$B_s \to J/\psi\ \varphi \to \mu^-\mu^+K^-K^+$ lifetime

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PhD seminar,
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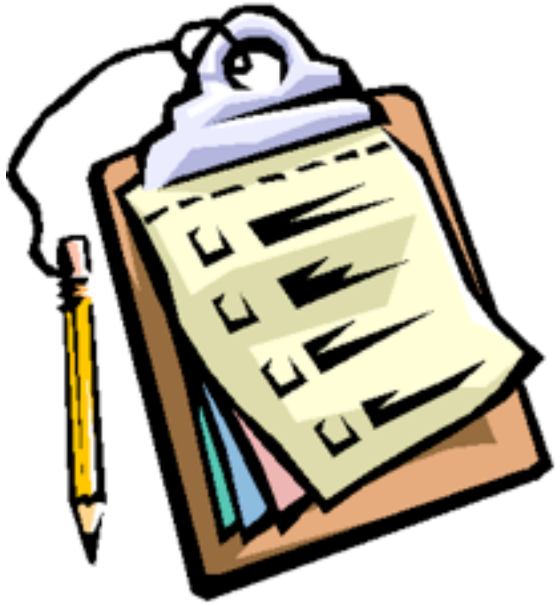
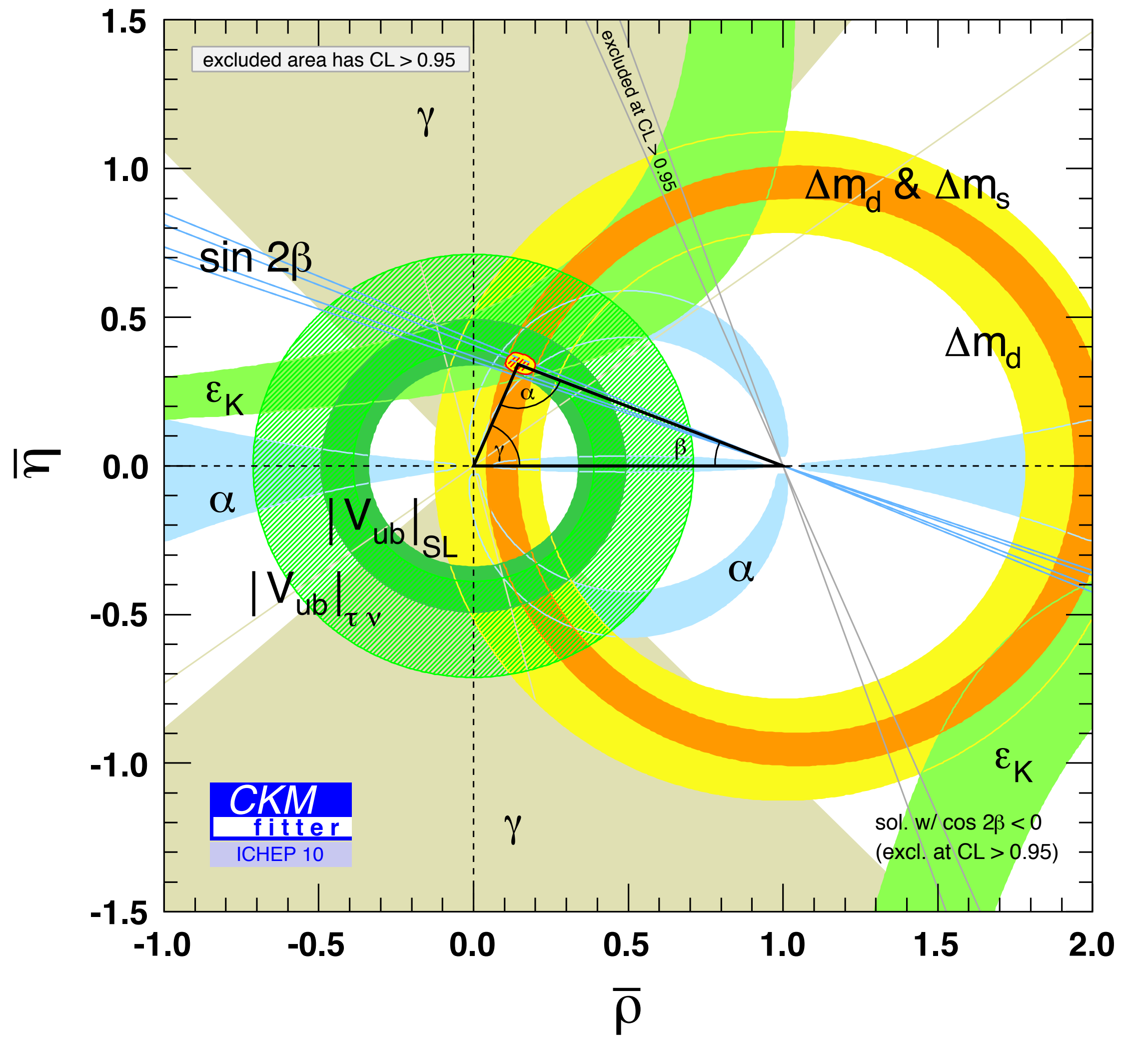
Agenda



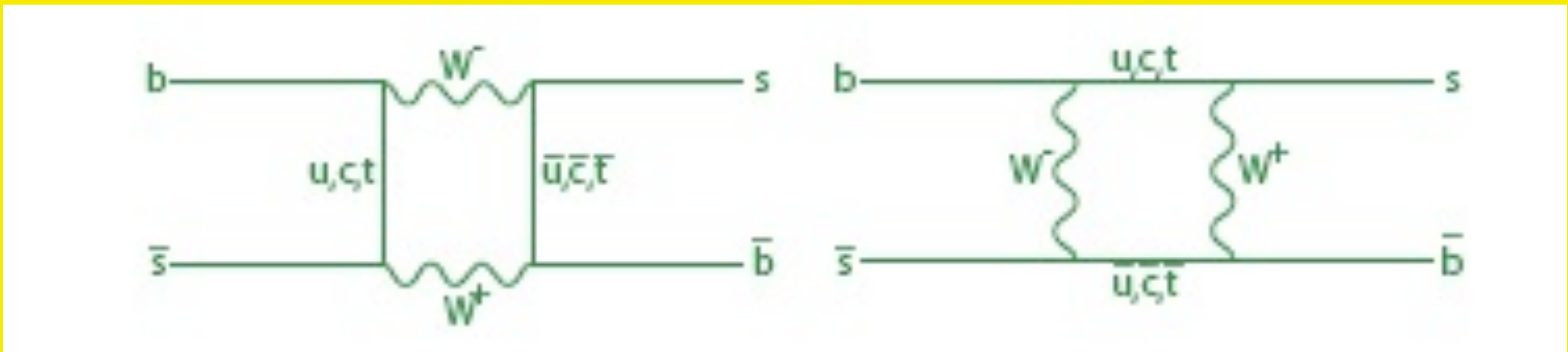
- Introduction
- B_s meson oscillation
- CMS Experiment
- Event reconstruction $J/\psi\ \varphi \rightarrow \mu^-\mu^+K^-K^+$
- Results & expectations with 2011 Data
- Conclusion

Why B_s meson?

- Accuracy studies
- This decay provides one of the best ways to determine the height of the unitarity triangle



B_s meson oscillation

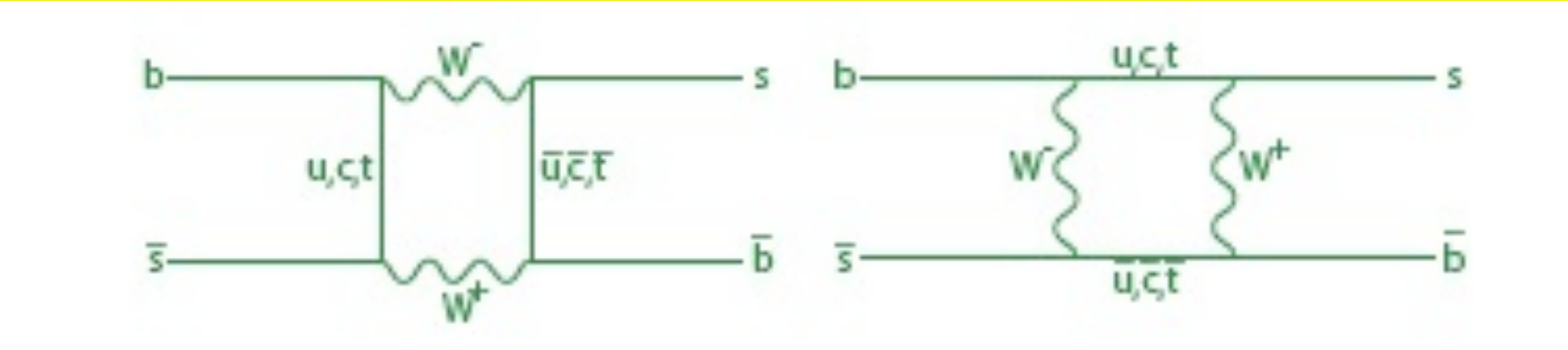


- Oscillation frequency is given by $\Delta m = m_s^H - m_s^L$

- 2 CP eigen-states B^H_s B^L_s with different life times $\Delta\Gamma = \Gamma_s^H - \Gamma_s^L$

- $$P(t) = \frac{e^{-\Gamma t}}{2}[cosh(\frac{\Delta\Gamma t}{2})] + (-)cos(\Delta m t)$$

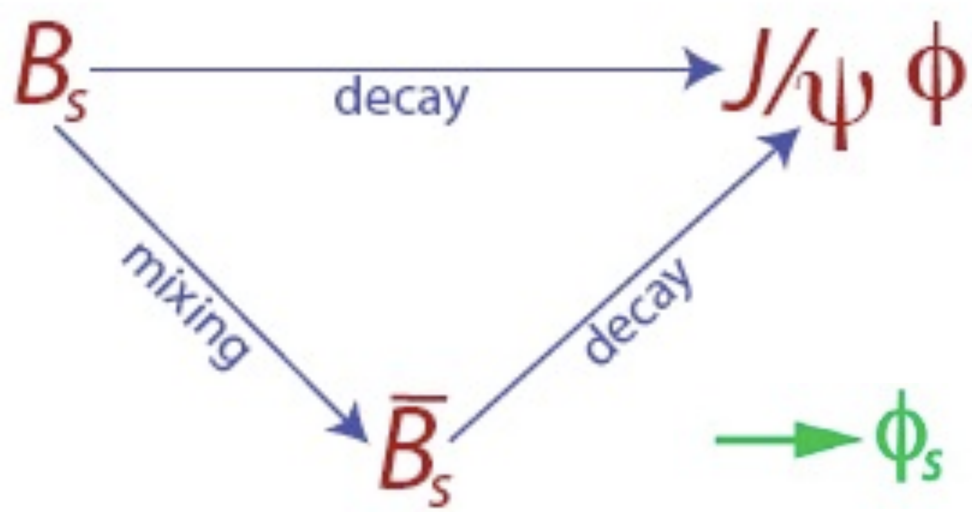
B_s meson oscillation



Oscillation frequency is given by 2 CP eigen-states

B^H_s B^L_s with different life times

$$\Delta\Gamma = \Gamma_s^H - \Gamma_s^L$$



- Interference of both decays involves CP violating phase Φ_s
- Φ_s expected to be small in the SM ($\approx$ -0.04)
- ~~Large observed Φ_s = new physics~~

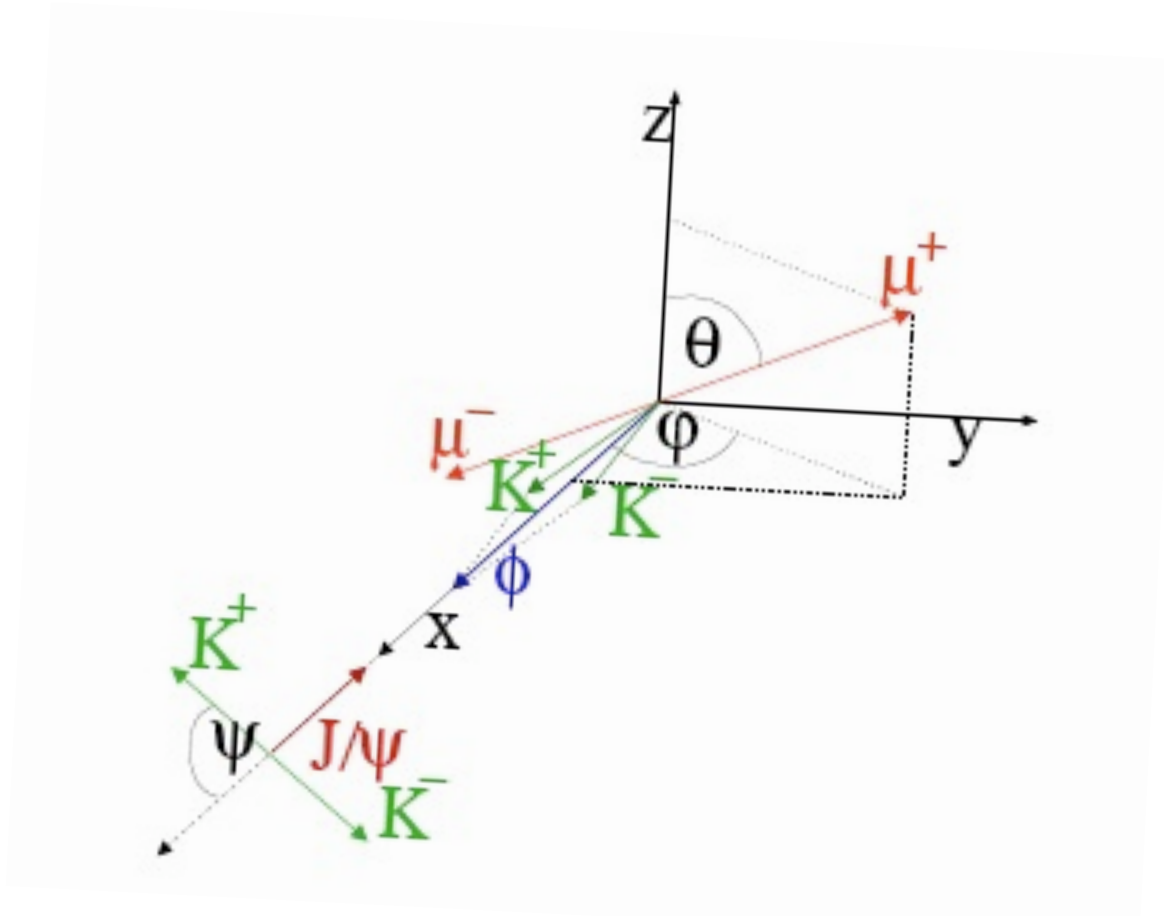
LHCb Preliminary

$\phi_s = 0.03 \pm 0.16 \pm 0.07$ rad

- b - factories run below threshold of B_s production, best result from B_s mixing come from Tevatron (last Saturday were released latest LHCb results)

Characteristic signal with untagged analysis

What can be observed:
Angular correlations
What I want to measure:
CP even/odd eigenstate
$\Delta\Gamma_s$
Assumed Φ_s=0



Physical angles defined to describe the decay

Decay rate

$$\frac{d^4\Gamma(B_s(t))}{d\Theta\, dt} = f(\Theta, \alpha, t) = \sum_{i=1}^{6} O_i(\alpha, t) \cdot g_i(\Theta)$$

α =physical parameters like decay time,difference decay time, and ϕ_s
Θ = three angles defined by the decay

Theory

Differential decay rate:

$$\frac{d^4\Gamma(B_s(t))}{d\mathbf{\Theta}\, dt} = f(\mathbf{\Theta},\alpha,t) = \sum_{i=1}^{6} O_i(\alpha,t)\cdot g_i(\mathbf{\Theta})$$

Θ≡(cosϑ,ϕ,cosψ)
α≡physical parameters

$$\begin{aligned}
O_1 &= |A_0(t)|^2 \\
&= |A_0(0)|^2\left[e^{-\Gamma_L t}+e^{-\Gamma_H t}-|\cos\phi_s|\left(e^{-\Gamma_H t}-e^{-\Gamma_L t}\right)\right], \\
O_2 &= |A_{\parallel}(t)|^2 \\
&= |A_{\parallel}(0)|^2\left[e^{-\Gamma_L t}+e^{-\Gamma_H t}-|\cos\phi_s|\left(e^{-\Gamma_H t}-e^{-\Gamma_L t}\right)\right], \\
O_3 &= |A_{\perp}(t)|^2 \\
&= |A_{\perp}(0)|^2\left[e^{-\Gamma_L t}+e^{-\Gamma_H t}+|\cos\phi_s|\left(e^{-\Gamma_H t}-e^{-\Gamma_L t}\right)\right], \\
O_4 &= \mathscr{I}m(A_{\parallel}^*(t)A_{\perp}(t)) \\
&= -|A_{\parallel}(0)||A_{\perp}(0)|\cos(\delta_1)\sin\phi_s(e^{-\Gamma_H t}-e^{-\Gamma_L t}), \\
O_5 &= \mathscr{R}e(A_0^*(t)A_{\parallel}(t)) \\
&= |A_0(0)||A_{\parallel}(0)|\cos(\delta_2-\delta_1)\left[e^{-\Gamma_L t}+e^{-\Gamma_H t}-|\cos\phi_s|\left(e^{-\Gamma_H t}-e^{-\Gamma_L t}\right)\right] \\
O_6 &= \mathscr{I}m(A_0^*(t)A_{\perp}(t)) \\
&= -|A_0(0)||A_{\perp}(0)|\cos(\delta_2)\sin\phi_s(e^{-\Gamma_H t}-e^{-\Gamma_L t}).
\end{aligned}$$

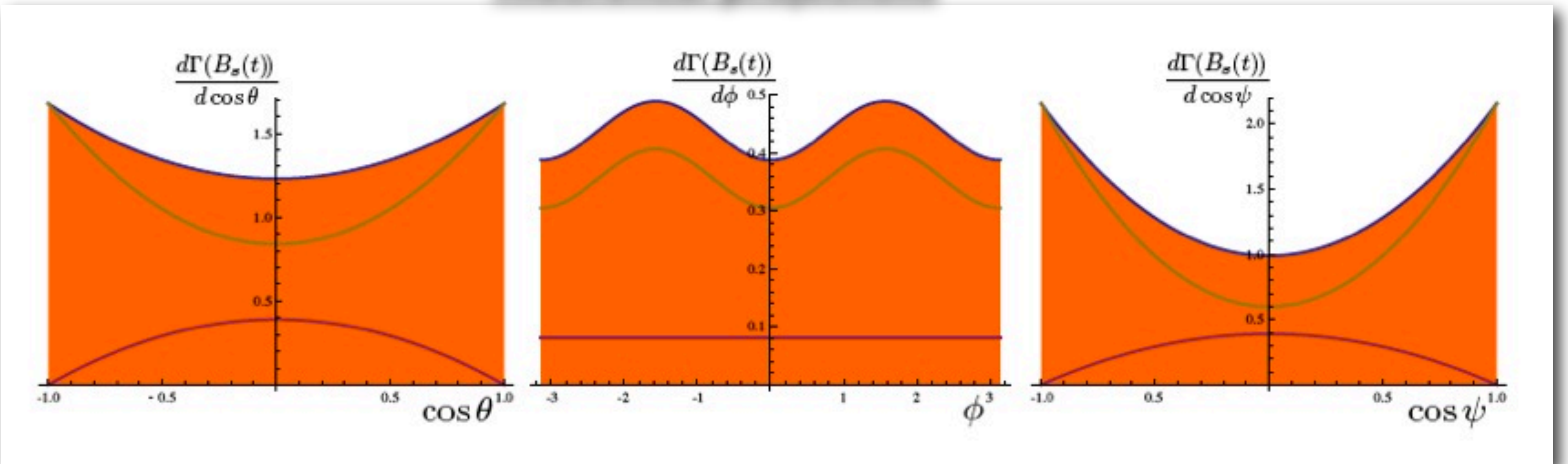
Individual angular distributions

$$\begin{aligned}
g_1 &= 2\cos^2\psi(1-\sin^2\theta\cos^2\varphi), \\
g_2 &= \sin^2\psi(1-\sin^2\theta\sin^2\varphi), \\
g_3 &= \sin^2\psi\sin^2\theta, \\
g_4 &= \sin^2\psi\sin 2\theta\sin\varphi, \\
g_5 &= 1/\sqrt{2}\sin 2\psi\sin^2\theta\sin 2\varphi, \\
g_6 &= 1/\sqrt{2}\sin 2\psi\sin 2\theta\cos\varphi.
\end{aligned}$$

$$|A_0|^2 + |A_\perp|^2 + |A_\parallel|^2 = 1$$

Fit in 4-Dimensions assuming $\phi_s=0$

Theoretical projections



$$P=(\epsilon(t).\epsilon(\Theta).f(\Theta,\alpha,t))\otimes G(t,0,\sigma_t)$$

$\Theta\equiv(\cos\vartheta,\varphi,\cos\psi)$

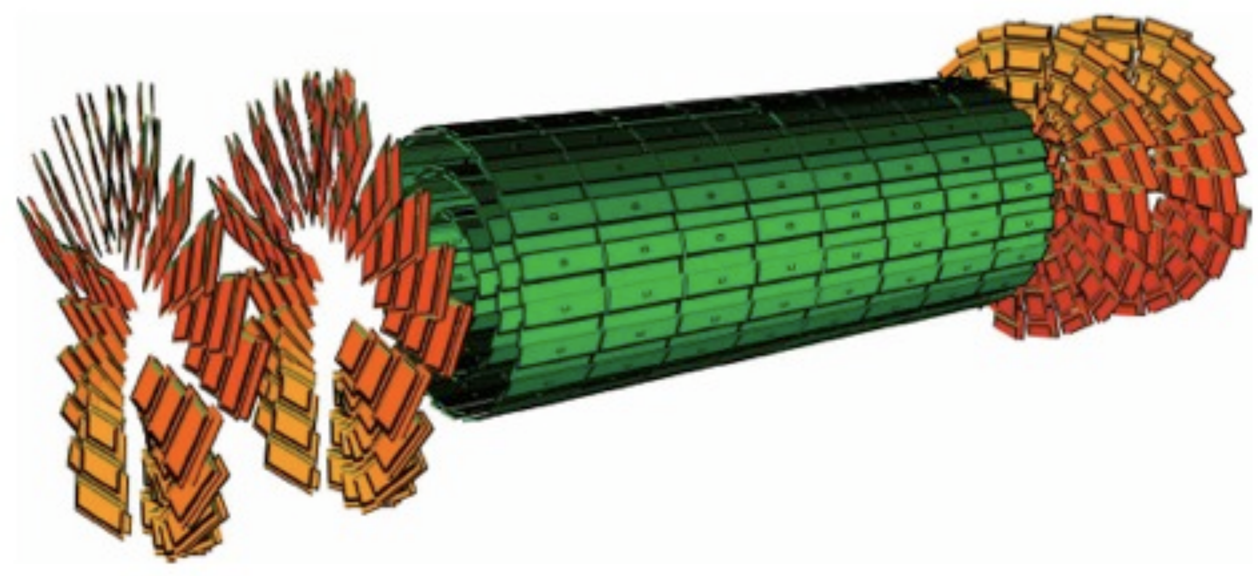
$\alpha\equiv$physical parameters

G≡Gaussian resolution function

$\epsilon(\Theta)\equiv$ angular distribution efficiency

$\epsilon(T)\equiv$time efficiency

CMS



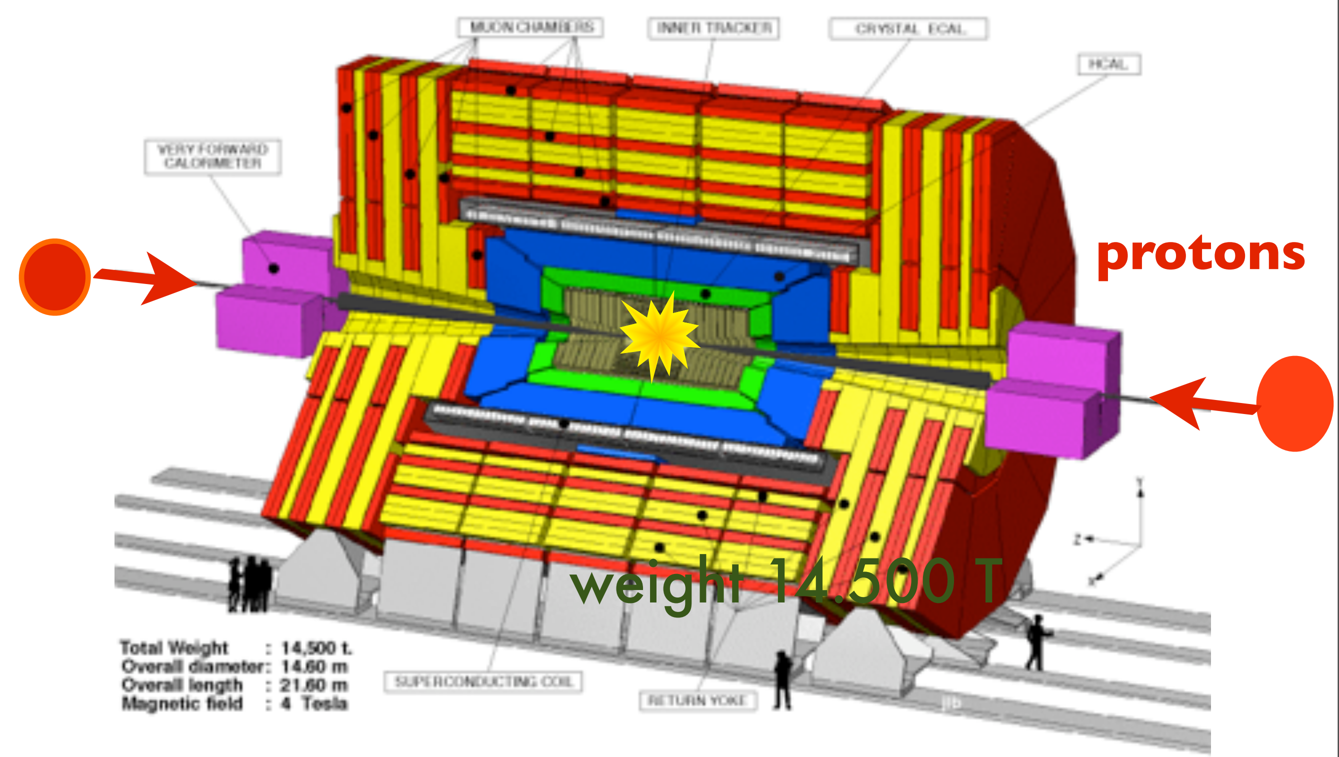
<u>Components:</u>

- **Inner tracker detector**:
  Silicon Pixel tracker and silicon strip tracker

- **Energy measurements:**
  Electromagnetic calorimeter
  Hadron calorimeter

- Superconducting solenoid (3.8 T)

- **Muon chamber with iron return yoke**

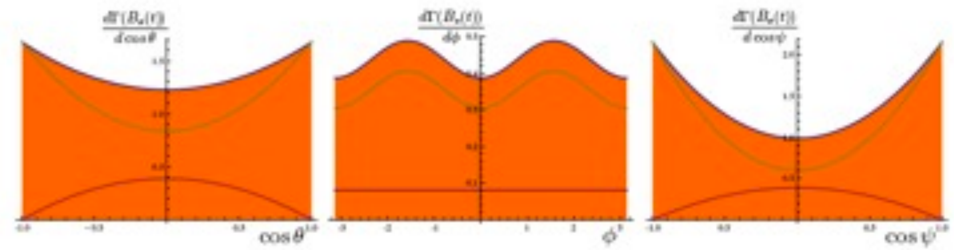


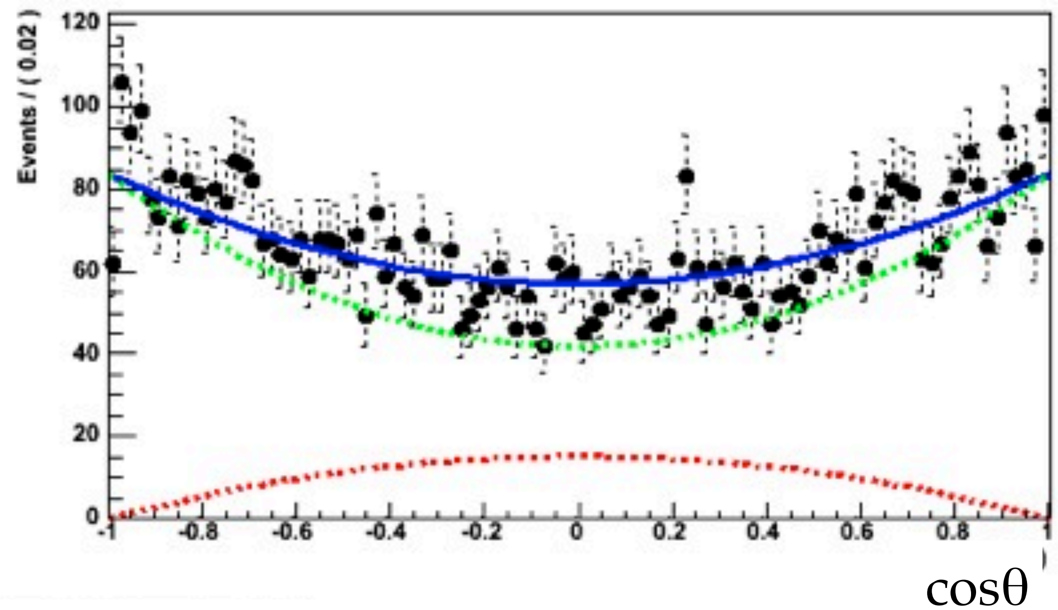
B_s selection cuts

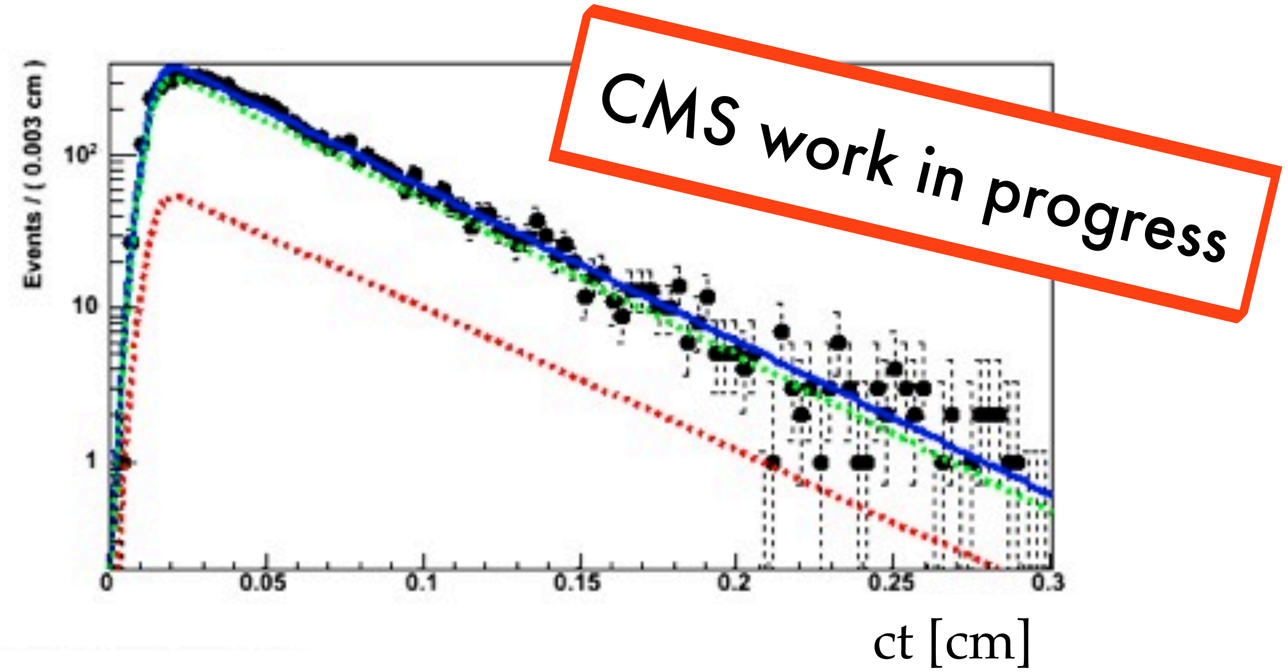
CMS work in progess

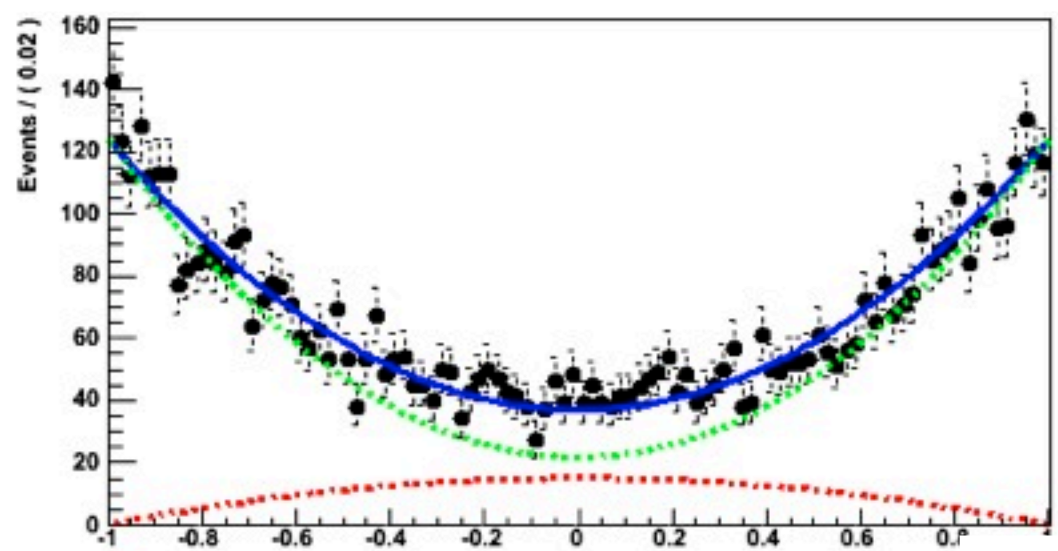
- Muons selection:
  - $P_T(\mu) > 3.5$ GeV/c
- $|J/\Psi^{mass} - J/\Psi^{nominal}| < 150$ MeV/c^2
- J/Ψ candidate with $P_T(J/\Psi) > 7$ GeV/c
- Kinematic fit and J/Ψ constraint
- B_s Vertex Probability >2%
- Both $P_T(K) > 0.7$ GeV/c
- $|\varphi^{mass} - \varphi^{nominal}| < 10$ MeV/c^2
- 5.20 MeV/c^2 < Mass (B_s) < 5. 65 MeV/c^2
- P_T (Bs) > 8 GeV/c

4-D ML fit assuming $\Phi_s=0$

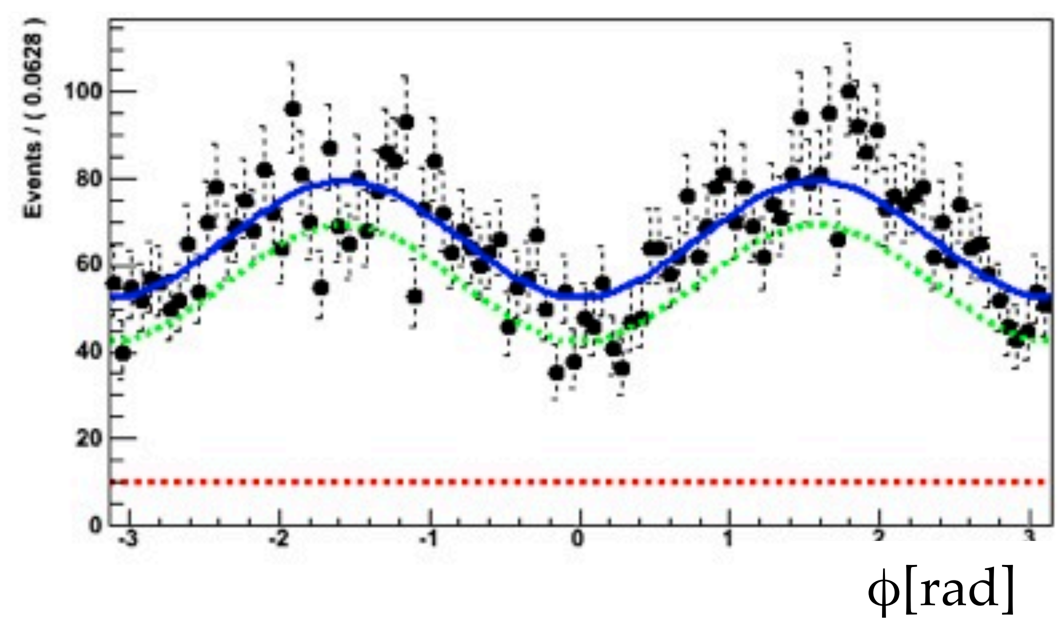








cosψ

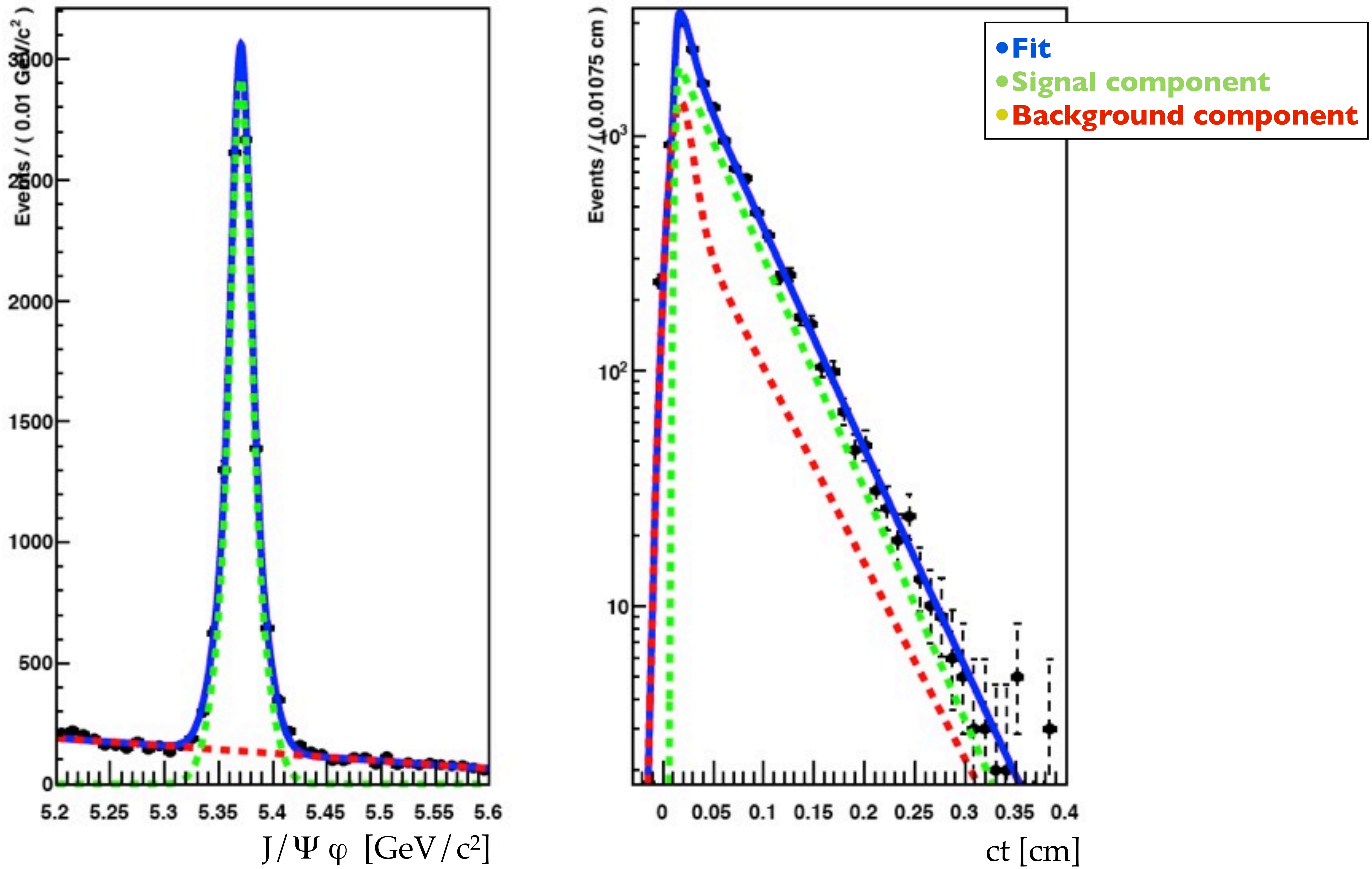


variable	input MC	fit output
$\|A_\perp\|^2$	0.16	0.17 ± 0.1
$\|A_0\|^2$	0.6	0.64 ± 0.1
$\Delta\Gamma_{Bs}$	6.85×10^{10}	$6.84\times10^{10} \pm 1.3\times10^{10}$
τ_{Bs}	0.044	0.045 ± 0.001

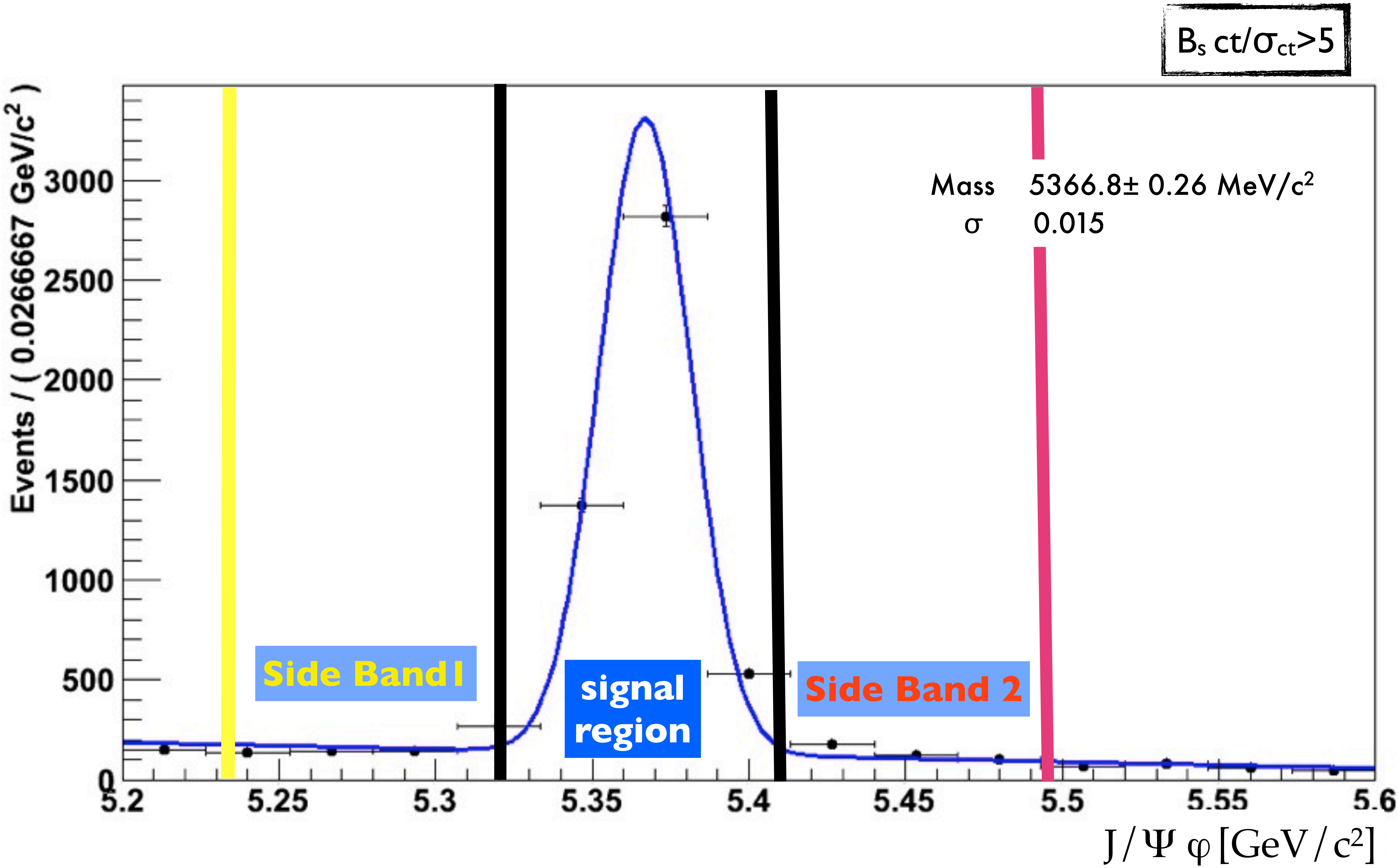
MC

DATA

B_s mass and decay length time



B_s mass candidates

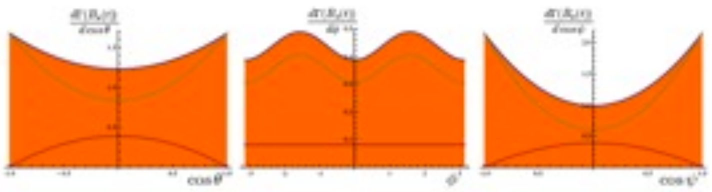


Fit in the signal region 5.30<BsMass<5.43

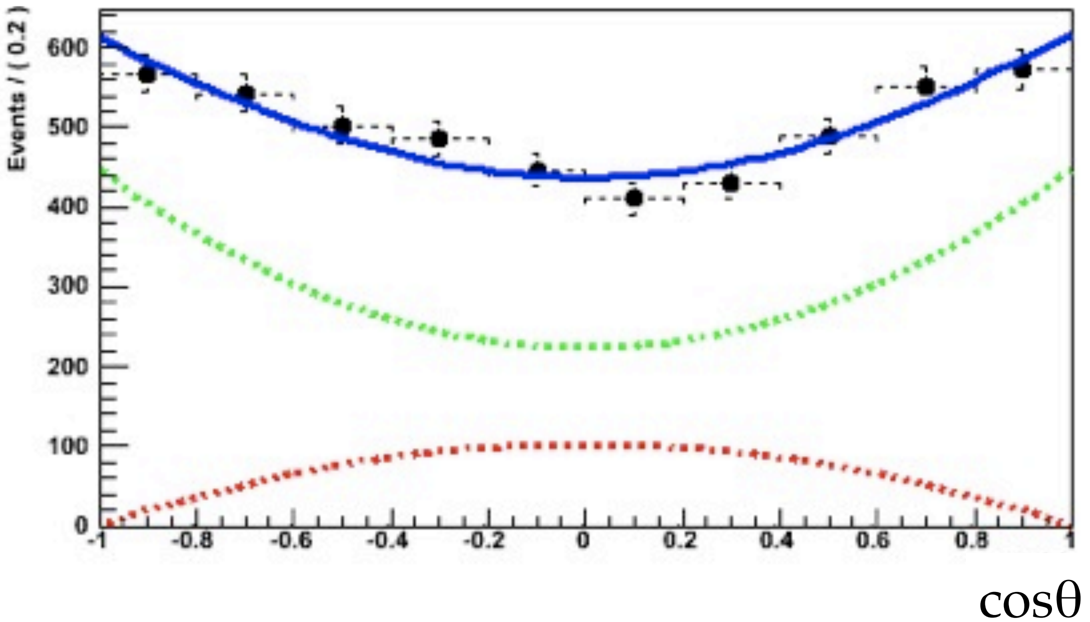
$PDF_{total} = (PDF_{SB}) + (f(\Theta,\alpha,t) \otimes G(t,\sigma_t))$

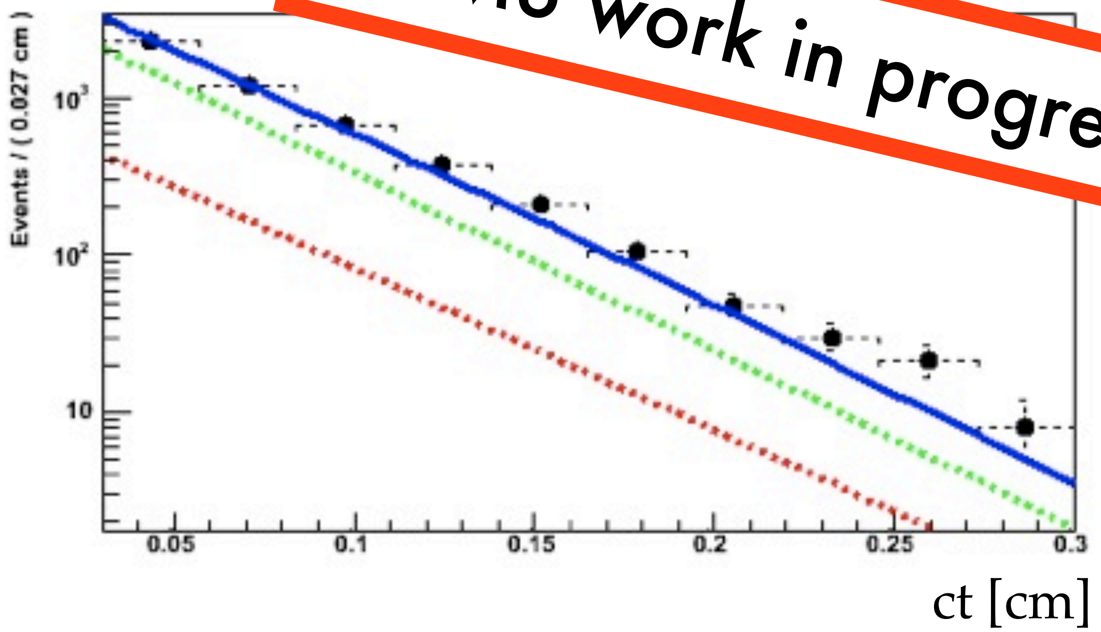
4-Dimension ML fit assuming $\Phi_s=0$

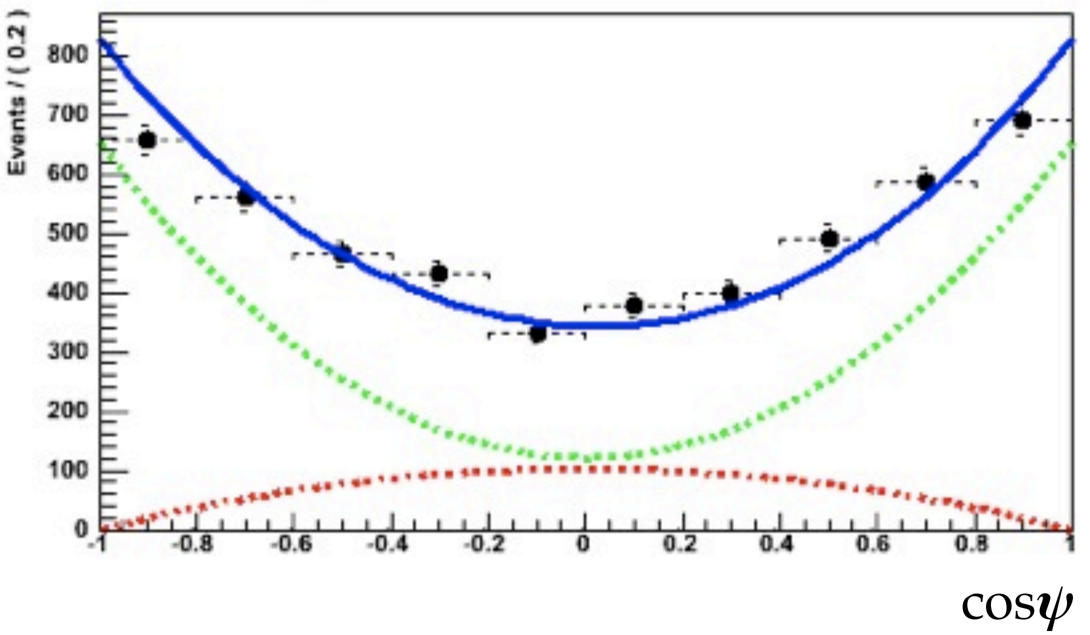
- **Fit**
- **CP Even component**
- **CP Odd component**

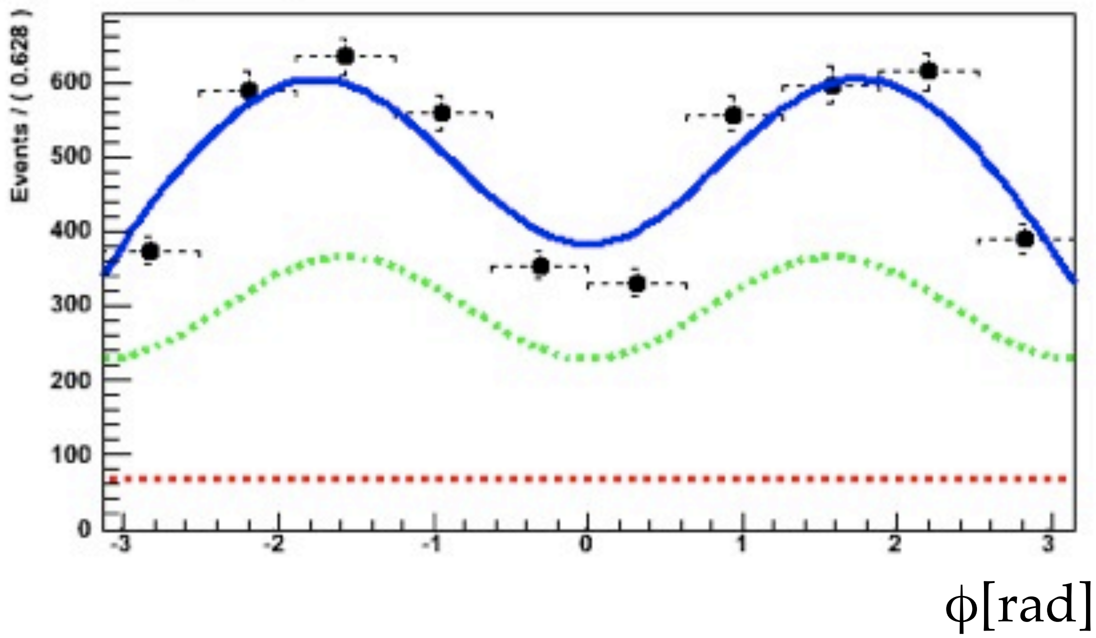


CMS work in progress









Summary

- Working on measurement of $\Delta\Gamma$
- Working on trigger acceptance
- Expecting final result at the end of 2011 with full statistics
- Exciting times ahead, new physics WHERE???

Thanks!