



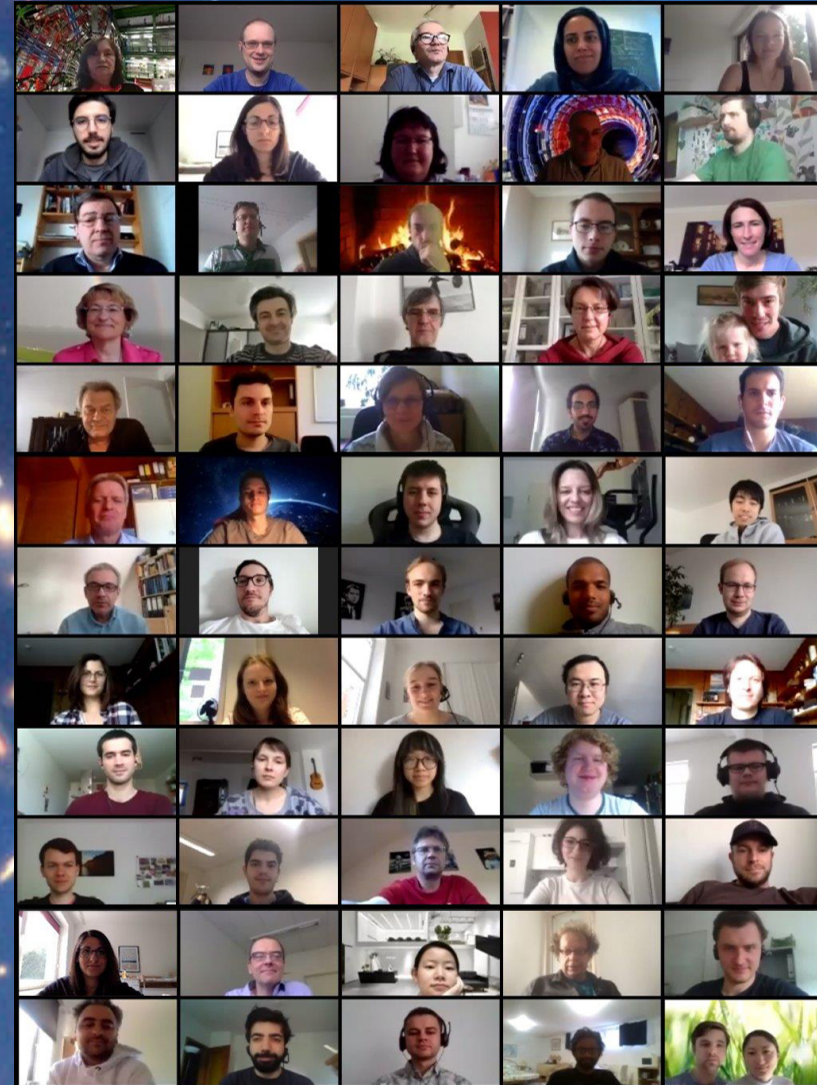
Welcome to the DESY CMS group



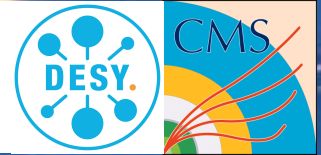


Welcome to the DESY CMS group

...now most of the time in home office...

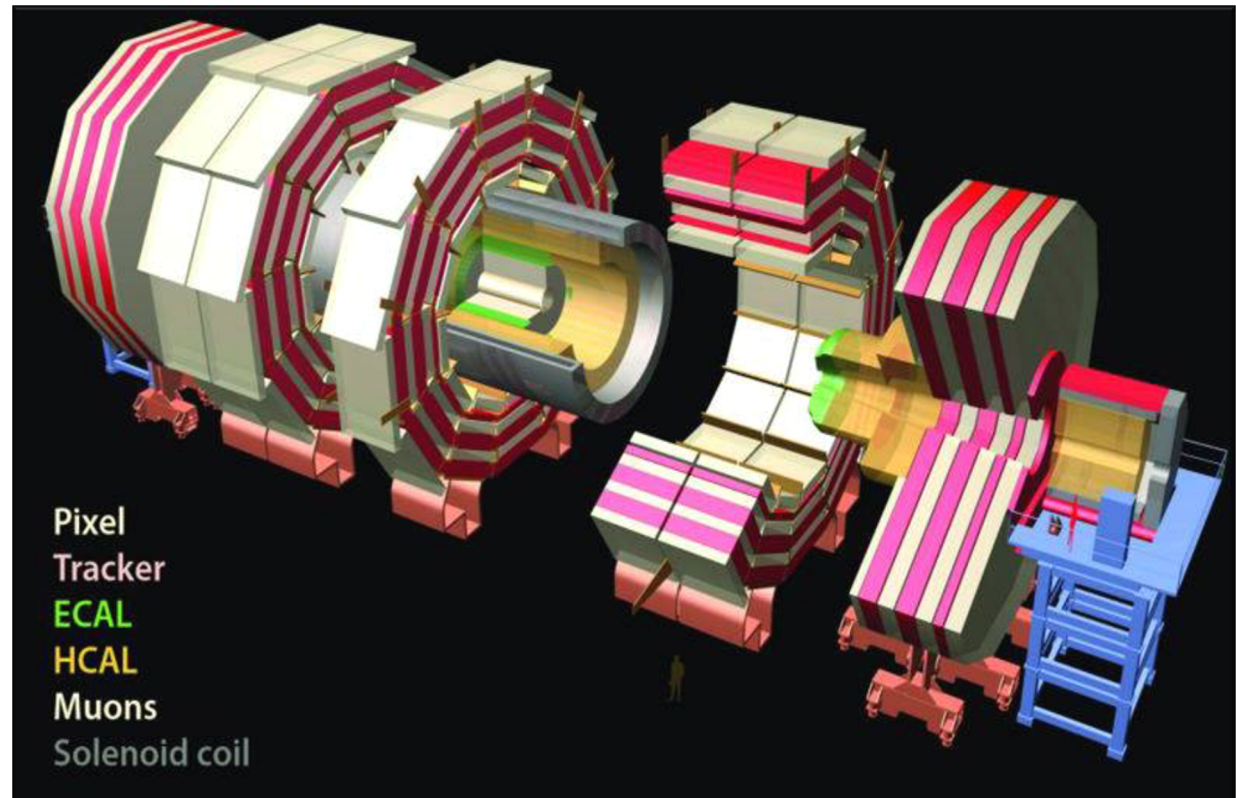


The CMS Experiment



Built by more than 2000 physicists and technicians

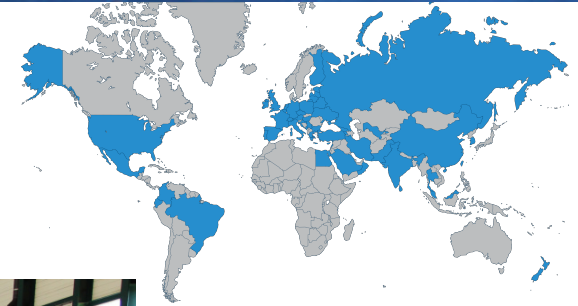
- ✦ 15m high, 21m long (2x smaller than ATLAS)
- ✦ 14 000 tons (2x heavier than ATLAS – and also heavier than the Eiffel tower)
- ✦ The solenoid contains the calorimeters (not the case in ATLAS), and is the biggest magnet of this kind with a diameter of 6m and a magnetic field of 4 Tesla



The CMS Collaboration



More than **5000 particle physicists**, engineers, computer scientists, technicians and students from **229 institutes and universities** from **51 countries**



1906	1036	1065	1110
PHD PHYSICISTS	PHYSICS	ENGINEERS	UNDERGRADUATES
(1569 MEN, 337 WOMEN)	DOCTORAL STUDENTS	(933 MEN, 132 WOMEN)	(824 MEN, 286 WOMEN)
	(796 MEN, 240 WOMEN)		

The **DESY** group with currently **112 registered members** is one of the largest institutes in CMS

Overview



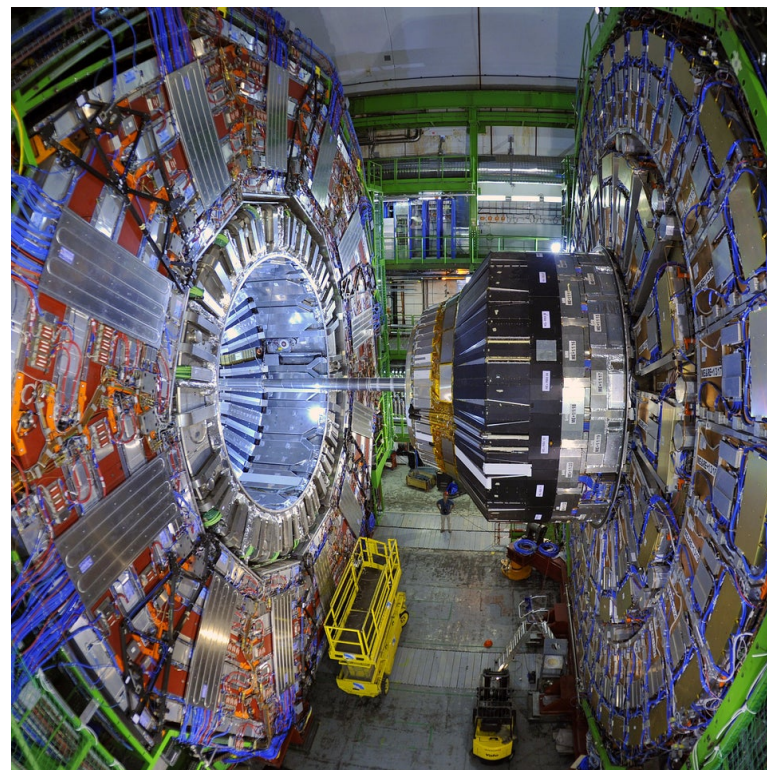
The DESY CMS group works on different activities, in detector physics as well as data analysis:

Detector projects:

- ◆ Silicon tracker
- ◆ BRIL detector and luminosity measurements
- ◆ High granularity calorimeter
- ◆ Hadron outer calorimeter

Analysis projects:

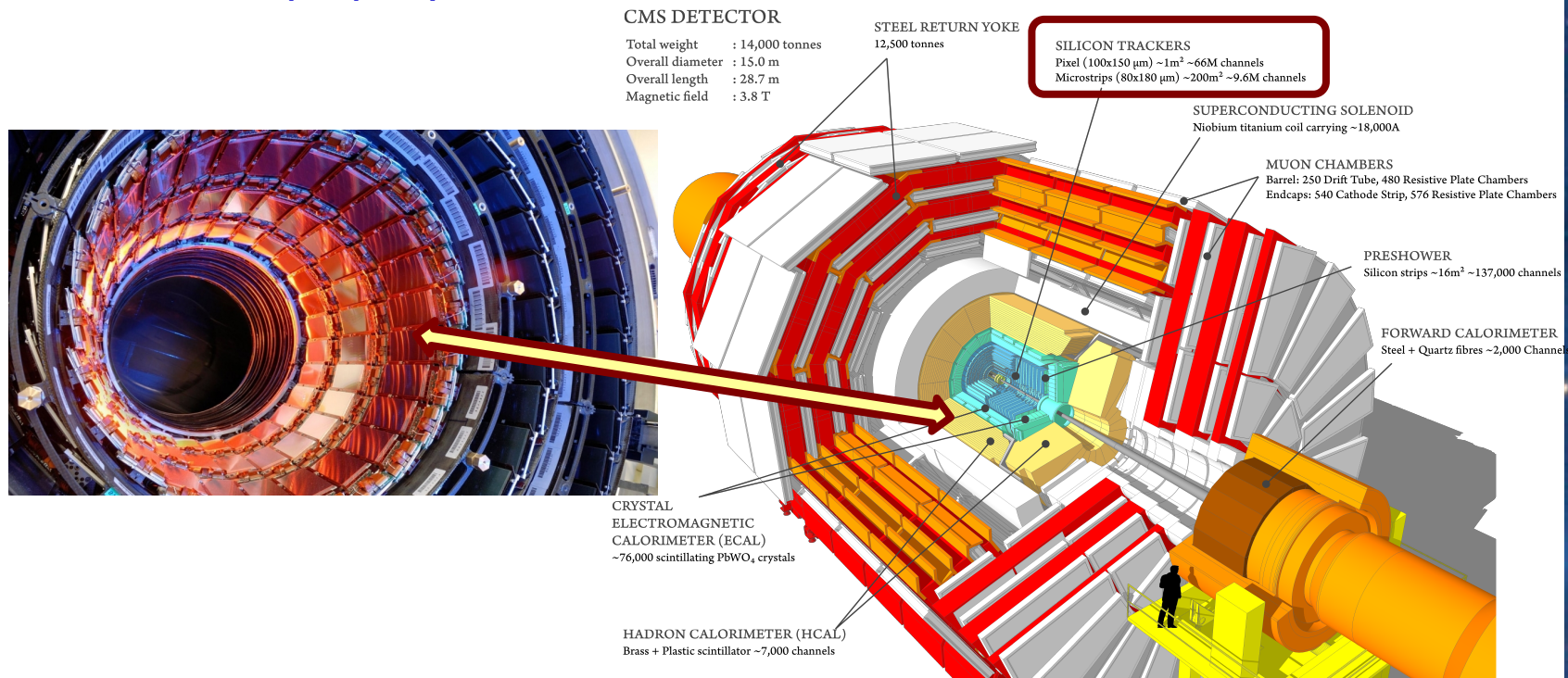
- ◆ Quantum Chromodynamics (QCD)
- ◆ Top quark physics
- ◆ Higgs measurements
- ◆ Searches:
 - ◆ Supersymmetry
 - ◆ Dark matter
 - ◆ Dark or heavy Higgs
- ◆ Tracker alignment and calibration
- ◆ Computing



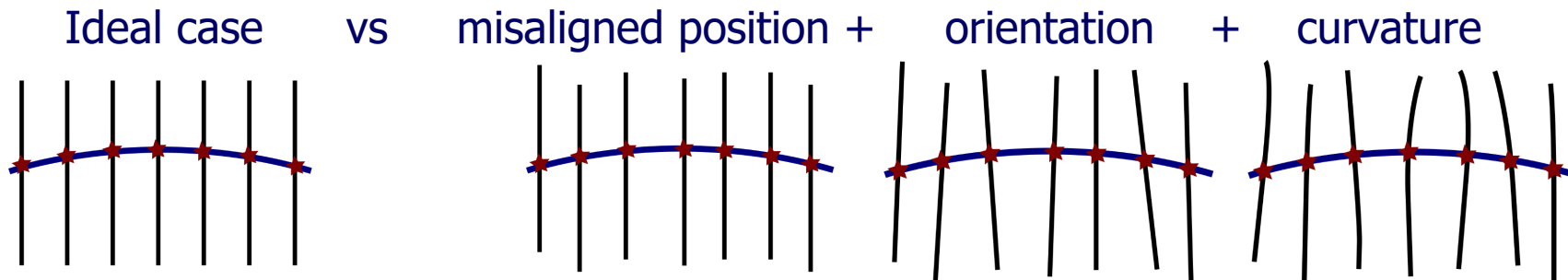
Example 1: Silicon tracker

We are passionate about the core of the CMS detector, the silicon tracker:

- ◆ Upgrade (see Doris' presentation later this session)
- ◆ We work not only on hardware, but also on **alignment** and calibration: each layer and module of the tracker needs to be exactly aligned in order to properly reconstruct tracks

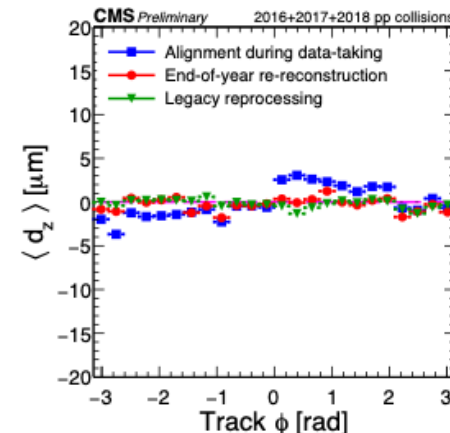
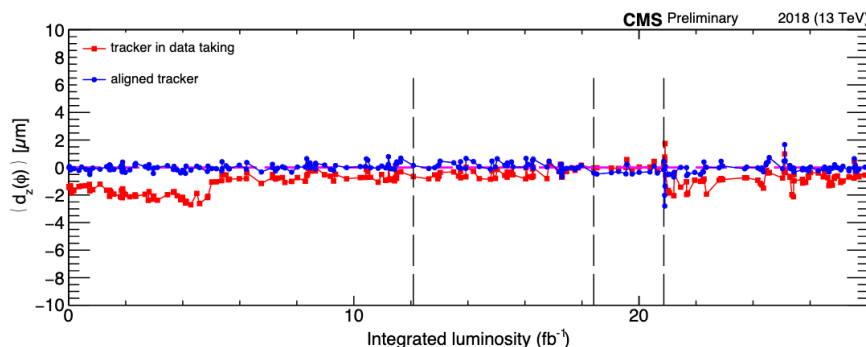


Tracker Alignment:



- ◆ Use tracks (e.g. cosmic muons) to align the layers ($O(10^5)$) parameters using a least squares fit
- ◆ Doing this once after building the detector is not enough, changes can be caused by magnet cycles, temperature variations, ageing,...
- ◆ Example of impact of alignment: primary vertex reconstruction:

- ◆ Reconstruct a vertex with $(N-1)$ tracks
- ◆ Check impact parameter with N^{th} track



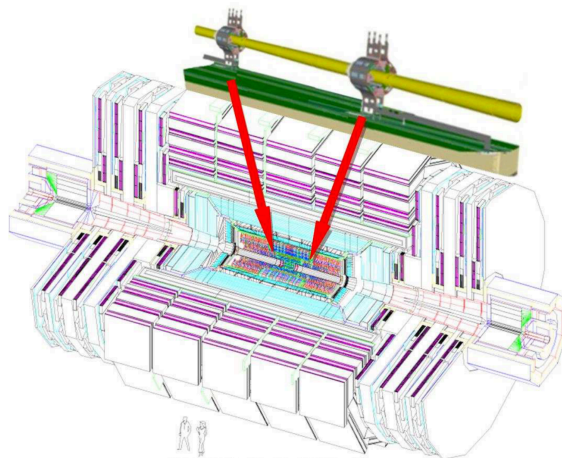
Example 2: BRIL

The BRIL group is responsible for various luminosity measurements

→ very important, already during data taking (making sure that LHC delivers a reasonable amount of collisions in our interaction point), as well as in nearly every analysis, e.g. to extract cross sections

DESY involvement:

- ✦ Online luminosity measurement with the beam condition monitor (BCM1F)
 - ✦ Refurbishment of Run 2 boards for Run 3: new Silicon sensors, active cooling, AC-coupled readout



- ✦ High-precision measurement of the integrated luminosity (offline)

Our Backbone – Computing

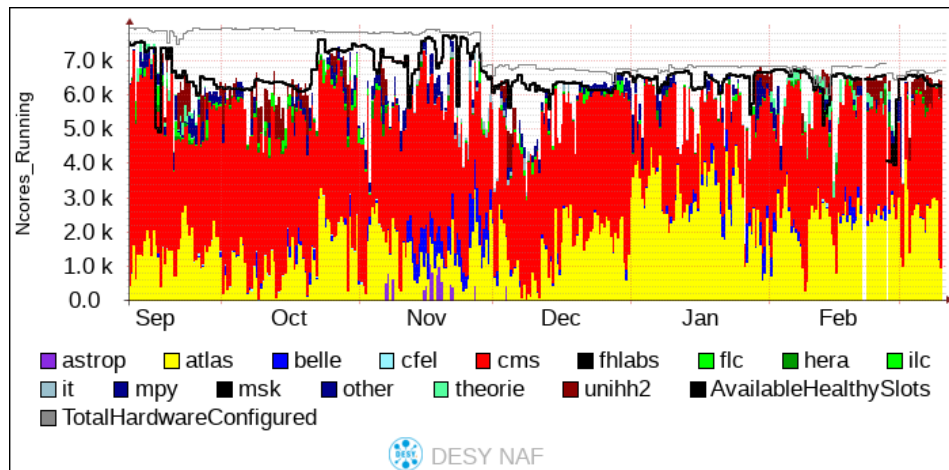


DESY runs a **Tier 2 center** and the **National Analysis Facility**

- ✦ The Worldwide LHC Computing Grid (WLCG) is composed of four levels, or “Tiers”, called 0, 1, 2 and 3
- ✦ Tier 0 is the CERN Data Centre – all data passes through this central hub, but it provides less than 20% of the Grid's total computing capacity
- ✦ Tier 1 consists of 7 centers around the world, large enough to store all LHC data
- ✦ DESY is hosting one of the 40 Tier-2 centers, storing both LHC data and simulated events for fast user access

National Analysis Facility:

- ✦ Big cluster; main purpose: individual analyses (Interactive and/or “prompt” batch processing)
- ✦ The NAF hosts a large number of CPUs, but also GPUs (becoming more and more important for machine learning)

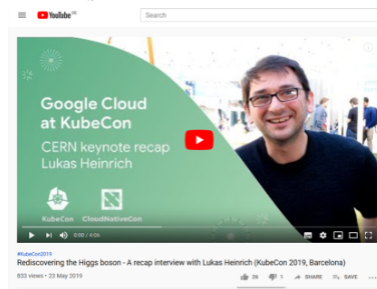
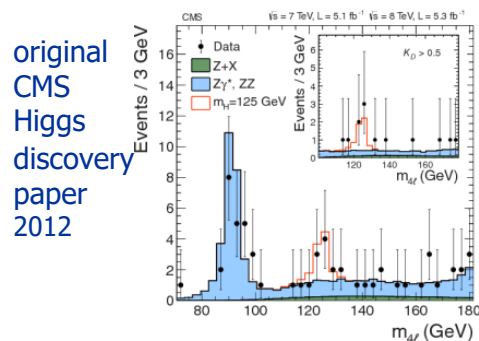


Open data

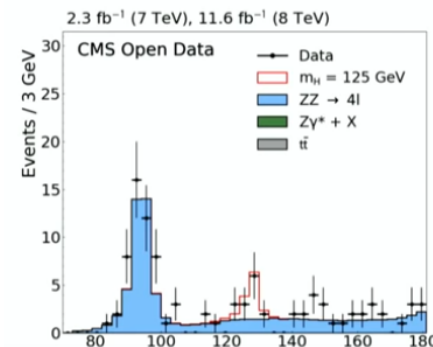


CERN/LHC program of **Open Data** for research purposes pioneered and co-led by CMS

- ◆ Already 100% of 2010 pp data and simulation, and 50% of all other CMS Run 1 legacy data and MC released in original CMS analysis format
- ◆ One of the CMS Open Data analysis examples provided by DESY upgraded to CHEP2019-highlight by CERN-IT and ATLAS people:



Level 4:
run on **25000 cores**
of Google cloud
+ 3 minutes



- ◆ You can even do an analysis by yourself, try here:
<https://twiki.cern.ch/twiki/bin/view/CMSPublic/CMSPublicDataLinks>

Example 3: Search for new physics

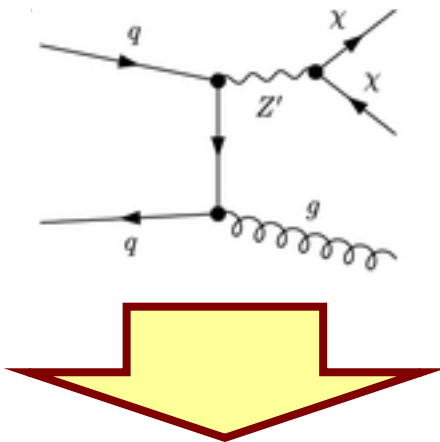
Can we produce Dark Matter in the lab?
And how can we see it?

Indeed **Dark Matter itself is invisible** to us, but it might be produced together with other particles, e.g.:

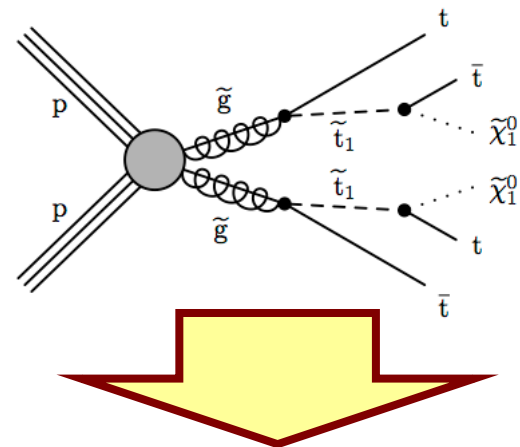
Initial State Radiation

or

other heavy particles

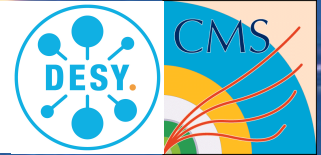


Search for events with large missing transverse momentum



Search for high-energetic events + missing transverse momentum

Dark Matter in the Detector?



This is how a typical SUSY event would look like...

... but there are also SM events that can look like this, we need to observe an excess in order to claim discovery...

... easily accessible models are already ruled out...

... now we are tackling models that are hard to distinguish from SM events using machine learning!



CMS Experiment at the LHC, CERN

Data recorded: 2018-Aug-13 20:24:00.350720 GMT

Run / Event / LS: 321219 / 504952772 / 344

