TOF Simulation in CDF Framework

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Outline:

we describe the recent updates to the TOF simulation code

- Why changes were needed.
- Simulation modes and their usability scope.
- Most important fixes.
- Performance plots.
- How to run the latest TOF MC.
- Conclusion.

Motivation

Most of TOF simulation code was rewritten. Why?

1. Existing simulation did not reproduce data.
2. Simulating is similar in spirit to applying calibrations – both parametrize detector response with a number of constants.

We wanted the code to be aware of this relationship.

3. Code had to be written to integrate with the new TOF reconstruction code. We do not want to duplicate functionality (e.g. managing calibrations, database access etc.)

Simulation Modes

1. **SIMPLE**: assumes the same naïve model for all channels.
Used for: to study simple processes without calibration effects.
Status: Completed.

2. **DETAILED**: Uses the same calibration classes, constants and parametrization as the TOF reconstruction. Applies calibrations in reverse to get measured time from hit time.
Used for: to do physics studies which make use of TOF detector. Most people will want this simulation mode.
Status: Completed.

3. **PHYSICAL**: attempts to simulate the pulse shape at the electronics level and predict the response based on that.
Used for: to study the calibrations, reconstruction code, other low-level effects.
Status: in progress.

Most important improvements

1. Using the same calibration classes as in reconstruction code guarantees that simulation will never go out of sync. In this mode we should get realistic detector simulation by construction.

2. We now attempt to simulate the effect of multiple hits on a bar. One hit determines the time measurement but others can contribute to charge measurement.

3. Related to (2) – more intelligent treatment of hadronic showers and very close hits. All light from the hits in the same place is treated as one hit.

4. Fixed a bug - particles that disappear within TOF while Geant is tracing them are now taken into account.

5. Updated TofMcHitColl storable objects (hit level truth information) to save relevant data .TOF reconstruction can be re-run very quickly after Geant tracing is done once and TofMcHitColl is saved in the events.

TofSimModule

New module in TofSim package. Some capabilities include:

* Can create TofMcHits out of CdfTracks and GenTrig truth information. Makes the entire TOF code compatible with GenTrig simulation.

* Can play the role of SimulationControlMod and call various components of TOF simulation itself. Useful for rerunning TOF simulation on events with pre-generated TofMcHit collection.

MC vs Data Comparison

We simulate conditions and compare to store 1116 (run > 141500). MC is generic $b\bar{b}$ Pythia with J/psi filter (used mbot421 sample as HEPG-level input to realistic simulation).

Only one interaction per event is simulated.

Comparison is done to J/psi data. All quantities shown are for the muons coming from the reconstructed J/psi's.

MC was reconstructed with Production 5.3.1 and data with 4.8.4 – might have impact on some distributions.

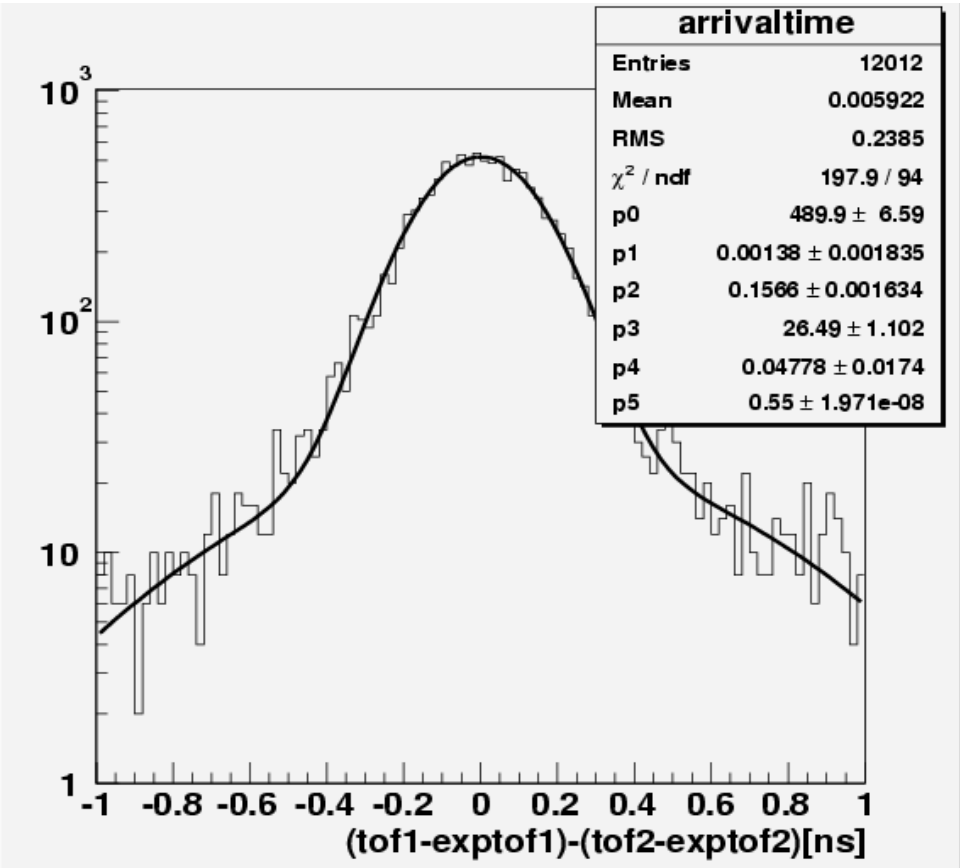
Footnote: for simulation and reconstruction non-standard TOF calibration set was used. Also applied are some non-standard matching cuts. There is a slide on how to set up your tcl to get these.

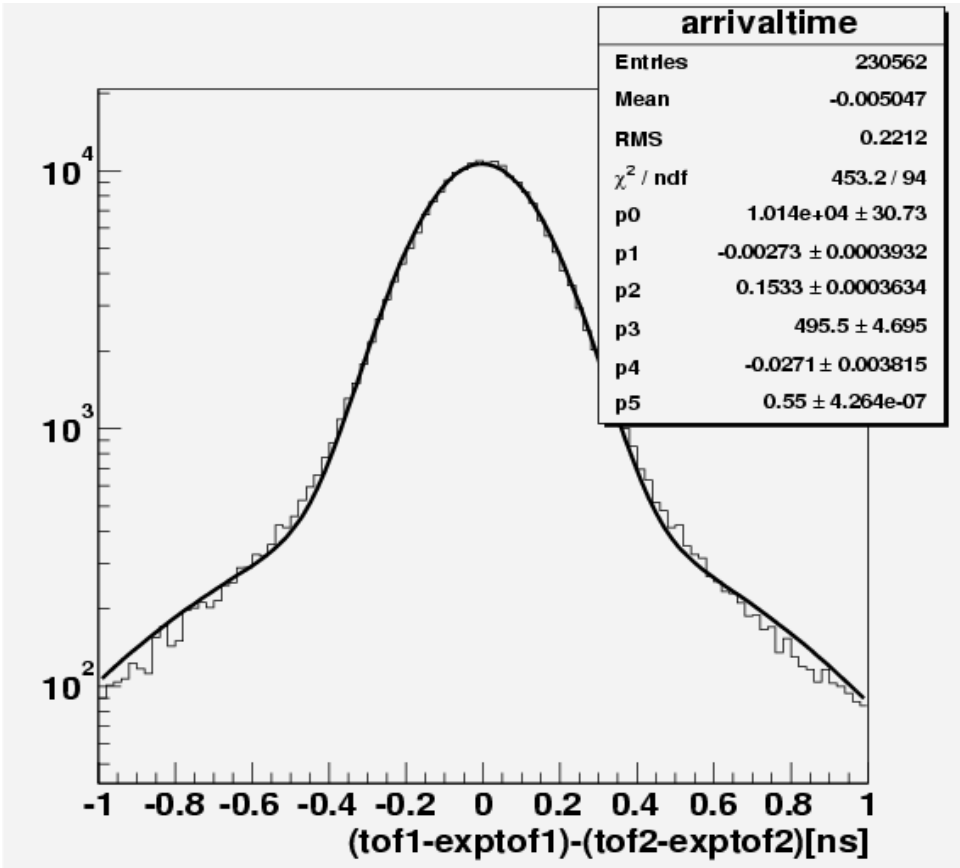
MC vs Data: Timing Resolution

Shown: difference in production times for two legs of J/psi as predicted by TOF measurements (MC plot is on the left).

Narrow gaussian sigma: 157ps vs 153ps.
Wide gaussian fraction: 15% vs 16%.

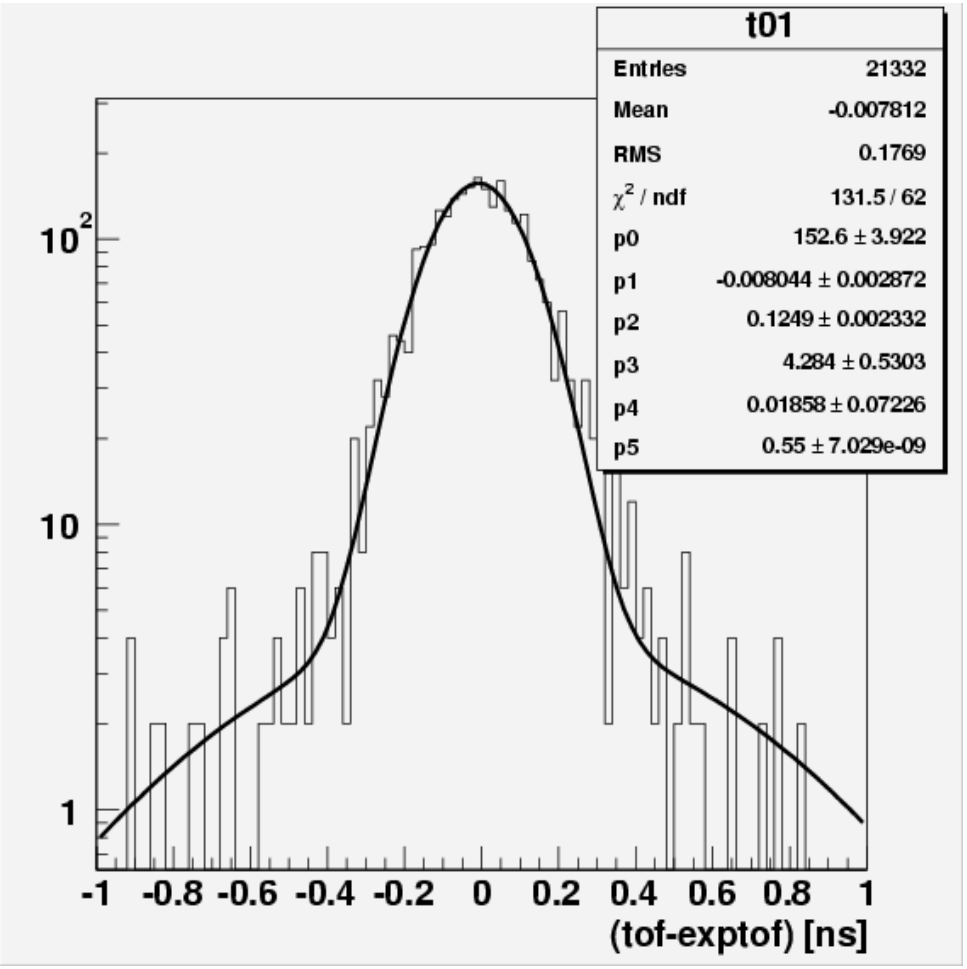
Wide gaussian sigma: 550ps vs 550ps.

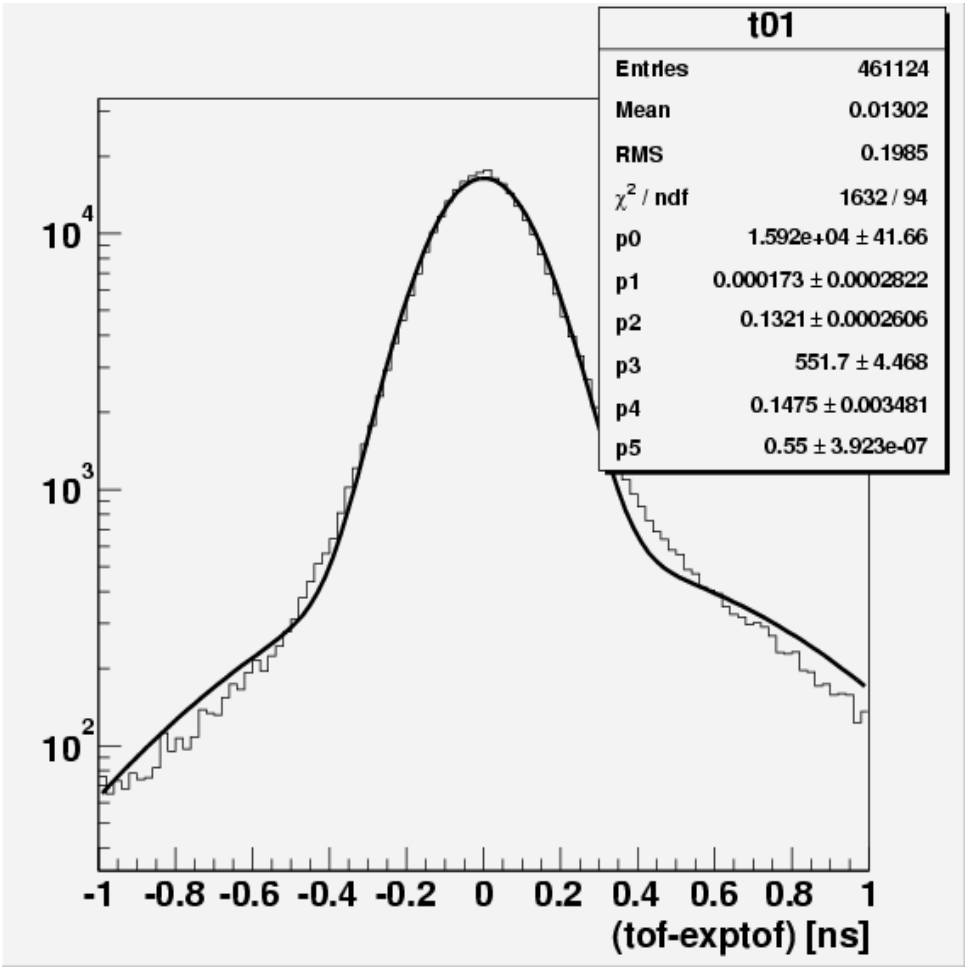




MC vs Data: Timing Resolution

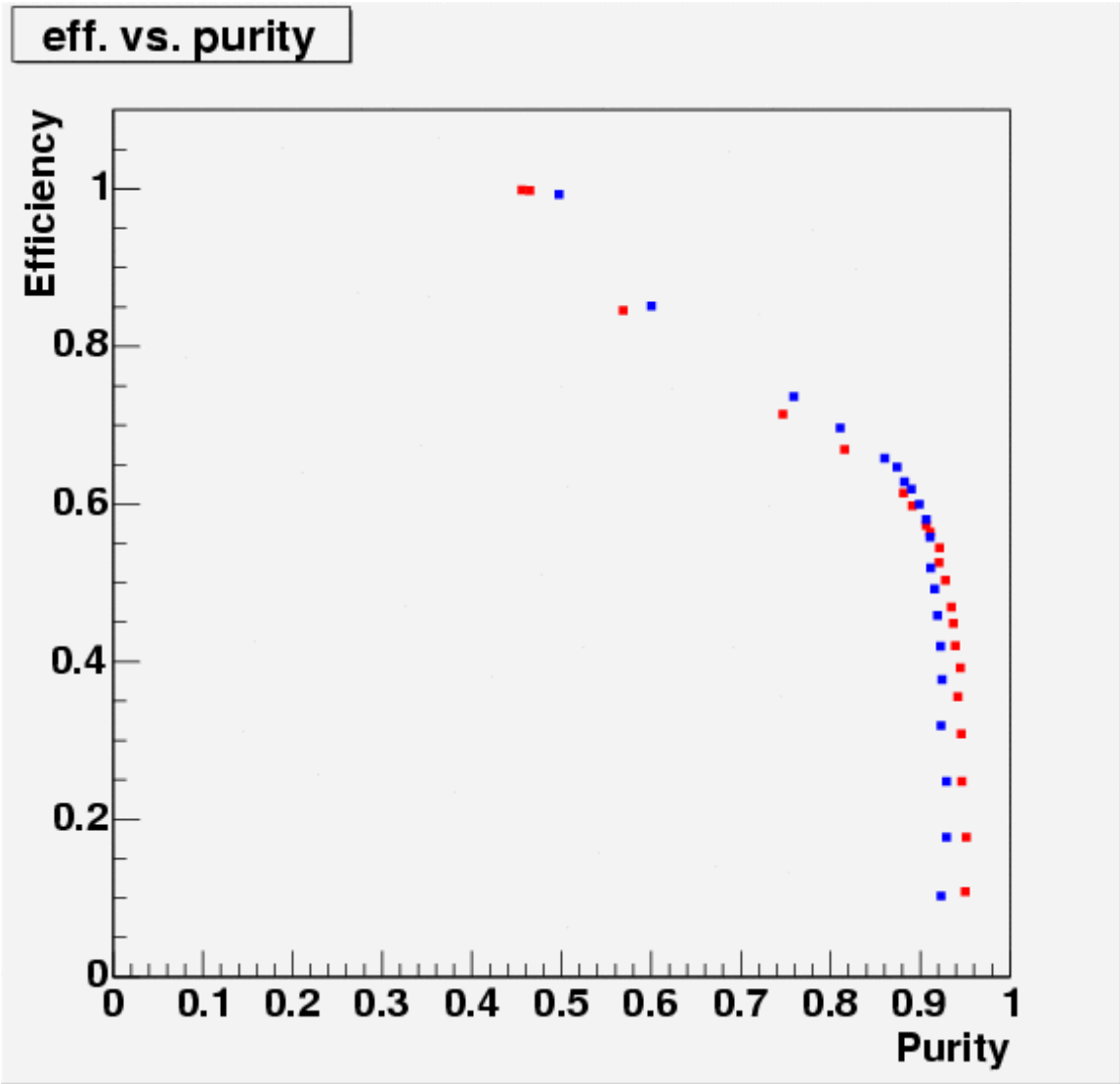
Shown: expected minus measured muon arrival time (MC on the left).
Narrow sigma: 125ps vs 132ps. Wide sigma: 550ps vs 550ps.
Wide fraction: 11% vs 13%.





MC/Data comparison: Efficiency vs Purity

MC:blue; Data: red.

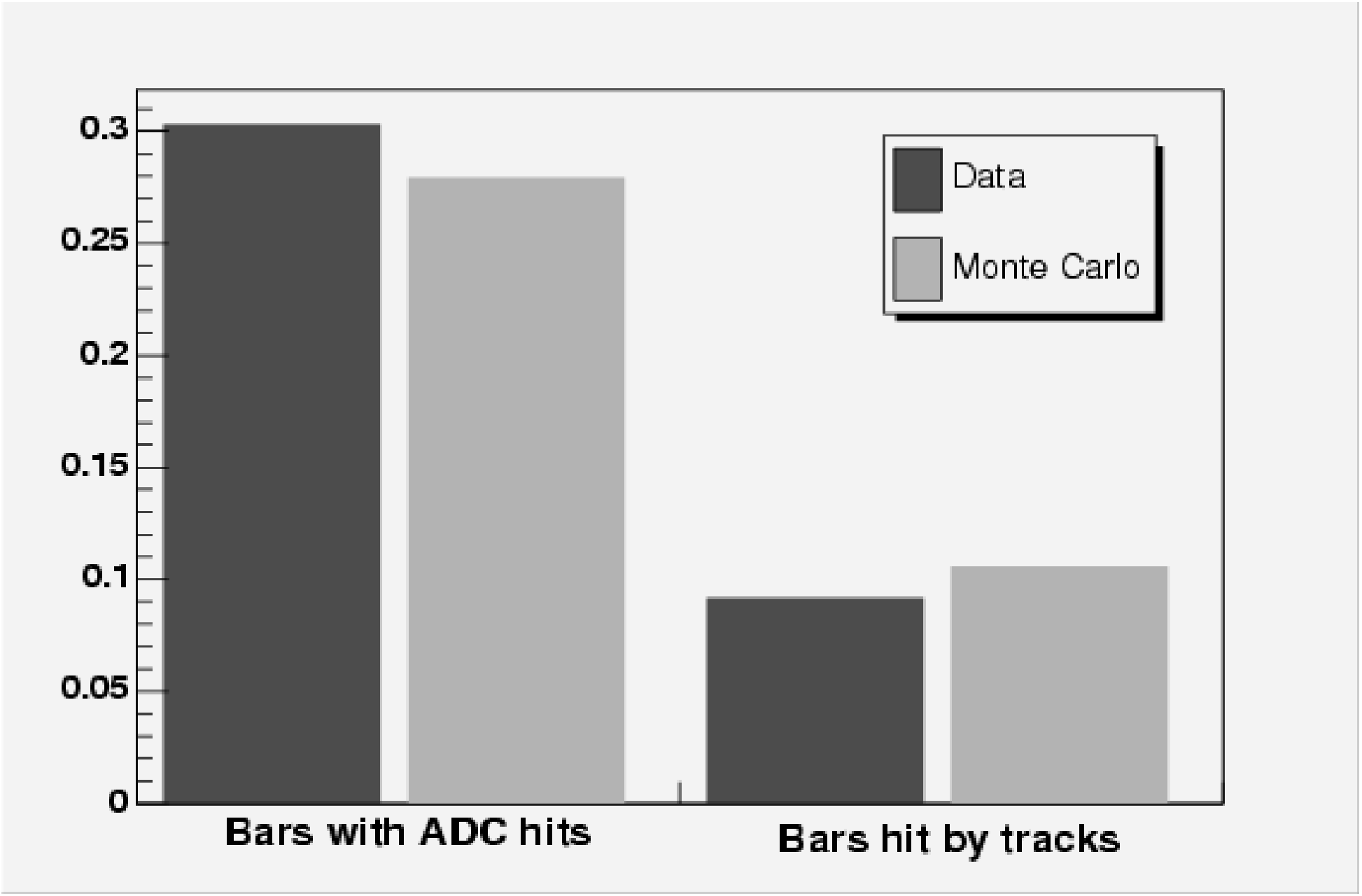


Efficiency: how often both J/psi muons pass the TOF matching cuts when both muons are TOF fiducial and traverse only one bar.

Purity: fraction of the narrow gaussian in the arrival time distribution.

Default reconstruction matching cuts correspond to the knee region.

MC vs Data: Occupancies



How to use the latest TOF simulation

1. Use standard cdfSim executable (5.3.1int1 or later) linked against TOF code from development. You will need: TofSim, TofAlgs, TofMods, TofObjects, TofCalibDBTables.
2. Modify the default tcl files so that you have

```
module talk TofManager
  CalibratorType set TestData
  Calibrator
# in the near future this talk-to won't be
# needed if you have valid run
# numbers in your MC
   OverrideOfflineDBRun       set 141507
   OverrideOnlineDBRun        set 141494
   OverrideOfflineDBVersion set -1
   OverrideOnlineDBVersion  set -1
  exit
exit

module talk GeometryManager
 TofGeometryMenu
   GeometryModel set Aligned
 exit
exit
```

```
module talk SimulationControlMod
  add Tof3Pack    TofDigi3Pack      TofGroup
  add TofBar      TofDigiBar        TofGroup

  ConfigMenus
   TofGroup_TofBar
      simModel      set DETAILED
   exit
   TofGroup_Tof3Pack
      simModel      set DETAILED
    exit
exit
```

Conclusions

* TOF simulation code was updated and takes advantage of the recent improvements in the rest of TOF code.

* The most important pieces are finished and ready to be used for physics studies. Data/MC agree within reason.

* We plan to do more validation studies.

* Implementation of the PHYSICAL simulation mode is on our longer-term plan.