World-Wide Perspectives in Accelerators and the Rôle of CERN

I. Present large accelerator-based facilities

II. Proposals and ideas for the next step

III. Approaches to organize the next steps and the rôle of CERN

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I.1 Development and Progress

Key for progress: development of techniques and technology

Main examples from the past:

- linac (Wideröe 1927)
- cyclotron (Lawrence 1931)
- colliding beams (Kerst, O'Neill 1956)
- alternating gradient (Courant & Snyder 1958)
- linear e+e- collider (Tigner 1965)
- electron cooling (Budker 1966)
- superconducting magnets (BNL, CERN, FNAL, RAL 70's)
- superconducting cavities (CERN, Cornell, DESY, FZK, KEK 70's)
- stochastic cooling (van der Meer 1972)

This results in an impressive set of tools for physics, science and industry.

Examples for Particle Physics, General Physics and Science →

I.2 Accelerators for High-Energy Physics

1.Proton Synchrotrons and their ν_μ beams

	In operation			Under construction		
	EU	Asia	US	EU	Asia	US
Proton Synchro - trons	IHEP/ U70 70 GeV CERN/PS 24 GeV /SPS 400 GeV	KEK/PS 12 GeV	BNL/AGS 28 GeV FNAL/MR 120 GeV /Booster 8 GeV		KEK/JAERI J-PARC 50 GeV	
ν_μ – beam		KEK/ K2K 1.3 GeV	FNAL/Mini- BooNE 1 GeV	CERN/ CNGS 18 GeV	KEK/JAERI OA2 0.7 GeV	FNAL/ NuMI 3.5 GeV

EU includes Russian Federation

I.3 Accelerators for High-Energy Physics

2. Colliders (E_{cm})

	In operation			Under construction		
	EU	**Asia**	**US**	**EU**	**Asia**	**US**
e+e-	**LNF/** **DAΦNE** (1 GeV) **BINP/** **VEPP-4** (12 GeV)	**KEK/** **KEKB** (11 GeV)	**SLAC/** **PEPII** (11 GeV) **Cornell/** **CESR-c** (≤ 6 GeV)	**BINP/** **VEPP2000** (1.8 GeV) **/VEPP-5** (≤ 5 GeV)	**IHEP/** **BEPCII** (≤ 5 GeV)	
e p	**DESY/** **HERA II** (314 GeV)					
p$\underline{p}$ or pp			**FNAL/** **Tevatron** (2 TeV)	**CERN/** **LHC** (14 TeV)		
ion-ion			**BNL/RHIC** **Au-Au** (39 TeV)	**CERN/LHC** **Pb-Pb** (1148 TeV)		

I.4 Large Accelerator-Based User Facilities in other Fields

Nuclear Physics: 18 facilities in operation, 3 under construction in AM, AS, EU providing hadrons and electrons, e.g. CEBAF, RHIC; RIKEN, J-PARC; GSI, LHC.

General Physics and Science:

- **Synchrotron radiation facilities**: now up to x-rays, e.g.

3rd generation: 19 facilities in operation, 8 under construction providing a peak brilliance up to 10^{25} ph/(s.mrad^2,mm^2, 0.1%)

4th generation: 1 in operation, 2 under construction
peak brilliance up to 10^{33} ph/(s.mrad^2,mm^2, 0.1%)

- **Neutron spallation sources**: proton drivers (E_p, P_b)

in operation ISIS (0.8 GeV, 180 kW), PSI (0.6 GeV,1 MW)
under constr.: J-PARC (50 GeV, 1 MW), SNS (1 GeV, 1.4 MW)

II.1 Possible Next Steps
in Accelerator-Based Particle Physics

hadrons: RHIC upgrade
LHC luminosity upgrade (10 times)
VLHC E_{cm} = 40, 200 TeV (Phase I,II)

e+e-: Linear collider with E_{cm} = 0.5 to 1 TeV
Upgrade B-Factories and phi-Factory
Multi-Tev linear collider 3 to 5(?) TeV

ν-beams: ν_μ-Superbeam (π and K decay)
ν_e ν_μ Neutrino factory (μ-decay in ring)
ν_e Neutrino factory (β-decay in ring)

II.2 Possible Next Steps for Accelerator-Based Nuclear Physics

medium-term:

upgrades: CEBAF, GSI, REX/ISOLDE, TRIUMF

new: FAIR/ GSI, RIA/ US, SPES/LNL, SPIRAL 2/GANIL

for example: FAIR versus present GSI: intensity of primary heavy-ion beams increase 100 x, secondary radioactive beams increase 10,000 x

long-term: EURISOL/ EU (combined with a neutrino-factory ?)

All hadron facilities provide in particular very intense radioactive beams. Strong overlap with HEP.

II.3 Possible Next Steps for Accelerator-Based Facilities for Physics and Science

Synchrotron Light sources: e.g. in EU

- add powerful 3rd generation sources: PETRA II, MAX IV
- add 4th generation sources (single-pass) FELs:
  soft x-rays: at BESSY, at Daresbury (4GLS),
  hard x-rays: at DESY (TESLA), in IT SPARX

Spallation Sources :

ESS in EU with proton driver 1.33 GeV. 2 x 5 MW ?

Transmutation:

TRASCO (ENEA, INFN): proton driver 1 GeV, 30 MW

Advanced Medical Accelerators:

Carbon ion and p-Synchrotrons: HICAT(Heidelberg), CNAO (Milano), ETOILE (Lyon), MedAustron (Austria)

III.1 International Initiatives I

- **OECD/Global Science Forum**:
- Consultative Group on HEP:

  Membership: Scientists and funding agencies.
  Report → priorities:

  i) exploitation of current frontier facilities; ii) completion and full exploitation of the LHC; iii) preparing for the development of a next-generation electron-positron collider; and iv) the continued support for appropriate R&D into novel accelerator designs. Endorsed by→
- Ministerial Meeting (Jan.04) which

”...noted the worldwide consensus of the scientific community, which has chosen an electron-positron linear collider as the next accelerator-based facility to complement and expand on the discoveries that are likely to emerge from the Large Hadron Collider currently being built at CERN…”

III.2 International Initiatives II

International Committee for Future Accelerators (ICFA): welcomes the OECD statement and reaffirms in February 04

"..its conviction that the highest priority for a new machine for particle physics is a linear electron-positron collider with an initial energy of 500 GeV, extendible up to about 1 TeV, with a significant period of concurrent running with the LHC".

It has set up previously →

- **International Linear Collider Technical Review Committee:**

  Report on recommended R&D for Linear Collider issued in 2003

- **International Linear Collider Steering Committee (ILCSC) →**

i) **Technology Recommendation Panel**: for choice of LC technology in 2004

ii) **Global Design Initiative**: after this choice → setting-up global "proto-collaboration" (central team and 3 regional teams) to get to a Conceptual Linear Collider Design Report

III.3 European Initiatives I

European Committee for Future Accelerators (ECFA)

- **Working Group** on the Future of Accelerator-based Particle Physics in EU in 2000-2001. Essential conclusions: priority LHC, on-going experiments, and

"…the realisation, in as timely fashion as possible, of a world-wide collaboration to construct a high-luminosity e+e- linear collider with an energy range up to at least 400 GeV as the next accelerator project….",

and continued Accelerator R&D (ν-F, Multi-TeV LC, VLHC)

- **European Linear Collider Steering Group** (ELCSG)

  set up in 2002 with sub-groups (accelerator, physics &detectors, organisation & management)

III.4 European Initiatives II

- **European Steering Group on Accelerator R&D (ESGARD)**

  set up in 2002 by the directors of CCLRC, CERN, DAPNIA/CEA, DESY, LNF, Orsay/IN2P3, and PSI

  in consultation with ECFA

  to "develop a proposal to optimize and enhance the outcome of the Research and Technical Development in the field of accelerator physics in Europe aimed at preparing and conducting a coherent set of bids to apply for EU funding in the 6th Framework Programme. "

III.5 Accelerator R&D for Particle Physics in 6th EU Framework Programme (2003-2006)

The European Union is launching a new Framework Programme (FP6). It is a unique opportunity to apply for funding in order to develop a coherent European accelerator R&D programme for Particle Physics.

Relevant activity in FP6:

2. **Structuring EU Research Area** (2.6 G€) containing

2.3 Support for Research Infrastructures (655 M€)→

2.3.2 Integrated Activities (IA): provision of infrastructure related services to the EU research community → CARE

a) **Networking Activities(NA)**: support for pooling of resources for meetings, workshops, special training, travel, manpower for web and date bases

b) **Joint Research Activities(JRA)**: developing high performance and innovative techniques to improve the services provided by existing infrastructure

2.3.4 Design Studies (DS): concepts, prototyping and testing for for future European or world-wide relevant facilities. → DS

FP6 supports also R&D for Nuclear Physics, Synchrotron Radiation, Transmutation

III.6 ESGARD Activity in FP6

ESGARD is active in

- **CARE** Project approved in 2003

-- FP6/ 2.3.2 a (NA): to coordinate studies and technical R&D for

- Electron linacs and colliders
- Beams for European neutrino experiments
- High-energy and high-intensity hadron beams

-- FP6/ 2.3.2 b (JRA): sc rf, photo-injectors, high-intensity p-acceleration, high-field sc magnets and cables

- Design Studies (**DS**) within FP6/ 2.3.4

- Global TeV Linear Collider submitted 2004, formal ok in July 04
- in preparation for possible bid in 2006:
  - Neutrino Factory based on μ-decay ring
  - Next generation Φ-Factory
  - LHC luminosity upgrade
- Neutrino Factory based on β-decay is within the EURISOL DS, submitted in 2004 by Nuclear Physics, ok in July 04 ?

III.7 Position of CERN I

Priorities for 2004 -2010:

- LHC completion and start operation in summer 2007
- CERN Neutrino Beam to Gran Sasso: start 2006
- Consolidation of injector complex for reliable LHC operation
- European coordinating accelerator R&D and studies with other European laboratories for
  -- LHC luminosity upgrade (primary goal)
  -- generic Linear Collider design issues
  -- keep in touch with EURISOL and FAIR

  Possible other goal: new fixed-target experiments to be defined in Workshop in September 2004 →┐
- Decision for minimal investment based on these studies in 2006 (e.g. proton linac 4, R&D, experiment defined in 2004 ┘)
- Accelerate tests of CLIC concept to understand feasibility by 2010 with voluntary, external contributions under common responsibility

III.8 Position of CERN II

Programme after 2010:

- In **2009-2010 review** and define strategy for the next decade in the lights of the results of LHC and the other actions taking into account the developments on the international level and in other regions….
- Guided by:

i) the very flexible **CERN Convention**, e.g. Art.II.1

“The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto…”

ii) **CERN Council** (20 Member States) which applies and interprets the Convention.

III.9 Final Comment I

Future large facilities are complex and expensive

→ each region cannot afford all types and get them in timely manner due to limited resources.

→ keep their creation, organization and operation simple:

- favour in each region/country the project which optimally uses

  -- **existing** resources (investment <u>and</u> competences)

  -- **existing** forms of organisation

- **concept of strong lead region/country** is the most realistic one:

  the resources of the host cover a large part of the project and make the project rather independent from outside contributions

- **limit** the number of large laboratories by (re)using existing facilities

III.10 Final Comment II

- **Global coordination** of planning, construction and operation of future large-scale scientific facilities amongst the major players
  → very desirable

  Example of large-scale coordination:
  "Facilities for the Future of Science: Twenty-Year Outlook"
  US/DOE/ Office of Science (November 2003)

  Body for such global coordination: difficult to find
  Maybe OECD/Global Science Forum to start the discussion?

- **Global cooperation** should largely replace competition.
  Excessive competition leads to redundancy and rash decisions
  → risk of loss in credibility

Facilities for the Future of Science: A Twenty-Year Outlook

DOE/ Office of Science, November 2003

Excerpt for accelerator-based science:

Priority	Program	Facility
Near-term		
Tie for 3	NP	Rare Isotope Accelerator (RIA)
Tie for 7	NP	CEBAF Upgrade
12	HEP	BTeV (FNAL fixed-target experiment)
Medium-term		
13	HEP	Linear Collider
Tie for 14	BES	Spallation Neutron Source (SNS) 2-4 MW upgrade
Tie for 18	NP	RHIC II
Far-term		
Tie for 21	BES	National Synchrotron Light Source Upgrade
	HEP	Super Neutrino Beam
Tie for 23	BES	Advanced Light Source Upgrade
	BES	Advanced Photon Source Upgrade
	NP	eRHIC

BES = Basic Energy Sciences

Conclusion

- **Accelerator-based science** is thriving
  -- large park of operating accelerators
  -- medium-term development well defined
  -- closely-knit network of specialists
- **Future accelerators** need continued innovation in technology and accelerator physics → vigorous R&D with strong international cooperation and communication is imperative
- **EPAC 2004** is a token for the good functioning of the latter two.