University of Zurich

Physics Institute

Particle and Astroparticle physics

University of Zurich[UZH]

Physik-Institut

Department • Research • Study • Seminars • News • Internal Information • Schools

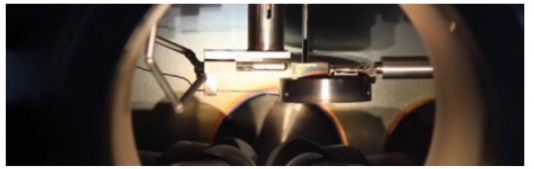
Annual report
https://www.physik.uzh.ch/en/reports/Annual-Report-2020.html

Videos
https://www.physik.uzh.ch/en/videos.html

Research

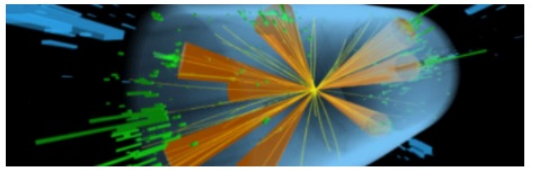
Our research covers a very rich portfolio over most of the subfields of physics. which are broadly divided in four core research areas:

Condensed Matter



Studying the macroscopic and microscopic physical properties of matter
→ more

Particle Physics

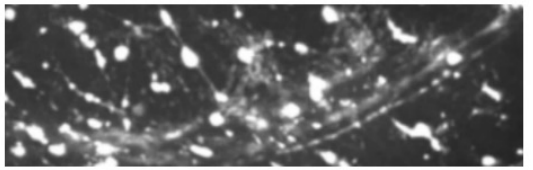


Understanding the building blocks of matter
→ more

Astro(particle) & Cosmology

Search for Dark Matter and neutrinoless double ß decay and studies of gravitational waves and theoretical astrophysics
→ more

Bio- & Medical Physics



Studying disordered and out-of-equilibrium systems and medical applications
→ more

The Physics Department has unique links with external institutes, particularly the Paul Scherrer Institute and the CERN laboratory.

University of Zurich[UZH]

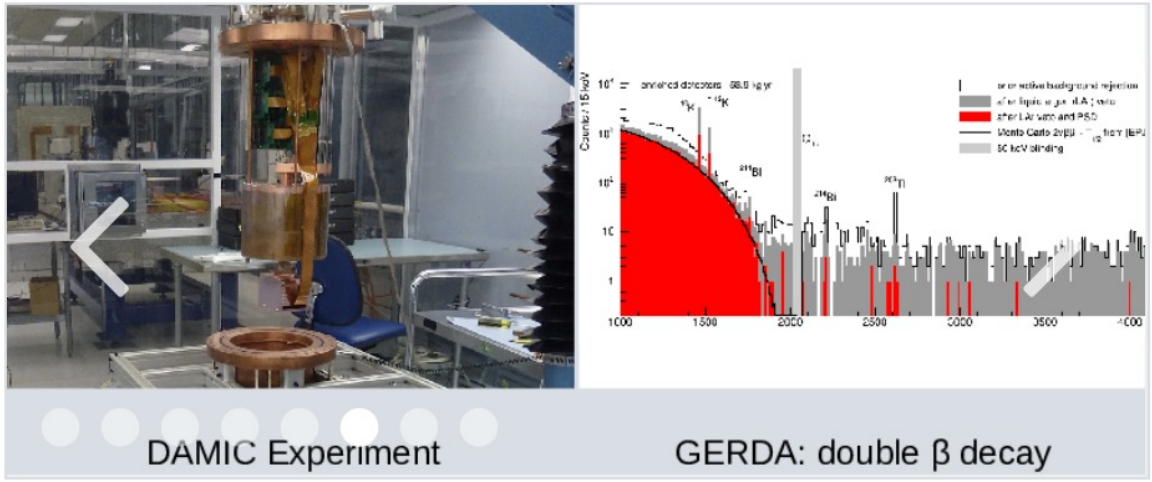
Physik-Institut

Department • Research • Study • Seminars • News • Internal Information • Schools

Professors

- Laura Baudis
- Philippe Jetzer
- Ben Kilminster
- Prasenjit Saha

Astrophysics and Cosmology



DAMIC Experiment

GERDA: double β decay

Our experimental groups in astroparticle physics is interested in understanding the nature of dark matter in our Universe, and in the fundamental properties of neutrinos.

On the theory side our groups are involved in the analysis of gravitational waves, an accurate modelling of gravitational waveforms and in the understanding of galaxies through gravitational lensing.

Our Research Areas

Direct Dark Matter: → XENON , → DARWIN , → DAMIC

Double Beta Decay: → GERDA , → LEGEND

Gravitational Waves → LIGO and LISA

Cherenkov Telescope Array: → CTA

→ Astrophysics theory

Affiliated groups: → Center for Theoretical Astrophysics and Cosmology

Astroparticle physics

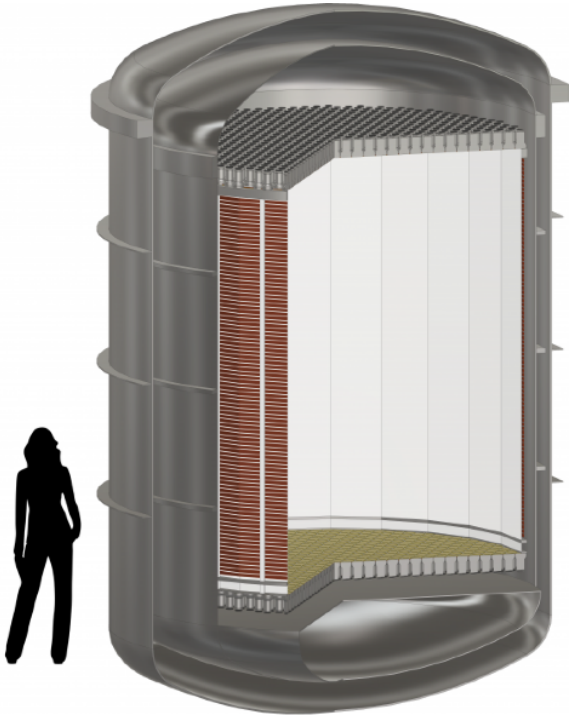
Group Baudis: https://www.physik.uzh.ch/en/groups/baudis.html

- Direct dark matter detection via NRs, ERs, absorption: WIMPs, light DM, ALPs and dark photons; solar axions
- Neutrino physics: double beta decay, double electron capture, solar neutrinos (pp, 8B), supernova neutrinos
- Detector R&D: Two-phase xenon TPCs, HPGe detectors, photosensors (PMTs, SiPMs), WLSR for liquid argon
- Material radio-assay: HPGe detector (Gator) at LNGS

LEGEND ^{76}Ge detectors

The XENONnT TPC

DARWIN: design and R&D



Xenoscope at UZH: DARWIN demonstrator

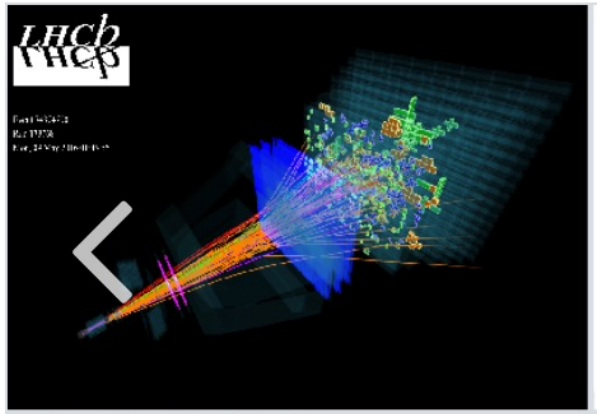
University of Zurich[UZH]

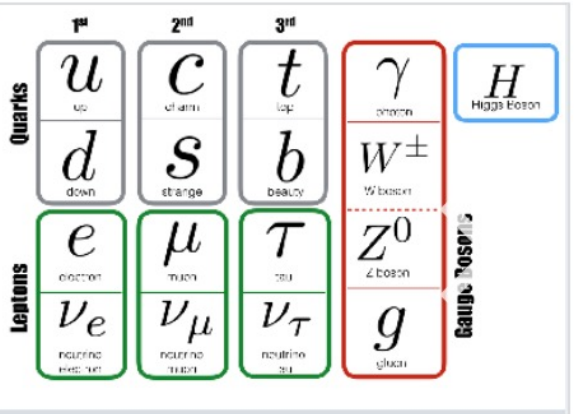
Physik-Institut

Department • Research • Study • Seminars • News • Internal Information • Schools

- **Professors**
- Florencia Canelli
- Thomas Gehrmann
- Massimiliano Grazzini
- Gino Isidori
- Ben Kilminster
- Stefano Pozzorini
- Nicola Serra
- Adrian Signer
- **SNF and ERC professors**
- Cristina Botta
- Lea Caminada
- Andreas Crivellin

Particle Physics





Our Particle Physics Groups theme to understand the fundamental building blocks of matter and how they interact with each other. Our researchers are actively involved in both, theoretical and experimental physics. The experimental groups are currently involved in two experiments based at the Large Hadron Collider at CERN, CMS and LHCb. We also develop novel detector technologies, and actively participate in the development of next-generation of proposed experiments, such as SHIP and FCC. Theoretical groups work on precision calculations in QCD and electroweak theory, flavour physics and new theories beyond the Standard Model.

Our Research Areas

Collider experiments: → CMS , → LHCb

Fixed target experiments: → SHiP , mu3e, → SND@LHC

Particle physics → theory :→ Crivellin | → Gehrmann | → Grazzini | → Isidori | → Pozzorini | → Signer

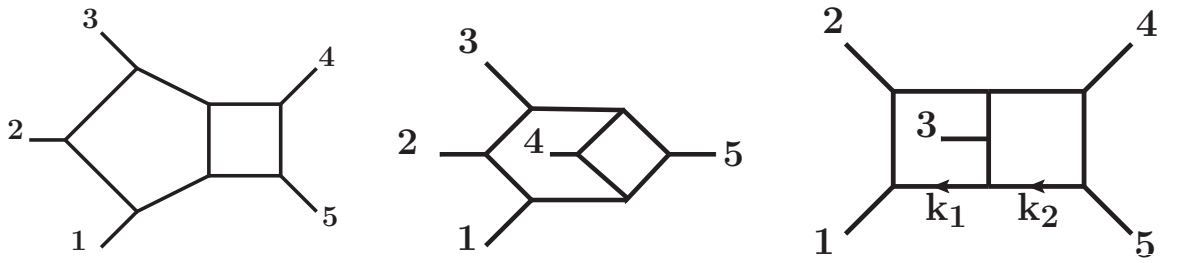
Affiliated groups: ↗ ETH particle physics theory

Former research group: → H1

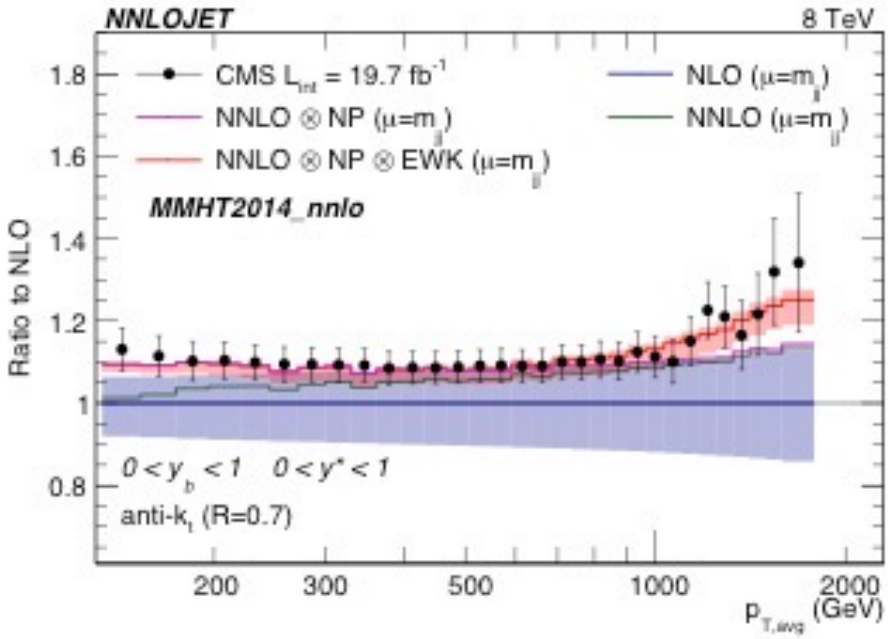
Physik-Institut – Group of Thomas Gehrmann

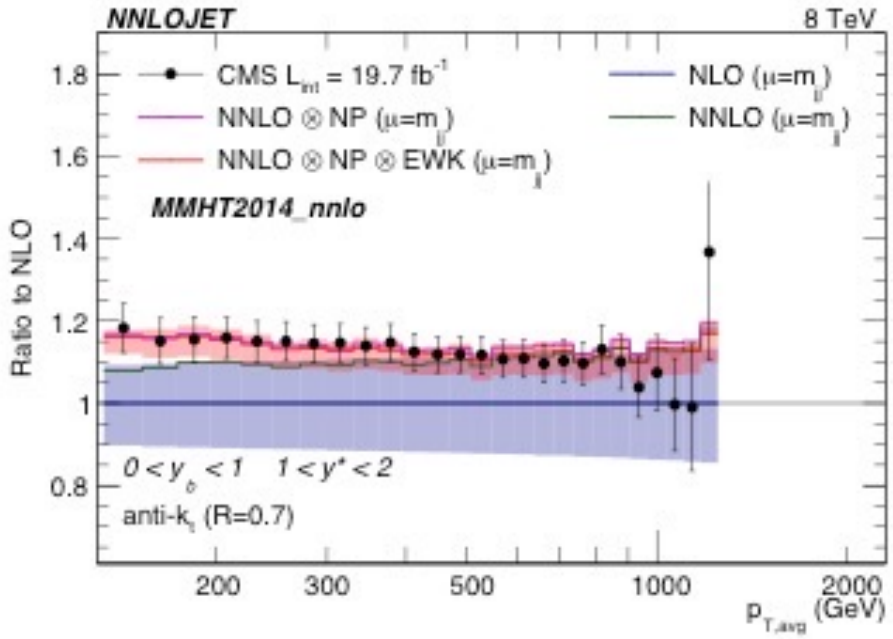
https://www.physik.uzh.ch/en/groups/gehrmann.html

- Multi-loop amplitudes in QCD
- Computer algebra techniques for particle physics (packages: HPL, HypExp, Reduze, FiniteFlow)
- Fully exclusive second order (NNLO) QCD: NNLOJET parton-level event generator
- Precision phenomenology
  - Higgs couplings
  - Electroweak parameters
  - parton distributions and α_s



(a) penta-box (b) hexa-box (c) double-pentagon





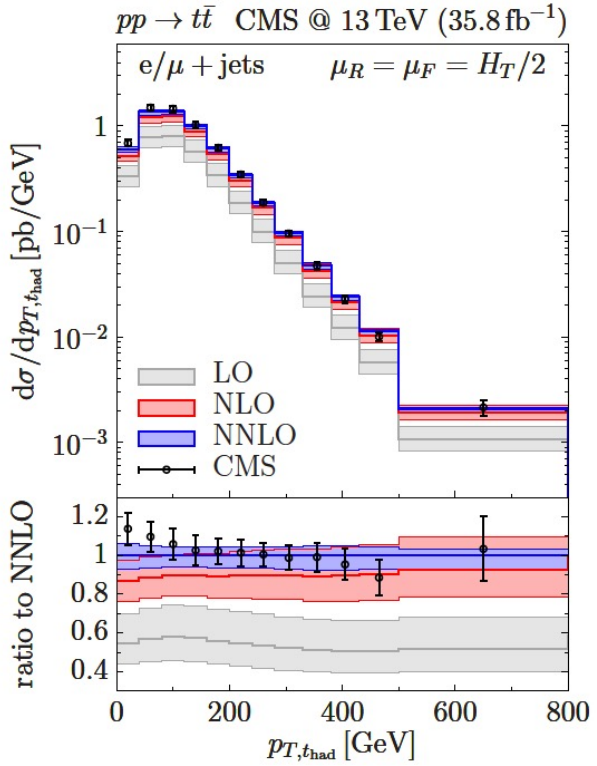
Physik-Institut – Group of Massimiliano Grazzini

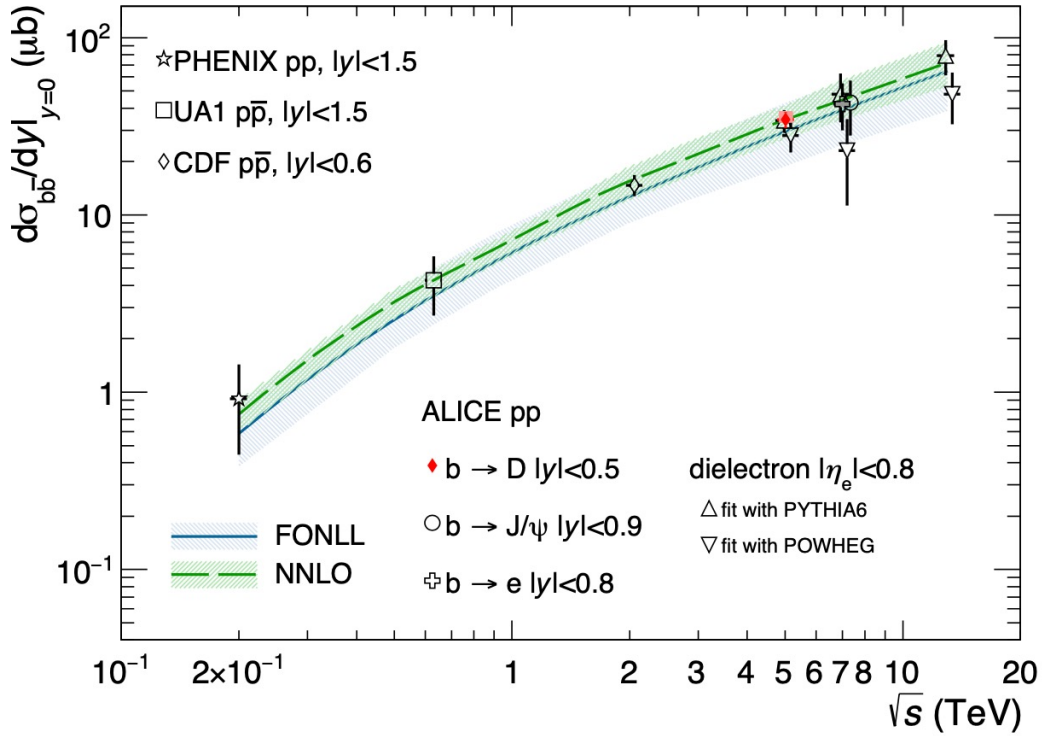
https://www.physik.uzh.ch/en/groups/grazzini.html





Our group performs accurate theoretical calculations for benchmark processes at the LHC and implements them in flexible tools that are eventually made available to the community arXiv:2102.13601
Recent highlights: top and bottom production at NNLO in QCD

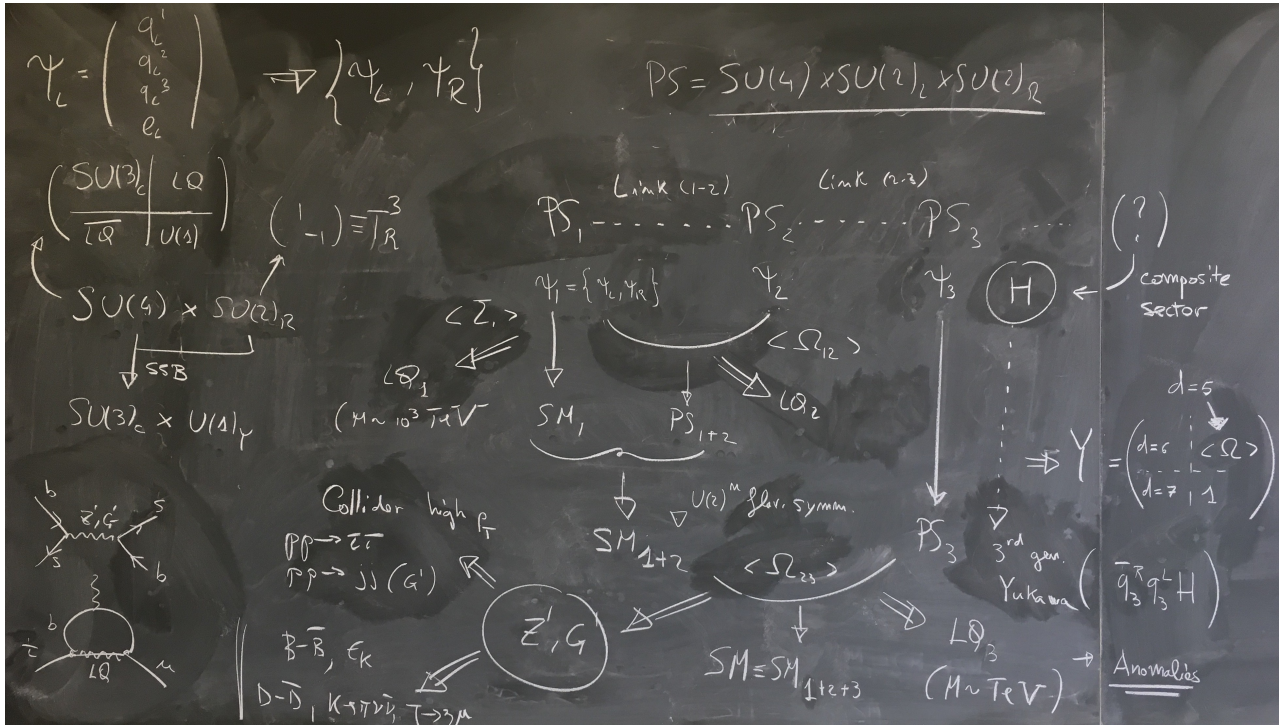




Physik-Institut – Group of Gino Isidori

https://www.physik.uzh.ch/en/groups/isidori.html

The (theoretical) research activity of our group deals with some of the most interesting open questions about the nature of basic constituents of matter and their fundamental interactions, in close connection with experimental activities in particle physics.



Main questions we are investigating these days:

- Theoretical interpretations of the flavor anomalies & implications
- Building SM extensions explaining the origin elementary particle masses
- Unification of fundamental forces, nature of dark matter, origin of neutrino masses

CMS experiment at CERN

Group Botta: https://www.physik.uzh.ch/en/groups/botta.html

PRIMA professor

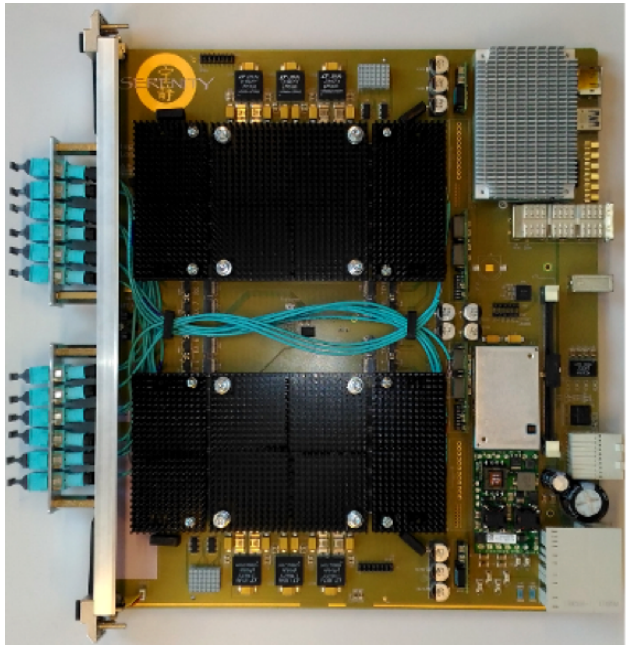


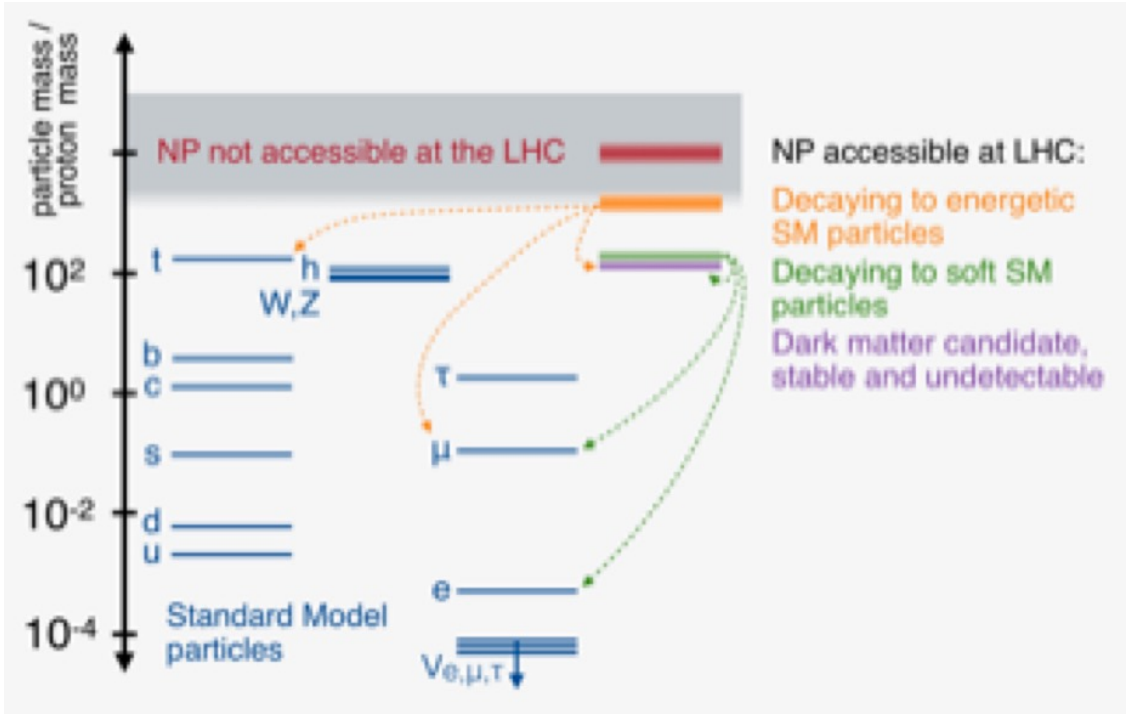
Searches for New Physics signatures related to WIMP Dark Matter in *"compressed spectra"*

an experimentally challenging region of the parameter space where Supersymmetry can still be light.

Invoveld in the upgrade of the CMS L1 Trigger

the L1 Trigger logic and architecture, instrumented by custom hardware processor boards, need to be completely redesigned to face the high luminosity challenge.





CMS experiment at CERN

Group Canelli: https://www.physik.uzh.ch/en/groups/canelli.html

Exploit LHC data to search for yet undiscovered particles and do precision measurements which might give hints to new physics

With special interest in top quark and Higgs boson physics, new direct searches for new physics

Development of multivariate algorithms and methods

Currently designing and prototyping a new pixel detector for HL-LHC: TEPX

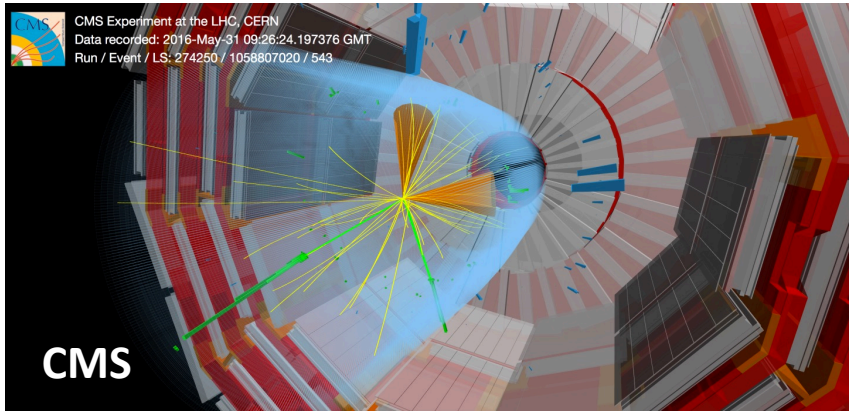
CMS experiment at CERN; Mu3e experiment

Group Caminada: https://www.physik.uzh.ch/en/groups/caminada.html

Eccelenza professor, jointly with PSI

CMS@LHC

- Physics analysis with a focus on SM processes with heavy quarks (t,b,c) and Higgs boson
- Development, construction and upgrade of CMS silicon pixel detectors

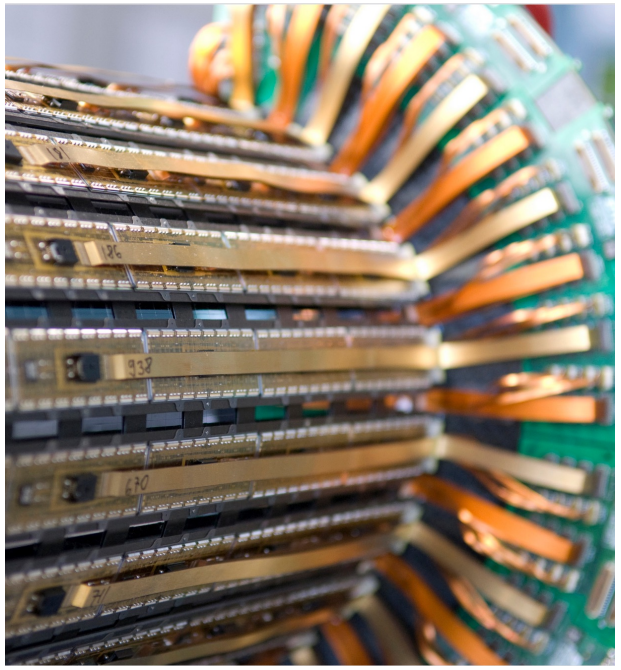


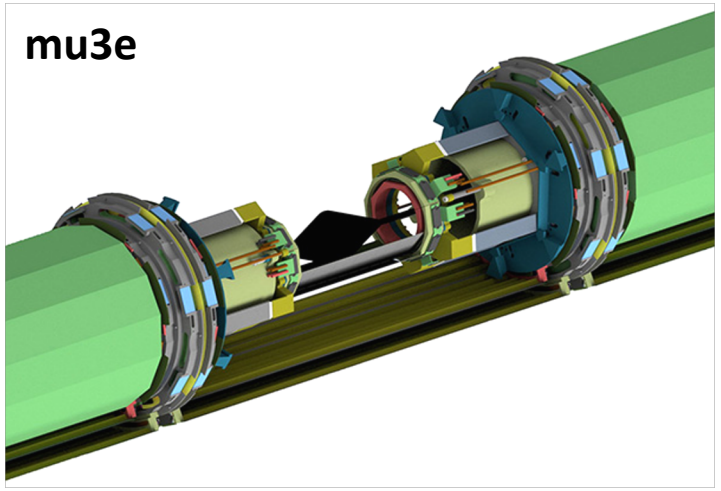
mu3e@PSI

- Data analysis and pixel detector mechanical design and construction

R&D for silicon pixel detectors

- Radiation tolerance, high-rate application, timing capability





CMS experiment at CERN; DAMIC experiment

Group Kilminster: https://www.physik.uzh.ch/en/groups/kilminster.html

General strategy : Students and postdocs have opportunity to work on both physics and detectors

CMS :

Physics analysis :

- Direct / indirect searches for Lepton Flavor Universality Violation
- New physics with tau leptons

Detectors :

- Silicon pixel detectors
- Precision timing detectors (LGADs)

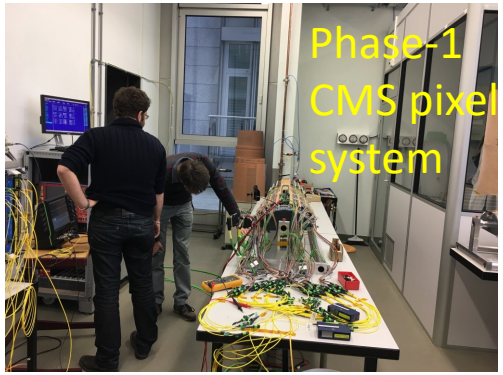
DAMIC (Dark Matter in CCDs) :

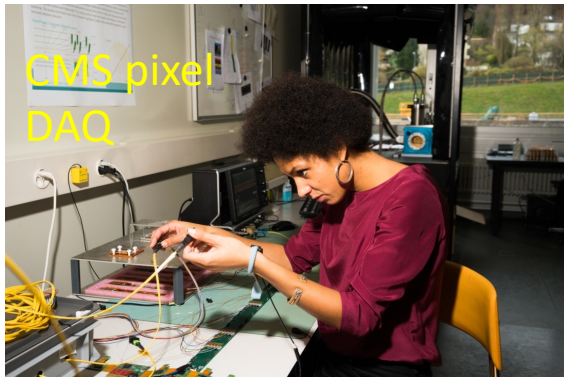
Physics analysis :

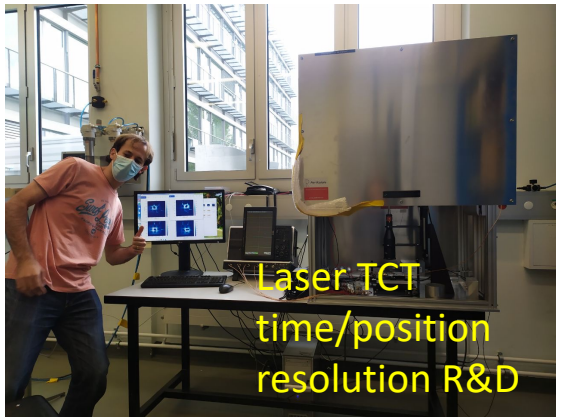
- Searching for DM using radiation damage
- Search for hidden sector DM

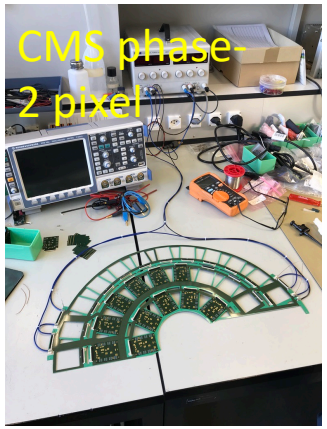
Detector :

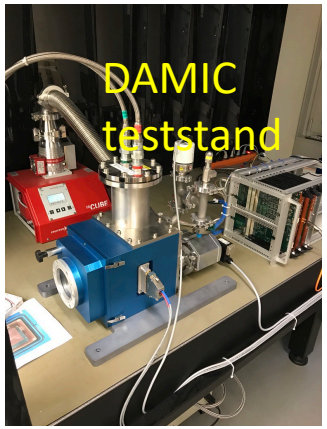
- New Experiment in Modane



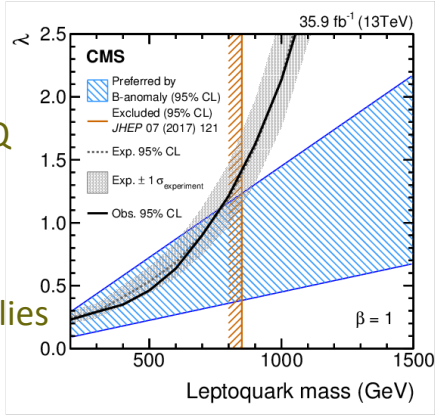


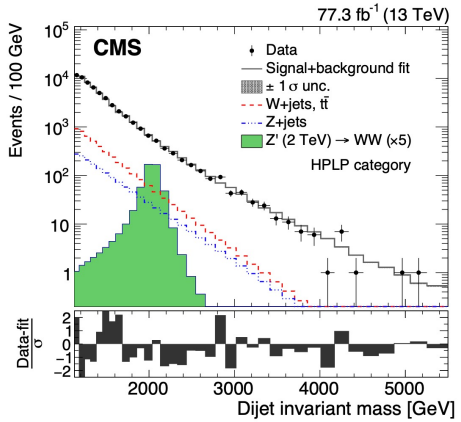




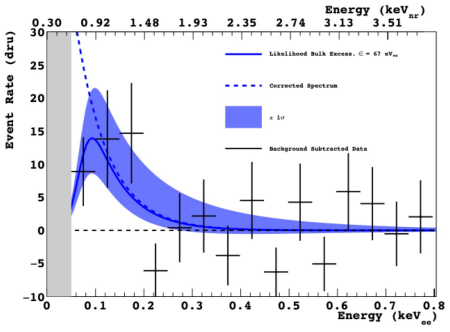


CMS LQ search testing LHCb anomalies





CMS search for diboson resonances

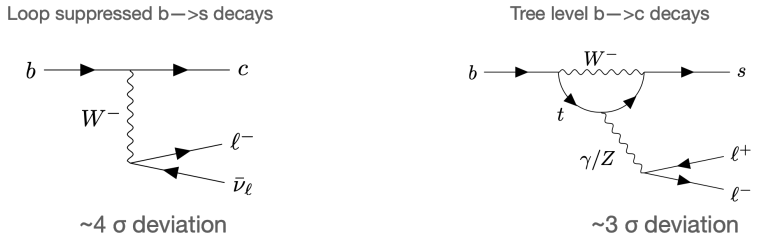


DAMIC 3σ excess low-mass DM

LHCb experiment at CERN, Mu3e and SND experiments

Group Serra: https://www.physik.uzh.ch/en/groups/baudis.html

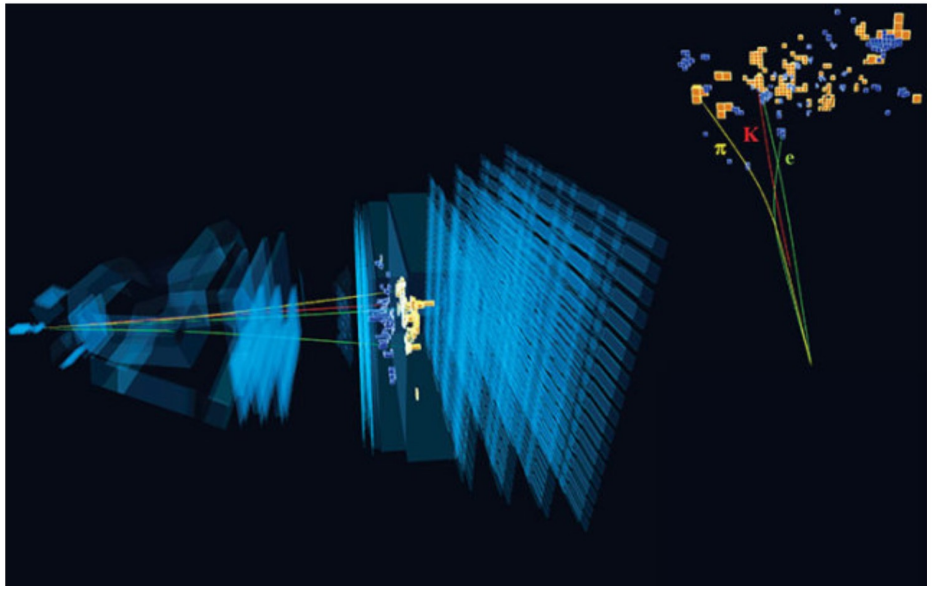
Test lepton universality in two different types of decays.



Intriguing new result from the LHCb experiment at CERN

The LHCb results strengthen hints of a violation of lepton flavour universality

23 MARCH, 2021



Strong connection with the group of Prof. Isidori with shared projects on flavour physics phenomenology.

Working on the tracker upgrades of the LHCb experiment.

Also involved in the Mu3e and SND experiments.