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

A plan for a plan

Stefano Lacaprara, Alessio Boletti

INFN Padova, Università di Padova

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Intro

Team Stefano (staff), Alessio (PhD student)

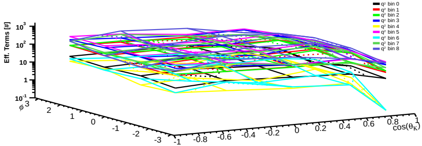
Goal Provide suitable description of the signal efficiency vs. θ_L, θ_K, ϕ to be used for fully angular fit of $B^0 \to K^{0*}(K\pi)\mu\mu$ decay.

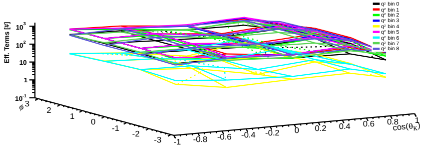
Status : very fruitful full-day discussion with Mauro at Milano (many thanks!)

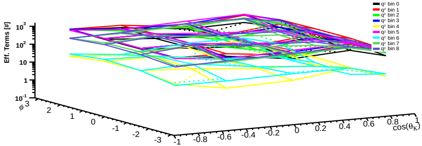
- learned how the 2D analysis was performed, in particular as far as efficiency is concerned;
- learned how to run Mauro's code and macros (almost);
- got all ntuple used for BPH-13-010 (2012 and 2011, data and MC)
  - ntuple have been copied to Legnaro-Padova T2, and available to be copied elsewhere if needed.

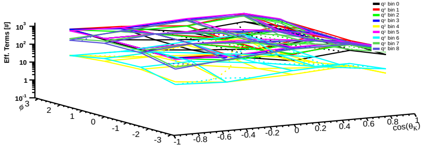
- Mauro's ntuple have all the needed information (including ϕ). No need to re-access data!
- Some initial distribution for efficiency vs ϕ already available!

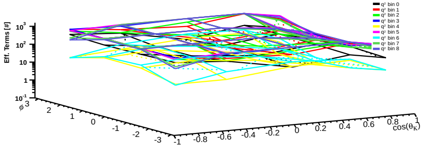
2D efficiency vs (θ_L, ϕ) for the various q^2 bins

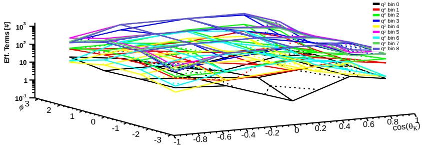




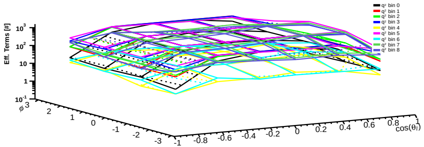


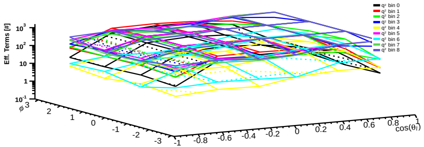


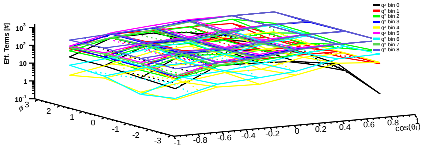


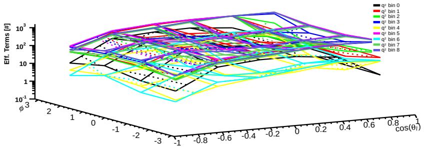


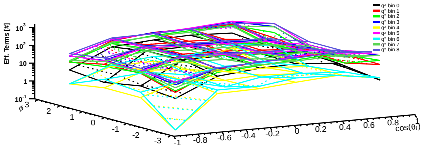
2D efficiency vs (θ_K, ϕ) for the various q^2 bins











Work plan

Deliverable:

- Final deliverable: $\epsilon(\theta_L, \theta_K, \phi)$ as a `RooAbsPdf`
  - For correct-tag and wrong-tag separately
  - to be used directly by the fitting procedure;
  - following current (2D) fit implementation;
    - to be discussed and agreed with fit-team
  - Focus on 2012 (8 TeV) data

Plan

- Study parametrization of $\epsilon(\theta_L, \theta_K, \phi)$
- Start with trivial MC closure test

Unit test Compare `MC-RECO` with `MC-GEN`$\otimes\epsilon(\theta_L, \theta_K, \phi)$ for various kinematic variables;

Longer term Compare parameters from `MC-GEN`-fit to `MC-RECO`-fit (as done in 2D analysis) once the 3D-fit is in place;

Ideas about parametrization of $\epsilon(\theta_L, \theta_K, \phi)$

Unit test

- Setup unit test using directly ϵ histogram (first step);
- Which histograms?
- What about MC statistics?
  - 3D histogram?
  - 2D histograms?
  - $\epsilon(\theta_L, \theta_K, \phi) = \epsilon(\theta_L, \theta_K) \times \epsilon(\phi)$
  - $\epsilon(\theta_L, \theta_K, \phi) = \epsilon(\theta_L, \theta_K) \times \epsilon(\theta_L, \phi) \times \epsilon(\theta_K, \phi)$
- Mostly to test machinery and look at ϵ distribution as well as histogram statistics;
  - is $\epsilon(\phi)$ symmetric wrt to $\phi = 0$?

Parametrization

- Try to expand actual polynomial parametrization to 3D
  - 2D Now is `pol-5`$\times$`pol-3`: 24 parameters with $6 \times 5 = 30$ bins;
  - 3D If `pol-5`$\times$`pol-3`$\times$`pol-3`: 96 parameters with $6 \times 5 \times 4 = 120$ bins;
- Alternatives:

LHCb used a Legendre polynomial expansion, using principal moment analysis;

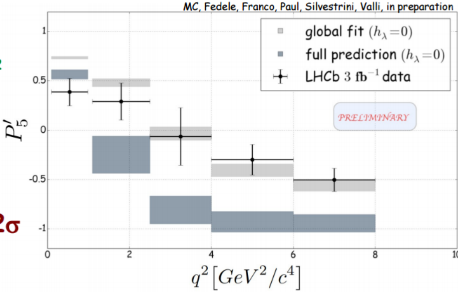
Cranmer Kernel estimator: unbinned and non-parametric arXiv:hep-ex/0011057

- ★ should be done independently for numerator and denominator (unbinned) $\epsilon = \frac{N}{D}$;
- ★ implemented in TMVA;
- ★ should work also for 2 and 3D distribution.

B physics: $B \to K^* \ell^+ \ell^-$

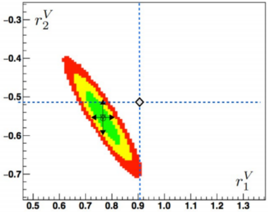
LHCb claims P_5' to be 3.7σ off for $4.3 < q^2 < 8.7$ GeV^2

Factorized formulae cannot fully reproduce the data: a fit shows that P_5' can be addressed but deviations ≥2σ are present in the other angular coefficients

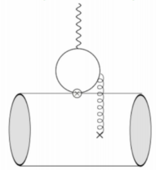


+ constraints on the FFs

Bin q^2 $[GeV^2/c^4]$	A_{FB}	F_L	S_3	S_4	S_5	S_7	S_8	S_9
[0.1, 0.98]	1.6	0.2	−0.9	0.6	−1.2	0.3	1.0	−1.4
[1.1, 2.5]	0.1	−0.6	−0.9	−0.6	−0.8	−2.2	−0.8	−1.3
[2.5, 4]	−0.6	0.7	0.8	−1.1	−0.1	0.6	0.2	−0.8
[4, 6]	−1.3	−2.4	1.8	−1.0	0.3	−0.2	1.8	−0.4
[6, 8]	−1.4	−1.6	1.4	−2.3	0.2	−0.7	−1.2	−0.4
[1.1, 6]	−1.2	−1.5	1.6	−1.2	−0.1	−1.5	0.6	−0.6



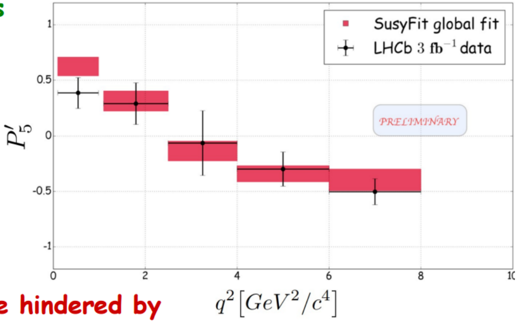
Non-factorizable terms may be important:



partly estimated in Kodjamirian et al., arXiv:1006.4945

$$h_\lambda = h_\lambda^{(0)} + h_\lambda^{(1)} q^2 + h_\lambda^{(2)} q^4$$

MC, Fedele, Franco, Paul, Silvestrini, Valli, in preparation



BSM sensitivity could be hindered by hadronic uncertainties. Inclusive $B \to X_s \mu^+\mu^-$ may help shedding light on this issue

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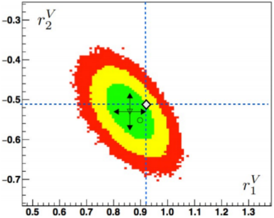
[1.1, 6]	−1.0	0.1	1.0	−1.3	0.1	−0.9	0.2	−0.6



Conclusion

- We have a team;
- We have data;
- We have code;
- We have a plan;