



16th May 2017

Roadmap to Sim10

Plan for next major step in Simulation versions

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on behalf of the Simulation PPWG

- Sim10 is the next major simulation version for production
 - Refers to Gauss and Boole applications and their configurations (and productions done with them)
- MC samples with a well defined production configuration with conditions (beam, detector and trigger) and processing (trigger, reconstruction and stripping) consistent with data for which they are made
- New features in the simulation itself to make it describe better the data whenever possible and profit from latest LHCb and external software development
 - Take also advantage of major change to clean up and improve the software itself and support new needs

What is Sim10 for and when?



- **Sim10 major change is the migration to Geant4 v10**
 - Given the importance of Geant4 for our simulation, a major simulation version is required when a new Geant4 version is used
- Sim 10 will also be the official simulation for Run2-2017 & all the previous conditions ...
 - Sim10 for Run1 will use the latest Reco + Stripping data processing
- ... and for Upgrade studies
 - Productions for Upgrade studies will also use Sim10
- Geometry + Trigger + Reco + Stripping as appropriate for data period MC is mimicking
- Sim10 release is planned for Mid-2017, with validation to be completed by the Fall 2017

What is new in Sim10 ?



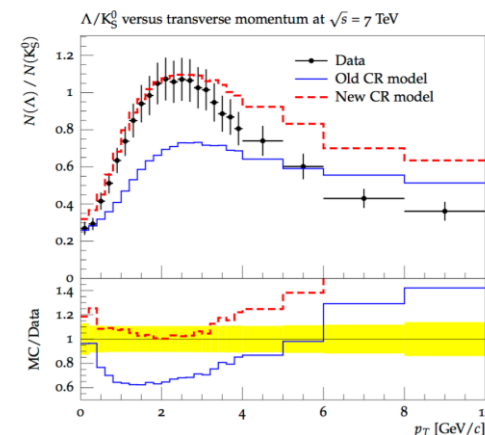
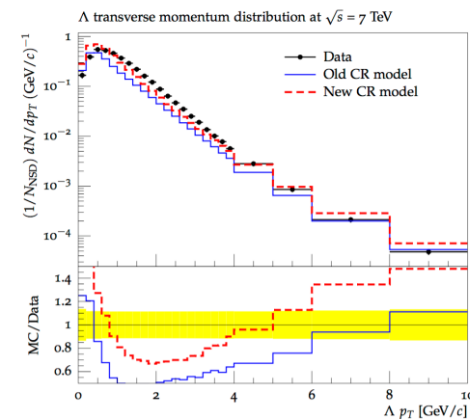
- Mostly changes in Gauss, not much for Boole per-se but...
 - New major version of Geant4
 - New versions of generators, i.e. Pythia8 186 → 226
 - Tuning of Pythia8
- New fast simulation options will be included as they become available
 - Latest improvement in the Rich, killing photons that will not reach the HPD, still to be validated
- Work started (see later)
 - Gauss v52r0 with new version of Pythia8, Gauss v52r1 with new Geant4 to be released in 2-3 weeks
 - Validation

- Sim09 will be THE productions for Physics analyses until the end of 2017
 - Expected Sim09c due changes in some EvtGen models and DECA.Y.DEC
 - Frozen generators and simulation settings
 - 50 models covering almost all the needed conditions and generators (from 2010 to 2016 heavyions)
- Still adding features and patches
 - New generator level cuts, new decay files, bug fixes, new generators
- Will continue to provide this level of support until Sim10 supersedes it
 - Gauss v49r7 currently used for production
 - Gauss v49r8 to be released end of May

Gauss

Generators and Tuning

- In Sim10 we will move to latest version of Pythia8, 186
 - 226 with new interesting features for us
 - technical/structure clean up, various minor bug fixes
 - new parton shower matching schemes introduced, including FxFx
 - ➔ two new color reconnection models added, impacts underlying event
 - new beam remnant model available
 - ➔ gluon splitting kernel weight for $g \rightarrow q\bar{q}$ changed, affects heavy quark production
 - ➔ hard diffraction machinery significantly upgraded
 - weak parton shower merging/matching implemented
 - ➔ fully flexible double quarkonia production processes added



- General hard process framework in place already in Sim09 – Will use only Pythia8 for showering
 - PowhegBox validation with next Sim09 version where use with Pythia6 still possible
 - In Sim10 will include MadGraph5 and aMC@NLO at some point
 - FxFx merging for aMC@NLO only available via Pythia 8.2

- Pythia6 will be dropped
 - Only Alpgen will use it behind the scenes for showering
 - BcVegPy hidden use of P6 should also be removed

- Will change the version of LHAPDF libraries but keep the same PDF as of now
 - LHAPDF 6.1.6.cxxstd – could move Pythia8 to used it directly
 - **CT09MCS**, recommended Leading Order PDF by the CTEQ group

P. Ilten, P. Robbe, M. Winn, Dortmund Group, J. Dalseno, etc...

- Continue support for other generally used generators
 - i.e. BcVegPy, GenXicc, EPOS, Hijing, PGun
- Investigate migration to Herwig7
 - provides significant NLO capability
- Investigate commissioning of SHERPA
 - Adaptor prototype developed by Dortmund group
- Review and clean up of 'obsolete' generators,
 - e.g. HiddenValley, OniaPairs, SuperChic (replaced by SuperChic2), Mint (replaced by Mint2), etc.

- No significant changes planned in EvtGen at the moment
 - Main changes will involve new decay models deployed when available in new Gauss releases
 - May need small adaptation for new version of Pythia8
 - May move to newer PHOTO++ version
 - We already use latest Tauola++ with LHCb extensions

- Do not expect major updated to Particle Properties tables not DECAY.DEC
 - Beside introduction of light baryons for Heavy Ions already in Sim09
- Move to GitLab for management of new 'users' decay files
 - But independent from Sim10
- Evaluate if to deploy extension of EventType code from 8 to 10 digits
 - Proposal done for Sim09 but need to be done carefully
 - Ensure backward compatibility in code and book-keeping
 - Not extremely urgent

and migration to xml format for decay file

- All user decay files will need to be converted and can already use it when a big advantage, i.e. in Dalitz and amplitude models

- New version of Pythia8 will require new tuning for
 - Minimum bias and underlying event
 - The parton IP distributions
 - Possibly look at a few other parameters

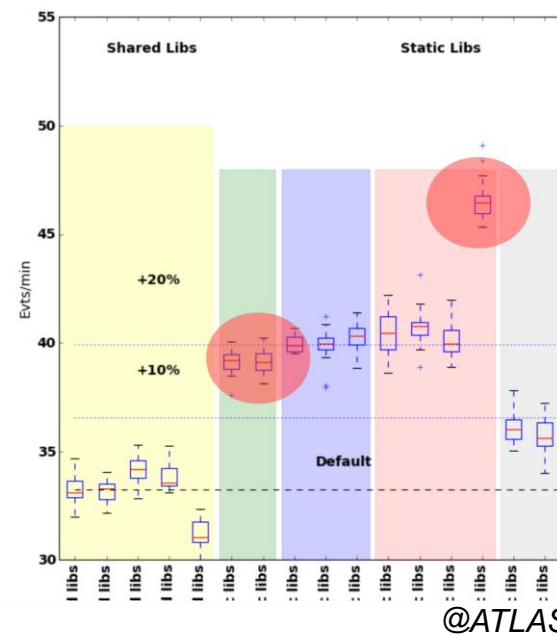
- Tuning procedure in 2 steps, using LHCb results as much as possible – Could some of the 13 TeV measurements also be used ?
 - 1) Flavor composition
 - 2) Multiplicities

- Tuning to be done in first stage of validation, but can use more person-power

Gauss (cont.)

Geant4

- A pre-requisite to make the full simulation faster and explore new technologies
 - Build of Gauss with G4 10.3 in sequential mode in nightly in few weeks
- Geant4 collaboration is not expected to support 9.6 after 2017
- Overall performance improvement expected
 - ATLAS observed ~ 15% speed up v10.1 vs 9.6 (same memory footprint)
 - ATLAS & CMS observed ~ 10-20% speed up static vs dynamic libraries



- Some obsolete physics has been removed
 - Should have minimal effect on LHCb as we should be using little
- Expect some changes in physics for LHCb
 - Keep FTFP_BERT for hadronic modelling, but **patch provided to us for Kaon cross sections in 9.6 should now be the default. Transition between models done more smoothly and at slightly different energies**
 - Use **LHCbEmNoCuts** for electromagnetic modelling, but should be **changed to match changes in EmOpt1** from which it originated. Once adapted to G4 10.3 will give it to G4 for them to maintain



- Extensive studies carried out with Geant4 stand-alone examples configured for LHCb environment and with Gauss
- No significant change with respect to what we use in Sim09 in Hadronic physics with default.
 - Improvement in the right direction with private patch for Kaons
- Some non negligible changes with respect to what we use in Sim08 in EM physics
 - fractional resolution being 3.3% better in v9.6 on LHCb-like ECAL with all fast EM physics list and cuts – *Confirmed by Geant4, partly due to change in Multiple Scattering*
 - Multiple Scattering angle (RMS) larger by 4-6% with modified LHCb EM (1-2% with old LHCb EM)
 - no significant change in dE/dx in thin layers
 - no large discrepancies in tracks' photon emission
 - Calorimeter calibration needed

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 - Improvement in the right direction for Kaons
- Some non negligible differences with respect to what we use in Sim08 in EM
 - fraction of tracks with $dE/dx > 1.5\sigma$ better in v9.6 on LHCb-like ECAL due to μ list and cuts – *Confirmed by Geant4, partly due to Multiple Scattering*
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Need to do the same and verify any changes of G4 10.3 for Sim10

- Validation similar to what done before but using LHCbPR2, see talk by T. Williams at last A&S week
- Implementation of tests into LHCbPR2 is ongoing details at LHCbGAUSS-866

	Geant4			Gauss				
Test:	ECal	MSc	Hadron Cross Sections	Hadronic Multiplicities	VELO Energy Deposits	Bremsstrahlung	Muon Multiple Scattering	Early Validation Checks
Status:	Ready	Ready	Ready	In Progress	In Progress	In progress	In Progress	Ready

- Work also ongoing in Gauss for Radiation length and Absorption map test, dE/dx in thin layer test, CPU and Memory consumption test and detailed timing

Gauss (cont.) and DDDB+SIMCOND

Geometry and detectors

- RICH simulation processes significantly slower in Sim09
 - Due to fraction of scintillation photons produced due to CO₂ content with respect to pure CF₄
 - F = 0.1 in Sim08 (as in 2011) → F = 0.6 in Sim09 (as in 2012 and 2016)

Extensive studies last year on how to reduce RICH CPU overall

- Killing the scintillation photons not reaching the detector before tracing them mitigate the CPU consumption
- Drop extra information from RICH needed for debugging and [detailed] monitoring

	RICH1	RICH2
Sim08	20%	14%
Sim09a	16%	45%
Sim09a+RICH2 improvements	18%	20%

by M.Rama, O(10) events



Various solutions from Clunker to F1

GTB is candidate choice for Sim10

Test productions to confirm 33% overall CPU improvement with no impact on PID.

- A new GaussGeo service will be deployed in Sim10 to replace the converters and conversion service passing the geometry to Geant4
 - Starting point to address well known shortcomings in how we provide the LHCb geometry to Geant4
 - Same functionality as existing mechanism verified to provide same radiation and interaction length maps.
 - Ready for production tests since many months
 - To come later in Sim10:
 - Implement how to completely misalign detectors
 - Need to understand how to implement and use additional G4 capabilities (parallel geometry can also be used for fast simulation)

- Test new geometry mechanisms available in Geant4 and how they impact the simulation
 - A lot of time in the simulation is spent transporting particles through volumes and in the magnetic field
- We can check different simulation engine descriptions – developments in Geant4/GeantV

Different options with Gauss based on G4 10

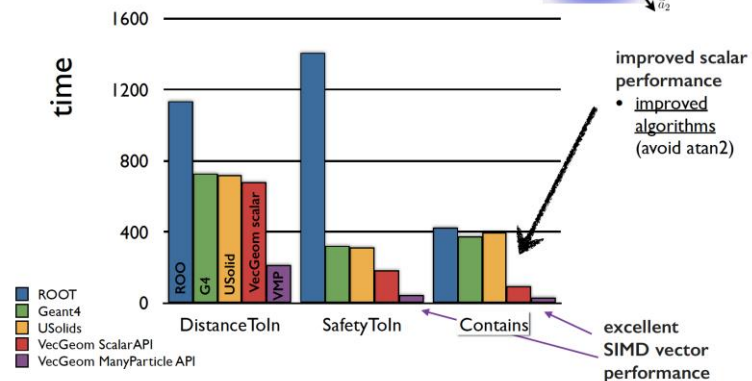
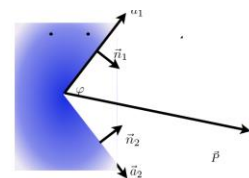
(a Geant4 compilation choice)

- USolid shape library in G4 10.2
- VecGeom library in G4 10.3

Preliminary tests dit not show differences in CPU with Gauss+USolid.
Will look directly in VecGeom and see if we can already use it in Sim10

Improvement - wedge

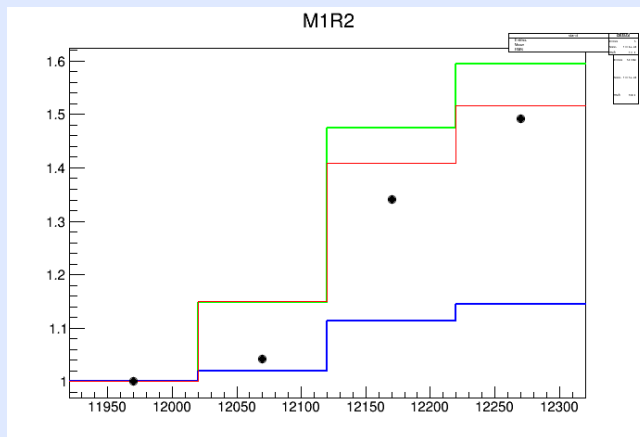
- Effect of „wedge“ on TubeSegment shape (SafetyToln and Contains)



M1 geometry description



- Known discrepancy of amount of material in M1
 - Effect studied by Muon Group and ‘educated pragmatic’ modeling with additional material provided and available in DDDB as local tag after validation of Sim09

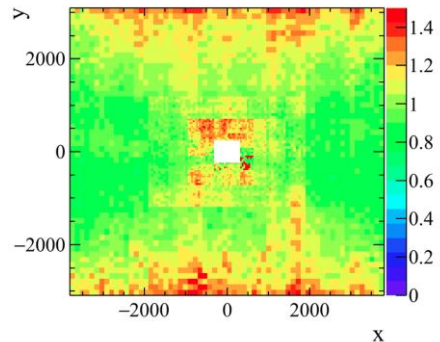
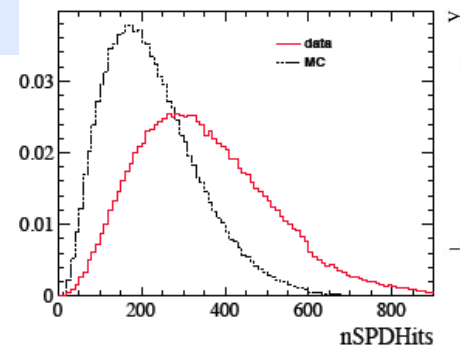


M1R2
data 7.9 Kg
MC default 4.9 Kg

Simple tests verifying the effect

MC w G10 frame
MC w Fe frame

**Check the effect on SPD/PRS
and RICH2 to deploy it
in Sim10**



- Need to check using the new Git CondDB
 - Should be transparent but... there may have some issues on running on the GRID
- Cannot check that the events are bit-wise identical since simulation relies on random sampling
- Verify the events are the same at the statistical level and check the radiation / absorption length maps
 - Can use LHCbPR2 😊

What else?

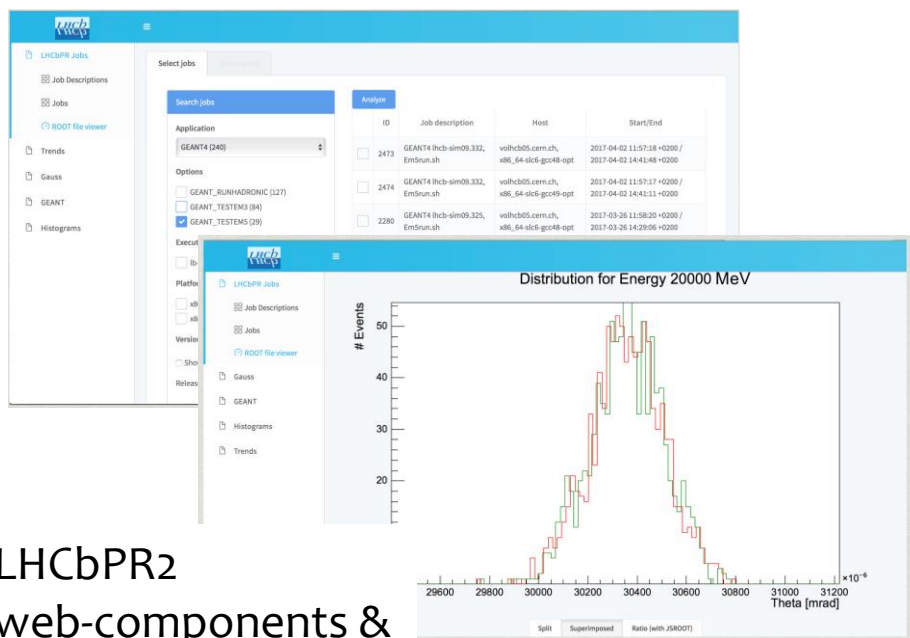
- A wide variety of options being explored from fully parameterized to fast detectors response to reuse of events
- No single size fits all solution but a palette of choices to pick and choose from as most appropriate
- They will be made available as they are mature for production as we are already doing in Sim09
- For more details see the following talk by R. Cenci

Test & test & test ...

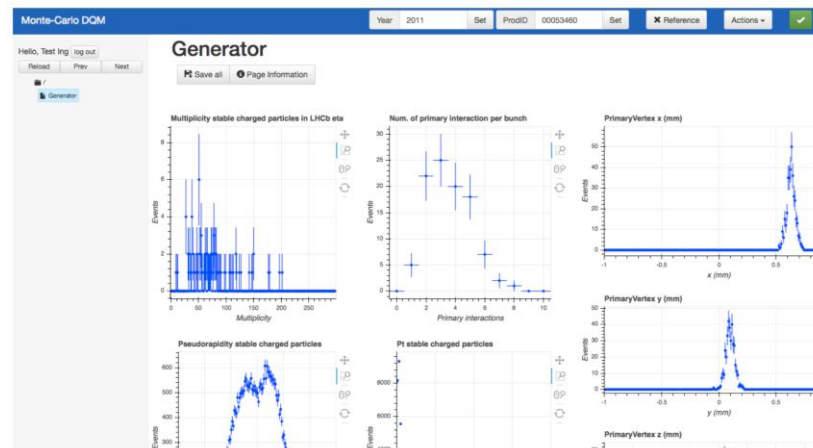
New testing infrastructures



- Robust infrastructure to validate Simulation at different levels: LHCbPR2 and SimDQ
 - To be fully exploited for the first time with Sim10



LHCbPR2
web-components &
microservices with
nightly builds



SimDQ in Monet
Under development
To use in early
production test

Validation of Sim10 by PhWG



- Extensive checks on test production by all Ph and some PP WG similarly to what done for Sim09

Thanks in advance to all MC liaisons That will be called to follow this up!

Hopefully it will be faster then for Sim09...

LHCb Simulation project / LHCBGAUSS-511 JIRA LHCBGAUSS-511

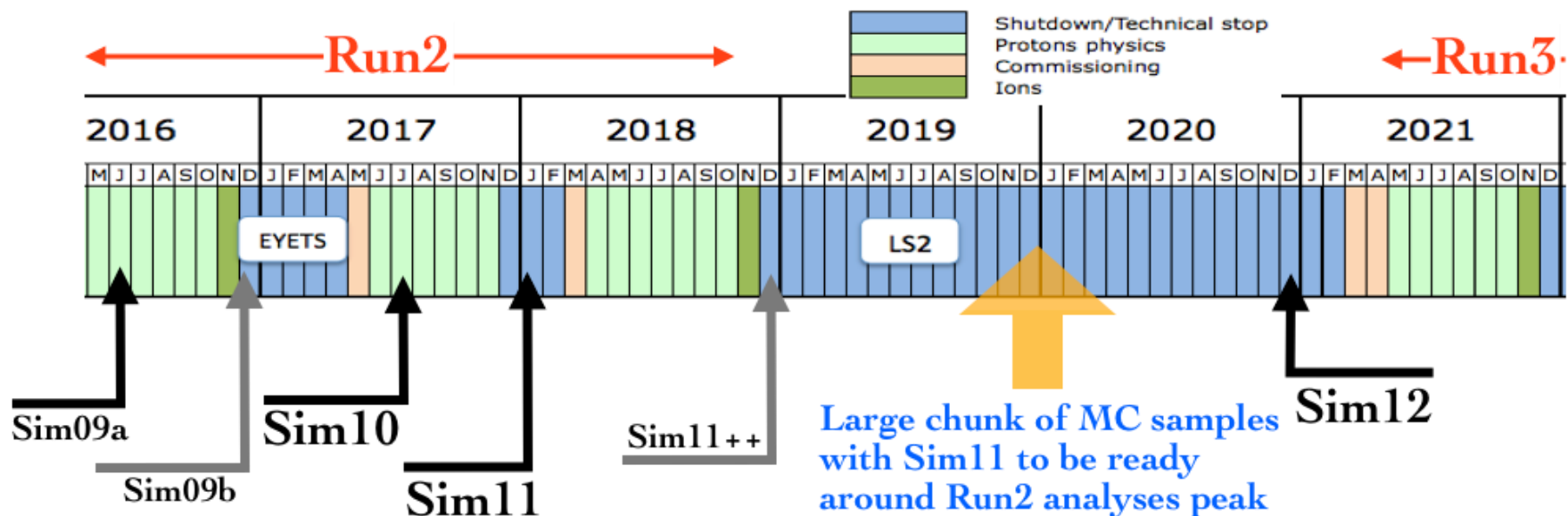
Productions for PhWG and PPWG for final commissioning and validation of Sim09

Issues in Epic +

<input checked="" type="checkbox"/>	LHCBGAUSS-474	Tests with Sim09Dev with inclusive J/Psi Early Measurements conditions	<input type="checkbox"/>	CLOSED	Ilya Komarov
<input type="checkbox"/>	LHCBGAUSS-477	Test samples of Sim09dev for tracking verification with 2012 and 2015 conditions	<input type="checkbox"/>	IN PROGRESS	Vladimir Romanovskiy
<input checked="" type="checkbox"/>	LHCBGAUSS-503	Test samples for Sim09 validation for RD WG	<input type="checkbox"/>	CLOSED	Carlos Sanchez Mayordomo
<input type="checkbox"/>	LHCBGAUSS-510	Generate Sim09 sample of Z->mumu (42112001)	<input type="checkbox"/>	WAITING FOR 3 RD PA...	Marcin Jakub Chrzasczcz
<input checked="" type="checkbox"/>	LHCBGAUSS-521	SLWG sim09 test samples	<input type="checkbox"/>	CLOSED	Svende Annelies Braun
<input type="checkbox"/>	LHCBGAUSS-522	BnoC Sim09 test samples	<input type="checkbox"/>	IN PROGRESS	Louis Henry
<input type="checkbox"/>	LHCBGAUSS-523	BandQ Sim09 test samples	<input type="checkbox"/>	IN PROGRESS	Liupan An
<input type="checkbox"/>	LHCBGAUSS-527	B2OC Sim09 Validation request	<input type="checkbox"/>	IN PROGRESS	Alex Birnkraut
<input type="checkbox"/>	LHCBGAUSS-533	B2CC Sim09 validation production request	<input type="checkbox"/>	IN PROGRESS	Ramon Niet
<input type="checkbox"/>	LHCBGAUSS-535	Validation samples for Sim09 for Charm WG	<input type="checkbox"/>	IN PROGRESS	Alex Pearce
<input type="checkbox"/>	LHCBGAUSS-536	Tagging Group: sim09 test samples	<input type="checkbox"/>	IN PROGRESS	Vladimir Romanovskiy
<input type="checkbox"/>	LHCBGAUSS-561	Minimum bias 10 M events sample in 2015 early measurement conditions for Sim09 validation	<input type="checkbox"/>	WAITING FOR 3 RD PA...	Alex Grecu
<input type="checkbox"/>	LHCBGAUSS-576	Submit MC request for 2015 pseudo nominal production for BandQ (set 2)	<input type="checkbox"/>	IN PROGRESS	Liupan An
<input type="checkbox"/>	LHCBGAUSS-586	2015 samples for PID tuning	<input type="checkbox"/>	WAITING FOR 3 RD PA...	Christopher Rob Jones
<input type="checkbox"/>	LHCBGAUSS-608	Simulation request for QEE, set 2	<input type="checkbox"/>	IN PROGRESS	William James Barter
<input type="checkbox"/>	LHCBGAUSS-613	B2CC Production of sample with Sim09 2012 Conditions in LDST format	<input type="checkbox"/>	IN PROGRESS	Ramon Niet
<input type="checkbox"/>	LHCBGAUSS-621	Failure with low crash rates or warnings in log file found in Sim09Dev tests	<input type="checkbox"/>	IN PROGRESS	Gloria Corti
<input type="checkbox"/>	LHCBGAUSS-635	J/psi PT distribution difference between Sim08 and Sim09	<input type="checkbox"/>	IN PROGRESS	Philip James Ilten

Summary and Outlook

- Sim10 is the next major step within the long term plan for the upgrade – but not only
- Sim11 and Sim12 (more fast sim options and multithread) will follow



- Work for Sim10 has been ongoing on a 'low key' and will move to full speed soon
 - Migration and test of Geant4 10, major change
 - Improved system for performance and regression test (LHCbPR2)
 - Update to latest version of Pythia8
- But still few pieces are missing
 - System for validation using higher-level quantities (SimDQ)
 - Additional tuning of generators
- Sim09 will be supported until Sim10 is not fully validated (Fall 2017) and phase out soon after that (Early 2018)