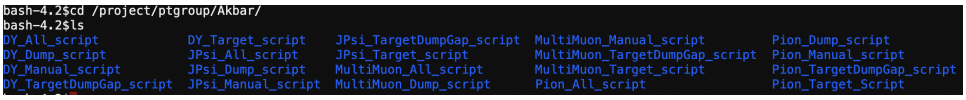
MC event generation with SpinQuest software on Rivanna

How to generate MC events on Rivanna?

1. Login to Rivanna
2. Create a folder under your name on /project/ptgroup/
3. There are various script to generate Monte Carlo (MC) events on Rivanna depend on the channel (reaction) and the vertex or location where the events are generated.
4. Those scripts are located under /project/ptgroup/Akbar. There are 20 folders containing the required script. The name of the folder is <channel>_<vertex origin>_scripts.



5. Option for <channel> are : Drell-Yan (DY), Jpsi and Psi prime (JPsi), Pion background (Pion), Random-multi muons (MultiMuon)
6. Option for <Vertex origin> : target (Target), Beam Dump (Dump), Everything that seen by the beam (All), The gap between the target and dump (TargetDumpGap), and arbitrary vertex origin (Manual)
7. For example, if you want to generate Drell Yan events from the target, then the folder that you need is DY_Target_scripts under /project/ptgroup /Akbar
8. Currently, we need various MC events for Neural-network training. The list is inside /project/ptgroup/spinquest/MC_storage/README. The script require to generate this list of MC is summarized in this table
9. Create a directory called "MC" on /scratch/<user_name> by "mkdir MC", and then navigate back to your directory inside /project/ptgroup /YourFolder/
10. Copy the relevant code-directory from /project/ptgroup/Akbar (please refer to the screenshot above) to your directory.

    a. Here is a simple way of copying a folder ("DY_Target_script" for example) except "scratch";

    cd /project/ptgroup/YourFolder

    rsync -av --exclude scratch /project/ptgroup/Akbar/DY_Target_script .

11. Navigate to the directory that you want to run the script.
12. Setup the environment using: **source /project/ptgroup/spinquest/this-e1039.sh** command
13. Submit your job using the following command.

    $ ./jobscript.sh <Output_folder_name> <No_of_jobs> <No_of_events_per_job>
    $ ./jobscript.sh DY_Target_1M 100 10000 (Here we need to generate ~1M events. The accepted events depend on the channel). Strongly recommended not to exceed 10K events per job.

    Following table shows useful information on how much events & jobs you need to submit

MC type	#of events generate	#of events gets through the acceptance
DY Target	1000 jobs x 10000 events per job = 10M events	~ 500k events
J/Psi Target		
DY Dump		
J/Psi Dump		
DY air-gap		
J/Psi air-gap		

14. Using "squeue -u cee9hc", you can check the status of your jobs (or use the "Active Jobs" tab on your UVA OpenOnDemand web page).
15. Once the job is finished, then you can find your output folder in "/scratch/<your_UVA_id>/MC
16. Copy /project/ptgroup/Akbar/analysis/histo_v2.C to your directory. Modify it with the correct path to your generated MC (eg: /scratch/Your_UVA_ID /MC/Folder_Name).
    Then run the macro by $ root -l histo_v2.C

    This file (histo_v2.C) create around 11 histograms to check the quality of your generated MC. Check whether the plots make sense; especially, see the x,y and z vertex origin. In the screen you will also see the number of accepted events.
17. Navigate to "/project/ptgroup/script" and then implement the following command (this script by-default will skip bad-files/corrupted-files/etc.)
    $ ./merge_mc_prod.sh /scratch/<your_MC_output_file_location>

    This will create a folder inside /project/ptgrpup/spinquest/MC_merge_files" with the same name as your MC_output_folder

18. Copy the "merged_trackQA_v2.root" file from the folder that you've newly generated by ./merge_mc_prod.sh and copy it to "/project/ptgroup /spinquest/MC_storage" location. Rename the file into <Channel>_<Vertex Origin>_<Number of accepted event>.root. for example: JPsi_Dump_300K.root

19. Use the label.C file in the "/project/ptgroup/spinquest/MC_storage" to add summary description of your MC .root file

Other Important Notes:

- When you generate single-muon events, you have to change the condition of `SQGeomAcc` in `Fun4Sim.C`.
  - SQGeomAcc skips (i.e. not save) an event in which a muon or a muon pair doesn't pass through the spectrometer acceptance, because such event is useless for analysis.
  - By default, SQGeomAcc requires a muon pair per event; "geom_acc->SetMuonMode(SQGeomAcc::PAIR);"
  - When you generate single-muon events, you have to modify `Fun4Sim.C` as follows, so that SQGeomAcc requires a muon per event;

    geom_acc->SetMuonMode(SQGeomAcc::SINGLE);

    or

    geom_acc->SetMuonMode(nmu_plus+nmu_minus==1 ? SQGeomAcc::SINGLE : SQGeomAcc::PAIR);
- Better configurations for J/psi and psi' are available in the E1039-Collaboration/e1039-analysis repository. Zulkaida could make use of them in "/project/ptgroup/Akbar/*/Fun4Sim.C".
  - https://github.com/E1039-Collaboration/e1039-analysis/blob/master/SimChainDev/phpythia8_Jpsi.cfg ... It produces J/psi and other charmonia (including psi'), where the rate of psi' is much lower than the current configuration.
  - https://github.com/E1039-Collaboration/e1039-analysis/blob/master/SimChainDev/phpythia8_psip.cfg ... It produces only psi', not J/psi.
  - Note: Even when using new configurations, you should still select the particle of your interest (i.e. J/psi or psi') by its truth mass in `histo.C`. It is because a random pair (like mu+ from pi+ and mu- from pi-) could be produced from the beam remnant.
- reco_vz
  - reco_vz is the reconstructed position of track (not dimuon) at the target position (i.e. z = -300 cm). Therefore "reco_vz" is always -300 cm
  - The meaning of "reco_vz" is defined in "AnaTrkQA". Actually the present naming is misleading.
  - When dimuon events are produced in the dump, each track should make the closest approach to the z-axis in the dump region. But "reco_vz" is not the position of the closest approach but the position of the track at z = -300 cm by definition. "reco_vx" and "reco_vy" are not peaked at 0 cm.
- Beam profile
  - The profile here means the distribution shape of beam protons in X and Y (= R).
  - When "legacyVtxGen = true"
    - The shape is "Gaussian" at "R < 5*sigma" and "1 / R" at "R >= 5*sigma" (cf. https://github.com/E1039-Collaboration/e1039-core/blob/master/generators/E906LegacyVtxGen/SQPrimaryVertexGen.C#L290)
    - The Gaussian width ("sigma" in cm) is defined by "SIGX_BEAM" and "SIGY_BEAM" in Fun4Sim.C.
  - When "legacyVtxGen = false"
    - The shape is defined by the following functions of event generators.
    - "set_vertex_distribution_function()" sets the shape to "Uniform" or "Gaussian".
    - "set_vertex_distribution_mean()" sets the mean of the distribution.
    - "set_vertex_distribution_width()" sets the half width in case of "Uniform" or "sigma" in case of "Gaussian".

MC events generation log-book

Please check the required/needed list of MC (at the moment) in the README file: "/project/ptgroup/spinquest/MC_storage/README"

Process	Vertex	Events needed	Filename(s) generated	Notes
Drell-Yan (DY)	Target	300K, 100K, 250K	DY_target_300K, DY_target_100K, DY_target_250K	
	Dump	300K	DY_Dump_498K.root	
	Air Gap		DY_AirGap_386K.root	
	No Target	300K		Require more modification in Fun4Sim.C (Zulkaida)
	All (proper target dimensions)	300K		Zulkaida
	Just Target (proper target dimensions)	300K		Zulkaida
	All except Target			
Jpsi	Target	300K, 70K, 130K	JPsi_target_300K, JPsi_target_70K, Jpsi_target_130K	

	Dump	130K, 300K	JPsi_Dump_130k	
	Air Gap		JPsi_AirGap_99k.root	
	No Target	300K		Zulkaida
	All (proper target dimensions)	300K		Zulkaida
	Just Target (proper target dimensions)	300K		Zulkaida
	All except Target			
Di-Muon	Target	100K, 300K	Dimuon_target_100K	
	Dump	300K	Dimuon_Dump_329k.root	
	Air Gap	2.5M	Dimuon_x15y15z300_2.5M	x=15, y=15, z=300 Note: 2.5M accepted events were generated out of 6M events
	No Target			
	All (proper target dimensions)			
	Just Target (proper target dimensions)			
	All except Target			
Single-Muon	Target	300K		Jay is working on this
	Dump			
	Air Gap			
	No Target			
	All (proper target dimensions)			
	Just Target (proper target dimensions)			
	All except Target			
Single-Muon plus	Target			
	Dump			
	Air Gap	300K	singMup_x2y2z300_370K.root	Note: ~370K accepted events were generated out of 750K events
	No Target			
	All (proper target dimensions)			
	Just Target (proper target dimensions)			
	All except Target			
Single-Muon minus	Target			
	Dump			
	Air Gap	300K	singMum_x2y2z300_370K.root	Note: ~350K accepted events were generated out of 750K events
	No Target			
	All (proper target dimensions)			
	Just Target (proper target dimensions)			
	All except Target			

Questions

Please record any questions that you find when generating/analyzing MC events. We try to answer each and/or write up a comprehensive document based on them.

- (Example) Differences between event vertex, target and dump.
- (Example) Difference between truth quantity and reconstructed quantity.