History, Current Status and Future Needs on Far Detector Design and Optimization

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Outline

- History - two codes
- Present status - successes and problems
- Future plans - where you can help
- Computing and Software requirements

History

- Two codes: one by R. Bayes and one by C. Tunnell
- MINDG4: Code by R. Bayes came from NF R&D and tuned for doing Golden Channel NF performance studies
- gnomon: Code by C. Tunnell designed for nuSTORM to be maintainable over long time period and accommodate multiple analyses but lacks the former's maturity (ie. Kalman filter). Based on RAT and MAUS codes.
- We agree we should combine somehow. These codes are like any HEP code: simulate, digitize, recon, etc.

Status: Event Generation

- We use Genie's gevgen. Assumes density-weighted uniform distribution throughout detector.
  - Thus can't do ND: flux varies depending on position in ND. Need tool like NuMI or T2K have: flux driver to genie and ND geometry. Maybe UniGe can help? They have experience.
- GDML is good here

Status: Scintillator Bar and Digitization

- Easy with siPM. We don't model light in bars.
- gnomon: energy deposited in bar times some N_pe/MeV. Require >2 pe.
- G4MIND: parameterize and smear; includes attenuation and > 5 pe.
- Benton Palka (FNAL) has a good light model for bars. Adey (FNAL) too. We want them once we starting clustering E_hadron.

Status: Pattern Recognition

- We both only find muon
  - We both do similar things: cellular automaton or graph theory "minimal spanning tree". Mathematically equivalent probably? --says two physicists
- No hadron or E&M shower clustering (G4MIND just smears E_hadron truth, gnomon doesn't need it since rates only)

Status: Reconstruction

- Muon only
  - G4MIND: Kalman filter - we currently use Recpack, but based on MICE experience, unless we get Anselmo it will be a burden to support long term. Recpack requires us to have two geometries
    - Can we steal from MINOS? (if Fortran, rewrite.)
  - gnomon: Range and 2nd order polynomial - polynomial gets muon sign well but momentum from curvature doesn't work
- Is there a "general purpose" and supported Kalman filter for track reconstruction routine? We both want Kalman long term but one that is supported or that is easy for us to support over 10 years
- The important part is how reconstruction ties into the geometry.

Status: Geometry

- G4MIND: define geometry with Geant4 calls. Includes hole in middle but no bars
- gnomon: Uses GDML. Bars but no hole
- Geometry is easy to do any which way
- GDML may give more flexibility with Genie, (hopefully) track fitting, and event display. GDML is ROOT write-able so can be stored in output
- Doesn't matter how we represent geometry as long as we only have one representation (scripts to generate, ex., Recpack geometry from GDML possible but hacky)

Future: Geometry

- GDML in fitter: Separation of processes
  - a top level “mother” volume for Kalman filter.
  - detailed geometry for showers.

Language

- We want to move to Python calling C++ routines. Python is a great "glue" language. Bayes wants to kill his shell scripts!
- C++ is great for things that need to run fast (ex. Geant4, ROOT files, fitting). However, Geant4 and ROOT have Python bindings so this isn't a new idea.

Wish list and new people

- ND simulation
- Genie with our flux
- nu_mu disp (cross section * efficiency must be understood)
- nu_e + NC clustering for that channel's analysis
- Polish appearance analysis
- ????

Hadronic Models

- Our hadronic models should be tuned because of MINOS CalDet
- http://inspirehep.net/record/666183/files/fermilab-thesis-2004-34.PDF?version=1

Support From Fermilab

- David Adey and Chris Tunnell wrote a note: "Software and Computing Requirements for nuSTORM's proposal and Future"
- Received well by CD
- Want basic software development infrastructure
- MIND simulation should be separate from LAr simulation

UK Support:

Software Sustainability Institute (SSI)

- Within the UK, there is an EPSRC-funded institute for writing good scientific software... where 'good' is correct, tested, sustainable over long periods of time
- software.ac.uk
- Liaising will not help pre-proposal, but we (2 UK physicists) strongly feel that software help could be one of the UK's helpful commitments with the SSI

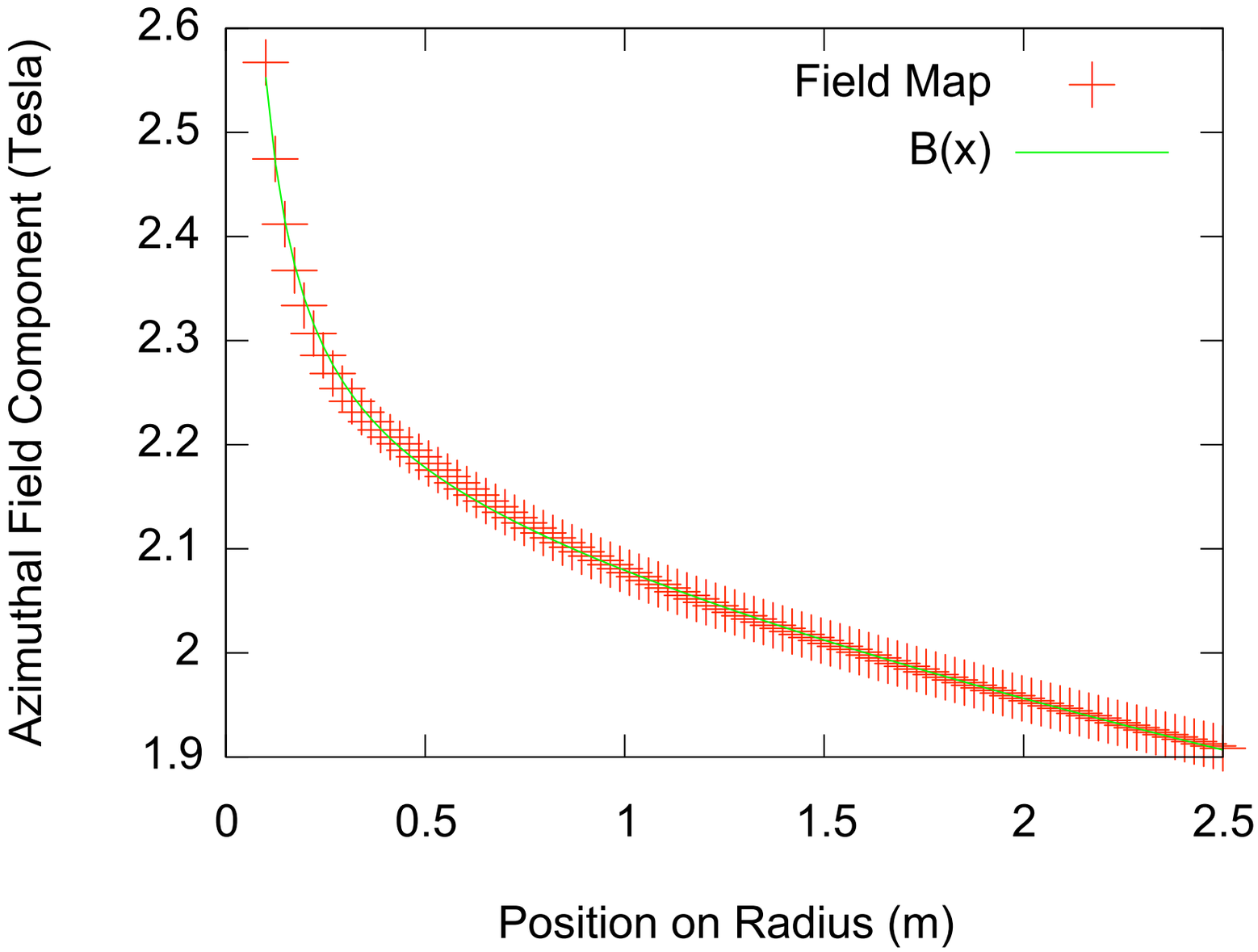
Manpower Concerns

- New people must be identified soon (<2 months) to be useful for a proposal:
  - 3 month ramp-up for PhD, 6 month for non-PhD
  - Now + 3 months = Christmas = February starting to do real work
    - ie. 3 good months of work / (FTE%)
- Current identified manpower: Bayes is part-time, Tunnell is doing appearance-only thesis, Adey is part-time
- More people will come at CD0, do we worry about infrastructure until then?

Conclusions

- Just ask us questions. What do you want to know?

$$B(R) = 1.36 + 0.0406/R + 0.80 * \exp(-R * 0.16)$$



Which channels for proposal?

Decaying Particle	Channel	$N_{\text{osc.}}$	N_{null}	Diff.	$(N_{\text{osc.}} - N_{\text{null}})/\sqrt{N_{\text{null}}}$
μ^+	$\nu_e \to \nu_\mu$ CC	332	0	∞	∞
	$\bar{\nu}_\mu \to \bar{\nu}_\mu$ NC	47679	50073	-4.8%	-10.7
	$\nu_e \to \nu_e$ NC	73941	78805	-6.2%	-17.3
	$\bar{\nu}_\mu \to \bar{\nu}_\mu$ CC	122322	128433	-4.8%	-17.1
	$\nu_e \to \nu_e$ CC	216657	230766	-6.1%	-29.4
π^+	$\nu_\mu \to \nu_\mu$ CC	?	?	?	?
	$\nu_\mu \to \nu_e$ CC	?	?	?	?
μ^-	$\bar{\nu}_e \to \bar{\nu}_\mu$ CC	117	0	∞	∞
	$\bar{\nu}_e \to \bar{\nu}_e$ NC	30511	32481	-6.1%	-10.9
	$\nu_\mu \to \nu_\mu$ NC	66037	69420	-4.9%	-12.8
	$\bar{\nu}_e \to \bar{\nu}_e$ CC	77600	82589	-6.0%	-17.4
	$\nu_\mu \to \nu_\mu$ CC	197284	207274	-4.8%	-21.9
π^-	$\bar{\nu}_\mu \to \bar{\nu}_\mu$ CC	?	?	?	?
	$\bar{\nu}_\mu \to \bar{\nu}_e$ CC	?	?	?	?