MC production for FCC-hh physics

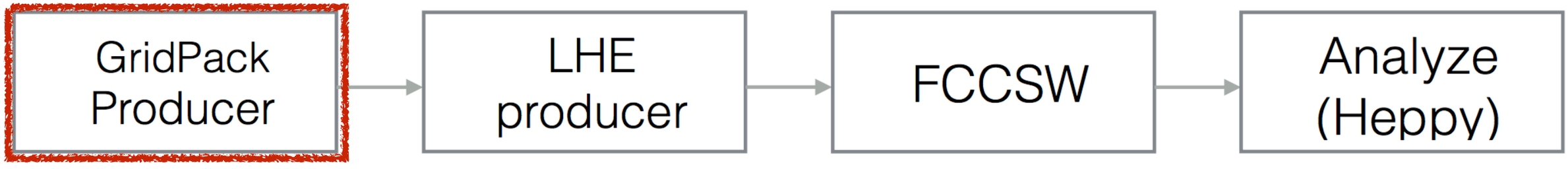
Michele Selvaggi, Clement Helsens
CERN

FCC-hh Physics Meeting - 28/04/2017 - CERN

Outline

- Status and plans
- Discussion on generation of specific processes (DY, γγ)

GridPacks



- **GridPack Producer**[1]
  - makes MG5_aMC@NLO GridPacks (i.e standalone program that produces LHE files)
  - Can be used either locally or on lxbatch/condor queues

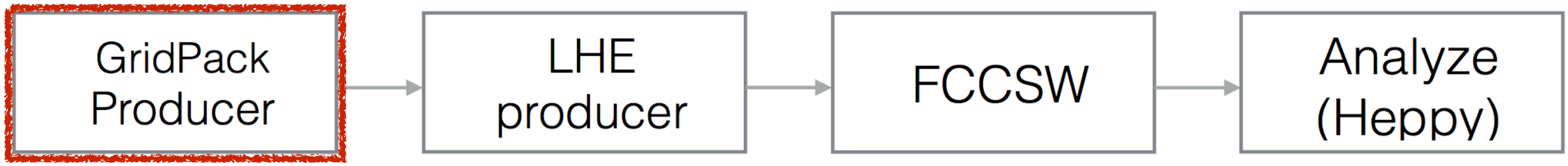
```
./run.sh [nevents] [seed]
```

- **For simplicity, GP that are of common interest have been produced centrally and stored here:**

/eos/fcc/hh/generation/mg5_amcatnlo/gridpacks

[1] https://github.com/selvaggi/GridPackProducer

GridPacks



Samples

H_T bins

```
"pp_v0123j_5f":[["vector boson + 0/1/2/3 jets", "inclusive", "xqcut = 30, qCut = 45"],0,1500,2900,5100,8500,100000],
"pp_vvv01j_5f":[["tri-vector boson + 0/1 jets", "inclusive", "xqcut = 60, qCut = 90"],0,1200,3000,6000,100000],
"pp_vv012j_5f":[["di-vector boson + 0/1/2 jets", "inclusive", "xqcut = 40, qCut = 60"],0,300,1400,2900,5300,8800,100000],
"pp_vbf_v01j_5f":[["vbf vector boson + 0/1 jets", "inclusive", "xqcut = 40, qCut = 60"],0,2000,4000,7200,100000],
"pp_llv01j_5f":[[" di-vector with V -> ll (l=e,mu,ve,vm,vt) + 0/1 jets", "", "xqcut = 40, qCut = 60"],0,800,2000,4000,100000],
"pp_ll012j_5f":[["V -> ll (l=e,mu,ve,vm,vt) + ", "", "xqcut = 30, qCut = 45"],0,200,700,1500,2700,4200,100000],
"pp_tv012j_5f":[["top pair off-shell t* -> Wj + 0/1/2 jets", "", "xqcut = 60, qCut = 90"],0,500,1500,2800,4700,7400,100000],
"pp_t123j_5f":[["single top (s,t channels)+ 1/2/3 jets", "", "xqcut = 40, qCut = 60"],0,1900,3500,5900,100000],
"pp_ttv01j_5f":[["top pair + boson + 0/1 jets", "inclusive", "xqcut = 80, qCut = 120"],0,1100,2700,4900,8100,100000],
"pp_tt012j_5f":[["top pair + 0/1/2 jets", "inclusive", "xqcut = 60, qCut = 90"],0,600,1200,2100,3400,5300,8100,100000],
"pp_h012j_5f":[["gluon fusion higgs (finite mt) + 0/1/2 jets", "inclusive", "xqcut = 30, qCut = 45"],0,100,400,1000,1900,4400,8500,
"pp_vh012j_5f":[["higgsstrahlung + 0/1/2 jets", "inclusive", "xqcut = 40, qCut = 60"],0,300,1400,2900,5300,8800,100000],
"pp_hh01j_5f":[["gluon fusion di-higgs + 0/1 jets", "inclusive", "xqcut = 60, qCut = 90"],0,300,1400,2900,5300,8800,100000],
"pp_tth01j_5f":[["higgs associated with top pair + 0/1 jets", "inclusive", "xqcut = 80, qCut = 120"],0,1100,2700,4900,8100,100000],
"pp_vbf_h01j_5f":[["vbf higgs + 0/1 jets", "inclusive", "xqcut = 40, qCut = 60"],0,2000,4000,7200,100000],
"pp_vbf_hh01j_5f":[["vbf di-higgs + 0/1 jets", "inclusive", "xqcut = 60, qCut = 90"],0,2000,4000,7200,100000],
"gg_aa01j_5f":[["gluon fusion di-photon + 0/1 jets", "inclusive", "xqcut = 20, qCut = 30"],0,500,1000,2000,4000,7200,100000],
"pp_aa012j_5f":[["di-photon + 0/1/2 jets", "inclusive", "xqcut = 20, qCut = 30"],0,500,1000,2000,4000,7200,100000],
"pp_aj012j_5f":[["photon + jet + 0/1/2 jets", "inclusive", "xqcut = 20, qCut = 30"],0,500,1000,2000,4000,7200,100000],
"pp_jj012j_5f":[["di-jet + 0/1/2 jets", "inclusive", "xqcut = 20, qCut = 30"],0,500,1000,2000,4000,7200,100000]
```

All “HT-binned” and “inclusive” gridpacks have been produced !

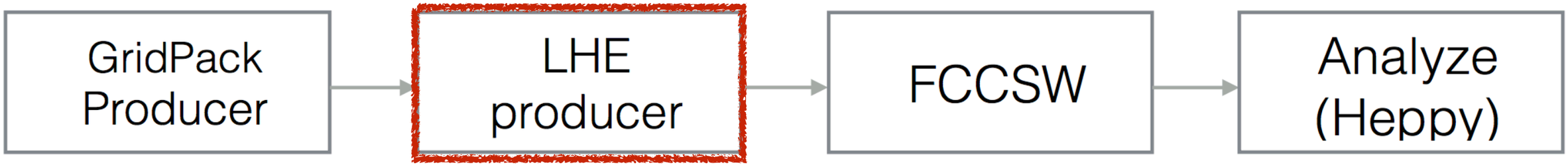
/eos/fcc/hh/generation/mg5_amcatnlo/gridpacks/

123 gridpacks in total

87 binned in HT -> 36 different processes

Les Houches Events

Clement Helsens



- LHE Producer[1]
  - Produces Les Houches Event (LHE) files using GridPacks using lxbatch queues (working on extending to HTCondor)
  - Procedure has been made more robust to allow multiple users
  - Comprehensive list of generated events can be found here:

http://fcc-physics-events.web.cern.ch/fcc-physics-events/LHEevents.php

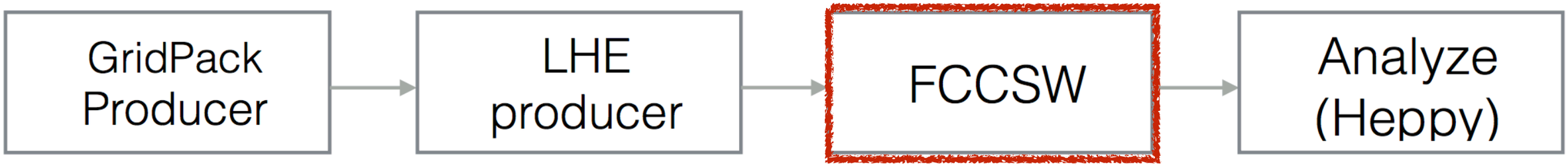
/eos/fcc/hh/generation/mg5_amcatnlo/lhe

  - With the intent of covering a large spectrum of processes, **mostly inclusive samples** have been generated but HT binned on the way
  - More than 440M events generated so far!

[1] https://github.com/clementhelsens/EventProducer

Pythia/Delphes events

Clement Helsens



- FCCSW Producer[1] (NEW!)
  - Runs FCCSW (**Pythia8+Delphes**) on LHE files using lxbatch queues
  - produces FCCSW n-tuples that can be analysed with Heppy

/eos/fcc/hh/generation/DelphesEvent/v0_0/

- With the intent of covering a large spectrum of processes, **mostly inclusive samples** have been generated so far
- More than 100M events generated!

[1] https://github.com/clementhelsens/EventProducer

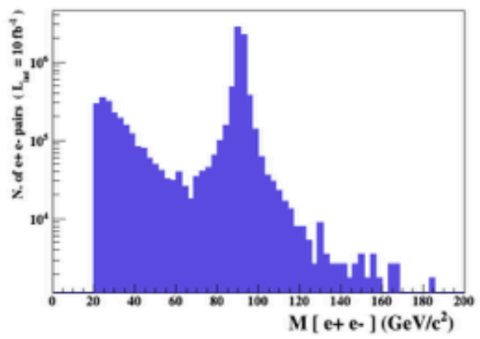
Plans

- **Heavy resonances - boosted topologies** studies require sufficient statistics in the tails
  → we need to start generating **HT binned** samples
- With the exception of few **loop-induced** processes (i.e gg→H, gg→HH, gg→γγ), LHE generation can be performed **pretty fast**
- **10 M** events can be generated in **~2-3 hrs** (with 1k jobs)
- There are ~20 processes and ~5 HT bins per process
  → 300 hrs for producing LHE
  → 300 hrs for Pythia+ Delphes (FCCSW)

- If production shared among 2-3 people, and no major show-stoppers most of the event production should be ready by the FCC week (this includes **all background + Higgs**)
- As a starting point will use the same LHE events to be decayed differently (wrong if we combine analyses channels)

Note on Drell-Yan

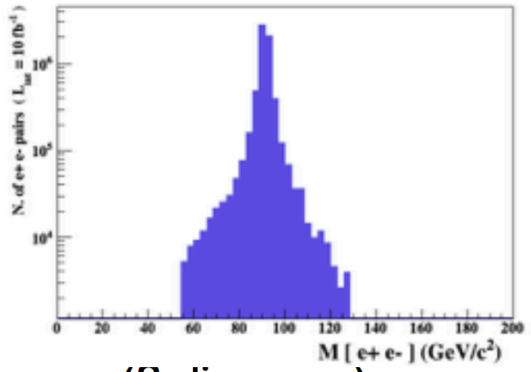
p p > e+ e-



(16 diagrams)

=

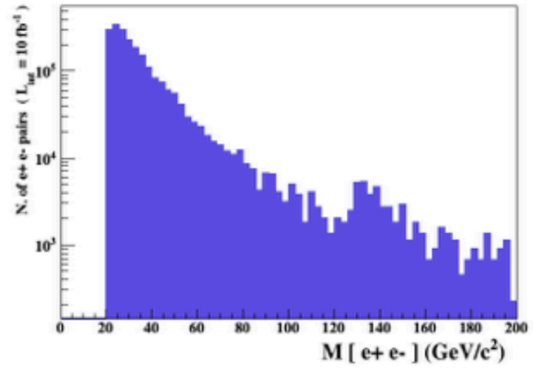
p p >z , z > e+ e-



(8 diagrams)

+

p p > e+ e- $ z



(16 diagrams)

pp_v0123j_5f

on-shell production

pp_ll012j_5f:

off-shell production

- At m_{ll} far from m_Z, i.e $|m - m_Z| > 15*\Gamma_Z$:
  - pp_v0123j_5f can be used alone
- In the vicinity of m_Z:
  - the sum of the two should be used!

→ very important for Higgs studies (H →μμ)

- Same approach used for:
  - pp_llv01j_5f and pp_vv012j_5f (di-boson)
  - pp_tt012j and pp_tv012j_5f (ttbar/single top)

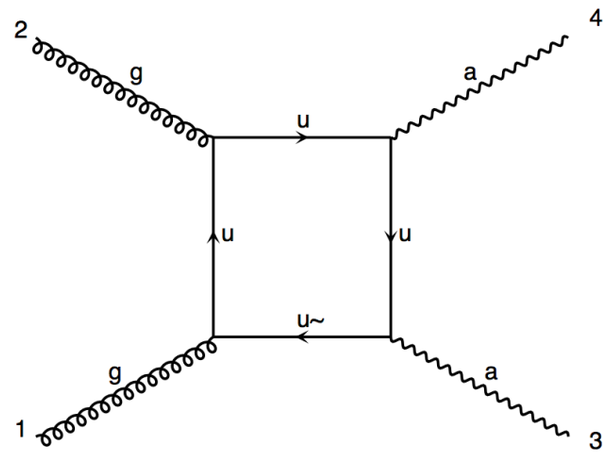
Bkgs for H→γγ (new)

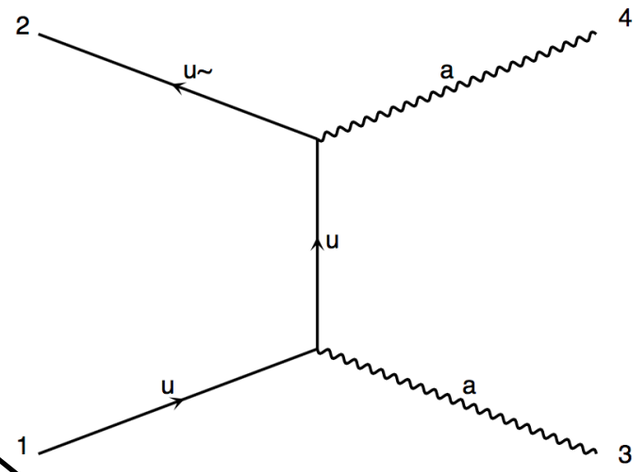
contributions @ 100 TeV:

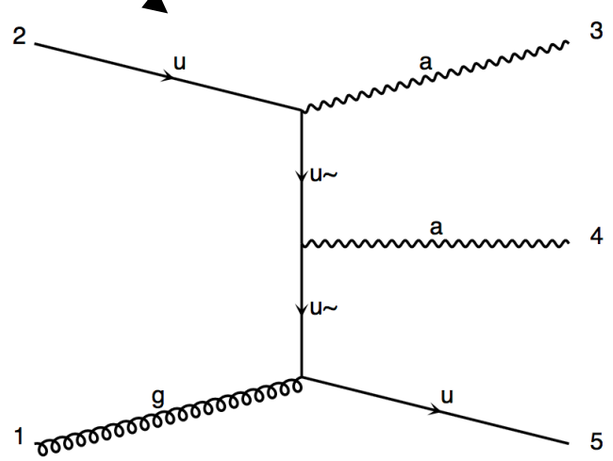
- 1) g g → γ γ (loop induced) + 0/1 jets
  - σ (m γ γ > 50 GeV) = 490 pb
- 2) p p → γ γ (tree-level) + 0/1/2 jets
  - σ (m γ γ > 50 GeV) = 2150 pb

  → neglecting qg / qq virtuals
- 3) p p → γ j (tree-level) + 0/1/2 jets (single-fake

on /eos:
1) gg_aa01j_5f
2) pp_aa012j_5f
3) pp_aj012j_5f







Conclusions

- Gridpack production is DONE for common backgrounds and Higgs
- almost all inclusive Les Houches event samples have been generated and stored on /eos/
- Large scale HT-binned sample production will start very soon
- Add more processes (ttHH, tttt, VVVV, etc..)