CAS Experience

Roger Bailey, Werner Herr, (CERN/CAS)

- **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"

- **No formal school in Europe until foundation of CAS, education at universities very scarce**

- **Occasional "International School of Particle Accelerators", i.e. 1976**

- **CERN as international organization, CAS not directly financed by government nor universities**
- **Takes place in different member states of CERN, all member states (20) visited at least once, foreseen: Turkey, Israel (member state since 2013)**
- **Participants and lecturers from CERN member states and other countries world-wide**

Provide framework for a series of courses:

- **General accelerator physics (yearly), alternating "Introductory" and "Advanced" course, emphasis on beam dynamics ($\approx$ 2/3)**
- **Topical schools specialized in a field, yearly up to 2013, now two per year due to high demand and TIARA outcome. (No dedicated courses on beam dynamics (yet), short introduction when required $\leq$ 10%)**
- **Occasional courses within framework of Joint Accelerator School (JAS) together with USPAS**
- **Since 2009: several courses on 'Basic Introduction to Accelerator Physics' for (CERN) technicians and technical engineers**

Schools

- **General courses (31 since 1983):**

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

- **Specialized topics (28 since 1983):**

  Residential courses, 1 week. Lectures, case studies

- **Joint Accelerator School (JAS, 11 schools since 1985):**

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

- **Basic introduction:**

  Not residential (but not at CERN), 1 week. Lectures and (few) exercises, accepted as formal training

Typical general school (Advanced level, 2013)

ADVANCED ACCELERATOR PHYSICS COURSE – NORWAY, 2013

Time	Sunday 18 August	Monday 19 August	Tuesday 20 August	Wednesday 21 August	Thursday 22 August	Friday 23 August	Saturday 24 August	Sunday 25 August	Monday 26 August	Tuesday 27 August	Wednesday 28 August	Thursday 29 August
08:30		Opening Talks	Transverse Dynamics II	New Tools for Non Linear Dynamics I	New Tools for Non Linear Dynamics II	Non Linear Dynamics II	Low Emittance Machines III		Landau Damping I	Landau Damping II	Timing and Synchronisation	
09:30			B. Holzer	W. Herr	W. Herr	O. Bruning	A. Wolski		W. Herr	W. Herr	H. Schlarb	
09:30		Transverse Dynamics I	Longitudinal Dynamics II	Beam Instabilities I	Beam Instabilities II	Low Emittance Machines I	Space Charge		RF Cavity Design	High Field Magnets	Feedback Systems I	
10:30	A	B. Holzer	F. Tecker	G. Rumolo	G. Rumolo	A. Wolski	M. Ferrario		E. Jensen	G. deRijk	H. Schmickler	
	R	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE		COFFEE	COFFEE	COFFEE	
11:00	R	Longitudinal Dynamics I	Introduction to Beam Diagnostics	Machine Protection	T1 Longitudinal Dynamics	Linear Accelerators I	T2 Transverse Dynamics	E	T3 Low emittance Machines	Medical Applications	T4 Non-linear Dynamics	
12:00	I	F. Tecker	H.Schmickler	R.Schmidt		M. Vretenar		X C U R S I O N		C. Biscari		
12:00	V	Introduction to Beam Instrumentation	Insertions	Private Study	Non Linear Dynamics I	Private Study	Instabilities in Linacs		Beam-beam	Private Study	Feedback Systems II	
13:00	A L	R. Jones	B. Holzer		O. Bruning		M. Ferrario		T. Pieloni		H. Schmickler	
		LUNCH	LUNCH	LUNCH	LUNCH	LUNCH			LUNCH	LUNCH	LUNCH	
15:00		Lattice Cells	C1	C1	FREE AFTERNOON	Low Emittance Machines II	C1		C1	C1	C1	
16:00	D A Y	B. Holzer	C2	C2		A. Wolski	C2		C2	C2	C2	
16:00		RF Measurement Concepts	C3	C3		Linear Accelerators II	C3		C3	C3	C3	
17:00		F. Caspers				M. Vretenar						
		TEA	TEA	TEA		TEA	TEA		TEA	TEA	TEA	
17:30		Discussion Session	C1 C2	C1 C2		Seminar Linear Colliders	Poster Session		Seminar	Seminar	Closing Talk	
18:30			C3	C3		E. Adli				CERN DG?		
19:30		**Welcome Drink/Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Dinner**	**Special Dinner**	
21:00			Discussion Session	Discussion Session					Discussion Session	Discussion Session		

Very diverse programme

C1, C2, C3 hands-on afternoon courses (Beam optics, RF, Diagnostics)

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)**
- **Vacuum: (1999, 2006, 2017)**
- **Power Converters: (1990, 2004, 2014)**
- **Small machine, high power machines: (1994, 2005, 2011)**
- **Synchrotron radiation, FEL: (1989, 1996, 2003, 2016)**
- **Ion Sources: (2012)**
- **Accelerators for medicine and industry: (2001, 2015)**
- **Colliding beam facilities(1983)**

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, 50%)**
- **Barbara Strasser (administrative assistance, full time)**
- **Bernhard Holzer (for some schools support during school preparation and running, part time)**

Not part of CERN departmental structure, reports to CERN directorate and Director General

Support and control by subsidiary bodies

Organization of CAS schools and programme:

- **CAS Advisory Committee (meets twice each year):**
  - **Membership: approved by CERN management (typically 50% - 60% non-CERN members)**
  - **Review previous schools, suggest changes if needed (consider students' evaluation where applicable)**
  - **Propose subjects for future topical schools**

    (consider demands and time since previous school on this topic)
  - **Propose venues (country) for future schools**
- **Proposals subject to approval by CERN directorate**

Organization of CAS schools and programme:

- **CAS Programme Committee (meeting for each school, further consultation if needed):**
  - **Membership: CAS staff, experts on the school topics (normally more than 50 % non-CERN members, local organizer)**
  - **Local university ($\approx$ 2/3) or laboratory ($\approx$ 1/3) as co-organizer**
  - **Review previous schools, suggest changes if needed, including students' feedback**
  - **Propose topics for the courses**
  - **Propose and invite lecturers**
- **Responsible for quality of the school**

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)
- **Scholarships (covers only fees, no travel): none directly from CAS, occasionally from local sponsor**

Expectations for lecturers

- **General and topical schools:**
  - **Working in the field, with good teaching and communication skills, able to adapt to the right level of the course**
  - **Contribute as tutor and facilitator in tutorials and group projects (including fields not related to own lectures), actively participate in discussions with students**
  - **Seek feedback and continue to improve lectures and keep material up to date (difficult)**
  - **Consult with other lecturers, agree on conventions, avoid contradictions (very difficult)**
  - **If foreseen: write up lectures for proceedings (extremely difficult)**
- **All lecturers invited on a personal basis**

Origin: Lecturers

	General schools	Topical schools
Laboratories (CERN):	**54 %**	**34 %**
Laboratories (non-CERN):	**34 %**	**47 %**
Universities:	**10 %**	**10 %**
Industry:	**2 %**	**8 %**

Rare: retired lecturers of previous schools

Level, prerequisite of participants (I)

- **General school (Introductory Course):**
  - **Staff of laboratories and universities (physicists, engineers, technicians), undergraduate and PhD students, post docs, staff in industry working with accelerators**
  - **Basic knowledge in mathematics and physics (high school level) or engineering, no training in accelerator physics (reference letter required if oversubscribed)**
- **For this Course: typically rather large spread of level:**

  (technicians, engineers, physicists - including particle physicist -, senior staff)

→ **Background material introduced at the beginning: Maps and matrices, Vector calculus, Basic Differential equations, Classical Electrodynamics, Relativity**

Level, prerequisite of participants (II)

- **General school (Advanced Course, all Topical schools):**
  - **Staff of laboratories and universities (physicists, engineers, technicians), PhD students, post docs, staff in industry working with accelerators**
  - **Solid background in mathematics and physics (1st year university level) or engineering. Basic training in accelerator physics or experience in Accelerator Operation or Technology**
- **In general: material based on Introductory Course (reference letter always required)**

Attendance:

- **Unlike USPAS/JUAS: much less focused on University Students**
- **General schools:**
  - **Introductory level: 110 - 130 participants**
  - **Advanced level: limited to 75 - 80 participants (due to afternoon courses)**
- **Topical schools:**
  - **Depends on topic: 60 - 100 participants**

General schools usually oversubscribed (up to 60%), ask for reference letter

Origin: Participants

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

Evaluation of the schools

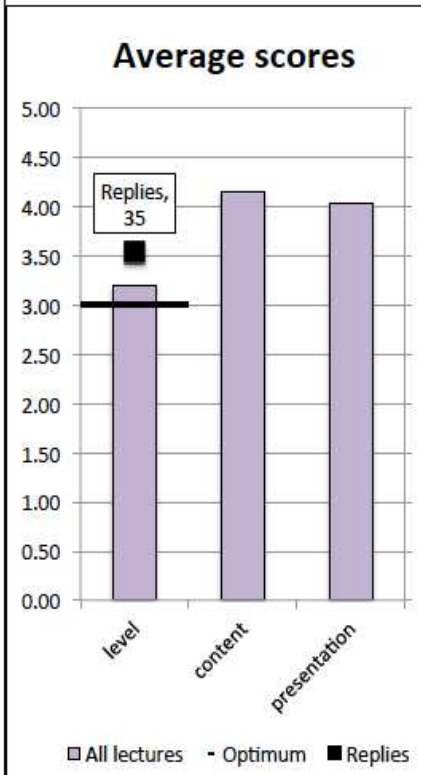
- **Quality of school and lectures are monitored:**
  - **Participants formally evaluate quality of lectures (level, contents and presentation)**

    (standard questionnaires and by additional comments)
  - **Evaluation includes organization and running of the school**
  - **Programme Committee includes evaluation to decide on lectures and lecturers**
  - **Encourage feedback from teaching staff (not yet very successful)**

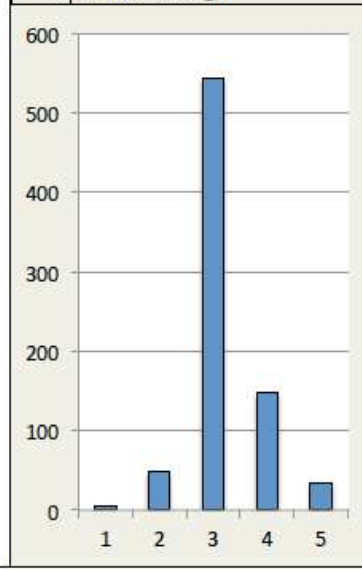
Evaluation of the schools

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

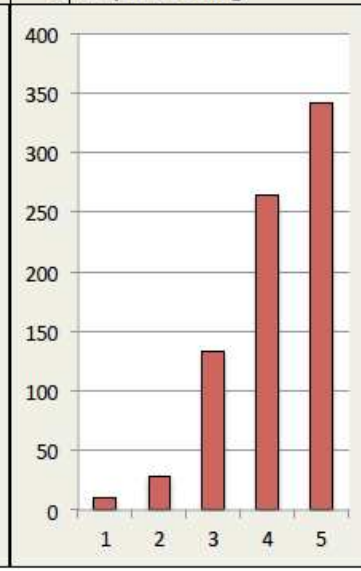
All lectures



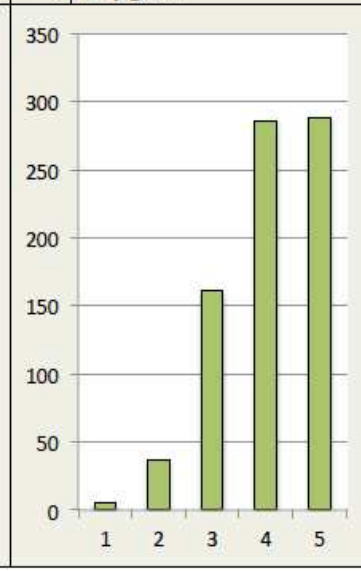
	Level
1	Much too low
2	Too low
3	Just right
4	Too high
5	Much too high



	Content
1	Completely uninteresting
2	Uninteresting
3	Of some interest
4	Interesting
5	Very interesting



	Presentation
1	Very poor
2	Poor
3	Fair
4	Good
5	Very good



- **Typical result (overall), separate for each lecture(r) as well**

Dissemination of material

- **Proceedings for General and Topical schools:**
  - **So far: 36 proceedings in paper form**
  - **General schools: updated/new when programme/contents have changed significantly**
  - **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 (slides, handouts, exercises*))**
  - **Material for hands-on courses (including software downloads) since 2003**
- **All CERN copyright (ISBN, ISSN, DOI), free of charge**

*) **can be somewhat problematic ...**

Credits for participation

- More focused on laboratory staff, no direct/permanent link to universities, credits on demand of students
- Has to be negotiated on a one to one basis with the university concerned, requirements have been:
  - Attendance
  - Syllabi
  - Attendance + Syllabi
  - Syllabi + Exam (by CAS and university lecturer)
- At CERN attending CAS accepted as training

Focus (I): training, i.e. applied physics

- **Mission:**
  - **React to demands from laboratories, universities and industry**
  - **Training of staff and students in accelerator physics and technology, mostly project oriented**
  - **Tries to cover different areas of accelerators (CERN legacy: bias toward synchrotrons)**
  - **Present accelerator technology (machine elements, diagnostics, ..)**
  - **Machine operation, control, performance**
  - **Applications of accelerators (often in Topical courses)**

Focus (II): "academic" work

(in close collaboration with some universities)

- **Intention (sometimes subjected to criticism):**
  - **Introduce new research fields and new developments (e.g. acceleration techniques, ..)**
  - **Improve questionable and obsolete treatment, in particular beam dynamics**
  - **Promote teaching of contemporary beam dynamics beyond standard*) textbooks (e.g. non-linear dynamics, collective effects, computational methods, ...)**

    (very well received by students, less by some lecturers)
  - **Improve teaching techniques**

*) .....

Evolution of the teaching strategies

- **Only subject-specific frontal teaching and rote learning at early schools**
- **Recent strategy (since $\approx$ 2003):**
  - **More focus on collaborative and problem based (active) learning (now $\approx$ 25 - 40 %, depending on level)**
  - **Well received in all schools, but strongly increases load on facilitators (full time available)**
  - **Our challenge: planning, organization and managing, provide necessary software and laboratory equipment (supply, transport, customs (many different countries, Switzerland not part of EU), setup, ..., wooden boxes)**
  - **Continuous evaluation of this approach to improve**

Future Schools

- **2015 (3 schools in preparation):**

  Advanced course (Poland), Medical applications (Austria), Intensity limitations (CERN)

- **Proposed (6 schools endorsed by Advisory Committee):**

  2016: Introductory course (Turkey), Injection/extraction/transfer lines (CERN), ERL and FEL (DESY)

  2017: Advanced course (Sweden ?), Vacuum (UK or Sweden ?), Cooling techniques (CERN)

- **Discussed (high priority and demand):**

  RF engineering, Small accelerators, Diagnostics, ...

Final considerations

- **CAS successful for more than 30 years, increasing number of schools and participants**
- **Complementary to university courses, different scope and audience, CAS does replace university courses**
- **Close contacts and synergy with universities, laboratories and private companies:**
  - **Provide infrastructure for lectures and practical work, including instructors**
  - **We strongly encourage (enforce) contacts between participants and with lecturers**
  - **Often results in recruitment of PhD students**
- **Last but not least: many students come back as lecturers ...**

  last schools (Trondheim, Prague): 19 ex-students (out of 45)

Hands-on courses - customs

Hands-on courses - optics

Hands-on courses - RF (I)