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CP Violation in B_s-->$J/\psi+\eta$ decay

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- γ-extraction strategy
- J/ψ -->$\mu3(5)\mu6$
- η --> $\gamma\gamma$
- B_s -->$J/\psi\ \eta$
- Tagging

Theoretical point of view

$B_{d,s}$ -->$J/\psi K$

$e^{i\gamma}$ in B_d -->$J/\psi K_s$ is CKM suppressed
$e^{i\gamma}$ in B_s -->$J/\psi K_s$ is CKM allowed

==> CP violating effects more visible in B_s -->$J/\psi K_s$.

U-spin summetry allows to fix the overall normalization of B_s -->$J/\psi K_s$ through the CP averaged $B_{d,s}$ -->$J/\psi K_s$ rates.

$B_{d,s}$ -->$J/\psi\eta$

$e^{i\gamma}$ in B_d -->$J/\psi\eta$ is CKM allowed
$e^{i\gamma}$ in B_s -->$J/\psi\eta$ is CKM suppressed

==> CP violating effects more visible in B_d -->$J/\psi\eta$.

U-spin summetry allows to fix the overall normalization of B_d -->$J/\psi\eta$ through the CP averaged $B_{d,s}$ -->$J/\psi\eta$ rates.

U-spin symmetry:

Br(B_d -->$J/\psi K_s$)=4.45 10^{-4}
Br(B_s -->$J/\psi K_s$) =2.7 10^{-5}

Br(B_d -->$J/\psi\eta$)=4 - 1.6 10^{-6}
Br(B_s -->$J/\psi\eta$) =8.3 - 9.5 10^{-4}

PYTHIA:

250 B_d for each B_s events

40 B_s for each B_d events

=> The statistical error is expected to be lower in the case of $B_{d,s}$ -->$J/\psi\eta$
(assuming perfect detector resolution)

Experimental point of view

Originally it was suggested to measure the asymmetries in the B_d -->$J/\psi\eta$, fix the overall normalization of this channel through the ratio of the CP averaged rates of the two channels.

Experimentally the B_d -->$J/\psi\eta$ channel is very difficult to reconstruct due to the bad mass resolution,

The inverse of the situation seems more promising:

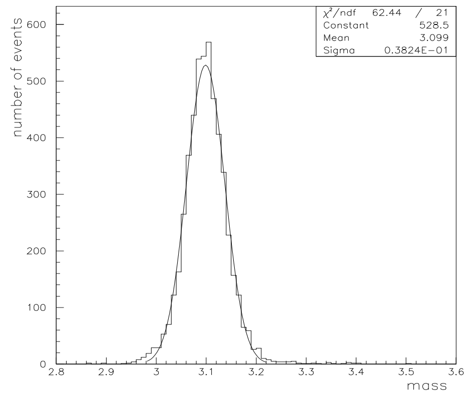
- Measure the asymmetries in the B_s -->$J/\psi\eta$, tagging required
- Measure the CP averaged rates of $B_{d,s}$ -->$J/\psi\eta$.
- Extract the γ angle.

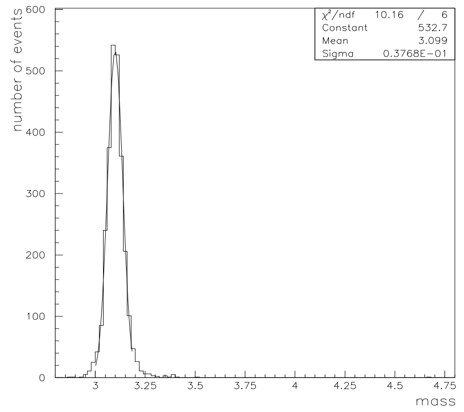
--> $J/\psi \rightarrow \mu3(5)\mu6$

All pairs of opposite charge muons are fitted to a common vertex and their invariant mass calculated.

Variable	*cut*	$J/\psi \rightarrow \mu3\mu6$	$J/\psi \rightarrow \mu5\mu6$
Acceptance	***LVL1* cuts**	**99.37%**	**99.45%**
matching + fit quality	$\chi2 < 6$	**90.96%**	**90.98%**
mass window σ=38 **MeV**	$[-3\sigma,+3\sigma]$	**98.14%**	**97.34%**
decay length	***Lxy*>250 μm**	**86.58%**	**87.84%**

Overall	**76.8%**	**77.32%**





--> η --> $\gamma\gamma$

The two highest clusters are combined to reconstruct η.

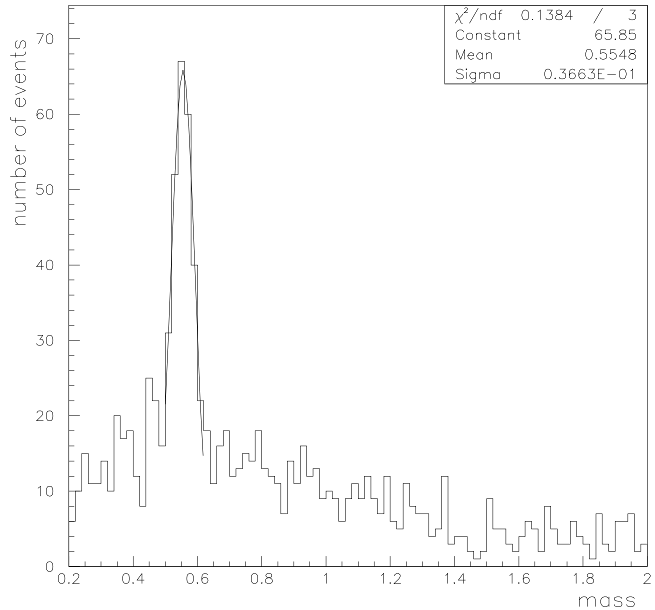
within $[-2\sigma,+2\sigma]$, $\sigma=37$ MeV the η reconstruction efficiency is:

$$\varepsilon(\eta \rightarrow \gamma\gamma) \sim 7.8\ \%\ (\mu3\mu6)$$

For the other case of $\mu5\mu6$: $\sigma=33$ MeV

$$\varepsilon(\eta \rightarrow \gamma\gamma) \sim 6.5\ \%\ (\mu5\mu6)$$

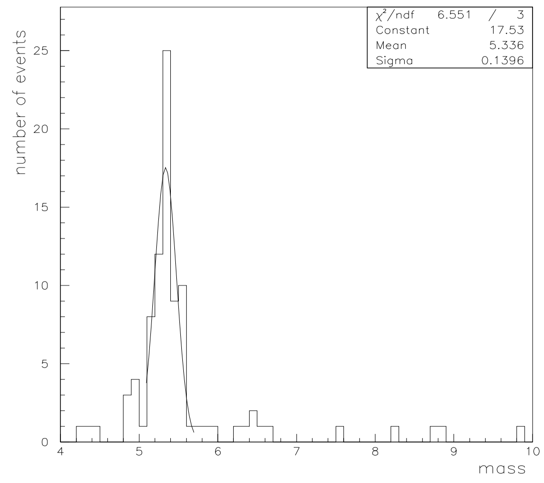
The size of the cluster window does not affect the mass resolution of η: $\sigma/m \sim 6.6$ %



--> B_s ->$J/\psi(\mu3\mu6)+\eta(\gamma\gamma)$:

mass resolution σ~140 MeV within $[-2\sigma,+2\sigma]$:

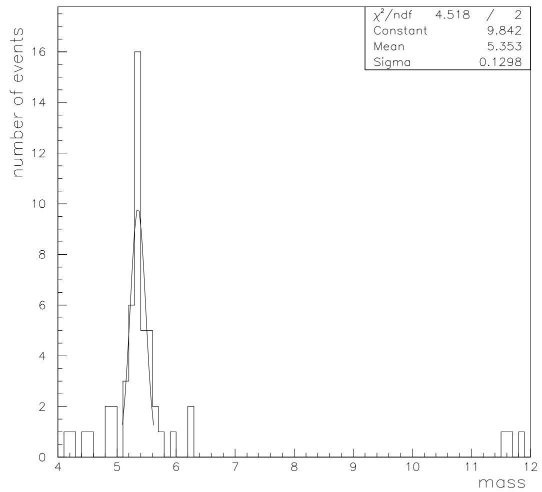
$\varepsilon \sim 1.2\%$



--> B_s ->$J/\psi(\mu5\mu6)+\eta(\gamma\gamma)$:

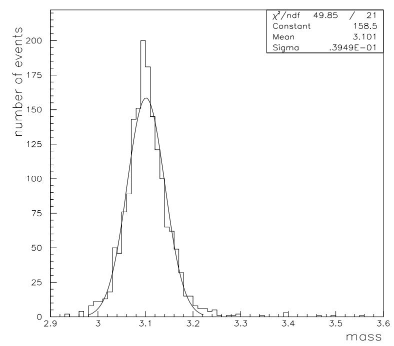
mass resolution σ~ 130 MeV within $[-2\sigma,+2\sigma]$:

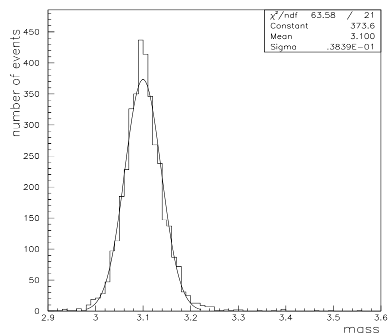
$\varepsilon \sim 0.48\%$



The background studied is *bb-->J/ψ+X:*

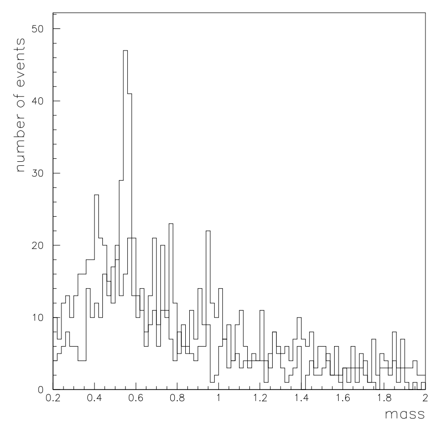
ε(***J/ψ->***$\mu 3 \mu 6$)~***72%***
ε(***J/ψ->***$\mu 5 \mu 6$)~***73.12%***





Within $[-2\sigma,+2\sigma]$, $\sigma=37$ **MeV the reconstruction efficiency of fake** η **->** $\gamma\gamma$ **is:**

ε ~ **4%**



ε(***bb->XJ/ψ(μ3μ6)***) ~ ***0.025 %***
ε(***bb->XJ/ψ(μ5μ6)***) ~ ***0.013 %***

Significance:

The cross sections for both signal and background are calculated from PYTHIA. For 3 years of initial running of LHC at low luminosity ($L=30fb^{-1}$), the number of signal and background events are estimated:

Signal:

$\sigma(bb \to B_sX \to J/\psi\eta + X) = 0{,}026\text{-}0.03$ nb

N = 780,000 - 894,000 events

background:

$\sigma(bb \to J/\psi X) = 4$ nb

N = 12.10^7 events

Channel	*Bs->J/ψ(μ3μ6)η*	*Bs->J/ψ(μ5μ6)η*	*bb->J/ψ(μ3μ6)x*	*bb->J/ψ(μ5μ6)x*
Reconstructed events	9360 - 10,070	3740 - 4290	30,000	15,600

Significance	54 - 62	75-80

Tagging:

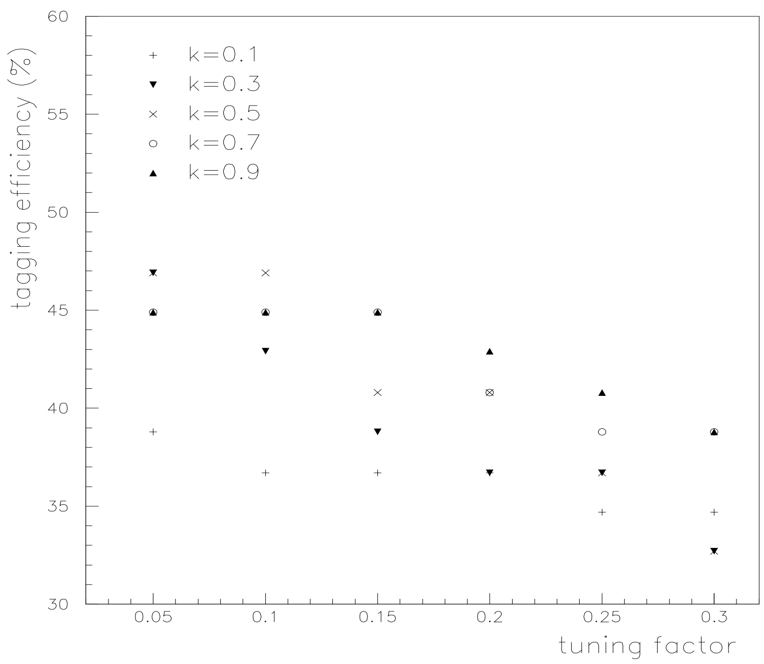
In principle two techniques of tagging can be used in this study:

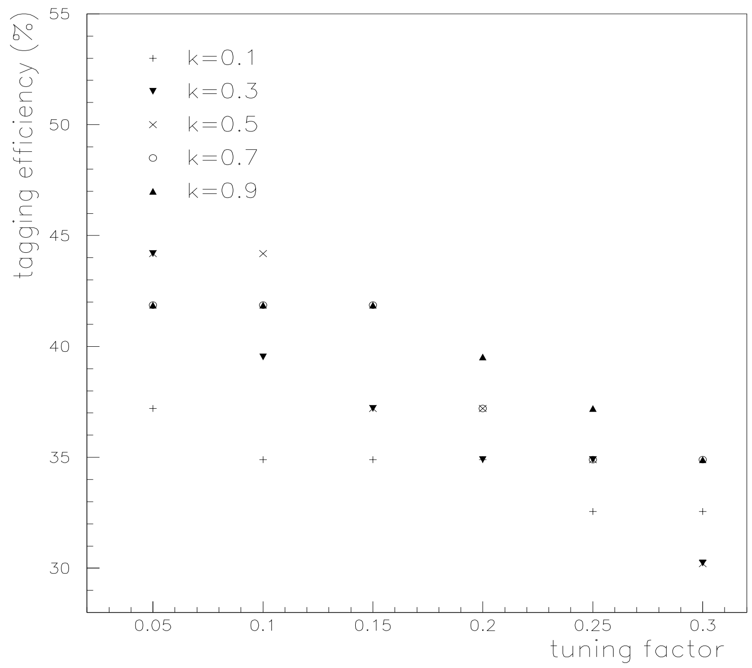
- lepton tagging
- JC-tagging

--> Lepton tagging: An electron or muon with a Pt > 5GeV. However the statisctics we have used is not enough to have a realistic results.

--> JC-tagging : all tracks with a Pt>0.5 GeV, |d0|<1 cm, $\Delta R<0.8$ are included in the charge calculation. The jet charge is defined as:

$$Q_{jet} = \frac{\Sigma q_i p^{i(k)}}{\Sigma p^{i(k)}}$$





2σ window for both η and B_s

1σ window for both η and B_s

In the fisrt case the optimal value of the εtag factor is around 38% and is obtained for k=0.5 and Qjet > 0.1, whereas in the second case the optimal value for εtag~ 44% and corresponds to k=0.5 for the same tunable cuts on Qjet.

These values are preliminary in the sense that the statistics used is small.

For *Bs->J*$\psi(\mu3\mu6)\eta$: εtag **= 0.44** **D**tag **= 0.21** **Q=1.9%**

***TDR**: ε**tag**=**0.62, Dtag=0.23 for Bs-->J/**$\psi+\phi$*

The number of tagged events is:

Method	*Lepton tagging*	*JC-tagging*
Events number	n/a	2060 - 2360

- More statistics of both signal and background.
- Generation of the B_d -->$J/\psi\ \eta$.
- Migration to ATHENA framework.