Testing χ_c properties at BELLE II

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Motivation

- The integrated luminosity in BELLE II experiment (20-50 ab^{-1}) will allow us to access information not available before.
- Many models ([1]-[5]) correctly describe $\chi_{ci} \to J/\psi\gamma$, $\chi_{ci} \to \gamma\gamma$ and $\psi' \to \chi_{ci}\gamma$ partial decay widths but give different predictions for the width $\chi_{c1,c2} \to e^+e^-$.

	[1]	[2]	[3]	[4]	[5]
$\Gamma(\chi_{c1} \to e^+e^-)[eV]$	0.37	0.43	0.046	0.367	0.1
$\Gamma(\chi_{c2} \to e^+e^-)[eV]$	3.86	4.25	0.037	0.137	-

Model

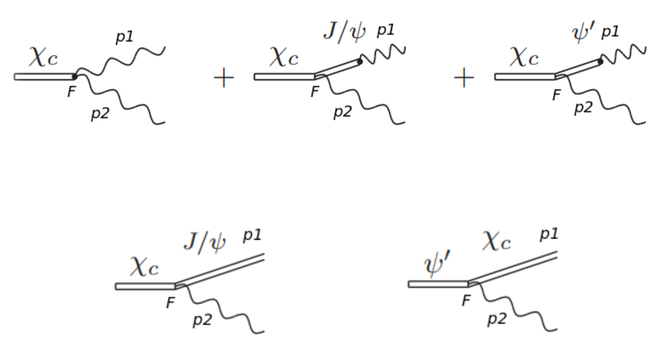


Figure: $F \sim \frac{1}{\sqrt{m}} \frac{1}{((p_1+p_2)^2/4-m^2+i\varepsilon)^2}$
Diagrams for decay widths $\Gamma(\chi_{ci} \to \gamma\gamma)$, $\Gamma(\chi_{ci} \to J/\psi\gamma)$ and $\Gamma(\psi' \to \chi_{ci}\gamma)$

6 parameters (a, m, a_J, a_J^0, $a_{\psi'}$ and $a_{\psi'}^0$) are fitted to
8 experimental values ($\Gamma(\chi_{c_0} \to \gamma\gamma)$, $\Gamma(\chi_{c_2} \to \gamma\gamma)$, $\Gamma(\chi_{c_i} \to J/\psi\gamma)$, $i = 0,1,2$, $\Gamma(\psi' \to \chi_{c_i}\gamma)$, $i = 0,1,2$).

χ^2 = 0.943

$a[GeV^{5/2}]$	$m[Gev]$	$a_J[GeV^{5/2}]$	$a_J^0[GeV^{5/2}]$	$a_{\psi'}[GeV^{5/2}]$	$a_{\psi'}^0[GeV^{5/2}]$
0.0796	1.67	0.129	0.073	-0.078	0.122

The EKHARA code

New implemented channels:

- $e^+e^- \to e^+e^-\chi_{ci}$
- $e^+e^- \to e^+e^-\chi_{ci}(\to \gamma J/\psi(\to \mu^+\mu^-))$

$e^+e^- \to e^+e^-\chi_{ci}$

Expected number of events for production (luminosity = 50ab^{-1}):

	Number of events for χ_{c0}	Number of events for χ_{c1}	Number of events for χ_{c2}
no cuts	140M	4.3M	143M
single tag	6.7M	1.4M	7.2M
double tag	249k	174k	295k

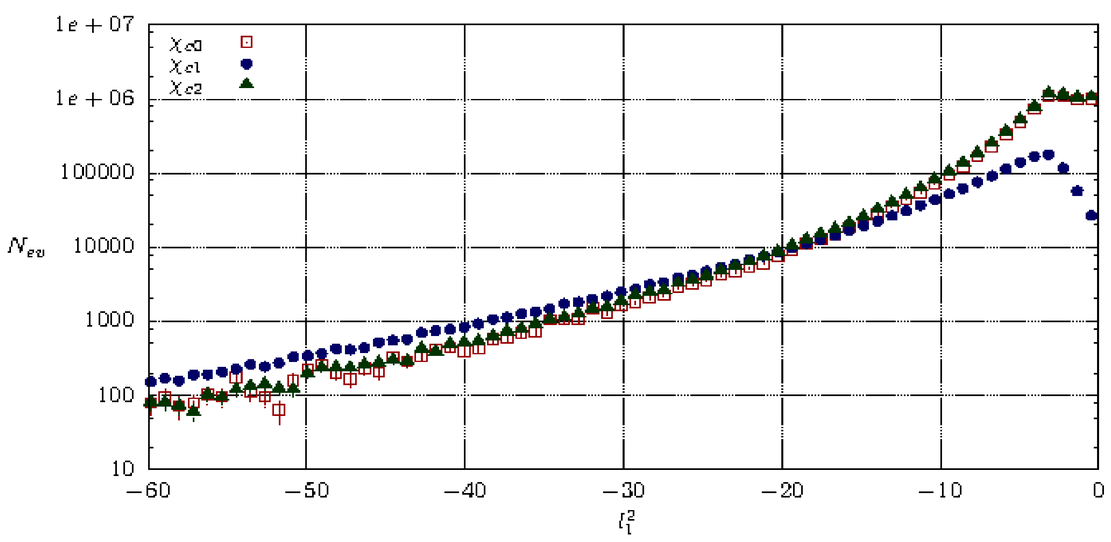
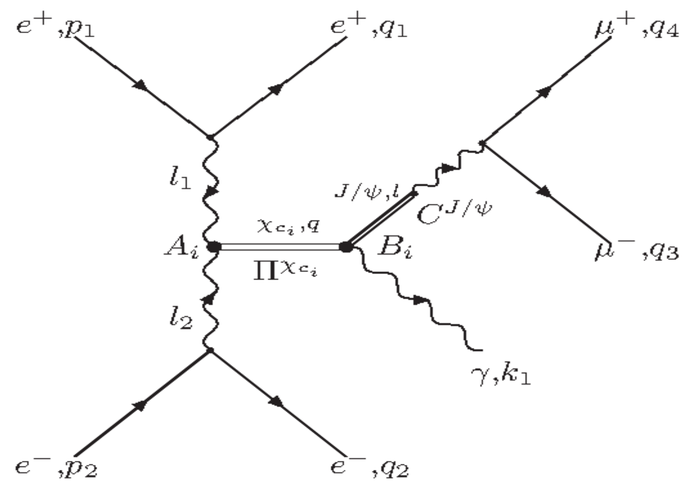


Figure: The distributions of expected number of events for χ_{ci} production, when one observes the positron in the angular range of 17° and 150°

$e^+e^- \to e^+e^-\chi_{ci}(\to \gamma J/\psi(\to \mu^+\mu^-))$



Expected number of events for decay (luminosity = 50ab^{-1}):

	Number of events for χ_{c0}	Number of events for χ_{c1}	Number of events for χ_{c2}
no cuts	114k	96k	1.6M
single tag	3.1k	22k	44k
double tag	136	2.5k	2.5k

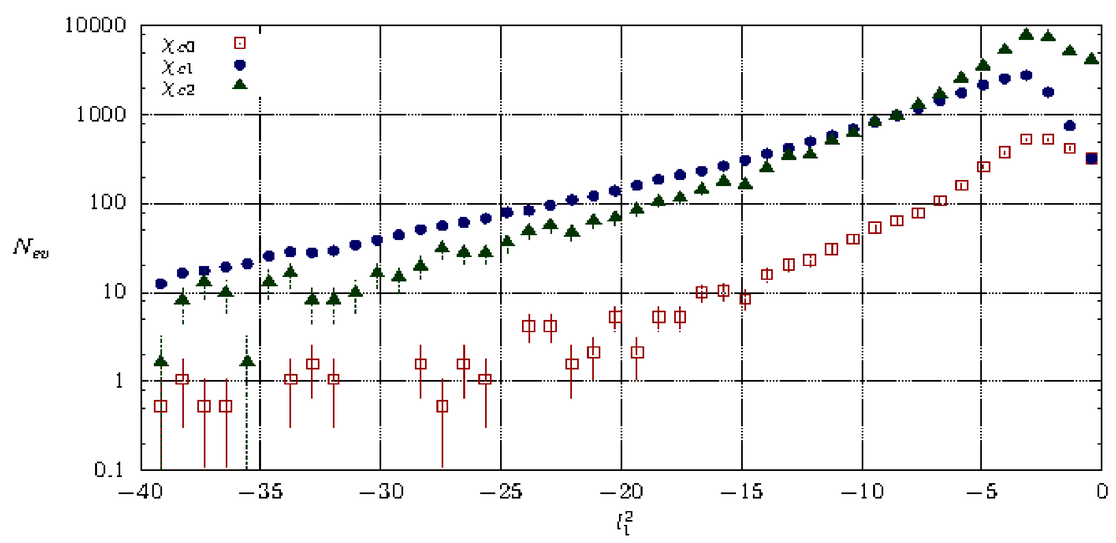


Figure: The distributions of expected number of events for χ_{c_i} production with subsequent decay to $J/\psi(\to \mu^+\mu^-) - \gamma$

Background

- To estimate non-resonant QED background the HELAC-PHEGAS generator was used.
- The event selections:
  - polar angles are between 17° - 150°,
  - invariant masses were chosen to contain 99% of the signal cross section.

	χ_{c0}	χ_{c1}	χ_{c2}
1 tag signal [nb]	$0.59 \cdot 10^{-7}$	$4.18 \cdot 10^{-7}$	$8.09 \cdot 10^{-7}$
1 tag background [nb]	$0.66 \cdot 10^{-7}$	$0.0064 \cdot 10^{-7}$	$0.057 \cdot 10^{-7}$
2 tags signal [nb]	$0.25 \cdot 10^{-8}$	$4.87 \cdot 10^{-8}$	$4.57 \cdot 10^{-8}$
2 tags background [nb]	$0.54 \cdot 10^{-8}$	$0.0033 \cdot 10^{-8}$	$0.080 \cdot 10^{-8}$

Summary

- Within the considered model at BELLE II it will be possible to study in detail $\chi_{c_i} - \gamma^* - \gamma^*$ **form factors** through measurements of the reaction $e^+e^- \to e^+e^-\chi_{ci}(\to J/\psi(\to \mu^+\mu^-)\gamma)$.
- The proposed measurements will serve as **tests of the models** predicting the χ_{c1} and χ_{c2} electronic widths.

References

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[4] D. Yang, S. Zhao, Eur. Phys. J. C72 (2012) 1996.
[5] A. Denig, F.K. Guo, C. Hanhart, A. V. Nefediev, Phys. Lett. B736 (2014) 221-225.