TIARA-REP-WP5-2013-016

Test Infrastructure and Accelerator Research Area

Status Report

Recommendations for promoting accelerator science and technology in Europe

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07 November 2013

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.

This work is part of TIARA Work Package **5: Education and Training**.

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Test Infrastructure and Accelerator Research Area

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

27 November 2013

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Content

EXECUTIVE SUMMARY OF KEY RECOMMENDATIONS

We propose that the implementation phase of the TIARA project could include, in the area of promoting accelerator science and technology in Europe, the following schemes:

- An ‘e-learning’ course, ‘Introduction to Accelerator Science and Technology’, primarily aimed at physics and engineering students at the undergraduate level, but potentially accessible to any interested person.
- A programme of internships to allow undergraduate students to spend a significant period of time at their ‘local’, or an international, accelerator laboratory, and thereby gain hands-on experience of accelerator science and technology.
- A programme of bursary support to enable Master’s-level students to attend established international and national accelerator schools to which they have been admitted on merit.
- A prestigious European Master’s fellowship scheme to support students admitted on merit into an existing Master’s training programme.
- A programme of internships to allow enrolled students to perform project work in support of a Master’s thesis at a national (or international) laboratory, company or medical facility.
- A programme of bursary support to enable PhD students to attend established international and national accelerator schools to which they have been admitted on merit.
- A prestigious European PhD fellowship scheme to support students admitted on merit into an existing PhD training programme.
- Monitoring of the situation with respect to training of medical facility and company personnel, and provision of appropriate advice to the TIARA governing board regarding resources for, and provision of, possible future training mechanisms for them beyond what is already available.
- Support for the existing accelerator schools’ programmes by monitoring training provision and advising on aspects in which additional provision (eg. enhanced numbers of places, or additional specialised courses) would be desirable. Where appropriate, funds should be made available to support such recommended increases in training provision via the accelerator schools.
- A www-portal for providing a comprehensive source of information on accelerator opportunities, namely job and internship vacancies, bursaries and fellowships, and research group and personnel expertise, as well as news on conferences, workshops and training schools and access to online training materials and resources.
- A programme to allocate resources to support a number of pan-European outreach activities.

1. INTRODUCTION

During the TIARA Preparatory Phase project we have performed two major surveys across the TIARA member European nations:

- Provision of education and training in accelerator science [1].
- Market needs for personnel trained in accelerator science and engineering [2].

Based on the results of these surveys here we propose and discuss mechanisms that can be considered for implementation in the TIARA project. We make a number of recommendations for promoting accelerator science and technology in Europe. Our recommendations are grouped in three major areas:

1. Improving the supply of trained personnel (Section 2).
2. Improving the opportunities for, and access to, trained personnel (section 3).
3. Outreach to the wider community (section 4).

A summary is given in Section 5, and a discussion and conclusions are presented in Section 6.

2. IMPROVING THE SUPPLY OF TRAINED PERSONNEL

2.1 Academic training

There is general agreement that increased provision of training in accelerator science and technology (and related disciplines) at universities would be beneficial for increasing the awareness of university students of the field as a serious intellectual discipline, with commensurate professional opportunities for employment and career development.

2.1.1 Undergraduate-level training

We have concluded that reaching students early in their university careers, i.e. at the undergraduate level, would be extremely beneficial for increasing the supply of people for entry to higher-level (Master's and PhD) dedicated training programmes, and hence for increasing the supply of trained personnel. However, as it stands, relatively few universities offer any significant exposure to particle accelerators through their mainstream teaching programmes, although many advanced physics courses do mention accelerators, at some level, as part of modules in eg. particle and nuclear physics. It should be borne in mind that aspects of such training could be provided by engineering or applied mathematics departments, as well as physics departments.

One example of a dedicated undergraduate programme is the 'minor option' on particle accelerators offered at Oxford University to 3rd-year physics undergraduates. This is an optional course comprising a series of 9 lectures at an introductory level, delivered over 3 weeks. The

course has been running for 5 years, and typically attracts around 5-10 students (out of a cohort of 180) to the lectures, with a handful each year going on to take the examination.

Such a mode of undergraduate training is also extremely useful for putting interested students in contact with accelerator-related faculty, and it can result in subsequent attraction of good students into Master's or PhD programmes. However, at any given higher-education institution, there is a significant overhead involved in providing lecture-based and/or laboratory training for (in all likelihood) relatively small numbers of students, although the market for such a course globally across European institutes is potentially tens of thousands of students studying physics and engineering.

2.1.1.1 Proposal for an e-learning course

Proposal 1: we propose an 'e-learning' course, 'Introduction to Accelerator Science and Technology', primarily aimed at physics and engineering students at the undergraduate level, but potentially accessible to any interested person.

Such a course could be offered by institutes that do not currently provide direct training in accelerator science to undergraduates, thereby opening up a potentially large pool of additional students. The online materials (lectures, notes, tests, exams etc.) could, in addition, be useful to those institutes that already provide such training themselves. In principle the course could be additionally available to any interested person.

There are now many examples of e-learning environments [3] that have been set up by universities or consortia of universities. One example in accelerator science is 'VU Beam' [4], run by Michigan State University. In order to be successful such courses need to be 'tailor-made', with professionally-filmed lectures that link directly to supporting materials (eg. notes, tests and exams) that are also provided online. Although there is a significant effort required to set up such a course, once operational the level of maintenance required is significantly lower, and, we believe, this could represent a highly cost-effective mechanism for reaching potentially tens of thousands of students across Europe. Although English is widely used in our field, in order to be optimally useful across Europe it is possible that such an e-learning course would be best provided in some countries' native languages, which would require translation of the relevant materials.

Issues that would need to be considered prior to setting up the course include:

- Its detailed structure, scope and content. For example, a typical traditional lecture-based university course in physics might comprise 3 lectures per week over a 10-week (semester) duration.
- Management and administration: should this be done centrally at the pan-European level, at the national level, or at the institute level?
- Accreditation: should the course be 'standalone' in terms of accreditation, or should credit be awarded by a single or multiple bodies, eg. via the European Credit Transfer and Accumulation System (ECTS) [5]?

- Charges and payment: should charges be made for participation, and, if so, what would be the mechanism for payment?

- Should the course materials be translated into different national languages? One obvious possibility would be to 'trial' the course in English, and, depending upon its success, consider translation into other languages in a future step.

We estimate roughly the resources required (a more detailed evaluation would be prudent prior to implementation):

- 6 person-months of faculty effort for defining and preparing the intellectual content of the course: lectures, teaching materials, tests, exams.

- 6 person-months of professional media support for setting up the course: recording of lectures and setting up of interactive www site and database infrastructure.

Additionally, assuming that the course were administered by a single central body:

- 1 person-month per year for IT maintenance: trouble-shooting and data management.

- 4 person-months per year of faculty/staff effort for monitoring the course: tutorials, exam grading etc. This estimate is based on a simple model comprising a team of 10 people providing 1 day per week of effort over a 10 week period.

Total resource estimate: 12 person months (course setup) + IT infrastructure (server, software tools etc.) + 5 person months per annum (centralised course monitoring and support).

Further resources would clearly be required if the course were translated from English into additional languages. A minimal option would be to make the English-language source materials available so that they could be translated 'unofficially' by users. If professional language translation were to be provided we estimate that this could require 3 person-months of translation effort per country; we do not include this step in this initial recommendation.

We also propose (see Section 4) that it would be a small additional effort, incremental to the infrastructure that would be set up for the undergraduate e-learning course, to provide a short e-learning course (one or two classroom lectures) suitable for high-school pupils.

2.1.1.2 Proposal for internships at accelerator laboratories

We have concluded that 'hands-on' access to accelerator facilities would be attractive as a means of stimulating wider interest in accelerator science at the undergraduate level. Such access could be provided primarily 'locally', at national facilities, or, where appropriate, at an international facility such as CERN. The scheme could be additional to, or independent of, the e-learning course, and be available to suitable students whether or not they had already benefitted from a

course in accelerator science. In order to benefit fully from this opportunity we expect that students would typically be in their penultimate or final year of study.

An existing example of this type of internship programme is provided by the CERN Summer Student Programme [6], although in this case the focus is mainly on particle physics and not on accelerator science per se. In this particular case, enhancement of the programme to include a larger component on accelerator science, or possibly even a dedicated accelerator stream, could therefore be considered.

Proposal 2: we propose a programme of internships to allow undergraduate students to spend a significant period of time at their 'local', or an international, accelerator laboratory, and thereby gain hands-on experience of accelerator science and technology.

For example, an internship could support a period of dedicated training of order 1-3 months, to be undertaken during the summer or other university vacation periods.

Issues that would need to be considered prior to setting up the programme include:

- Management and administration of applications and support for intern positions: should this be done centrally at the pan-European level, at the national level, or at the laboratory level?
- Possible enhancement of the CERN Summer Programme to include a greater component dedicated to accelerator science and technology.

We estimate roughly the resources required:

- 100 intern-months per annum (eg. 50 internships of 2 months duration), at 1500 Euro per month (partial support for local living expenses and travel): 150,000 Euro per annum.
- 3 person-months per annum for central administration of internship scheme: selection of applicants and monitoring of placements.

Total resource estimate: 150,000 Euro + 3 person months, per annum.

2.1.2 Master's-level training

We have concluded that there is a significant demand for Master's-level training in accelerator science and technology. The cohort of European Master's students is currently approximately 350 per annum [1].

A vital component of Master's-level (and PhD-level, see below) training is already delivered via international accelerator schools [1], for example the CERN Accelerator School (CAS) [7] and Joint Universities Accelerator School (JUAS) [8] as well as USPAS [9] in the United States and some national schools, eg. WILGA [10]. These are typically long-running, well-organised and

highly-respected programmes that, we believe, should be capitalised on and, where appropriate, be further enhanced and supported by TIARA. National schools offer the advantageous possibility of local training, in some cases to particular types of trainee (eg. technicians), in the local language.

There is evidence that there is a demand for further provision of places at both national and international schools, as well as in specialist subject areas [2]. Some dedicated EU-supported programmes, for example DITANET and OPAC [11], have supported training at the Master's and PhD level in specific areas.

2.1.2.1 Proposal for bursary scheme for attendance at accelerator schools

Proposal 3: we propose a programme of bursary support to enable Master's-level students to attend established international and national accelerator schools to which they have been admitted on merit.

Issues that would need to be considered prior to setting up the programme include:

- Management and administration of applications and award of bursaries: should this be done centrally at the pan-European level or at the national level?
- Possible need for direct support of existing schools (eg. CAS and JUAS) so as to accommodate additional numbers of students (see also Section 2.3).

We estimate the resources required:

- 50 bursaries per annum, at 2,000 Euro (partial support for fees, local living expenses and travel): 100,000 Euro per annum.
- 2 person-months per annum for central administration of bursary scheme: selection of applicants and award of funds.

Total cost estimate: 100,000 Euro + 2 person-months, per annum.

2.1.2.2 Proposal for a European Master's fellowship scheme

We note the success of programmes such as DITANET and OPAC [9], which have helped to enhance the profile of accelerator science and technology, to support input of additional people into the field, and to support mobility within the EU. We conclude that a similar 2-year (or, in the case of PhD students, 3-year, see below) fellowship scheme has considerable merits and would help significantly to increase the profile of the field.

Proposal 4: we propose establishment of a prestigious European Master's fellowship scheme to support students admitted on merit into an existing Master's training programme.

This could comprise funding for c. 10 students per annum to participate in existing Master's training programmes across Europe, ideally with a trans-national mobility requirement between at least two different European institutions. The scheme would probably be best administered centrally.

We estimate the resources required:

- 10 fellowships per annum, at 20,000 Euro (partial support for fees, living expenses and travel).
- 2 person-months per annum for central administration of scholarship scheme: selection of applicants and award of funds.

Total resource estimate: 200,000 Euro (year 1), 400,000 Euro (year 2 and per annum thereafter) + 2 person months per annum.

2.1.2.3 Proposal for internships at accelerator laboratories and/or in industry

We believe that an internship programme, such as that described above for undergraduates, would also be relevant for Master's students, and would allow them to gain significant hands-on experience as part of their Master's training programme, eg. for gathering of data in support of a Master's thesis. Such internships could be for a significant period, eg. 6-12 months, to allow for project work at typically a national, or in relevant cases, an international accelerator facility, or where applicable, at a company or medical facility.

Proposal 5: we propose a programme of internships to allow enrolled students to perform project work in support of a Master's thesis at a national (or international) laboratory, company or medical facility.

For example, this could comprise funding for c. 50 students per annum to spend 6 months on project work. A trans-national mobility requirement could be considered. The scheme would probably be administered centrally.

We estimate the resources required:

- 300 intern-months per annum (eg. 50 internships of 6 months duration), at 1000 Euro per month (top-up support for local living expenses and travel): 300,000 Euro per annum.
- 3 person-months per annum for central administration of internship scheme: selection of applicants and monitoring of placements.

Total resource estimate: 300,000 Euro + 3 person months, per annum.

2.1.3 PhD-level training

We have concluded that there is a significant demand for PhD training in accelerator science and technology. The cohort of European PhD students is currently approximately 200 per annum [3].

We consider that the measures proposed for Master's students (above) are, with appropriate modifications, highly relevant for PhD students also.

2.1.3.1 Proposal for bursary scheme for attendance at accelerator schools

Proposal 6: we propose a programme of bursary support to enable PhD students to attend established international and national accelerator schools to which they have been admitted on merit.

The same issues as in proposal 3 would need to be considered prior to setting up the programme, and it could be managed in association with the corresponding Master's programme:

We estimate the resources required:

- 50 bursaries per annum, at 2,000 Euro (partial support for fees, local living expenses and travel): 100,000 Euro per annum.
- 2 person-months per annum for central administration of bursary scheme: selection of applicants and award of funds.

Total cost estimate: 100,000 Euro + 2 person-months, per annum.

2.1.3.2 Proposal for a European PhD fellowship scheme

Proposal 7: we propose establishment of a prestigious European PhD fellowship scheme to support students admitted on merit into an existing PhD training programme.

The same issues as in proposal 4 would need to be considered prior to setting up the programme, and it could be managed in association with the corresponding Master's programme:

We estimate the resources required:

- 10 fellowships per annum, at 25,000 Euro (partial support for fees, living expenses and travel).
- 2 person-months per annum for central administration of scholarship scheme: selection of applicants and award of funds.

Total resource estimate: 250,000 Euro (year 1), 500,000 Euro (year 2), 750,000 Euro (year 3 and per annum thereafter) + 2 person months per annum.

2.2 Training of medical and company personnel

Some dedicated training in aspects of accelerator science and technology is required for personnel at relevant medical facilities (eg. hadron therapy and medical isotope production) and industrial suppliers. Such personnel do participate [1] in existing general training programmes such as CAS and JUAS, as well as receiving 'on the job' training. We found considerable merit in the idea of a future specialised CAS course on medical accelerators; a first such course is currently being planned for spring 2015.

Proposal 8: at this time we propose that TIARA should monitor the situation with respect to training of medical facility and company personnel, and provide appropriate advice to the TIARA governing board regarding resources for, and provision of, any future training mechanisms beyond what is already available.

2.3 Dedicated training in specialised disciplines

We have found evidence [2] that there is a demand for further provision of specialised training in areas of identified key skills shortages, such as RF systems, beam dynamics, instrumentation and control, and vacuum systems. Provision of training in such areas is provided currently via, for example, CAS specialised courses, one of which is run every year in some particular topic. The evidence suggests that the demand for such courses, as well as for the non-specialised courses, exceeds their current frequency and number of available student places. In principle course places, and frequency, could be expanded, but this would require commensurate resources to meet the demand.

Proposal 9: we propose that TIARA support the existing accelerator schools' programmes by monitoring training provision and advising on aspects in which additional provision (eg. enhanced numbers of places, or additional specialised courses) would be desirable. Where appropriate we propose that funds be made available to support such recommended increases in training provision via the accelerator schools.

We estimate the resources required for such structural support of training programmes:

- 100,000 Euro per annum for enhanced training provision. Based on the example of current net costs to CERN of running CAS, such an amount could allow the provision of up to two extra CAS courses, with at least one in a specialised area.
- 1 person-month per annum for administration of the scheme.

Total resource estimate: 100,000 Euro + 1 person-month, per annum.

2.4 Access to training-scheme information

We recommend that a www-based infrastructure could serve as a portal for information on, and access to, the above schemes. For example, online application forms could be provided for the bursary, internship and fellowship schemes that we have proposed. This idea is developed and discussed further in section 3.

3. IMPROVING OPPORTUNITY ACCESS FOR, AND TO, TRAINED PERSONNEL

We recommend that opportunity access for, and to, trained personnel would be improved by providing the following capabilities via a www-portal. In advance it will be necessary to discuss whether the portal will be generally open access for all community members, and whether, or the degree to which, some functions should be restricted to institutes, groups or organisations that are affiliated with TIARA.

3.1 Job, internship and other opportunity advertisements

For job-seekers, a single, 'comprehensive' source of links to advertisements of accelerator-related job and internship opportunities would be a considerable resource. We recognise that a number of laboratories already partly fulfil this function; the CERN Courier job opportunities board is a good example. However the coverage of accelerator-related jobs is patchy and, eg. in the case of CERN Courier, there is naturally a focus on opportunities in the particle-physics accelerator sector.

We believe that TIARA could significantly improve this opportunity-advertisement function in a more complete manner. This could be done in a number of ways:

a) by simply pointing to the relevant job/internship vacancy www pages of TIARA partner (and possibly other) institutes;

b) by allowing partner (and possibly other) institutes to supply job/internship vacancy information via a simple standardised www form; or

c) by populating the www-portal with regularly-updated information compiled and collated via an automated 'Google-like' search tool. In any of these cases effort will be required to set up the www infrastructure, and, especially in cases a) and b), update and monitor the links to the relevant opportunities.

User signup capability could be provided for receiving regular email information on job vacancies and internship opportunities, as well as on the TIARA bursary, internship and fellowship schemes proposed in section 2. 'News' items, as well as notices of schools, conferences and workshops, could also be provided; a good example of this, specific to linear colliders, is given by the 'LC Newsline' [12].

3.2 Database of expertise ('professional register')

For employers, the www-portal could contain a database of links to lists of Master's and PhD students and postdocs, and their training backgrounds and topics of research, with a keyword-search capability, which would be a powerful tool for identifying potential recruits. This concept could be extended to provide a keyword-search function for R&D topics being pursued by TIARA partner institutes so as to provide a tool for, for example, companies that are seeking academic expertise for potential partnership in key areas.

3.3 Professional networking

We recognise that 'networking' is an important function in contemporary professional life. Although such a function could be provided via TIARA, we feel that current existing networking platforms, such as LinkedIn, ResearchGate, and Google Scholar, provide considerable capabilities in their respective areas, and we would not recommend providing a networking function that would largely duplicate what already exists.

3.4 Proposal for a www-portal of accelerator opportunities

We propose a www-portal to implement the ideas outlined in sections 3.1 and 3.2.

Proposal 10: we propose that TIARA set up a www-portal for providing a comprehensive source of information on accelerator opportunities, namely job and internship vacancies, bursaries and fellowships, and research group and personnel expertise, as well as news on conferences, workshops and training schools and access to online training materials and resources.

We estimate the resources required:

- 6 person-months per year of IT professional effort to set up the www portal.
- 2 person-months per maintain to maintain and enhance the www-portal.

Total resource estimate: 6 person months (setup) + IT infrastructure (server, software tools etc.) + 2 person months per annum (maintenance and enhancement).

An example to illustrate how such a portal could appear is given in Appendix 1.

4. 'OUTREACH' ACTIVITIES

We recognise that communications, dissemination and outreach to the wider community and the general public are of tremendous value in informing and stimulating interest in accelerator science and technology. We make a number of recommendations below, which should be discussed and coordinated across the TIARA consortium before arriving at a final set of pan-European outreach activities.

Proposal 11: we propose that TIARA allocate resources to support a number of outreach schemes, including:

- Local, national, and international laboratory access and visits by public and school groups.
- Summer internship programmes at local laboratories for high school pupils.
- Education packs for teachers and pupils. We note the examples of materials provided by CERN for particle physics education [13].
- An interactive e-learning-based lecture for pupils. This could be implemented efficiently by capitalising on the e-learning scheme in Proposal 1, with suitable adaptation of the materials to provide one or two class-period duration lectures at an elementary level.
- Dedicated local public 'showcase/classrooms'. One example is the GSI 'pupils' lab' [14], which allows pupils to spend a day performing experiments and sharing results in a dedicated classroom.
- Travelling national exhibitions.
- Public lecturer programme, to be delivered by 'champions' of accelerator science.
- www-accessible lists of national events: masterclasses, science festivals, public lectures, laboratory open-days etc.

We recognise that many such activities are already going on, but we have concluded that better coordination, sharing of good practice and outreach materials, and greater provision and access could be facilitated by TIARA. There are several possible modes of delivery that would need to be considered prior to setting up the programme:

a) Centralised management of resources and schemes. For example, bids could be solicited from across Europe for funds for particular schemes, to be delivered at a European level.

b) Management devolved to the national level. One laboratory or organisation per country could take responsibility for coordinating activities in that country. This mode would

leverage the existing staff and resources and allow direct expansion of ongoing local activities.

c) Resources allocated directly to individual institutes, or consortia of institutes.

Resource estimate: We estimate that resources at the level of 100,000 Euro per annum per country would have a huge impact if leveraged with existing personnel and activities.

For example, such an amount could allow employment of a national coordinator, as well as support for enhanced national outreach programmes. In countries where outreach is already coordinated by a national agency or laboratory, the added resource would allow significant expansion of multiple activities, or it could, if appropriate, be used to invest (for example) in a major exhibit or showcase of lasting value.

We recommend that these ideas be discussed across the TIARA consortium before concrete mechanisms are implemented.

5. SUMMARY OF PROPOSALS AND REQUIRED RESOURCES

Here we summarise our recommendations. We propose that the implementation phase of the TIARA project could include, in the area of promoting accelerator science and technology in Europe, namely education, training, and outreach, the following schemes:

1. An ‘e-learning’ course, ‘Introduction to Accelerator Science and Technology’, primarily aimed at physics and engineering students at the undergraduate level, but potentially accessible to any interested person.

2. A programme of internships to allow undergraduate students to spend a significant period of time at their ‘local’, or an international, accelerator laboratory, and thereby gain hands-on experience of accelerator science and technology.

3. A programme of bursary support to enable Master’s-level students to attend established international and national accelerator schools to which they have been admitted on merit.

4. A prestigious European Master’s fellowship scheme to support students admitted on merit into an existing Master’s training programme.

5. A programme of internships to allow enrolled students to perform project work in support of a Master’s thesis at a national (or international) laboratory, company or medical facility.

6. A programme of bursary support to enable PhD students to attend established international and national accelerator schools to which they have been admitted on merit.

7. A prestigious European PhD fellowship scheme to support students admitted on merit into an existing PhD training programme.

8. Monitoring of the situation with respect to training of medical facility and company personnel, and provision of appropriate advice to the TIARA governing board regarding resources for, and provision of, possible future training mechanisms for them beyond what is already available.

9. Support for the existing accelerator schools' programmes by monitoring training provision and advising on aspects in which additional provision (eg. enhanced numbers of places, or additional specialised courses) would be desirable. Where appropriate, funds should be made available to support such recommended increases in training provision via the accelerator schools.

10. A www-portal for providing a comprehensive source of information on accelerator opportunities, namely job and internship vacancies, bursaries and fellowships, and research group and personnel expertise, as well as news on conferences, workshops and training schools and access to online training materials and resources.

11. A programme to allocate resources to support a number of pan-European outreach activities that are described in Section 4.

Our estimates of the resources required are summarised in Tables 5.1 and 5.2. It should be noted that these should be considered 'reasonable estimates', based on the knowledge and experience of the working group members. In particular the estimates of staff time for each proposed scheme assume that the respective activity is 'standalone'; obvious efficiencies could be made if a dedicated staff team were to assume responsibility for multiple schemes, thereby reducing the total staff effort. The details would depend on the TIARA staff model that is eventually implemented, for example whether there is a centralised pan-European administrative team, or whether management is devolved to the country or laboratory level. In any case, once the overall administrative structure has been decided, and it is known which schemes are to be proposed for implementation, and at what proposed level of support, the overall staff needs can be re-evaluated and the staff deployment can be optimised. This issue is discussed further in Section 6.

Table 5.1: Summary of proposals and associated resources.

	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 person months (course setup) + 5 person 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 person months (course setup) + 2 person 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

Table 5.2: Summary of resources by year.

			Year			
			1	**2**	**3**	**4**
Undergraduates	1. E-learning	Person months	12	5	5	5
	2. Internships	Person months	3	3	3	3
		Cash (Euro)	150k	150k	150k	150k
Master's level	3. Bursaries	Person months	2	2	2	2
		Cash (Euro)	100k	100k	100k	100k
	4. European master's fellowship	Person months	2	2	2	2
		Cash (Euro)	200k	400k	400k	400k
	5. Internships	Person months	3	3	3	3
		Cash (Euro)	300k	300k	300k	300k
PhD level	6. Bursaries	Person months	2	2	2	2
		Cash (Euro)	100k	100k	100k	100k
	7. European PhD fellowship	Person months	2	2	2	2
		Cash (Euro)	250k	500k	750k	750k
Structural support	9. Accelerator schools	Person months	1	1	1	1
		Cash (Euro)	100k	100k	100k	100k
	10. www-portal	Person months	6	2	2	2
Outreach	11. Outreach	Cash (Euro)	1M	1M	1M	1M
Total		Person months	33	22	22	22
		Cash (Euro)	2.2M	2.65M	2.9M	2.9M

6. DISCUSSION AND CONCLUSIONS

Based on the information collected in our surveys on education and training and market needs for trained personnel, we have formulated a number of proposals for mechanisms that can be considered for implementation in the TIARA project for promoting accelerator science and technology in Europe.

In terms of staff effort, in total the resource scale to support these proposals amounts to roughly 3 FTEs in the first year, for setup and implementation, and thereafter a 'steady-state' level of roughly 2 FTEs for maintenance and ongoing support. We believe that some efficiencies may be possible if there is a dedicated administration team that supports most, or all, of our proposed activities, but the scale of the required effort is clearly of the order of 2-3 FTEs of administrative and IT support.

In terms of 'cash' resource, support for our full set of proposals amounts to just over 2 MEuro in year 1, rising to a 'steady-state' level of just under 3MEuro from year 3 onwards (Table 5.2); the increase represents the turn-on of the proposed bursary schemes for Master's and PhD students.

We have presented the proposals as individual items, so that each can be considered on its merits in relation to the others, taking account of the implied resources (Table 5.1). We have also identified 'unit costs' where relevant, for example for bursary and fellowship funding, so that a desired total cost can be derived from the number of units that are chosen for funding. It is now a matter for discussion within the TIARA consortium as to the choice of schemes, and level of resource, that could be carried forward to a proposal for the implementation phase of TIARA.

We have considered the issue of prioritisation of our proposals. This is not entirely straightforward, as different proposals target different communities:

- Proposals 1 and 2 are targeted towards undergraduates in physics, engineering and related scientific disciplines. Across Europe this is clearly a huge potential community of many tens of thousands annually.
- Proposals 3, 4 and 5 are targeted towards potential Master's students in accelerator science and engineering, which is currently a community of several hundred annually.
- Proposals 6 and 7 are targeted towards potential PhD students in accelerator science and engineering, which is currently a community of around two hundred annually.
- Proposals 8, 9 and 10 are essentially structural, including monitoring functions, and provision of structural support to the accelerator community, which amounts to approximately 5,000 people across Europe [1,2].
- Proposal 11 is for communication, dissemination and outreach targeted towards the European public.

We consider that, in terms of the size of their respective target audiences, and the potential 'return' on investment, Proposals 1 and 10 are clearly of high priority.

Proposal 1 (the e-learning course) would be designed to reach potentially tens of thousands of undergraduate-level students across Europe. We believe it could make a significant impact on training in the scientifically and economically important discipline of accelerator science and technology, as well as in raising awareness of professional opportunities for students. It would have the additional benefit of attracting high-quality students into higher-level dedicated training courses in the discipline. The e-learning course could, in addition, form a vital element of continuing professional development for people who are already in the field, for example technicians. It could also be made available to any interested person, and serve as an outreach vehicle. We also strongly support the idea of extending the e-learning environment to include some lectures suitable for high-school pupils studying science and engineering; this target audience is also very substantial.

Proposal 10 (the www-portal) would provide a significantly enhanced information and resource service for students and professionals in the field. It is aimed at improving access to news, conferences, workshops, training schemes, training resources, and internship and employment opportunities, as well as for the identification of expertise (people, facilities, research teams) by potential employers and users. It is also aimed at providing access to communication, dissemination and outreach schemes and materials.

However, we also feel strongly that each of proposals 2-9 would be of tremendous benefit to those embarking upon training, or who are involved in professional activity, in European accelerator science and engineering. Proposal 11 (support for outreach activities) targets engagement with the public in general, which we feel is of major importance in bringing awareness of the broad applications and societal benefits of accelerator science and engineering. Together with proposals 1 and 10 these form a coherent package of support for the promotion of the discipline at multiple levels.

In the case of proposals 2-7 there are well-defined cost units (bursaries or fellowships), and the total cost is in proportion to the number of such bursaries and fellowships that can be supported. Therefore, in the event that full financial resources were not available, support for a smaller number of bursaries and fellowships could still form an essential component of the overall programme. The monitoring function (Proposal 8) and (if appropriate) structural support for an enhanced programme of accelerator schools (Proposal 9) that augments existing well-running schemes, as well as enhanced support for outreach (Proposal 10) should also be pursued if possible.

A possible time-ordered, prioritised implementation plan for our proposals would be: 1) Set up the e-learning infrastructure, with the target user groups being undergraduates and high-school pupils, for whom provision of education in accelerator science and engineering is low. 2) Set up the www-portal for serving the existing community of students and professionals as well as the training monitoring function. 3) As experience is gained, provide the accelerator school structural support and implement the schemes for internships, bursaries and fellowships, subject to availability of funds. 4) Implement a set of the public outreach activities to enhance what is already being done in this domain.

ACKNOWLEDGEMENTS

We thank our colleagues in the TIARA consortium for their inputs and advice concerning this report.

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[3] See, for example:

edx: https://www.edx.org/

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[6] CERN Summer Student Programme: http://home.web.cern.ch/students-educators/summer-student-programme

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[8] Joint Universities Accelerator School: www.cern.ch/juas

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[10] WILGA: http://wilga.ise.pw.edu.pl/

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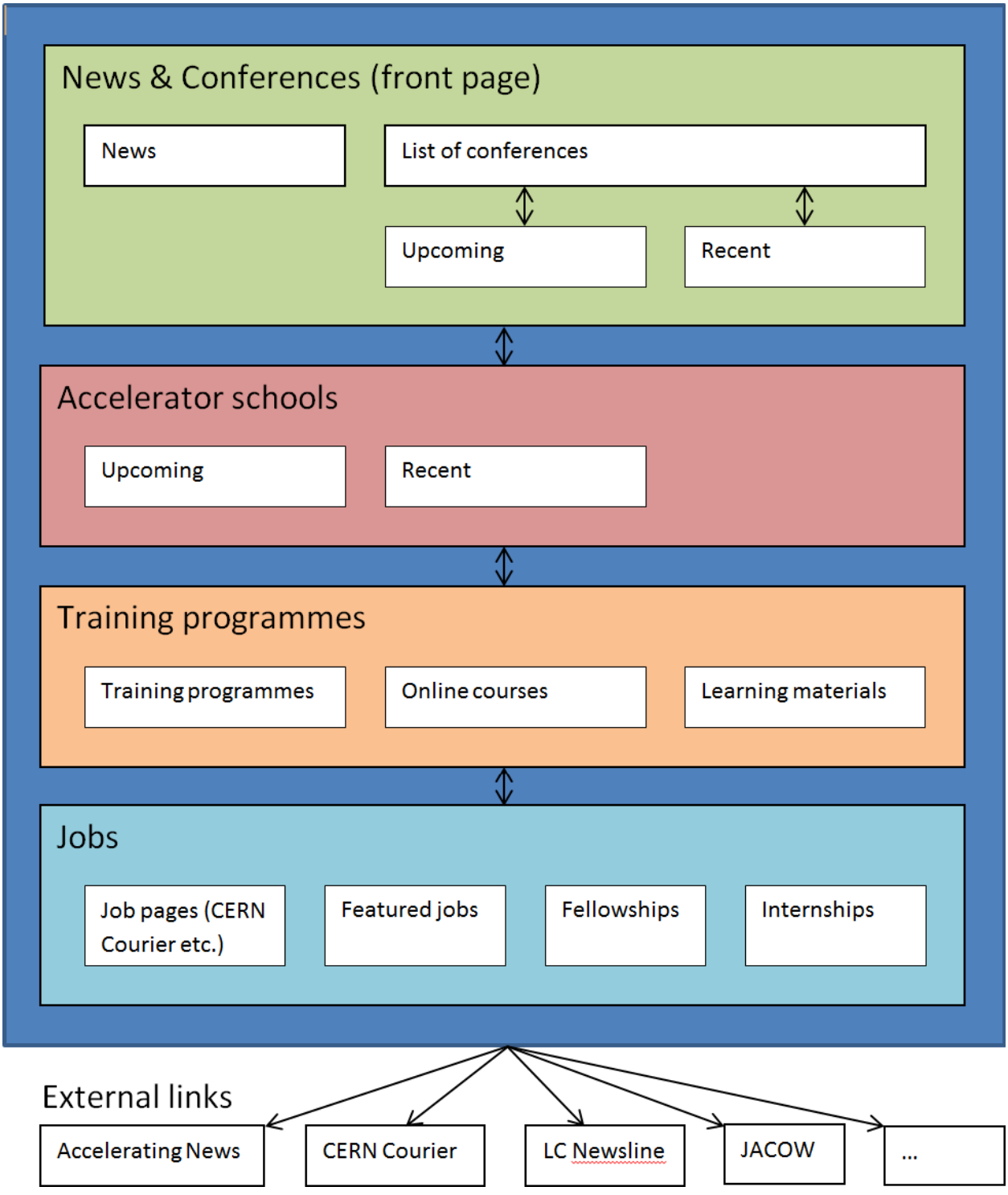
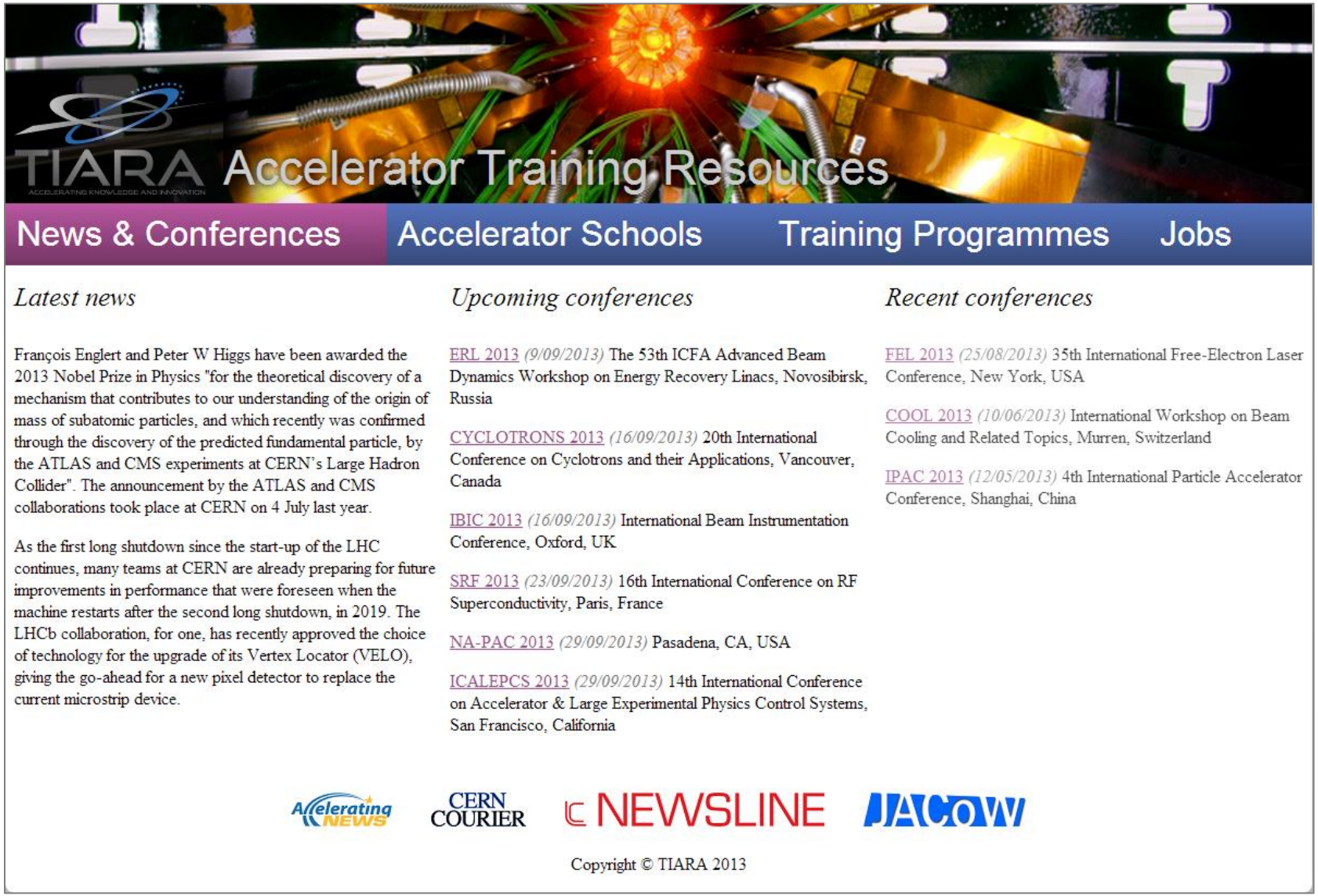
APPENDIX 1: example www-portal

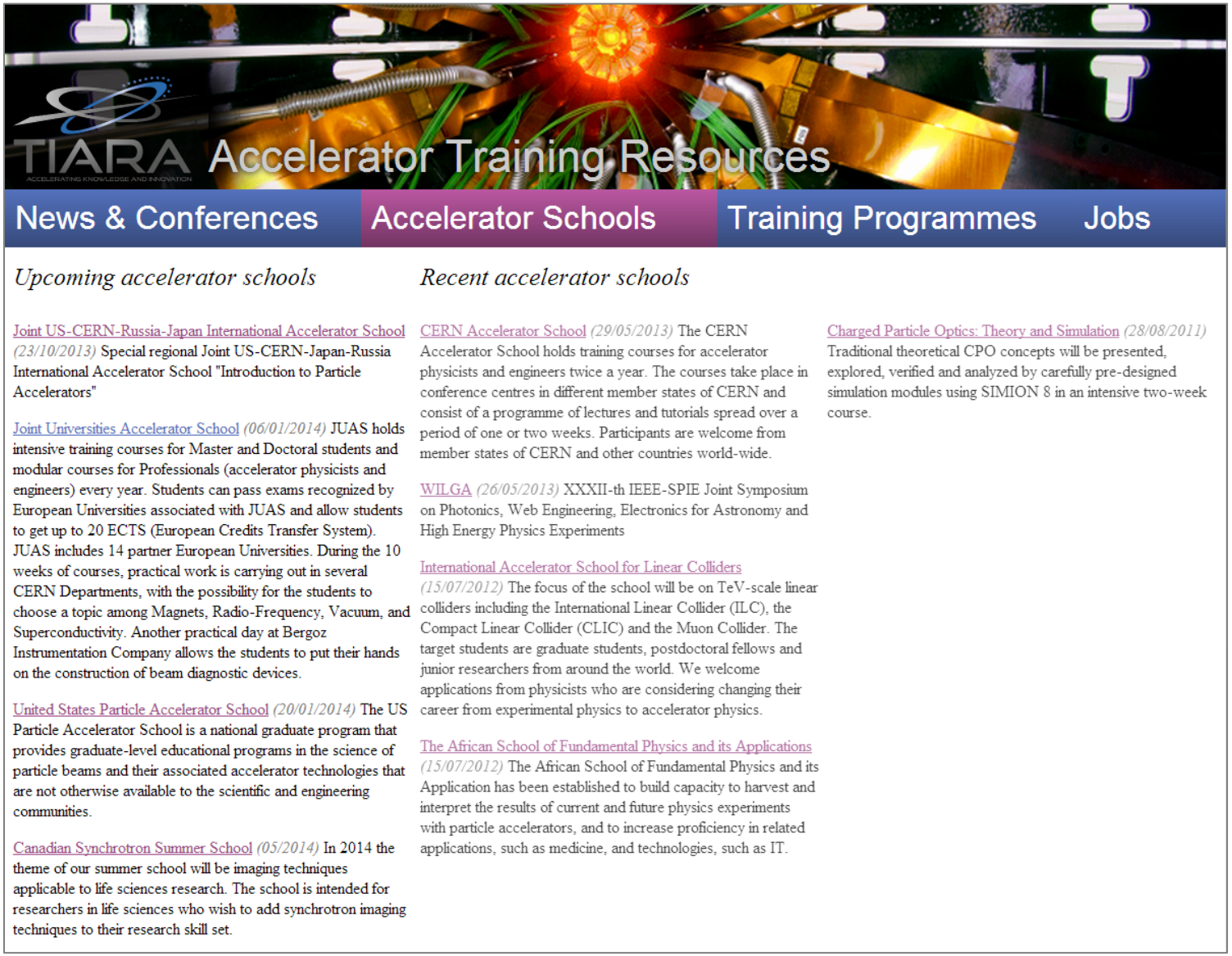
We present an example model of the www-portal for serving the accelerator community and interested other parties. The basic functionality is illustrated below, with example screenshots following to illustrate the concept.


News & Conferences (front page)
News
List of conferences
Upcoming
Recent
Accelerator schools
Upcoming
Recent
Training programmes
Training programmes
Online courses
Learning materials
Jobs
Job pages (CERN Courier etc.)
Featured jobs
Fellowships
Internships
External links
Accelerating News
CERN Courier
LC Newsline
JACOW
...

Example of the front page (‘News and Conferences’) of the www-portal:



Example of the ‘Accelerator Schools’ page of the www-portal:



Example of the ‘Training Programmes’ page of the www-portal:

Example of the ‘Jobs’ page of the www-portal: