Analysis Validation in Belle II

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What is Validation?

In general validation is an umbrella name for several **different tasks that follow a similar workflow**

Release-Validation

- **Goal: verify that the new release is not introducing unwanted features in the reconstruction**
- Looking at basic and low level variables to spot such issues
- e.g. tracking performances, PID performance, π^0-recosntruction, ...

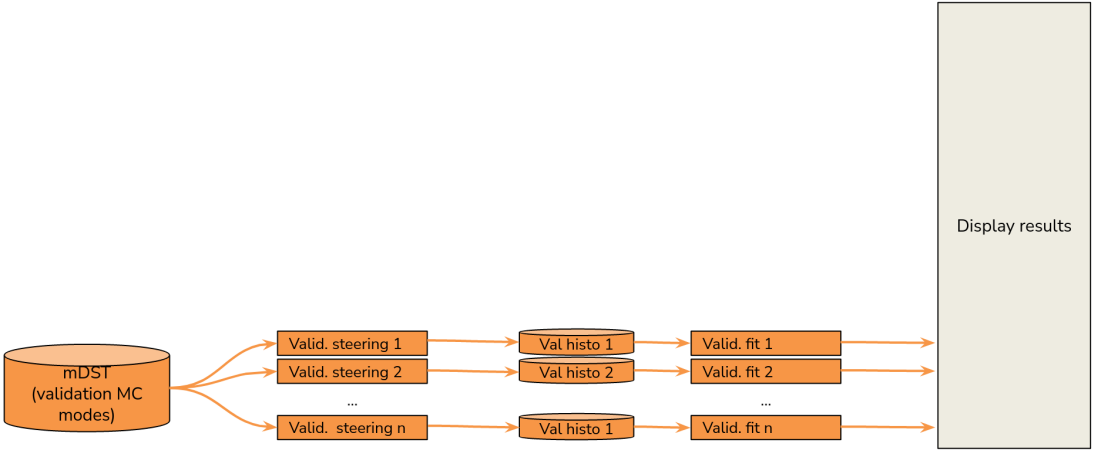
Analysis-Validation

- **Goal: verify that the new release and MC generation is ok for analysis**
- Data Production (DP) produces a set of modes and liaisons of working groups run analysis on them
- This is done when a new pre-release has passed the release-validation

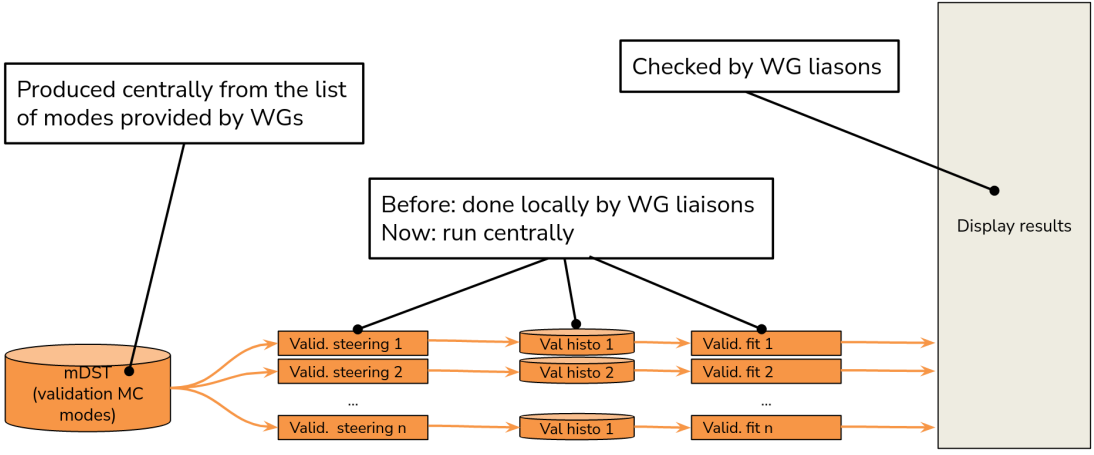
Data/MC-Quality → Planned

- **Goal: check that no mistake occurred during production**
- DP runs a set of analysis scripts on any produced sample (Data, MC) and displays results
- plan to provide the "Ultimate DQM"

Current Status of Analysis Validation



Current Status of Analysis Validation



Old versus new Approach

Rel6 analysis validation samples

- SL and Missing Energy (6 productions, 1M-4M events each)
  - B → τ ν: 2M BGx0 4M BGx1 4M BGx2
  - B → π l ν : 1M BGx0 2M BGx1 2M BGx2
- EWP (6 productions, 2M events each)
  - $B^+ \to K^{*+}\,\nu\,\bar{\nu}$: 2M BGx1
  - $B^+ \to K^+\,\nu\,\bar{\nu}$: 2M BGx1
  - B → K*[K π] γ: 2M BGx1
  - $B^0 \to \rho^0\,\gamma$: 2M BGx1
  - $B^0 \to K^{*0}\,e^+\,e^-$: 2M BGx1
  - $B^0 \to K^{*0}\,\mu^+\,\mu^-$: 2M BGx1
- TDCPV (6 productions, 1M events each)
  - $B^0 \to [J/\psi \to \mu\,\mu]\,[K^0_S \to \pi^+\,\pi^-]$: 1M BGx0 + 1M BGx1
  - $B^0 \to [J/\psi \to e\,e]\,[K^0_S \to \pi^+\,\pi^-]$: 1M BGx0 + 1M BGx1
  - $B^0 \to [J/\psi \to \mu\,\mu]\,K^0_L$: 1M BGx0 + 1M BGx1

See [2]

- B to Charmless (2 productions, 2M events each)
  - $[B^+ \to K^{*+}\,\rho^0]$ fL = 1: 2M BGx1
  - $[B^+ \to K^{*+}\,\rho^0]$ fT = 1: 2M BGx1
- B to Charm (3 productions, 2M events each)
  - $B^+ \to \bar{D}^0[K^0_S\,\pi^+\,\pi^-]\,K^+$: 2M BGx1
  - $B^+ \to \bar{D}^0[K^0_S\,\pi^0]\,K^+$: 2M BGx1
  - $B^+ \to \bar{D}^0[K^-\,\pi^+]\,\pi^+$: 2M BGx1
- Bottomonium (6 productions, 500k events each)
  - Y3S_gchib2P_gYXS: 500k BGx0 + 500k BGx1
  - Y3S_pipiYXS: 500k BGx0 + 500k BGx1
  - Y6S_piZb_pihb1P: 500k BGx0 + 500k BGx1

- Charmonium (4 productions, 10M events each)
  - $e^+\,e^-$ (ISR) → $\pi^+\,\pi^-\,J/\psi$: 10M BGx0 + 10M BGx1
  - $e^+\,e^-$ (ISR) → $\pi^+\,\pi^-\,\psi(2S)$: 10M BGx0 + 10M BGx1
- Charm (6 productions, 1M events each)
  - $D^{*+} \to D^0[K^-\,\pi^+]\,\pi^+$: 1M BGx1
  - $D^{*+} \to D^0[K^-\,\pi^+]\,\pi^+$: 1M BGx1
  - $D^+ \to \pi^+\,\pi^+$: 1M BGx1
  - $D^+_s \to K^0_S\,\pi^+$: 1M BGx1
  - $\Lambda^+_c \to p^+\,K^-\,\pi^+$: 1M BGx1
  - $\Lambda^+_c \to \bar{p}^-\,K^+\,\pi^-$: 1M BGx1
- Low multiplicity (2 productions, 2M events each)
  - $e^+\,e^-$ (ISR) → $\pi^+\,\pi^-$: 2M BGx1
  - $e^+\,e^-$ (ISR) → $\mu^+\mu^-\,(\gamma)$: 2M BGx1

- Tau (**18** productions, 1M events each)
  - 347001200(0/1) (tau(-/+) → (rho → pi pi0) with TauolaBelle): 1M BGx0 + 1M BGx1
  - 347003000(0/1) (tau(-/+) → (a0 → 3 pi) with TauolaBelle): 1M BGx0 + 1M BGx1
  - 347001201(0/1) (tau(-/+) → (rho → pi pi0) with TauolaBBB): 1M BGx0 + 1M BGx1
  - 347003001(0/1) (tau(-/+) → (a0 → 3 pi) with TauolaBBB): 1M BGx0 + 1M BGx1
  - 347003002(0/1) (tau(-/+) → (a0 → 3 pi) with TauolaBBB and IRCHL3PI): 1M BGx1

- Summary
  - 59 total productions for validation campaign!! Most are 1M events or more.
  - If we want a streamlined, centralized procedure for the analysis validation, we cannot be looking at this many modes. Also, why are validation samples requiring 1M events or more?
  - Why BGx0/BGx1/BGx2? What are we learning from these different productions?
  - One problem has been that the Charm and Tau WGs must produce charge conjugate modes in a separate production. A recent PR fixed this for Charm: https://stash.desy.de/projects/B2/repos/basf2/pull-requests/639/overview

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Old versus new Approach

- DP had to produce a total of **59 modes** which most of the time contained **more than 1M events**
- Process involved **liaisons of 10 WGs**, who work at different speed and with different styles
- This made the analysis validation **very slow**

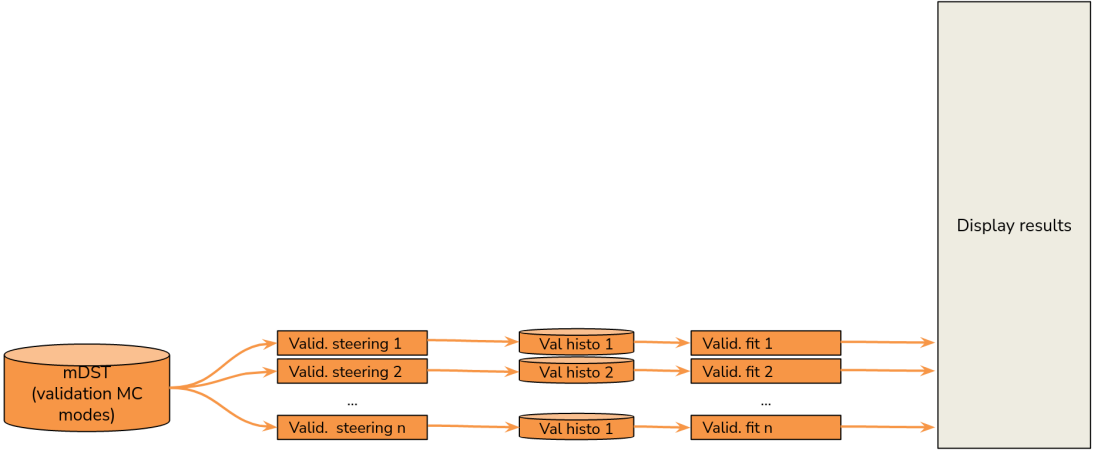
Old versus new Approach

- DP had to produce a total of **59 modes** which most of the time contained **more than 1M events**
- Process involved **liaisons of 10 WGs**, who work at different speed and with different styles
- This made the analysis validation **very slow**
- **Solution: Perform the analysis validation centralized**
  - Only produce **6 modes** with 1M events each
  - **Run the analysis scripts centrally** and report results to physics performance

Modes for release-7 validation

- $B \to \pi \ell \nu$
- $B^+ \to \overline{D}^0 \left[K^0_S \pi^0\right] K^+$
- $B^0 \to [J/\psi \to \mu\mu] K^0_L$
- $D^{*+} \to D^0 \left[K^- \pi^+\right] \pi^+$
- $\Lambda_c^+ \to p^+ K^- \pi^+$
- $e^+e^- (ISR) \to \mu^+\mu^- (\gamma)$
- $B^0 \to \rho^0 \gamma$

Analysis validation & quality control workflow → Planned



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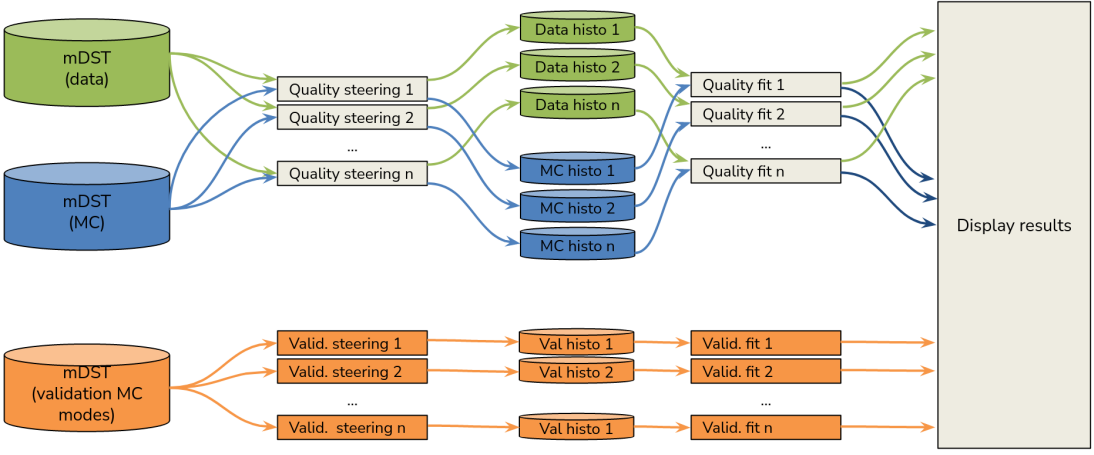

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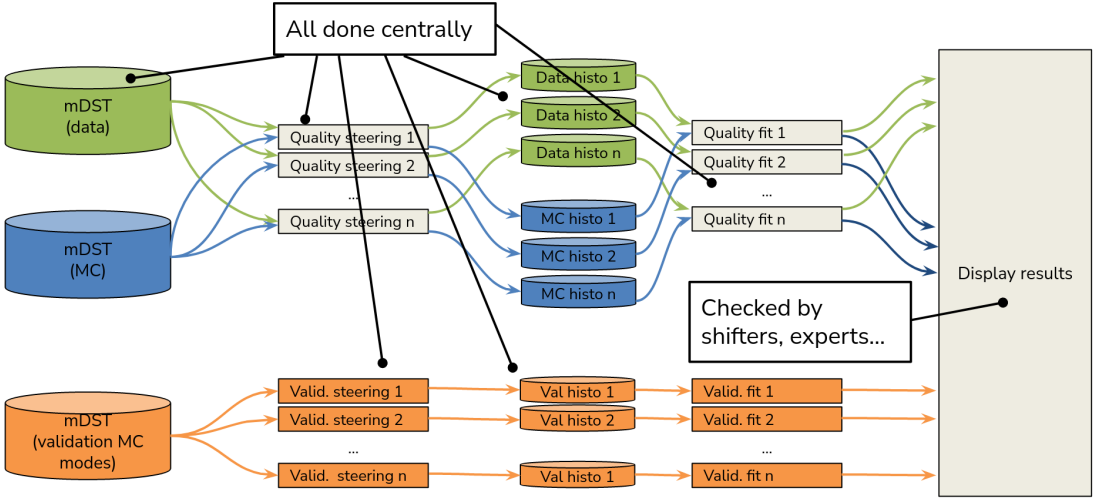

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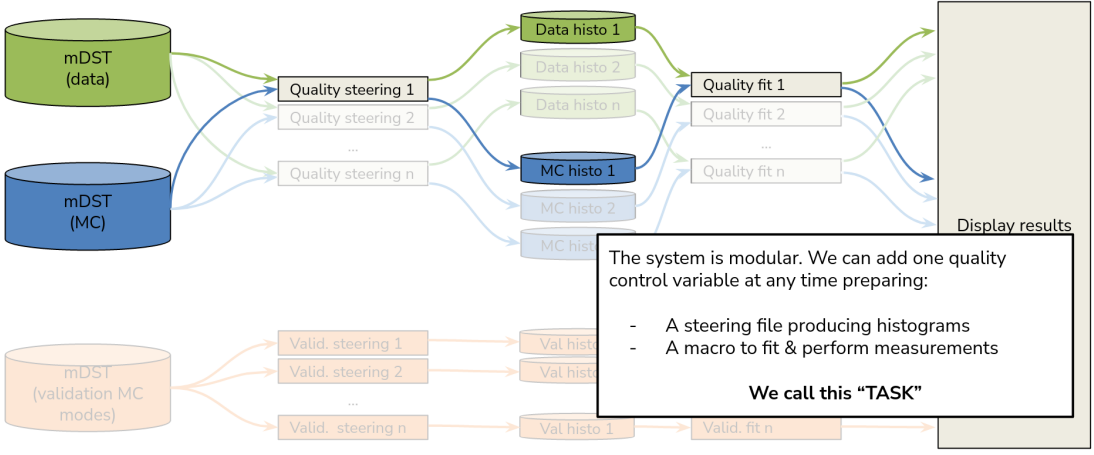


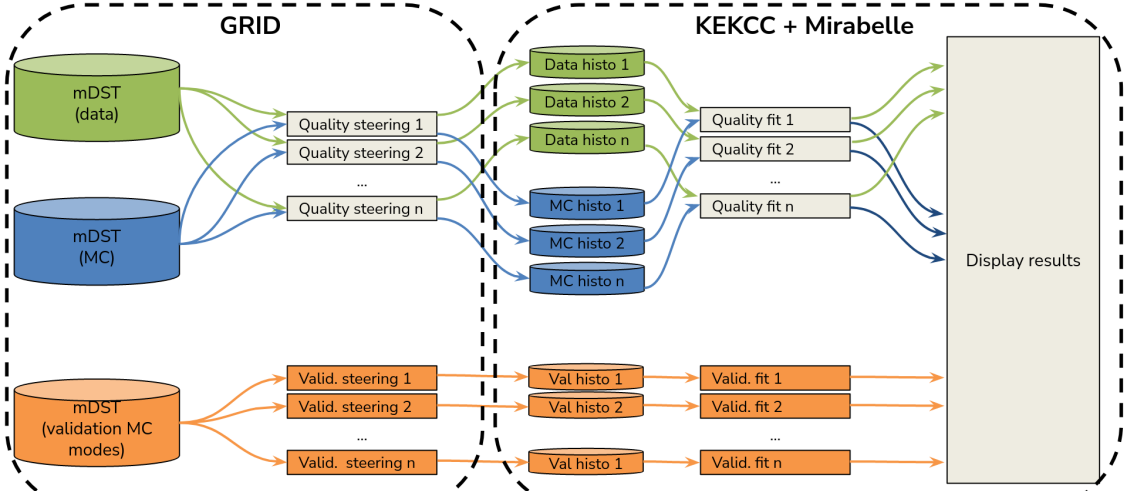
Definition of a task

- **Task defintion = which quantities do we want to monitor**
- **Incremental approach** for testing:
  - **Start with a sensitive set of quantities** (not fixed yet)
  - Keep adding tasks/quantities over time according to needs, workforce availability, new ideas, e.g.
    - Add a test for every new bug that is discovered
    - Convert physics performance studies into tests
    - Maybe convert full analyses into tests as well
- **Run this tasks on all samples that are produced, directly after production! "Real-time" monitoring!**

Hierarchical Approach

- **Few high-level variables** (act as miners' canaries)
  - B decay modes
  - Lifetimes
  - ...
- **Low-level quantities** (to debug problems)
  - Beam energy
  - Number of tracks
  - PID
  - Tracking resolution
  - ...

Implementation on the system



Summary

- Validation helps us to test the features and performance of our code
- Switch to a **centralized analysis validation** with release-7 to **speed up the process**
- Want to add an **automatized quality control workflow** to ensure the sanity of our **data**/**MC**
- **How can you help us?**
  - A lot of code to write for the automatized control workflow (framework, analysis script, . . .) → **Service Tasks**
  - **Provide us with feedback** about monitored quantities and make suggestions about new tests that should be included
  - Once the workflow is running, **add new analysis "scripts"**