Dark Matter in the Left Right Twin Higgs Model

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Work done with
Shufang Su and Jessica Goodman

Outline

- Left Right Twin Higgs Model
- Relic Density Analysis
- Direct and Indirect Detection
- Conclusion

Left Right Twin Higgs Model

- Chacko, Goh, and Harnik:
  arXiv:hep- ph/0506256v1

- Solution to Little Hierarchy Problem

- To avoid EW precision constraints, add a second
  Higgs Ĥ that couples to gauge bosons only

Left Right Twin Higgs Model

$$H = \begin{pmatrix} H_L \\ H_R \end{pmatrix}$$

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Couples only to
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DM candidate

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  → Natural WIMP candidates

Left Right Twin Higgs Model

- Need to impose mass splitting between A and S:
  Constraints from direct detection

$$\delta_2 = M_A - M_S$$

- $\hat{h}_1$ and $\hat{h}_2$ mass splitting

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$$L = \frac{\lambda_5}{2}((H_L^\dagger \hat{H}_L)^2 + h.c.)$$

- $\hat{h}_1$ and $\hat{h}_2$ mass splitting

$$\delta_1 = M_{\hat{h}_1} - M_S$$

Left Right Twin Higgs Model

- Similar to Inert Higgs Doublet Model
  - Proposed by Barbieri, et al.
    - arXiv:hep-ph/0603188v2
  - Dark matter analyzed by Honorez, et al.
    - arXiv:hep-ph/0612275
  - Indirect detection analyzed by Gustafsson, et al.
    - arXiv:astro-ph/0703512

Model Comparison

Inert Higgs Doublet Model	Left Right Twin Higgs Model
$M_{hsm} \sim 500$ GeV	$M_{hsm} \sim 170$ GeV
New particles	New particles
Extra scalars	Extra scalars
	Heavy gauge bosons
	Heavy top, heavy neutrinos

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- Used program micrOmegas_2.0

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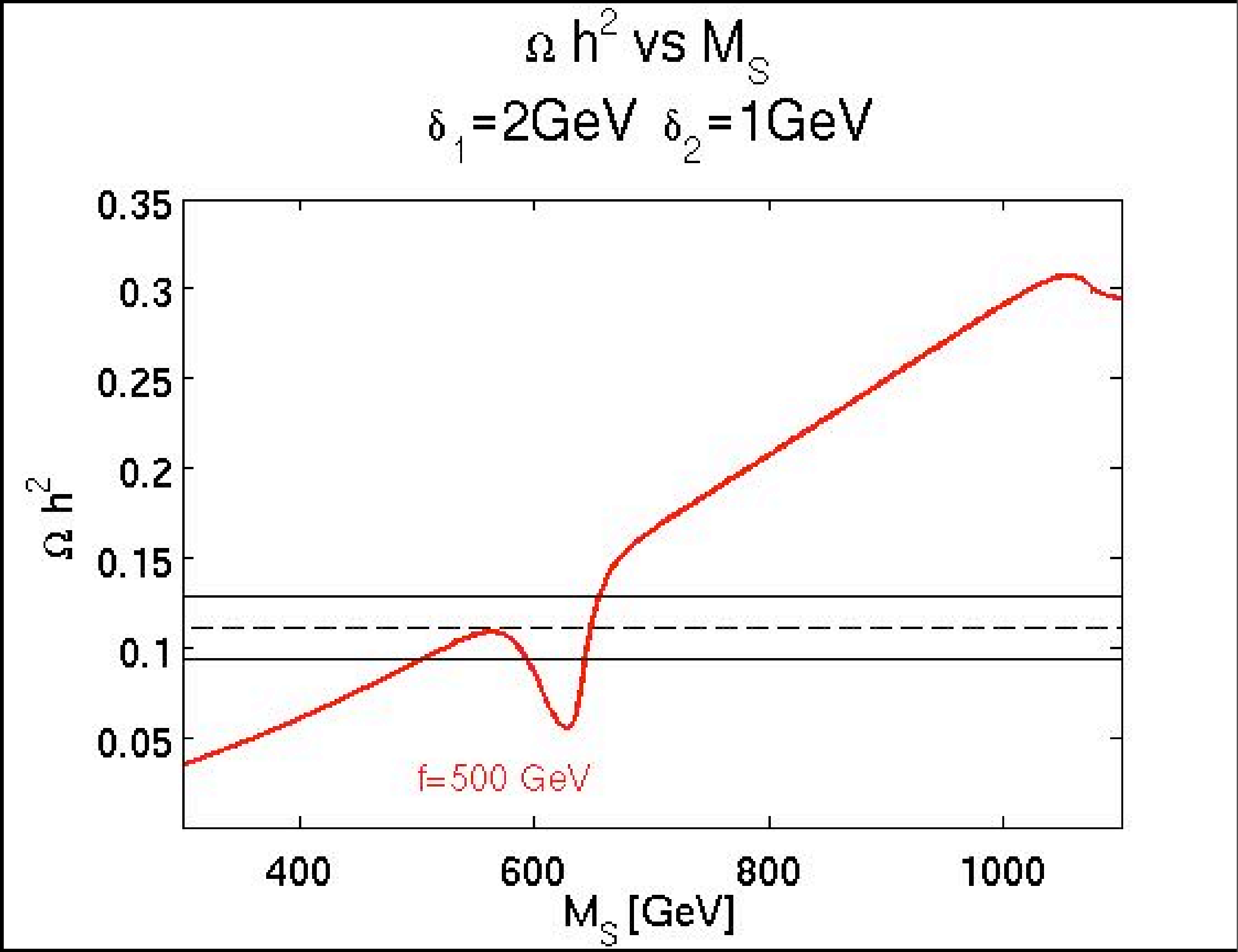
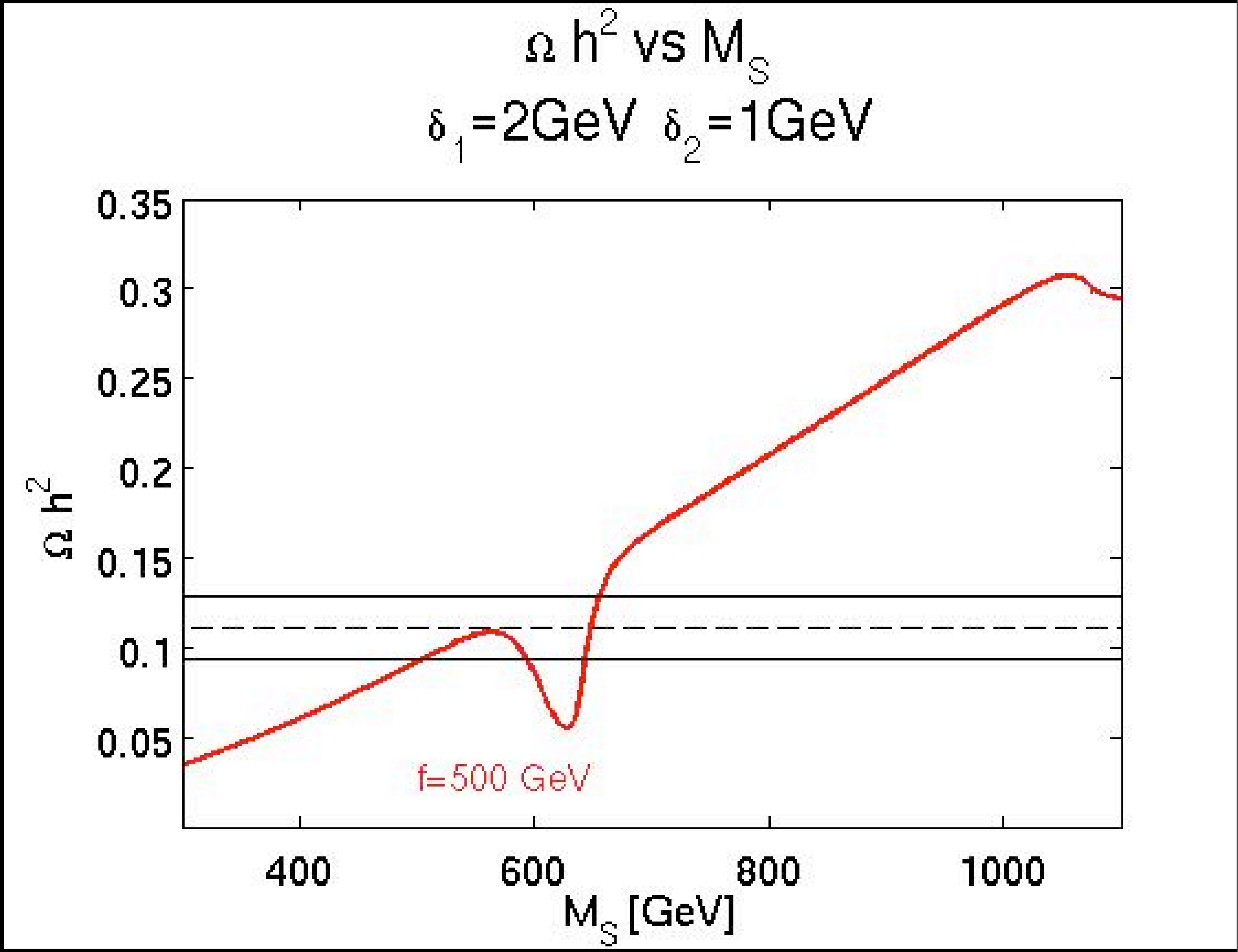
  - High mass: $M_S \sim 500$ GeV
  - Low mass: $M_S < M_W$ (in progress)

$\Omega\, h^2$ vs M_S



$\Omega\ h^2$ vs M_S

- Two regions:



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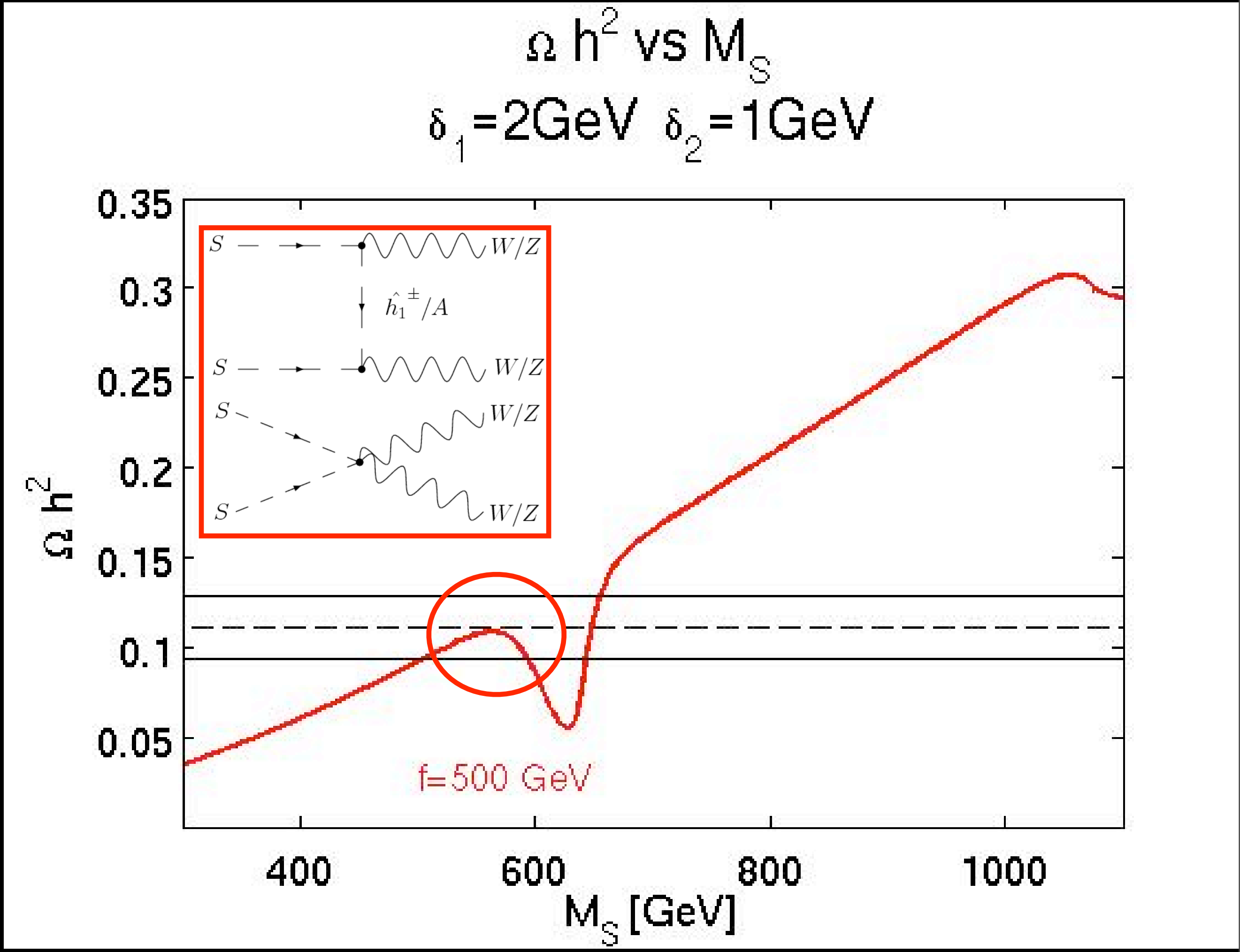

$\Omega\ h^2$ vs M_S

- Two regions:
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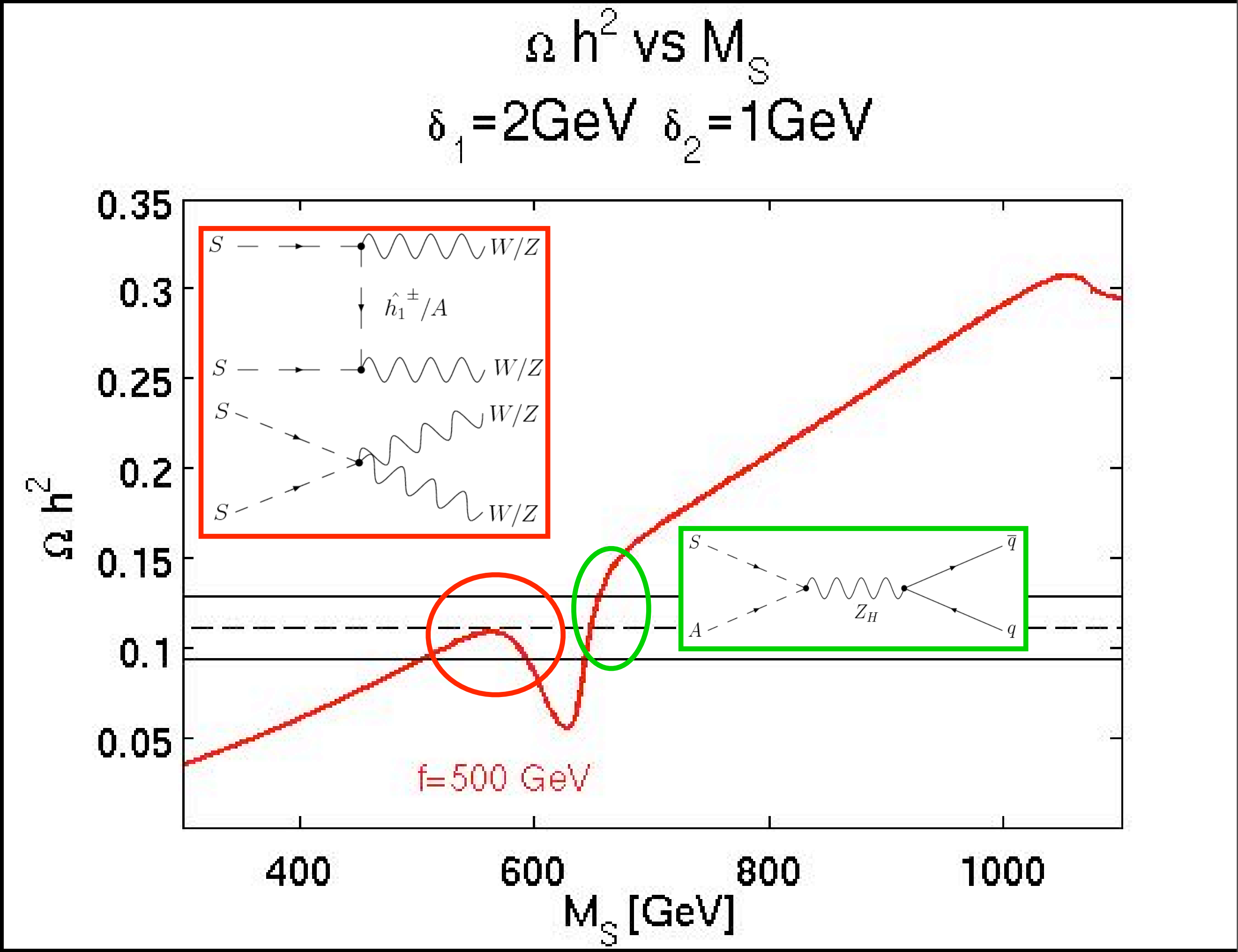
  - Pole



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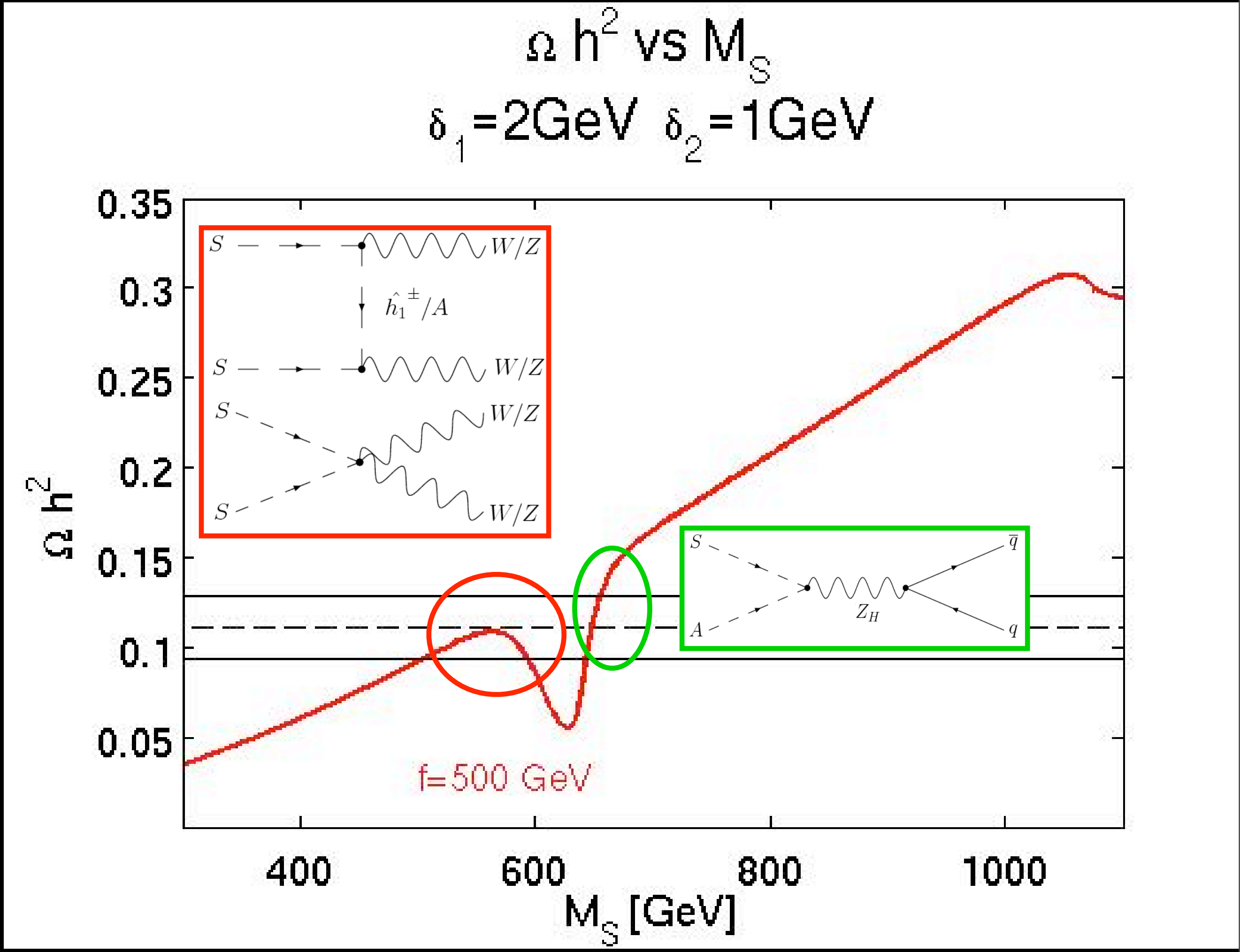

Ωh^2 vs M_S

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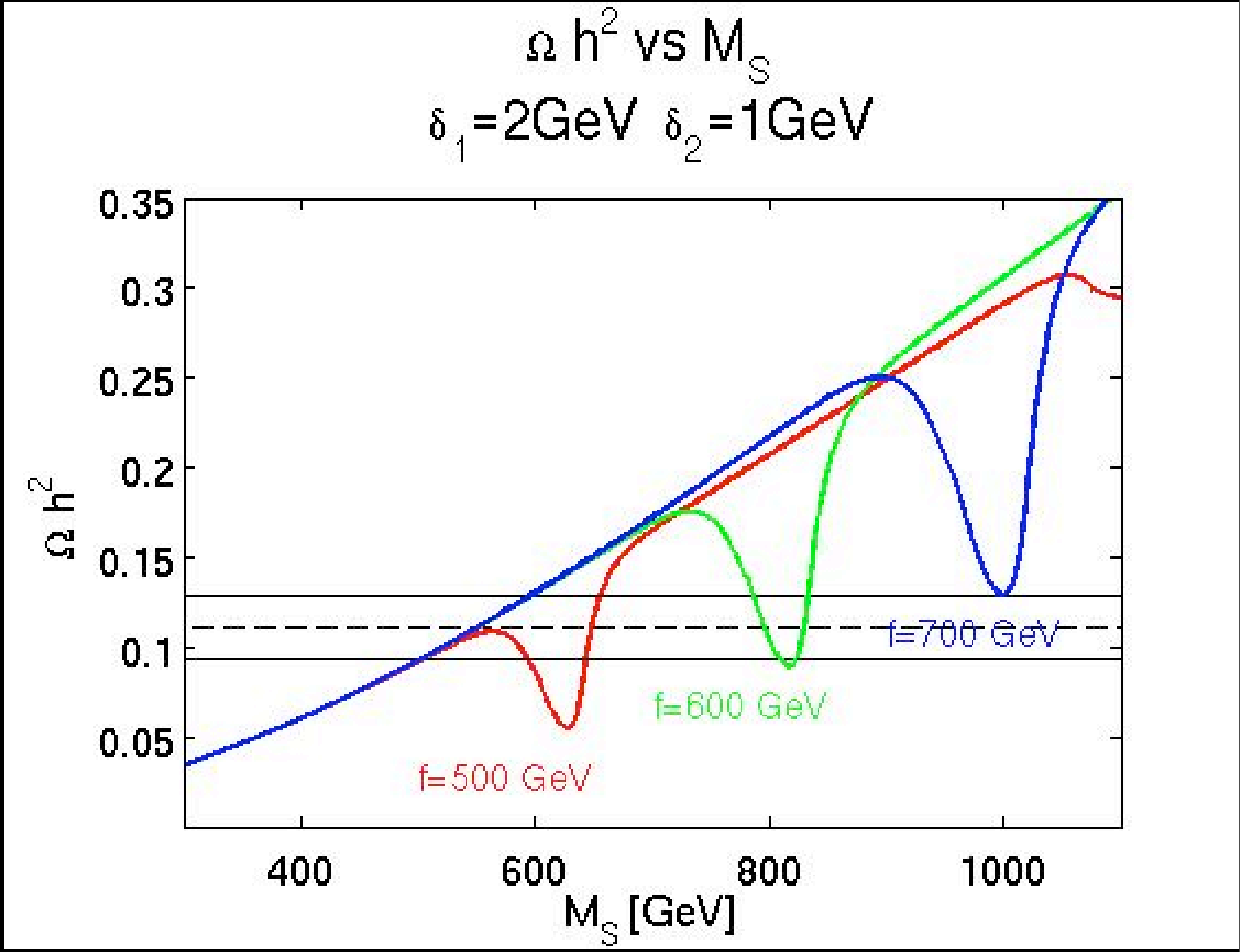

$\Omega\, h^2$ vs M_S

- Two regions:
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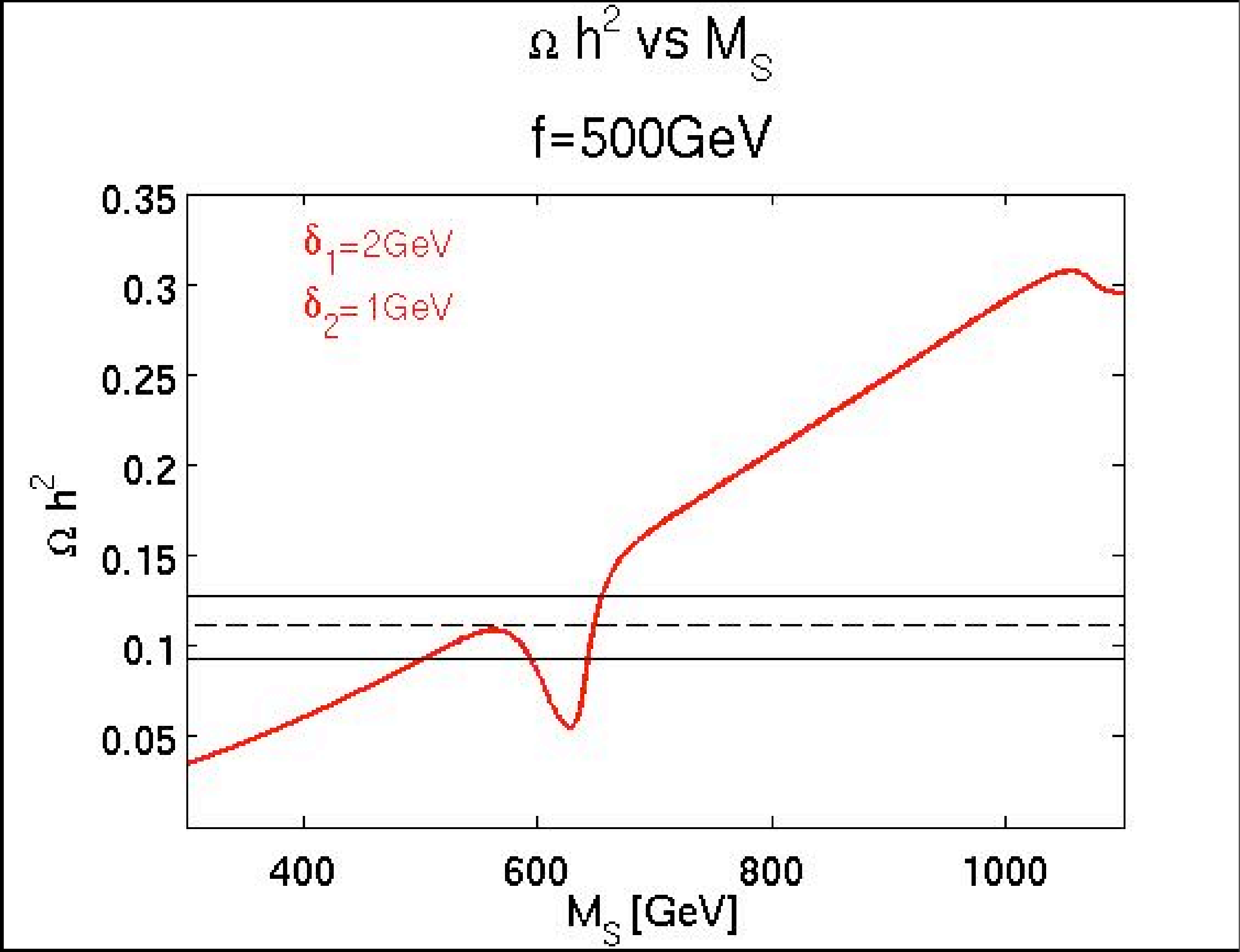

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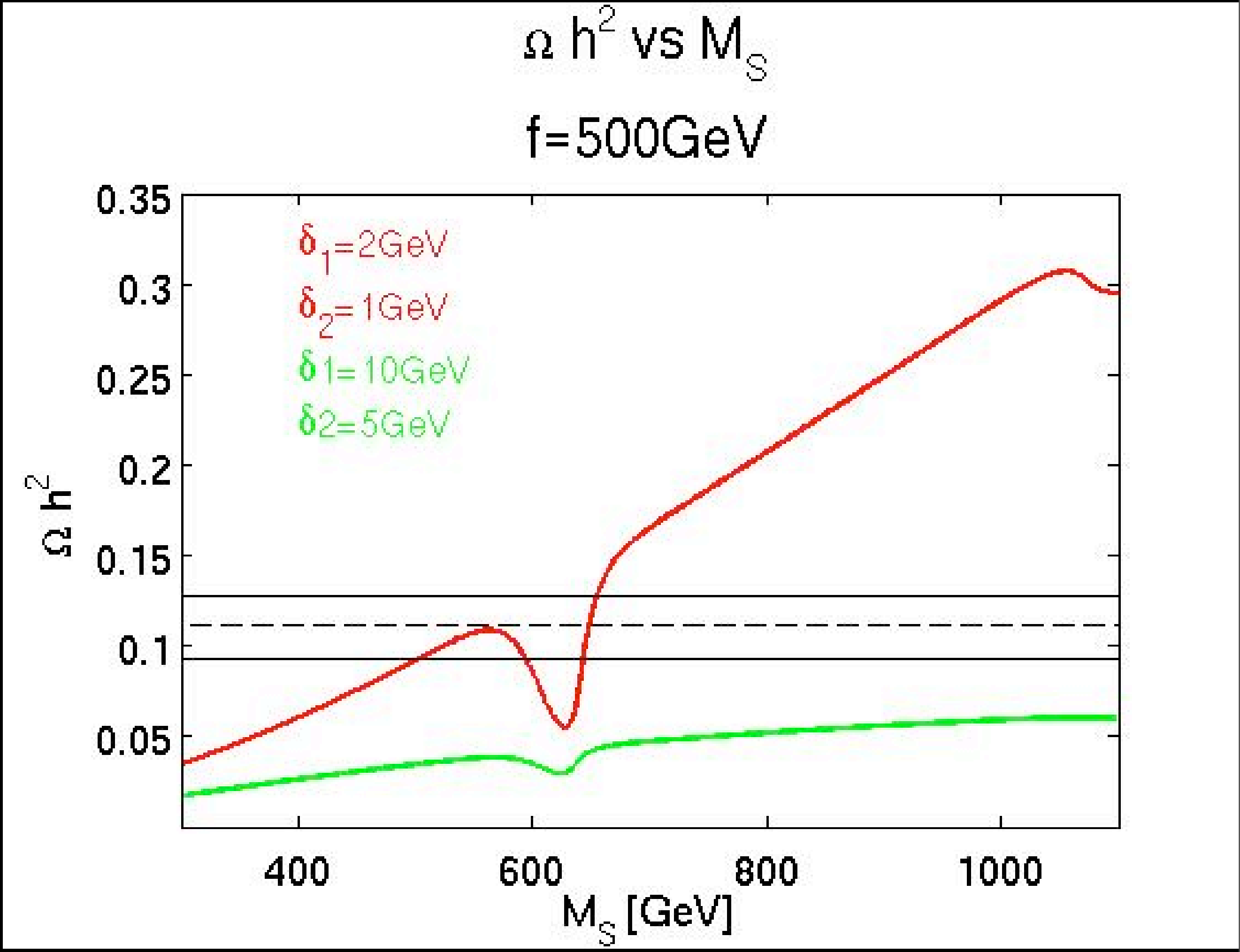
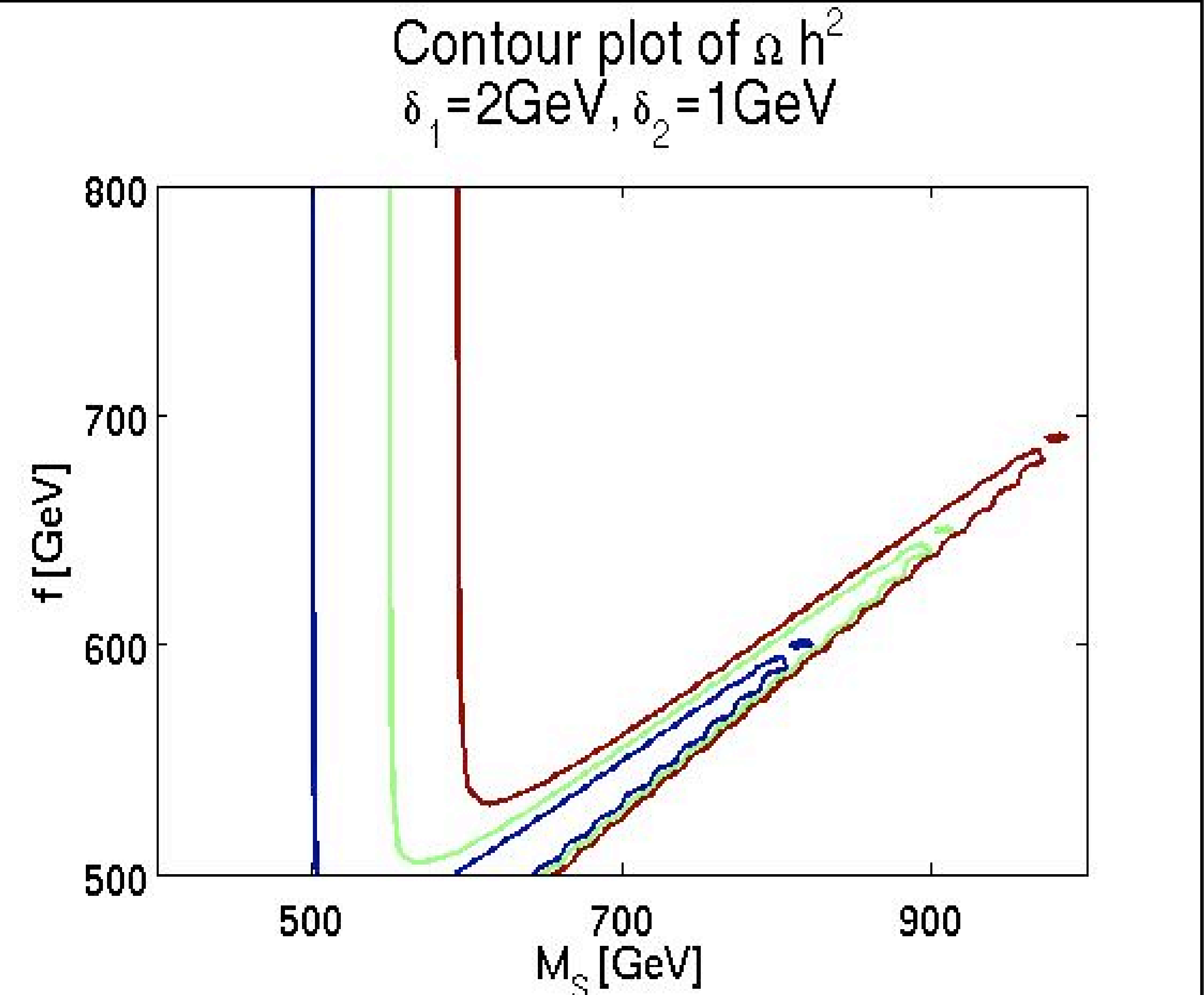


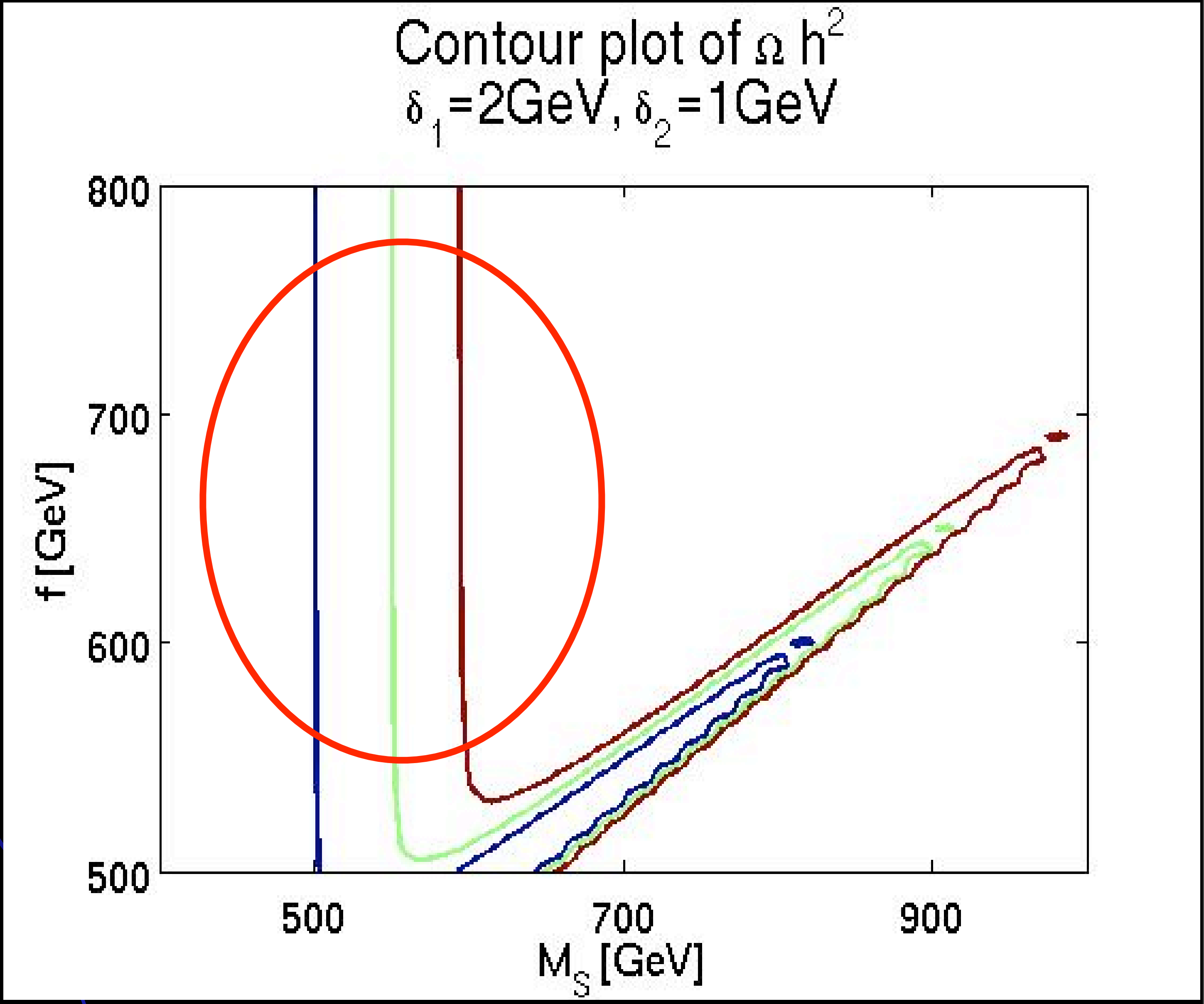
M_S-f plane



Contour plot of Ω h2
δ1=2GeV, δ2=1GeV
800
700
600
500
f [GeV]
500
700
900
MS [GeV]

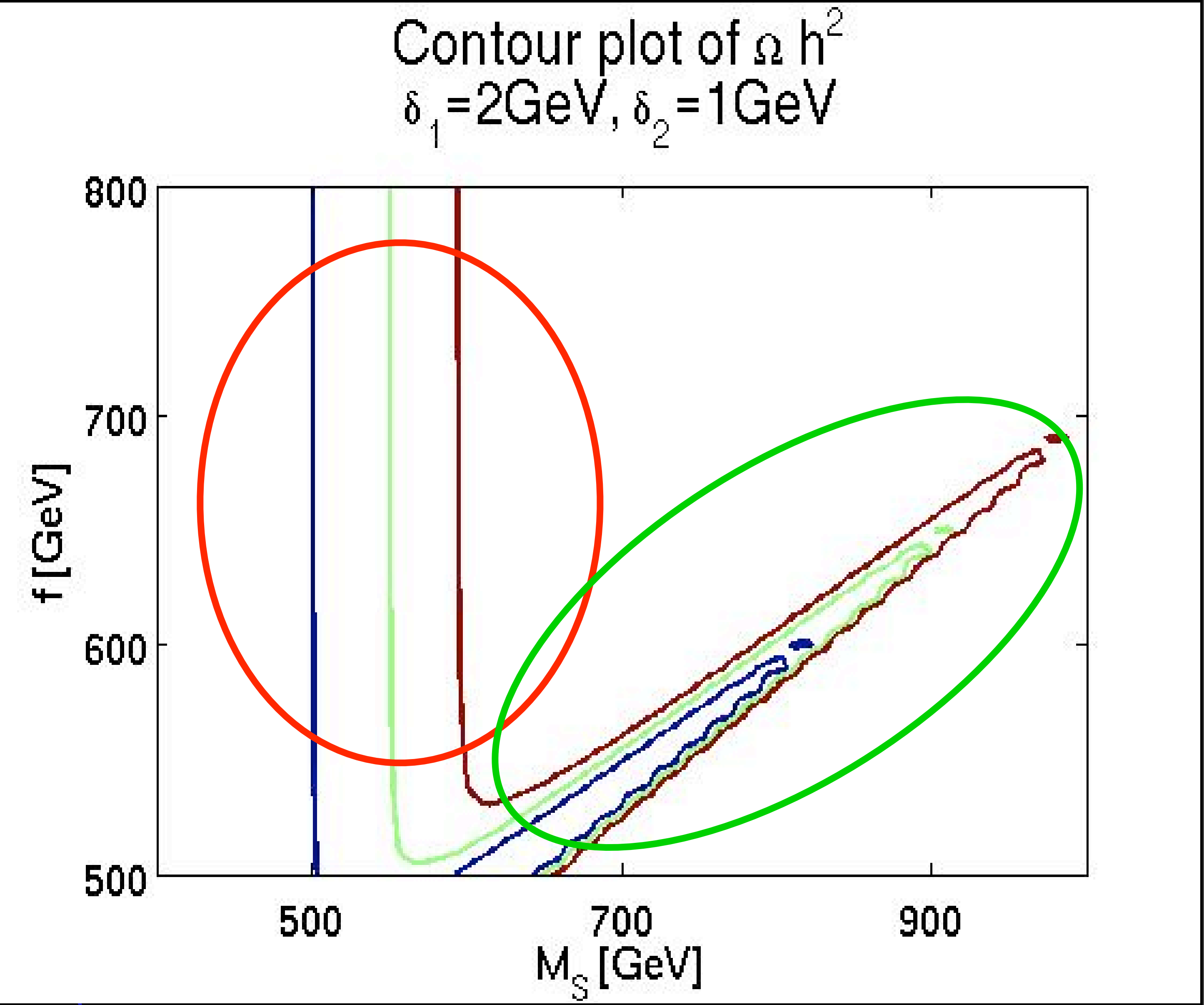
M_S-f plane

- M_S~550 GeV in bulk region

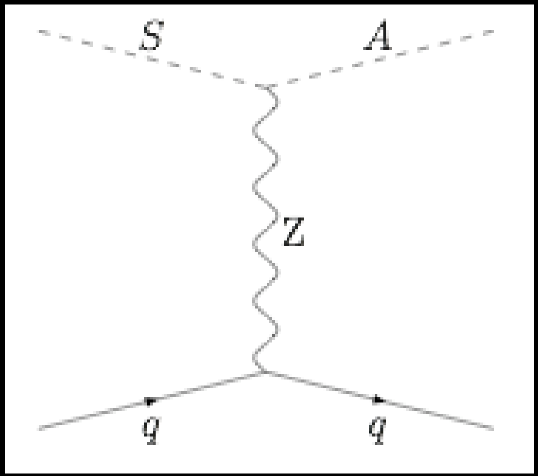


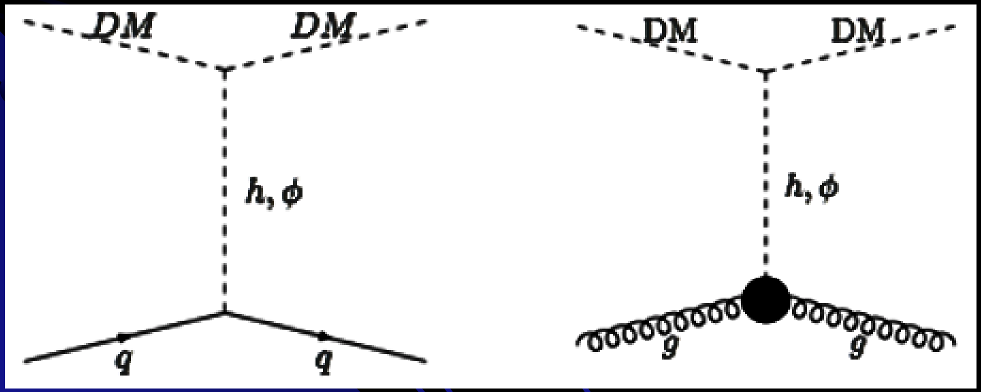
M_S-f plane

- M_S~550 GeV in bulk region
- M_S varies in pole region



Direct Detection





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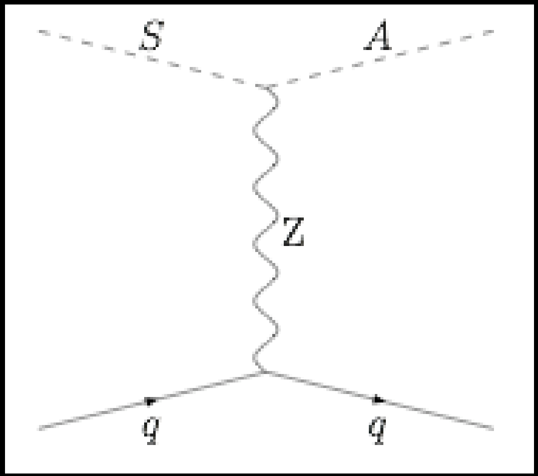

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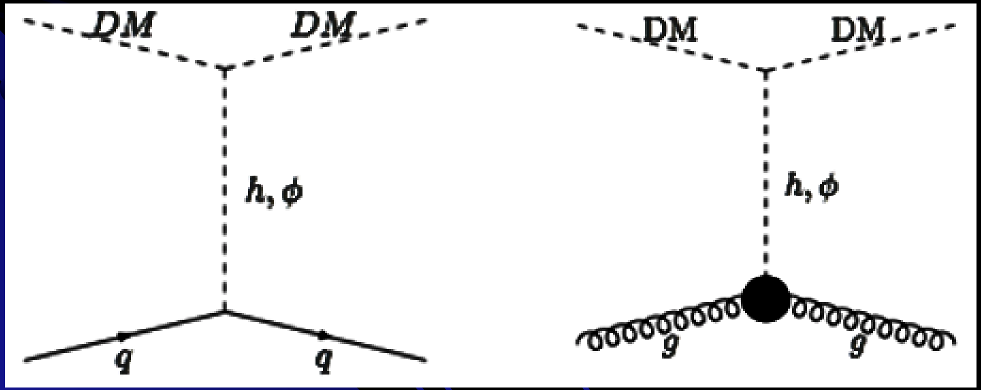

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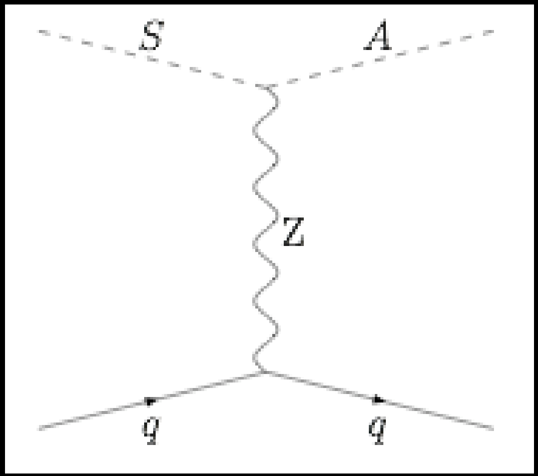

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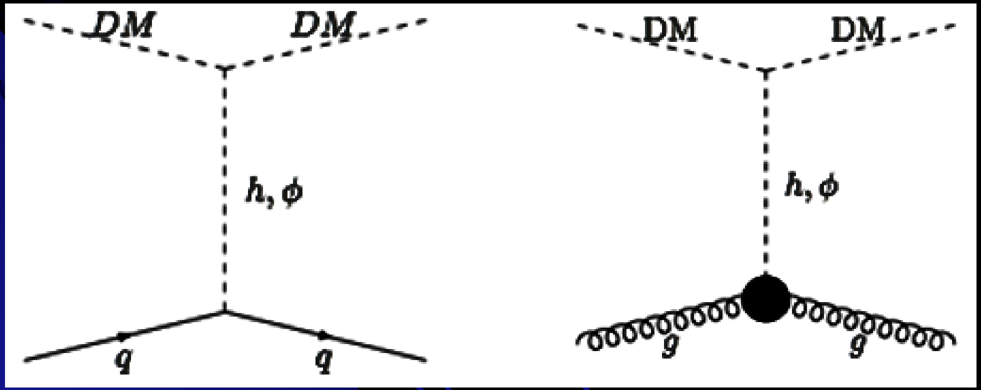

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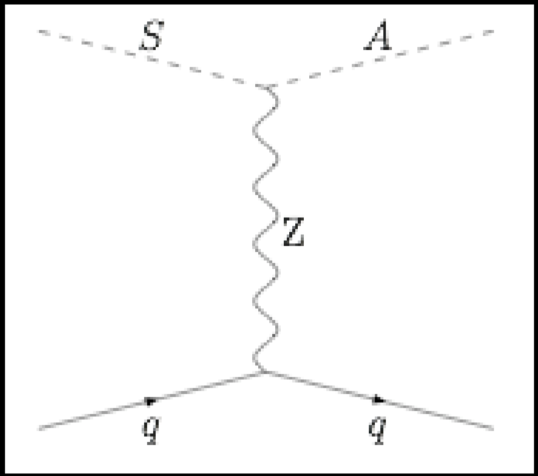

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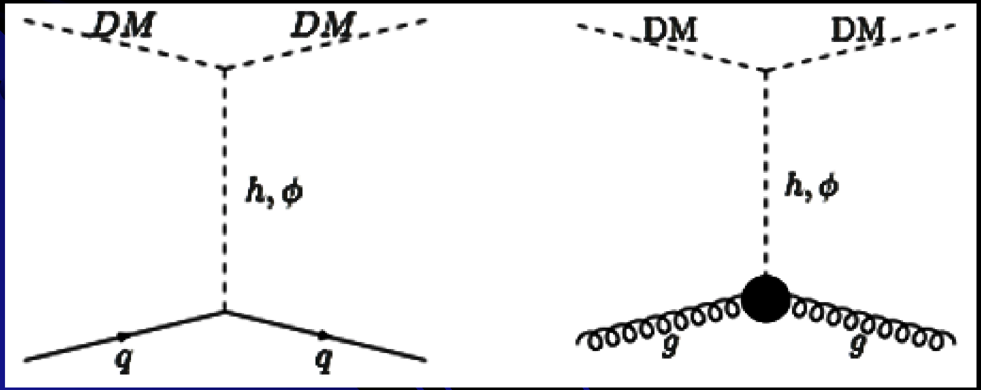

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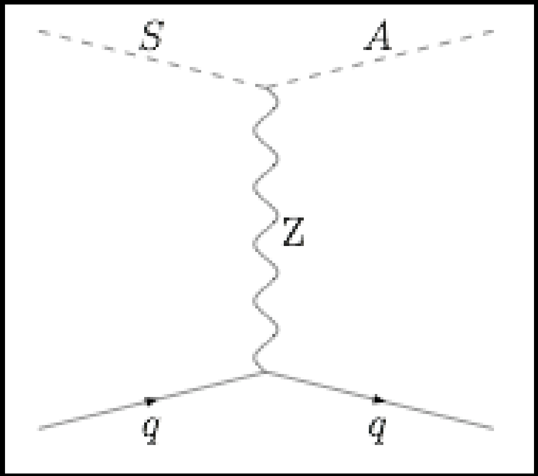

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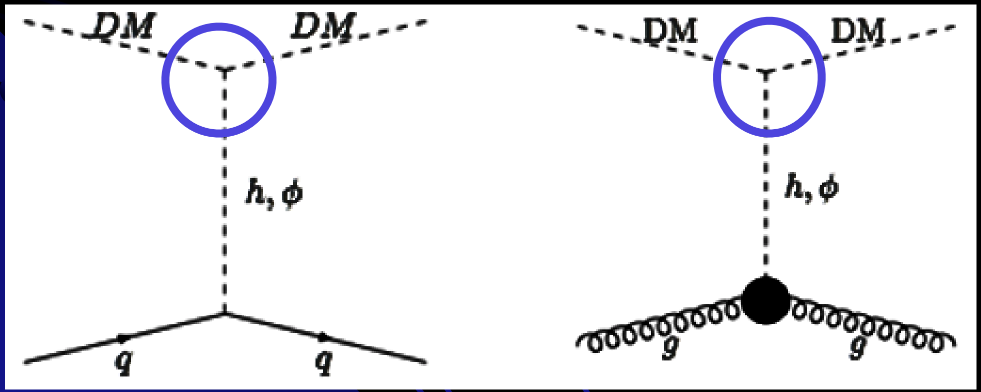

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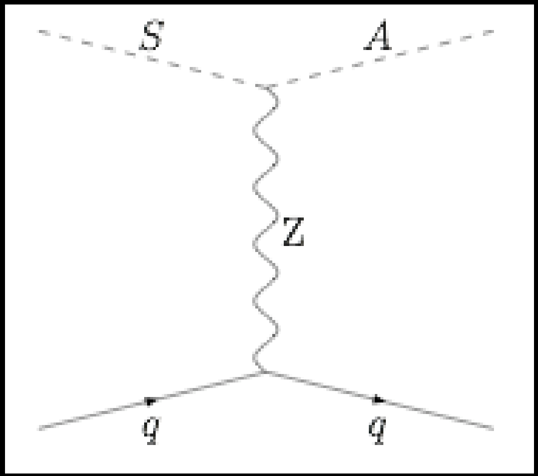

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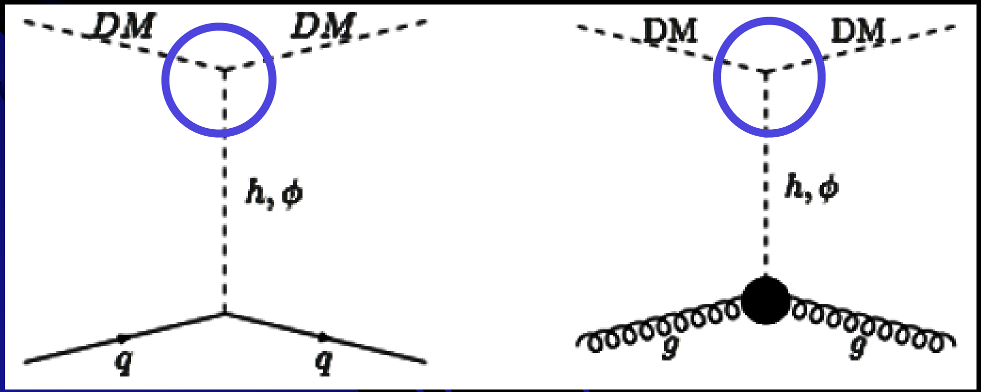

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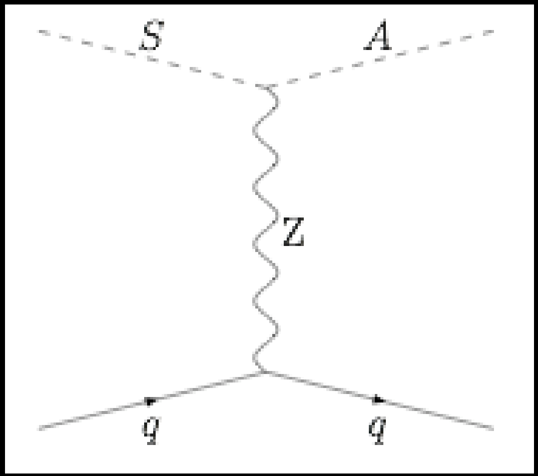

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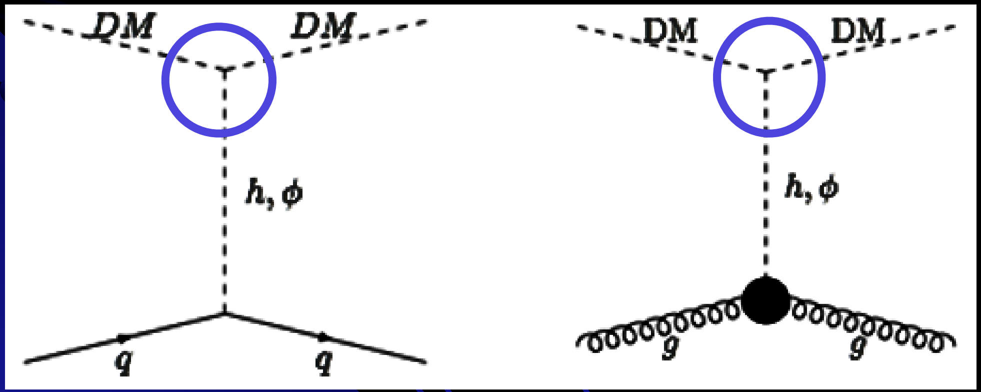

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Direct detection difficult!

Indirect Detection

- Dark matter annihilates into photons, positrons, and neutrinos

- Looked at photons
  - Monochromatic
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  - Hadronization and fragmentation

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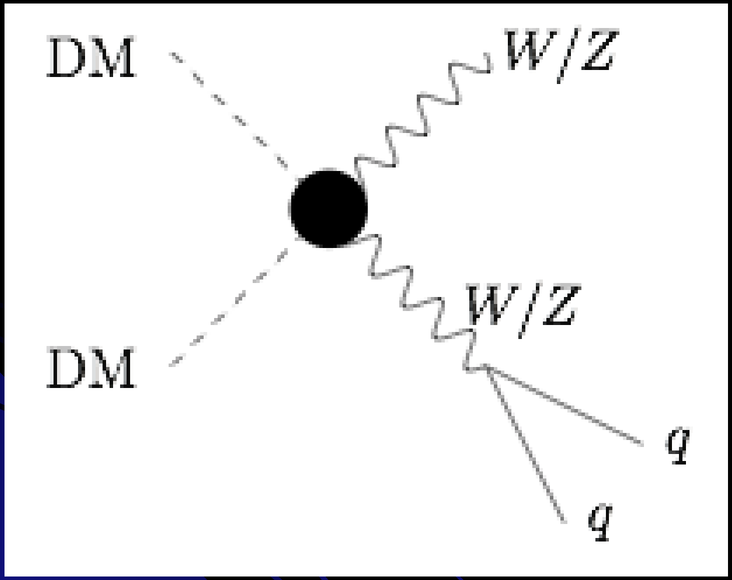
Monochromatic, Final state radiation → **Difficult**

Hadronization and fragmentation → **Possible**

Hadronization and Fragmentation

- Contributing process



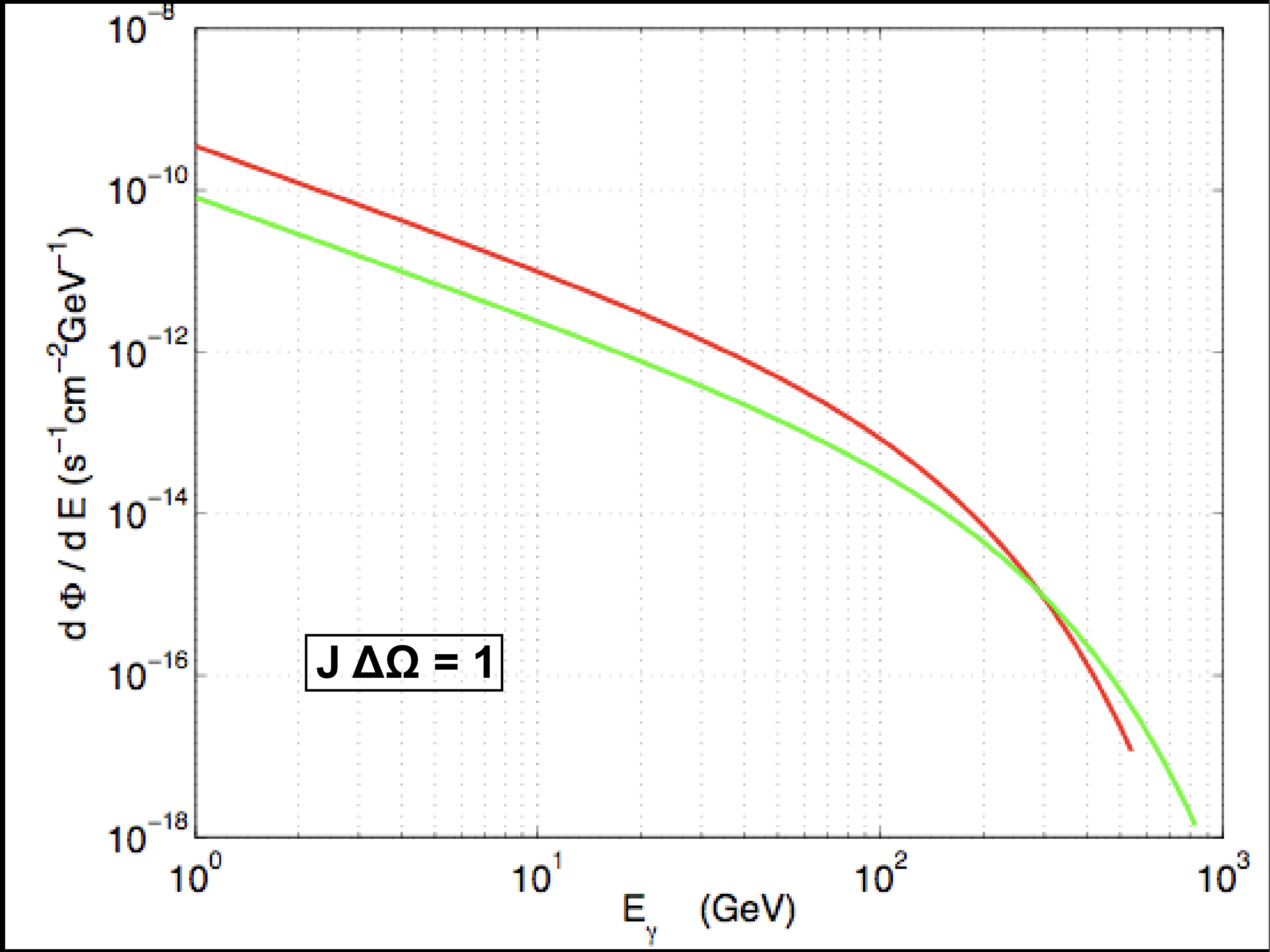
- Number as a function of Eγ

$$\frac{\mathrm{d}N_\gamma}{\mathrm{d}x} = 0.73x^{-1.5}\mathrm{e}^{-7.8x}$$

$$x = \frac{E_\gamma}{M_{DM}}$$

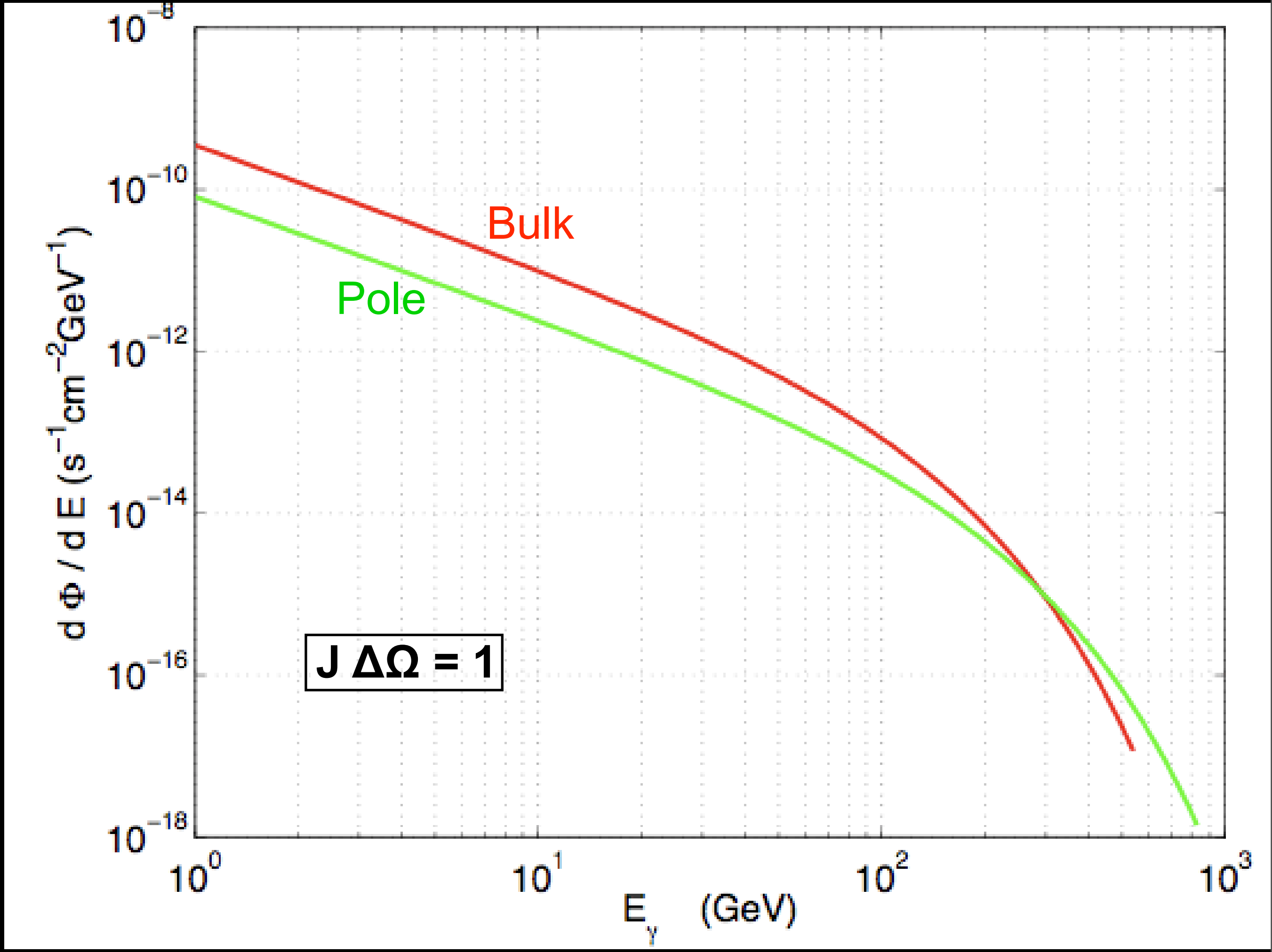
- Spectra depends only on initial W/Z energies

Hadronization and Fragmentation



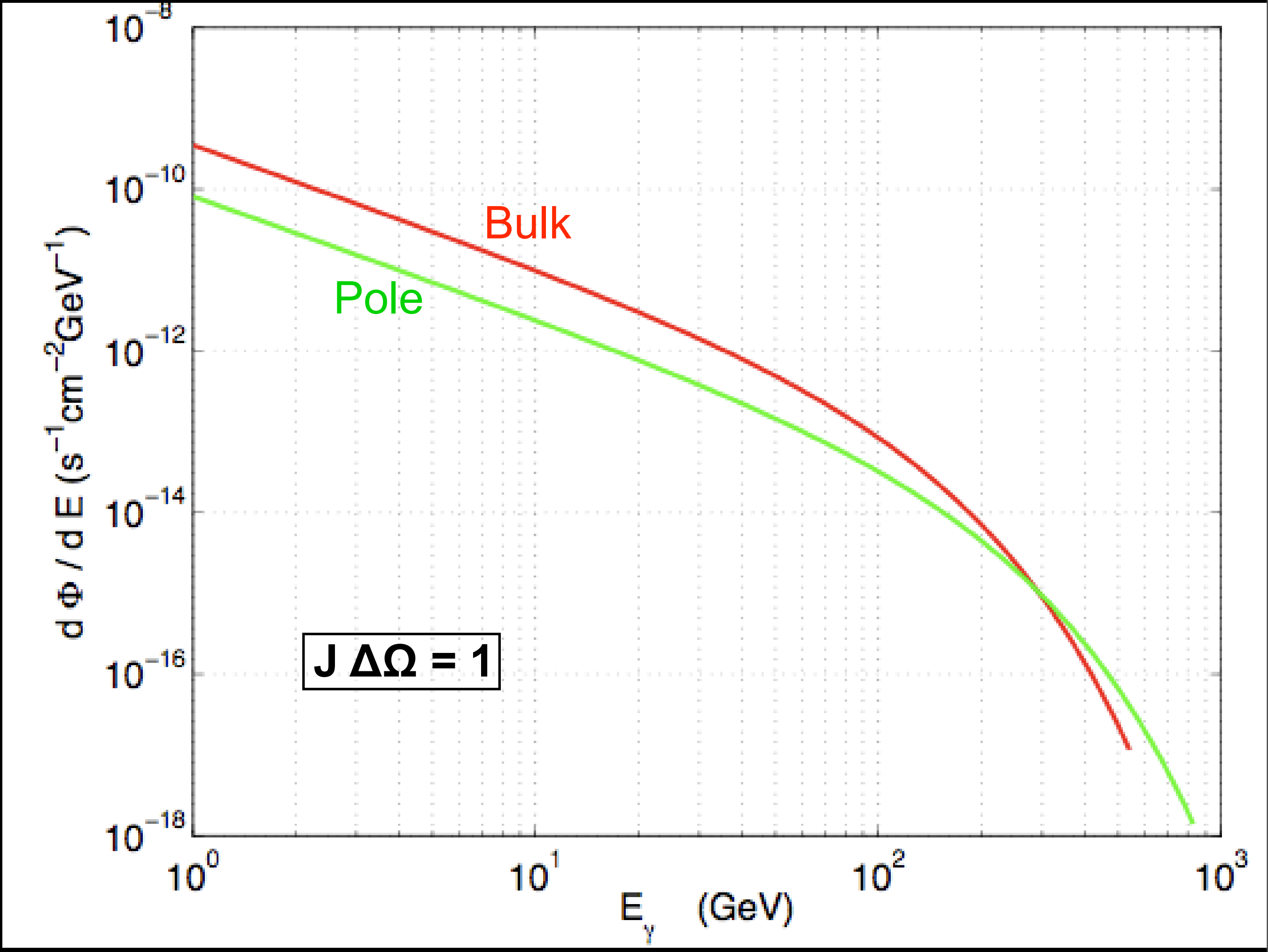
Hadronization and Fragmentation

- 2 regions



Hadronization and Fragmentation

- 2 regions
- Detector limits:



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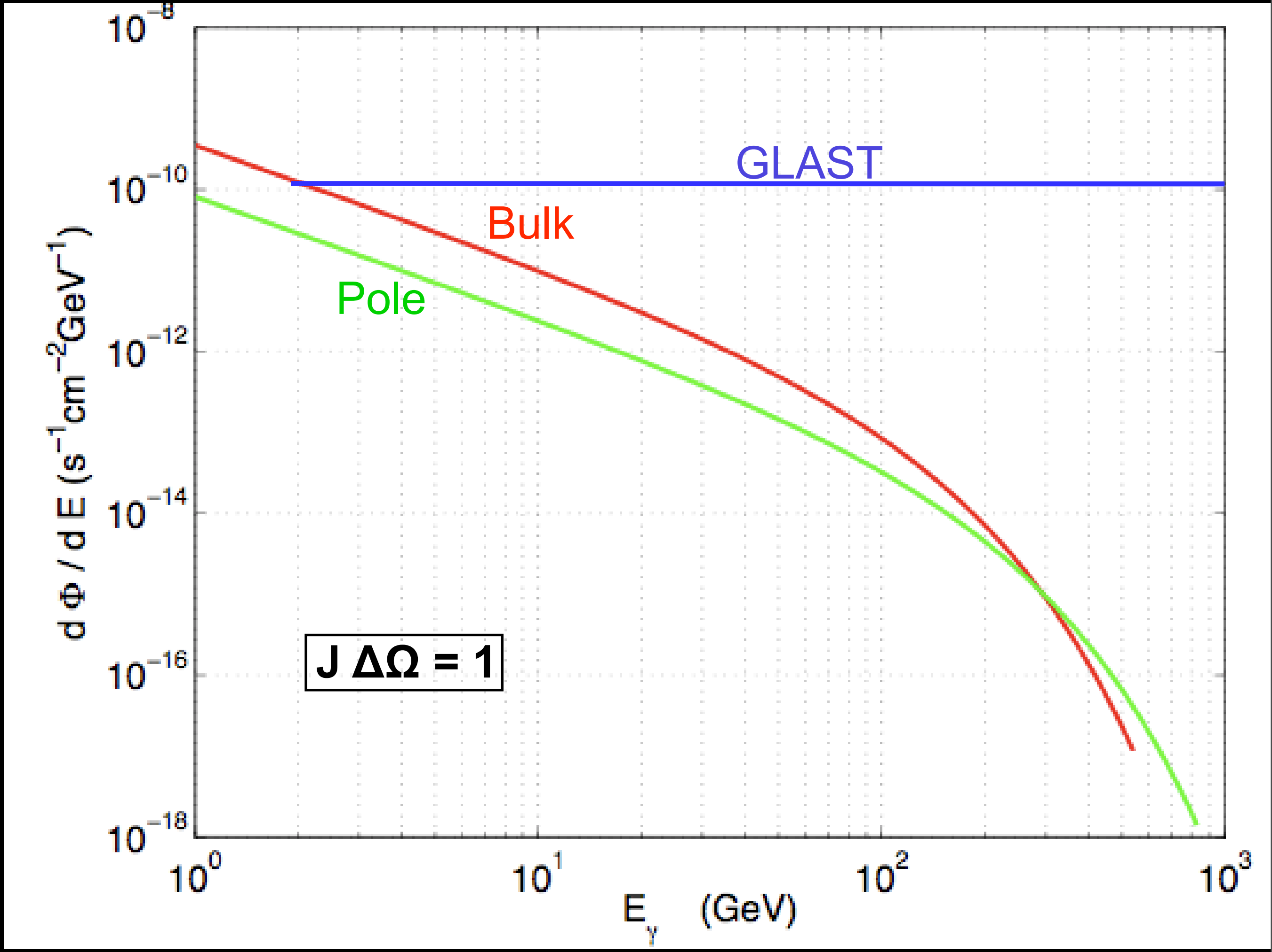

Hadronization and Fragmentation

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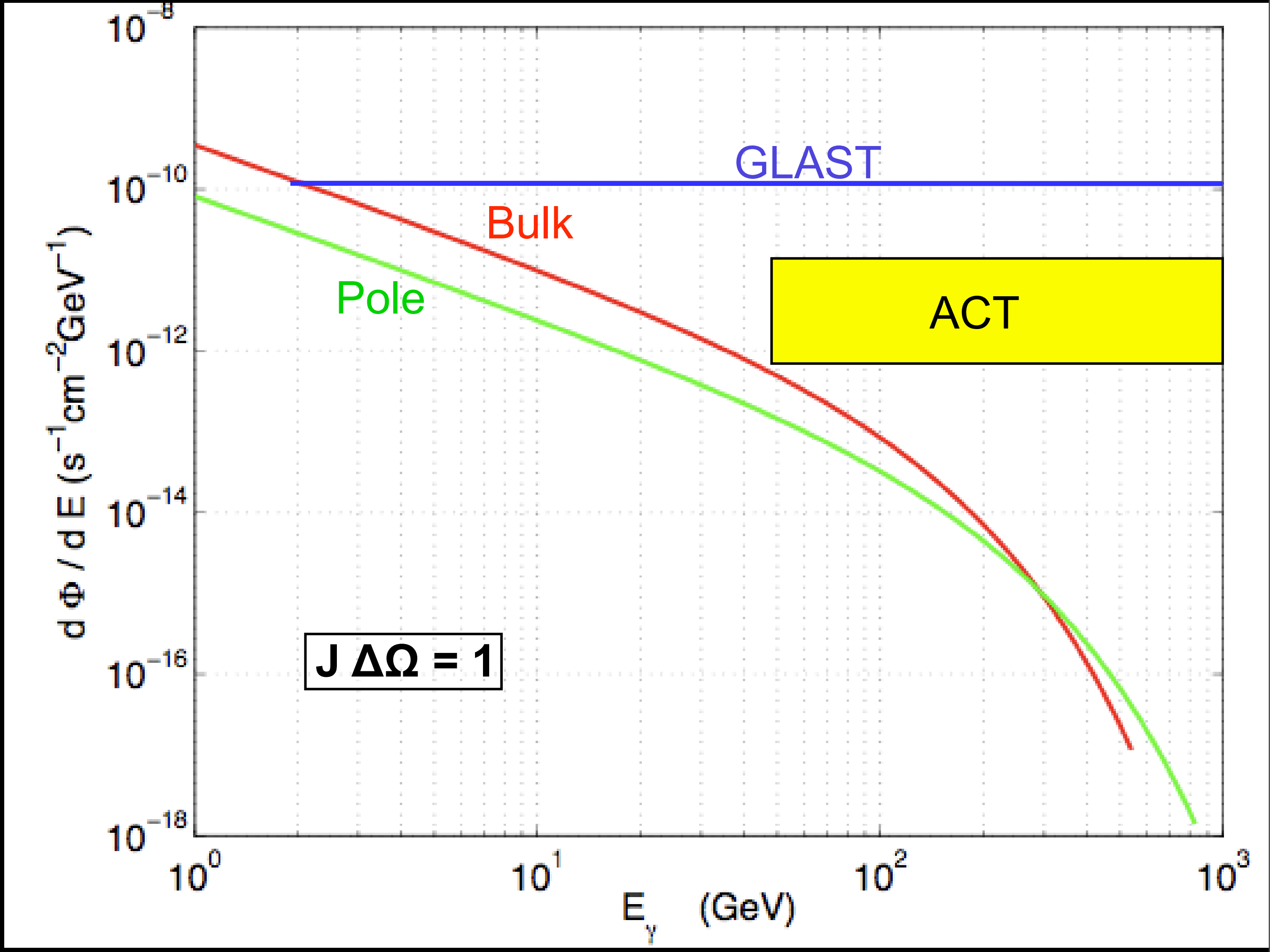
  - ACTs



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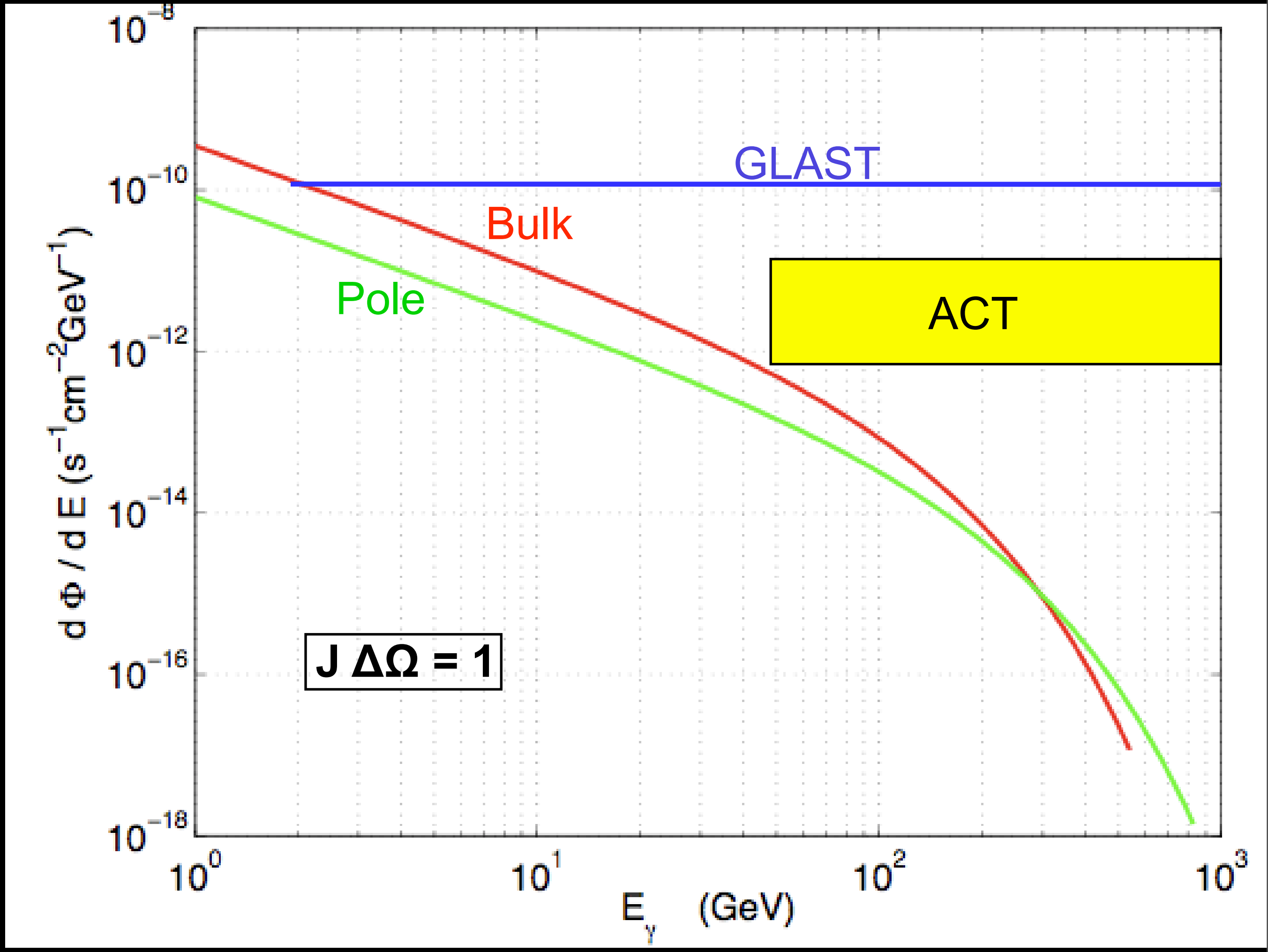

→ **Possible if J is large**

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- Thank you!