“hitting limits”, both in terms of budgets and launchers. Hence, the time has come to think seriously about more new technology, notably miniaturization (the US Clementine spacecraft is a good example). Meanwhile, one has to be careful that partners are “reliable” when extending international cooperation to generate critical masses.

Structures to Handle Facilities’ Growth

Astroparticle physics has been characterized by “dogs that did not bark” (null signals) involving such things as proton decay, magnetic monopoles, neutrinoless decay and dark matter. However, there have been some positive results and L. Maiani, the President of Italy’s INFN, in reviewing under-ground and under-water facilities for astrophysics, highlighted work on supernovae and solar neutrinos. We concentrated on the latter to illustrate the growing importance of large facilities such as the Gran Sasso Laboratory for astrophysics. Solar neutrinos from beryllium have been seen and the neutrino spectrum is inconsistent with the standard solar model. Two major new underground neutrino experiments come on-line shortly (Sudbury in 1995; Super Kamiokande in 1996) and there are good possibilities that Borexino will be approved. The main question now is if third-generation experiments will be needed. There is also continuing progress in the field of under-water (under-ice) neutrino telescopes, and long-baseline experiments will be needed to eventually check neutrino oscillations. With this expansion, there is a need to organize in some way the development of the various facilities. An inter-regional approach, that addresses increasingly finer structures, is one proposal for tackling an issue that will repeatedly challenge physics as it plans the ever more powerful and sophisticated instruments that are essential for future advances.

Luciano Maiani, on the left, spoke about Earth-based facilities for astrophysics.

The evolution of ESA’s Space Science Missions.

On the right: there has been a massive increase in the payloads as more powerful launchers became available.

On the left: the costs (in millions of Accounting Units) of the large CS-Class (Cornerstone) and M-Class (Medium-sized) missions have reached a plateau in spite of increasing complexity.

1994 EPS Large Facilities in Physics Conference

ROUND-TABLE DISCUSSIONS

Three round-table discussions were held during the 1994 EPS Large Facilities in Physics Conference.

Large and Small Science

Challenges and Benefits of Large Facilities

Selection Procedures & Priority Assessment for Future Large Facilities

ROUND-TABLE: Large and Small Science

Promoting Opportunities Together

Science has a place for all styles, whether collective, cooperative or small-group based. Attracting young people into the whole of science, both large- and small-scale, is appropriate and would be the most effective. Facilities can help by stressing ways to channel creativity and to transfer technology, and by training engineers.

The level of public support for science seems good, but the interest is not translated into more opportunities for young people since the mechanisms to promote science are inadequate.

Facilities, and more recently large cooperative science, is extending into the traditional small-science fields, with traditional large science providing a valid model.

Facilities have a special role to play in some countries, where special organizational structures may be appropriate.

Specific statistics about funding should help in reducing tension between the different branches of science.

Discussing the correct balance between large and small science was for Hans Chang (Director of the Dutch funding agency FOM) an irrelevant, emotional issue stirred up by governments seeking reductions in difficult economic times. Physics certainly needs to stand united, but this will be difficult when it comes to bread and butter issues, especially since certain fields need a boost to maintain them as interesting to areas outside physics. However, he questioned the wisdom of placing large facilities in a special category to insulate them somewhat because they are showing traditional small-science fields the way forward. The important feature today is that owing to improved communications and organization and increased size and internationalism we are now dealing with a new way to do science, and it is this that one should look at.

Attracting Young People

Aside from asking whether a particular field delivers high-quality results, the real question is if a large or not large science attracts young people, for facilities will come to a premature end not from a lack of money, but through a lack of talented young people.

The large collaborations found at some facilities are often seen by those working in small groups elsewhere as being unattractive. Herwig Schopper, the conference chairman, stressed that the small-group culture in fact thrives inside most facilities. The real drawback is that their scientists now often only work on a few experiments in a lifetime, so there is a need to make better use of creativity.

After an animated discussion, speakers agreed that there was “a place for all” for large collaborations and small university-based groups. Any tension arising from differences in the working styles cannot be too great because people in both environments appreciate each others’ efforts, especially in theory where ideas move freely.

As Norbert Kroo, EPS President and Director of the Insti-
Hans Chang, on the left, with Cecilia Jarlskog, who chaired the round-table on large and small science.

Institute of Solid State Physics in Budapest, put it, both soloists and symphonies are needed—the challenge is to optimize the outcome of both.

Alberto Santoro, a theoicn from the Brazilian Centre for Fundamental Physics in Rio di Janeiro, also wanted to rephrase the issue of large versus small science because he felt that it was often raised simply because one could discuss things elegantly, using sophisticated concepts. But for him the real question also concerned young people as not enough is done to ensure that they are able to work in large facilities. In particular, in his region, where facilities are rare, young people will be lost to parts of science if the difficulties in financing international facilities persist. It was Yoshiro Yamaguchi, the President of the International Union of Pure and Applied Physics, who explained that large facilities are extremely precious in developing countries. Instead of trying to build up a broadly based small-science community from scratch, it is more effective to focus resources on part of the spectrum, and to use successes to expand into other fields.

Defusing Emotion

Nevertheless, the emotional issues attached to large and small science were to Peter Wyder, Director of the High Magnetic Field Laboratory in Grenoble, very real for the reflected real tensions. The emotions need to be controlled or they will explode, as happened in the lead up to the closure of the Superconducting Super Collider. Although his field of small science is growing up in the sense that larger facilities are crystallizing out of small groups of condensed-matter physicists distributed throughout the world, he had no easy answers as to how large and small science should coexist, especially because Hubert Curien had stressed that funds are not transferred between fields. Instead, he urged people in large facilities to be more sensitive for it is a “question of taste” whether high-temperature superconductors are more important than Higgs bosons.

To Burton Richter, President of the American Physical Society and Director of the Stanford Linear Accelerator Center, emotional aspects are a distraction because the real issue concerns the instruments needed to advance the various fields of physics. Traditional small science is moving towards larger facilities so in spite of the undoubted successes of small groups, the world has maybe moved on.

Herwig Schopper suggested that the best way to reduce the emotion amongst what he assumes is a rational community is to put facts on the table. For instance, one needs to clear up the misunderstanding that people in large facilities compared to universities have more resources simply because all their costs are included. To illustrate the point, Hans-Christian Walter, head of nuclear and particle physics at the Paul Scherrer Institute, Zurich, noted that at least one speaker had claimed that a particle physicist cost more than an average physicist whereas a recent study in Switzerland has shown that they cost about the same as a solid-state physicist. However, David Wallace, presently Vice-Chancellor at Loughborough and formerly a member of the former Science and Engineering Research Council in the UK, explained that his research council typically needed two-times more funds to support a physicist in “extremely large” science than an individual, university-based condensed-matter physicist. The factor dropped to three for scientists using facilities for structural studies, and there could be some offsetting by funds from other sources, including industry. Burton Richter then spoke of annual budgets at SLAC and CERN, and probably the European Synchrotron Radiation Facility (ESRF) as well, working out at about US$ 120 000 per user. This compares with average government support in the US of US$ 150 000 across all fields of science. So while a factor of two might be appropriate for particle physicists (owing to the cost of running accelerators), an order of magnitude difference seemed unlikely. He was supported by figures given by Yves Petroff, the ESRF’s Director-General, showing that an ESRF user costs about the same as a scientist working in the French CNRS research system. The comment that such figures are prone to double counting only reinforced the feeling that accurate statistics are lacking. However, much good quality data already exists so it is probably specific information which is needed (e.g., the evolution of the funds spent on scientists in various sub-fields).

New Structures

P. Ahluwalia who works for Canada’s research council felt it was incorrect to equate large science with large facilities. One needs to go beyond instruments and look at organizational structures, for the communities involved in traditional small science now require the organizational support found in large science in order to participate in the human genome, global climate change and ocean drilling programmes (José-Mariano Gago, a particle physicist from Lisbon, referred to “large cooperative science” as distinct from large corporate science).

Many of the young participants contributed to the discussion.

Yoshiro Yamaguchi, on the left, addressing the audience during the round-table. With him are (from the left) Peter Wyder, Alberto Santoro and José-Mariano Gago.

Deszö Kias from Budapest, formerly Director-General of the Joint Institute of Nuclear Research in Dubna, pointed out that the organizational aspects of large facilities are in fact already highlighted in smaller countries where such facilities potentially need a much larger share of science budgets. Starting from the premise that physicists would not wish to turn their backs on a field simply because the instruments it needs are large, Hungary’s solution has been to fund space research and the like through a ministry for technical development. This is a delicate and far from ideal approach as the controlling body is not rooted in basic research. Nonetheless, it seems to work in Hungary.

Generating Support

Science is under stress today owing to reduced public (and hence political) support. Nonetheless, surveys show that a large proportion (about 70%) of the general public is interested in knowing more about basic science. The problem is that they are poorly served because popularisers of science are lacking in the media and government. P. Verplancke, a young physicist from the Max Planck Institute for Plasma Physics, Garching, reproached his senior colleagues for not translating this public interest into more support because the growing number of young people interested in science do not have enough jobs.

Herwig Schopper felt it necessary to point out that alarmist projections in Germany of the lack of jobs were probably “completely wrong”. In any event, young physicists should be encouraged to work in other fields. Physicists can undoubtedly bring valuable skills to areas outside research such as banking and government.

It was Burton Richter who explained in straightforward terms what needs to be done to stop support from “shrinking inexorably.” One has to accept that a scientist’s motives may only partly overlap with government’s, and that physics once enjoyed military and politically motivated support. The time has come to spend much more time thinking collectively about how to explain the short and long-term benefits of science in intellectual and scientific terms. Herwig Schopper refined the objective by saying that it was not a question of “defending” science (certainly legitimate because scientists draw satisfaction from science) but of pointing out that in the long run society’s problems can only be solved with more science.

Stress Multidisciplinarity

Herwig Schopper also wanted to clear up
any misconception that large facilities as compared to small science do not provide an adequate training ground for young people by being too removed from economic reality. This was completely wrong because large facilities regain public esteem since adequate training ground for young people by being too removed from economic reality. This was completely wrong because that large facilities as being the greatest challenge — but primarily at the political level in assuring the community's consent that regions participating in detector collaborations when a facility begins to function must contribute to detector collaborations and planning stages, not only to ensure good science but also to develop political support, and to identify a host laboratory that plays an important but not a dominant role.

Particle physics, unlike synchrotrons and similar sources, has to integrate two types of equipment (the accelerator and detectors). This has traditionally been done by forming detector collaborations and having them report on the scientific needs and the needs of the user community via community-based bodies (e.g., ICFA), to involve users in the definition and planning stages, not only to ensure good science but also to develop political support, and to identify a host laboratory that plays an important but not a dominant role.

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many parameters are involved. More data is needed and possible solutions maybe include data distribution and the remote control of experiments.

John Peoples pointed out that unlike astronomy, most fields of physics have not worried too much about data archival. One may now have to adopt the astronomers' model by having cataloging devices that can be reused after a suitable initial period. Some speakers thought archiving data would be difficult in practice as raw data often needs considerable manipulation before being useful. However, some manipulation is already being done by facilities. So while one may argue about the sort of information that should be stored (storing raw data is best if one can afford it, because the ultimate value is so unpredictable), it is now only a matter of "carrying the idea further". Burton Richter also endorsed the idea as it is not a huge task to transform data so that it is easily accessible to anyone other than members of the "in group" that performed an experiment.

David Wallace commented that one should go further by exploring opportunities offered by information technology as a whole because topics such as the use of information highways to provide electronic access have not roused much interest so far. Hewig Schopper pointed out an important advantage of the remote control of experiments is that scientists would be kept where they belong, namely in their universities and institutes participating in normal academic life.

Speakers agreed that it is unwise to take considerations of the relative costs of remote and personal (face-to-face) access too far because topics such as the use of information highways to provide electronic access have not roused much interest so far. Hewig Schopper pointed out an important advantage of the remote control of experiments is that scientists would be kept where they belong, namely in their universities and institutes participating in normal academic life.

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ROUND-TABLE: Selection Procedures and Priority Assessment for Future Large Facilities

The Basket Finds Favour

Different perspectives, and the balance between them, come into play when setting priorities for facilities, with political aspects dominating. Consideration of a proposal, including its difficult non-rational aspects, at the appropriate governmental and political level will lead to a successful outcome provided there is general agreement on the scientific goals. Appropriate bodies and channels are needed at and between the various levels separating a proposed facility’s user community from the decision-makers. Several types of suitable bodies exist at some levels and in some fields, so there are models available for ways to fill in what is missing.

Both bottom-up and top-down approaches have been used successfully to promote facilities at the European level and in general there are no rules for deciding which is best. The situation is much less promising at the international level. The basket approach of sharing out a suite of regional and international projects is robust enough to serve as a way for governments to reach decisions on projects that are increasing in size and scale. Implementing the approach needs some formal steps.

Deciding whether or not a proposed facility is international in scope and access is maybe too difficult for scientists to take alone, especially since there is a natural tendency to promote and operate facilities according to national interests.

The round-table Selection Procedures and Priority Assessment for Future Large Facilities came to some definite conclusions concerning most of the themes that it was asked by Hubert Curien, the chairman, to discuss. The main themes were:

1. The complementarity of scientific and political approaches in selection procedures;
2. The role of international organizations and governmental bodies;
3. The type of advice decision-seekers from users;
4. Importance of advising governments on a wide scientific front;
5. What determines if a facility should be national, regional or global in scale.

Science Proposes, Politics Disposes

Promoting a facility calls for an acute awareness that different communities have very different perspectives when they set priorities for fundamental research. Herbert Walther, the Director of the Max-Plank Institute for Quantum Optics, Garching, noted that, broadly speaking, scientists think in terms of originality, quality, feasibility, infrastructure, and value for universities; industrialists worry about spin-off; general opportunities for exploitation and technical significance, while politicians have in mind possibilities for regional development, society’s needs, and the publicity value. Moreover, the balance between the various priorities changes. Right now governments attach more importance to industrial and social needs, and the public is wary of certain fields such as nuclear physics.

For Luciano Maiani, the President of the Italy’s Institute for nuclear and particle physics (the INFN), approving projects is “in the end a political issue”, coming after discussions between politicians and scientists. However, for this stage to be reached the scientific relevance must be clearly established as being at the fronts, and the planned facility must be accepted by a large community. Many of the failures in promoting facilities arose because the sector of science not directly affected were not in agreement. Facilities must be "science driven" with scope and goals set by scientific needs (J.R. O’Fallon, US Department of Energy). They must also be presented to government at an early stage, and later at a formal level to ensure that the desired funding is reasonable and the political implications acceptable.

Herwig Schopper pointed out that setting priorities becomes difficult for both scientists and politicians when issues with non-rational answers are raised, such as how to distribute resources between different fields and how to determine the interval between successive large projects (using natural human time-scales seems to be the sensible answer).

Forums are Needed

It becomes increasingly difficult to discuss needs and priorities as one moves from the community level, through community/government dialogue to intergovernmental negotiation. From her perspective as Secretary of the OECD’s Megascience Forum, Françoise Praderie argued that “things work” at the scientific level. Integrating what scientists want into the broader political perspective at the national level has also been shown to work if special structures are set up (such as France’s ministerial advisory committee on large instruments that examines needs throughout science). Government-level agencies play a valuable role in co-ordinating the views of scientists and government, but here there is an imbalance, at least in Europe. Governments apparently communicate to the agencies extensive descriptions of long-term strategic plans whereas scientists only get short-term funding.

On moving further up the chain one finds that we are “less well equipped at the international level” (Praderie), although some examples of the essential elements are already in place. For instance, international, community-based discussion bodies such as ICFA and its European counterpart, ECFA (one of a number of European-level discussion groups, including academies of sciences and the scientific unions) that interface between the scientific community and government have already shown their usefulness. Fields other than particle physics have “missing links” — missing lines of communication — that could be filled by bodies of the ICFA type.

Finally, at the intergovernmental level, the first step towards creating a environment where governments can coordinate approaches efficiently has been taken by forming the OECD Megascience Forum. Norbert Kroó pointed out that there are some general issues in setting priorities such as the need to achieve a proper “balance” between intellectual potential (which is fairly uniformly distributed) and economic capacity (which is not). Physical scientists are very well placed to advise on such a problem (i.e., the effects of a stringing decision on the brain drain).

Appropriate Channels to Deciders

Examining how existing facilities were promoted gives some ideas on what type of advice deciders seek from users and how it is communicated. Europe has been fairly successful in creating facilities as there are at least seven physics-related European-scale facilities and organizations. Herbert Walther felt that the best way to promote a facility is the bottom-up approach where an ad hoc community-based discussion group
initially seeks a consensus. However, some European institutions have also successfully promoted facilities, notably the European Science Foundation in establishing the ESRF, so this avenue should not be ignored.

The record is not so brilliant at the world-scale where among the few projects, the International Thermonuclear Experimental Reactor (ITER) project has problems stemming from its regional bias. ITER evolved out of top-down discussions in a sub-group called the Attali committee that prepared joint projects in many topics (not just science) for meetings of the heads of governments of the G7 countries. This subgroup represents one of the relatively few international-level discussion bodies with interests in science.

The variety of at least partially successful approaches supported Luciano Maiani's view that there are no general rules for the discussions between science and politicians (apart from a need for "fair play", which science can best ensure by putting forward widely accepted frontier projects).

**Baskets Across a Broad Front**

It was Luciano Maiani who introduced Burton Richter's basket concept that aims to help the "selling" of projects to government by introducing a mechanism to distribute the economic benefit of hosting a facility. One puts various large projects into a basket and has government decide upon major issues such as a priorities and siting, because whatever scientists think, it is politicians who decide such things. The advantage is that one can envisage the simultaneous operation of a number of projects.

On the time-scale aspect, Hubert Curien argued that the difference between various projects are not large enough to "destroy the basket" because major facilities take a long time to realize, construction times are similar (and should anyway be increased to enable parts of the process (e.g., the R. & D. phase) do not need to be coordinated between different projects.

The problem of having the basket operated by organizations of different size and scale, perspectives have changed; the large space agencies, even if not so pressing, which naturally leads to thinking in international terms. This problem is neutralised by using national facilities to address particular kinds of frontier problems, or instance, those of a relatively large amount of user time (which is less restricted at a national facility) or a long duration (national facilities tend to have long life-spans). Burton Richter felt it could also judge if a national facility is preferred because industry is involved or because one needs to translate the project into a national project.

Hubert Curien was not so sure scientists alone could judge adequately, because, to put it bluntly, "nobody wants to be second class, even for a national facility". There is an understandable desire to seek the best, which naturally leads to thinking in international terms. This problem is neutralised by using national facilities to address particular kinds of frontier problems, or instance, those needing a relatively large amount of user time (which is less restricted at a national facility) or a long duration (national facilities tend to have long life-spans).

Generally speaking, "national tendencies ones include the difficulty of synchronising the operation of a facility, especially if it comes from equally well-developed countries. This must be resisted otherwise there will be "a trade war in science". It can be resisted because although the books may not balance in a given area, they are sure to balance across the whole of science.