Tuning of pythia parameters for the generic B-decay in EvtGen with data

master thesis project

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EvtGen Community Workshop, 23. January 2014

Outline

Motivation

- $\mathcal{O}(50\%)$ of the exclusive final states of the B-meson decay are not measured yet (in particular higher multiplicities)
- and therefore over 40% of the generic B-decay in DECAY_2010.DEC is done by pythia
- Try to tune pythia flavour/(fragmentation) parameters to obtain the best agreement between simulation and data

Strategy

General strategy:

1. find observables to tune the parameters
2. find parameters that affect this observable
3. tune these parameters while making sure that no other observable is negatively affected
4. try to achieve N° 3 with as few parameters as possible

Technical setup

- EvtGen 1.2.0
- pythia 8.175 (from now on called pythia default)
- Rivet[1] 1.8.3 for analyses
- Professor[2] 1.3.3 for tuning

[1] arXiv:1003.0694
[2] Eur.Phys.J. C65 (2010) 331-357

Specific measurements from BABAR

mesons

- Measurement of the average ϕ multiplicity in B meson decay PRD 69, 052005 (2004)[1]
- Study of inclusice B^- and $\bar{B}^0$ decays to flavor-tagged D, D_s and Λ_c^+ PRD 75, 072002 (2007)[1]
- Study of Inclusive Production of Charmonium Mesons in B Decay http://arxiv.org/abs/hep-ex/0207097 [2]
- Measurement of D_s^+ and D_s^{*+} production in B decays and from continuum e^+e^- annihilations at $\sqrt{s} = 10.6$ GeV, hep-ex/0107060
- Study of semi-inclusive production of η' mesons in B decays, hep-ex/0109034
- Study of high momentum η' production in $B \to \eta' X_s$, PRL 93, 061801 (2004)

[1] We have already implemented this analysis in rivet, to be submitted

[2] implemented in rivet

Specific measurements from BABAR

baryons

- Inclusive Λ_c^+ production in e^+e^- annihilations at $\sqrt{(s)} = 10.54$ GeV and in Upsilon(4S) decays, PRD 75, 012003 (2007) [1]
- Ξ_c' Production at BABAR, hep-ex/0607086
- Production and Decay of Ξ_c^0 at BABAR, PRL 95, 142003 (2005) [1]

[1] implemented in rivet

Specific measurements from Belle

- Measurement of Inclusive Production of Neutral Pions from Upsilon(4S) Decays, PRD 64, 072001 (2001) [1]
- Charm Hadrons from Fragmentation and B decays in e^+e^- Annihilation at $\sqrt{s}$ =10.6 GeV, PRD 73, 032002 (2006)[1]
- Measurement of inclusive D_s, D^0 and J/ψ rates and determination of the $B_s^{(*)}\overline{B}_s^{(*)}$ production fraction in $b\,\bar{b}$ events at the $Y(5S)$ resonance, PRL 98, 052001 (2007)

[1] implemented in rivet

Started with following first example

- simulated ϕ multiplicity using DECAY_2010.DEC and default pythia parameters overestimates the measurement by about 3σ
- MC: about 10% of all ϕ's are direct decay products from a B meson

$\Rightarrow$ Main source of ϕ's: $B \to D^{\pm/0}_{(s)}$ decay channels

(pdg edition 2012):

- BR($D^{\pm} \to \phi$ anything) $= (1.03 \pm 0.12)\%$
- BR($D^{0}(\bar{D}^{0}) \to \phi$ anything) $= (1.05 \pm 0.11)\%$
- BR($D^{\pm}_{s} \to \phi$ anything) $= (15.7 \pm 1.0)\%$

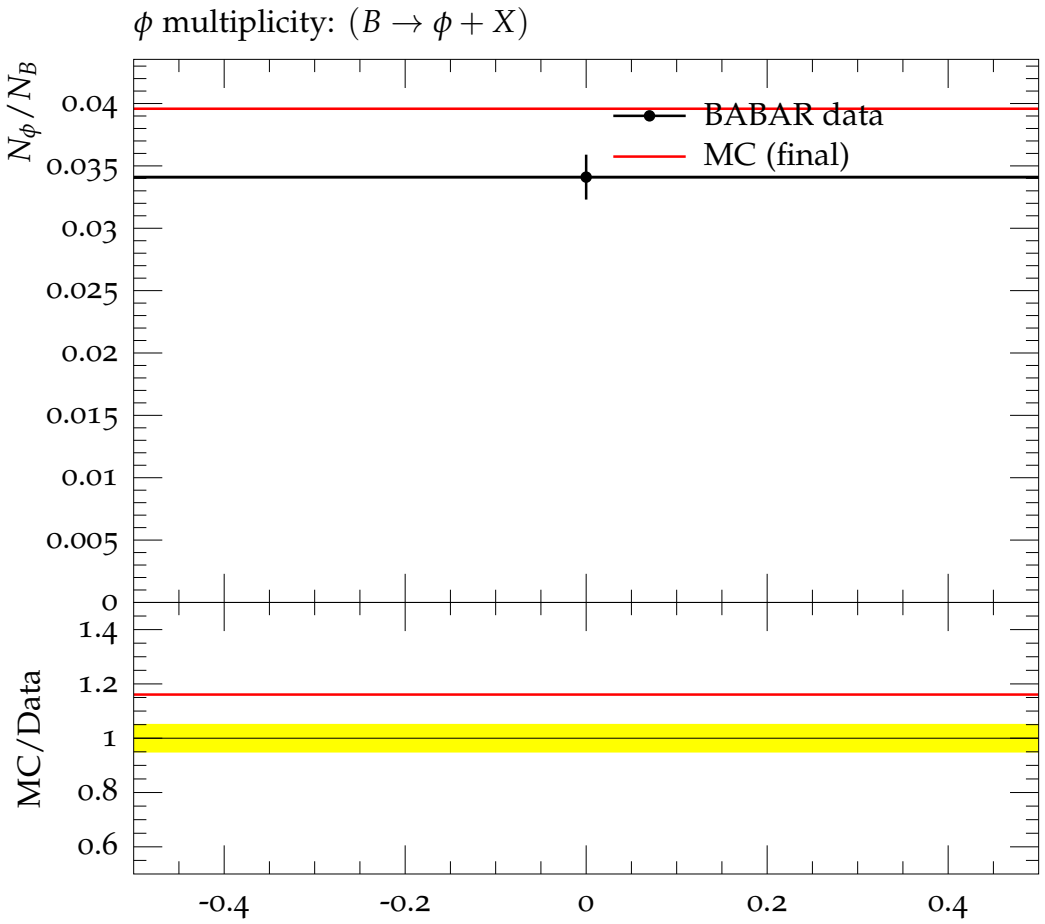


Figure: simulated ϕ multiplicity using DECAY_2010.DEC and default pythia parameters
Source of the datapoint: "Measurement of the average ϕ multiplicity in B meson decay" PRD 69, 052005 (2004)

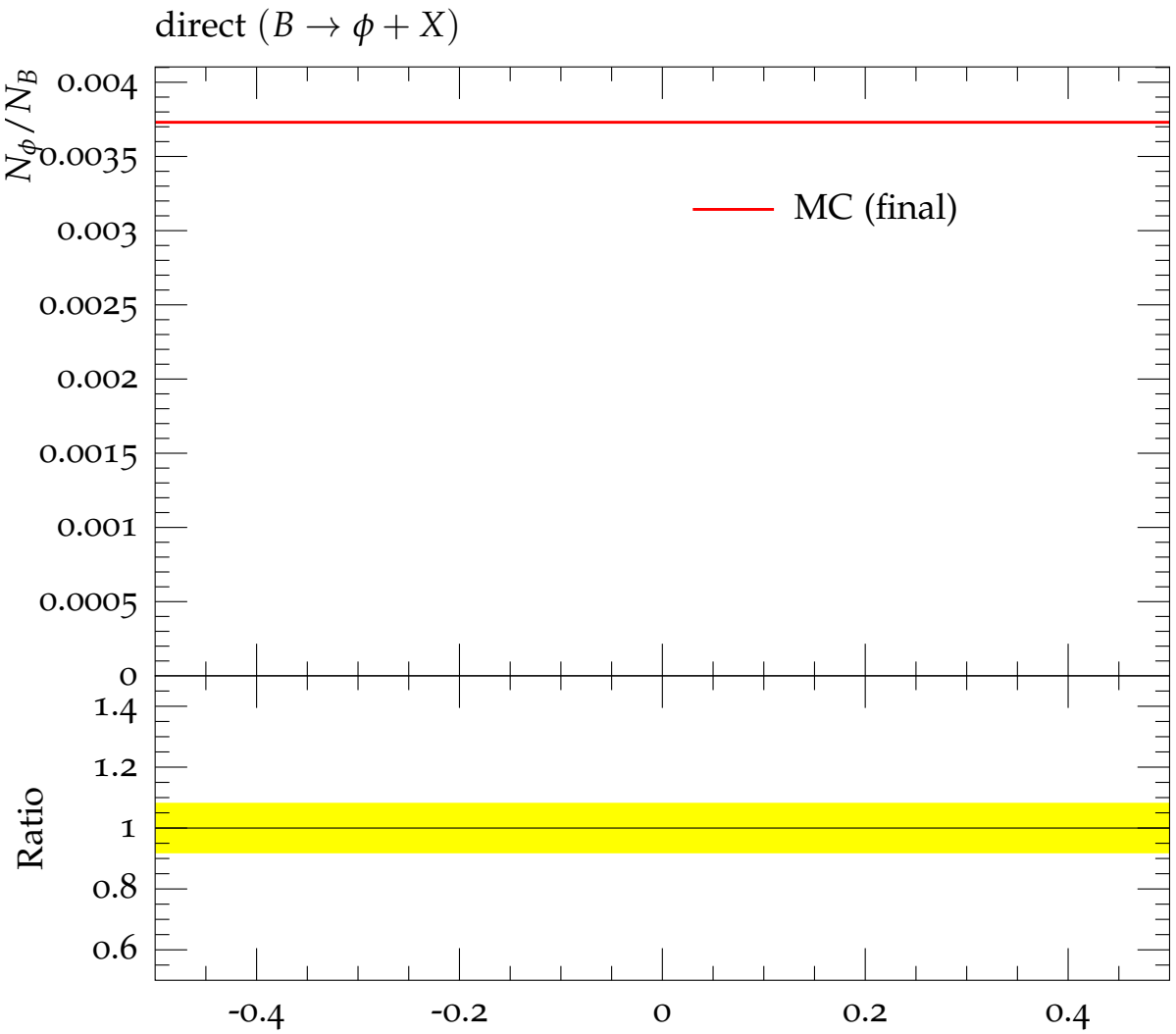


Figure: MC: about 10% of all ϕ's are direct decay products from a B meson

- therefore we also have to consider (pdg2012):
- $\mathrm{BR}(B^+ \to D^+ \text{ anything}) = (2.5 \pm 0.5)\%$
- $\mathrm{BR}(B^+ \to D^- \text{ anything}) = (9.9 \pm 1.2)\%$
- $\mathrm{BR}(B^+ \to D_s^+ \text{ anything}) = (7.9\ ^{+1.4}_{-1.3})\%$
- $\mathrm{BR}(B^+ \to D_s^- \text{ anything}) = (1.10\ ^{+0.40}_{-0.32})\%$
- $\mathrm{BR}(B^+ \to D^0 \text{ anything}) = (8.6 \pm 0.7)\%$
- $\mathrm{BR}(B^+ \to \bar{D}^0 \text{ anything}) = (79 \pm 4)\%$
- $\mathrm{BR}(B^0 \to D^+ \text{ anything}) = (< 3.9)\%$
- $\mathrm{BR}(B^0 \to D^- \text{ anything}) = (36.9 \pm 3.3)\%$
- $\mathrm{BR}(B^0 \to D_s^+ \text{ anything}) = (10.3\ ^{+2.1}_{-1.8})\%$
- $\mathrm{BR}(B^0 \to D_s^- \text{ anything}) = (< 2.6)\%$
- $\mathrm{BR}(B^0 \to D^0 \text{ anything}) = (8.1 \pm 1.5)\%$
- $\mathrm{BR}(B^0 \to \bar{D}^0 \text{ anything}) = (47.4 \pm 2.8)\%$

Additional available information I:

$B^{\pm}/B^{0}$ admixture (pdg edition 2012)

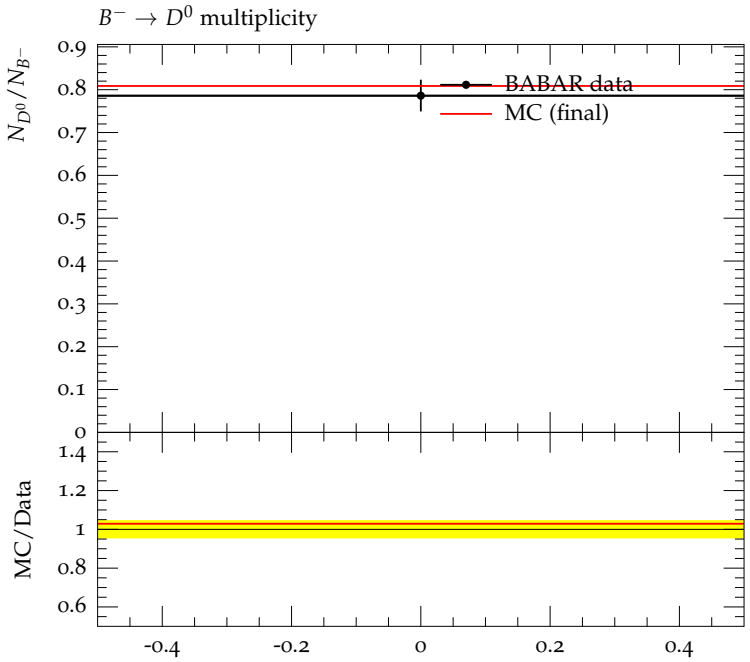
- BR($B \to D^{\pm}$ anything) $= (23.7 \pm 1.3)\%$(CLEO, ARGUS)
- BR($B \to D^{0}/\overline{D}^{0}$ anything) $= (62.7 \pm 2.9)\%$(CLEO, ARGUS)
- BR($B \to D^{*\pm}$ anything) $= (22.5 \pm 1.5)\%$(CLEO, ARGUS)
- BR($B \to D^{*0}$ anything) $= (26.0 \pm 2.7)\%$(CLEO)
- BR($B \to D_s^{\pm}$ anything) $= (8.3 \pm 0.8)\%$(CLEO, BABAR, ARGUS)
- BR($B \to D_s^{*\pm}$ anything) $= (6.3 \pm 1.0)\%$(BABAR)

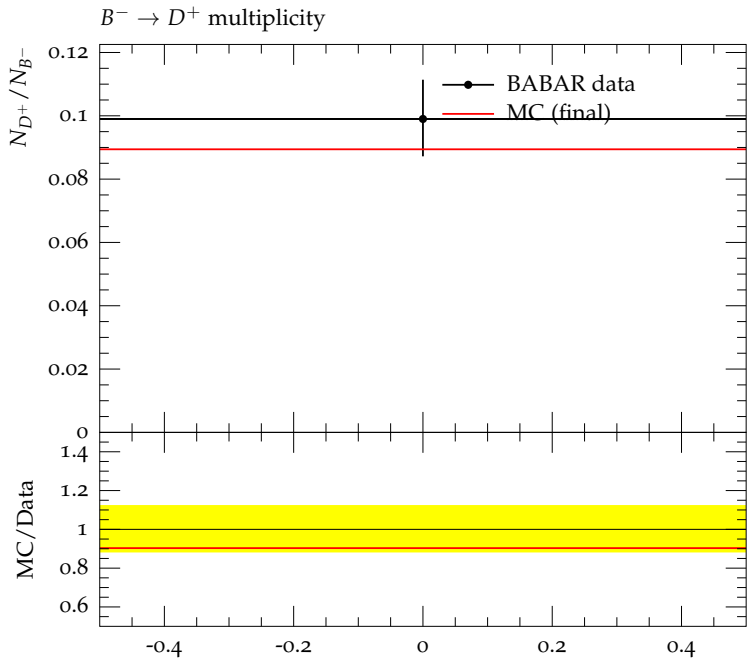
Additional available information II:

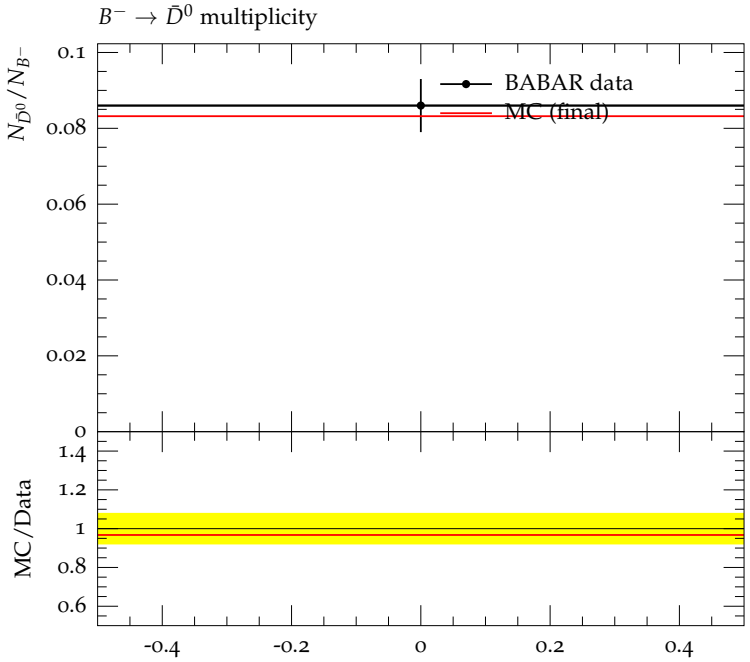
$B^{\pm}/B^{0}$ admixture (pdg edition 2012)

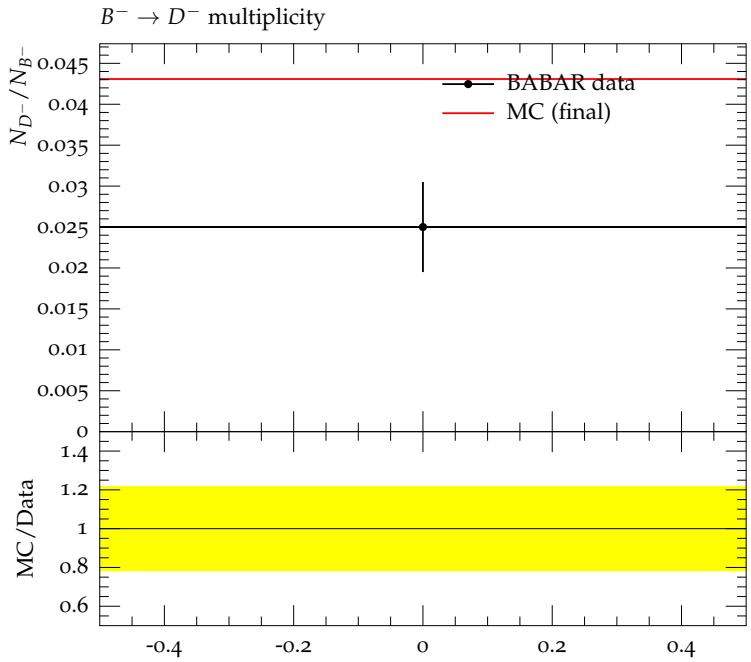
- BR($B \to K^{\pm}$ anything) $= (78.9 \pm 2.5)\%$(ARGUS, CLEO)
- BR($B \to K^{+}$ anything) $= (66 \pm 5)\%$(ARGUS)
- BR($B \to K^{-}$ anything) $= (13 \pm 4)\%$(ARGUS)
- BR($B \to K^{0}/\overline{K}^{0}$ anything) $= (64 \pm 4)\%$ (ARGUS, CLEO)
- BR($B \to \pi^{\pm}$ anything) $= (358 \pm 7)\%$ (ARGUS)
- BR($B \to \pi^{0}$ anything) $= (235 \pm 11)\%$[1] (BELLE)
- BR($B \to \eta$ anything) $= (17.6 \pm 1.6)\%$ (CLEO)
- BR($B \to \rho^{0}$ anything) $= (21 \pm 5)\%$ (ARGUS)
- BR($B \to \phi$ anything) $= (3.43 \pm 0.12)\%$ (CLEO, BABAR, ARGUS)

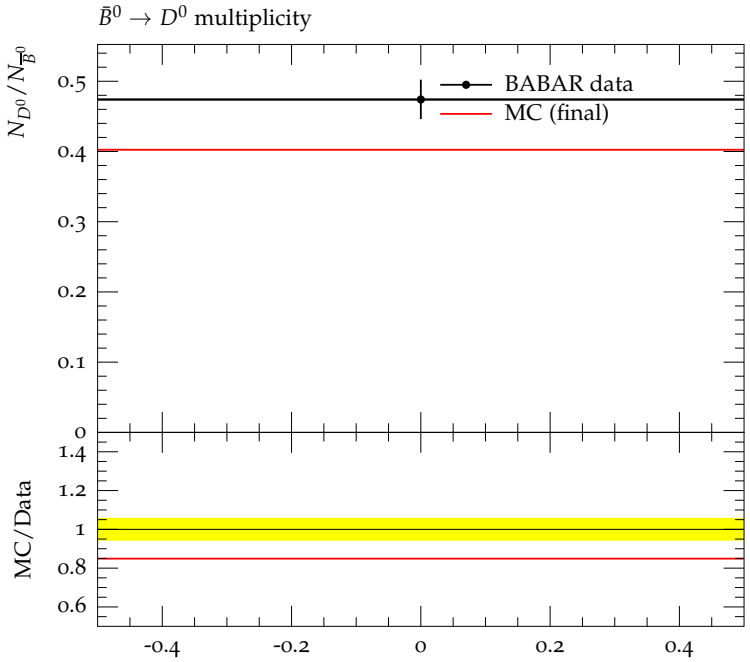
[1] implemented in rivet

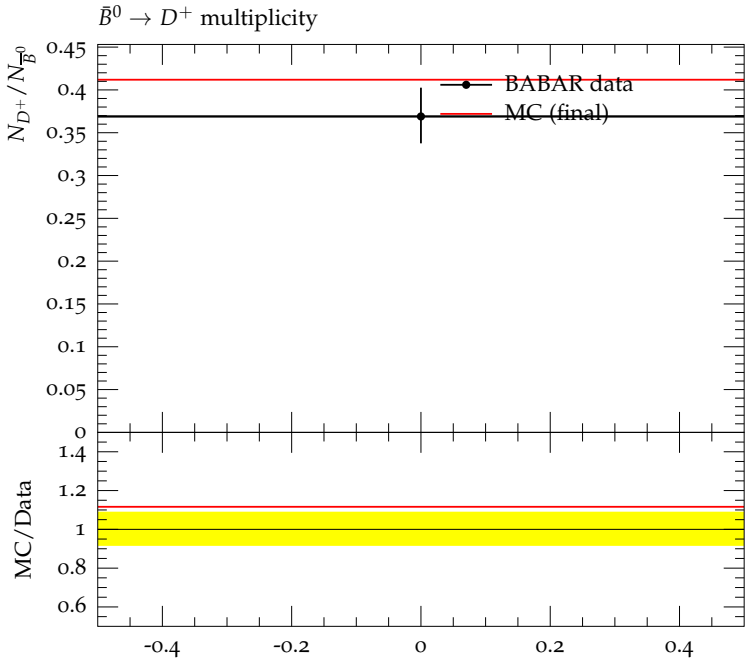

$B^- \to D^0$ multiplicity
N_{D^0}/N_{B^-}
BABAR data
MC (final)
MC/Data

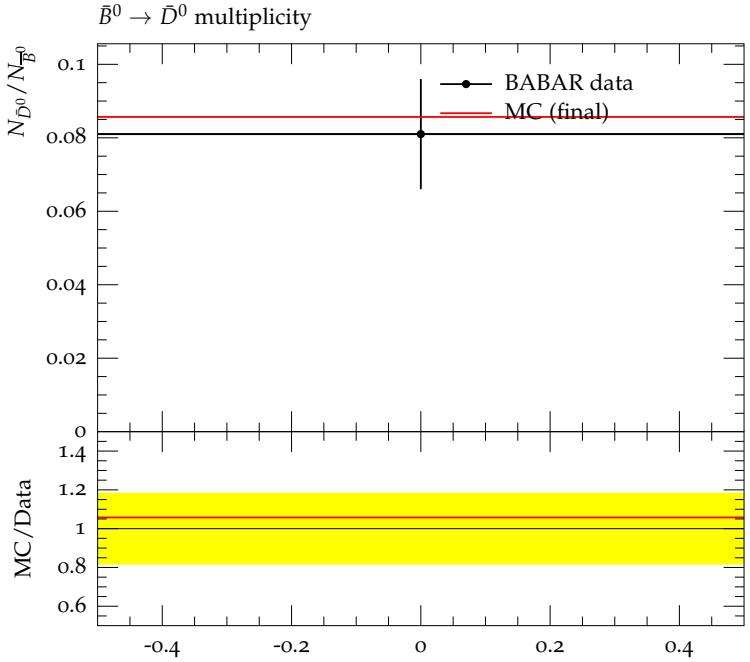

$B^- \to D^+$ multiplicity
N_{D^+}/N_{B^-}
BABAR data
MC (final)
MC/Data

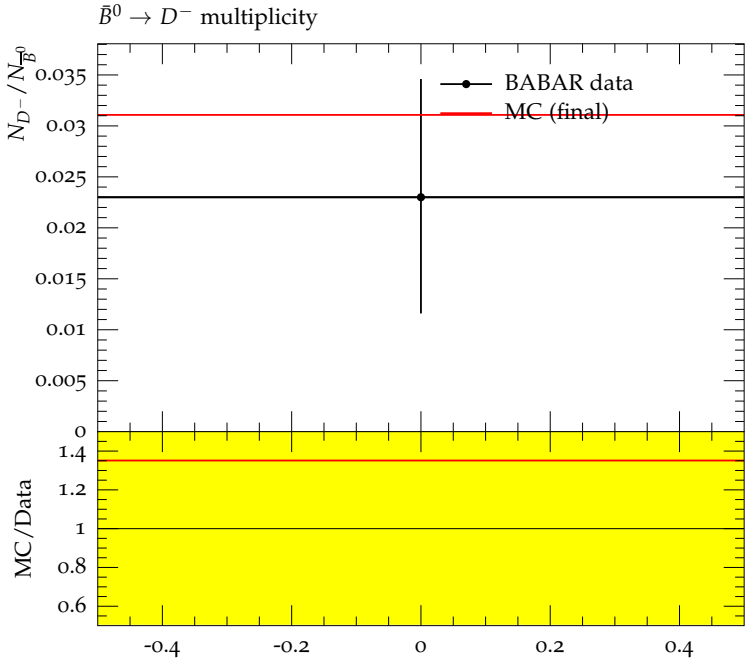

$B^- \to \bar{D}^0$ multiplicity
$N_{\bar{D}^0}/N_{B^-}$
BABAR data
MC (final)
MC/Data

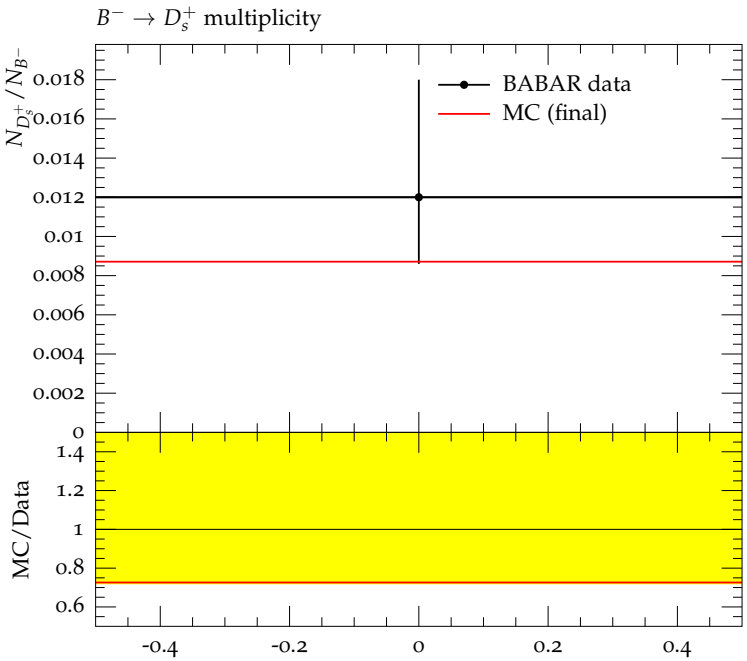

$B^- \to D^-$ multiplicity
N_{D^-}/N_{B^-}
BABAR data
MC (final)
MC/Data

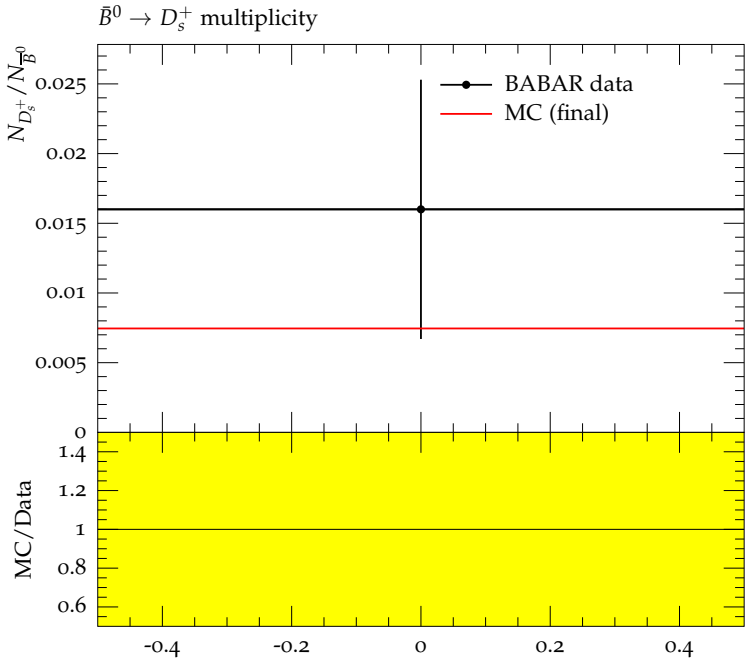

$\bar{B}^0 \to D^0$ multiplicity
$N_{D^0}/N_{\bar{B}^0}$
BABAR data
MC (final)
MC/Data

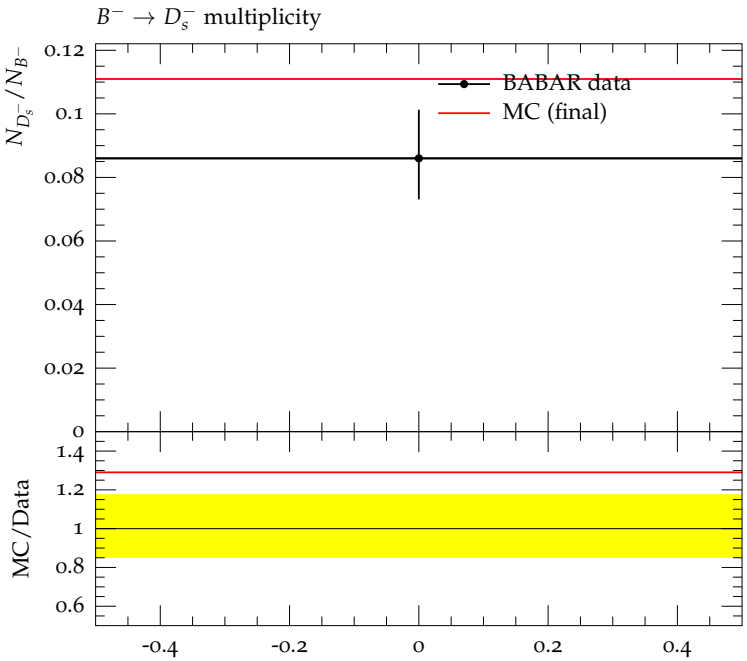

$\bar{B}^0 \to D^+$ multiplicity
$N_{D^+}/N_{\bar{B}^0}$
BABAR data
MC (final)
MC/Data

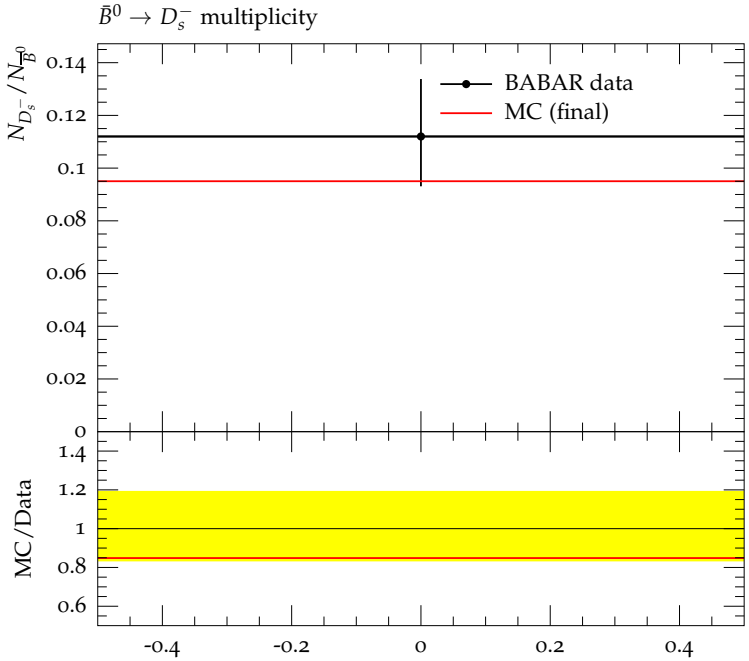

$\bar{B}^0 \to \bar{D}^0$ multiplicity
$N_{\bar{D}^0}/N_{\bar{B}^0}$
BABAR data
MC (final)
MC/Data


$\bar{B}^0 \to D^-$ multiplicity
$N_{D^-}/N_{\bar{B}^0}$
BABAR data
MC (final)
MC/Data


$B^- \to D_s^+$ multiplicity
$N_{D_s^+}/N_{B^-}$
BABAR data
MC (final)
MC/Data


$\bar{B}^0 \to D_s^+$ multiplicity
$N_{D_s^+}/N_{\bar{B}^0}$
BABAR data
MC (final)
MC/Data


$B^- \to D_s^-$ multiplicity
$N_{D_s^-}/N_{B^-}$
BABAR data
MC (final)
MC/Data


$\bar{B}^0 \to D_s^-$ multiplicity
$N_{D_s^-}/N_{\bar{B}^0}$
BABAR data
MC (final)
MC/Data

Tuning parameters in pythia

- We will focus in the beginning on the tuning of flavour parameters in pythia.
- Depending on the agreement with measured momentum distributions, e.g. for the ϕ or D, we might consider tuning the fragmentation-function parameters in pythia as well.
- Compare with LEP-tunings:
  Does one want to enforce consistency in these tunings?

The next steps

1. implementing further analyses in Rivet (help is welcome)
2. sensitivity studies of relevant pythia tuning-parameters with professer
3. use professor to tune these observables
4. compare with $e^+e^- \to q\bar{q}$