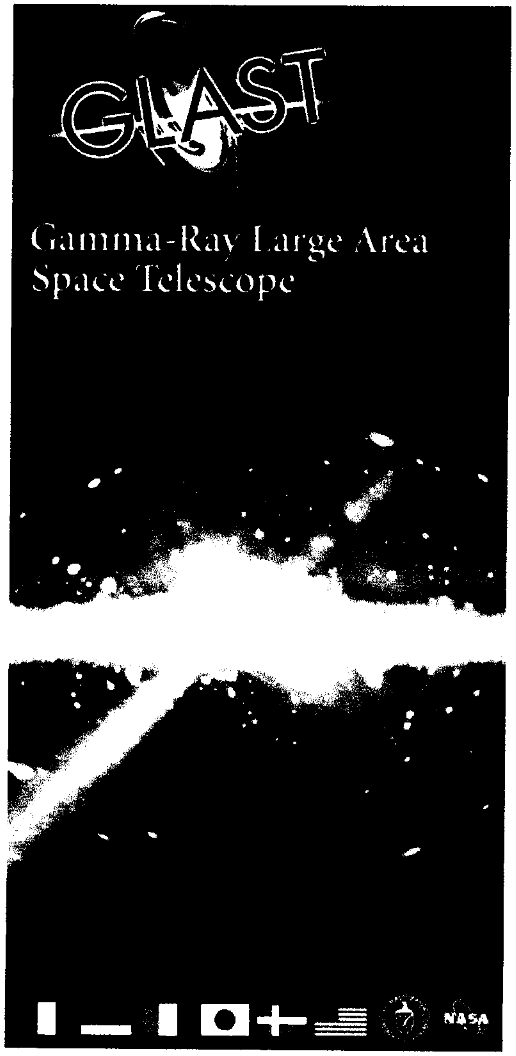
Searching for Dark Matter Signatures in the GLAST LAT Electron Flux



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On behalf of the GLAST LAT Collaboration

Purpose of this talk:

- ***demonstrate GLAST LAT capability to detect high energy cosmic ray electrons***
- ***apply this capability to different DM models to get a feeling about LAT sensitivity***
- ***let people do the same and check if LAT will be capable to test their models***

Indirect Evidence for Dark Matter in Cosmic Rays

- ❑ Indirectly observe DM by detecting its interaction or annihilation products
- ❑ WIMP annihilation into γ, neutrinos, antiprotons, positrons – indirect DM searches in cosmic radiation (Pamela, GLAST, BESS, CALET, ATIC, other experiments)
  - ✓ Attempts to find DM signature that is clearly distinguished from all other CR phenomena
    - Cleanest signature if a spectral line is found – *smoking gun!*
    - Also seeking characteristic spectral shape (excess or bump)

Dark Matter Observation in Cosmic Rays (cont.)

- ✓ Always a background question – what DM models can be seen by any given experiment
- ✓ How to prove that Dark Matter is found? – Consider all alternative explanations (sources, propagation)
- ✓ Search for DM appearance in anti-particles seem to be favorable – expect higher "signal-to-noise ratio" or lower background of expected particles,

But: simpler instruments, incapable to distinguish p-bar/p, e+/e$^-$ normally have larger geometry. They become more efficient in search for DM in "normal" particle fluxes when their geometry is larger than that for magnetic spectrometers etc. by a factor of $\sqrt{F_{particle} / F_{antiparticle}}$

We want to check what will be the LAT perspectives in finding DM signatures in its electron+positron flux

LAT Capability to detect CR electrons

Being a γ–ray telescope, LAT intrinsically is an electron spectrometer, we only need to teach it how to tell electrons from hadrons (AntiCoincidence Detector does it for gammas)

Remark: LAT does not distinguish electrons from positrons, so we refer to their sum as electrons for simplicity

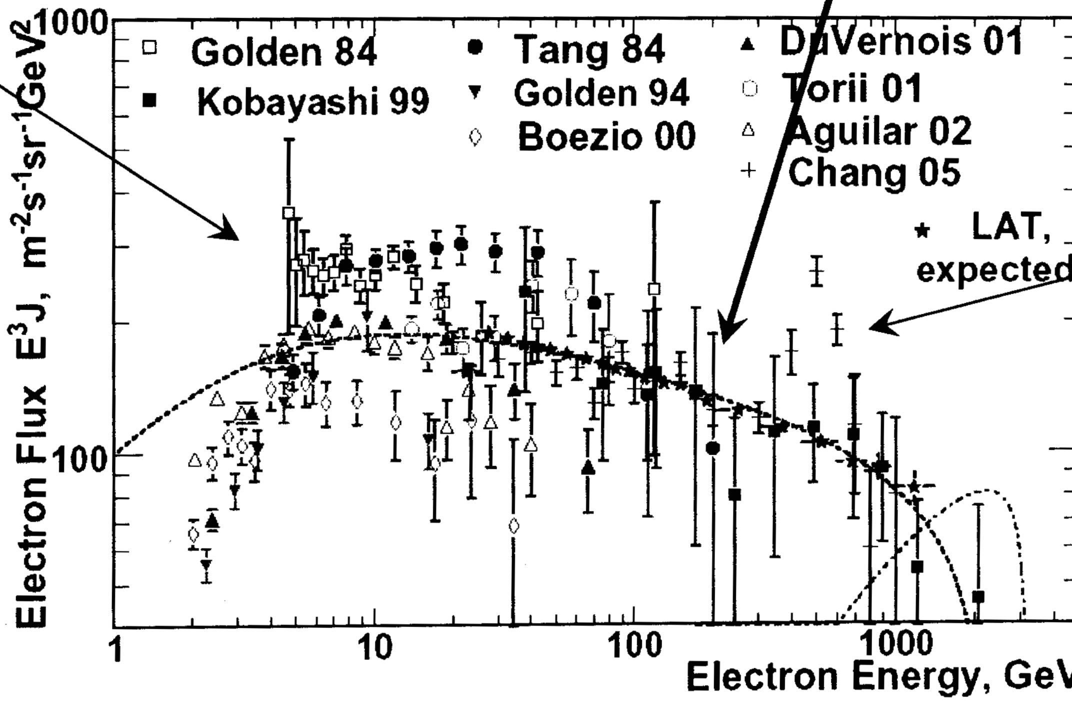
- **We have shown that LAT can efficiently detect cosmic ray electrons from 20 GeV to ~1 TeV with ~3% residual contamination of hadrons (in respect to the number of detected electrons)**
- **The <u>effective</u> geometric factor after applying our electron selections is ~1 m^2sr and energy resolution (σ) is 5-20% depending on the energy (compare with ~0.06 m^2sr for Pamela calorimeter only)**

LAT Capability to detect CR electrons (cont.)

• LAT will be able to **precisely reconstruct the electron spectrum** in 20 GeV – 1 TeV energy range

• LAT should detect > 10^7 electrons above 20 GeV (> 2,500 above 500 GeV) per year of operation. Excellent statistics, never achieved before. Systematic errors are under careful investigation

All currently available experimental results. Not much can be said about spectral features



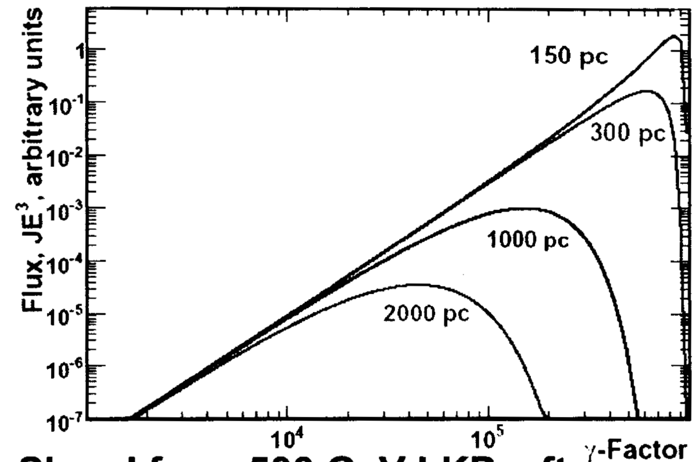
Promising feature detected by ATIC.

Now we will apply LAT capability to detect electrons to some of Dark Matter models

We expect that the dominant background consists of "conventional" electrons with a contamination by hadrons (and gammas) of only a few percent.

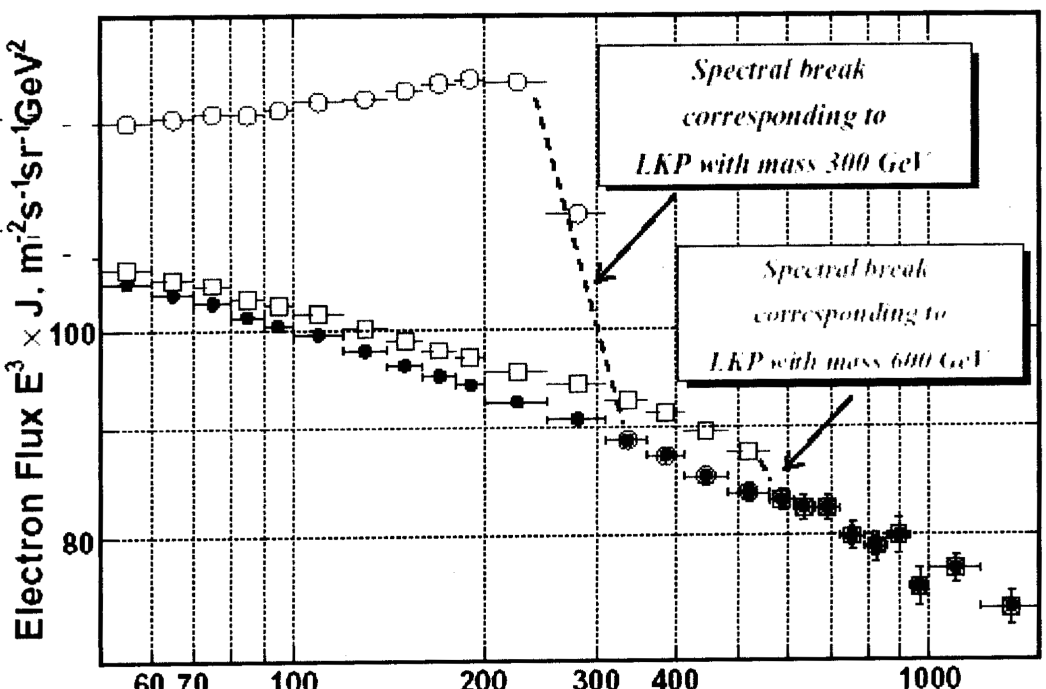
Simulated LAT sensitivity for the scenario given in Baltz and Hooper (JCAP 7,2005, 1):

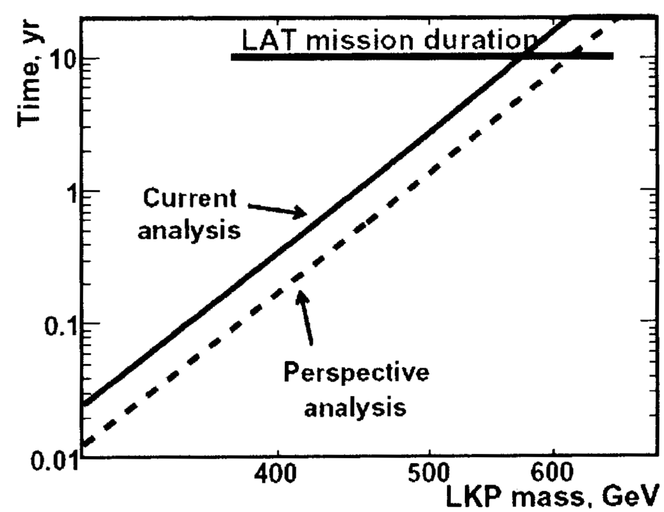
- LKP annihilation, with 20% yield in e+ e-
  boost factor of 5 and ρlocal =0.4 GeV/cm3
- LKP mass 300 GeV and 600 GeV
- signal from closest clump at 150 pc – propagation effect is small



Signal from 500 GeV LKP, after propagation from different distances

5 years of LAT observation



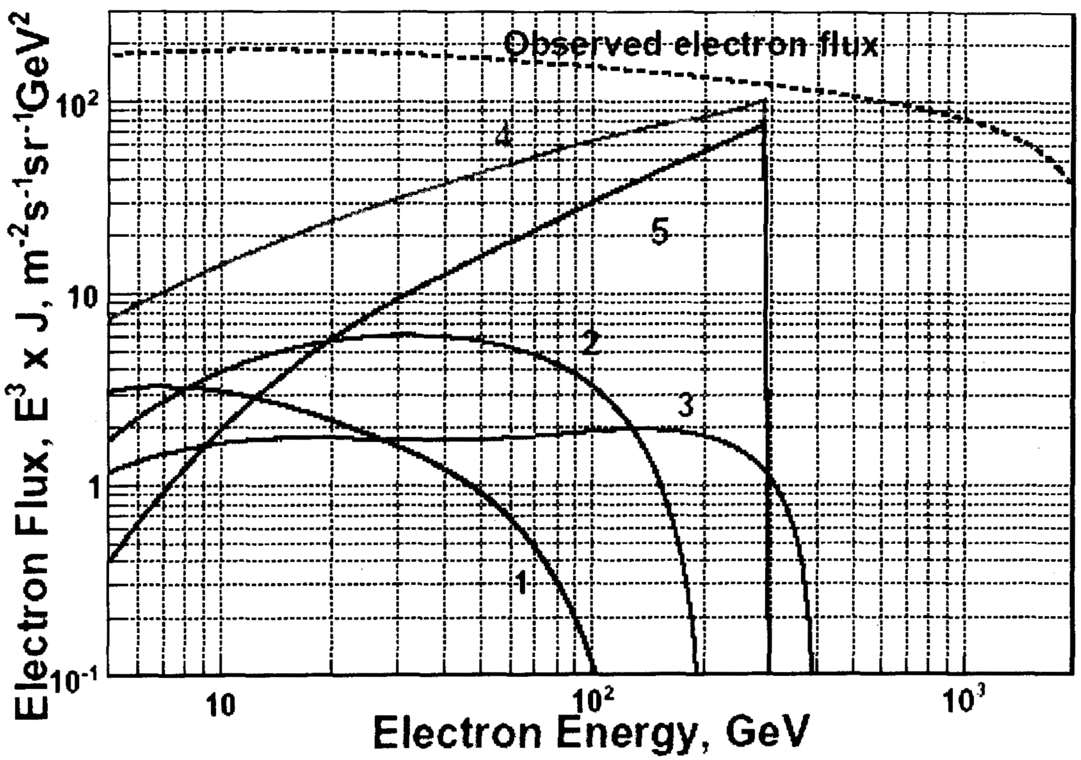


Time needed to detect LKP with 5σ significance

More examples of LAT sensitivity to DM signals

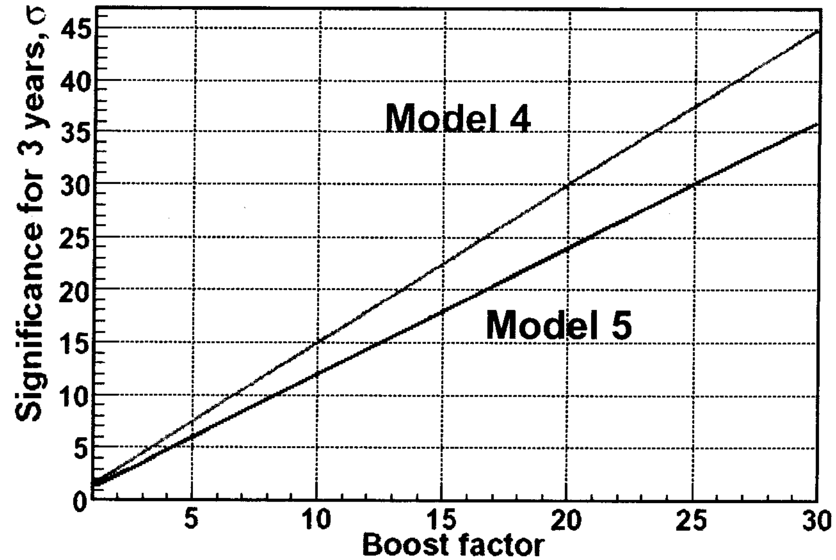
- ***Model 1*** Mass 200 GeV, final state b-bar, b [SUSY benchmark; e.g. mSUGRA in bulk or funnel region, bino-like LSP]
- ***Model 2*** Mass 200 GeV, final state $\tau^+ \tau^-$ [SUSY benchmark; e.g. mSUGRA in stau coannihilation region, bino-like LSP]
- ***Model 3*** Mass 400 GeV, final state W W [SUSY benchmark; e.g. MSUGRA in focus point region, higgsino-like LSP, or minimal anomaly mediation, wino-like LSP]
- ***Model 4*** Mass 300 GeV, final state UED [~20% BR in each charged lepton flavor, ~ 7% in up-type quarks, plus other SM channels]
- ***Model 5*** Mass 300 GeV, final state $e^+ e^-$ [most extreme case; similar models proposed in the context of the DM annihilation interpretation of the 511 keV line (Boehm, Fayet et al.)]

Predicted e^+e^- flux for Models 1 – 5, with boost factor 100, smooth halo, compared with observed "conventional" electron-positron flux

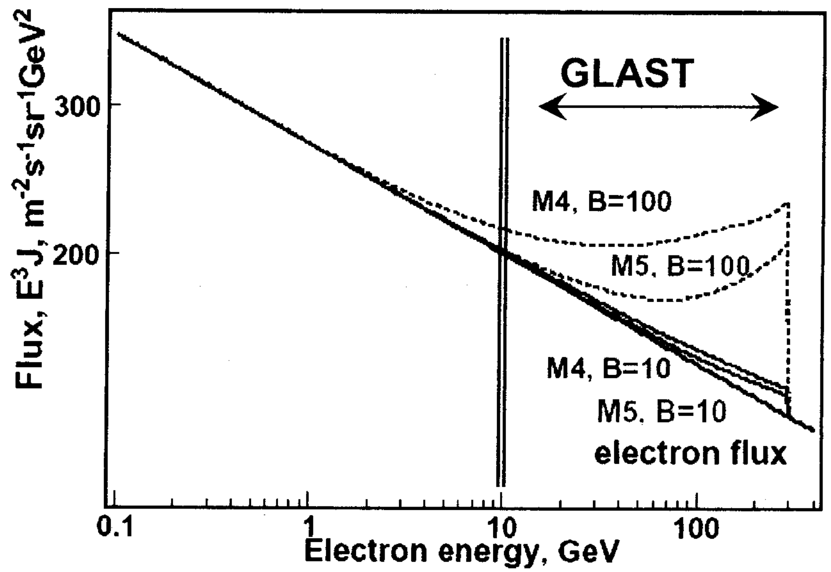


- ***Models 4 and 5, where we have a mode with direct production of e^+e^-, look very promising. Sharp spectral feature should be easily recognizable***
- ***Models 1-3, with less obvious spectral features, much more questionable for detection, unless the boosting factor is >1,000***

Significance to see the edge (in 50 GeV wide bin) in the electron spectrum, created by 300 GeV DM for Models 4 and 5, for 3 years of LAT observations



Expected electron spectra for Models 4 and 5, with boost factor 10 and 100



- We demonstrated the LAT capability to detect DM-caused spectral features in cosmic ray electron flux
- The question is – why not in gammas? Is there any advantages in searching for DM signatures in electron flux?
- Obvious advantage for gamma-observation is that they are free of propagation effects
- Here are the signals in gamma-radiation, caused by Model 1-5 (give plot similar to that in slide 8)

Placeholder

Discussion - …

Summary

- We explored several viable scenarios of how LAT might observe DM, when the spectral feature is predicted to be observed in the HE electron flux
- It has been demonstrated elsewhere that LAT will be capable to detect HE electrons flux in energy range from 20 GeV to ~ 1 TeV with 5-20% energy resolution and good statistics
- If there is a DM-caused feature in the HE electron flux (in the range 20 GeV – 1 TeV), LAT will be the best current instrument to observe it!