Training in Accelerator Science & technology

Philip Burrows

Director,

John Adams Institute for Accelerator Science

Outline

- Introductory remarks
- TIARA education and training surveys
- ARIES + I.FAST
- Forward look

Introductory remarks (1)

- **Training is a big topic!**
- **Community:**
  - Physicists / engineers / technicians …
- **Academic level:**
  - Undergraduate / Master's / PhD / staff …
- **Delivery:**
  - Lectures, seminars, lab work, 'on the job' …
- **Institutions:**
  - Universities, national + international labs, facilities, accelerator schools …
- **How many trained people do we need?**
  - How does this help society more generally?

Introductory remarks (2)

- Particle-physics accelerators
- Light sources
- Neutron sources
- Medical accelerators
- Industrial accelerators
- Industry

A lot has been done

- Several EU-funded projects have explicitly addressed the provision of accelerator training in Europe:

  TIARA, ARIES, AMICI, I.FAST, EJADE …

- TIARA, ARIES, I.FAST include dedicated WPs on training coordination (led by PNB)

  → review of some key activities follows …

Test Infrastructure and Accelerator Research Area
Preparatory Phase

The main objective of TIARA is the integration of national and international accelerator R&D infrastructures into **a single distributed European accelerator R&D facility** with the goal of developing and strengthening state-of-the-art research, competitiveness and innovation in a sustainable way in the field of accelerator Science and Technologies in Europe.

Besides maximizing the benefits for the owners of the infrastructures and their users, TIARA aims at establishing a framework for developing and supporting strong joint European programmes:

› for accelerator Research and Development
› for education and training
› for enhancing innovation in collaboration with industry

HOT NEWS

TIARA-PP extended for one year

TIARA-PP final general meeting held at Daresbury lab, November 25-27

NEWSLETTER »

Accelerating NEWS

ACCELERATORS FOR SOCIETY »

MEETING DATES

Governing Council

10:00 - 17:00
Governing Council meeting (CERN)
Governing Council

Archives »

TIARA Management

Archives »

TIARA WP5: Education & Training

WP5.1 Make a survey of the number of students, courses and teaching resources in Accelerator Science and establish a common resources database

WP5.2 Evaluate and develop the "market" for trained Accelerator Scientists (physicists, engineers, technicians) for research, healthcare, industry and public service

WP5.3 Determine a plan of action for promoting Accelerator Science and Technology within schools, universities, research organisations, industry and society

TIARA WP5 participants

1	CEA:	Phu-anh Phi Nghiem, Francois Kircher
2	CERN:	Roger Bailey (CAS), Kate Kahle/ Agnes Szeberenyi (EUCARD), Louis Rinolfi (JUAS)
3	CNRS:	Alex Muller, Catherine Clerc
4	CIEMAT:	Marisa Marco, Diego Obrador, Susanna Falcon
6	GSI:	Oliver Boine-Frankenheim, Sabrina Appel
7	INFN:	Vittorio Vaccaro, Francesca Galluccio
8	PSI:	Lenny Rivkin
9	STFC:	Philip Burrows, Max Bradbury
10	Nordic group:	Soren Pape Moeller + Ole Petter Nordahl
11	IFJ:	Piotr Malecki

Survey of accelerator training

Training survey topics

- **Institutes providing training**
- **Personnel involved in delivering training**
- **Type of training**
- **Numbers and types of students**
- **Training materials and facilities**
- **Career destinations**

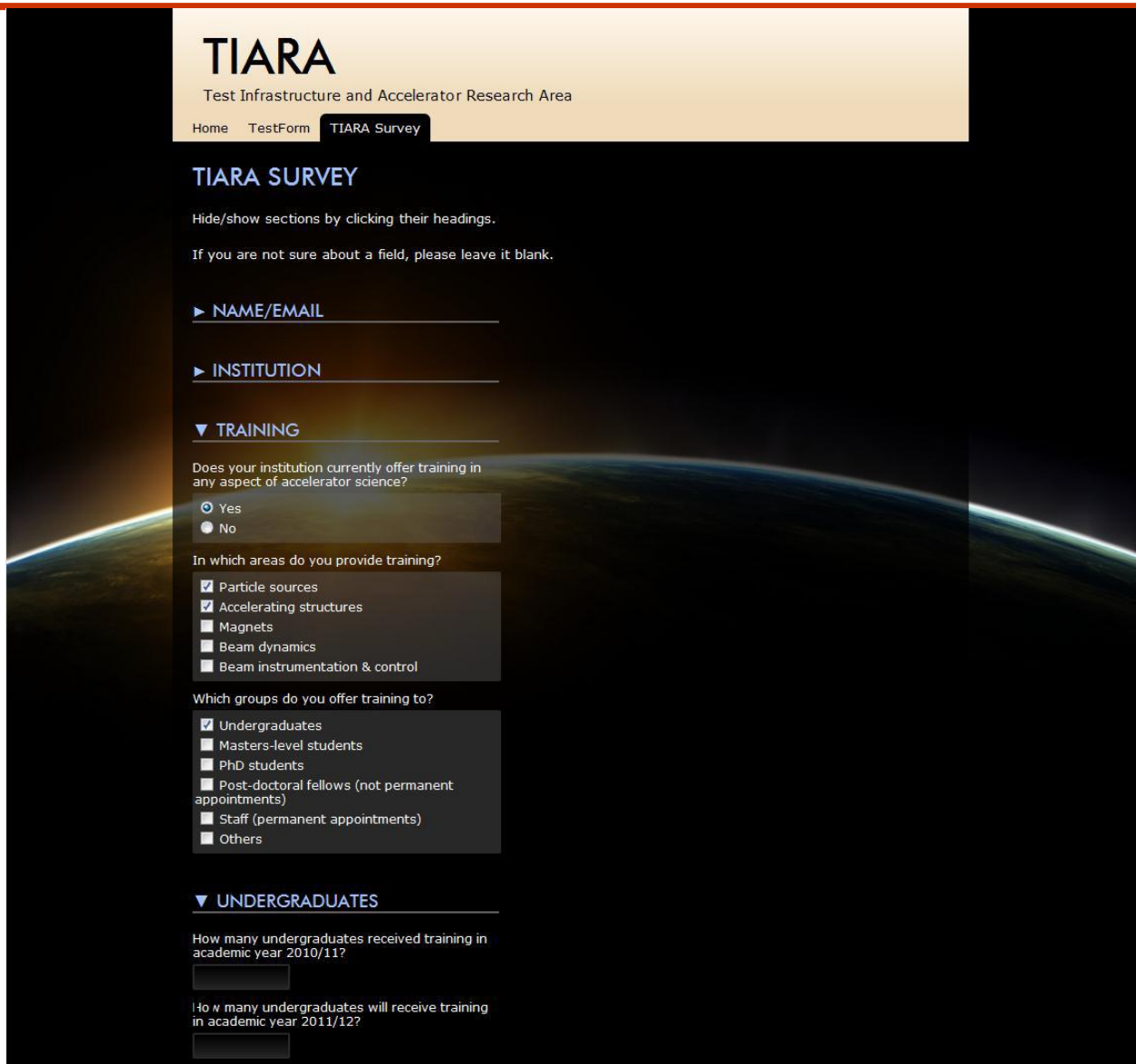
www-based survey

www-based questionnaire

+ interactive www-site of results

/

Thanks to Max Bradbury



Survey responses

- **Responses from 88 institutes across Europe**
- **We captured the vast majority of the key players**

Training survey report

https://cds.cern.ch/record/1442599/files/TIARA-REP-WP5-2012-006.pdf

Test Infrastructure and Accelerator Research Area

TIARA WP5
Deliverable 5.1 - ETR
Education and Training Survey Report

2 May 2012

François Kircher, Phu-Anh-Phi Nghiem, ***CEA, France***

Roger Bailey, Louis Rinolfi, ***CERN, Switzerland***

*M. Luisa Marco Arboli (****WP Deputy****), Susana Falcon, Diego Obradors,* ***CIEMAT, Spain***

*Catherine Clerc, Alex C. Mueller (****WP Deputy****),* ***CNRS/IN2P3/LLR, France***

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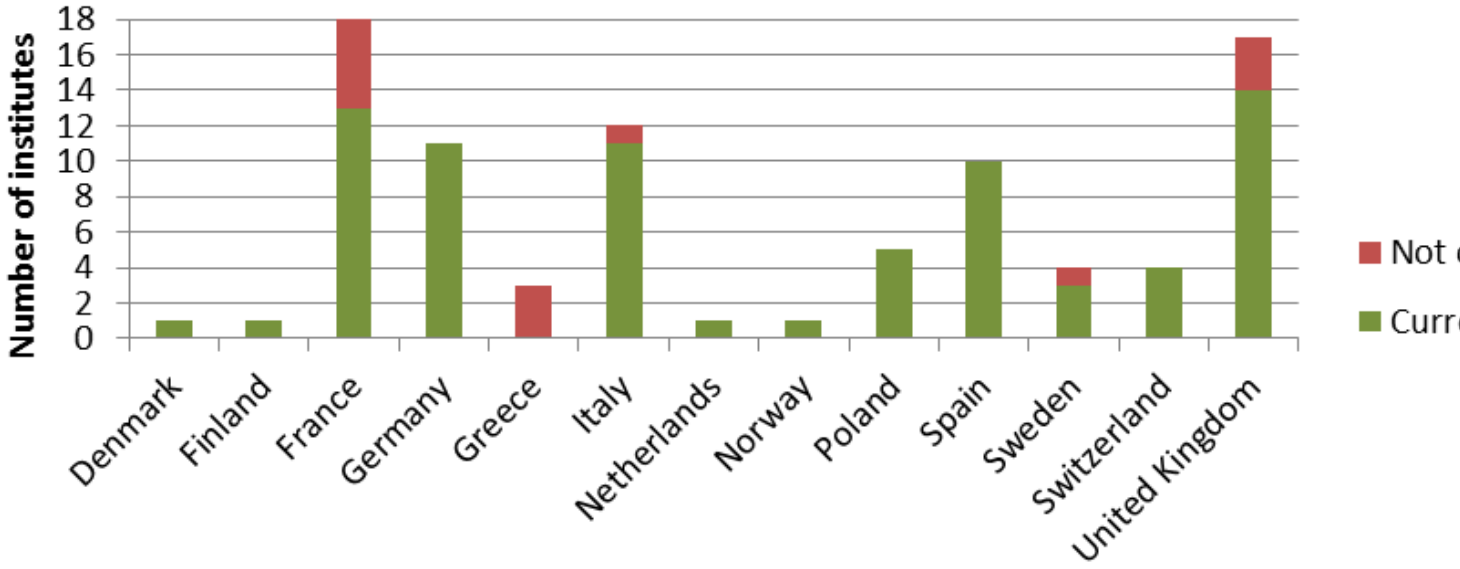
The research leading to these results has received funding from the European Commission under the FP7-INFRASTRUCTURES-2010-1/INFRA-2010-2.2.11 project TIARA (CNI-PP).

Grant agreement no 261905.

Content

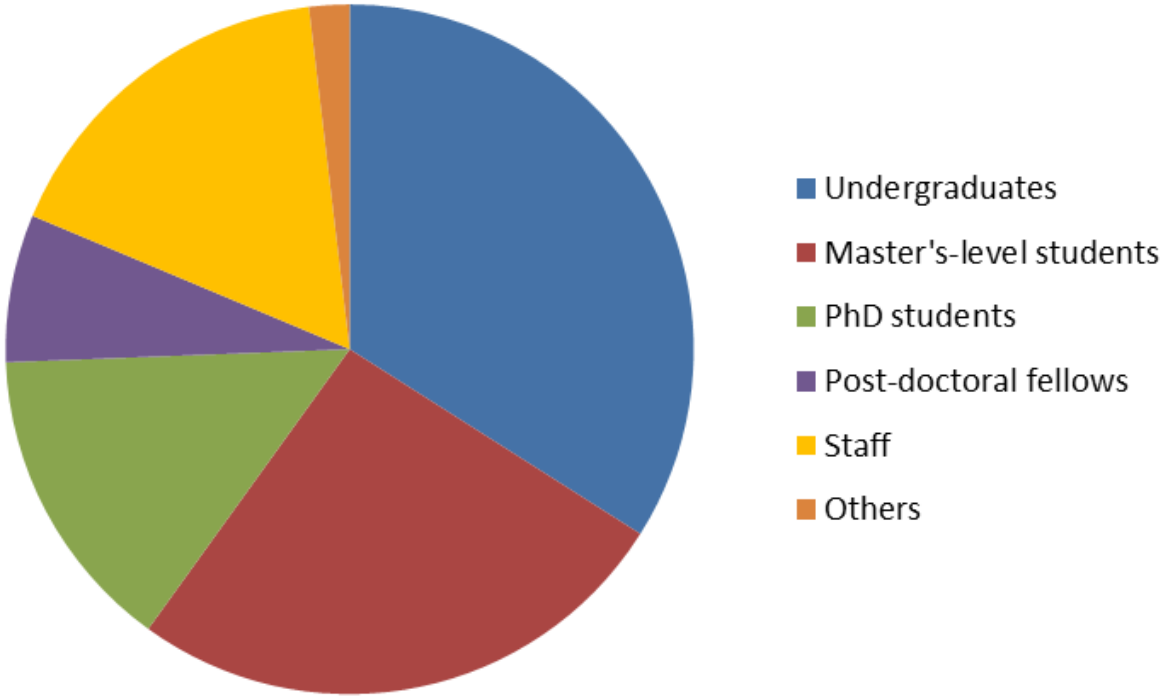
Survey highlights: institutes

- 88 responding institutes
- 3060 personnel engaged in accelerator science
- 75 institutes (85%) provide training themselves
- 12 institutes plan/desire to train in future



Survey highlights: trainees

- **1371 people (2011) received formal training:**
  - **34% undergraduates**
  - **26% masters**
  - **14% PhD**
    - **7% postdocs**
  - **17% staff**



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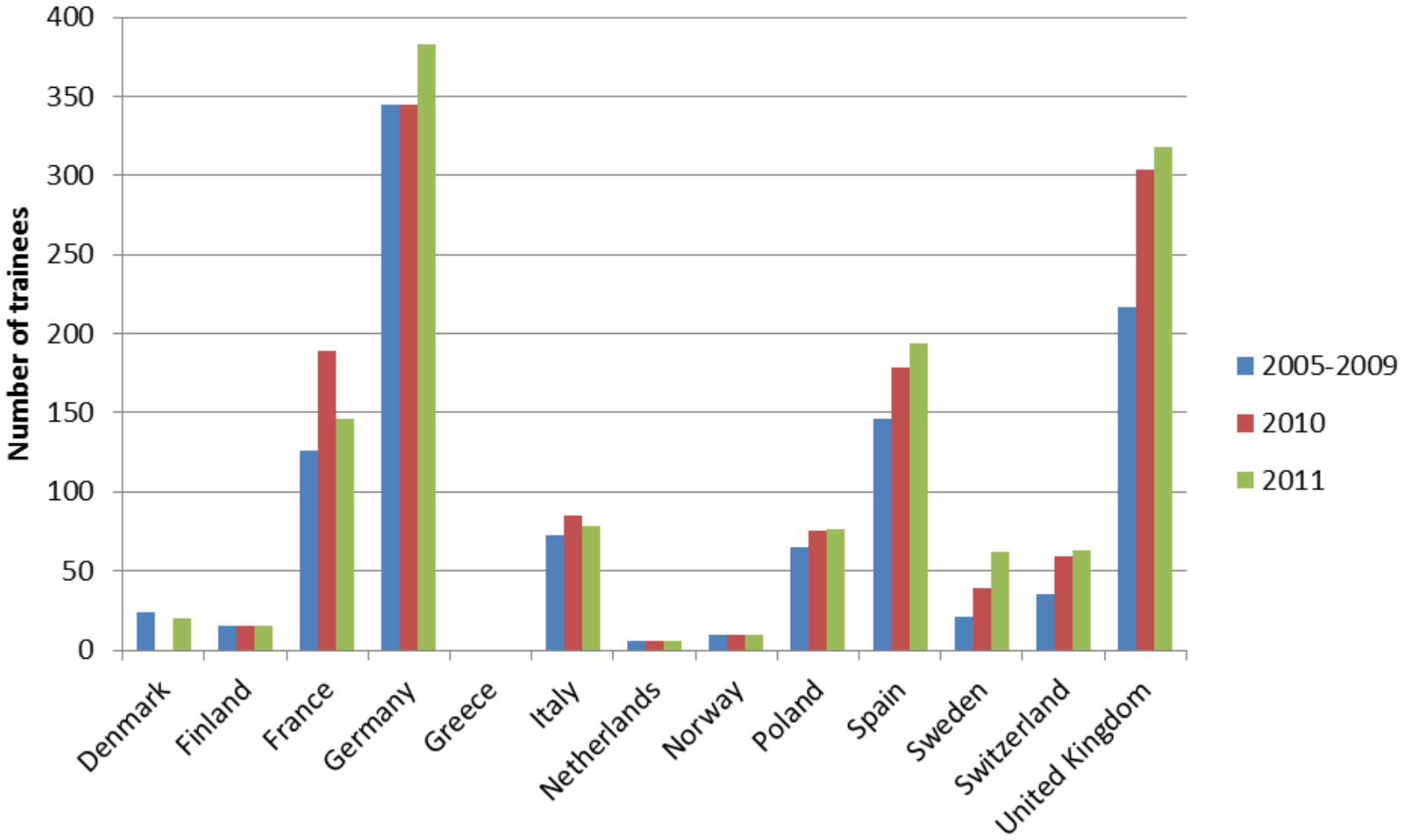

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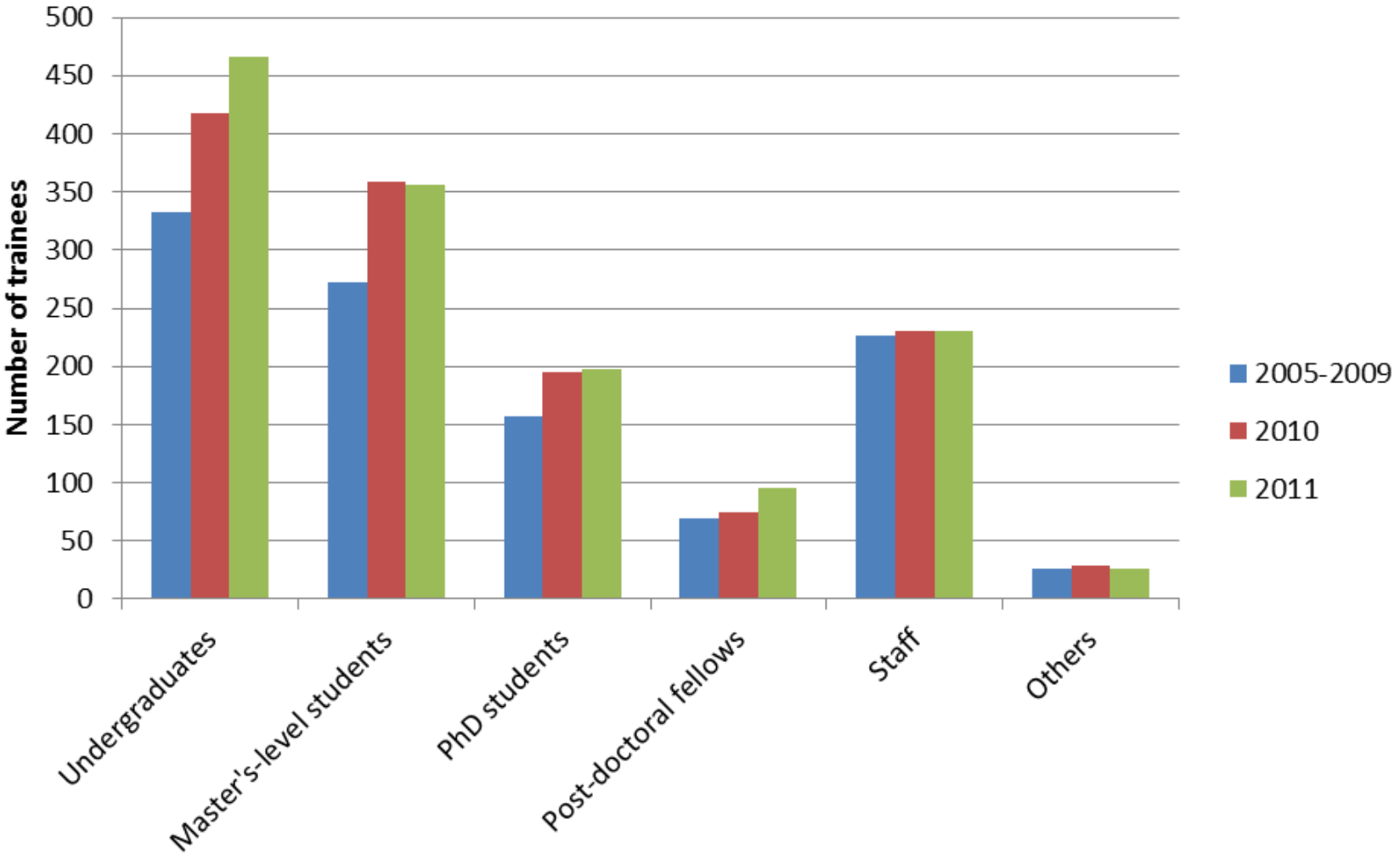
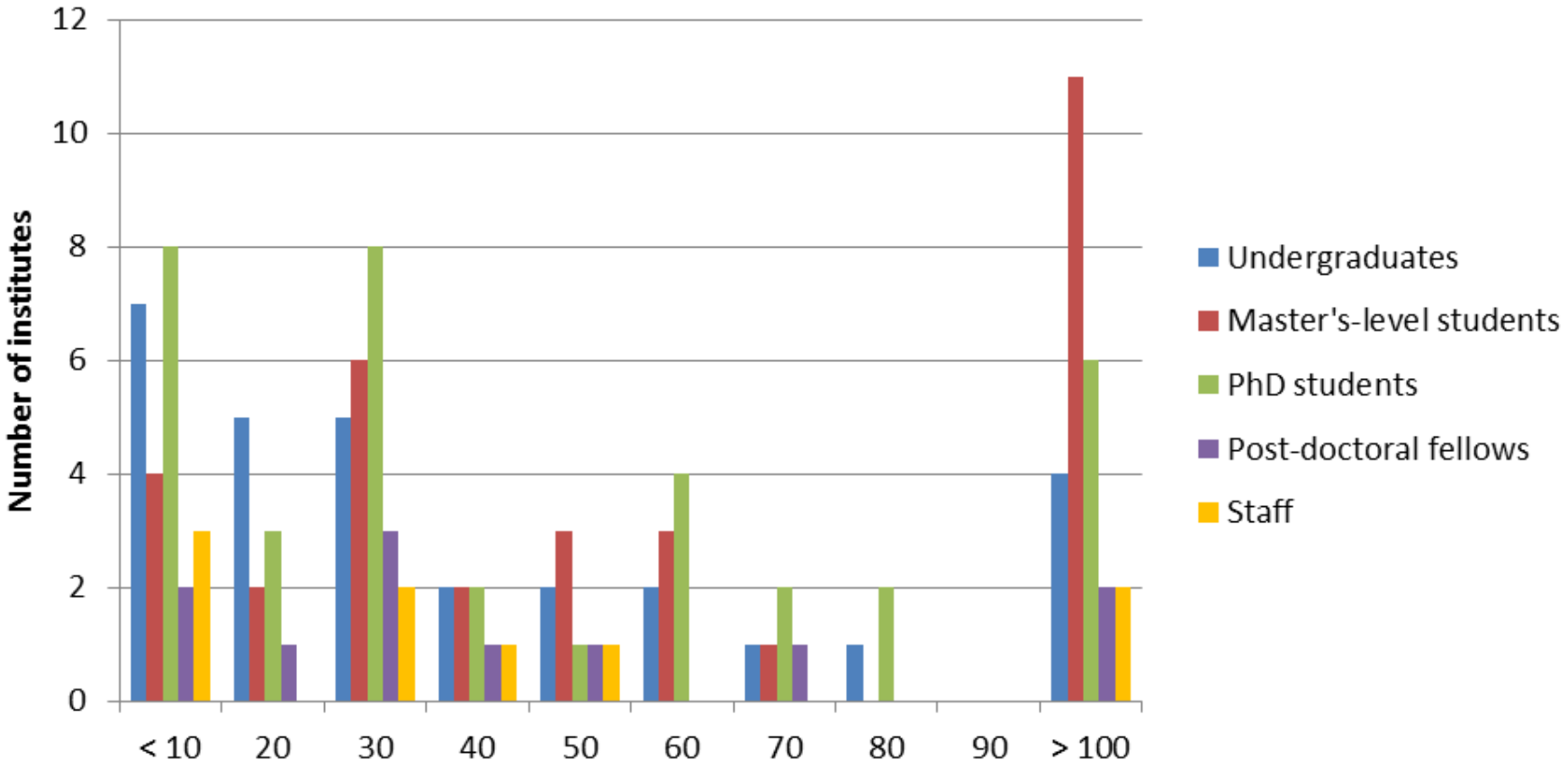


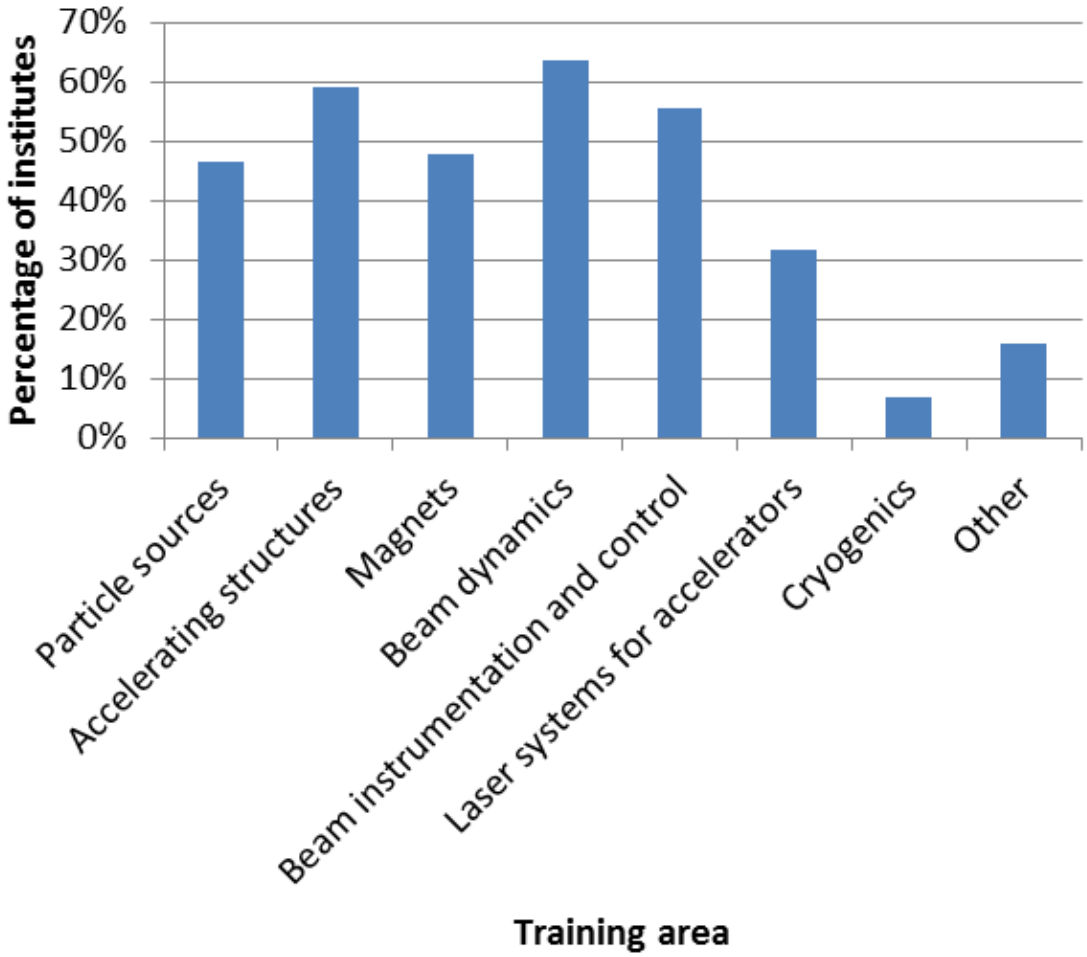
Formal training hours

- **55 / 75 institutes reported ‘formal’ training hours**



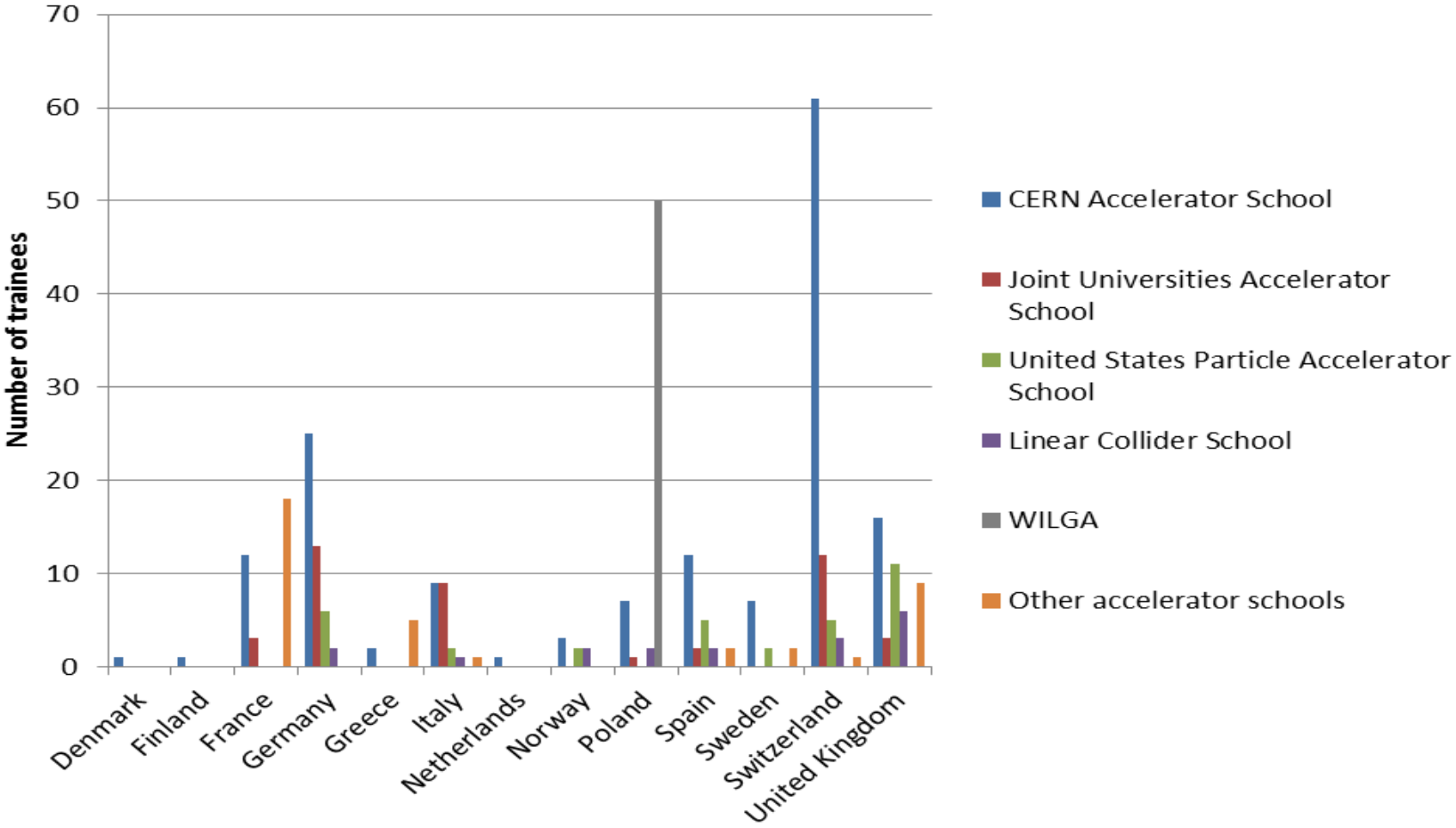
Training subjects

- **72 institutes reported on training subjects**



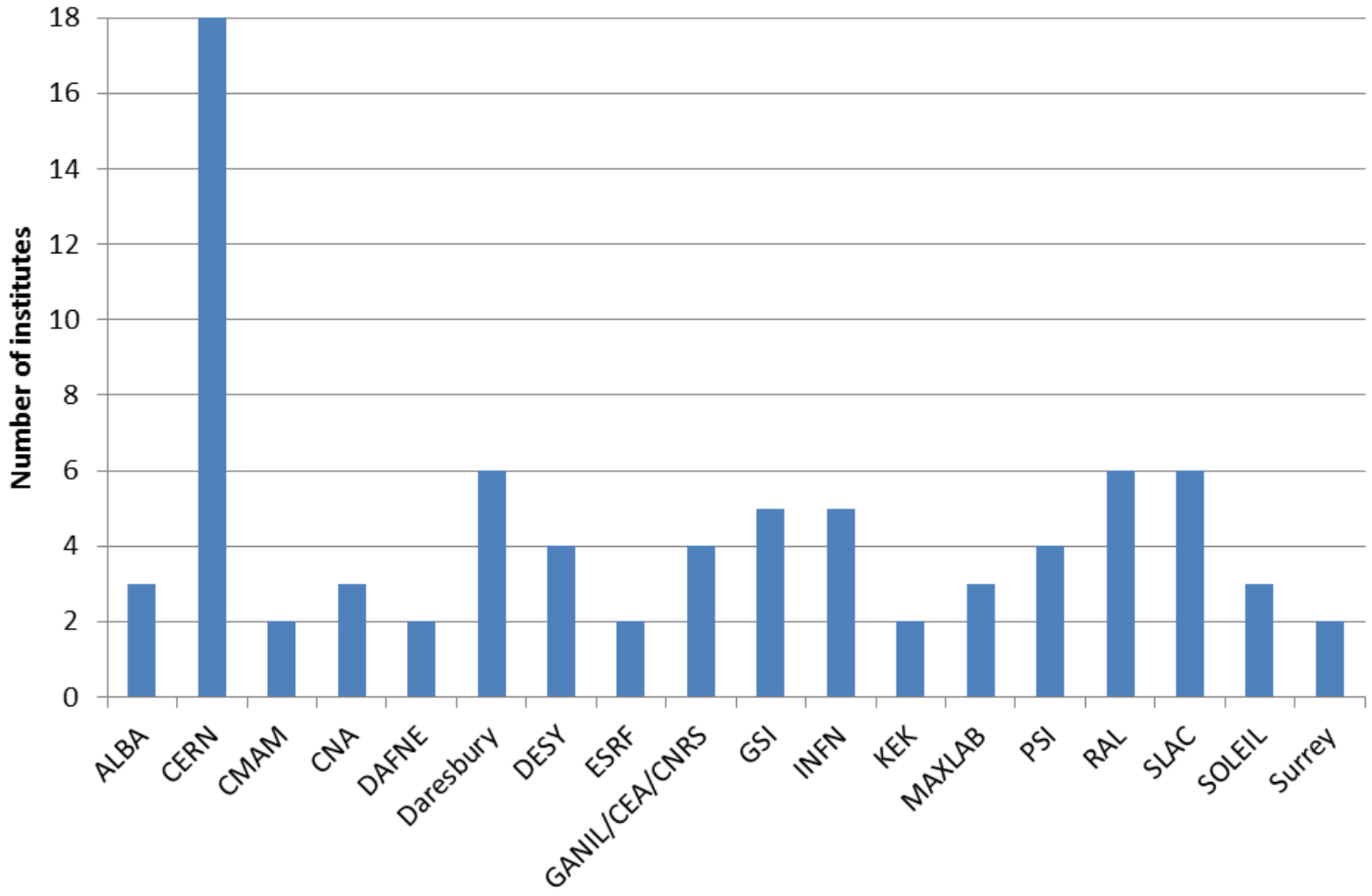
Accelerator school attendance

- **83 institutes send people to accelerator schools: 339 people (2011)**



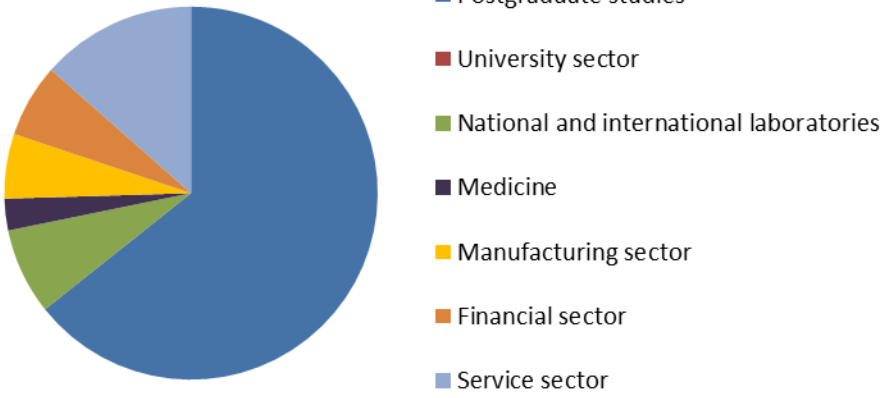
Use of facilities for training

- **59 institutes reported using 51 facilities**

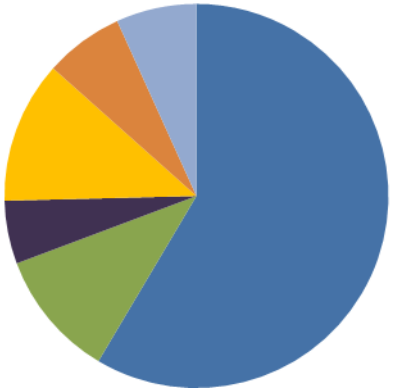


Career destinations

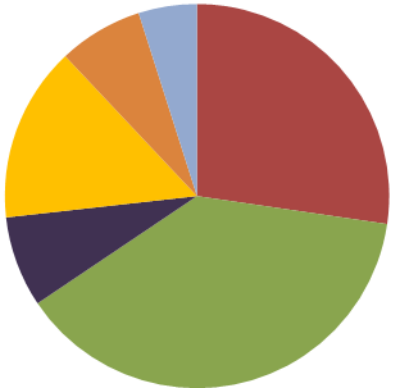
Undergraduates



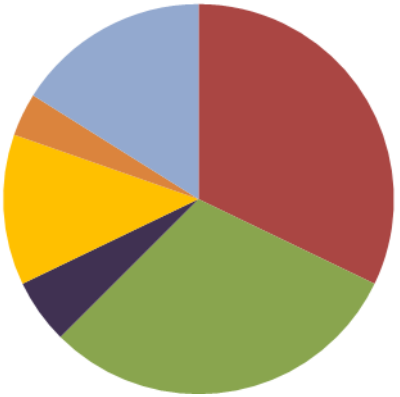
Master's-level students



PhD students



Post-doctoral fellows



Training survey conclusions

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- 11 institutes provide > 100 hours to Master's stud
- 83 institutes send people to accelerator schools:

  339 people (2011)
- At each educational stage, about 1/3 of trainees go to industry, finance, medicine …

Survey of ‘needs’ for personnel

Markets surveyed

- **Major laboratories:**

  CERN, DESY, GSI, INFN, STFC, CEA, CNRS, CIEMAT …

- **Universities**

- **Large projects/facilities:**

  XFEL, FAIR, ESS, MaxIV, SuperB, IFMIF …

- **Companies**

- **Medical facilities:**

  X-ray and hadron therapy, isotope production …

Issues investigated

- How many accelerator personnel required?
- Of what type? physicist, engineer, technician …
- At what qualification level? PhD, master's, bachelor's …
- Dedicated training of staff required?
- Issues of recruitment/access?
- Areas of key skills shortages?

Survey responses

- **70 research institutes**

  accelerator-related personnel 3638

- **44 companies**

  accelerator-related personnel 993

  ‘patchy’ response

  company data ‘anonymised’

  nevertheless some conclusions can be drawn

- **X-ray and hadron therapy facilities**

Accelerator personnel

	Research institutes	№ staff	Companies	№ staff
France	16	562	2[1]	87
Germany	5	809	1	10
Italy	12	412	10	95
Nordic countries	10	142	1	90
Poland	2	64	1	504
Spain	9	161	27	137
Switzerland	2	1247	1	45
United Kingdom	16	242	1	25
Total	70	3638	44	993

Table 1. Number of responding research institutes and companies by country

‘Needs for accelerator scientists’ report

http://cds.cern.ch/record/1521336/files/TIARA-REP-WP5-2013-005.pdf

Test Infrastructure and Accelerator Research Area

TIARA WP5
Deliverable 5.3 - ASR
Needs for Accelerator Scientists Report

27 February 2013

*François Kircher, Phu-Anh-Phi Nghiem, Celine Tanguy, **CEA, France***

*Roger Bailey, Louis Rinolfi, **CERN, Switzerland***

*M. Luisa Marco Arboli **(WP Deputy)**, Susana Falcon, Diego Obradors, **CIEMAT, Spain***

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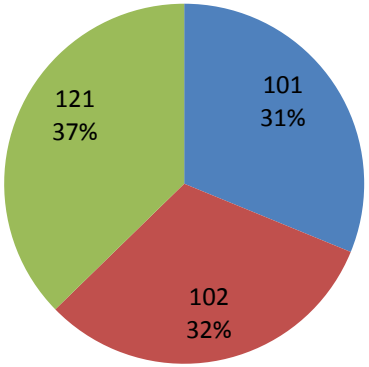
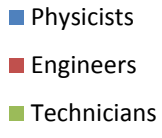
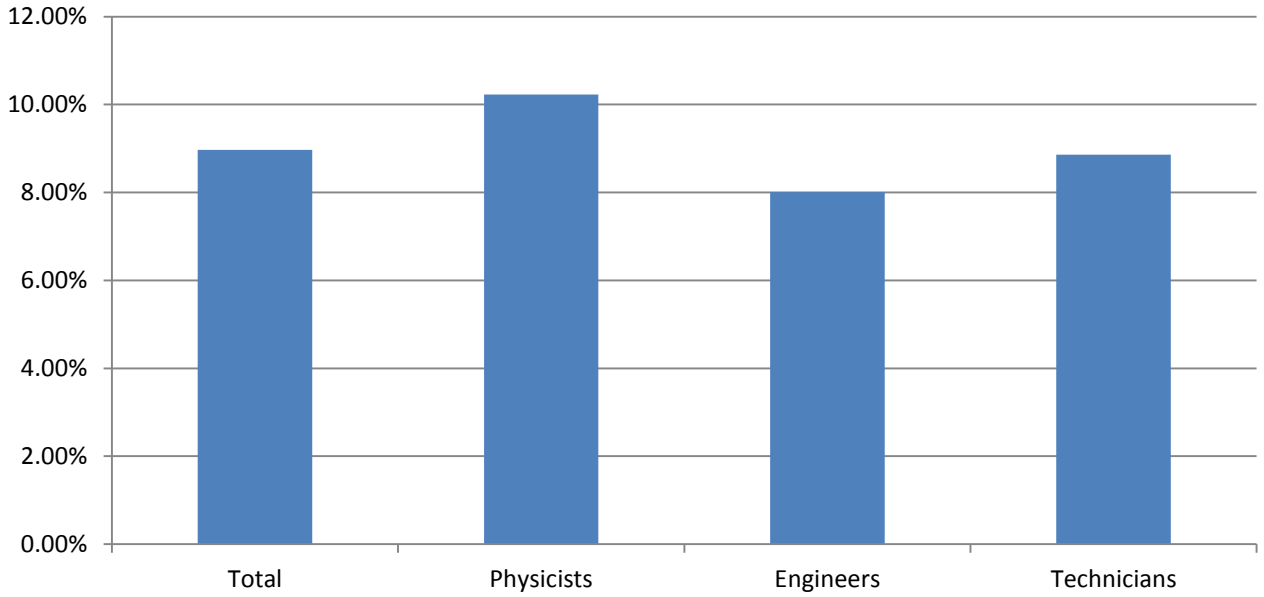
Content

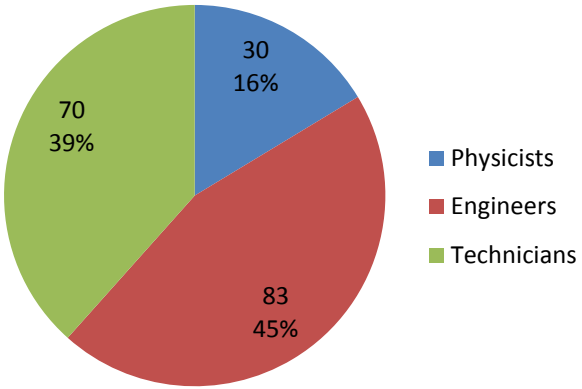
Recruitment: institutes

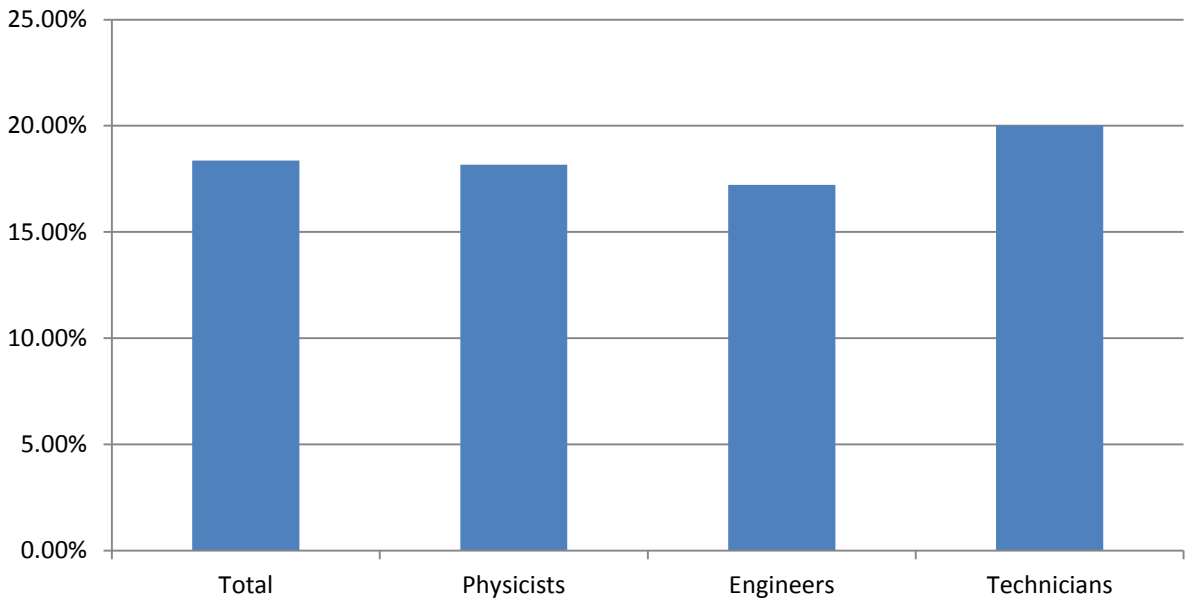




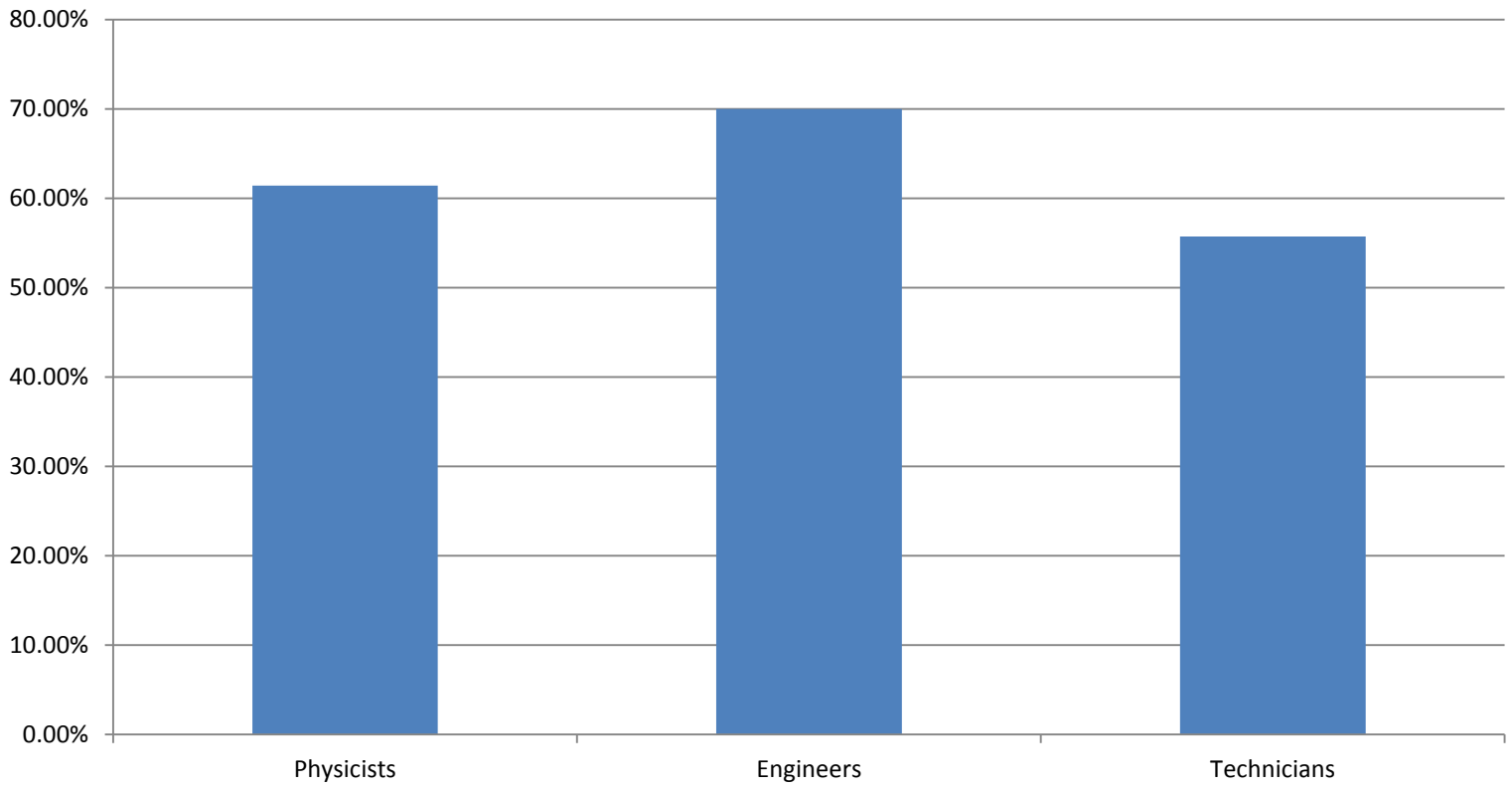


Recruitment: companies





Recruitment difficulty: institutes



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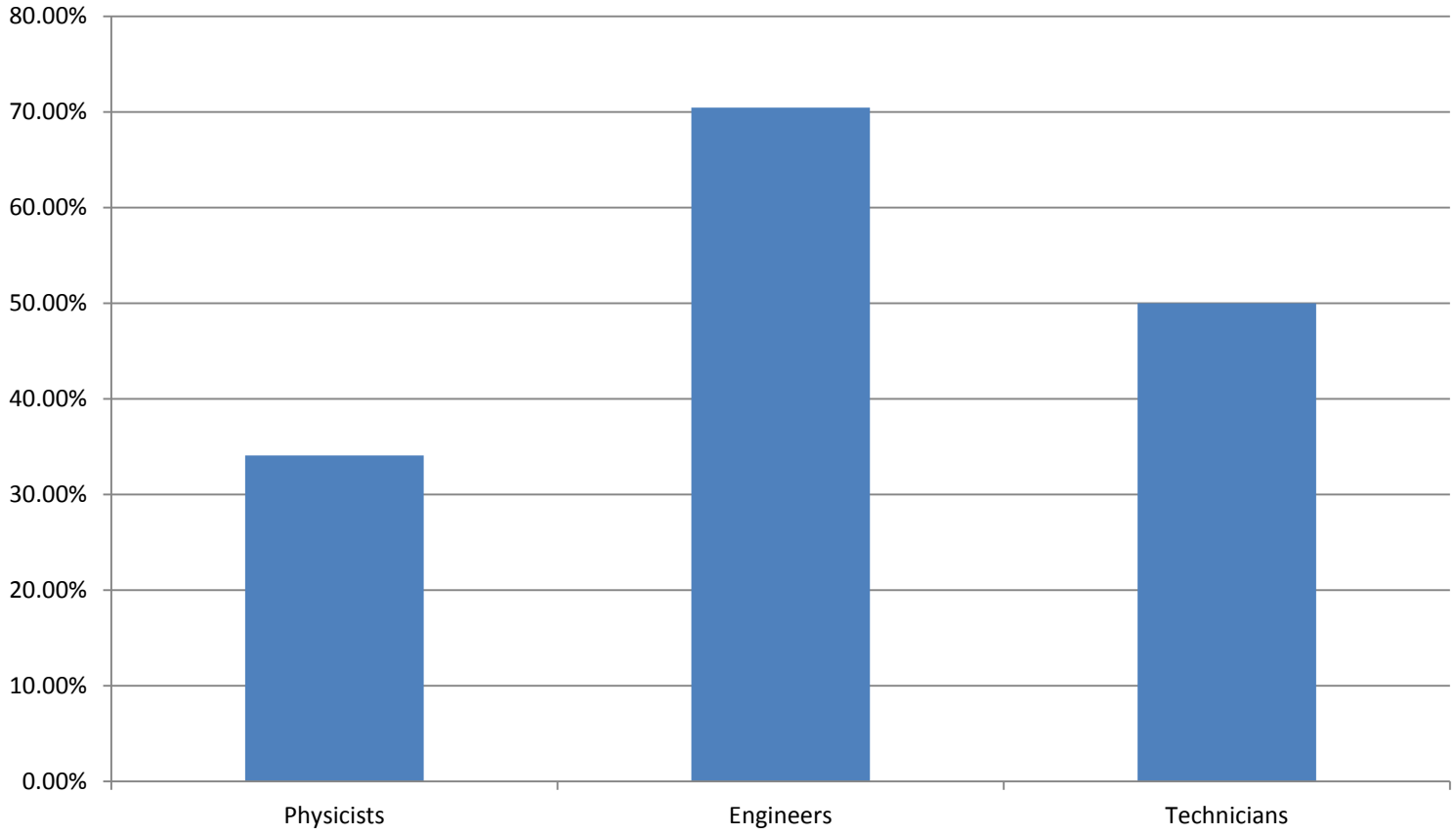
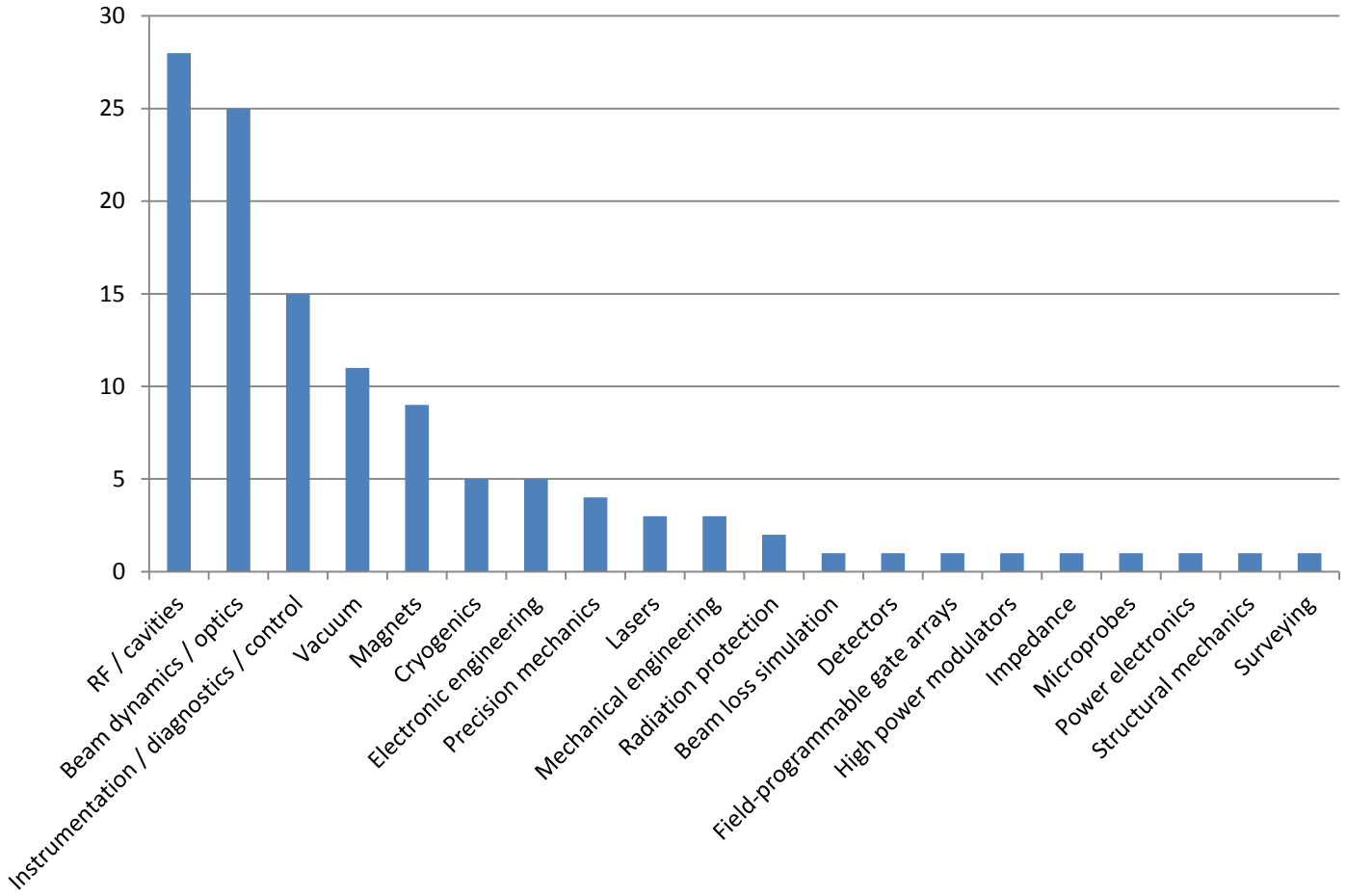


Skills shortages: institutes



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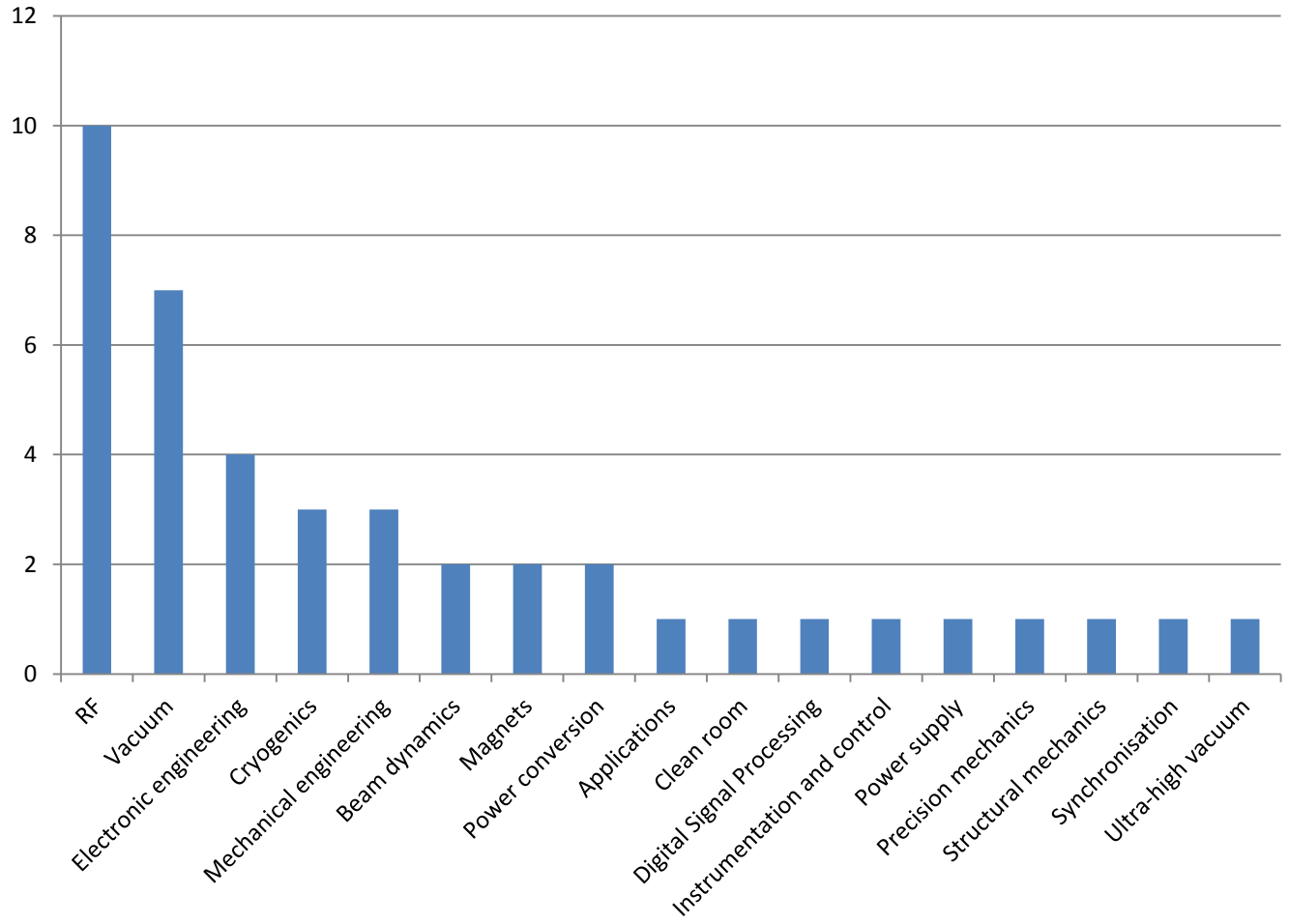

Medical facilities

- **Europe:**
  - **5000 physicists and engineers working in 'medical physics' (EFOMP)**
  - **> 200 PET cyclotrons in EU**
- **UK: 700 physicists in 54 radiotherapy depts.**
- **Vast majority of systems are turn-key**

→ Not obvious how many accelerator personnel

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- **Hadron therapy in Europe (PTCOG):**
  - **12 operating centres: 10-15 accel. staff each**
  - **+9 in construction, +2 UK**

→ Doubling of trained personnel within 5-10 years?

Market survey conclusions

- **Projected growth in personnel 18-20% in 5 years:**
  Germany (+24%), Italy (+55%), Nordic (+68%);
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- **Difficulties in recruiting trained personnel, especially engineers (70%)**
- **Skills shortages: RF, vacuum, beam dynamics, instrumentation + controls …**
- **Training: 94% institutes, 75% of companies; significant need (c. 60%) for external training**

Recommendations

- **Improving supply of trained personnel**
- **Improving access to opportunities for personnel**
- **Improving external access to trained personnel**
- **Promoting accelerator science in society**

Final TIARA WP5 report

https://cds.cern.ch/record/1627600

Test Infrastructure and Accelerator Research Area

TIARA WP5
Deliverable 5.4
Recommendations for promoting accelerator science and technology in Europe

7 November 2013

François Kircher, Phu-Anh-Phi Nghiem, Celine Tanguy, ***CEA, France***

Roger Bailey, Louis Rinolfi, ***CERN, Switzerland***

*M. Luisa Marco Arboli (****WP Deputy****), Susana Falcon, Diego Obradors,* ***CIEMAT, Spain***

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Content

	Proposal	Estimate of resources needed	Unit cost (Euro)	Number of units
Undergraduate-level training	1. 'e-learning' course, 'Introduction to Accelerator Science and Technology'.	12 months (course setup) + 5 months per annum thereafter (centralised course monitoring and support) + IT infrastructure (server, software tools etc.).	N/A	
	2. Internships at 'local', or an international, accelerator laboratory.	150,000 Euro + 3 person months, per annum.	Intern month 1,500	100
Master's-level training	3. Bursary support to attend established international and national accelerator schools.	100,000 Euro + 2 person-months, per annum.	Bursary 2,000	50
	4. European Master's fellowship scheme.	200,000 Euro (year 1), 400,000 Euro (year 2 and per annum thereafter) + 2 person months per annum.	Fellowship 20,000 Euro	10
	5. Internships for project work in support of a thesis.	300,000 Euro + 3 person months, per annum.	Intern month 1,000	300
PhD-level training	6. Bursary support to attend established international and national accelerator schools.	100,000 Euro + 2 person-months, per annum.	Bursary 2,000	50
	7. European PhD fellowship scheme.	250,000 Euro (year 1), 500,000 Euro (year 2), 750,000 Euro (year 3 and per annum thereafter) + 2 person months per annum.	Fellowship 25,000	10
Structural support	9. Enhanced accelerator schools provision.	100,000 Euro + 1 person-month, per annum.	N/A	
	10. www-portal	6 months (course setup) + 2 months per annum thereafter (centralised course monitoring and support) + IT infrastructure (server, software tools etc.).		
Outreach	11. Outreach support	1 MEuro per annum	Per country 100,000	10

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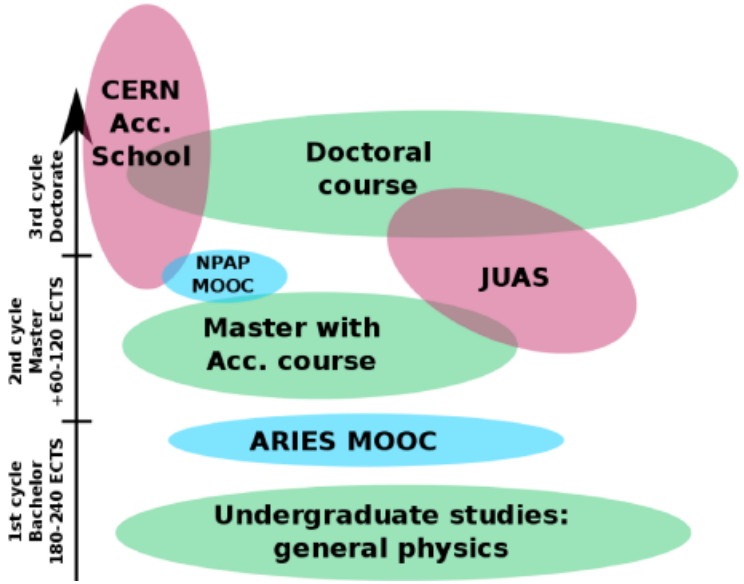
	2. Internships at 'local', or an international, accelerator laboratory.	150,000 Euro + 3 person months, per annum.	Intern month 1,500	100
Master's-level training	3. Bursary support to attend established international and national accelerator schools.	100,000 Euro + 2 person-months, per annum.	Bursary 2,000	50
	4. European Master's fellowship scheme.	200,000 Euro (year 1), 400,000 Euro (year 2 and per annum thereafter) + 2 person months per annum.	Fellowship 20,000 Euro	10
	5. Internships for project work in support of a thesis.	300,000 Euro + 3 person months, per annum.	Intern month 1,000	300
PhD-level training	6. Bursary support to attend established international and national accelerator schools.	100,000 Euro + 2 person-months, per annum.	Bursary 2,000	50
	7. European PhD fellowship scheme.	250,000 Euro (year 1), 500,000 Euro (year 2), 750,000 Euro (year 3 and per annum thereafter) + 2 person months per annum.	Fellowship 25,000	10
Structural support	9. Enhanced accelerator schools provision.	100,000 Euro + 1 person-month, per annum.	N/A	
	10. www-portal	6 months (course setup) + 2 months per annum thereafter (centralised course monitoring and support) + IT infrastructure (server, software tools etc.).		
Outreach	11. Outreach support	1 MEuro per annum	Per country 100,000	10

ARIES WP2: e-learning initiative ('MOOC')

Accelerator Research and Innovation for European Science and Society

- This Massive Open Online Course aims at raising awareness on Accelerator Science and Technology among University students.
- Complementary to JUAS, CAS and University courses.
- It is organised in 2 modules:
  - an introductory module
    4 topics of 1 hours each
  - an advanced module
    6 topics of 1 hours each

Also eg. Nordic MOOC



ARIES MOOC Status (21/4/21)

- **Introductory module**
  - Introduction (Philippe Lebrun):

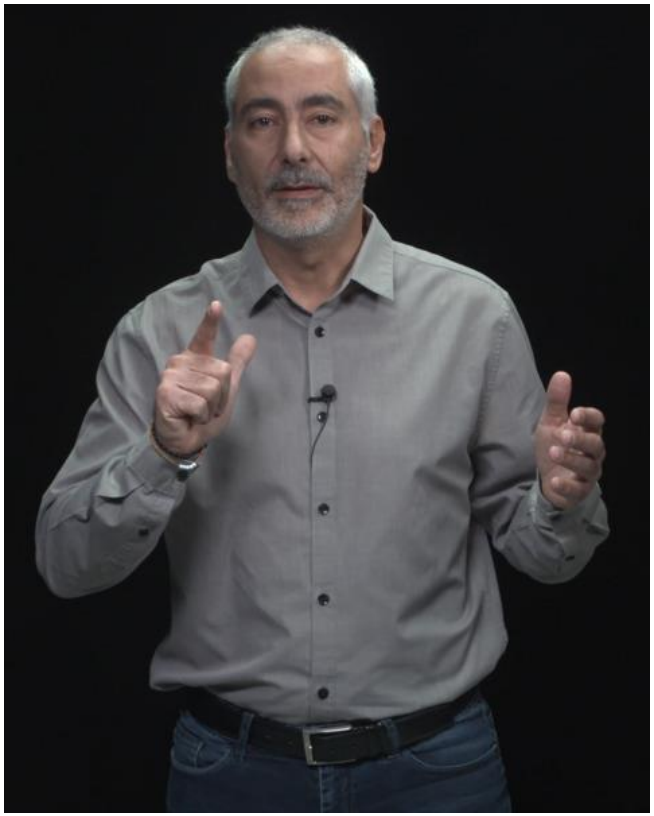
    Almost ready for recording
  - Electromagnetism (Vittorio Vaccaro):

    Recording almost complete, some extra audio to be done
  - Relativity (Elias Metral): **Complete**
  - Applications (Angeles Faus-Golfe):

    Planning for recording
- **Advanced module**
  - RF (Graeme Burt):

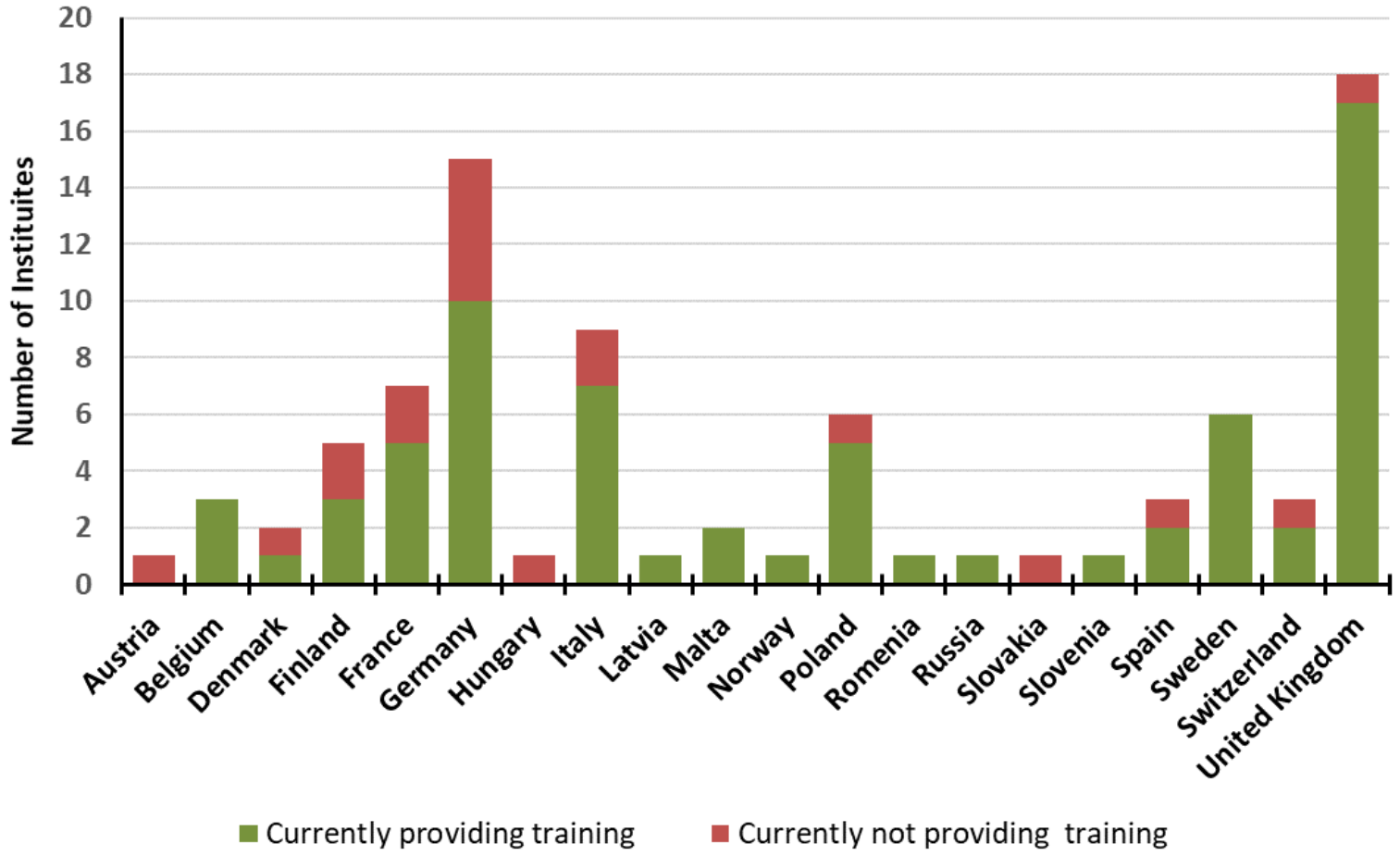
    Final meeting before recording (23rd April)

Screenshots from the Relativity module



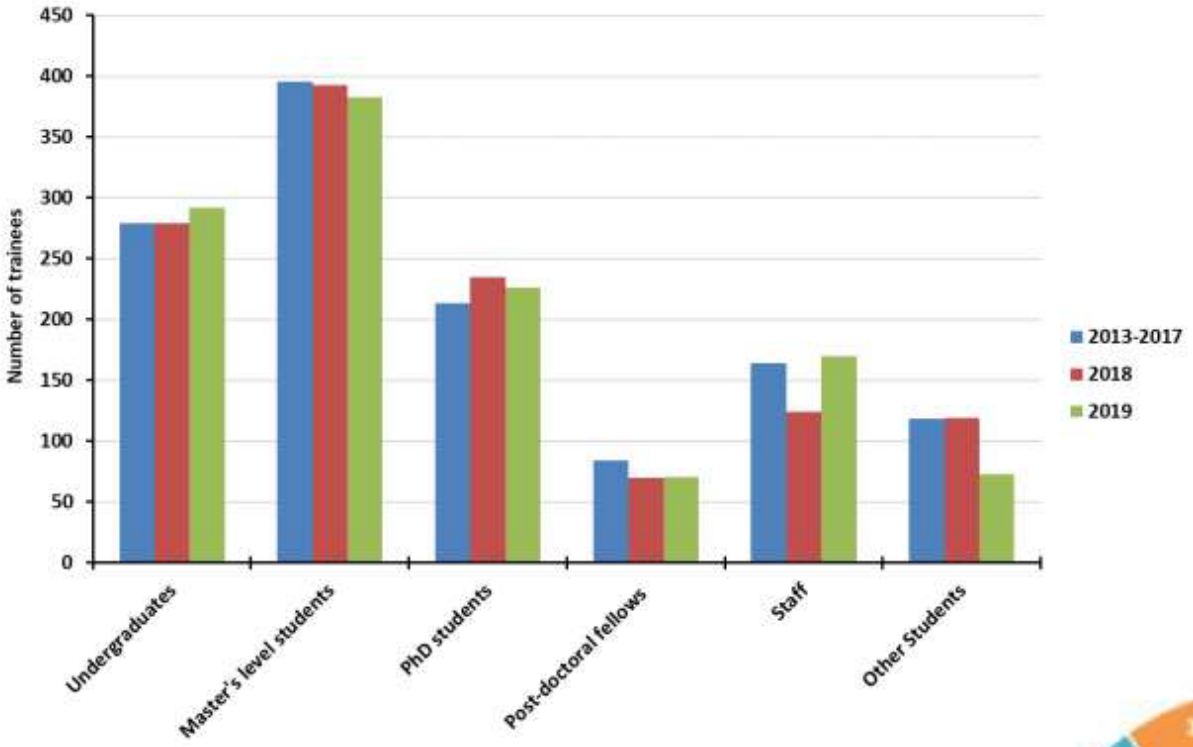
http://particle-accelerators.eu/mooc-preview/

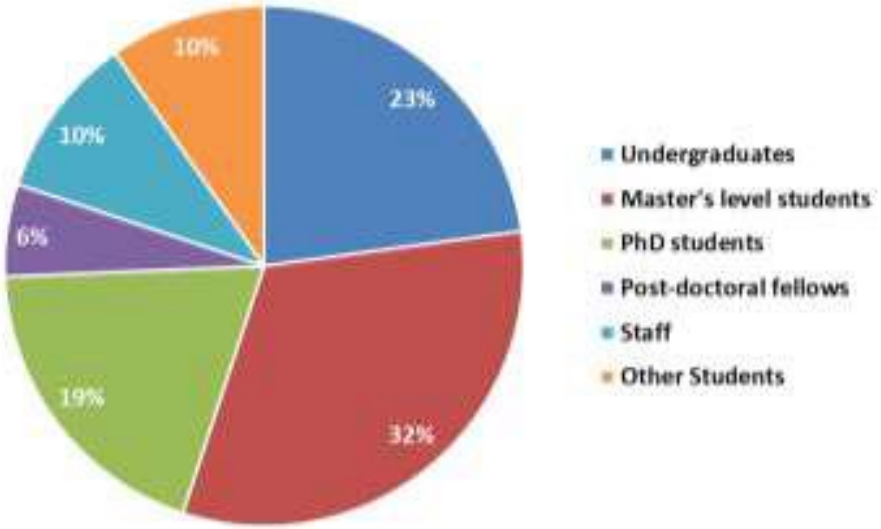
ARIES WP2: training survey updated in 2020



Extended to 20 countries

2011 survey conclusions validated in 2020





iFAST starts 1/5/21: Innovation Fostering in Accelerator Science & Technology

- WP2 (PNB): Training, Communications & Outreach
- Task 2.3 (Nicolas Delerue et al):

  'Challenge-based innovation' with particle accelerators

- Task 2.4 (Tord Ekelof et al):

  Industrial Training with Knowledge Transfer

  → internships at accelerator labs for early-career technicians and engineers at companies

Imperial College London

ROYAL HOLLOWAY UNIVERSITY OF LONDON

UNIVERSITY OF OXFORD

Conclusions

- Coordination and improvement of training at a European level has received serious attention within accelerator community > 10 years
- Superb training provided via universities, labs, accelerator schools …
- EU projects TIARA, ARIES, iFAST provide framework for:
  - understanding ‘where we are’
  - identifying areas needing improvement
  - sharing of best practices + resources
  - promoting training opportunities within community
  - stimulating new initiatives (MOOC, CBI, internships)
- Areas of skills shortage (eg. engineering, RF technology …)
- Much more could be done if resources were available