Searching for $K^0 \rightarrow \mu^-\mu^+\pi^-\pi+$ Decays

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- Initial interest – small Q-value allows precise measurement of K^0 mass, reducing systematic uncertainties related to momentum scale uncertainty.
- Guesstimated BF($K^0 \rightarrow \pi^-\pi^+\mu^+\mu^-$) ~ 10^{-8} based on other branching fractions and phase space.
  - BF($K_S \rightarrow \pi^-\pi^+$) ~ 0.69
  - BF($K_S \rightarrow \pi^-\pi^+\gamma$) ~ 1.8×10^{-3}
  - BF($K_S \rightarrow \pi^-\pi^+e^+e^-$) ~ 4.8×10^{-5}
- Giancarlo D'Ambrosio calculates SM contribution to BF($K_S \rightarrow \pi^-\pi^+\mu^+\mu^-$) ~ 4×10^{-14}. This offers the possibility that this decay could probe New Physics.
- Guesstimate how many K_S are produced in a "year" of running LHCb: (5×10^6 sec/year) x (1 MHz L0) x (μ = 1.6) x (1 K_S per event) ~ 10^{13} K_S per year.

Work To Date

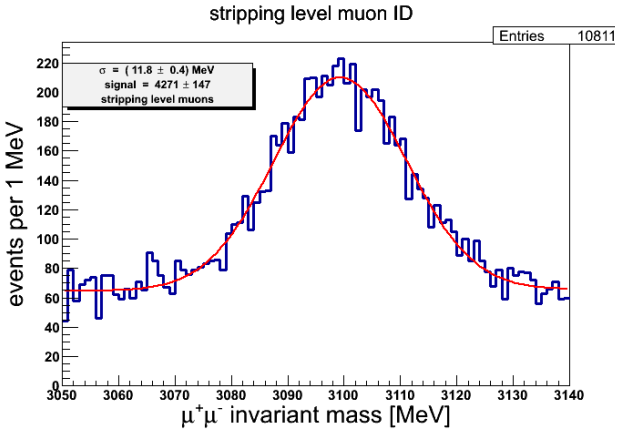
- Hlt2 trigger line deployed following August 2012 TS.
- Corresponding stripping line run on 2011 and 2012 data, no TOS requirement.
- 2011 MagnetDown data (~ 400 pb^{-1}) studied.

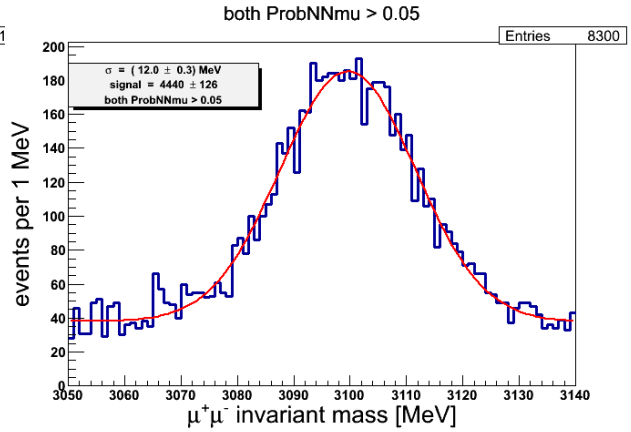
Core elements of stripping code

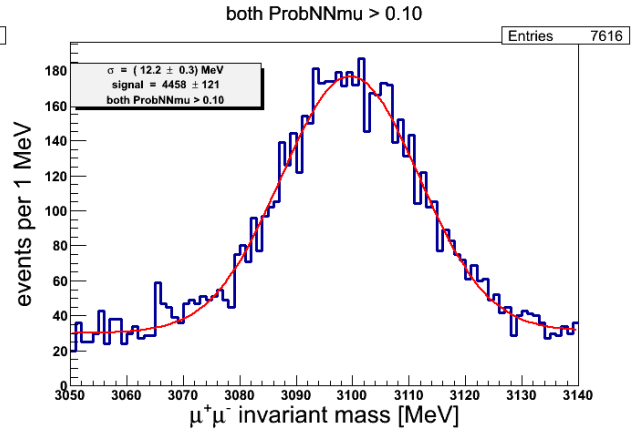
```
_combcut = "(AM < %(MaxKsMass)s *MeV) & "\   (550 MeV)
        "(AMAXDOCA('')<%(DMAXDOCA)s) & " \   (0.2 mm)
        "(AM34 < %(MaxDimuonMass)s *MeV) &"\  (260 MeV)
        "(AHASCHILD( (MIPCHI2DV(PRIMARY)>%(KsDauMAXIPCHI2)s)  )   )" %locals()   (15)
                                                [might relax this requirement in 2015]

_mothercut   = "(VFASPF(VCHI2/VDOF) < %(DVCHI2DOF)s) & "\
           "(PT > %(DPT)s *MeV) &"\    (2500 MeV)  [might relax this requirement in 2015]
           "(M < %(KsMotherMassCut)s *MeV) &"\     540 MeV
           "(BPVVDCHI2>%(DFDCHI2)s) & (BPVIPCHI2()< %(DIPCHI2)s) & "\     (9 & 20)
           "(BPVDIRA > %(DDIRA)s)" % locals()    (0.9999)
```

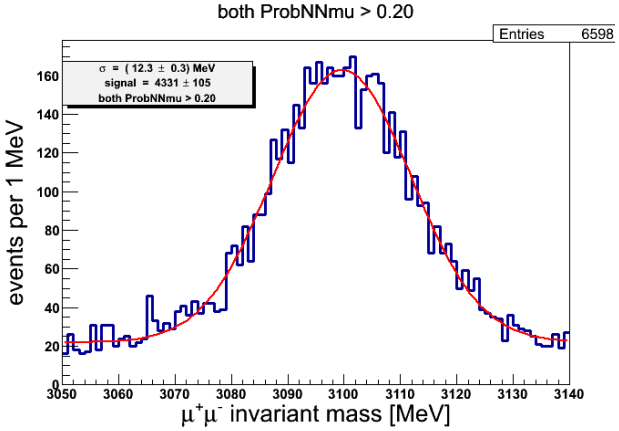
Muon selection includes
(PIDmu-PIDpi > %(MuonPIDmu_CS_hhmumu)s) (-1)

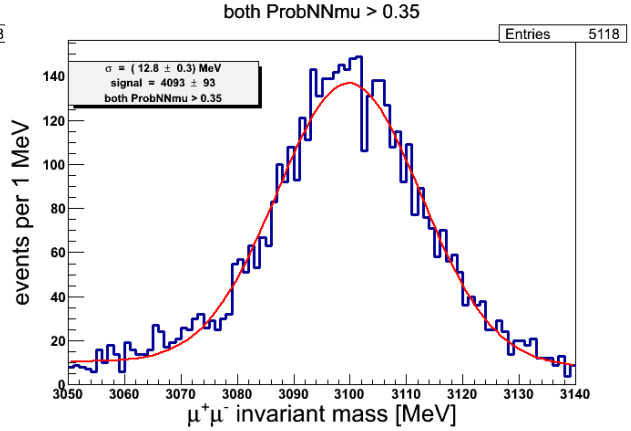
Muon ID studied using J/ψ candidates







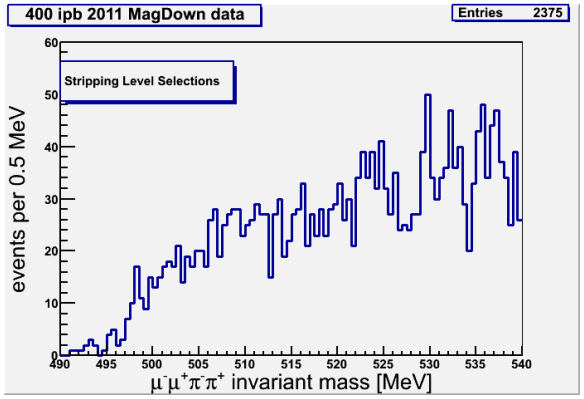


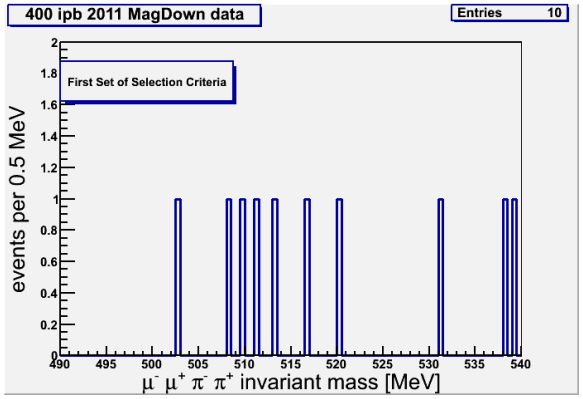


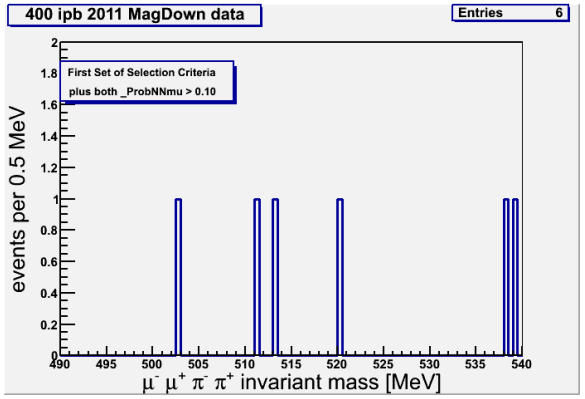
fitted $\mathbf{J/\psi \to \mu^+\mu^-}$

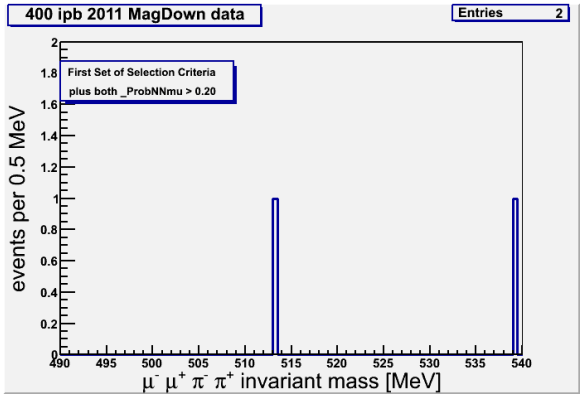
Stripping Level	4271 +- 147
ProbNNmu > 0.05	4440 +- 126
ProbNNmu > 0.10	4458 +- 121
ProbNNmu > 0.20	4331 +- 105
ProbNNmu > 0.35	4093 +- 93

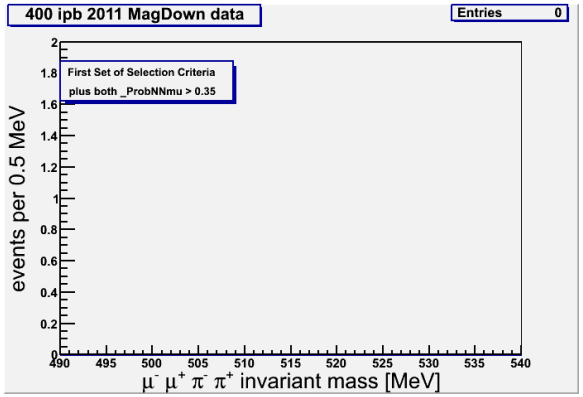
$K^0 \rightarrow \mu^-\mu^+\pi^-\pi+$ Candidates











Observations

- entries with loosest cuts suggest lack of blatant bugs.
- entries with tighter cuts are consistent with removing hadrons misidentified as muons.

Moving Forward

- Run trigger/stripping/analysis code on Monte Carlo to determine efficiencies.
- Study normalization channel ($K_S \rightarrow \pi^-\pi^+$); MC and data.
- Analyze remaining untriggered 2011 & 2012 data; then triggered 2012 data.