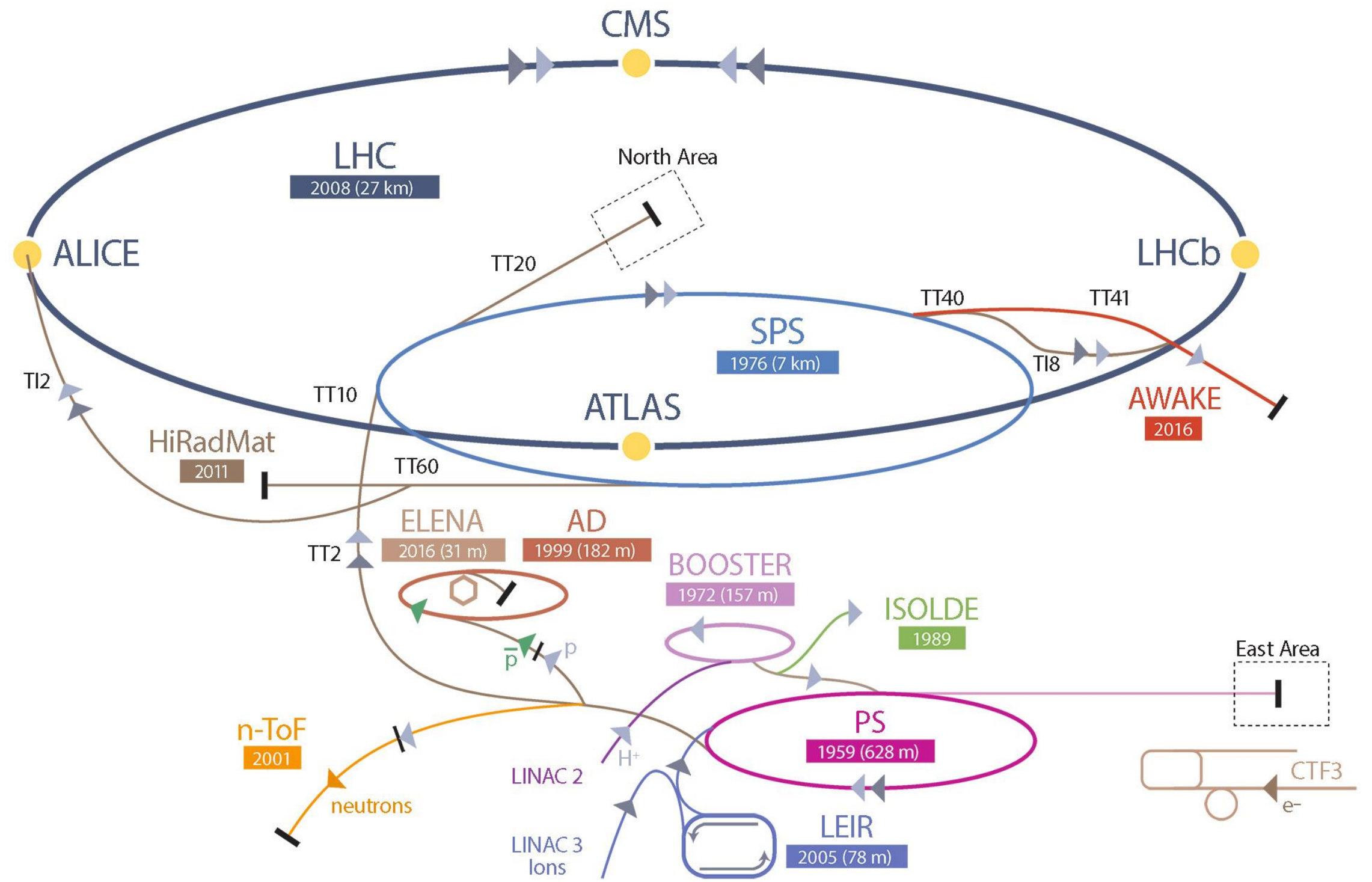


CMS MasterClasses

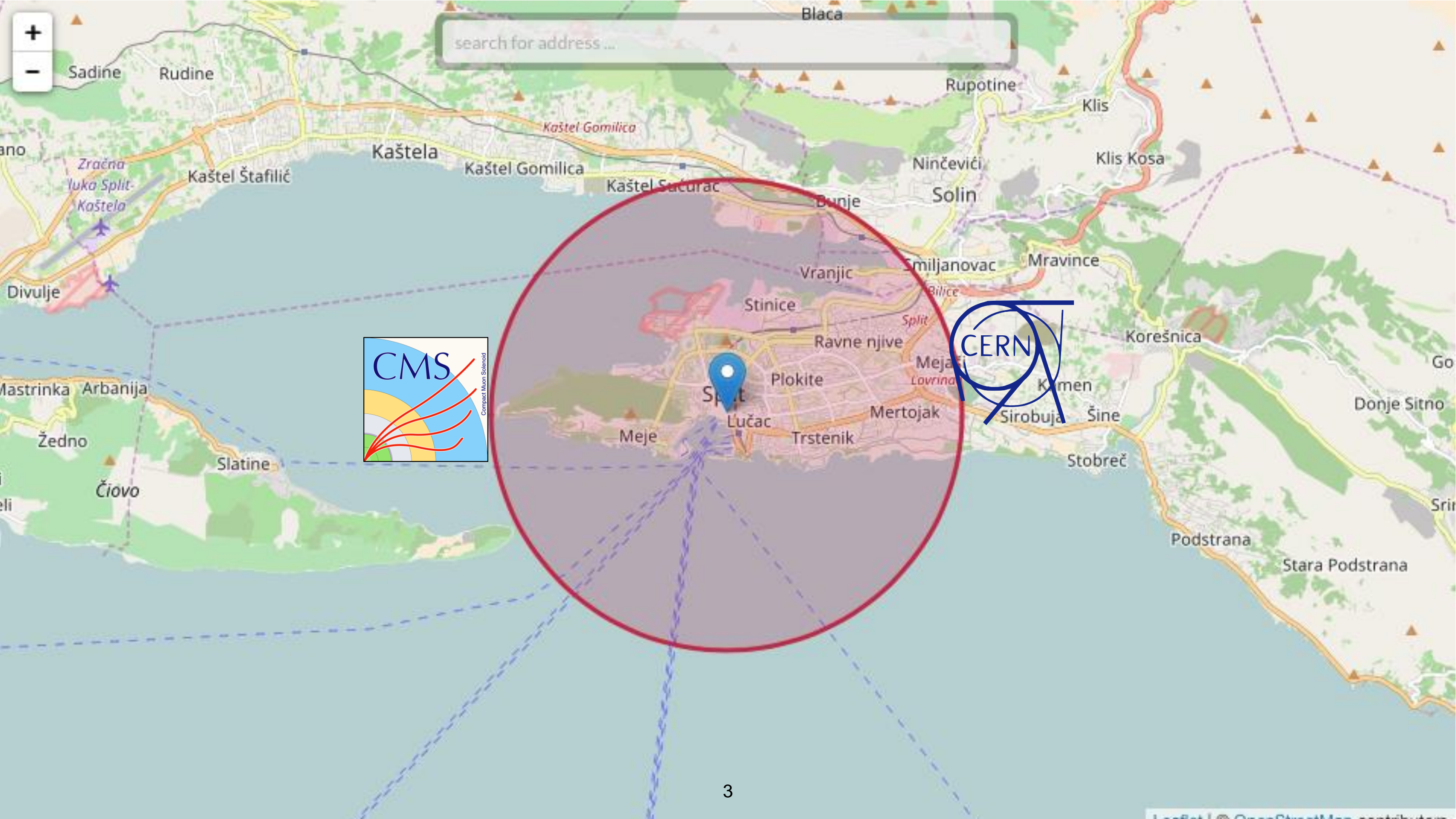
2019

CERN's Accelerator Complex

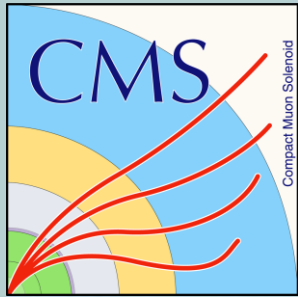
LHC



▶ p (proton)
 ▶ ion
 ▶ neutrons
 ▶ \bar{p} (antiproton)
 ▶ electron
 ▶ \leftrightarrow proton/antiproton conversion



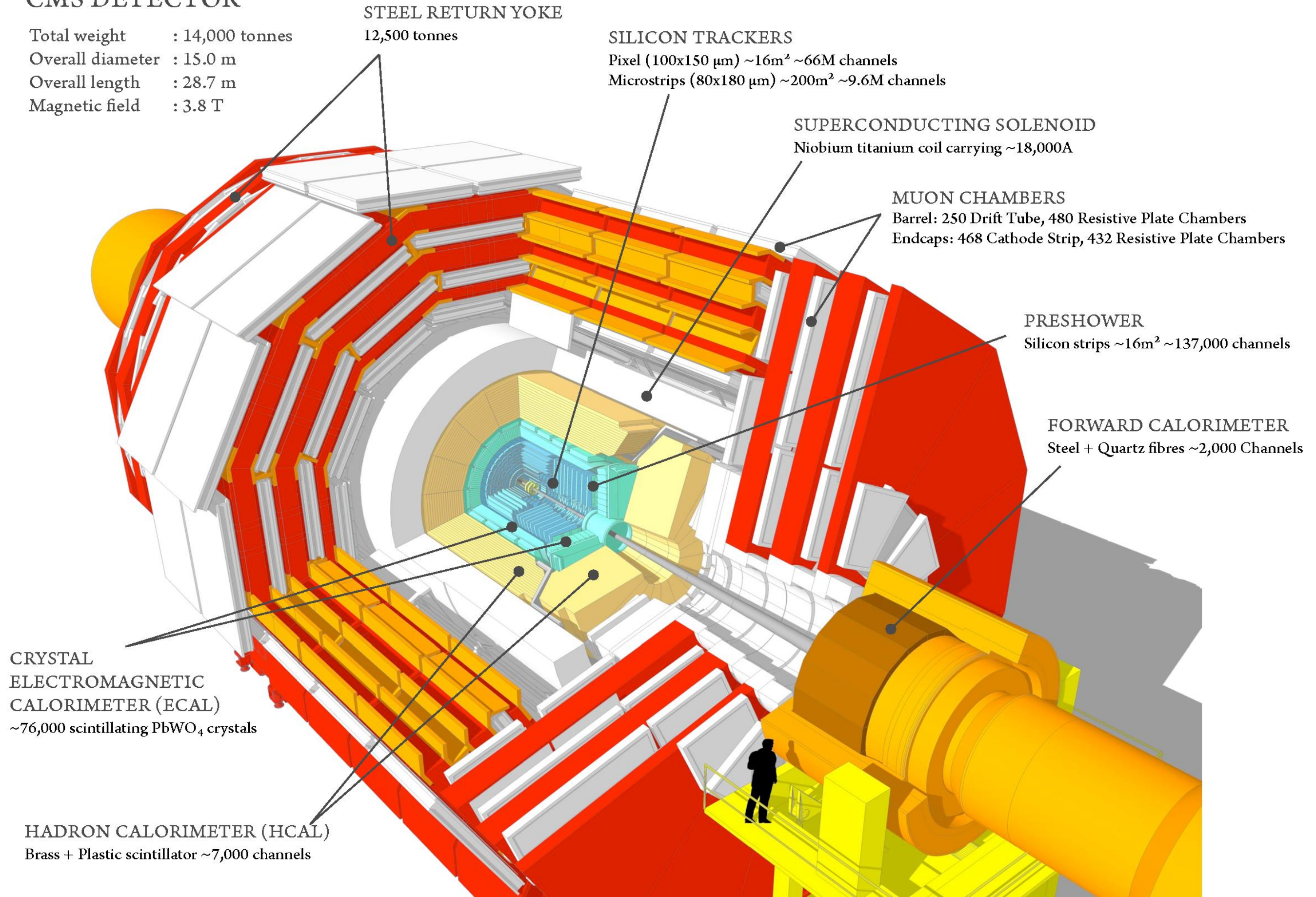
search for address ...



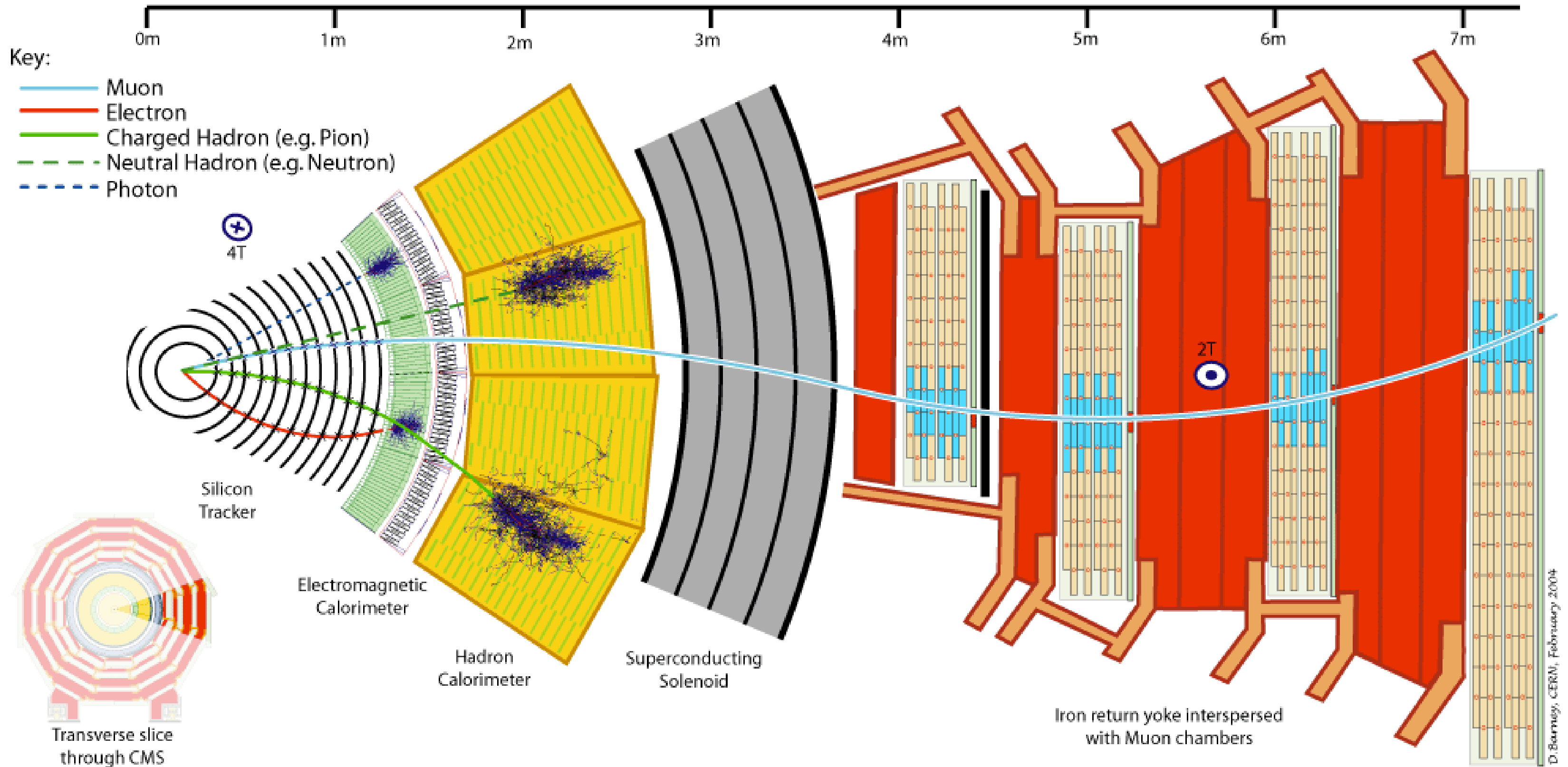
CMS

CMS DETECTOR

Total weight : 14,000 tonnes
Overall diameter : 15.0 m
Overall length : 28.7 m
Magnetic field : 3.8 T



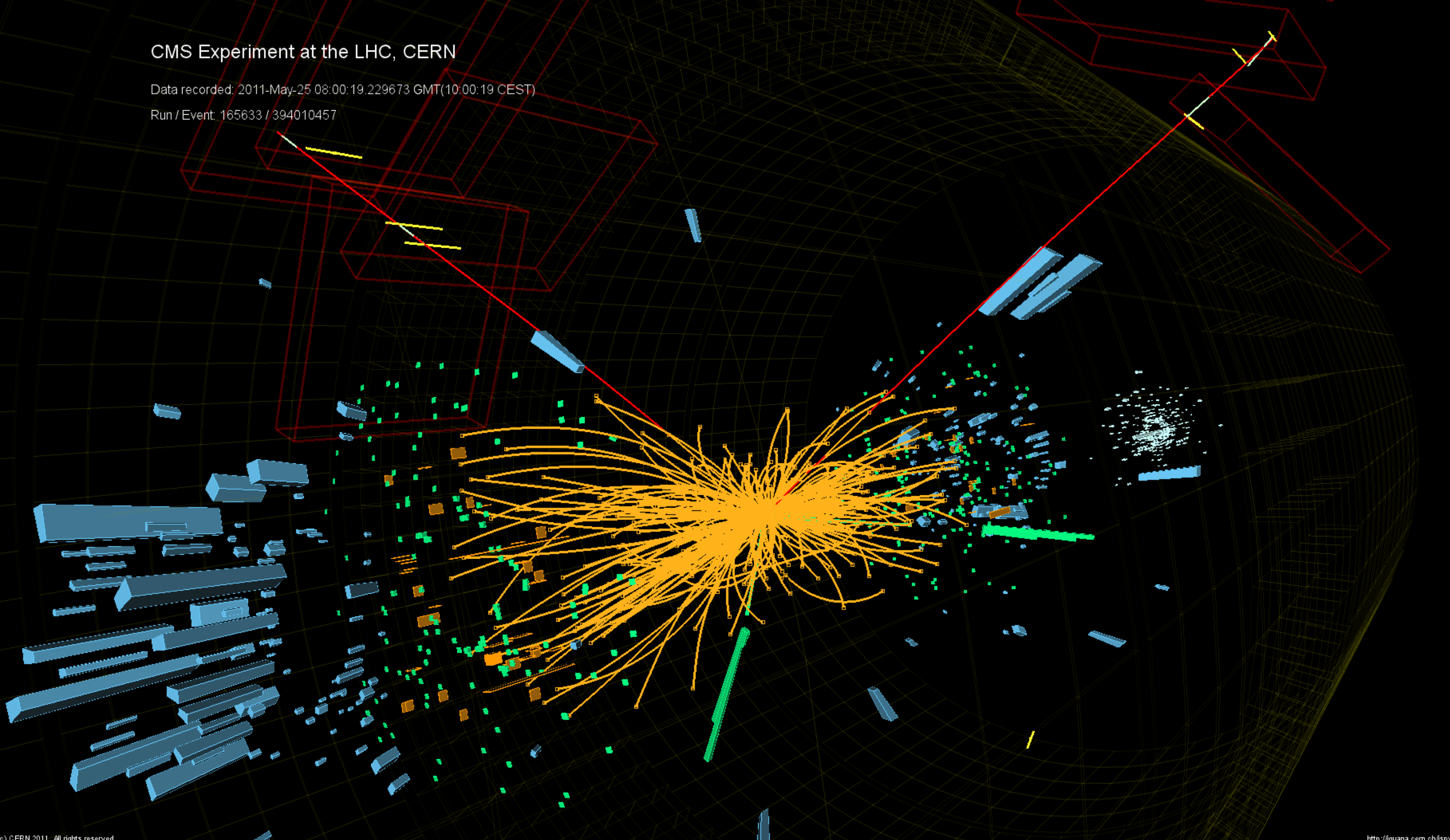
CMS detektor



CMS Experiment at the LHC, CERN

Data recorded: 2011-May-25 08:00:19.229673 GMT(10:00:19 CEST)

Run / Event: 165633 / 394010457



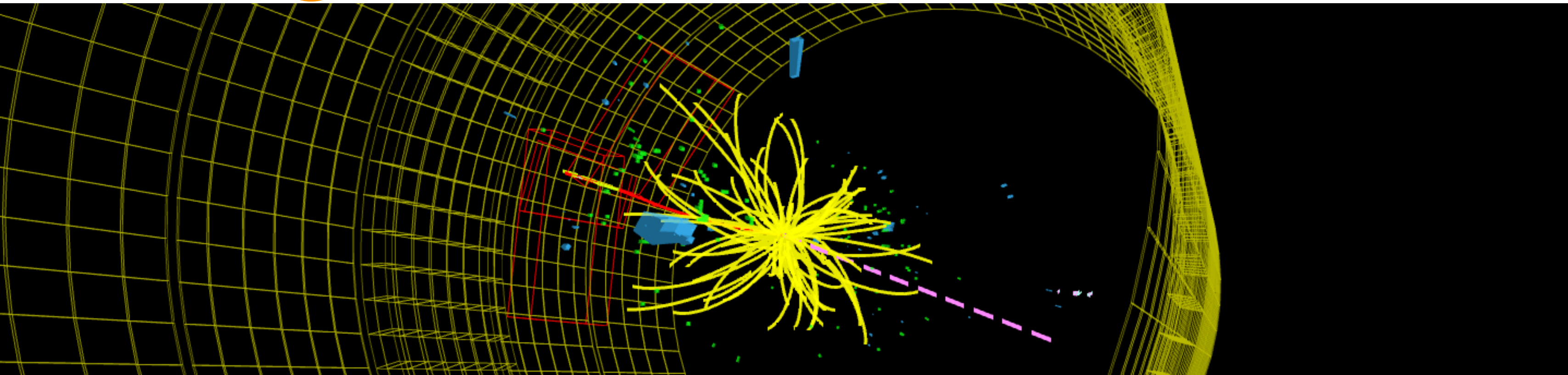
```

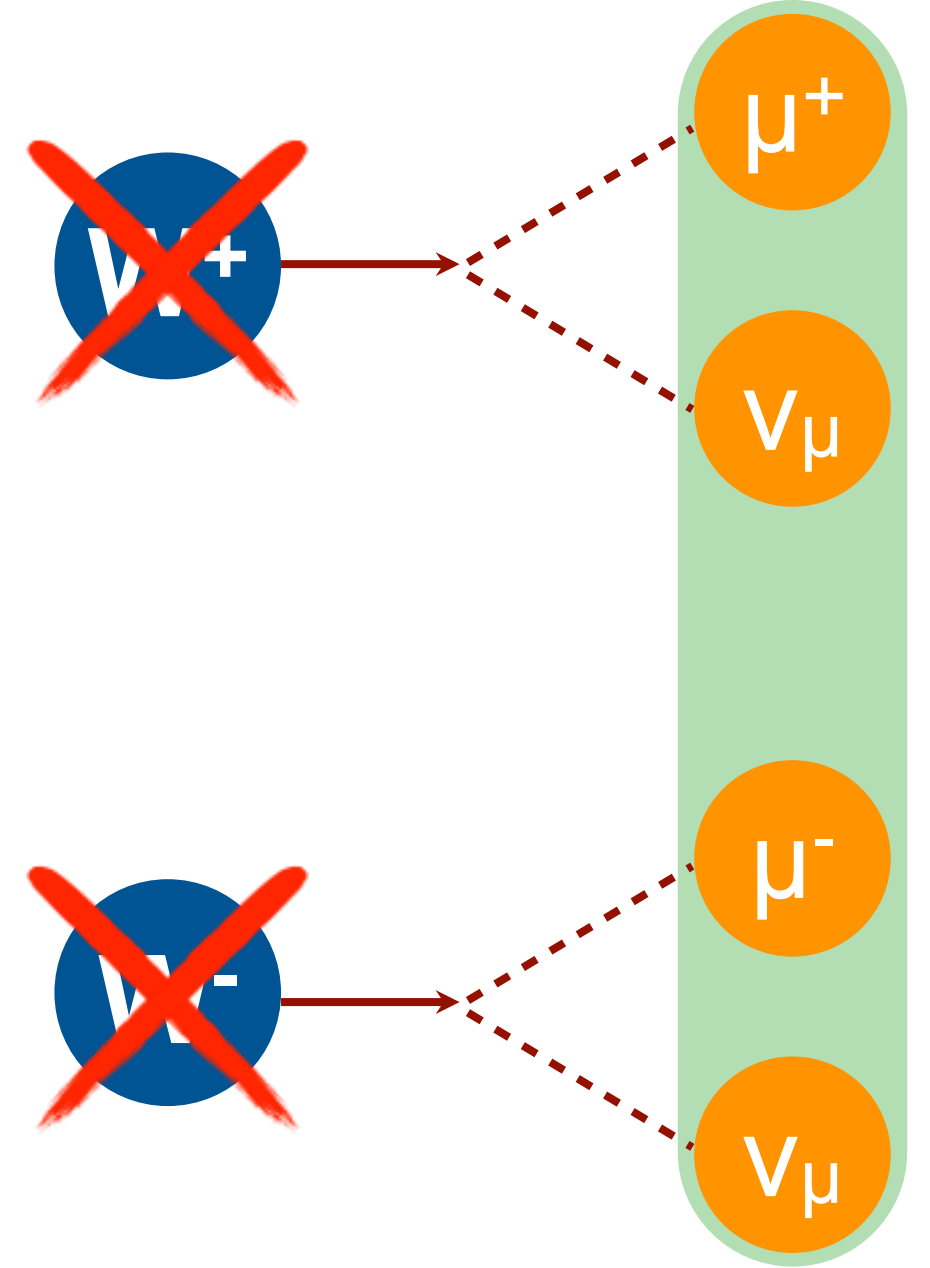
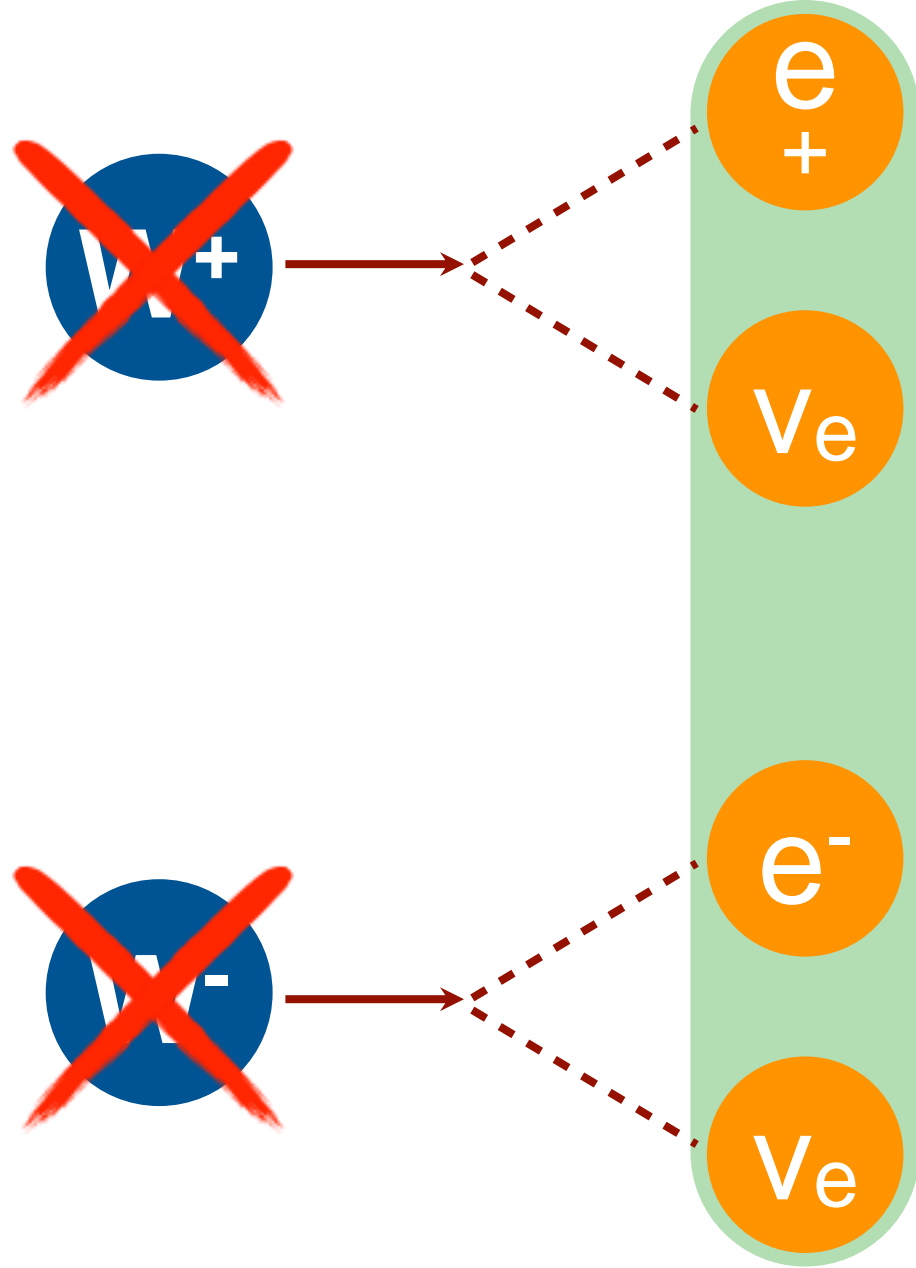
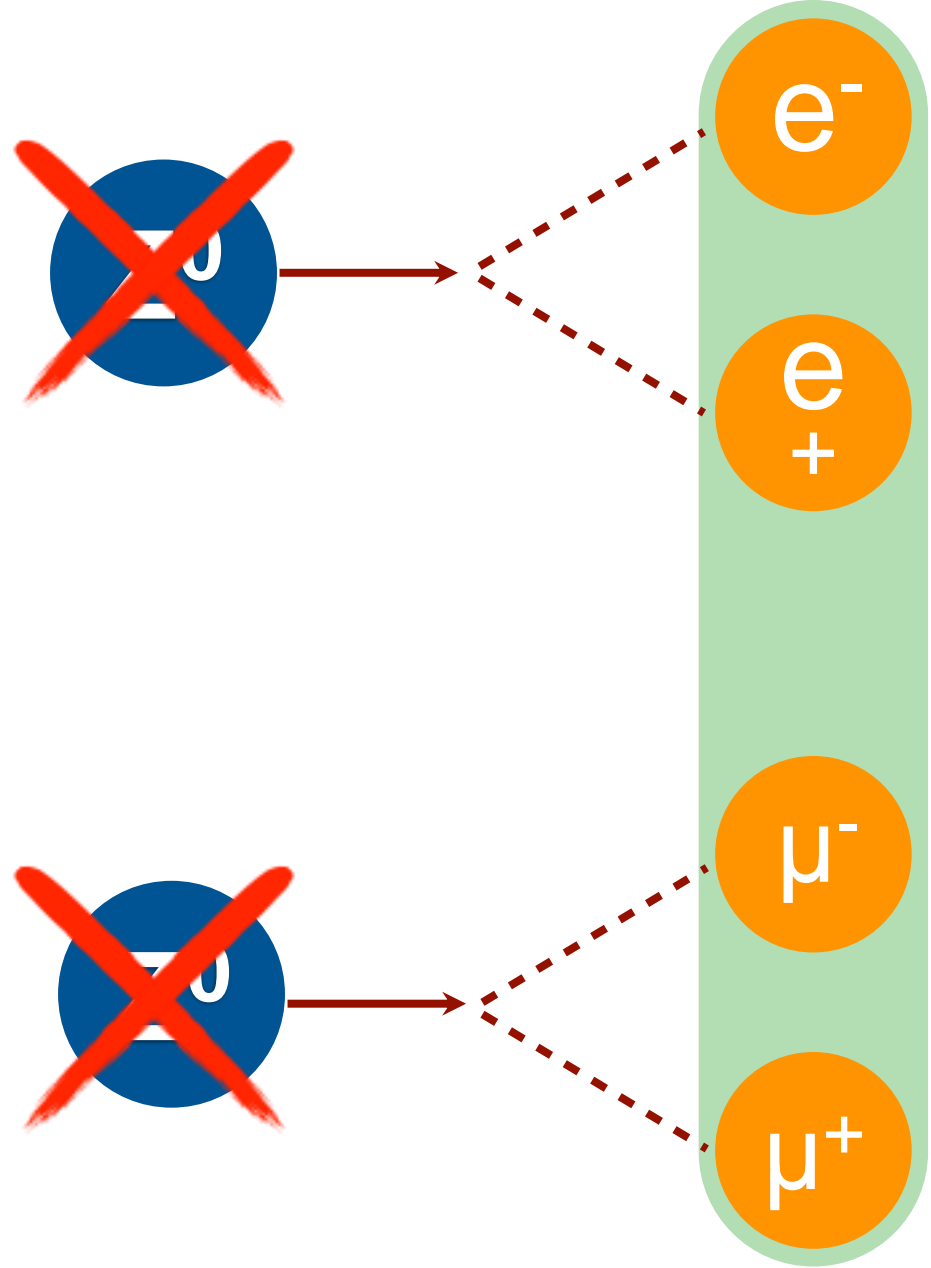
266 //=====
267 void Plotter::MakeHistogramsZX( TString input_file_data_name, TString input_file_FR_name )
268 {
269
270     FakeRates *FR = new FakeRates( input_file_FR_name );
271
272     input_file_data = new TFile("./" + input_file_data_name);
273     input_tree_data = (TTree*)input_file_data->Get("CRZLLTree/candTree");
274     Init( input_tree_data, input_file_data_name );
275
276
277     if (fChain == 0) return;
278
279     Long64_t nentries = fChain->GetEntriesFast();
280
281     Long64_t nbytes = 0, nb = 0;
282
283     for (Long64_t jentry=0; jentry<nentries;jentry++)
284     {
285
286         Long64_t ientry = LoadTree(jentry);
287         if (ientry < 0) break;
288         nb = fChain->GetEntry(jentry);
289         nbytes += nb;
290
291         if ( !CRflag ) continue;
292         if ( !test_bit(CRflag, CRZLLss) ) continue;
293
294         _current_final_state = FindFinalStateZX();
295
296         _current_category = categoryMor17(nExtraLep, nExtraZ, nCleanedJetsPt30, nCleanedJetsPt30BTagged_bTagSF, jetQGL,
297                                         p_JJQCD_SIG_ghg2_1_JHUGen_JECNominal, p_JQCD_SIG_ghg2_1_JHUGen_JECNominal, p_JJVBF_SIG_ghv1_1_JHUGen_JECNominal,
298                                         p_JVBF_SIG_ghv1_1_JHUGen_JECNominal, pAux_JVBF_SIG_ghv1_1_JHUGen_JECNominal, p_HadWH_SIG_ghw1_1_JHUGen_JECNominal,
299                                         p_HadZH_SIG_ghz1_1_JHUGen_JECNominal, jetPhi, ZZMass, PFMET, true, false);
300
301
302         // Calculate yield
303         _yield_SR = _fs_ROS_SS.at(_current_final_state)*FR->GetFakeRate(LepPt->at(2),LepEta->at(2),LepLepId->at(2))*FR->GetFakeRate(LepPt->at(3),LepEta->at(3),LepLepId->at(3));
304
305         _expected_yield_SR[_current_final_state][_current_category] += _yield_SR; // this number needs to be used when renormalizing histograms that have some cut/blinding
306         _number_of_events_CR[_current_final_state][_current_category]++;
307
308         if ( MERGE_2E2MU && _current_final_state == Settings::fs2mu2e ) _current_final_state = Settings::fs2e2mu; //We can only do this after _yield_SR is calculated
309
310         // Calculate kinematic discriminants
311         KD = p_GG_SIG_ghg2_1_ghz1_1_JHUGen / ( p_GG_SIG_ghg2_1_ghz1_1_JHUGen + p_QQB_BKG_MCFM*getDbkgkinConstant(Z1Flav*Z2Flav,ZZMass) );
312         D2jet = (nCleanedJetsPt30>=2) ? DVBF2j_ME(p_JJVBF_SIG_ghv1_1_JHUGen_JECNominal, p_JJQCD_SIG_ghg2_1_JHUGen_JECNominal, ZZMass) : -2 ;
313         D1jet = (nCleanedJetsPt30==1) ? DVBF1j_ME(p_JVBF_SIG_ghv1_1_JHUGen_JECNominal, pAux_JVBF_SIG_ghv1_1_JHUGen_JECNominal, p_JQCD_SIG_ghg2_1_JHUGen_JECNominal, ZZMass) : -2 ;
314         DWH = (nCleanedJetsPt30>=2) ? DWHh_ME(p_HadWH_SIG_ghw1_1_JHUGen_JECNominal, p_JJQCD_SIG_ghg2_1_JHUGen_JECNominal, ZZMass) : -2 ;
315         DZH = (nCleanedJetsPt30>=2) ? DZHh_ME(p_HadZH_SIG_ghz1_1_JHUGen_JECNominal, p_JJQCD_SIG_ghg2_1_JHUGen_JECNominal, ZZMass) : -2 ;
316
317         // Fill m4l Z+X histograms
318         unblinded_histos->FillM4lZX( ZZMass, _yield_SR, _current_final_state, _current_category );
319         blinded_histos->FillM4lZX( ZZMass, _yield_SR, _current_final_state, _current_category);

```

Čestice u modelu detektora

- e^- elektron = kratka **zelená** linija
- μ^- mion = duga **crvena** linija
- ν_e neutrino = isprekidana **ljubičasta (lila)** linija
- γ foton = kratka **žuta** linija





CMS Instrument for Masterclass Analysis

CIMA



1.

Otvorite link goo.gl/8rDQbh

2.

Odaberite CERN-16Apr2019

- Zagrab-25Feb2019
- CERN-08Mar2019
- SerbianStudentsMar2019
- A
- B
- Providence-17Apr2019
- APS-AprMtg2019
- CERN-16Apr2019

3.

Odaberite CroatianTeachers2019

Choose your location
CroatianTeachers2019

Choose your group

- 1
- 2
- 3
- 8
- 9

Odaberite broj svoje grupe

4.

5.

Kliknite "Event Display"

Back Events Table (Group 1) Mass Histogram (CroatianTeachers2019) Results (CroatianTeachers2019) Event Display

Masterclass: CERN-16Apr2019
location: CroatianTeachers2019
Group: 1

Instructions (also available as [screencast](#)):

- For each event, identify the final state and select a primary state candidate.
 - For Higgs or Zoo candidate, no final state is chosen
 - If you cannot decide between W+ and W-, choose W instead
- If you think the final state is a neutral particle (like a Z), but you don't know its exact type, select NP for "neutral particle." Find its mass from the Event Display and enter it.
- Once you have selected everything, click "Submit".

In case of an error, double clicking the data line will reload it; you can then try it again.

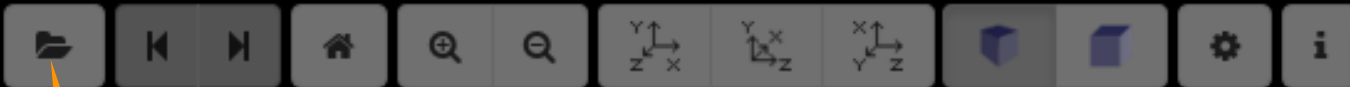
Select Event Event index: <input type="text" value="1"/> Event number: 1-1	final state <input type="checkbox"/> Electron <input type="checkbox"/> Muon (μ)	primary state candidate <input type="checkbox"/> W ⁻ <input type="checkbox"/> NP <input type="checkbox"/> W ⁺ <input type="checkbox"/> W <input type="checkbox"/> Higgs <input type="checkbox"/> Zoo
---	--	---

Event index

Event number

Chosen Values

Mass



- Detector
- Pix Barrel
- Pix
- Pix
- Trac
- Tracker Outer Barrel
- Tracker Inner Detector (+)
- Tracker Inner Detector (-)
- Tracker Endcap (+)
- Tracker Endcap (-)
- ECAL Barrel
- ECAL Endcap (+)
- ECAL Endcap (-)
- HCAL Barrel



6.
Kliknite na ikonu foldera

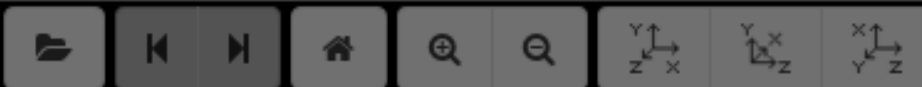
Open File

Open file(s) from the Web

Open local file(s):
Choose Files No file chosen

Close

7.
Odaberite "Open file(s) from Web"



Detector

Pixel Barrel

8.

Odaberite “masterclass_#.ig”
koji odgovara broju vaše
grupe

Tracker Inner Detector (-)

Tracker Endcap (+)

Tracker Endcap (-)

ECAL Barrel

ECAL Endcap (+)

ECAL Endcap (-)

HCAL Barrel

Open Event

Files	Events
masterclass_samples.ig	Events/Run_1/Event_1
masterclass_1.ig	Events/Run_1/Event_2
masterclass_2.ig	Events/Run_1/Event_3
masterclass_3.ig	Events/Run_1/Event_4
masterclass_4.ig	Events/Run_1/Event_5
masterclass_5.ig	Events/Run_1/Event_6
masterclass_6.ig	Events/Run_1/Event_7

masterclass_1.ig: Events/Run_1/Event_1

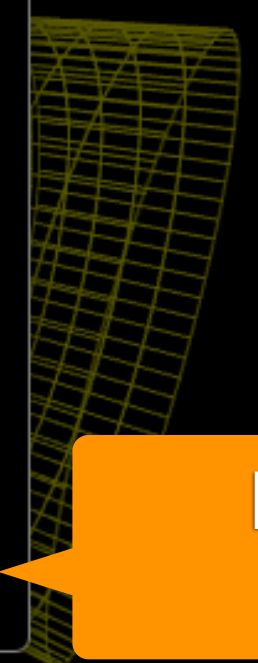
Close Load

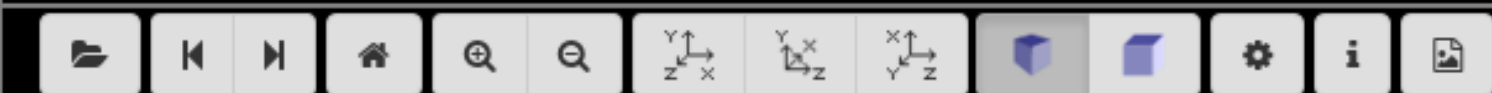
9.

Odaberite događaj koji
želite analizirati

10.

Kliknite
“Load”



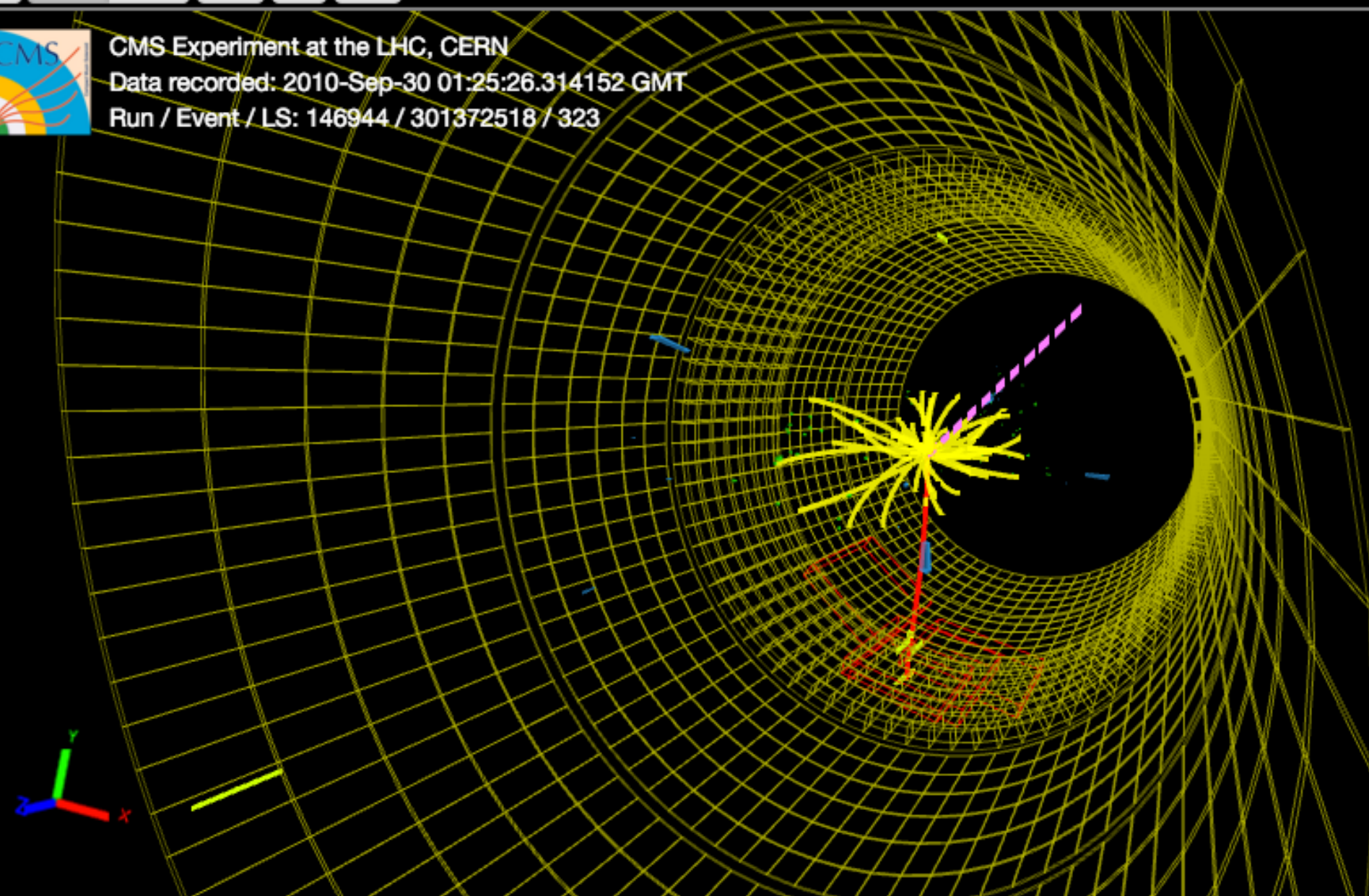


- > Provenance ⓘ
- > Tracking ⓘ
- > ECAL ⓘ
- > HCAL ⓘ
- > Muon ⓘ

- ▼ Physics ⓘ
 - Vertices (reco)
 - Tracker Muons (Reco)
 - Stand-alone Muons (Reco)
 - Global Muons (Reco)
 - Jets (PF)
 - Jets (Reco)
 - Missing Et (Reco)

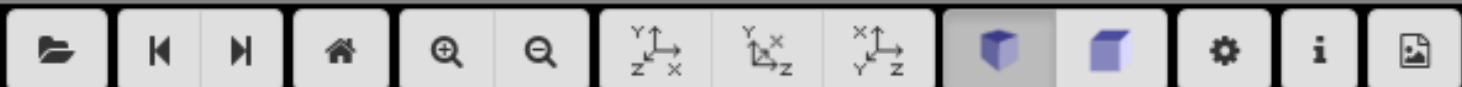


CMS Experiment at the LHC, CERN
Data recorded: 2010-Sep-30 01:25:26.314152 GMT
Run / Event / LS: 146944 / 301372518 / 323




Global Muons (Reco)
Electron Tracks (GSF)
Photons (Reco)
Missing Et (Reco)

Objekti koji moraju biti uključeni u modelu detektora

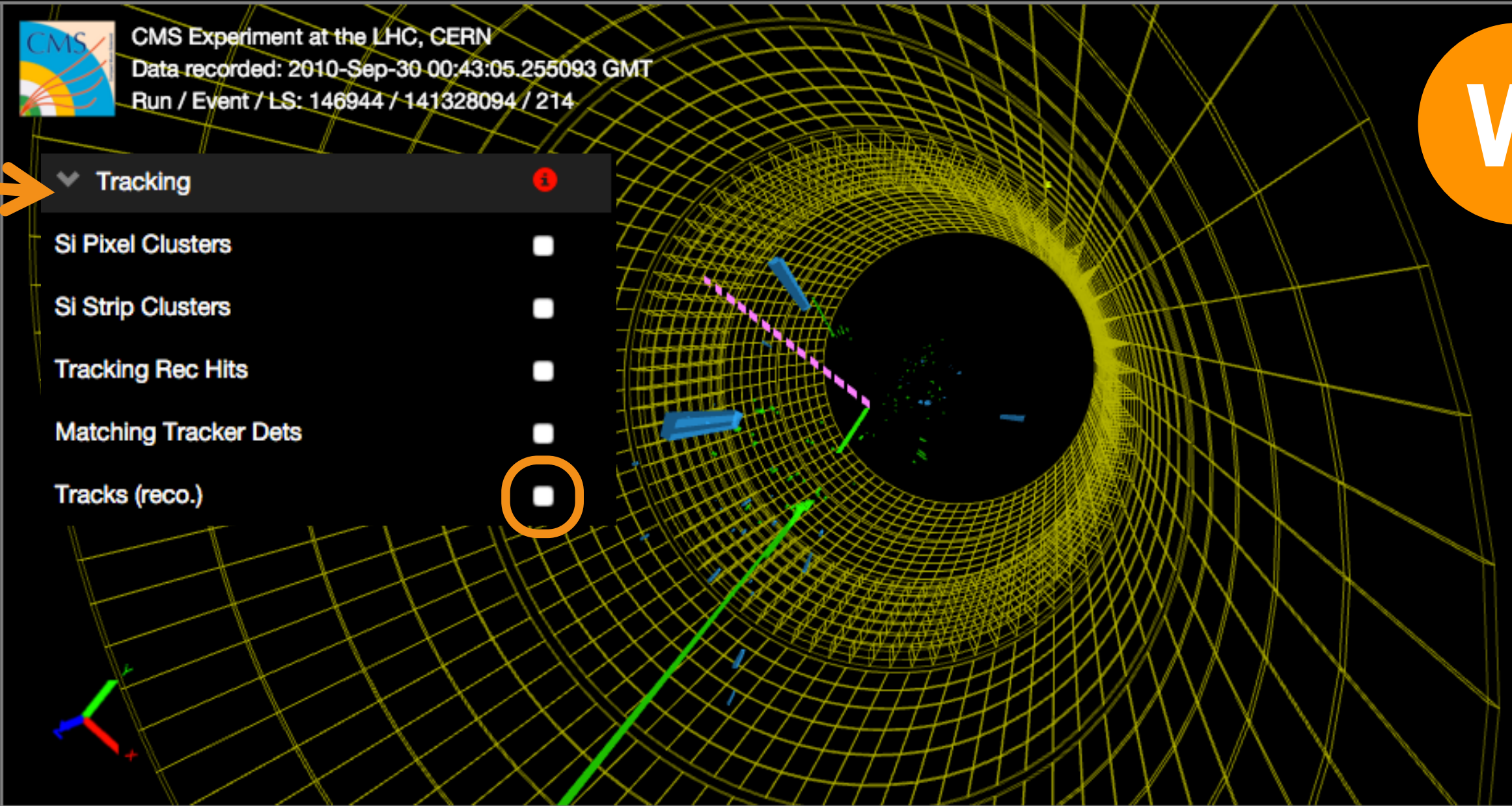


- ▼ Imported ⓘ
- Provenance ⓘ
- Tracking ⓘ
- ECAL ⓘ
- HCAL ⓘ
- Muon ⓘ
- ▼ Physics ⓘ

- Vertices (reco)
- Electron Tracks (GSF)
- Photons (Reco)
- Jets (PF)
- Jets (Reco)
- Missing Et (Reco)

 CMS Experiment at the LHC, CERN
Data recorded: 2010-Sep-30 00:43:05.255093 GMT
Run / Event / LS: 146944 / 141328094 / 214

- ▼ Tracking ⓘ
- Si Pixel Clusters
- Si Strip Clusters
- Tracking Rec Hits
- Matching Tracker Dets
- Tracks (reco.)



Click on a name under "Provenance", "Tracking", "ECAL", "HCAL", "Muon", and "Physics" to view contents in table

W^+ ili

W^-

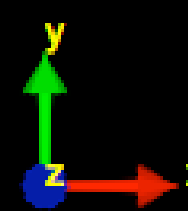
+

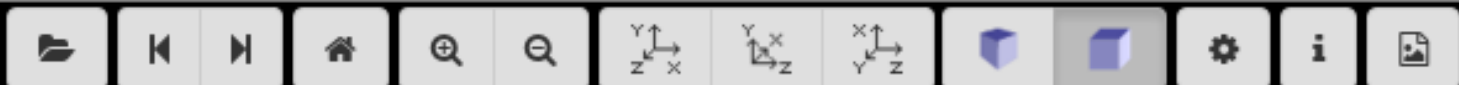
■

B

Stvarni trag čestice

Trag bez zakrivljenja





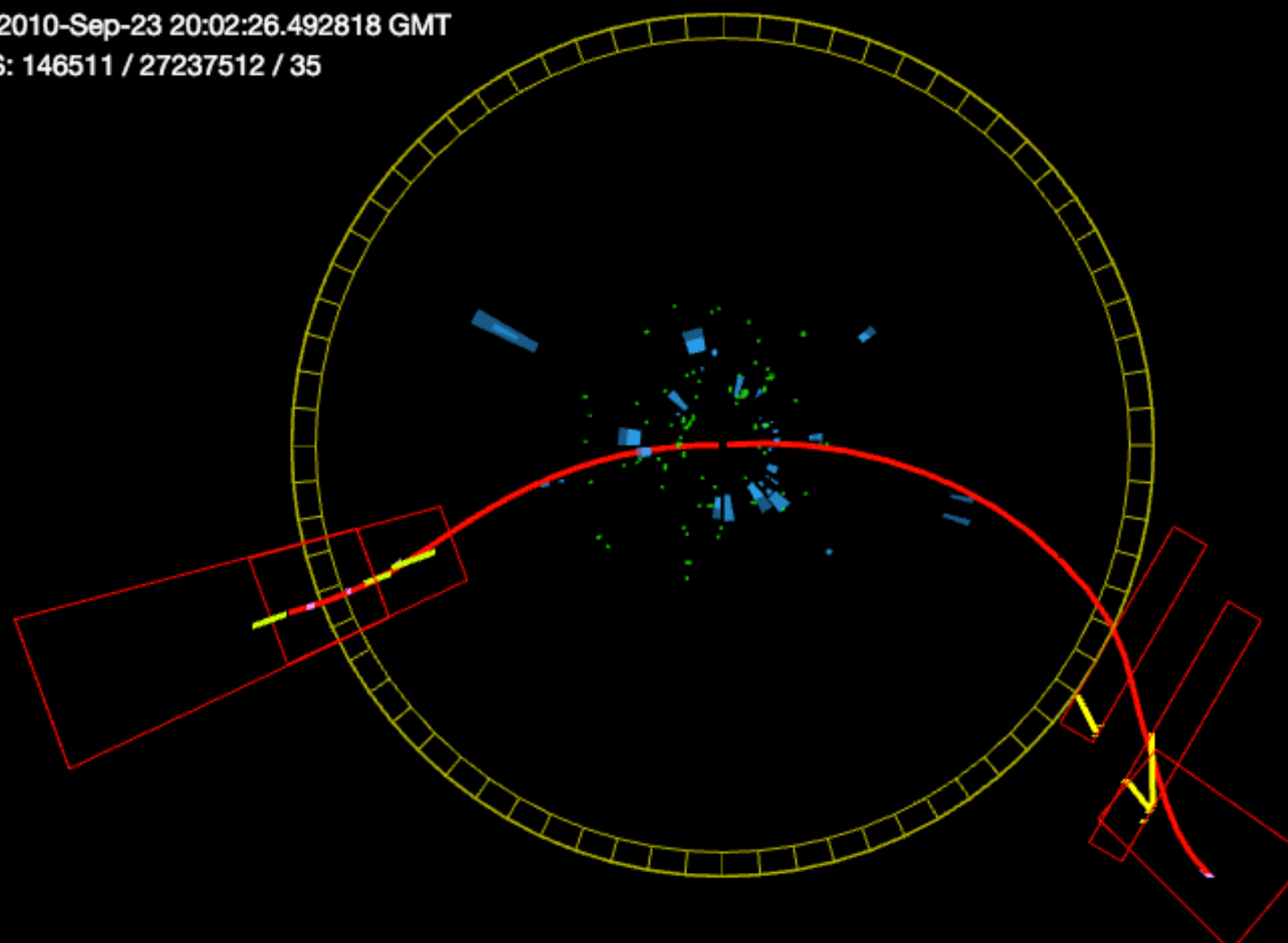
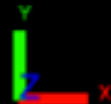
- ▼ Muon ⓘ
 - Matching muon chambers
 - CSC Segments
 - RPC Rec. Hits
 - DT Rec. Segments (4D)
 - DT Rec. Hits
- ▼ Physics ⓘ
 - Vertices (reco)
 - Tracker Muons (Reco)
 - Stand-alone Muons (Reco)
 - Global Muons (Reco)
 - Jets (Reco)
 - Missing Et (Reco)



CMS Experiment at the LHC, CERN

Data recorded: 2010-Sep-23 20:02:26.492818 GMT

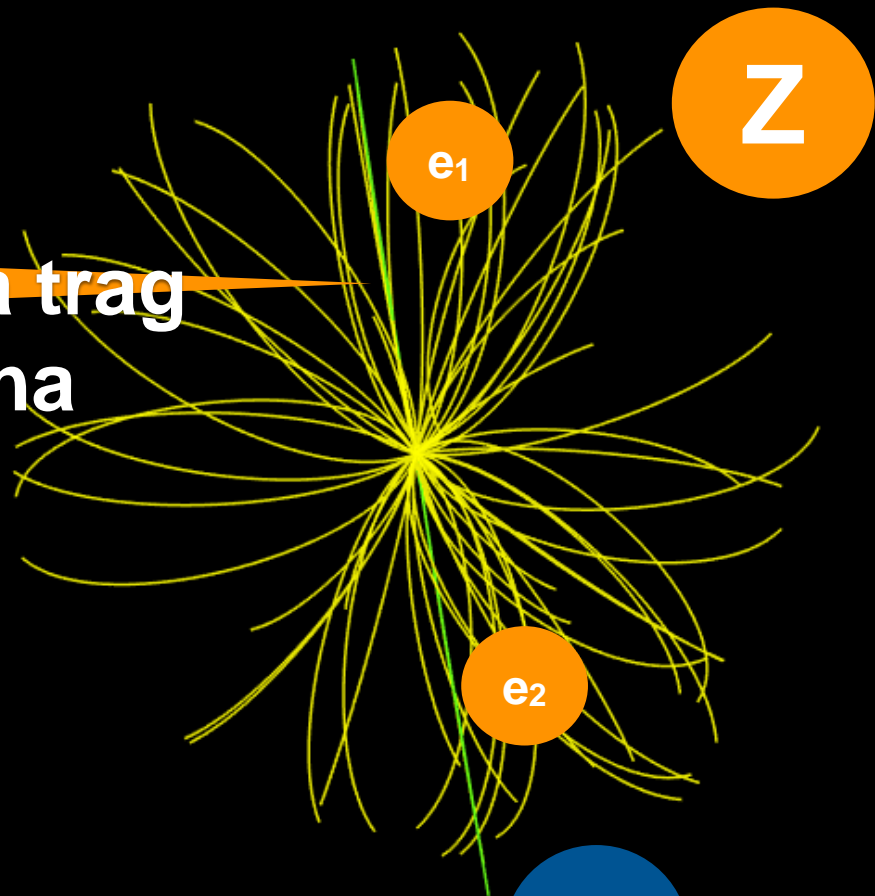
Run / Event / LS: 146511 / 27237512 / 35



Click on a name under "Provenance", "Tracking", "ECAL", "HCAL", "Muon", and "Physics" to view contents in table

1.

Kliknite na trag elektrona



3.

Izračunajte masu Z bozona

$$M = \sqrt{E^2 - p_x^2 - p_y^2 - p_z^2} = 84.74 \text{ GeV}$$

Z

2.

Zbrojite energije i količine gibanja elektrona

Z

$E = 84.95 \text{ GeV}$
 $p_x = -2.01 \text{ GeV}$
 $p_y = 1.53 \text{ GeV}$
 $p_z = -5.28 \text{ GeV}$

Electron Tracks (GSF) 1

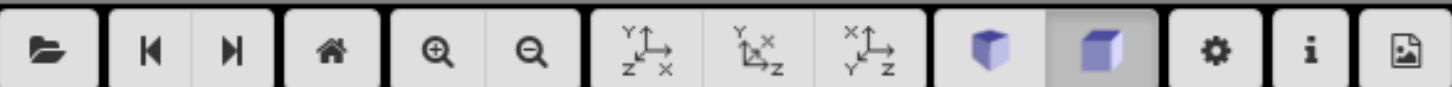
Type	Value
pt	31.6415
eta	-0.888014
phi	1.76504
charge	
E	44.959
px	-6.10763
py	31.0465
pz	-31.9394

+


Type	Value
pt	
eta	
phi	
charge	
E	39.9871
px	4.09373
py	-29.5211
pz	26.6593

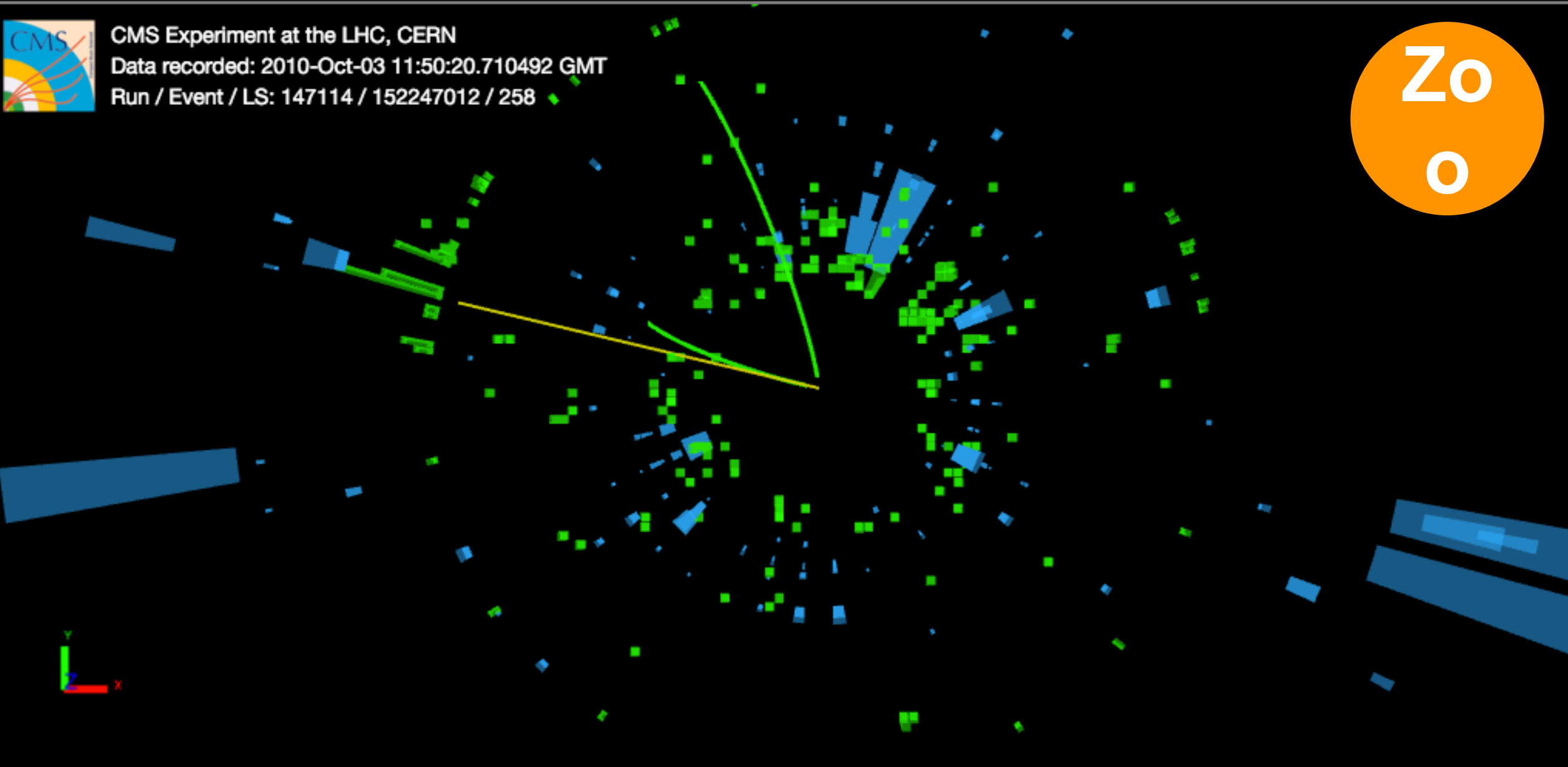
Close

Close

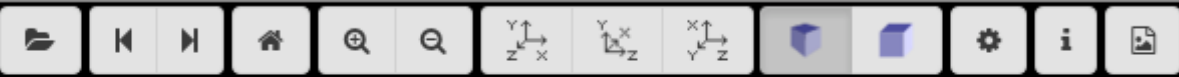


- ▼ **HCAL** ⓘ
 - Barrel Rec. Hits
 - Endcap Rec. Hits
 - Outer Rec. Hits
 - Forward Rec. Hits
- ▼ **Muon** ⓘ
 - RPC Rec. Hits
- ▼ **Physics** ⓘ
 - Vertices (reco)
 - Electron Tracks (GSF)
 - Photons (Reco)
 - Jets (Reco)
 - Missing Et (Reco)

 CMS Experiment at the LHC, CERN
Data recorded: 2010-Oct-03 11:50:20.710492 GMT
Run / Event / LS: 147114 / 152247012 / 258



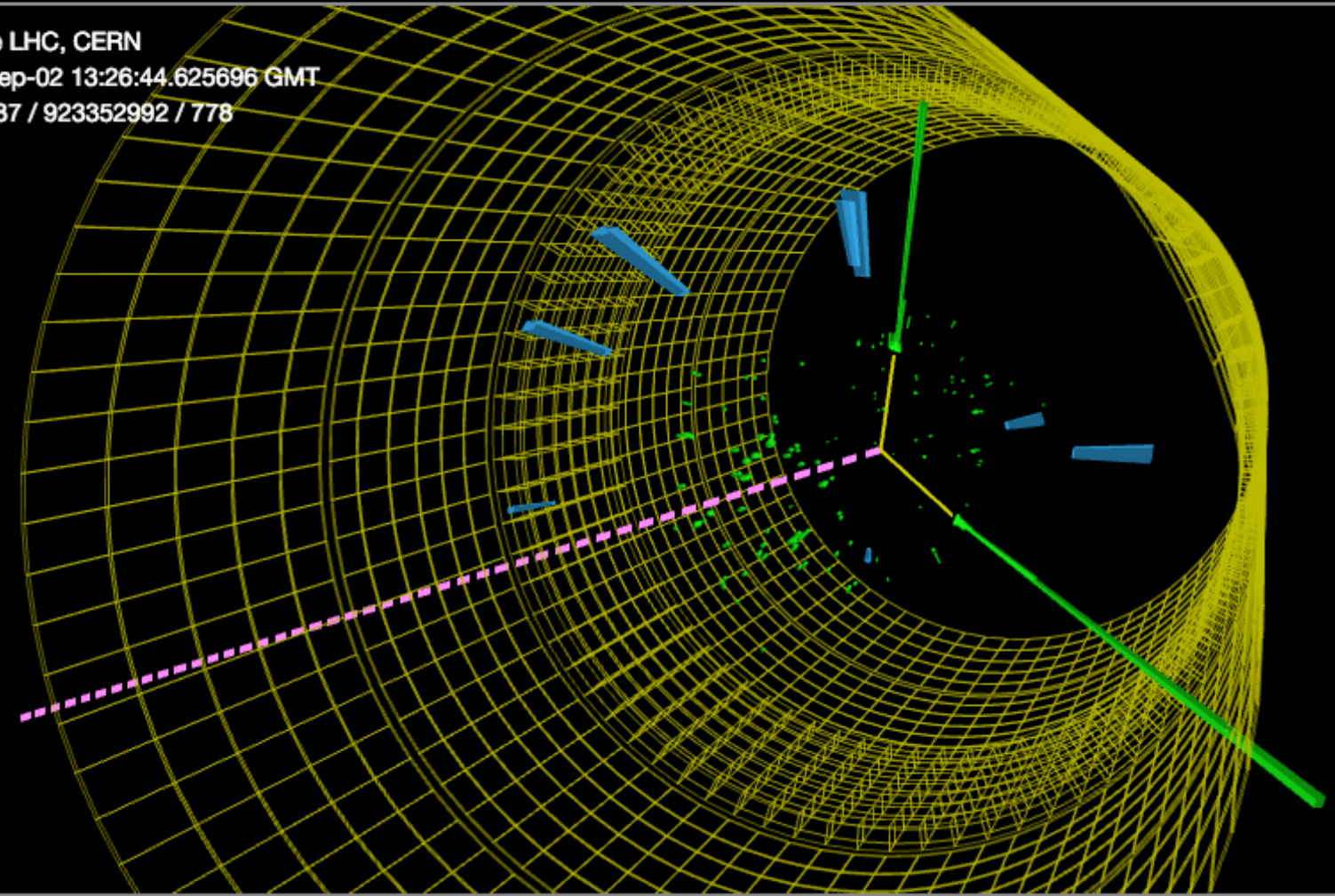
Click on a name under "Provenance", "Tracking", "ECAL", "HCAL", "Muon", and "Physics" to view contents in table



- > Detector 3
- ▼ Imported 3
- > Provenance 3
- > Tracking 3
- > ECAL 3
- ▼ HCAL 3
- ▼ Muon 3
- ▼ Physics 3
- Vertices (reco)
- Photons (Reco)
- Jets (Reco)
- Missing Et (Reco)



CMS Experiment at the LHC, CERN
 Data recorded: 2012-Sep-02 13:26:44.625696 GMT
 Run / Event / LS: 202087 / 923352992 / 778



Click on a name under "Provenance", "Tracking", "ECAL", "HCAL", "Muon", and "Physics" to view contents in table

Masterclass: CERN-16Apr2019
location: CroatianTeachers2019
Group: 7

- Instructions (also available as [screencast](#)):
- For each event, identify the final state and select a primary state candidate.
 - For Higgs or Zoo candidate, no final state is chosen
 - If you cannot decide between W+ and W-, choose W instead
 - If you think the final state is a neutral particle (like a Z), but you don't know its exact type, select NP for "neutral particle." Find its mass from the Event Display and enter it.
 - Once you have selected everything, click "Submit".

In case of an error, double clicking the data line will reload it; you can then try it again.

Izračunajte i unesite masu čestice - samo za NP

vaše grupe

događaja

Select Event
Event index: 17
Event number: 7-17

final state
 Electron
 Muon (μ)

primary state candidate
 W⁻
 W⁺
 NP
 W
 Higgs
 Zoo

NP Mass: 84.74 GeV/c²
Submit

Kliknite ako mislite da je čestica elektron

Kliknite ako mislite da je elektron nastao raspadom neutralne čestice

Kliknite "Submit"

Event index
Back Events Table (Group 7)
Masterclass: CERN-16Apr2019
location: CroatianTeachers2019
Group: 7

Select Event
Event index: 1
Event number: 7-1

final state
 Electron
 Muon (μ)

primary state candidate
 W⁻
 W⁺
 NP
 Higgs
 Zoo

NP Mass:
Submit

Zaokružite na najbliži neparni broj

Event index	Event number	Chosen Values	Mass
17	7-17	e, NP	21 84.74

Back

Events Table (Group 7)

Mass Histogram (CroatianTeachers2019)

Results (CroatianTeachers2019)

below the histogram. Please be aware that the mass histogram is us

Nakon svakog analiziranog NP ili H događaja otvorite “Mass Histogram (SplitA2019)”

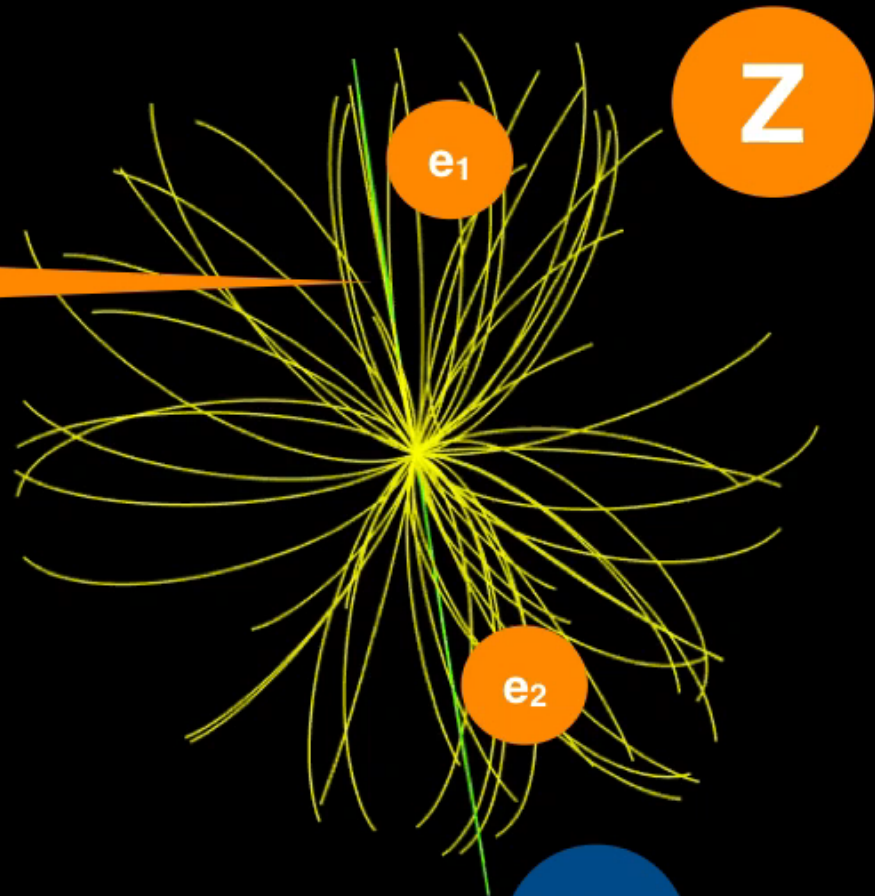
Kliknite stupac poviše odgovarajuće mase





1.

Kliknite na
trag
elektrona



3.

Izračunajte masu Z
bozona

$$M = \sqrt{E^2 - p_x^2 - p_y^2 - p_z^2} = 84.74 \text{ GeV}$$

2.

Zbrojite energije i
količine gibanja
elektrona

$$\begin{aligned}
 E &= 84.95 \text{ GeV} \\
 p_x &= -2.01 \text{ GeV} \\
 p_y &= 1.53 \text{ GeV} \\
 p_z &= -5.28 \text{ GeV}
 \end{aligned}$$

Electron Tracks (GSF) 1

Type	Value
pt	31.6415
eta	-0.888014
phi	1.76504
charge	

E	44.959
px	-6.10763
py	31.0465
pz	-31.9394

+

Type	Value
pt	39.9871
eta	
phi	
charge	

E	39.9871
px	4.09373
py	-29.5211
pz	26.6593

Close

Close