International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES
hands on particle physics

International Masterclasses

CERN Videoconference Manual

for Local Organizers

10.02.2023

Technical details (Zoom)

The official videoconference service is Zoom. Videoconferences will be “meeting” style, so connecting groups are supposed to share video and audio.

The links to the Zoom videoconferences will be sent a few days ahead of your Masterclass.

All videoconferences are from 16:00 – 17:00 CET.

The most important rules

To make the videoconference enjoyable for both moderators and students and to ensure a smooth flow of information:

- The VC starts at 4:00 pm CET sharp.
- Stay muted unless you are supposed to talk.
- Select students beforehand (for answering moderators´ questions on results).
- Ask students to have some questions ready for the moderators (Q&A session).
- For the quiz, students need answer sheets (download from https://physicsmasterclasses.org/downloads/answersheet-2023.pdf)

Elements of the Videoconference

1. Overview & Timing

Welcome & Icebreaker ____________________ 10' (16:00 – 16:10)

Combination & Discussion of Measurement ______ 20' (16:10 – 16:30)

Open Discussion ________________________ 19' (16:30 – 16:49)

Quiz __________________________________ 10' (16:49 – 16:59)

Good Bye ______________________________ 01’ (16:59 – 17:00)

2. Welcome & Icebreaker (10’)

Moderators will welcome participants, explain the timeline and ask each group one short question and let them speak.

Moderators will display a map showing all connecting sites. Example:

3. Combination & Discussion of Measurements (20’)

Moderators show combined results. They will ask one question to each group, on the measurements and the results.

- Select students to answer the question already before the VC starts!
- To prepare your students you can use the information given in ***Scenarios for Discussion of Measurements***, p. 4 ff.

It is **not** intended that institutes present reports.

4. Open Discussion (19’)

After the specific discussion of the measurement, the discussion can expand to more open and general questions. The students should be prepared by you, in order to have some questions ready.

5. Quiz (10’)

The quiz will be presented by moderators as ppt slideshow. Students need answer sheets (download from https://physicsmasterclasses.org/downloads/answersheet-2023.pdf)

The quiz includes 7 multiple choice questions (4 answers each), and every students plays on his/her own. The correct answer will be revealed immediately after each question.

You can download the quiz from https://physicsmasterclasses.org/downloads/quiz-2023-en.pptx

6. Common Good Bye (01')

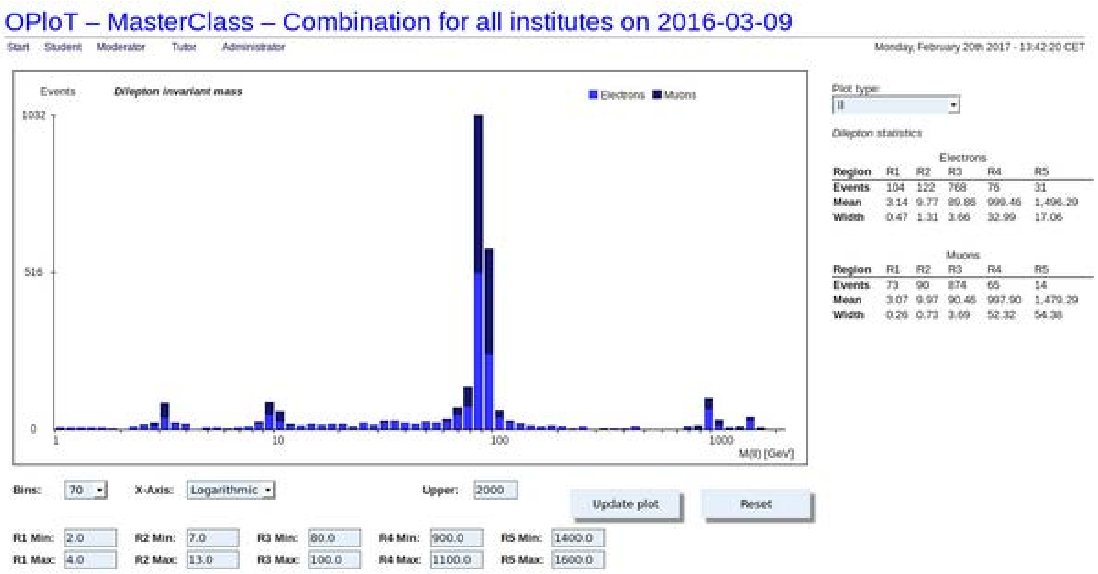
Moderators are supposed to close the session after 60 minutes!

Also in the case of very lively discussions, the moderators still have to officially end the VC in time. They can, however, offer to stay online after the official end. But this is completely on a voluntary basis. Alternatively, students can be offered to continue the discussion locally with the local experts.

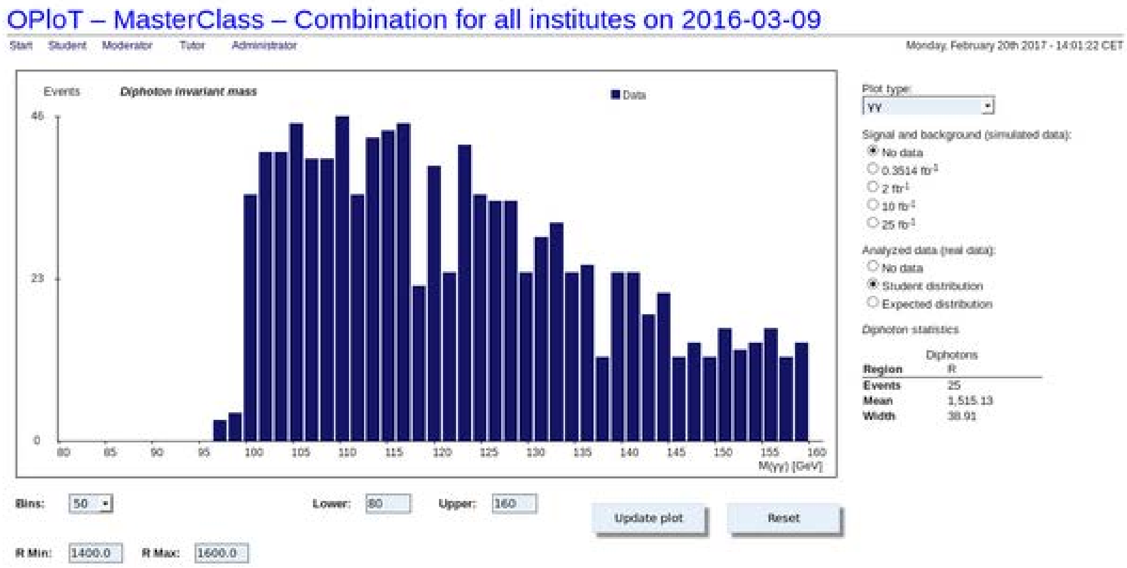
7. Scenarios for Discussion of Measurements

To streamline the discussion of measurements sets of questions (scenarios) have been developed which will be used by the moderators. Each scenario consists of a plot/histogram/table/etc. and 1-2 relevant question(s) that students are supposed to answer. These scenarios will help moderators and institutes to go through the results and the physics discussion in an efficient way.

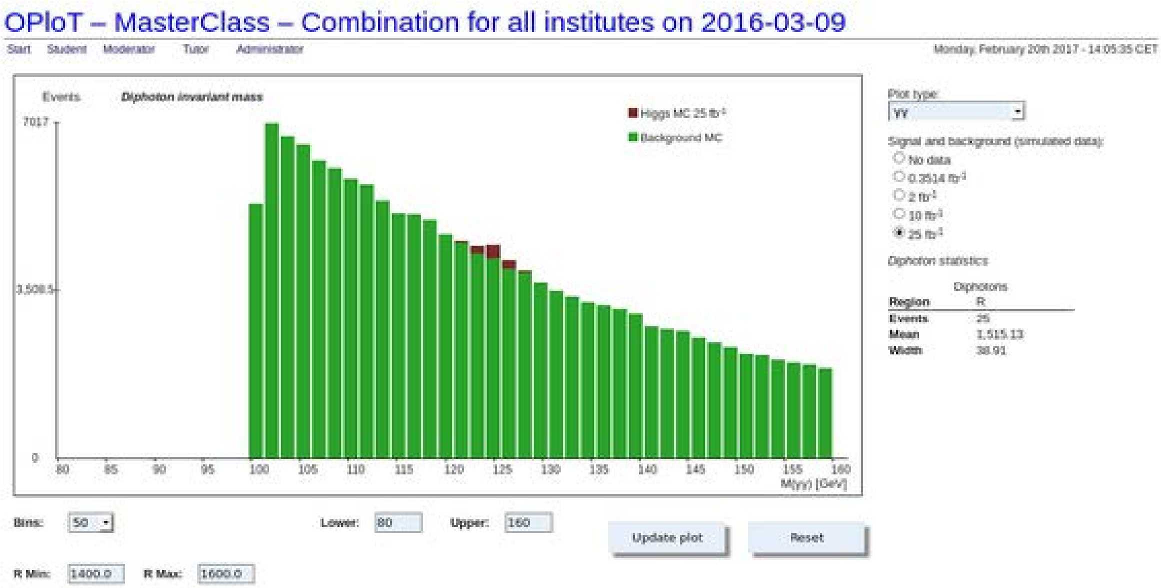
a) ATLAS Z path



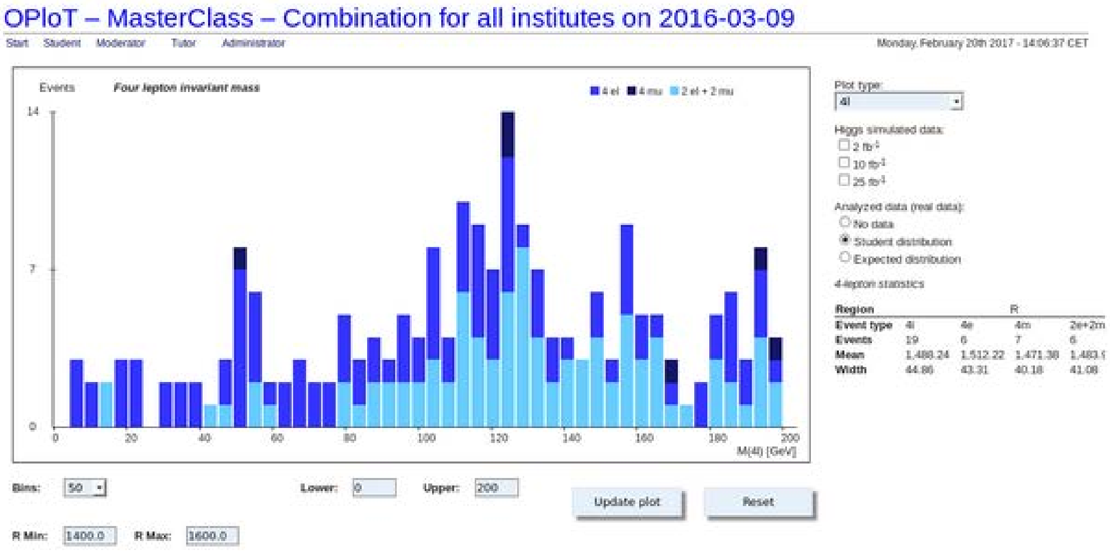
- Question 1: What does it mean when we see a peak in the distribution? Do you see any peaks that you did not expect?



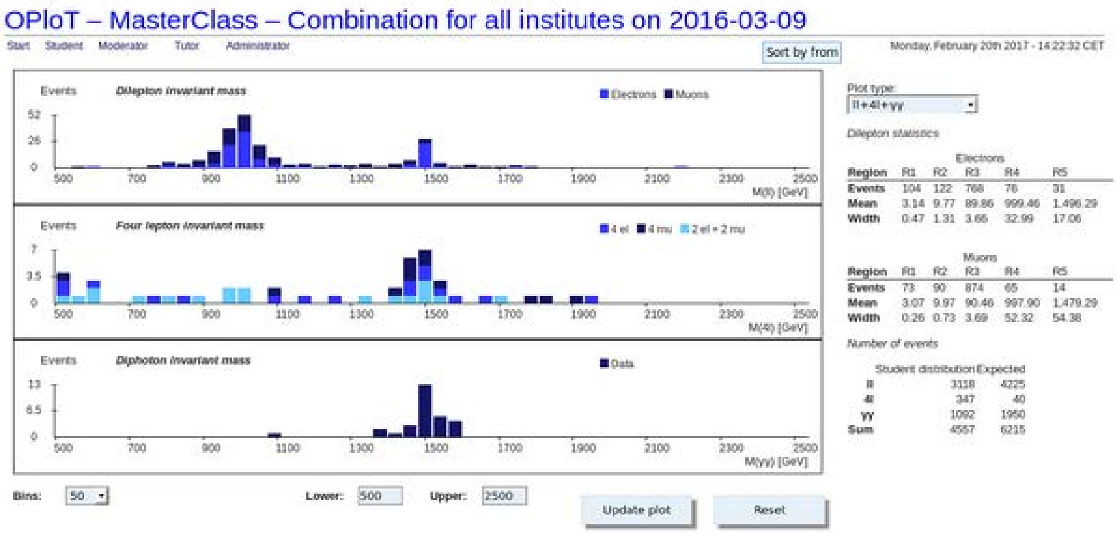
- Question 2: Do you see a peak corresponding to the Higgs boson? Why not? (Hopefully students are aware of statistics limitations from local institute discussions.)



- Question 3: Do you think we could see the peak here even if it had the same color as the background? Why does it help to collect more data?



- Question 4: Why are there many more 4-lepton events than expected? (Here you can compare to the table in the summary screen or to the expected distribution.) What can you say about the composition in terms of 4e, 2e2μ, and 4μ?



- Question 5: What does it tell us that the particle at 1000 GeV is not seen in the 4-lepton and diphoton distributions, while the particle at 1500 GeV is seen in all distributions?

b) ATLAS W path

Moderators show combined online spreadsheet.

Analysis

Total #	W → ... + ν				Background	WW
1615	e^+	e^-	μ^+	μ^-		
ATP	56	56	56	56	343	133
Bonn-NTW						
BSZ Riesa	18	27	22	16	86	21
Hamburg-NTW-1	25	17	19	14	149	20
R.-Hildebrand-Gym. Ma	0	0	0	0	390	91
Total	99	100	97	86	968	265
$\Sigma\|W^+\|,\Sigma\|W^-\|$	$\|W^+\|$	196	$\|W^-\|$	186	$\|W^+\| + \|W^-\|$	382
Ratio	$\|W^+\|/\|W^-\|$			1.0538	±	0

Comparison with results of the ATLAS collaboration (from 2011):

Measurement of the W -> lnu and Z/gamma* -> ll production cross sections in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector*) and Search for the Standard Model Higgs boson in the H→WW(*)→lνlν decay mode using 1.7 fb−1of data collected with the ATLAS detector at √s = 7 TeV **)

*) Authors: The ATLAS Collaboration (Submitted on 5 Dec 2011): http://arxiv.org/abs/1109.5141.pdf

**) Authors: The ATLAS Collaboration (24 Aug 2011): ATLAS-CONF-2011-134

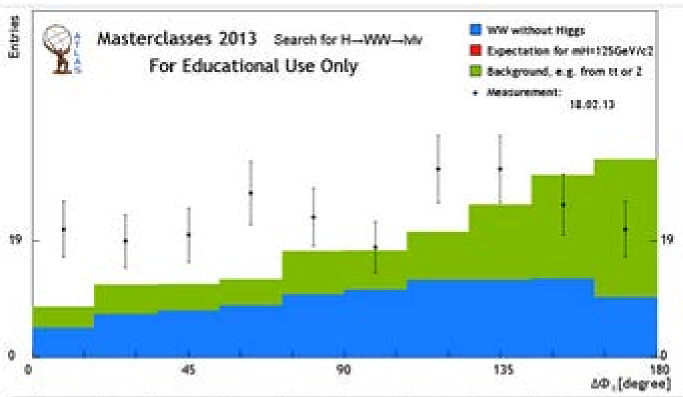
	W → ... + ν				Background	WW cand.
	e^+	e^-	μ^+	μ^-		
Total	77885	52856	84514	55234	21930	469
$\Sigma\|W^+\|,\Sigma\|W^-\|$	$\|W^+\|$	162399	$\|W^-\|$	108090	$\|W^+\| + \|W^-\|$	270489
Ratio	$\|W^+\|/\|W^-\|$			1.50	±	0.01

Question 1: What was your result for R±? How did the combination with the other institutes change the total result?

Question 2: Is the result compatible with the results measured in ATLAS?

Then moderators show combined histogram.

WW-Histogramme



	bin 1	bin 2	bin 3	bin 4	bin 5	bin 6	bin 7	bin 8	bin 9	bin 10	sum
N	21	19	20	27	23	18	31	31	25	21	236
B	8.1	11.8	11.9	12.7	17.3	17.4	20.6	25	29.9	32.5	187.3
S	12.9	7.2	8.1	14.3	5.7	0.6	10.4	6	-4.9	-11.5	48.8
Z	4.5	2.1	2.3	4	1.4	0.1	2.3	1.2	-0.9	-2	3.6

number of bins [1 ... 20] maximum of y axis Submit

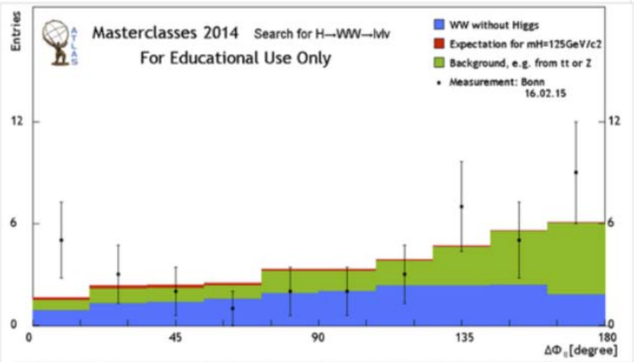
standardization 1 2 3 cut on bin number Default

Higgs contribution

Question 3: You have measured the angle between two leptons. Let´s have a look at that. What exactly do the black data points mean?

Question 4: How would you interpret the blue and green areas? What do they mean?

Then moderators show the Higgs contribution (in red).



	bin 1	bin 2	bin 3	bin 4	bin 5	bin 6	bin 7	bin 8	bin 9	bin 10	SUM
N	5	3	2	1	2	2	3	7	5	9	39
B	1.5	2.2	2.2	2.4	3.2	3.2	3.8	4.6	5.6	6	34.7
S	3.5	0.8	-0.2	-1.4	-1.2	-1.2	-0.8	2.4	-0.6	3	4.3
Z	2.8	0.5	-0.1	-0.9	-0.7	-0.7	-0.4	1.1	-0.2	1.2	0.7

number of bins [1 ... 20]

maximum of y axis

Submit

standardization 1 2 3

cut on bin number

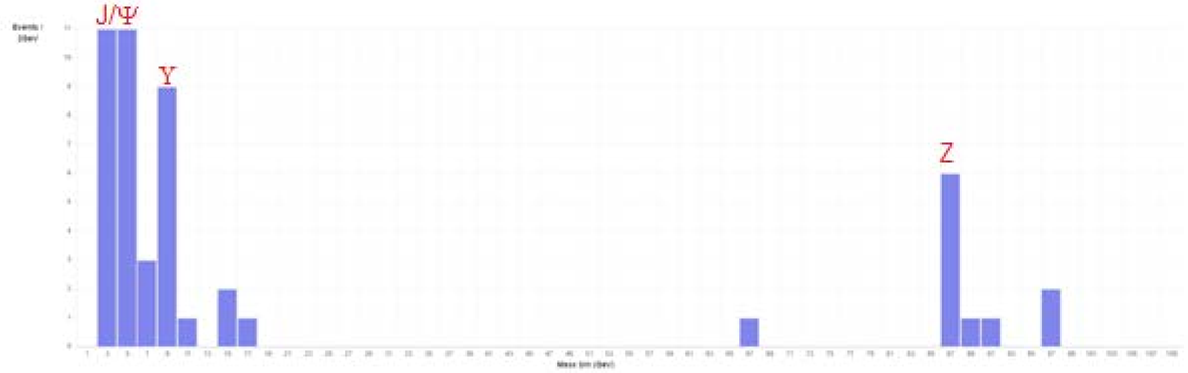
Default

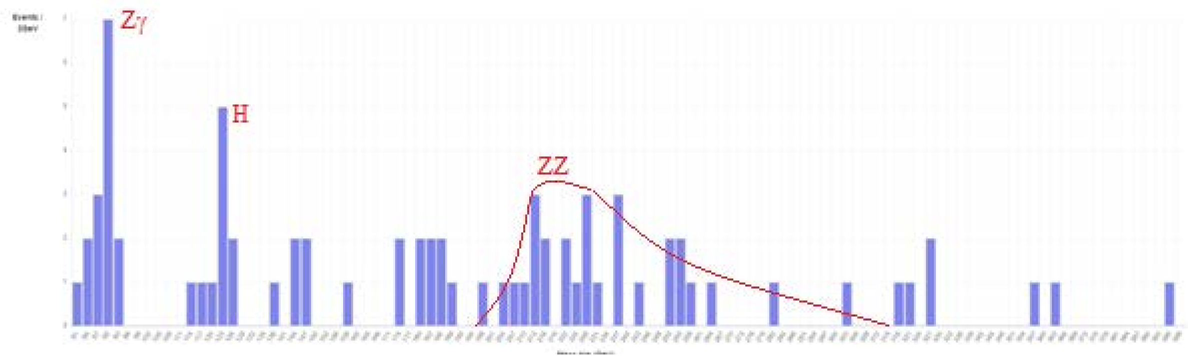
Higgs contribution

Question 5: Can we claim a Higgs discovery? What would be necessary to claim a discovery?

c) CMS

Moderators share overall 2- and 4-lepton mass plots. The mass plots appear together in CIMA in the Mass Histogram tab with the 2-lepton plot at the top and the 4-lepton plot at the bottom. Expected peaks are marked here in red.





The above plots were made with limited data. The full masterclass plots may look different and the relative heights of peaks may appear to be different.

Question 1: Where are the peaks in the Mass Histograms? What do they represent?

Question 2: Where is Z boson in the 2-lepton plot? What are the other peaks, then?

Question 3: Do you have possible Higgs events in the 4-lepton plot? Where? Can we claim discovery?

Question 4: Why does there appear to be a Z peak in the 4-lepton plot as well? Since the Z does not directly decay to 4 leptons, how do we explain this?

Question 5: Is there anything else significant in the 4-lepton plot?

Moderators share key ratios. The key ratios, e/μ and W+/W- are in the Results tab toward the bottom, isolated here in red.

Group	e	μ	W+	W-	W±	Neutral	Zoo	Total
	0	0	0	0	0	0	0	0
5.1	4	7	1	0	0	7	1	9
5.2	11	14	6	2	1	13	1	23
5.3	0	0	0	0	0	0	0	0
5.4	0	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0	0
10.1	7	6	1	1	0	5	7	14
10.2	6	5	2	2	0	5	0	9
10.3	13	22	9	5	2	13	1	30
10.4	33	43	17	16	0	33	1	67
10.5	17	18	11	8	0	13	0	32
10.6	46	59	31	17	0	44	8	100
10.7	12	18	6	10	1	6	12	35
10.8	2	6	1	0	1	6	0	8
10.9	21	24	10	5	5	19	4	43

Total:

Group	e	μ	W+	W-	W±	Neutral	Zoo	Total
All	172	222	95	66	10	164	35	370

Ratios:

e/μ	W+/W-
0.73	1.44

The expected values are e/μ = 1.0 and W+/W- = 1.4, though results will vary.

Question 6: What do you expect the ratio of electron events to muon events to be? Is your result consistent with this?

Question 7: What is the ratio of W+ to W- bosons? What does this ratio tell us about protons?

d) ALICE – Looking for strange particles

Why are the two tracks of each V0 curved in opposite directions?

Why is the radius of curvature of the proton bigger than that of the pion in Λ decays?

Why don't you see the Λ or the K0 before their decay?

Why does the Λ not decay to two pions, like the K0?

Why does the invariant mass have a width and is not a delta-function?

e) ALICE – R_AA

Visual analysis: where do the clusters come from that are not associated with a reconstructed track?

Visual analysis: did you observe more positively or negatively charged particle tracks? Why is this so?

Visual analysis: why do most of the produced particles have low momenta?

What is a reconstruction efficiency and why is it important?

What is the difference between R_CP and R_AA?

Why is R_AA < 1 consistent with energy loss in a quark-gluon plasma?

f) LHCb

Moderators introduce measurement, say now we merge data from all groups and show the combined plot of D0 invariant mass distribution

Question 1: How did the D0 mass distribution change with more data?

Moderators discuss statistics and importance of collecting large datasets

Question 2: What can cause the background in the invariant mass distributions?

Moderators show the lifetime plot

Question 3: Did your result of lifetime agree with the world average value listed in PDG tables?

Usually students measure larger lifetime than PDG. Moderators can discuss the sources of bias, using more cuts and better selection in real analyses etc.

Question 4: How much data would you need to be as precise as the current world average? As example take your error ~5 fs, PDG world average error ~1 fs.

Moderators can discuss statistics, future experiments etc.

Question 5: Is it a good idea to measure D0 lifetime by more than one experiment?

Question 6: What experimental effects might cause a difference between the measured lifetime and the world average?