Composition Working Group Report

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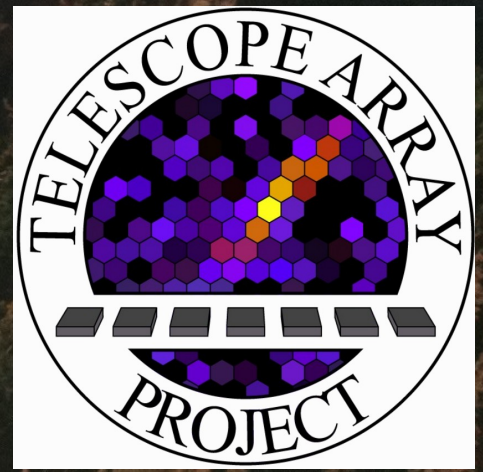
UHECR2014
15 October 2014



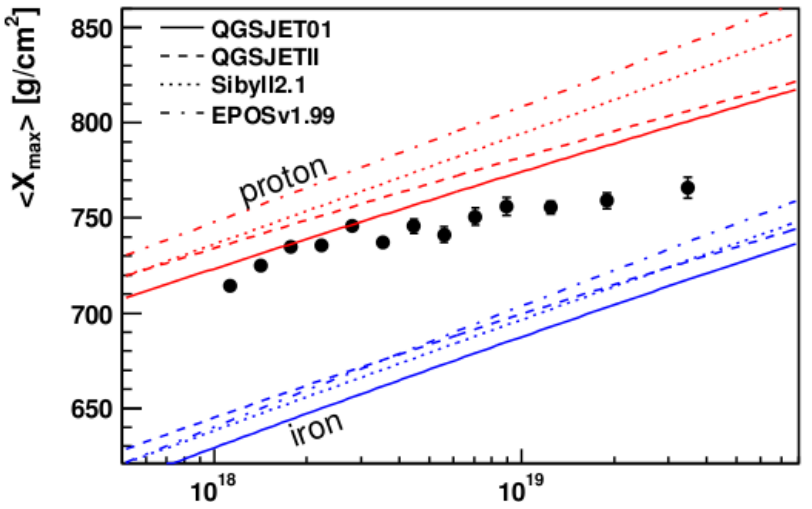
Outline

- recap UHECR2012
- *ad hoc* mix analysis
- future plans

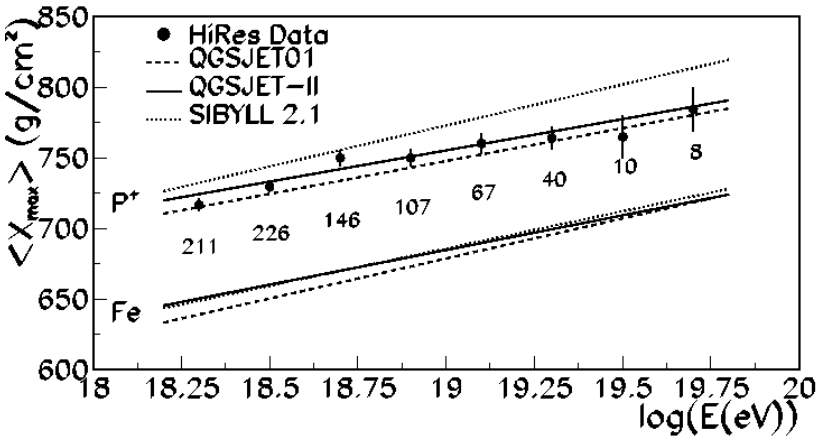
UHECR2012

- Composition W.G. formed to address “inconsistency” between Auger, HiRes, TA compositions.
- Outline differences between approaches
- Cross-checks
- Evaluating differences in the light of different hadronic models.
- Report published:

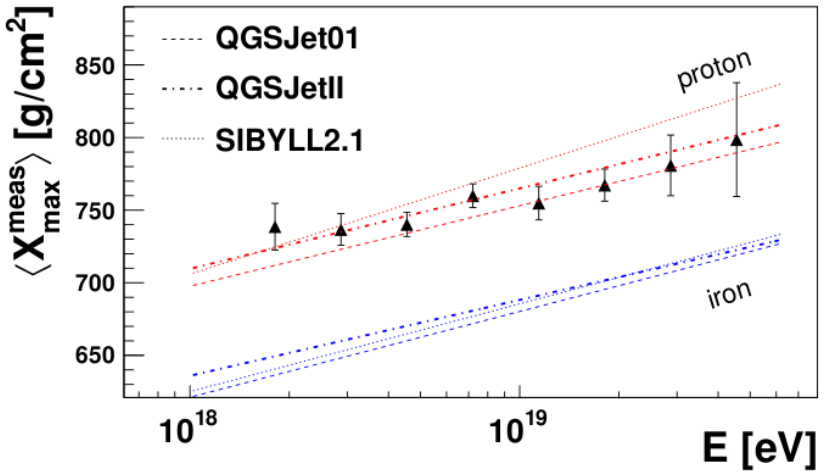
EPJ Web Conf. 53 (2013) 01006



PAO Hybrid



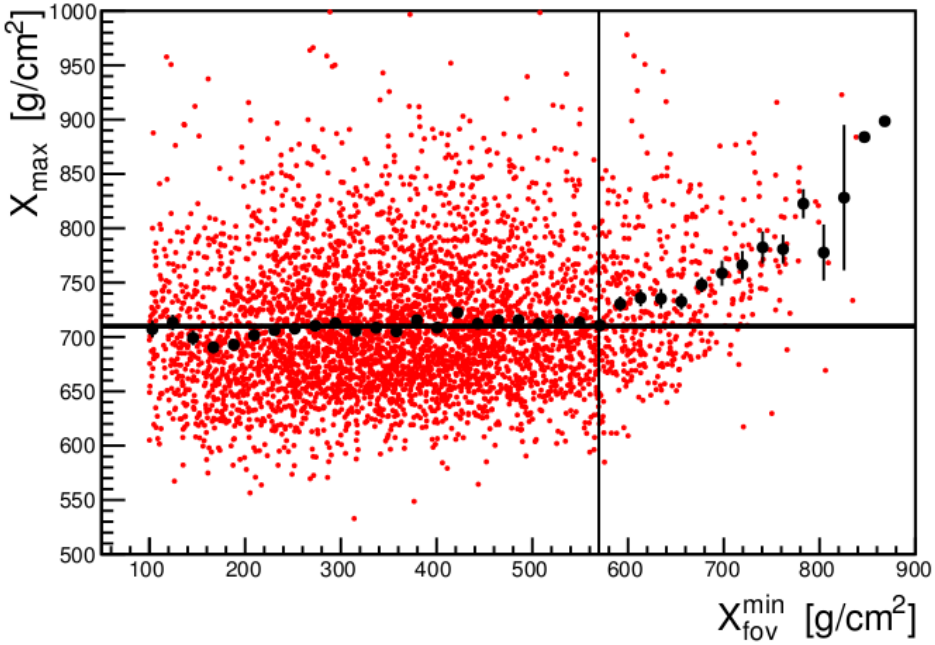
HiRes Stereo



TA Stereo

Different Approaches: Auger

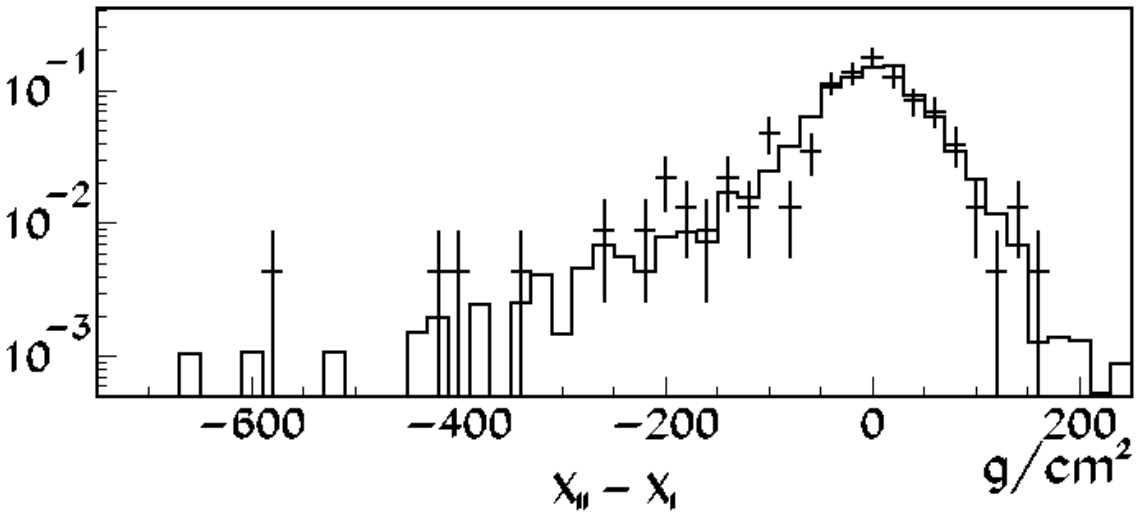
- Limited field-of-view (FOV) of fluorescence detectors (FDs) introduces geometry-dependent detector bias.
- **Auger Approach:**
  - Select showers with geometries that will allow X_{max} to be inside a detector FOV that is "wide enough" to cover the full X_{max} distribution.
  - Infer moments of unbiased X_{max} distribution
  - Can be compared directly to simulations at generator-level



X_{max} versus minimum observable X for the particular event geometry.
$18.0 < \log(E(eV)) < 18.2$

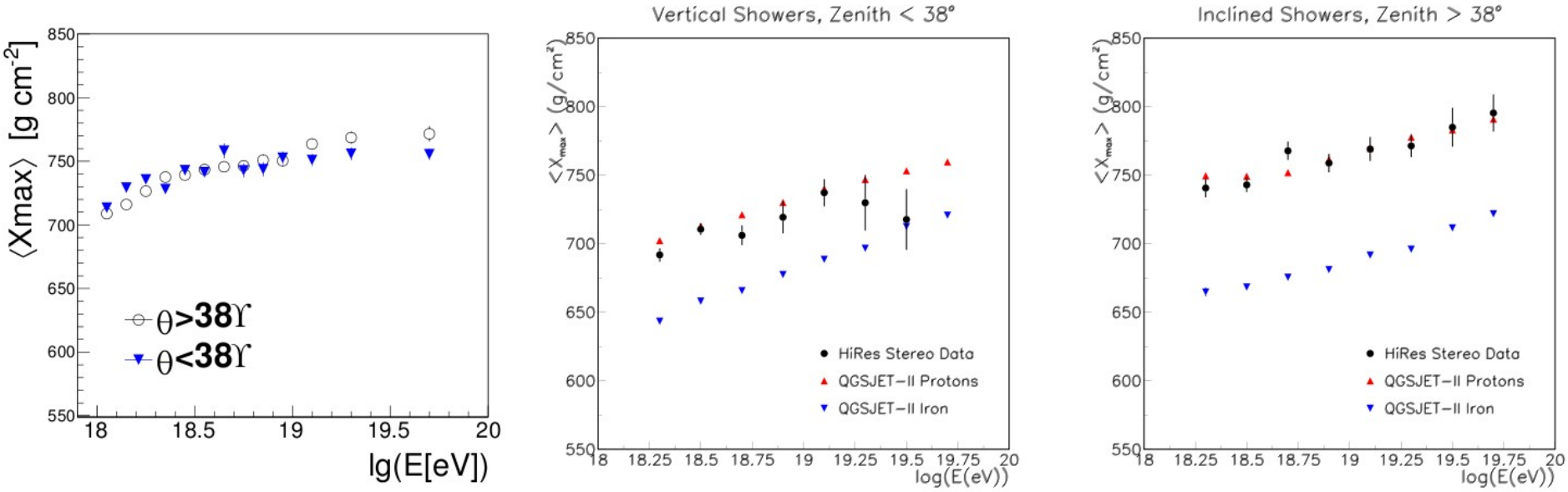
Different Approaches: HiRes/TA

- Limited field-of-view (FOV) of fluorescence detectors (FDs) introduces geometry-dependent detector bias.
- **HiRes/TA Approach:**
  - Simulate X_{max} biases with detailed detector Monte Carlo.
  - Compare measured X_{max} distributions with MC predictions including effects of detector biases.
  - Identical cuts for data and Monte Carlo.
  - Not directly comparable to other experiments.



Difference in X_{max} as measured by the two HiRes detectors: Monte Carlo (histogram) and data (points).

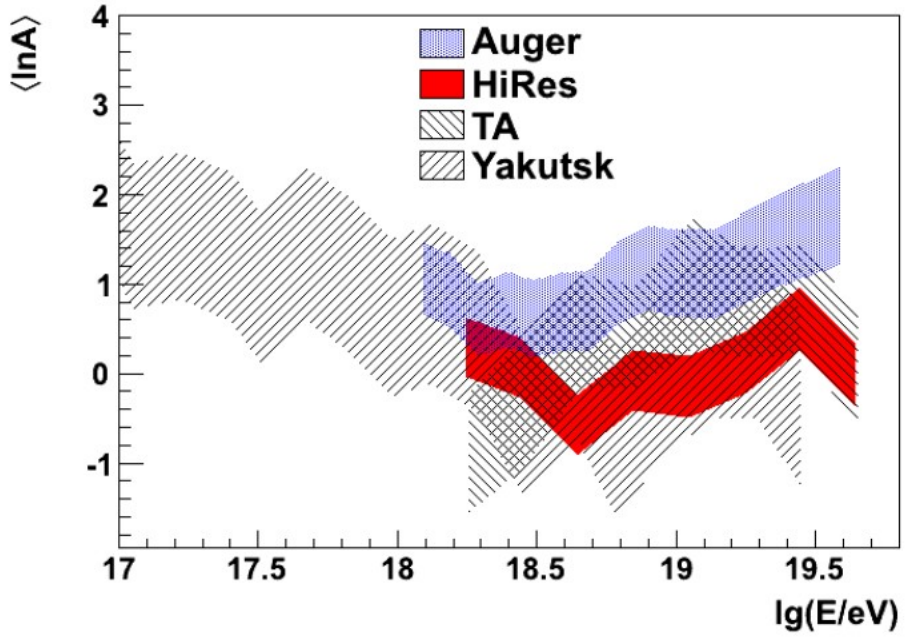
Cross Checks



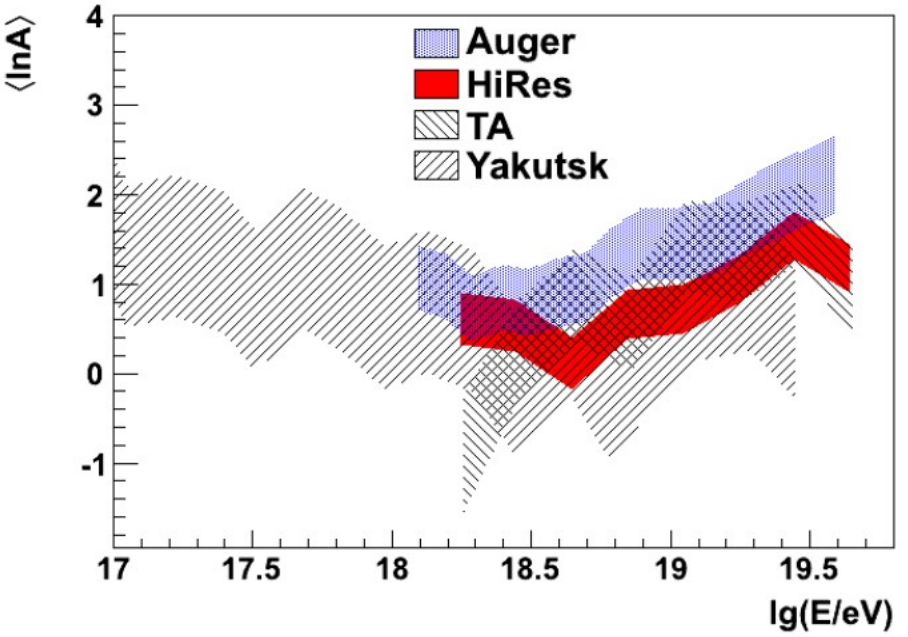
(a) Auger $\langle X_{\max} \rangle$ (b) HiRes $\langle X_{\max}^{\text{meas}} \rangle$ (c) HiRes $\langle X_{\max}^{\text{meas}} \rangle$

Fig. 8. The $\langle X_{\max} \rangle$ and $\langle X_{\max}^{\text{meas}} \rangle$ for Auger and HiRes using showers from different zenith angle ranges.

Different Hadronic Models



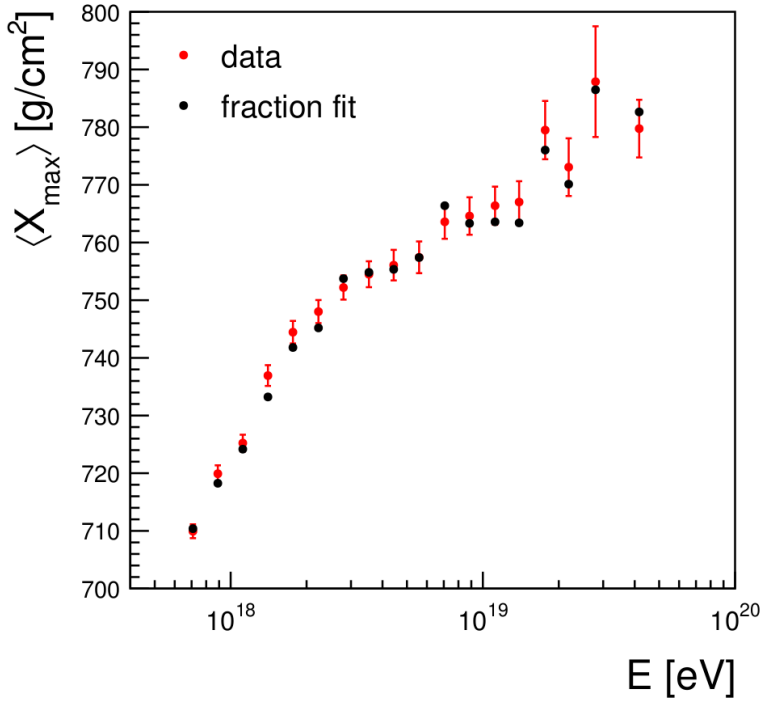
(a) using QGSJet-II model.

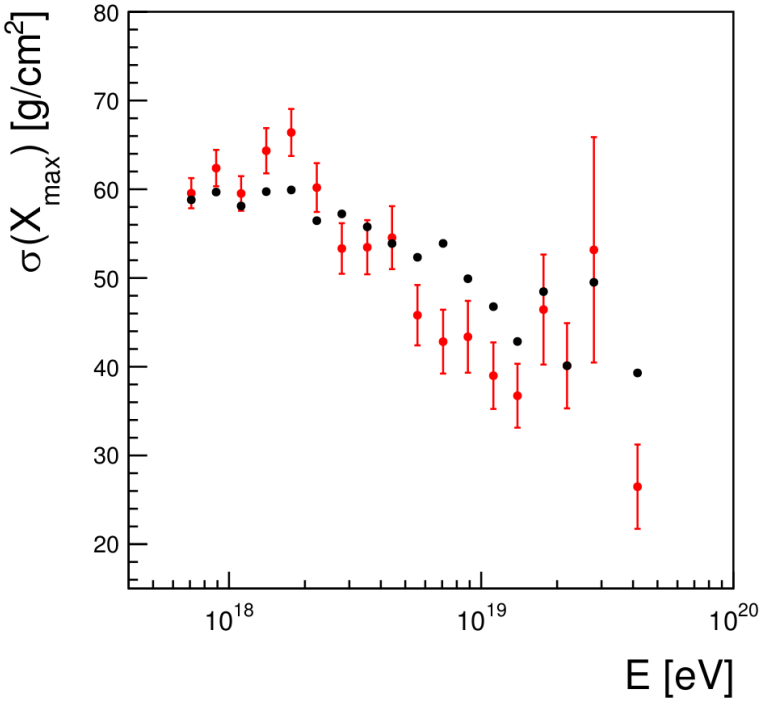


(b) using SIBYLL model.

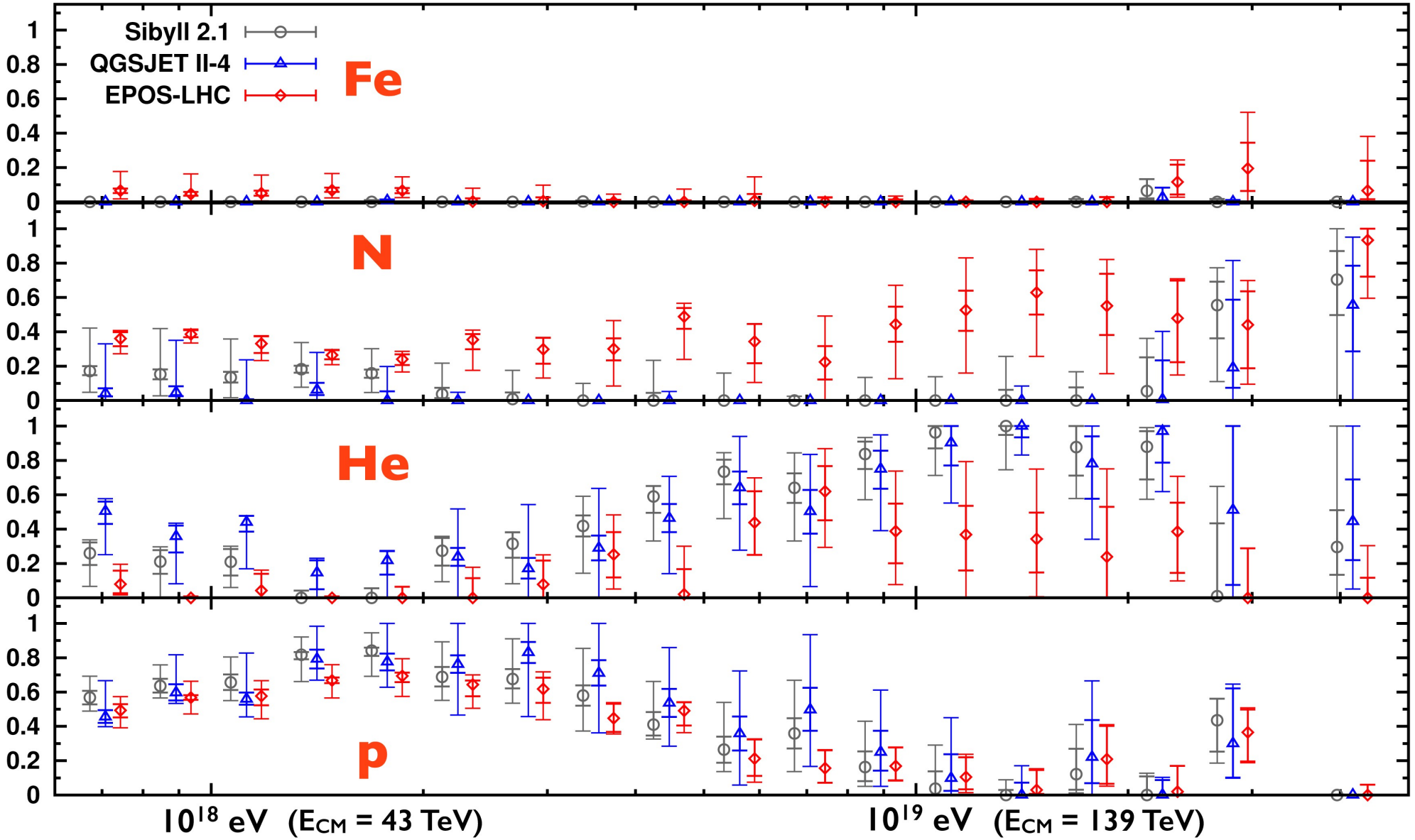
Fig. 11. Comparing the average composition ($\langle \ln A \rangle$) estimated using Auger, HiRes , TA and Yakutsk data. The shaded regions correspond to the systematic uncertainty ranges. To infer the average composition from $\langle X_{\max} \rangle$, QGSJet-II and SIBYLL models have been used.

ad hoc Mix Analysis (begun ICRC2013)



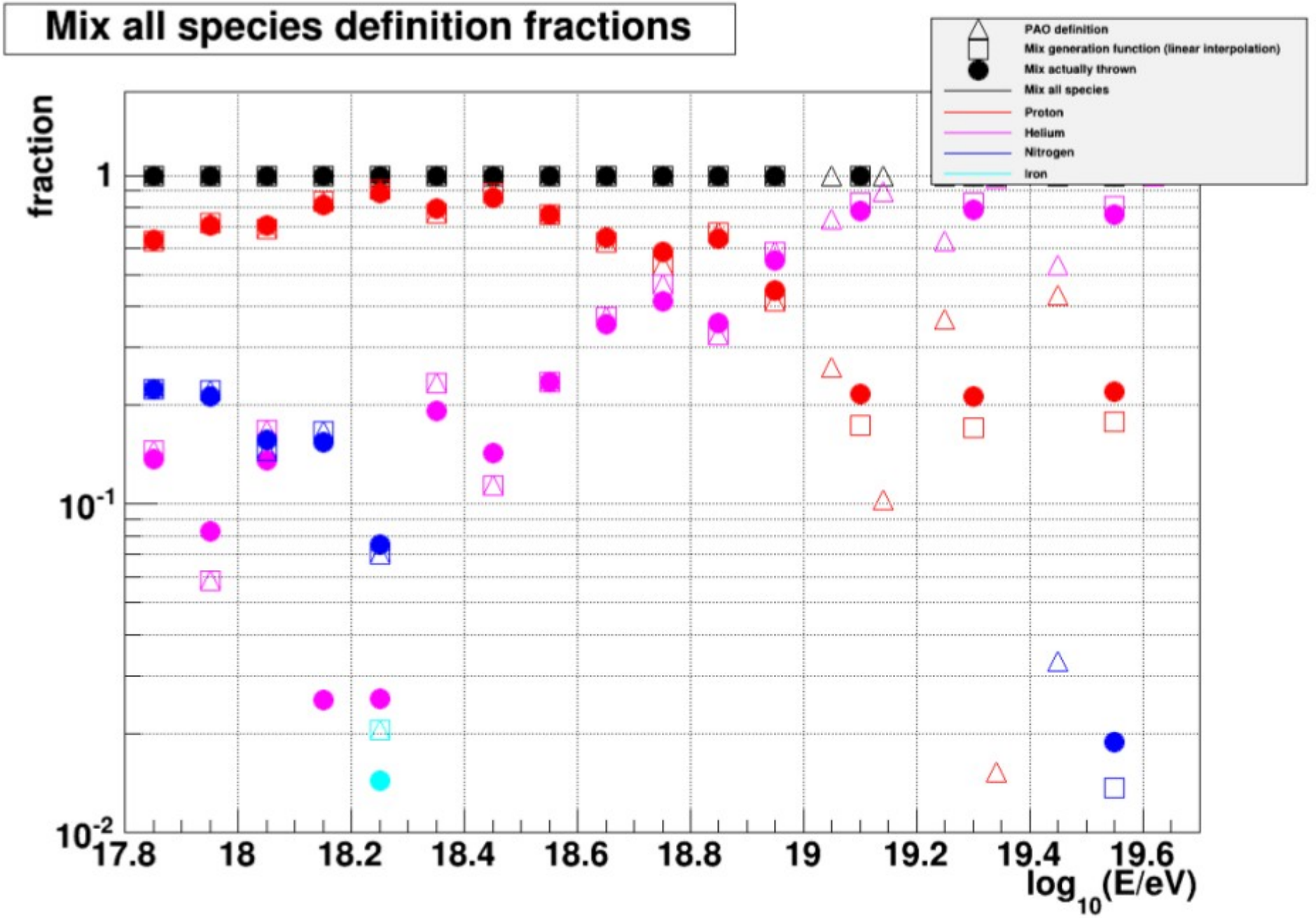


- Use X_{max} distribution as reported by Auger
  - use *ad hoc* fraction mix of H, He, N, Fe primary nuclei to ensemble Auger X_{max} distributions.
  - QGSJETII-03 only (computing time)
  - Roughly reproduces Auger $<X_{max}>$ and $\sigma(X_{max})$ (above)
- Process through TA detector simulation, reconstruction, selection
- Is TA detector & analysis sensitive to similar composition change?

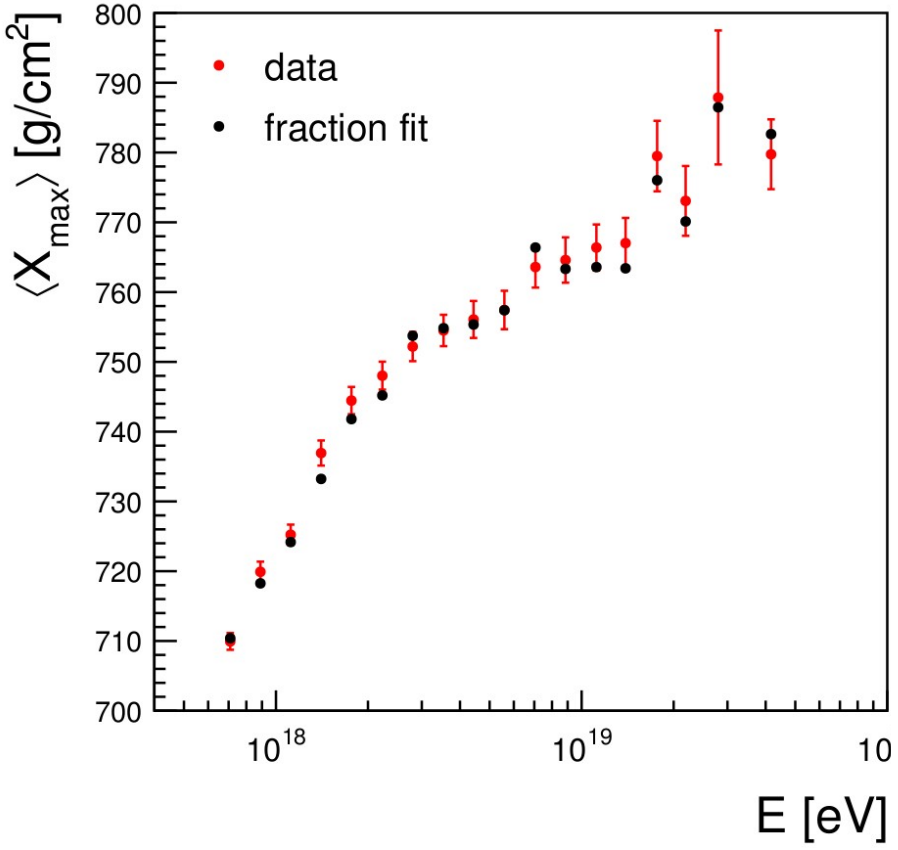


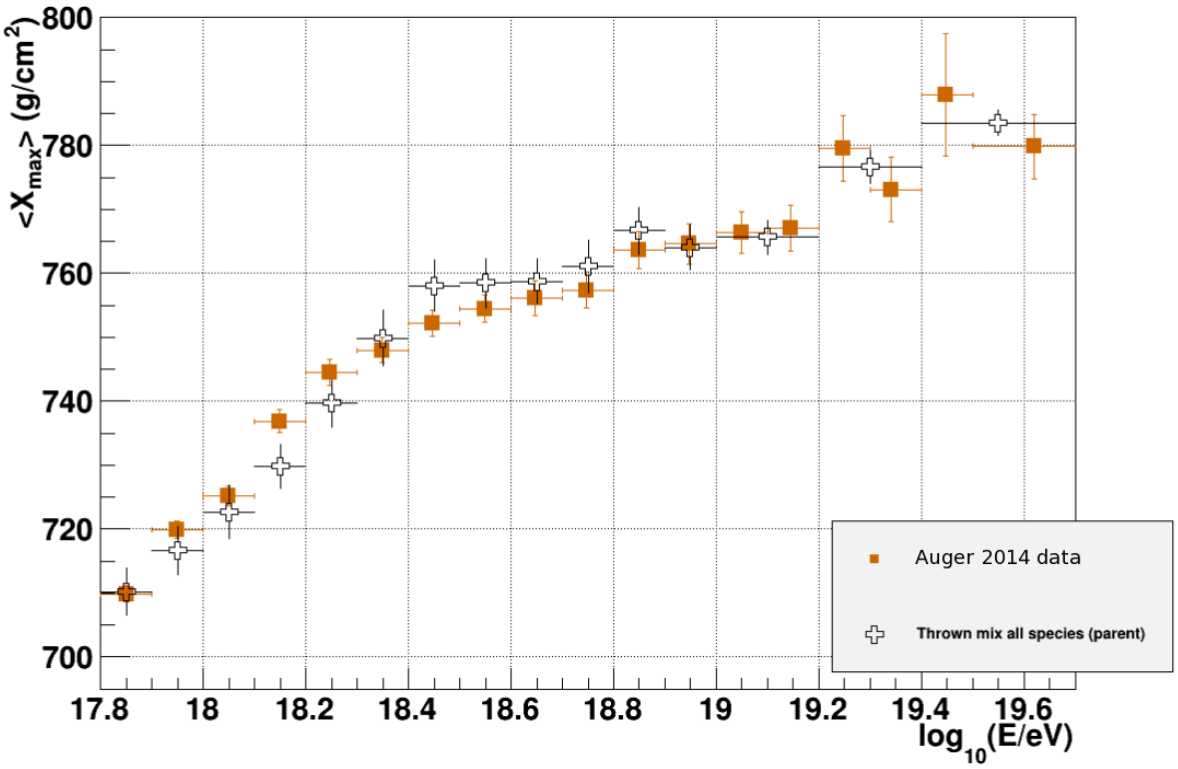
http://arxiv.org/abs/1409.5083

QGSJETII-03 Mix Fractions



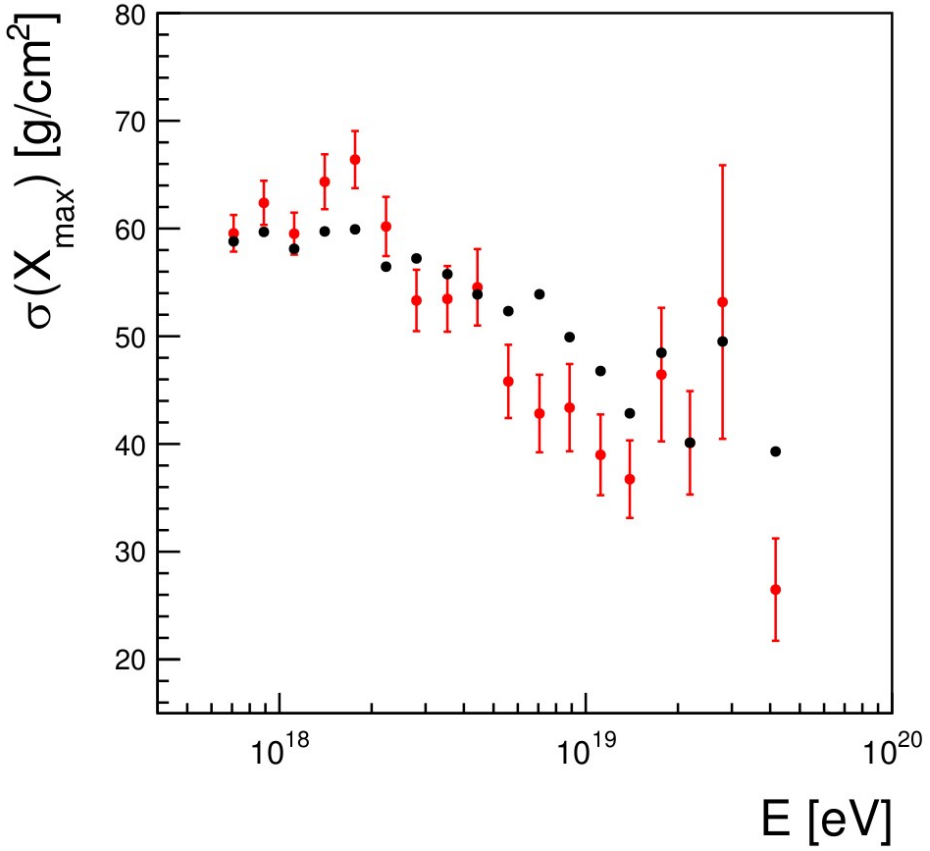
Mix Comparison (BR/LR)

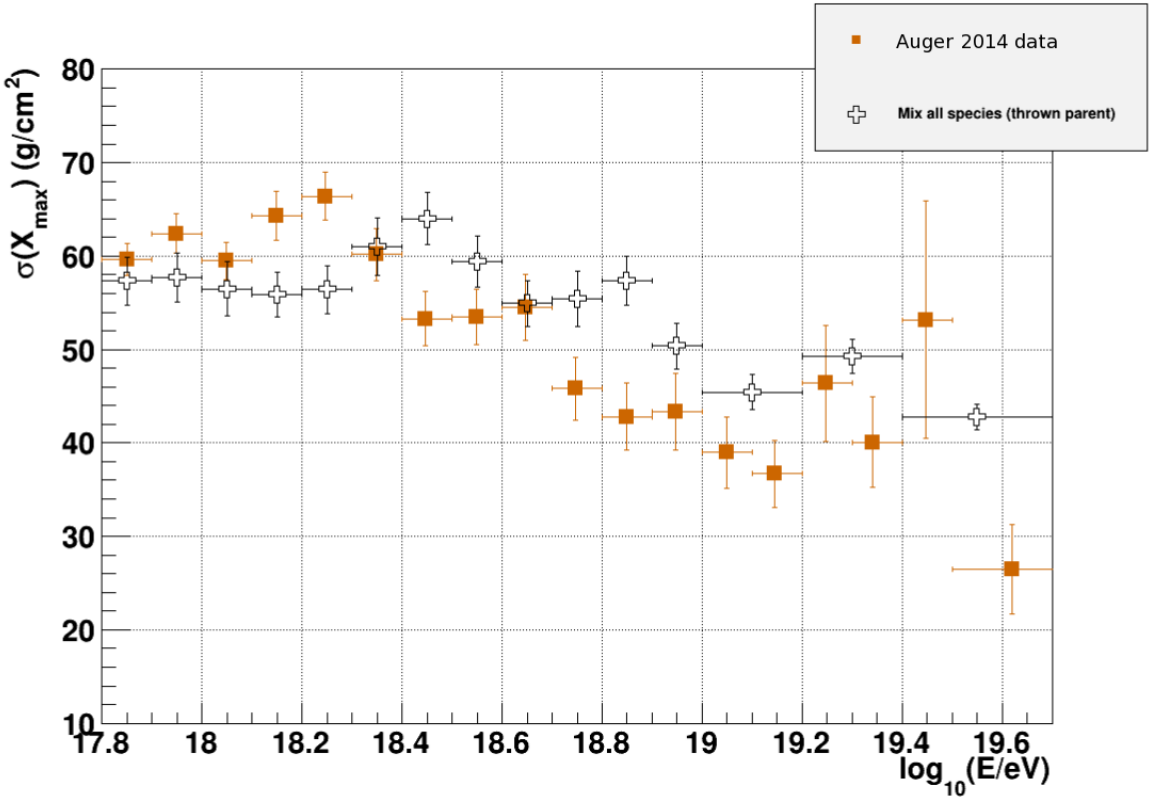




TA “Parent” Mix <Xmax>, with Auger data

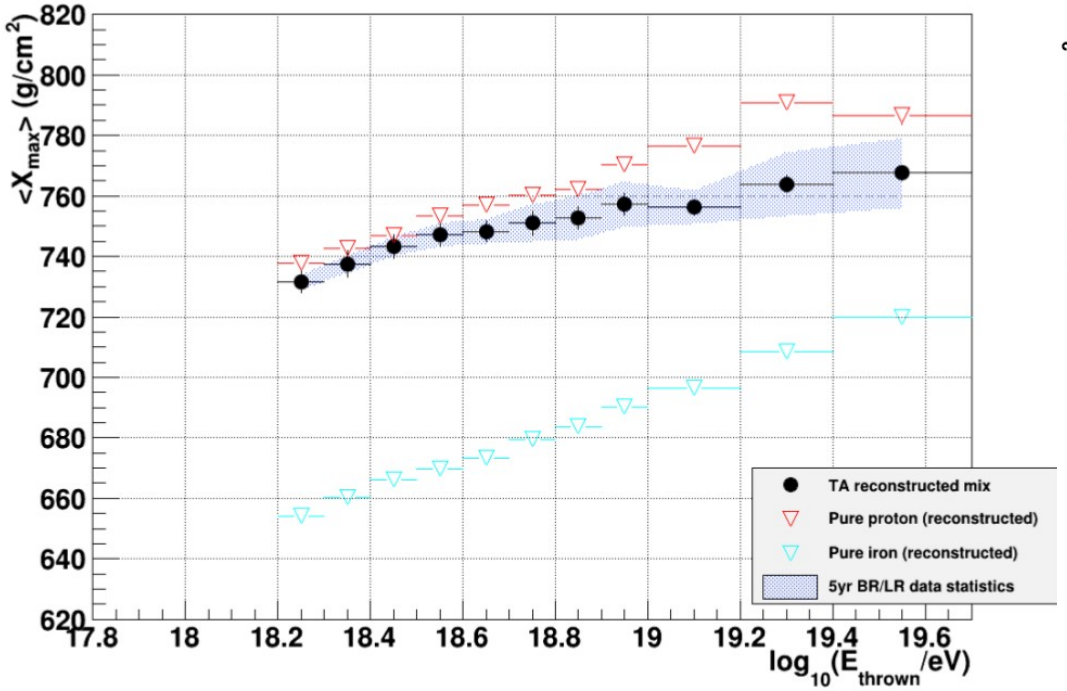
Mix Comparison (BR/LR)

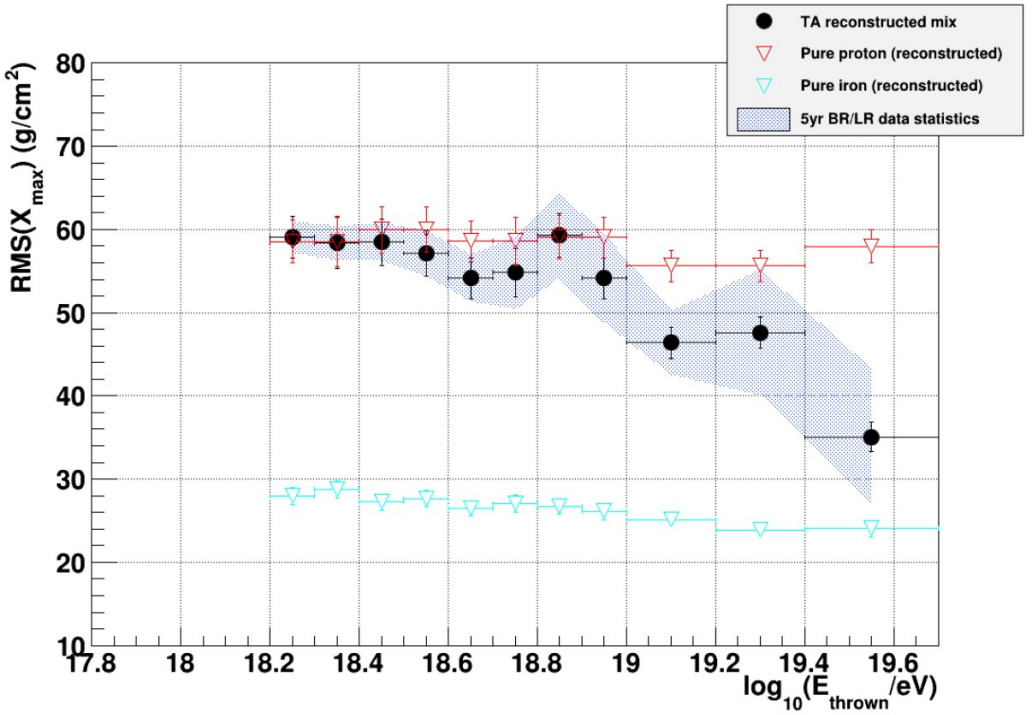




TA "Parent" Mix σ(Xmax), with Auger data

Auger Mix Observed with TA Hybrid Analysis (Black Rock/Long Ridge)





- 5 year TA BR/LR hybrid data should distinguish mix from QGSJETII-03 protons in $\langle X_{max} \rangle$
- 5 year TA BR/LR has less statistical power in $\sigma(X_{max})$.

Future: Direct Comparison of TA/Auger Data

- "The observed agreement between the measured $\langle X_{max} \rangle$ and $\langle X_{max}^{meas} \rangle$ is not expected." (2012 working group report).
- Is agreement
  - Coincidental; *i.e.* experiments are actually observing different X_{max} distributions?
  - Real, i.e. tthe observed distributions are the same and differences lie in comparison to shower models?
- Either way, a definitive answer would be a significant statement.

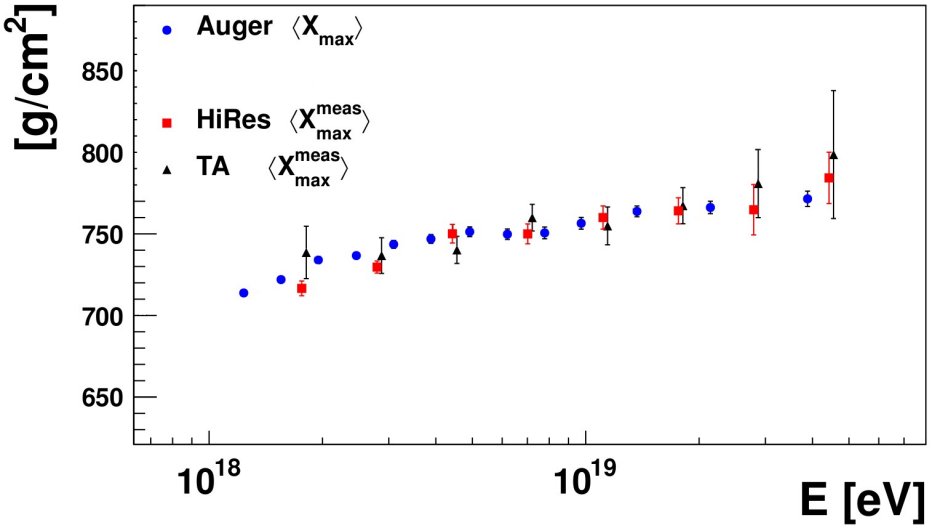


Figure 2 of UHECR2012 C.W.G. Report (Yakutsk points removed.)

Summary

- W.G. studying response of TA detector to Auger X_{max} distribution; evaluate agreement between two results.
- Planning joint paper on mixture via “Middle Drum” Fluorescence Detector and mixture ~few months
- Future of working group: data-data comparison?

Backup

TA BR/LR Analysis:

- All work done based on Auger ad hoc mixture fit to QGSJet II-03 hadronic model.
- We have generated ~4 year (20080527 - 20120219) QGSJet II-03 MC for proton, helium, nitrogen, and iron.
  - Thrown using HiRes I/HiResII combined monocular spectrum.
  - Mixed according to Auger QGSJet II-03 recipe.
- Thrown mix: 74 million events between $10^{17.5}$ and 10^{20} eV.

- Reconstruction of mix via standard BR/LR hybrid analysis suite.
- Analysis cuts (events accepted if they meet the following criteria):
  - $\log_{10}(E) > 18.2$ eV
  - zenith angle < 55 degrees
  - geometry chi^2 < 5
  - profile chi^2 < 10
  - X_{max} bracketed
  - # good tubes > 11
  - track length > 10 degrees
  - psi angle < 130 degrees
  - time extent > 7 usec
  - core falls within the SD array
- No extra weather cuts applied