Triggers for New Physics at the LHC
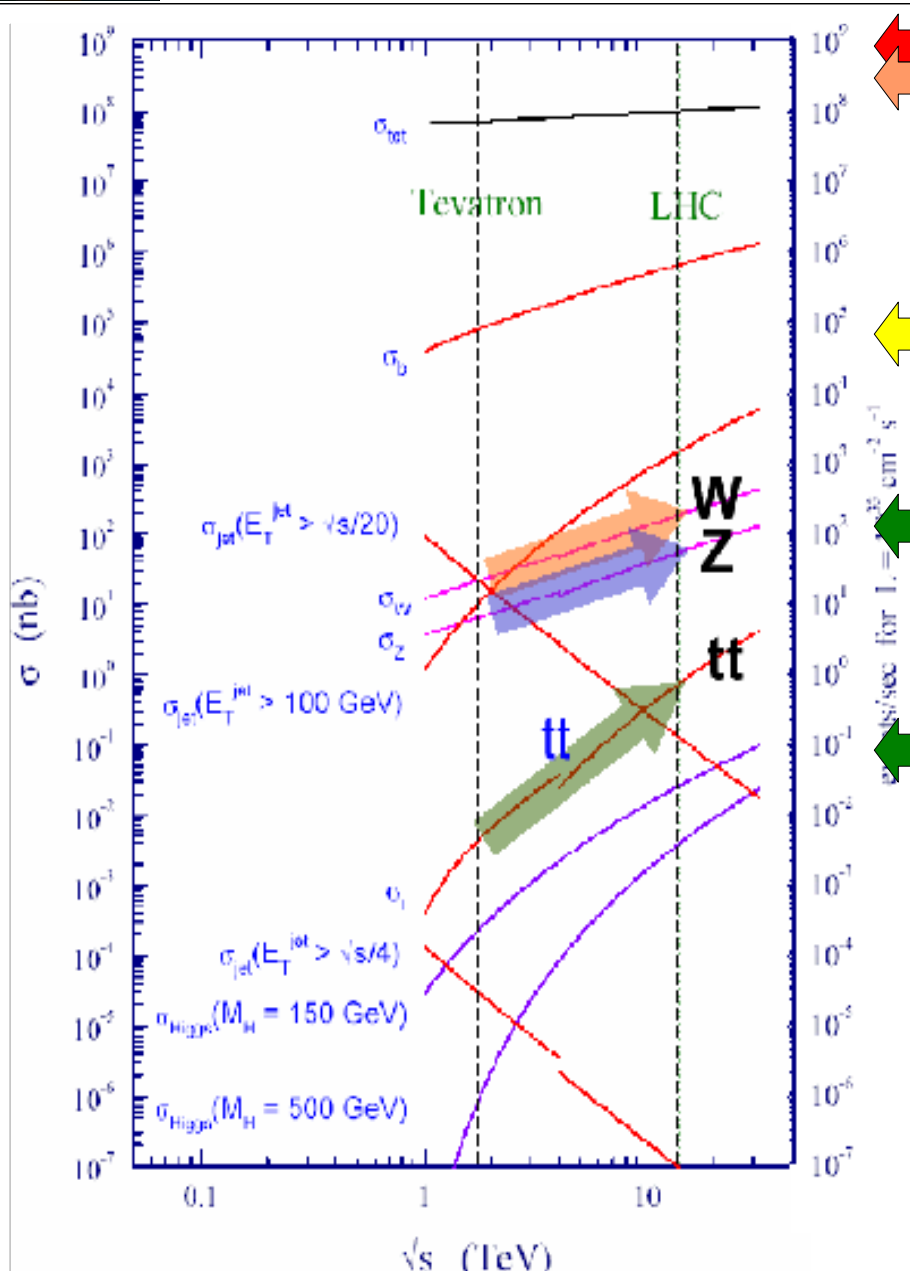
M. Mozer
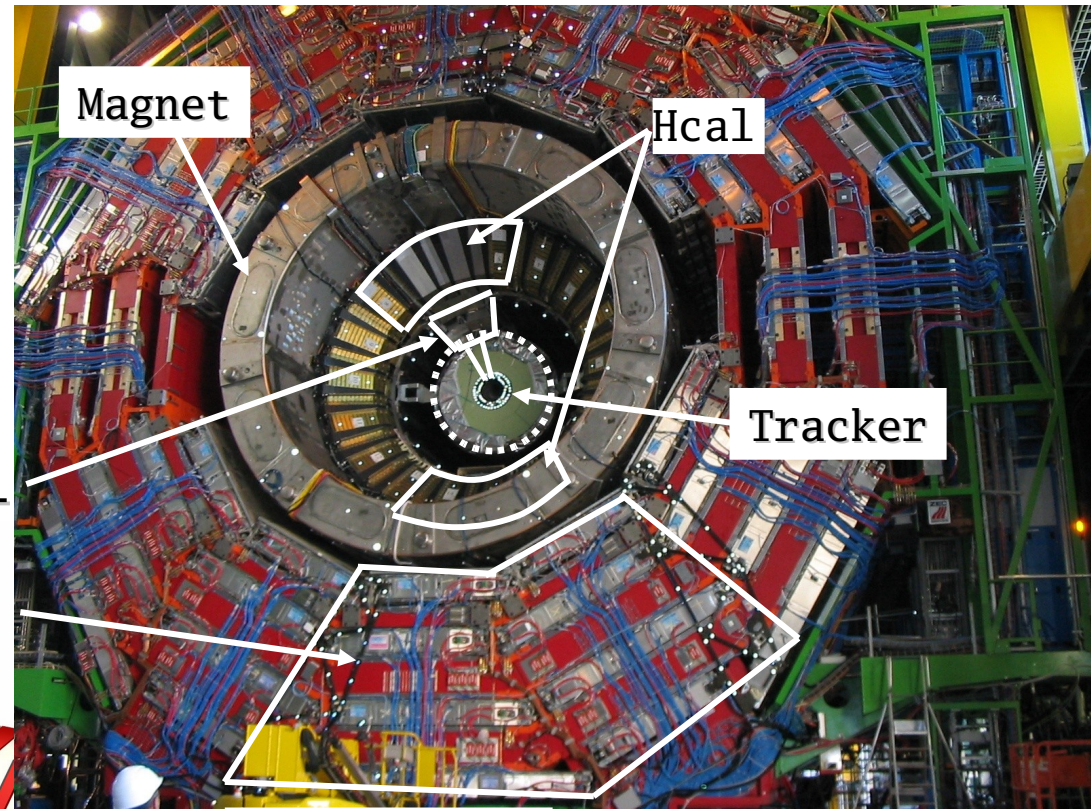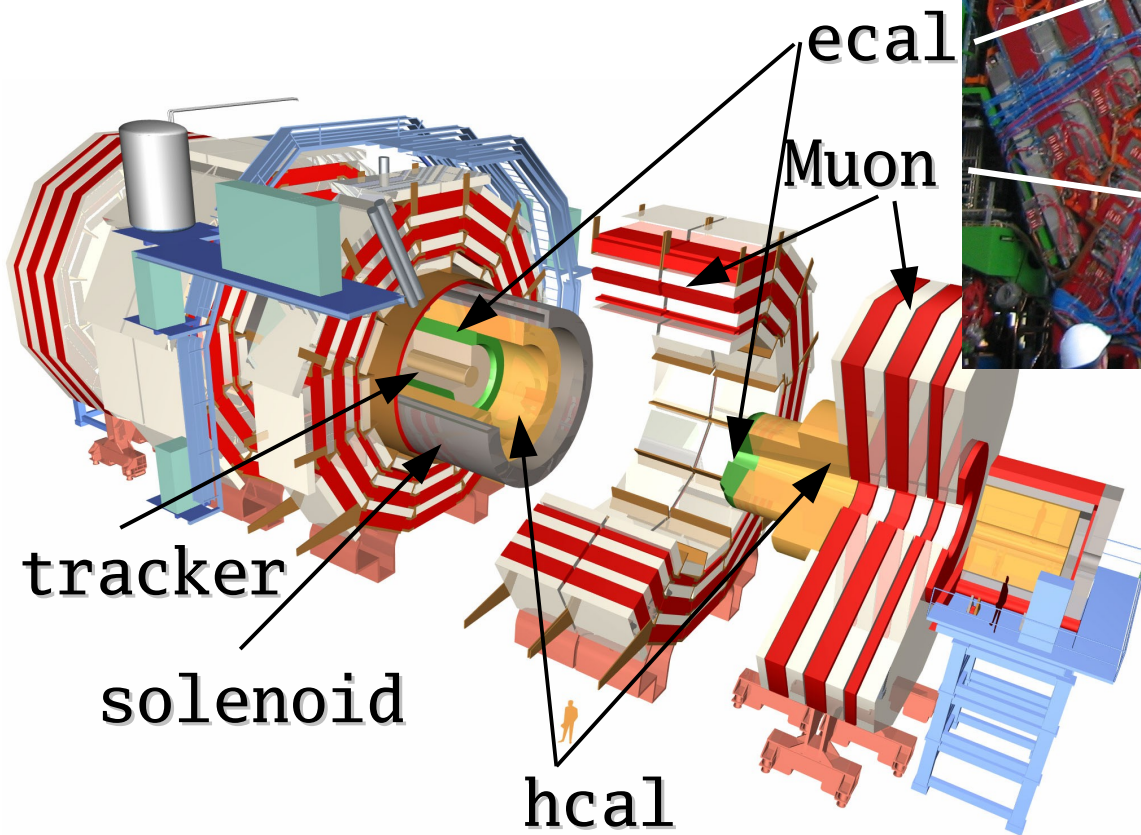### IIHE Vrije Universiteit Brussel

DISCRETE'08

Total rate: ~10^9 Hz
Bunch crossing: 40 Mhz

L1 rate: 100 kHz
(read out)

HLT rate: 100 Hz
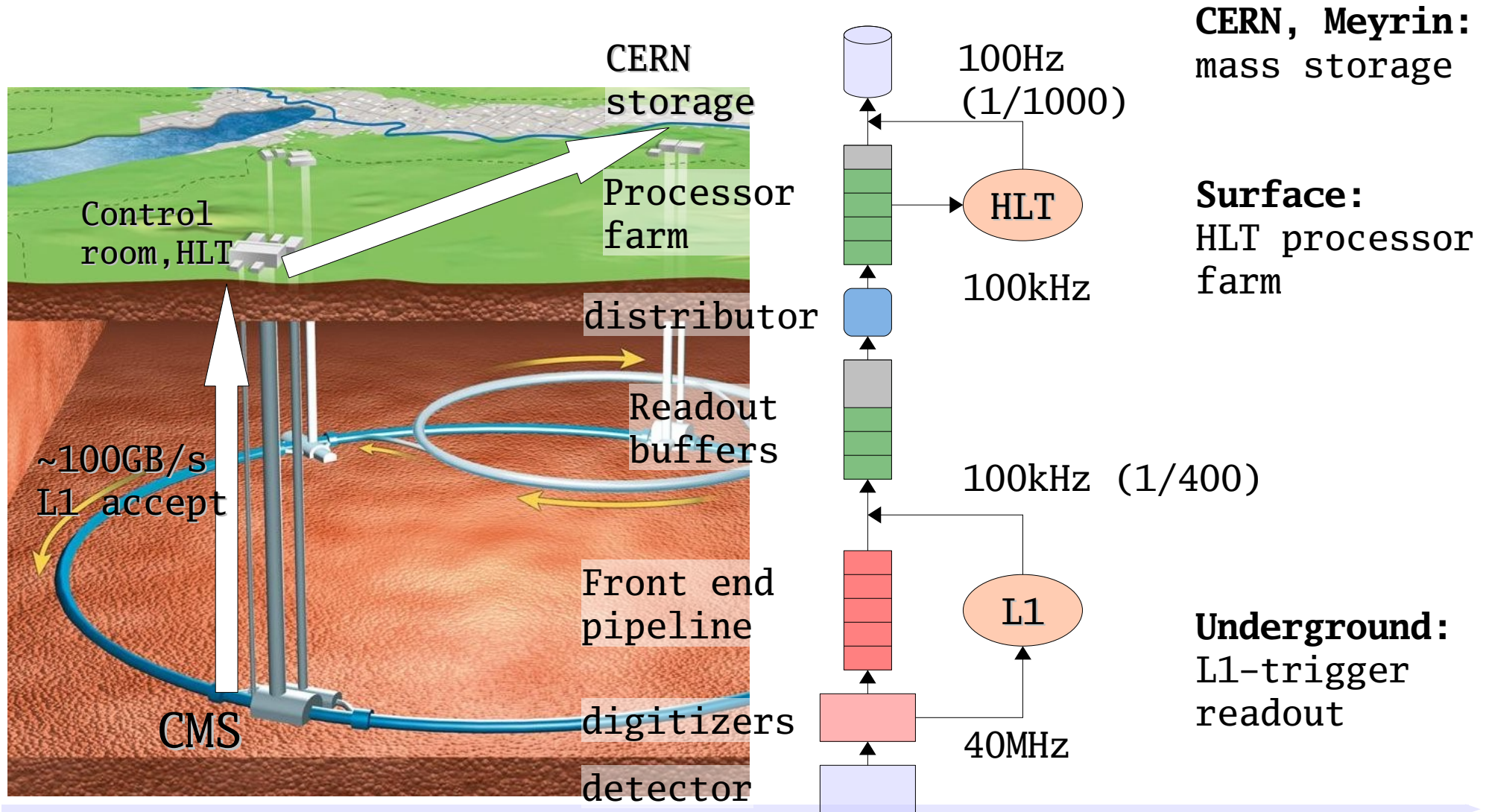(permanent storage)

exotic signals
(analysis results)

Magnet

Hcal

Tracker

ecal

Muon

tracker

solenoid

hcal

Global Layout

Only two trigger levels
- L1: custom electronics/FPGAs
- HLT: large PC cluster

CERN storage

Processor farm

distributor

Readout buffers

Front end pipeline

digitizers

detector

~100GB/s L1 accept

CMS

Control room, HLT

100Hz (1/1000)

HLT

100kHz

100kHz (1/400)

L1

40MHz

CERN, Meyrin: mass storage

Surface: HLT processor farm
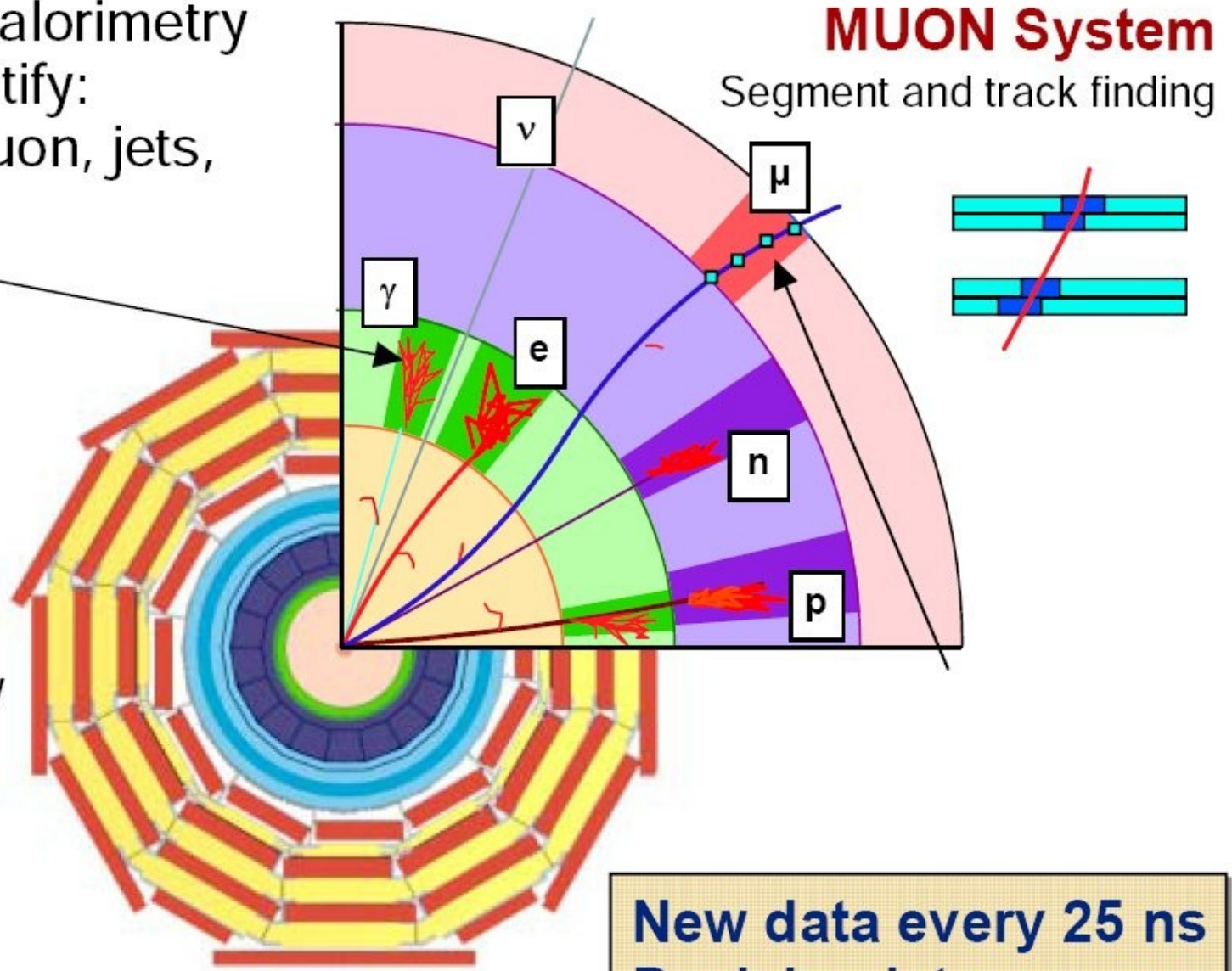
Underground: L1-trigger readout

L1 Overview

Use prompt data (calorimetry and muons) to identify:
High p_t electron, muon, jets, missing E_T
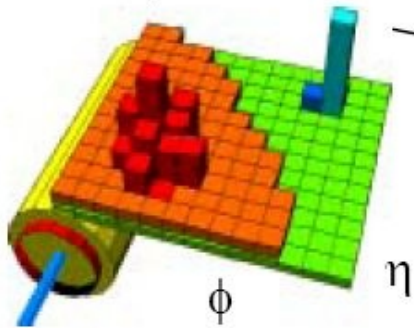
CALORIMETERs
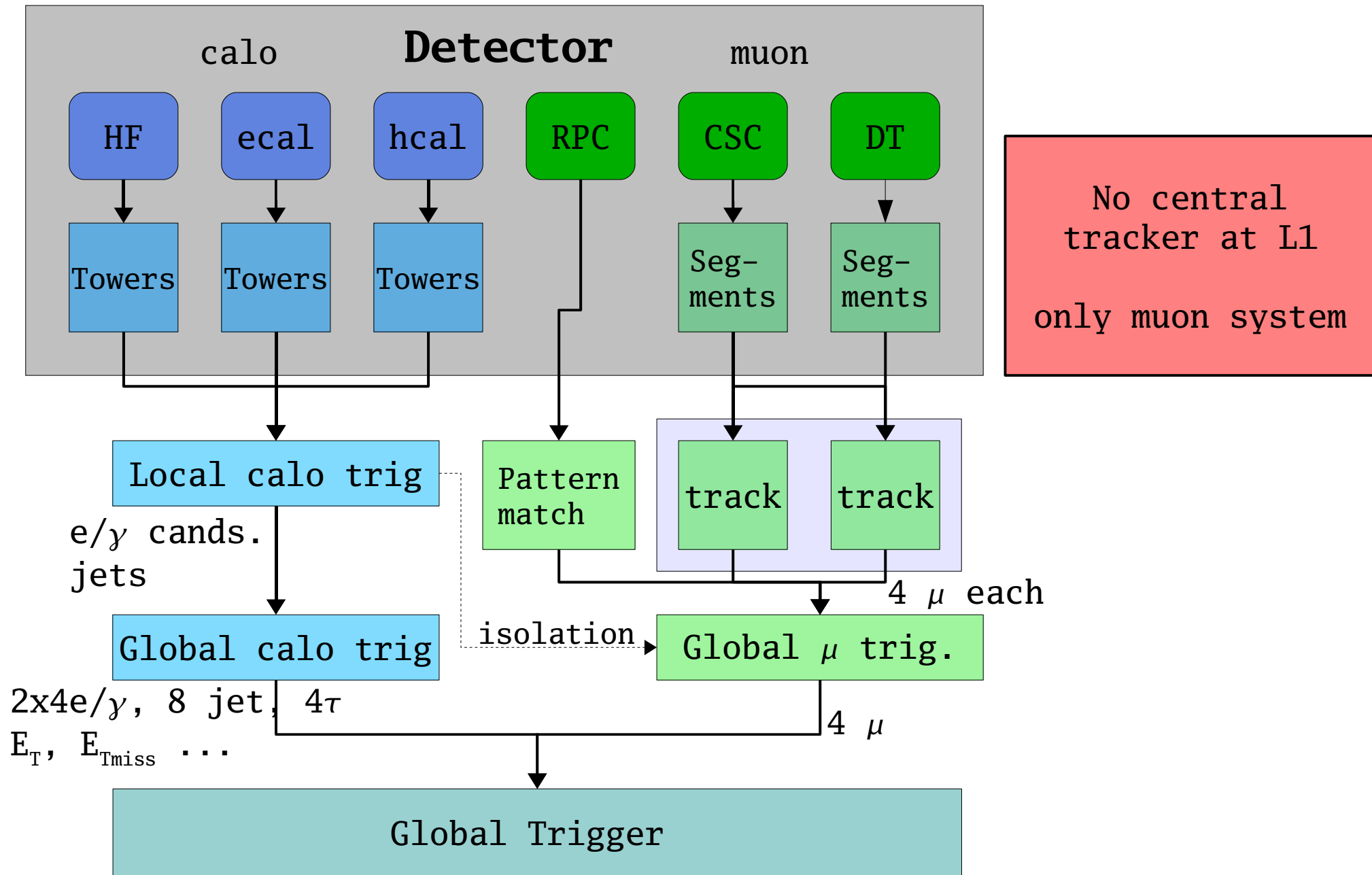Cluster finding and energy deposition evaluation

MUON System
Segment and track finding

New data every 25 ns
Decision latency ~ µs

L1 Data Flow

Detector

calo   muon

HF   ecal   hcal   RPC   CSC   DT

Towers   Towers   Towers   Seg-ments   Seg-ments

No central tracker at L1

only muon system

Local calo trig   Pattern match   track   track

e/γ cands.
jets

isolation

Global calo trig   Global μ trig.

4 μ each

2x4e/γ, 8 jet, 4τ
E_T, E_{Tmiss} ...

4 μ

Global Trigger

- Trigger Path: sequence of reconstruction, filters, prescales
- Ordered for best timing performance (do slowest reconstruction step last)
- All paths run for all events
- Set of all Paths = Menu
- Use local reconstruction only
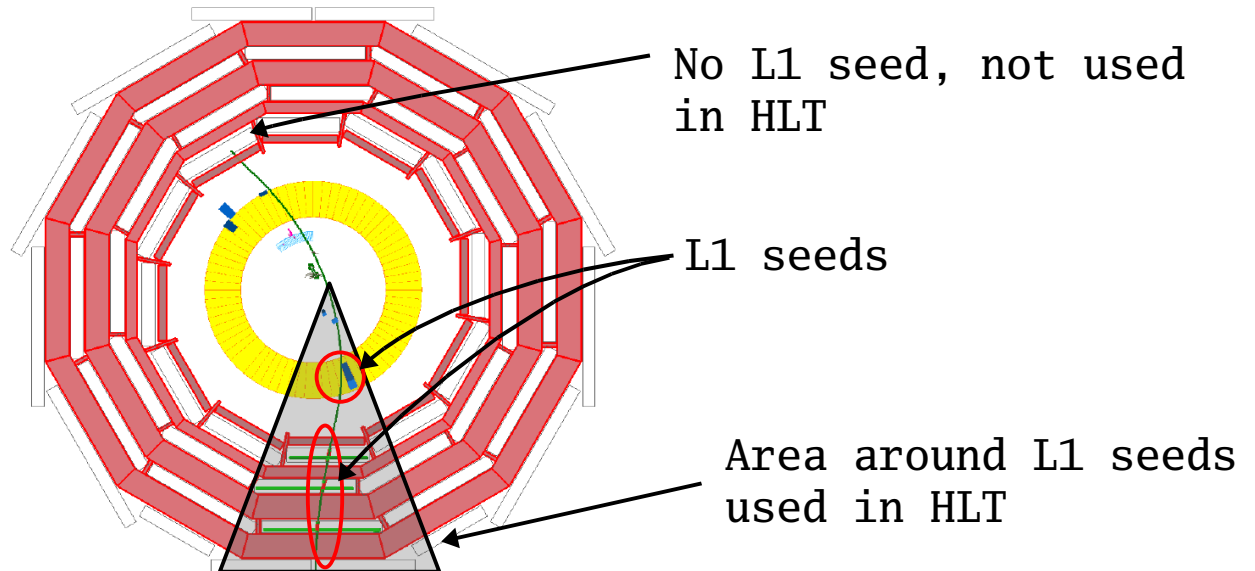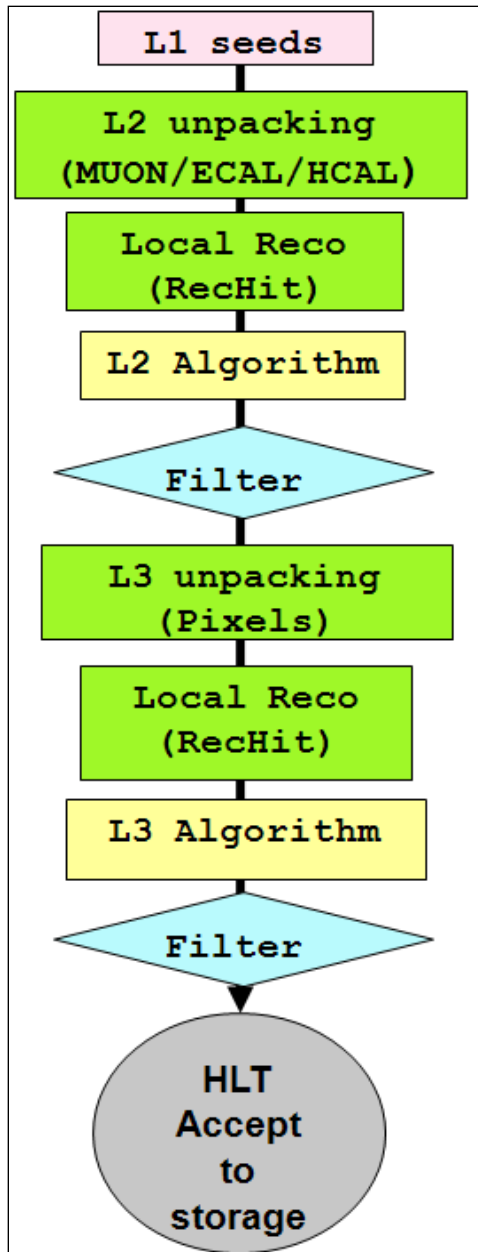
New Physics, Old Signatures

	Standard Model	New Physics

Inclusive
ΣE_T, $E_{T,miss}$ ...

Single Objects
(electrons, muons, jets, ...)

tight isolation/high thresholds
efficiencies well known

Combinations
(di-electron, electron+jet, muon+$E_{T,miss}$ ...)

loose isolation/low thresholds
efficiencies difficult

New Physics, Old Signatures

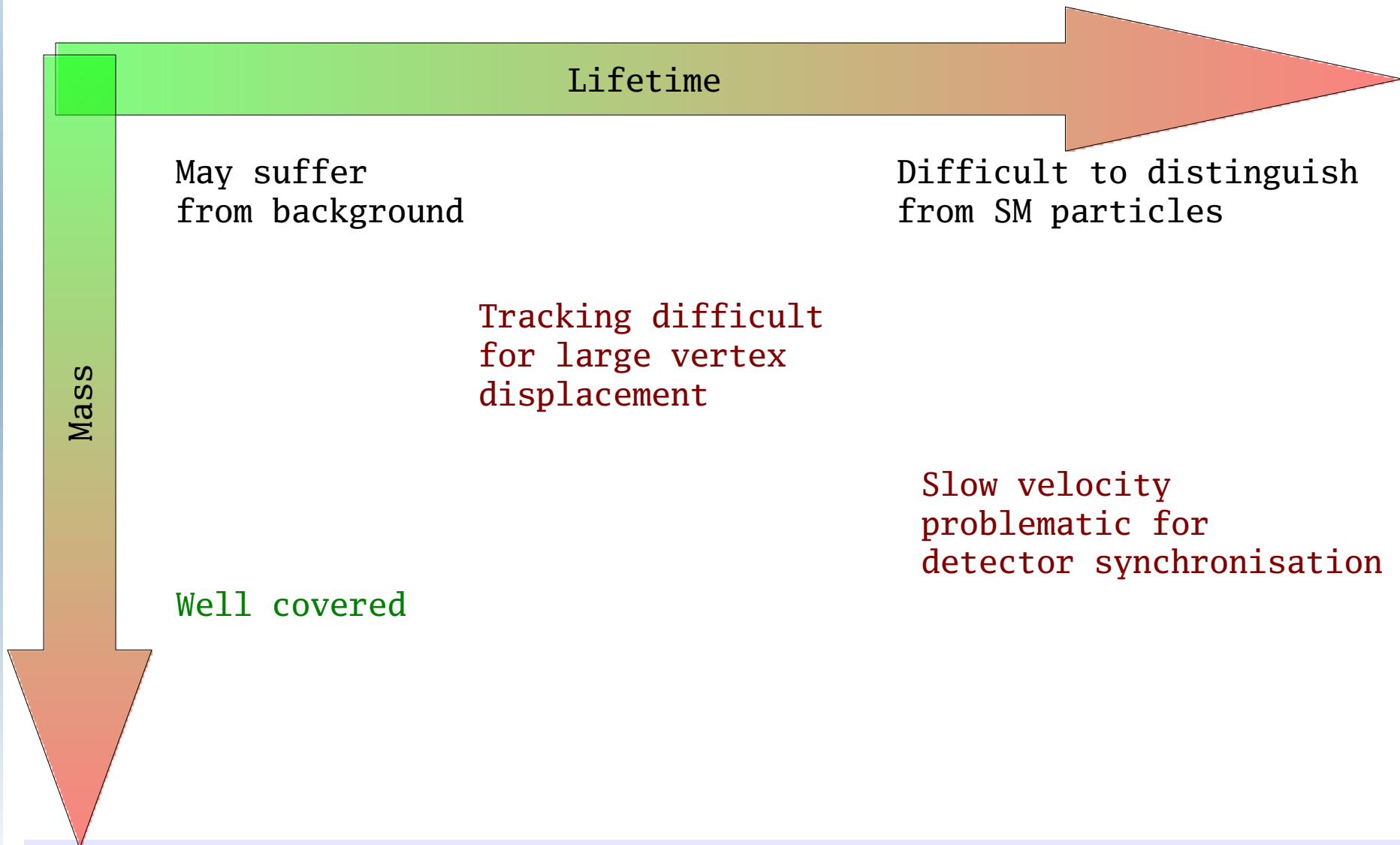|	**Standard Model**	**New Physics**
Inclusive ΣE_T, $E_{T,miss}$ ...	calibration background detector studies	
Single Objects (electrons, muons, jets, ...)	EW, QCD, Drell-Yan	various SUSY Z', W' Graviton leptoquarks ...
Combinations (di-electron, electron+jet, muon+$E_{T,miss}$ ...)	W, top,...	various SUSY

New Physics, New Signatures

SM-like signatures well covered, but exotics may fail to trigger:

Lifetime →

Mass ↓

May suffer
from background

Difficult to distinguish
from SM particles

Tracking difficult
for large vertex
displacement

Slow velocity
problematic for
detector synchronisation

Well covered

Example

Heavy, metastable, charged particles
(i.e. R-hadrons in split SUSY)
=> produced in collision
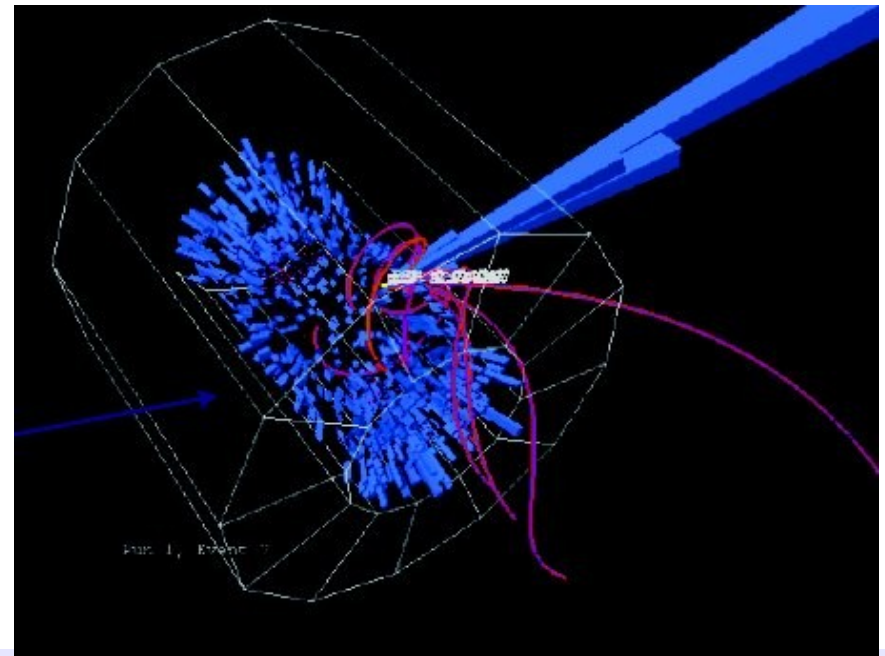=> loose energy from ionisation
=> may be stopped in the detector material
=> decay at a later time (minutes...hours)

Signature: Jets originating from dense detector parts while beam is off

**Solution:** run Calo trigger during beam off periods

Running since
September to
gather background
data

Trigger in Practice

Most of the HLT functionalities tested

- Online reconstruction (CPU performance, memory footprint)
- High rate tests (random trigger up to ~80kHz)
- L1 seed to HLT
- Streaming calibration data (reduced event content) parallel to full events
- Complete chain of data transfer up to Tier0 at CERN

Global Run July 08
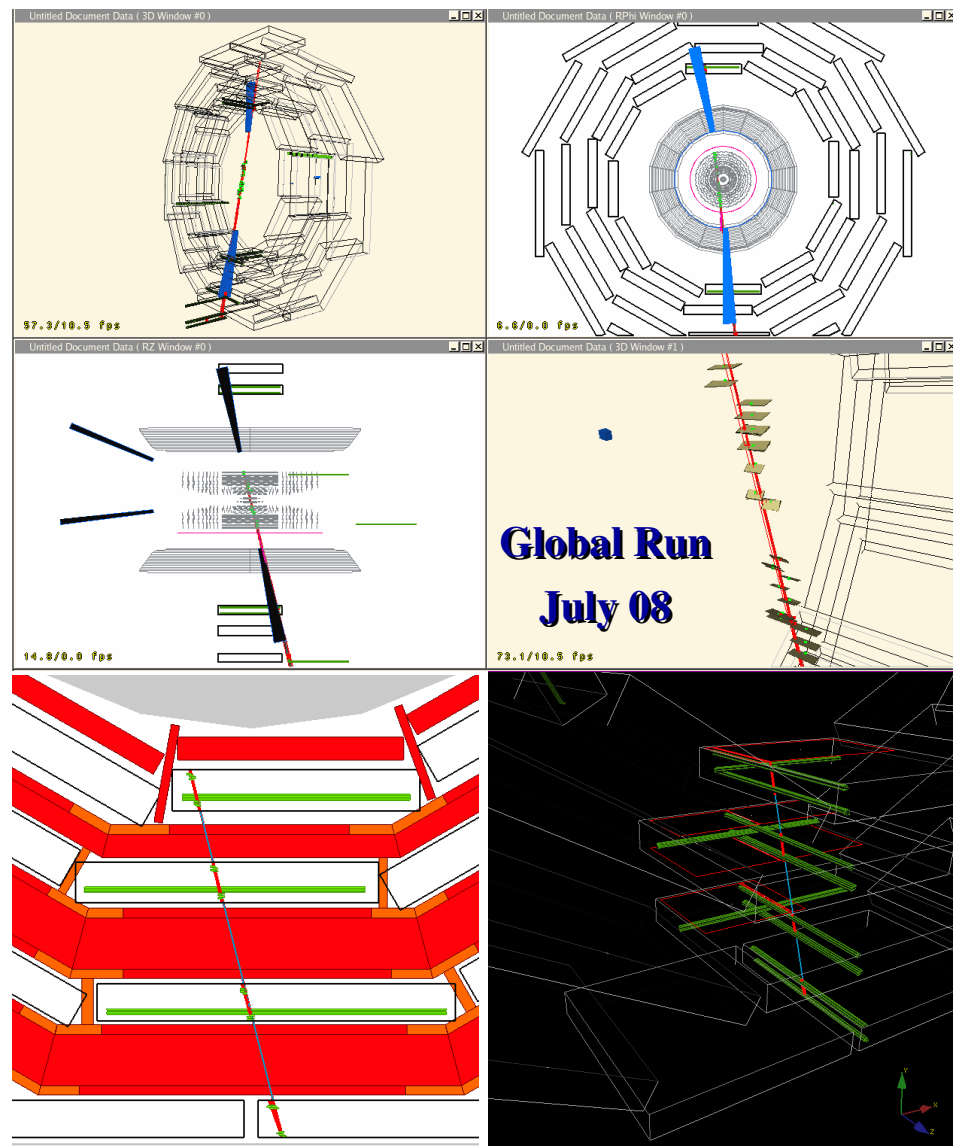
- Routinely running High-Level-Trigger menu (+ dedicated cosmic muon trigger path)
- Global fit with "L3"tracker track, seeded from "L2"muon track, seeded from "L1" trigger candidate:

Run 58733, event 1741135
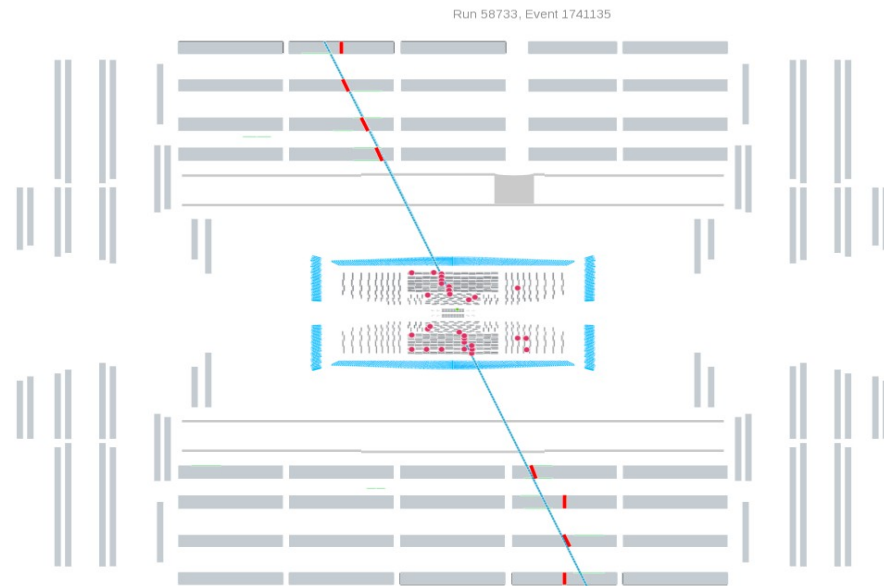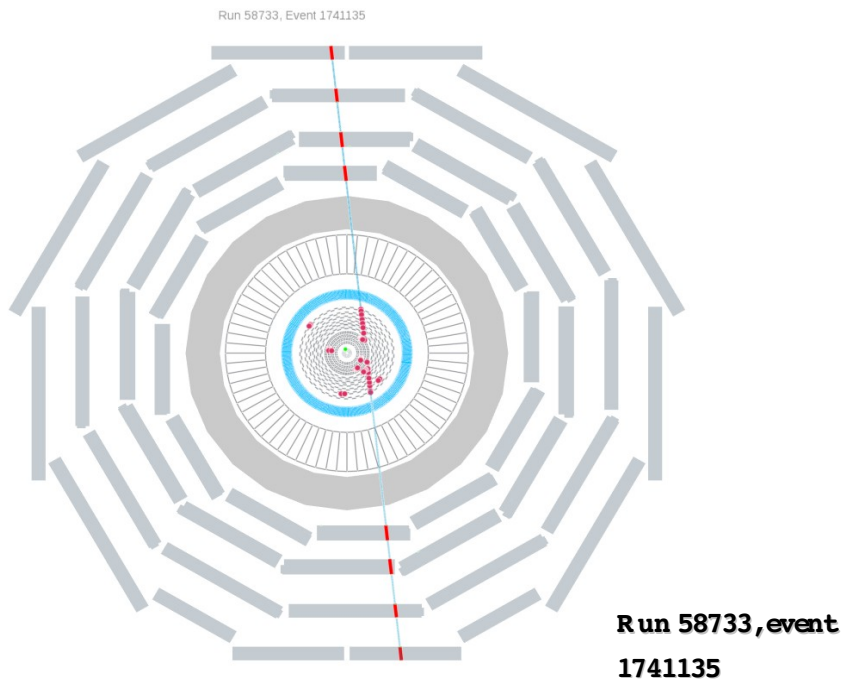
Technical status:
- CMS trigger hardware/software ready for data
- Successfully running with cosmic muons
- Performs as expected

New Physics Prospects:
- SM like signatures (leptons, jets, ...) well covered
- Many exotic signatures covered

To Do:
- Take data
- Find Signal