CSN4 the INFN theory activity

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INFN

AST Ateneo della Scienza e della Tecnologia La Sapienza

CSN4

Outlook of the Presentation:

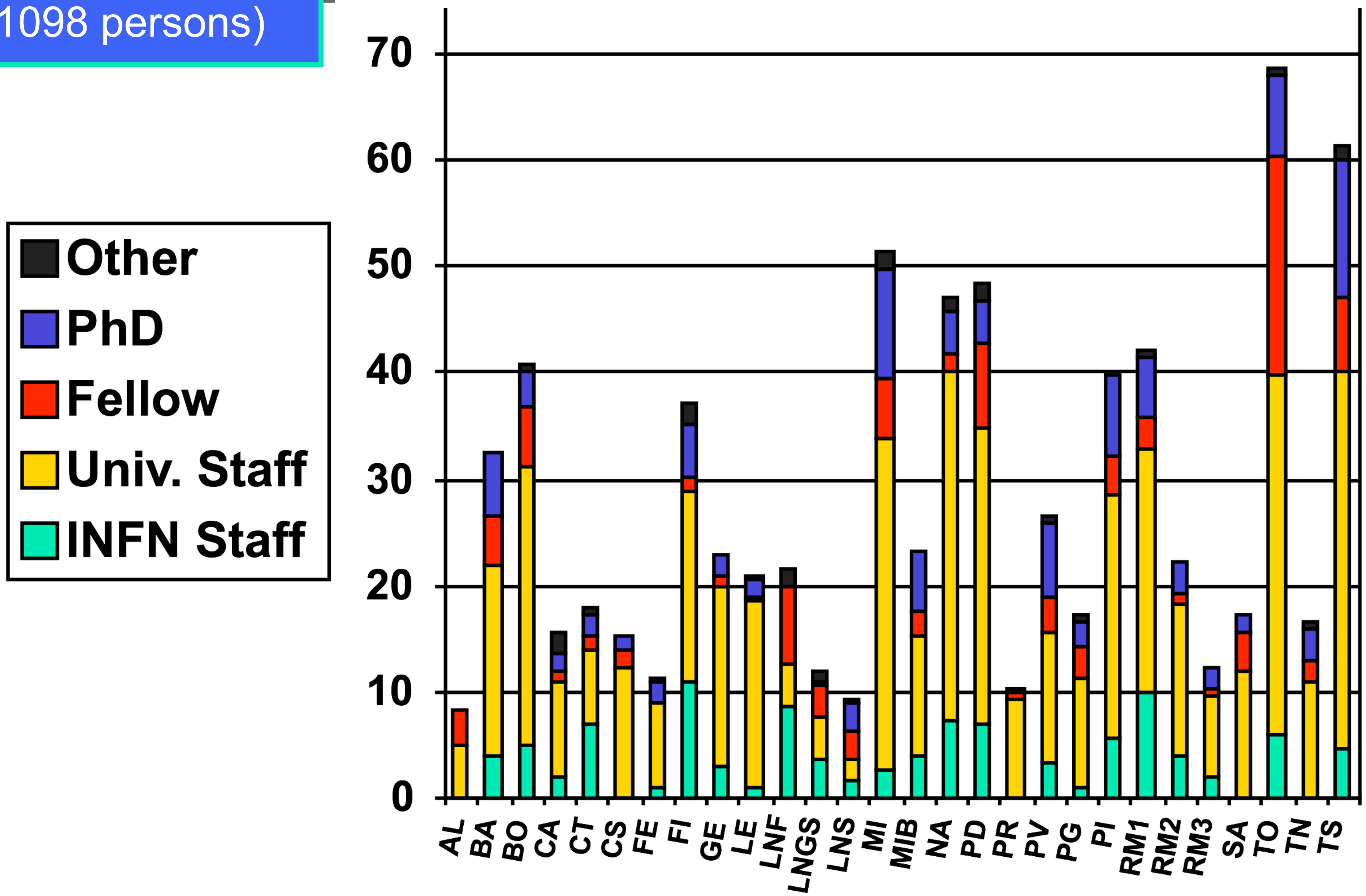
1. Research
2. Training and jobs
3. Galileo Galilei Institute for Theoretical Physics
4. Computing
5. LHC

RESEARCH

FTE
2008: 717.4
(950 persons)
FTE 2009:
770.5
(1098 persons)

STRUCTURE OF CSN4

4 National Labs and
20 Divisions (Sezioni)



Six Sectors denoted as Linea Scientifica (with some overlap)

- **String & Field Theory:**

QFT, Strings & M-Theory, Gravity, Lattice Gauge Th. and confinement, AdS/CFT;

Nparticipants=258; Npublications=295 ; funds 2008= 535 K€ ;

- **Particle Phenomenology:**

SM and BSM (Susy, Extra Dim., Composite Higgs), QCD at colliders (MC simulations, finite T and μ), Flavor Physics (and lattice) and EFT for heavy flavors, AdS/CFT and QCD;

Nparticipants=148; Npublications=203 ; funds 2008= 321 K€ ;

- **Hadronic & Nuclear Physics:**

nuclear structure and reactions (radioactive beams, stability valley and beyond), heavy ion collisions (quark-gluon plasma, T and μ phase transitions), confined hadronic matter (spin structure of hadrons, exotic spectroscopy);

Nparticipants=128; Npublications= 150; funds 2008= 286 K€ ;

- **Mathematical Methods:**

general relativity (gravitational waves,..), quantum theory (foundations, chaos,..), conformal field theories;

Nparticipants=113; Npublications= 119; funds 2008= 196 K€ ;

- **Astroparticle & Cosmology:**

neutrino physics, “dark things” (matter, energy,..), astrophysical radiation sources, astronuclear physics, gravitational waves;

Nparticipants=131; Npublications= 249; funds 2008= 268 K€ ;

- **Statistical Field Theory & Applications:**

complex & non-eq. systems, spin glasses, applications (quant. biology, turbulence,..).

Nparticipants=112; Npublications=175 ; funds 2008= 178 K€ ;

Total Persons =950 Total Npublications=1191 Total Funds (Sectors) = 1784.5 K€;

Funds for the local CSN4 groups (Dotazioni) 899.5 K€;

Six Sectors denoted as Linea Scientifica (with some overlap)

• **String & Field Theory:**
QFT, Strings & M-Theory, Gravity, Lattice Gauge Th. and confinement, AdS/CFT;

• **Particle Phenomenology:**
SM and BSM (Susy, Extra Dim., Composite Higgs), QCD at colliders (MC simulations, finite T and μ), Flavor Physics (and lattice) and EFT for heavy flavors, AdS/CFT and QCD;

• **Hadronic & Nuclear Physics:**
nuclear structure and reactions (radioactive beams, stability valley and beyond), heavy ion collisions (quark-gluon plasma, saturation, jet quenching, T and μ phase transitions), confined hadronic matter (spin structure of hadrons, exotic spectroscopy, GPD);

• **Mathematical Methods:**
general relativity (gravitational waves,..), quantum theory (foundations, chaos,..), conformal field theories;

• **Astroparticle & Cosmology:**
neutrino physics, "dark things" (matter, energy,..), astrophysical radiation sources, astronuclear physics, gravitational waves

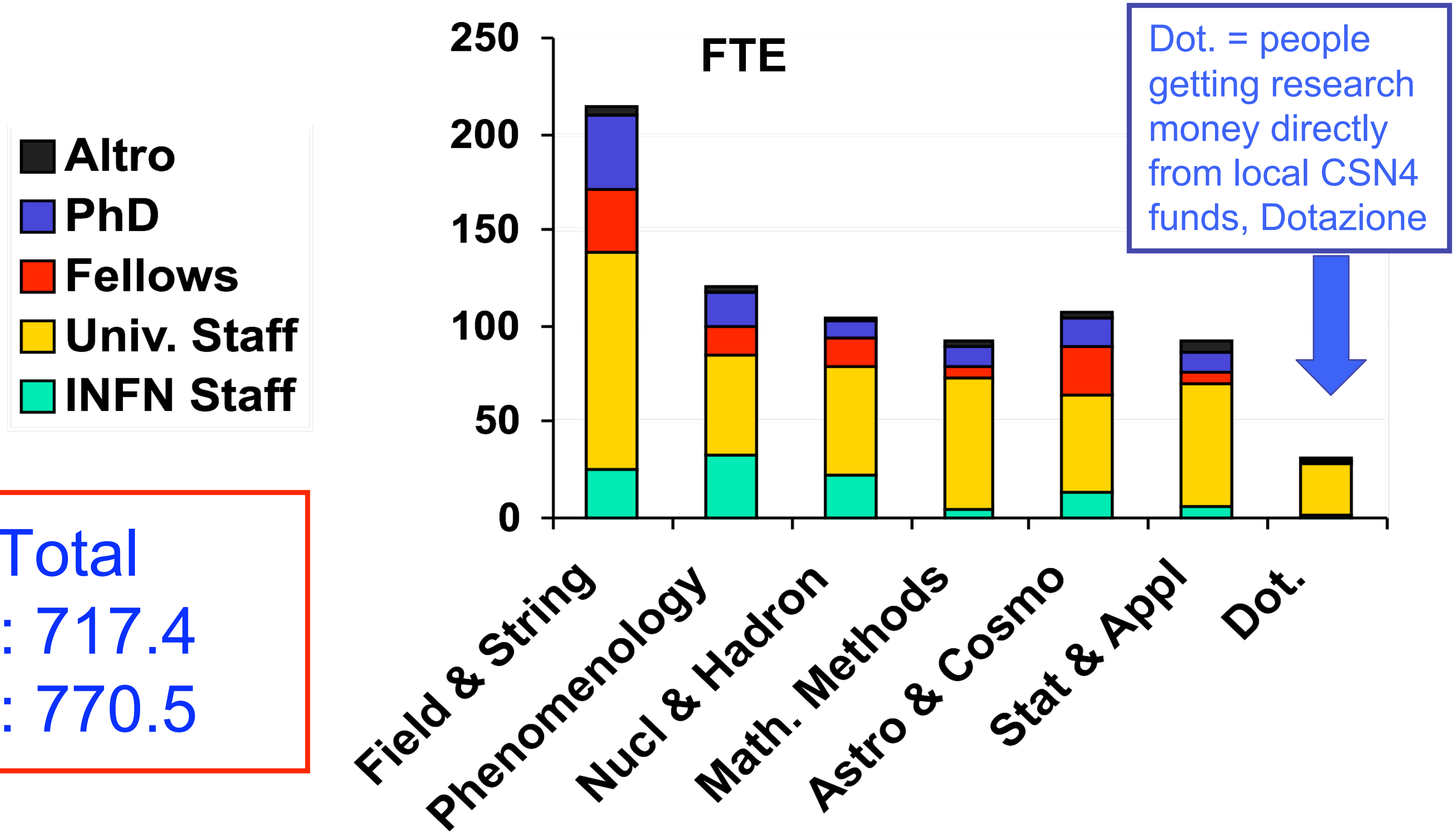
• **Statistical Field Theory & Applications:**
complex & non-eq. systems, spin glasses, applications (quant. biology, turbulence,..).

54 Research Projects called ``Iniziativa Specifica” (IS) organized in the six scientific sectors

since 2005 a reduction of number of IS from 64 to 54

elimination of IS which are mono-site or under critical

increased circulation of PostDoc and GradStuds



FTE Total
2008: 717.4
2009: 770.5

Internal and external referees for the ``Iniziative Specifiche” in the six Sectors (special thanks to the internal referees)

- String & Field Theory:
  Alberto Lerda & Domenico Seminara
- Particle Phenomenology:
  Giovanni Ridolfi & Marco Fabbrichesi
- Hadronic & Nuclear Physics:
  Marco Radici & Silvano Simula
- Mathematical Methods:
  Enrico Onofri & Gaetano Vilasi
- Astroparticle & Cosmology:
  Francesco Vissani & Giancarlo D’Ambrosio
- Statistical Field Theory & Applications:
  Leonardo Cosmai & Ettore Vicari

Every three years the Iniziative Specifiche are evaluated by external referees (from a list of 150), chosen from research institutions spread all over the world.

A stronger quantitative* correlation between ranking and the allocation of resources to the IS could be introduced.

* The introduction of a ``referee template” will certainly useful in this respect

APPLICANT DETAILS	Principal Investigators Name & Institution.
THE APPLICANT	How well do you know the applicant and by what route?
CONFLICT OF INTEREST	Referees are required to declare whether they have/have not any conflicts of interest. **Failure to make this declaration will invalidate the report.**
PROPOSAL DETAILS	Reference Number, Assessor Name and Grant Type (see letter heading for details) & Title.
THE PROPOSAL Please consider the following factors when identifying strengths and weaknesses:	Is the science high quality/worthwhile? Are the objectives of the proposal clearly stated and soundly based? Is there a sensible, clearly stated management and programme plan with timescales and milestones? Novelty, originality, timeliness and likely significance to astronomy or particle physics? Relationship with other work in the UK and abroad? Reliability of methods and techniques proposed? Industrial relevance and potential for exploitation? Viability Planning Past effectiveness of applicant(s) Suitability of applicant(s)/research team Suitability of Institution/Group Quality of leadership and management Cost-effectiveness/value for money (taking account of any resource modifications which you have recommended Quality of the outreach plan Strategy. How does the proposal map onto STFCs high priority future programme?
AREA OF RESEARCH	Please identify whether you are commenting on the proposal as a whole, or if commenting on a particular area. What is the level of worldwide activity? What is the level of UK activity in the area & its international standing? What is the importance of supporting at the present time?
THE RESEARCH TEAM	What is the international and national standing of the research team? What is the past record of, present level of output? What level of resources presently available to support the credibility of the proposal? Can the applicants deliver the stated aims and are they a competent team?
RESOURCES	Please state whether the resources requested have been justified and are appropriate (including facility requests such as computing etc. Or what modifications you would recommend). Please pay particular attention to staffing and equipment.
COMMENTS FOR THE PEER REVIEW PANEL	These comments will remain confidential and will not be disclosed to the applicant.
OVERALL SCIENTIFIC ASSESSMENT Please grade the application according to the following scale	Fundable: The proposed project is of the highest scientific merit. It is novel and/or timely and has such potential that it will, or is likely to, make a significant contribution to the field at world level or is at the forefront within the UK and is internationally competitive. The case for support demonstrates that the proposed project is feasible, well planned and cost effective. Unfundable: The science case is not compelling. The proposed research lacks originality or is not critical to any new understanding of the subject. It is either too removed from STFC's strategic plan to be funded or is not scientifically competitive. Reject: The case for support cannot be accepted for one or more of the following reasons: The Science case is technically flawed The case for resources (e.g. PDRA, other costs) has not been made
REFEREE DETAILS	Your Name, Institution and email address (you will receive confirmation by email of submission).
THE REFEREE	Please rate your confidence in your evaluation of the applicant and the research proposed (high/satisfactory/low), and indicate your areas of particular expertise.

Total	FTE	persons	budget (K€)
2008	691	950	1784,5 (+ 899.5)

CSN4 sectors	FTE 2008 (%)	Budget 2008 (%)
Linea 1 : String and Field Theory	29	30
Linea 2 : Particle Phenomenology	17	18
Linea 3 : Hadronic and Nuclear Physics	14	16
Linea 4 : Mathematical Methods	13	11
Linea 5 : Astroparticle and Cosmology	14	15
Linea 6 : Statistical Field Theory	13	10

Composition of the CSN4 (in parentheses 2008)

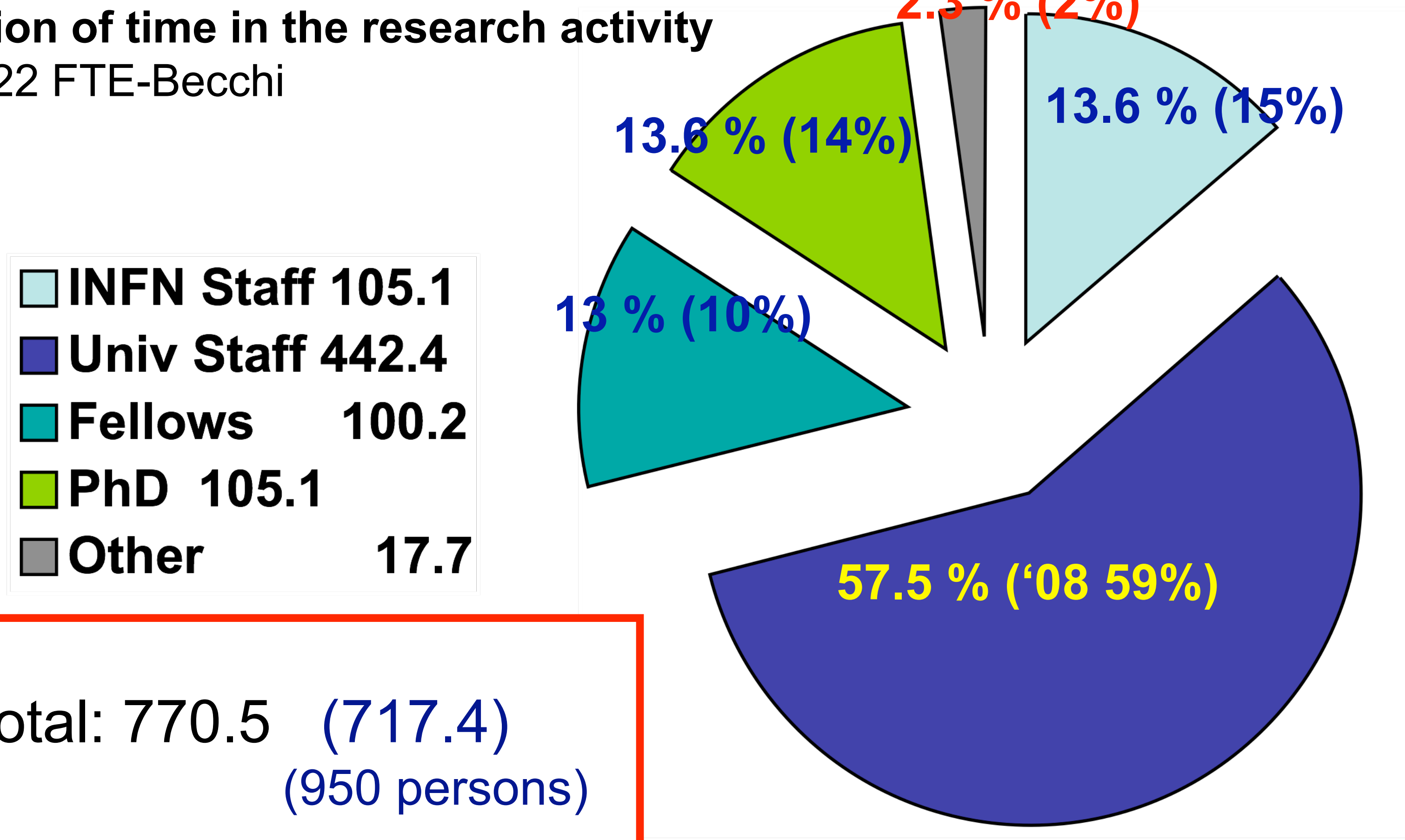
Becchi algorithm:

1) Active (at least one pub. in the last two years) → TE=1, otherwise TE=0; 2) Fellow beyond october → TE=1, between june and october → TE=0.5, otherwise TE=0;

3) PhD → TE=0.5 for the first year,→TE=0.5/1 for the second year with 0/>0 publications, TE=0/1 for the last year with 0/>0 publications

FTE = TE * fraction of time in the research activity

1 FTE-INFN ~ 1.22 FTE-Becchi



FTE 2009 Total: 770.5 (717.4)
1098 persons (950 persons)

1) STRING AND FIELD THEORY 214.9 FTE09

Superstrings, Supergravity, Supersymmetric theories: AdS/CFT duality, Branes at singularities, Intersecting and Magnetized Branes, Flux compactifications, Instanton corrections, Attractors and black holes, Tachyon condensation and string field theory, Non-commutative geometry, Anomalous dimensions and Wilson loops in N=4 SUSY, Integrability in AdS/CFT, Topological strings and Chern-Simons theory, Higher spin theory.

Extra-dimensions: EW symmetry breaking, Anomalies, Physics beyond the Standard Model.

Quantum Gravity and Cosmology: Black Hole entropy, Dark Energy and Dark Matter models, Back-reaction problems, Curvature perturbations for inflationary models, Unparticle physics and cosmology, CMB anisotropies.

Non-perturbative Dynamics in Gauge Theories: Non-Abelian monopoles, vortices, Argyres-Douglas vacua and their role for confinement and dynamical symmetry breaking; Multi-instanton effects.

QCD at large distances and applications to statistical mechanics: Lattice Gauge Theories, Color Confinement and chiral deconfining transitions, Phase diagram in temperature and density, Effective string description and quantum fluctuations of flux tubes, Stochastic perturbation theory on a lattice, Algorithms for numerical simulations.

Critical phenomena and renormalization group theory: Conformal field theory and exact results for critical phenomena; Critical phenomena in out-of-equilibrium statistical mechanics; Polymer physics and its relation with Quantum Field Theories. Spin models.

Close interaction with all the other CSN4 sectors, organization of several GGI programs and schools, large number of GradStuds

2) PHENOMENOLOGY 120.0 FTE09

Neutrino physics: neutrino mass scale and spectrum, neutrino mixing, Majorana neutrino and CP-violation, neutrinoless double-beta decay;

Flavour physics: Flavour physics with lattice simulations: CKM quark matrix and the Unitarity triangle, C, P, T and L violation, Rare decays, Electroweak Hamiltonian parameters, including g-2, Hadronic spectrum and Decay rates;

BSM: Beyond the Standard Model at LHC: Supersymmetry, Extra dimensions, AdS/CFT inspired models, EW scale strong dynamics and TC models, GUTs;

Dark Matter: models for PAMELA anomaly and dark matter physics. Data from other experiments (as ATIC);

QCD: QCD shower Monte Carlo at NLO, Sudakov distributions, QCD resummations of hadronic radiation, NLO and NNLO calculations in QCD of hard processes for LHC physics. Lattice simulations. Gauge/gravity correspondence as a model in QCD, AdS/CFT and QCD;

Miscellanea: Parton energy loss at RHIC and LHC, Heavy quark production at RHIC, Four quark meson states.

Close connection with CSN1 (particularly LHC activity), organization of several GGI programs and schools, large number of GradStuds

3) HADRONIC and NUCLEAR PHYSICS 103.7 FTE09

Heavy ion physics at LHC and RHIC: Small x physics and saturation, jets quenching and shear viscosity, Heavy flavour emission and suppression;

Hadron matter and QCD models: Space- and time-like form factors, Spectroscopy of exotic multiquark bound states, Structure functions and duality, Chiral perturbation theory, Color transparency; Partonic spin structure of the nucleon and spin sum rule, Azimuthal asymmetries, Generalized parton distributions (GPD), Transverse-momentum dependent parton distributions (TMD), Hadron fragmentation, Jet physics;

Nuclear structure and reactions: Giant resonance, Few- and many-body systems, Beyond the stability valley, Reactions of astrophysical interest like neutron stars and gamma-ray bursts.

Radioactive beams: Isospin dynamics in heavy ion collisions at intermediate energy, Exotic nuclei, Isospin symmetry, Collective excitations;

Miscellanea: Numerical studies of QCD phases in temperature and density; Flavour locking models.

Close connection with CSN1 and CSN3, in progress agreement for a collaboration between two IS of CSN4, Jlab12 of CSN3 and Jlab, organization of several GGI programs and schools, large number of GradStuds (see below)

4) MATHEMATICAL METHODS 91.7 FTE09

- General relativity and gravitational physics, including waves;
- Non commutative geometry and Quantum groups;
- Algebraic structures in QFT;
- Methods of quantization;
- Stability of quantum and classical dynamics and Entanglement;
- Randomness and chaos. Pseudo-random states from chaotic maps;
- Geometry of dynamical systems and integrable systems.

Overlap with STRING AND FIELD THEORY (general relativity, quantum groups, non commutative geometry, integrable models, non linear evolution equations). An important development concerns the mathematical properties of Quantum Mechanics for applications to computing and criptography.

5) ASTROPARTICLES AND COSMOLOGY 106.7 FTE09

• Physics of neutron stars. Quark deconfinement. Supernovae.

• Astrophysical sources of radiation. Gamma rays sources. UHE cosmic rays and neutrinos.

• Neutrinos in physics, astrophysics and cosmology. Oscillation in supernovae. Matrix elements for 0v2B. Geo / relic / solar neutrinos.

• Gravitational wave sources. Black holes. Numerical simulations.

• Cosmology. Inflation: predictions and observations. Large scale structure of the Universe. String cosmology. Leptogenesis. Big-bang nucleosynthesis.

• Dark matter and dark energy, cosmology and astrophysics. Direct and indirect tests of dark matter. Dark matter and LHC.

• Cosmological models for PAMELA anomaly. Data from other experiments (as ATIC).

• Phenomenology of Planck scale physics. Theories of gravity.

Close connection with CSN2, organization of several GGI programs and schools, large number of GradStuds (see below)

6) STATISTICAL FIELD THEORY 91.8 FTE09

Non-perturbative methods of quantum field theory applied to statistical systems: Quantum Hall effect, Strongly correlated electron systems, Long range interactions, Bose-Einstein condensation, Statistics of wave functions in quantum systems, Non-equilibrium statistical mechanics;

Quantitative biophysics: Protein folding models, Genetic functions and regulation, Mechanical properties of DNA related to the microscopic disordered structures;

Turbulence: Two-dimensional systems and conformal invariance; Lagrange theory of turbulence;

Disordered Systems like spin glasses, Neural networks.

Interdisciplinary activities in close connection with biologists, chemists, physicians, engineerings and even sociologists, with also important resources coming from beyond INFN, large number of GradStuds and substantial job flow.

A FEW NUMBERS (Year 2008)

Topics		Articles (A)	Time cited (TC)	TC/A
flavour	WHOLE	112	372	3.32
	INFN	18	70	3.89

Topics		Articles (A)	Time cited (TC)	TC/A
CP violation	WHOLE	371	976	2.63
	INFN	36	177	4.91

Topics		Articles (A)	Time cited (TC)	TC/A
Rare decays	WHOLE	119	217	1.82
	INFN	17	36	2.17

Topics		Articles (A)	Time cited (TC)	TC/A
Quantum field theory or physics, particles&field	WHOLE	2408	4768	1.98
	INFN	56	123	2.19

Topics		Articles (A)	Time cited (TC)	TC/A
Neutrino physics	WHOLE	344	1005	2.92
	INFN	32	105	3.28

Topics		Articles (A)	Time cited (TC)	TC/A
Quantum Gravity	WHOLE	808	1994	2.47
	INFN	42	97	2.31

Topics		Articles (A)	Time cited (TC)	TC/A
Branes or String or Quantum Gravity	WHOLE	3567	10282	2.88
	INFN	126	400	3.17

Topics		Articles (A)	Time cited (TC)	TC/A
Beyond Standard Model	WHOLE	1969	6472	3.28
	INFN	130	814	6.26

MAIN 2008 RESULTS

Studies on string instantons and moduli stabilization, the AdS/CFT correspondence and modified gravity theories;

Development of tools for the analysis of LHC data, flavour physics analyses and the study of scenarios of non-standard physics, within supersymmetry, or in the presence of new mechanisms for the electroweak symmetry breaking, and the connection of particle physics with cosmology and astrophysics. Within this last subject, we remark a work on observable signatures generated by dark matter annihilations in our galaxy.

In addition, the parametrization of the nucleon transversity distribution function, recently achieved for the first time, has been subject to intense investigation and interesting results on the behaviour of meson correlation functions in the confined hadronic and deconfined plasma phases of QCD have been presented. Accurate methods in few body systems and studies of collective exotic excitations in nuclei far from stability were of particular interest also for their astrophysical applications, e.g. to proton capture on deuterium or He3 and to the evolution of (neutron) stars.

In astroparticle and cosmology, besides dark matter studies, we recall the important activity coming from analyses of neutrino oscillation data and their implications for model of flavour mixing, the studies on the primordial density fluctuations, and gravitational waves.

Important results on the precise definition of multipartite entangled states and for the description of the quantum dynamics of a ``qbit” coupled to a spin system were obtained, together with interesting studies on the application of chaotic dynamics to quantum computing, on non-commutative space-time and spin glass systems.

SELECTED TOPICS AND FIGURES (too few for lack of time/space)

Gravity S. Capozziello & M. Francaviglia Gen. Rel. Grav. . 40 357:420 (2008) (108 cites on Spires)

A survey of Extended Theories of Gravity is presented, with a detailed discussion of the ``Palatini” and ``metric” approaches. Several cosmological and astrophysical applications are discussed, in particular with reference to the dark components.

[152, 154], one gets as exact solution from a theory $f(R) = f_0 R^n$, the modified gravitationa

$$\Phi(r) = -\frac{Gm}{2r}\left[1 + \left(\frac{r}{r_c}\right)^{\beta}\right]$$

$$\beta = \frac{12n^2 - 7n - 1 - \sqrt{36n^4 + 12n^3 - 83n^2 + 50n + 1}}{6n^2 - 4n + 2}$$

$$v_c^2(r) = \frac{Gm}{2r}\left[1 + (1-\beta)\left(\frac{r}{r_c}\right)^{\beta}\right] .$$

Compared with the Newtonian result $v_c^2 = Gm/r$, the corrected rotation curve i

37

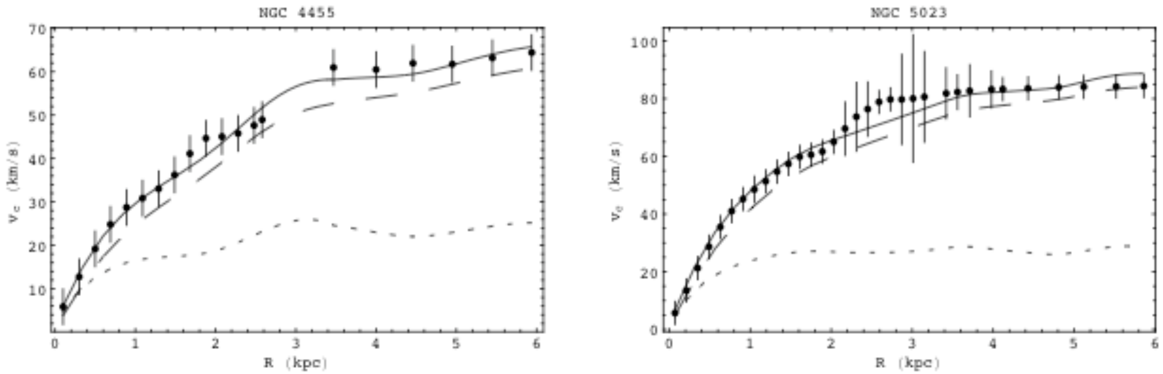


Figure 10: Best fit theoretical rotation curve superimposed to the data for the LSB galaxy NGC 4455 (left) and NGC 5023 (right). These two cases are considered to better show the effect of the correction to the Newtonian gravitational potential. We report the total rotation curve $v_c(r)$ (solid line), the Newtonian one (short dashed) and the corrected term (long dashed).

SELECTED TOPICS

LHC   J. Alwall et al. Eur. Phys. J. C53 473:500 (2008) (61 cites on Spires)

This paper compares different approaches for Monte Carlo event generators which combine matrix elements and parton shower. A good control of the predictions for SM events is essential to find signals of new physics, which involve chain decays of heavy coloured particles such as squarks, gluinos and heavier partner of the top

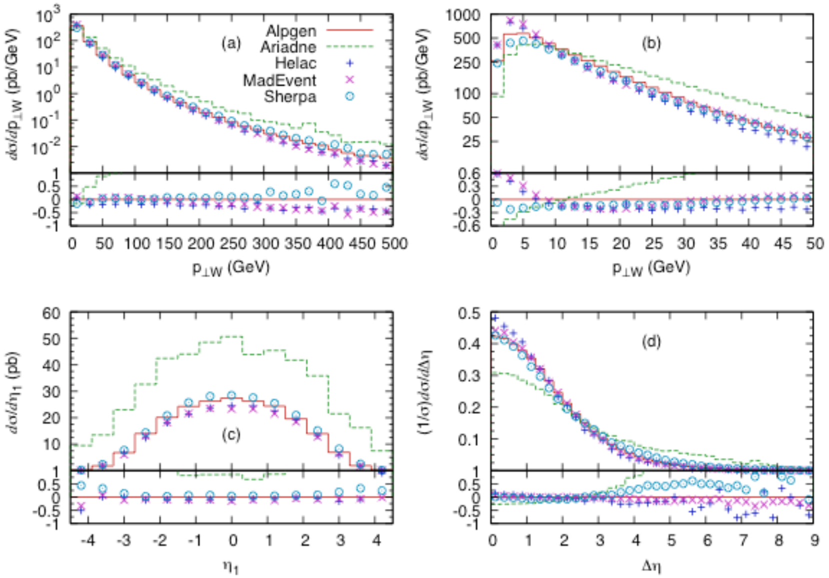
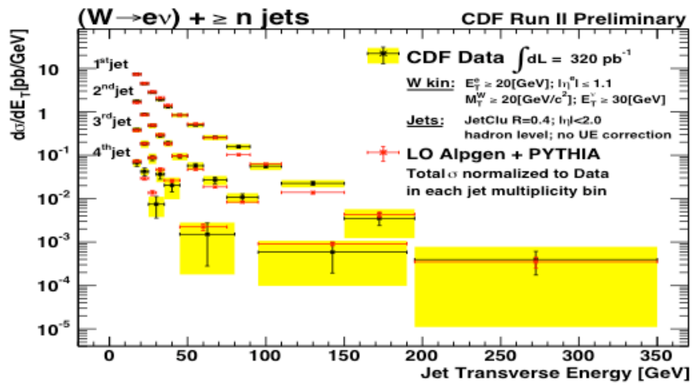


Figure 3.26: (a) and (b) $p_\perp$ spectrum of W^+ bosons at the LHC (pb/GeV). (c) η spectrum of the leading jet, for $p_\perp^{jet1} > 100$ GeV; absolute normalization (pb). (d) Pseudo-rapidity separation between the W^+ and the leading jet, $\Delta\eta = |\eta_{W^+} - \eta_{jet1}|$, for $p_\perp^{jet1} > 40$ GeV, normalized to unit area. In all cases the full line gives the ALPGEN results, the dashed line gives the ARIADNE results and the "+", "x" and "o" points give the HELAC, MADEVENT and SHERPA results respectively. In the lower frame relative deviation with respect to ALPGEN predictions are shown.



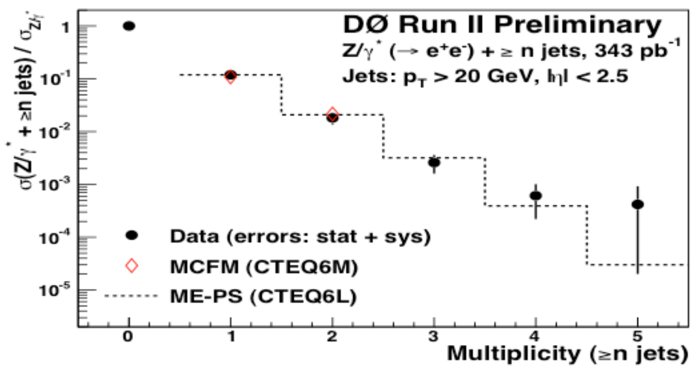


Figure 3.24: **Left:** differential cross section $d\sigma(W \to e\nu + \geq n-\text{jets})/dE_T^{jet}$ (Right) for the first, second, third and fourth inclusive jet sample. Data are compared to `Alpgen+PYTHIA` predictions normalized to the measured cross section in each jet multiplicity sample. **Right:** Measured cross section for Z+jets production as a function of inclusive jet multiplicity compared to MADGRAPH + PITHYA. Absolute cross section normalized to data.

SELECTED TOPICS

Dark Matter M. Cirelli, R. Franceschini and A. Strumia Nucl. Phys. B800, 204:220 (2008)
(40 cites on Spires)

This paper computes the energy spectra of the fluxes of photons, positrons and anti-protons generated by Dark Matter annihilations in our galaxy, as predicted by the model of Minimal Dark Matter. The conclusion is that dinstinctive signals can be generated above the background in the range of energies soon to be explored by cosmic ray experiments.

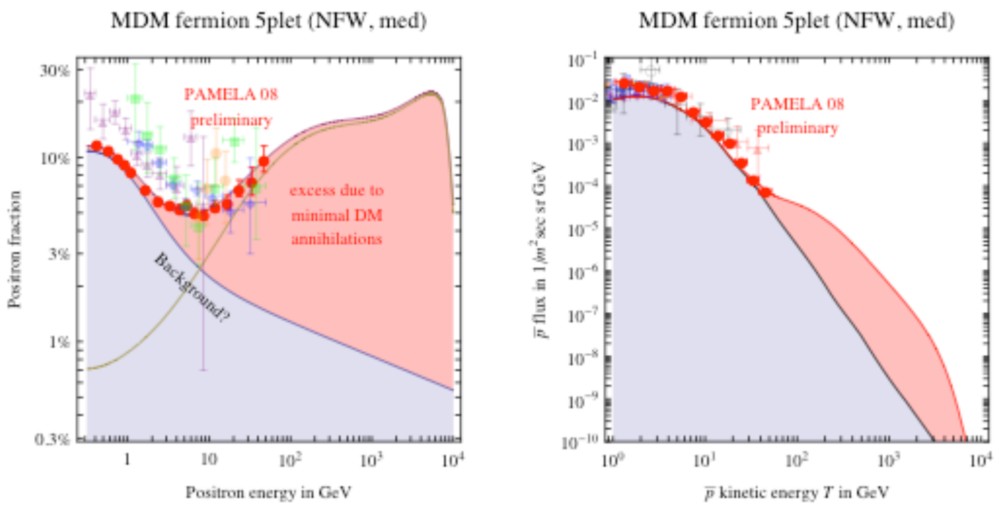


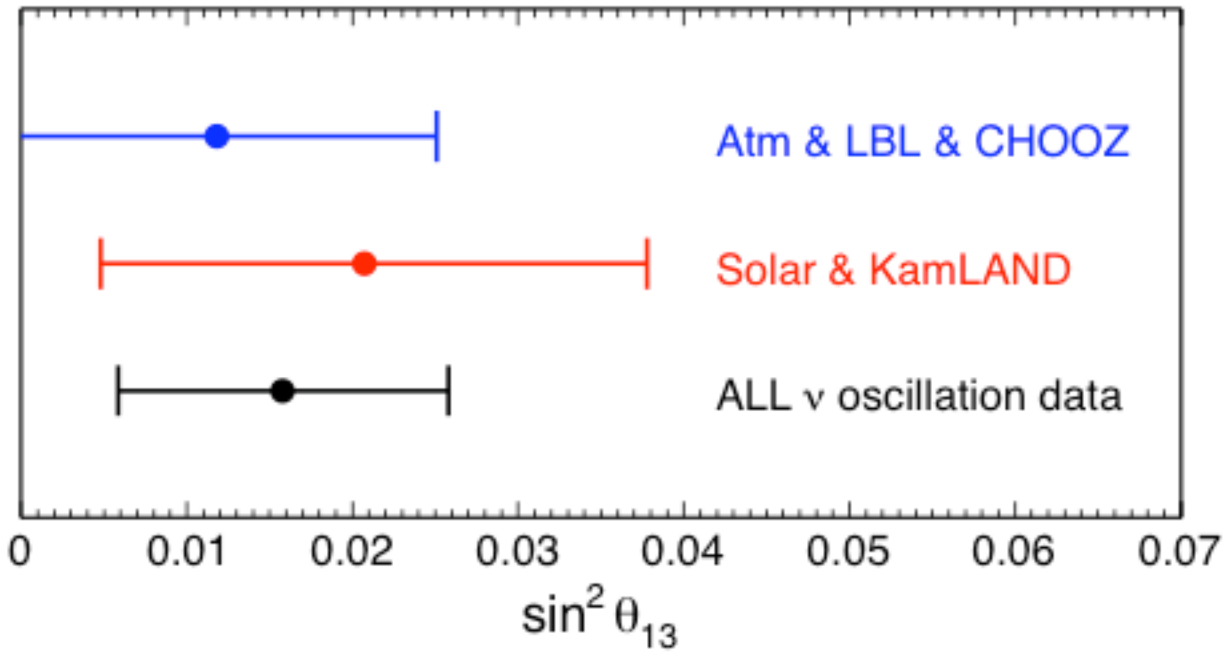
Figure 7: *Predicions of the Minimal Dark Matter fermion quintuplet compared to preliminary PAMELA data. In both figures the boost factor equals* $B = 3$ *if* $\langle\sigma v\rangle_{WW} = 9 \cdot 10^{-23}\,\mathrm{cm}^3/\mathrm{sec}$ *which corresponds to* $M = 9.2\,\mathrm{TeV}$, *or* $B = 30$ *if* $\langle\sigma v\rangle_{WW} = 1.1 \cdot 10^{-23}\,\mathrm{cm}^3/\mathrm{sec}$, *obtained for* $M = 9.6\,\mathrm{TeV}$, *within the range inferred from the measured DM cosmological abundance.*

SELECTED TOPICS

Neutrino Physics G.L. Fogli, E. Lisi, A. Marrone, A. Palazzo, A.M. Rotunno
Phys. Rev. Lett. 101:141801 (2008) (63 cites on Spires)

From a global analysis of neutrino oscillations, using new results from solar and lon-baseline reactor neutrino data, the authors provide the global extimate

$$\sin^2\theta_{13} = 0.016 \pm 0.010 \quad (1\sigma)$$



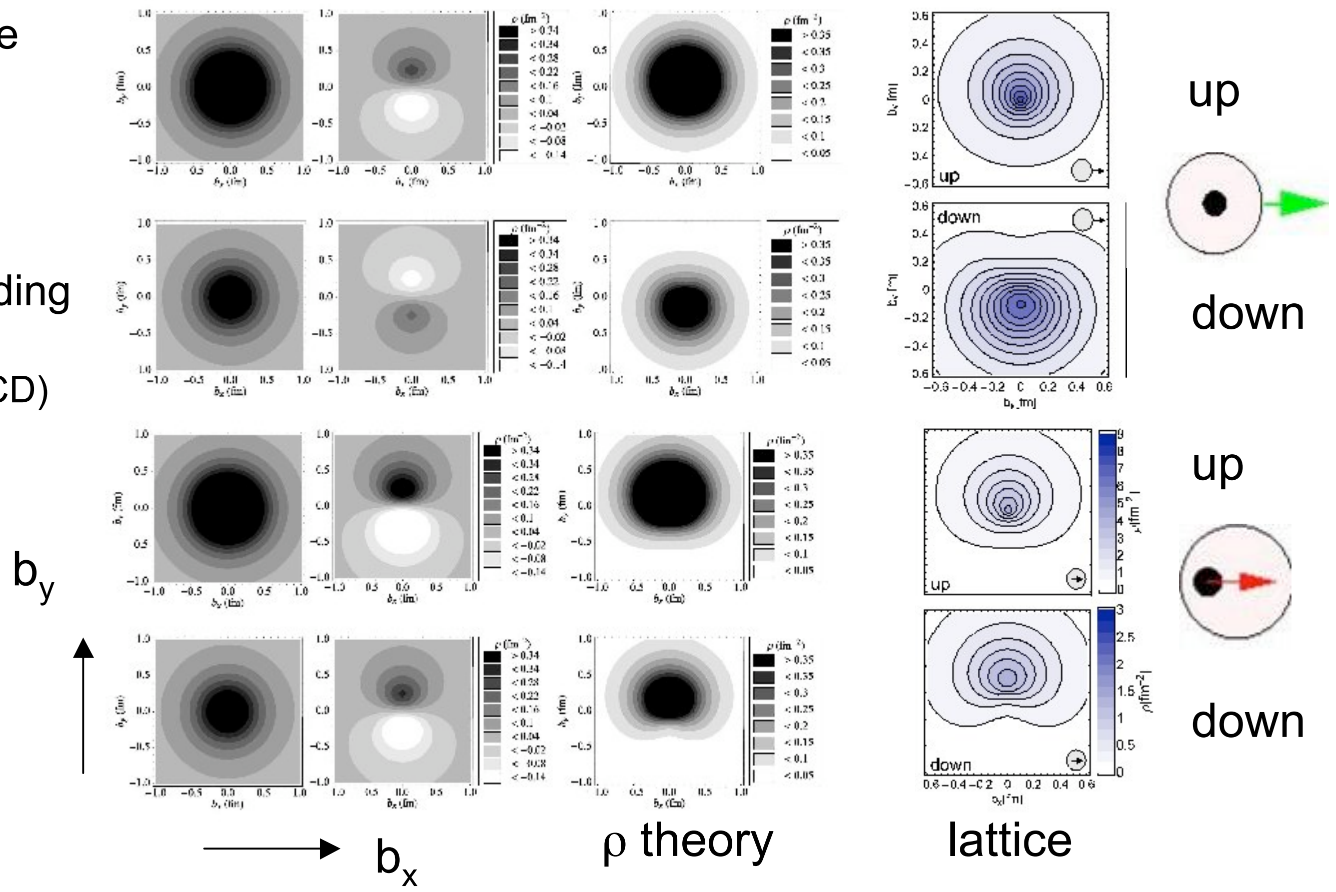
GPD and hadronic physics   S. Boffi, B. Pasquini Riv. Nuovo Cim. **30** (07) 387 (45 cites Spires)

First x-moments of Generalized Parton Distributions (GPD) allow to construct quark densities $\rho(\mathbf{b},\mathbf{s},\mathbf{S})$ in impact parameter space $\mathbf{b}=(b_x,b_y)$ for transverse polarization **s** of the quark and **S** of the proton.
First two rows: $\rho(\mathbf{b},\mathbf{s}=0,S_x)$ for up and down, i.e. how the distribution of unpolarized quarks is deformed by the transverse polarization of the parent proton.
Next two rows: the symmetric situation, i.e. $\rho(\mathbf{b},s_x,\mathbf{S}=0)$ for up and down.

First two columns: monopole and dipole contributions

Third column: the sum = ρ

Last column: the corresponding results on lattice from
Goeckeler *et al.* (QCDSF/UKQCD) PRL **98** (07) 222001



SUMMARY OF RESEARCH ACTIVITIES

Large spectrum of reseach subjects
Leadership in various fields
Raising LHC activity
Increasing Astroparticle & Cosmology interest

Unfortunately -> the average age of the INFN and
of university staff is also continously
increasing in the years

TRAINING & JOBS

- Schools for GradStuds: Parma, Frascati, Otranto, ICTP (50% support from INFN)
- Visiting days at GGI 150/year
- Visiting days at ICTP 400/year
- Over 70/year get PhD in CSN4 activities (and about 50/year get a postdoc abroad)
- About 40/year got a permanent job abroad in the last 5 years *
- GradStuds + Postdocs ~ 35% of the CSN4 and ~ 40% of the papers
- Sergio Fubini Prize: best 3 PhD thesis/year (most winner abroad)

Job flow in CSN4 (rough estimate)

- over 70/year obtain PhD in CSN4 activities then

  40-50 abroad and 10-15 inside as PostDocs

- New PostDocs/year in Italy: 40

  20 Italians back (after few years) + 10 foreigners+10

- Total GradStuds+PostDocs in CSN4 = $250(60 \times 3 + 40 \times 2)$

  $= 35\%$ of CSN4 personnel

- Overall new permanent positions in last five years

  - 25-30 University jobs
  - no INFN jobs, but expected (need selection on worldwide bases)

- but more than 30 found permanent jobs abroad in last five years

By Giuseppe Marchesini last year (I did have not time to update these figures)

International collaborations are strongly supported. Over 50% of the full CSN4 budget is used for exchanges with foreign Institutions (with comparable investments made by these Institutions). In addition, the INFN agreements with ITEP, JINR, IHEP (Russia), MEC (Spain), MIT (US), ICTP and ECT* are intensively used by CSN4 members.

Galileo Galilei Institute

GGI Florence

PRESENT GGI ORGANIZATION

Coordinator: Giuseppe Marchesini
Deputy Coordinator: Roberto Casalbuoni (special thanks)

Advisory Committee: Gabriele Veneziano* (chair), Marcello Ciafaloni, Paolo Di Vecchia, Guido Martinelli, Alfred Mueller, Giorgio Parisi, Valery Rubakov

Scientific Committee: Giuseppe Marchesini (chair), Roberto Casalbuoni (deputy chair), Gia Dvali, Pilar Hernandez, Jan Louis, Michelangelo Mangano, Alex Pomarol, Eliezer Rabinovici, Antonio Riotto

Local Committee: Andrea Cappelli, Stefano Catani, Stefania De Curtis, Daniele Dominici, Domenico Seminara, Marco Tarlini

Local Staff: Antonio Orlando, Antonella Pagliai, Margherita Pazzaglia

* Gabriele Veneziano participates (part time) to all programs

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GGI participation & results (average)

workshop duration: 2-3 months
average presence on site per participant: 3 weeks
participants per workshop: 70-90 (20-25 INFN) + 10-15 grad. stud.
articles produced per workshop: 15-20

GGI activity during the workshop

few seminars per week (30 seats lecture hall)
general introductory lectures (90 seats lecture hall)
small size conference within the workshop
four small group discussion rooms - 35 desks
exit report (scientific report, suggestions, general considerations and evaluation, so far very positive)

GGI and training

specific budget from CSN4 for 150 day-visits for grad. stud. & post-docs.
GGI participants encouraged to bring their GradStuds
GGI workshops organize introductory lectures for GradStuds

Parallel activities: two week School for Graduate Students in Parma

2006 Strings, D-Branes and Extra Dimensions
2007 New Physics at the LHC: from model building to event generation
2008 Current Trends in Theoretical Physics
2009 Theoretical tools for the LHC

COST

70 € /day for each participant ≈ 50 K€ /month for the workshop (all incuded)
INFN for perdiem + extra costs: 350 K€ (including 100 K€ from CSN4) in 2007
INFN Agreement with University of Florence: 2 secretaries, 1 computer manager

2009: 330 K€ (WS) + 20 K€ (Visits) + 10 K€ (General) (60 from CNS4)

http://ggi-www.fi.infn.it/

Calendar of current & next year workshops:

- **2009** New horizons for Modern Cosmology (Jan 19th – Mar 13th)
- **2009** New perspectives in String Theory (Apr 4th – June 19th)
- **2009** Searching for new physics at LHC (Aug 31st – Oct 10th)

- **2010** Indirect searches for new physics at the time of LHC (Feb 15th – Mar 26th)
- **2010** Dark Matter: its origin, nature and prospects for detection (Apr 26th – June 19th)
- **2010** AdS4/CFT3 and the Holographic States of Matter (Aug 30th – Nov 5th)

last meeting of the scientific committee

on november 2nd 2009

1) **Large-N Gauge Theories:** period spring 2011; duration 10-12 weeks; focused on several aspects of large N gauge theories - phenomenology, formal, and lattice -; organizers A. Armoni (Swansea), T. Cohen (Maryland), G. Grignani (Perugia), H. Neuberger (Rutgers), L. Yaffe (Seattle), A. Zaffaroni (Milano Bicocca).

The SC finds the proposal scientifically interesting and well formulated, the composition of the organizing committee, the list of potential participants, timing and duration of the workshop adequate.

The SC suggests the inclusion of an expert on integrability in the organizing committee.

The organizing committee is strongly advised to contact as soon as possible their list of key participants to secure the participation of a large number of them.

2) **High Energy QCD after the start of LHC:** period autumn 2011; duration 8 weeks; focused on the main aspects of QCD physics at LHC - hard scattering and multiparticle final states, Monte-Carlo generators, jet studies and dynamics of jet production and fragmentation, parton distribution functions (high precision, dynamics of strong colour fields), new (formal) developments, minimum bias, underlying event, soft and diffractive processes, forward physics, ultraperipheral collisions, heavy ion collisions -; organizers Stefano Catani (INFN, Florence), Yuri Dokshitzer (LPTHE, Paris), Massimiliano Grazzini (INFN, Florence and ETH, Zurich), Mark Strikman (Penn State Univ.).

The SC finds the proposal scientifically interesting and well formulated, the composition of the organizing committee, the list of potential participants and the timing of the workshop all adequate.

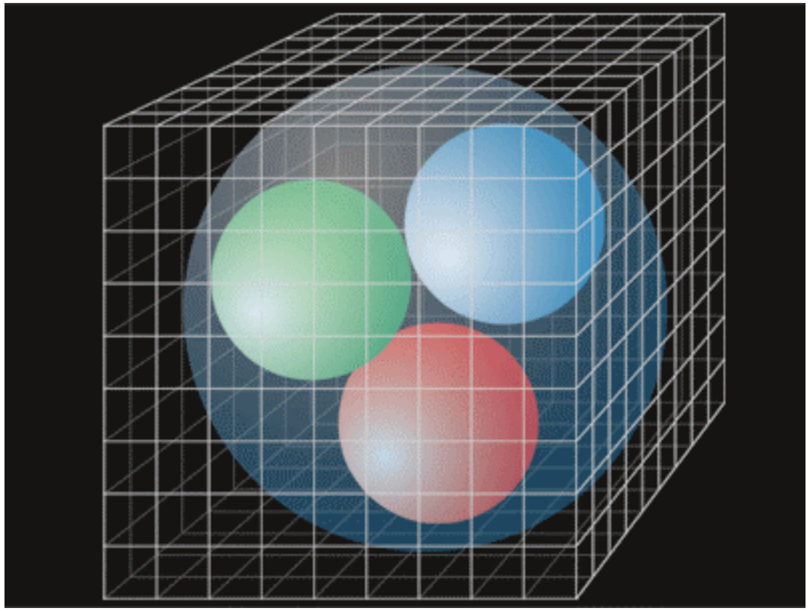
The SC asks the organizers to reduce the duration of the workshop to six weeks, plus a week entirely dedicated, according to the proposal, to pedagogical overview lectures for the benefit of PhD students and young postdocs. The request of a reduction of the overall duration is motivated by the observation that the present program looks too diluted and there is the risk that people interested in the same subjects will not be present in the same period. Practical reasons force to concentrate the pedagogical lectures, which are strongly appreciated by the SC, in the same week.

3) **Interpreting LHC discoveries:** period from summer to end 2011; duration 4 weeks; focused on the data analysis and interpretation of the first signal from the LHC – Higgs boson search and electroweak symmetry breaking, rare decays, dark matter -; organizers Joseph Lykken, Daniele Pedrini, Andrea Romanino Gavin Salam, Avi Yagil.

The SC finds the proposal scientifically interesting and well formulated, the composition of the organizing committee, the list of potential participants and the timing of the workshop all adequate.

The most suitable date is end of 2011 (novembre-december), just after the the workshop on ``High Energy QCD after the start of LHC", with the recommendation that, in case by November 2010 there will be clear problems with keeping the present LHC schedule, the possibility of postponing the workshop to 2012 will be rediscussed with the organizers.

COMPUTING: PC CLUSTERS & APE



PC CLUSTERS

2007: investment of 200 K€ in the start up of four PC clusters,
i) BARI ii) CATANIA iii) MILANO BICOCCA iv) PISA,
corresponding to pools of several Divisions:

Bari-Cosenza-Genova-Lecce-Napoli-Torino
Catania (used by Rome La Sapienza and Perugia)
MI-Bicocca-Parma-Rome TVergata-Torino
Pisa-Milano-Roma La Sapienza

2008: further 200 K€, mostly to improve the four clusters + peanuts for smaller local farms

Increasing computer power necessary for particle phenomenology, nuclear theory, statistical mechanics, turbulence, complex systems, quantitative biology, ..

Bari-Cosenza-Genova-Lecce-Napoli-Torino (responsible L. Cosmai)

14 (112 core Opteron 2347) + 20 nodes (biprocessors quad-core Xeon, 160 core), in Grid (within a priority system)
Started in october 2008 (1st tranche), + (2nd tranche 2009)
Power xxxx, used at 91%
Next october a workshop will be held in Bari (in collaboration with Grid) on the farm for scientific computing

Scientific Activity:

Studies of dynamical behaviour of topological defects with nematic order parameters (G. Gonnella & A. Piscitelli);
Statistical mechanics of multipartite entanglement (S. Pascazio & G. Florio);
Flux tubes at the deconfining transition point in QCD (P. Cea, L. Cosmai (BA), R. Falcone & A. Papa (CS));
Analytic continuation from imaginary to real chemical potential in QCD (M. D'Elia (GE), F. Sanfilippo(RM1))

Cholesterolic phase

Catania (responsible G. Andronico)

*1U machines for a total of 46 core, * blade IBM LS21 with 10 blades, each with double Opteron dual core, for a total of 40 core, * blade IBM LS22 with 3 blades, each with double Opteron quad core, for a total of 24 core, present in GRID, VO theophys*

Milano-Bicocca-Parma-Roma TV-Torino (responsible C. Destri)

One storage 4U, 6TB (12x500GB SATAII 7200, hot swap)
in raid 6 with two processors Opteron 2216 dual core, 2.4GHz & 4GB ram
DDR2 EEC 667MHz. 9 nodes diskless DELL SC1435, format 1U,
with two processors Opteron 2216 dual core, 2.4GHz e 4GB ram
DDR2 EEC 667MHz. -- Infiniband Net (switch 24 DDR 4X
Flextronix F-X430044 certified Mellanox e local interfaces
Mellanox MHGS18-XT). Not yet in GRID

Scientific Activity (selected topics):

Studies of spin sytems at high temperature (P. Butera)
SU(3) gauge theory at high temperature (M. Caselle)
ϕ^4theory and cosmic inflation (C. Destri);
Unstable string decays (M.Pepe)

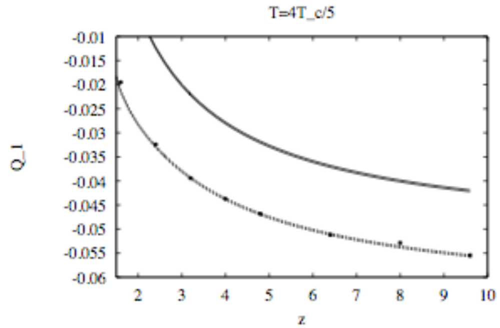
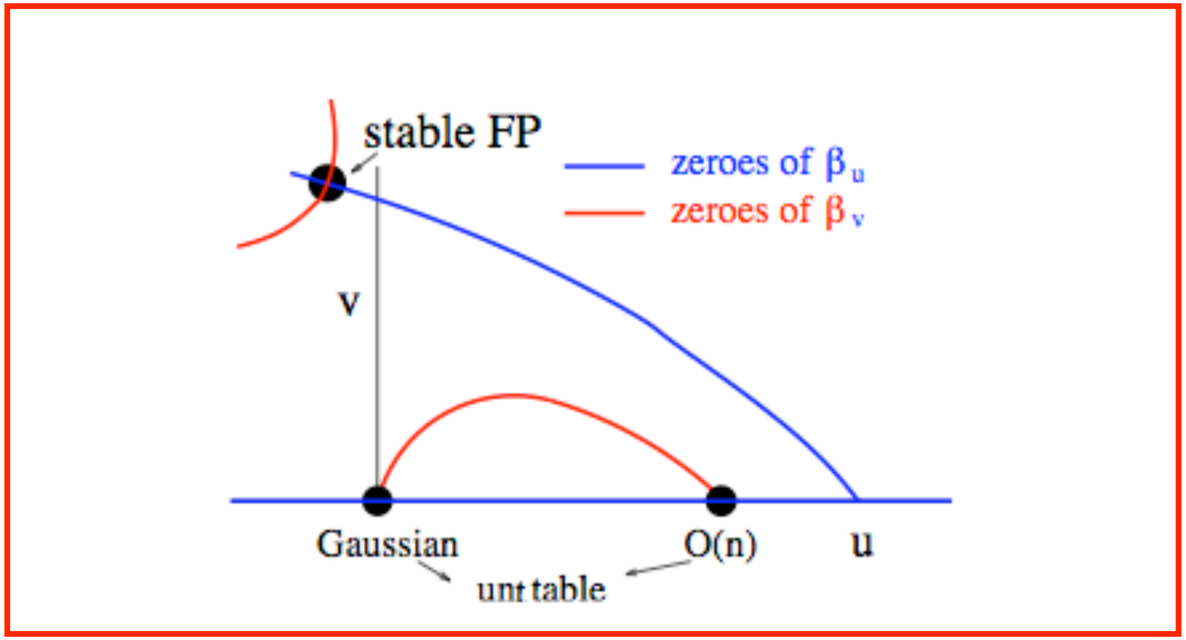


Figure 1. $Q(R,L)$ for $L=10$ (i.e. $T=4T_c/5$) at $\beta=0.75180$. z is defined as: $z\equiv\frac{2R}{L}$. Solid curves correspond to the free bosonic string prediction, while dashed lines are the NLO Nambu–Goto correction. A pure area–law would be described by $Q=0$.

Milano-Bicocca: P. Butera, C. Destri, M. Pepe, F. Rapuano, H. Simma; Parma: R. Alfieri, R. Burioni, R. Covati, R. De Pietri, F. Di Renzo, E. Onofri; Roma TV: R. Frezzotti, S. Morante, G. Rossi, A. Vladikas; Torino: M. Caselle, A. Feo, N. Gliozzi, I.Pesando.

Pisa-MI-Roma LS (responsible M. Campostrini)
12 nodes (biprocessors, quad-core Xeon) (installed 2008)
12 nodes (biprocessors, quad-core AMD, (installed 2009)
total 192 cores; in GRID, VO theophys, used at 80%

Scientific Activity (selected topics):
Large N QCD, QCD at finite temperature, disordered systems, spin glasses, critical behaviour of confined systems, nuclear systems
Staff: S. Caracciolo, R. Ferrari (MI), A. Pelissetto (Roma I),
P. Calabrese, M. Campostrini, A. Di Giacomo, A. Kievsky, E. Vicari,
M. Viviani (PI)



APE
(APE, APE100, APEmille, APEnext, AP????URORA

- Status
  - 1988 APE: use commercial chips (INFN project)
  - 1993 APE100: use custom chips (INFN project) (no suitable chip on market)
  - 1999 APEmille: use custom chips (INFN+DESY+Orasy project)
  - 2005 apeNEXT: use custom chips (INFN+DESY+Orasy project)
  - 2006 apeNEXT: 10Tflops for CSN4 (La Sapienza) 6 Tflops sustained
    increase of almost one order of magnitude in computer power
- Computations with dynamical fermions: $\int D\psi \, e^{-S_{\mathrm{quark}}[A,\psi]} = \mathrm{Det}[S''_{\mathrm{quark}}[A]]$
  - Flavour physics (physics and chiral fermion algorithms) (60% of use)
  - QCD at high density and Alice physics (10%)
  - QCD phases and non-perturbative field theories (20%)
  - turbulence in non-linear regimes (10%)
- need of large collaborations (high computer power+new algorithms)
  INFN (40 participants) + 12 European Institutions (40 participants): CERN, DESY-Zeuthen, DESY-Hamburg, LPT-Orsay, Liverpool, Edinburgh, Valencia, Zurich, Munster, Cyprus

Taken from G. Marchesini

Most cited lattice papers published in 2008 (Spires)

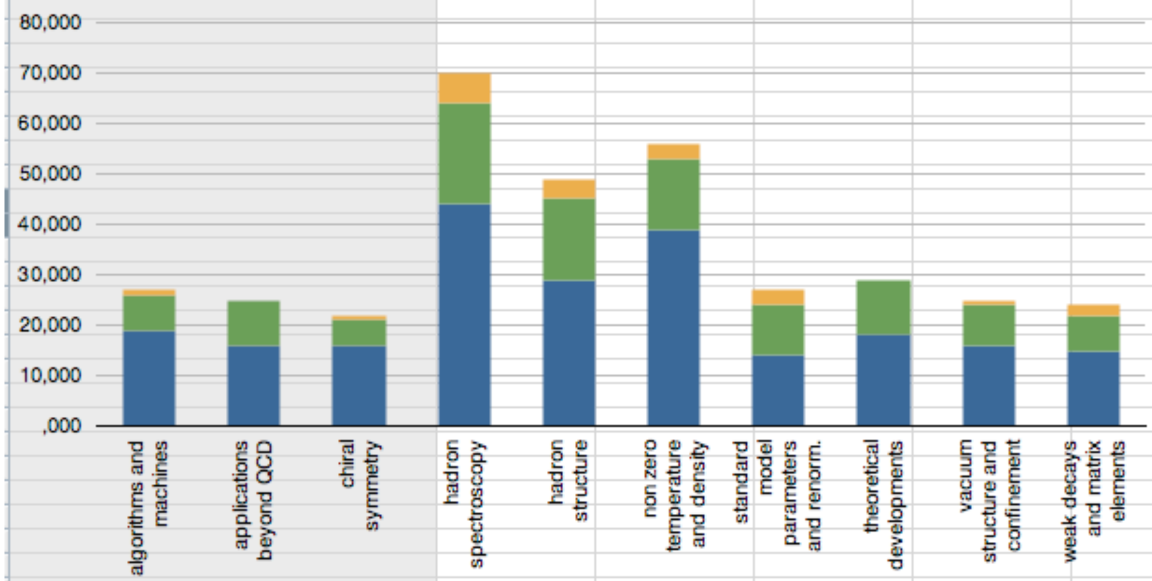
M. Cheng et al.
``The QCD Equation of State with almost Physical Quark Masses"
139 cites

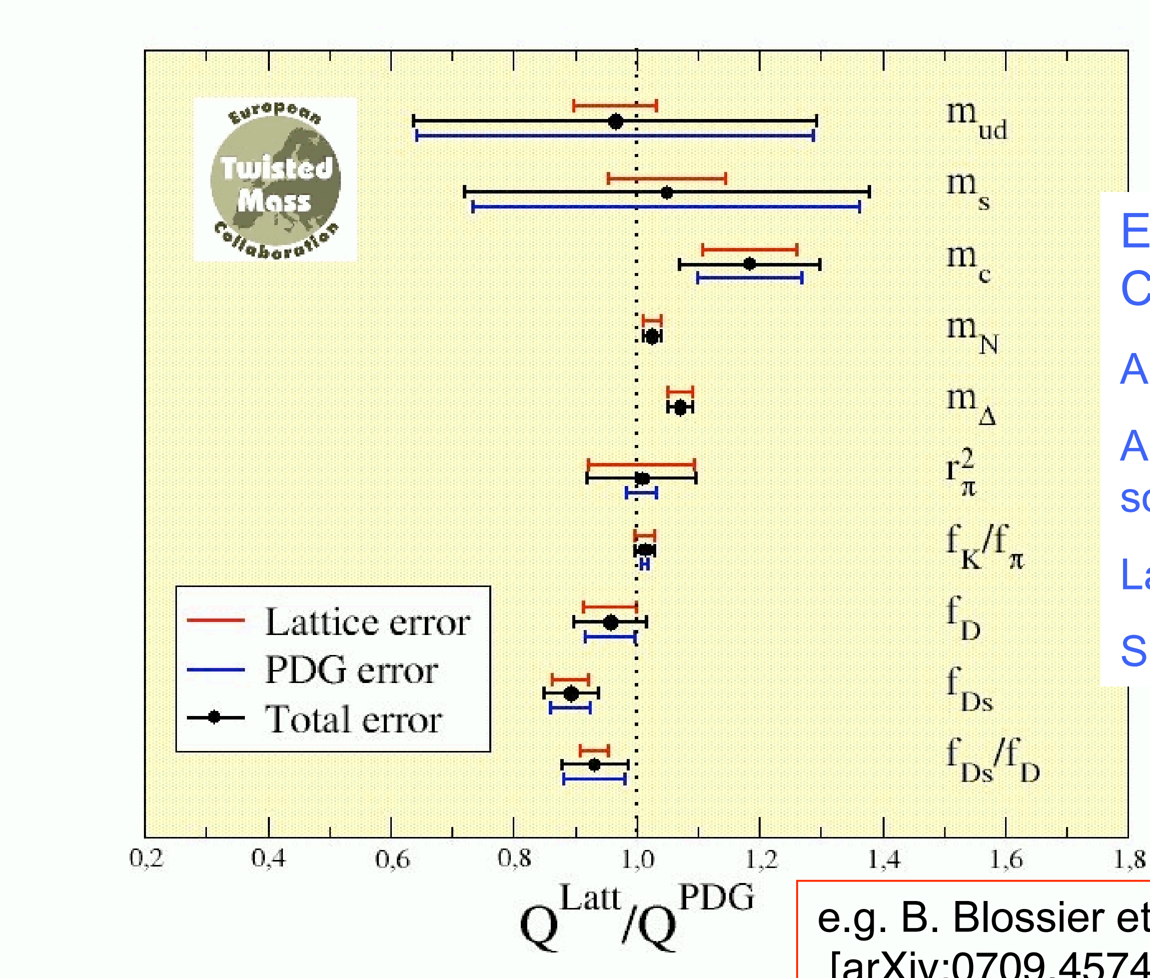
Most cited APE paper
B. Blossier et al.
``Light quark masses and pseudoscalar decay constant form Nf=2 lattice QCD with twisted mass fermions"
37 cites (within the first 20 cited ``lattice" papers)

Most cited lattice paper with INFN authors
L. Del Debbio et al.
``QCD with light Wilson quarks on fine latttices. II.DD-HMC simulations and data analysis"
38 cites

	Total	Europe	APE	Percent
algorithms and machines	19	7	1	0,05
applications beyond QCD	16	9		0,00
chiral symmetry	16	5	1	0,06
hadron spectroscopy	44	20	6	0,14
hadron structure	29	16	4	0,14
non zero temperature and density	39	14	3	0,08
standard model parameters and renorm	14	10	3	0,21
theoretical developments	18	11		0,00
vacuum structure and confinement	16	8	1	0,06
weak decays and matrix elements	15	7	2	0,13
total	226	107	21	0,09

Chart 1





European Twisted Mass Collaboration

About 50 Participants + 20 PhD students

Abot 2 Tflops from APE +15 from other sources

Lack of an Italian Large

SuperComputing Network

e.g. B. Blossier et al. JHEP 0804 (2008) 020 [arXiv:0709.4574 [hep-lat]]

The computer time for this project was made available to us by the John von Neumann-Institute for Computing on the JUMP and Jubl systems in Jülich and apeNEXT system in Zeuthen, by UKQCD on the QCDOC machine at Edinburgh, by INFN on the apeNEXT systems in Rome, by BSC on MareNostrum in Barcelona (www.bsc.es) and by the Leibniz Computer centre in Munich on the Altix system. We thank these computer centres and their staff for all technical advice and help.

Cost of the target simulations:

Light quarks phys.	Heavy quarks phys
Nconf = 120	Nconf = 120
a = 0.05 fm [$1/a$ = 3.9 GeV]	a = 0.033 fm [$1/a$ = 6.0 GeV]
$\hat{m}/m_s$ = 1/12 [m_π = 200 MeV]	**$\hat{m}/m_s$ = 1/12** [m_π = 200 MeV]
L_s = 4.5 fm [$V = 90^3 \times 180$]	L_s = 4.5 fm [$V = 136^3 \times 270$]
0.07 PFlop-years Wilson **1-2 PFlop-years GW**	**0.9 PFlop-years Wilson**

Overhead for Nf=2+1 and lattices at larger a and m is about 3

Affordable with 1-10 PFlops !!

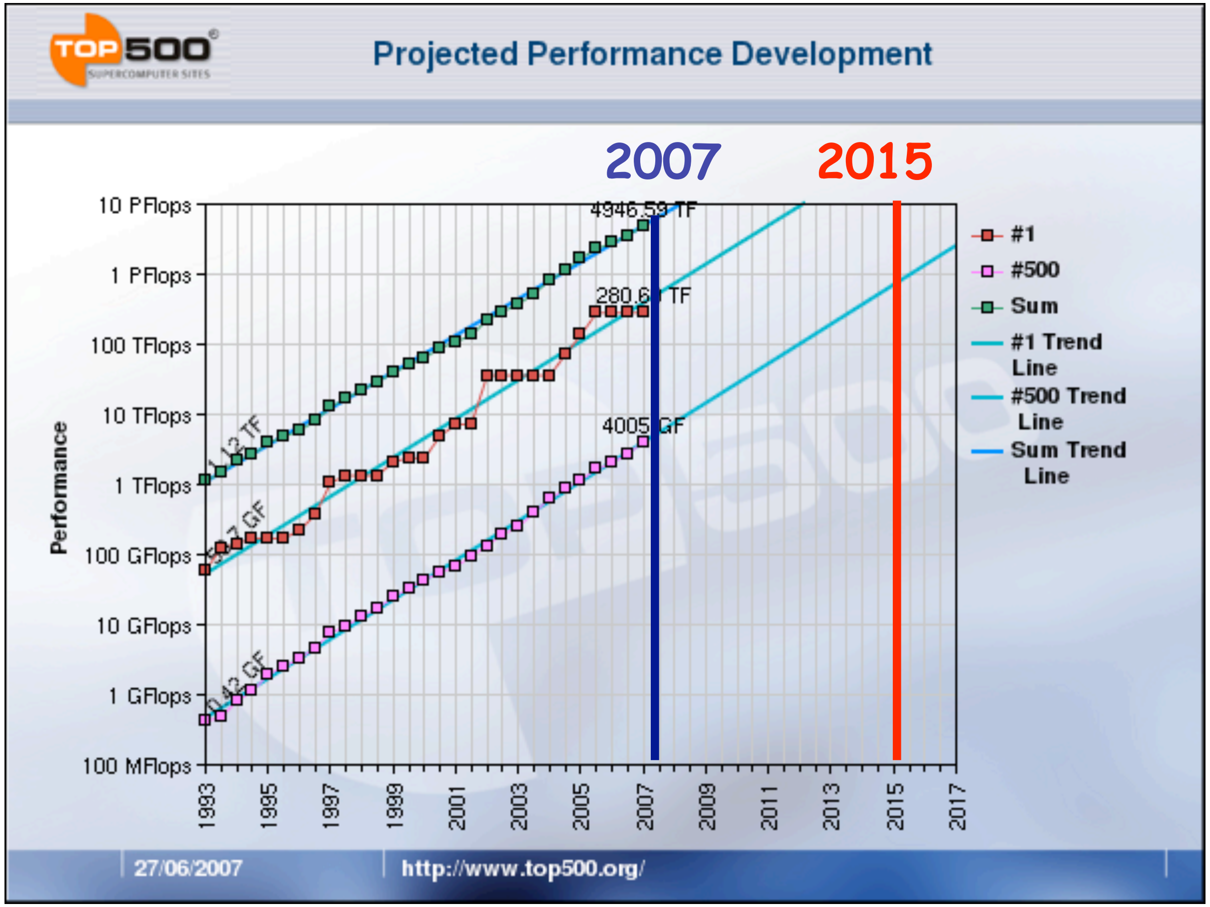
V. Lubicz, SuperB_Padova 2008

Estimates of error for 2015

Hadronic matrix element	Current lattice error	6 TFlop Year	60 TFlop Year [2011 LHCb]	1-10 PFlop Year [2015 SuperB
$f_+^{K\pi}(0)$	0.9% (22% on $1-f_+$)	0.7% (17% on $1-f_+$)	0.4% (10% on $1-f_+$)	**< 0.1% (2.4% on $1-f_+$)**
$\hat{B}_K$	11%	5%	3%	**1%**
f_B	14%	3.5 - 4.5%	2.5 - 4.0%	**1 – 1.5%**
$f_{Bs}B_{Bs}^{1/2}$	13%	4 - 5%	3 - 4%	**1 – 1.5%**
ξ	5% (26% on ξ-1)	3% (18% on ξ-1)	1.5 - 2 % (9-12% on ξ-1)	**0.5 – 0.8 % (3-4% on ξ-1)**
$\mathcal{F}_{B\to D/D^*l\nu}$	4% (40% on $1-\mathcal{F}$)	2% (21% on $1-\mathcal{F}$)	1.2% (13% on $1-\mathcal{F}$)	**0.5% (5% on $1-\mathcal{F}$)**
$f_+^{B\pi}$,...	11%	5.5 - 6.5%	4 - 5%	**2 – 3%**
$T_1^{B\to K^*/\rho}$	13%	----	----	**3 – 4%**

Estimate of computational power

The Moore's Law



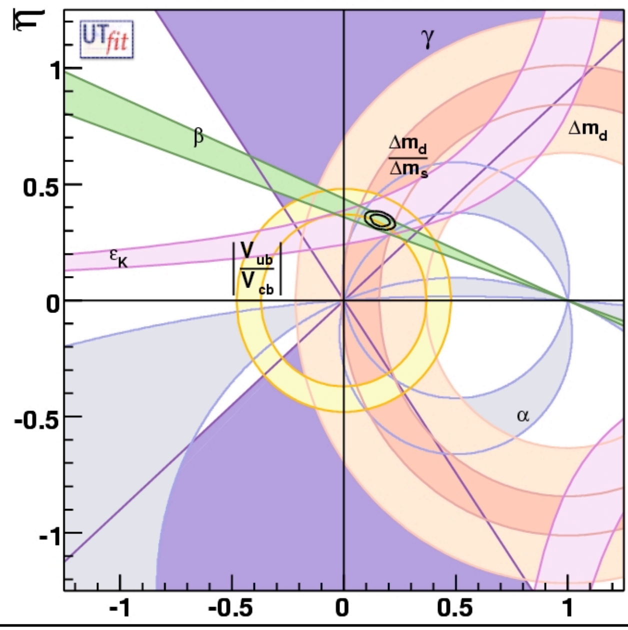
For Lattice QCD:

Today ~ 1 – 10 TFlops

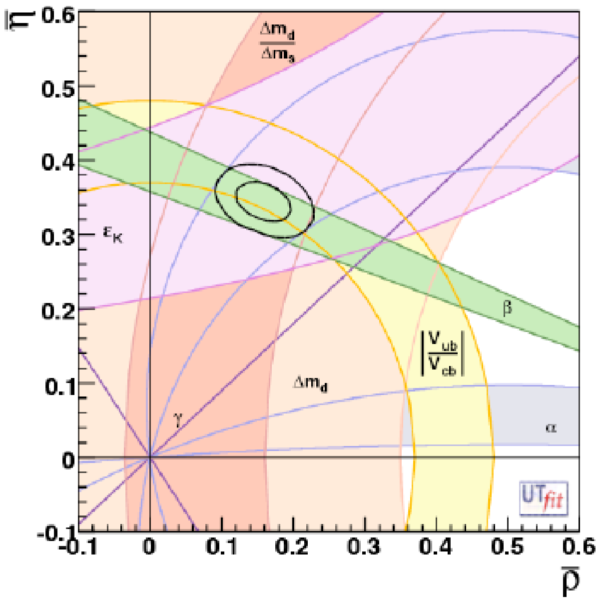
2015 ~ 1 – 10 PFlops

The goal of a SuperB factory:
Precision flavour physics
for indirect New Physics
searches

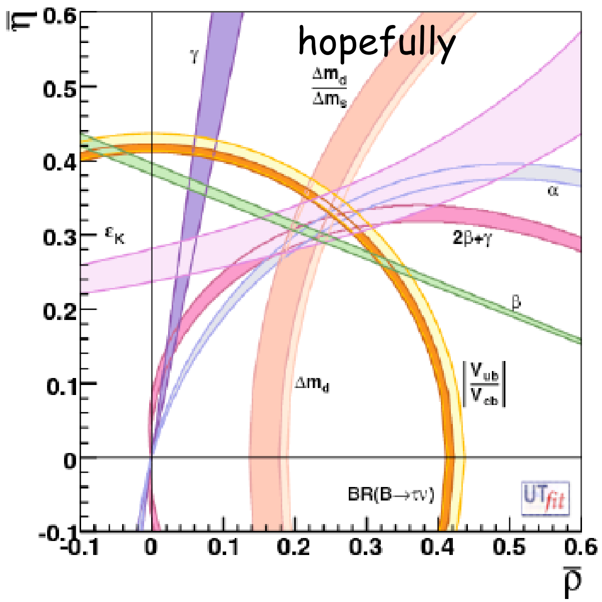
Test the CKM paradigm
at the 1% level

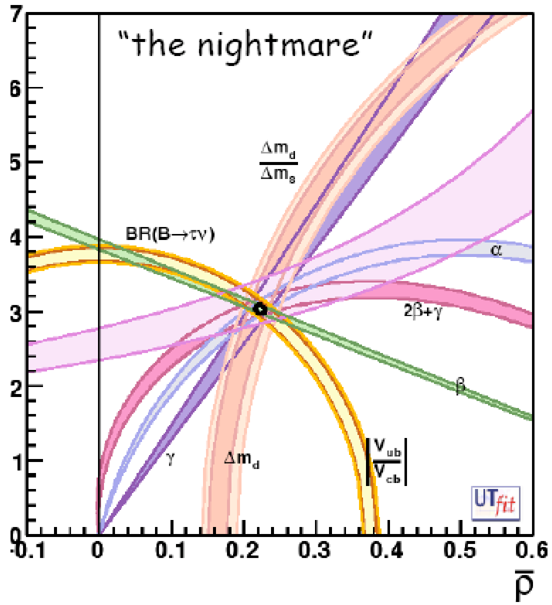


Today



With a SuperB in 2015





APE

1988 APE,

1993 APE100

1999 APEmille

2005 APEnext

WE NEED 30 Tflops in 2010

60 Tflops in 2011

1-10 Pflops 2015 AP????URORA

commercial chips + hardware net or

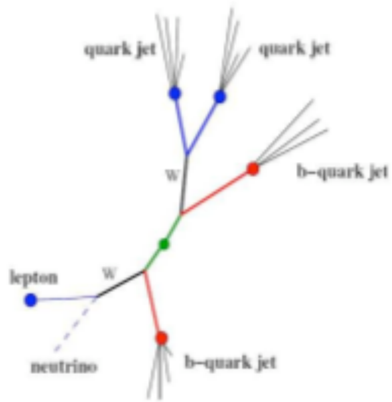
custom chips or all commercial ?

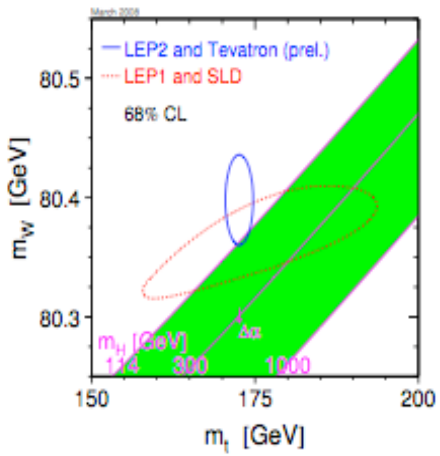
a decision must be taken very rapidly

CSN4@LHC

LHC

In preparation of LHC analysis CSN4 has organized a series of workshops (see https://agenda.infn.it/conferenceDisplay.py?confId=334), in collaboration with CSN1. The aim is to promote collaborations between theory and experimental communities in defining tools and strategies for the analysis of forthcoming ATLAS and CMS data (see arXiv:0902.0293 [hep-ph]). The RM31 is the IS that has been formed to help coordinating the activity of the nuclear theory community on the physics of the LHC for the ALICE experiment (see the GGI workshop on QCD at high density http://ggi-www.fi.infn.it//index.php?p=events.inc&id=9)





Workshop sui Monte Carlo, la Fisica e le Simulazioni a LHC

18-20 February 2008 — **Laboratori Nazionali di Frascati dell'INFN**

Obiettivi del Workshop

L'enfasi del workshop e' sui Monte Carlo, che nell'ambito della fisica di LHC sono la naturale interfaccia tra fisici teorici e sperimentali. Il proposito del workshop e' di riunire fisici sperimentali di ATLAS e CMS (e anche di LHCb e Alice per quanto riguarda aree di comune interesse), teorici esperti in Monte Carlo per collisioni adroniche, e teorici esperti in fisica oltre il Modello Standard, al fine di:

(a) promuovere nelle rispettive comunita' una maggiore comprensione delle problematiche relative alla fisica di LHC;
(b) favorire una maggiore coesione tra le comunita` suddette. Pertanto gli incontri non saranno suddivisi in sessioni parallele, le presentazioni avranno inizialmente carattere introduttivo, e ampio spazio verra' riservato alla discussione.

Il workshop e' organizzato nell'ambito dell'INFN, ed avra' percio' carattere essenzialmente nazionale. Un primo ciclo di 3 meetings si e' svolto nel 2006. Si prevede un nuovo ciclo nel 2008.

Il workshop si articolera' in quattro settori, ciascuno coordinato da uno o piu' "convener":

1) Shower Monte Carlo (SMC); convener: S. Frixione, L. Fano' (CMS)

Argomenti: Stato e prospettive degli Shower Monte Carlo,
interfacciamento con calcoli al "tree level"
e con calcoli al Next-to-Leading order (NLO)

2) Matrix elements (ME); convener: F. Piccinini, P. Azzi (CMS)

Argomenti: programmi per la generazione di processi complessi;
automatizzazione dei calcoli NLO; calcoli NNLO.

3) SM e BSM a LHC, convener: S. Rychkov, M. Cobal (ATLAS), F. Fabbri (CMS)

I processi di riferimento: (jets, gamma,
W, Z, WW, WZ, ZZ e coppie t tbarra, etc.)
Processi oltre il modello standard
(in special modo per L <~ 1 fb^-1)

4) Studi sperimentali, F. Tartarelli (Atlas), C. Mariotti e E. Migliore (CMS)

Caratteristiche e potenzialita' dei detectors ai fini delle simulazioni;
studio e calibrazione dei detector con fisica del Modello standard.

Dates: from 18 February 2008 14:00 to 20 February 2008 14:00
Location: *Laboratori Nazionali di Frascati dell'INFN*
Via Enrico Fermi 40
00044 Frascati (Rome)
Room: Auditorium Bruno Touschek
Additional info: **http://moby.mib.infn.it/~nason/mcws/index.html**

- A framework for integration and interactions of 70 th+exp
  - Monte Carlo, BSM and String theorists
  - ATLAS and CMS experimentalists
- Topics:
  - Shower MC: development, interface with tree level and NLO calculations
  - Matrix element computation of multi-legs amplitudes (SM&BSM)
  - SM: signals and background
  - Detector simulations and calibration with SM physics

A New Initiative from Rome I-II-III + LNF ``Seminari alla russa" (Russian style seminars)

Joint exps-theos seminars, of undetermined duration, with possibility of interrupting the speaker at will and of asking any (nasty) question.

First seminar by R. Contino (June 30th):

Higgs: Composite or Elementary ?

CSN4

Chair
Giuseppe Marchesini

Internal Referees
String & Field Theory:
Alberto Lerda & Domenico Semkinara
Particle Phenomenology:
Giovanni Ridolfi & Marco Fabbrichesi
Hadronic & Nuclear Physics:
Marco Radici (Wizard of CSN4 data)
Mathematical Methods:
Enrico Onofri & Gaetano Vilasi
Astroparticle & Cosmology:
Francesco Vissani & Giancarlo D'Ambrosio
Statistical Field Theory & Applications:
Leonardo Cosmai & Ettore Vicari

GLV
Renzo Collina, L. Canton, D. Zappala`

Computing
Enrico Onofri
Ettore Vicari

Observers (our agents in others CSN)
Paolo Gambino (Del Duca) CSN1
Francesco Vissani CSN2
Silvia Lenzi CSN3
Sebastiano Stramaglia CSN5

Sergio Fubini Prize
Silvia Penati
Leonardo Cosmai
Massimo Pietroni

INFN-Dubna
Adriano di Giacomo
Alexandre Filipov

INFN-Mec
Giuseppe Marmo

Secretariat
Mauro Mancini & Liliana Ubaldini

SUMMARY

CSN4 represents a strategic organism for the development of theoretical physics in Italy, in a spectrum of sectors much wider than those of strict interest for INFN. This role is possible thanks to a wise and open culture attitude and the close relationships with the academic world: many of the top level results are a product of the cross-fertilization of INFN with Universities and other scientific institutions.

LHC WANTS YOU