Direct constraints on minimal supersymmetry from Fermi observations of Segue 1

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We show the constraints placed upon neutralino dark matter in the Constrained Minimal Supersymmetric Standard Model (CMSSM) by 9 months of Fermi Large Area Telescope observations of the dwarf spheroidal galaxy Segue 1.

Based on Scott et al, arXiv:0909.3300 (submitted to *JCAP*)

Abstract

The dwarf galaxy Segue 1 is one of the most promising targets for the indirect detection of dark matter. This poster explains what constraints 9 months of Fermi Large Area Telescope (LAT) data on Segue 1 place upon the Constrained Minimal Supersymmetric Standard Model (CMSSM), with the lightest neutralino as the dark matter particle. We used nested sampling to explore the CMSSM parameter space, simultaneously fitting other relevant constraints from accelerators and the microwave background. These scans included spectral and spatial fits to the Fermi observations, a full treatment of the instrumental response and its related uncertainty, and detailed background models. We also show predicted impacts upon the CMSSM parameter space after 5 years of observations, assuming no signal is observed from Segue 1. Results marginally disfavour models with low neutralino masses and high annihilation cross-sections, though virtually all of these models are already disfavoured by existing experimental or relic density constraints.

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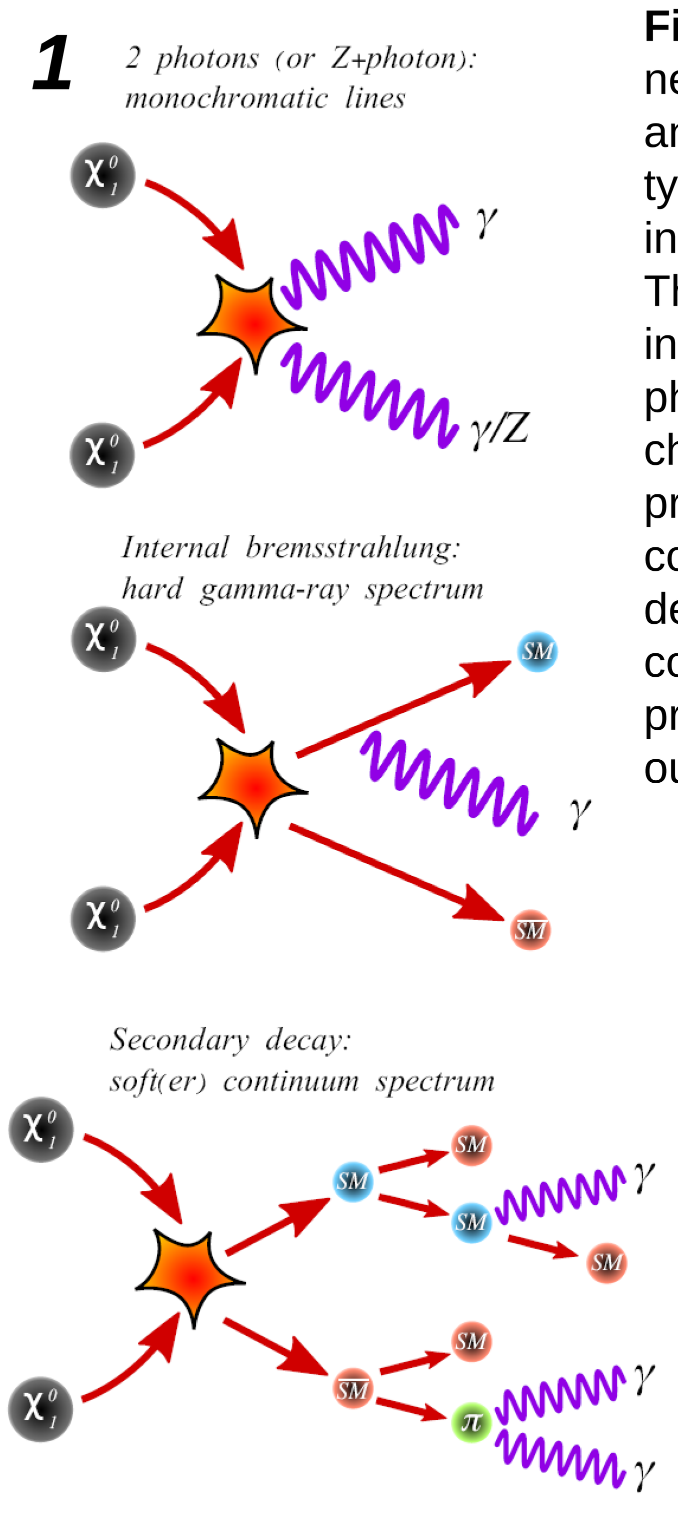

Fig 1: The three routes from neutralinos to gamma-rays via self-annihilation. The hardest (but typically rarest) channel is directly into monochromatic photon lines. The next hardest and rarest is via internal bremsstrahlung, where a photon is radiated from a virtual charged particle participating in the process. The softest and most common channel is via secondary decay of pions, producing a continuum spectrum. All three process are explicitly included in our scans.

Fig 2: Photon counts observed by Fermi in the region around Segue 1 during the first 9 months of LAT operation in all-sky survey mode. Counts are integrated over all energies between 100MeV and 300 GeV. The red cross shows the exact location of the centre of Segue 1, and the red box shows the region included in our likelihood calculations. In all of our calculations, we assumed the best-fit Einasto dark matter profile found for Segue 1 from kinematic data by Martinez et al (2009, *JCAP* **6**:14).

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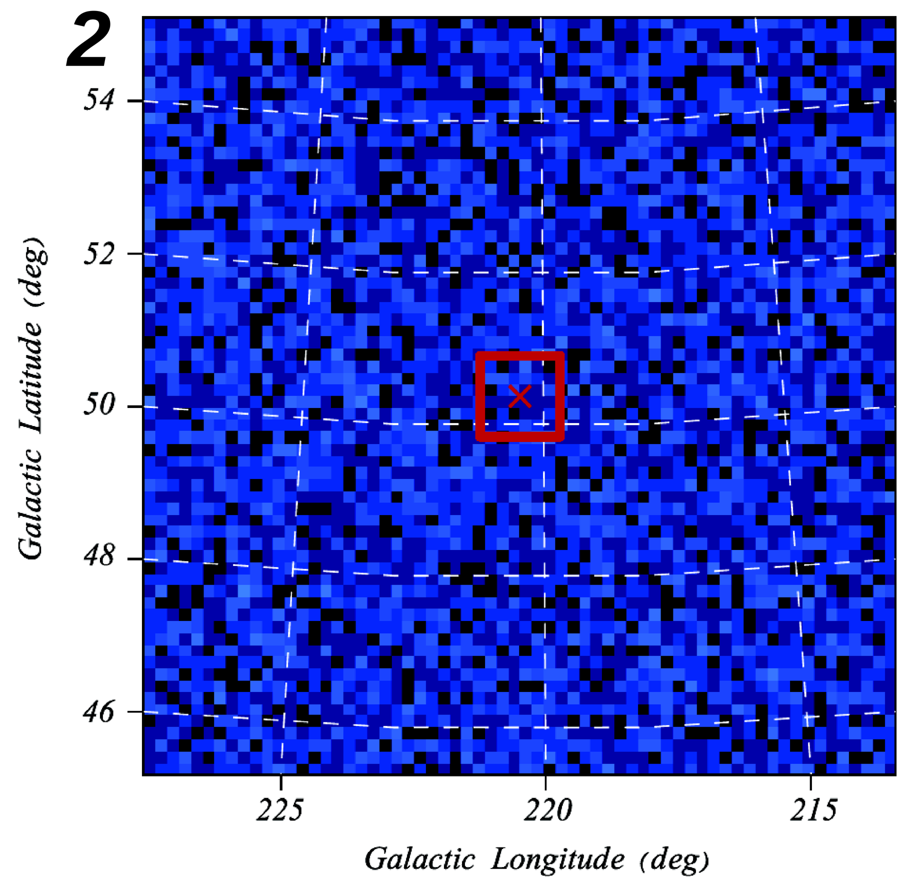

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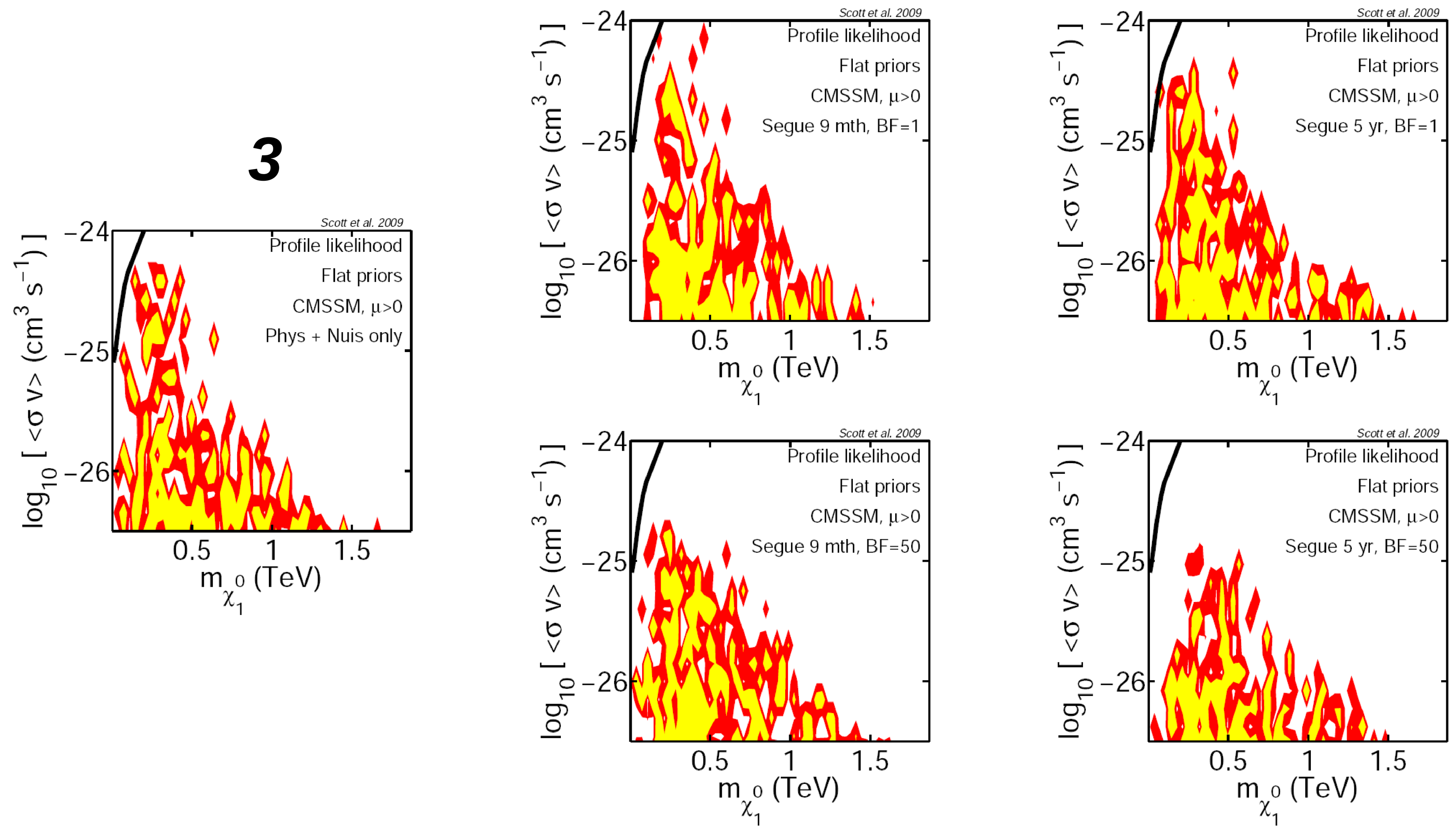

Fig 3: Neutralino self-annihilation cross-sections in the CMSSM. *Left*: with no constraining experimental data except measurements of standard model nuisance parameters and physicality requirements. *Middle:* constraints provided by 9 months of Fermi data on Segue 1, under the most pessimistic (top) and optimistic (bottom) assumptions about the substructure boost factor. *Right:* projected constraints after 5 years of Fermi observations. Colours indicate 68% (yellow) and 95% (red) confidence regions. The preliminary 95% confidence level upper limit on the annihilation cross-section from 9 months of Fermi data, assuming 100% WIMP annihilation into *b*-quarks, is given for comparison (black curve).

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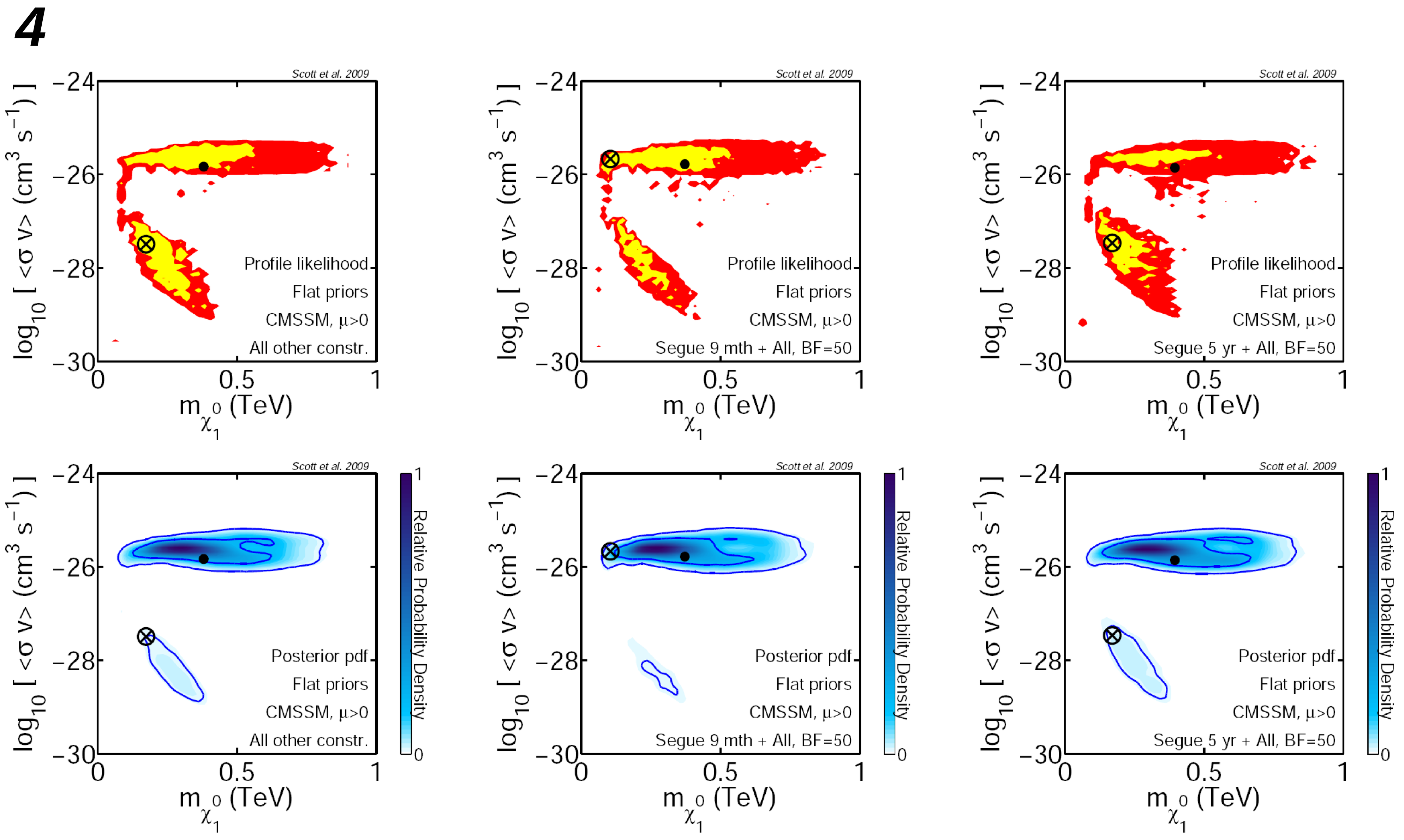

Fig 4: WMAP-compatible annihilation cross-sections in the CMSSM, assuming the neutralino to be the dominant component of dark matter. Favoured regions are as implied by existing experimental data only (left), and with the addition of 9 months of Segue 1 observations by Fermi (middle). We also show the extrapolated impact of a non-observation of Segue 1 after 5 years (right). Upper plots show profile likelihoods (where yellow and red indicate 68% and 95% confidence regions respectively), while lower plots show marginalised posterior PDFs (where solid blue contours give 68% and 95% confidence regions). Solid dots indicate posterior means, whereas crosses indicate best-fit points.

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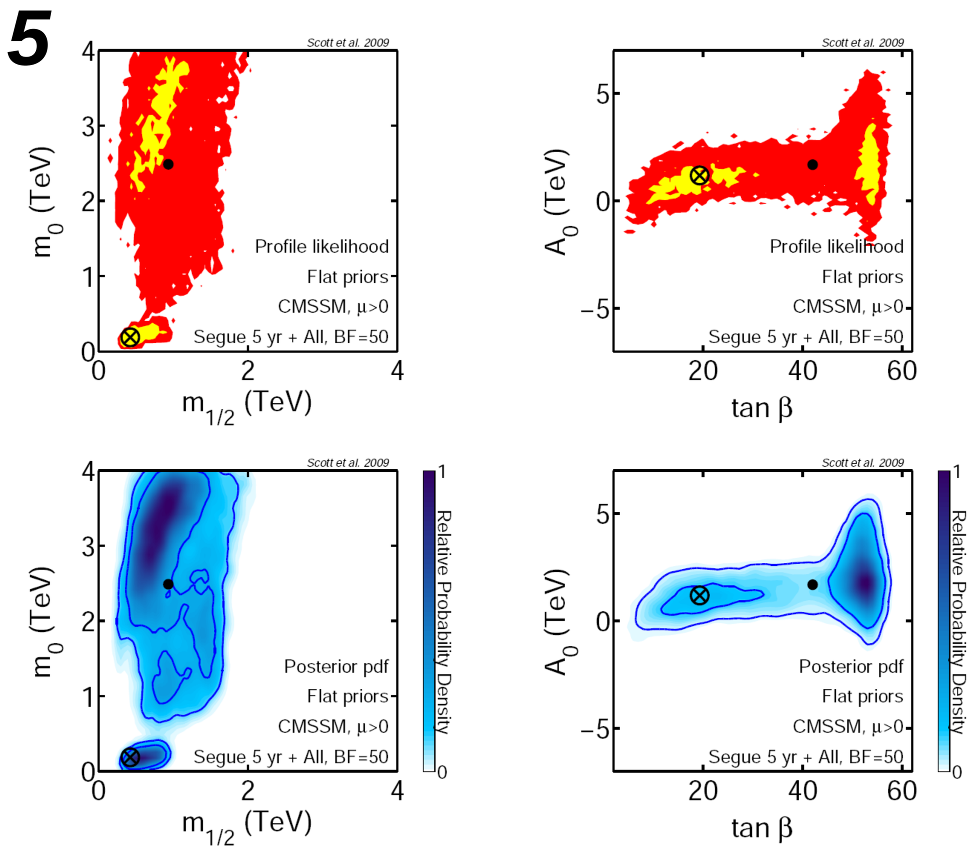

Fig 5: Preferred CMSSM parameter regions including Fermi-LAT observations of Segue 1 and all other observables. Shadings and markings are as per Fig. 4. Preferred regions are very similar whether one considers the existing 9 months of LAT data or extrapolates to 5 years of observations.