Common matters in overall muon system simulation

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Disclaimer

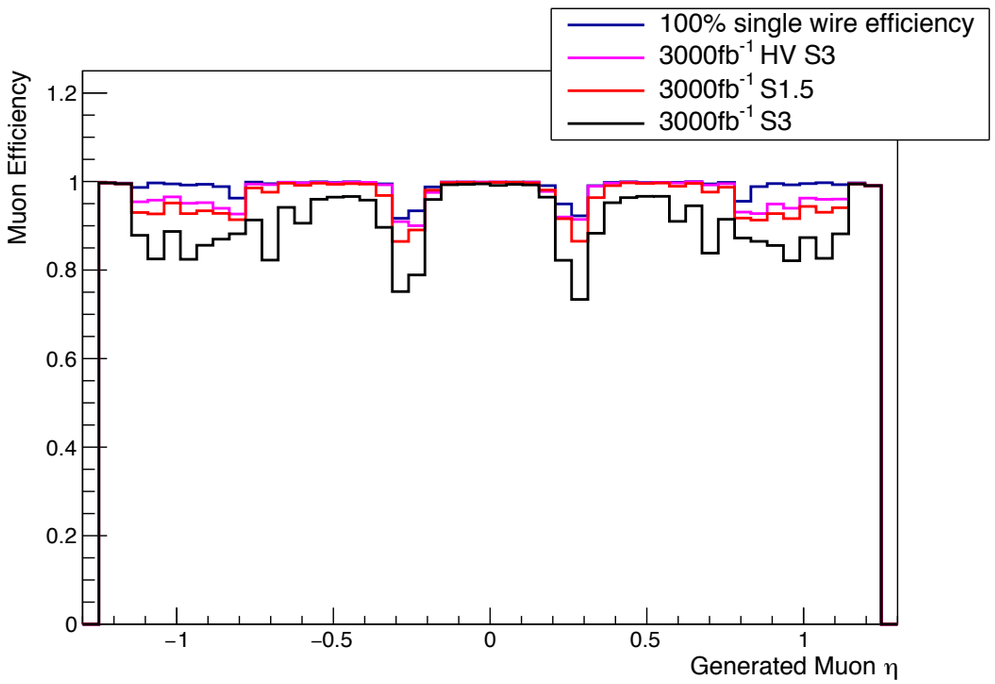
- The next slides try to summarise the status (and raise some questions) about common DPG (office) matters (tools to model ageing, neutron BKG simulation, event content, samples, alignment …)
- They mostly represent the point of view of DPGO, which is mostly concerned with making tools / code / configuration-fragments available, more details (for example on the exact definition of sample requests) should come as input from people actually making the studies and have been historically pertinence of UCO (actually of a dedicated task-force for the time of the TDR)
- In the spirit of a workshop, the talk includes points that should need some discussion. They are highlighted in **green** in the coming slides

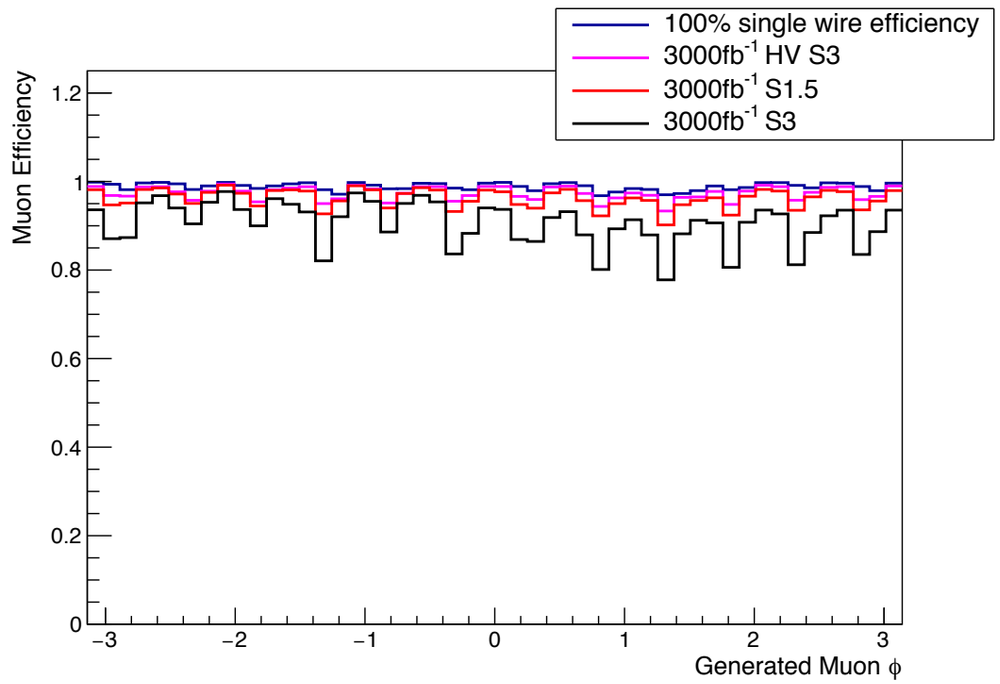
Topics addressed in the talk

- Status and next steps for *toy models* for ageing
- Status and next steps for *simulation of background from thermal neutrons*
- Alignment scenarios
- Details/needs for production requests (event-content, mixing strategy, BX windows …)
- Minimal, rough proposal of samples to be requested (still evolving)

Toy model for ageing: one slide summary

- For the muon TDR, a simple toy model allowing to:
  - Mask out parts for the detectors (use case for CSC, RPC, GEM)
  - Simulate flat hit inefficiencies by tossing away hits randomly (use case for DT)
- A reference ageing scenario was prepared for existing detectors in the database (link to confDB)
  - Additional tags, representing different staging of options (e.g. exclude ME0 …) were also prepared (link to confDB)
- Ageing/masking was applied on top of non aged digis unpacked from RAW at the RECO step
  - Apply a customisation function with the RECO cmsDriver.py command + including the proper DB payload
  - To keep the possibility of reRECO the same "RAW" sample with multiple ageing conditions if needed



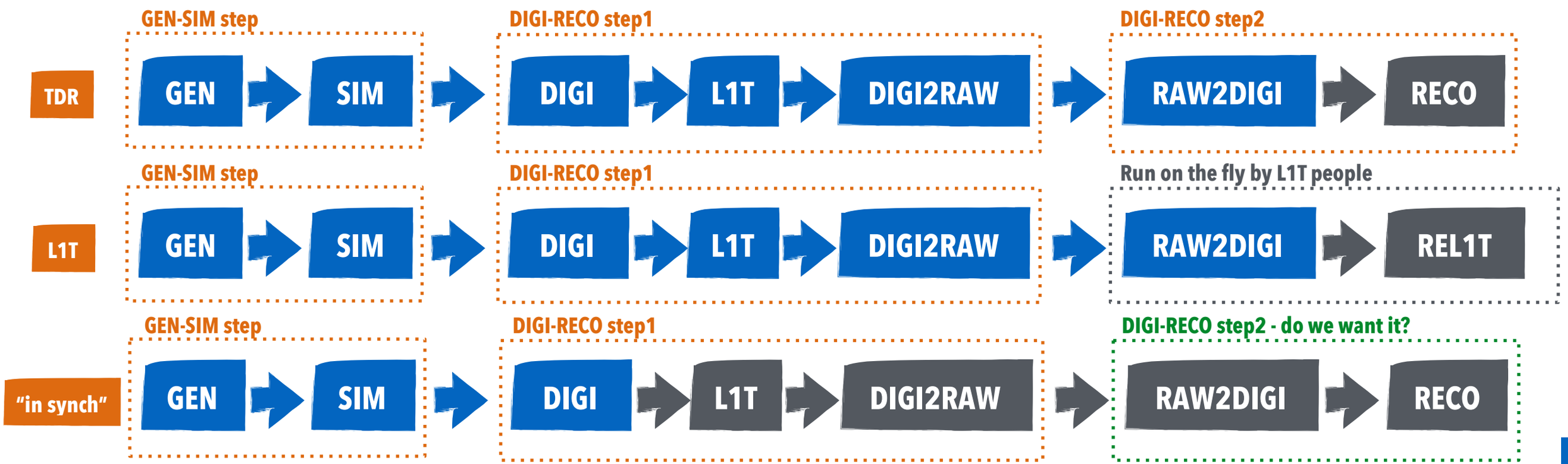


Example of different ageing scenarios simulated by DTs for the muon TDR (from C. Heidemann)

Toy model for ageing: details about workflows

- Recently worked with L1T (Vladimir) to extend this tool to be included it in their workflows
  - The strategy is to apply ageing ON THE FLY, together with reEMULATION, @ ntuple production (more in Vladimir's talk)
- It's worth noticing that none of the present options produces "in synch" aged L1T and RECO
  - Even running the ageing twice can't grant consistency, as the decision to keep/discard a digi is pseudo-random
- But there are use cases for which one might want to compare with RECO
  - AFAIK, local RECO segments, are used for DT primitive resolution studies
  - Might be interesting to see how much inefficiency L1T adds on top of RECO in specific cases (e.g. for displaced muons)
  - Re-running RECO on the fly is a rather tough task (better run it centrally - unless just local RECO is needed)

"Approximated" production workflows:

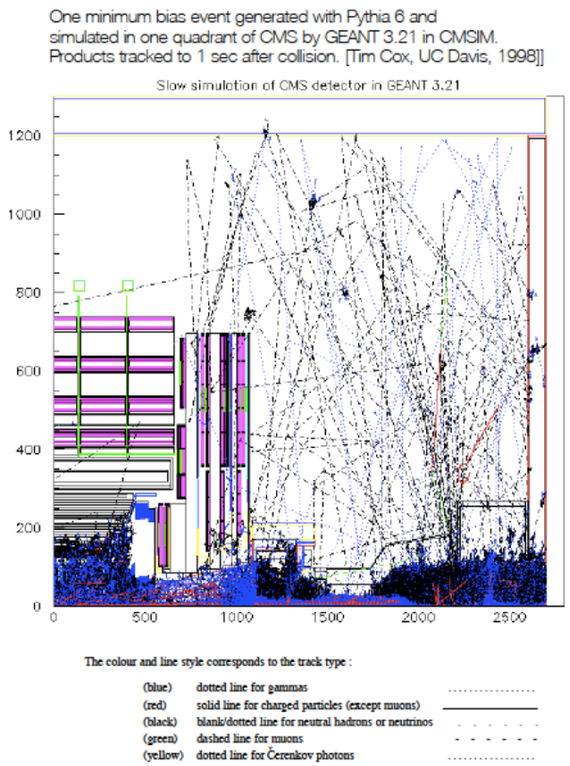


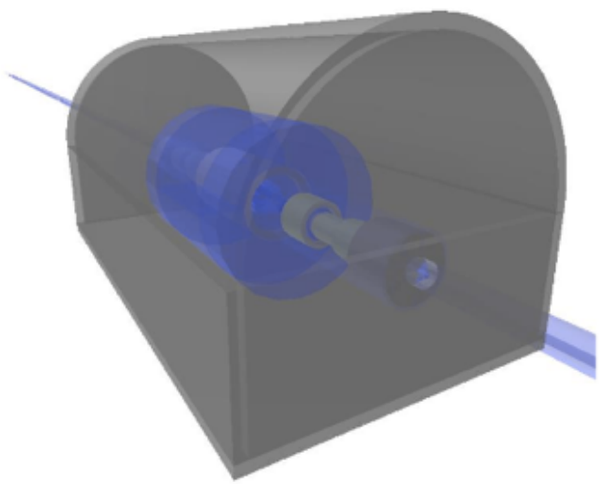
Toy model for ageing: notes and open points

- The ageing toy model is presently ready to be plugged at RECO or L1T reEMULATION steps
  - And it's fast, for L1T reEMULATION can be applied on the fly
- Must though agree on the actual definition of the ageing scenarios to be used
  - E.g. do we have updates for DTs to be implemented based on recent GIF++ studies?
- Must clarify the need of having "in-synch" aged L1T and RECO information
  - This implies providing new customisation functions to be used in production, but code should already be OK
  - Of course also implies actually a new production
- More "in depth studies" using more complex ageing models also exist
  - E.g. model non "flat" response within single cells for DT
  - Analyses worth to be continued, but present model is likely OK to model inefficiency that are not too big

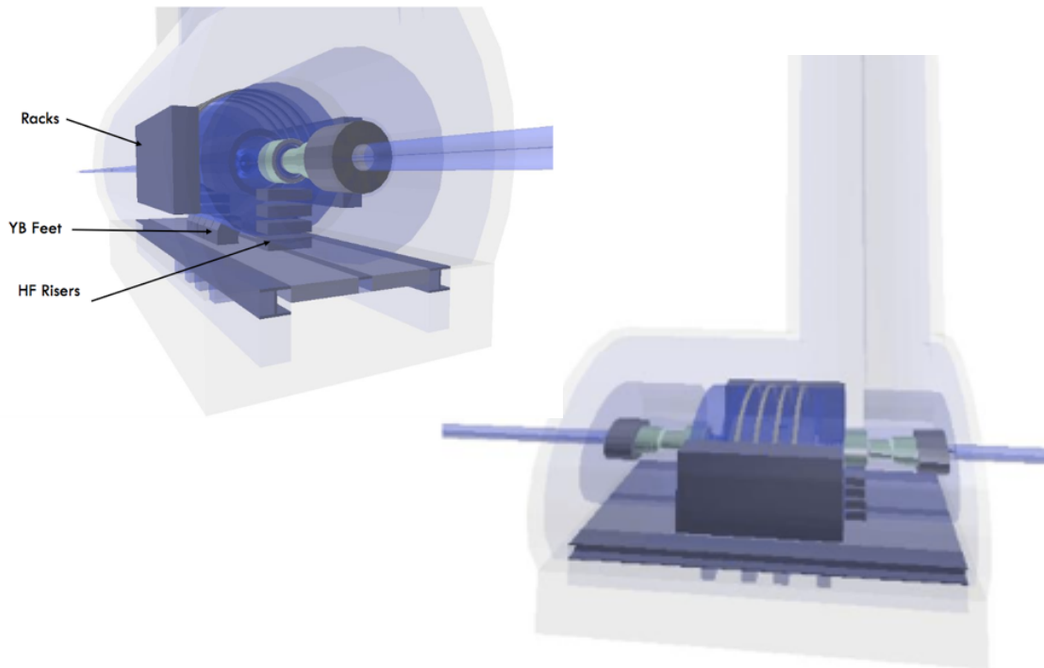
Simulations with background from thermal neutrons: introduction

- Simulation of thermal neutrons in a nutshell (more from P. Verwilligen here):
  - Using dedicated CMSSW customisations GEANT can be set to simulate **MinBias events** up to several milli seconds
  - The timing of these hits is adjusted to fall in the time window of normal simulation
  - Hits from MinBias are then added on top of signal hits via the mixing step
- Neutrons propagate "like a gas" within the cavern → an accurate description of its geometry is also needed to improve accuracy (work at the time of the Muon TDR from A. Magnani)
- Samples with BKG from thermal neutrons, incl. "accurate" cavern were produced for the Muon TDR
  - Worth to note: this strategy is needed to have "proper" BKG simulation in DT and CSC
  - RPC and GEM can inject "random" hits representing neutron BKG (for a target lumi in digitization)





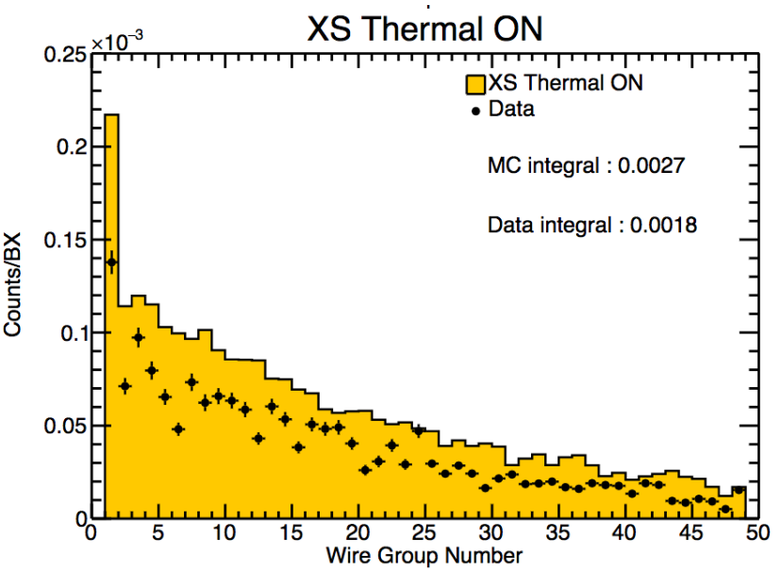
"Standard" geometry



"Accurate cavern" geometry

Simulations with background from thermal neutrons: status and plan

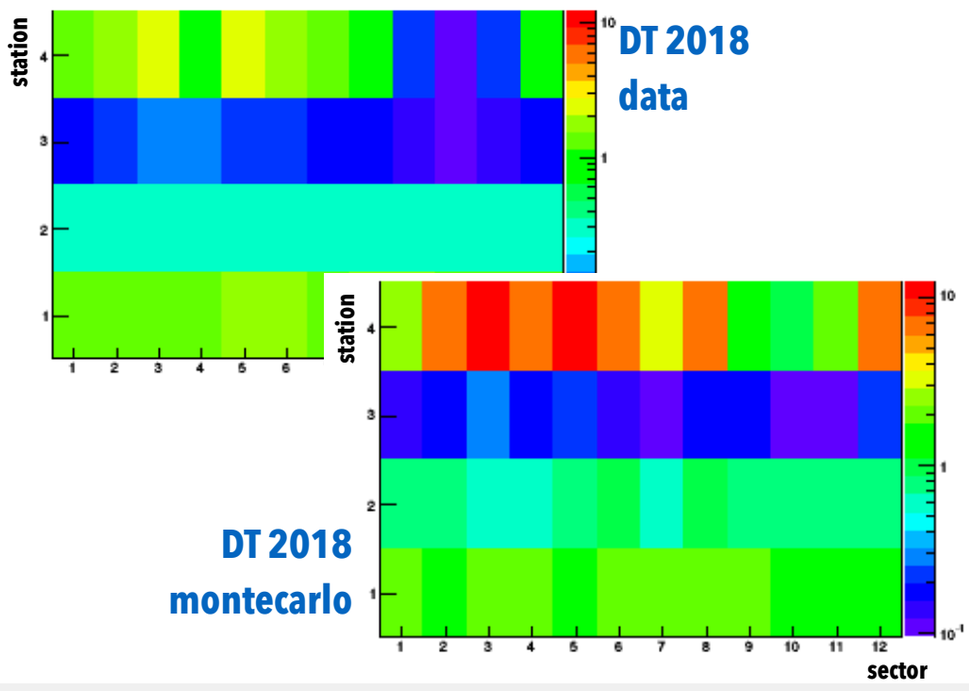
- A first, data/MC comparison from CSC (performed in 2017) shows agreement within a factor ~2
- In 2018, activity connected to the simulation of BKG continued (S. Lo Meo) with the aim of:
  - Further improving the geometry description (e.g. including shields on top of MB4 of YB+/-2)
  - Produce a reference sample for data/MC comparison studies with 2018 conditions
- Presently all technical ingredients are there, validation is pending due to issues under investigation
- Once validations problems are overcome, Run-2 campaign proceed
- Still a new geometry update (e.g. including extension of MB4 shields) must be prepared for use in Phase-2 scenarios

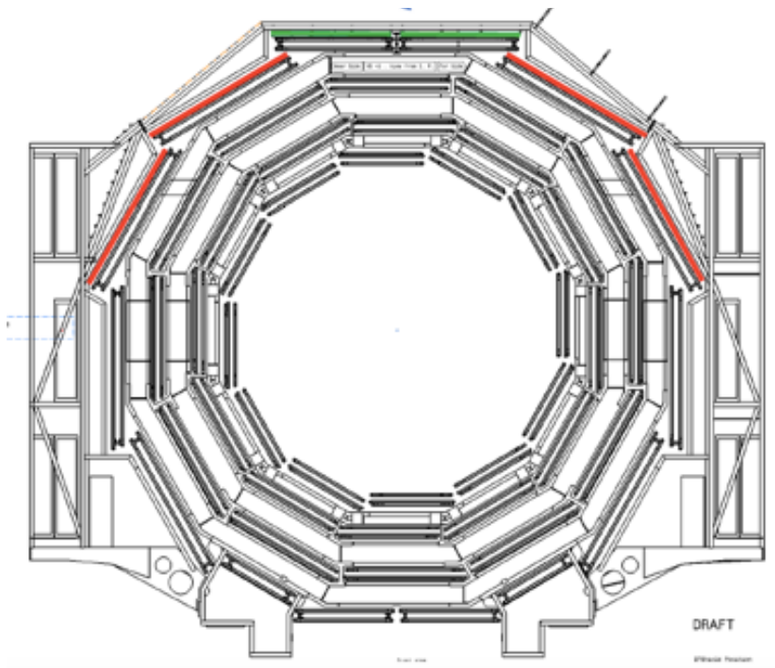


CSC ME1/1

(results from C. Schnaible and A. Dasgupta)

Validation of "2018" production (from F. Cavallo)





Simulations with background from thermal neutrons: notes and open points

- Main issue the production of **MinBias** samples with this method is very CPU demanding, and:
  - A16 BX PU window @ 200 PU / BX → means 320 M MinBias events for a 100K events sample
  - Considering "just BX 0" @ 200 PU → means 20 M MinBias events for a 100K events sample
  - AFAIK, the largest production attempted (for Muon TDR) was of 10 M MinBias events
- If we want **ZeroBias** samples with neutron background for rate studies, **MinBias** statistics becomes bottleneck:
  - What is the minimal size of such sample that is OK?
  - What is the level of PU replication that we can accept?

- This is not "ready to use tool" and implies dedicated central production (even of a **MinBias** library) we need to agree on the use we want to make of it
- Assuming validation issues are solved soon, Run-2 production + data/MC comparisons will likely come sometime (close to the end) of Q1 2019
- If deemed useful, we can start to prepare a Phase-2 production in parallel with Run-2 validation
  - Producing already an appropriate detector+cavern+shielding geometry
  - And decide only later if whatever agreement we reach in Run-2 is "good enough"

Alignment conditions

- All Phase-2 studies performed up to now assume ideal detector geometry
  - Alignment is a deliverable from DPGO to consider for MC productions, hence, in principle, a topic for this talk
  - There has recently been discussion about any possible impact of significant "day-1" misalignment between the muon chambers and the tracker on the Phase-2 trigger (e.g. as part of discussion about the decommissioning of the link system)
- Hence (without taking any part on whether this is an issue or not) it's probably worth agreeing for good in this meeting whether we want to perform any study (e.g. with dedicated MC samples)
  - Assuming that a MC-based study can be performed at all (is Phase-2 tracker "alignable"? GEMs are not as of today…)
  - Do we need any sample with "drastic" distortion between tracker and muon chamber?
  - If so, how do we agree on any concrete proposal for a set of alignment conditions?

Towards the definition of sample requests

- An "typical" wish-list of performance studies includes:
  - Test general performance on a usual "bulk" of low and intermediate, prompt, p_T muons
  - Test performance on a sample of hight-p_T muons (e.g. in case of showers)
  - Test cases where multiple muons come "close-by"
  - Test any "non standard" physics signature (displaced muons, HSCP …) the muon trigger should be sensitive to
  - Test production of fakes and study rates on a background "enriched" sample (mostly for L1T)
- Would likely be turned into a request of samples like the ones in the table:
  - Not an actual proposal, rather a zero order draft the muon group is still iterating on, discussion has "just" started
  - Furthermore we must also still optimise the permutation of potential requests in terms of ageing, neutron BKG simulation, PU scenatios, etc …
- With a few additional notes:
  - Flat guns with many (10) muon pairs per event allow to use smaller samples, with less problems with mixing large PU
  - In this case one can even agree on having large-scale RelVals instead of "standard" productions
  - But can't fully substitute DY, if some workflows which are TnP-like, are used to simplify comparisons with Run-2

Option 1	Option 2
DY→μμ	Flat p_T μ guns [3:200] GeV (10 μ?)
Z′ (e.g. M5000)→μμ	Flat p μ guns [200:2500] GeV (10 μ?)
Jψ→μμ (boosted)	/
Displaced muons (x3?)	multiple displacement scenarios (?)
HSCP (x3?)	multiple particle mass scenarios (?)
τ→3μ	/
ZeroBias	/

Sample requests: event content matters and other production "technicalities"

- The most basic need is re-emulation of trigger primitives, hence GEN-SIM-DIGI-RAW is necessary
  - Some studies rely on digi-sim-links, should be there in "standard" event content definition (but worth checking)
  - Muon digis are "small" compared to "the rest" of the detectors, in principle, "we" could store only those
  - But from now on it is wiser to make common requests with L1T if we have any, even if event-content is "larger"
- (At least for some studies) Might be worth getting RECO (or AOD) centrally produced
  - Some comparisons are done using RECO as a proxy and/or exploiting existing workflows based on them
  - Implies that we need to ensure consistency between L1T and RECO for samples with ageing
- Other workflows rely on the presence of tracking particles (TPs)
  - AFAIK L1T use a customised skim of TPs, must accommodate muon group needs in case of common productions
- In addition there are a few known customisations in the wish-list for muon studies:
  - Due to DT sensitivity for out-of-time signals ideally production should have PU mixing in a [-8:+8] BX window
  - some groups warmly prefer to use standard mixing instead of premixing
- Likely, nothing of the above above a showstopper for a common production request with L1T (if we agree to have one)
  - Of course assuming that some "minor" adjustments will need to be followed-up

Summary

- The status of tools to model ageing and neutron background was discussed:

1. For ageing a toy model is provided for study, it is not demanding in term of CPU consumption and can be used on-the-fly with L1T emulation
   - But for cases were "in synch" ageing of L1T primitives and RECO objects is requested
2. To obtain simulation of BKG from thermal neutrons more work, as well as dedicated campaigns, are needed, plus this is a rather demanding task "resources wise"
   - Also, a validation of the method under Run-2 condition shows that simulations overshoot data significantly
   - If not understood/fixed we must also agree if we are fine with the present level of agreement before proceeding
   - Statistics of MinBias sample is a bottleneck, we must understand how much of it can be obtained

- Plans for a production campaign are under discussion within the muon community
  - Actual request details (exact samples definitions, statistics, permutation of combinations with different ageing and neutron simulations) have not yet been be defined
  - But many technical aspects (event content definition, mixing strategy and PU windows) are rather clear
  - If considered of interest for L1T, it is worth getting "in synch" to ensure that any productions satisfies the needs of both groups