

Kick-Off Meeting Hamburg Excellence Initiative November 3 - 4, 2009







Connecting Particles with the Cosmos



LANDESEXZELLENZINITIATIVE

Kick-off Meeting Cluster of Excellence Nov. 3 - 4, 2009, Hamburg

Peter Schleper Hamburg University



Connecting Particles with the Cosmos

Particles and Cosmology

The Standard Model

- Symmetries: Leptons and Quarks
- Symmetries: U(1) x SU(2) x (SU(3)
- Predictive Power
 - Gluon, W, Z, top, Higgs

Experiment

- Standard-Model is in agreement with "all" laboratory experiments
- Consistent picture of "all" physics up to ~ 200 GeV
 - ➔ Surprising success

Application to Cosmology

- Quantum Physics governs early Universe
- Do we understand History of the Universe ?
- Extrapolation 10⁻¹⁹ 10⁺²⁵ m →





Particle Physics

Standard Model

- Quantum Field Theory
- Renormalizeable, anomaly-free

Collider Experiments are the Key

- HERA ep collider
- Tevatron pp collider
- LEP e+e- collider

Missing: Symmetry breaking

- Higgs particle or Alternatives ?
- LHC pp collider will decide

Limitations

- No explanations for particle content, parameters, symmetries
- Gravitation ? Scales ?
- Extrapolation to high energies
- Physics beyond the Standard Model Supersymmetry + GUTS, LEDs ?

→Next generation of colliders ILC,CLIC



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Cosmology

Observations

- Cosmic microwave background fluctuations → large scale structure
- Supernova redshift
 → expansion rate of Universe
- Gravitational lensing
- Galaxy rotation curves
- Galaxy collision dynamics

Standard Model of Cosmology





Colliding Clusters of Galaxies

- Visible: Stars
- X-ray: Intergalactic Gas
- Gravitational lensing: Matter
- Dark Matter Confirmation

 Particle as Relic of Big Bang ?
 → No known particle candidate Strong impact on particle physics and next generation experiments

Questions

- What is the mechanism of electroweak symmetry breaking?
- Does the world become supersymmetric at the TeV scale?
- Is the nature of dark matter related to TeV scale physics?
- Can the Standard Model of Particle Physics and the Cosmological Standard Model be embedded in String Theory?



Accelerators

LEP – HERA – LHC – SLHC – ILC – CLIC – Plasma?

ILC

- Superconducting cavities: 30 MV / m
- Industrial Production for XFEL

CLIC

- Drive beam concept 100 MV / m
- R&D → 2012



Plasma

- non-linear plasma wave breaking GV / m, factor 10³
- multi TW laser of particle beam

electron beams produced and accelerated





Detector R&D

HERA expertise \rightarrow LHC exp. S-LHC:

• Si-detect., radiation-hard Si, ...





ILC precision detectors

• Calice calor., SiPM, TPC





Neutrino & Astroparticle det.



- ββ0ν decay
 CdZnTe detector
- CTA Cherencov photodetectors

Aim: New Detector Lab

- Uni + DESY groups
- All R&D projects

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Phenomenology & String Theory

Progress in Physics linked to Mathematics

• Newton, Einstein, ...

Phenomenology

- Highly complex interpretation of LHC – Lin.-Coll. Data
- Close collaboration with exp. strength of experimental program
- Break through for precision calculation



String theory

- extension of Quantum Field Theory incl. Gravity
 Impact for particle physics and cosmology
 Phenomenology ?
- Connection between Strong Interacting QFT (QCD) and weak interacting systems in higher dimensions (AdS/CFT)
- Motivate model of particle theory by String theory, e.g. Supersymmetry, LED

"Zentrum für Mathematische Physik":

• Focus on mathematical aspects of string theory and quantum field theory.

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Astro & Astroparticle & Cosmology

Astrophysics

- Theory of Supernova Explosion
- Observational Cosmology

Astroparticle Physics

- Cosmic rays (Auger, H.E.S.S., CTA)
- Search for annihilation / decay of dark matter
- Axions (ALPS)

Particle Cosmology

- Baryo- and Lepto-Genesis
- Model building for Inflation
- Dark Matter candidates from Supersymmetry, hidden photons, axions





The Cluster

University Hamburg, MIN Faculty

- Department of Physics: Theoretical Physics
 Experimental Physics
 Hamburg Observatory
- Department of Mathematics Mathematical Physics

DESY

- Particle Physics Devision
- Theory Division
- Accelerator Division (HEP)

Together:

220 Scientists + 110 PhD Students



Combines Accelerator, Detector & Collider expertise with the SFB "Particles, Strings and the Early Universe"

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Research Structures

University – DESY: Hamburg Center for Particle and Astroparticle Physics



Scientists



Young Investigator Groups

- 4 Emmy Noether / Marie Curie Excel. Grants
- 6 HGF young investigator groups
- 1 DFG/SFB
- 3 LEXI

Scientists for strategic projects

- Accelerators, Detector Lab,
- Theory for HGF Analysis Center

Graduate School

- for PhD students
- to be jointly organized with the SFB
- based on Grad.-School of MIN Faculty

Summer Student Program

Students from abroad

Support re-newed faculty positions

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Conclusion

Research topic

- Exciting steps expected now/soon from new experiments
- LHC \rightarrow Higgs, Supersymmetry, DM production
- Astroparticle detection of DM
- ➔ Understanding fundamental quanta and the early universe by experiments?!

Hamburg

- Major expertise in most relevant fields
- University + DESY Campus

LEXI Cluster

- Strategic research planning and focus
- Interconnection of research areas
- Enable and promote new groups & ideas
- W. Pauli Centre, Detector Lab
- Promotion of Young Scientists
- Coherent research project
- exciting and inspiring basis for you !

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