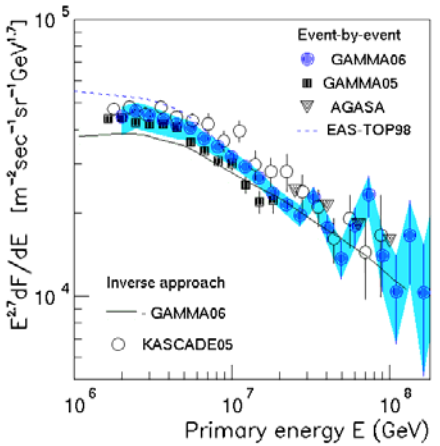
GAMMA Experiment

All-particle primary energy spectrum in the knee region: GAMMA Experiment



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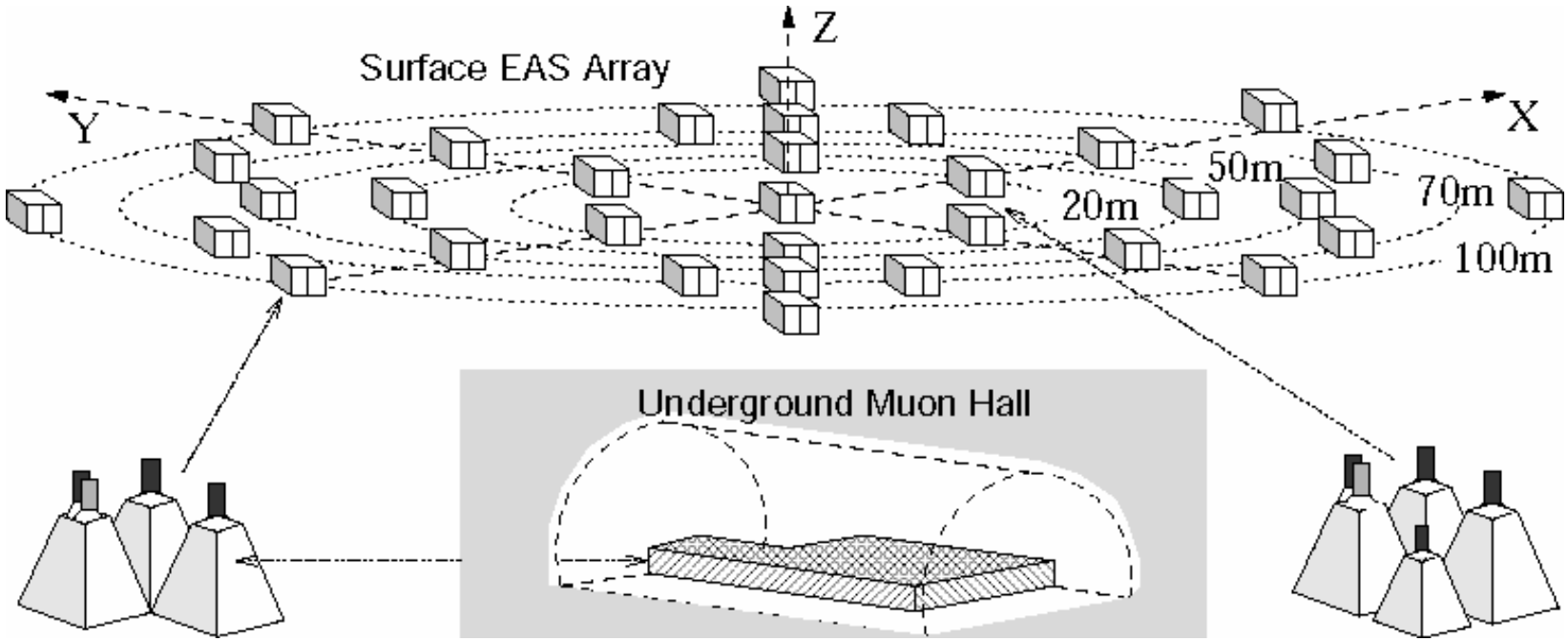
GAMMA facility

Yerevan Physics Institute



• **Location:**
Armenia, Mt.Aragats
3200 m a.s.l.
• **EAS array:**
33x3 (1x1x0.05)m^3+
+9(0.3x0.3x0.05) m^3
• **Muon hall:**
2500 g/cm^2 of rock
150 (1x1x0.05)m^3

• **EAS data:**

$\mathbf{N_{ch}} > 5 \cdot 10^5$ (100%)

$\mathbf{R} < 25$ m (50 m)

$\boldsymbol{\theta} < 30^0$

$\mathbf{N_\mu}(R_\mu<50m) > 10^3$

$\mathbf{E_\mu} > 5$ GeV

$\mathbf{T} = 6.2 \cdot 10^7$ sec

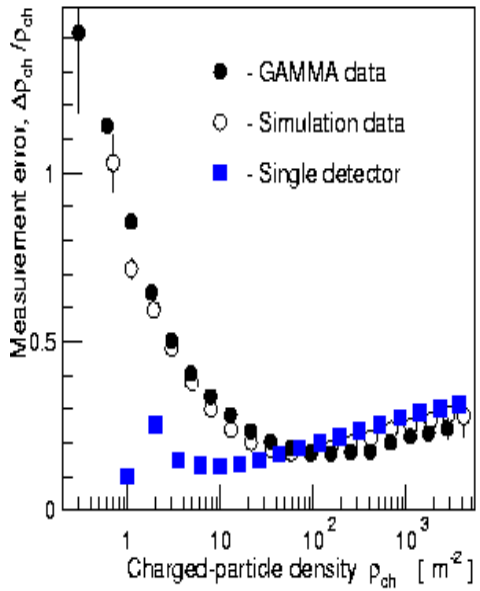
Biblical ARARAT and GAMMA facility

Surface array of GAMMA facility

Errors

$$\frac{\Delta N_{ch}}{N_{ch}} \approx 0.1,\ \Delta s \approx 0.05,\ \Delta x, \Delta y \approx 0.5 \div 1\text{m},\ \Delta\vartheta \approx 1.5^0$$

$$\frac{\Delta N_{\mu}}{N_{\mu}} \approx 0.35 \div 0.2 \quad \text{at} \quad N_{\mu}(R_{\mu} < 50\text{m}) \approx 10^3 \div 10^5$$



EAS Simulations:

CORSIKA6031(EGS, NKG)

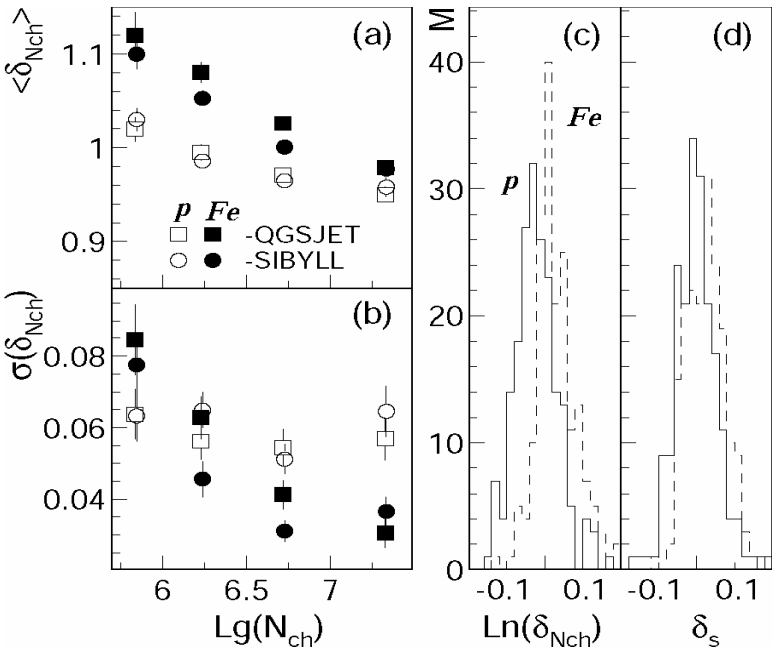
SIBYLL2.1

A	*p*	*He*	*O*	*Fe*
E_{min}(PeV)	0.5	0.7	1.0	1.2

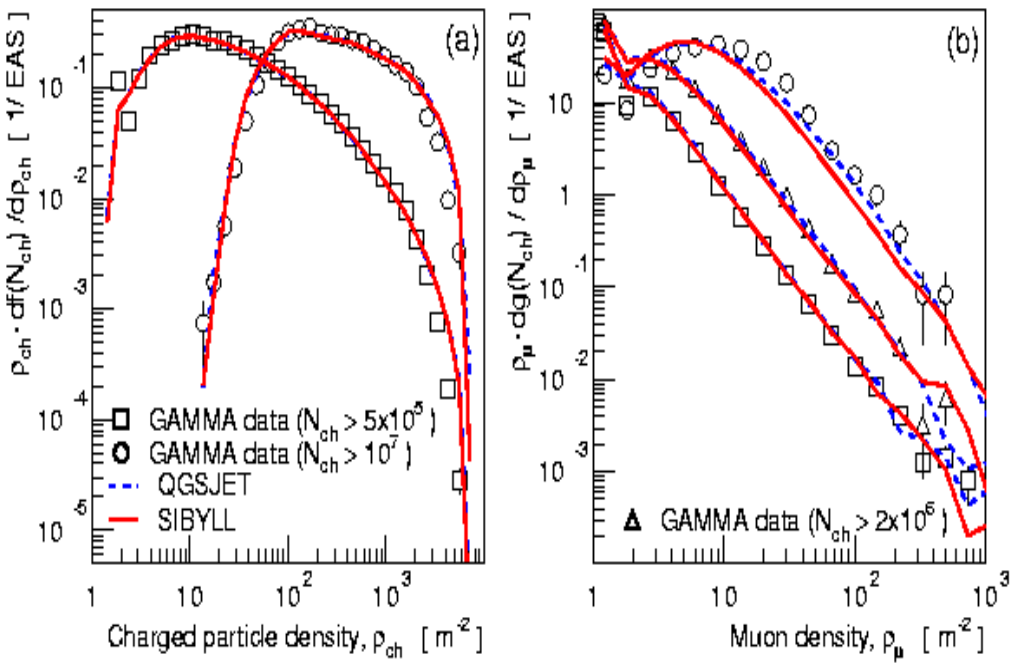
N=10^4

E_{max} =5·10^3 PeV
$\theta < 30^0$
γ = -1.5
E_e > 1 MeV
E_{μ} > 150 MeV
E_{μ} > 4 GeV ($e^{+/-}$)

Detector response



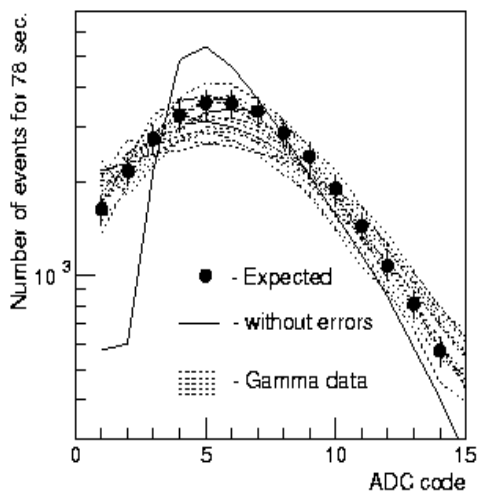
Density spectra



$$\delta_{N_{ch}}(A, N_{ch}) \equiv \frac{N_{ch}(E_e = 1MeV, \text{NKG})}{N_{ch}(E_d, \gamma, \text{EGS})}$$

$$\delta_s(A) \equiv s(E_e = 1MeV, \text{NKG}) - s(E_d, \gamma, \text{EGS})$$

➢ s(7m < r_i < 90m)



Energy estimator: $Ln(E_0) \approx Ln(E_1) = f(N_{ch}, N_\mu, s, \cos\theta)$

if $F(E_0) \propto E_0^{-\gamma}$ & $W(E_0, E_1) \equiv N(\delta, \sigma | \mathrm{Ln}E_1)$, $\delta(E) = \langle E_1 / E_0 \rangle$

then $\tilde{F}(E_0) \cong F(E_1) \cdot \delta^{1-\gamma} \cdot \exp((\sigma(1-\gamma))^2 / 2)$

$$\left(\frac{\Delta\tilde{F}}{\tilde{F}}\right)^2 \cong \left(\frac{\Delta F}{F}\right)^2 + (\Delta\delta(\gamma-1))^2 + [(\sigma(\gamma-1))^2 (\frac{\Delta\sigma}{\sigma} + \frac{\Delta\gamma}{\gamma-1})]^2$$

Statistic Errors ***Methodic Errors***

Let $E_1 = f(a_1, \ldots, a_n | N_{ch}, N_\mu, s, \theta)$

$$\chi^2 = \sum_A \sum_{i=1}^{10^4} \frac{(\ln E_{0,A,i} - \ln E_{1,i})^2}{\sigma^2}$$

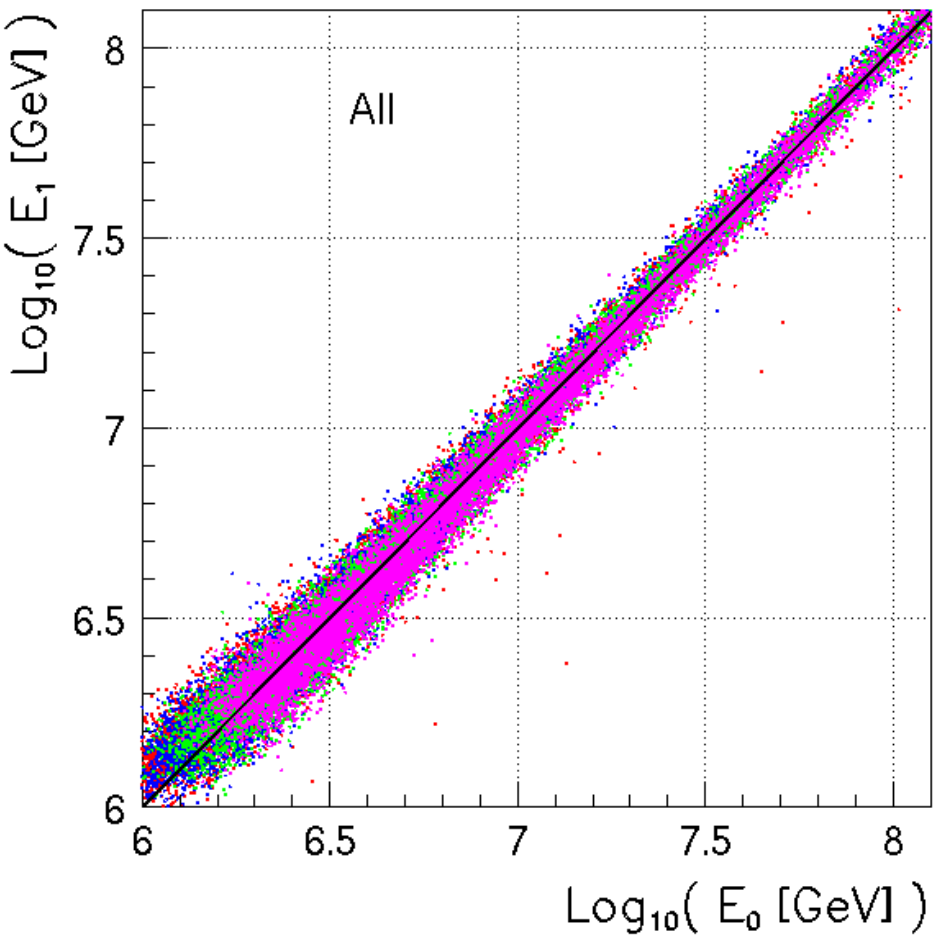
CORSIKA

$(A, E_0, N_{ch}, N_\mu, s, \theta)_{i=1,\ldots 10^4,\ A=1,\ldots 4}$

E_0-E_1 plot

$\chi^2_{min}(E_0,E_1)$

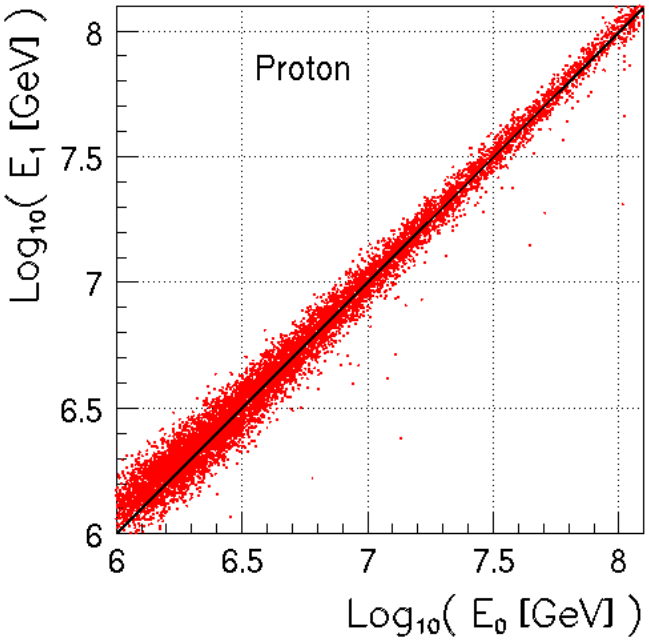
a_1	0.997
a_2	2.37
a_3	-3.72
a_4	0.583
a_5	10.42
a_6	1.002
σ	0.13
χ^2	~1

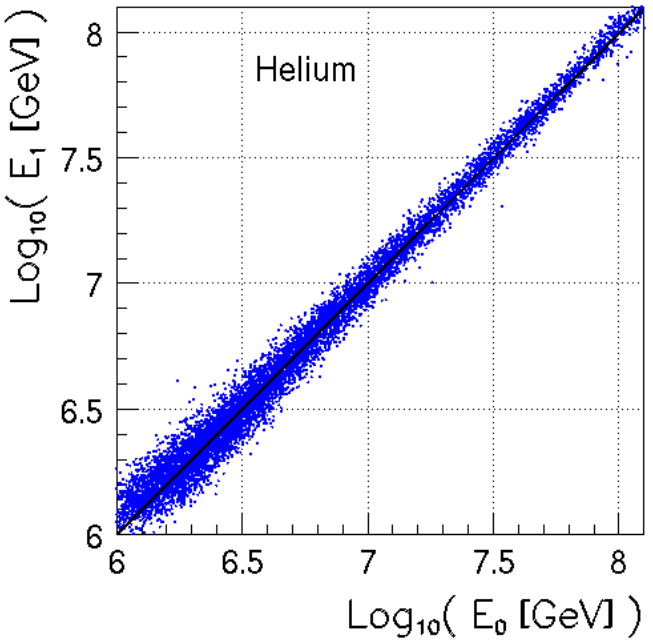


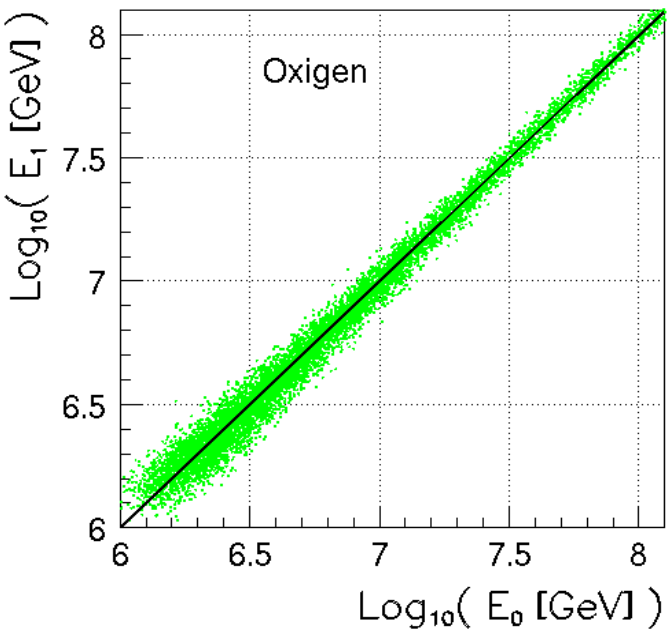
$$LnE_1 = a_1 x + a_2\sqrt{s/c} + a_3 c + a_4 + a_5/(x - a_6 y)$$

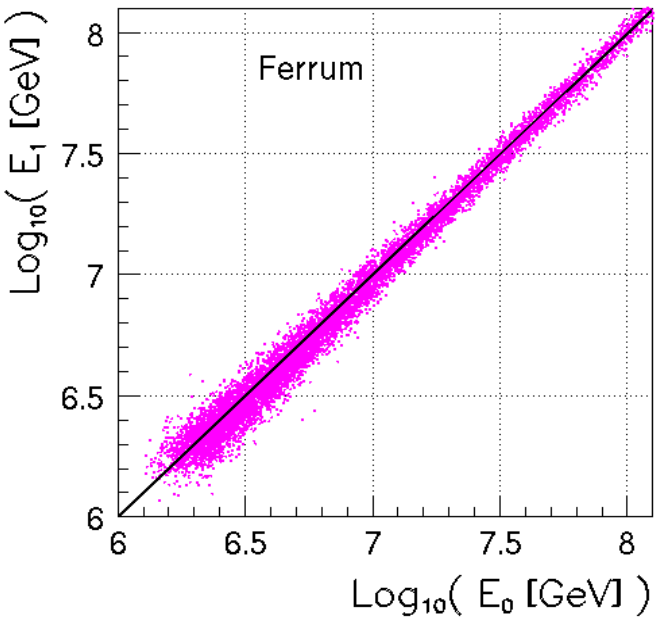
$$x = Ln(\mathbf{N_{ch}}), \quad y = Ln(\mathbf{N_{\mu}}), \quad c = cos(\theta)$$

Energy estimations for ***P, He, O, Fe***

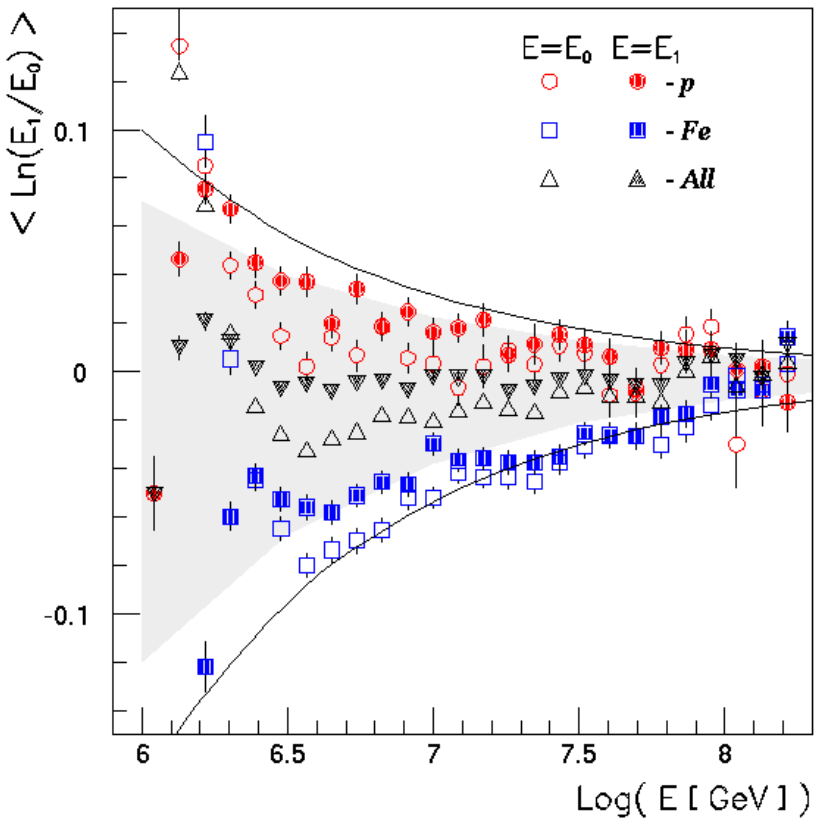


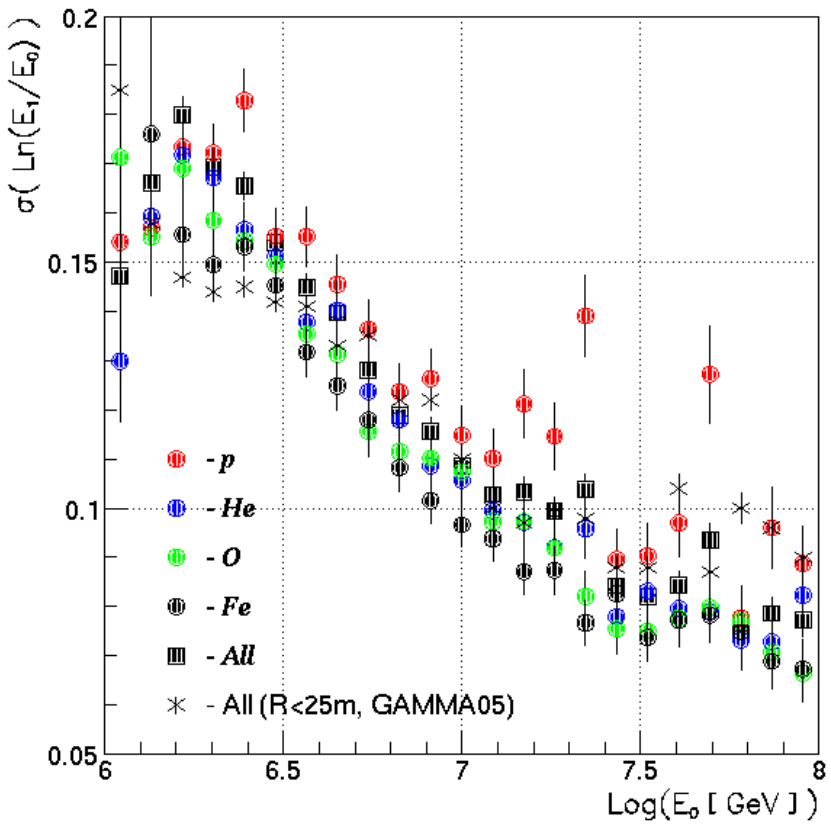






$\delta_A(E)$, $\sigma_A(E)$

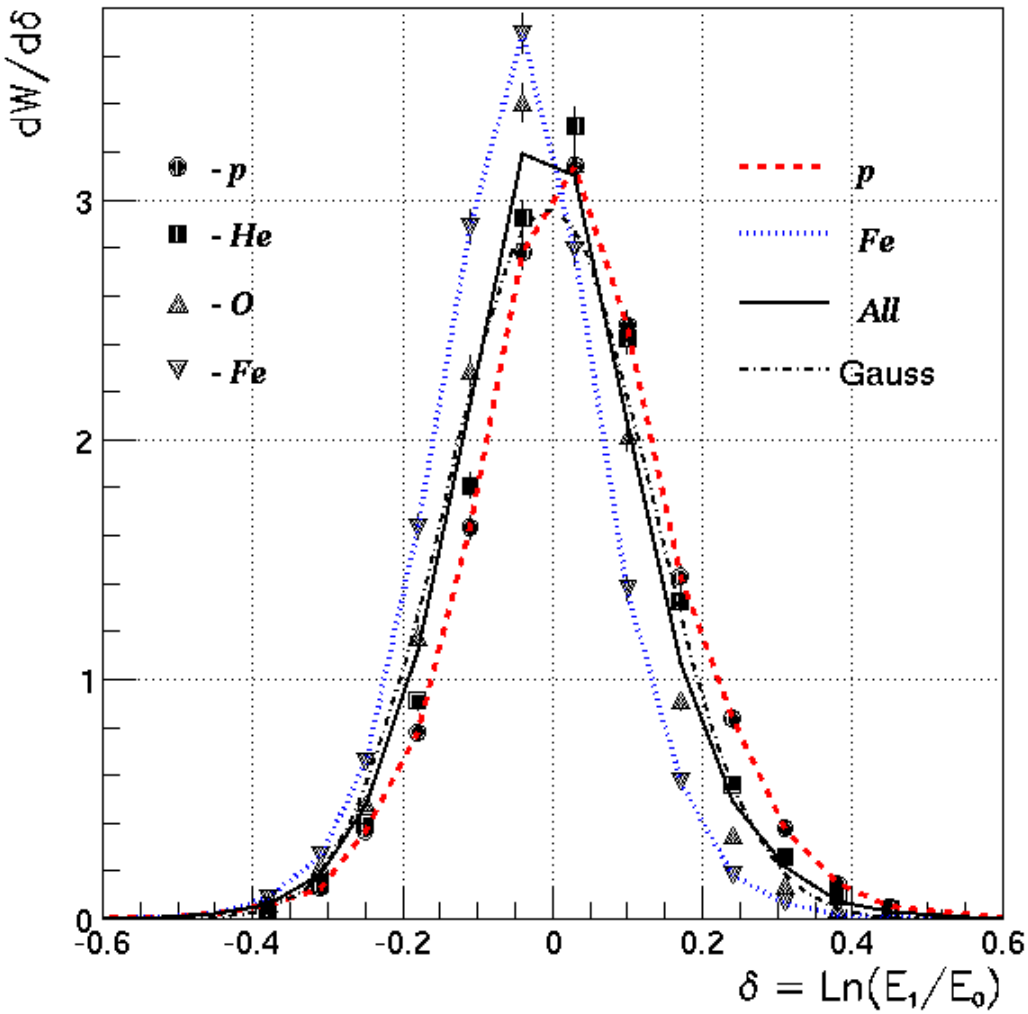




$$\Delta\delta \approx \begin{matrix}(+0.10)\\(-0.17)\end{matrix} / (E_{PeV})^{0.5}$$

$$\sigma = 0.13, \quad \Delta\sigma = 0.03$$

Error distributions



All-Particle Spectrum