Global PID

MICE CM43

29/10/15

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Outline

Main points for this talk:

- Status of PID.
- Revision of using PID – input and output, for commissioning and Step IV.
- PID variables.
- Efficiency/purity for commissioning variables.
- Validation of PID.
- PID on cycle 2015/01 data.

Status of PID

- Most up-to-date PID work can be found in my branch lp:~c-e-pidcott/maus/1389a.
- Collection of PID variables, for Step IV and commissioning, now exists, using all detectors except Cherenkovs.
- PID has been run on (MC) tracks produced by global reconstruction.
- Unit tests have been written for all variables.
- Waiting for JG's trackmatching to be in MAUS before pushing most up-to-date version of PID.
- Updates to MAUS user guide 50% done and will be complete by December.

Using PID - input

• Global PID can be used for commissioning (field off) or Step IV data, by setting the **pid_config** datacard to “step_4” or “commissioning”.

• If step_4 is selected, the PIDVar set of variables will be used. If commissioning is selected, the ComPIDVar variables will be used.

• The actual variables then used is determined by the **pid_mode** datacard, which can be set to “online”, “offline”, or “custom”.

• If custom is selected, the user must set the variables to be used using the **custom_pid_set** datacard. However, this setting should only really be used by someone developing the PID... i.e. someone in Globals.

PID input – online vs offline

- "Online" variables are ones which are beam (momentum) independent, and so are suitable for online running, and for which their PDFs can be pre-produced and packaged with MAUS.

- "Offline" variables depend on the beam settings, and so should be produced by the user once they have determined their simulation settings. A library of the core MICE settings can be included with MAUS, but for anything off-menu, the user would need to produce their own PDFs.

Using PID - input

• Particle identification is performed by the MapCppGlobalPID mapper in MAUS. An input_json_file_name and output_json_file_name must also be set in the datacards.

• PDFs are produced using the ReduceCppGlobalPID reducer. An input_json_file_name, global_particle_hypothesis and unique_identifier (i.e. time stamp) must also be set in the datacards.

• The precursors to using the global PID (both to run PID using pre-existing PDFs and to produce new PDFs) are MapCppGlobalReconImport and MapCppGlobalTrackMatching*.

*** The version of MapCppGlobalTrackMatching currently in MAUS is soon to be replaced by one that incorporates the Runge-Kutta, users should wait until that is in place to use global PID**

Using PID – input/output

• TrackMatching supplies multiple potential tracks to the PID, each with an assigned pid.

• The PID clones these tracks, into Candidate PID tracks, and performs PID on each of them.

• This is done by calculating the values of pid variables (described in later slides) and comaparing them to PDFs of the same variables for each potential particle hypothesis, obtaining a log-likelihood value for each hypothesis (method described in further detail here).

• Each candidate track is then assigned an object that holds the likelihoods for each hypothesis.

Using PID - output

• The confidence level for each hypothesis is calculated for the track. If the confidence level of a given hypothesis clearly distinguishes it from the others, this is set as the pid of the candidate track. The confidence level cut off can be defined by the user.

• If the pid of the candidate track matches the pid of the original trackmatching track, then this is taken to be the correct track, and is added to the global event as the Final PID track.

• All candidate tracks are retained by the event, so that during analysis they can be referred back to by the user.

Commissioning PID Variables

Class Name	Variable Name	Description	Online/Offline	Notes
ComPIDVarA	diffTOF1TOF2	Time of flight between TOF1 and TOF2.	Offline	Suitability as a variable will be investigated via efficiency/purity studies.
ComPIDVarB	KLChargeProdvsDiffTOF1TOF2	KL ADC charge product vs the time of flight between TOF1 and TOF2.	Online	Reduces dependence on beam momentum, making it suitable for online use.
ComPIDVarC	CommissioningKLADCChargeProduct	KL ADC charge product.	TBD	Suitability as a variable will be investigated via efficiency/purity studies.
ComPIDVarD	CommissioningEMRrange	Range of particle in EMR.	Offline	Suitability as a variable will be investigated via efficiency/purity studies.
ComPIDVarE	CommissioningEMRrangevsDiffTOF1TOF2	Range of particle in EMR vs the time of flight between TOF1 and TOF2.	Online	Reduces dependence on beam momentum, making it suitable for online use.
ComPIDVarF	CommissioningEMRdensity	EMR plane density.	TBD	Awaiting efficiency/purity studies.
ComPIDVarG	CommissioningEMRdensityvsDiffTOF1TOF2	EMR plane density vs the time of flight between TOF1 and TOF2.	TBD	Awaiting efficiency/purity studies.

Step IV PID Variables

Class Name	Variable Name	Description	Online/Offline	Notes
PIDVarA	diffTOF1TOF0	Upstream time of flight	Offline	Suitable for offline use only, as momentum dependent.
PIDVarB	diffTOF0TOF1vsTrackerMom	Upstream time of flight vs momentum measured in US tracker	Online	Reduces dependence on beam momentum, making it suitable for online use.
PIDVarC	KLChargeProdvsDSTrackerMom	KL ADC charge product vs momentum measured in DS tracker	TBD	Suitability as an online/offline variable will be investigated via efficiency/purity studies.
PIDVarD	KLADCChargeProduct	KL ADC charge product	Offline	Suitability as a variable will be investigated via efficiency/purity studies.
PIDVarE	EMRrange	Range of particle in EMR	Offline	Suitability as a variable will be investigated via efficiency/purity studies.
PIDVarF	EMRrangevsDSTrackerMom	Range of particle in EMR vs momentum measured in DS tracker	Online	Reduces dependence on beam momentum, making it suitable for online use.
PIDVarG	EMRdensity	EMR plane density.	TBD	Awaiting efficiency/purity studies.
PIDVarH	EMRdensityvsDSTrackerMom	EMR plane density vs momentum measured in DS tracker	TBD	Awaiting efficiency/purity studies.

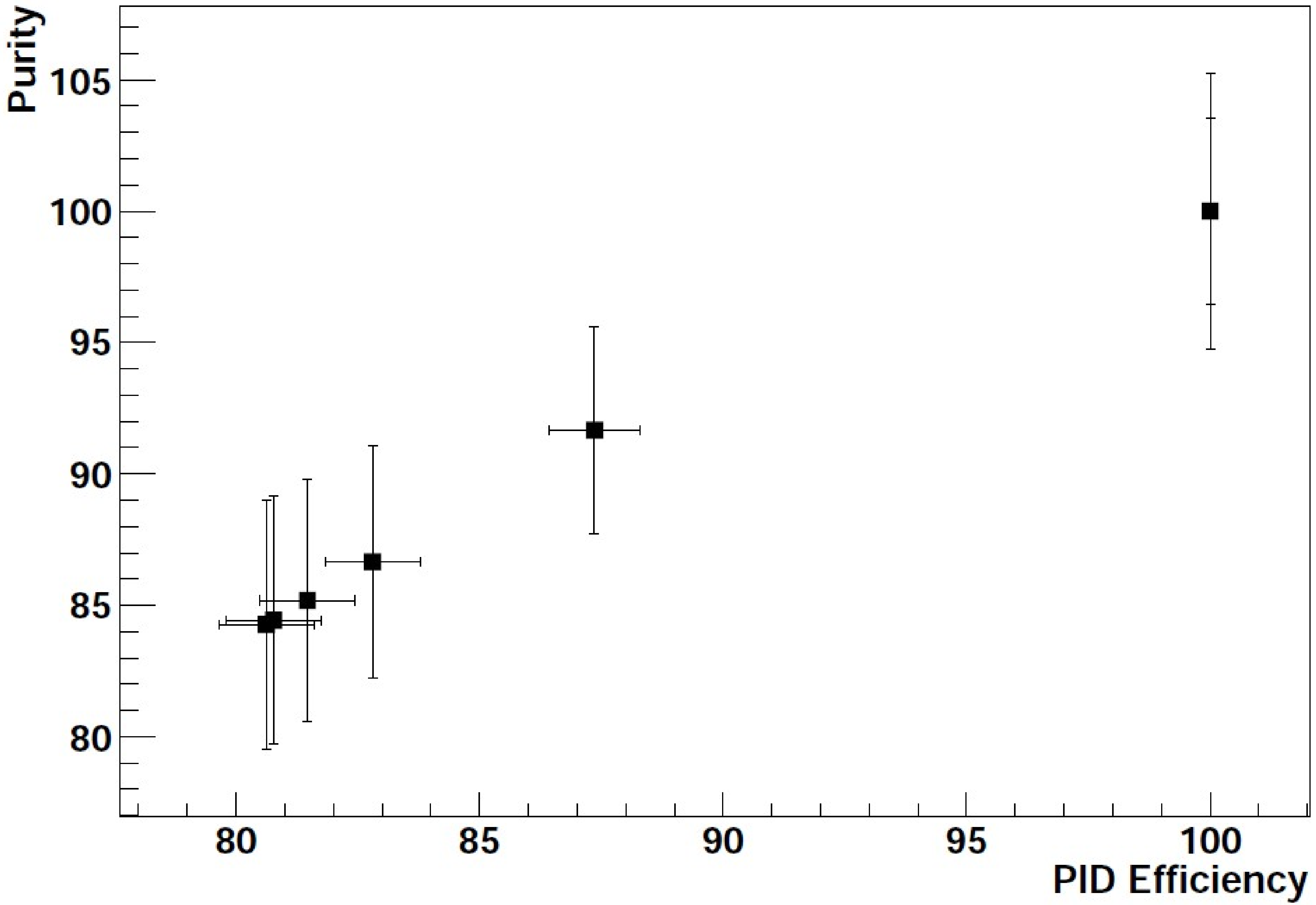
Efficiency and purity of commissioning variables

- Following plots produced for simulations of 200MeV/c muons.

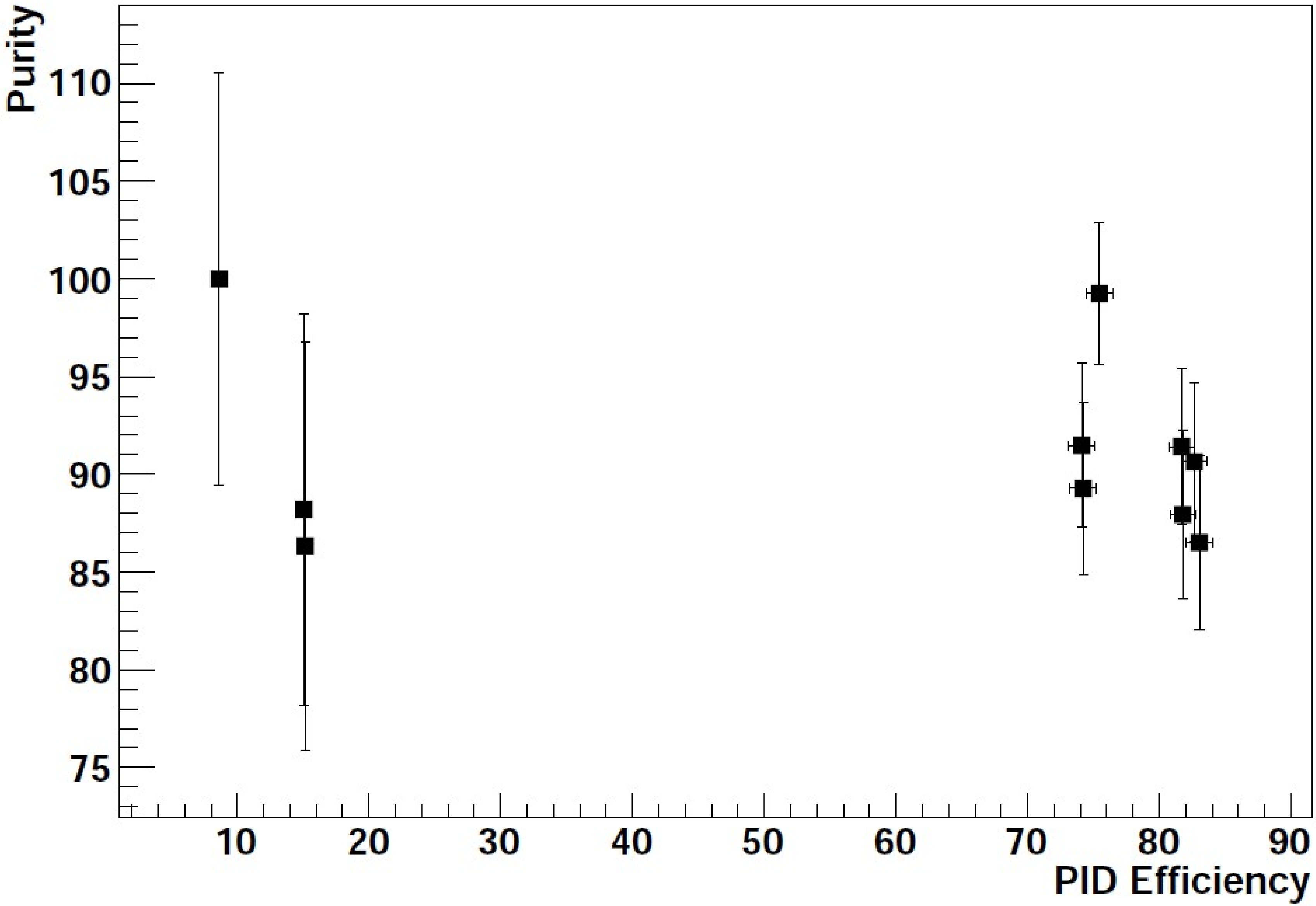
- Currently focusing on commissioning variables as
  1) the data already exists.
  2) waiting to hear what beam settings we are expecting to run with in Step IV.

- These are preliminary as
  1) They use my version of trackmatching.
  2) They have been run for legacy geometries due to issues with cdb geometries.

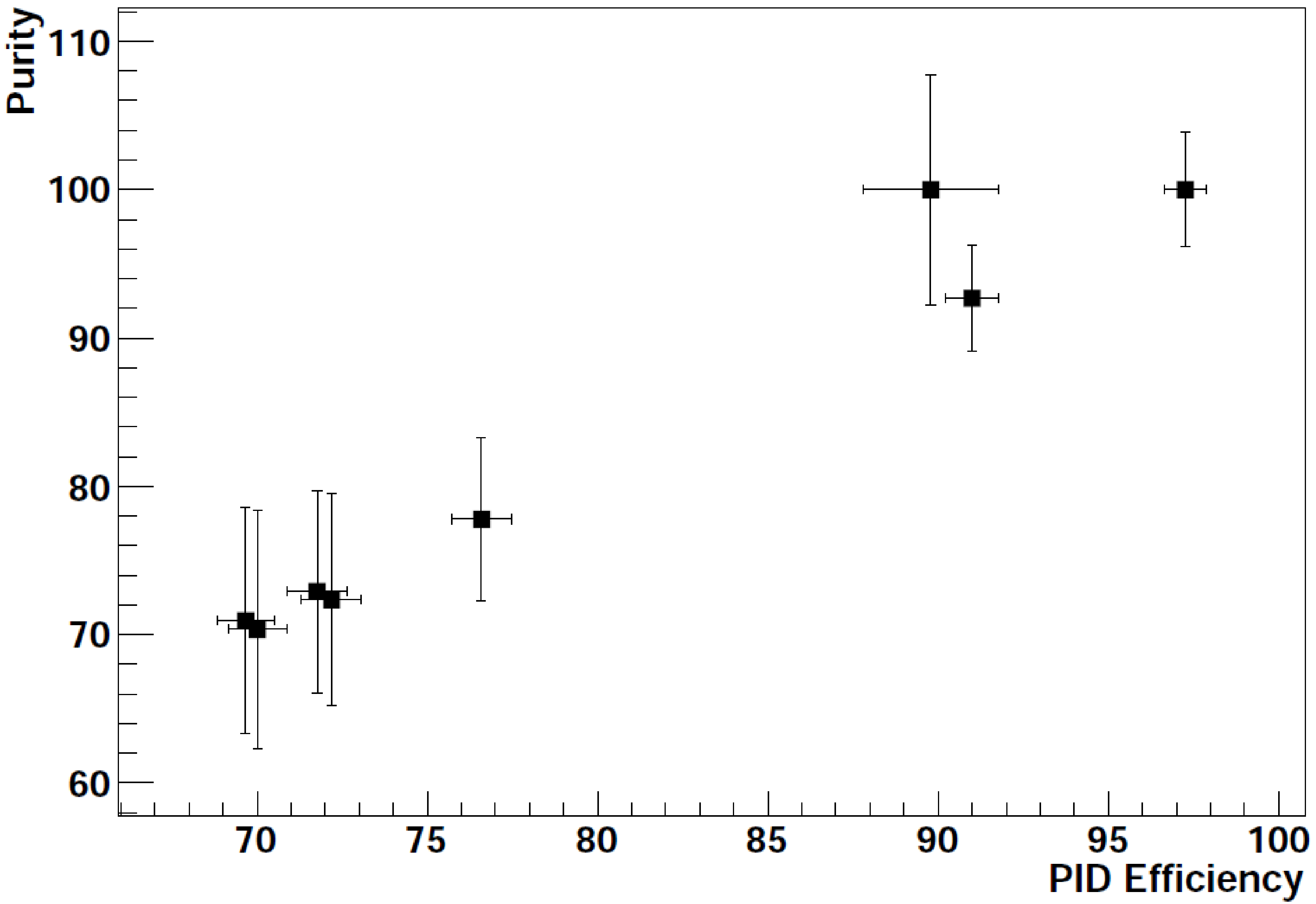
ComPIDVarA- diffTOF1TOF2



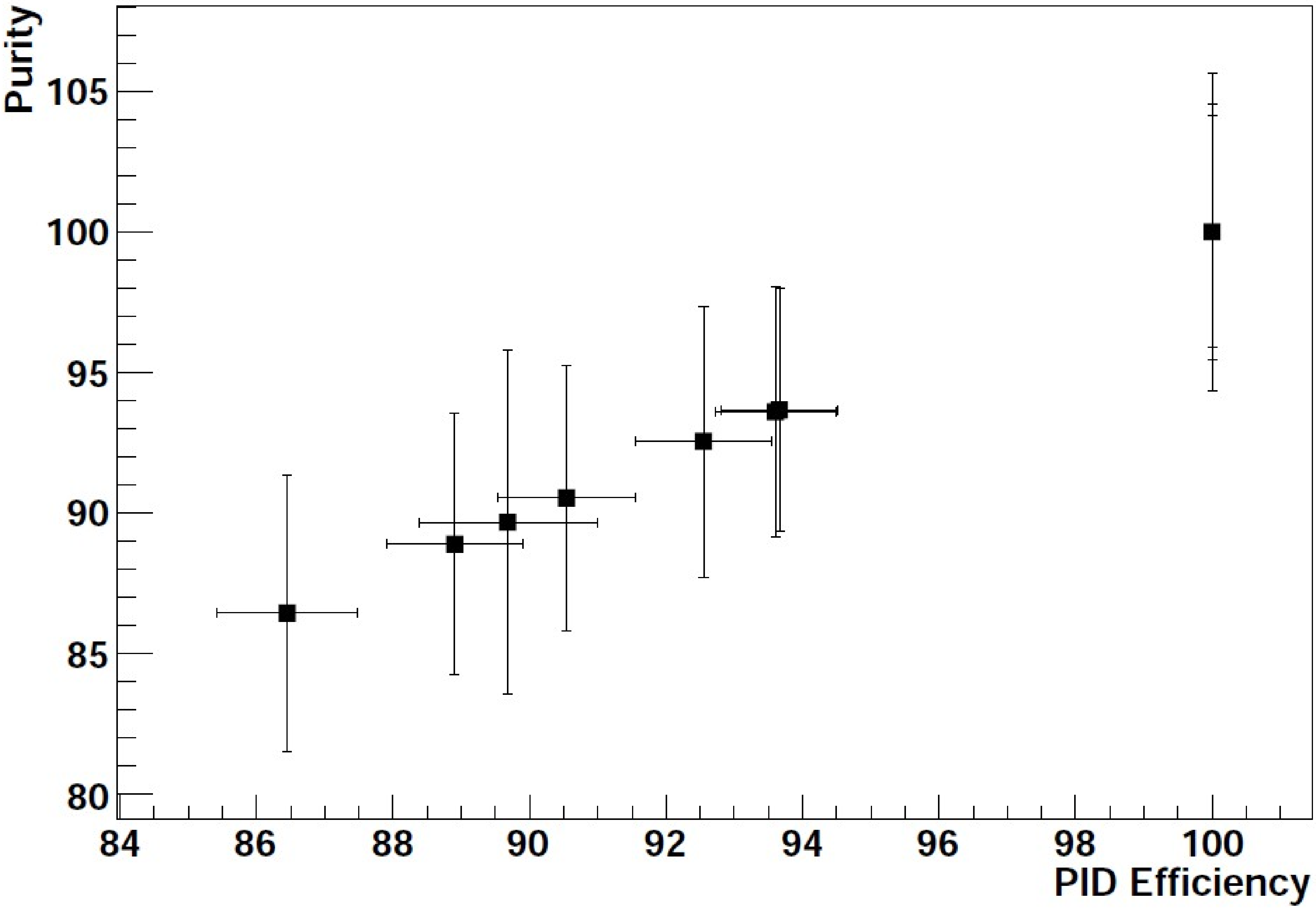
ComPIDVarB-KLChargeProdvsDiffTOF1TOF2



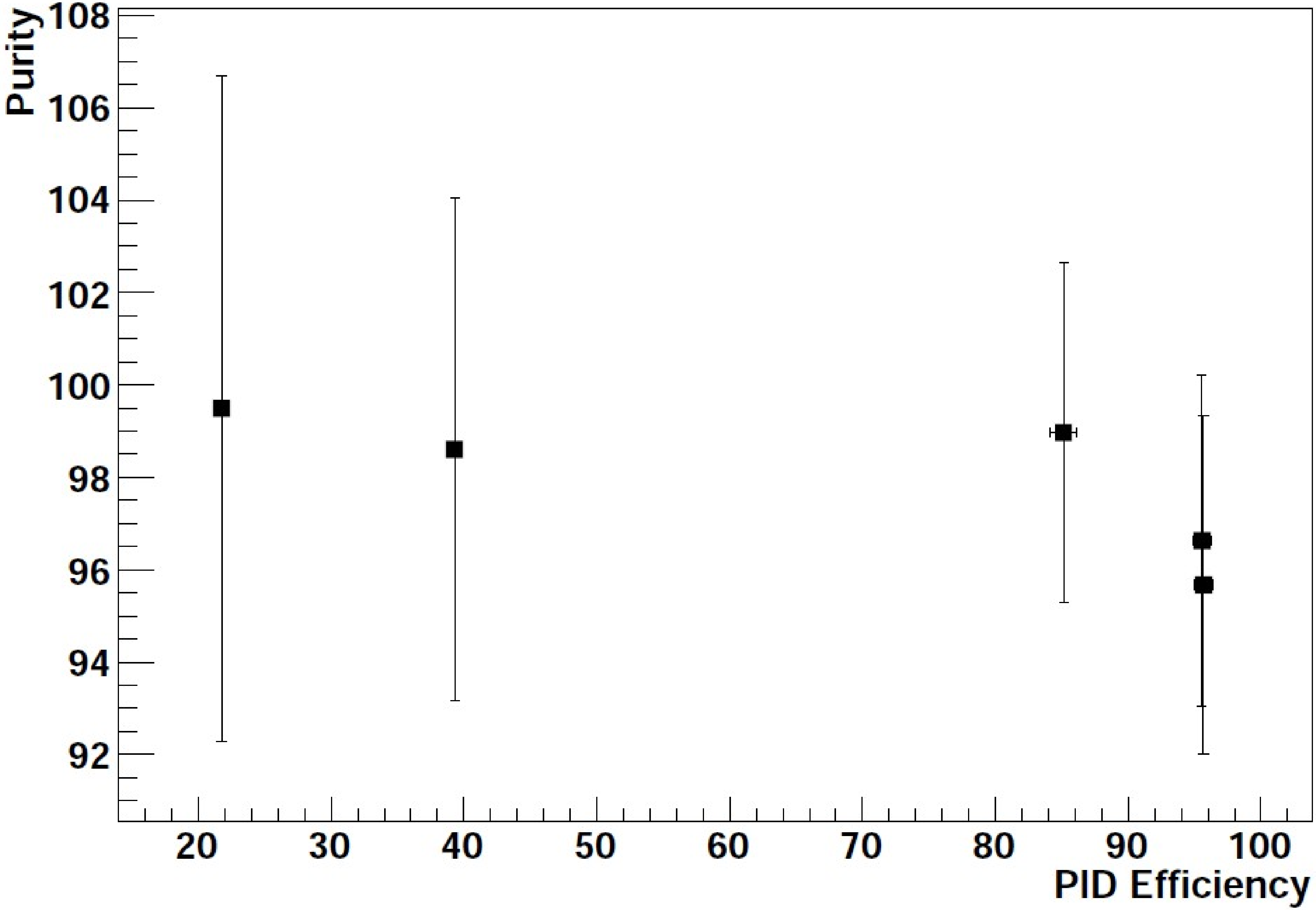
ComPIDVarC-CommissioningKLADCChargeProduct



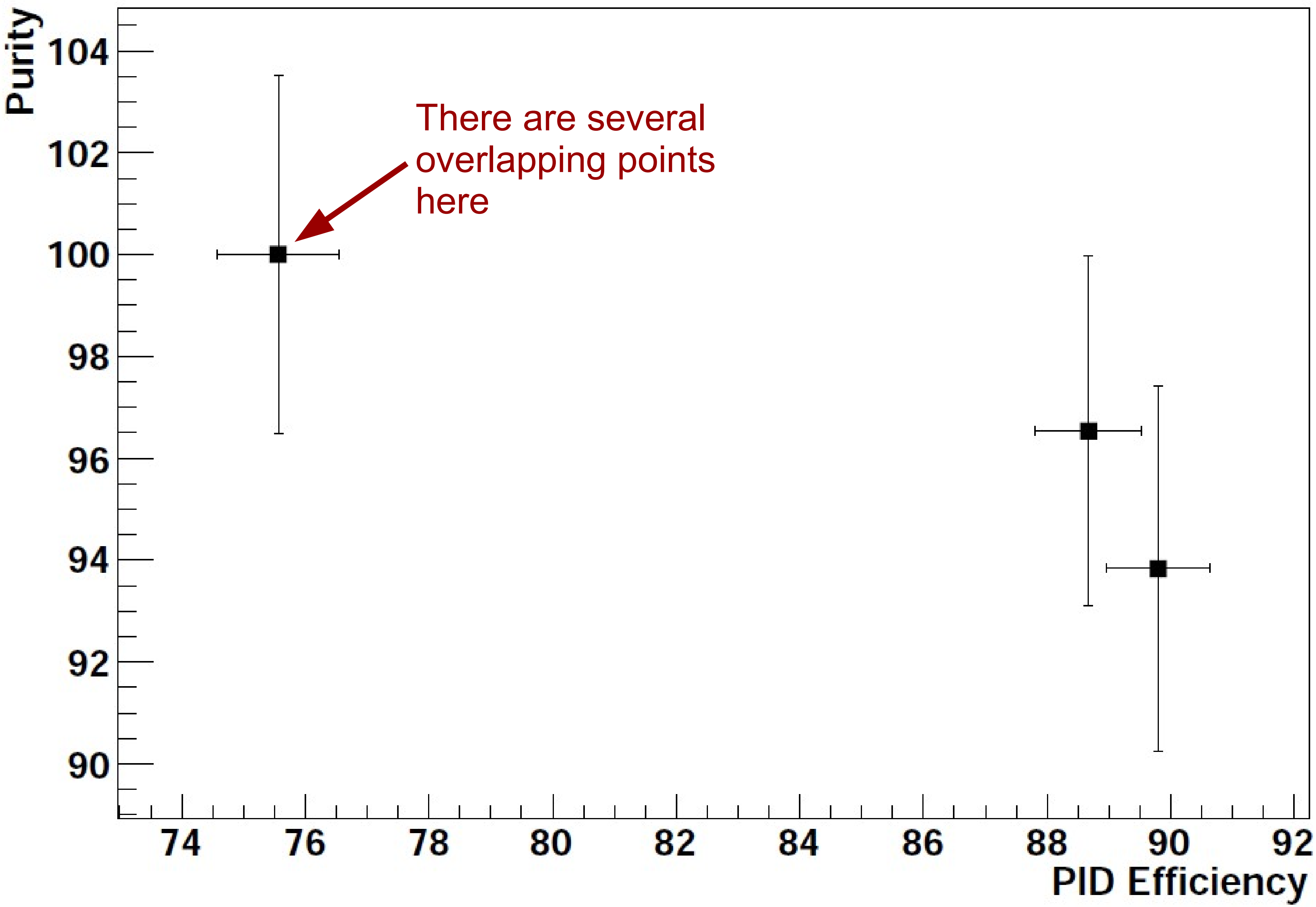
ComPIDVarD-CommissioningEMRrange



ComPIDVarE-CommissioningEMRrangevsDiffTOF1TOF2



ComPIDVarG-CommissioningEMR densityvsDiffTOF1TOF2



PID validation routines

• The aim of the validation is to confirm consistency of individual variables with MC, consistency between the the variables themselves (on MC), and then consistency between the variables on real data.

• Consistency with MC is determined by the purity.

• Consistency between the variables is determined by how often they agree on a pid hypothesis.

PID validation routines

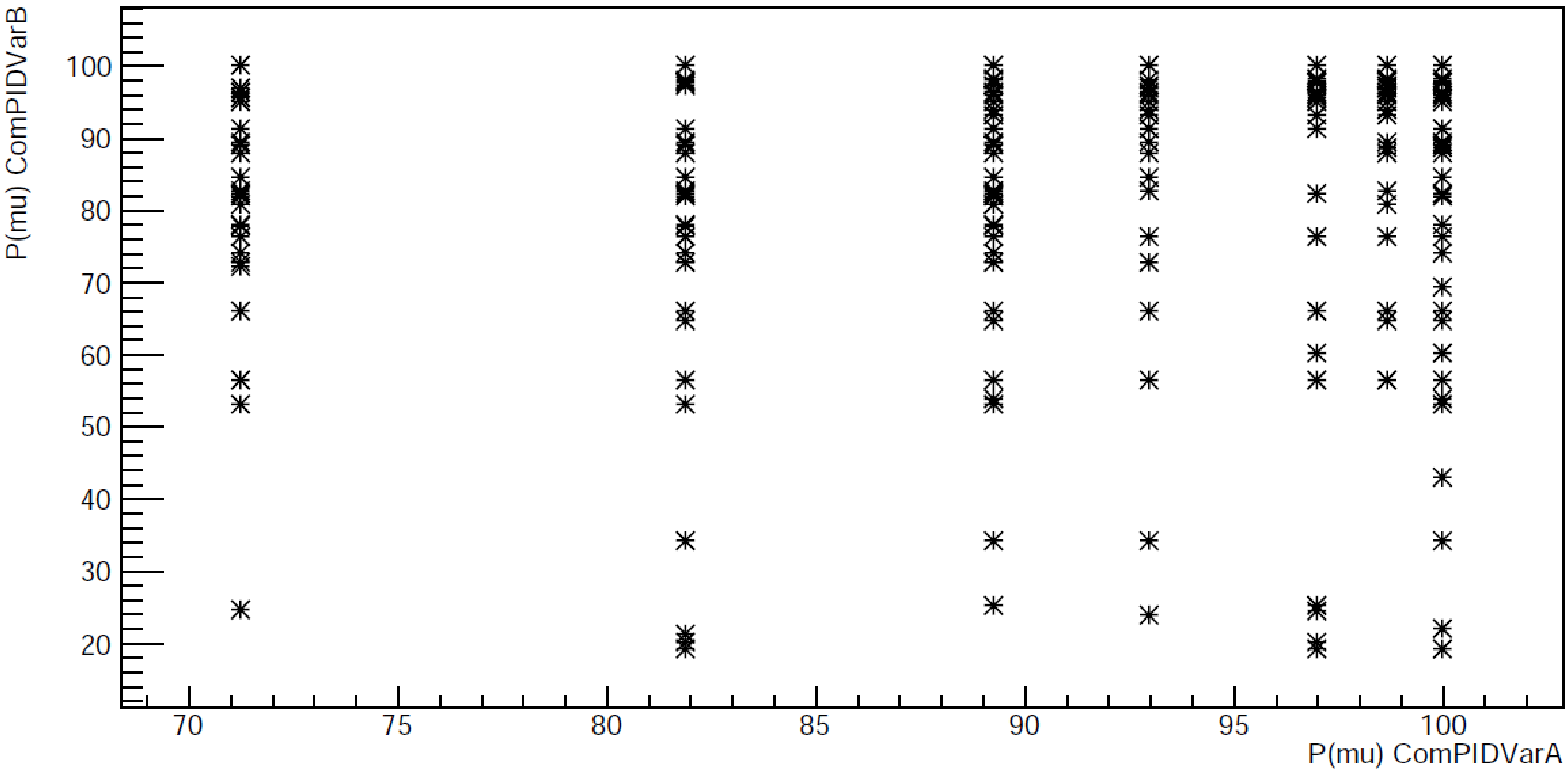
- Next few slides show comparisons of the probability that a particle is a muon, P(mu), as calculated by the PID variables, on a simulated sample of 200MeV/c muons.

- Points are only plotted in cases where PID has returned a pid for the track.

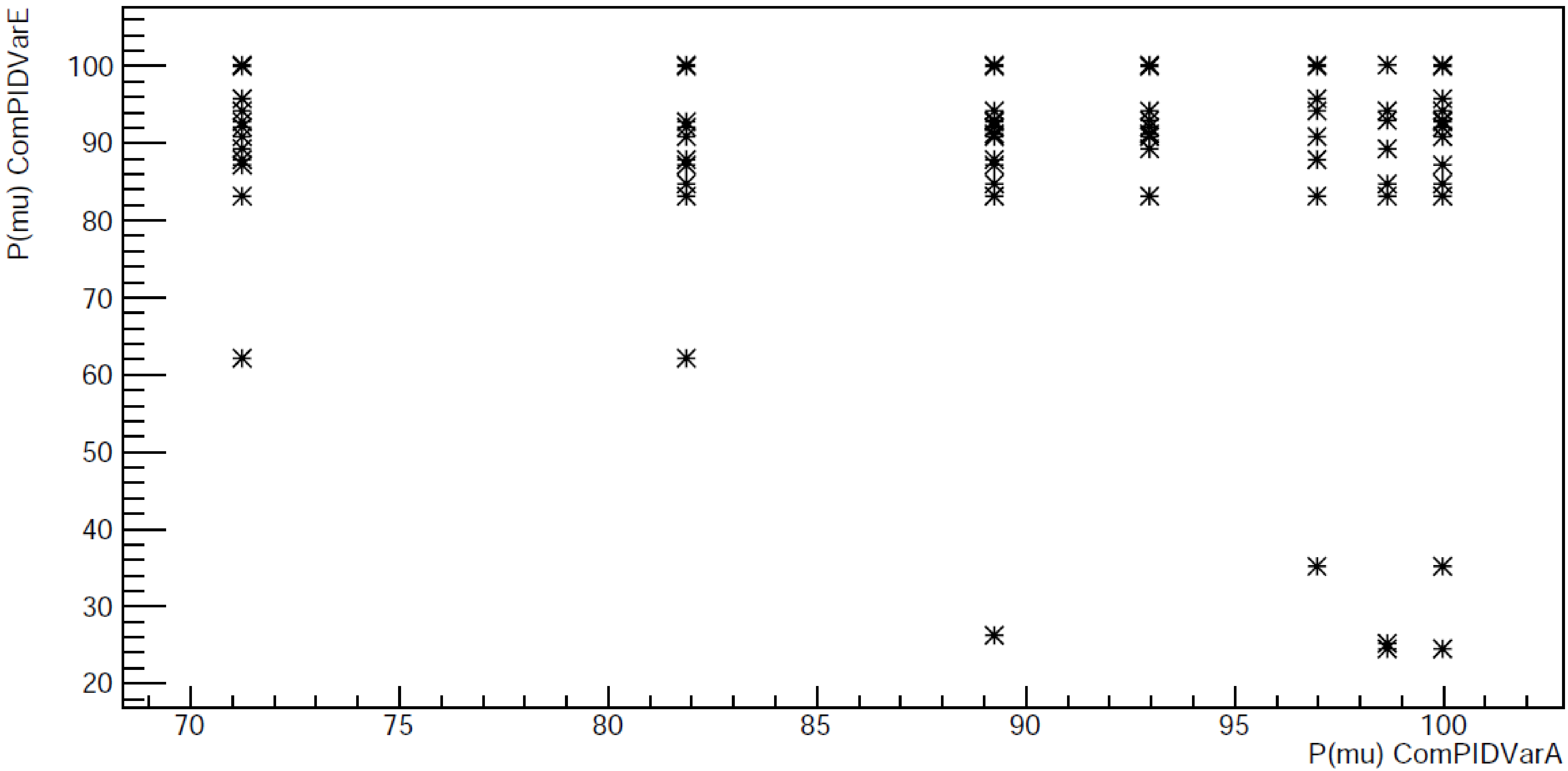
- Confidence level cut off is 10%

- A P(mu)>45% will have been identified as a muon.

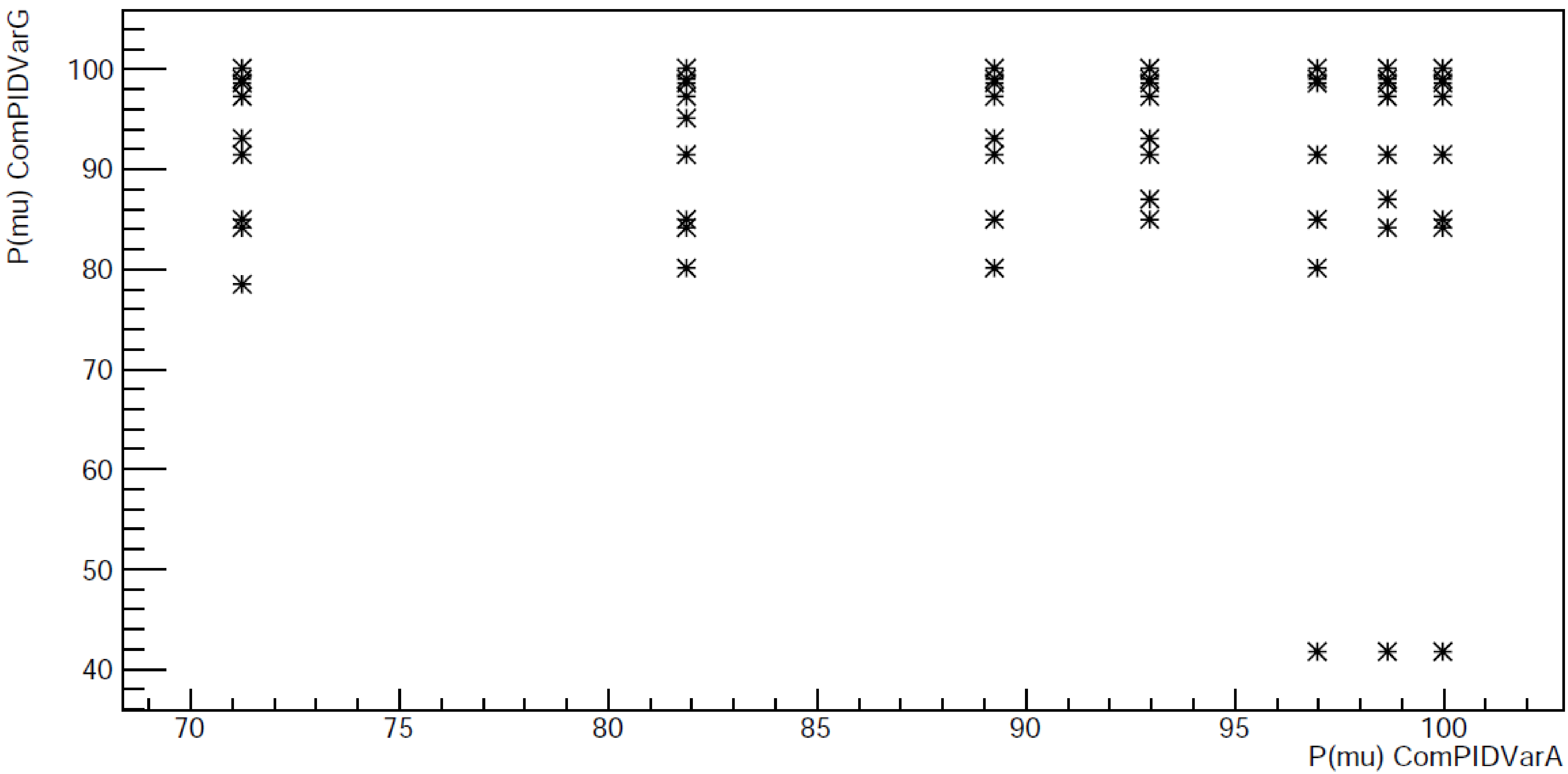
PID validation – ComPIDVarA/ComPIDVarB comparison



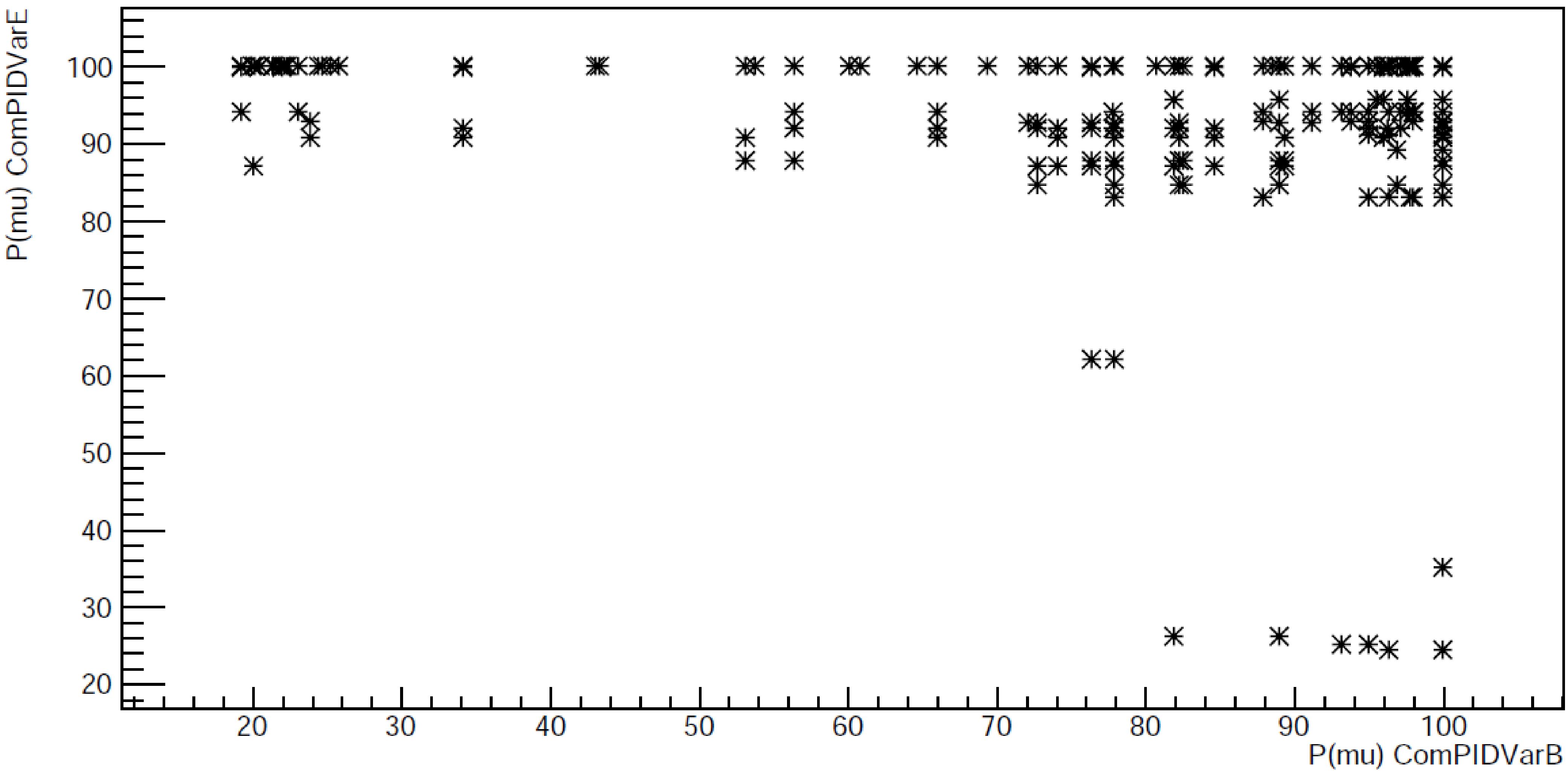
PID validation – ComPIDVarA/ComPIDVarE comparison



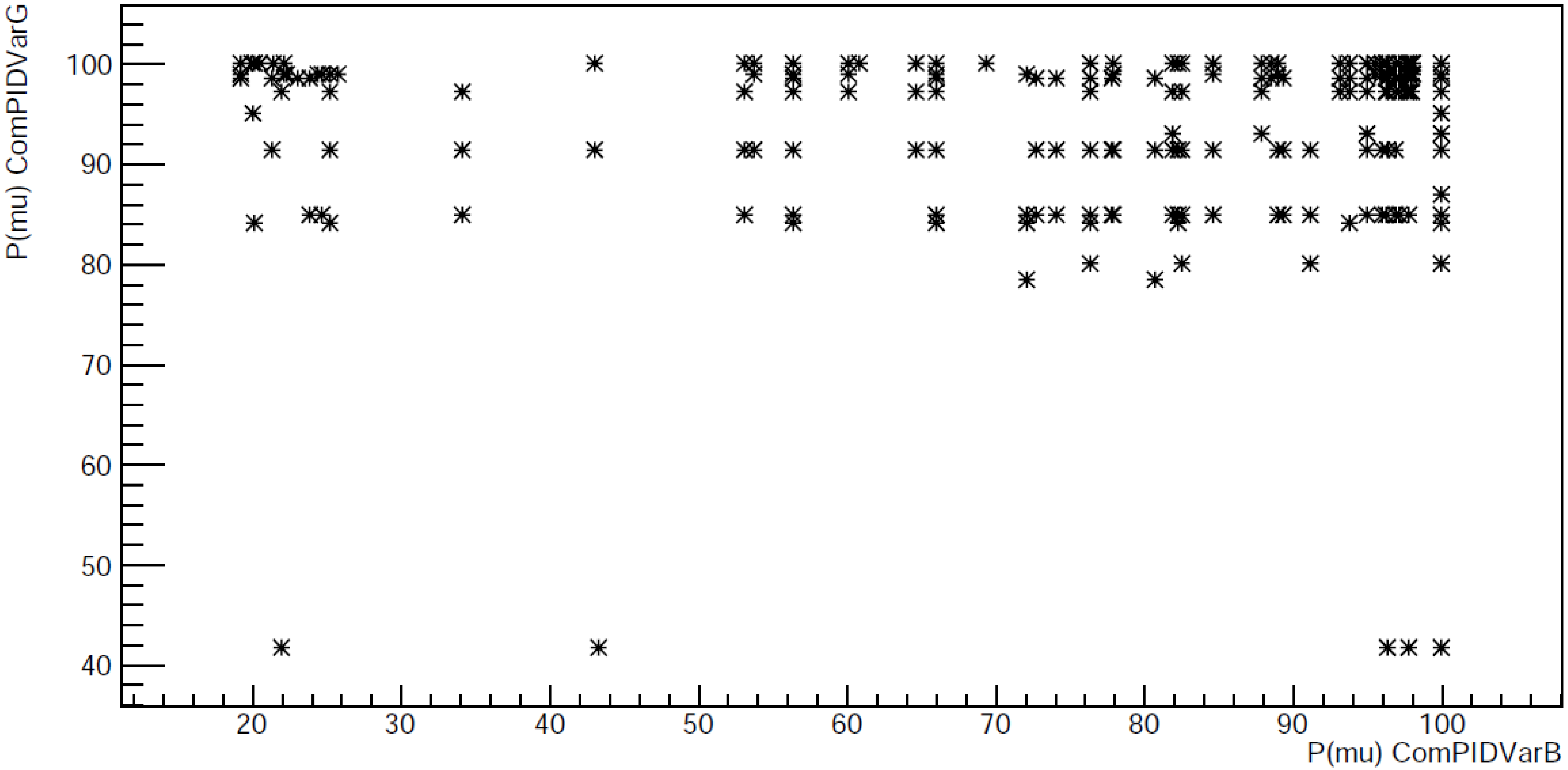
PID validation – ComPIDVarA/ComPIDVarG comparison



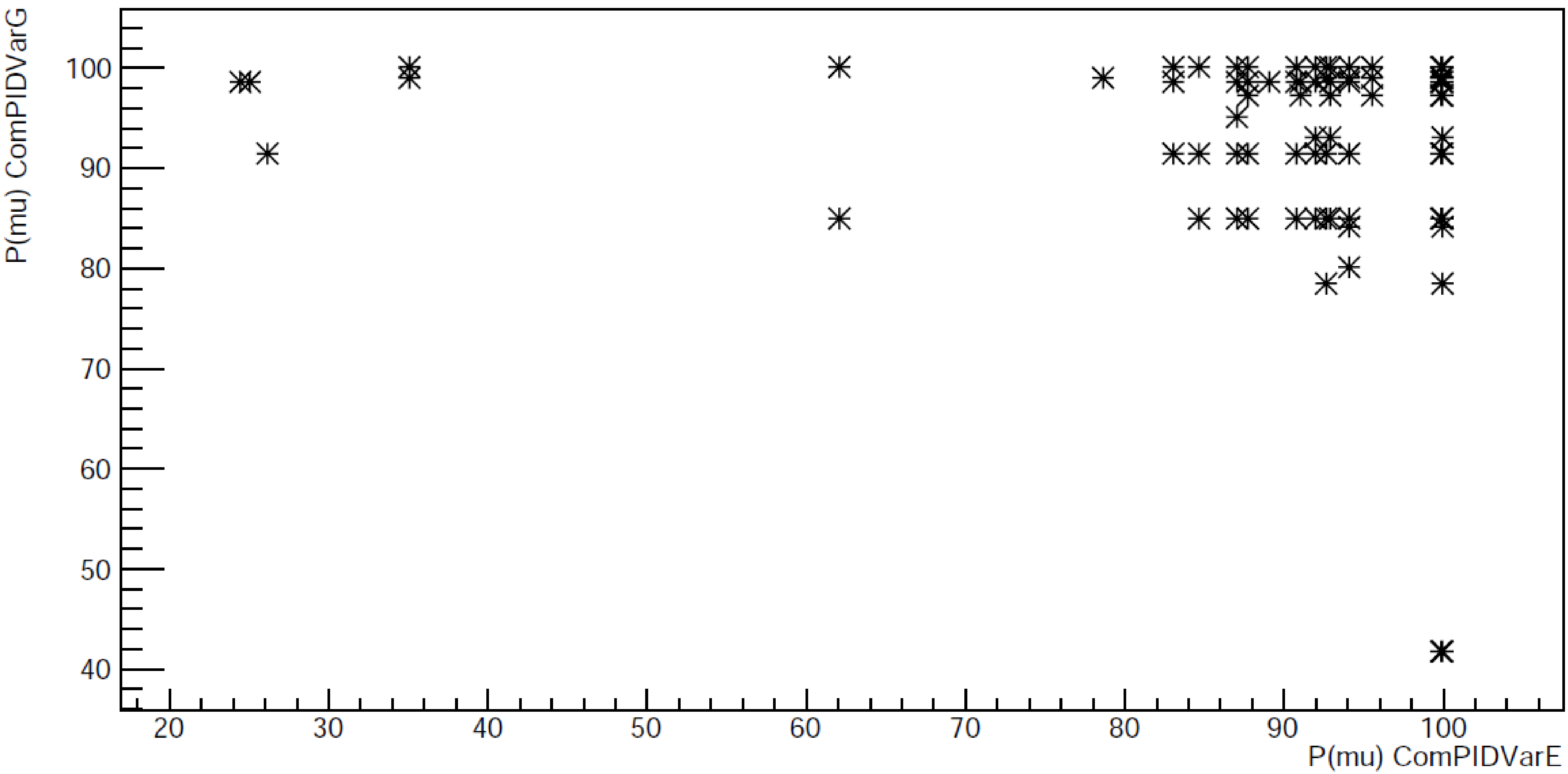
PID validation – ComPIDVarB/ComPIDVarE comparison



PID validation – ComPIDVarB/ComPIDVarG comparison



PID validation – ComPIDVarE/ComPIDVarG comparison



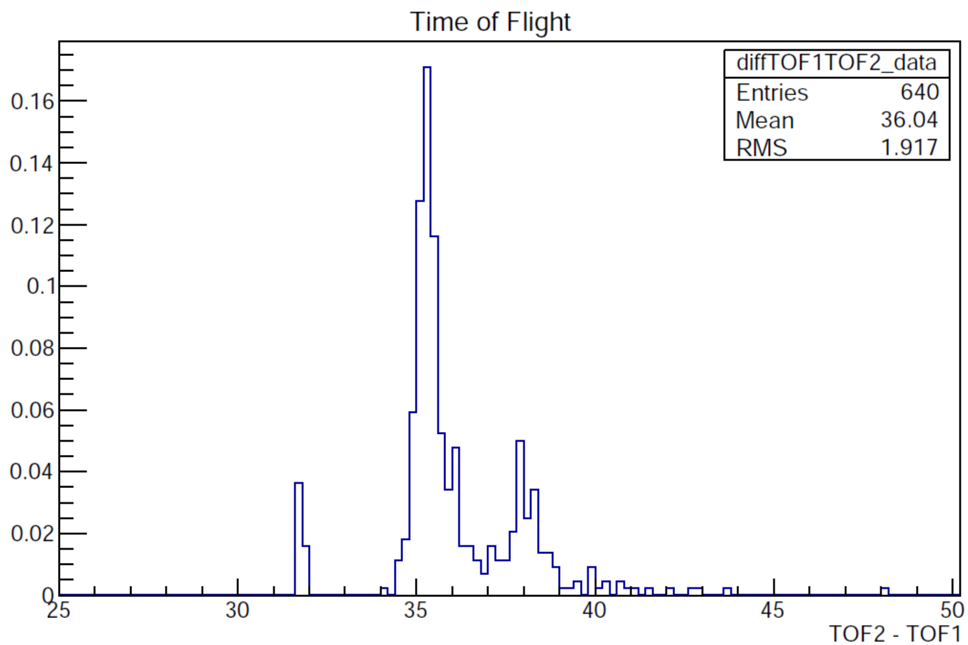
PID on 2015/01 data

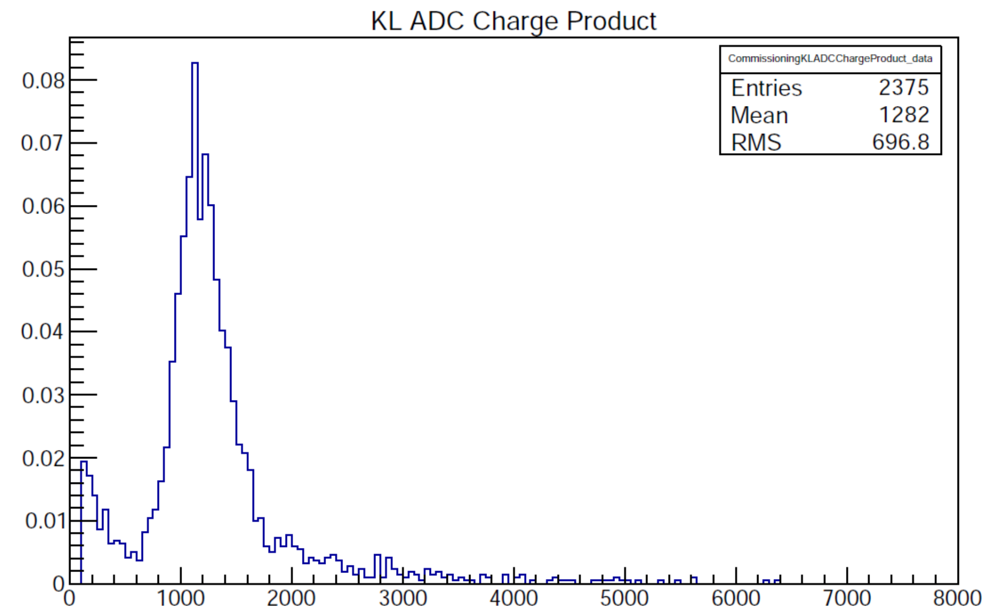
- Performed PID for runs 7076 and 7157 (both 200MeV/c muon beams)

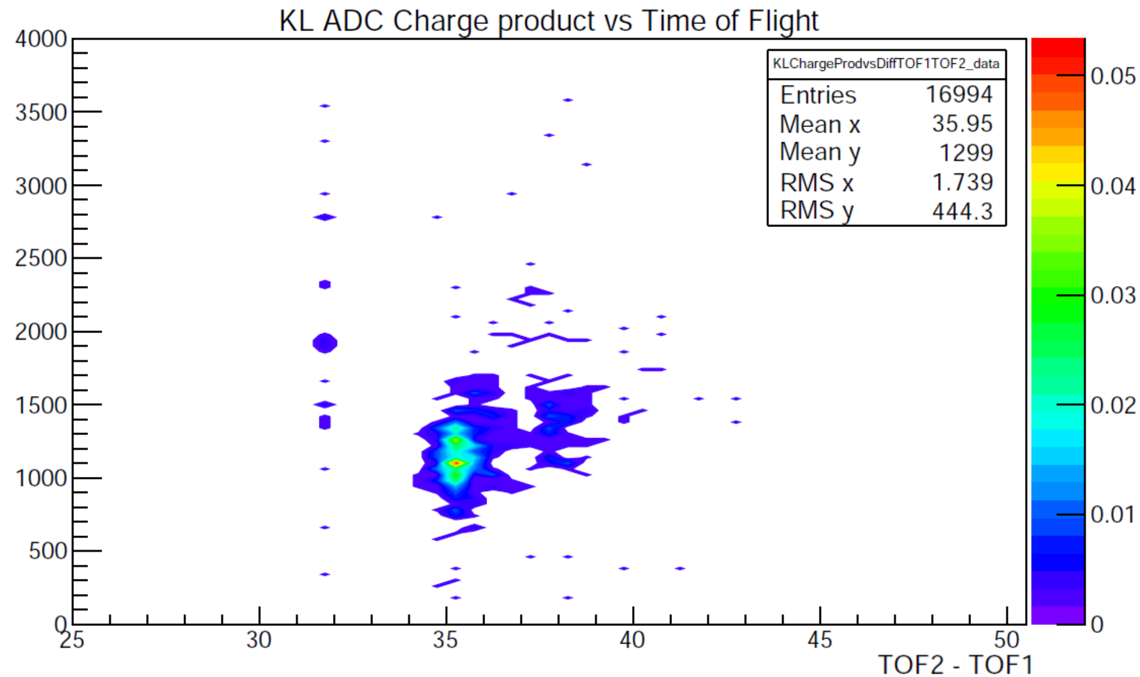
- 7076 produced no hits in the EMR, and 7157 only had 20 reconstructed EMR hits from ~10,000 recon events, so PID is based on TOF and KL.

- Still allows for a testing of the PID routines, even if not at full power.

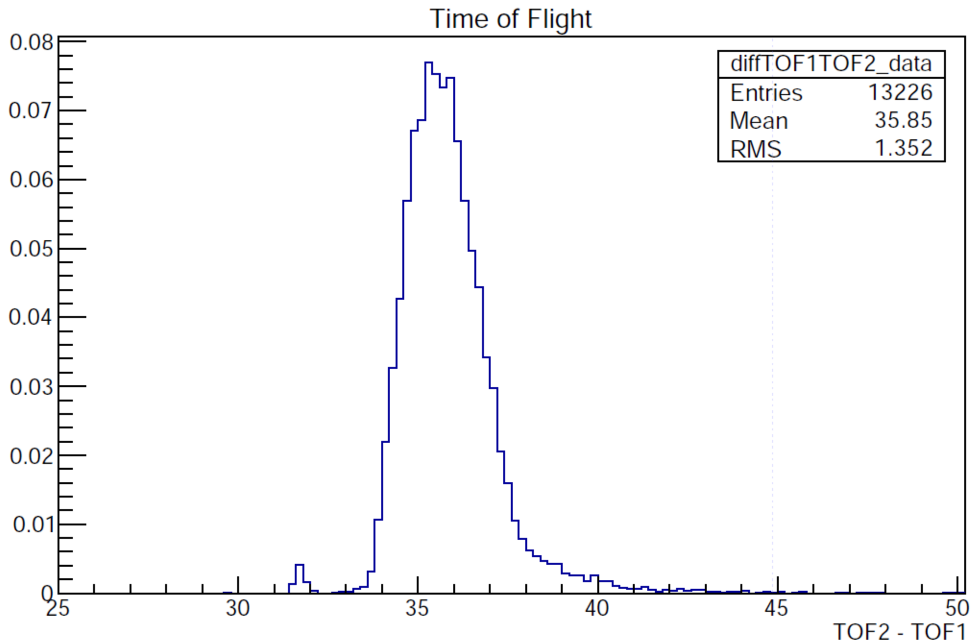
Run 7076 – distributions of data

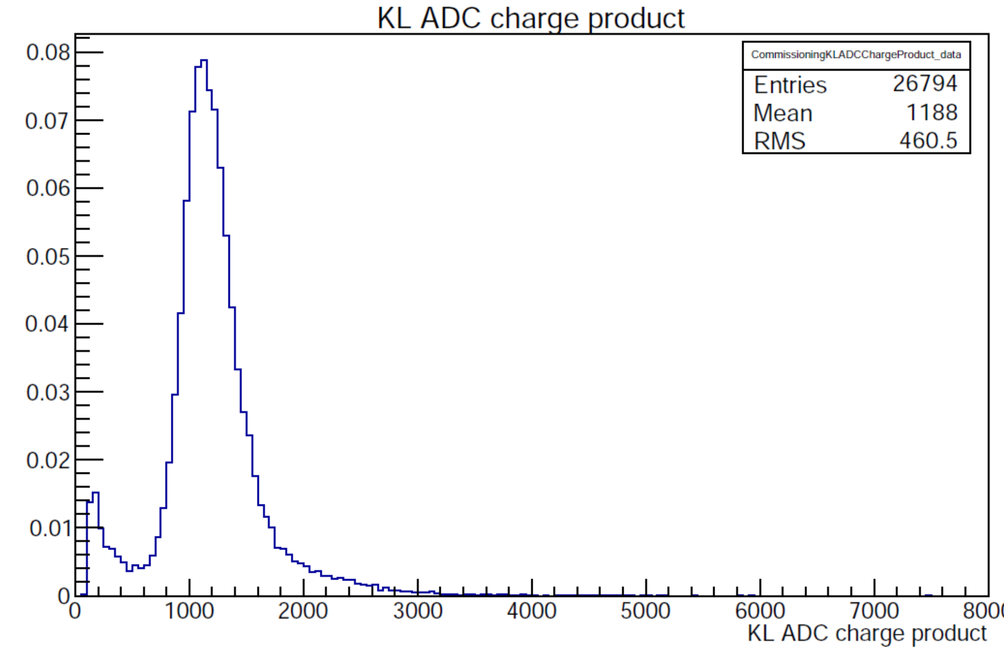


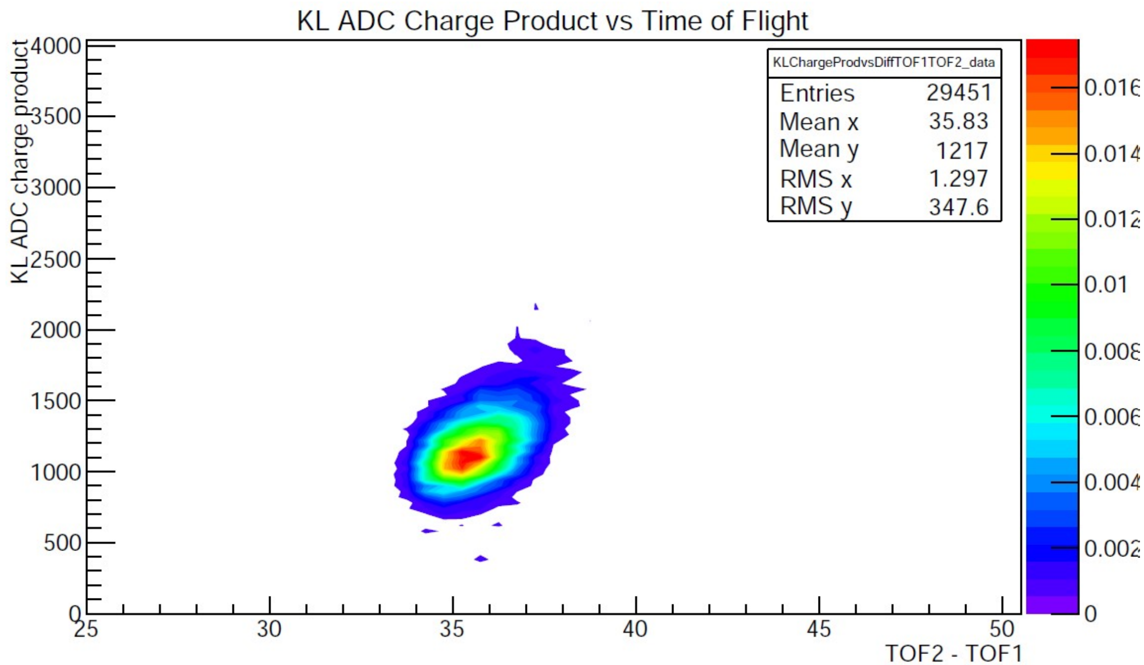




7157 – distributions of data







Next steps

• Ongoing efficiency/purity and validation studies.

• Improvements to PID variables based on these studies.

• Produce PDFs from more realistic beam simulations (g4bl).

• Update documentation and write a simplified guide to using PID.

Summary

- Efficiency and purity studies are ongoing.

- An approach to validation has been decided on and work has begun.

- PID of commissioning data has begun.

- Improvements to PID variables and to PDF generation are underway.

- Updates to tests and documentation are on the way.