Summary and Outlook

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Some Remarks on Theoretical Developments

- Superstring theory is going strong, but hasn't reproduced the SM yet!
- MSSM (and variants) are still in fine shape.
- Nevertheless, model builders are running wild: "hidden valleys", "unparticles", "10^{32} hidden sectors", ...
- Phenomenologists are waiting for LHC (used to be waiting for SSC...): work on (N)NLO corrections; improved mass reconstruction techniques; . . . .
  Will be useful *if* LHC finds right kinds of particles.

2 Challenges to the SM

2a: $g_\mu - 2$

- Still differs from SM:

  $$a_\mu^{\rm exp} - a_\mu^{{\rm SM},ee\ {\rm data}} = (292 \pm 63 \pm 58) \cdot 10^{-11} \quad {\rm PDG}$$

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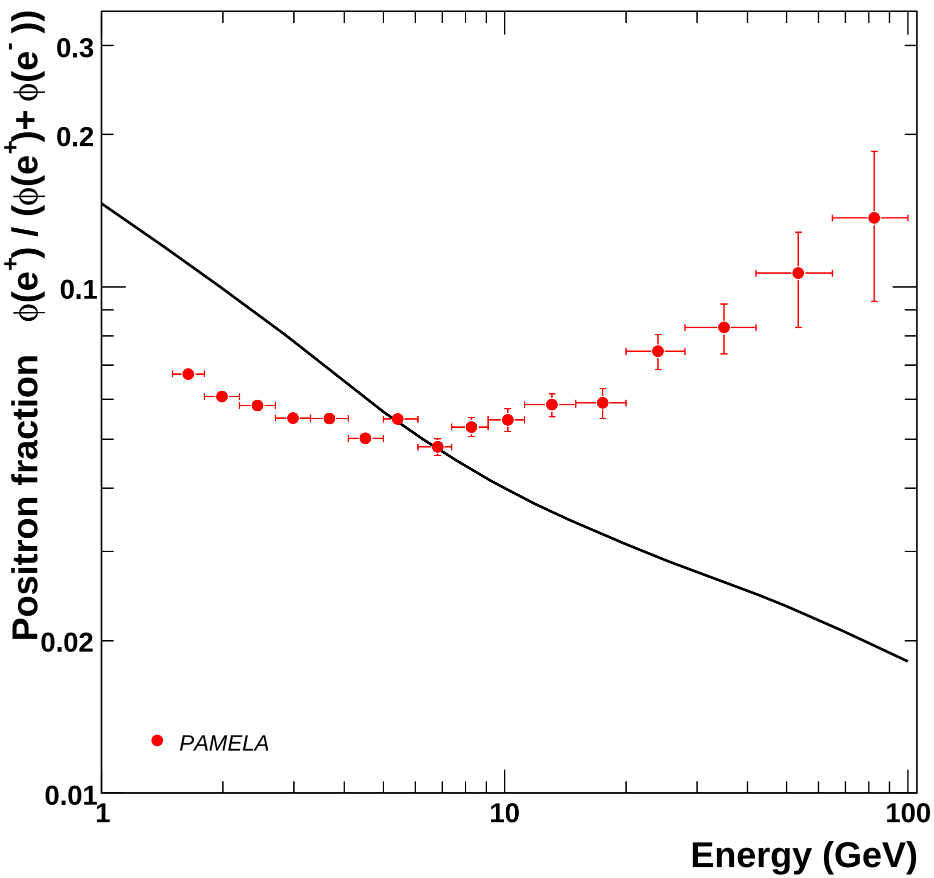
- New FNAL proposal for next generation expt. (R.M. Carey et al.)

2b: PAMELA etc.

PAMELA shows rising e^+ fraction, after a minimum:



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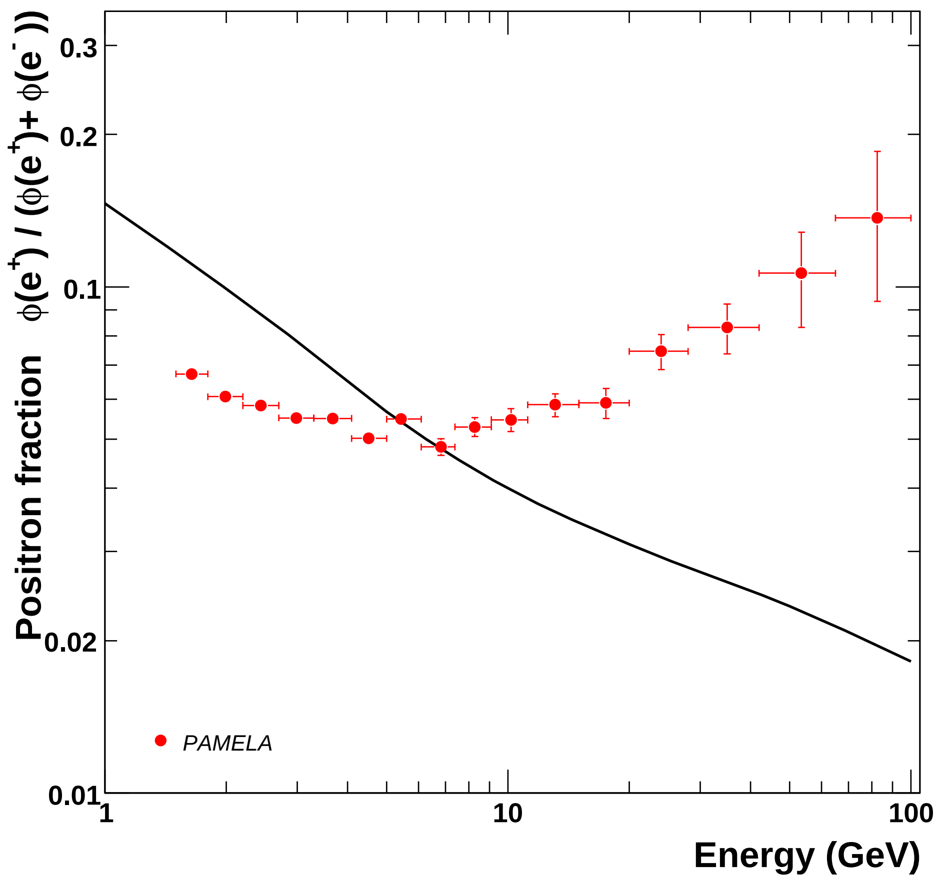
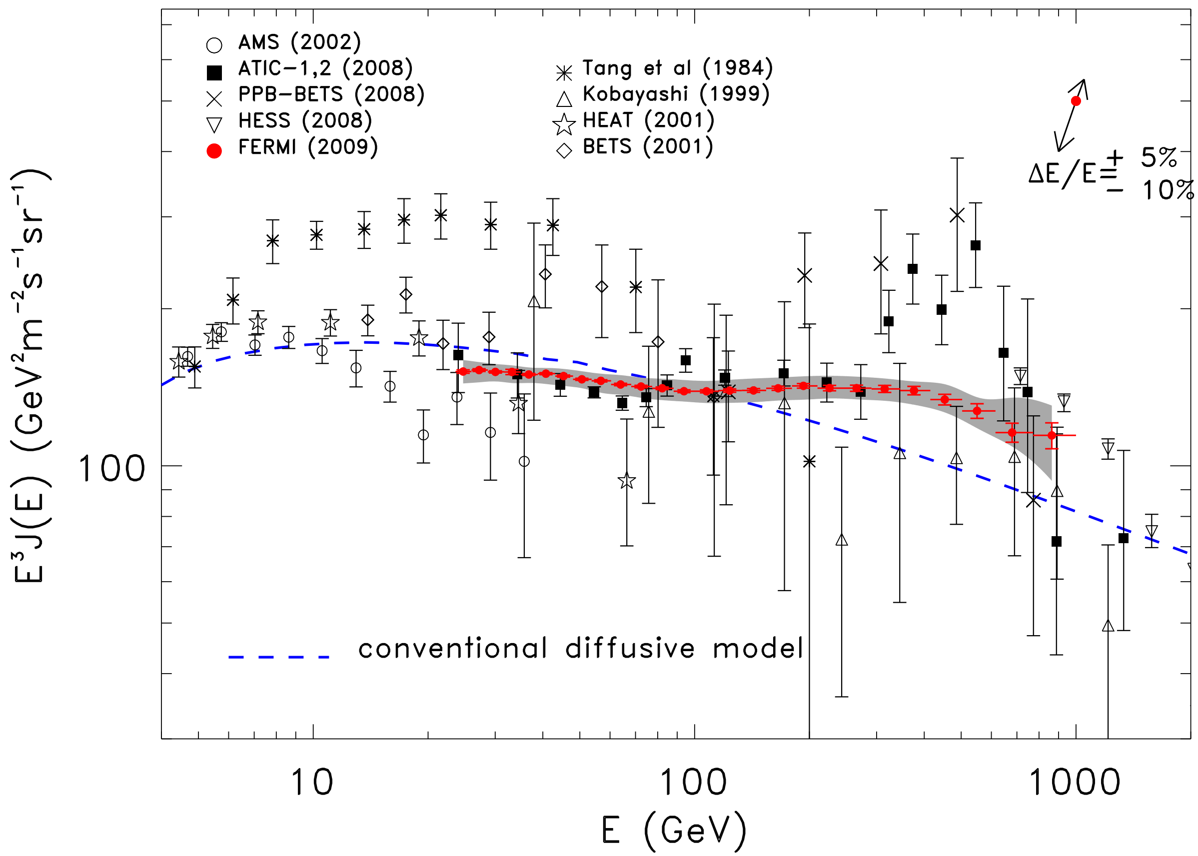


Very poor agreement between data and “theory” over almost entire energy range!

PAMELA etc. (cont'd)

ATIC, PPB–BETS: Claimed "peak" in $e^+ + e^-$ spectrum (after multiplying with E^3!): Refuted by Fermi–LAT!



H.E.S.S. finds steeply falling spectrum at $E \gtrsim 1$ TeV

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- Experimental results are frequently wrong!

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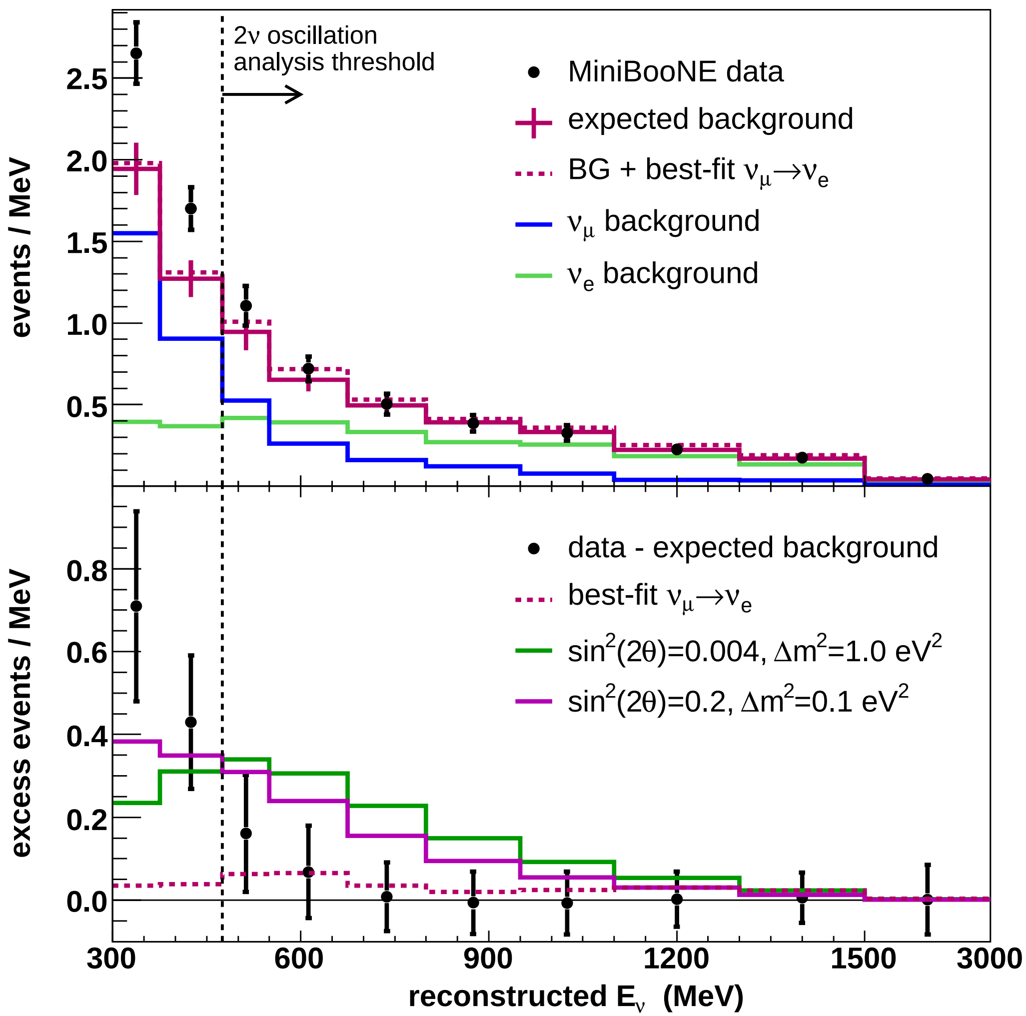

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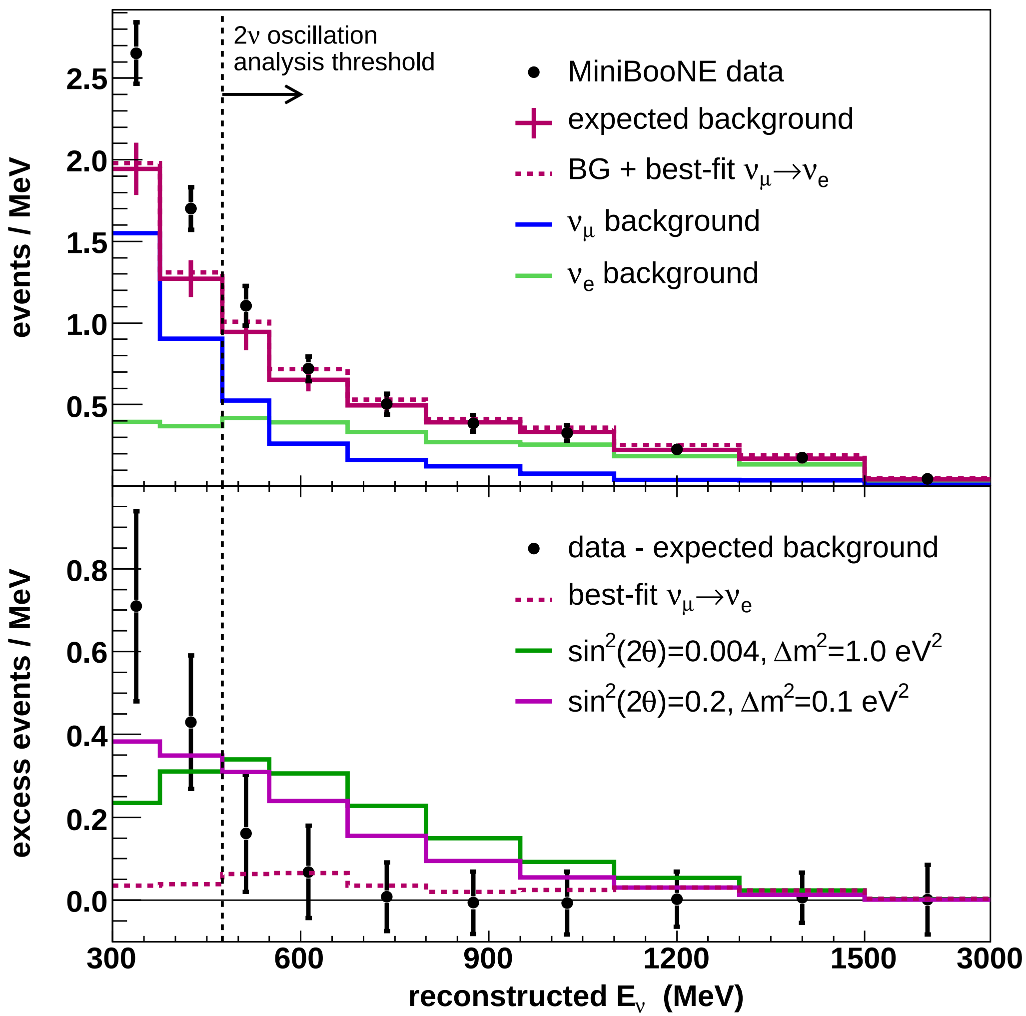

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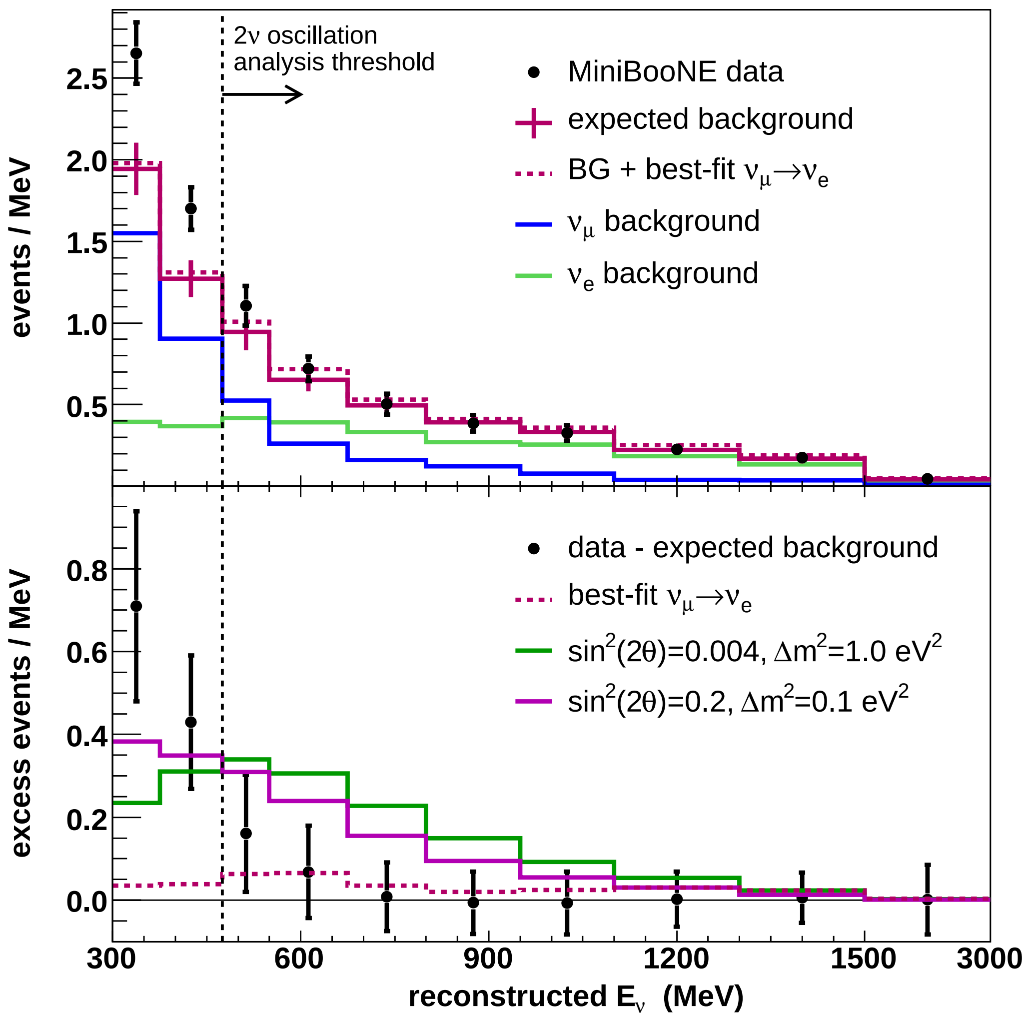

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$96 \pm 17 \pm 20$ excess events below 475 MeV!

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- Excess probably due to low–energy hadronic/nuclear effects (e.g. R.J. Hill, arXiv:0905.0291)

2d: CDF Ghosts arXiv:0810.5357

Look at di–muon sample:
$p_T(\mu) > 3$ GeV, $|\eta(\mu)| < 0.7,\ 5\ \mathrm{GeV} < M_{\mu\mu} < 80$ GeV,
behind 8.8 interaction lengths (“CMUP” muons):

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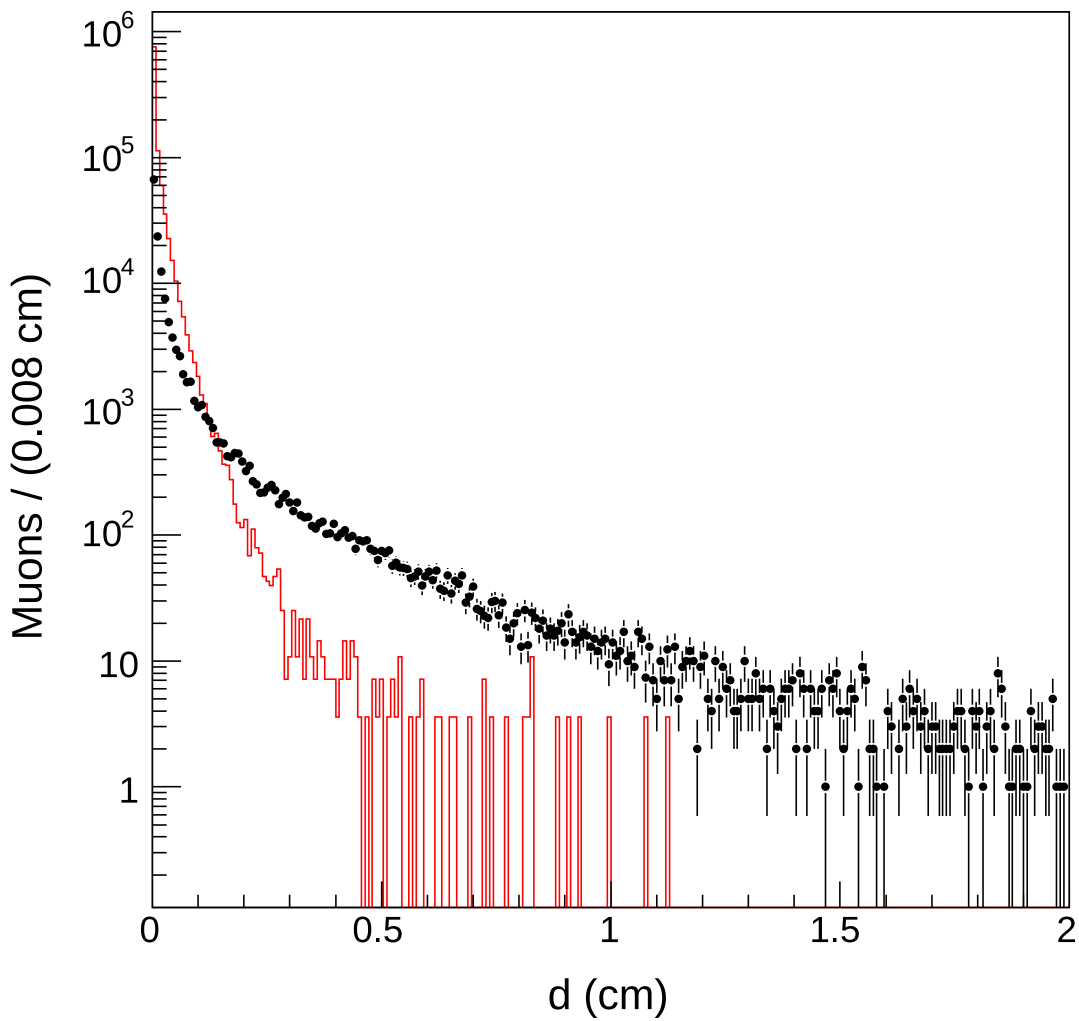
W/ “loose SVX”, requiring origin w/in 10 cm of primary vertex: half of “ghosts” gone; $\epsilon_{\rm SM} = 88\%$.

CDF Ghosts (cont'd)

Many ghost events have very large impact parameter:



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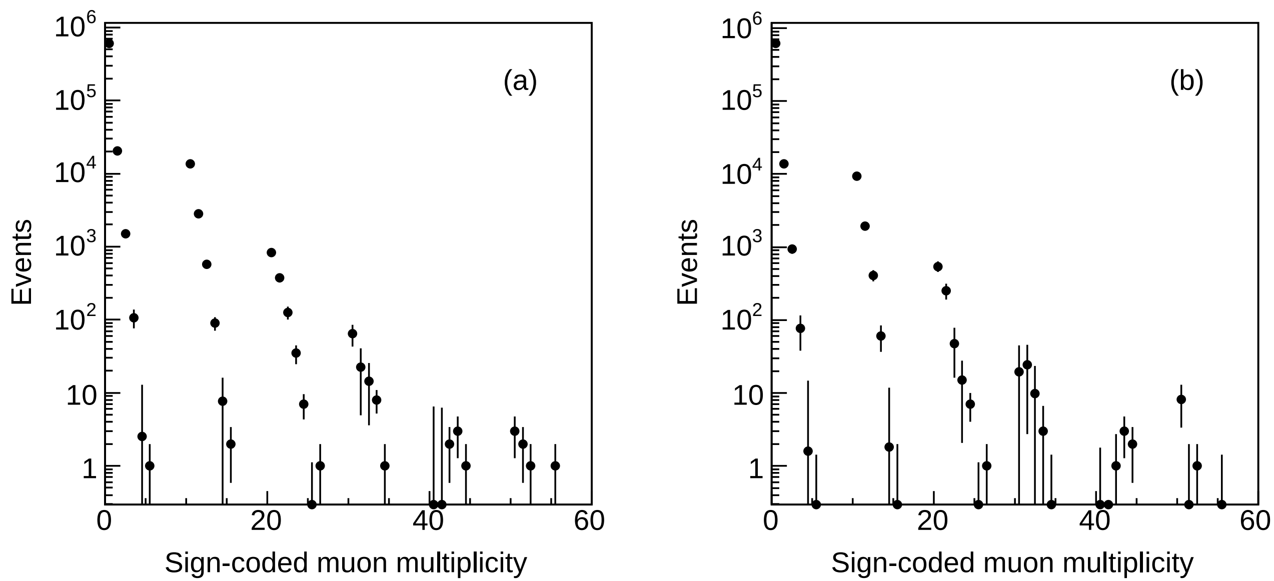

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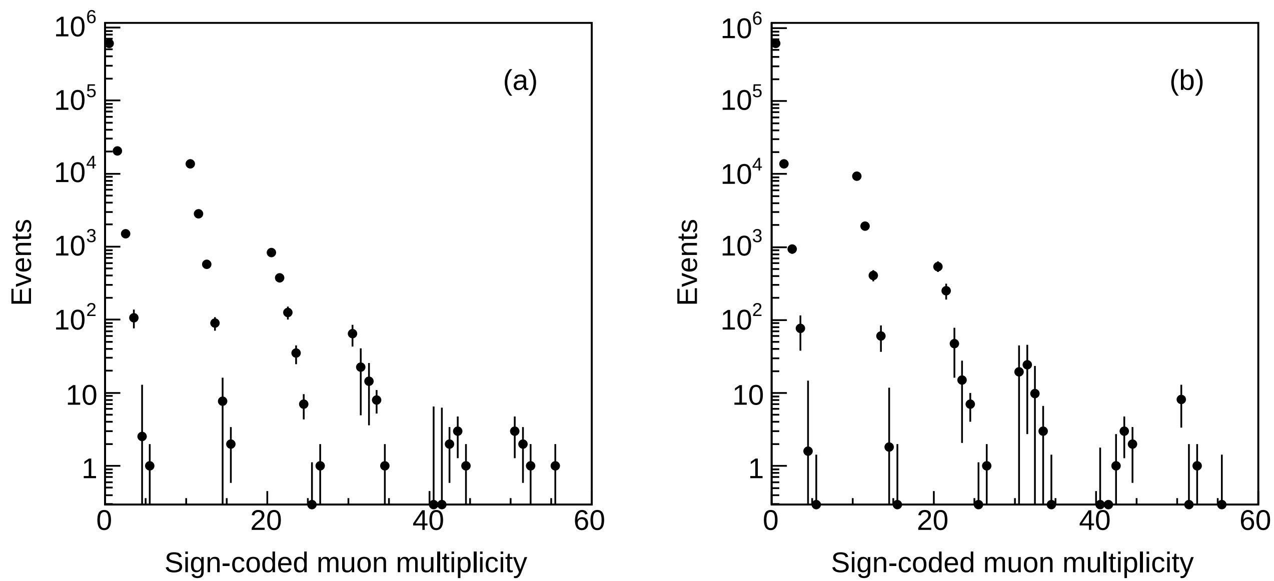

Nearly equal numbers of same–sign and opposite–sign combinations!

CDF Ghost Events: Kinematics

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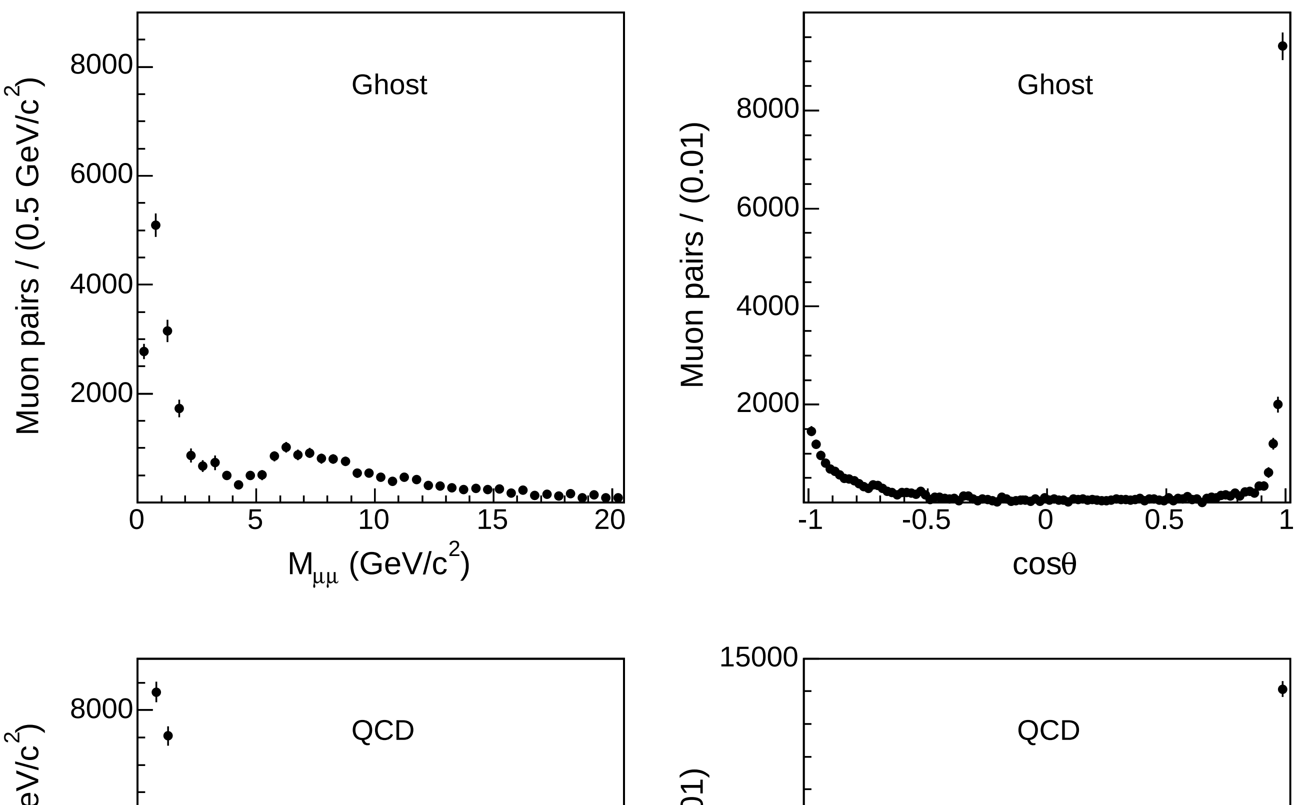
- $M_{\mu_p \mu_s}$ distribution, and large event no., suggest low mass scale of ghost events!



CDF Ghosts: Checks

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- Low$-E$ data: Look for events with muon(s) at large impact parameter or from far distant decay vertex. Scales are centimeter: Don't need fancy SVX detector! pp at RHIC; CERN SpS data? FNAL fixed target; HERA–B; . . .

2e: SHALON Anomaly arXiv:0903.4654

SHALON: 11.2 m^2 Cherenkov telescope in Tien–Shan mountains (China), 3.3 km a.s.l: Can see “below the horizon:”

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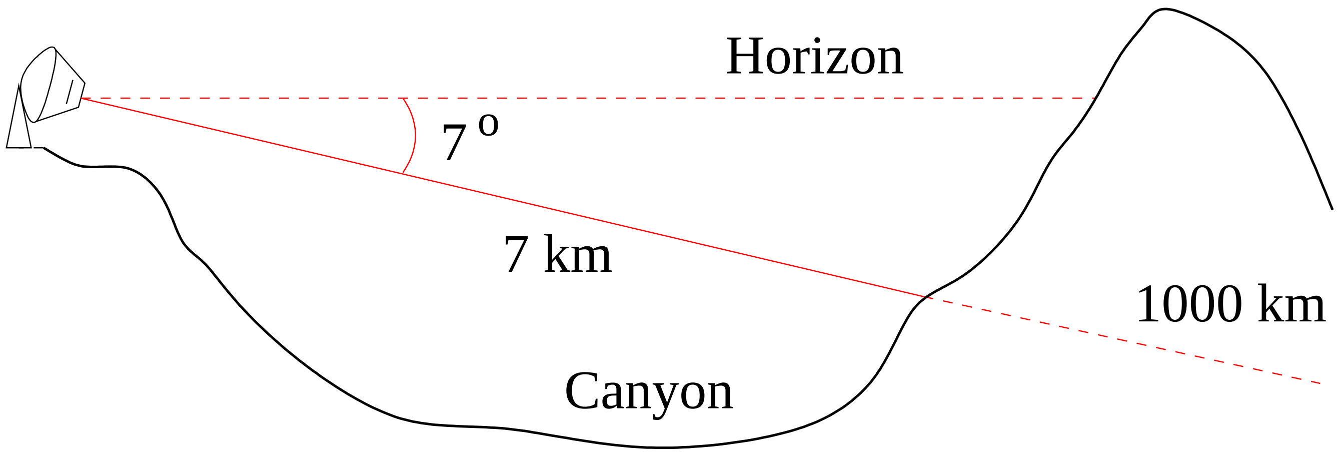

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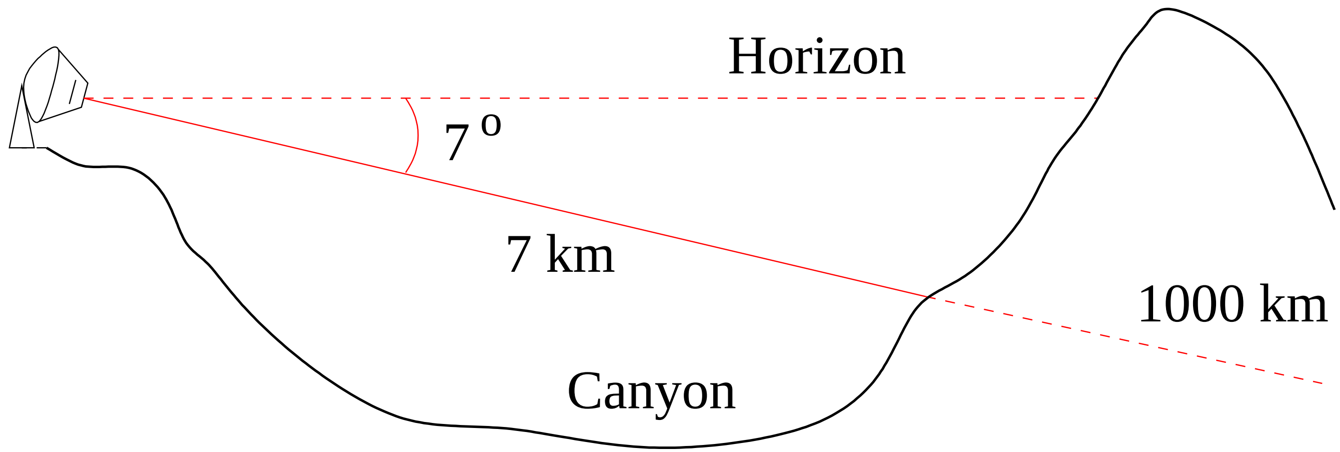

234 h observation time at 7° below horizon

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- Same model supposedly explains MiniBooNE anomaly (arXiv:0902.3802)

SHALON Anomaly: comments

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- Something for future expts of this kind to get excited, or worry, about.

3 Challenges to the Concordance Model

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Is this evidence for MOND/TeVeS?

Cannot make this claim! Nobody knows how structure formation works in MOND!

CDM Problems: To–do–list

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  - GAIA for our own galaxy. Launch 2011. Should measure 10^9 stars in 3D (position and radial velocity); get tangential velocity in 40M stars to better than 0.5 km/s! $v_{\rm rot} \sim 220$ km/s.

3b: CMB Anomalies

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- But: Any measured complicated distribution is bound to look unlikely in some ways! (Any one phase space point has vanishing probability.)
- WMAP still dominates determinations of many cosmological parameters.
- PLANCK launched successfully May 14. Should improve precision of parameters, e.g. $\Omega_{\rm DM} h^2$ to few%: Also need improved calculations!

3c: Large Scale Velocity Flows

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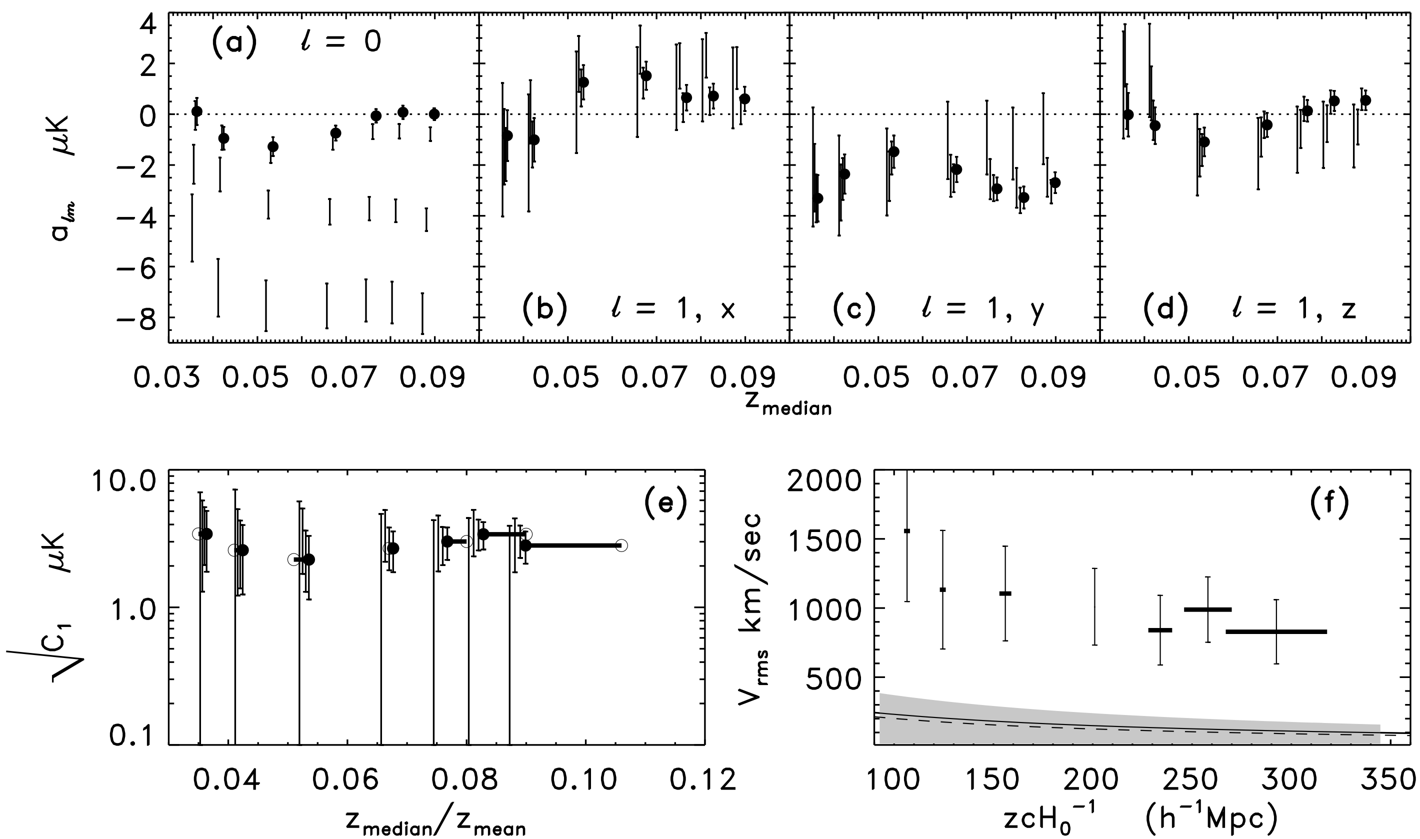

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- Sign for DGP gravity? Graviton gets tiny mass, i.e. longitudinal component; *increases* density perturbations at small scales. Afshordi et al., arXiv:0812.4684

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- As long as effective Ω_Λ from quantum fluctuations is not understood: can we trust inflationary model building? Based on *classical* vacuum energy $\ll M_P^4$ being the dominant term!
- Other way round: testing details of inflation (e.g. non–Gaussianity; gravity waves) may shed new light on Λ problem! PLANCK, again!

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- MiniBooNE excess will probably find SM explanation
- Weird anomalies (CDF ghosts; SHALON) will probably go away – but why not hasten their demise by looking elsewhere?

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4 Summary

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- Large scale velocity flows mostly ignored so far: ~ 20 citations; also true for most other anomalies I discussed.