6/13

↳ ssh -Y tkrishna@lxplus.cern.ch (use -XY for display)
↳ to login

↳ emulsion film labeling

RUN_WALL_BRICK_PLATE

↳ swan.cern.ch
↳ jupyter notebooks connected to CERNBox

↳ github.com/SND-LHC/sndsw#readme
↳ SND software documentation

↳ twiki.cern.ch/twiki/bin/view/SndLHC/WebHome
↳ SND documentation/tutorials

↳ https://snd-lhc-monitoring.web.cern.ch
↳ load ROOT files quickly, show detector layout etc

↳ Simulation: FLUKA models LHC p-p collisions, neutrino production and GENIE models neutrino interactions

↳ angle of tracks (x-y, relative to x-axis): $\tan^{-1}\left(\frac{P_y}{P_x}\right)$ or np.arctan2(Py, Px)

↳ pseudorapidity of tracks: $\tanh^{-1}\left(\frac{P_z}{P}\right)$ or np.arctanh(Pz/P)

Logistics:
- meetings on Monday + Tuesday afternoons
- complete basic required trainings
- Next week: 3 days of collaboration meeting

☑ Plot angle of neutrinos
☑ Plot angle of neutrino daughters
☑ Plot angle of all other tracks

When adding to/modifying scifi hits, modify SWAN config memory to be 16 GB

☑ Plot angle of all charged particles in emulsion
↳ split into neutrino daughters & all other tracks
↳ match with TrackID

① Get trackID for emulsions + tracks
② Get charges from PDG values for emulsion hits
↳ vectorize
③ select particles with nonzero charge and compute their angles

→ given a hit with a certain trackID, get the mother ID by finding the mother ID of the track with the same trackID
↳ saved in trackmothers.pickle for this set of 750 events

↳ for each event, dictionary of trackID vs motherID

→ also saved scifi hits as scifihits.pickle after new variables were added for efficiency when re-running

↳ if memory is filling up, restart kernel & make use of the pkl files to save memory

6/14

☑ Make Intro presentation about project

☑ Repeat angular distribution analysis for muon background
- ↳ Don't separate daughter b/c these aren't neutrinos
- ↳ Just look at charged particles in the emulsion
  - ⇒ Do I look at the muons vs all resultant tracks then? Or is there some other, more useful characterization?
    - ↳ we don't really care about the muons, don't bother separating
    - ↳ only look at ~1000 events

6/15

↳ AD and Data Center Tour

↳ help set up stuff in new microscope room

☑ Check out PDG codes of particles with larger angles

PDG	Count	Particle
-11	332494	e^+
11	309001	e^-
2212	112893	p
-211	69810	π^-
211	63018	π^+
321	4608	K^+
1000010020	4289	deuteron
-13	2557	μ^+
-321	791	K^-
1000010030	425	triton
13	285	μ^-
3112	159	Σ^-
1000020030	79	He3
-2212	64	$\bar{p}$
3222	63	Σ^+
1000020040	21	alpha
1000030060	12	Li6
1000020060	11	He6
3312	2	Ξ^-
1000040090	1	Be9
-3222	1	$\bar{\Sigma}^-$

↓ cut

Simulated 750 neutrinos
↳ how many → meeting at 10am
fb^{-1}
for normalization

☆ updated numbers because before I only looked at positive X & Y angles → now look at absolute value of angles to threshold comparison

☐ Cut of 0.1, ..., 0.5 to see how many hits we lose from neutrino daughters & other tracks

→ microtrack in single layer of film
  ↳ 2 layers connect to make base track (linking)
  ↳ reconstruction creates volume tracks

EdbSeg P → base track
  ↳ X, Y, Tx, Ty, Plate info, χ^2
  ↓
  combine lots to get

EdP Track P → volume track
  ↳ # seg, # plates, if any holes, array of base tracks (s) and fitted tracks (sf)

EdP Vertex
  ↳ Vx, Vy, Vz, n = # of tracks, prob = prob of vertex (usually ~1), flag = # saying vertex topology, maxaperture = max angle b/w pairs of products

"incoming" → 0 is incoming, 1 is outgoing
impact param → dist from track to vertex

→ 3, 4, 5 have linking
e.g.

6/16

☑ look at new muon file from simulation
  ↳ with volume tracks like MCTrack
  ↳ simulated MC Track, used it to get EmulsionDetPoints and then apply reconstruction algorithm to get volume tracks

* this file has only muons! (PDG 13 & -13) ⇒ why?

6/19

↳ completed self-rescue mask training, got access to emulsion dry room & LHC tunnel
  ↳ ask about dosimeter

☑ look at new muon file with not just muons (Project Montecarlo-Reconstruction)

  ↳ look at with + without muons
    ↳ why is PDG code not in PID? ⇒ what is that then?
      In ReconstructedEmulsionSimulation
        ↳ this is plate ID, starting at 0 for the last plate, which is from where tracks are measured

6/21

☑ compare before + after reconstruction → base tracks + volume tracks
↳ simulated muon datafile

☑ check that before reconstruction, angular dist has ~4mm spread
↳ original simulated tracks have some "smearing" of angle

☑ see how much this smearing is using EdbSegP and original simulated file

↳ then, ~3 mrad smearing is added before reconstruction
↳ measured this to be ~4 mrad
↳ reconstruction further increases SD a bit to 5 mrad, due to scattering and purity/mismatching
↳ is the pandas df method for all plates? it seems to be looping so not just plate 11...
↳ documentation says it's brick 11, and Antonio agrees!
↳ in what step is the 3mm smearing added?
↳ after simulation, before reconstruction

6/26

☑ look at angular distribution of simulated neutrino data
↳ for brick 11
↳ which file has motherID? → don't have EdbSegP data!
↳ tried b000011.0.0.0.trk.root → no motherID to distinguish neutrino daughters
↳ tried vertextree.root → much fewer events
↳ are these grouped by vertex, not event?
↳ neither file seems to have any neutrinos...? → no entries w/ pdg code 14 (ν_e)
↳ then what is the 1st elem of each evt/vtx → not neutrino?

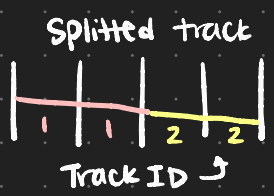
☑ look at neutrino vertices
↳ are neutrino vertices ones with ≥1 neutrino daughters or only neutrino daughters?
↳ MCMotherID = 0
↳ going with all neutrino daughters for now

Results:
- flag → neutrino daughters have more 1 & 4, similar 0 & 3 (slightly less) and hardly any 2 & 5
↳ wouldn't you expect mostly 0 & 3 if you couldn't "see" the neutrino? As it isn't included in the file

6/28

☑ convert track_analysis.C and trackingquality.py → or launch/modify this code into Python → adapt to my selections, etc
Goal: Quantify efficiency + try to improve it
↳ plot of purity + efficiency as func of the cut

↳ try with real data → can't do efficiency (small sample)
↳ look at multiplicity, segments, long tracks
↳ don't have MC info → dummy info



Say 7 segments for a track, 5 are most common trackID
↳ purity for that track is 5/7
↳ make histogram of purity for all tracks

nsplit is the number of pieces of track that was reconstructed

6/30

- Plan: Compare dist of base tracks + volume tracks in real data to simulation
↳ effect of smearing + density on efficiency ↳ vertex topology

☑ Sim muon efficiency → compare w/ all tracks and only muons → slight efficiency improvement

☑ Sim muon efficiency → compare w/ subset 1000, 10000 tracks (and larger sample, Antonio is currently processing ☒)

☑ Sim muon efficiency → compare w/ reduced smearing → Antonio is currently processing
↳ get these files from Antonio

↳ both work to good quality of emulsion
↳ two parts of project now

☐ segments, angles, track nseg, play around with real data (vertices)
↳ what Fabio is working on → output of analysis code → look at GC

☑ prepare presentation for Monday @ 3pm

7/3

↳ Meeting @ 2pm presentation
↳ look at signal (neutrino) tracks
↳ look at track efficiency → # tracks reconstructed / # tracks simulated
↳ not just muons → want to compare signal v. background efficiency
↳ generate some type of mixed sample? → hard to do accurately b/c lots of muons to simulate

$\frac{31}{57}$ segments is our threshold for passing muon → low efficiency of getting all segments reconstructed

☑ look at efficiency w/ neutrino sim?

☑ x-y dist of base tracks compared to vertex position
↳ see how far spread the tracks are
↳ maybe do smaller region for mixed simulation

↳ look at real MC data, not vertex file (reconstruction messes with positions?)
↳ memory issues
↳ iterate through file
↳ only look at neutrino daughters
↳ only until first <0 tracknumber → what does negative track number mean?

↳ only if vertex + base track in same brick
↳ 7500 events → 51176 hits kept out of 597,855,888 base tracks in file
↳ with momentum + charge cuts → 2505 hits remaining

☑ Vertex wrt Base track pos
↳ only p > 100 MeV and charged
↳ code in GeV
↳ plot angles of tracks

7/5

☑ Angular dist → real vtx data
☑ Ntrks + other vars plot → real vtx data

☑ Angular dist of neutrino daughter vertices
☑ Muon MC 1 mrad smearing plots

↳ What to work on next?
↳ Poster for July 25 (Thursday) → contents?
↳ Look at lower + higher density muon sim samples? → get higher density from Antonio?
↳ What else to do for neutrino MC data? → is it possible to reasonably do a mixed simulation? Anything else needed from me to decide? → Not rn, present tomorrow

☑ compare muon sample (3 mrad smearing) (also neutrino sample) segments with real data
↳ compare same vars
↳ good content for poster/presentation
☑ look at lower density muon sim samples → 10^5 is bad enough, no need to increase LOL
☑ tomorrow @ 2 pm → Neutrino MC Efficiency present from my room!
↳ discuss about simulation with Daniele

7/6

☑ Plot efficiency vs. z pos of vertex in brick

↳ Load Muon MC and Neutrino MC vertex data along with real data, begin to compare

Q: In real data, why is fillfact different from $\frac{nseg}{npl}$?

↳ sometimes same, sometimes very different!
↳ fill fact counts plates from first in track to end of brick!
↳ decided to use nseg/npl instead

7/7

↳ How to do tracking with modified sample?
Example:

nano track.rootrc → add cuts
emtra -set=11.0.0.0 -new -v=2 → from outside b000011 folder
mv b000011.0.0.0.trk.root run-01_*description*.trk.root

☑ Compare data with simulation
↳ Present on Monday
☑ Design poster → brainstorm
☑ look at 1k and 10k muon simulations

Goals:
- Look at reconstruction problems (MC vs data)
- Work to improve reconstruction
  ↳ Muons 1k, 10k, 100k, tracking diff groups
- Work to improve signal efficiency
  ↳ How will I do this?
  ↳ Open question → need simulation, ask Daniele

How does this help:
- 3mrad v. 1 mrad
  ↳ need to improve alignment of plates, which is what causes this smearing
- 10^5 v. 10^4 v. 10^3 track density
  ↳ Need stricter cuts in place prior to reconstruction to improve efficiency
  ↳ Not feasible to reduce density of films → need much more films + scanning for that!

but then, need to be stricter about the cuts → test doing 10× of the 10⁴ track selection → increase algorithm time + memory, but higher accuracy

For Monday:

- Neutrino + Muon simulation
  - MC v data, ideas for next steps
- Algorithm improvement → Muon density
  ↳ Reconstruction
  ↳ 10^4 seems good, 10^3 only slightly better

Poster brainstorm:

↳ What is SND? Experiment Goals, Detector setup
↳ Emulsion Data + Reconstruction Overview
↳ Reconstruction Efficiency
  ↳ Ideas to improve
↳ Signal Detection Efficiency
  ↳ Ideas to improve
↳ Next steps for improving efficiencies

? How to tie in the data vs MC comparison?
↳ data has lower efficiency than MC
↳ do we want to try to distinguish data signal + background?

* add one MC and one data vertex to poster
↳ since display works

To play with real data, use these vars:
↳ prob → probability of χ^2 fit
↳ BDT → output of multivariate analysis
  ↳ probability of signal vs. background (boosted decision tree)