Delphes Tutorial

Jan Eysermans (Massachusetts Institute of Technology)

Second Annual U.S. Future Circular Collider (FCC) Workshop 2024

March 26, 2024

Various Needs for Detector Simulation

FCC-ee covers a wide-range of potential physics

- 4 interaction points asks for 4 detectors

Detector design crucial

- Maximize the sensitivity and physics potential
- Differentiate among detector technologies
- General purpose vs. physics-oriented (e.g. flavour)
- Statistics are high so take into account systematics in detector design – redundancy, efficiency, stability

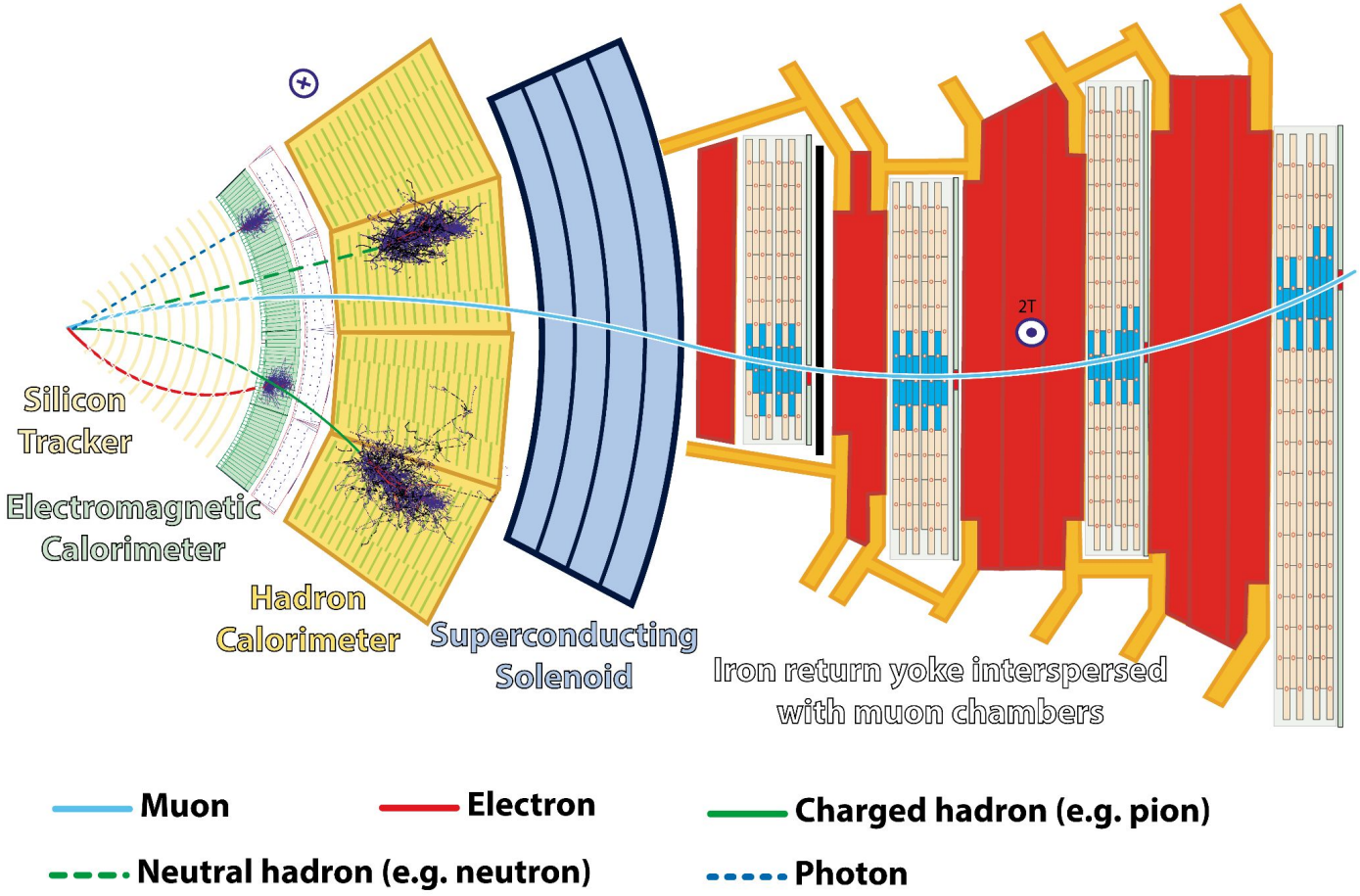
Detector concepts are in continuous development

- Hardware prototyping, electronics design
- Reconstruction techniques (high granularity and Machine Learning)

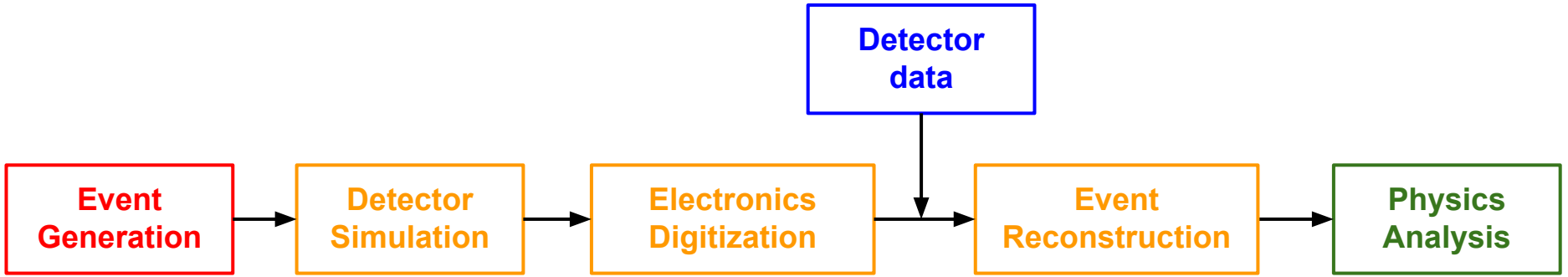
Need simulation for guidance and optimization

- Fast-simulation O(0.1 s/ev) can be used for quick turnaround and iterations of detector concepts → see this tutorial
- Full Simulation O(100 s/ev) with solid detector concepts with → see tutorial Brieuc after

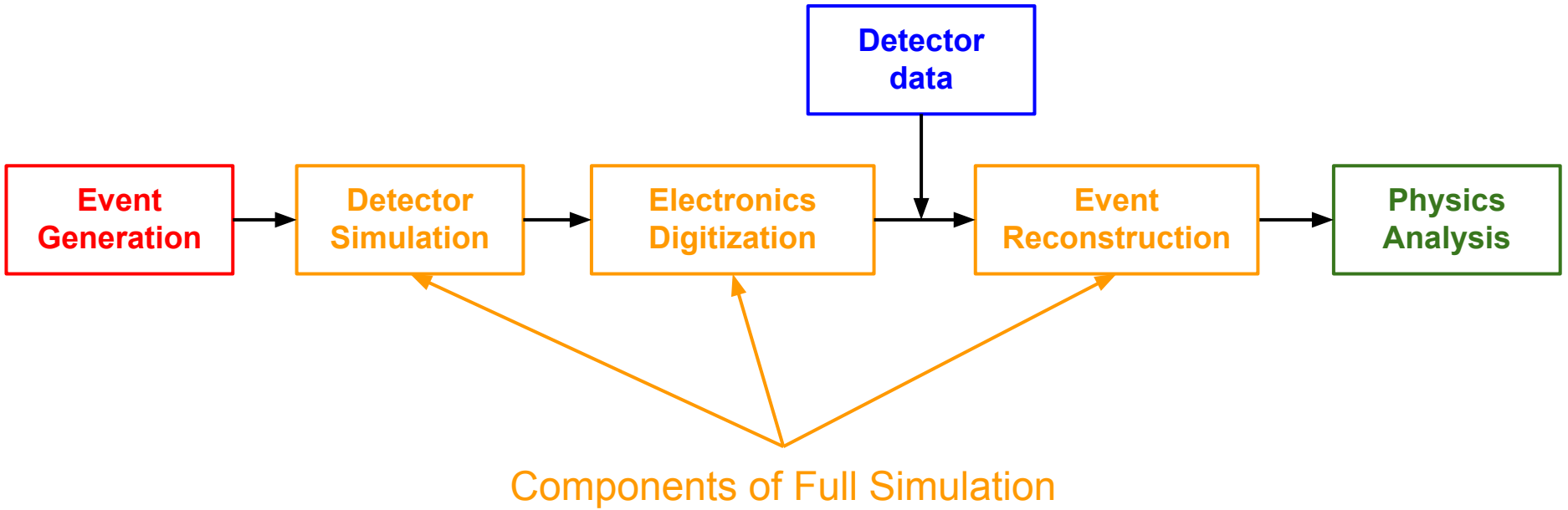
A Typical Detector Layout



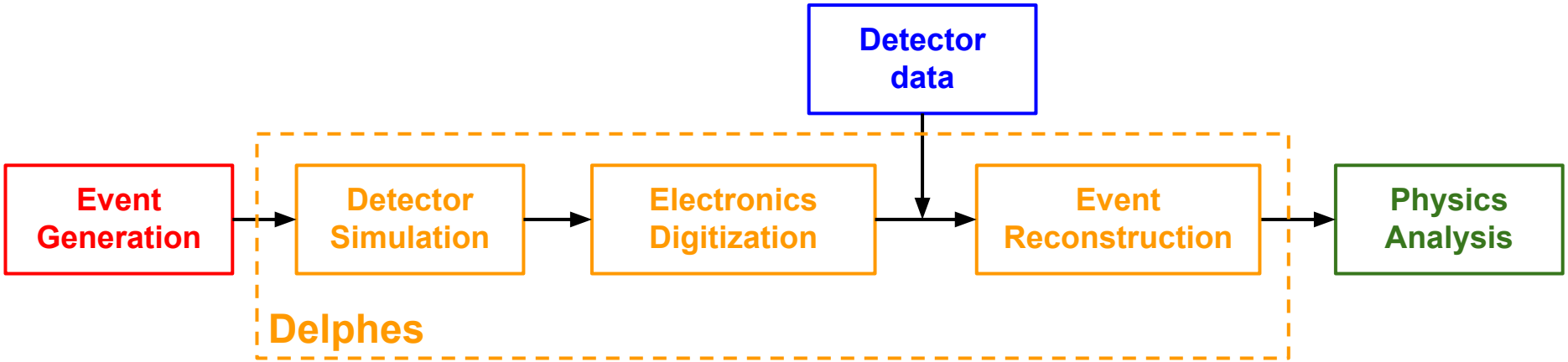
Detector, Simulation and Reconstruction Chain



Detector, Simulation and Reconstruction Chain



Detector, Simulation and Reconstruction Chain



Fast Simulation package Delphes combines the 3 steps (SIM/DIGI/RECO) into one:

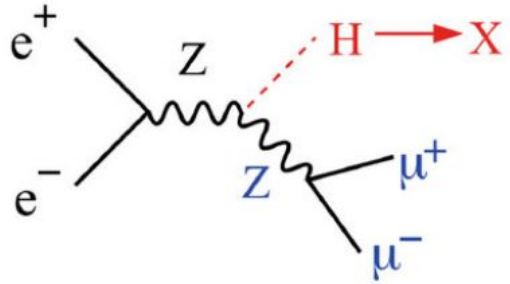
- Transport in an (empty) homogeneous magnetic field
- Parametric approach: smear Monte Carlo particles to match desired reconstruction behavior
- Include ad-hoc detector inefficiencies
- Particle Flow and PID implemented

Added slides from M. Selvaggi to the agenda for more info about Delphes

Delphes Tutorial (1)

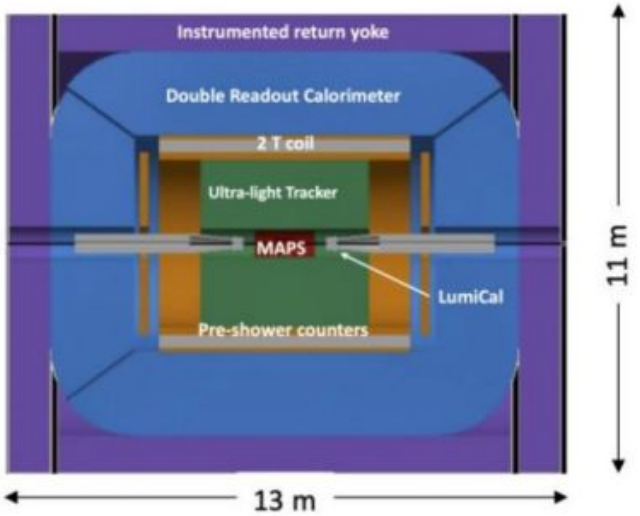
We will generate events $e^+e^- \rightarrow Z(\mu\mu)H$ and plot the recoil distribution for several detector concepts

- Event generator Pythia8
- Using Delphes for detector simulation and reconstruction
- Simple python script to analyze events and plot the recoil mass distribution
  - Can also use FCCAnalyzer software tools



We will use two detector configurations:

- **Default IDEA detector (see talk yesterday)**
  - Silicon pixel vertex
  - Light drift chamber → excellent tracking resolution
  - Monolithic dual readout calorimetry
  - 2T magnetic field, thin coil
- **Replace Drift Chamber with Silicon tracker**
  - Due to heavier material (silicon), there will be more multiple scattering w.r.t. drift chamber
  - Slightly worse tracking resolution expected



Delphes Tutorial (2)

Step 1: login to a computer node (alma9 node, with cvmfs)

- **CERN** lxplus.cern.ch
- **MIT** submit81.mit.edu

link to all commands

Step 2: download the necessary files

```
wget http://submit08.mit.edu/~jaeyserm/fccee/tutorial_delphes/delphes.tar.gz
tar -xvf delphes.tar.gz
cd delphes
source setup.sh
```

Step 3: generate events and run Delphes on top of it

```
DelphesPythia8_EDM4HEP detector_card.tcl config_card.tcl pythia_card.cmd output.root
DelphesPythia8_EDM4HEP gen/card_IDEA.tcl gen/edm4hep.tcl gen/p8_ee_mumuH_ecm240.cmd p8_ee_mumuH_ecm240_IDEA.root
DelphesPythia8_EDM4HEP gen/card_IDEA_SiTrck.tcl gen/edm4hep.tcl gen/p8_ee_mumuH_ecm240.cmd p8_ee_mumuH_ecm240_IDEA_SiTrck.root
```

Step 4: analyze events and make plots

```
python makePlot.py
display recoil_mass.png # (or cp *.png /home/submit/$USER/public_html/)
```

All in one go: `./run.sh`

Delphes Tutorial (3)

Tasks:

- Run with higher statistics: 1000 → 10000 (Pythia cmd card)
- Increase magnetic field from 2T to 3T (detector tcl card)
- Reduce or remove the Beam Energy Spread (Pythia cmd card)
- Increase the center-of-mass energy to 365 GeV