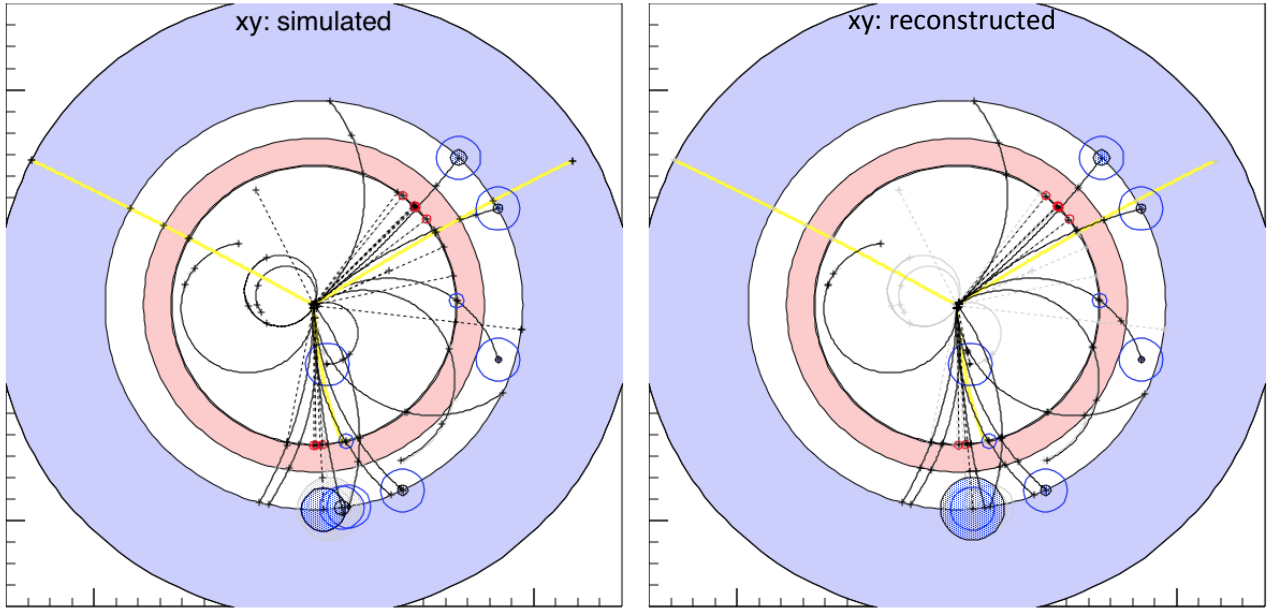
Fast Physics with Papas and Heppy for FCC-ee



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UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES

CERN

Talk Outline

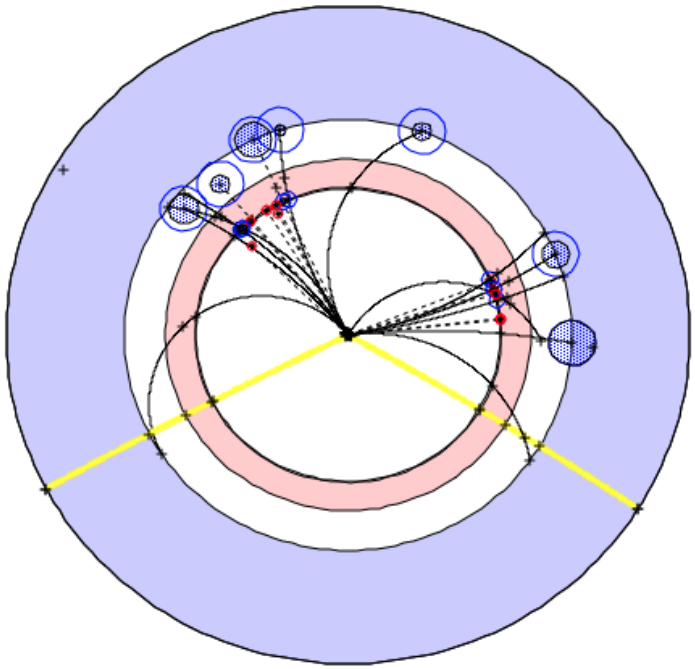
Outline

- Introduction to Papas
- Physics analyses using Papas and Heppy
- Practicalities & Plans

Introduction to Papas

Papas: Parameterized Particle Simulation

- simulation of clusters and tracks
- particle flow reconstruction algorithm



Goal: easy/fast/good physics studies

Papas Approach:

- parameterize detector
- run Papas simulation/reconstruction
- run physics analyses (Heppy)
- determine what physics is possible for the detector
- define target performance for detector

Detector Parameterisation

Parameterized Inner Tracker

```
class Tracker(DetectorElement):

    def __init__(self):
        volume = VolumeCylinder('tracker', 1.29, 1.99)
        mat = material.void
        super(Tracker, self).__init__('tracker', volume,  mat)

    def acceptance(self, track):
        pt = track.p3() .Pt()
        eta = abs(track.p3() .Eta())
        if eta < 1.35 and pt>0.5:
            return random.uniform(0,1)<0.95
        elif eta < 2.5 and pt>0.5:
            return random.uniform(0,1)<0.9
        else:
            return False

    def resolution(self, track):
        return 1.1e-2
```

Parameters used to define:

- simple geometry (cylinder)
- acceptance model
- resolution model
- (+ B field)

Easy to create/ easy to change

Detectors for Papas

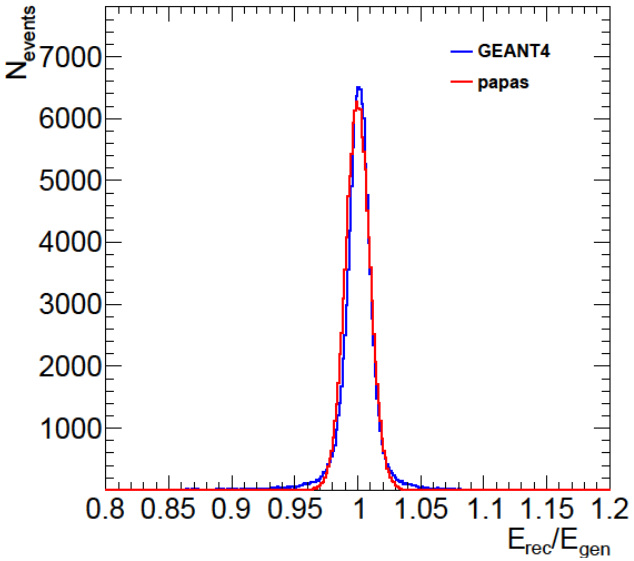
Available detectors for PAPAS

CMS detector: fully supported,

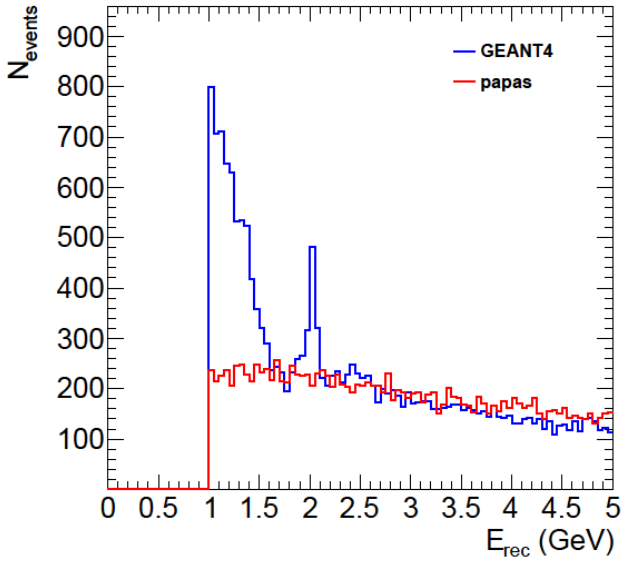
tuned to CMS

able to reproduce results

175 lines of code



ILD detector: (under development: M Dams)



or

Create your own/work with us

(should be able to create a new detector in a few hours)

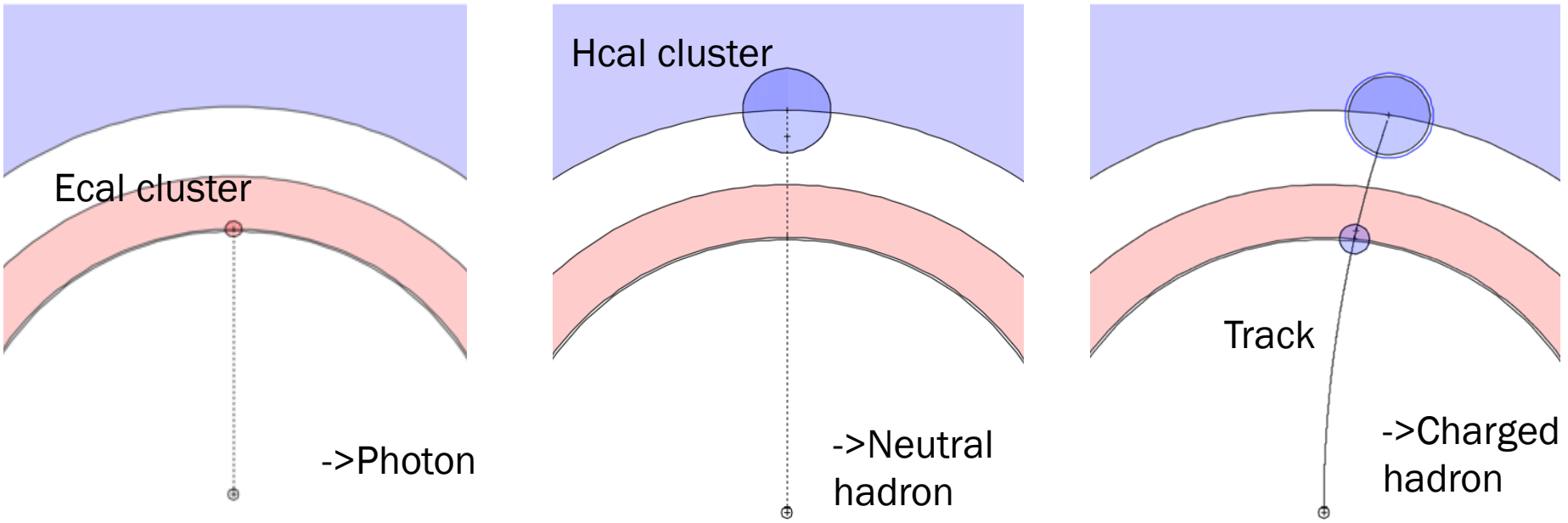
Papas Reconstruction

Papas uses particle flow algorithm

~ same as in CMS

Find "connected" sets of clusters/tracks

Build particles from "connected" clusters/tracks



Analyses using Heppy

Heppy: High Energy Physics in PYthon

- Heppy is a python based modular analysis framework
- Independent of Papas
- Papas (python) fully integrated as Heppy modules
- Heppy reads root files (eg outputs from Delphes, FCCSW)
- widely used in CMS
- many tools available (filtering, jet clustering etc)
- easy to configure

http://fccsw.web.cern.ch/fccsw/tutorials/heppy/README.html

Papas Analysis: examples

Several analyses already done with Papas and Heppy

Maintained as part of heppy/papas

- Z (mumu) H (bb) (C Bernet)
- ZH (fully hadronic) (K Behr, K. Peters et al)

Online tutorial

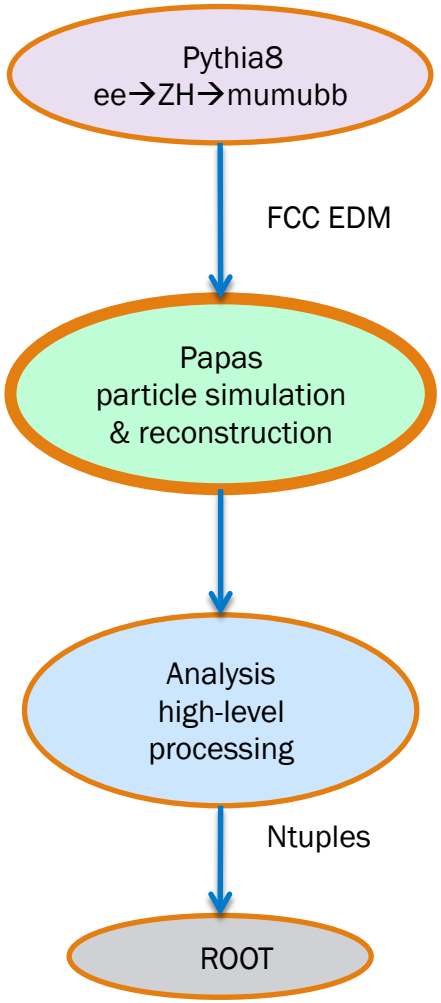
Done in the past

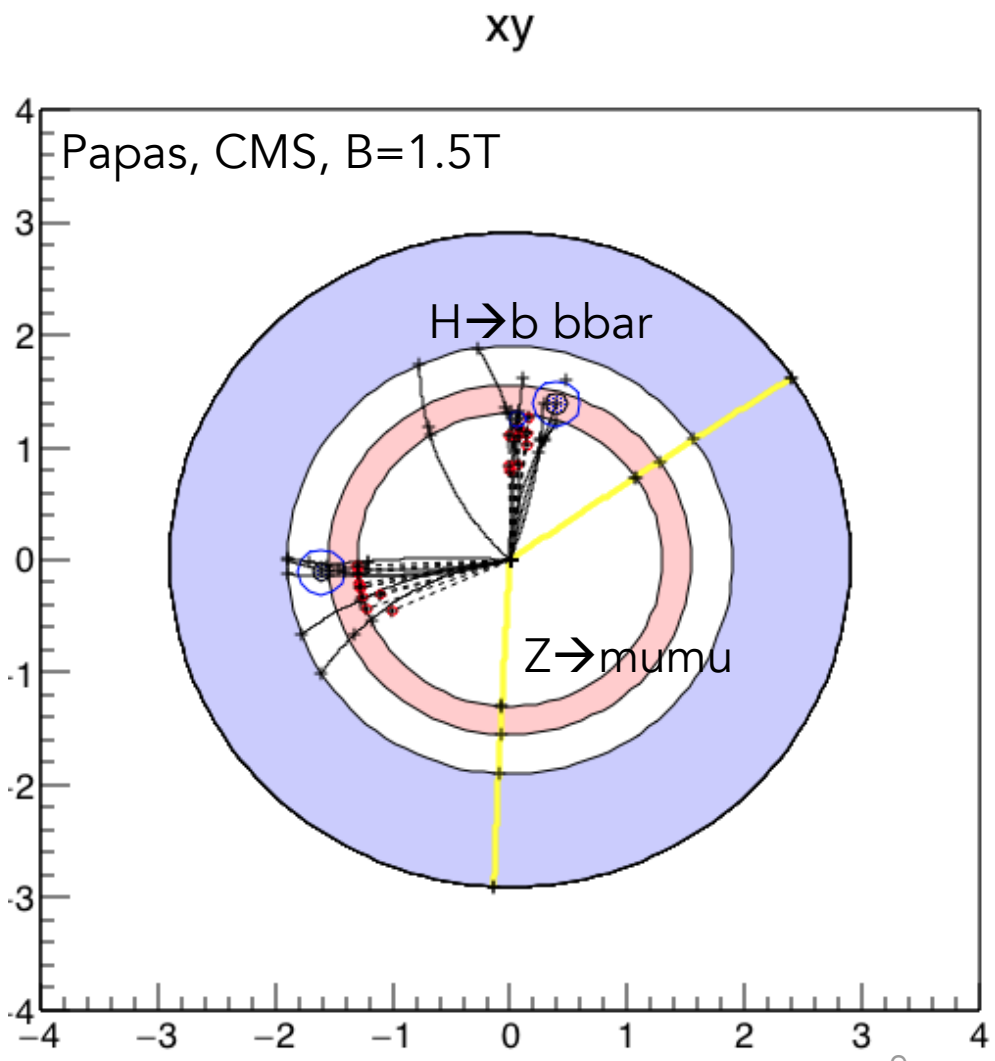
- Ttbar analysis (including b-tagging) (N Foppiani, P. Janot, P. Azzi)
- WW analysis (E. Locci, M. Beguin)
- Sterile neutrinos (M. Dam, S. Bay Nilsen)

NB Most analyses are realizable

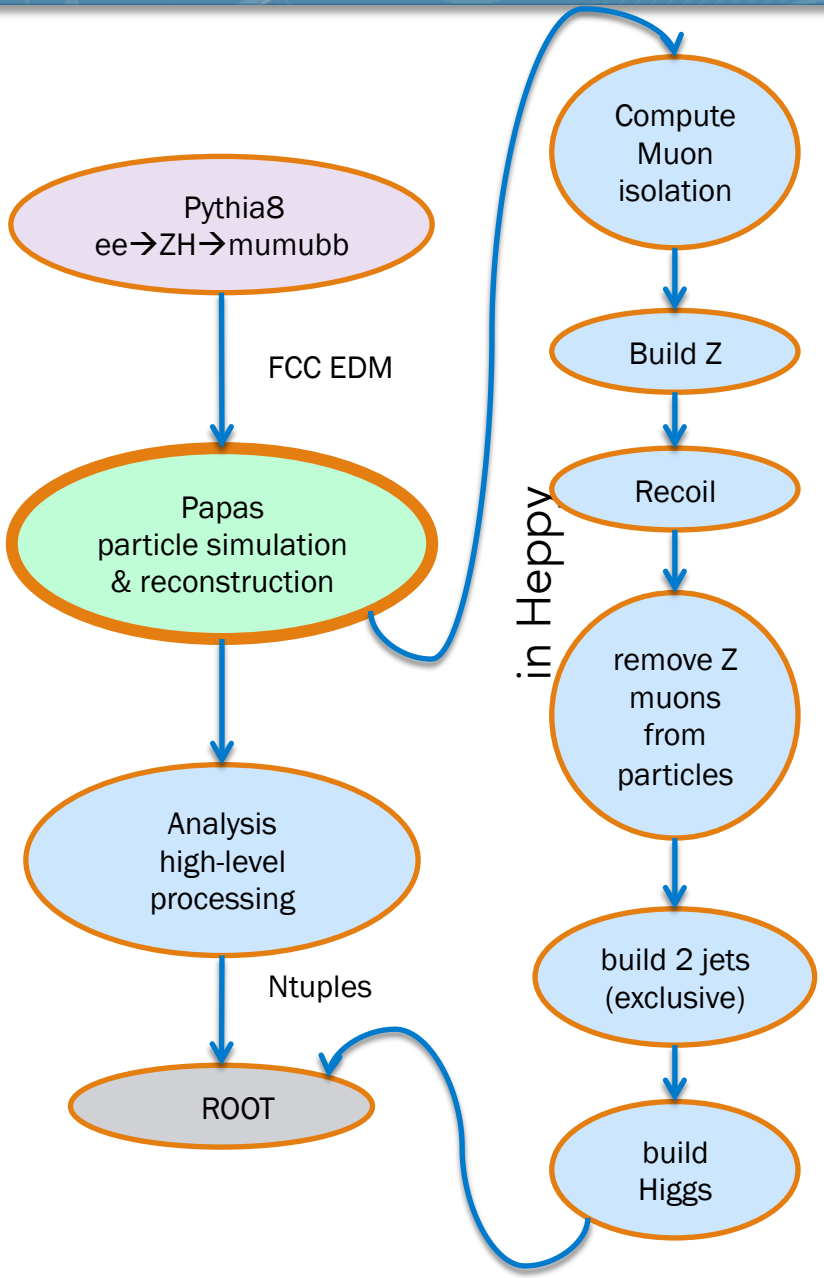
Example ZH analysis

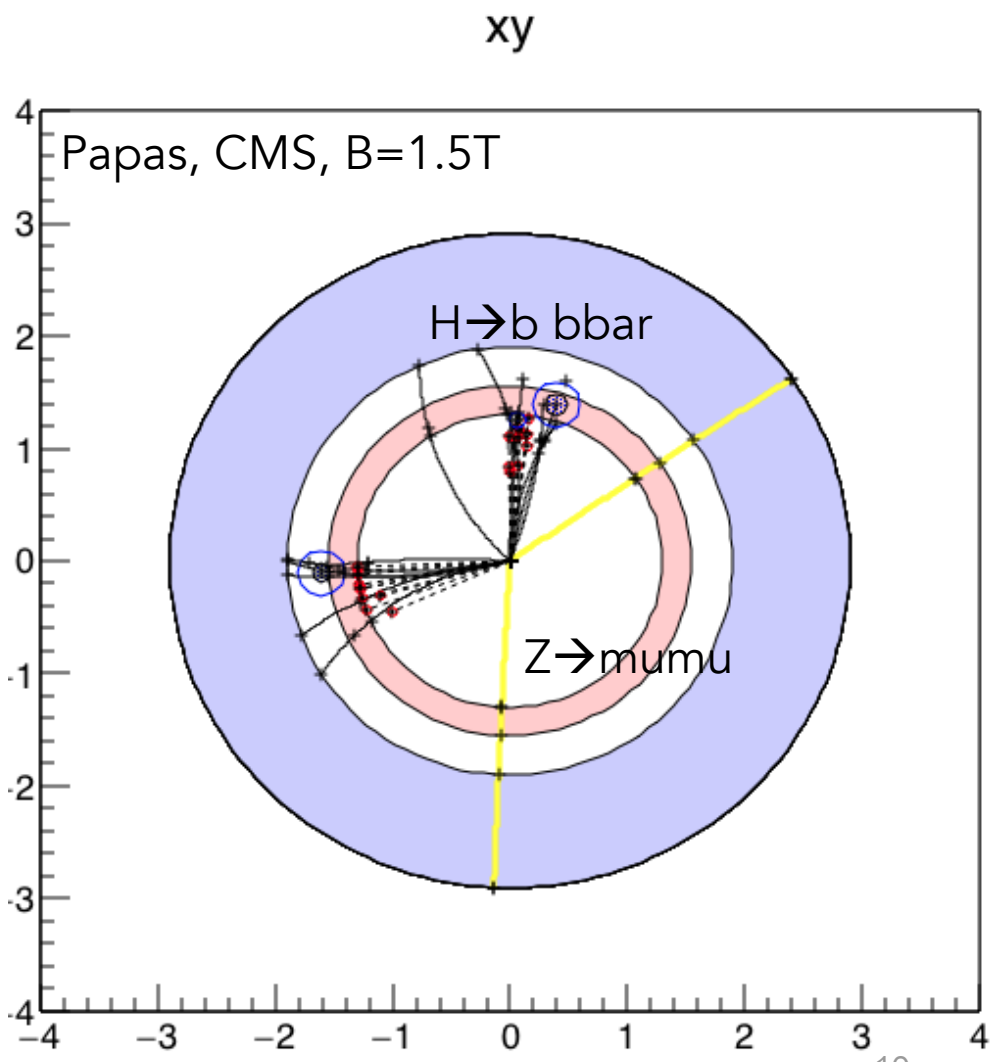
Find how B-field and tracking efficiency parameters effect estimate of Higgs mass:-





Example ZH analysis

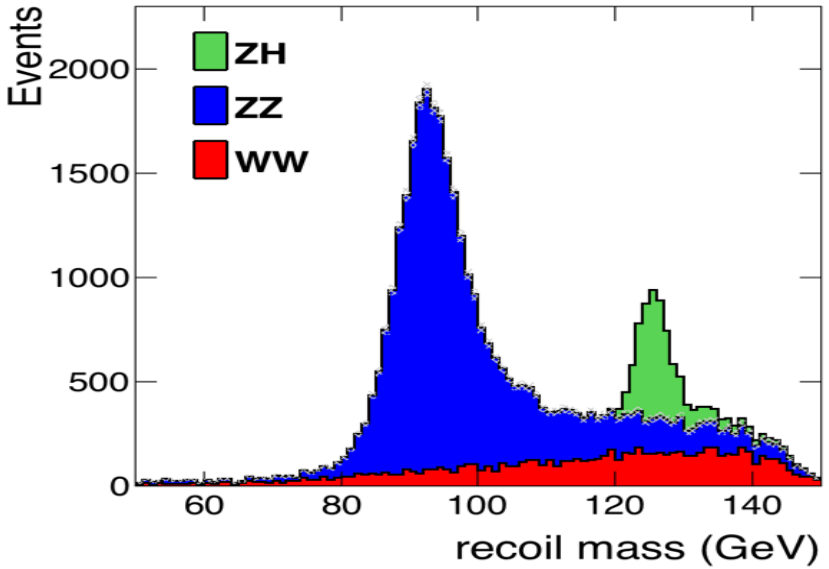


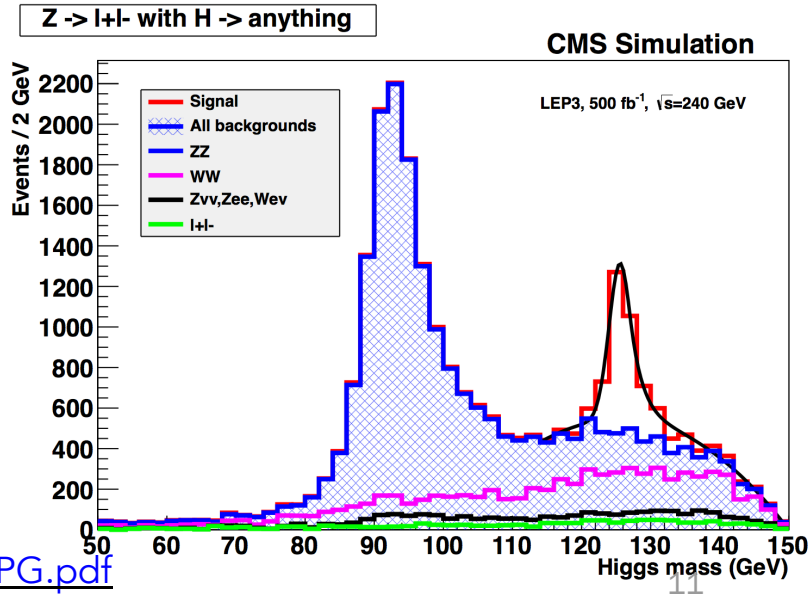


Example ZH analysis

Aim: measure ZH inclusive cross-section at 240 GeV, 500 fb^{-1}

- Generate: ZH, ZZ, WW samples
  - two muon channel
  - retain events with 2 muons in final state
  - cuts and normalisation as in LEP3
- 600k events in total
- e and mu resolution coarser in papas and not yet tuned.





https://espace.cern.ch/LEP3/LEP3_docs/Documents/CMS_LEP3_ESPG.pdf

How fast is Fast?

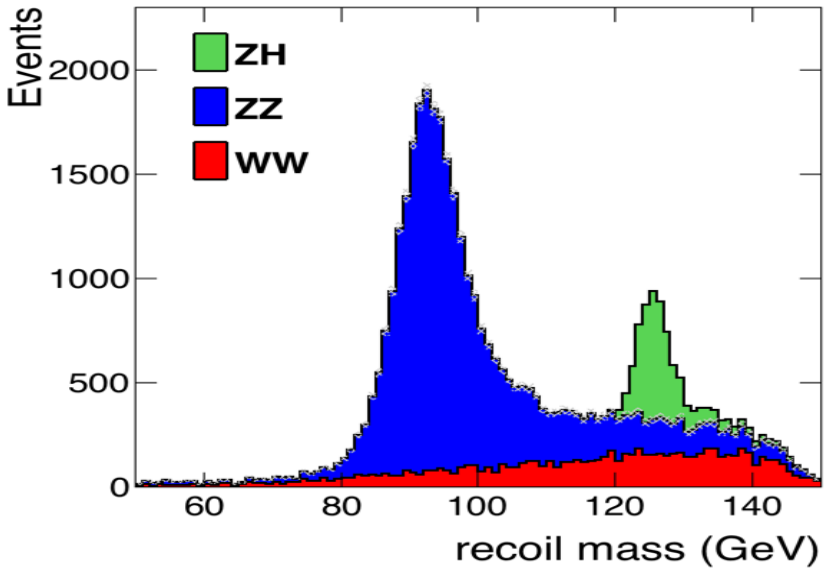
For this analysis

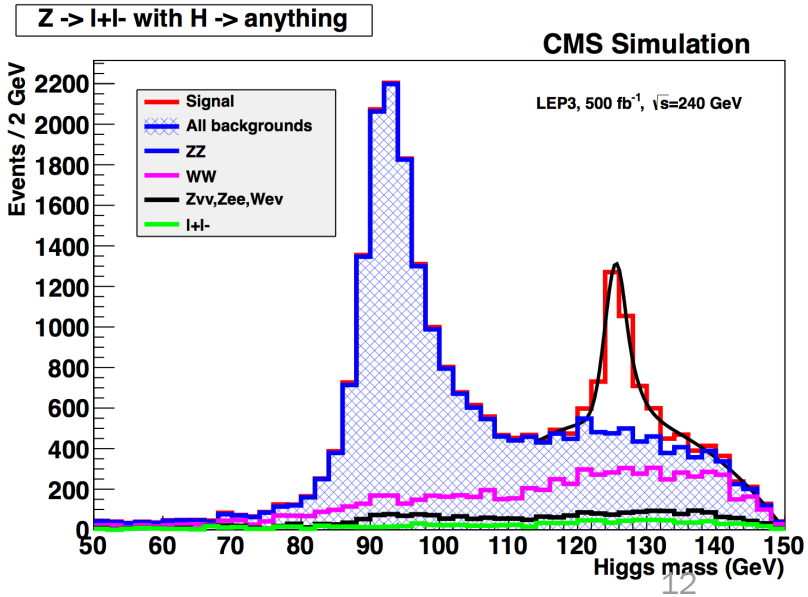
10 mins to analyse 600k events

Papas python ≈10 events/sec

Speed was then increased by
- Batch processing (x100)
- Pre-filtering (perhaps x10)

Future:
- Papas C++ (x10)





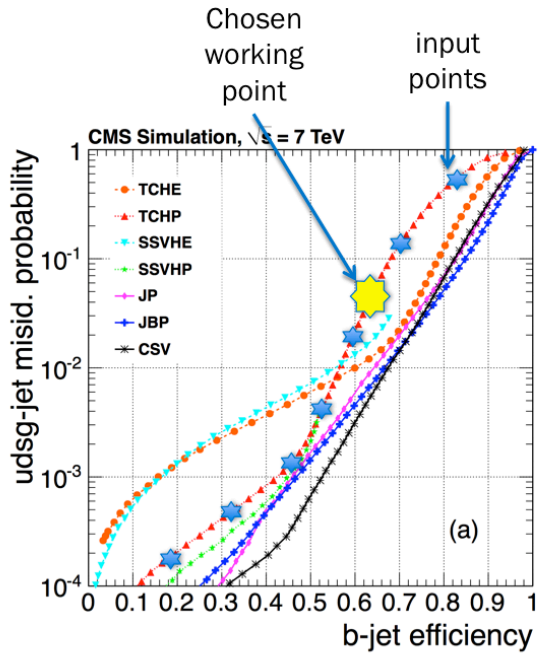
Implementing b-tagging

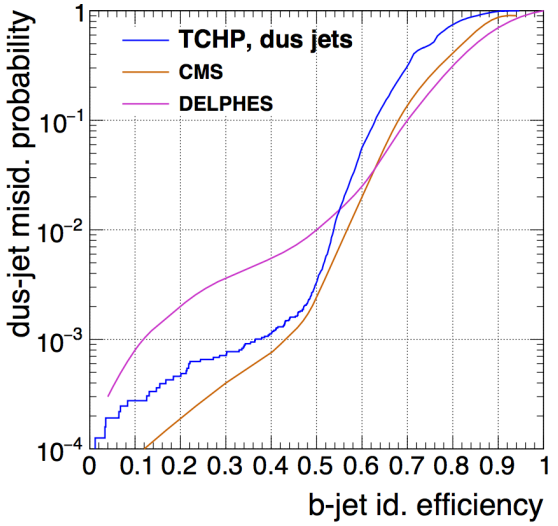
b-tagging modelling techniques available:

(1) using interpolated performance from existing detector ROC curves (C.B.)

(2) parameterizing the track impact parameter resolution (N. Foppiani, P. Janot)

(3) modelling the effect of tracker material with Molière theory (L. Torterotot, C. B.)

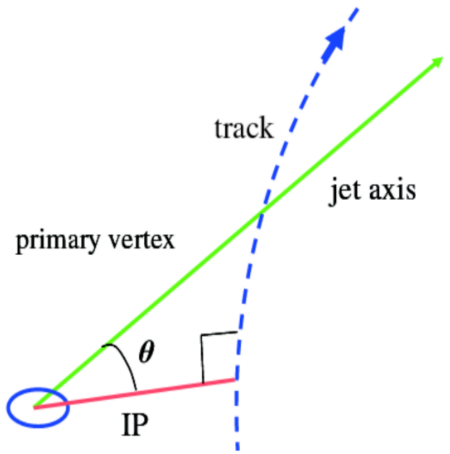




Implementing b-tagging

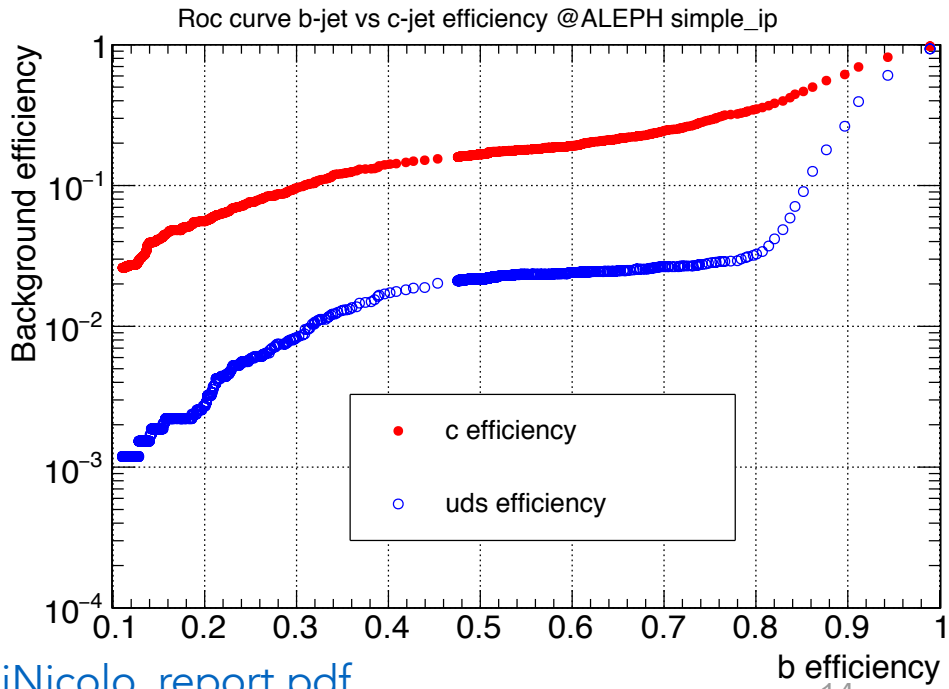
Impact Parameter (IP) resolution

- parameterize IP resolution (by track pT, theta, …)
- determine IP and sigma(IP) for each track
- run a b-tagging algorithm for each track



pros & cons:

- models correlations with jet kinematics
- needs some tuning



https://cds.cern.ch/record/2222396/files/FoppianiNicolo_report.pdf

Practicalities

Papas is simple to setup and use: accessible to anyone:

- Documentation and tutorials online http://fccsw.web.cern.ch/
- Runs on lxplus, virtual machine, Mac
- few minutes to set up
- Use with batch commands for speed

http://fccsw.web.cern.ch/fccsw/tutorials/heppy/doc/Heppy_-_Parallel_Processing.html

Work with us

- Get in touch
- Don't hesitate to ask!
- Come to the first FCC-ee software workshop...

https://indico.cern.ch/event/639736/

Contacts: Colin Bernet, Alice Robson

Papas Plans

Plans for Papas

Expand number of analyses/ users

Add more detectors : ILD on the way

Integration in FCCSW

- (underway) Papas C++ will run in Gaudi:-

  flexibility, speed, and batch processing
- (planned) Papas C++ fast simulation to be integrated with Full simulation

Key Points

Key points to take away:

1) Papas provides a comprehensive model of particle flow:
   allows rapid testing of effect of detector parameters/detector optimization

2) Papas with Heppy allows full analysis sequence:
   most analyses can be carried out; functionality can be added quickly

3) Easy to get started, its ready to go!
4) We are keen to work with you