Summary of last week Detector Performance and MDI meeting

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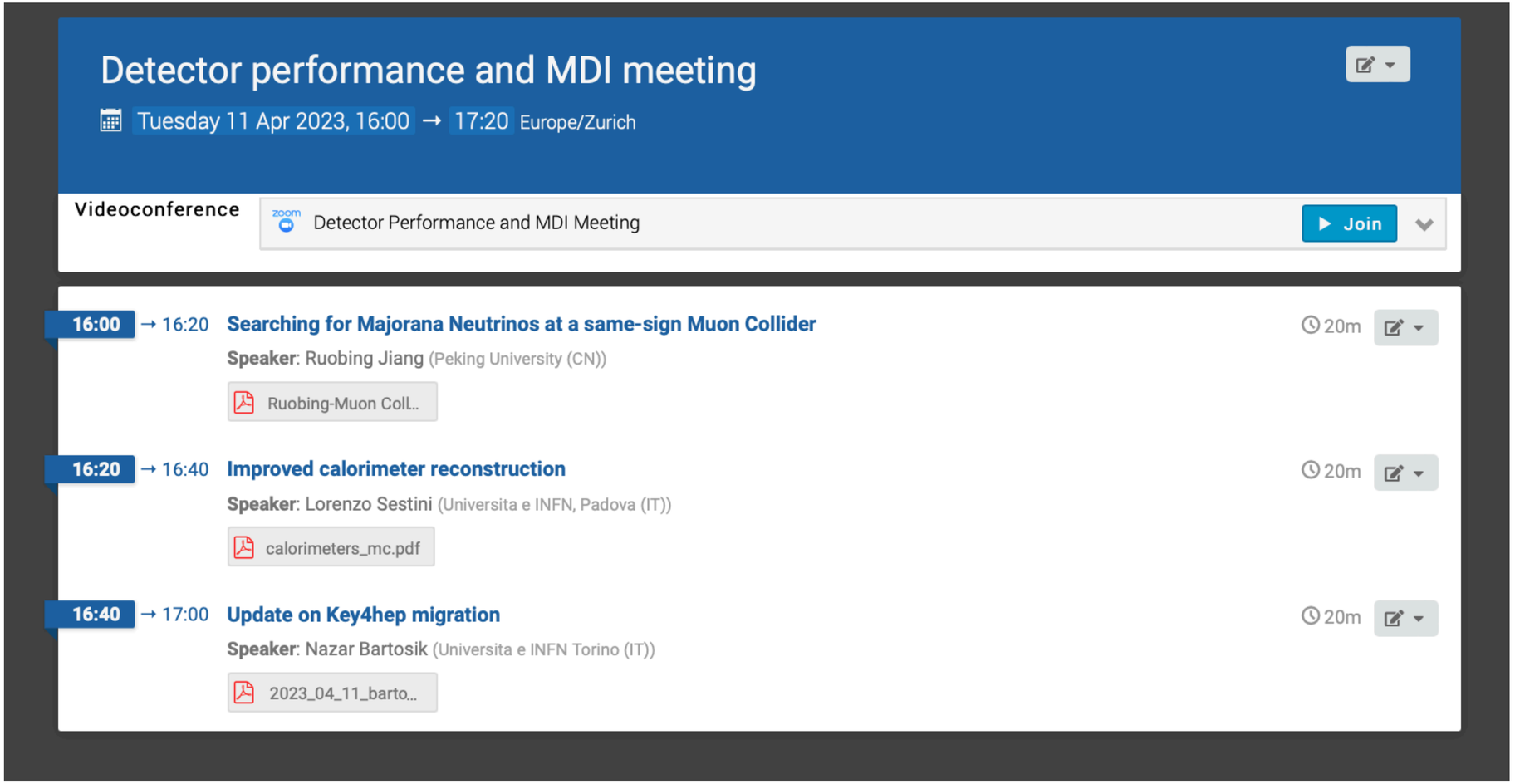
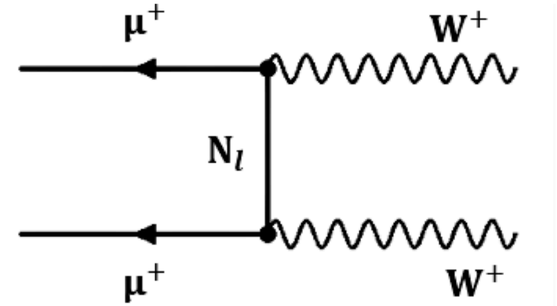
Physics and Detector Studies and WP2 - MuCol Activities, 18/4/2023

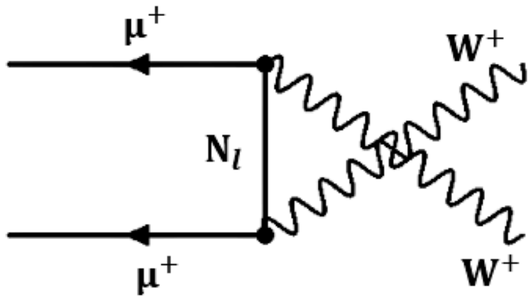

Detector performance and MDI meeting
Tuesday 11 Apr 2023, 16:00 → 17:20 Europe/Zurich
Videoconference
Detector Performance and MDI Meeting
Join
16:00 → 16:20 Searching for Majorana Neutrinos at a same-sign Muon Collider
20m
Speaker: Ruobing Jiang (Peking University (CN))
Ruobing-Muon Coll...
16:20 → 16:40 Improved calorimeter reconstruction
20m
Speaker: Lorenzo Sestini (Universita e INFN, Padova (IT))
calorimeters_mc.pdf
16:40 → 17:00 Update on Key4hep migration
20m
Speaker: Nazar Bartosik (Universita e INFN Torino (IT))
2023_04_11_barto...

Search for Majorana neutrinos

Signal process: $\mu^+\mu^+ \to W^+W^+$



(a) t-channel



(b) u-channel

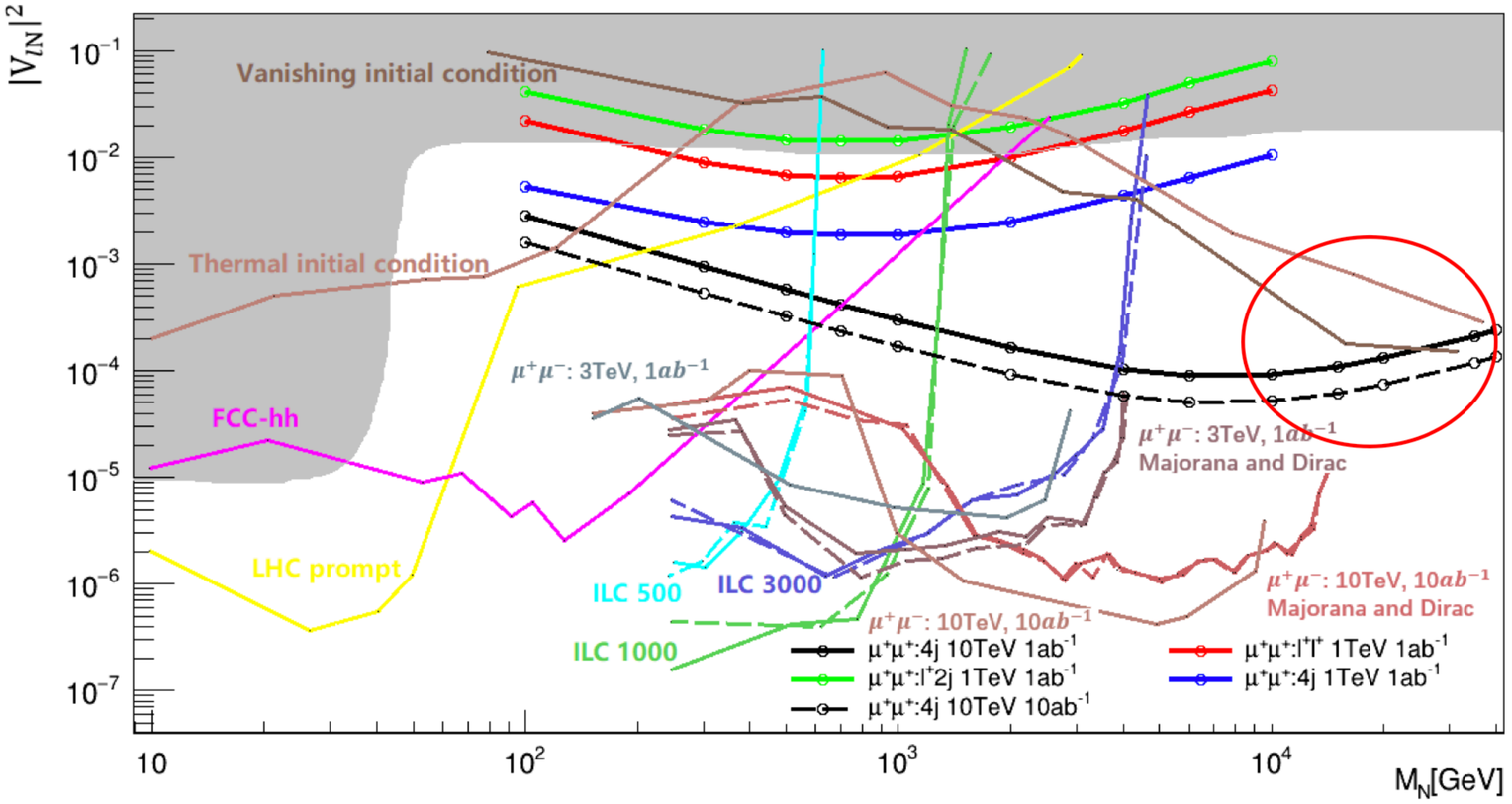
- This process is a typical LNV process.
- This process related to the mediation by Majorana neutrinos.
- This t(u)-channel process is less kinematically suppressed.
- The final states of this process are not complicated.

Backgrounds of this process:

- $\mu^+\mu^+ \to W^+W^+\bar{\nu}_\mu\bar{\nu}_\mu$
- $\mu^+\mu^+ \to ZW^+\mu^+\bar{\nu}_\mu$
- $\mu^+\mu^+ \to W^+\mu^+\bar{\nu}_\mu\bar{\nu}_\mu$
- $\mu^+\mu^+ \to Z\mu^+\mu^+$
- $\mu^+\mu^+ \to ZZ\mu^+\mu^+$
- $\mu^+\mu^+ \to W^+W^-\mu^+\mu^+$
- $\gamma\gamma \to W^+W^-$

Search for Majorana neutrinos

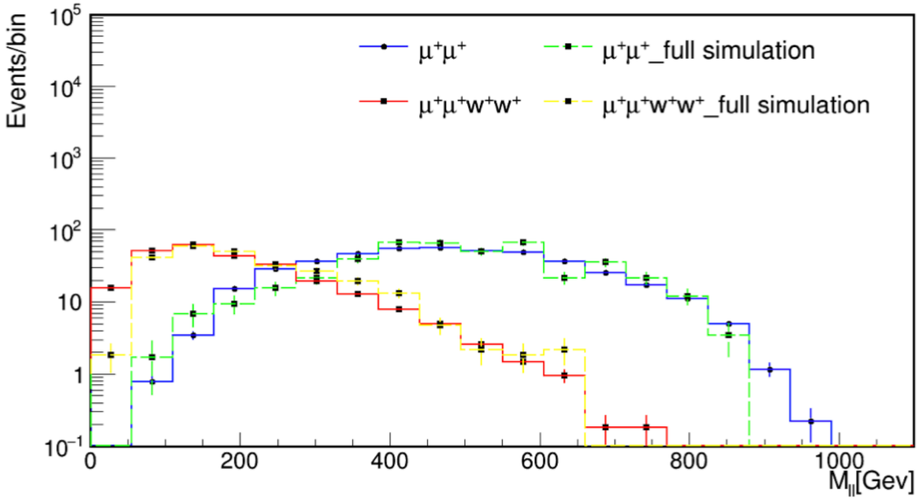
CL=95% exclusion limit of squared mixing element $|V_{\mu N}|^2$ as a function of varying Majorana neutrino mass M_N.

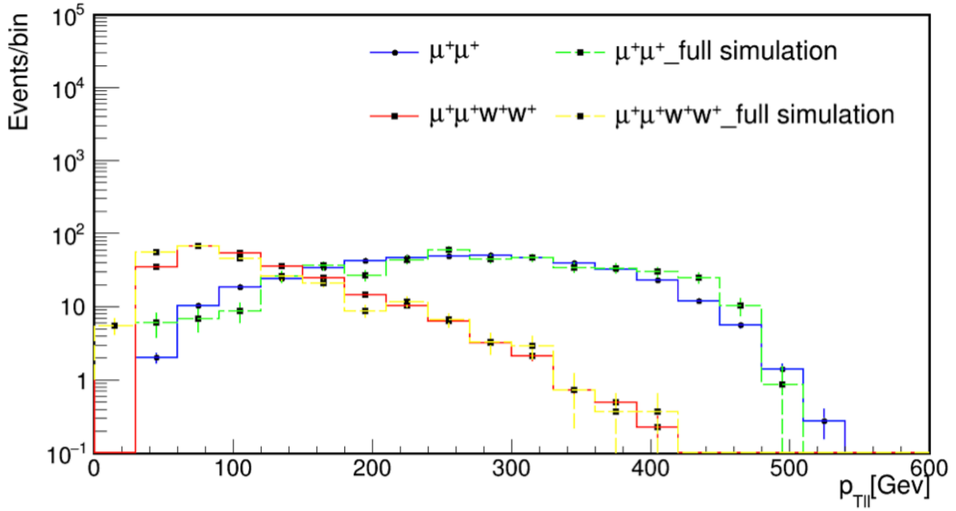


Summary of fast simulation studies

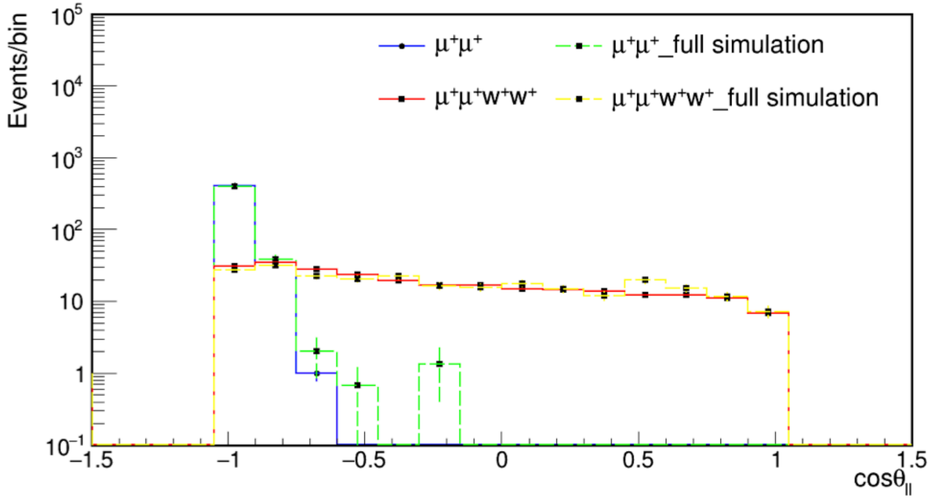
Search for Majorana neutrinos

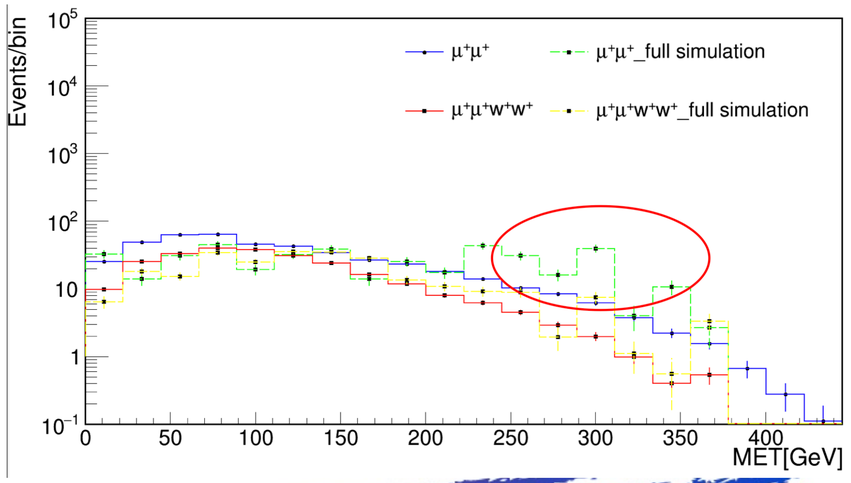
- Signal: $\mu^+\mu^+ \to W^+W^+, W^+ \to \mu^+\nu_\mu, W^+ \to \mu^+\nu_\mu$.
- Background: $\mu^+\mu^+ \to W^+W^+\bar{\nu}_\mu\bar{\nu}_\mu, W^+ \to \mu^+ + \nu_\mu, W^+ \to \mu^+\nu_\mu$





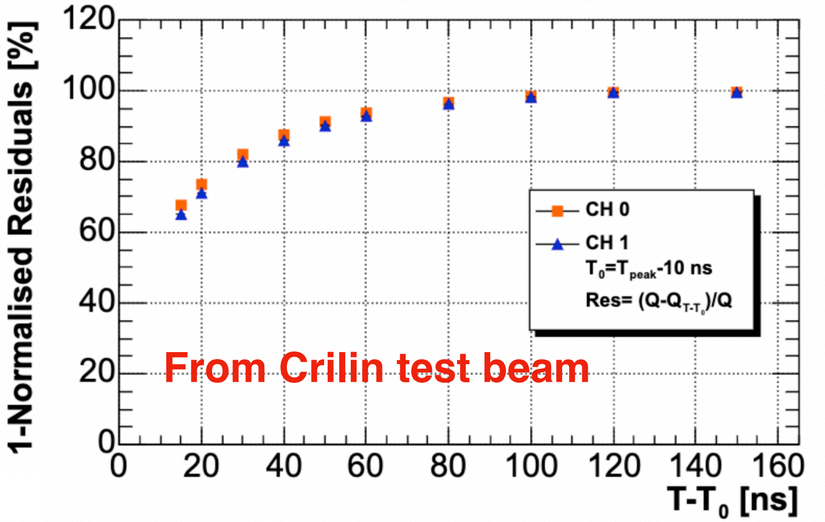
Comparison between fast and full simulation



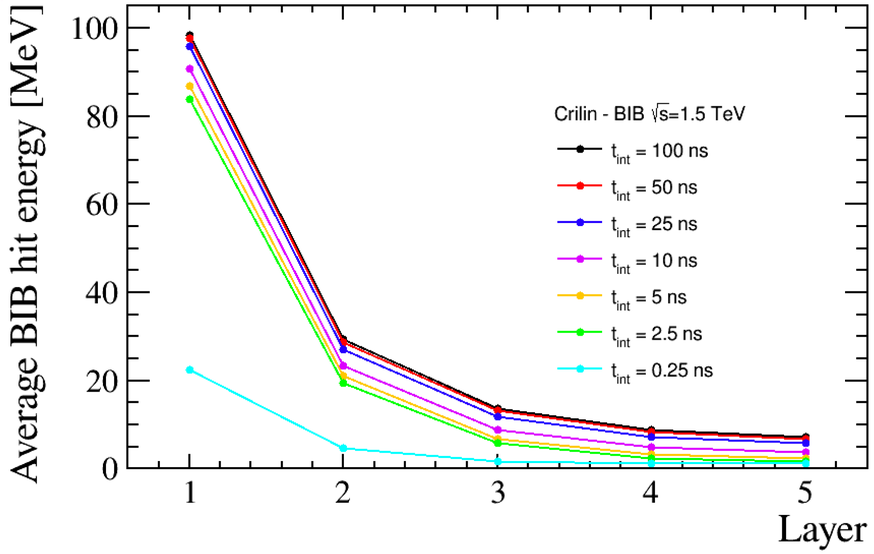


Improved calorimeter reconstruction

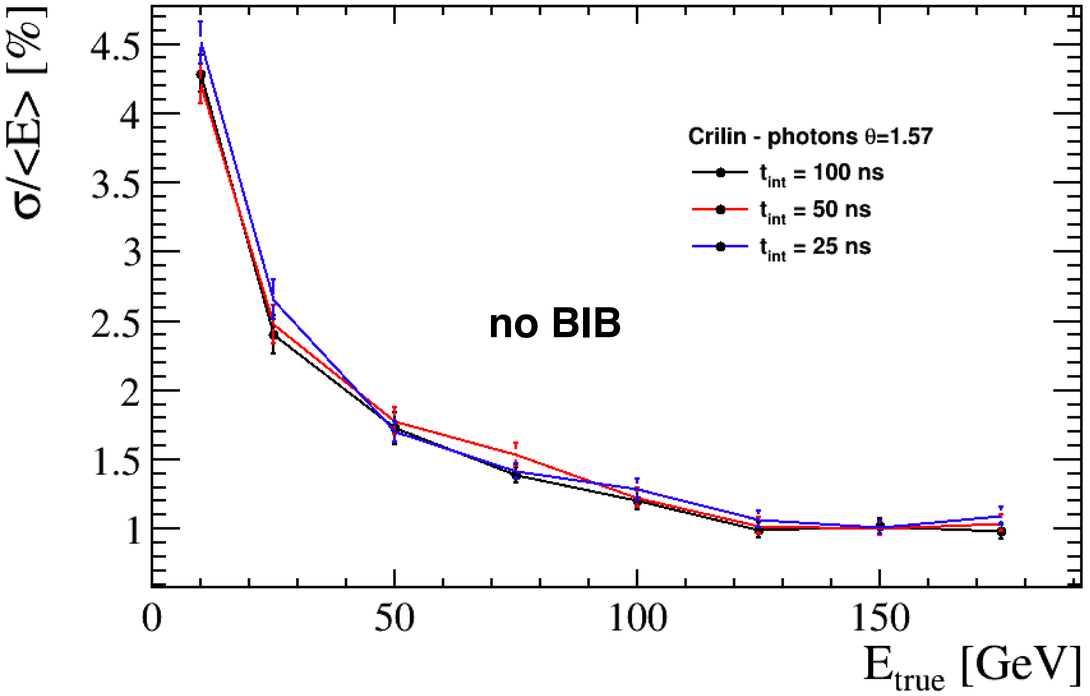
The fraction of signal charge collected



The effect of the integration time has been implemented in the digitization of Crilin ECAL barrel (5 layers PbF_2)



Peak resolution after calibration



Improved calorimeter reconstruction

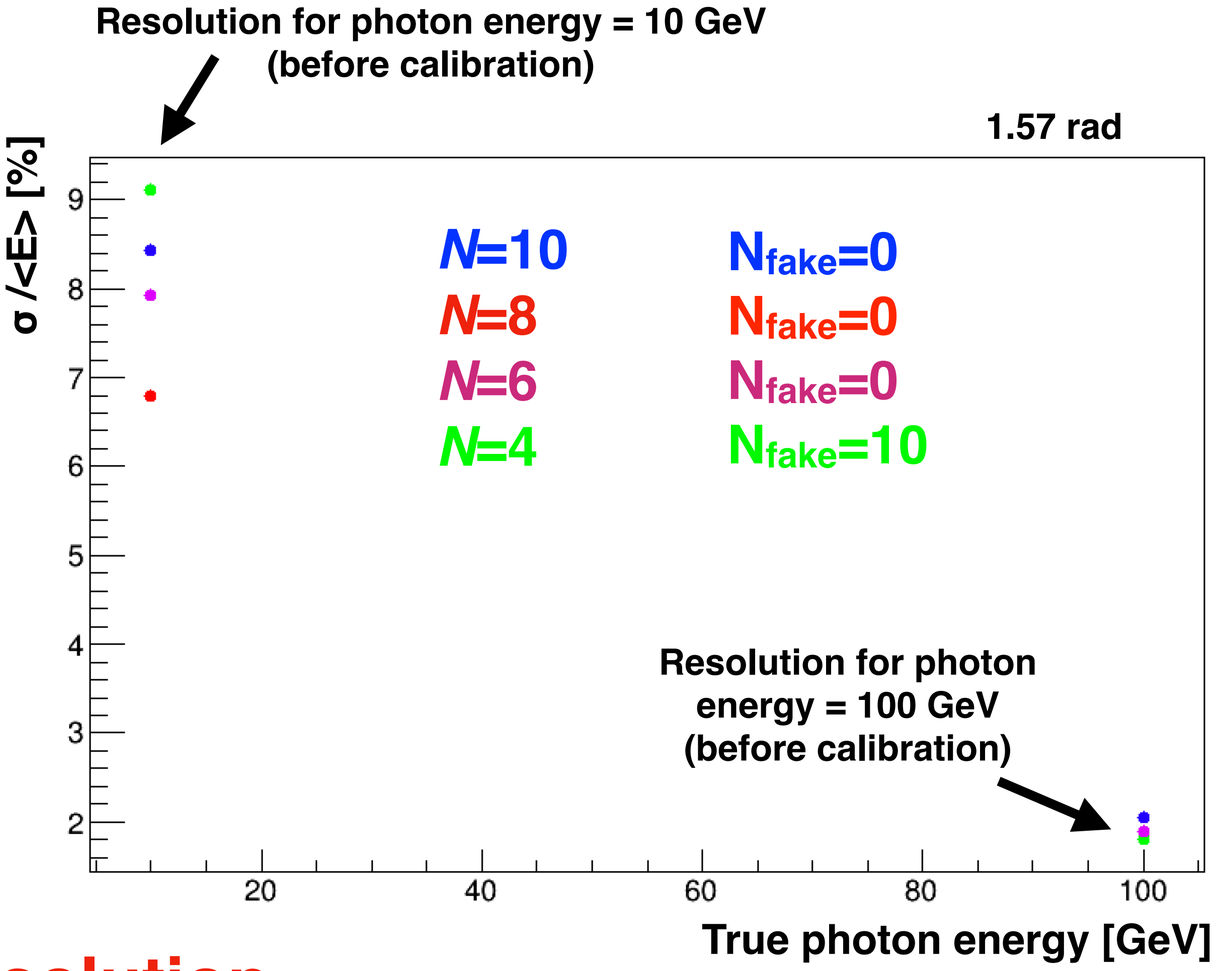
- Thresholds are defined as

$$E_{th}(L,Z) = < E_{BIB} > (L,Z) + N \cdot STD_{BIB}(L,Z)$$

Where ***<E$_{BIB}$>(L,Z)*** is the average and ***STD$_{BIB}$(L,Z)*** is the standard deviation of BIB cell energy in **layer *L*** and **region *Z***

N is a parameter to be tuned with Signal+BIB

- Lower *N* means higher efficiencies and fake rate
- Not-trivial relation between *N* and peak resolution

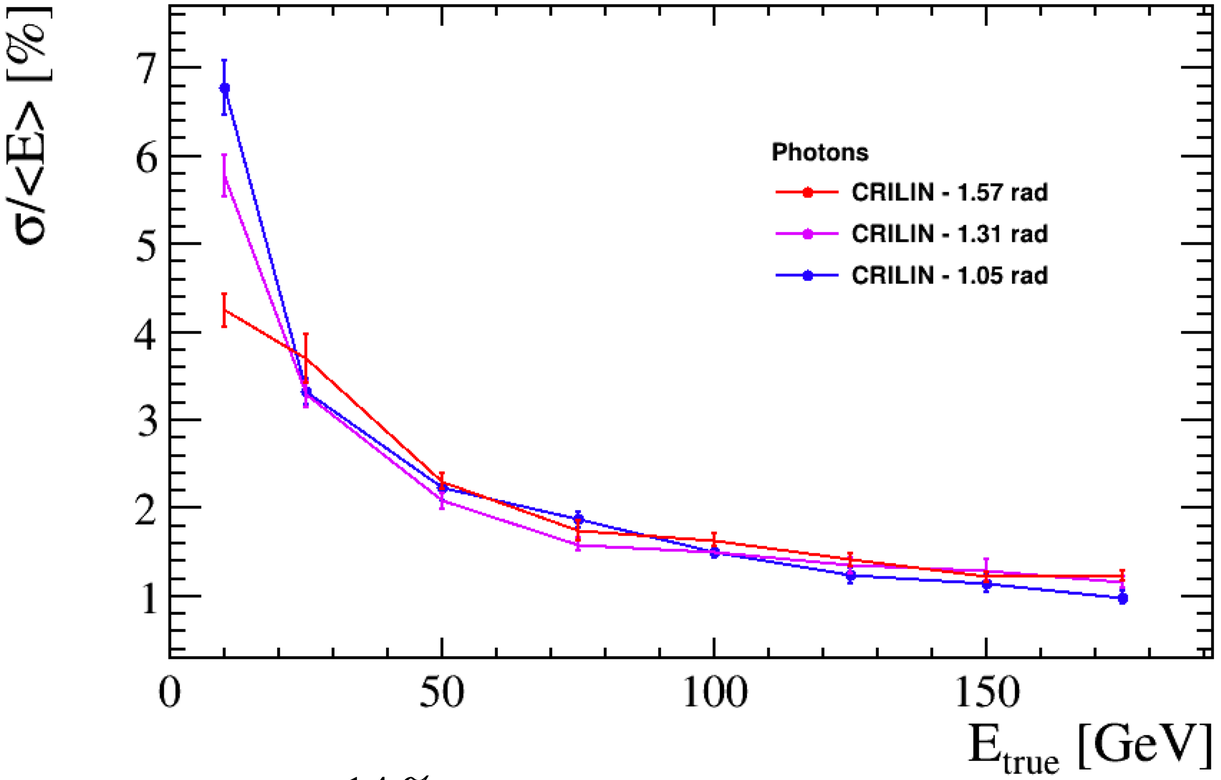


Optimized for best energy resolution

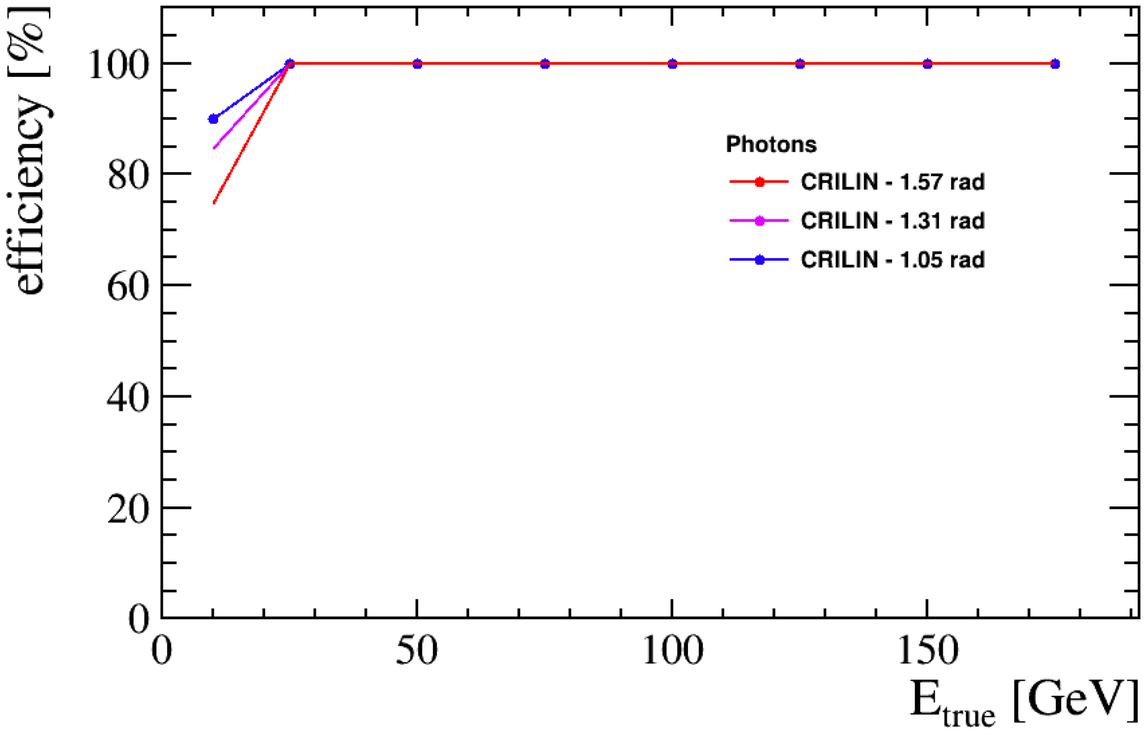
***N* = 7 is used**

Improved calorimeter reconstruction

BIB included



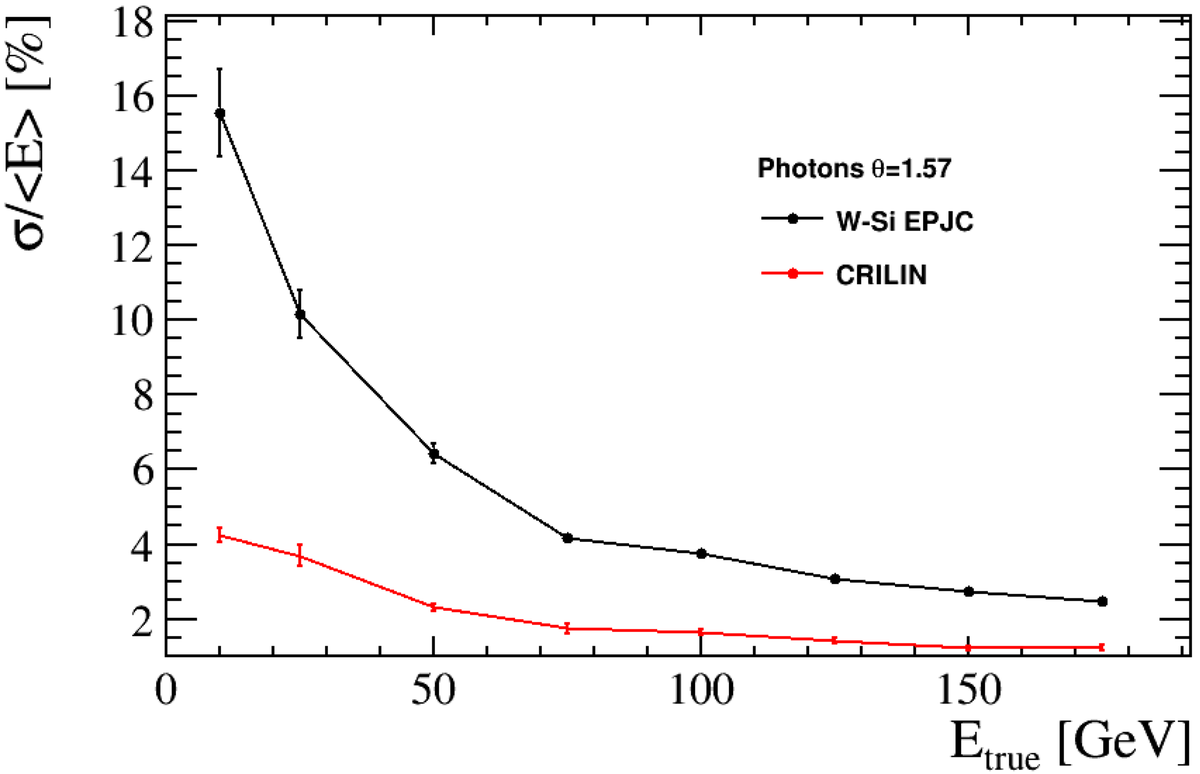
$$\frac{\sigma}{E} \simeq \frac{14\,\%}{\sqrt{E}}$$ for theta = 1.57

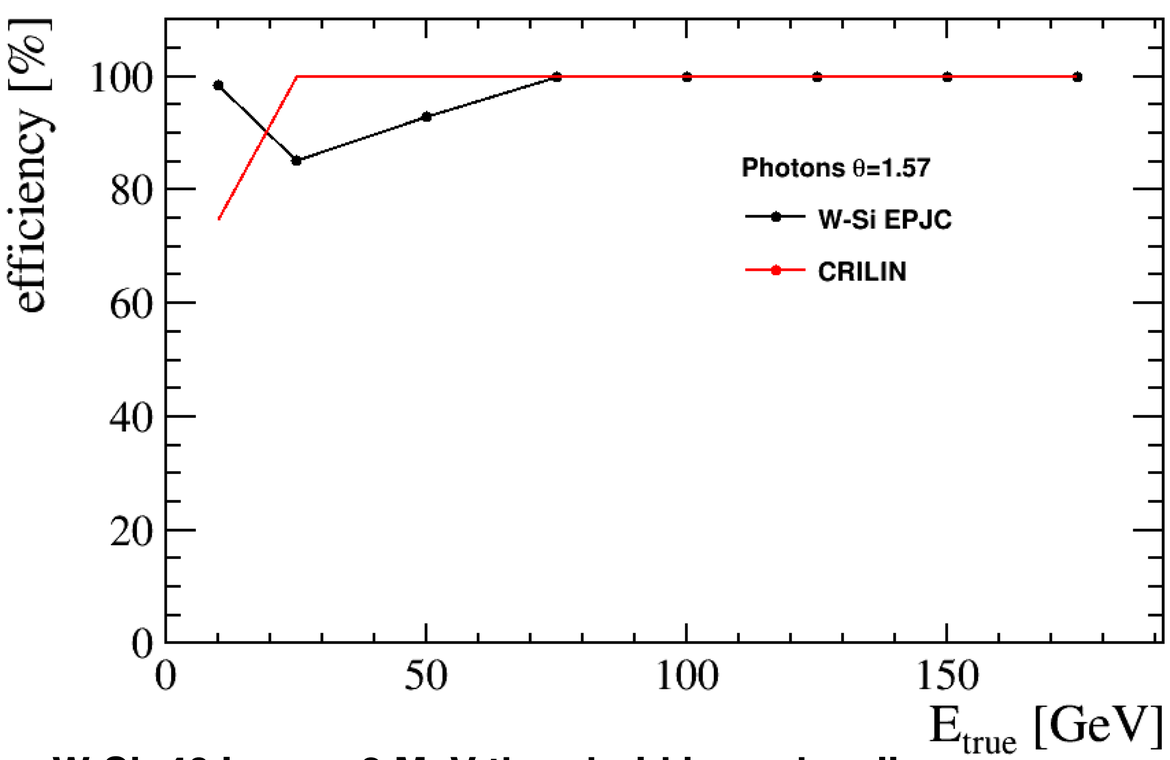


$N^{fake}_{CRILIN} \simeq 0$ number of fake clusters per event

Improved calorimeter reconstruction

BIB included





W-Si: 40 layers, 2 MeV threshold in each cell

$$N^{fake}_{CRILIN} \simeq 0$$

$$N^{fake}_{W-Si} \simeq 60$$

This optimization does not work for jets but the same strategy could be employed (WIP)

Update on Key4hep migration

Steps for the gradual transition to Key4hep:

1. **Spack** ✓ **working Docker image prepared, using Spack package manager:** key4hep branch
   ↳ based on AlmaLinux 9 (EL9) distribution

2. **Gaudi** **converting reference Marlin configurations to Gaudi**
   ↳ will be placed in mucoll-benchmarks repository: baseline analysis reference

Key4hep and Spack: few technicalities

Repositories involved in the new setup:

1. MuonCollider-docker: **build.sh + run.sh scripts for easy building and running of the image**

2. mucoll-spack: **Spack repository of packages specific to Muon Collider**
   ↳ used as a 2nd layer on top of the official Key4hep repository

   - **versioning done via realease tags** → to be created soon
   - **requires Spack version >= 19.0** (in progress of adoption by Key4hep)
     ↳ to define exact versions of all the dependencies
   - **currrently using versions identical to ILCSoft release 2.8**
     ↳ defined in the environment configuration: packages.yaml

Update on Key4hep migration

Repositories under MuonColliderSoft need some restructuring

MuonCutil is becoming obsolete

- **SoftCheck/** configuration files for installation tests → **new repository: mucoll-test?**
- **confile/** reference sim-reco configuration files → **should move to mucoll-benchmarks**
- **macros/** example plotting macros → **should move to mucoll-benchmarks**
- **releases/** latest release configuration → **moved to mucoll-spack**

reference for tutorials

detector-simulation is becoming obsolete

- **geometries/** compact XML geometry definitions → **should go to lcgeo**
  ensures consistency between C++ and XML parts within a single package version
- **utils/** MARS15/FLUKA → LCIO scripts → **should go to mucoll-benchmarks**

Old repositories will remain on GitHub for a while for backward compatibility with ILCSoft

Update on Key4hep migration

Geometries naming

Moving to lcgeo is a good moment to homogenise the naming of our geometries:

- `MuColl_v1` major version of the geometry, relevant for the outside world
  e.g. geometry designed for $\sqrt{s}$ = 1.5 TeV, frozen for Snowmass studies
- `MuColl_v1.1` minor version with backward-compatible changes: code imrovements, fixes
  ↳ no changes to sensitive-volume layout → no need to rerun BIB simulation
  newer versions can be gradually adopted by users
- `MuColl_v1.1.1` same as **v1.1**, but with some experimental change in the geometry
  e.g. increased thickness of passive material in VXD to account to cooling;
  e.g. alternative technology for ECAL detector

There are two alternative geometries in detector-simulation

- Crilin_ECAL/ in the ***master*** branch → `MuColl_v1.1.4`
- MPGD_Muons/ in the ***picosec*** branch → `MuColl_v1.1.5`
  + MuonProcessorPV Marlin processor → is it strictly coupled to the geometry?

Thanks for your attention!

Backup