Gluinos in Split

hep-ph/0504210
hep-ph/0506242

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Susy 2005 July 22, 2005

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Scales in Split Susy

$M_{\rm Pl.}$ 10^{16} TeV

Scalars
(Squarks, sleptons, ...)

$M_{\rm susy}$? { 10^{15} TeV, 10 TeV

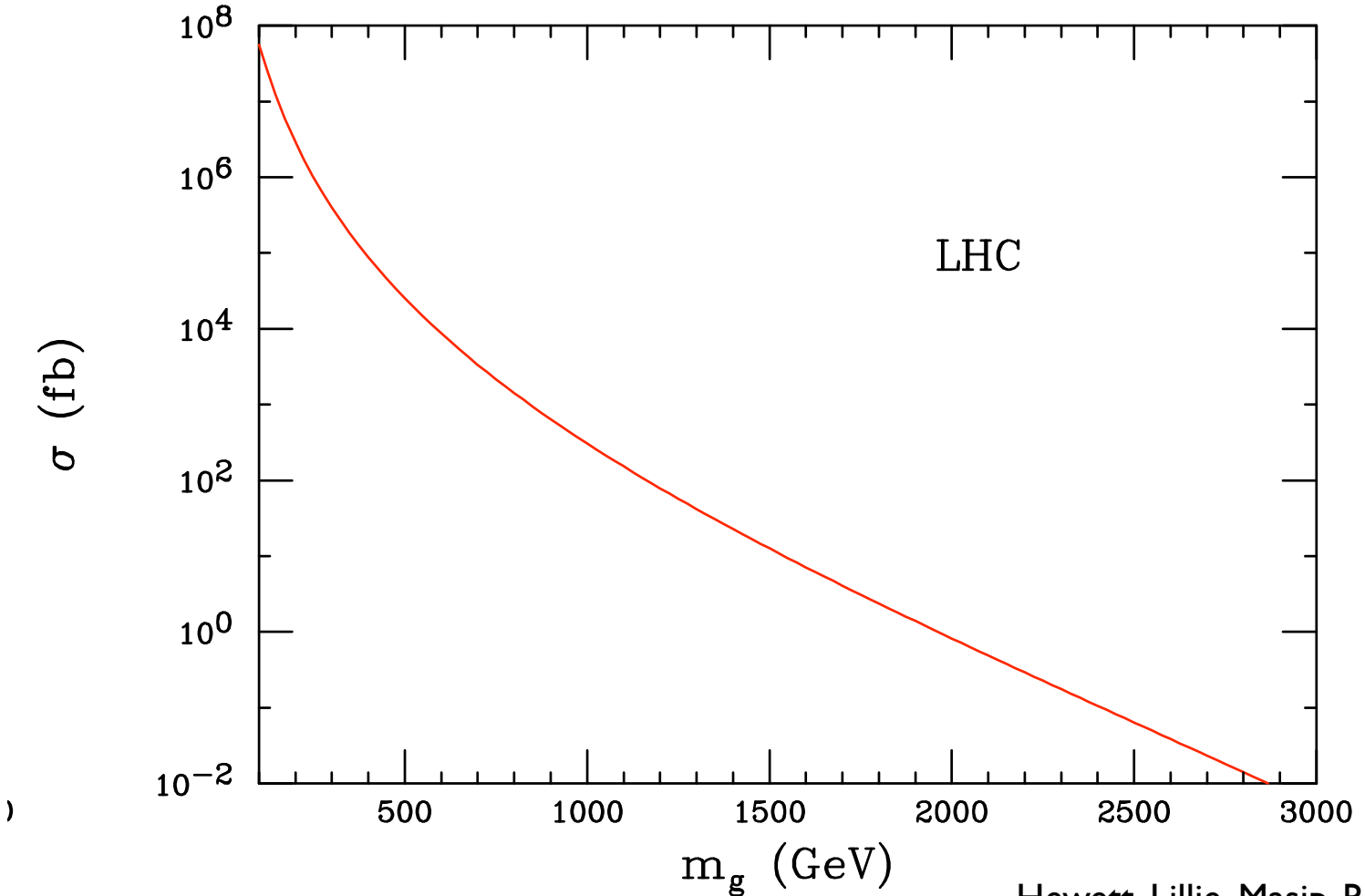
Fermions
(Higgsinos, gauginos)
+SM Higgs

$M_{\rm weak}$ ~ 1 TeV

$M_{\rm CC}$ 10^{-15} TeV

Gluinos are windows to Split Susy

Only coloured particle

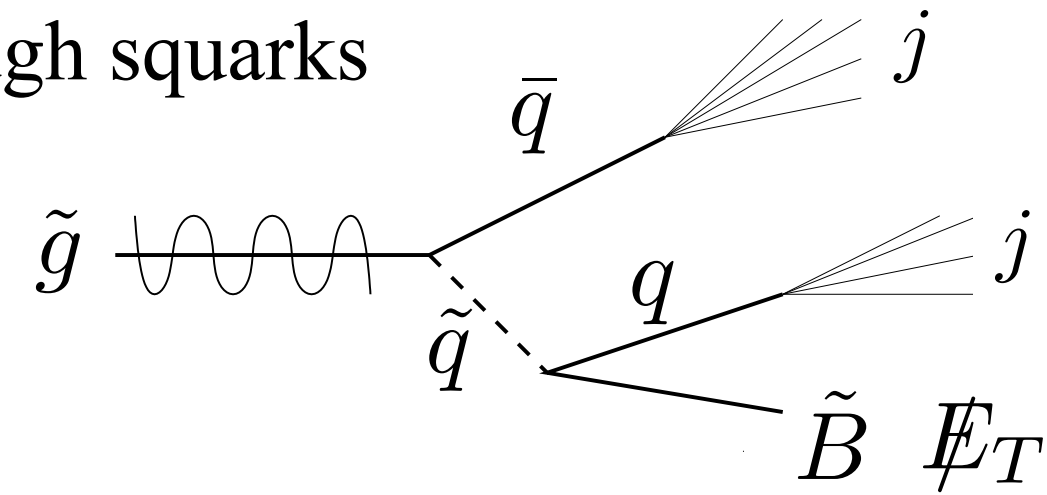


Hewett, Lillie, Masip, Rizzo hep-ph/0408248

Gluinos are windows to Split Susy

Are long lived

Must decay through squarks



$$\tau_{\tilde{g}} \simeq 2 \text{ sec.} \left(\frac{350 \text{ GeV}}{m_{\tilde{g}}} \right)^5 \left(\frac{M_{\text{Susy}}}{10^6 \text{ TeV}} \right)^4$$

Limits on $\tau_{\tilde{g}}$ places limits on M_{Susy}

Late Decays Modify Cosmology

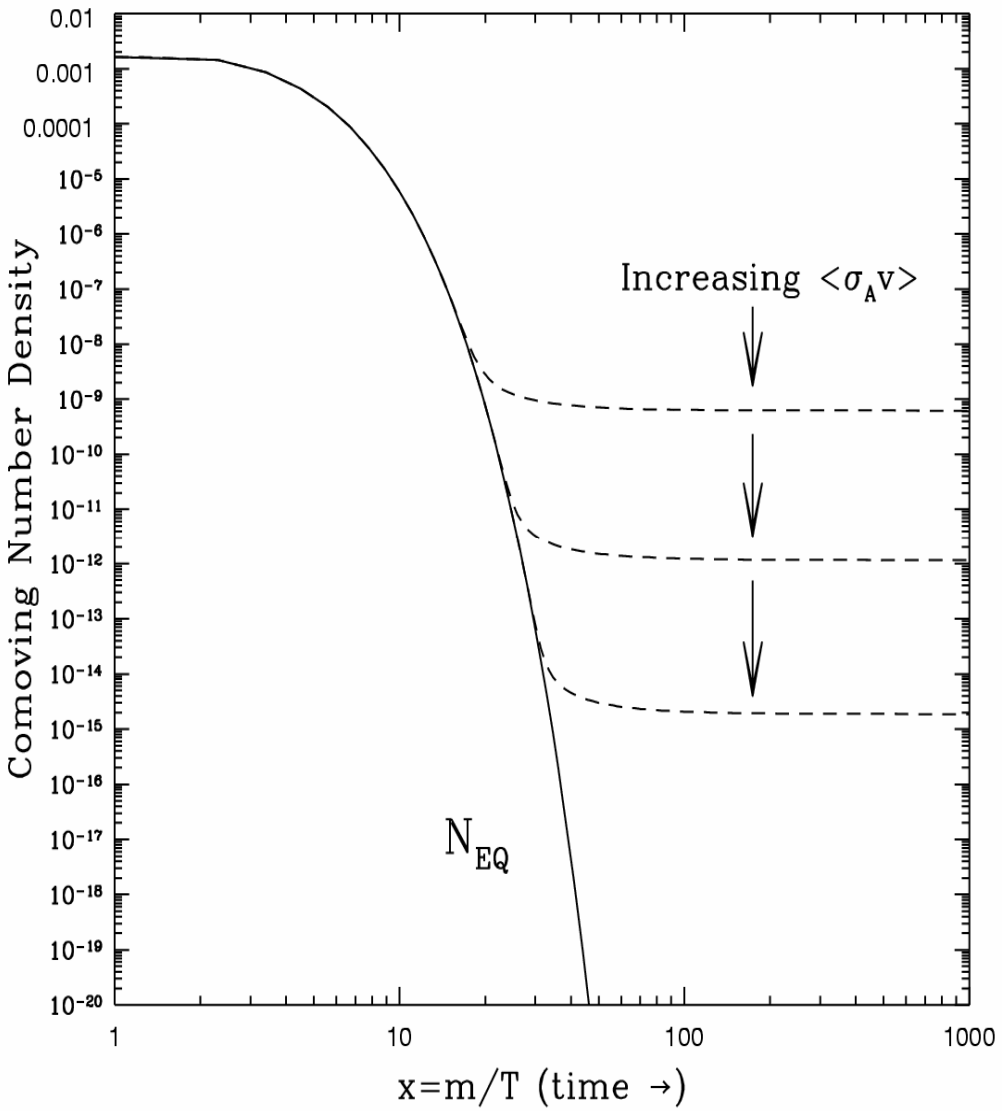
Limits on depositions of energy in early universe

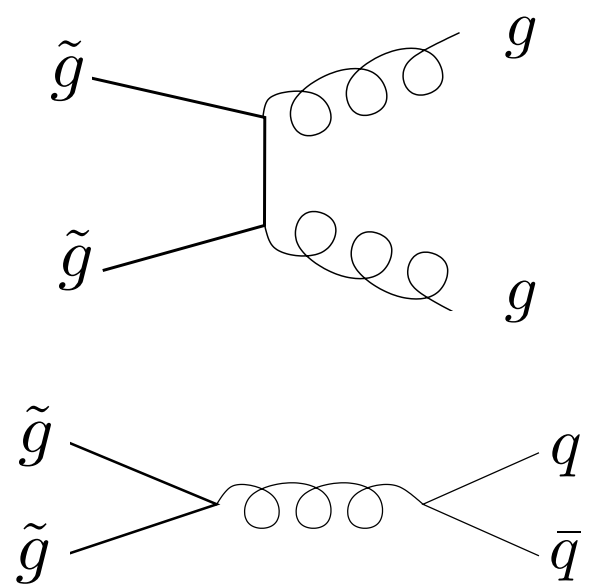
Depends on:

$E_{\rm vis}$	Energy per decay $\sim m_{\tilde{g}}$
$\tau_{\tilde{g}}$	Lifetime
$Y_{\tilde{g}}$	Abundance

Big Bang Nucleosynthesis	0.1 sec to 10000 years
CMB Spectrum	At recombination
Diffuse Gamma Rays	After recombination
Heavy Stable Elements	Not yet decayed

Perturbative Gluino Annihilation





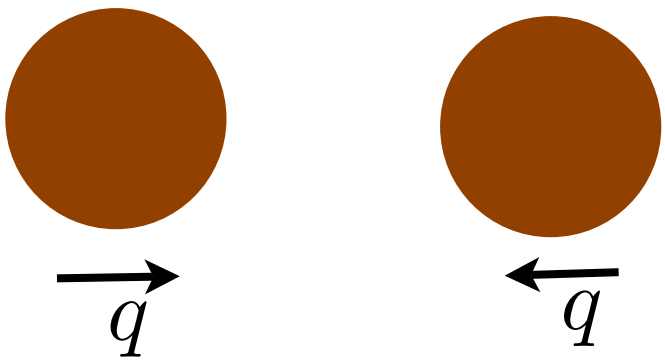
$$\sigma(\tilde{g}\tilde{g} \to X) \simeq \frac{\pi \alpha_s^2}{m_{\tilde{g}}^2 v}$$

see Baer, Gunion, Cheung

After QCD Phase Transition

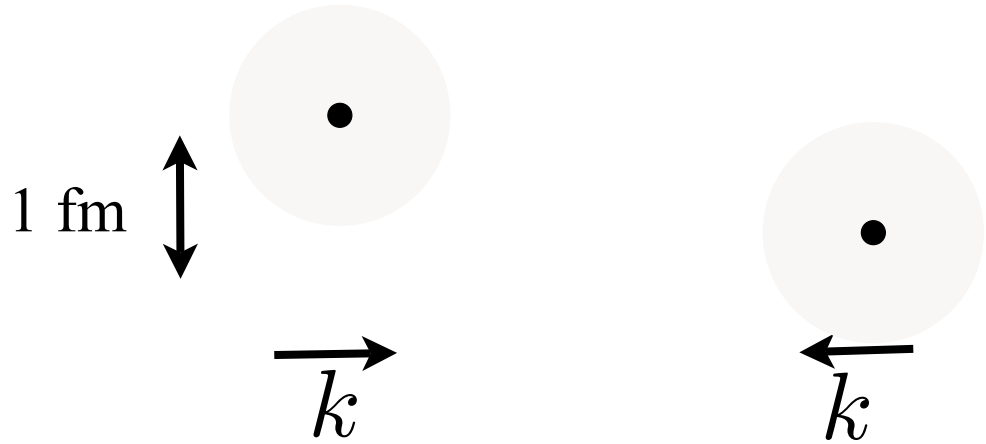
$$\sigma(\tilde{g}\tilde{g} \to X) = \pi R^2 = 30\text{mb}\ !??$$

R-Hadron Collisions



After QCD Phase Transition

R-Hadron Collisions



$$\Lambda_{\rm QCD} \ll m_{\tilde{g}}$$

$$\sigma_j^{\rm inelastic} < \frac{4\pi(2j+1)}{k^2}$$

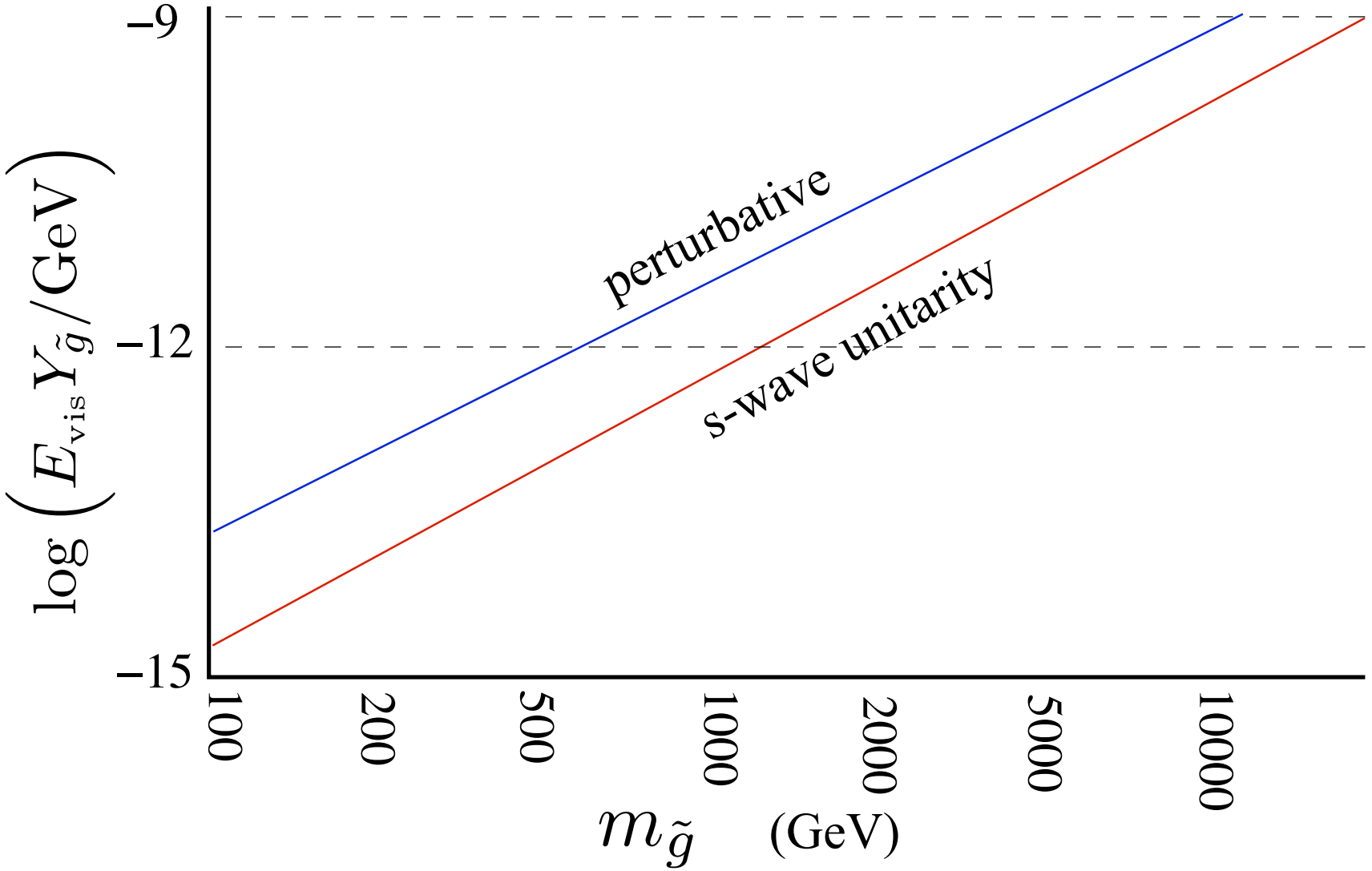
(set by deBroglie wavelength)

large j give geometric cross-section $\quad j \simeq kR \simeq 30$

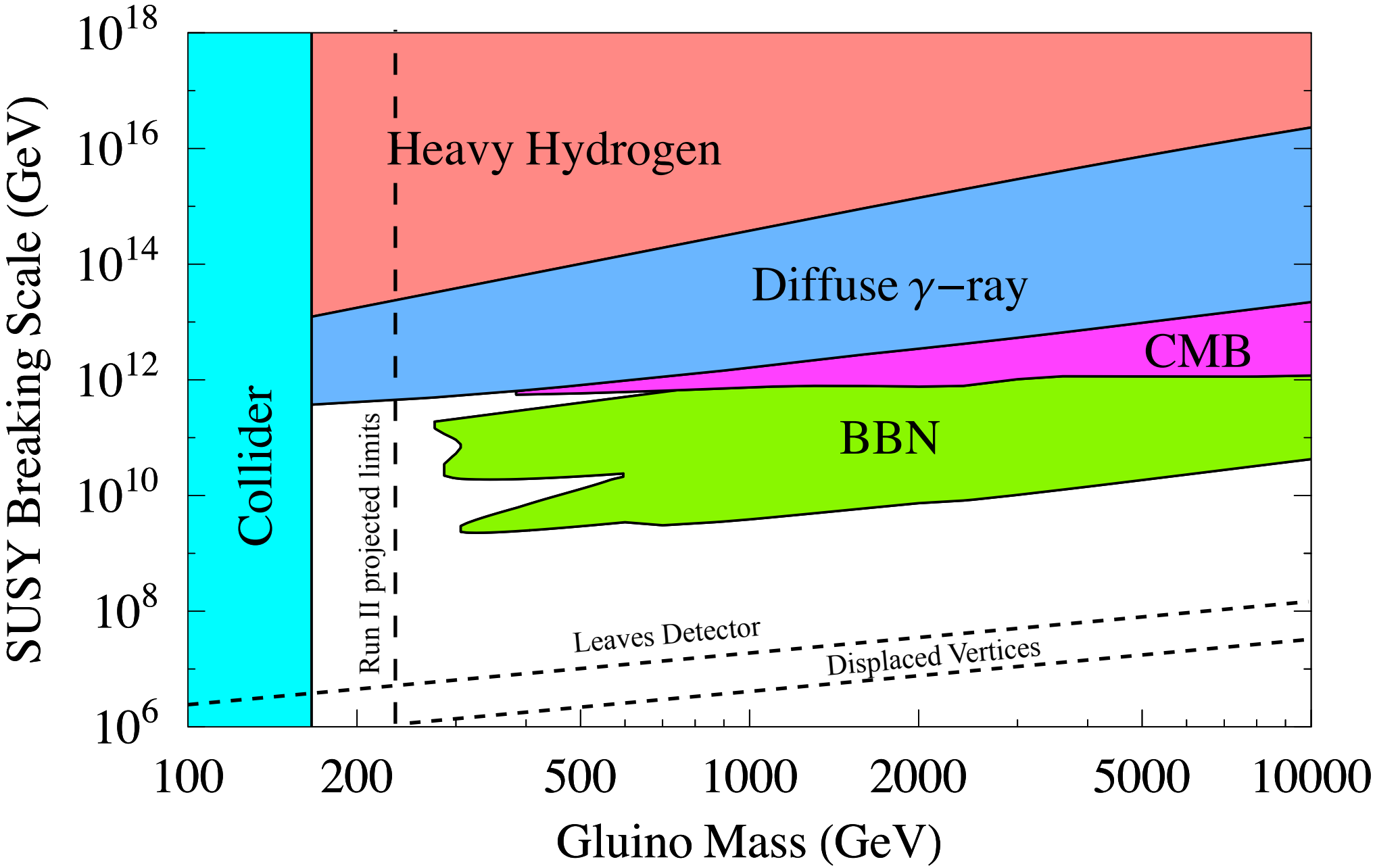
angular momentum barrier for annihilation

use s-wave unitarity as upper bound on annihilation

Relic Abundance

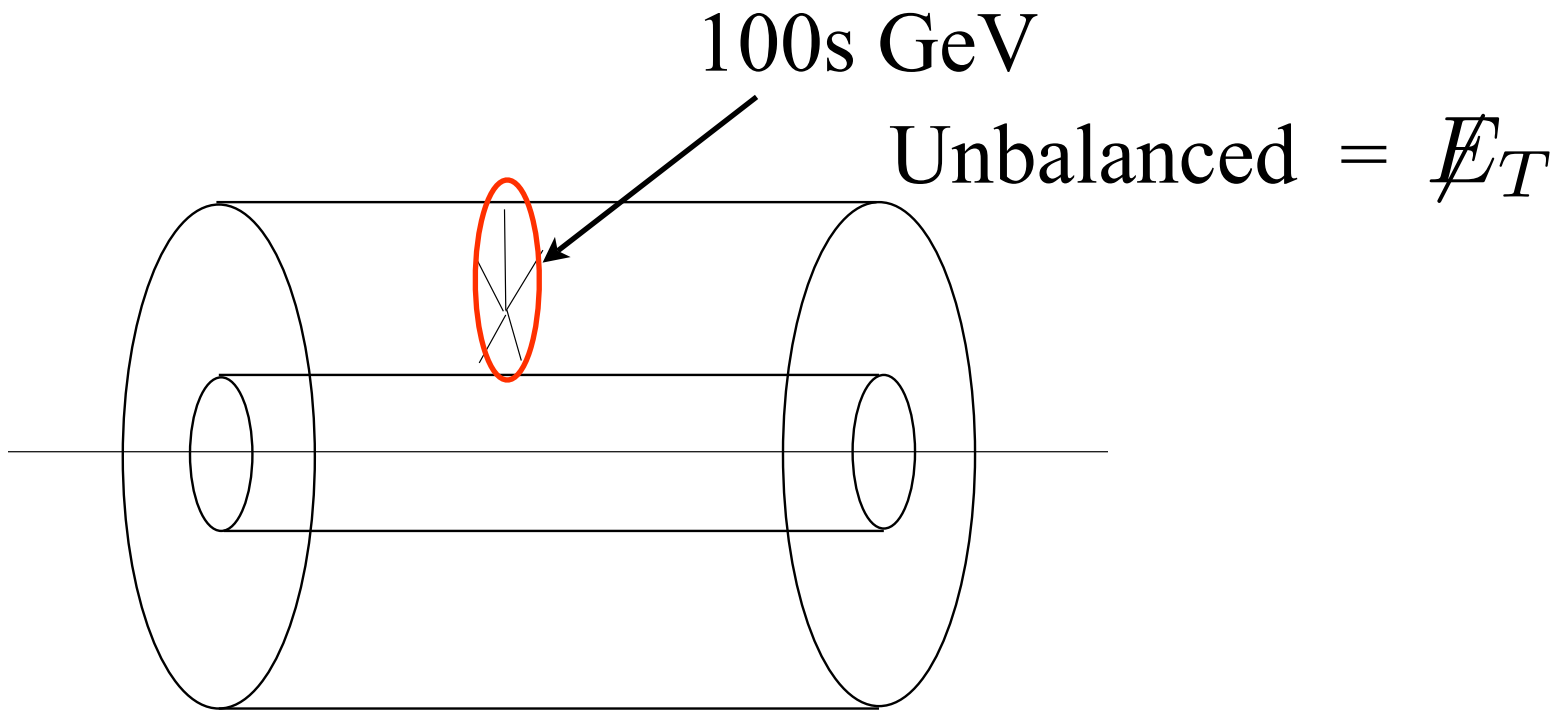


Limits from Gluinos



Short lifetimes $\tau_{\tilde{g}} < 100$ sec

Motivates looking for stopped gluinos that later decay



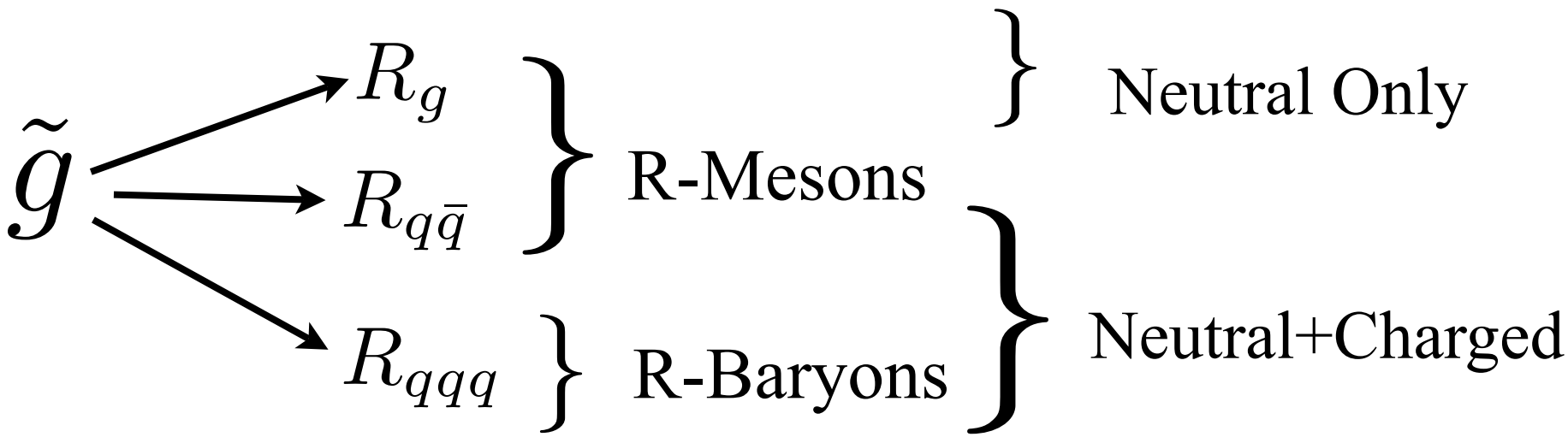
Uncorrelated with any beam crossing

Not uniformly distributed in detector

R-Hadrons

EM Interactions will stop gluino

R-spectroscopy matters...



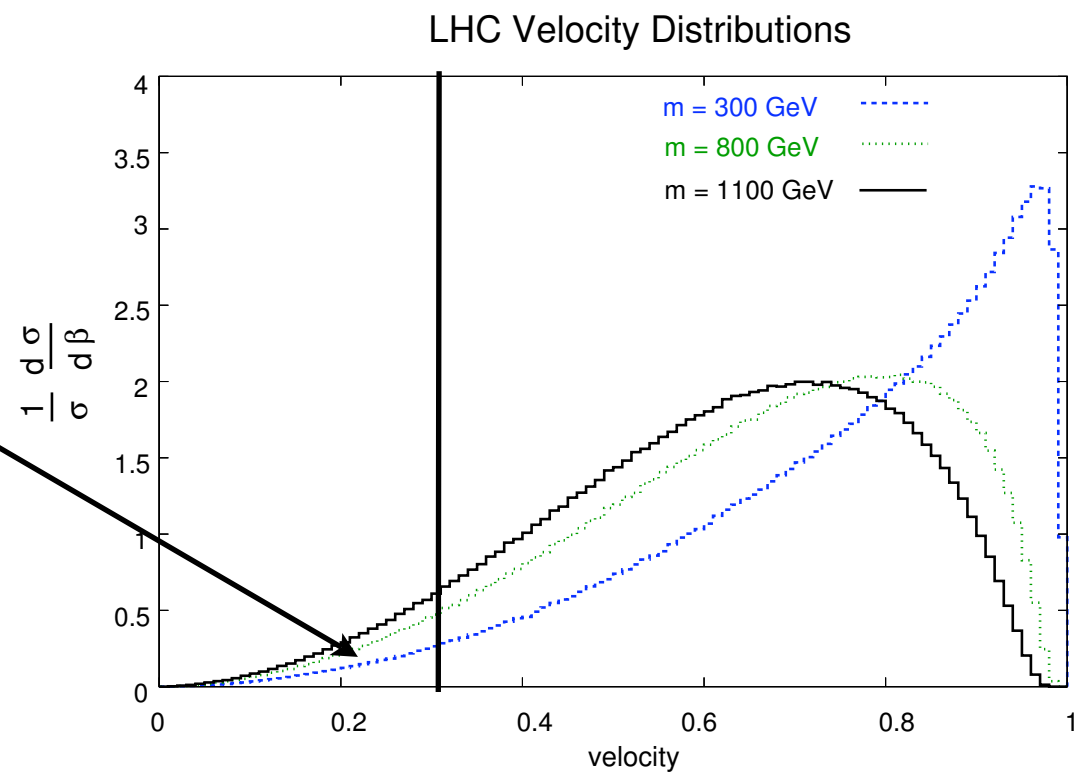
... difficult to predict from first principles

Stopping of Charged Particle

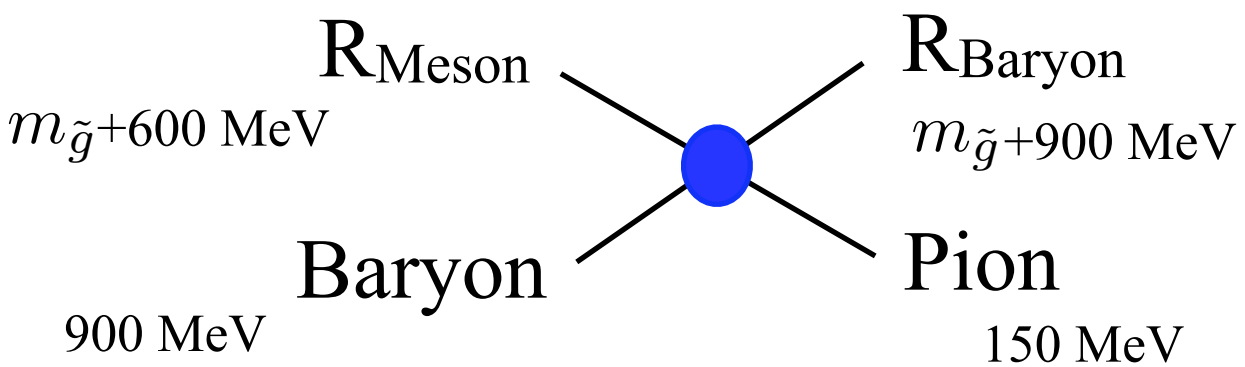
Bethe-Bloch $\frac{dv}{dx} \simeq \frac{1}{x_0 v^3}$ $x_0 \simeq 500\ \mathrm{m} \left(\frac{500\ \mathrm{GeV}}{m_{\tilde{g}}}\right)$

$x_{\mathrm{stop}} = \frac{1}{4} v_0^4 x_0$ for $x_{\mathrm{stop}} = 2\mathrm{m}$ $v_0 = 0.3$

Stop in 2m



Unified Theory of Stopping



$$\Delta Q \simeq +400\text{MeV}$$

incident velocity = small

Pion velocity =1

$$\sigma v_i = \sigma_{\text{strong}} v_f$$

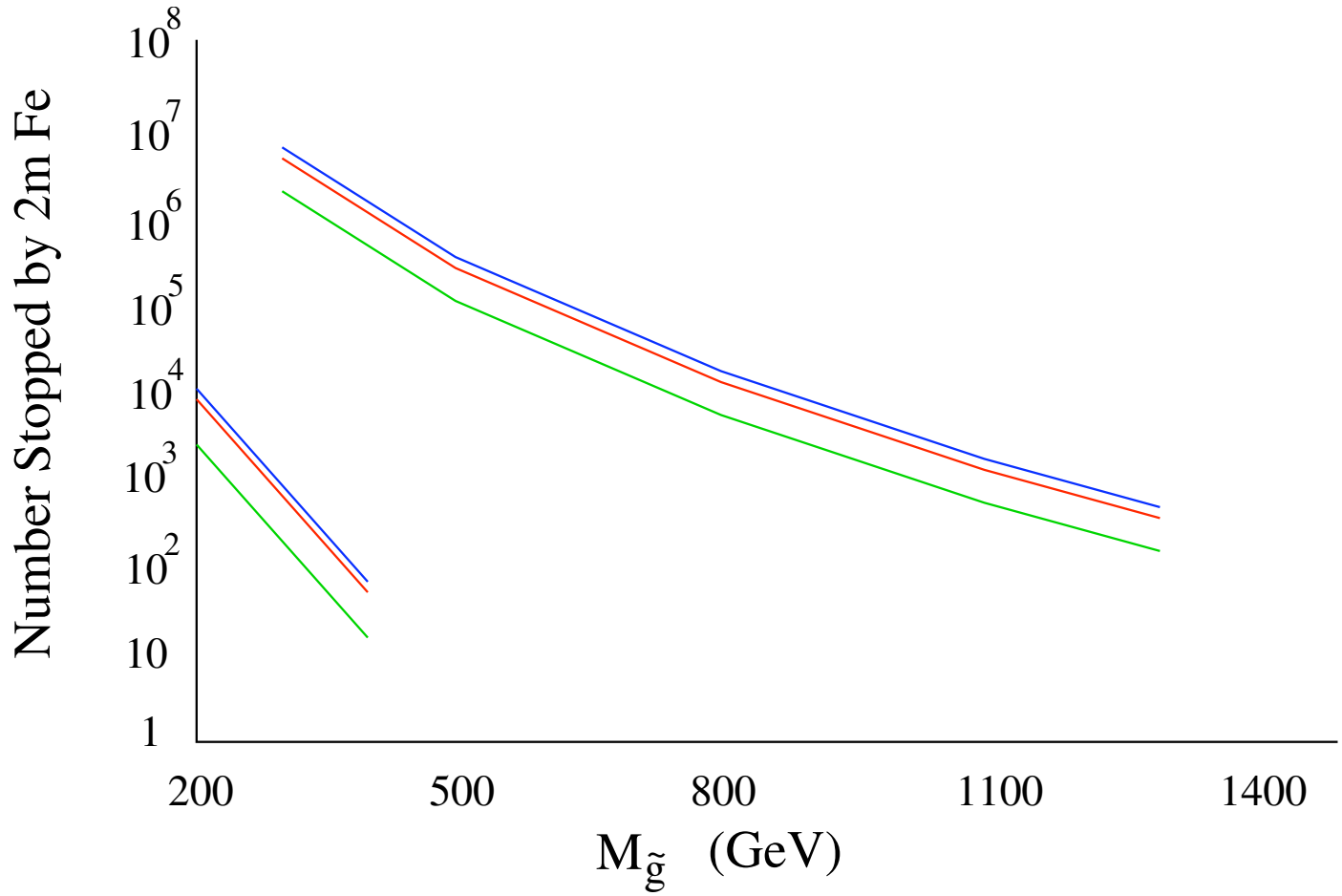
Short!

	30mb	3mb	0.3mb
Interaction length	0.17m	1.7m	17m

All slow R-hadrons become R-baryons

See A. Kraan et al

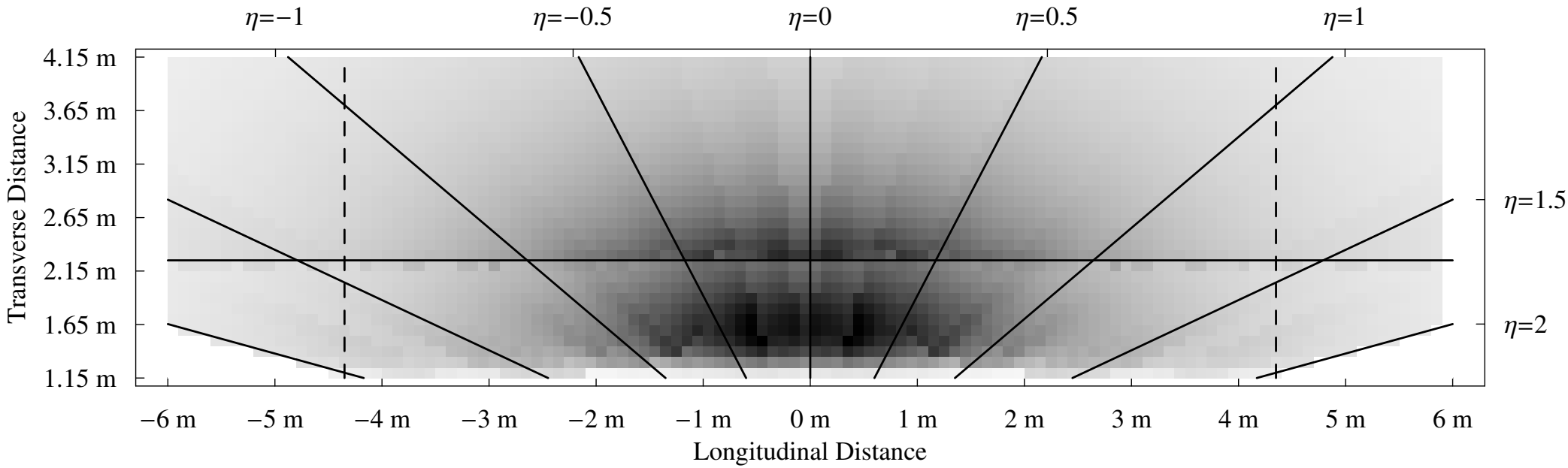
Total Number of Stopped Gluinos

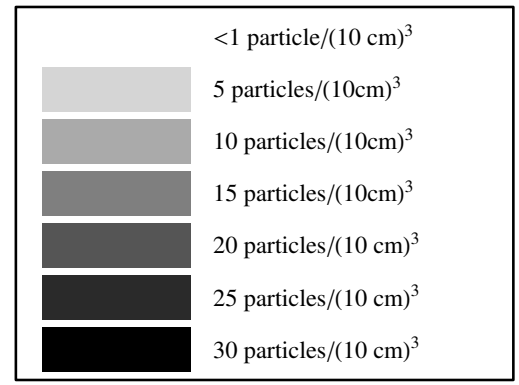


2 fb^{-1}	200 GeV	300 GeV	400 GeV
CDF	4.1×10^3	3.1×10^2	3.3×10^1
D0	4.5×10^3	3.3×10^2	3.4×10^1
100 fb^{-1}	300 GeV	800 GeV	1300 GeV
ATLAS	5.8×10^6	1.8×10^4	6.2×10^2
CMS	3.7×10^6	1.2×10^4	3.9×10^2

Density of Stopped Gluinos

Atlas Detector (100 fb^{-1})



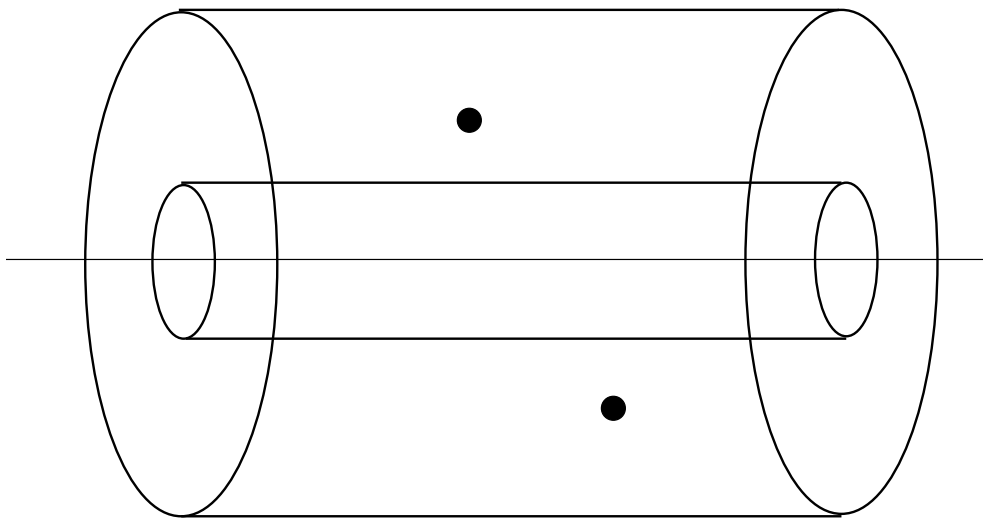


300 GeV gluino

Lifetime Measurement

gluinos are pair produced

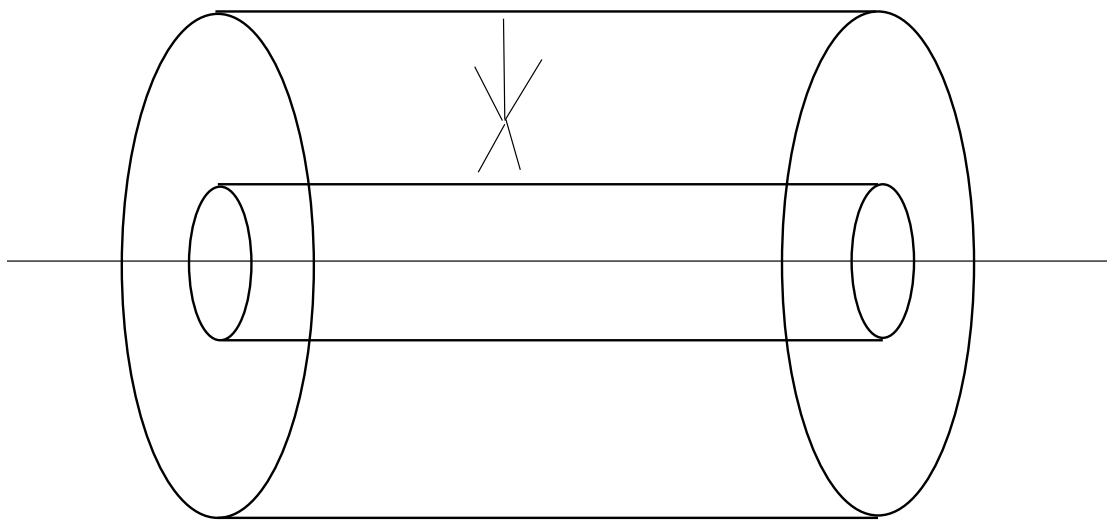
and both stop 20% of the time



Won’t trigger on the initial event

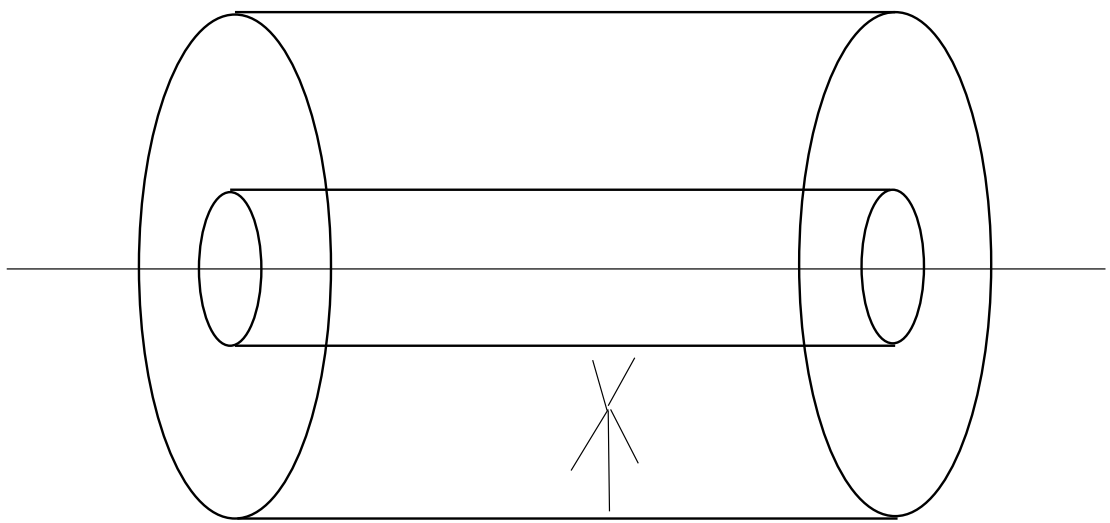
Lifetime Measurement

After a gluino lifetime



Lifetime Measurement

After another gluino lifetime



Looking for pairs of gluino decays measures the lifetime