Status Report

-on-

FD X_{max} Composition Analysis

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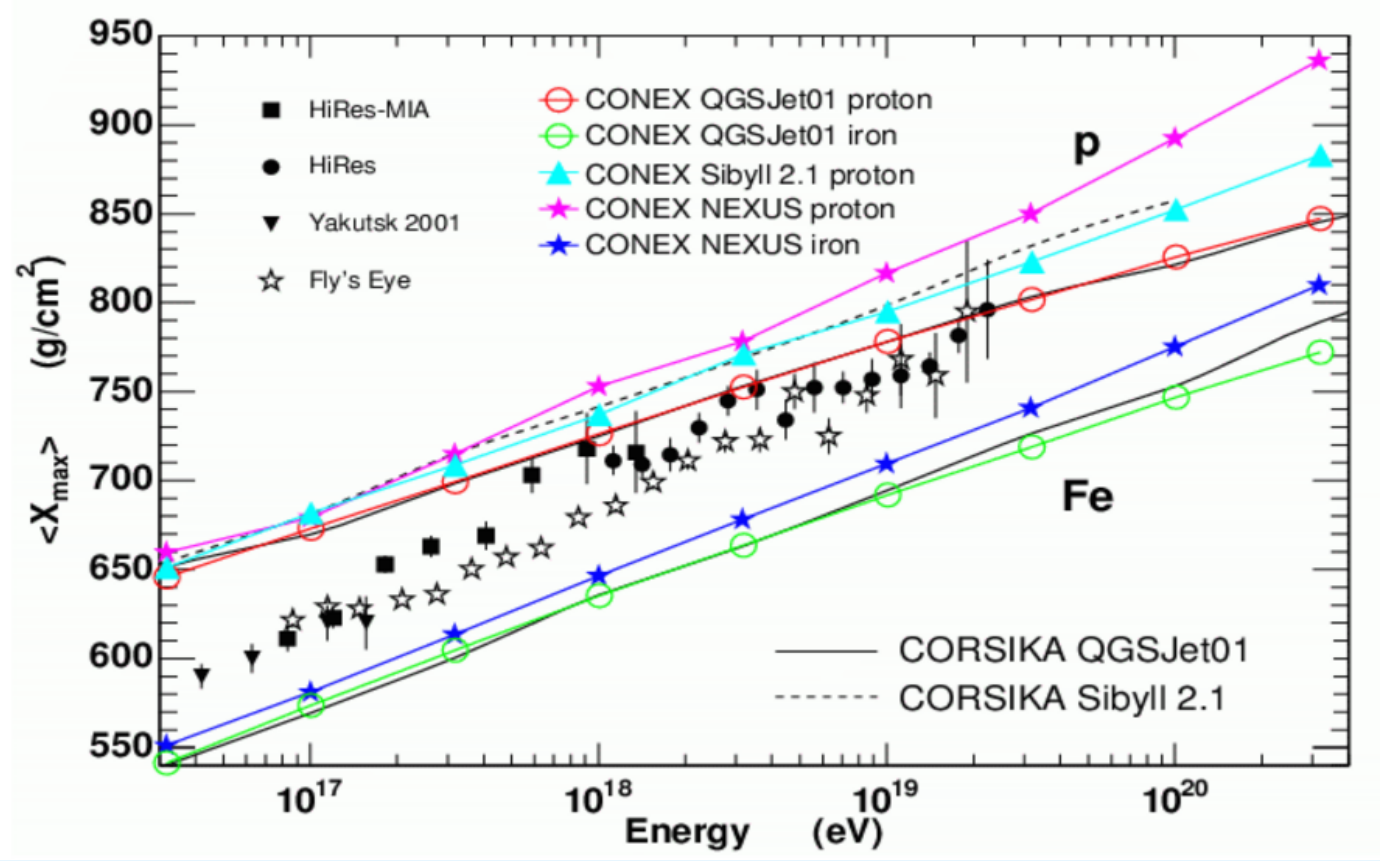
At least ... **three problems**



- Variety of model predictions for $<X_{max}>$ ... possibly an **intrinsic limitation?**
- *and* absolute normalizations are always difficult!
- *and* modest difference between p/Fe!

But ... **what about X_{max} distribution?**

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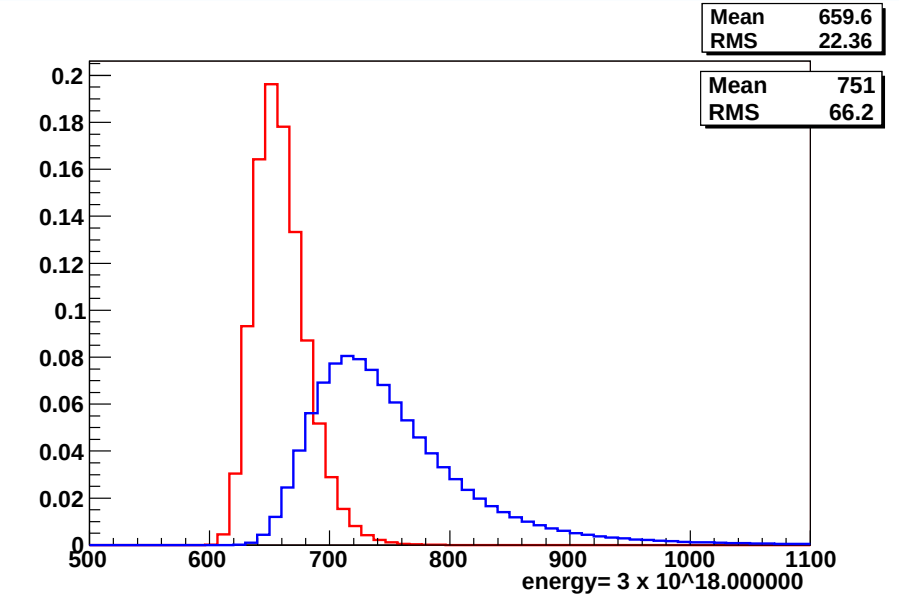
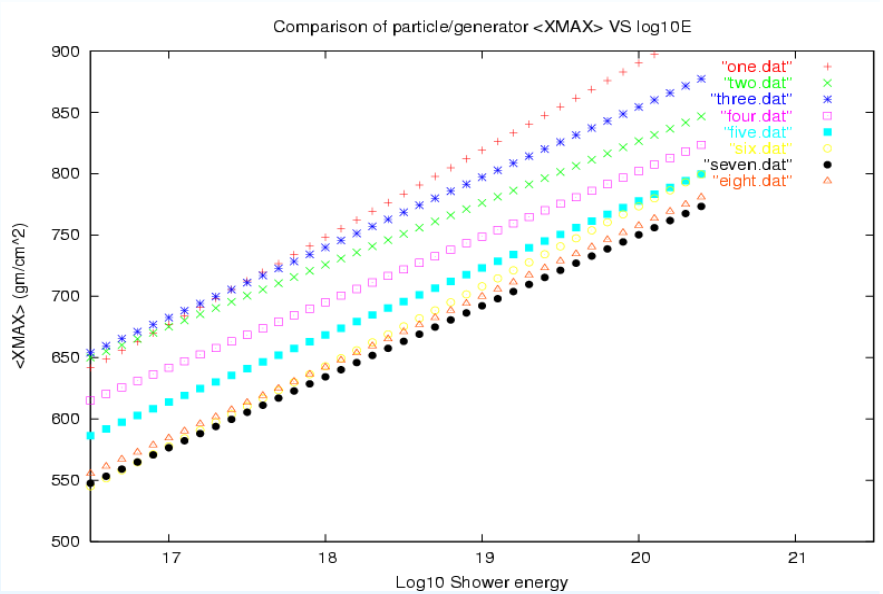
(left) QGSjet p VS Fe Xmax distributions



(right) $< X_{max} >$ VS energy



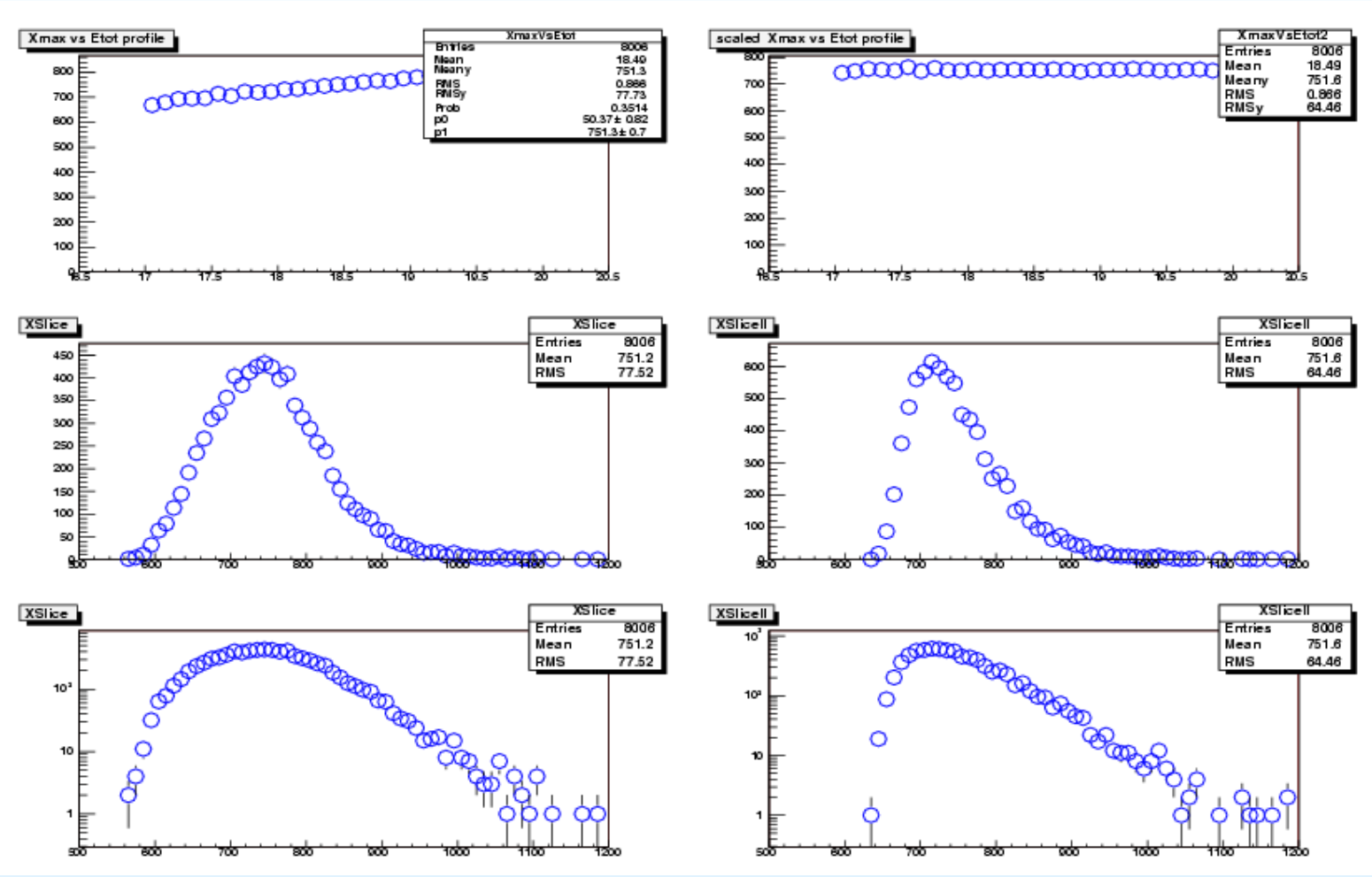
- Use the **new** CONEX generator ... fast!!
- Nexus, QGSjet01 (not QGSjet II), and Sibyll ... with **Root** output!
- (**only QGSjet results shown for p, He, carbon and Fe**)
- They agree where there is data ... *i.e.* below 10^{17}eV.
- **Nexus most *different* ... drop it for now!**

$X_{max}(E)$... mostly linear in log10E

QGSjet protons: generated uniformly between $0.1 < X_{max} < 100$ EeV

(top) $< X_{max} >$ VS E; (2 bottom rows) X_{max} distribution

(left) “all” (right) with linear log10E removed



Compatible with ... **simple functional form!**

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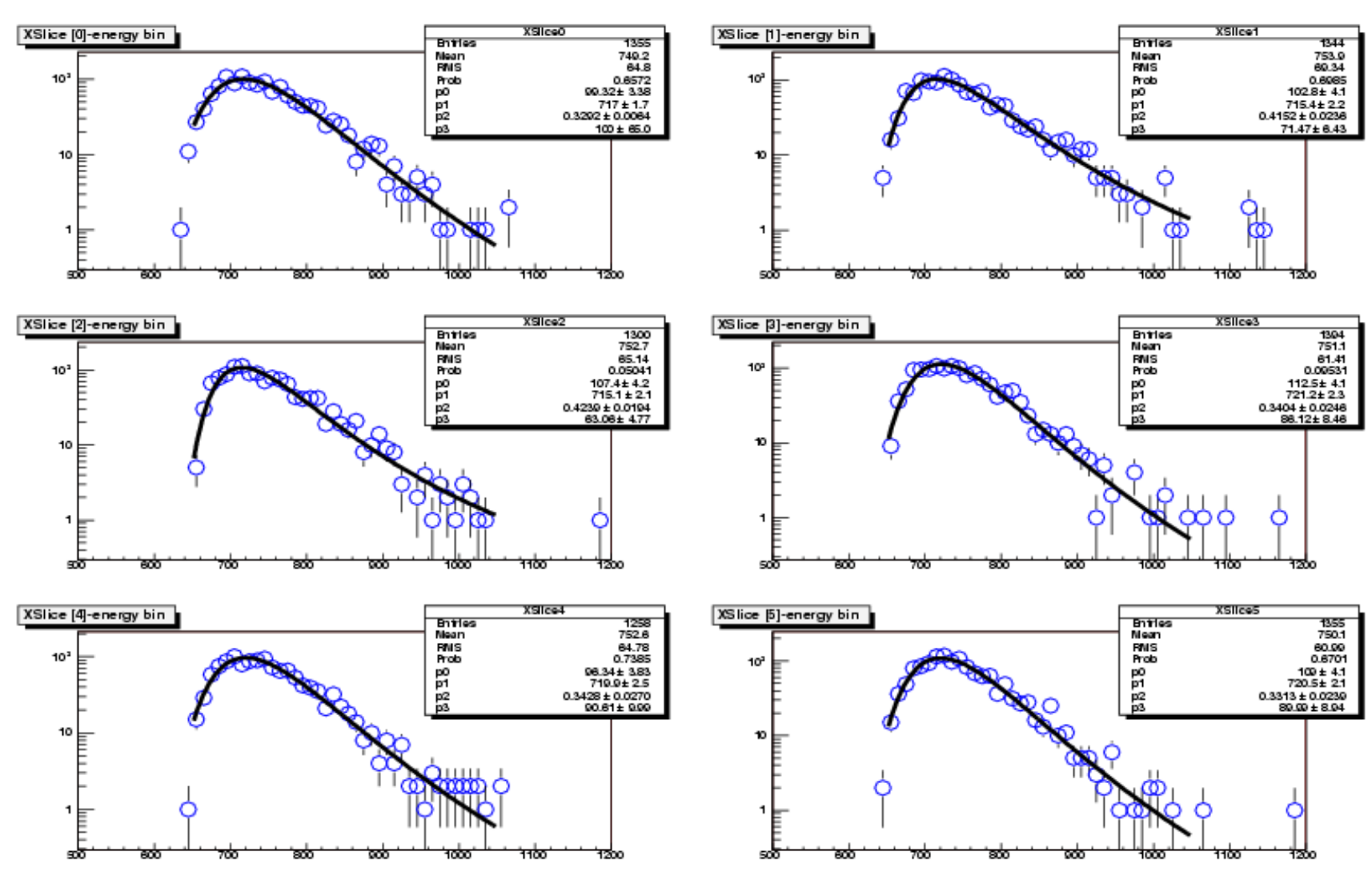
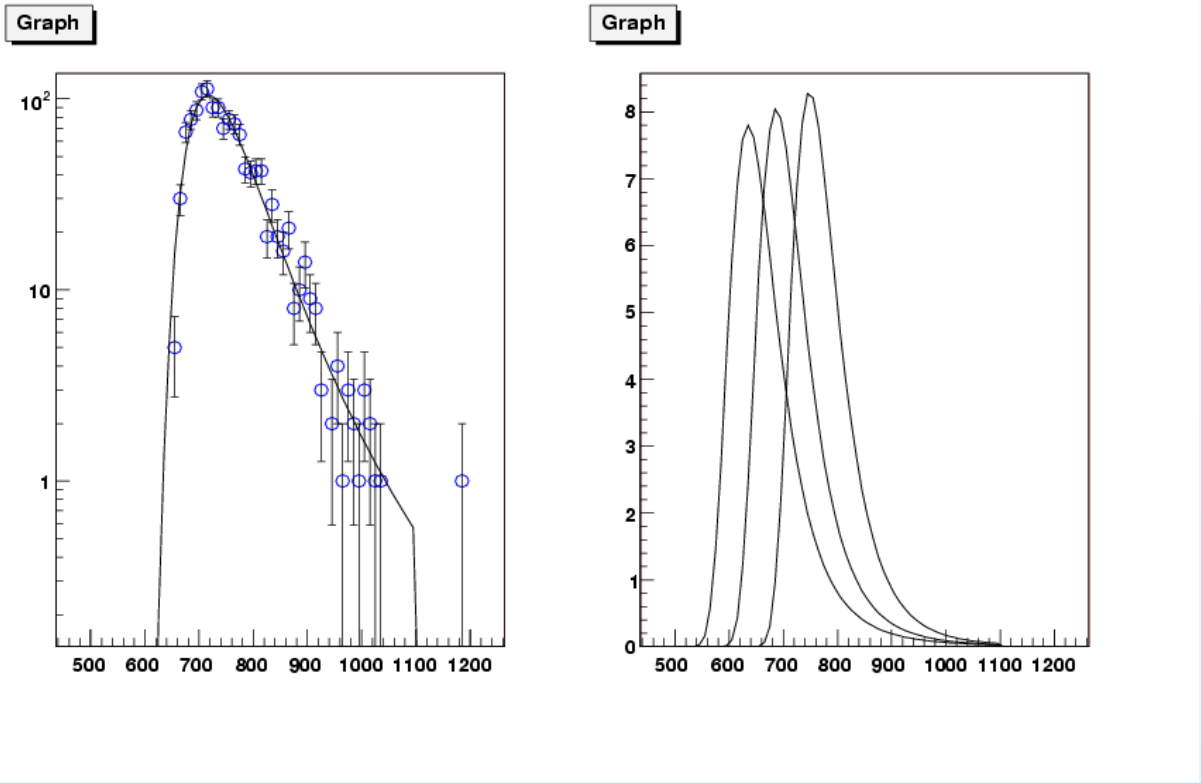
QGSjet protons: $0.1 < X_{max} < 100$ EeV in 6 “equal” bins



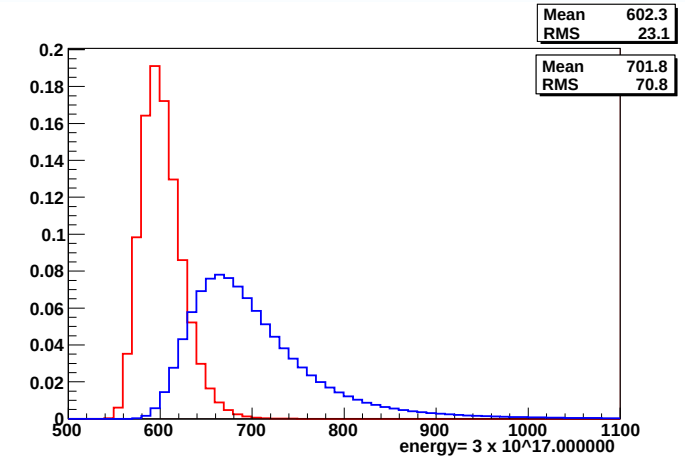
So ... **function(*MC*, *p/Fe*, *log10E*)**

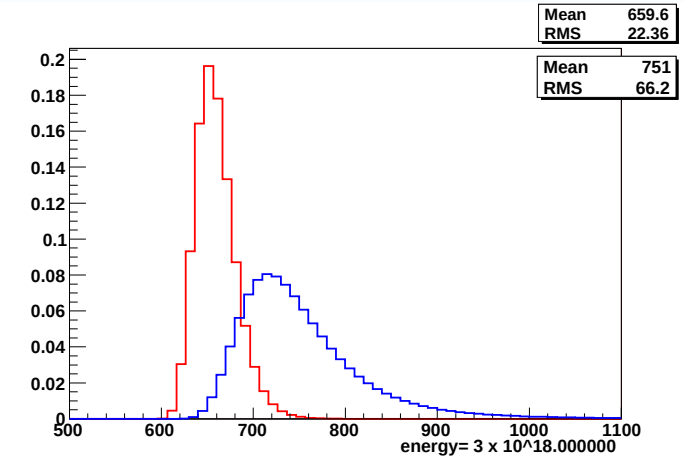


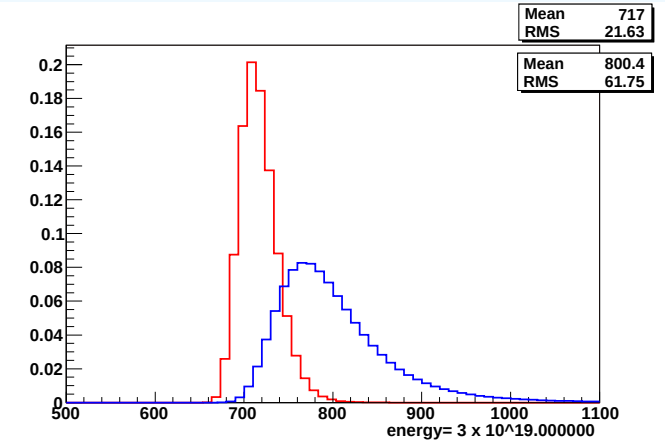
LEFT: functional form (solid curve) VS Monte Carlo simulation: **QGSjet**, p, $1 \sim 3 \times 10^{18}$eV

RIGHT: functional form evaluated at: 3×10^{17}eV, 3×10^{18}eV, and 3×10^{19}eV.

What about ... p VS Fe?







- X_{max} distributions from QGSjet
- **AND** in QGSjet the p:Fe differences **decrease** with energy!

Next ... **use it!!**

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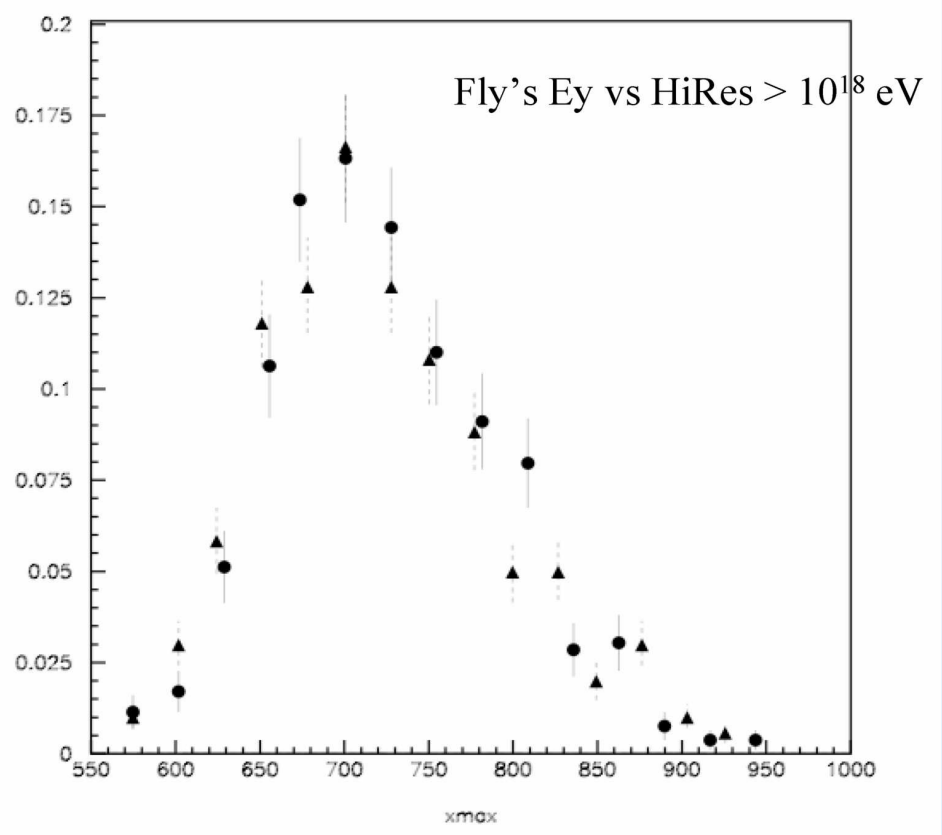
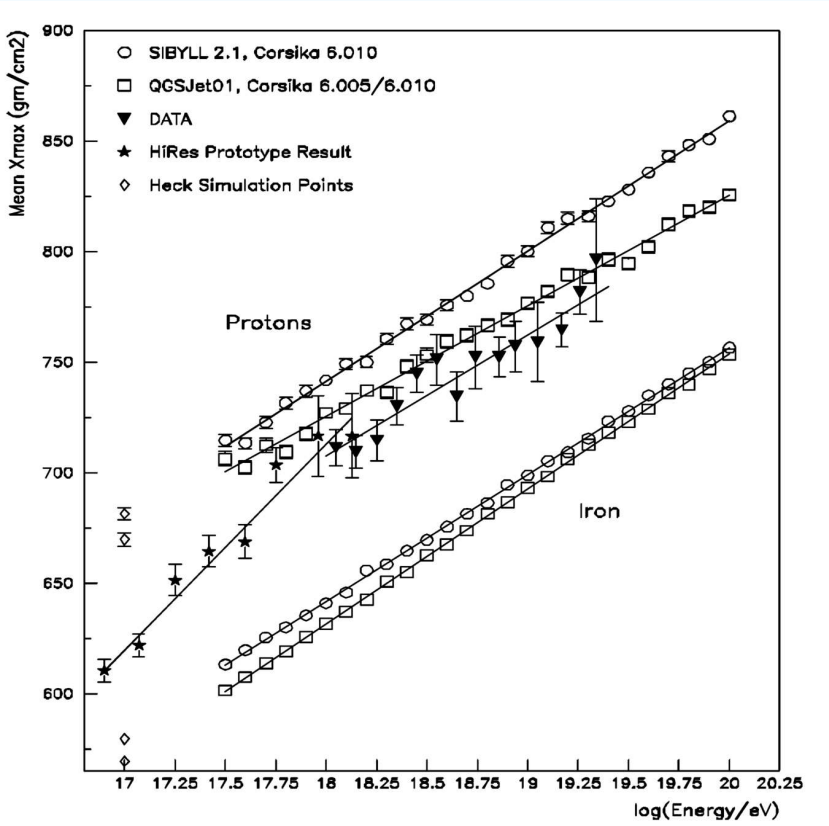
First (in process) ... try it out to fit HiRes Stereo data = Sokolsky talk (ICRC 2005)

HiRes data = circles (●), dE/E = 25%, dXmax = 30 gm/cm^2

With thanks for Pierre's help! ... but the mistakes are ours!

In parallel we are checking for bugs ...





Practice fi t ... **HiRes data > 1EeV**

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Fit X_{max} distribution to $f \times p + (1 - f) \times Fe$

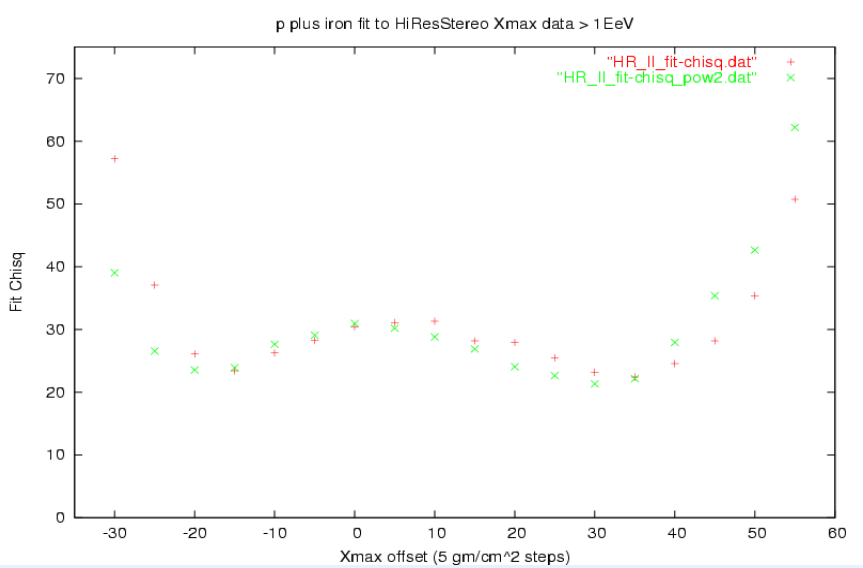
Repeat fit in 5 gm/cm^2 *steps* ... because we do not know possible data:MC (absolute) offsets

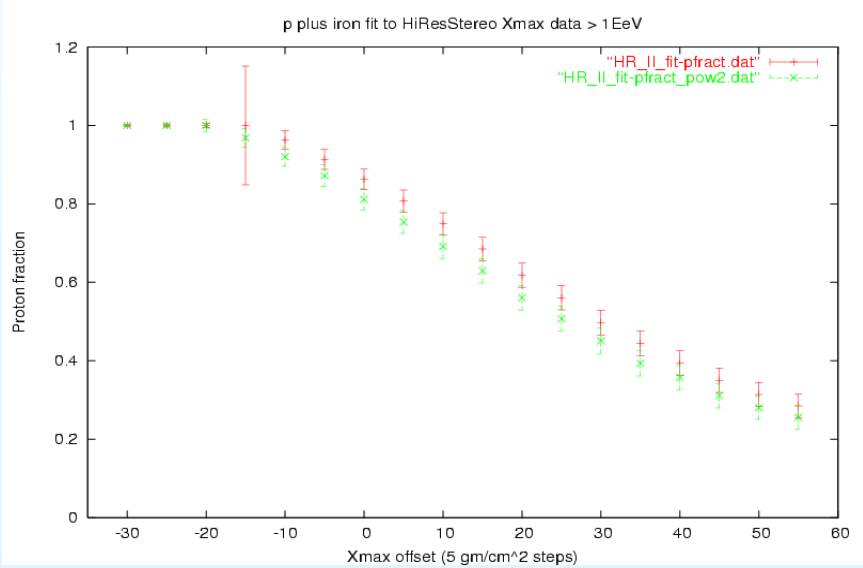
Repeat assuming data $\propto E^{-3}$ or $\propto E^{-2}$

In parallel keep checking for bugs ...

(left) fit χ^2 VS grammage offset

(right) proton fraction, f, VS grammage offset





Two *minima* ... **44%p : 56%Fe**

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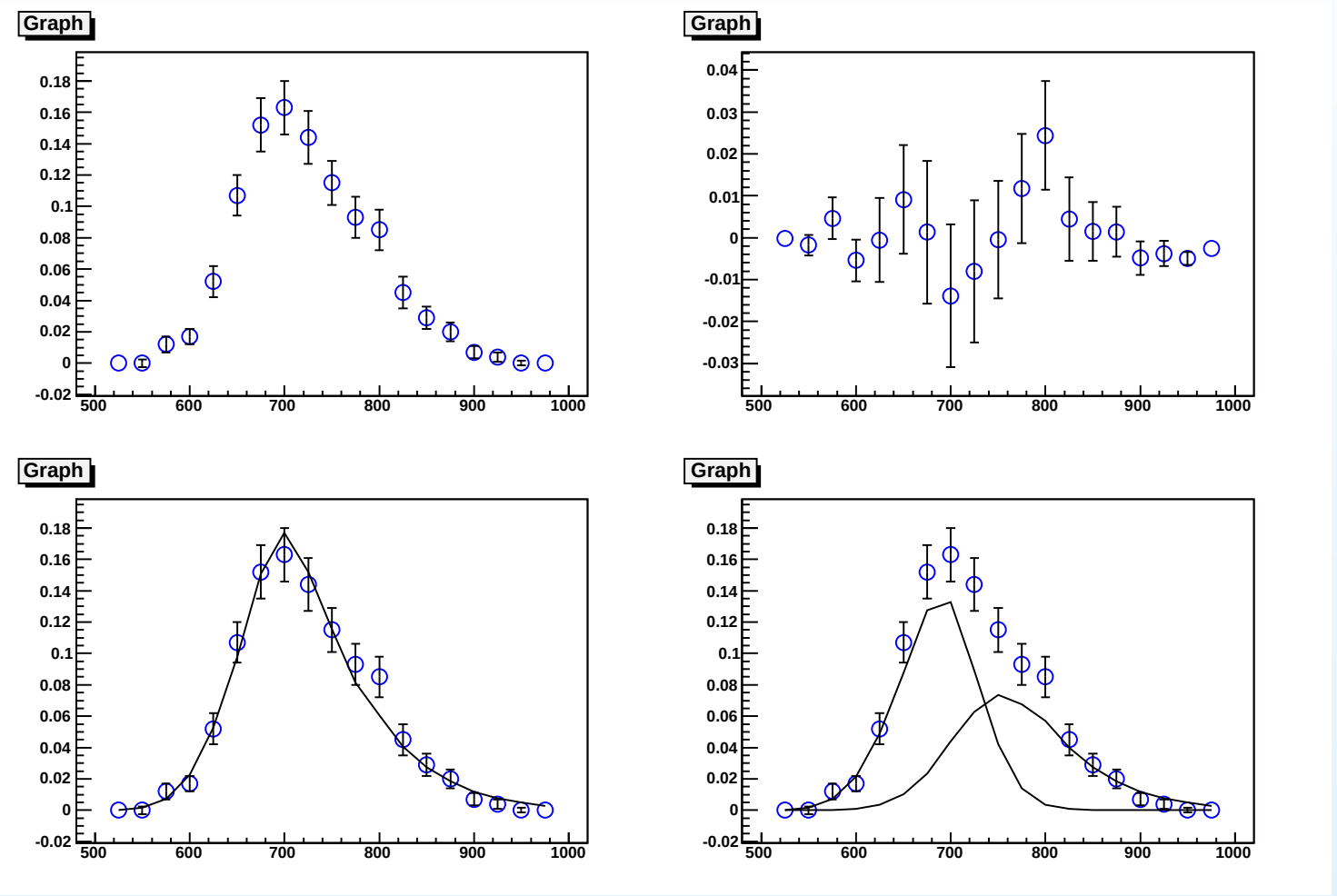
Offset QGSjet p,Fe X_{max} distributions **deeper** into the atmosphere

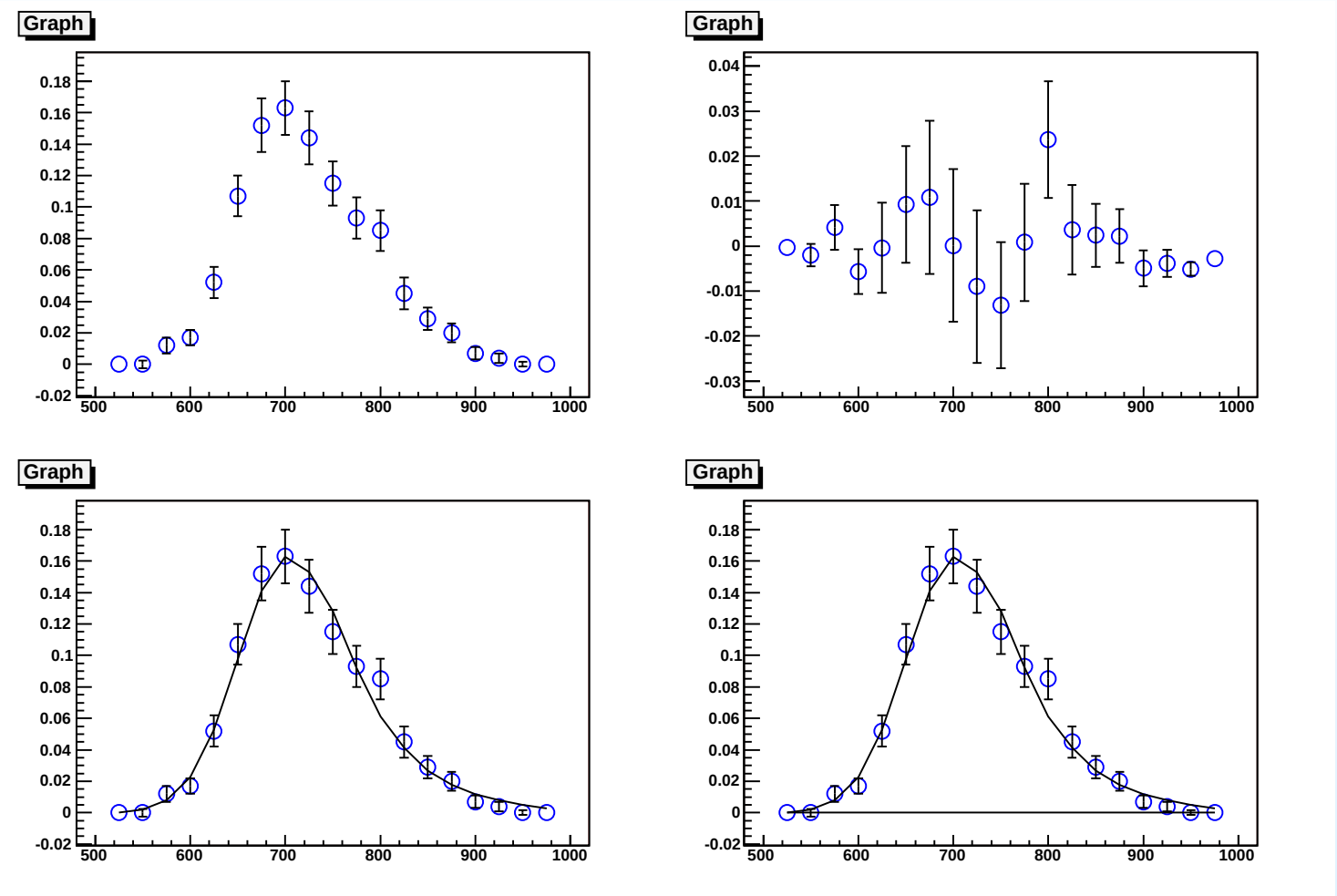
i.e. move QGSjet-p $< X_{max} >$ **away from** the data



Two *minima* ... **100%p : 0%Fe**

Offset QGSjet p,Fe X_{max} distributions **less deep** into the atmosphere

i.e. move QGSjet-p $< X_{max} >$ **toward** the data



Just in time ... **small-x gluons!**

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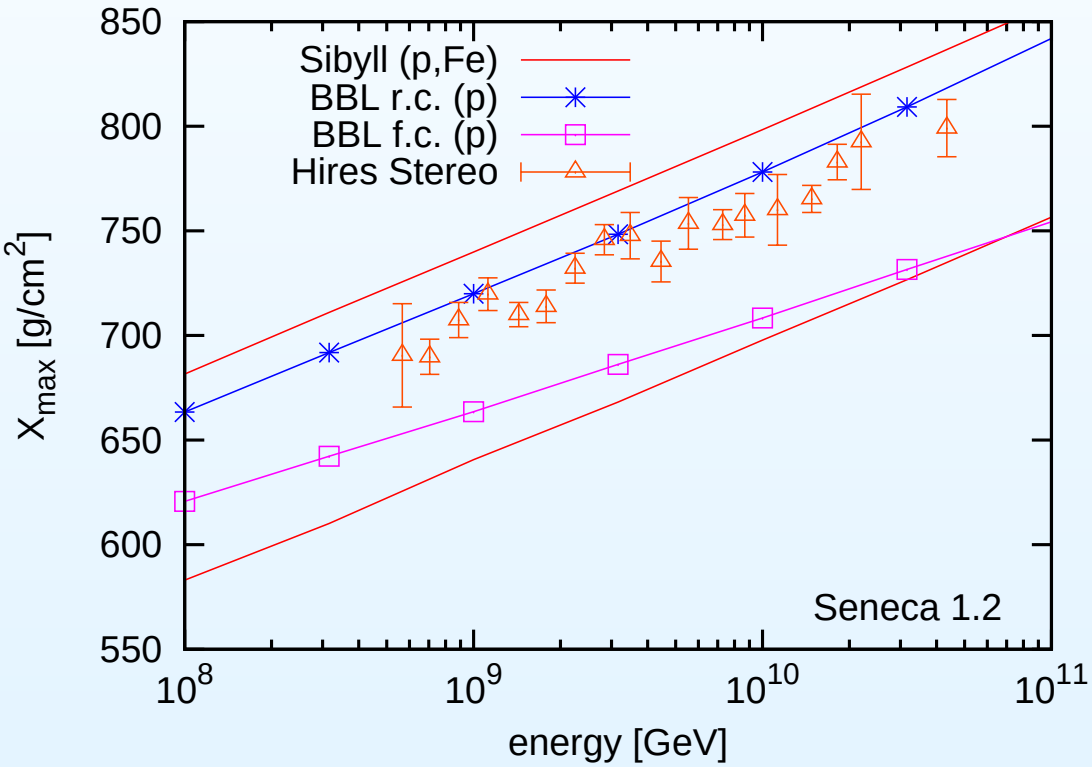
Theory ideas from Drescher, Dumitru, Strikman PRL **94** , 231801 (2005).
Predictions for Sibyll with new saturation model (running VS fixed coupling).

New model brings the prediction (blue) closer to the HiRes stereo data ... this is the same direction favored by the 100%p:0%Fe solution!



Summary ... **good news and bad news!**

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- Progress toward analyzing full $X_{max}(E)$ data distributions (instead of just data $< X_{max}(E) >$).
- Still early ... so beware of possible bugs!
- First comparison of QGSjet p+Fe to HiRes Stereo data > 1EeV has both good news and bad news.
- Good news is that a simple sum of QGSjet p-$X_{max}(E)$ + Fe-$X_{max}(E)$ *agrees* with the data.
- Bad news is we still don't know the fraction of protons ... **but it could be 100%**!
- Next step: analyse Auger FD X_{max} data!