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Verification of final 2002 pnn1 analysis cuts and PV acc./rej. measuring techniques

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Introduction

The goal of the studies described below was to verify cut sets and some procedures used in 2002 pnn1 analysis in order to use this as a reference point for the current pnn2 analysis. Three things were done:

1. the procedure of getting the final set of cuts used for the box opening is verified (identical results were obtained);
2. PV rejection with 2/3 with pnn1 data was remeasured (close, but not identical results);
3. PV acceptance with 2/3 with km21 (newly produced for pnn2) was remeasured. The results are close, a flaw seems to be found in the way correction is applied with blank-out method. When the new correction is applied the results of layer 18 method and blankout method are almost the same and both are higher than in TN K-034.

1 The final cut set

The verification of the final cut set is based on the following facts (files to be mentioned are on the `rarek*.triumf.ca` cluster):

- `~chensm/pnn_box` directory contains the, so called, small ntuple and a script. The script using data from the ntuple exactly reproduces the pictures in fig. 12, 13 in TN K-038 (the signal event in the box);
- the set of cuts was obtained which exactly reproduces this small ntuple;
- in combination with cuts in the script this gives the final set of cuts, i.e. cuts used to select events in the box.

With 2002 pnn1 analysis the final cut set had a form of a comis function. So the study aimed to make such a function. Also, to be useful this function should be automatically built by a script from individual cut codes located in the designated common area with minimal further editing (see the description of "Analysis system" in `/home/e949/pass2/02/anal/README`). The script takes `.def` file as its input where a few top level cuts are defined.

One of the ways of getting the final cut set as a combination of `.def` file and some manual editing was verified and described in a letter to pnn2 analysis developers which is also reproduced in the appendix A of this document.

The ntuples used for verification were the same ones used for 2002 pnn1 analysis (currently in `/home/e949/nt_pnn1/pnn_tmp`).

Note that at the time of this study `/home/e949/pass2/02/anal` directory (the area where, among other things, the individual cut codes are kept) was the same as for pnn1 analysis. It is going to (has been) evolve(d) as the pnn2 analysis develops. So following the procedure described in appendix A one will get different results (supposedly more appropriate for pnn2 analysis) with changes in the directory tree above. The original pnn1 analysis directory was renamed to `/home/e949/pass2/02/anal_pnn1`. To get the pnn1 final cut set one should set the environment variable `PASS2_ANAL` to this directory before running the building script. Even in this case one will not get the exact set of pnn1 cuts. The reason is that there was some further cut development after the box was opened. It seems to be reasonable to make use of it (see appendix A for more details).

2 PV rejection

With this study only the offline PV rejection was remeasured. It is measured by applying the PV cuts (simply referred to as PV in the following) to Kp2 peak events and observing directly the suppression factor. For studies described in TN K-034 a special sample of preselected events (passed setup cuts) was used which is still on disks (`rarek*.triumf.ca:/kdecay/data10a/e949/nt/phveto_rej_23`). This sample was not quite compatible with the code used for remeasuring so it was not used[1]. Instead I started from 2/3 pnn1 data supposedly the same which was used for producing the sample. The code for setup cuts seemed to be lost so setup cuts were constructed according to the description in p.23 of the TN K-034. Basically they select kp2 events from the peak.

Results were obtained for almost all (137 of 145) available tightness levels of the PV. They are shown in Fig. 1 as rej. vs acc. curves (red and blue points) where the acceptance for a given tightness of the PV is assumed to be the same as in the TN K-034 (The K-034 acceptance and rejection measurements are tabulated in `rarek00.triumf.ca:~e949/pass2/02/anal_pnn1/calib/pvprob02.dat-3.2`). For comparison the K-034 rej. vs acc. curve is also shown as magenta point connected by a line.

Originally red points were measured which correspond to the fully applied PV. However better agreement can be achieved if one of the PV component, BASTRD1, is turned off (blue points). BASTRD1 stands for "Both ADC and Single ended TDC in RS". This seemed to be how the curve in TN was measured. Blue point shows that the remeasured rejection values for the same PV tightness are slightly lower compared to what is in the TN.

[1]Although it's not completely impossible to use it

There are a few thing which may be worth to mention here regarding the 2002 pnn1 analysis PV rejection measurement: the PV rejection seemed to be never measured with Kp2 peak events with all other cuts applied (except r,p,E box, of course, which should be modified to select the Kp2 peak). It seems to be measured with the special sample mentioned above and with BASTRD1 category turned off. If true the latter should likely result in overestimation of the level of Kp2 background in the signal cells. The 2002 event is considered to be more muon-like, i.e. the cell it's located is dominated by muon background and changes in Kp2 background should not affect the final result. The effect of the former is probably small. My study shows, for instance, that applying final TD cuts, skim level TD cuts or not applying TD cuts at all almost does not affect the curve in Fig. 1.

The code used for the rejection remeasurement is in `rarek*.triumf.ca:/data00c/data13b/vavilov/pnn/pv`. `REAMDE.txt` file in there and Appendix B provide more information on this.

3 PV acceptance

As in TN K-034 the acceptance was measured with km21 monitoring data with two methods: layer 18 (L18) one and blankout one. With the former an additional setup cut, `layv4.le.18`, was applied which means that muons should stop before layer 19. With this method PV can be applied as usual. The fraction of events passed the PV is the acceptance measurement. Both total and online acceptances can be measured this way. With the latter method muons are allowed to hit BL and BV — we just ignore hits in the [-8,+4] sector range of the stopping sector in these subsystems of the PV. These 12 sectors are 1/4-th of the total (48). From here and on, these subsystems will be referred to as **blanked out** or **blanked subsystems**, the parts where hits are ignored will be called **blanked parts**. Then one needs to correct (reduce) the acceptance obtained in this way accounting for accidental hits in the blanked parts. Obviously one can apply only offline component of PV with this method. Assuming that the offline cuts are always tighter than online ones we consider this as the total acceptance measurement.

In K-034 the online acceptance was measured with the L18 method and the total acceptance was measured with the blankout method. Remeasuring is done with the L18 method for online acceptance and with both methods for the total acceptance.

3.1 blankout correction

You measure the apparent acceptance a and the failure fraction in the blanked out subsystems only f_1 (which mean that other subsystems are ignored; the blanked parts of blanked subsystems remain blanked, of course).

Then, with old method of correction, one seems to speculate that if the blanked out subsystems are back on the failure fraction would increase by 1/3. So one needs to subtract $1/3f_1$ from the apparently measured acceptance:

$$a_{bl} = a - 1/3f_1 = a - 1/3 \cdot (1 - a_1), \tag{1}$$

where a_{bl} is the final (corrected) acceptance obtained with blankout method, $a_1 = 1 - f_1$ is the acceptance measured with the blanked PV subsystems only. That should be a good approximation for small failure rates but is not correct in general, at least for the model of vetoing because of accidental hits. This way of calculation assumes that failure fractions in subparts of a detector are additive values, e.g. the failure fraction in some detector is equal to the sum of failure fraction in its halves (measured with other halves ignored). To prove that it's wrong it's enough to assume the failure fraction of 0.6 in each half...

It's easier to think about this in terms of acceptances. In the model of accidental vetoing acceptances of isolated parts of a detector are multiplied to get the overall acceptance. Indeed, the probability for an events to pass is equal to the probability not to have accidental hits in one part of the detector times the probability not to have accidental hits in the next part times..., etc. Unblanking 1/4 of the of blanked subsystems adds a factor of $a_1^{1/3}$ (remember a_1 is the acceptance measured with 3/4) and this is the correction term:

$$a_{bl} = a \cdot a_1^{1/3} \tag{2}$$

3.2 The measurement

Statistics used were 2/3 of km21 from the recent (June(?), 2005) production run.
Setup cuts were as described in "Acceptance Sample" subsection in p.24 of TN K-034 plus bad_run cut including some manually added runs found in Kentaro's script. Basically the standard PSCUT02 were applied, kinematic cuts were set to select muons in the muon peak in (p,E) space with $R > 37$ cm.

The comparison of the online acceptance measurements is given in Tab. 1.

Table 1:

	Remeasurement	K-034
HEX	0.935 ± 0.001	$14168/15183{=}0.933 \pm 0.002$
HEXafter	0.965 ± 0.001	$13869/14168{=}0.979 \pm 0.001$
EC	0.989 ± 0.001	$13711/13869{=}0.987 \pm 0.001$
BV	0.988 ± 0.001	$13562/13711{=}0.989 \pm 0.001$
BL	0.981 ± 0.001	$13308/13562{=}0.978 \pm 0.001$
(L20ct+L21ct)	0.993 ± 0.001	$(13220/13308{=}0.993 \pm 0.001)$
Online TOTAL	0.859	0.871 ± 0.003

The worse matching line is for HEX afterburner, but Kentaro is known to use a software simulation of this condition while here a real trigger bit is used.

The total acceptance measurements were done for almost all (137 of 145) available levels of tightness of PV. Fig. 2 compares them to ones from the TN K-034 (Kentaro's blankout 145-level measurements are tabulated in `rarek00.triumf.ca:~e949/pass2/02/anal_pnn1/calib/pvprob02.dat-3.2`). The horizontal axis is Kentaro's tabulated acceptance measurements, the vertical axis is remeasured values. Blue points are a_1 measurement, dark blue ones are a measurements, black ones is the blankout acceptance corrected according to (2), red — according to (1), magenta points are layer 18 method measurements.

The points of interest here are red, magenta and black ones. Red points are close to the diagonal line which means that applying the old style correction reproduces quite close the K-034 results. Applying the new style correction (black points) produces results very close (<1%) to L18 method measurement (magenta). This is also illustrated in Fig. 3 where differences of above measurements and black points (the new style correction blankout acceptance A) are plotted as a function of A (color codes are the same).

Appendix A

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Short instruction
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1) Use the following instruction in your .def file:
FUNC_DEF: TRBIT_1 SKIM1_OR_SKIM4 BAD_RUN PVPROB02 TDPROB02 PSCUT02 KINCUT01

2) Build a comis function and myfunc_dir in an usual way:
   $PASS2_ANAL/build_func.csh your.def comis

3) Add the following to your code:
   a) CALL FIX_ALL(0.) - Should be called before any other function,
      makes some correction to kinematical quatities. Perhaps, it's not
      needed if KINCUT01 is called as a first function in your code
      because it calls FIX_ALL inside. According to Shaomin it's safe
      to call it at the beginning anyway.
   b) IF(CUT(13)) RETURN !bad stc PASS1 cut. Shaomin had it.
   c) Use the condition bgpv.lt.Npv.and.bgtd.lt.Ntd after all other
      functions to make a final box. "bgpv" and "bgtd" come from the
      calls to PVPROB_02(0,bgpv,sigpv) and TDFUNC_02(0,bgtd,sigtd)
      respectively. Npv=1.0, Ntd=1.0 should correspond
      to the 1x1 box, Npv=4.00489, Ntd=4.23529 correspond, accoding to
      what written in Shaomin's script, to extended box.
      I haven't check which of this settings correspond to using
      PVCUT02/PVCUTNEW, TDCUT02 if latters were ever used in the final
      analysis at all.

      I must also note here that if one wants to define a standard PV
      cut position with bgpv, he/she should use bgpv.lt.1.0
      (not  bgpv.le.1.0) as I wrote above. It's a bit confusing:
```

```
   bgpv=1.0 corresponds to events which fail standard PV cut (but
   pass the next looser cut position).

You code should be now almost indentical to what was used for opening the box.



Comments
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0) The above was found out in the course of a few trial (finally
   successfull) to reproduce
   the statistics of the so called small ntuple which contains only in
   box (big one) events and without cuts on (p,R,E). The ntuple was
   produced by Joe/Jingliang/Shaomin and used at least for making
   picture for the tn-038 and acticles.
1) Differences between the code made as above and the actuall code
   found in Shaomin's area will be:
   a) the actual code used by Shaomin read in pvprob02.dat-3.2 (with
      myfunc_dir/pvprob_02.f) while the code above will use pvprob02.dat
      the latest version recommended by Kentaro.
   b) dbgeo_tgic_pv.f will be different from Shaomin's one and,
      according to Jingliang, more appropriate for further studies.
3) Don't use a 2003 version of pawX11 (at least at rarek* machines) -
   the results are completely screwed up with it. To reproduced the
   small ntuples exactly I used the 2001 version (can found at
   rarekXX:~vavilov/cern/2001/bin/pawX11). 2002 version seems to be
   ok too although it doesn't reproduce the ntuple exactly.
4) The code above rely on some external stuff, in directories:
   /home/e949/pass2/02/anal/include
   /home/e949/pass2/02/anal/calib (all on rarekXX cluster)
5) The working code (although reproducing Shaomin version) can be found
   at /kdecay/data00c/data13b/vavilov/pnn/mixture,
   DVREADME.txt file is provided there.
6) Original Shaomin' directory regarding making the small ntuple is
   ~chensm/pnn_box (on rarek's again). Look for skim1.f.
```

Appendix B. Some technical details about implementation of PV acc./rej. remeasuring code.

The PV acc./rej. studies assume that repeating measurements are done for the different PV tightness. Instead of doing this by hands the standard `pvprob_02(0,bgpv,sigpv)` function is used. It calculates so called background and signal numbers (`bgpv,sigpv`) for an event based on how tight is the PV the event is able to pass. If the event fails the n-th level of PV tightness but passes the (n-1)-th one (looser PV) it's assigned a particular unique background number. The higher is n the lower is the assigned number. So counting the number of events with $bgpv < bgpv_1$ one counts the number of events which passed the PV of a particular known tightness.

Technically at the beginning of execution of the main comis function (named `skim1.f` for both acceptance of rejection measurements) the set of possible background number values is calculated based on the data in `rarek*.triumf.ca:~e949/pass2/02/anal_pnn1/calib/pvprob02.dat-3.2` in the same way `pvprob_02` function itself does that. Then a non-equividistant histogram is booked so that each different background number would fall into the different histogram bin. The histogram is filled with events passed setup cuts. Then the set of acc./rej. measurements can be found as $a_i = \left(\sum_{j=1}^{i} b_j\right)/N_{setup}$ (acc.) or $r_i = N_{setup}/\sum_{j=1}^{i} b_j$ (rej.), where b_j is the number of events in the j-th bin, N_{setup} is the number of events after setup cuts.

All my code as well as some of Kentaro's is located in `rarek*.truimf.ca:/data00c/data13b/vavilov/pnn`. README.txt files should be useful. Below the top level README.txt is reproduced.

```
Summer 2005 studies
===================
acc/                    - PV acceptance measurement

confirm/                - Kentaro's 2002 PV rejection measuring code adopted by
                          DV and run once to confirm that Kentaro's code
                          reproduces K-034 results with Kentaro's code
                          (results were positive).
confirm.tar.gz          - original file sent by Kentaro.

mixture/                - the final cut set verification

pv/                     - PV rejection measurement

pv_acc_blankout/        - example of Kentaro's blankout acc. measurement
pv_acc_blankout.tar     - original file sent by Kentaro.

pv_acceptance/          - Kentaro's acc. measurement code (the one he uses
                          in KEK)
pv_acceptance.tar.gz    - original file sent by Kentaro.

pv_rejection/           - Kentaro's rej. measurement code (the one he uses
                          in KEK)
pv_rejection.tar.gz     - original file sent by Kentaro.
```

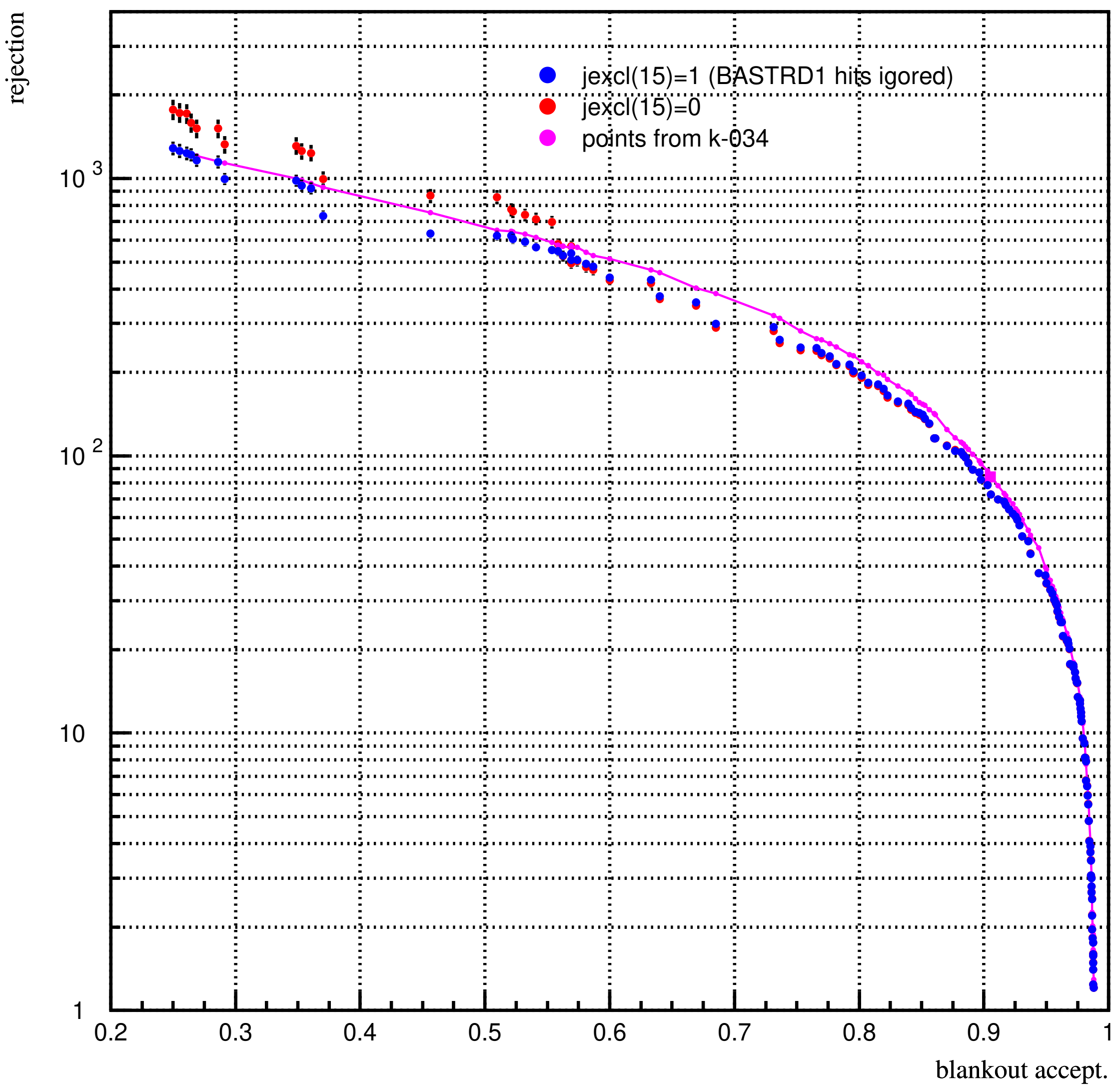

Figure 1: PV rejection vs acceptance plot. Here only the rejection was remeasured, acceptance values for different tightness of the PV were taken as in TN K-034

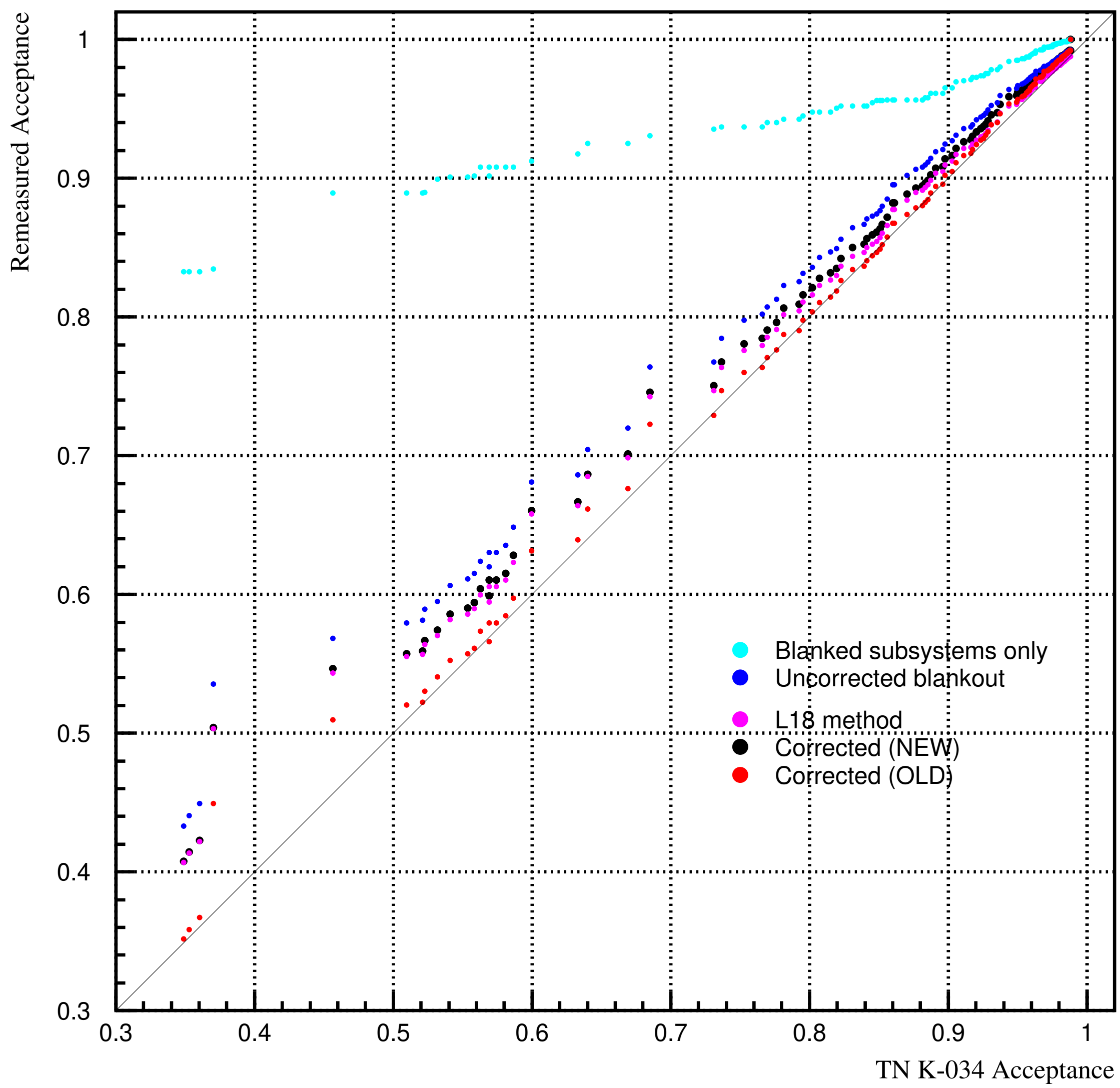

Figure 2: Acceptance remeasurements for different tightness of the PV

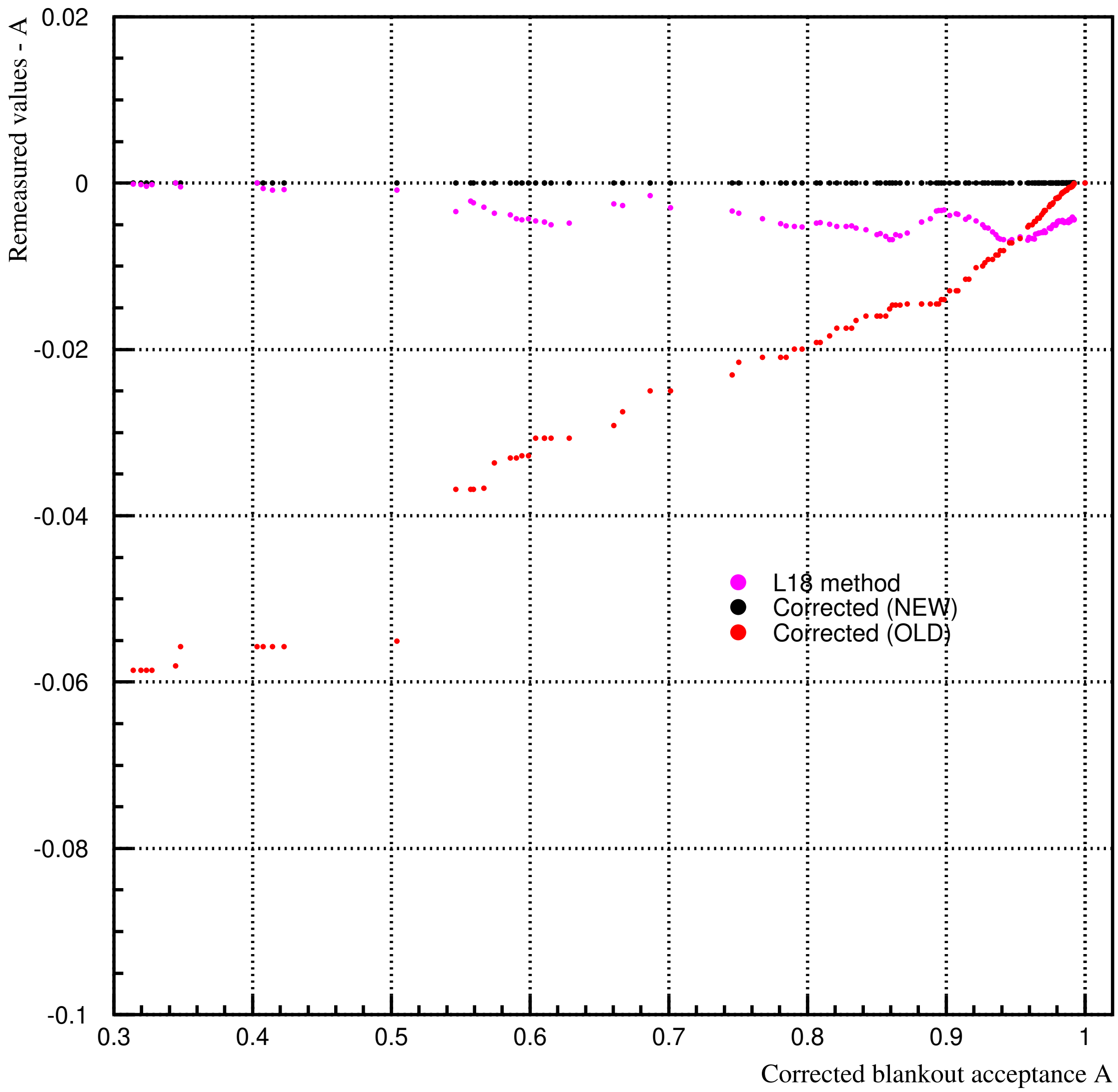

Figure 3: The difference to corrected blankout acceptance for different tightness of the PV