Physics Performance and Jet Energy Resolution

SiD Advisory Group
May 19, 2008

John Jaros

What Jet Energy Resolution do we Need? (Old Argument)

Need clean identification of W's, Z's, H's, tops,…

This requires dijet mass resolution ≤ few GeV.

$$M_{12}^2 \approx 2E_1E_2\left(1-\cos\theta_{12}\right)$$

$$\frac{dM_{12}}{M_{12}} \approx \frac{1}{2}\left[\frac{dE_1}{E_1} \oplus \frac{dE_2}{E_2} \oplus \ldots\right]$$

Requiring $\sigma \sim \Gamma_Z$, sets dM/M = 2.5/92 = 2.7 %.

This requires

$dE_{jet}/E_{jet} = \sqrt{2}$ (2.7%) = 3.8 %, independent of E_{jet}.

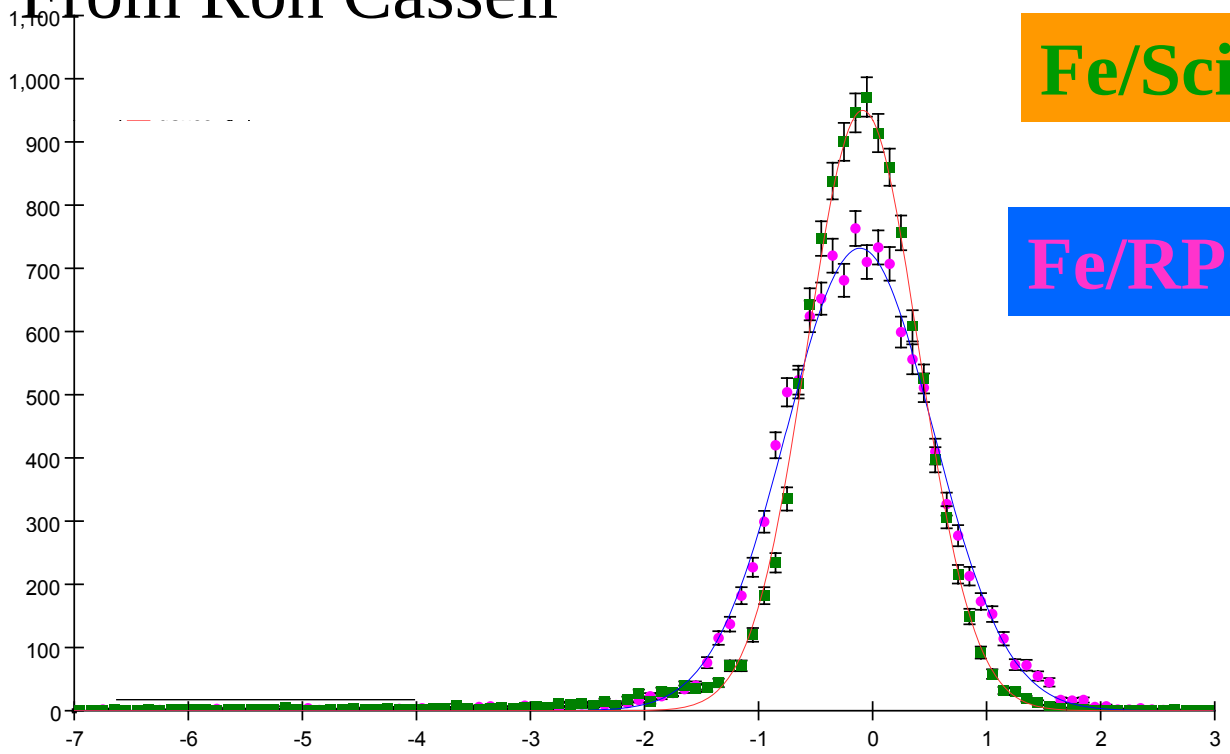
This is roughly comparable to the goal often cited,

$dE_{jet}/E_{jet} = 30\%/\sqrt{E(GeV)}$, for $E_{jet} \leq 100$ GeV.

Energy Resolution for Neutrals in Jets

ZZ 500 Gev

From Ron Cassell



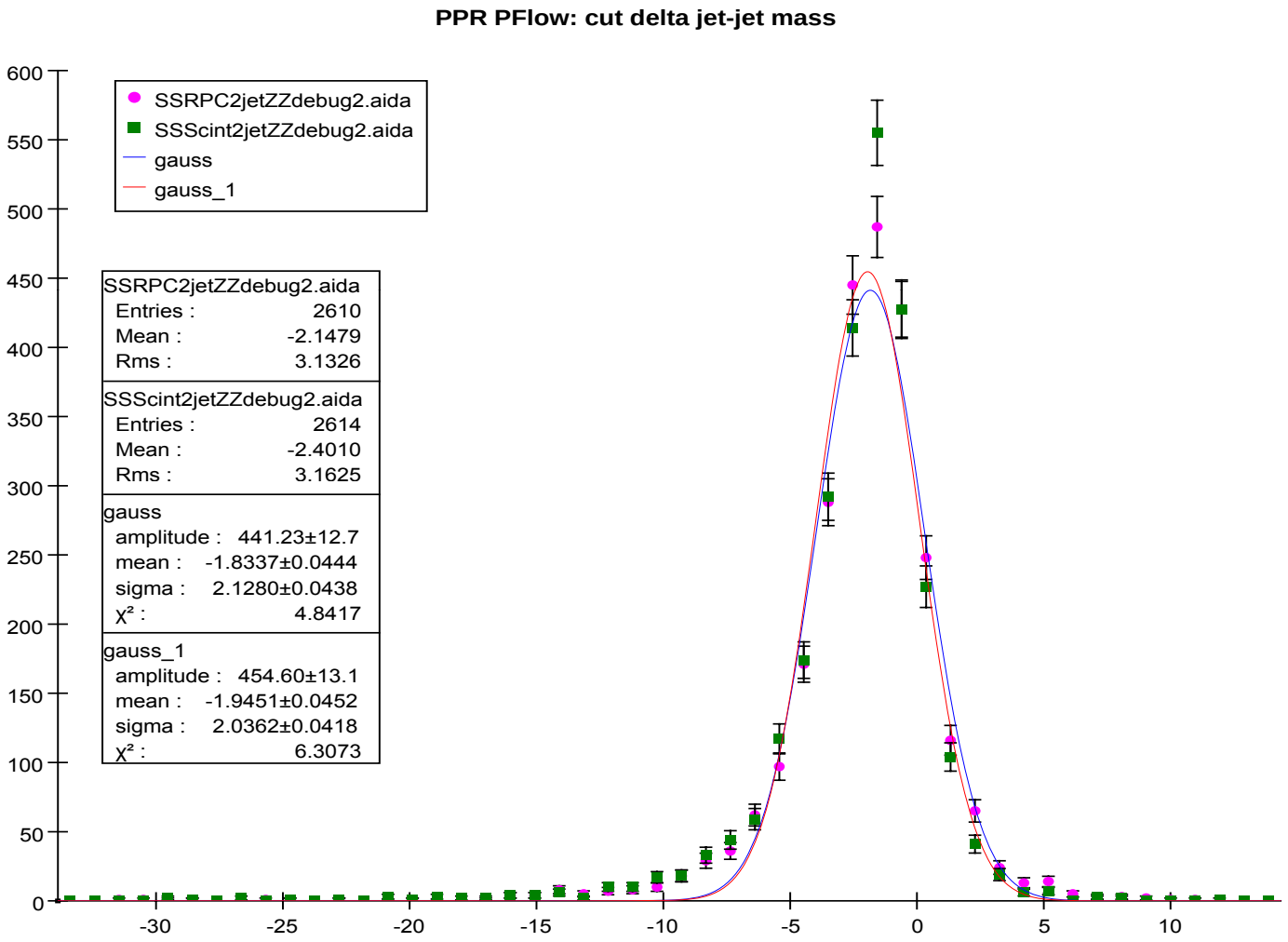
Fe/Scint α=.49

Fe/RPC α=.64

$(E^0_{meas} - E^0_{act})/\sqrt{E}$

Effect on Dijet Mass Resolution…Small

(still assuming perfect pattern reconstruction)



Requirements for Jet Energy Resolution

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SLAC
October 23, 2007

The approximate expression for the two-jet mass M is

$$M \approx 2E_1E_2(1-\cos\theta)$$

$$\frac{\Delta M}{M} \approx \frac{1}{2}\left[\frac{\Delta E_1}{E_1} \oplus \frac{\Delta E_2}{E_2}\right]$$

but the full expression is

$$M = m_1^2 + m_2^2 + 2E_1E_2(1-\beta_1\beta_2\cos\theta) \quad , \quad \beta_j = \left(1-\frac{m_j^2}{E_j^2}\right)^{\frac{1}{2}}$$

$$\frac{\Delta M}{M} \approx \frac{1}{2}\left[\frac{\Delta E_1}{E_1} \oplus \frac{\Delta E_2}{E_2} \oplus \frac{\theta\sin\theta}{1-\cos\theta}\frac{\Delta\theta}{\theta} \oplus \frac{1+r^{-1}\cos\theta}{1-\cos\theta}\frac{m_1^2}{E_1E_2}\frac{\Delta m_1}{m_1} \oplus \frac{1+r\cos\theta}{1-\cos\theta}\frac{m_2^2}{E_1E_2}\frac{\Delta m_2}{m_2}\right]$$

$$r = \frac{E_1}{E_2}$$

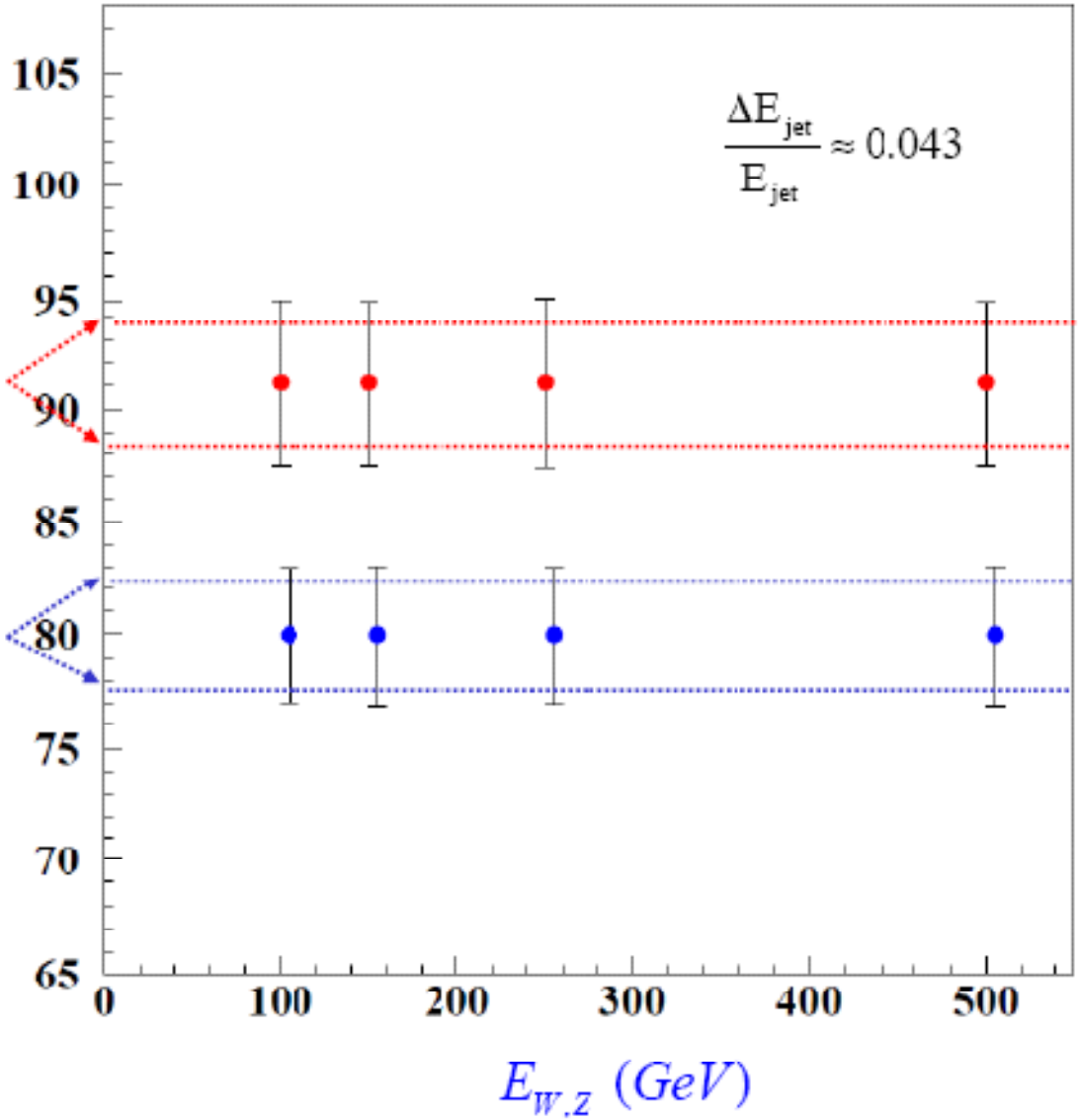
How important are the $\frac{\Delta\theta}{\theta}$, $\frac{\Delta m_1}{m_1}$, $\frac{\Delta m_2}{m_2}$ terms?

Jet Energy Resolution, Jet Angle and Mass, Jet Finding, and the intrinsic width of W's and Z's all contribute to Mass

$$\Delta M_Z = \pm\frac{1}{2}\left[\frac{\Delta E_1}{E_1}\oplus\frac{\Delta E_2}{E_2}\right]M_Z$$

$$M_{W,Z}$$

$$\Delta M_W = \pm\frac{1}{2}\left[\frac{\Delta E_1}{E_1}\oplus\frac{\Delta E_2}{E_2}\right]M_W$$



Physics Performance Improves Slowly with Jet Energy Resolution.

$BR(H \to b\bar{b}) = 0.678$

$e^+e^- \to ZHH$

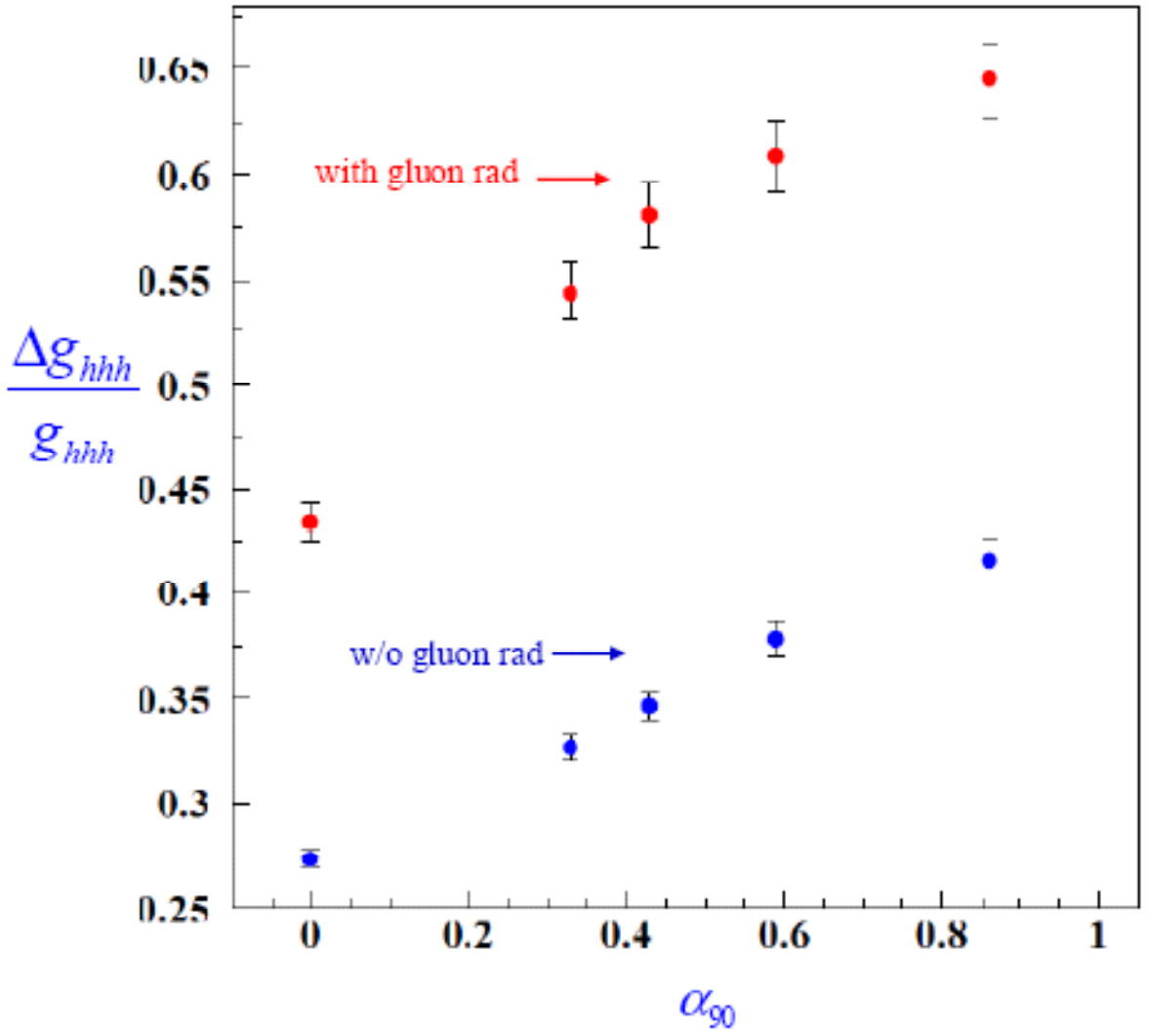
$\to qqb\bar{b}b\bar{b}$

$\sqrt{s} = 500\ GeV$

$L = 2000\ fb^{-1}$

$\Delta E/\sqrt{E} = 60\% \to 30\%$

equiv to 1.4× Lumi



More to Come

- Tim is expanding this study on contributions to dijet mass resolution.