

MAIA Digitization for Pixels

Ryan Roberts
Oct. 13 2026

MuColl/MAIA Simulation Pipeline

Here we are focused on the digitization that happens within the MuonColliderSoft workflow, which is used for reco-level performance and physics studies.

Similar role to PixelAV, but ideally less compute-intensive

Step	Signal	BIB	Output
Generation	MadGraph/ Particle Gun	Accelerator sim. + Fluka (run centrally)	MC Truth Particles (at IP/entry to detector volume)
Simulation	Geant4	Geant4 (run centrally)	Sim Hits (energy deposits in active detector material)
Digitization	MuCollSoft		Reco Hits (~clusters for pixel)
Reconstruction	MuCollSoft		Tracks, clusters, photons, jets, ...

Input to
PixelAV

MAIA Pixel Digitization Algorithms

- Digitization algorithms defined from steering [file](#).
- Default config uses [DDPlanarDigi](#). Hereafter “smearing”.
 - Originally for gas detector at ILC
 - Gaussian smearing of hit position. No pixels, no clusters.
- “Realistic” option in current [configs](#) uses [MuonCVXDigitizer](#). Hereafter “one at a time”.
 - Multiple scattering, diffusion, Landau fluctuations, threshold noise...
 - 1 sim hit at a time, might have multiple reco hits which include the same pixel.
 - Might have pixels that only fire when considering two sim hits.
- “Realistic” option developed by Angira, Simone is MuonCVXDRealDigitiser (same package as MuonCVXDDigitizer). Hereafter “all at once”.
 - Charge deposits from all hits in time window simulated. Then thresholding, then clustering.
 - No cluster or pixel timing.

MuonCVXDDigitizer Pixel Digitization Algorithms

- “One at a time” and “all at once” algorithms both in the same package.
- 3 important versions of this package
 - MuonColliderSoft/MuonCVXDDigitiser [master](#)
 - Parent version. Used in latest version of container. (*Ben suggests this isn't true in the beta version)
 - MuonColliderSoft/MuonCVXDDigitiser [gaudification](#)
 - Branch from Federico to migrate Marlin->Gaudi (also contains useful AI-generated README)
 - spg-berkeleylab/MuonCVXDDigitiser [master](#)
 - Contains latest developments from Angira
 - Includes support for endcaps, varying sensor thickness
 - Open [Pull Request](#) with lots of discussion and slides attached

MuonCVXDDigitizer Pixel Digitization Algorithms

- “One at a time” and “all at once” algorithms both in the same package.
- 3 4 important versions of this package
 - MuonColliderSoft/MuonCVXDigitiser [master](#)
 - MuonColliderSoft/MuonCVXDDigitiser [gaudification](#)
 - spg-berkeleylab/MuonCVXDDigitiser [master](#)
 - My branch (not yet in github, based on Federico’s gaudification branch)
 - Algorithms don’t save fired pixels by default.
 - “One at a time” has an option to do so. Pixels are in a separate collection with links between pixels and clusters (reco hits).
 - I added this option for “all at once” algorithm.

Takeaways

- Landscape of digitization is non-trivial.
 - Multiple algorithms, multiple versions of each, each has tunable parameters.
- Working setup to generate pixel clusters at scale using MuColl Software stack.
 - Tested on 10 events of muon gun with and without BIB (0.5% bunch crossing for testing).
 - Restricted to vertex barrel for now.
 - Results seem sane so far. About 2k clusters per event, 10-20k pixels fired.
- Seems likely we will observe differences beyond merged clusters.
 - Cleanest comparisons will be signal muons without BIB and then non-overlapping BIB.
 - Would also want pixelAV simulations on the latest BIB to compare to.
- Should have everything we need to start generated samples!