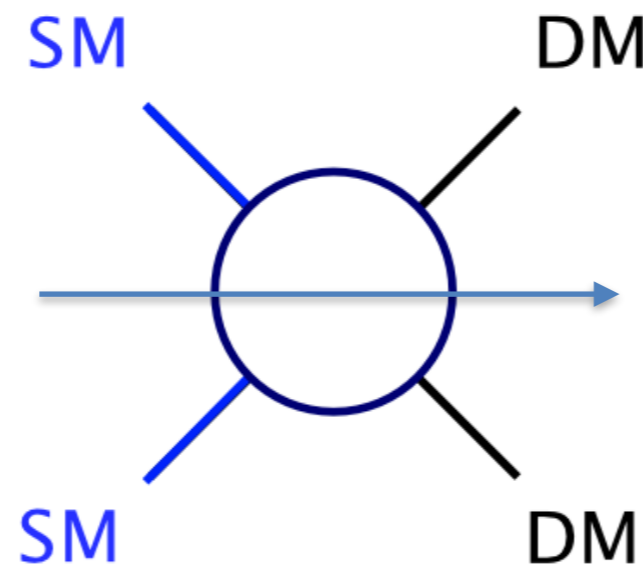# Accelerators & particle physics

How do we search for new particles with accelerators?

- Generally assume some properties for the new particle
  - interacts with known particles → we can **produce it at particle colliders**
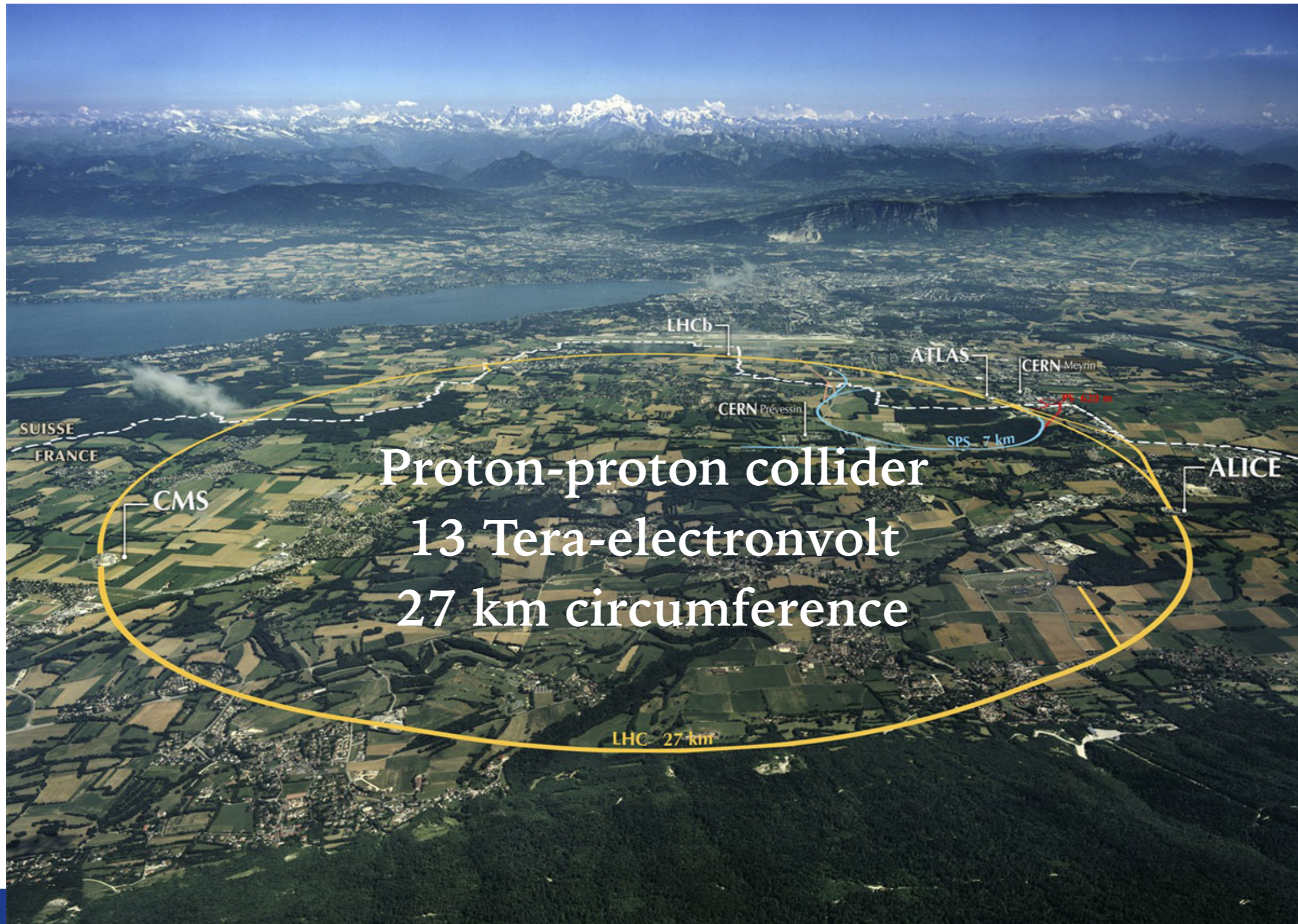
SM   DM

known particle collision   e.g. production of
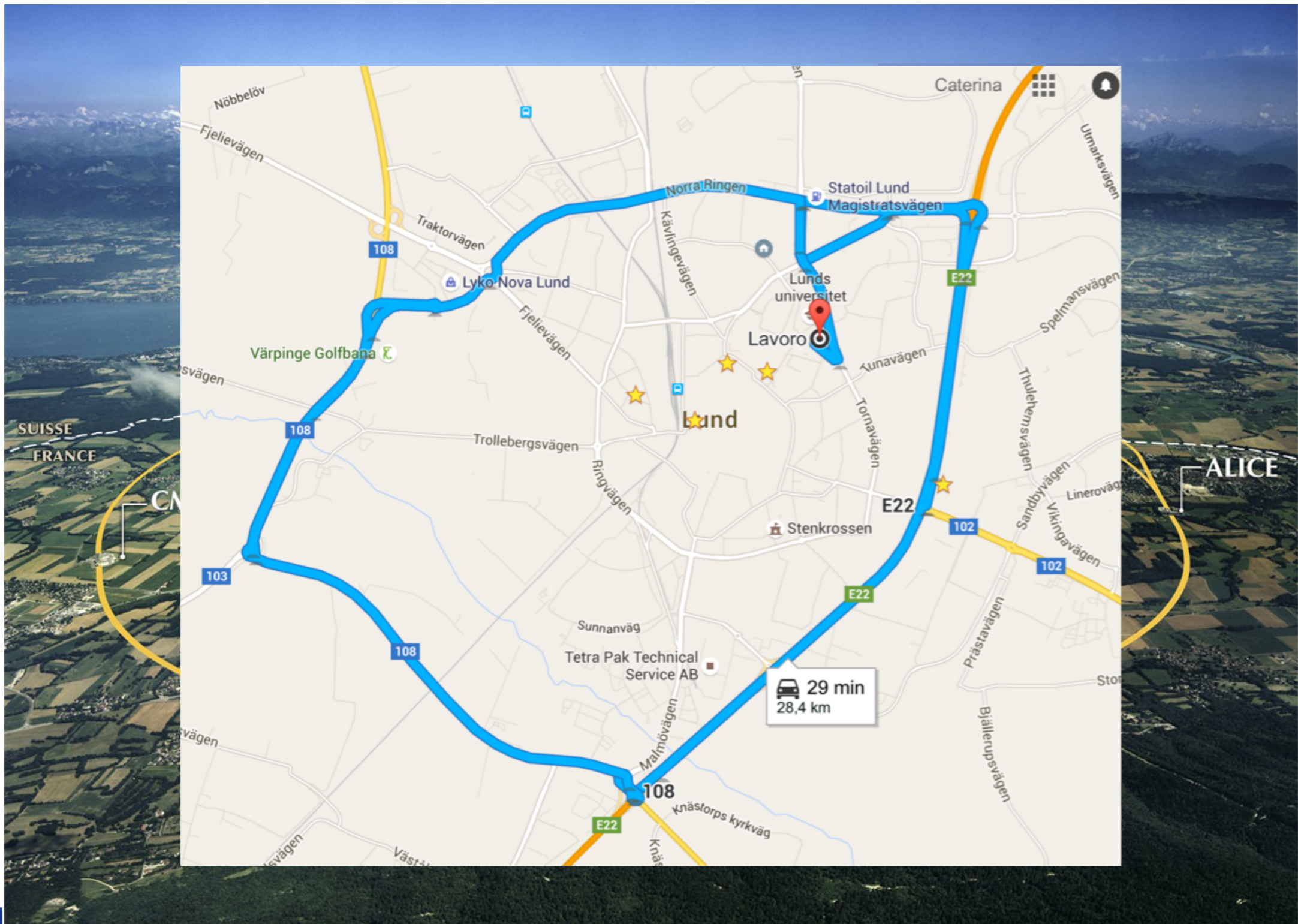   dark matter (DM) particles

SM   DM

Caveat: very simplified diagram

Accelerator: The Large Hadron Collider

Proton-proton collider
13 Tera-electronvolt
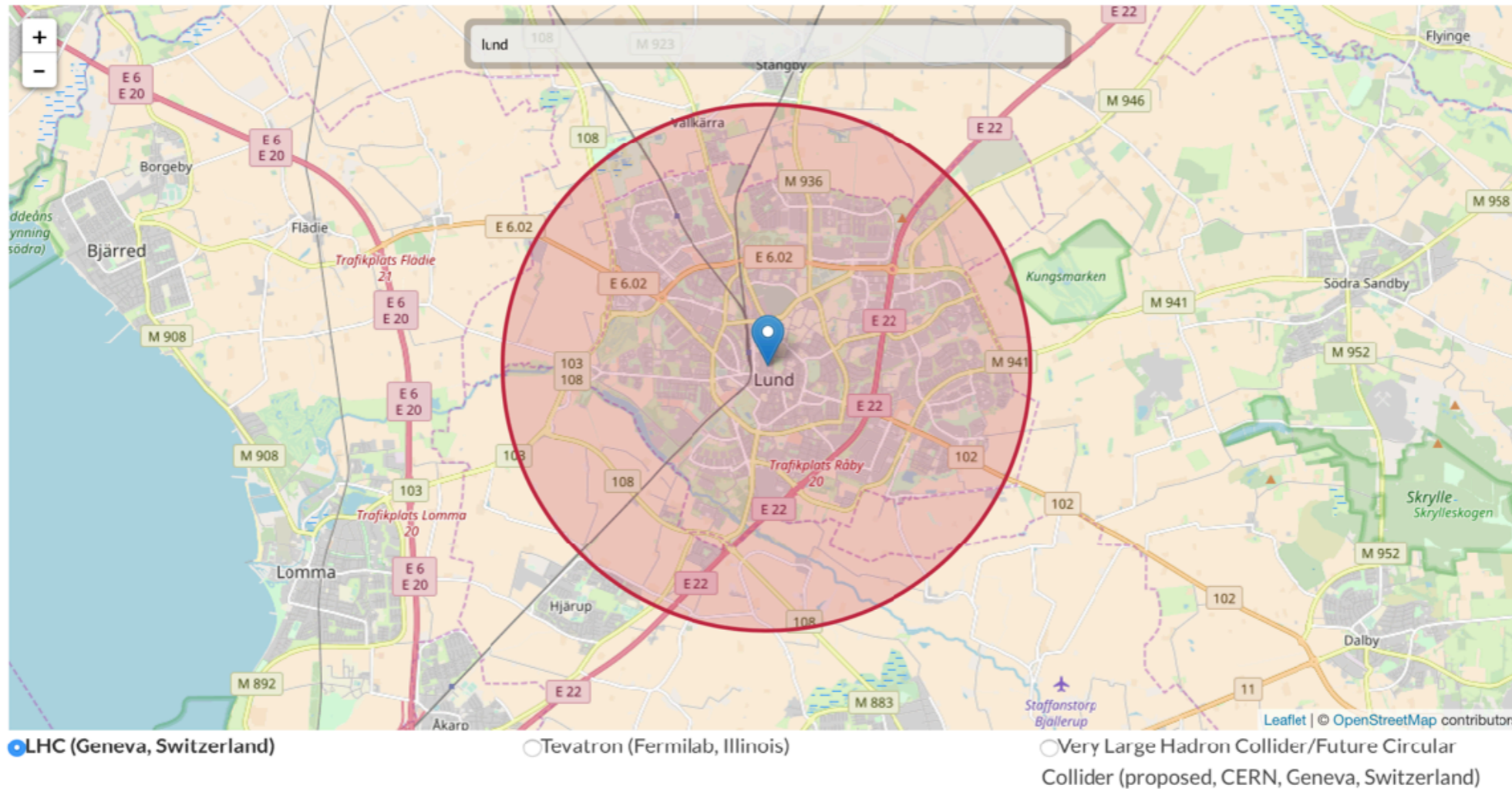27 km circumference

The Large Hadron Collider

The Large Hadron Collider

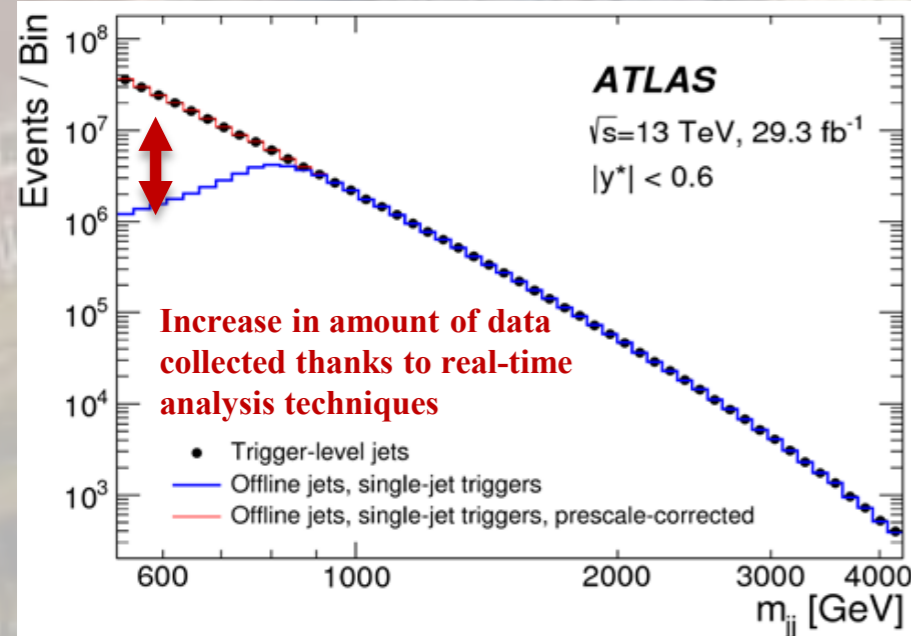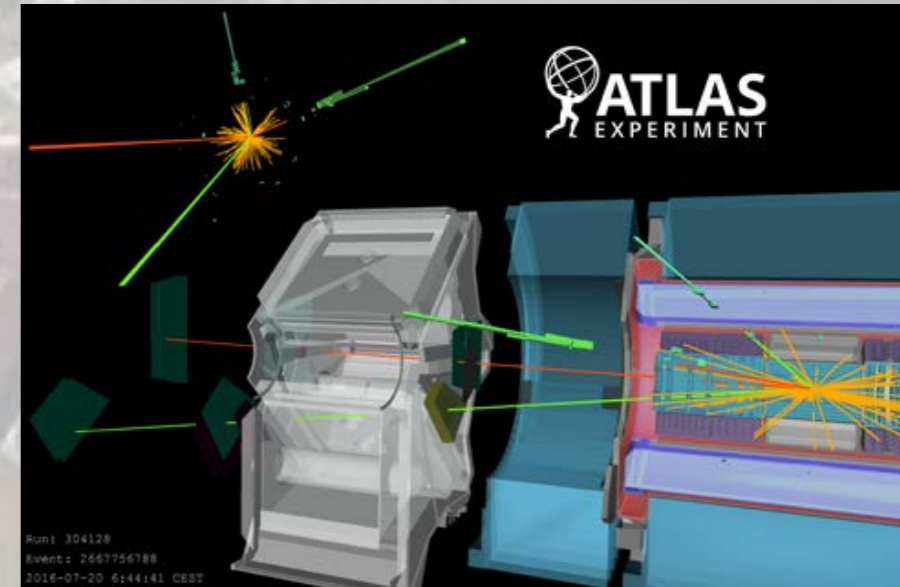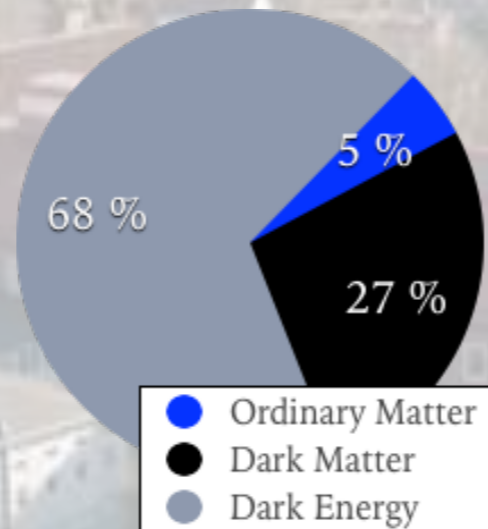https://natronics.github.io/science-hack-day-2014/lhc-map/

Particle Physics: ATLAS at CERN LHC

Searches for exotic particles and interactions

Looking for:

New heavy particles
Dark matter/ Dark sectors
Flavor/CP violation
Additional Higgs bosons
Strong gravity
Extra dimensions

Pie chart:
- 5 % — Ordinary Matter (blue)
- 27 % — Dark Matter (black)
- 68 % — Dark Energy (grey)

ATLAS EXPERIMENT
Run: 304128
Event: 2667756788
2016-07-20 6:44:41 CEST

ATLAS
$\sqrt{s}=13$ TeV, 29.3 fb^{-1}
$|y^*| < 0.6$

Events / Bin vs m_{jj} [GeV]

Increase in amount of data collected thanks to real-time analysis techniques

- Trigger-level jets
- Offline jets, single-jet triggers
- Offline jets, single-jet triggers, prescale-corrected

Strategies:

- Kinematic edges and resonance searches
- Dijet mass and angular distributions
- Trigger-level ("real-time") analysis
- Tagging of jets from heavy flavor quarks
- Multilepton and same-sign dilepton searches

Slides prepared by the particle physics division for Max Planck Institute visit to Lund

Heavy Ion Physics at the LHC: ALICE

Colliding heavy ions to explore nuclear matter under extreme temperature and densities

- *Recreating the Quark-Gluon Plasma state that existed shortly after the Big Bang*
- *Unique tracking and particle ID capabilities at the LHC*
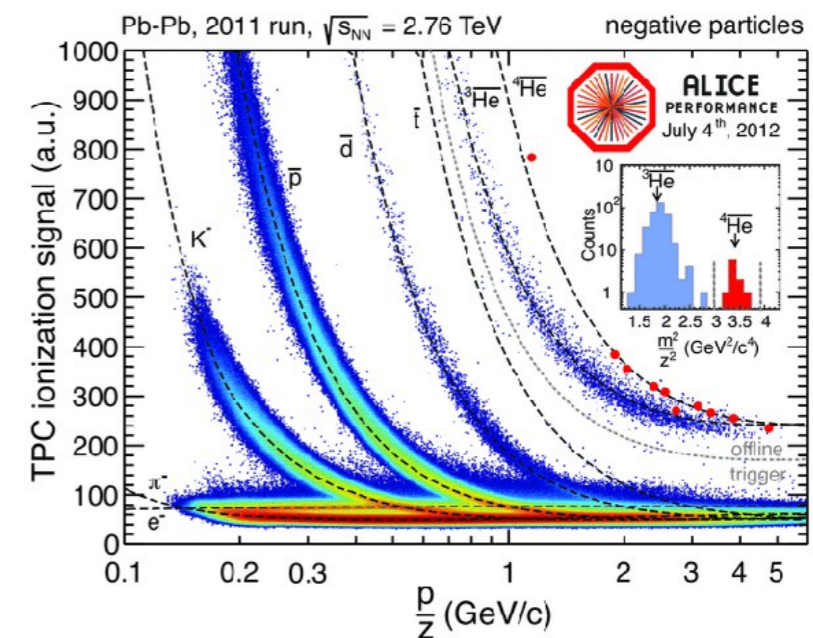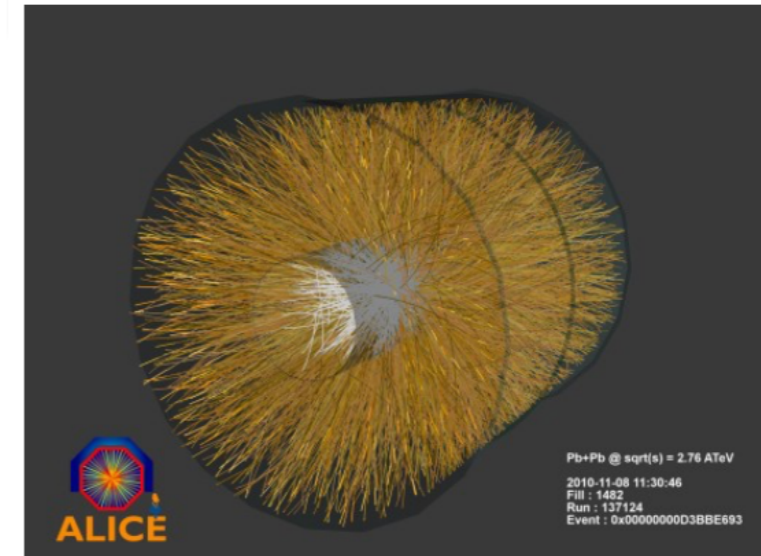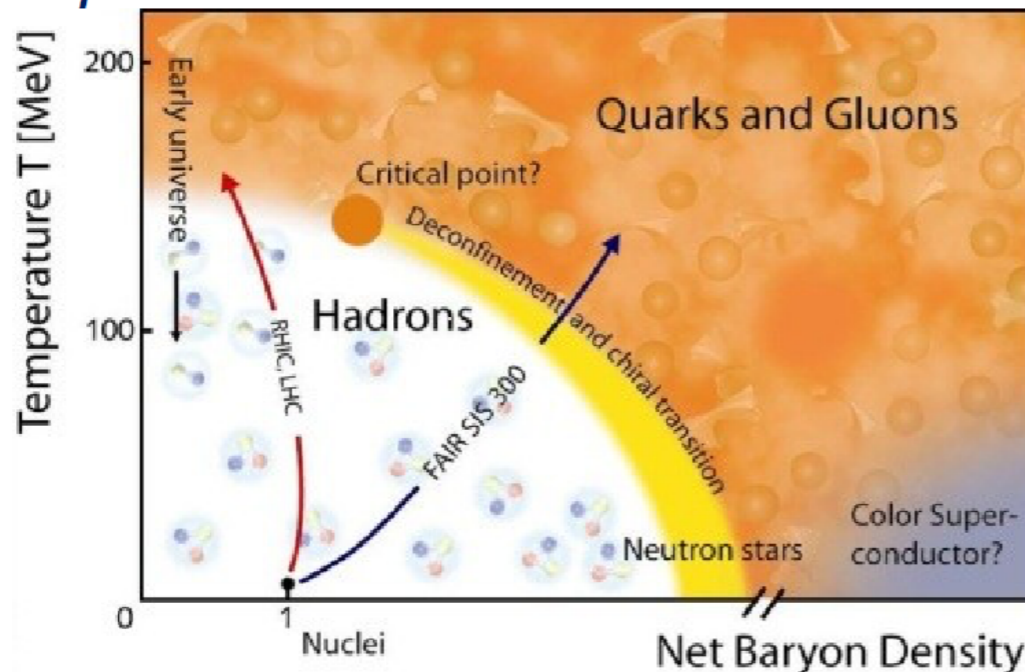
ATLAS and ALICE upgrades

- New challenges brought by high number of interactions and radiation damage
- Production and testing of almost 10% of the whole new end caps modules in Scandinavia
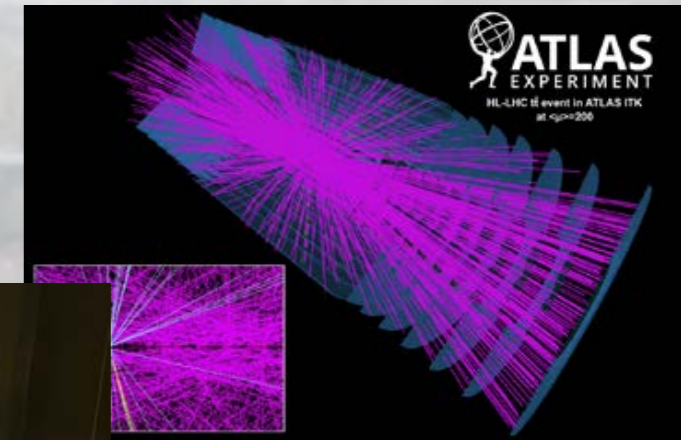
- Key member institute of the ALICE Time Projection Chamber (heart of ALICE tracking)
- Involvements in monitoring, simulations, software, and (primarily) readout electronics
- Testing and qualification of 100% of the readout chips for the TPC upgrade for LS2 (GEM replacing MWPC, continuous readout, 2019-2020) done in Lund
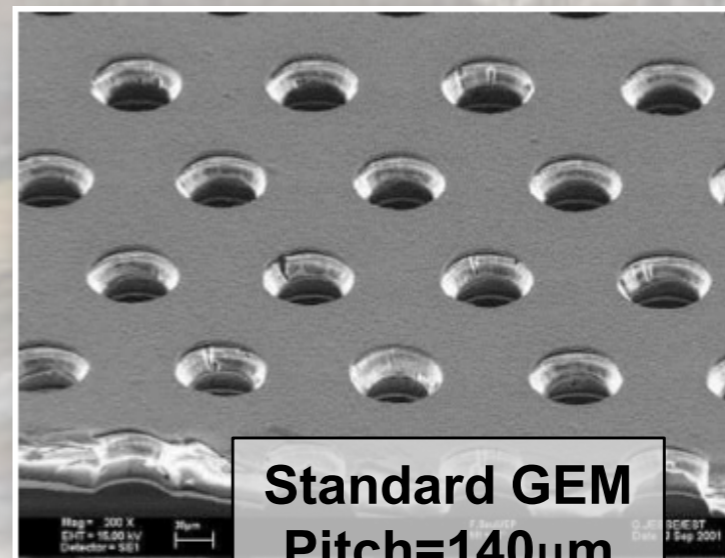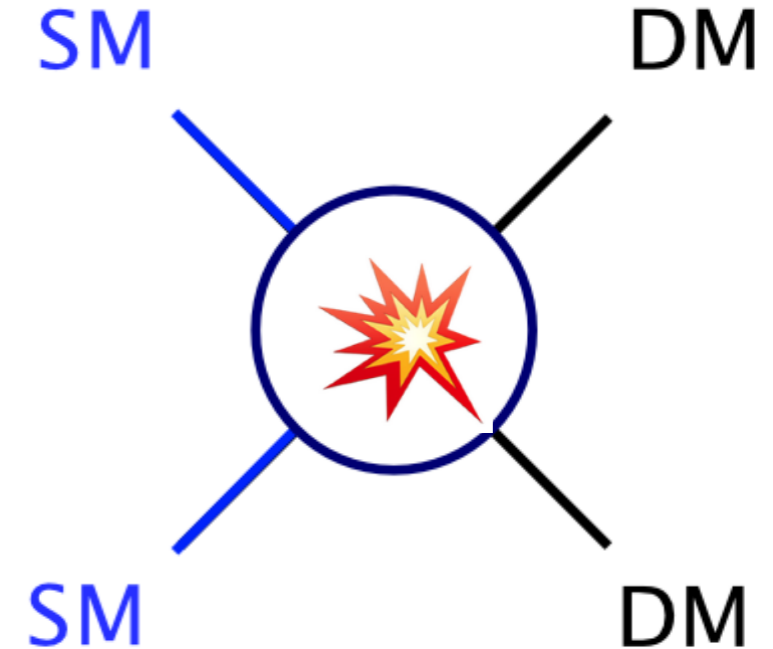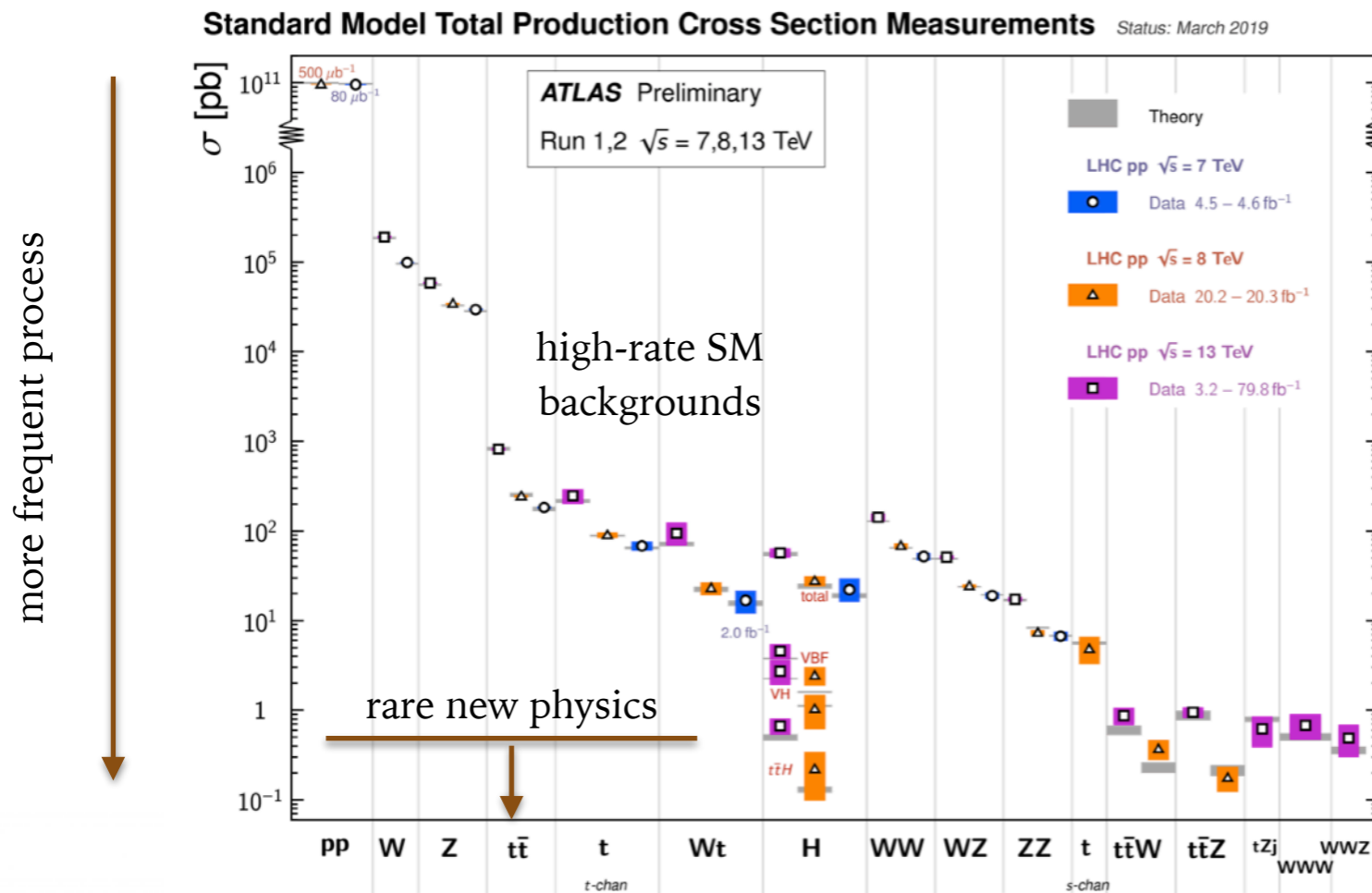
Standard GEM
Pitch=140μm
Hole ϕ=70μm
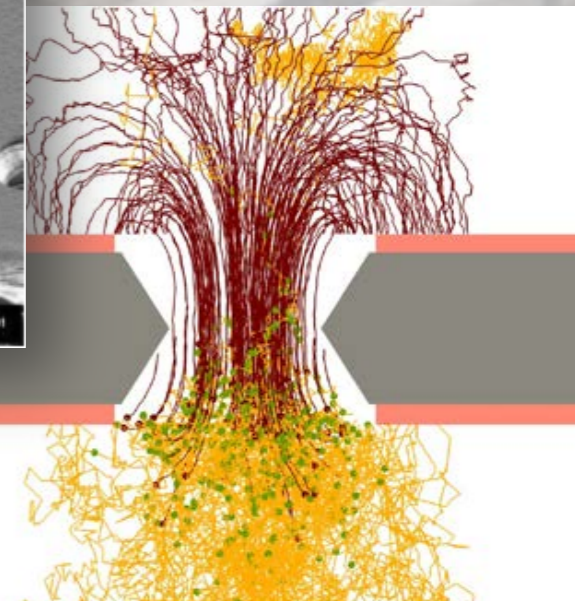
Enabling discoveries in particle physics

- **Many different theories** can explain **known theory** shortcomings
  - None of these theories is yet favored by data
  - Very different signatures in the detector
    - Some signals buried in **high-rate backgrounds**
- (Real-time) data selection, data analysis: **common challenges**

new experiment to search for light Dark Matter
- fixed-target experiment in *electron* beam
- measure missing energy and momentum
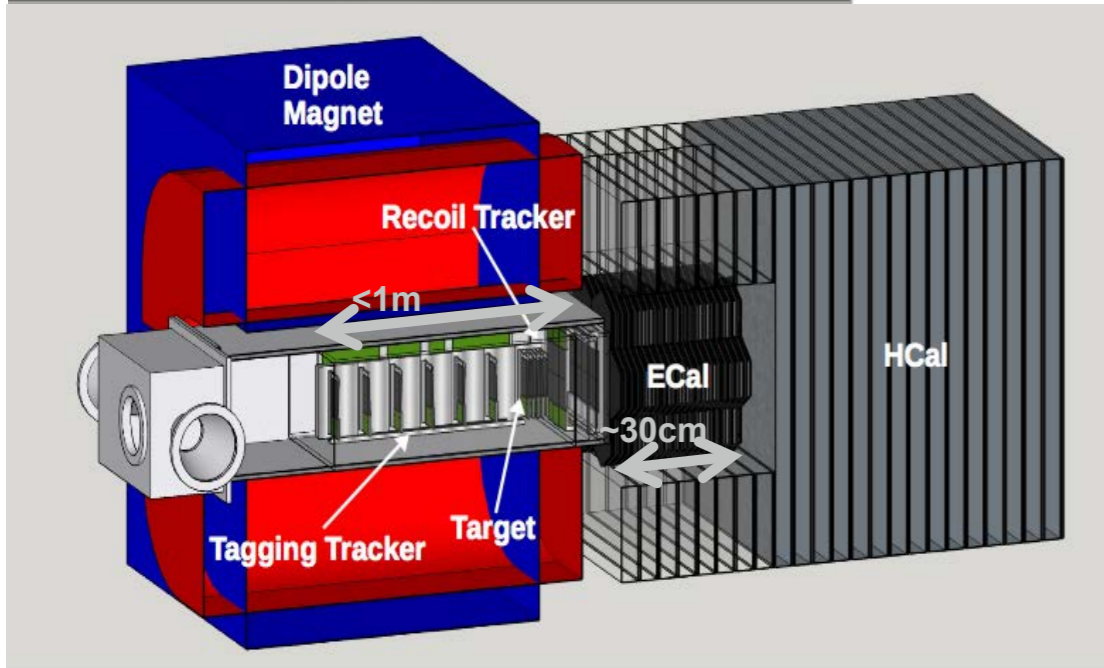- requires beam with
      - high duty-cycle
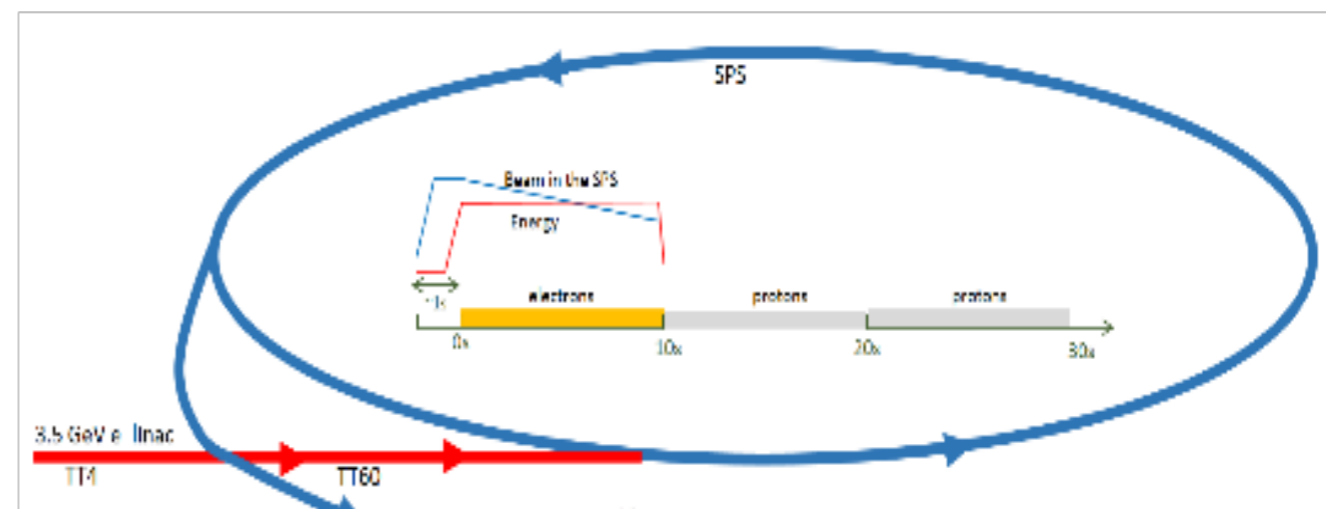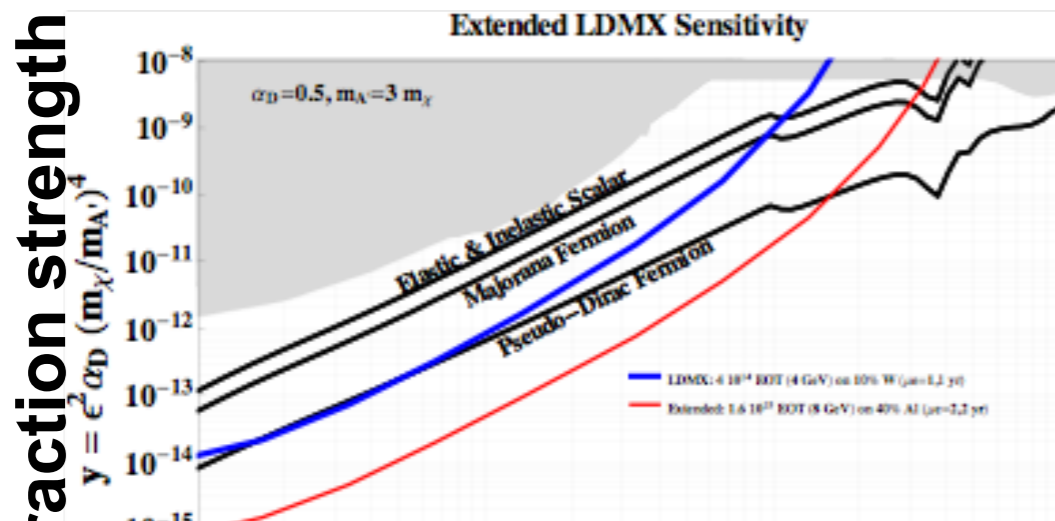   - high repetition rate
      - low intensity
- phase-1 at SLAC (4 GeV, 10^{14} electrons on target)
- phase-2: at CERN (16 GeV 10^{16} e$^-$ on target)
CERN initiative includes accelerator R&D with MPI

LU initiative

Where we are working together / planning to do so