LHCphenOnet

Netherlands team

Eric Laenen [team leader], Jos Vermaseren, Robert Fleischer [Staff]
Domenico Bonocore [ESR], Kasper Larsen [ER]
Lisa Hartgring, Robbert Rietkerk, Rob Knegjens, Kristof de Bruyn [PhD students]
Pierre Artoisenet, Jan Kuipers, Mert Aybat [PD]

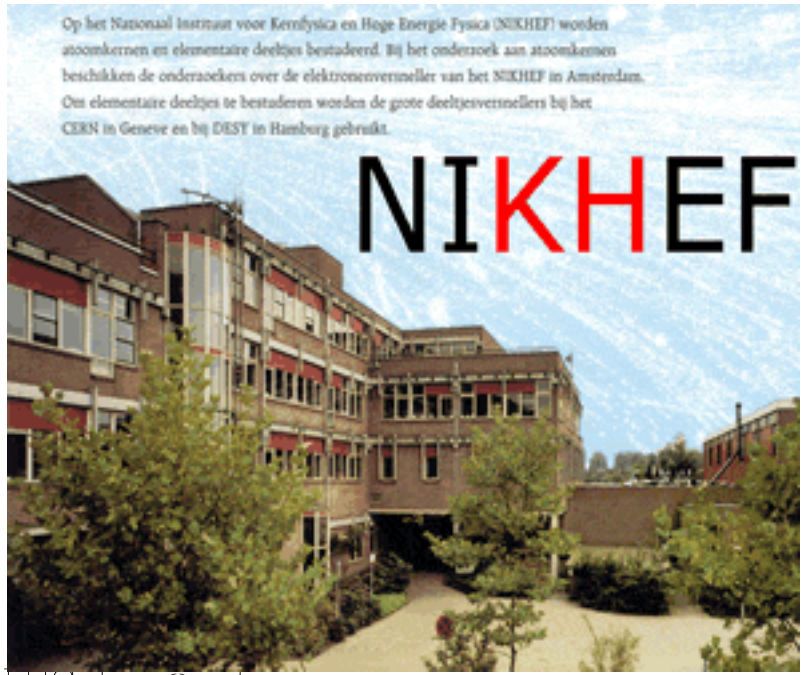
Eric Laenen

LHCPhenoNet Midterm Review, Ravello, Sept. 16-20, 2012

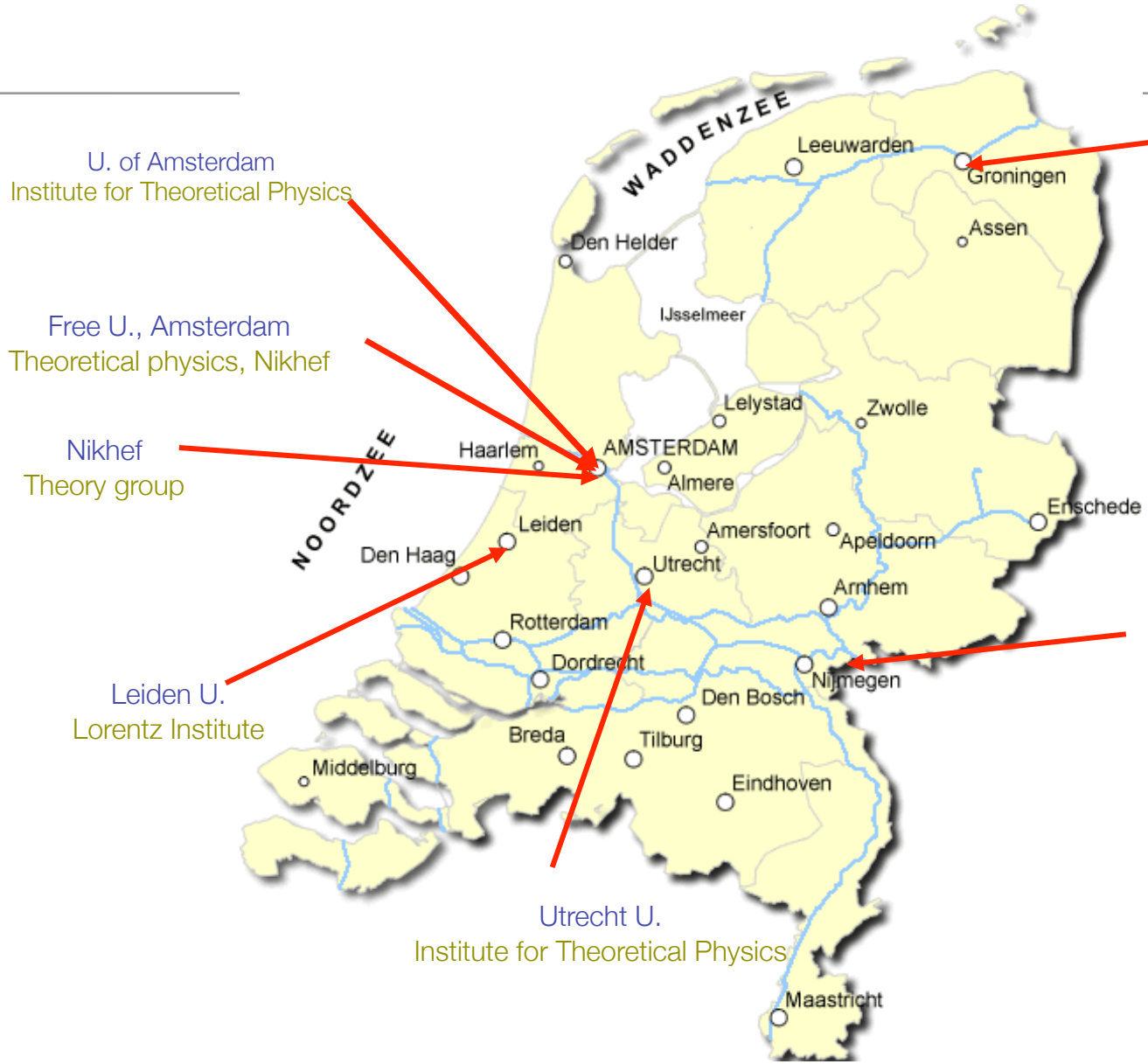
Nikhef [=FOM + 2 Amsterdam U's + Utrecht U + Nijmegen U]

Coordinates and supports (astro)particle physics in NL

- 60 scientific staff, 160+ scientists total
- ATLAS, LHCb, ALICE + AP
- Theory, Computing etc



High energy theory groups in Netherlands



U. of Amsterdam
Institute for Theoretical Physics

Free U., Amsterdam
Theoretical physics, Nikhef

Nikhef
Theory group

Leiden U.
Lorentz Institute

Utrecht U.
Institute for Theoretical Physics

Groningen U.
Center for Theoretical Physics

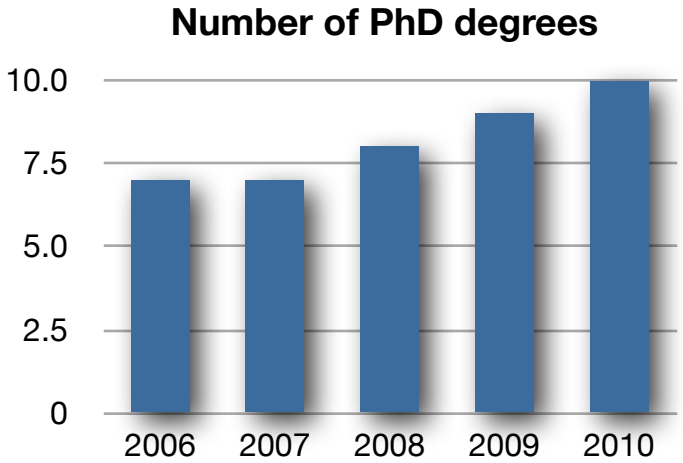
KVI
Theory group

Radboud U.
IMAPP, Nikhef

How do we train theory PhD students?

Dutch Research School of Theoretical Physics

- Coordinated by Utrecht
- Educates PhD students
- Two themes: HEP and CM
- School, Biennial Symposium, PhD student day
- Very well run since > 20 years



Theoretical physics PhD training

- DRSTP organizes annual 2-week PhD school, mandatory to go twice
  - 2x2 lecturers
  - near Utrecht (but twice in Sao Paolo)
- Training also takes place through
  - advanced classes at Universities
  - attendance of about 2 other international schools
  - participation in local seminars, discussion clubs, some joint with University of Amsterdam (across the street)

Nikhef theory group

Staff

- Jan-Willem van Holten [Nikhef+Leiden]; Gravitational waves, cosmology, BSM
- Bert Schellekens [Nikhef+Nijmegen]; string theory, landscape, BSM
- Marieke Postma [Nikhef]; cosmology, inflation as probe of particle physics
- Eric Laenen [Nikhef+UvA+UU]; QCD, resummation, Monte Carlo, top quark physics
- Jos Vermaseren [Nikhef (+Madrid)]; higher order QCD, FORM
- Robert Fleischer [Nikhef+VUA]; B-physics, CP violation
- Bernard de Wit; supergravity, black hole thermodynamics
- VUA: Piet Mulders; spin physics, family symmetries
- Nijmegen: Wim Beenakker, Ronald Kleiss; susy phenomenology, MC, Higgs physics

Postdocs

- Kasper Larsen
- Pierre Artoisenet
- Jan Kuipers
- + 4 more postdocs

PhD students

- Domenico Bonocore
- Lisa Hartgring
- Robbert Rietkerk
- Rob Knegjens
- Kristof de Bruyn
- + 3 more PhD students

+ Master, Bachelor students

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LHCphenonet

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LHCPhenoNet, team Netherlands

- Postdocs, just left
  - *Sahap Mert Aybat* : Resummation, heavy quark, BSM [-> Software]
  - *Thomas Reiter* : Loops, FORM [-> MPI Munich -> Industry]
  - *Jan Kuipers*: FORM [-> Google]
- Postdocs/ER now
  - *Pierre Artoisenet*: MadEvent, NLO Monte Carlo, top physics
  - ***Kasper Larsen*** [ER LHCPhenoNet]: Amplitudes, two-loop unitarity, resummation
- PhD/ESR now
  - ***Domenico Bonocore*** [ESR LHCPhenoNet]: Precision physics, Monte Carlo
  - *Robbert Rietkerk:* Automated loops
  - *Lisa Hartgring:* Top physics, (Vincia) Monte Carlo
  - *Rob Knegjens:* B-decays
  - *Kristof de Bruyn:* B-decays, CP violation
- Visitor
  - ***Lorenzo Magnea*** [Torino] [VS LHCPhenoNet]: May, June 2012, to work also with ESR and ER

Links with LHCPhenoNet network nodes [NL team members]

- CH (CERN [Skands])
  - work on MadLoop, MC@NLO, Vincia@NLO [Laenen, Rietkerk, Bonocore, Hartgring]
- UK (Liverpool [Vogt], Cambridge [Webber])
  - work on FORM, 3-loop QCD [Vermaseren]
  - work on MC@NLO [Laenen, Hartgring]
- DE (Zeuthen [Bluemlein, Moch], Karlsruhe [Ueda])
  - work on FORM, 3-loop QCD [Vermaseren]
- FR (Saclay [Kosower])
  - work on two-loop unitarity [Larsen]

Nikhef theory group

1. pursues its own research programme
   - output: about 40 papers/year, public codes
2. interacts with experimental colleagues at laboratory
3. functions as national center for phenomenology, broadly defined
   - frequent meetings (1/month)
   - make visits easy (office space, wifi)

Nikhef as national phenomenology center

- once-a-month workshop day in theory group: 2 talks + discussion
- well-attended, nearly 60 meetings since 2006, “runs itself”
  - + Nijmegen, VU, Groningen, Utrecht, Leiden..
- lectures, by and for PhD students only
- advanced lectures

Theory and experiment

Theorists in the Netherlands work closely with experiment

- research: to support, learn from, and inform experimental efforts
  - joint papers of Fleischer, Knegjens, de Bruyn with LHCb colleagues
- teaching: lectures, shared PhD and Master students
- organizing: conferences, symposia, workshops
- outreach: participate in many public events, open days etc

(No real divide between hep-th and hep-ph, we are one community

- with overlap with hep-ex, cond-mat, math-ph, nucl-th)

NL team Network research

- WP1: Precision
  - Soft gluon resummation for Drell-Yan, prompt photon, squarks&gluinos
    - NNLL resummation for squarks, gluinos production
  - New methods: next-to-eikonal logarithm resummation
  - (Single) top production, tests for new physics (see snapshot)
  - Tools: FORM computer algebra
  - Monte Carlo: VINCIA and NLO matching
- WP3: Support to experiments
  - Spin correlations into MadGraph, for automatic NLO
  - aMC@NLO for single top physics

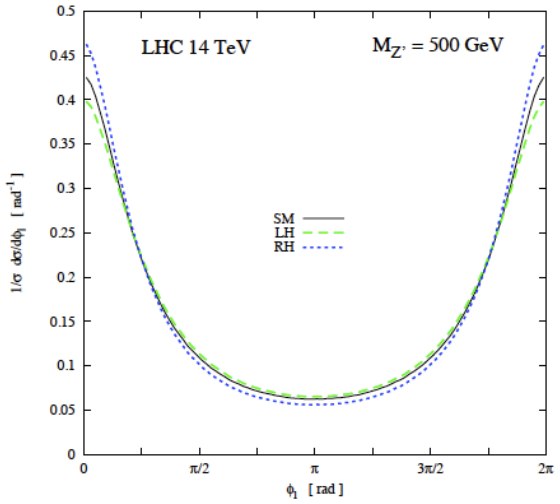
Snapshot: Top quark azimuthal distributions

- Angular distributions of top quark decay productions can be selective probes of new physics
  - Rely on nearly 100% correlation of decay- lepton with top spin
  - If, e.g., Z' polarizes the tops, can use distribution in azimuthal angle of lepton (wrt. beam-top plane) to study dynamics
  - Construct asymmetry

$$A = \frac{\sigma(\cos\phi_l) > 0) - \sigma(\cos\phi_l) < 0)}{\sigma(\cos\phi_l) > 0) + \sigma(\cos\phi_l) < 0)}$$

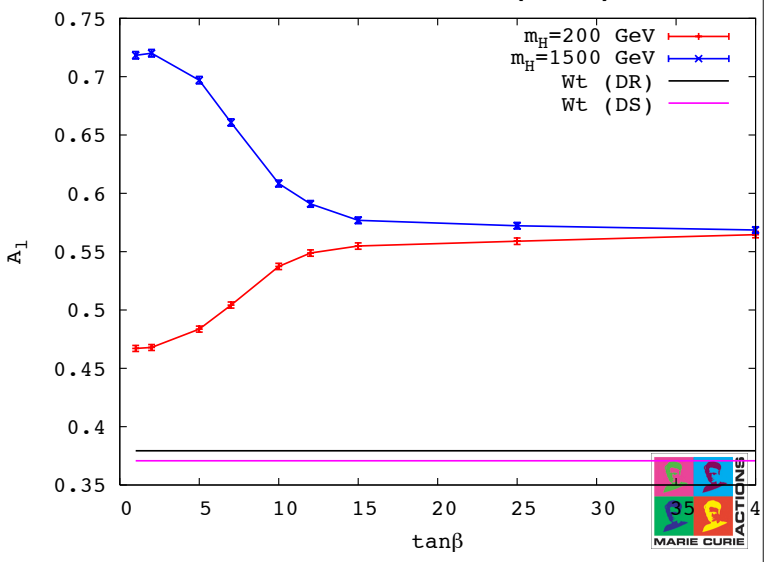
- MC@NLO and MadEvent
  - Discriminates Higgs+top and W+top production, and sensitive to parameters
  - Robust under HO corrections

Godbole, Rao, Rindani, Singh



Godbole, **Hartgring**, Niessen, White

JHEP 1201 (2012) 011

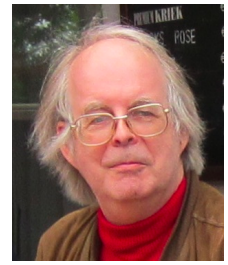


Public codes with Dutch LHCPhenoNet members

- MadGraph 5 [Artoisenet]
  - event generation
- MC@NLO [Laenen, Hartgring]
  - single top
- GOLEM, Samurai, Spinney [Reiter]
  - loop integrals, spinor methods,
- TMDProject [Aybat]
  - transverse momentum PDF's

FORM computer algebra program

- Extraordinarily powerful, vital for precision collider physics calculations
  - developed by Jos Vermaseren over 20 years
  - Led to 3-loop splitting functions Moch, Vermaseren, Vogt
  - open source



- Vermaseren teaches FORM at LHCPhenoNet CAPP school
- FORM v4 out! [March'12]. Powerful new capabilities
  - factorization of polynomials: speed, compactness
  - rational functions
  - coming: optimization of long expressions for fast numerical evaluation (Horner schemes)

Summary

- Netherlands team of LHCPhenoNet active in
  - precision physics (WP1) for vector boson and top quark production at the LHC
  - support to experiments (WP3) via Monte Carlo's, a natural role for our team
- Output in terms of papers, software, and local outreach
  - FORM, version 4, with major new capabilities, important for next step in precision
- Team is naturally embedded in Nikhef (th+exp), and national activities
- PhD students receive extensive training through DRSTP and various lecture series
- Team collaborates with various network nodes, and many more beyond