Misura di J/ψ nello Spettrometro per Muoni in p-p

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Fare clic per modificare lo stile del sottotitolo dello schema
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16/09/09

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Outlook

Physics motivations for J/ study in p-p

The ALICE Muon Spectrometer

First J/ paper analysis

The polarization issue

Fare clic per modificare lo stile del sottotitolo dello schema

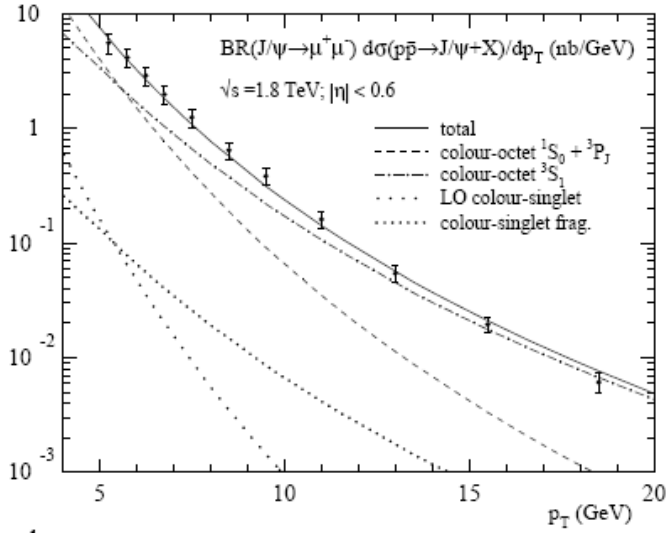
Conclusions and Ongoings

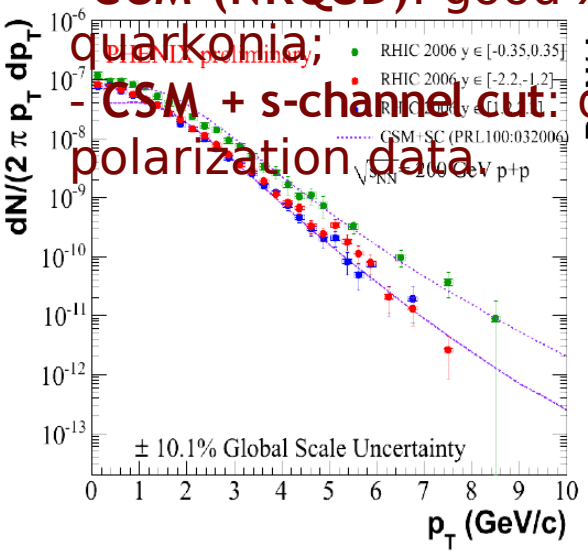
J/ψ in pp: physics motivations (I)

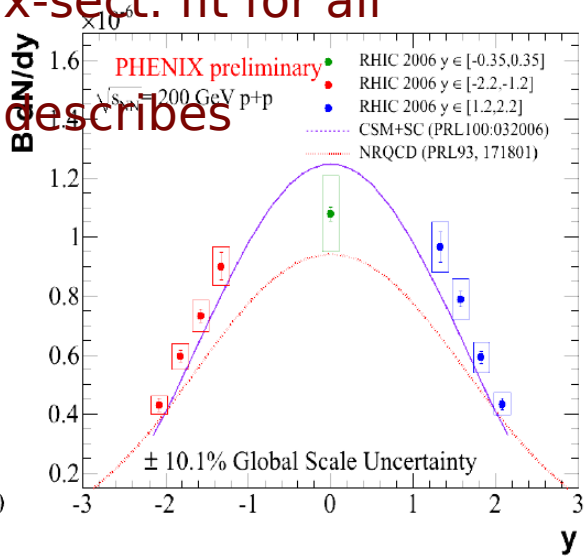
Need to understand the production mechanism.

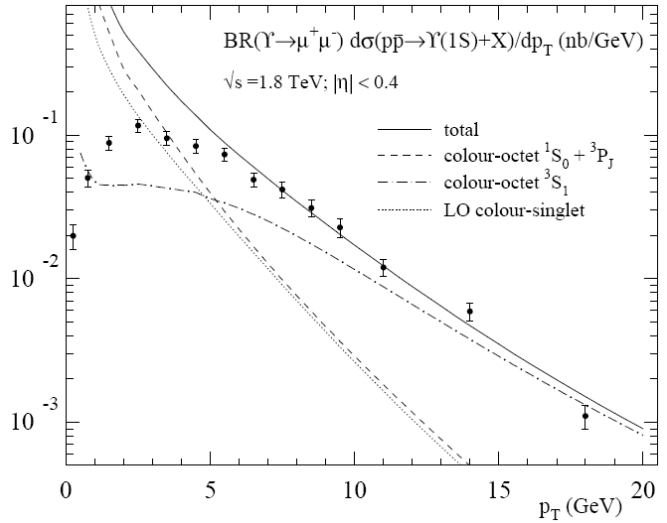
Several models:

- **CEM**: phenomenological, not so predictive;
- **CSM**: bad x-sect. Fit (ruled out in the '90s);
- **COM (NRQCD)**: good x-sect. fit for all quarkonia;
- **CSM + s-channel cut**: describes polarization data.



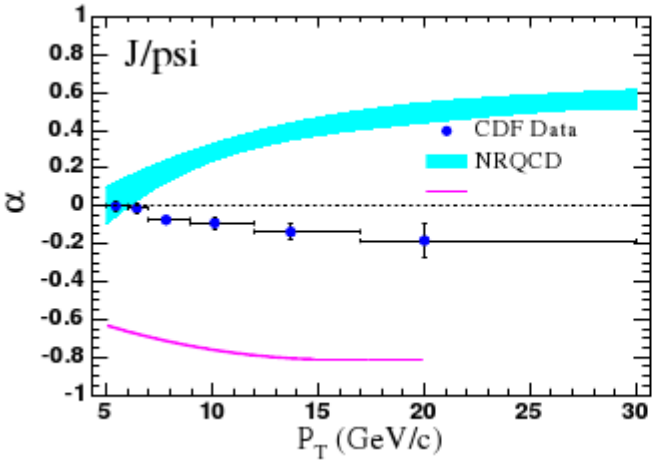


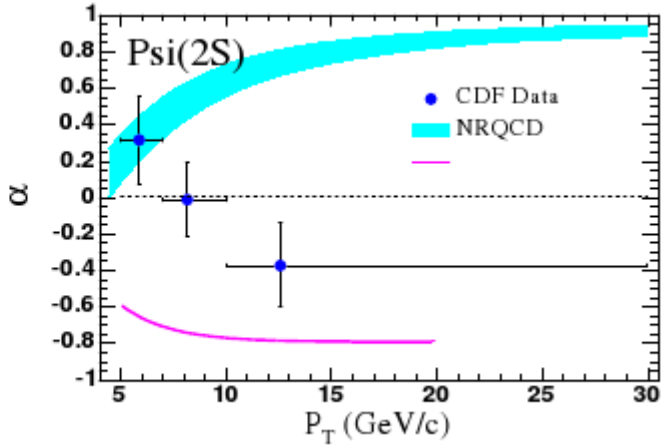




J/ψ in pp: physics motivations (II)

NRQCD fails in predicting polarizatio n at high PT





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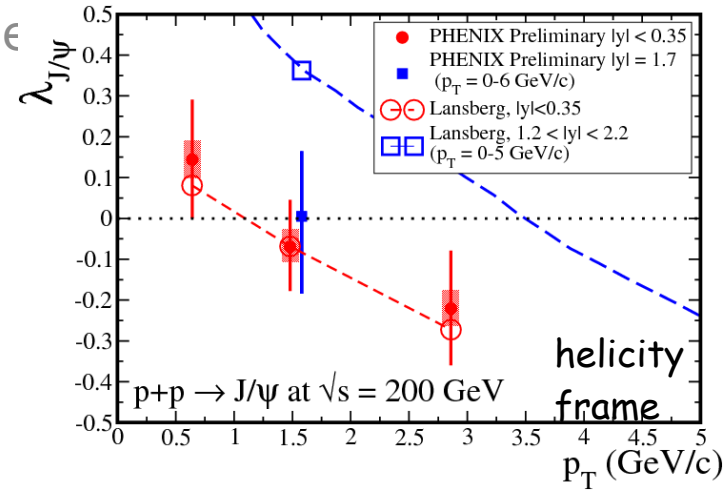
CSM+ s-channel cut (NNLO perturbative calculation): describes polarization data from PHENIX at mid-rapidity. Still problems at forward rapidity.



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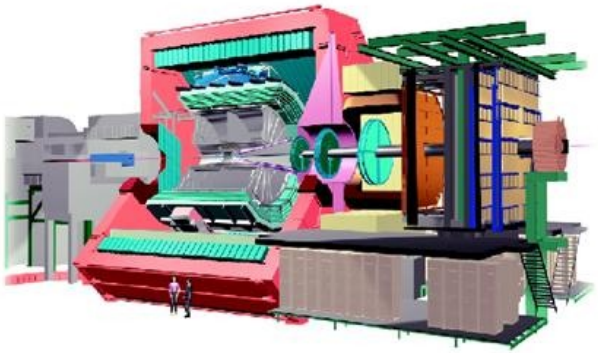
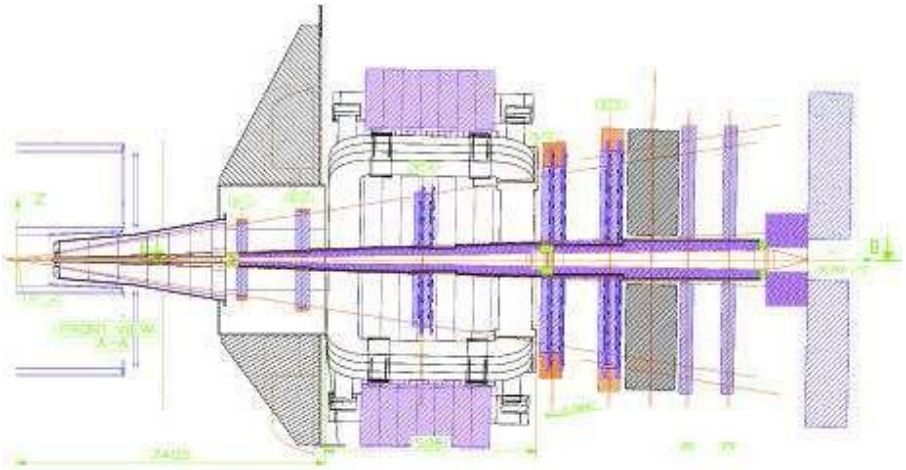
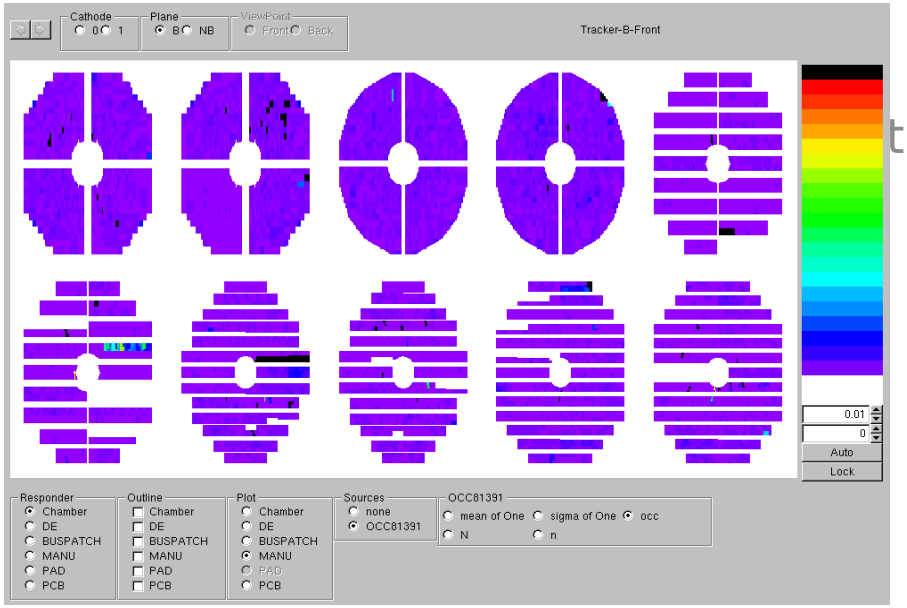
Muon Spectrometer: Setup

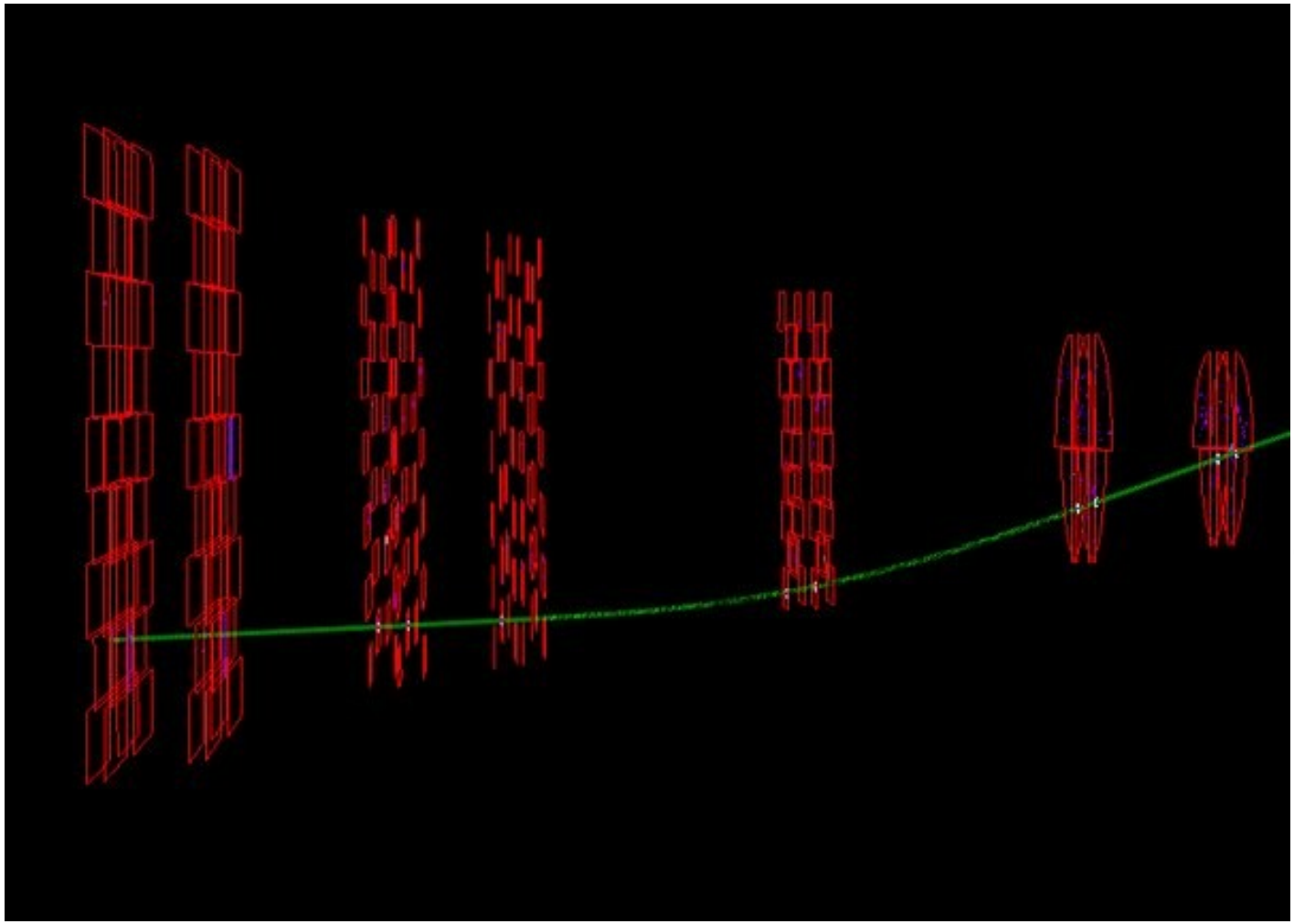






- Front absorber
- Beam Shield
- Dipole magnet (∫Bdl=3Tm)
- 5 tracking stations (MWPCs with bi-cathode pad readout): spatial resolution below 100 μm in the bending plane, around 700 μm in the non-bending plane
- Iron wall (muon filter)
- 2 trigger stations (4 planes of RPCs): fast response (~2 ns), spatial resolution ~1 cm

Muon Spectrometer: cosmic run



First curved cosmic muon event (tracked and triggered)

Nice view!

But we expect more than 90 couples of this tracks per hour coming from J/ψs during the first run of LHC...!*

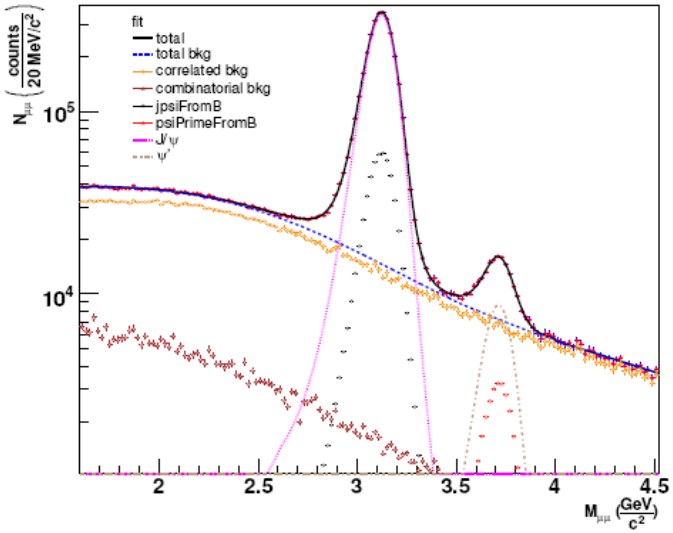
*actually this number refers to the trigger rate.

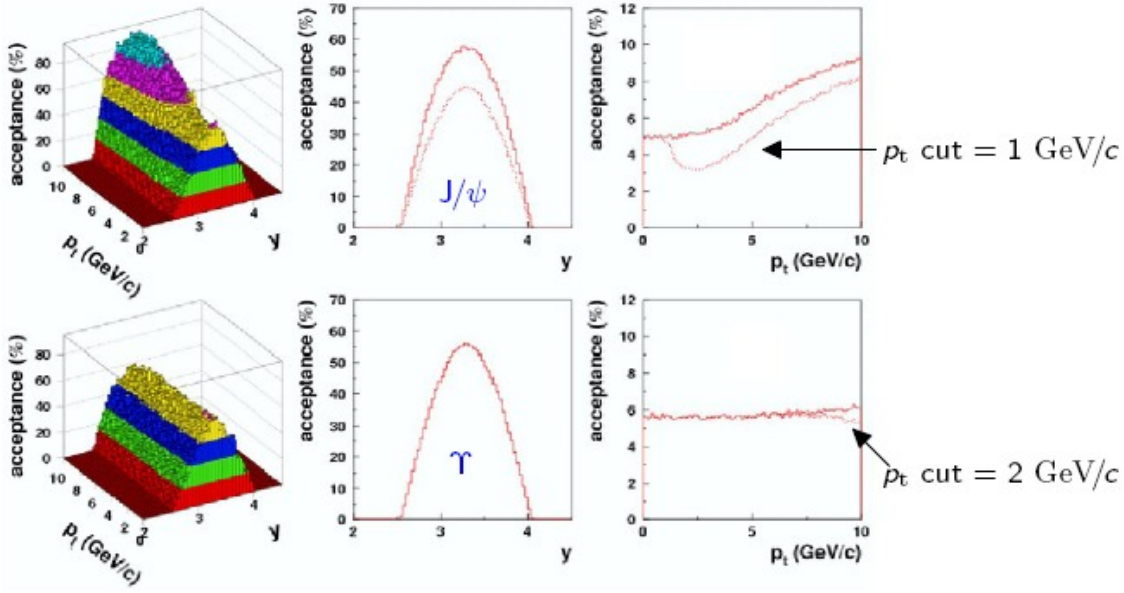
Muon Spectrometer: performances in pp

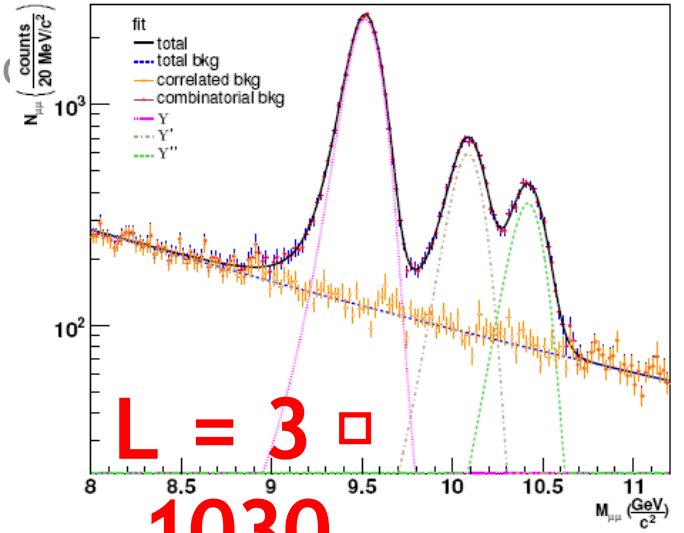
state	S ($\times 10^3$)	B ($\times 10^3$)	S/B	$S/\sqrt{S+B}$
J/ψ	2807	235	12.0	1610
ψ'	75	120	0.62	170
Υ	27.1	2.6	10.4	157
Υ'	6.8	2.0	3.4	73
Υ''	4.2	1.8	2.4	55

ALICE-INT-2006-029

Mass resolution : 70 MeV for the J/□, 100 MeV for the ϒ







L = 3 □ 1030 cm-2 s-

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First Analysis

Assuming 340□10-3 Hz J/□ trigger rate low pT at L=3□1030 cm-2 s-1 (ALICE-INT-2006-0002), at L=2.3□1029 cm-2 s-1 we expect: J/□ trigger rate ~ 26□10-3 Hz

Assuming 12% running efficiency (F. Antinori - Physics Forum July 2009) we expect from 104 to 4□104 J/□s in the first 5 months

For 104 J/□s we expect 100 J/ □s with pT >11 GeV □ Good for differential studies!

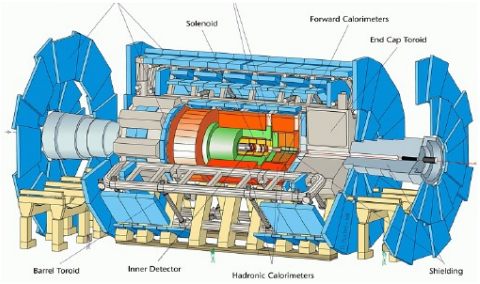
Which measurements can be performed with this statistics?

· J/□ integrated production cross section
· J/□ differential cross section
· J/□ polarization (integrated over the other kinematical variables?)

First J/□ papers

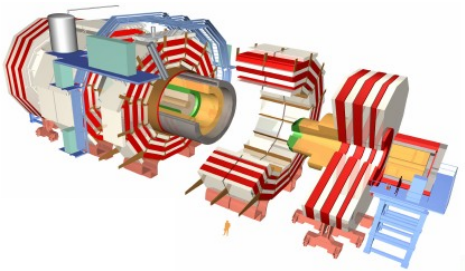
CDF	Paper based on 889 J/□	► Integrated cross section Differential cross section d□/dpT
PHENIX	Paper based on 65 J/□ in □+□-	► Differential cross section d□/dpT, d□/dy

Other LHC experiments



ATLAS:

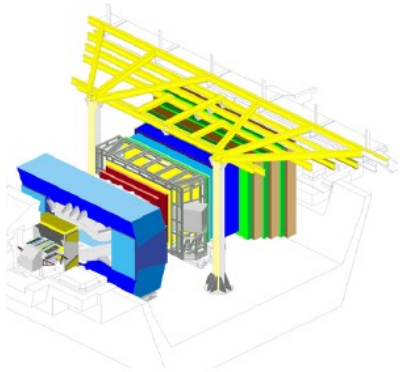
- -2.5 < □ < 2.5
- mass resolution ~ 50MeV
- prompt J/□s separated with fit to proper time distribution
- 104 J/□ for 1pb-1 at √s=10TeV (high pT trig)
- can cover the full cos□ range reaching very high pT



scnema

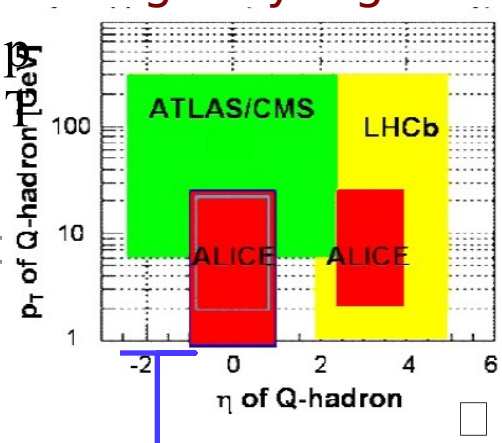
CMS:

- -2.5 < □ < 2.5
- mass resolution ~ 30MeV
- 2□104 J/□ for 1pb-1 at √s=10TeV (high pT trig)



LHCb:

- 2 < □ < 5.5
- vertex tracking detector (VELO) covering the forward region ->very good mass resolution □(M)~ 11MeV
- 2□105 J/□ for 1pb-1 at √s=10TeV (larger acc.)



Very competitive wrt ALICE

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Polarization: basic concepts

The polarization of Quarkonium is gleaned through the analysis of the angular distribution of daughter particles (e.g. μ+μ-) which follows the trend:

$$\frac{1}{\sigma}\frac{d\sigma}{d\cos(\theta)d\phi} = 1 + \lambda\cos^2(\theta) + \mu\sin(2\theta)\cos(\phi) + \frac{\nu}{2}\sin^2(\theta)\cos(2\phi)$$

$\lambda = 1$

Transverse polarization

$\lambda = -1$

Longitudinal polarization

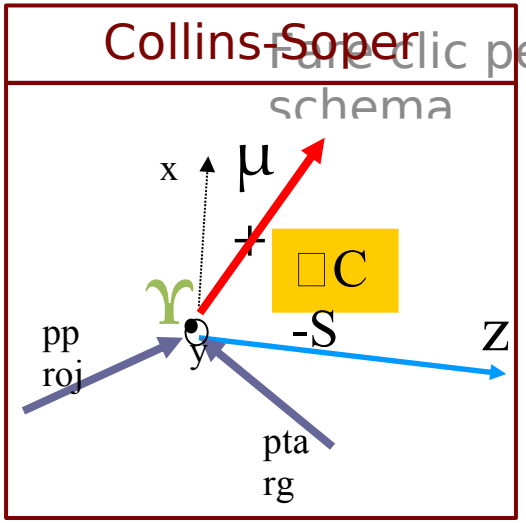
Fare clic per modificare lo stile del sottotitolo dello schema

Reference frames:

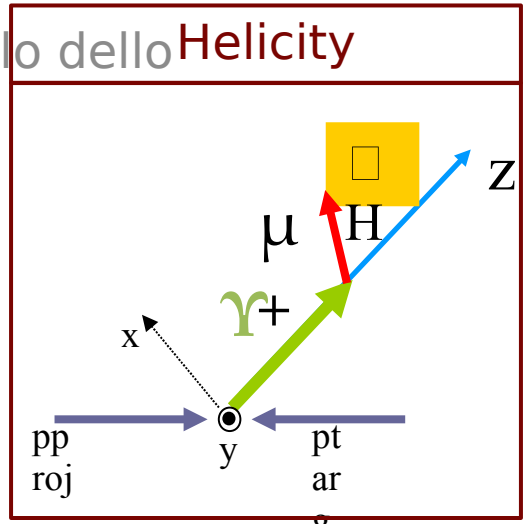
Collins-Soper (CS):
The z-axis is the bisector of the projectile and - the target in the quarkonium rest frame.

Helicity (HE):
The z-axis is the direction of the quarkonium in the (2M

Collins-Soper



Helicity

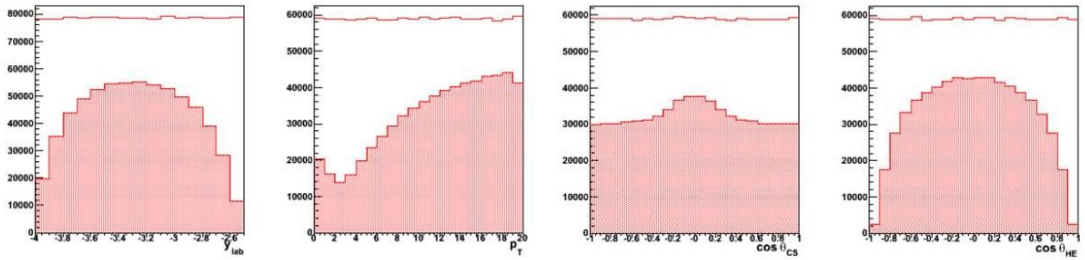


J/psi polarization in pp: acceptance

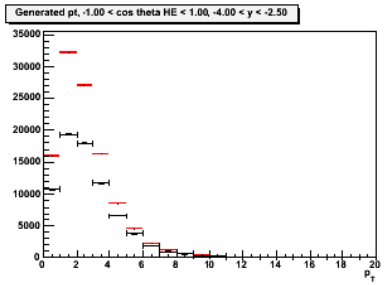
High S/B: bkg. neglection

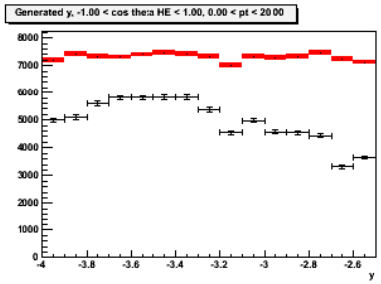
state	S ($\times 10^3$)	B ($\times 10^3$)	S/B	$S/\sqrt{S+B}$
J/ψ	2807	235	12.0	1610
ψ'	75	120	0.62	170
Υ	27.1	2.6	10.4	157
Υ'	6.8	2.0	3.4	73
Υ''	4.2	1.8	2.4	55

3-D acceptance correction: flat y, pT, cos□



The correction has to be made in fiducial regions where the 3D acceptance do not range over too many orders of magnitude.





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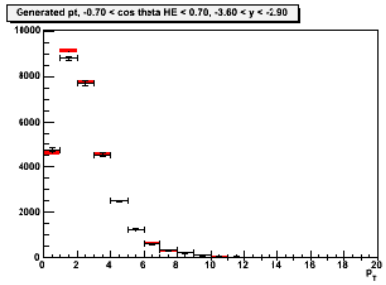
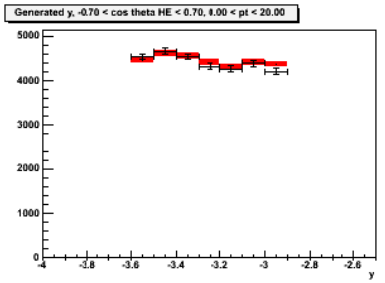
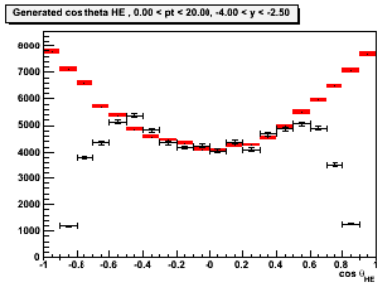
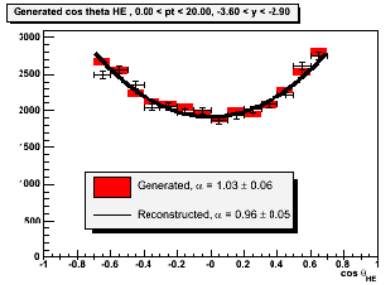






Generated

Accept. corrected



-3.6<y<2.9, -0.7< cos θ <0.7

Generated

Accept. corrected

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J/□ polarization in pp@14TeV

Luminosity = 3 1030 cm-2 s-1
time = 107 s
J/□ = 2.8 106

The number of J/□ is enough to perform a detailed study as a function of pT.

Assuming 200000 reconstructed J/□ in p-p @ 14 TeV (all the statistics we have)

when injecting □=0 we get:

- 1<pT<4 GeV/c: □ = -0.02 ± 0.02
- 4<pT<7 GeV/c: □ = -0.03 ± 0.04
- pT>7 GeV/c: □ = -0.03 ± 0.05

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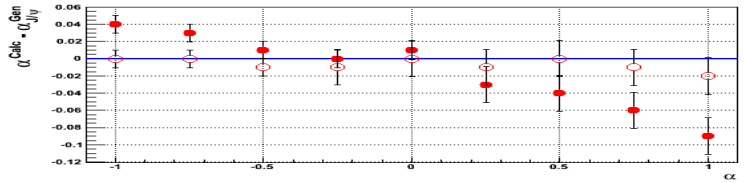


○ □(J/□ bck
● □(J/□ + subtr) bck)

The background contribution is estimated by:

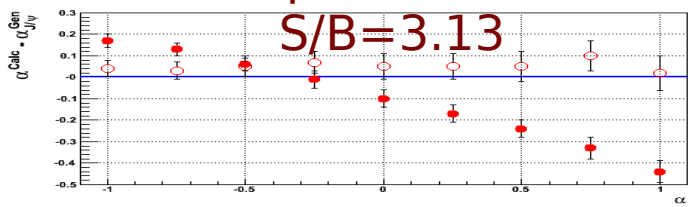
- Adding CORR+UNCORR bkg to the J/□ peak;
- Using the MC Templates method* to subtract it (see the 1st case)

The bias of the □ parameter estimation depends on □ itself (in any case not too big)

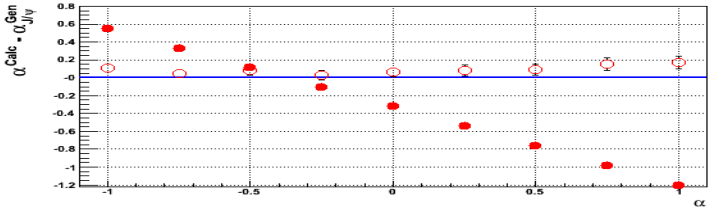
*Robert J. Cropp, *A Measurement of the Polarization of J/psi Mesons Produced in High-Energy pp Collisions*, 16/09/09

J/psi polarization in PbPb@5.5A TeV

Peripheral PbPb: S/B=3.13



Central PbPb: S/B=0.2



□(J/□ bck subtr)

□(J/□ + bck)

In this case the Bkg cannot be neglected. New method for extracting polarization

Fare clic per modificare lo stile del sottotitolo dello schema

Luminosity = 5 1026 cm-2 s-1
time = 106 s
J/□ = 133000 (central events)
J/□ = 21700 (peripheral events)

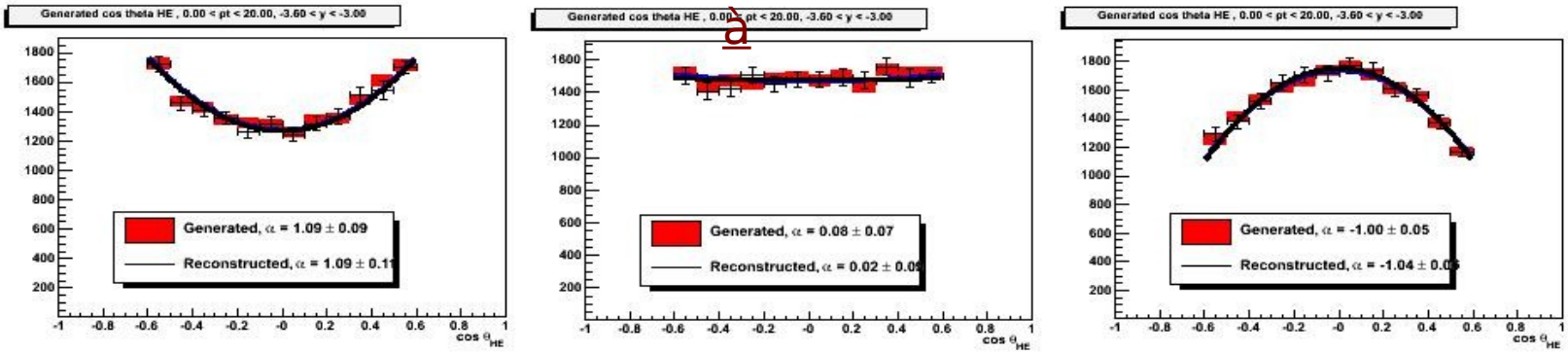
The number of J/□ is enough to perform a study as a function of centrality.
Absolute statistical error ~0.05 for all centralities (for peripheral, smaller statistics compensated by the smaller background)

ϒ polarization in pp: performances

Analysis made on a sample of 27100 ϒ (expected yield in pp @ L=3□1030cm-2s-1 in 107 s (*)).

→ After kinematical cuts we have 13000 ϒ

Elicit a



pT bin (GeV/c)	αgen	αrec (HE)	αrec (CS)
0 < pT < 20	1	1.09 □ 0.11	0.96 □ 0.10
	0	0.02 □ 0.09	0.02 □ 0.08
	-1	-1.04 □ 0.05	-0.94 □ 0.05

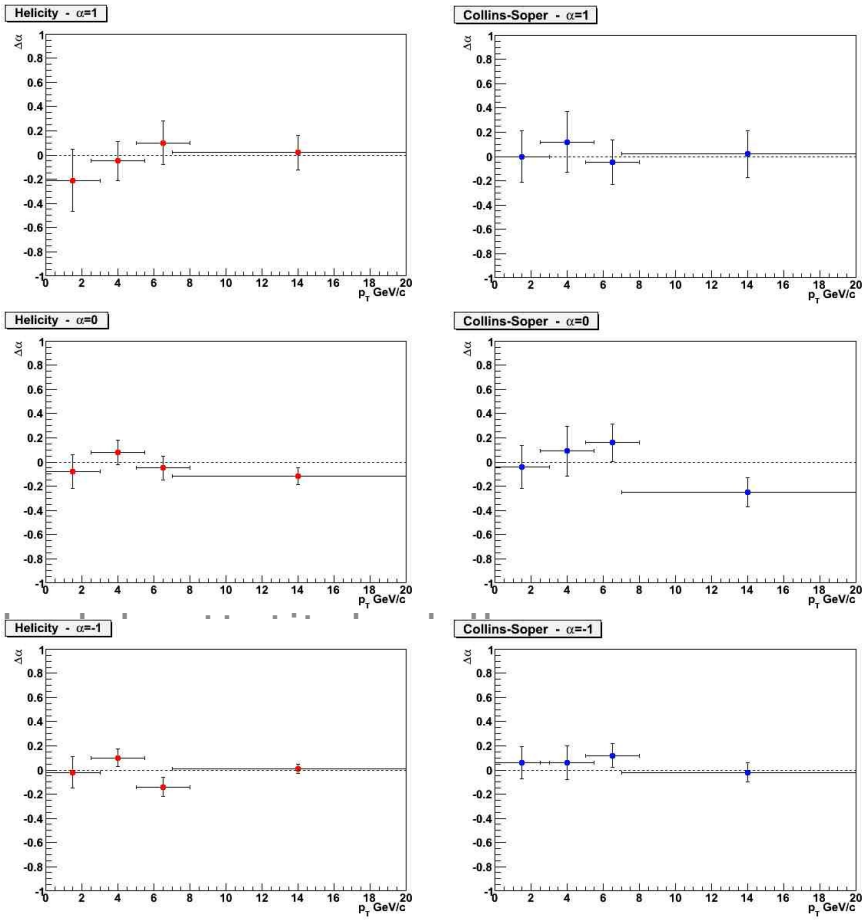
Statistical error ranges from 0.05 and 0.11

Good agreement between αgen and αrec after acceptance corrections

(*) ALICE-INT-2006-029

ϒ polarization in pp: performances

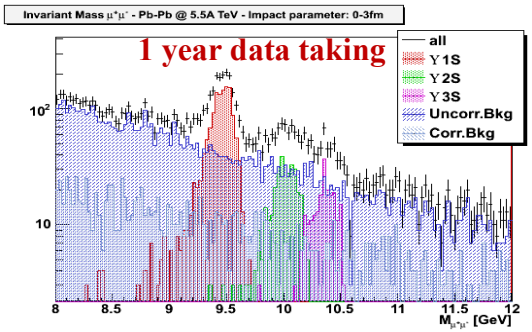
pT bin (GeV/c)	αgen	□αrec		Yrec dopo tagli (#Ygen = 27100)	
		HE	CS	HE	CS
0 < pT < 3	1	-0.21 □ 0.25	0.00 □ 0.21	□5100	□4900
	0	-0.11 □ 0.18	-0.04 □ 0.18		
	-1	-0.02 □ 0.13	0.06 □ 0.13		
3 < pT < 5	1	-0.05 □ 0.16	0.12 □ 0.25	□5600	□4700
	0	0.14 □ 0.12	0.09 □ 0.21		
	-1	0.10□ 0.07	0.06 □ 0.14		
5 < pT < 8	1	0.10 □ 0.18	-0.05 □ 0.18	□5100	□4600
	0	-0.04 □ 0.12	0.16 □ 0.16		
	-1	-0.14 □ 0.08	0.12 □ 0.10		
	1	0.02 □ 0.14	0.02 □ 0.19		

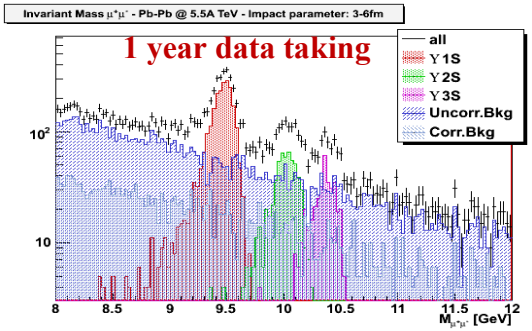


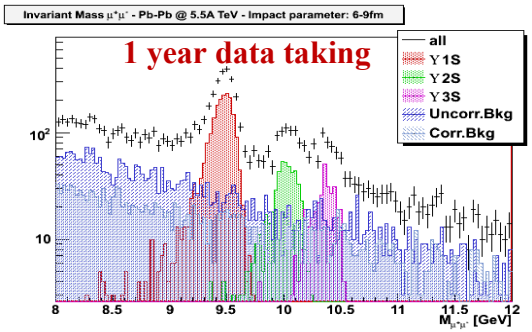
Good agreement between αgen and αrec

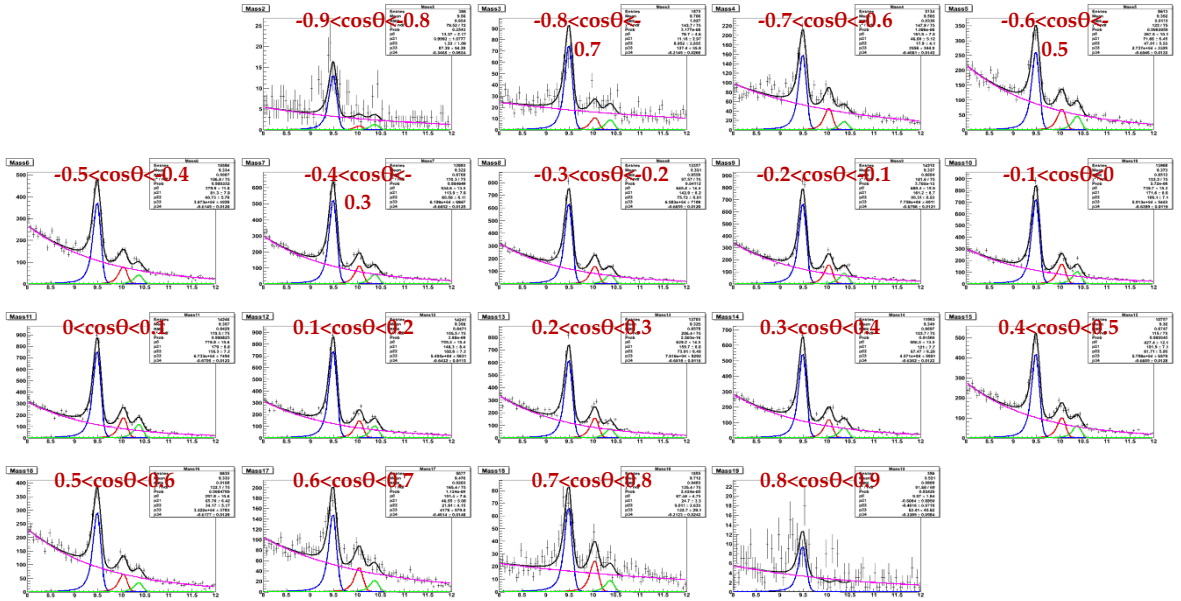
Statistical errors: from 0.03 to 0.19

ϒ polar. in PbPb: MC Template





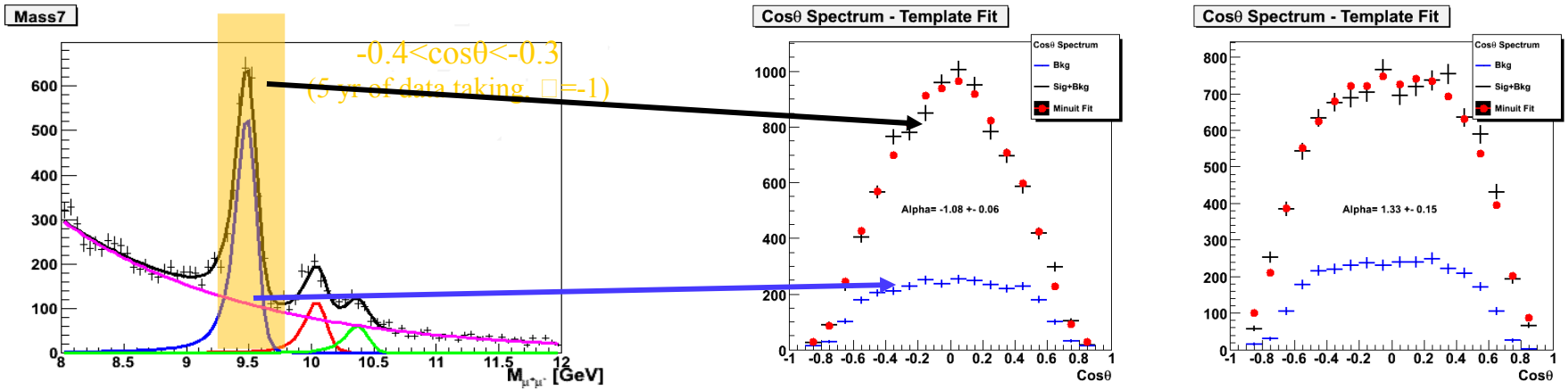


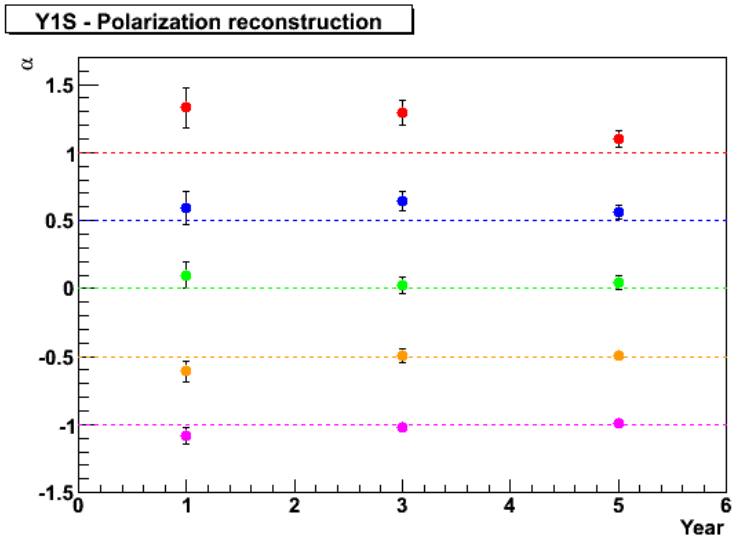


modificare lo stile del sottotitolo dello

- Sample divided in 20 cos bins;
- For each cos bin a mass spectrum is done and fitted;
- The fits allow the evaluation of the bkg. (B) and of the signal+bkg (S+B) contributions;
- The values of B and S+B are plotted in a cos spectrum;

ϒ polarization in PbPb:





·The S+B cosθ spectrum is fitted with a linear superposition of two templates (one transversly polarized and one longitudinally) plus the Bkg contribution;
·The coefficients of the linear superposition give the value of α.

$$\left\{\left[\frac{1-\alpha}{3+\alpha}\right]\cdot T_L(\cos\vartheta)+\left[\frac{2(1+\alpha)}{3+\alpha}\right]\cdot T_T(\cos\vartheta)\right\}+Bkg(\cos\vartheta)=F_{S+B}(\cos\vartheta)$$

Polarization in PDC09 (pp @10TeV)

Id	cycle	description	software	run range	events per sub-run	events produced	status	request
91	LHC09a10	diμ trigger, w/o polarization, residual	v4-17-Rev-04 (root: v5-24-00, geant3: v1-11)	100400 to 100436	100	3420400	completed	$2 \cdot 10^6$
94	LHC09a11	diμ trigger, pol. (.3/.3/0./1./0), residual	v4-17-Rev-05, (root: v5-24-00, geant3: v1-11)	101014 to 101018	100	475400	completed	$4 \cdot 10^5$
95	LHC09a12	diμ trigger, pol. (-.3/-.3/0./1./0.), residual	same as 94	102000 to 102005	100	270000	completed	$4 \cdot 10^5$
96	LHC09a13	diμ trigger, pol. (0./0./0./1./0.), residual	same as 94	103000 to 103005	100	371900	completed	$4 \cdot 10^5$
98	LHC09a16	diμ trigger, w/o pol, full, secret deadmaps & x-sect.	same as 94	111001 to 111005	100		not yet started	$4 \cdot 10^5$
99	LHC09a17	1μ trigger, full, w/o field	same as 94	112001 to 112008	100	662700	completed	$6 \cdot 10^5$
100	LHC09a18	min. bias, w/o pol., residual	same as 94	113001 to 1000001	400	9856800 (until 113040)	runnning	$2 \cdot 10^8$

nicole.bastid @ clermont.in2p3.fr, aug 23th

In particular 3 productions with polarized quarkonia:

- LHC09a11: $\lambda_{J/\psi}$= 0.3, $\lambda_{\psi'}$= 0.3, λ_{Υ}=0., $\lambda_{\Upsilon'}$=1., $\lambda_{\Upsilon''}$=0.
- LHC09a12: $\lambda_{J/\psi}$= -0.3, $\lambda_{\psi'}$=-0.3, λ_{Υ}=0.,

Simulation done using AliGenMUONCocktail pp:

- Pythia mBias
- 5 resonances
- Open heavy flavors.

ottotitolo dello

The polarization is given using AliDecayerPolarized. It can be set with different values to each resonance. Only the cosθ spectrum can be changed (until now)

Polarization analysis from PDC09

Flat J/ψ production (1.2 Mevts)

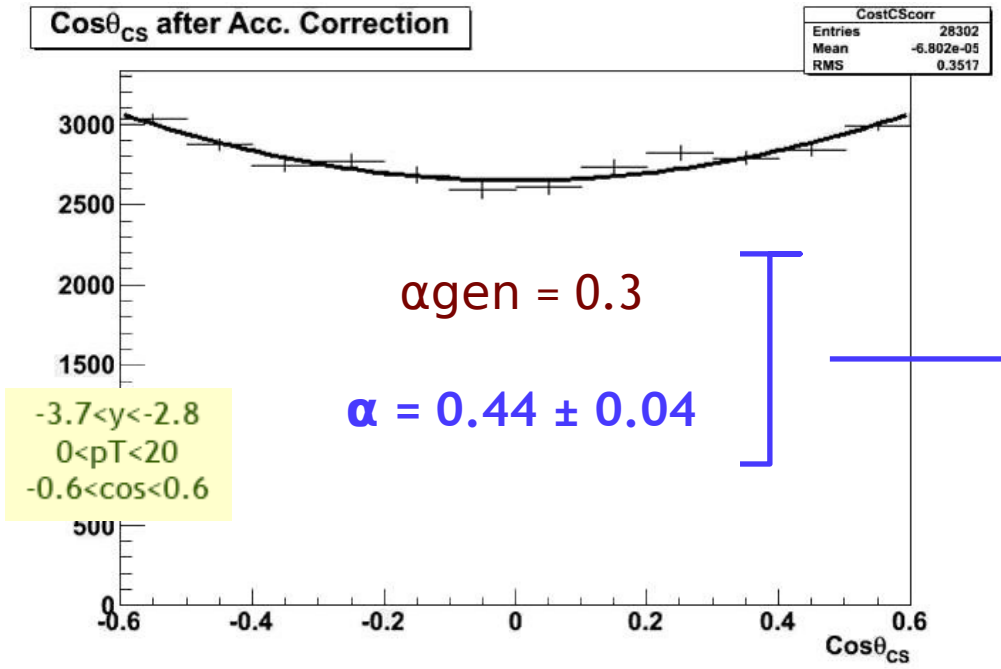
PDC09 Data (a11)

CFContainer for acceptance

CFContainer for data

Corrected data

All the work done through AliAnalysisTaskMuonCFPolar.{cxx,h}, inside the analysis train



αgen = 0.3

α = 0.44 ± 0.04

The 3D acceptance correction (y, pT and cos□ - 2D and 4D are possible) is made in fiducial regions chosen in order to hace acceptance not rangin on too many orders of magnitude.

Discrepancy: due to B -> J/ψ + X ? UNDER STUDY.

Conclusions and Ongoings

Conclusions

The muon spectrometer of the ALICE experiment is ready to take data – cosmic runs show good performances of the entire detector.

The first J/ψ paper could be done using statistics of 104 events (less than 5 monts of data taking) allowing the study of integrated and differential (dσ/dpT, dσ/dy) cross sections and (maybe) an integrated over pT value of polarization.

The polarization analysis can be done both in pp and PbPb. The bkg contribution has been studied and, at least in the second case, a bkg-subtraction strategy has to be implemented.

A first look to PDC09 data gives encouraging results.

Coming next

Full analysis of PDC09 data (polarization & pT/y spectra)

Study of B→J/ψ+X contribution to the cosθ spectrum

Backup Slides

Fare clic per modificare lo stile del sottotitolo dello schema

Muon spectrometer parameters (I)

Muon detection		
Polar, azimuthal angle coverage	$2 \leqslant \theta \leqslant 9,\ 2\pi$	
Minimum muon momentum	4 GeV/c	
Resonance detection	J/ψ	Υ
Pseudo-rapidity coverage	$-4.0 \leqslant \eta \leqslant -2.5$	$-4.0 \leqslant \eta \leqslant -2.5$
Transverse momentum range	$0 \leqslant p_t$	$0 \leqslant p_t$
Mass resolution	70 MeV	100 MeV
Front absorber		
Longitudinal position (from IP)	$-5030mm \leqslant z \leqslant -900mm$	
Total thickness (materials)	10λ (carbon-concrete-steel)	
Dipole magnet		
Nominal magnetic field, field integral	0.7 T, 3 Tm	
Free gap between poles	2.972 – 3.956 m	
Overall magnet length	4.97m	
Longitudinal position (from IP)	-z = 9.87m (centre of the dipole yoke)	
Tracking chambers		
Number of stations, number of planes per station	5, 2	
Longitudinal position of stations	-z = 5357, 6860, 9830, 12920, 14221 mm	
Anodecathode gap (equal to wire pitch)	2.1 mm for st. 1; 2.5 mm for st. 2-5	
Gas mixture	$80\%Ar/20\%CO_2$	
Pad size st. 1 (bending plane)	$4 \times 6,\ 4 \times 12,\ 4 \times 24mm^2$	
Pad size st. 2 (bending plane)	$5 \times 7.5,\ 5 \times 15,\ 5 \times 30mm^2$	
Pad size st. 3, 4 and 5 (bending plane)	$5 \times 25,\ 5 \times 50,\ 5 \times 100mm^2$	
Max. hit density st. 15 (central PbPb×2)	$5.0,\ 2.1,\ 0.7,\ 0.5,\ 0.6 \cdot 10^{-2}$ hits cm^{-2}	
Spatial resolution (bending plane)	$\simeq 70\ \mu m$	

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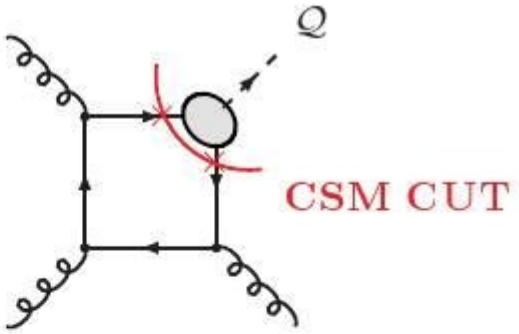
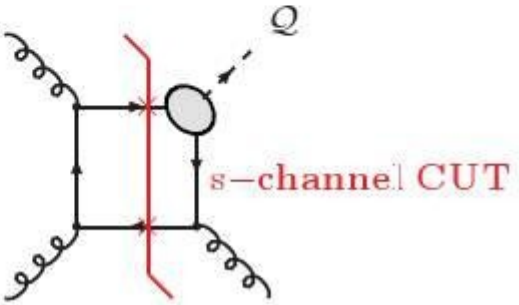
Muon spectrometer parameters (II)

Tracking electronics	
Total number of FEE channels	1.09×10^6
Shaping amplifier peaking time	1.2 μs
Trigger chambers	
Number of stations, planes per station	2, 2
Longitudinal position of stations	-z = 16 120, 17 120 mm
Total number of RPCs, total active surface	72, $\sim 150 m^2$
Gas gap	single, 2 mm
Electrode material and resistivity	Bakelite^{TM}, $\rho = 24 \times 10^9$ cm
Gas mixture	$Ar/C_2H_2F_4$/i-butane/SF_6 ratio 49/40/7/1
Pitch of readout strips (bending plane)	10.6, 21.2, 42.5 mm (for trigger st. 1)
Max. strip occupancy bend. (non bend.) plane	3%(10%) in central Pb-Pb
Maximum hit rate on RPCs	3 (40) Hz cm^{-2} in Pb-Pb (Ar-Ar)
Trigger electronics	
Total number of FEE channels	2.1×10^4
Number of local trigger cards	234 + 2

Font: ALICE Physics Performance Report Vol. I, J. Phys. G: Nucl. Part. Phys. 30 (2004)

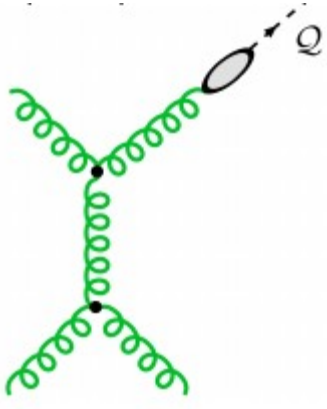
Production mechanism



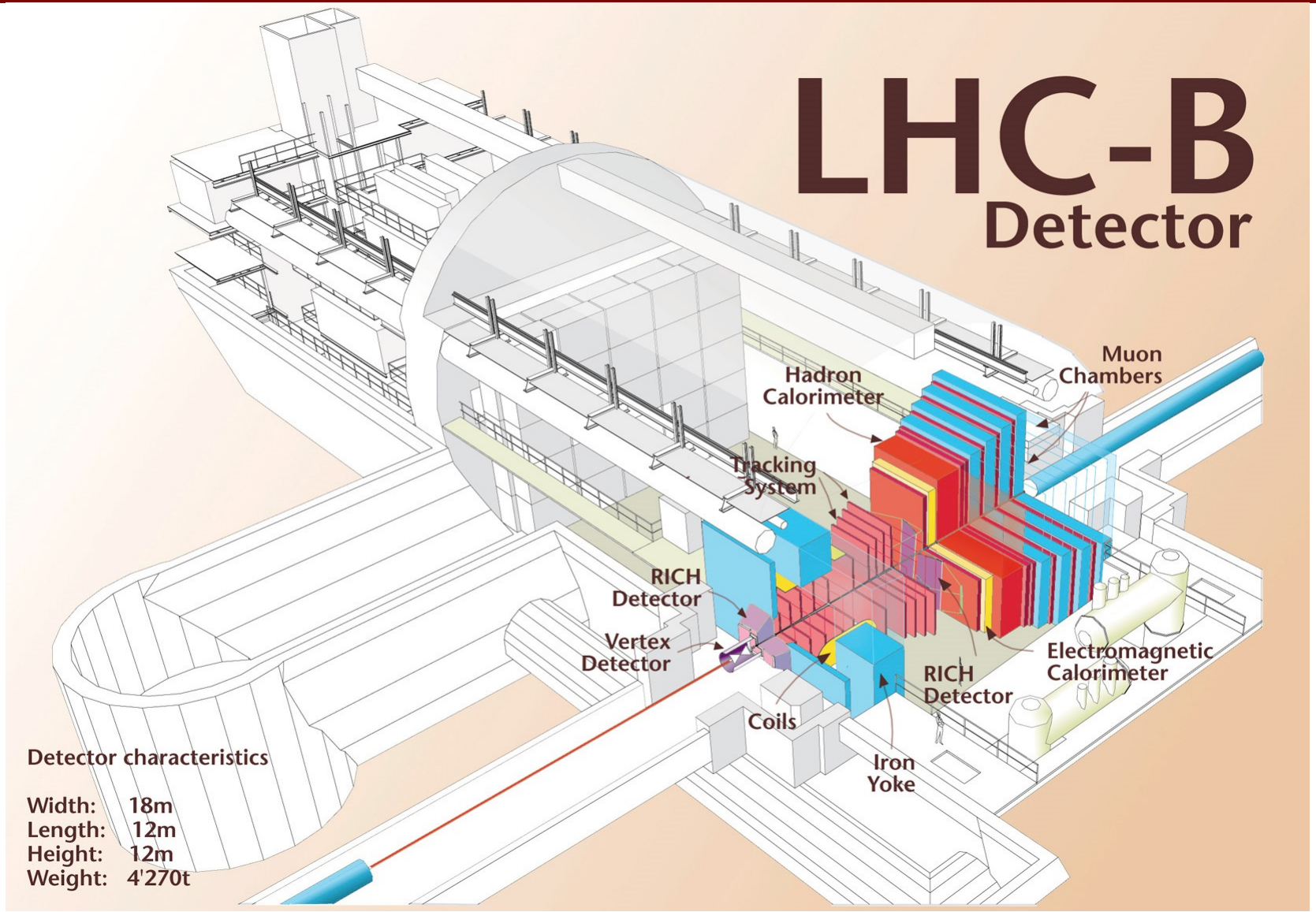


JPL, J.R. Cudell, Yu.L. Kalinovsky, PLB633:301,2006

del sottot



The LHCb Detector



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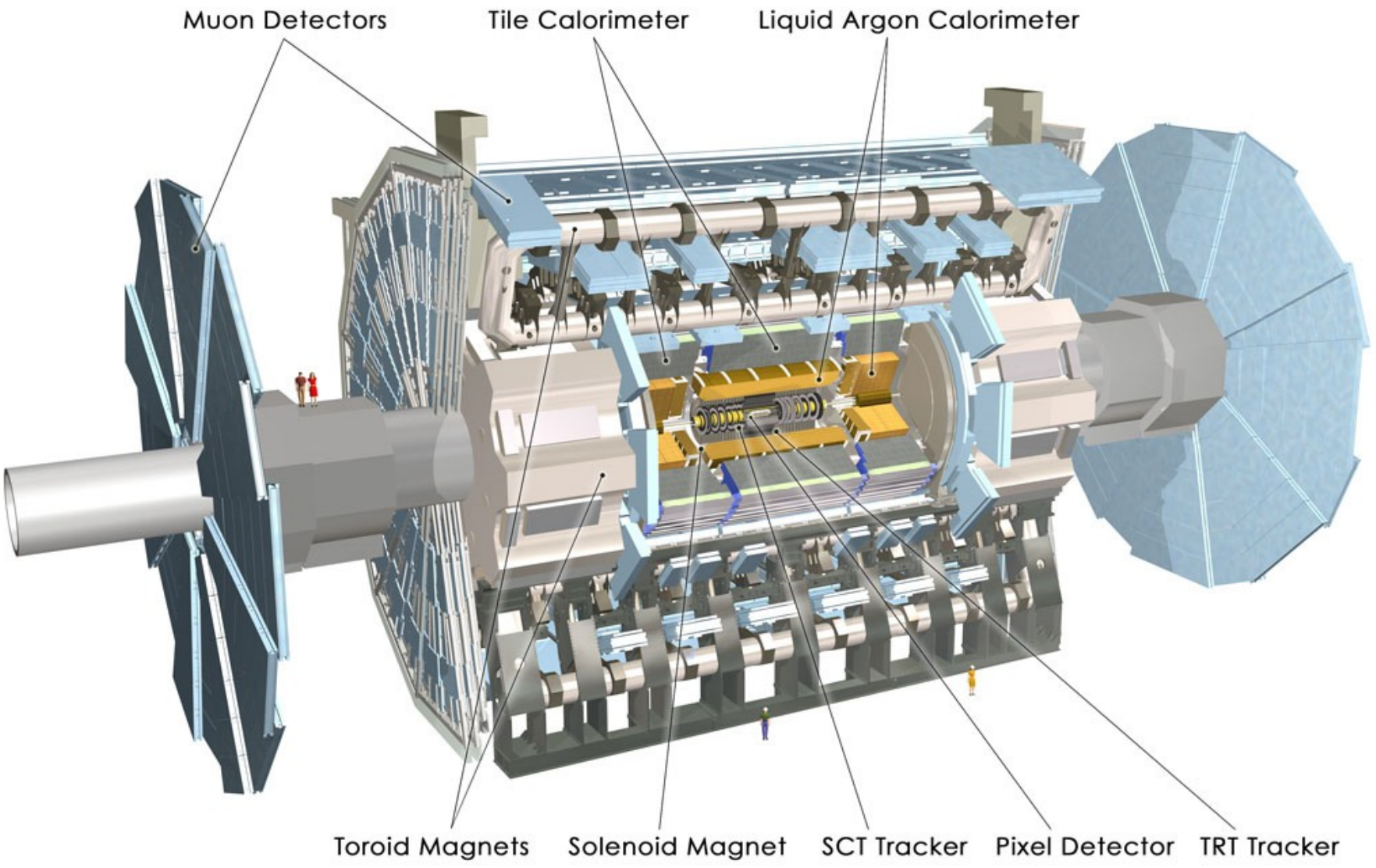
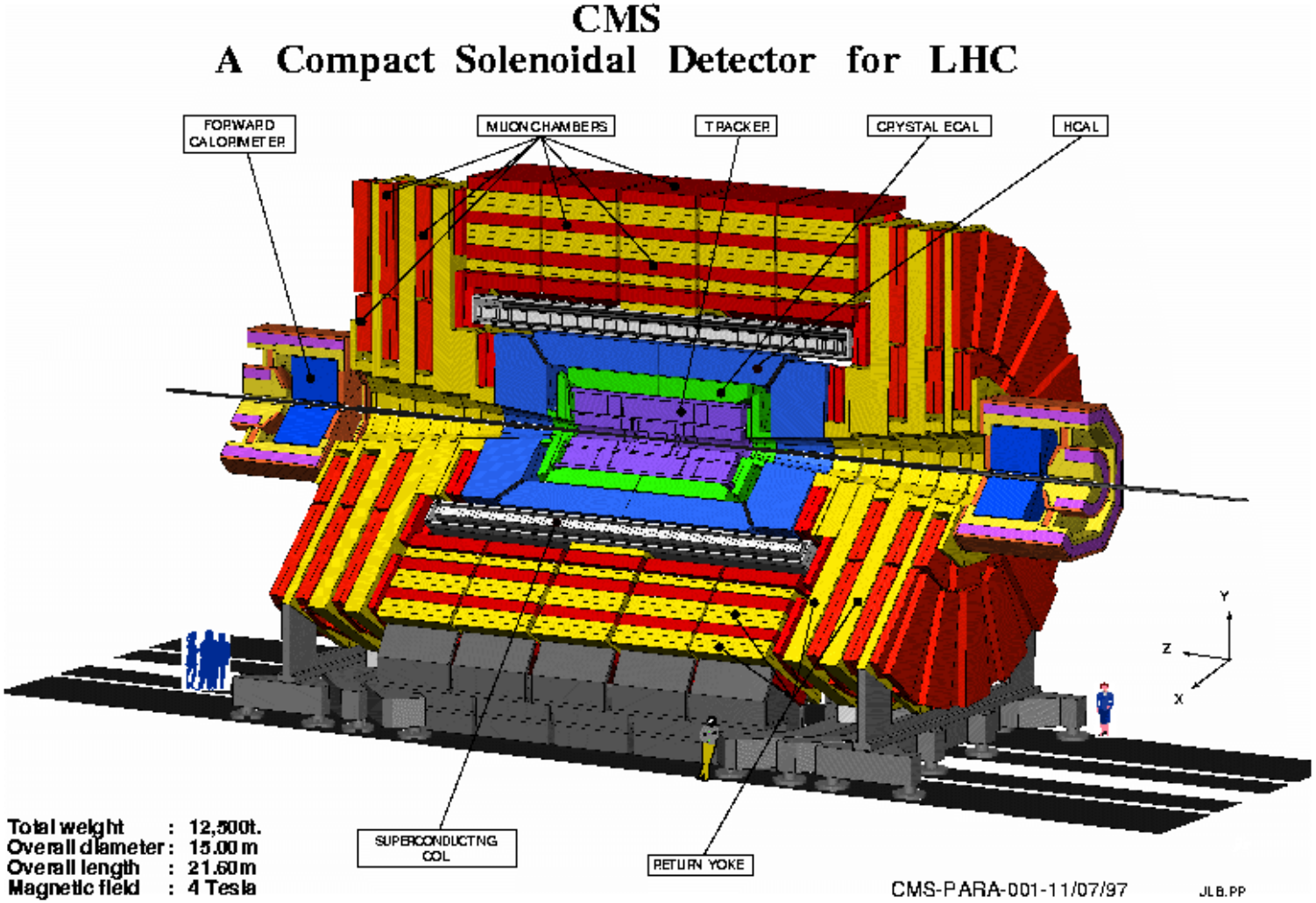
The ATLAS Detector



The CMS Detector



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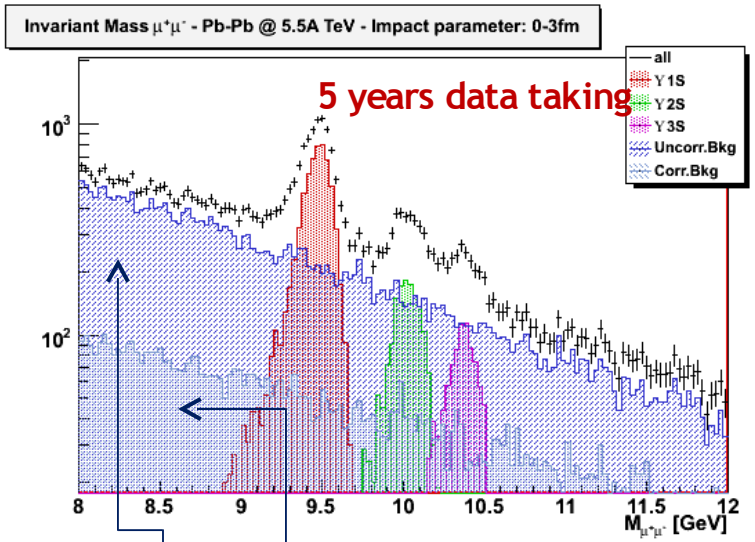
Preparing Data Samples (I)



$b\bar{b} \rightarrow \bar{B}0B{+}{+}X \rightarrow D+ \ \mu- \ \bar{\nu}\mu \ + D0 \ \mu+ \nu\mu \rightarrow \mu+ \mu- \ \nu\mu \ + \mu- \ \mu+ \nu\mu \ + X$

$c\bar{c} \rightarrow D+ \ + \bar{D}0 + X \rightarrow \mu+ \mu- \ + X$

bb – cc – bc contributions

- **Signal**: Υ(1S), Υ(2S) and Υ(3S) samples generated with AliGenParam and reconstructed with full-simulation. Generation done with several degrees of polarization: -1, -0.5, 0, 0.5, 1.
- **Correlated Background**: generated with Pythia by Rachid Guernane* and reconstructed with fast simulation
- **Uncorrelated Background**: generated through parametrization and reconstructed with the fast simulation approach (see $ALICE_ROOT/FASTSIM/UncorrBg.C)

π and K contribution to background negligible in 8-12 GeV mass region

1, 3 and 5 years of data taking have been considered (L= 5▫1026 cm-2 s-1)

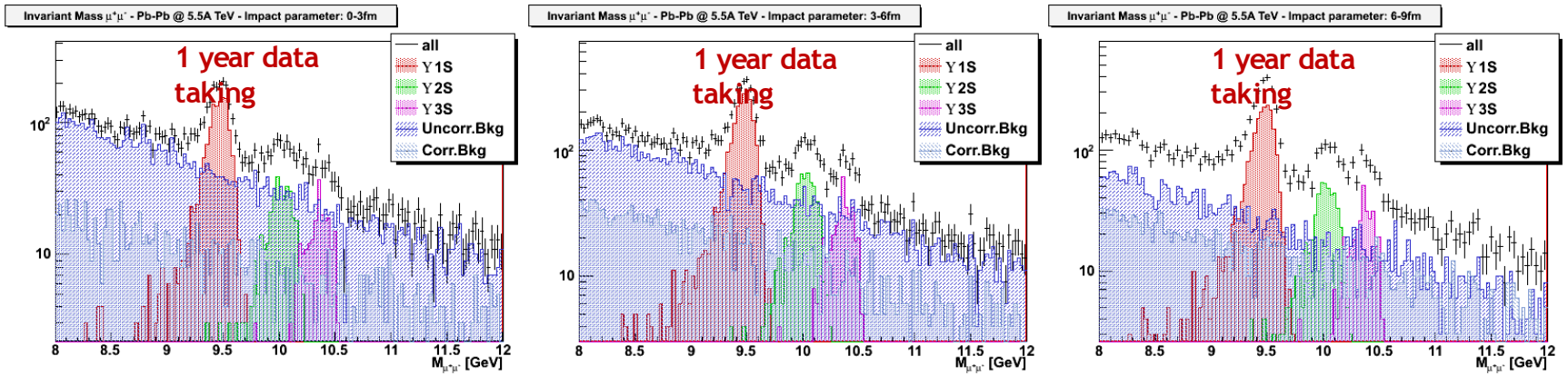
*ALICE-INT-2005-018 version 1.0

Preparing Data Samples (II)

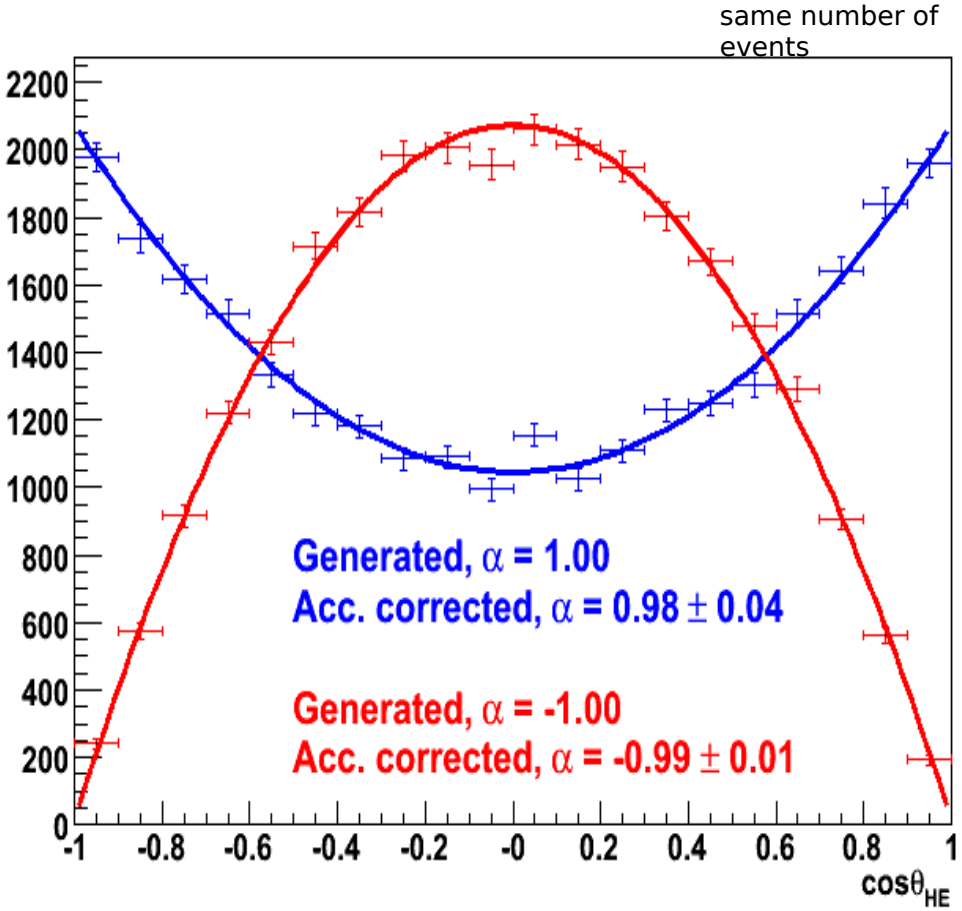
The relative weights of correlated and uncorrelated bkgs have been taken from Smbat Grigoryan's work, published in PPR-Vol.2

The contribution of each type of bkg is different in the 5 centrality classes: 5 different data samples have been prepared for each polarization

We did all the work integrating over the impact parameter, but in the future a study of the centrality dependence of the α parameter could be done using the same generated data



Angular distribution fit: error on α

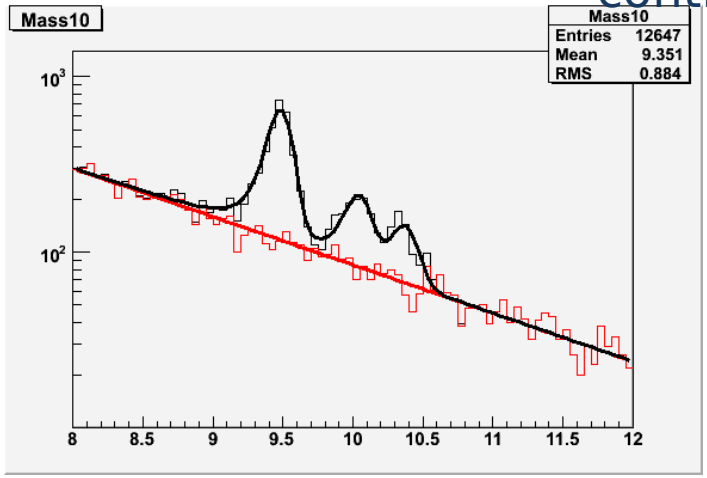


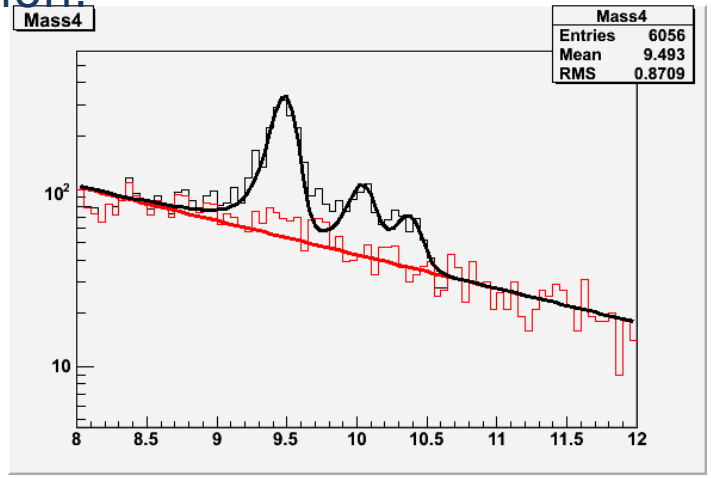
With the same number of reconstructed events the error on α increases while α

In the Least Squares fitting method if f(x) = p0×(1+α×x²) then for p0 large σα ∝ 1/p0

Bias on high values of □

In peripheral cosθ bins we sometimes underestimate the background contribution:





Central cosθ bins: the Bkg shape seems to be perfectly exponential -> the contribution is well estimated

Edges of the cosθ distribution: the Bkg shape is not exponential -> the contribution is underestimated

↓

The spectrum shape is wider

↓

α is bigger

Only for high values of α because in that case the shape of the cosθ depends more directly on the behaviour of the most

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Fit of the cos spectrum: minimization

Template fit to the cosθ spectrum done with MINUIT minimizing the quantity:

$$\chi^2 = 2 \cdot \sum_i \left\{ (E_i + \beta_i - D_i) - D_i \cdot \ln\left(\frac{E_i + \beta_i}{D_i}\right) + (\beta_i - S_i) - S_i \cdot \ln\left(\frac{\beta_i}{S_i}\right) \right\}$$

where

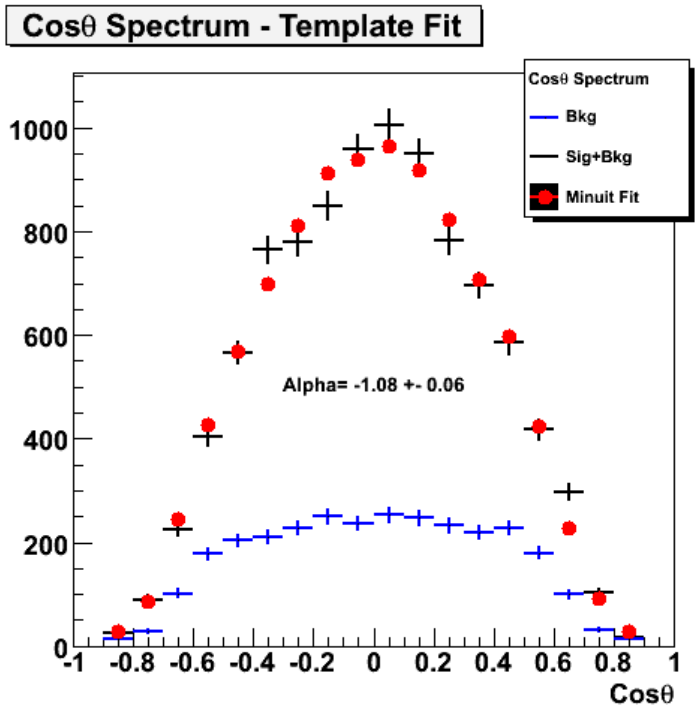
:

$$\beta_i = \frac{1}{4}\left[-(2E_i - D_i - S_i) + \sqrt{(2E_i - D_i - S_i)^2 + 8S_iE_i}\right]$$

D_i : $Signal + Bkg\ events$ $\qquad$ S_i : $Bkg\ events$

E_i : $expected\ number\ of\ Signal\ events$

β_i : $expected\ number\ of\ Bkg\ events$



The formula is correct when signal+background and background errors are both poissonian.
We suppose background errors to be poissonian: not completely correct because not obtained from an event counting technique.

T. Devlin, *Correlations from Systematic Corrections to Poisson-Distributed Data in Log-Likelihood Functions*, CDF public note CDF/DOC/JET/PUBLIC/3126 (1995)

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How to study polarization

The polarization of Quarkonium is gleaned through the analysis of the angular distribution of daughter particles (e.g. μ+μ-) which follows the trend:

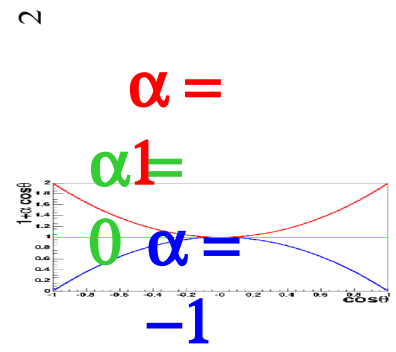
$$\frac{d\Gamma}{d\cos\theta^*} \propto \frac{3}{2(\alpha+3)}(1+\alpha\cos^2\theta^*)$$

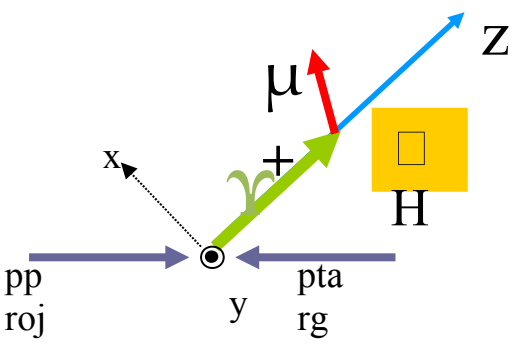
$$\xi_L = \frac{\sigma_L}{\sigma_{TOT}} = \frac{1-\alpha}{3+\alpha}$$

$$\xi_T = 1 - \xi_L$$

α=1 Transverse polarization

α=−1 Longitudinal polarization





The angular distribution is usually analyzed in the ϒ C.M. frame. Polarization angle defined as the angle between μ+ momentum and a "polarization axis" which can be chosen in different ways.

We use the helicity (HE) reference frame, in which the z-axis is the direction of the ϒ momentum in the p-p C.M. frame.