

Revitalizing the OPAL masterclass

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Outline

- OPAL and LEP
- OPAL masterclass
- Status and next steps

Identifying Interesting Particle Physics Events at LEP

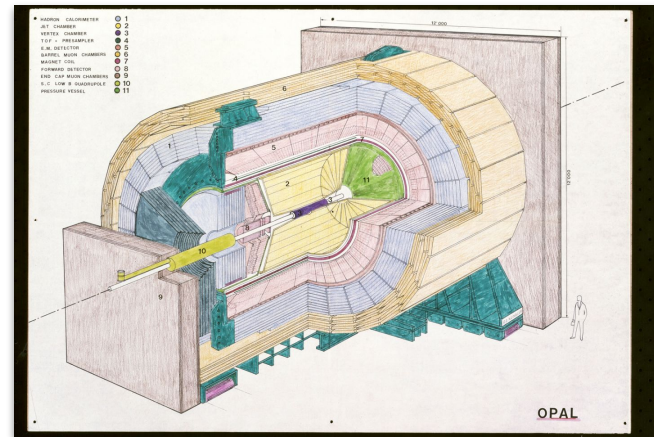
The purpose of these web pages is to allow you to identify for yourself some interesting particle physics interactions or "events". These events have been seen using an experiment called [OPAL](#), at [CERN](#), near to Geneva. This experiment that runs at [LEP](#) (the Large Electron-Positron collider), which is the largest particle accelerator in the world.

The emphasis is very much on your active participation. I have tried to explain as simply as possible a few important things you need to know about our experiment and the different types of events that can occur. But the main parts are where you play the role of "particle detective" and identify for yourself pictures of different types of event.

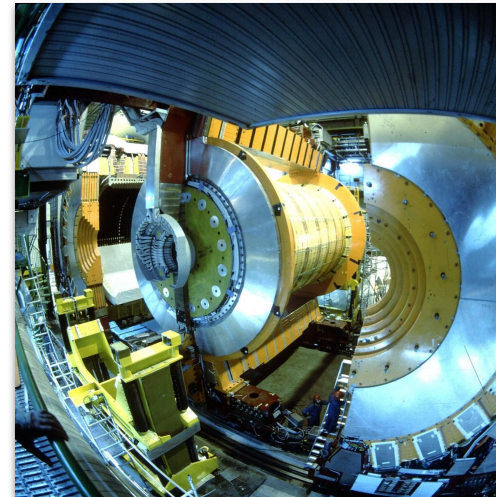


OPAL and LEP

- OPAL: Omni-Purpose Apparatus at LEP
- One of the 4 experiments at the LEP (Large Electron-Positron) collider
- Collected data from Aug 1989 - Nov 2000
- LEP1 (1989-1995): e^+e^- collisions at 91 GeV, producing millions of Z bosons
- LEP2 (1996-2000): e^+e^- collisions at increased energy to produce W^+W^- pairs
- <http://opal.web.cern.ch/Opal/>



<https://cds.cern.ch/record/970281>
















<https://cds.cern.ch/record/39049>

OPAL masterclass

- Developed by Terry Wyatt [et al.](#) at University of Manchester, UK
- Students examine static event display images and learn how to identify various events
- Measurements: Z branching ratio (to electrons, muons, taus, and jets) and W+W- branching ratios (lepton+jets:jets and leptons:jets)

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OPAL masterclass

- 1000 Z events and ~500 W+W- events
- Masterclass was last updated in 2003

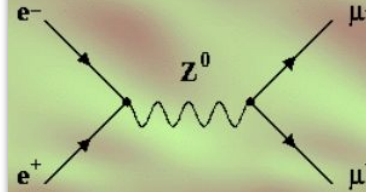
Links:

[page at Manchester](#), [page at physicsmasterclasses.org](#)

How to Identify Events

Perhaps the simplest types of events to identify are those in which the elect...

the detector. We represent the production of, for example, a muon-antimuon

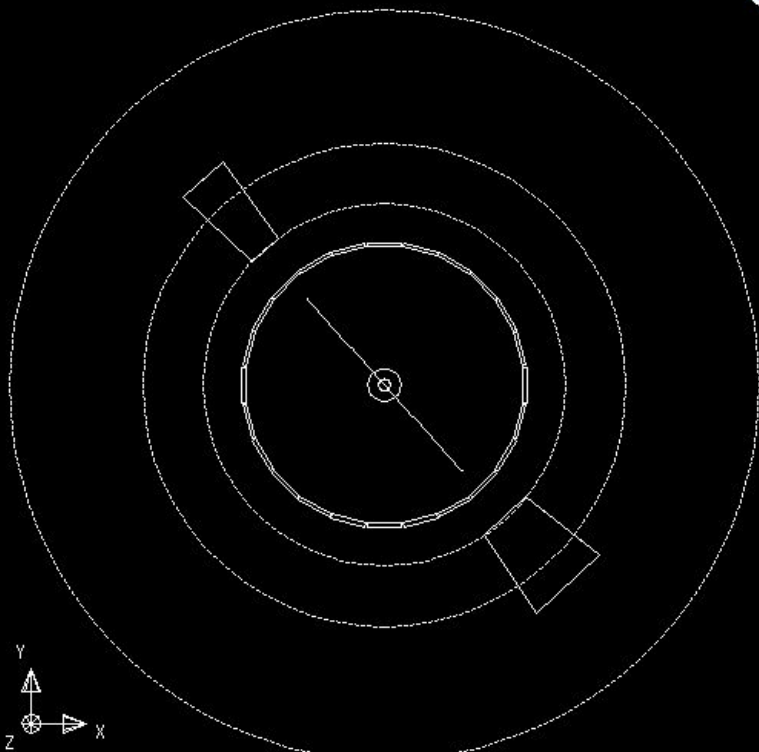


Here are some events containing the different types of particle-antiparticle p

- [example](#) $e^+e^- \rightarrow \mu^+\mu^-$ events
- [example](#) $e^+e^- \rightarrow e^+e^-$ events
- [example](#) $e^+e^- \rightarrow \tau^+\tau^-$ events
- [example](#) $e^+e^- \rightarrow q\bar{q}$ events

$$e^+e^- \rightarrow e^+e^-$$

Run:event 7575: 13812 Ctrk(N= 2 Sump=140.6) Ecal(N= 15 SumE=175.3)
Bbeam 86.148 Vtx (-0.06, 0.06, 0.48) Hcal(N= 0 SumE= 0.0) Muon(N= 0)

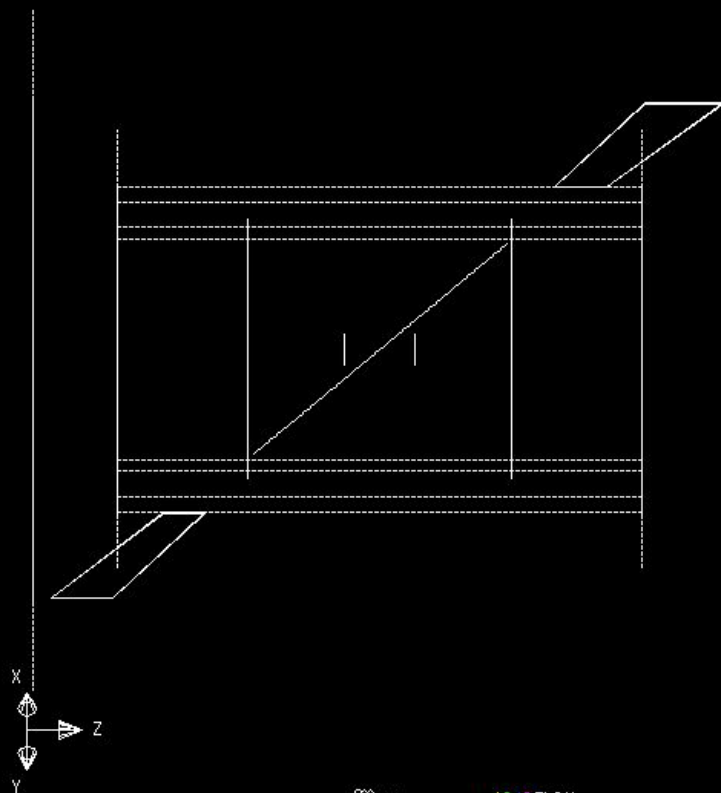


Centre of screen is (0.000, 19.287, 0.000)

200 cm

1248 50 DelV

Run:event 7575: 13812 Ctrk(N= 2 Sump=140.6) Ecal(N= 15 SumE=175.3)
Bbeam 86.148 Vtx (-0.06, 0.06, 0.48) Hcal(N= 0 SumE= 0.0) Muon(N= 0)



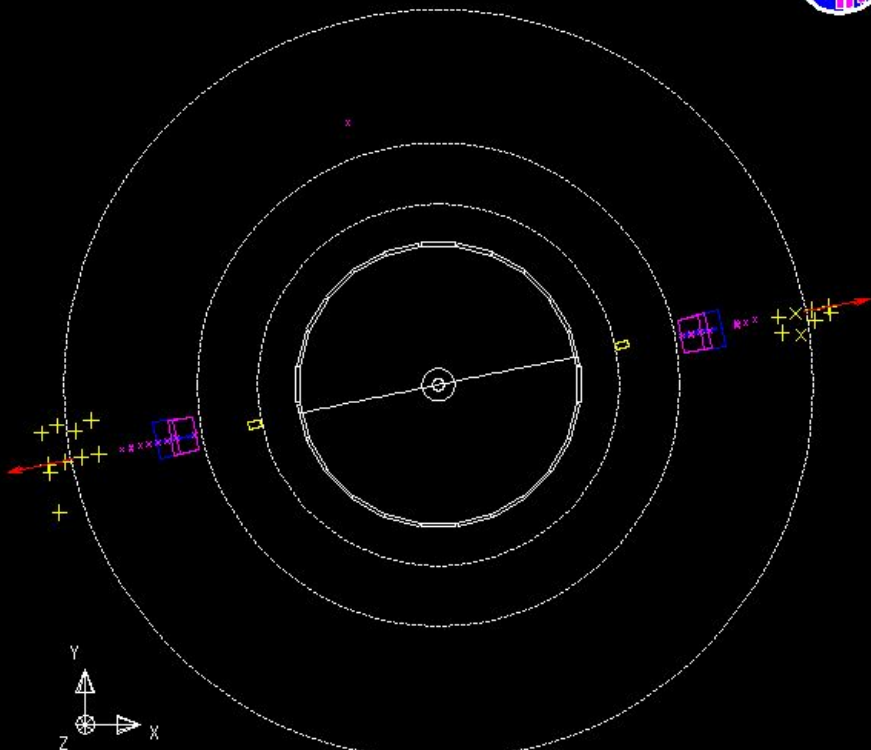
Centre of screen is (-27.704, 30.661, 0.000)

200 cm

1248 50 DelV

$$e^+e^- \rightarrow \mu^+\mu^-$$

Run:event 7592: 53783 Ctrk(N= 2 Sump=159.0) Ecal(N= 7 SumE= 1.4)
Ebeam 86.187 Vtx (-0.06, 0.06, 0.35) Hcal(N= 6 SumE= 6.2) Muon(N= 2)

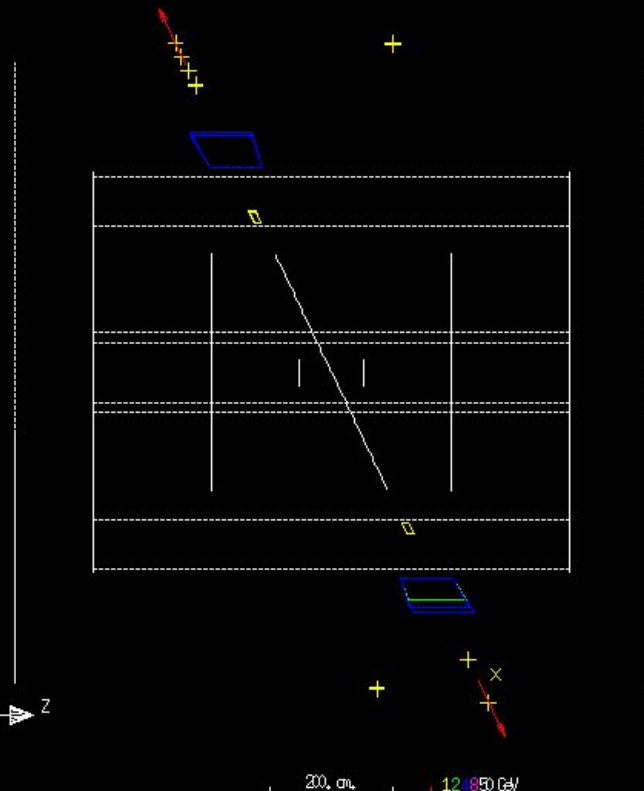


Centre of screen is (0,000, 18,353, 0,000)

200, cm

124850 GeV

Run:event 7592: 53783 Ctrk(N= 2 Sump=159.0) Ecal(N= 7 SumE= 1.4)
Ebeam 86.187 Vtx (-0.06, 0.06, 0.35) Hcal(N= 6 SumE= 6.2) Muon(N= 2)



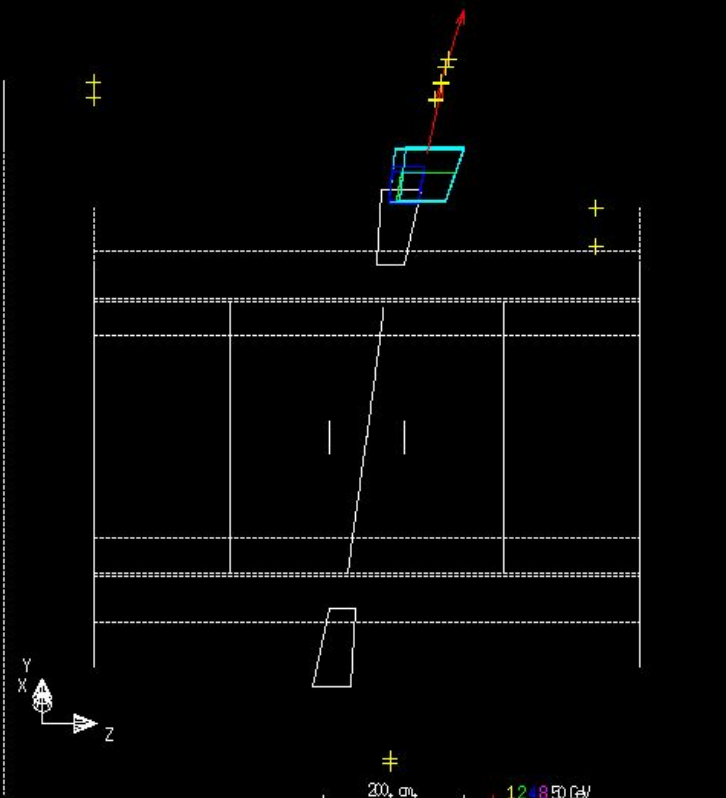
Centre of screen is (-18,007, -3,640, 0,000)

200, cm

124850 GeV

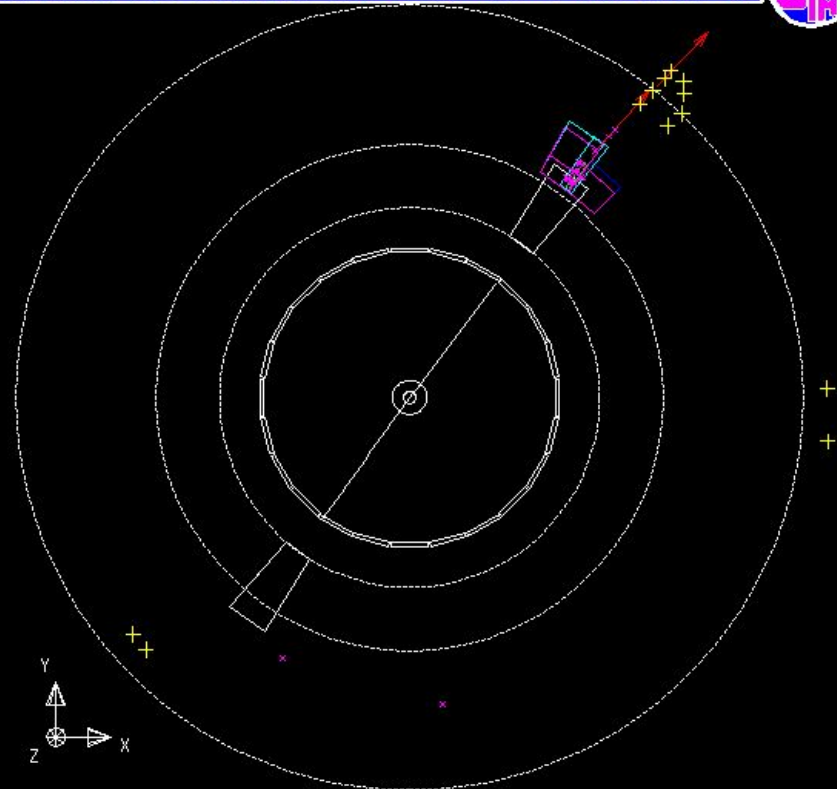
$$e^+e^- \rightarrow \tau^+\tau^-$$

Run:event 7592: 36349 Ctrk(N= 2 Sump= 38.2) Ecal(N= 8 SumE= 78.6)
Ebeam 86.182 Vtx (-0.06, 0.06, 0.35) Hcal(N= 4 SumE= 10.3) Muon(N= 2)



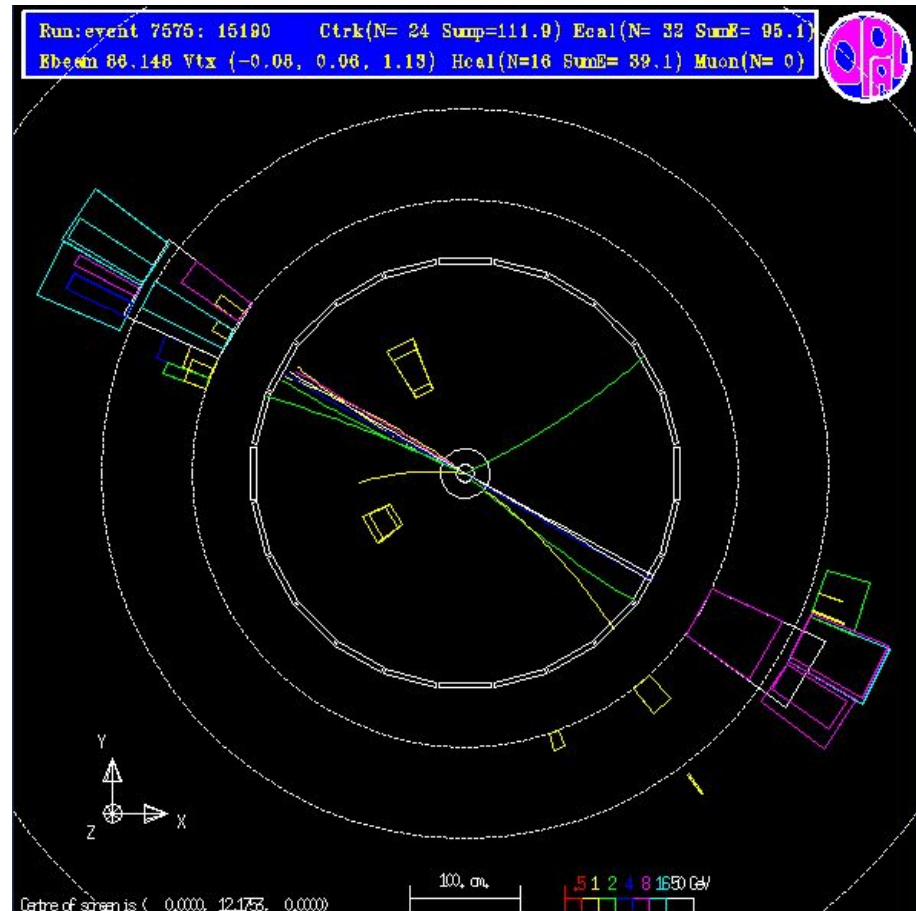
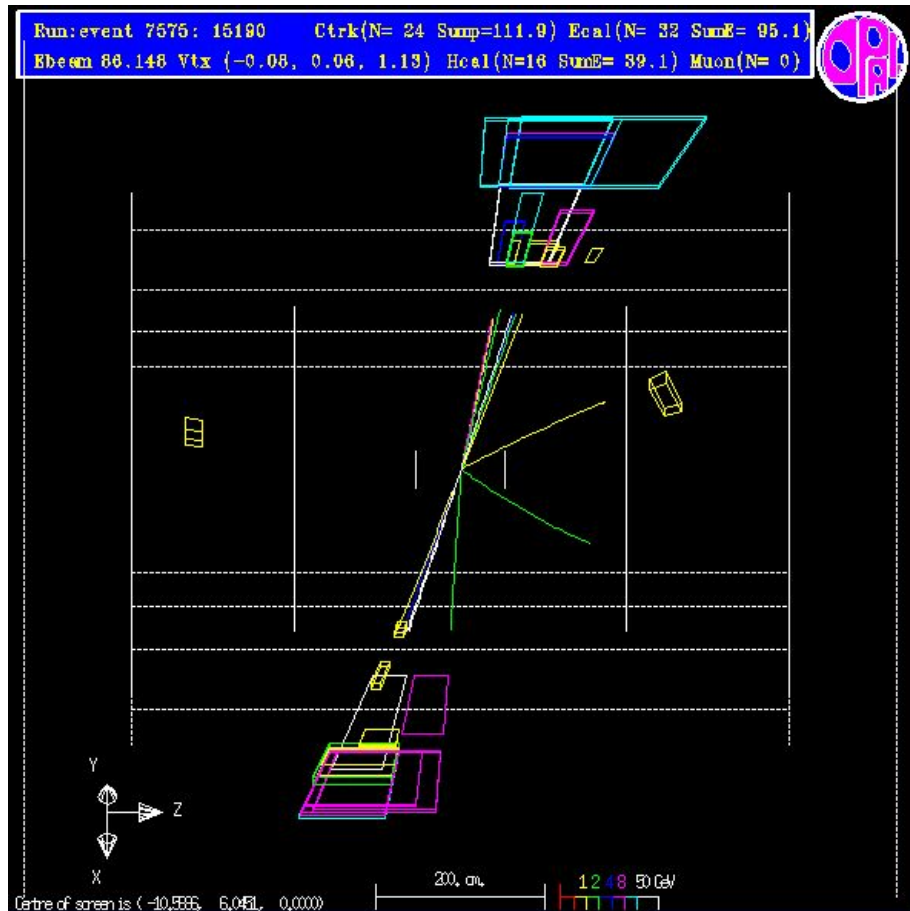
Centre of screen is (55,764, 76,538, 36,5715)

Run:event 7592: 36349 Ctrk(N= 2 Sump= 38.2) Ecal(N= 8 SumE= 78.6)
Ebeam 86.182 Vtx (-0.06, 0.06, 0.35) Hcal(N= 4 SumE= 10.3) Muon(N= 2)

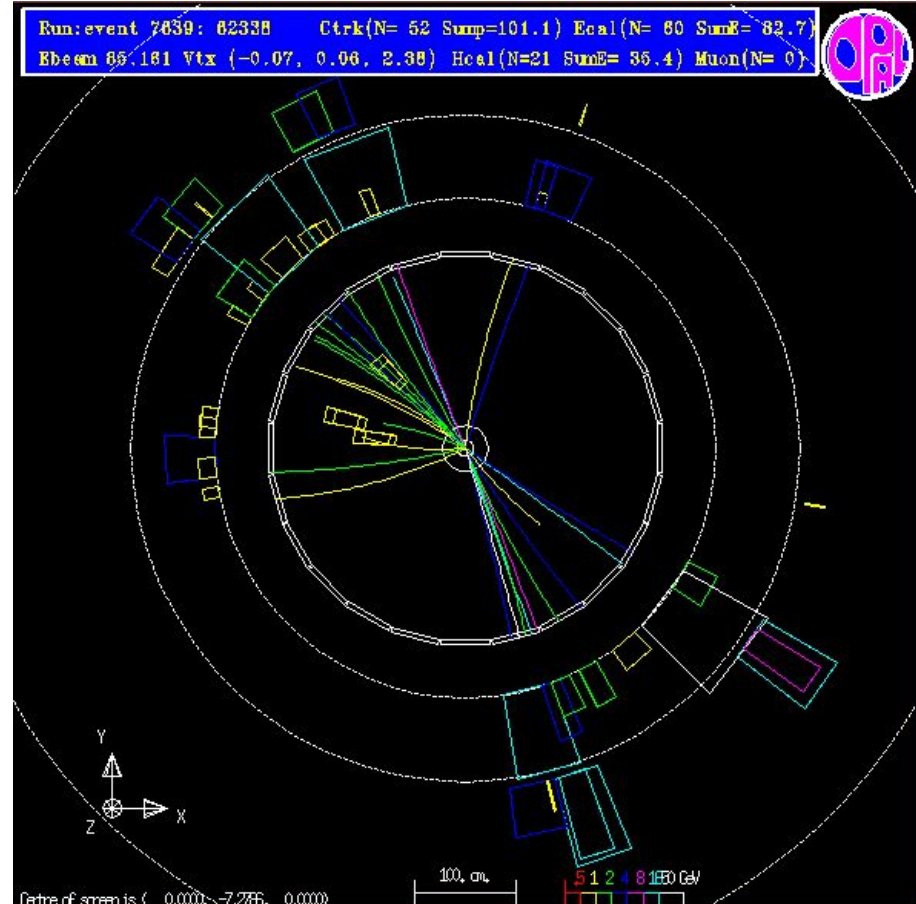
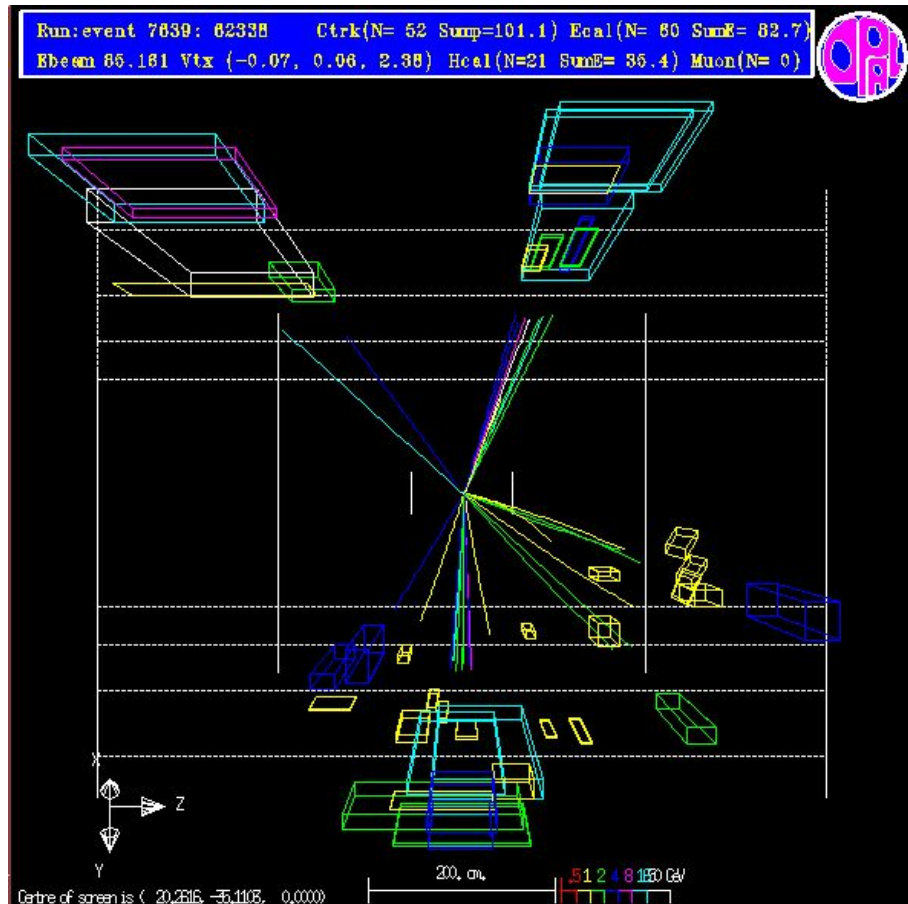


Centre of screen is (0,000, 17,5825, 0,000)

$$e^+e^- \rightarrow q\bar{q}$$

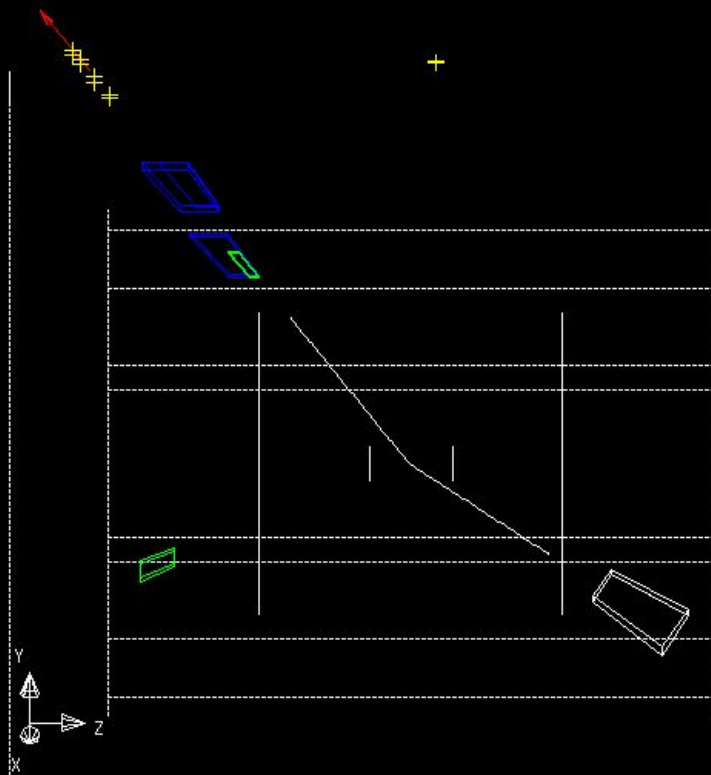


$$W^+W^- \rightarrow q\bar{q}q\bar{q}$$



$$W^+W^- \rightarrow \ell^+\nu\ell^-\bar{\nu}$$

Run: event 7402:203918 Ctrk(N= 2 Sump= 86.4) Ecal(N= 9 SumE= 49.9)
Ebeam 80.874 Vtx (0.00, 0.00, 0.00) Hcal(N= 3 SumE= 5.1) Muon(N= 1)

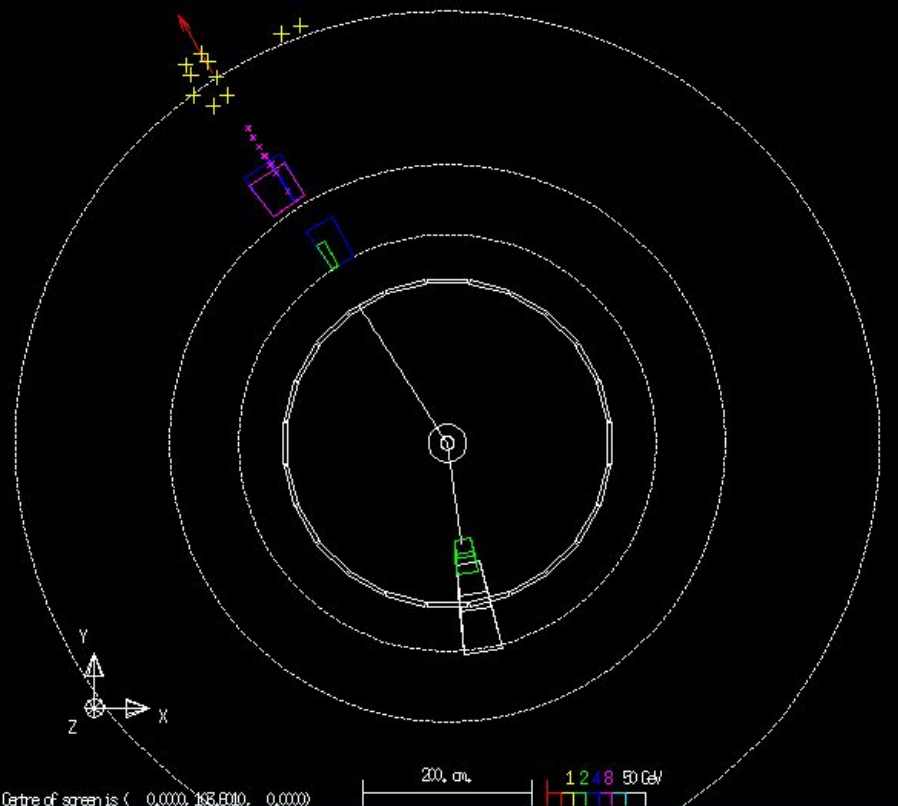


Centre of screen is (-47.1102, 111.5572, -5.0549)

200 cm

12.48 50 GeV

Run: event 7402:203918 Ctrk(N= 2 Sump= 86.4) Ecal(N= 9 SumE= 49.9)
Ebeam 80.874 Vtx (0.00, 0.00, 0.00) Hcal(N= 3 SumE= 5.1) Muon(N= 1)



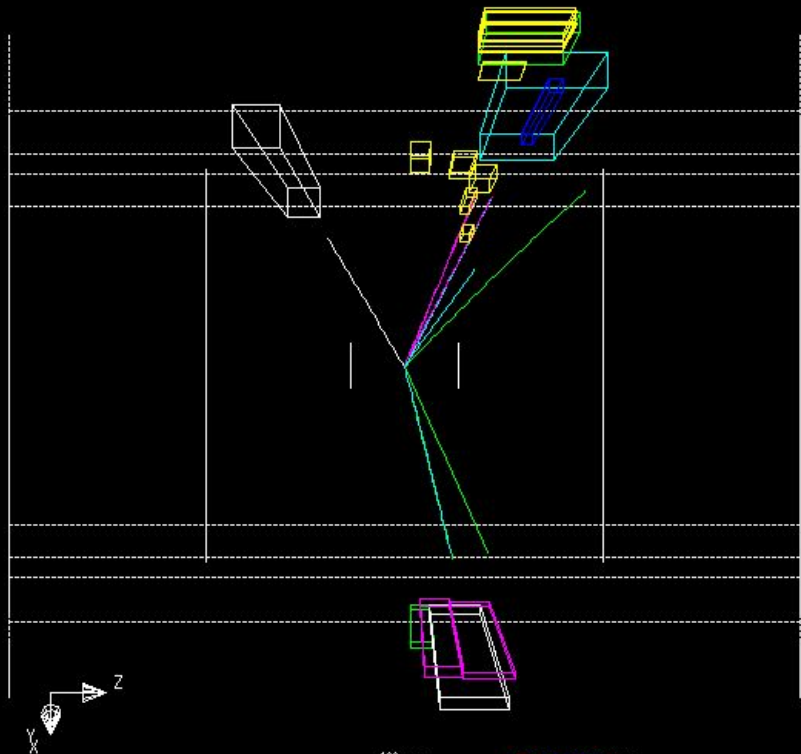
Centre of screen is (0.0000, 165.6010, 0.0000)

200 cm

12.48 50 GeV

$$W^+W^- \rightarrow e\bar{\nu}q\bar{q}$$

Run: event 7590: 9003 Ctrk(N= 37 Sump=102.5) Ecal(N= 41 SumE=111.3)
Ebeam 86.168 Vtx (-0.09, 0.06, -0.13) Hcal(N= 8 SumE= 3.2) Muon(N= 0)

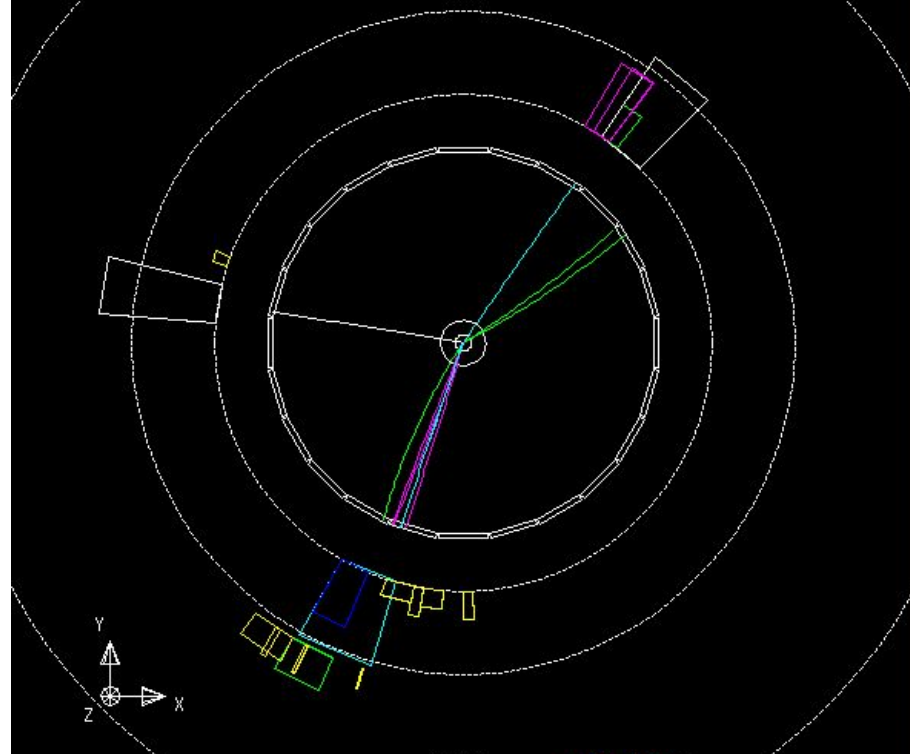


Centre of screen is (-20.6101, -17.1084, 0.0000)

100, cm

5 1 2 4 8 16 GeV

Run: event 7590: 9003 Ctrk(N= 37 Sump=102.5) Ecal(N= 41 SumE=111.3)
Ebeam 86.168 Vtx (-0.09, 0.06, -0.13) Hcal(N= 8 SumE= 3.2) Muon(N= 0)

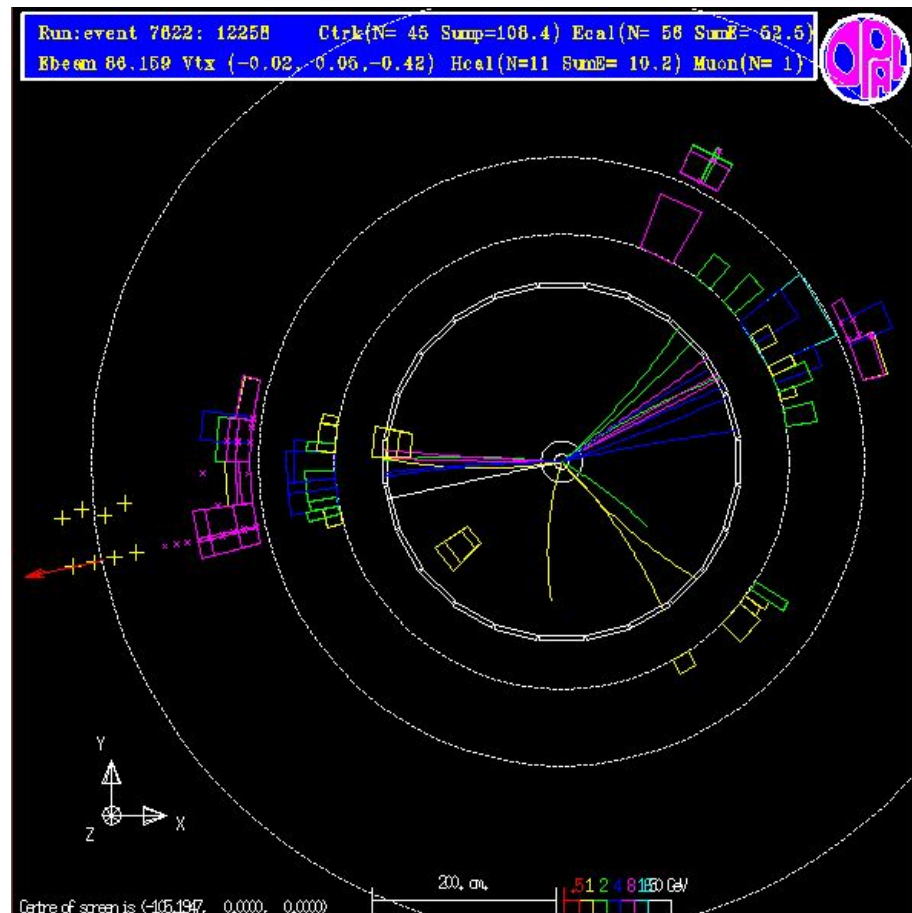
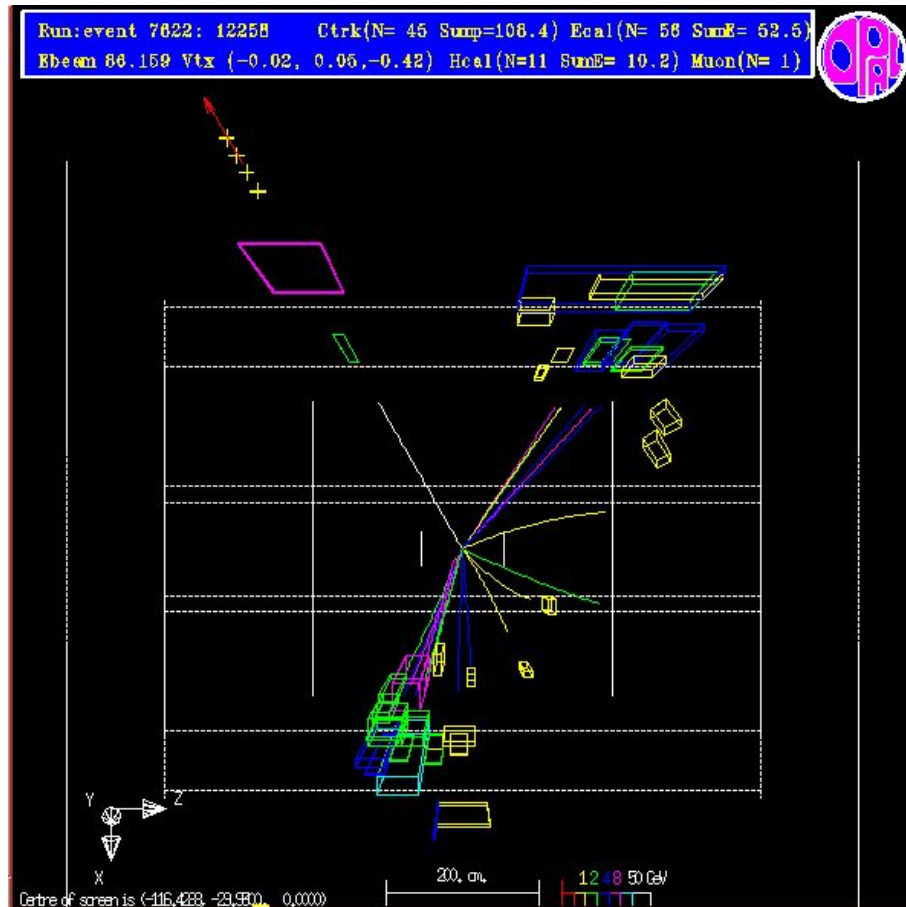


Centre of screen is (0.0000, 0.0000, 0.0000)

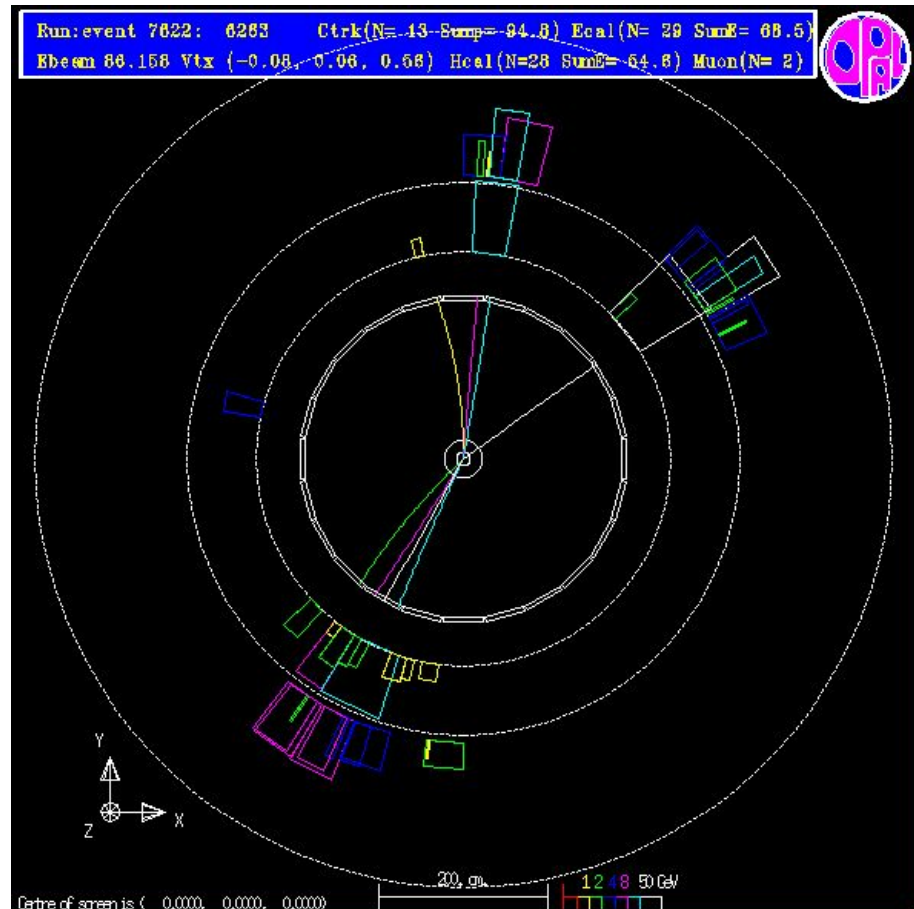
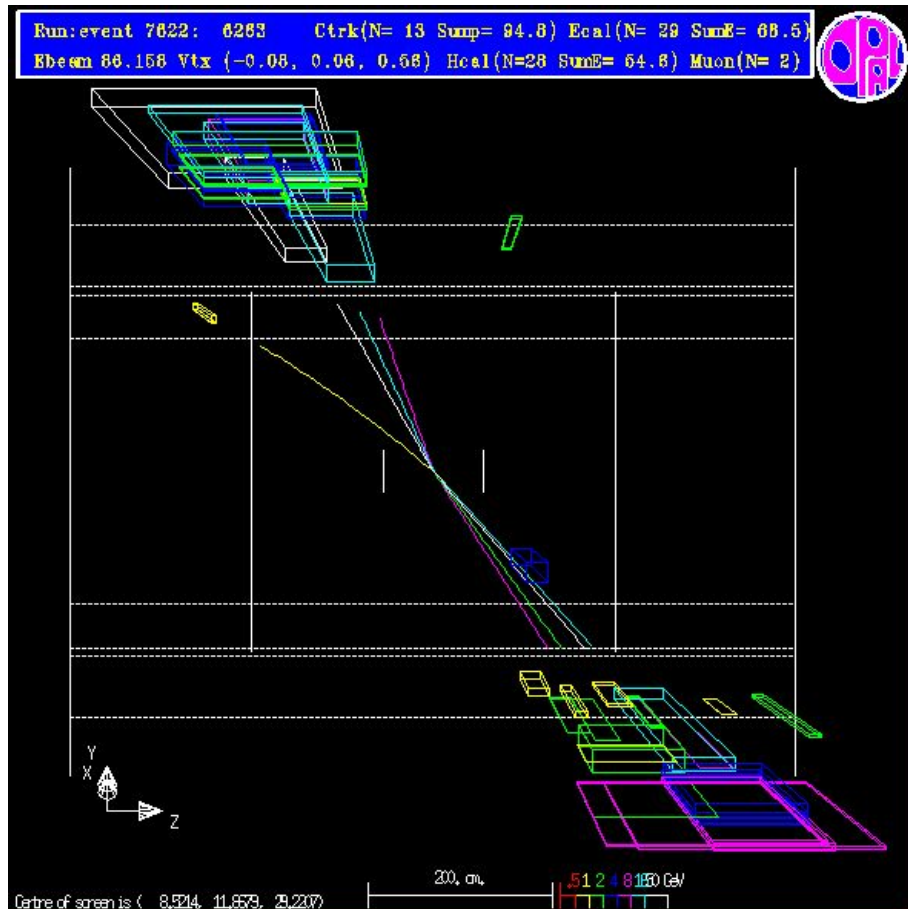
100, cm

5 1 2 4 8 16 GeV

$$W^+W^- \rightarrow \mu\bar{\nu}q\bar{q}$$



$$W^+W^- \rightarrow \tau\nu q\bar{q}$$



Status and next steps

- We've collected the material from physicsmasterclasses.org and been in touch with Terry Wyatt who's kindly provided the contents of the Manchester page
- We've started to collect content in this [GitHub repo](#)
- Checks have been run on images and 6 are missing (but apparently no one ever noticed until now)
- The original page is late-90s HTML design so can be straightly-forwardly upgraded and adapted to something more modern (as one option)

Status and next steps

- The original page is also in various languages: need to think about how to make best use of this
- A “minimum-viable-product” masterclass to start would include only Z events (perhaps only just e^+e^- and $\mu^+\mu^-$ decays?)
- We’ve also been in touch with the CERN open data team for inclusion and preservation of this masterclass material on the CERN Open Data Portal
- In addition, Uta B has pointed out that Christian Klein-Bösing has created a [ML masterclass](#) using the same OPAL images (see their slides in this session)
- thomas.mccauley@cern.ch, kcecire@nd.edu