TIARA WP5

Philip Burrows

John Adams Institute for Accelerator Science

Oxford University

Developing education and training for Accelerator Science in Europe

… development of structures and mechanisms that allow efficient education and training of human resources and facilitate their exchange among the partner facilities.

WP5: outline

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

WP5: deliverables

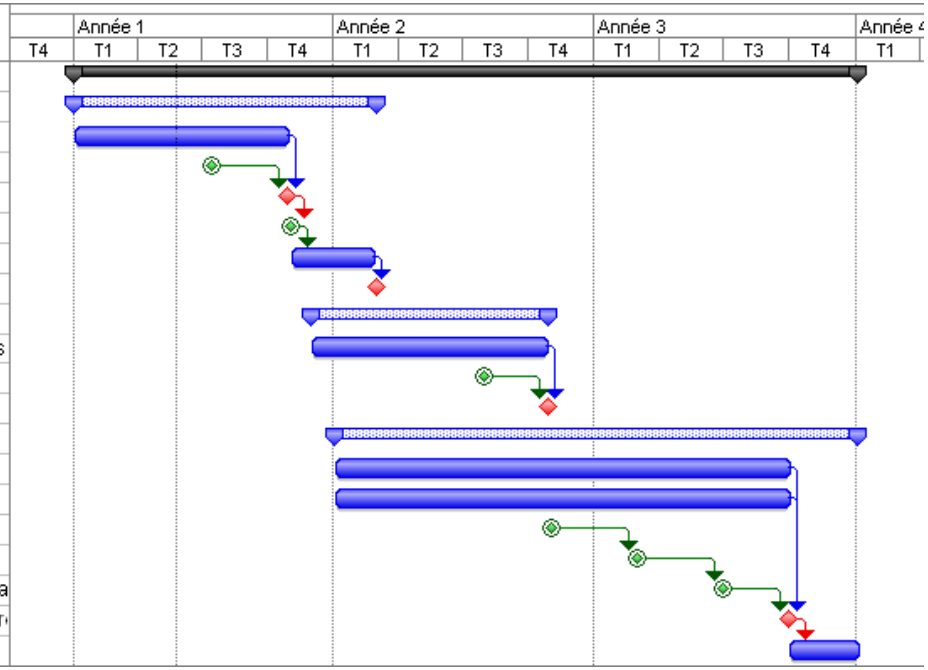
	month
D5.1 Education and training survey report (ETR)	10
D5.2 Education and training resources database (ETD)	14
D5.3 Needs for accelerator scientists report (ASR)	22
D5.4 Recommendations for promoting Accelerator Science and Technology in Europe report (PAR)	33

WP5: milestones

MS19: meeting to plan ETR report	**7**
D5.1 Education and training survey report (ETR)	***10***
MS20: meeting to plan ETD database	**11**
D5.2 Education and training resources database (ETD)	***14***
MS21: meeting to plan ASR report	**19**
MS22: Interim report for input to WP2.2.4	**20**
D5.3 Needs for accelerator scientists report (ASR)	***22***
MS23: Meeting with WPs 3 and 4	**26**
MS24: Meeting to plan report	**30**
D5.4 Recommendations for promoting Accelerator Science + Technology in Europe report (PAR)	***33***

WP5: work flow

N°	WBS	Task Name
1	**5**	**WP5: Education and Training for Accelerator Sciences**
2	**5.1**	**5.1 SAS: Survey of Accelerator Science**
3	5.1.1	5.1.1 SASS: Survey of Students, Courses and Teaching Resources
4	M5.1	M5.1 METR: Meeting to Plan Education and Training Survey Report (ETR)
5	**D5.1**	**D5.1 ETR: Education and Training Survey Report**
6	M5.2	M5.2 METD: Meeting to Plan Education and Training resources Database
7	5.1.2	5.1.2 SASD: Development of Education and Training Resources Database
8	**D1.2**	**D5.2 ETD: Education and Training Resources Database**
9	**5.2**	**5.2 MAS: Market for Accelerator Science**
10	5.2.1	5.2.1: Evaluation and study of the Development of the Market for Accelerator Sciences
11	M5.3	M5.3 MASR: Meeting to plan for Accelerator Scientist Report
12	**D5.3**	**D5.3 ASR: Accelerator Scientist Report**
13	**5.3**	**5.3 PAS: Plan for Promoting Accelerator Sciences**
14	5.3.1	5.3.1 DAS: Development of the Academic Sector
15	5.3.2	5.3.2 TEK: Training and Exchange of Knowledge
16	M5.4	M5.4 MIRW: interim report for input to WP2.2.4
17	M5.5	M5.5 MMWP: Meeting with WP4 and WP6
18	M5.6	M5.6 MPAR: Meeting to plan the Report on Recommendations for Promoting Accelera
19	**D5.4**	**D5.4 PAR: Report on Recommendations for Promoting AcceleratorSciences in Eur**
20	5.3.3	5.3.3 CFTR: Contribution to the Final TIARA-PP Report



WP5 participants / contacts

1	CEA:	Francois Kircher
2	CERN:	Daniel Brandt, Naomi Gilraen Wyles (EUCARD), Louis Rinolfi (JUAS)
3	CNRS:	Alex Muller, Bernard Laune
4	CIEMAT:	Marisa Marco, Diego Obrador, Susanna Falcon
6	GSI:	Oliver Boine-Frankenheim
7	INFN:	Vittorio Vaccaro
8	PSI:	Lenny Rivkin
9	STFC:	Philip Burrows *
10	Nordic group:	Soren Pape Moeller + Ole Petter Nordahl
11	IFJ:	Piotr Malecki

Kick-off meeting: participants

1	CEA:	Francois Kircher
2	CERN:	Daniel Brandt, Naomi Gilraen Wyles (EUCARD), Louis Rinolfi (JUAS)
3	CNRS:	Alex Muller, Bernard Laune
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WP5 kick-off meeting aims

- **Each participant to come with 'snapshot' of student types + numbers, known courses, teaching resources etc. in his/her region / institute / lab …**
- **… plus any *relevant* information from outside Europe ***
- **Will digest + collate information**
- **Discuss template for gathering further information, and for eventual use in the www database**

*** We feel that taking account of 'worldwide' information will be helpful, but we are not proposing a global survey!**

Kick-off meeting: agenda

- **Reminder of scope and purpose – PNB**
- **Reports from labs / countries / regions:**

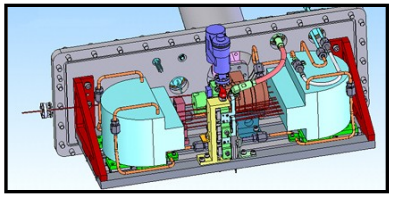
UK	PNB
Poland	Piotr Malecki
Spain	Diego Obradors
Nordic group	Soren Pape Moller, Ole Petter Nordahl
Switzerland	Lenny Rivkin
Italy	Vittorio Vaccaro
France	Francois Kircher
CAS	Daniel Brandt
JUAS	Louis Rinolfi
IN2P3	Bernard Laune (for Alex Mueller)
EUCARD	Naomi Wyles

Spain (Marco, Obradors)

Tandem 5MV (Crockcroft-Walton).

Tandem 3MV (Peletron), and 1MV (Crockcoft-Walton)

Synchrotron Light Facility, 3GeV



Microtron, 6,8,10,12 MeV.

Poyect: Linac 50 MeV, H^+,H^-

Spain (Marco, Obradors)

1. Undergraduate: → **Subjects:**

- ✓ *Synchrotron engineer:* ~20 Students, 20 hours, UPC
- ✓ *Working and application of particles accelerator:* ~25 Students, 60 hours, UPC

2. Master:

- ✓ *Synchrotron radiation and particles accelerator:* ~ 9 students, 60 ECTS, UPC, UAB, UB, ALBA CELLS.
- ✓ *R&D of industrial technology:* ~36 students, 60 ECTS, UNED → **Subjects:**
  - ✓ *Security and environment impact of nuclear fusion facilities.*
  - ✓ *Technologies for nuclear waste management and disposal.*
- ✓ *Nuclear engineering:* ~ 25 students, 60 ECTS, CIEMAT-UAM → **Subjects:** ✓ *Particle accelerators*
- ✓ *Physics engineering:* ~Next year, ESS Bilbao -UPV/EHU → **Subjects:**
  - ✓ *Control and instrumentation for p.a.*
  - ✓ *Components and power systems for p.a.*
  - ✓ *Neutron techniques.*
  - ✓ *Industrial, medical and research facilities.*
  - ✓ *Radiological protection.*

3. PhD: →

Institution	CIEMAT	IFIC	UNED	UPC	ESS Bilbao	ALBA
Number of PhD	**5**	**4**	**3**	**3**	**7**	*

Italy (Vaccaro)

University courses

Universit y	Faculty-School	ECTS	
Napoli	Scienze Fisiche	8	
Napoli	Medical Physics School	8	
Roma	Ingegneria Elettronica	6	JUAS
Milano	Scienze Fisiche		
Catania	Scienze Fisiche		
Padova	Scienze Fisiche		

Attendance to CERN Accelerator School: Standard Courses

Where, when, what	IT/Total
BADEN 2004 (Introductory Accelrator Physics)	4/94?
TRIESTE 2005 (Intermediate Accelrator Physics)	6/73?
ZAKOPANE 2006 (Introductory Accelrator Physics)	10/113
DARESBURY 2007 (Intermediate Accelrator Physics)	15/80
FRASCATI 2008 (Introductory Accelrator Physics)	19/115
DARMSTADT 2009 (Intermediate Accelrator Physics)	6/68
VARNA 2010 (Introductory Accelrator Physics)	16/109

Philip Burrows

Denmark + Sweden (Pape Moller)

- At Aarhus University, ~15 students attend the course mentioned below. Very few write their master thesis in Accelerator Physics (2/10 years).

- Every 3 years PhD student over 10 years in Accelerator Physics/Industrial PhD (Technical Physics)

- **Lund University**

- **Intro to Accelerators and FEL**
- Accelerators are an important tool for research in many disciplines of natural sciences and for applications in medicine and industry. In this course we will focus on the basic technology of accelerators.
  MAXM07, 7.5 ECTS credits Course information...

- **Accelerator technique**
- Electromagnetic fields, particle sources, accelerator types, vacuum, basic physics, magnetic elements, synchrotron radiation.
  MAXM03, 7,5 ECTS credits Course information...

- I guess ~1masters or PhD students graduating annually

Norway (Nordahl)

- Number of students
  - 5 doctoral students spending most of their time at CERN
  - 1 post-doc (SLAC)

- Courses
  - No dedicated courses in accelerator science.
  - Accelerator science is part of particle physics course at University of Oslo and University of Bergen

Switzerland (Rivkin)

Semester projects (2 – 3), Masters (2 – 3), PhDs

CERN (16 doctoral students at EPFL)

- LHC and its upgrades, injectors
- future linear colliders R&D
- beta beams
- Hadron therapy

PSI (several postdocs, a few doctoral students)

- SwissFEL: future X-Ray Free Electron Laser
- Swiss Light Source (SLS)
- neutrons, muons beams
- cancer proton therapy

France (Kircher)

Enseignement de la physique des accélérateurs en région Parisienne *Historique*

Diplôme d'Etudes Approfondies

Physique et Technologie des Grands Instruments

Université Paris 6, Paris 7, Paris 11, Versailles Saint Quentin en Yvelines, Ecole Polytechnique

1985 – 2004

Formation de 257 étudiants
204 étudiants ont poursuivi par une thèse

Les Débouchés:

➢ *1985-1999*: 144 thèses

- Un tiers travaille dans le secteur public: enseignement supérieur (11), CNRS (15), CEA (24),
- Dans les organismes nationaux et internationaux: GANIL (1), SOLEIL (7), CERN (3), ESRF (2)
- Secteur industriel (Ingénieur)
- Laboratoires étrangers : USA, UK, Espagne, Suisse.

France (Kircher)

Enseignement de la physique des accélérateurs en région Parisienne *Historique*

2006 – 2009: Situation du parcours **PT.G.I.**

- 2006 – 2007 : **4** étudiants dans le parcours «**P.T.G.I.**» et **2** étudiants en **M.I.P.**
- 2007 – 2008 : **2** étudiants dans le parcours «**P.T.G.I.**» et **4** étudiants en **M.I.P.**
- 2008 – 2009 : **4** étudiants dans le parcours «**P.T.G.I.**» et **0** étudiants en **M.I.P.**
- 2009 – 2010 : **0** étudiants dans le parcours «**P.T.G.I.**» et **6** étudiants en **M.I.P.**

- La discipline des grands instruments n'attire plus autant d'étudiants
- Des sujets de thèse ne trouvent plus preneurs

Poland (Malecki)

CRACOW – (INP PAN, AGH, CUT)

~ 50 specialists in acc. construction (LHC, XFEL, Stellarator, ... SPIRA2, SuperB ...)

Hadron therapy (60 MeV cyclotron, melanoma treatment just started, CCB 250 MeV 2011-2013, gantry, mostly medical appl. , research, material studies, irradiation tests ...

Dosimetry – "patent" TLD – ALFA S.S., CERN ...

Electronics, control systems, mechanical design

Accelerator science ?

WARSAW – (IPJ, WUT)

outstanding individuals (HG structures ...)

Design and construction of small linear acc. - medical, food ind. ...

Electronics, control systems

WROCŁAW – (PWR)

Cryogenics

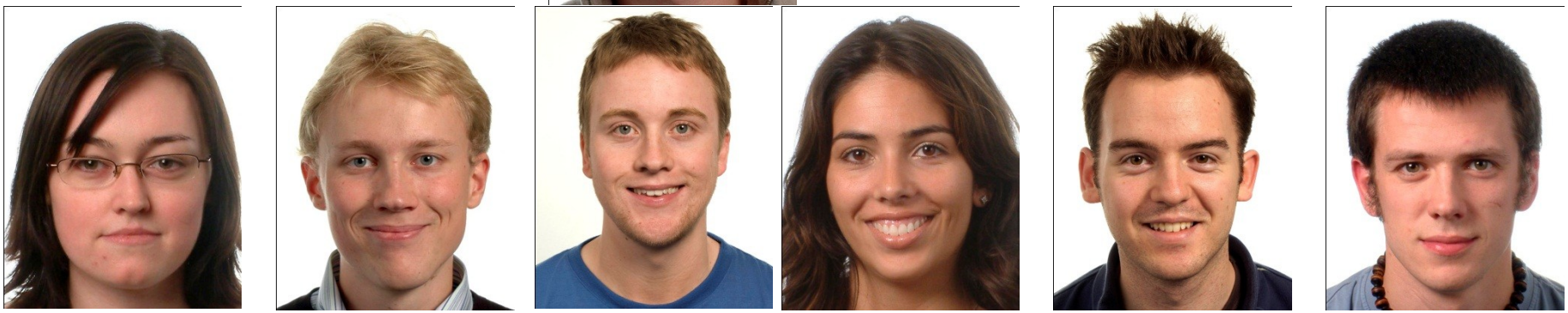
Industrial partners - ("Poland at CERN", liaison officer)

ŁÓDŹ – (TUL)

Electronics, mechatronics, control systems

UK PhD Students (PNB)

c. 12 students/year



UK Teaching (JAI example)

First year of PhD programme, courses in:

- **Accelerator physics:** **Ted Wilson + Riccardo Bartolini**
- **Hamiltonian dynamics:** **Chris Warsop**
- **Specialist lectures in magnets, RF …**
- **Accelerator applications:** **(Diamond, ISIS, CERN, medical)**
- **Design study project as a team:**

  eg. Diamond booster, CLIC damping ring …

JUAS (Rinolfi)

12 European Universities	Member of Advisory Committee	Since
Université Joseph Fourier Grenoble	François Montanet	1994
Technische Universität Darmstädt	Joachim Enders	1994
Universität Karlshure	Anke Suzanne Müller	1994
Universitat Politècnica de Catalunya	Francisco Calviño	1994
Universitat Autonoma de Barcelona	Antoni Mendez	1994
Institut Polytechnique de Grenoble	Elsa Merle-Lucotte	1994
Università degli studi di Napoli “Federico II”	Vittorio Vaccaro	1994
Università degli studi di Roma “La Sapienza”	Luigi Palumbo	1994
Università degli studi di Genova	Marco Bozzo	2002
Technische Universität Berlin	Heino Henke	2002
Universitat de Valencia	Angeles Faus-Golfe	2002
Universität Heidelberg	Carsten Welsch	2007

JUAS 2011 week 2	Monday 10 Jan.	Tuesday 11 Jan.	Wednesday 12 Jan.	Thursday 13 Jan.	Friday 14 Jan.	JUAS 2011 week 2
9:00	Transverse Dynamics B. Holzer	Longitudinal Dynamics E. Métral	Longitudinal Dynamics E. Métral	Longitudinal Dynamics E. Métral	Longitudinal Dynamics E. Métral	9:00
9:50	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	9:50
10:15	Transverse Dynamics Dynamics B. Holzer	Transverse Dynamics Guided studies B. Holzer & R. Alemany	Longitudinal Dynamics E. Métral	Longitudinal Dynamics Guided studies E. Métral	Longitudinal Dynamics Tutorial E. Métral	10:15
11:05						11:05
11:10	Longitudinal Dynamics E. Métral	Transverse Dynamics Tutorial B. Holzer & R. Alemany	Transverse Dynamics B. Holzer	Longitudinal Dynamics Guided studies E. Métral	Longitudinal Dynamics E. Métral	11:10
12:00	LUNCH BOX	LUNCH	LUNCH	LUNCH	LUNCH	12:00
	Departure 12:10:00	Transverse Dynamics B. Holzer	MADX tutorial	MADX tutorial	MADX tutorial	
15:00	VISIT OF ESRF	Transverse Dynamics Guided studies B. Holzer & R. Alemany	Transverse Dynamics Guided studies B. Holzer & R. Alemany	Transverse Dynamics Tutorial B. Holzer & R. Alemany	Longitudinal Dynamics Guided studies E. Métral	15:00
15:50		Coffee break	Coffee break	Coffee break	Coffee break	15:50
16:10		INTRODUCTION TO MADX G. Sterbini	Transverse Dynamics Guided studies B. Holzer & R. Alemany	Transverse Dynamics Dynamics B. Holzer	Longitudinal Dynamics Guided studies E. Métral	16:10
17:00	Return 18:00:00					17:00

Course 1

Accelerator Physics is composed of 5 weeks

Course 2

Accelerator Technology is composed of 5 weeks

← **Example**

Week 2 in the 2011 Time Table

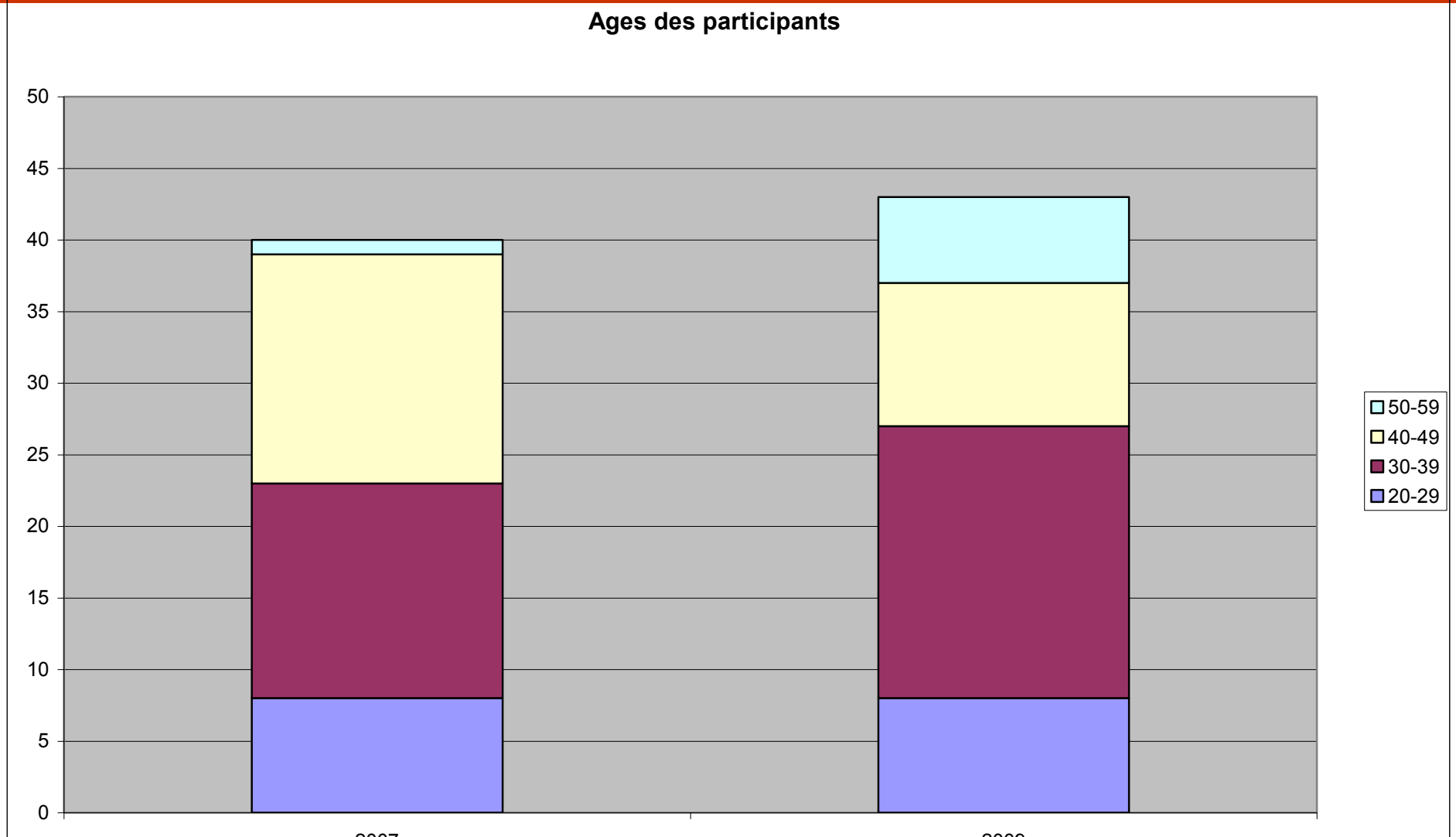
CAS (Brandt)

- Started 1983
- Introductory, intermediate + specialised courses
- Typically > 100 / 80 participants introductory / intermediate
- Approx. 25 nationalities attending
- 5% undergraduate / 85% PhD-level / 10% professional
- Industry interest in specialised courses (eg. vacuum)

IN2P3 school (Laune/Mueller)

	Ecole 2002		Ecole 2003		Ecole 2007		Ecole 2009	
	Intervenant	Durée	Intervenant	Durée	Intervenant	Durée	Intervenant	Durée
Utilité des accélérateurs et généralites	Alex Mueller	4h	Alex Mueller	4h	Alex Mueller	4h	Alex Mueller	3h
Types d'accélérateurs et applications	Joël Le Duff	7h	Joël Le Duff	4h	Eric Baron	4h	Fabian Zomer	4h
Optique faisceaux	Jean-Marie De Conto	3h	Jean-Marie De Conto	3h	Jean-Marie De Conto	3h	Jean-Marie De Conto	2h
Magnétisme et aimants	Antoine Dael	2h	Antoine Dael	2h30	Antoine Dael	2h	Antoine Dael	3h
TD Optique et aimants	De Conto + Dael	2 h	De Conto + Dael	2h30	De Conto + Dael	1h30		
Vide	Nelly Rouvière	2h	Nelly Rouvière	1h30	Patrick Dolegieviez	1h	Patrick Dolegieviez	2h
Sources	Joël Arianer	2h	Joël Arianer	1h	Joël Arianer	2h	Monard + Pottin	2h
TD Vide et sources	Rouvière + Arianer	1h30	Rouvière + Arianer	2h30	Arianer + Dolegieviez	1h40		
Systèmes et mesures RF	Claude Bieth	2h	Patrick Ausset	1h	Gérard Bienvenu	3h	Jean Lesrel	2h
Cavités froides et chaudes	Jean-Luc Biarrotte	2h	Le Duff + Biarrotte	3h	Jean-Luc Biarrotte	2h30	Jean-Luc Biarrotte	3h
Diagnostics faisceaux	Patrick Ausset	3h	Patrick Ausset	2h30	Patrick Ausset	2h30	Patrick Ausset	2h
SOLEIL	Jean-Marc Filhol		Amor Nadji	1h	Marie-Agnes Tordeux	1h	Jean-Marc Filhol	1h
Rayonnement synchrotron	Amor Nadji	1h	Amor Nadji	1h				
Dispositifs d'insertion	Amor Nadji	1h	Amor Nadji	1h				
Lasers à électrons libres	Amor Nadji	1h						
R&D à l'IN2P3	Lieuvin + Mueller	30'	Lieuvin + Mueller	30'				
Radioprotection			Eric Baron	1h	Eric Baron	1h30	François Ledu	1h30
Accélérateurs et énergie nucléaire			Jean-Claude Le Scornet	1h	Jean-Claude Le Scornet	1h	Alex Mueller	1h
Le CPO					Sabine Delacroix	1h	Sabine Delacroix	1h30
ESRF					Laurent Hardy	2h	Laurent Hardy	2h
TOTAL		34h		33h		33h40		30h

IN2P3 school (Laune/Mueller)



Synergies with EUCARD (Wyles)

WP5.1 Survey of available accelerator science courses and of teaching resources

- EuCARD is collating information on available courses in member institutes

WP5.3 Promotion of accelerator science and technology at multiple levels

- EuCARD also trying to do this (see previous slide)
- EuCARD is more public and school children whereas TIARA more at university level but still some overlap inc. industry, schools and society at large

Preliminary synthesis 1

- The situation is different in every country!
- In general, there are relatively small numbers of students (10s – 100s) studying accelerator science at any level in any country
- Numbers declining in some, increasing in others
- Not so many undergraduate level courses
- Well established master's courses in some countries
- Not a lot of formal education at PhD level

  → need to attract students EARLY
- Many come from engineering, maths, IT …

Preliminary synthesis 2

- The accelerator schools are playing a vital role in training:
- JUAS: undergraduate level: 30 / year
- CAS: PhD level: > 100 / year
- IN2P3: professional level: 40 / year
- (also USPAS …)
- CERN doctoral programme provides vital support for PhD-level training

Preliminary synthesis 3

- Formal teaching can be sporadic, even within a single country
- Often done by individual professors with strong connections with large labs
- Consolidation could offer critical mass (ECTS)
- General shortage of trained accelerator scientists: hard to fill positions (at labs)

Next steps

- Have a snapshot of situation in several countries
- Need to:

  define set of information we want,

  decide how to collect it,

  extend survey to other countries
- Working plan:

  define www-based survey, with database behind it

  have single national contact to lubricate gathering

  1st pass: contact the known institutes

  (may have a wider 2nd pass later)

  gather 'market' information in parallel w. educational

  have set up Sharepoint workspace

Additional material

Work plan: WP5.1

WP5.1 will carry out a survey of the number of Accelerator Science students and trainees and its evolution in Europe. It will also survey the available courses and teaching resources (including text books, lecture courses, and www-based materials) in European universities, laboratories and research organisations. A database of accessible training materials will be set up and updated regularly.

Work plan: WP5.2

WP5.2 will evaluate and develop the "market" for trained Accelerator Scientists, including physicists, engineers and technicians, for research, healthcare, industry and public service. One possibility to be explored is the creation of a centralized database of career opportunities for Accelerator Scientists within Europe. This study will be widely publicized and regularly updated to reflect (often rapid) developments in the field.

Work plan: WP5.3

WP5.3 will establish of a plan of action for promoting Accelerator Science and Technology at multiple levels:

i) within schools, in order to help attract bright young people into science and engineering disciplines;

ii) within universities, in order to enhance the pool of graduate-level trained individuals;

iii) within universities and research organisations that provide postgraduate qualifications (Masters and PhDs), in order to ensure the flow of highly-skilled individuals;

iv) within industry, so as to capitalize on Accelerator Science technologies and applications;

v) within society at large, in order to assist understanding of the many societal benefits that are built upon Accelerator Science.