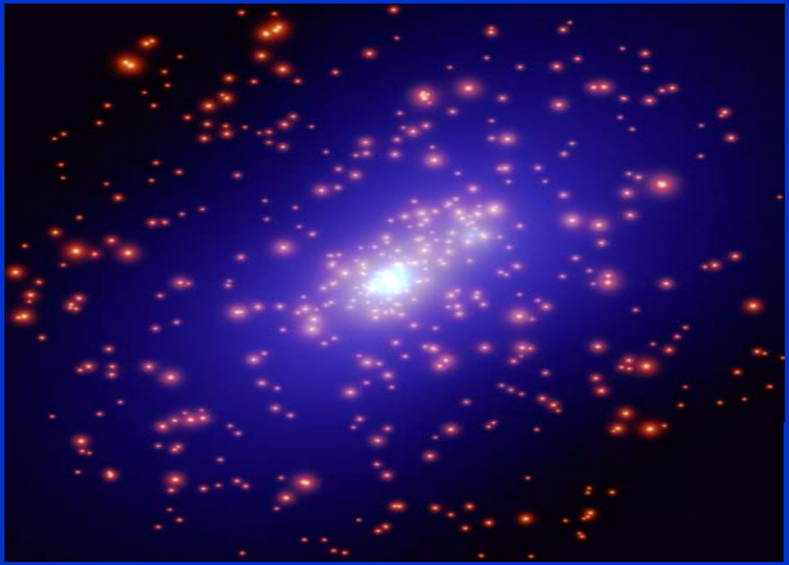
Why the EGRET excess points to heavy scalars

- What is the EGRET excess?

  Excess of diffuse gamma rays above 1 GeV compared with background (mainly pp-> π^0)



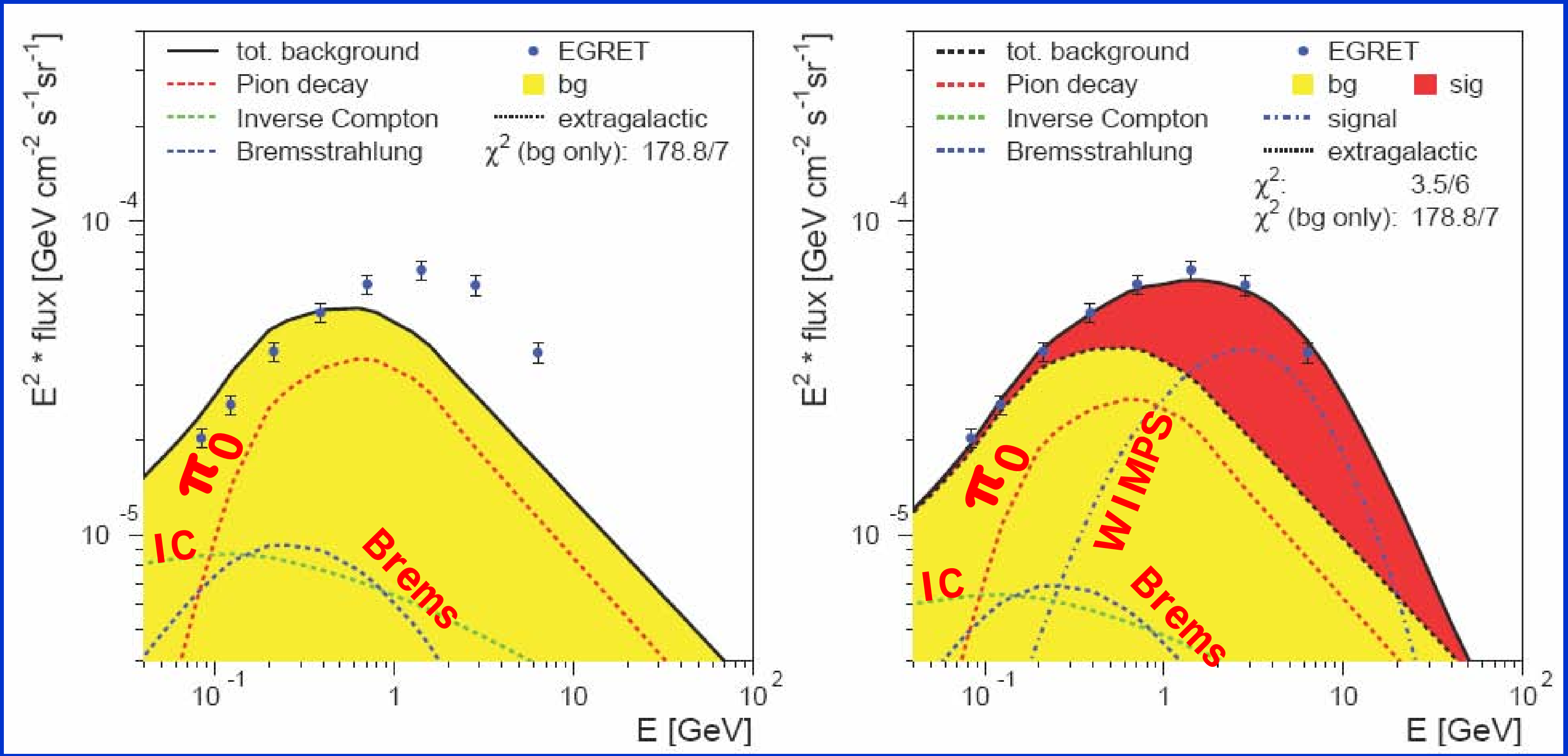
- Can DM Annihilation (DMA) explain it?

  DMA into quark pairs-> π^0 decays-> Excess in galactic Gammarays in ALL sky directions with SAME shape

  Halo-profile from all sky directions-> RECONSTRUCT ROTATION CURVE

- EGRET excess consistent with mSUGRA + ALL constraints if scalars are in TeV range

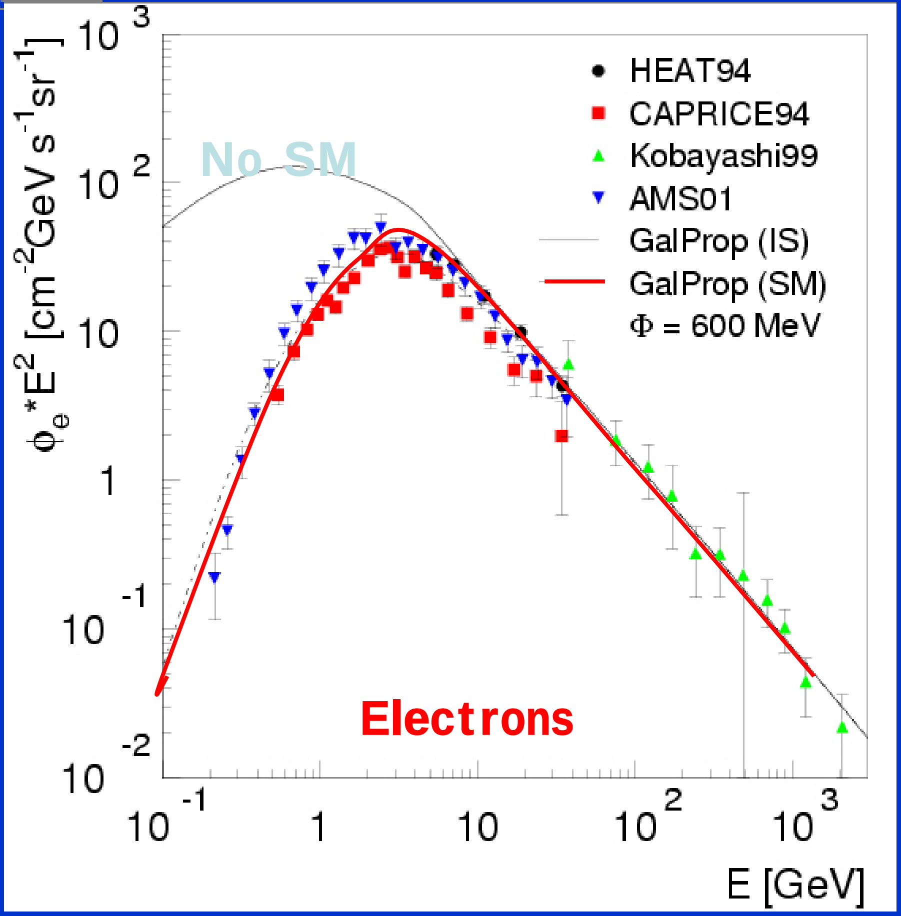
The EGRET excess of diffuse galactic gamma rays without and with DM annihilation

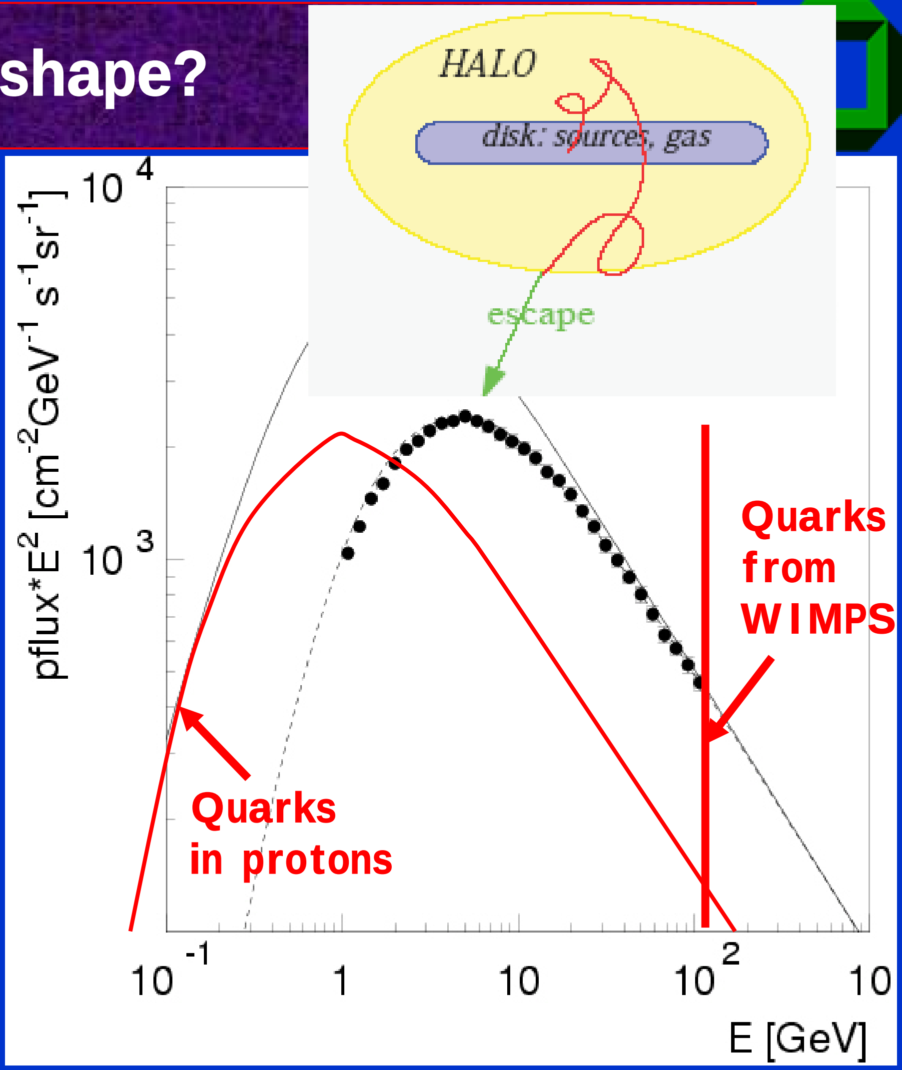


Fit only KNOWN shapes of BG + DMA, i.e. 1 or 2 parameter fit
NO GALACTIC models needed. Propagation of gammas straightforward

Gamma ray flux measured towards Galactic center

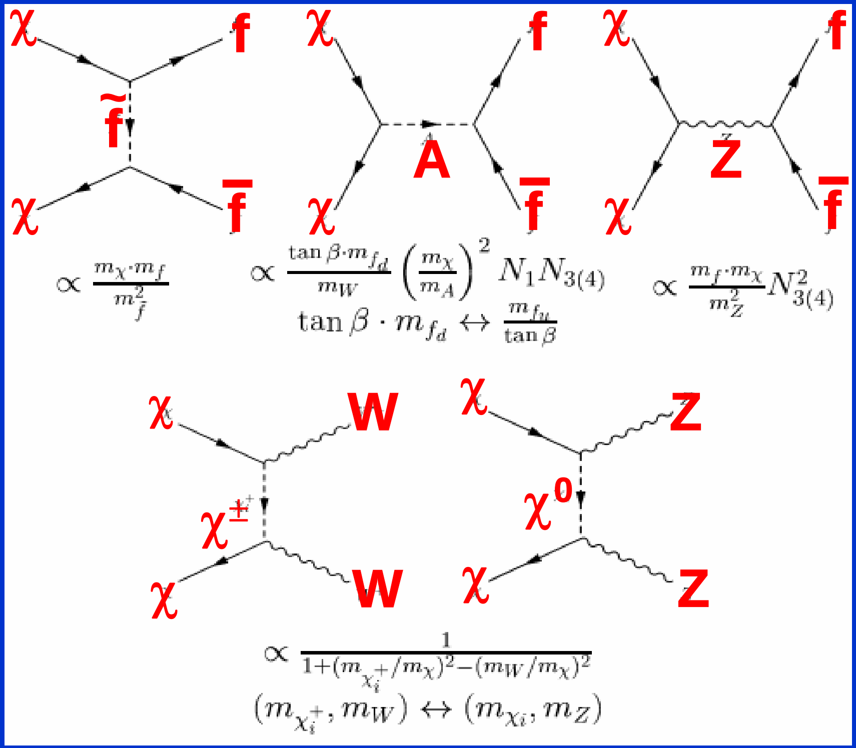
How to obtain background shape?

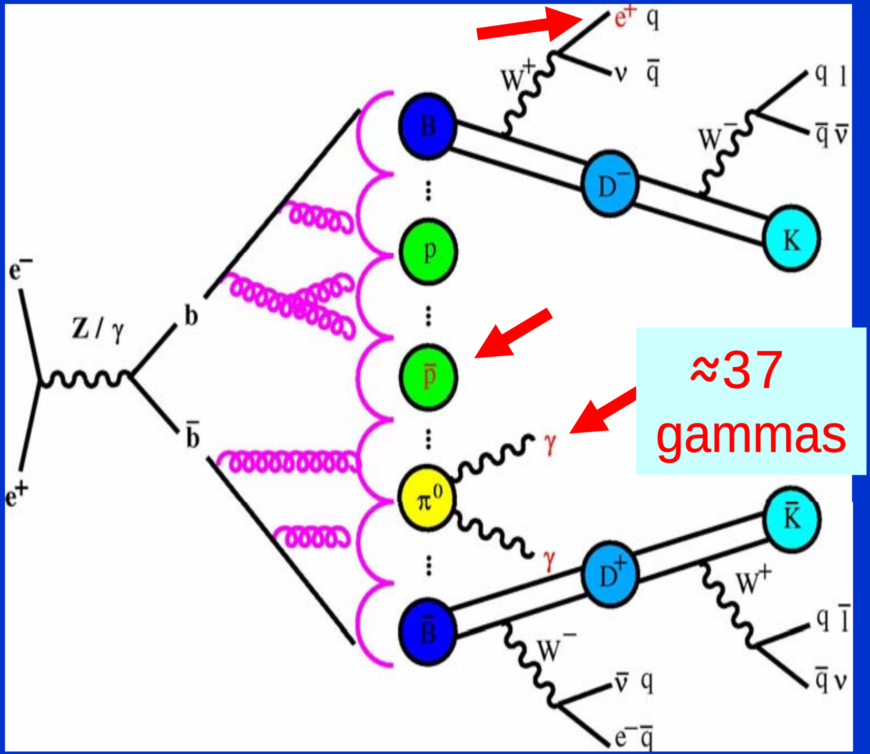




Background from nuclear interactions (mainly p+p-> π0 + X -> γ + X
inverse Compton scattering (e-+ γ -> e- + γ)
Bremsstrahlung (e- + N -> e- + γ + N)
Shape of background KNOWN if Cosmic Ray spectra of p and e- known

What about signal shape?



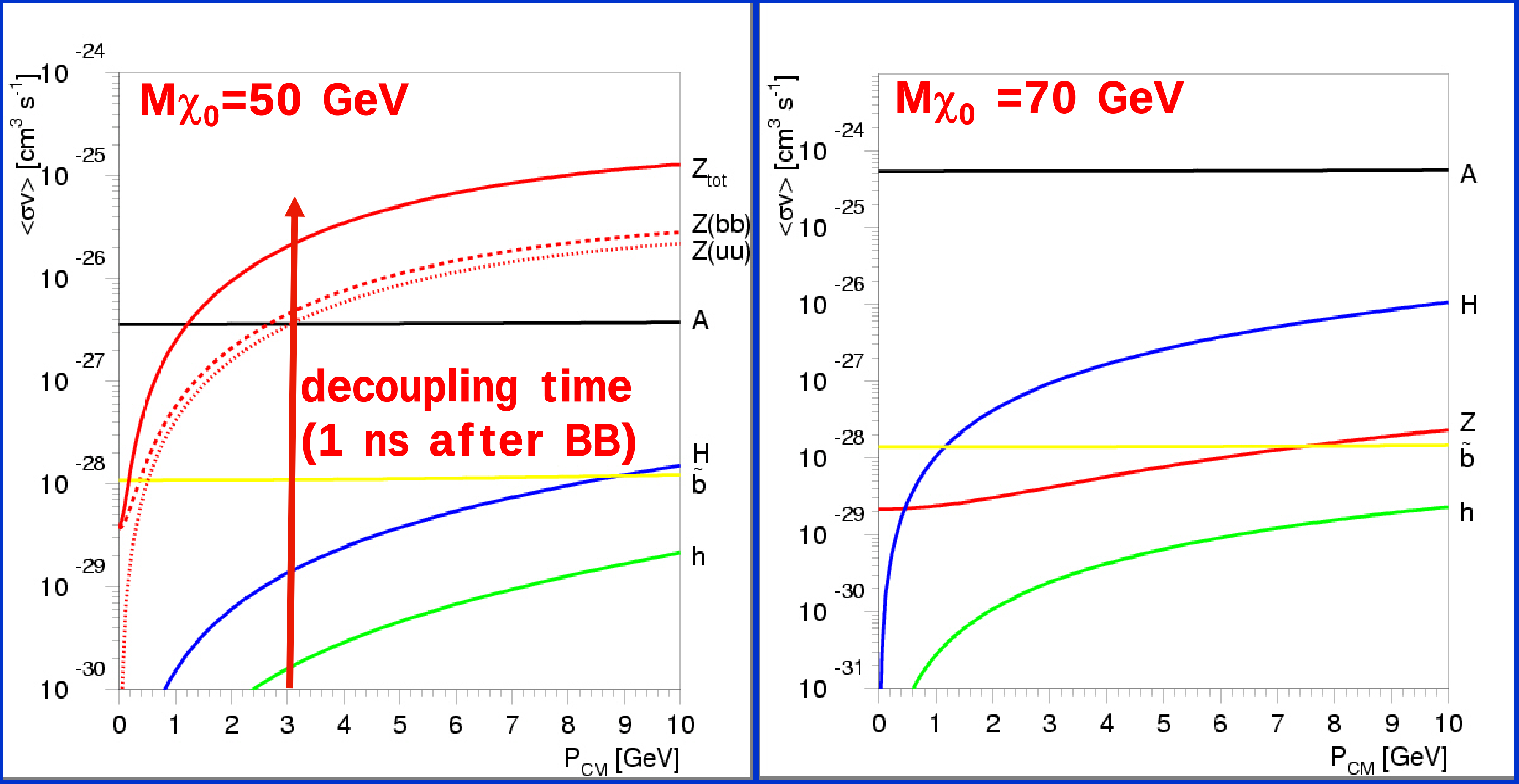


Dominant
$\chi + \chi \Rightarrow A \Rightarrow$ b bbar quark pair

B-Fragmentation known ->
Spectra of Positrons,
Gammas and Antiprotons known!

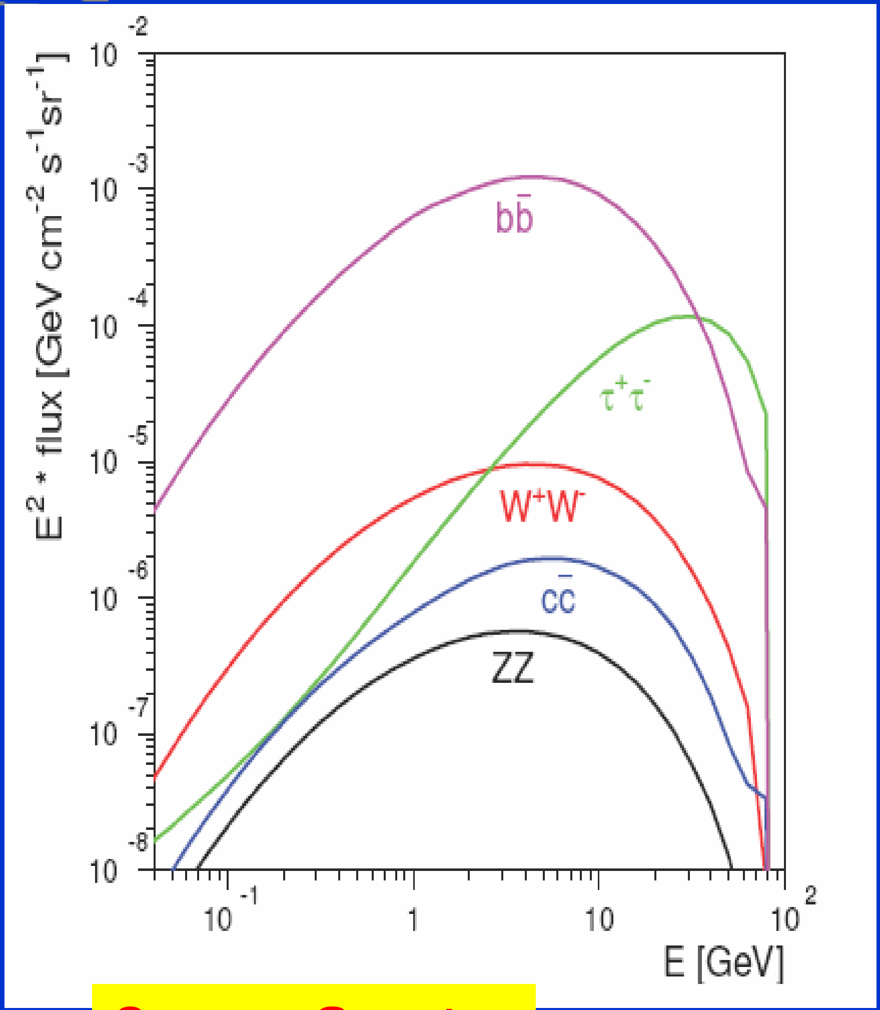
Galaxy = Super B-Factory with rate 10^{40} x B-Factory

Momentum dependence of contributions to DM annihilation

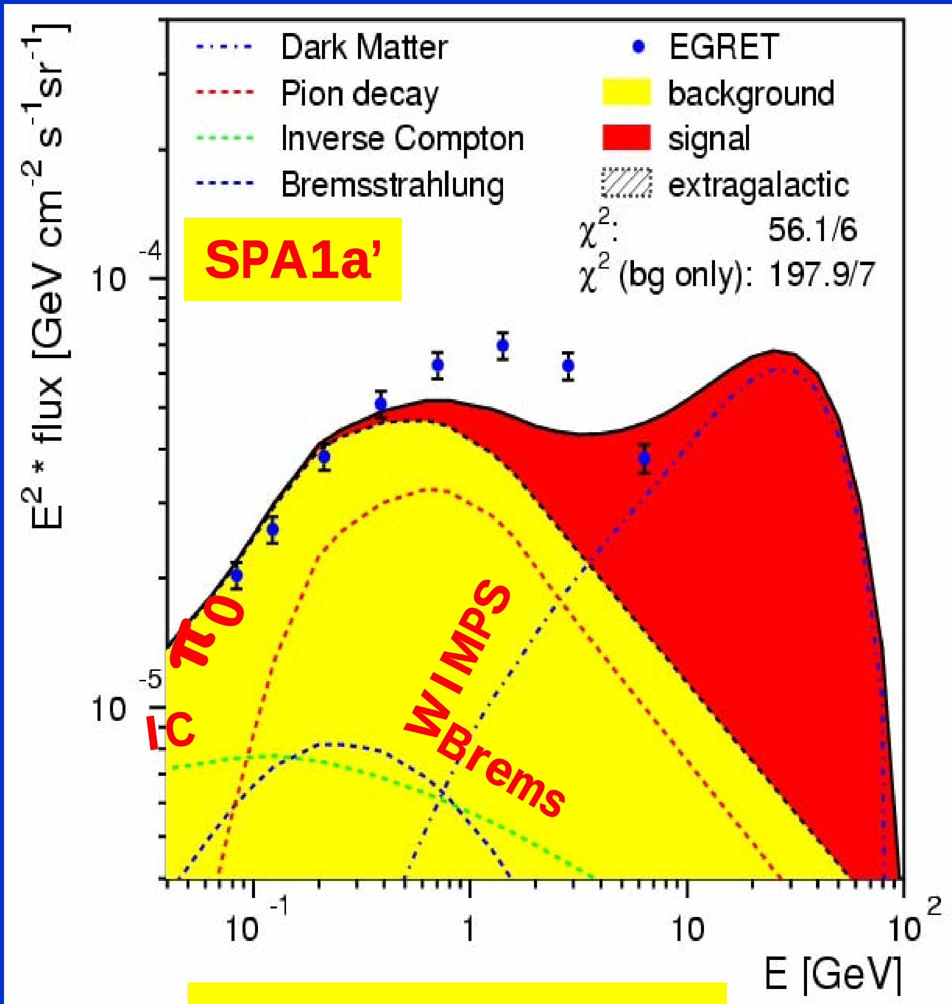


Z-exchange ∝ $N_{3,4}^2$ with both s- and p-wave
A-exchange ∝ $N_1 N_{3,4}$ only s-wave (p-independent)

Gamma Spectra from WIMP Annihilation

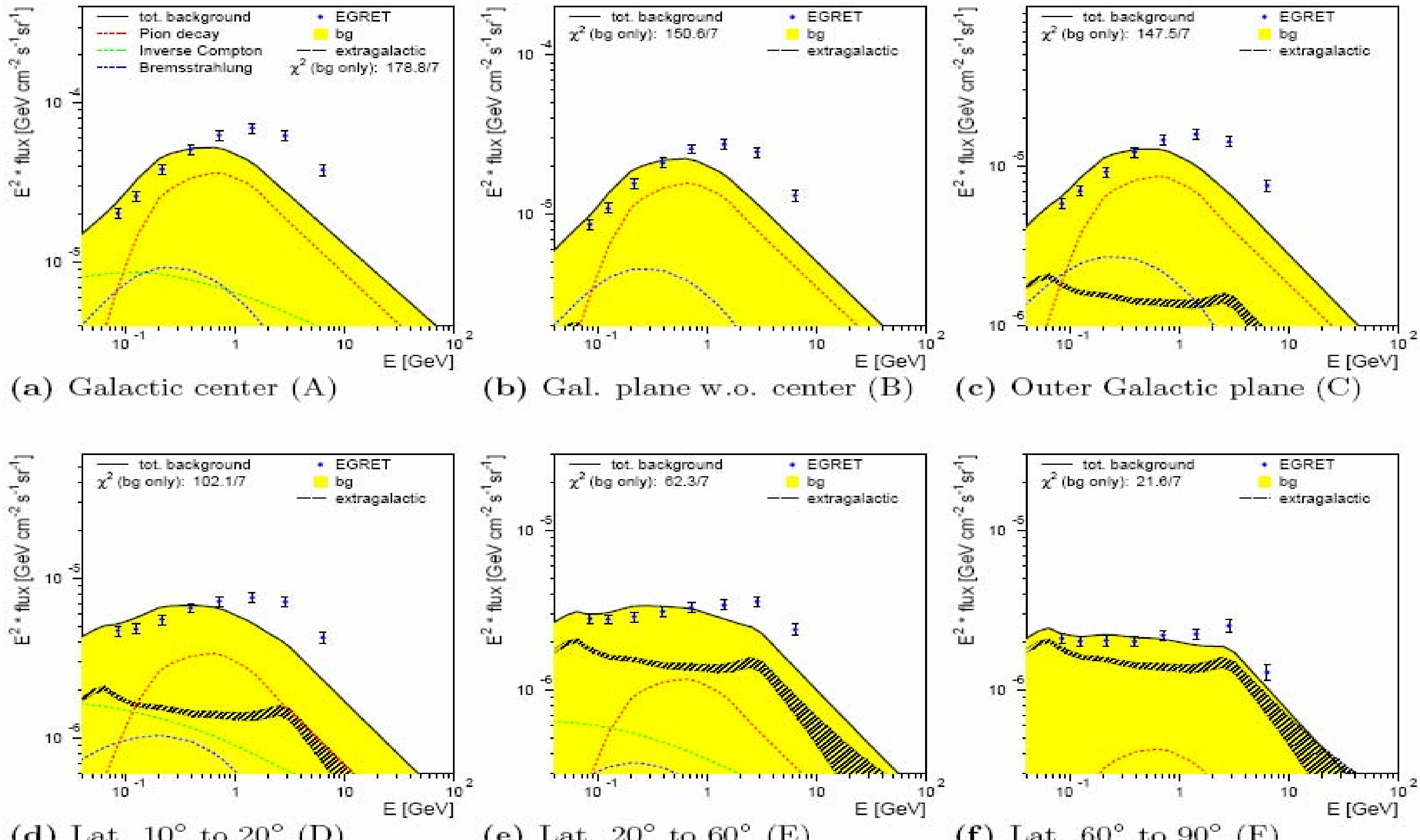


Gamma Spectra for different decay channels



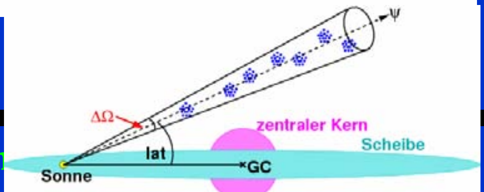
Gamma Spectra with tau-decays dominant (m_0 small)

Conventional Model without DMA in 6 sky regions

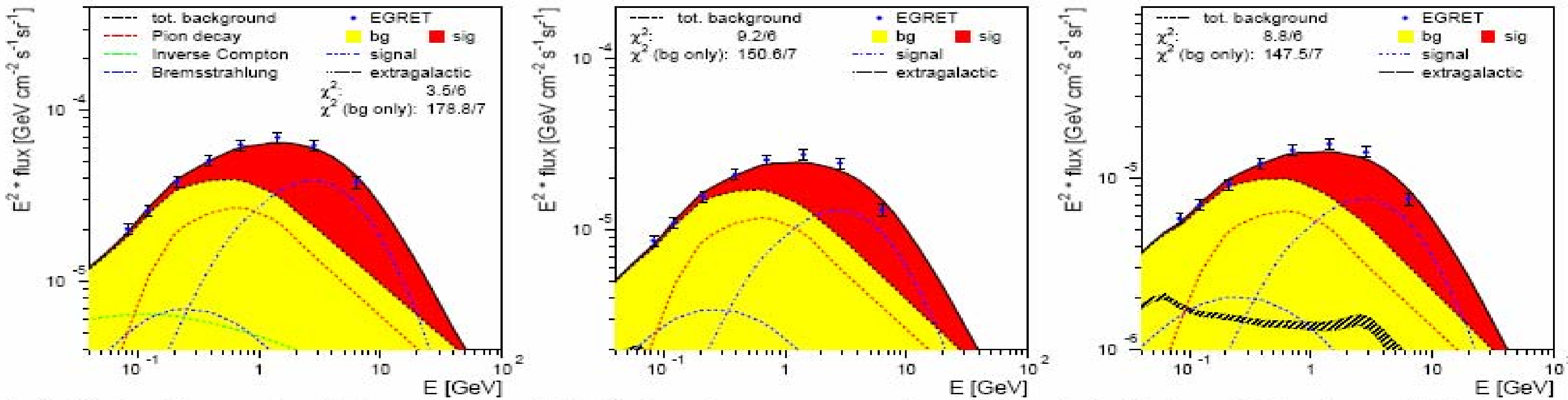


(a) Galactic center (A)
(b) Gal. plane w.o. center (B)
(c) Outer Galactic plane (C)
(d) Lat. 10° to 20° (D)
(e) Lat. 20° to 60° (E)
(f) Lat. 60° to 90° (F)

χ^2 of optimized model:663/42 ⇒ Prob. = 0



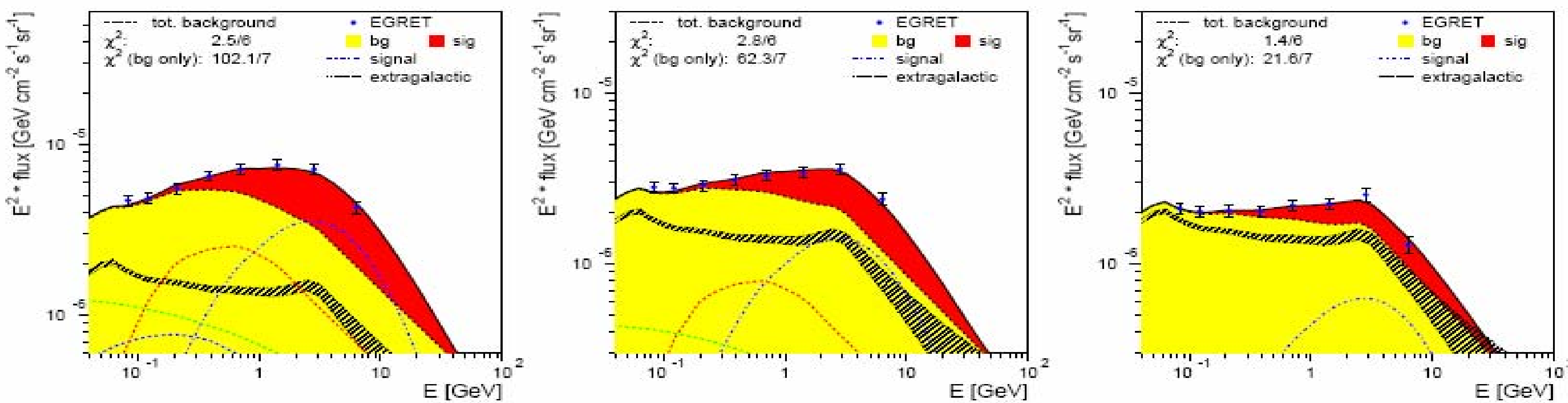
Conventional Model with DMA in 6 sky regions



(a) Galactic center (A)

(b) Gal. plane w.o. center (B)

(c) Outer Gal. plane (C)

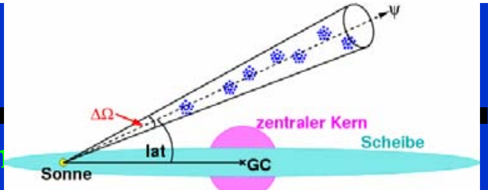


(d) Lat. 10° to 20° (D)

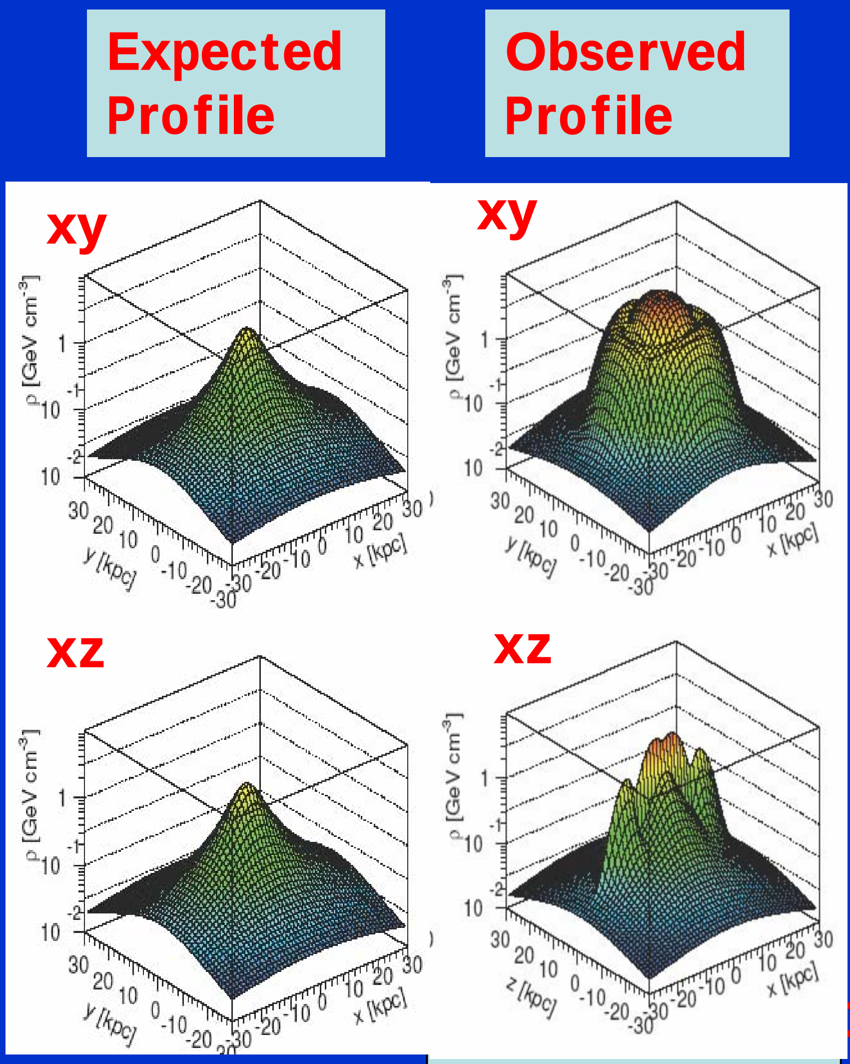
(e) Lat. 20° to 60° (E)

(f) Lat. 60° to 90° (F)

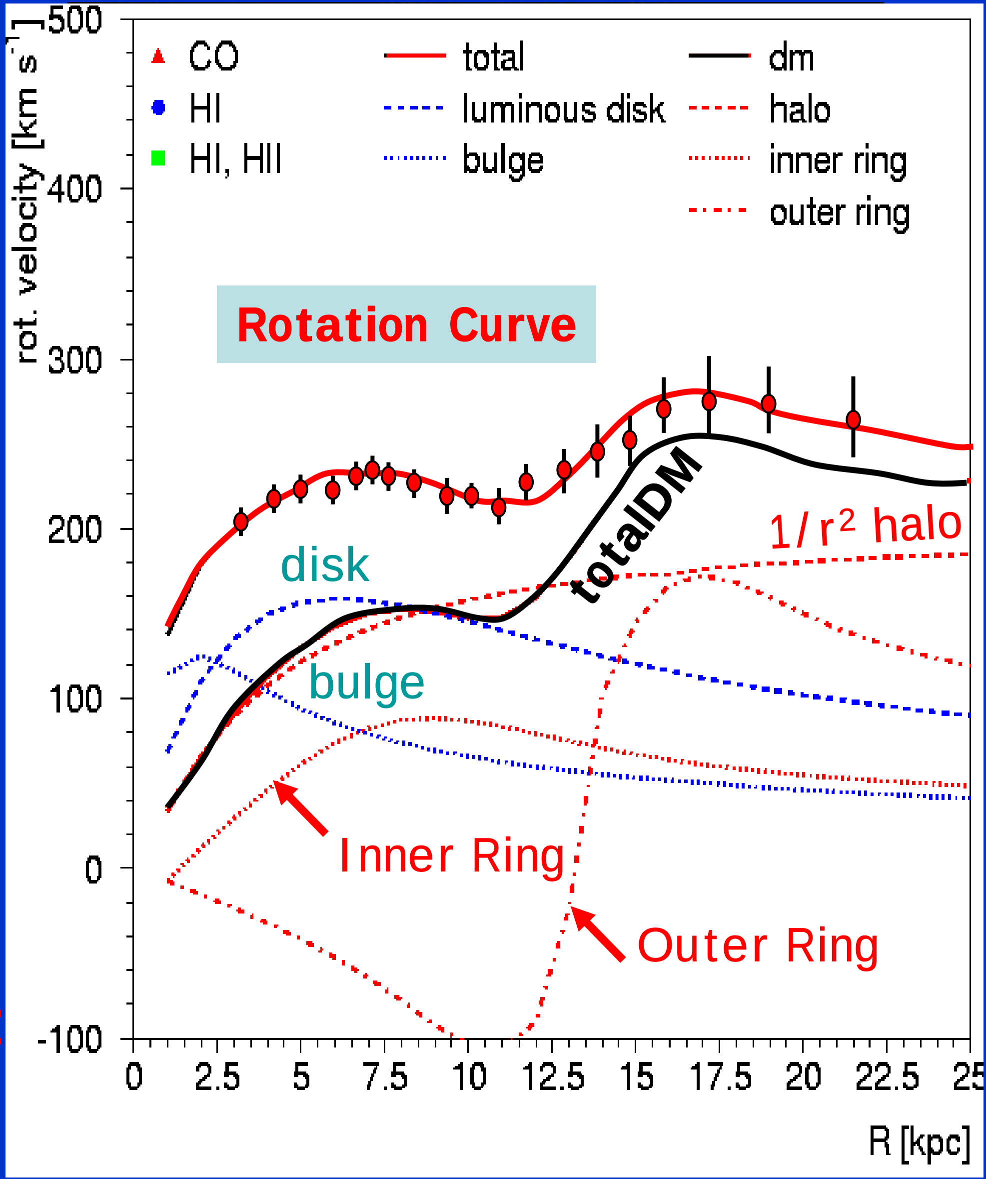
χ^2 of optimized model:28/36 $\Rightarrow$ Prob.= 0.8



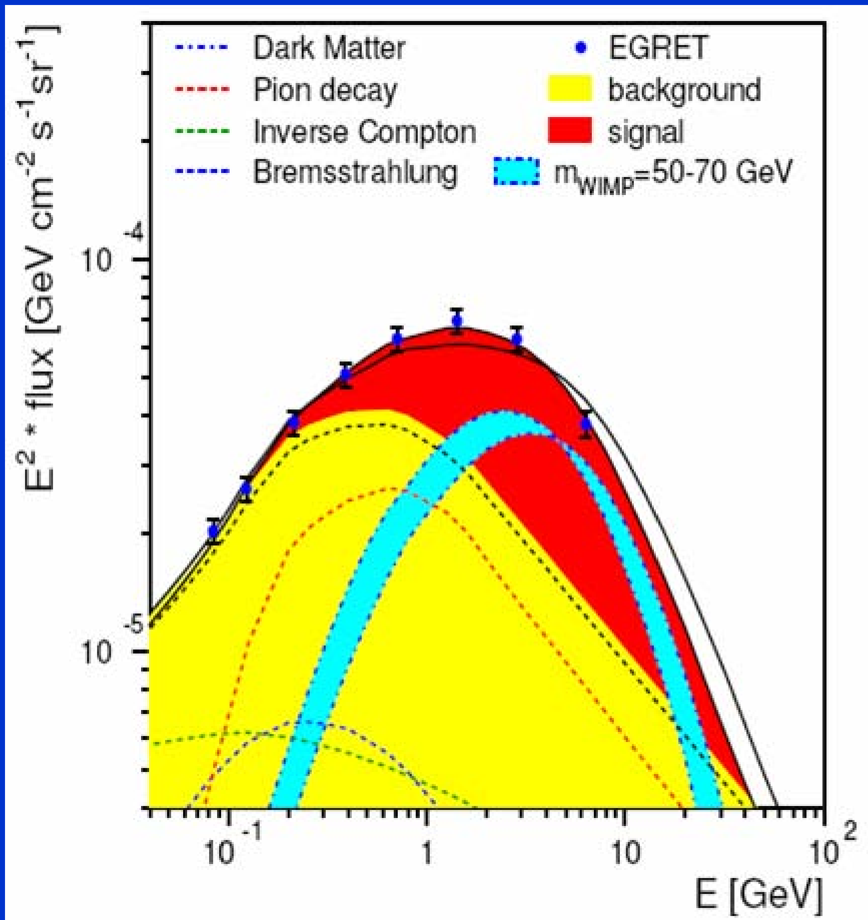
"Executive Summary"

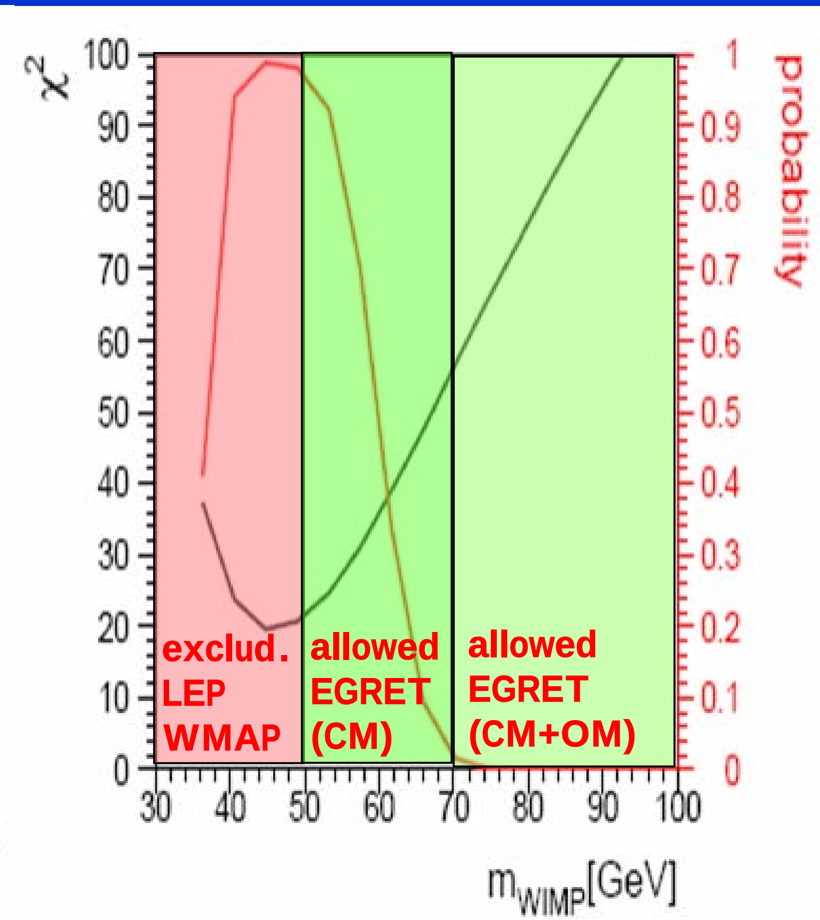


Halo profile



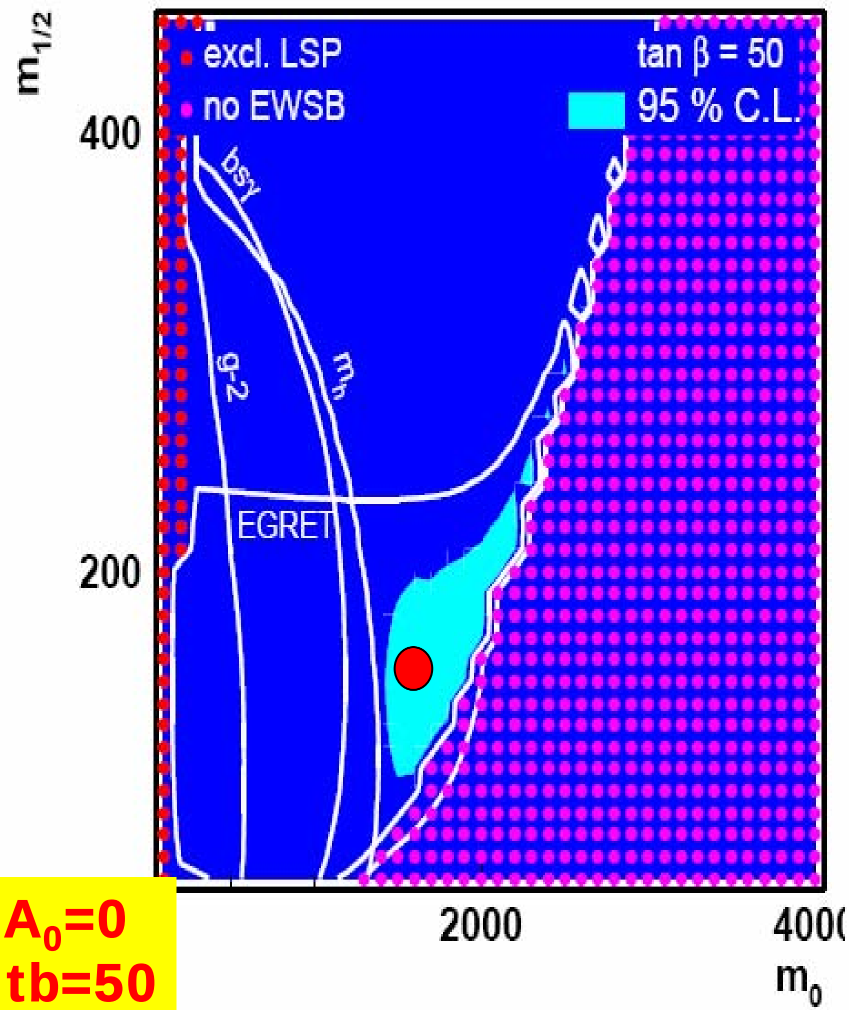
Allowed WIMP mass

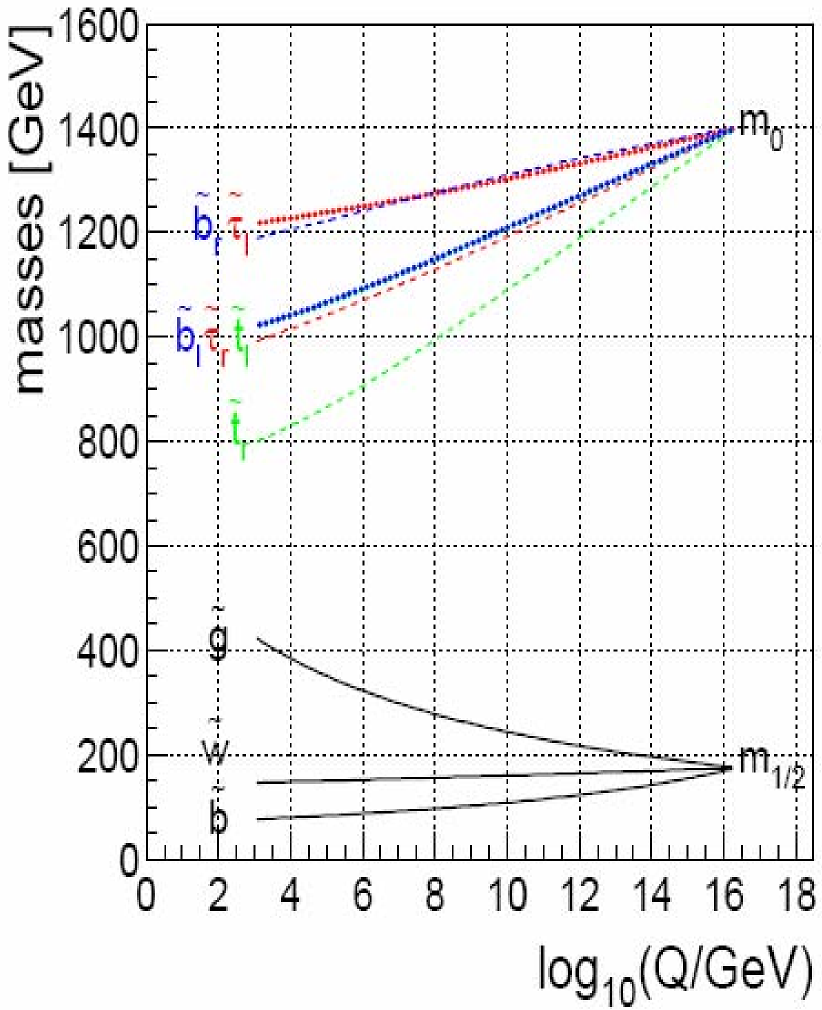




WIMP Mass from EGRET: 50-70 GeV in CM
50-100 GeV in CM+OM

Allowed mSUGRA region

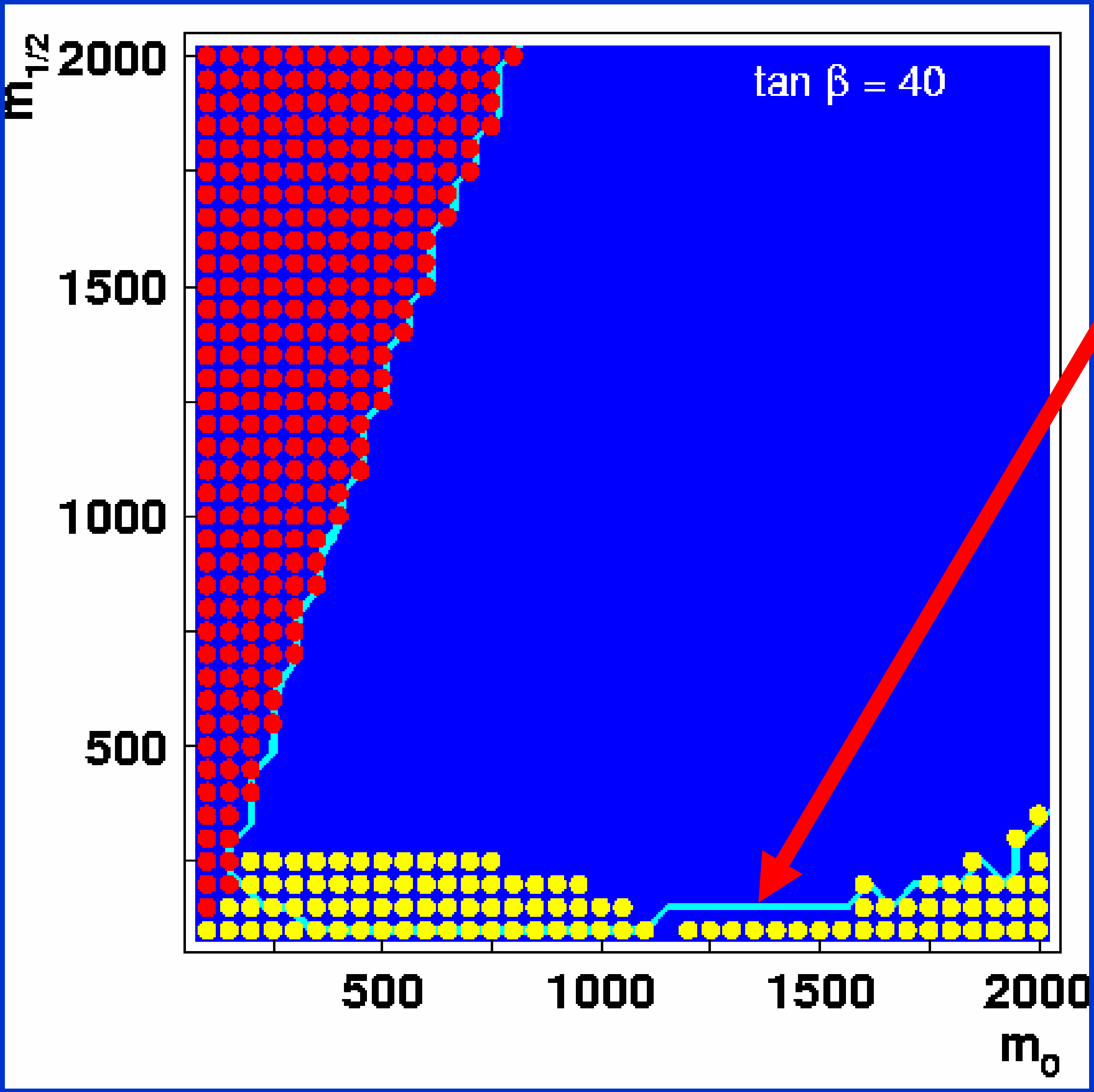




A_0=0
tb=50

What about WMAP? Not used sofar.

tanβ dependence of relic density



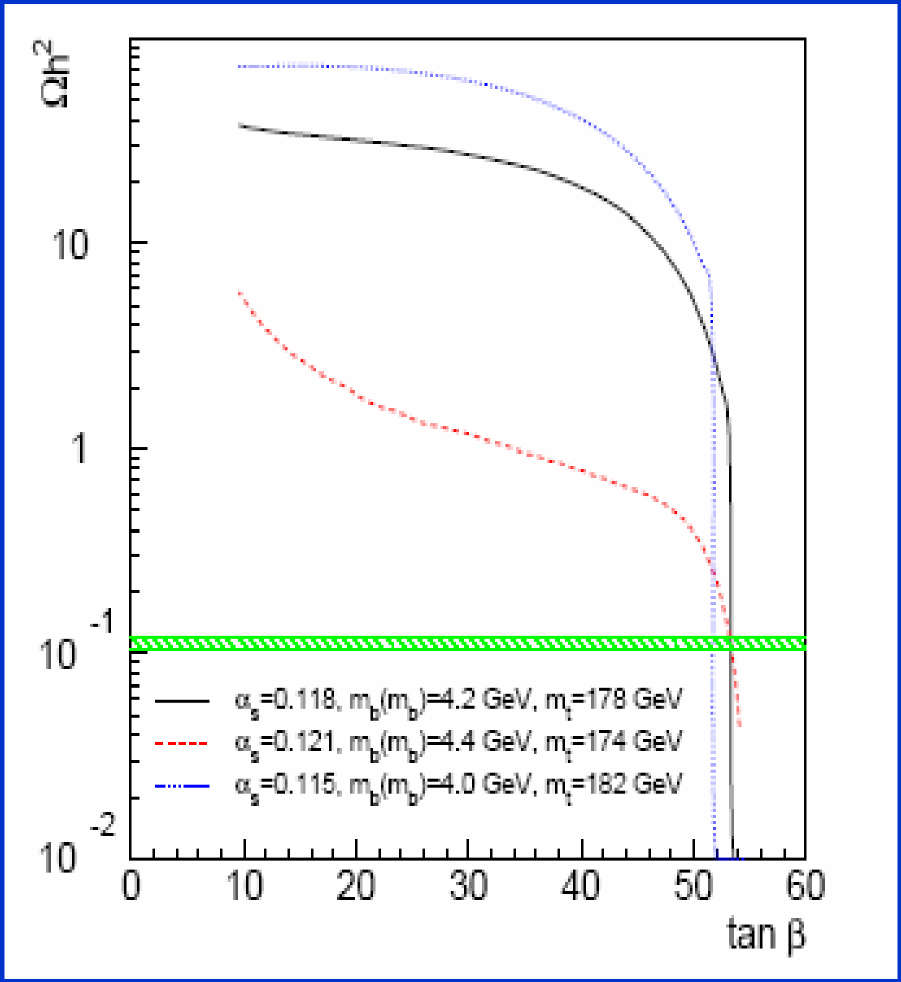
EGRET Point:

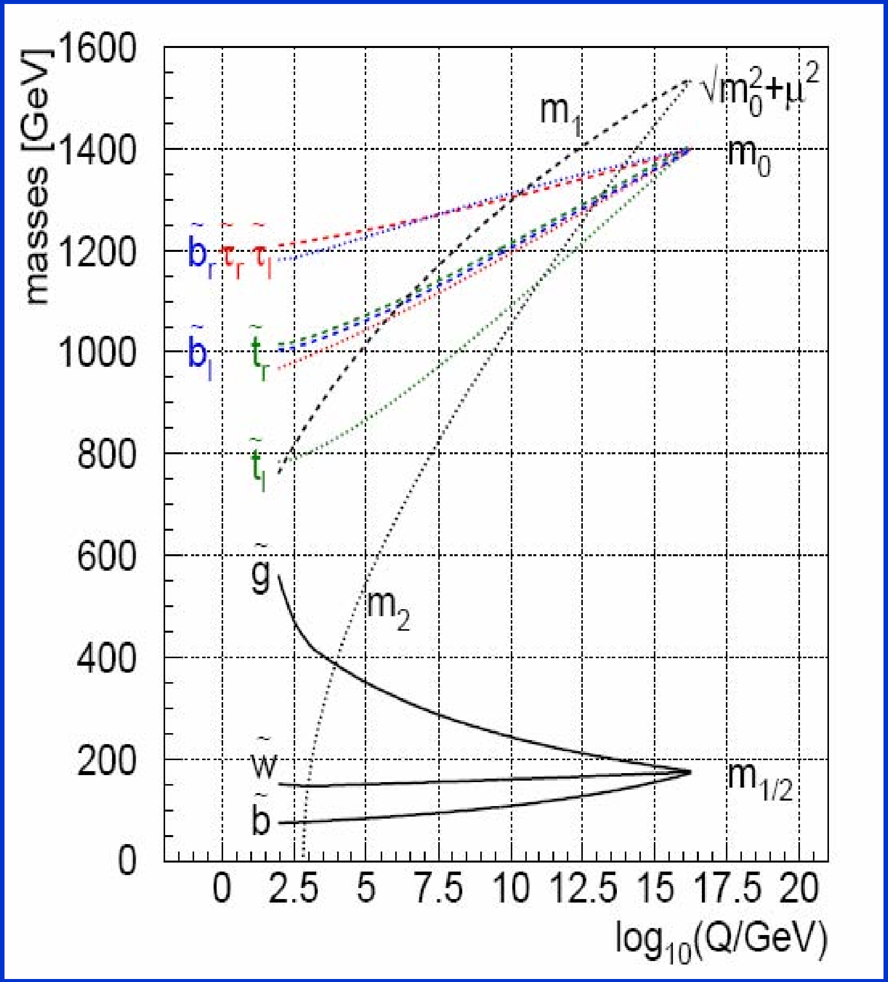
BULK region

NO Coannilation

Dominant: A-exchange

Relic density extremely sensitive to tb at large tb.
Determining relic density at colliders -> Δtb ≈ 0.1





Sensitivity from fast running of Higgs mass terms: $m_A^2 = m_1^2 + m_2^2$

http://kraml.home.cern.ch/kraml/cgi-bin/micromegas_slha.cgi

Sparticle	Isajet	Softsusy	Spheno	Suspect	(max-min)	diff[%]
nt_1	55.95	60.29	60.77	60.27	4.81	8.12
nt_2	101.90	114.67	116.60	114.40	14.70	13.14
nt_3	203.80	295.84	338.39	292.99	134.60	47.60
nt_4	231.70	308.31	348.00	305.71	116.30	38.97
ch_1	102.23	114.42	116.65	114.13	14.42	12.89
ch_2	231.38	310.98	351.35	308.38	119.97	39.92
gluino	448.18	430.90	426.35	455.07	28.72	6.53
h0	115.08	114.79	115.12	114.75	0.37	0.33
H0	411.12	358.84	439.27	240.08	199.20	54.98
A0	408.40	358.86	439.32	239.93	199.39	55.14
H+	423.01	369.53	447.77	256.47	191.29	51.12
snu_e	1497.63	1494.16	1496.04	1494.19	3.47	0.23
snu_mu	1497.63	1493.49	1495.34	1494.19	4.14	0.28
snu_tau	1288.93	1280.20	1283.31	1275.56	13.37	1.04
sel_L	1500.10	1496.21	1499.09	1496.25	3.89	0.26
sel_R	1499.66	1498.67	1499.29	1498.69	0.99	0.07
smu_L	1500.10	1495.55	1497.48	1496.25	4.55	0.30
smu_R	1499.66	1497.33	1498.80	1498.69	2.33	0.16
stau_1	1038.26	1023.47	1026.87	1010.95	27.31	2.66
stau_2	1291.64	1283.06	1286.75	1278.42	13.22	1.03

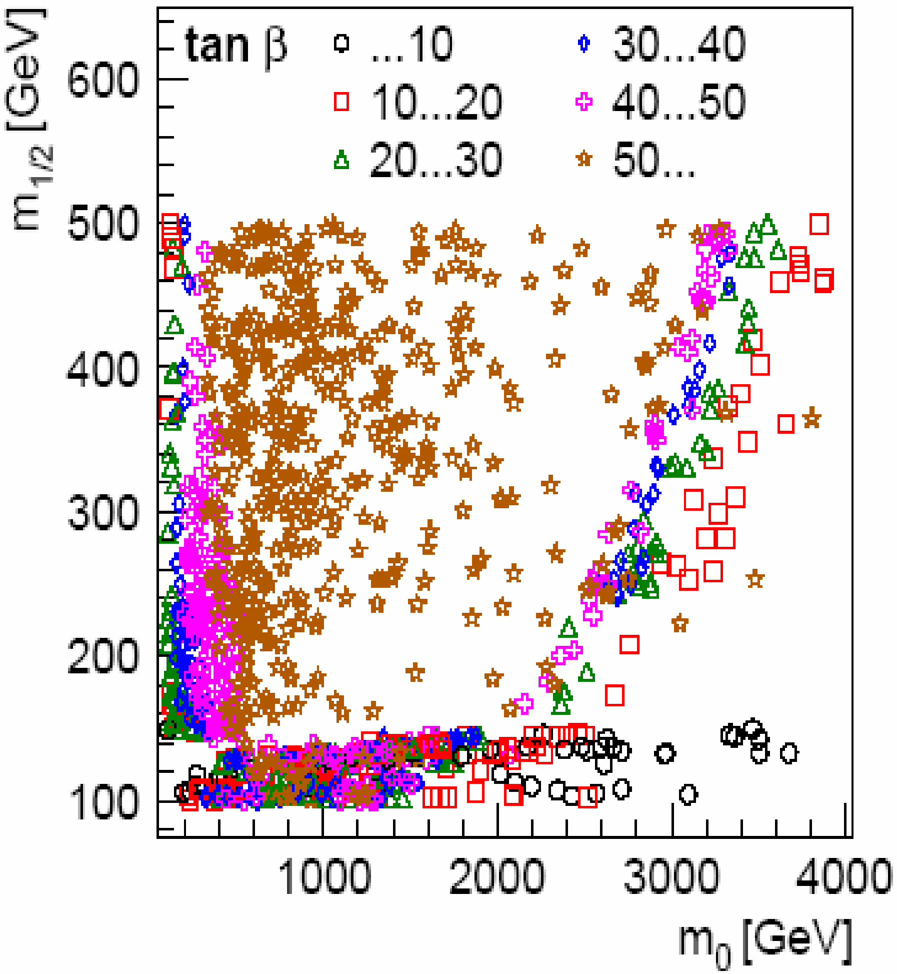
Your input was

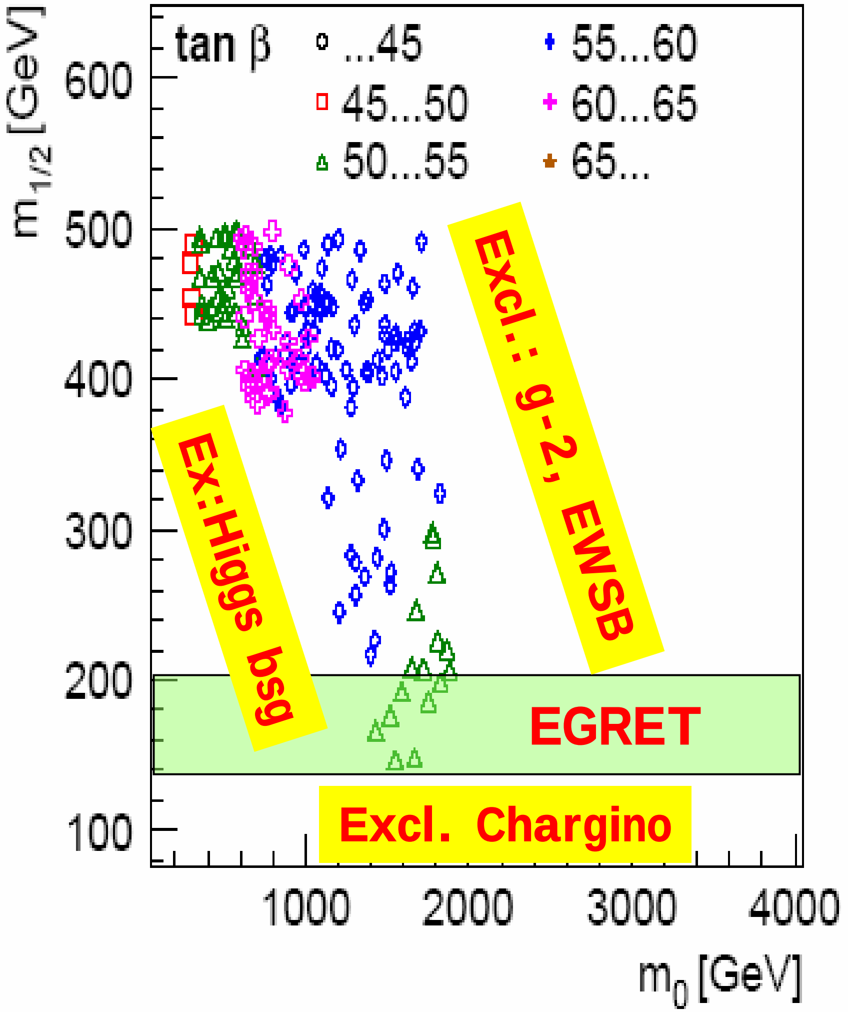
```
m0          = 1500
m12         = 150
A0          = 0
tan(be)     = 53
sgn(mu)     = 1
mt          = 175
mb          = 4.214
alphas(MZ)  = 0.1172
```

http://kraml.home.cern.ch/kraml/cgi-bin/micromegas_slha.cgi

sc_L	1514.47	1509.54	1522.26	1509.79	12.72	0.84
sc_R	1518.61	1513.77	1517.48	1513.87	4.83	0.32
stop_1	899.33	873.58	865.43	874.17	33.90	3.86
stop_2	1041.07	1011.74	1022.92	1006.12	34.95	3.42
sbot_1	1023.22	996.70	1007.09	997.69	26.52	2.64
sbot_2	1131.25	1110.56	1126.60	1110.11	21.14	1.89
omega	2.47e-03	4.77e-01	1.30e+00	8.97e-02	1.29e+00	277.52
deltarho	9.30e-05	3.88e-05	3.84e-05	1.68e-06	9.14e-05	212.62
gmuon	1.18e-09	9.84e-10	9.63e-10	9.87e-10	2.20e-10	21.35
bsgamma	2.84e-04	2.86e-04	2.73e-04	3.18e-04	4.52e-05	15.56
bsmumu	5.18e-09	1.26e-08	9.74e-09	5.02e-08	4.51e-08	231.87

Parameter scan confirms large tb and large m0
All points have correct relic density





All SUSY masses allowed by WMAP, if scanned over all tb and A0

Only large tb left, if all constraints from Higgs, chargino, g-2 and bsgamma required

Why large tanβ preferred?

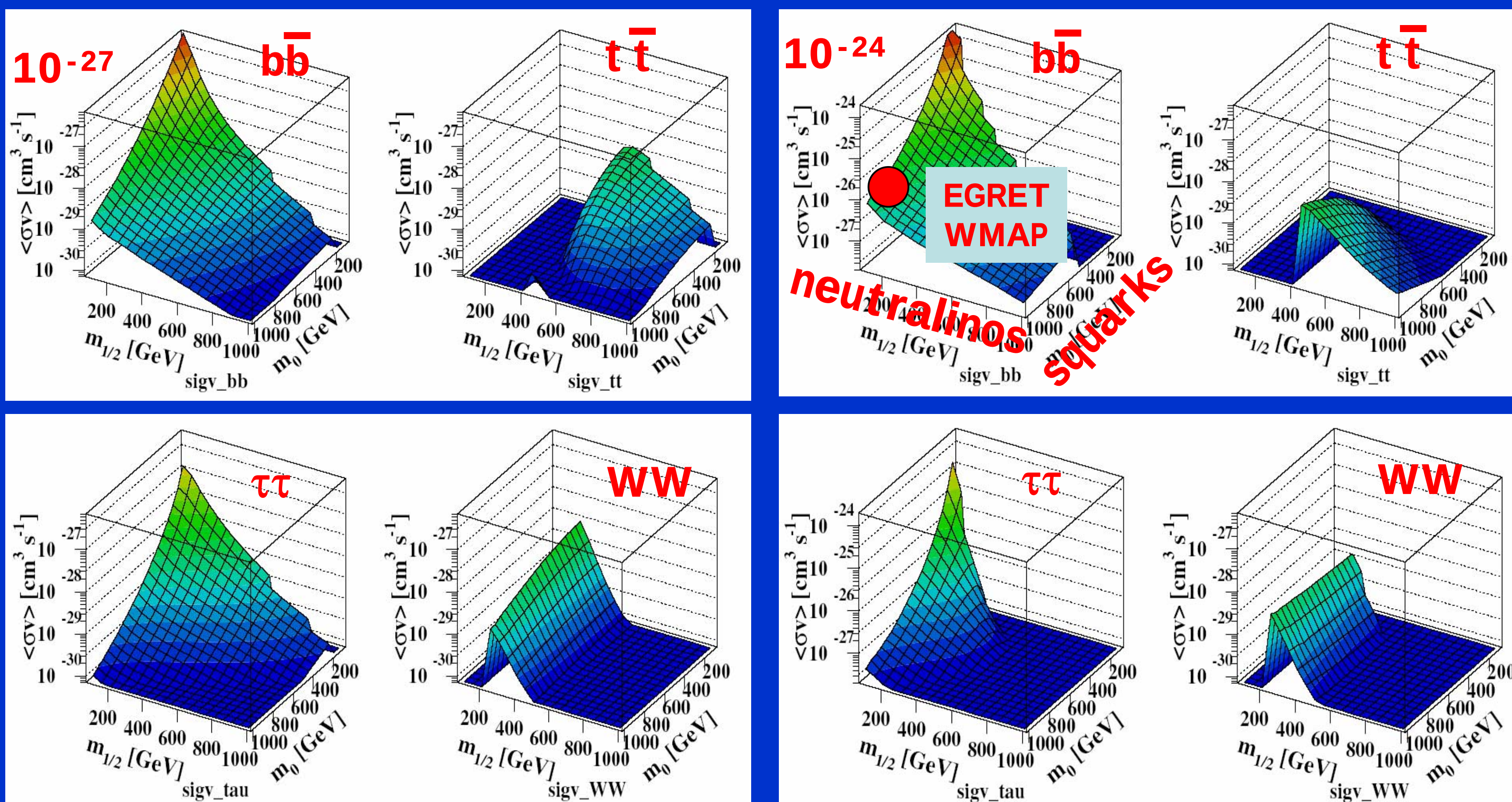
Answer: pseudoscalar Higgs exchange is s-wave contribution,
i.e. independent of momentum ->
large self-annihilation in present universe!
BUT ONLY DOMINANT AT LARGE TANB!

Note: Z-exchange = largely p wave ->
if dominant, than almost
no indirect DM detection possible
(unless extreme clustering of DM allowed)

WW, ZZ kinematically suppressed by light LSP
sfermion t-channel suppressed by heavy scalars

Annihilation cross sections in m_0-$m_{1/2}$ plane ($\mu > 0$, $A_0=0$)

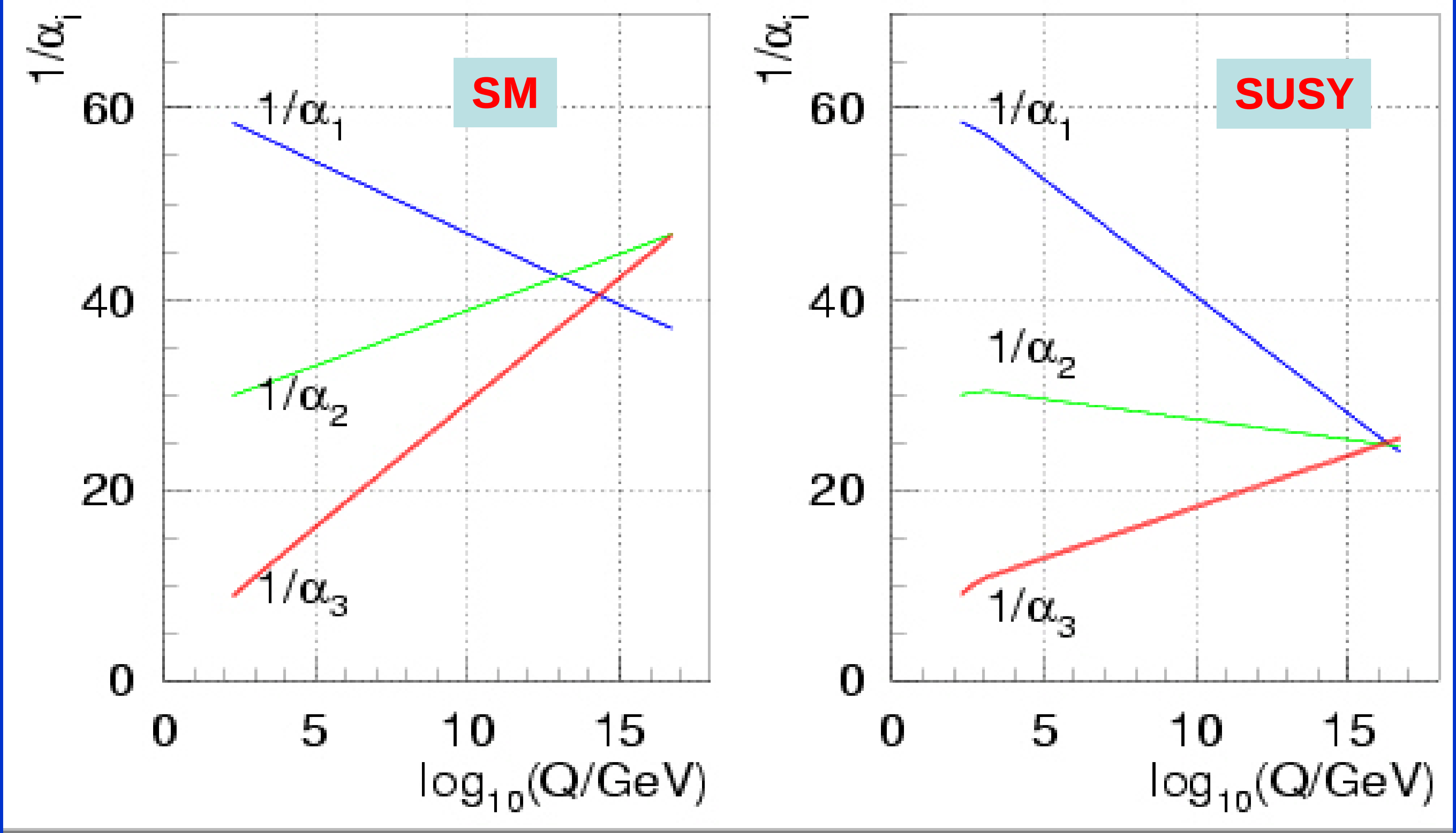
tan=5 | tan=50



For WMAP x-section of $\langle\sigma v\rangle \cong 2.10^{-26}$ cm^3/s one needs large tanβ

Gauge unification perfect with SUSY spectrum from EGRET

Update from Amaldi, dB, Fürstenau, PLB 260 1991



With SUSY spectrum from EGRET + WMAP data and start values of couplings from final LEP data perfect gauge coupling unification!

Also b->sγ and g-2 perfectly fitted with SUSY spectrum from EGRET

Summary on evidence for DMA

Interpretation of EGRET excess as DM Annihilation can:

1) explain all features of EGRET excess
2) determine WIMP mass (50-100 GeV)
3) determine the DM halo profile
4) explain peculiar shape of rotation curve
5) statistical significance > 10 σ!

Reconstruction of rotation curve from GAMMA RAYS-> EGRET excess = Tracer of Dark Matter!

Results practical model independent, since only KNOWN spectral shapes of signal and background are used, NOT model dependent calculations of absolute fluxes.

Conclusion for SUSY spectrum

EGRET excess:

LSP light (50-70 GeV preferred, 50-100 GeV possible)

Higgs limit requires then: squarks and sleptons above ≈ TeV

EWSB (and g-2) require: squarks and sleptons ≤ 2 TeV

tanβ ≈ 50-55 preferred

LSP:

mostly binolike (98%) (->DM is SUSY partner of CMB)
no coannihilation
bulk annihilation with A-exchange dominant, but not on A-resonance