



# BESIII Status and Prospects

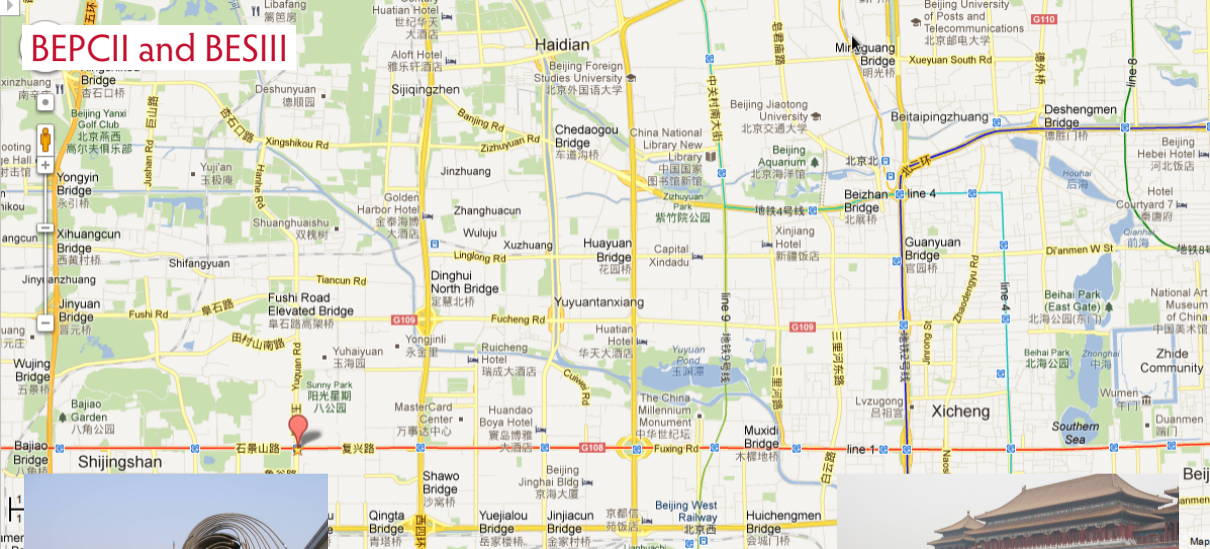
Wolfgang Gradl

JGU Mainz

PhiPsi26, Pisa

10<sup>th</sup> June 2026

# BEP CII and BES III



BEP CII and BES III

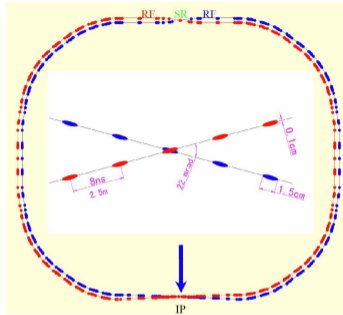
Linac

BES III

BSRF

Tiananmen 天安门 10km

# BEPCII storage rings: a $\tau$ -charm factory



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

Beam energy	1 ... 2.45 GeV
Optimum energy	1.89 GeV
Single beam current	0.91 A
Crossing angle	$\pm 11$ mrad

Design luminosity  $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$

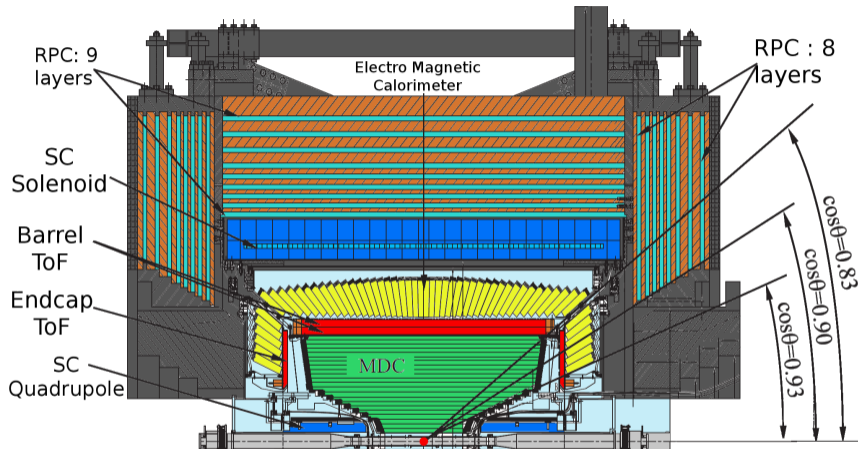
Achieved  $1.1 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$

Beam energy measurement:

Laser Compton backscattering

$$\Delta E/E \approx 5 \times 10^{-5}$$

( $\approx 50$  keV at  $\tau$  threshold)

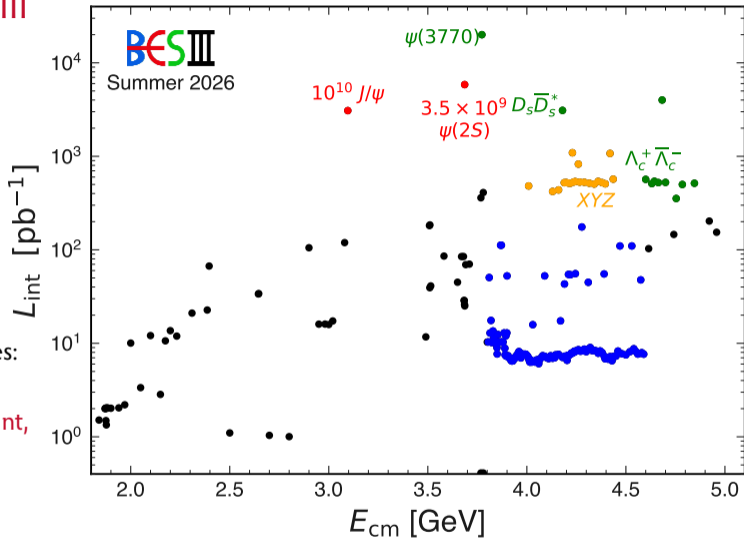


Extremely reliable operation of detector and readout electronics

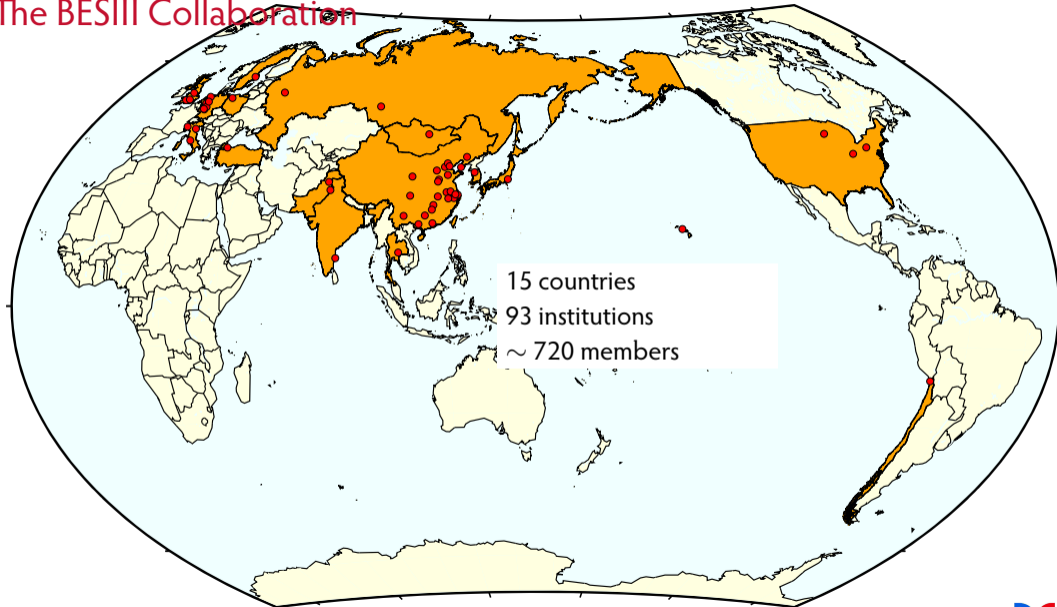
# 16 years data taking at BESIII

Data sets collected so far include

- $10 \times 10^9$   $J/\psi$  events
- $3.5 \times 10^9$   $\psi'$  events
- $20 \text{ fb}^{-1}$  on  $\psi(3770)$
- scan data between 1.8 and 3.08 GeV, and above 3.735 GeV
- large datasets for  $XYZ$  studies: scan with  $> 500 \text{ pb}^{-1}$  per energy point, spaced 10 – 20 MeV apart



# The BESIII Collaboration



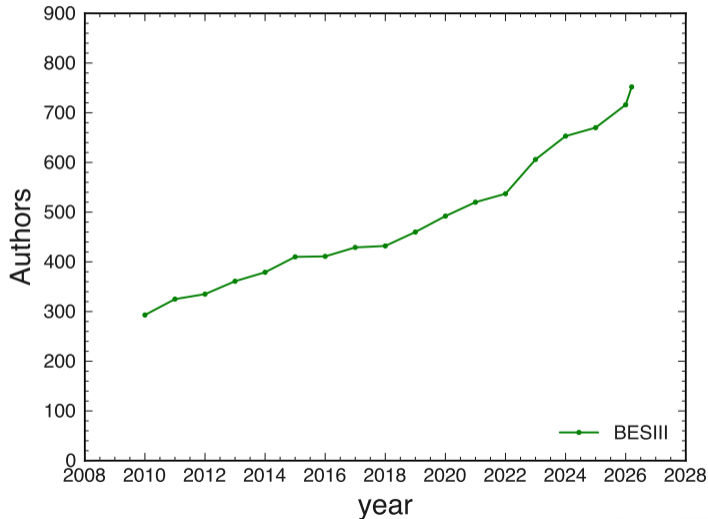
# Growth of collaboration

BESIII has grown a lot since the start of operation

2.6× number of institutions

2.4× number of authors

makes evolution of structures within collaboration essential





Recent results

## $J/\psi$ as source of hyperons

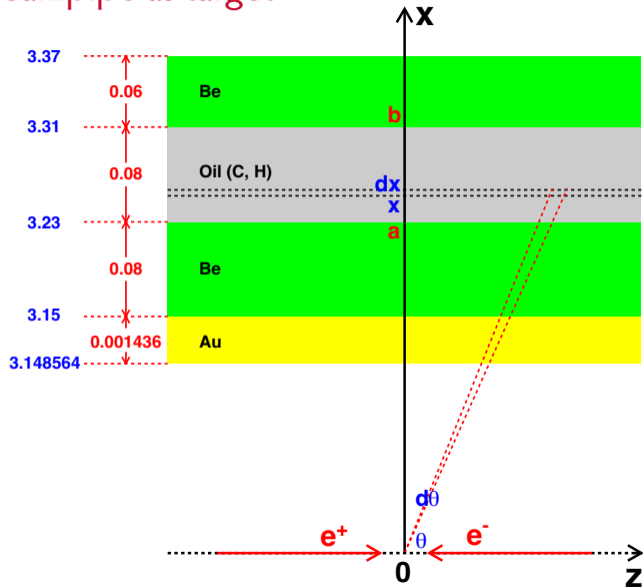
Decay mode	$\mathcal{B}$ [PDG]	$p$ / MeV
$\Lambda\bar{\Lambda}$	$(1.88 \pm 0.03) \times 10^{-3}$	1074
$\Sigma^+\bar{\Sigma}^-$	$(1.07 \pm 0.04) \times 10^{-3}$	992
$\Sigma^0\bar{\Sigma}^0$	$(1.172 \pm 0.032) \times 10^{-3}$	988
$\Xi^0\bar{\Xi}^0$	$(1.17 \pm 0.04) \times 10^{-3}$	818
$\Xi^-\bar{\Xi}^+$	$(9.7 \pm 0.8) \times 10^{-4}$	807

Use  $N_{J/\psi} = 1 \times 10^{10}$  as source of almost mono-energetic beams of hyperons and anti-hyperons  
three-body decays suppressed — possibility for next-generation facility with  $\geq 10^{12} J/\psi$  !

Analysis steps:

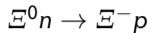
- Reconstruct one of  $Y$  or  $\bar{Y}$  in the event, use recoil mass to select two-body decays
- Select signal events by transverse position of interaction vertex in beam pipe (resolution not very good, but sufficient)

# Beampipe as target

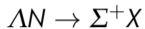


- Sandwich of Au, Be, Oil (C:H ~ 1:2.13)
- Located about 3 ··· 3.5 cm away from IP
- Take geometry into account (target thickness increases as  $\theta \rightarrow 0, \pi$ )

# YN reactions studied so far



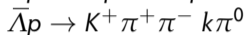
Phys. Rev. Lett. **130** (2023) 251902



Phys. Rev. C **109** (2024) L052201



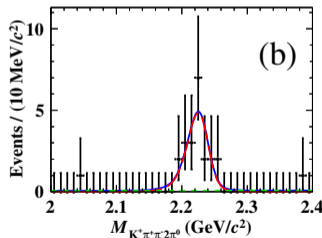
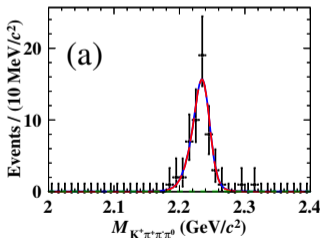
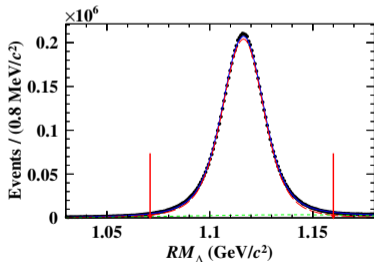
Phys. Rev. Lett. **132** (2024) 231902



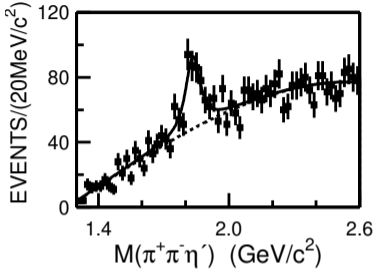
Phys. Rev. Lett. **136**, 171904

More details:  
Tao Luo / W. Wang,  
Thurs

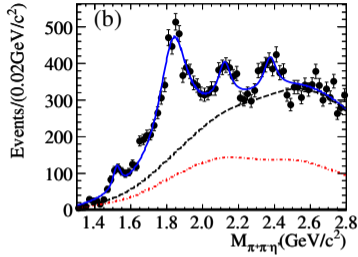
Small statistics for signal reactions, but very valuable measurements!



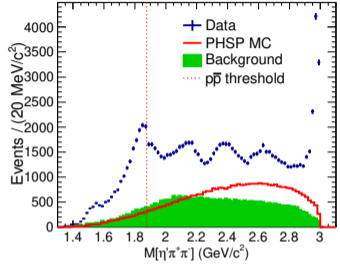
$$J/\psi \rightarrow \gamma \eta' \pi^+ \pi^-$$



$58 \times 10^6 J/\psi$  events  
 BES, PRL 95 (2005) 262001



$225.2 \times 10^6 J/\psi$  events  
 BESIII, PRL 106 (2011) 072002



$1090 \times 10^6 J/\psi$  events  
 BESIII, PRL 117 (2016) 042002

Structure just at or below  $p\bar{p}$  threshold:  $X(1835)$ , with non-trivial lineshape

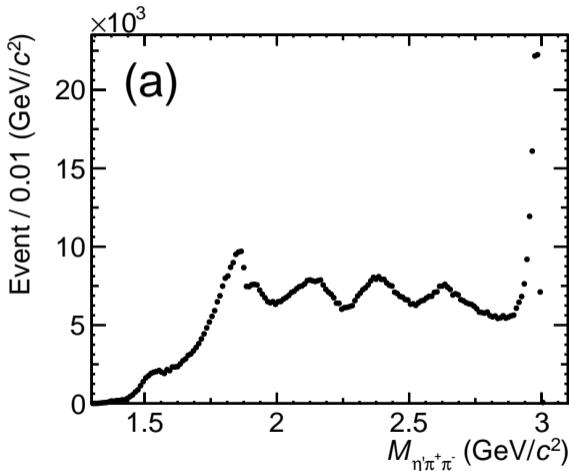
Additional structures visible with higher statistics:  $X(2120)$ ,  $X(2370)$

$$J/\psi \rightarrow \gamma \eta' \pi^+ \pi^-$$

$10\,087 \times 10^6 J/\psi$  events

Confirmation of  $X(1835)$ ,  $X(2120)$ , and  $X(2370)$  decays to  $\eta' \pi^+ \pi^-$

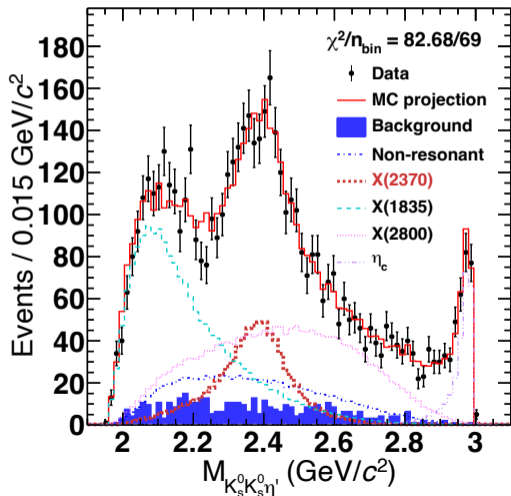
Determination of quantum numbers of these objects complicated by background from  $J/\psi \rightarrow \pi^0 \pi^+ \pi^- \eta'$



$$X(2370) \rightarrow K_S^0 K_S^0 \eta'$$

Restrict  $K_S^0 K_S^0$  system to  $f_0(980)$  region:

$$M_{KK} < 1.1 \text{ GeV}$$



$X(2370)$  also seen in  $J/\psi \rightarrow K\bar{K}\eta'$

BESIII Eur. Phys. J. C 80, 746 (2020)

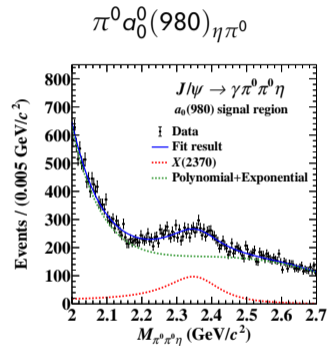
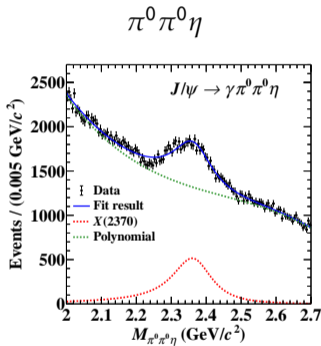
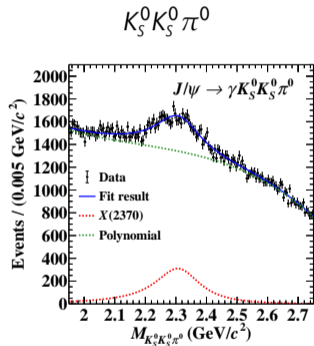
C parity and exchange symmetry forbid  $\pi^0 K_S^0 K_S^0 \eta'$ : reduced backgrounds

can perform PWA to determine  $J^{PC}$  of  $X(2370)$

Result:  $0^{-+}$  by far most preferred assignment

# New decay modes of $X(2370)$

$X(2370)$  seen with roughly compatible mass and width in other decay channels:



also suggestive of similar signal strength

# $X(2370)$ : candidate for pseudoscalar glueball?

## YES?

- Seen to decay into 3 pseudoscalar mesons:  $\pi\pi\eta'$ ,  $\pi\pi\eta$ ,  $K\bar{K}\eta'$ ,  $K\bar{K}\eta$ ,  $K\bar{K}\pi^0$ , not dominated by one single mode  
individual partial widths hint at OZI forbidden decays
- Mass and width agree well with recent LQCD calculations for  $0^{-+}$  glueball

## NO?

- Branching fraction  $J/\psi \rightarrow \gamma X(2370)$  seems to be too large by an order of magnitude  
[Sun et al. PRD 105 \(2022\) 034010](#)
- More quantitative comparison of different decays desirable

Need to search for and study more decay modes,  
esp. absence in  $K^*K$  (see e.g. [Lipkin, Phys. Lett. B 109 \(1982\) 326](#))

More details:  
Emma Di Fiore,  
Thurs

Not sufficient to search for peaks ...



... but need to measure what they do!



## BESIII results at PhiPsi2026

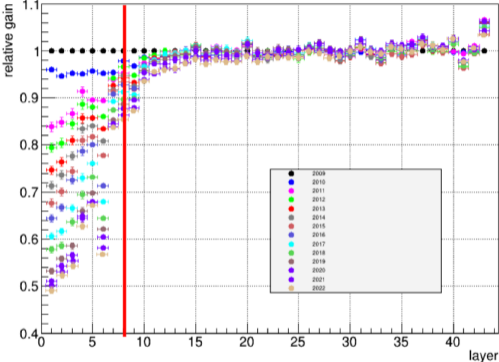
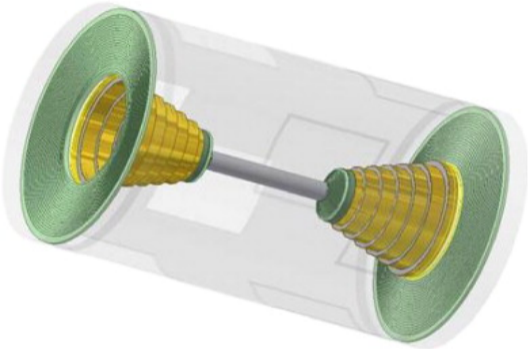
Wang Weiping	Inclusive $R$ measurements	Mon
Qin Xiaoshuai	Search for dark sector at BESIII	Tues
Isabella Garzia	Fragmentation Function Studies	Wed
Liu Kailu	Light Meson Decays	Wed
Francesca De Mori	Relative phase between strong and e.m. decays	Wed
Max Lellmann	EM TFF in two-photon collisions	Wed
Jing Maoqiang	Charmonium-like states in hidden-charm production	Wed
Andrzej Kupsc	Spin effects in baryon-antibaryon pair production	Thurs
Wang Weiping / Tao Luo	Hyperon physics	Thurs
Song Hailin	Baryon EMFF	Thurs
Guo Yuping	Exotic hadron studies	Thurs
Emma Di Fiore	Light exotics	Thurs
Yan Yueqiang	$\eta_c(1S)$ decays	Thurs
Li Xiaokang	Search for rare charm decays	Thurs
Qin Xiaoshuai	Status of Super-Tau Charm Facility	Thurs



Upgrades

# Upgrade of inner tracking system: GCEM-IT

Inner part of drift chamber showed ageing after a few years of operation



Drop in efficiency  $\approx 4\%$  per year

# CGEM Construction and installation

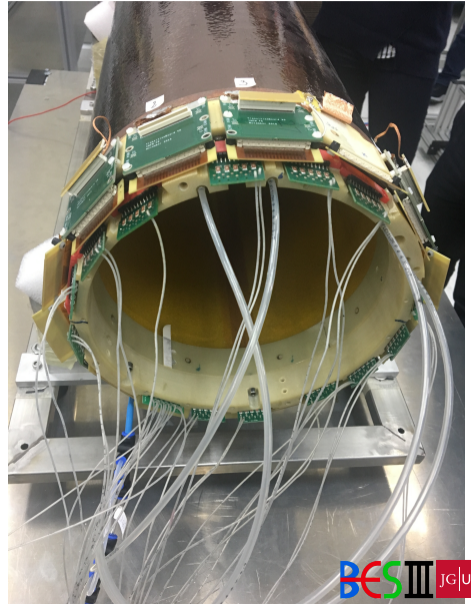
**CGEM:** replace inner drift chamber  
three layers of cylindrical GEM detectors.

Radiation hard, efficient, fast, better hit resolution along  
beam direction.

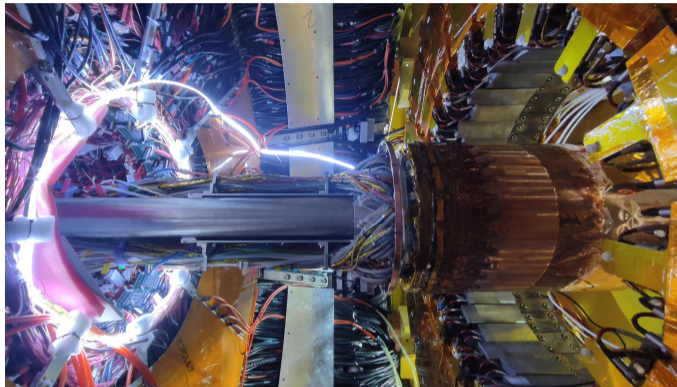
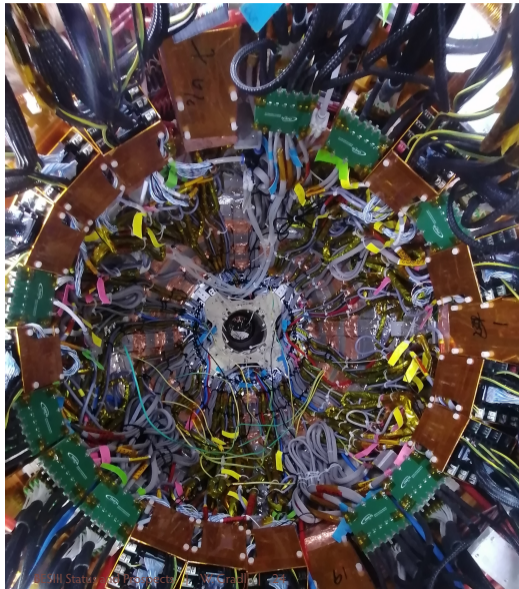
Italy/INFN, with strong support of IHEP,  
Germany, and Sweden.

Improvements w.r.t. KLOE CGEM detector:

- Improved anode design
- Analogue readout (new ASIC, designed in Torino)
- Micro-TPC reconstruction: get coordinates and  
direction of track layer-by-layer  
(yet to be fully implemented and calibrated)



# CGEM installation in Autumn 2024



Most critical step: unglue and remove inner part of drift chamber **without destroying remaining, outer MDC**

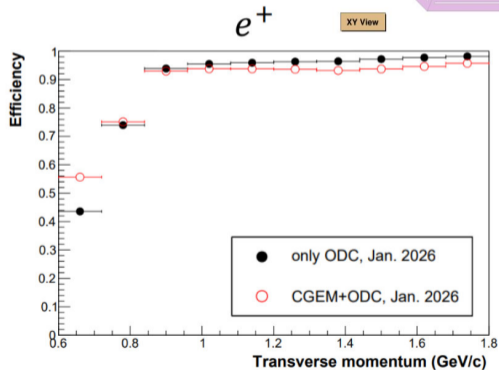
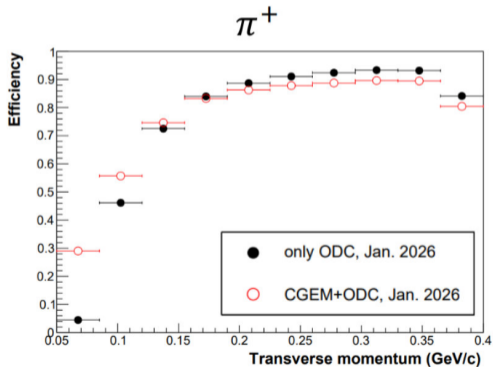
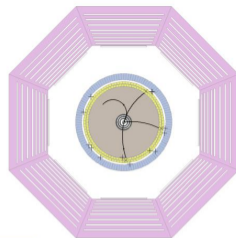
successfully accomplished

# First performance results: tracking efficiency

HV Training of GEM, first alignment with beam data, ...

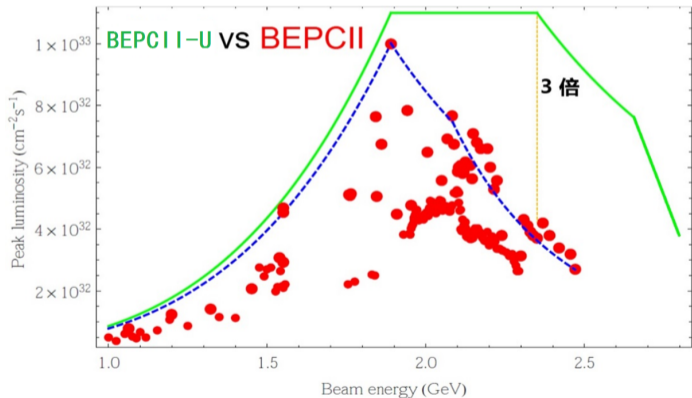
$\mu$ TPC mode not yet implemented. Expect significant improvement.

First results very encouraging.

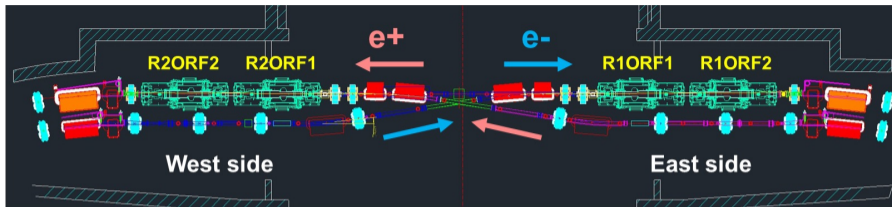


# Accelerator upgrade: BEPCII-U

- **Goal:** improve luminosity at large  $\sqrt{s}$
- **Upgrade path:** install more RF power, optimize machine lattice
- **Bonus:** running above  $\sqrt{s} \sim 5$  GeV becomes feasible



# BEPCII-U: 2 RF cavities per ring



<b>R2ORF2</b>
<b>MHI East cavity</b> (2006-2017)

<b>R2ORF2</b>
<b>MHI West cavity</b> (2006-2024) (FPC exch. 2015)

<b>R1ORF1</b>
<b>BII-U cavity</b> (Fab. 2024)

<b>R1ORF2</b>
<b>Spare cavity</b> (2017-2024) (FPC exch. 2018)



**Online > 2 Months  
(Smooth)**



# Accelerator upgrade: BEPCII-U

Additional upgrades:

- Improved feedback systems
- Power supplies and cooling for magnets, to support running at higher  $\sqrt{s}$
- Automated switching from  $e^-$  to  $e^+$  in accelerator chain, for top-up injection ( $\mathcal{L}_{\text{int}} + 30\%$ )

Current state: all upgrades in place and commissioned

Achieved peak luminosities so far:

---

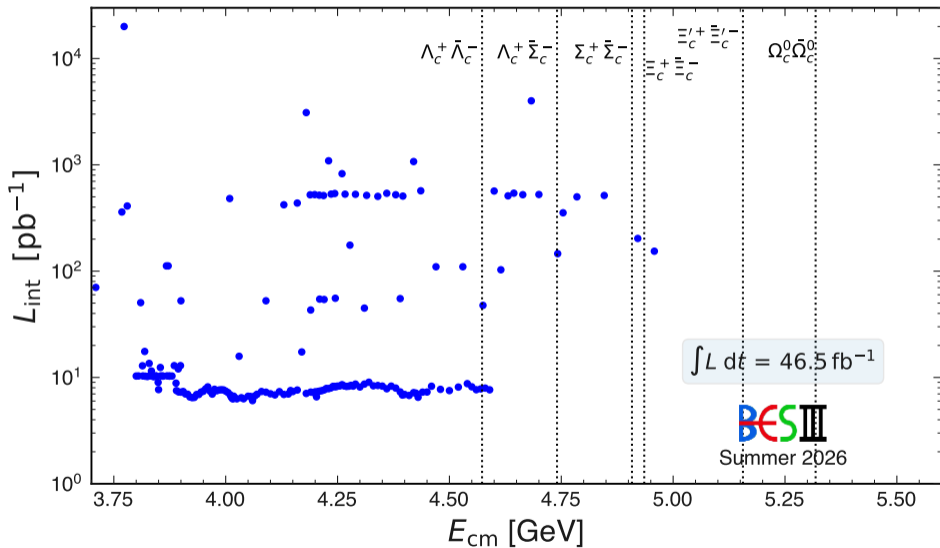
$\sqrt{s}$ [GeV]	$\mathcal{L}_{\text{peak}}$ [ $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$ ]	
3.686	1.05	exceeding design of BEPCII
4.68	1.06	reached $3 \times$ pre-upgrade value!

---

Some minor issues open (e.g. feedback system, HV training of cavity), but upgrade goal achieved!

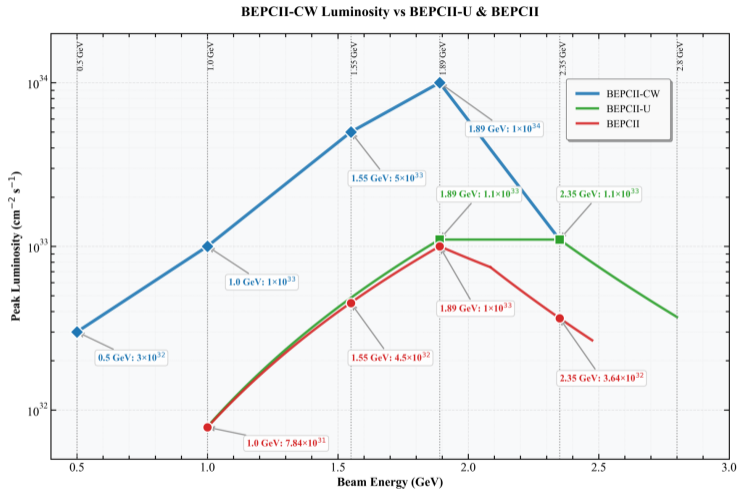
Running at highest energy to be demonstrated

# BEPcII-U: increased reach at high $\sqrt{s}$





# BEPCII-CW optimistic luminosity projection



operation at low  $\sqrt{s}$ ! Impact on detector under study.

# Summary



# Summary

- BESIII's large and clean data sets allow studies in wide variety of topics:  
spectroscopy with light and charmonium(-like) states, hyperon interactions,  
open charm physics ...  
precision measurements of hadronic cross sections,  $R$
- Looking into the future:  
Energy upgrade for BESIII up to 5.6 GeV now in operation  
Future upgrade BEPCII-CW under study
- Detector allows extremely reliable and stable data taking
- Operation until 2030, and beyond?

# Summary

- BESIII's large and clean data sets allow studies in wide variety of topics: spectroscopy with light and charmonium(-like) states, hyperon interactions, open charm physics ...  
precision measurements of hadronic cross sections,  $R$
- Looking into the future:  
Energy upgrade for BESIII up to 5.6 GeV now in operation  
Future upgrade BEPCII-CW under study
- Detector allows extremely reliable and stable data taking
- Operation until 2030, and beyond?

謝

謝

!