GALACTIC DARK MATTER & SUSY PARAMETER SPACE

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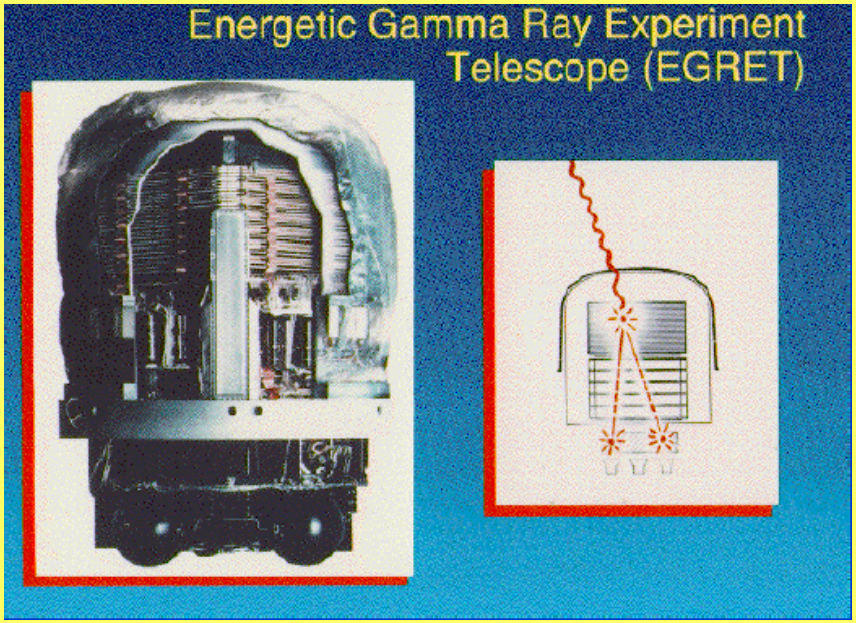
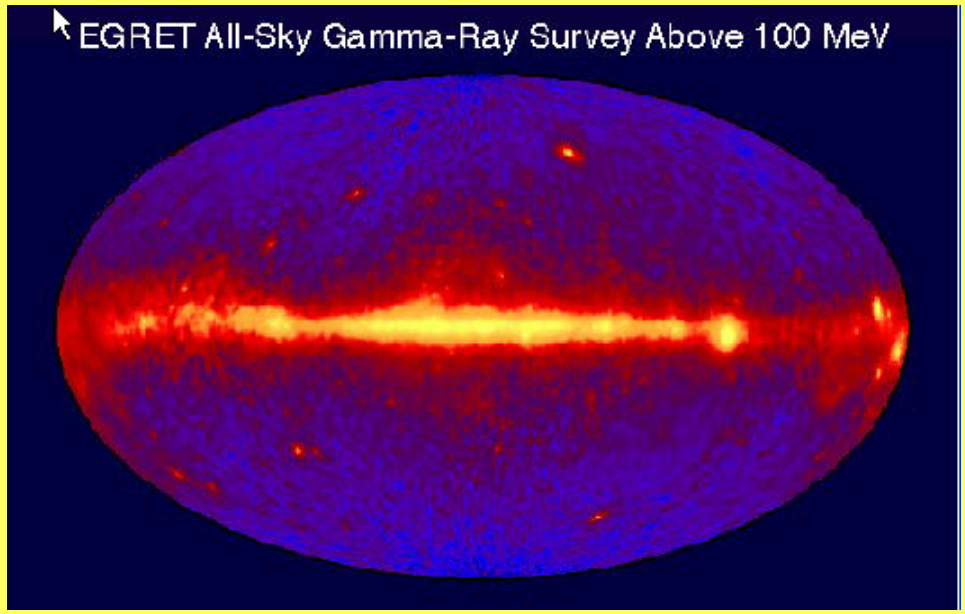
Outline

- Diffuse Galactic γ Rays from EGRET
- DM annihilation in the MSSM
- Restriction to SUSY Parameter Space
- SUSY Production at LHC in EGRET Region
- Conclusions

DIFFUSE GAMMA RAYS FROM THE SKY





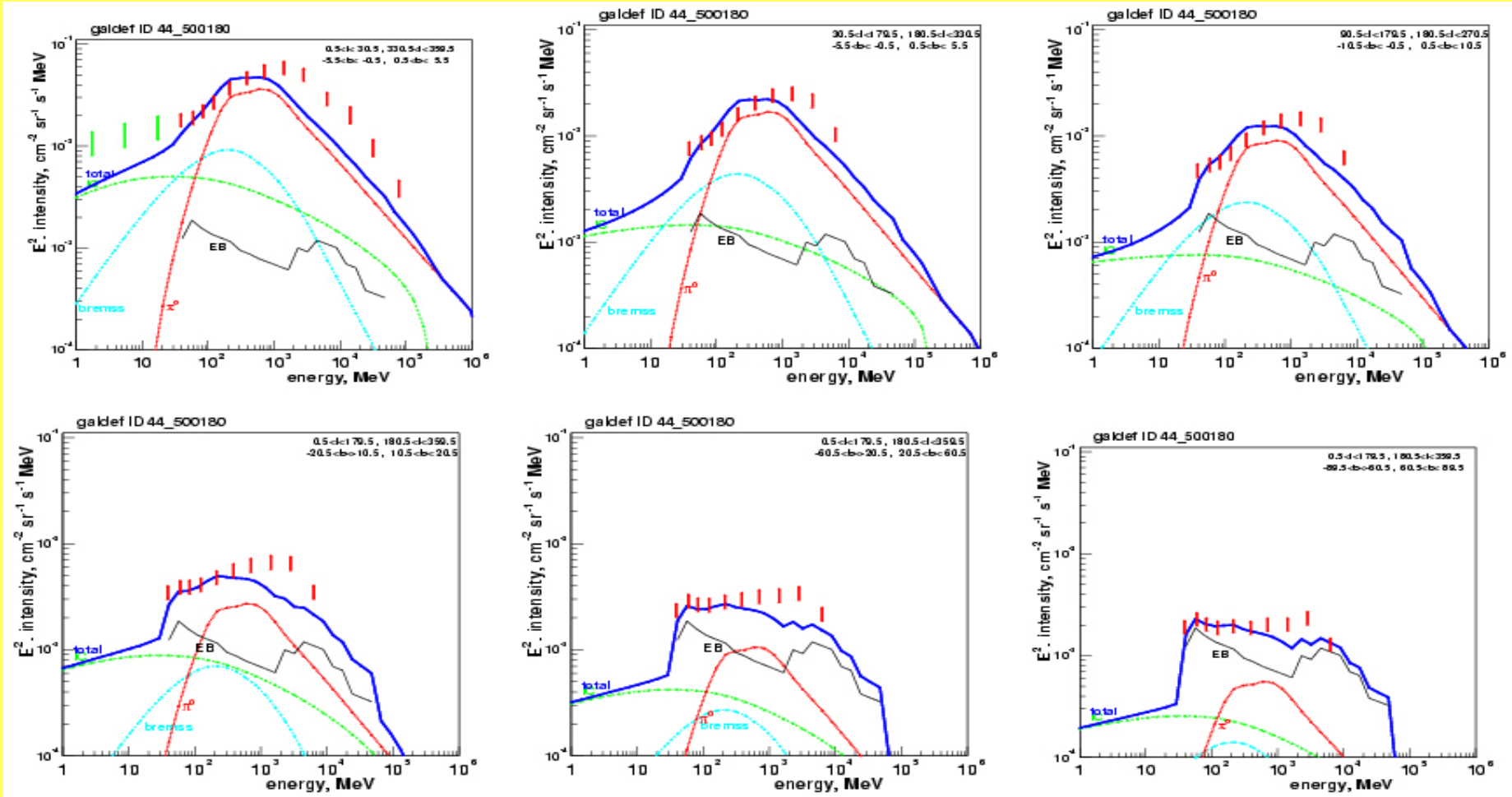
Instrumental parameters:

Energy range: 0.02-30 GeV
Energy resolution: ~20%
Effective area: 1500 cm^2
Angular resol.: $<0.5^0$

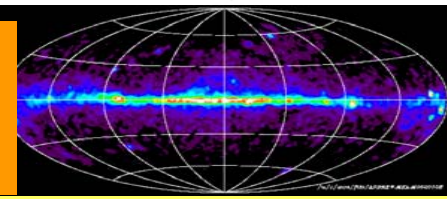
Data taking: 1991-2000

Main EGRET results:
Catalogue of point sources
Excess in diffuse gamma rays

EXCESS OF DIFFUSE GAMMAY RAYS ABOVE 1 GEV



A: inner Galaxy (l=±30⁰, |b|<5⁰)
B: Galactic plane avoiding A
C: Outer Galaxy
D: low latitude (10-20⁰)
E: intermediate lat. (20-60⁰)
F: Galactic poles (60-90⁰)



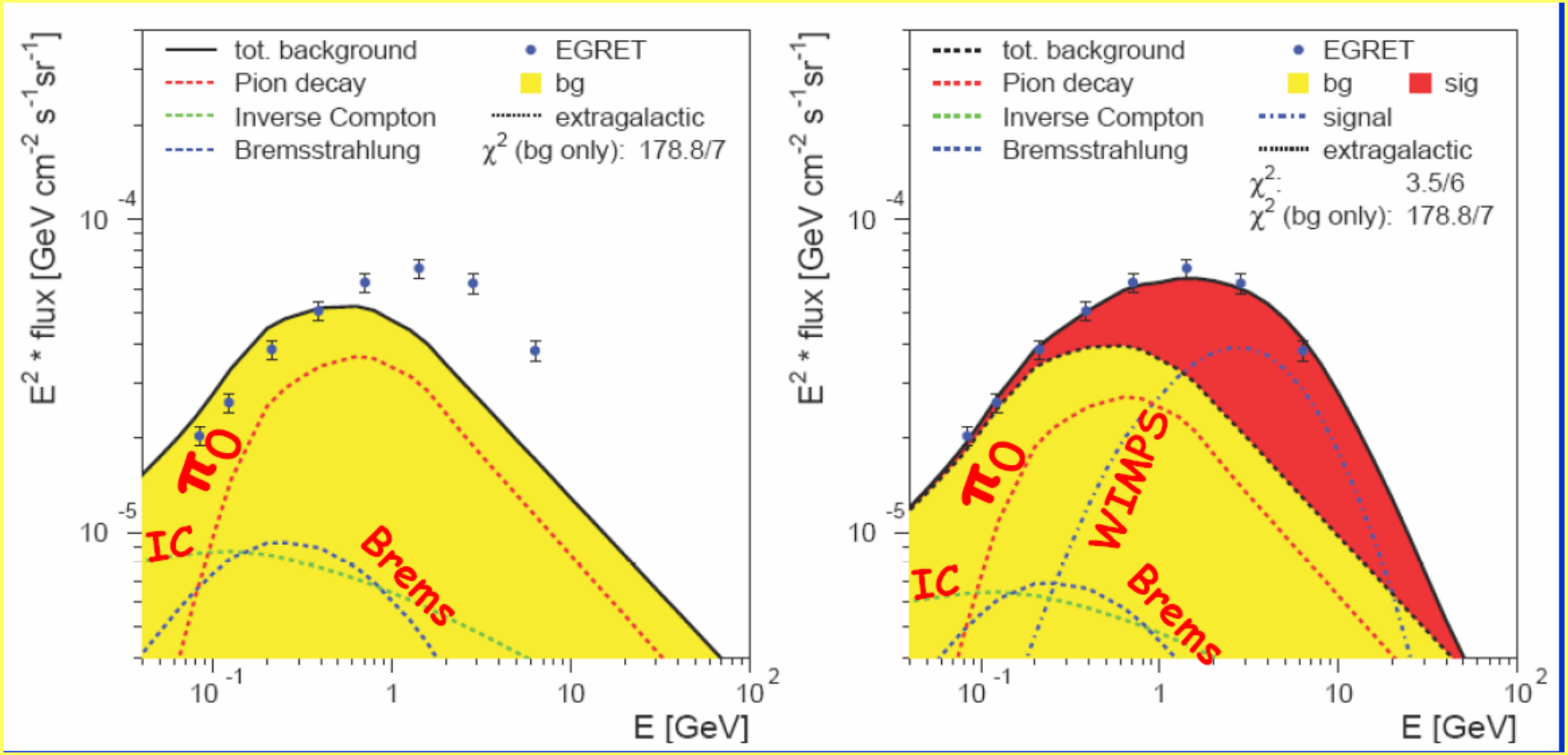
PHYSICS PROBLEMS

- What is the origin of excess of diffuse Galactic Gamma Rays?
- What is Cold Dark Matter made of?
- Where are the Supersymmetric Particles?

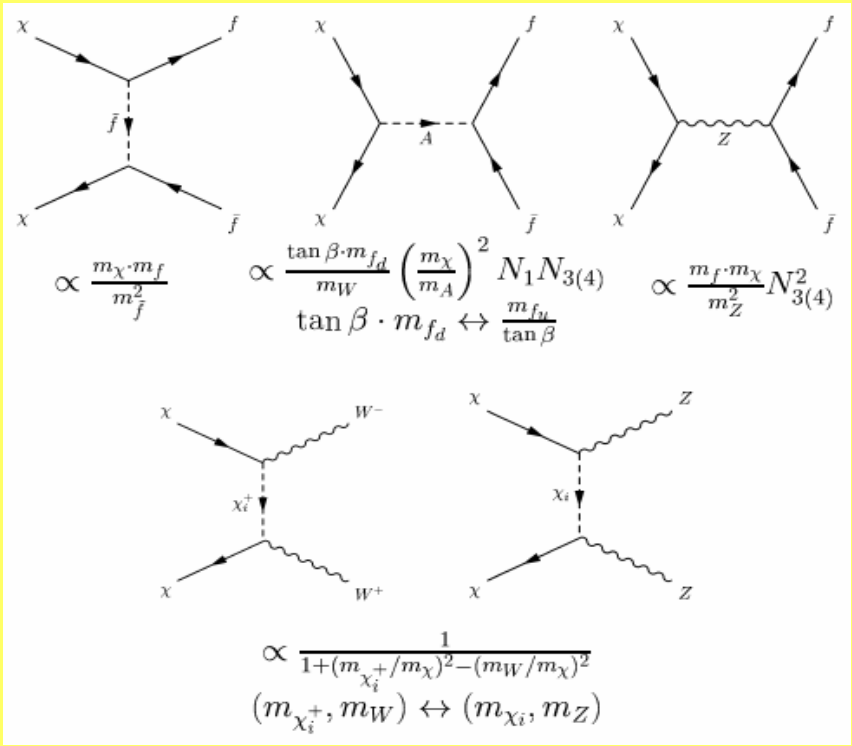
Solution:

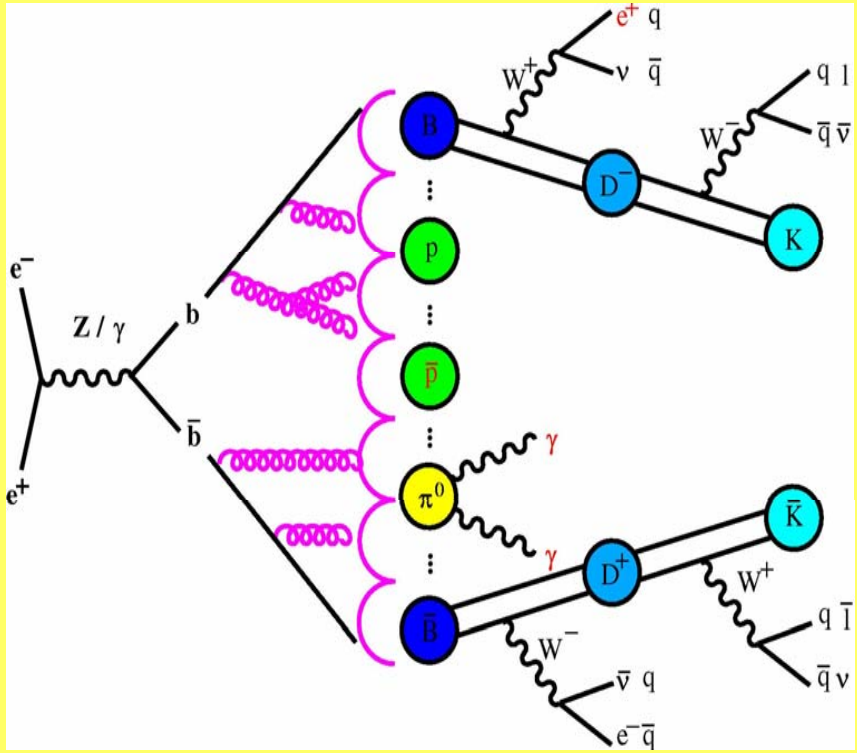
- EGRET excess is due to DM annihilation
- DM is made of WIMPs which are SUSY particles distributed in Halo of our Galaxy
- SUSY Neutralinos have a mass around 60 GeV and should be observable at the LHC

EXCESS OF DIFFUSE GAMMAY RAYS WITH AND WITHOUT DM ANNIHILATION



DM NEUTRALINO ANNIHILATION FINAL STATES



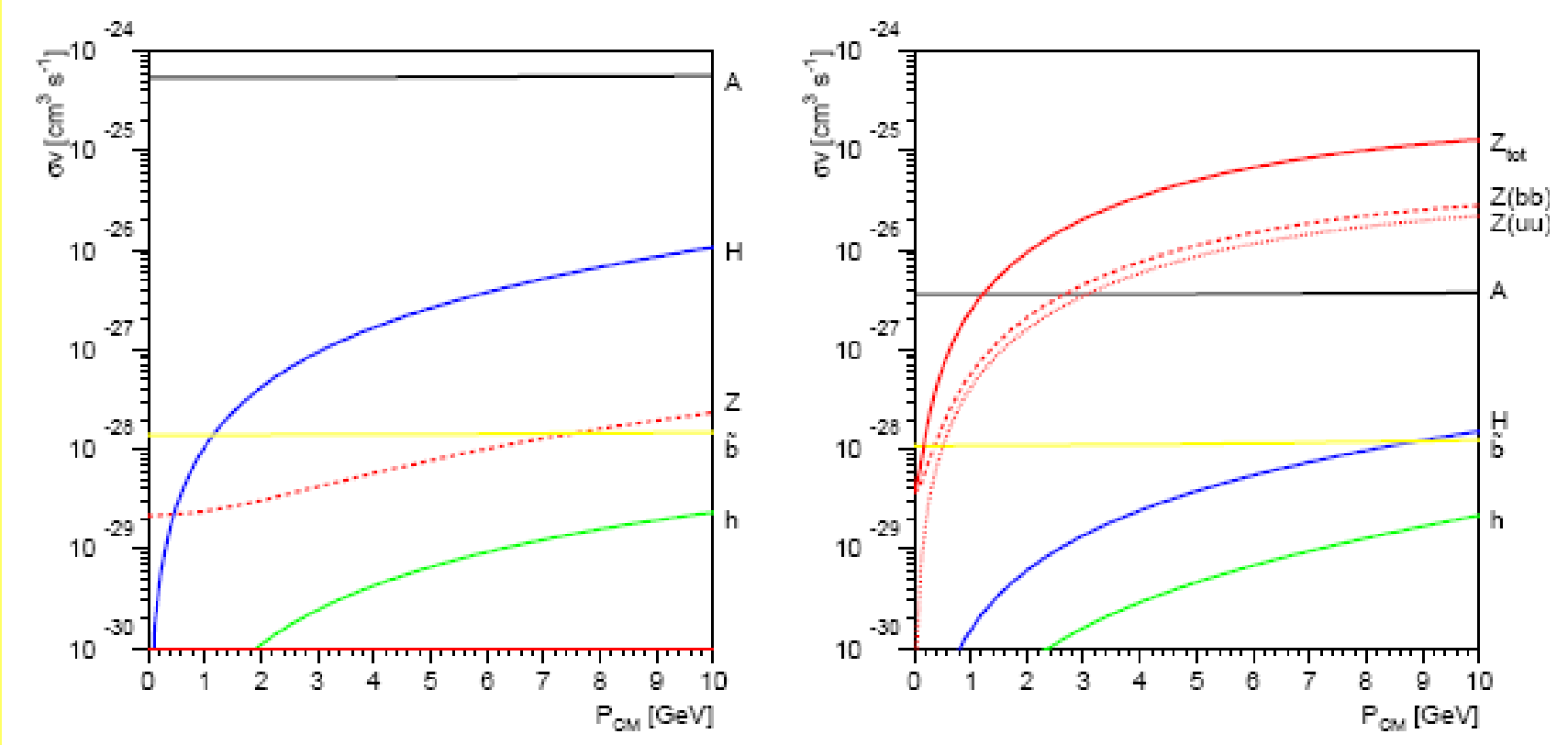


Dominant annihilation x-section:
$\chi + \chi \Rightarrow A \Rightarrow b\bar{b}$ quark pair

Sum of diagrams should yield $\langle\sigma v\rangle = 2.10^{-26}$ cm^3/s to get correct relic density

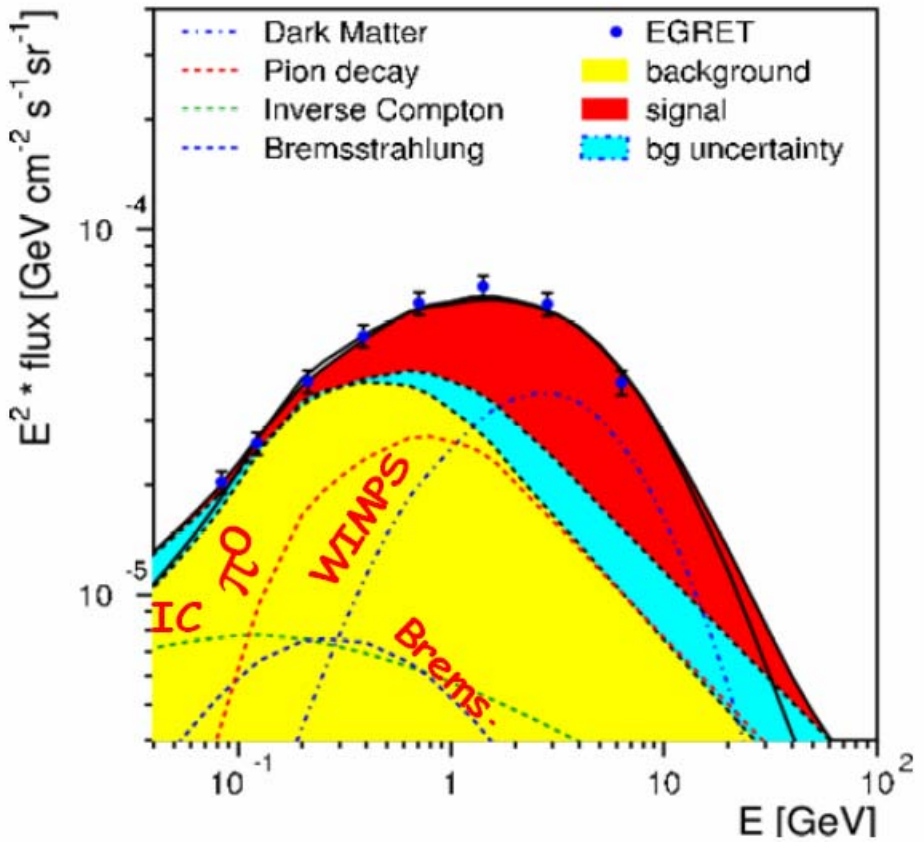
B-fragmentation well studied at LEP! Yield and spectra of positrons, gammas and antiprotons well known!

DM NEUTRALINO ANNIHILATION CROSS-SECTION

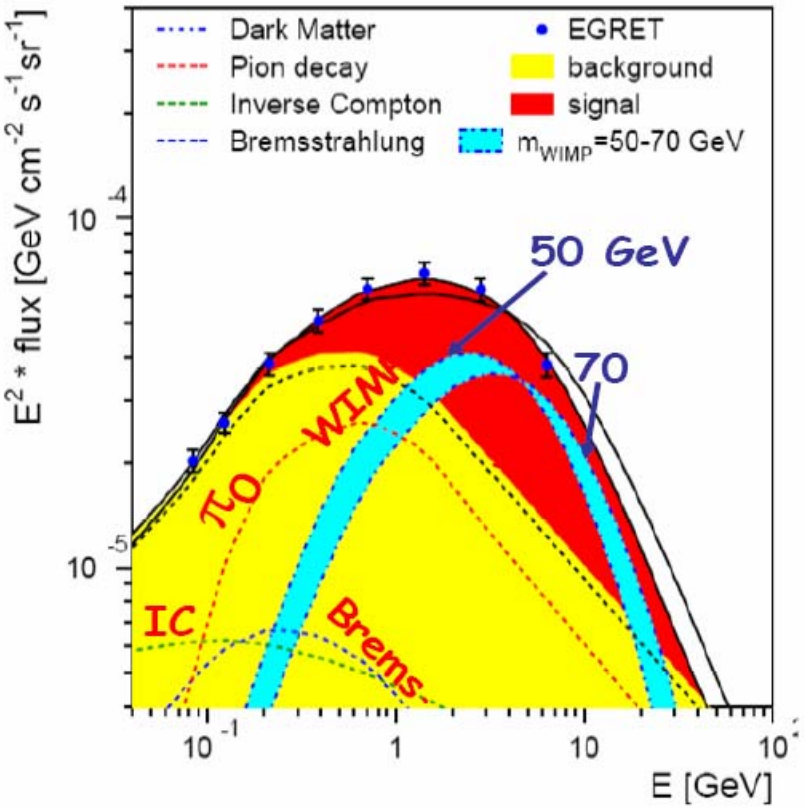


Dominant annihilation x-section:
$\chi + \chi \Rightarrow A \Rightarrow$ bb quark pair

BACKGROUND + SIGNAL DESCRIBE EGRET DATA

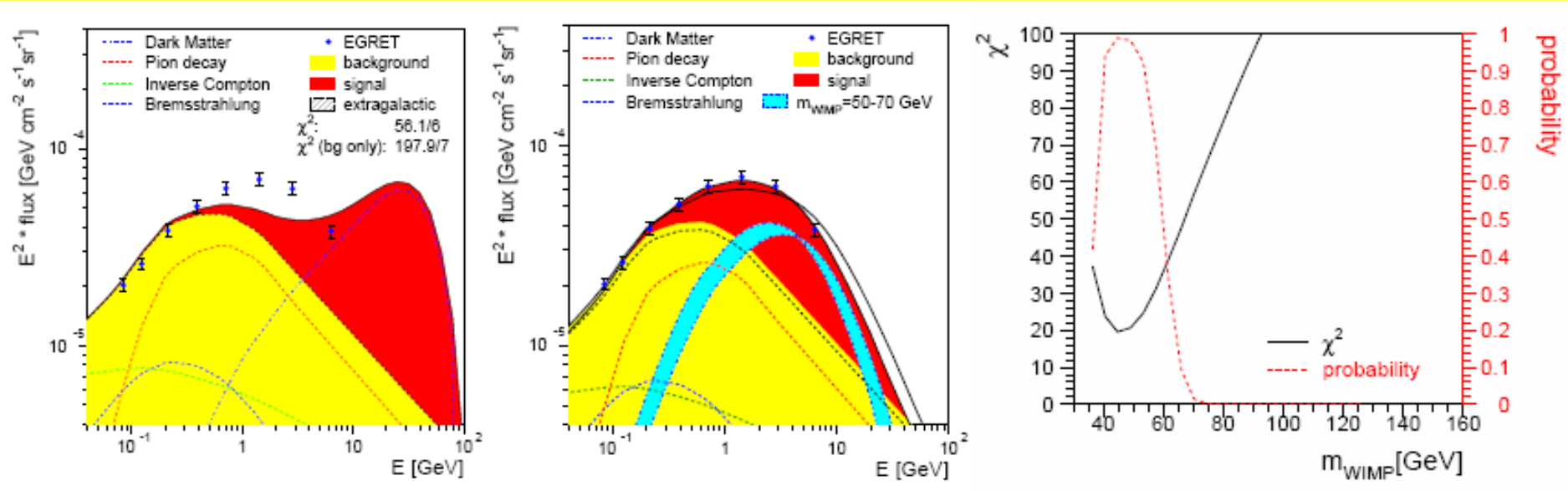


Blue: background uncertainty



Blue: WIMP mass uncertainty

FIT TO WIMP MASS



Heavy neutralino M_χ ~ 50-80 GeV

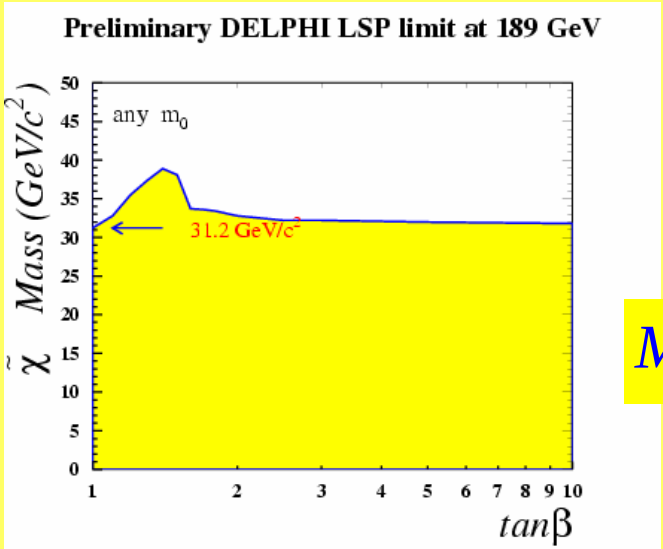
Heavy WIMP is excluded

SUSY DARK MATTER

Neutralino = SUSY candidate for the cold Dark Matter
Neutralino = the Lightest Superparticle (LSP) = WIMP

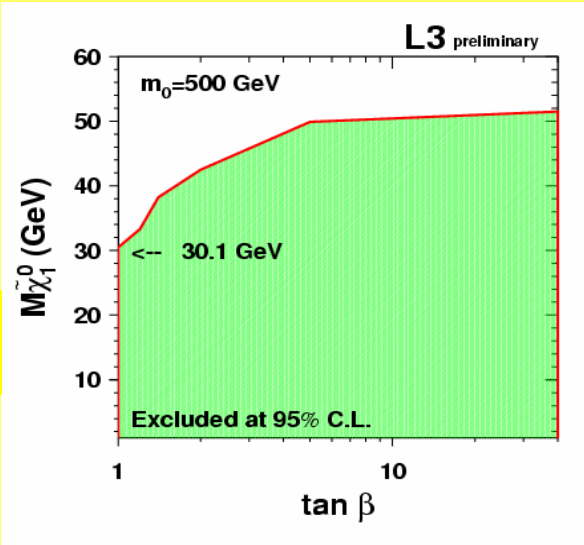
$$\tilde{\chi}^0 = N_1\tilde{\gamma} + N_2\tilde{z} + N_3\tilde{H}_1^0 + N_4\tilde{H}_2^0$$

photino zino higgsino higgsino



$$M_\chi^{exp} \geq 40 \text{ GeV}$$

$$M_\chi^{theor} = 40 \div 400 \text{ GeV}$$

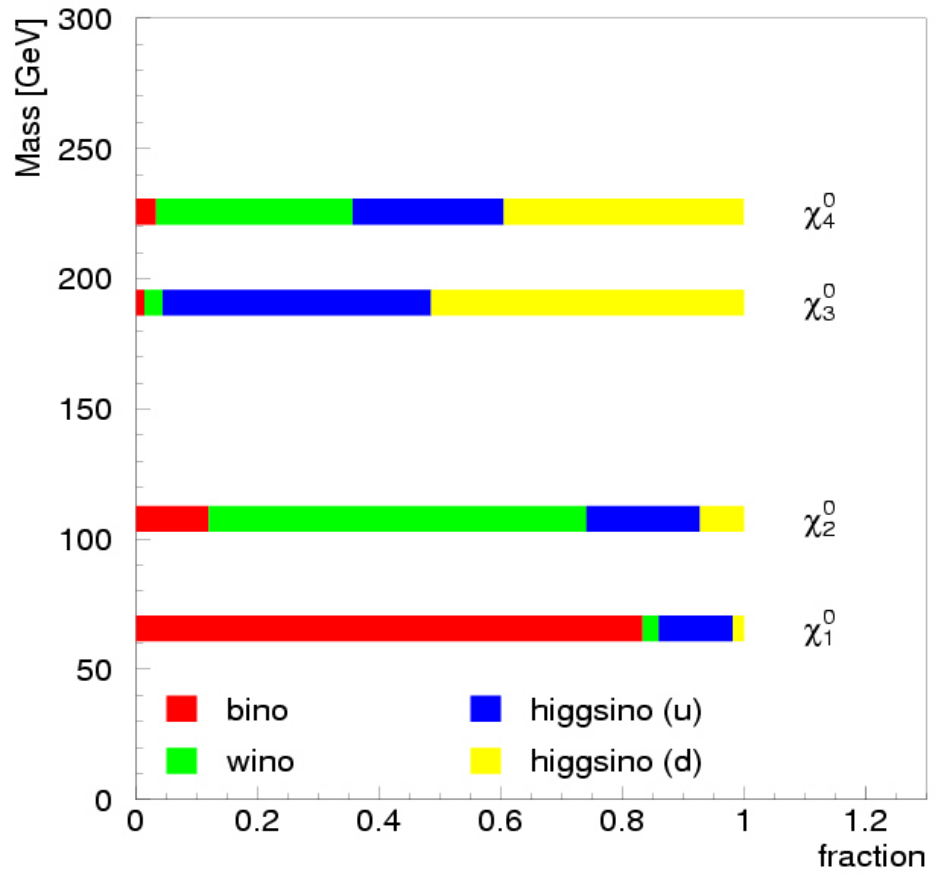


$$R = (-1)^{3(B-L)+2S}$$

$$R_p = +1,\ R_{\tilde{p}} = -1$$

- **Superparticles are created in pairs**
- **The lightest superparticle is stable**

GAUGINO CONTENT OF THE LIGHTEST NEUTRALINO

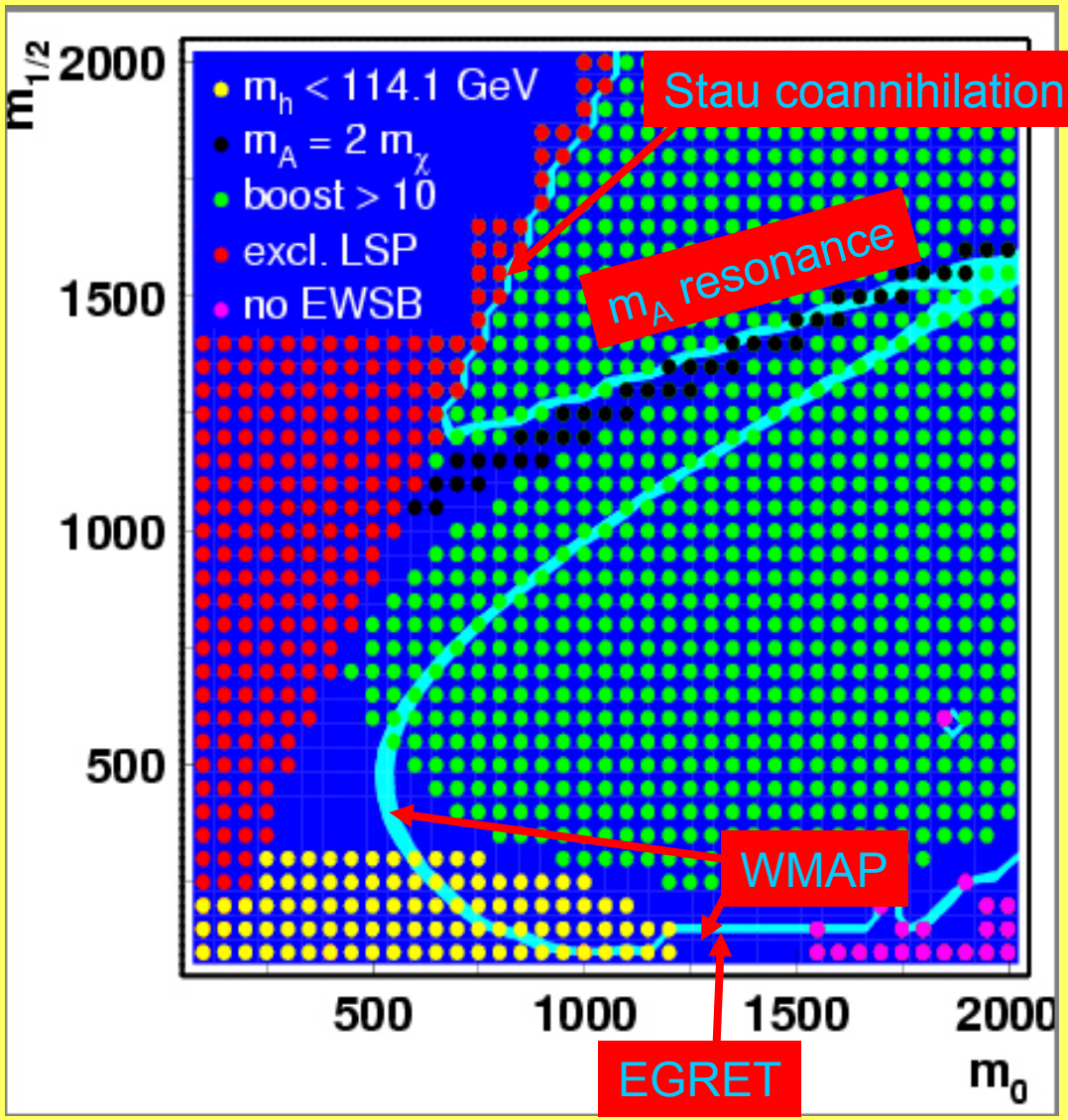


	$\tilde{b}^0$	$\tilde{w}^0$	$\tilde{h}_1^0$	$\tilde{h}_2^0$
$\tilde{\chi}_1^0$	0.833	0.026	0.122	0.018
$\tilde{\chi}_2^0$	0.119	0.621	0.187	0.072
$\tilde{\chi}_3^0$	0.014	0.030	0.442	0.515
$\tilde{\chi}_4^0$	0.033	0.323	0.249	0.395

The lightest neutralino is almost bino – the superpartner of a photon

DM = superpartner of the CMB

ALLOWED SUSY PARAMETER SPACE

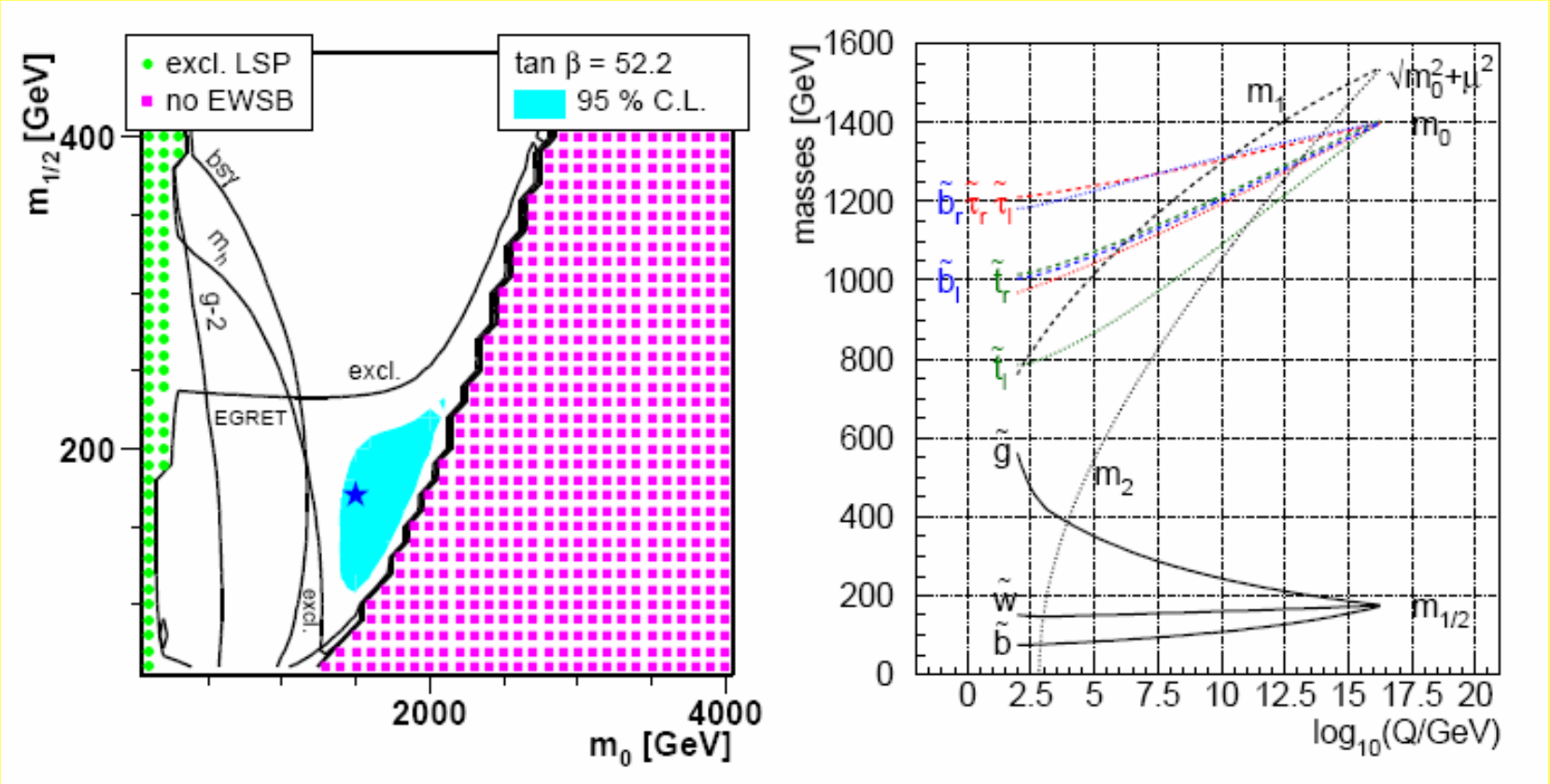


MSUGRA can fulfill all constraints from WMAP, LEP, b->sγ, g-2 and EGRET simultaneously, if DM is neutralino with mass in range 50-100 GeV and squarks and sleptons are O(1 TeV)

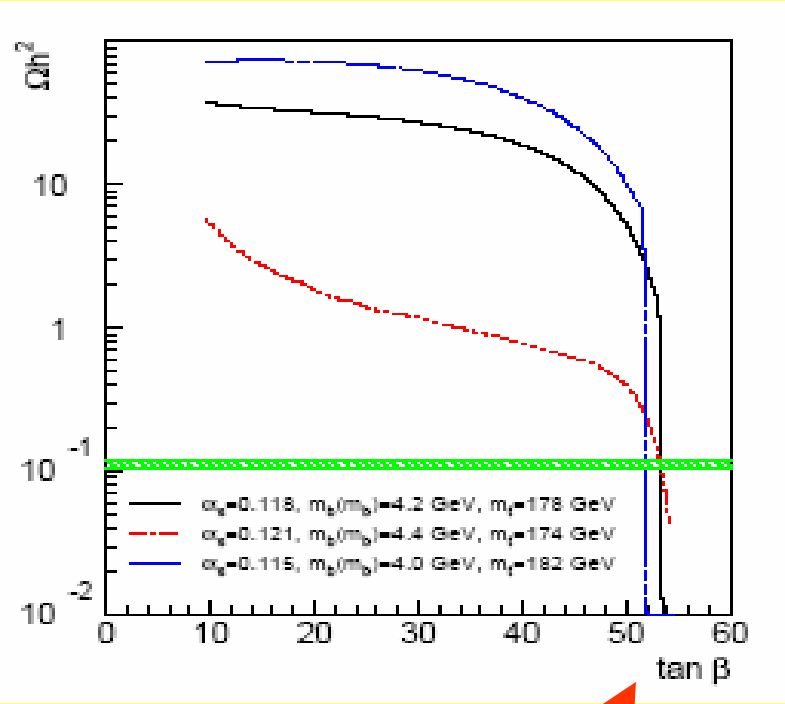
m_0 common spin 0 mass
$m_{1/2}$ common spin ½ mass
$\tan\beta = v_2/v_1$

High tanβ solution
tanβ = 50

EGRET POINT AND MASS SPECTRUM



FIT TO tan β



tan β ~ 50

SUSY MASS SPECTRUM

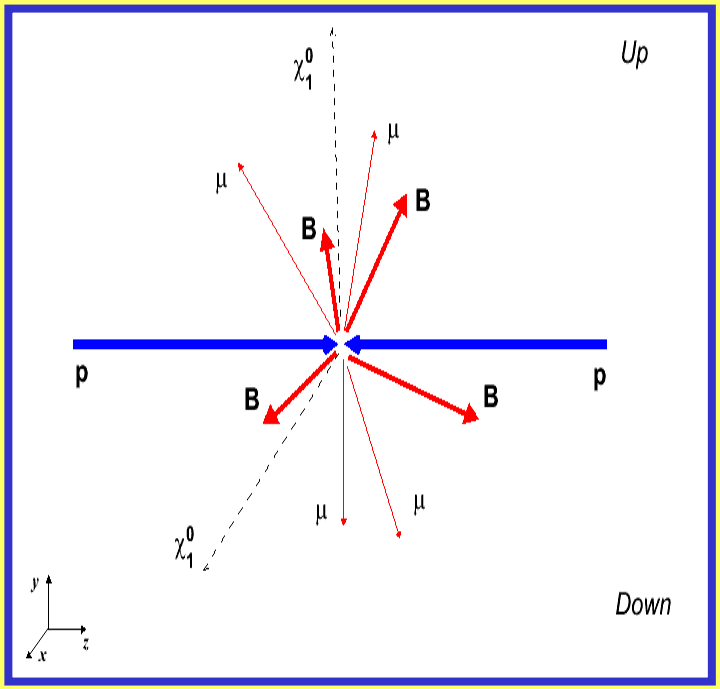
Fitted SUSY Parameters

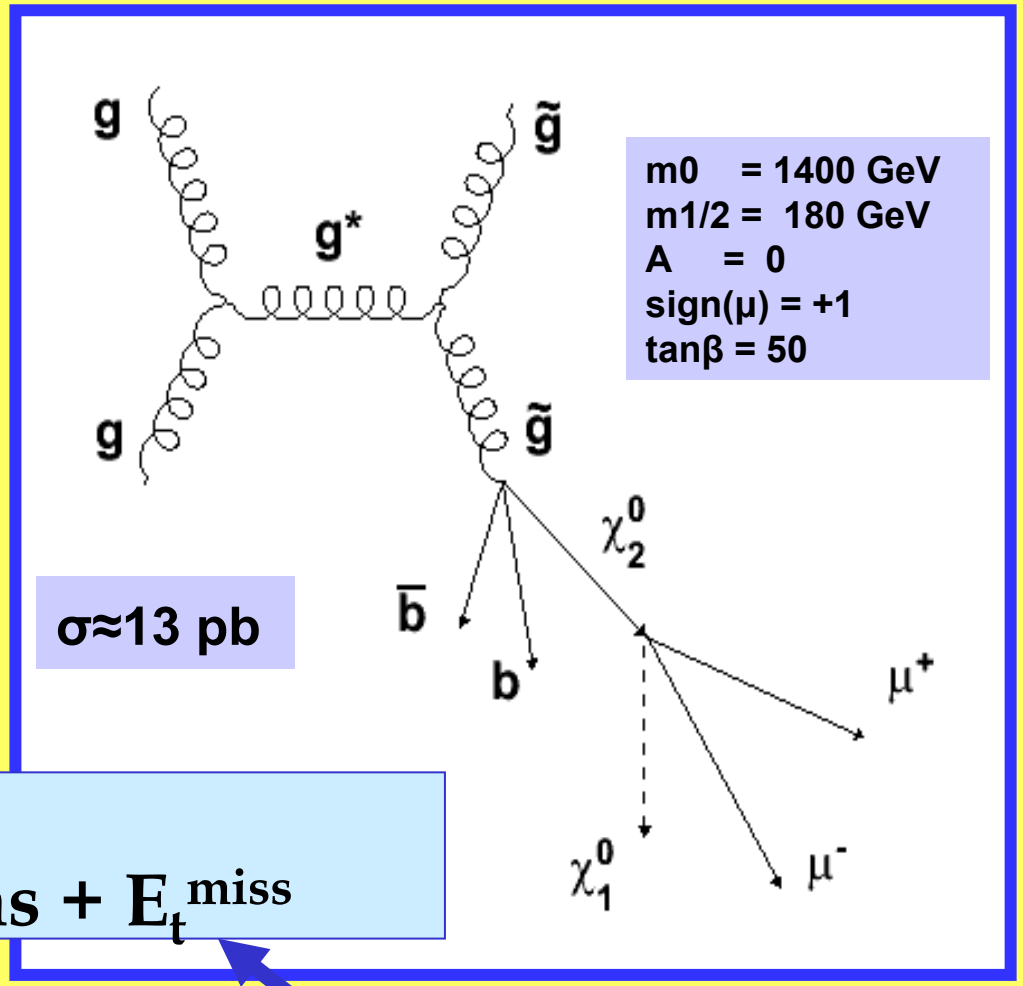
Parameter	Value
tan β	52.2
m_0	1500
$m_{1/2}$	170
Sign μ	+
A(0)	0
$\alpha_s(M_Z)$	0.122
$\alpha_{em}(M_Z)$	0.0078153697
$Sin^2\theta_W\|_{\overline{MS}}$	0.2314
m_t	175 GeV
m_b	4.214 GeV

SUSY Masses in GeV

Particle	Mass
$\tilde{\chi}^0_{1,2,3,4}$ →	64, 113, 194, 229
$\tilde{\chi}^{\pm}_{1,2}$, $\tilde{g}$ →	110, 130, 516
$\tilde{u}_{1,2} = \tilde{c}_{1,2}$	1519, 1523
$\tilde{d}_{1,2} = \tilde{s}_{1,2}$	1522, 1524
$\tilde{t}_{1,2}$	906, 1046
$\tilde{b}_{1,2}$	1309, 1152
$\tilde{e}_{1,2} = \tilde{\mu}_{1,2}$	1497, 1499
$\tilde{\tau}_{1,2}$	1305, 1288
$\tilde{\nu}_e, \tilde{\nu}_\mu, \tilde{\nu}_\tau$	1495, 1495, 1286
h, H, A, $H^{\pm}$ →	115, 372, 372, 383

SUSY PRODUCTION AT LHC





SIGNATURE:
4 b-jets + 4 muons + E_t^{miss}

LARGE!

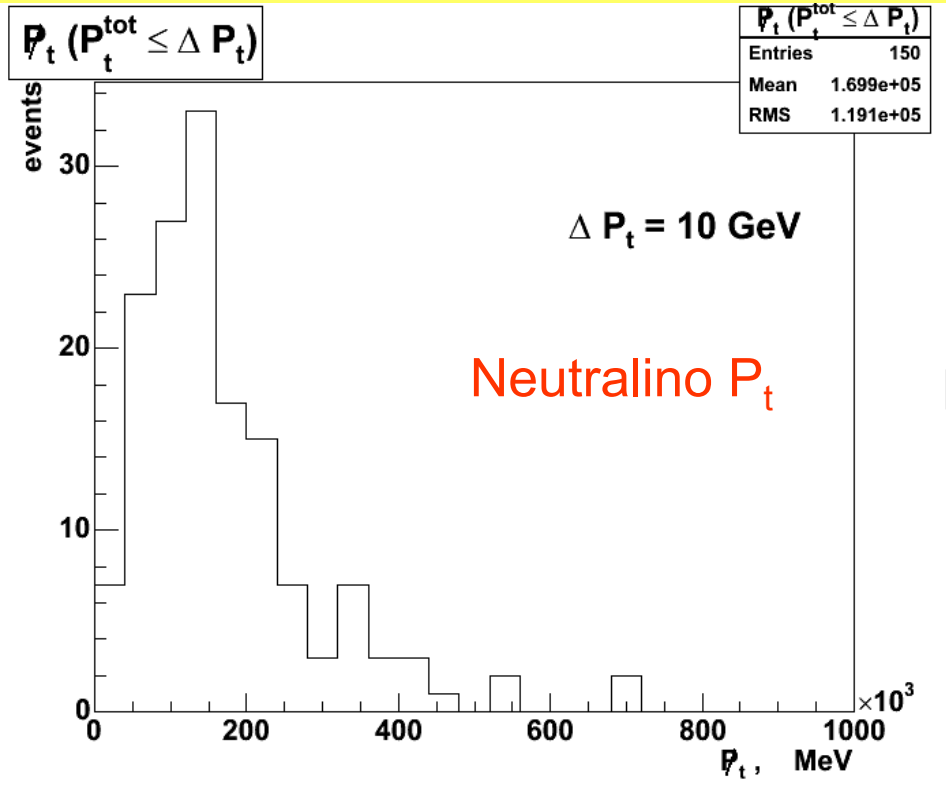
SUSY $gg \rightarrow \tilde{g}\tilde{g}$ IN ATLAS

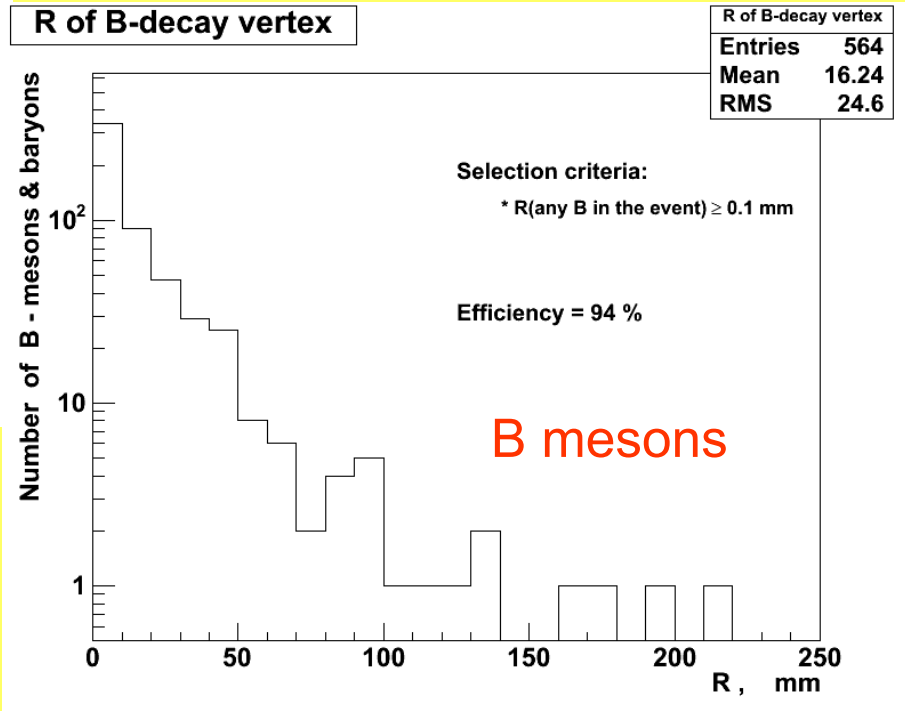
JINR(Dubna) ATLAS Group

V. Bednyakov, Y.Budagov, G. Khoriauli, J.Khubua

Pythia within ATHENA,

B-vertex taging

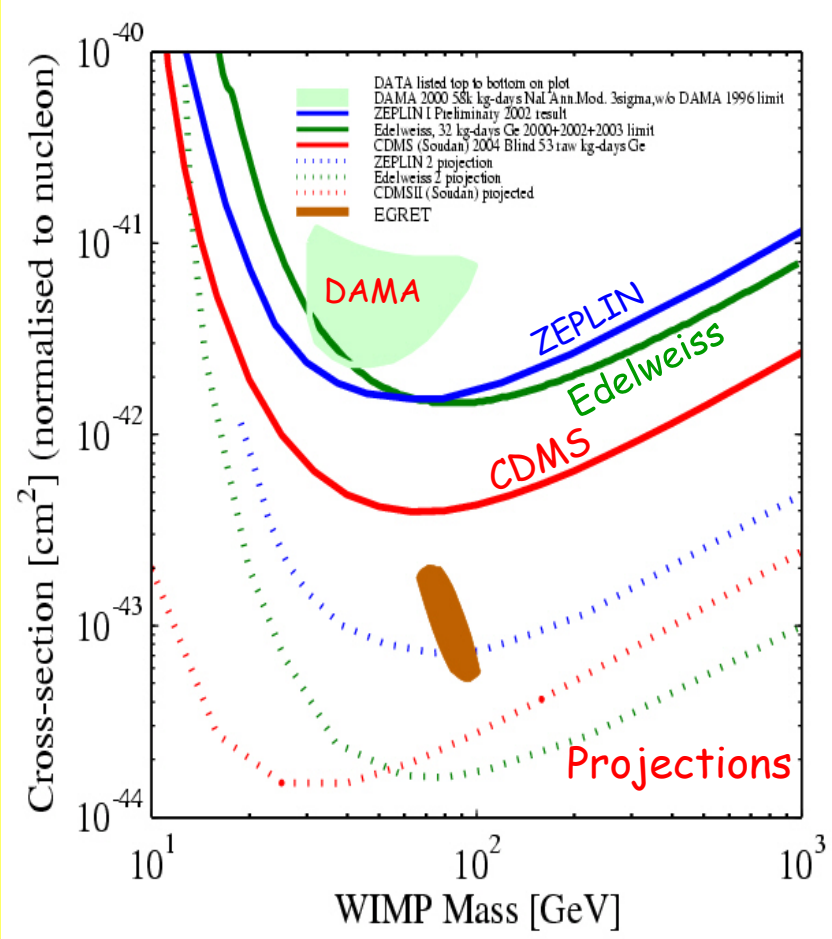




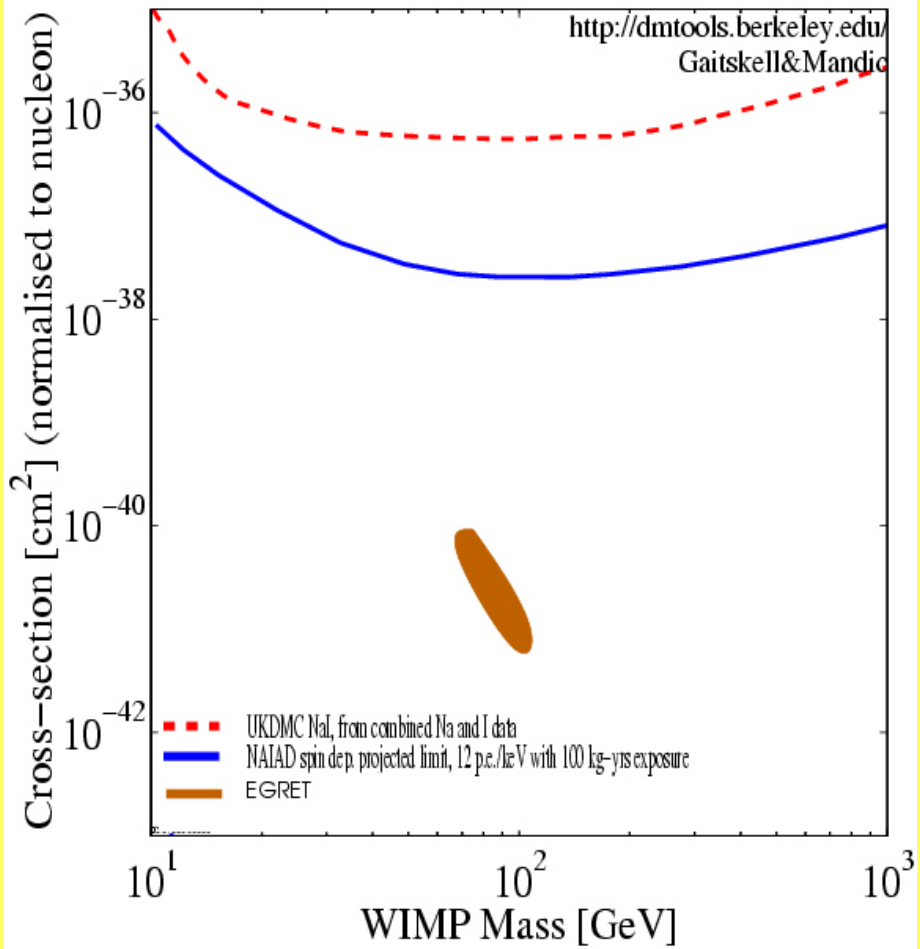
$$\Sigma P_t^{B,B,\mu,\mu}(\text{down}) - \Sigma P_t^{B,B,\mu,\mu}(\text{up}) = \not{P}_t \equiv \not{E}_t$$

DIRECT DM SEARCHES

Spin-independent



Spin-dependent



Predictions from EGRET data assuming Supersymmetry

CONCLUSIONS

If one accepts:

- **the interpretation of excess in diffuse galactic gamma rays as a signal of the DM annihilation**
- **the interpretation of the Cold Dark Matter as SUSY neutralino particles**

Then:

- **SUSY provides simultaneous consistent description of all observable data including astrophysics**
- **Parameter space of SUSY is highly restricted**
- **In the narrow allowed region the SUSY mass spectrum may be predicted**
- **Light superpartners are observable at the LHC**