SUMMARY OF THE EuTuCHe WORKSHOP – CERN, APRIL 23rd-25th 2007

The first EUropean workshop on TUrbulence in Cryogenic HElium (EuTuCHe) was held at CERN from Apr 23rd to Apr 25th, following a joint initiative of ICTP (Trieste), CEA and Institut Néel (Grenoble) and CERN (Geneva).
The homepage of the workshop can be consulted at:
http://indico.cern.ch/internalPage.py?pageId=3&confId=11920

The motivations behind the organization of this workshop and its main purposes are respectively detailed at:
https://at-div.web.cern.ch/at-div/Cryogenic%20turbulence/EuTuCHe_motivations.htm
and
https://at-div.web.cern.ch/at-div/Cryogenic%20turbulence/EuTuCHe_purposes.htm ,
but they can be briefly resumed as follow:

The enormous potential of experiments in Cryogenic Helium to improve the understanding of turbulent phenomena and push forward the possibilities of forecast and control of turbulent flow makes no doubt. Yet, the progress in this field is slower than one would hope or expect, and three main causes can be identified for this situation:
1) The high costs;
2) The lack of suitable reliable instrumentation;
3) The dispersion of resources on multiple experiments with poor synergy.

Starting its operation at the end of the year, the LHC – the new CERN particle collider – will incorporate the largest cryogenic installation in the world. Therefore CERN, which already engineers, owns and operates a large amount of unique cryogenic equipments will permanently have on site the world's largest quantity of cryogenic helium.
Recent discussions brought into light an exciting long-term possibility: the development of a large multi-purpose cryogenic Facility for turbulence studies, designed to be adapted to host in time different kind of experiments and shared in use among different research collaborations.
There is a general agreement that the first step is to create a real Network among the existing European facilities through the creation of a multi-site integrated infrastructure, regrouping the existing laboratories and involving all other European institutes interested in the application of Cryogenic Helium to turbulence research. This would provide the required critical mass to tackle the technical challenges posed by the conception of the Large Facility, while already allowing for important steps forward towards a deeper and more complete understanding of turbulence.
The FP7 "Capacity" programme for Research Infrastructures (RI) includes funding schemes, *viz*. Design Studies (DS) and Integrating Activities (IA), that appear to be perfectly suited for this two-step approach of the project.

The workshop, structured in invited presentations followed by wide open discussions, was meant to start providing answers to some basic questions:
- Does the project gather a convinced and widespread support?
- Which are the open problems in turbulence that should be pursued in priority?
- Which technical developments are needed for the available measurement techniques?
- Are there new measurement techniques to be envisaged?
- Which synergies with "non-cryogenic" (computational and experimental) communities should be better exploited and how?
- How to proceed towards an FP7 funding proposal?

Sixty-one researchers in representation of 32insitutions from 12 countries attended the workshop (see the attendance list is available at http://indico.cern.ch/confRegistrantsDisplay.py/list?confId=11920). But the expressions of interest and the support received by the initiative, although announced only two months before the starting day of the workshop, have been even wider, as detailed in Fig.1

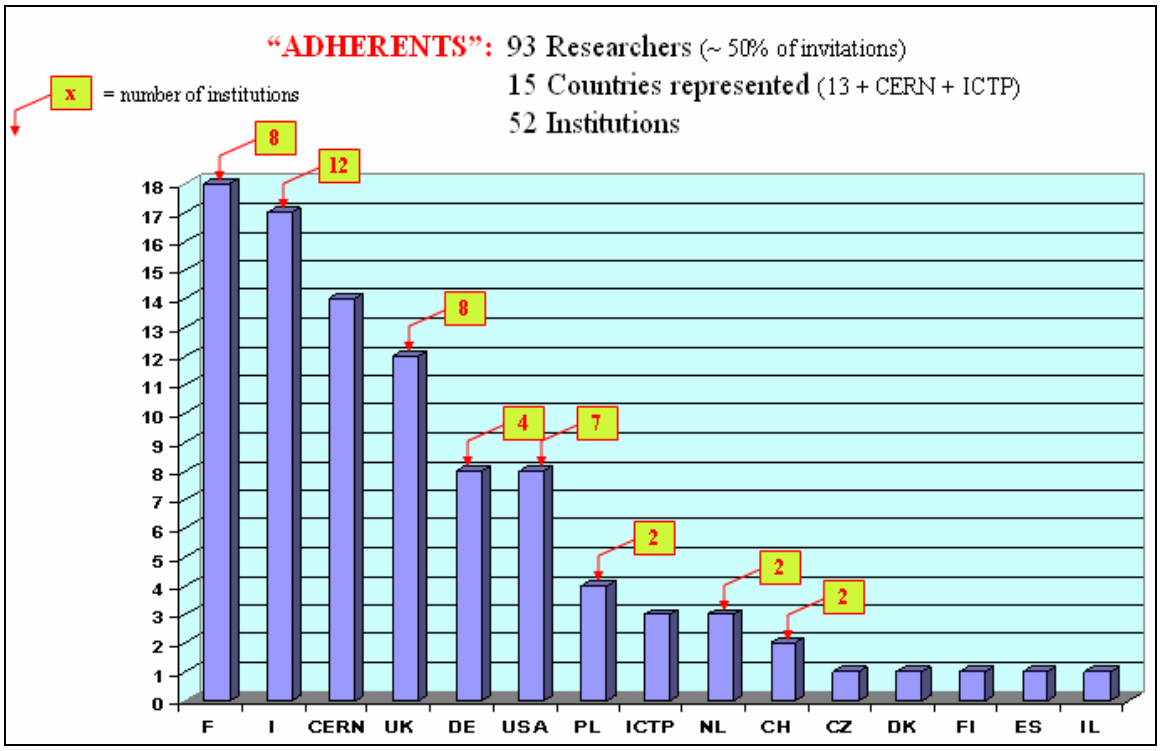


Fig.1 Explicit adhesions and expressions of interest received to the project and to the workshop

The detailed programme for the three days can be consulted at:
http://indico.cern.ch/conferenceTimeTable.py?contribId=10&confId=11920
The material presented or distributed is visible and downloadable by selecting the desired session and then clicking on the applicable type of "material" (slides, paper, movie…). All contributions have been uploaded (except the slides presented by E.Bodenschatz, not yet available). The presentations and the discussions have also been integrally video-recorded. Unfortunately, due to an overload of the responsible office at CERN, it has not been possible up to now to split the whole 3-days recording into smaller files in order to allow their use: the videos will be added to the contributions in each session upon their availability. A notification will be sent to the distribution list receiving this summary.

Two fundamental references from previous experiences can be found in the lectures of K.Sreenivasan and S.Nazarenko: the first one provides a detailed account of the activities – spanning the full decade of the '90s – developed in USA towards a project very similar to the one presently in discussion here. The project was finally abandoned although interesting preliminary results had been obtained and the presentation includes the ideas behind it, a reference to the produced documentation, a discussion of the "mistakes" made and some advices for the present project. The second one, through the experience of the organizer of the "Academic Year-long Warwick Turbulence Symposium", provides an impressive sample (yet not complete) of the large variety of scientific fields related to turbulence and of approaches used by the different communities. It also brings to the discussion the contribution of ideas coming from communities with which the communication is not always efficient.
The problem of turbulence understanding, forecast and control is "the" open issue in fluid dynamics; but fluid dynamics is at the centre of so many and so different scientific and technological applications that today fruitful cross-field synergies in turbulence seem to be much more happy exceptions than the rule. At least at first sight, the old controversial between "application" and "physics" and, within the latter, between "basic science" and "applied science" seem to be still fully topical. On the other hand, this seem to be more a surmountable "cultural block" than an absolute necessity, as the conscience of the need of synergetic efforts putting together different competences is more and more present. Large long-term projects opened to wide collaborations, like the new SF6 wind tunnel at MPI Goettingen, are probably the good kind of catalyzer in this respect. Nevertheless, the issue of which role should be attributed to the aspects linked to

applications and to those linked to basic science in a new project is still at the base of lively discussions; and is probably highly related to the particular funding scheme pursued for the project realization.

This discussion spontaneously digressed into the subject of the following one, to which it was naturally linked. Although it was not possible to get a common and convinced agreement on the formalization of a list of open problems in highly turbulent flows that would need to be pursued with the highest priority in order to get to the breakthrough of the widest possible relevance (the "Holy Grail" of turbulence, so to speak), some subjects in particular seemed to be particularly recurrent. It is indeed an interesting exercise the comparison of the "lists" proposed by I.Procaccia, D.Lohse and R.Benzi et al (the latter through a document distributed to the audience):

Procaccia:

- Strong shear flows;
- Wall-bounded turbulence;
- Flow on a flat plane (transition to turbulence);
- Free jets;
- Flow in rough pipes;
- Turbulence with small concentration of additives (polymers or bubbles).

Lohse:

- Rayleigh-Bénard convection;
- Taylor-Couette flows;
- Boundary layers;
- Two-phase flows
- Turbulence with phase transition.

Benzi et al:

- Universal properties of small-scale intermittent fluctuations;
- The dissipative structure of turbulent flows;
- Rayleigh-Bénard convection;
- Turbulence in non-isotropic flow and channel flows;
- Turbulence and roughness;
- Rayleigh-Taylor turbulence.

The choice of the subjects listed by each researcher is unavoidably biased by his particular field of activity, but it is nevertheless striking the recurrence of similar problems (sometimes identical, sometimes "masked" under slightly different definitions). Anisotropic and evolutionary flows, large scales, transitions phenomena, turbulence interactions with walls or particles, typical problems relevant to "applied flows", all seem to be in the collimator of the specialists of turbulence physics. This is indeed a guide towards an optimal use of the existing experimental and numerical resources; and towards the definition of what one should expect from a new large multi-purpose experimental facility thought to be shared in use by different collaborations.

The cryogenic infrastructure potentially available at CERN both for medium-size experiments funded by an IA proposal and for the setting up of a future permanent large-scale experimental facility was presented to the community by F.Haug at the end of the workshop: this detailed presentation, concluded by an impressive inventory of cryogenic material available at CERN, left no doubt on the choice of CERN as the best possible European site to host such a Facility.

The enormous potentiality of cryogenic Helium - in its normal or superfluid states - for turbulence study was authoritatively discussed in some detail in the lectures by R.Donnelly, B.Castaing, C.Barenghi and L.Skrbek. In addition, the presentations of B.Rousset, J.Niemela, Ph.Roche, O.Pirotte and the contribution of V.Tsepelin completed the survey of the existing experimental facilities in Europe and of their present capabilities. The resulting global picture, although perhaps not completely exhaustive (some additional small scale devices may not have been mentioned, e.g. in UK or in Wroclaw), show the interest of a first important effort towards the integration of the European activities on turbulence in cryogenic Helium. Not only would the key issues related to the instrumentation largely benefit from a more continuous exchange of experiences between the different labs; not only would the complementary character of the different experimental facilities be better exploited if the activities of the laboratories were better integrated. But the

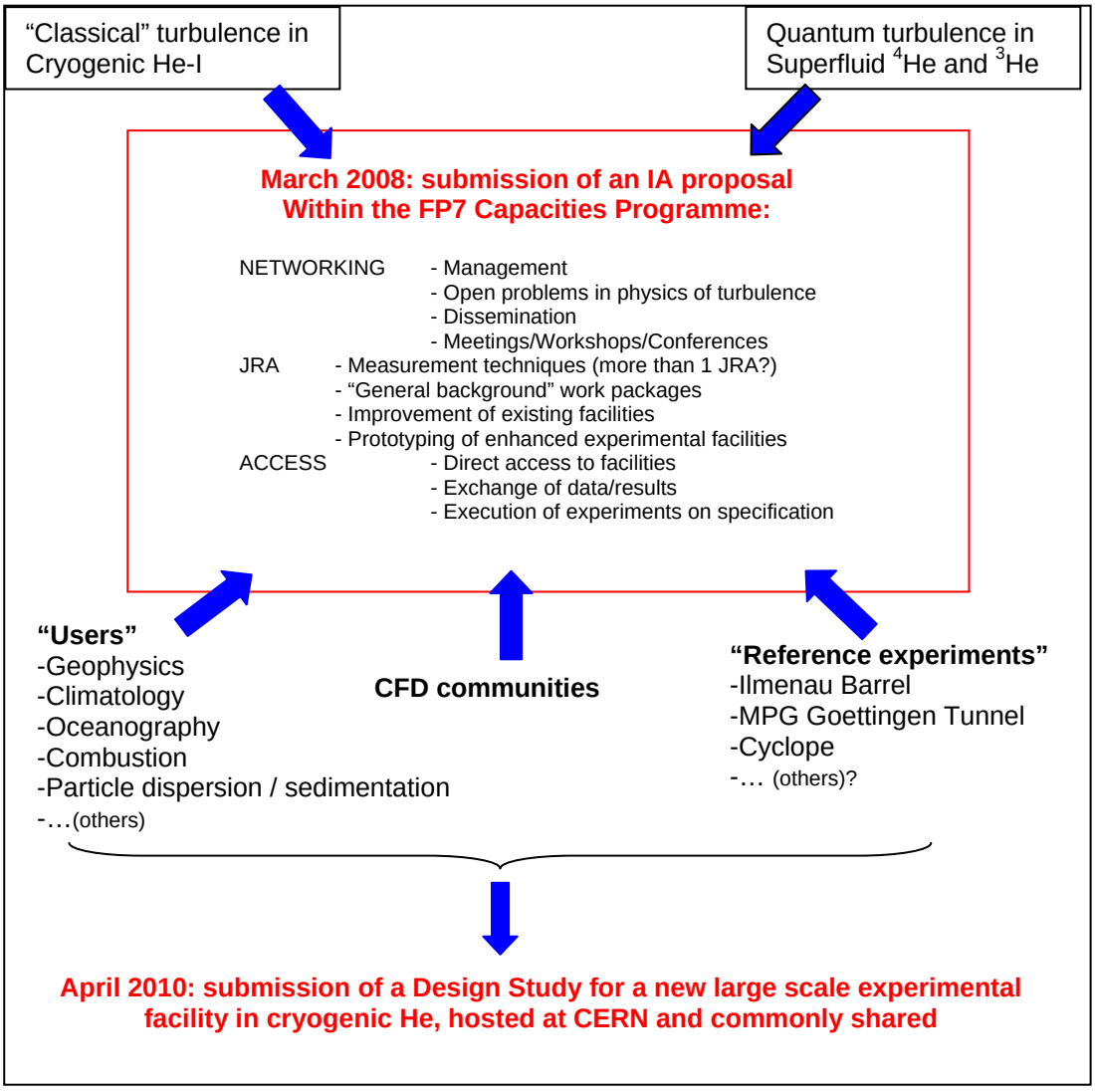
creation of an integrated network among the existing facilities would allow for an important widening of the community, be it through direct access to the laboratories or through access to experimental data or, finally, through the participation to the definition of the design of new experiments.

The role and the relevance to the project of turbulence communities outside the one of cryogenic He specialists were at the centre of important discussions in the second part of the workshop.
Existing or forthcoming large-scale experimental facilities using non-cryogenic fluids may for example produce reference experiments to be analysed and evaluated in connection with twin cryogenic Helium experiments. Indeed, if the latter ones can reach much higher Re or Ra regimes and allow for a wider spanning of parameters in a single experiment, the former ones today have access to more standard and reliable measurement instruments and allow for a better resolution of the small scales. Examples of such "reference" experimental facilities can be the "Ilmenau Barrel" for R-B convection (see the contribution from R.du Puits), the already mentioned SF6 wind tunnel in preparation at MPI Goettingen for free flows and flow/body interactions (the slides presented on this subject by E.Bodenschatz will be uploaded as soon as available), or "Ciclope" for pipe and wall-bounded flows (due to overlap of engagements Ciclope was unfortunately non represented at the workshop but a contact is active with this facility soon to be operational).

The CFD community must certainly play a fundamental role in a new European project on turbulence, even when the accent is posed on experiments. Vortex models of different kinds (see the contribution of K.Bayer & T.Lipniacki, and the one of P.Regucki as examples) are fundamental to study the details of mechanisms such as the vortex reconnection or the vortex interactions with particles both in classical and in quantum turbulence. And DNS can provide a powerful insight into physical modelling through associated supercomputing projects (see the contribution of J.Schumacher on this). All this is not only relevant to a deeper understanding of the physics of turbulence, but can also provide guidelines for the experimenters and fundamental information about specific measurement techniques – suffice it to mention here all the problems of neutral tracer seeding of flows. On top of this, the new generation both of experiments and of numerical simulations are going to face the same class of problems related to data handling. Indeed, the huge quantity of data produced by new tests – physical experiments of numerical simulations – starts to pose serious problems of data processing, post-processing, storage, access and sharing. And this tendency will certainly increase in the near future: an integrated effort of the numerical and the experimental communities may avoid that this become indeed the bottle-neck to a real scientific progress.

The third important pole of interaction with the cryogenic He experiments will be of course that of the numerous communities of "turbulence users". With this term we refer (somehow improperly) to all researchers active in one of the many fields of science that deal with the problem of turbulent flows behaviour, who make extensive use of turbulence models or of turbulence properties, but for which the deep understanding of turbulence dynamics is more a fundamental tool for a scientific or technical advancement in their field than the final goal of the research. This may involve an extremely wide range of disciplines – from Geophysics to Combustion, from Plasma physics to Climatology, etc – under the condition that the interaction with the project develops through a proactive approach moving from these communities and not vice versa. Indeed, experience says that the situation, where the specialist of pure turbulent physics autonomously picks-up a problem from a scientific or technological application and tackles it without a direct link with the specialists of that particular field, too often develops into a very inefficient (or inexistent) final improvement of the real understanding of the initial problem. A much more fruitful approach is the one that can be seen in the contribution submitted by P.L.Read & B.Galperin on Geostrophic and Zonostrophic Turbulence: the field specialist presents his problem, explain the models they use, submit a set of observable ranges that he cannot reach and ask the experiment specialist if he can provide with his experimental facility the desired added value. This forms a sound basis to start a productive collaboration: well-posed problems of applied science or technology can both enter the core of an IA proposal – as one of the benchmark experiments selected for the development of the research activities – or form the object of a subsidiary funding proposal under the FP7 Specific Programmes "Cooperation" or "Ideas" to be presented in collaboration either with the IA consortium or with a specific laboratory belonging to it.

The global picture resulting from the whole discussion can be summarized by the following scheme, which is indeed a very first draft of a programme for the future activities: both “classical” and “quantum” turbulence will be part of the investigation programme. The definition of an IA proposal, including the definition of the Consortium Partners and their Associates plus the detail of the Networking and JRA work packages and the Trans-national Access programme, must be ready for submission by the indicated deadline for the INFRA-2008-1.1.1 call. This proposal will be opened to the interested CFD communities, to “Reference Experiments” in non-cryogenic fluids and to groups of “Turbulence Users” (in the sense explained above), on the basis of an agreed collaboration programme on specific activities. Once this proposal submitted and (hopefully) accepted by EC, the Consortium will start the preparation of a second funding proposal – to be submitted in the first part of 2010 – for a DS of the future Large Facility to be hosted at CERN, a step required to have this new Research Infrastructure included in the next revision of the “ESFRI Roadmap” for future Research Infrastructures of European interest.



Starting in Summer 2007, a series of smaller meetings and discussions through document exchanges should allow for a skeleton of the proposal and of the consortium to be available at the end of the Summer, with particular reference to the coordination responsibility of the whole proposal and of the single work packages. In this way it should be possible to start detailing the aspects of the different work packages during Fall 2007 – making a maximum use of the available contacts within the Research Directorate of the EC to be guided in difficult choices – and finally to have a reasonable time to complete the proposal write-

up as soon as the official Call is published. During the last session of discussion of the workshop a very preliminary list of the work packages that could be included in the JRA's regarding "Measurement Techniques" and "General Background" (a poor naming to be substituted by a better definition) was drafted:

"General Background" work packages:

- Handling / Storage / Availability of large packages of data (link to GRID?)
- Data processing techniques
- Signal processing techniques (e.g. de-noising…)
- Core electronics development (miniaturization, cryogenic compatibility…)

"Measurement Techniques" work packages:

- Hot wire / Hot film anemometry; Cold wire thermometry
  Technical development
  Reproducibility and reliability enhancement
  Wire size reduction to nm level
- LDV / PIV; Ultrafast tracking of lagrangian tracers
  Choice of best seeding
  Theoretical understanding of seeding particle behaviour
- Pressure / Temperature devices; Cantilevered fibres
  Better technological development
- Second sound attenuation; Acoustic scattering; Acoustic detectors
  Reduce the size of space averaging
- Vibrating Forks ("Skrbek')
  Better modelling of the device
  Technical development
- SQUIDS
  Electronics development
- Ions shooting
  General development of the technique
- NEW TECHNIQUES
  Laser Induced Fluorescence in He
  Optical Fibre Sensors
  Levitation objects

This draft list, together with the present summary notes, will form the basis for the future discussions in view of the organization of the Consortium.
Additional contributions that groups or single researchers would like to add for consideration and discussion can be temporarily sent to paolo.petagna@cern.ch and they will made available to the community through the web page of the workshop at:
http://indico.cern.ch/contributionDisplay.py?contribId=23&confId=11920
Additional contribution can be Activity Proposals, Comments, Presentation of interests, or other. Two additional contributions, from M.S.Mongiovì et al. and from A.Muriel, have been already uploaded and can be consulted.
In the next future, a dedicated space will be opened in the CERN Engineering Data Management System (EDMS), allowing for an easy classification,management and browsability of the material submitted.

CERN – Geneva, June 21st 2007 Paolo Petagna.