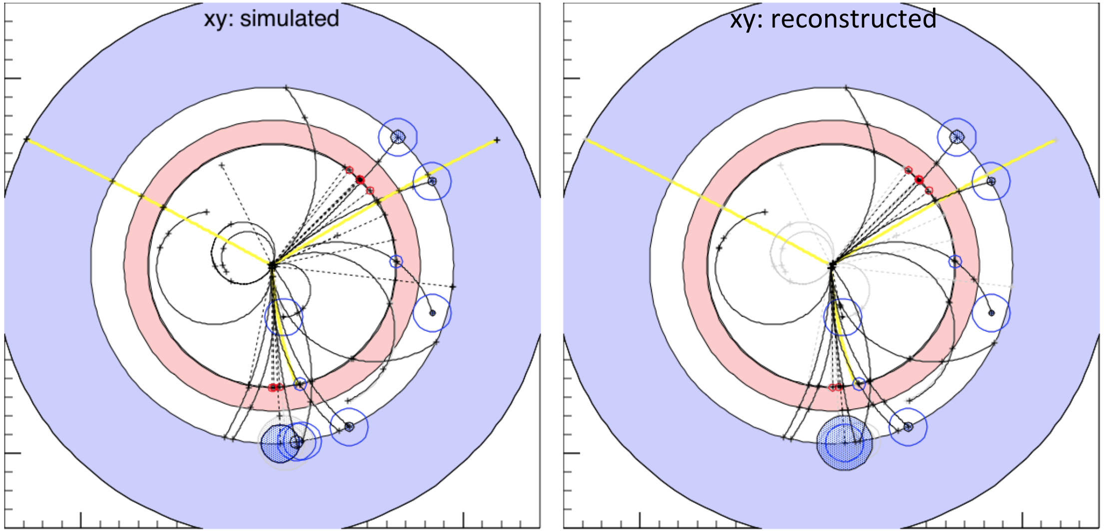
Fast Physics with Papas and Heppy for FCC-ee



Alice Robson (CERN/UNIGE)
Colin Bernet (IPNL)

FCC Berlin 31 May 2017

UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
CERN

Outline

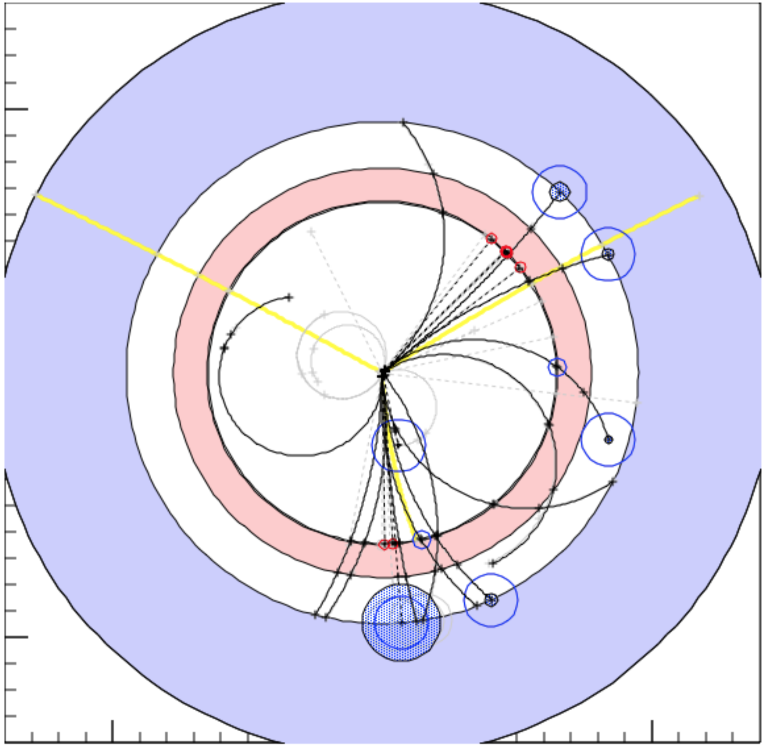
- Introduction to Papas
- Physics analyses using Papas and Heppy
- Practicalities
- Plans

Papas: Parameterized Particle Simulation

includes Particle Flow reconstruction

Approach:

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



Python and C++ versions of Papas

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)

Available detectors for PAPAS

CMS detector: fully supported,

tuned to CMS

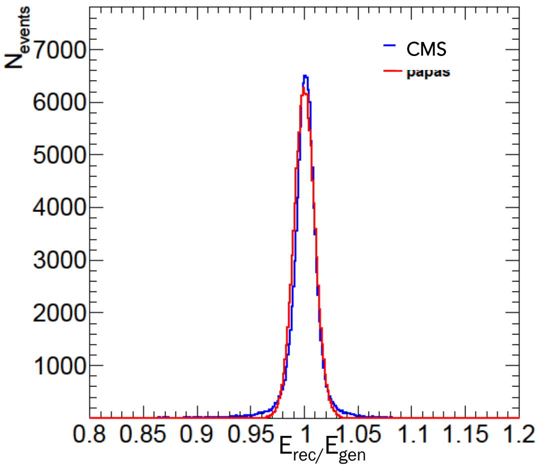
able to reproduce results

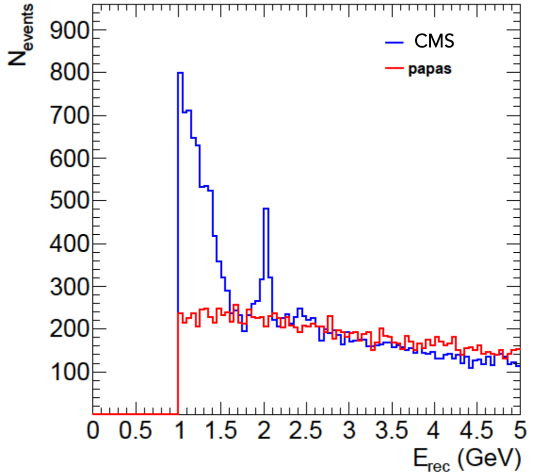
175 lines of code

ILD detector: (under development: M Dams)

Easy to set up new detector designs

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



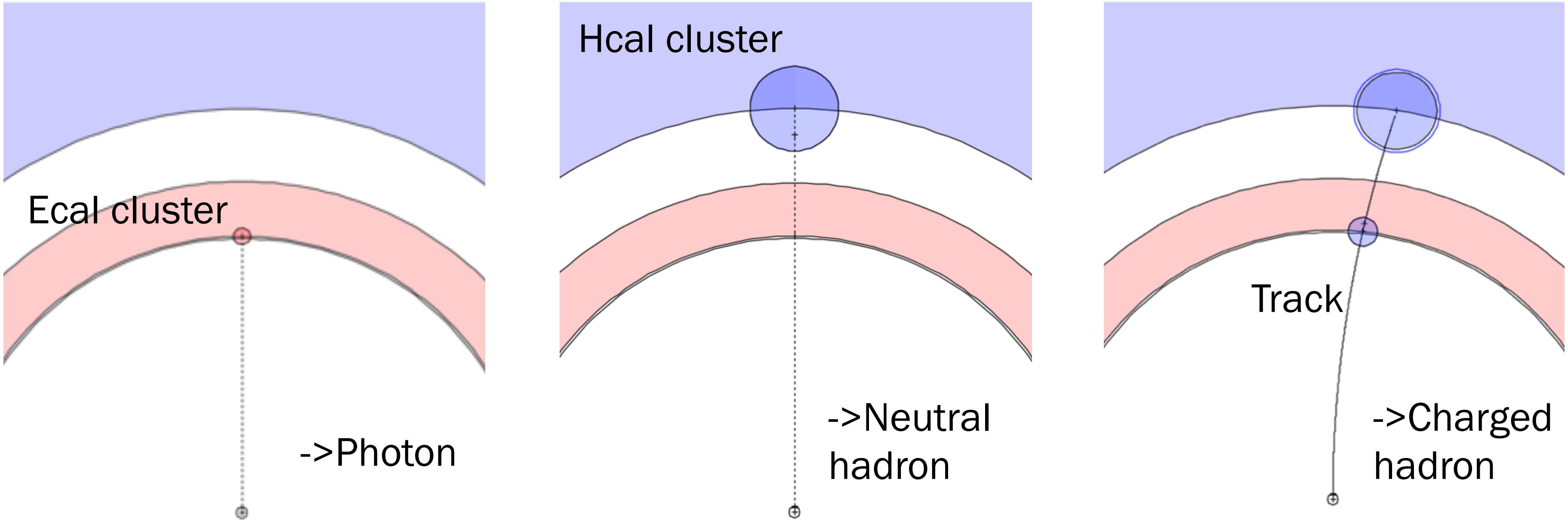


Papas uses particle flow algorithm

~ 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
- widely used in CMS
- reads root files (eg outputs from Delphes, FCCSW)
- many tools available (filtering, jet clustering etc)
- easy to configure, powerful

Papas Analysis: examples

Several analyses already done with Papas and Heppy

Maintained as part of heppy/papas

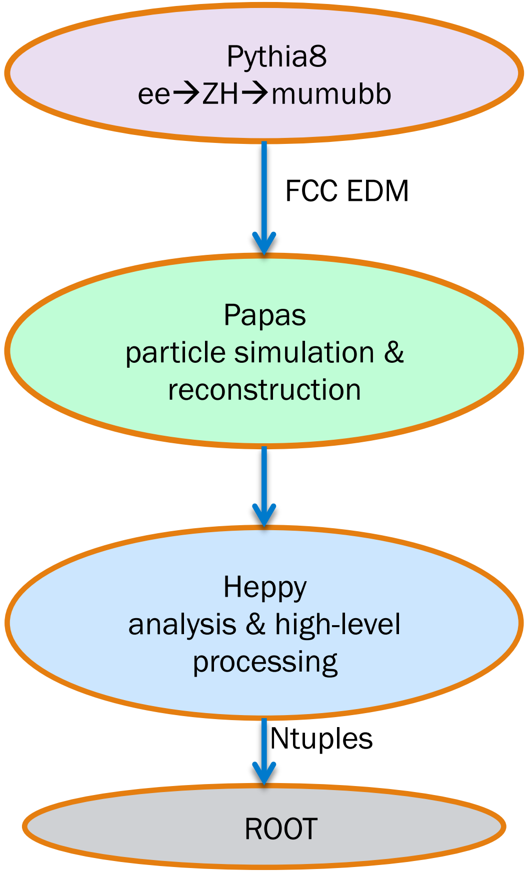
- Z (mumu) H (C Bernet) ← Online tutorial
- ZH (fully hadronic) (K Behr, K. Peters et al)

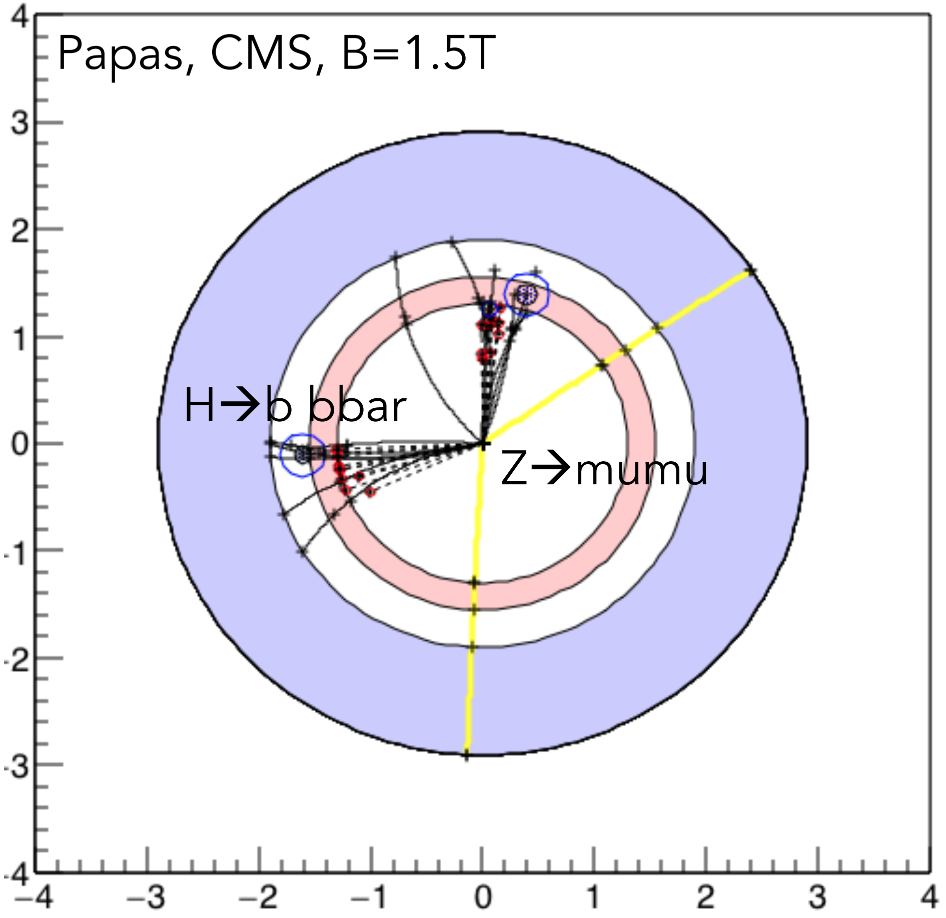
Done in the past

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

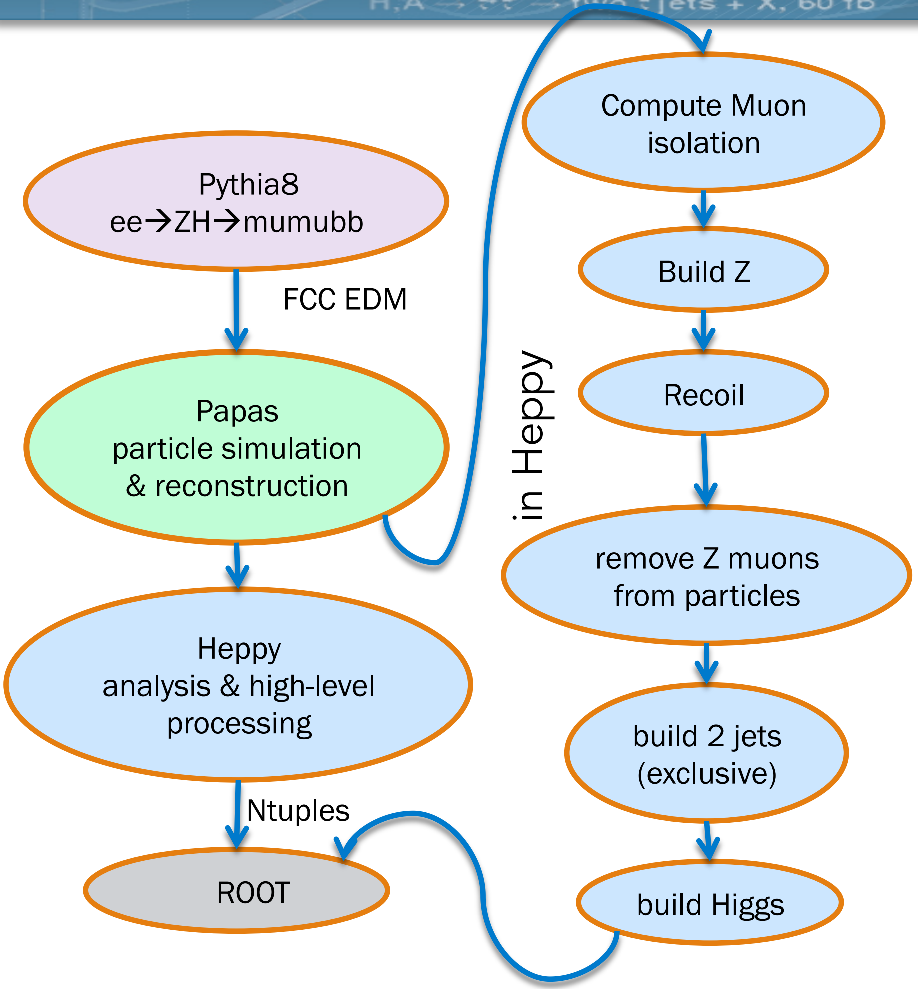
NB Most analyses are realizable

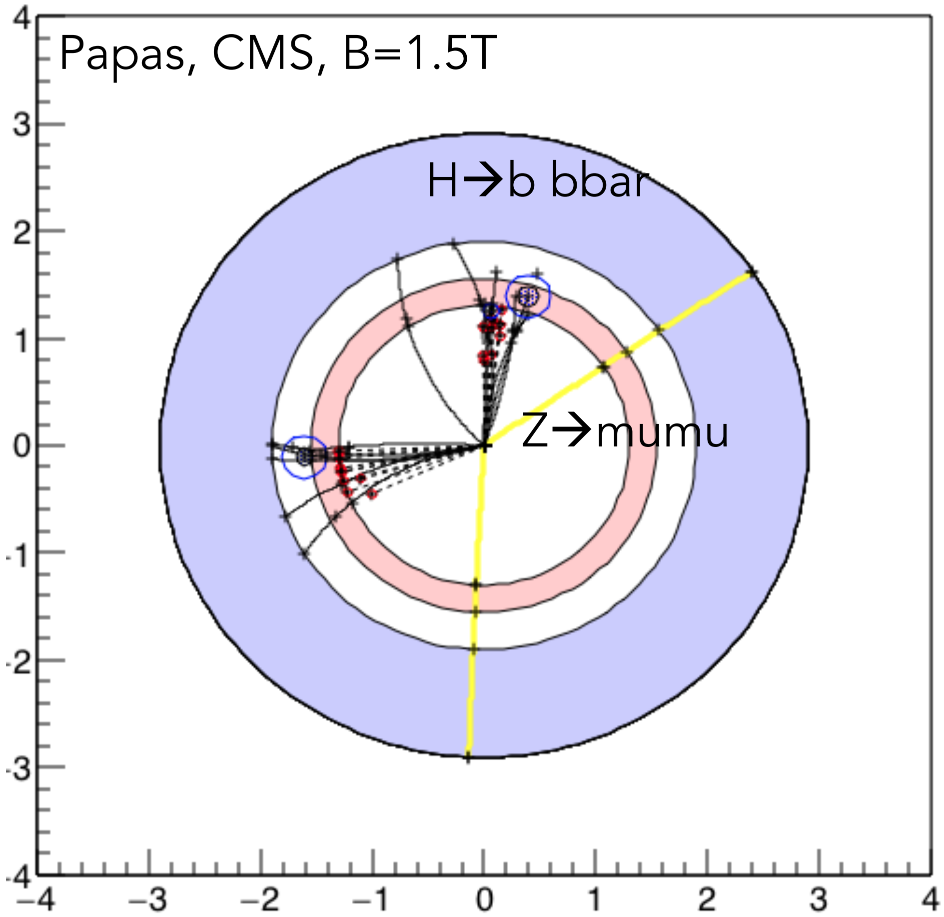
Example ZH analysis





Example ZH analysis



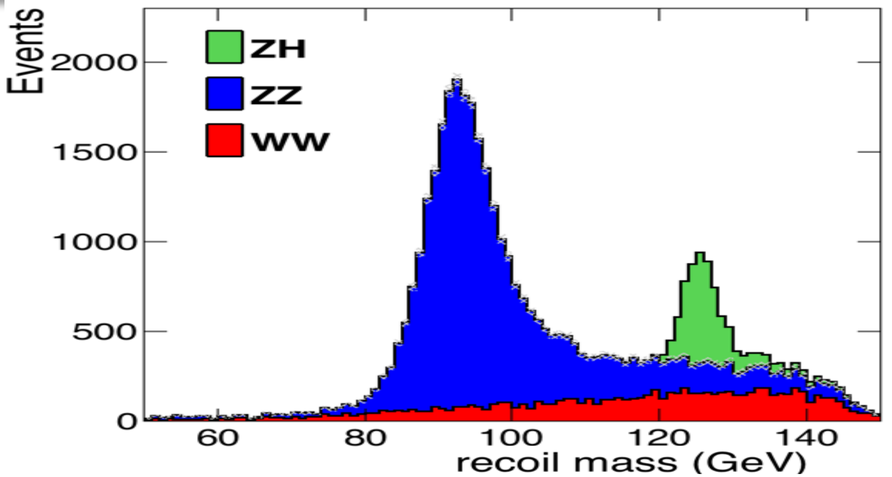


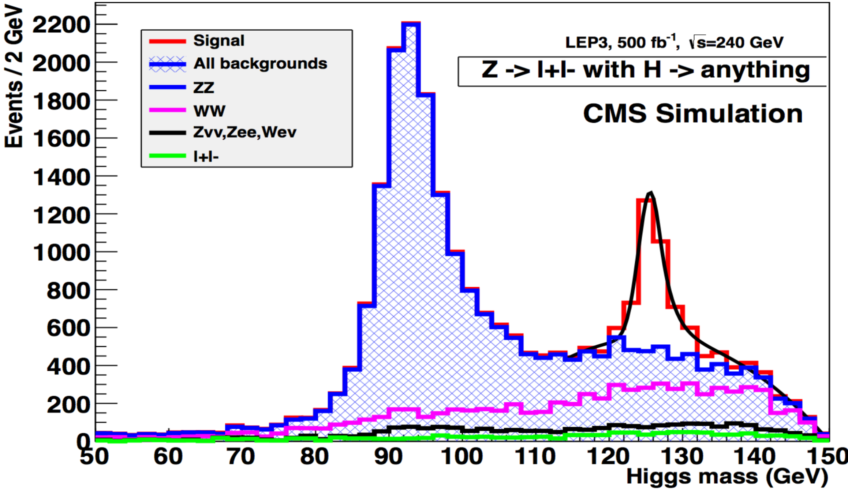
Example ZH analysis

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

- Generate: ZH, ZZ, WW samples
  - two lepton channel
  - determine recoil
  - cuts and normalisation as in LEP3

- 600k events in total
- more tuning needed for e and mu resolution (a bit too coarse)





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

How fast is fast?

For this analysis:

10 mins to simulate 600k events

Papas python ≈10 events/sec

Batch procesing increases speed (x100)

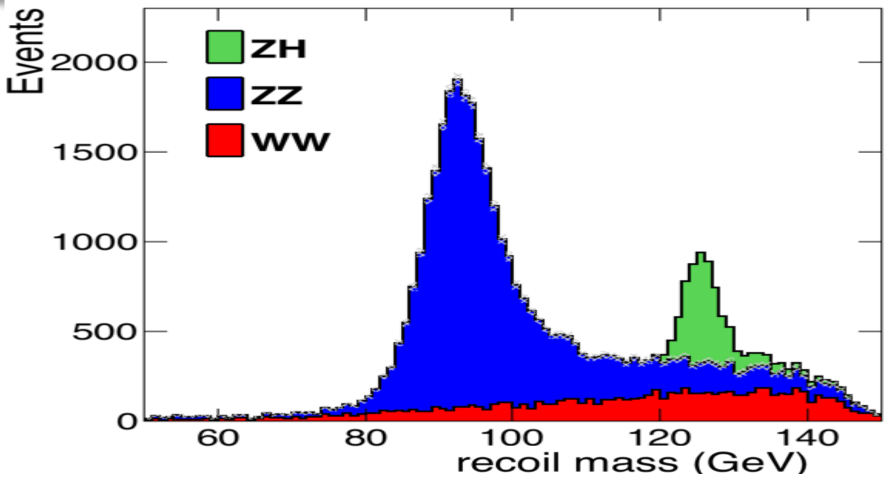
NB Don't forget the 'obvious' :

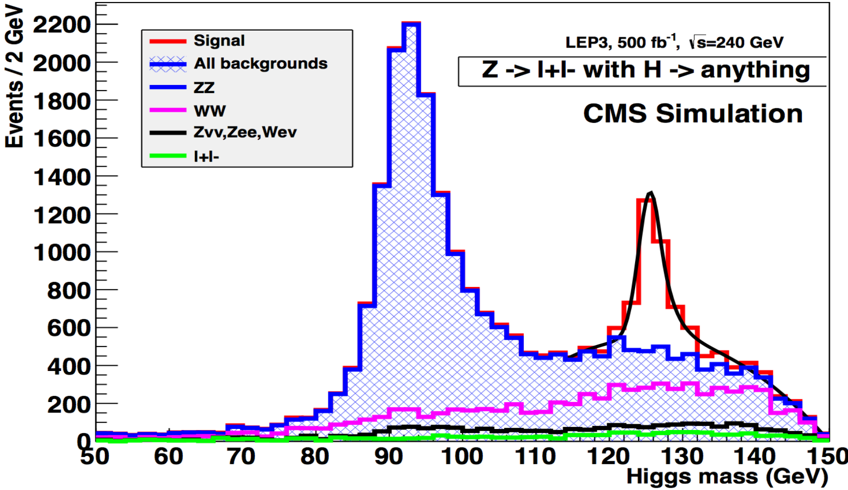
generator level selection:

here 2 leptons (x10)

Future:

- Papas C++ (x10)





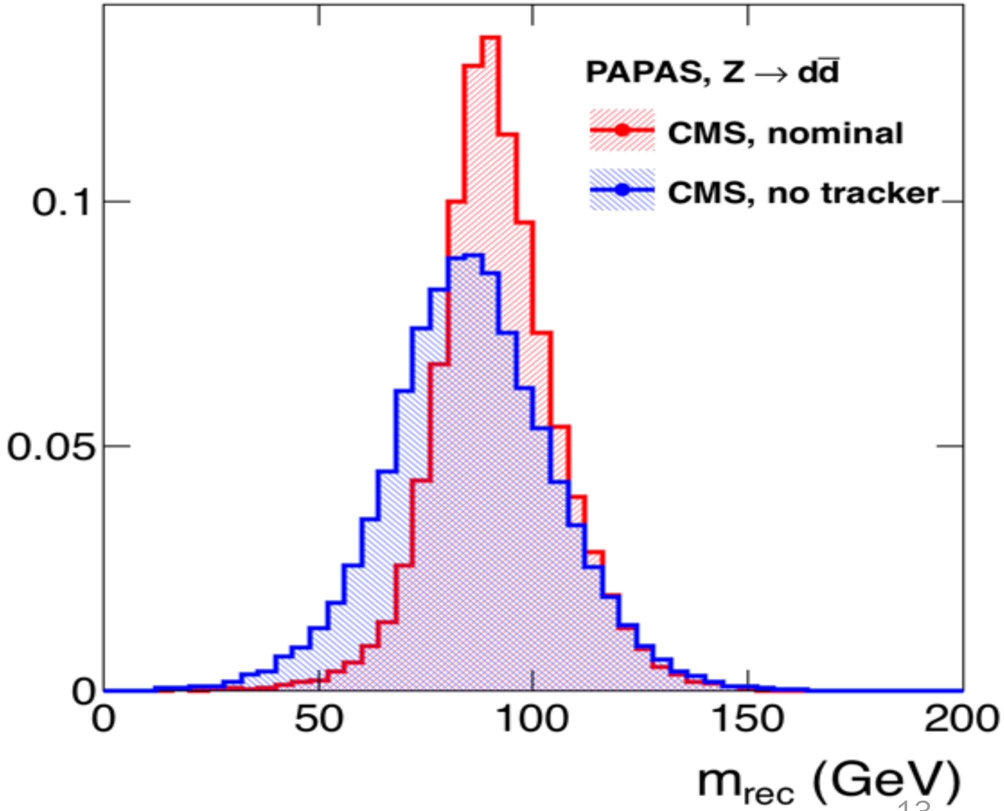
Effect of tracker on Z-mass reconstruction

Turn off the tracker

No tracker =>

calorimetric reconstruction

of all particles



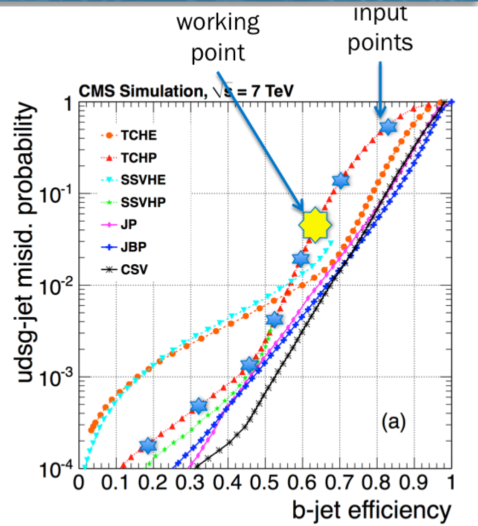
Implementing b-tagging

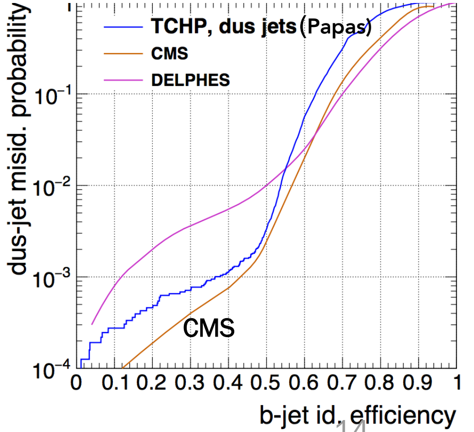
b-tagging modelling techniques available:

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

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

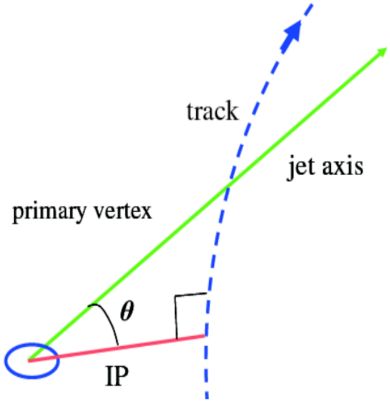
(3) parameterizing the track impact parameter resolution (N. Foppiani, P. Janot)



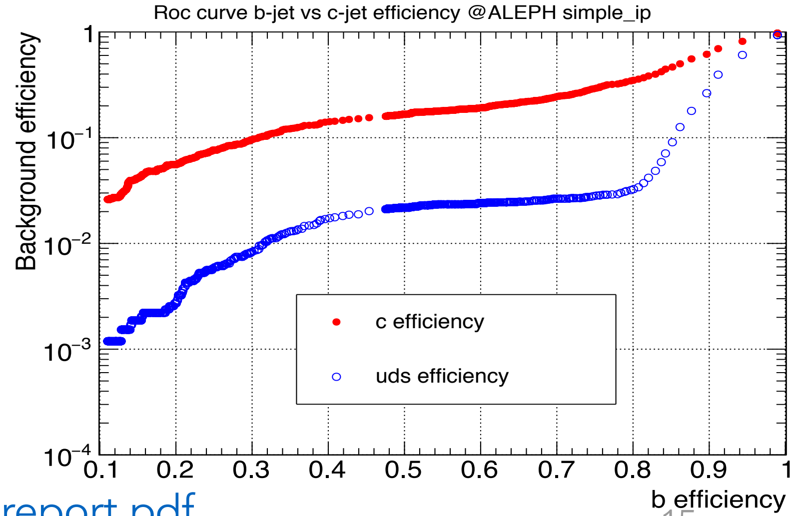


Impact Parameter (IP) resolution

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



- implemented for ALEPH:
  needs fine tuning



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

Practicalities

Papas is simple to use: accessible to anyone:

- Few minutes to set up
- Documentation and tutorials online http://fccsw.web.cern.ch/
- Details of batch commands

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 (3 - 4July)

Contacts: Colin Bernet, Alice Robson https://indico.cern.ch/event/639736/

Plans for Papas

More Physics:

Expand number of analyses/ users

Add more detectors : ILD on the way

Automate parameter searches

C++:

- Inclusion in FCCSW (nearly there)
  - flexibility, speed, and batch processing
- Integrate with FCCSW Full simulation (planned)

Key points to take away:

1) Papas provides a comprehensive model of particle flow:

   allows rapid 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