$\tau \to \mu\mu\mu$ Run 2 plans

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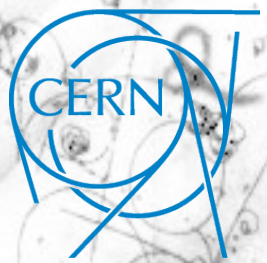

With M. Palutan (INFN Frascati), F. Teubert (CERN),
R. Vazquez Gomez (CERN)

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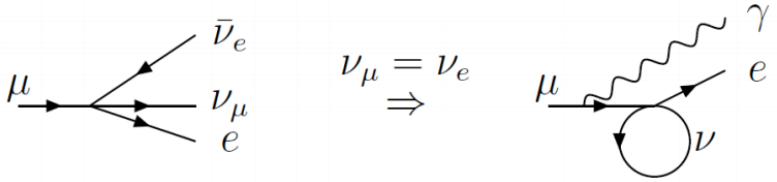
Lepton Flavour/Number Violation

Lepton Flavour Violation(LFV):
After μ^- was discovered it was logical to think of it as an excited e^-.

- Expected: $B(\mu \to e\gamma) \approx 10^{-4}$
- Unless another ν, in intermediate vector boson loop cancels.

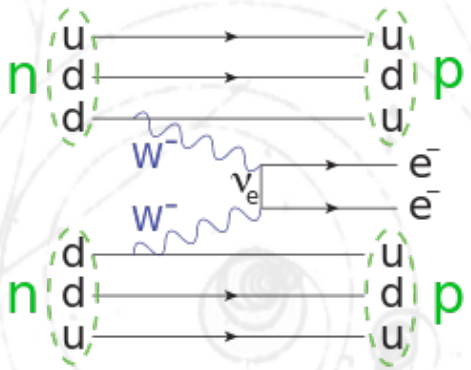


I.I.Rabi:
"Who ordered that?"

- Up to this day charged LFV is being searched for in various decay modes.
- LFV was already found in neutrino sector.

Lepton Number Violation (LNV)

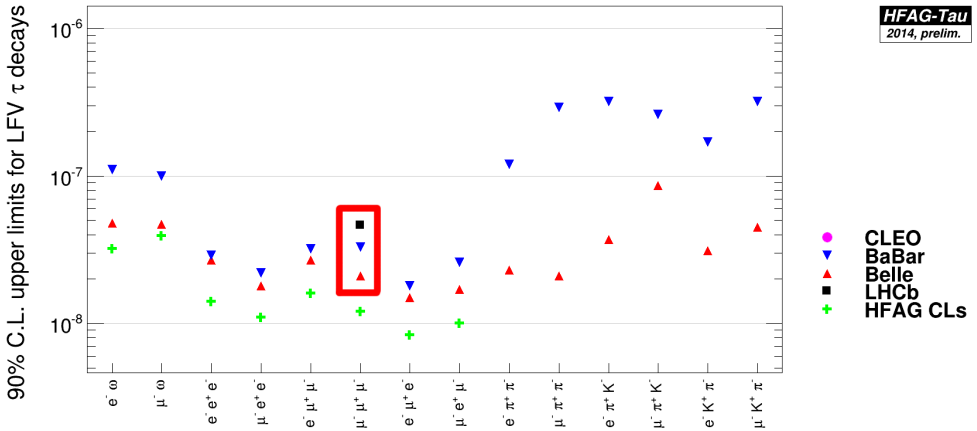
- Even with LFV, lepton number is a conserved quantity.
- Many new thesis predict it violation(Majorana neutrinos)
- Searched in so called Neutrinoless double β decays.



”The Rule of Three”

$\Rightarrow$ Since 4 years thee experiments are chasing the $\tau \to \mu\mu\mu$ decay:

$\tau \to \mu\mu\mu$ limits (90 % CL)	
BaBar(FC)	3.3×10^{-8}
Belle(FC)	2.1×10^{-8}
LHCb(CLs)	4.6×10^{-8} (3fb^{-1})
HFAG(CLs)	1.2×10^{-8}



- Thanks to 3 experiments we have a world limit: $\mathcal{B}(\tau \to \mu\mu\mu) < 1.2 \times 10^{-8}$ at 90% CL.
- Would be nice to put LHCb ahead of the game!
- We are getting close to B-factories with the Run2 data but still would be nice to have some boost!

Extra Gain ?

$\Rrightarrow$ The stripping that we are using takes 3 `StdLooseMuons` and construct a τ candidate.

$\Rrightarrow$ Now the stripping is loose in other variables.

Category	Gain wrt. 3 isM [%]	
	2 isM	2isM + 3AccM
$B \to \tau$	44.53	12.67
$B \to D_s \to \tau$	44.37	12.44
$D_s \to \tau$	43.78	12.34
$B \to D \to \tau$	46.31	13.97
$D \to \tau$	43.70	11.87

Legend:

- isM -IsMuon.
- AccM - Muon in Acceptance.

$\Rrightarrow$ There is extra gain $\mathcal{O}(40\ \%)$ that could be included!

$\Rrightarrow$ We have already modified the Stripping line and will be run in the S28 restripping.

Initial trigger study

IsMuon == 3 WITH TOS BUG FIXED!!

Name	Eff	Gain wrt. to previous
Hlt2TriMuonTau23Mu	0.76343	0.763439
Hlt2SingleMuonLowPT	0.764768	0.001328
Hlt2CharmHadDpToPimPipPipTurbo	0.76515	0.00038
Hlt2RareCharmD02KPi	0.76528	0.00012
Hlt2SingleMuon	0.765369	0.00008
Hlt2LowMultDiMuon	0.765454	0.00006
Hlt2XcMuXForTauB2XcMu	0.765454	0.0

How to read table

Example: Hlt2CharmHadDpToPimPipPipTurbo, 0.76444, 0.00071

Eff. of Hlt2CharmHadDpToPimPipPipTurbo || Hlt2SingleMuonLowPT || Hlt2TriMuonTau23Mu is 0.76444.

Gain of adding Hlt2CharmHadDpToPimPipPipTurbo to previous Hlt2SingleMuonLowPT || Hlt2TriMuonTau23Mu is 0.00071.

IsMuon == 2 WITH TOS BUG FIXED!!

Name	Eff	Gain wrt. to previous
Hlt2CharmHadDpToPimPipPipTurbo	0.22792	0.22792
Hlt2SingleMuon	0.28015	0.052231
Hlt2SingleMuonLowPT	0.28975	0.00960
Hlt2RareCharmD02KPi	0.293869	0.004115
Hlt2CharmHadDspToKpPimPipTurbo	0.297034	0.003165
Hlt2CharmHadInclSigc2PiLc2HHX	0.29946	0.00242
Hlt2RareCharmD02MuMu	0.30115	0.00168
Hlt2LowMultDiMuon	0.302732	0.001582
Hlt2TopoMu3Body	0.303999	0.001266
Hlt2CharmHadDspToKmPipPipTurbo	0.30452	0.00052

Trigger conclusion

- For the 3 `ISMuon` case we are safe.
- The 2 `ISMuon` :
  - Problem will be fixed in 2017 data after bug fix of the Hlt2DiMuonDetached line.
  - For 2015, 2016 we will define our strategy later.

MC filtering

⇛ Producing MC becomes more and more a problem.
⇛ Need a smart way to reduce the data set at the production level:

MC Filtering:

Select only the events that are needed for the analysis ⇛ Saving disk space.
Caveat: once lost events cannot be recovered.

What to filter on?

⇛ Stripping?
⇛ Trigger?
⇛ Reconstruction!

⇛ Filtering on MCTRUTHMACHED is the safest thing to do!

How does this work?

⇛ You check that the Particle lists (ex. `Phys/StdAllNoPIDsMuons/Particles`) contain all particles from the decay (ex. $\tau \to 3\mu$).

⇛ Very robust! Sensitive only to bugs in reconstruction and TruthMaching.

⇛ Already tested this in $B \to K^* \mu\mu$ with success.

⇛ Now implemented for $\tau \to \mu\mu\mu$ analysis.

Filter efficiency

Channel	Fraction of save events
$\tau \to 3\mu$	0.553
$D_s \to \phi\pi$	0.481

$\Rrightarrow$ FILTER IS IMMUNE TO ANY `isMuon` REQUIREMENT.

$\Rrightarrow$ We save around 50 % of disk space!

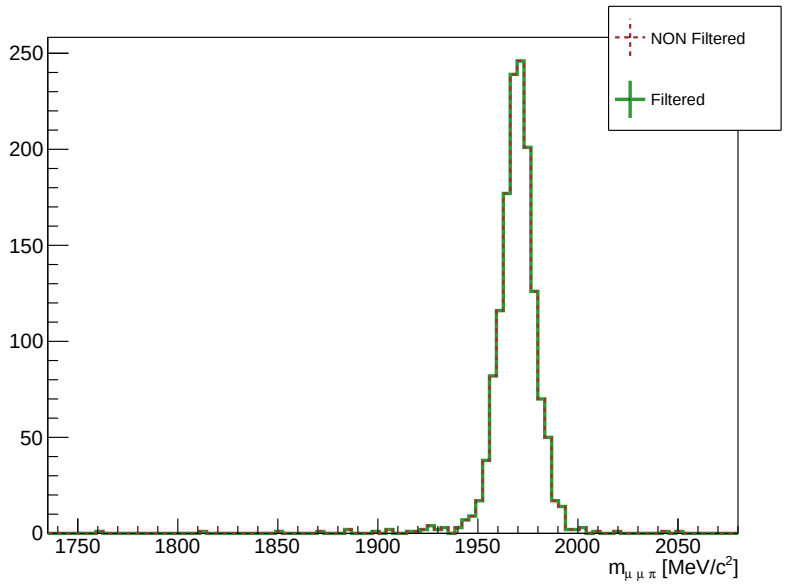
Cross check

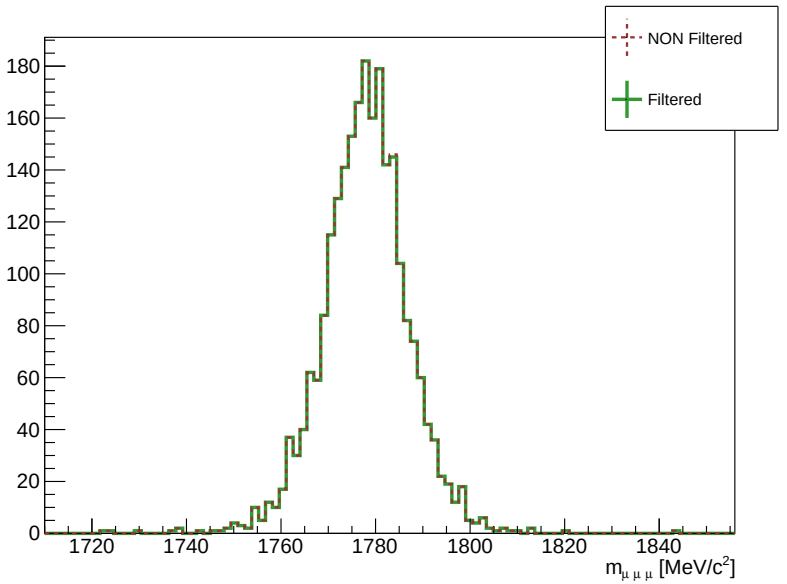
⇛ As a cross-check is performed:

- Strip the filtered dst.
- Strip the non filtered dst.

⇛ After truthmaching they both should be identical.

⇛ And they are:





(Yes there are two IDENTICAL histograms on each plot :))

Conclusions

- ⇛ There is a potential $40\ \%$ gain of the signal!
- ⇛ Stripping implemented.
- ⇛ Filter for MC production developed and tested!
- ⇛ We gain $50\ \%$ on disk space!
- ⇛ Trigger strategy on the way.
- ⇛ We would like to ask for 2015,2016,2017 Filtered signal MC.

IsMuon == 3 WITH TOS BUG!!

Name	Eff	Gain wrt. to previous
Hlt2TriMuonTau23MuDecision	0.76343	0.76343
Hlt2SingleMuonLowPTDecision	0.76372	0.00136
Hlt2CharmHadDpToPimPipPipTurbo	0.76444	0.00071
Hlt2SingleMuonDecision	0.76459	0.00015
Hlt2RareCharmD02KPiDecision	0.76474	0.00015
Hlt2LowMultDiMuon	0.76482	0.00008
Hlt2XcMuXForTauB2XcMuDecision	0.76482	0.0

How to read table

Example: Hlt2CharmHadDpToPimPipPipTurbo, 0.76444, 0.00071

Eff. of Hlt2CharmHadDpToPimPipPipTurbo || Hlt2SingleMuonLowPT || Hlt2TriMuonTau23Mu is 0.76444.

Gain of adding Hlt2CharmHadDpToPimPipPipTurbo to previous Hlt2SingleMuonLowPT || Hlt2TriMuonTau23Mu is 0.00071.

IsMuon == 2 WITH TOS BUG!!

Name	Eff	Gain wrt. to previous
Hlt2CharmHadDpToPimPipPip	0.18769	0.18769
Hlt2SingleMuonD	0.25864	0.07095
Hlt2SingleMuonLowPT	0.27076	0.01212
Hlt2RareCharmD02KPi	0.27431	0.003543
Hlt2CharmHadDspToKpPimPip	0.27738	0.00307
Hlt2CharmHadInclSigc2Pi	0.279347	0.00195
Hlt2RareCharmD02MuMu	0.28121	0.00186
Hlt2LowMultDiMuon_PS	0.28279	0.00158
Hlt2TopoMu3Body	0.28400	0.001212
Hlt2PIDKs2PiPiLLTurboCalib	0.284568	0.00055