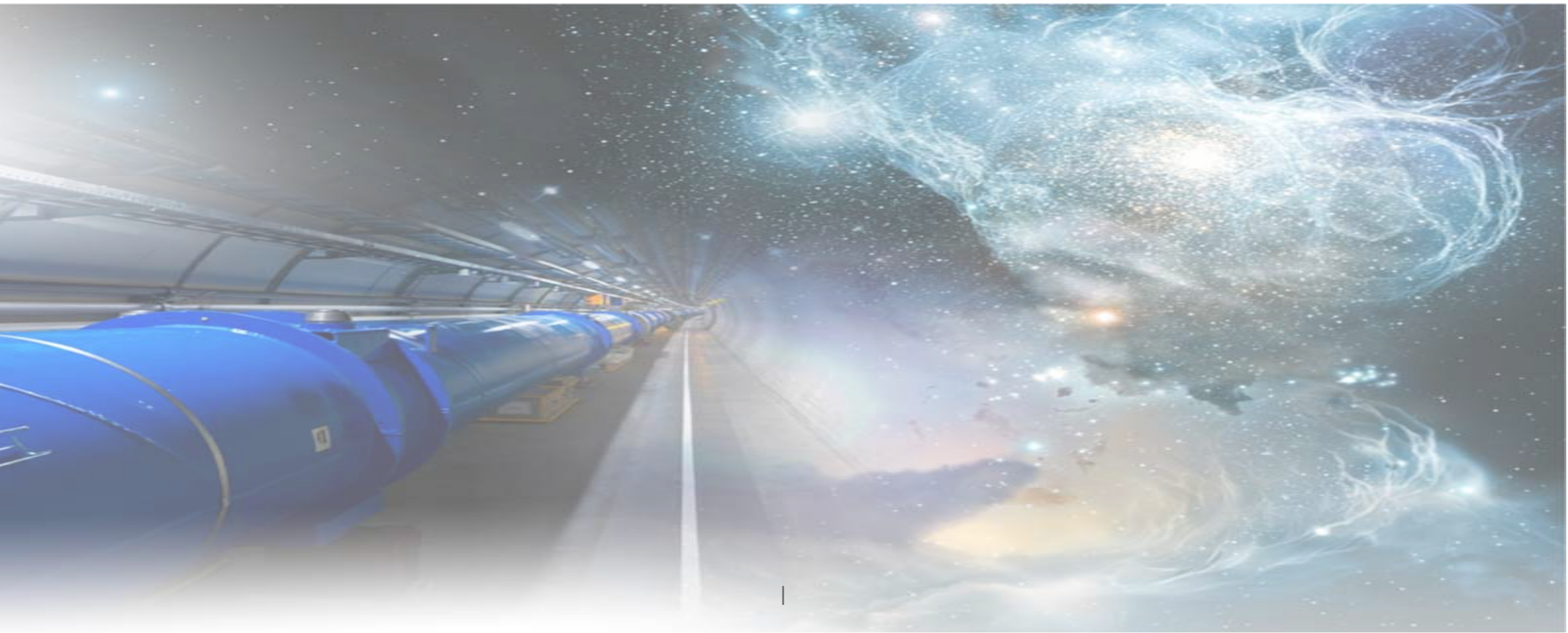


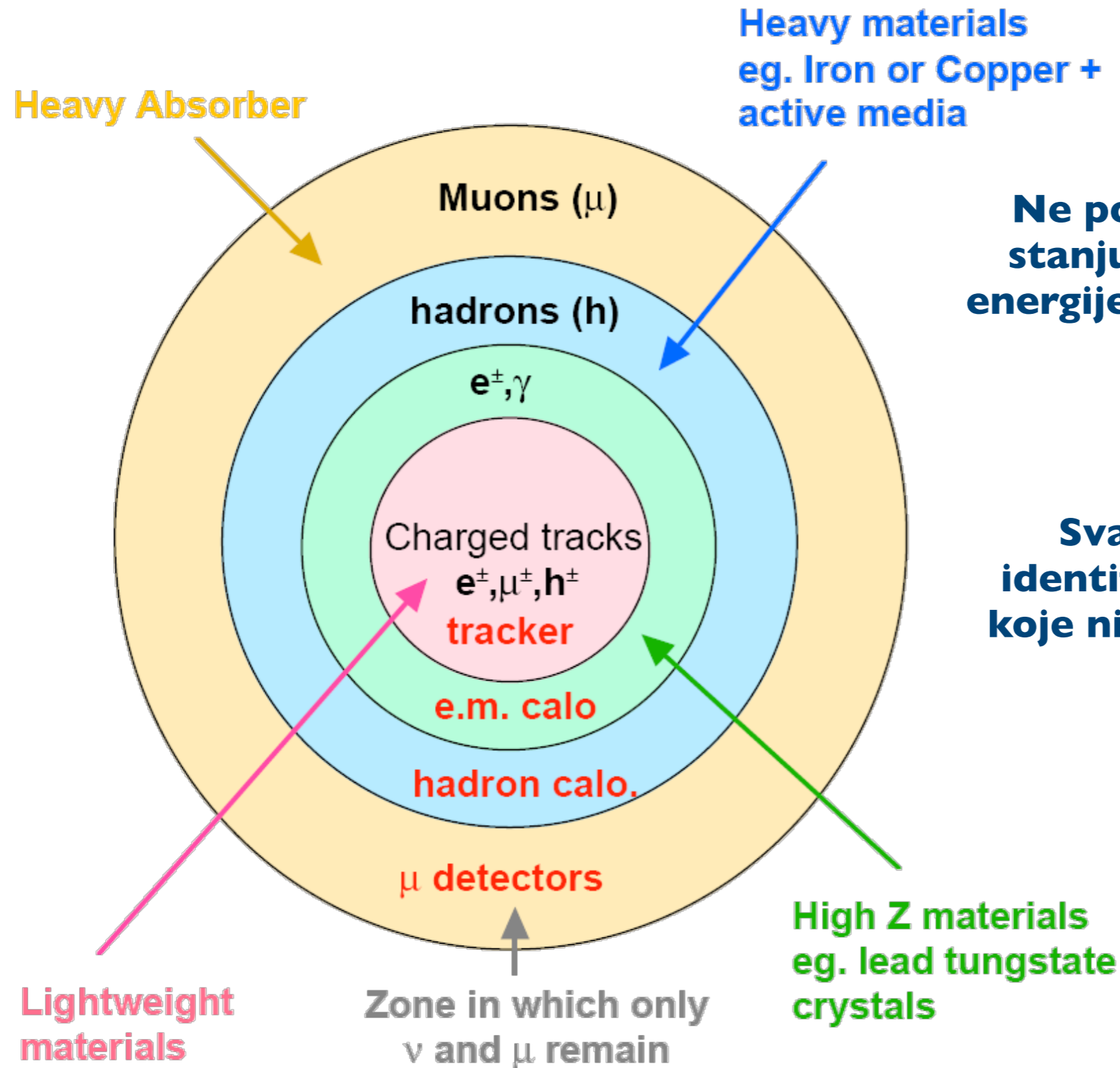
# Detekcija elementanih čestica i analiza događaja

Physics Masterclasses u Srbiji

J. Jovićević (IPB)

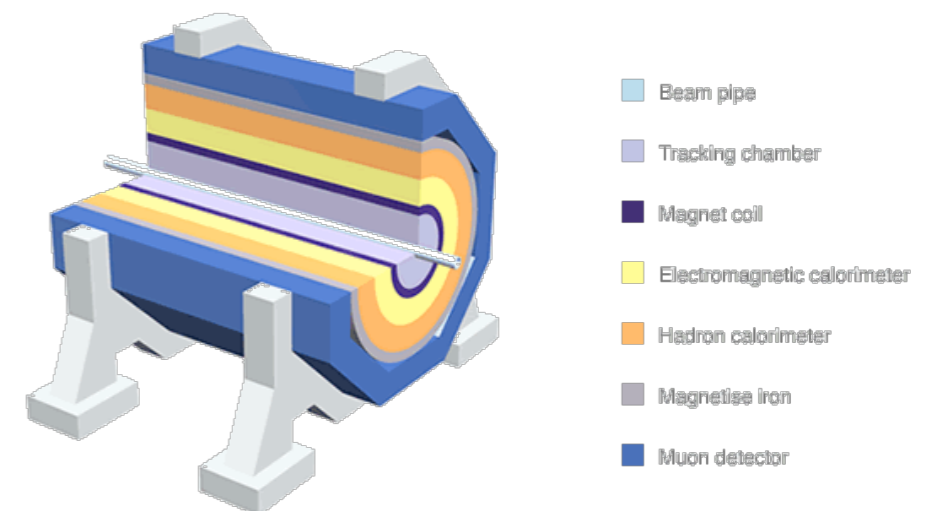


# Struktura detektora u HEP



**Ne postoji sloj-detektor koji je u stanju da efikasno odredi i izmeri energije/impulse svih čestica nastalih u nekom događaju**

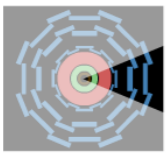
**Svaki naredni sloj detektora identifikuje i meri energiju čestica koje nisu detektovane i izmerene u prethodnim slojevima**



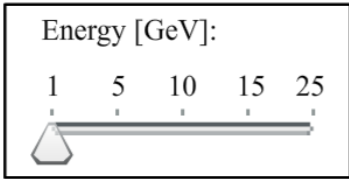
# Detekcija elektrona

## ATLAS

animation

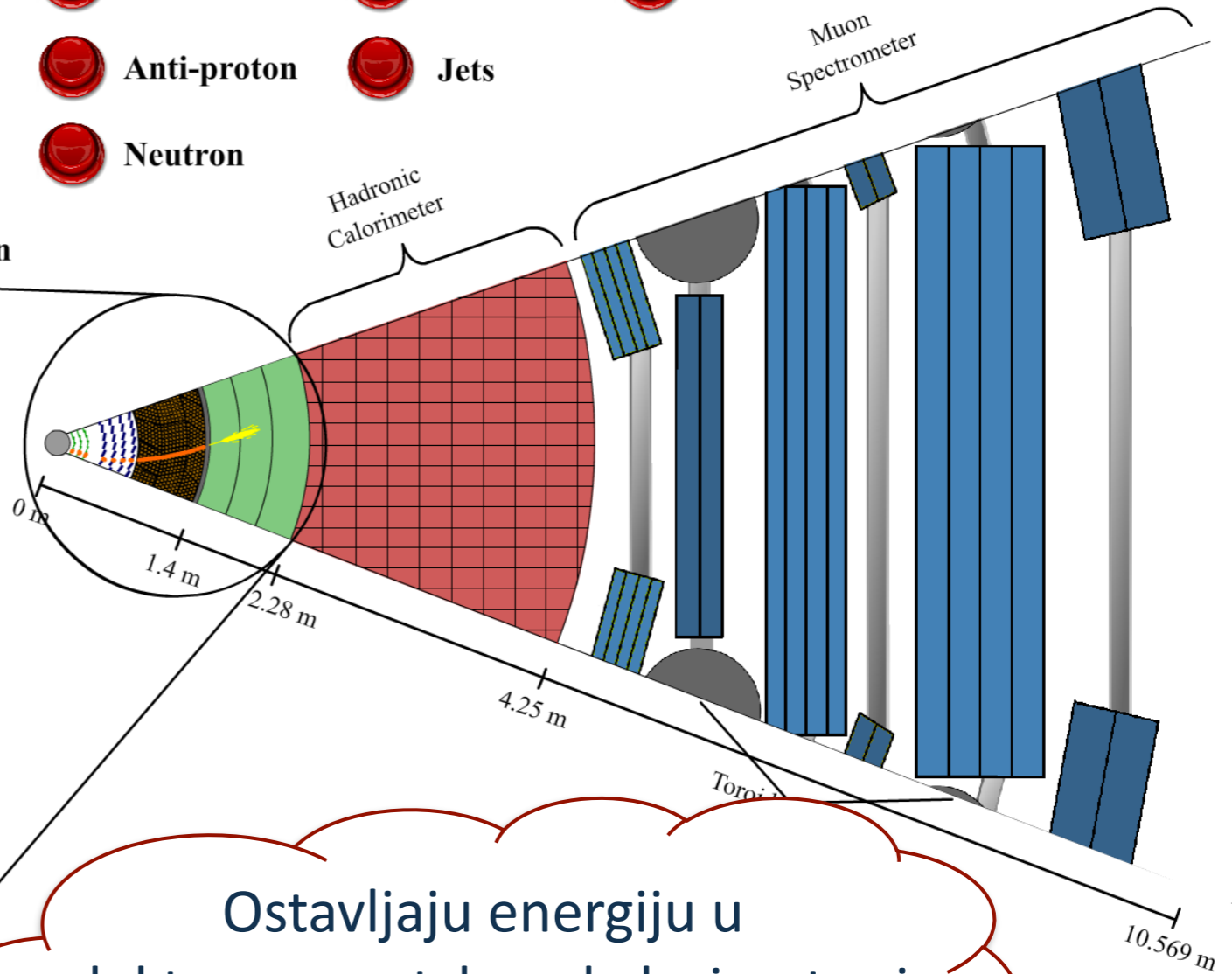
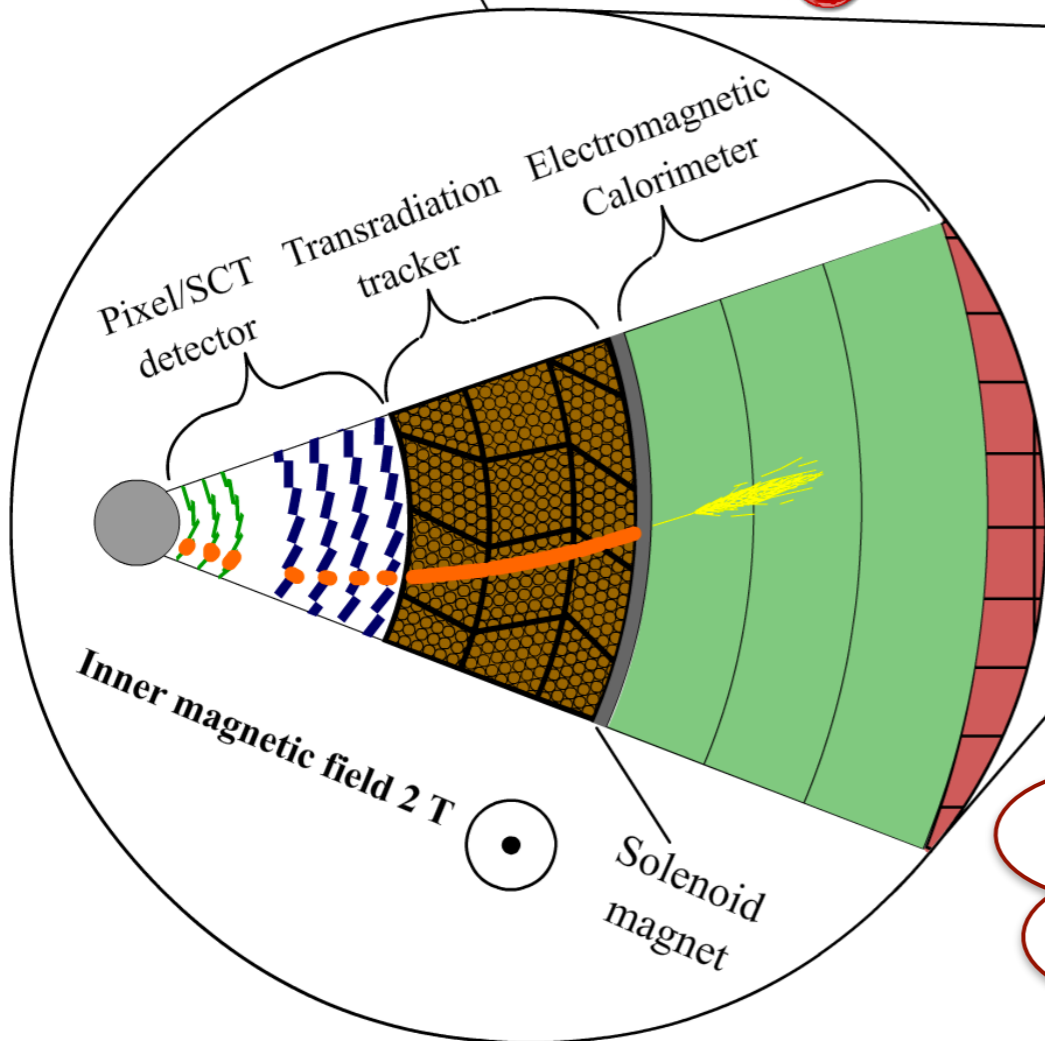


display instantly



- Electron
- Proton
- Neutrino
- Photon
- Positron
- Anti-proton
- Jets
- Muon
- Neutron
- Anti-muon

Magnification 3x



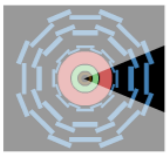
Ostavljaju energiju u elektromagnetskom kalorimetru i tragove u tracker-u

Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

# Detekcija pozitrona

**ATLAS**

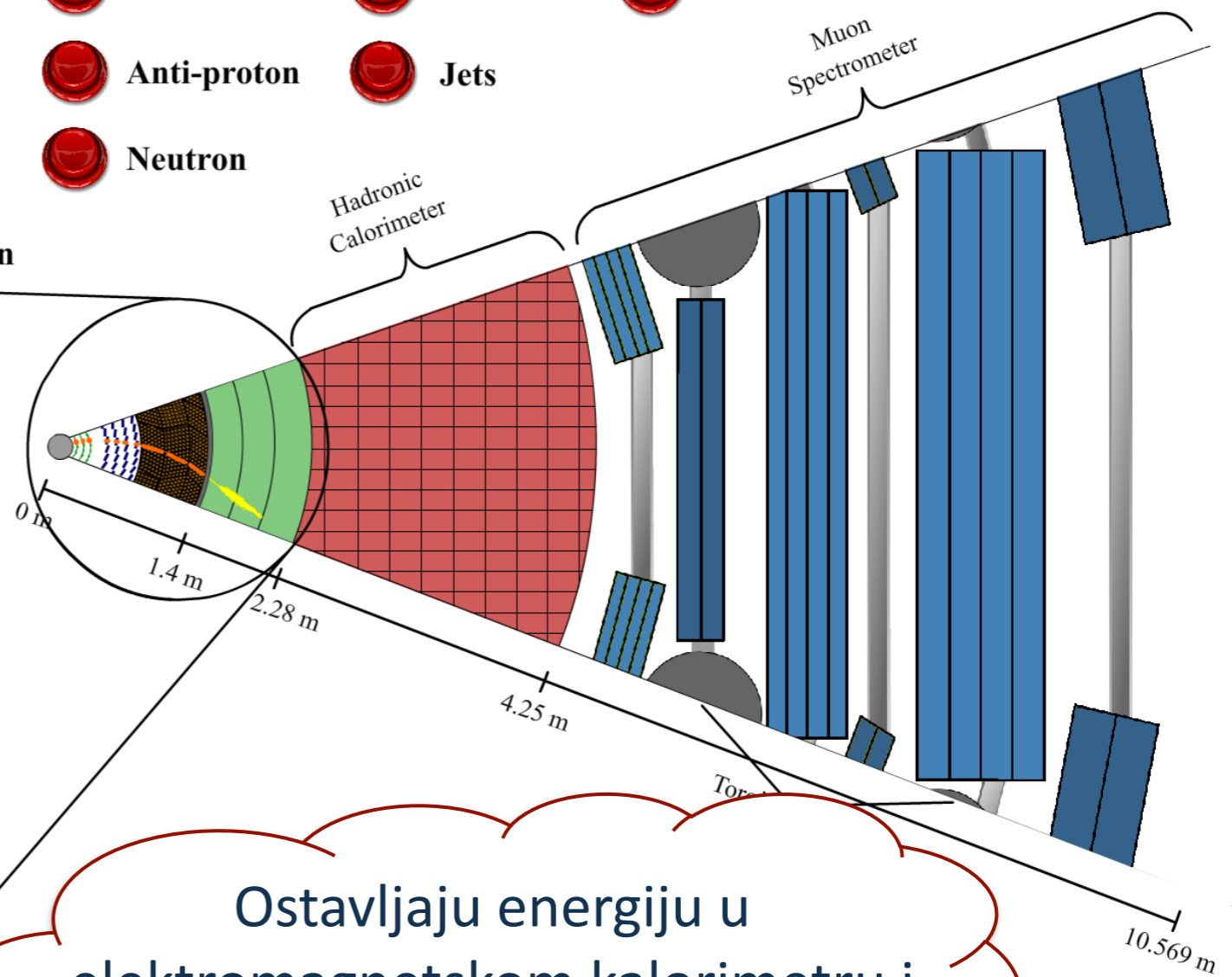
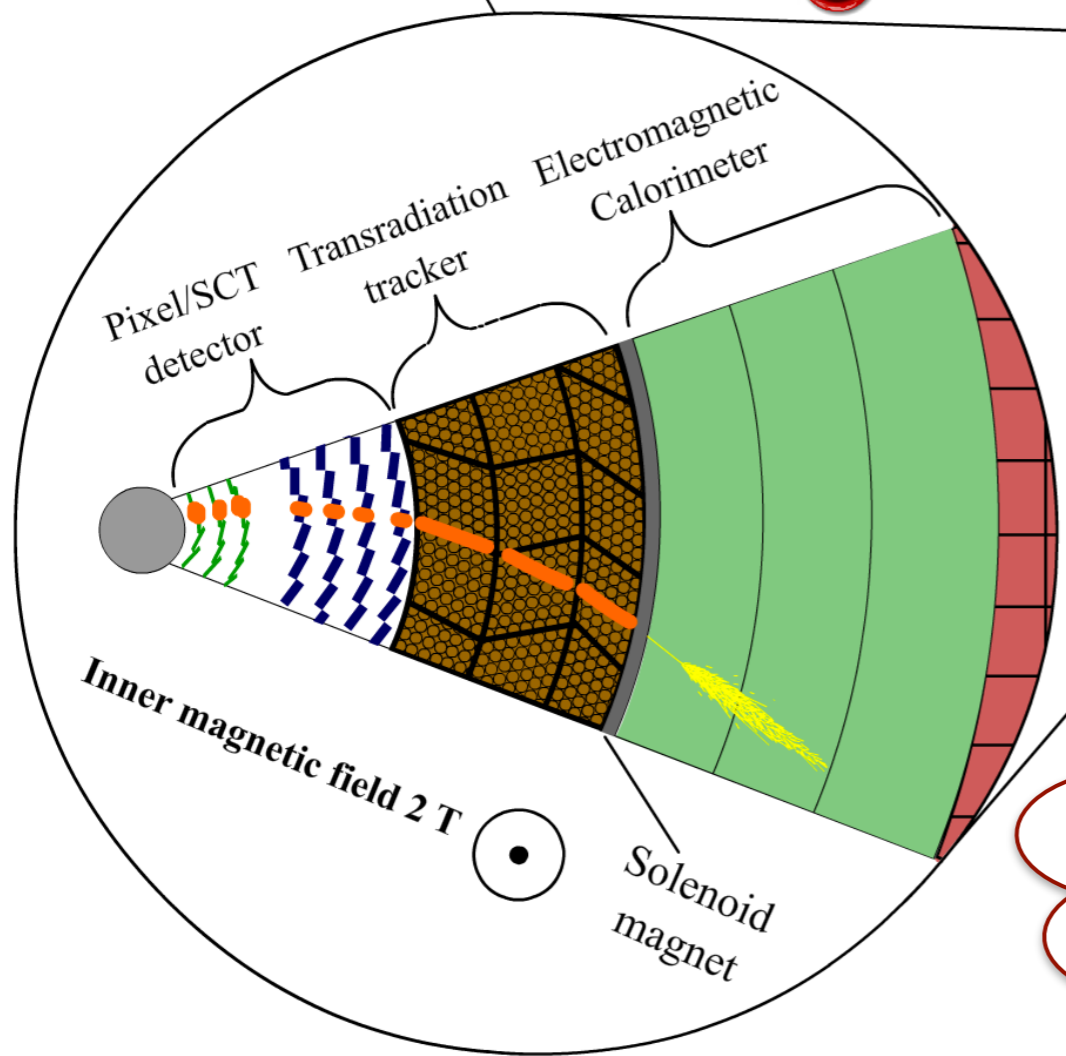
animation



display instantly

- Electron
- Proton
- Neutrino
- Photon
- Positron
- Anti-proton
- Jets
- Muon
- Neutron
- Anti-muon

Magnification 3x



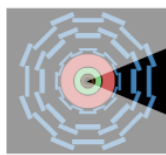
Ostavljaju energiju u elektromagnetskom kalorimetru i tragove u tracker-u

Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel











# Detekcija fotona

## ATLAS

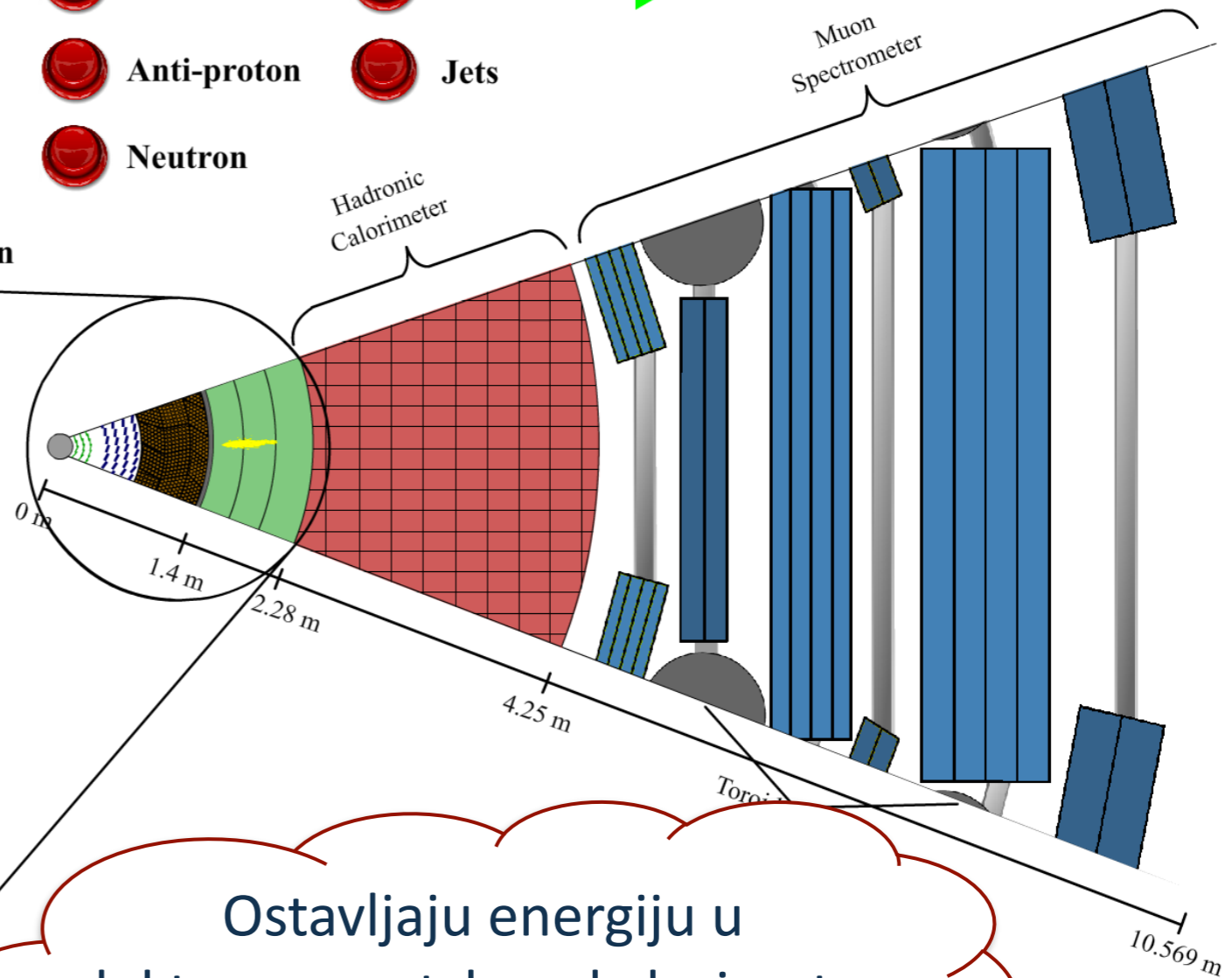
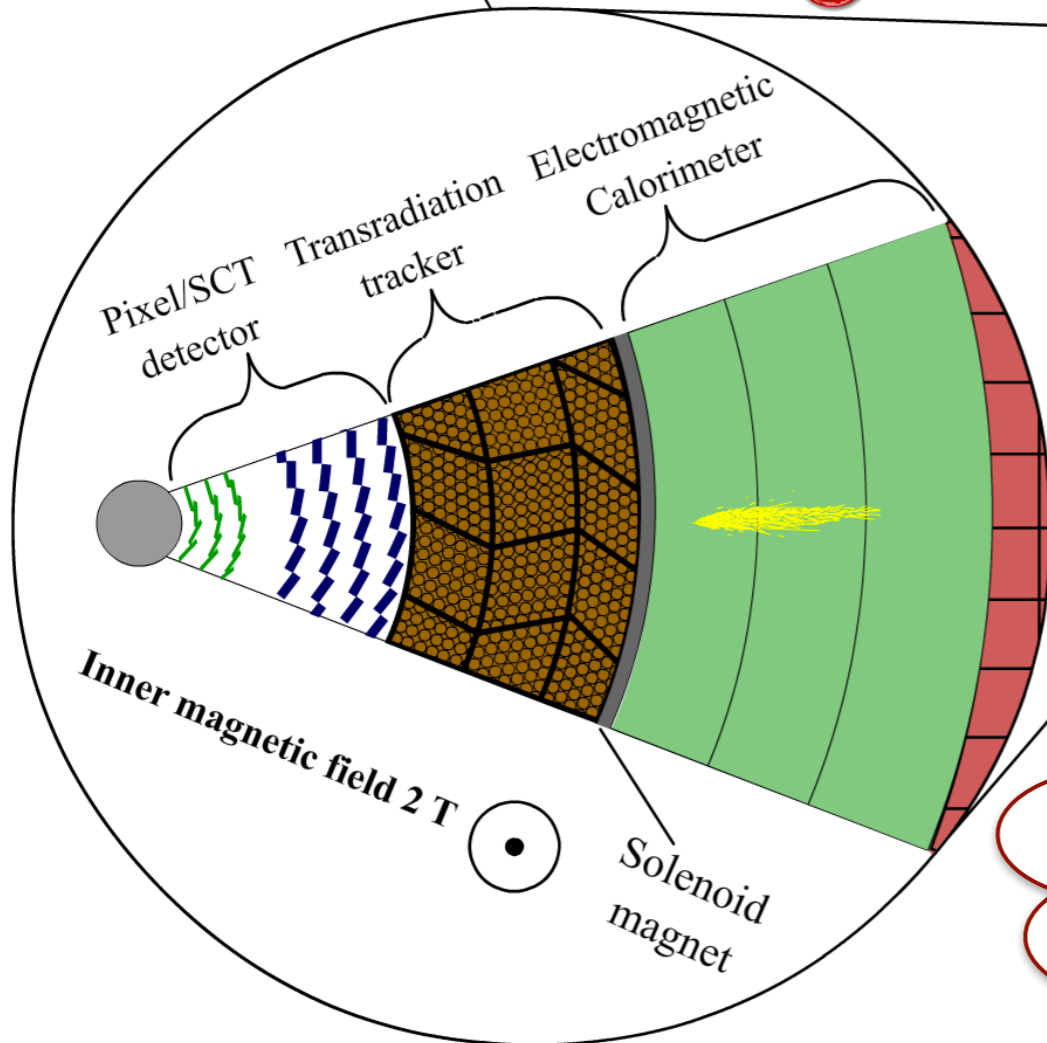
animation



display instantly

-  Electron
-  Proton
-  Neutrino
-  Photon
-  Positron
-  Anti-proton
-  Jets
-  Muon
-  Neutron
-  Anti-muon

Magnification 3x



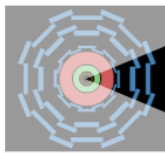
Ostavljaju energiju u  
elektromagnetskom kalorimetru,  
bez tragova u tracker-u

Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

# Detekcija naelektrisanih hadrona

## ATLAS

animation



display instantly



Electron



Proton



Neutrino



Photon



Positron



Anti-proton



Jets



Muon

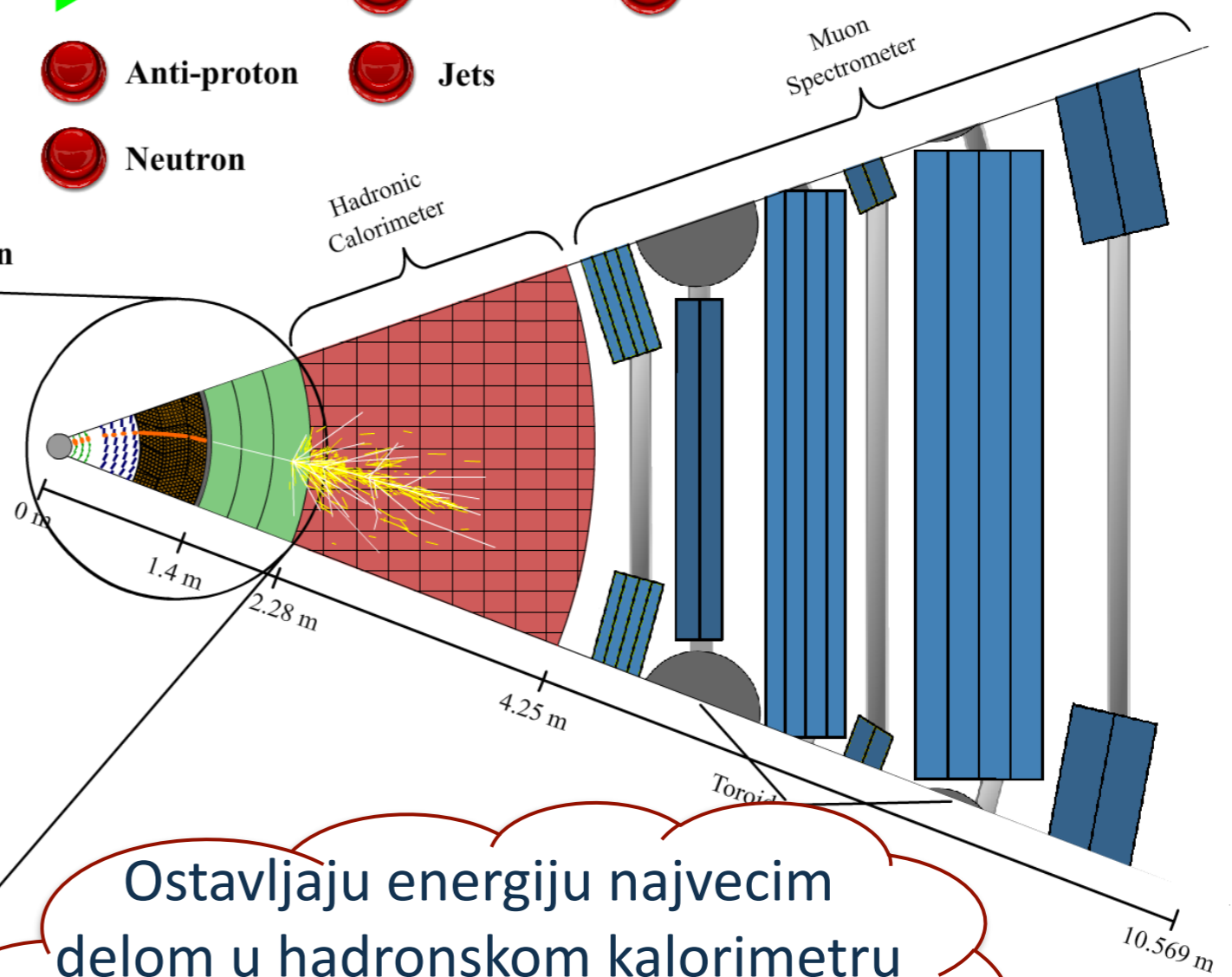
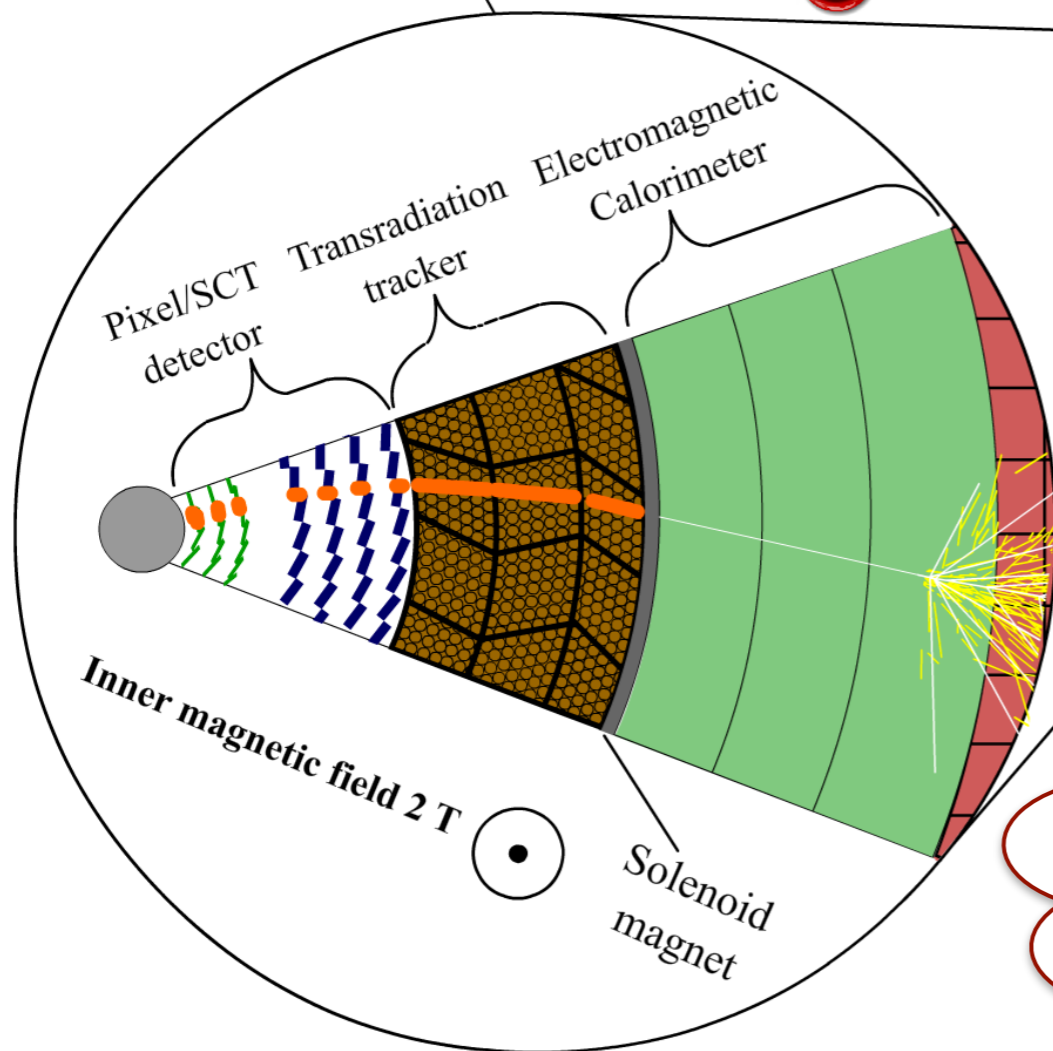


Neutron



Anti-muon

Magnification 3x



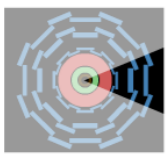
Ostavljaju energiju najvećim delom u hadronskom kalorimetru i tragove u tracker-u

Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

# Detekcija neutralnih hadrona

## ATLAS

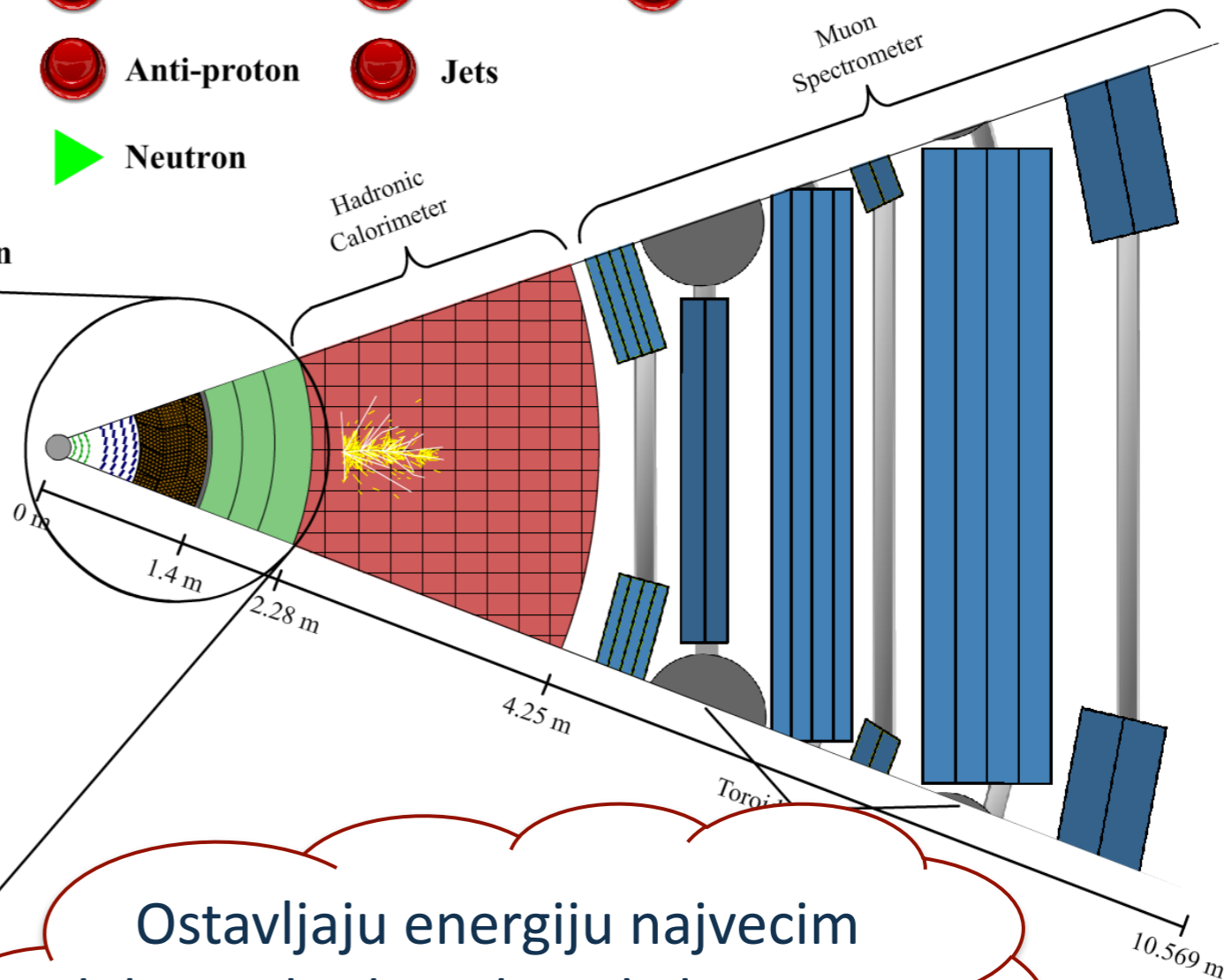
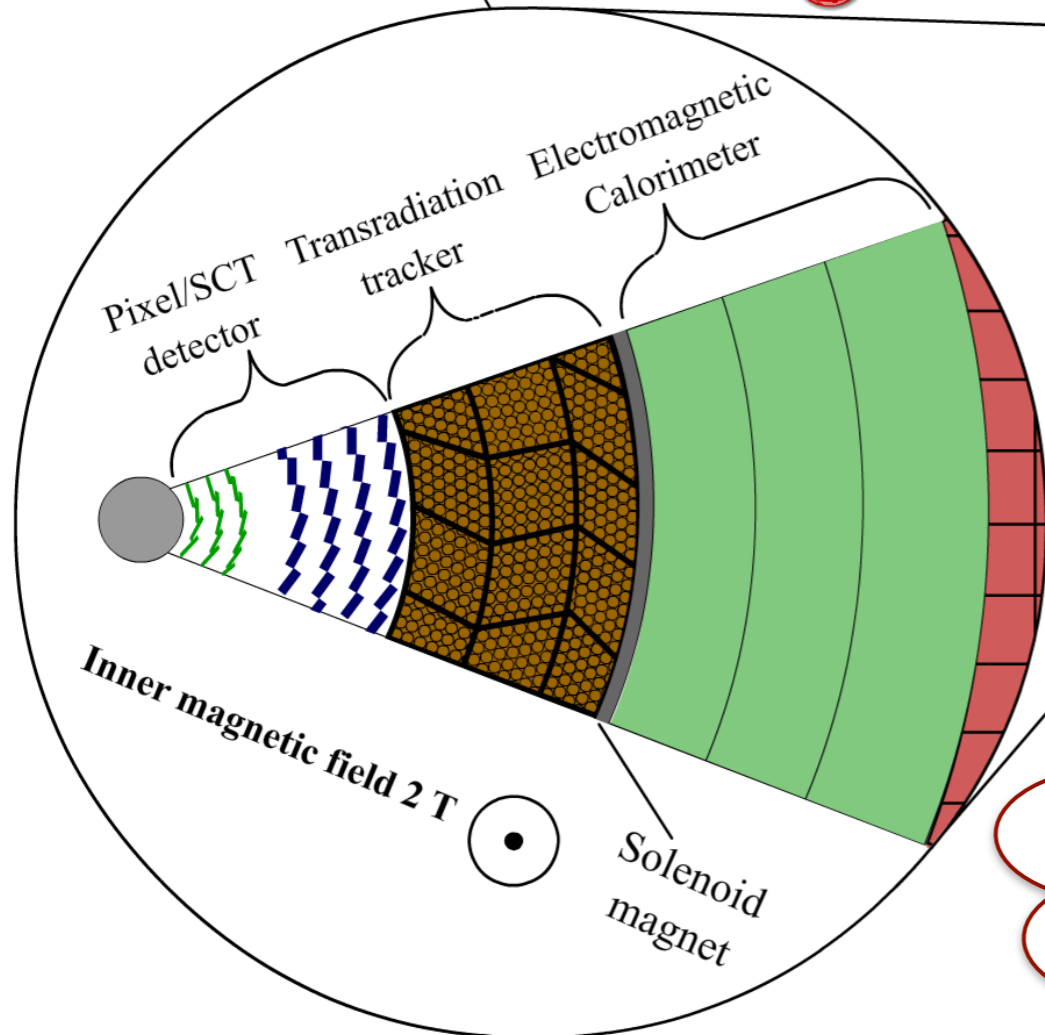
animation



display instantly

- Electron
- Proton
- Neutrino
- Photon
- Positron
- Anti-proton
- Jets
- Muon
- Neutron
- Anti-muon

Magnification 3x



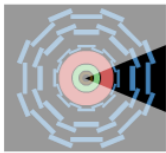
Ostavljaju energiju najvećim delom u hadronskom kalorimetru, bez tragova u tracker-u

Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

# Detekcija miona

**ATLAS**

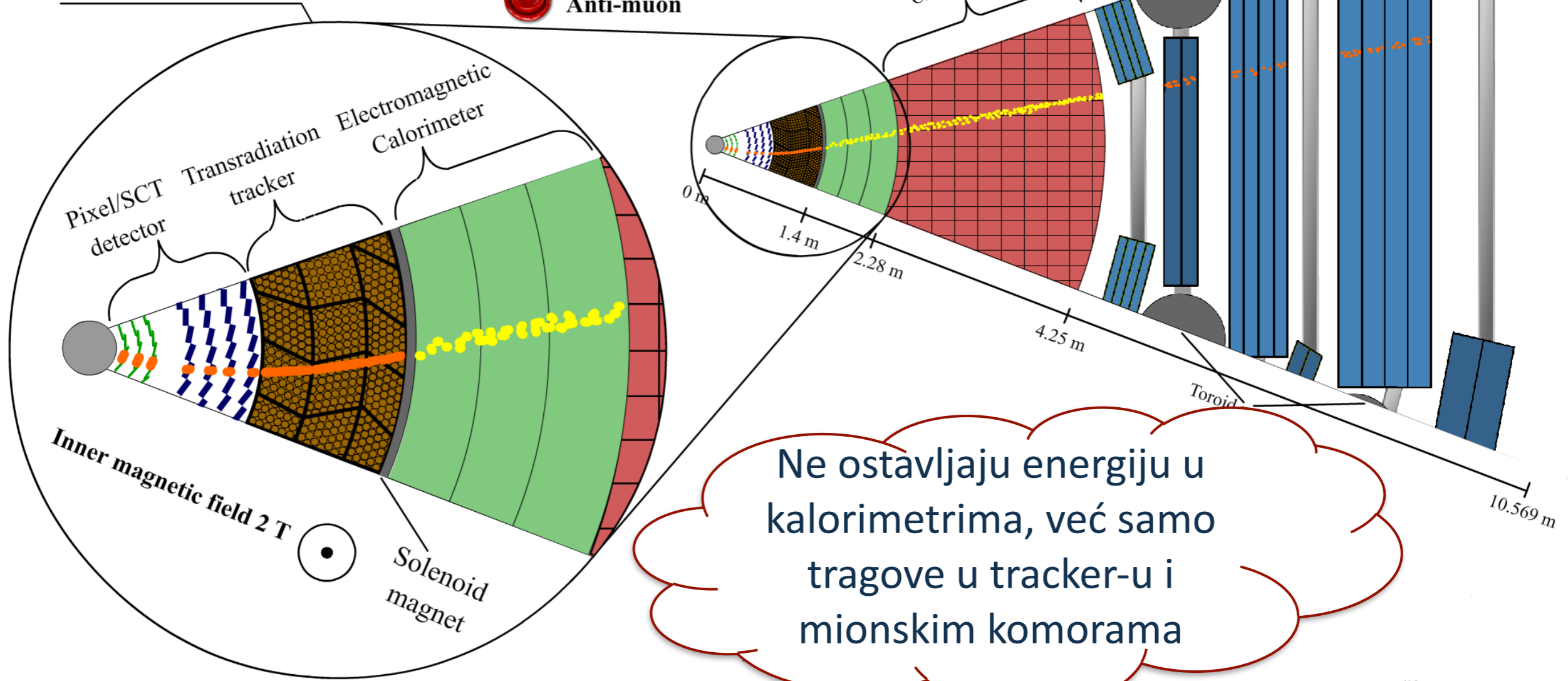
animation



display instantly

- Electron
- Proton
- Neutrino
- Photon
- Positron
- Anti-proton
- Jets
- Muon
- Neutron
- Anti-muon

Magnification 3x



Ne ostavljaju energiju u kalorimetrima, već samo tragove u tracker-u i mionskim komorama

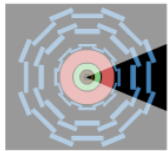
Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel



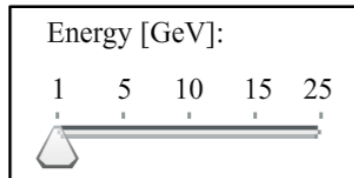
# Detekcija anti-miona

## ATLAS

animation

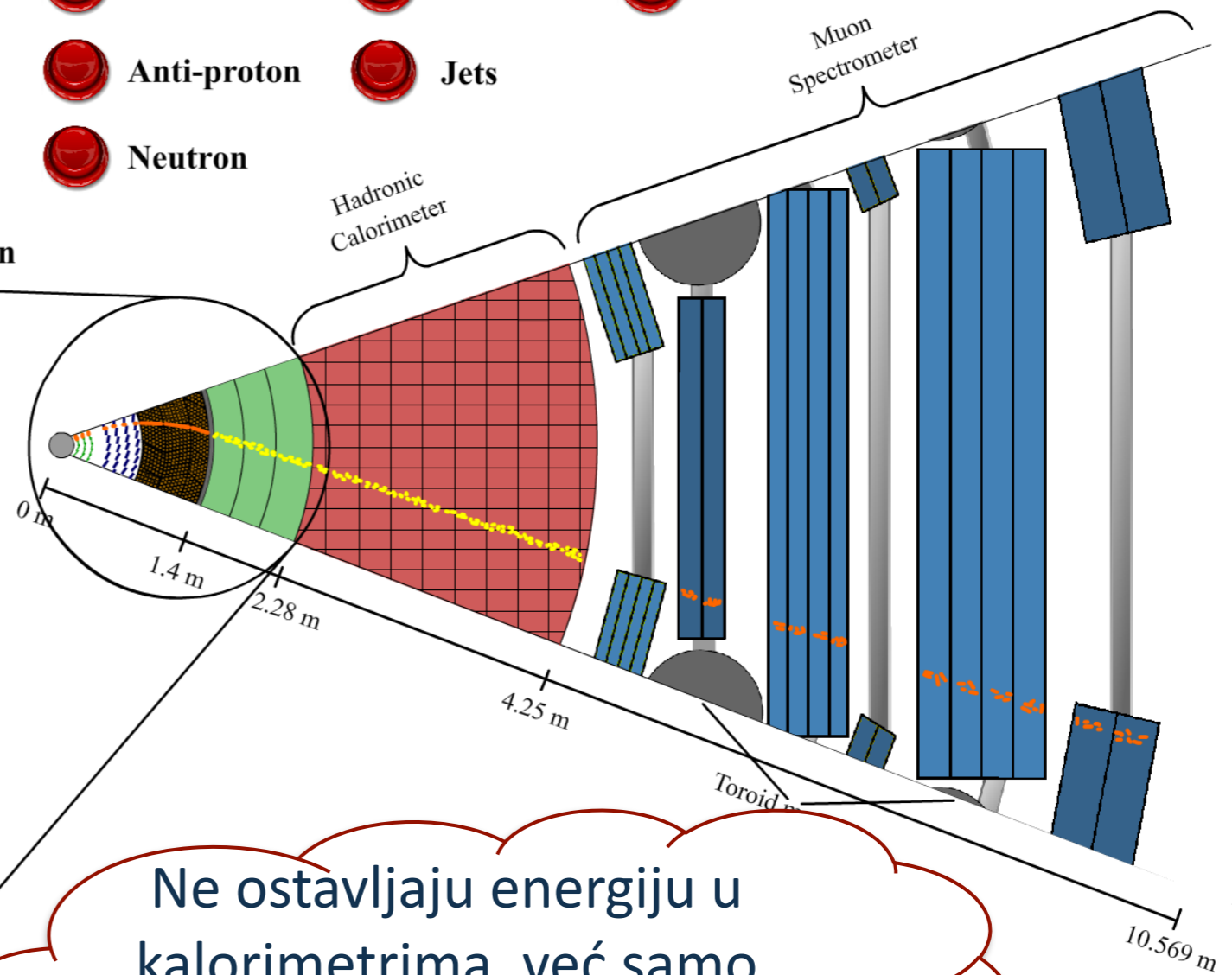
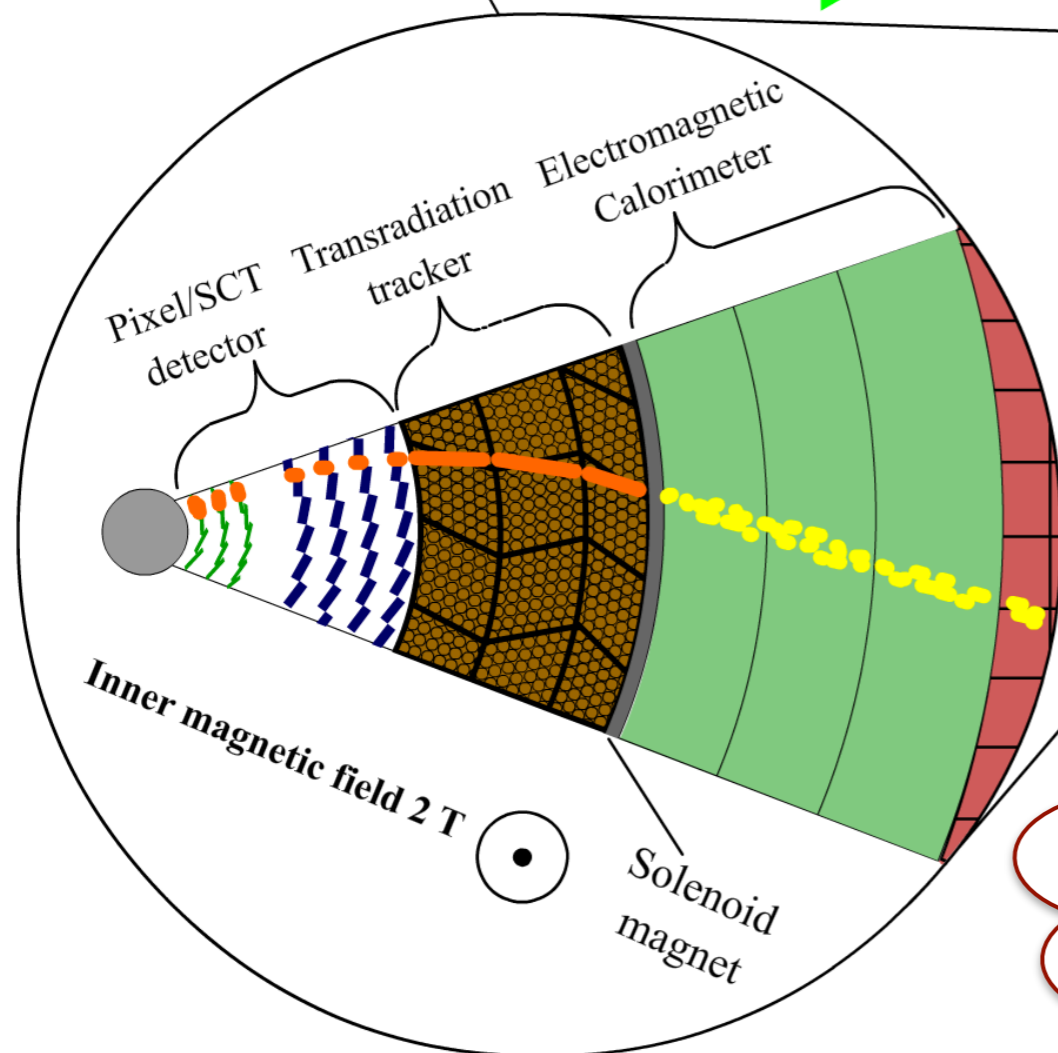


display instantly



- Electron
- Proton
- Neutrino
- Photon
- Positron
- Anti-proton
- Jets
- Muon
- Neutron
- Anti-muon

Magnification 3x



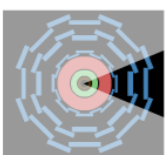
Ne ostavljaju energiju u kalorimetrima, već samo tragove u tracker-u i mionskim komorama

Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

# Detekcija jet-ova hadrona

## ATLAS

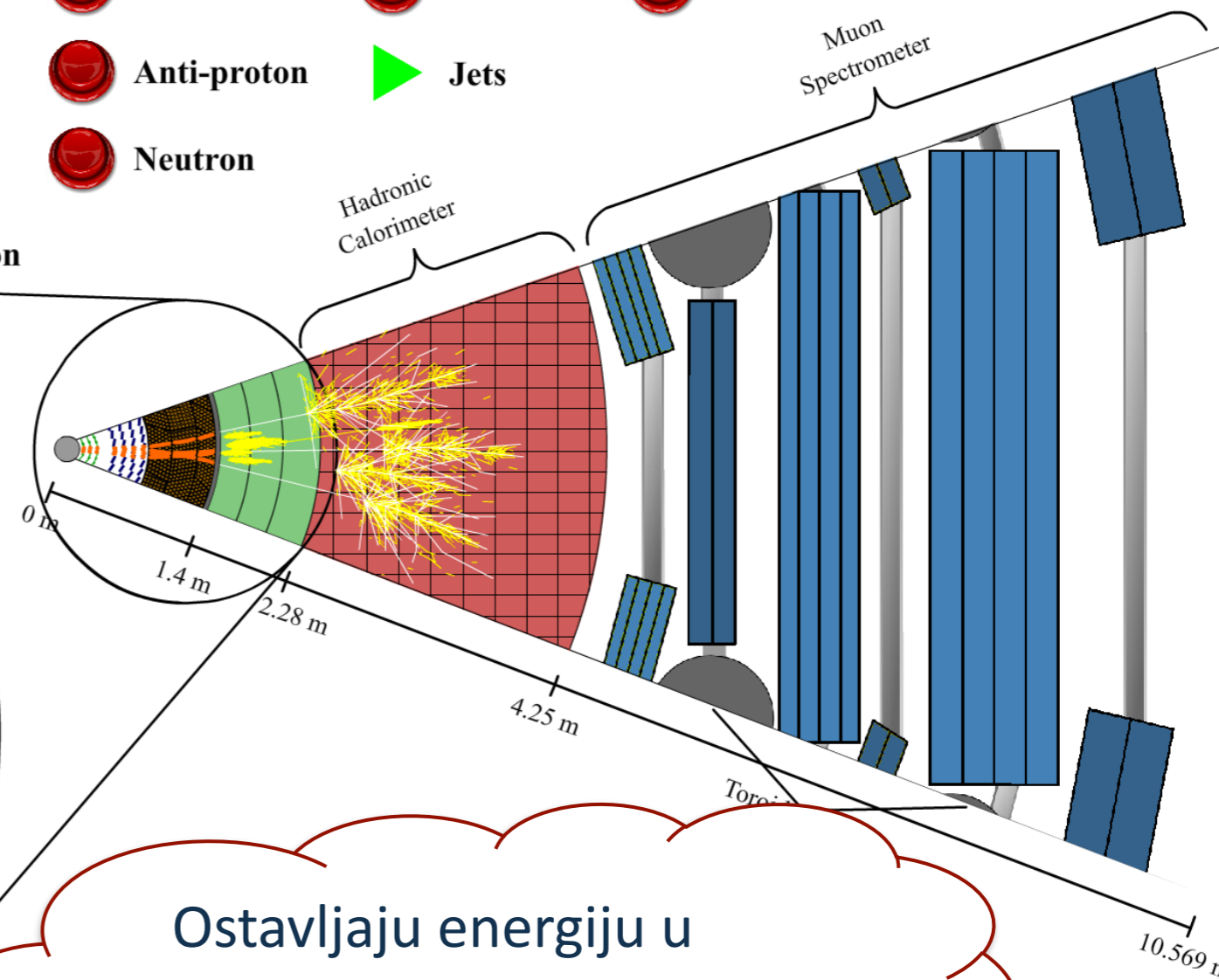
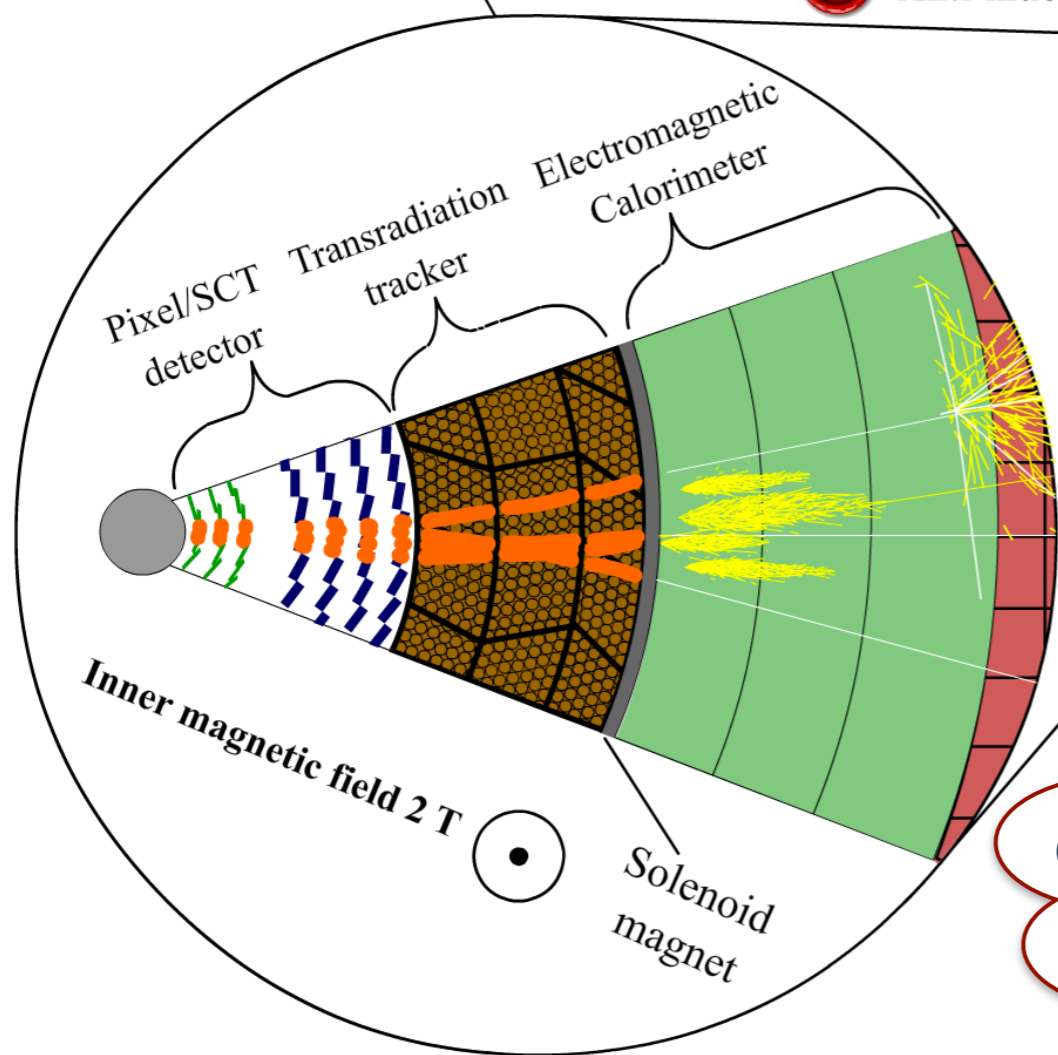
animation



display instantly

- Electron
- Proton
- Neutrino
- Photon
- Positron
- Anti-proton
- Jets
- Muon
- Neutron
- Anti-muon

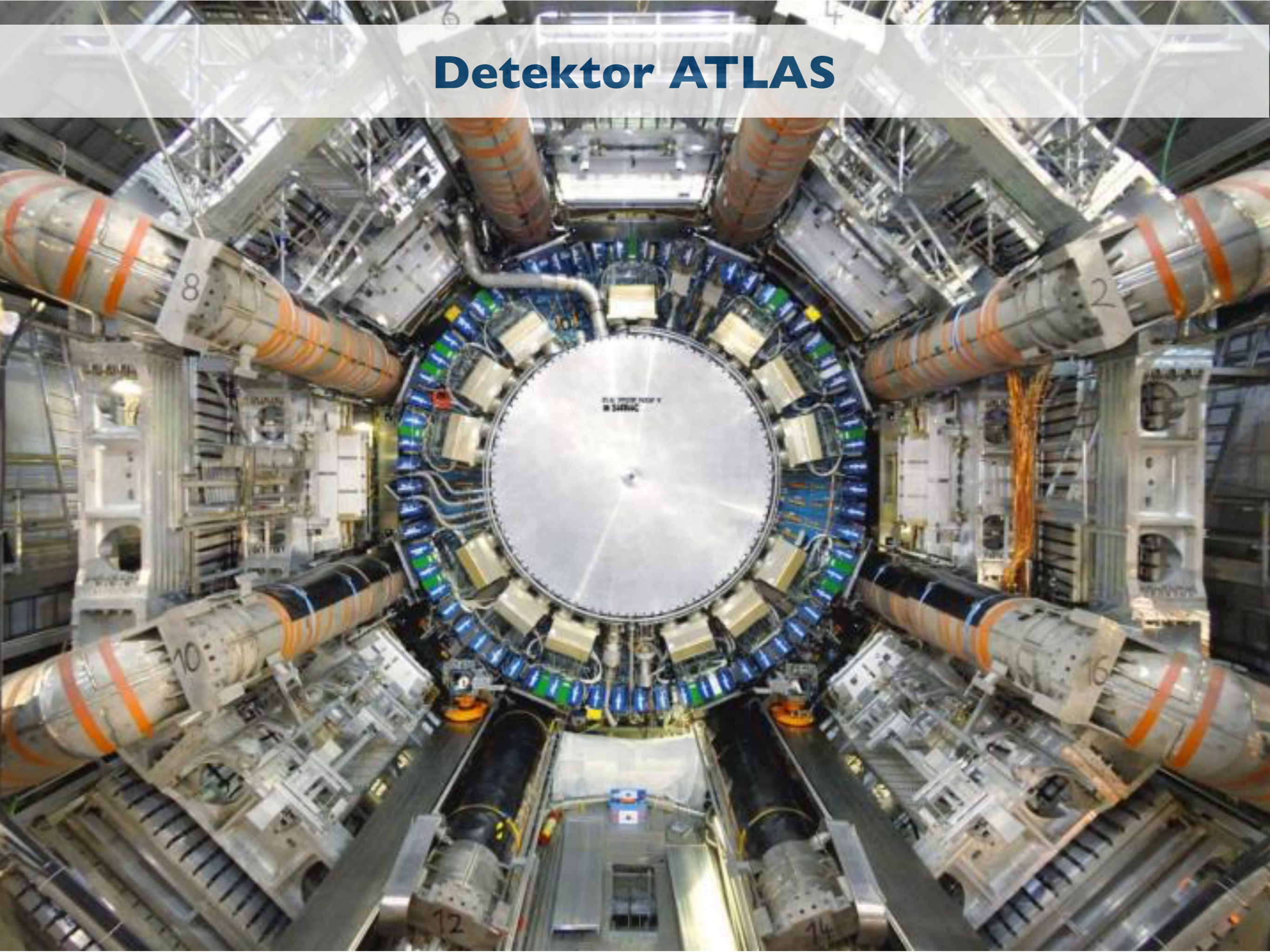
Magnification 3x



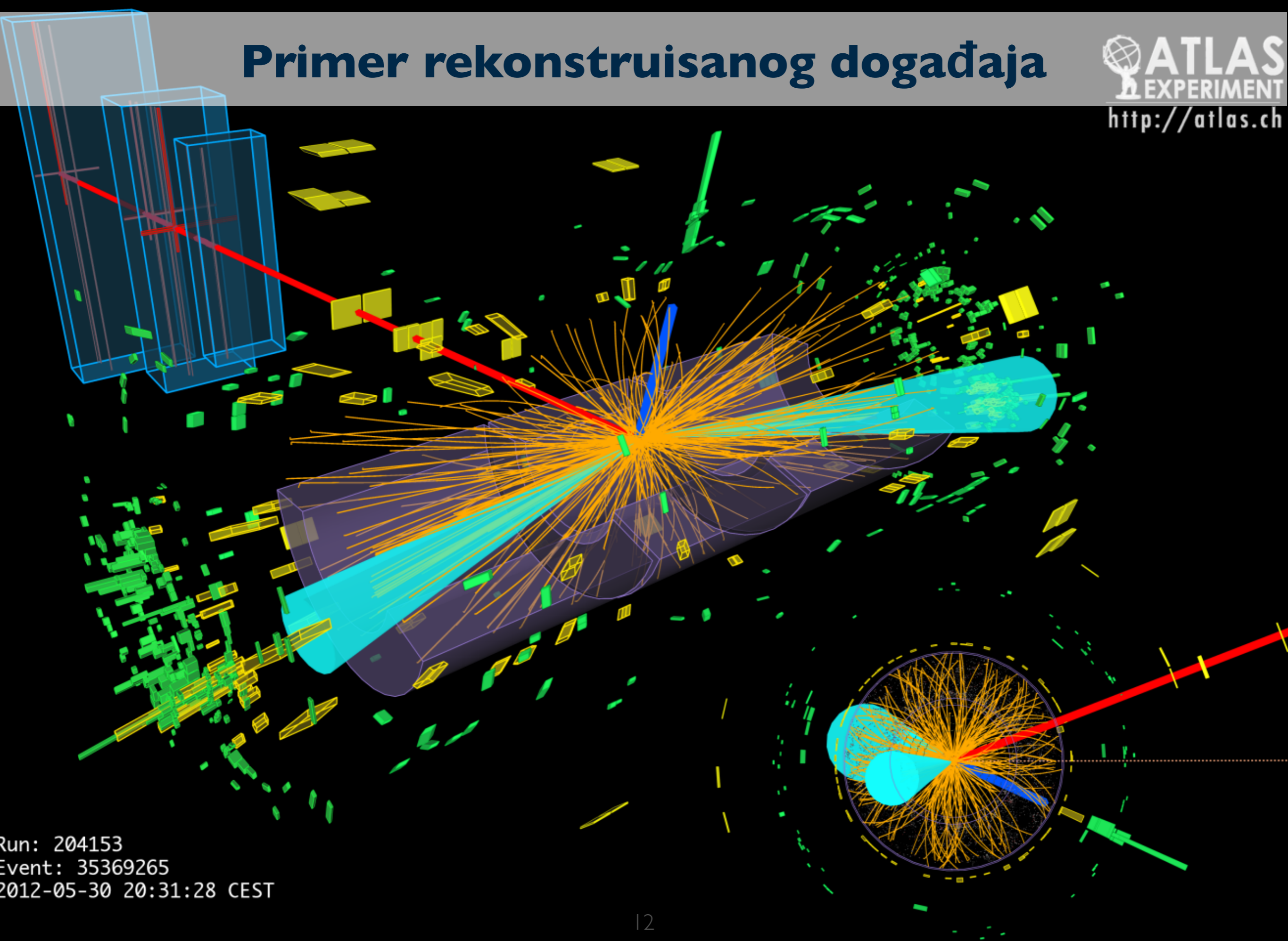
Ostavljaju energiju u elektromagnetskom i hadronskom kalorimetru i tragove u tracker-u

Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

# Detektor ATLAS



# Primer rekonstruisanog događaja



Run: 204153  
Event: 35369265  
2012-05-30 20:31:28 CEST

# Analiza događaja

- **Akcelerator LHC:** proton–proton sudari energije **8 TeV**
- Edukativni program za vizuelizaciju događaja : **HYPATIA**
- **Zadatak 1:** Rekonstrukcija događaja i potraga za:
  - Raspadima neutralnih čestica na par elektrona ili miona ( $J/\psi$ ,  $\Upsilon$ ,  $Z^0$ ...)  
Primer:  $Z^0 \rightarrow \mu^- \mu^+$  &  $Z^0 \rightarrow e^- e^+$
  - Raspadima Higgs bozona na par fotona ili par  $Z^0$  bozona  
Primer:  $H^0 \rightarrow \gamma \gamma$   
 $H^0 \rightarrow e^- e^+ e^- e^+$  &  $H^0 \rightarrow \mu^- \mu^+ \mu^- \mu^+$  &  $H^0 \rightarrow \mu^- \mu^+ e^- e^+$
- **Zadatak 2:** Snimanje masenog spektra za događaje sa **parom leptona**, ili **parom fotona**, ili **parom  $Z^0 Z^0$**  bozona.  
Upoređivanje rezultata sa merenjima na eksperimentima ATLAS i CMS.
- **Zadatak 3:** Upoređivanje i kombinovanje rezultata sa rezultatima studenata ostalih instituta koji učestvuju u ovom programu (V.C.)

# Analiza događaja programom HEPATIA

The screenshot displays the HYPATIA software interface, which is used for analyzing particle collision events. The main window is titled "HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window". It features a menu bar (File, View, Histograms, Preferences, Help) and a data table at the top. Below the table are three main visualization panels: a top-left detector view, a top-right 3D histogram, and a bottom detector view. To the right, there is a "HYPATIA - Track Momenta Window" with a track list and a "Parameter Control" panel at the bottom.

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	$\varphi$	$\eta$	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
JiveXML_106051_1950731.xml	13.877	Tracks 1	126.1	+	39.4	-2.413	1.830	91.054				e
		Tracks 3	167.9	-	53.0	0.906	1.820					e

Track	+/-	P [GeV]	Pt [GeV]	$\varphi$	$\theta$
Tracks 2	-	108.74			0.562
Tracks 4	+	9.28			1.473
Tracks 10	-	10.52			0.754
Tracks 21	+	10.52			0.347
Tracks 410	-	10.52			1.914
Tracks 579	-	10.52			0.881
Tracks 626	+	10.52			2.633
Tracks 627	+	10.52			2.555
Tracks 629	+	10.52			2.900
Tracks 631	-	81.25			0.754
Tracks 632	+	97.55	33.18	-2.863	0.347
Tracks 634	-	29.37	27.66	2.324	1.914
Tracks 635	-	36.12	27.85	-2.173	0.881
Tracks 636	+	96.97	47.21	2.286	2.633
Tracks 643	-	58.49	32.36	-0.636	2.555
Tracks 655	-	12.49	8.29		
Tracks 657	-	13.39			
Tracks 664	+	10.52			
Tracks 667	-	7.87			
Tracks 669	+	22.48			
Tracks 673	+	9.86			
Tracks 675	-	9.28			

Projection	Name	Value
InDet	<input checked="" type="checkbox"/>  Pt	> 5.0 GeV
	<input type="checkbox"/>  Pt2	< 700.0 MeV
Calo	<input checked="" type="checkbox"/>  d0	< 2.5 mm
	<input checked="" type="checkbox"/>  z0	< 20.0 cm
MuonDet	<input type="checkbox"/>  d0 Loose	< 2.0 cm
	<input type="checkbox"/>  z0-zVtx	< 2.5 mm

**Transverzalni prikaz**

**Longitudinalni prikaz**

**Prozor za biranje događaja i selekciju objekata**

**Prozor za kontrolu prikaza detektora i objekata**

# Kontrola prikaza detektora i objekata

The image displays two screenshots of the HYPATIA Control Window interface. The top screenshot shows the 'Interaction and Window Control' tab with a toolbar containing icons for Zoom, Pick, and other functions. The bottom screenshot shows the 'Parameter Control' tab with a table of parameters for various detector components.

**Zoom**

**Pick**

Interakcija sa prikazom detektora i objekata

Kontrola parametara prikaza

Granična vrednost transverzalnog momenta za prikaz objekta

Component	Name	Value
Calo	<input checked="" type="checkbox"/>  Pt	> 1.5 GeV
	<input type="checkbox"/>  d0 Loose	< 2.0 cm
MuonDet	<input checked="" type="checkbox"/>  d0	< 2.5 mm
	<input type="checkbox"/>  z0-zVtx	< 2.5 mm
Objects	<input checked="" type="checkbox"/>  z0	< 20.0 cm
	<input type="checkbox"/> Layer	> 0
	<input type="checkbox"/> Number Pixel Hits	>= 2
ATLAS	<input type="checkbox"/> Number SCT Hits	>= 7

# Analiza događaja programom HEPATIA

The screenshot displays the HYPATIA software interface, which is used for analyzing particle collision events. The main window is titled "HYbrid Pupils' Analysis Tool for Interactions in ATLAS - version 7.4 - Invariant Mass Window". It features a menu bar (File, View, Histograms, Preferences, Help) and a data table at the top. The table lists event parameters such as File Name, ETMis [GeV], Track, P [GeV], +/-, Pt [GeV],  $\varphi$ ,  $\eta$ , M(2) [GeV], M(eeee) [GeV], M(eemm) [GeV], M(mmmm) [GeV], and e/m/g.

The interface is divided into several panels:

- Transverzalni prikaz (Transverse view):** A circular plot showing the detector's cross-section with tracks and energy deposits. A callout bubble points to this view.
- Longitudinalni prikaz (Longitudinal view):** A 3D plot showing the detector's longitudinal structure. A callout bubble points to this view.
- Prozor za biranje događaja i selekciju objekata (Event selection and object selection window):** A window titled "HYPATIA - Track Momenta Window" containing a table of tracks and a control panel for selecting events and objects. A callout bubble points to this window.
- Prozor za kontrolu prikaza detektora i objekata (Detector and object display control window):** A window titled "Parameter Control" with tabs for Projection, Data, Cuts, InDet, Calo, MuonDet, Objects, and Geometry. It contains a table of parameters and their values, such as |Pt| > 5.0 GeV. A callout bubble points to this window.

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	$\varphi$	$\eta$	M(2) [GeV]	M(eeee) [GeV]	M(eemm) [GeV]	M(mmmm) [GeV]	e/m/g
JiveXML_106051_1950731.xml	13.877	Tracks 1	126.1	+	39.4	-2.413	1.830	91.054				e
		Tracks 3	167.9	-	53.0	0.906	1.820					e

Track	+/-	P [GeV]	Pt [GeV]	$\varphi$	$\theta$
Tracks 2	-	108.74			0.562
Tracks 4	+				473
Tracks 10	-				
Tracks 21	+				
Tracks 410	-				
Tracks 579	-				
Tracks 626	+				
Tracks 627	+				
Tracks 629	+	44			2.900
Tracks 631	-	81.25			0.754
Tracks 632	+	97.55	33.18	-2.863	0.347
Tracks 634	-	29.37	27.66	2.324	1.914
Tracks 635	-	36.12	27.85	-2.173	0.881
Tracks 636	+	96.97	47.21	2.286	2.633
Tracks 643	-	58.49	32.36	-0.636	2.555
Tracks 655	-	12.49	8.29		
Tracks 657	-	13.39			
Tracks 664	+	10.52			
Tracks 667	-	7.87			
Tracks 669	+	22.48			
Tracks 673	+	9.86			
Tracks 675	-	9.28			

Name	Value
<input checked="" type="checkbox"/>  Pt	> 5.0 GeV
<input type="checkbox"/>  Pt2	< 700.0 MeV
<input checked="" type="checkbox"/>  d0	< 2.5 mm
<input checked="" type="checkbox"/>  z0	< 20.0 cm
<input type="checkbox"/>  d0 Loose	< 2.0 cm
<input type="checkbox"/>  z0-zVtx	< 2.5 mm



# Biranje prethodnog/sledećeg događaja

HYPATIA - Track Momenta Window

File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 33.441 GeV  $\varphi$ : 0.518 rad Collection: MET\_RefFinal

/Users/predram/Downloads/groupA/event021.xml

Tracks Physics Objects

Track	Charge	P [GeV]	Pt [GeV]	$\varphi$	$\theta$
Tracks 0			3.78	3.017	0.219
Tracks 7			4.82	3.088	0.736
Tracks 8		1.30	1.01	0.972	2.967
Tracks 9		1.30	1.29	2.753	1.442
Tracks 10	+	6.28	1.34	-0.133	2.927
Tracks 11	-	5.93	1.04	-0.829	2.966
Tracks 12	+	4.59	1.35	1.769	0.298
Tracks 13	+	6.48	2.11	0.257	0.332
Tracks 15	+	6.50	1.16	2.404	0.179
Tracks 17	+	6.19	2.52	0.122	2.722
Tracks 18	-	4.68	1.07	2.430	2.912
Tracks 19	+	3.53	1.26	1.626	2.777
Tracks 20	+	6.55	1.43	-1.504	0.219
Tracks 22	-	7.52	1.54	2.978	0.206
Tracks 24	+	2.28	2.28	-2.111	1.657
Tracks 26	+	12.72	2.55	-1.088	2.940
Tracks 27	-	6.60	1.50	1.665	2.912
Tracks 29	+	2.35	2.16	-2.994	1.163
Tracks 30	+	3.95	1.09	-0.813	2.863
Tracks 32	+	28.89	16.72	-3.081	0.617
Tracks 34	-	3.73	1.86	1.054	2.620
Tracks 35	+	4.01	1.30	2.397	2.813

Biranje prethodnog ili sledećeg događaja

# Selekcija rekonstruisanih objekata

HYPATIA - Track Momenta Window

File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 33.441 GeV  $\varphi$ : 0.518 rad Collection: MET\_RefFinal

/Users/predragm/Downloads/groupA/event021.xml

Tracks Physics Objects

Track	+			$\varphi$	$\theta$
Tracks 0	-			3.017	0.219
Tracks 7	-			3.088	0.736
Tracks 8	+	5.8		0.972	2.967
Tracks 9	+	1.30		2.753	1.442
Tracks 10	+	6.28	1.34	-0.133	2.927
Tracks 11	-	5.93	1.04	-0.829	2.966
Tracks 12	+	4.59	1.35	1.769	0.298
Tracks 13	+	6.48	2.11	0.257	0.332
Tracks 15	+	6.50	1.16	2.404	0.179
Tracks 17	+	6.19	2.52	0.122	2.722
Tracks 18	-	4.68	1.07	2.430	2.912
Tracks 19	+	3.53	1.26	1.626	2.777
Tracks 20	+	6.55	1.43	-1.504	0.219
Tracks 22	-	7.52	1.54	2.978	0.206
Tracks 24	+	2.28	2.28	-2.111	1.657
Tracks 26	+	12.72	2.55	-1.088	2.940
Tracks 27	-	6.60	1.50	1.665	2.912
Tracks 29	+	2.35	2.16	-2.994	1.163
Tracks 30	+	3.95	1.09	-0.813	2.863
Tracks 32	+	28.89	16.72	-3.081	0.617
Tracks 34	-	3.73	1.86	1.054	2.620
Tracks 35	+	4.01	1.30	2.397	2.813

Selekcija rekonstruisanih elektrona i miona

# Brisanje selektovanih objekata

HYPATIA - Track Momenta Window

File Previous Event Next Event Electron Muon Photon Delete Track Reset Canvas

ETMis: 33.441 GeV  $\varphi$ : 0.518 rad Collection: MET\_Reffinal

/Users/predragm/Downloads/groupA/event021.xml

Tracks Physics Objects

Track	+/-	P [GeV]	Pt [GeV]	$\theta$
Tracks 0	-	17.40	3.78	1.9
Tracks 7	-	7.18	4.82	1.736
Tracks 8	+	5.84	1.01	2.967
Tracks 9	+	1.30	1.29	2.753
Tracks 10	+	6.28	1.34	-0.133
Tracks 11	-	5.93	1.04	-0.829
Tracks 12	+	4.59	1.35	1.769
Tracks 13	+	6.48	2.11	0.257
Tracks 15	+	6.50	1.16	2.404
Tracks 17	+	6.19	2.52	0.122
Tracks 18	-	4.68	1.07	2.430
Tracks 19	+	3.53	1.26	1.626
Tracks 20	+	6.55	1.43	-1.504
Tracks 22	-	7.52	1.54	2.978
Tracks 24	+	2.28	2.28	-2.111
Tracks 26	+	12.72	2.55	-1.088
Tracks 27	-	6.60	1.50	1.665
Tracks 29	+	2.35	2.16	-2.994
Tracks 30	+	3.95	1.09	-0.813
Tracks 32	+	28.89	16.72	-3.081
Tracks 34	-	3.73	1.86	1.054
Tracks 35	+	4.01	1.30	2.397

Brisanje selektovanih objekata iz liste

# Selekcija rekonstruisanih fotona

File   ←   →   e   μ   γ   X   ↔

Previous Event   Next Event   Electron   Muon   Photon   Delete Track   Reset Canvas

ETMis: 33.441 GeV   φ: 0.518 rad   Collection: MET\_RefFinal

/Users/predragm/Downloads/groupA/event021.xml

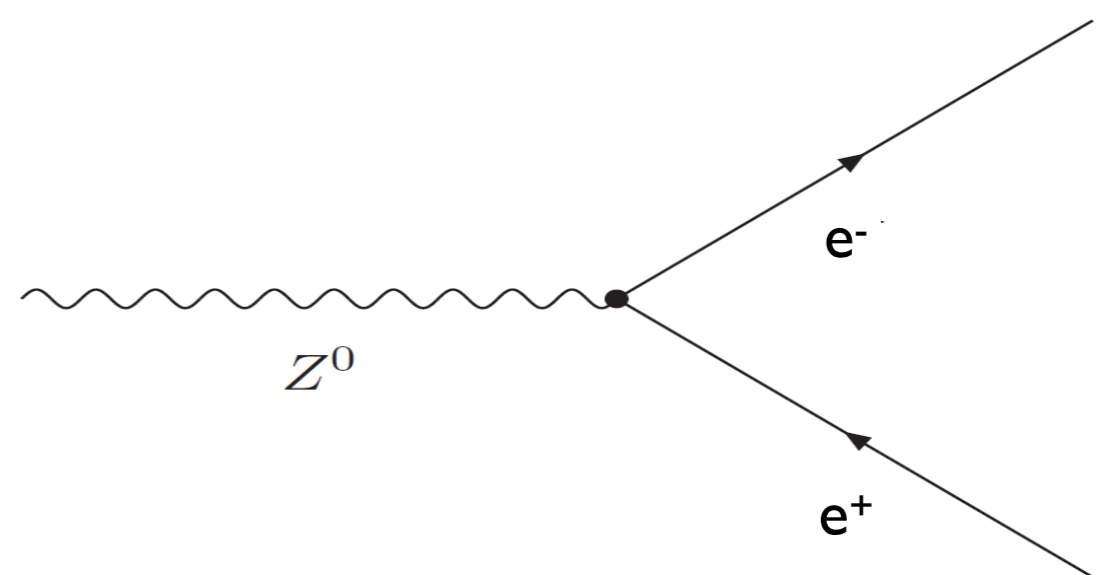
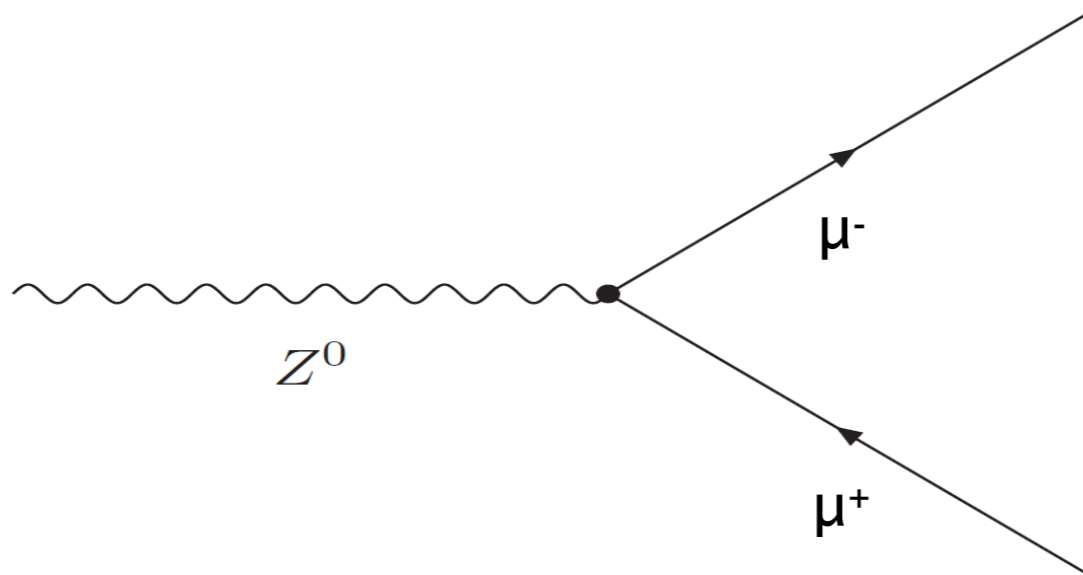
Tracks   **Physics Objects**

Track	P [GeV]	Pt [GeV]	φ	θ
Object 0	191.71	57.84	0.372	0.268
Object 1	32.13	31.11	-1.763	1.745

**Selekcija rekonstruisanih fotona**

# Detekcija $Z^0$ bozona

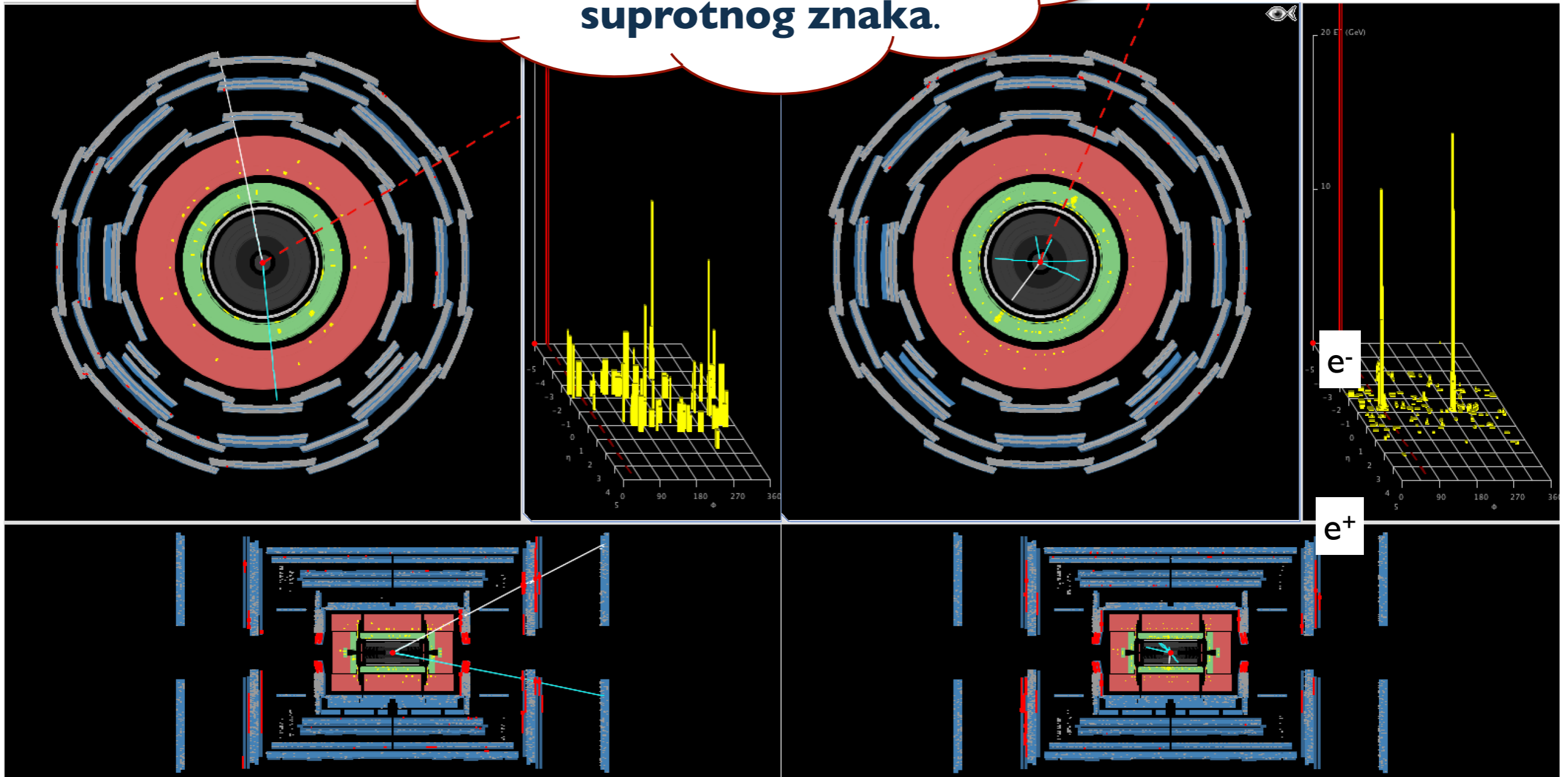
$Z^0 \rightarrow \mu^+ \mu^-$ ,  $Z^0 \rightarrow e^+ e^-$   
Zapis u detektoru sadrži jedan  
**par miona ili elektrona**  
**suprotnog znaka.**



# Detekcija $Z^0$ bozona

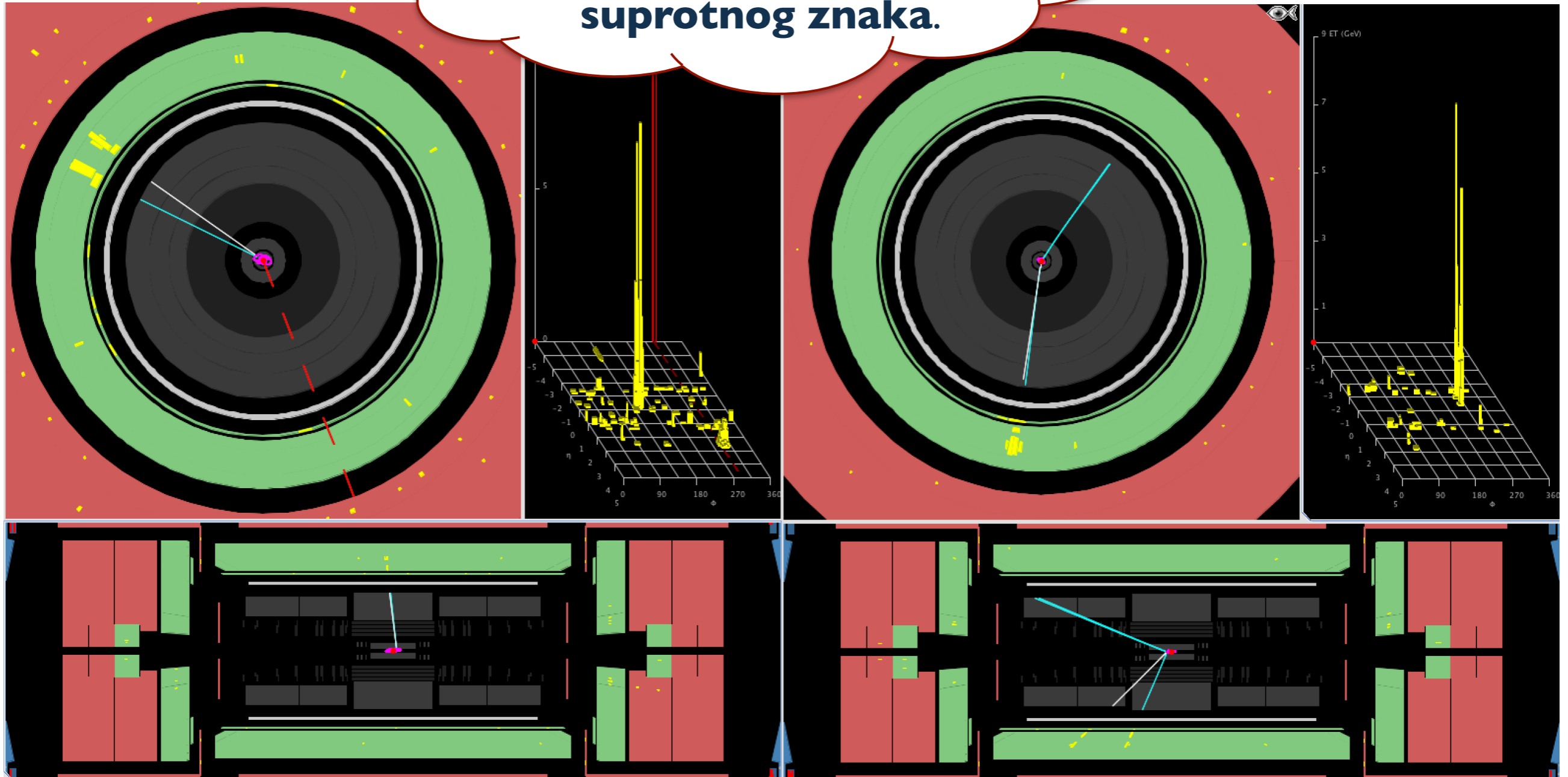
$$Z^0 \rightarrow \mu^+ \mu^-, Z^0 \rightarrow e^+ e^-$$

Zapis u detektoru sadrži jedan par miona ili elektrona suprotnog znaka.



# Detekcija J/ψ and γ mezona

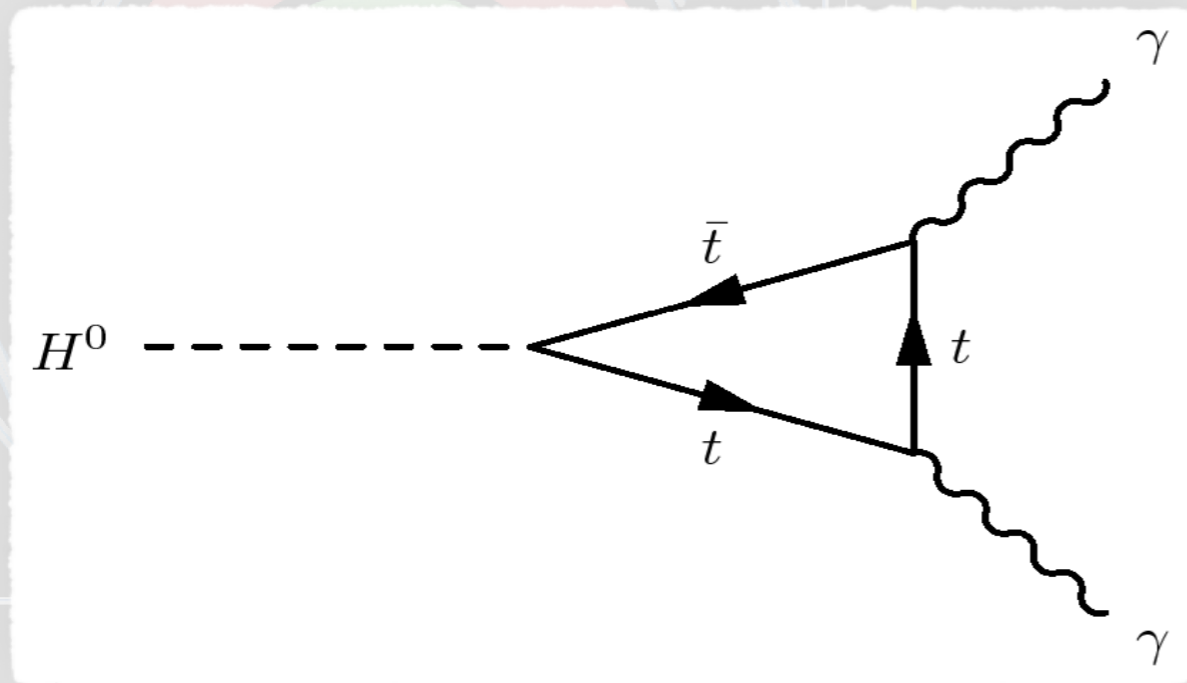
$J/\psi^0 \rightarrow \mu^+ \mu^-$ ,  $\Upsilon^0 \rightarrow e^+ e^-$   
Zapis u detektoru sadrži jedan  
**par miona ili elektrona**  
**suprotnog znaka.**



# Detekcija $H^0$ bozona

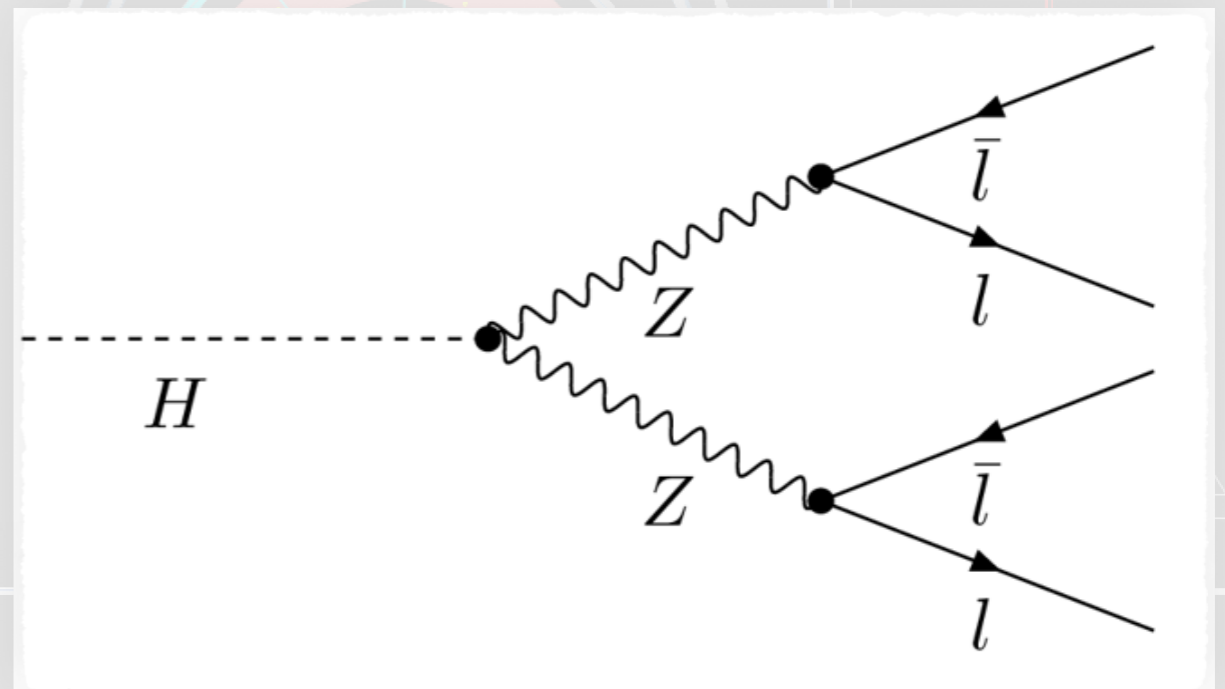
$$H^0 \rightarrow \gamma\gamma$$

Zapis u detektoru sadrži  
jedan para fotona.



$$H^0 \rightarrow Z^0 Z^0 \rightarrow 4 \text{ leptona}$$

Zapis u detektoru sadrži **dva**  
**para miona ili elektrona.**

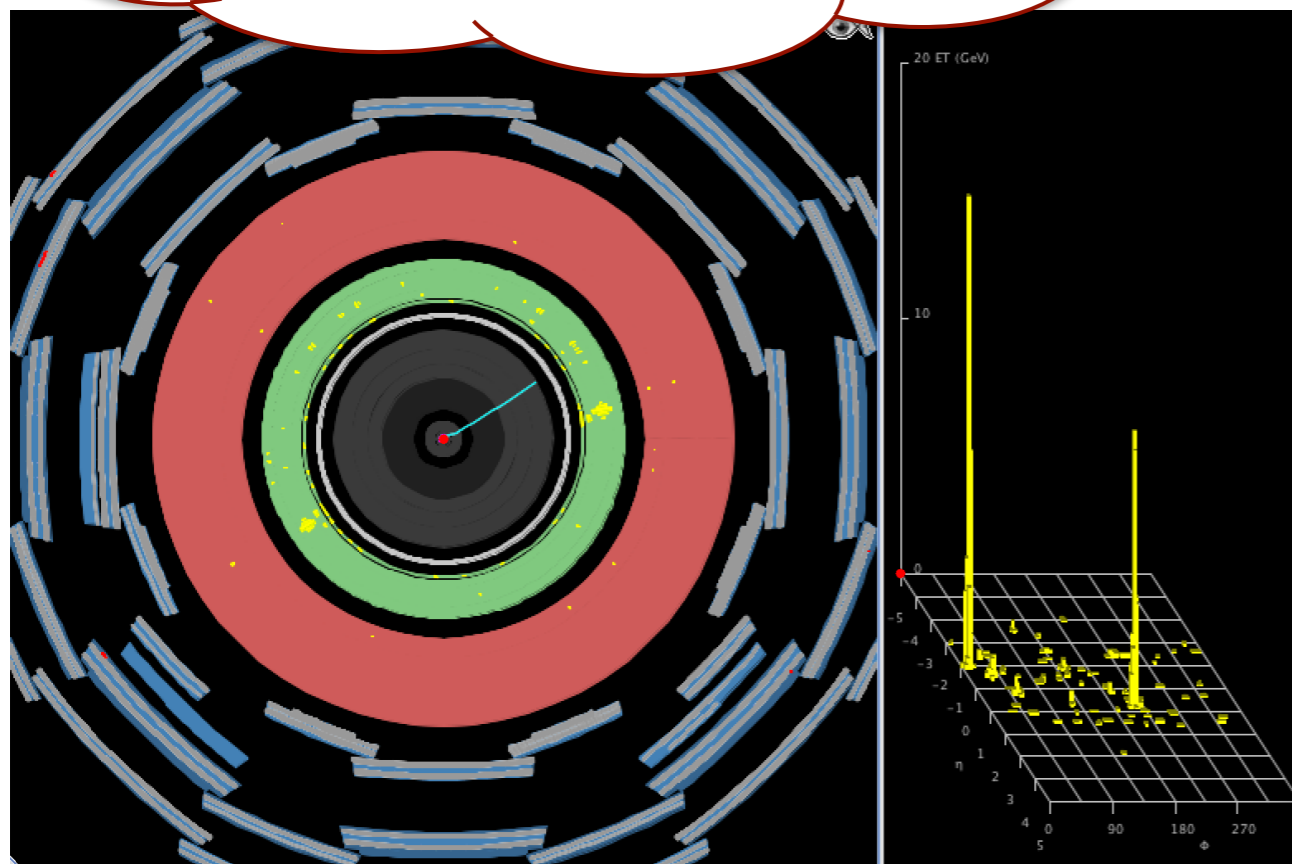




# Detekcija $H^0$ bozona

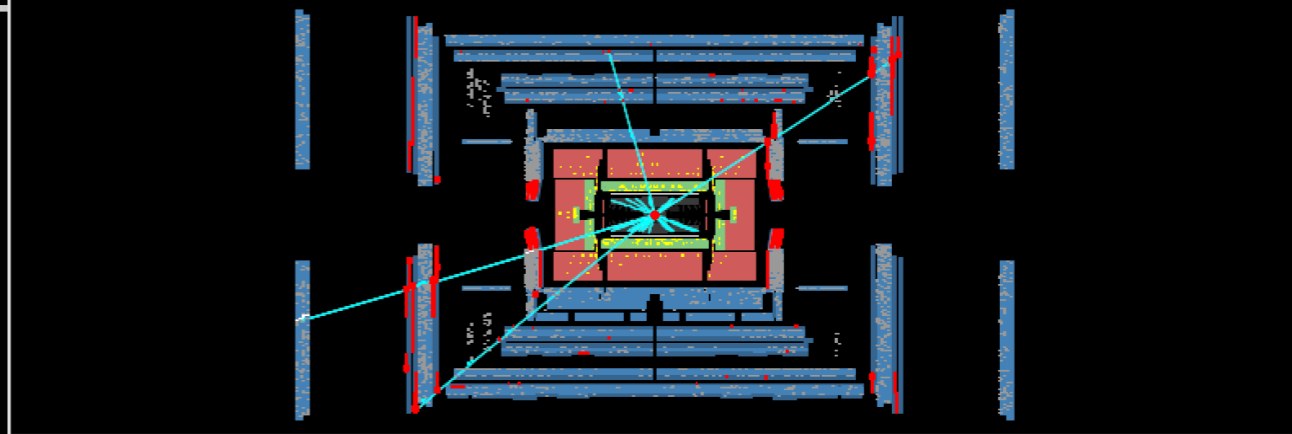
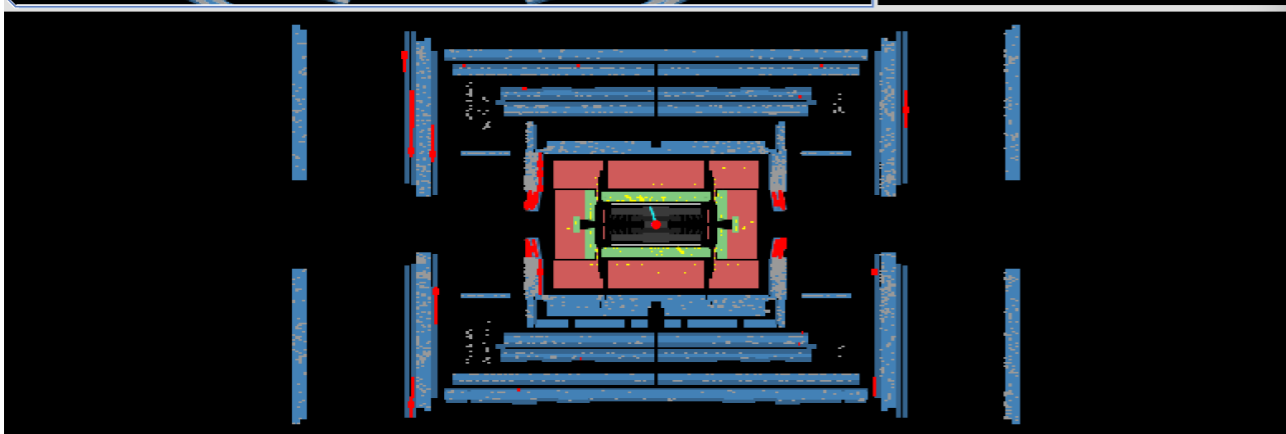
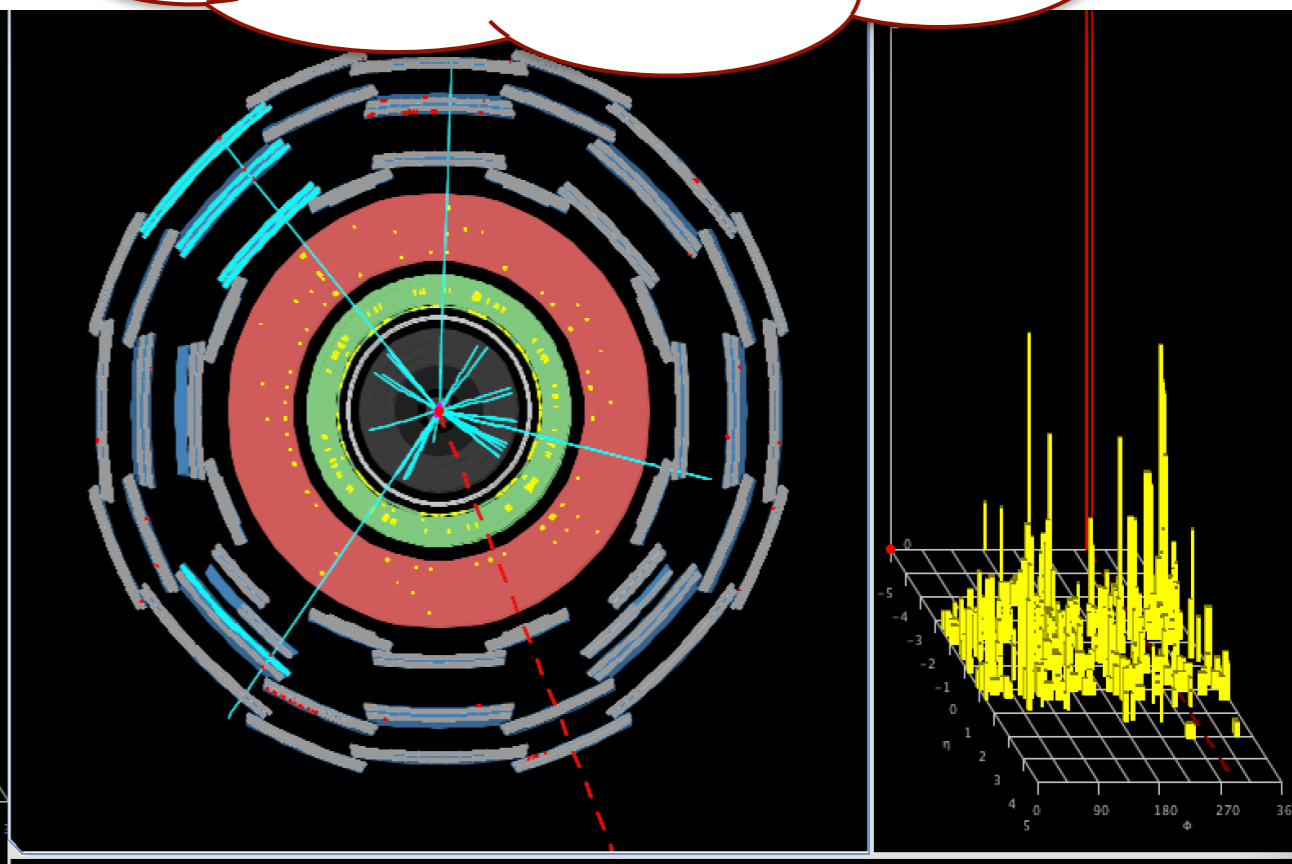
$$H^0 \rightarrow \gamma\gamma$$

Zapis u detektoru sadrži jedan para fotona.



$$H^0 \rightarrow Z^0 Z^0 \rightarrow 4 \text{ leptona}$$

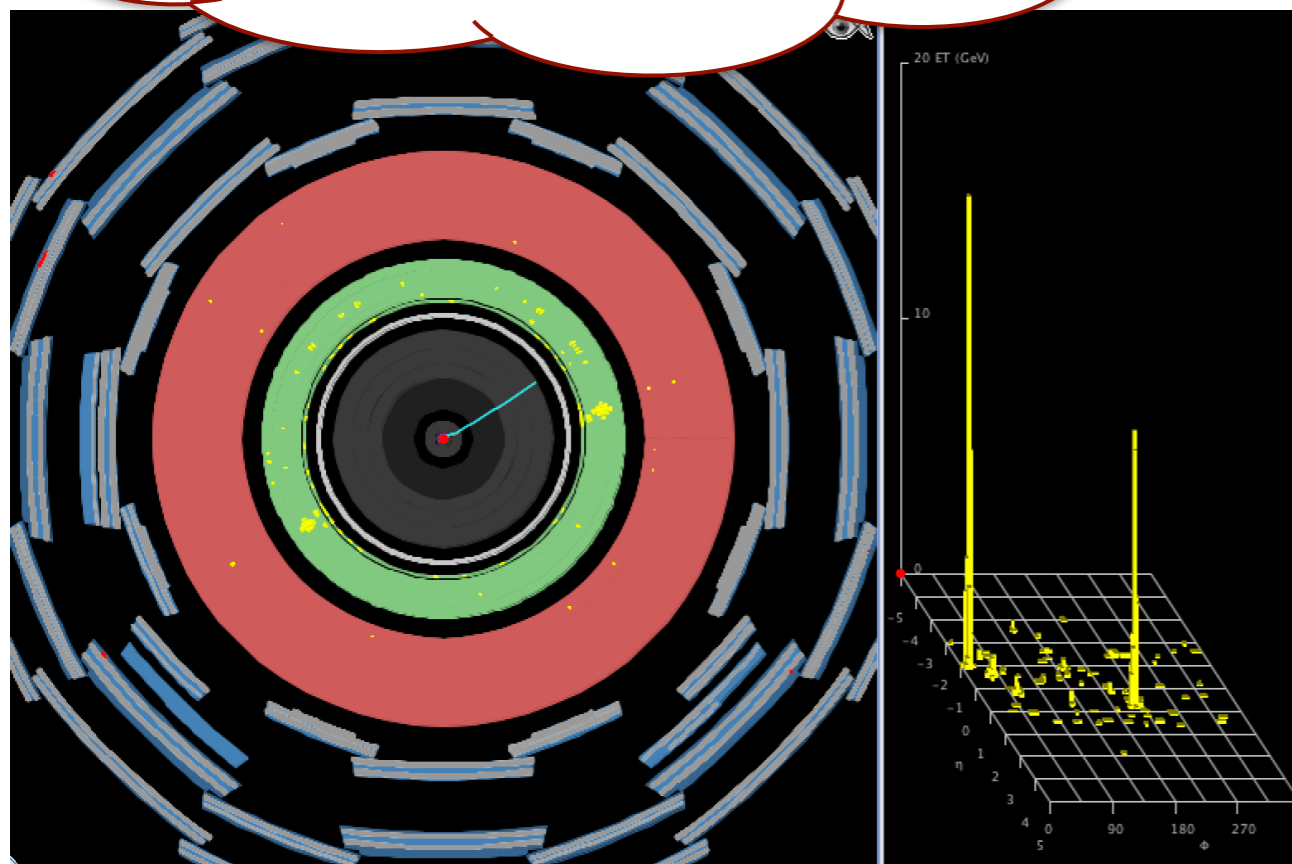
Zapis u detektoru sadrži dva para miona ili elektrona.



# Detekcija $H^0$ bozona

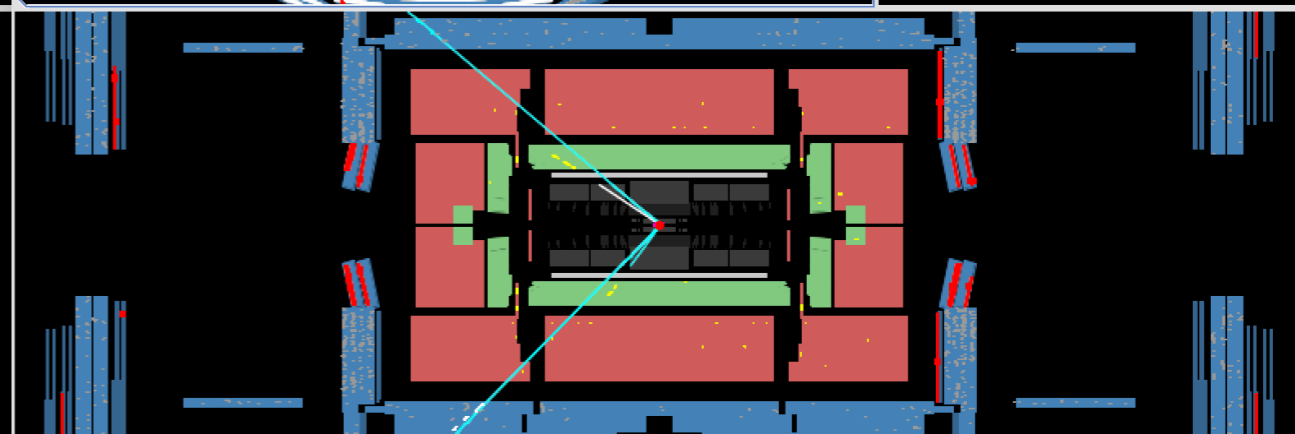
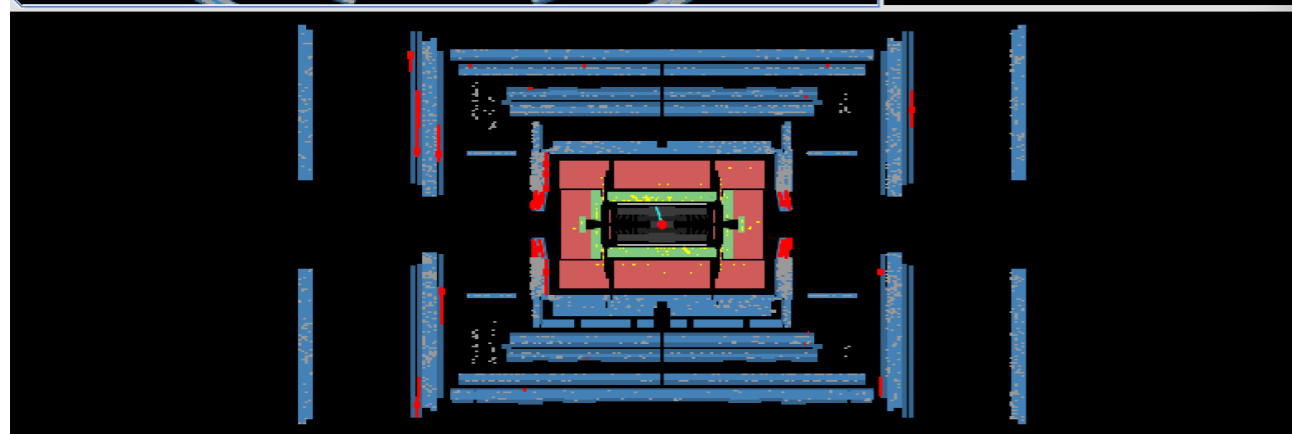
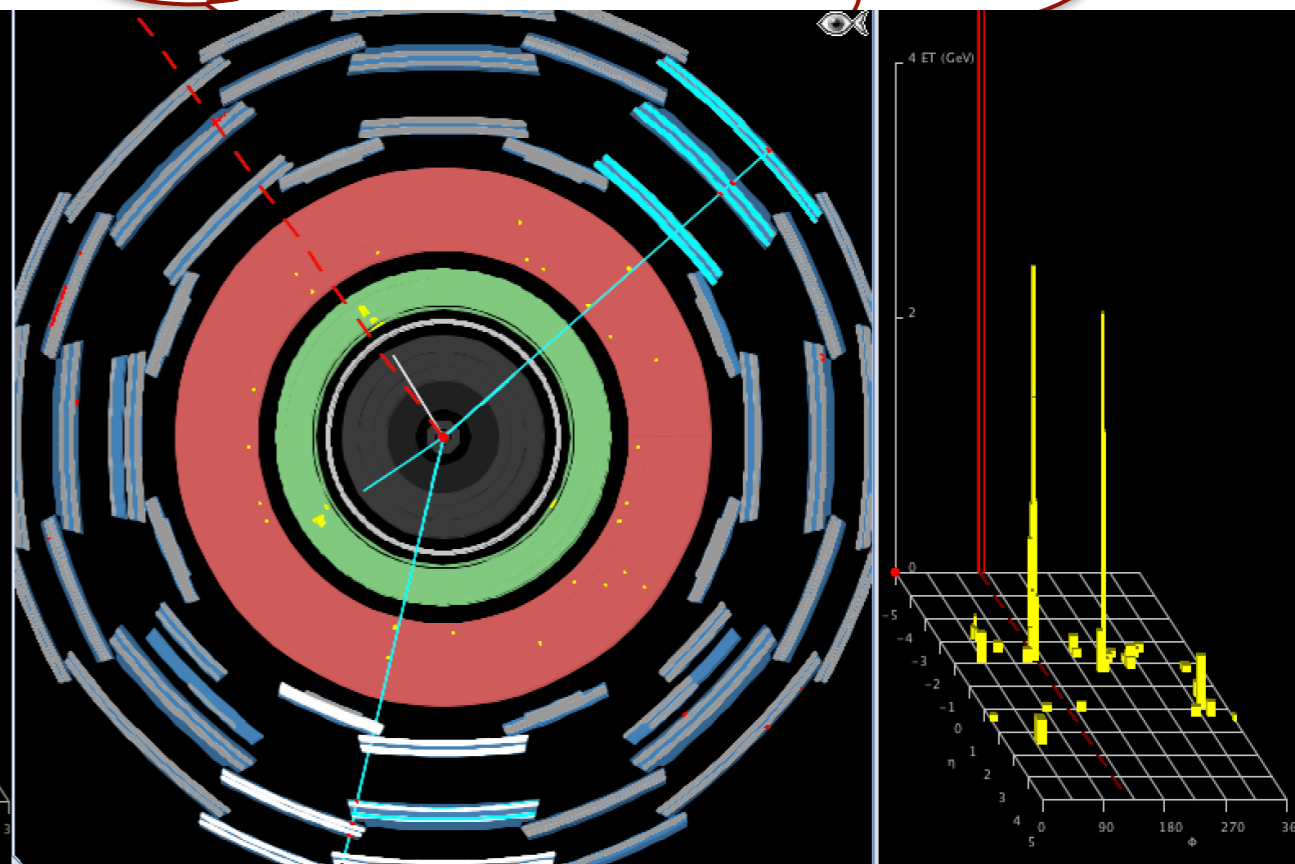
$$H^0 \rightarrow \gamma\gamma$$

Zapis u detektoru sadrži jedan para fotona.



$$H^0 \rightarrow Z^0 Z^0 \rightarrow 4 \text{ leptona}$$

Zapis u detektoru sadrži dva para miona ili elektrona.



# Čuvanje rezultata - invarijantne mase

Hybrid pupils' analysis tool for interactions in ATLAS - version 7.2.1 - Invariant Mass Window

File View Histograms Preferences Help

Read Event Locally  
 Read Event From URL (live)  
 Clear Hypatia Project  
 Load Hypatia Project  
 Save Hypatia Project  
**Export Invariant Masses (MII)**  
 Loop over events  
 Save Image of Canvas  
 Animated Event  
 Event Properties  
 Read Geometry  
 Read G4Steps  
 Exit

ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	$\varphi$	$\eta$	M(2l) [GeV]	M(4l) [GeV]	e/ $\mu$
9.980	Tracks 2	6.9	+	2.5	1.917	1.662	13.167		e
	Tracks 5	6.7	-	1.2	3.127	-2.391			e
	Tracks 4	5.8	+	1.0	-2.037	2.401	6.195		$\mu$
	Tracks 8	1.9	-	1.1	-2.995	-1.136			$\mu$
28.772	Tracks 6	3.9	+	3.8	-2.674	0.147	8.274		e
	Tracks 10	7.5	+	2.4	1.902	-1.796			e

Previous Event Next Event Insert Electron Insert Muon Delete Track Reset Canvas  
 ETMis: 23.276 GeV  $\varphi$ : -2.006 rad Collection: MET\_Reffinal  
 /Users/nenadv/Downloads/groupA-1/event006.xml

Reconstructed Tracks

Track	+/-	P [GeV]	Pt [GeV]	$\varphi$	$\theta$
s 1	+	117.38	42.10	1.169	2.775
s 2	+	12.75	2.50	-0.965	2.944
s 3	+	4.28	1.25	-2.531	2.846
s 4	-	17.94	6.68	1.240	2.760
s 5	+	3.35	1.19	1.057	2.777
s 6	+	3.87	3.83	-2.674	1.425
s 8	-	7.01	6.92	-2.596	1.414
s 9	+	8.62	3.61	-1.861	0.431
s 10	+	7.48	2.42	1.902	2.813
s 11	+	3.03	2.10	-0.237	0.763
s 13	-	1.69	1.23	-1.888	2.327
s 14	-	5.29	2.45	-1.734	0.482
s 15	-	3.90	1.80	-1.566	0.480
s 17	+	3.54	1.30	-1.211	2.766
s 18	-	9.05	2.99	2.147	2.805
s 20	-	6.17	1.06	-1.262	0.173
s 23	-	1.07	1.06	-2.187	1.419
s 24	-	11.34	11.20	-2.706	1.415
s 25	-	5.19	1.33	1.715	2.882
s 29	+	9.95	1.75	0.060	0.176
s 31	+	3.40	1.60	-0.837	0.489
s 34	+	1.34	1.32	2.876	1.416
s 36	+	8.72	3.71	0.804	0.439
s 39	-	24.27	8.30	1.160	2.793
s 41	+	2.17	2.17	-2.828	1.623
s 44	+	1.80	1.77	2.560	1.384
s 46	-	3.64	2.05	0.331	2.543

HYPATIA - Control Window  
 meter Control Interaction and Window Control Output Display  
 Event Data  
 W S X LMR 1123 U 13  
 B 456 C 6  
 B 789 D 9

# Konačni rezultati

## OPlOT – MasterClass – Student page

Start Student Moderator Tutor Administrator

### Student Tasks

Please select items from the drop-down boxes to submit your results!

2019 ▾ November ▾ 28 ▾ Introductory Masterclasses for IPPOGers and CERNois ▾ 1 ▾

✓ Group letter

A  
B  
C  
D  
E  
F  
G  
H  
I  
J  
K  
L  
M  
N  
O  
P  
Q  
R  
S  
T

**Sačuvajte podatke pod imenom vaše grupe (A, B, C...), i submit-ujte ih na:**  
**<http://cernmasterclass.uio.no/OPlOT/>**

# Konačni rezultati

## OPlot – MasterClass – Student page

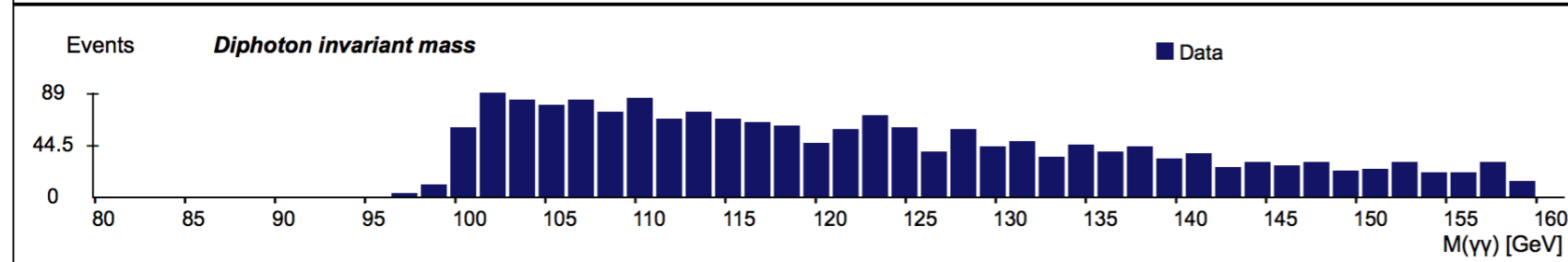
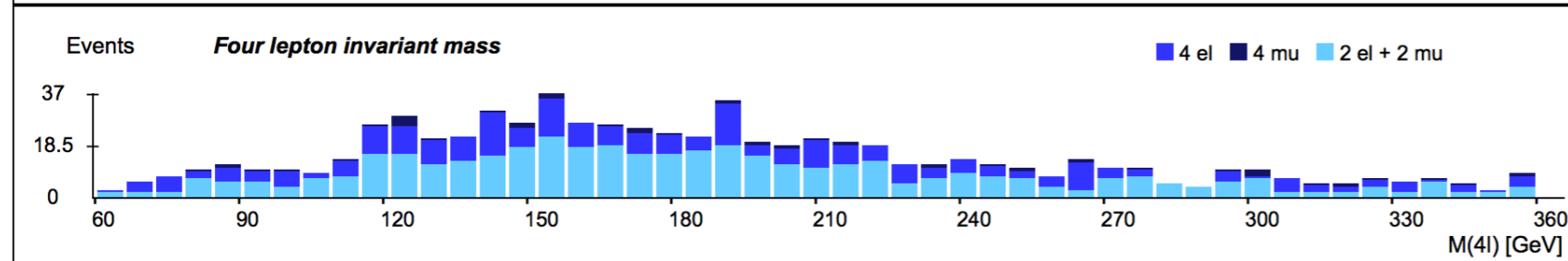
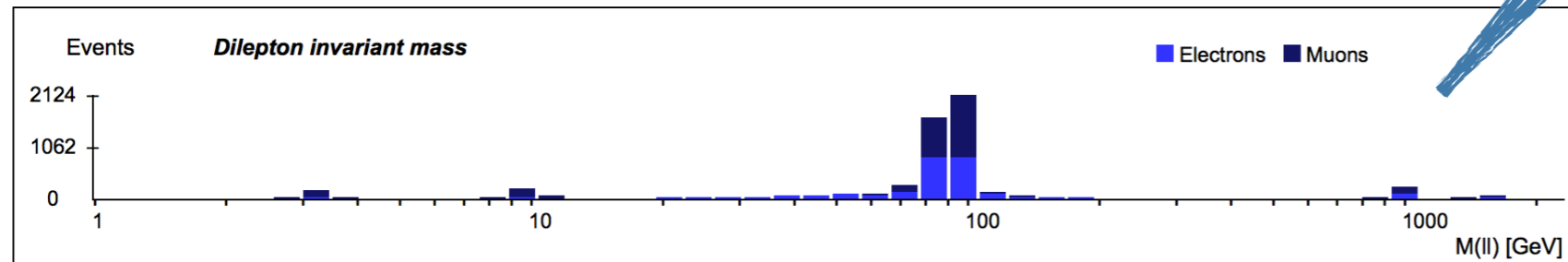
Start Student Moderator Tutor Administrator

### Student Tasks

Please select items from the drop-down boxes to submit your results!

distribucije invariantnih masa svih analiziranih događaja

2019 ▾ November ▾ 28 ▾ Introductory Masterclasses for IPPOGers and CERNOis ▾  
▾ ✓ Group letter  
A



Bins: 50 ▾

Update plot

Reset

Plot type:

ll+4l+γγ overview ▾

Dilepton statistics

Region	Electrons				
	R1	R2	R3	R4	R5
Events	132	148	1599	142	53
Mean	3.02	9.72	89.74	991.79	1,491.61
Width	0.53	1.30	3.80	36.43	17.98

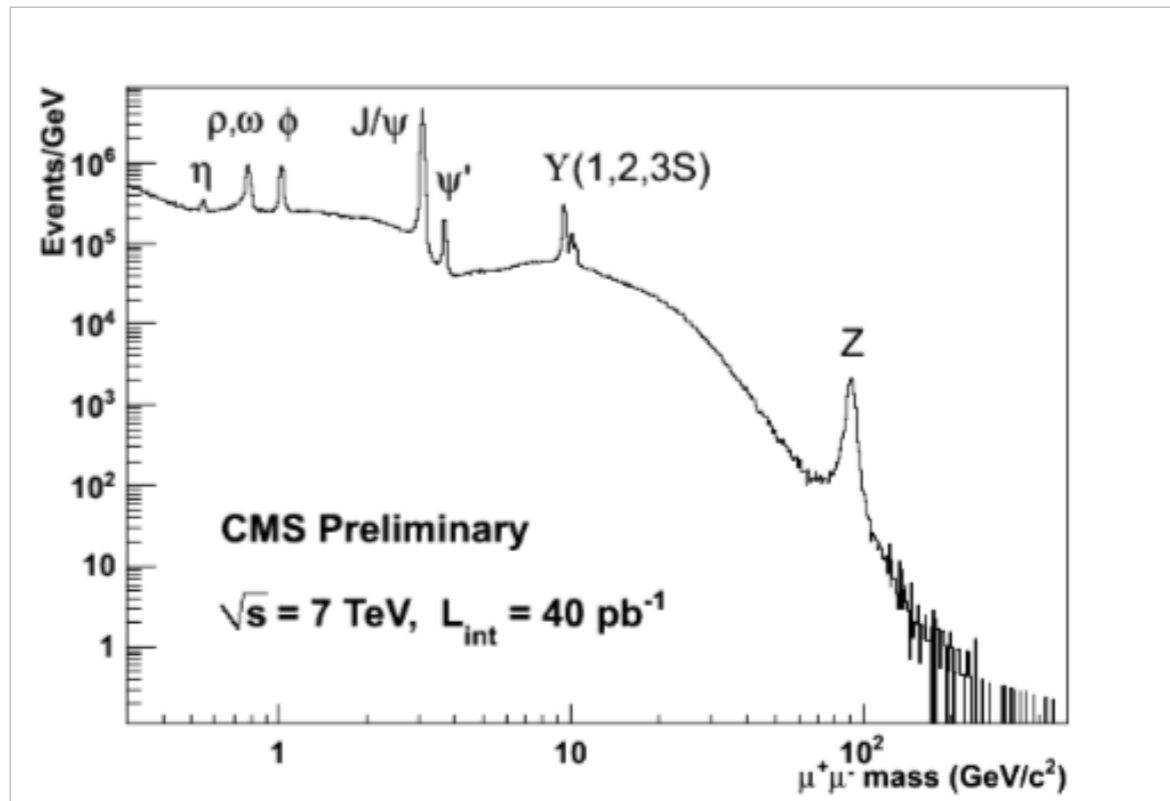
Region	Muons				
	R1	R2	R3	R4	R5
Events	175	218	1996	150	39
Mean	3.07	9.90	90.56	993.71	1,487.66
Width	0.28	0.72	3.52	48.41	56.27

Number of events

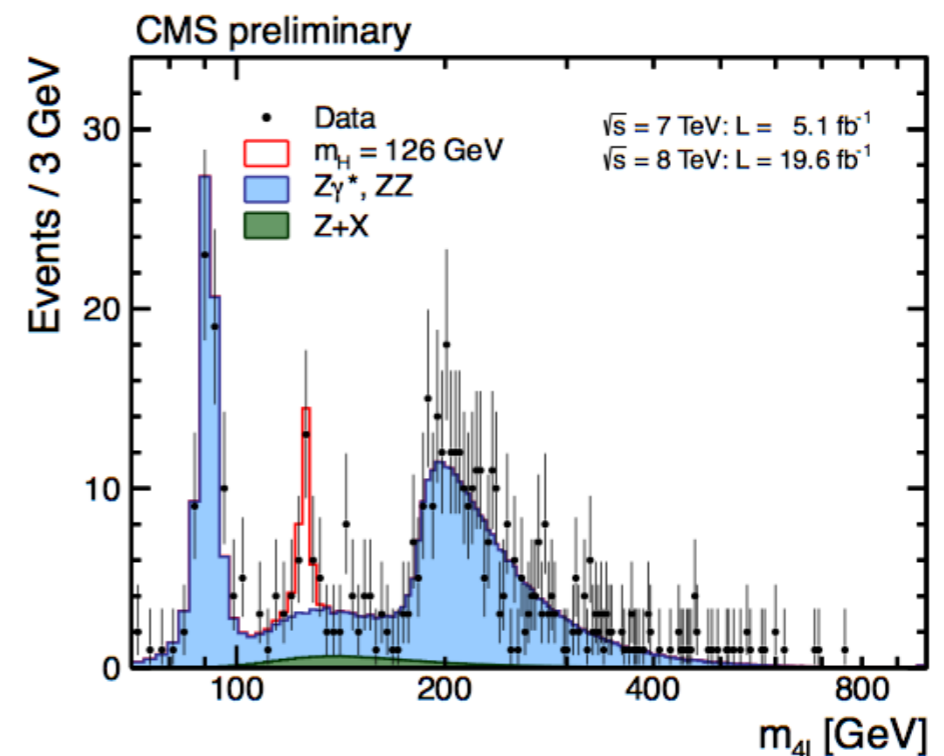
	Student distribution Expected	
	ll	4l
ll	6682	6468
4l	972	40
γγ	1919	2985
Sum	9573	9493

# Maseni spektar za jedan ili dva $Z^0$ bozona

Masesni spektar J/Psi i Y mezona,  $Z^0$  bozona i mnogih drugih čestica



Masesni spektar za par  $Z^0Z^0$  bozona



**Kreirajte i vi histogram invarijantne mase za vaše događaje!**

**Mozda ćete baš vi imati sreće da pronađete događaje koji su potencijalno raspadi Higgs bozona na par fotona ili par  $Z^0Z^0$  bozona!**



**Nadamo se da čete uživati i da čete se dobro zabaviti!**

Run: 204153  
Event: 35369265  
2012-05-30 20:31:28 CEST