FairSHiP
Software for SHiP

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Outline

- Status
- Future

FairSHiP

- Lightweight simulation, reconstruction and analysis framework
- Overall philosophy: Keep it simple.
  - Use directly external tools: root, geant4, pythia6/8, genfit, genie, … as much as possible.
  - Do not invent a FairShip kingdom, with specific interfaces, wrappers, etc.
  - Use Python as the glue between all the available tools and packages.

- Mailing list
  - ship-software@cern.ch (SHIP Collaboration mailing list dedicated to software)
  - Archive: https://groups.cern.ch/group/ship-software/default.aspx
- Web page
  - http://ship.web.cern.ch/ship/FairShip/default.html
- More at Software Tutorial session today, link

Status of Physics Simulation

- Setup in place to produce charm/beauty hadrons in thick targets, taking into account cascade processes.
  - Sample of charm hadrons used for HNL signal and muon/neutrino background simulation.
  - A first tuning of Pythia6 with available data a low energies done, further pursued by University of London.
  - Described in SHiP public note: CERN-SHiP-NOTE-2015-009
- HNL signals simulated using Pythia8 by decaying above charm/beauty hadrons
  - Branching ratios for decays of HNLs calculated as function of couplings and HNL mass on the fly
  - Branching ratios for charm hadrons to HNL mass to be committed next week,
- Neutrino interactions simulated with the Genie generator
  - To be done: Checking realism of the neutrino events with existing data.
- Muon background simulation
  - Geant4 for electromagnetic processes
  - Pythia6 for inelastic scattering, DIS
- Others:
  - NuageGenerator for ν_τ detector simulation
  - Particle Gun

Status of Detector Simulation

- Detailed geometry for Mo/W/$H_2$0 target, hadron absorber, active muon shield (optional: passive shield), cavern.
  - Assumptions about magnetic field in iron cross
  - Currently running the TP design with wide cavern
  - To be done: Shape of magnetic field in the corners, vertical ↔ horizontal
- Detailed geometry for ν_τ detector with sensitive elements
  - No digitization.
- Sensitive planes for the Upstream Veto Tagger and Timing detector
  - No digitization.
- Detailed geometry for the HS vacuum vessel, spectrometer magnet.
  - Magnetic field based on parametrization of Opera simulation result.
  - Sensitive liquid scintillator volumes. Some digitization made on the fly when calculating Veto response.
- Detailed geometry for the straw (veto) tracker
  - Digitization including detector timing resolution.

Status of Detector Simulation, cont.

- Detailed geometry for ECAL.
  - Digitization, cluster reconstruction exist.
- Detailed geometry for HCAL
  - No digitization, no cluster reconstruction.
- Sensitive planes for the muon detector
  - No digitization.
- Optional: Sensitive planes in front of ECAL for studying a Preshower detector which would provide neutral shower direction

Status of Reconstruction

- Track reconstruction
  - True pattern recognition exists and working. Need somebody to study in detail its efficiency and background
  - Current default: Fake pattern recognition based on association of hits with MC particles
  - Track fit using the Genfit package
- Photon reconstruction
  - No public code yet.
- Particle ID
  - Work started. First attempt, electron ID.
  - Muon ID missing digitization, otherwise resolution too optimistic.
- Veto: Simple tool to estimate response of UVT, SVT, SBT and ν_τ detector

Overview of simulated data

- Charm hadrons
  - root://eoslhcb//eos/ship/data/Charm/
  - Decays to muons and neutrinos
    - Cascade-parp16-MSTP82-1-MSEL4-ntuple_prod_18M.root
    - Decay-Cascade-parp16-MSTP82-1-MSEL4-ntuple_prod_18M.root

- Muon/neutrino background after hadron absorber
  - 10B events = 2 months
  - Need another large production to study effect of a magnetized hadron absorber

- root://eoslhcb//eos/ship/data/Mbias/
  - pythia8_Geant4_xxx.root xxx=onlyMuons, onlyNeutrinos
    - $E > 100\ GeV$: 12.7×10^9 pot
    - $E > 10\ GeV\ \&\&\ E < 100\ GeV$: 1.22×10^9 pot
    - $E > 1\ GeV\ \&\&\ E < 10\ GeV$: 0.11×10^9 pot
  - pythia8_Geant4_Yandex_xxx.root
    - $E > 5\ GeV$: 2.1×10^9 pot
    - $E > 0.5\ GeV\ \&\&\ E < 5\ GeV$: 0.1×10^9 pot
  - pythia8_Geant4_Yandex2_xxx.root
    - $E > 10\ GeV$: 10.0×10^9 pot
- **All combined with proper weights and charm replaced by cascade production:**
  - **pythia8_Geant4-withCharm_xxx.root**

Overview of simulated data

- Neutrino background events
  - Using as input muon neutrinos from cascade production
  - root://eoslhcb//eos/ship/data/neutrinoBackground/YandexProd-Dec-2015/
    - output_nu (-14=nu_mu_bar): 100 files x 640k events each
    - output_nubar (14=nu_mu): 103 files x 1M events each
    - All with reconstructed data

- Muon background events
  - Muons passing shield and producing tracks in the detector:
    - /eos/ship/data/DAFreco/muonBackground/rareEvents_81-102.root
  - In addition, files for muon background studies for backscattering from concrete walls, EM interactions in material

Future

- Main goal for this year: Optimization of the experimental layout
- Need to stay flexible. Don't need (yet) everywhere sophisticated reconstruction algorithms, some shortcuts using MC truth should still be allowed for feasibility studies.

- For the physics simulation, still missing generators for dark photon, hidden scalars, …, essentially everything which is not HNL.
- Tuning and cross checking physics engines
  - Pythia6, Pythia8, GENIE, Geant4 (μ-scattering)
- For the reconstruction, highest priority should be on:
  - Charged PID
  - Neutral PID, γ and π^0 reconstruction, decay vertex with neutrals
  - Combining Veto information
    - Globally and locally

Future, cont.

- On the more technical side
- Needed: bookkeeping tool to keep track of simulated data with different detector geometries, different physics, different versions of software.
  - Sasha Baranov has setup a prototype, but needs some more iterations to fulfill the requirements: http://sashabaranov.github.io/ship-bk-proto/
  - My interpretation of current discussions (Andrey, Sasha, Fons, me):
    - The description of the data will be stored together with the data. Not yet clear at what level, directory only, or by file? Can easily add a python object (text, numbers) to a root file.
    - Information should be required by the production script, updated by reconstruction step.
    - An agent should run regularly and make an inventory of the existing data. This updates a web page, database, with the list of files, description, file size, ...
    - Anybody interested in such an activity, mostly welcome!

Future, cont.

- For mass production of background, rely on Yandex cluster
  - Submitting jobs to SkyGrid and retrieving data is done in a semi-automatic way.

    Write a mail to skygrid-users@cern.ch

      - Muon background, 10B events, ~2months
      - Neutrino background, 0.1B , ~4 weeks

- Last not least, technical help would be appreciated in
  - Optimizing storage. Some objects stored with ShipReco take twice the space than other stored via dedicated ROOT streamers.
  - Optimizing CPU in simulation (Geant4) step.
  - Fight against memory leaks. Prevent running long jobs.

Summary

- Interesting times ahead !

Summary

- Confident, we do better !

Summary

- And finally, end here: