Data taking proposal in the continuum with BESIII

What we have proposed

White paper CPC 44, 4 (2020)

Table 4.4. Proposed data for τ-QCD study.

energy	physics highlight	current data	expected final data	time/d
1.8-2.0 GeV	R, nucleon, resonances	*N/A*	96 pb^{-1} at 23 points	66
around 2.2324 GeV	$\Lambda\bar{\Lambda}$ threshold	one point	40 pb^{-1} at 4 points	17
2.35-2.83 GeV	R & resonances	few points	260 pb^{-1} at 13 points	60
2.5 GeV	hyperon	1 pb^{-1} data	100 pb^{-1}	26
J/ψ scan	phase	100 pb^{-1} data	1000 pb^{-1}	150

Table 7.1. List of data samples collected by BESIII/BEPCII up to 2019, and the proposed samples for the remainder of the physics program. The right-most column shows the number of required data taking days with the current (T_C) and upgraded (T_U) machine. The machine upgrades include top-up implementation and beam current increase.

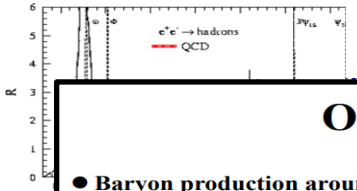
Energy	Physics motivations	Current data	Expected final data	T_C / T_U
1.8 - 2.0 GeV	R values Nucleon cross-sections	N/A	0.1 fb^{-1} (fine scan)	60/50 days
2.0 - 3.1 GeV	R values Cross-sections	Fine scan (20 energy points)	Complete scan (additional points)	250/180 days
J/ψ peak	Light hadron & Glueball J/ψ decays	3.2 fb^{-1} (10 billion)	3.2 fb^{-1} (10 billion)	N/A
$\psi(3686)$ peak	Light hadron & Glueball Charmonium decays	0.67 fb^{-1} (0.45 billion)	4.5 fb^{-1} (3.0 billion)	150/90 days
$\psi(3770)$ peak	$D^0/D^{\pm}$ decays	2.9 fb^{-1}	20.0 fb^{-1}	610/360 days

The scan data is important for:

- **Precision test of the SM: R value**
- **Hadron structures: Fragmentation function, Nucleon EMFFs, Hyperon polarization**
- **Hadron Spectroscopy: Light Vector states**
- **Testing pQCD: Phase in Jpsi decay**
- **New physics: D* production**

Data taking proposals @ τ-QCD

τ-QCD group



Outline

- Baryon production around threshold
  - ✓ Proton form factor @ [1.9, 2.0]GeV
  - ✓ Scan for $\Lambda\bar{\Lambda}$ threshold
  - ✓ $\sqrt{s}$= 4.575GeV for $\Lambda_c\bar{\Lambda}_c$ threshold
  - ✓ $\sqrt{s}$= 2.512GeV for Σ triplet
  - ✓ Scan for $\Sigma\bar{\Sigma}$ threshold: share with structure @ 2.4GeV
- Vector states @ $\sqrt{s} \in$ [2.0, 3.0]GeV
  - ✓ Structure around 2.2GeV: share with $\Lambda\bar{\Lambda}$ scan
  - ✓ Structure around 2.4GeV
  - ✓ Structure around 2.7GeV

Proposal for additional 100 pb^{-1} at 2.512 GeV

la University,

meeting

Coll. Meeting in Winter of 2016

Outline

- Hyperon form factors – a short introduction
- The 2014/2015 scan
- Proposal for data taking at 2.512 GeV
  - Objective 1: Complete measurement of the Σ EMFF
  - Objective 2: Precision measurement of nucleon EMFF
  - Objective 3: Search for a Landau singularity
- Summary

More data around 2.2 & 2.5GeV

Wenbiao Yan
For Tau-QCD group

Summary

- More data around 2.2 GeV
  - ✓ A very narrow resonance or $\Lambda\bar{\Lambda}$ threshold
  - ✓ 10 pb^{-1} data @ 2.222, 2.227, 2.242, 2.252GeV, about 20 days
- More data at 2.5GeV
  - ✓ Study diquark structure at baryon in e^+e^- collision
  - ✓ Mesure Σ form factor
  - ✓ threshold effect by Landau singularity
  - ✓ 100pb^{-1} @ 2.5GeV, about 22 days

Coll. Meeting in Summer of 2018

Data taking in 1.8–2.0 GeV?

Guangshun Huang
University of Science and Technology of China

BESIII
Nov.30,

Summary

- 1.8–2.0 GeV: never in 30-year BEPC/BES;
- Quite interesting, and feasible at BEPCII;
- R value: exclusive vs. inclusive;
- Proton form factors at threshold;
- Mystery behind NN threshold?
- 23 points, ~ 2-month beam time;
- Very rough plan, to be refined.

Coll. Meeting in Winter of 2018

Data around ΛΛ̄ & NN̄ threshold

Wenbiao Yan
For Tau-QCD gro

- More data around ΛΛ̄ th
  - ✓ @ 2.222, 2.227, 2.242
- Data around NN̄ threshol
  - ✓ @ [1.8, 2.0]GeV, abou
- Reduced 20% by Topup

Summary

- More data around ΛΛ̄ threshold
  - ☐ A very narrow resonance or ΛΛ̄ threshold
  - ☐ 10 pb^{-1} @ 2.222, 2.227, 2.242, 2.252GeV, about 20 days
  - ☐ Reduced 20% by Topup operation
- Data around NN̄ threshold [1.8, 2.0] GeV
  - ☐ BEPCII: feasible, need machine tuning
  - ☐ Total 23 points in 66 days
  - ☐ Reduced 20% by Topup operation
  - ☐ Physics motivation
    - ✓ Nucleon form factor
    - ✓ Sharp dip around nucleon threshold e.g. 6π
    - ✓ $J^{PC} = 1^-$ resonance: ρ*, ω* and ϕ*
    - ✓ R value: exclusive method vs. inclusive method

Coll. Meeting in Summer of 2019

R values, QCD and τ Physics

BESIII τ-QCD group

Internati
Sc

Data taking

- Use 20 fb^{-1} ψ(3770) & XYZ data by BESIII
  - ✓ JGU Mainz: ISR physics and gamma-gamma physics
- [1.8, 2.0] GeV, 23 points, total 96 pb^{-1} in 66 days
  - ✓ HIM + IHEP + USTC + others: R values, nucleon form factor, line-shape of exclusive modes
- Around 2.2324 GeV, 4 points, total 40 pb^{-1} in 17 days
  - ✓ INFN-LNF Frascati + USTC: ΛΛ̄ and ϕK$^+$K$^-$
- 100pb^{-1} @ 2.5 GeV + scan, 1+13 points, total 360 pb^{-1} in 86 days
  - ✓ IHEP + Uppsala + USTC + others: baryon form factor, line-shape of exclusive modes for resonances
- J/ψ scan, total 1000 pb^{-1} in 150 days:
  - ✓ INFN-LNF Frascati + others: phase
- τ mass: IHEP + JINR
- R values
  - ✓ IHEP + JGU Mainz + USTC

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International Review of BESIII white paper,2019

Data NN̄ threshold & 2.007 GeV

Wenbiao Yan
For Tau-QCD and New Physics group

- D
  - ✓
- D
  - ✓

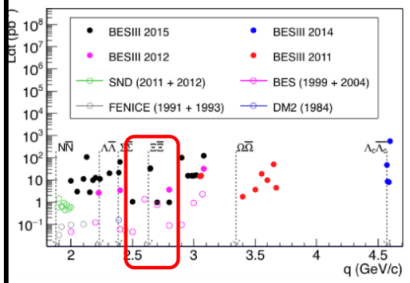
Summary

- Data around NN̄ threshold [1.8, 2.0] GeV
  - ☐ BEPCII: feasible, need machine tuning
  - ☐ Total 23 points in 66 days
  - ☐ Reduced 20% by Topup operation
  - ☐ Physics motivation
    - ✓ Nucleon form factor
    - ✓ Sharp dip around nucleon threshold e.g. 6π
    - ✓ $J^{PC} = 1^-$ resonance: ρ*, ω* and ϕ*
    - ✓ R value: exclusive method vs. inclusive method
- Data @ 2.007 GeV
  - ☐ With 50 pb^{-1} data at D^{*0} resonance energy, the UL of BF(D^{*0} -> e$^+$e$^-$) could reach 1.8×10^{-9}

Coll. meeting in Summer of 2020

Hunting for Vector States @ [2.42, 2.88] GeV

Wenbiao Yan (USTC)

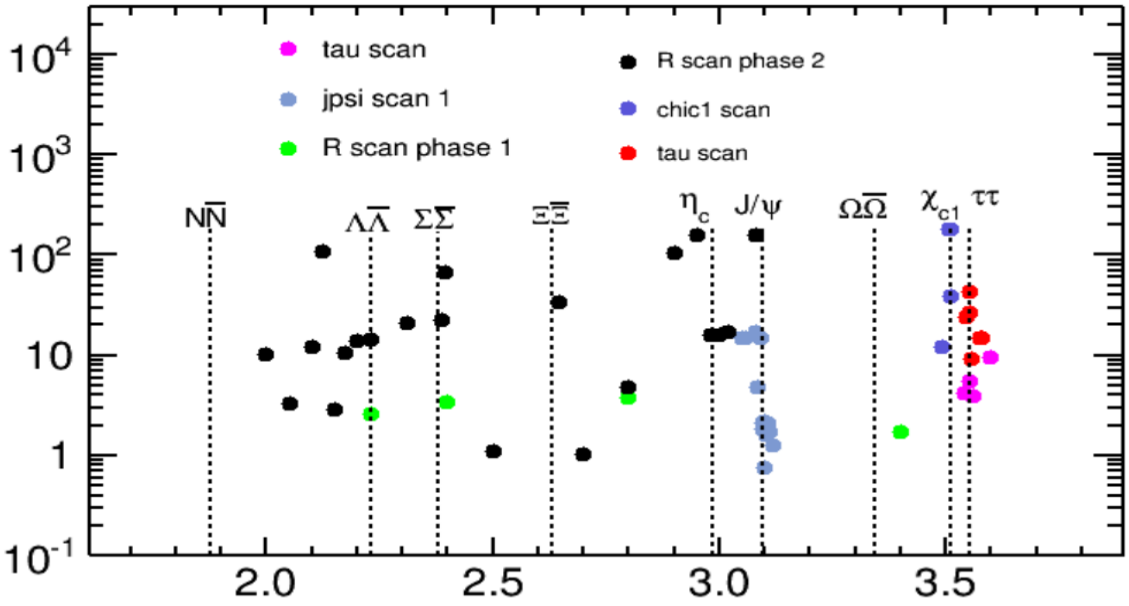


2.3864	2.3853	20	8.7	Hyp Threshold ($\Sigma^0\bar{\Sigma}^0$) Hyp FFs
2.3960	2.3949	≥64	27.8	Nucleon & Hyp FFs Hyp Threshold ($\Sigma^-\bar{\Sigma}^+$)
2.5		0.4895	8h	R scan
2.6444	2.6434	65	18	Nucleon & Hyp FFs Hyp Threshold ($\Xi^-\bar{\Xi}^+$)
2.7		0.5542	4.2h	R scan
2.8		0.6136	4h	R scan
2.9		100	18.5	Nucleon & Hyp FFs

- Data sets @ [2.42, 2.88] GeV
- (most) few hours data taking
  - ✓ Except 2.6444 GeV: 33.7 fb^{-1}
  - ✓ Except 2.6464 GeV: 34.0 fb^{-1}
- Study of vector states: missing

Coll. Meeting in Summer of 2021

Overview of the current data set



- **2011** tau scan: **11** days
- **2012** Jpsi phase scan: 3.05-3.10 GeV (**13** days)
- **2012** R scan phase 1: 2.2324, 2.4, 2.8, 3.4 GeV (**9** days)
- **2015** R scan phase 2: 21 points from 2.0 to 3.08 GeV (141231-150430, **120** days) + 2.125 GeV(150501-150620, **51**days)
- **2017** chic1 scan: 3.49-3.51 GeV (**23** days)
- **2018** tau scan: **20** days

247 days in total

Physics Results

which only use scan data below 3.773

- **Publications:**

1. *Tau mass measurement, Phys. Rev. D 90, 012001 (2014)*
2. *Proton FFs with R scan phase 1 data, Phys. Rev. D 91, 112004 (2015)*
3. *Threshold effect for Lambda Lambdabar, Phys. Rev. D 97, 032013 (2018)*
4. *Complete measurement of Lambda EMFFs, Phys. Rev. Lett. 123, 122003 (2019)*
5. *Proton EMFFs with scan technique, Phys. Rev. Lett. 124, 042001 (2020)*
6. *$\Sigma^{\pm}$ EMFFs, Phys. Lett. B 814, 136110 (2021)*
7. *Ξ^{-} EMFFs, Phys. Rev. D 103, 012005 (2021)*
8. *Ξ^{0} EMFFs, arXiv:2105.14657, submitted to PLB*
9. *Neutron EMFFs, arXiv:2103.12486, accepted by Nature Physics*
10. *$e^+e^- \to K^+K^-$, Phys. Rev. D 99, 032001 (2019)*
11. *$e^+e^- \to K^+K^+K^-K^-$ and ϕK^-K^-, Phys. Rev. D 100, 032009 (2019)*
12. *Partial wave analysis of $e^+e^- \to K^+K^+\pi^0\pi^0$, Phys. Rev. Lett. 124, 112001 (2020)*
13. *$e^+e^- \to \phi\eta'$, Phys. Rev. D 102, 012008 (2020)*
14. *$e^+e^- \to \omega\pi^0/\eta$, Phys. Lett. B 813, 136059 (2021)*
15. *$e^+e^- \to \eta'\pi\pi$, Phys. Rev. D 103, 072007 (2021)*
16. *$e^+e^- \to K_L K_S$, arXiv:2105.13597, submitted to PRD*
17. *$e^+e^- \to \phi\eta$, arXiv:2104.05549, accepted by PRD*
18. *Phase in $J/\psi \to \mu^+\mu^-$, 5π, $\eta\pi^+\pi^-$, Phys. Lett.B 791, 375-384 (2019)*
19. *Luminosity measurement for R scan, Chin. Phys. C 41, 063001 (2017)*

Physics Results

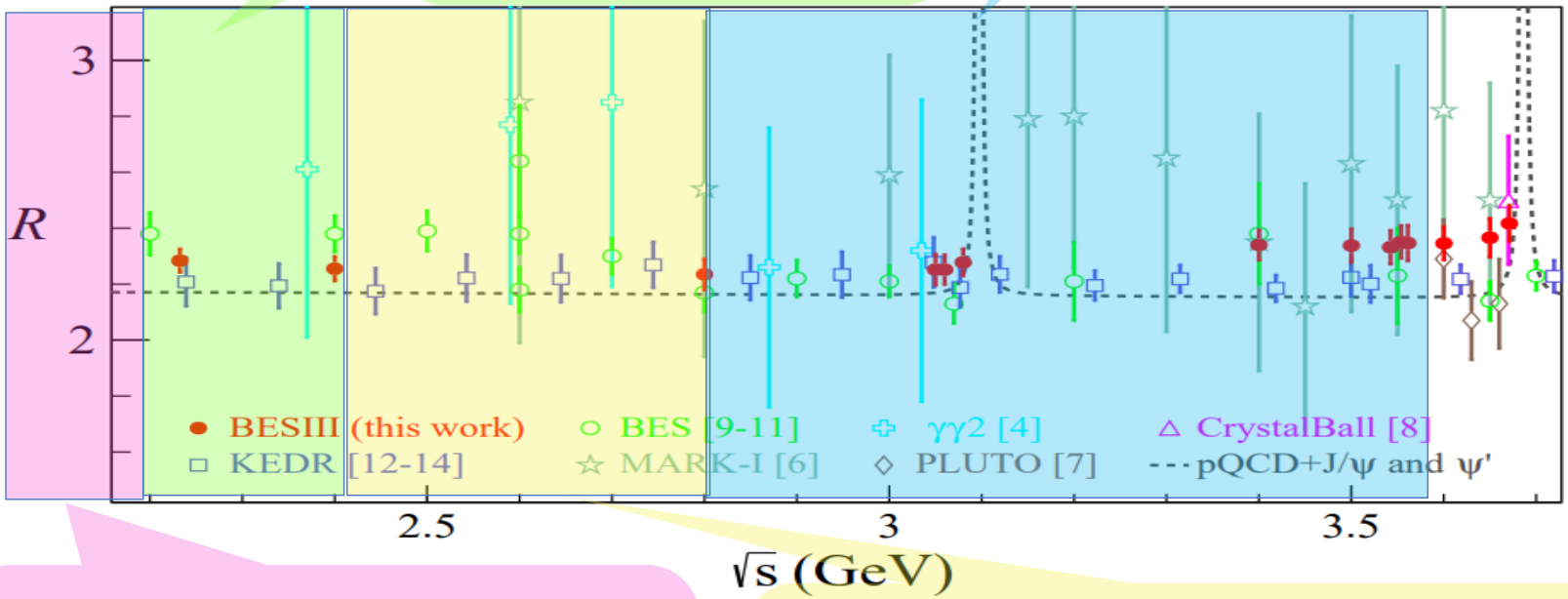
which only use scan data below 3.773

- **Analysis under review:**
  1. *Measurement of R values (BAM-00330, CWR)*
  2. *Σ^0 EMFFs (BAM-00441,CWR)*
  3. *$e^+e^- \to \phi\pi^0$ (BAM-00376,draft)*
  4. *$e^+e^- \to \eta_c$(BAM-00385)*
  5. *$e^+e^- \to \chi_{c1}$(BAM-00403, draft)*
  6. *$e^+e^- \to \phi\pi^+\pi^-$ (BAM-00417, PubComm)*
  7. *$e^+e^- \to \omega\pi^+\pi^-$ (BAM-00433, CWR)*
  8. *$e^+e^- \to \omega\pi^0\pi^0$ (BAM-00454, CWR)*
  9. *Phase in $J/\psi \to p\bar{p}$ decay (BAM-00106)*
  10. *J/ψ resonance parameter measurements (BAM-00268, Spokesperson approval)*
  11. *Fragmentation functions of Ks/pi0 (Convener Review)*
  12. *$e^+e^- \to \pi^+\pi^-\pi^0$ (Convener Review)*
  13. *Lambda Sigma cross section (Convener Review)*
  14. *Gam eta cross section (Convener Review)*
  15. *Lambda Lambda cross section and polarization (Convener Review)*
  16. *Omega Omega cross section (Convener Review)*
  17. *Two photon exchange in $e^+e^- \to p\bar{p}$(Convener Review)*

What physics results we expect

LamLam threshold
Structure in phiKK at LL
D* production
Exclusive processes

Phase in Jpsi, psip decay
Omega Omega cross section
Chic2 scan
Collins effect



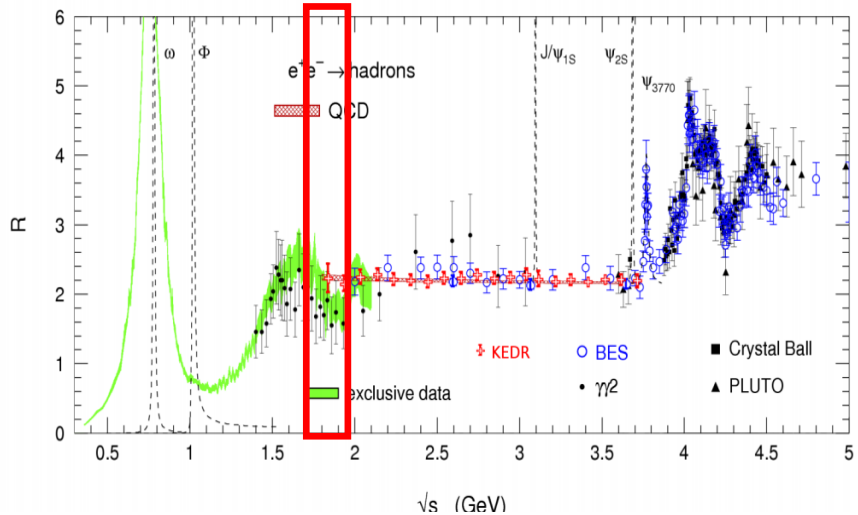
R value, Nucleon FFs at threshold
3(pi+pi-),kkpipi: sharp drop at NN thr.
Rho(1910), Phi(1D)

Partner of phi(2175)
Sssbarsbar candidate: Structure in phiKK omega3pi
Polarization of hyperons: Lambda, Sigma, Xi

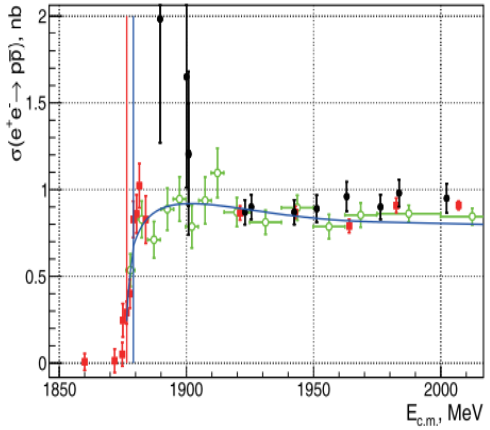
Data taking in 1.8-2.0 GeV

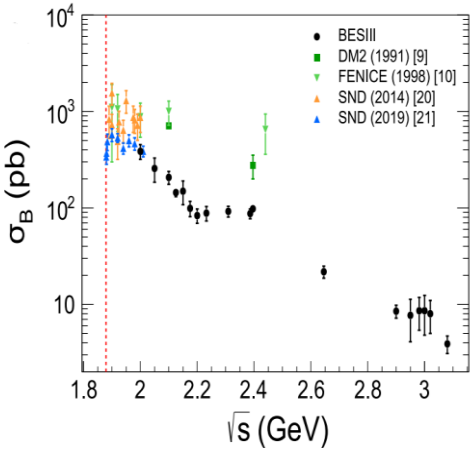
23 points, 96pb^{-1} , 2 months beam time

R value: both exclusive and inclusive

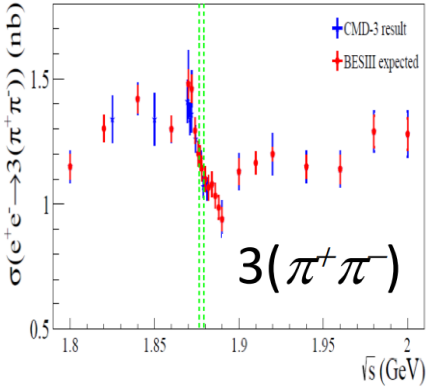


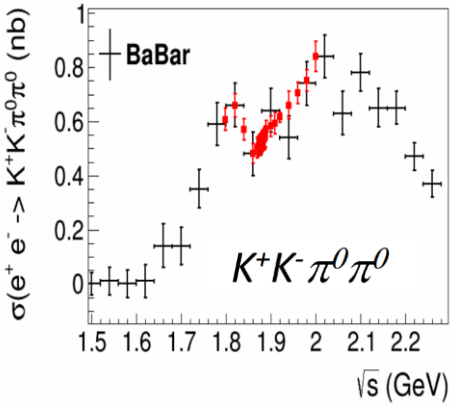
Nucleon FFs near threshold



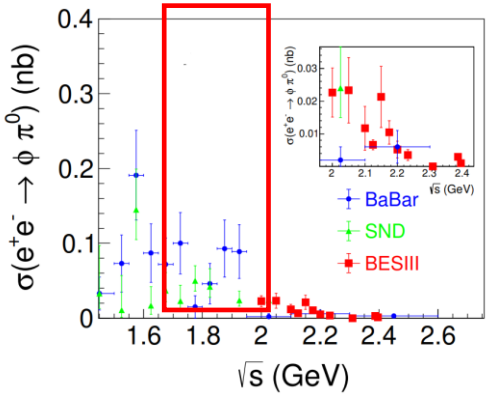


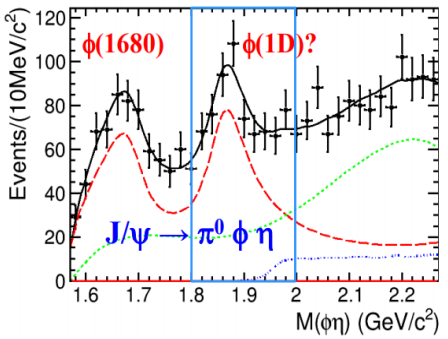
Structures at NN threshold





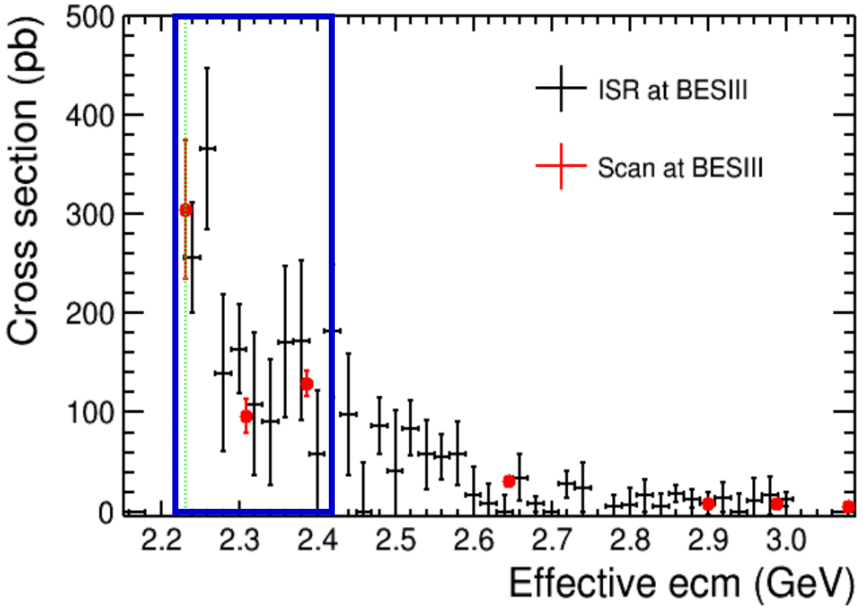
Vector states rho, phi …

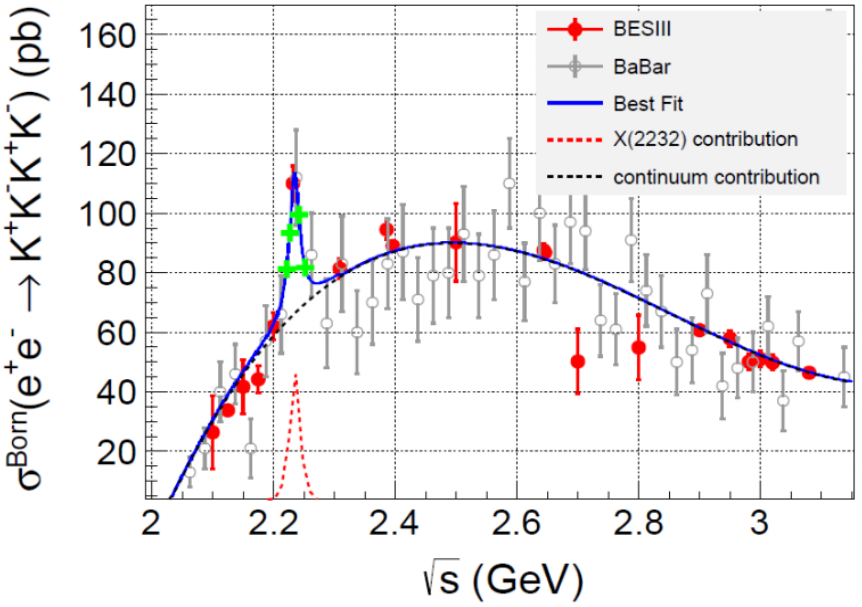




Data taking around 2.2324 GeV

4 points, 40pb^{-1}, 20 days



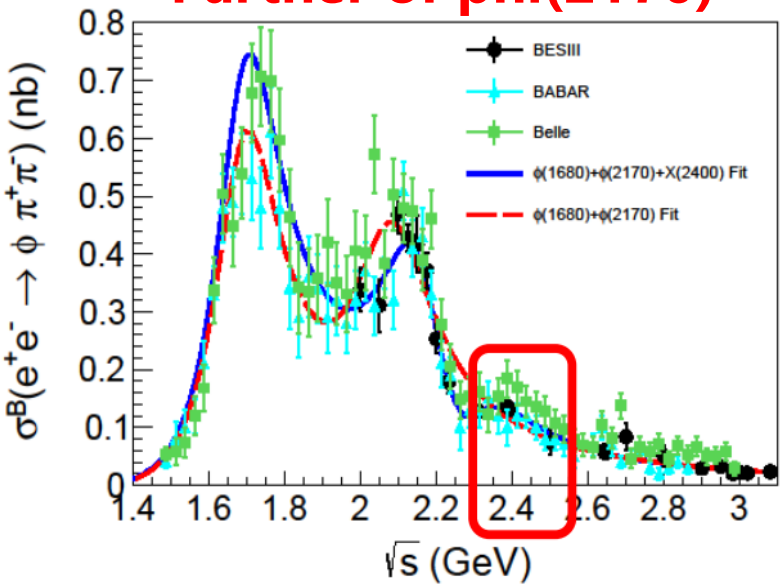


10 pb^{-1} data @ 2.222, 2.227, 2.242, 2.252GeV, about 20 days

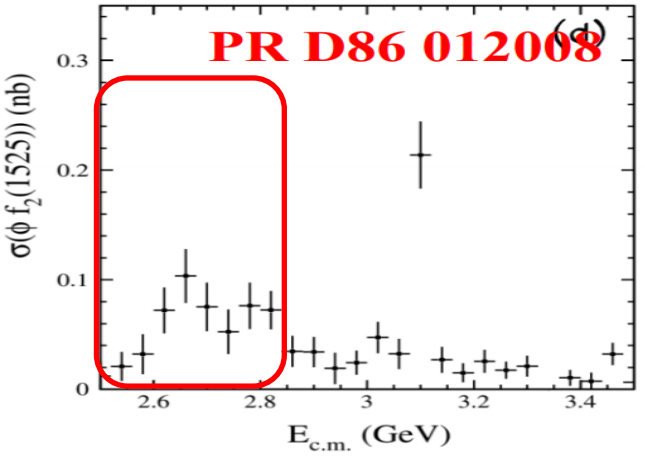
Data taking around 2.4-2.8 GeV

17 points, 340 pb^{-1}, 88 days

Partner of phi(2170)



$ss\bar{s}\bar{s}$ Candidate



- Data taking @ [2.56-2.88]GeV
- 9 points, 37 days in total

- Data taking @ [2.26-2.52]GeV: 8 points, 51 days in total

$\sqrt{s}$ (GeV)	2.26	2.34	2.42	2.44	2.46	2.48	2.50	2.52
Int. lumi.	20	20	20	20	20	20	20	20
Time(day)	8.4	7.3	6.4	6.2	6.0	5.8	5.6	5.5

$\sqrt{s}$ (GeV)	2.56	2.60	2.64	2.68	2.72
Int. lumi.	20	20	20	20	20
Time(day)	5.1	4.8	4.5	4.3	4.0
$\sqrt{s}$ (GeV)	2.76	2.80	2.84	2.88	
Int. lumi.	20	20	20	20	
Time(day)	3.8	3.6	3.4	3.2	

Data taking at 2.007 and 2.512 GeV

50 pb^{-1} data at D^{*0} resonance

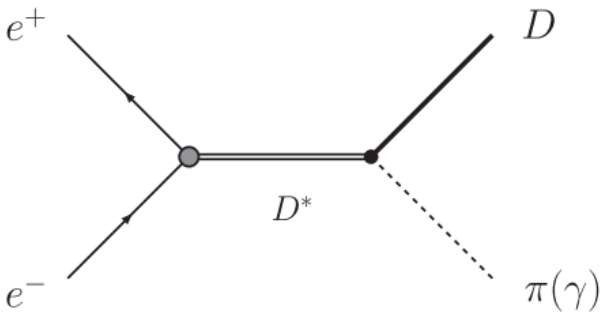


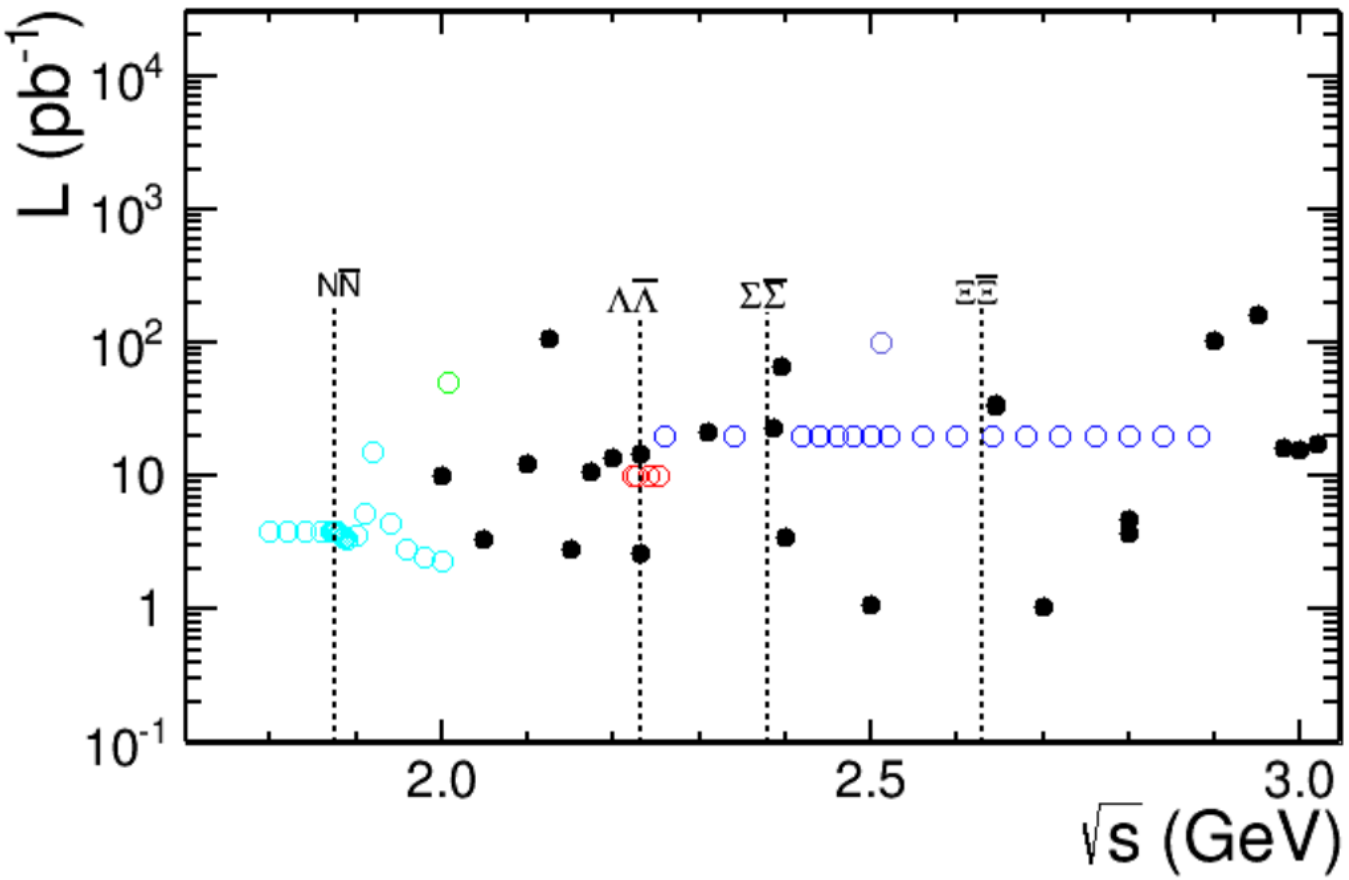
Fig. 6.3. Probing the $c\bar{u} \to e^+e^-$ vertex with $D^*(2007)^0$ resonant production in e^+e^- collisions.

- **Data @ 2.007 GeV**
  - **With 50 pb^{-1} data at D^{*0} resonance energy, the UL of BF(D^{*0} -> e$^+$e$^-$) could reach 1.8×10^{-9}**

100 pb^{-1} data at 2.512 GeV

Final state	σ (pb)	ε (%)	BR (%)	L (pb^{-1})	N_γ
$\Lambda\bar{\Sigma}^0$	30	20	0.64	100	380
$\bar{\Sigma}^0\Sigma^0$	20	15	0.64	100	190
$\Sigma^+\bar{\Sigma}-$	80*	16*	0.52	100	620

It would be possible to measure the ratio R for all three channels!


L (pb^{-1})
10^4
10^3
10^2
10
1
10^{-1}
$N\bar{N}$
$\Lambda\bar{\Lambda}$
$\Sigma\bar{\Sigma}$
$\Xi\bar{\Xi}$
2.0
2.5
3.0
$\sqrt{s}$ (GeV)

Some issues

From BEPCII accelerator team:

- July-Dec. 2024, Shutdown for Hardware Installation
- January 2025, Restart
- 2025-2028, Beam Commissioning (2.3-2.5 GeV)
- 2028-2030, Beam Commissioning (2.5-2.8 GeV)

From Spokesperson:

When you make your proposal, please use different phases, one is for 2-4 months, the other is for 4-6 months (in case machine is really can do top-up at highest beam current)

We need to optimize the data taking plan

(FOM = $N_{impacts}/N_{days}$?)

BEPCII-U vs BEPCII