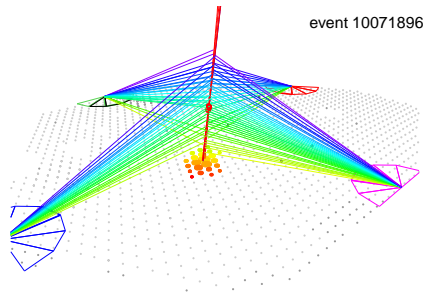




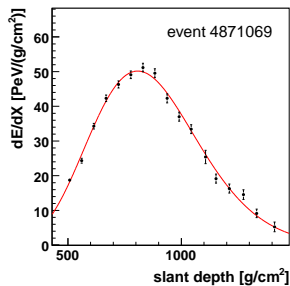
Composition with Auger

M. Unger for the Pierre Auger Collaboration

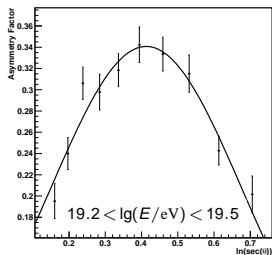
Composition Parameters under Study



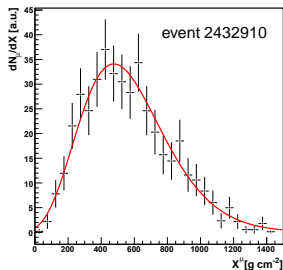
energy deposit profile



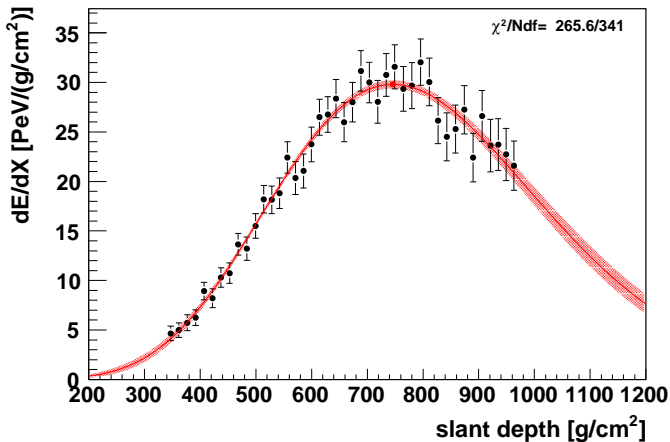
rise time asymmetry



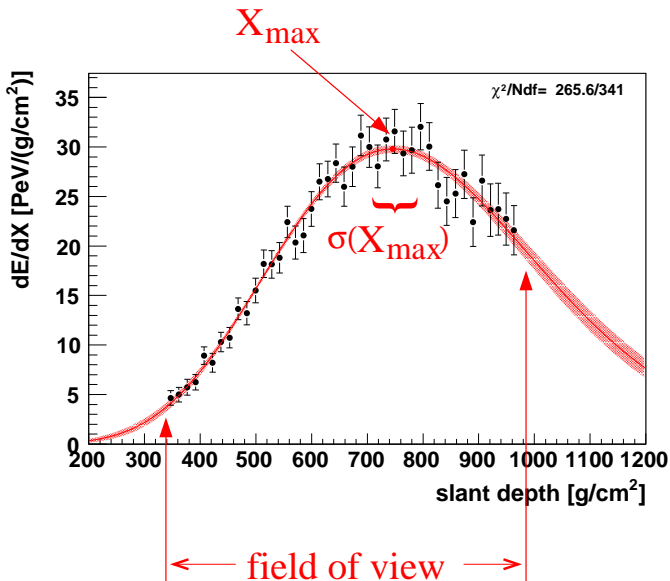
muon production depth



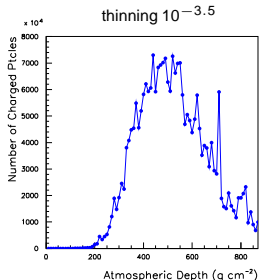
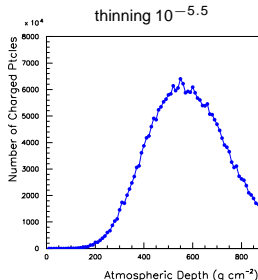
Measurement of the Shower Maximum with FD



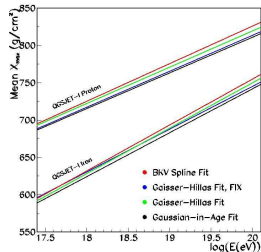
Measurement of the Shower Maximum with FD



Definition of X_{\max}



C.L. Pryke, APP14 (2001), 319

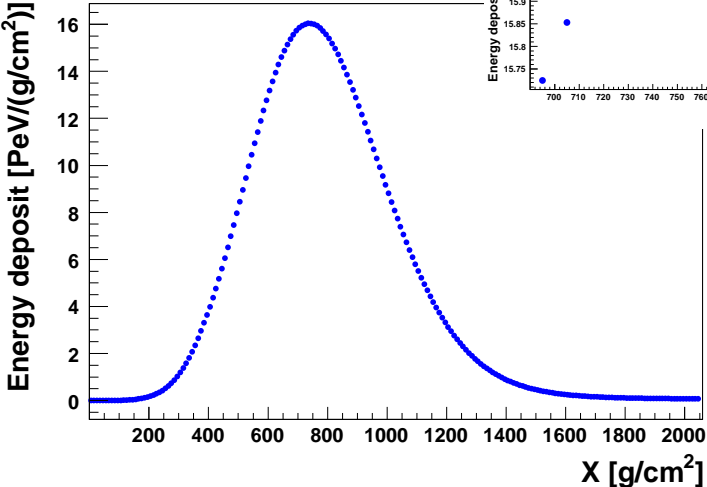


J. Belz, Bartol workshop 2009

differences $\gtrsim 10 \text{ g/cm}^2$?!

Definition of X_{\max}

maximum of Conex shower



Field of View Bias

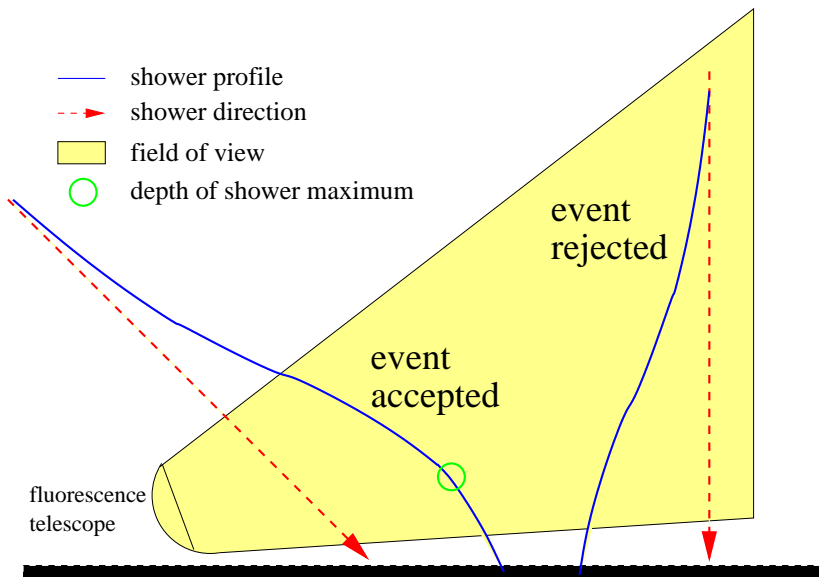


Illustration with CONEX Simulations

$$dN/d\cos\theta \propto \cos\theta, R_{\max}=30 \text{ km}$$

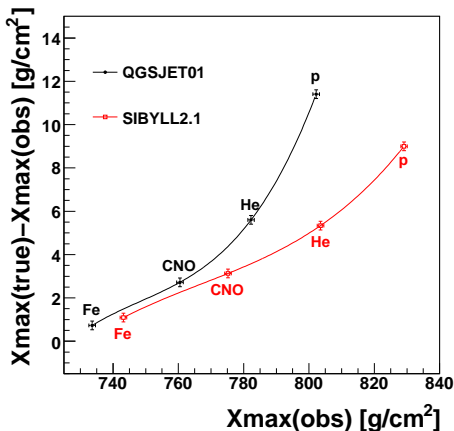
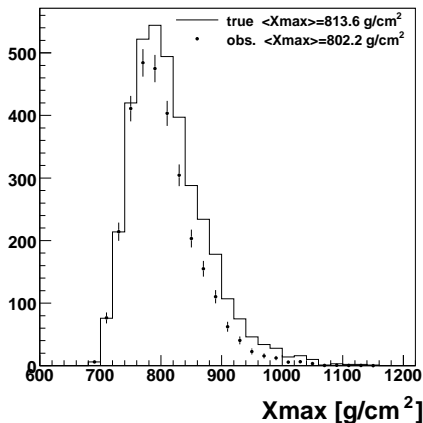
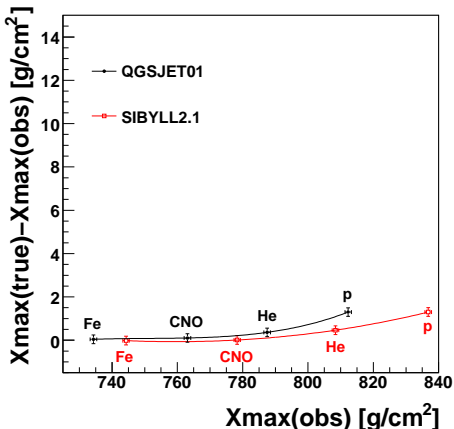
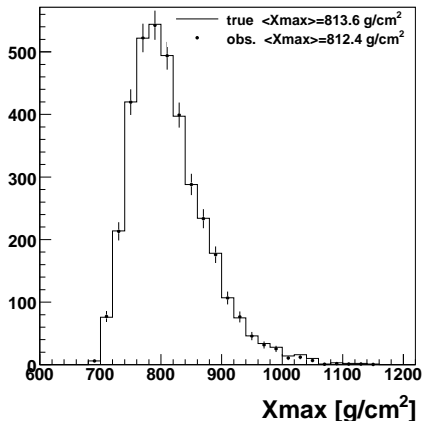
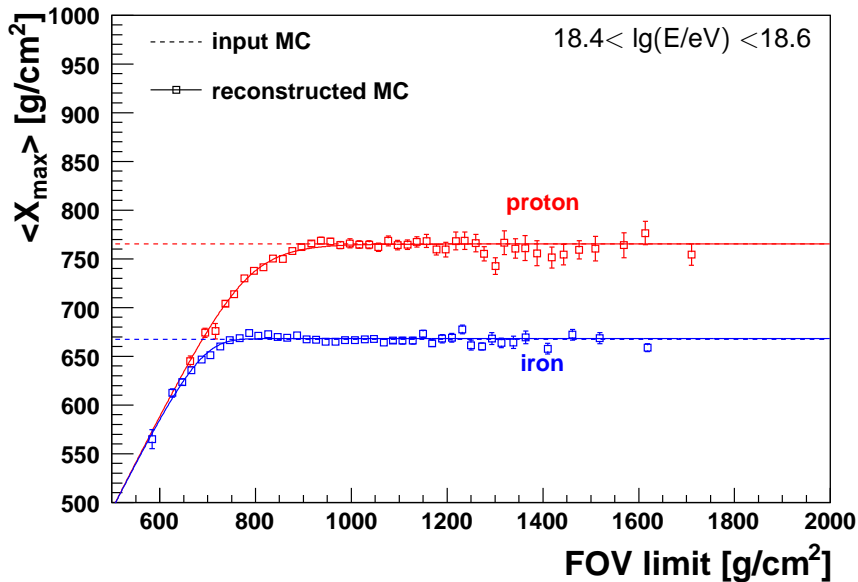


Illustration with CONEX Simulations

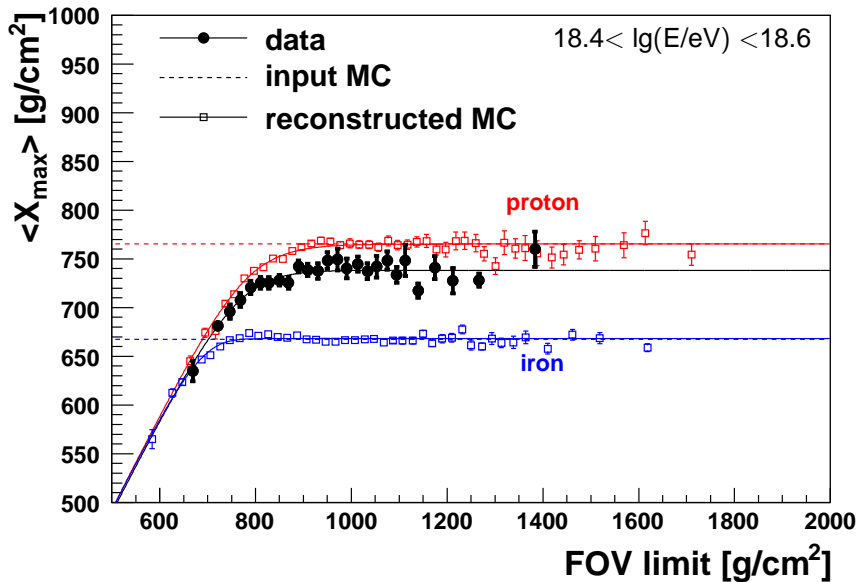
$dN/d\cos\theta \propto \cos\theta$, $R_{\max}=30$ km, max. viewable depth >950 g/cm²



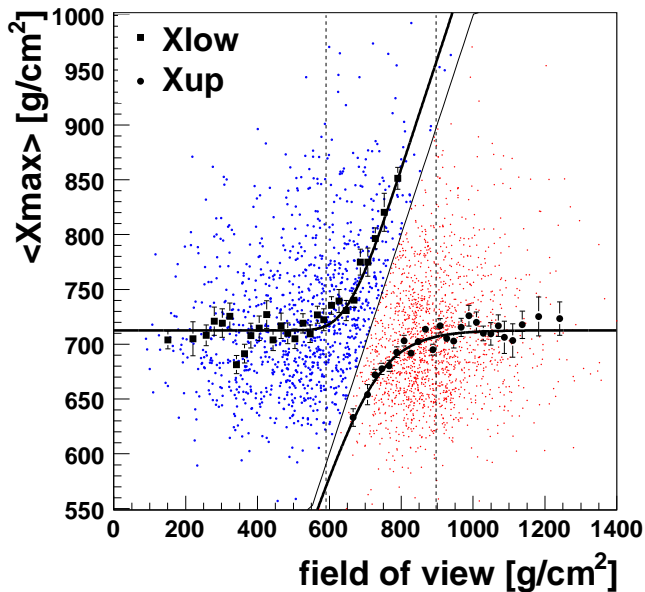
Field of View Bias - Detector Simulation



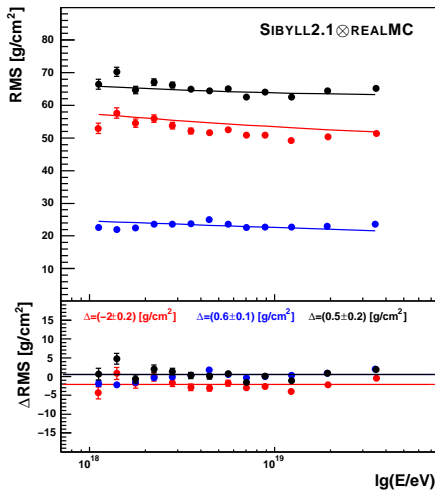
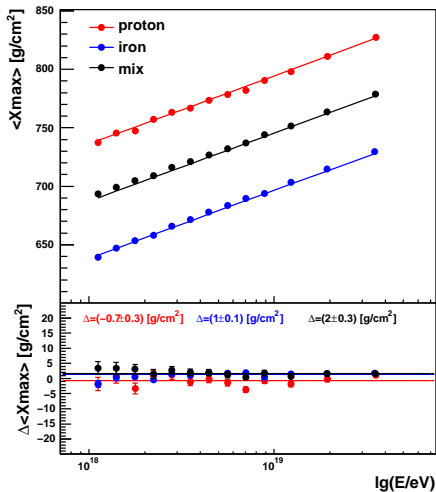
Field of View Bias - Detector Simulation & Data



Field of View Cuts - Data $10^{18.0} - 10^{18.1}$ eV



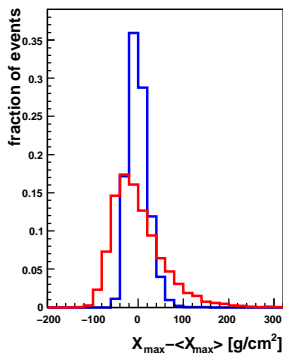
Validation of full Analysis Chain



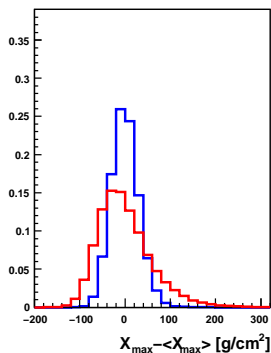
lines: 'true' values, dots: 'measured' values

X_{\max} -resolution

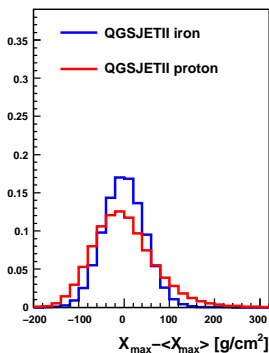
$$\sigma(X_{\max}) = 0 \text{ g/cm}^2$$



$$\sigma(X_{\max}) = 20 \text{ g/cm}^2$$

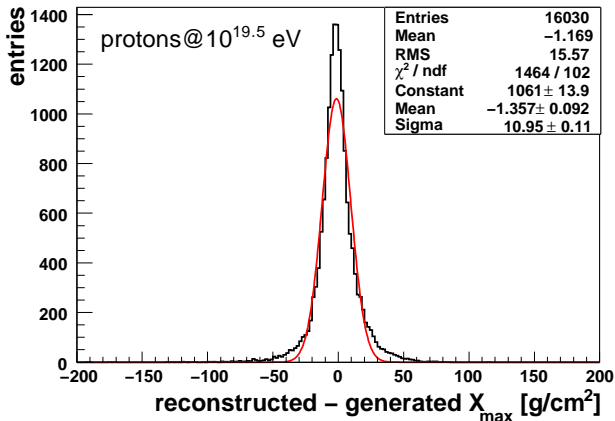


$$\sigma(X_{\max}) = 40 \text{ g/cm}^2$$



→ **need excellent X_{\max} -resolution for p/Fe discrimination!**

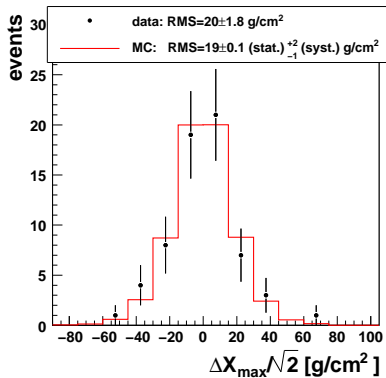
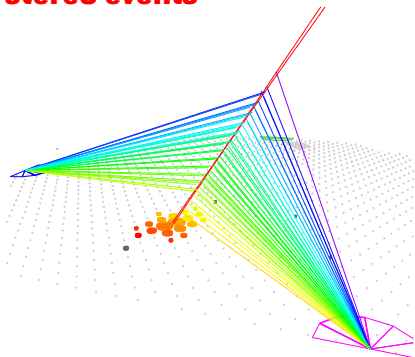
X_{\max} -resolution



quoted resolution:

HiRes/TA: Gaussian σ , Auger: standard deviation (RMS)

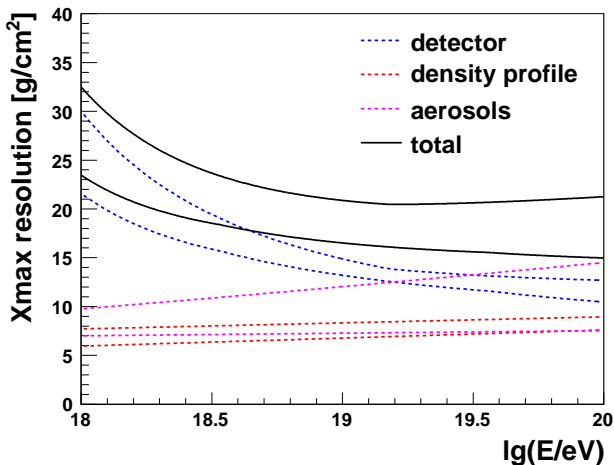
MC validation with stereo events



Auger Stereo-Hybrids:

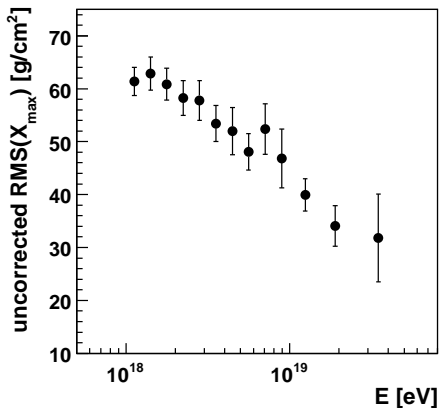
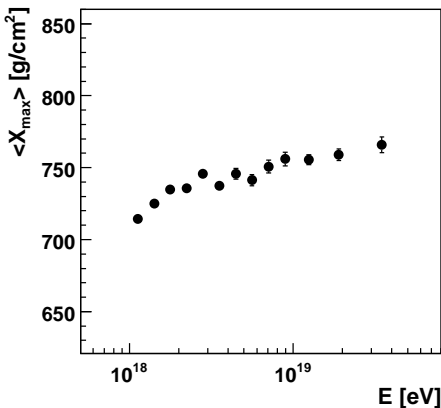
- ▶ independent geometries
- ▶ similar detectors

X_{\max} -resolution



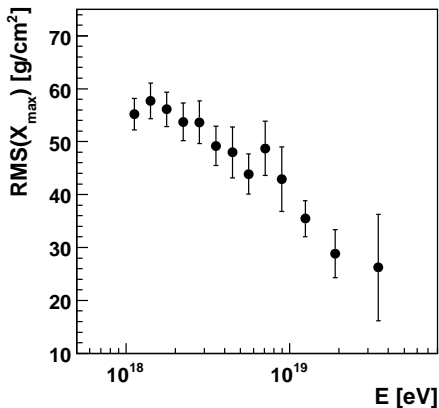
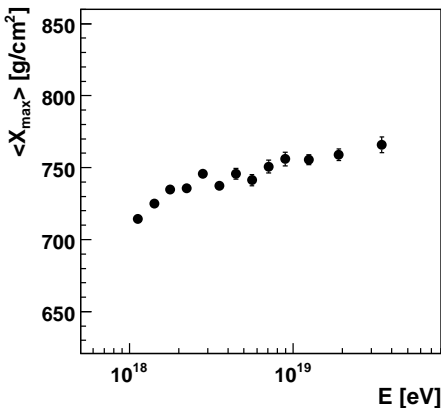
standard deviation of $X_{\max}(\text{rec}) - X_{\max}(\text{true})$

Moments of X_{\max} -distribution



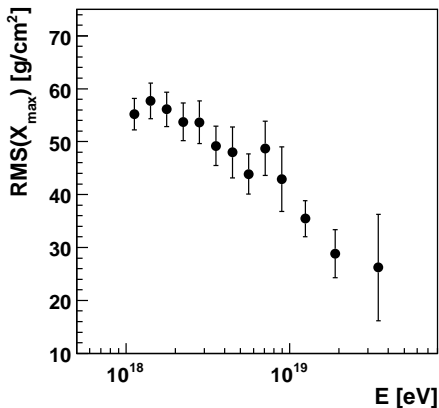
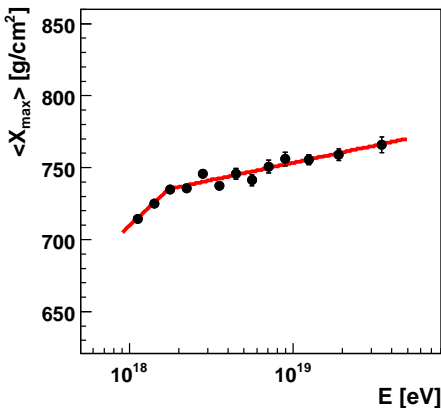
- ▶ **sys.** $\langle X_{\max} \rangle \leq 13 \text{ g/cm}^2$, **sys. RMS** $\leq 6 \text{ g/cm}^2$
- ▶ **RMS is corrected for resolution**
- ▶ **elongation rate:** $(24 \pm 3) \text{ g/cm}^2/\text{decade}$ above $10^{18.24 \pm 0.05} \text{ eV}$
- ▶ **comparison to CONEX simulation**

Moments of X_{\max} -distribution



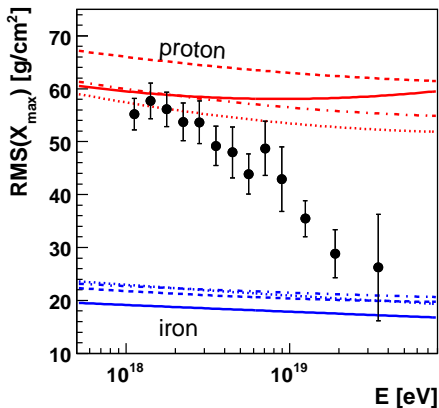
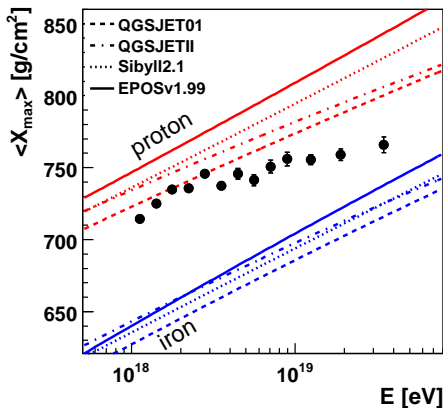
- ▶ **sys.** $\langle X_{\max} \rangle \leq 13 \text{ g/cm}^2$, **sys.** $RMS \leq 6 \text{ g/cm}^2$
- ▶ **RMS is corrected for resolution**
- ▶ **elongation rate: $(24 \pm 3) \text{ g/cm}^2/\text{decade}$ above $10^{18.24 \pm 0.05} \text{ eV}$**
- ▶ **comparison to CONEX simulation**

Moments of X_{\max} -distribution



- ▶ **sys.** $\langle X_{\max} \rangle \leq 13 \text{ g/cm}^2$, **sys.** **RMS** $\leq 6 \text{ g/cm}^2$
- ▶ **RMS is corrected for resolution**
- ▶ **elongation rate: $(24 \pm 3) \text{ g/cm}^2/\text{decade}$ above $10^{18.24 \pm 0.05} \text{ eV}$**
- ▶ **comparison to CONEX simulation**

Moments of X_{\max} -distribution



- ▶ **sys.** $\langle X_{\max} \rangle \leq 13 \text{ g/cm}^2$, **sys.** $\text{RMS} \leq 6 \text{ g/cm}^2$
- ▶ **RMS is corrected for resolution**
- ▶ **elongation rate: $(24 \pm 3) \text{ g/cm}^2/\text{decade}$ above $10^{18.24 \pm 0.05} \text{ eV}$**
- ▶ **comparison to CONEX simulation**

Suggestions

Can we agree on a

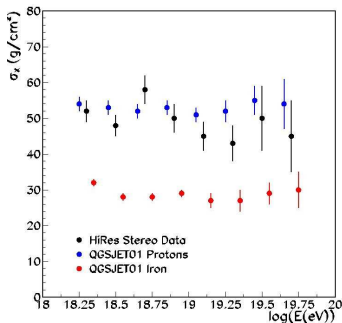
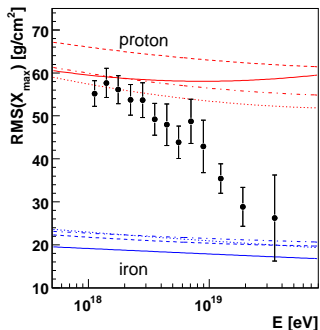
- ▶ **common theoretical definition of X_{\max} ?**

Can we compare the p/Fe sensitivity

- ▶ **quoting the full width of X_{\max} resolution?**

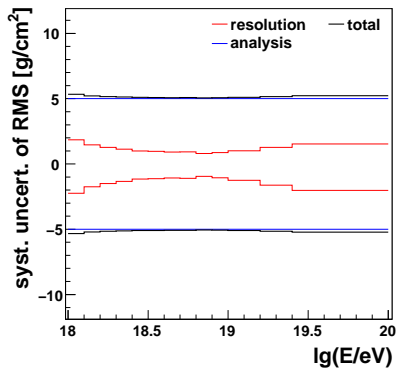
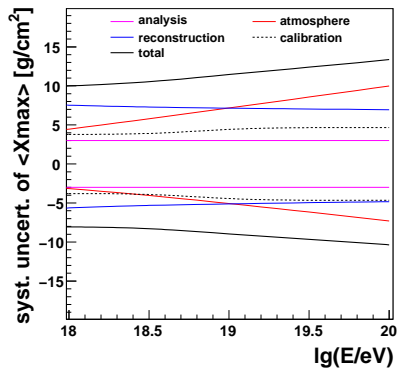
Is it possible to directly compare results after

- ▶ **correction of $\langle X_{\max} \rangle$ and RMS for detector effects?**



backup slides ...

Systematics



Biased estimator RMS?

