Scanning the CMSSM parameter space considering H.E.S.S. data

Joachim Ripken, Pat Scott, Jan Conrad

- Motivation
- Methods
- Comparison of H.E.S.S. Data with models
- The Galactic Center
- The Sagittarius dwarf galaxy
- Summary and outlook

Motivation

Perform a CMSSM parameter scan taking H.E.S.S. results into account

Using SuperBayes with MultiNest scanning algorithm, because

- Random scan not adequate for large number of dimensions in parameter space
- Nuisance parameter (e.g. top mass) marginalized and not fixed
- Scan together with other experimental observables (e.g. relic density...)

- Use physical annihilation branching ratios and annihilation spectra (using DarkSUSY) and not a priori assumptions

Second time use >GeV data in such scans

SuperBayes

(see http://www.ft.uam.es/personal/rruiz/superbayes/)

- Program providing several scanning algorithms
- Varying all parameters (also *nuisance parameters* in SM like *t*-mass within errors)
- Need routine(s) for individual likelihoods of theoretical calculated observables compared to experiments
- RGE solution and observable calculation with DarkSUSY
- Get maps about likelihood of models

- We used Multimodal nested sampling method so far (see arXiv:0704.3704)

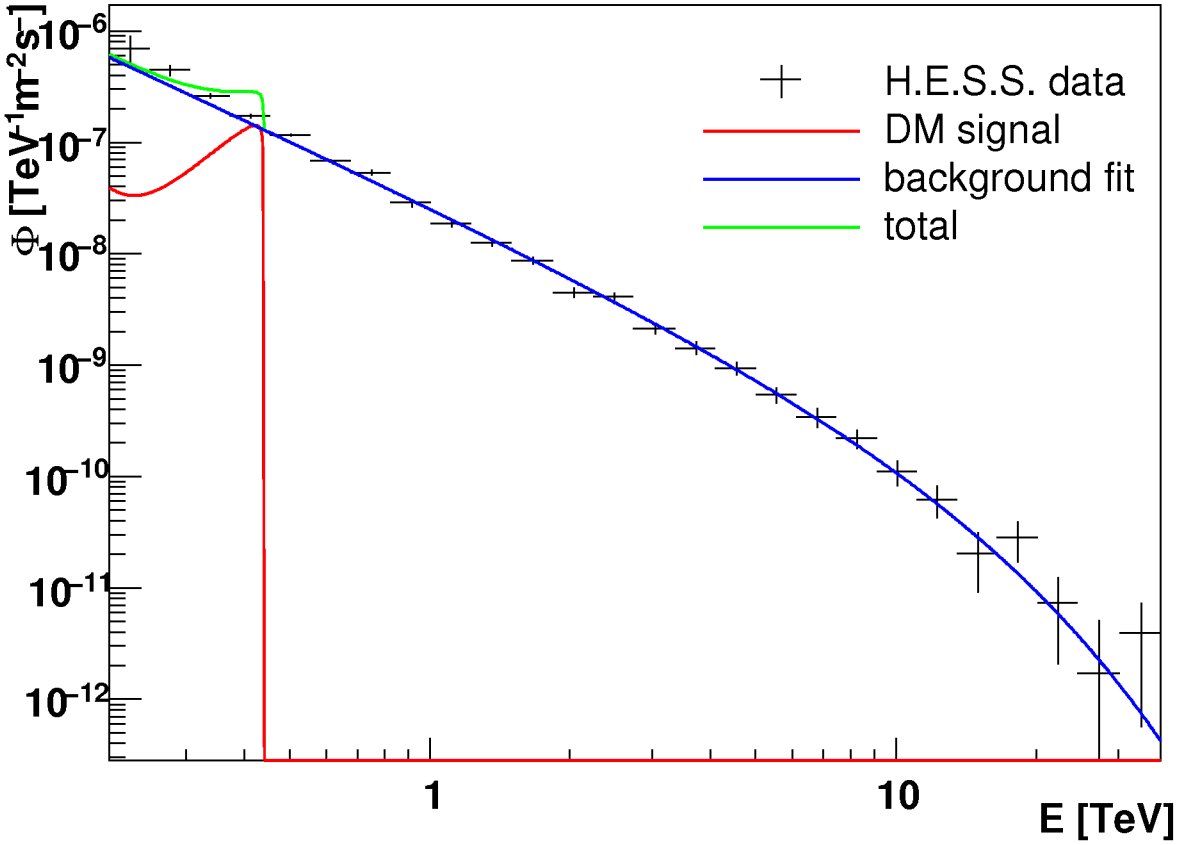
- Program with γ-ray observations already used with Fermi observations of Segue 1 (see arXiv:0909:3300)

Nested sampling Algorithm

- Distribute *N* “living” points in parameter space (flat prior probability distribution)
- Calculate likelihood L for each point
- Remove point with lowest likelihood L_0 and replace by point with $L>L_0$
  (several algorithms possible to find one in an effective way)
- Repeat thes steps iteratively
- => Reductions of parameter space
- Algorithm scan parameter space by going through nested iso-likelihood shells
- Removed points deliver information about posterior probability distribution

- Other algorithms accessible
- In Stockholm knowledge about Genetic Algorithms (see arXiv:0910.3950)

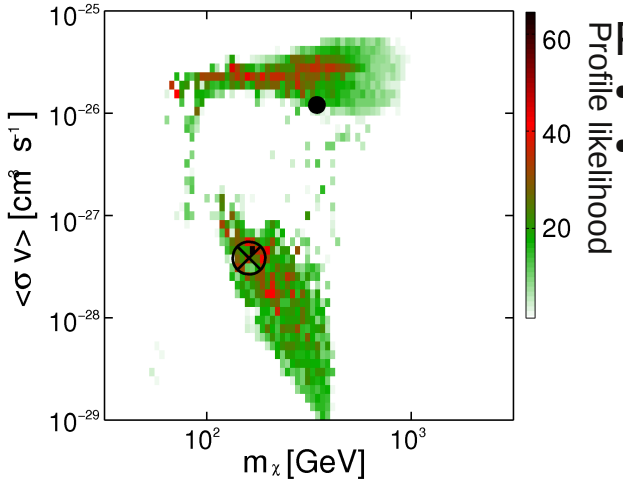
Compare models with H.E.S.S. data



- Calculate DM annihilation fraction
- If necessary: Fit astrophysical background to minimize χ^2 of sum
- Calculate Likelihood (-ln L = $\chi^2/2$)

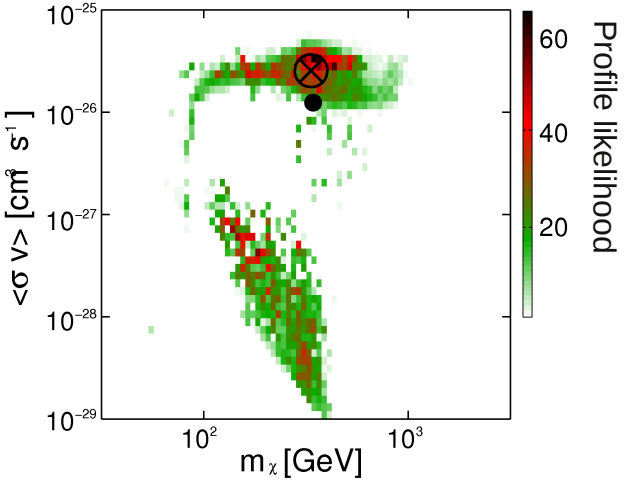
H.E.S.S. GC data and SuperBayes

No H.E.S.S. data

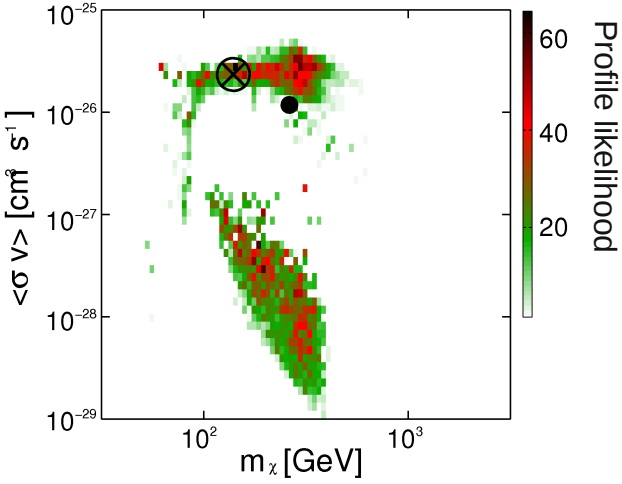


- Results of the scans for different (unrealistic) values for J
- High mass neutralinos become unlikely
- Coannihilation region truncated due to internal bremsstrahlung

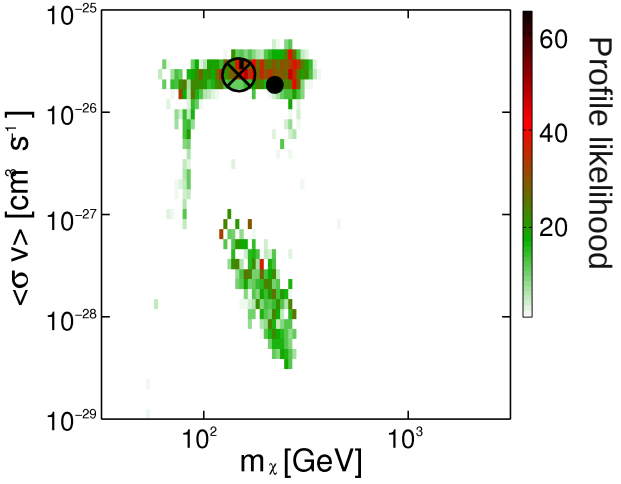
J = 10



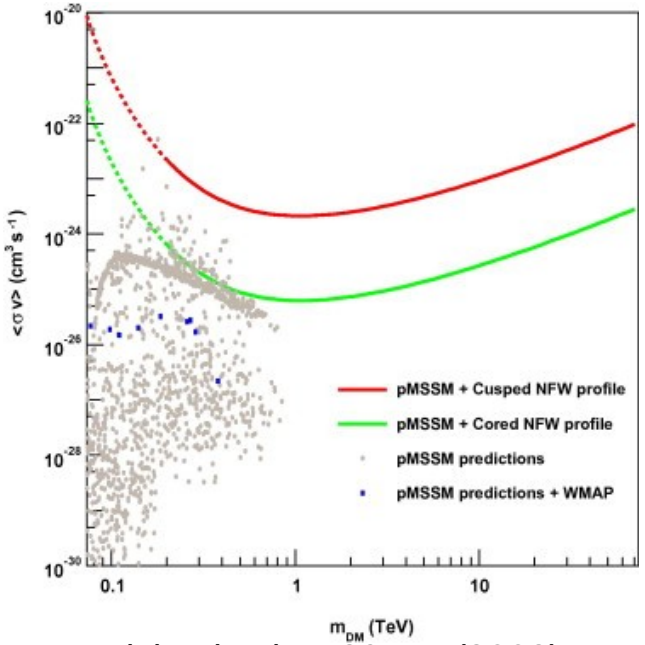
J = 32



J = 100



H.E.S.S. Limits on DM in Sgr dwarf



Astroparticle physics, 29, 55 (2008) - Eratum

- ~12 h of observation time
- No signal detected
- Upper limit of annihilation cross section calculated for two different scenarios, but generic spectrum
- Limits begin to cut in interesting parameter space

- N_{ON} = 437, N_{OFF} = 4270, N_{excess} = 14.2

$N_{95\%}$ = 56

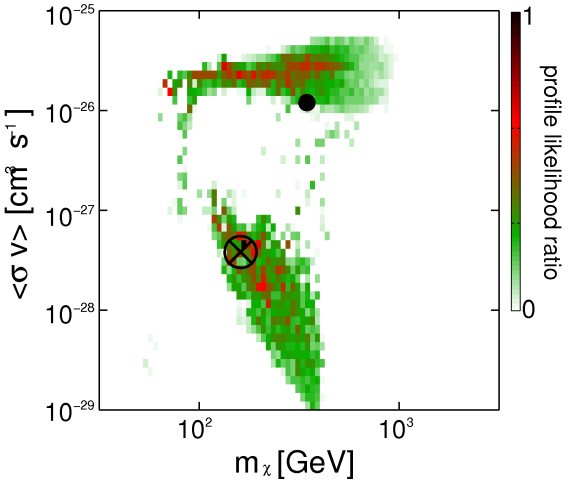
→ Flux upper limit:

$\Phi_{95\%}(E>250\ GeV) < 3.6 \times 10^{-12}\ cm^{-2}\ s^{-1}$

→ or $\Phi = (0.9 +- 1.9) \times 10^{-12}\ cm^{-2}s^{-1}$ using gaussian likelihood

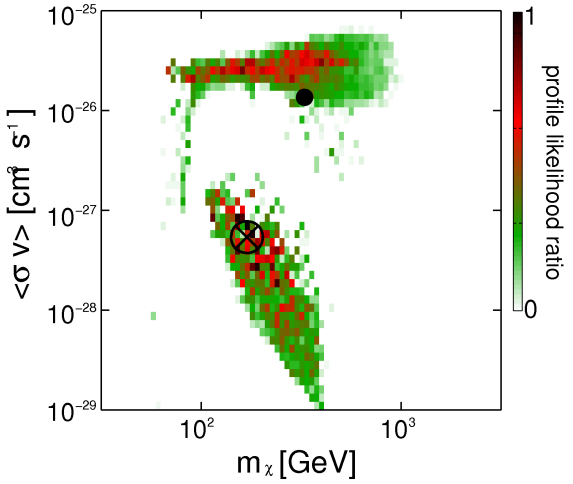
H.E.S.S. Limits on DM in Sgr dwarf

No H.E.S.S. data

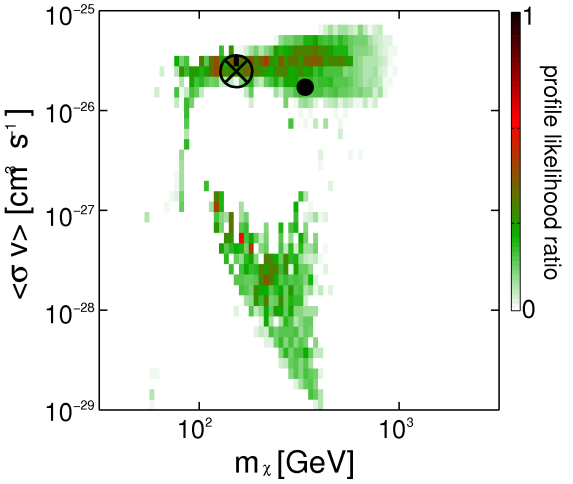


•Coannihilation region looses likelihood

NFW profile



Cored density profile



Summary and Outlook

- Implement algorithms into SuperBayes in order to consider H.E.S.S. Data
- Results for GC with unrealistic high density profile
- Interesting results for Sgr dwarf galaxy (already published)
  - Coannihilation region disfavored

- Consider observations on more DM related objects (open for suggestions)