Selected University instrumentation programs

Eric Chabert (University of Strasbourg, IPHC)

Introduction

Disclaimer:

- *This talk uses feedback collected by national contacts as input.*
- *By definition this talk does not aim to be exhaustive but it's an attempt to draw main ideas from existing programs/initiatives.*
- *There are certainly personal biases/point of views but the purpose it to generate discussions !*

The **main questions** related to **what Universities could propose to prepare the future generation of instrumentalists in HEP** could be summarised as**:**

1- How to **attract** bright talents in our field (instrumentation in HEP) ?

2- How to **train** students at University (bachelor/master) ?

3- How to **complete** the curriculum offered by universities with external resources ?

Outline

1- Attracting bright talents in our field

- Attracting high school students to (subatomic) physics
- Attracting bachelor students to HEP/instrumentation

2- **Training** students at University (up to master level)

3- **Completing** the curriculum proposed by universities

1 - Attracting high school students

Several successful actions already exist:

- Physics master classes (IPPOG): 13 000 students – 60 countries
  - → Introduce students to physics @ university / research centers
  - → Introduction to our field mainly through data analysis – international event
  - → **Local actions**: visit of sites (accelerator), local experiments, etc …

Visit of a 24 MeV accelerator

Hands-on

Cloud chamber

Usage of VR for public events

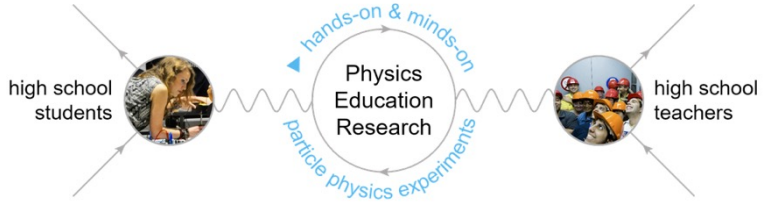
Few illustrative pictures of a Master Class session @ IPHC

1 - Attracting high school students

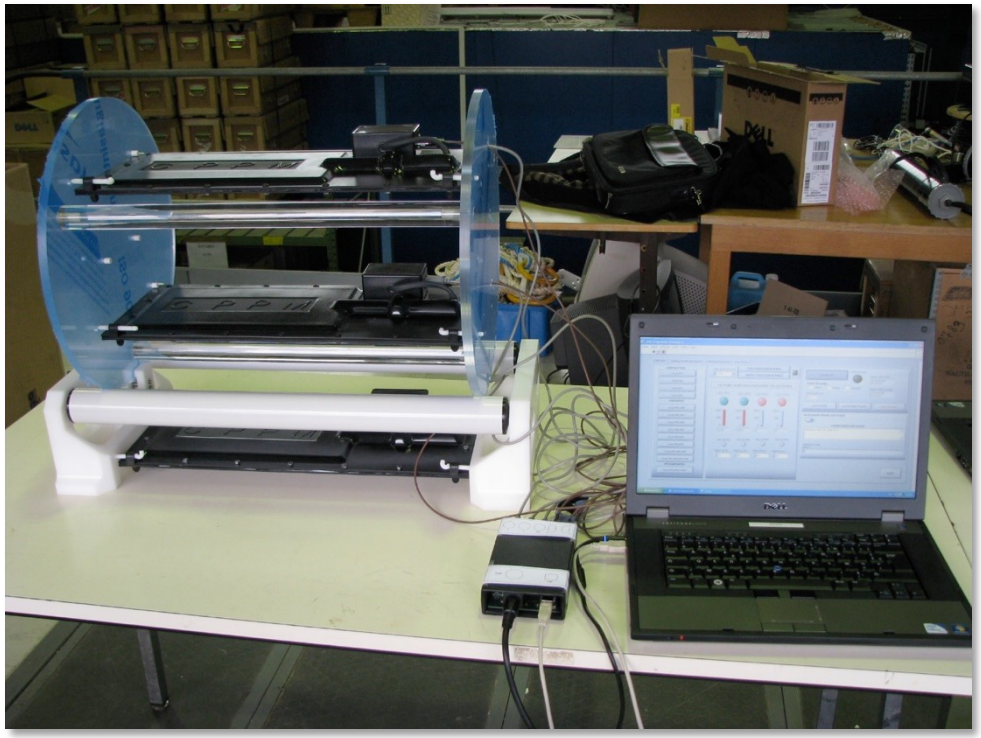
Several successful actions already exist:

- Beam line for schools
  - Contest: high-school students propose a scientific experiment they would like to perform at a particle accelerator
  - 2 winner teams can perform their experiment
- S'Cool LAB
  - hands-on & minds-on particle physics experiment sessions on-site at CERN

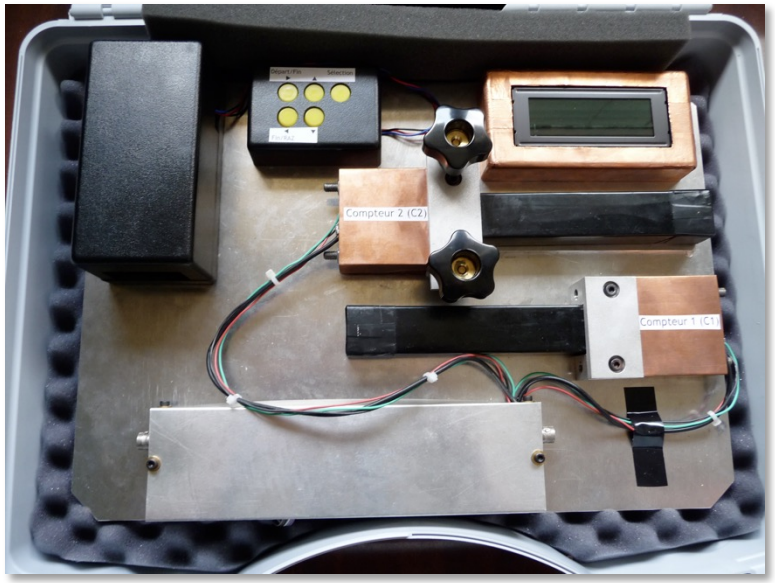
  for high school students & their teachers
- Other actions:
  - Loan of detectors to high school
  - Conferences in high school



1 - Attracting high school students



“cosmo-detector” (France)
3 rotating scintillator planes



COSMIX (mall) (Bordeaux, France)
(spare from Fermi-LAT)

Does anybody know studies evaluating the impact of such actions ?
I don’t have but personal experiences show that such events can trigger choices !

1 - Attracting students to our domain

- Presentation of **lab/research activities** to young students
  - Visit of labs
  - Conferences/seminars accessible to bachelor students
- Proposing **internships** during the first years (bachelor)
- Proposing electives (**introductory**) courses within bachelor programs
- **Programs of excellence** tends to attract students ! *(discussed in next section)*
  - Several examples in France, Germany, …
- Visit of **large infrastructure** such as CERN
- Encouraging **exchanges** between bachelor/master/PhD students …

Visits to CERN

Many countries organize visits to CERN

- Play a role on student motivation
- Being on site is a must !
- Interest for the detector/instrumentation is as large as the purpose(s) of the experiments
- It can trigger choices !

Master I - II + PhD students
from Strasbourg University visiting CMS/CERN

Outline

1- **Attracting** bright talents in our field

2- Training students at University (up to master level)

- I didn’t list all the programs but it could be don’t through this link
- Selection of "elements” within university programs that are interesting for training students
- Collecting a feedback/**evaluation** on those programs would be interesting (not done here)

3- **Completing** the curriculum proposed by universities

2 - Training: instrumentation @University

- Instrumentation in HEP is at the frontier between **fundamental research** in particle physics and **technology**
- **Diversity of competences** needed in the field should be acknowledged and even encouraged

→ Academic background of HEP instrumentalists is (*luckily*) **not unique**

→ Break-through may come from technologies/skills not yet applied in our domain …

A balance between **broadness** and **specialisation** should be found

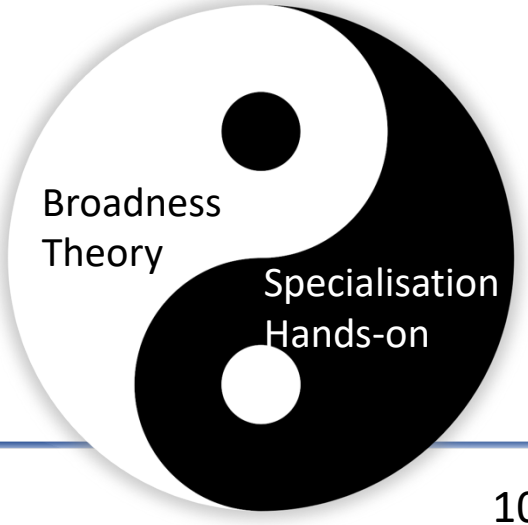
→ **broadness**: requires to have an overview - ensures evolution during the career

→ **specialisation**: giving (high) skills directly applicable to our domain

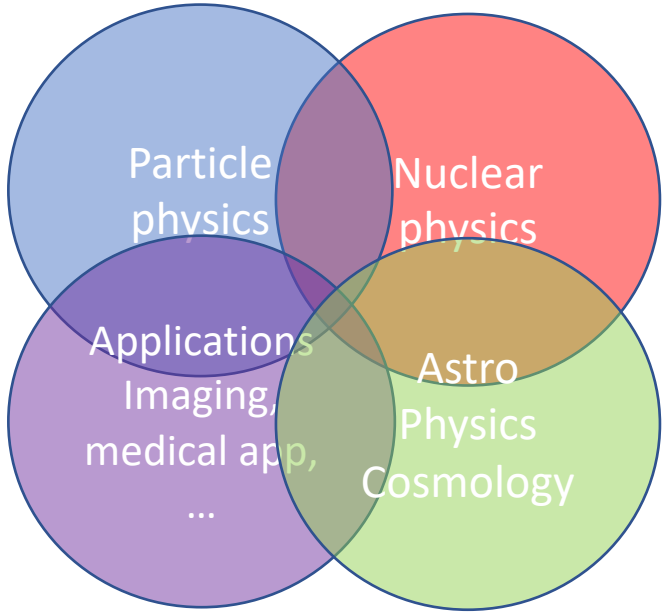
Balance between "theoretical" knowledge & **hands-on**

→ **theoretical knowledge**: requires to have a deep understanding

→ **hands-on**: necessary to prepare instrumentalists but requires equipment, time, …



2 - Training: University programs



2 main paths for instrumentalists in HEP are:

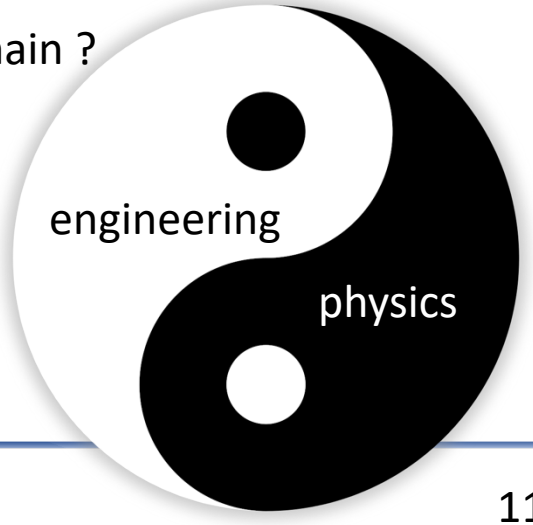
- **Bachelor/Master in physics** with track/specialization/electives courses in instrumentation

Several proposed by most of the EU countries (can't list all of them: link)
Only few of them mentioned in that talk
→ How detector related knowledge/skills is/could be provided ?
→ How hands-on is/could be provided ?

- **Bachelor/Master in "engineering"** (often proposed by Technical Universities) where one of the domains of application is HEP

→ How knowledge of our physics domain is/could be provided ?
→ How can we attract students to applied their skills in our domain ?

The student density is not large enough to have a master dedicated to HEP instrumentation
Most of the universities propose masters covering several close-by domains (**broadness**)
→ Mutualization of the "generic courses"
→ Often correlated with the broadness of research programs in the associated labs
→ **Specialisation** done mainly in Master (sometimes only during the 2nd year)
→ Many master propose several "tracks"



2 - Training: University programs

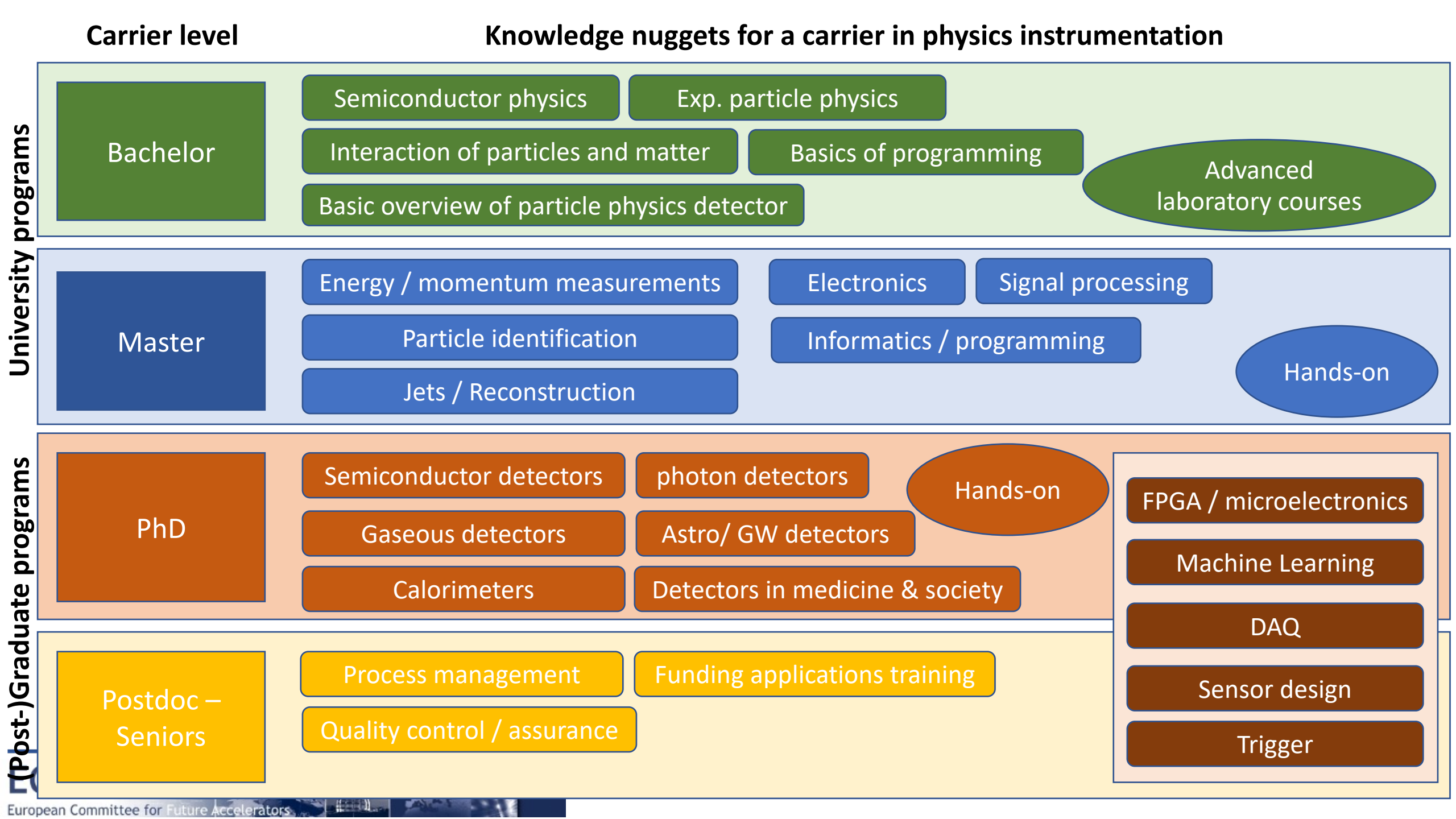
Could we draw "recommended knowledge" to be acquired at the various carrier level in instrumentation training ?

Although diversity of skills and education background are encouraged, such attempt could be useful for

1 – Defining **entrance knowledge** required for graduate schools

2 – It could help students to **gauge their level of preparation** when entering the field
3 – It could help nations/universities where training in instrumentation is not yet strongly developed to compensate some of the missing courses though over means
→ using online/virtual courses provided on a EU wide platform covering this complete program ?

Attempt presented in next slides (done by organizers/speakers of today's session), see Erika's talk


Carrier level
Knowledge nuggets for a carrier in physics instrumentation
University programs
(Post-)Graduate programs
Bachelor
Semiconductor physics
Exp. particle physics
Interaction of particles and matter
Basics of programming
Basic overview of particle physics detector
Advanced laboratory courses
Master
Energy / momentum measurements
Electronics
Signal processing
Particle identification
Informatics / programming
Jets / Reconstruction
Hands-on
PhD
Semiconductor detectors
photon detectors
Hands-on
Gaseous detectors
Astro/ GW detectors
Calorimeters
Detectors in medicine & society
FPGA / microelectronics
Machine Learning
DAQ
Sensor design
Trigger
Postdoc – Seniors
Process management
Funding applications training
Quality control / assurance
European Committee for Future Accelerators

2 – Hands-on: lab courses

Hands-on is a key element for preparing future experimentalists …

- It requires equipment, time, supervision and has a cost …
- *My personal opinion*: should be reinforced, already at bachelor level !
- Laboratory courses can strongly depend on the associated research laboratories

1 – basic “educational” equipment

- many universities have “nuclear physics” laboratory courses
- already many things to **learn from basic setups** ... (pedagogically better to start from simple ones !)
- regular lab sessions are opportunities to promote a **positive vision** of experimental physics

→ Skipping that step would induce knowledge gaps …

2 - modern research platforms

- access to state-of-the-art detectors
- access to accelerator on site

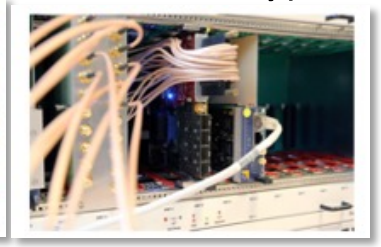
3 - Access to large infrastructure

- PSI, DESY, NIKEF, KIT (RIRO)

An example of program of excellence: Ex^2

Excellence by **Ex**periment

- Program proposed in **Strasbourg** (France) for bachelor/master students
- Now part of larger program QMat (international graduate school on Quantum science & nanomaterial)
- 8 experimental platforms in various domains (nuclear physics, particle physics, astroparticles, astrophysics, …)
  - 3 of them uses local accelerators (4 MeV)
  - Available for internships or could replace “regular lab sessions”
  - Example: Rutherford’s experiment
    - Installation, DAQ, etc
    - Detector characterization (calibration, efficiency)
    - Geant4 simulation
    - Data analysis



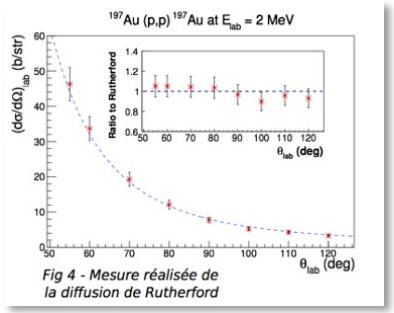
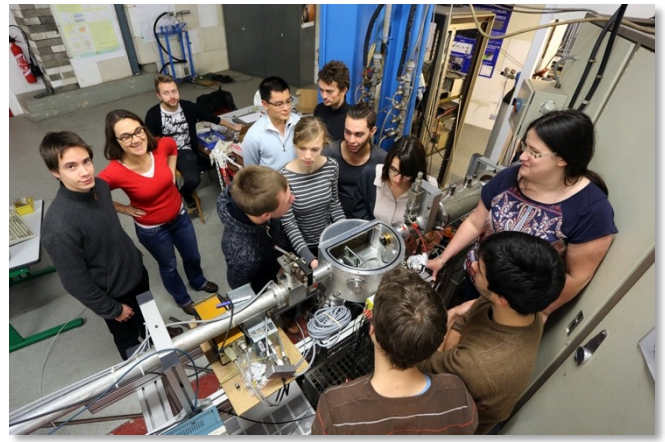


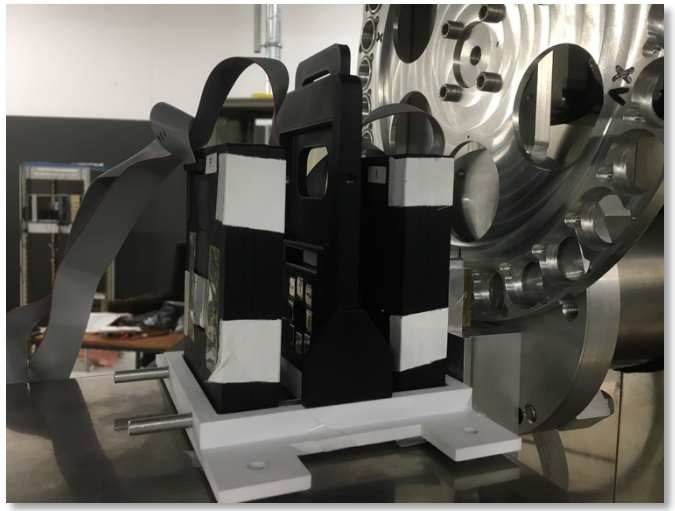
Fig 4 - Mesure réalisée de la diffusion de Rutherford



An example of program of excellence: Ex^2

Excellence by **Ex**periment @ Strasbourg (France)

- **S**ilicon **T**racker with **I**nternational **E**ducation **O**bjective [link]
  - Setup:
    - 4 planes of high granularity (pitch = 20.7 µm)thin (50 µm) CMOS pixelated sensors (MIMOSA-28)
    - a permanent magnet (0.5 T)
    - FPGA based DAQ
  - Sources:
    - Beta source: Sr90
    - 24 MeV proton line
    - Cosmics
  - Students (>20)
    - from bachelor to PhD students



  - Cover mainy domains of instrumentation (calibration, noise analysis, DAQ, data analysis, simulation, …)

→ Aim to reproduce the same setup in other universities [already in Daegu (Korea)]

Contacts: J. Baudot, E. Chabert

2- Lab courses using large infrastructure

Experiments at PSI [ref, Contact: André Schöning]

- 10-12 students from ETH Zürich, Heidelberg and Mainz Universities
- one week of preparation + two weeks of beam @ PSI
- example of measurements:

  lifetimes and decay parameters of muons and pions, $B(\pi \rightarrow e\nu)/B(\pi \rightarrow \mu\nu)$

2 – Few selected university programs

Karsruhe Institute of Technology

- Master in physics with a dedicated track
- Graduate school: KSETA: Karlsruhe School of Elementary Particle and Astroparticle Physics: Science and Technology
- University of Excellence program “Research Infrastructure in Research-Oriented Teaching” (RIRO) **[ref, André Schöning]**

→ integration of the large KIT research infrastructures into teaching activities

Heidelberg

- Master in physics with dedicated courses
- Research Training Group: - High Resolution and High Rate Detectors in Nuclear and Particle Physics [GRK 2058]
- Graduate School of Fundamental Physics

2 - Selected universities in instrumentation (not HEP specific)

Master dedicated to instrumentation have a **broad range of applications**, one of them could be HEP.

- Telft University of Technology (Netherlands): Physics for instrumentation [link]
  - Applications: cosmology and particle physics, medical therapy, …
  - Courses: elementary particles, nanotechnology, electronics for physicists, charged particle optics, ….
- University of Twente (Netherlands) : Master in applied physics in Energy, Materials and Systems [link]
  - Courses in HEP, nanophysics, surface and thin layers, electrical power & system integration, fluid mechanics, solid mechanics, …
- Inter-university master in Paris: Large instruments, plasmas, laser, accelerators, tokamaks [link]
- …

Outline

1- **Attracting** bright talents in our field

2- **Training** students at University (up to master level)

3- Completing the curriculum proposed by universities

- Broadening the supply of training
- Summer schools
- Summer student programs

3 – Completing the curriculum with external resources

Proposing the **access to a school in instrumentation within the Master diploma**:

→ Both Grenoble & Strasbourg Universities are proposing to their Master 2 students to participate to the school ESIPAP (4 weeks of lectures/hand-ons: ~ 120 hours) [8 ECTs]

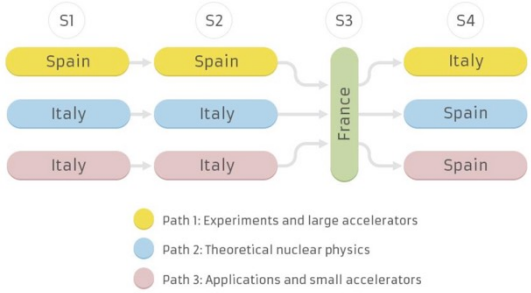
In Strasbourg, other students have 2 other options:

- working 4 weeks on an experimental project

- working 4 weeks to developpe a computing project in the domain of subatomic physics

2 – How to broaden the supply of training

- Promoting student mobility
  - Through programs such as ERASMUS
- Proposing double diploma (at national or european level)
  - Ex: In Strasbourg (France), students for engineer school can obtain a double diploma in their last year (5^{th}) by following a Master 2 in subatomic physics
- Proposing diploma at national level
  - Inter-university master degree in nuclear physics: 8 universities in spain [link]
- Proposing diploma at european level
  - Erasmus mundus on nuclear physics [link]
- Access to virtual resources ?



3 - Summer school for bachelor/Master students

Some universities are organizing summer schools

- Recontre physique des infinis (France): 2 weeks of lectures/visits
- GRASPA (Annecy, France): school in particle/astroparticle physics
- …

- Interesting events to attract students to our field
- Improve the background
- Play a key role on the motivation
- There are rarely hands-on session

3 - Summer student programs

Many universities/countries/infrastructures organize summer students programs

- CERN
  - Summer student program [8-13 weeks]
  - Openlab summer student program [IT project – 9 weeks]
- DESY
- Niham (Roumania)
- …

Summary & conclusions

1 - Attracting students …. motivation is the key word !

- Successful great initiatives already exist and should be pursued (**evaluation of their impact ?)**
- Declination of such initiatives on site with **local** specialities (contact with research group, etc) should be encouraged
- Increase the opportunities for **hands-on already at bachelor level**
- Increase the connections btw researchers & students

2 - Training students…. balance is one the key words !

- Finding a balance between theory & **hands-on**
- Finding a balance between broadness & **specialisation**
- Defining a "**reference knowledge**" could be useful (common effort)

- Reinforcing bridges between students & researchers through **internships** by example
- Program of **excellence**, graduate schools, … [linked to research/university funding/organization …]
- **Site specialization** (based on existing infrastructure, equipment, research activities, …)

Summary & conclusions

Completing the curriculum… **mutualization is the key word !**

- diploma at national/european level (inter-university): AFAIK we don't have one (with a track) dedicated to instrumentation in HEP
  - Having in mind a site specialisation
- access to instrumentation schools / graduate school

- access to a **bank of online courses** (to be created ?)
- Internships
  - more time than during lectures/labs to learn
  - being involved within research teams early in university studies has a large positive influence

Conclusions & discussions

Beyond a review of existing programs/initiatives …

- It will be valuable to evaluate of the initiatives (NB: some are too recent)
- A large panel of programs/initiatives exist to prepare the future generation of instrumentalists
- Attracting/training is a long-term investment

  → Need to be pursued and generalized
- Need an articulation between all initiatives
- Training requires time …
  - Time to learn the basics on both theoretical and experimental sides (with hands-on !)
  - Time for specialisation, immersion within research projects, …
- **Mutualization of equipment/knowledge/expertise through common programs could be our next steps**
  - European schools in instrumentation school integrated within Master
  - National/European inter-university master degree specialized to our domain
  - Bank of online courses

It’s time for discussion ….