Comparisons between MC and data for R measurement in 3.850-4.590 GeV

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January 16, 2018

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- Data sets and MC samples
- Event selection
- The comparisons
- Conclusion

Introduction

Precise hadronic cross sections (R value) will improve the determination of:

- QED running coupling constant at Z pole, *i.e.* $\alpha(M_Z^2)$.
- Anomalous magnetic moment of the muon, $a_\mu = (g-2)/2$.

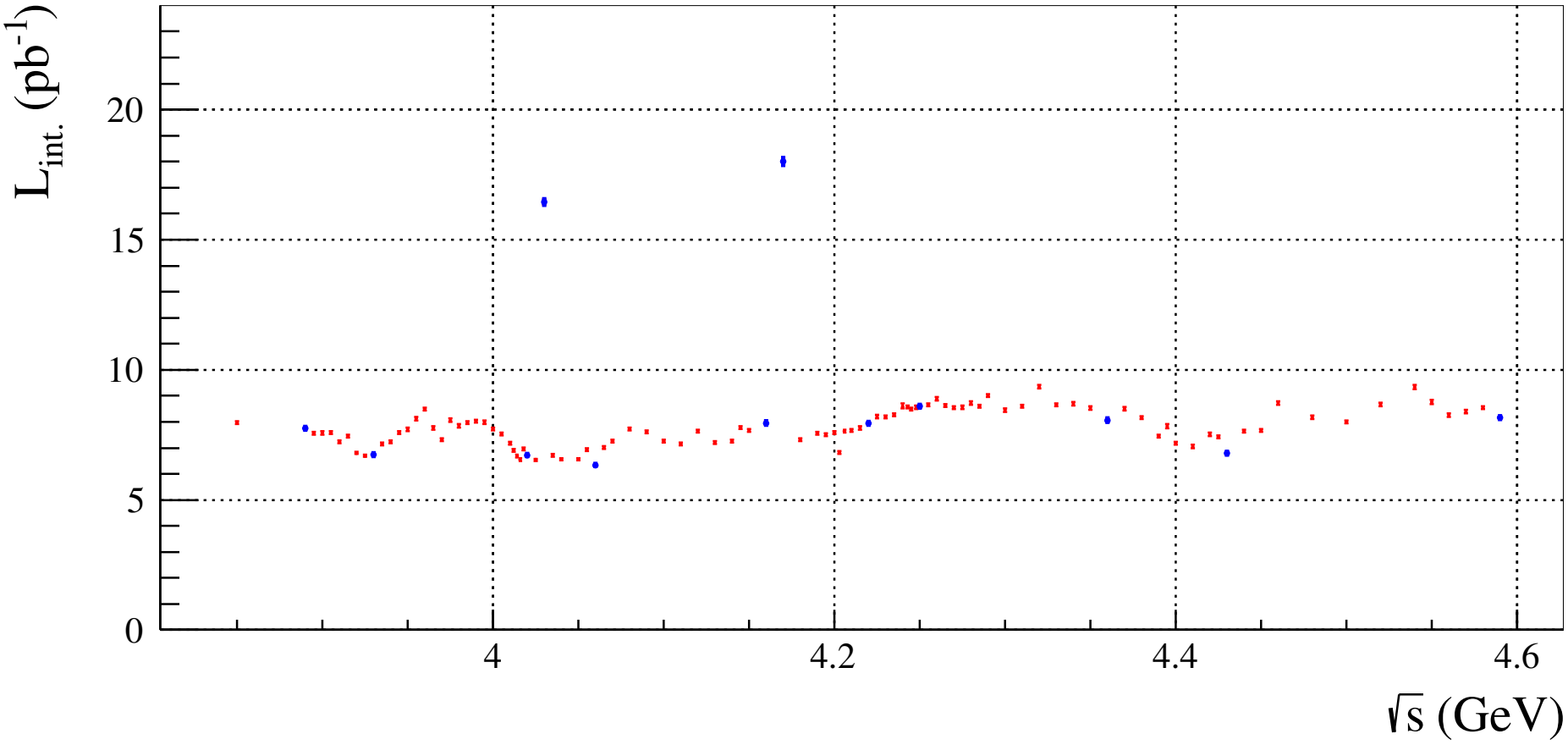
Experimentally, R value is determined by

$$R = \frac{N_{had.}^{obs.} - N_{bkg}}{\sigma_{\mu\mu}^0 \cdot \mathcal{L}_{int} \cdot \varepsilon_{trig.} \cdot \varepsilon_{had.} \cdot (1+\delta)}$$

- $N_{had.}^{obs.}$: Numbers of observed hadronic events.
- N_{bkg}: Number of the residual background events.
- $\mathcal{L}_{int}$: Integrated luminosity.
- $\varepsilon_{trig.}$: Trigger efficiency.
- $\varepsilon_{had.}$: Detection efficiency of the hadronic events.
- $(1+\delta)$: ISR correction factor.
- $\sigma_{\mu\mu}^0(s) = 86.8\ \mathrm{nb}/s$: Leading order QED cross section for $e^+e^- \to \mu^+\mu^-$.

Data sets

BOSS version: BOSS7.0.3
A total of 104 energy points from $\sqrt{s} = 3.850$ to 4.590 GeV.



Signal MC samples

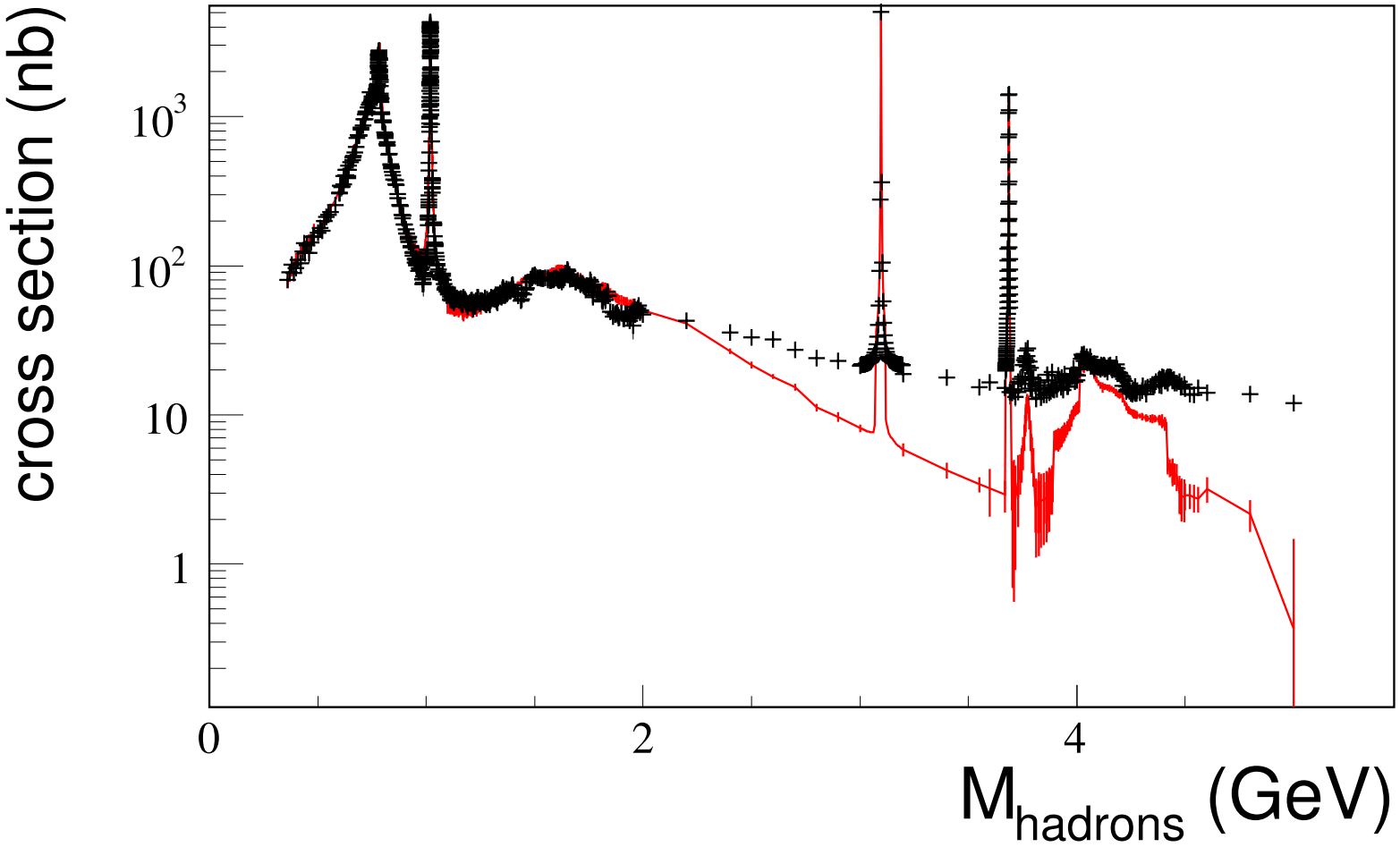
Two options:

- Pure Lunda (see Lipeng Zhou's talk):
- ConExc + Phokhara + Lunda:
  - Phokhara is used to simulate the 10 processes whose cross section and intermediate substructures of final states are known.
  - Using Conexc model, exclusive processes with known cross section are simulated, including $e^+e^- \to D^{(*)}_{(s)}\bar{D}^{(*)}_{(s)}, D\bar{D}\pi, D\bar{D}^*\pi + c.c.$, and final states containing charmonium states J/ψ, $\psi(2S)$, η_c, and h_c.
  - In ConExc, the latest BESIII measurements of the cross section are used after performing phenomenological fit of the line-shape.
  - In ConExc, the polar angle distributions of two-body processes are simulated by $1 + \alpha\cos^2\theta$, while the multi-body processes are simulated with PHSP model.
  - The Lunda model is used to simulate unknown processes.
  - A set of parameters are obtained by tunning at 4.26 GeV by Maoqiang Jing.

The signal MC is generated at $\sqrt{s}$ = 3.890, 3.930, 4.030, 4.170, 4.220, 4.250, 4.360, 4.430, and 4.590 GeV with 0.5 million events for each energy point.

hadronic cross sections

The sum of the known cross section and the total hadronic cross sections:



Background MC samples

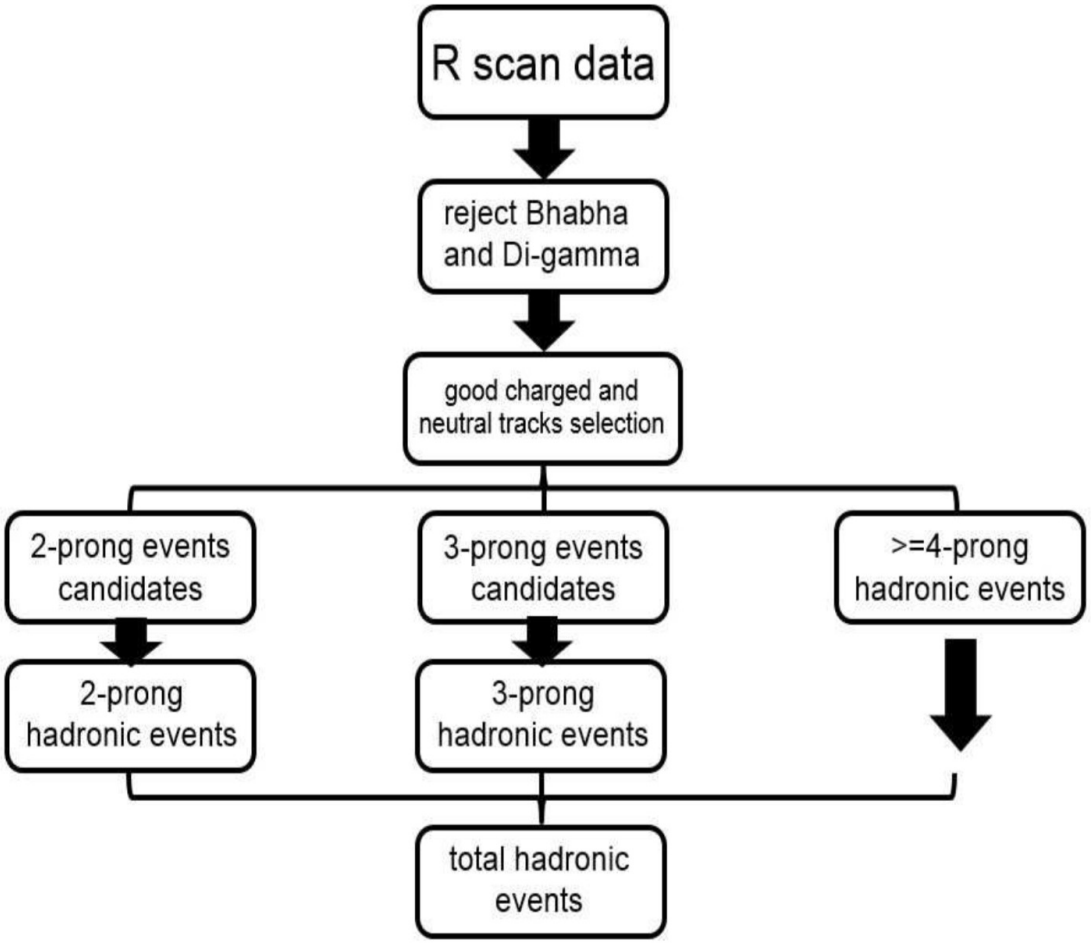
- Including bhabha, di-gamma, di-tau, di-muon, and two-photon events.
- The two-photon events $e^+e^- \to e^+e^- + X$, where $X = e^+e^-$, $\mu^+\mu^-$, $\pi^+\pi^-$, K^+K^-, η, and η'.
- Temporally generated in BOSS6.6.4p01 by Bingxin Zhang.
- A scaling process is applied according to the relative luminosity between background MC and data.
- Scaled background events which survive the hadronic event selection criteria are subtracted from data.

The background-to-signal ratio at $\sqrt{s} = 4.170$ GeV.

Bkg. MC	Gen. Events	Sur. Events	Obs. cross section (nb)	*Ratio* (%)
e^+e^-	8000000	1673	426.88	0.37
$\gamma\gamma$	500000	171	20.23	0.00
$\mu^+\mu^-$	500000	1361	5.25	0.23
$\tau^+\tau^-$	500000	242135	3.45	6.98
$e^+e^- + X$	500000	6184	3.44	1.78
Total				7.22

The event selection method

The selection criteria of hadronic events is carefully studied by Zhen Gao at low energies, we directly applied them in higher eneries.



Veto bhabha events and select good tracks

- Veto the bhabha and di-gamma events:
  - $N_{shower} \geqslant 2$.
  - $E_1 \geqslant E_2 \geqslant 0.65 E_{\text{beam}}$.
  - $|\Delta\theta| = |\theta_1 + \theta_2 - 180^\circ| < 10^\circ$.
- Good photon:
  - $E_{cluster} \geqslant 25$ MeV when $|\cos\theta| < 0.8$.
  - $E_{cluster} \geqslant 50$ MeV when $0.86 < |\cos\theta| < 0.92$.
  - $0 < T_{EMC} < 700$ ns.
- Isolated photon:
  - Energy deposition should larger than 0.1 GeV.
  - Angle from the nearest charged track should larger than 20°.
  - $0 < T_{EMC} < 700$ ns.
- Good charged tracks:
  - $|V_r| < 0.5$ cm, $|V_z| < 0.5$ cm, and $|\cos\theta| < 0.93$.
  - $p_{track} < 0.94\, p_{\text{beam}}$, where $p_{\text{beam}} \approx E_{\text{beam}}$.
  - $\chi = \frac{\mathrm{dE/dx}_{measure} - \mathrm{dE/dx}_{proton}}{\sigma_{proton}} > 10$.
  - Remove charged tracks when $E/p > 0.8$ && $p > 0.65\, p_{\text{beam}}$.
  - Veto γ-conversions when $M(e^+e^-) < 0.1$ GeV && $\theta_{ee} < 15^\circ$.

Select good hadronic events

- At least 2 good hadronic tracks
- If the number of good hadronic tracks = 2:
  - $|\Delta\theta| = |\theta_1 + \theta_2 - 180^\circ| > 10^\circ$
  - $|\Delta\phi| = ||\phi_1 - \phi_2| - 180^\circ| > 15^\circ$
  - At least 2 isolated photons
- If the number of good hadronic tracks = 3:
  - $|\Delta\theta| = |\theta_1 + \theta_2 - 180^\circ| < 10^\circ$
  - $|\Delta\phi| = ||\phi_1 - \phi_2| - 180^\circ| < 15^\circ$
  - (number of track with E/P>0.8) $\leqslant 1$.
  - (number of track with PID ratio >0.25) $\leqslant 1$.

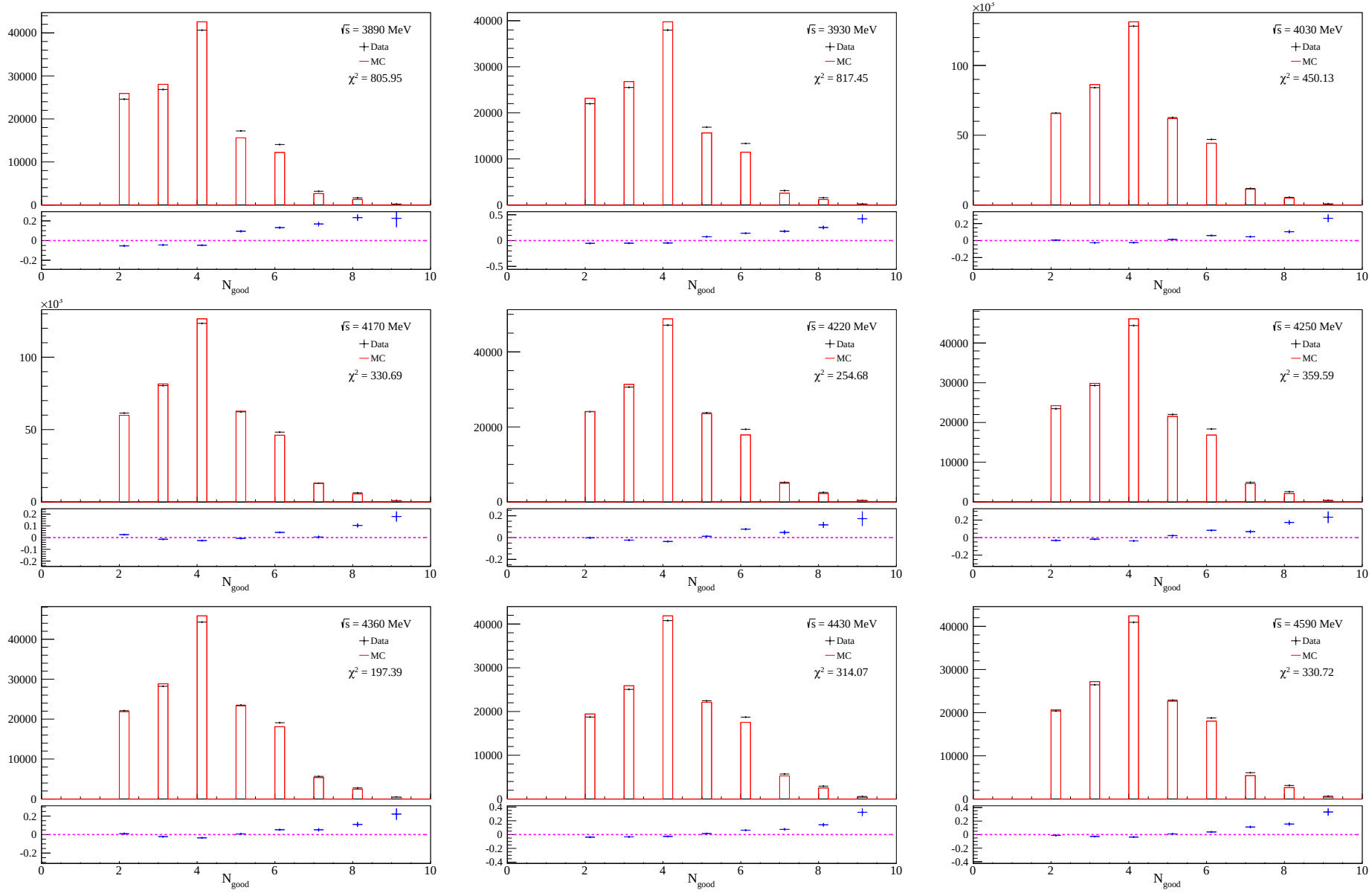
  where the PID ratio is defined as:
  $r_{\mathrm{PID}} = \mathrm{Prob.}(e)/\big(\mathrm{Prob.}(p) + \mathrm{Prob.}(K) + \mathrm{Prob.}(\pi) + \mathrm{Prob.}(e)\big)$
- If the number of good hadronic tracks $\geqslant 4$:
  - No additional requirements

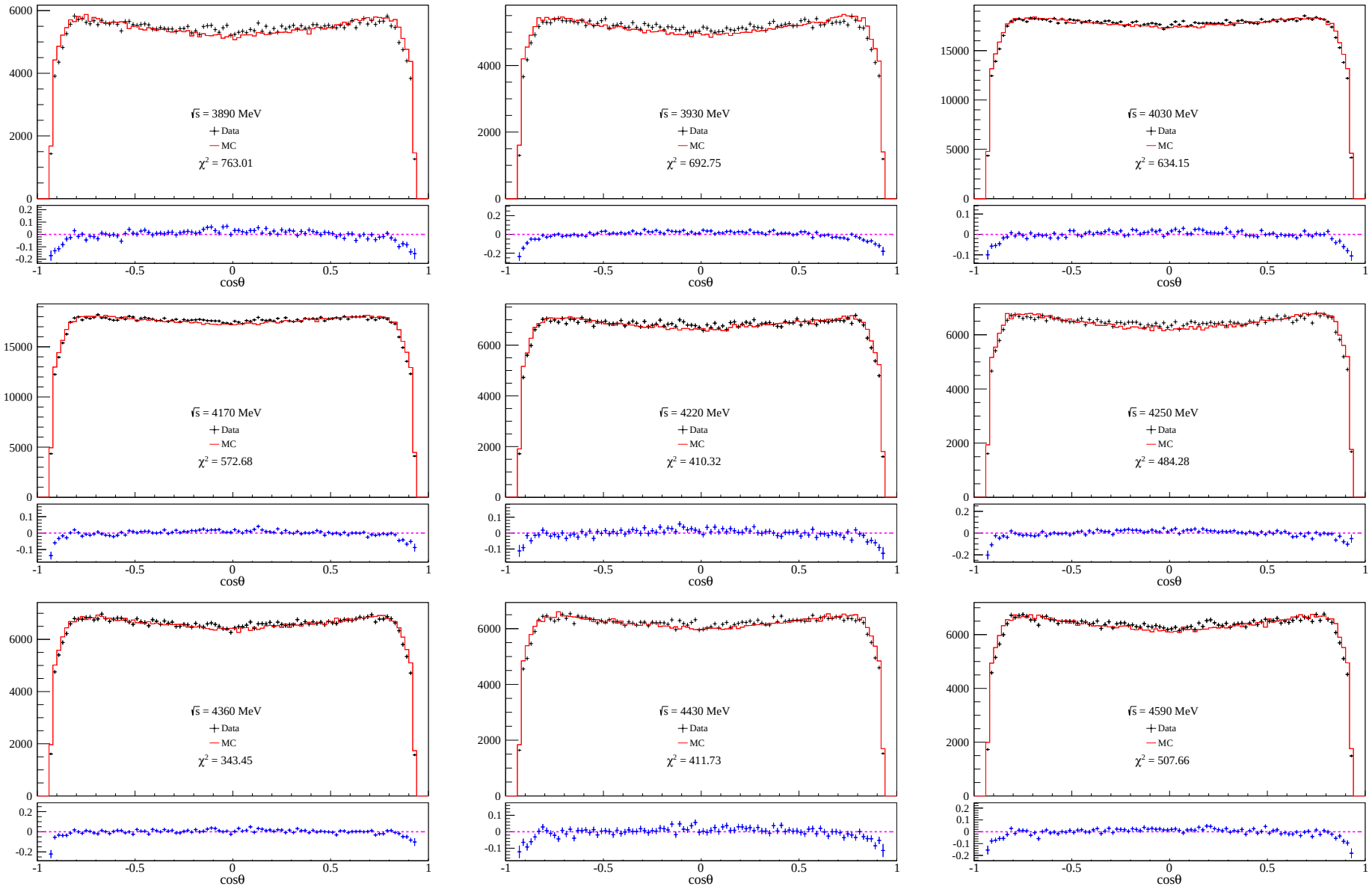
Definitions and variables

- In the comparisons, the χ^2 is defined as: $\chi^2 = \sum_{i=1}^{Nbin} \frac{(N^i_{data} - N^i_{MC})^2}{N^i_{data}}$
- The number of good charged tracks: N_{good}.
- The number of good neutral tracks (good photons): N_γ.
- The number of good isolated photons: N_{isogam}.
- The polar angle distributions: $cos\theta$.
- Deposited energy of charged tracks in EMC: $E^{ctrk.}_{emc}$.
- Momentum of charged tracks measured with MDC: p_{ctrk}.
- The ratio between deposited energy and momentum of charged tracks: E/P.
- Positions of charged tracks: V_r, V_z.
- Total visible energy of each event: $E_{visable}$.
- The multiplicities of proton, kaon, pions.
- The mass and momentum spectra of K^0_S, ϕ, π^0, and Λ.
- The mass and momentum spectra of D^0, D^+, D^+_s, and their excited grounds.

Definitions and variables

- The K_S^0, ϕ, π^0, and Λ are reconstructed by
  - $K_S^0 \to \pi^+\pi^-$.
  - $\phi \to K^+K^-$.
  - $\pi^0 \to \gamma\gamma$.
  - $\Lambda \to p\pi^-$.
- The DD events are singly reconstructed by using DTagTool
  - $D^0 \to K^-\pi^+, D^{*0} \to D^0\pi^0$.
  - $D^+ \to K^+\pi^+\pi^-, D^{*+} \to D^0\pi^+$.
  - $D_s^+ \to K^+K^-\pi^+, D_s^{*+} \to D_s^+\gamma$.


√s = 3890 MeV
Data
MC
χ² = 805.95
√s = 3930 MeV
χ² = 817.45
√s = 4030 MeV
χ² = 450.13
√s = 4170 MeV
χ² = 330.69
√s = 4220 MeV
χ² = 254.68
√s = 4250 MeV
χ² = 359.59
√s = 4360 MeV
χ² = 197.39
√s = 4430 MeV
χ² = 314.07
√s = 4590 MeV
χ² = 330.72
N_good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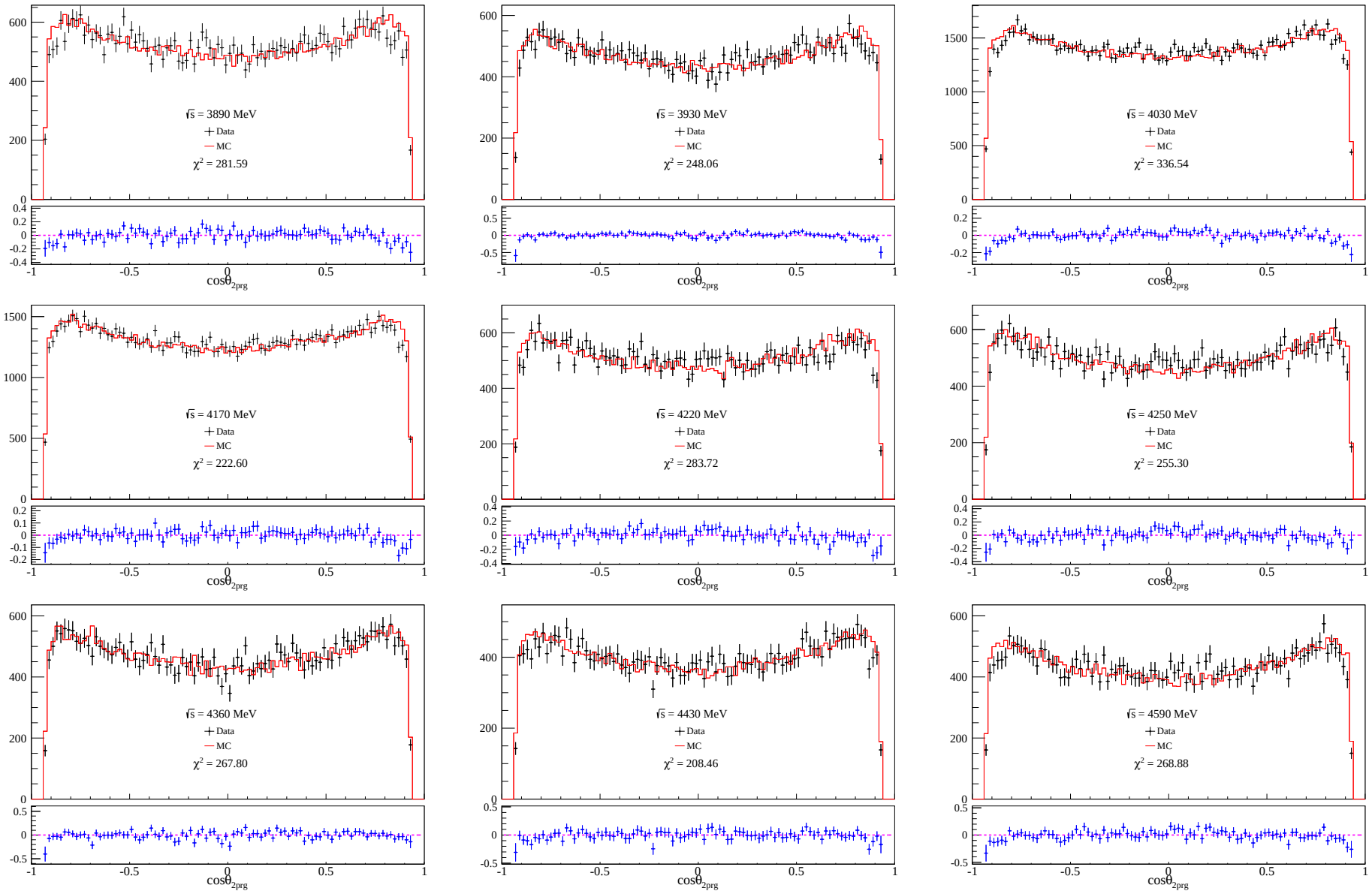
Data
MC
χ² = 763.01
√s = 3930 MeV
χ² = 692.75
√s = 4030 MeV
χ² = 634.15
√s = 4170 MeV
χ² = 572.68
√s = 4220 MeV
χ² = 410.32
√s = 4250 MeV
χ² = 484.28
√s = 4360 MeV
χ² = 343.45
√s = 4430 MeV
χ² = 411.73
√s = 4590 MeV
χ² = 507.66
cosθ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Data
MC
χ² = 281.59
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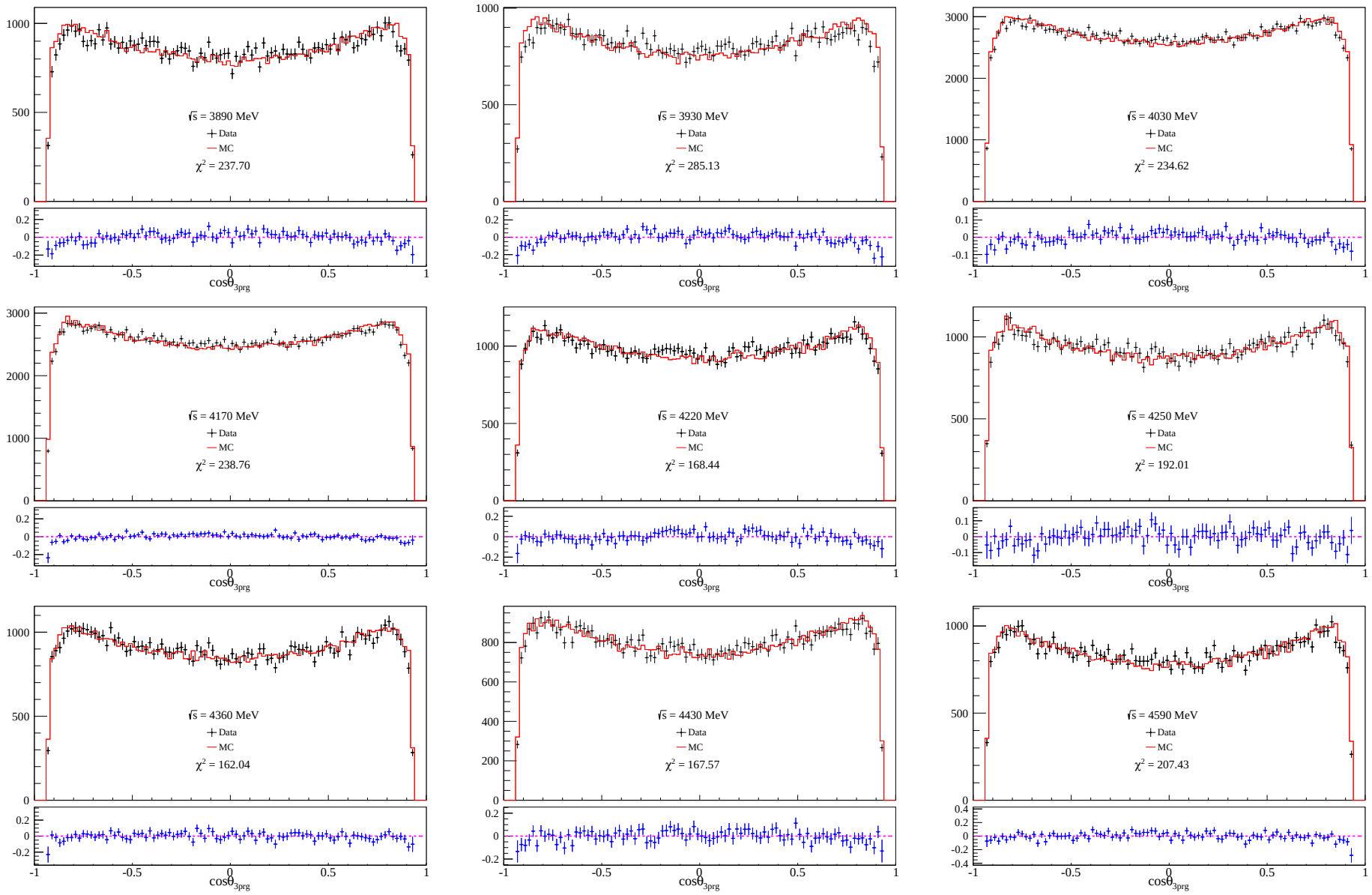
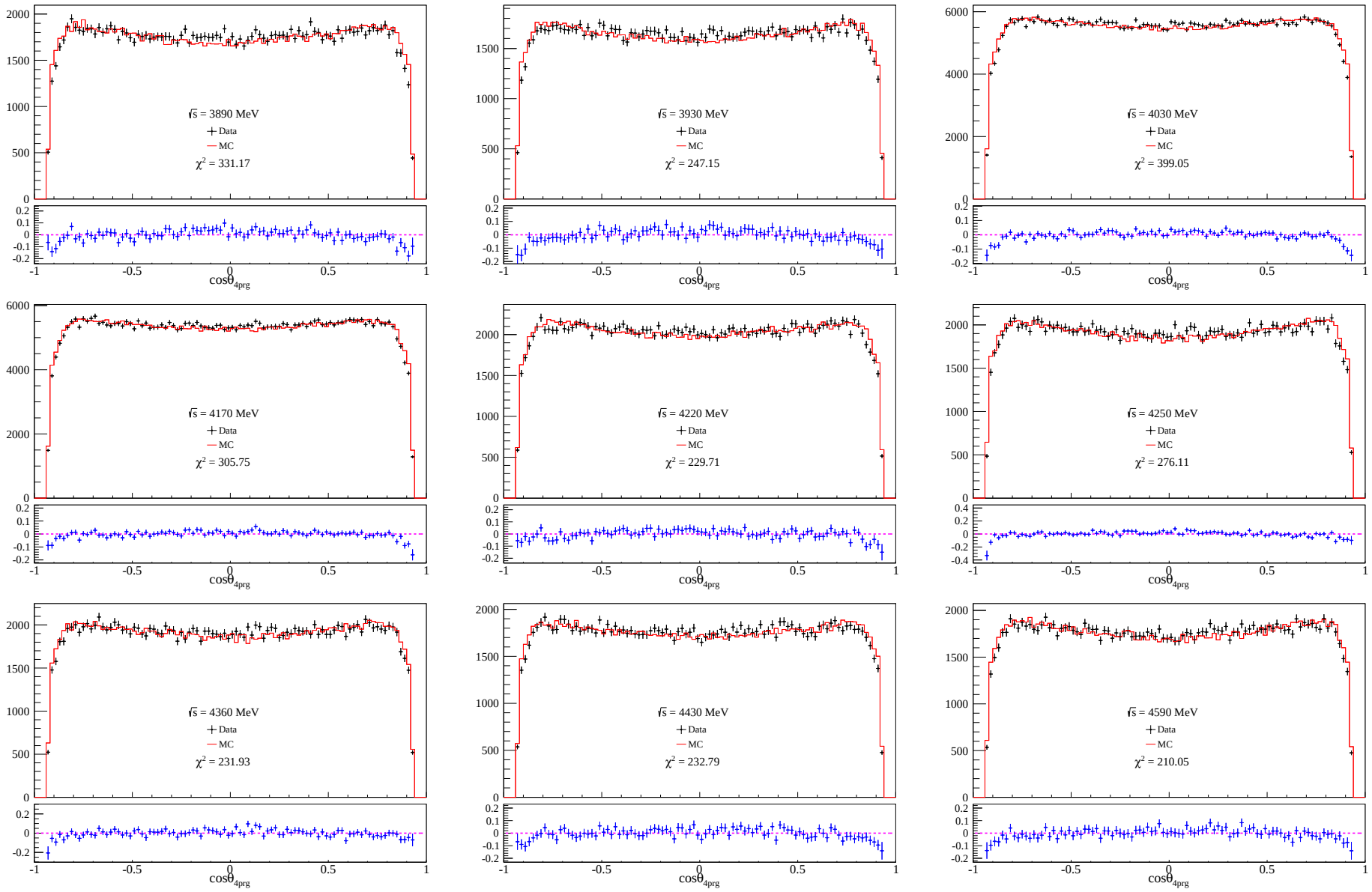
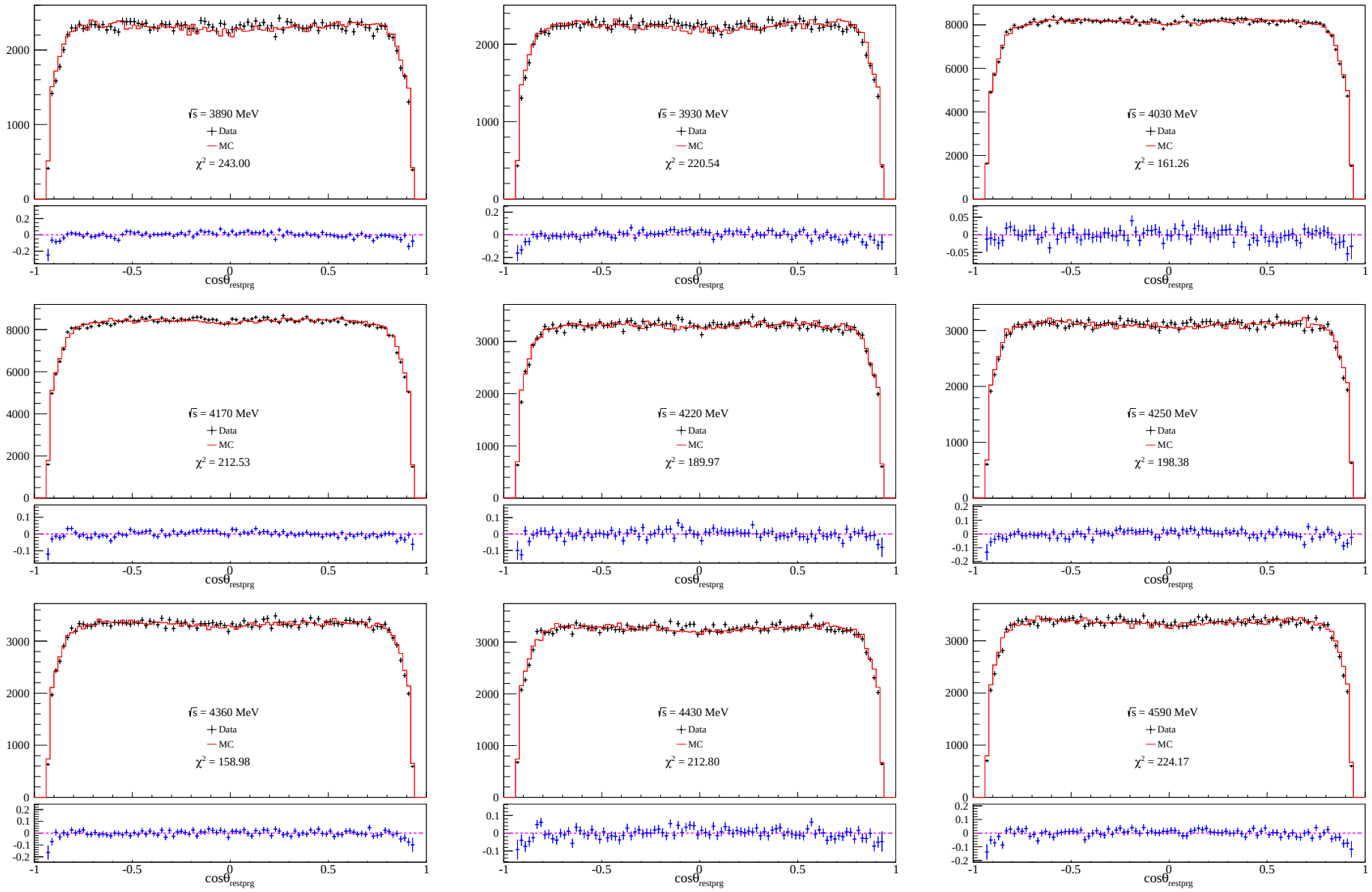
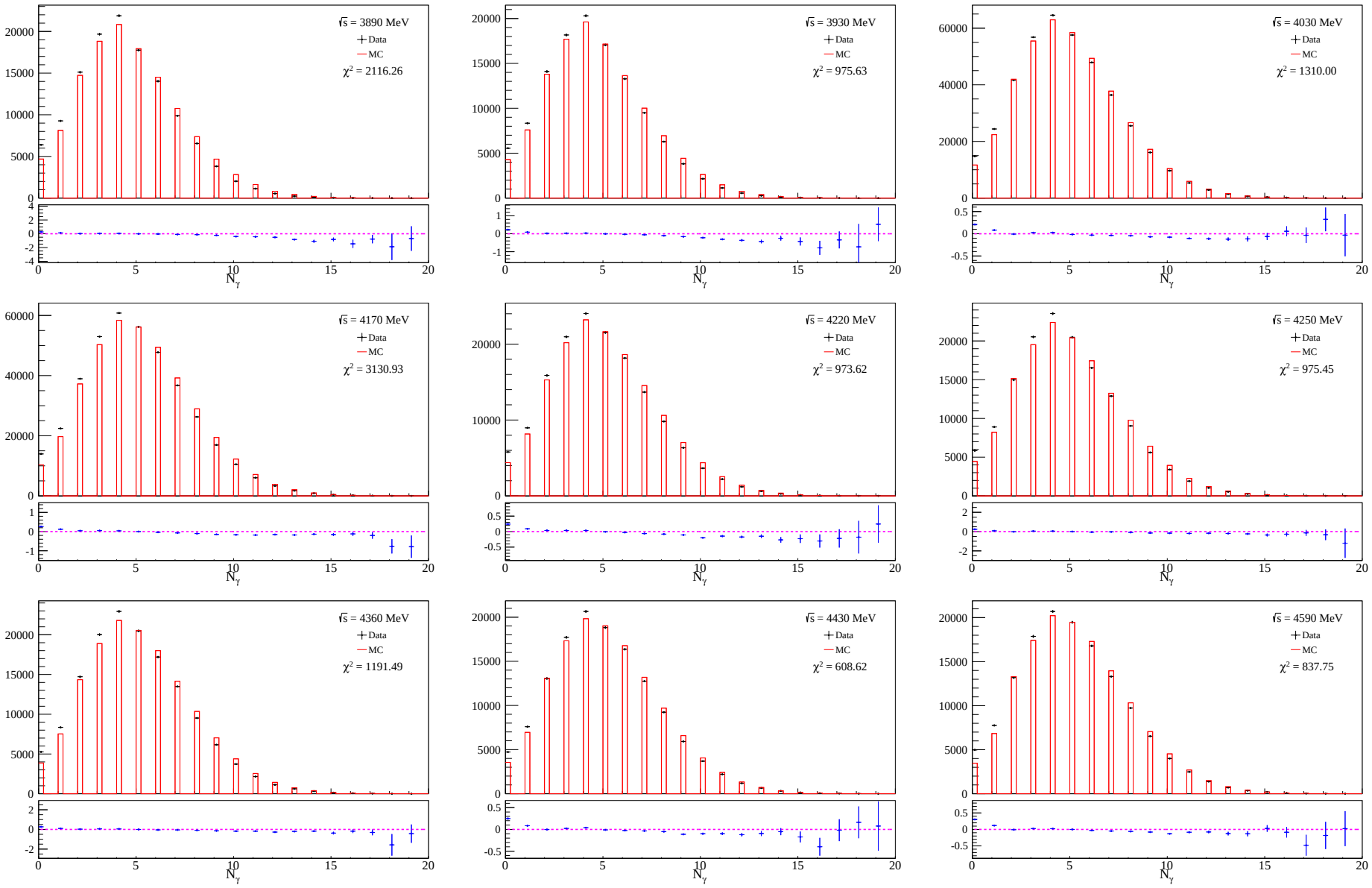
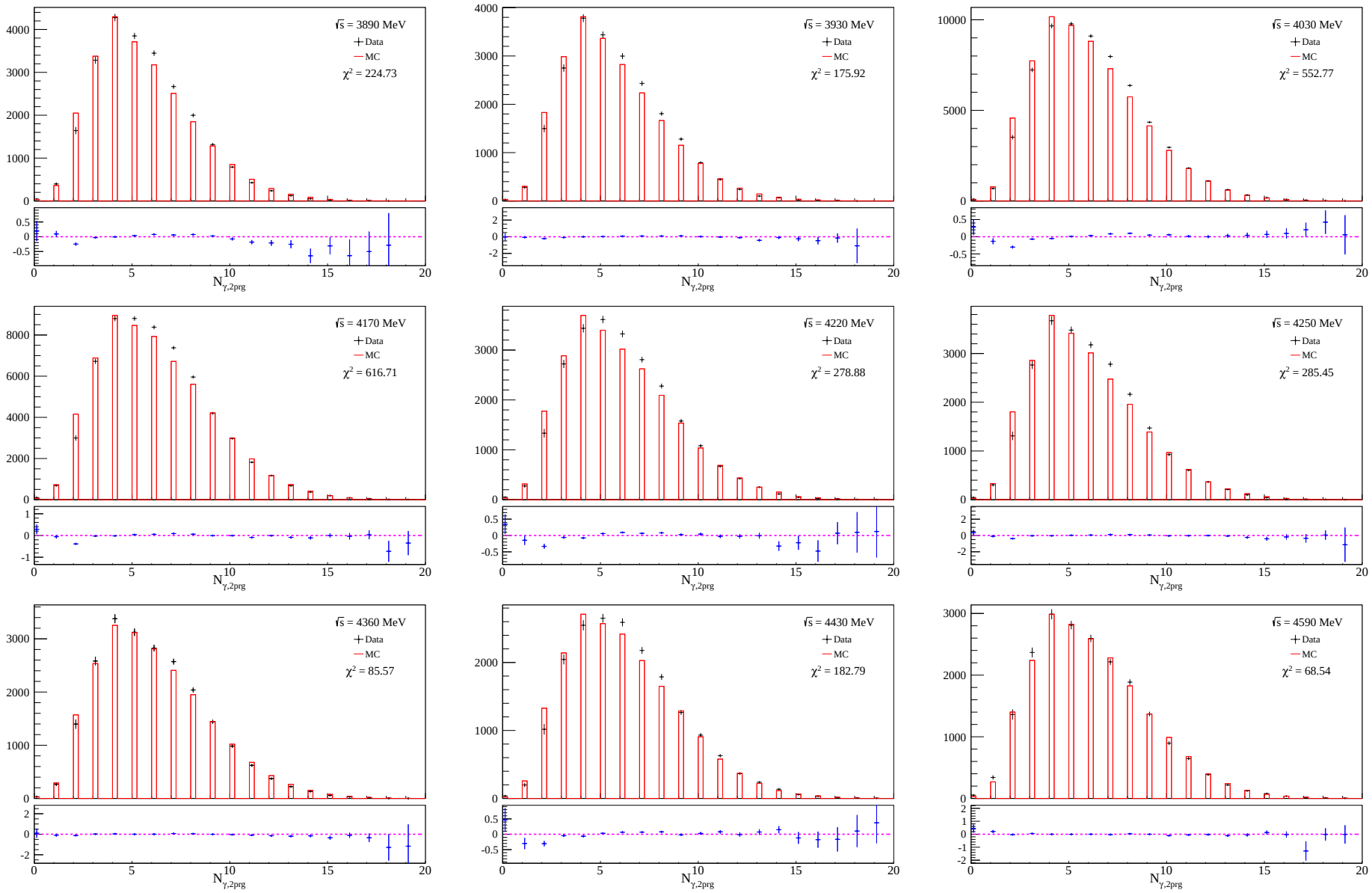
χ² = 248.06
√s = 4030 MeV
χ² = 336.54
√s = 4170 MeV
χ² = 222.60
√s = 4220 MeV
χ² = 283.72
√s = 4250 MeV
χ² = 255.30
√s = 4360 MeV
χ² = 267.80
√s = 4430 MeV
χ² = 208.46
√s = 4590 MeV
χ² = 268.88
cosθ2prg

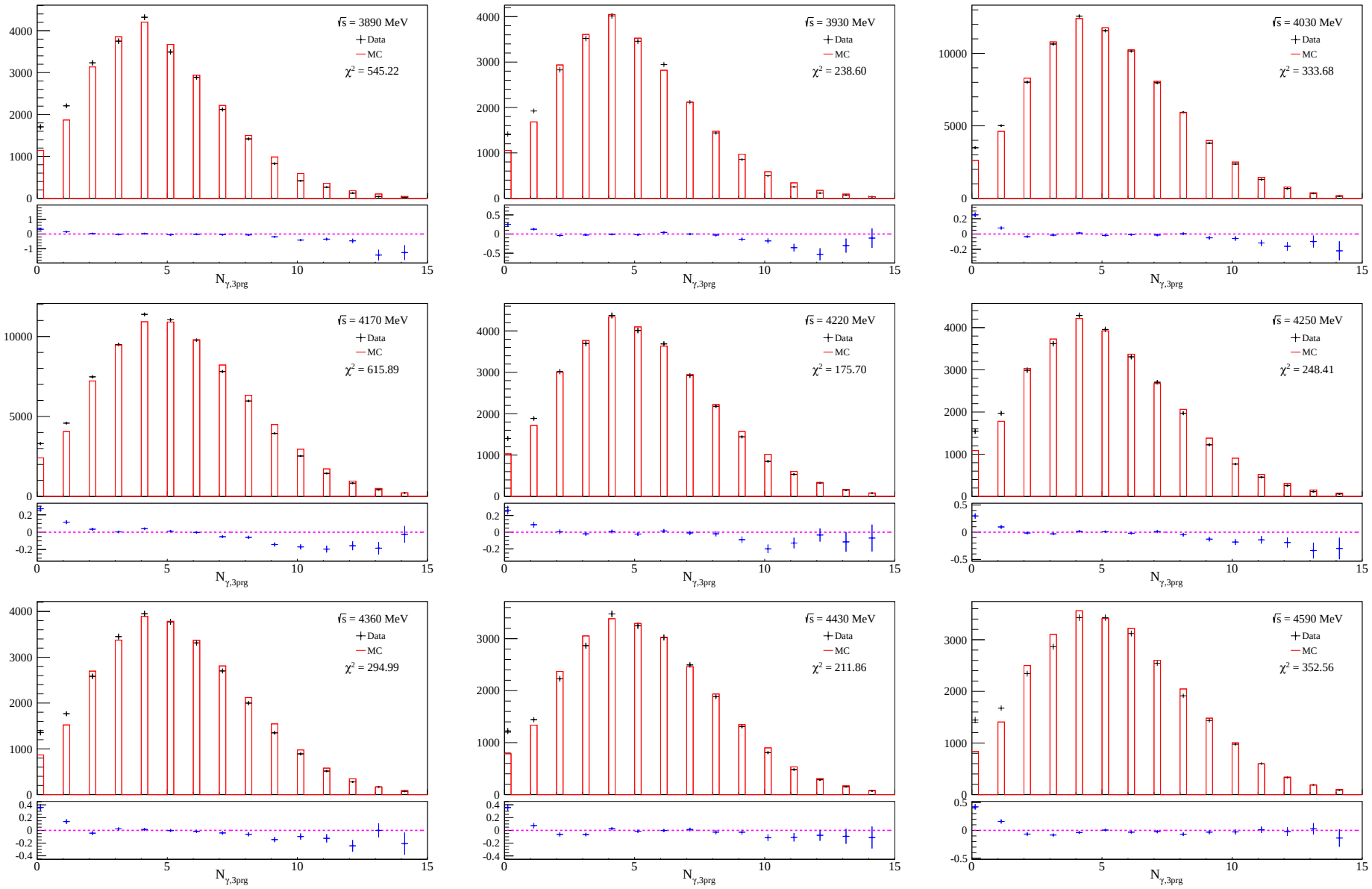

√s = 3890 MeV
Data
MC
χ² = 237.70
√s = 3930 MeV
χ² = 285.13
√s = 4030 MeV
χ² = 234.62
√s = 4170 MeV
χ² = 238.76
√s = 4220 MeV
χ² = 168.44
√s = 4250 MeV
χ² = 192.01
√s = 4360 MeV
χ² = 162.04
√s = 4430 MeV
χ² = 167.57
√s = 4590 MeV
χ² = 207.43
cosθ3prg


√s = 3890 MeV
Data
MC
χ² = 331.17
√s = 3930 MeV
Data
MC
χ² = 247.15
√s = 4030 MeV
Data
MC
χ² = 399.05
√s = 4170 MeV
Data
MC
χ² = 305.75
√s = 4220 MeV
Data
MC
χ² = 229.71
√s = 4250 MeV
Data
MC
χ² = 276.11
√s = 4360 MeV
Data
MC
χ² = 231.93
√s = 4430 MeV
Data
MC
χ² = 232.79
√s = 4590 MeV
Data
MC
χ² = 210.05
cosθ4prg


√s = 3890 MeV
Data
MC
χ² = 243.00
√s = 3930 MeV
Data
MC
χ² = 220.54
√s = 4030 MeV
Data
MC
χ² = 161.26
√s = 4170 MeV
Data
MC
χ² = 212.53
√s = 4220 MeV
Data
MC
χ² = 189.97
√s = 4250 MeV
Data
MC
χ² = 198.38
√s = 4360 MeV
Data
MC
χ² = 158.98
√s = 4430 MeV
Data
MC
χ² = 212.80
√s = 4590 MeV
Data
MC
χ² = 224.17
cosθrestprg


√s = 3890 MeV
Data
MC
χ² = 2116.26
√s = 3930 MeV
χ² = 975.63
√s = 4030 MeV
χ² = 1310.00
√s = 4170 MeV
χ² = 3130.93
√s = 4220 MeV
χ² = 973.62
√s = 4250 MeV
χ² = 975.45
√s = 4360 MeV
χ² = 1191.49
√s = 4430 MeV
χ² = 608.62
√s = 4590 MeV
χ² = 837.75
N_γ


√s = 3890 MeV
Data
MC
χ² = 224.73
√s = 3930 MeV
χ² = 175.92
√s = 4030 MeV
χ² = 552.77
√s = 4170 MeV
χ² = 616.71
√s = 4220 MeV
χ² = 278.88
√s = 4250 MeV
χ² = 285.45
√s = 4360 MeV
χ² = 85.57
√s = 4430 MeV
χ² = 182.79
√s = 4590 MeV
χ² = 68.54
N_γ,2prg


√s = 3890 MeV
Data
MC
χ² = 545.22
√s = 3930 MeV
χ² = 238.60
√s = 4030 MeV
χ² = 333.68
√s = 4170 MeV
χ² = 615.89
√s = 4220 MeV
χ² = 175.70
√s = 4250 MeV
χ² = 248.41
√s = 4360 MeV
χ² = 294.99
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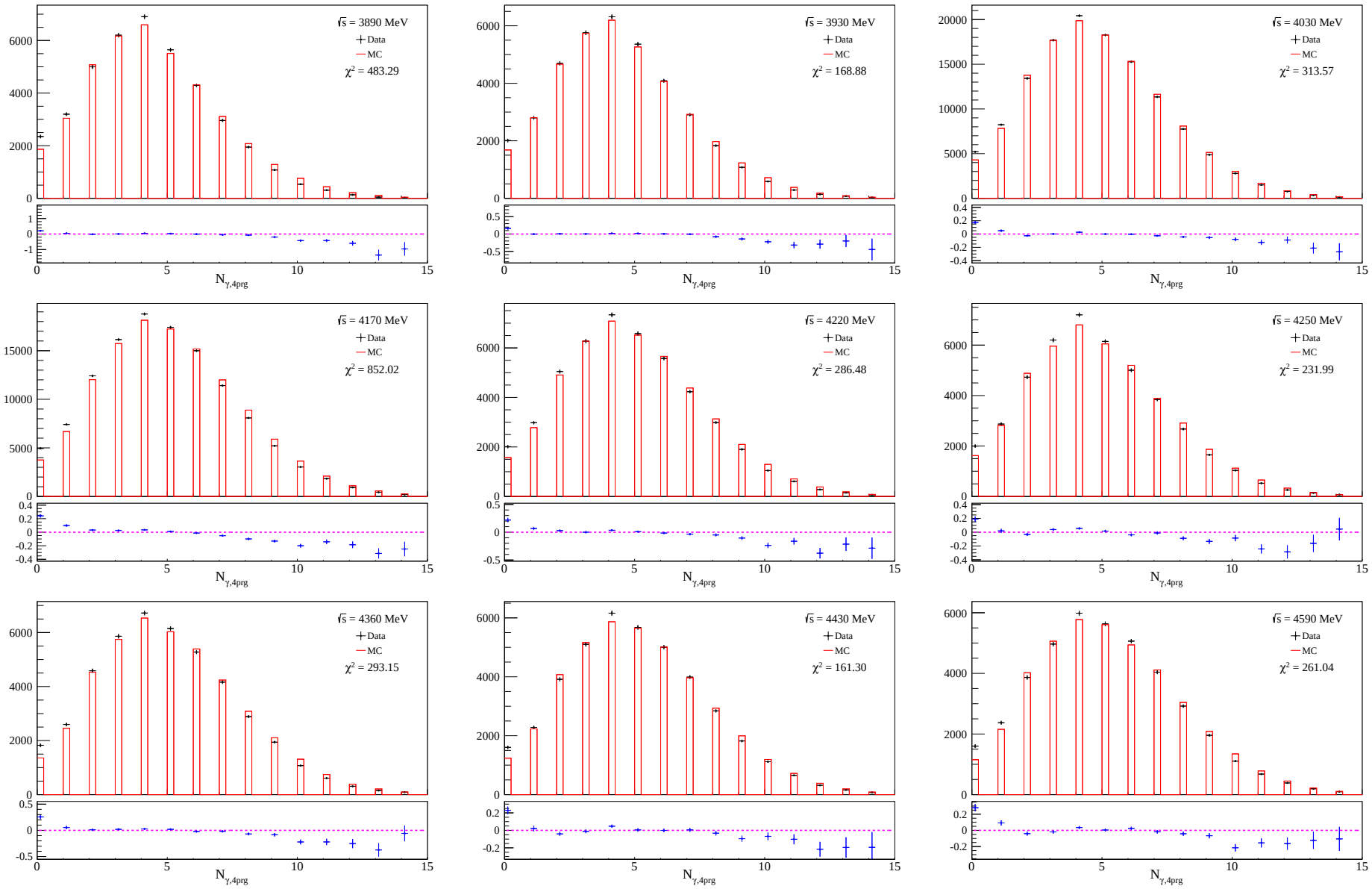
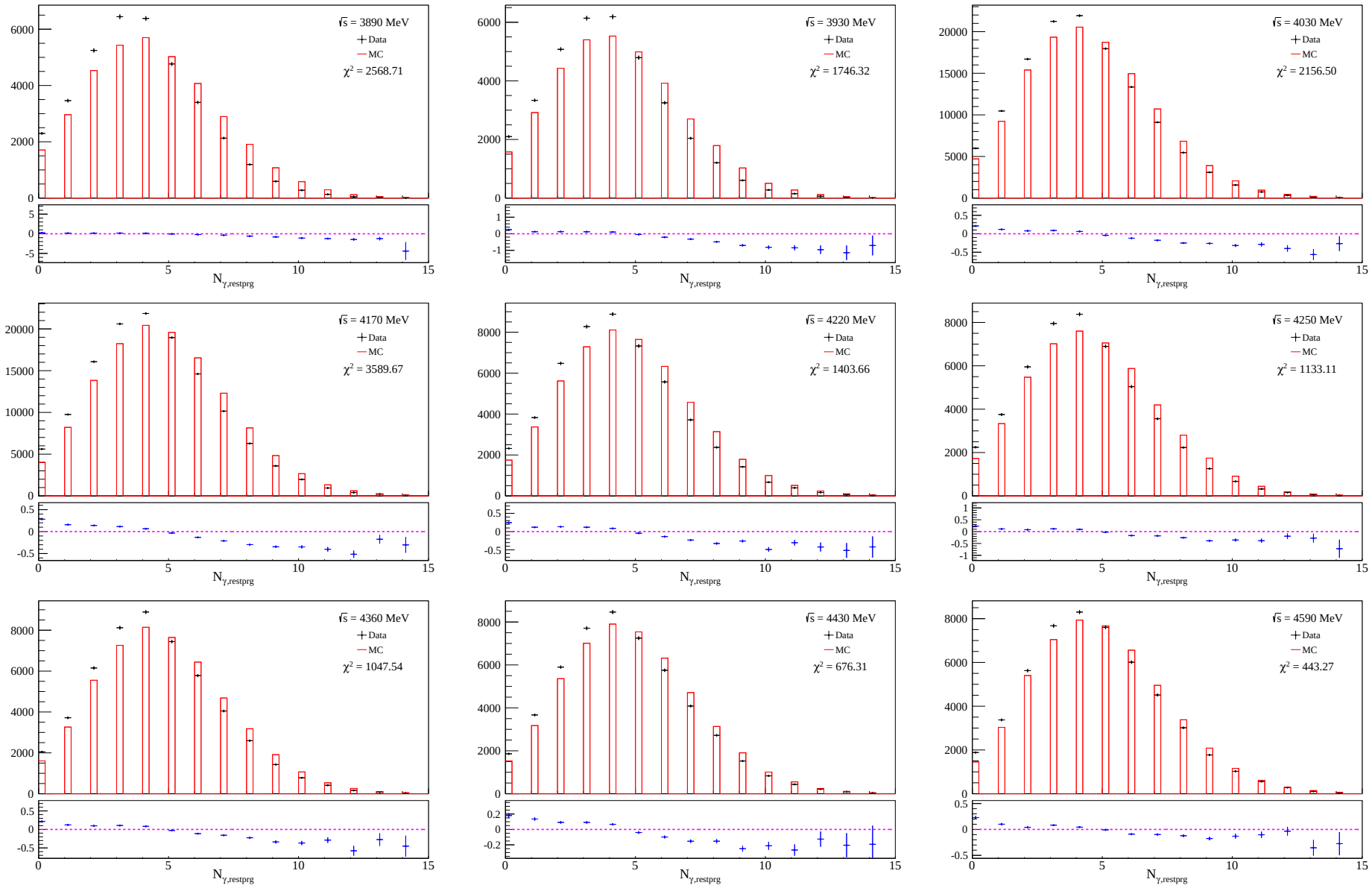
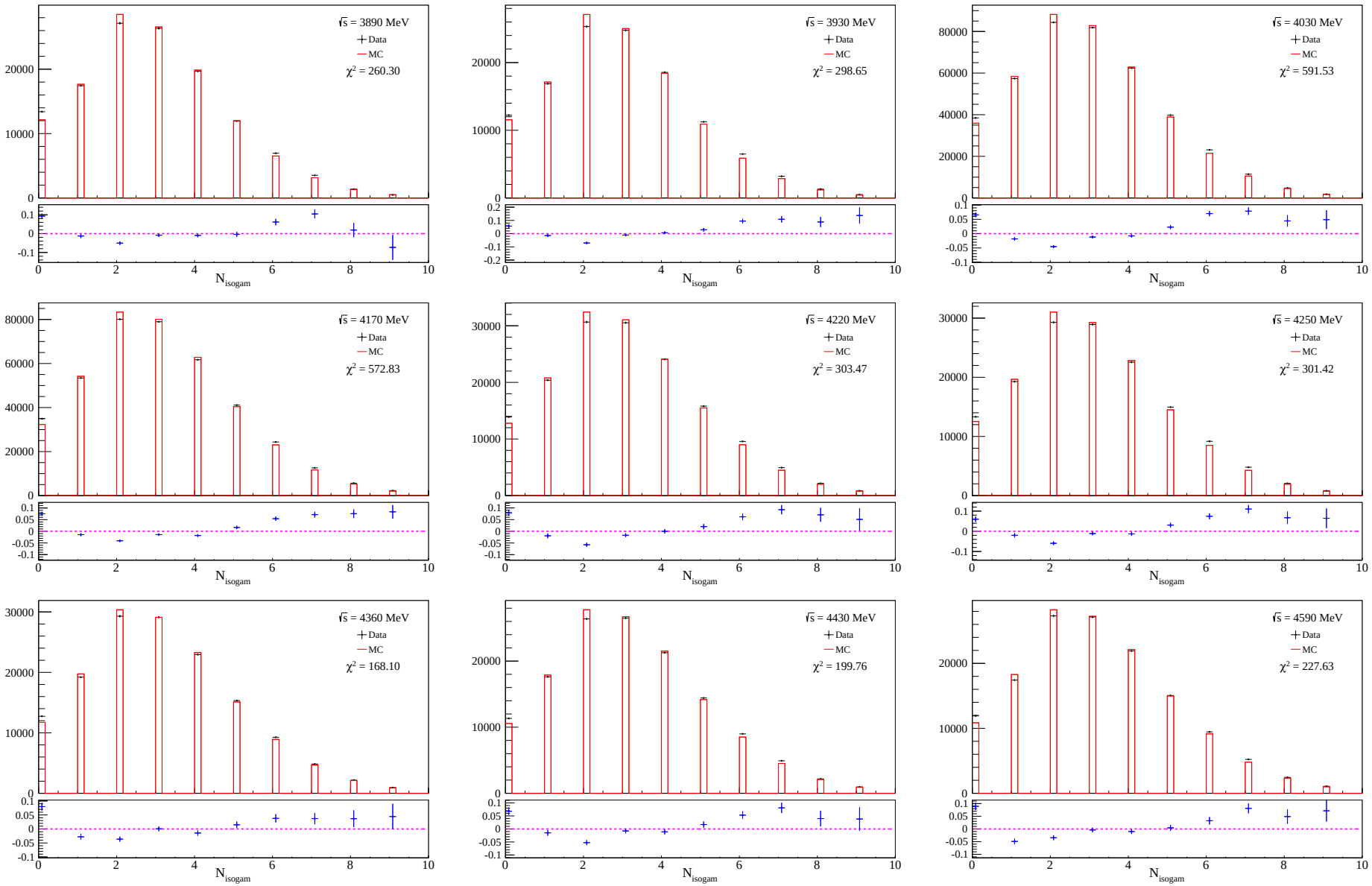
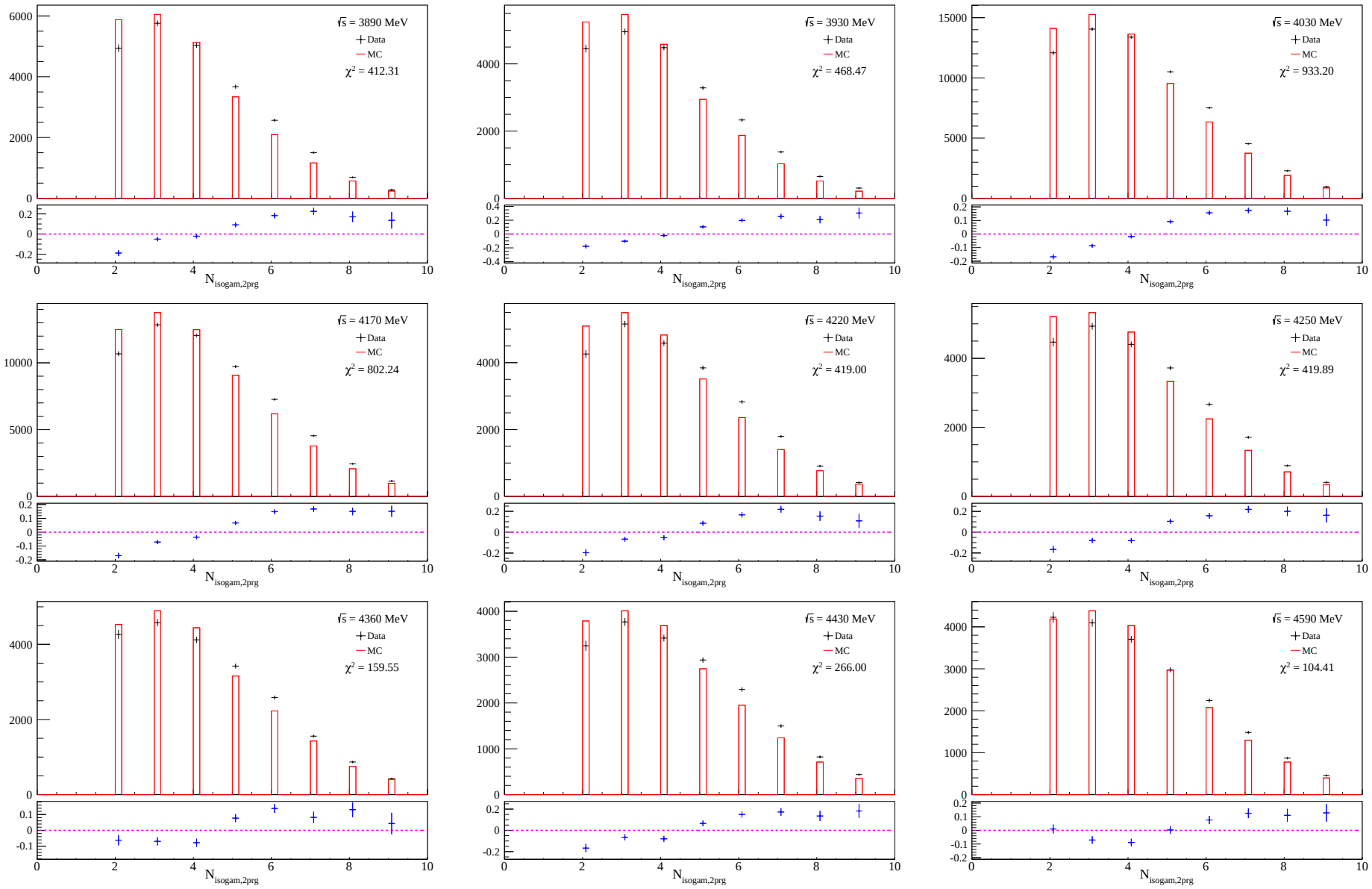
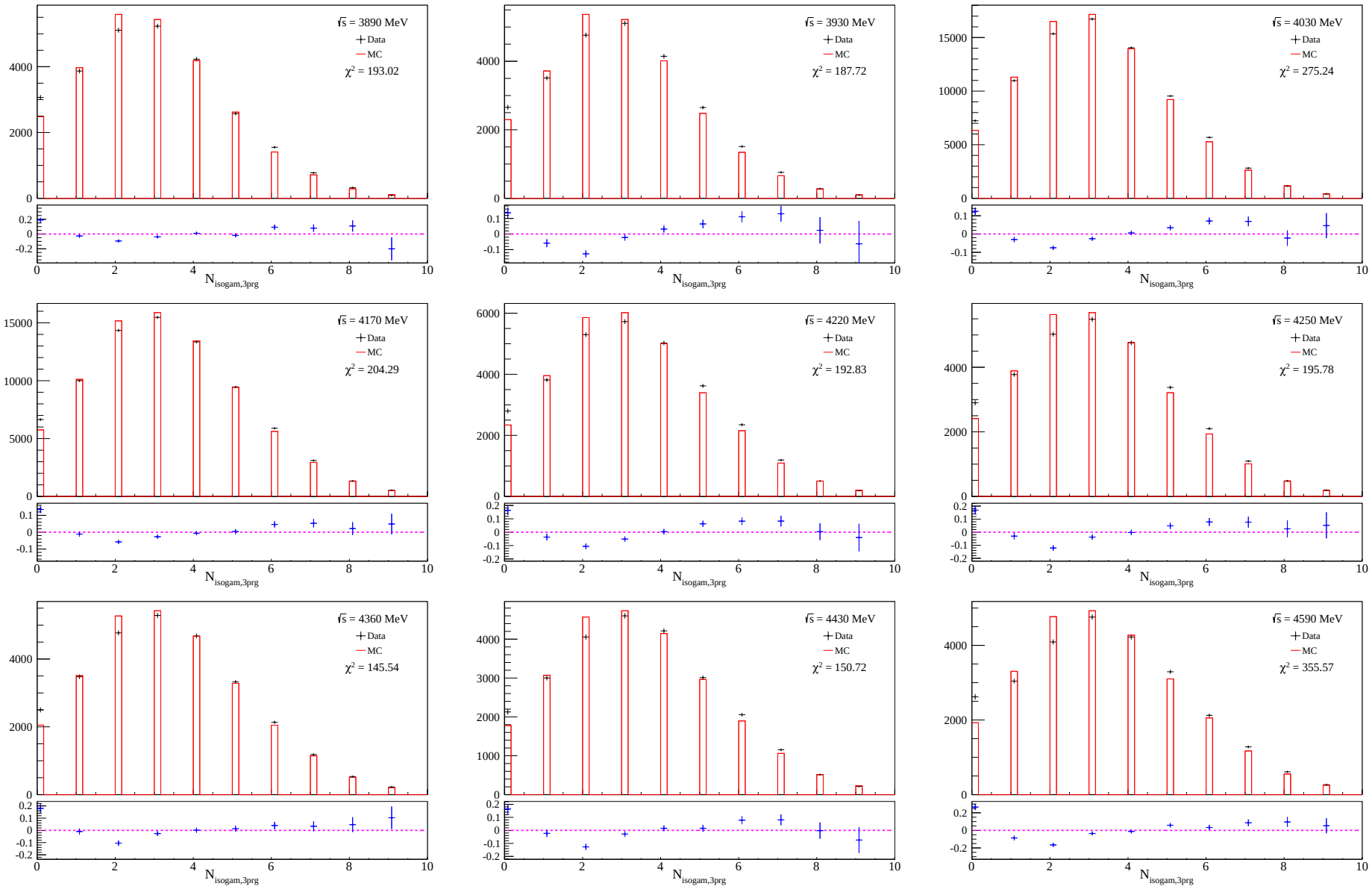
χ² = 352.56
N_γ,3prg

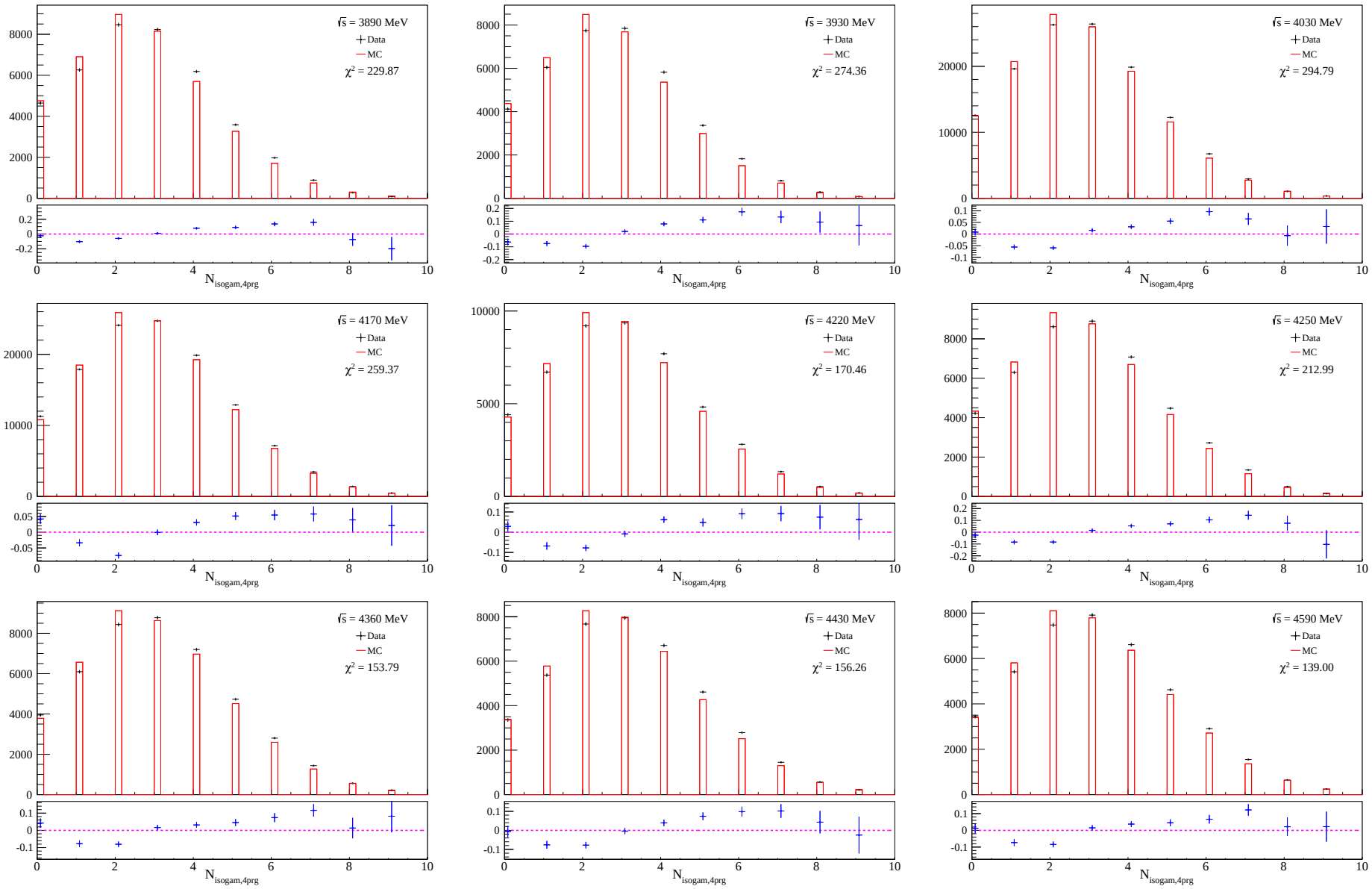

√s = 3890 MeV
Data
MC
χ² = 483.29
√s = 3930 MeV
χ² = 168.88
√s = 4030 MeV
χ² = 313.57
√s = 4170 MeV
χ² = 852.02
√s = 4220 MeV
χ² = 286.48
√s = 4250 MeV
χ² = 231.99
√s = 4360 MeV
χ² = 293.15
√s = 4430 MeV
χ² = 161.30
√s = 4590 MeV
χ² = 261.04
N_γ,4prg


√s = 3890 MeV
Data
MC
χ² = 2568.71
√s = 3930 MeV
χ² = 1746.32
√s = 4030 MeV
χ² = 2156.50
√s = 4170 MeV
χ² = 3589.67
√s = 4220 MeV
χ² = 1403.66
√s = 4250 MeV
χ² = 1133.11
√s = 4360 MeV
χ² = 1047.54
√s = 4430 MeV
χ² = 676.31
√s = 4590 MeV
χ² = 443.27
N_γ,restprg

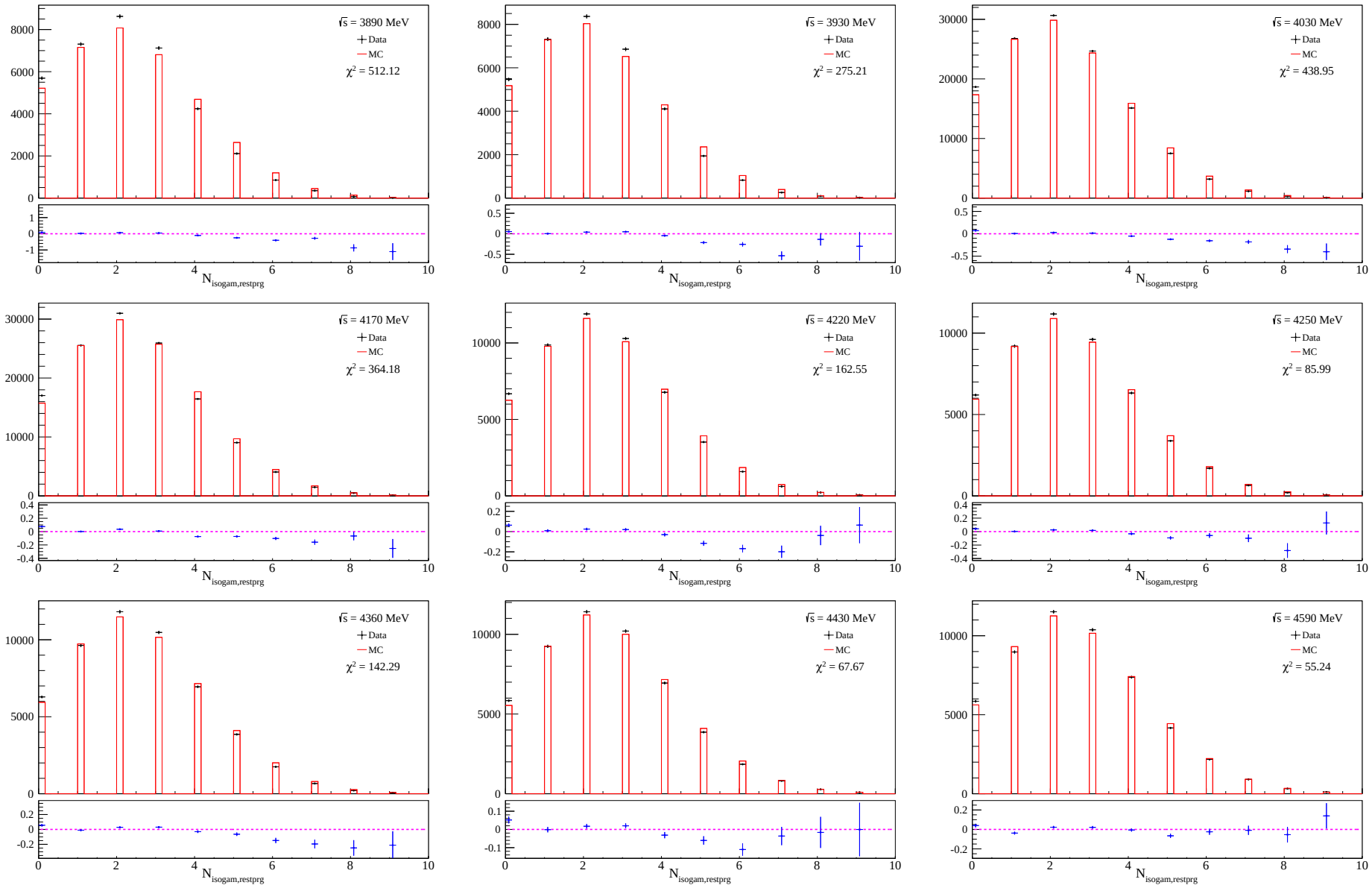

√s = 3890 MeV
Data
MC
χ² = 260.30
√s = 3930 MeV
χ² = 298.65
√s = 4030 MeV
χ² = 591.53
√s = 4170 MeV
χ² = 572.83
√s = 4220 MeV
χ² = 303.47
√s = 4250 MeV
χ² = 301.42
√s = 4360 MeV
χ² = 168.10
√s = 4430 MeV
χ² = 199.76
√s = 4590 MeV
χ² = 227.63
N_isogam

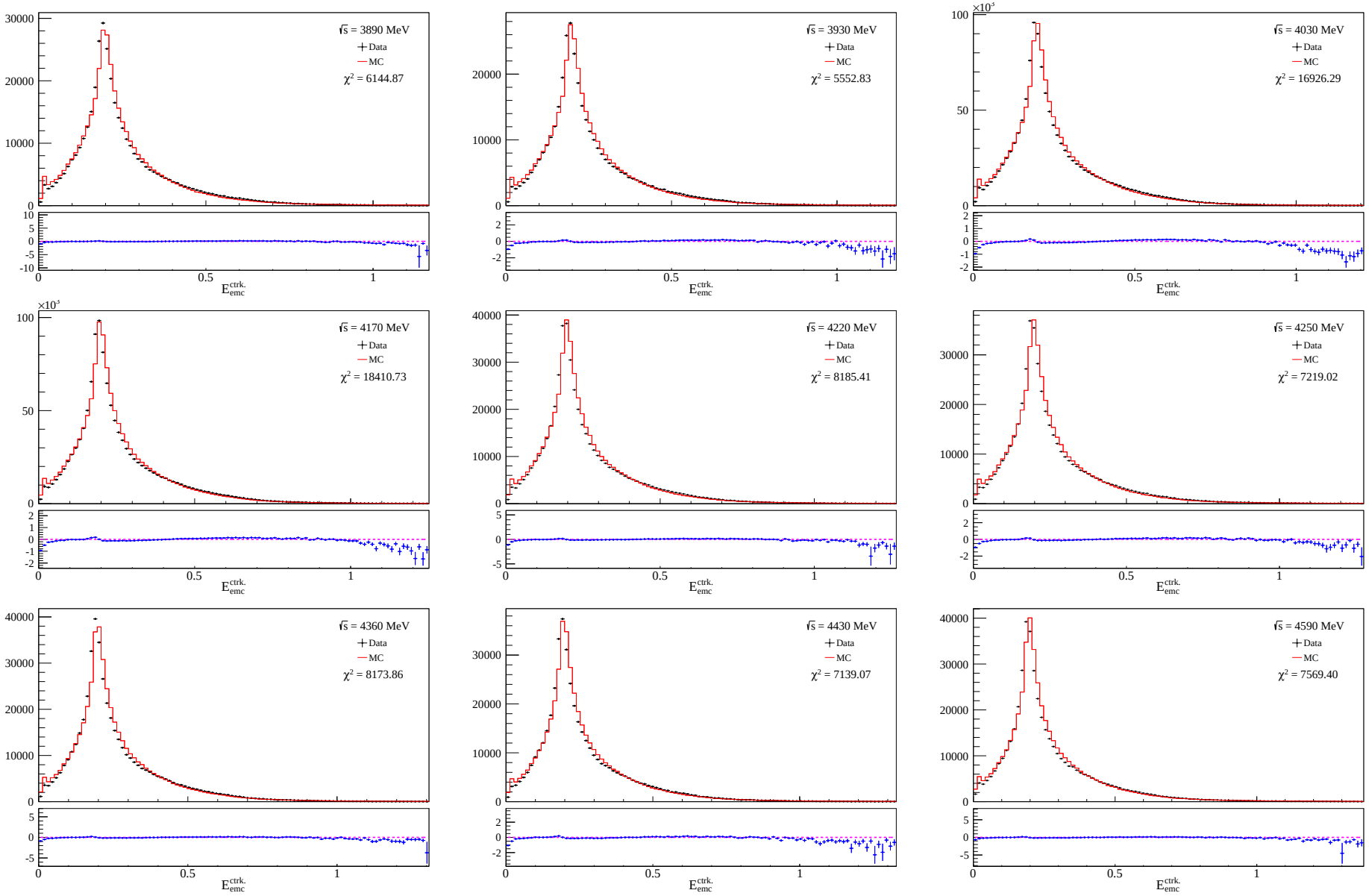

√s = 3890 MeV
Data
MC
χ² = 412.31
√s = 3930 MeV
χ² = 468.47
√s = 4030 MeV
χ² = 933.20
√s = 4170 MeV
χ² = 802.24
√s = 4220 MeV
χ² = 419.00
√s = 4250 MeV
χ² = 419.89
√s = 4360 MeV
χ² = 159.55
√s = 4430 MeV
χ² = 266.00
√s = 4590 MeV
χ² = 104.41
N_isogam,2prg


√s = 3890 MeV
Data
MC
χ² = 193.02
√s = 3930 MeV
χ² = 187.72
√s = 4030 MeV
χ² = 275.24
√s = 4170 MeV
χ² = 204.29
√s = 4220 MeV
χ² = 192.83
√s = 4250 MeV
χ² = 195.78
√s = 4360 MeV
χ² = 145.54
√s = 4430 MeV
χ² = 150.72
√s = 4590 MeV
χ² = 355.57
N_isogam,3prg


√s = 3890 MeV
Data
MC
χ² = 229.87
√s = 3930 MeV
χ² = 274.36
√s = 4030 MeV
χ² = 294.79
√s = 4170 MeV
χ² = 259.37
√s = 4220 MeV
χ² = 170.46
√s = 4250 MeV
χ² = 212.99
√s = 4360 MeV
χ² = 153.79
√s = 4430 MeV
χ² = 156.26
√s = 4590 MeV
χ² = 139.00
N_isogam,4prg

The comparison of $N_{isogam,restprg}$




√s = 3890 MeV
Data
MC
χ² = 6144.87
√s = 3930 MeV
χ² = 5552.83
√s = 4030 MeV
χ² = 16926.29
√s = 4170 MeV
χ² = 18410.73
√s = 4220 MeV
χ² = 8185.41
√s = 4250 MeV
χ² = 7219.02
√s = 4360 MeV
χ² = 8173.86
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χ² = 7139.07
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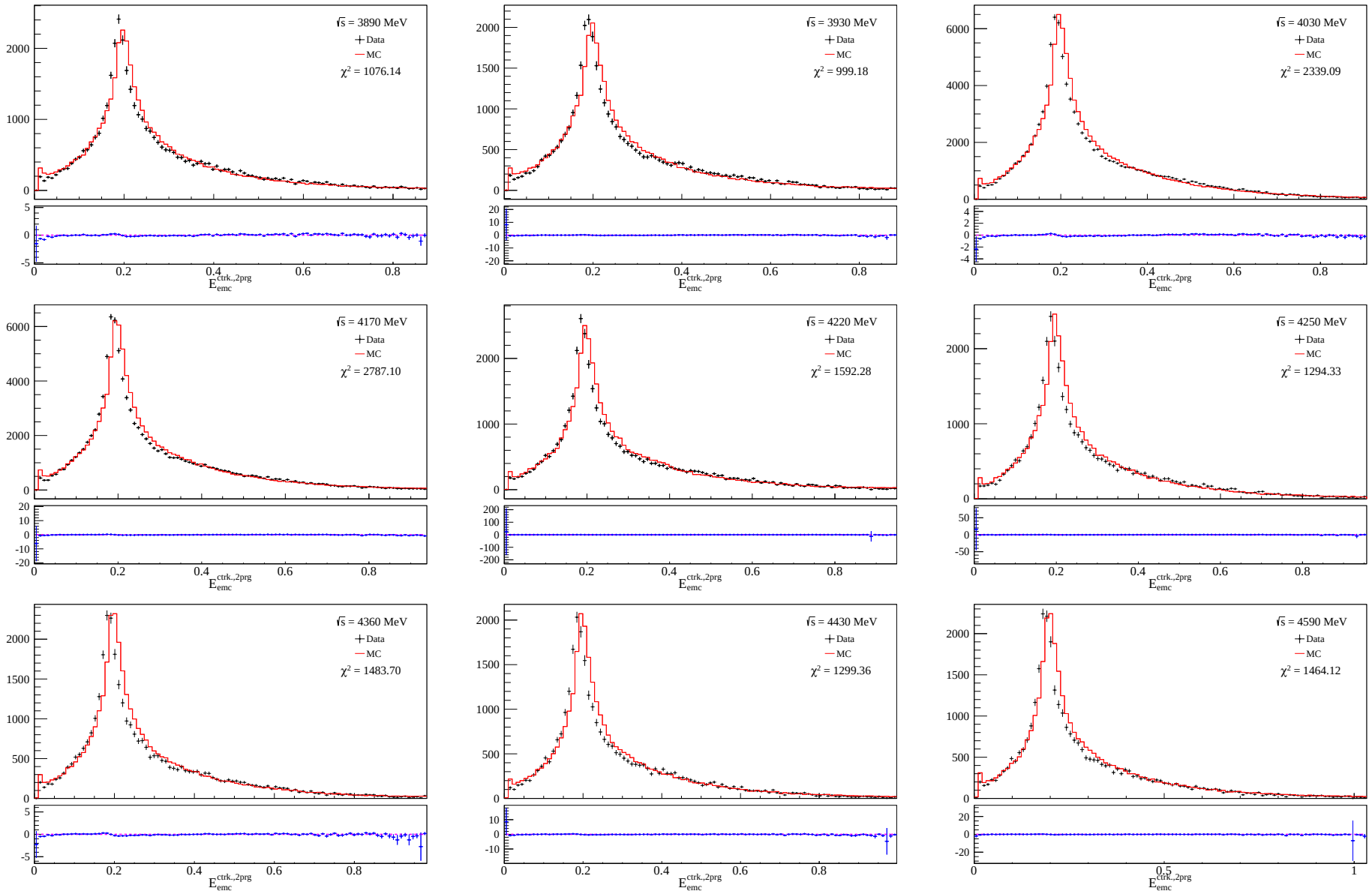
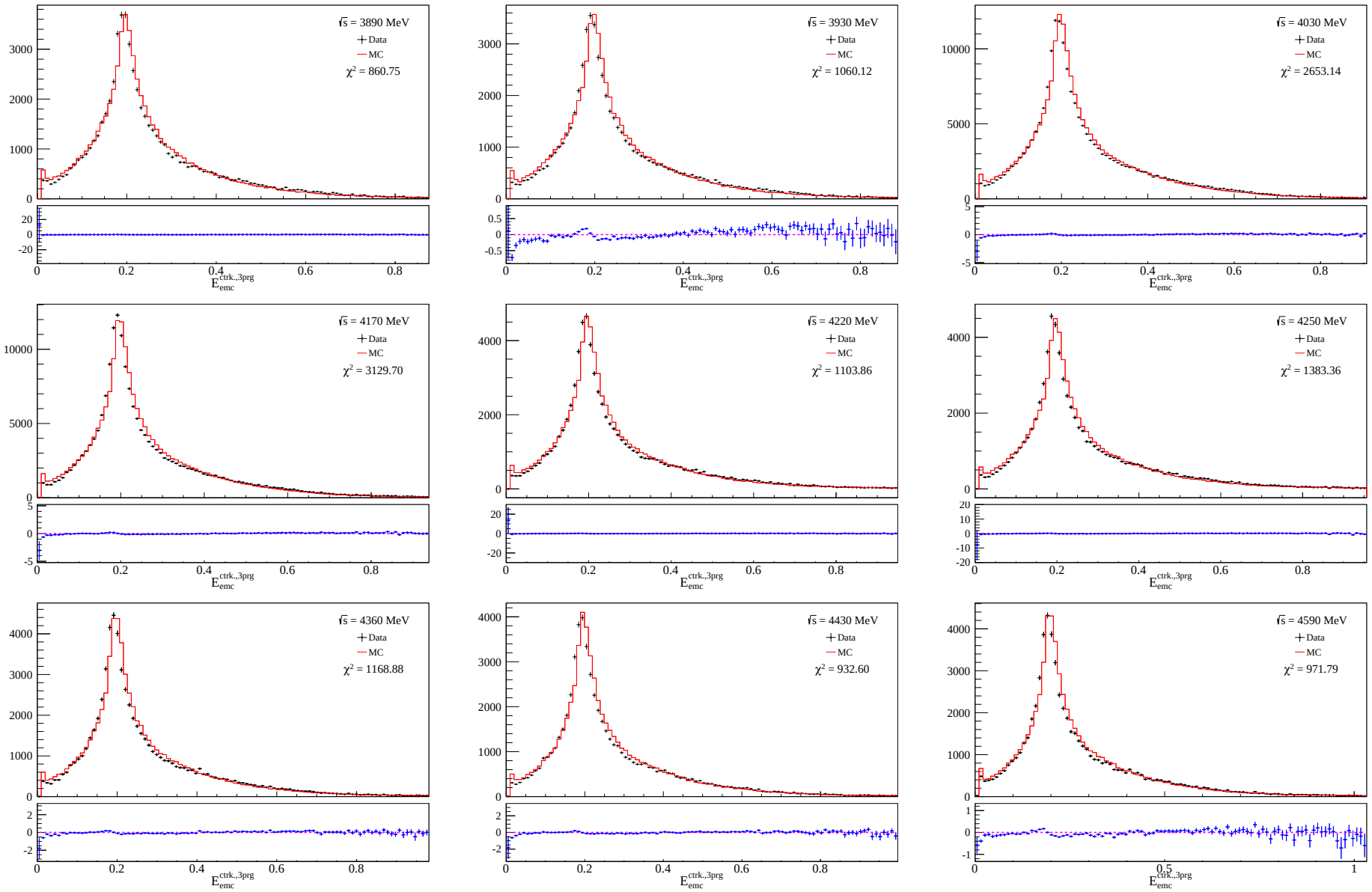
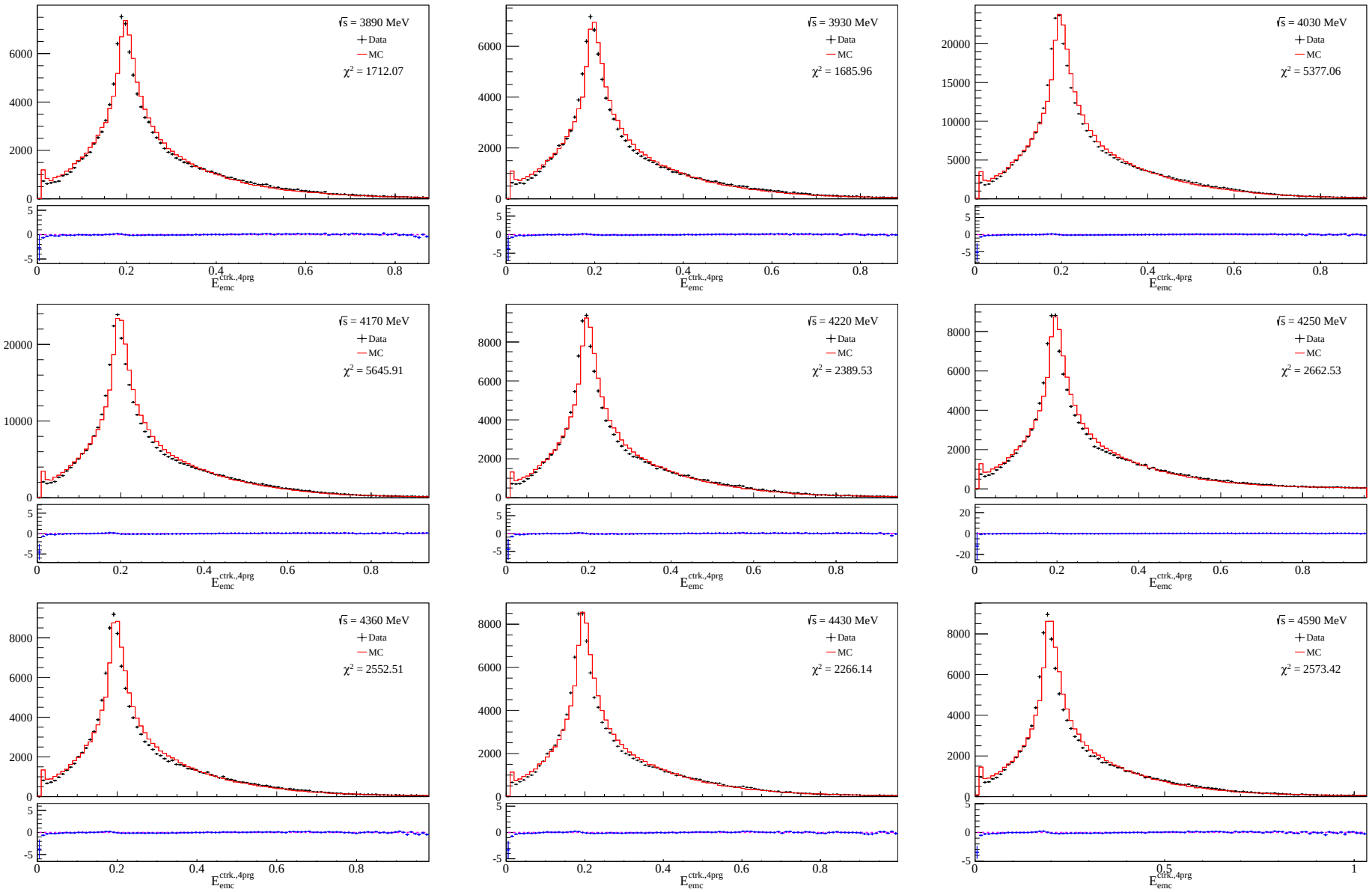
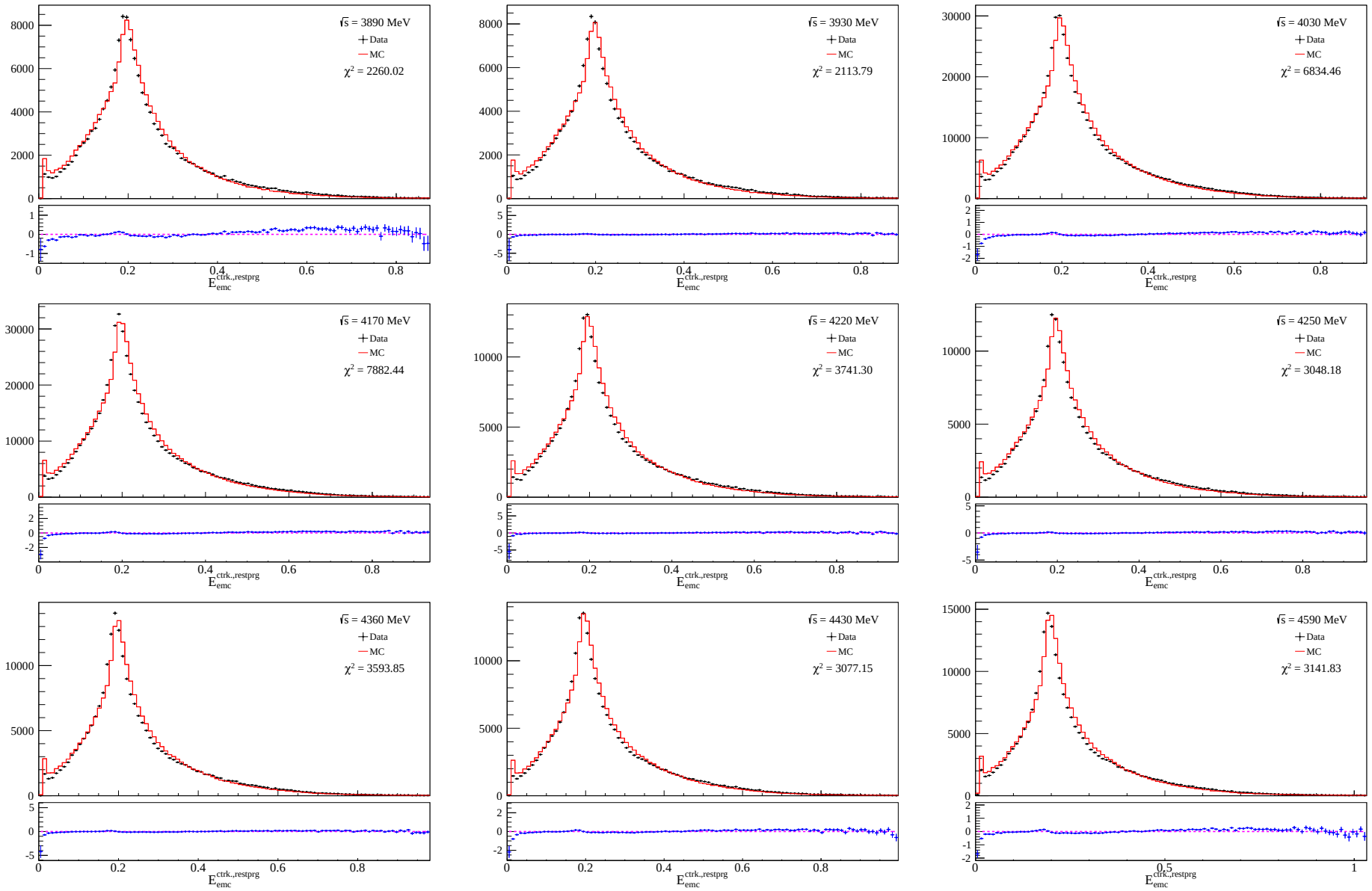
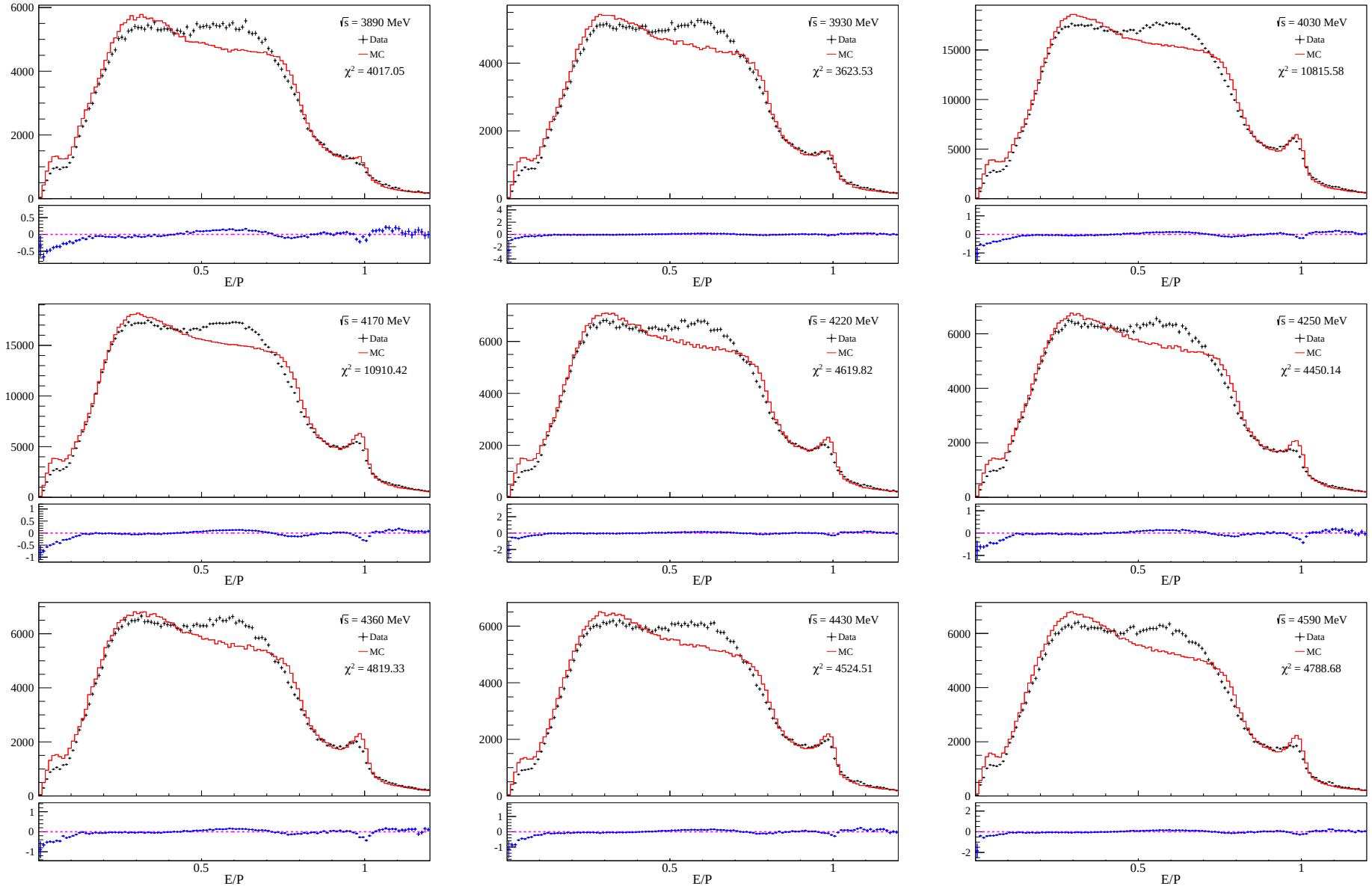
χ² = 7569.40
E_emc^ctrk.

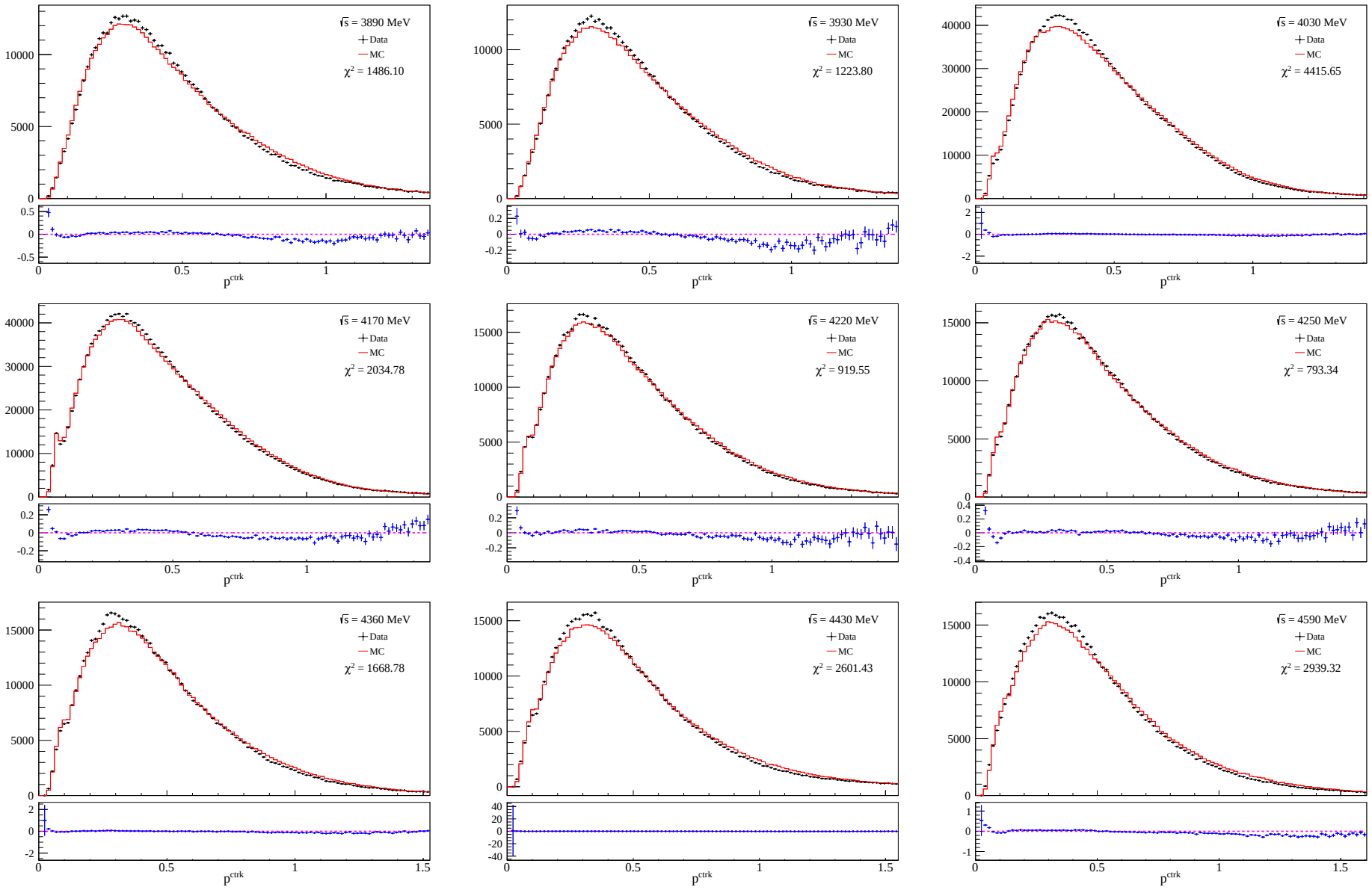

√s = 3890 MeV
Data
MC
χ² = 1076.14
√s = 3930 MeV
χ² = 999.18
√s = 4030 MeV
χ² = 2339.09
√s = 4170 MeV
χ² = 2787.10
√s = 4220 MeV
χ² = 1592.28
√s = 4250 MeV
χ² = 1294.33
√s = 4360 MeV
χ² = 1483.70
√s = 4430 MeV
χ² = 1299.36
√s = 4590 MeV
χ² = 1464.12
E^ctrk.,2prg_emc

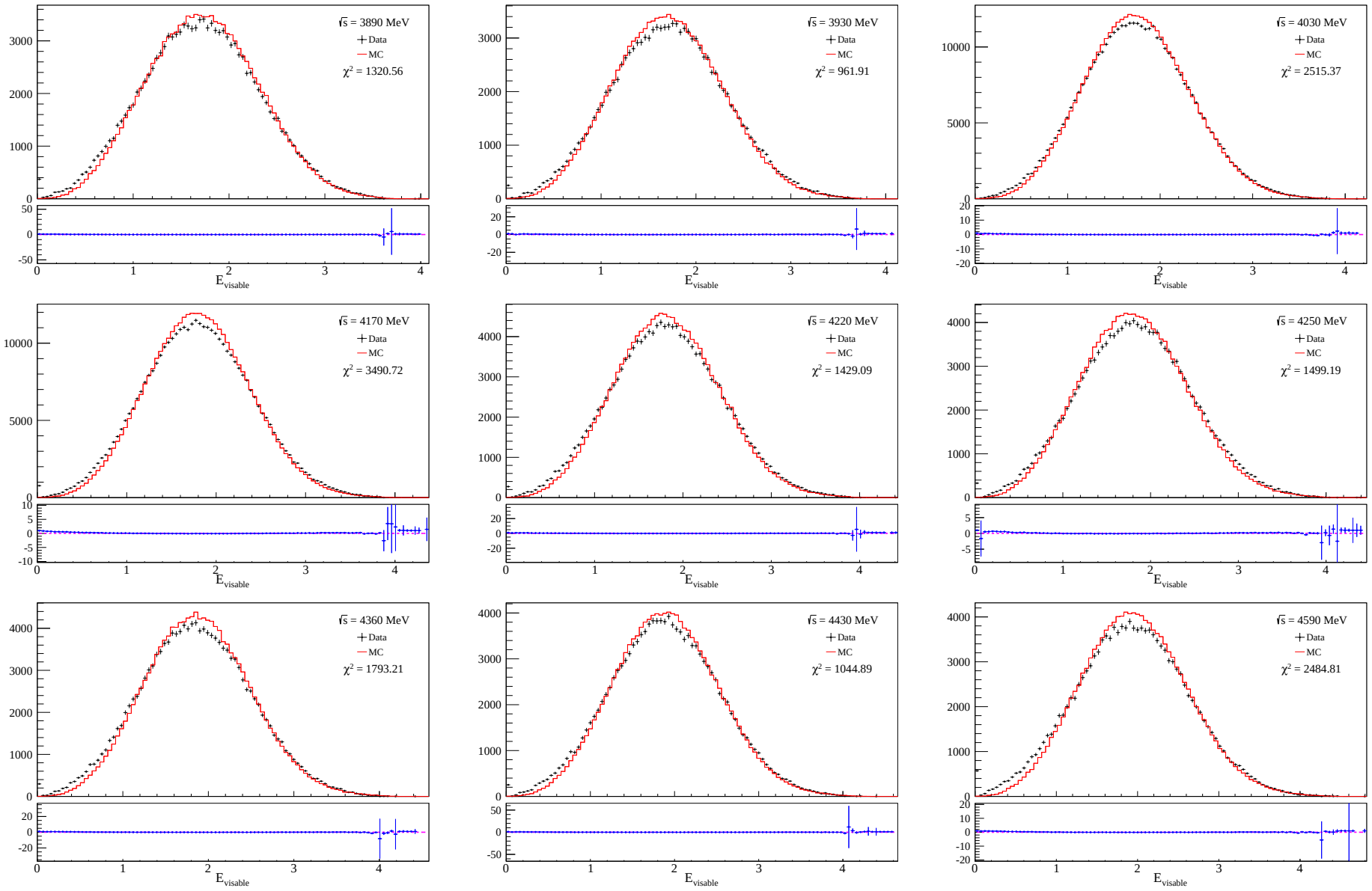

√s = 3890 MeV
Data
MC
χ² = 860.75
√s = 3930 MeV
χ² = 1060.12
√s = 4030 MeV
χ² = 2653.14
√s = 4170 MeV
χ² = 3129.70
√s = 4220 MeV
χ² = 1103.86
√s = 4250 MeV
χ² = 1383.36
√s = 4360 MeV
χ² = 1168.88
√s = 4430 MeV
χ² = 932.60
√s = 4590 MeV
χ² = 971.79
E^ctrk.,3prg_emc

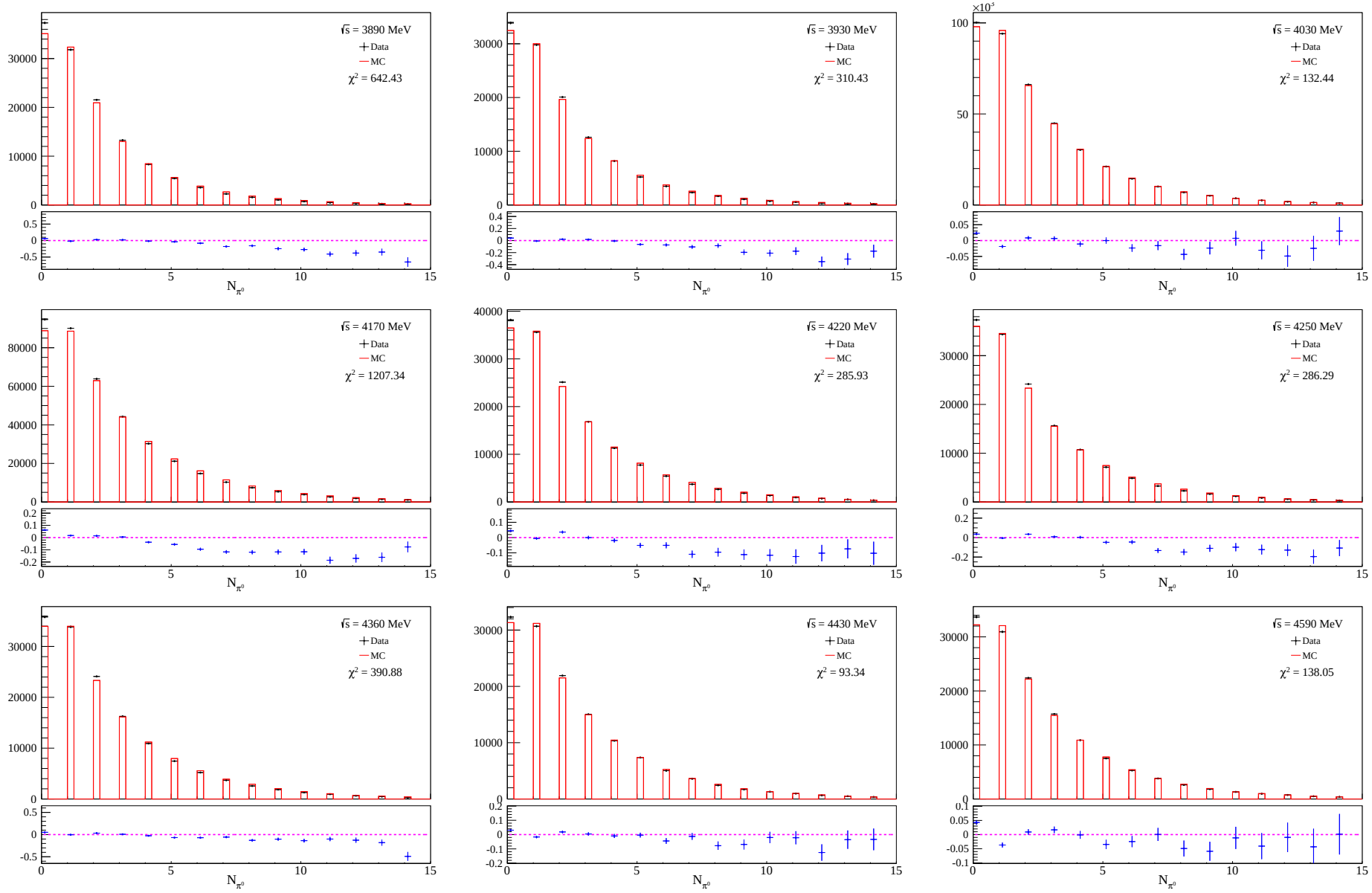

√s = 3890 MeV
Data
MC
χ² = 1712.07
√s = 3930 MeV
χ² = 1685.96
√s = 4030 MeV
χ² = 5377.06
√s = 4170 MeV
χ² = 5645.91
√s = 4220 MeV
χ² = 2389.53
√s = 4250 MeV
χ² = 2662.53
√s = 4360 MeV
χ² = 2552.51
√s = 4430 MeV
χ² = 2266.14
√s = 4590 MeV
χ² = 2573.42
E^{ctrk.,4prg}_{emc}

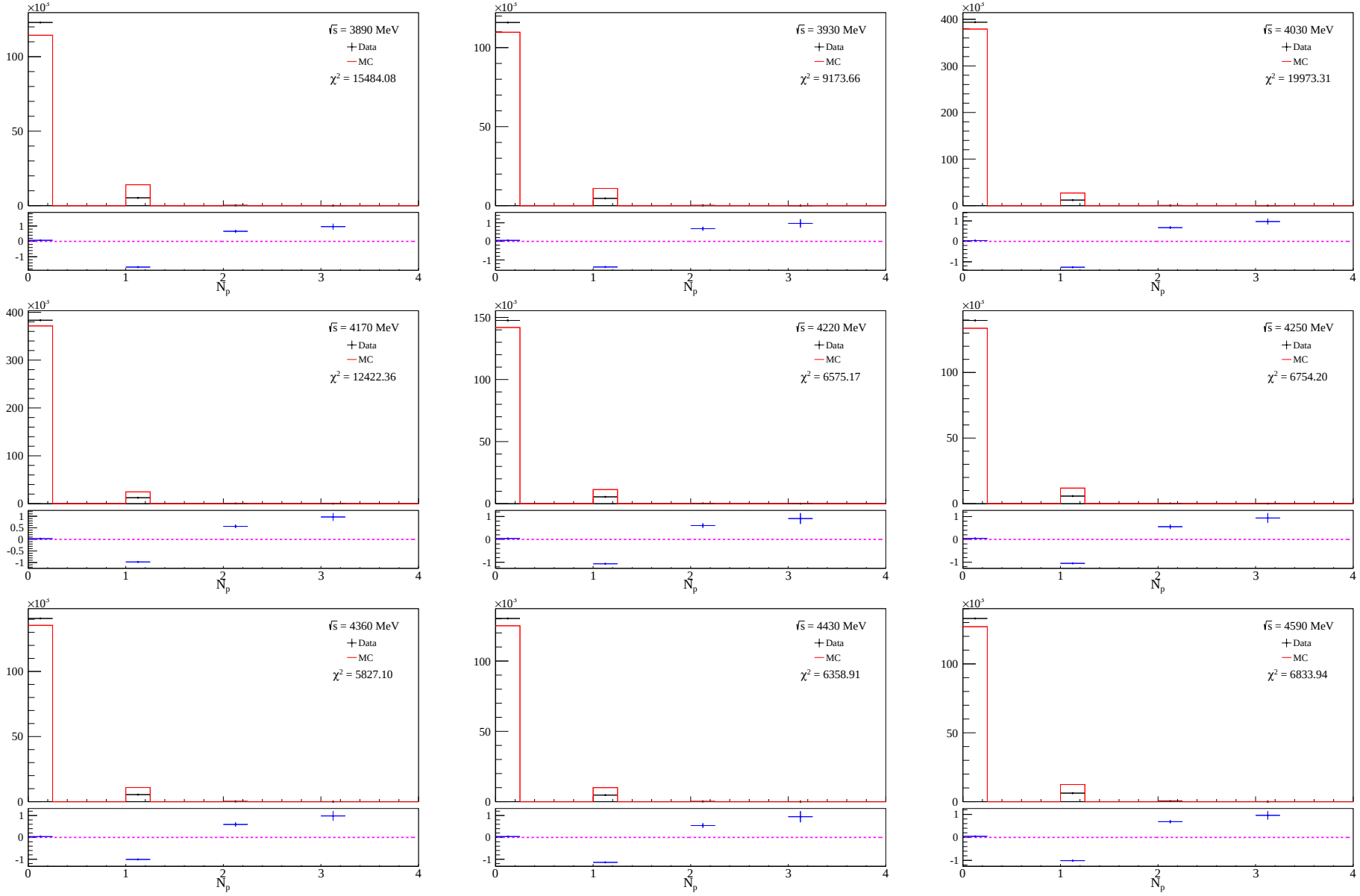

√s = 3890 MeV
Data
MC
χ² = 2260.02
√s = 3930 MeV
χ² = 2113.79
√s = 4030 MeV
χ² = 6834.46
√s = 4170 MeV
χ² = 7882.44
√s = 4220 MeV
χ² = 3741.30
√s = 4250 MeV
χ² = 3048.18
√s = 4360 MeV
χ² = 3593.85
√s = 4430 MeV
χ² = 3077.15
√s = 4590 MeV
χ² = 3141.83
E^{ctrk.,restprg}_{emc}

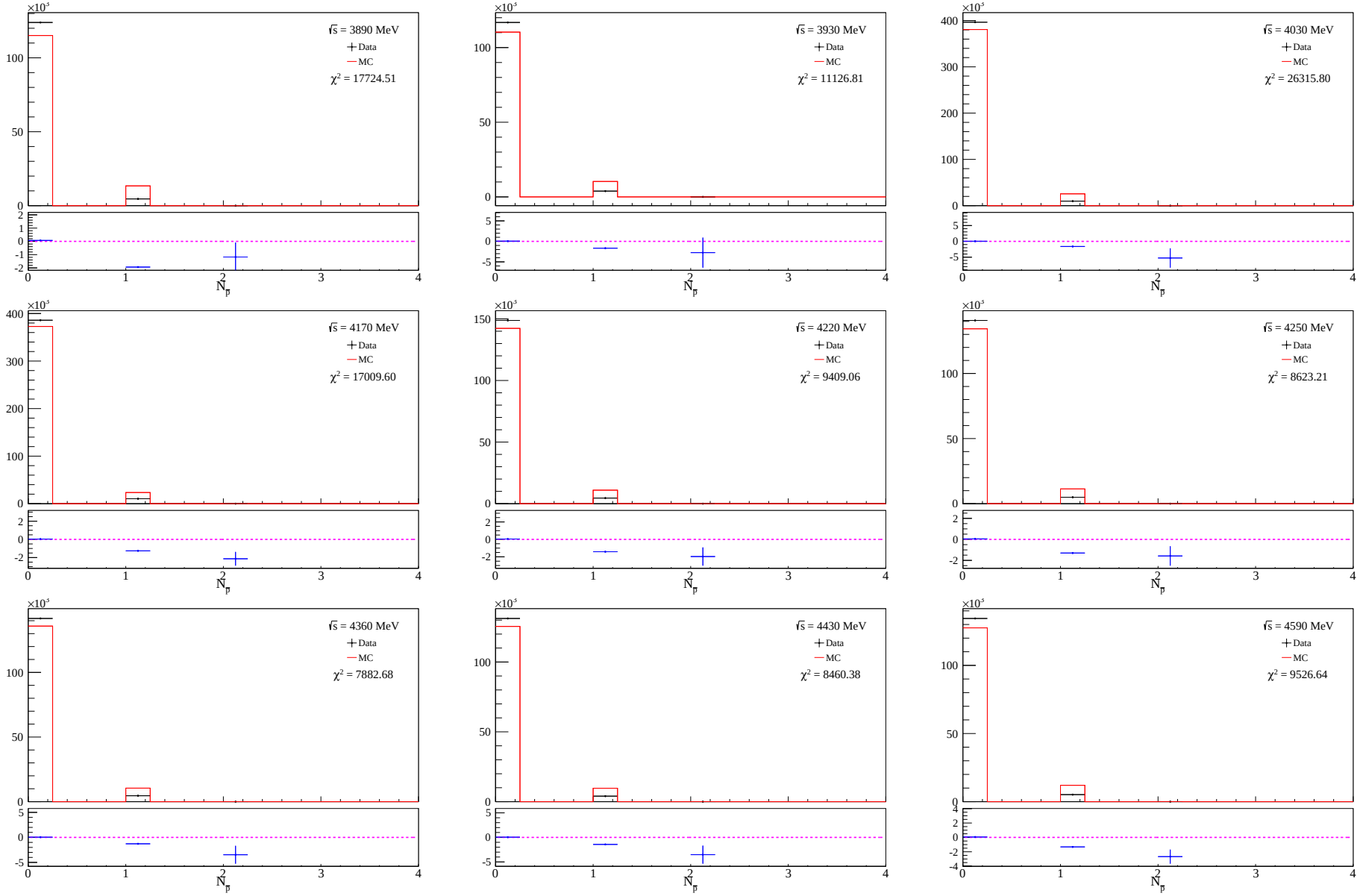

√s = 3890 MeV
Data
MC
χ² = 4017.05
√s = 3930 MeV
χ² = 3623.53
√s = 4030 MeV
χ² = 10815.58
√s = 4170 MeV
χ² = 10910.42
√s = 4220 MeV
χ² = 4619.82
√s = 4250 MeV
χ² = 4450.14
√s = 4360 MeV
χ² = 4819.33
√s = 4430 MeV
χ² = 4524.51
√s = 4590 MeV
χ² = 4788.68
E/P

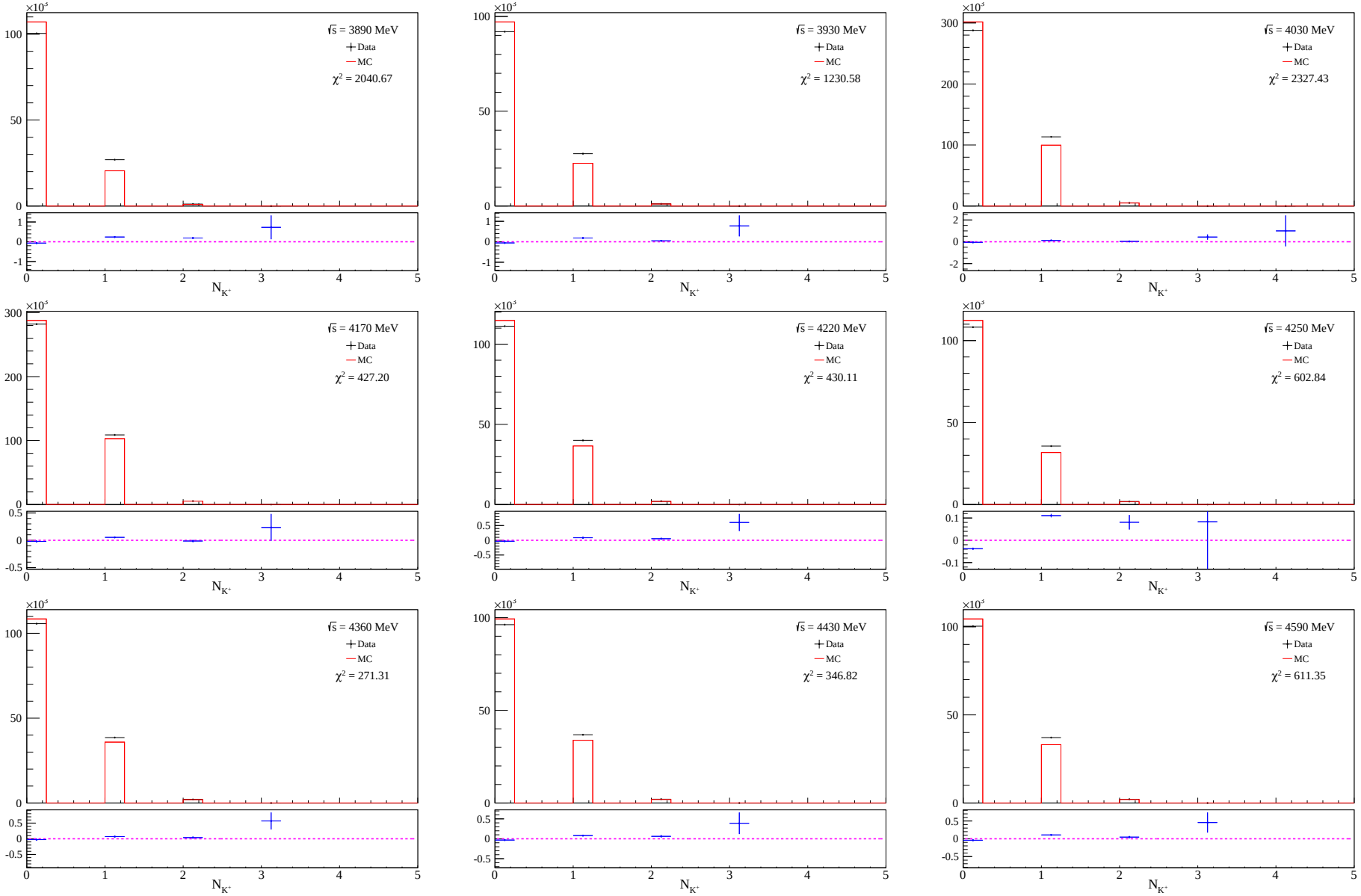

√s = 3890 MeV
Data
MC
χ² = 1486.10
√s = 3930 MeV
χ² = 1223.80
√s = 4030 MeV
χ² = 4415.65
√s = 4170 MeV
χ² = 2034.78
√s = 4220 MeV
χ² = 919.55
√s = 4250 MeV
χ² = 793.34
√s = 4360 MeV
χ² = 1668.78
√s = 4430 MeV
χ² = 2601.43
√s = 4590 MeV
χ² = 2939.32
p^ctrk

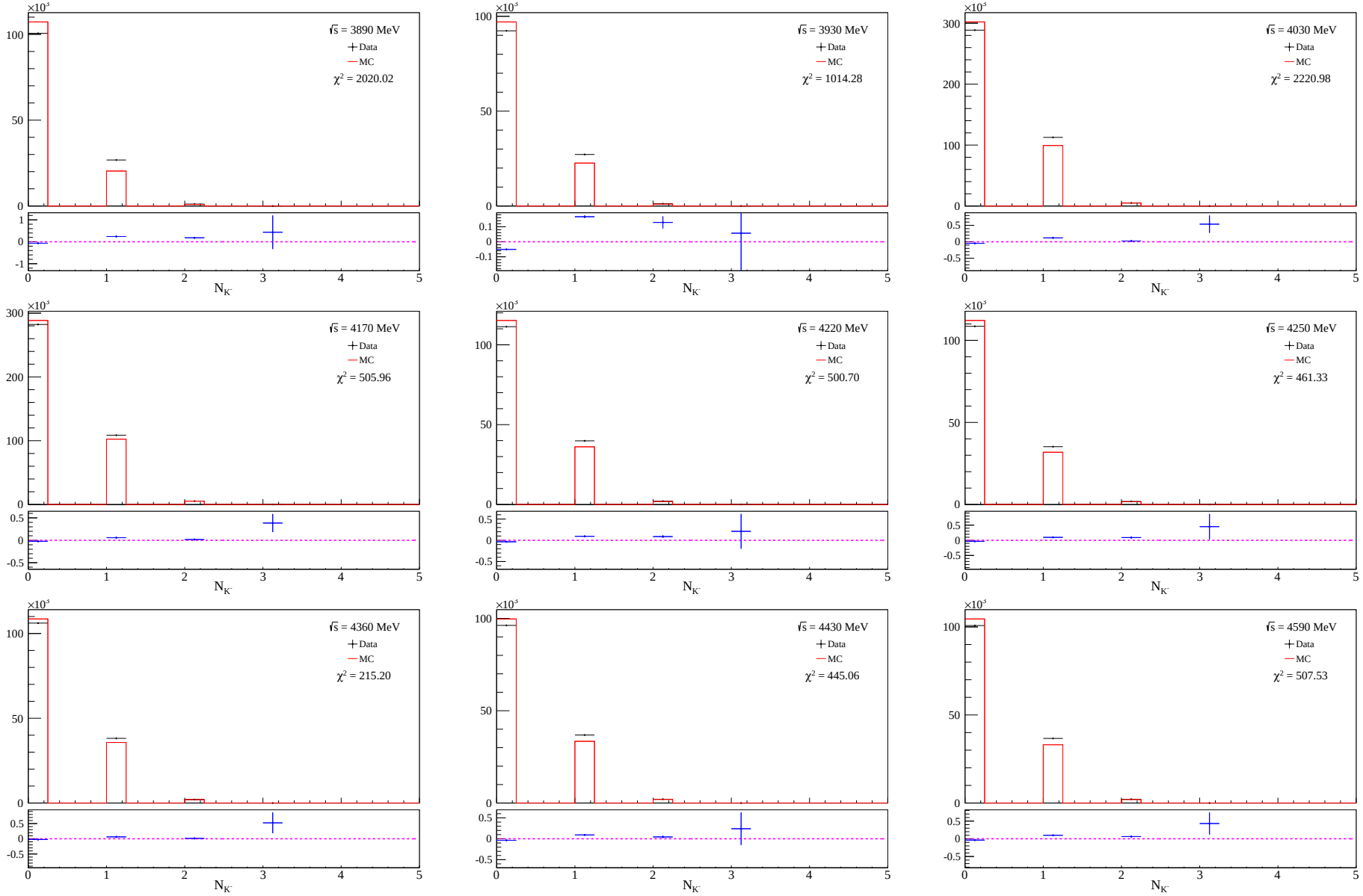

√s = 3890 MeV
Data
MC
χ² = 1320.56
√s = 3930 MeV
χ² = 961.91
√s = 4030 MeV
χ² = 2515.37
√s = 4170 MeV
χ² = 3490.72
√s = 4220 MeV
χ² = 1429.09
√s = 4250 MeV
χ² = 1499.19
√s = 4360 MeV
χ² = 1793.21
√s = 4430 MeV
χ² = 1044.89
√s = 4590 MeV
χ² = 2484.81
E_visable

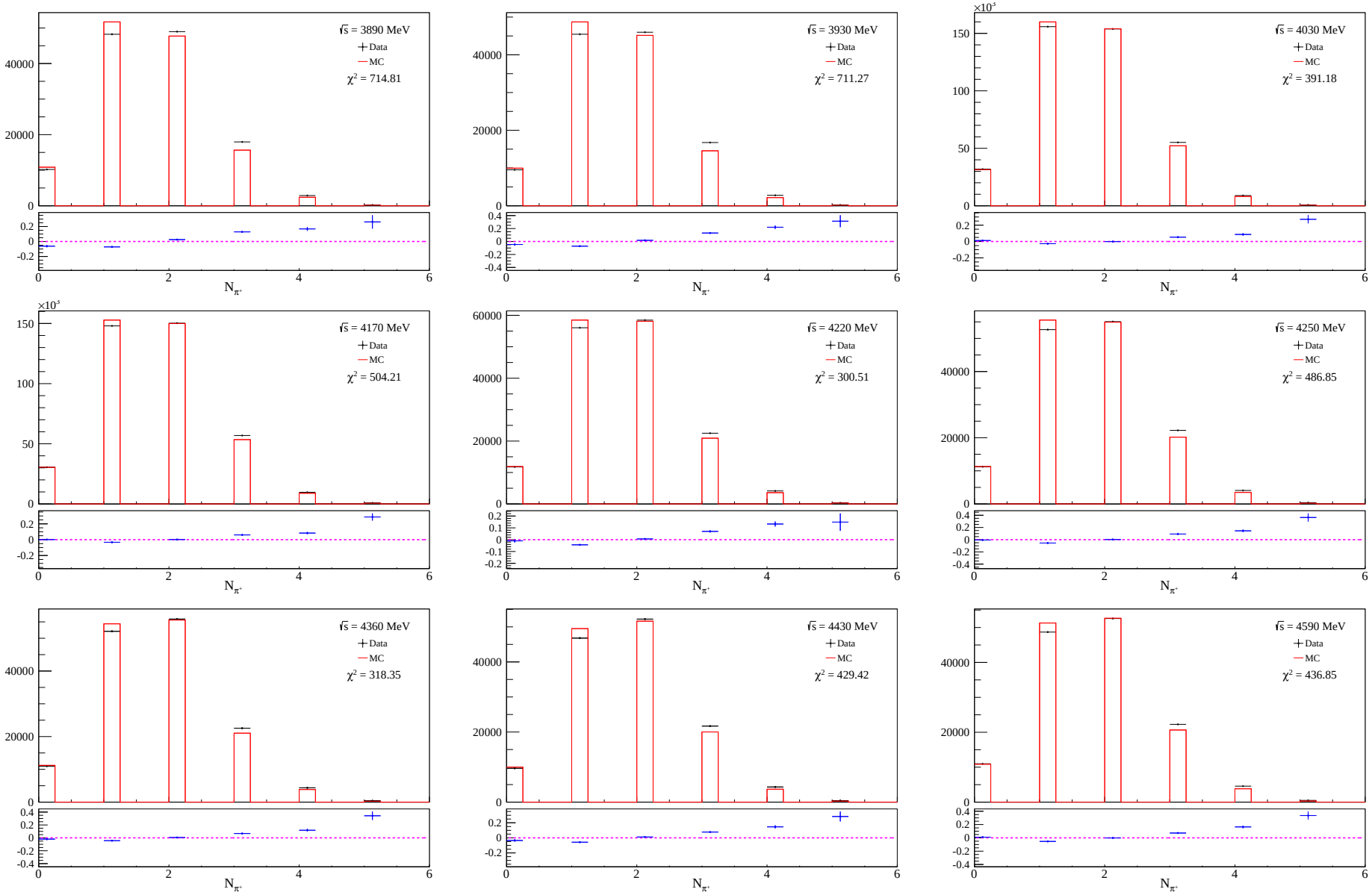

√s = 3890 MeV
Data
MC
χ² = 642.43
√s = 3930 MeV
χ² = 310.43
√s = 4030 MeV
χ² = 132.44
√s = 4170 MeV
χ² = 1207.34
√s = 4220 MeV
χ² = 285.93
√s = 4250 MeV
χ² = 286.29
√s = 4360 MeV
χ² = 390.88
√s = 4430 MeV
χ² = 93.34
√s = 4590 MeV
χ² = 138.05
N_π0

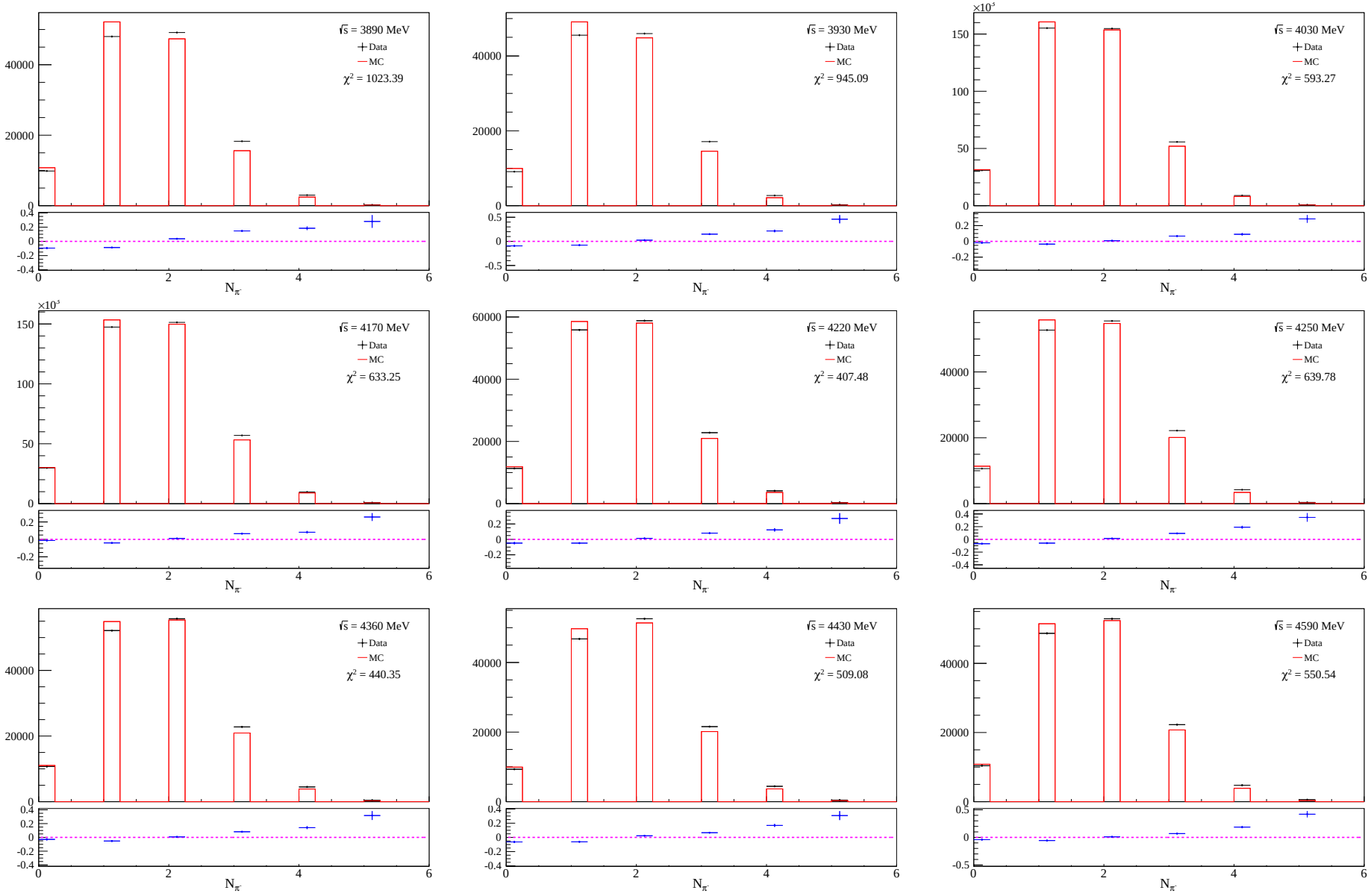

√s = 3890 MeV
Data
MC
χ² = 15484.08
√s = 3930 MeV
χ² = 9173.66
√s = 4030 MeV
χ² = 19973.31
√s = 4170 MeV
χ² = 12422.36
√s = 4220 MeV
χ² = 6575.17
√s = 4250 MeV
χ² = 6754.20
√s = 4360 MeV
χ² = 5827.10
√s = 4430 MeV
χ² = 6358.91
√s = 4590 MeV
χ² = 6833.94
×10⁻³
N_p

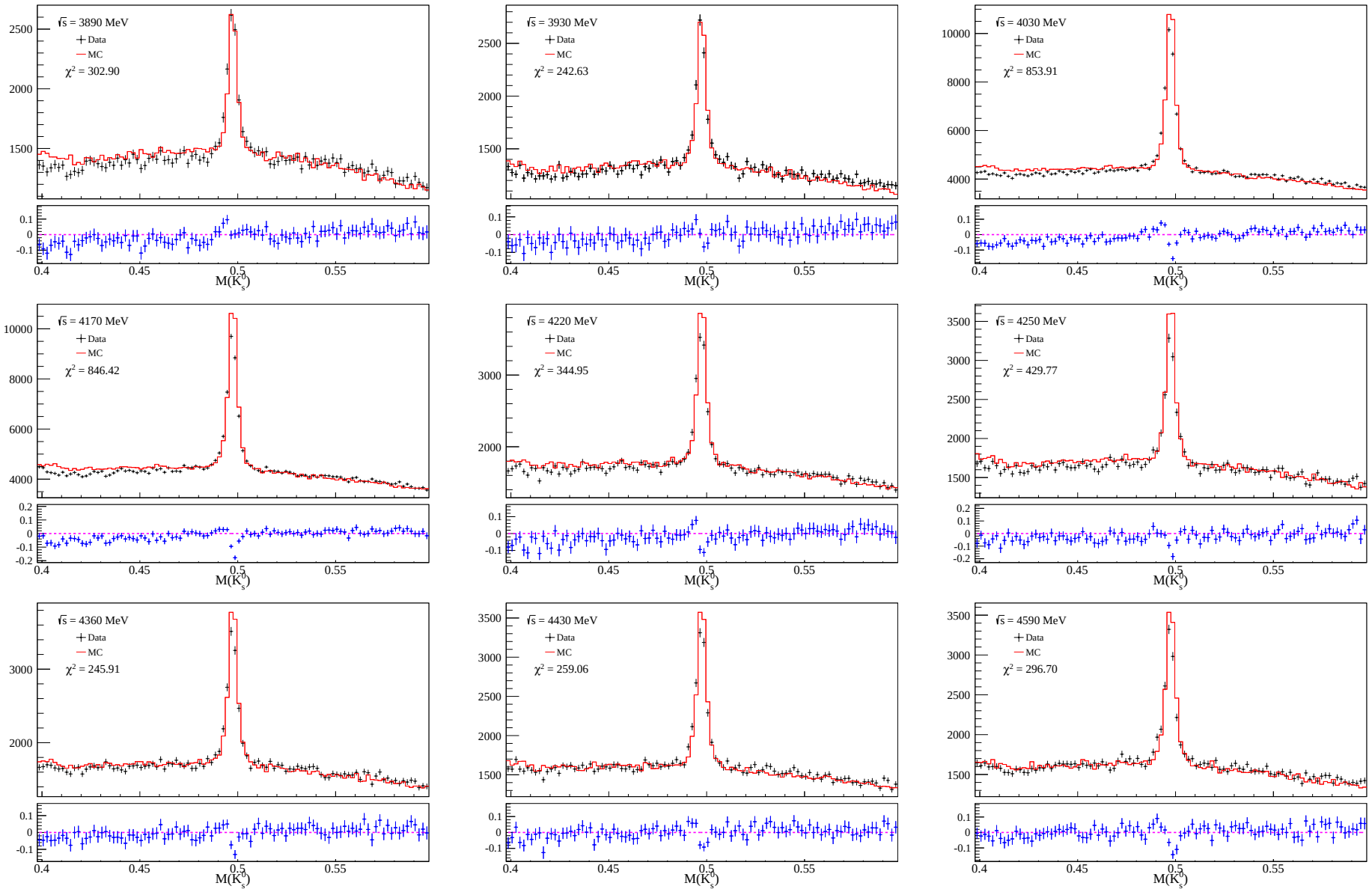

√s = 3890 MeV
Data
MC
χ² = 17724.51
√s = 3930 MeV
χ² = 11126.81
√s = 4030 MeV
χ² = 26315.80
√s = 4170 MeV
χ² = 17009.60
√s = 4220 MeV
χ² = 9409.06
√s = 4250 MeV
χ² = 8623.21
√s = 4360 MeV
χ² = 7882.68
√s = 4430 MeV
χ² = 8460.38
√s = 4590 MeV
χ² = 9526.64
N_p̄

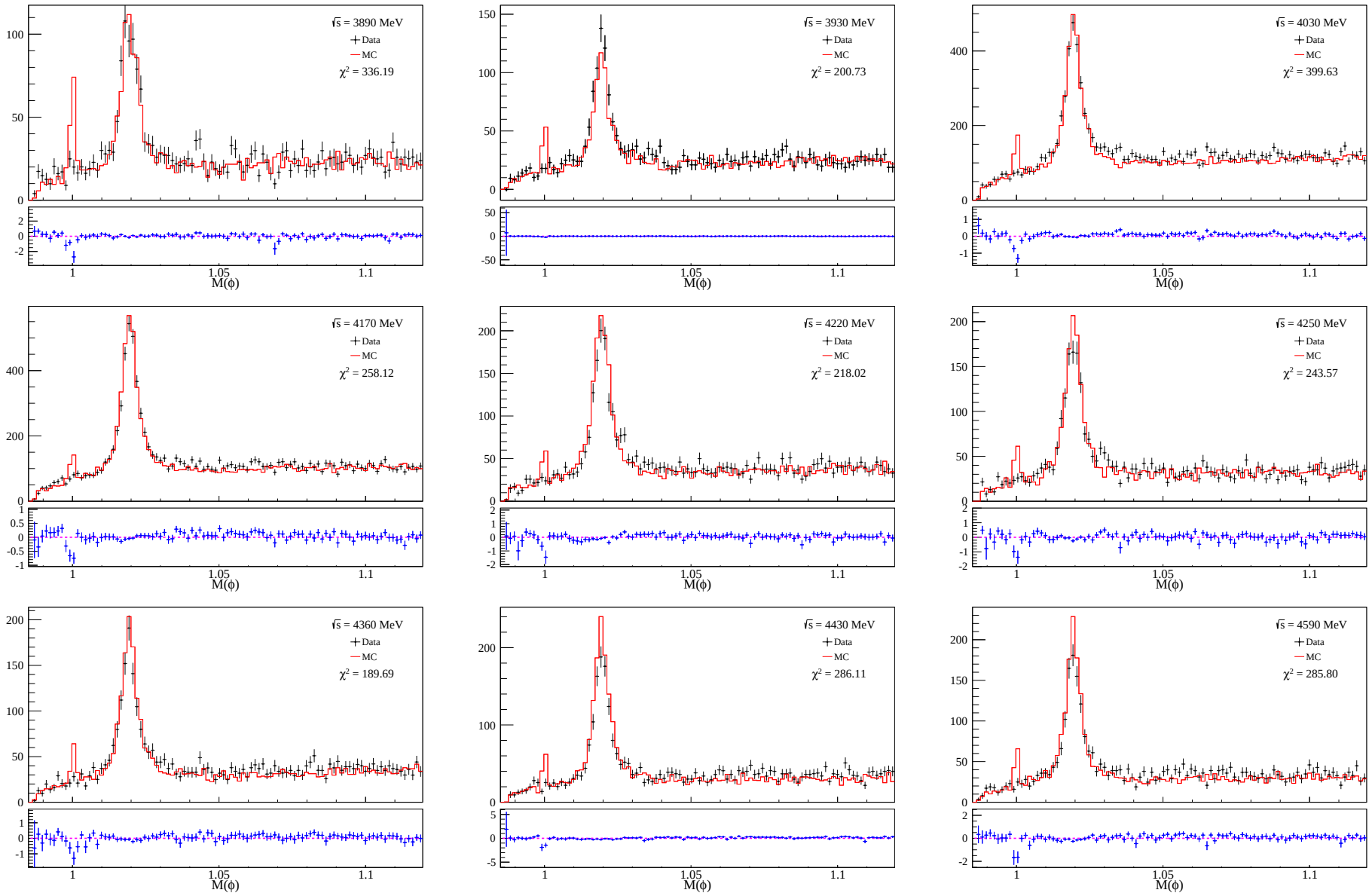

√s = 3890 MeV
Data
MC
χ² = 2040.67
√s = 3930 MeV
χ² = 1230.58
√s = 4030 MeV
χ² = 2327.43
√s = 4170 MeV
χ² = 427.20
√s = 4220 MeV
χ² = 430.11
√s = 4250 MeV
χ² = 602.84
√s = 4360 MeV
χ² = 271.31
√s = 4430 MeV
χ² = 346.82
√s = 4590 MeV
χ² = 611.35
N_K+

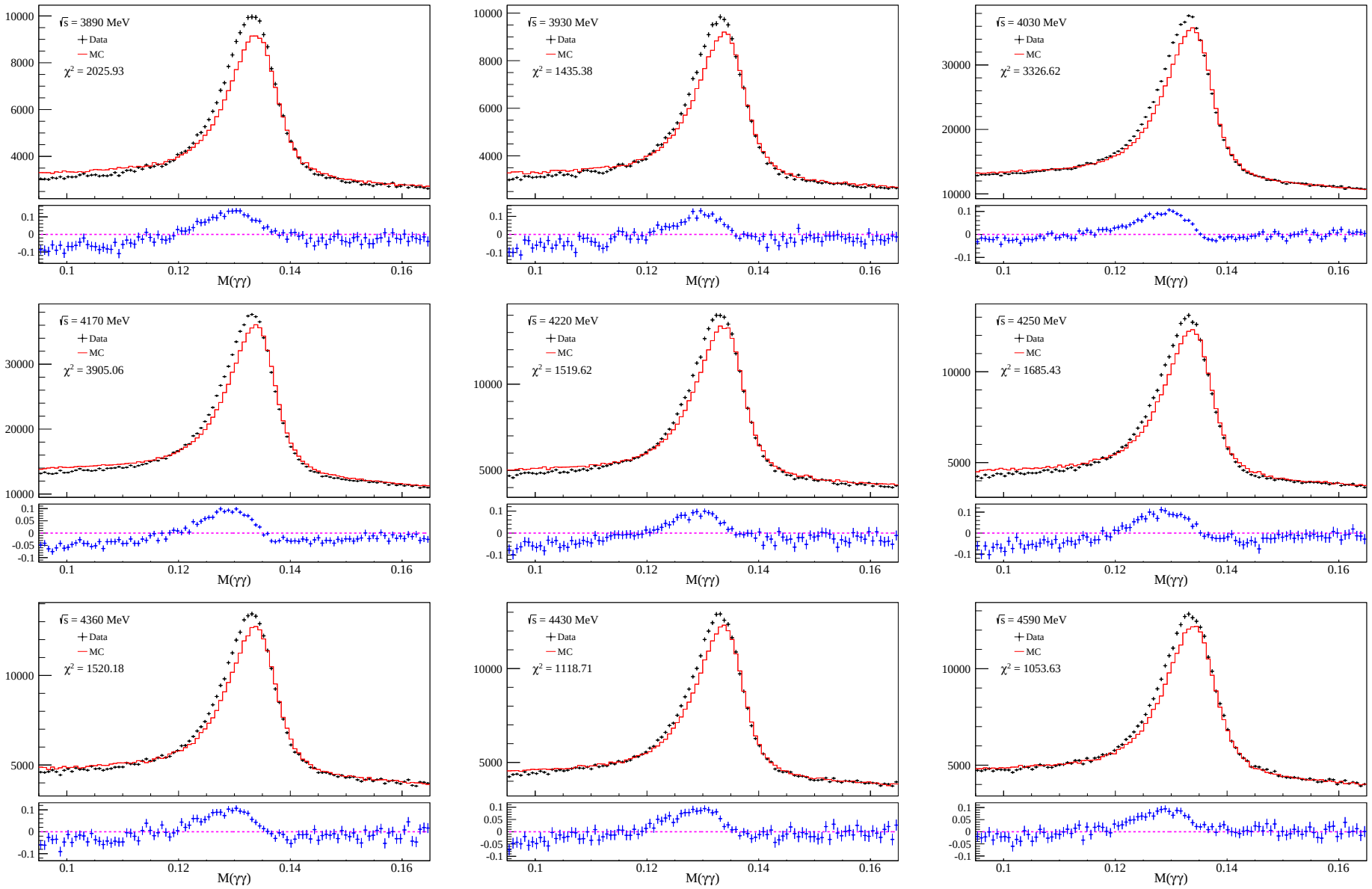

√s = 3890 MeV
Data
MC
χ² = 2020.02
√s = 3930 MeV
χ² = 1014.28
√s = 4030 MeV
χ² = 2220.98
√s = 4170 MeV
χ² = 505.96
√s = 4220 MeV
χ² = 500.70
√s = 4250 MeV
χ² = 461.33
√s = 4360 MeV
χ² = 215.20
√s = 4430 MeV
χ² = 445.06
√s = 4590 MeV
χ² = 507.53
N_K-

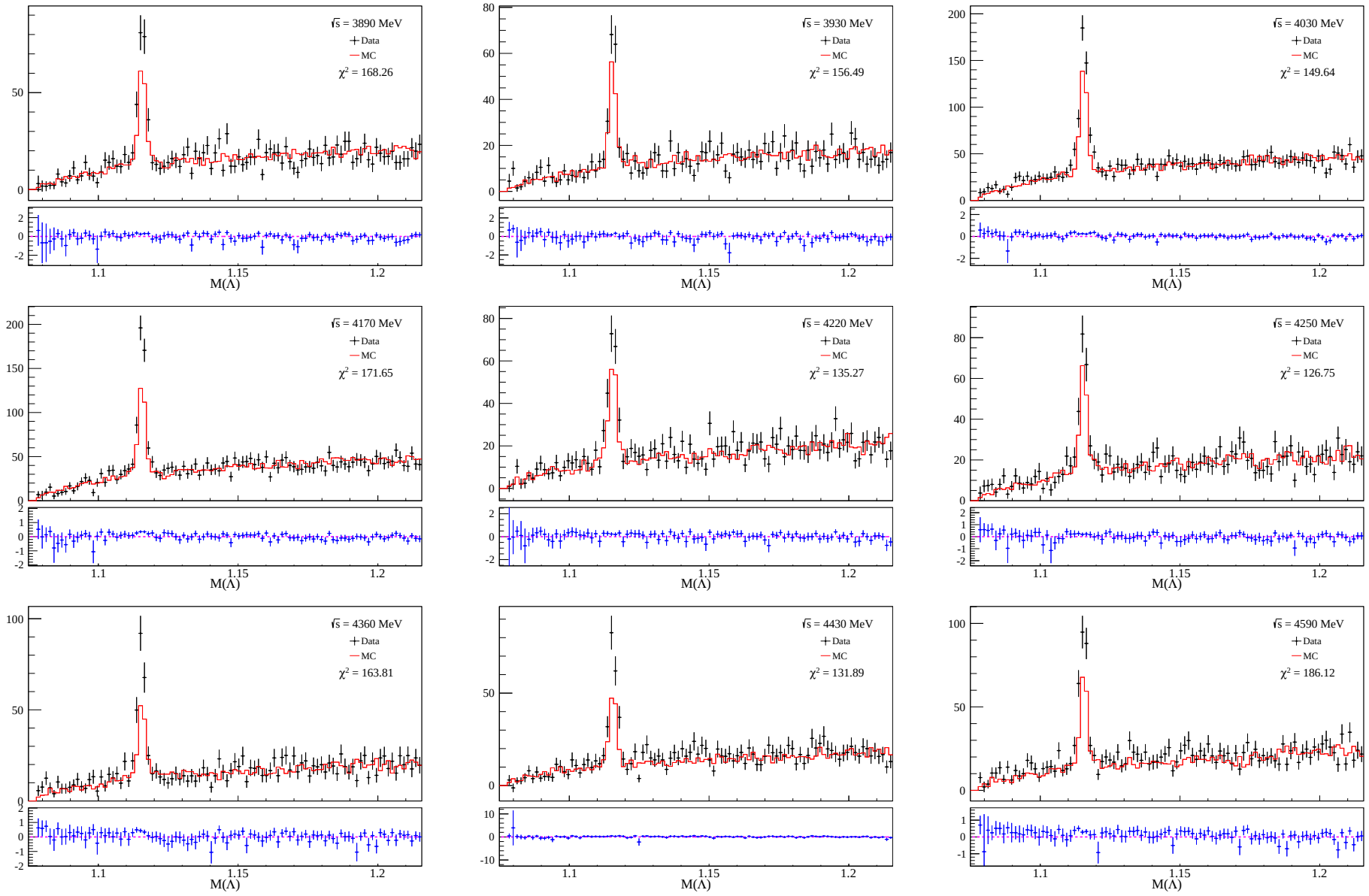

√s = 3890 MeV
Data
MC
χ² = 714.81
√s = 3930 MeV
χ² = 711.27
√s = 4030 MeV
χ² = 391.18
√s = 4170 MeV
χ² = 504.21
√s = 4220 MeV
χ² = 300.51
√s = 4250 MeV
χ² = 486.85
√s = 4360 MeV
χ² = 318.35
√s = 4430 MeV
χ² = 429.42
√s = 4590 MeV
χ² = 436.85
N_π+

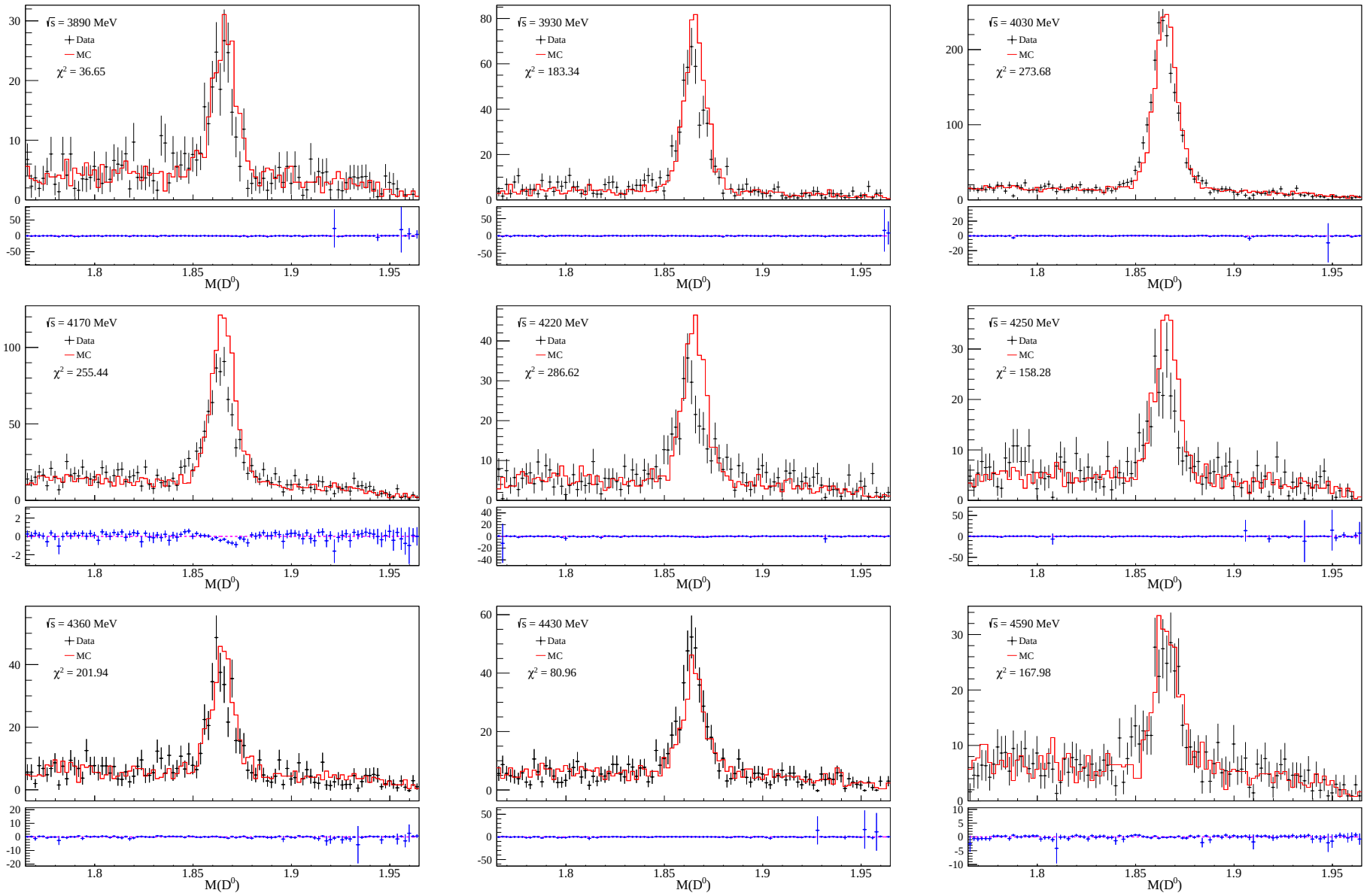

√s = 3890 MeV
Data
MC
χ² = 1023.39
√s = 3930 MeV
χ² = 945.09
√s = 4030 MeV
χ² = 593.27
√s = 4170 MeV
χ² = 633.25
√s = 4220 MeV
χ² = 407.48
√s = 4250 MeV
χ² = 639.78
√s = 4360 MeV
χ² = 440.35
√s = 4430 MeV
χ² = 509.08
√s = 4590 MeV
χ² = 550.54
N_π-

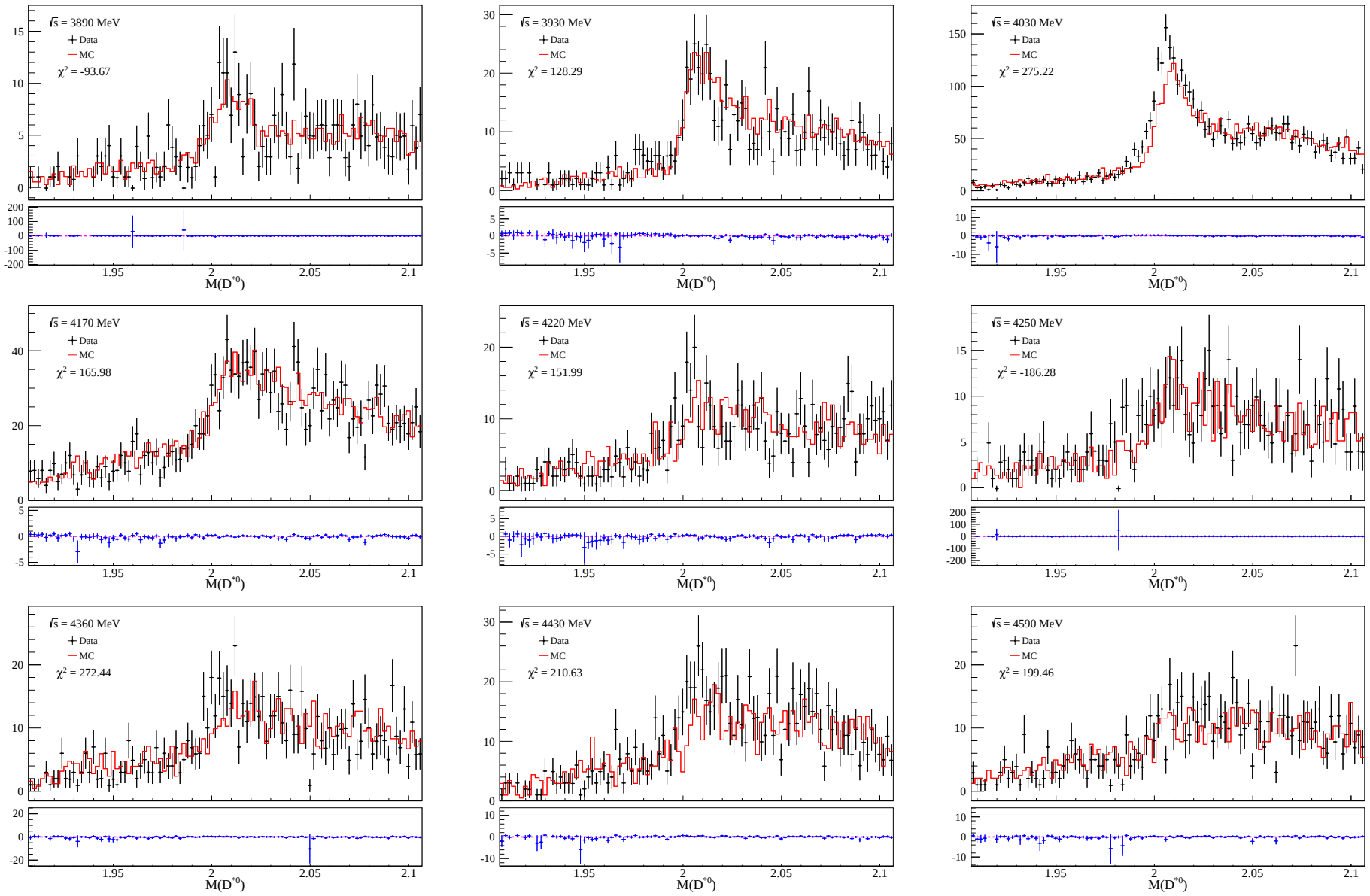

√s = 3890 MeV
Data
MC
χ² = 302.90
√s = 3930 MeV
χ² = 242.63
√s = 4030 MeV
χ² = 853.91
√s = 4170 MeV
χ² = 846.42
√s = 4220 MeV
χ² = 344.95
√s = 4250 MeV
χ² = 429.77
√s = 4360 MeV
χ² = 245.91
√s = 4430 MeV
χ² = 259.06
√s = 4590 MeV
χ² = 296.70
M(K⁰s)

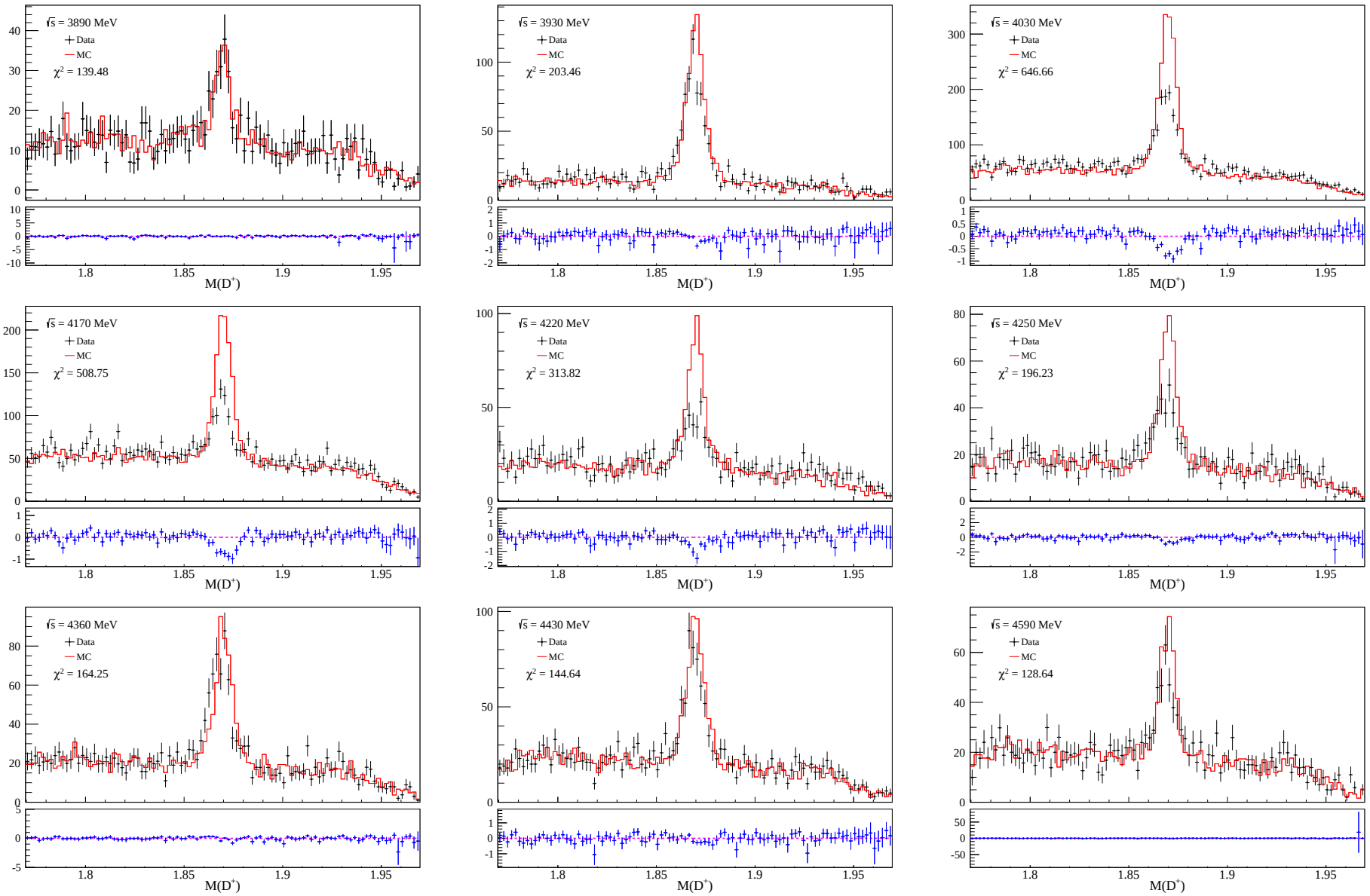

√s = 3890 MeV
Data
MC
χ² = 336.19
√s = 3930 MeV
χ² = 200.73
√s = 4030 MeV
χ² = 399.63
√s = 4170 MeV
χ² = 258.12
√s = 4220 MeV
χ² = 218.02
√s = 4250 MeV
χ² = 243.57
√s = 4360 MeV
χ² = 189.69
√s = 4430 MeV
χ² = 286.11
√s = 4590 MeV
χ² = 285.80
M(ϕ)

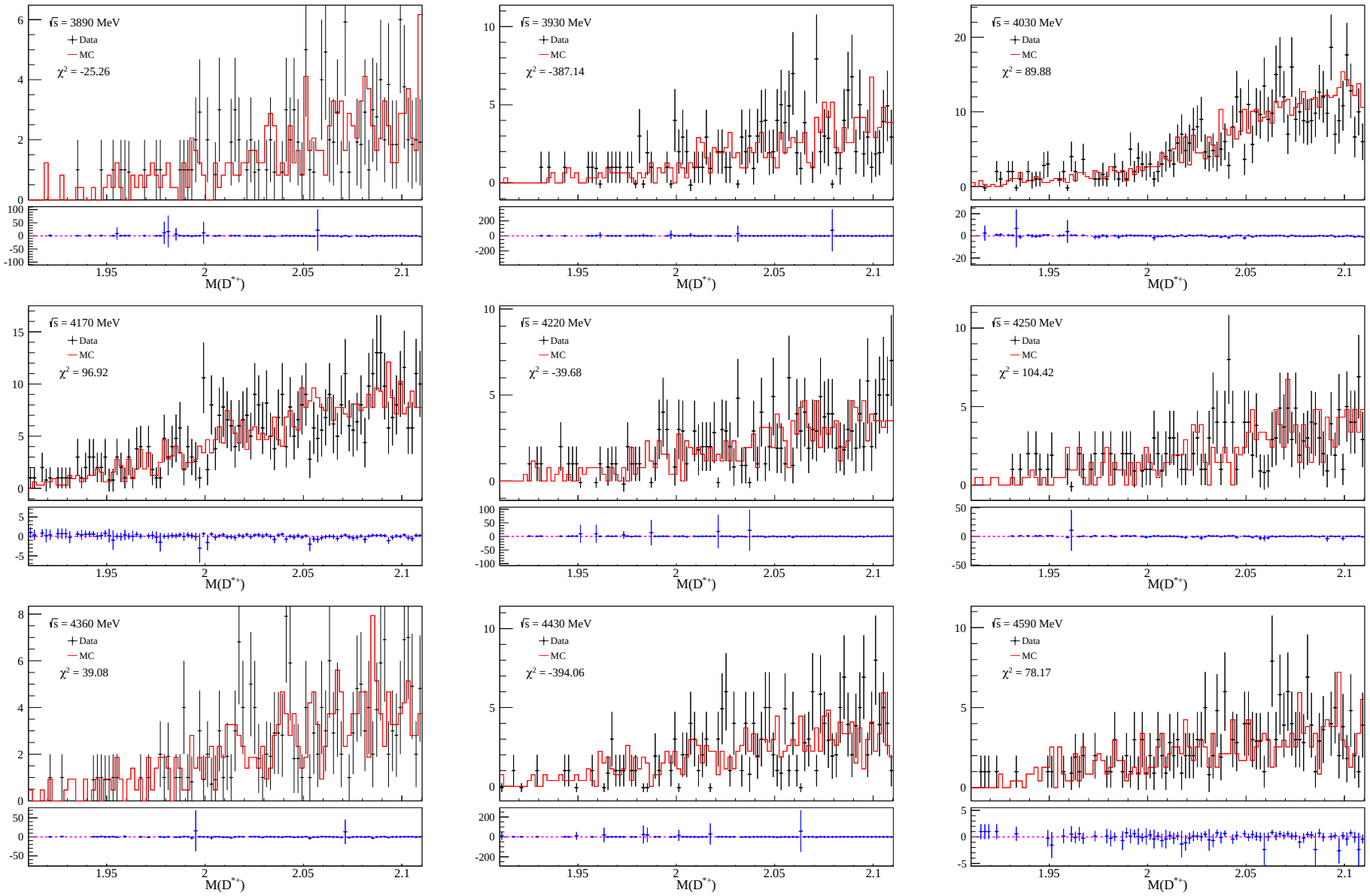

√s = 3890 MeV
Data
MC
χ² = 2025.93
√s = 3930 MeV
χ² = 1435.38
√s = 4030 MeV
χ² = 3326.62
√s = 4170 MeV
χ² = 3905.06
√s = 4220 MeV
χ² = 1519.62
√s = 4250 MeV
χ² = 1685.43
√s = 4360 MeV
χ² = 1520.18
√s = 4430 MeV
χ² = 1118.71
√s = 4590 MeV
χ² = 1053.63
M(γγ)

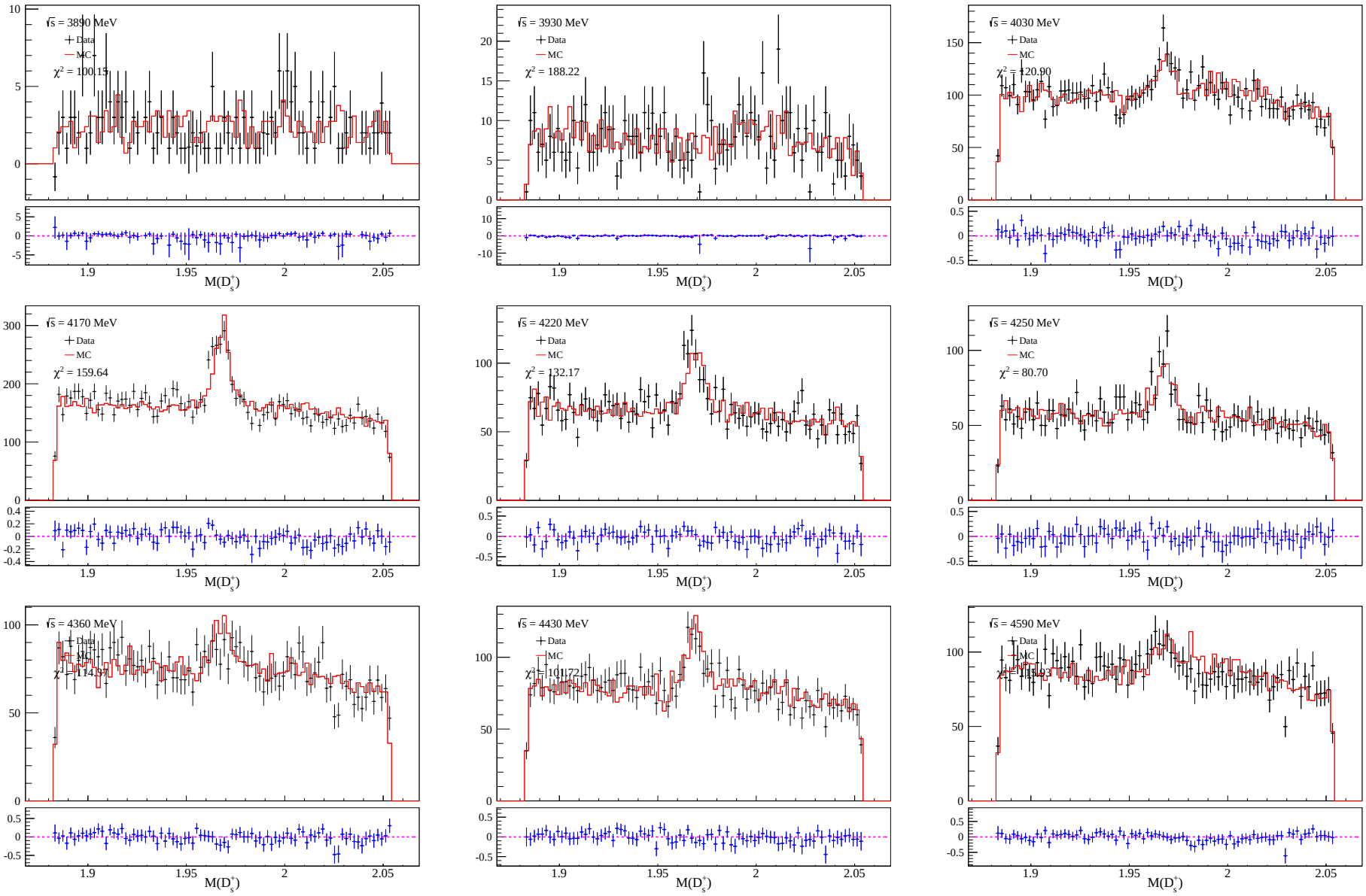

√s = 3890 MeV
Data
MC
χ² = 168.26
√s = 3930 MeV
χ² = 156.49
√s = 4030 MeV
χ² = 149.64
√s = 4170 MeV
χ² = 171.65
√s = 4220 MeV
χ² = 135.27
√s = 4250 MeV
χ² = 126.75
√s = 4360 MeV
χ² = 163.81
√s = 4430 MeV
χ² = 131.89
√s = 4590 MeV
χ² = 186.12
M(Λ)

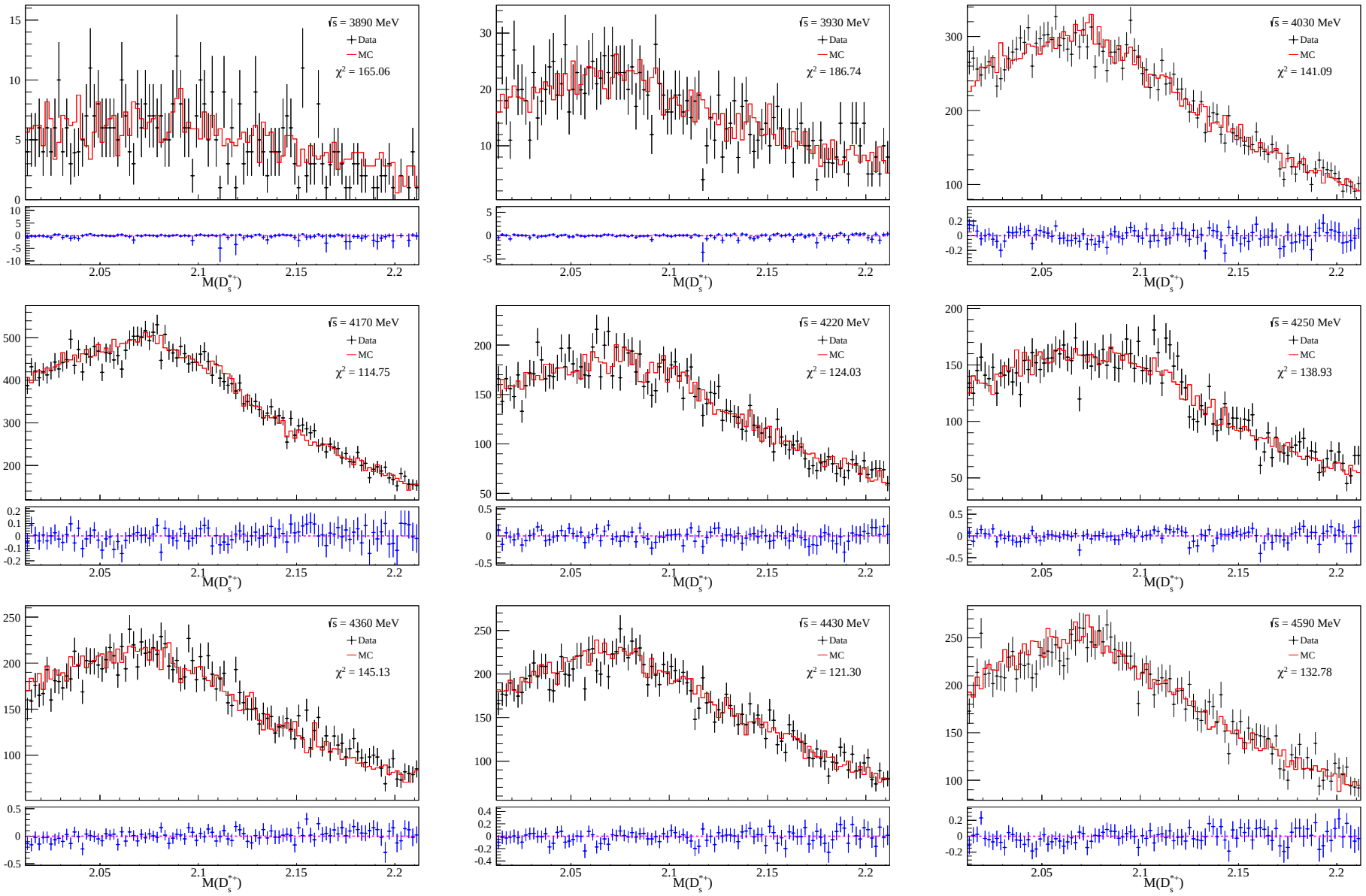

√s = 3890 MeV
Data
MC
χ² = 36.65
√s = 3930 MeV
χ² = 183.34
√s = 4030 MeV
χ² = 273.68
√s = 4170 MeV
χ² = 255.44
√s = 4220 MeV
χ² = 286.62
√s = 4250 MeV
χ² = 158.28
√s = 4360 MeV
χ² = 201.94
√s = 4430 MeV
χ² = 80.96
√s = 4590 MeV
χ² = 167.98
M(D⁰)

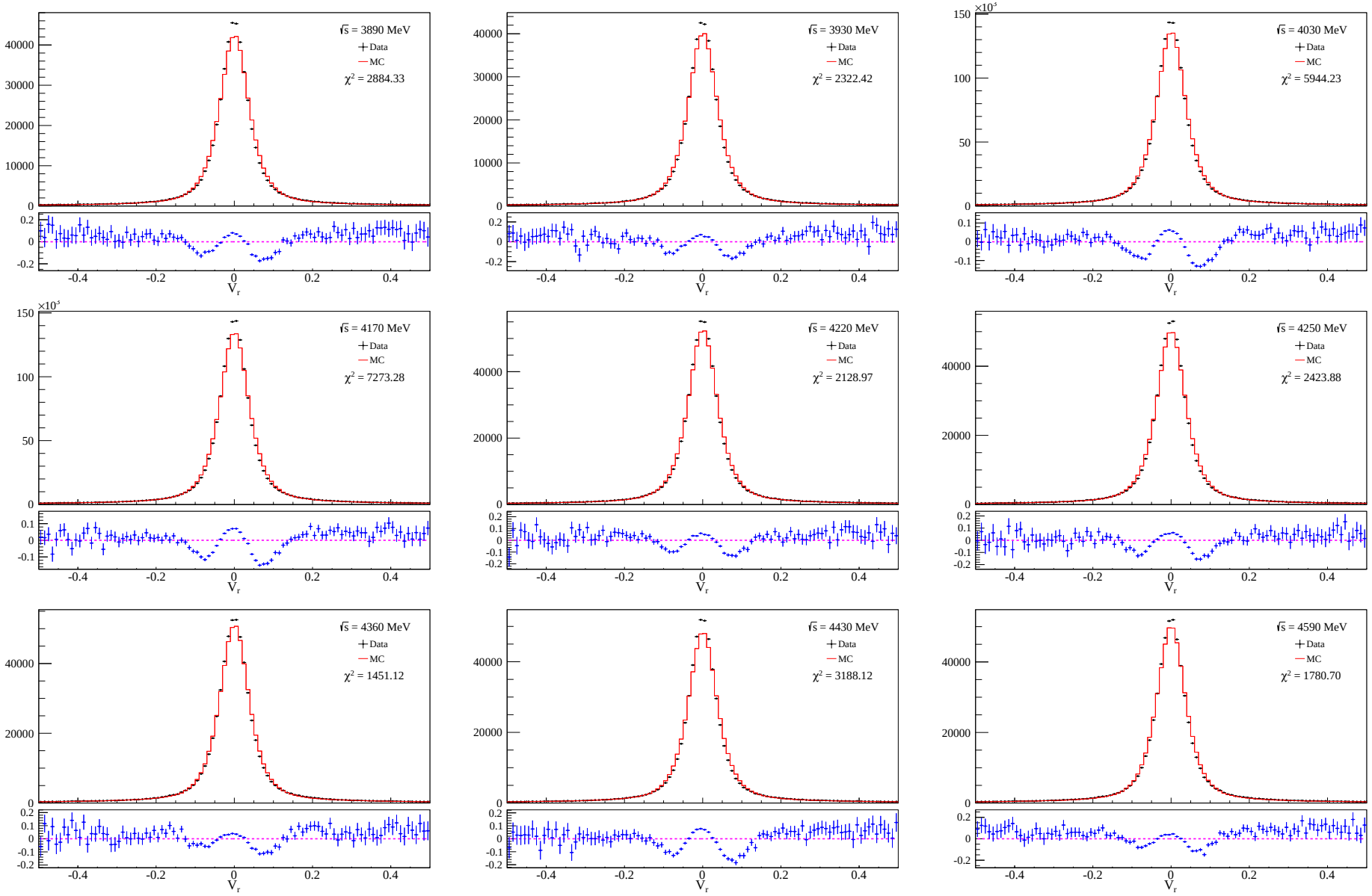

√s = 3890 MeV
Data
MC
χ² = -93.67
√s = 3930 MeV
χ² = 128.29
√s = 4030 MeV
χ² = 275.22
√s = 4170 MeV
χ² = 165.98
√s = 4220 MeV
χ² = 151.99
√s = 4250 MeV
χ² = -186.28
√s = 4360 MeV
χ² = 272.44
√s = 4430 MeV
χ² = 210.63
√s = 4590 MeV
χ² = 199.46
M(D*0)

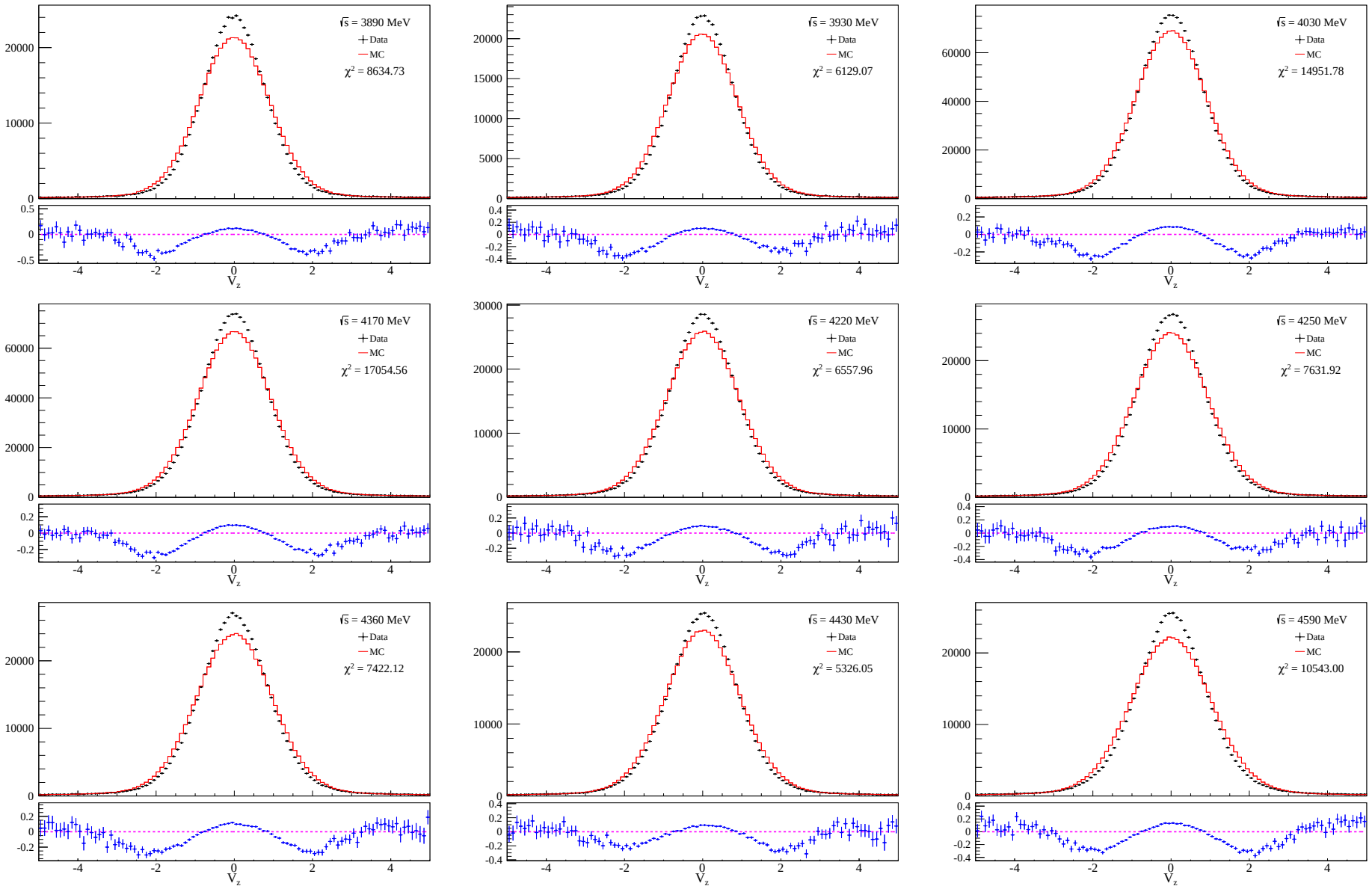

√s = 3890 MeV
Data
MC
χ² = 139.48
√s = 3930 MeV
χ² = 203.46
√s = 4030 MeV
χ² = 646.66
√s = 4170 MeV
χ² = 508.75
√s = 4220 MeV
χ² = 313.82
√s = 4250 MeV
χ² = 196.23
√s = 4360 MeV
χ² = 164.25
√s = 4430 MeV
χ² = 144.64
√s = 4590 MeV
χ² = 128.64
M(D⁺)


√s = 3890 MeV
Data
MC
χ² = -25.26
√s = 3930 MeV
χ² = -387.14
√s = 4030 MeV
χ² = 89.88
√s = 4170 MeV
χ² = 96.92
√s = 4220 MeV
χ² = -39.68
√s = 4250 MeV
χ² = 104.42
√s = 4360 MeV
χ² = 39.08
√s = 4430 MeV
χ² = -394.06
√s = 4590 MeV
χ² = 78.17
M(D*+)

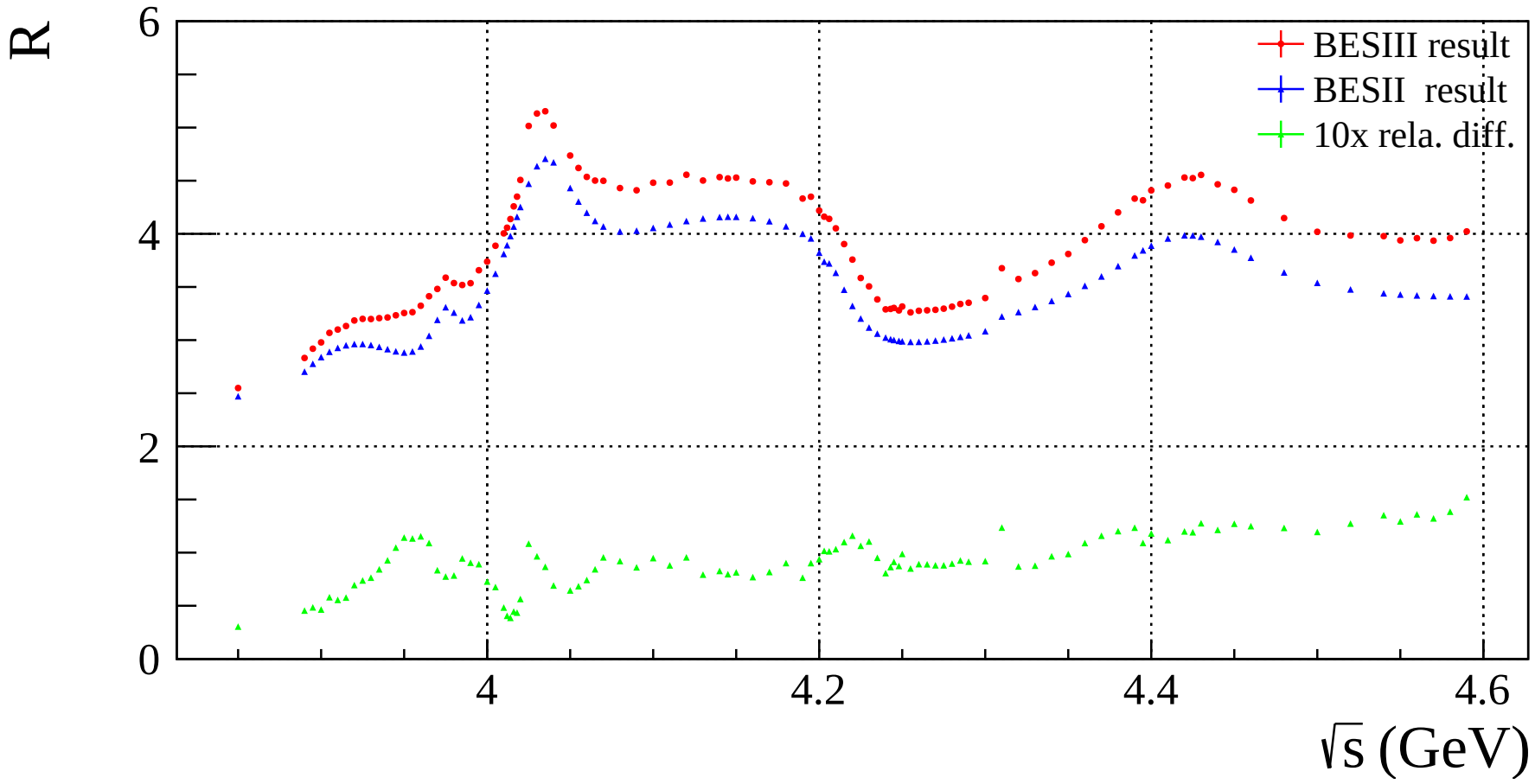

√s = 3890 MeV
Data
MC
χ² = 100.15
√s = 3930 MeV
χ² = 188.22
√s = 4030 MeV
χ² = 120.90
√s = 4170 MeV
χ² = 159.64
√s = 4220 MeV
χ² = 132.17
√s = 4250 MeV
χ² = 80.70
√s = 4360 MeV
χ² = 114.37
√s = 4430 MeV
χ² = 101.72
√s = 4590 MeV
χ² = 115.03
M(D_s^+)


√s = 3890 MeV
Data
MC
χ² = 165.06
√s = 3930 MeV
χ² = 186.74
√s = 4030 MeV
χ² = 141.09
√s = 4170 MeV
χ² = 114.75
√s = 4220 MeV
χ² = 124.03
√s = 4250 MeV
χ² = 138.93
√s = 4360 MeV
χ² = 145.13
√s = 4430 MeV
χ² = 121.30
√s = 4590 MeV
χ² = 132.78
M(D_s^{*+})

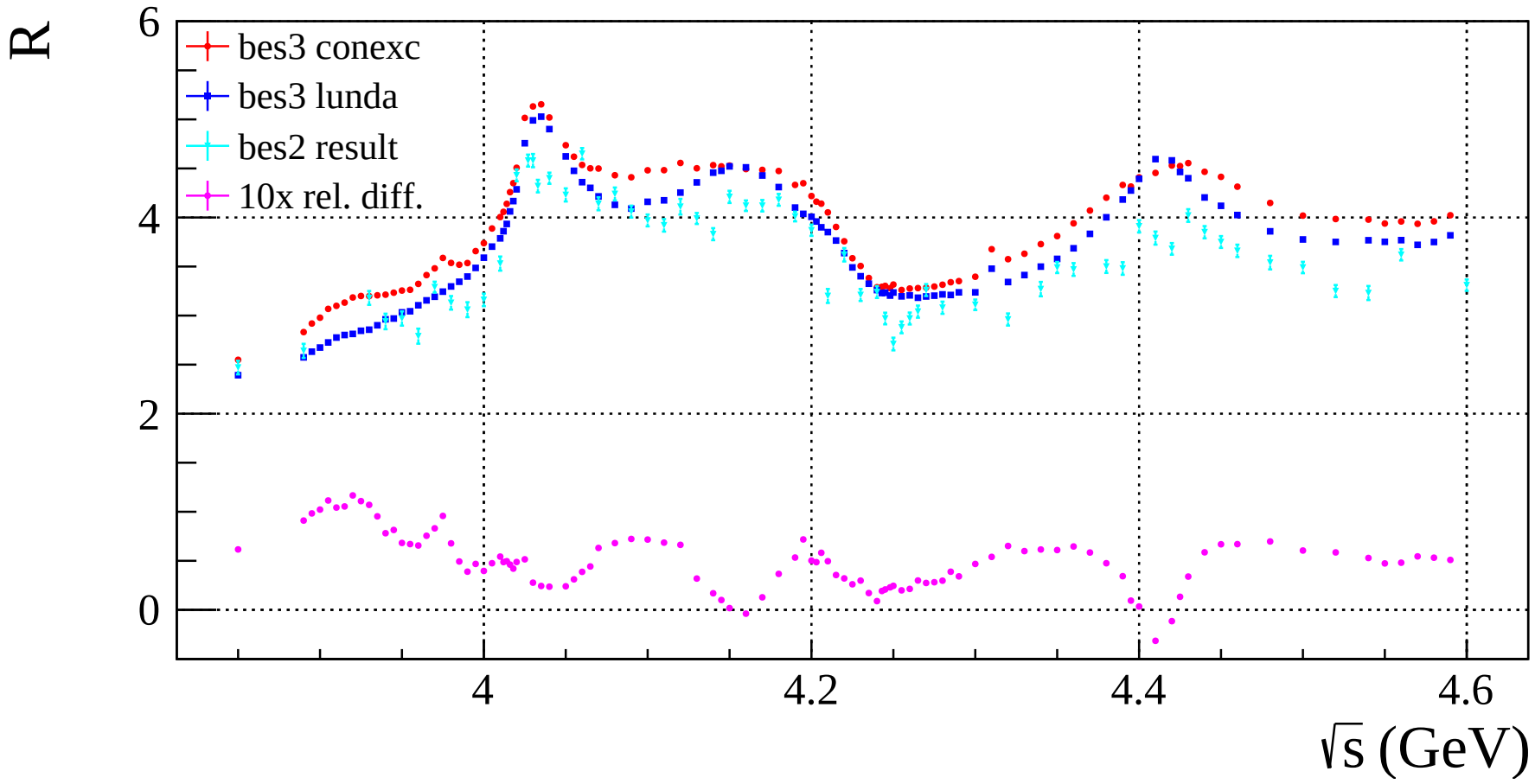

√s = 3890 MeV
Data
MC
χ² = 2884.33
√s = 3930 MeV
χ² = 2322.42
√s = 4030 MeV
χ² = 5944.23
√s = 4170 MeV
χ² = 7273.28
√s = 4220 MeV
χ² = 2128.97
√s = 4250 MeV
χ² = 2423.88
√s = 4360 MeV
χ² = 1451.12
√s = 4430 MeV
χ² = 3188.12
√s = 4590 MeV
χ² = 1780.70
V_r


√s = 3890 MeV
Data
MC
χ² = 8634.73
√s = 3930 MeV
χ² = 6129.07
√s = 4030 MeV
χ² = 14951.78
√s = 4170 MeV
χ² = 17054.56
√s = 4220 MeV
χ² = 6557.96
√s = 4250 MeV
χ² = 7631.92
√s = 4360 MeV
χ² = 7422.12
√s = 4430 MeV
χ² = 5326.05
√s = 4590 MeV
χ² = 10543.00
V_z

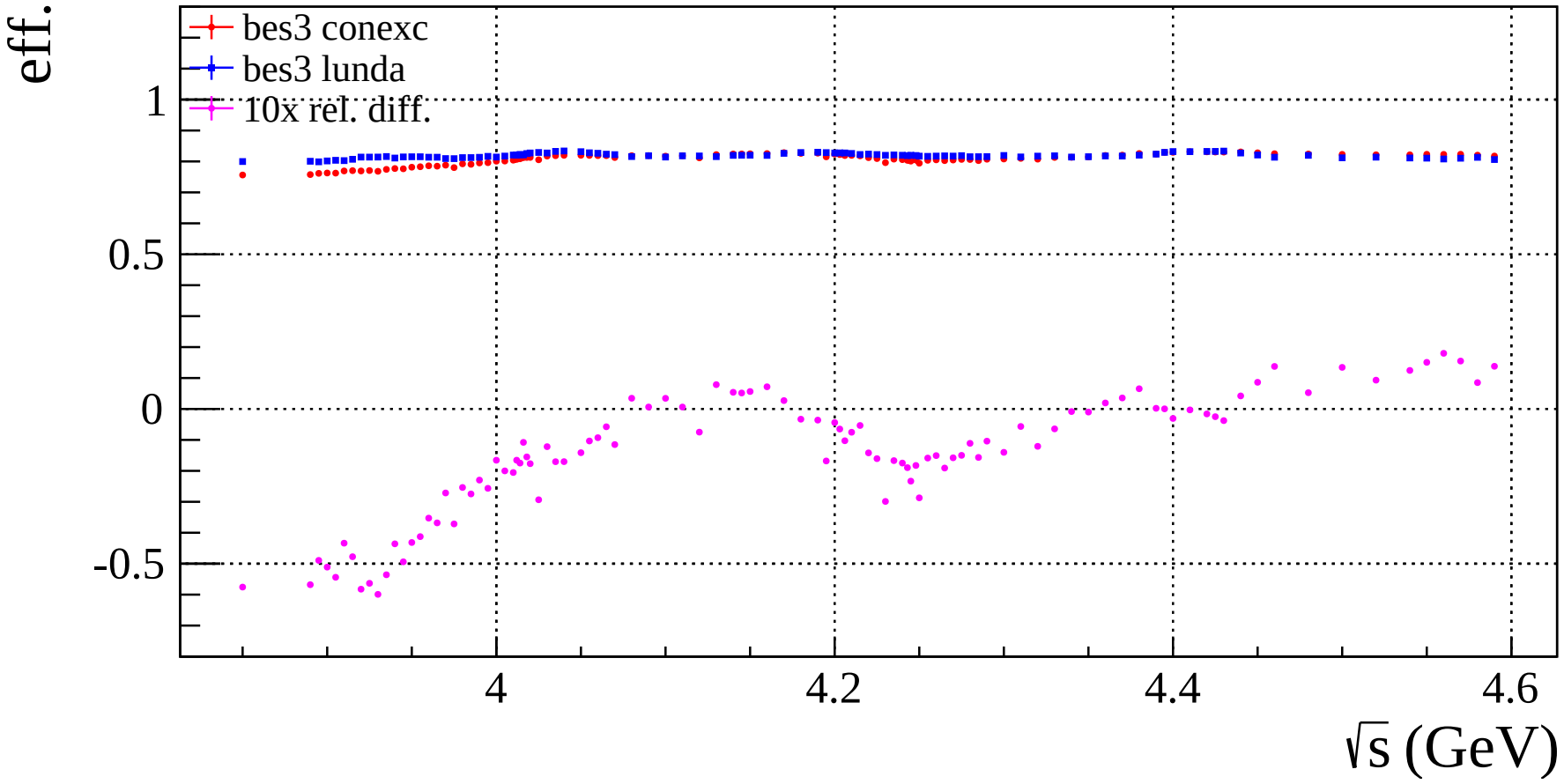
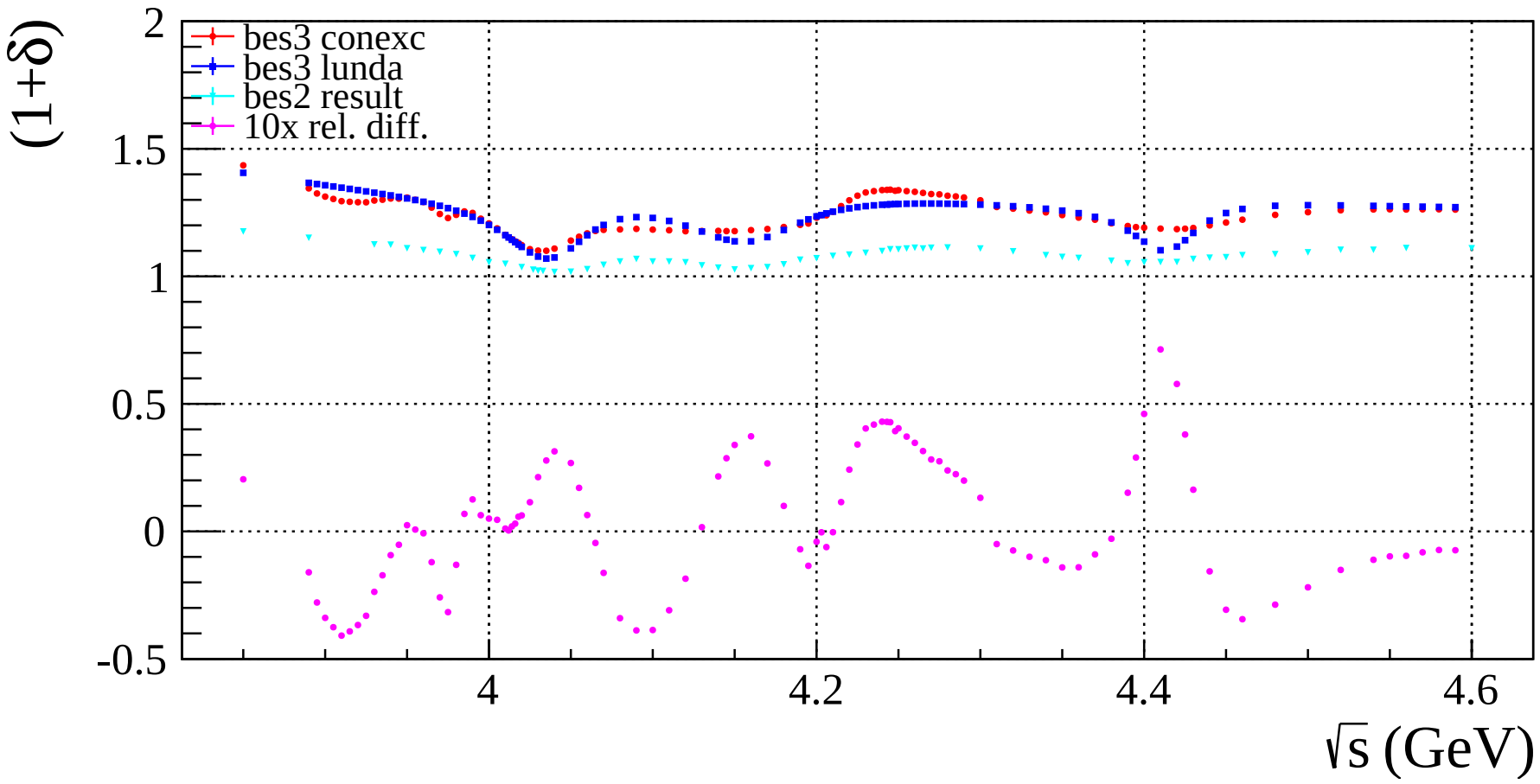
R value


R
6
4
2
0
4
4.2
4.4
4.6
√s (GeV)
BESIII result
BESII result
10x rela. diff.

R value


R
6
4
2
0
bes3 conexc
bes3 lunda
bes2 result
10x rel. diff.
4
4.2
4.4
4.6
√s (GeV)

efficiency



$f_{ISR} \cdot f_{VP}$