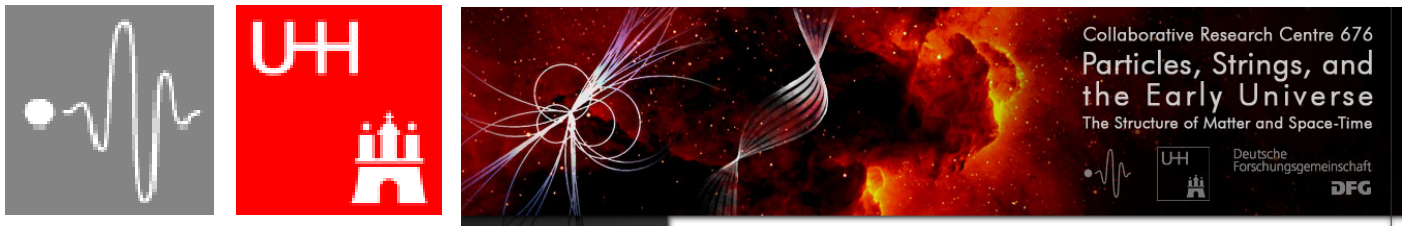
Indirect Search for Dark Matter

Fittino Workshop 2009

Nelly Nguyen

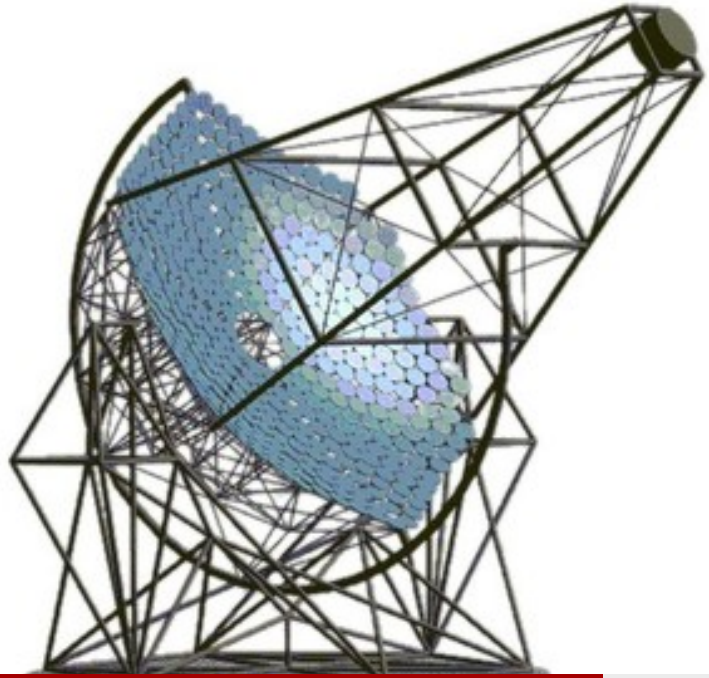
University of Hamburg

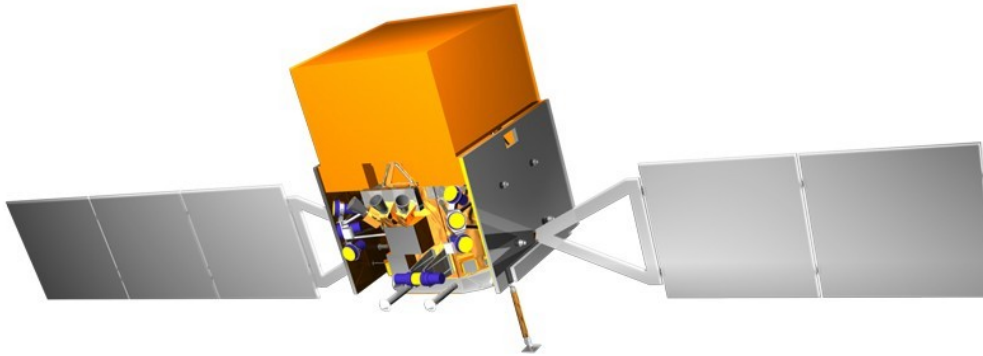


Overview

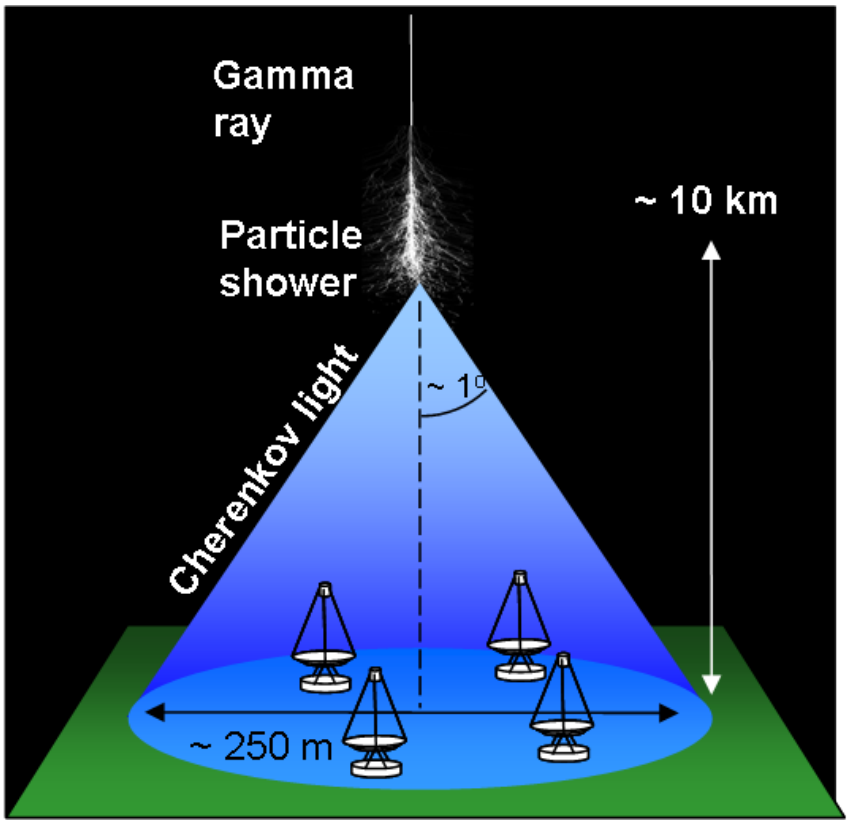
The Idea

- Indirect Dark Matter search with gamma-ray telescopes
- Combined constraints with accelerator experiments
- Including astrophysical components into Fittino
- Data taken from the HESS and FERMI LAT experiments





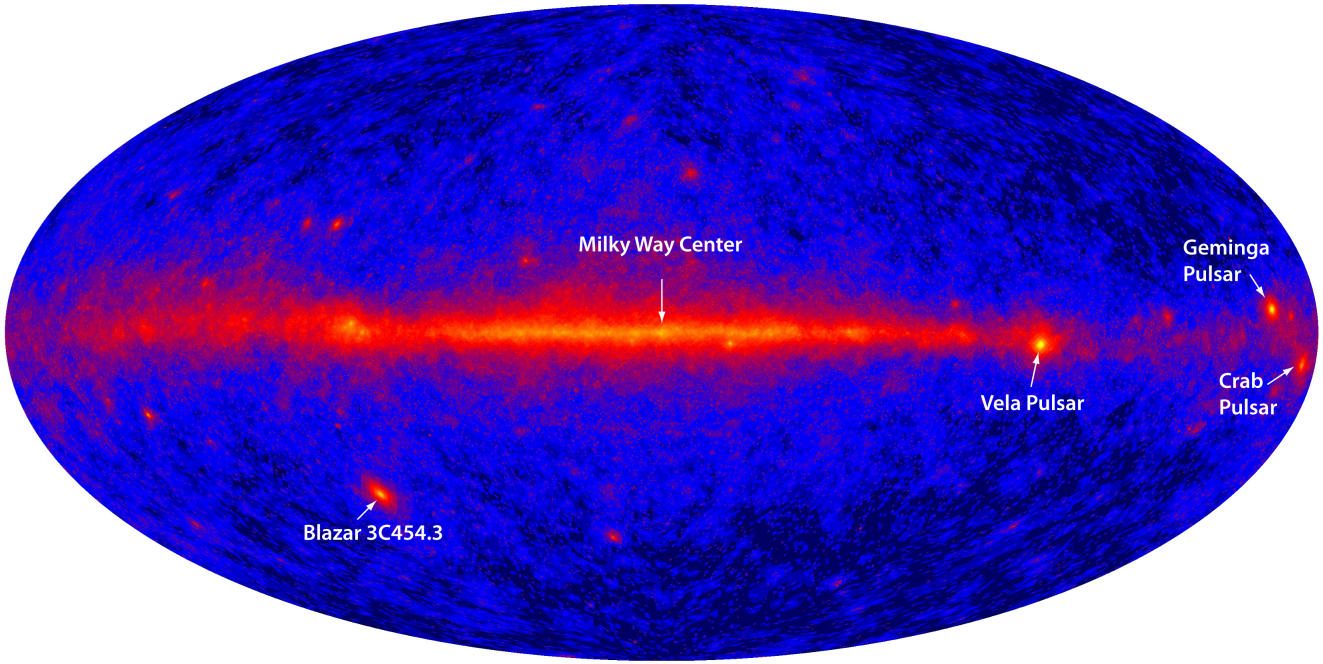
The HESS Experiment



HESS - High Energy Stereoscopic System

- System of Imaging Atmospheric Cherenkov Telescopes
- observes cosmic gamma-rays in the range of 100 GeV - 100 TeV
- four ground based gamma-ray telescopes located in Namibia
- energy resolution of 15%
- field of view: 5°

The FERMI LAT Experiment

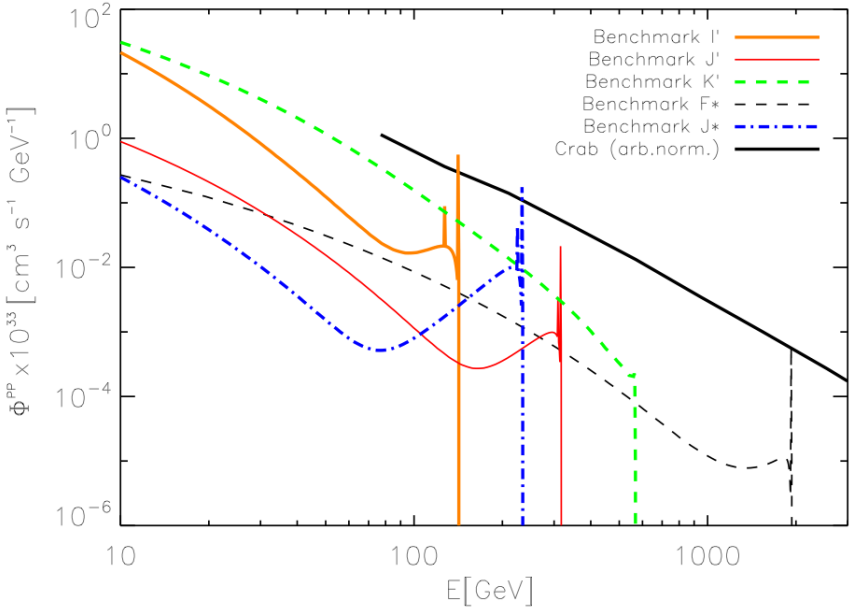


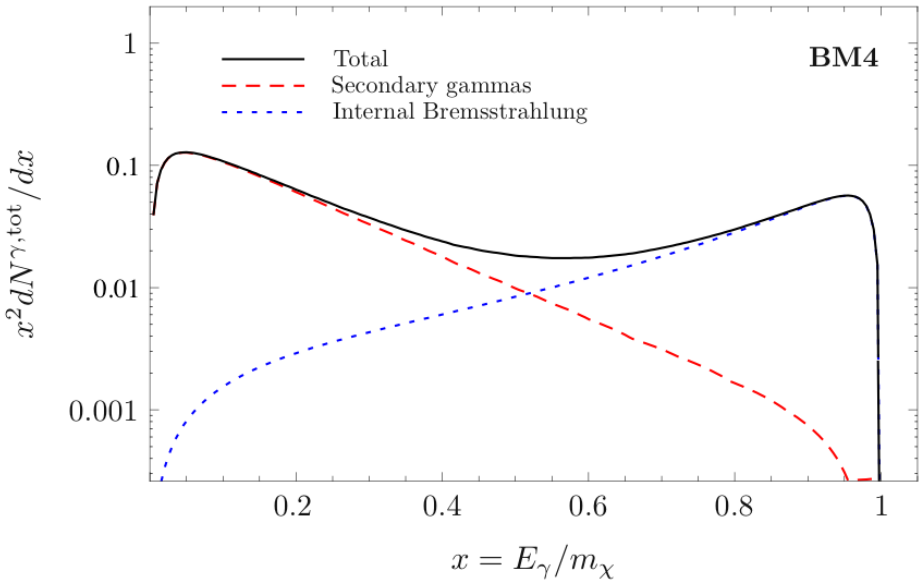
Fermi Gamma-Ray Space Telescope (formerly known as GLAST)

- space observatory sensitive in the range of 20 MeV - 300 GeV
- instrument for DM detection: Large Area Telescope (LAT)
- pair-production telescope
- all-sky survey with wide field of view > 2 sr

Photon Signals

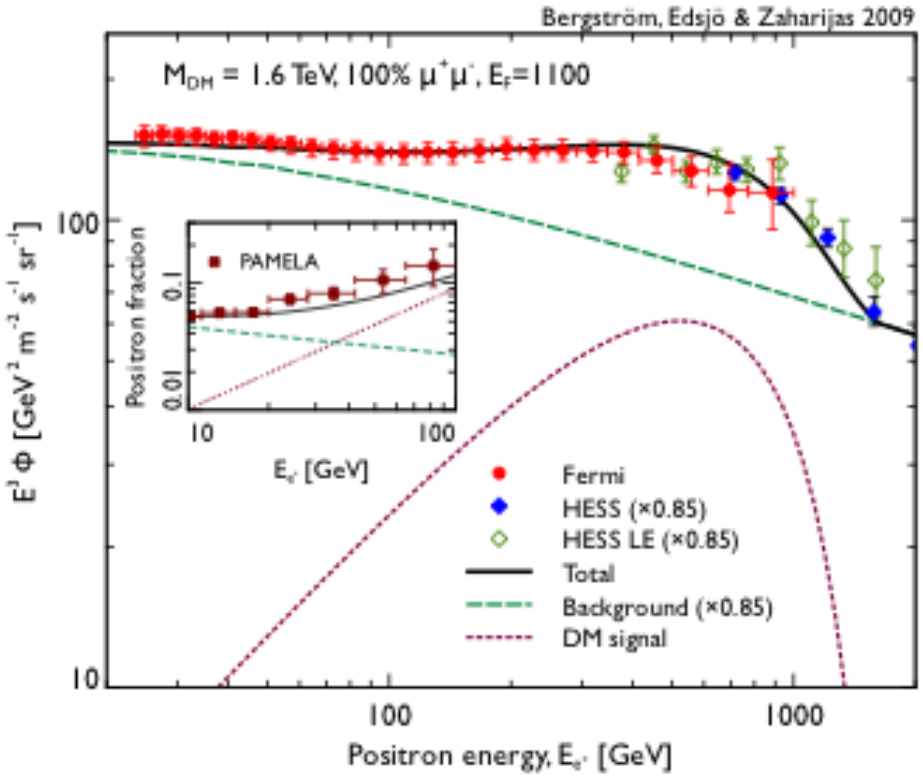
- self-annihilation of Neutralinos produces high energy photons
- shape of photon flux sensitive to Neutralino composition
- continuum from hadronization and muon decay
- monochromatic spectral line emission ('smoking gun')
- spectrum with significant rate of internal bremsstrahlung





Antimatter Signals

- observation of electron-positron flux
- Dark Matter decay produces matter and antimatter equally
- unexpected cut-off in HESS and FERMI spectra
- antimatter excess measured by PAMELA



Relic Density

Density Distribution in the Universe

$$\Omega = \Omega_B + \Omega_{DM} + \Omega_\Lambda$$

$$\Omega_{DM} h^2 = 0.113 \pm 0.003$$

rescaled hubble constant $h = 0.70 \pm 0.01$

- Relic Density of Dark Matter Ω_{DM}
- precise measurements from cosmology, i.e. measured with WMAP
- calculating relic density with Boltzmann equation
- precise calculation possible with DarkSUSY or MicrOmegas
- comparison between accelerator results and Universe

Astrophysics goes Fittino

- library of subroutines and functions
- written in Fortran
- SUSY Les Houches Accord (SLHA) implemented
- calculates relic density, gamma ray signals, electron-positron flux
- MSSM and mSUGRA
- consistent calculations for astrophysical and particle physics
- good documentation for interfaces available

DarkSUSY 5.0.5

http://www.physto.se/ edsjo/darksusy/

Relic Density Calculator

Programming Steps

- improve already existing interface to MicrOmegas
- create a new interface to DarkSUSY
- use SLHA to transfer input data to the according routine
- get result back from routine to Fittino

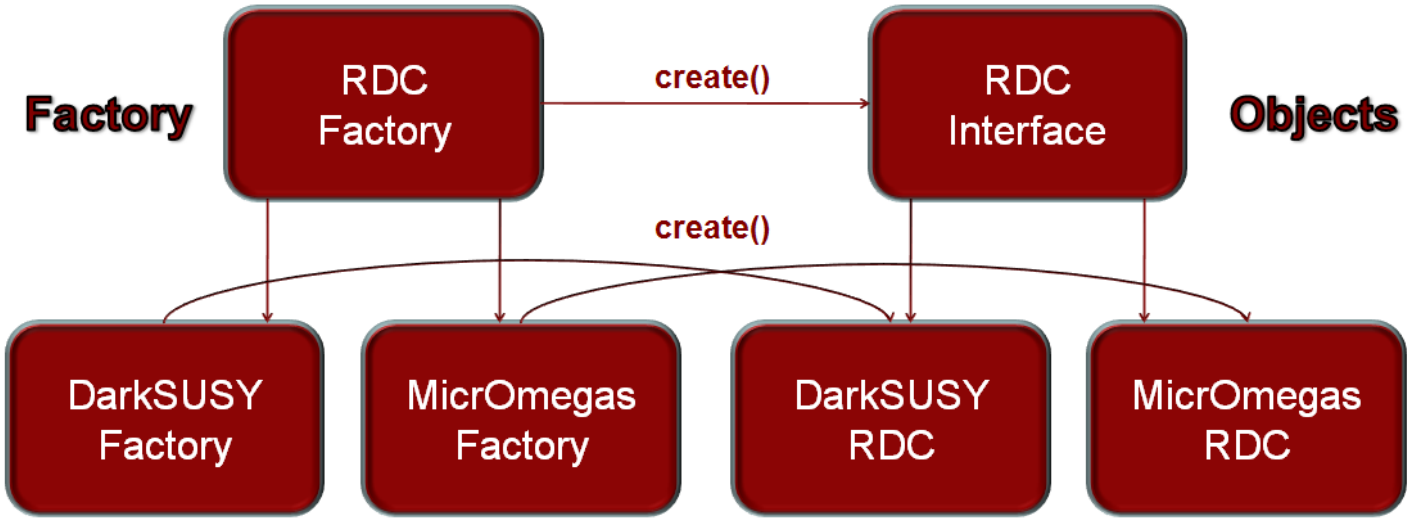
Constraints

- if $\Omega_{DM} h^2 = 0.113 \pm 0.003$
- add factor to χ^2

Relic Density Calculator

Interface Architecture and Use

- set up Relic Density Calculator object
- choice between DarkSUSY and MicrOmegas
- write factories that create objects
- compare results from DarkSUSY and MicrOmegas



New Interface for Measured Photon Flux

Total Photon Flux

$$\frac{\mathrm{d}\Phi}{\mathrm{d}E\mathrm{d}\Omega} = \frac{1}{2}\cdot\frac{1}{4\pi}\cdot\underbrace{\frac{1}{m^2}\sum_i\left(\langle\sigma v\rangle_i\frac{\mathrm{d}N_{\gamma,i}}{\mathrm{d}E}\right)}_{\text{particle physics}}\cdot\overbrace{\int_{LoS}\mathrm{d}s\,\rho^2}^{\text{astrophysics}}$$

Annotation

- rare process: direct self-annihilation of Neutralinos into photons
- at higher rate: photons from fragmentation of other annihilation products
- astrophysics: strength of signal (square density along line-of-sight)
- particle physics: photon spectrum per annihilation

New Interface for Measured Photon Flux

Programming Steps

- initialize line-of-sight integral (LoS) once for each source: galactic center, dwarf galaxies, ...
- get DarkSUSY spectrum calculation
- include DarkSUSY results into fit

Constraints

- use flux limit as constraint
- $\frac{\mathrm{d}\Phi}{\mathrm{d}E} <$ flux limit
- add constraint to χ^2

Summary and Outlook

Summary

- use Fittino in indirect Dark Matter detection
- take data from HESS and FERMI LAT
- find constraints for accelerator experiments
- compare results

Next Steps

- write object for Relic Density calculation
- create interface to DarkSUSY and MicrOmegas for relic density
- include Radiant Flux from observation
- create interface to DarkSUSY for spectrum calculation
- add constraints to the fit