The CERN Accelerator School

Present CAS Activities and Experience

Outlook to future CAS

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Based primarily on slides of R.Bailey and W.Herr

The CERN Accelerator School

- CERN Accelerator School (CAS) established in 1983, with the mandate:

  ”To preserve and transmit knowledge accumulated, at CERN and elsewhere, on particle accelerators and colliders of all kind”

- Takes place in different member states of CERN, member states (22) visited at least once, except Israel (member state since 2014), Romania (member state since 2016)

- Participants and lecturers from CERN member states and other countries world-wide

Provide framework for a series of courses:

- General accelerator physics (annually), alternating ”Introductory” and ”Advanced” course
  Very diversified programme to give an overview, but strong emphasis on beam dynamics (≈ 2/3)

- Topical schools specialized in a field, yearly up to 2013, now 2 or 3 per year due to high demand and TIARA outcome. (Usually no dedicated courses on beam dynamics)

- Occasional courses within framework of Joint Accelerator School (JAS) together with USPAS, Japan, and Russia
  → next JAS: RF technologies: Japan, October 2017

Previous Schools

- General courses (33 since 1983):

  Residential courses, 2 weeks (50-60 hrs). Lectures, exercises, group projects and hands-on courses

- Specialized topics (32 since 1983, 2 courses per year):

  Residential courses, 1 week. Lectures, case studies

- Joint Accelerator School (JAS, 13 schools since 1985):

  Residential courses, 1 - 2 weeks. Lectures, homework, case studies

Introductory course:

- Lectures largest part of the programme (typically ≈ 45)

  Core topics: linear beam dynamics and related themes

- Complemented by tutorials and dedicated discussion sessions

Advanced course:

- Strong focus on hands-on courses (all afternoons, lectures the only in morning)
- New core topics: Advanced beam dynamics concepts (in particular non-linear dynamics, collective effects, light sources)

Previous topical schools - training the skills

- Magnets and alignment: (1986, 1992, 1997, 2009)
- Superconductivity, Cryogenics: (1988, 1995, 2002, 2013)
- RF Systems: (1991, 1993, 2000, 2010)
- Diagnostics, signal processing: (2007, 2008, 2018)
- Vacuum: (1999, 2006, 2017)
- Power Converters: (1990, 2004, 2014)
- Small machine, high power machines: (1994, 2005, 2011)
- Synchrotron radiation, FEL: (1989, 1996, 2003, 2016)

cont'd:

- Ion Sources: (2012)
- Accelerators for medicine and industry: (2001, 2015)
- Colliding beam facilities (1983)
- Plasma Wake Acceleration (2014)
- Intensity Limitations (2015)
- Injection, extraction and beam lines (2017)

Organization of CAS schools and programme:

CAS management staff, ≈ 2.5 FTE (since 2011):

- Roger Bailey (head of school, full time)
- Werner Herr (deputy head of school, presently 50%)
- Barbara Strasser (administrative assistance, full time)
- Bernhard Holzer (for part of topical courses organizes the preparation and running of the school, part time, ≈ 20%)
- Hermann Schmickler (appointed as head of school from 2018)

Not part of CERN departmental structure, reports to CERN Directorate

Consultation with supporting bodies

Evolution of the programme:

- Schools are regularly revised to adapt to evolution in the field and improved teaching methods
- Recent (since 2016): updated common syllabus for general schools (Introductory and Advanced level)

  Purpose:

  - Ensure a coherent set of lectures, with advanced course as follow up of introductory course
  - Take into account advancement in the field
  - Input from lecturers and students, single programme committee for both schools
  - Provide a well-defined foundation for topical courses

Financing

- Try to be cost neutral with students' fees: for running of the school, this includes accommodation, all meals, course material (fees strongly depend on local costs and country)
- All expenses for lecturers covered by CAS, but no remuneration for lecture

  (relying on good will and dedication of lecturers, has not been a problem so far)
- Financial support for students (covers only fees, no travel): typically up to 5 students per school

Attendance:

- Unlike USPAS/JUAS: much less focused on University Students

  Staff of laboratories and universities (physicists, engineers, technicians), undergraduate and PhD students, post docs, staff from in industry working with accelerators

- General schools:
  - Introductory level: 110 - 130 participants (aim for 120)
  - Advanced level: limited to 75 - 80 participants (due to afternoon courses)

- Topical schools:
  - Depends on topic: 60 - 100 participants

General schools often oversubscribed (up to 60%), then CV and reference letter required

Origin: Participants

	General schools	Topical schools
Laboratories:	78 %	80 %
Universities:	20 %	16 %
Industry:	max 2 %	4 - 10 *) %
Non-member states: (by affiliation)	8 %	12 %

*) depending on topic

Education and background: Participants

As example: Introductory course, Budapest 2016

Participants with post-graduate university degree *) (Physics or engineering) 85 %

Where:

Without PhD:	49 %
With PhD: PhD	29 %
students:	22 %

Others: Technical engineers, technicians, operators, undergraduate students, BSc

*) Minimum: MSc/Diploma ⇒ BSc not counted

Level, prerequisites for participants (I)

- Introductory Course:
  - Basic knowledge in physics or engineering and mathematics (1st year university level) *).
  - No training in accelerator physics expected
- For this Course: typically rather large spread of background:

  (technicians, engineers, physicists (various disciplines), senior staff)

→ Short recapitulation of background knowledge: Classical Electrodynamics, Special Relativity

*) Basics of differential equations recommended

Level, prerequisites for participants (II)

- Advanced Course, all Topical schools:
  - Good knowledge in mathematics (1st year university level) *) and physics or engineering.
  - Basic training in accelerator physics or experience in Accelerator Operation or Technology
  - Reference letter always required
- In general: material based on Introductory Course

*) Basics of complex calculus and differential equations recommended

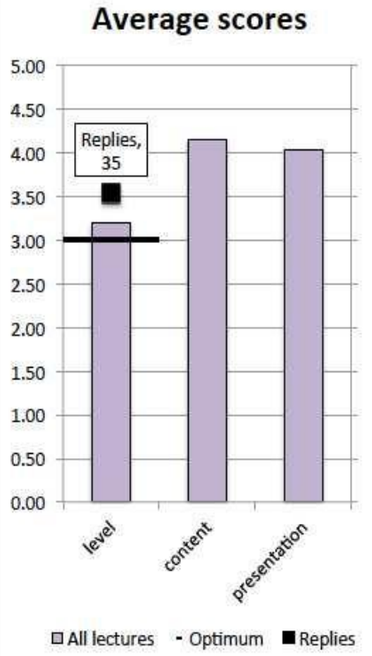
Evaluation of the schools

- Quality of school and lectures are monitored:
  - Participants are asked to evaluate quality and benefit of lectures (level, contents and presentation)
    (standard questionnaires and additional comments)
    Evaluation includes organization and running of the school
  - Encourage feedback from teaching staff (not yet very successful)

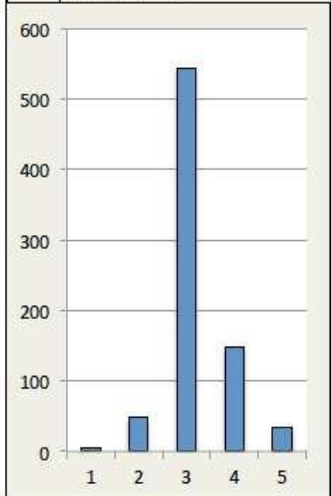
- CAS Committees include evaluation to propose topics, lectures and lecturers

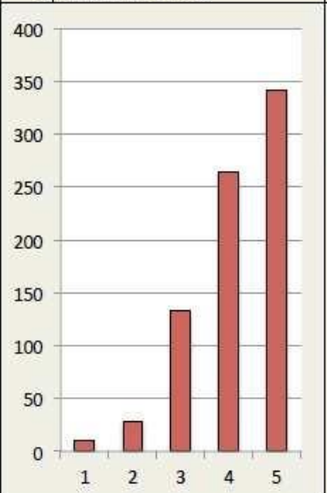
CERN Accelerator School,Advanced Accelerator Physics, Trondheim, August 2013 - Replies from 36/70 students

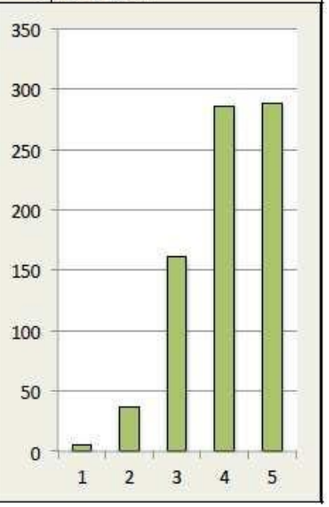
All lectures



	Level		Content		Presentation
1	Much too low	1	Completely uninteresting	1	Very poor
2	Too low	2	Uninteresting	2	Poor
3	Just right	3	Of some interest	3	Fair
4	Too high	4	Interesting	4	Good
5	Much too high	5	Very interesting	5	Very good







- Typical result (overall), separate for each lecture(r) as well
- Individual results available to the lecturer concerned

Dissemination of material

- Proceedings for General and Topical schools:
  - So far: 36 proceedings in printed form
  - General schools: only when programme/contents have changed significantly, most recent: Advanced Course 2013
  - Topical schools: every school
- On-line:
  - On-line versions of written proceedings available since 1983 (CERN Document Server), on arXiv since 2010
  - On INDICO since 2007/2009 (all slides and handouts)
  - Material for hands-on courses (including software downloads) since 2003
  - Budapest 2016: all lectures recorded for the first time
- All free of charge, but CERN copyright (ISBN, ISSN, DOI)

More details on Advanced courses:

- Strong focus on hands-on courses
- All afternoons, lectures only in the morning
- Students choose one of 3 courses:
  - Optics design
  - RF measurements techniques
  - Beam measurements

Hands-on courses: Optics Development

Personal Computer for each participant

Limited to 25 participants

Typically 3 to 5 tutors

Software installed :

Methodical Accelerator Design (MAD)

PTC, TPSA package (CAS version)

LINUX operating system

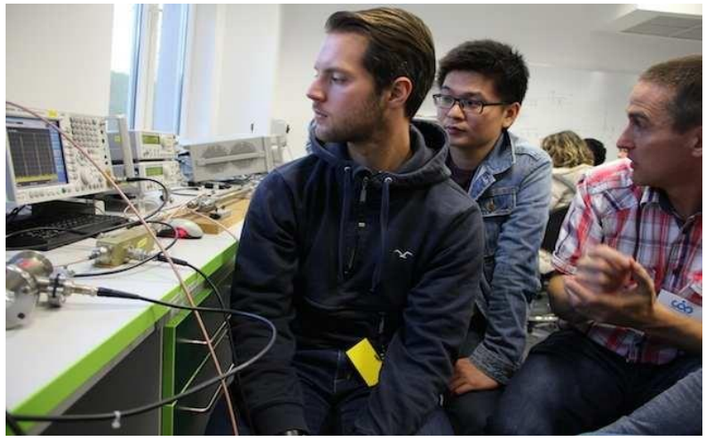
(WINDOWS versions available)

Courtesy V. Chetvertkova

Hands-on courses: RF Measurement Techniques

- RF measurement techniques with modern equipment
- Typically 2 - 3 tutors for 25 participants

Hands-on courses: Beam Measurement



- Understand basics of measurement principles and their implementation
- Working in small groups and present the outcome
- Interactive simulation tools are available

Upcoming Schools

Vaccum	Lund, Sweden	Jun-17
Advanced Accelerator Physics	Egham, UK	Sep-17
JAS: Rf technology	Japan	Oct-17
Introduction to Future Colliders	Switzerland	Mar-18
Beam Instrumentation	Finnland	Jun-18
Introduction Accelerator Physics	Romania	Sep/Oct 2018
Simulation tools for Acc. Design	?	Dec-18

Proposed as future topical CAS

Digital Signal Processing
Material Science and Precsion Engineering

Proposed for future JAS

Advanced Future Collider beam dynamics	2019
Advanced Future Collider technologies	2021

Further details on upcoming new CAS website

Next slide: Tentative program (still under discussion)

Non authorized tentative school poster

08:30	Arrival day and registration	Opening Seminar	Detectors for HE colliders/MDI I L.Linssen	Recap of long. BD I F.Tecker	Collider Diagnostics / Measurement of critical beam parameters I J.Wenniger	Beam-Beam/Beamstrahlung I X. Buffat	Instabilities/Collective effects/transverse and long. Damping/RT feedbacks I O.Boine-Fr...	Excursion	LC Beam dynamics I D.Schulte	NC & pm magnets T. Zickler	NC high gradient Rf systems I W.Wuensch	Collimation Systems, Lossmaps, safe beam handling and dump, MP concepts, interaction of particles with matter I N. Mokhov	LLRF challenges/timing T.Schilcher
09:20		Discussion								Discussion			
09:30		HE physics at colliders M. Mangano	Recap of transverse BD I H.Schmickler	cryogenics P. Lebrun	Circular Hadron Collider beam dynamics I M.Syphers	Circular Lepton Collider beam dynamics/damping rings I K. Oide	injection and extraction M.Aiba		SC RF systems I E.Jensen	SC RF systems III E.Jensen	NC high gradient Rf systems II W.Wuensch	magnet vibration and feedbacks A.Seryi	Kickers & Septa M.Paraliev
10:30		Coffee							Coffee				
11:00		Luminosity goals, critical parameters B. Muratori	Detectors for HE colliders/MDI II L.Linssen	Recap of long. BD II F.Tecker	Collider Diagnostics / Measurement of critical beam parameters II J.Wenniger	Beam-Beam/Beamstrahlung II X. Buffat	Instabilities/Collective effects/transverse and long. Damping/RT feedbacks II O.Boine-Fr...		LC Beam dynamics II D.Schulte	Single Shot high brillance beam transport W.Bartmann	RF power systems, CLIC drive beam S. Doebert	Collimation Systems, Lossmaps, safe beam handling and dump, MP concepts, interaction of particles with matter II N. Mokhov	alignment/metrology D. Missiaen
11:50		Discussion							Discussion				
12:00		Linear Collider studies overview S.Stapnes	Recap of transverse BD II H.Schmickler	Discussion Session I B.Holzer	Circular Hadron Collider beam dynamics II M.Syphers	Circular Lepton Collider beam dynamics/damping rings II K. Oide	Discussion Session II B.Holzer		SC RF systems II E.Jensen	beams production and transport to collider W.Bartmann	Discussion III B.Holzer	Final Focus/IR/Quadrupole stabilization A. Seryi	positron production M. Kuriki
13:00		Lunch								Lunch			
14:30		Large circular colliders overview, he incl. M.Benedikt	Lessons learnt from LHC M.Lamont	Case Studies Introduction W.Herr/B.Holzer	Free	Case Studies II W.Herr/B.Holzer	Case Studies IV W.Herr/B.Holzer		sc material C. Senatore	Case Studies VI W.Herr/B.Holzer	Free	Case Studies VIII W.Herr/B.Holzer	Reliability Engineering/Availibity of Complex A.Luedecke
15:30		Other HE collider projects (uu, gg) W.Chou	Lessons learnt from LEP W.Herr	Case Studies I W.Herr/B.Holzer		Case Studies III W.Herr/B.Holzer	Case Studies V W.Herr/B.Holzer		Sc magnets /LTS L. Bottura	Case Studies VII W.Herr/B.Holzer		Case Studies IX W.Herr/B.Holzer	Case Studies Presentations I W.Herr/B.Holzer
16:30		Coffee				Coffee				Coffee			Coffee
17:00		The big picture Fabiola Giannoti	technology overview and siting P. Lebrun	polarized electron beams/energy calibration J.Wenninger		Seminar I local	Vacuum Challenges R.Kersevan		SC magnets /HTS L. Bottura	Advanced technologies for collider P. Muggli		collimators & Dumps & Masks M.Seidel	Case Studies Presentations II W.Herr/B.Holzer
18:00		Extended Discussion											Closing
19:30	Dinner												

Outlook:

- No revolution…but steady evolution
- Adopt a scheme of 4 schools/year
- Presently under discussion:
  - Introductory school every year
  - Advanced School as topical school less frequent
  - “Even more advanced school “ even less frequent

- New website operational end June 2017
- Complement CAS by MOOCs
  specifically targeted at recapitulating the expected starting level for the (yearly) introductory courses