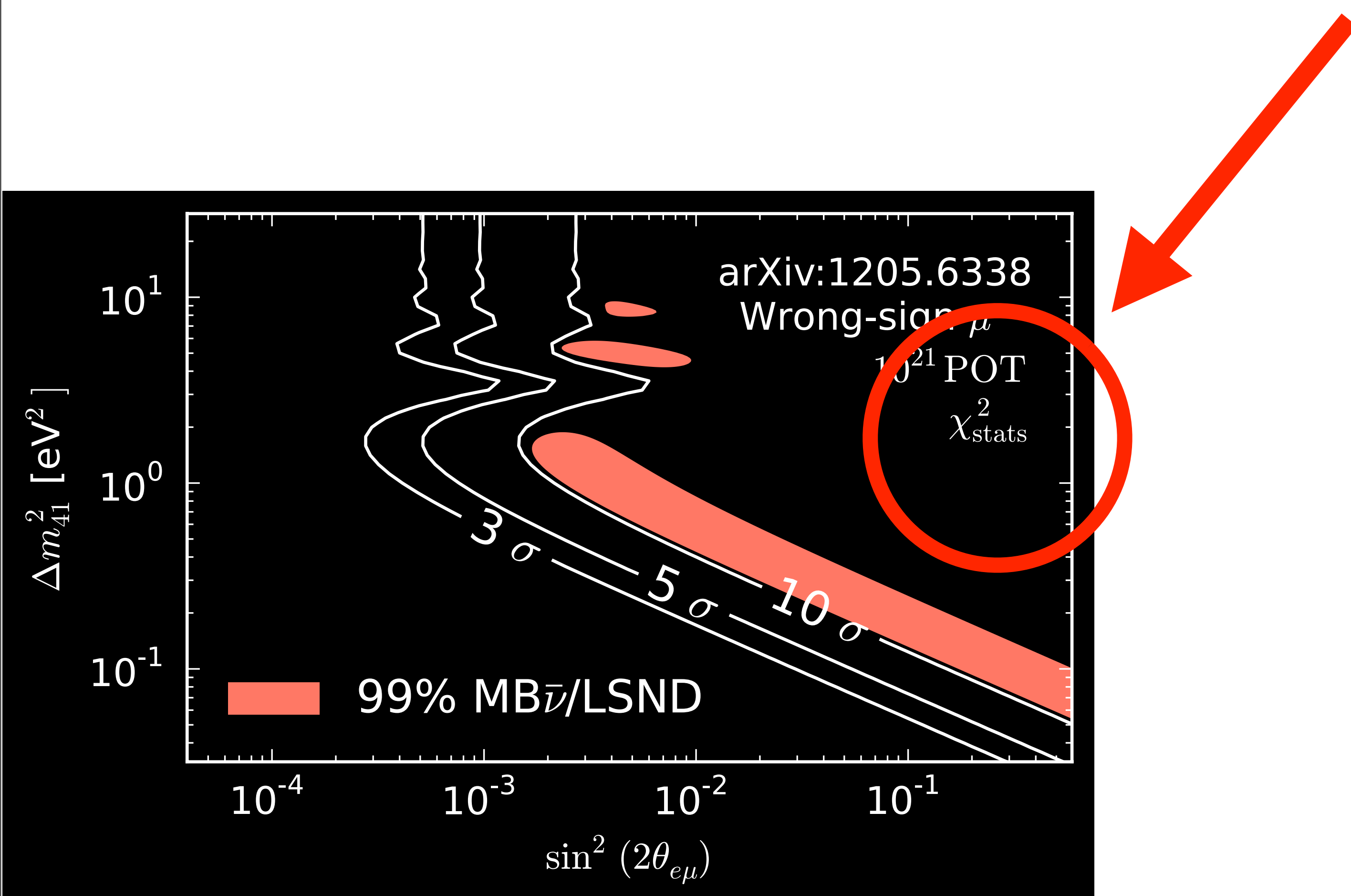
Sensitivity Systematic Musings

C.D. Tunnell's summary of conversations with:
D. Adey, R. Bayes, A. Bross, J. Cobb, B. Palka

What work needs doing



- This is stats only. What about systematics?
- Asked this question at workshop by YKK
- Should be small, but Ryan and I need list for proposal
- If you can think of something we forgot, tell us!
- 10 sigma prefers systematic error <100%; rare process search

Systematics List for ‘wrong-sign muon’

- Hadronic and Electromagnetic Models
- Magnetic field (bend) and Steel (range) uncertainties
- Atmospheric Neutrinos
- Beam+‘Rock’ muons
- Cross sections
- Cosmic Rays

Hadronic and Electromagnetic Models

- MINOS had the CalDet at a CERN test beam to verify physics models (CDHS>10 GeV) and learn calibration procedure
- X-Axis is pion 'range'
- ~15% uncertainty using SLAC-GEISHA. We use 'Geisha' now. Assume agreement could only be better now and take 15%?
- CalDet also observed muon range issue on ~4%, so take systematic (after they corrected a Bethe-Block density effect term)
- Taken from Kordosky (MINOS/ UTexas) thesis

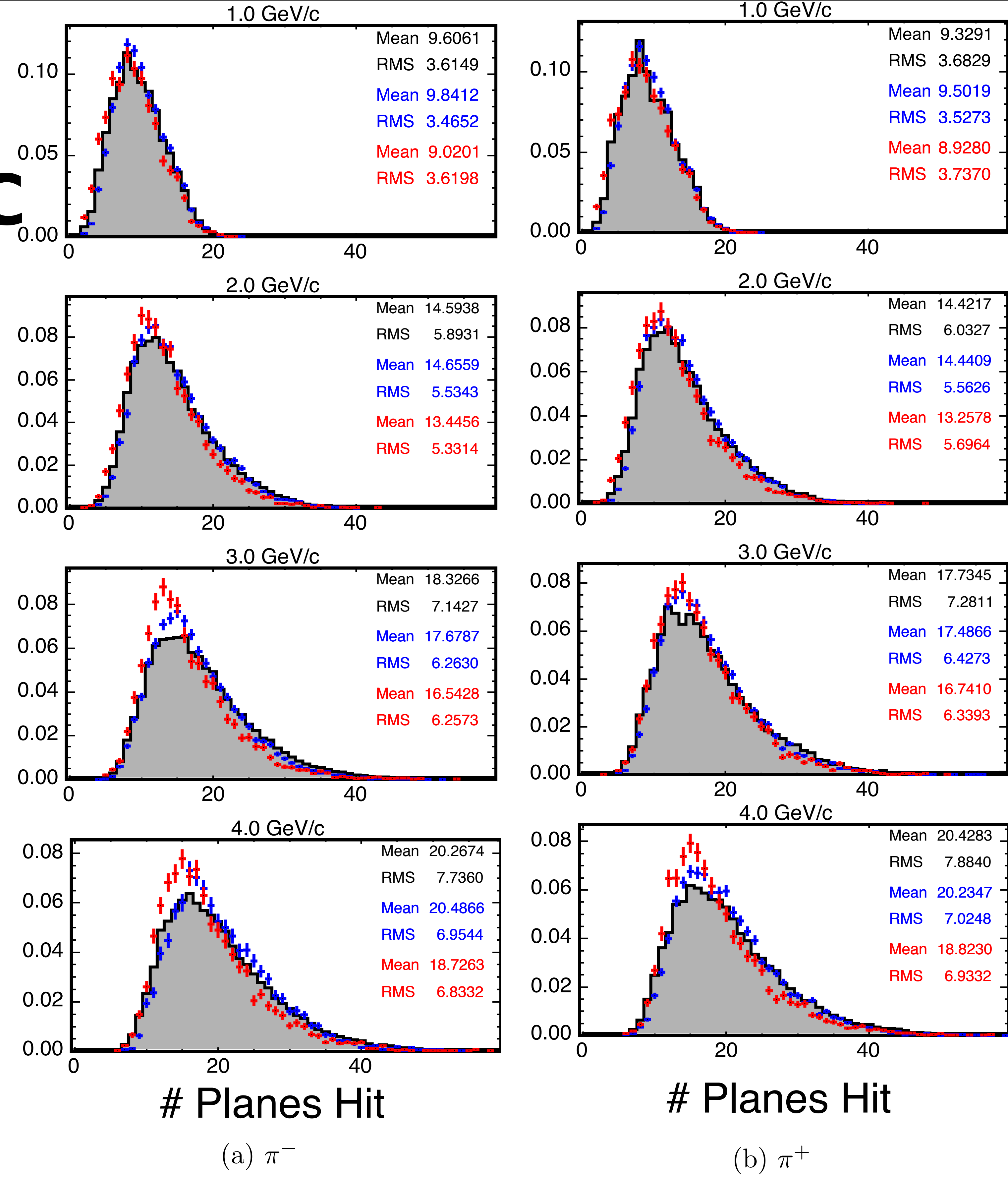


Figure 3.7: Data and MC comparison for π^+ and π^- hit-plane multiplicity in CalDet. Data collected from T11 are shown shaded, pions simulated with GCALOR are shown in blue, and pions simulated with SLAC-GHEISHA are shown in red. Taken from thesis of [4].

Field and Iron Uncertainties

- Ways to measure field (MINOS knows to ~3%):
  - Current shunts at power supply - field of cable very well known
  - Measure B-H curve then finite element analysis - MINOS observed stable B-H curves across plates across foundry runs
  - Induction coil to integrate field - mixed success on MINOS, as I understand
  - Cosmic rays (p_bend v.s. p_range)
- +/- 3% does not affect 10 sigma contour
- Biggest uncertainty: if we can't build STL to full current since, -20% shift in field

Atmospheric Neutrinos

- 2e-4 duty factory
- Barr-Gaisser-Stanev model
- 10 kt-year at solar minimum in Midwest (without duty factor): 74 nu_mu_bar, 156 nu_mu
- Roughly agrees with MINOS and Soudan2
- No problem.

‘Rock’ muons

- Interesting point: range [g/cm^2] roughly equal for all possible materials. Exact material density doesn’t matter. We have ‘till’
- 0.5 kt ‘target’ before our far detector, 1e6 events
- Cracks on order 10^-4, but can stagger layers
- Probability of <2 npe after traversal: 10^-7
- If SiPM 90% efficient, cutting first 3 layers sufficient

Table 3.4: Material Properties surrounding the DAB [8, 9]. Estimates for the range in till are shown.

	Liquid Water	Till	Limestone	Standard Rock
$\langle Z/A \rangle$	0.55		0.4955	0.5
Mean excitation energy [eV]	75		136.4	136.4
Density [g/cm^3]	1.0	2.12	2.8	2.65
Range 4 GeV μ [g/cm^2]	1.8×10^3	$\sim \mathit{2} \times \mathit{10^3}$	2×10^3	2.1×10^3
Range 4 GeV μ [m]	18	$\sim \mathit{9.5}$	7	8

Cross sections

- Conservative estimates based on other experiments:
    - Signal ~ 1%
    - Background ~ 30%
- Not motivated by MC yet and unknown how well near detector will perform
- Work to be done here

Cosmic Rays

- Assuming 4 m below surface. No closed form solution since hypergeometric functions
- Muon rate: 295 Hz (for 2kt)
- Apply duty factor of 10^-4 (ie., when taking data): 0.02 Hz
- 1e7 seconds per accelerator year for 5 years, 1M cosmics to reject; okay using rock muon cuts
- No DAQ problem: if 1 MB each, 0.2 TB of data over 5 years
- Calculations in attached note
- Prescale cosmics? They are calibration source

Summary

- Systematics small but need final numbers for proposal
- Parameter precision will have different systematics such as energy scale
- Are we missing any systematic for proposal?