Prospects for Future Tau and Charm Study

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(On behalf STCF Steering Committee)

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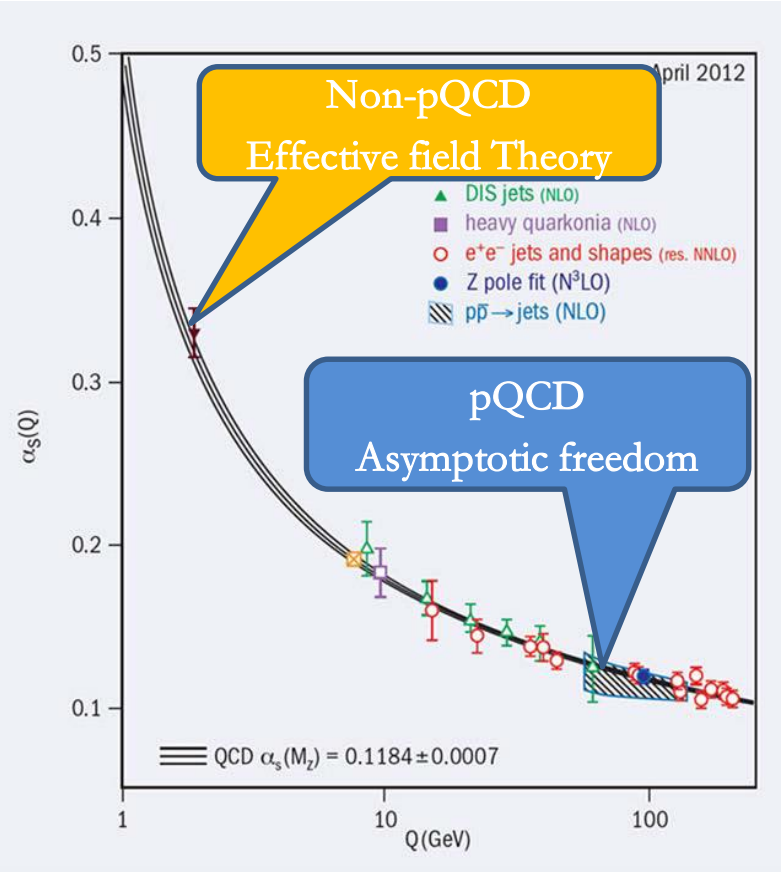
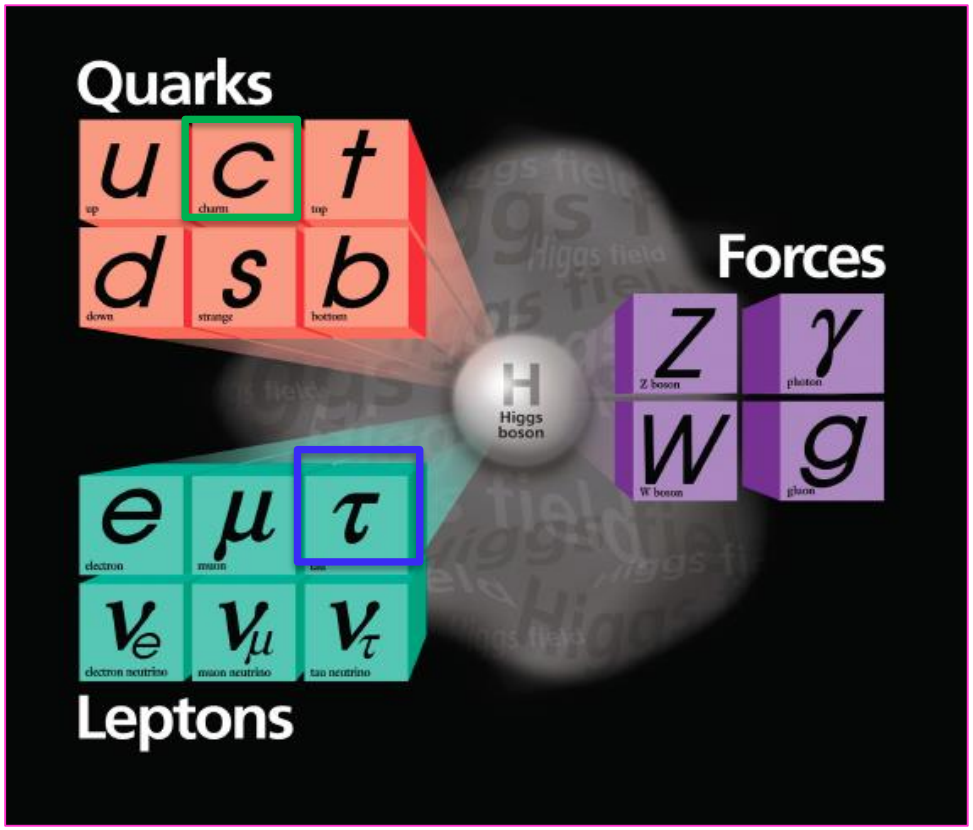
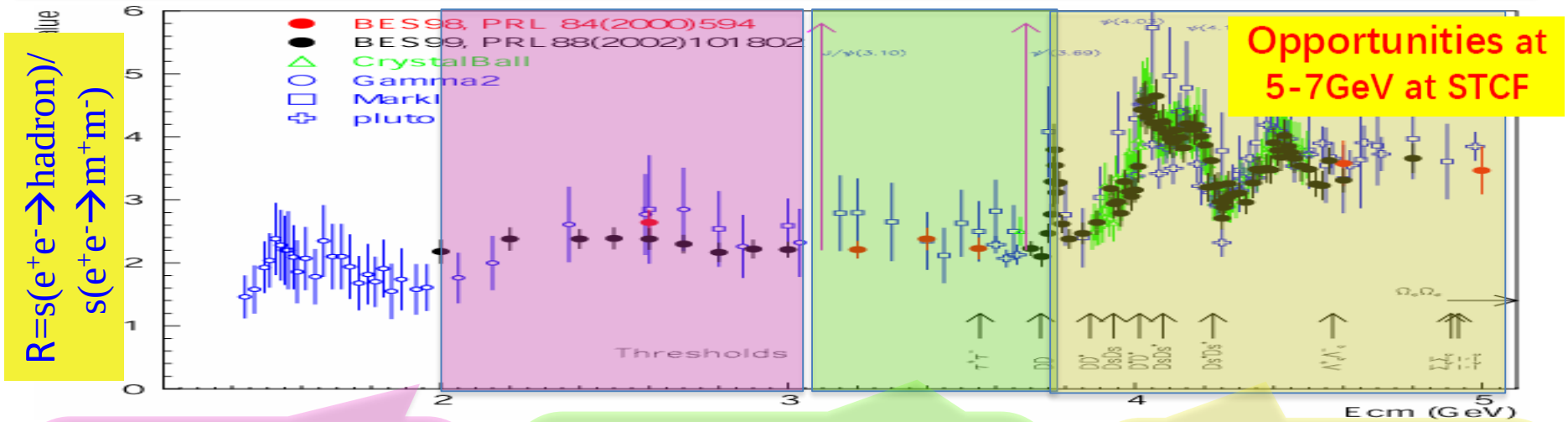
SM & QCD





- The asymptotic freedom of QCD in high energy region is precisely test
- But need more experimental inputs in the low energy region
- τ Lepton and charmed quark provide excellent platform to study the QCD

Broad Physics at τ-c Energy Region



- Hadron form factors
- Y(2175) resonance
- Mutltiquark states with s quark, Zs
- MLLA/LPHD and QCD sum rule predictions

- Light hadron spectroscopy
- Gluonic and exotic states
- Process of LFV and CPV
- Rare and forbidden decays
- Physics with τ lepton

- XYZ particles
- Physics with D mesons
- f_D and f_{Ds}
- D_0-D_0 mixing
- Charm baryons

- Unique features： Rich of resonance, Threshold characteristics, Quantum Correlation
- Abundant physics

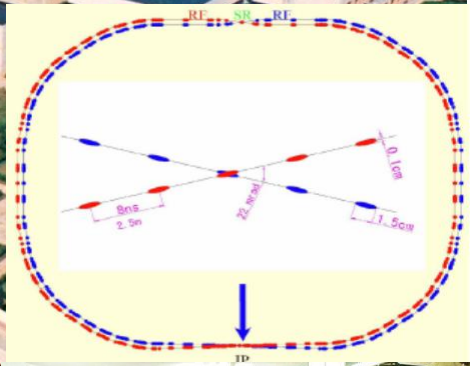
BEPCII

Upgrade of BEPC (started 2004, first collisions July 2008)

Beam energy	1 GeV to 2.3 GeV
Optimum energy	1.89 GeV
Single beam current	0.91 A
Crossing angle	±11 mrad

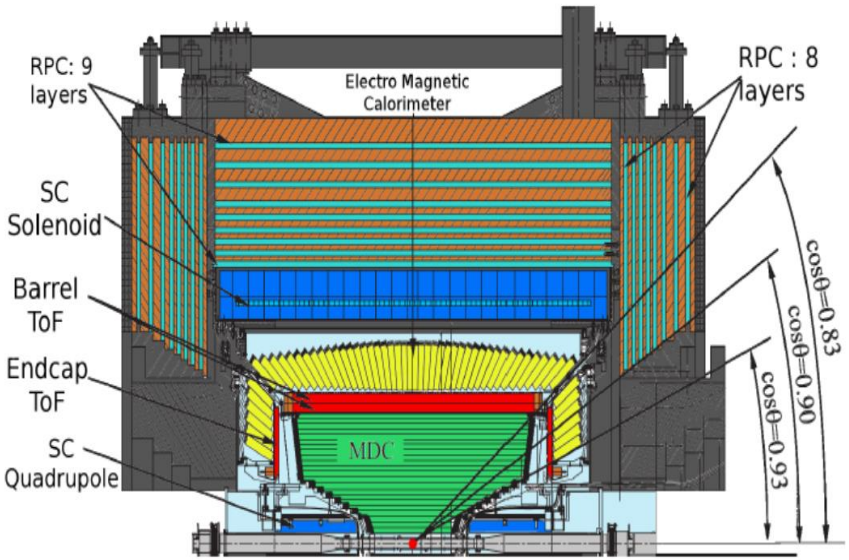
Design luminosity $1 \times 10^{33}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
Achieved in 2016

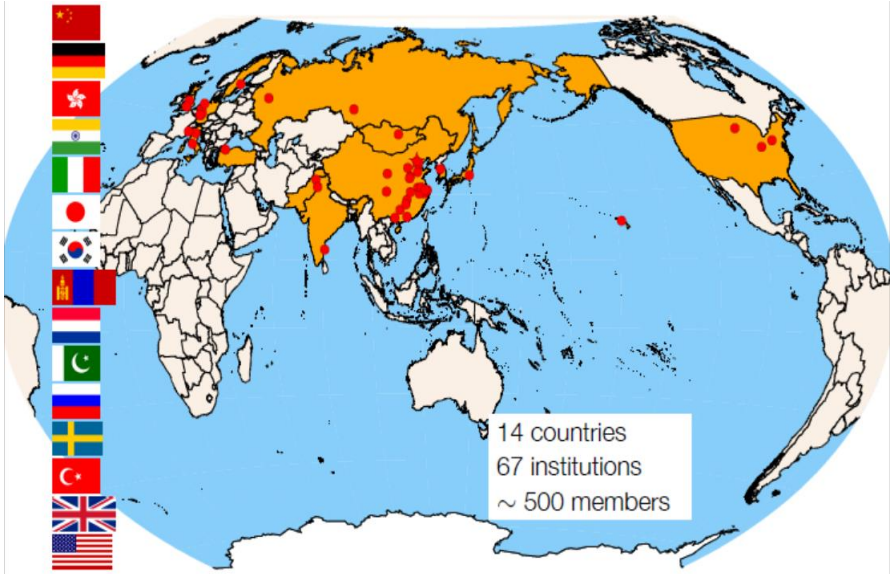
Beam energy measurement:
Laser Compton backscattering
$\Delta E/E \approx 2 \times 10^{-5}$
(contributes ≈ 50 keV to m_τ uncertainty)



BESIII Experiment

BESIII detector





The BESIII Collaboration 2019

10 years data taking at BESIII

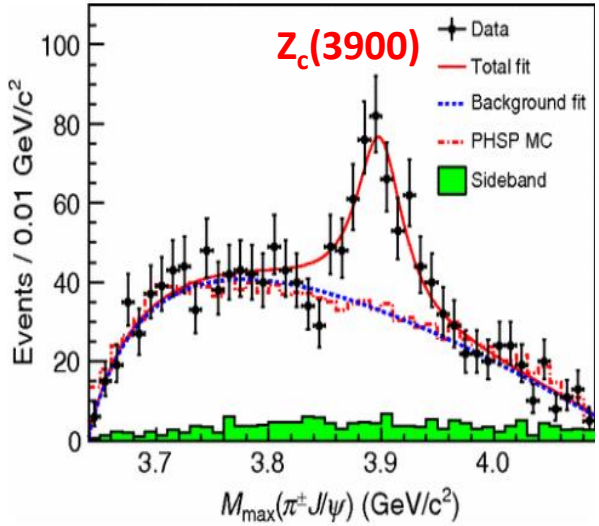
Data sets collected so far include

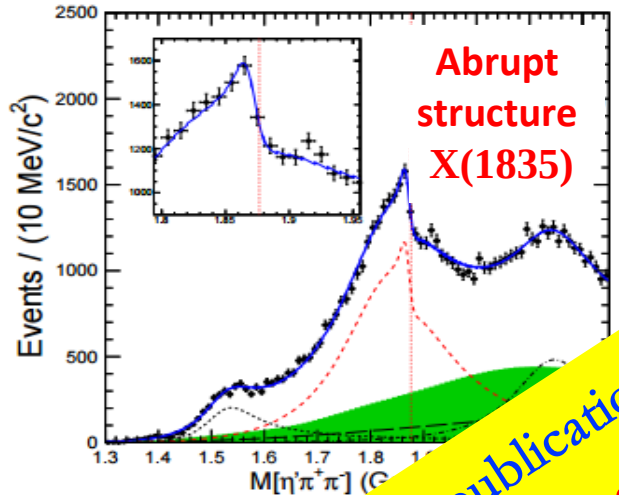
- 10×10^9 J/ψ events
- 448×10^6 ψ' events
- scan data between 2.0 and 3.08 GeV, and above 3.735 GeV
- large datasets for XYZ studies

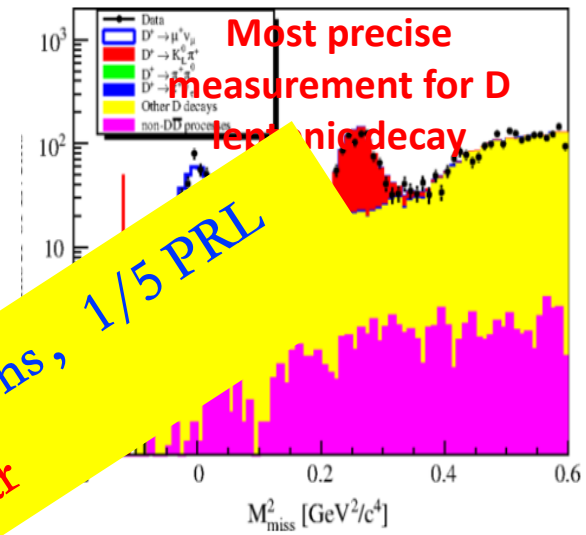
Unique data sets for open charm:

$\sqrt{s}$ / GeV	$\mathcal{L}$ / fb^{-1}	
3.77	2.93	$D\bar{D}$
4.008	0.48	DD^*, $\psi(4040)$, $D_s^+D_s^-$
4.18	3.2	$D_sD_s^*$
4.6	0.59	$\Lambda_c^+\bar{\Lambda}_c^-$

Fruitful BESIII Results

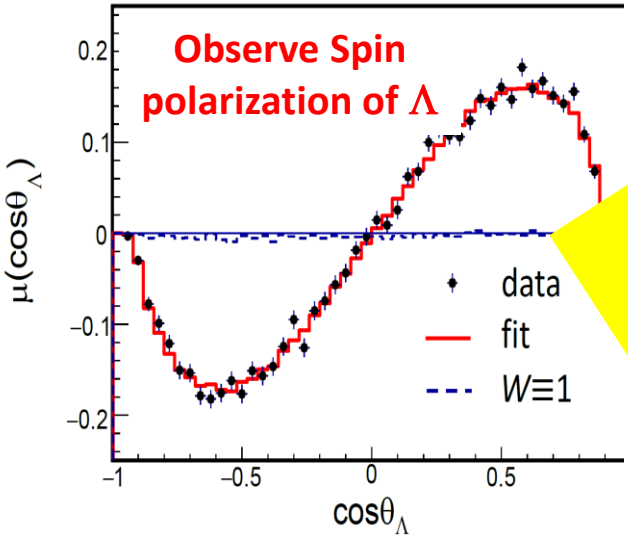


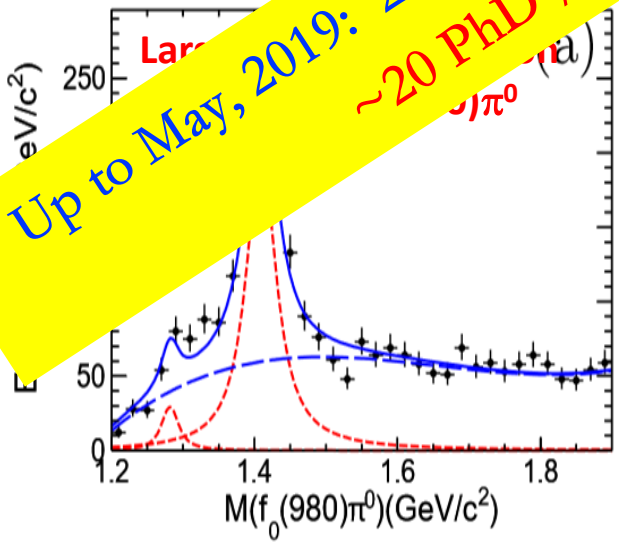


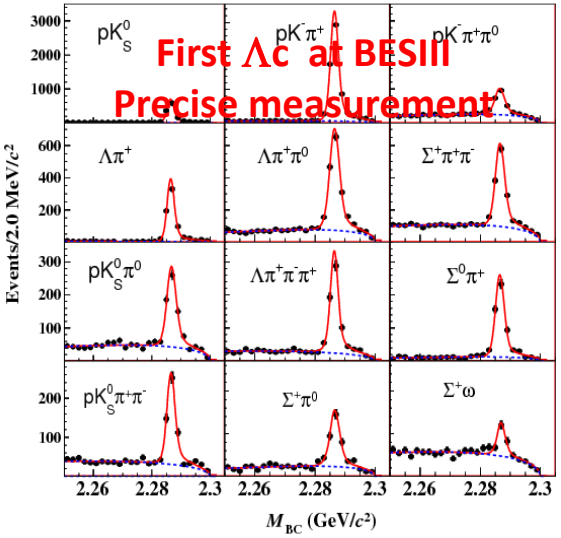


Up to May, 2019: 254 publications, 1/5 PRL

~20 PhD / year







Limitation for BEPCII/BESIII

- BEPCII/BESIII have run 10 years, and are playing a leading role in tau-charm physics area.
- Limited by length of storage ring, no space and potential for the upgrade.
- Physics study limited by the Statistics (luminosity), CME ……
- Challenged by Belle II
- BEPCII/BESIII will end her mission in 5 - 8 years (?)

A Super τ-charm Facility is the nature extension and a viable option for a post-BEPCII HEP project in China

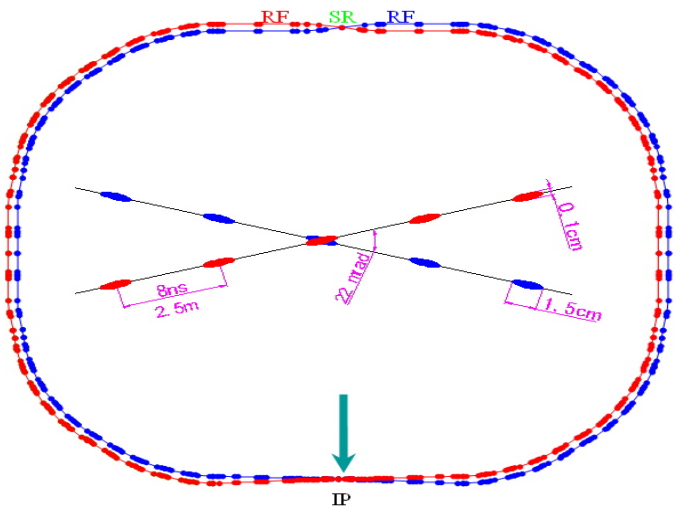
BEPCII vs STCF in China

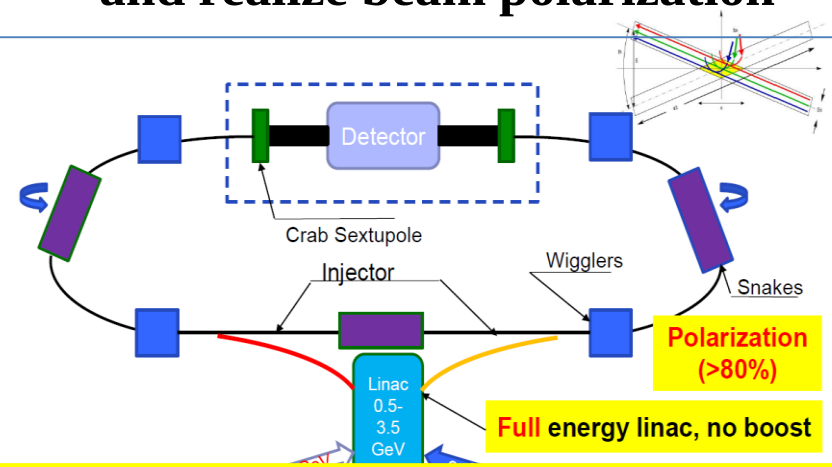
BEPCII

- **Peak luminosity 0.6-1×10^{33} $cm^{-2}s^{-1}$ at 3.773 GeV**
- **Energy range E_{cm} = 2 – 4.6 GeV**
- No Polarization

Designed STCF

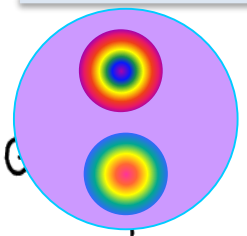
- **Peak luminosity 0.5-1×10^{35} $cm^{-2}s^{-1}$ at 4 GeV**
- **Energy range E_{cm} = 2–7 GeV**
- **Potential to increase luminosity and realize beam polarization**





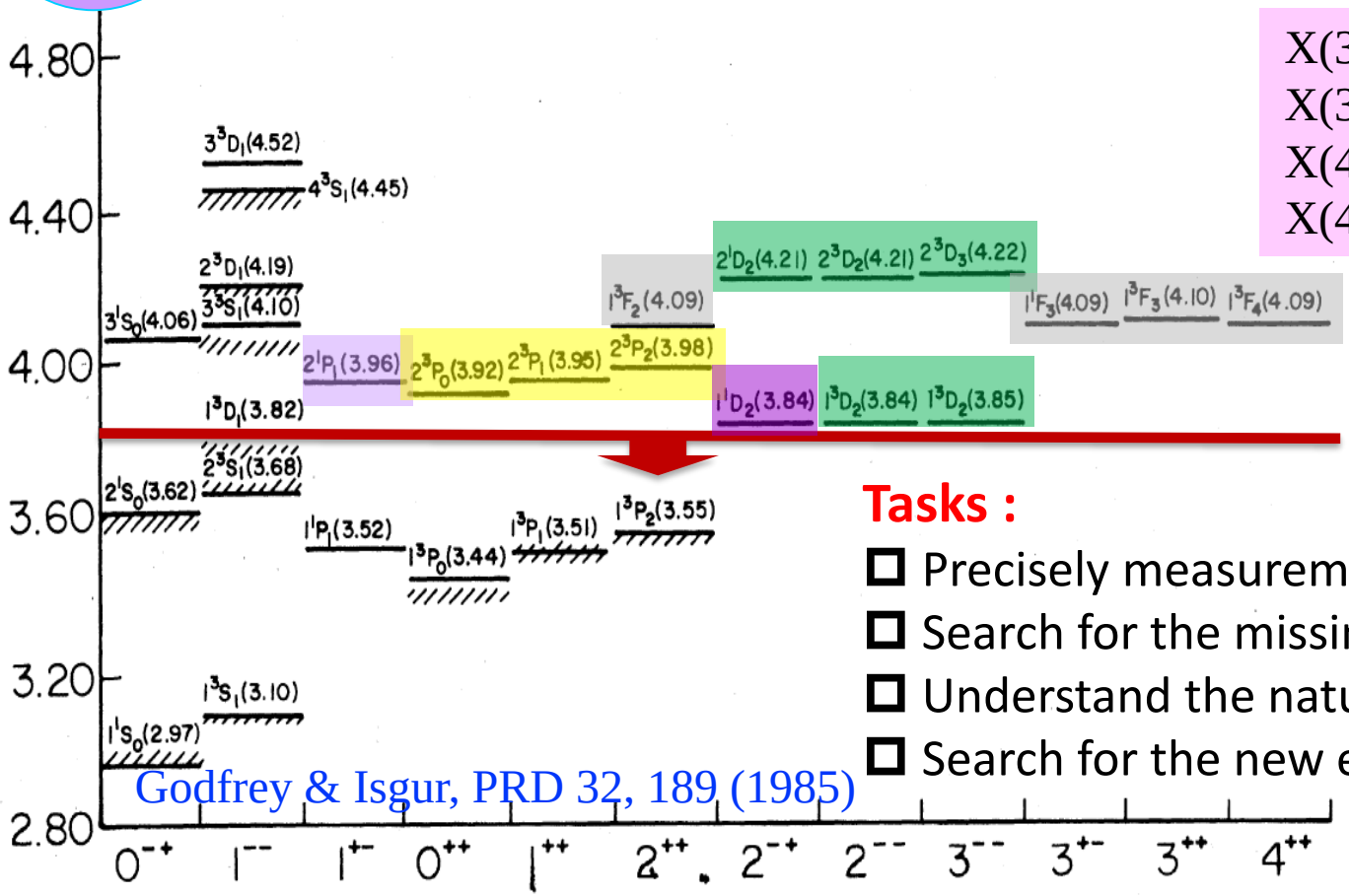
1 ab^{-1} data is expected per years

Charmonium (Like) Spectroscopy



Excellent platform to explore the QCD

Fruitful results in past decade, a new territory to study exotic hadrons



X(3872)
X(3940)
X(4160)
X(4350)

Y(3940)
Y(4008)
Y(4260)
Y(4360)
Y(4660)

Z(3900)
Z(4020)
Z(4050)
Z(4200)
Z(4250)
Z(4430)

Godfrey & Isgur, PRD 32, 189 (1985)

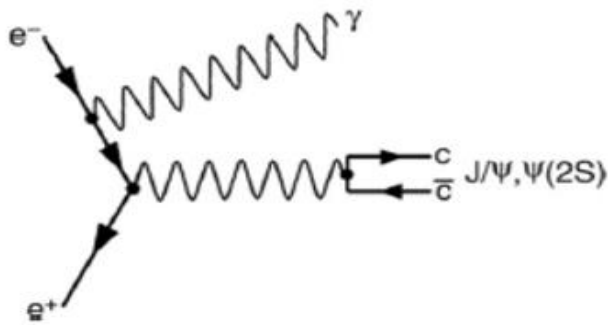
Tasks :

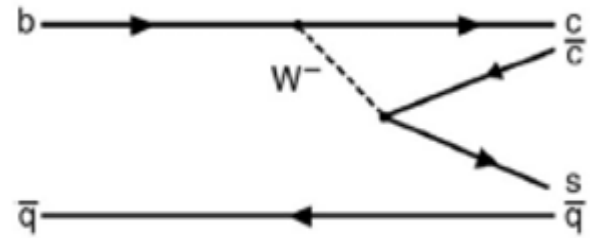
- ☐ Precisely measurement the transition
- ☐ Search for the missing states
- ☐ Understand the nature of unknown states
- ☐ Search for the new exotic states

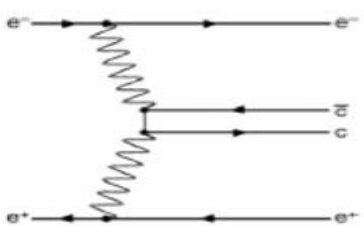
Charmonium (Like) Spectroscopy

Charmonium (Like) states are prominently produced in e^+e^- collision and B decays,

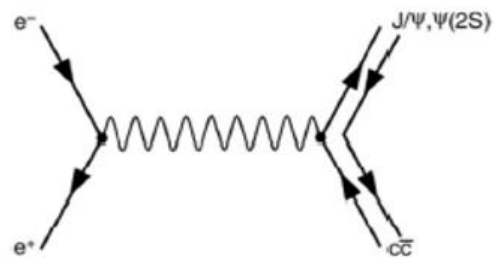
Thus are competed between τ-charm factory and B factory.



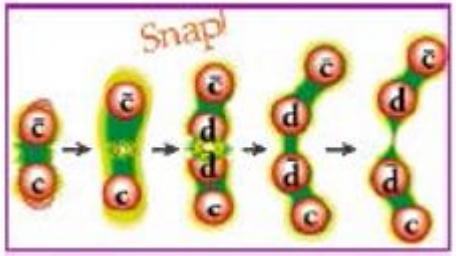




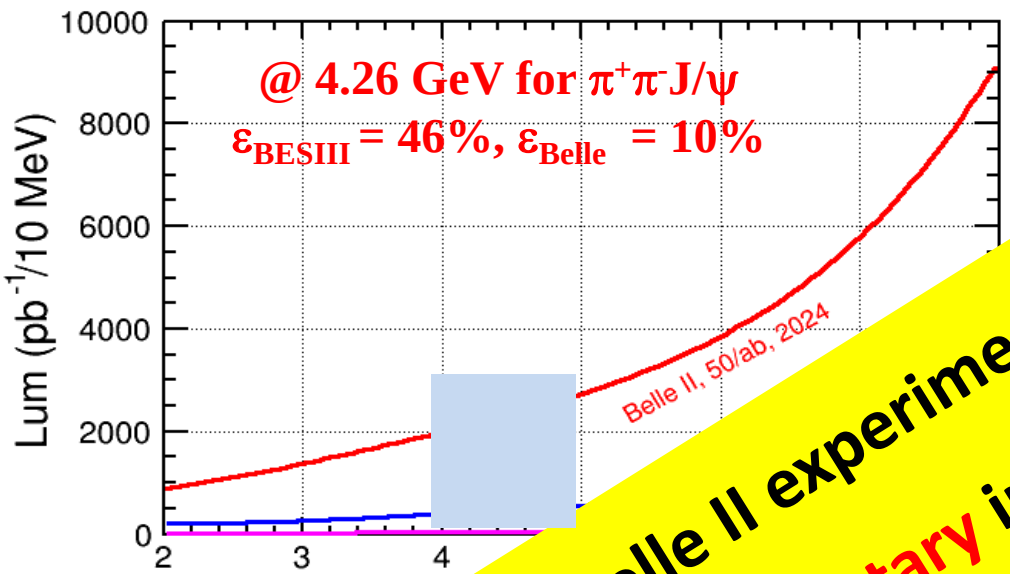
2γ production



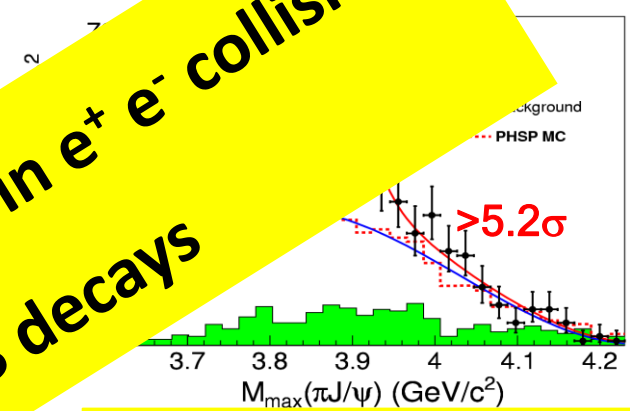
Double charmonium production



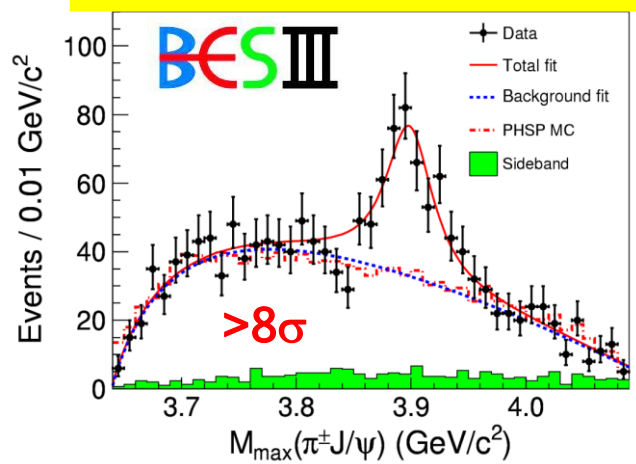
Charmonium(Like) in e^+e^- collision



Belle wi[illegible], 252002
967 [illegible] ng time



BESIII at 4.260 GeV: PRL110, 252001
0.525 fb^{-1} in one month running time



- B factory : T[illegible]minosity betwee[illegible] 50 ab^{-1} data
- τ [illegible] V, 10 MeV/step, [illegible]$^{-1}$/year, 5 time of Belle [illegible]ta
- [illegible]y have much higher efficiency and low background than B Factory

No challenge from Belle II experiment in e^+e^- collision, but complementary in B decays

Facilities for Charm Study

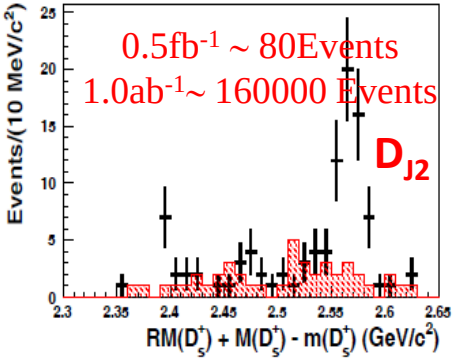
- LHCb: huge x-sec, boost, 9fb^{-1} now (x40 current B factories)
- B-factories (Belle(-II), BaBar): more kinematic constrains, clean environment, ~100% trigger efficiency
- τ-charm factory : Low backgrounds and high efficiency, Quantum correlations and CP-tagging are unique

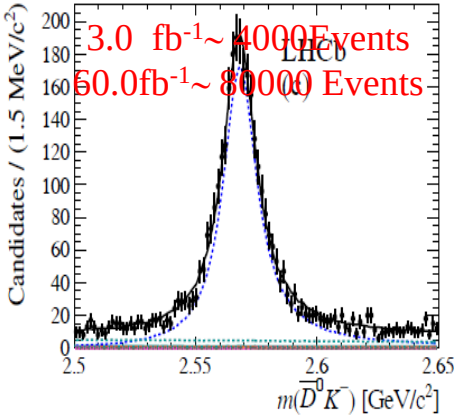
- STCF :

- 4×10^9 pairs of $D^{\pm,0}$ and 10^7~$10^8 D_s$ pairs per year
  - 10^{10} charm from Belle II/year
- Highlighted Physics programs
  - Precise measurement of (semi-)leptonic decay (f_D, f_{Ds}, CKM matrix…)
  - $D^0 - \bar{D}^0$ mixing, CPV
  - Rear decay (FCNC, LFV, LNV….)
  - Excite charm meson states D_J, D_{sJ} (mass, width, J^{PC}, decay modes)
  - Charmed baryons (J^{PC}, Decay modes, absolute BF)
  - Light meson and hyperon spectroscopy studied in charmed hadron decays

Features for Charm Study

	STCF	Belle(-II)	LHCb
Production yields	★★	★★★★	★★★★★
Background level	★★★★★	★★	★★
Systematic error	★★★★★	★★★	★★
Completeness	★★★★★	★★★	★
(Semi)-Leptonic mode	★★★★★	★★★	★
Neutron/K_L mode	★★★★★	★★	☆
Photon-involved	★★★★★	★★★★★	☆
Absolute measurement	★★★★★	★★★	☆





- Most are precision measurements, which are mostly dominant by the systematic uncertainty
- STCF has overall advantages in several studies

Precision measurement of CKM elements

CKM matrix elements are fundamental SM parameters that describe the mixing of quark fields due to weak interaction.

- A precise test of EW theory
- New physics beyond SM?

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

BESIII + B factories + LQCD

Three generations of quark?

Unitary matrix?

Expected precision < 2% at BESIII

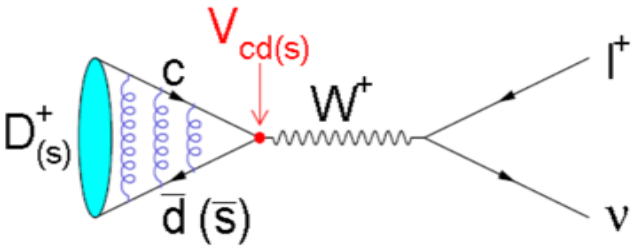
BESIII + B factories + LHCb + LQCD

A direct measurement of $V_{cd(s)}$ is one of the most important task in charm physics

$D_{(s)}$ (Semi-)Leptonic decay

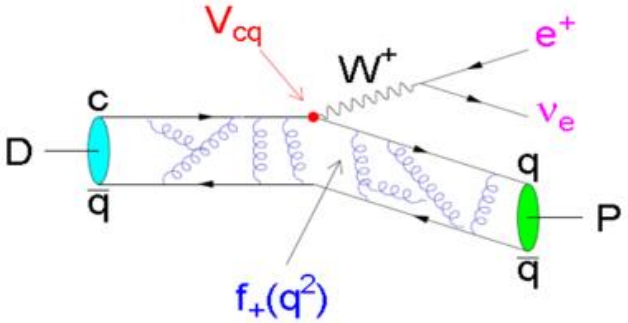
Purely Leptonic:

$$\Gamma(D^+_{(s)} \to \ell^+\nu_\ell) = \frac{G_F^2 f^2_{D^+_{(s)}}}{8\pi} \mid V_{cd(s)} \mid^2 m_\ell^2 m_{D^+_{(s)}} \left(1 - \frac{m_\ell^2}{m^2_{D^+_{(s)}}}\right)^2$$



Semi-Leptonic:

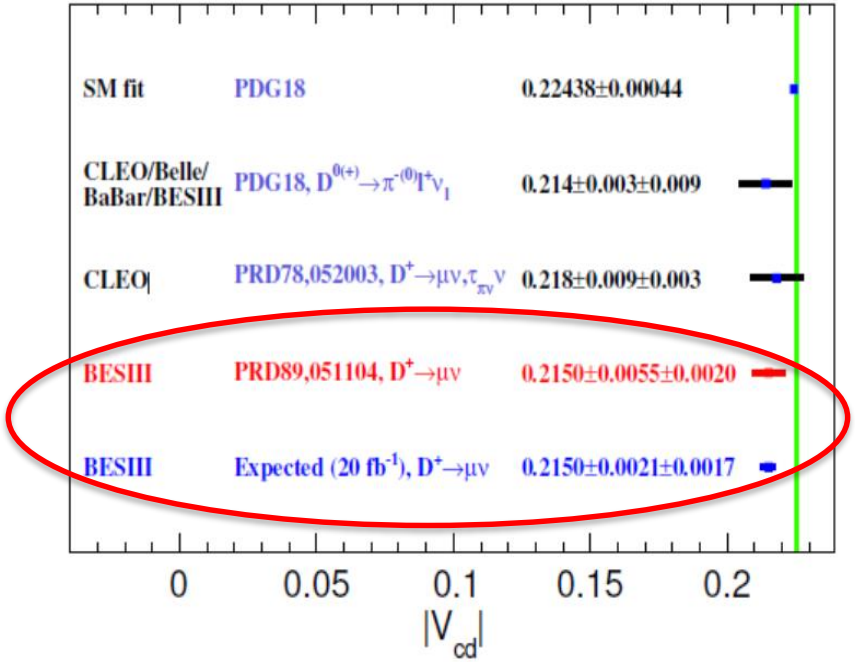
$$\frac{d\Gamma}{dq^2} = \frac{G_F^2}{24\pi^3} |V_{cs(d)}|^2 p^3_{K(\pi)} |f_+^{K(\pi)}(q^2)|^2$$

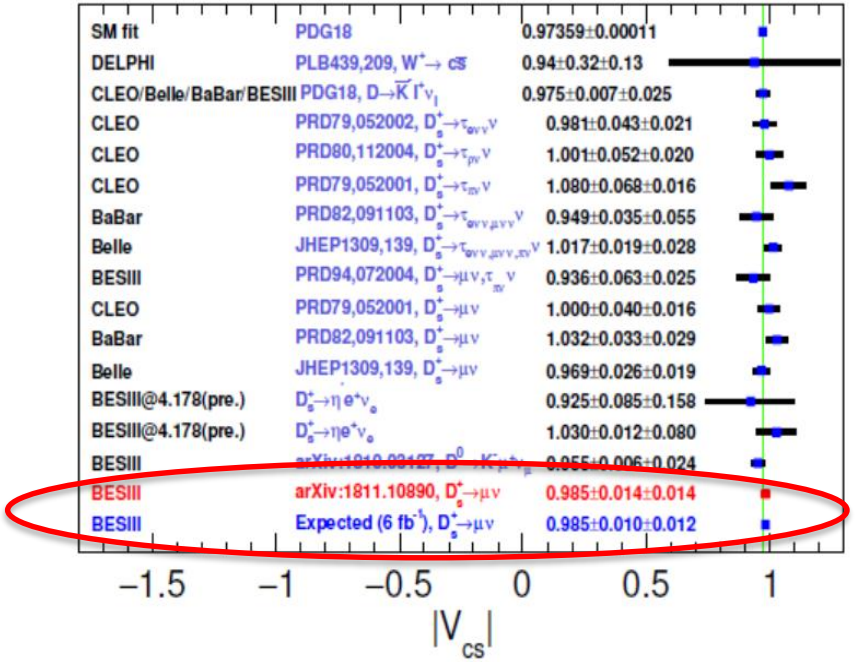


Directly measurement : $|V_{cd(s)}|$ x $f_{D(s)}$ or $|V_{cd(s)}|$ x FF

- ☐ Input $f_{D(s)}$ or $f^{k(\pi)}(0)$ from LQCD $\Rightarrow$ $|V_{cd(s)}|$
- ☐ Input $|V_{cd(s)}|$ from a global fit $\Rightarrow$ $f_{D(s)}$ or $f^{k(\pi)}(0)$
- ☐ Validate LQCD calculation of Input $f_{B(s)}$ and provide constrain of CKM-unitarity

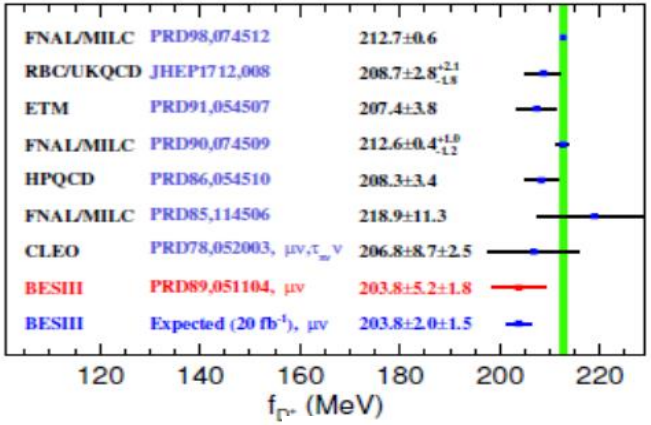
$D_{(s)}$ (Semi-)Leptonic decay

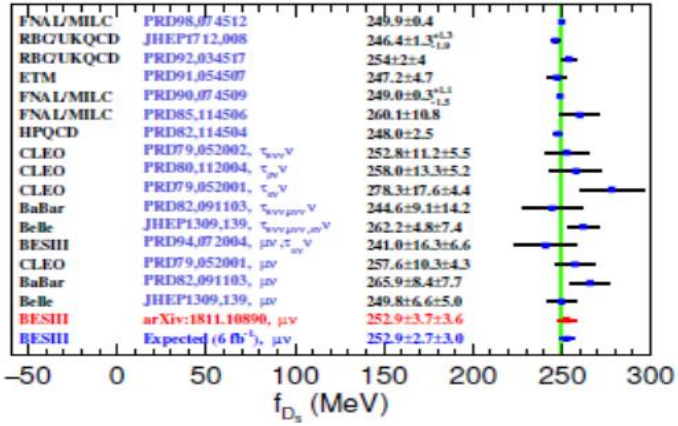




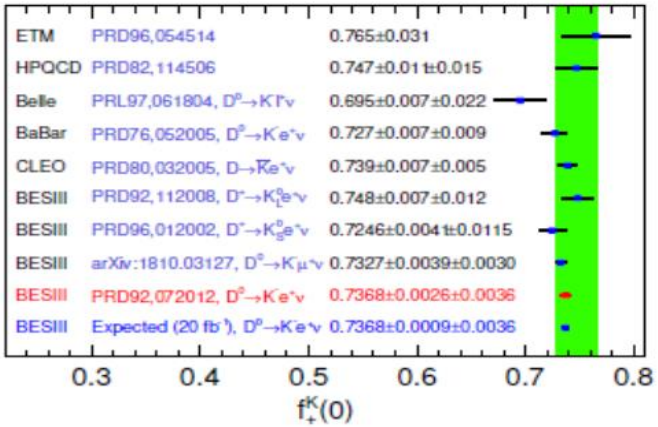
- The **best approach** to measure $|V_{cd(s)}|$ from pure **leptonic decays** from BESIII
- Semi-leptonic decay suffer large **uncertainty** of **FF** from LQCD calculation

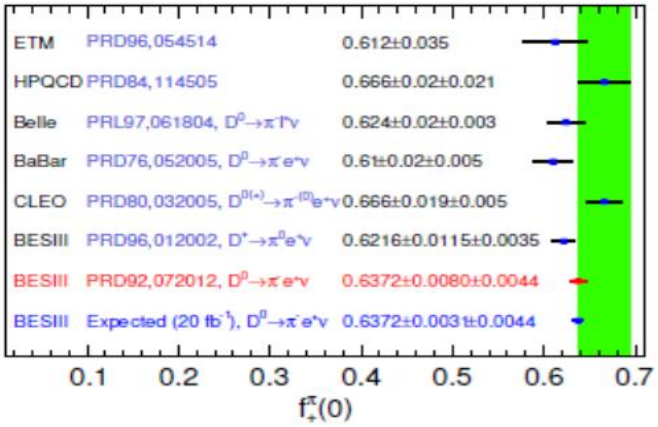
$D_{(s)}$ (Semi-)Leptonic decay





Green bands are LQCD results





- ☐ **BESIII provide the best uncertainties**
- ☐ **LQCD are expected to be improved for semi-leptonic decays**

Lepton Flavor universality

LFU is critical to test the SM and search for new physics beyond SM

Purely Leptonic:

$$R_{D^+_{(s)}} = \frac{\Gamma(D^+_{(s)} \to \tau^+\nu_\tau)}{\Gamma(D^+_{(s)} \to \mu^+\nu_\mu)} = \frac{m^2_{\tau^+}\left(1 - \frac{m^2_{\tau^+}}{m^2_{D^+_{(s)}}}\right)^2}{m^2_{\mu^+}\left(1 - \frac{m^2_{\mu^+}}{m^2_{D^+_{(s)}}}\right)^2}.$$

Semi-Leptonic:

$$R_{\mu/e} = \frac{\Gamma_{D\to h\mu\nu_\mu}}{\Gamma_{D\to he\nu_e}}$$

	$R(D_s^+)$	$R(D^+)$	$R(K^-)$	$R(\bar{K}^0)$	$R(\pi^-)$	$R(\pi^0)$
SM	9.74(1)	2.66(1)	0.975(1)	0.975(1)	0.985(2)	0.985(2)
BESIII	10.19(52)	3.21(64)	0.974(14)	1.013(29)	0.922(37)	0.964(45)

BESIII preliminary
1σ difference

BESIII publication
~2σ difference

Large uncertainty from BESIII, dominant by statistically limited

$D_{(s)}$ Leptonic decay

	BESIII	STCF	Belle II
Luminosity	2.92 fb^{-1} at 3.773 GeV	1 ab^{-1} at 3.773 GeV	50 ab^{-1} at
$\mathcal{B}(D^+ \to \mu^+\nu_\mu)$	$5.1\%_{stat.}$ $1.6\%_{syst.}$ [6]	$0.28\%_{stat.}$	
f_{D^+} (MeV)	$2.6\%_{stat.}$ $0.9\%_{syst.}$ [6]	$0.15\%_{stat.}$	
$\lvert V_{cd}\rvert$	$2.6\%_{stat.}$ $1.0\%^{*}_{syst.}$ [6]	$0.15\%_{stat.}$	
$\mathcal{B}(D^+ \to \tau^+\nu_\tau)$	$20\%_{stat.}$ $10\%^{\dagger}_{syst.}$ [7]	0.41%	
$\frac{\mathcal{B}(D^+ \to \tau^+\nu_\tau)}{\mathcal{B}(D^+ \to \mu^+\nu_\mu)}$	$21\%_{stat.}$ $10\%^{\dagger}_{syst.}$ [7]		
Luminosity	3.2 fb^{-1} at 4.178 GeV		ab^{-1} at $\Upsilon(nS)$
$\mathcal{B}(D_s^+ \to \mu^+\nu_\mu)$	$2.8\%_{stat.}$ 2.7%		$0.8\%_{stat.}$ $1.8\%_{syst.}$
$f_{D_s^+}$ (MeV)	$1.5\%_{stat}$		
$\lvert V_{cs}\rvert$	1.5%	$\%_{stat.}$	—
$f_{D_s^+}/f_{D^+}$		$0.21\%_{stat.}$	—
$\mathcal{B}(D_s^+ \to \tau^+$		$0.24\%_{stat.}$	$0.6\%_{stat.}$ $2.7\%_{syst.}$
$f_{D_s^+}$ (M	syst.	$0.11\%_{stat.}$	
	$1.5\%^{\dagger}_{syst.}$	$0.11\%_{stat.}$	—
	$\%_{stat.}$ $1.0\%^{\dagger}_{syst.}$	$0.09\%_{stat.}$	$0.3\%_{stat.}$ $1.0\%_{syst.}$
	$0.9\%_{stat.}$ $1.0\%^{\dagger}_{syst.}$	$0.09\%_{stat.}$	—
$\frac{\tau)}{\to \mu^+\nu_\mu)}$	$3.6\%_{stat.}$ $3.0\%^{\dagger}_{syst.}$	$0.38\%_{stat.}$	$0.9\%_{stat.}$ $3.2\%_{syst.}$

Theory : 0.2%(0.1% expected)

Theory : 0.2%(0.1% expected)

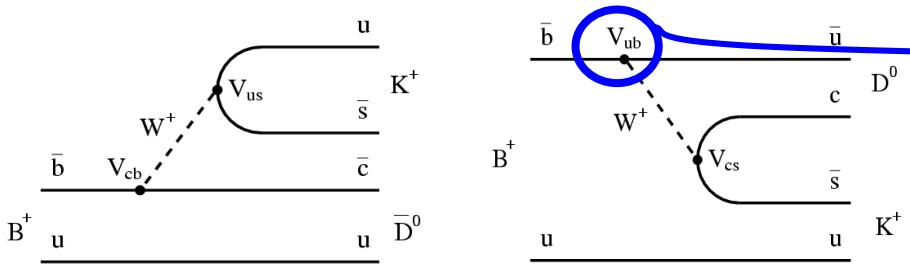
Stat. uncertainty is closed to theory precision

Sys. is challenging

* As[illegible]me $f_{D(s)}$ with 0.2% uncertainty; + preliminary results; assume Belle II improved systematics by a factor 2

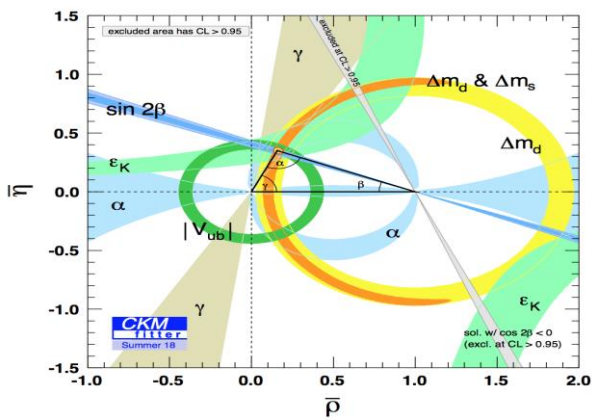
Determination of γ/ϕ_3 angle

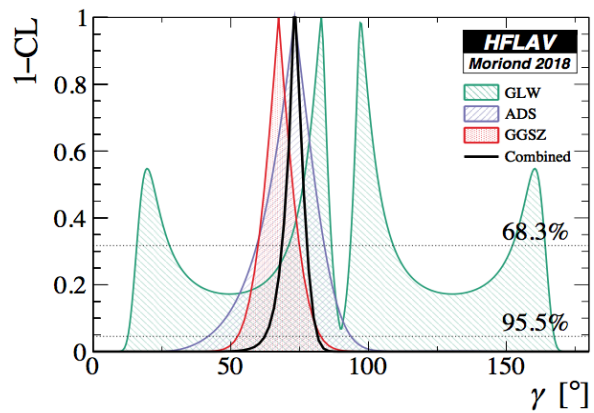
- The cleanest way to extract γ is from B→DK decays:



$$\frac{A(B^+ \to D^0 K^+)}{A(B^+ \to \overline{D^0} K^+)} \equiv r_B e^{i(\delta_B + \phi_3)}$$

  - Interference between tree-level decays; theoretically clean
  - current uncertainty $\sigma(\gamma) \sim 5^0$
  - however, theoretical relative error $\sim 10^{-7}$ (very small!)
- Information of *D decay strong phase* is needed
  - Best way is to employ quantum coherence of DD production at threshold





Determination of γ/ϕ_3 angle

Runs	Collected / Expected integrated luminosity	Year attained	γ/ϕ_3 sensitivity
LHCb Run-1 [7, 8 TeV]	3 fb^{-1}	2012	8°
LHCb Run-2 [13 TeV]	5 fb^{-1}	2018	4°
Belle II Run	50 ab^{-1}	2025	1.5°
LHCb upgrade I [14 TeV]	50 fb^{-1}	2030	$< 1°$
LHCb upgrade II [14 TeV]	300 fb^{-1}	(>)2035	$< 0.4°$

BESIII 20/fb: $\sigma(\gamma) \sim 0.4^o$

STCF is needed!

Three methods for exploiting interference (choice of D^0 decay modes):

- Gronau, London, Wyler (GLW): Use CP eigenstates of $D^{(*)0}$ decay,

  e.g. $D^0 \rightarrow K_s\pi^0$, $D^0 \rightarrow \pi^+\pi^-$

- Atwood, Dunietz, Soni (ADS): Use doubly Cabibbo-suppressed decays, e.g. $D^0 \rightarrow K^+\pi^-$
  - With 1 ab^{-1} @ STCF : $\sigma(\cos\delta_{K\pi}) \sim 0.007$; $\sigma(\delta_{K\pi}) \sim 2^o$ ➔ $\sigma(\gamma) < 0.5^o$

- Giri, Grossman, Soffer, Zupan (GGSZ): Use Dalitz plot analysis of 3-body D^0 decays, e.g. $K_s\pi^+\pi^-$; high statistics; need precise Dalitz model
  - STCF reduces the contribution of D Dalitz model to a level of $\sim 0.1^o$

D^0-$\bar{D}^0$ mixing and CPV

STCF provide a unique place for the study of D^0 -$\bar{D}^0$ mixing and CPV by means of quantum coherence of D^0 and $\bar{D}^0$ produced through

$$\psi(3770) \to (D^0\bar{D}^0)_{\mathrm{CP}=-} \text{ or } \psi(4140) \to D^0\bar{D}^{*0} \to \pi^0(D^0\bar{D}^0)_{\mathrm{CP}=-} \text{ or } \gamma(D^0\bar{D}^0)_{\mathrm{CP}=+}$$

- Mixing rate $R_M = \frac{x^2+y^2}{2} \sim 10^{-5}$ with 1 ab^{-1} data at 3.773 GeV via same charged final states $(K^{\pm}\pi^{\mp})(K^{\pm}\pi^{\mp})$ or $(K^{\pm}l^{\mp}v)(K^{\pm}l^{\mp}v)$
- Mixing parameter $(x, y) \sim 0.05\%$ with 1 ab^{-1} data at 4.040 by $e^+e^- \to \gamma D^0\bar{D}^0$
- $\Delta A_{CP} \sim 10^{-3}$ for KK and ππ channels

Precision study of the B_c decay

Era of precision study of the charmed baryon (Λ_c, Ξ_c and Ω_c) decays

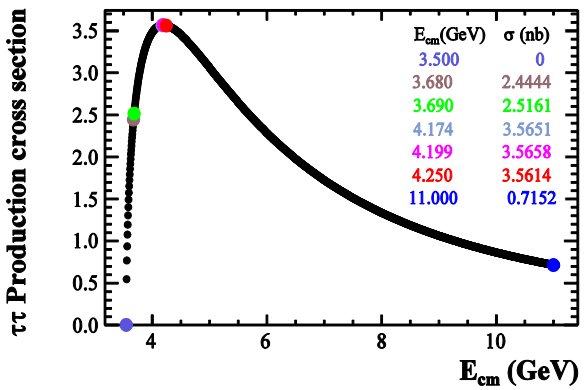
to help developing more reliable QCD-derived models in charm sector

- Hadronic decays:
  to explore as-yet-unmeasured channels and understand full picture of intermediate structures in B_c decays, esp., those with neutron/Σ/Ξ particles
- Semi-leptonic decays:
  to test LQCD calculations and LFU
- CPV in charmed baryon: BP and BV two-body decay asymmetry, charge-dependent rate of SCS
- Charmed Baryons Spectroscopy : (63 P wave states from QM, 16 observed!)
- Rare decays: LFV, BNV, FCNC

STCF will provide very precise measurements of their overall decays, up to the unprecedented level of 10^{-6} ~10^{-7}

τ Lepton Physics

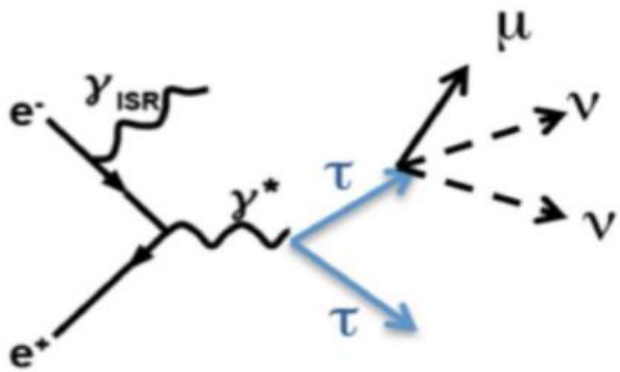
- X sec grows from 0.1nb near threshold to 3.5nb at 4.25GeV
  - 1×10^8 tau pairs/year at threshold (x-sec = 0.1nb)
  - 3.5×10^9 tau pairs/year at 4.25GeV (x-sec = 3.5nb)
  - 10^{10} tau pairs per year for Belle II (x-sec = 1nb)

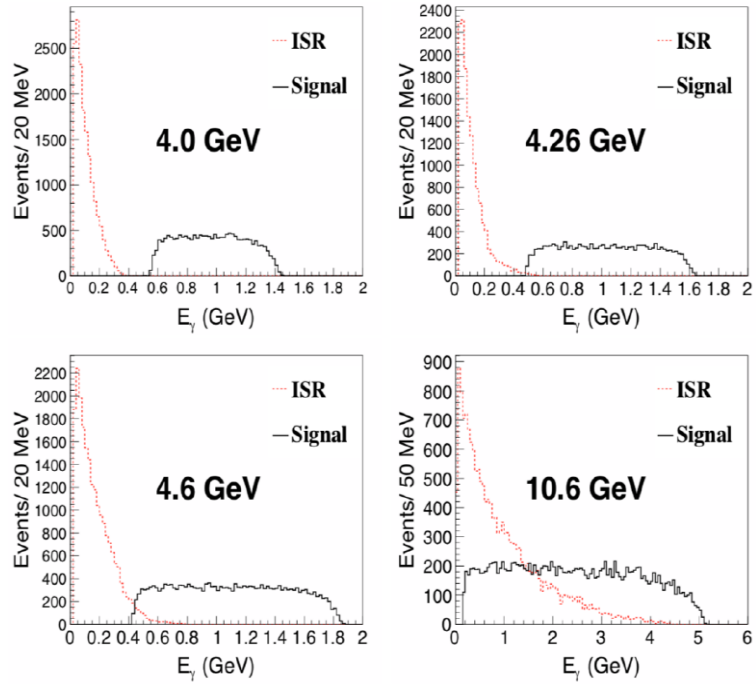


- Highlighted Physics program
  - τ properties : m_τ, $(g-2)_\tau/2$
  - SM properties : universality test, Michel parameters, α_s, V_{us}
  - CPV test : $\tau^- \to K_S^0 \pi^- \nu_\tau$, T-odd triple product in polarization beam
  - LFV : $\tau \to \ell\gamma$, $\ell\ell\ell$, ℓh

- Competition to Belle II
  - Threshold effect is important for controlling and understanding background
  - Relatively high efficiency
  - Longitudinal polarization of the initial beams will significantly increase sensitivity in searches for CPV in lepton decays.

LFV Decay $\tau \to \gamma\mu$





B Factory :

- Dominant background :

  $\tau^- \to \mu^- \nu_\tau \bar{\nu}_\mu$ with ISR

- BaBar : $B(\tau^- \to \gamma\mu^-) < 4.5 \times 10^{-8}$

Belle II with 50 ab^{-1} : $B(\tau^- \to \gamma\mu^-) < 6 \times 10^{-9}$

STCF with 3 ab^{-1} : $B(\tau^- \to \gamma\mu^-) < 5 \times 10^{-9}$

CPV in τ decays

CPV in SM is not enough to explain the asymmetry of matter and anti-matter in universe, new CPV source are demanded.

τ Lepton decays are a potential place where new CPV may show up

CPV sourced $K^0 - \bar{K}^0$ mixing

Theory :

$$A_Q = \frac{B(\tau^+ \to K_S^0 \pi^+ \bar{\nu}_\tau) - B(\tau^- \to K_S^0 \pi^- \nu_\tau)}{B(\tau^+ \to K_S^0 \pi^+ \bar{\nu}_\tau) + B(\tau^- \to K_S^0 \pi^- \nu_\tau)} = (+0.36 \pm 0.01)\%$$

BaBar experiments :

$A_Q = (-0.36 \pm 023 \pm 0.11)\%$ 2.8σ away from the SM prediction

Theorist try to reconcile the deviation, but not coverage even NP included

STCF can provide a crucial validation since the background can be well controlled

CPV in τ decays

New T-odd observables

Use T-odd rotationally in products in >=2 hadrons

Polarized τ are necessary

such as $\tau^- \to \pi^- \pi^0 \nu_\tau / k^- \pi^0 \nu_\tau$, $\tau^- \to \pi^- \pi^+ \pi^- \nu_\tau / K^- \pi^+ \pi^- \nu_\tau$

Polarized τ sourced from polarized beam

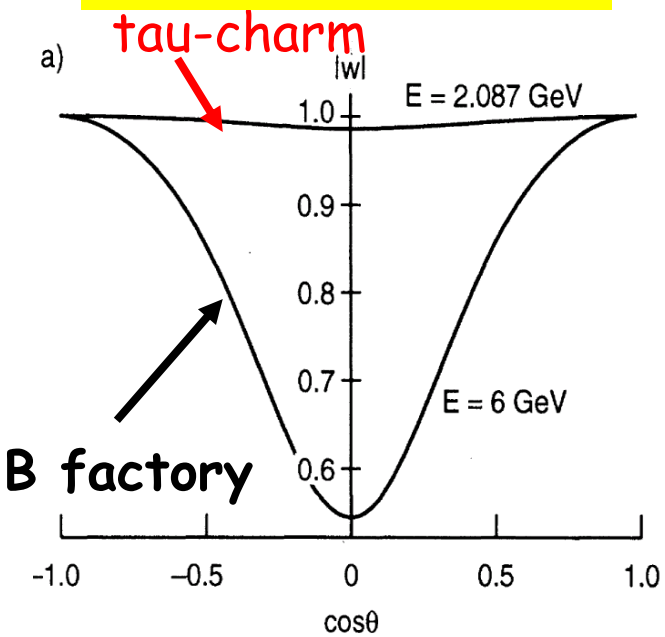


Figure of Merits

$$\begin{aligned} \text{merit} &= \text{luminosity} \times \bar{w}_Z \times \text{ total cross section} \\ &\propto \text{luminosity} \times (w_1 + w_2) \\ &\quad \times \sqrt{1-a^2}\, a^2 (1+2a) \ , \end{aligned}$$

Y. S. TSAI, PRD 51 (1995) 3172

BESIII @ 4.25 (10^{33}cm^{-2}s^{-1}) FOM=1

STCF @ 4.25 (10^{35}cm^{-2}s^{-1}) FOM=100

SuperKEKB @ (8×10^{35}cm^{-2}s^{-1}) FOM=52

Experimental challenge:
reconstruction of τ (No secondary vertices)

CPV in Hyperon Decays

- In 1958, Okubo: CPV in hyperon-antihyperon allows ⇒ "Okubo effect"(Direct CPV) Phys. Rev. 109, 984 (1958).
- In 1959, Pais: extended Okubo's proposal to asymmetry parameters in Λ and Λ decays. Phys. Rev. Lett. 3, 242 (1959).
- In the 1980s, a number of calculations were made. CKM predictions, CPV in Λ: $10^{-4} \sim 10^{-5}$
- One example: Phys. Rev. D34, 833 (1986).

PHYSICAL REVIEW D VOLUME 34, NUMBER 3 1 AUGUST 1986

Hyperon decays and *CP* nonconservation

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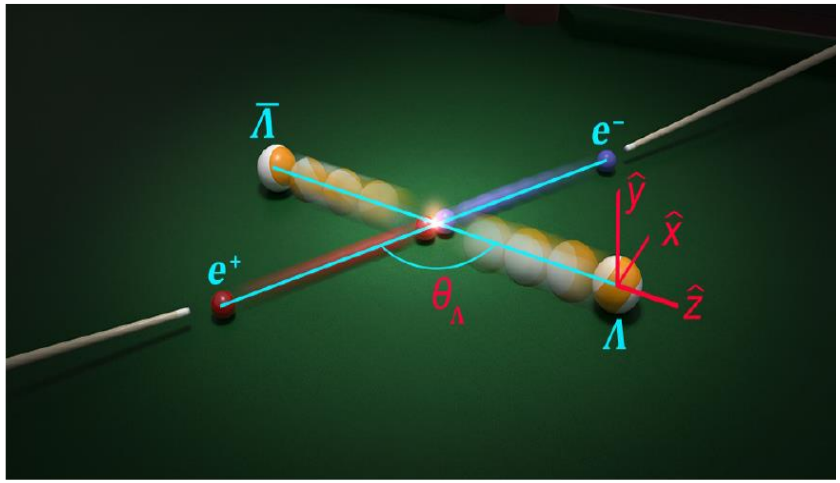
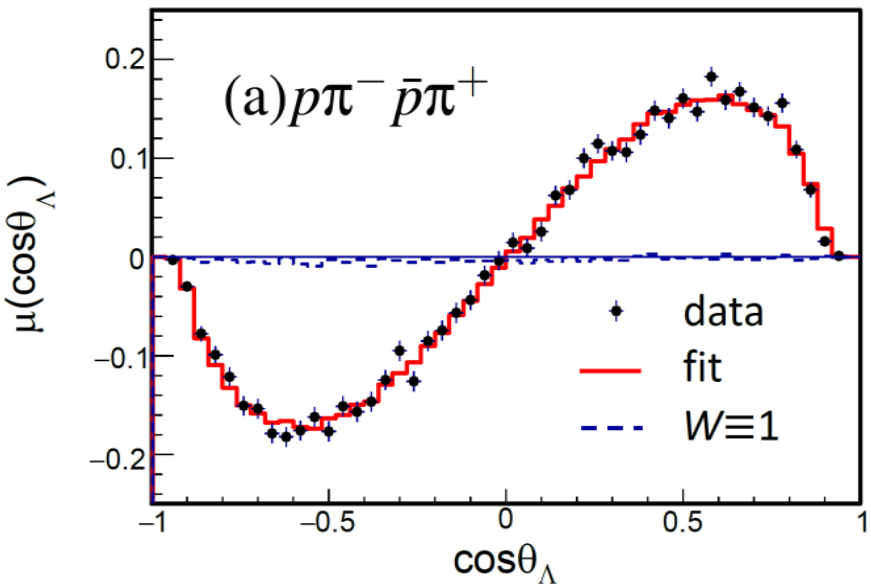
Department of Physics and Astronomy, University of Hawaii at Manoa, Honolulu, Hawaii 96822
(Received 7 March 1986)

We study all modes of hyperon nonleptonic decay and consider the *CP*-odd observables which result. Explicit calculations are provided in the Kobayashi-Maskawa, Weinberg-Higgs, and left-right-symmetric models of *CP* nonconservation.

Spin polarization of Λ in $J/\psi \to \Lambda\bar{\Lambda}$





Nature Phys. **15**, 631–634 (2019)

arXiv:1808.08917

1.31 B J/ψ events

Quantum correlation in Λ pair

Parameters	This work	Previous results
α_ψ	$0.461 \pm 0.006 \pm 0.007$	0.469 ± 0.027 [14]
$\Delta\Phi$	$(42.4 \pm 0.6 \pm 0.5)^\circ$	–
α_-	$0.750 \pm 0.009 \pm 0.004$	0.642 ± 0.013 [16]
α_+	$-0.758 \pm 0.010 \pm 0.007$	-0.71 ± 0.08 [16]
$\bar{\alpha}_0$	$-0.692 \pm 0.016 \pm 0.006$	–
A_{CP}	$-0.006 \pm 0.012 \pm 0.007$	0.006 ± 0.021 [16]
$\bar{\alpha}_0/\alpha_+$	$0.913 \pm 0.028 \pm 0.012$	–

CP test $A_{CP} = \frac{\alpha_- + \alpha_+}{\alpha_- - \alpha_+}$

A_{CP} Sensitivities in STCF

- 4 trillion J/ψ events ⇒ $A_{CP} \sim 10^{-4}$
  - Luminosity optimized at J/ψ resonance
  - Luminosity of STCF: × 100
  - 2 – 3 years data taking
  - No polarization beams are needed
- Beam energy trick ⇒ small beam energy spread ⇒ J/ψ cross-section: × 10 ⇒ $A_{CP} \sim 10^{-5}$?
- Challenge: Systematics control

Others interested

- Baryon Form Factors (produced at threshold)
- Collins Fragmentation function
- Two photon physics
- ……

Strategy& Activities

CDR → TDR → project application → construction → commissioning

- Strategy: focus on CDR (3 years) and TDR (6 years) depend on the available resources. the construction site open.
- Webpage: http://wcm.ustc.edu.cn/pub/CICPI2011/futureplans/
- Domestic Workshops (2011, 12, 13, 14, 16)
- International Workshops (2015, 18)
- 2015 Fragrance Hill-Science Conference (No. 533)
- Report to USTC Scientific Committee and USTC presidents
- Report to local government
- Form the Organization (including project manager, physics/detector/accelerator work groups ….)
- Regular weekly meetings for Accelerator/Detector/physics !

Activities

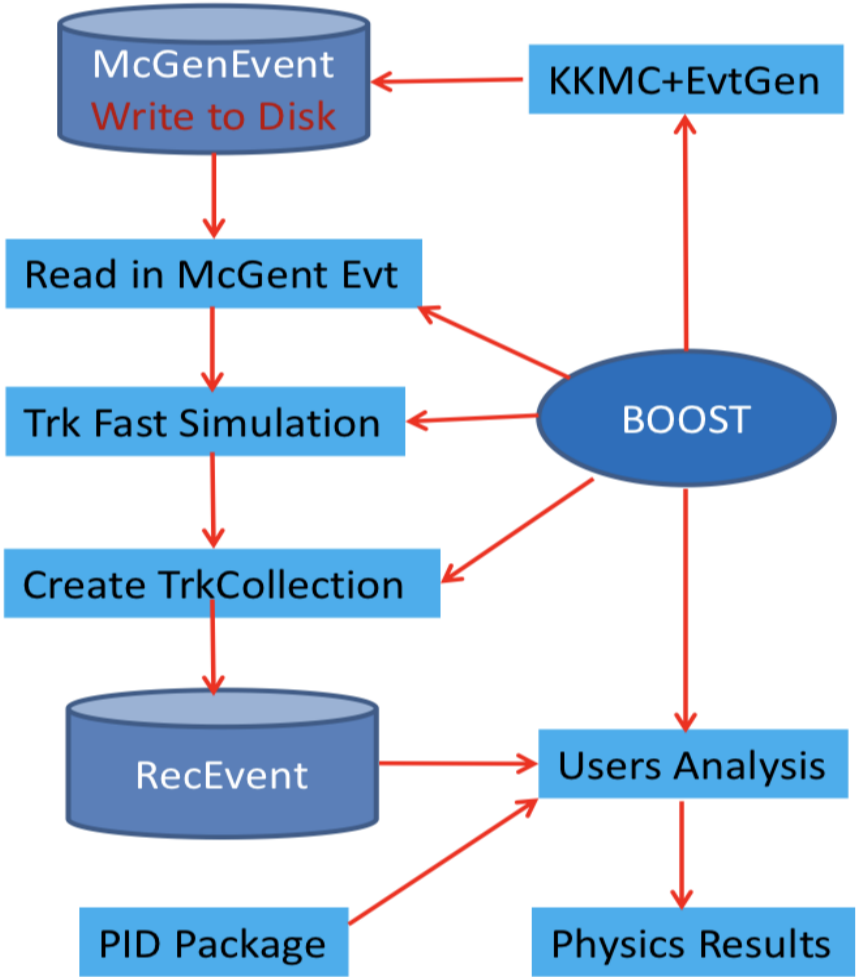
High Luminosity Tau Charm Physics

Indico for High Luminorcity Tau Charm Physics R&D

STCF Steering Committee	1 event
STCF Accelerator	27 events
STCF Physics	6 events
STCF Detector	99 events
STCF Accelerator-Detector Joint meetings	4 events
STCF International Conference	7 events
STCF Domestic meeting	7 events

Physics Progress

Studying the physics sensitivity, guiding the optimization of Detector design

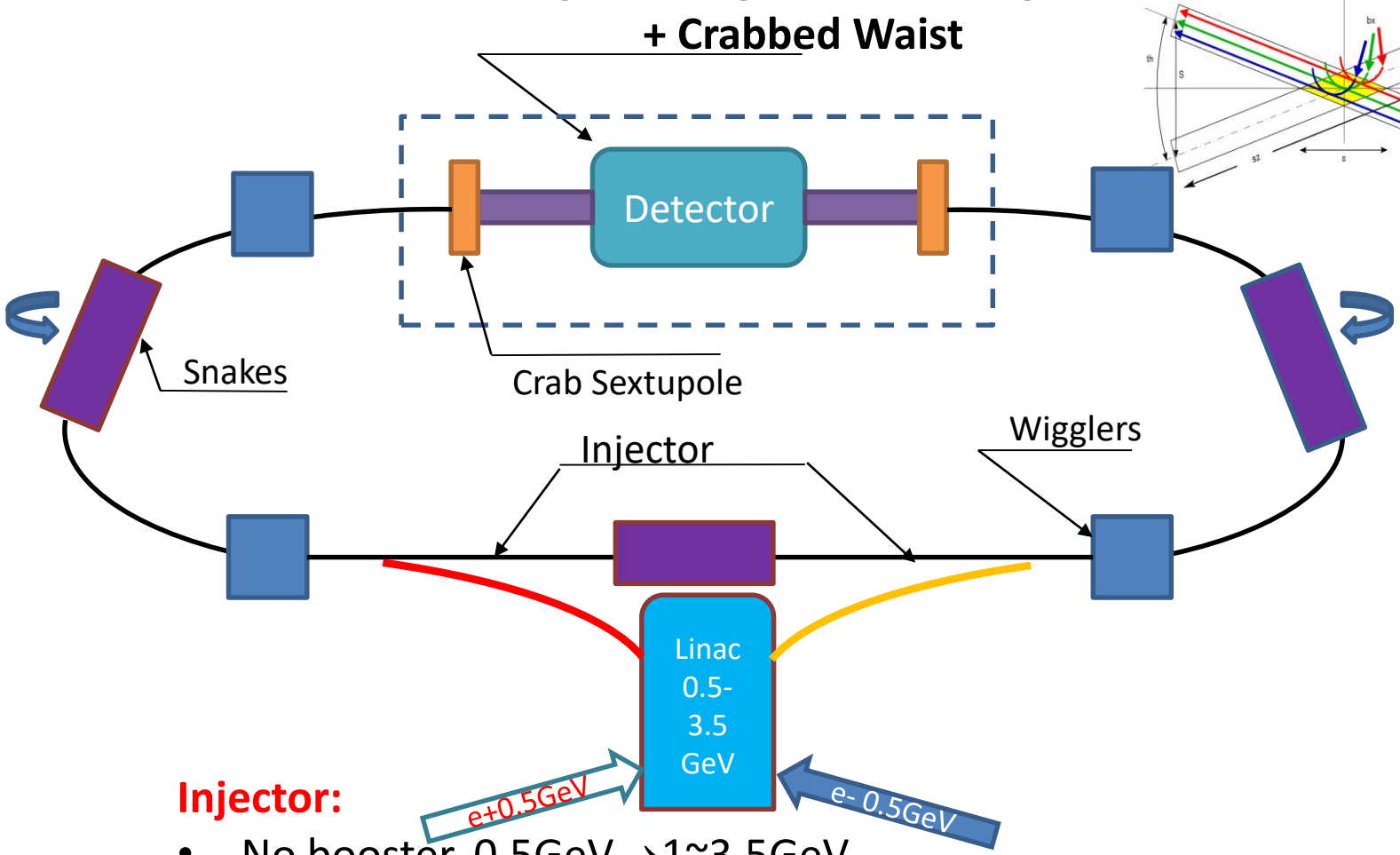


- Same as BESIII for McGenEvt, and keep events in storage.
- Fast simulation for charge and neutral tracks(resolution, efficiency, error matrix etc.).
- Do not keep RecEvt information, fix random seed for repeating analysis.
- User analysis the same as BESIII jobs.
- Optimize STCF detector by scaling

Fast simulation for several interested physics processes are going on

Layout of Machine

Interaction Region : Large Piwinski Angle Collision + Crabbed Waist



Injector:

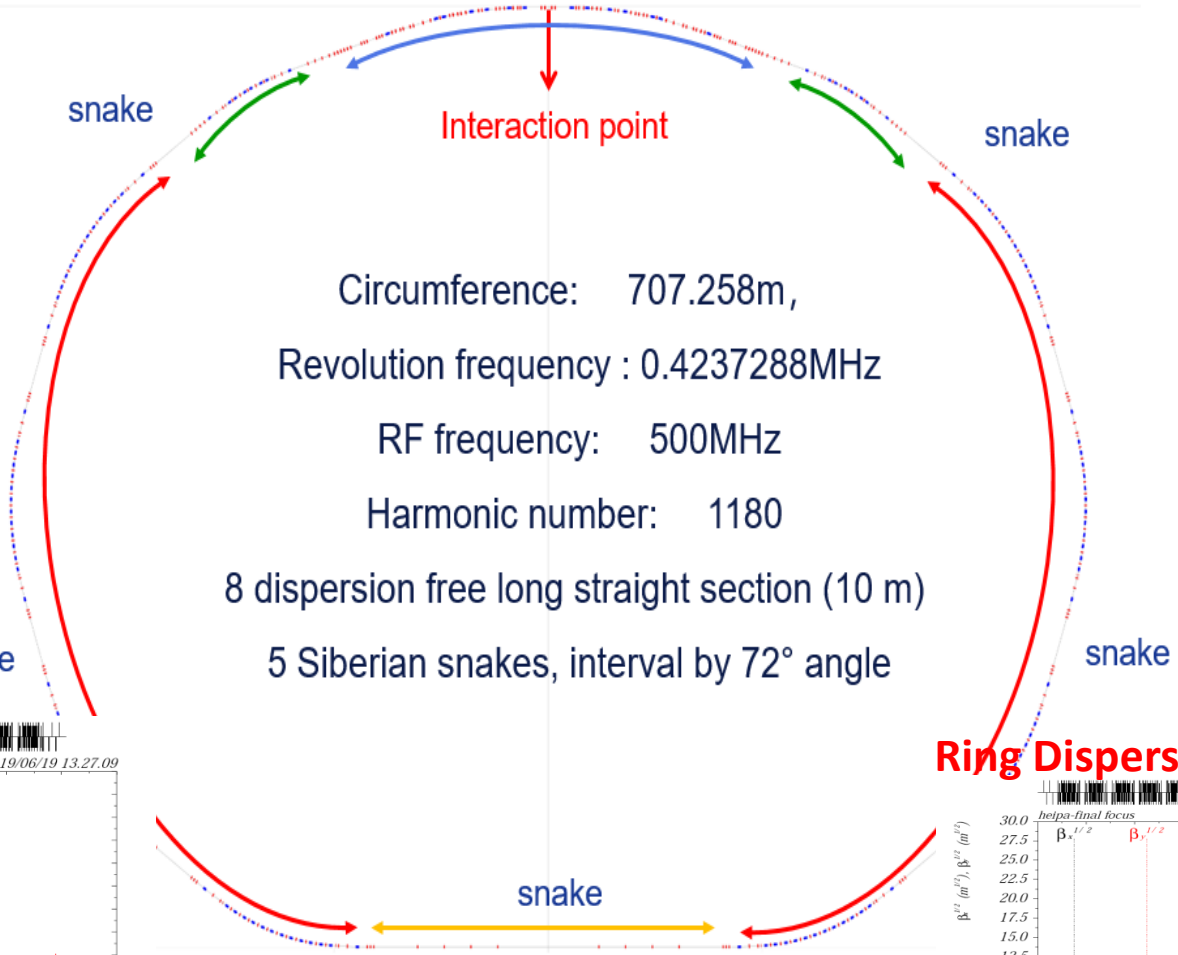
- No booster, 0.5GeV→1~3.5GeV
- e+, a convertor, a linac and a damping ring, 0.5GeV
- e-, a polarized e- source, accelerated to 0.5GeV

Machine parameters

Parameters	Phase1	Phase2
Circumference/m	600~800	600~800
Optimized Beam Energy/GeV	2.0	2.0
Beam Energy Range/GeV	1-3.5	1-3.5
Current/A	1.5	2.0
Emittance $(\varepsilon_x/\varepsilon_y)$/nm·rad	6/0.06	5/0.05
β Function @IP (β_x^*/β_y^*)/mm	60/0.6	50/0.5(estimated)
Full Collision Angle 2θ/mrad	60	60
Tune Shift ξy	0.06	0.08
Hourglass Factor	0.8	0.8
Aperture and Lifetime	15σ, 1000s	15σ, 1000s
Luminosity @Optimized Energy/ $\times 10^{35}$cm^{-2}s^{-1}	~0.5	~1.0

Lattice with FODO-Like Arc

1. Interaction region
2. Long arc section
3. Short arc section
4. Technical section



Circumference: 707.258m,

Revolution frequency : 0.4237288MHz

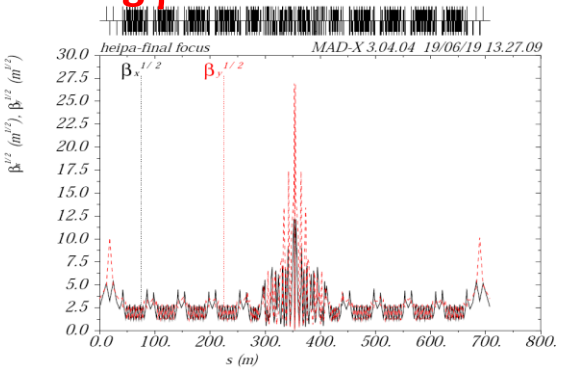
RF frequency: 500MHz

Harmonic number: 1180

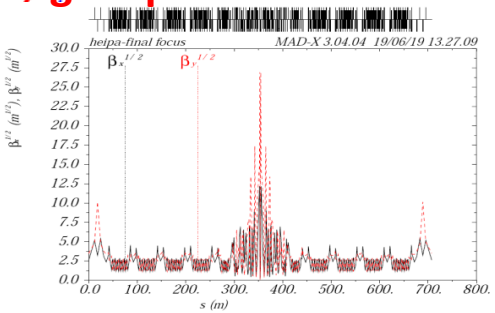
8 dispersion free long straight section (10 m)

5 Siberian snakes, interval by 72° angle

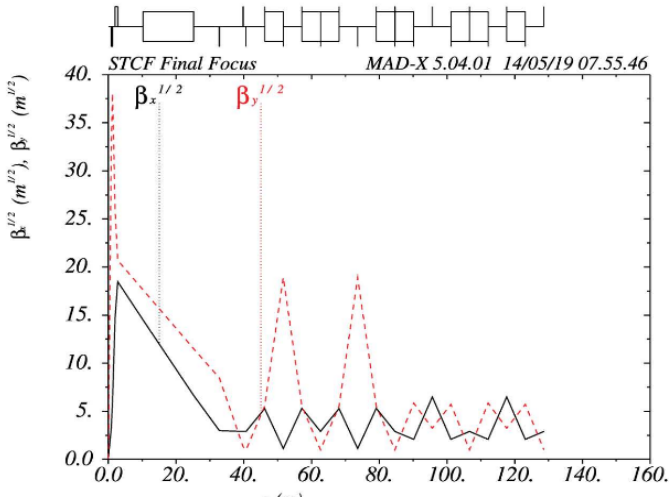
Ring β function

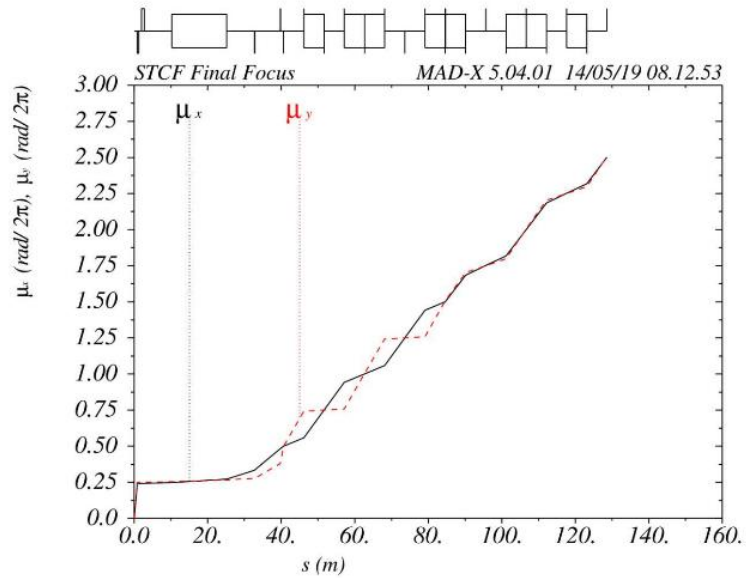


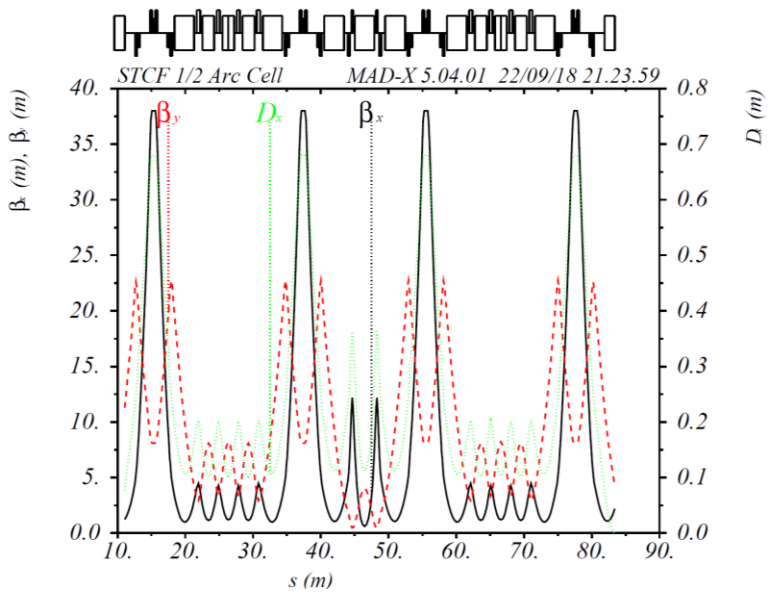
Ring Dispersion function



Lattice with MBA-Like Arc







Parameters	Achieved Now
Circumference/m	~540
Beam Energy/GeV	2; 1-3.5tunable
Current/A	1.5
Emittance$(\varepsilon_x/\varepsilon_y)$/nm·rad	2.4/0.03
β Function @ IP (β_x^*/β_y^*)/mm	60/0.6
ν_x /υ_y	17.2/10.7
Collision Angle(full θ)/mrad	60
Tune Shift ξ_y	0.06-0.1 (estimated)
Hour-glass Factor	0.8 (estimated)
Luminosity/ $\times 10^{35}$cm^{-2}s^{-1}	0.8~1.3 (estimated)

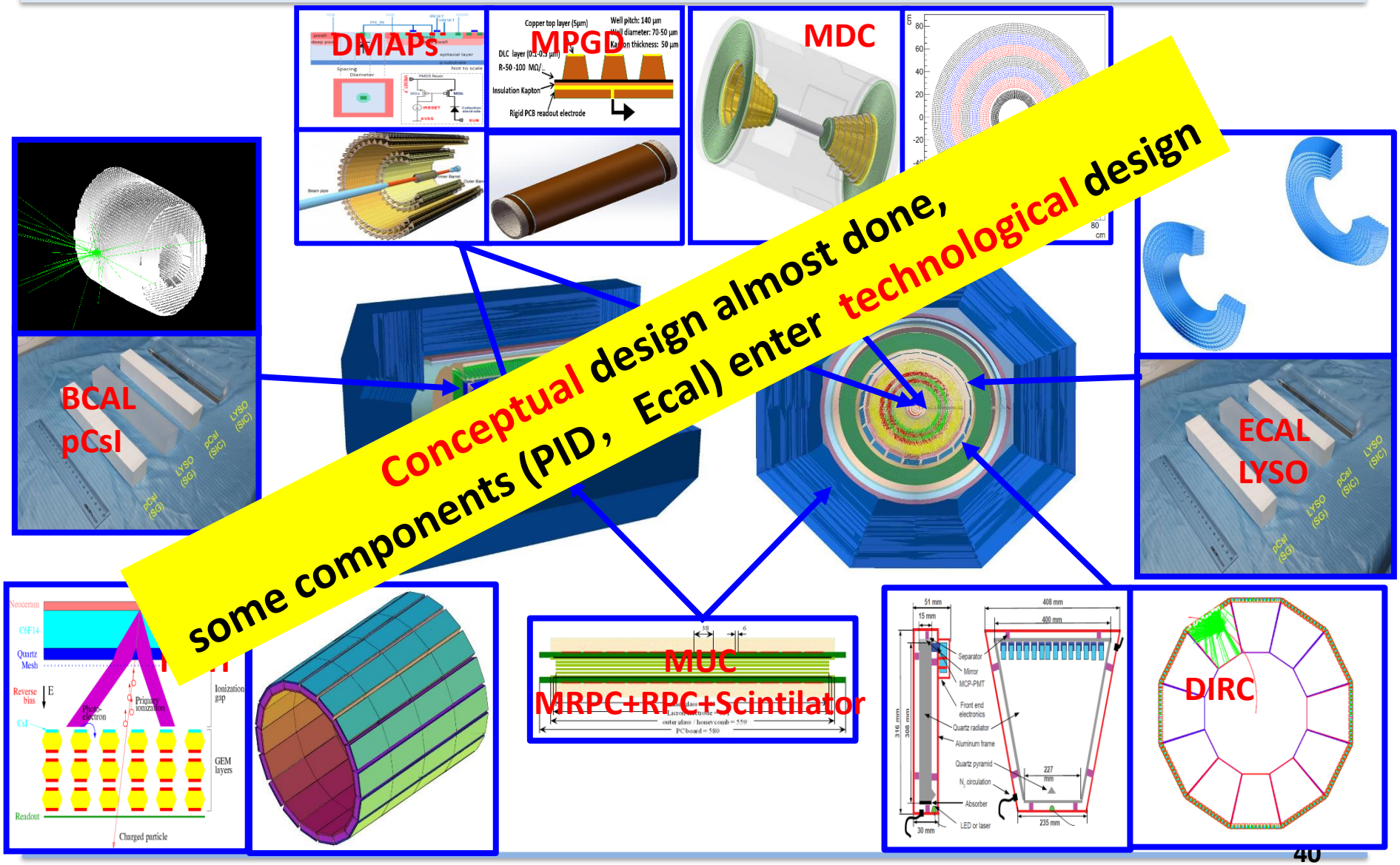
Key technologies

关键技术研究内容与路线

内容	技术路线
束流测量	能量、位置、极化度，束团尺寸，束流反馈，亮度反馈
微波高频	超导高频腔，低电平控制系统
真空	真空室镀膜，异形真空室研制，阻抗优化与测量
磁铁	超导磁铁，超导螺线管，永磁铁，异形铁……
极化束技术	试制光阴极极化电子枪

计算与仿真研究，制定技术方案 → 样机设备的加工，离线测试 → 搭建集成测试平台，预研样机测试与定型

Spectrometer



Tentative Plan

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030-2040	2041-2042
Form International Collaboration														
Conception Design Report (CDR)														
Technical Design Report (TDR)														
Construction														
Commissioning														
Upgrade														

R&D budget: 200M RMB
Total budget: 4B RMB
(estimated in 2014)

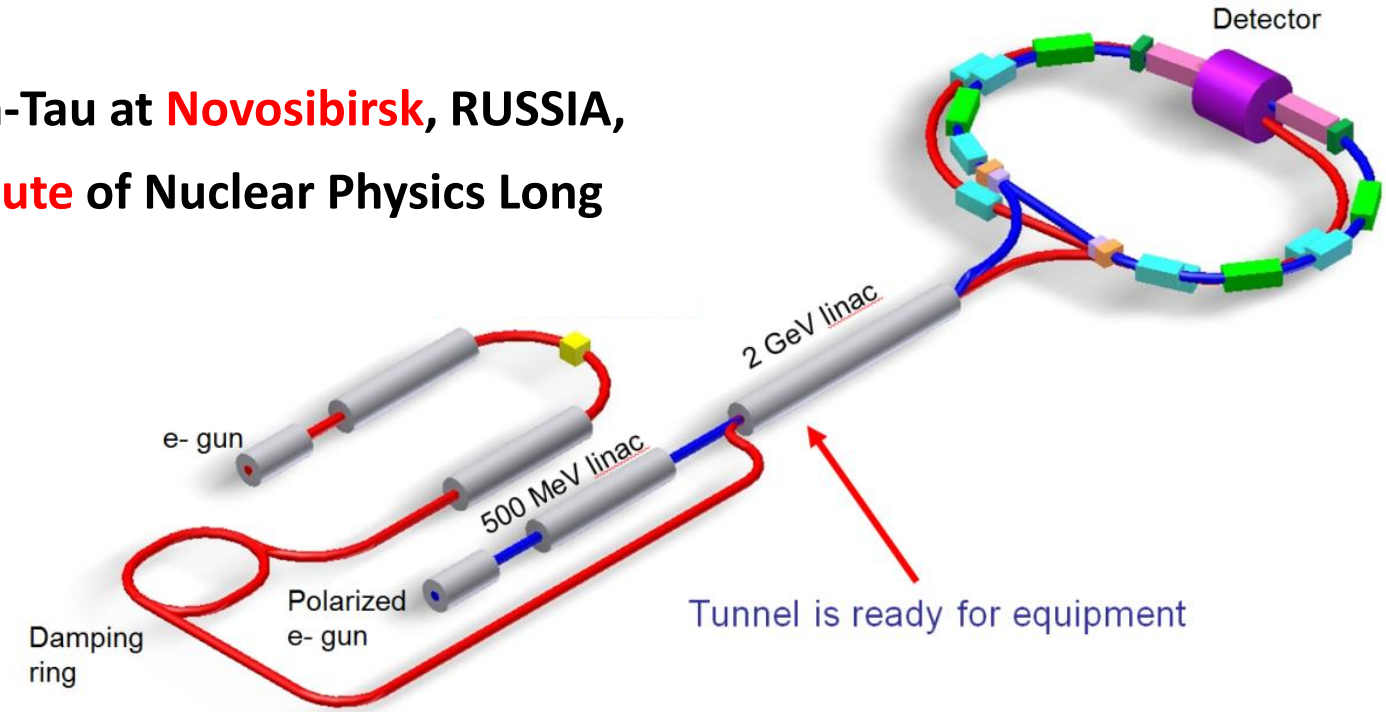
单位：亿元	
eLinac	4.0+1.0 (阻尼环)
Electron ring	7.0
Positron ring	7.0
束线	1.2
实验谱仪	8.0
低温	1.0
配套设施	1.8
装置土建	6.0
不可预见	3.0
合计	40

USTC Scientific Committee Review

- USTC president agreed, and scientific committee endorsed supporting R&D → 10 M RMB (2018)
- Agree to support another 10-20 M RMB (2019)

International Collaboration

Super Charm-Tau at Novosibirsk, RUSSIA, Budker Institute of Nuclear Physics Long history…..



- Pre-Agreement of Joint effort on R&D, details are under negotiation
- Joint workshop between China, Russia, and Europe
  - 2018 UCAS (March), Novosibirsk (May), Orsay (December)
  - 2019 Moscow(September)

Summary

- **Super τ-c Factory (STCF):**
  - double ring with circumference around 600~1000 m
  - e^+e^- collision with E_{cm} = 2 – 7 GeV, L = 1 × 10^{35} $cm^{-2}s^{-1}$
- **STCF is one of the crucial precision frontier**
  - rich of physics program
  - unique for physics with c quark and τ leptons,
  - important playground for study of QCD, exotic hadrons and search for new physics.
- **We initialized 10 M CNY (2018), 10-20M CNY(2019) for start R&D.**
- **Project organization is setup, a working group is toward for CDR/TDR**
- **An International collaboration is essential for promoting the project.**

Welcome to join the effort

谢谢
Thanks.