$\tau \to \mu\mu\mu$ at LHCb

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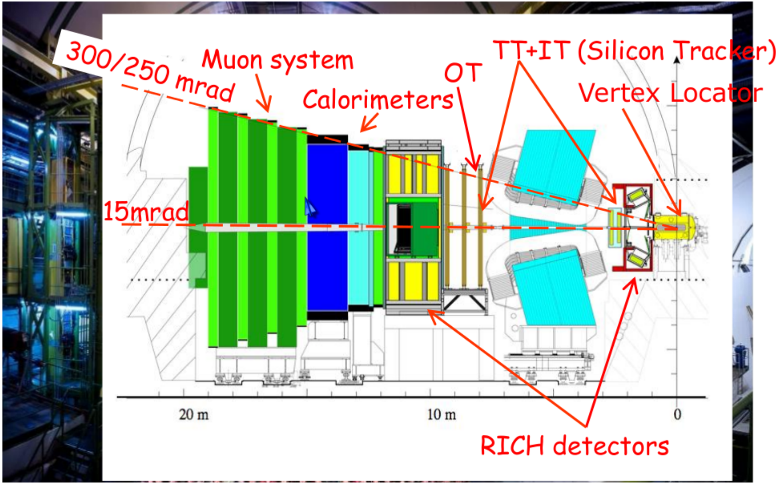
Introduction

- Fresh analysis! Approved less than 24hrs ago.
- Permission to speak only in general sense without going into any details.
- Will try to give a closed talk with as much information as possible.

Apologise

All the details will be available on the FPCP conference so stay tuned!

LHCb detector



LHCb detector

Strong features of the LHCb detector:

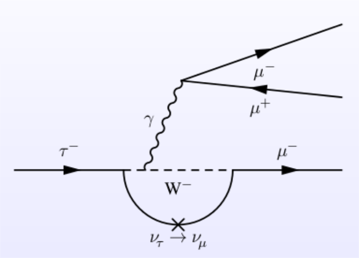
- Good particle identification thanks to the RICH detectors.
- State of the art silicon strip detector provides good vertex resolution.
- High luminosity: currently operating $4 \times 10^{-32} cm^{-2} s^{-1}$; we target to get $1.5 fb$ in 2012.

Theoretical and experimental status

Strong features of LHCb detector:

- LFV has been observed in neutrino oscillations.
- Never seen in the charged lepton sector.
- Depending on the model $\tau \to \mu\mu\mu$ can be dominant over $\tau \to \mu\gamma$.

SM prediction: BR $\sim 10^{-54}$
Best limits (90 %CL):
BaBar: 3.3 x 10-8 ($468 fb^{-1}$)
Belle: 2.1 x 10-8 ($782 fb^{-1}$)
LHCb: X.Y ($1 fb^{-1}$)



General information

1. Three separate likelihoods to discriminate background
   - Geometry and topology
   - Particle identification
   - Three body invariant mass
2. Training done on MC samples:
   - $\tau \to \mu\mu\mu$
   - $b\bar{b} \to \mu\mu X$ and $c\bar{c} \to \mu\mu X$
3. Different input variables, MVA operators and training methods examined, choice: highest performance & simplest

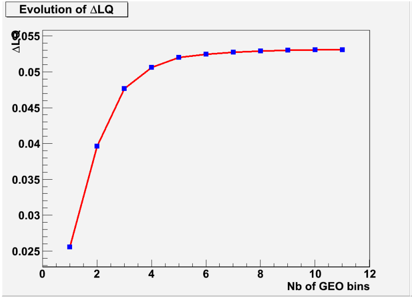
τ production

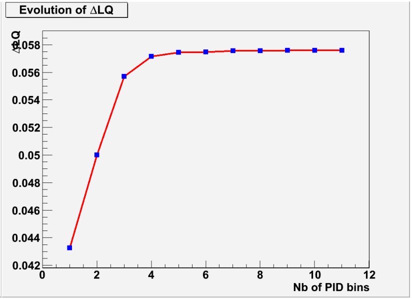
Decay chain	Gauss no DPC (%)	Calc (%)	$w_{MC \to calc}$
$D_s \to \tau$	72.3 ± 0.1	77.9 ± 4.7	
$D_s \to \tau$	62.6 ± 0.2	67.8 ± 4.8	1.08 ± 0.08
$B_x \to D_s \to \tau$	9.56 ± 0.07	10.1 ± 2.1	1.1 ± 0.2
$D^- \to \tau$	2.08 ± 0.03	4.6 ± 4.4	
$D^- \to \tau$	1.90 ± 0.02	4.4 ± 4.2	2.3 ± 2.2
$B_x \to D^- \to \tau$	0.18 ± 0.01	0.3 ± 0.3	1.5 ± 1.5
$B_x \to \tau$	25.5 ± 0.1	17.5 ± 3.3	0.7 ± 0.1

MC signal sample generated with phase space distribution

Binning optimisation

The 3D plane(mass, kinematics, and geometry with topology) mentioned was divided into bins. The optimisation of that binning was done using CLs method.





$\Delta LQ = 2ln(Q_{SB}) - 2ln(Q_B)$ where,

$Q_{SB} = \prod \frac{P(s_i+b_i,s_i+b_i)}{P(s_i+b_i,b_i)}$

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$P(a,b)$ is the probability that the expected number of background a fluctuates (by Poisson distribution) to b, and i is the bin number.

SM background

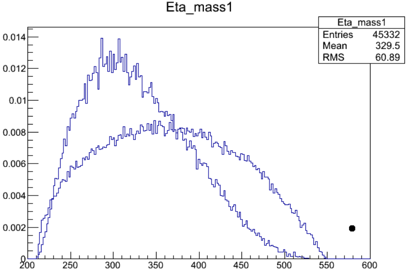
LHCb is not a B factory. We have irreducible background! And we have to live with it.

D_s^+ decay	$\mathcal{B}_1^{(*)}$	Secondary decays	$\mathcal{B}_2$	$\mathcal{B}_{tot} = \mathcal{B}_1 \times \mathcal{B}_2$	$\sigma(D_s \to 3\mu X)$
$\eta\mu^+\nu_\mu$	2.67×10^{-2}	$\eta \to \mu^+\mu^-$	5.8×10^{-5}	1.5×10^{-6}	0.3 nb
		$\eta \to \mu^+\mu^-\gamma$	3.1×10^{-4}	8.2×10^{-6}	1.7 nb
		$\eta \to \pi^0\mu^+\mu^-\gamma$	$< 3 \times 10^{-6}$	$< 8.0 \times 10^{-8}$	$<$ 0.02 nb
$\eta'\mu^+\nu_\mu$	9.9×10^{-3}	$\eta' \to \mu^+\mu^-\gamma$	1.07×10^{-4}	1.1×10^{-6}	0.2 nb
$\phi\mu^+\nu_\mu$	2.49×10^{-2}	$\phi \to \mu^+\mu^-$	2.87×10^{-4}	7.1×10^{-6}	1.6 nb
		$\phi \to \mu^+\mu^-\gamma$	1.4×10^{-5}	3.4×10^{-7}	0.07 nb
		$\phi \to \mu^+\mu^-\pi^0$	$1.2 \times 10^{-5}(\dagger)$	2.8×10^{-7}	0.06 nb

(*) : given branching ratios are from corresponding $e\nu_e$ decays.
($\dagger$) : given branching ratio is from $\phi \to e^+e^-\pi^0$ decays.

$D_s \to (\eta \to \mu\mu\gamma)\mu\nu$

This decay was badly simulated in current version of MC. For proper simulation new method in EvtGen has been written. It takes into account of the factors from the NA60 experiment.
arXiv:1108.0968

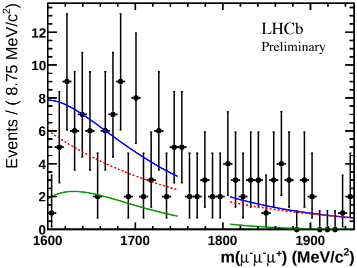


For the purpose of this analysis 5M events were simulated in a private production in IFJ computing cloud. Many thanks to Mariusz Witek for the computing resources!

Background extraction

There are 3 possibilities to deal with the background.

- Treat it as normal combinatorical background.
- Veto the η.
- Parametrize the η background and fit with combinatorical.



Results

As mentioned before I can't give the number. Please see slides from FPCP conference.

Summary

- LHCb is capable of performing $\tau \to \mu\mu\mu$ measurements.
- Method is completely different from that used in the B factories. We are cutting the phase space.
- Looking for particular model of decay could increase our sensitivity. Need MC generators for that.

Thank you for your attention.