$\psi(3770)$ Round17 Data Taking Report

2024 BESIII Charm Hadron Physics Seminar in Zhengzhou

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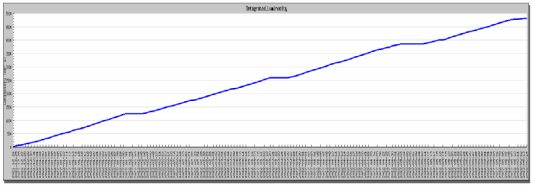
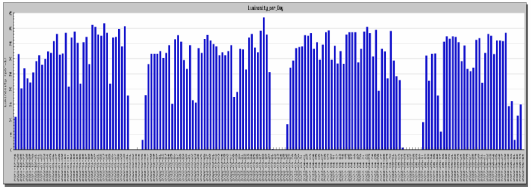
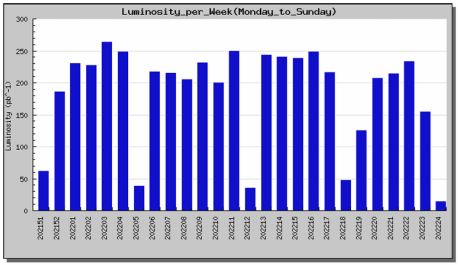
May 12, 2024

Outline

Round15 Data Collected







Total luminosity is up to 4815.775 pb^{-1}ended at 2022-06-13

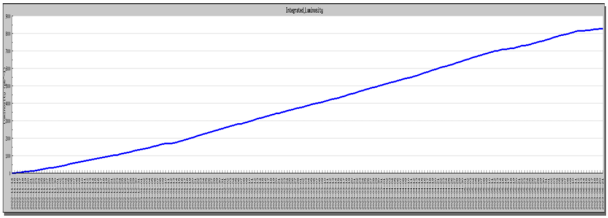
Average per day is 30.480 pb^{-1}, peak is 43.614 pb^{-1}

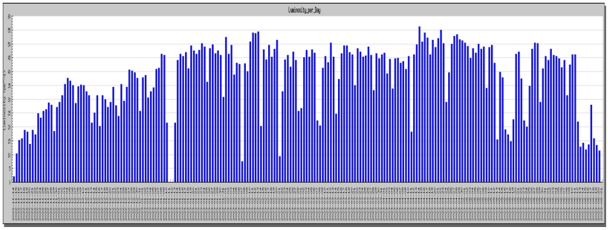
Average per week is 192.033 pb^{-1}, peak is 264.229 pb^{-1}

Information can be found at

BESIII Database: http://bes3db.ihep.ac.cn/

Round16 Data Collected

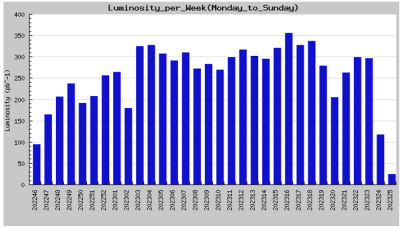




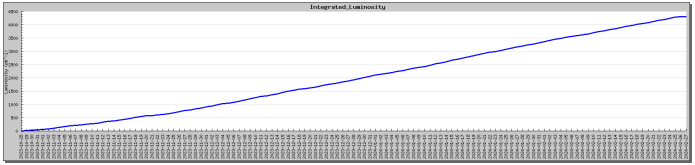
- Total integrated luminosity: 8.2 fb^{-1}
- Average: 38 pb^{-1}/Day

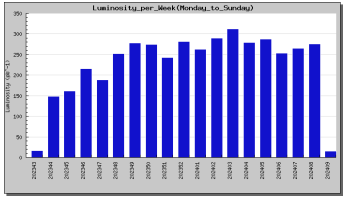
More information:
http://bes3db.ihep.ac.cn/

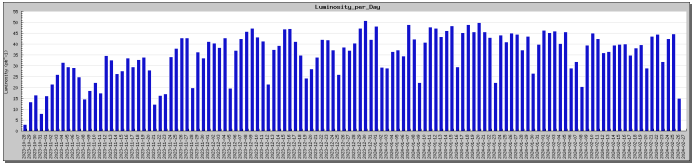
bes3
bes3charm



Round17 Data Collected (231029-240224)







Integrated Luminosity = 4.212 fb^{-1}

Week Average = 235.945 pb^{-1}

Day Average = 35.178 pb^{-1}

Outline

Data Set

Original Work⇐

- BOSS version: BOSS 7.1.1;
- Data: Round17 231029-240224 ;
- Control samples: BhaBha and Di-gamma
- Signal MC: generated by Babayaga-00-00-26, calibrated by round17 $\psi(3770)$ data(BhaBha and digamma);

Parameter	Value
BeamEnergy	1.8865 GeV
MinThetaAngle	33.87 deg.
MaxThetaAngle	146.13 deg.
MinimumEnergy	0.00158 GeV
MaximumAcollinearity	180 deg.
RunningAlpha	1(0 = off, 1 = on)
FSR Switch	1(0 = off, 1 = on)

Table: Babayaga Generator Information

Event Selection

BhaBha

- $V_{xy} < 1.0$ cm; $|V_z| < 10.0$ cm for charged tracks;
- $0.05 < P_{\text{trk}} < E_{\text{beam}} + 0.3$ GeV/c;
- $P_{e^+} + P_{e^-} > 0.9 * E_{\text{ecm}}$;
- $1.0 < E_{\text{EMC}} < 2.5$ GeV;
- $5^\circ < |\Delta\phi_{\text{EMC}}| < 40^\circ$, $(\Delta\phi_{\text{EMC}} = |\phi_1 - \phi_2| - 180^\circ)$;
- $|\cos\theta_{\text{EMC}}| < 0.80$;
- $N_{\text{Good}} = 2$ and $Q_1 + Q_2 = 0$;

Di-gamma

- $E_{\text{EMC}} > 0.7 E_{\text{beam}}$;
- $|\cos\theta_{\text{EMC}}| < 0.80$;
- $N_\gamma \geq 2$ and $N_{\text{Good}} = 0$;
- $|\Delta\phi_\gamma| < 2.0$;
- $|\Delta\theta_\gamma| < 10.0$;

BhaBha: Distributions of Observables

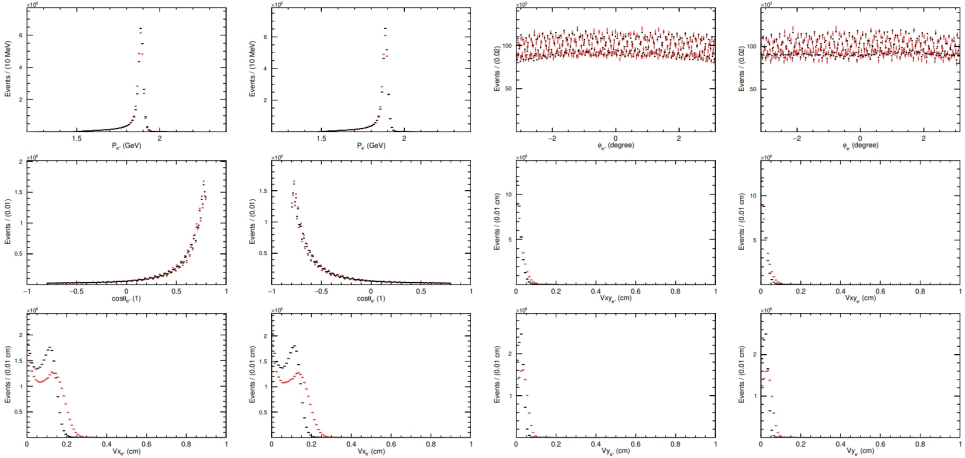


Figure: Black is data, red is MC

BhaBha: Distributions of Observables

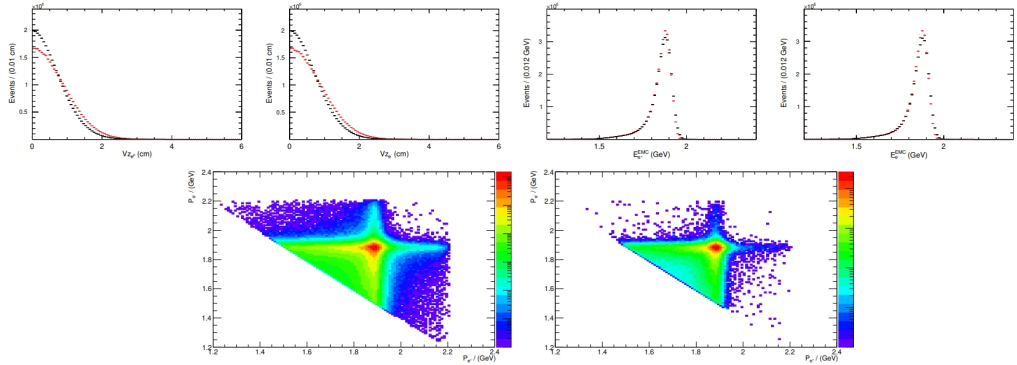


Figure: Black is data, red is MC. For 2D Plots, left is data and right is MC

Online & Offline Luminosity

The luminosity is calculated by following formula

$$L = \frac{N_{obs}}{\sigma \times \epsilon}$$

where N_{obs} is the total number of observed signal events, cross section σ is given by accurate QED theoratical calculation and ϵ is estimated by signal MC;

Parameter	BhaBha	Di-gamma
N_{MCGen}	1000000	1000000
N_{MCObs}	611474	746704
N_{obs}	424070312	46915912
σ	148.21 nb	14.62 nb
ε	61.15%	74.67%
L_{online}	4.23 fb^{-1}	4.23 fb^{-1}
$L_{offline}$	4.19 fb^{-1}	4.18 fb^{-1}
Deviation	-0.9%	-1.18%

Run by Run Luminosity

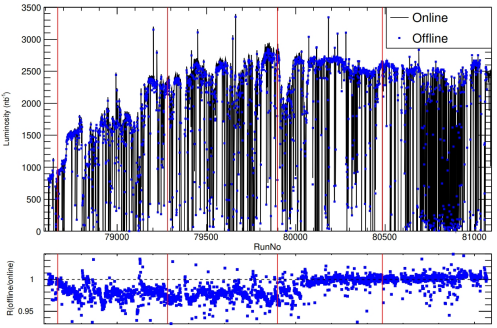


Figure: BhaBha

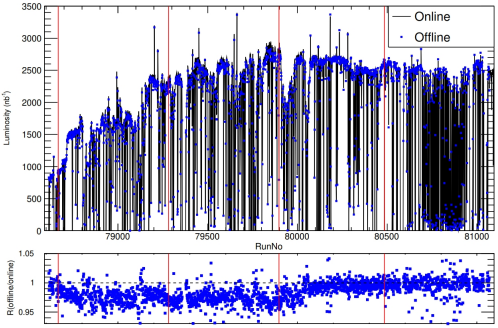


Figure: Di-gamma

Outline

Calibration Method

- **Calibration method:**

  Pair production of $D\overline{D} \Rightarrow$ beam energy = energy of D meson

$$E_b^2(output) = E_b^2(input) + m^2(PDG) - M_{BC}^2(measured)$$

  $m(PDG)$: PDG value of D meson
  $E_b(input)$: input beam energy 1.8865 GeV
  $M_{BC}(measured)$: beam constrained mass of D meson $M_{BC} = \sqrt{E_b(input)^2 - P_D^2}$,

- **Three channels are used in this study:**

$$D^0 \to K^-\pi^+ \,,\, D^0 \to K^-\pi^+\pi^+\pi^-,\, D^+ \to K^-\pi^+\pi^+.$$

Original Work⇐

Event Selection

Based on DTagAlg Package in BOSS 7.1.1

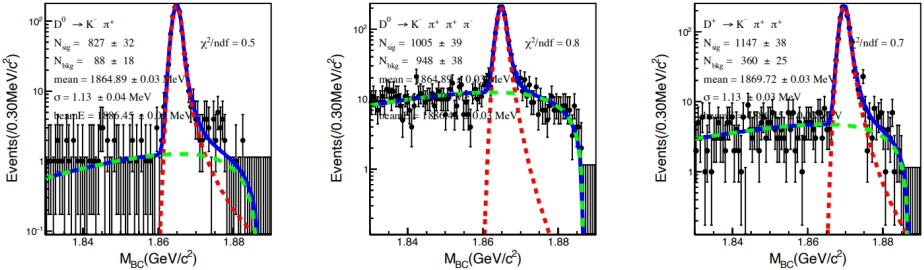
- **Charged track selection**:
  - $|V_z| \leq 10cm, |V_{xy}| \leq 1cm, |cos\theta| \leq 0.93$

- **PID**:
  $\pi: P(\pi) > P(K)$
  $K: P(K) > P(\pi)$

- **Cosmic rays rejection for $D^0 \to K^-\pi^+$**
  - The two charged tracks used must have a TOF time difference less than 5ns
  - They must not be consistent with being a muon pair or an electron-positron pair
  - The event will be accepted if the angles between any one good shower and two good charged tracks are larger than 20°

- **Tag D Reconstruction:**
  - $\Delta E = E_D - E_{beam}$, $M_{bc} = \sqrt{E_{beam}^2 - \vec{P}_D^2}$
  - Minimum ΔE is used to select best candidate
  - ΔE cut: $(-0.025, 0.025)$ GeV

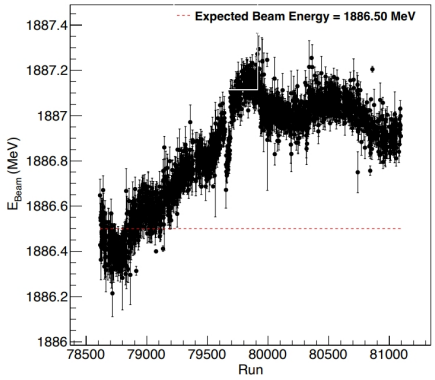
Fit to M_{BC}



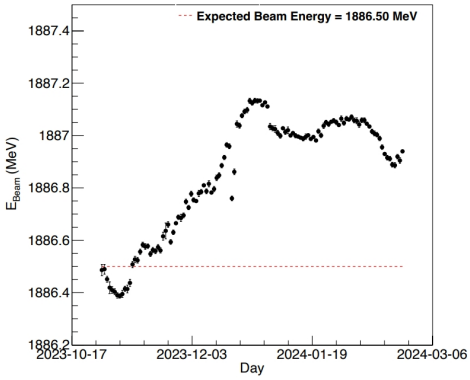
Signal : Crystal Ball; Background: ARGUS function.

The means of m_{BC} of D^0 and D^+ are constrained by $m(D^+) - m(D^0) = 4.822$ MeV, quoted from PDG.

Results for Run78615-81094

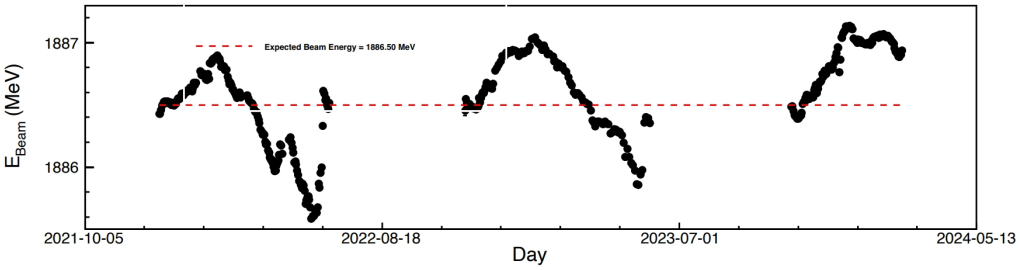


Calibration beam energy vs Run number



Calibration beam energy vs Date

Results for Round15, 16 and 17 Data

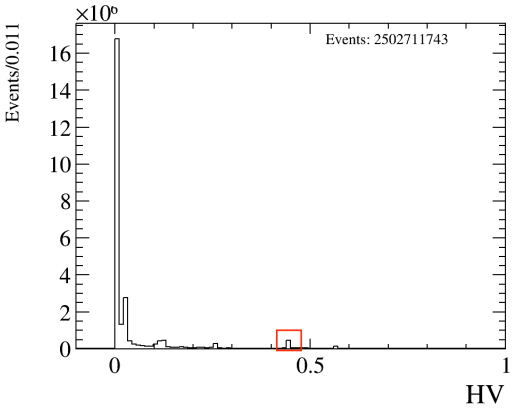


Summary

The calibration for round17 data shows that the average E_{beam} is 1886.85 MeV, which is deviated from expected energy about 0.4 MeV.

Outline

Definition



Voltage drop leads to dE/dx drop, which complies the following relation

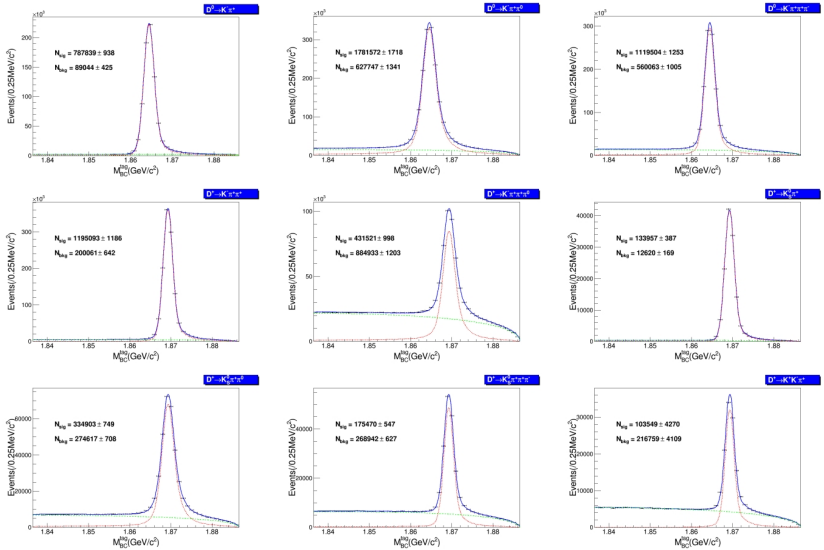
$$\frac{\Delta(\mathrm{d}E/\mathrm{d}x)_m}{(\mathrm{d}E/\mathrm{d}x)_m} \approx 13.6 \cdot \mathrm{HV} \qquad (1)$$

where HV(namely Rd) is the average high voltage drop ratio

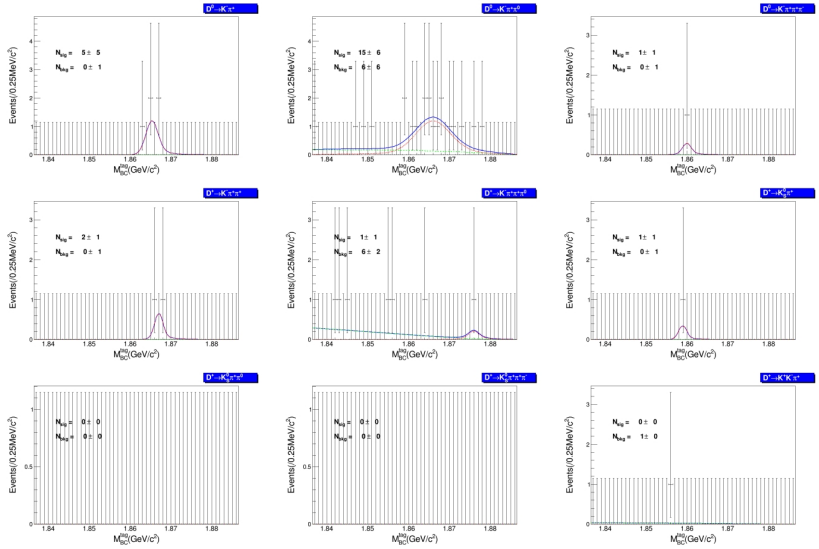
$$\mathrm{HV} = \frac{1}{N_{layer}} \sum_{i=1}^{N_{layer}} \frac{\Delta V_i}{V_i} \qquad (2)$$

Original Work⇐

Fitting When HV < 0.40



Fitting When HV > 0.40



Result

We have 9934078233 events with HV < 0.40 and 3410699 with HV > 0.40. And events with HV > 0.40 accounted for 0.034% of the total.

Decay Mode	D Yields(HV<0.40)	Ratio($\times 10^{-5}$)	D Yields(HV>0.40)	Ratio($\times 10^{-5}$)
$D^0 \to K^-\pi^+$	787839 ± 938	7.931	5 ± 5	0.14
$D^0 \to K^-\pi^+\pi^0$	1781572 ± 1718	17.930	15 ± 6	0.43
$D^0 \to K^-\pi^+\pi^+\pi^-$	1119504 ± 1253	11.27	1 ± 1	0.02
$D^+ \to K^-\pi^+\pi^+$	1195093 ± 1186	12.03	2 ± 1	0.05
$D^+ \to K^-\pi^+\pi^+\pi^0$	431521 ± 998	4.344	1 ± 1	0.02
$D^+ \to K^0_S\pi^+$	133957 ± 387	1.348	1 ± 1	0.02
$D^+ \to K^0_S\pi^+\pi^0$	334903 ± 749	3.371	0 ± 0	0.
$D^+ \to K^0_S\pi^+\pi^+\pi^-$	175470 ± 547	1.766	0 ± 0	0.
$D^+ \to K^+K^-\pi^+$	103549 ± 4270	1.042	0 ± 0	0.

Outline

Event Selection

9 dominate ST tag modes of D (Based on DTagAlg Package in BOSS 711 & Boss 710)

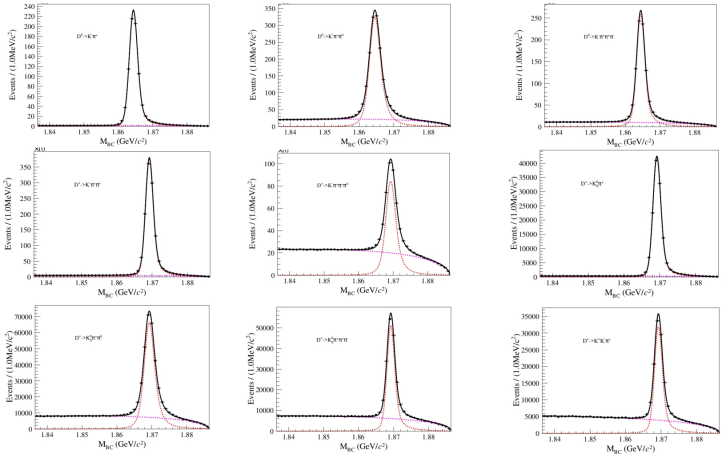
- **Good charged tracks**:
  |Rz|⩽10cm, |Rxy| ⩽ 1cm, |cosθ| ⩽0.93
- **Good Photons:**
  - Barrel : $E_\gamma > 0.025\text{GeV}$, |cosθ |⩽ 0.8
  - Endcap : $E_\gamma > 0.05\text{GeV}$, 0.84⩽|cos θ |⩽ 0.92
  - Time cut: 0⩽ T⩽ 14 (in unit of 50 ns);
  - |dang|> 10^o;
- **PID (Particle ID Package):**
  - TOF + dE/dx
  - Pion : prob(π) > prob(K);
  - Kaon: prob(K) > prob(π);
- **π^0 Candidates :**
  - π^0 : 0.115<M(γγ)<0.150 GeV/c^2, X^2_{1c}<50;
- **K^0_S Candidates :**
  - Daughter tracks: |Rz|⩽20cm, |cosθ| ⩽0.93 ;
  - No PID for tracks
  - Mass window: 0.487<M($\pi^+\pi^-$)<0.511 GeV/c^2,
  - Vertex fit $\chi^2 < 100$
  - Secondary vertex fit $\chi^2 < 100$ & $L/\sigma > 2.0$
- **Cosmic Ray Veto**
- **Tag D Reconstruction:**
  - $\Delta E = E_D - E_{beam}$, $M_{bc} = \sqrt{E^2_{beam} - \vec{P}^2_D}$
  - Minimum ΔE is used to select best candidate
  - ΔE cut: Same with Xiang Pang's work
- **K^0_S Veto for K3π tag mode:**
  - $|M(\pi^+\pi^-) - 0.4976| > 0.03\ \text{GeV}/c^2$

Original Work⇐

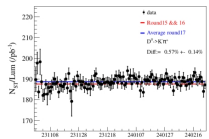
Fit to Data

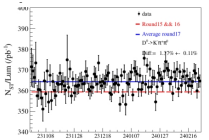
Signal PDF (MC shape$\otimes$ Gaussian) + Background PDF (Argus function: cutoff = 1.8865)

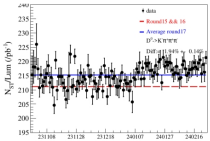
New data: 231029-240224 @ 711 PID

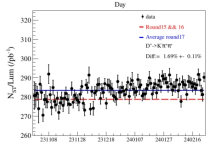


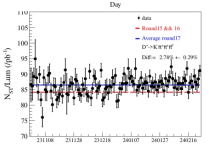
ST Yields / Offline Lum of Data(231029-240224)

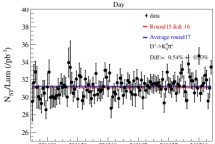


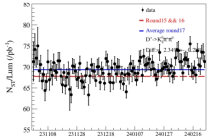


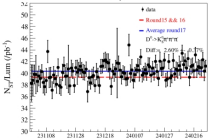


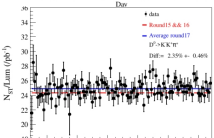




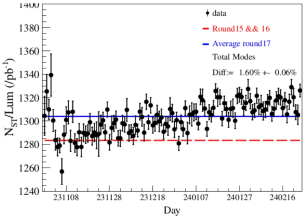








Lum: provided by Han Zhang



ST yields/pb^{-1}(offline) of new data (231029-240224 @ 711) are , mainly from beam shift,higher ($\sim$ 1.6%) than that of the old data (round15 & 16 @ SimplePID) on average, primarily due to beam shift.

Summary

- BESIII round17 data taking collect about 4.2fb^{-1} data @ 3.770 GeV, total luminosity adds up to more than 20fb^{-1}.
- Some checks on round17 $\psi(3770)$ has been done:
  - The offline luminosity is, on average, 1.0% lower than the online luminosity;
  - The beam energy is checked with a shift < 0.4 MeV;
  - The HV trip events accounted for 0.034% of the total;
  - ST yields/$\mathrm{fb}^{-1}$is checked with a deviation 0.5% compared with round16 data.

Thank you!