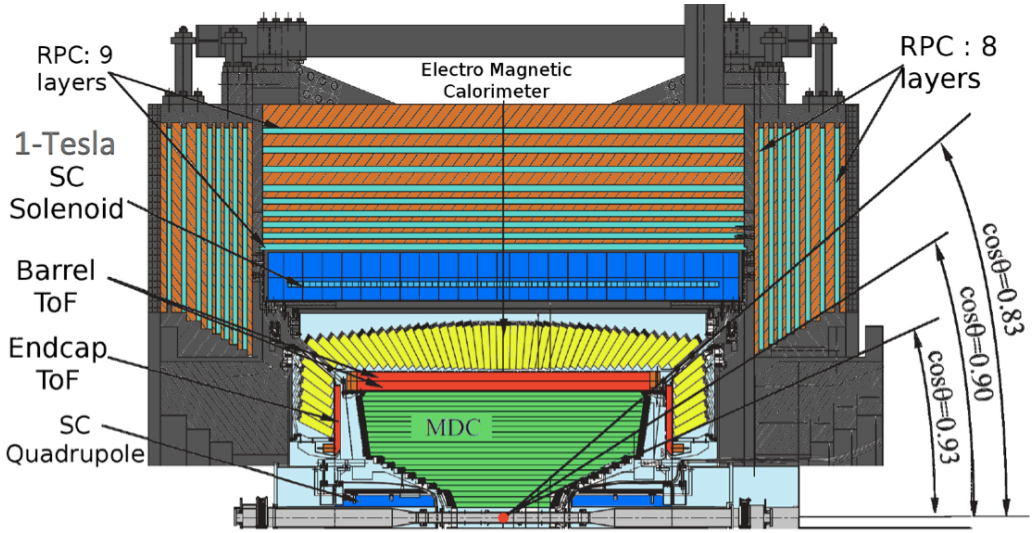
Sneha Malde, Oxford

The BESIII experiment and Collaboration

Cornerstone of the Chinese experimental particle physics programme



Located in Beijing @ BEPCII accelerator

e^+e^- collider $\sqrt{s}$ = 2-4.6 GeV
Hermetic detector

Third generation of BES experiments

BESIII first hadrons detected 18/7/2008
- 10 years ago!

Collaboration size ~450 authors
38 institutes from China
16 from Europe
12 from USA/Other Asia

Oxford and Manchester joined in December 2017, specifically due to expertise in charm strong phase measurements

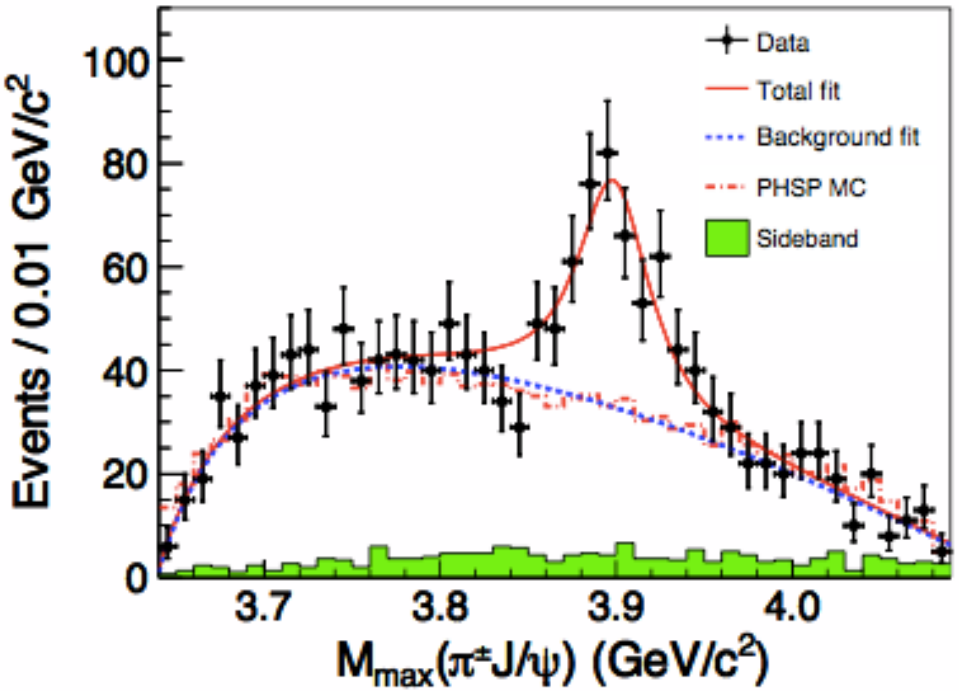
Broad physics programme

Range of energies → Range of physics interests

Light quark studies, QCD, charm, charmonium, tau, "XYZ states", new physics

Top cited publication

Observation of a charged charmonium like state Z(3900) PRL 110 (2013) 252001



Specific UK interests

- UK interests in BESIII are primarily tied to the interests of some flagship LHCb Upgrade (and BELLE II) measurements.

- Production mechanisms at BESIII allow for unique, precise, and vital, charm measurements which essentially cannot be performed elsewhere.

  - CKM angle gamma
  - Charm CPV and mixing

  } Charm strong-phase parameters

  - $|V_{ub}|$
  - Lepton Flavour Violation

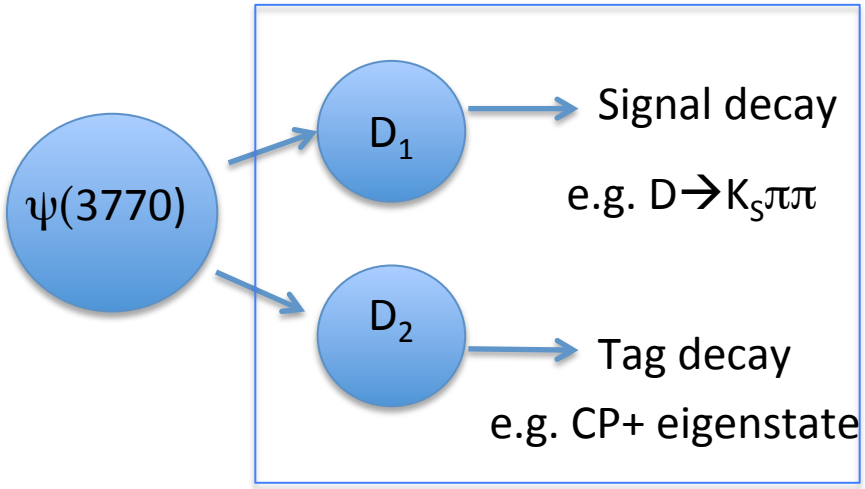
  } Branching fractions

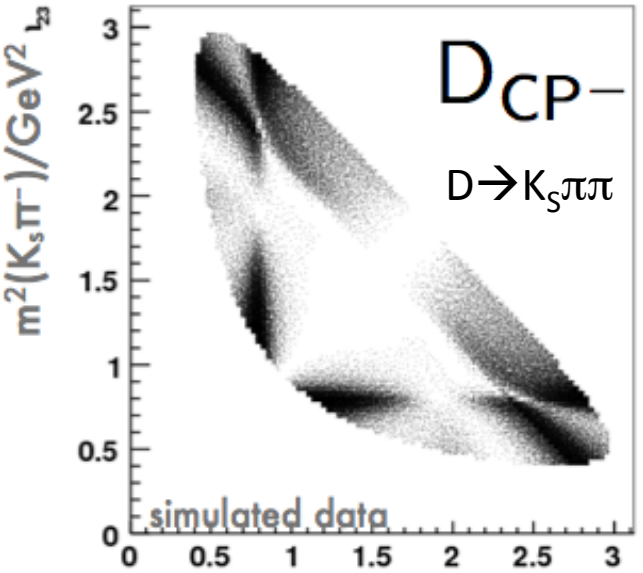
- Joint LHCb-BESIII workshop in Feb 2018 to explore mutual benefit (LHCB-PUB-2016-025)
- Perfect fit with the European strategy
- Replicate the success of the UK CLEO-c contribution

Strong phase parameters from ψ(3770)

Strong phase parameters relate to differences in the amplitudes and phases between D^0 and $\overline{D^0}$ to a common final state

- Phase measurement requires system with interference
- $e^+ e^- \rightarrow \psi(3770) \rightarrow DD$
- Two D mesons are quantum correlated.



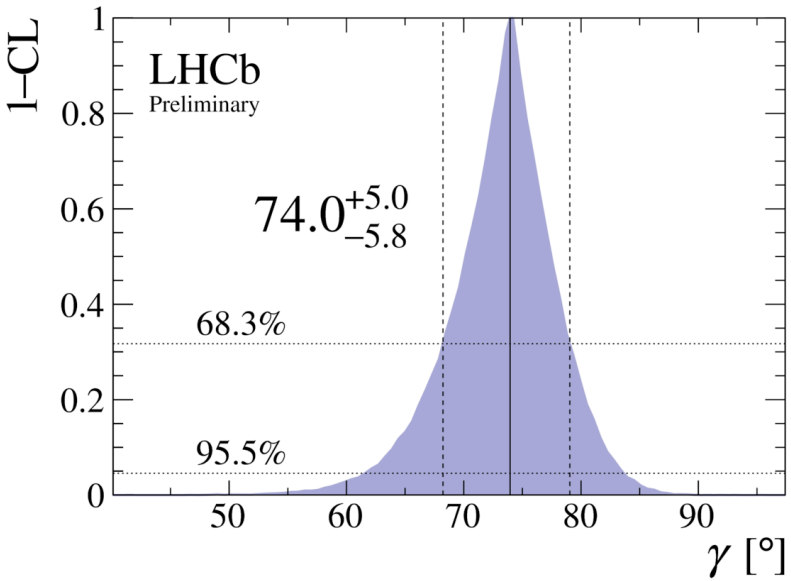


Density of signal

$$\propto |A|^2 + |\bar{A}|^2 - 2|A||\bar{A}|\cos(\delta)$$

$D \rightarrow K_S\pi\pi$ is one decay mode, of interest. There are many more of interest to LHCb and BELLEII

Strong phase parameter uses

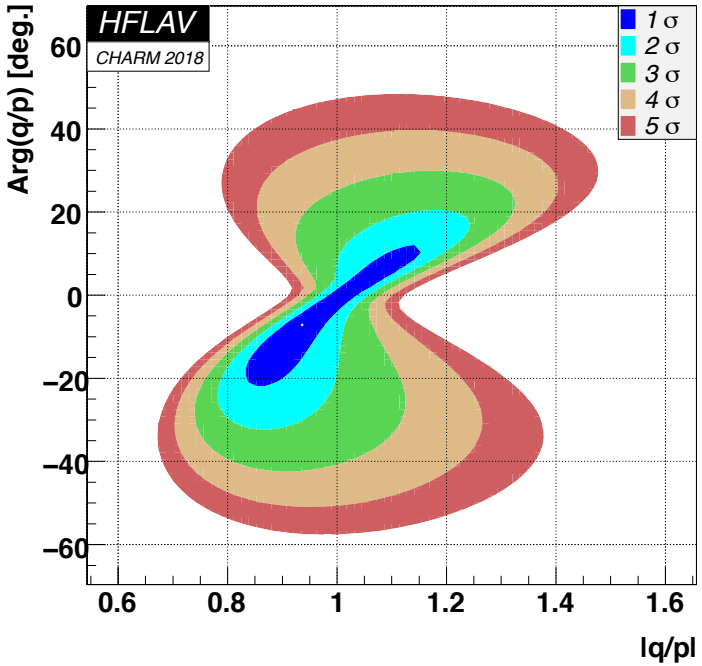


- CKM angle γ is measured in a variety of B decays
- Most of these measurements include a decay of a neutral D
- Strong phase parameters provide input on this part of the decay in a model-independent way → crucial for precision measurement.
- Analyses of BESIII data would open new channels and methods for γ measurement.
- A number of current inputs only possible due to the UK involvement in CLEO-c

CLEO-c precise enough for 2010s, BESIII required for 2020s and 2030s

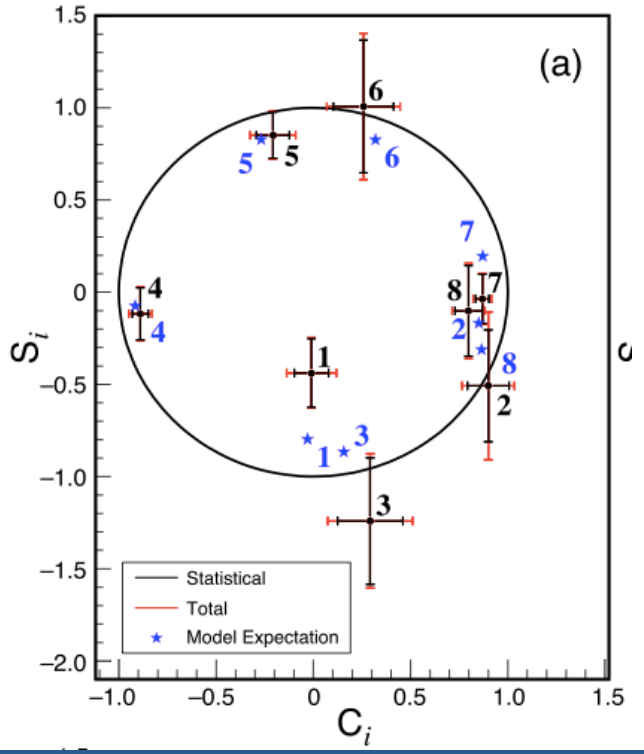
Dataset	Contribution to $\sigma(\gamma)$	Comment
CLEO-c 0.8 fb^{-1}	2°	Not precise enough + limited observables
BESIII 3 fb^{-1} (2010 + 2011)	Projected : 1°	Data analysis now underway
BESIII 10-20 fb^{-1} (planned)	Projected : 0.5°	Essential for LHCb upgrade and BELLE II

Other uses of strong phase parameters



- Knowledge of charm strong phase parameters also opens new channels and methods for CP violation in charm mixing
  - As yet unobserved, and another key goal of LHCb

- Validation of amplitude models → interest for QCD
  - Phase information predicted by amplitude models is hard to verify
  - BESIII future measurements could allow for some verification

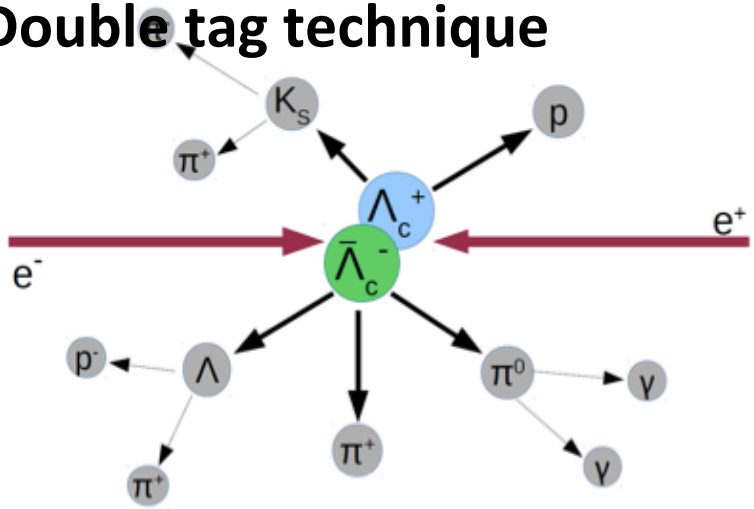


Precision branching fractions (1)

Double charm production at BESIII allows for measurement of absolute branching fractions

- Absolute BF measurements are not viable at LHCb
- Current Λ_c and D_s absolute branching fractions do/will form leading experimental systematic uncertainties in LHCb measurements of $|V_{ub}|$.

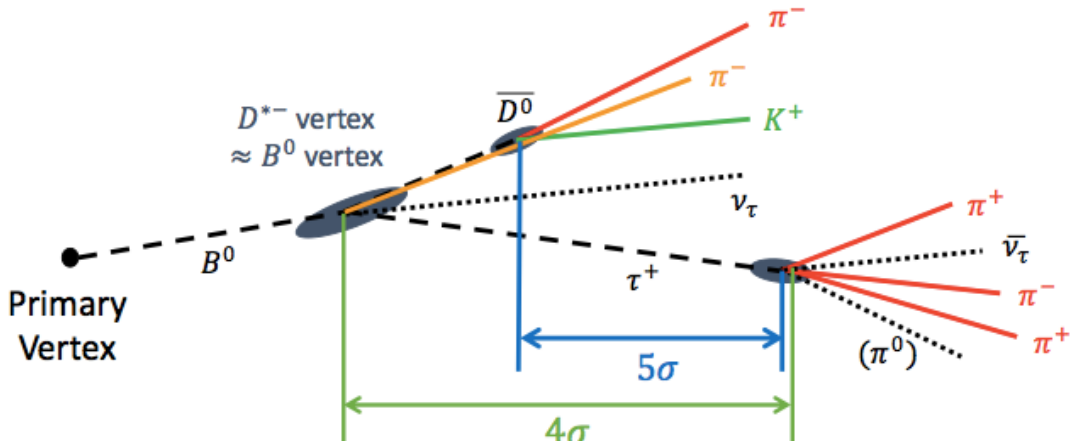
Double tag technique



- **Single tag side:**
  - -Tag the charmed baryon flavor via hadronic decays with large branching fractions
- **Signal side:**
  - -Hadronic decays
  - -(Semi-)leptonic decays

Precision branching fractions (2)

- Testing lepton universality with $B^0 \rightarrow D(*)\tau\,\nu$
  - One of the most striking anomalies in HEP
  - Hadronic 3 prong decay of the τ is looking very promising to improve precision.



- Potential backgrounds include any D decay to 3 charged pions + N neutral particles (Ks, π^0, K_L, η, η')
- Cannot be studied directly at LHCb.
- Possible at BESIII, information would be very useful in constraining bkgs in this type of analysis.

Future plans for BESIII

- Life expectancy of the experiment 5-7 years
  - Detector ageing
  - Chinese funding priorities

- UK focus is on data analysis and software improvements.

- Desired accuracy of strong phase measurements requires **more ψ(3770) data**
- Current plans indicate accumulation in 2021 + 2022

Group composition & funding

Oxford

- PI : Sneha Malde (RS and ERC funded)
- Guy Wilkinson
- Lei Li (2 yr Newton International Fellow)
- Postdoc (ERC funded) from Autumn 2018

Manchester

- PI: Eva Gersabeck (RS funded)
- 2 Students from Autumn 2018 (RS funded)
- Use of HEP-Blackett Cluster for BESIII jobs

- Both groups actively pursuing further external funding for postdocs & students
  - Primary focus for both groups is charm strong phase parameters
  - Additional resources required to follow other interesting avenues

- Current bulk funding ends for both PI in early 2023
  - Close to end of accumulation of the larger $\psi(3770)$ sample
    - Data analysis would continue for a few years
      - ideally with additional funds for personpower and travel

- **Expect important physics results for modest investment.**

Summary

- Oxford and Manchester have joined the BESIII collaboration
- Strengthening of UK-China ties in HEP

- Production mechanism at BESIII gives access to parameters difficult/ impossible to measure elsewhere.
  - Many vital measurements → crucial to achieving the goals of (LHCb), LHCb Upgrade, BELLE II

- Physics reach at BESIII has the potential to provide significant positive impact on the UK Beauty and Charm flavour physics programme

Backup

Bigger, Better, & Broader

version of the UK CLEO-c venture

1. arXiv:1710.10086 Quantum-correlated measurements of $D \to K0S\pi+\pi-\pi0$ decays and consequences for the determination of the CKM angle γ
2. arXiv:1709.03467 Model-independent determination of the strong phase difference between $D0$ and $D^-0 \to \pi+\pi-\pi+\pi-$ amplitudes
3. arXiv:1703.08505 Amplitude Analyses of $D0 \to \pi+\pi-\pi+\pi-$ and $D0 \to K+K-\pi+\pi-$ Decays
4. arXiv:1611.09253 Amplitude analysis of $D0 \to \pi+\pi-\pi+\pi-$ decays using CLEO-c data
5. arXiv:1602.07430 Improved determination of the $D \to K-\pi+\pi+\pi-$ coherence factor and associated hadronic parameters from a combination of $e+e- \to \psi(3770) \to cc^-$ and $pp \to cc^-X$ data
6. arXiv:1504.05878 First determination of the CP content of $D \to \pi+\pi-\pi+\pi-$ and updated determination of the CP contents of $D \to \pi+\pi-\pi0$ and $D \to K+K-\pi0$
7. arXiv:1410.3964 First determination of the CP content of D->pi+pi-pi0 and D->K+K-pi0
8. arXiv:1401.1904 New determination of the D0->K-pi+pi0 and D0->K-pi+pi+pi- coherence factors and average strong-phase differences
9. arXiv:1203.3804 Studies of the decays D^0 →K_S^0K^-π^+ and D^0 → K_S^0K^+π^-
10. arXiv:1010.2817 Model-independent determination of the strong-phase difference between D^0 and D^0-bar-> K^0_S,L h^+ h^- (h=pi,K) and its impact on the measurement of the CKM angle gamma/phi_3
11. arXiv:1201.5716 Amplitude analysis of D0->K+K-pi+pi-
12. arXiv:0903.4853 Determination of the D0 -> K-pi+pi0 and D0 -> K-pi+pi+pi- Coherence Factors and Average Strong-Phase Differences Using Quantum-Correlated Measurements

- In 2006 UK institutes joined CLEO-c with the purpose of making charm strong phase measurements. 12 publications
- Provided inputs essential to the first phase of γ studies at LHCb
- CLEO dataset provides sufficient precision for 2010s
- **BESIII data required for 2020s & 2030s**