超级陶粲装置
Super Tau-Charm Facility

Study of hyperon CPV and EDM at STCF

Mingyu Yu[3], *Jianyu Zhang[1]*, *Yue Xu[2]*, *Xingtao Huang[3]*, *Jinlin Fu[1]*, *Liang Yan[2]*

University of Chinese Academy of Sciences[1]
Fudan University[2]
Shandong University[3]

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01 Motivation

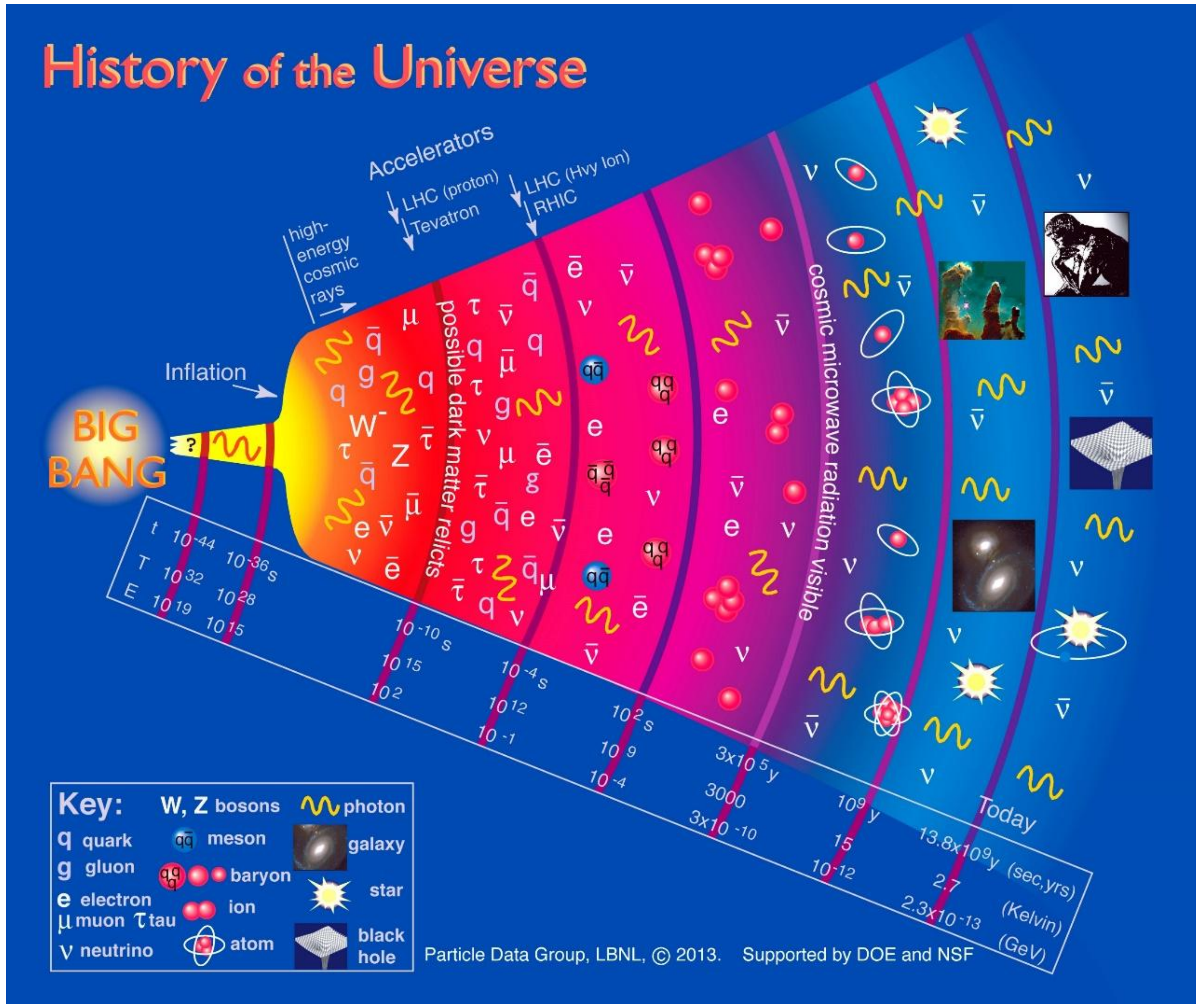
part one

01 Matter-Antimatter Asymmetry

➢ Astronomical observations find big matter and anti-matter asymmetry in the universe!

WMAP+COBE(2012):

$$(n_B - n_{\bar{B}})/n_\gamma|_{CMB} = (6.08 \pm 0.09) \times 10^{-10}$$



➢ Sakharov three conditions require:

- Baryon number violation
- **C and CP symmetry violation**
- Thermal equilibrium violation

01 Limitation of SM & Asymmetry Parameters

- CP violation is described by the CKM matrix phase in Standard Model(SM)
  - CP violation(CPV) has been observed in K, B, D meson systems and Λ_b^0 baryon system,consistent with SM predictions ------confirming the accuracy of SM
  - But CPV in SM is insufficient to explain the asymmetry

$$SM\ prediction: \widehat{d}_{CP} = \frac{d_{CP}}{D^{12}} \sim 10^{-18} \ll 10^{-10}$$

Exploring new mechanisms of CPV is extremely important

Understanding Matter-Antimatter Asymmetry

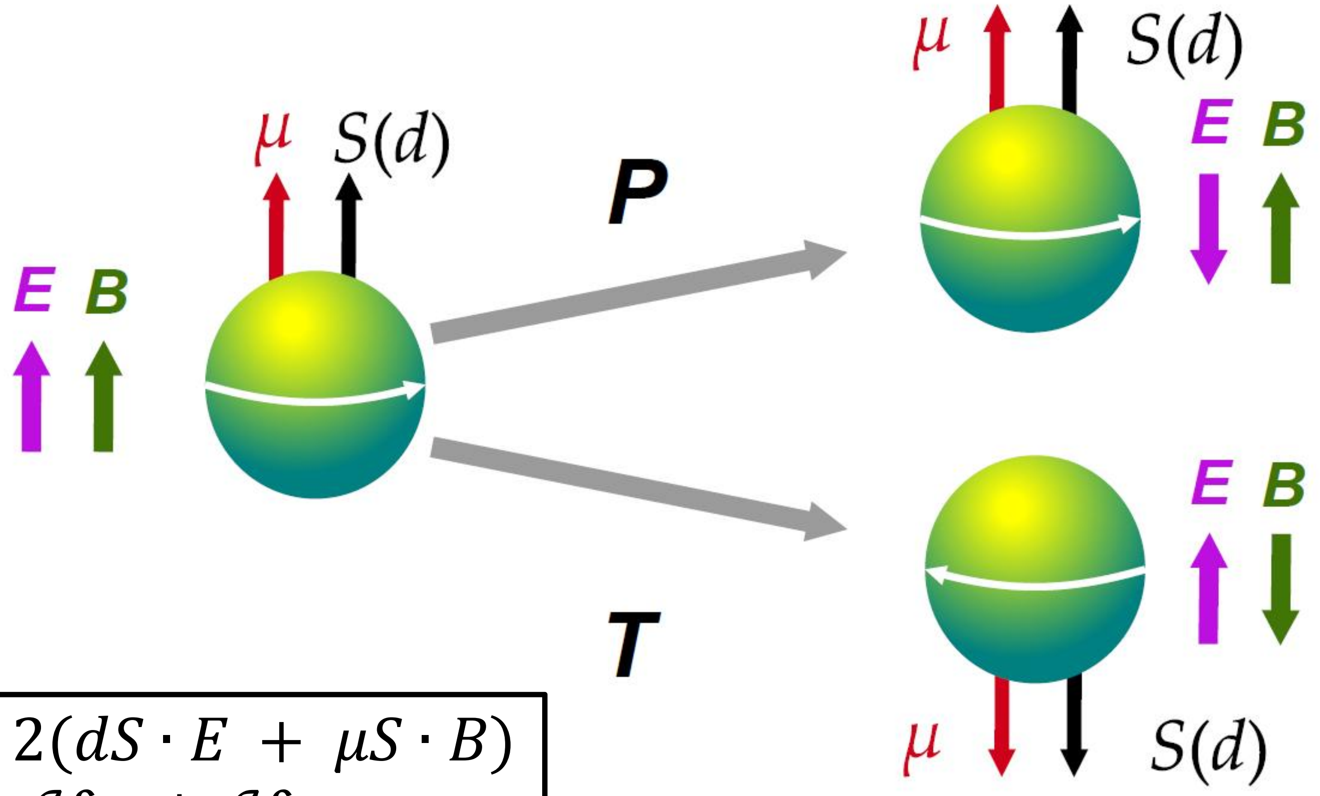
Discovering new physics beyond the SM

- Hyperon decay asymmetry parameters used to test CPV

$$\alpha = \frac{2Re(A_S^* \cdot A_p)}{|A_S|^2 + |A_P|^2} \qquad \frac{dN}{d\Omega} \propto 1 + \alpha \overrightarrow{P_Y} \cdot \hat{p}_d \qquad A_{cp} = \frac{\alpha + \bar{\alpha}}{\alpha - \bar{\alpha}} \quad (A_{cp} = 0, \text{if CP } conservation)$$

01 Electric Dipole Moments (EDM)

$$\mathcal{H} = -2(dS\cdot(-E) + \mu S\cdot B) = -\mathcal{H}_d + \mathcal{H}_\mu$$



$$\mathcal{H} = -2(dS\cdot E + \mu S\cdot B) = \mathcal{H}_d + \mathcal{H}_\mu$$

$$\mathcal{H} = -2(d(-S)\cdot E + \mu(-S)\cdot(-B)) = -\mathcal{H}_d + \mathcal{H}_\mu$$

$\boldsymbol{\mu}$**:Magnetic Dipole Moment**
$\boldsymbol{d}$**:Electric Dipole Moment**

B:Magnetic Field
E:Electric Field

- Non-zero EDM will violate P and T symmetry:
  - T violation ↔ CP violation, if CPT holds.

EDM holds significant importance for research into CPV.

Electric Dipole Moments (EDM)

➢ The contribution of the Standard Model to EDM is very small

Very sensitive to BSM physics, large windows of opportunity to observe New Physics!

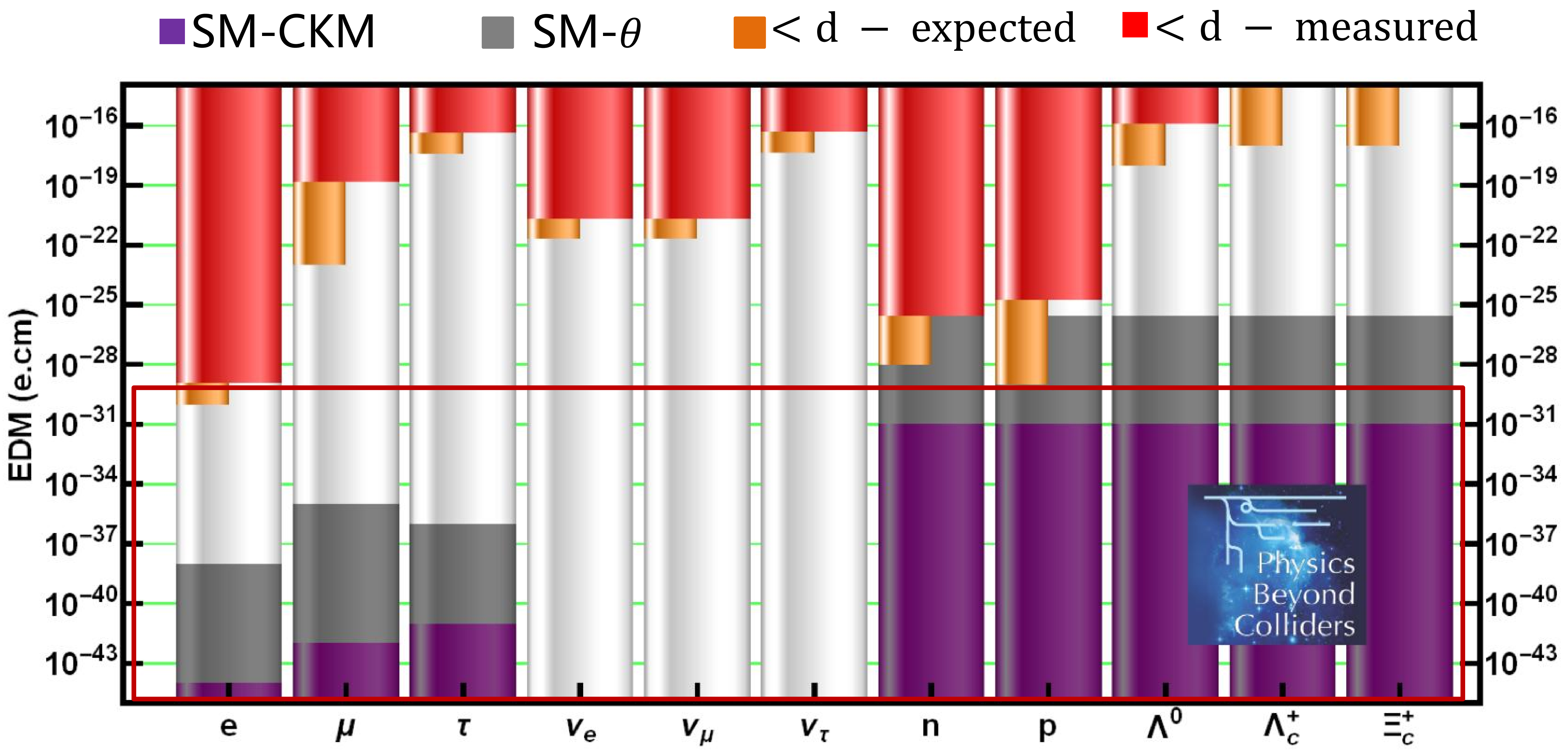


Figure.The precision of EDM for different particles

J.Phys.G 47 (2020) 1, 010501

01 BESIII Results

- Hyperon non-leptonic two-body decays provide a valuable opportunity to study CPV
  - Quantum correlation effects in hyperon pairs greatly enhances measurement sensitivity
  - Low background

- Systematic studies of hyperon EDM are crucial
  - In the field of hyperons,only the EDM of Λ has been measured with a relatively large uncertainty

- BESIII Results

Based on 10 billion J/ψ events,BESIII has obtained results for A_{cp} and EDM of Λ

Phys. Rev. Lett.129, 131801

$$A_{cp} = -0.0025 \pm 0.0046 \pm 0.0012 \qquad (SM: O(10^{-5}))$$

arXiv:2506.19180

$$Re(d_\Lambda) = (-3.1 \pm 3.2 \pm 0.5) \times 10^{-19} e\ cm$$
$$Im(d_\Lambda) = (2.9 \pm 2.6 \pm 0.6) \times 10^{-19} e\ cm$$

01 STCF(Super Tau-Charm Facility)

➢ Proposal of STCF

A next-generation electron-positron collider STCF will operate in the transition region between perturbative and non-perturbative QCD,offering a rich array of physics topics.

STCF	BesIII
peak luminosity: $0.5 \times 10^{35} cm^{-2}s^{-1}$	peak luminosity: $1 \times 10^{33} cm^{-2}s^{-1}$
center-of-mass energy: $2 \sim 7Gev$	center-of-mass energy: $2 \sim 4.6Gev$

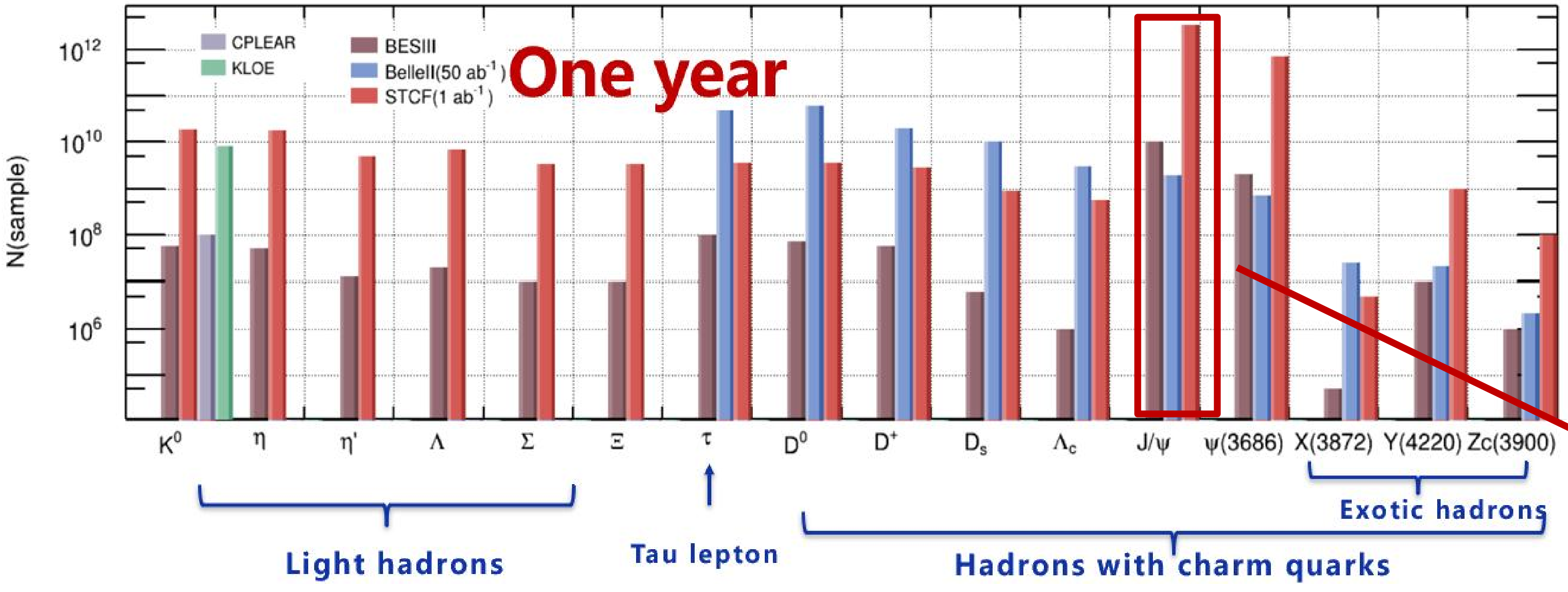


Figure.Expected Data Production at STCF

3.4×10^{12} J/ψ →Enable more precise tests

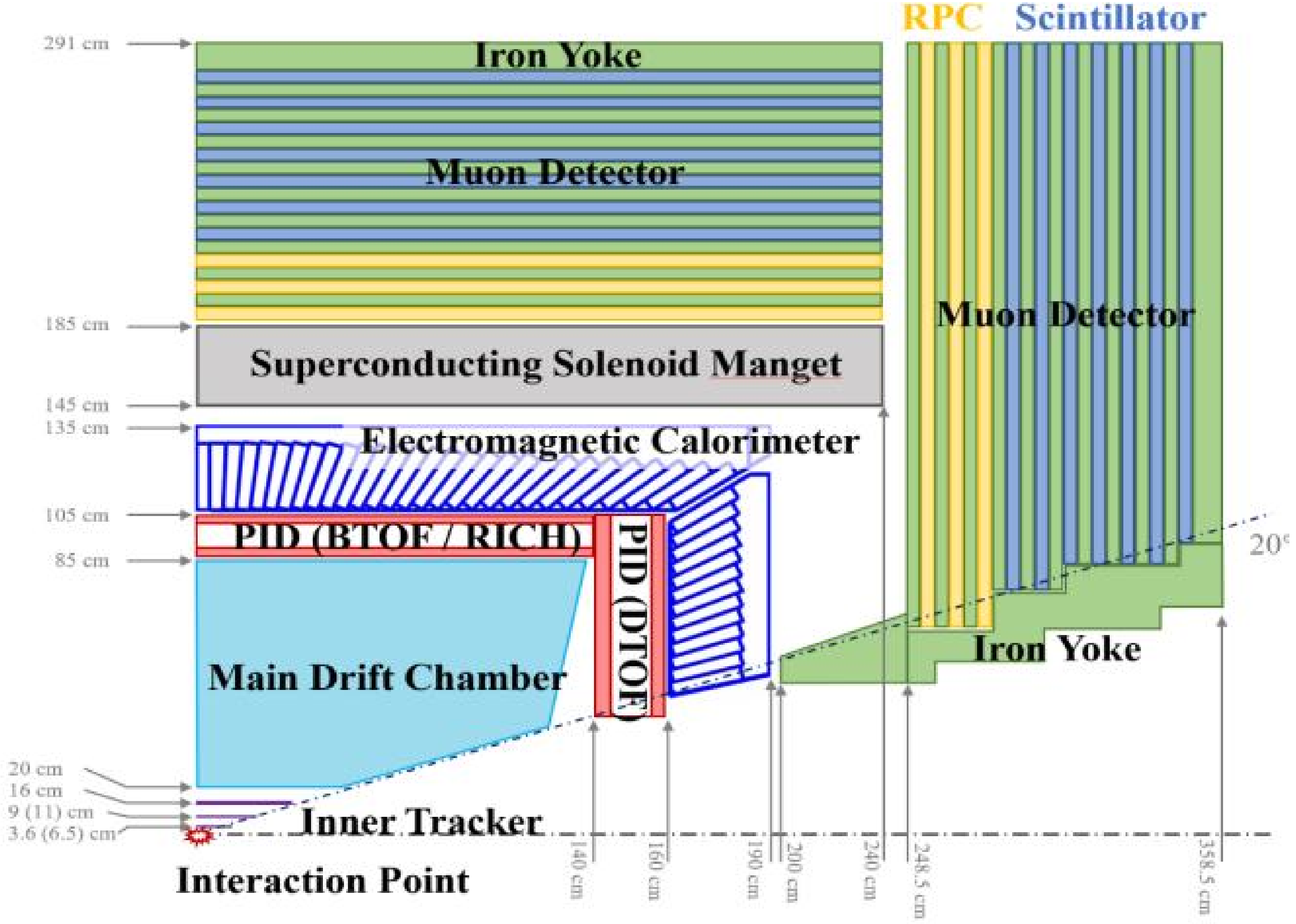


Figure. SuperTau-Charm Facility, STCF

01 Study of hyperon CPV and EDM at STCF

- Follow the method of BESIII

  Full Angular Analysis Method

Processes	Contributors	Extract Parameters
$J/\psi \to \Lambda\bar{\Lambda}$	Mingyu Yu,Jianyu Zhang	A_{cp} , EDM
$J/\psi \to \Xi^{+}\bar{\Xi}^{-}$	Yue Xu	A_{cp}

- Expect to improve the precision of A_{cp} and EDM by one order of magnitude

STCF	vs	BESIII
$A_{cp}\sim10^{-4}$ EDM~10^{-20}		$A_{cp}\sim10^{-3}$ EDM~10^{-19}
10^{12} J/ψ		10^{10} J/ψ

02 Formalism & MC production

part two

02 Formalism — $J/\psi \to \Lambda\bar{\Lambda}$

➤ Full angular distribution based on Helicity Amplitude

PhysRevD.108.L091301

$$\frac{d\sigma}{d\Omega_k d\Omega_p d\Omega_{\bar{p}}} = N \sum_{[\lambda]} R(\lambda_1, \lambda_2; \lambda_1', \lambda_2') \times$$

$$D^{j=1/2}_{\lambda_1,\lambda_p}(\theta_1,\phi_1) D^{*j=1/2}_{\lambda_1',\lambda_p}(\theta_1,\phi_1) \left|h_{\lambda_p}\right|^2 D^{j=1/2}_{\lambda_2,\lambda_{\bar{p}}}(\theta_2,\phi_2) D^{*j=1/2}_{\lambda_2',\lambda_{\bar{p}}}(\theta_2,\phi_2) \left|h_{\lambda_{\bar{p}}}\right|^2$$

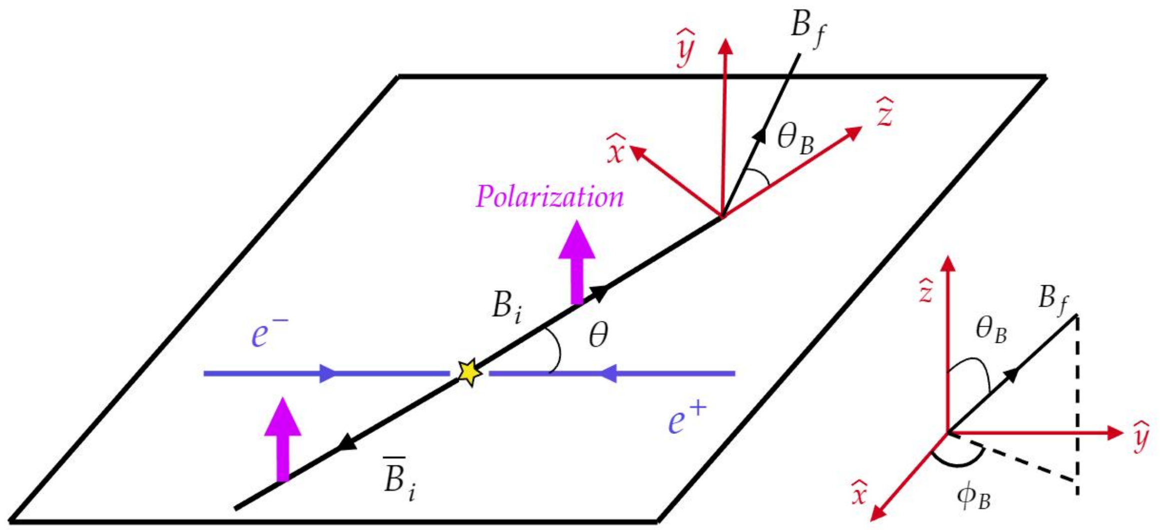
- Helicity angles: $\xi(\theta, \theta_1, \phi_1, \theta_2, \phi_2)$
- Parameters:

$\vec{\lambda} = (Re(G_2), Im(G_2), P_L, Re(F_A), Im(F_A), Re(H_T), Im(H_T), \alpha_\Lambda, \alpha_{\bar{\Lambda}})$

- Spin density matrix of baryon pair $B\bar{B}$

$$R(\lambda_1, \lambda_2; \lambda_1', \lambda_2') \propto \sum_{m,m'} \rho_{m,m'} d^{j=1}_{m,\lambda_1-\lambda_2}(\theta) d^{j=1}_{m',\lambda_1'-\lambda_2'}(\theta) \boxed{\mathcal{M}_{\lambda_1,\lambda_2} \mathcal{M}^*_{\lambda_1',\lambda_2'}} \delta_{m,m'}$$

Phys.Lett.B 839 (2023) 137834



Helicity amplitude in $J/\psi \to B\bar{B}$: $\mathcal{M}(\lambda_1, \lambda_2) = \epsilon_\mu(\lambda)\bar{u}(\lambda_1)\left(F_V\gamma^\mu + \frac{i}{2M_\Lambda}\sigma^{\mu\nu}q_\nu H_\sigma + \gamma^\mu\gamma^5 F_A + \sigma^{\mu\nu}\gamma^5 q_\nu H_T\right)v(\lambda_2)$

Dominant contribution

F_V: *Pauli* form factor
H_σ: *Dirac* form factor
can also be represented as G_1 and G_2

Associated to $\alpha_{J/\psi}, \Delta\Phi$

F_A:P violation term

Complex form factor, $F_A \neq 0$ indicate P violation

H_T : CP violation term

$$H_T(q^2) = \frac{2e}{3m^2_{J/\psi}} g_V d_B(q^2)$$

Assuming $d_B(q^2) \equiv d_B(0)$
$d_B(q^2)$: electric dipole form factor
$d_B(0)$: electric dipole moment

Physics Letters B 551 (2003) 16–26

02 Formalism — $J/\psi \to \Xi^{+}\bar{\Xi}^{-}$

➢ Joint angular distribution:

Phys. Rev. D 99, 056008 (2019)

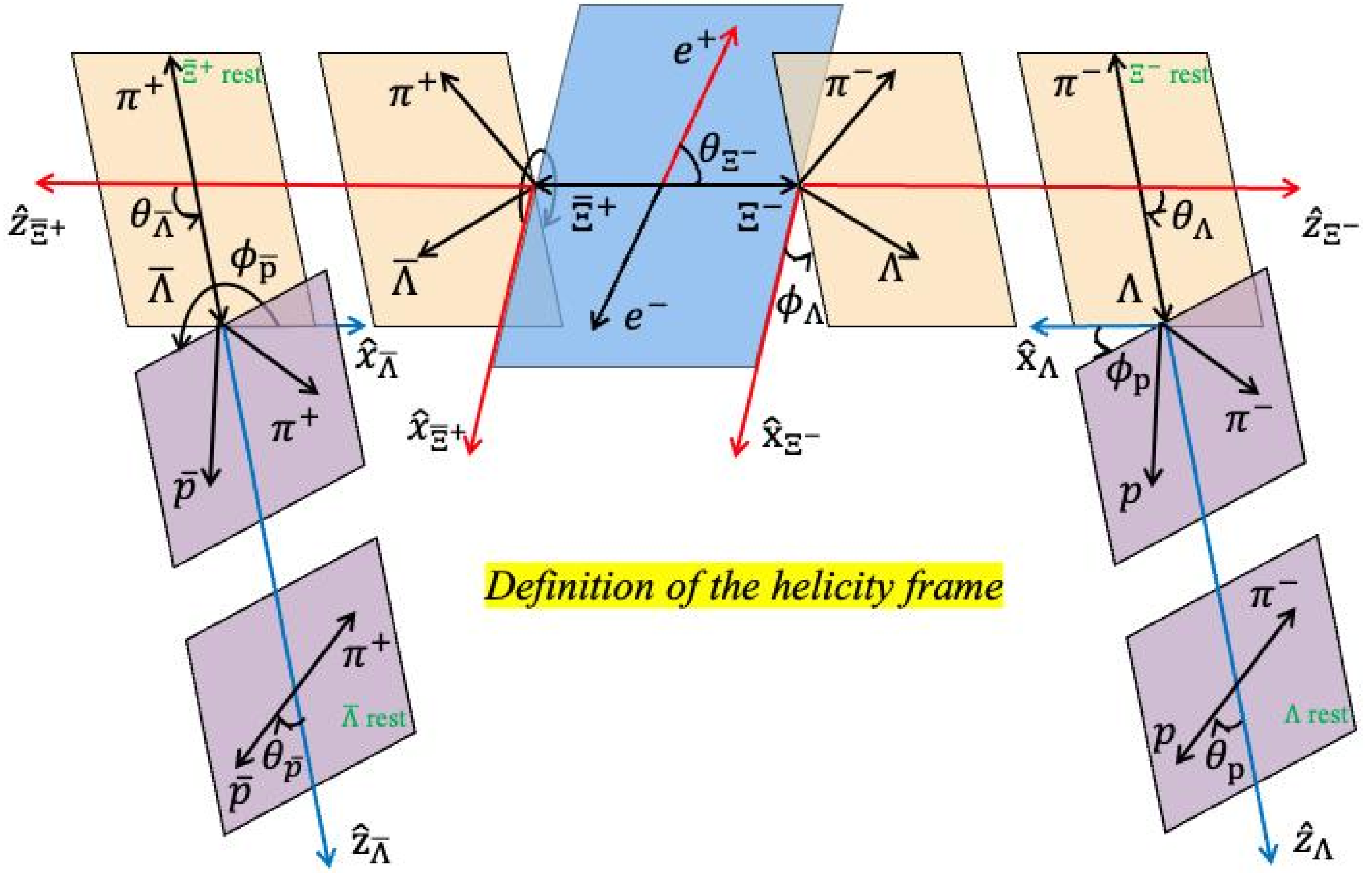
$$\mathcal{W}(\xi;\omega) = \sum_{\mu,\bar{\nu}=0}^{3}\sum_{\mu'=0}^{3}\sum_{\bar{\nu}'=0}^{3} C_{\mu\bar{\nu}} a^{\Xi}_{\mu\mu'} a^{\Lambda}_{\mu'0} a^{\bar{\Xi}}_{\bar{\nu}\bar{\nu}'} a^{\bar{\Lambda}}_{\bar{\nu}'0}$$

- Parameters:

  $(\alpha_{J/\psi},\ \Delta\Phi,\ \alpha_{\Xi},\ \bar{\alpha}_{\Xi},\ \phi_{\Xi},\ \bar{\phi}_{\Xi},\ \alpha_{\Lambda},\ \bar{\alpha}_{\Lambda})$

- Helicity angles:

  $(\theta_{\Xi},\ \theta_{\Lambda},\ \phi_{\Lambda},\ \theta_{\bar{\Lambda}},\ \phi_{\bar{\Lambda}},\ \theta_{p},\ \phi_{p},\ \theta_{\bar{p}},\ \phi_{\bar{p}})$



The multi-step decay chain $J/\psi \to \Xi^{-}\bar{\Xi}^{+}$ offers us much more experimental information than Λ decay. And this decay features a multi-particle final state, making it useful for evaluating OSCAR's performance.

02 MC production

- Oscar Version：2.6.2

- Signal MC

$J/\psi \to \Lambda\bar{\Lambda} \to p\pi^-\bar{p}\pi^+$

  - 1M DIYMC with the input parameters from *Phys. Lett. B* 839 337 (2023) 137834 *and* *Phys. Rev. Lett.* 129 (2022) *no.* 13,131801
  - 10M PHSPMC to calculate the normalization factor

- Signal MC

$J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda\pi^-\bar{\Lambda}\pi^+ \to p\pi^-\pi^-\bar{p}\pi^+\pi^+$

  - 1M mdiyMC with the input parameters from *Nature 606, 64–69 (2022)*
  - 10M PHSPMC to calculate the normalization factor

03 Event selection

part three

03 Event selection

$J/\psi \to \Lambda\bar{\Lambda} \to p\pi^-\bar{p}\pi^+$

- Chared tracks
  - $|cos\theta| < 0.93$
  - No requirement for vertex
  - $N_{pos} >= 2$ & $N_{neg} >= 2$
- Proton and pion identification
  - $p(\bar{p})$: $|mom| > 0.5GeV/c$,
  - $\pi^+(\pi^-)$: $|mom| < 0.5GeV/c$
  - $N_p >= 1$ & $N_{\bar{p}} >= 1$ & $N_{\pi^+} >= 1$ & $N_{\pi^-} >= 1$

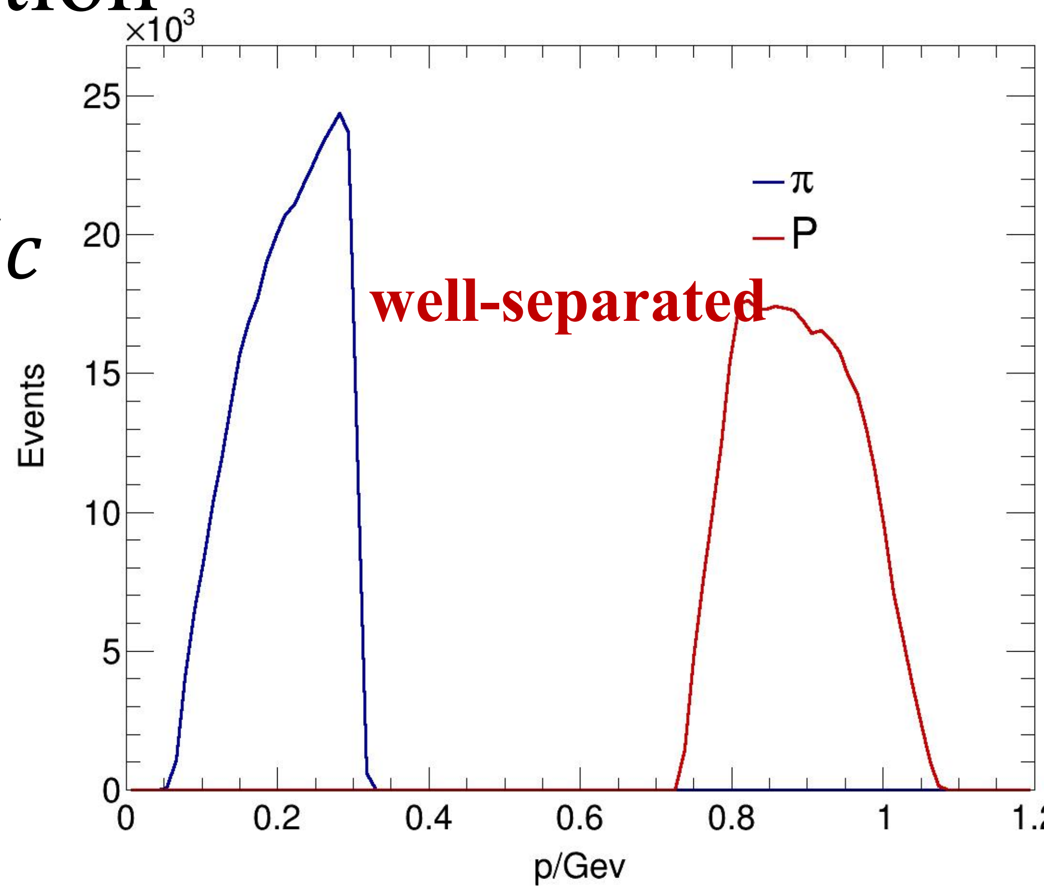


Figure. The momentum distribution of p an $\pi(J/\psi \to \Lambda\bar{\Lambda})$

$J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda\pi^-\bar{\Lambda}\pi^+ \to p\pi^-\pi^-\bar{p}\pi^+\pi^+$

- Charged tracks
  - $|cos\theta| < 0.93$
  - No requirement for vertex
  - $N_{pos} \geq 3$ & $N_{neg} \geq 3$
- Proton and pion identification
  - $p(\bar{p})$: $|mom| > 0.3GeV/c$,
  - $\pi^+(\pi^-)$: $|mom| < 0.3GeV/c$

03 Event selection

$J/\psi \to \Lambda\bar{\Lambda} \to p\pi^-\bar{p}\pi^+$

- $\Lambda(\bar{\Lambda})$ reconstruction
  - Loop $p(\bar{p})$ and $\pi^-(\pi^+)$ candidates
  - Λ $(\bar{\Lambda})$: VertexFit & χ^2<200
  - $\Lambda(\bar{\Lambda})$: SecondVertexFit & $1.1107 < |M_{p\pi^-(\bar{p}\pi^+)}| < 1.1207 GeV/c^2$
  - The best $\Lambda(\bar{\Lambda})$ candidates from combination with minimum χ^2_{SVF}
- DecayLength cut
  - $L_{\Lambda/\bar{\Lambda}} > 0$ cm
- 4C kinematic fit
  - Do kinematic fit on $p\bar{p}\ \pi^-\pi^+$ and χ^2<200

$J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda\pi^-\bar{\Lambda}\pi^+ \to p\pi^-\pi^-\bar{p}\pi^+\pi^+$

- $\Lambda(\bar{\Lambda}), \Xi^-(\bar{\Xi}^+)$ reconstruction
  - Loop $p(\bar{p})$ and $\pi^-(\pi^+)$ candidates
  - Λ $(\bar{\Lambda})$: VertexFit
  - Ξ^-: VertexFit and SecondVertexFit
  - The best $\Lambda(\bar{\Lambda})$ and $\Xi^-(\bar{\Xi}^+)$ candidates from combination with minimum

$$\sqrt{(m_{p\pi^-} - M_\Lambda)^2 + (m_{p\pi^-\pi^-} - M_\Xi)^2}$$

- 4C kinematic fit
  - Do kinematic fit on $\Xi^-\ \bar{\Xi}^+$

The selection criteria are the same as BESIII

03 Event selection efficiency

- The Event selection efficiency

$$J/\psi \to \Lambda\bar{\Lambda} \to p\pi^-\bar{p}\pi^+$$

With background mix in OSCAR

BESIII Signal MC	**Events**	**Eff. (%)**	**Re. Eff.(%)**
	100000	100.0	
Charged tracks	55912	55.91	
Λ Rec.	45772	45.77	81.86
$\bar{\Lambda}$ Rec.	38341	38.34	83.77
$L_{\Lambda/\bar{\Lambda}}$ cuts	35982	35.98	93.84
4C fit	35293	$\boxed{35.29}$	98.09

OSCAR Signal MC	**Events**	**Eff. (%)**	**Re. Eff.(%)**
	1000000	100.0	
Charged tracks	640948	64.10	
Λ Rec.	506784	50.68	79.07
$\bar{\Lambda}$ Rec.	400592	40.06	79.05
$L_{\Lambda/\bar{\Lambda}}$ cuts	384515	38.45	95.98
4C fit	376990	$\boxed{37.70}$	98.04

03 Event selection efficiency

➢ With reference to BESIII, we have added further selection criteria.

- χ^2<200
- $L_{\Xi^-/\bar{\Xi}^+} > 0$ cm
- $1.306\ \mathrm{GeV}/c^2 < M_{\Xi^-/\bar{\Xi}^+} < 1.338\ \mathrm{GeV}/c^2$
- $1.111\ \mathrm{GeV}/c^2 < M_{\Lambda/\bar{\Lambda}} < 1.121\ \mathrm{GeV}/c^2$

$\boxed{J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda\pi^-\bar{\Lambda}\pi^+ \to p\pi^-\pi^-\bar{p}\pi^+\pi^+}$

No background mix in OSCAR

BESIII Signal MC	Events	Eff. (%)	Re. Eff.(%)
	9,000,000	100.0	
Charged tracks	3057857	34.0	
Λ、Ξ⁻ Rec.	2545353	28.3	83.2
$\bar{\Lambda}$、$\bar{\Xi}^+$ Rec.	2092432	23.2	82.2
4C fit	1724213	19.2	82.4
χ^2_{4C} cut	1526267	17.0	88.5
$L_{\Xi^-/\bar{\Xi}^+}$ cuts	1359450	15.1	89.1
$M_{\Xi^-/\bar{\Xi}^+}$ cuts	1281108	14.2	94.2
$M_{\Lambda/\bar{\Lambda}}$ cuts	1126527	$\boxed{12.5}$	87.9

OSCAR Signal MC	Events	Eff. (%)	Re. Eff.(%)
	200,000	100.0	
Charged tracks	106291	53.1	
Λ、Ξ⁻ Rec.	85268	42.6	80.2
$\bar{\Lambda}$、$\bar{\Xi}^+$ Rec.	68674	34.3	80.5
4C fit	44665	22.3	65.0
χ^2_{4C} cut	40014	20.0	89.6
$L_{\Xi^-/\bar{\Xi}^+}$ cuts	36764	18.4	91.9
$M_{\Xi^-/\bar{\Xi}^+}$ cuts	35385	17.7	96.3
$M_{\Lambda/\bar{\Lambda}}$ cuts	31196	$\boxed{15.6}$	88.2

04 BESIII & STCF data comparisons

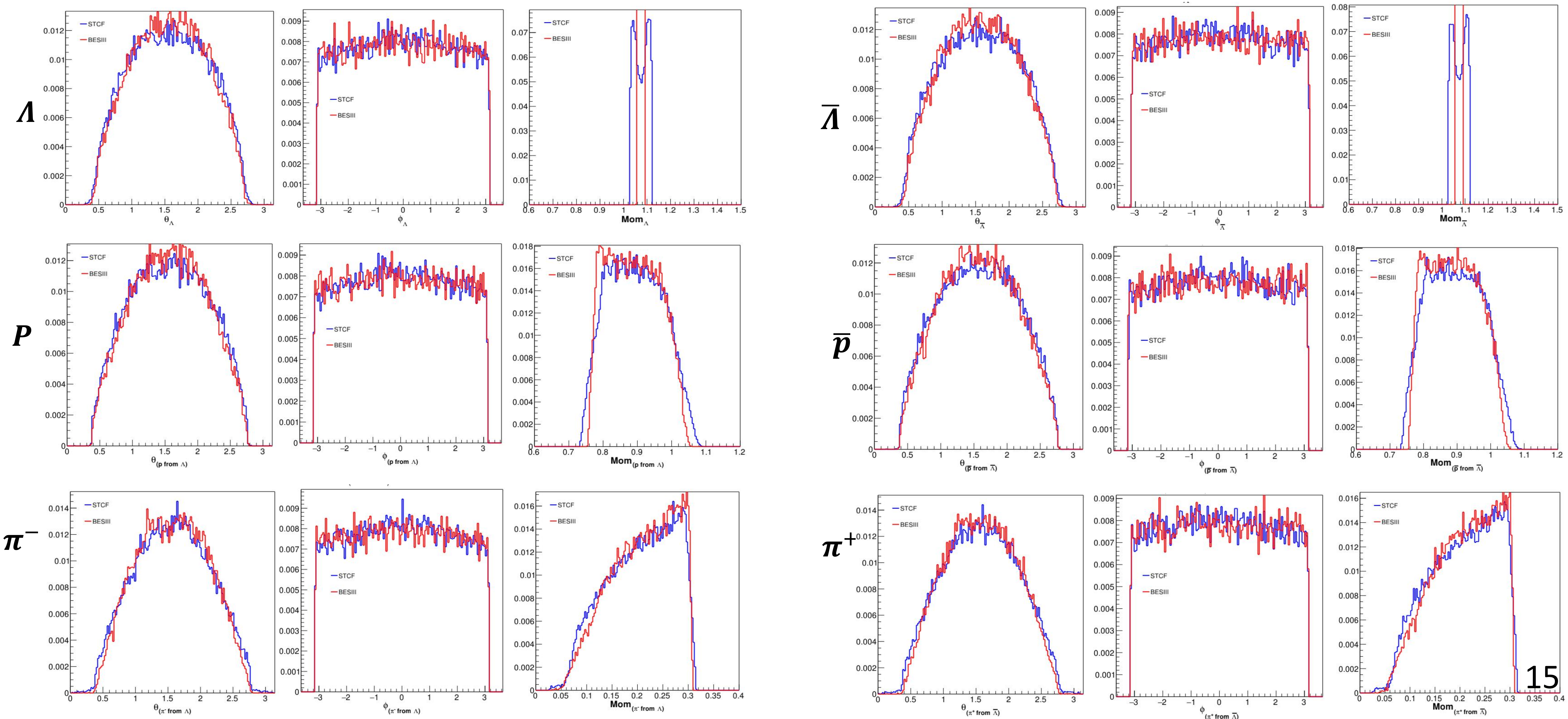
part four

Taking $J/\psi \to \Lambda\bar{\Lambda} \to p\pi^-\bar{p}\pi^+$ as example

04 STCF VS BESIII

➢ In Truth level :check θ, ϕ, Mom

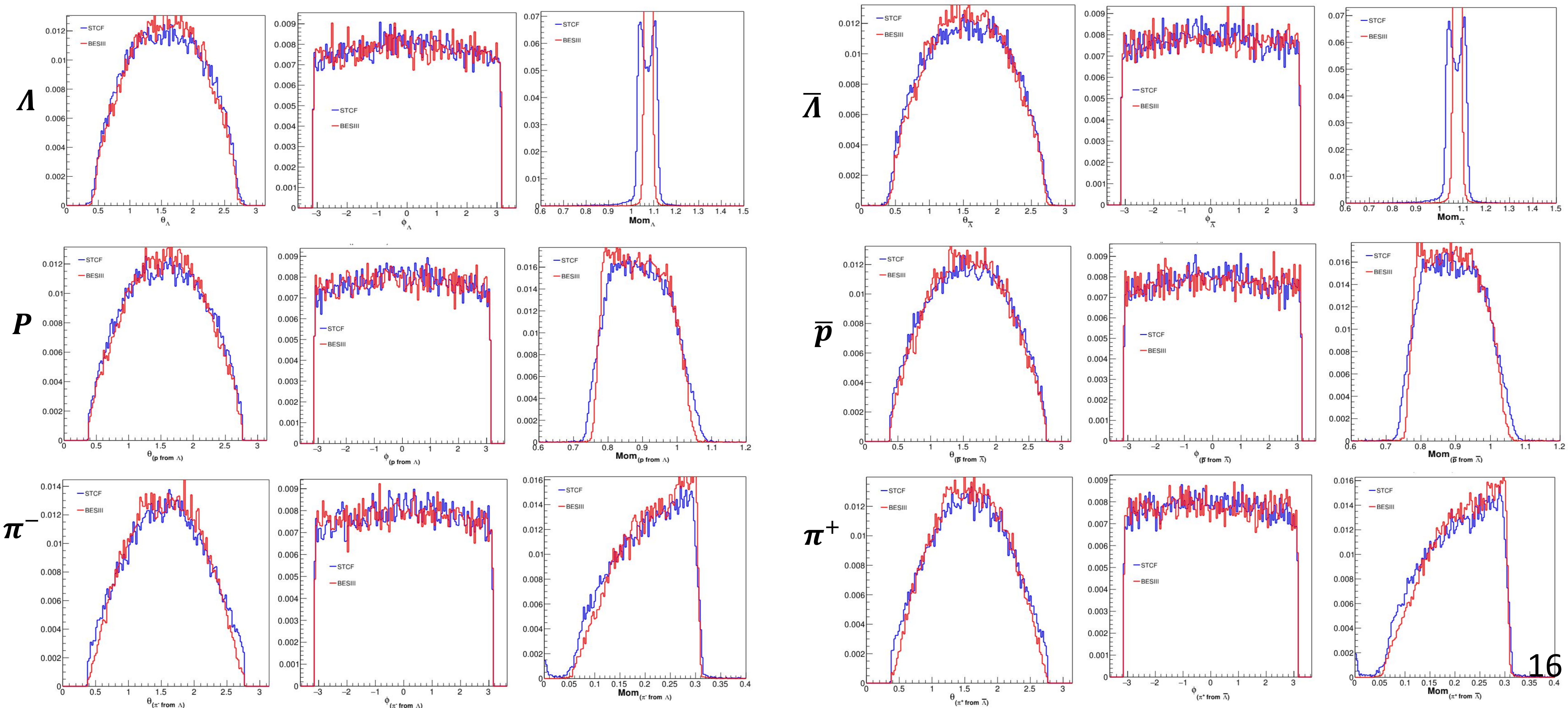
Consistent



04 STCF VS BESIII

- In reconstruction level :check θ, ϕ, Mom

Consistent



04 DecayLength comparion

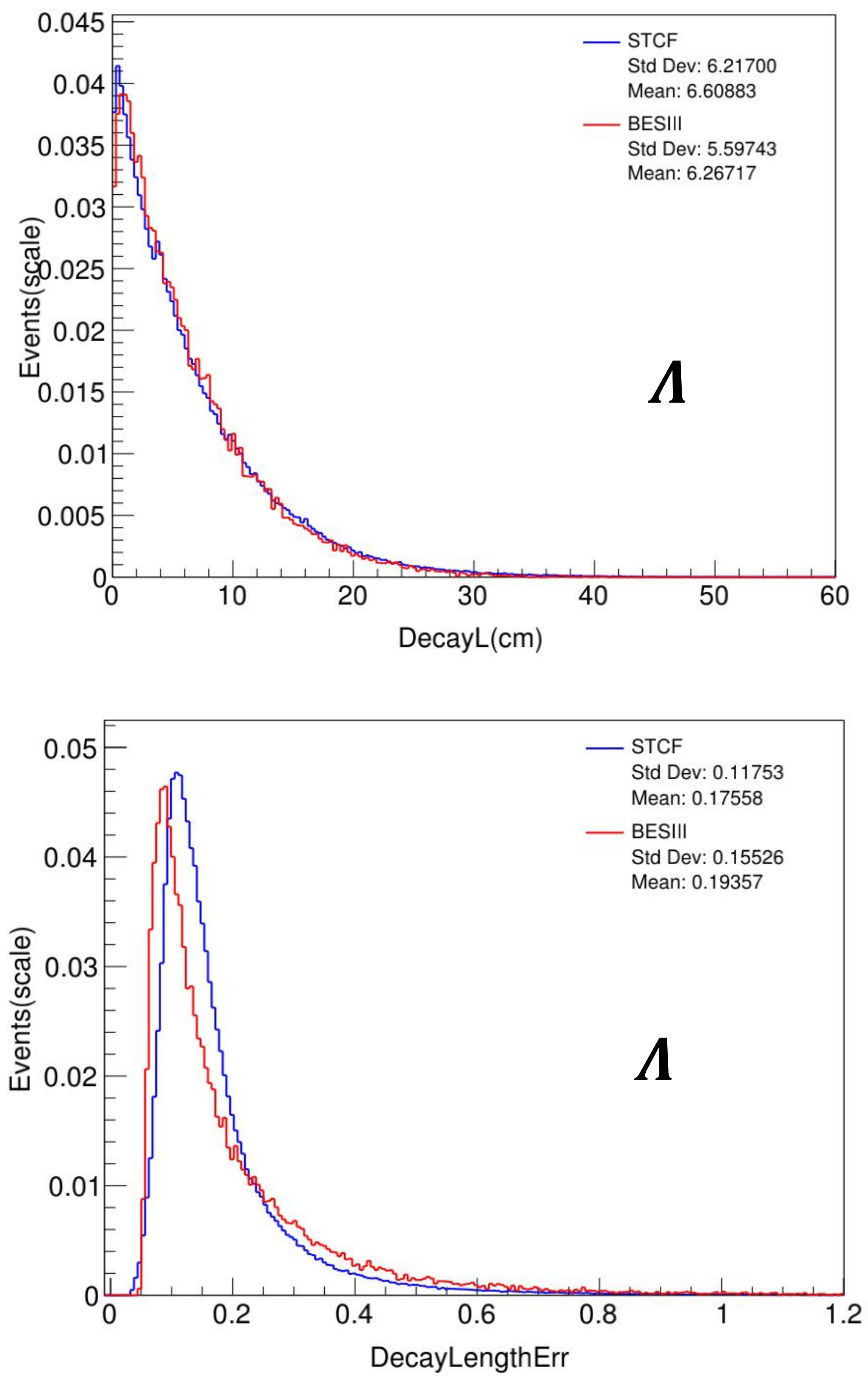


Figure. L_{Λ}(Top) and $Lerr_{\Lambda}$(Bottom) comparion

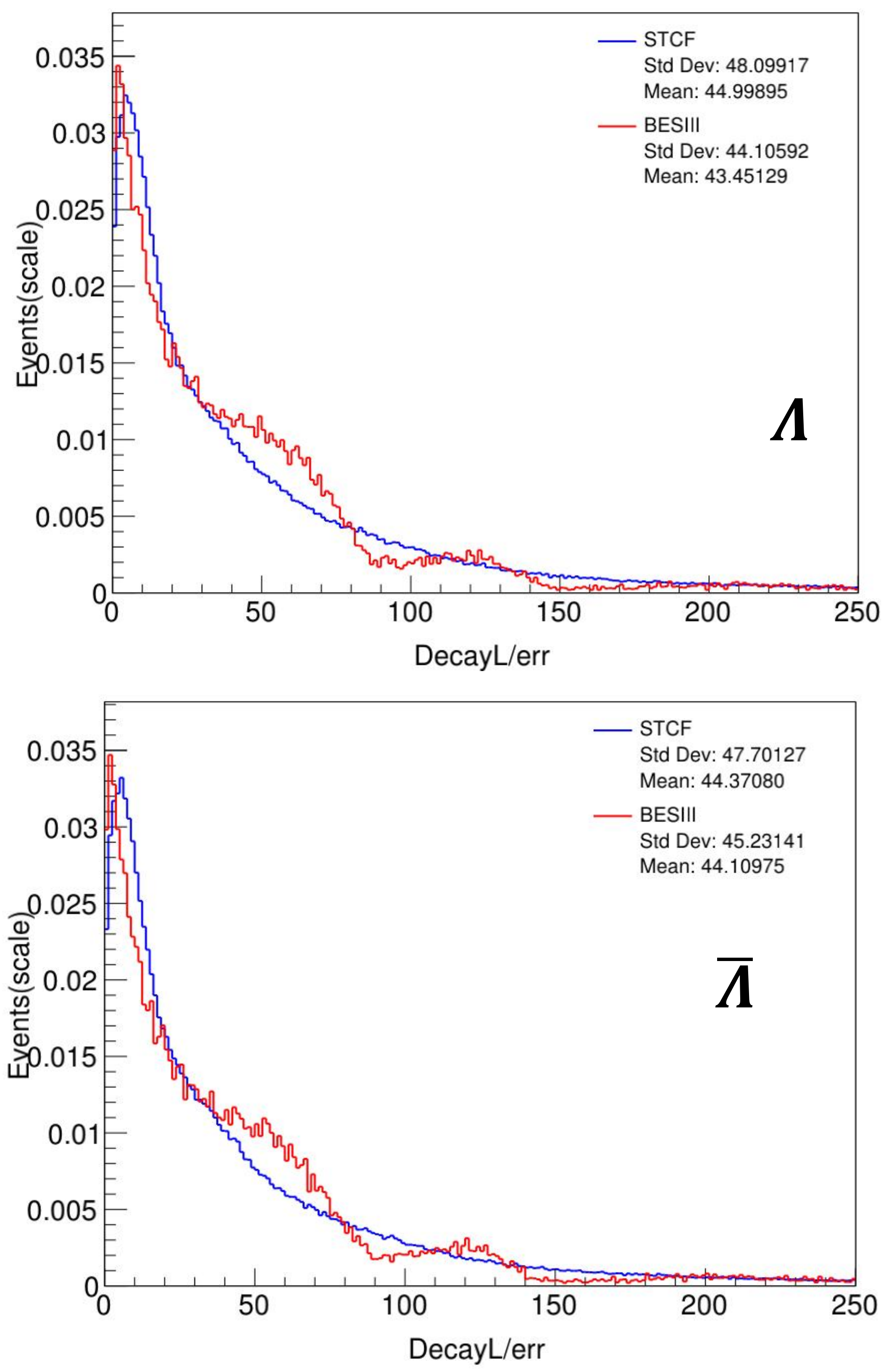


Figure. $L/Lerr$ comparion of Λ (top) and $\bar{\Lambda}$ (bottom)

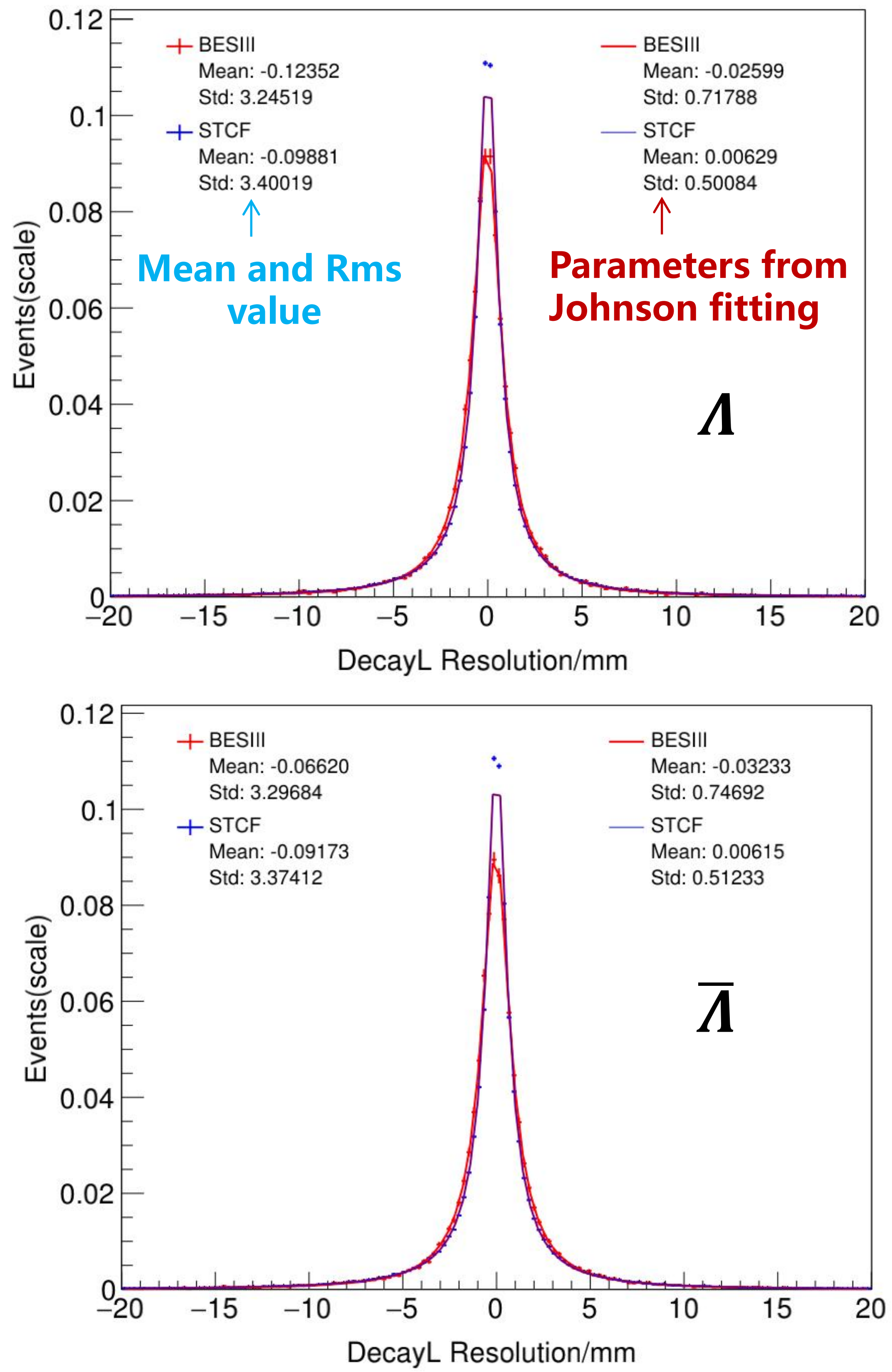


Figure. DecayL resolution comparison for Λ (top) and $\bar{\Lambda}$ (bottom)

05 Results

part five

05 Maximum likelihood fit method

➢ Likelihood function

$$\mathcal{L} = \prod_{i=1}^{N} \mathcal{P}(\xi^i;\vec{\lambda}) = \prod_{i=1}^{N} C\boxed{\mathcal{W}(\xi^i;\vec{\lambda})}\epsilon(\xi^i),$$

Angular distribution

- Normalization factor

$$C^{-1} = \frac{1}{N_{MC}}\sum_{j=1}^{N_{MC}} \mathcal{W}(\xi^j;\vec{\lambda})\epsilon(\xi^j)$$

Calculated from PHSPMC

- MLL function:

$$S = -ln\mathcal{L}_{data} + ln\mathcal{L}_{bkg}$$

Extracting parameters and their error matrix using RooFit:

- MIGRAD：
  Finds the optimal parameter values for the maximum likelihood function.
- HESSE：
  Computes the covariance matrix and parameter uncertainties, providing correlation information.

05 Extract parameters

$J/\psi \to \Lambda\bar{\Lambda} \to p\pi^- \bar{p}\pi^+$

➢ Using the maximum likelihood fitting method to extract parameters

Parameters	This work (1M *signal events*)	BESIII (3M *signal events*) arXiv:2506.19180
$Im(F_A)$	(-5.3 $\pm$ 10.8) $\times$ 10^{-6}	(7.9 $\pm$ 3.7) $\times$ 10^{-6}
$Im(H_T)$	(4.7 $\pm$ 3.2) $\times$ 10^{-6}	(1.3 $\pm$ 1.2) $\times$ 10^{-6}
$Im(G_2)$	(9.2 $\pm$ 0.11) $\times$ 10^{-4}	(9.14 $\pm$ 0.04) $\times$ 10^{-4}
P_L	(-2.3 $\pm$ 3.4) $\times$ 10^{-3}	(-1.8 $\pm$ 1.2) $\times$ 10^{-3}
$Re(F_A)$	(-7.3 $\pm$ 4.4) $\times$ 10^{-6}	(-2.4 $\pm$ 1.6) $\times$ 10^{-6}
$Re(H_T)$	(0.6 $\pm$ 4.1) $\times$ 10^{-6}	(-1.4 $\pm$ 1.4) $\times$ 10^{-6}
$Re(G_2)$	(9.88 $\pm$ 0.15) $\times$ 10^{-4}	(9.71 $\pm$ 0.06) $\times$ 10^{-4}
α_Λ	0.7641 $\pm$ 0.0103	0.7524 $\pm$ 0.0036
$\alpha_{\bar{\Lambda}}$	-0.7466 $\pm$ 0.0101	-0.7571 $\pm$ 0.0036
$\alpha_{J/\psi}$	0.4645 $\pm$ 0.0061	0.4748 $\pm$ 0.0022
$\Delta\Phi$	0.7503 $\pm$ 0.0116	0.7552 $\pm$ 0.0041
A_{cp}	(1. 1 $\pm$ 1.3) $\times$ 10^{-2}	(-3.1 $\pm$ 4.6) $\times$ 10^{-3}
$Re(d_\Lambda)$	(-1.4 $\pm$ 9.3) $\times$ 10^{-19}	(-3.1 $\pm$ 3.2) $\times$ 10^{-19}
$Im(d_\Lambda)$	(10.7 $\pm$ 7.3) $\times$ 10^{-19}	(2.9 $\pm$ 2.6) $\times$ 10^{-19}

05 Estimate statistical uncertainty

➢ Based on 1 million statistics to estimate the statistical uncertainty of the parameters.

- STCF expected J/ψ events: 3.4×10^{12}
- Branch ratio of $J/\psi \to \Lambda\bar{\Lambda}$: 1.88×10^{-3}
- Branch ratio of $\Lambda(\bar{\Lambda}) \to p\pi^-(\bar{p}\pi^+)$: 0.639

The precision of A_{cp} is expected to be at the level of 10^{-4}
The precision of EDM is expectec to be at the level of 10^{-20}

- The expected events of $J/\psi \to \Lambda\bar{\Lambda} \to p\pi^-\bar{p}\pi^+$ is about 2.63×10^9.
- The scale factor can be defined: $\sqrt{1\text{M}/2.63 \times 10^9} \approx 0.0195$

Par	1M signal	Estimate statistical uncertainty		1M signal	Estimate statistical uncertainty
$Im(F_A)$	(-5.3 $\pm$ 10.8) $\times 10^{-6}$	2.11×10^{-7}	$\alpha_{J/\psi}$	0.4645 ± 0.0061	1.19×10^{-4}
$Im(H_T)$	$(4.7 \pm 3.2) \times 10^{-6}$	6.24×10^{-8}	$\Delta\Phi$	0.7503 ± 0.0116	2.26×10^{-4}
$Im(G_2)$	$(9.2 \pm 0.11) \times 10^{-4}$	2.14×10^{-7}	A_{cp}	$(1.1 \pm 1.3) \times 10^{-2}$	2.53×10^{-4}
P_L	$(-2.3 \pm 3.4) \times 10^{-3}$	6.63×10^{-5}	$Re(d_\Lambda)$	$(-1.4 \pm 9.3) \times 10^{-19}$	1.81×10^{-20}
$Re(F_A)$	$(-7.3 \pm 4.4) \times 10^{-6}$	8.58×10^{-8}	$Im(d_\Lambda)$	$(10.7 \pm 7.3) \times 10^{-19}$	1.42×10^{-20}
$Re(H_T)$	$(0.6 \pm 4.1) \times 10^{-6}$	8.0×10^{-8}			
$Re(G_2)$	$(9.88 \pm 0.15) \times 10^{-4}$	2.92×10^{-7}			
α_Λ	7.6409 ± 0.0103	2.01×10^{-4}			
$\alpha_{\bar{\Lambda}}$	-7.4661 ± 0.0101	1.97×10^{-4}			

consistent with our expectation!!!

05 Extract parameters

$J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda\pi^-\bar{\Lambda}\pi^+ \to p\pi^-\pi^-\bar{p}\pi^+\pi^+$

- Using the maximum likelihood fitting method to extract parameters

Parameters	This work (1M *signal events*)	Nature Physics 2022 (BESIII 09+12 data)
$\alpha_{J/\psi}$	0.5832 ± 0.0081	0.586 ± 0.012
$\Delta\Phi$	1.2690 ± 0.0313	1.213 ± 0.046
α_Ξ	-0.3769 ± 0.0048	-0.376 ± 0.007
$\bar{\alpha}_\Xi$	0.3741 ± 0.0048	0.371 ± 0.007
α_Λ	0.7555 ± 0.0074	0.757 ± 0.011
$\bar{\alpha}_\Lambda$	-0.7552 ± 0.0074	-0.763 ± 0.011
ϕ_Ξ	-0.0006 ± 0.0135	0.011 ± 0.019
$\bar{\phi}_\Xi$	-0.0087 ± 0.0135	-0.021 ± 0.019
$A_{CP}^{\Xi}=(\alpha_\Xi+\bar{\alpha}_\Xi)/(\alpha_\Xi-\bar{\alpha}_\Xi)$	0.0038 ± 0.0092	0.006 ± 0.013
$A_{CP}^{\Lambda}=(\alpha_\Lambda+\bar{\alpha}_\Lambda)/(\alpha_\Lambda-\bar{\alpha}_\Lambda)$	0.0002 ± 0.0082	-0.004 ± 0.012
$\Delta\phi_{CP}^{\Xi}=(\phi_\Xi+\bar{\phi}_\Xi)/2$	-0.0046 ± 0.0098	-0.005 ± 0.014

The results are consistent with the BESIII published results within 2σ.

05 Estimate statistical uncertainty

- Based on 1 million statistics to estimate the statistical uncertainty of the parameters.
  - STCF expected J/ψ events: 3.4×10^{12}
  - Branch ratio of $J/\psi \to \Xi^-\bar{\Xi}^+$: 9.7×10^{-4}
  - Branch ratio of $\Xi^-(\bar{\Xi}^+) \to \Lambda\pi^-(\bar{\Lambda}\pi^+)$: 0.999
  - Branch ratio of $\Lambda(\bar{\Lambda}) \to p\pi^-(\bar{p}\pi^+)$: 0.639
- The expected events of $J/\psi \to \Xi^-\bar{\Xi}^+ \to \Lambda\pi^-\bar{\Lambda}\pi^+ \to p\pi^-\pi^-\bar{p}\pi^+\pi^+$ is about 1.34393×10^9.
- The scale factor can be defined: $\sqrt{1.0 \times 10^6/1.34939 \times 10^9}$ ≈0.0272

The precision of A_{cp} in Ξ and Λ is expected to be at the level of 10^{-4}

Par	1M signal	Estimate statistical uncertainty		1M signal	Estimate statistical uncertainty
$\alpha_{J/\psi}$	0.5832 ± 0.0081	2.20×10^{-4}	A_{CP}^{Ξ}	0.0038 ± 0.0092	$2.5 \times \boxed{10^{-4}}$
$\Delta\Phi$	1.2690 ± 0.0313	8.51×10^{-4}	A_{CP}^{Λ}	0.0002 ± 0.0082	$2.2 \times \boxed{10^{-4}}$
α_{Ξ}	-0.3769 ± 0.0048	1.31×10^{-4}	$\Delta\phi_{CP}^{\Xi}$	-0.0046 ± 0.0098	2.7×10^{-4}
$\bar{\alpha}_{\Xi}$	0.3741 ± 0.0048	1.31×10^{-4}			
α_{Λ}	0.7555 ± 0.0074	2.01×10^{-4}			consistent with our expectation!!!
$\bar{\alpha}_{\Lambda}$	-0.7552 ± 0.0074	2.01×10^{-4}			
ϕ_{Ξ}	-0.0006 ± 0.0135	3.67×10^{-4}			
$\bar{\phi}_{\Xi}$	-0.0087 ± 0.0135	3.67×10^{-4}			

06 Summary

part six

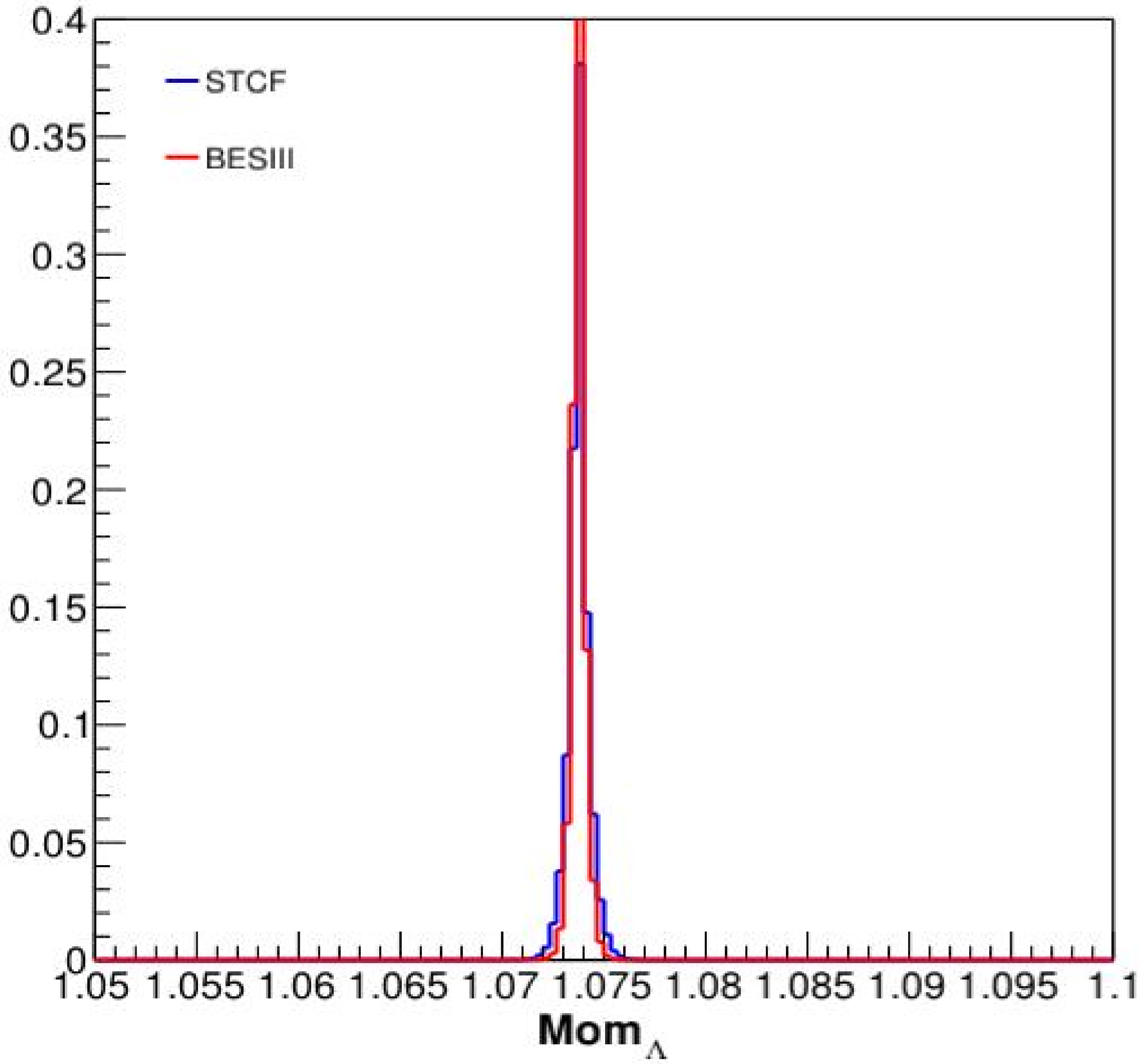
06 Summary

- The process $e^+e^- \to J/\psi \to \Lambda\bar{\Lambda}$ and $e^+e^- \to J/\psi \to \Xi^- \bar{\Xi}^+$ have been generated using the OSCAR software. And the signal events have been preliminarily selected.
- We compare the data between BESIII and STCF and find the consistence.
- Based on the expectation that the STCF will collect 3.4×10^{12} J/ψ events per year, the precision of CP violation in Ξ and Λ decays is expected to be at the level of 10^{-4} and the precision of EDM in Λ is expected to be at the level of 10^{-20}

Thank you!

backup

- In Truth level :Mom



Boost angle:
BESIII:0.011
STCF:0.03

Resutl after boosting lam momentum into the J/ψ center-of-mass frame and find a consistent result.

Constistent!!!

backup

➢Result after using VertexRefine

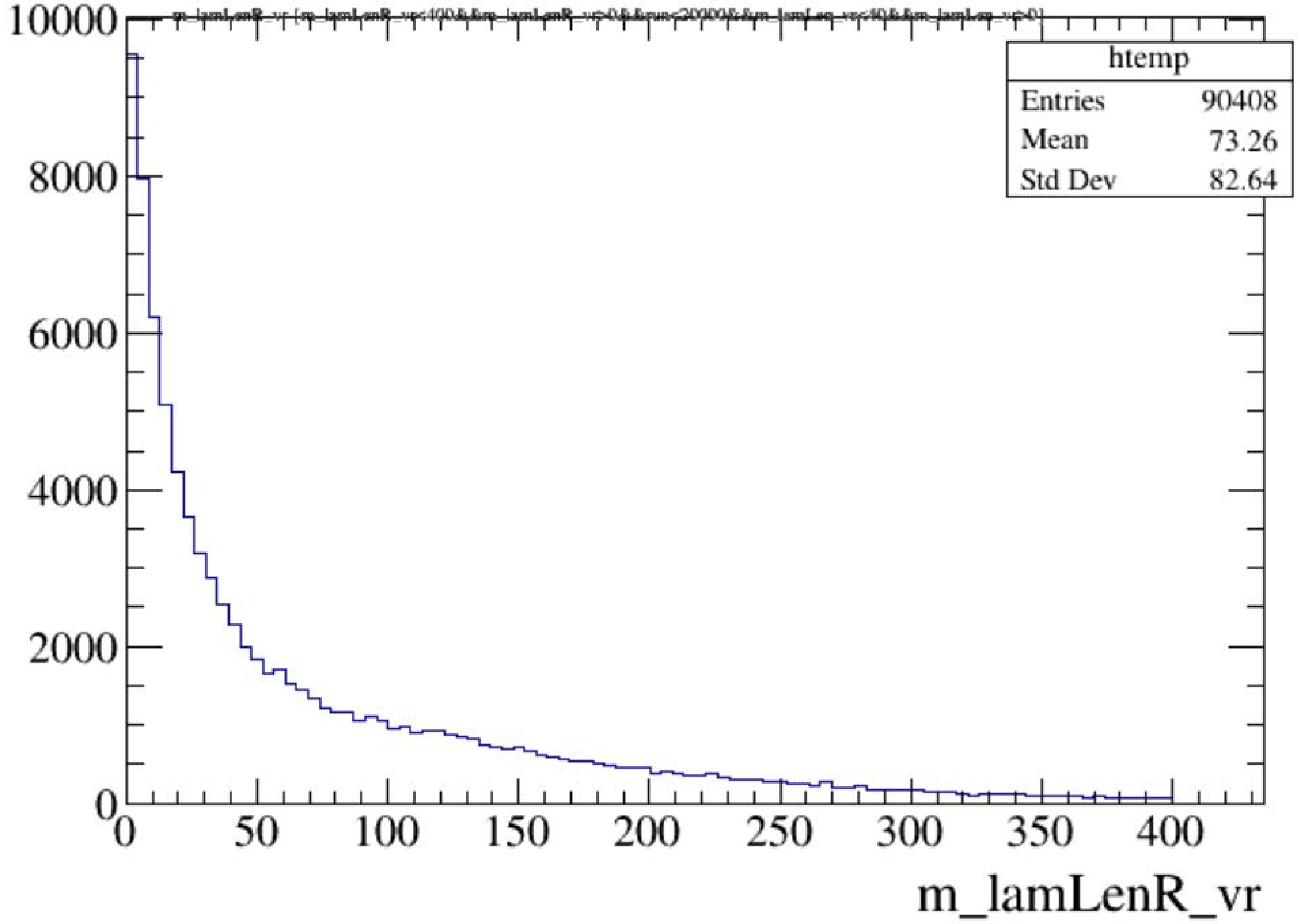


Figure. $L/Lerr$ of Λ in BESIII

Normally, we can obtain the parameters of a charged particle at two points

- **First**： Reconstructed position of the first hit of the charged track; material effects before this point are not considered.
- Poca： The point where the charged track is extrapolated to be closest to a reference point in the xy plane,material effects will be taken into account

The reasons for multiple peaks appearing in BESIII:
When doing VertexFit,stcf will use the first rec hit information while besiii will use the poca information ,for long-lived particles, more material correction effects may be considered.

VertexRefint
Correctly account for the material effects correction on the track.

BESIII & STCF comparisons

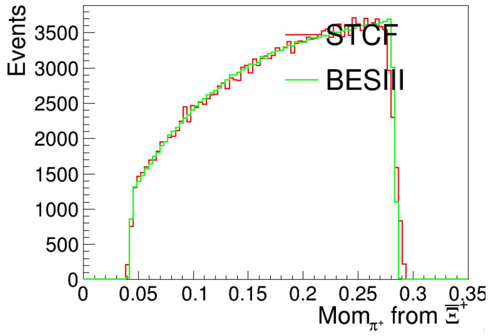
In Truth level: check $\theta,\ cos\theta,\ Mom$

Ξ^-

$\bar{\Xi}^+$

π_1^-

π_1^+



Λ

$\bar{\Lambda}$

π_2^-

π_2^+

p

$\bar{p}$

BESIII & STCF comparisons

In reconstruction level: check θ, $cos\theta$, Mom

Ξ^-

$\bar{\Xi}^+$

π_1^-

π_1^+

Λ

$\bar{\Lambda}$

π_2^-

π_2^+

p

$\bar{p}$

BESIII & STCF comparisons

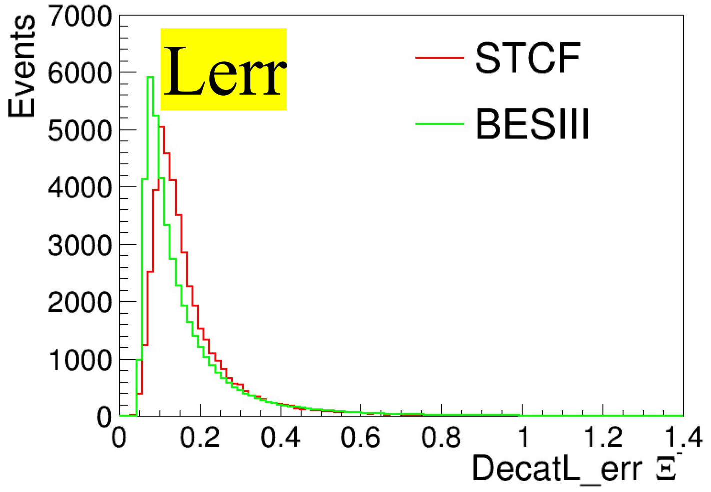
Check χ^2, L, Lerr, L/Lerr, Mass

χ^2

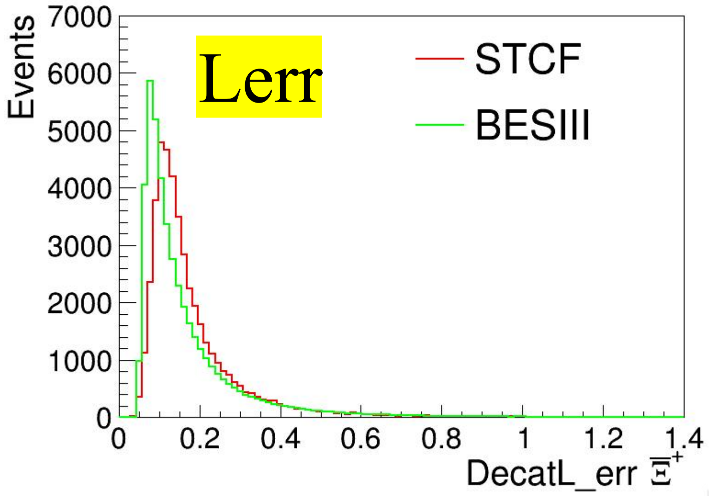
L

L

Lerr



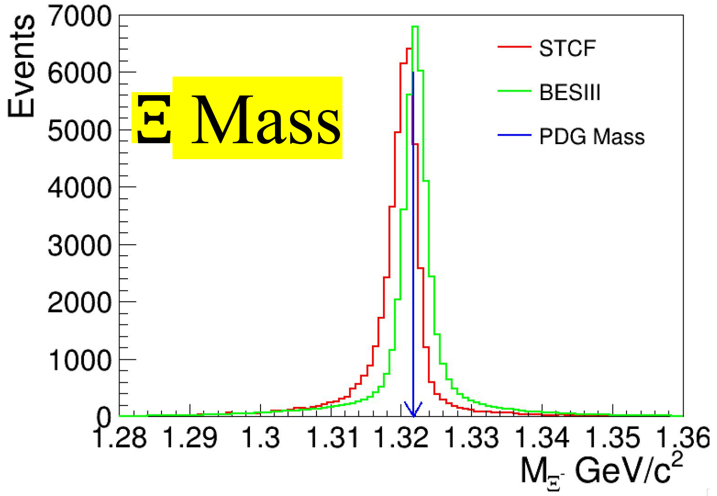
Lerr



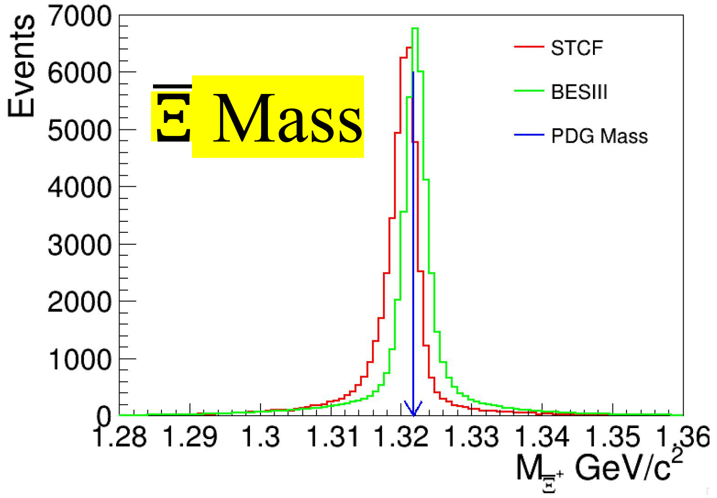
L/Lerr

L/Lerr

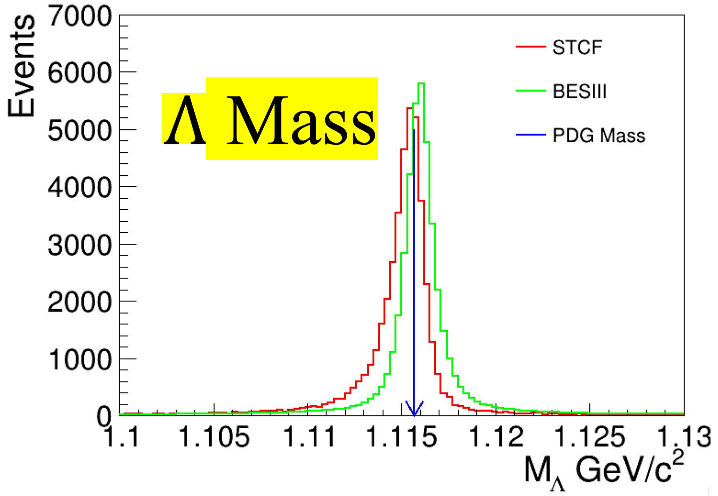
Ξ Mass



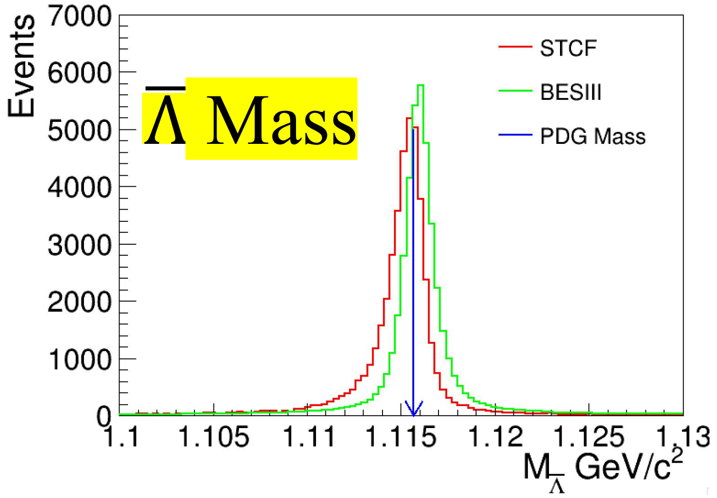
$\bar{\Xi}$ Mass



Λ Mass



$\bar{\Lambda}$ Mass



BESIII & STCF comparisons

Check Helicity angles in truth level:

BESIII & STCF comparisons

Check Helicity angles in reconstruction level:

backup

backup

backup