

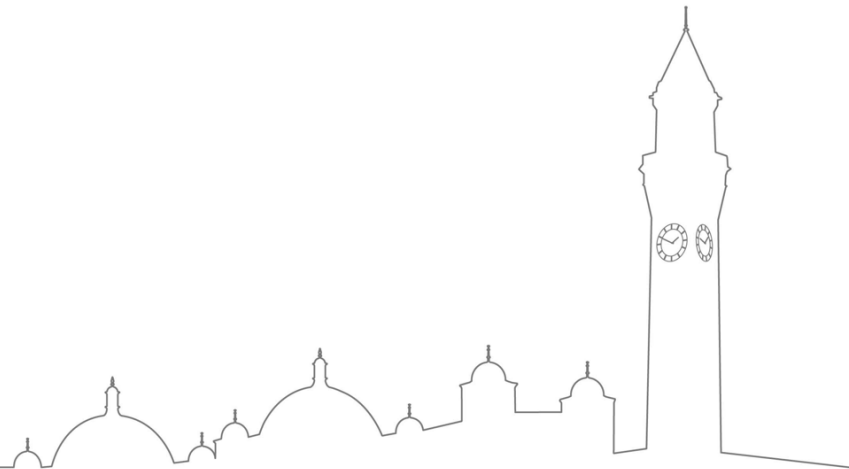


Performance Dashboard for UII Studies

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With thanks to Paula Collins & Victor Coco for the original idea & Tim Evans, Dima Popov (and others!) for (much) work along the way...

LHCb UII Tracking Workshop 07/03/24



Better U2 scenario evaluation

Problem:

- Proliferation of private stacks: irreproducible builds
- Guessing-game of key results: irreproducible plots

Solution:

- Framework to evaluate U2 scenarios
- Lift build & production load off analysts
- Use official sim as far as available
- Span detector-performance metrics to physics benchmarks
- *Speed*: ultimately release code, but don't wait for release
- *Transparency*: plots preserved permanently; samples temporarily

**Rapid evaluation of scenarios at interface
between detector experts & analysts**



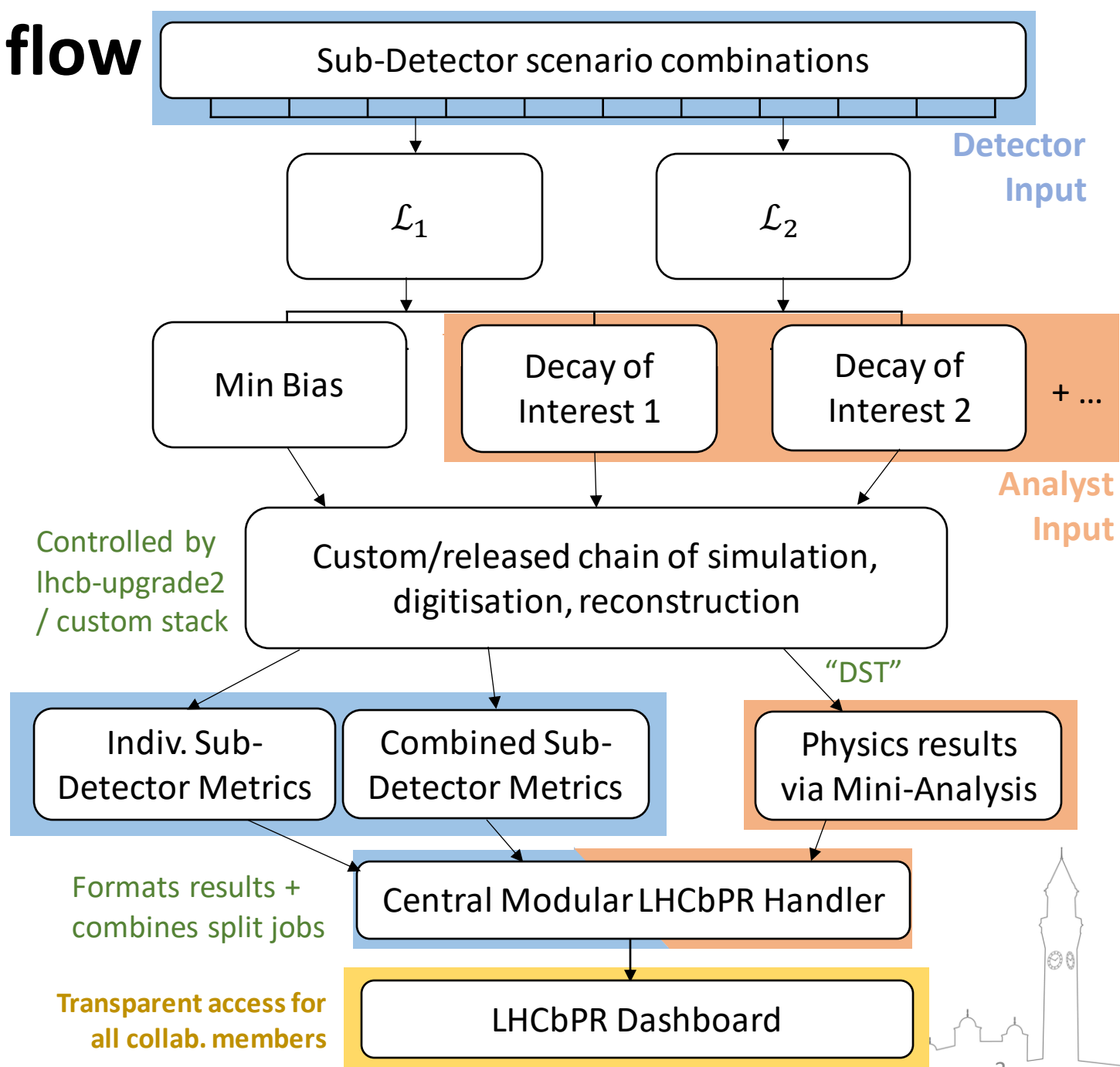
Processing flow

Luminosity
Scenarios

Simulation
Types

Performance
Metrics

Display



Dashboard implementation with LHCbPR

Example stack-builder config

```
{
  "name": "U2_Trk",
  "binaryTag": "x86_64_v2-centos7-gcc12-opt",
  "lcgVersion": "103",
  "checkouts": {
    "Detector": "e33c0ce",
    "Gaudi": "0dc529d",
    "Gauss": "ecfd1ec",
    "Gaussino": "488dbbf",
    "Geant4": "5e093ad",
    "GaussinoExtLibs": "25e72f9",
    "LHCb": "9ee03eb",
    "Run2Support": "430100e"
  },
  "projectsToBuild": ["Gauss"]
}
```

User provides commits to build stack + options for testing

Build, clean and zip core software stack(s) with UII sim + reco branches **New!**

Standard set of Gauss/Moore options covering detector metrics and physics benchmarks

Min-bias, Layout 1

Min-bias, Layout 2

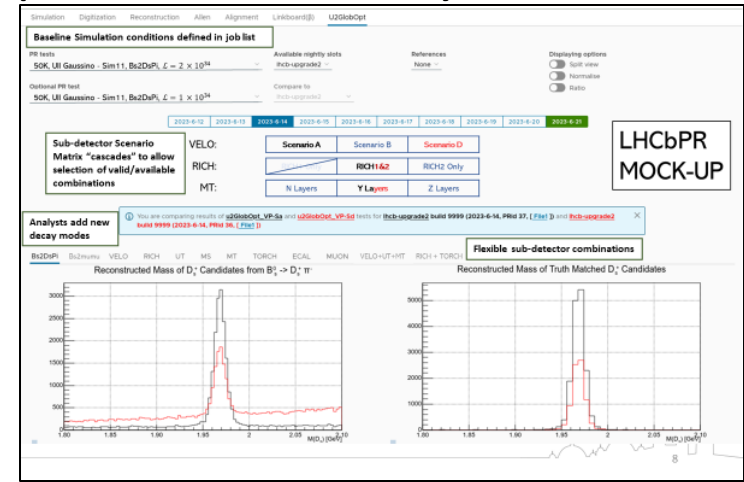
Bs2Dspi, Layout 1

Different simulation conditions + layout

Submit to LHCbPR2Grid **New!**

LHCbPR handler collates results

Dashboard to view and compare relative performance of detector layouts



LHCbUpgrade2StackTester

- Many tests run on **private stacks**, small sample sizes, hard to reproduce results.
- Official stacks require review to change, not independent from other users
- [LHCbUpgrade2StackTester](#) fills this gap
 - **User** can make quick changes
 - Stacks are stripped to **~300 MB**, zipped and **uploaded to CERN SE**
 - Framework manages building, testing, uploading + submission and running of jobs automatically
- **Not a replacement for nightlies** and can be swapped out for nightly stacks / released software seamlessly

User provides [Stack config](#) in MR

```
{
  "name": "U2_Trk",
  "binaryTag": "x86_64_v2-centos7-gcc12-opt",
  "lcgVersion": "103",
  "checkouts": {
    "Detector": "e33c0ce",
    "Gaudi": "0dc529d",
    "Gauss": "ecfd1ec",
    "Gaussino": "488dbbf",
    "Geant4": "5e093ad",
    "GaussinoExtLibs": "25e72f9",
    "LHCb": "9ee03eb",
    "Run2Support": "430100e"
  },
  "projectsToBuild": ["Gauss"]
}
```

U2_Trk

binaryTag: x86_64_v2-centos7-gcc12-opt
lcgVersion: 103
Detector: e33c0ce
Gaudi: 0dc529d
Gauss: ecfd1ec
Gaussino: 488dbbf
Geant4: 5e093ad
GaussinoExtLibs: 25e72f9
LHCb: 9ee03eb
Run2Support: 430100e

Gauss: Completed

Zip and Upload Status: Completed

LHCbPR2Grid



- Merged with active development of extension to [LHCbPR](#) allowing jobs to run on the grid
 - Dramatically larger tests, running for longer, **split over sub-jobs**
 - Enables chaining applications together** Gauss → Moore etc.
- Custom stack jobs instruct grid node to **download and run with prepared container from CERN SE**
- Framework accepts Python as an application for running **higher-level analysis on the grid** (e.g [U2 Selections](#))

```
{
  "jobTitle": "U2_MinBias_nu60_2p5K_TRK_TV-UP-MT_Moore-queue",
  "days": ["Once"],
  "time": 11,
  "platform": "x86_64_v2-el9-gcc13-opt",
  "stackName": "",
  "stackTimestamp": "",
  "nightlyFlavour": "run5",
  "nightlySlot": "9",
  "PRJobOptions": "U2TrkStack_MooreU2-scripts/upgrade_2.py",
  "PRExtractInputScript": "",
  "PRRemoveInputOption": "",
  "inputFiles": [".sim"],
  "outputFileTypes": [".root"],
  "splitJob": 25,
  "handlerToRun": "U2_Trk_MooreHandler",
  "application": "Moore",
  "applicationVer": "run5",
  "requiresJob": "U2_MinBias_nu60_2p5K_TRK_TV-UP-MT_Gauss-queue",
  "newDir": "U2_MinBias_nu60_2p5K_TRK_TV-UP-MT",
  "newDevDir": "DEVDIR"
},
```

User provides [Job config](#) in MR

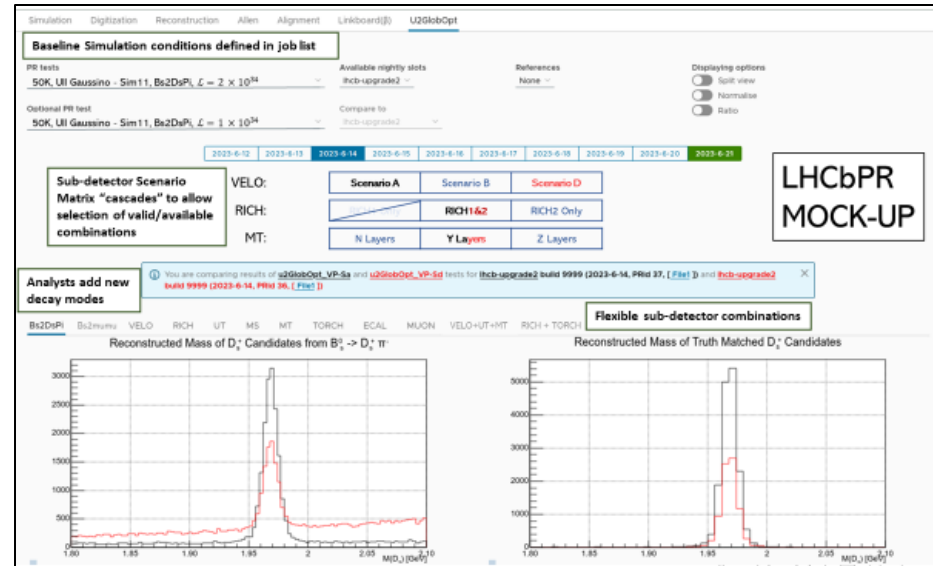
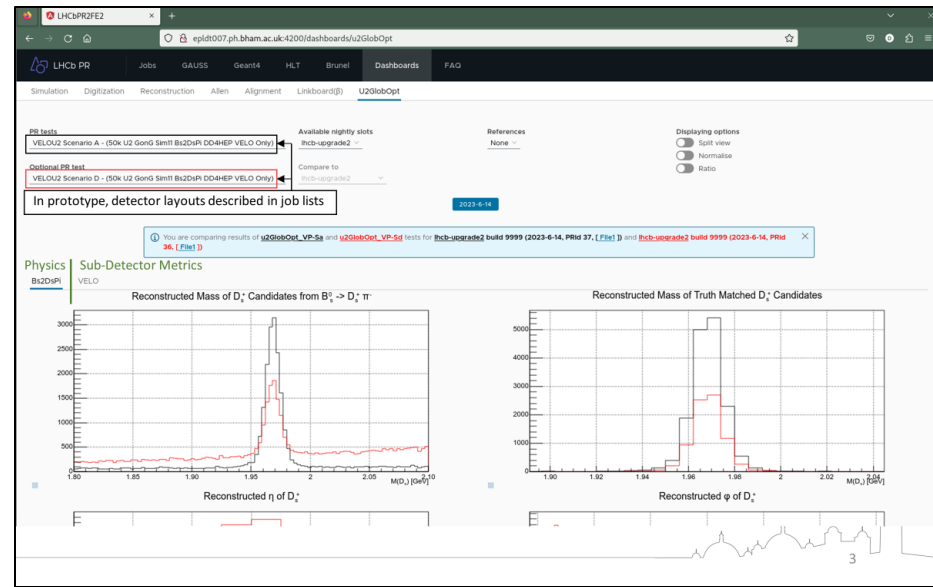
- Specify stack type and application
- Provide options files
- Specify **input files** or **“JobTitle”** to chain together

U2_MinBias_nu60_2p5K_TRK_TV-UP-MT_Moore-queue								
Platform	Stack Used	Nightly Flavour	Nightly Slot	Job Options	Handler	Application	Status	Output
x86_64_v2-centos7-gcc12-opt	U2_Trk			\\${DECFILESROOT}/options/30000000.py U2TrkStack_MinBias_nu60_MaterialChanges-scripts/Gauss-TVUPMP-Sim11.py U2TrkStack_MinBias_nu60_MaterialChanges-scripts/Gauss-Setup-Trunk.py U2TrkStack_MinBias_nu60_MaterialChanges-scripts/Beam7000GeV-md100-nu60-VerExtAngle.py U2TrkStack_MinBias_nu60_MaterialChanges-scripts/UseBeamSpot4D_sim11.py U2TrkStack_MinBias_nu60_MaterialChanges-scripts/2p5KEvents.py	U2_Trk_GaussHandler	Gauss	Completed	
x86_64_v2-el9-gcc13-opt		run5	9	U2TrkStack_MooreU2-scripts/upgrade_2.py	U2_Trk_MooreHandler	Moore	Completed 6	LFNs (ROOT files)

LHCbPR handlers

- **Auto-run** on the GRID-job output; ~one handler per plot
- **Wide range** of plots produced automatically
- Code-versioning ensures **reproducibility**
- **Plots preserved** for future comparisons

Results **currently** uploaded to local-instance of LHCbPR, plan to switch to official CERN instance when continuous development complete



LHCbPR
MOCK-UP

Dashboard - live

<https://epgr03.ph.bham.ac.uk/dashboards/u2GlobOpt>

(will move to a CERN address soon...)

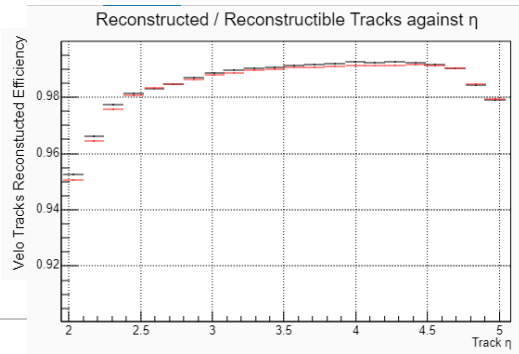
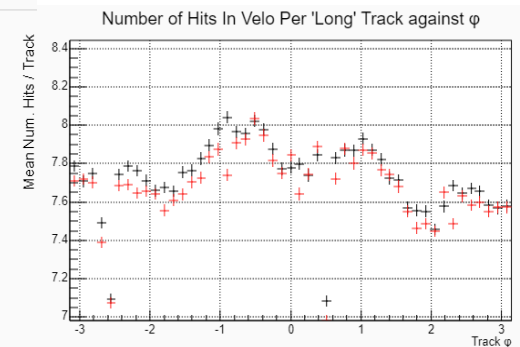
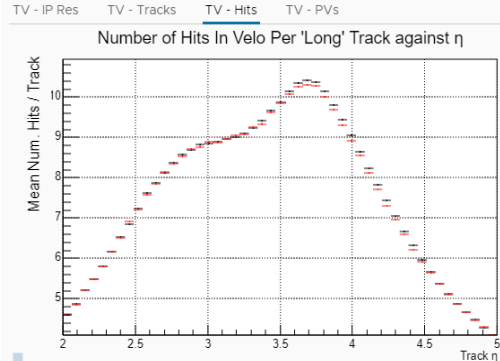
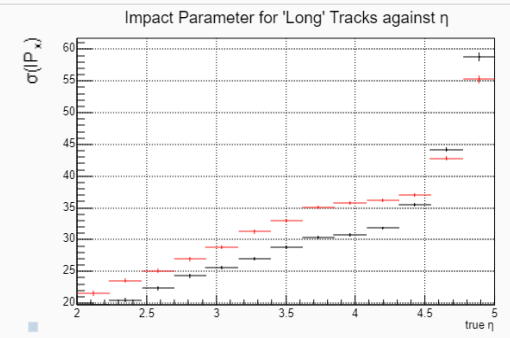
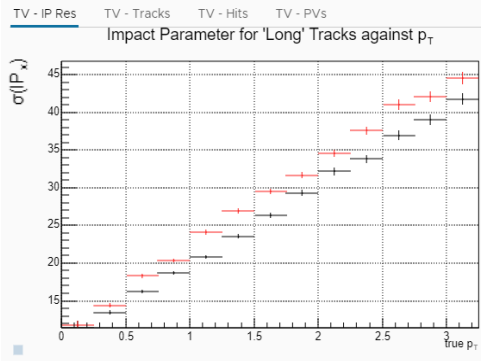


Results – Velo RF Shield

- Velo with **changing foil design** as first sub-detector testbench
- Custom stack with
 - Gauss: TV + Foil with Cylindrical, Corrugated, different radius, thickness
 - Moore: Customised reconstruction checkers
- 10K events take < 2 hours, split over 100 grid jobs
- **Results consistent with offline studies**
- Automatic production of all plots already **highlighting features/issues in unexpected places**

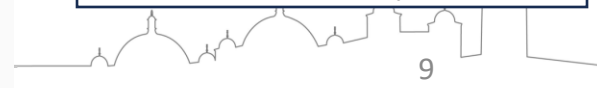
Many more metrics available under [“U2 Velo”](#) ...

You are comparing results of U2_MinBias_nu60_10K_TVOnly_75um3p5mmCylindFoil_10um50ps_Moore and U2_MinBias_nu60_10K_TVOnly_75um5p7mmCorrugFoil_10um50ps_Moore tests for lhcb-upgrade2-U2_TV build 9999 (2024-3-6, PRid 66, [File1]) and lhcb-upgrade2-U2_TV build 9999 (2024-3-6, PRid 67, [File1])



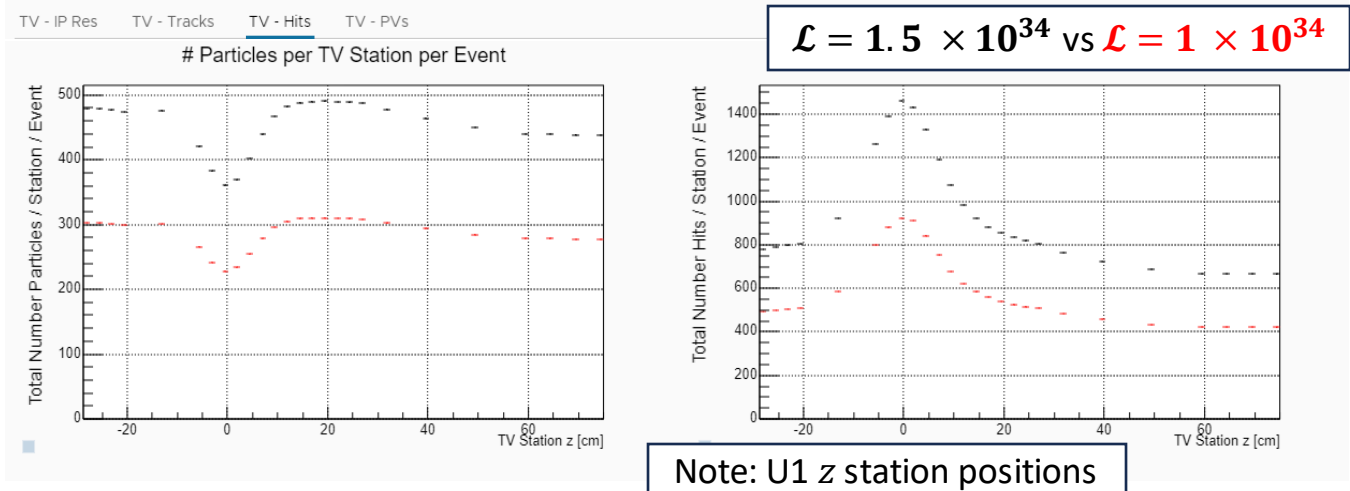
Cylindrical w/ $r = 3.5$ mm vs Corrugated w/ $r = 5.7$ mm (both $75 \mu\text{m}$ thick)

Note: Reco. with $\sigma_{xy} = 10 \mu\text{m}$

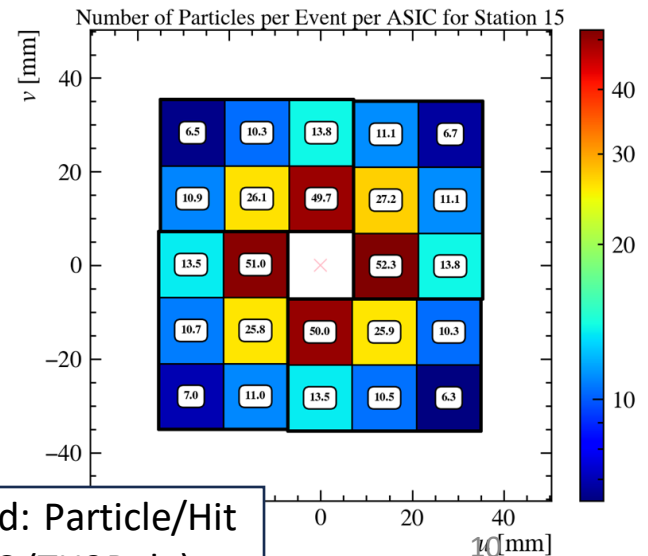


Results – Data rate

ⓘ You are comparing results of [U2_MinBias_nu60_10K_TVOnly_75um3p5mmCylindFoil_10um50ps_Moore](#) and [U2_MinBias_nu38_10K_TVOnly_75um3p5mmCylindFoil_10um50ps_Moore](#) tests for [lhcb-upgrade2-U2_TV build 9999 \(2024-3-6, PRid 66, \[File1\]\)](#) and [lhcb-upgrade2-U2_TV build 9999 \(2024-3-6, PRid 68, \[File1\]\)](#)



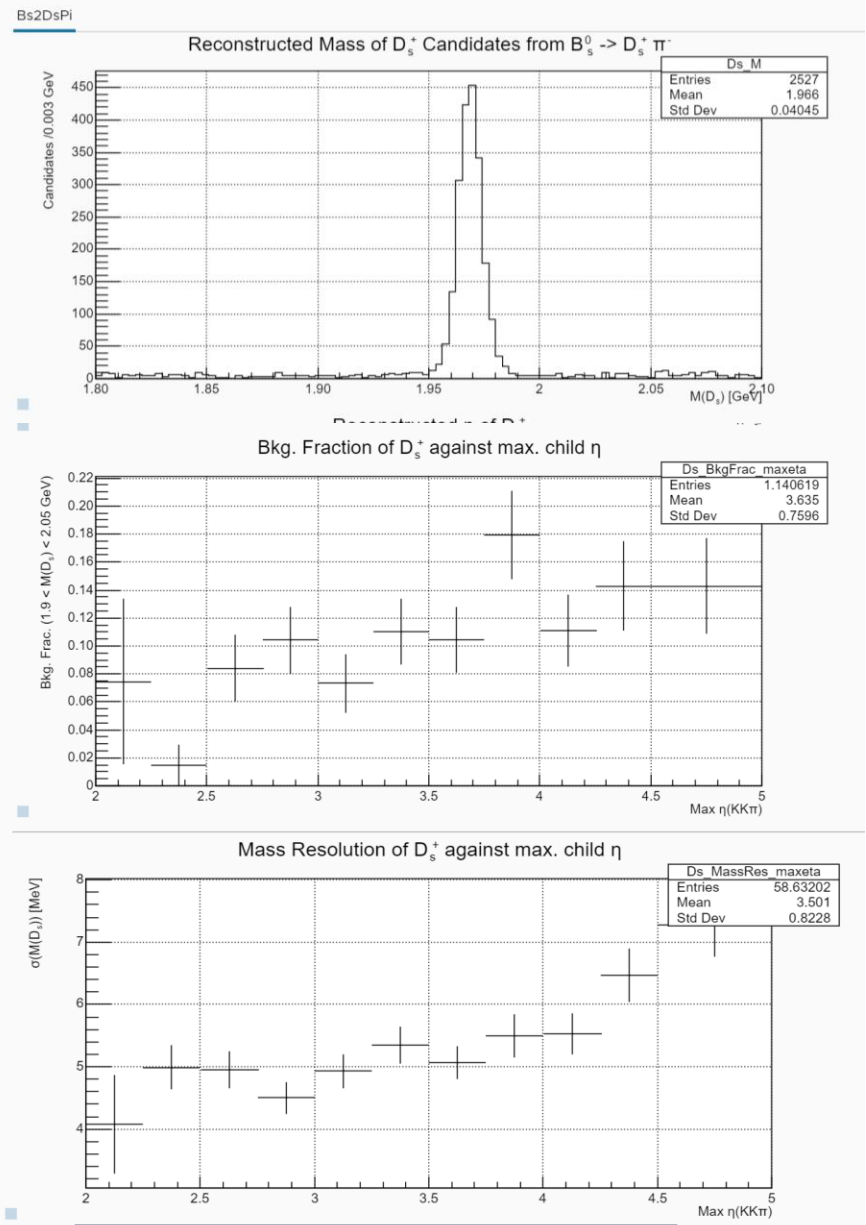
- Important to monitor **the particle rate and pixel hit rate** as designs change
- Results consistent with estimates, inner-most ASIC on Station 15 → **52 Particles / Event** ≈ **1 GHz/cm² track rate**
- Important metric for **ASIC designers** as station layout and size/numbers of ASICs change



Results - Physics

- Framework ready for studies beyond detector metrics towards projected physics results
- Analysis in Moore or Python based on Job outputs, handler to collect and present results
- VELO U2 study of $B_S^0 \rightarrow D_S^+ \pi^-$ implemented and presented here using [U2 Selections repo](#)
- Interest from U2 **Physics Benchmark analysis groups** to implement studies and present results on the Dashboard

Job Config
Handler



$B_S^0 \rightarrow D_S^+ \pi^-$ Sim. @ $\mathcal{L} = 1 \times 10^{34}$

Tracking Detectors – MT Occupancy

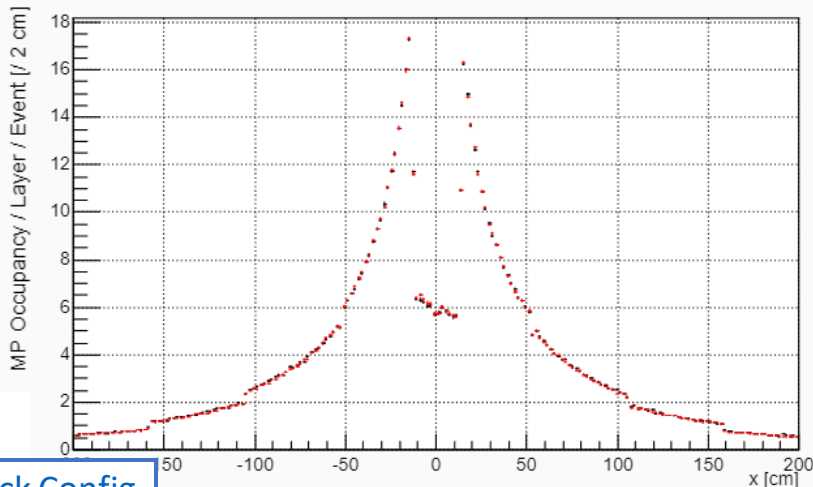
- Simulation of TV + UP + MT implemented using **custom Gauss stack** with rough/example sub-detector layout options, 2.5K events per sample:
 - TV Shield: **Cylindrical / Corrugated** (both 75 μm)
 - UP Material: **4 Planes / “3” Planes** (from 0.75 scaling of UP material ρ)
- **MT occupancy** studied as func. of material with MCHits in MP/FT
 - MCHits in MP footprint removed from FT

ⓘ You are comparing results of [U2_MinBias_nu60_2p5K_TRK_TV-UP-MT_Gauss](#) and [U2_MinBias_nu60_2p5K_TRK_TV_UP3Plane-MT_Gauss](#) tests for [lhcb-upgrade2-U2_Trk build 9999 \(2024-3-5, PRid 63, \[File1\]\)](#) and [lhcb-upgrade2-U2_9999 \(2024-3-5, PRid 60, \[File1\]\)](#)

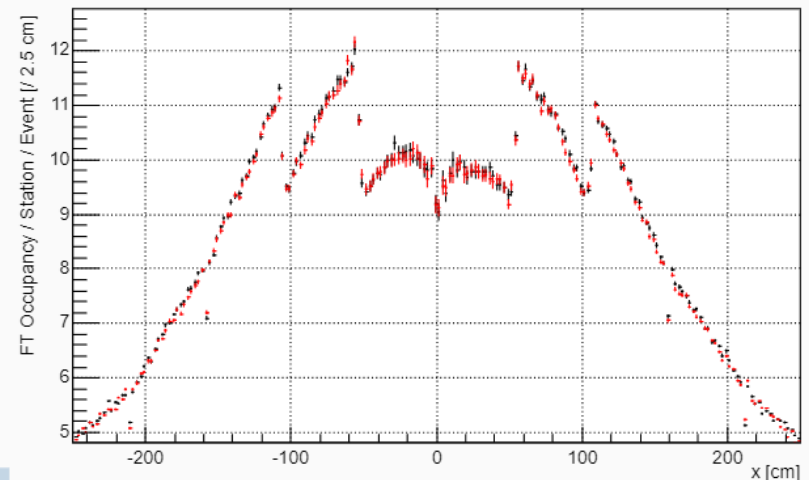
UP 4 Planes vs UP “3” Planes
@ $\mathcal{L} = 1.5 \times 10^{34}$

Occ. MP Occ. FT Occ.

MP MCHit Occupancy against x for Layer 0 / Event / 2 cm



FT MCHit Occupancy against x for Station 0 / Event / 2.5 cm

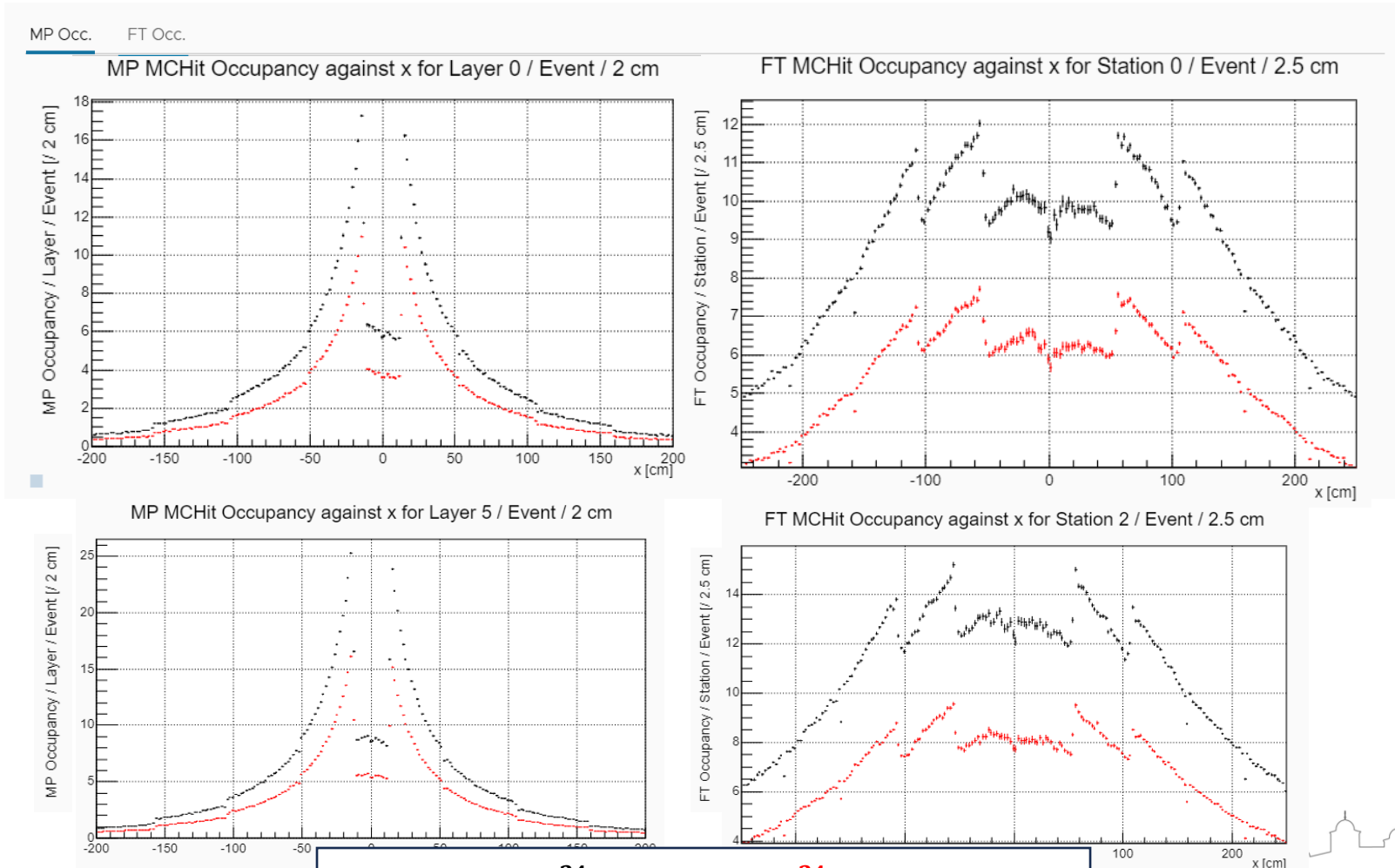


[Stack Config](#)
[Job Config](#)
[Handler](#)

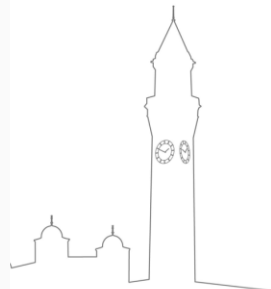
Supports conclusion that beam pipe showering is increasing occupancy in FT, **not the UP material**

Tracking Detectors – MT Occupancy

- **Occupancy** also studied for low and high luminosity scenarios
 - All MP layers + FT stations available on [dashboard](#) under “UII Trk. Det. Occupancy”

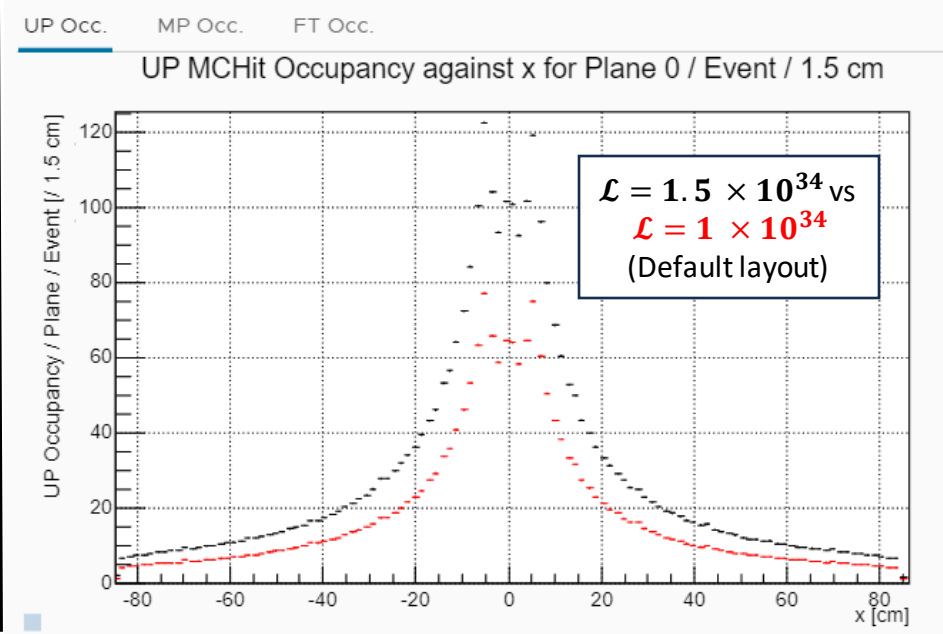
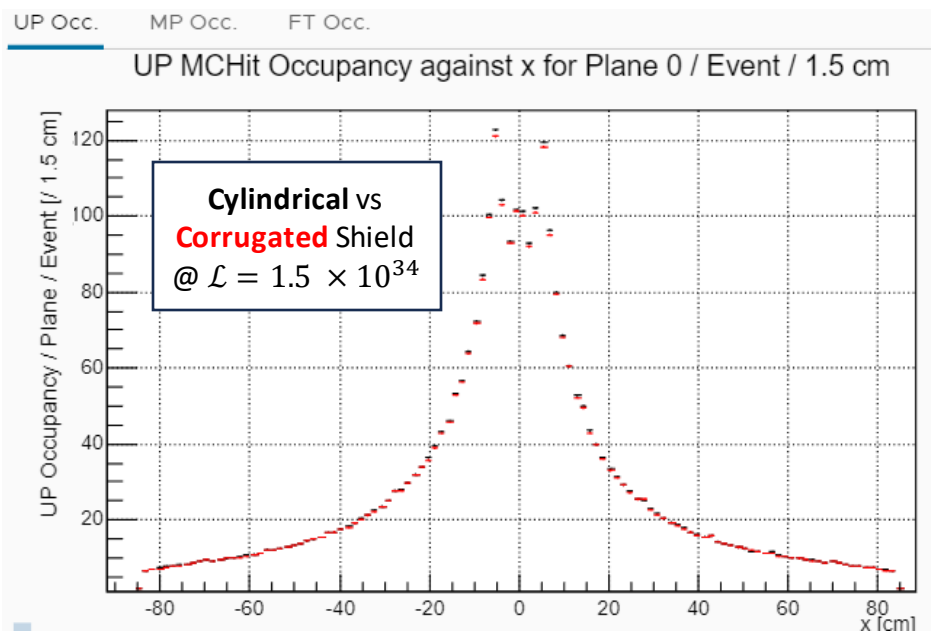


$\mathcal{L} = 1.5 \times 10^{34}$ vs $\mathcal{L} = 1 \times 10^{34}$ (Default layout)



Tracking Detectors – UP Occupancy

- **Occupancy** of UP measured with same method as a function of **RF Shield Design**
 - Does change in RF shield design change secondary track distribution in UP?

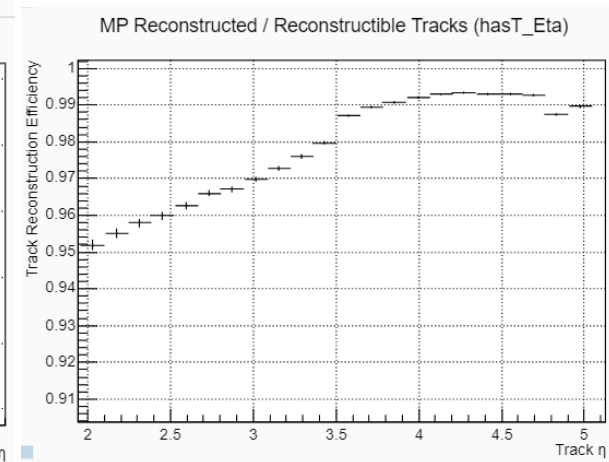
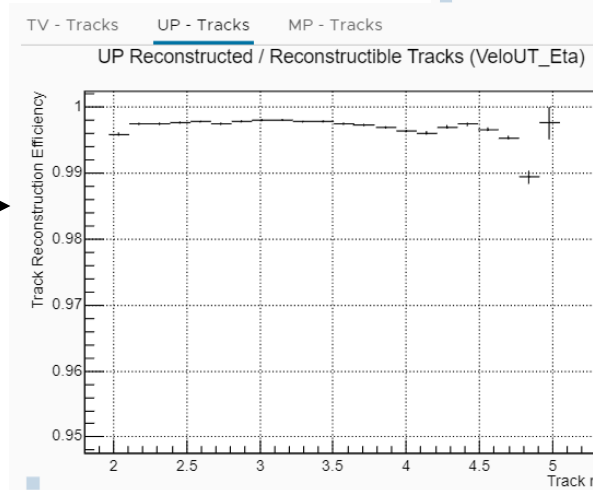
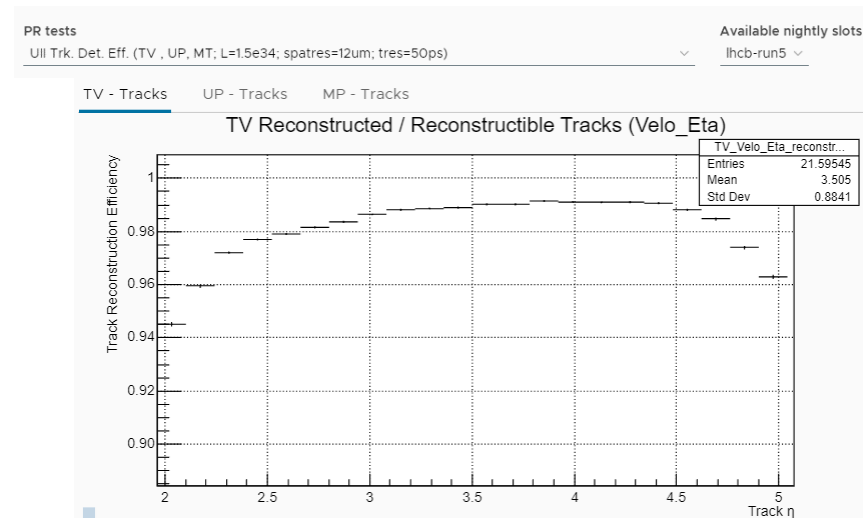


- These studies can **expand** simply by **adding more layout options** to stack
 - Change beam pipe and RICH1 material
 - **Add Magnet Stations**



Tracking Detectors - Reconstruction

- Run reconstruction automatically on **output** from TV+UP+MT Gauss jobs using [lhcb-run5](#) nightly stack release
- Use in-development [upgrade 2.py](#) script (Tim E. + Renato)
- Results will **improve and expand** as central script develops and further **sub-detectors** are added
- Now: reconstruction efficiency of **TV, UP and MP tracks** →
- Future: **Long + downstream tracking efficiency, ghost rates etc.**



[Job Config Handler](#)



Summary

- **New tool** for optimisation studies
 - Based on existing LHCbPR tools
 - New – stack book-keeping, build, slimline
 - New – backend GRID submission; 10k's of events
 - New – library of new handlers for U2
- **Already operational:** [at UoB now](#) ... soon moving to CERN
- New users for physics benchmark studies & detector performance
- To try it out, go to [this how-to](#), or get in touch with @dathomps

