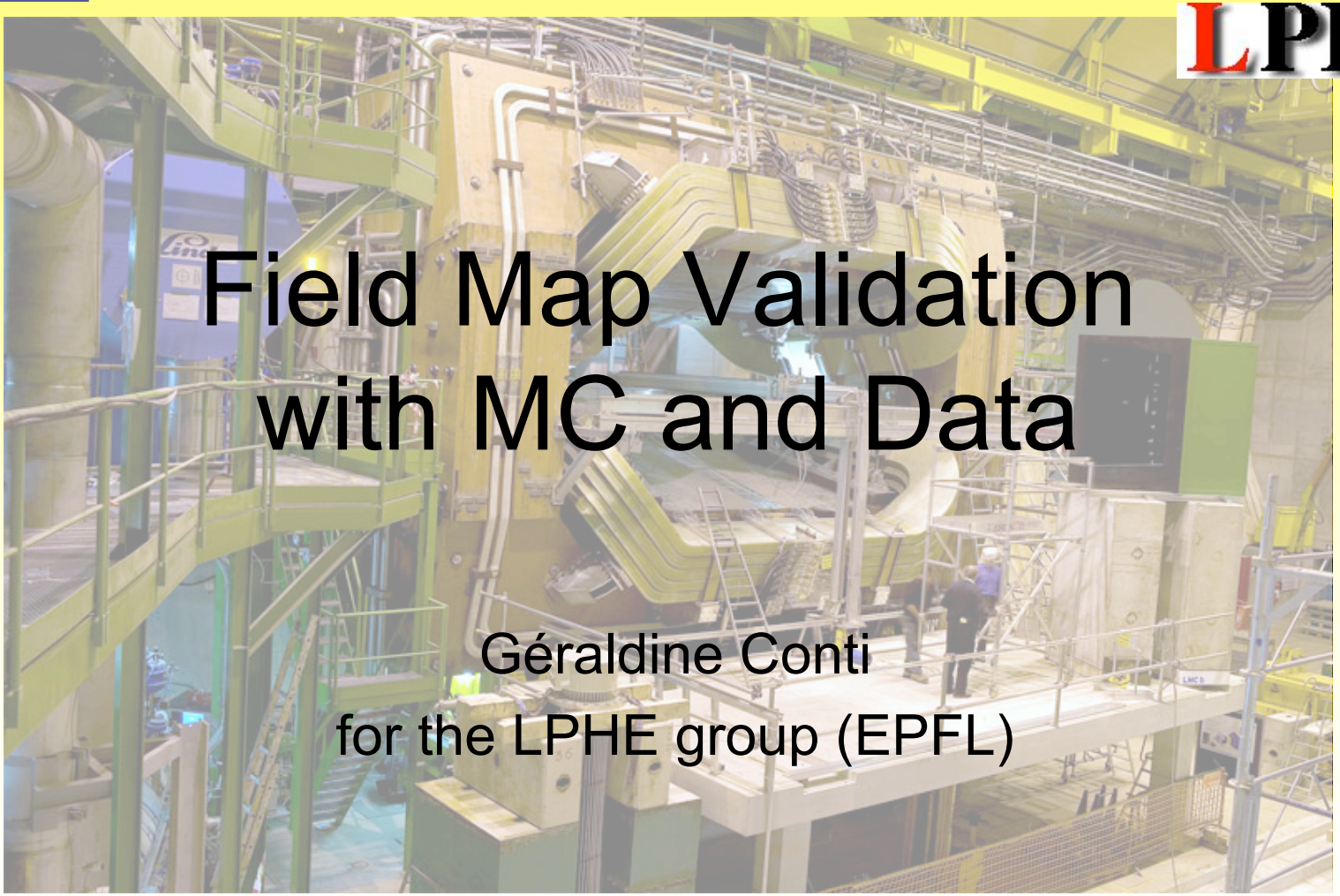
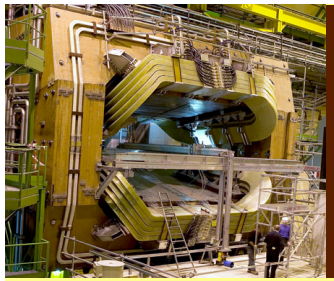


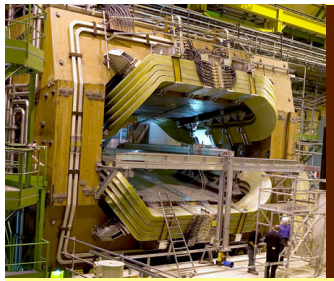
Field Map Validation with MC and Data

Géraldine Conti
for the LPHE group (EPFL)



Outline

- Presentation of the method to derive a momentum scale factor α from the data
- Overview of the selections applied for K_s, Λ and Λ_{bar}
- Validation of the method with Monte Carlo data
- Momentum scale factor α :
  - Comparison between data before (RecoToDST-05) and after the improved alignment (RecoToDST-06)
  - Comparison between K_s, Λ and Λ_{bar}
  - Comparison between measured and TOSCA B maps
- Conclusions and next steps



Momentum Scale Calibration

Invariant mass : $m^2_{d_1 d_2} = (E_{d_1} + E_{d_2})^2 - (\vec{p_{d_1}} + \vec{p_{d_2}}) \cdot (\vec{p_{d_1}} + \vec{p_{d_2}})$

$m(d_1)=m(d_2)$:

$K_s \rightarrow \pi^+\pi^-$

$m^2_{d_1 d_2} = m^2_d R + 2 \cdot (p_{d_1} p_{d_2} - \vec{p_{d_1}} \vec{p_{d_2}})$ 1st order Taylor expansion

$$R = 2 + \frac{p_{d_1}}{p_{d_2}} + \frac{p_{d_2}}{p_{d_1}}$$

Hyp. : B field wrong by a scale α (p_1 and p_2 scaled by $(1+\alpha)$ each)

$$m^2_P = m^2_d R + 2 \cdot (1+\alpha)^2 \cdot (p_{d_1} p_{d_2} - \vec{p_{d_1}} \vec{p_{d_2}})$$

$$m^2_{d_1 d_2} = \frac{m^2_P - m^2_d R}{(1+\alpha)^2} + m^2_d R$$

R=4.7 (mean value of the R distribution for data) (Mean value of R with MC data (R=4.9) allowed to have a correct field scale)

$\alpha << 1$: $\Delta m = \alpha \cdot \frac{m^2_d R - m^2_P}{m_P}$

$$\Delta m = \alpha \cdot 314$$

M. Needham, LHCb 2008-037

$m(d_1) \neq m(d_2)$:

$\Lambda \rightarrow p\ \pi$

$$m^2_{p\pi} = \frac{m_\Lambda - f}{(1+\alpha)^2} + f$$

$$f = m^2_p + m^2_\pi + \frac{p_\pi}{p_p} \times m^2_p + \frac{p_p}{p_\pi} \times m^2_\pi$$

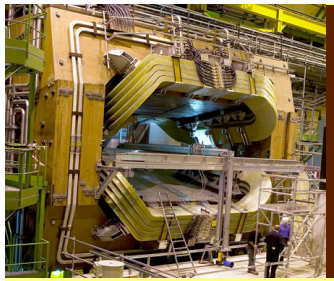
f=1.21 for Λ and 1.218 for Λ_{bar} (mean values taken from the data)

(f=1.208 for Λ and 1.216 for Λ_{bar} from MC)

$$\Delta m = \alpha \cdot \frac{f - m^2_\Lambda}{m_\Lambda}$$

$$\Delta m_\Lambda = \alpha \cdot 31$$

$$\Delta m_{\bar{\Lambda}} = \alpha \cdot 24$$



K_s, Λ and Λ_{bar} selections

- Data Beam450GeV-VeloOpen-MagDown**(RecoToDST-05/06)**
- Use of the three configurations : “All in”, “No RICH1”, “No RICH1-2”

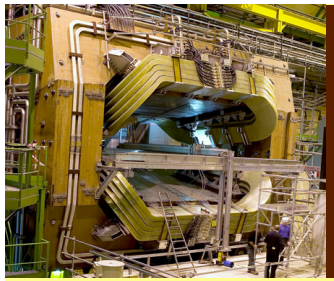
	ALL IN (v05 / v06)	No RICH1 (v05 / v06)	No RICH1-2 (v05 / v06)
Events processed	~3,670,000 / ~3,600,000	~176,000 / ~176,000	~589,000 / ~413,000

- K_s selection presented by M. Needham (Alignment, 6.01.2010) :

IPS > 3	Vertex χ^2 < 25	Cos(θ)>0.99995
χ^2/dof < 10	Vertex z < 220cm	±16MeV veto on mass in Λ hypothesis
P(track) > 2GeV	FD to PV > 20mm	

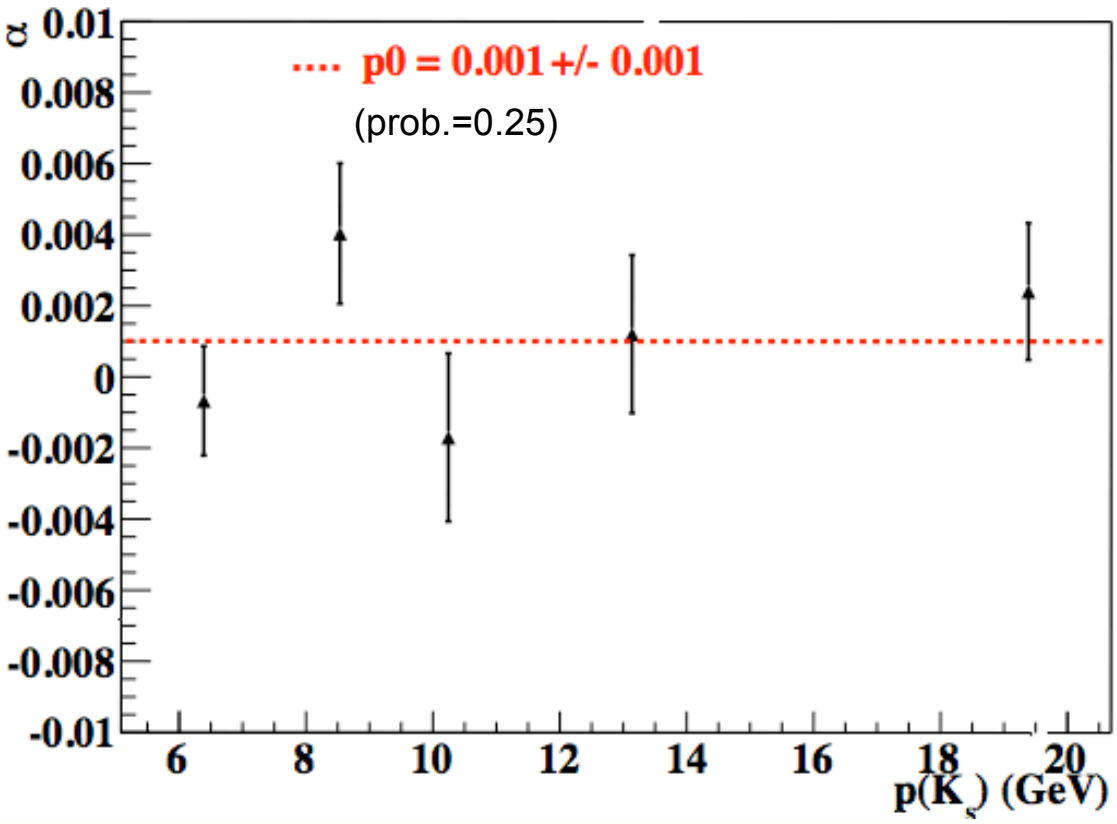
- Similar Λ selection with ±12 MeV veto on mass in K_s hypothesis
- Λ and Λ_{bar} separated by a cut derived from Armenteros plot
- Only Long-Long tracks used in the following studies

Long-Long Tracks only	K_s (v05 / v06)	Λ (v05 / v06)	Λ_{bar} (v05 / v06)
Selected Candidates	1275 / 1454	288 / 330	242 / 267



Validation of the method with MC data

A check is performed with MC data to ensure that no biases are observed :

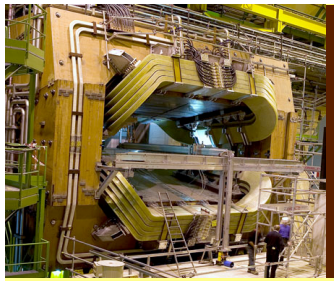


▲ Monte Carlo

~220,000 events processed
Selected candidates : 191

p0 = 0.001 ± 0.001

→ p0 is consistent with zero, hence no bias is observed with MC data.

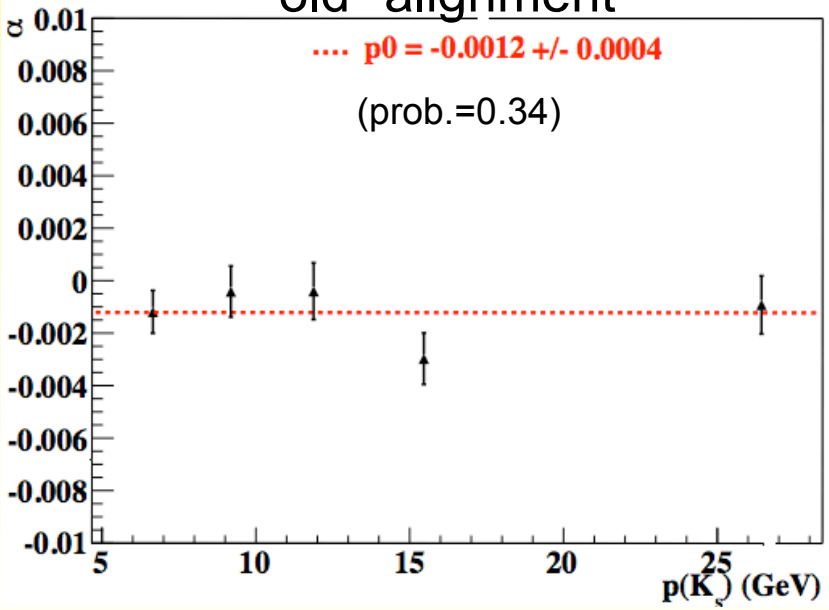


Effect of improved alignment on α

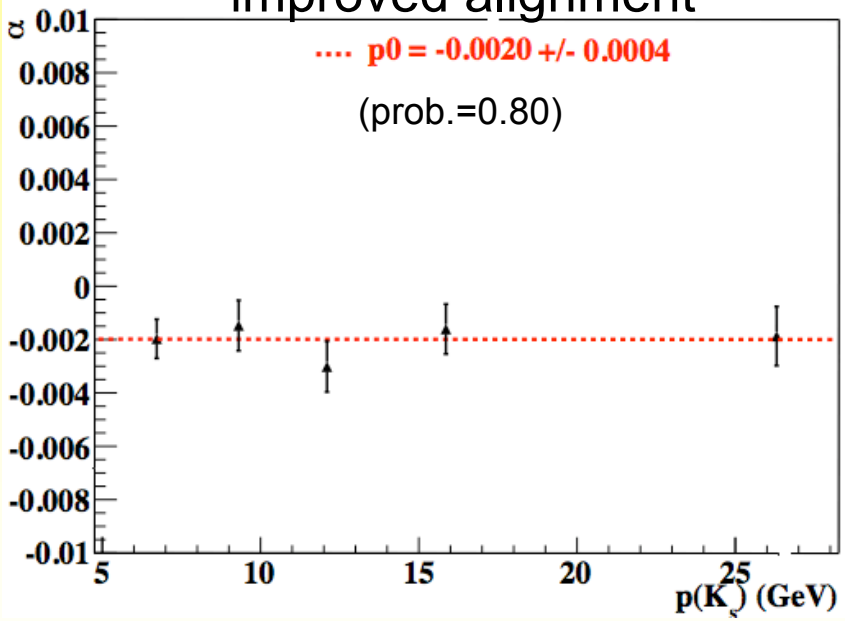
The effect of the improved alignment (v06) is compared with the older one (v05) :

▲ Real Data

"old" alignment

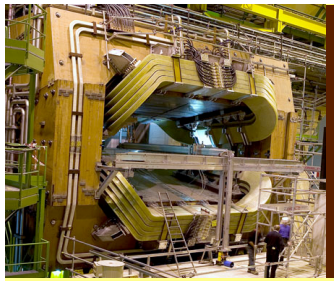


improved alignment



→ The average value is significantly different between the two data sets.

→ The average value has gone further away from 0 for improved alignment.

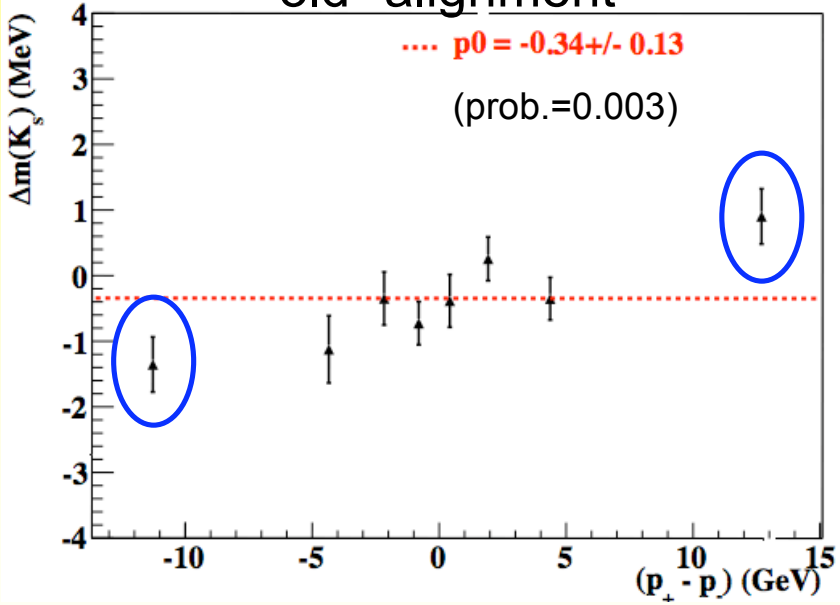


Other effect of the improved alignment

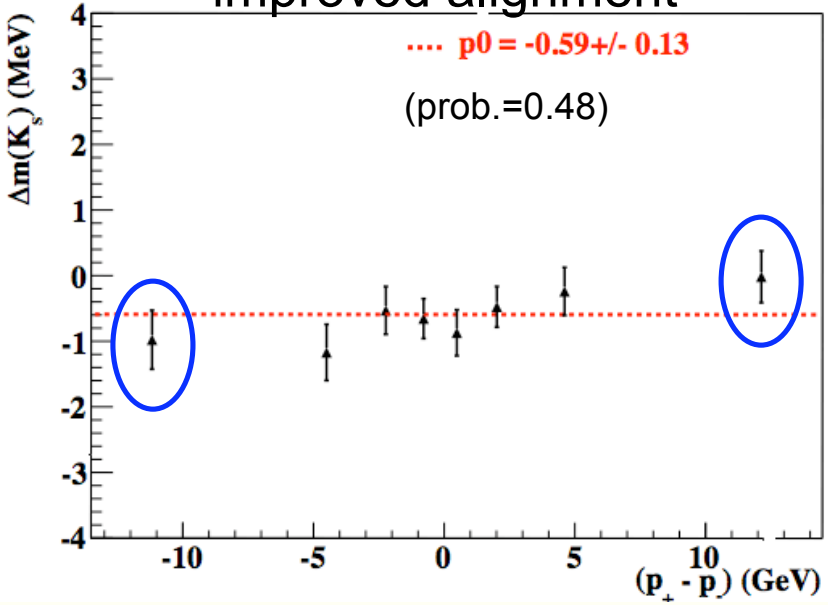
$\Delta m(K_s)$ is shown as a function of $(p(K_{\pi+})- p(K_{\pi-}))$:

▲ Real Data

"old" alignment

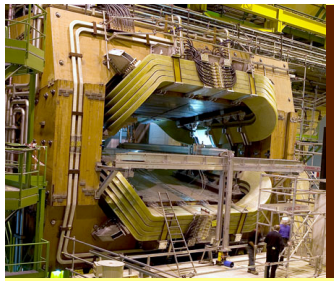


improved alignment

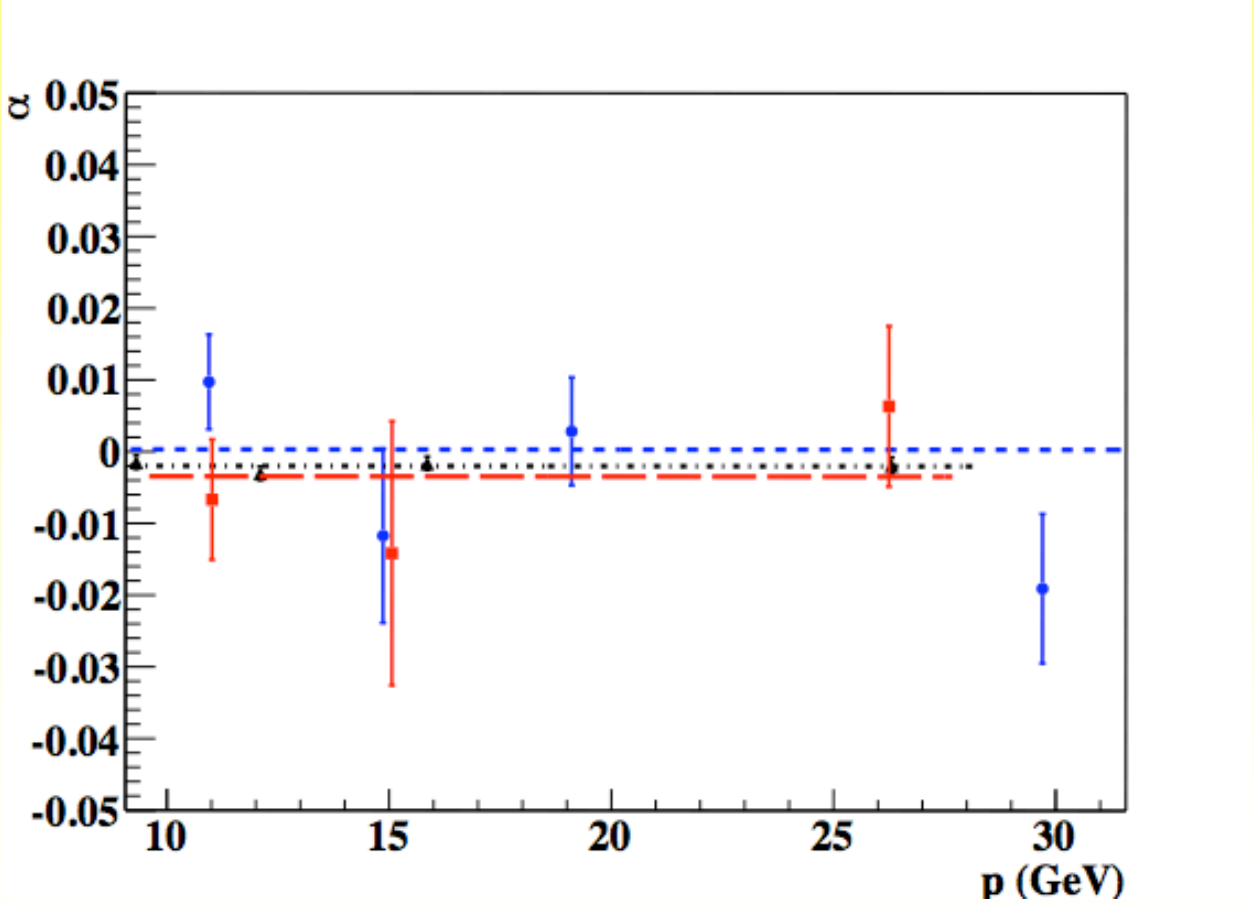


→ $\Delta m(K_s)$ has become closer to p0 for large $|p(K_{\pi+})- p(K_{\pi-})|$ values.

→ $\Delta m(K_s)$ has become larger with the improved alignment.



α for $K_s \leftrightarrow \Lambda, \Lambda_{bar}$



K_s

p0=-0.0020 ± 0.0004
(prob.=0.80)

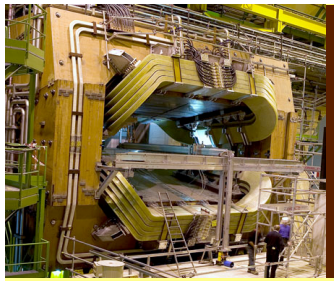
Λ

p0= 0.0003 ± 0.0042
(prob.=0.087)

Λ_{bar}

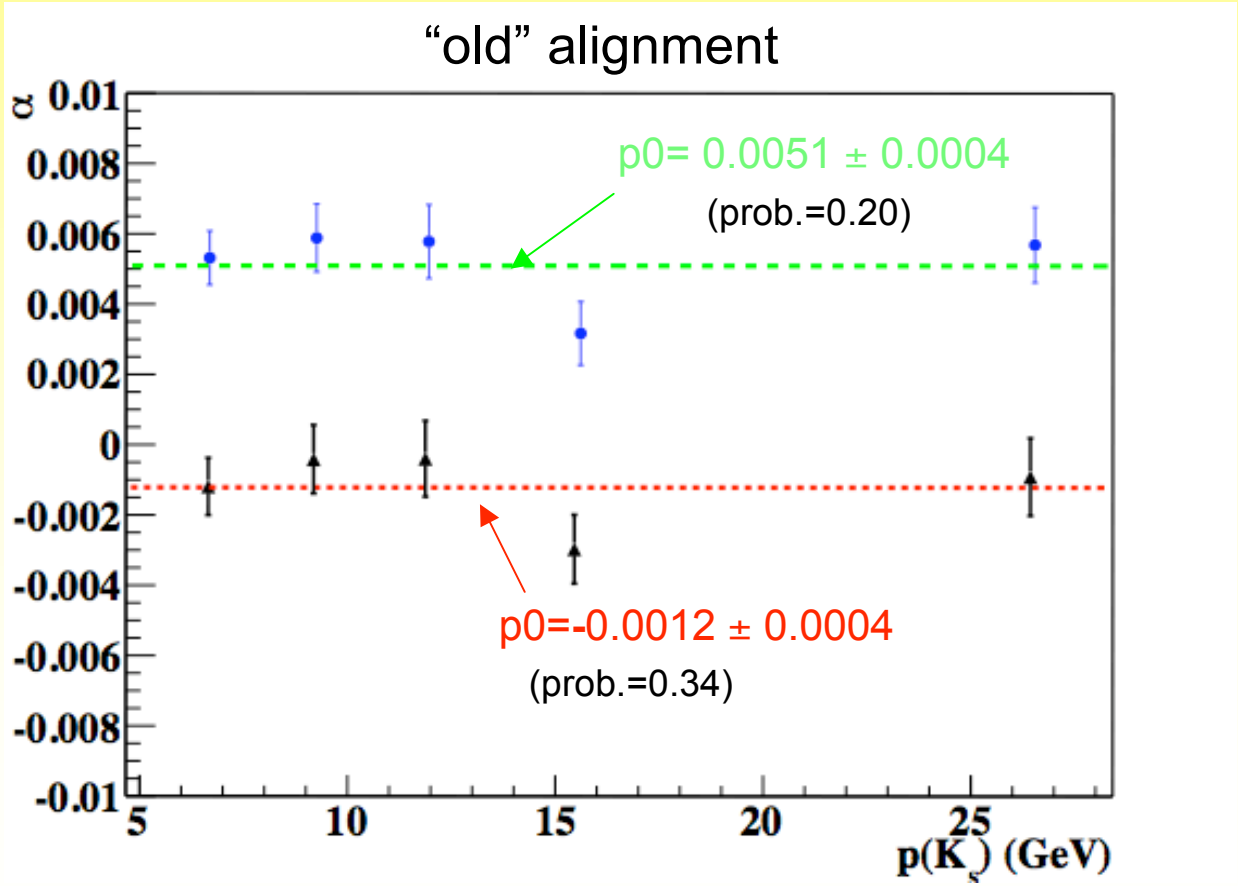
p0=-0.0034 ± 0.0063
(prob.=0.53)

→ Results for K_s, Λ and Λ_{bar} are consistent (need for more statistics…).



Effect of the B field map on α

Real data are reconstructed either with the measured or the TOSCA maps :

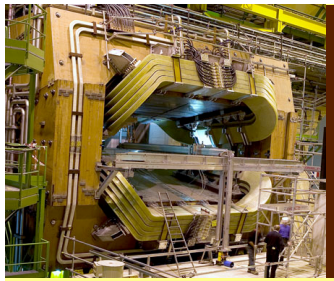


TOSCA

Measured

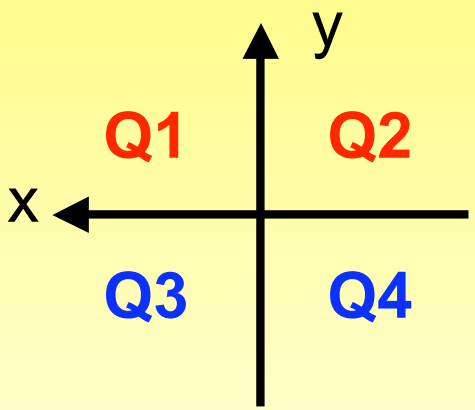
→ The α scale of the measured map is closer to zero than the α obtained from TOSCA.

→ The 0.006 difference is compatible with what had been shown for MC J/ψ (G.Conti, T-Rec, 14/12/09)



Effect of the B field map on the K_s mass

B field measurements for quadrants Q1 and Q2 are similar.
They differ from values from quadrants Q3 and Q4.
Measurements from Q3 and Q4 are similar.
(G.Conti, PPM, 11.01.2010 ; A.Keune, T&A workshop, 28.01.2010)



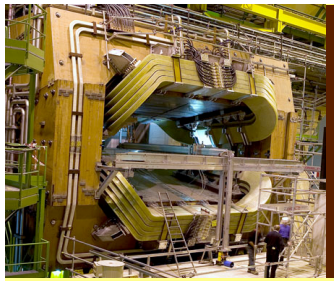
→ Difference for y>0 and y<0 (observed in B_y and B_z)

To estimate the impact of this difference, MC J/ψ are first generated with the measured field map and refitted using the TOSCA map. The masses are plotted separately for μ^+/μ^- coming from quadrants Q1-Q2 and from Q3-Q4.

To understand whether the up-down asymmetry in the measured B field is :

1) a real effect due to the asymmetry of the magnet ?
2) a fake effect introduced by the imperfect measurements ?

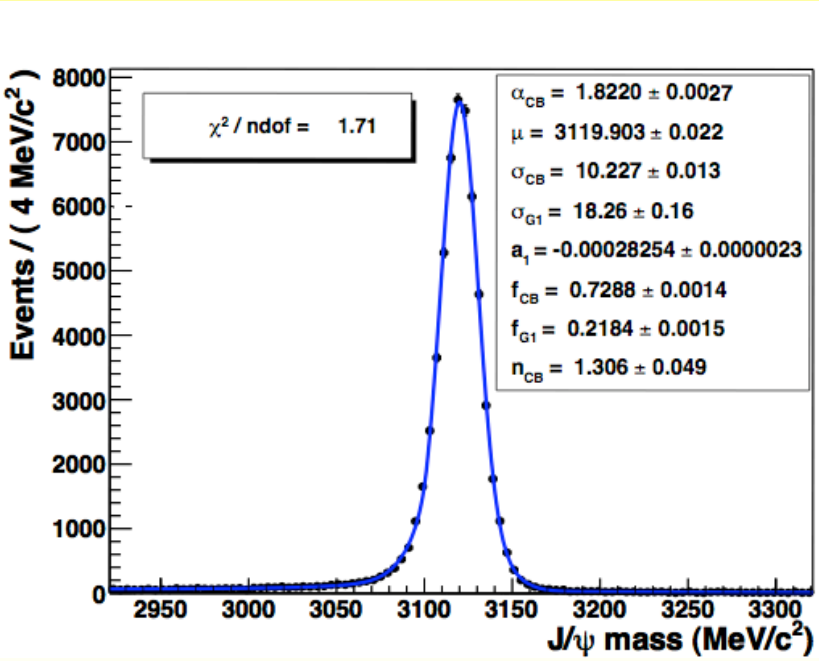
K_s masses are plotted with real data separately for $\pi^+\pi^-$ coming from Q1-Q2 and from Q3-Q4, using the measured field map and the TOSCA field map.



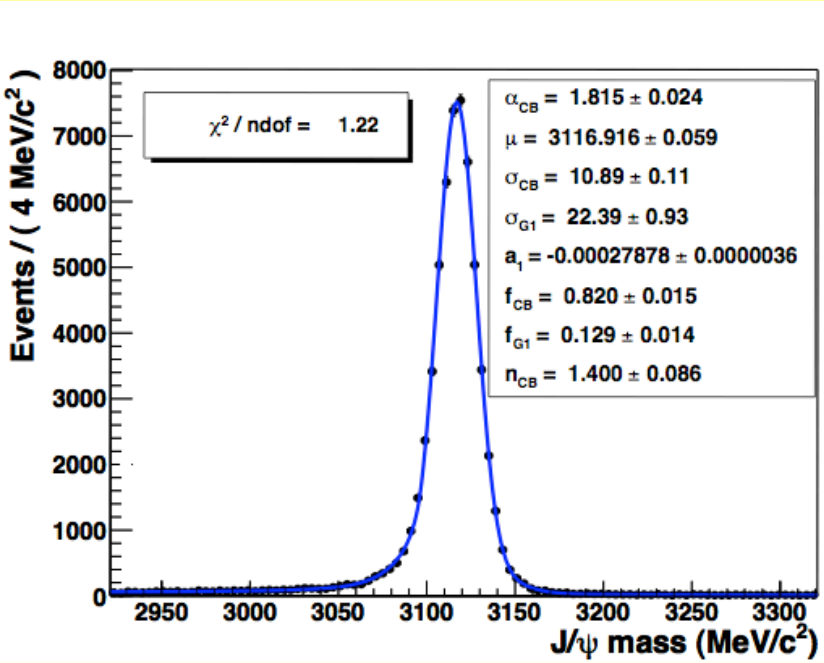
MC J/ψ mass for Q12 and Q34

J/ψ are generated with the measured field map and are reconstructed using TOSCA :

Q12

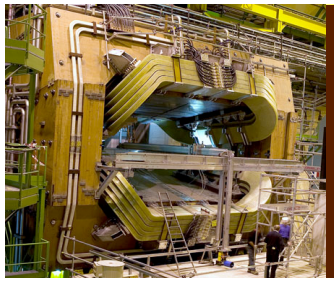


Q34



StdLooseMuons (CombineParticle), with a cut on the J/ψ mass at ± 300MeV/c² (~360,000 events processed)

→ A 3MeV/c² shift is observed between J/ψ masses from Q12 and Q34, corresponding to a ~0.1% effect.

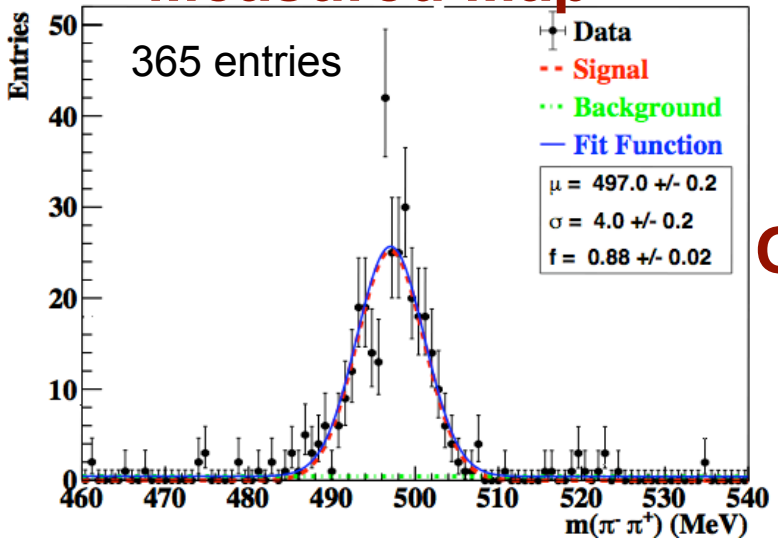


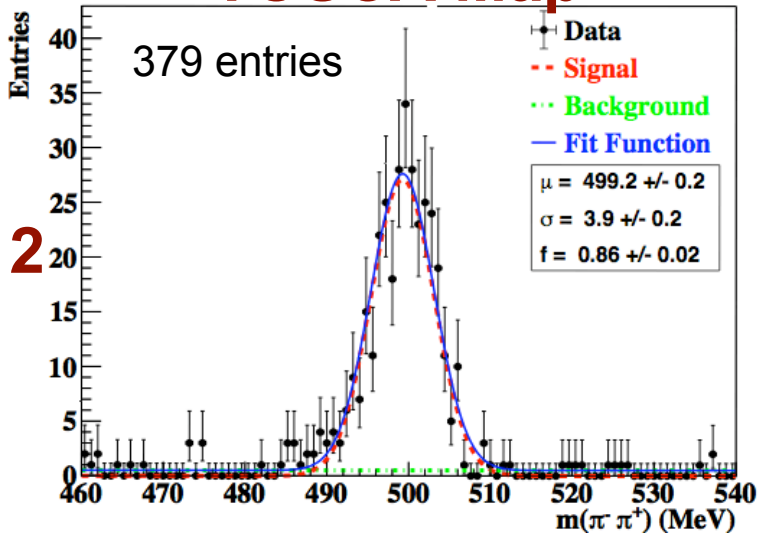
Effect of the B field map with the real data

(K_s masses with "old" alignment)

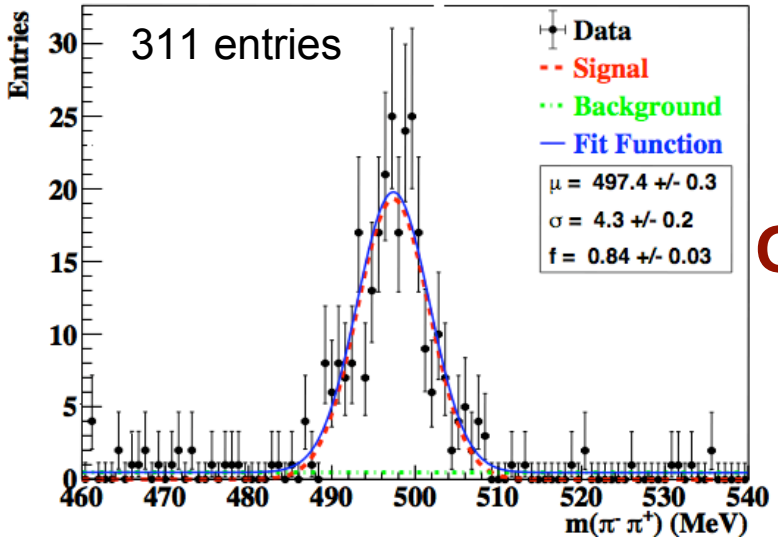
Measured Map | **TOSCA Map**

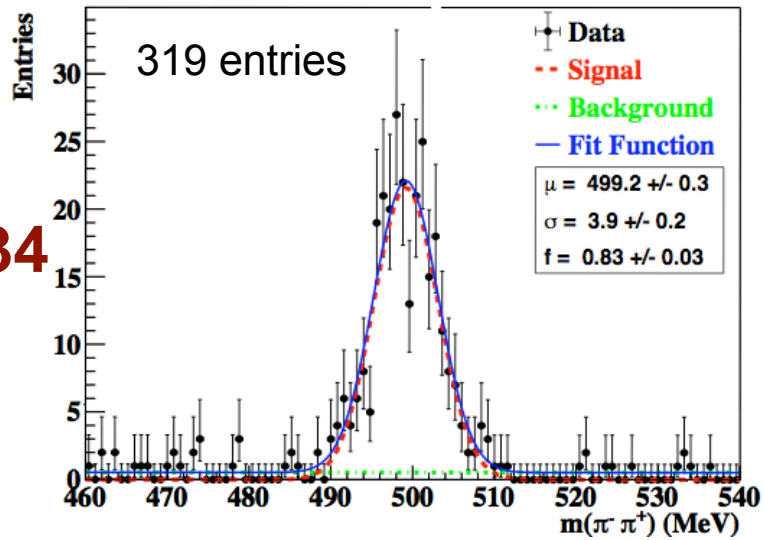
Q12





Q34

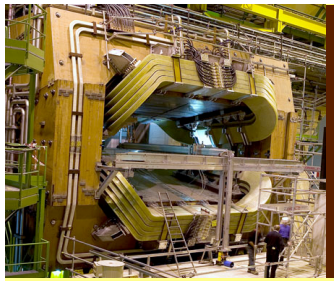




Fit model :

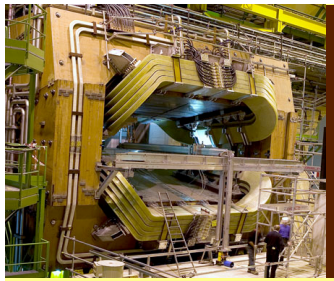
Gaussian fit **+** constant Bkg

f = fraction of the Gaussian

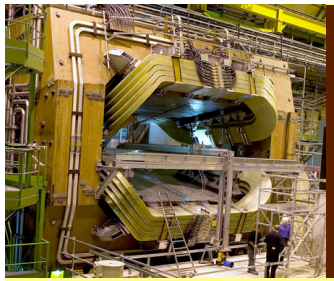


Conclusions and Next Steps

- A method for calibrating the momentum scale has been presented, validated using MC data, and applied on real data (K_s, Λ and Λ_{bar}).
- Significant effects from the new alignment
  - → Importance of understanding well the alignment before concluding on the α scale value
- Consistent results are found for K_s, Λ and Λ_{bar} (however, more statistics needed).
- K_s mass results obtained with the measured map show a better agreement with the expected value than results obtained with TOSCA (~1.6MeV shift).
- The nature of the up-down asymmetry in the measured B field needs to be further studied (real or fake effect ?)
  - → From MC studies, a ~0.1% effect is expected to be observed between Q1-2 and Q3-4.
  - → Up to now, no differences observed in real data between K_s masses reconstructed from Q1-Q2 or Q3-Q4 and using the TOSCA field map (need for ~4 times more statistics)
- Larger samples (J/ψ, K_s, Λ) are needed to understand the field integral, and downstream tracks will help understand more about the field components.



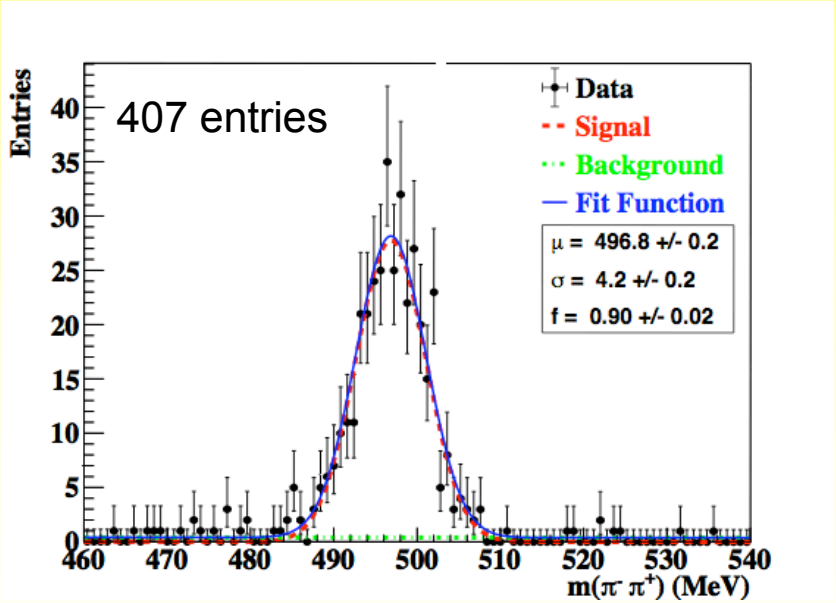
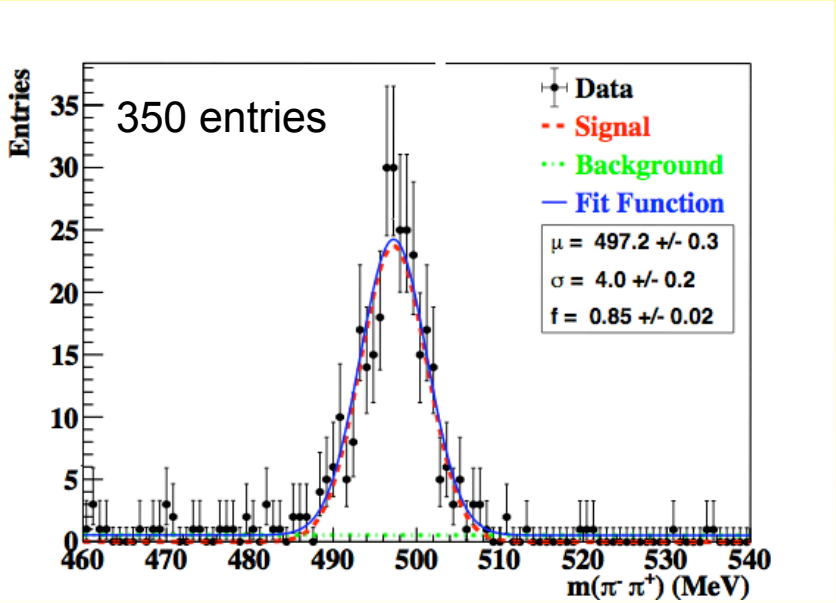
Back-Up Slides



Effect of the B field map with the real data (K_s masses)

Using the new alignment (v6) :

Q12



Q34