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Meeting notes:

- ↳ MC vs. data
  - ↳ In MC, figure out how to make segment reconstruction efficiency align with data
  - ↳ slide 6 → higher efficiency in MC than data
  - ↳ MC doesn't have alignment issues that data has
    - ↳ MC isn't very accurate representation of data, alignment issues cause data to significantly deviate from MC
  - ↳ send slides to Napoli Emulsion Lab
  - ↳ can crudely fix efficiency for number of segments per track by randomly removing segments to adjust for the lower segment reconstruction
- ↳ Muon density
  - ↳ Maybe add cut before reconstruction of all small-angle tracks (hole in center of angular distribution)
  - ↳ This would remove most of the passing muons
  - ↳ find angles of penetrating muon tracks from slope of muons in MC
  - ↳ test making a hole in Neutrino angular dist, erasing muon beam region, and see what we lose
  - ↳ suggested previously to avoid very penetrating tracks, as they are bad for efficiency
  - ↳ must remove a decent amount of muons early (reduce density) to have a decent efficiency

Look at what Fabio sent about BDT → ask Antonio about GUI

Make plots with data using BDT  
     use BDT to compare data vs MC → ask about running BDT on MC

Try making the central cuts on neutrinos, see what fraction we lose compared to what fraction of muons we lose

- ↳ probably for a few different cuts?
- ↳ should this happen before tracking though to see how efficiency changes?

Try randomly removing segments of MC to adjust for lower segment reconstruction

- ↳ Is this to see if MC then follows same dist. as data?
- ↳ Is this before or after tracking? → probably before

BDT questions:

- ↳ Is this the BDT output or the probability scaled from [-1, 1] of signal v. background?
  - ↳ How can you tell from this if a vtx is signal or background? Set a cutoff?
  - ↳ Do I need BDT output of MC to compare?

Cut questions

- ↳ Do we want number of muons + neutrinos left? What segments/tracks in the vtx do we care about
  - ↳ we care about 1st and last segments of track
  - ↳ rn, have proportion of base tracks in file that are kept

↳ How would we apply this to data when data isn't centered at (0,0)  
↳ how to deal with this misalignment

Sign into SLAC account

Do FNAL computer training

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Perform angle cuts before tracking + vertexing

↳ Run tracking

↳ Run vertexing (vertex.C) → how to run vertexing?

mv vertextree.root save.root  
root -l vertexing.C  
↳ save vertextree.root

Find number of base tracks in each plate

↳ Are there any plates with no base tracks?

↳ Don't seem to be any gaps

↳ BDT used to see what kind of sample passes cuts (eventually run on MC)

Perform same cuts in Sim as data

↳ Select correct z-range for the brick → s/s.eZ in plate 0 & 59

↳ # plates and # tracks + segments per vertex looks much closer to data now

↳ muon MC better matches data

↳ Cuts: vtx z-pos in brick, n tracks in vtx > 3, flag=0 or 3

↳ Efficiency of data still much lower

↳ Some data-driven inefficiency present, possibly with alignment

↳ Update with this on Thursday and

★ Inform about poster ★

To do:

Make presentation for Thursday w/ cuts applied to MC to match data

Inform about poster! Send to print next Friday

Fill in easy parts of poster

Random selection of segments → does this cause efficiency to match?

↳ first just w/ vertex cuts

↳ later before tracking + reconstruction

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Muons:

Angular Study:	Tracking	Save	Vertexing	Save	Angle
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.01
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.02

<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.05
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.1
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.2

Neutrinos → Don't have edit permissions update: fixed!

Tracking	Save	Vertexing	Save	Angle
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.01
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.02
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.05
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.1
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.2

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- angular study
- angular study with data cuts
- make presentation for meeting for meeting:

ask about poster

present update on data vs MC

present about angular cuts

figure out plan/structure for project

Neutrino:

Tracking	Save	Vertexing	Save	
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.003
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.005

Muon:

Tracking	Save	Vertexing	Save	
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.001
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.003
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.005

Data: Make sure to center angle first!

Tracking	Save	Vertexing	Save	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0.001
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0.003
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0.005

Poster:



- ↳ include event display pic
- ↳ intro to experiment with pic of layout, integrated luminosity, goals
- ↳ how emulsion scanning is performed + reconstruction
- ↳ motivation for project, why to look at reconstruction performance
- ↳ data only background to first approx ↳ 0.005, 0.003, 0.001
- ↳ but first center zero around peak
- ↳ reduce base tracks

Next todo:

- 1) MC vs data
  - ↳ vary MC efficiency to see if efficiency disagreement improves → maybe too optimistic
- 2) Angle Study
  - ↳ try 0.005, 0.003, 0.001 rad
  - ↳ ~angular resolution for run 1, smearing in MC
  - ↳ also do this for data (assume only muons to 1st approx)

↳ first center peak of angle at (0,0)  
↳ goal: reduce base tracks, not necessarily vertices

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Make cuts on segments before tracking of MC and neutrino

Poster

Try tracking into other folder, look at one cell → Antonio will try and link

Segcuts	muon:		neutrino:	
	track	vertex	track	vertex
↳ remove 1 in 4	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
↳ remove 1 in 6	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
↳ remove 1 in 8	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

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Why is efficiency > 1 for muon MC w/ small cuts (0.05)

↳ perhaps splitting? Only consider unique ones...

↳ No! All unique

↳ event IDs unique too

Poster Draft 1

↳ data gets cleaned a bit so reconstruction is better

Poster Bullet Point Draft

↳ but this is for the muons

Plot segcut efficiency → even removing 1 in 4 has  
too high efficiency! Try 1 in 2?

Match plots of efficiency  
↳ probably not worth it...

Redo Muon Angles → Vertexing

0.003  → same as before!

0.005  → also same!

Open questions:

- ↳ neutrino+muon mixed MC to compare signal+background
- ↳ why does data have lower segment reconstruction efficiency than MC?
  - ↳ try to add position misalignment to MC, maybe alignment issue, doesn't seem like just an inefficiency problem
- ↳ Apply angular cuts to actual data
- ↳ Once data and sim match, use BDT to see what kinds of stuff passes the cuts

\*pseudorapidity range  $7.2 < \eta < 8.4$

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Finished + sent 1st draft of poster

Ask Antonio about stuff I'm waiting for

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No cut	Track	Vtx
0.001	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
0.003	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
0.005	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

0.01

## ↳ Meeting:

- ↳ Maybe higher Plate ID has lower residual/efficiency/# of segments
- ↳ Send updated poster w/ new reconstruction picture
  - ↳ 1 mm<sup>2</sup> of reconstructed muon from run 2

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- ↳ Redo trk+ vtx of data with correct cuts and centered!!

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- ↳ Finished Angular cuts on data
  - ↳ reduces vtx + seg more steeply than muons
  - ↳ Perhaps try using BDT to see how it differs, but is this worth it if sample is almost entirely muons?
- ↳ Present on alignment issue at group meeting
- ↳ for angular cuts, redo with 0.005, 0.008, 0.01 → for data
  - ↳ use elliptical cut and plot efficiency v.  $\sigma$ , not aperture
  - ↳   
more precise gaussian fit, with narrower selection

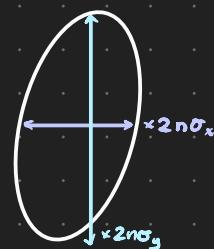
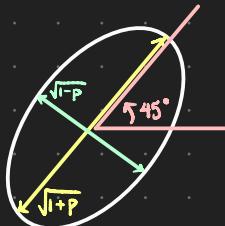
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- ↳ for elliptical cut, should use 2D fit, not 1D gaussian fits
    - ↳ to automatically calculate width and angle
    - ↳ which might vary between datasets
    - ↳ Oliver will send code
  - ↳ Ask Antonio what to do about alignment → maybe add 1-2 to presentation
    - ↳ still look at plots?
    - ↳ Not much to do here... if we don't want to make MC much worse, we need to make data alignment better
    - ↳ Antonio working on improving alignment using more of the base tracks: 500 mrad → 50 mrad
  - figure out how to run BDT code!
  - run BDT on muon+neutrino MC
  - run BDT on data w/ diff angular cuts
    - ↳ circular + elliptical
  - implement Oliver's code to get elliptical cuts
  - run tracking+vertexing with elliptical cuts
- Logistics:
- Start putting code in Github + work on documentation
  - Write final report

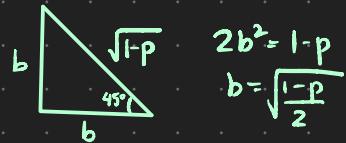
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- ↳ get matplotlib elliptical fit running
- ↳ get ellipse eqn

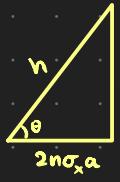
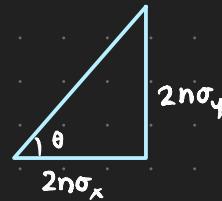
center: mean-x, mean-y



$$2a^2 = (1+p)4 \\ a = \sqrt{2(1+p)}$$



$$2b^2 = 1-p \\ b = \sqrt{\frac{1-p}{2}}$$



$$h^2 = 4n^2\sigma_x^2 a^2 + 4n^2\sigma_y^2 a^2 \\ h = \sqrt{2(1+p)} \sqrt{s\sigma_x^2 + s\sigma_y^2} \\ \uparrow \\ s\sigma_x = 2\sigma_x n \\ s\sigma_y = 2\sigma_y n$$



$$k^2 = 4n^2\sigma_y^2 b^2 + 4n^2\sigma_x^2 b^2 \\ k = \sqrt{2(1-p)} \sqrt{s\sigma_x^2 + s\sigma_y^2}$$

$$\theta = \tan^{-1}\left(\frac{\sigma_y}{\sigma_x}\right)$$

↳ angle of ellipse

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Eqn of ellipse:  $x = s \cdot e \cdot T X$      $y = s \cdot e \cdot T Y$

$$\left( \frac{\left( (x - m_x) \cos(a) - (y - m_y) \sin(a) \right)^2}{\left(\frac{h}{2}\right)^2} + \frac{\left( (x - m_x) \sin(a) + (y - m_y) \cos(a) \right)^2}{\left(\frac{w}{2}\right)^2} \right) > 1$$

↳ constants come from elliptical fit

↳ tracking + vertexing +

$$\sigma = 0.2$$



$$\sigma = 0.4$$



$$\sigma = 0.6$$



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↳ From vertextree.root to BDT

1. Use python vtx\_cell\_analysis.py to get vertex-selected.root  
 ↳ Note: Modify python file with correct input/output filepaths

2. Use TMVA Classification Application.C to get BDT response added  
 ↳ Note: Modify .C file with correct input/output filepaths

- |         |  |         |  |
|---------|--|---------|--|
| Step 1: | <input checked="" type="checkbox"/> Original | Step 2: | <input checked="" type="checkbox"/> Original |
|         | <input checked="" type="checkbox"/> 0.20     |         | <input checked="" type="checkbox"/> 0.20     |
|         | <input checked="" type="checkbox"/> 0.40     |         | <input checked="" type="checkbox"/> 0.40     |
|         | <input checked="" type="checkbox"/> 0.60     |         | <input checked="" type="checkbox"/> 0.60     |

- Program Evaluation
- Cultural Essay
- Technical Report
- Final Presentation
- Code Documentation

To run step 1:

cell we're looking  
at

`python vtx-cell-analysis.py -x 8 -y 13`

To run step 2:

root

.x TMVAClassificationApplication.C

↳ ask on Thursday → any other aspects to this study?

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↳ Code Documentation

↳ Efficiency + Purity Analysis → complete!

- trackingquality-angleCuts
- AngleCutsDataFitting
- BDT\_angleCuts
- realdata
- trackingquality

} this is all the useful stuff

↳ Montecarlo\_Reconstruction

NeutrinoSimAnalysis → for MC mixed simulation

8/2

Upload code to Github

technical report

final presentation

double-check slides for Friday

updated version of poster?

↳ get poster tube tonight!

↳ Rename Scripts + Descriptions:

↳ AngleCuts-EllipticalDataFits

↳ Derive equations of best-fit ellipses at 3 chosen confidence intervals from the mean of base track angular distribution of data

- ↳ tracking Quality - muonMC
  - ↳ look at how diff cuts on tracking can modify reconstruction efficiency of muons (MC)
- ↳ tracking Quality - angleCuts
  - ↳ look at how cuts on shallow-angled base tracks alters vtx + seg reconstruction efficiencies for MC and data
- ↳ BDT - angleCuts
  - ↳ look at BDT output given diff angle cuts
  - ↳ see how signal v background (using best cut provided by fabio) are affected by cuts
    - ↳ does this really improve signal-to-background ratio?
- ↳ Real Data - v - MC
  - ↳ preliminary look at vars from data, comparison b/w data + MC
- ↳ MixedSim - feasibility Analysis
  - ↳ look at neutrino MC and check feasibility of mixed muon-neutrino simulation

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- ↳ work on presentations + reports

8/11 (Last day!)

Unfinished Work:

- ↳ highDensity (/afs/cern.ch/work/t/tkrishna/public/highDensity) (5e5 tracks selected)
- ↳ completed tracking + vertexing (in sim-data folder)
- ↳ insufficient memory locally, so run csvconversion.py on condor
  - ↳ see error log for last crash (missing sim file argument in csvconversion.py)
  - ↳ likely from missing import
- ↳ after completing csv conversion, add this to trackingQuality - muonMC.ipynb to compare with lower densities
- ↳ Next steps:
  - ↳ run same procedure on this sample choosing only 1e5, 1e4, or 1e3 tracks to verify prior pattern

Thank you for an amazing summer!