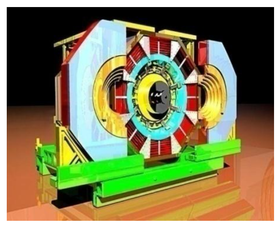
Experimental study of the relative phase between J/ψ production amplitudes



Marco DESTEFANIS*

on behalf of the BESIII Collaboration

***Università degli Studi di Torino and INFN**

J/ψ Strong and Electromagnetic Decay Amplitudes

Resonant contributions

$\Gamma_{J/\psi} \sim 93$KeV → pQCD

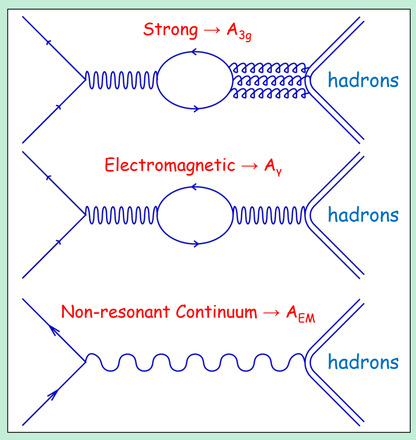
pQCD: all amplitudes almost real [1,2]

QCD -> $\Phi_p \sim 10°$ [1]

Non-resonant continuum

pQCD regime

$A_{EM} \in \Re$



- If both real, they must interfere ($\Phi_p \sim 0°/180°$)
- On the contrary $\Phi_p \sim 90°$ → No interference

  $J/\psi \to N\bar{N}$ ($\frac{1}{2}^+\frac{1}{2}^-$) $\Phi_p = 89° \pm 15°$ [3]; $89° \pm 9°$[4]

  $J/\psi \to$ VP (1^-0^-) $\Phi_p = 106° \pm 10°$ [5]

  $J/\psi \to$ PP (0^-0^-) $\Phi_p = 89.6° \pm 9.9°$ [6]

  $J/\psi \to$ VV (1^-1^-) $\Phi_p = 138° \pm 37°$ [6]
- Results are model dependent
- Model independent test:

  interference with the non resonant continuum

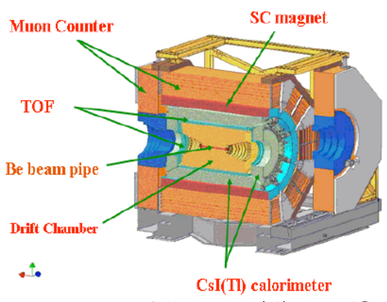
[1] J. Bolz and P. Kroll, WU B 95-35.
[2] S.J. Brodsky, G.P. Lepage, S.F. Tuan, Phys. Rev. Lett. 59, 621 (1987).
[3] R. Baldini, C. Bini, E. Luppi, Phys. Lett. B404, 362 (1997); R. Baldini et al., Phys. Lett. B444, 111 (1998).
[4] M. Ablikim et al., Phys. Rev. D 86, 032014 (2012).
[5] L. Kopke and N. Wermes, Phys. Rep. 174, 67 (1989); J. Jousset et al., Phys. Rev. D41,1389 (1990).
[6] M. Suzuki et al., Phys. Rev. D60, 051501 (1999).

The BESIII Experiment @ IHEP

BEijing Spectrometer III

e^+e^- collisions

√S tuned depending on energy

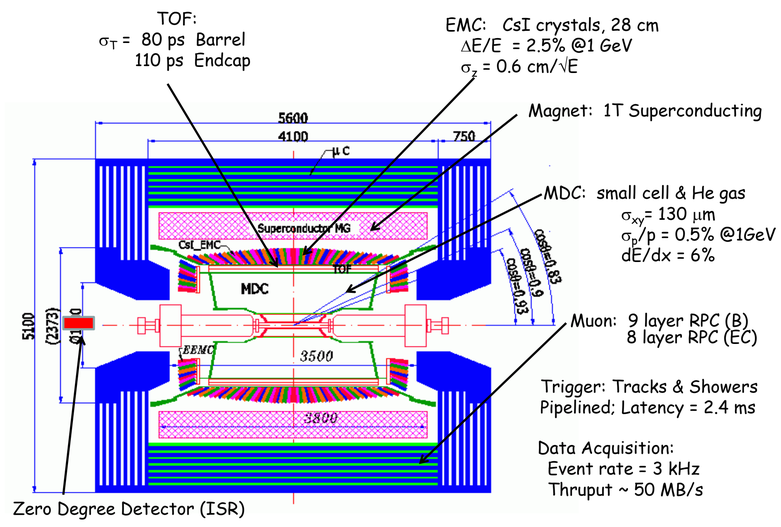


Physics program

- Charmonium Physics
- D-Physics
- Light Hadron Spectroscopy
- τ-Physics
- ...

D.M. Asner et al, Physics at BES-III, arXiv:0809.1869v1 [hep-ex] (2008)

BESIII Detector



Investigated Processes

➢ Inclusive scenario: does not see anything

The phase is there, but the mean goes to 0

Interference $\propto \langle f|3g\rangle^*\langle f|\gamma\rangle$

Sum over all the final states $\sum\langle 3g|f\rangle\langle f|\gamma\rangle$

Closure approximation $\sum|f\rangle\langle f| \approx 1$

But $\langle 3g|\gamma\rangle \cong 0$ orthogonal states

If we sum over all the channels, the interference ≈ 0

➢ Exclusive scenario: could see interference effects

- e^+e^- -> J/ψ -> $p\bar{p}$, $n\bar{n}$ $N\bar{N}$

  BR ~ 2.17×10^{-3} σ_{cont}~ 11 pb
- e^+e^- -> J/ψ -> ρπ VP

  BR ~ 1.69% σ_{cont}~ 20 pb
- e^+e^- -> J/ψ -> $2(\pi^+\pi^-)\pi^0$

  BR ~ 5.5% σ_{cont}~ 500 pb

Phase Generator

- Event generator
- Monte-Carlo method (100000 iterations)
- Cross section evaluation at each point
- Beam spread gaussian (0.93 MeV)
- Radiative correction (simple model to be optimized)
- Max radiation 300 MeV (~20% E_{CM})
- Cross section:

$$\sigma[nb] = 12\pi B_{in}B_{out}\left[\frac{\hbar c}{W}\right]^2 \cdot 10^7 \cdot \left|-\frac{C_1 + C_2 e^{i\varphi}}{W - W_{ris} + i\Gamma_{ris}/2} + C_3 e^{i\varphi}\right|^2$$

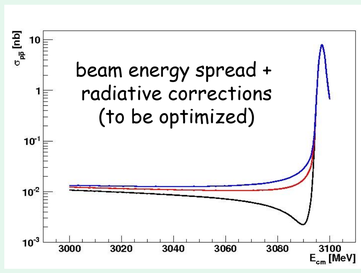
Simulated Yields for e^+e^--> $p\bar{p}$

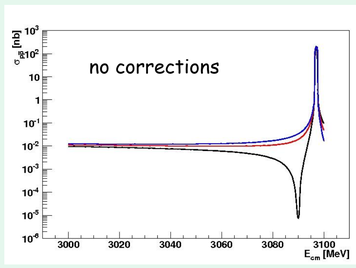
— Δφ = 0°

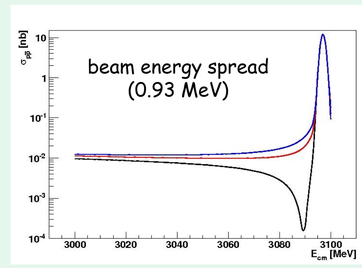
— Δφ = 90°

— Δφ = 180°

continuum reference
σ ~ 11 pb







Precision of the Fit

Statistical error for:

$p\bar{p}$ circle

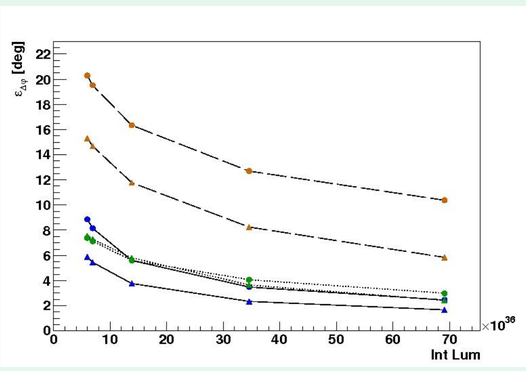
ρπ triangle

..... 10°

——— 90°

– – – – 170°

2 parameters:
φ and σ_{cont}



170°

- Lower sensitivity

(No 0°-90° and 90°-180° symmetry)

Energy Points Choice

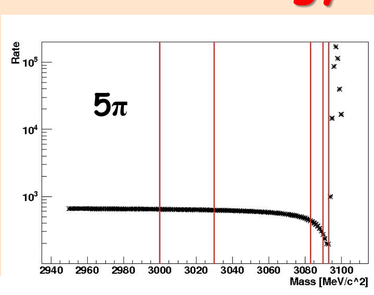
Depends on the process

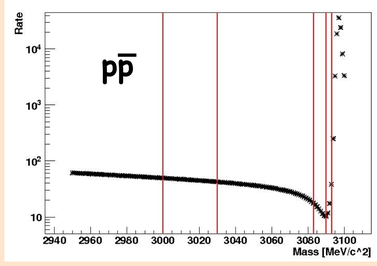
Maximum interference: 0°

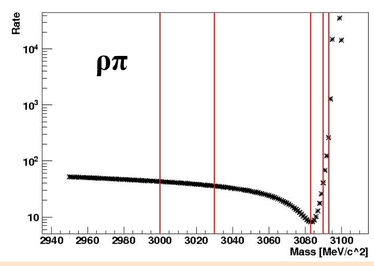
➢ 2 pts at low W
  fix the continuum
  fix the slope

➢ 2 pts at deep positions

➢ 1 pt Beginning of the BW

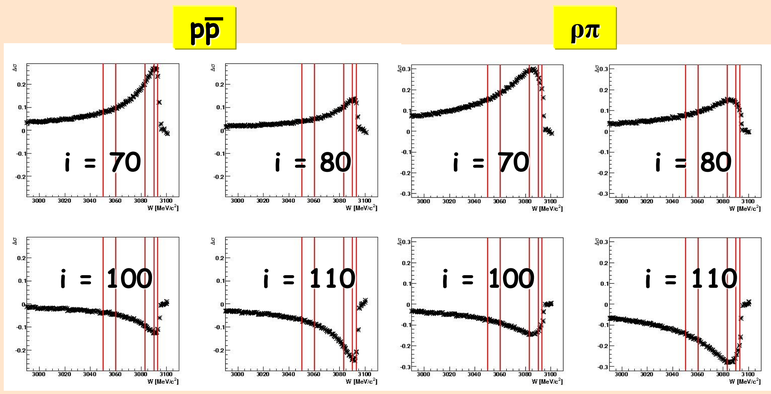






➢ What happens at 90° $(\sigma_{90}-\sigma_i)/\sigma_{90}$
Gradient calculation

The deep corresponds roughly to the maximum gradient



Statistical error:

$p\bar{p}$ circle

ρπ triangle

..... 10°

——— 90°

– – – – 170°

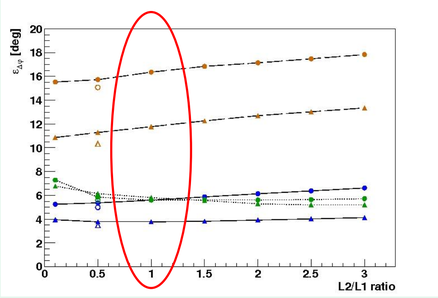
Open points:

1:1:0.5:0.5:2

5 days $L_{int} = 1.4\times10^{37}$ [cm^{-2}]

points: 3050,3060, 3083,3090, 3093 MeV

$\ell_1 : \ell_1 : \ell_2 : \ell_2 : \ell_1$



Very low sensitivity to Luminosity ratios
Best and simplest choice: 1:1:1:1:1

J/ψ Phase

$p\bar{p}$

Δφ = +90°

σ_{cont} = 11 pb $B_{out} = 2.17\cdot10^{-3}$

3 parameters:
φ, σ_{cont} and B_{out}

Points	Par	Inj. eff.	Δφ [°]	Δσ [pb]	ΔB_{out}
5	3	0.7	29.3	1.3	$0.7\cdot10^{-3}$
5	3	0.8	26.7	1.3	$0.7\cdot10^{-3}$
6	3	0.8	6.1	0.9	$0.4\cdot10^{-5}$
12	3	0.7	6.3	0.9	$0.7\cdot10^{-4}$
12	3	0.8	5.9	0.9	$0.7\cdot10^{-4}$

3 parameters: 3096.9 needed
(1 point more with high statistics)

J/ψ Phase

Energy requested [MeV]	Energy collected [MeV]	L_{int} [pb^{-1}]
3050	3046	14.0
3060	3056	14.0
3083	3086	16.5
3090	3085	14.0
3093	3088	14.0
3097	3097	79.6

PRELIMINARY

Expected Achievements

- J/ψ decay amplitude phase: 0° (theory) but 90° (data)
- Required Luminosity collected during run 2012
- Evaluation fit d.o.f.: 3 parameters
- High level analysis in progress

Acknowledgements:

This work was supported in part by **Regione Piemonte, Università degli Studi di Torino, INFN, and IHEP.**