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

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   - SM background
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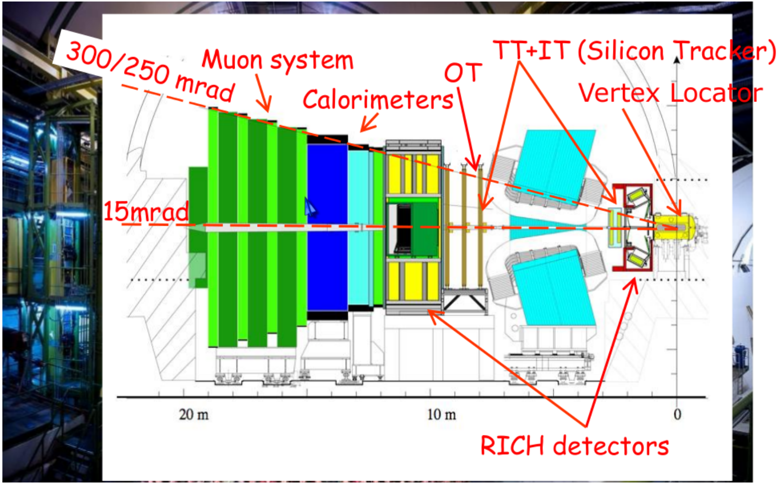
General Informations

- Fresh analyses! Aproved less than 24h ago.
- Premision to only speak generally without going to any details.
- Will try to be clouse to the boundry of what I can say

Appologyse

All details will be avaible avaible on FPCP conference so stay tune!

LHCb detector



LHCb detector

Strong features of LHCb detector:

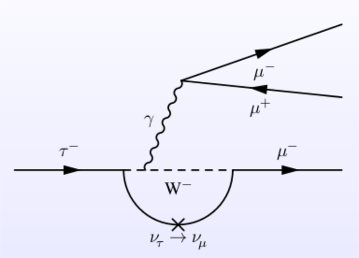
- Good particle indentyfication due to RICH detectors.
- State of the art strip detector provides good
- High luminosity. Nowadays operating 4 $10^{-32} cm^{-2} s^{-1}$. We target to get 1.5fb in 2012.

Theoretical and experimental status

Strong features of LHCb detector:

- LFV has been observed in neutrino oscillations.
- Never saw in charge 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 ($782 fb^{-1}$)



General informations

1. Three separate Likelihoods to discriminate background
   - Geometry and topology
   - Particle indentyfication
   - 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

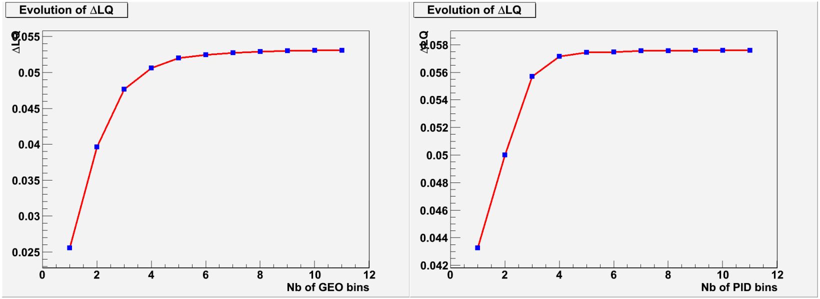
τ production

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



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

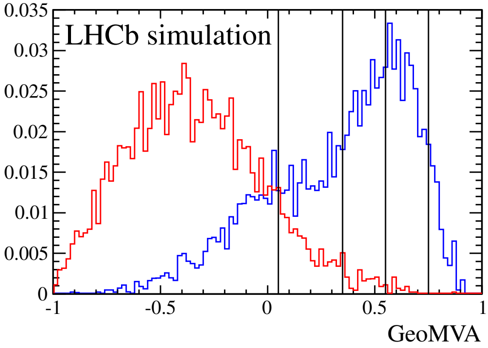
$Q_{SB} = \prod \frac{P(s_i+b_i,s_i+b_i)}{P(s_i+b_i,b_i)}$

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

$P(a, b)$ is the propabylity that expected number of backgound a fluctuated (by Poisson distribution) to b, and i is the bin bumber.

MVA parameter space

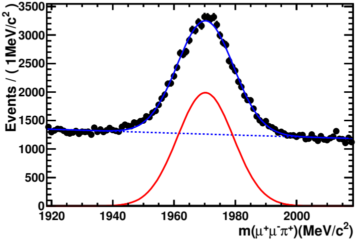
For the geometry and kinematics MVA is callibrated using $D_s \to \phi(\mu\mu)\pi$.



Normalization

τ BR was normalized to $D_s \rightarrow \phi(\mu\mu)\pi$

$$BR = BR_{Ds\rightarrow\phi\pi} \cdot \frac{f(\tau(D_S))}{BR(D_S \rightarrow \tau X)} \cdot \frac{\varepsilon_{cal}^{\mathrm{Re}cSel} \cdot \varepsilon_{cal}^{Trig}}{\varepsilon_{Bs}^{\mathrm{Re}cSel} \cdot \varepsilon_{Bs}^{Trig}} \cdot \frac{N_{\tau\rightarrow\mu\mu\mu}}{N_{D_S\rightarrow\phi\pi}} = \alpha \cdot N_{\tau\rightarrow\mu\mu\mu}$$



SM background

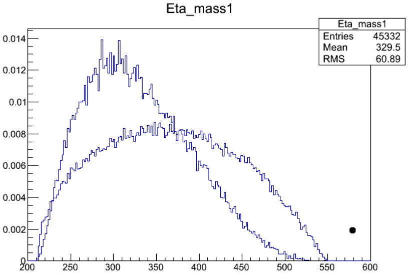
LHCb is not a B factory. We have ireducable background! And we have to life with it.

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.
(†) : 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 was written. It took into account form factors comming from NA60 experiment.
arXiv:1108.0968

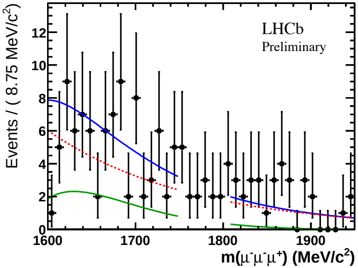


For the purpouse of this analyses 5M events were simulated in a private production in IFJ computing cloud. Many thanks to Mariusz Witek for computing resourses!

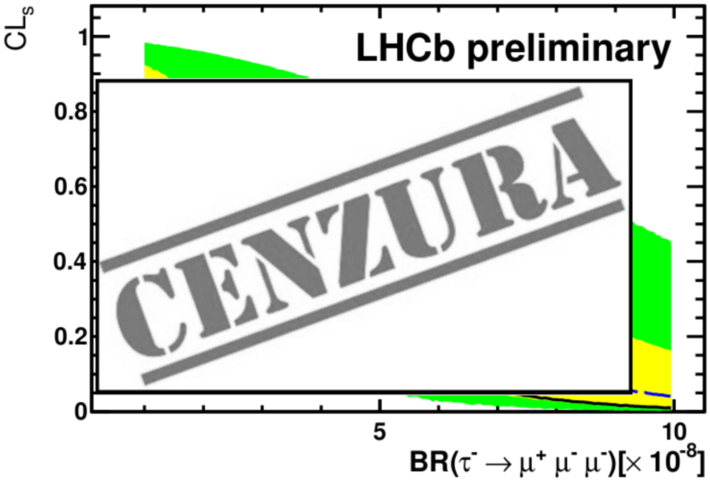
Background extraction

There are 3 possibilities to deal with background.

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



Results


CL_s
1
0.8
0.6
0.4
0.2
0
LHCb preliminary
CENZURA
5
10
$BR(\tau^- \to \mu^+ \mu^- \mu^-)[\times 10^{-8}]$

Summary

- LHCb is capable of performing $\tau \rightarrow \mu\mu\mu$ measurements.
- Method is completly different from the one used in B factories. We are cuting the phase space
- Looking for perticular model of decay could increase our sensetiwity. Need MC generators for that.

Thank you for your attention.