

LC Energy, Luminosity and

Polarization Studies :

Reaches for contact interactions
(in progress)

→ How important are 'variations' in $\sqrt{s}$, $\mathcal{L}$ and P in searches for new physics ??

- New physics as "C.Int's" are the first to study....
- How is the 'reach' for different 'C.Int's' modified as $\sqrt{s}$, $\mathcal{L}$ + P are varied..?
- Even at very high lumi's, errors are approx.
stat. dominated $\Rightarrow$ scaling laws !!

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4/03

Specifics

- $\sqrt{s} = 0.5, 0.8, 1.0, 1.2 + 1.5 \text{ TeV}$
- $0.1 \leq \mathcal{L} \leq 3 \text{ ab}^{-1}$
- $P = \{ P_{e^-} = 80\%, P_{e^+} = 0 \} \quad \underline{\text{or}}$
 $\{ P_{e^-} = 80\%, P_{e^+} = 60\% \}$
- Statistical $\oplus$ $\delta P \oplus \delta \mathcal{L}$ errors included
- ISR + $\theta_{\min}$ cuts, NO Beamstrahlung
- finite efficiencies etc (flavor tagging, etc)

Total cross sections : σ_i

Angular distributions : $\frac{1}{\sigma_i} \frac{d\sigma_i}{d\cos\theta}$

Polarization asymmetries : $A_{LR}(\cos\theta)$

tau polarization : A_τ

Models

(I) Conventional 4-fermion ^{compositeness} case $\sim \frac{4\pi}{\Lambda^2} \bar{e}e\bar{e}e$
in Bhabha scattering $e^+e^- \rightarrow e^+e^-$

$$(\eta_{LL}, \eta_{RR}, \eta_{LR}, \wedge) \left\{ \begin{matrix} LL & RR & LR \\ VV & AA & \end{matrix} \right\}$$

(II) Z' exchange in $e^+e^- \rightarrow f\bar{f}$ (M_{Z_2})
($f = \mu, \tau, c, b, t$) $\{ \chi, \psi, LR, SSM \}$

(III) 5-dim SM with $\gamma + Z$ KK towers
($f = \mu, \tau, c, b, t$) (M_c)

(IV) KK graviton exchange in ADD [RS]
($f = \mu, \tau, c, b, t$) (M_H)

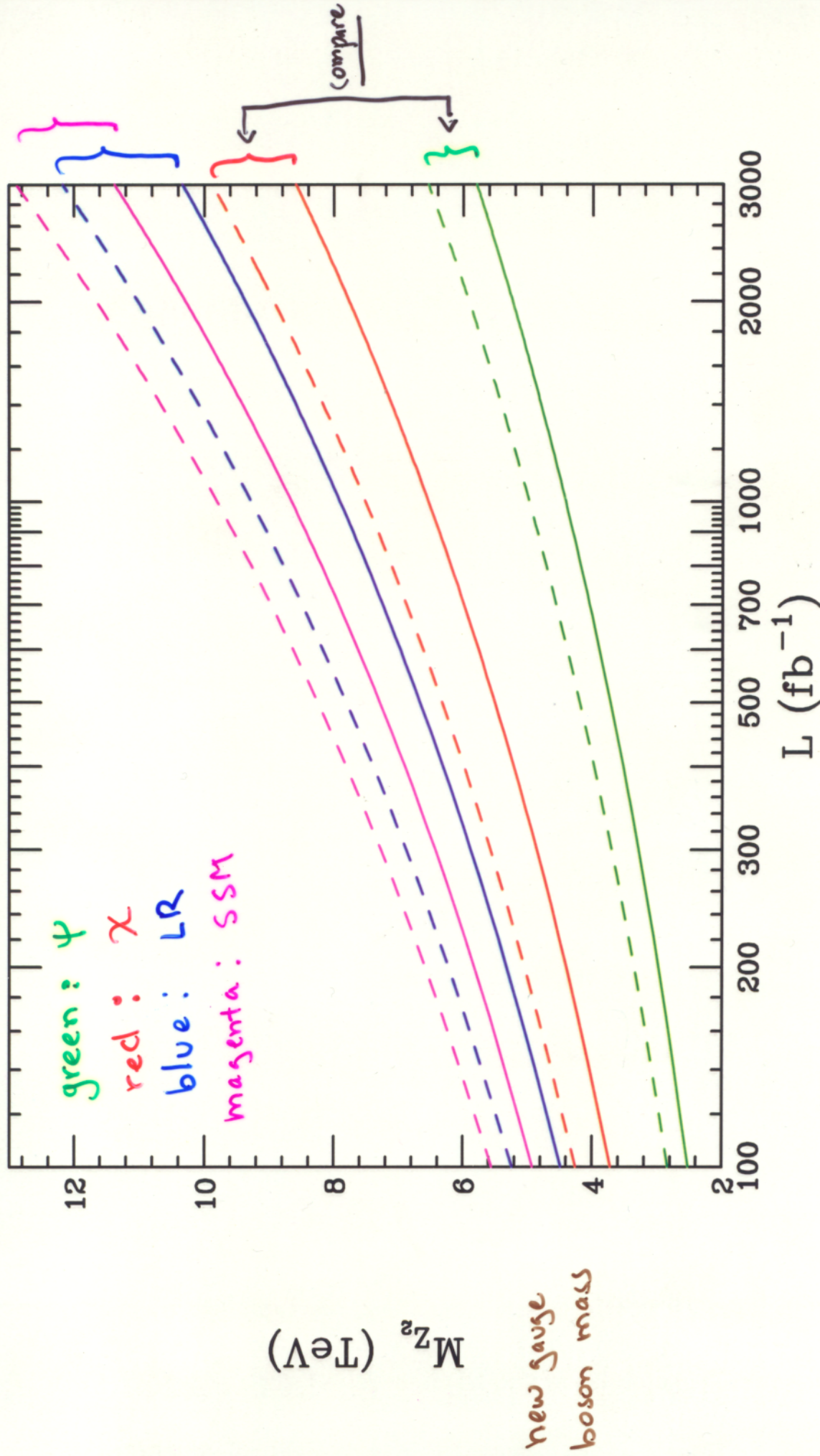
→ A wide spectrum of couplings + behaviors...

⇒ Lots + Lots of PLOTS

Solid: 80%
dash: 80 + 60%

$\sqrt{s} = 500 \text{ GeV}$

95% CL



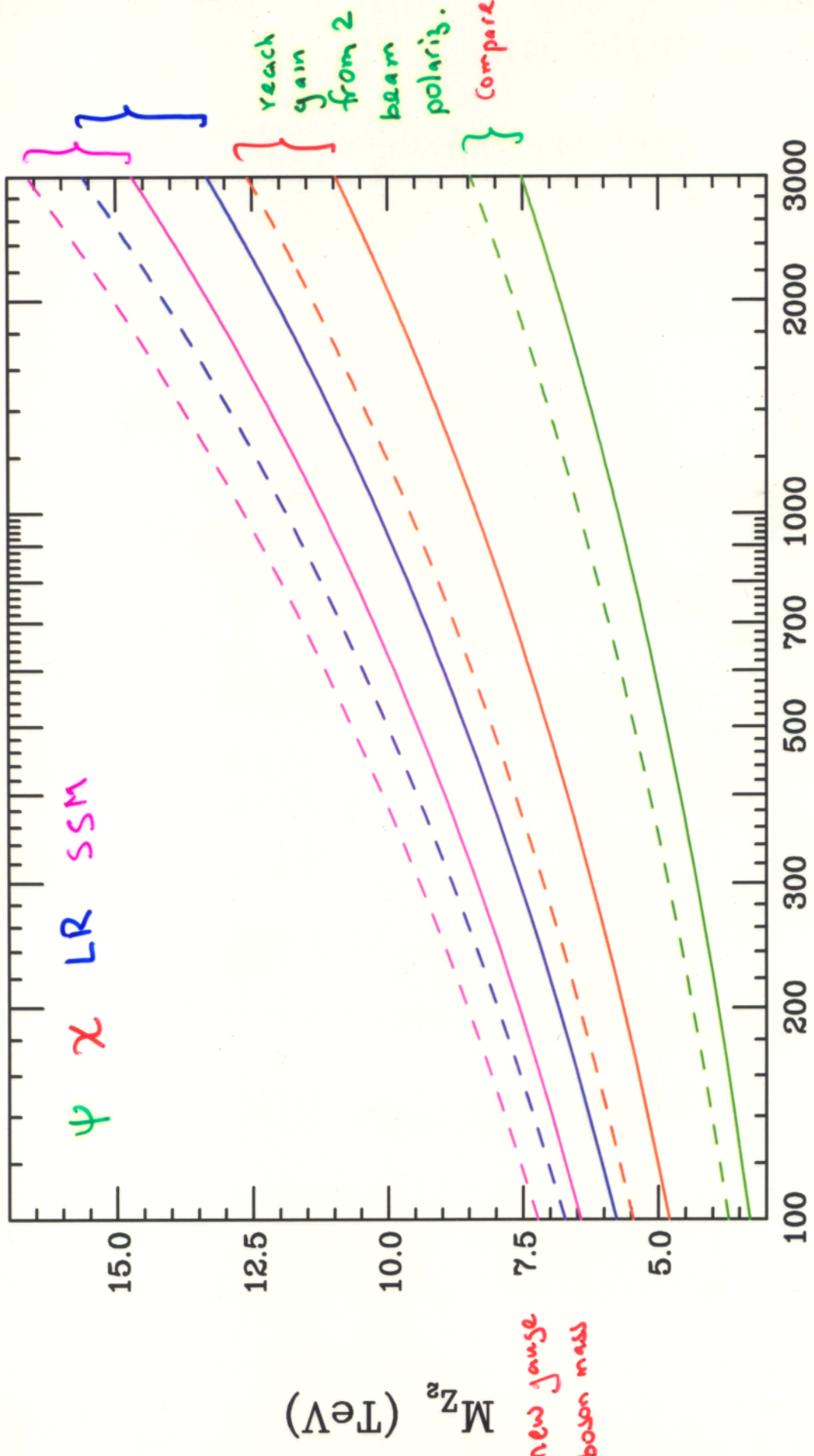
'Extra lumi = ? 2 beam polarization'

Model dependence of gain w/ lumi + 2 beam polarization.

Solid : 80%
 dash : 80+60%

$\sqrt{s} = 800 \text{ GeV}$

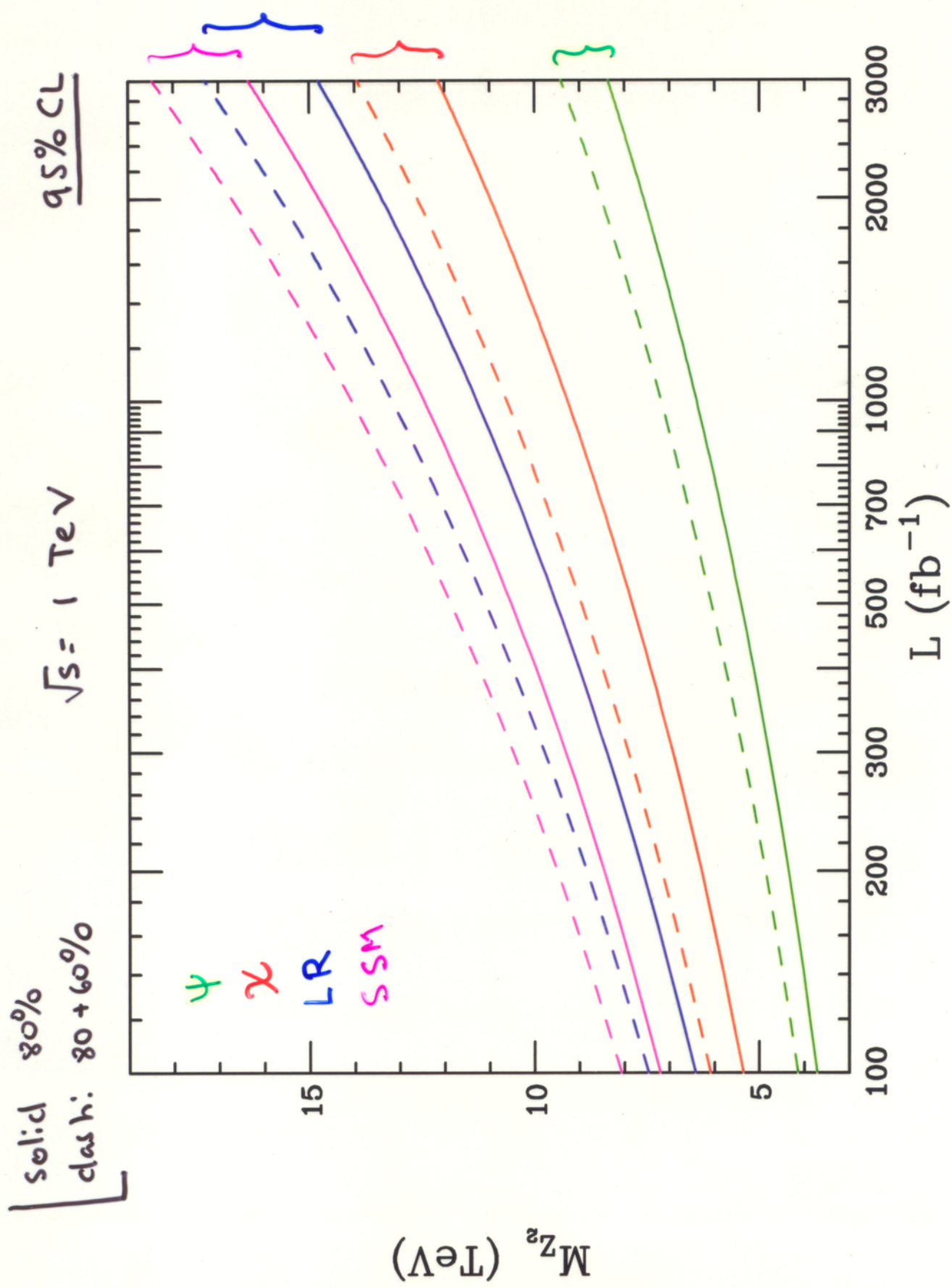
95% CL



$L \text{ (fb}^{-1}\text{)}$

Extra lumi = ?
 2 beam polarization
 → model dep. σ gain

M_{Z_2} reach grows with $\sqrt{s}$

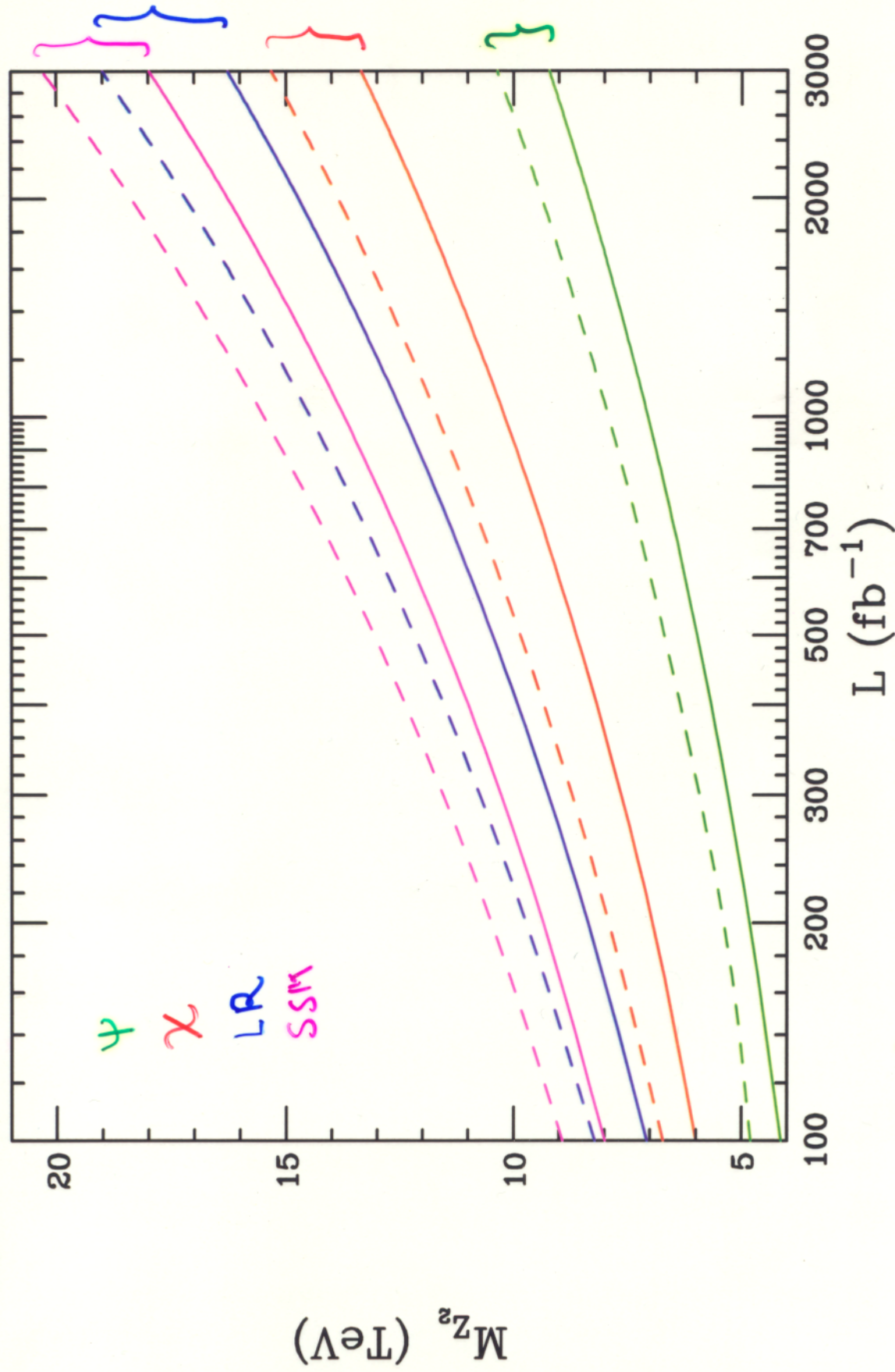


For fixed $\sqrt{s}$, Reach $\sim L^{1/4}$ when stat. errors dominate
 Indep. of Polarization

clash: 80+60%
solid: 80%

$\sqrt{s} = 1.2 \text{ TeV}$

95%CL

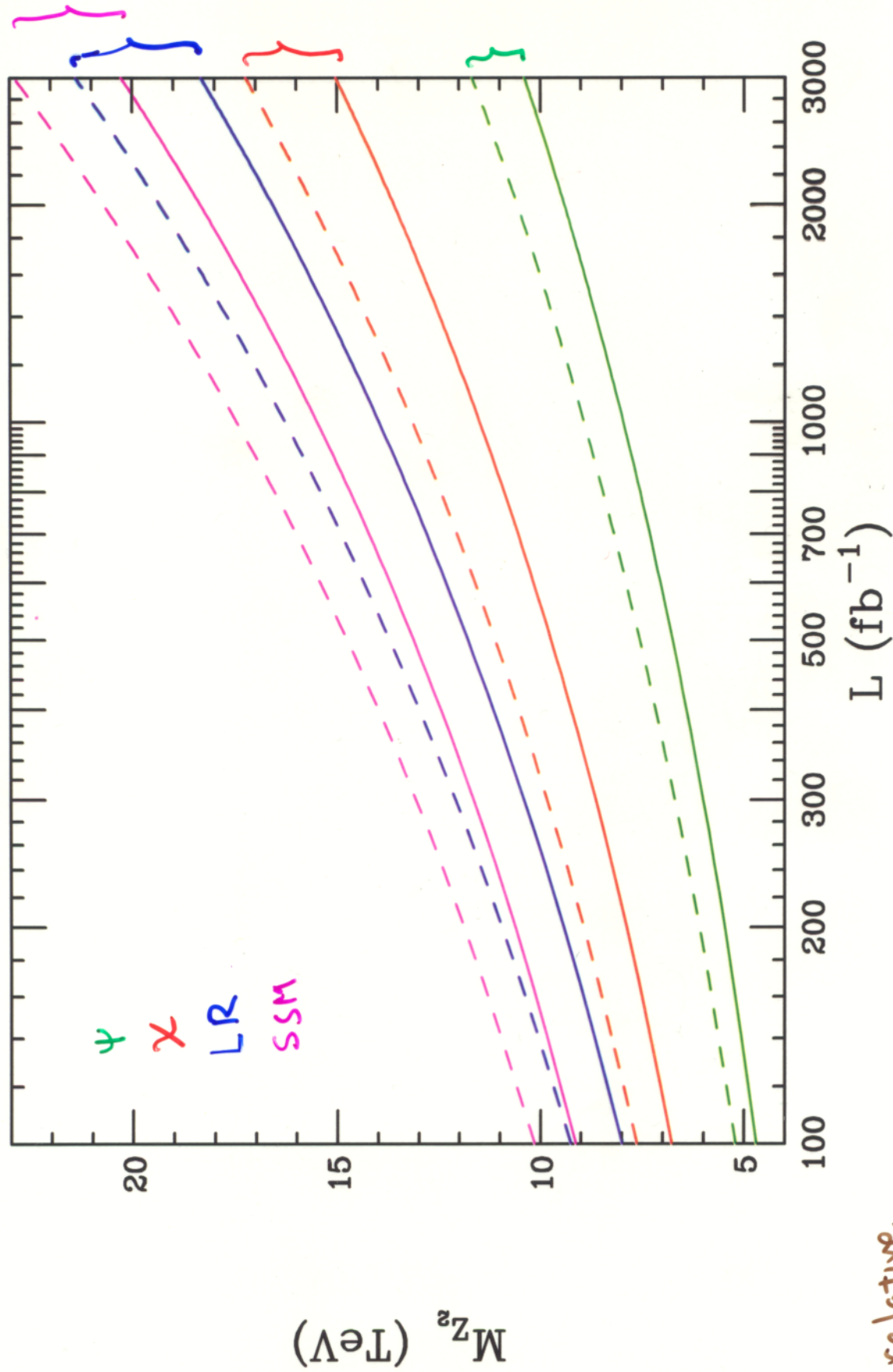


For fixed lumi, reach $\approx (\sqrt{s})^{1/2}$

solid : 80%
dash : 80+60%

$\sqrt{s} = 1.5 \text{ TeV}$

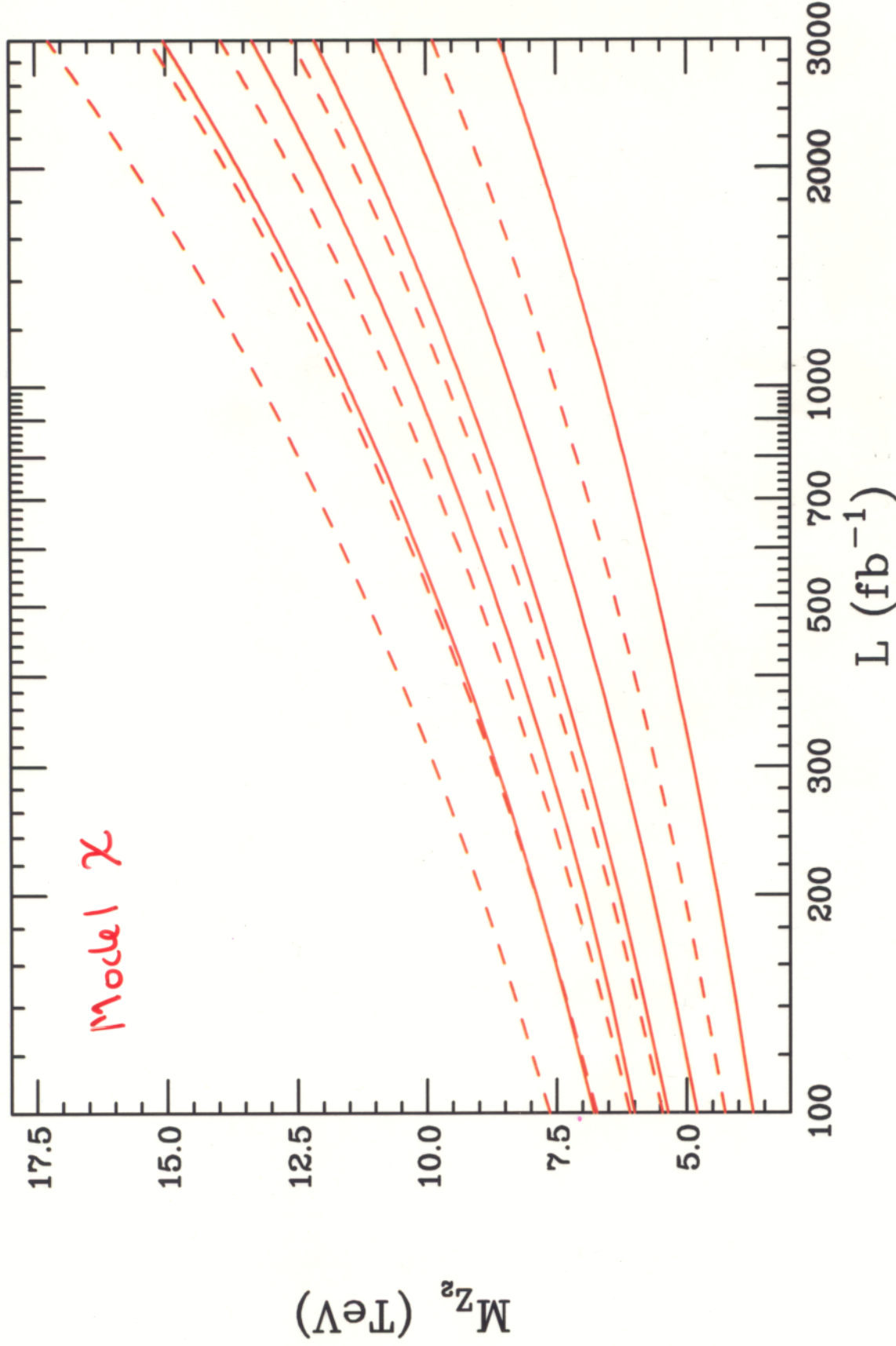
95%CL



relative
Incremental gain from 2 beam polarization is $\approx \sqrt{s}$ independent.

Solid: 80%
dash: 80+60%

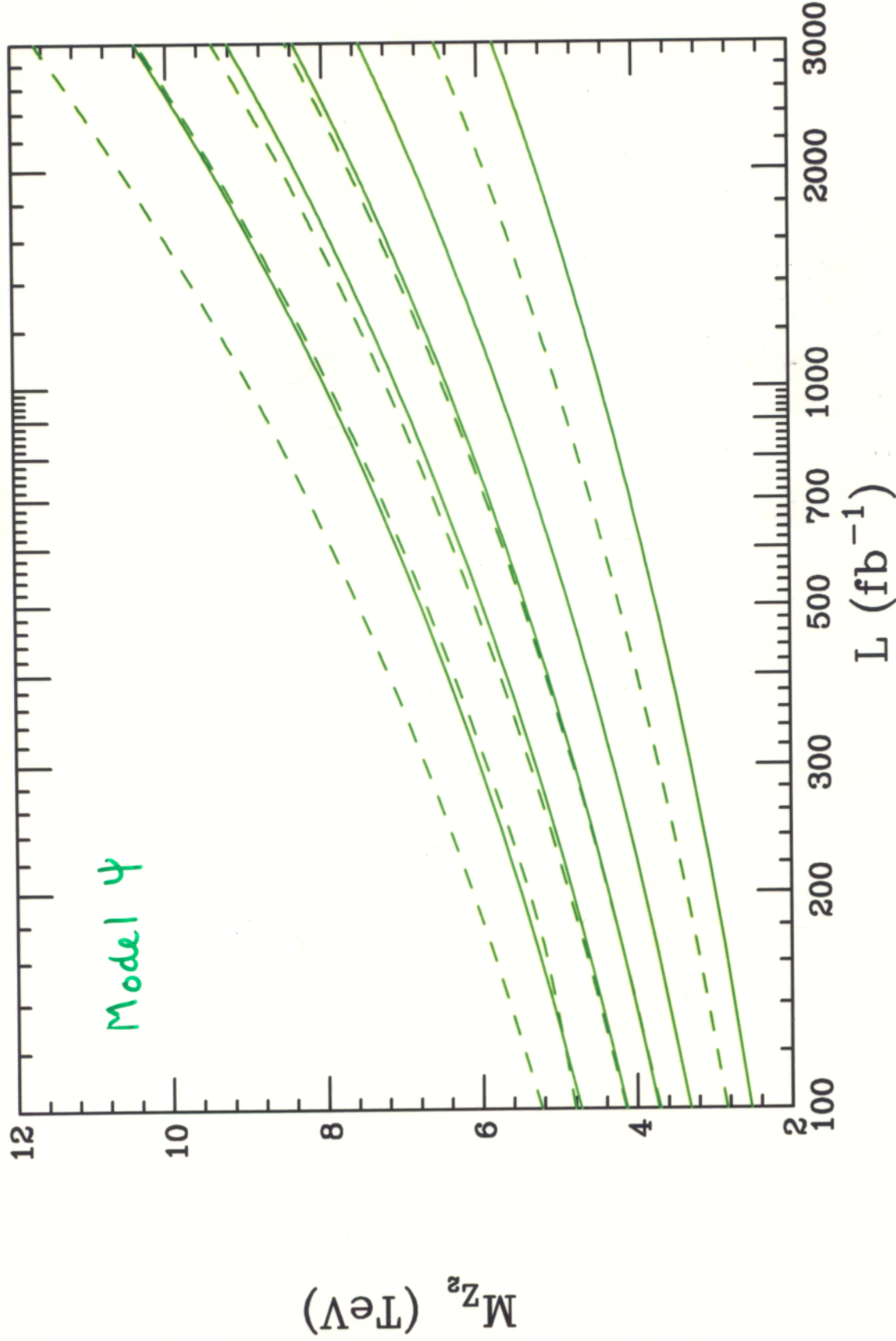
95%CL



reach $\sim (sL)^{1/4}$ when stat. dominated
good approx to what is found

solid 80%
dash: 80+60%

95%CL

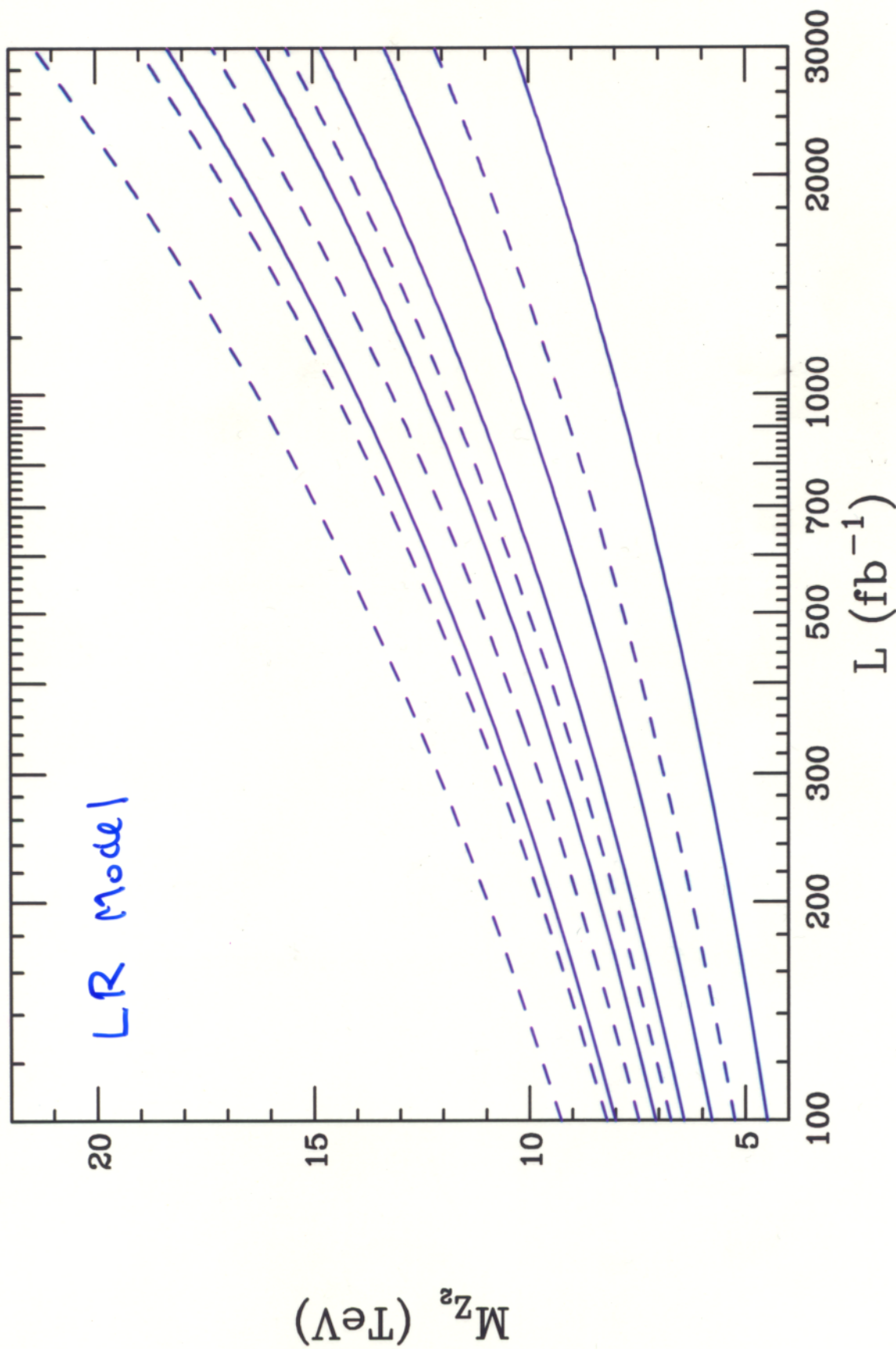


reach $\approx C_i [sL / (1+r_i^2)]^{1/4}$
model) $\leftarrow$ systematics

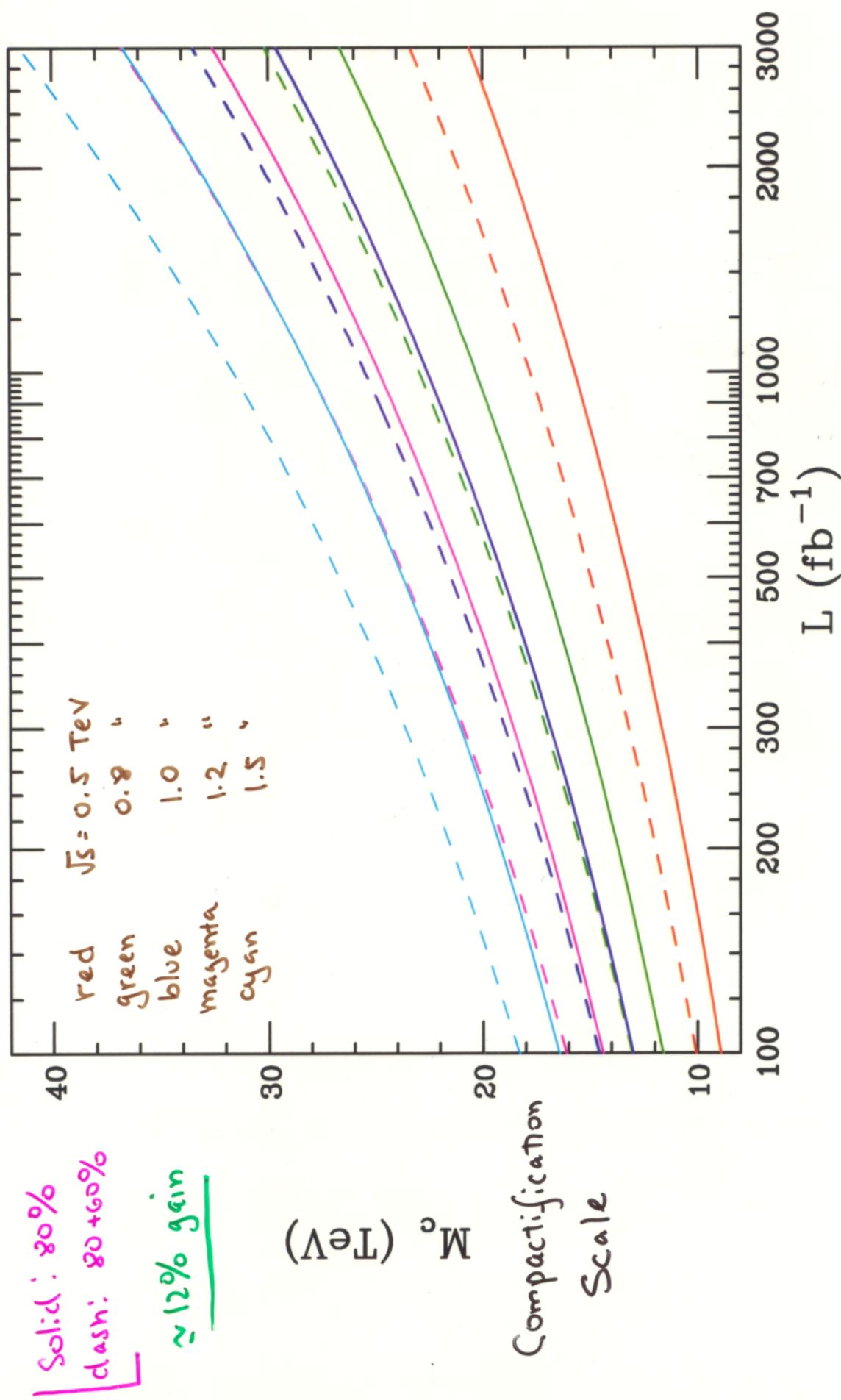
solid 80%
dash: 80+60%

95%CL

LR Model



KK gauge bosons SD SM 95%CL



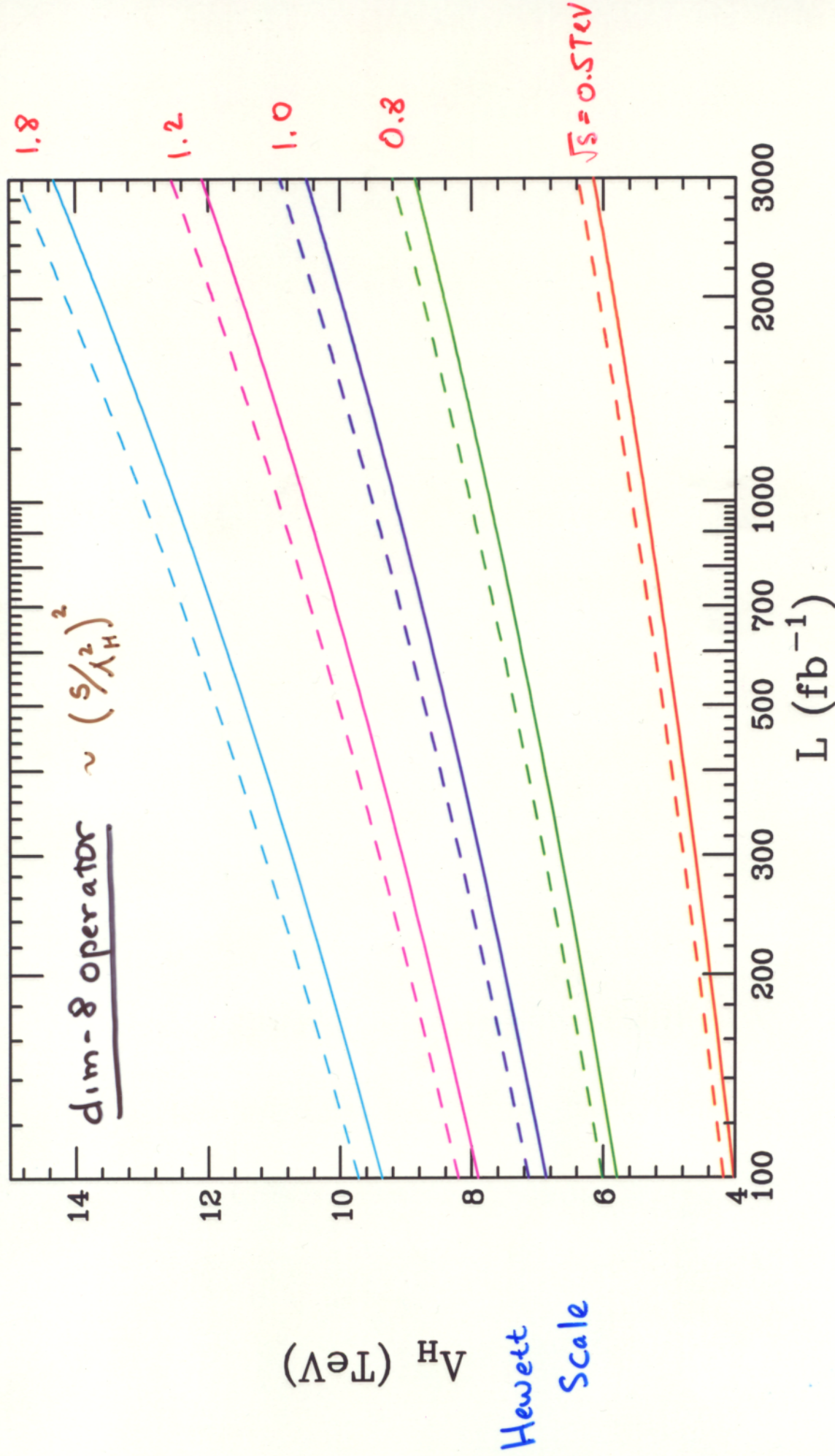
Again, reach $\approx (sL)^{1/4}$

slightly different slopes seen.

Solid: 80%
dash: 80+60% {+5%}

ADD Model

95% CL



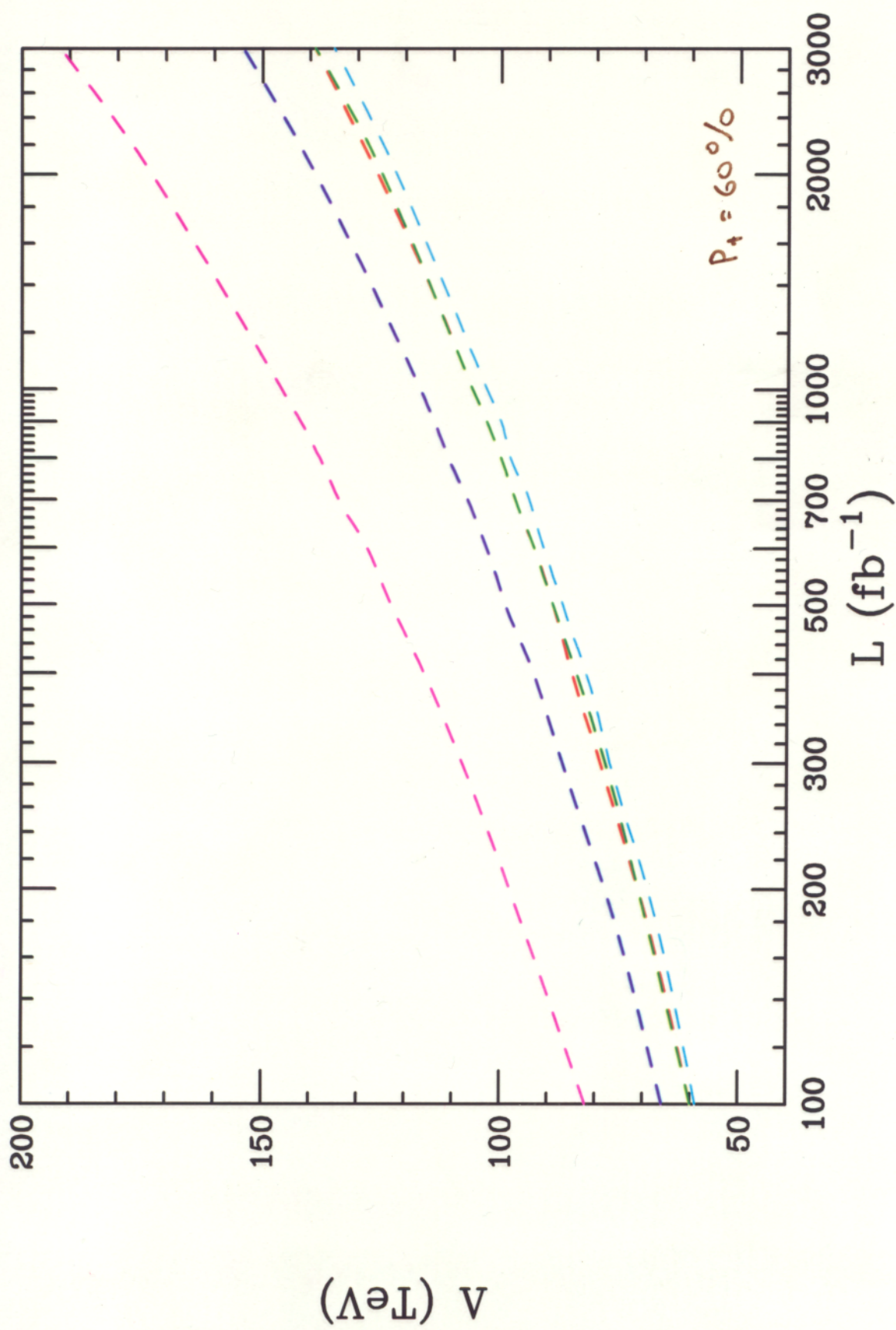
Hewett
Scale

$$O \sim \left(\frac{s}{\Lambda_H^2} \right)^d$$

$$\rightarrow \text{Reach} \sim (s^{2d-1} L)^{\frac{1}{4d}} \quad (d=2) \rightarrow \sim (s^3 L)^{\frac{1}{8}}$$

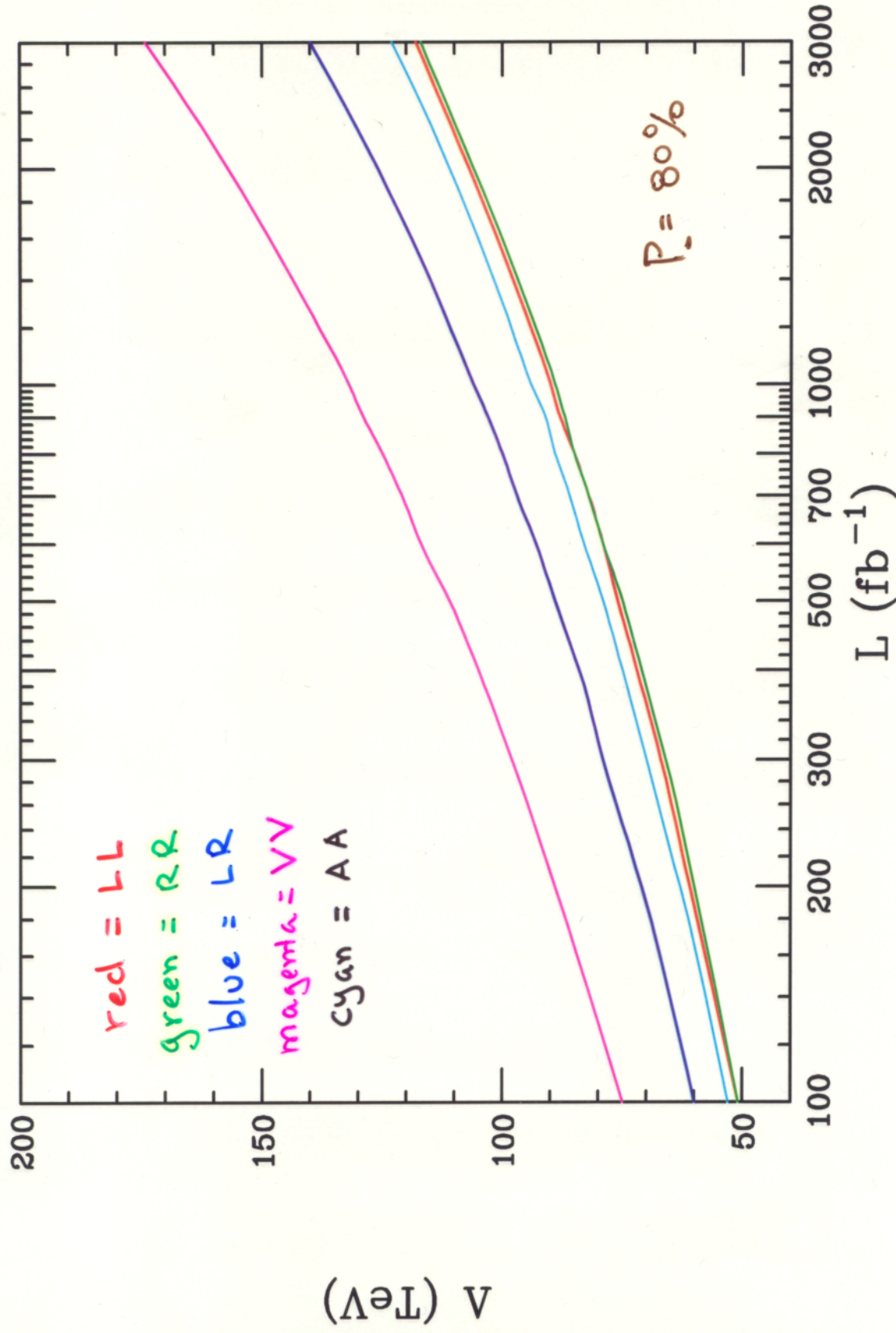
[if stat. dominated]

OK! ✓



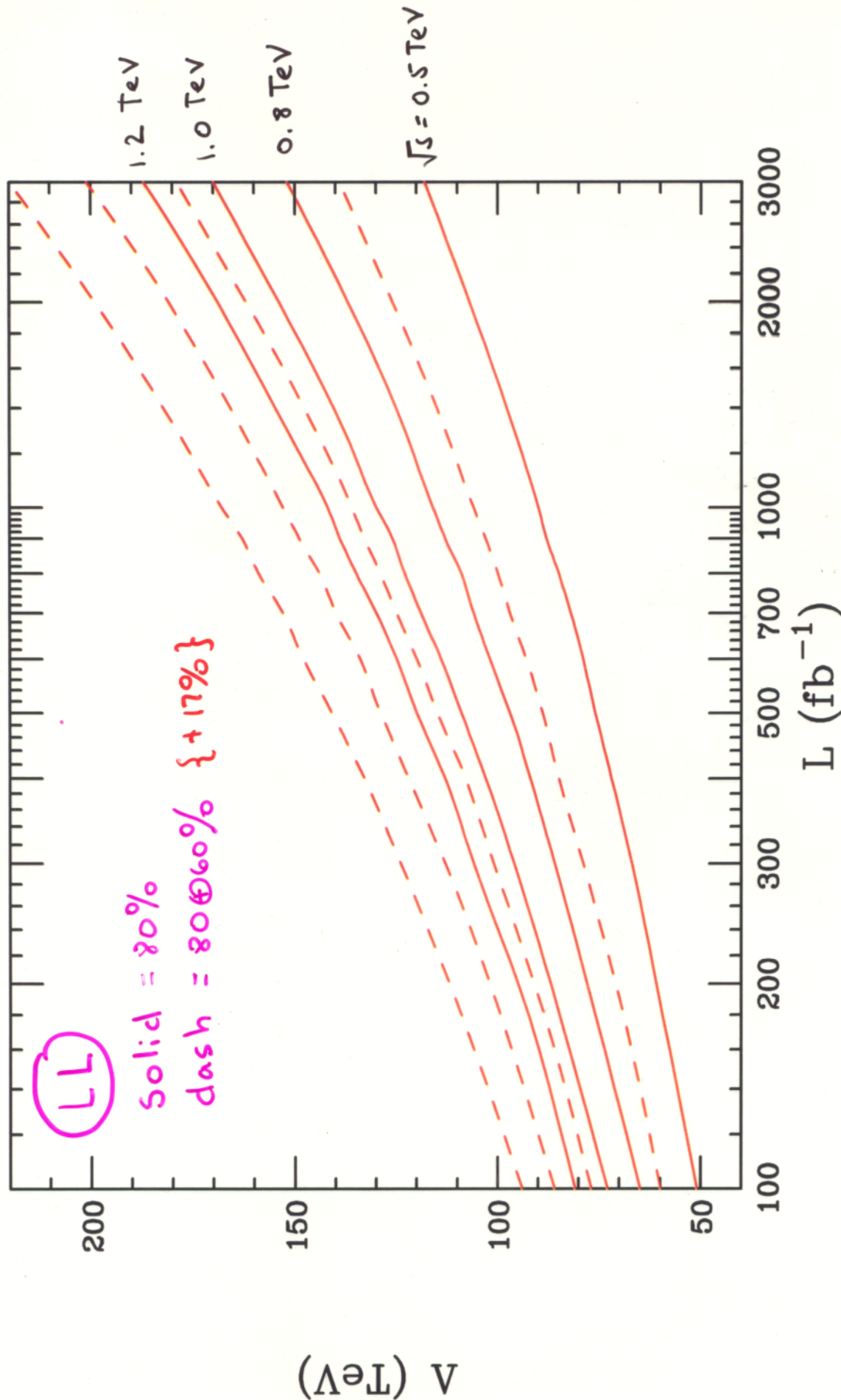
'Gain' from $80 \rightarrow 80 \oplus 60$ model dependent

$\sqrt{s} = 500 \text{ GeV}$ 95% CL



- Reach is quite coupling sensitive
 - 'Slope' w/ L has weak coupling dependence
- reach $\sim L^{1/4}$

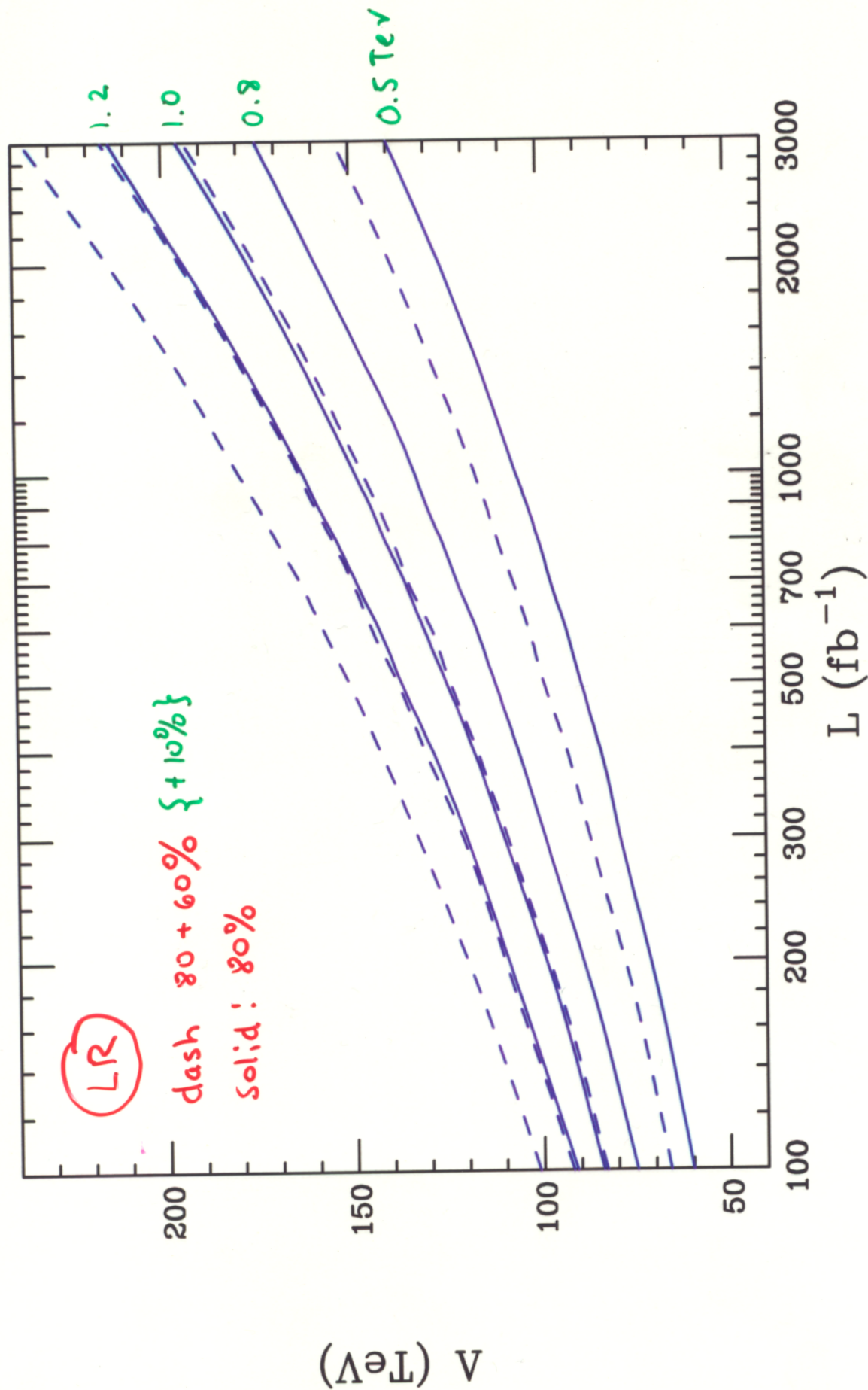
95%CL



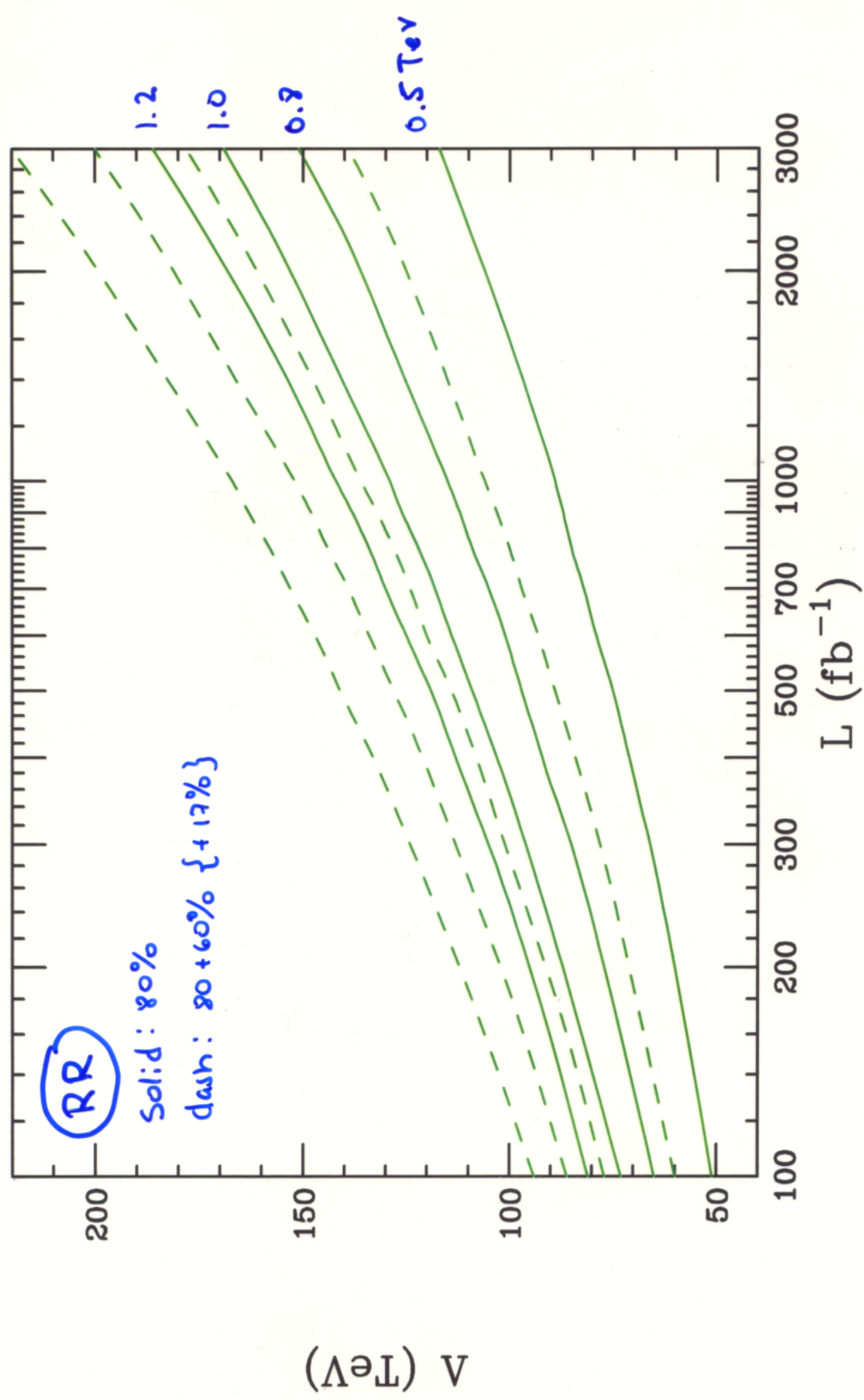
Reach $\sim (\sqrt{s})^{1/2} L^{1/4}$

repeats itself for all other cases

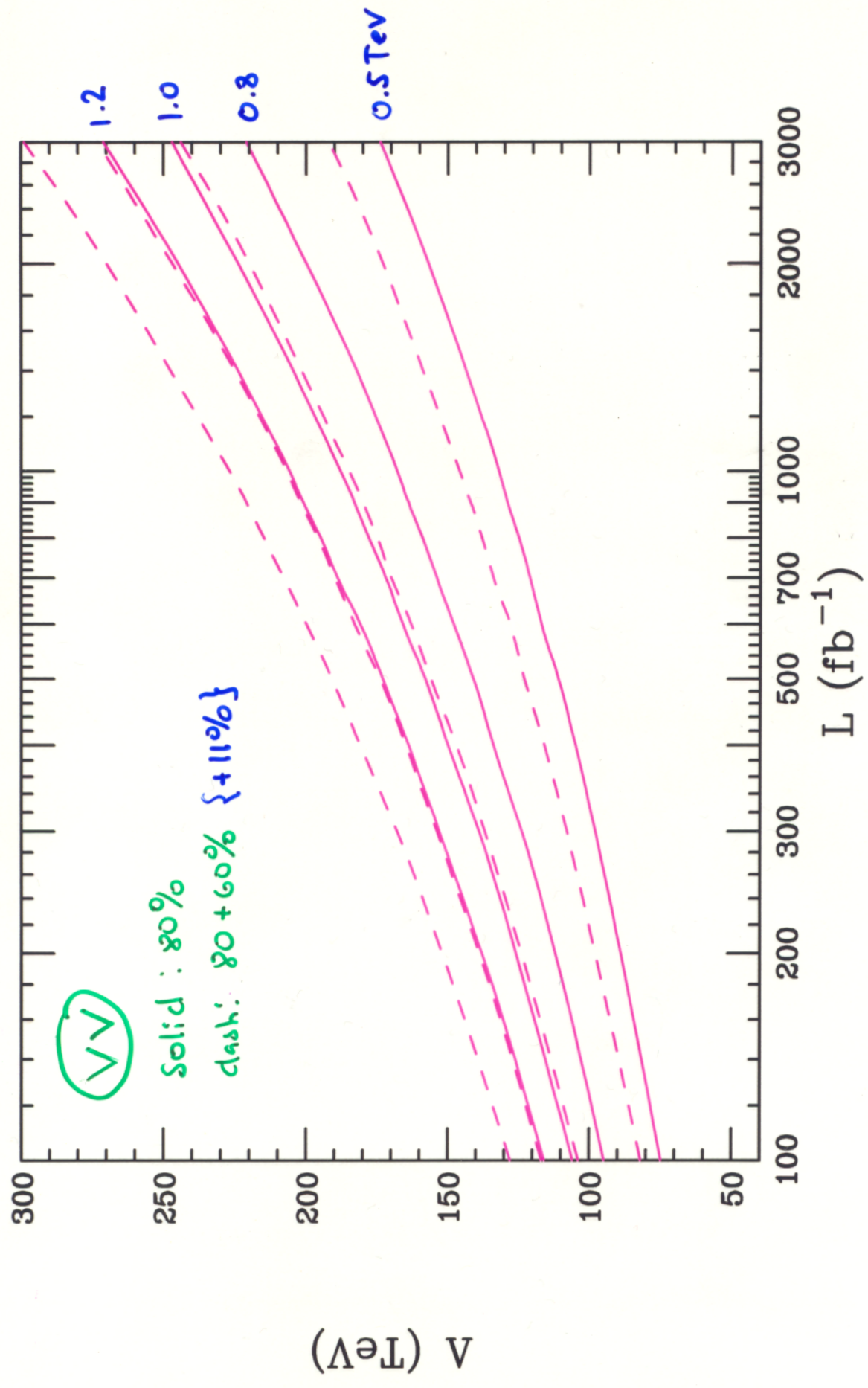
95%CL



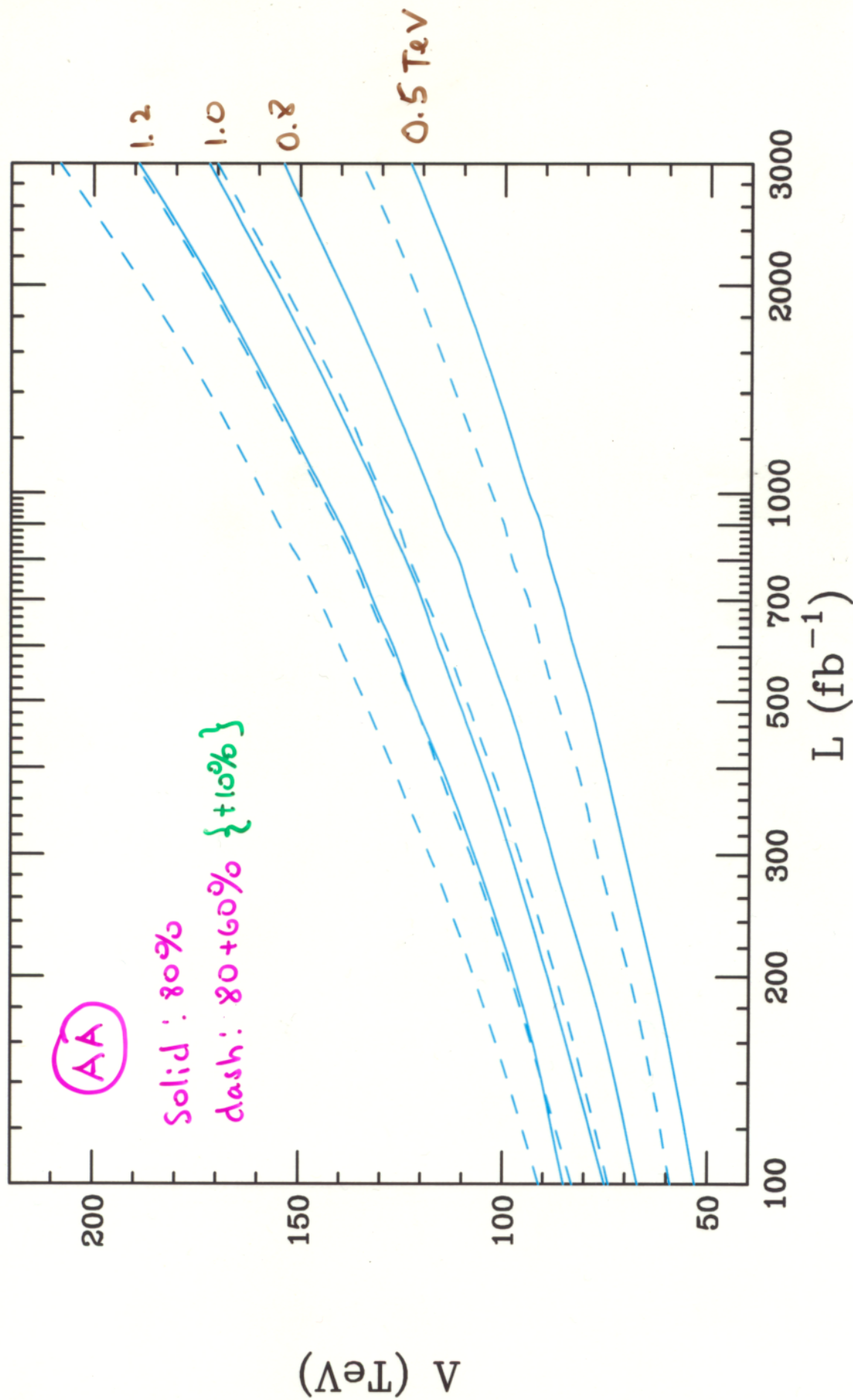
95%CL



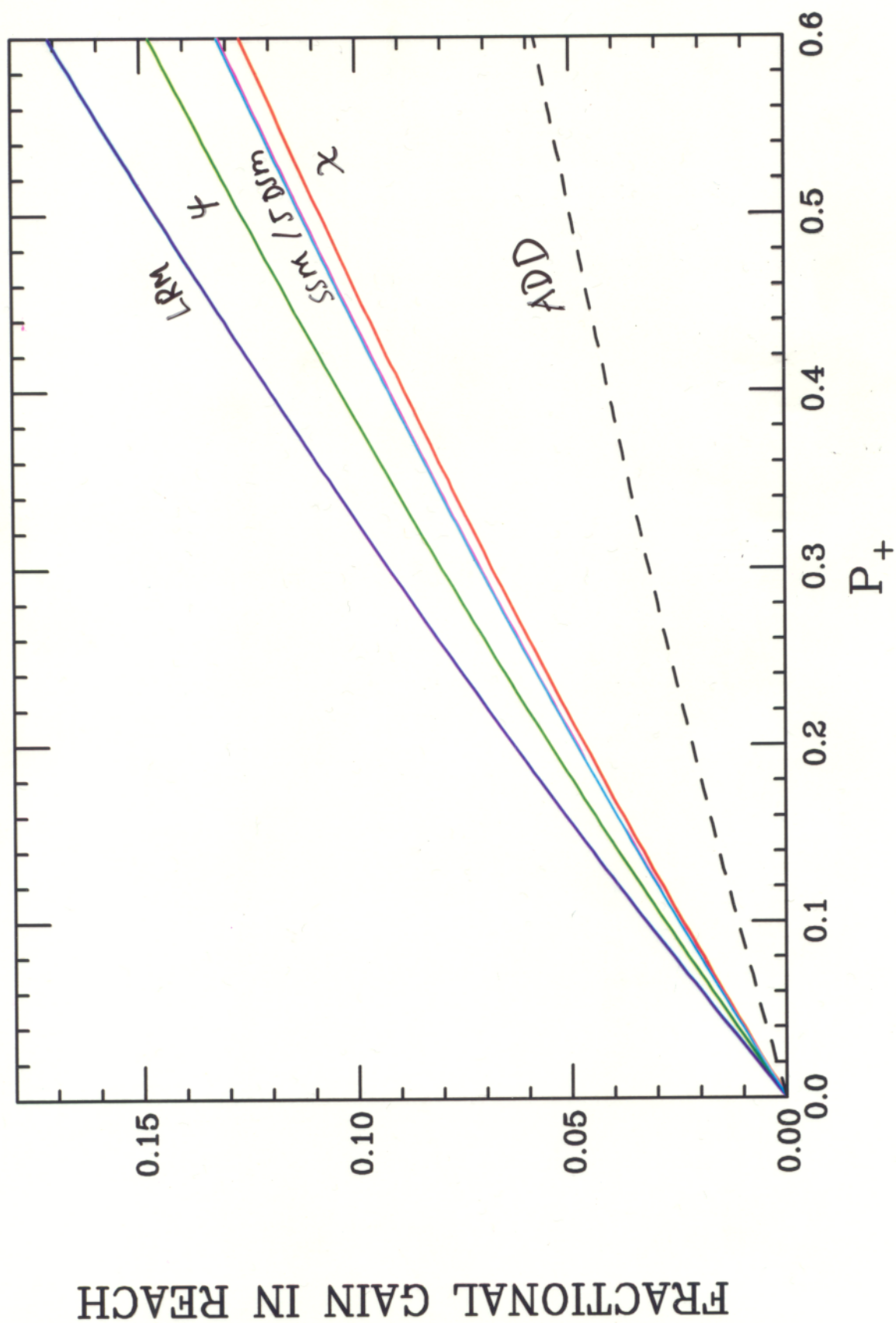
95% CL



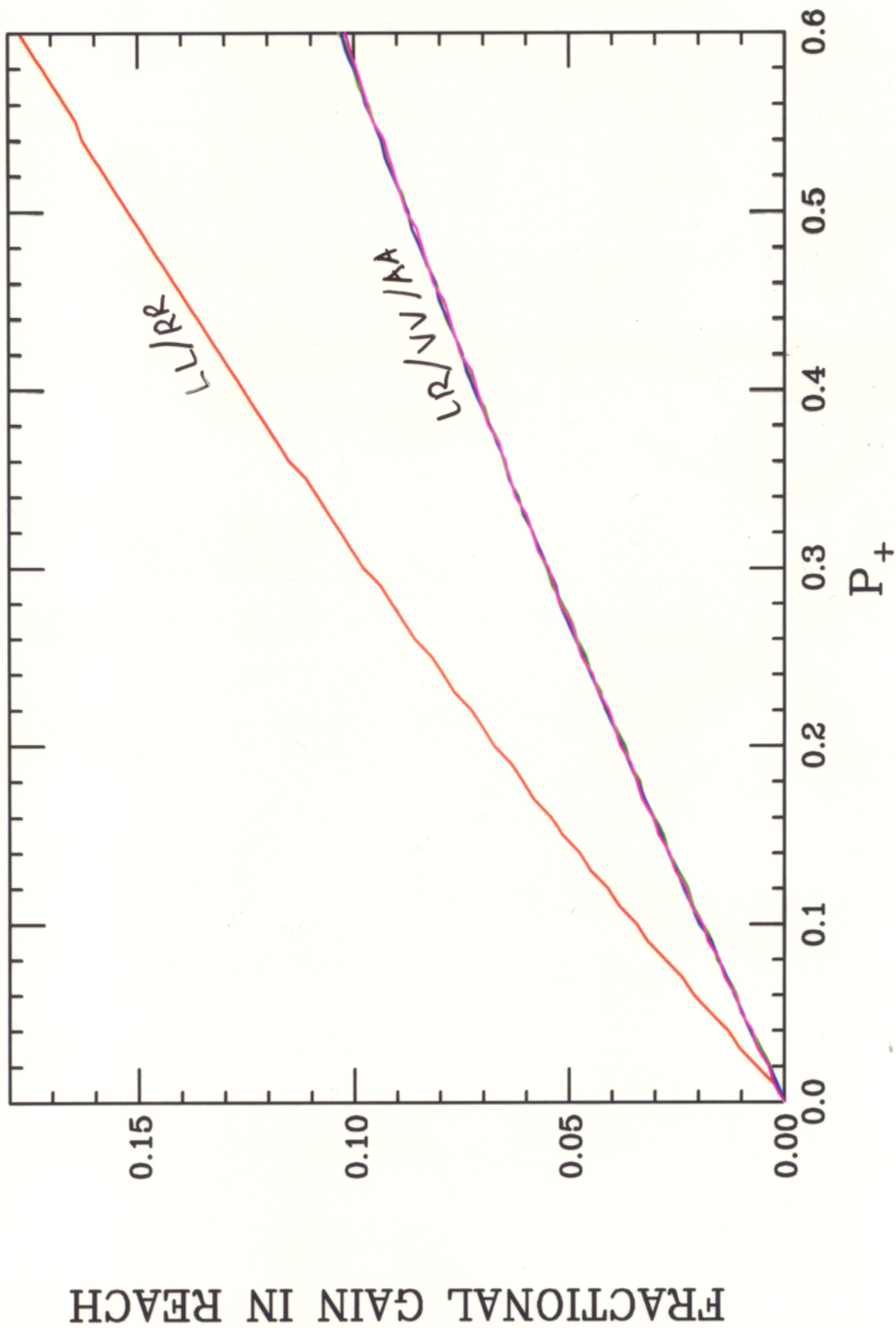
95%CL

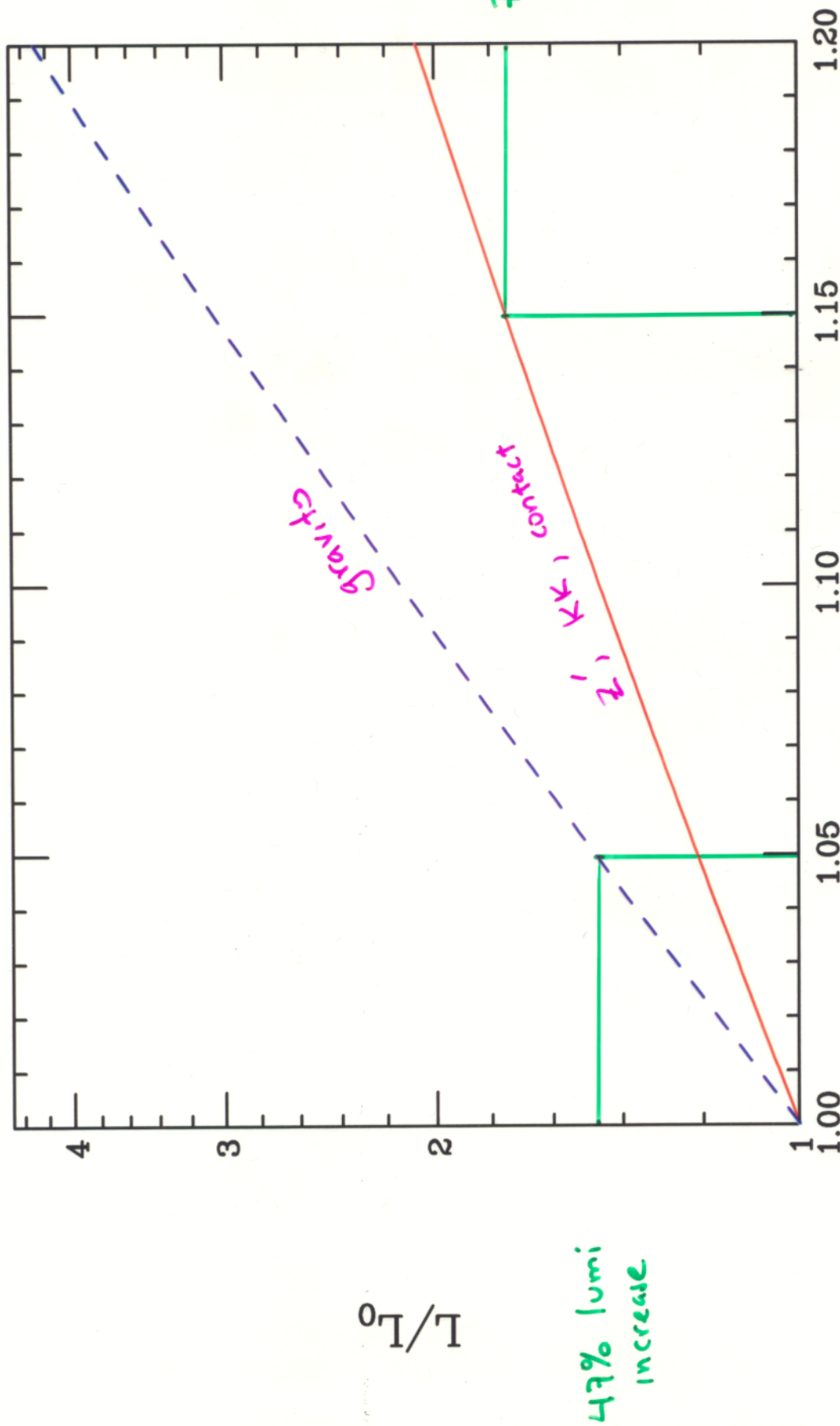


s-channel

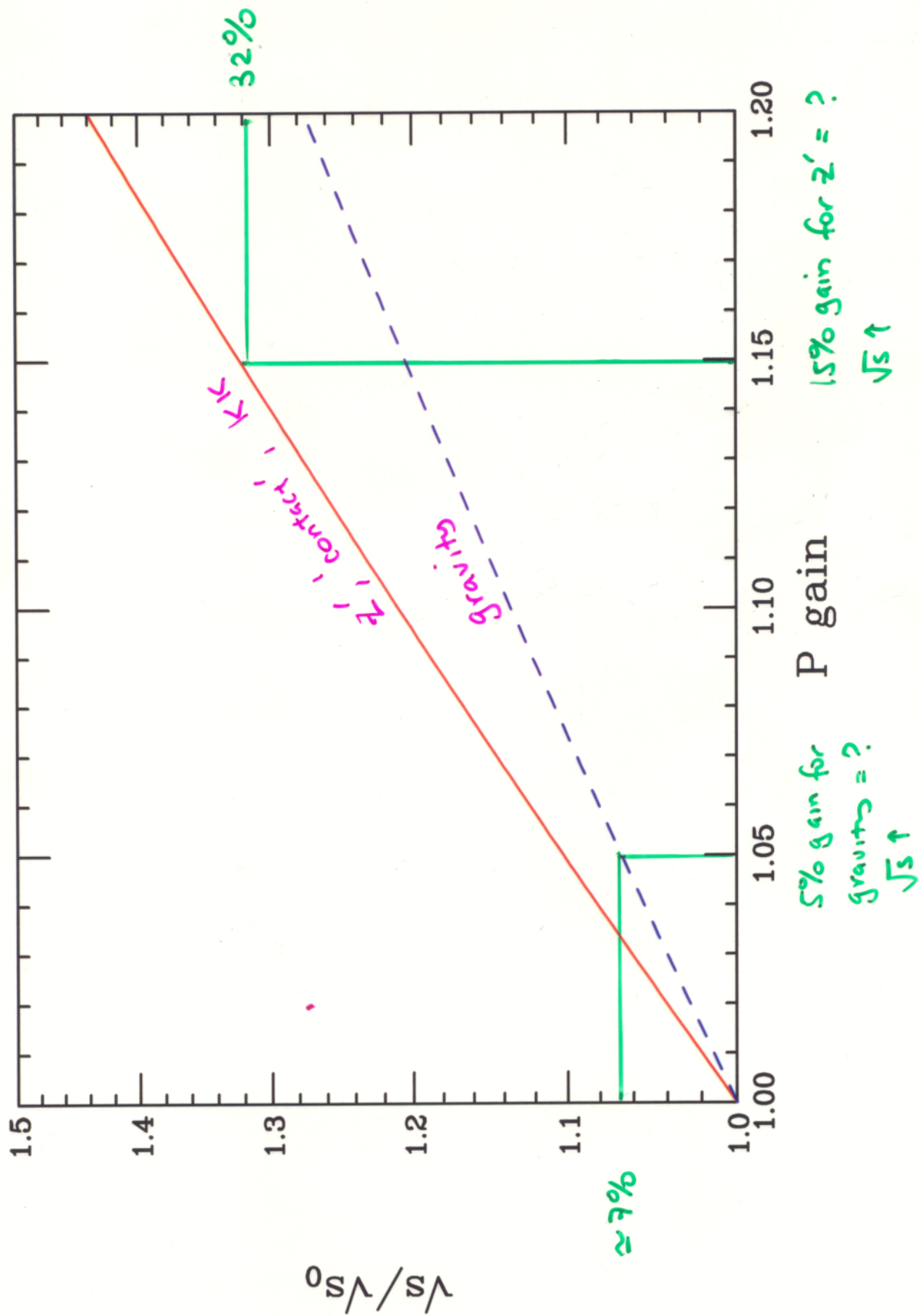


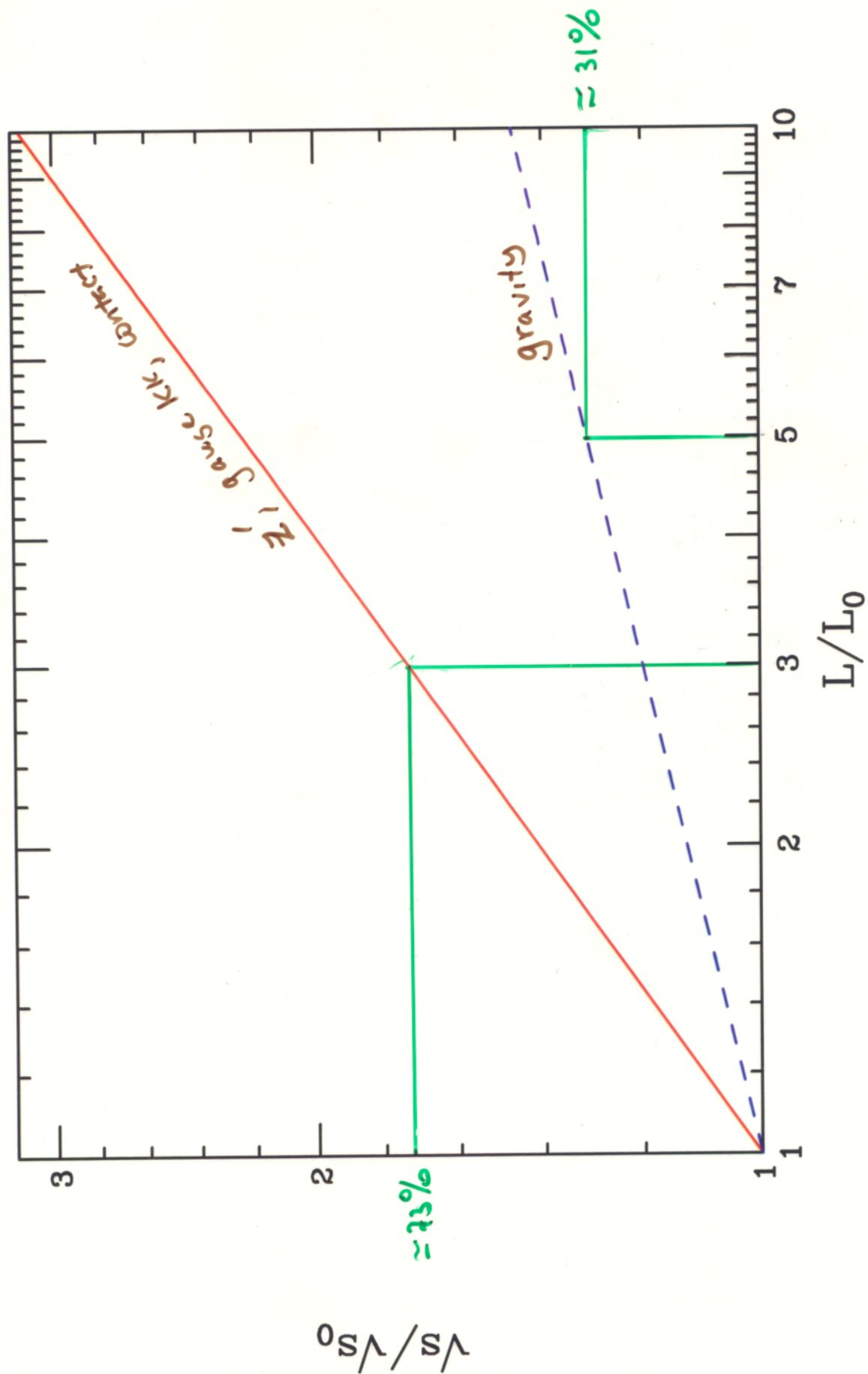
Bhabha Scattering





15% gain from z'
 $80 \rightarrow 80 + 60\%$ for z'
 is = how much more lumi
 ?





Examples:

Suppose we want to know, for a LRM z' , what effect there is on the reach by $P_t: 0 \rightarrow 50\%$

$\rightarrow \approx 15\%$ increase
Figs

$$\begin{array}{l} \text{Figs} \rightarrow \left\{ \begin{array}{l} \approx 75\% \text{ increase in } L \quad \underline{\text{or}} \\ \approx 32\% \quad \quad \quad \quad \quad \quad \sqrt{s} \end{array} \right. \end{array}$$

For ADD? $\rightarrow$ reach increase is $\approx 5\%$

$\approx 47\%$ increase in L or

$\approx 7\%$ increase in $\sqrt{s}$

IF I have ADD + increase L by a factor of 5,
what increase in $\sqrt{s}$ is this equivalent to?

$\approx 31\%$ increase

Summary (so far)

- Reaches for the 4 model classes studied show approx. dominance of statistical errors $\rightarrow$ appropriate scaling law:

$$\mathcal{O} \sim \left(\frac{s}{M^2}\right)^d, \quad \text{Reach} \sim (s^{2d-1} L)^{\frac{1}{4d}}$$

$d=1$ (dim-6) for Z' , gauge KK, conventional cont. ints

$$\text{Reach} \sim (sL)^{1/4}$$

$d=2$ (dim-8) for gravity

$$\text{Reach} \sim (s^3 L)^{1/8}$$

- For fixed $\sqrt{s} + \mathcal{L}$ adding 2 beam 80+60% to 1 beam 80% polarization increases reach by

5-18%

depending on model details

