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THE LOW-ENERGY FRONTIER
OF THE STANDARD MODEL

Direct Production of χ_{c1} at BESIII

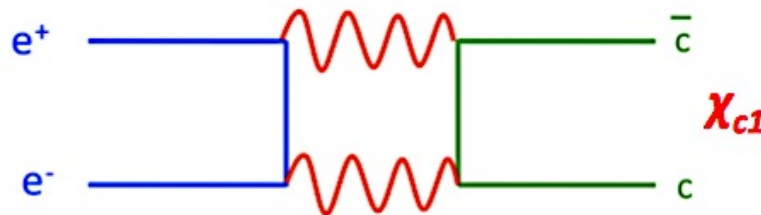
Yuping Guo for BESIII Collaboration



Motivation

- So far in e^+e^- annihilation only vector resonances with quantum numbers $J^{PC}=1^{--}$ have been observed
- Excellent performance of BEPCII/BESIII offer opportunity to measure for the first time process $e^+e^- \rightarrow \chi_{c1}(1^{++})$ through a time-like two photon process

$$e^+e^- \rightarrow 1^{++}$$

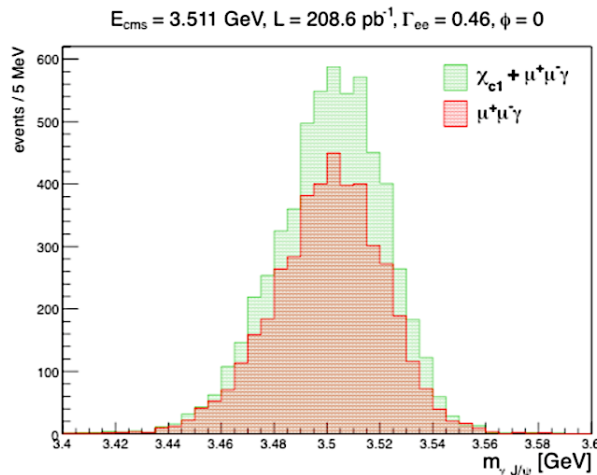


Motivation

- Signal process: $e^+e^- \rightarrow \chi_{c1}, \chi_{c1} \rightarrow \gamma J/\psi(34\%), J/\psi \rightarrow \mu^+\mu^-(6\%)$
- Irreducible background process: ISR production of $(J/\psi + \mu^+\mu^-)$
- Signal cross section (electronic width Γ_{ee}) unknown
 - Unitarity limit: $\Gamma_{ee} > 0.044 \text{ eV}$
 - Vector Dominance Model: $\Gamma_{ee} = 0.46 \text{ eV}$ J. Kaplan, H. Kühn, PLB78 (1978) 252

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Full simulation, no interference

- Signal: $\sim 1.5 \text{ pb}$
- Background: $\sim 19 \text{ pb}$

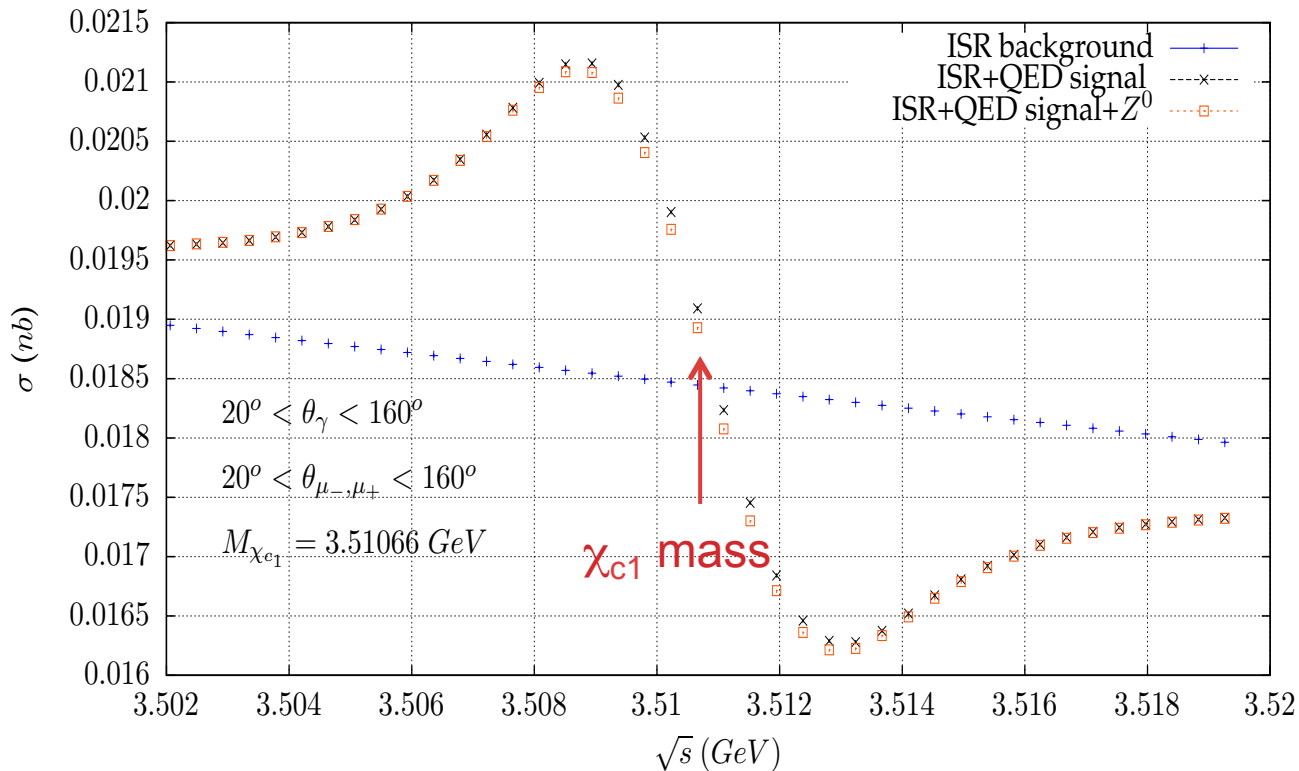
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 - Two post-proposal theory predictions: $\Gamma_{ee} \sim 0.1 \text{ eV}$
 - A. Denig, F.-K. Guo, Ch. Hanhart, A. Nefediev. PLB736 (2014) 221
 - N. Kivel, M. Vanderhaeghen, JHEP02 (2016) 032
 - Latest prediction: $\Gamma_{ee} = 0.43 \text{ eV}$

H. Czyz, J. H. Kühn. S. Tracz, PRD94, 034033 (2016)

Latest Theoretical Prediction

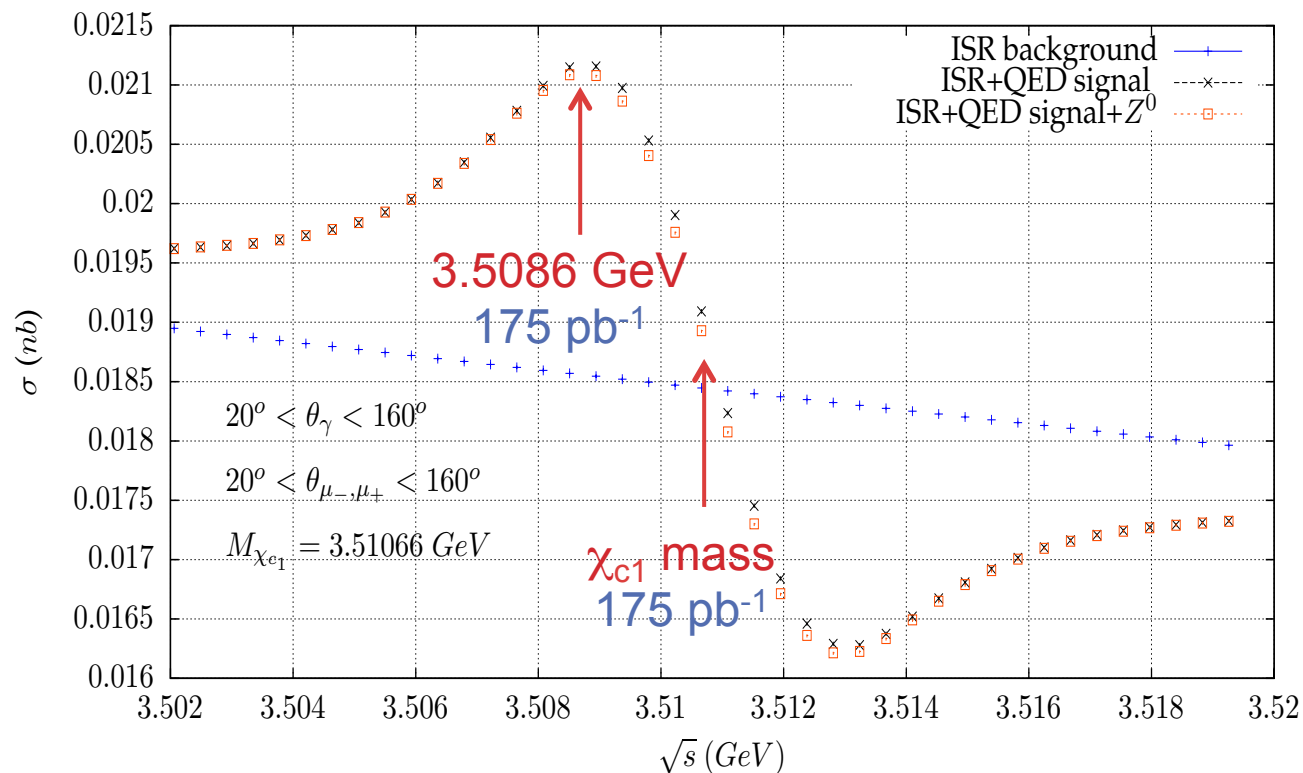
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- Large interference effects in internal loop
- Phase predicted from theory

Data Points Approved

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$\Gamma_{ee} > 0.4 \text{ eV}$
 5 sigma discovery

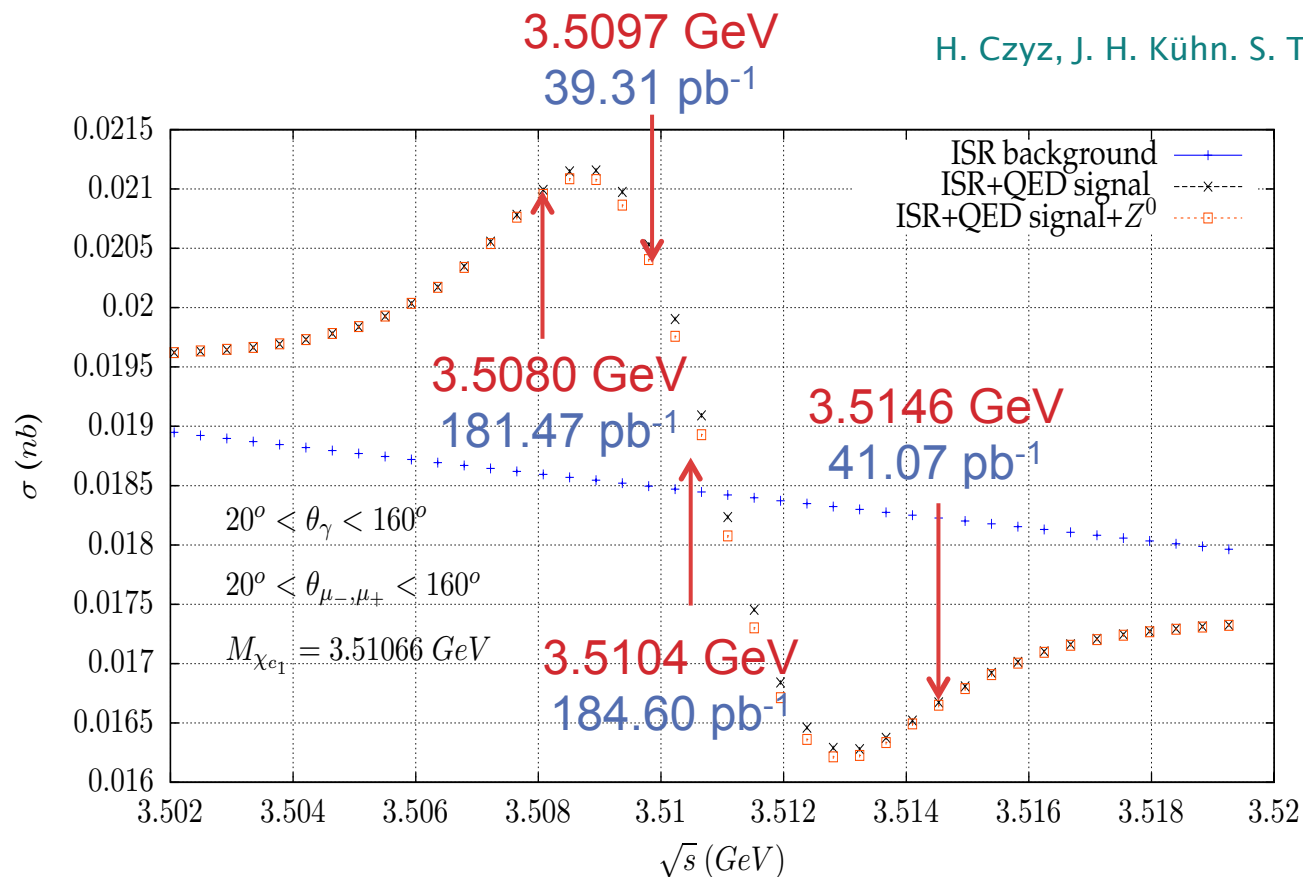
$\Gamma_{ee} \sim 0.1 \text{ eV}$
 1 sigma effect

3.4900 GeV
 20 pb^{-1}

➔ Background study

Data Points Taken

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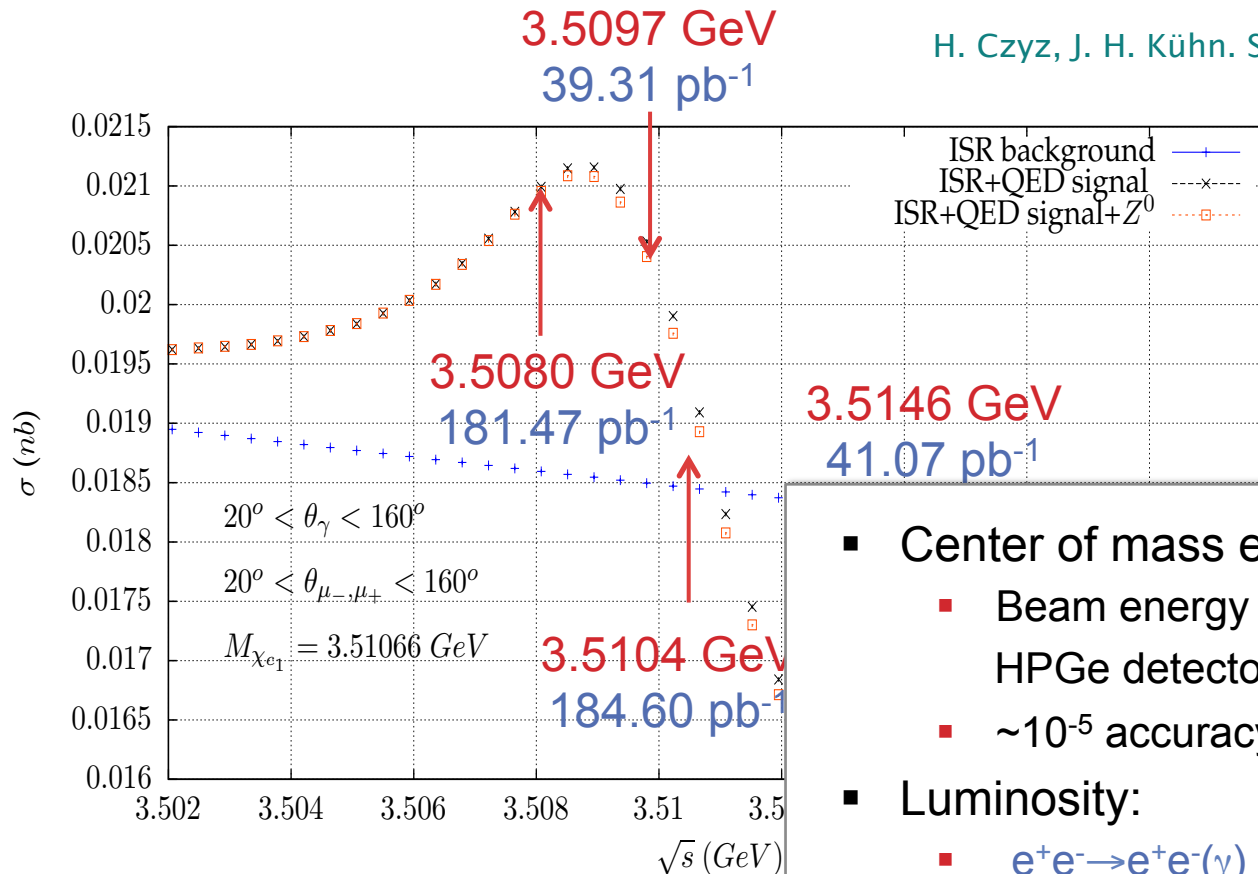


3.4900 GeV
11.71 pb⁻¹

➔ Background study

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3.4900 GeV
11.71 pb⁻¹

➔ Background study

- Center of mass energy:
 - Beam energy measurement system, HPGe detector, Compton scattering
 - $\sim 10^{-5}$ accuracy
- Luminosity:
 - $e^+e^- \rightarrow e^+e^-(\gamma)$ and $e^+e^- \rightarrow \gamma\gamma(\gamma)$ process
 - $\sim 0.6\%$ accuracy each, agreement with 0.4%

Search Strategy

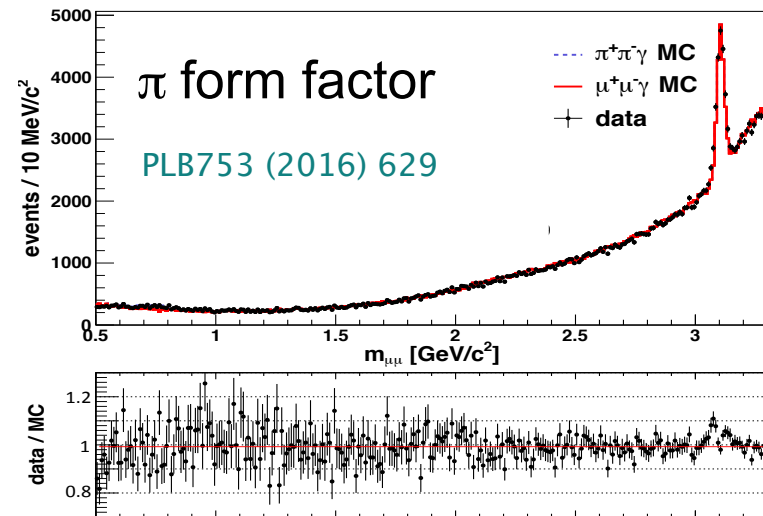
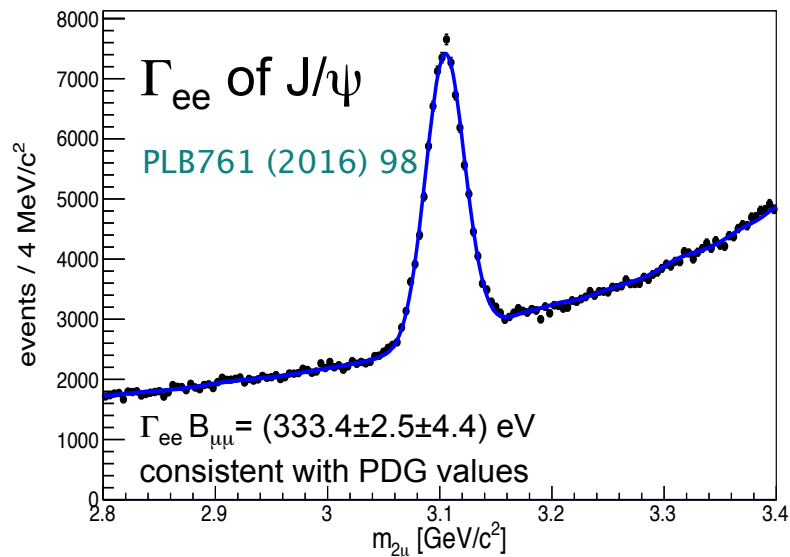
- Proof that the ISR background is well described by PHOKHARA from:
 - Off-peak data set below χ_{c1} mass
 - High statistics data sets above, $\psi(3770)$ and 4180 MeV, $\sim 3 \text{ fb}^{-1}$ each
- Search for excess (decrease) of events beyond ISR background
- Study interference structure by combining all the energy points

Analysis of $e^+e^- \rightarrow \gamma\mu^+\mu^-$

- Two good charged tracks, opposite charge
- At least one good photon
- Select photon with 4C kinematic fit, smallest χ^2
- Bhabha events suppression:
 - $E(+/-) < 0.4$
 - $|\cos\theta_\mu| > 0.86$ or < 0.8
- Background level: $< 1\%$, flatly distributed in $M(\mu^+\mu^-)$

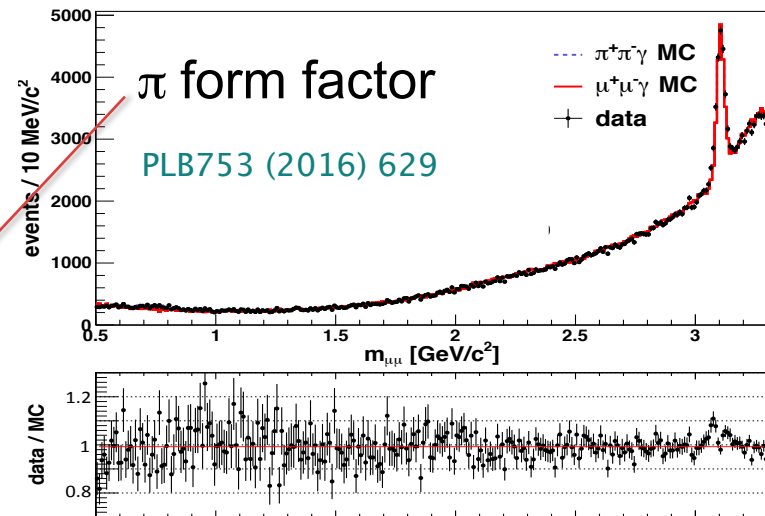
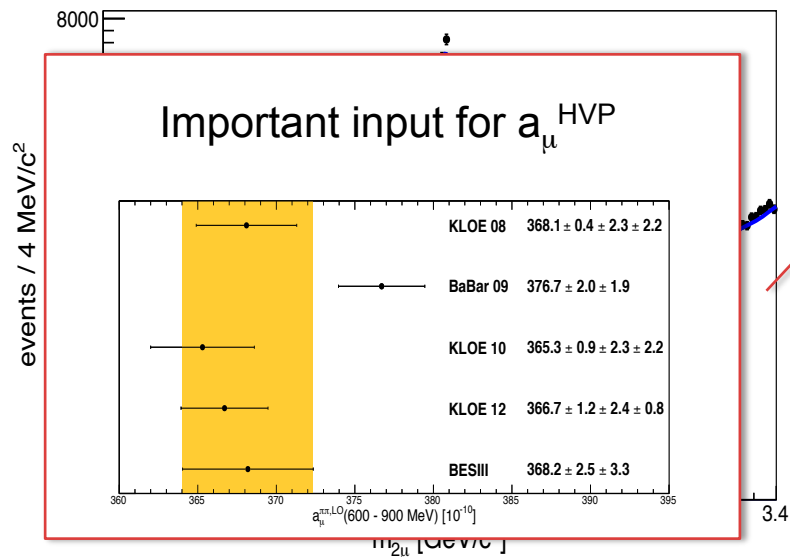
Analysis of $e^+e^- \rightarrow \gamma\mu^+\mu^-$

- Good agreement between data and PHOKHARA simulation at 3490, $\psi(3770)$, and 4180 data samples
- Also demonstrated in previous publications:



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Expected Number of Events

With interference, efficiency (~60%) taken into account

Energy Points	\sqrt{s} (GeV)	Luminosity (pb ⁻¹)	N(ISR)	N(ISR+ χ_{c1})
1	3.5097	39.31	436±21	483±22
2	3.5080	181.47	2025±45	2286±48
3	3.5104	184.60	2043±45	2132±46
4	3.5146	41.07	450±21	411±20

Summary and Outlook

- First search of the χ_{c1} direct production at e^+e^-
 - Data samples collected at 5 energy points, signal search as well as interference effect study
 - Offline luminosity measurement
 - Event selection established
 - Proof of PHOKHARA simulation at data points out of χ_{c1} mass region
 - Analysis strategy for χ_{c1} scan data sample: blind J/ψ signal region, good agreement in sideband region, open J/ψ signal region

THANK YOU!