Issue with ProbNNp in $\Lambda^0 \to p\pi$ sample

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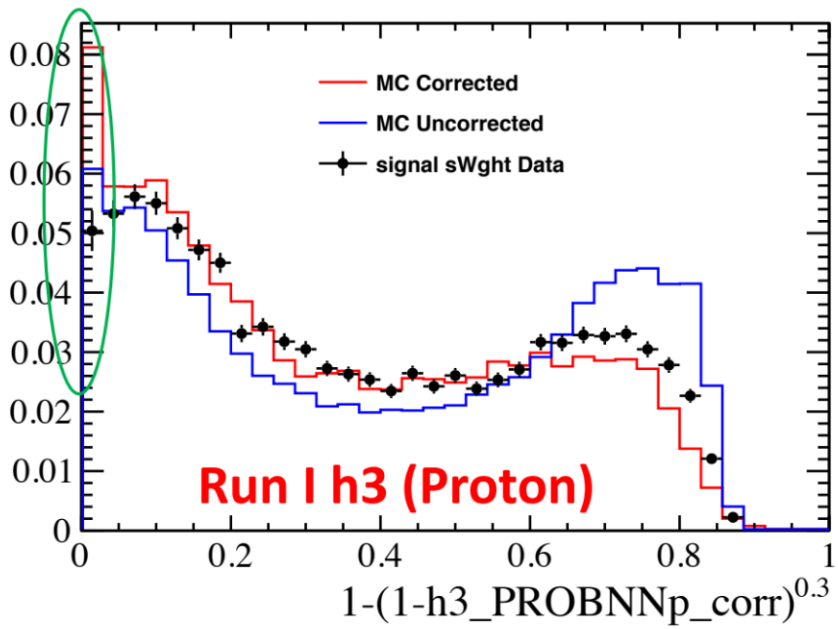
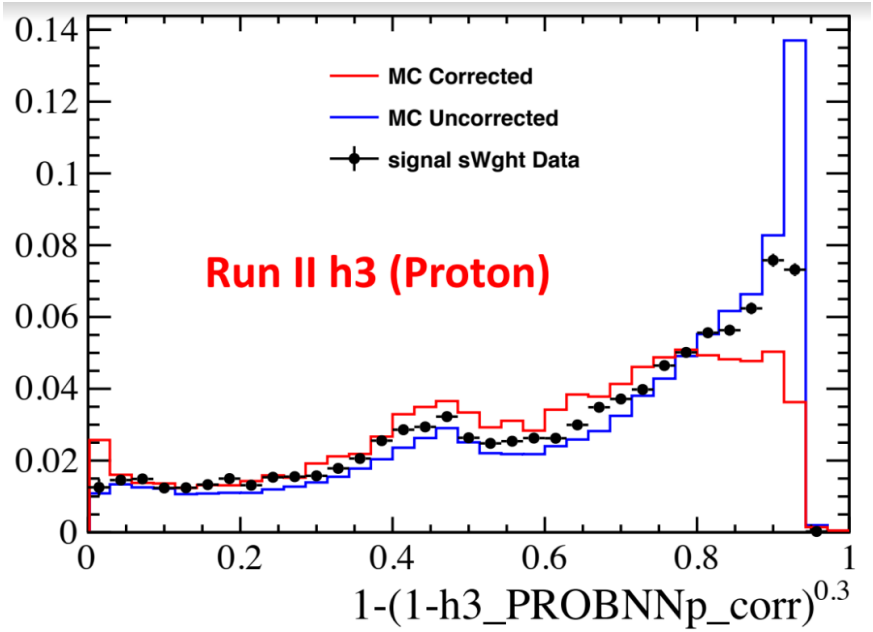
ProbNNp distributions in Run2

Issue first seen by Abhijit in his $\Xi_b \to pKK$ analysis.
Resampling of ProbNNp variable in Run1 (left) and Run2 (right). Control channel $B \to p\bar{p}K$.

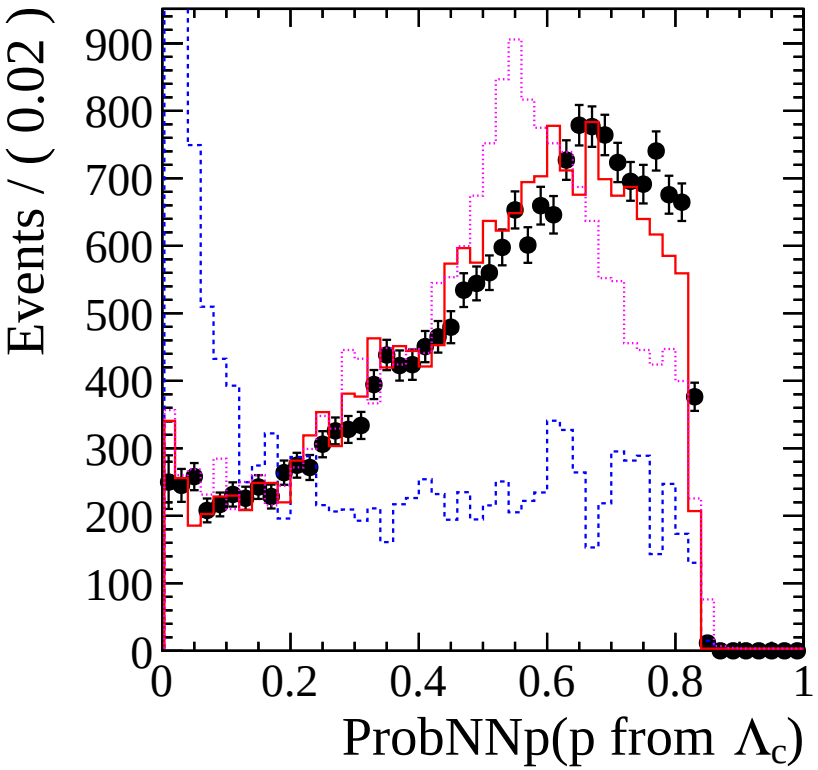




Some difference in Run1 due to loose PIDp cut in the stipping, but Run2 a lot worse in high-ProbNNp region.
(All kinematic distibutions are reweighted, so the difference is due to PID response only).

ProbNNp distributions in Run2

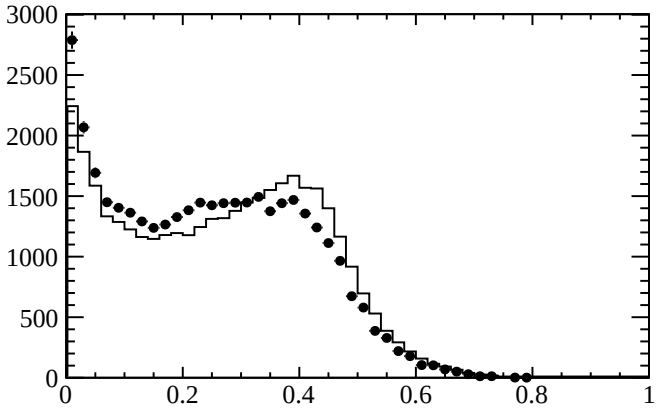
After some investigations with $\Lambda_b \to \Lambda_c \pi$ sample, issue tracked down to the dependence of ProbNNp distibution on track displacement from PV.
Run1 used IncLc sample, while Run2 uses $\Lambda \to p\pi$. Λ's are long-lived.

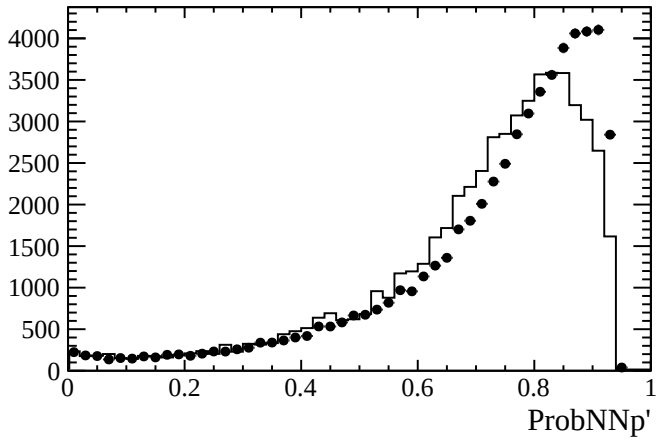


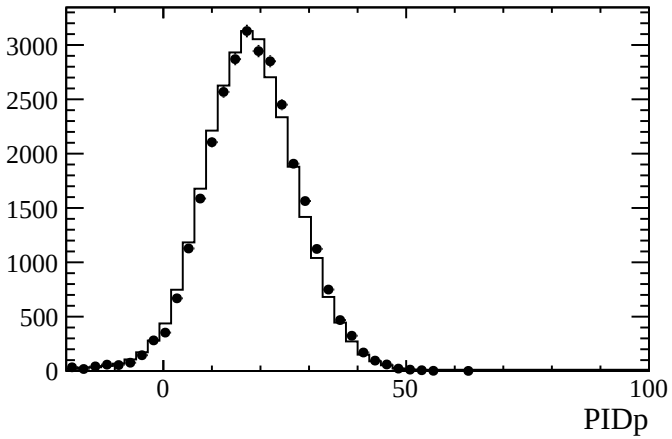
Resampled ProbNNp'$= 1 - (1 - \text{ProbNNp})^{0.25}$ distibutions with MINIPCHI2<100 (red) and MINIPCHI2>400 (pink), tracks, sWeighted data (black).

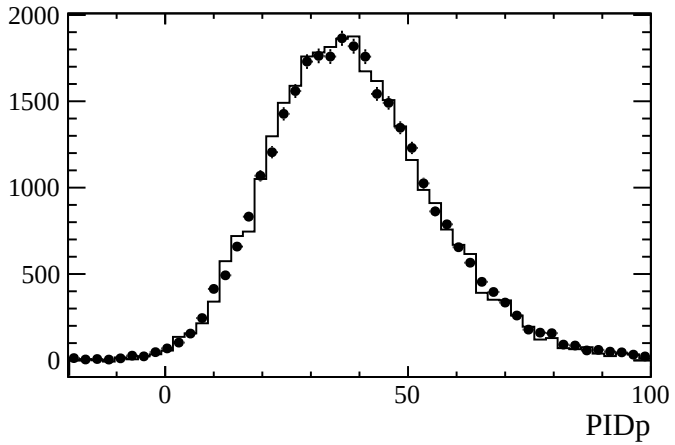
ProbNNp and PIDp distibutions in narrow Pt,Eta bins

$\eta \in (3.4, 3.6)$;
$P_T \in (600, 750)$ MeV (left), $(2500, 3000)$ MeV (right),





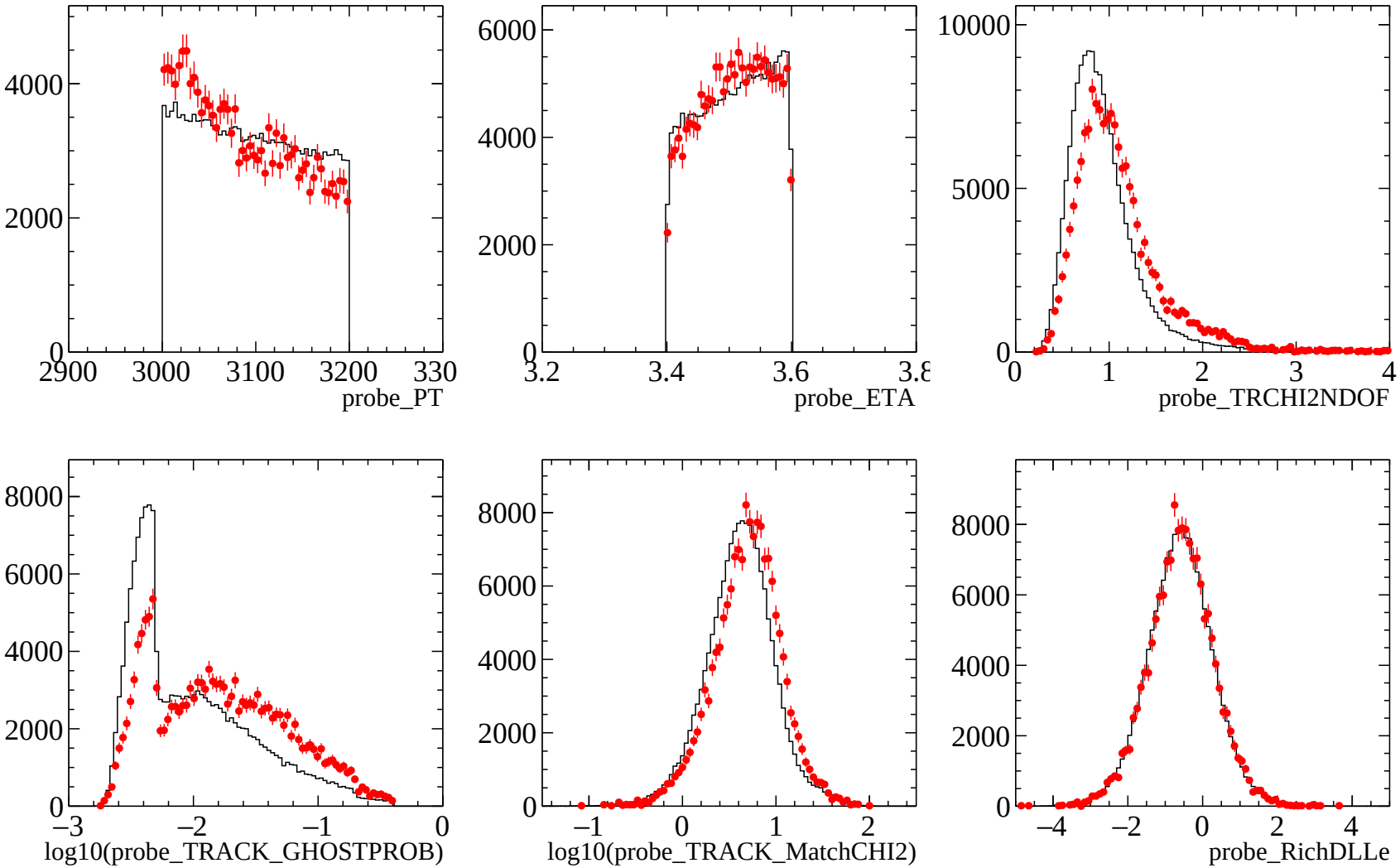




Disagreement is more pronounced for high-momentum tracks.
No significant disageement for PIDp

Variables intering ProbNN

Distributions for variables entering ProbNN's, for MINIPCHI2$<$ 100 (black) and MINIPCHI2$>$ 400 (red)



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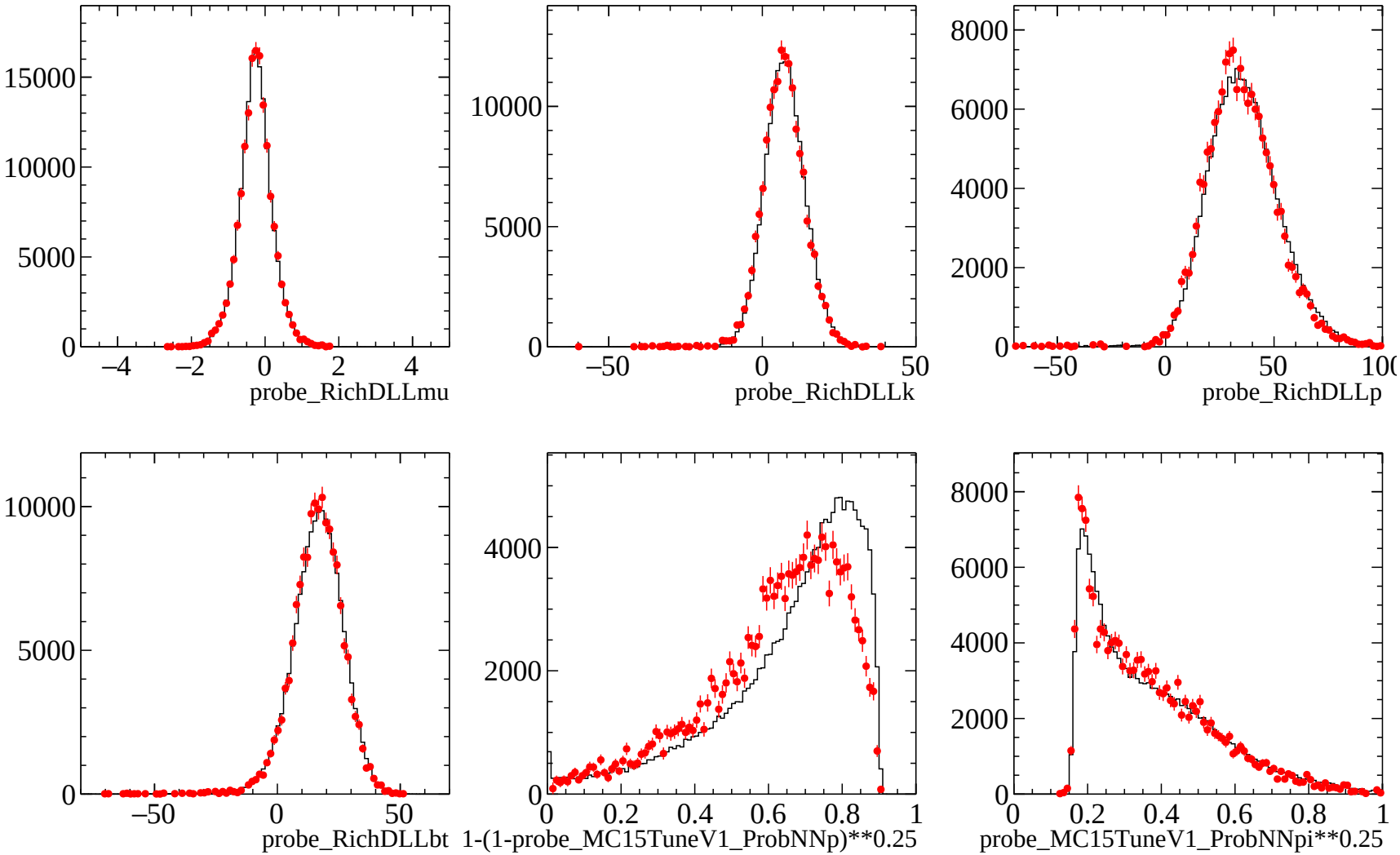

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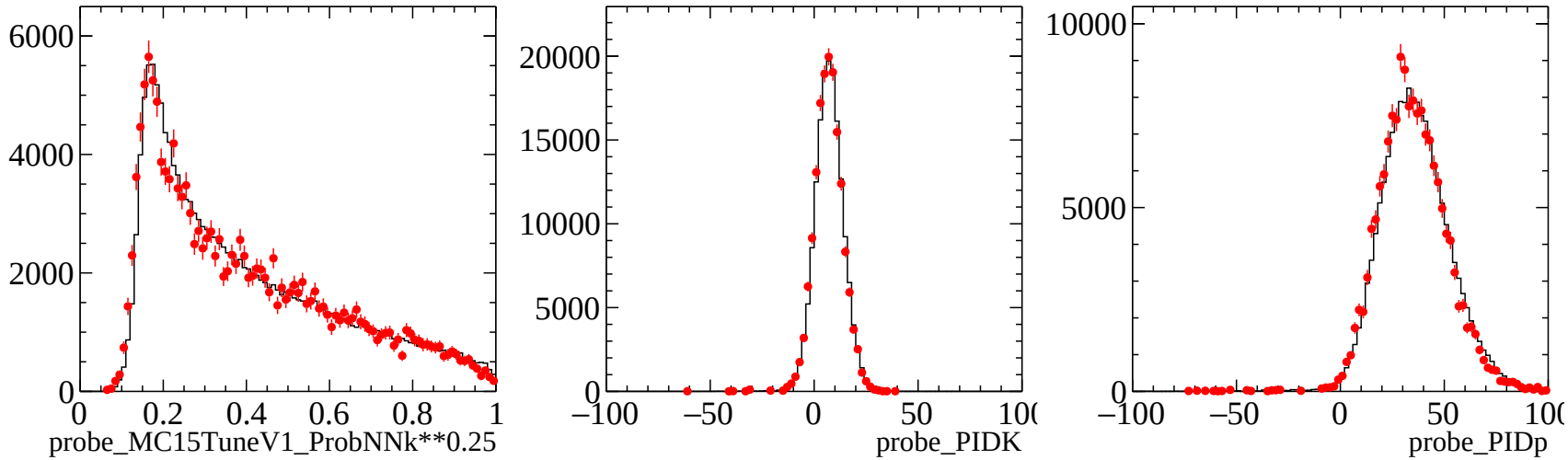
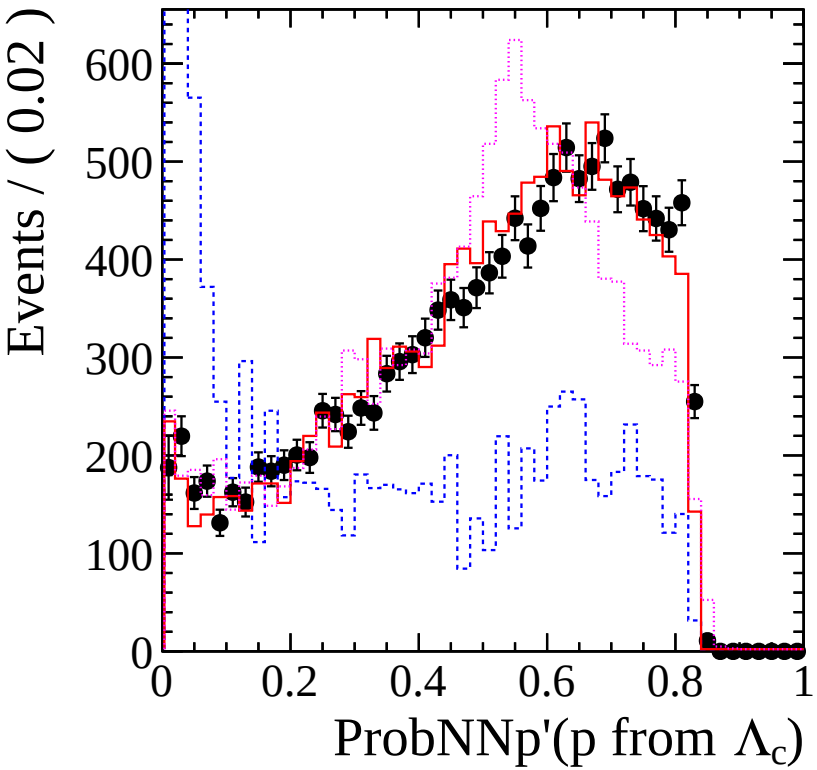


Alternative calibration: $\Lambda_b \to \Lambda_c \pi$

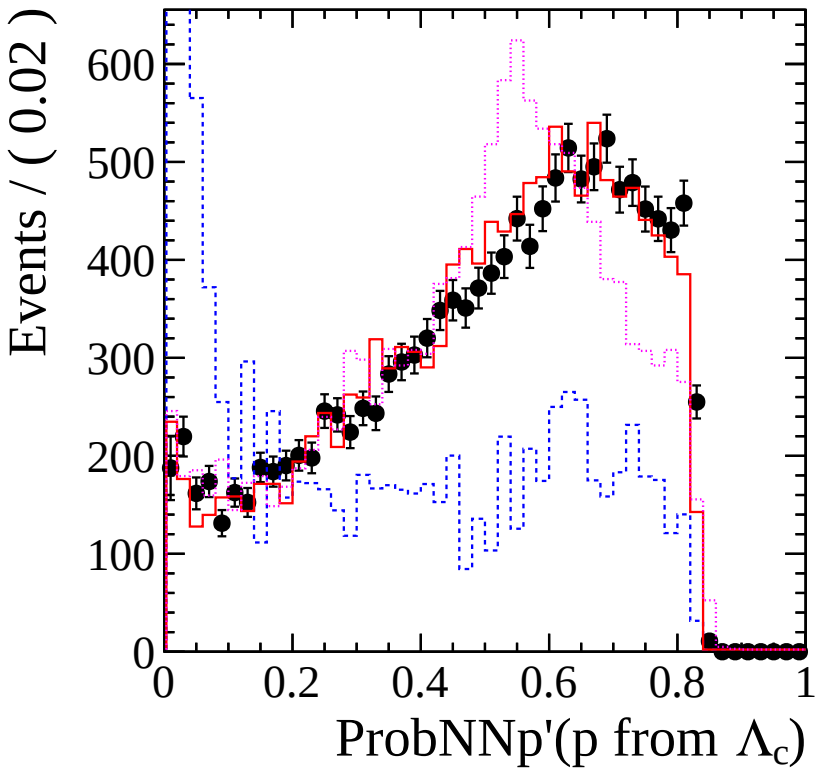
Tempoary solution adopted for $\Xi_b \to pKK$ analysis: use $\Lambda_b \to \Lambda_c \pi$ as a calibation sample.
Corresponding templates are available in PIDGen as "p_LbLcPi_MC15TuneV1_ProbNNp_Brunel".

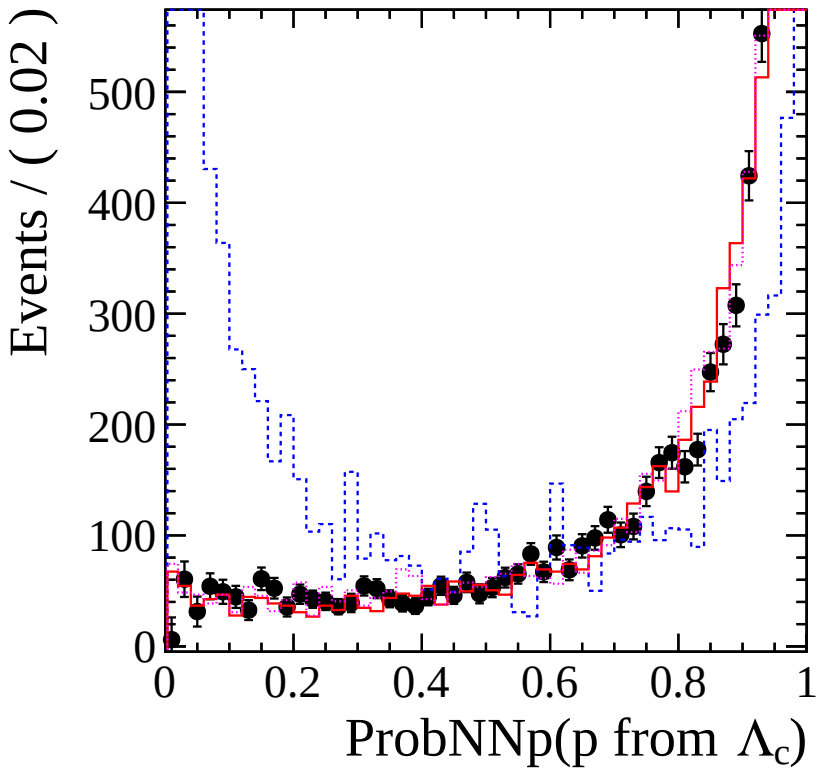


Red: resampling from $\Lambda_b \to \Lambda_c \pi$ calibration, pink: $\Lambda \to p\pi$ calibration.

ProbNNp' and ProbNNp

Note that the disagreement is apparent in the transformed variable, ProbNNp'$= 1 - (1 - \text{ProbNNp})^{0.25}$ (left) where the region with ProbNNp=1 is zoomed in.
In ProbNNp (right), this corresponds to the region around ProbNNp$\simeq 0.95$, so should only affect you if you are cutting *very* tight on ProbNNp, or using it in the MVA.





Discussion

- ProbNN variables are correlated with track displacement (e.g. MINIPCHI2).
  - Via tracking variables, such as ghost probability, track χ^2.
  - Causes problems if calibration sample has different lifetime than your signal.
- This becomes apparent for ProbNNp in Run2
  - Only available calibration sample: $\Lambda \to p\pi$, long lived
  - CombDLL seem not affected, ProbNNpi,K much less than ProbNNp
  - Disagreement is pronounced for high-P tracks, around ProbNNp>0.9
- Issue is possibly present in Run1 as well, but there we have IncLc.
  - No corresponding variables in PIDCalib samples to check.
- Possible fixes:
  - Use $\Lambda \to p\pi$, but cut MINIPCHI2$< X$ for calibation: loose stats, still biased
  - Use $\Lambda \to p\pi$, but reweigh tracking distributions?
  - Use $\Lambda_b \to \Lambda_c\pi$, but low stats
  - Use SL $\Lambda_c\mu$, but $P_T > 1$ GeV cut on proton (can be relaxed)?
  - Resurrect IncLc sample?