Auger-TA Composition Working Group Report

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PIERRE AUGER OBSERVATORY

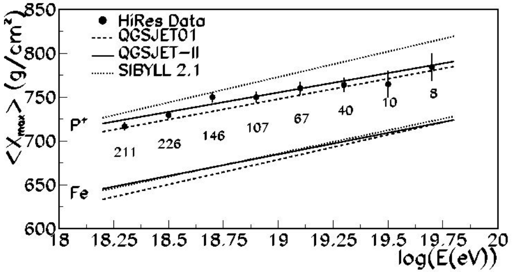
TELESCOPE ARRAY PROJECT

UHECR 2016, Kyoto, Japan
12 October 2016

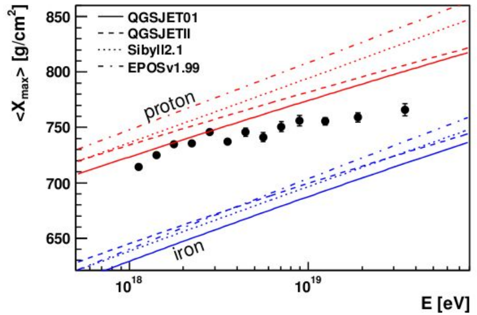
Mass Composition Working Group

- At UHECR 2012 the mass composition working group was formed to bring together X_{max} analysts from Auger and TA to stimulate further focused discussions about the discrepancies seen in HiRes, Auger, and TA X_{max} results.
- Understand differences in analysis methodologies.
- Encourage cross-checking of results through data exchange.

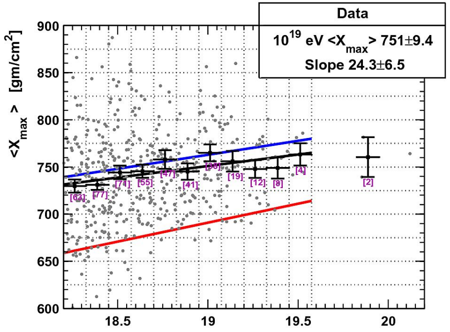
Auger X_{max} data
http://journals.aps.org/prd/abstract/10.1103/PhysRevD.90.122005



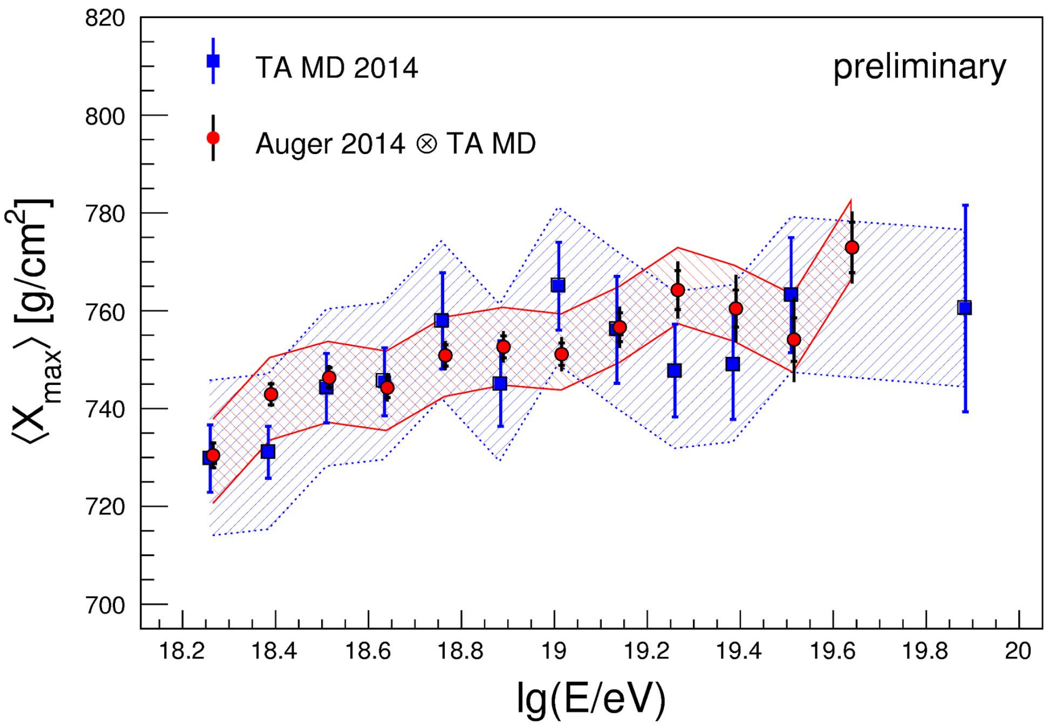
HiRes



Auger



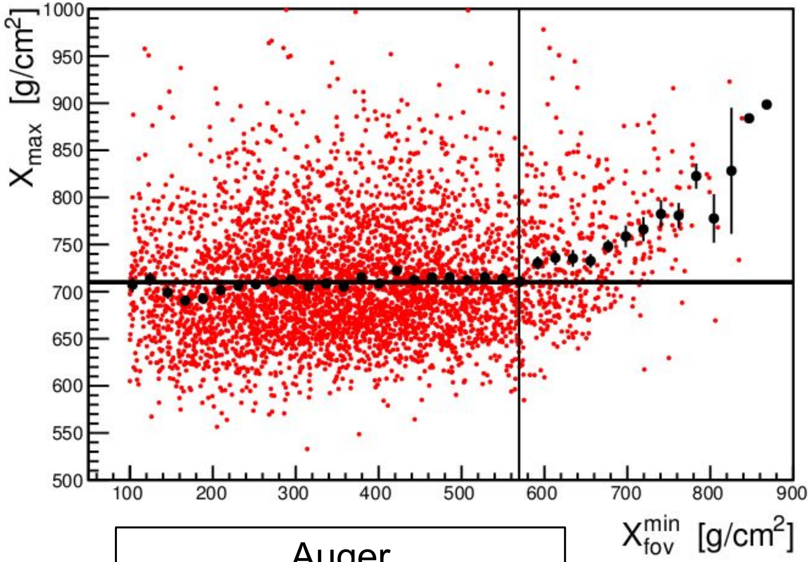
TA MD



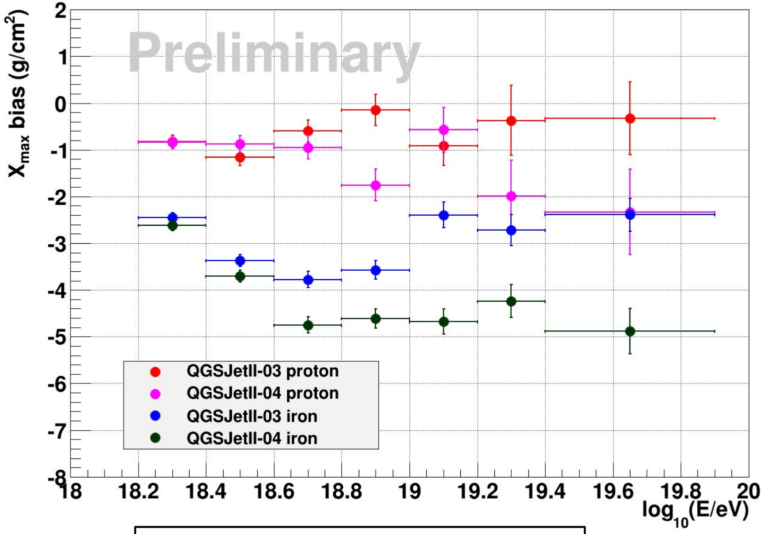
TA MD hybrid $<X_{max}>$ data and Auger mix reconstructed via TA MD hybrid analysis and systematic uncertainties.

- At UHECR2014 the working group reported on the latest efforts of reconstructing an Auger prescribed mix using TA Middle Drum reconstruction. All reconstruction shown here is done using BR/LR hybrid analysis.
- Different detectors and different exposures

Analysis Methodology



Auger

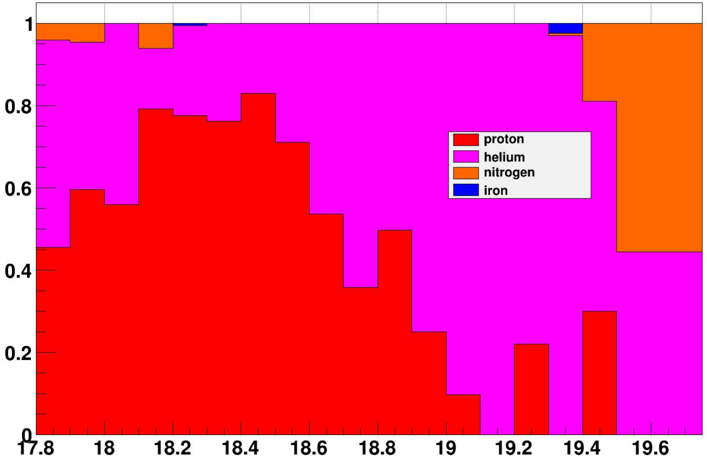


TA

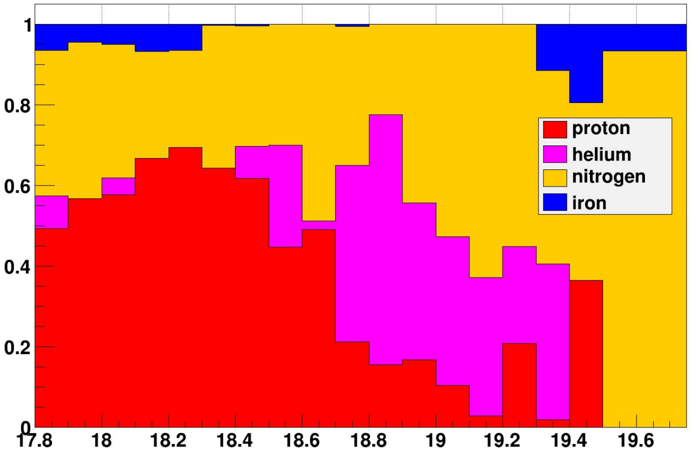
- Fiducial volume cuts based on shower geometry are applied to select showers with minimum resolution bias and covers the full X_{max} distribution.
- Moments of the unbiased X_{max} distribution are obtained.
- X_{max} moments can be directly compared to unbiased, thrown distributions from models.
- Identical reconstruction procedure, software, and event selection algorithm.

- Simulate X_{max} biases via detailed detector Monte Carlo
- Compare measured X_{max} distributions with Monte Carlo predictions including effects of detector biases.
- Identical reconstruction procedures, software, & cuts are applied to data and Monte Carlo.
- Biases in data due to unique aperture, efficiency, & reconstruction shown.

QGSJet II-04

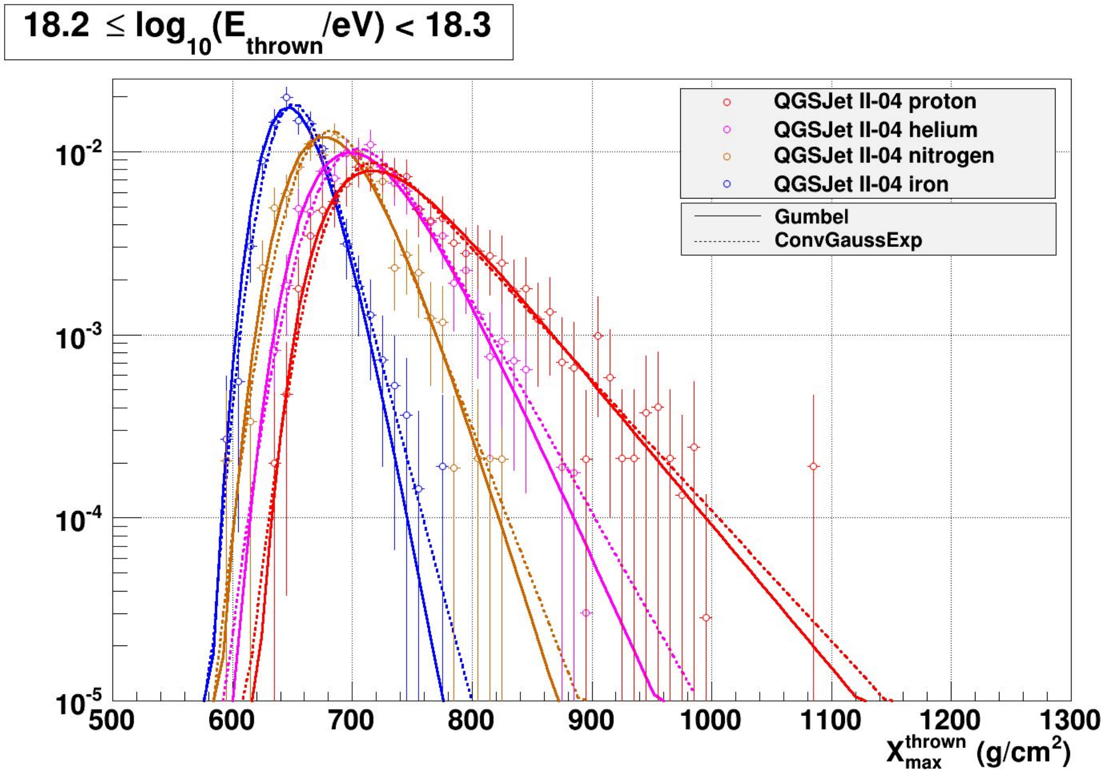


EPOS-LHC



1. Check the consistency of TA CORSIKA QGSJet II-04 simulations
2. Use Auger p, He, N, Fe fractions from X_{max} fits using QGSJet II-04 to construct X_{max} distributions in the TA detector.
3. Use Auger p, He, N, Fe fractions from X_{max} fits using EPOS-LHC to construct X_{max} distributions in the TA detector.
   a. Due to the absence of full EPOS-LHC simulations for TA this is done via weighting QGSJet II-04 distributions as will be described later.

Auger fractions: http://journals.aps.org/prd/abstract/10.1103/PhysRevD.90.122006

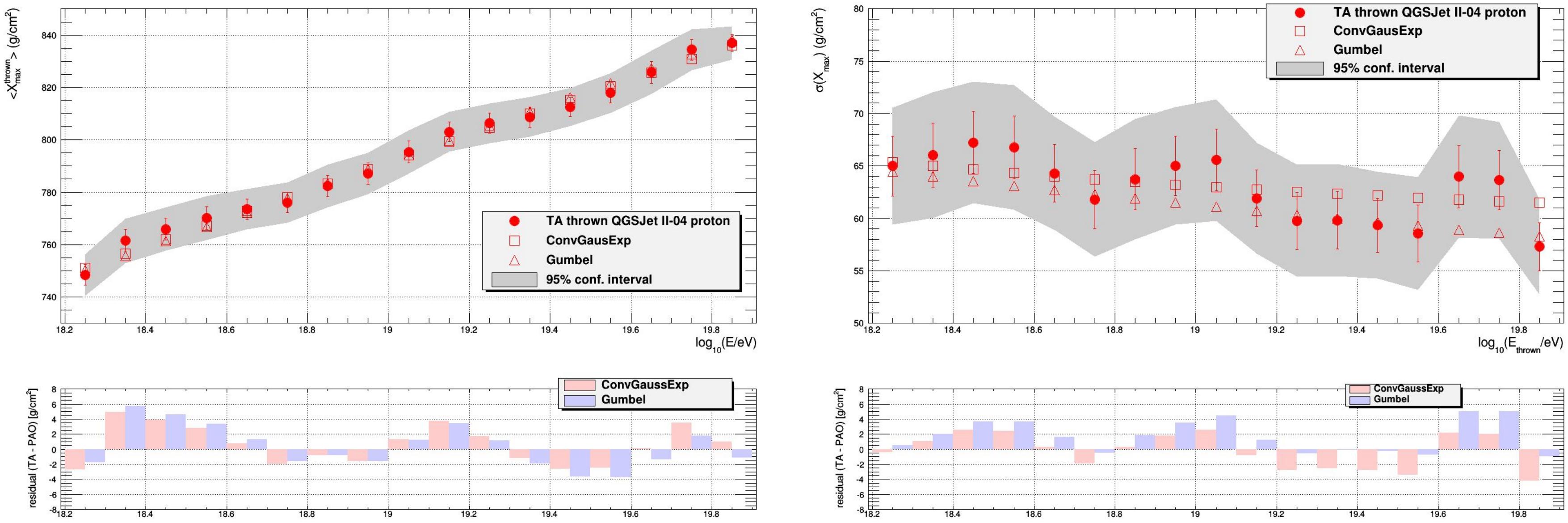


	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	748.5 ± 4.0	751.2 (-2.7)	750.2 (-1.8)
helium	718.0 ± 2.7	720.3 (-2.3)	715.0 (3.1)
nitrogen	688.3 ± 2.2	690.3 (-2.1)	687.5 (0.8)
iron	655.5 ± 1.5	656.8 (-1.3)	652.5 (3.0)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	65.0 ± 2.8	65.3 (-0.3)	64.4 (0.6)
helium	43.6 ± 1.9	46.1 (-2.5)	44.7 (-1.0)
nitrogen	35.3 ± 1.5	34.7 (0.6)	35.4 (-0.04)
iron	24.5 ± 1.1	24.0 (0.5)	23.6 (1.0)

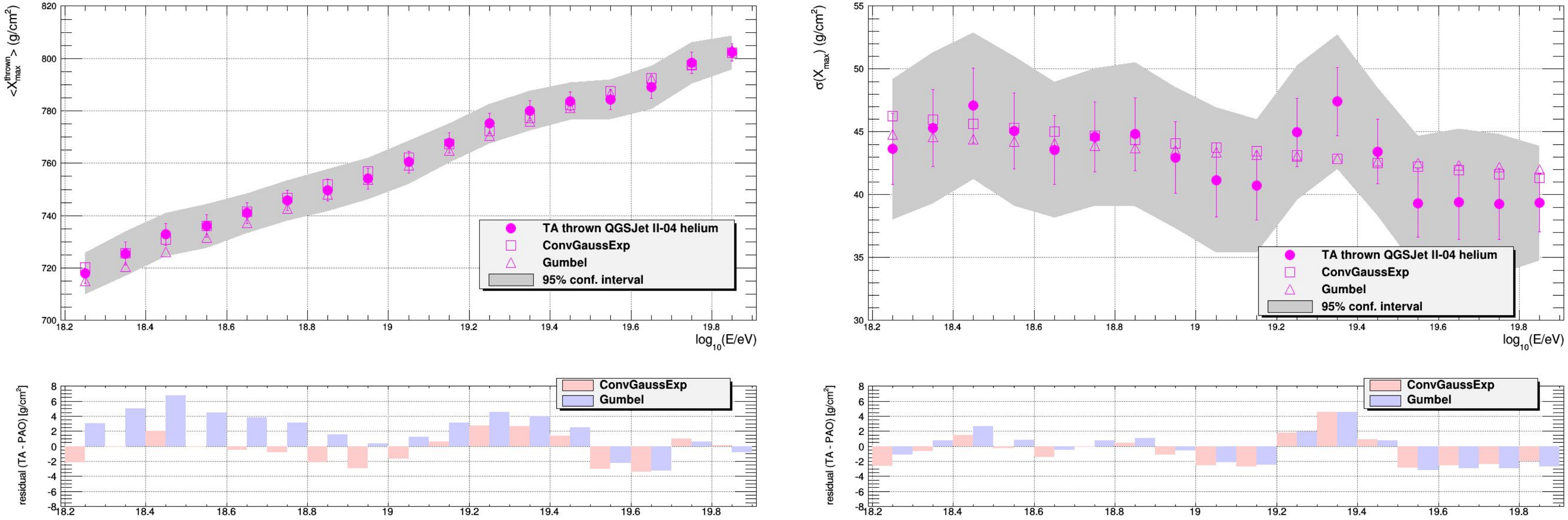
Comparison of TA thrown QGSJet II-04 CORSIKA shower library (unbiased) (points) to Auger parameterizations (lines). The lines are not fits to the points. We have good agreement between two independently generated sets of shower distributions among all four species across two decades of energy.

QGSJet II-04 protons



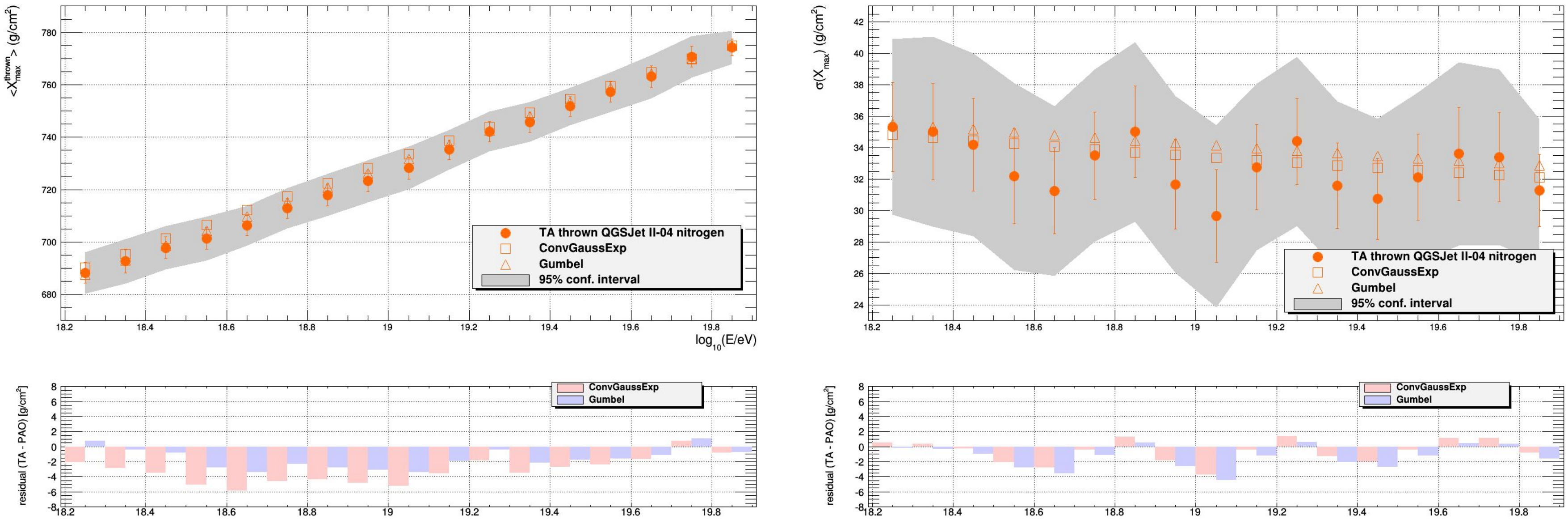
Consistency check of TA shower libraries and Auger parameterizations before beginning the mixing process. Two forms of parameterizations were provided fits to gumbel distributions and fits to gaussian-exponential convolutions. Residuals between the<X_{max}> of the TA shower library and the Auger parameterizations are shown on the bottom. Residuals are □ 6 g/cm^2 for all species.

QGSJet II-04 helium



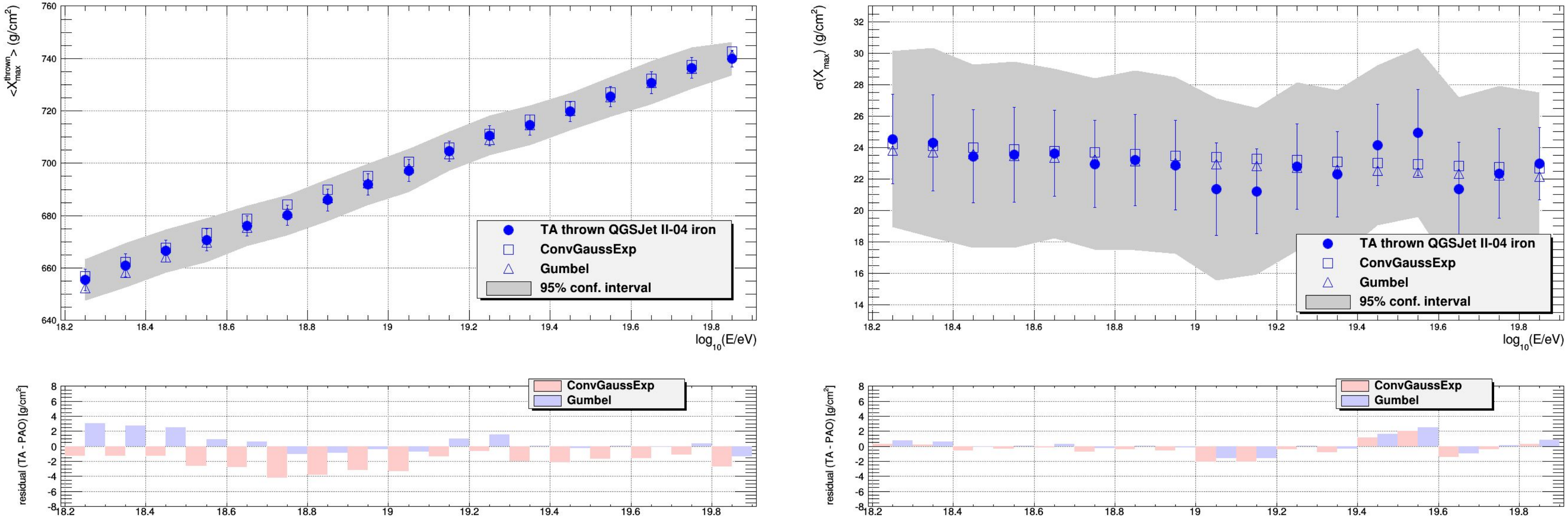
Consistency check of TA shower libraries and Auger parameterizations before beginning the mixing process. Two forms of parameterizations were provided fits to gumbel distributions and fits to gaussian-exponential convolutions. Residuals between the< X_{max} > of the TA shower library and the Auger parameterizations are shown on the bottom. Residuals are □ 6 g/cm^2 for all species.

QGSJet II-04 nitrogen

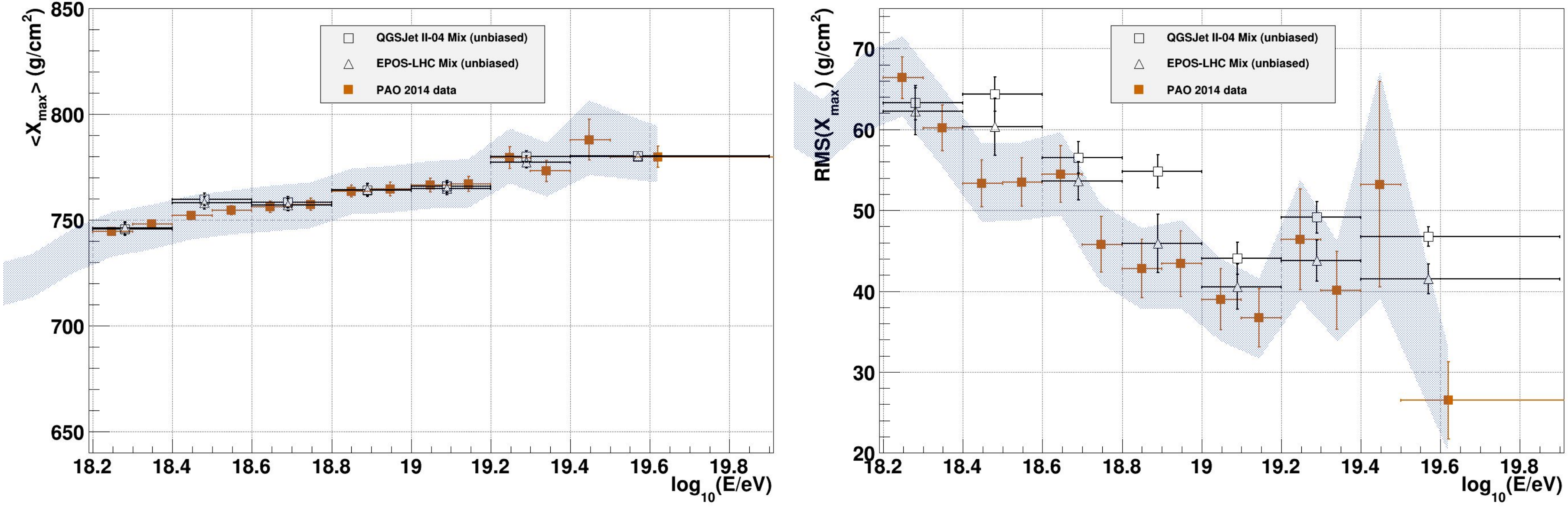


Consistency check of TA shower libraries and Auger parameterizations before beginning the mixing process. Two forms of parameterizations were provided fits to gumbel distributions and fits to gaussian-exponential convolutions. Residuals between the$<X_{max}>$ of the TA shower library and the PAO parameterizations are shown on the bottom. Residuals are □ 6 g/cm^2 for all species.

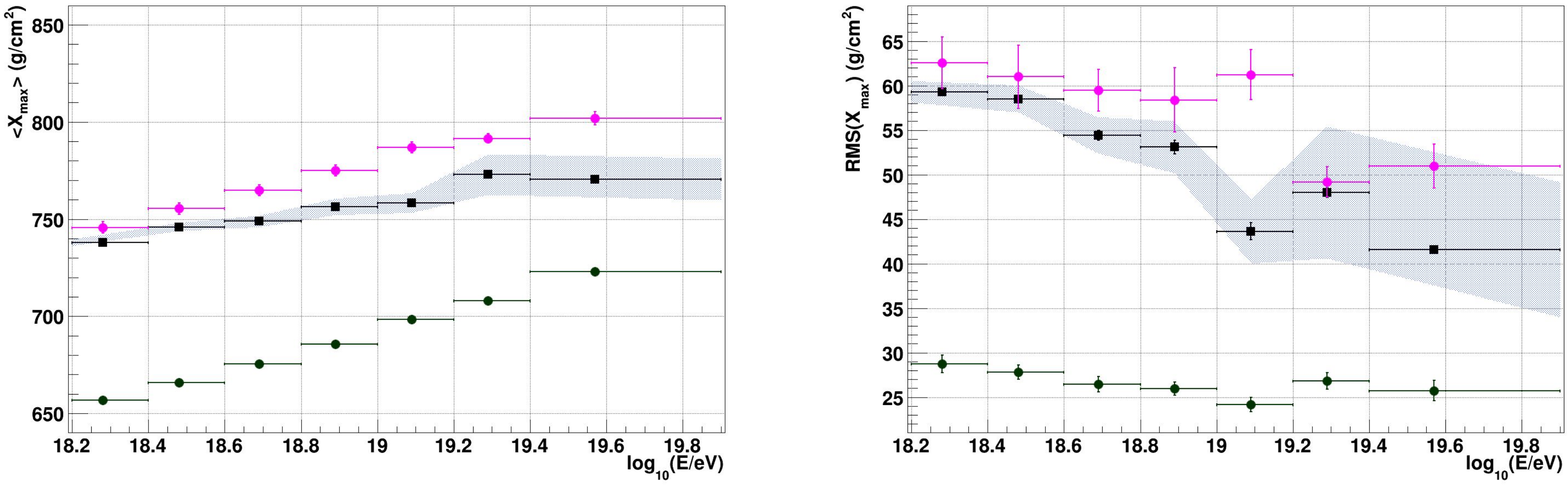
QGSJet II-04 iron



Consistency check of TA shower libraries and Auger parameterizations before beginning the mixing process. Two forms of parameterizations were provided fits to gumbel distributions and fits to gaussian-exponential convolutions. Residuals between the$<X_{max}>$ of the TA shower library and the PAO parameterizations are shown on the bottom. Residuals are □ 6 g/cm^2 for all species.

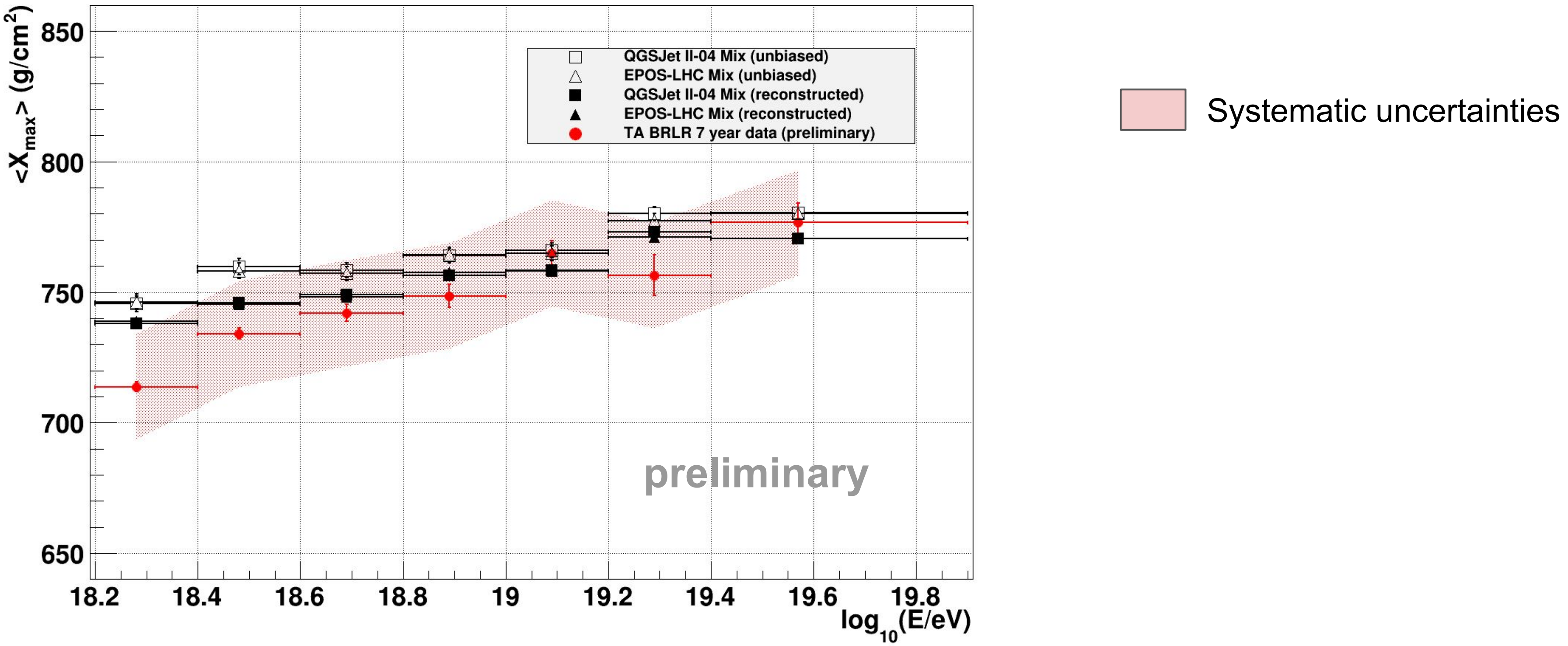


Unbiased <X_{max}> and RMS(X_{max}) of the mix for QGSJet II-04 and EPOS-LHC models compared to last published Auger X_{max} data, for above $E \geq 10^{18.2}$ eV. Distribution widths of EPOS-LHC appears to be a better match to data as expected.

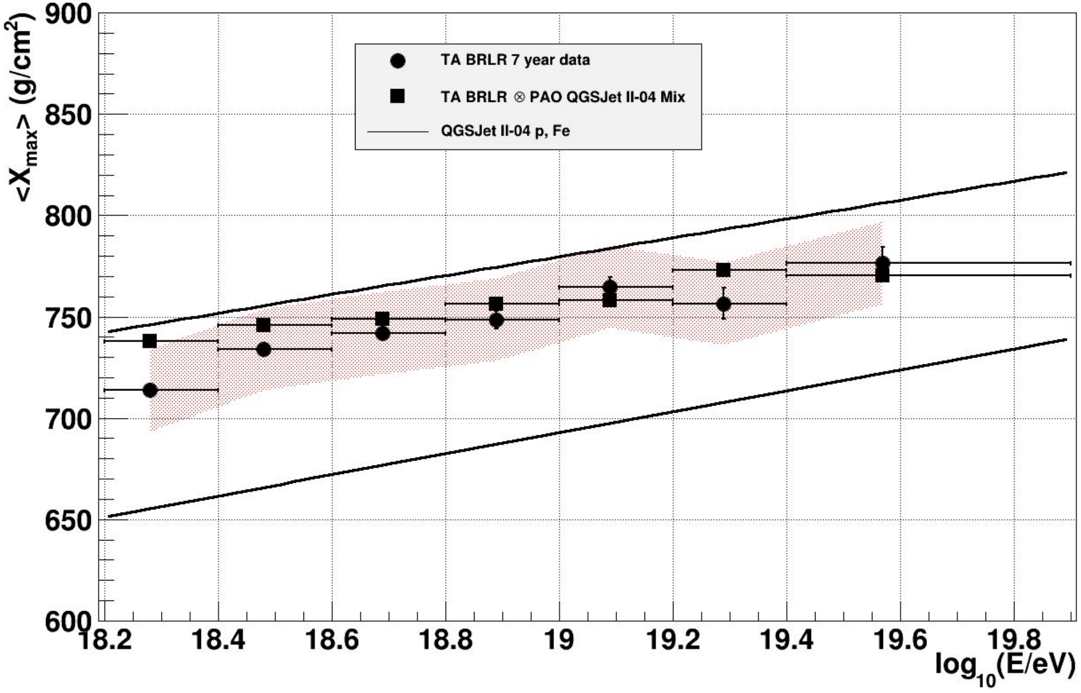


Statistical uncertainties for seven years exposure

Reconstructed QGSJet II-04 mix with expected uncertainties based on seven years of BR/LR hybrid data exposure compared to reconstructed pure proton and iron distributions.

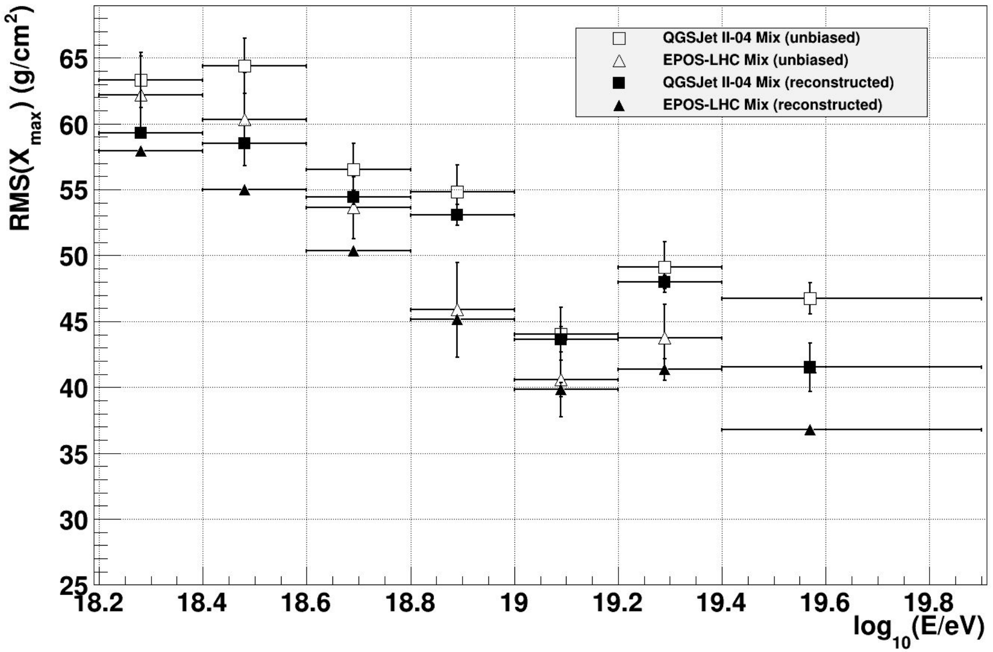


Thrown and reconstructed mix compared to preliminary TA 7 year data - all reconstructed using BR/LR hybrid analysis. Data systematics shown as well.



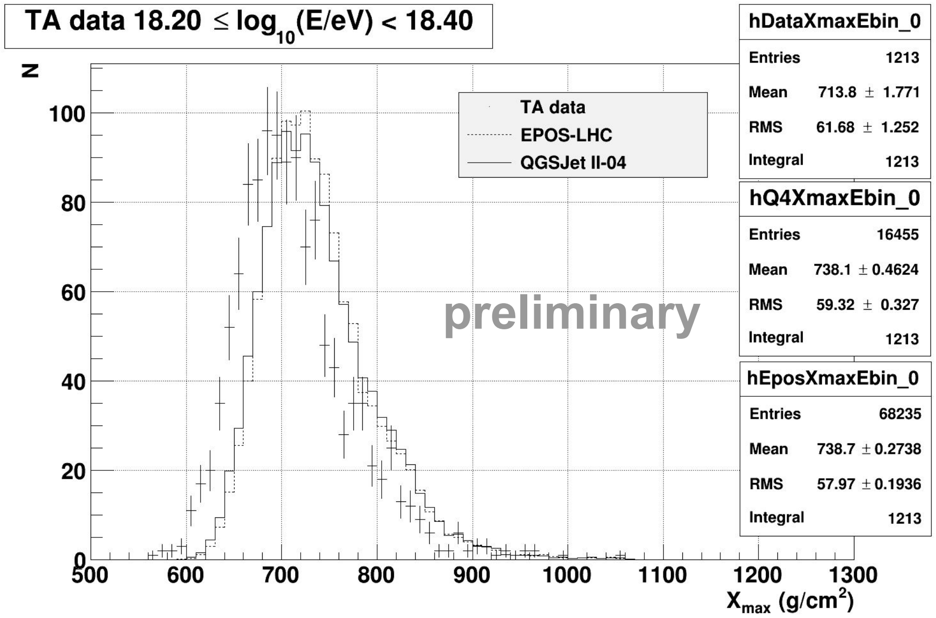
Systematic uncertainties

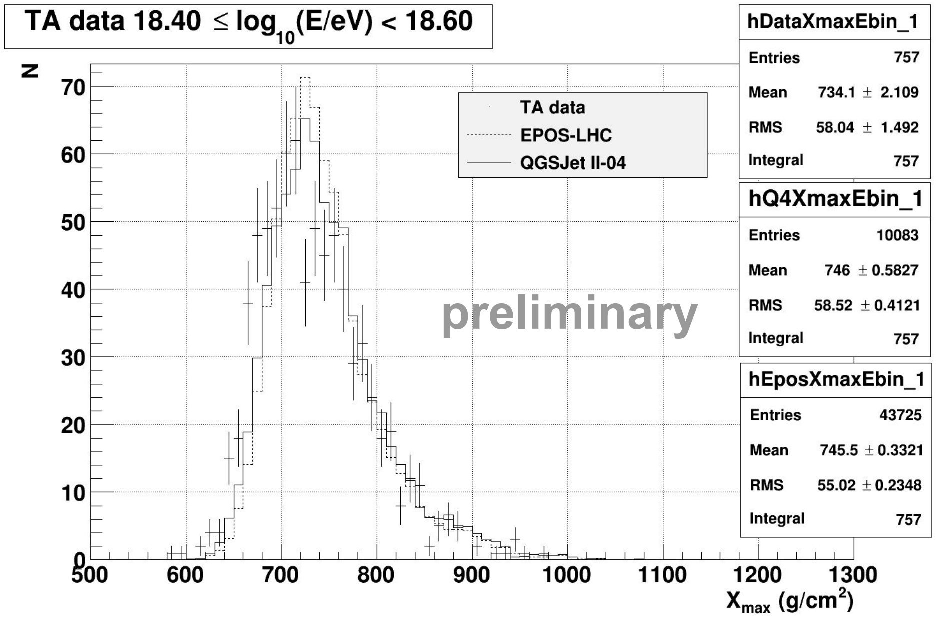
Using seven years of BR/LR hybrid X_{max} data there is good agreement with the Auger mix at the current level of sensitivity.



Widths of unbiased and reconstructed QGSJet II-04 and EPOS-LHC mix distributions. EPOS-LHC X_{max} distributions are consistently narrower than QGSJet II-04 distributions.

X_{max} Distributions

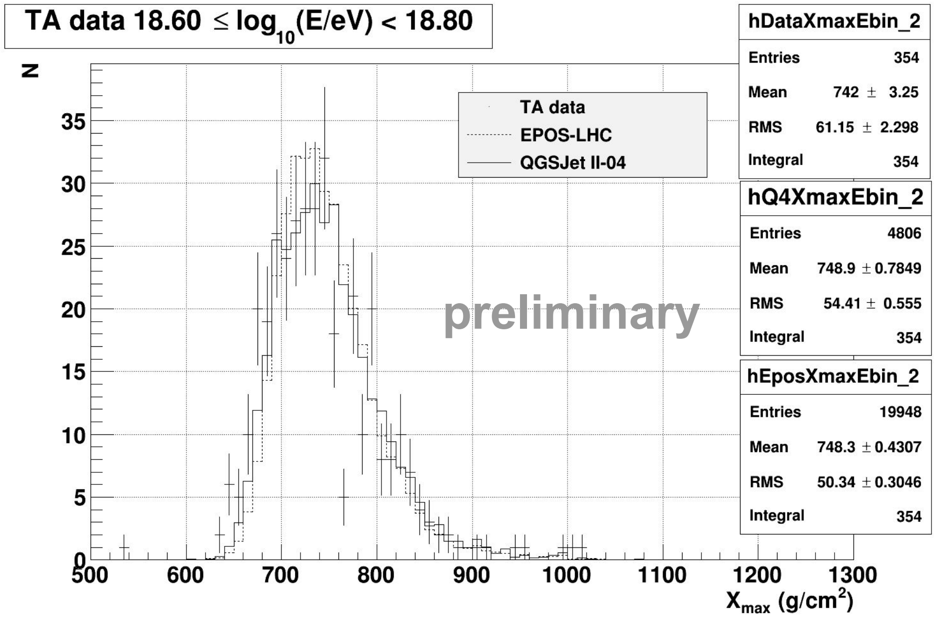


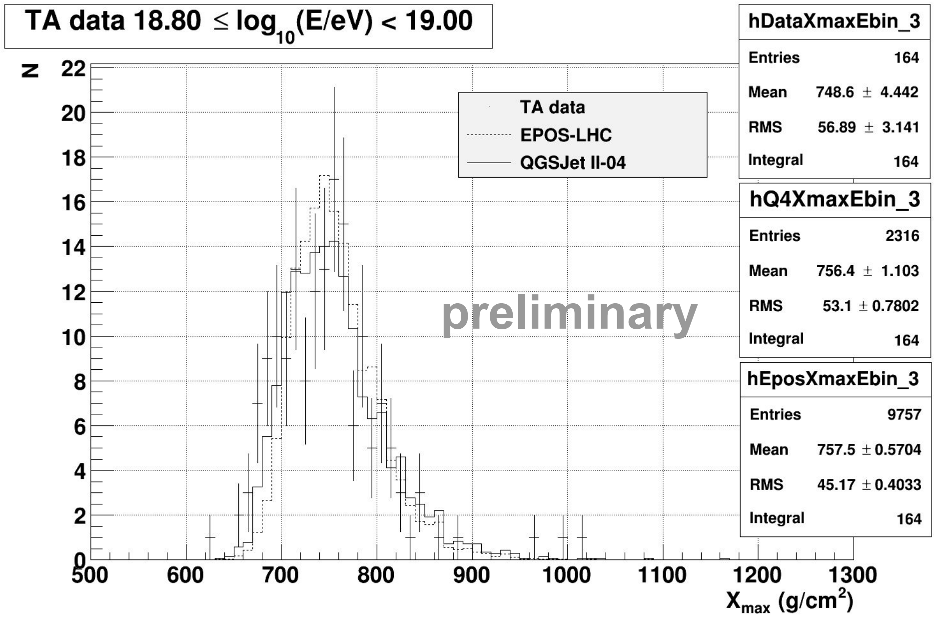


Auger mix after full exposure to Telescope Array analysis routines. Same analysis procedures used for all TA data and Monte Carlo. Data is seven years of preliminary BR/LR hybrid X_{max} analysis.

Reconstructed mix distributions are normalized to the data.

X_{max} Distributions





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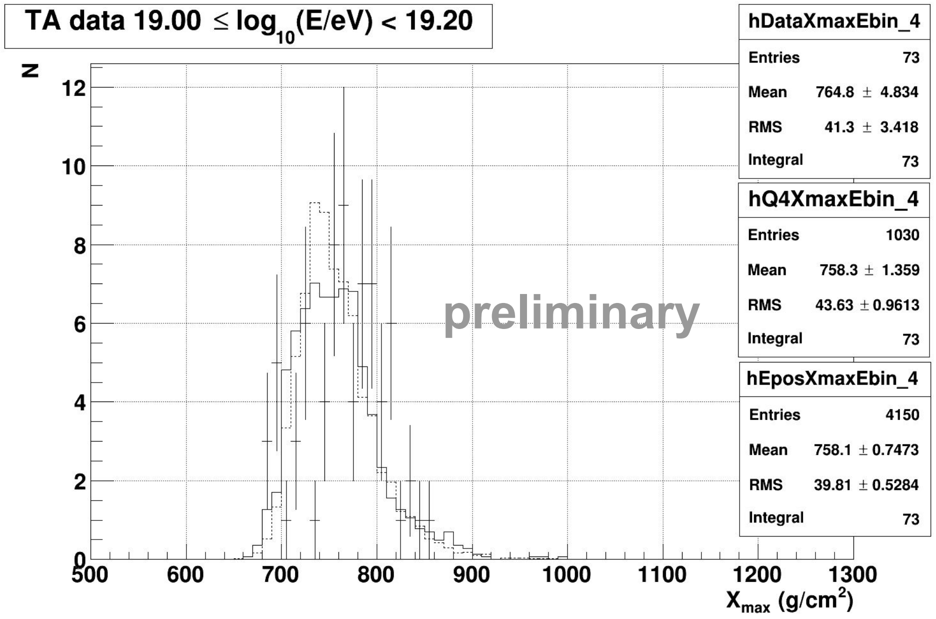
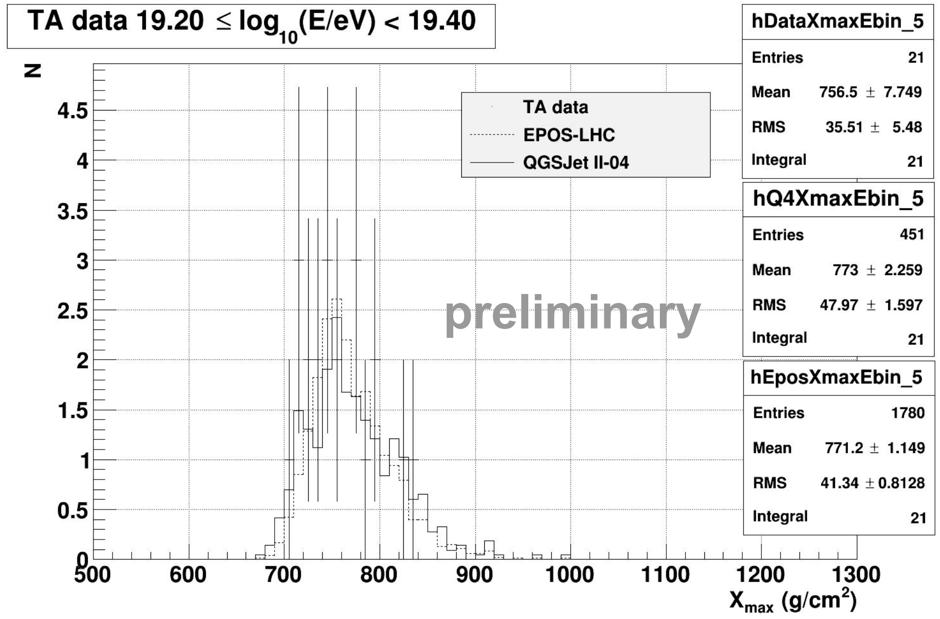
X_{max} Distributions





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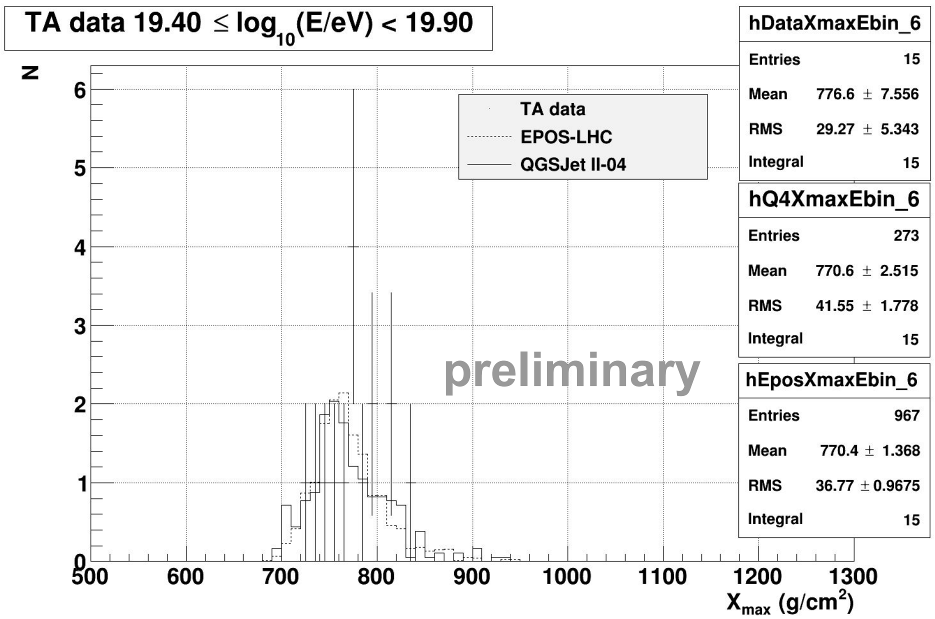
Reconstructed mix distributions are normalized to the data.

X_{max} Distributions



Auger mix after full exposure to Telescope Array analysis routines. Same analysis procedures used for all TA data and Monte Carlo. Data is seven years of preliminary BR/LR hybrid X_{max} analysis.

Reconstructed mix distributions are normalized to the data.

Summary

- The working group continues to evaluate the compatibility of Auger and TA X_{max} results.

- This time we tried new procedures
  - Evaluated the consistency of thrown Monte Carlos of Auger and TA.
  - Simulating EPOS-LHC distributions in TA reconstruction.

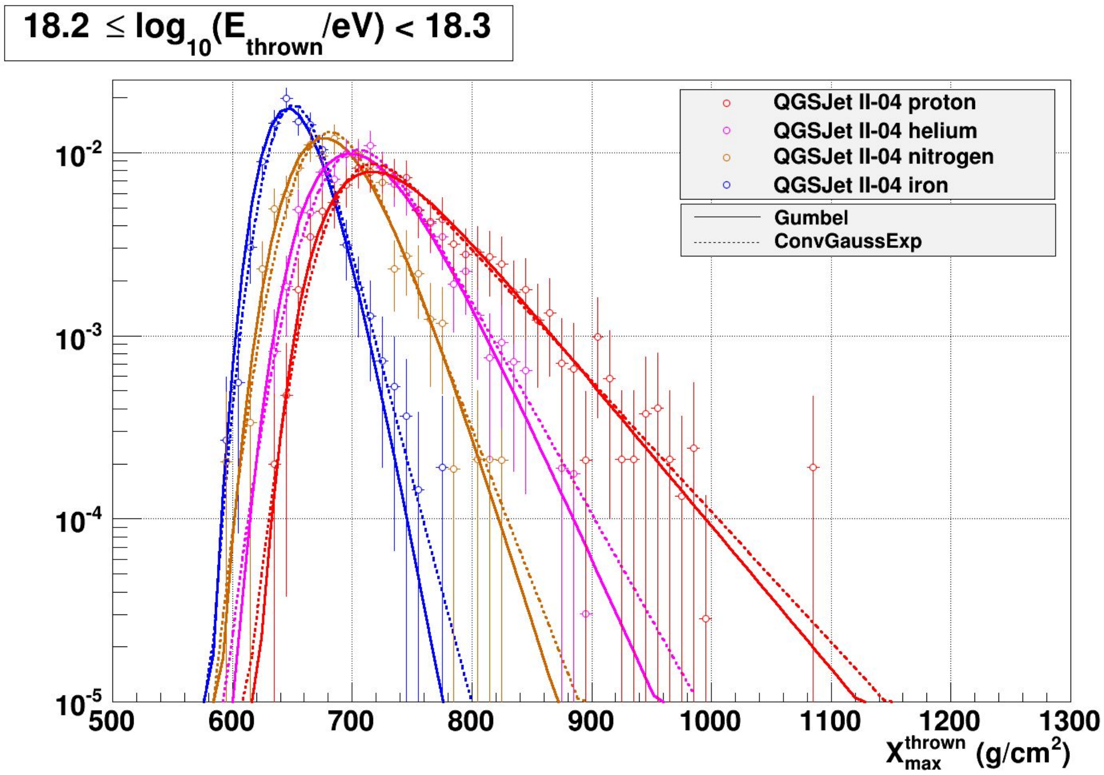
- This analysis is *necessary* because we can not directly compared unbiased Auger data to biased TA data.
- Auger mix is consistent with TA data within our systematics in $\langle X_{max} \rangle$.

- We've shown there is good qualitative agreement between TA and Auger X_{max} distributions.

- Publish seven year TA hybrid X_{max} result → summarize the current state Auger and TA composition working group findings in a publication.

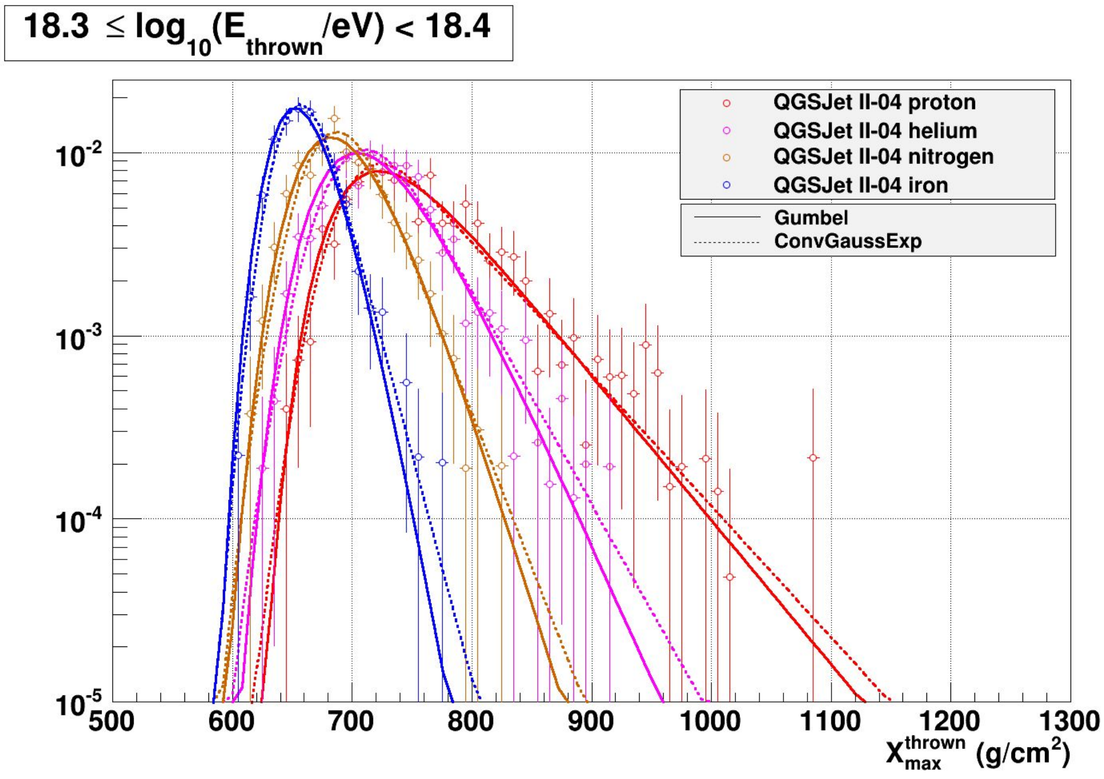
Extras

Consistency of TA Thrown Monte Carlo and PAO Parameterizations Distribution Plots



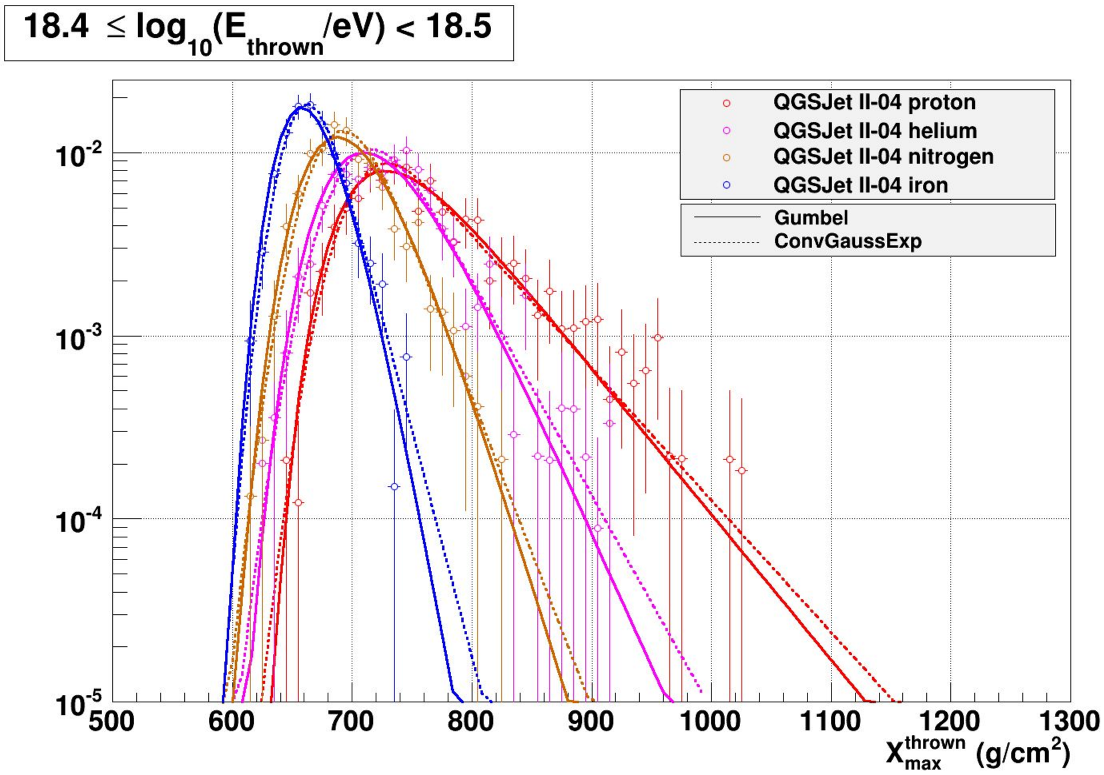
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	748.5 ± 4.0	751.2 (-2.7)	750.2 (-1.8)
helium	718.0 ± 2.7	720.3 (-2.3)	715.0 (3.1)
nitrogen	688.3 ± 2.2	690.3 (-2.1)	687.5 (0.8)
iron	655.5 ± 1.5	656.8 (-1.3)	652.5 (3.0)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	65.0 ± 2.8	65.3 (-0.3)	64.4 (0.6)
helium	43.6 ± 1.9	46.1 (-2.5)	44.7 (-1.0)
nitrogen	35.3 ± 1.5	34.7 (0.6)	35.4 (-0.04)
iron	24.5 ± 1.1	24.0 (0.5)	23.6 (1.0)



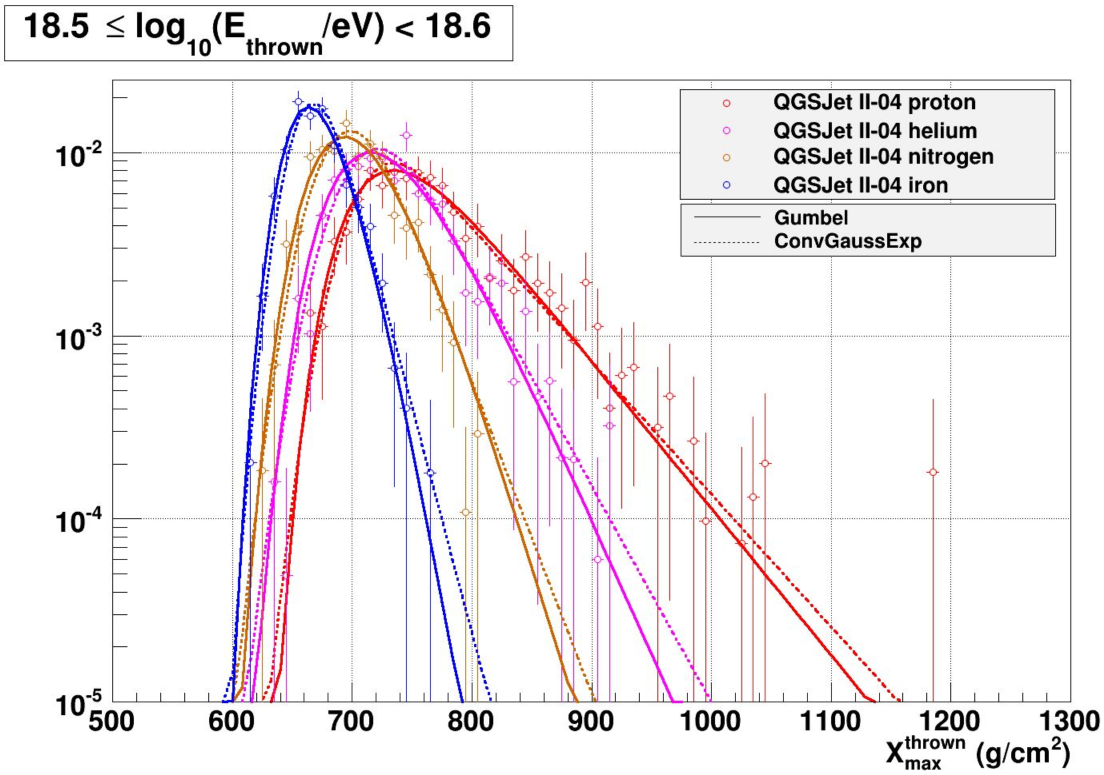
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	761.5 ± 4.3	756.6 (4.9)	755.8 (5.7)
helium	725.5 ± 3.0	725.6 (-0.1)	720.5 (5.0)
nitrogen	692.6 ± 2.3	695.8 (-3.2)	693.1 (-0.4)
iron	661.0 ± 1.5	662.3 (-1.3)	658.3 (2.8)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	66.0 ± 3.1	64.9 (1.1)	63.9 (2.1)
helium	45.3 ± 2.2	45.8 (-0.5)	44.4 (0.8)
nitrogen	35.0 ± 1.6	34.5 (0.5)	35.2 (-0.2)
iron	24.3 ± 1.1	23.9 (0.4)	23.5 (0.8)



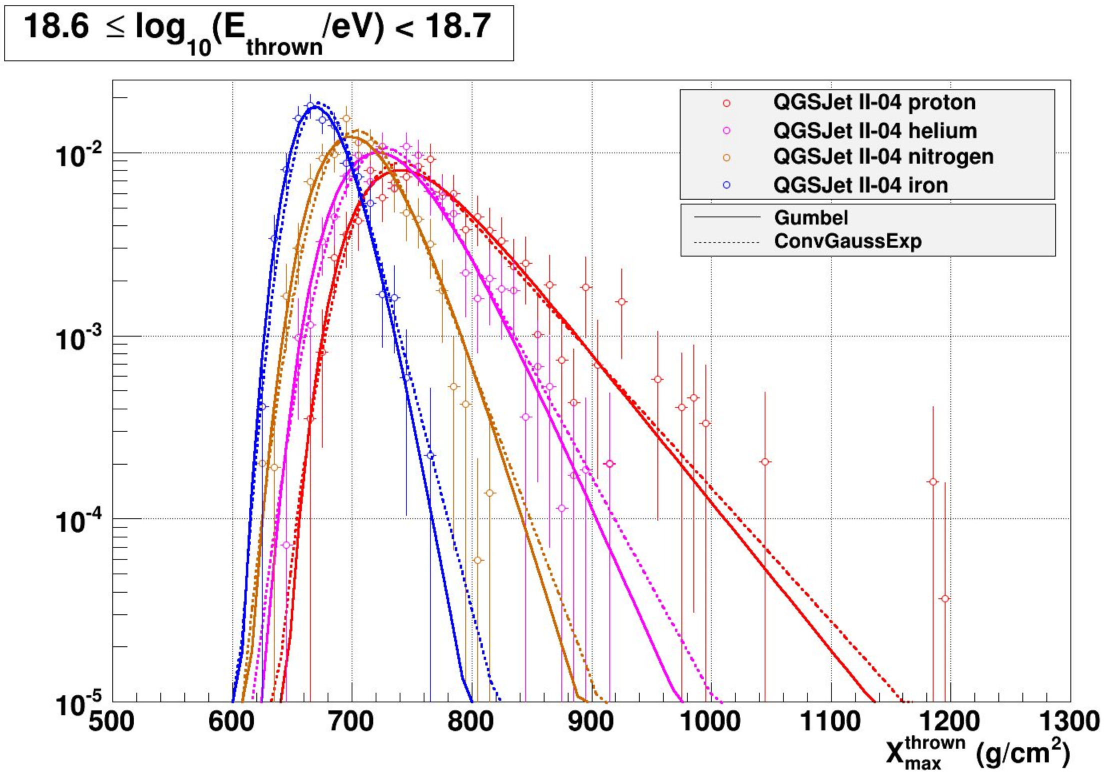
	dist $\langle X_{max} \rangle$	ConvGaussExp $\langle X_{max} \rangle$	Gumbel $\langle X_{max} \rangle$
proton	765.9 ± 4.2	762.0 (3.9)	761.3 (4.7)
helium	732.8 ± 2.9	730.9 (1.9)	726.1 (6.8)
nitrogen	697.8 ± 2.0	701.3 (-3.5)	698.6 (-0.8)
iron	666.5 ± 1.4	667.9 (-1.4)	664.0 (2.5)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	67.3 ± 3.0	64.6 (2.7)	63.5 (3.8)
helium	47.1 ± 2.1	45.5 (1.6)	44.3 (2.8)
nitrogen	34.2 ± 1.4	34.3 (-0.1)	35.0 (-0.8)
iron	23.4 ± 1.0	23.8 (-0.3)	23.4 (0.1)



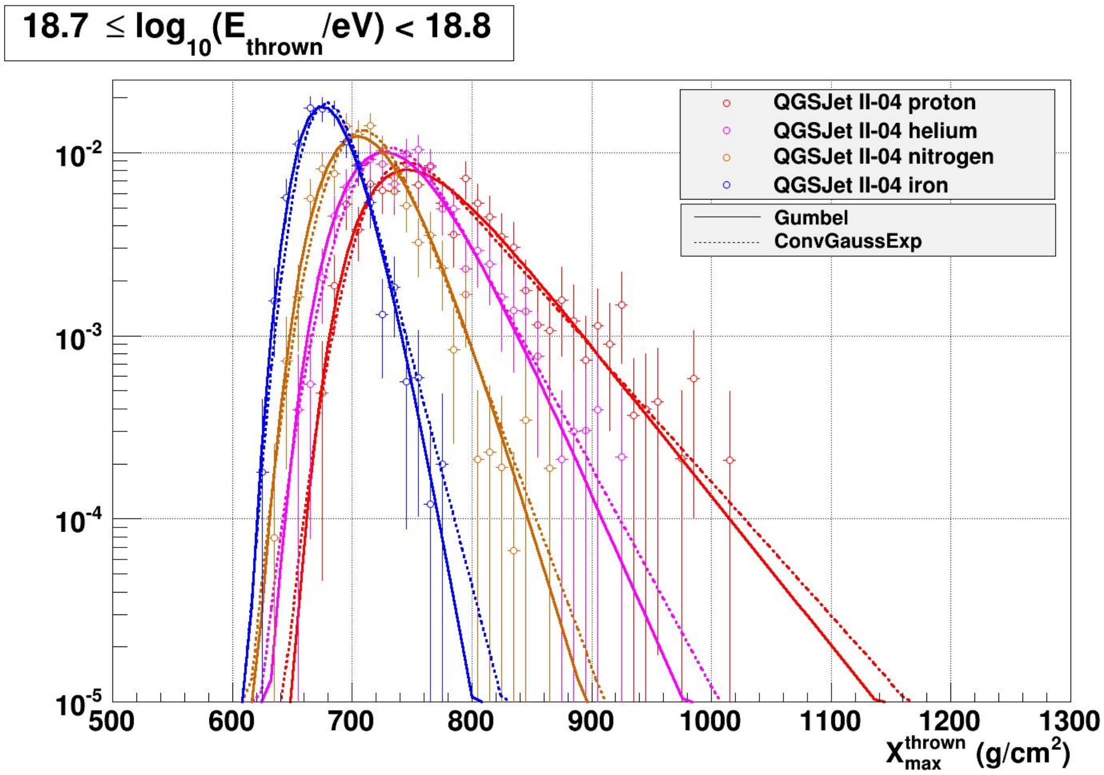
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	770.1 ± 4.3	767.4 (2.8)	766.7 (3.4)
helium	736.0 ± 2.8	736.2 (-0.2)	731.6 (4.4)
nitrogen	701.4 ± 2.0	706.7 (-5.3)	704.2 (-2.7)
iron	670.7 ± 1.5	673.4 (-2.7)	669.8 (1.0)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	66.8 ± 3.0	64.2 (2.5)	63.0 (3.8)
helium	45.1 ± 2.0	45.2 (-0.1)	44.1 (1.0)
nitrogen	32.2 ± 1.4	34.1 (-1.9)	34.8 (-2.7)
iron	23.5 ± 1.1	23.7 (-0.1)	23.2 (0.3)



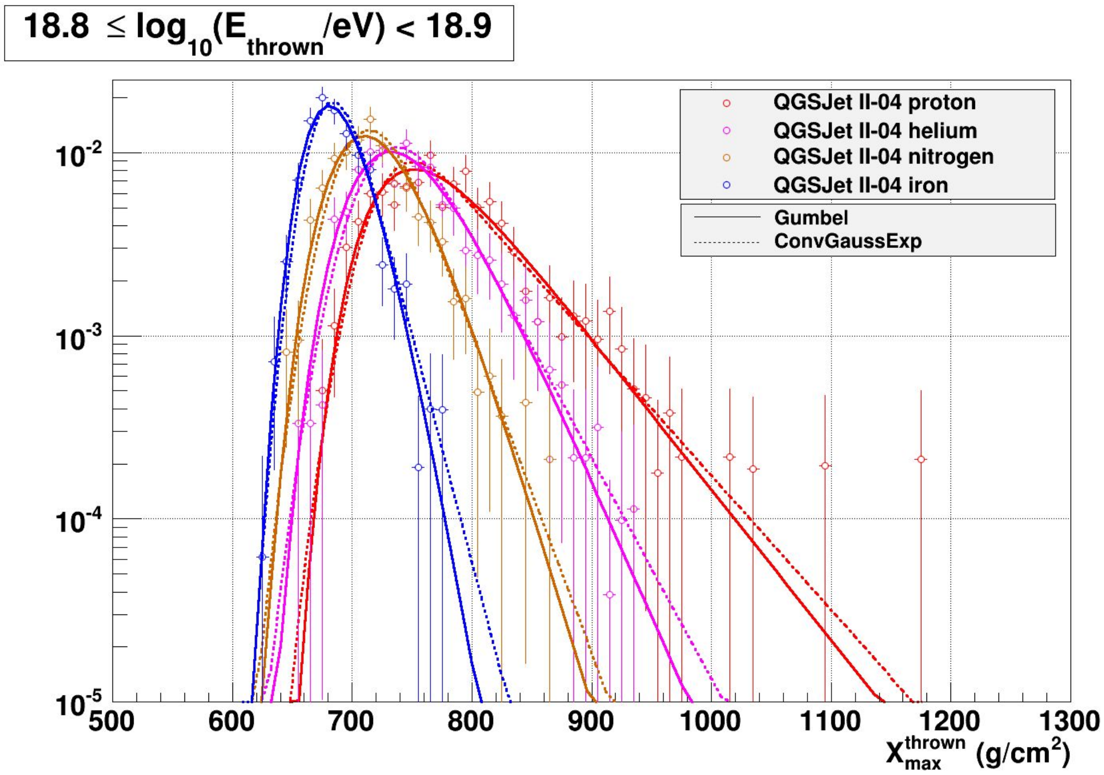
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	773.6 ± 3.9	772.7 (0.9)	772.2 (1.3)
helium	741.0 ± 2.7	741.5 (-0.5)	737.1 (3.8)
nitrogen	706.2 ± 1.9	712.1 (-5.9)	709.7 (-3.5)
iron	676.1 ± 1.4	678.8 (-2.8)	675.5 (0.6)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	64.3 ± 2.7	63.9 (0.4)	62.6 (1.7)
helium	43.6 ± 1.9	44.9 (-1.3)	43.9 (-0.4)
nitrogen	31.3 ± 1.4	33.9 (-2.7)	34.7 (-3.4)
iron	23.6 ± 1.0	23.6 (0.1)	23.1 (0.5)



	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	776.1 ± 3.9	778.1 (-2.0)	777.7 (-1.7)
helium	745.8 ± 2.9	746.7 (-0.8)	742.7 (3.2)
nitrogen	712.9 ± 2.3	717.5 (-4.6)	715.2 (-2.3)
iron	680.1 ± 1.5	684.3 (-4.2)	681.1 (-1.0)

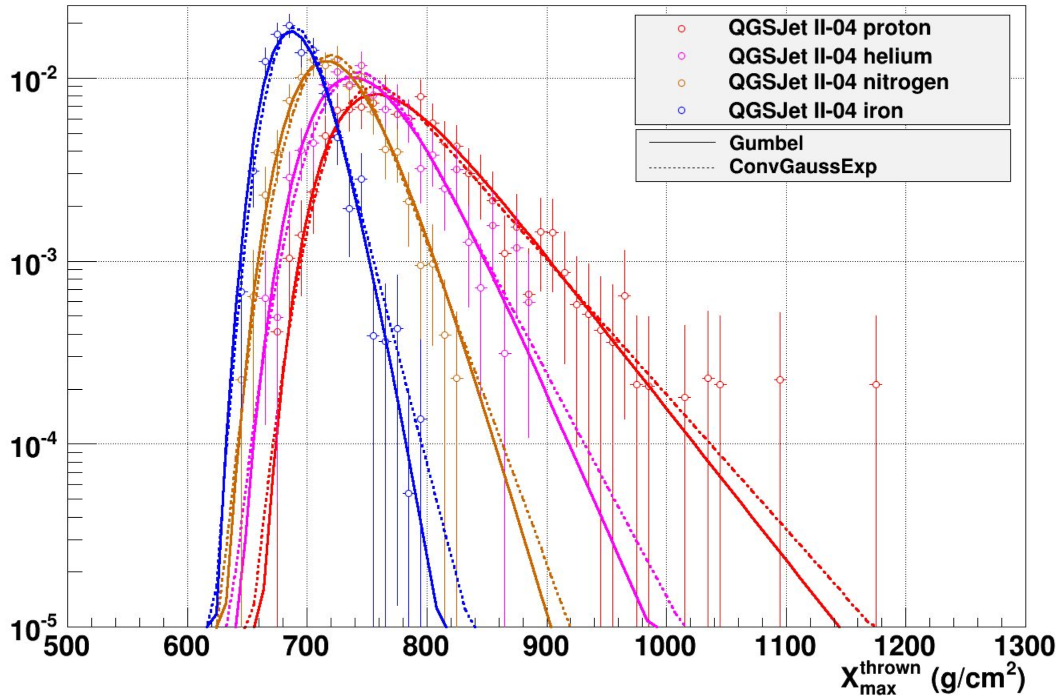
	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	61.8 ± 2.8	63.7 (-1.9)	62.2 (-0.4)
helium	44.6 ± 2.1	44.6 (0.04)	43.8 (0.9)
nitrogen	33.5 ± 1.6	33.7 (-0.2)	34.5 (-1.0)
iron	23.0 ± 1.0	23.5 (-0.5)	23.0 (-0.05)



	dist $\langle X_{max} \rangle$	ConvGaussExp $\langle X_{max} \rangle$	Gumbel $\langle X_{max} \rangle$
proton	782.4 ± 4.1	783.4 (-1.0)	783.2 (-0.8)
helium	749.8 ± 2.7	751.9 (-2.1)	748.2 (1.6)
nitrogen	718.0 ± 2.1	722.8 (-4.9)	720.7 (-2.8)
iron	686.0 ± 1.5	689.8 (-3.8)	686.8 (-0.8)

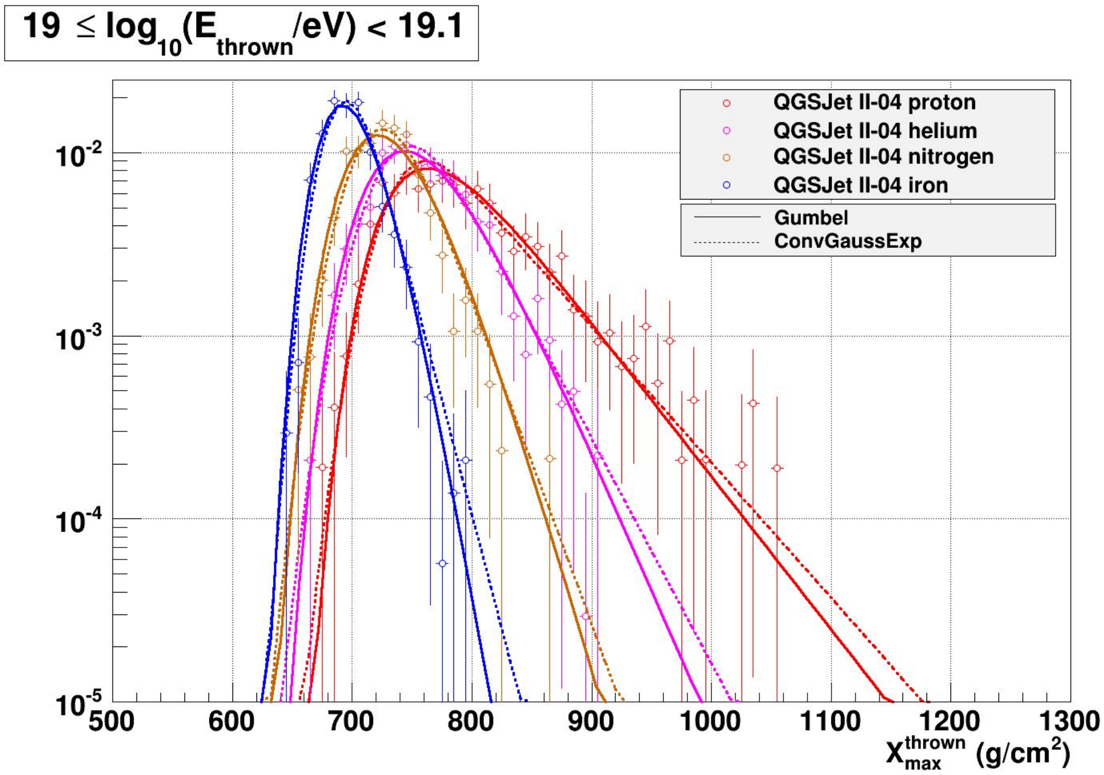
	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	63.7 ± 2.9	63.4 (0.4)	61.8 (2.0)
helium	44.8 ± 1.9	44.3 (0.6)	43.6 (1.2)
nitrogen	35.0 ± 1.5	33.6 (1.4)	34.3 (0.7)
iron	23.2 ± 1.0	23.4 (-0.2)	22.9 (0.3)

$18.9 \leq \log_{10}(E_{thrown}/eV) < 19$



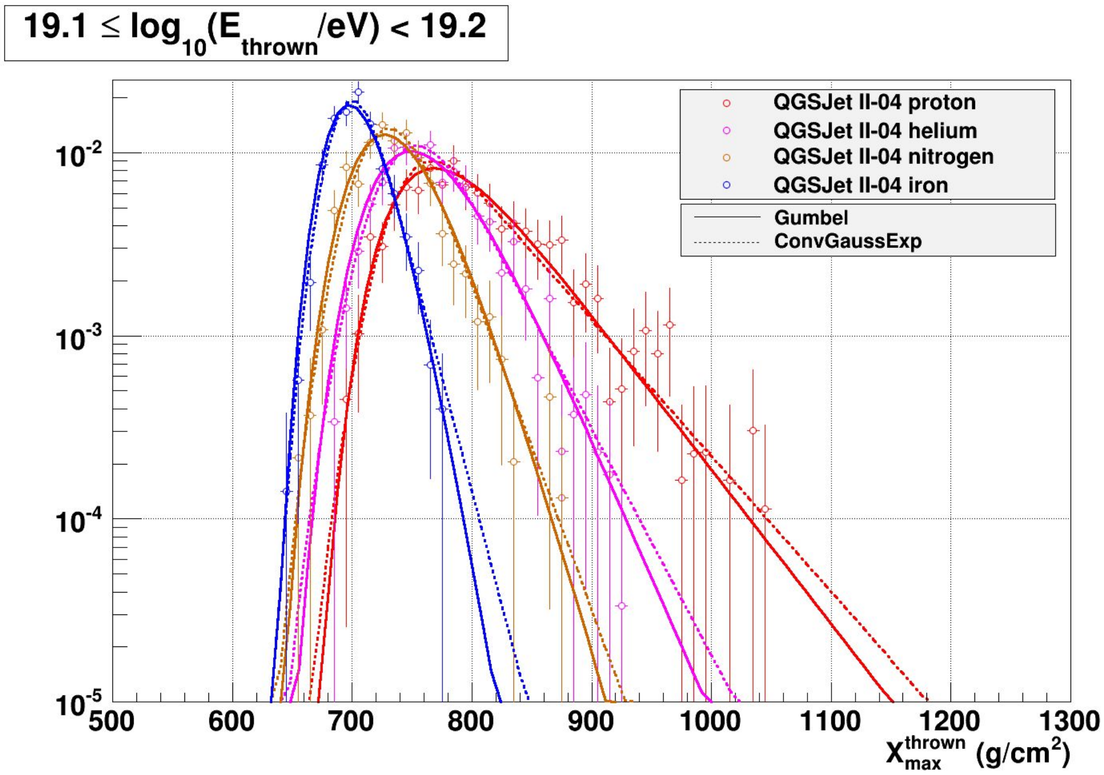
	dist $\langle X_{max} \rangle$	ConvGaussExp $\langle X_{max} \rangle$	Gumbel $\langle X_{max} \rangle$
proton	787.1 ± 4.0	788.7 (-1.6)	788.7 (-1.6)
helium	754.1 ± 2.7	757.0 (-2.9)	753.7 (0.4)
nitrogen	723.2 ± 1.9	728.2 (-5.0)	726.2 (-3.0)
iron	692.0 ± 1.4	695.2 (-3.2)	692.4 (-0.4)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	65.0 ± 2.9	63.1 (1.9)	61.4 (3.6)
helium	43.0 ± 1.9	43.9 (-1.0)	43.4 (-0.4)
nitrogen	31.7 ± 1.3	33.4 (-1.7)	34.1 (-2.5)
iron	22.9 ± 1.0	23.3 (-0.4)	22.8 (0.1)



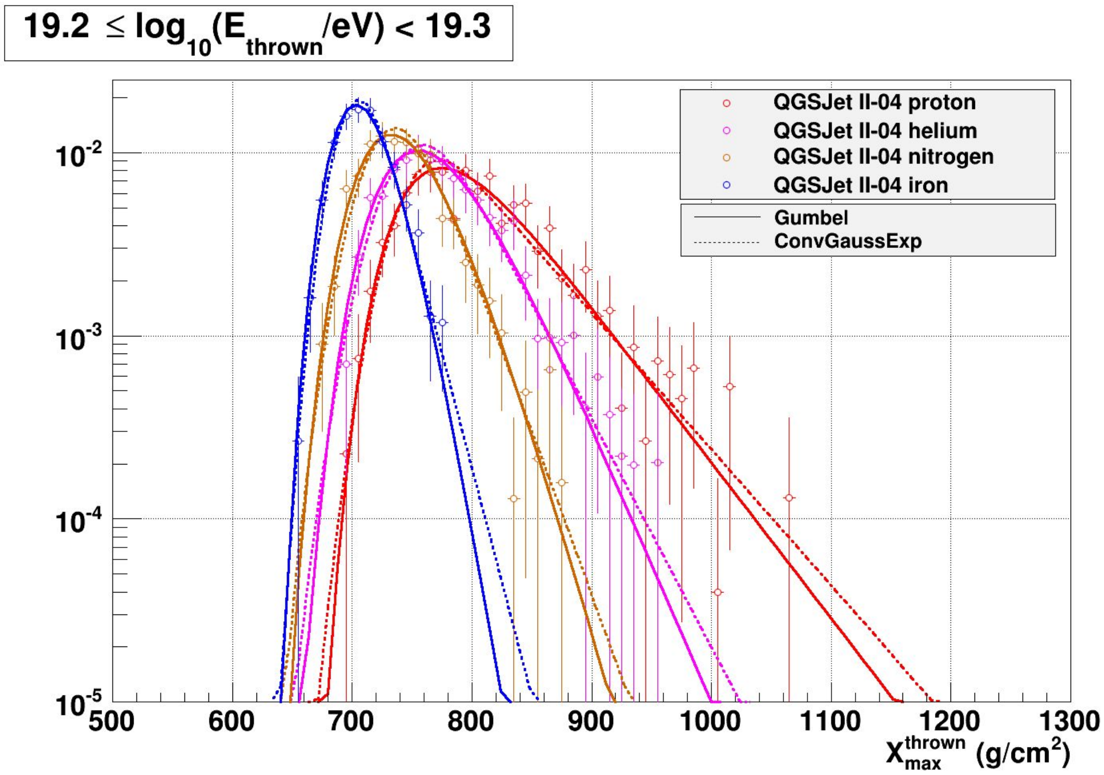
	dist $\langle X_{max} \rangle$	ConvGaussExp $\langle X_{max} \rangle$	Gumbel $\langle X_{max} \rangle$
proton	795.4 ± 4.2	794.0 (1.3)	794.2 (1.2)
helium	760.5 ± 2.5	762.2 (-1.7)	759.2 (1.2)
nitrogen	728.2 ± 1.8	733.5 (-5.2)	731.7 (-3.5)
iron	697.2 ± 1.2	700.6 (-3.3)	698.0 (-0.7)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	65.6 ± 2.9	62.9 (2.7)	61.0 (4.6)
helium	41.2 ± 1.8	43.6 (-2.5)	43.2 (-2.1)
nitrogen	29.6 ± 1.3	33.2 (-3.6)	34.0 (-4.3)
iron	21.3 ± 0.9	23.2 (-1.8)	22.7 (-1.4)



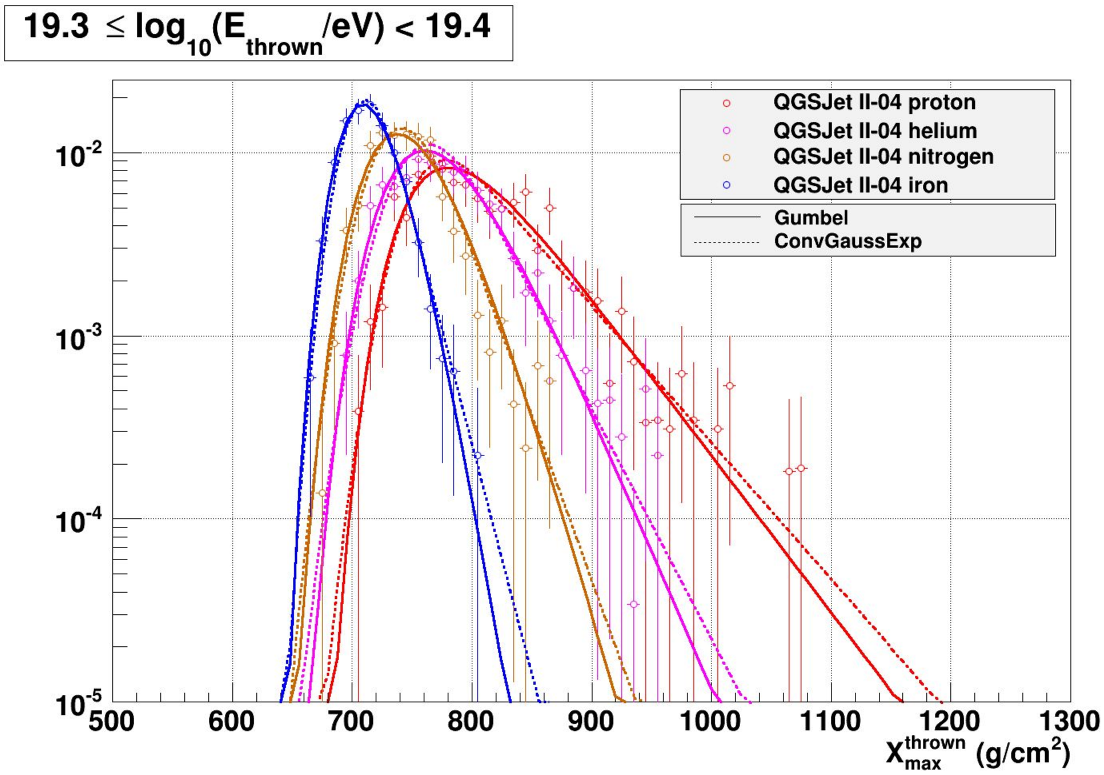
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	803.1 ± 3.8	799.4 (3.7)	799.7 (3.4)
helium	767.8 ± 2.6	767.3 (0.6)	764.7 (3.1)
nitrogen	735.2 ± 2.2	738.8 (-3.6)	737.2 (-2.0)
iron	704.6 ± 1.4	705.9 (-1.4)	703.5 (1.0)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	61.9 ± 2.7	62.7 (-0.7)	60.6 (1.3)
helium	40.7 ± 1.8	43.3 (-2.6)	43.1 (-2.4)
nitrogen	32.8 ± 1.6	33.0 (-0.3)	33.8 (-1.0)
iron	21.2 ± 1.0	23.1 (-1.8)	22.6 (-1.4)



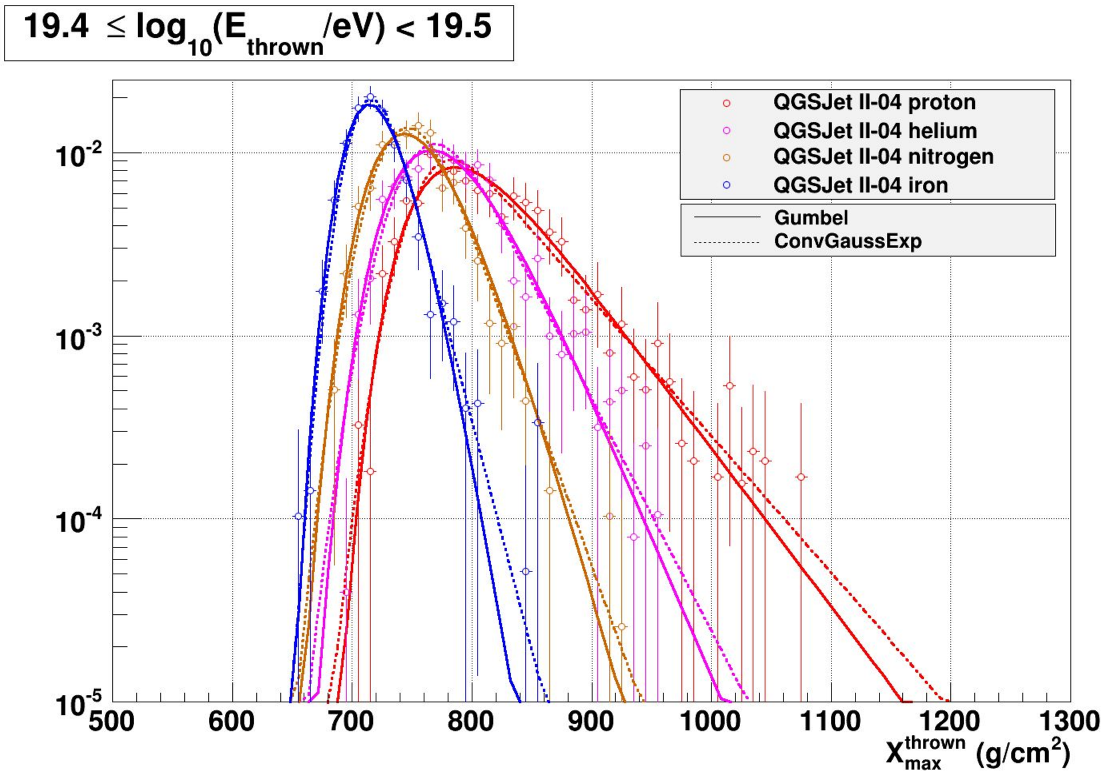
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	806.3 ± 3.9	804.6 (1.7)	805.2 (1.2)
helium	775.2 ± 3.1	772.3 (2.8)	770.3 (4.9)
nitrogen	742.2 ± 2.1	744.0 (-1.9)	742.6 (-0.4)
iron	710.6 ± 1.5	711.3 (-0.6)	709.0 (1.6)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	59.8 ± 2.7	62.5 (-2.7)	60.3 (-0.5)
helium	45.0 ± 2.2	43.0 (1.9)	42.9 (2.1)
nitrogen	34.4 ± 1.5	32.9 (1.5)	33.6 (0.7)
iron	22.8 ± 1.0	23.0 (-0.2)	22.5 (0.3)



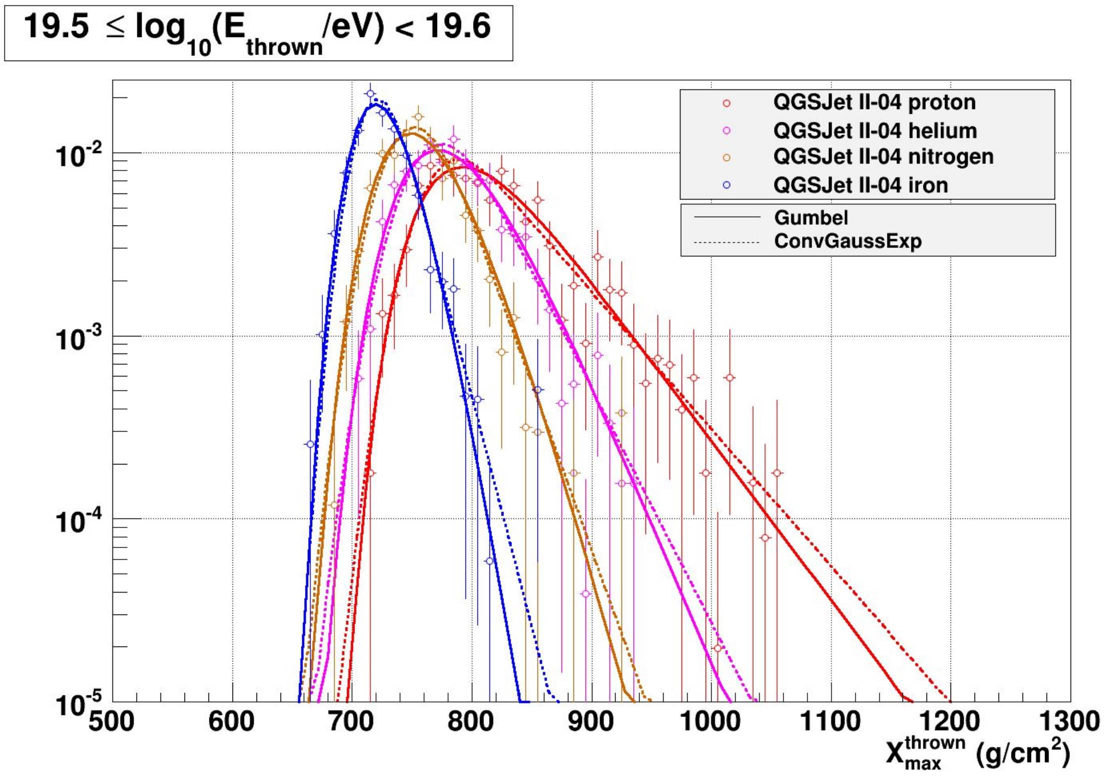
	dist $\langle X_{max} \rangle$	ConvGaussExp $\langle X_{max} \rangle$	Gumbel $\langle X_{max} \rangle$
proton	808.7 ± 3.8	809.9 (-1.2)	810.7 (-1.9)
helium	780.0 ± 2.9	777.4 (2.6)	775.8 (4.3)
nitrogen	745.8 ± 1.9	749.2 (-3.5)	748.0 (-2.3)
iron	714.6 ± 1.3	716.6 (-2.0)	714.5 (0.1)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	59.8 ± 2.7	62.3 (-2.4)	59.9 (-0.1)
helium	47.4 ± 2.1	42.7 (4.7)	42.7 (4.7)
nitrogen	31.6 ± 1.3	32.7 (-1.1)	33.5 (-1.9)
iron	22.3 ± 0.9	22.9 (-0.6)	22.4 (-0.1)



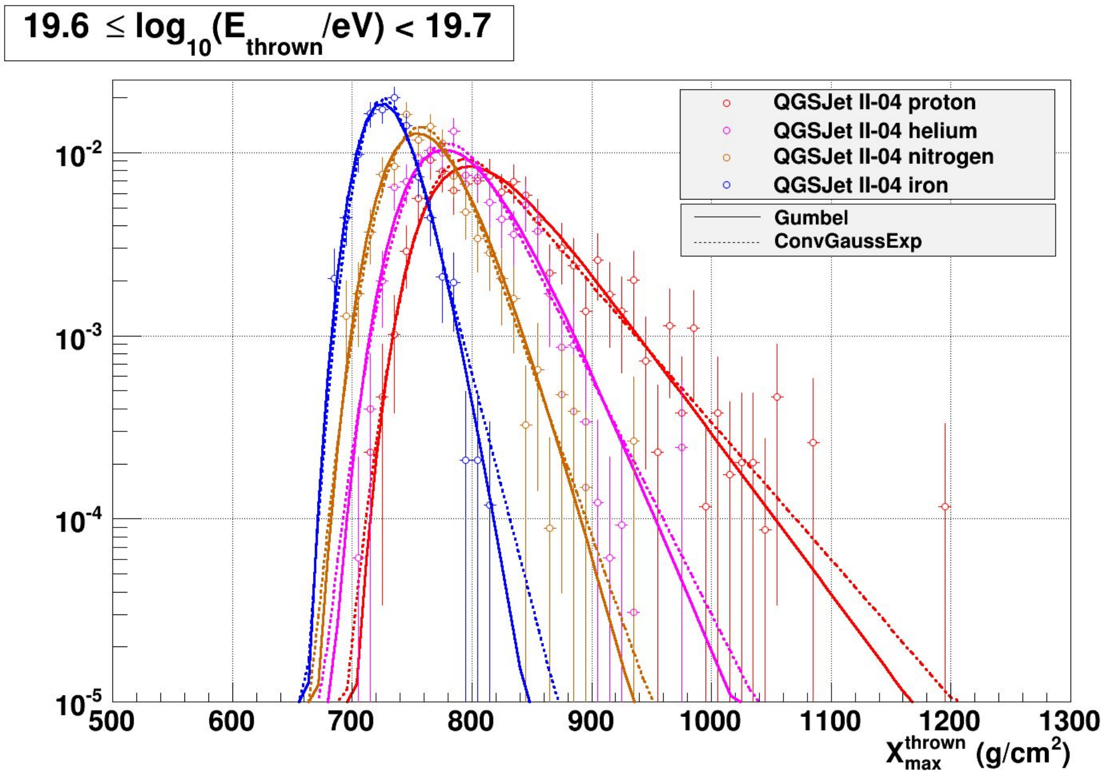
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	812.5 ± 3.7	815.2 (-2.6)	816.1 (-3.6)
helium	783.7 ± 2.6	782.4 (1.3)	781.2 (2.5)
nitrogen	751.7 ± 2.0	754.5 (-2.7)	753.5 (-1.7)
iron	719.7 ± 1.7	721.8 (-2.1)	719.9 (-0.2)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	59.3 ± 2.6	62.1 (-2.7)	59.5 (-0.2)
helium	43.4 ± 1.8	42.4 (1.0)	42.6 (0.9)
nitrogen	30.7 ± 1.4	32.6 (-1.8)	33.3 (-2.6)
iron	24.2 ± 1.2	22.8 (1.4)	22.3 (1.9)



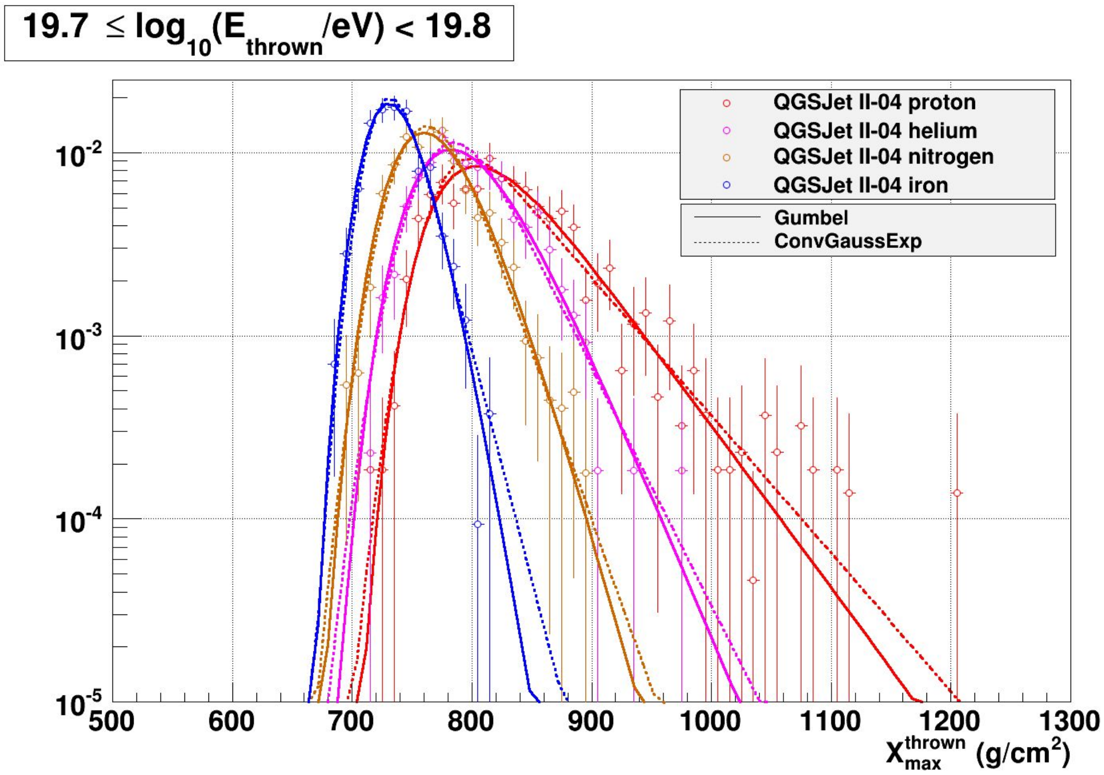
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	817.9 ± 3.9	820.4 (-2.5)	821.6 (-3.7)
helium	784.4 ± 2.4	787.4 (-3.0)	786.7 (-2.3)
nitrogen	757.3 ± 2.1	759.6 (-2.4)	758.9 (-1.6)
iron	725.4 ± 1.4	727.1 (-1.7)	725.3 (0.1)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	58.6 ± 2.7	61.9 (-3.3)	59.2 (-0.6)
helium	39.3 ± 1.7	42.1 (-2.8)	42.4 (-3.1)
nitrogen	32.1 ± 1.5	32.4 (-0.3)	33.2 (-1.0)
iron	25.0 ± 1.0	22.7 (2.3)	22.2 (2.8)



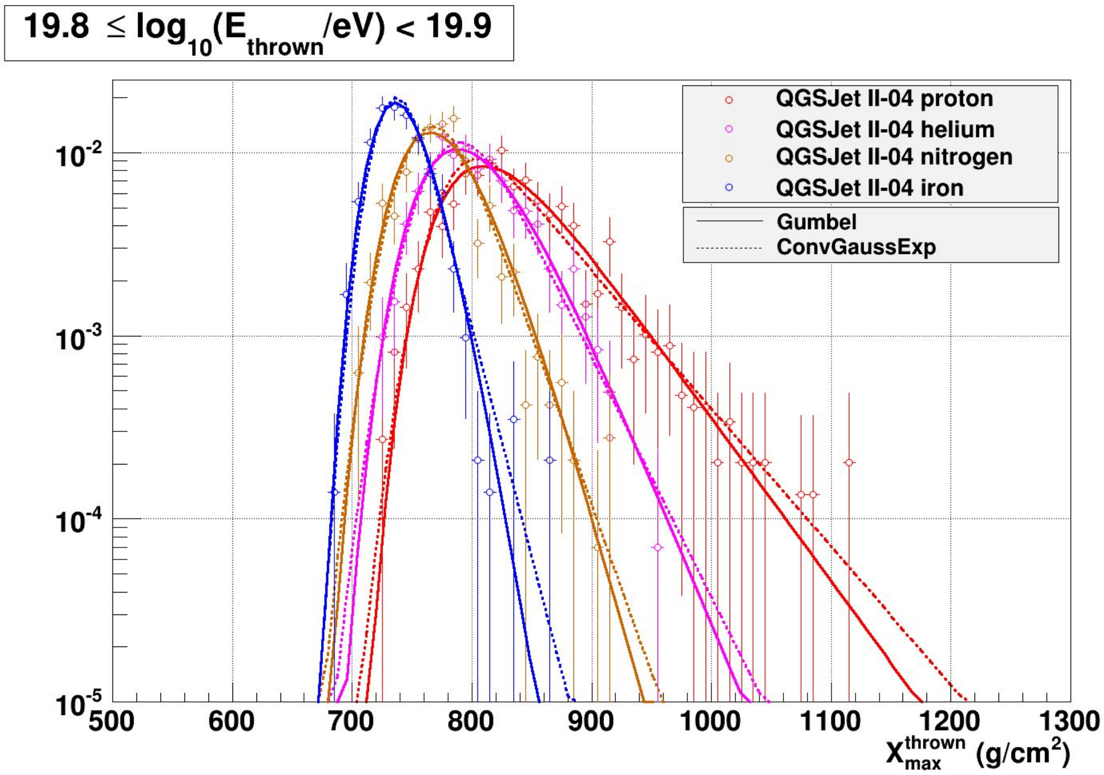
	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	825.8 ± 4.2	825.6 (0.2)	827.1 (-1.3)
helium	789.0 ± 2.5	792.4 (-3.4)	792.2 (-3.2)
nitrogen	763.1 ± 2.1	764.8 (-1.7)	764.3 (-1.2)
iron	730.7 ± 1.3	732.3 (-1.6)	730.7 (0.01)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	64.0 ± 3.0	61.7 (2.3)	58.8 (5.1)
helium	39.4 ± 1.8	41.8 (-2.4)	42.2 (-2.8)
nitrogen	33.6 ± 1.5	32.2 (1.4)	33.0 (0.6)
iron	21.4 ± 1.0	22.6 (-1.2)	22.1 (-0.7)



	dist $<X_{max}>$	ConvGaussExp $<X_{max}>$	Gumbel $<X_{max}>$
proton	834.4 ± 4.0	830.8 (3.5)	832.6 (1.8)
helium	798.4 ± 2.6	797.4 (1.0)	797.7 (0.7)
nitrogen	770.7 ± 2.0	769.9 (0.8)	769.6 (1.0)
iron	736.4 ± 1.4	737.5 (-1.1)	736.0 (0.3)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	63.7 ± 2.8	61.6 (2.1)	58.5 (5.1)
helium	39.3 ± 1.8	41.5 (-2.2)	42.1 (-2.8)
nitrogen	33.4 ± 1.4	32.1 (1.3)	32.9 (0.5)
iron	22.4 ± 1.0	22.5 (-0.2)	22.0 (0.4)



	dist $\langle X_{max} \rangle$	ConvGaussExp $\langle X_{max} \rangle$	Gumbel $\langle X_{max} \rangle$
proton	837.0 ± 3.3	836.0 (1.0)	838.1 (-1.1)
helium	802.4 ± 2.5	802.3 (0.1)	803.2 (-0.8)
nitrogen	774.3 ± 2.0	775.0 (-0.8)	775.0 (-0.7)
iron	739.9 ± 1.4	742.7 (-2.7)	741.3 (-1.4)

	dist $\sigma(X_{max})$	ConvGaussExp $\sigma(X_{max})$	Gumbel $\sigma(X_{max})$
proton	57.3 ± 2.3	61.4 (-4.1)	58.2 (-0.9)
helium	39.3 ± 1.8	41.2 (-1.9)	41.9 (-2.6)
nitrogen	31.3 ± 1.4	31.9 (-0.7)	32.7 (-1.4)
iron	23.0 ± 1.0	22.4 (0.5)	21.9 (1.1)