International Masterclasses

Videoconference

Manual

for

Moderators

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Introductory Remarks

This manual is the result of a working group set up at the 1st IPPOG Meeting in Košice, consisting of two experienced video conference moderators (Kate Shaw, Michael Hauschild), Uta Bilow, responsible for coordination of the International Masterclasses, and Laurenz Widhalm[†] as head of the group.

Based on feedback collected over the years from students, teachers, moderators and (local and global) organizers, we defined the aims and structure of the video conference, and compiled a list of dos and don'ts to achieve the best possible video conference experience for the students.

Please read this manual carefully to be optimally prepared for your Masterclass video conference!

<u>Abbreviations used in this manual:</u>

VC	refers to the masterclass video conference

<u>Symbols used in this manual:</u>

Mandatory or strongly advised!

Avoid this!

[†] This manual is dedicated to the memory of Laurenz Widhalm, who initiated the Masterclasses Video Conference WG, and died after long illness on December 24, 2012.

Contents

1) About International Masterclasses

International Masterclasses provide a unique opportunity for High school students to be "scientists for a day". 16- to 19-year-old students in 37 countries around the whole world are invited to one of about 160 nearby universities or research centres for one day in order to take part in an authentic research process. They hear lectures from active scientists and gain insight into topics and methods of basic research into the fundamentals of matter and the forces. Thus prepared, students perform measurements themselves on real data from particle physics experiments at the LHC (ALICE, ATLAS, CMS, LHCb). At the end of each day, as in an international research collaboration, the participants join in a video conference for discussion and combination of their results. In summary, International Masterclasses offers students the chance to close their textbooks and experience modern science first-hand.

The International Masterclasses are a core activity of IPPOG, the International Particle Physics Outreach Group. The program is organized and run by Michael Kobel of the Technical University Dresden, Germany, and coordinated by Uta Bilow from TU Dresden.

Particle Physics Masterclasses began in 1997 in the United Kingdom. The European program started in 2005, the World Year of Physics, and has grown constantly since then. In 2006 American students participated for the first time in a parallel program organized by QuarkNet, and since then more and more countries have joined in.

With its unique approach the International Masterclasses cover various aims:

- link school and research institutions
- bridge the gap between science education at school and modern scientific research
- stimulate interest in science
- improve understanding in science and scientific research
- demonstrate the scientific research process
- provide an attractive opportunity to get a first glimpse of modern physics research

Int. Masterclasses:	www.physicsmasterclasses.org
IPPOG:	http://ippog.web.cern.ch/ippog/
QuarkNet:	http://quarknet.fnal.gov/

2) The Aim of the Video Conference

The Video Conference (VC) has to:

- **convey the internationality of the event**
- **demonstrate how physicists work together internationally**
- **encourage students to exchange experiences between masterclasses**
- **demonstrate improvement in accuracy by combination of different data sets**
- **most importantly: BE FUN FOR THE STUDENTS!**

it is NOT supposed to:

- **deepen the understanding of the physics** (better done locally in the native language)
- **teach English vocabulary of particle physicists** (vocabulary should not distract from physics)
- **contain a basic discussion of the measurement** (has to be done locally before)
- **create a competition regarding the measurements** (“who is the best?“)

3) Integration in the Local Event

Based on frequent feedback we received and from our experience, we set the following limits for the VC as part of a local masterclass event:

The VC has to start at 4:00 pm sharp!

Strict time limit of 60 minutes!

While there are always a few students that cannot get enough, feedback tells us that the majority are too exhausted at the end of a long day for a longer VC; the VC should be the closing highlight of the day, not remembered as the one thing that just would not end!

On several days **two parallel VCs** will be organized (**VC1, VC2**).

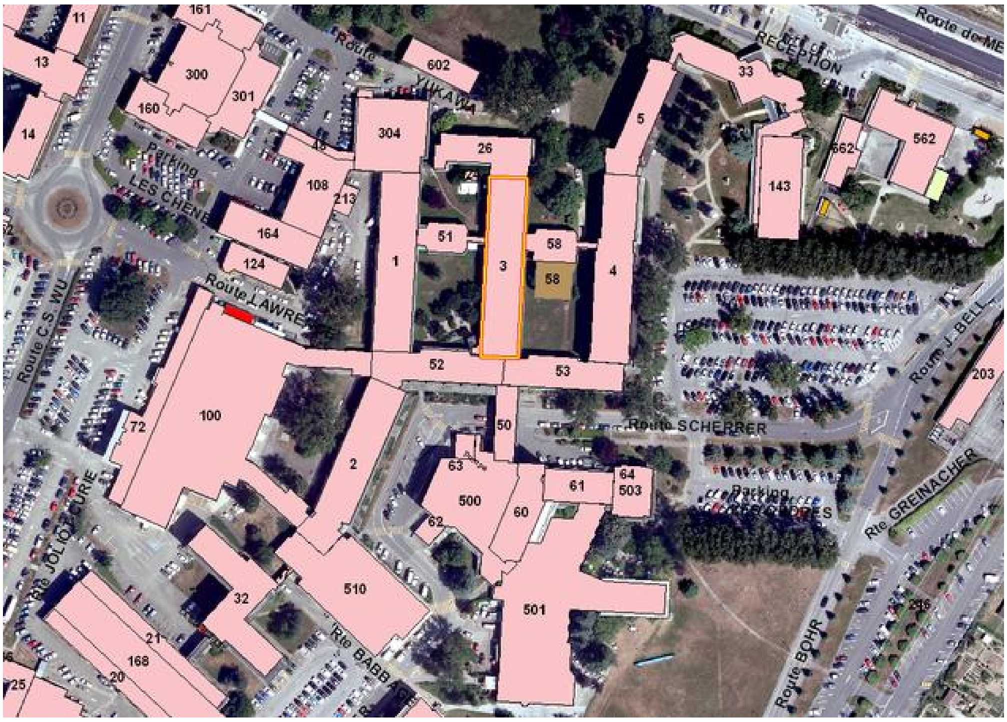
Moderators have to pay attention to go to the right VC location and connect to the correct VC!

The two VC rooms are at different locations at CERN, not close to each other. If it happens that you went to the wrong VC, you might need 10-15 minutes to move to the right VC. The correct VC can be seen from the schedule:

http://physicsmasterclasses.org/index.php?cat=schedule

4) Locations of the Video Conferences at CERN (I)

VC1: Teachers Lab (building 3-R-002)



VC1 is held in the Teachers Lab (building 3-R-002), close to the CERN main building.

Keys can be obtained from the following people, their office (3-R-006) is just next door of the Teachers Lab:

- Konrad Jende: +41 22 767 1395 (71395 internal), +41 76 487 0246 (mobile, 16 0246 internal)
- Martin Hawner: +41 22 767 1395 (71395 internal), +41 76 487 8956 (mobile, 16 8956 internal)

On weekends, or in case you don't find any of the above people the **key is usually deposited in an open cupboard** next to the door of the Teachers Lab:

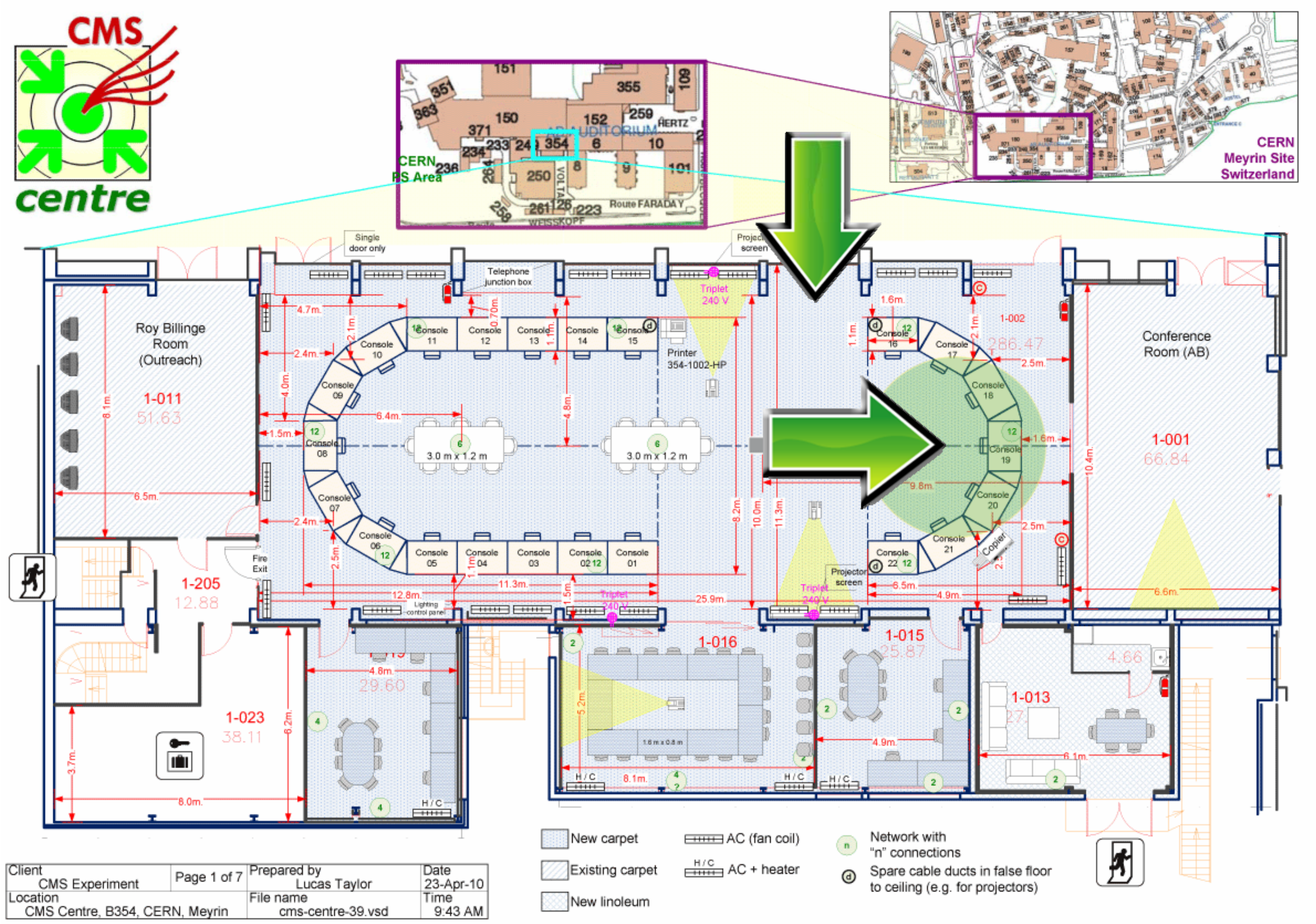
VC 1 moderators are typically sitting in front of a large photo with a view of the LHC tunnel and magnets.

This sometimes gives the impression that moderators are **REALLY** sitting in the LHC tunnel. You may expect questions about that.

VC1-PC: pcvc33.cern.ch
(presently 137.138.201.149, but IP address may change)

5) Locations of the Video Conferences at CERN (II)

VC2: CMS Centre (building 354-1-002, first floor)



VC2 will be held in the main room of the CMS Centre, in the smaller of the two arcs of computers. The **green circle** in the plan shows the location. There are usually one or two shifters in this arc, but they can possibly move to the other end for the duration of the conference.

The idea of the VC is to give the students in the institutes an insight into life at CERN, and this includes showing them physicists working right behind the conference moderators!

If you're unfamiliar with the location, please feel encouraged to pass by the CMS Centre a day before, to check the room, how to switch on the PC, and connect to EVO.

Access to the CMS Centre is restricted and requires specific access rights. For entry you can contact the following people:

- Marzena Lapka: +41 22 767 2484 (72484 internal), +41 76 487 2346 (mobile, 16 2346 internal)
- Achintya Rao: +41 76 487 1468 (16 1468 internal)

Alternatively, you wait in front of the door until a CMS person lets you in.

VC2-PC: vccmscentre02.cern.ch
(Presently 137.138.72.240, but IP address may change)

NOTE: the setup in the CMS Centre is PC based so operation is simpler then in 3-R-002, since it works like your own Desktop.

6) Before the Video Conference

Arrive at the correct VC location at least 30 minutes before start of the conference.

- There are **sometimes trivial problems** which may keep you busy, e.g. empty batteries of the remote controls for screens, PC start-up problems etc.

- You need to **foresee enough time** to solve these problems before the VC official start.

Make yourself familiar with the correct pronounciation of the names of the participating institutes

- It's sometimes challenging to correctly pronounce some names. If in doubt, just call them by their country.

Check the communication with the participants one-by-one before the official start of the VC

- Say "Hello", ask if they can hear us and can see us in ...
- Ask if they could wave their hands...

In case of communication problems with one or more participants or missing participants

- **do not wait a long time** until they have solved their problems
- start the VC on-time, **give a maximum of 2 minutes** to participants in case there is hope that they might solve their problems
- pay attention to participants that are obviously connected to the wrong video conference, urge them to change the meeting room

Prepare/upload all material you will need

- map
- table/website for combination of results
- animated quiz

7) Basic Communication Issues

There are (mostly) **two moderators** running the show

- both moderators should talk roughly equal amounts
  - in case of a (more) senior + (more) young moderator, the senior one should not answer all questions
- **avoid talking too much to your co-moderator**
  - a long dialog only between the moderators may disconnect the students
- if you feel you've talked too much, **hand over to your co-moderator**, e.g. "Uta, this seems a perfect question to be answered by you..."

Most of the students are not native English speakers and don't understand and speak English very well

- speak slowly and clear
- avoid using complicated and long sentences
- use simple words (vocabulary of the students is limited)
- don't use acronyms, abbreviations, physics slang not common outside of our community, avoid talking "CERNish"

Keep explanations short

- answer questions in a precise and brief manner – if it takes more than a minute to explain, that's too much information to give them in one go.
- don't try to explain the LHC in 5-minutes – give them answers that are short and understandable

Keep the answers interesting – don't go into details!

8) Elements of the Video Conference

a) Overview & Timing

- Welcome & Icebreaker ____________________ 10' (16:00 – 16:10)
- Report of Measurements __________________ 15' (16:10 – 16:25)
- Combination & Discussion of Measurement __ 10' (16:25 – 16:35)
- Open Discussion _________________________ 14' (16:35 – 16:49)
- Quiz ____________________________________ 10' (16:49 – 16:59)
- Good Bye ________________________________ 01' (16:59 – 17:00)

b) Welcome & Icebreaker (10')

The welcome has to be on schedule, common and interactive!

It has to immediately establish the fact that there is a two-way connection between students and the moderators, and that students can and should actively take part in the VC, and not just listen to the moderators.

Introduce yourself

- e.g. "My name is Michael, I'm working at ..., one of the 4 large experiments at the LHC collider at CERN in Geneva Switzerland…"

Explain where we are (the moderators)

- e.g. "Right now we are sitting at CERN. CERN is the largest centre for particle physics research in the world and a rather cool place..."

Say in a few words what's happening in the next hour

- read the agenda, e.g. report of measurements and discussion of the results, questions to the moderators, quiz

Display a map showing all connecting sites

- an actual map of today's VC is available, produced by the Masterclasses organizers before the VC: https://twiki.cern.ch/twiki/bin/view/Main/InternationalMasterclassesModeratorManual
- *can be used to explain to the institutes in which order you will look at their results (e.g. north to south or similar), to give some more structure to this procedure*

example:

Ask one short question to each masterclass

- address each masterclass individually, one by one
- **answers** should be given **by a student** (not the organizers or teachers), **no longer than 2 minutes**.
- questions **could be localized questions**, that you might have received from the local organizers beforehand, e.g. "Vienna, have you seen the VERA accelerator?"

  In case of no localized questions, you might try some general questions, e.g. was it difficult to follow the lectures, have you heard from CERN / the LHC before (more ideas for welcome questions on *https://twiki.cern.ch/twiki/bin/view/Main/InternationalMasterclassesModeratorManual*

c) Report of Measurements (15')

The reports of results are given by the students!

Put the results page onto the shared desktop and address each masterclass individually, one by one.

- ALICE – Looking for Strange Particles:
  www.editgrid.com
  User : alice-masterclass
  Password: alice
  Example: http://www.editgrid.com/user/alice-masterclass/centr-results-example.csv

- ATLAS Z-path:
  http://cernmasterclass.uio.no/OPloT/index.php
  username: ippog, password: mc13

- ATLAS W-path: combination:
  http://www.cern.ch/kjende/results/wpath_moderator.php

- CMS:
  http://quarknet.us/library/index.php/CMS_Combination_of_Results_2013
  (scroll to the "Moderators Level" under "W/Z Measurement"

Students should report on **results**, **uncertainties**, **difficulties** they had, **questions** that arose, etc.
(they should talk about that themselves, instead of having the moderators repeating the same questions again and again!)

Each report is limited to 2 minutes!

- all reports are **given in a row, not interrupted by questions or comments** (neither from moderator nor students)

- afterwards, students have a chance to comment / ask questions

d) Combination & Discussion of Measurements (10')

After the collection of the results and the immediate discussion, **the moderators combine the results** (all masterclasses in a given VC will do the same measurement[1], but will have different data), **summarize** and **comment**.

Detailed information is included in the annex:

- **CMS**: p. 34
- **ATLAS Z-path**: p. 37
- **ATLAS W-path**: p.45
- **ALICE – Looking for strange particles**: p. 48
- **ALICE R_{AA}**: p. 53

Afterwards, there is another opportunity for the students to comment/ask.

e) Open Discussion (14')

After the specific discussion of the measurement, the discussion can expand to more open and general questions.

The students should be prepared by local organizers, in order to have some questions ready.

Questions can be on anything, not only related to physics

- life at CERN, how many people, what are you doing
- LHC, size, magnets, costs, power consumption
- Detectors, size, how do they work
- Experiments, how many people in ALICE/ATLAS/CMS
- Universe, big bang, dark matter
- How to I (the student) can come/visit to CERN

Try to give <u>short interesting</u> answers, to allow more students to ask questions.

Some most **frequently asked questions** (and answers) can be found in the annex, p. xx

f) Quiz (10')

A new concept for the quiz has been developed in 2011 Style of 'Who wants to be a millionaire'!

Boundary conditions:

- multiple choice questions (4 answers)
- everybody involved (plays on his/her own)
- correct answer will be revealed immediately after each question
- scoring done by each student him/herself
- answer sheets should be distributed **before** the VC starts
- no public comparison of scoring
- **no prizes, just for fun**

Moderators will present **only the English version** via video stream. Local language versions are available for download and can be shown locally in parallel (second set of PC and beamer).

Detailed instructions for the quiz can be found in the annex, p. 29

Phase-out the quiz (1'-2'), e.g. ask students to raise their hands if they got the last question right, or ask students to cheer if they had reached 7 TeV. Moderators need to know that they might feel frustrated but students do not.

g) Common Good Bye (01')

There has to be a clear, common end of the VC after 60 minutes!

What happened in the past and has to be completely avoided is masterclasses quitting the VC one after the other (because of local time constraints, or because of the VC getting over time), with no clear end of the VC.

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.

As moderators cannot watch students during quiz they feel strange with the good-bye so short after getting in contact with students again, but for students it is okay.

ANNEX

a) Vidyo

The video linkup is via Vidyo.

Meeting rooms
The VC´s will be held in the following venues (accessible directly via the web link).

Masterclasses 2013 VC1:
https://vidyoportal.cern.ch/flex.html?roomdirect.html&key=tvdZ8uKKtQJc

Masterclasses 2013 VC2:
https://vidyoportal.cern.ch/flex.html?roomdirect.html&key=ye8a5NXdyHJM

The correct Vidyo room for your masterclass can be seen from the schedule:
http://physicsmasterclasses.org/index.php?cat=schedule

Login
Access the meeting link (described above) and enter the credentials that correspond to the CERN moderators:
VC1: mcmod1 / mcmod1
VC2: mcmod2 / mcmod2
Do not use your private account!

Then connect to the system in the physical room, see next pages
3-R-002: p. 23
CMS Centre: p.25

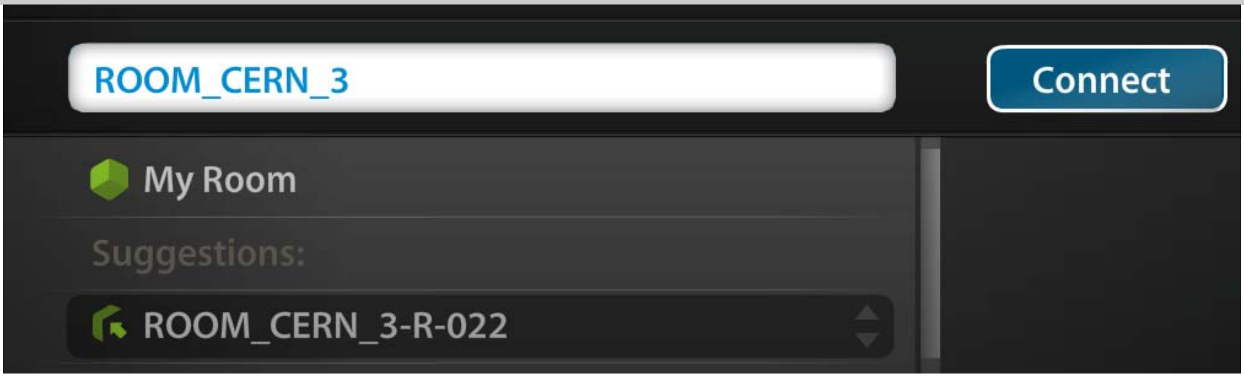
i) Connection of the CERN physical room (H323 device as in 3-R-002)

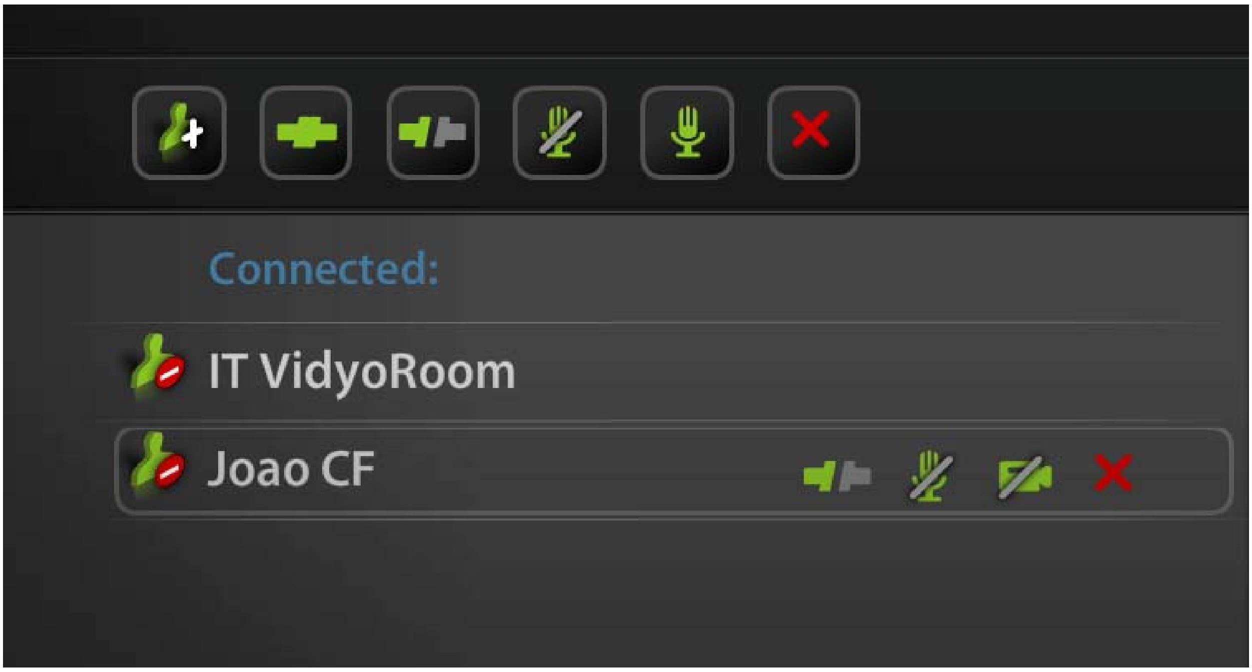
Turn on the projector
Turn on TV plasma, press TV/AV
Videoconference: press green button, choose “Selfview”

Start the Vidyo desktop from the menu bar
then enter the credentials mcmod1
or use the twiki bookmark and connect via the link included

The connection of the physical room has to be done by clicking on add participant and typing ROOM_CERN_name_of_the_room:

One needs to select the room and click on Connect





NOTE: the VidyoDesktop client will be launched on the room VC PC, but since the communication is done via the H323 terminal installed in the room, **one needs to mute immediately** the desktop client (6th and 7th buttons on the interface:

with the speaker and mic icons) to avoid any echoes.

ii) Connection of the CERN Physical Room (CMS Control Centre)

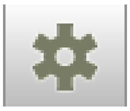
1) switch on the large monitor, with remote control select input: AV

open Firefox, then go to bookmark (top right) MASTERCLASS use either: Viydoconferencing, then enter the credentials mcmod2 or use the twiki bookmark and connect via the link included

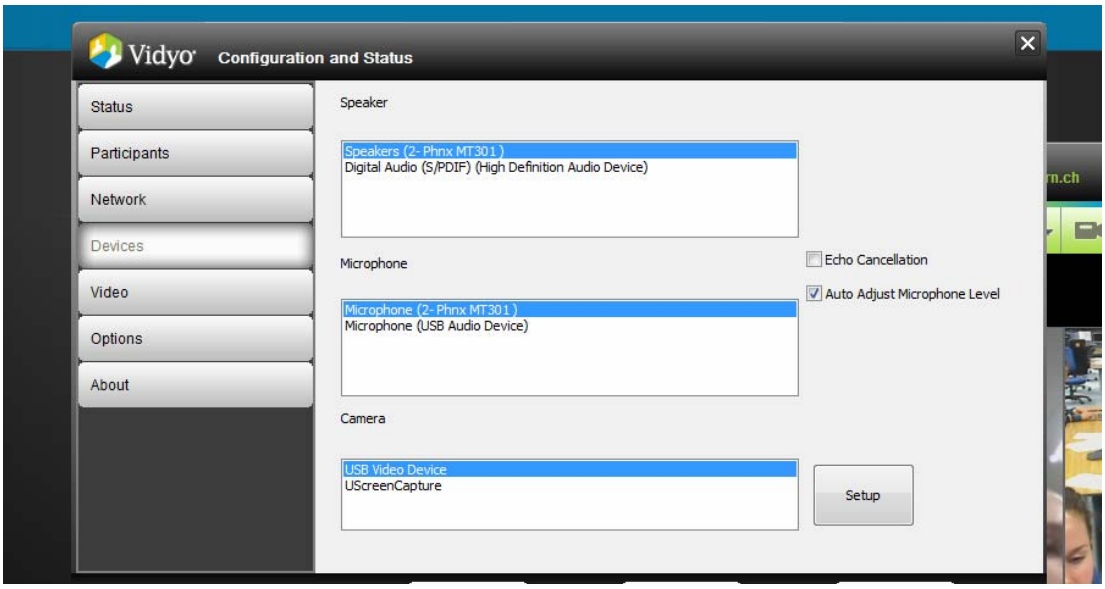
https://vidyoportal.cern.ch/flex.html?roomdirect.html&key=ye8a5NXdyHJM

Then enter the moderator credentials

Once the Vidyo Desktop client splashes you may be asked to configure your Video/Audio Devices. For this go to Configuration:



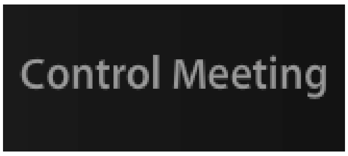
Then in Devices select the proper ones:



NOTE: DO NOT Select Echo Cancelation (as the installed speakerphone has already built-in echo suppression).
Selecting it will result in canceling the HW built-in echo cancellation.

Important features of VIDYO:

To moderate the meeting go to the vidyoportal and click on:



and see the active list of participants.

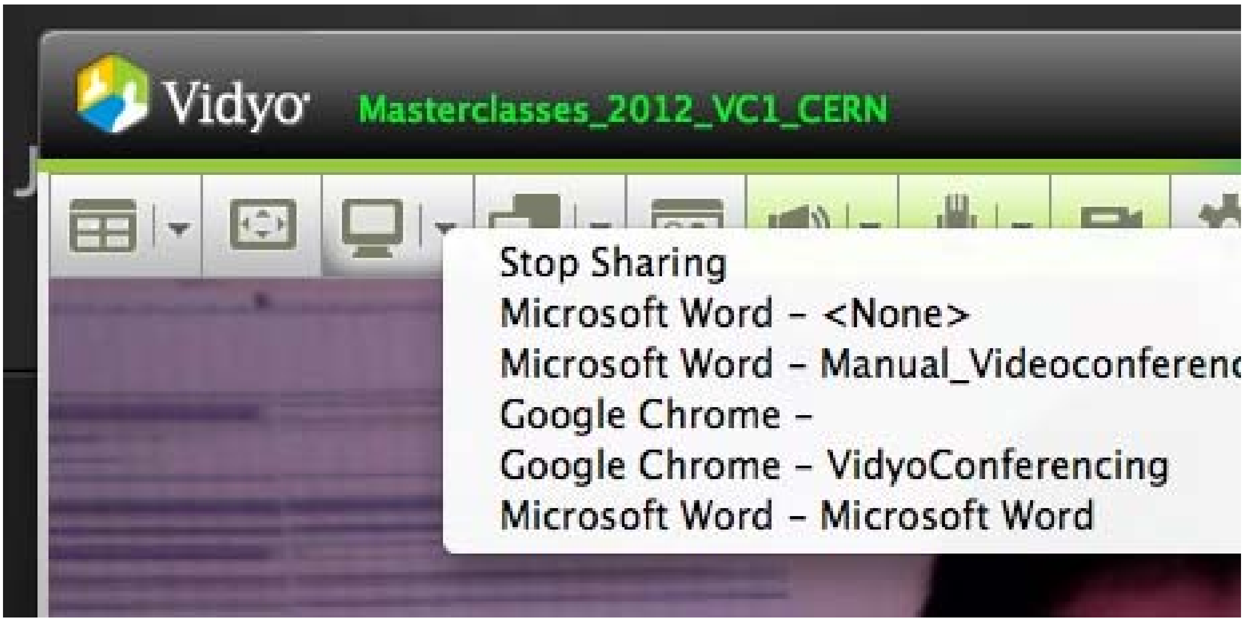
Hovering the mouse on the participants you can get the buttons to mute/unmute and kick off participants:

Mute participants that cause noise!

Mute All: if moderators use this option, muted participants will not be able to unmute themselves, only the moderator can do this.
Silence All: mutes all participants but lets them unmute themselves.

Desktop Sharing

To share the Desktop from the VC PC, one needs to click on the 3rd button of the VidyoDesktop interface and select the application one wants to share:



For the **quiz**: To share the slideshow: Start the slideshow (press F5), then press Alt-Tab to switch to the Vidyo-desktop, select the powerpoint slideshow window for sharing, and then switch back (Alt-Tab again).

Vidyo entrance and documentation
http://www.cern.ch/vidyo
http://www.vidyo.com/knowledge-center/
http://vidyoportal.cern.ch/

Vidyo Tests
A Vidyo test session period (~ 4 weeks before masterclasses begin) will be conducted. The tests have to be performed by all participants. All tests should be performed with exactly the same equipment and in exactly the same room as the real event.

Vidyo client users guide
http://information-technology.web.cern.ch/services/fe/vidyo/howto/users-install-vidyo-desktop-client

To use of an H.323 system with Vidyo:
http://information-technology.web.cern.ch/services/fe/vidyo/howto/users-use-h323sip-client-connect-vidyo-meeting

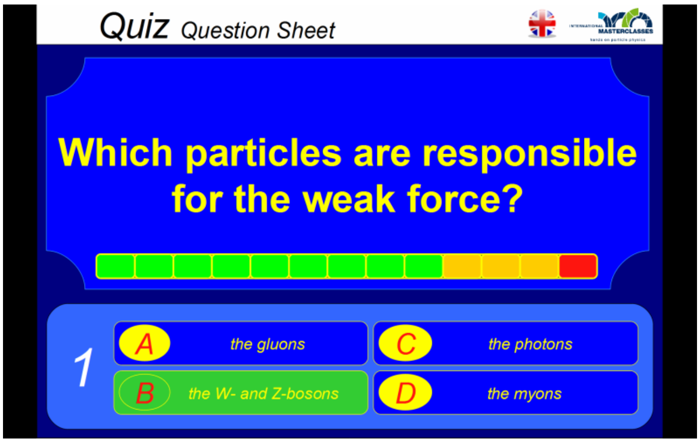
Vidyo frequently asked questions:
https://cern.service-now.com/service-portal/faq.do?name=vidyo

A tutorial on Vidyo from the CERN Training catalogue:
https://indico.cern.ch/conferenceDisplay.py?confId=173834

Vidyo support
vidyo-support@cern.ch

b) Instructions for the Quiz

The purpose of the quiz is to have a highlight at the end of the video conference, and to get everybody involved. It also helps to have a clear, common end of the video conference after the open discussion*



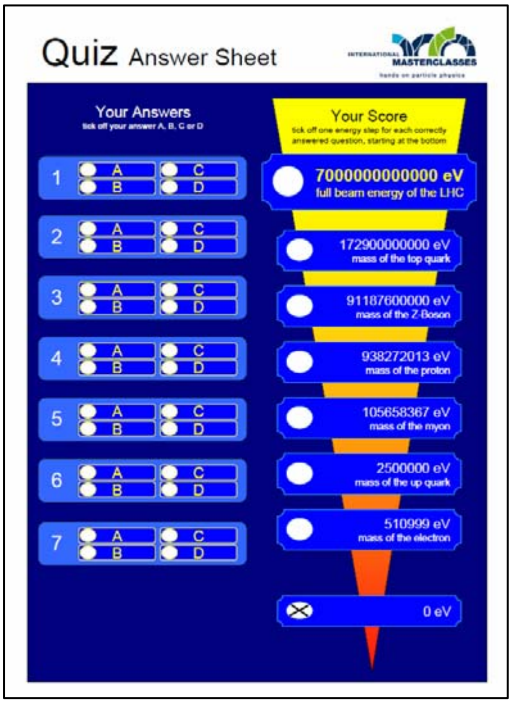
concept of the quiz:

- the presentation is based on the TV-show “Who wants to be a millionaire?”
- there are 7 multiple choice questions (4 answers) of increasing difficulty
- everybody plays on his/her own
- the correct answer is revealed immediately after each question
- scoring is done by each student him/herself (answer sheet is provided, see below)
- the measure for the score is eV (electron volts); for each correct answer the student increases his/her energy level, the top level is 7 TeV
- as in the TV-show, reaching top score will be very hard
- **there is no public comparison of the scoring**
- **there are no prizes to win**, the quiz is just for fun

* It is better to tell the students to end the discussion because it is time for the quiz instead of just cutting the discussion off and saying good bye.

material for the quiz:

the following material is available for download in the TWiki (*https://twiki.cern.ch/twiki/bin/view/Main/InternationalMasterclassesModeratorManual*
or in the IPPOG database: https://cms-docdb.cern.ch/cgi-bin/PublicEPPOGDocDB/ShowDocument?docid=305



- **English animated version**, including timer and answers (to be shown by the *moderators* via Vidyo)

Institutes should have downloaded:

- an answer sheet (pdf) to be filled out by the students (to be printed and distributed by the *local organizers*; there are two versions in color and b/w)
- possibly a .ppt file with the questions translated in the local language (to be optionally shown by the *local organizers* in parallel with the moderator's ppt); this file only contains questions, no timer, no answers

procedure of the quiz:

- 10' before the end of the VC (**latest!**) moderators announce the end of the discussion and start of the quiz
- local organizers distribute the answer sheets to the students
- in parallel, the moderators start the animated .ppt and explain the rules (do not stop transmitting your own vidyo

- each question and the 4 answers are read aloud by the moderators; optionally, local organizers show the translated question in parallel
- moderators start the timer, students have to tick off their answer on their answer sheet within this time
- moderators reveal the correct answer, and **briefly** explain why this is correct
- all students that got the answer right may now tick of their next energy level on the answer sheet
- now proceed to the next question…
- after the last question and explanation of the correct answer, moderators say something like: “I hope you all had fun with the quiz – and the whole video conference. Now time is up…”

moderators: do not start a lengthy discussion about the quiz answers – if any questions are open, they should be answered locally

c) Most Frequently Asked Questions by the students

How can I come to work at CERN?

There are 2 possibilities for students and more possibilities at a later stage of career:

- ***Internships*** *(2 weeks) for school students (unpaid)*
- ***"Summer Student"*** *(2-3 months) for university students (paid) after ~2-3 years of study (physics, computing science, engineering)*

More information can be found on the CERN homepage under "Jobs".

What's the salary of PhD students / CERN staff etc.?

You don't get rich but it's enough to have a nice life and fun at work.
[Don't give a precise answer in terms of numbers, can only be wrong.]

What's cost of the LHC?

Cost of the LHC alone is ***5 billion CHF (4 billion €)*** *(personnel + materials). Cost of the experiments and computing is approximately 1.5 billion CHF (1.25 billion €) (materials only). The construction costs were spent over ~15 years and mainly shared by the 20 member states of CERN.*

What's the power consumption of the LHC?

If the LHC is running, with all the pre-accelerators, experiments and infrastructure, CERN in total takes ***~180 MW****. That's equivalent to 180'000 households.*

How much Helium is needed to cool the LHC magnets and what's their temperature?

About ***120 tons*** *of liquid Helium is needed (~0.4% of the annual world production) at a temperature of* ***1.9 K*** *(-271.3 ^{o}C), which is colder than the universe at 2.7 K [temperature of cosmic microwave background radiation].*

What's speed of protons in the LHC? Are they travelling with light speed?

*At 7 TeV [design energy] protons are travelling with **99.9999991%** speed of light. This is just 2.7 m/s slower than light!*

Will Peter Higgs / CERN / the LHC experiments get the Nobel Prize?

The Nobel Prize in physics can be given to a maximum of 3 people, for their individual work. It cannot be given to an institution, e.g. CERN, or to an experiment, and not even to a person representing an institution, e.g. the CERN director.

Hence, it is likely that the physics Nobel Prize will be awarded to Peter Higgs and perhaps 2 other physicists, who had similar ideas. Maybe 2013 will be the year of the Higgs Nobel Prize.

Can the LHC create black holes that destroy the earth?

***NO!** Some theories predict the creation of microscopic black holes at LHC energies but they would immediately evaporate into ordinary particles [in <10^{-24} s via Hawking radiation], who do not harm.*

Cosmic rays are hitting the earth since billions of years and the energies in those collisions [in the upper atmosphere] are up to 1000x higher than at the LHC. If such microscopic black holes would be produced and be dangerous, the earth wouldn't exist anymore. LHC experiments have searched for microscopic black holes, but haven't found any.

More facts on
http://public.web.cern.ch/public/en/lhc/Facts-en.html
http://cdsweb.cern.ch/record/1165534/files/CERN-Brochure-2009-003-Eng.pdf

d) CMS measurement

Author: Ken Cecire

Topic of the Measurement: W and Z Bosons (and more)
Find/create:

- Ratios e/μ and W+/W-.
- Mass of Z from plot.
- J/Psi and Y peaks in Z mass plot.
- Mass associated with ZZ events from Z mass plot.

Key Activites of Students, Mentors, and Moderators
Students will:

- Distinguish W from Z boson candidates from event displays.
- Use curvature of lepton tracks to distinguish W+ from W-.
- Distinguish electron from muon events.
- Automatically transfer the following data to mentors:
  - Numbers of electron and muon events
  - Numbers of W+ and W- candidates
- Transfer manually to Institute mass plot:
  - Invariant masses (from spreadsheet) of Z candidates

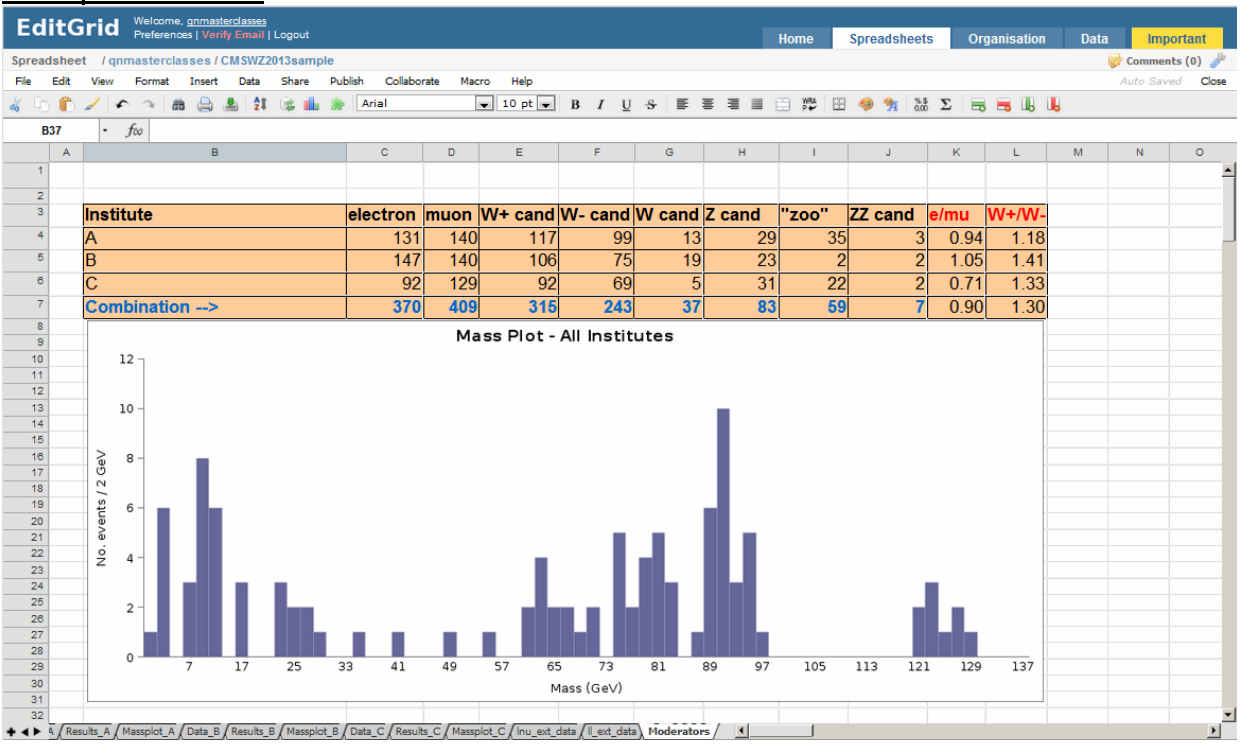
Mentors (or their assistants) will:

- Show students Institute result for ratios e/μ and W+/W-, discuss significance.
- Discuss mass plot with students:
  - Z peak and width
  - J/Psi and Y peaks
  - Peak for ZZ events – why it is not twice Z mass
  - Sources of uncertainty, noise
- Automatically transfer to “Moderators” tab on spreadsheet:
  - Numbers of electron and muon events
  - Numbers of W+ and W- candidates
  - Invariant masses (from spreadsheet) of Z candidates
  - Mass plot for all Institutes in videoconference

Moderators will:

- Create a scatter plot from momentum data on spreadsheet. (Optional)
- Allow students to present Institute results.
- Share with students:
  - o Overall e/μ and W+/W- results.
  - o Overall mass plot.
  - o Optional scatter plot.

<u>Sample Results</u>



Institute	electron	muon	W+ cand	W- cand	W cand	Z cand	"zoo"	ZZ cand	e/mu	W+/W-
A	131	140	117	99	13	29	35	3	0.94	1.18
B	147	140	106	75	19	23	2	2	1.05	1.41
C	92	129	92	69	5	31	22	2	0.71	1.33
Combination -->	370	409	315	243	37	83	59	7	0.90	1.30

All Institutes for a given videoconference (here, A, B, and C) use the same online spreadsheet. In the "Moderators" tab, the moderators see summary results and a summary mass plot. They share these on Vidyo and discuss with students. Individual Institute massplots are on their "Massplot" tabs.

<u>Notes on Results</u>:

- Ideal ratios e/μ = 1 and W^+/W^- = 1.4
- Looking at mass plot, ask students about:
  - o Z mass.
  - o Low mass (J/Ψ and Υ) results.
  - o Bump at ~125 GeV. (If ZZ, why not ~184 GeV?)

Links and Resources

CMS Masterclass:
http://cms.physicsmasterclasses.org/cms.html (IMC server; preferred)
http://leptoquark.hep.nd.edu/~kcecire/mc/cms.html (Notre Dame server)

Combination of Results:
http://quarknet.us/library/index.php/CMS_Combination_of_Results_2013

- Spreadsheets:
  http://quarknet.us/library/index.php/Spreadsheets_2013

Slides:
http://tinyurl.com/a2hrj5b (PPT)
http://tinyurl.com/aqwlltg (PDF)

Key Words and Phrases

Mass plot

- Peak
- Width
- Resonance
- Bump
- Background
- Bin width

Ratios

- Detector performance
- Selection criteria

General

- Expected/Unexpected
- Uncertainty
- Discovery

e) ATLAS Z-path measurement

Authors: Maiken Pedersen, Farid Ould-Saada, Eirik Gramstad, Magnar Bugge, Vanja Morisbak, Silge Raddum.

You will be using the web-plot tool OPloT accessible from here:
http://cernmasterclass.uio.no/OploT/index.php

- username: ippog
- password: mc13

1. Topic of the measurement

a. Identify lepton pairs (e^+e^- and $\mu^+\mu^-$), photon pairs ($\gamma\gamma$) and 4-lepton combinations ($e^+e^-e^+e^-$, $e^+e^-\mu^+\mu^-$, $\mu^+\mu^-\mu^+\mu^-$), and calculate the invariant mass $M(l^+l^-)$, $M(\gamma\gamma)$ and $M(l^+l^-\ l^+l^-)$.
   i. The resulting di-lepton distribution obtained with many proton-proton collision data events show various clear particle resonances, such as the Z particle. Measure their masses and widths. A clear Z' simulated-signal shows up at 1 TeV and would have been observed by ATLAS and CMS if it were there
   ii. The 4-lepton distribution has at least one clear Higgs-candidate around 125 GeV. With more data at hand, a signal would show up where ATLAS and CMS had observed one
   iii. The di-photon distribution contains some Higgs-like candidates. The statistics is too low to observed a bump on top of the background. The whole data sample available is at most a factor 10 smaller than what ATLAS and CMS have analysed to claim discovery.

b. The idea of the measurements is to convey a powerful tool – the invariant mass technique - to “observe” and measure known particles, to trace the newly-discovered Higgs-like particle, and to discover new physics, for example a hypothetical new Z' boson. For this, simulated high mass Z' events are mixed with real LHC data.

2. Exactly what students will do during measurement

a. With the help of the HYPATIA event display program (modified version of ATLAS official event-display program ATLANTIS) students loop through a sample containing real collision events mixed with a small fraction of Z' simulated events.

b. They try to find signs of the existence of particles such as
    i. a Z boson or other known (J/ψ, Υ) or unknown (Z') particles, by hunting for pairs of leptons (e^+e^- or $\mu^+\mu^-$)
    ii. a Higgs boson by hunting for a photon-photon pair
    iii. a Higgs boson by hunting for 2 lepton-pairs ($e^+e^-e^+e^-$, $e^+e^-\mu^+\mu^-$, $\mu^+\mu^-\mu^+\mu^-$)
c. They pick the corresponding tracks or physics objects and insert them into the HYPATIA invariant mass table.
d. They finally upload the invariant mass file they have made into the web-based plotting tool - OPloT.

3. Results the students will come up with

a. 3 invariant mass plots combined for the institute. Each student analyses 50 events, containing, among others, roughly 50% Z particles, 35% of events containing candidates of the newly discovered Higgs-like particle, as well as smaller fractions of J/ψ, Υ and Z'.
b. The main result are the invariant mass plots and the resonances they contain or may contain
c. The students will have observed that various resonances are more clearly visible in the combined invariant mass plot from the whole institute compared to their 50 events.
    i. The students will have compared the proportion of e^+e^- and $\mu^+\mu^-$
    ii. The students will be aware that they have measured important properties of some particles: mass and width, both given by OPloT
d. The students will have tracked the Higgs particle as ATLAS did in 2 photons and 4 leptons.
    i. They should be aware that they worked with real Higgs candidates which they had “at hand”
    ii. They will have realized this by uploading some simulated Higgs simulated signal to the measured combined invariant mass distributions of 2 photons and 4 leptons
    iii. They will also have learned that the event statistics at hand is too low to clearly discover the new particle themselves, as ATLAS and CMS did on July 4th 2012.

4. **Institutes will present their combination plot**

   Most of the material must have been discussed at the institute level.

   a. They might comment on the various particles they have observed in the di-lepton plot (J/ψ, Υ, Z and Z'), identified by their mass (3~ GeV, ~10 GeV, ~90 GeV and ~1000 GeV, respectively) and their widths. (The mean values are indicated in the legend of the plot)
   b. They might comment on the e^+e^- and $\mu^+\mu^-$ composition of the di-lepton plot. (It could be that electrons are more difficult to recognize than muons).
   c. They might comment that there are some entries between the resonances. (This background is due to combinations of leptons not coming from resonances. The lepton might also be incorrectly assigned as such; for example photons can be misidentified as electrons.
   d. They might comment on the Z' peak and remind that it is a simulated signal of a hypothetical brother of the Z which is predicted by some theories proposed to unify all fundamental forces.
   e. They might question the Higgs measurement and comment on the difficulty to conclude whether they have observed the Higgs or not, see discussion in point 7 below.
   f. They may claim that they have observed a Higgs candidate in the 4 lepton channel. Congratulations!
   g. Congratulate the students to have almost succeed in observed the Higgs in the di-photon channel and have already done most of job.
      i. With 10 times more statistics they would have reproduced the July 4th revolution!
      ii. However, it takes a long time to go through very large number of events. Without the worldwide Grid, it would have taken ATLAS and CMS many years to digest the data and results
   h. Institutes leaders may use the slides where the ATLAS measurement and the student combined measurements are put side by side, these are an extended version of the slides that you can also use – see point 6e below

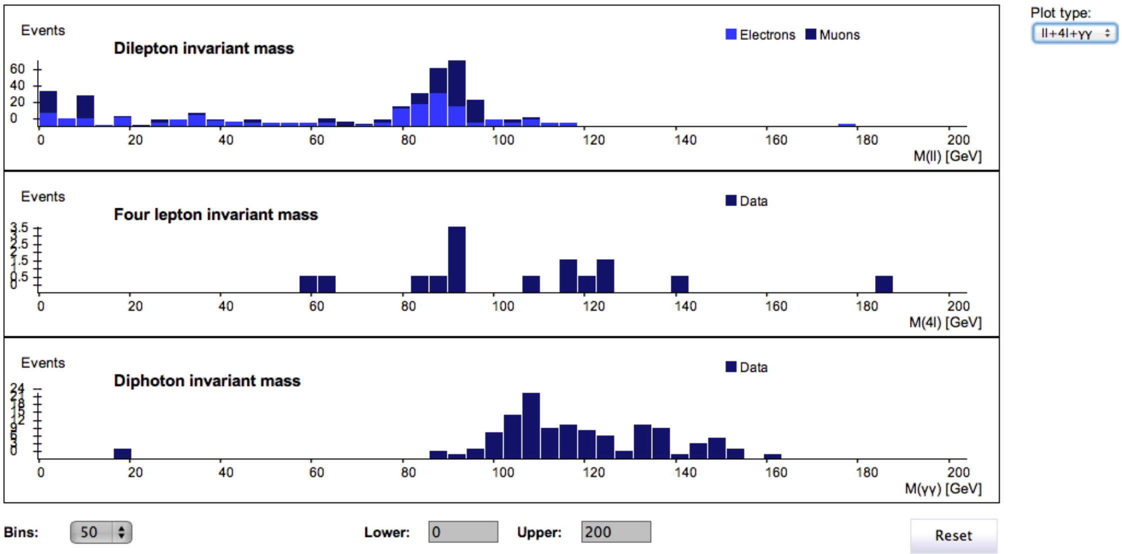
5. **Link to moderators** “access-point” for discussion, namely the OPloT-web-interface: http://cernmasterclass.uio.no/OPloT/index.php

    a. username: ippog
    b. passwd: mc13

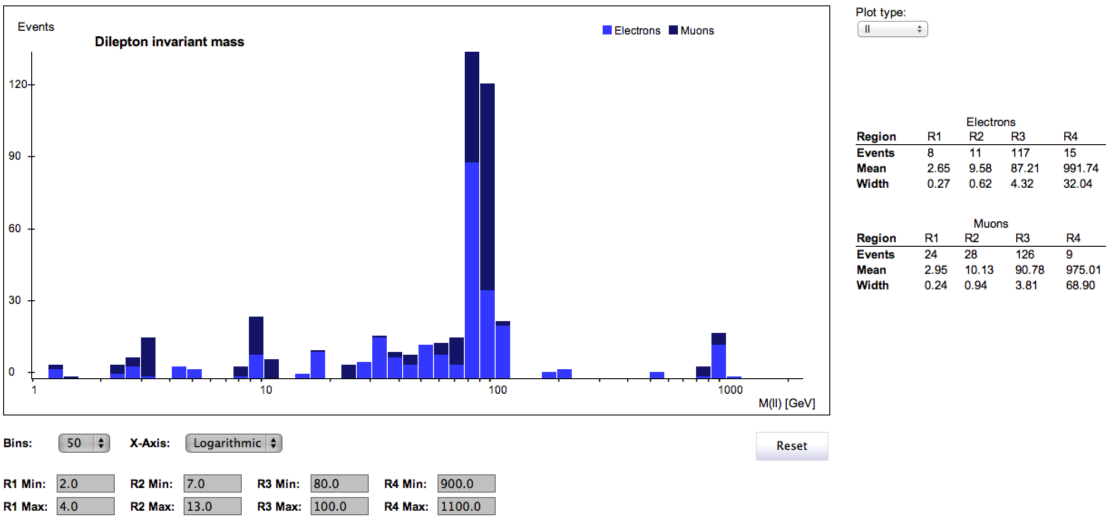
6. **Moderators will access the “Moderator” page on the OPloT-web-interface**

    a. Click on the “Moderator” menu-item on Start-page
    b. Choose the right year-month-day in the three drop-down menus
    c. Click on "Combination plot - all institutes" for the total combination of all the institutes participating that day
    d. A set of plots will appear, which is the combination of all groups’ results
    e. Moderators may use the slide(s) where the ATLAS measurements and the student combined measurements are put side by side – click on link “Official ATLAS results”

In the following, some examples of combined plots obtained with a small sample of events are commented. *Moderators (and tutors at the institute level) will have access to combined plots with more statistics.*
The first figure below shows the 3 invariant mass distributions (“ll+4l+gg” chosen as “Plot type”). Number of bins and lower/upper values of x-axis can be changed. *There will be a possibility for a summary plot including a full mass range (in logarithmic scale) of the di-lepton distribution, as well as summary plot for the Higgs distributions.*



In the plot below, only the “ll” type is chosen. Note that logarithm scale is used for the x-axis in order to clearly see 4 resonances simultaneously: J/ψ (~3 GeV), Υ(~10 GeV), , Z(~90 GeV), and Z’(~1000 GeV). The table to the right summarises the results (mass and width) of the 4 particles corresponding to the 4 regions R1-4. Final states with electrons and with muons can be compared.



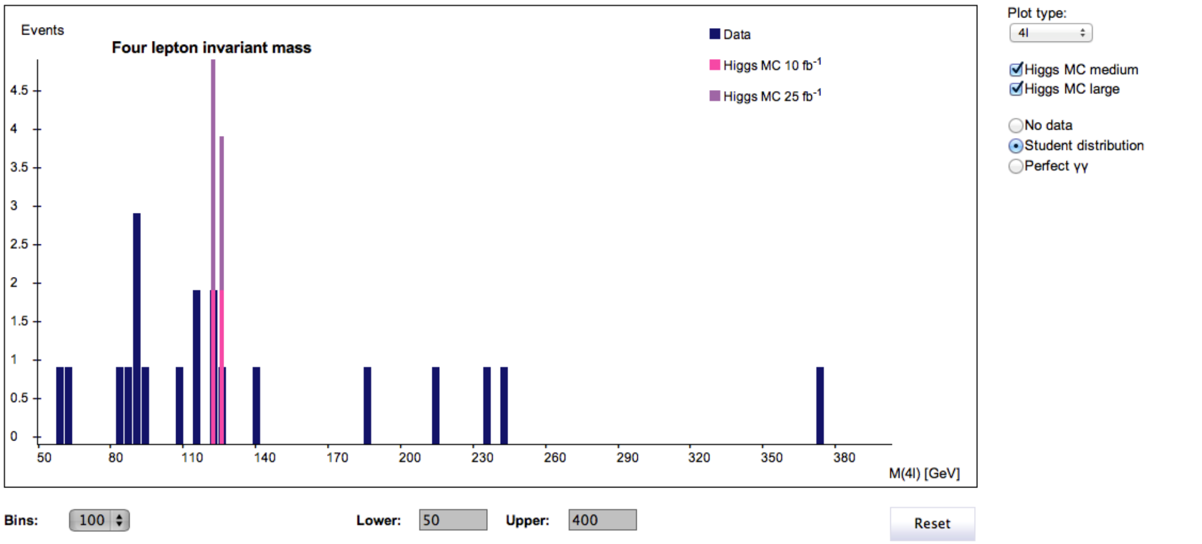
Electrons

Region	R1	R2	R3	R4
Events	8	11	117	15
Mean	2.65	9.58	87.21	991.74
Width	0.27	0.62	4.32	32.04

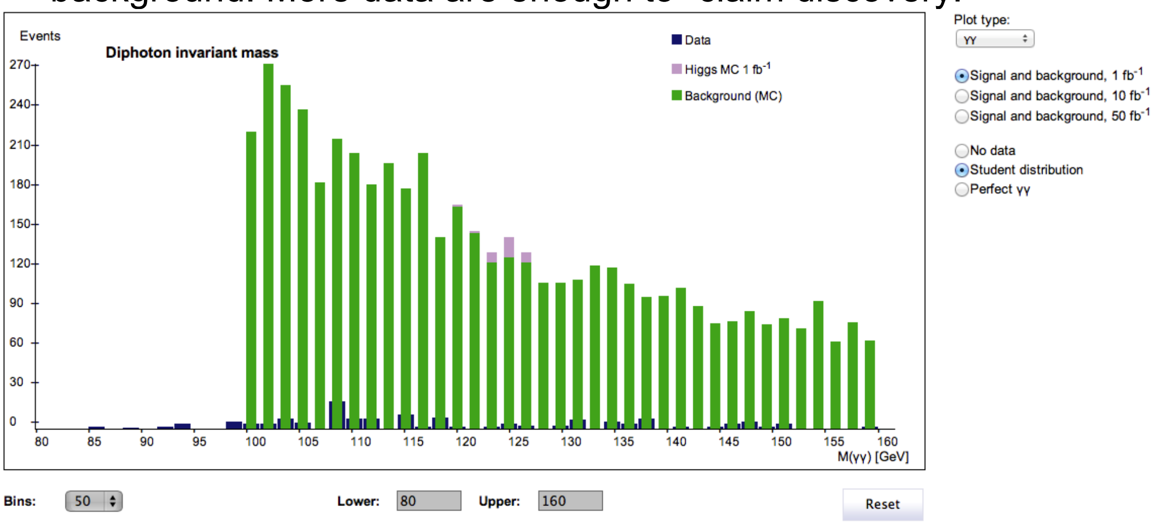
Muons

Region	R1	R2	R3	R4
Events	24	28	126	9
Mean	2.95	10.13	90.78	975.01
Width	0.24	0.94	3.81	68.90

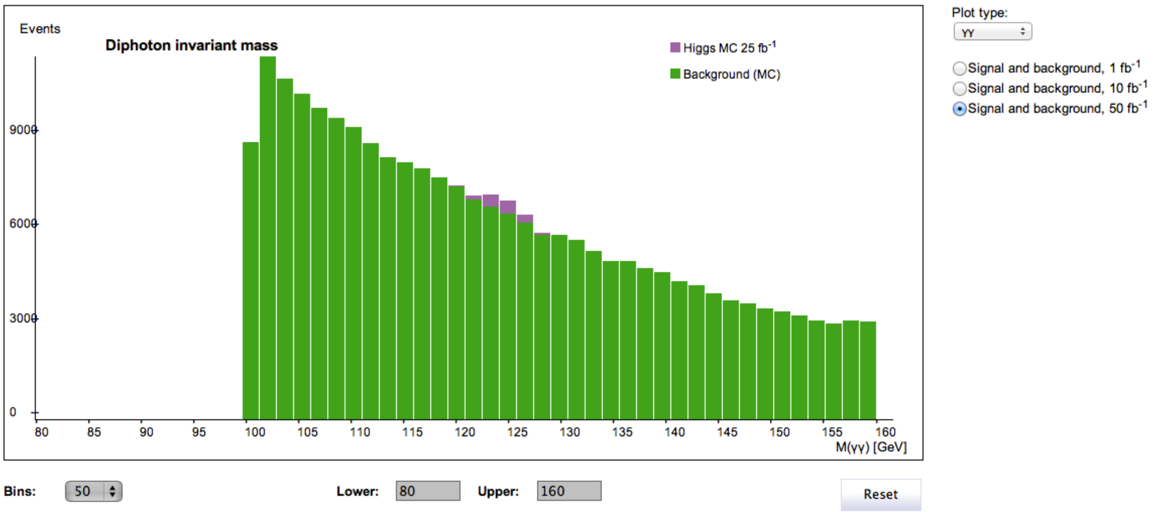
Next, the invariant mass of 4 leptons is shown below – plot type “4l” chosen. In addition to the “student distribution”, two coloured “Higgs MC” distributions are added for two luminosities (medium 10fb^{-1} and large 50 fb^{-1}), showing how many Higgs events are expected assuming the Higgs mass to be 125 GeV. A comment: there are too few 4-lepton events and identical events are analysed by many students. In the combination 4-lepton plots, however, the duplicates are removed.



Finally, the invariant mass of 2 photons is given below – plot type “$\gamma\gamma$” chosen. Data obtained by the students are in blue. The expected simulated background (green) and 125 GeV Higgs signal (in a yet different colour) (“Signal and background 1fb^{-1}” ticked). Note that if all $\gamma\gamma$ data had been used, the blue (student) distribution would be close to the green background MC. The goal of these comparisons is to show that given the high background, compared to the tiny Higgs signal, 1fb^{-1} of data are not enough to disentangle the signal from the background. More data are enough to “claim discovery.



To claim discovery, ATLAS analysed more than 10fb^{-1} of data. The next figure demonstrates that with 50fb^{-1}, for example, a clear signal singles out on top of a smooth exponential background.



7. Keywords for discussion

Most of the items below should first have been discussed at the institute level.

- di-lepton measurement

a. Compare the histograms of the e^+e^- or $\mu^+\mu^-$ pairs.
   i. Point out differences/similarities?
   ii. How often does the Z boson decay into e^+e^-? How often does the decay result in $\mu^+\mu^-$?
   iii. What was expected? Why?
b. Any notice of other particles? At which invariant masses?
c. What is the most probable mass of the Z boson?
   i. Why is there not one exact value for the Z boson mass?
   ii. What could be the possible explanations of why the distribution is so wide?
d. Any sign of the Z' boson?
   i. If yes, what is the Z' boson's mass?
e. Why is it useful to combine your results with those obtained by other groups?

- di-photon measurement

a. Any sign of Higgs decaying to 2 photons, $H \rightarrow \gamma\gamma$?
   i. If not, what could be the reasons?
b. In fact the full sample does contain some real Higgs candidates at a mass of ~125 GeV, even if it is not possible to tell exactly which ones they are!

- 4-lepton measurement

a. Any sign of Higgs decaying to 4 leptons, H→ZZ→llll?
    i. If not, what could be the reasons?
b. In fact the whole sample contains at least one Higgs candidate. At which mass?

- General discussion

a. How do the individual institute-plots look compared to the combined plot of the day?
    i. More data (obviously)
    ii. Have the widths of the observed particles gotten smaller? (The width is a property of a particle and should not change too much with much higher statistics).
    iii. Comment on the strength of combining data, that for example possible mistakes by single analyzers – the students – become relatively less important
b. Why does the combination not help much in the case of the Higgs search?
    i. Comment that the process H→ZZ→4l is really rare. Students have been looking at the same small number of candidates (~25 in total). The 4-lepton combinations made they made enter only once into the combined plot!
    ii. Comment that the 1 fb^{-1} statistics is not enough for the Higgs signal to appear clearly on top of the much larger background due to background due to other Standard Model processes. Be prepared to show the simulation comparison between 1fb^{-1} and 50 fb^{-1} provided for this purpose

d) ATLAS W-path measurement

Author: Konrad Jende

Slides:

Students´ tasks include:

- Explore the inner structure of the proton by counting the number of W^+ and W^- events in W candidate events: Students identify W candidate events, decay products and (if possible) determine their electric charge, calculate ratio R±
- Search for the Higgs in $l^+ \nu l^- \nu$ + 0/1 Jets final state (693 real data events ($l^+ \nu l^- \nu$ + 0/1 Jets) from 2011 were mixed with the data set). Students identify WW candidate events and measure the angle $\Delta\varphi_{ll}$

Each venue presents:

- measured ratio R± of number of W^+ to number of W^- events in W candidate events
- local histogram - distribution of $\Delta\varphi_{ll}$ (angle between the two detectable leptons in transverse plane) in WW candidate events

Combination and discussion of measurement:

- Discuss development of R± after combination and compare with current ATLAS measurement on the online spreadsheet accessible for moderators by choosing the date from the first drop down menu on this WEBSITE:

http://www.cern.ch/kjende/results/wpath_moderator.php

sample spreadsheet:

Analysis

Total #	W → _ + ν				Background	WW
	e^+	e^-	μ^+	μ^-		
Bratislava						
CERN 1						
Goettingen						
Irfu Saclay 1						
Paris						
Paris-2						
Total						
$\Sigma\|W^+\|,\Sigma\|W^-\|$	$\|W^+\|$		$\|W^-\|$		$\|W^+\| + \|W^-\|$	
Ratio	$\|W^+\|/\|W^-\|$				±	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 **)

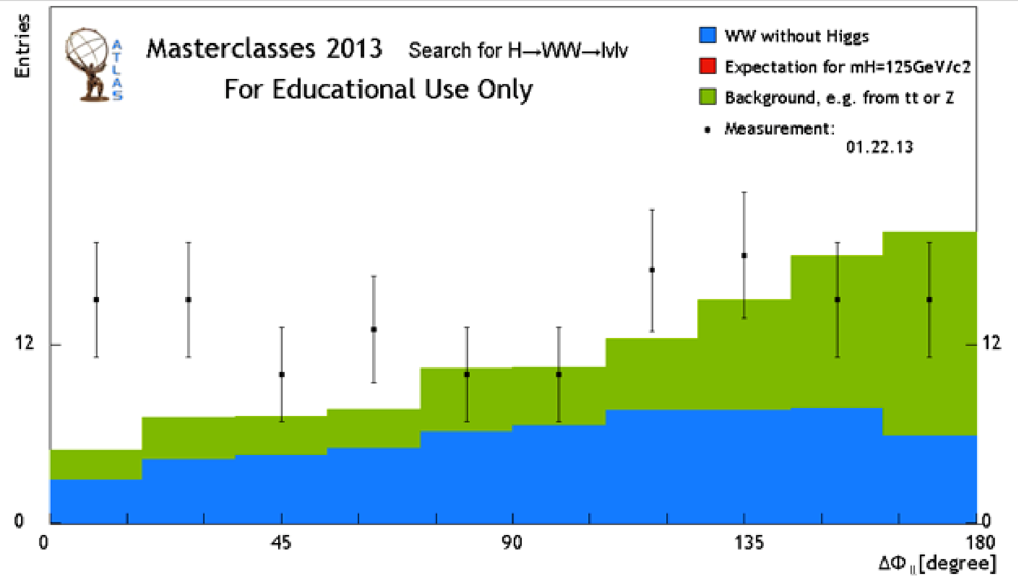
*) Authors: The ATLAS Collaboration (Submitted on 5 Dec 2011): http://arxiv.org/abs/1109.5141.pdf

**) 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

- Discuss the meaning of that result
- Discuss development of histograms after combination (choose the date from the second drop down menu on the website mentioned above)

sample plot:



	bin 1	bin 2	bin 3	bin 4	bin 5	bin 6	bin 7	bin 8	bin 9	bin 10	SUM
N	15	15	10	13	10	10	17	18	15	15	138
B	4.9	7.1	7.2	7.6	10.4	10.5	12.4	15	18	19.6	112.7
S	10.1	7.9	2.8	5.4	-0.4	-0.5	4.6	3	-3	-4.6	25.3
Z	4.6	3	1.1	1.9	-0.1	-0.1	1.3	0.8	-0.7	-1	2.4

number of bins [1 … 20]
maximum of y axis
Submit
standardization 1 2 3
cut on bin number
Default
Higgs contribution

- Discuss selection of events, pre-conditions for claiming a discovery, shape of the angular distribution (at this kind of level: “By taking spin relations of the produced particles into account we expect to find the Higgs events mainly at angles less than 90 degrees while Standard Model WW events appear in the whole angle range in which they prefer to appear at angles greater than 90 degrees.”) and current result of this search
- Discuss difficulties occurred during the measurement

e) ALICE measurement: Looking for strange particles in ALICE

Author : D. Hatzifotiadou

Topic of the measurement

- Identify strange particles (V0s : Ks, Λ, anti-Λ) from their decay pattern, combined with calculation of their invariant mass.
- Find number of Ks, Λ, anti-Λ for different centrality regions for lead-lead data
- Calculate yields for Ks, Λ, anti-Λ and strangeness enhancement factors by comparing to proton-proton data
- Optional: particle ratios as input to thermal model to estimate temperature

What the students do in each institute

Visual analysis

Using a simplified version of the ALICE event display based on ROOT, they identify and classify strange particles (V0s : Ks, Λ, anti-Λ) from their decay pattern, combined with invariant mass calculation. Each group of 2 or 3 students looks at 15 events.

At the end of this first part, the tutor merges the results of all groups and produces invariant mass plots for Ks, Λ, anti-Λ.

They can give the mass values and width of the peaks.

Large scale analysis - Find V0s in different centrality regions in PbPb collisions

Students analyse large datasets, by running a programme that selects V0s, calculates the invariant mass and produces an invariant mass plot; each group of 2 or 3 students is assigned a centrality region and they have to find the number of K_s, Λ, anti-Λ in this region. To do this, they have to fit curves to the combinatorial background and the peak and subtract.

Calculation of particle yields and strangeness enhancement factors

Each group reports the number of K_s, Λ, anti-Λ they found in the centrality class that they have analysed. The results for the whole class are entered in a spreadsheet as the following.

centrality	<Npart>	Nevents	NKs	efficiency Ks	yield Ks	Ks enhancem
0-10	360	213	4816	0.26	86.963	1.933
10--20	260	290	4638	0.26	61.512	1.893
20-30	186	302	3750	0.29	42.818	1.842
30-40	129	310	2610	0.29	29.032	1.800
40-50	85	302	1493	0.29	17.047	1.604
50-60	52	300	777	0.29	8.931	1.374
60-70	30	315	409	0.35	3.710	0.989
70-80	16	350	149	0.26	1.637	0.819

The number of events in each centrality region is given in the spreadsheet.

The number of participating nucleons in the collision, N_{part}, which is correlated with the centrality, is also given in the table for each centrality class.

The number of particles measured is less than the number of particles produced; to find the latter we need to take into account the efficiency; efficiency values, for K_s, Λ and anti-Λ, have been estimated and are given in the table.

In the spreadsheet, there are embedded formulas to calculate:

Yield : the number of particles (of a certain type) produced per interaction = Nparticles(produced)/Nevents = Nparticles(measured)/(efficiency x Nevents)

Strangeness enhancement: the particle yield normalised by the number of participating nucleons in the collision, and properly normalised by the yield in proton-proton collisions at the same collision energy.

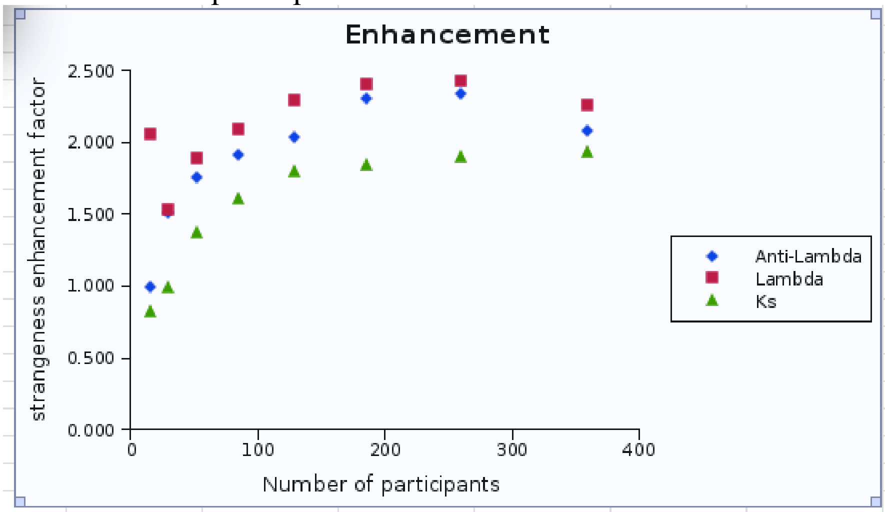
Ks-Yield(pp) = 0.25 /interaction
Λ-Yield(pp) = 0.0615 /interaction ; the same for anti-Λ
<Npart> = 2 for pp

NOTE: the above yields for Ks and Λ refer to proton-proton collisions at 2.76 TeV (same energy as for Pb-Pb collisions, 2.76 TeV per nucleon pair); they have been calculated by interpolation, between measured K_s and Λ yields at 900 GeV and 7 TeV [internal ALICE notes].

With all this information a spreadsheet like the following is produced with the information for K_s, Λ and anti-Λ.

centrality	<Npart>	Nevents	NKs	efficiency Ks	yield Ks	Ks enhancem	Nlambda	efficiency L	Yield Lambda	Lambda enh	Nantilambda	effic antiL	yield antiLam	antiL enha
0-10	360	213	4816	0.26	86.963	1.933	1066	0.2	25.023	2.253	980	0.2	23.005	2.071
10--20	260	290	4638	0.26	61.512	1.893	1185	0.21	19.458	2.426	1142	0.21	18.752	2.338
20-30	186	302	3750	0.29	42.818	1.842	917	0.22	13.802	2.405	875	0.22	13.170	2.295
30-40	129	310	2610	0.29	29.032	1.800	621	0.22	9.106	2.288	550	0.22	8.065	2.026
40-50	85	302	1493	0.29	17.047	1.604	363	0.22	5.464	2.084	332	0.22	4.997	1.906
50-60	52	300	777	0.29	8.931	1.374	182	0.2	3.033	1.891	169	0.2	2.817	1.756
60-70	30	315	409	0.35	3.710	0.989	89	0.2	1.413	1.526	88	0.2	1.397	1.509
70-80	16	350	149	0.26	1.637	0.819	71	0.2	1.014	2.055	34	0.2	0.486	0.984

Embedded in the spreadsheet is a scatter plot, showing the enhancement factors for K_s, Λ and anti- Λ versus the number of participants.



These results can be produced as follows:
Go to www.editgrid.com and login as

User alice-masterclass
Password alice

The example spreadsheet is
http://www.editgrid.com/user/alice-masterclass/centr-results-example.csv

Each institute can fill in a spreadsheet
http://www.editgrid.com/user/alice-masterclass/centr-results_inst_name.csv
(inst_name will be the name of the institute, e.g. CERN, Nantes, Heidelberg…)

DISCLAIMER : The results in this example – and the results produced by this analysis – are based on a small dataset selected for this measurement and on a number of assumptions and simplifications; therefore they may differ from official ALICE results.

Institutes' report and comments

The institutes must prepare one of the students to report the results during the videoconference.

He/she could report on the visual analysis first: they could say that they analysed xxx number of events, found y1, y2, y3 number of Ks, Lambda and antiLambda and the values of the mass (peak of the distribution) were as expected.

They should then report on the large scale analysis in centrality regions.

By logging in at the site www.editgrid.com as in the previous section, the moderator should bring to the screen and show the spreadsheet with the institute's results, including scatter plot.

Once all institutes have presented their results, comparisons can be made.
If there is enough time, the moderators can fill online a summary spread sheet.
For example, for Lambdas, the spread sheet :

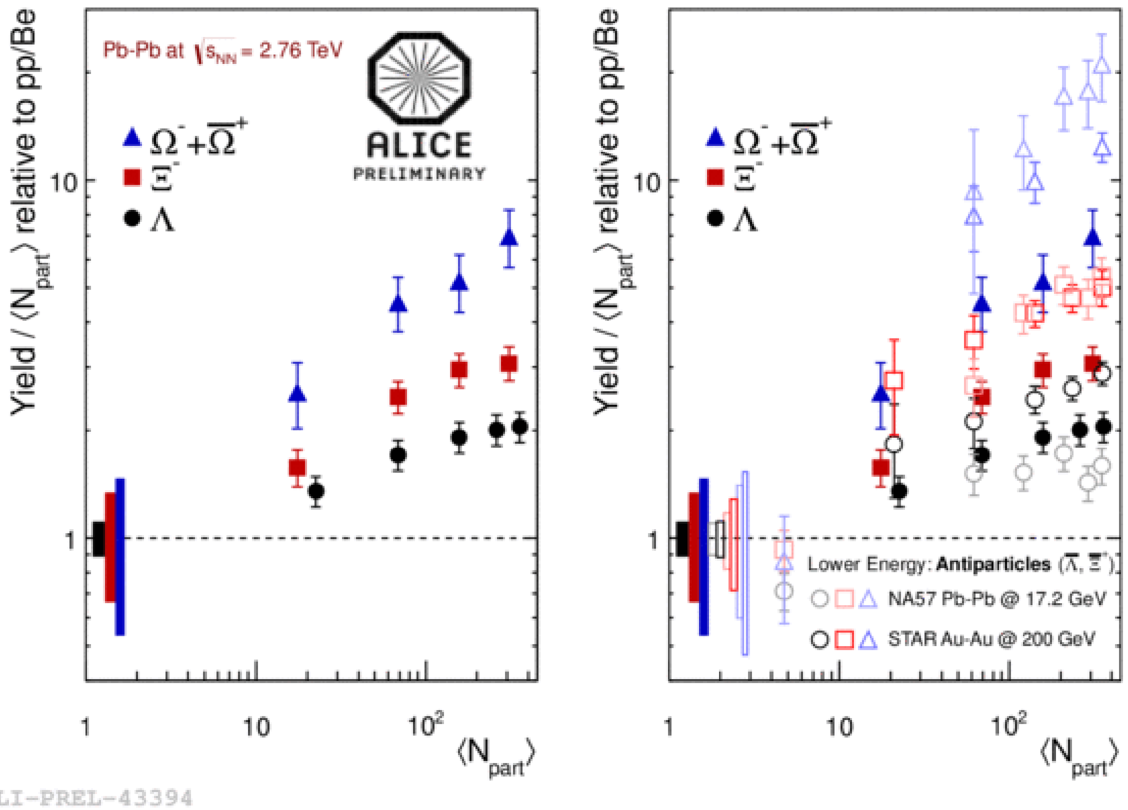
http://www.editgrid.com/user/alice-masterclass/ centr-results-lambda-all.csv

Possible comments :

The number of Ks, Lambda and antiLambda (and the calculated yield) is higher for more central collisions. This is normal since, in the most central ones, up to ~400 nuclei in total interact, which results in thousands of particles produced per collision.

Strangeness enhancement is observed (ratio >1). Ratio=1 would mean that there is no difference between collisions of nucleons of the lead nuclei and collisions of protons.

Show ALICE preliminary results



The students have only measured Λ (1 strange quark); Their measurement is in agreement with the ALICE preliminary results, within errors. (In addition, assumptions were made about the efficiency – real life analysis takes much longer – things were simplified here to complete the measurement).

The other particles shown on the plot have higher content of s-quarks: the Ξ has 2, the Ω 3. Strangeness enhancement increases with the number of strange quarks in

the baryon.
The right-hand plot shows preliminary results of ALICE and for comparison results from lower energy heavy ion collisions. (NA57 and RHIC)

Note

If there is a problem with accessing editgrid, the institutes can use excel spreadsheets with embedded scatter plots, or extract the necessary data from the excel file and create a text file which is read by a root macro and thus produce plots. They can then show them by screen sharing.

Additional information can be found at the URL

http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html

the text describing the measurement
also “Instructions to the Institutes”
http://aliceinfo.cern.ch/public/MasterCL/InstituteInstructions2013.pdf

Temperature Calculation

An additional comment can be made by the mpoderators on the calculation of temperature from particle ratios, see above document “Instructions to the Institutes”, along the lines:

Based on the measured particle yields, particle ratios can be calculated, i.e. K0s/pions, Λ/pions etc. These, together with many other particle ratios, are used by a model which can estimate the temperature of the created matter.

This is found to be of the order of 200 000 times higher than at the centre of the sun. Normal matter cannot exist at such temperatures. Furthermore, this temperature is compatible with the one expected if a quark-gluon plasma is created.

f) ALICE R_{AA} measurement

Author: Ralf Averbeck

Web page with further documentation: http://www-alice.gsi.de/

Students´ tasks include:

- Measurement of the p_T-integrated nuclear modification factor R_{AA} for peripheral, mid-central, and central Pb-Pb collisions at the LHC based on a visual analysis
- Measurement of the p_T-differential yields of charged particles in Pb-Pb collisions of various centralities in a large scale analysis
- Measurement of the nuclear modification factor R_{CP} in various Pb-Pb centrality classes in a large scale analysis
- Measurement of the nuclear modification factor R_{AA} in various Pb-Pb centrality classes in a large scale analysis

During the video conference the different institutions should NOT present the same results. Instead each institute should report on a different aspect of the measurement. Therefore, it is important that the participating institutes and the moderators agree on 'who presents what' before the video conference. In the usual case of four participating institutes the individual reports could deal with:

- p_T-integrated R_{AA} from visual analysis
- p_T spectra in Pb-Pb collisions
- R_{CP} in Pb-Pb centrality bins
- R_{AA} in Pb-Pb centrality bins

In case of fewer or more institutions participating in this Masterclass the topics to be reported on should be redistributed among the institutions.

In addition to the students' presentations the result should be put in context by either the moderators or local experts from the participating institutions. Issues that should be addressed include:

- how do the results obtained by the students compare with the published results?
- what is the reason for (small) differences between the students' results and the published results?
- what has been observed elsewhere, e.g. in Au-Au collisions at RHIC where nuclei collide with lower energies as compared to the LHC?
- how can the measurement be interpreted?
- are there other measurements that support this interpretation?
- is the observed suppression ($R_{AA} < 1$ at high p_T) the same for all hadrons?

Example presentations discussing the points mentioned above will be made available at http://www-alice.gsi.de/.