MARIE CURIE ACTIONS

Midterm report, RTN-Network

Project No. 5104

Constituents, Fundamental Forces and Symmetries of the Universe

presented by
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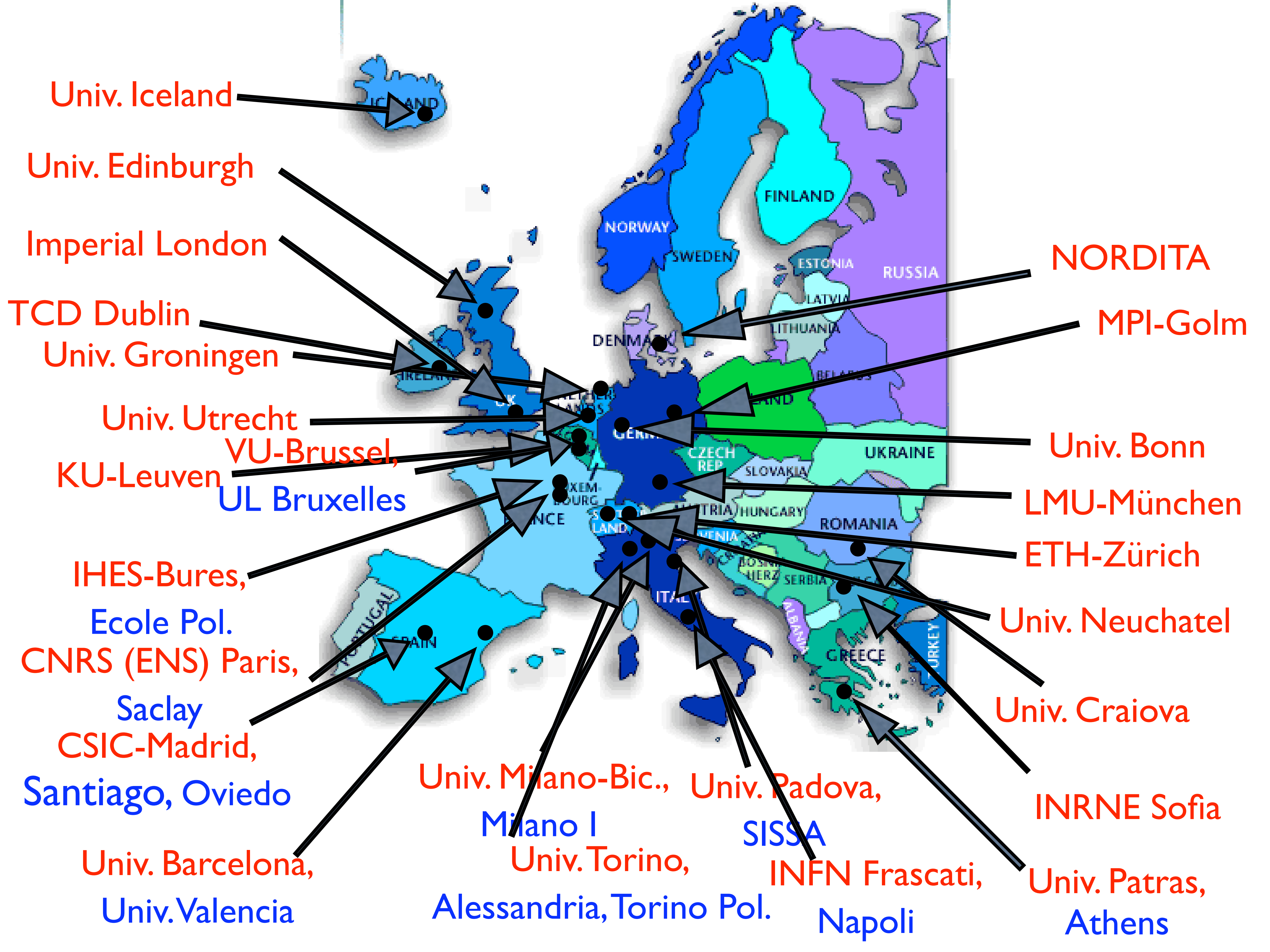
Napoli, 12th. October 2006

Midterm meeting: Outline

- The consortium
- The recruited researchers
- The research of the network
- The training of the young researchers
- The network management
- Problems and conclusions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Univ. Edinburgh
Imperial London
TCD Dublin
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Univ. Utrecht
VU-Brussel,
KU-Leuven
UL Bruxelles
IHES-Bures,
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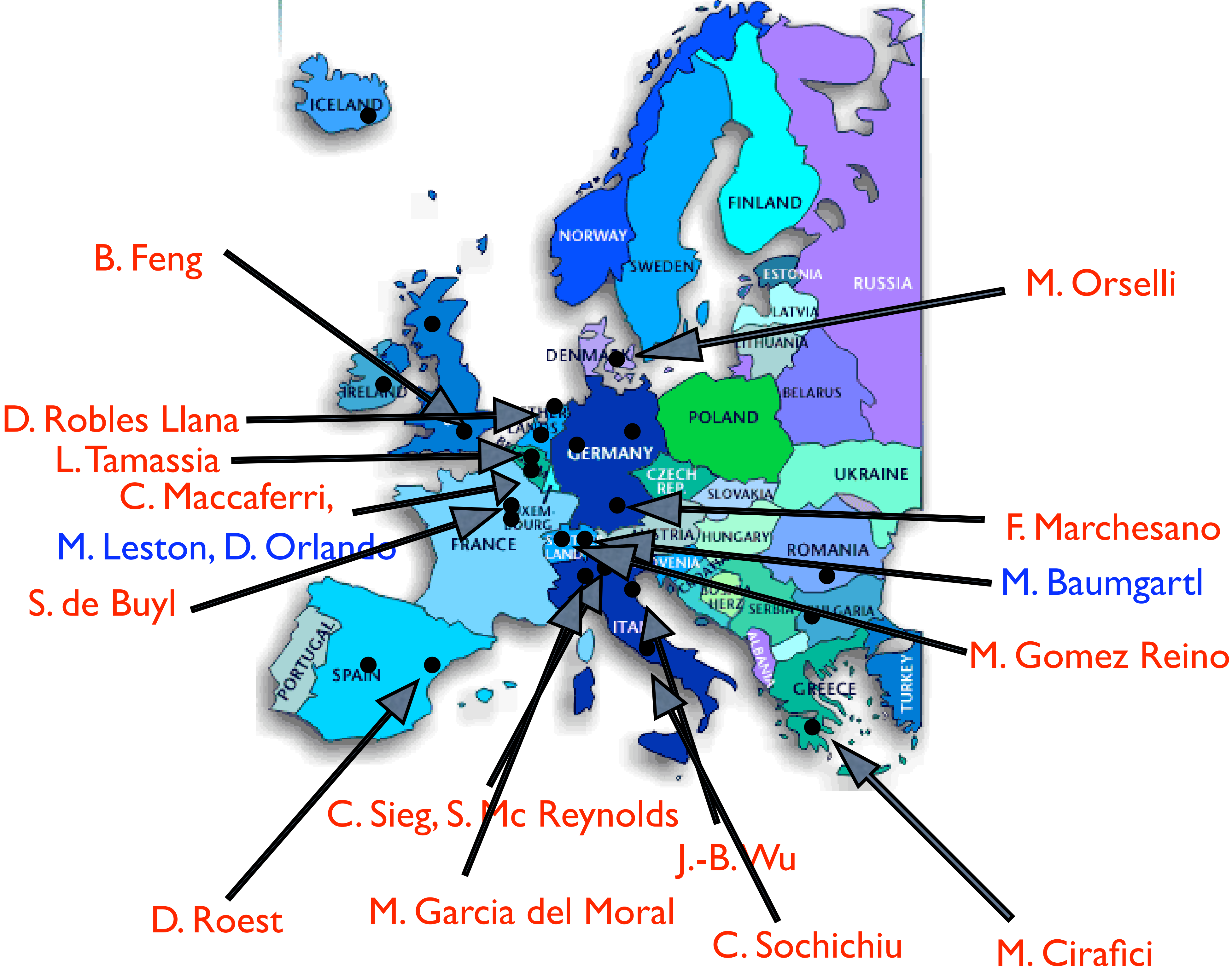

B. Feng
D. Robles Llana
L. Tamassia
C. Maccaferri,
M. Leston, D. Orlando
S. de Buyl
M. Orselli
F. Marchesano
M. Baumgartl
M. Gomez Reino
C. Sieg, S. Mc Reynolds
J.-B. Wu
D. Roest
M. Garcia del Moral
C. Sochichiu
M. Cirafici
ICELAND
FINLAND
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GREECE
TURKEY
PORTUGAL
SPAIN

The network seems to be very attractive:

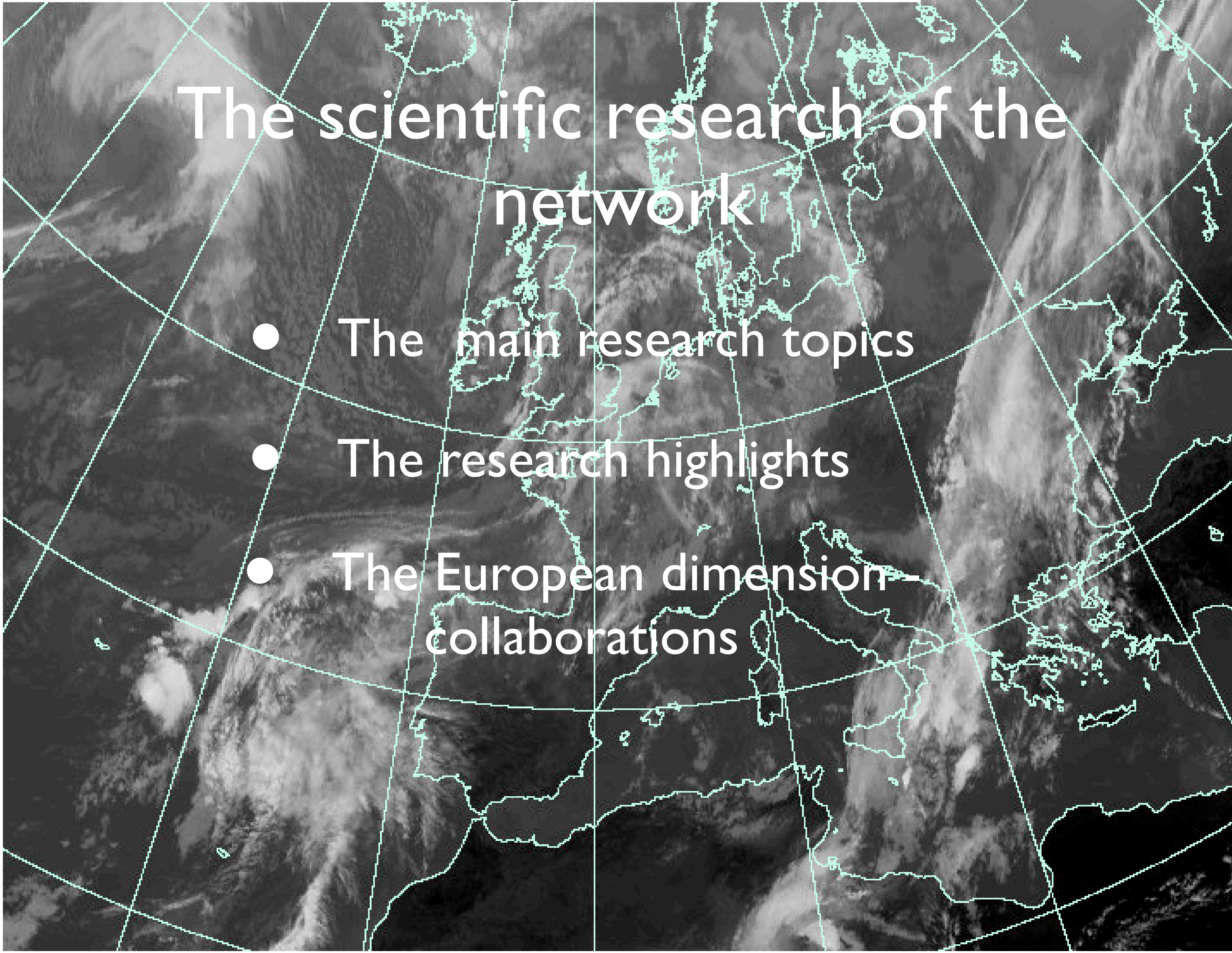
Large number of applications (ER) during the first two rounds!

Used months: ER: 186 (of in total 306).

ESR: 24 (of in total 138).

More on the recruitment of the young researchers

→ Talks by A. Van Proeyen/A. Ceresole



The scientific research of the network

- The main research topics
- The research highlights
- The European dimension - collaborations

Main theme of the network:

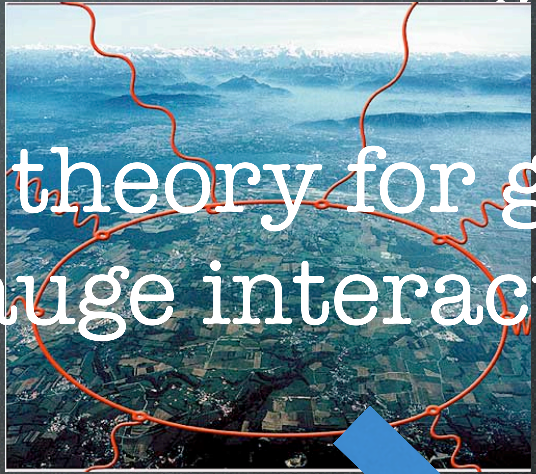
Exploration of the fundamental structures of the universe!

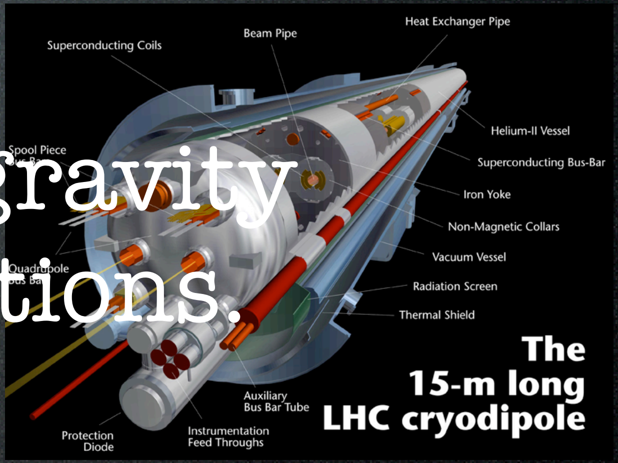
Upcoming exciting experiments:

Strings, branes and their symmetries.

Particle physics:

Unified theory for gravity and gauge interactions.

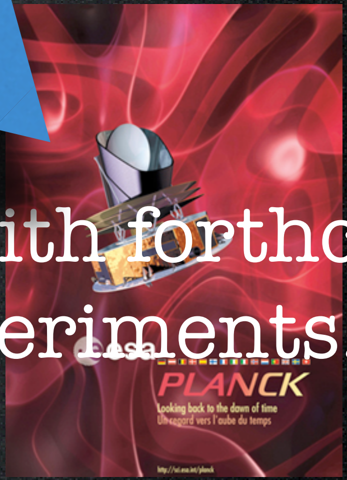




Cosmology:

Strong relation with modern mathematics.

(?)



Contact with forthcoming experiments.

Power and particles

String theories dominate for good reason.

For decades, high-energy physicists have basked in the glow of a theory that can apparently do no wrong. Prosaic though the 'standard model' may sound, every experimental observation from accelerators has fulfilled its predictions, often to extraordinary precision. It is also falsifiable, in that it predicts particles that should be observed in the new experimental regimes to be explored by the Large Hadron Collider at CERN from 2007 or 2008 onward. And it's conceptually sweet, exploiting mathematical symmetries to integrate three of the fundamental forces — electromagnetism and the strong and weak nuclear forces — within a single framework.

It has its weaknesses and embarrassments, however. It doesn't predict particle masses: these and many other observed parameters have to be plugged in by hand. Also, it has infinities, due to the fact that its fundamental particles are point-like. A technique ('renormalization') that gets around these infinities was a great piece of inventiveness and enables the model to deliver its sweeping successes, yet also seems like a sleight-of-hand.

Now imagine a theory that incorporates the standard model within it, that includes just one arbitrary parameter rather than many, incorporates the fourth fundamental force — gravity — within its framework, removes the need for renormalization, allows us to describe the extreme conditions of the earliest moments of the Big Bang and also resolves long-frustrating mismatches between quantum mechanics and relativity. Imagine also that such a model requires new types of mathematics in order to make progress, and that work on it repeatedly reveals levels of order that had not previously been appreciated or even suspected.

There is no theory exactly like the above, but string theory is the closest we have to it. The fundamental entities are no longer point-like but have a finite extent. The vibrations of these features of space-time should in principle give rise to observed particles. Even the example, the liquid rather than gaseous nature of the quark–gluon 'porridge' produced in collisions of gold nuclei. They also suggest enticing insights into controversies surrounding the thermodynamics of black holes.

These are no more than suggestions, and major new uncertainties have opened up alongside new opportunities. There seems to be a vast number of possible universes in such theories. Such embarrassments could prove fatal. But pursuing them is just as likely to lead to insights that make the theory seem all the more inevitable.

Two recent books have attacked the dominance of string theory among the high-energy theoretical community (see pages 491 and 507). They allege that string theory should have proved itself by now and should have made testable predictions. They also claim that string theorists have exerted an intellectual hegemony, accompanied by downright arrogance, over the field that has discouraged alternatives from being pursued.

The complaints of undue influence and arrogance are not without foundation. And string theory is very far from experiment. There is no point in making predictions prematurely, but some theorists seem to positively revel in the lack of them. A prime goal must be to turn this project, ultimately, into a testable science.

This remoteness from experiment reflects the magnitude of the task. It doesn't justify any suggestion that string theory is played out. The many theorists excited by string theory (perhaps ten times as many as those excited by any competing idea, to judge by the meetings) are going where they think the most innovative and intriguing prospects are to be found.

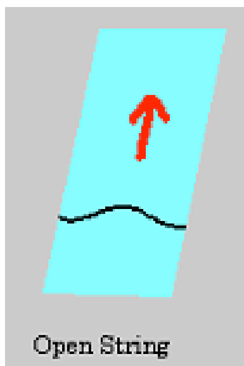
What drives them? There may be esoteric beauties perceivable to some string *cognoscenti*. But much more compelling is the sheer scope of what string theories seem to encompass. Such power, as expressed in the community, has attracted resentment and embitterment. But this power offers insight of unmatched depth and breadth, and the development of its mathematical foundations has been full of tantalizing incident.

Critical-mindedness is integral to all scientific endeavour, but the

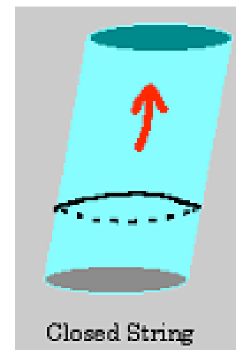
5 research topics:

Underlying symmetries

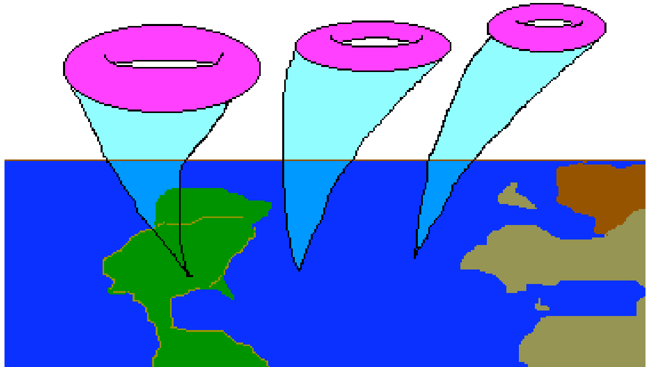
Gauge/gravity correspondences



Basic constituents:
Strings & branes

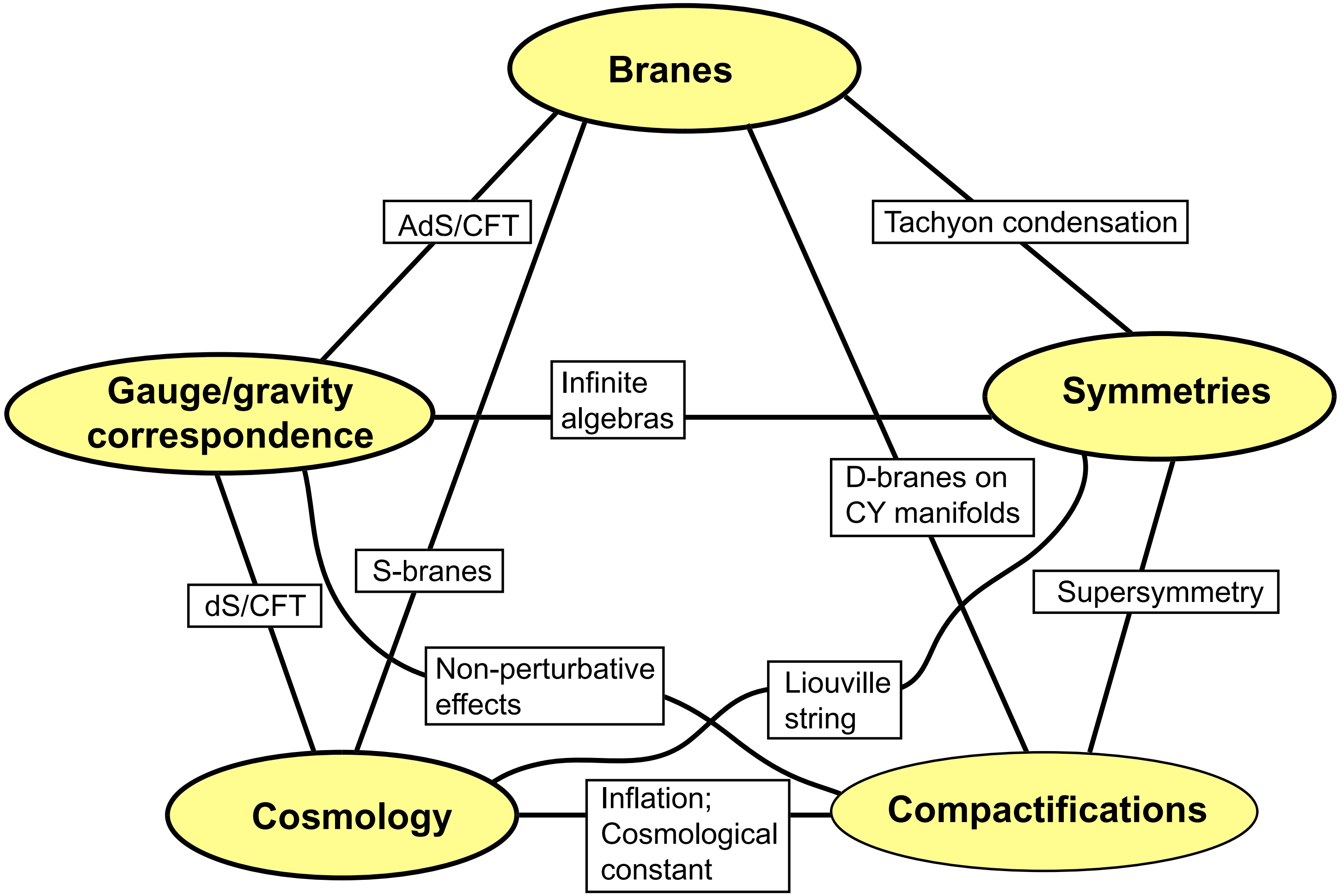


Compactifications and relation to the Standard Model



The early universe: supergravity, string and brane cosmology

These 5 topics are closely intertwined:



Scientific highlights (milestones):

1. Strings & branes:

- Development of a novel method for constructing the effective D-brane action.
- Construction of the D-brane effective action and tachyon condensation in topological models.
- Construction of (wrapped) D-branes on Calabi-Yau spaces and in conformal field theory.
- Derivation of an index for the Dirac operator on D-branes with background fluxes.
- Discussion of the open/closed string duality.

Scientific highlights (milestones):

2. Gauge theory/gravity correspondence:

- The discovery of integrable structures in gauge and string theory.
- Generalization of the AdS/CFT correspondence for gauge theories with matter fields and/or broken supersymmetry.
- The development of gravity duals of deformed gauge theories and generalized complex geometry.
- Discussion of the AdS/CFT correspondence at finite temperature.
- The discussion of the Wlison loop in the AdS/CFT correspondence.

Scientific highlights (milestones):

3. Underlying symmetries:

- The discussion of the symmetry structure of supergravity theories: quaternionic manifolds, exceptional groups, hyperbolic algebras, 10-form potentials ....

- The discussion of the dynamics of higher spin fields.

- Discussion on the emergence of space-time in quantum gravity.

Scientific highlights (milestones):

4. Compactifications and the connection to the SM:

- The construction and classification of (semi)realistic 4D string models: heterotic & orientifolds with intersecting D-branes.

- The statistics of 4D string models.

- The study of flux compactifications (with non-perturbative superpotentials): effective action, moduli stabilization, supersymmetry breaking, D-terms, de Sitter uplifts, ...

- The mathematical development of new geometries with generalized holonomies.

Scientific highlights (milestones):

5. String & brane cosmology:

- Compactifications with stabilized moduli leading to 4D models with positive cosmological constant and/or early time inflation.
- Formulation of mirage mediation for brane cosmology.
- The discovery of cosmic billiard solutions in relation to hyperbolic symmetries in supergravity theories.

Scientific highlights:

New developments:

- The understanding of the macroscopic and microscopic properties of black holes: entropy counting of BPS black holes, duality invariant black hole partition functions, non-BPS black hole solutions, study of black ring solutions, ...

European dimension:

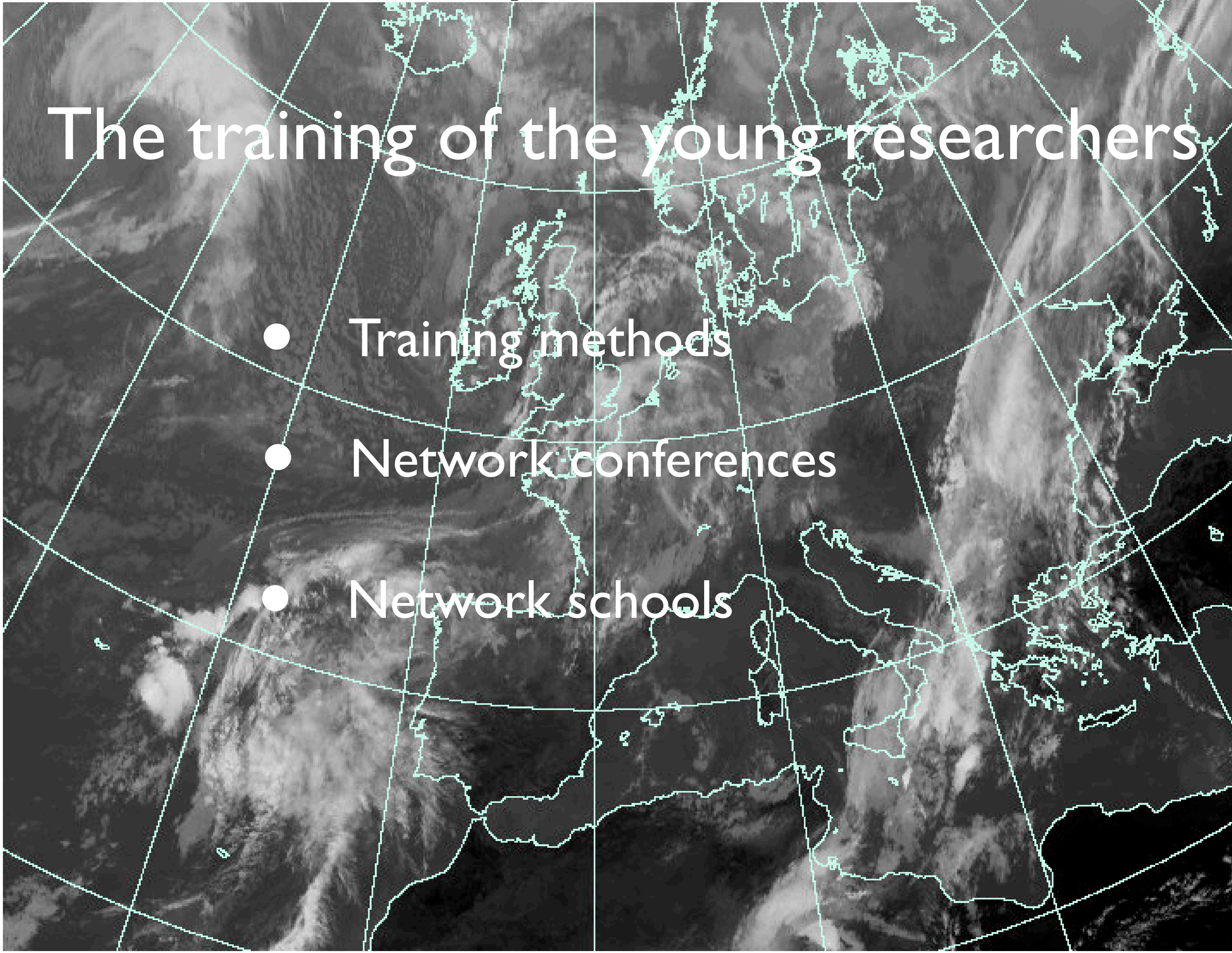
Most of these research topics are of world wide interest.

The EC-network gave opportunity for many collaborations that contributed significantly and timely to all of these advances:

This keeps Europe at the forefront of research in theoretical high energy physics!

176 joint publications involving at least 2 network contractors!

The young, recruited researchers substantially contributed to the research of the network!



The training of the young researchers

- Training methods
- Network conferences
- Network schools

Training methods:

- Individual training within the research groups and individual visits of other groups.

- Network conferences.

- Network schools.

Network conferences:

The annual network conferences usually take place in fall.

They attract (>200) participants from the network and also from other institutions.

Excellent speakers give overview talks over the topics of current interest.

Young researchers have the opportunity to present their works.

More on the network conferences

→ Talk by E. Kiritsis

Network schools:

The annual network schools usually take place in winter.

They attract (>200) participants from the network and also from other institutions.

Excellent speakers give lectures over the topics of current interest.

More individual training is provided during the working groups.

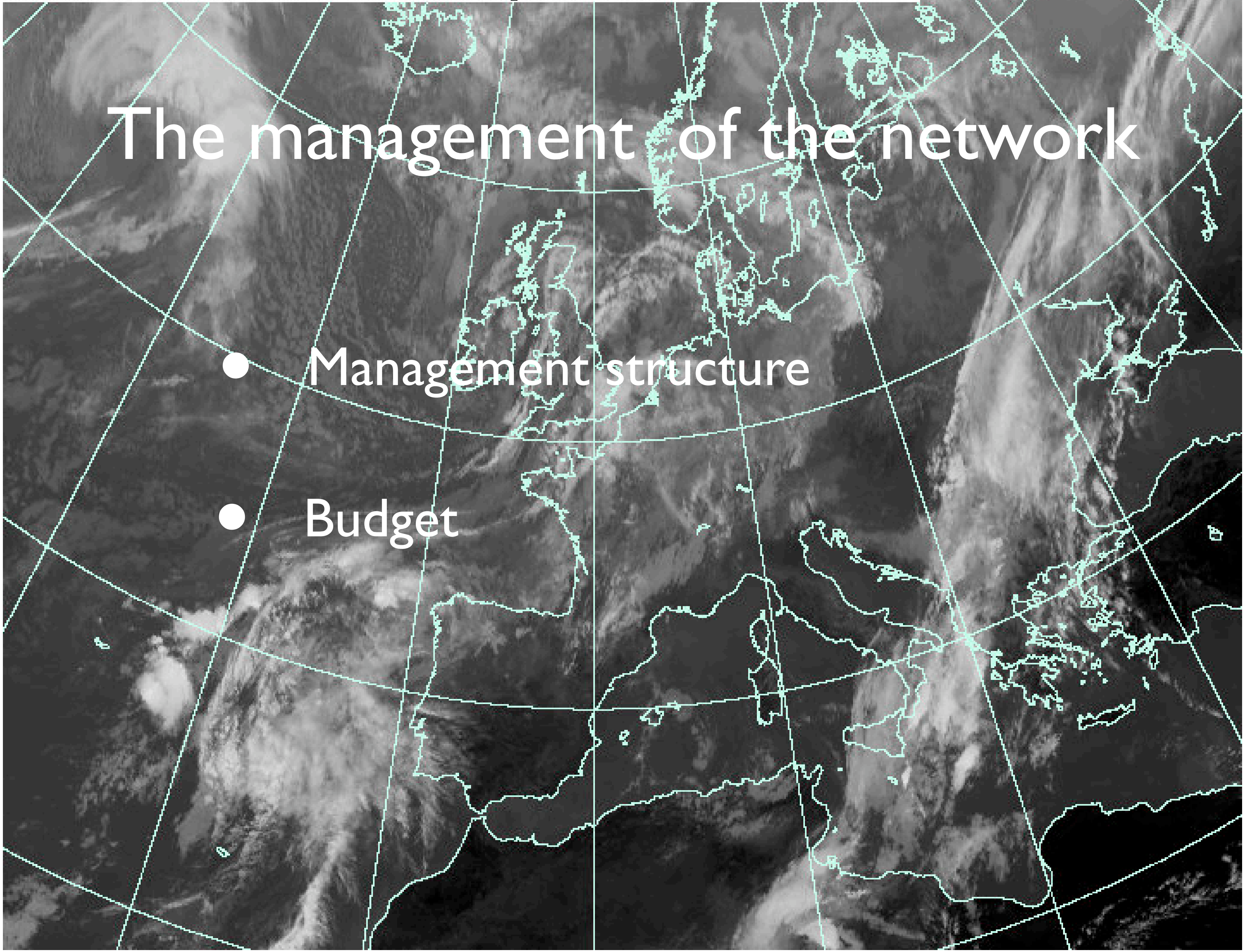
Our RTN-school is regarded as the major winter school in Europe.

More on the network schools

⟶ Talk by D. Zanon

The management of the network

- Management structure
- Budget



Management structure:

- Coordinator: D. Lüst
- Deputy coodinator: A. Sevrin
- Executive board: all scientists in charge of the contractors
- Secretaries:

  Outreach: K. Stelle

  Recruitment of young researchers: A. Van Proeyen, A. Ceresole

  Training of young researchers and schools: D. Zanon

  Research issues, workshops, conferences: E. Kiritsis
- Work group leaders.

This management structure was approved at a kick-off meeting in November 2004 in Munich.

At each conference/school we also hold an organisatorical meeting among all scientists in charge (executive board, ..).

This management structure works smoothly and without problems.

Budget:

- For the young researchers (A-E):

  2051.3 k€ (17.9 k€) ← First year

- Contribution to the training and transfer of knowledge programme (F):

  628.4 k€ (88.9 k€)

- Managment (G):

  114.0 k€ (15.4 k€)

- Overhead (H):

  267.9 k€ (10.3 k€)

- Total: 3061.8 k€ (132.5 k€)

Conclusions:

- The network has produced several world-wide recognized results concerning the fundamental structure of the universe.

  Many of the indicated milestones were reached in time, showing that the network puts and can also answer the appropriate questions.

  In addition, interesting new directions were opened.

- The network gave opportunity to many intense collaborations, strengthening already existing scientific relations and also giving rise to new scientific contacts. In this way scientific knowledge was combined and transferred at a very high degree.

Conclusions (cont.):

- The network offers intense training opportunities to the young researchers

  by the training inside their nodes and by travelling to other nodes and conferences,

  by participating at the annual network conferences and presenting their results there,

  by participating at the annual network schools and actively deepening the presented material in smaller working groups.

Problems:

- Some of the nodes have problems to fill their ESR positions. During this meeting we discussed some actions to overcome this problem.

  However it would be desirable if the budget would allow for more flexibility.

- Some of the nodes suffer serious problems from not having yet received an additional payment.