Flavour Physics Prospects at BESIII

Wolfgang Gradl

11th December 2018
BABAR 25th Anniversary

SFB 1044
THE LOW-ENERGY FRONTIER OF THE STANDARD MODEL

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

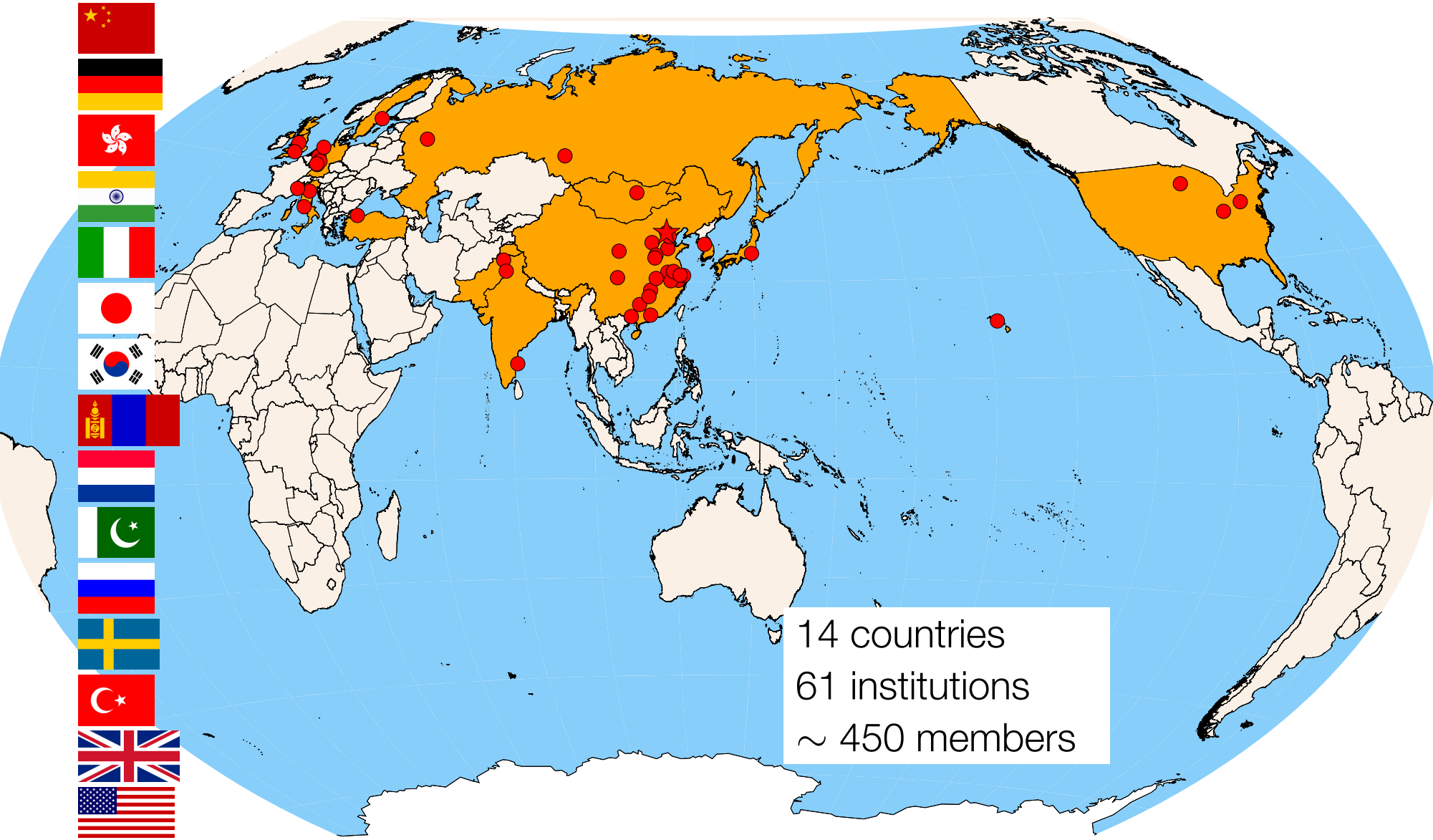
PRISMA

Physics in the τ-charm region in China

Long and successful history, with major contributions from SLAC:

- 1981 T. D. Lee and W. Panofsky suggest e^+e^- collider in China
- 1982 e^+e^- collider endorsed by Deng Xiaoping
- 1984 Approval, ground breaking (Deng Xiaoping wielding shovel)
- 1988 First collisions in BEPC
- 1991 US scientists join BES ($\approx$ 145 authors)
- 2003 Approval of major upgrade: BEPCII and BESIII
- 2008 First hadron events recorded in BESIII
- 2018 BESIII: international collaboration with 450 authors, 228 papers

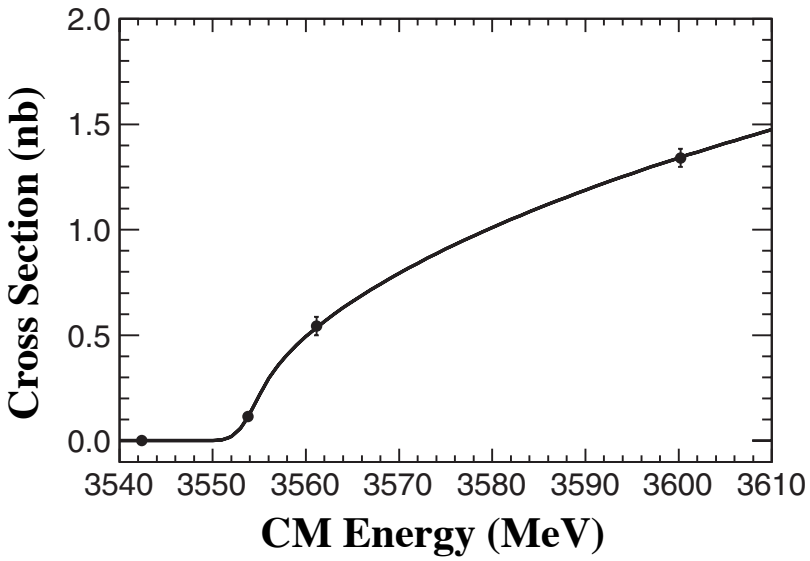
IHEP

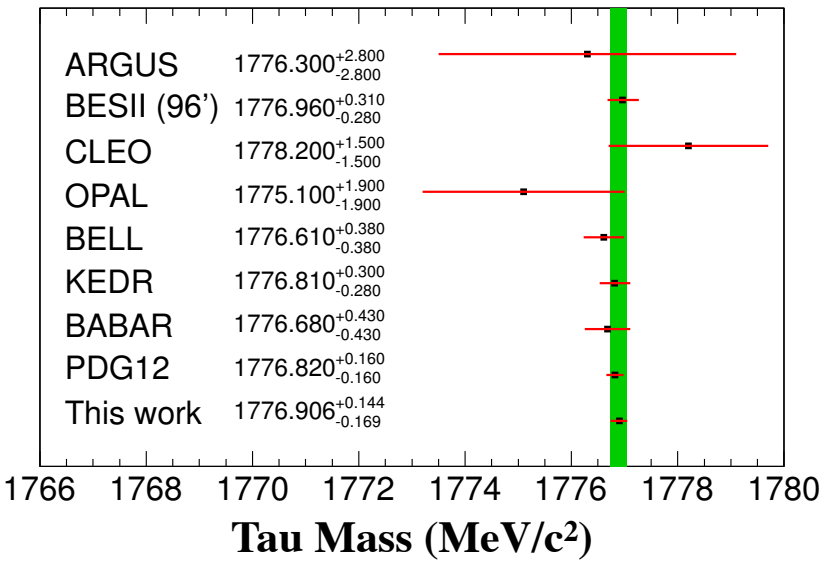


The BESIII Collaboration 2018

Achievements: τ

Most precise single measurement of τ mass, using 24 pb^{-1} using threshold scan and beam energy measurement via Laser Compton backscattering





BESIII, Phys. Rev. D 90, 012001 (2014)

$$m_\tau = (1776.91 \pm 0.12^{+0.10}_{-0.13})\mathrm{MeV}/c^2$$

New scan data taken in 2018

Unique datasets collected so far for open charm

$\sqrt{s}$ / GeV	$\mathcal{L}$ / fb^{-1}	
3.77	2.93	$D\bar{D}$
4.08	0.48	DD^*, $\psi(4040)$
4.18	3.2	$D_s D_s^*$
4.6	0.56	$\Lambda_c^+ \bar{\Lambda}_c^-$

Threshold production: double-tag method possible, giving access to absolute branching fractions, leptonic and semi-leptonic decays!

Tagged samples of 2.76×10^6 neutral D and 1.57×10^6 charged D in 3.77 GeV data sample

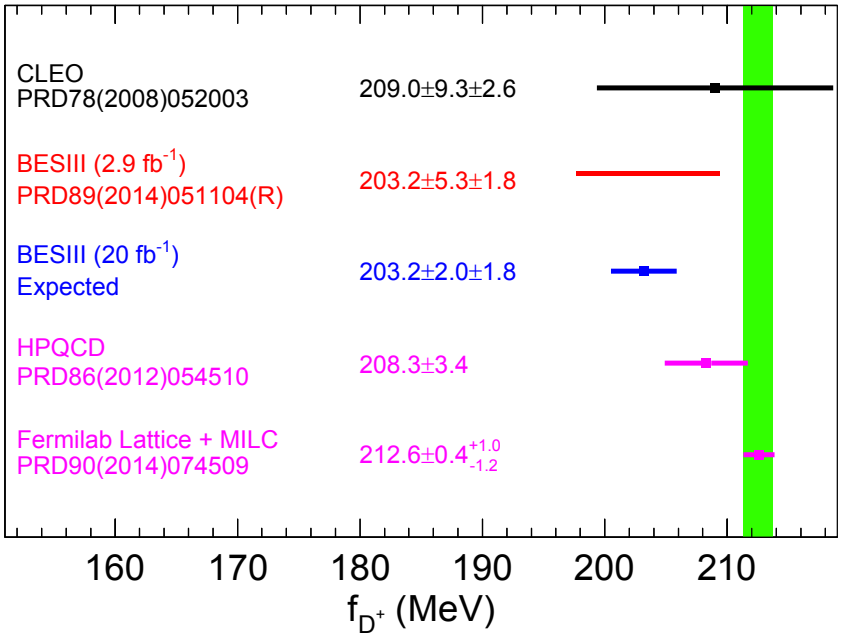
106×10^3 $\Lambda_c^+ \bar{\Lambda}_c^-$ pairs produced in 4.6 GeV data
15×10^3 single-tag Λ_c events

Leptonic and semileptonic D decays

Clean way to measure $|V_{cd}|$, $|V_{cs}|$, hadronic decay constants f_D, and form factors

Example: $D^+ \to \mu^+\nu$, measure f_{D^+} using world average for $|V_{cd}|$

PRD 89, 051104(R) (2014)



Strong phase between D^0 and $\bar{D}^0$ decays

Needed for precision measurement of CKM UT angle γ via $B \to D^{(*)}K^{(*)}$ decays

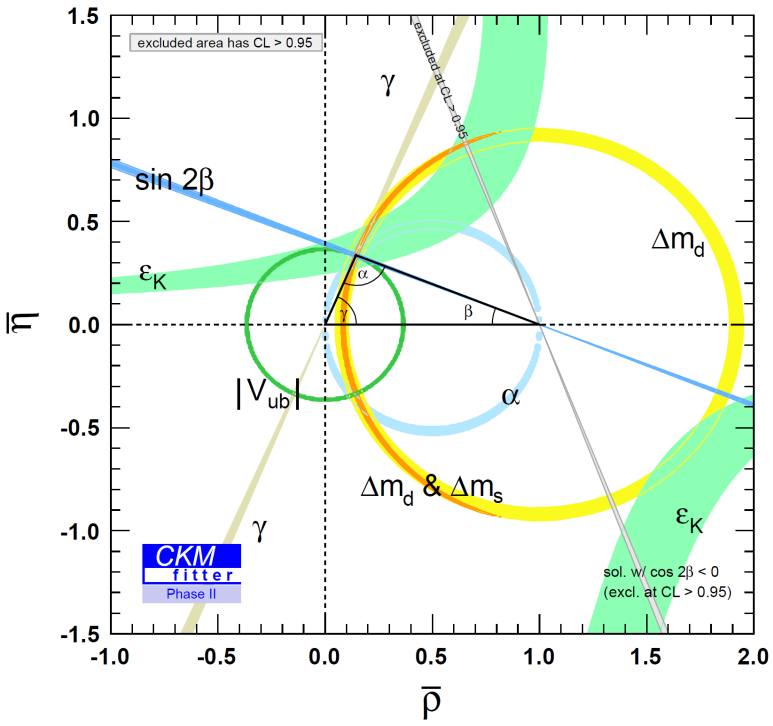
Current best measurement from CLEO-c. Limits systematic uncertainty on γ to 2°, with current LHCb dataset

Strong phases from $2.93\,\mathrm{fb}^{-1}$ at BESIII sufficient for LHCb Run II, but not precise enough beyond that (or for Belle II, eventually)

Joint LHCb-BESIII workshop in February 2018 to discuss synergies, needs …

LHCb-PUB-2016-025

$20\,\mathrm{fb}^{-1}$ on $\psi(3770)$ would give 0.7° systematics due to strong phases



Other open charm topics, in particular CPV in Charm

Data sample is small compared to charm samples at B factories, LHCb and (eventually) Belle II

No Lorentz boost $\Rightarrow$ no decay time information, no time-dependent measurements

On the other hand, inherently symmetric source of D^0 and $\bar{D}^0$ (no production asymmetry)

Rare decays, in particular with neutrals / neutrinos in final state

Test lepton flavour universality

Outlook: machine and detector upgrades

Planned and funded upgrades of BEPCII:

- Top-up injection: level off instantaneous luminosity gain $\approx 30\%$ in $\mathcal{L}_{\text{int}}$
- Energy upgrade:
  - currently, $E_b^{\text{max}} = 2.3\,\text{GeV}$ due to power supplies, cooling of magnets
  - upgrade I: $E_b^{\text{max}} = 2.35\,\text{GeV}$: done in summer shutdown 2018
  - upgrade II: $E_b^{\text{max}} = 2.45\,\text{GeV}$: requires rebuilt septum magnets (in progress)

  will give access to resonance around 4.66 GeV seen by Belle in $\Lambda_c^+ \overline{\Lambda}_c^-$ and much larger Λ_c^+ sample
- Detector: replace inner part of drift chamber by Cylindrical GEM detector (Italy, IHEP, Germany, Sweden)

Outlook

Whitepaper with outline of physics programme for the next 5 $\sim$ 10 years in preparation

Wish list for charm physics:

- 20 fb^{-1} on $\psi(3770)$
- 6 fb^{-1} at 4.18 GeV
- 5 fb^{-1} at 4.64 GeV

Competition for beam time from *XYZ* programme, light hadron spectroscopy

Super-τ-charm factory ($1 \times 10^{35}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$)
Hefei, Novosibirsk?