

Particle accelerator education in universities and the role of JUAS in the future

Contribution from France

M. Baylac (LPSC-Grenoble, CNRS), S. Kazamias (IJCLab-Orsay, université Paris Saclay),
E. Merle (LPSC-Grenoble, Grenoble INP)



Role of JUAS for France

- Present existing courses in accelerator physics in France
 - **Master 2 Grands Instruments – Plasmas Lasers – Tokamaks (GI – PLATO) and Erasmus Mundus LASCALA**
 - from Université Paris-Saclay and Institut Polytechnique de Paris (IPP)
- **Since its creation, JUAS is THE training for French students & early careers colleagues in accelerators**
 - **Pioneering and unique school**
 - **Best experts in Europe to teach to the students**
 - **The students are proud to attend this school and really feel they are part of a European research community**
 - **It helps them become real professionals**
- France heavily involved in JUAS since its creation
 - Several education staff
 - Many students from French teaching institutions
- French students come from
 - Université Paris-Saclay
 - Université Grenoble-Alpes, Grenoble INP

Students from France

- **PHELMA engineering school (Grenoble INP) and Université Grenoble-Alpes**
 - JUAS proposed as a part of « energy and nuclear engineering (PHELMA/GEN) » (12 ECTS, 20 % of total grade)
 - Mandatory period of 17 weeks abroad : JUAS can be attractive
 - **In total, 63 students since 2006 (3 from Université Grenoble-Alpes)**
 - **4 or 5 students per year, about 55% pursuing a PhD in the field**
 - Some former students teach at JUAS
- **Université Paris Saclay**
 - JUAS is a part of the M2 GI/PLATO, mandatory and corresponds to 6 ECTS (20% of the total grade)
 - JUAS is a part of the LASCALA Erasmus Mundus program and corresponds to 6 ECTS
 - **In total, close to 100 students since 2016**
 - **10 students per year, more than 80% pursuing a PhD in the field (IJClab, SOLEIL, CERN, PSI, CEA)**

Some general comments

- **Lack of university professors in the field of accelerators**
 - Lack of direct contact with the students since many of the most prestigious accelerator research centers in France are not inside the university (CERN, GANIL, ESRF, SOLEIL)
 - In 2024 hardly no accelerator expert is university professor
 - We have to build bridges and encourage young people for this type of carrier
- **National network of accelerator sciences (*Groupement de Recherche*)**
 - Launched in 2023, <https://scipac.in2p3.fr/>
 - All french institutions in the field are participating (CNRS, CEA, SOLEIL, ESRF, GANIL)
 - **Several actions for students in the field of accelerators**
 - List of on-going PhD, list of people with Habilitation à diriger des Recherches (HDR)
 - Monthly newsletter (job offers, PhD topics, internships ...)
 - Travel money for some trainings



→ **JUAS : excellent and unique school**

France will continue to send as many students as we can recruit and fund (Europe can be a tool)

Italian contribution to JUAS

M. Migliorati

DIPARTIMENTO DI SCIENZE
DI BASE E APPLICATE
PER L'INGEGNERIA



SAPIENZA
UNIVERSITÀ DI ROMA



JUAS Agreement with Italian Universities

Italy has been active for a long time for the JUAS school. Collaboration agreements with some Italian universities have existed for many years and experts from Italy have taught in the JUAS courses since its inception.

Moreover, the Italian National Institute of Nuclear Physics (INFN) is one of the JUAS sponsors (together with Elettra Sincrotrone Trieste).

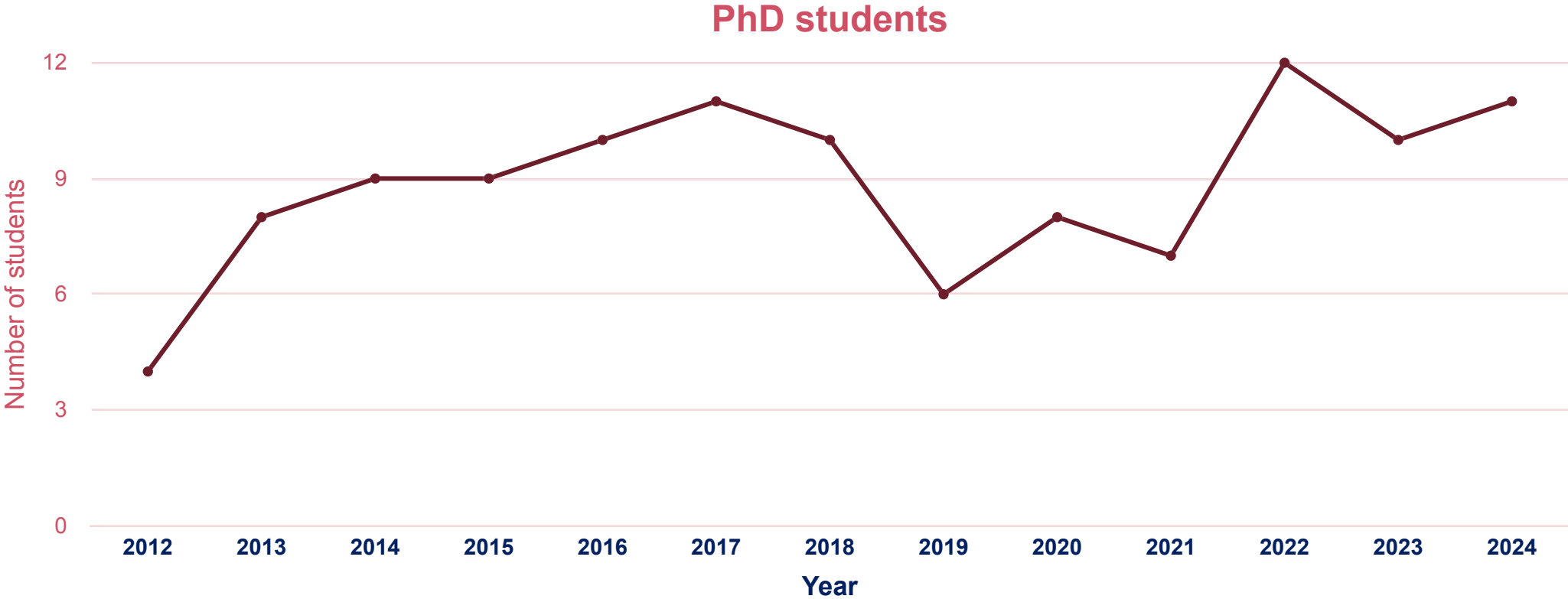
Italian Partner Universities:

Univeristy name	1994	1995	1996	1997	1998	1999	2000	2001	...	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
University of Roma La Sapienza - SBAI Dept.				█	█	█	█	█	}	█	█	█	█	█	█	█	█	█	█	
Doctorate in Acc. Phys. and Tech. - Physics Dept.										█	█	█	█	█	█	█	█	█	█	█
University of Napoli Federico II				█	█	█	█	█		█	█	█	█	█	█	█	█	█	█	█
University of Genova								█		█	█	█	█	█	█	█	█	█	█	█
Politecnico di Torino				█	█	█	█													

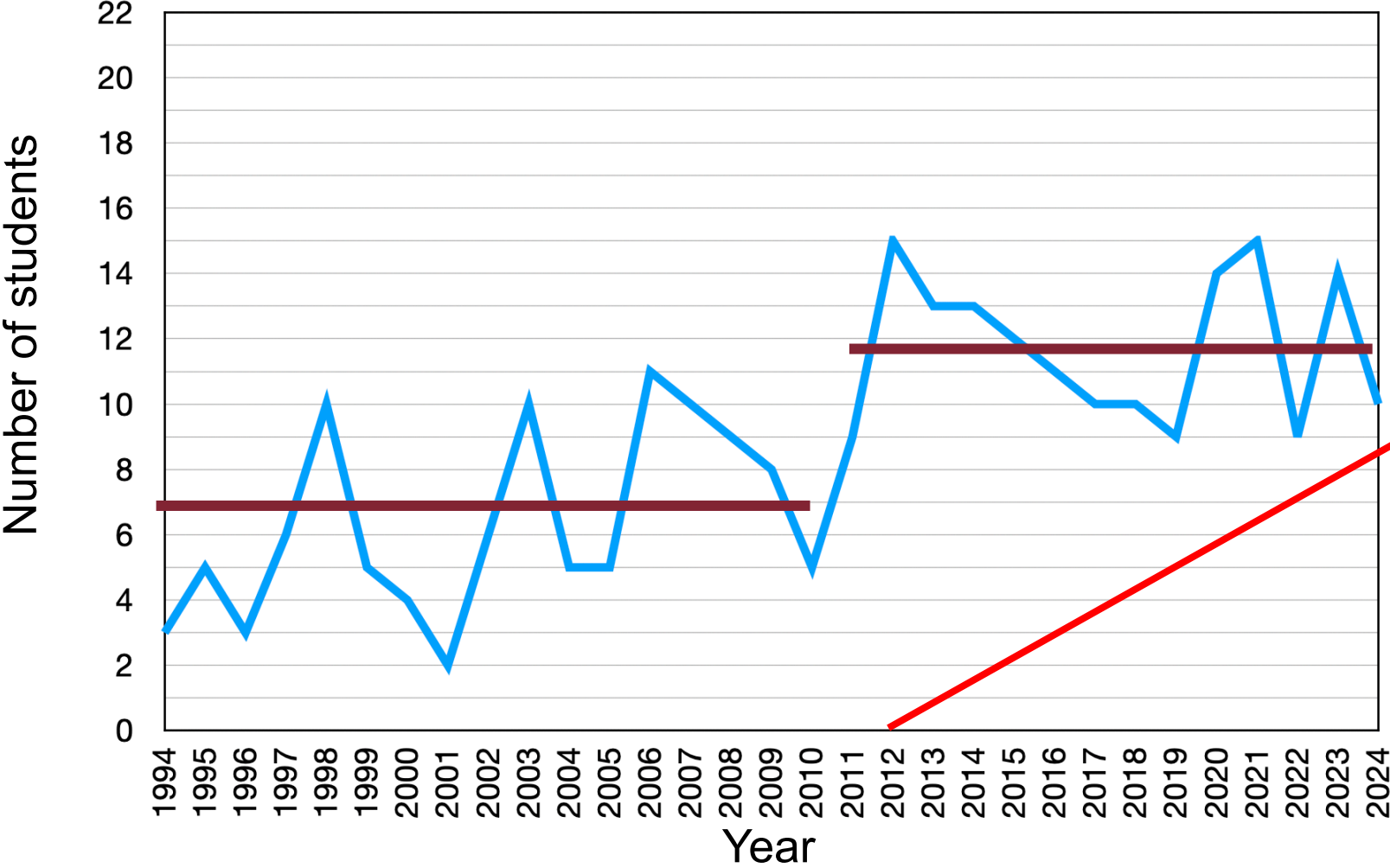
Doctorate in Physics and Technology of Accelerators of the University of Rome La Sapienza

- An important activity in Italy on Accelerator Physics is carried on by the Doctorate in Physics and Technology of Accelerators of the University of Rome La Sapienza.
- The PhD has been active in Italy since 2012.
- It is a unique and specific doctorate course that allows the students to perform their research in various laboratories connected to Universities, INFN units, CERN, ...
- INFN (with the main contribution) and Sapienza are sponsors of this PhD.
- During the first year, the PhD students must obtain 18 ECTS. JUAS is (almost) mandatory and, for each JUAS course, 9 ECTS are recognized.

Doctorate in Physics and Technology of Accelerators of the University of Rome La Sapienza



Italian students attending JUAS during the years



Birth of the doctorate in Physics and Technology of Accelerators of the University of Rome La Sapienza

Master's courses on Accelerator Physics in Italian Universities

- In addition to the PhD of La Sapienza, several Universities in Italy hold Master's courses specifically dedicated to accelerators.
- A survey conducted in 2022 showed that 10 universities have such courses:
 - Milan, Trieste, Turin, Genoa, Pisa, Rome (Sapienza and Tor Vergata), Naples, Catania, Bologna
- La Sapienza is one of the four European partner universities of the Erasmus Mundus Lascala Master on “Large Scale Accelerators and Lasers” .



Master courses on Accelerator Physics in Italian Universities

- In addition to the courses specifically dedicated to particle accelerators, there are other master university courses in Italy containing topics related to particle accelerators, such as, for example:
 - Accelerators and plasma physics
 - Introduction to accelerator physics and particle detectors
 - Accelerators and nuclear reactors
 - Superconductivity
 - ...
- Also in Pavia, during the past academic years, there have been master's and PhD courses dedicated to particle accelerators and linked to CNAO (National Center for Oncological Hadrontherapy)

Accelerator Physics courses in Italian Universities

- In total there are about **20 University courses** in Italy that teach accelerator physics providing a total of about **122 ECTS**.
- Of these, approximately 50% are taught by staff from institutions (mainly INFN, but also ELETTRA) and the remaining 50% by university professors.
- In addition to these courses, there are other courses (**12 ECTS**) offered specifically to the doctorate in Physics and Technology of Accelerators of the University of Rome La Sapienza:
 - Collective effects in Circular Accelerators - Physics of High Brightness Accelerators - Physics, Technology and Applications of Linear Accelerators

Accelerator Physics courses in Italian Universities

- The total number of students who every year attend all the master university courses is about 120-130. Such students are essentially from the Physics faculties. An exception is Sapienza in Rome where they also come from the Engineering faculty.
- The number of students who continue in this field with the PhD in Physics and Technology of Accelerators is about 10 – 12 per year.

The courses in Italian Universities are held in collaboration with important institutions:

- CNAO, ELETTRA Sincrotrone Trieste, Legnaro National Laboratories of INFN, Frascati National Laboratories of INFN, Southern National Laboratories of INFN

German Accelerator Physics Education and Perspective for JUAS

JUAS 30th anniversary, 27th of November 2024

Peter Forck

Gesellschaft für Schwerionenforschung (GSI) and University Frankfurt

Accelerator Physics Education in Germany

Regular courses in accelerator physics at 12 German universities (alphabetic order):

Humboldt University Berlin, Bonn, **Darmstadt** (physics & engineering), Dortmund, Dresden, Frankfurt, Hamburg, Heidelberg, **Karlsruhe**, Mainz, **Rostock** (engineering), Siegen

German Semester schedule: $\approx 15^{\text{th}}$ Oct. to $\approx 15^{\text{th}}$ Feb. & $\approx 15^{\text{th}}$ April to $\approx 15^{\text{th}}$ July

Green marked: JUAS partner universities



- Accelerators at universities: Bonn, Darmstadt, Dortmund, Frankfurt, Heidelberg & Mainz
- Several accelerator scientists from Helmholtz-Centers have a professorship at a university

Hamburg



Darmstadt



Berlin



Dresden



Karlsruhe



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Hamburg



Darmstadt



Berlin



Dresden



Karlsruhe



New: Collaboration between the Rhein-Main Universities (RMU)
 Darmstadt, Frankfurt & Mainz
 Foreseen: Master Program in Acc. Physics starting in ≈ 2026



Benefits for master students:

- **Intensive course** on an exciting and innovative subject
- Good pedagogical lectures and **practical course** typically not available at universities
- **International environment** concerning students and lecturers

Problem for Germans: Date of JUAS doesn't fit to semester schedule.

However, regularly students from **TU-Darmstadt**



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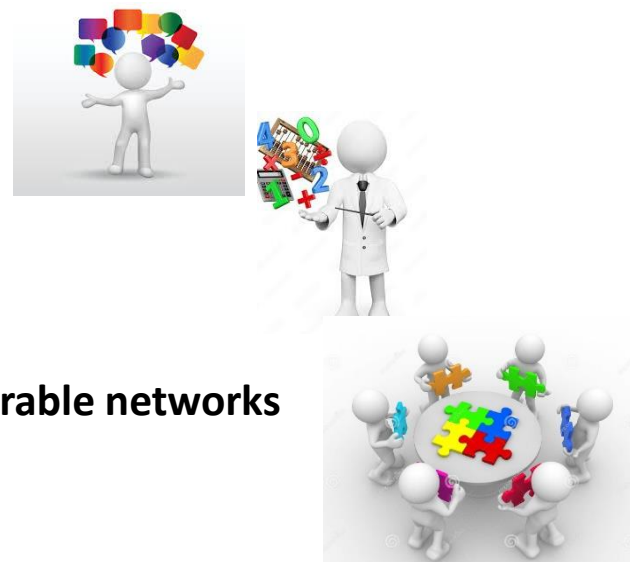
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Additional benefits for PhD students & young engineers:

- Intensive course related to their subject plus covering the **entire accelerator physics**
- Practical courses for subject **beyond** their 'daily' work
- **Contact** to experts in accelerator physics and technology
- International environment with the possibility to establish **durable networks**



My perspective as a scientist at a Helmholtz Center:

- JUAS is **best** education for **young** PhD students and engineers
 - Most PhD students at GSI Beam Instrumentation participated in JUAS course 1 and/or 2
 - Duration (2 times 5 weeks) is long, but still acceptable
- Basic knowledge on **entire** accelerator physics is very beneficial for any 'daily' work
- Networks helps the PhD student and supervisor to **realize** challenges



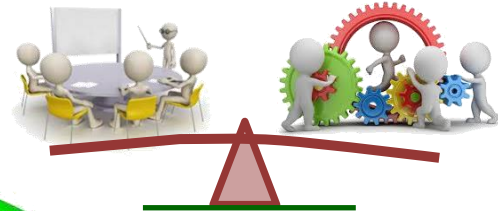
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General benefits of JUAS:

- Theory, practical work, group exercises and tours are well **balanced**
- Starting from basics gives more time to '**digest**' than in other schools
- Intensive **exchanges** between the participants (and partly lecturers) concerning physics
- Common **private activities** are attractive for young people
- Possibility to establish **durable networks** between participants (and with lecturers)



JUAS provides an excellent education in accelerator physics; integrated at some universities!

Firstly, preserve the high quality. Secondly, possible improvements and wish list:

Strengthen the participation of:

- Master students from further universities (even without ECTS; unrealistic)
 - PhD students and young engineers
 - Members from non-European labs
- ⇒ Announcements at partner & non-partner universities **and** worldwide accelerator centers
(by e.g. printed posters, social media, booth at IPAC, personal contact to acc. centers...)
- Improvements concerning the accommodation for the students (without cost increase)



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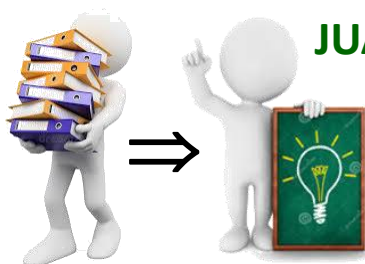


JUAS is an intensive, and exhausting, time for the participants;

however, they will never forget this event !!!

Congratulation and Happy Birthday to JUAS !!!

Thank you for your attention!



JUAS for Spain, Spain at JUAS

Round table 2: Particle accelerator education in universities and the role of JUAS in the future

Caterina Biscari, Daniel Esperante, Ángeles Faus-Golfe, Yuri Kubyshin

CERN, November 27, 2024

1. Particle accelerator education in Spanish universities

Universitat Politècnica de Catalunya: Prof. Y. K.

- JUAS partner university
- Master level courses
 - ❑ "Large Facilities" in the Master program on Physics Engineering (48h, ~30-35 students)
 - ❑ "Electron Beams Applications" in the Master of Interdisciplinary Engineering (40h, ~10 students)
 - ❑ Hands-on practical works at ALBA
- These courses are taught in collaboration with professors from the UPC.
- Undergraduate course
 - ❑ "Design of an electron accelerator" (24h, ~15 students) at the *Escola Tècnica Superior d'Enginyeria Industrial de Barcelona*



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH



Linac energy measurements. Practical work of "Electron Beams Applications" students in the ALBA control room.

November, 2024

1. Particle accelerator education in Spanish universities



Universitat Autònoma de Barcelona: Prof. Caterina Biscari

- **JUAS partner university**
- **Course on Accelerator Physics for 4th year undergraduate students in Physics, since 2014 (50h course).**
- **Participation of some accelerator physicists from ALBA.**
- **Course includes hands-on practical works at ALBA.**



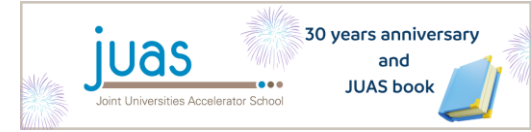
Synchrotron radiation facility ALBA

- **Practical works for university students from the UAB and UPC. (beam simulations, magnetic measurements, emittance measurements, linac energy measurements).**
- **15 – 17 internships each year for university students.**
- **Educational projects and other resources for school teachers.**

Existing problems:

- **Lack of university professors in the field of particle accelerators**
- **Absence of master programs with the JUAS course in its curriculum**

2. Training of Spanish students and specialists at JUAS: 100 in total



ALBA

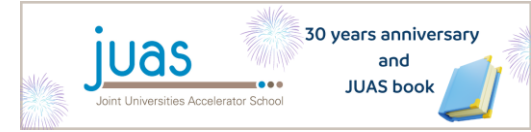
- **Trained at JUAS: 14 people in total.**
- 2 of them were the best in the corresponding course.
- 11 of them worked or are still working at ALBA.
- 3 of them have now prominent positions at ALBA Management and Accelerators division:
 - Francis Perez is the Head of AD,
 - Montse Pont is the Operation Coordinator for the full infrastructure,
 - Pep Campany was the Head of the Magnets and IDs Section
- The first group of students trained at the JUAS1994 course had a key role in the creation of the ALBA Team.
- ALBA has been contributing to JUAS with **sponsorships** and providing **lecturers.**
- The impact of training at JUAS has been important for the design, construction and operation of ALBA, currently the major accelerator facility in Spain.



Year	Students
1994	9
1996	2
2014	2
2017	1



2. Training of Spanish students and specialists at JUAS: 100 in total



IFMIF-DONES & Granada University

- **2003 – 2024 4 JUAS students.**
- One of them was the best student in the 2016 course.

➤ Ivan Podadera, one of them, is the Head of the Department of Engineering of IFMIF-DONES and Head of the Section of Accelerator Systems.

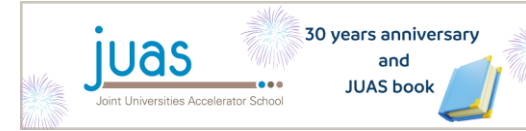


Particle Accelerator Unit, CIEMAT

- **4 JUAS students.**

The impact of training at JUAS has been essential for the development of accelerator technologies in these centers.

2. Training of Spanish students and specialists at JUAS: 100 in total



Instituto de Física Corpuscular (IFIC) & University of Valencia

2001- 2023 13 JUAS students in total.

- 2 of them were the best in the corresponding course.
- 2 of them are heads of groups at CERN and EIC project-BNL.
- 1 of them was a **lecturer** at JUAS

Representative at JUAS AB: Ángeles Faus-Golfe till 2014,
Daniel Esperante now

Universitat Politècnica de Catalunya (UPC)

- **1994 – 2014 4 JUAS students.**
- 1 of them was a **lecturer** at JUAS

Representative at JUAS AB: Francisco Calviño till 2013,
Youri Koubychine now

Training of PhD students at JUAS is crucial for maintaining activities in accelerators physics and related technologies at the IFIC and UPC.



3. Concluding remarks

Impact of JUAS

Training of specialists and PhD students at the JUAS has been very important for the development of the accelerator science and technologies in Spain for

- ALBA
 - IFMIF-DONES
 - S-band High-Gradient (HG) RF Lab at the IFIC
 -
- JUAS sets the standard in training of specialists in particle accelerators which serves as a reference in the university courses.



3. Concluding remarks

Challenges for Spain, perspectives for JUAS

- Creation of an interuniversity master program with JUAS courses on accelerator science and technologies as a part of the curriculum, student mobility, etc.
 - For setting such program a financial support and scholarships for students from EU programs are essential.
- Need in training of students and specialists at JUAS in the coming years:
 - ALBA II, the upgrade of ALBA facility project, has begun, awaiting for full funding
 - Development of the IFMIF-DONES is afoot.
 - Interest in JUAS at ESS-Bilbao and CNA (*Centro Nacional de Aceleradores*), Sevilla.

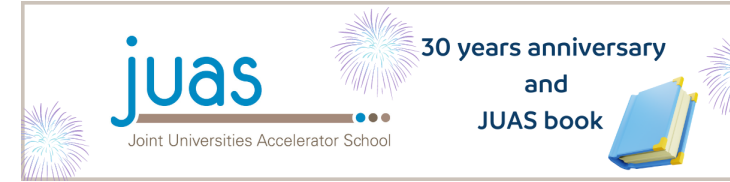
JUAS, we need you!
Happy Birthday!



Particle Accelerator Education in the UK

Phil Burrows and Carsten P Welsch

UK Accelerator Education



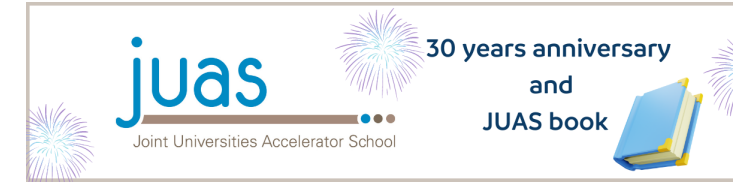
Key Institutions

- John Adams Institute (JAI)
- Cockcroft Institute (CI)

Goals

- Training the next generation of scientists and engineers
- Filling gaps left by limited undergraduate exposure to accelerator physics
- Emphasis on both foundational knowledge and transferable skills

JAI Overview



- Established: 2004
- Affiliated Universities: Oxford, Royal Holloway, Imperial College
- 109 members, of which 53 PhD students

Training Programme

- Graduate and undergraduate accelerator physics courses
- Transferable skills training
- Dedicated training on communications/outreach + KT
- Summer internship program for undergraduates
- Teacher training programs
- Joint JAI - Cockcroft Institute Advanced Lecture Program
- JAI Seminars and UK Accelerator Institutes Seminars
- Contributions to external training programs, e.g. CAS, JUAS, etc.

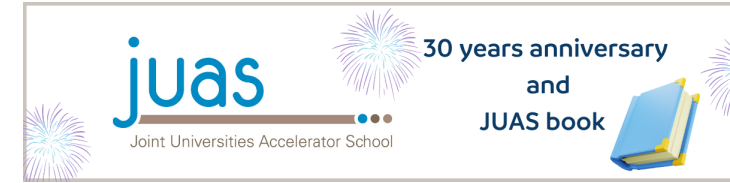
Impact

- Over 120 PhD graduates since inception
- Strong accelerator science outreach program
- Alumni employed globally at leading labs: STFC, CERN, DESY, EPFL, SLAC, FNAL, BNL, LBNL, etc



Class of 2023, visit to CERN.

CI Overview



- Established: 2004
- Affiliated Universities: Liverpool, Lancaster, Manchester and Strathclyde
- +200 members, of which +50 are PhD students

Training Programme

- One of, if not the, largest accelerator training programs in the world
- Graduate and undergraduate accelerator physics courses
- Engaging students with practical skills and peer support
- Hosting a dedicated postgraduate conference annually
- Summer internship Program for undergraduates

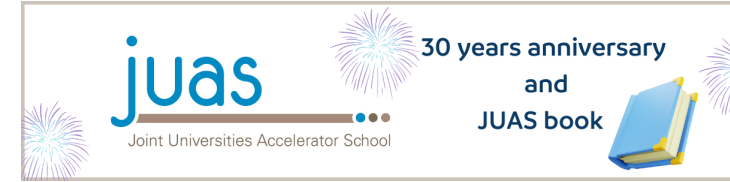
Impact

- Multi-award-winning outreach activities, including Tactile Collider and QUASAR Group outreach films
- Almost 200 PhD students have graduated already
- Textbooks developed from CI lectures, e.g. *Wolski "Beam Dynamics"*, *Appleby et al., "Science + Technology of Particle Accelerators"*
- Leading large number of international doctoral networks



CI PGR conference 2023.

Shaping training across borders



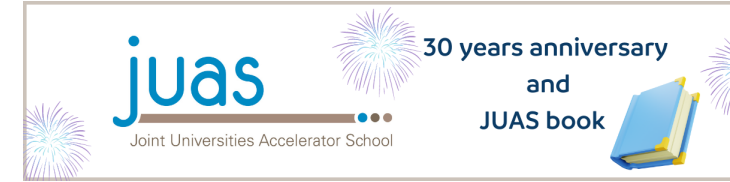
- Beam Diagnostics 2008 – 2012 (*physics*)
21 Fellows, 32 Partners www.liv.ac.uk/ditanet
- Laser Applications 2011 – 2015 (*engineering*)
19 Fellows, 38 Partners www.la3net.eu
- Accelerator Optimization 2011 – 2015 (*physics*)
23 Fellows, 35 Partners www.opac-project.eu
- Medical Applications 2016 – 2020 (*life sciences*)
15 Fellows, 33 Partners www.oma-project.eu
- Antimatter R&D 2017 – 2021 (*physics*)
16 Fellows, 35 Partners www.ava-project.eu
- EuPRAXIA Doctoral Network 2023 - (*physics*)
12 Fellows, 23 Partners <https://www.eupraxia-dn.org/>



- UK is at the forefront of modern PhD training through pan-European networks, frequently identified as best practice by EU, REA, UKRI, KOWI, etc
- CPW chaired STFC's Education Training & Careers Committee 2021-2023, shaping PG training across UKRI



Challenges and Future Directions

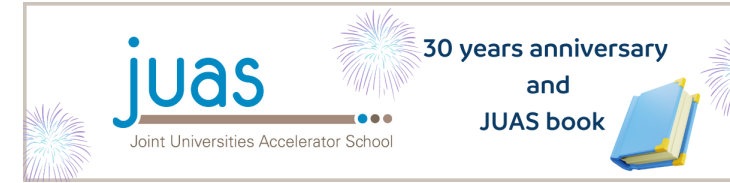


- Pandemic disruptions affecting research and mental well-being
- Need for diversity and equitable recruitment practices

Future Plans

- Further develop curriculum, e.g., AI and machine learning
- Continue focus on complementary skills development
- Increase industry engagement in all aspects of training
- Enhancing student support through representation and streamlined processes

Conclusion



- The UK is one of the leaders in particle accelerator education.
- JAI and CI provide comprehensive training that combines theoretical and practical knowledge.
- Looking ahead to further advancements in education and training!



Calcul, technique et réalisation des accélérateurs de particules

D.Manglunki , CERN and ULB

- Created by accelerator pioneer, Proton Synchrotron commissioner, and PS division leader Pierre Germain in the 1970ies
- Course given over one week, full time, to the students in 5th year of physics engineering (now 2nd year of Master) in Ecole Polytechnique, Université Libre de Bruxelles
- Introduction to the physics of particle accelerators with
 - 1/3 lessons
 - 1/3 exercises
 - 1/3 visits (accelerators, workshops, detectors, control rooms,...)
 - Oral exam at the end of the week (with possible distribution of vacancy notices)
- Over 500 students introduced to accelerator physics
 - Some kept working in the field, some at CERN in accelerators or as users

Topics covered

- Physics and research needs, special relativity, CERN's complex
- Transverse dynamics
- Longitudinal dynamics
- DC accelerators, linacs, cyclotrons, synchrotrons, colliders
- Emphasis on variety of machines, limited to linear dynamics, no collective effects

“Yellow” report CERN 89-07 (now rev. 19)

- One of the very few yellow report in french
- Redacted in 1989 by D.Dekkers, using Pierre Germain’s notes after his passing, and with the help of R.Cailliau, S.Neboux
- Revised regularly in order to keep the numbers, list of machines, etc, up to date

Contributors

- 197? – 1988 Pierre Germain / D.Dekkers
- 1989 – 1999 D.Dekkers / D.Manglunki
- 2000 – 2017 D.Manglunki
- 2018 – 2019 C.Hernalsteens / R.Aleman
- 2019 - present C.Hernalsteens / M.Vanwelde