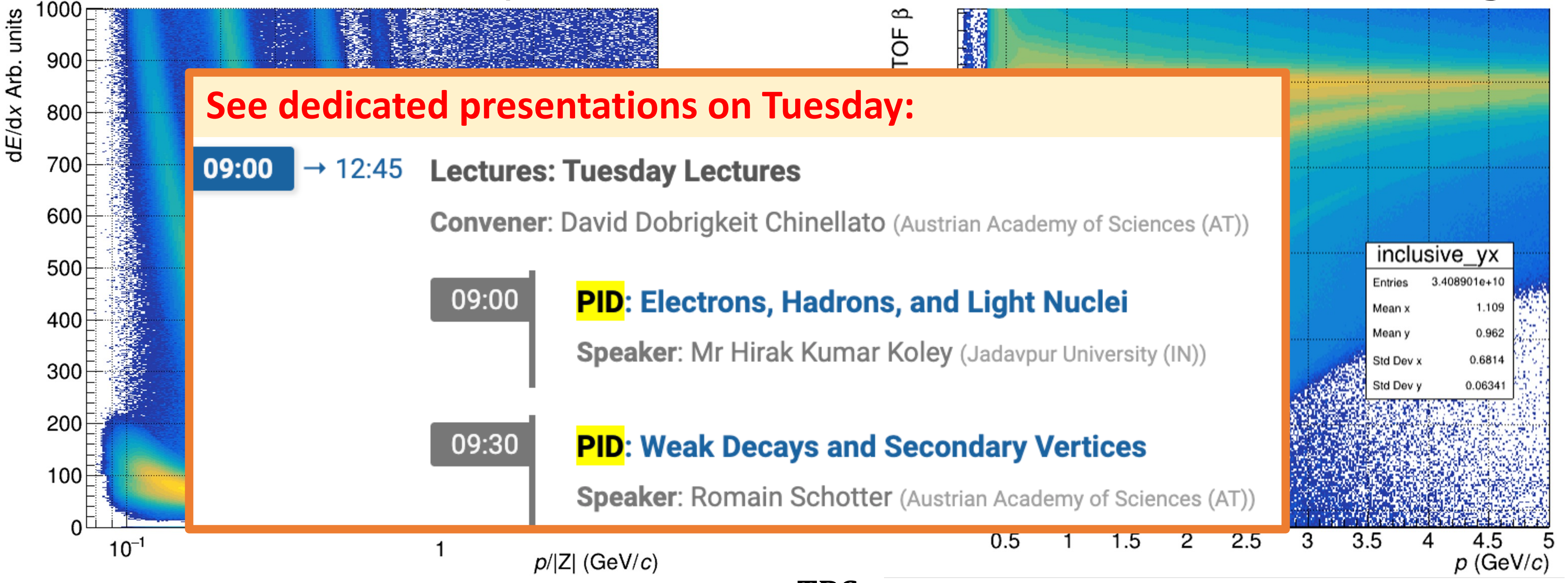
- Calibrations provided via Bethe-Block (BB) parametrizations and via Neural Network (use "NN" when available, list here)
- In MC the dE/dx observed in data is reproduced by random-sampling the dE/dx parametrizations from data → *"tune-on-data"*
  - n_σ centered at 0 and with σ=1

Tools/parameterizations provided by TPC, TOF experts (not by DPG)

Extra - Particle identification (PID) in TPC and TOF

PID in TPC via dE/dx

PID in TOF via time-of-flight



- Different particle species have separate distributions of dE/dx (TPC) and time-of-flight (TOF)
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  - n_σ centered at 0 and with σ=1

Useful links

Join DPG AOT meetings (Thu, 9.30)
report your findings/problems/ideas

- Review on Event selection in Run2:
  https://indico.cern.ch/event/760954/contributions/3172100/
- Documentation in O2 on Event and Track Selection :
  aliceo2group.github.io/analysis-framework/docs/analysis-tools/
- Event selection tables:
  O2Physics/Common/DataModel/EventSelection.h
- Trigger aliases:
  O2Physics/Common/CCDB/TriggerAliases.h
- Event selection criteria:
  O2Physics/Common/CCDB/EventSelectionParams.h
- Event selection parameters:
  O2Physics/Common/CCDB/EventSelectionParams.cxx
  O2Physics/Common/CCDB/macros/upload_event_selection_params.C
- Luminosity normalization tools:
  https://indico.cern.ch/event/1305271/#10-tools-for-luminosity-monito
- Event selection QA repository:
  https://evsel-qa.web.cern.ch/

The end

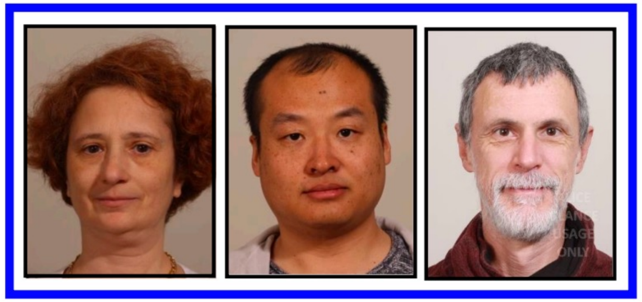
Contacts

- alice-dpg-aot-event-props@cern.ch → subscribe!
- alice-dpg-aot-track-props@cern.ch → subscribe!
- jouri.belikov@cern.ch, felix.schlepper@cern.ch, luca.barioglio@cern.ch, andrea.ferrero@cern.ch, igor.altsybeev@cern.ch, stefano.trogolo@cern.ch

Mesut Michal

Data & MC Productions

Elena Jian Andrea



Async Quality Control

Luca Jouri Felix

AOT-Tracks

Igor Stefano

AOT-Events

Thank you for your attention!

Backup

Event selection criteria

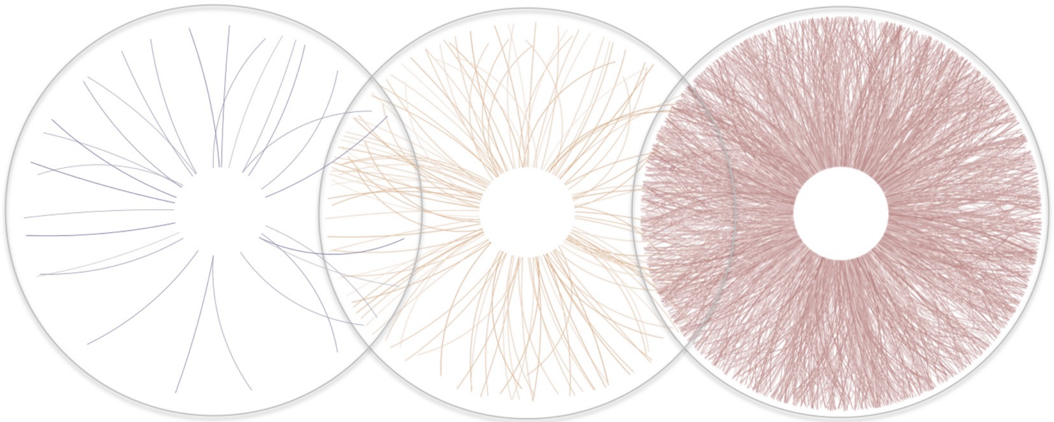
Full list of event selection criteria can be found in `Common/CCDB/EventSelectionParams.h`

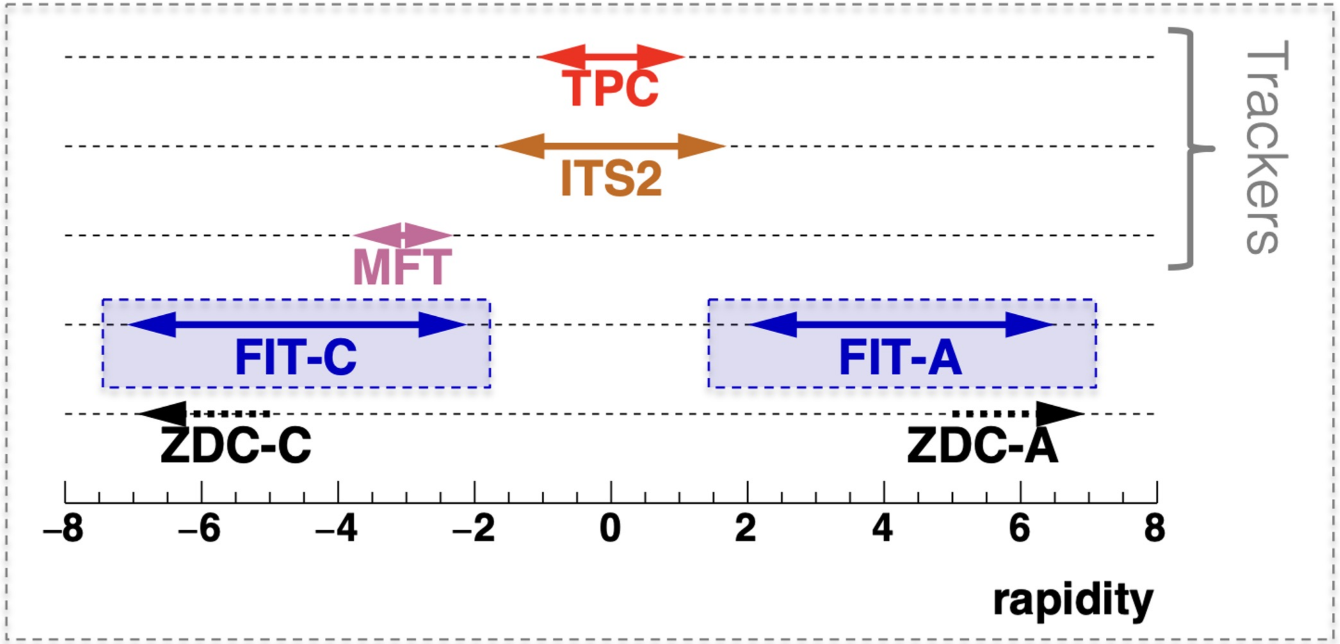
```
enum EventSelectionFlags {
  kIsBBV0A = 0,              // cell-averaged time in V0A in beam-beam window
  kIsBBV0C,                  // cell-averaged time in V0C in beam-beam window (for Run 2 only)
  kIsBBFDA,                  // cell-averaged time in FDA (or AD in Run2) in beam-beam window
  kIsBBFDC,                  // cell-averaged time in FDC (or AD in Run2) in beam-beam window
  kIsBBT0A,                  // cell-averaged time in T0A in beam-beam window
  kIsBBT0C,                  // cell-averaged time in T0C in beam-beam window
  kNoBGV0A,                  // cell-averaged time in V0A in beam-gas window
  kNoBGV0C,                  // cell-averaged time in V0C in beam-gas window (for Run 2 only)
  kNoBGFDA,                  // cell-averaged time in FDA (AD in Run2) in beam-gas window
  kNoBGFDC,                  // cell-averaged time in FDC (AD in Run2) in beam-gas window
  kNoBGT0A,                  // cell-averaged time in T0A in beam-gas window
  kNoBGT0C,                  // cell-averaged time in T0C in beam-gas window
  kIsBBZNA,                  // time in common ZNA channel in beam-beam window
  kIsBBZNC,                  // time in common ZNC channel in beam-beam window
  kIsBBZAC,                  // time in ZNA and ZNC in beam-beam window - circular cut in ZNA-ZNC plane
  kNoBGZNA,                  // time in common ZNA channel is outside of beam-gas window
  kNoBGZNC,                  // time in common ZNC channel is outside of beam-gas window
  kNoV0MOnVsOfPileup,        // no out-of-bunch pileup according to online-vs-offline VOM correlation
  kNoSPDOnVsOfPileup,        // no out-of-bunch pileup according to online-vs-offline SPD correlation
  kNoV0Casymmetry,           // no beam-gas according to correlation of V0C multiplicities in V0C3 and V0C012
  kIsGoodTimeRange,          // good time range
  kNoIncompleteDAQ,          // complete event according to DAQ flags
  kNoTPCLaserWarmUp,         // no TPC laser warm-up event (used in Run 1)
  kNoTPCHVdip,               // no TPC HV dip
  kNoPileupFromSPD,          // no pileup according to SPD vertexer
  kNoV0PFPileup,             // no out-of-bunch pileup according to V0 past-future info
  kNoSPDClsVsTklBG,          // no beam-gas according to cluster-vs-tracklet correlation
  kNoV0C012vsTklBG,          // no beam-gas according to V0C012-vs-tracklet correlation
  kNoInconsistentVtx,        // no inconsistency in SPD and Track vertices
  kNoPileupInMultBins,       // no pileup according to multiplicity-differential pileup checks
  kNoPileupMV,               // no pileup according to multi-vertexer
  kNoPileupTPC,              // no pileup in TPC
  kIsTriggerTVX,             // FT0 vertex (acceptable FT0C-FT0A time difference) at trigger level
  kIsINT1,                   // SPDGFO >= 1 || V0A || V0C
  kNoITSROFrameBorder,       // bunch crossing is far from ITS RO Frame border
  kNoTimeFrameBorder,        // bunch crossing is far from Time Frame borders
  kNoSameBunchPileup,        // reject collisions in case of pileup with another collision in the same foundBC
  kIsGoodZvtxFT0vsPV,        // small difference between z-vertex from PV and from FT0
  kIsVertexITSTPC,           // at least one ITS-TPC track (reject vertices built from ITS-only tracks)
  kIsVertexTOFmatched,       // at least one of vertex contributors is matched to TOF
  kIsVertexTRDmatched,       // at least one of vertex contributors is matched to TRD
  kNoCollInTimeRangeNarrow,  // no other collisions in specified time range (narrower than Strict)
  kNoCollInTimeRangeStrict,  // no other collisions in specified time range
  kNoCollInTimeRangeStandard, // no other collisions in specified time range with per-collision multiplicity above threshold
  kNoCollInRofStrict,        // no other collisions in this Readout Frame
  kNoCollInRofStandard,      // no other collisions in this Readout Frame with per-collision multiplicity above threshold
  kNoHighMultCollInPrevRof,  // veto an event if FT0C amplitude in previous ITS ROF is above threshold
  kIsGoodITSLayer3,          // number of inactive chips on ITS layer 3 is below maximum allowed value
  kIsGoodITSLayer0123,       // numbers of inactive chips on ITS layers 0-3 are below maximum allowed values
  kIsGoodITSLayersAll,       // numbers of inactive chips on all ITS layers are below maximum allowed values
  kNsel                      // counter
}; // (as of October 2025)
```

https://aliceo2group.github.io/analysis-framework/docs/analysis-tools/EventSelection.html

Multiplicity/Centrality

- Many analyses need the **event multiplicity/centrality**:
  - Study an **observable** as a function of multiplicity/centrality
  - Other **tasks depends on multiplicity/centrality** selection (e.g. PID, Q-vector, …)

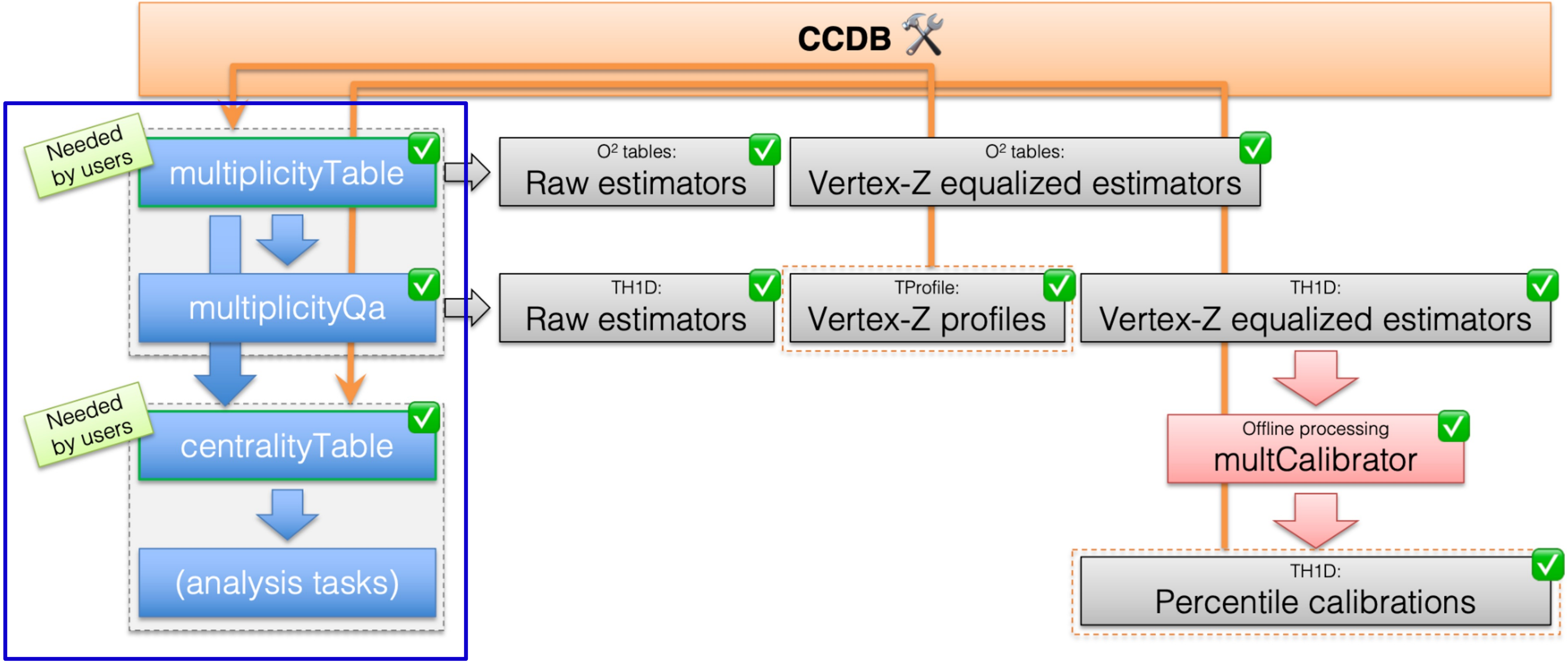




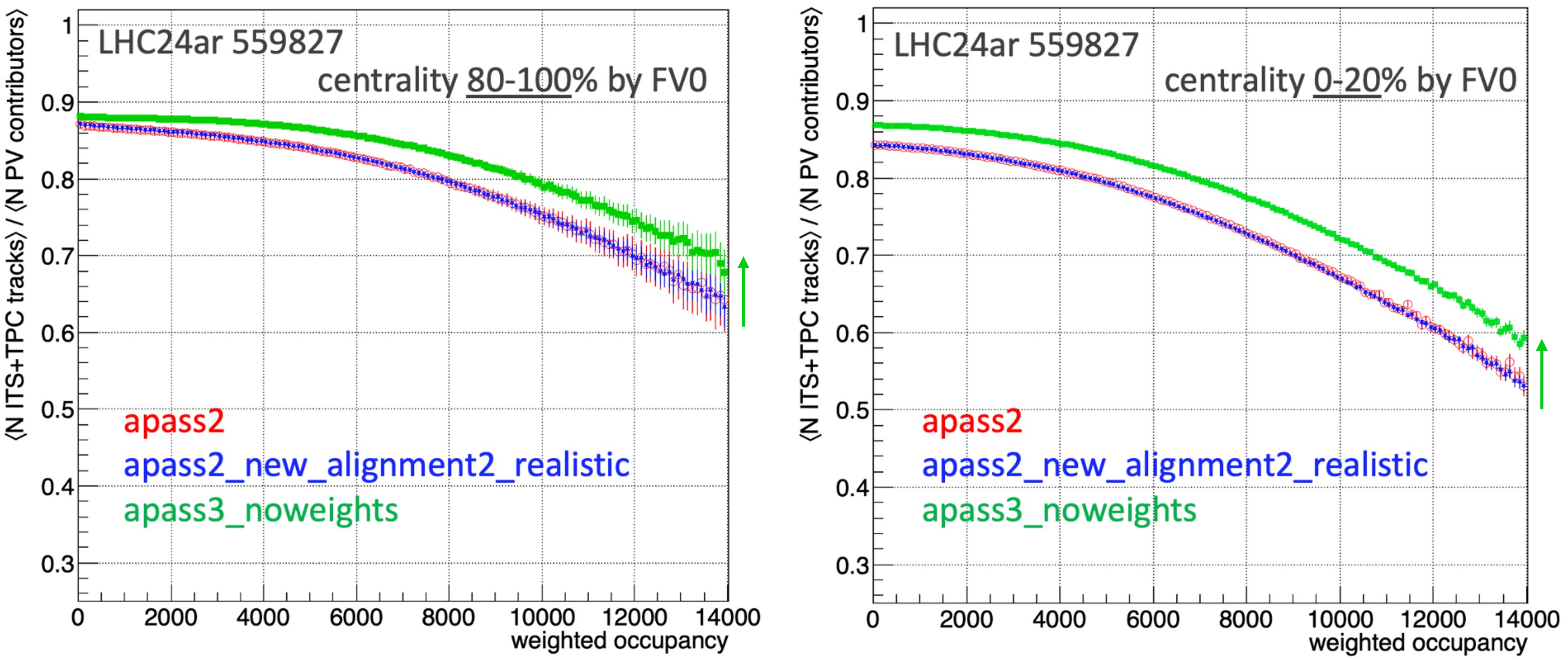
- Detectors used for multiplicity/centrality:
  - FT0: $-3.3 < \eta < -2.1$, $3.5 < \eta < 4.9$
  - FV0: $2.2 < \eta < 5.0$
  - FDD: $-6.9 < \eta < -4.9$, $4.7 < \eta < 6.3$
  - Central barrel detectors → number of tracks used to fit the primary vertex (N_PV_{tracks})

Multiplicity/Centrality

- A complex procedure to get the calibration but only a **small part is for analysers**
    - calibrations are provided centrally by DPG-AOT/Events-group via central ALICE CCDB



Occupancy selection in Pb-Pb

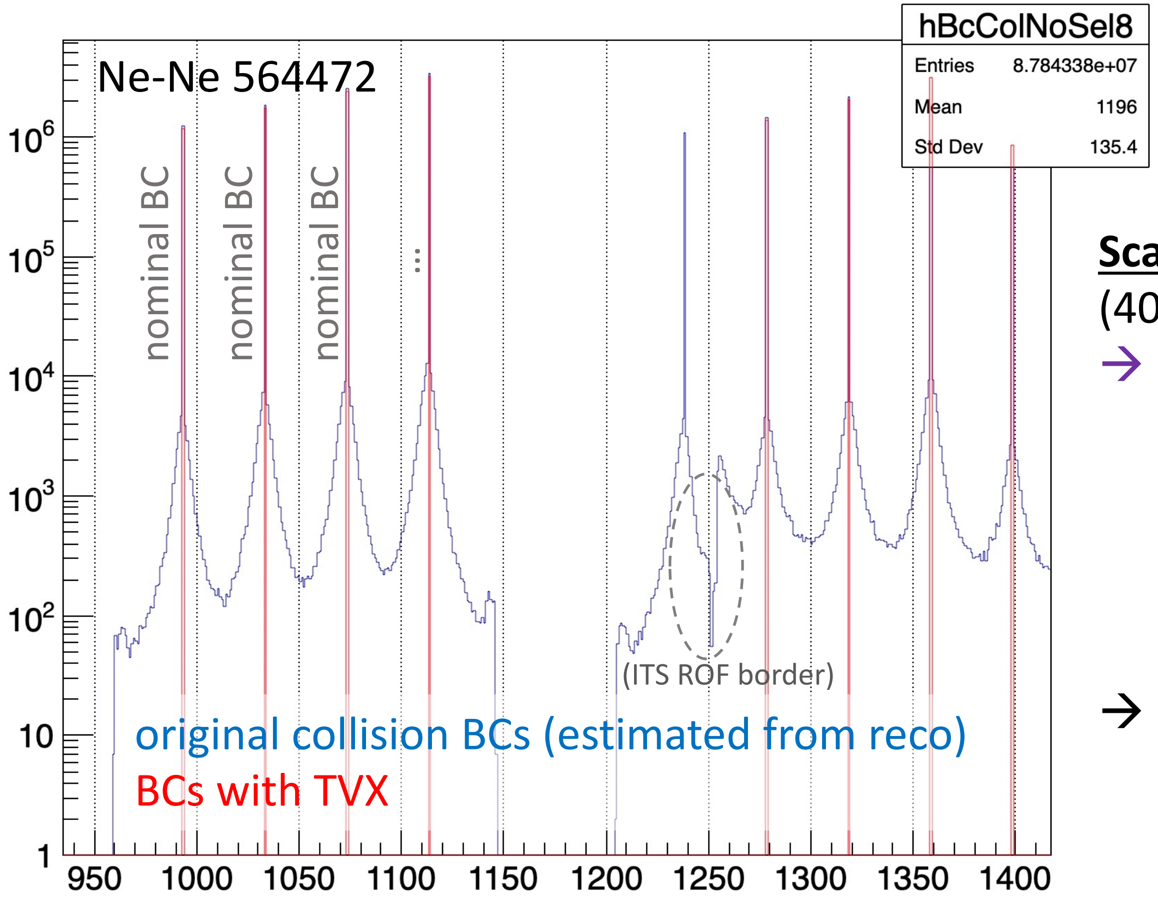


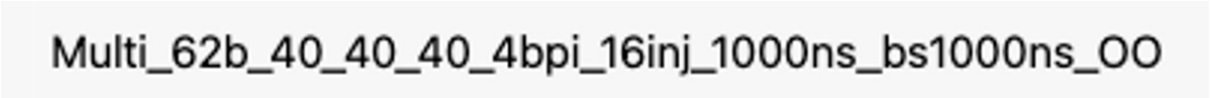
Improvements in the TPC tracking:

- fixes in shared clusters accounting, cluster rejections during refit, loopers treatment, …

→ visible improvement in Pb-Pb 24ar apass3_noweights: better (+~2%) ITS-TPC matching efficiency, flatter occupancy dependence

Alternative BC-collision matching algorithm for OO and Ne-Ne





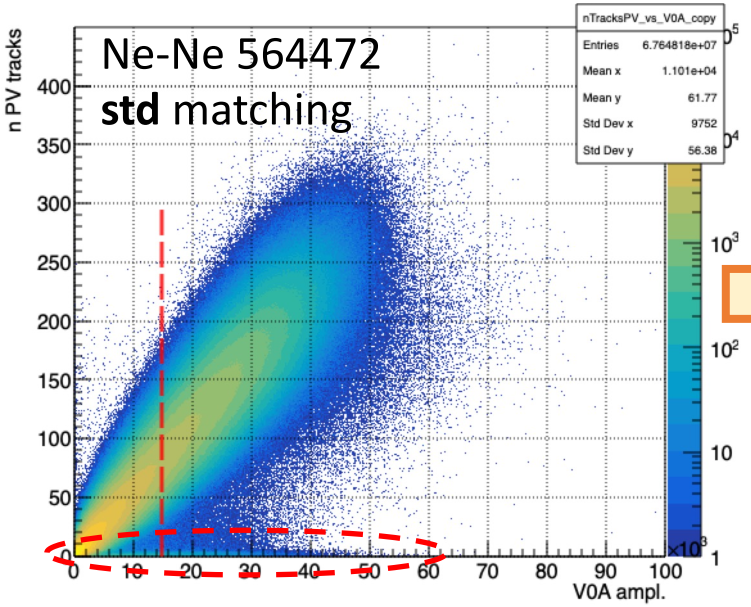
<u>Scarce</u> filling scheme in OO and Ne-Ne
(40 BC = 1 μs b/n bunch crossings)

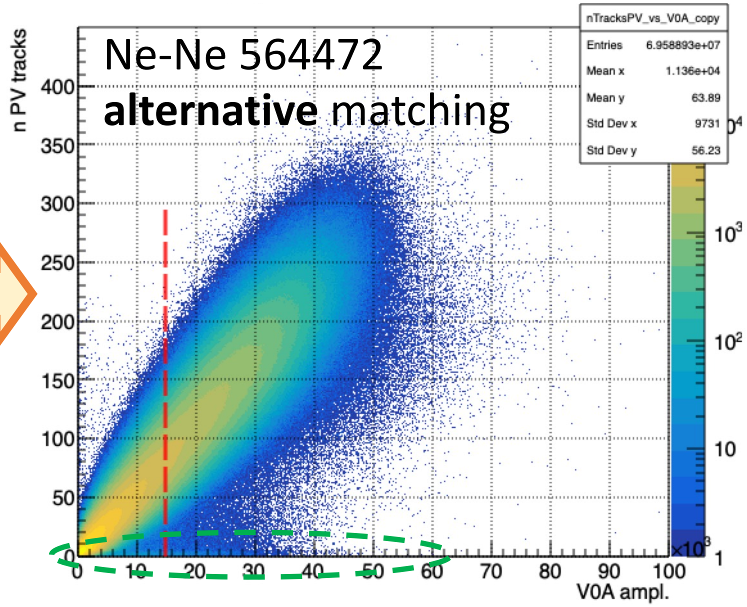
→ this allows us to re-assign collision BCs (calculated in reco) to the closest "nominal" BCs from the filling scheme, instead of trying to match with the closest TVX (as it is done in the std matching algo)
  - for vertices not matched to TOF (i.e. mainly low-mult vertices with poor time resolution), an attempt to find a nearby TVX with small coll-FT0 diff in vertex Z is made

→ a number of collisions assigned to the same "nominal BC" is checked
  → pileup can be rejected by the kNoSameBunchPileup ev. sel bit

Since mid-October 2025 – it's the default method for OO and Ne-Ne runs.

Alternative BC-collision matching algorithm for OO and Ne-Ne

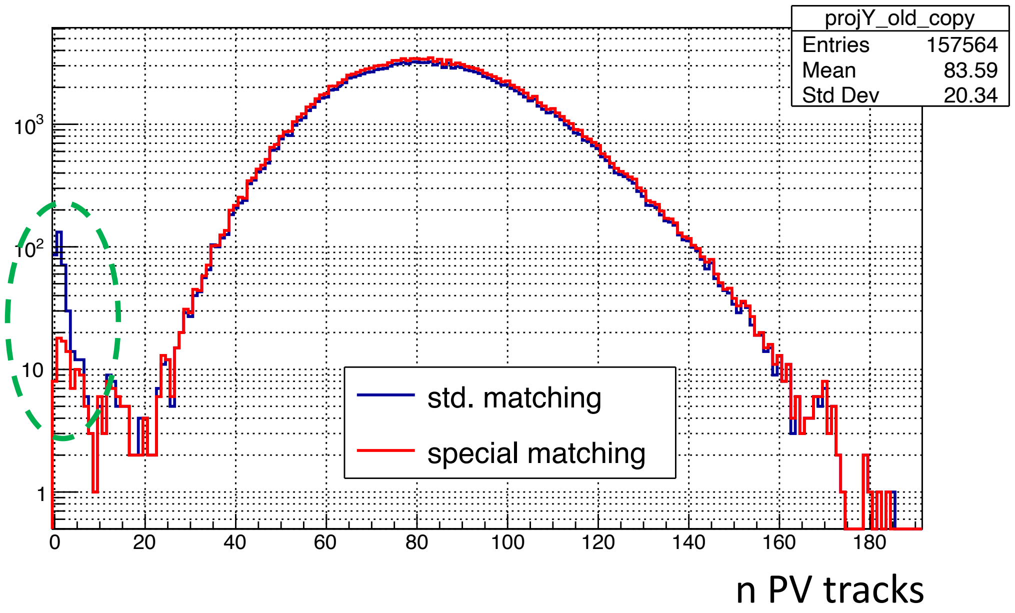




sel8 && kNoSameBunchPileup

QA with nPVtracks vs V0A histograms:
with the alternative matching, the outliers at low nTracks are suppressed by ~x5

slice at V0A 15000



- Further improvement and quantification are possible with the MC – to be done.

New columns in RCT

GMU	MUD	CEN	EVP	EVS	MTE	VTX
0	0	+QC	+QC	+QC	+QC	+QC
0	0	+QC	+QC	+QC	+QC	+QC
0	0	+QC	+QC	+QC	+QC	+QC
0	0	+QC	+QC	+QC	+QC	+QC
0	0	+QC	+QC	+QC	+QC	+QC
0MC.R	100	+QC	+QC	+QC	+QC	+QC
0MC.R	100	+QC	+QC	+QC	+QC	+QC
0MC.R	0MC.R	+QC	+QC	+QC	+QC	+QC
100	100	+QC	+QC	+QC	+QC	+QC

- Muon detectors (2 columns)
  - GMU: MFT-MCH-MID
  - MUD: MCH-MID
- AOT-Tracks (2 columns)
  - VTX: vertexing
  - MTE: ITS/TPC matching efficiency
- AOT-Events (3 columns)
  - EVS: event selection
  - EVP: event plane
  - CEN: centrality
- Started organizing the flag assignments; still need some time to verify all runs
- Runlist creation does not depend on these flags (it relies on detector flags)
- These flags will be added to the CCDB status word in addition to the existing detector bits

Example of advanced usage: occupancy effects

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stefano.trogolo@cern.ch
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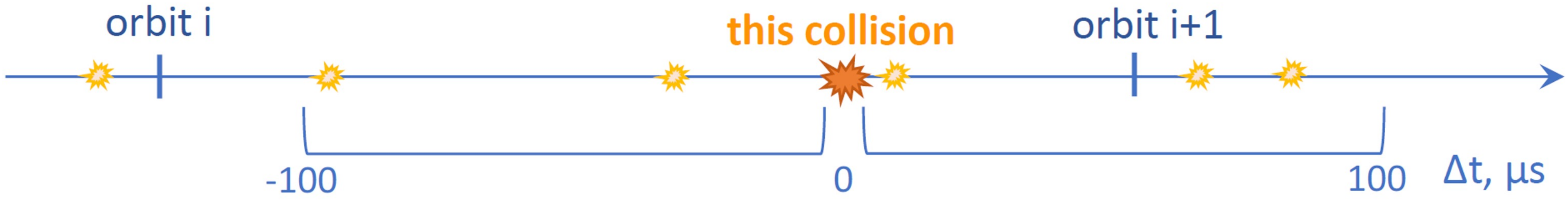
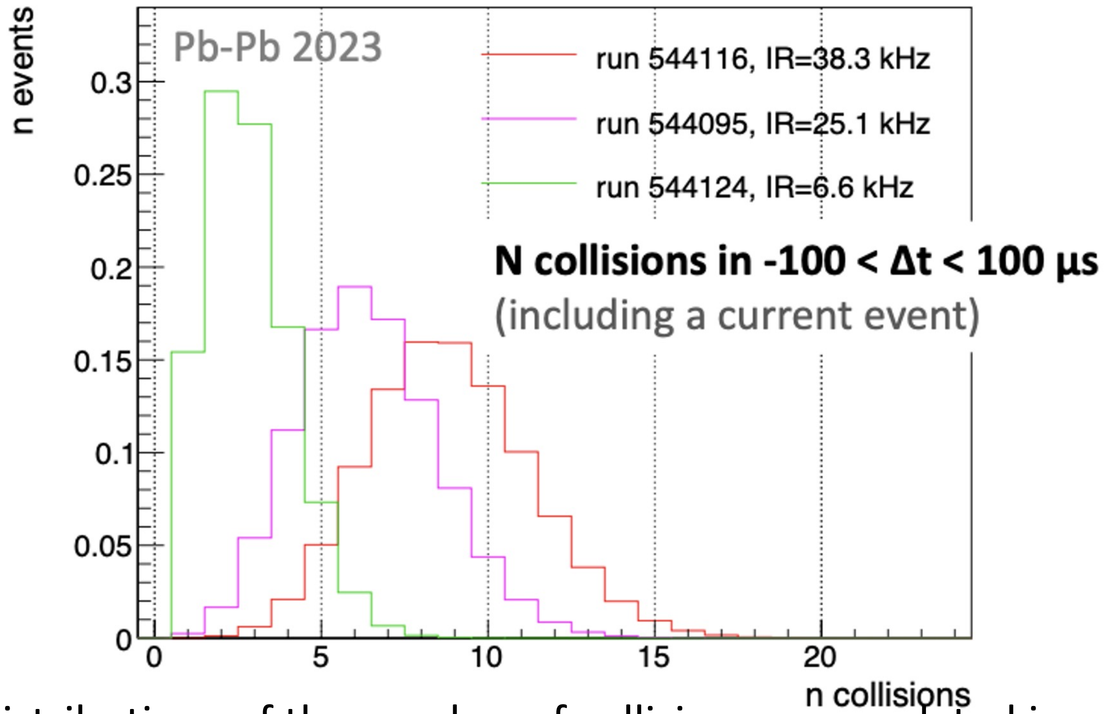
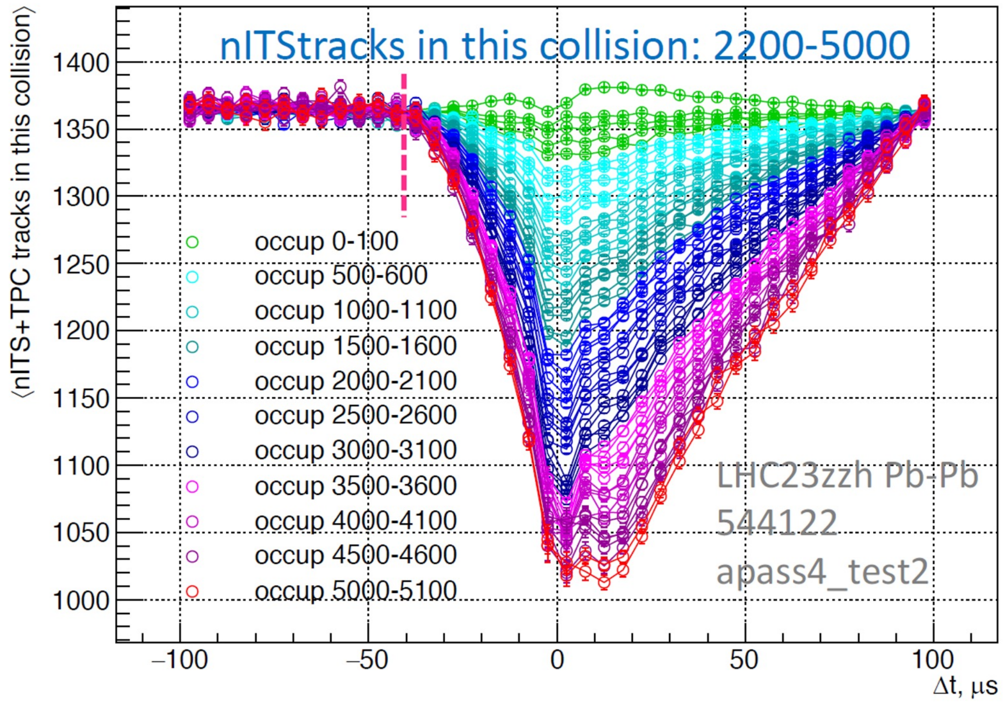




Distributions of the number of collisions accumulated in a time interval for different IRs



Using number of ITS tracks as a proxy for occupancy

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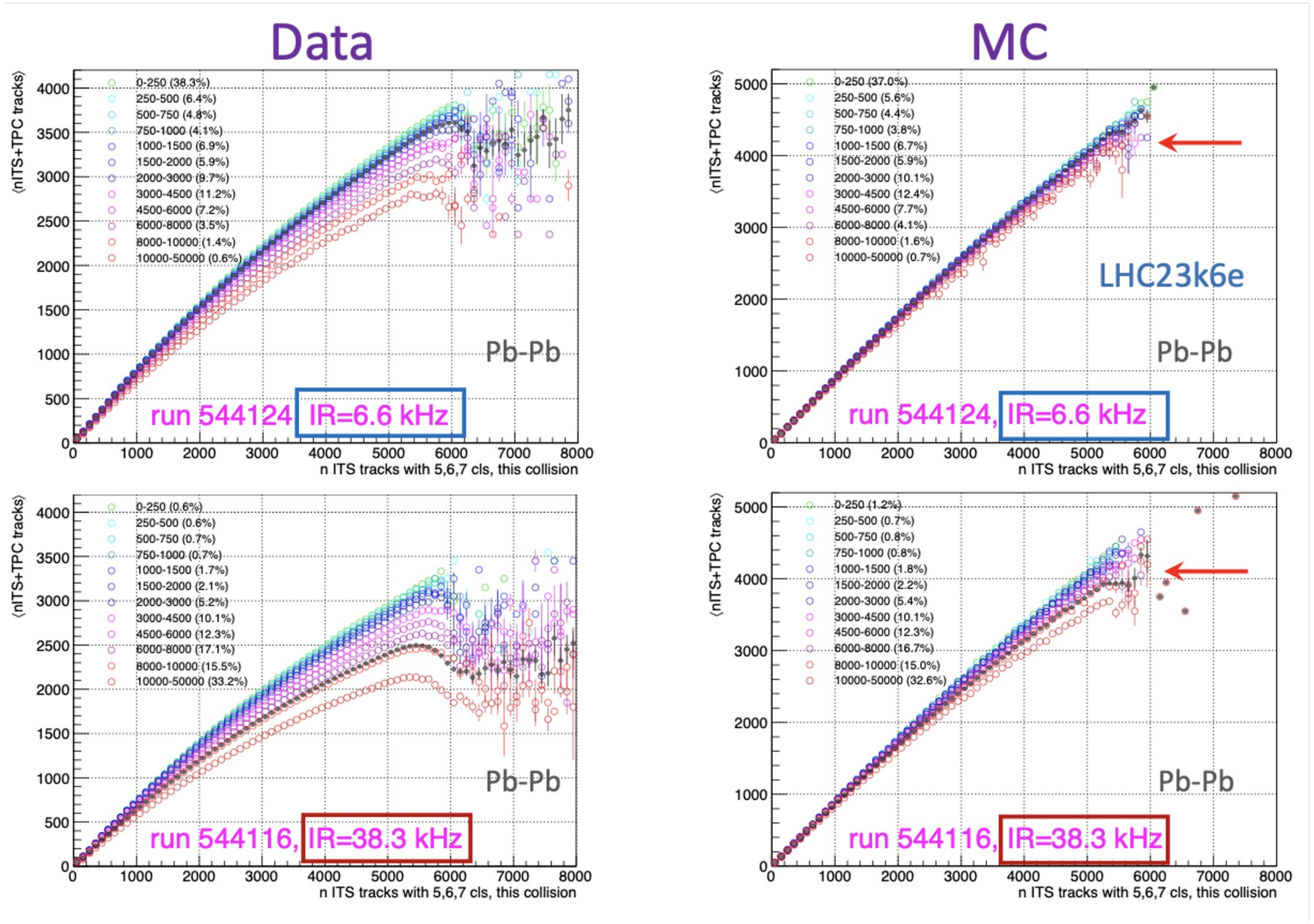
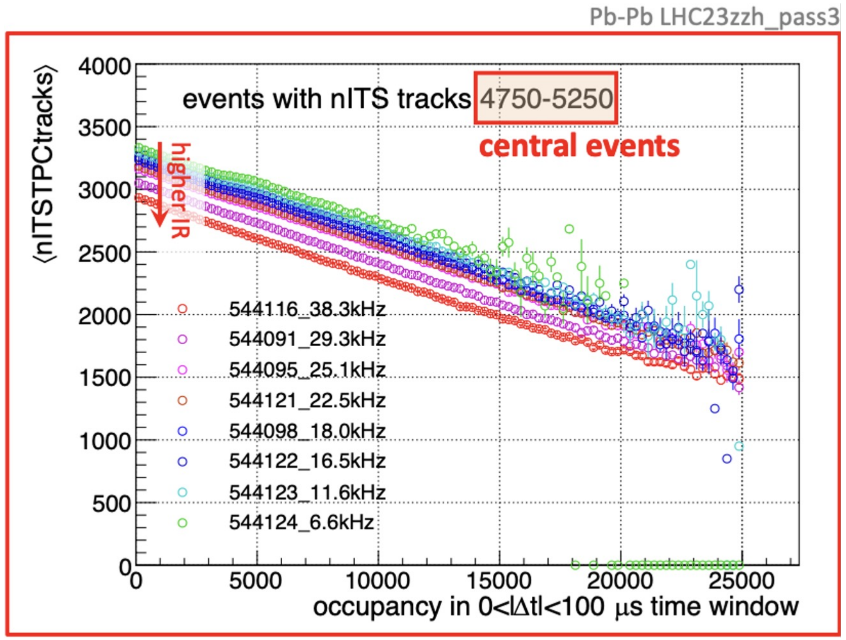


TPC-ITS matching degrades with occupancy

Currently, these occupancy effects are not well reproduced by MC



- Selection bits available to test sensitivity of your analyses to occupancy effects, e.g.:

  col.selection_bit(kNoCollInTimeRangeStandard)

- More details in Igor's talk

Trigger aliases for triggered detectors in Run 3

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ALICE

Trigger alias: association of trigger class names (defined by CTP) to bits in the alias bit array (note: strings are not supported in the O2 data model)

Aliases for pp in Run 3:

```
mAliases[kEMC7] = "CTVXEMC-B-NOPF-EMC";
mAliases[kDMC7] = "CTVXDMC-B-NOPF-EMC";
mAliases[kTVXinTRD] = "CMTVX-B-NOPF-TRD,minbias_TVX";
mAliases[kTVXinEMC] = "C0TVX-B-NOPF-EMC,minbias_TVX_L0,CMTVXTSC-B-NOPF-EMC,CMTVXTCE-B-NOPF-EMC";
mAliases[kTVXinPHOS] = "C0TVX-B-NOPF-PHSCPV,minbias_TVX_L0,CMTVXTSC-B-NOPF-PHSCPV,CMTVXTSC-B-NOPF-PHSCPV";
mAliases[kTVXinHMP] = "C0TVX-B-NOPF-HMP,minbias_TVX_L0,CMTVXTSC-B-NOPF-HMP";
mAliases[kPHOS] = "CTVXPH0-B-NOPF-PHSCPV,mb_PH0_TVX,CPH0SC-B-NOPF-PHSCPV,CPH0CE-B-NOPF-PHSCPV";
```

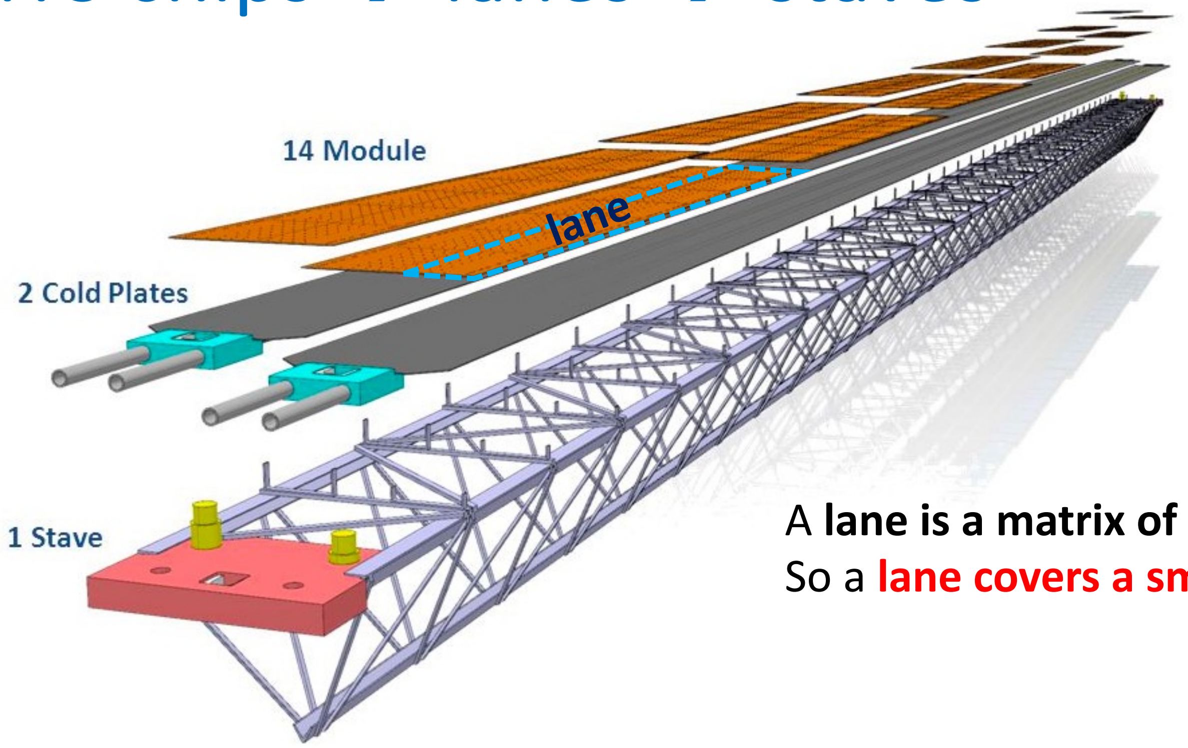
Aliases for Pb-Pb in Run 3:

```
mAliases[kTVXinTRD] = "CMTVXTSC-B-NOPF-TRD,CMTVXTCE-B-NOPF-TRD";
mAliases[kTVXinEMC] = "CMTVXTSC-B-NOPF-EMC,CMTVXTCE-B-NOPF-EMC,C0TVXTSC-B-NOPF-EMC,C0TVXTCE-B-NOPF-EMC";
mAliases[kTVXinPHOS] = "CMTVXTSC-B-NOPF-PHSCPV,CMTVXTCE-B-NOPF-PHSCPV,C0TVXTSC-B-NOPF-PHSCPV,C0TVXTCE-B-NOPF-PHSCPV";
mAliases[kTVXinHMP] = "CMTVXTSC-B-NOPF-HMP,CMTVXTCE-B-NOPF-HMP";
mAliases[kPHOS] = "CPH0SC-B-NOPF-PHSCPV,CPH0CE-B-NOPF-PHSCPV";
```

https://github.com/AliceO2Group/O2Physics/blob/master/Common/CCDB/macros/upload_trigger_aliases_run3.C

ITS chips → lanes → staves

Nicolo Valle



One Outer Barrel stave is (two halves) a matrix of
49 x 4 chips (for Layer **5 and 6**)
28 x 4 chips (for Layer **3 and 4**).

A **lane is a matrix of 7x1 chips,** read out by the same data cable.
So a **lane covers a small fraction of Eta and ~1/4 of the Phi acceptance of a stave**.

One lane dead → very short time → full stave is blind for several seconds because of the recovery

The failures almost always happen at the level of the high speed link reading out the full lane (7 chips).
It's not only the occupancy, even though at higher rate we have higher chance of failure. The root causes are many, difficult to find a single reason. To recover a single lane (7 chips), the DCS gates the trigger from the readout unit to the full stave.

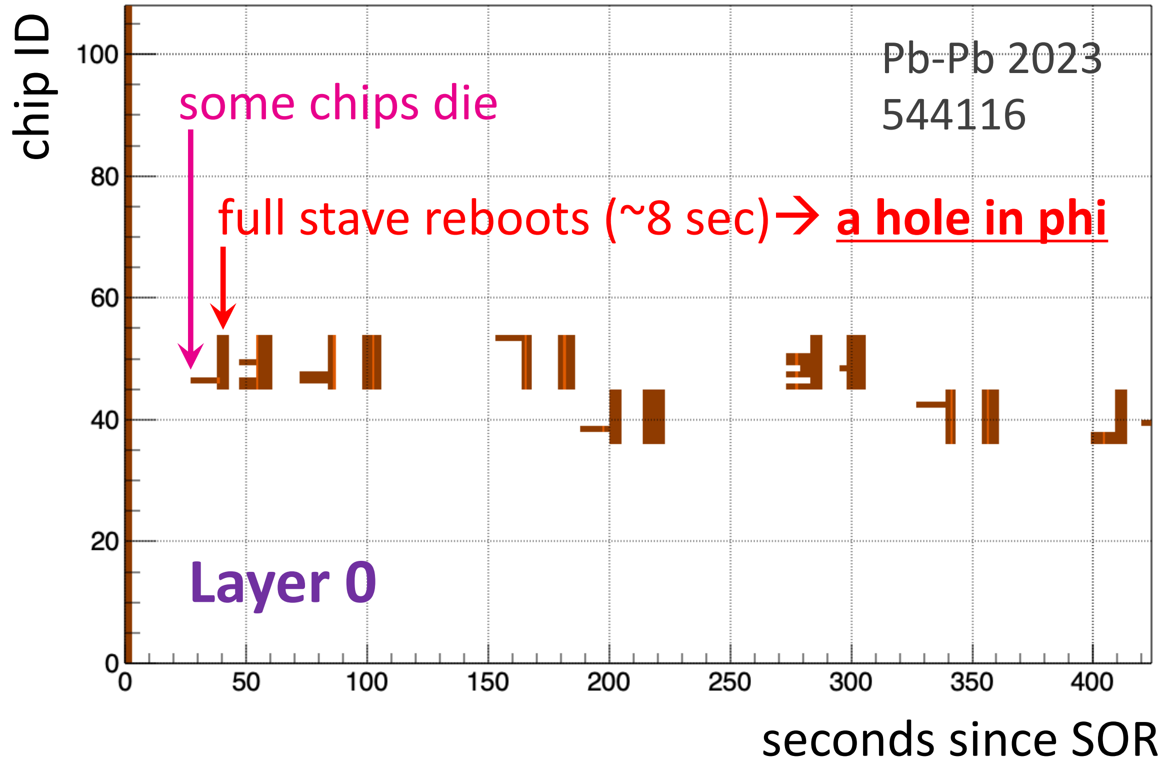
CCDB objects with maps of ITS dead chips

The ccdb objects contain info about:

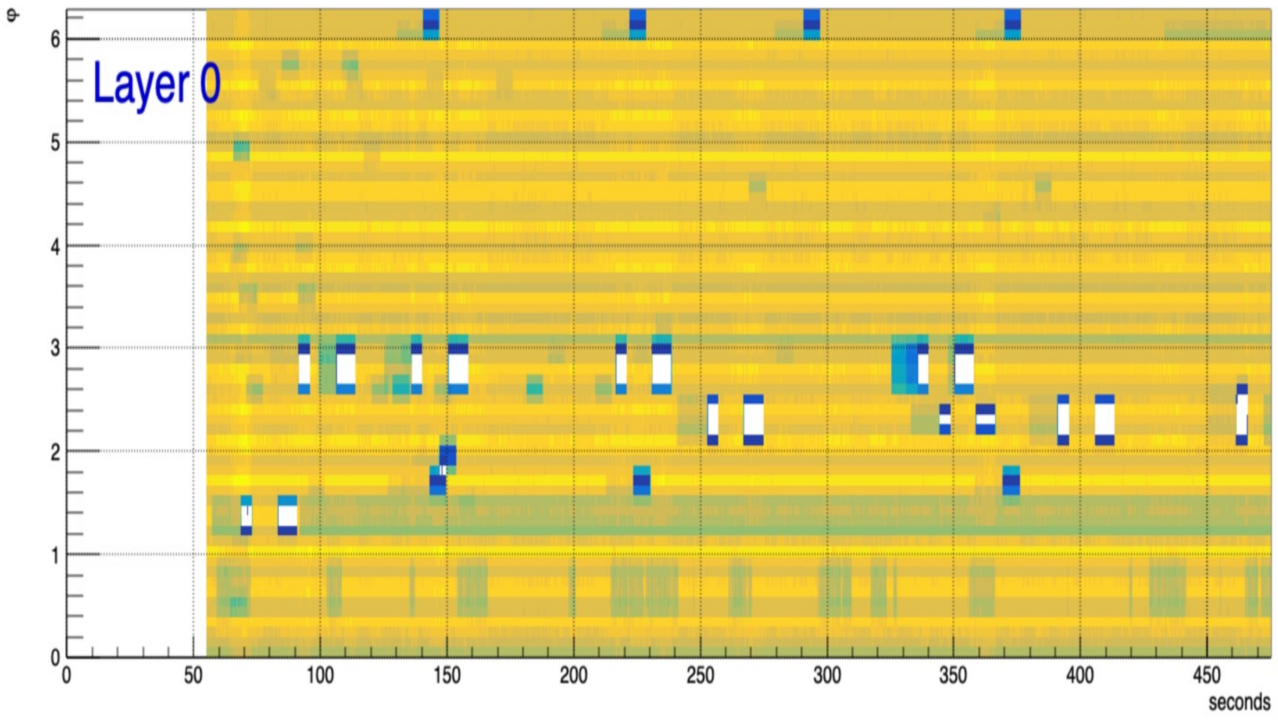
- single chips of the full detector which are fully dead **for the full run**
- **single chips of 3 Inner layers,** in a **time-evolving map**
- not single chips but **groups of 7 chips (lanes) for 4 Outer layers**, in a **time-evolving map**

First chipID of each layer:

int FirstChip[7] = { 0, 108, 252, 432, 3120, 6480, 15072 };



Compare with track-based plot (data):

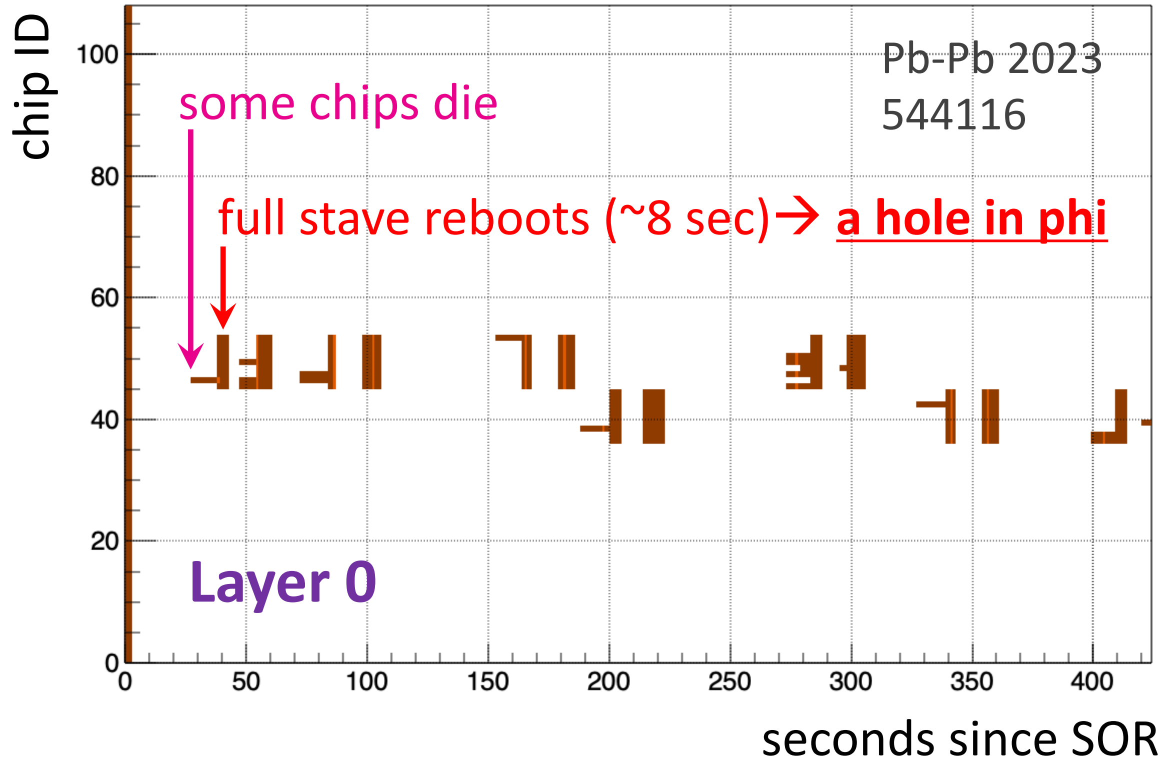


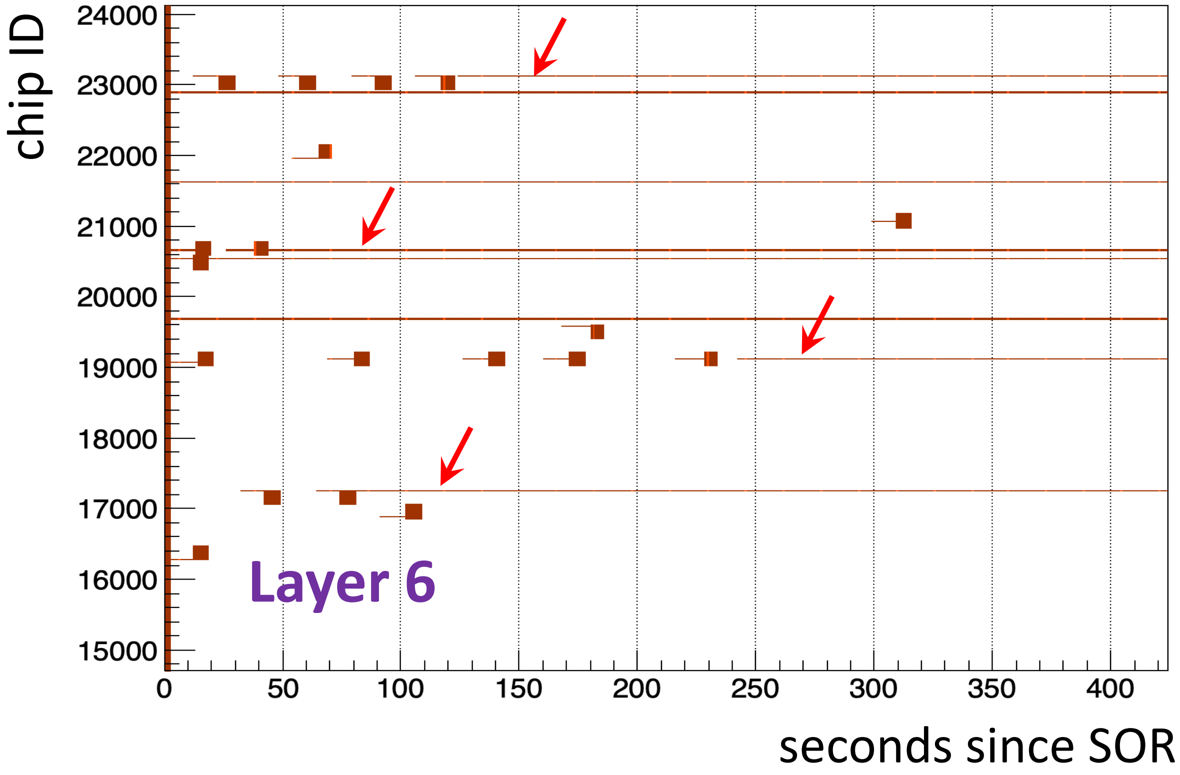
CCDB objects with maps of ITS dead chips

The ccdb objects contain info about:

- single chips of the full detector which are fully dead **for the full run**
- **single chips of 3 Inner layers,** in a **time-evolving map**
- not single chips but **groups of 7 chips (lanes) for 4 Outer layers**, in a **time-evolving map**

Note: if a chip **fails to be recovered few times**, then it **doesn't trigger the recovery anymore**.
→ we have some "extra recovery activity" at the beginning of the run
→ shorter runs are more affected by these fluctuations





New event selection bits to cut time intervals with dead ITS staves

First "pilot" version for the event selection bits: O2Physics/Common/CCDB/EventSelectionParams.h

```
kIsGoodITSLayer3,          // number of inactive chips on ITS layer 3 is below maximum allowed value
kIsGoodITSLayer0123,       // numbers of inactive chips on ITS layers 0-3 are below maximum allowed values
kIsGoodITSLayersAll,       // numbers of inactive chips on all ITS layers are below maximum allowed values
```

Usage in analysis:

```
if (col.selection_bit(o2::aod::evsel::kIsGoodITSLayersAll)) { ..do analysis..}
```

The criteria to set bad quality according to the map should be decided

→ for now, we set "thresholds" for a number of inactive chips per layer as **N_chips_in_stave-1 :**

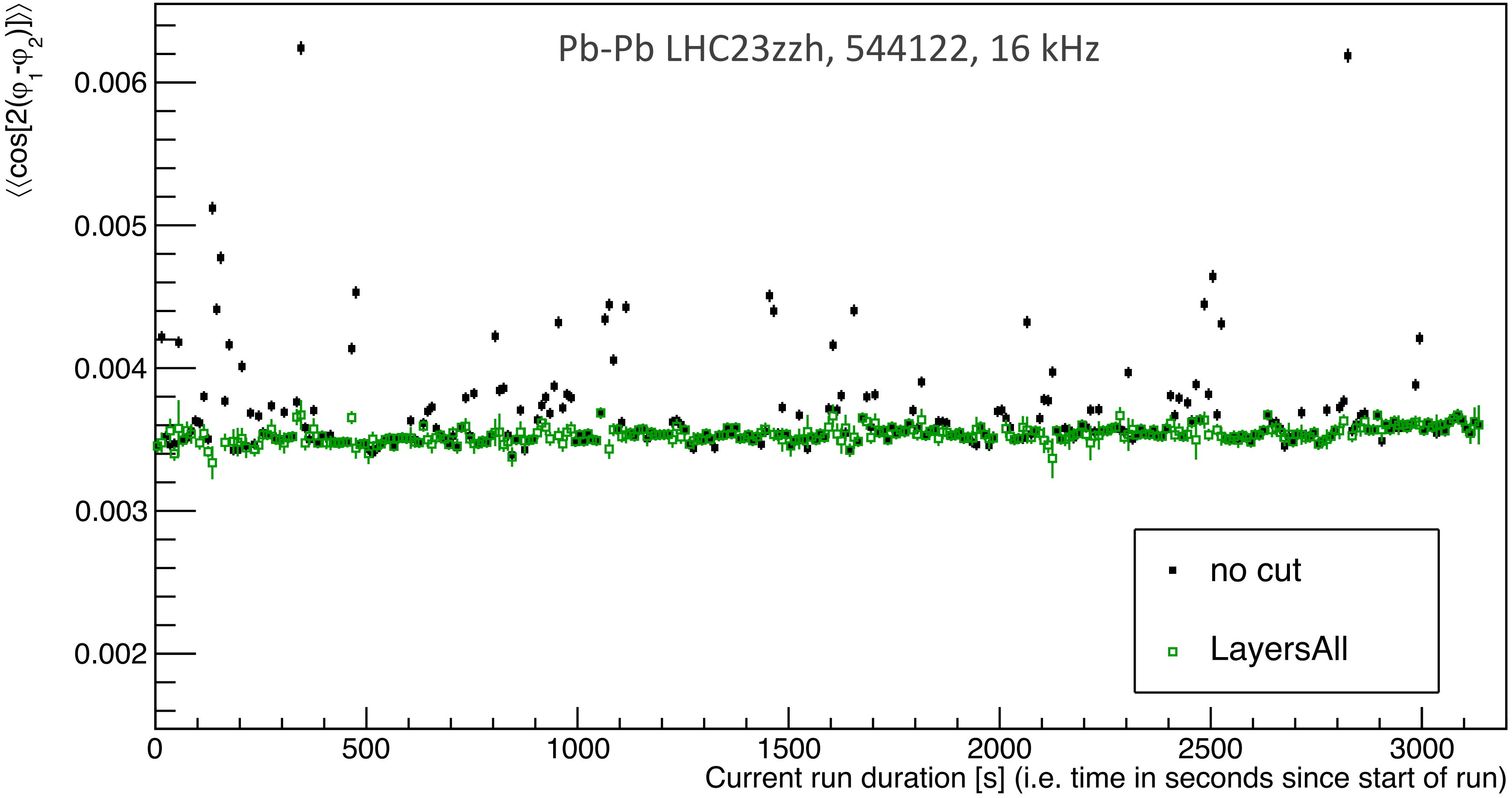
Configurable<std::vector<int>> maxInactiveChipsPerLayer{"maxInactiveChipsPerLayer",
{8, 8, 8, 111, 111, 195, 195}, "Maximum allowed number of inactive ITS chips per layer"};

→ if exceeded on some layer, we assume some stave is rebooting → cut such events

Caveat:

this needs to be improved: e.g. if a full stave is off in a given run, the events will not pass this selection.
We might need to introduce run-by-run thresholds in the event selection CCDB.
The aim of the current implementation - to test this approach in general.

Example usage of new bits in analysis: v_2 in Pb-Pb 2023

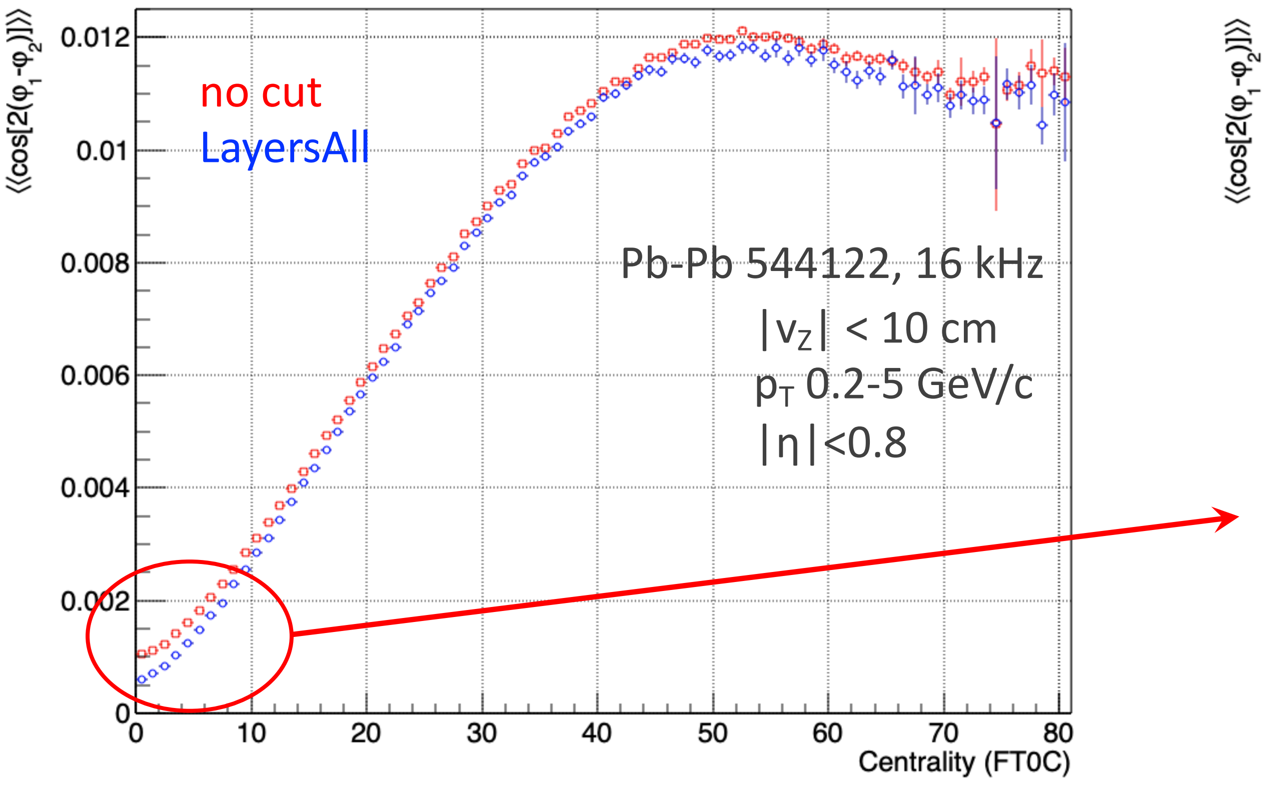


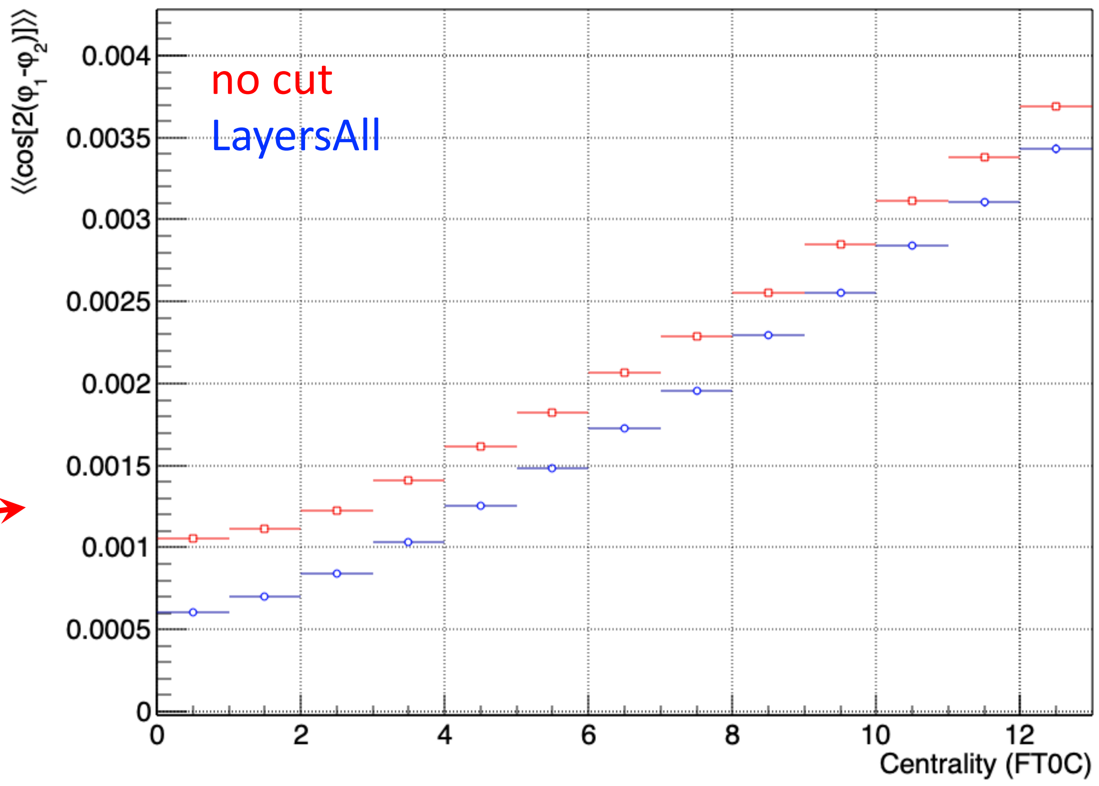
$|v_Z| < 10$ cm
p_T 0.2-5 GeV/c
$|\eta|<0.8$

- Time dependence of 2-particle correlator shows **spikes** that are well-correlated with the dead staves in the ITS
- The bit `kIsGoodITSLayersAll` allows to remove "spiky" time intervals → **much flatter dependence with time!**

Example usage of new bits in analysis: v_2 in Pb-Pb 2023

Ante Bilandzic

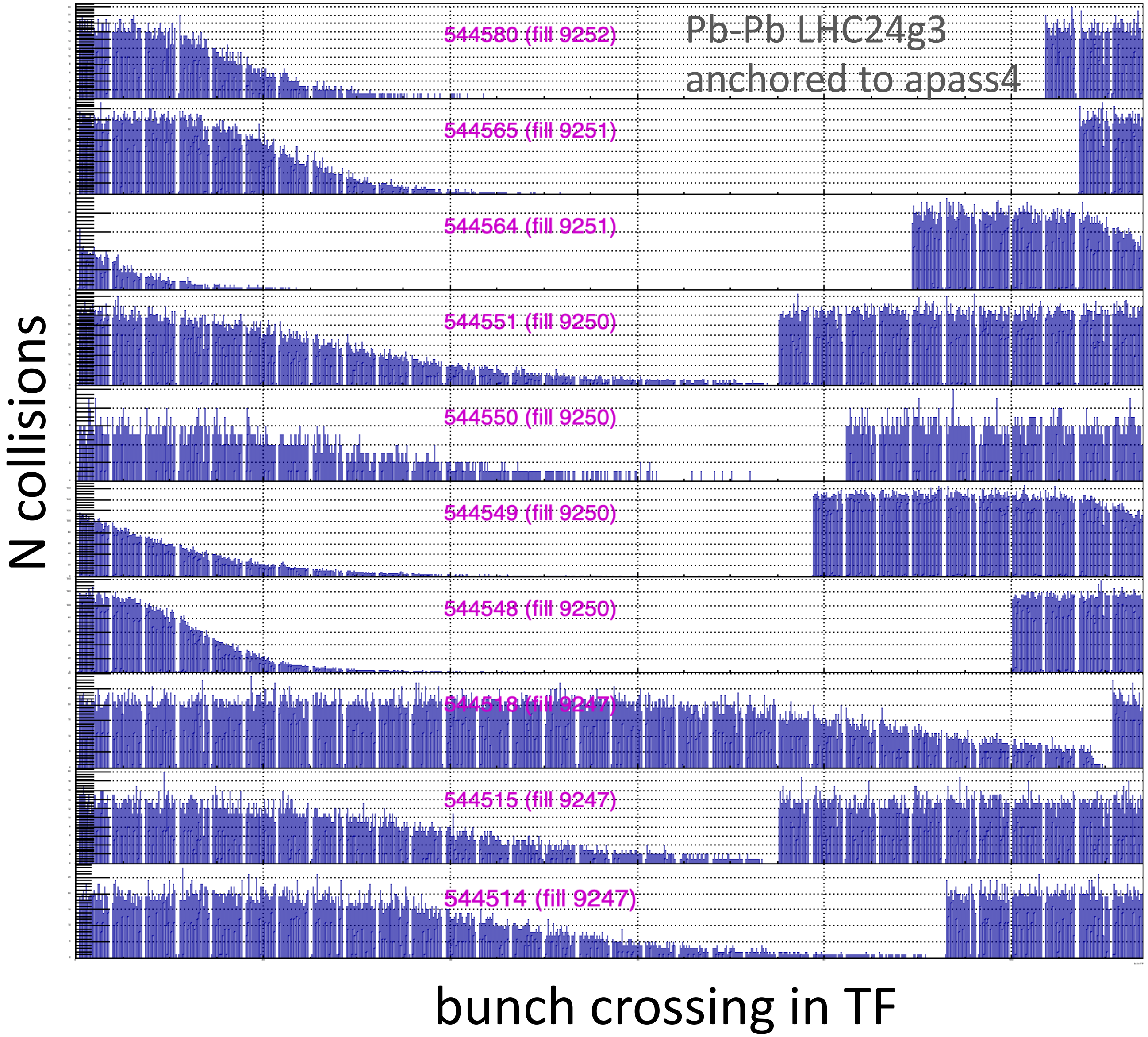




- Clear impact from the cuts on the 2-particle correlator (→ on the v_2 itself) at all centralities
  - … especially for central events, where the v_2 signal is low, and the dead-stave impact is more pronounced

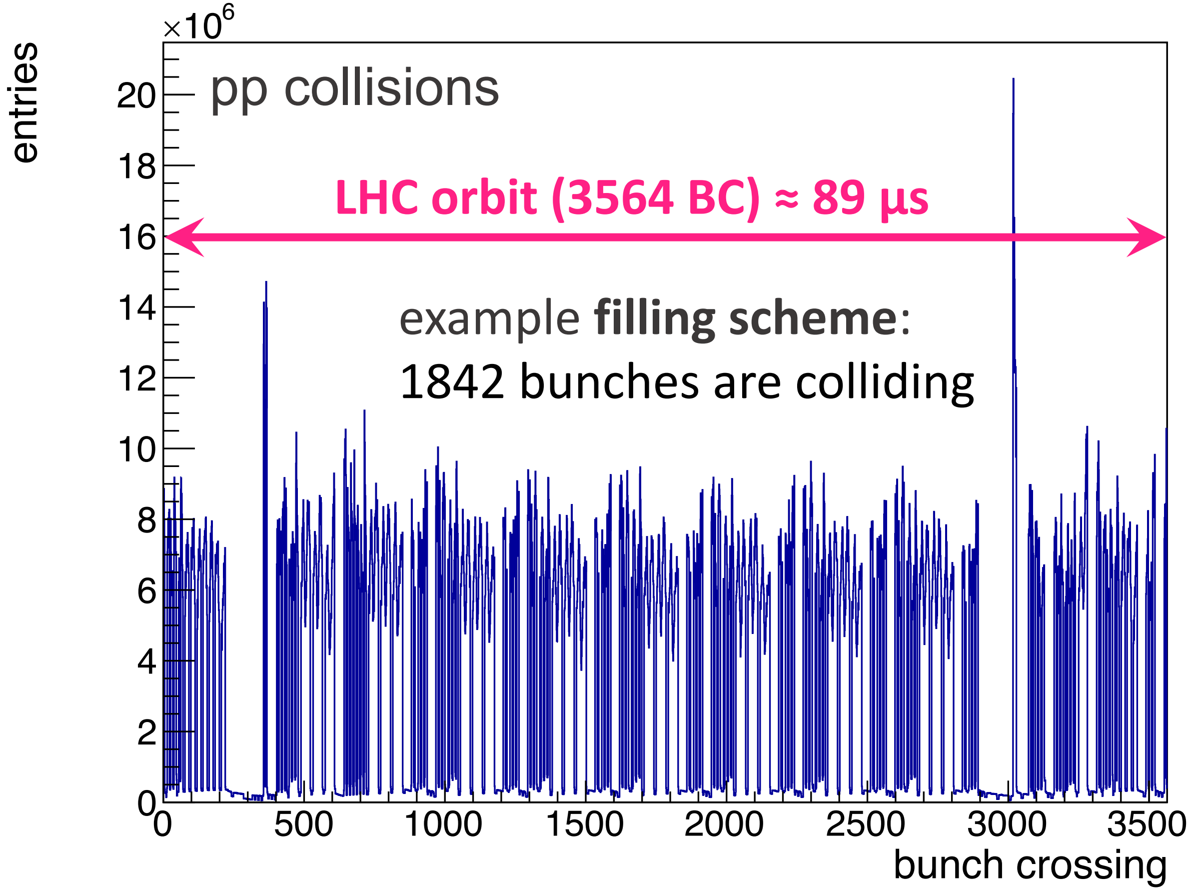
Collision distribution within Time Frames in Pb-Pb MC

More runs:

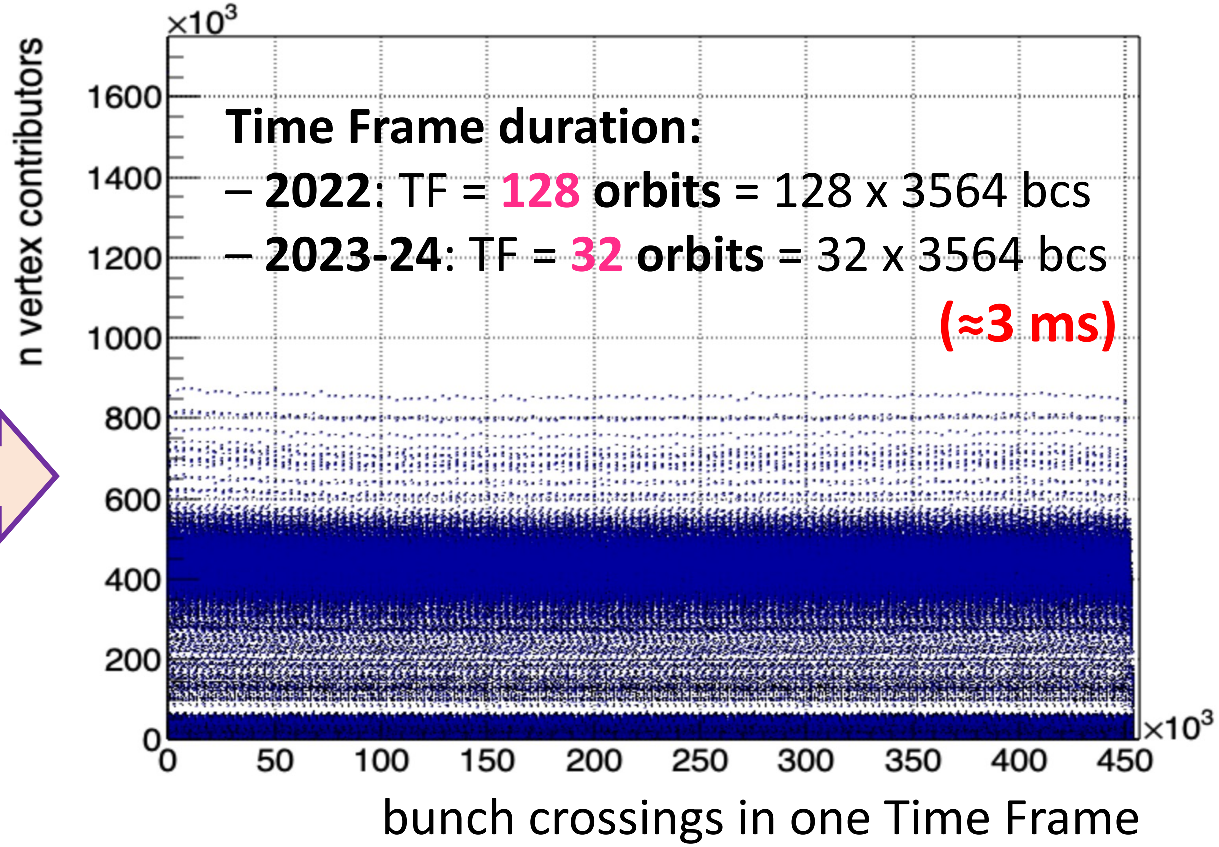


This issue is fixed in more recent MC productions (starting from ~May 2025)

Colliding bunches, continuous readout, Time Frames

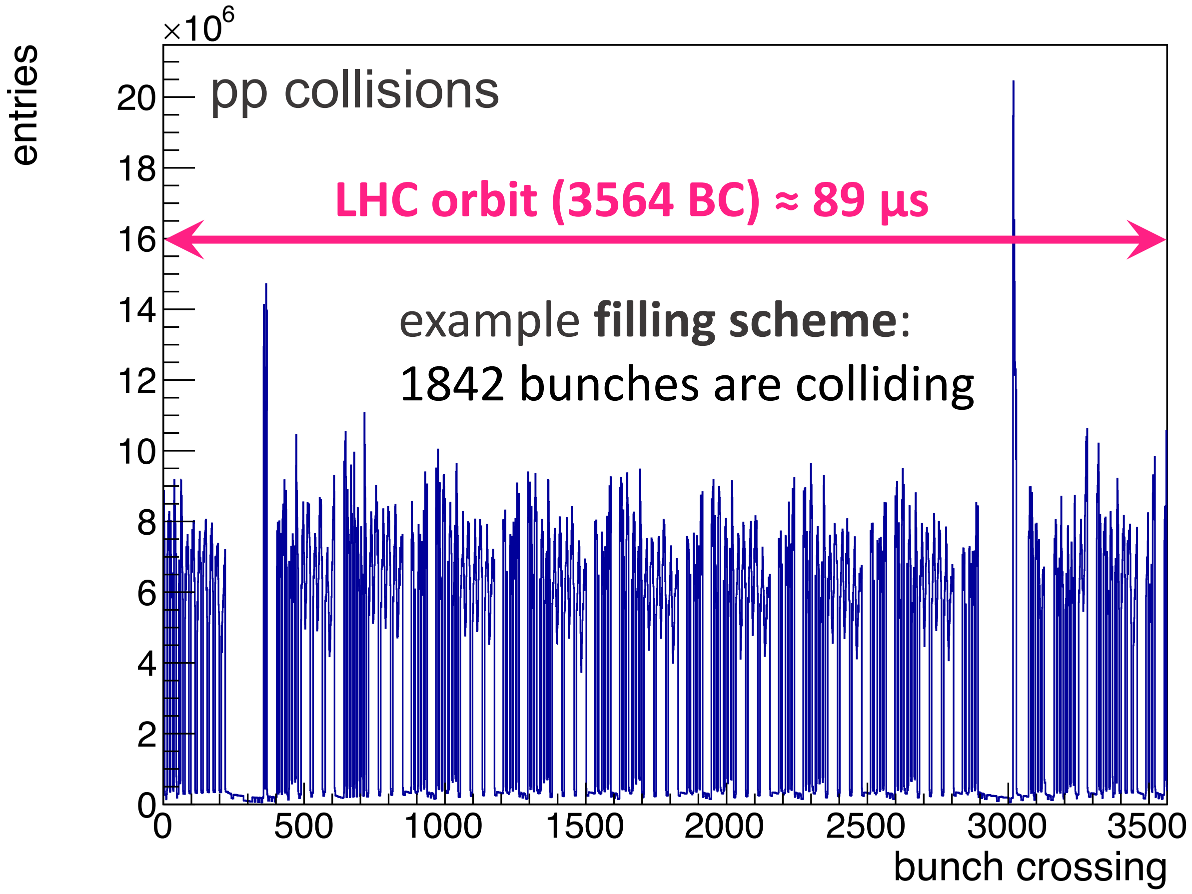


Continuous readout in Run 3+4:
data is readout & stored as **Time Frames**

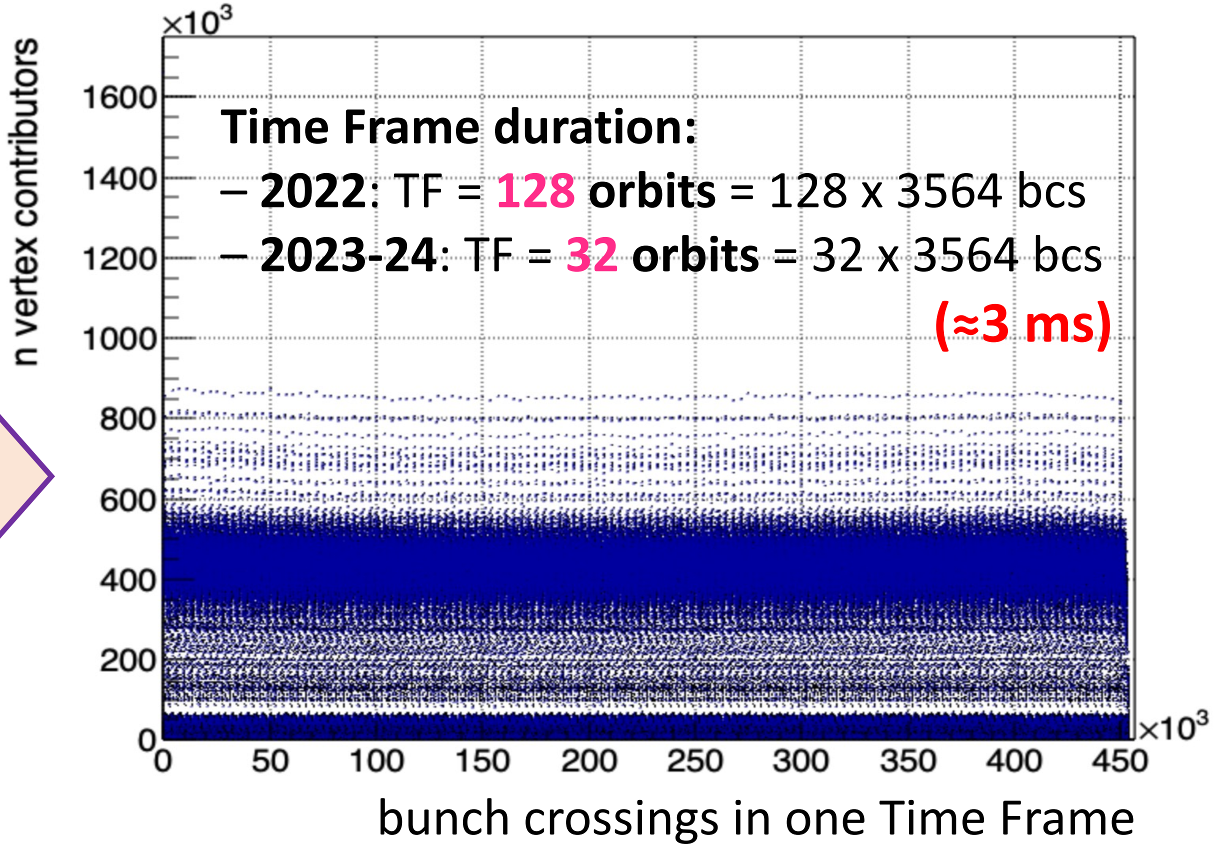


500 kHz interaction rate in pp → 500kHz / 11kHz **≈ 45 collisions per orbit** → **~1500 collision per TF**

Colliding bunches, continuous readout, Time Frames

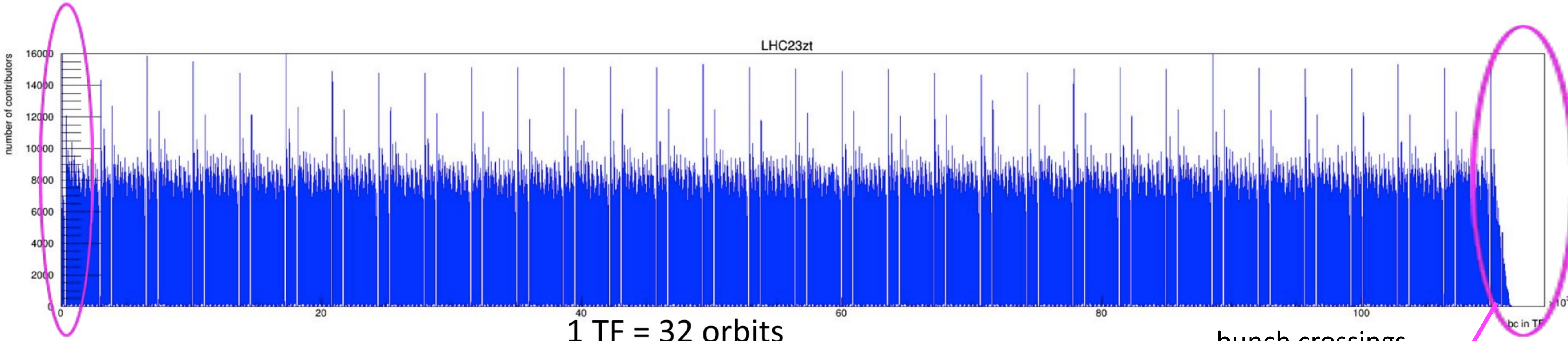


Continuous readout in Run 3+4:
data is readout & stored as **Time Frames**



All TFs are reconstructed "independently"! (TFs don't talk to each other)
→ Reconstruction at the TF edges is limited by construction

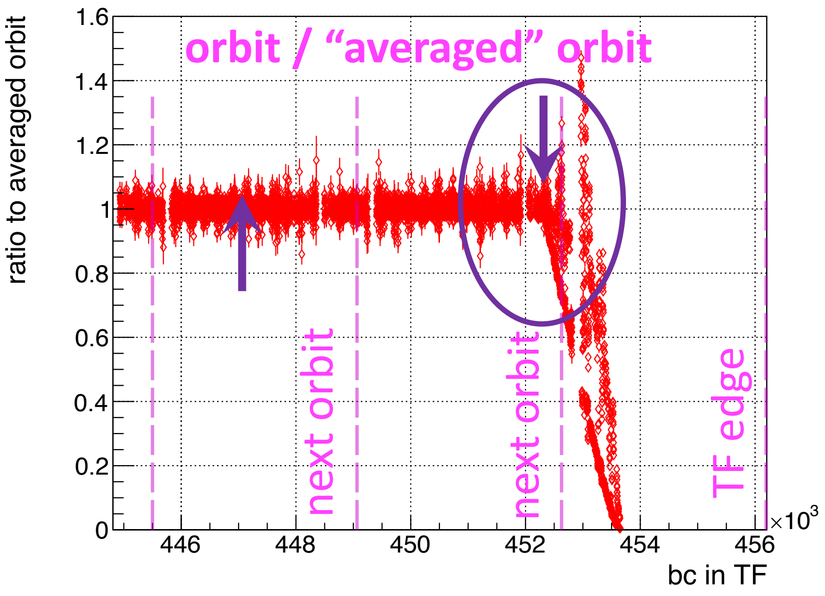
The Time Frame “**border effect**”



1 TF = 32 orbits

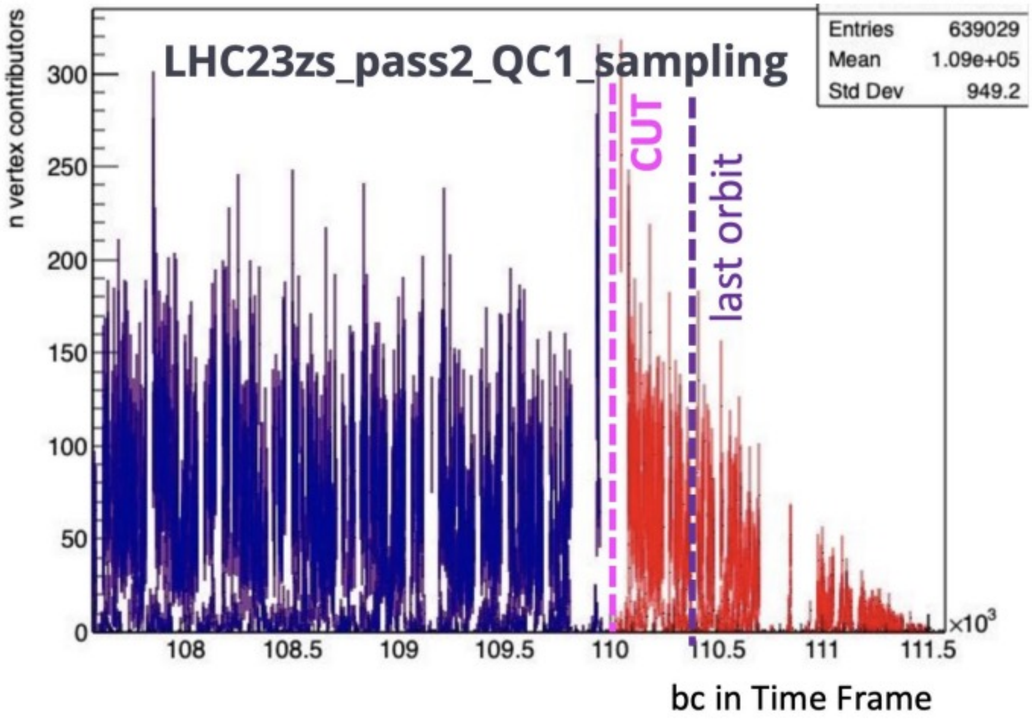
bunch crossings

- Start of **depletion in number of vertex contributors**:
  ≈97 μs before TF ends, this corresponds to **TPC drift time** (**≈100 μs**)
- Reason: **Incomplete information in TPC at the borders of Time Frame!**
  Last ~1.1 LHC orbits affected (LHC orbit = 3564 BC is **≈89.1 μs**)

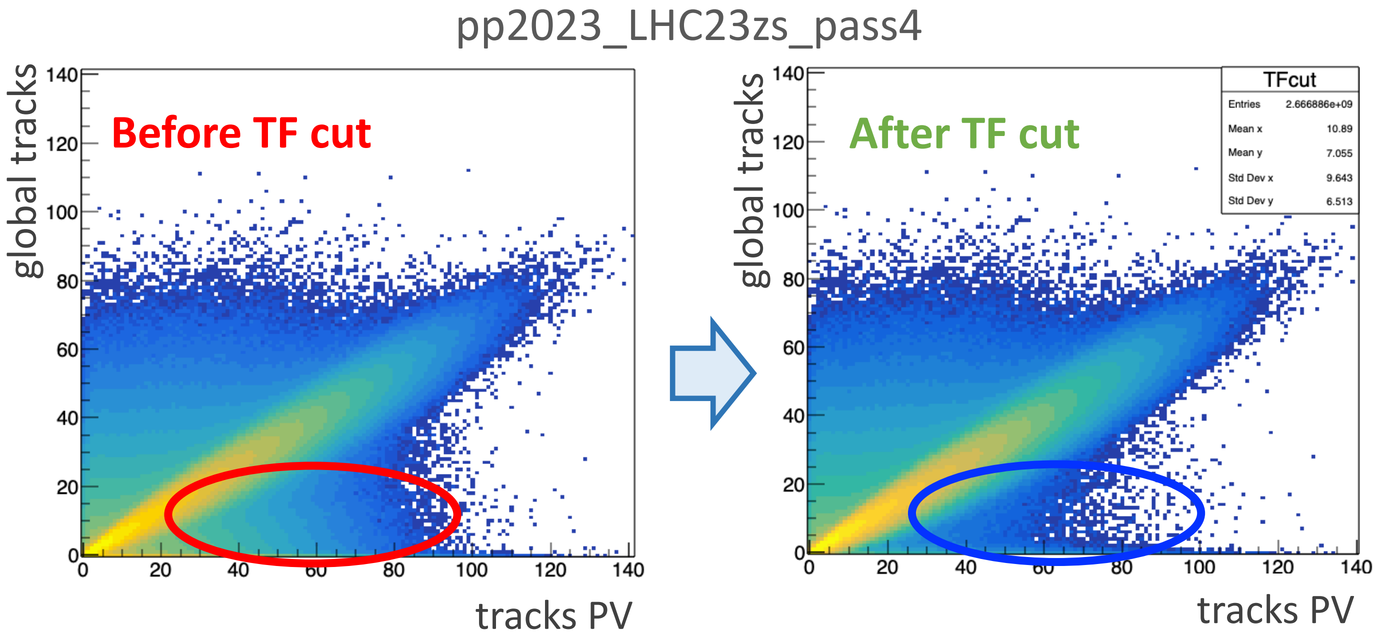


kNoTimeFrameBorder cut was introduced (Feb 2024), it rejects:
- **300 bcs** in the beginning of TF
- **4000 bcs** at the end of TF

The Time Frame “border cut”



- **kNoTimeFrameBorder** cut was implemented in Feb 2024
  see more in [AW DPG report](), slide 25, also [JIRA]()



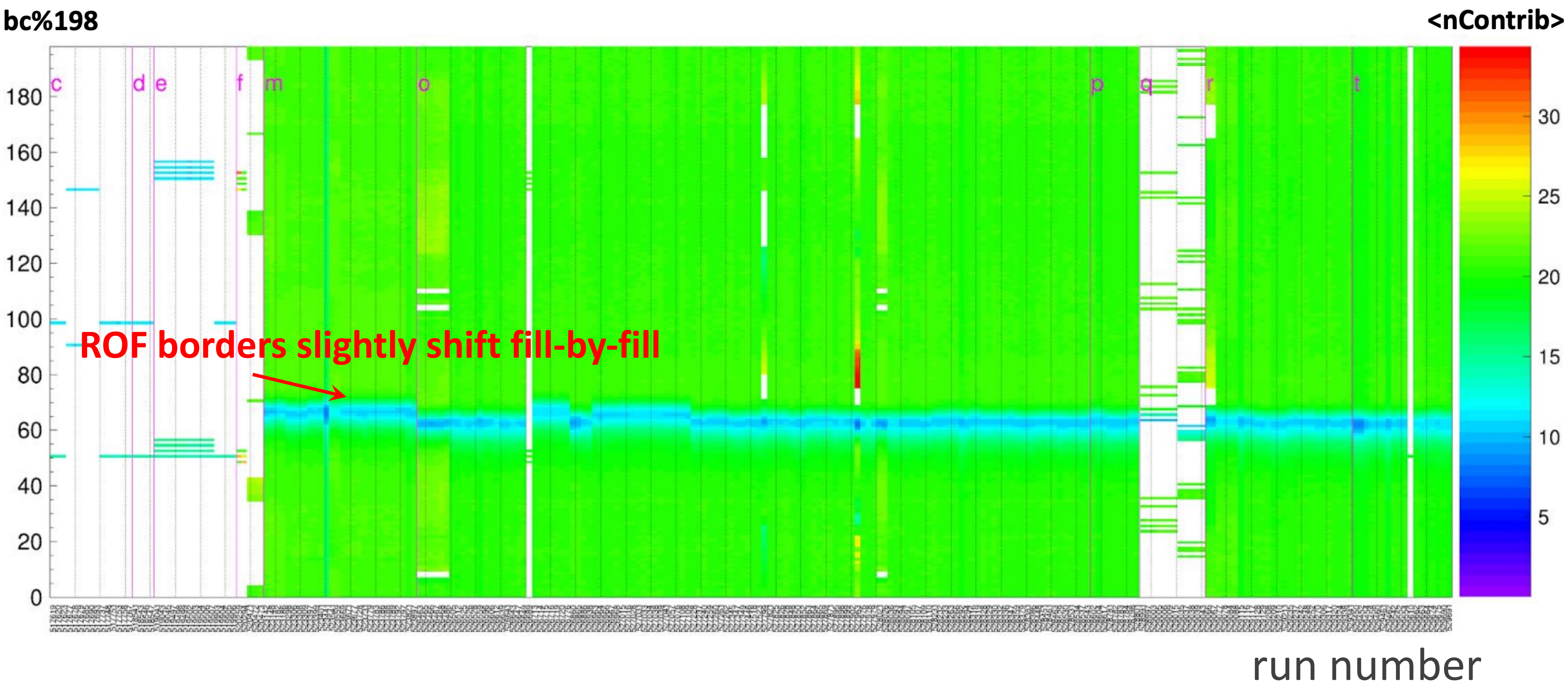
Time frame duration:

– in 2022: TF = 128 orbits → **~1.1% rejected**

– in 2023-24: TF = 32 orbits → **~3.7% rejected**

Validation of RO Frame border in pp 2022

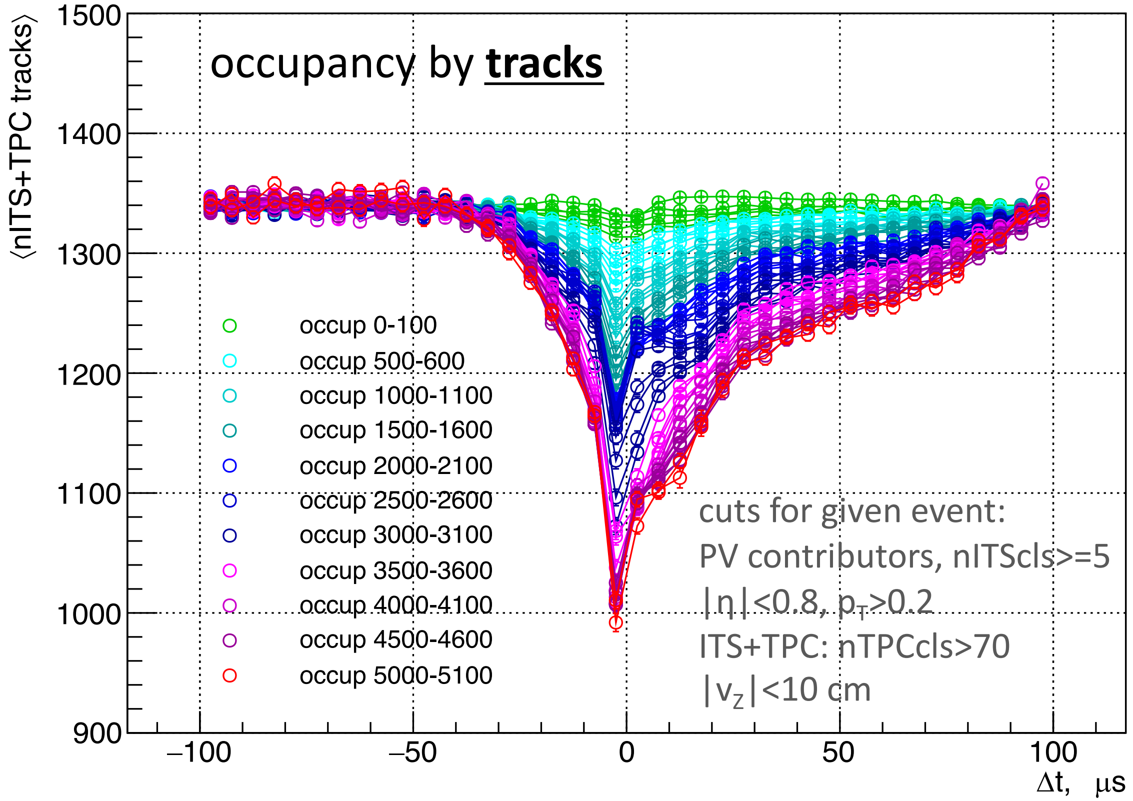
link to AOT meeting

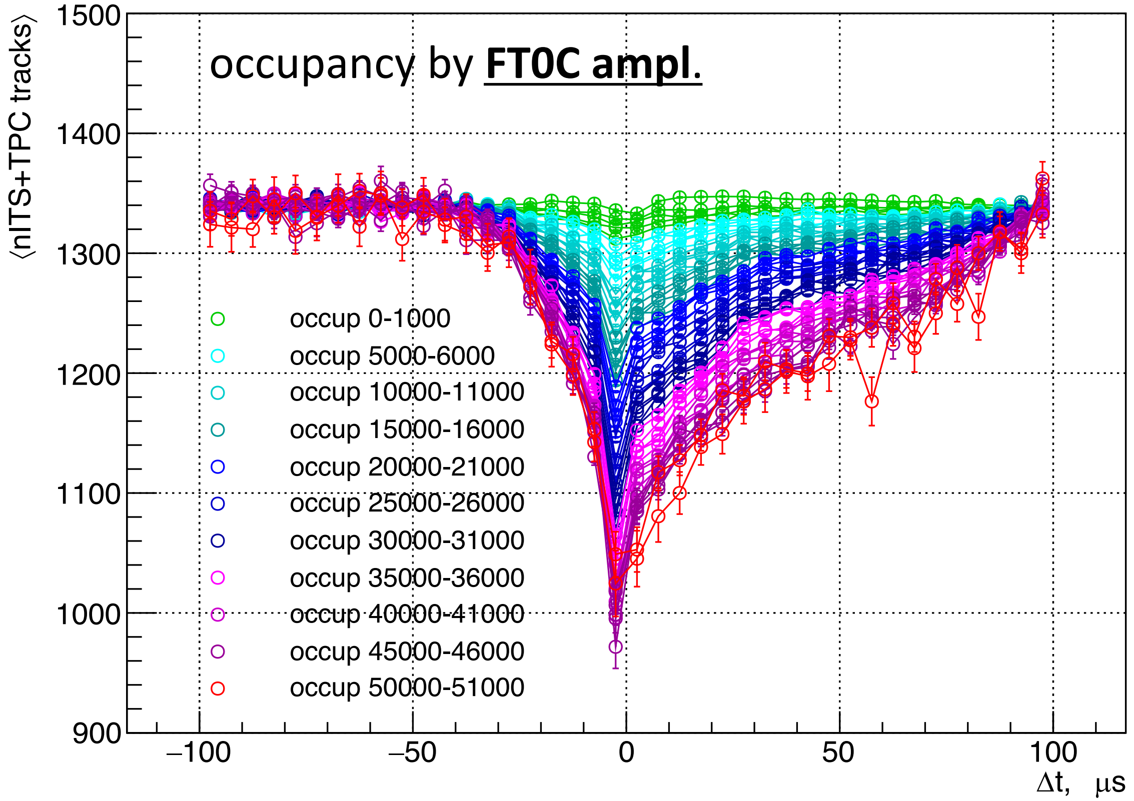


<n ITS+TPC tracks> *vs* multiplicity of nearby collisions

(FT0C amplitude "class" of a given event is 25000-40000, i.e. semicentral collisions)

Pb-Pb apass4, 544122, 16kHz





- Similar performance "degradation pattern" with both occupancy estimators

* kNoCollInTimeRangeNarrow selection (+/- 2 μs cut) is applied here to suppress remaining BC mis-associations