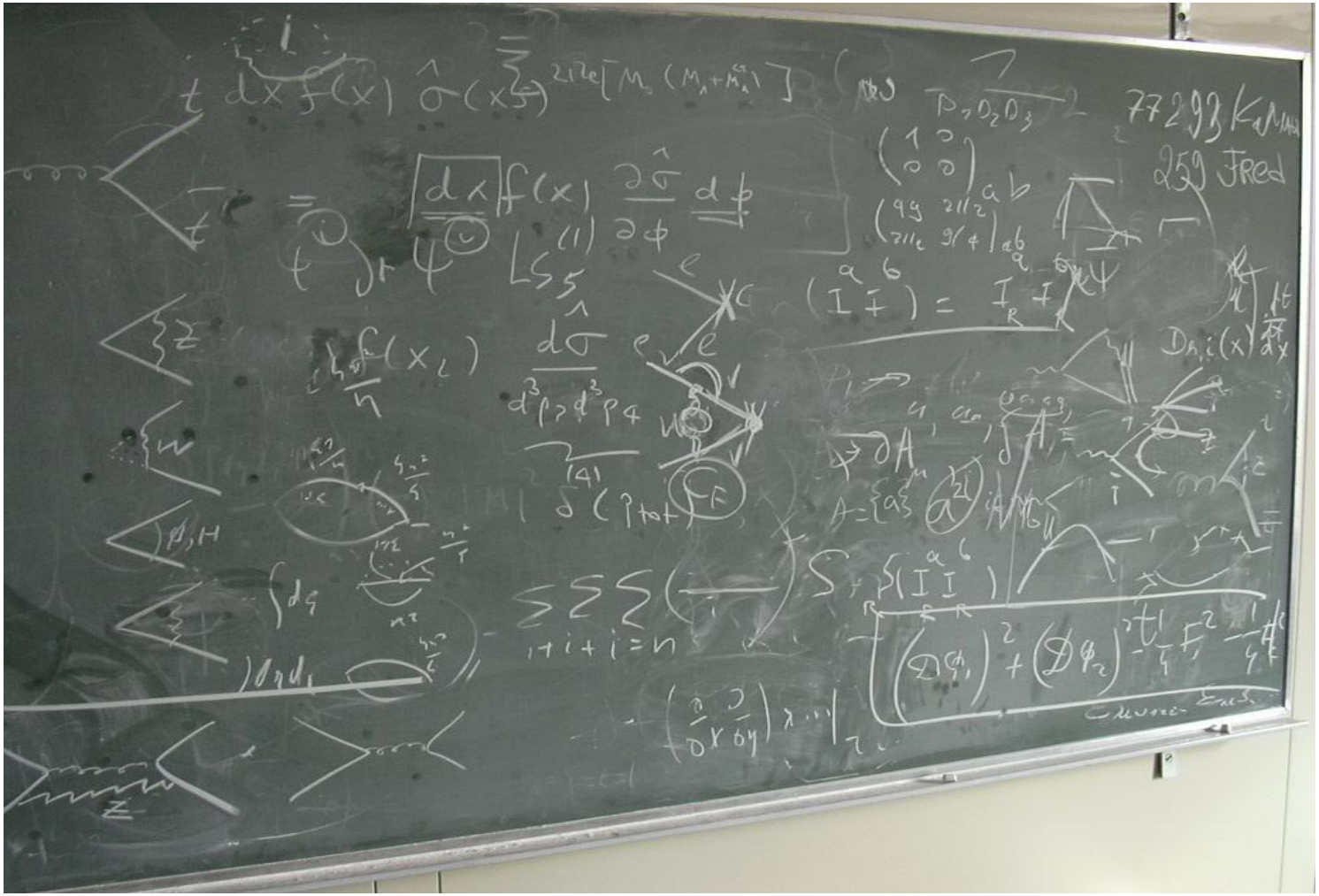
Theory: Projects and Funding



TTP (Institut für Theoretische Teilchenphysik)

J. H. Kühn
U. Nierste
M. Steinhauser
P. Uwer (Heisenberg Fellow)

ITP (Institut für Theoretische Physik)

F. Klinkhamer
D. Zeppenfeld

Limited resources,
concentrated mainly in phenomenological particle physics

TTP + ITP

7 mostly non-permanent positions funded by university

third-party funding:

10 postdocs funded by DFG (SFB-TR9)

3.5 postdocs funded by BMBF (Theorie-Verbund)

3 positions Helmholtz Alliance "Terascale"

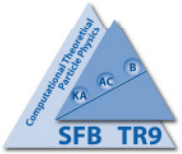
1 position EU-Project

20 PhD students Graduiertenkolleg (DFG)
Strukturiertes Promotionskolleg (Land,Uni)

22 diploma students

2–4 long term guests

3 secretaries

- SFB-TR/9 

  "Computational Particle Physics" (2003-2006-2010-2014)

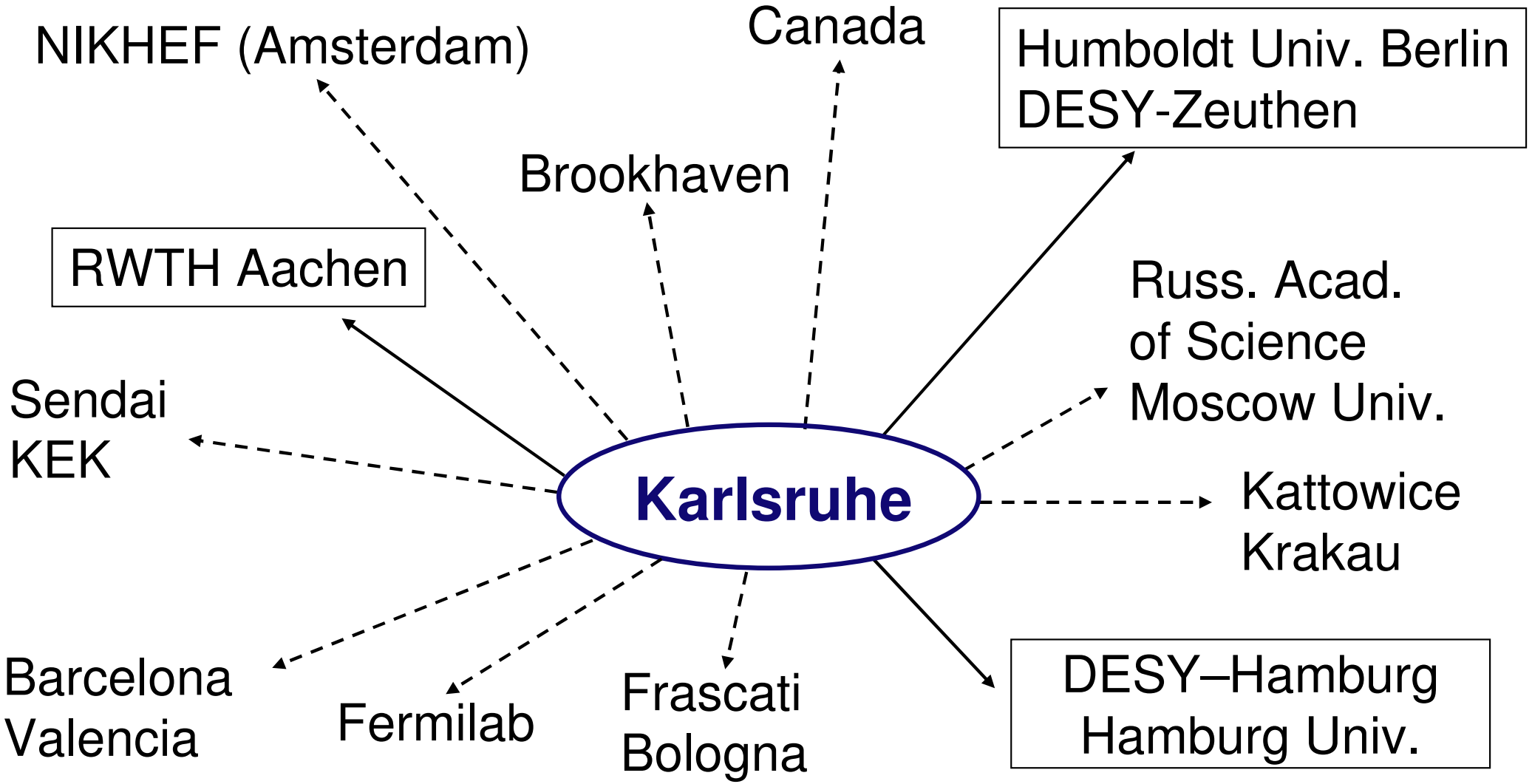
- BMBF-Verbundforschung (Theorie-Verbund), 3 years+3years+...

  "High Energy Reactions at Lepton- and Hadron Colliders"
  "Top- and Bottom Physics"
  "Phenomenological Studies and Monte Carlo Programs"

EU-Projects

Flavia-Net
HEP-Tools

Collaborations



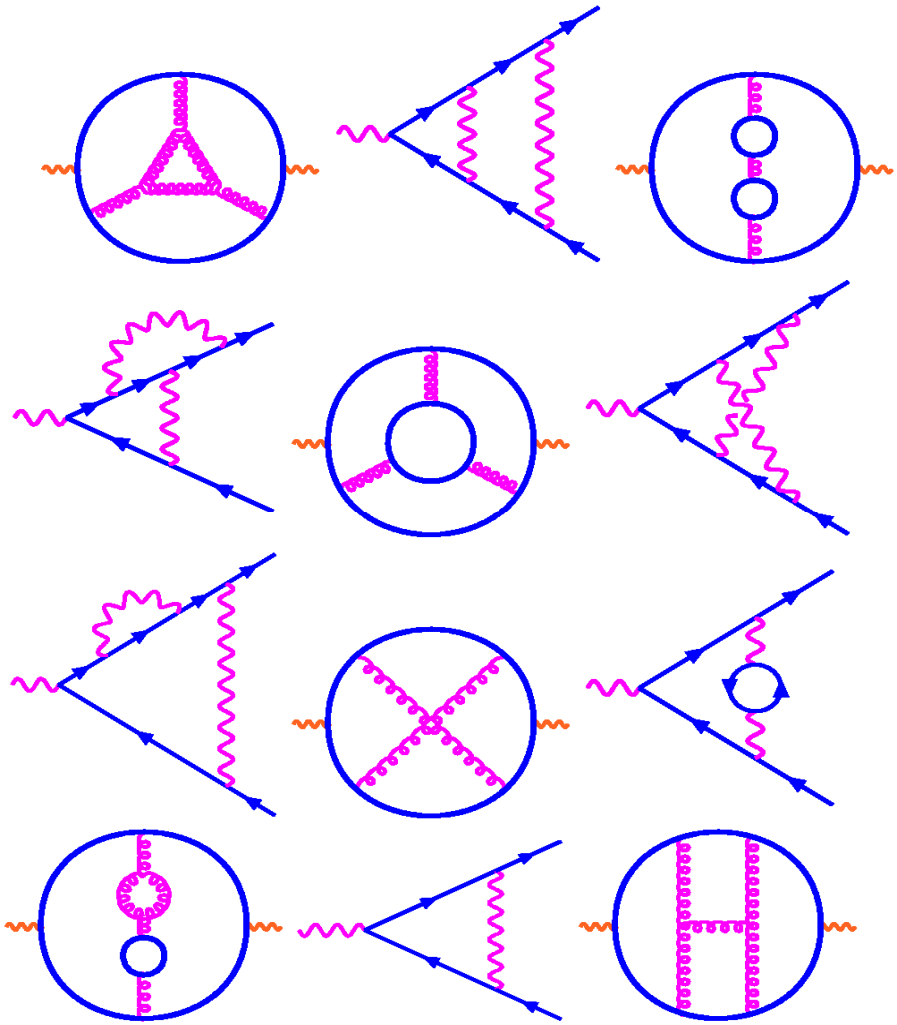
Theoretical concepts and calculational tools

Improved understanding and new formulations of the fundamental laws of nature

Interpretation of current and future experiments
→ collider physics

Large scale computing, computer algebra, parallel computing

Precision Calculations



conceptual developments:

multiloops

- 4-loop massive tadpole amplitudes
- 4-loop massless propagator amplitudes
- large demand on computer algebra

- SUSY and renormalization

- computer algebra and parallelization (`PARFORM`)

- precise quark masses (world record)

  $m_c = 1286 \pm 13$ MeV

  $m_b = 4164 \pm 25$ MeV

- evaluation of $R = \sigma(e^+e^- \to \mathrm{had})/\sigma_{\mathrm{pt}}$ in $\mathcal{O}(\alpha_s^4)$ completed

  GIGA-Z $\Rightarrow$ $\delta\alpha_s < 0.001$

- NRQCD
  - effective theories
  - QCD potential
  - $b\bar{b}$ bound states
- top quarks at threshold and in the continuum
- radiative return at DAΦNE and B-factories

  $\Rightarrow R$ at low energies

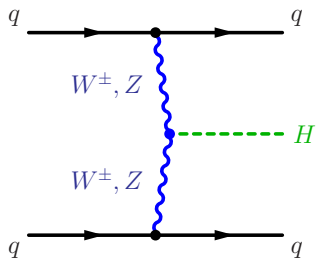
Collider Physics

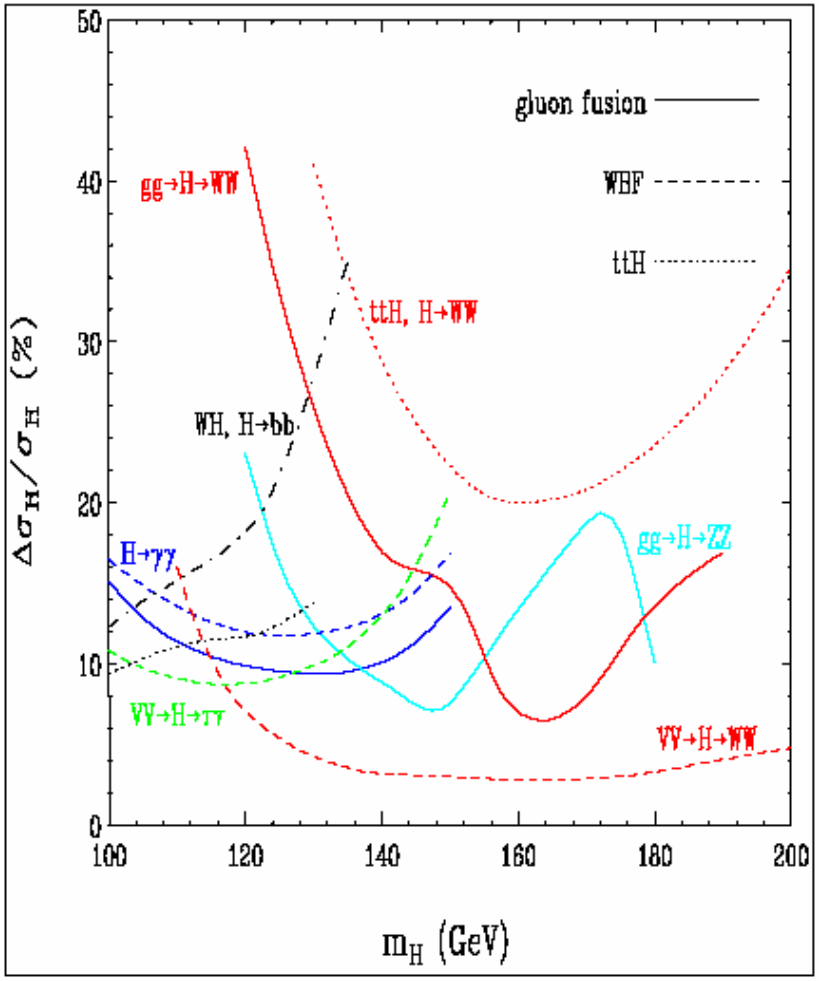
Tevatron

LHC

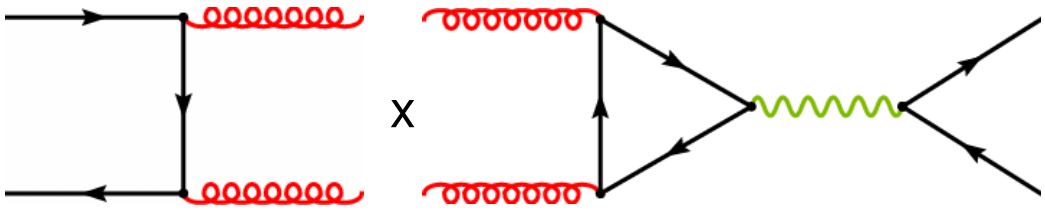
ILC

- NLO QCD calculations
  loop corrections for LHC processes
- Higgs physics
  - measurement of Higgs couplings at LHC
  - anamalous couplings in VBF processes
  - central jet veto against VBF backgrounds
  - Hjj events from gluon fusion
  - Higgs physics in the MSSM
- Parton shower Monte Carlos
  - development of Herwig++
    (Helmholtz Alliance "Terascale")

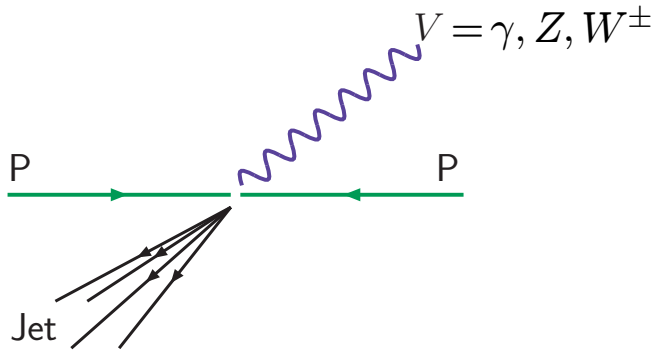



gluon fusion
WBF
ttH
gg→H→WW
ttH, H→WW
WH, H→bb
H→γγ
gg→H→ZZ
VV→H→ττ
VV→H→WW
$\Delta\sigma_H/\sigma_H$ (%)
m_H (GeV)
0
10
20
30
40
50
100
120
140
160
180
200

- top quark physics
  QCD and electroweak effects



- gauge boson, quark and jet production at large momentum transfers

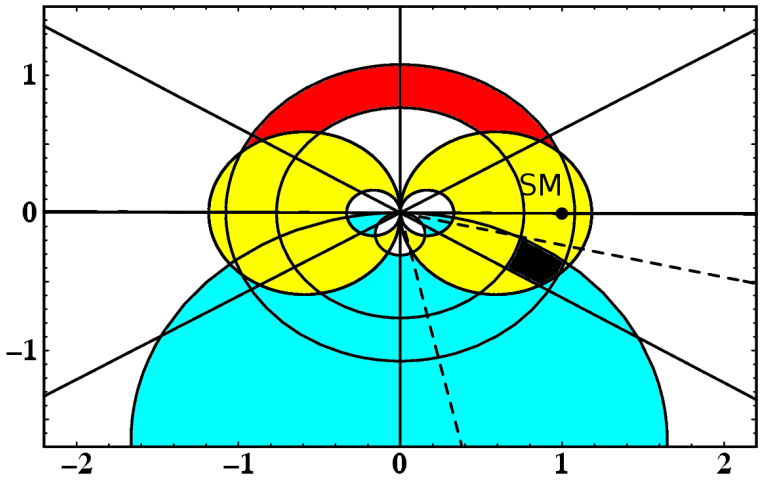


Flavour Physics

- flavour physics as a probe of the TeV scale and interplay with collider physics
- multi-loop calculations in Kaon and B physics
- phenomenology of supersymmetric theories
- Grand Unification and Higgs physics
- lepton flavour violation

Theory meets Experiment:

constraints on the complex $B_s - \overline{B}_s$ mixing amplitude

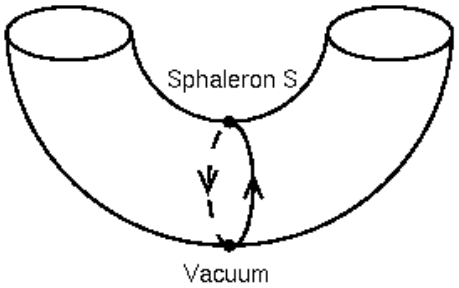


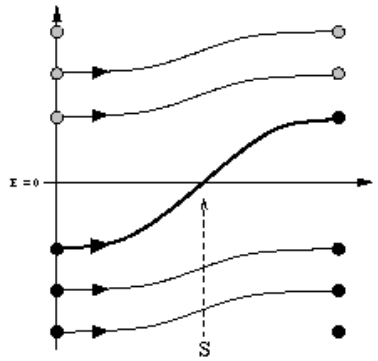
Field theory and mathematical physics

- baryon number violation in the SM
  sphalerons and effects of non-trivial field configurations

- CPT anomaly
  chiral gauge theories on non-trivial space manifolds
  → cosmology
  → microscopic space time structure

- number theory





Future

Large external funding (80% of staff!)

- SFB-TR9
  - 2nd funding period 2010 approved
  - 3rd funding period 2011-2014 !
- Graduiertenkolleg
  - 14 fellowships! 2nd funding period ends 2010
- Strukturiertes Promotionskolleg
  - 21 fellowships, funding of new positions on annual basis
- New directions in theory
  - Theoretical Astroparticle Physics (financed by KIT)
  - hopefully starting fall 2008

With the help of

Research staff:

Guido Bell, Guiseppe Bozzi, Konstantin Chetyrkin, Stefan Gieseke, Martin Gorbahn, Agnieszka Grzelinska, Ralf Hofmann, Artyom Hovhannisyan, Yuichiro Kiyo, Wolfdieter Lang, Quiang Li, Schedar Marchetti, Peter Marquard, Luminita Mihaila, Christian Schappacher, Dirk Seidel, Michael Spannowsky, Mikhail Tentyukov, Stephanie Trine, Sandro Uccirati, Peter Uwer, Sören Wiesenfeldt, Malgorzata Worek

PhD Students:

Stefan Bekavac, Joachim Brod, Manuel Bähr, Momchil Davidkov, MS Luca D'Errico, Christoph Englert, Vera Hankele, Elisabeth Kant, Philipp Kant, Gunnar Klämke, Michael Kubocz, Philipp Maierhöfer, Falk Metzler, Simon Plätzer, Andreas Scharf, Karsten Schnitter, Marco Schreck, Markus Schulze, Markus Schwarz, Susanne Westhoff

22 Diploma Students

Long Term Guests: (4 Humboldt Awards)

Pavel Baikov, Henryk Czyz, Andrey Grozin, William Marciano, Chris Quigg, Ettore Remidi, Jos Vermaseren