

$B^0 \rightarrow K^{0*}(K\pi)\mu\mu$ full angular analysis

Status update

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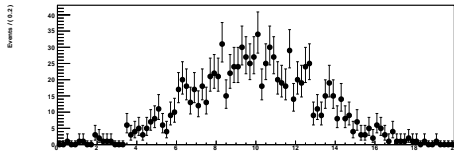
AFB meeting,
CERN, 13 Aug 2015

Status update

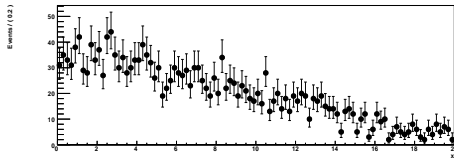
- Alessio showed our progress for the efficiency as $3D (\theta_L, \theta_k, \phi)$ and $2D \times 2D \times 2D ((\theta_L, \theta_k) \times (\theta_L, \phi) \times (\theta_k, \phi))$
- and corresponding closure test
- next step in our plan was to try 3-dim Kernel Estimator
 - ▶ Cranmer KS, Kernel Estimation in High-Energy Physics. Computer Physics Communications 136:198-207,2001 - e-Print Archive: [hep-ex/0011057](https://arxiv.org/abs/hep-ex/0011057)
 - ▶ Basic idea is to describe any unbinned distribution as a superposition of N 3-dimensional gaussian kernels, each contributing to $1/N$ to the total pdf
 - ▶ available in RooFit class `RooNDKeysPdf`
- being unbinned, we cannot use it directly on the efficiency, but we have to work separately on numerator and denominator, and then take the ratio.
- this is possible and has been done.

A 1D toy example to describe the method

Adaptive kernel estimation pdf for Numerator



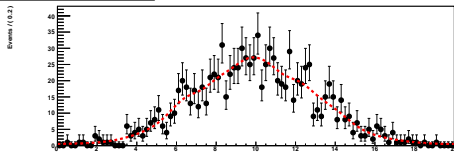
Adaptive kernel estimation pdf for Denominator



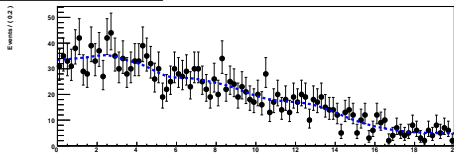
- unbinned distribution of numerator
- unbinned distribution of denominator

A 1D toy example to describe the method

Adaptive kernel estimation pdf for Numerator



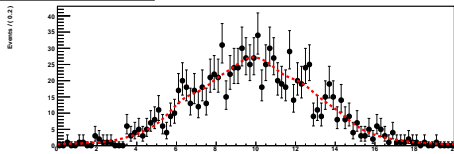
Adaptive kernel estimation pdf for Denominator



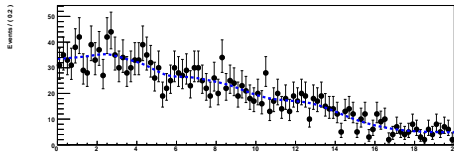
- unbinned distribution of numerator
- with **kernel estimation pdf** obtained with roofit
- unbinned distribution of denominator
- with **kernel estimation pdf** obtained with roofit

A 1D toy example to describe the method

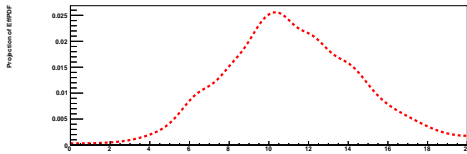
Adaptive kernel estimation pdf for Numerator



Adaptive kernel estimation pdf for Denominator



Ratio of KE pdf



- unbinned distribution of numerator
- with **kernel estimation pdf** obtained with roofit
- unbinned distribution of denominator
- with **kernel estimation pdf** obtained with roofit
- **"efficiency" pdf** defined as pdf-numerator/pdf-denominator.

What is the efficiency

Definition as in 2-D angular analysis

$$\epsilon(q^2, \theta_L, \theta_K, \phi) = \frac{N_{gen}}{D_{gen}} \times \frac{N_{reco}}{D_{reco}}$$

where, for each bin of $q^2, \theta_L, \theta_K, \phi$:

D_{gen} # of GEN events with $P_T(B_0) > 8 \text{ GeV}$ and $|\eta(B_0)| < 2.2$;

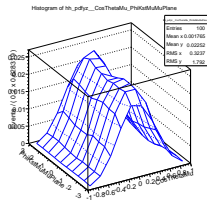
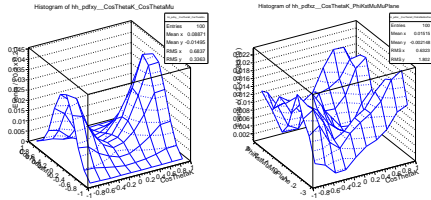
N_{gen} # of GEN events with \oplus $P_T(\mu_{1,2}) > 3.5 \text{ GeV}$ and $|\eta(\mu_{1,2})| < 2.2$;

D_{reco} # of RECO events with a $B_0 \rightarrow K^*(K\pi)\mu\mu$ candidate;

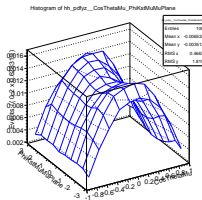
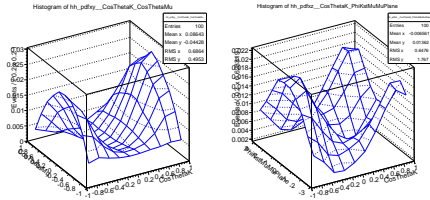
N_{reco} # of RECO events with \oplus all final cuts;

Actual implementation for q^2 bin 2 of signal sample

Numerator of GEN Eff

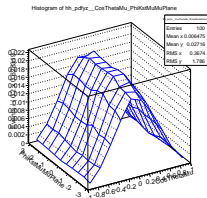
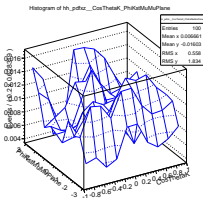
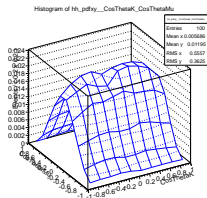


Denominator of GEN Eff

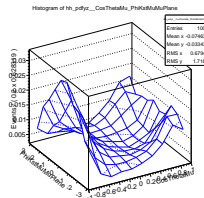
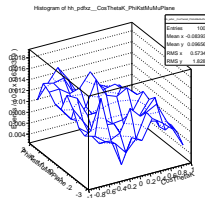
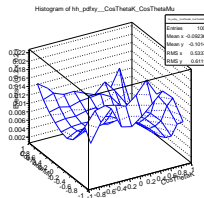


Showing only the pdf as returned by RooNDKeysPdf

GEN Efficiency



RECO Efficiency



Still some problem of smoothness

- The actual computation of pdf is complex
 - ▶ 2 numerator and 2 denominator
 - ▶ two ratios (GEN and RECO)
 - ▶ one product (Total)
 - ▶ or just $N_{gen}/D_{gen} \times N_{reco}/D_{reco}$
- Both implemented: working but very slow
 - ▶ hours for each bin, mostly due to the integration of the pdf needed to compute the ratio or the product;
 - ▶ possibly some optimization in the integration algo;
- **MAJOR issue** and totally unexpected: root **is not able to save the output pdf produced by RooNDKeysPdf**
 - ▶ A solution promised since as long as 2009, but none available!
 - ▶ asked again, no answer yet (vacation time?)

- further investigate if the output of RooNDKeysPdf is writeable (and readable) somehow
- investigate other implementation of Kernel Estimator
- try to use a legendre polynomial expansion of the binned efficiency (as done by LHCb) within root