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Contents

libroGTC_ELTF061109.indd 244 12/11/2009 12:46:10

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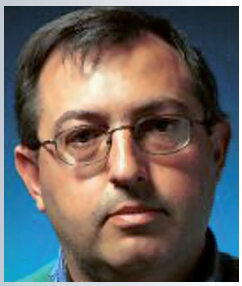

FAST CONCLUSIONS

libroGTC_ELTF061109.indd 245 12/11/2009 12:46:11

1. Fast Conclusions

First of all, I would like to remind you of the reason why we are here: the GTC is now operating! As a community, I'm sure we all welcome this news, we all congratulate those who made it possible and thank the organizers of this meeting for providing us with an exciting overview of current 8-10 m telescopes and other similar, future, or related facilities.

I have been impressed by the presentations. Impressed, but not surprised, as they referred to some of the best currently available telescopes and instruments and to some of the most promising future facilities.

It is not easy to extract just a few points out of all these excellent presentations, and their corresponding discussions. Of course, this summary is necessarily subjective. It may be that some of those present in the meeting find their ideas here not properly expressed or recognized, or feel that I have skipped important points, comments or conclusions. I can only apologize in advance, and remember an old german saying: Wer nichts tut, macht keinen Fehler; wer keinen Fehler macht, wird befördet (who does nothing, makes no errors; who makes no errors, is promoted). I have no interest in being promoted, so I'll try to provide this summary, in the hope that it can be of help for you and also for those that couldn't attend the meeting.

I wish to be brief in my conclusions. To this aim, I'll follow the outline provided by the questions presented yesterday in the "Wine and Cheese discussion". This session brings me to my first, zero-order, conclusion:

Conclusion 0: Cheese and wine are really fine!

libroGTC_ELTF061109.indd 246 12/11/2009 12:46:11

2. Question 1: Scientific strategies

The first question presented in yesterday's discussion was: What should be the role of the 8-10 m telescopes in the era of the ELT and the JWST (or any other equivalent facility)? In other words, what should be the scientific strategy of these telescopes? To open the discussion, three possible approaches were presented: a) the nurturing approach: start to dedicate a significant amount of observing time to projects that will later be explicitly aimed at ELT and JWST; b) dedicate as much time as possible to individual projects, trying to collect as many new results as possible; and c) maintain competitiveness in the new era, by optimizing the operation efficiency, enlarging the instrument suite or specializing in unique capabilities.

This question was already addressed in his talk by William Smith, who described possible organizational models for observatories, and recommended to carefully select the optimum one in each particular case. An important point of his presentation was that there were successful examples of all models among the 8-10 m telescopes. Taft Armandroff pointed out that observatories should pay attention to all three aspects, but always having the opt priority be scientific merit.

The discussion continued with important comments by other participants. Thomas Henning and Bruno Leibundgut reminded us that the ELTs and the JWST are still a long way from construction. Furthermore, the ELT will need additional time for its instrumental suite to be ready. As pointed out by Jean Rene Roy, "8-10 m telescopes have a decade of scientific freeway ahead", and many participants emphasised the need to make use of all facilities, not just the largest or newest, in order to carry out top-level science (even including telescopes like KELT, the Kilodegree Extremely Little Telescope).

The answer I have chosen for these questions, my conclusion number 1, makes direct use of two sentences expressed during the discussion, one by Bruno Leibundgut and the second one by Phil Charles:

Conclusion 1: do your best science now, do it as well as you can, pushing current telescopes to their limits, and in a natural way these projects will lead the way towards the ELTs when these become available (or are close to completion).

libroGTC_ELTF061109.indd 247 12/11/2009 12:46:11

3. Question 2: Science topics

A question that we didn't address during the Cheese and Wine discussion but is clearly in our minds, is that of the hot science topics, those that should guide our way towards the ELT and the JWST.

I would like to mention here an important remark made by Bruno Leibundgut during his talk. He noted that we live in a Golden Age of Astrophysics, as we have access to all possible wavelengths, from gamma-rays to radio, and have access to a large number of excellent telescopes of all sizes, well equipped with modern instruments and sensitive detectors. Combined with powerful number-crunching machines we can study the Universe at any wavelength. At the same time, there is wide public interest in Astronomy (the success of activities during IYA2009 is a nice confirmation) and other communities (like the astro-particle community) are approaching us. This situation is the result of the sustained efforts made during the recent past, and it is our responsibility to preserve and improve it (as difficult as improving a "Golden Age" situation may be…).

Without meaning that they are more important than other topics, Planets and Planetary/Stellar disk systems clearly have dominated the presentations, with interest presently shifting from discovery, to how planetary systems form (see Matt Greenhouse's presentation). Instrumentally, the demands for such research are linked to the AO systems either operating or under development at all major observatories (and which can be applied to many other problems). As examples, AO was explicitly mentioned by Jerry Nelson to be one of the main drivers for TMT, and Taft Armandroff demonstrated how LGS systems can overcome the limitations inherent in NGS. In some cases (VLT, LBT, Keck) interferometry can take such work one step further.

Many other topics were mentioned by several speakers: galaxy formation and evolution, dark matter and dark energy, GRBs and supernovae, the reionization epoch… Actually, the science cases seemed to be quite similar across the presentations, with perhaps the main (still relatively small) differences being between space and ground-based facilities. As a consequence, extensive interest in multiplexing capabilities and broad wavelength coverage can be seen in new and planned instrumentation. Another dimension was present in science cases based on new technological developments, such as high temporal resolution (LSST, SALT), or the combination of high temporal and spectroscopic resolution (LBT), as well as the remarkable microshutter arrays for NIRSpec.

Conclusion 2: We have seen interesting and important science cases covering all areas of astrophysics. It's very difficult to predict which will be the main drivers in ten years. Be prepared for the unexpected.

libroGTC_ELTF061109.indd 248 12/11/2009 12:46:11

4. Question 3: Data archives & mining

The comparison of CCD versus mirror growth made by William Smith and Tony Tyson clearly demonstrates the impact large CCDs are having in astronomy. Whereas the mirror area available for observations has increased since 1980 by less than an order of magnitude (which is however very appreciable) the number of detector pixels has increased by more than three orders of magnitude, and is maintaining a substantial growth rate. When we reach the dimensions of the LSST or SASIR projects (see Tony Tyson and José Franco's papers) the handling of such huge amounts of data, in real time, including potentially thousands of alerts per night, may become a problem in its own right.

The importance of Virtual Observatories and Archives is therefore rapidly increasing and there are real efforts at many observatories and institutions to create archives that conform to the International Virtual Observatory Alliance, so that these (expensively) collected photons can be used for the maximum amount of science. According to numbers presented by William Smith, archives in the US already contain 0.5 Pb of data, increasing at a rate of 250 Tb/yr. When fully in operation, LSST will deliver 3 Tb per hour.

Handling and interpreting these gigantic datasets may be an even larger problem. To extract the relevant information will be a very demanding task, even with modern computers and automatic analysis techniques. It is thus important, as pointed out by Phil Charles, to deliver already processed and science-ready data to the community.

Conclusion 3: Important resources and efforts will go in the immediate future into data handling and archives, and related software and infrastructure. When planning our telescopes we must pay attention not only to the instruments, but also to the resultant archives and data handling.

libroGTC_ELTF061109.indd 249 12/11/2009 12:46:11

5. Question 4: Collaboration

The issue of collaboration captured the immediate attention of the audience. Actually, several already ongoing collaborations between observatories were mentioned, such as Gemini and Keck for the LGS contract, or the agreement for observing time exchange between Subaru, Keck and Gemini. In future, the potential for other possible collaborations, like that of GTC with LSST, GMT and SASIR, or that of SASIR with LSST, was acknowledged. Moreover, both Álvaro Giménez and Matt Greenhouse emphasized the collaboration possibilities of JWST with ESA missions.

Jean René Roy and Thomas Henning also pointed out the difficulties that always occur in collaborations: the need for clear goals in the collaboration, the different interests of the partners, the asymmetries present in large multi-partner collaborations, the need to recognise all points of view, among others. And strictly focussing on the ELTs, Carme Gallart complained that Americans and Europeans are not really collaborating in the ELT effort, and spoke in favour of such collaborations, as in the cases of HST and JWST.

Generally speaking, there was an extended feeling that any collaboration would be possible and positive, and that it would be worthwhile to work in such direction.

The discussion was particularly interesting when it came to discussing instrumental projects. José Miguel Rodríguez-Espinosa expressed support for a scientific competition; but not a competition in instrument building. He proposed that instruments for large telescopes be built in a complementary manner, trying to avoid duplicity (or at least multiplicity). Phil Charles agreed, but noted the distinction between workhorse instruments and those with a specific scientific objective. Finally, Massimo Tarenghi reminded us how convenient it would be to collaborate also in our relations with industry: we are a small community, more and more left on our own with industry and we are effectively competing with other larger communities: so organization and collaboration are essential to fulfil our goals.

An interesting idea that was raised during the discussion is that of having regular (or semi-regular) meetings to try to find new ways of collaboration. People (particularly observatory directors) should often talk to each other. I personally am very in favour of this, although I recognize that it is very easy for me to say what other people should do with their time!

Conclusion 4: there is a real interest in collaborations. Although they are not easy to establish, they will bring an increasing reward for the astronomical community. Moreover, being in competition with other large communities and industry, fair and equitable collaborations may be the only way for large telescope astronomy to succeed.

libroGTC_ELTF061109.indd 250 12/11/2009 12:46:11

6. Question 5: Access, training and young people

If the few big telescopes and top science projects are undertaken more and more in service mode, how are we going to ensure the training of our young observers? This question summarized the worry of many people present in the meeting that led to an open and worthwhile discussion.

Some people, like Alfonso Serrano, found this to be a real problem for the future, and he expressed his concerns. Masahiro Iye and Jean René Roy proposed some ideas about how to train people in large telescopes (through a Visiting Queue Astronomers programme, for example). Bruno Leibundgut looked at the problem a bit more optimistically than others: training in 2 and 4 m telescopes should be enough to train young people and make the jump to larger telescopes easier (and there are many 2-4 m telescopes, and even quite a few 8-10 m telescopes). Tony Tyson stressed the point that young researchers should also be trained in the laboratory, emphasizing the importance of having well-trained people in instrumental development. Related to the training problem, but on a larger scale, Massimo Tarenghi recalled the successful experience of the NTT as a test-bench for the VLT, and supported the idea that 8-10 m telescopes should play a similar role for the ELTs.

William Smith noted "the demise of the lone astronomer": projects (and papers) are carried out by a larger number of scientists than they were in the past. While this is in general positive, as it strengths collaborations and makes it possible to tackle more difficult problems, it also has a negative aspect, as pointed out by Thomas Henning: the lack of personal contribution possibilities and the hierarchical structure of large projects may push young talented people to other scientific areas. Clearly, our community should keep an eye on these issues.

Conclusion 5: There is agreement on the need to train young people, although there are different views on the seriousness of the problem and ways to tackle it (probably all ways are valid). And there is agreement on the (obvious) need to attract talented young people to astronomy!

libroGTC_ELTF061109.indd 251 12/11/2009 12:46:11

7. Question 6: Construction of ELTs

The construction of ELTs, although strictly not yet guaranteed, raised several hot topics that provoked a very lively discussion.

The meeting organizers asked who is actually driving the construction of ELTs; astronomers or engineers? After some opinions, Massimo Tarenghi quoted Ricardo Giacconni, about the VLT construction: "Science, technology and politics are required, and in the right order. And there is only one right order: science, technology and politics". I can only agree with this sentence, and therefore the question was settled for me. Of course, it is our responsibility as people interested in the ELTs to guarantee that priorities are kept in the right order.

Participants were confronted with a second question: how many ELTs can be expected to be built? Only 15 years ago, no 8-10 m telescope was operating. Nowadays, there are 10 of them, and LSST will probably join them soon. Presently, 3 telescopes of the ELT-class are planned, two led by Americans (one foreseen for the southern hemisphere, the other in the north) and one by Europeans (without a site decision yet). Probably it is not unreasonable for our community to aim at building 4 ELT-class telescopes. Time and experience will make telescope construction cheaper, and this would allow Americans, Europeans and their partners' full sky access, with one telescope in each hemisphere for each community. This would open many collaborating possibilities, including instrument complementarities.

A final question related to the ELT construction was: are we envisioning the end of the large telescope business? This question got a clear answer from Jean René Roy: No!! And he referred to the many ongoing projects: SASIR, GMT, LSST… and even to the next possible step: OWL wasn't discarded by any clearly insurmountable difficulty. However, it is possible that we have to open our minds and find new ways for our wishes to become reality, as radio astronomers did with ALMA or as segmented telescopes did through Keck.

Conclusion 6: We have as yet no total guarantee that the ELTs will be built, but we should always be ambitious: ELTs do not have to be single entities, nor do they represent the end of the line. We will find, if needed, new ways to look deeper and see better.

libroGTC_ELTF061109.indd 252 12/11/2009 12:46:11

libroGTC_ELTF061109.indd 253 12/11/2009 12:46:11