Theoretical High Energy Physics

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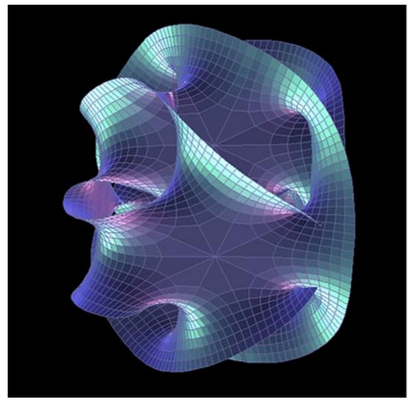
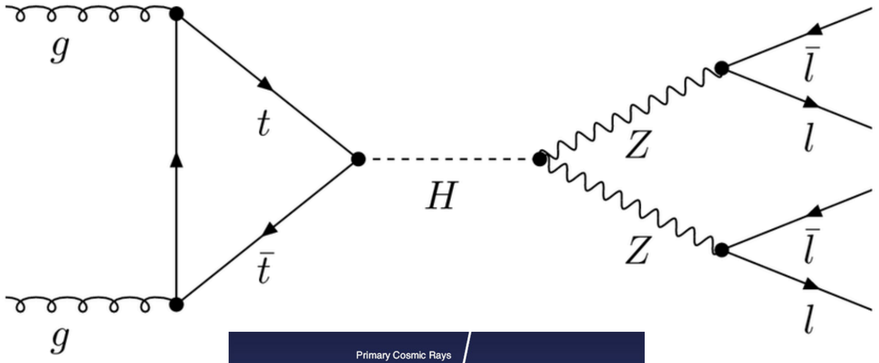
Wide range of research

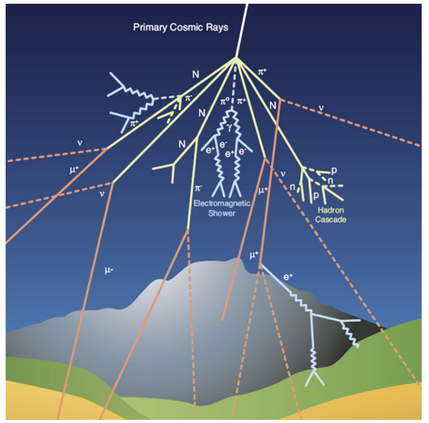
- **Formal theory - trying to understand fundamental properties of theories:**
  Chalmers U, Nordita*, Stockholm U, Uppsala U also Karlstad U and Örebro U



- **Particle physics phenomenology - making detailed predictions and testing them:**
  Lund U, KTH (Royal Inst. of Tech.), Uppsala U



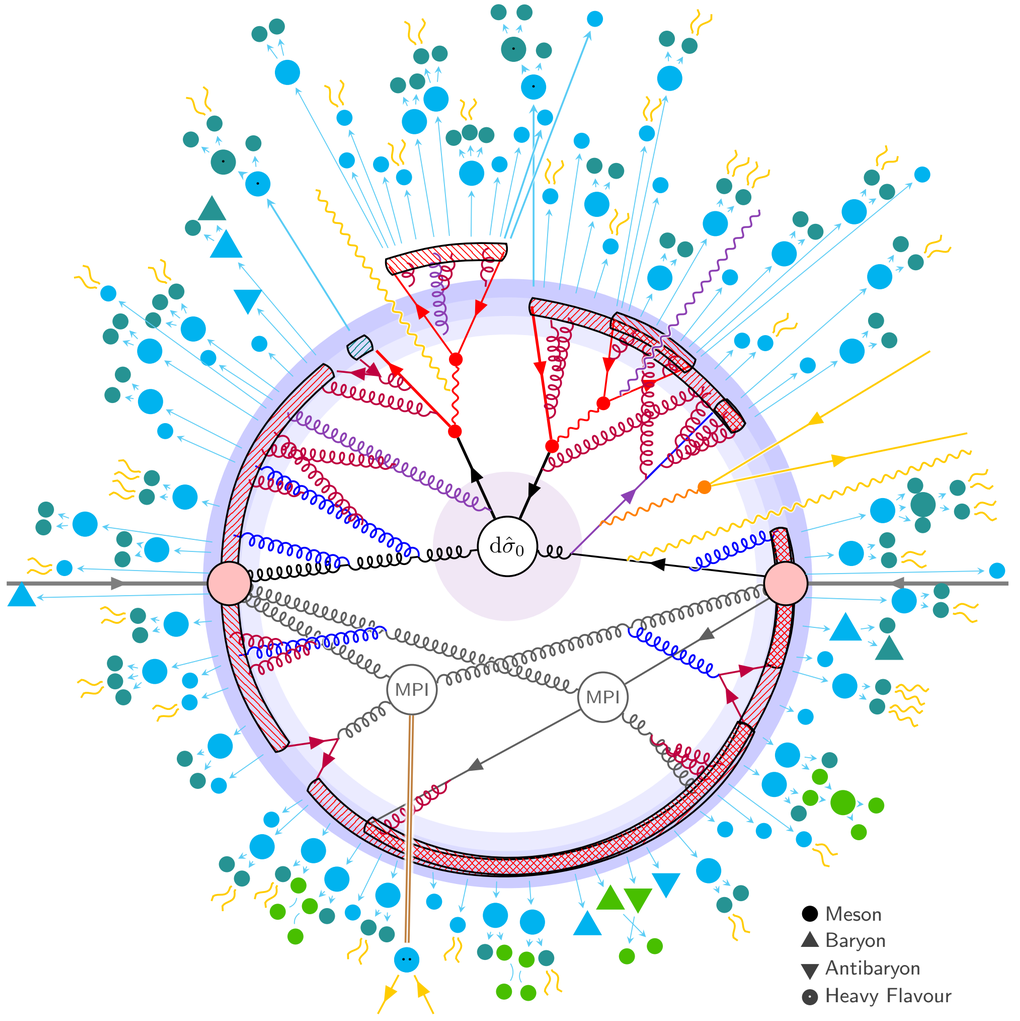
- **Theoretical astroparticle physics - including neutrinos and dark matter:**
  see presentation by Riccardo Catena



*Nordita: Nordic institute for theoretical physics in Stockholm

Event generators and QCD pheno

Astronomical clock Lund Cathedral



Hard Interaction
Resonance Decays
MECs, Matching & Merging
FSR
ISR*
QED
Weak Showers
Hard Onium
Multiparton Interactions
Beam Remnants*
Strings
Ministrings / Clusters
Colour Reconnections
String Interactions
Bose-Einstein & Fermi-Dirac
Primary Hadrons
Secondary Hadrons
Hadronic Reinteractions
(: incoming lines are crossed)*

PYTHIA generated pp-event

Event generators: Christian Bierlich (**LU**), Leif Lönnblad (**LU**)
G Gustafson (**LU**, emeritus),T Sjöstrand (**LU**, emeritus)

- essential for experiments - both design and data analysis
- PYTHIA for pp collisions - ongoing since 1980's (pythia.org)
- ANGANTYR for heavy ion collisions - based on Lund string model
- comparisons to data - continuous development of RIVET

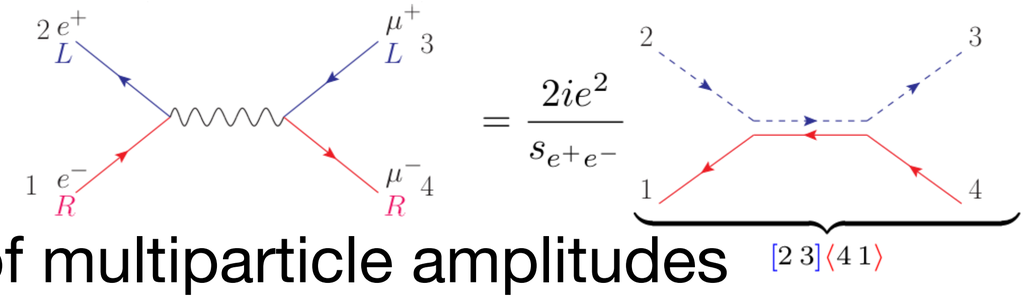
Kinetic theory for heavy ion collisions: Korinna Zapp (**LU**)

- jet quenching as probes of QCD plasmas
- event generators for effective theory with thermal effects

Precision calculations & Madgraph_aMC@NLO: Rikkert Frederix (**LU**)

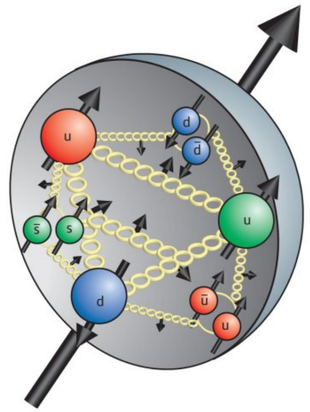
- heavy quark and vector boson production
- development of perturbation theory methods

Colour and helicity flow: Malin Sjödahl (**LU**)



- helicity flow for more efficent calculation of multiparticle amplitudes
- calculating and observing subleading colur effects

QCD phenomenology: Stefano Moretti (**UU**), Stefan Leupold (**UU**),
G Ingelman (**UU**, emiritus)



- capturing subleading colour effects in ISR, hard ME, FSR
- proton spin problem
- machine learning for jet physics

Low-energy particle physics: Johan Bijnens (**LU**)

- chiral perturbation theory and finite volume effects in Lattice Calc
- precision calculations in flavour physics such as $(g-2)_\mu$ (4.2σ deviation)

Physics Beyond the SM

LU: Roman Pasechnik, Johan Rathsman **UU:** Rikard Enberg, Stefano Moretti

CU: Gabriele Ferretti **KTH:** Mattias Blennow, Tommy Ohlsson **KU:** Marcus Berg

- **Collider phenomenology:** e.g. distinguishing supersymmetry, compositeness and other theories, constraining new models for BSM physics, etc
  - often in close collaboration with experiments
- **Model building:** simplified models and bottom-up approach, 2HDMC program
- **(Grand) Unification and RGE running:** top-down approach
- **Phase transitions in SMEFT and beyond:** models with strong first order
- **Tools for thermal field theory:** DRalgo, BubbleDet, Interface to CosmoTrans.
- **Gravitational waves:** collider constraints and input for searches at colliders

Formal (string) theory

UU: J Minahan, A Bissi, D Volin, H Johansson, O Schlotterer, M Zabzine, U Lindström (emiritus), J Qiu, G Festuccia, M Larfors, M del Zotto, P Longhi, U Danielsson, L Freyhult

Nordita: K Zarembo, P di Vecchia (emiritus)

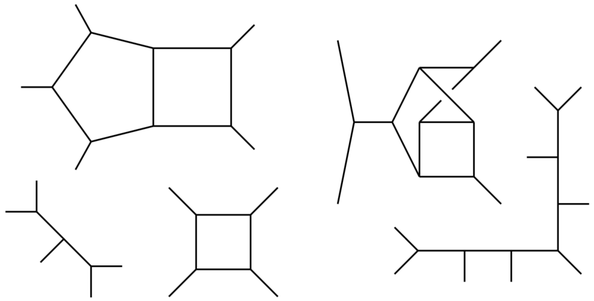
SU: B Sundborg

CU: M Cederwall, G Ferretti, U Gran

KU: M Berg, J Fuchs

ÖU: J Palmkvist

(effectively two clusters: east and west coast)



- **AdS/CFT and Integrability**
- **Supersymmetry on curved space times**
- **Kac-Moody and Lie superalgebras**
- **Scattering amplitudes**
- **String cosmology**
- **Holography**

Participation in international commissions

- IUCAP - C11 (Particles and Fields): Roman Pasechnik (LU)

Structural problems with funding

- typically 50% university funding of permanent positions for research
- limited university funding for PhD students, postdocs and travel
- external funding almost only for specific projects and not running costs
- lack of research group grants for furthering existing collaborations
- large fluctuations in funding due to low success rate for funding from Swedish and European research councils as well as KAW foundation
- **event generators (PYTHIA)** used by world wide experimental community - need to be treated as an infrastructure for experiments

Summary

Main research areas in theoretical high energy physics (not including astroparticle physics)

- event generators and QCD phenomenology (mainly Lund U) ∼ 10 PIs
- phenomenology of BSM physics (mainly Lund and Uppsala U) ∼ 5-10 PIs
- formal theory (mainly Uppsala U/Nordita) ∼ 25 PIs

Funding by Swedish and European Research Councils as well as KAW crucial for building and maintaining research groups but very uncertain

Thank you!