Charm physics at BESIII

Martin Tat, on behalf of the BESIII Collaboration

University of Oxford

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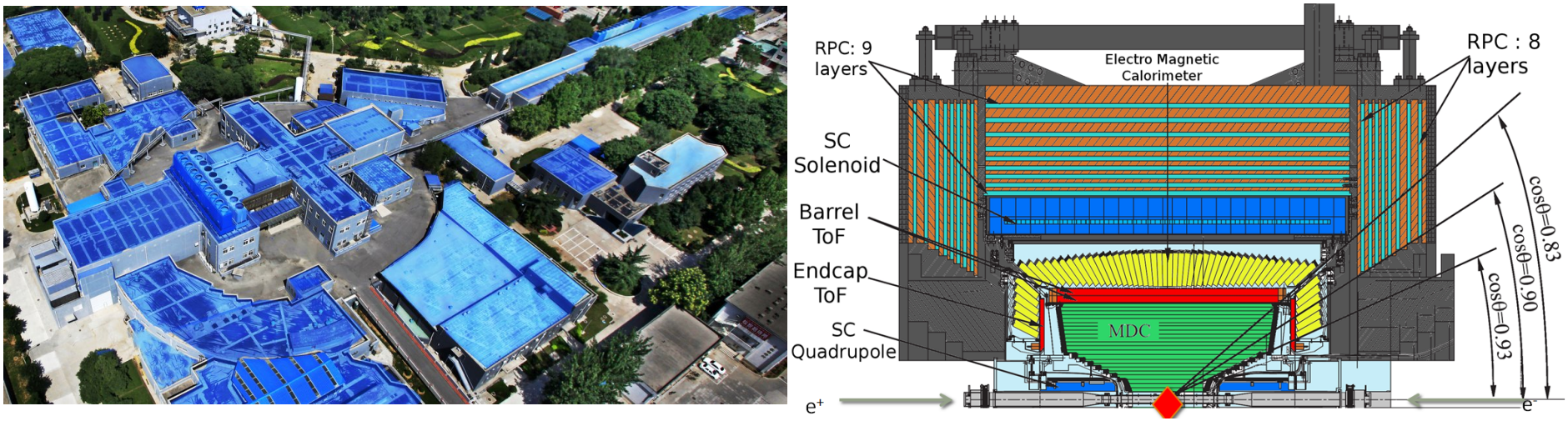
Outline

The BESIII experiment

- BEPCII is a symmetric e^+e^- collider with a peak luminosity of $1 \times 10^{33}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$ at $\sqrt{s} = 3.773\,\mathrm{GeV}$
- Tracking: Helium-based multilayer drift chamber (MDC)
- PID: Plastic scintillator TOF system and $\frac{\mathrm{d}E}{\mathrm{d}x}$
- Magnet: 1.0 T superconducting solenoid
- Neutral particle tracking: CsI(Tl) electromagnetic calorimeter (EMC)



Overview of (left) BEPCII and (right) BESIII

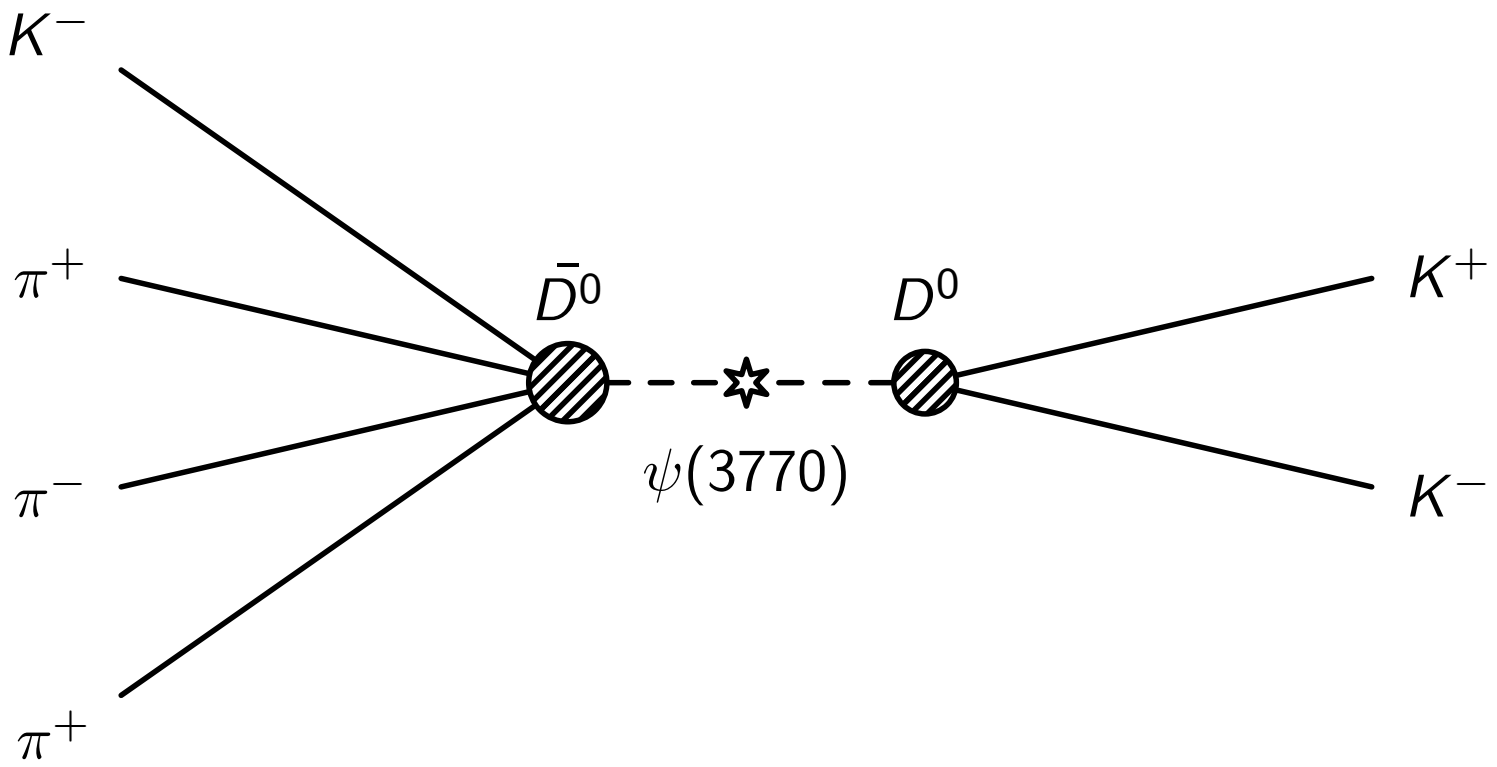
Recent charm results from BESIII

BESIII has a rich programme of charm physics:

1. Strong-phase measurements
   - Measurement of $\delta_{K\pi}$ EPJC **82** 1009 (2022)
   - $D \to K^-\pi^+\pi^-\pi^+$ strong-phase measurement JHEP **5** (2021) 164
   - $D \to K^+K^-\pi^+\pi^-$ F_+ measurement Phys. Rev. D **107** 032009
2. Amplitude analysis
3. Semileptonic charm decays
4. Searches for rare decays
5. Branching fraction measurements

No time to cover all topics in this talk!
I will mainly focus on strong-phase measurements in charm decays

Double-tag analysis

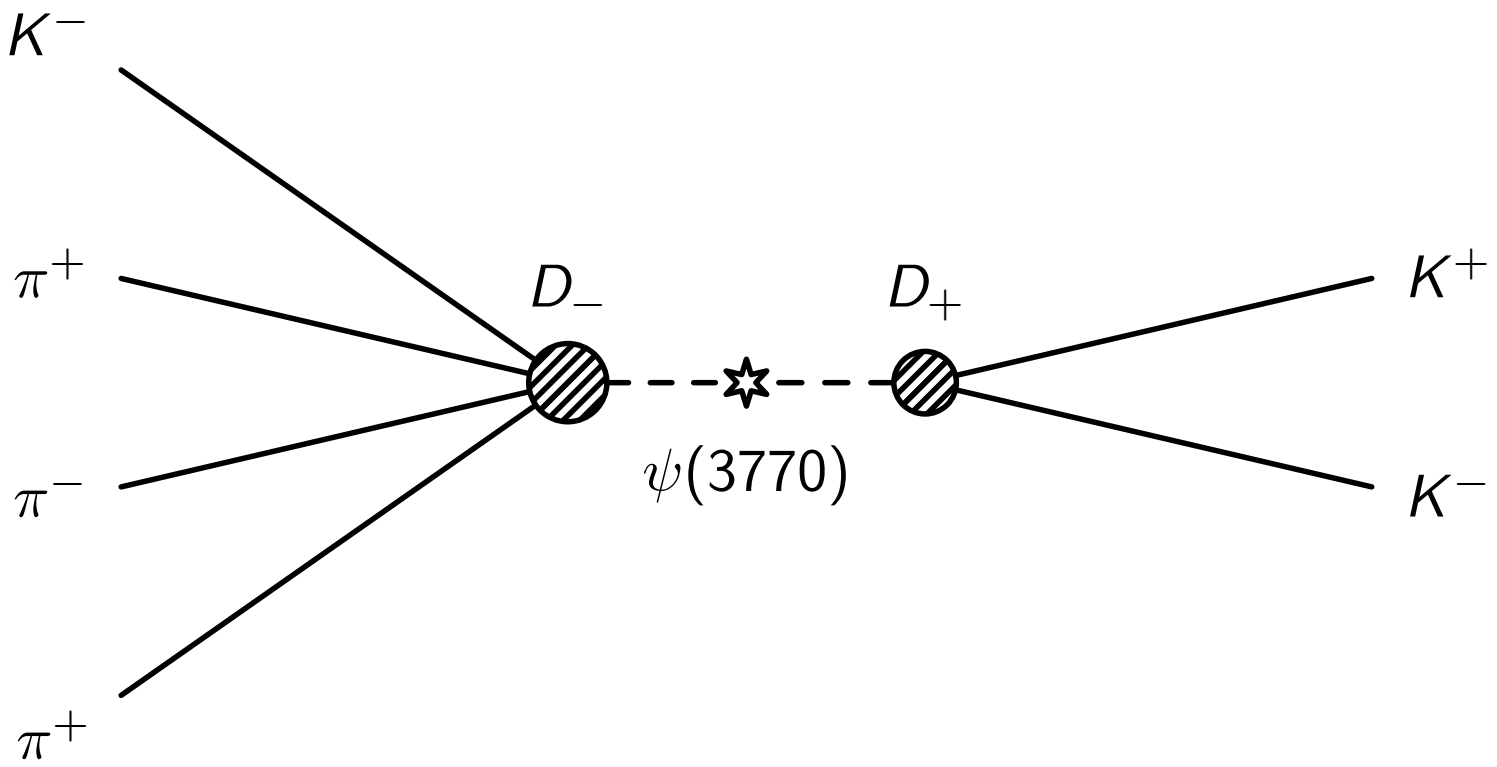


Double-tag method

The D mesons are produced in a quantum correlated state:

$$|\psi\rangle = \frac{1}{\sqrt{2}}\left(|D^0\rangle|\bar{D}^0\rangle - |\bar{D}^0\rangle|D^0\rangle\right)$$

Double-tag analysis



Double-tag method

Equivalently, we can consider the CP even (odd) eigenstates D_+ (D_-):

$$|\psi\rangle = \frac{1}{\sqrt{2}}\big(|D_+\rangle|D_-\rangle - |D_-\rangle|D_+\rangle\big)$$

Double-tag analysis

Double-tag analysis has many advantages:

1. $D\bar{D}$ pairs are quantum correlated, which provide direct access to the D^0-$\bar{D}^0$ strong-phase difference
2. Measurement are, to first order, free from systematic uncertainties due to efficiencies and branching fractions
3. Full reconstruction ensures that the environment is extremely clean

Only one minor drawback:

1. Lower statistics

EPJC **82** 1009 (2022)

Improved measurement of the strong-phase difference $\delta_D^{K\pi}$ in quantum-correlated $D\bar{D}$ decays

What is measured:

- Strong-phase difference between CF and DCS $D \to K^{\mp}\pi^{\pm}$ decays

Analysis strategy:

- Extensive use of $D \to K^0_L X$ tags
- Independent determinations of $D \to K^0_L X$ branching fractions

Significance:

- Most precise measurement of $\delta_D^{K\pi}$ in quantum-correlated $D\bar{D}$ decays
- Complementary to γ and charm combination from LHCb

$D \to K^-\pi^+\pi^-\pi^+$

JHEP **5** (2021) 164

Measurement of the $D \to K^-\pi^+\pi^-\pi^-$ and $D \to K^-\pi^+\pi^0$ coherence factors and average strong-phase differences in quantum-correlated $D\bar{D}$ decays

What is measured:

- Strong-phase difference and coherence factors between CF and DCS $D \to K^\mp\pi^\pm\pi^\mp\pi^\pm$ decays in phase space bins
- Phase-space integrated analysis of $D \to K^\mp\pi^\pm\pi^0$

Analysis strategy:

- Binning of 5D phase space enhances the coherence factors

Significance:

- Crucial input to one of the most precise measurements of γ

Phys. Rev. D **107** 032009

Measurement of the CP-even fraction of $D^0 \to K^+K^-\pi^+\pi^-$

What is measured:

- Phase-space integrated strong-phase analysis of $D \to K^+K^-\pi^+\pi^-$

Analysis strategy:

- Uses a combination of CP and multi-body tags
- Novel partially reconstructed technique to mitigate low efficiencies

Significance:

- First model-independent study of the CP content of this decay
- Will complement the existing charm decay modes, both binned and phase-space integrated, that are used for γ and D^0-$\bar{D}^0$ mixing studies