

Detekcija elementarnih čestica i analiza događaja

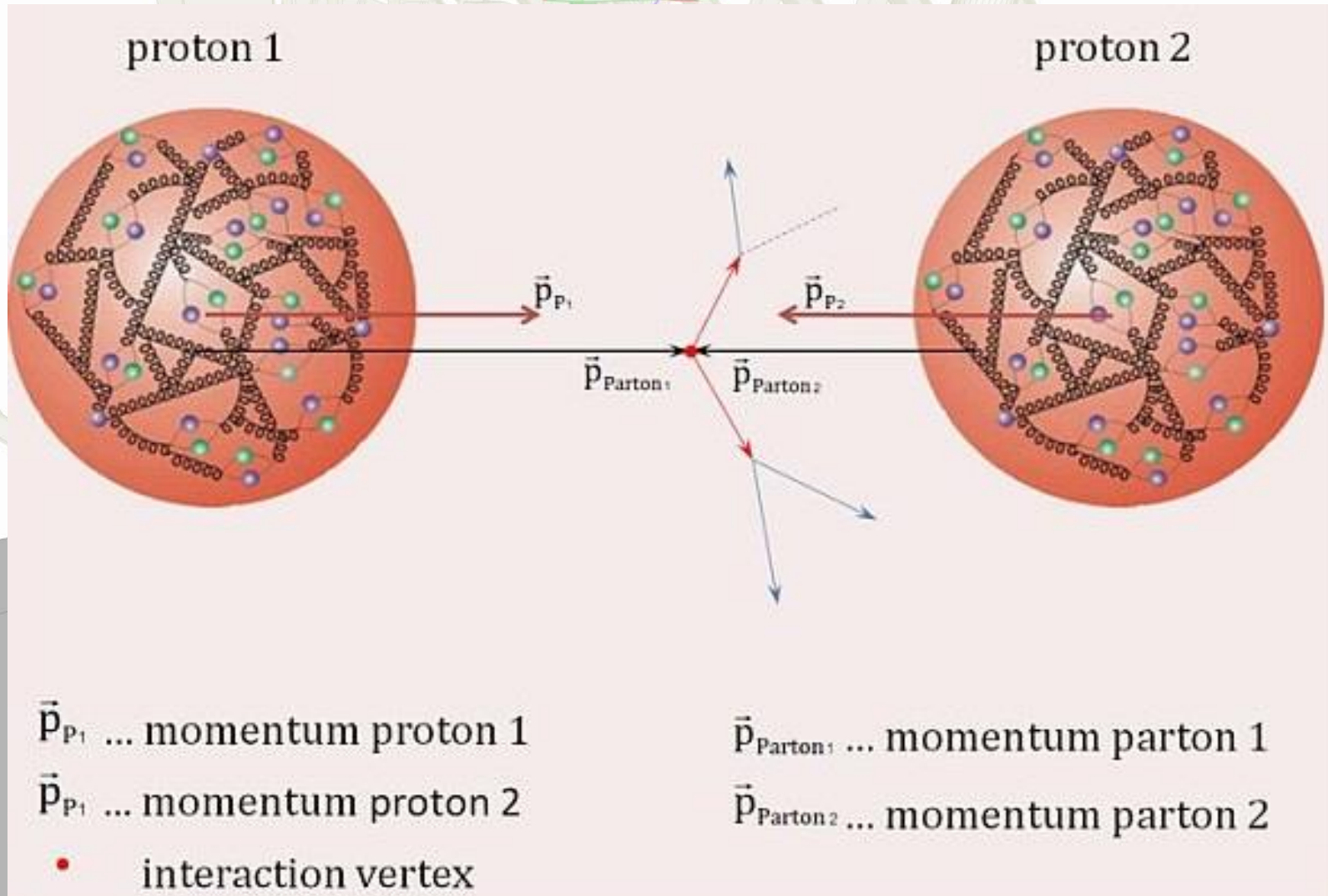
Serbian Teachers Program



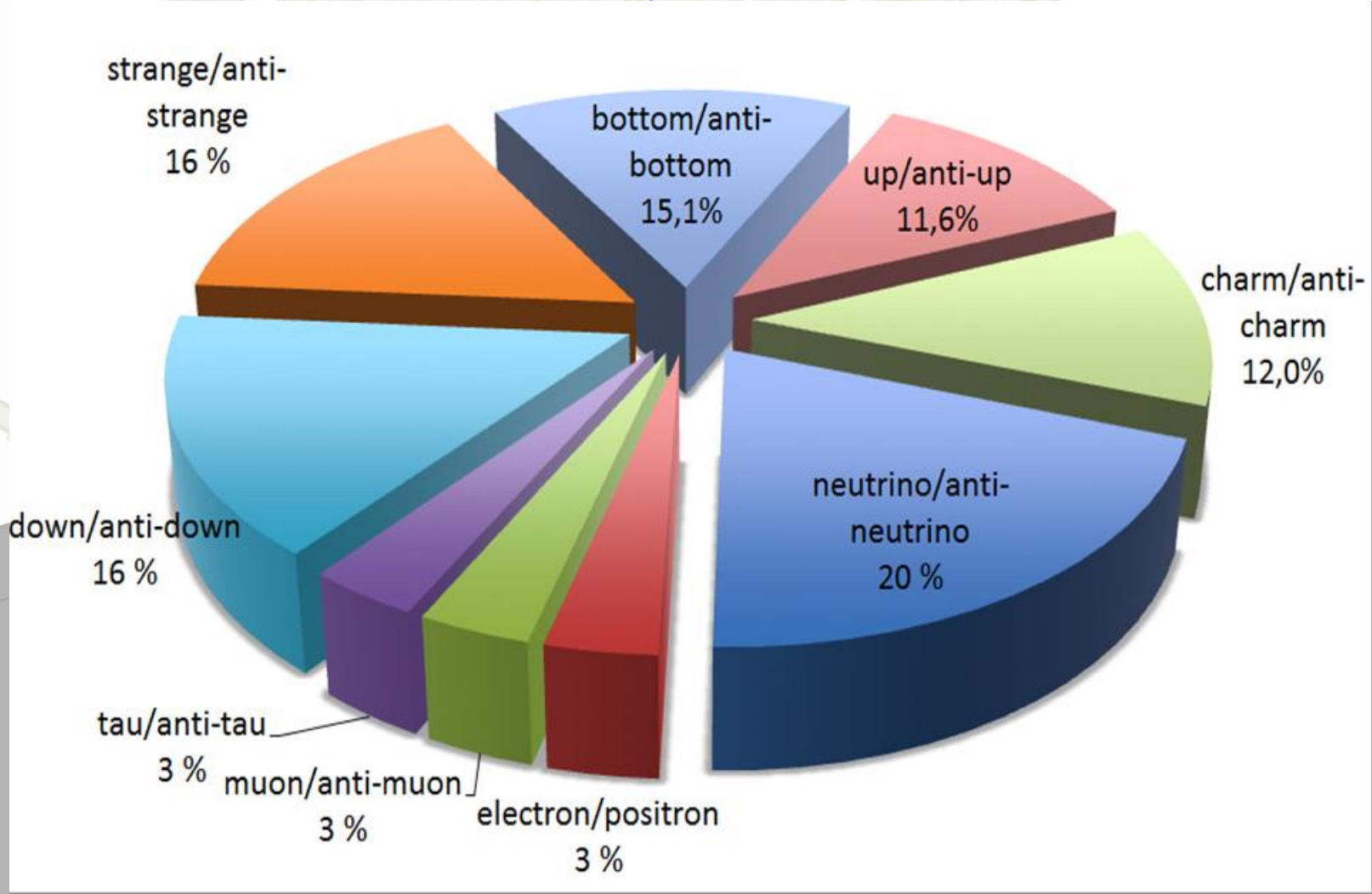
Danijela Bogavac
Institut za fiziku Beograd
CERN, August 4-11, 2015



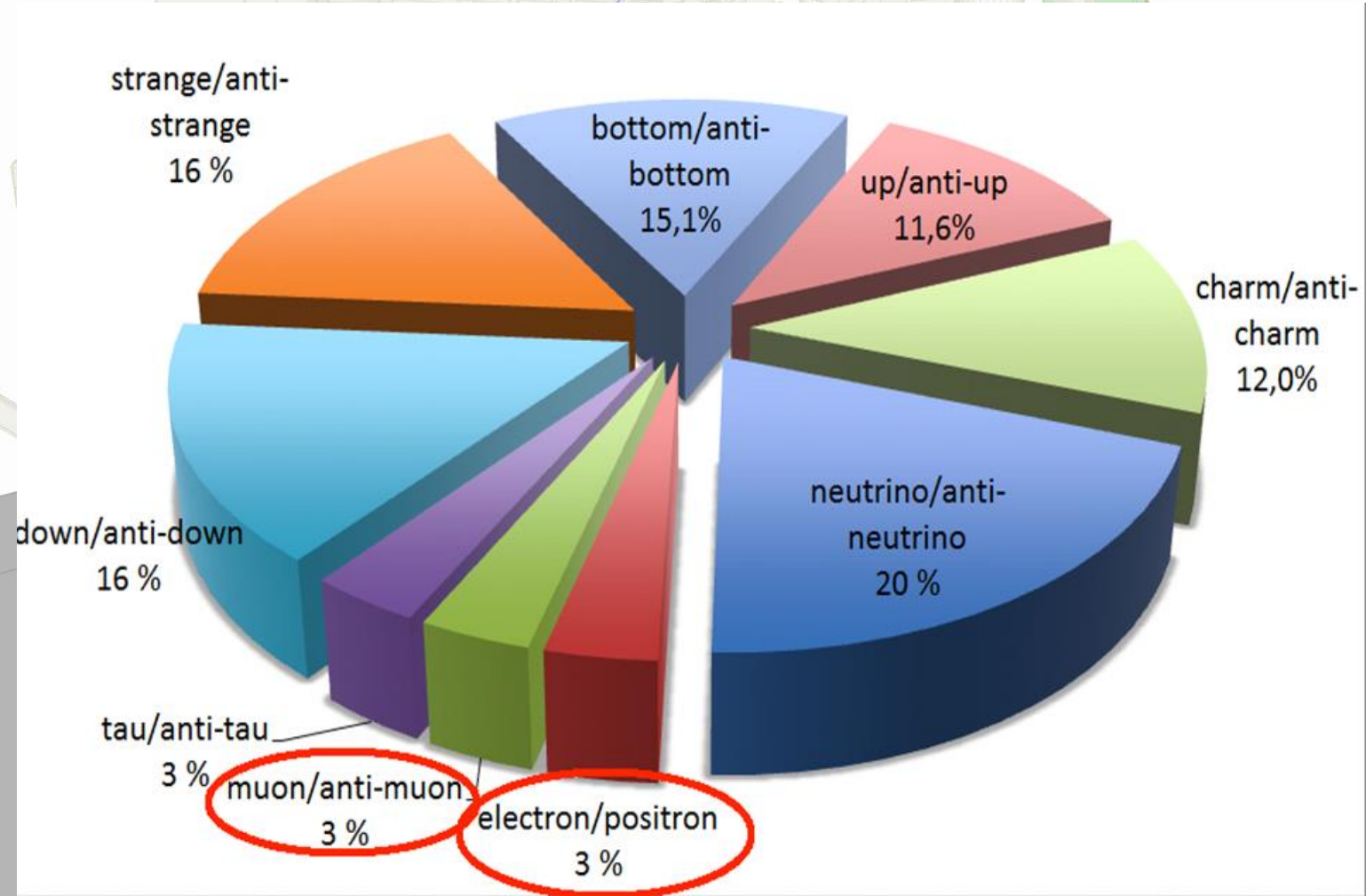
PROTON – PROTON SUDARI



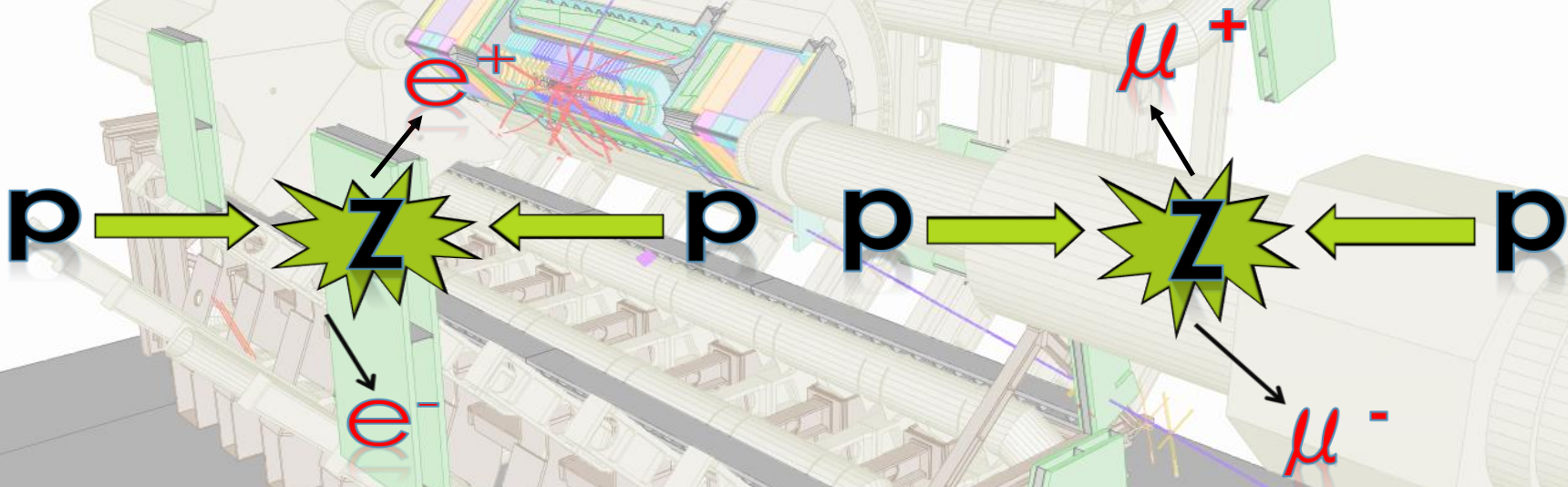
Z 0 bozon



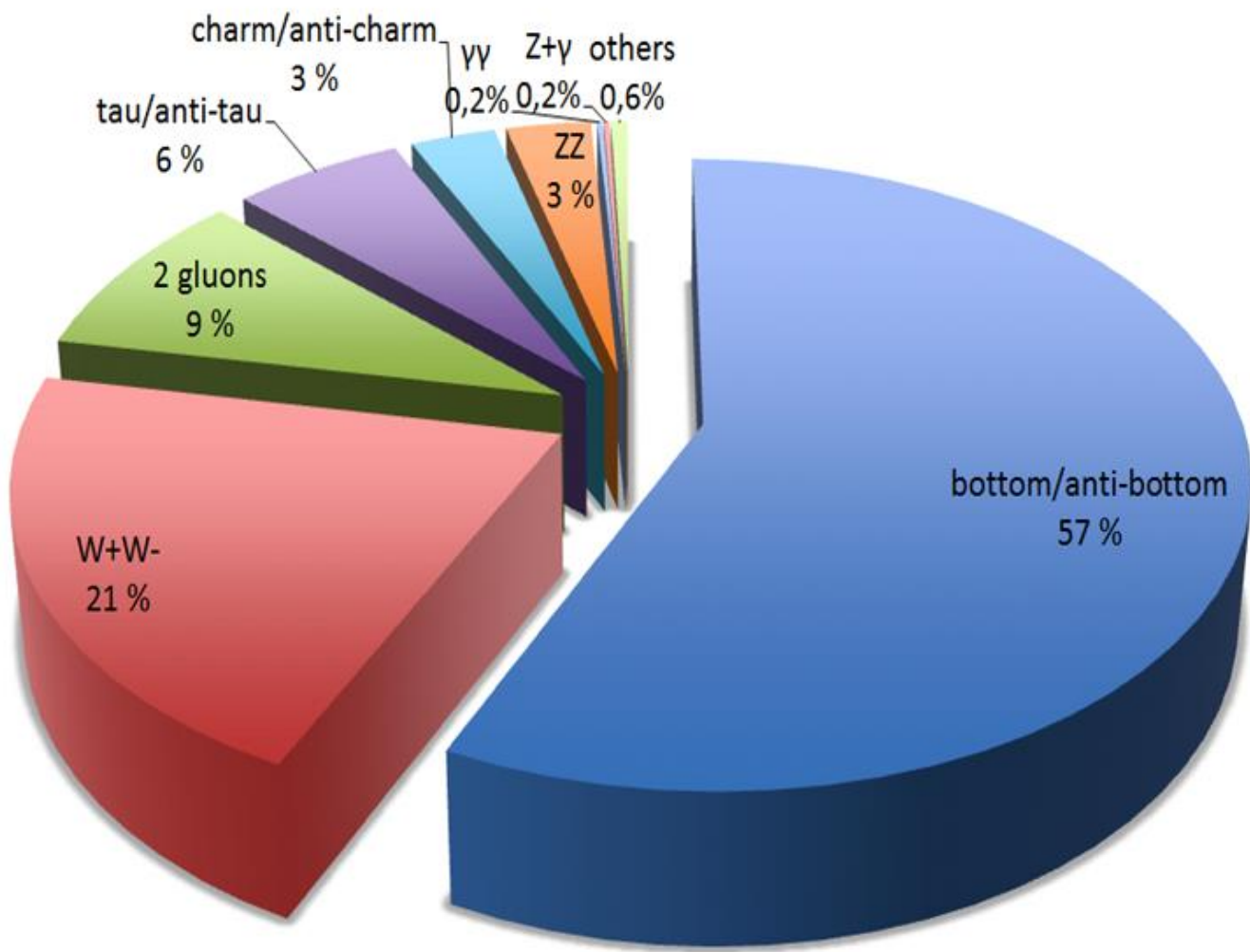
Raspad Z 0 bozona



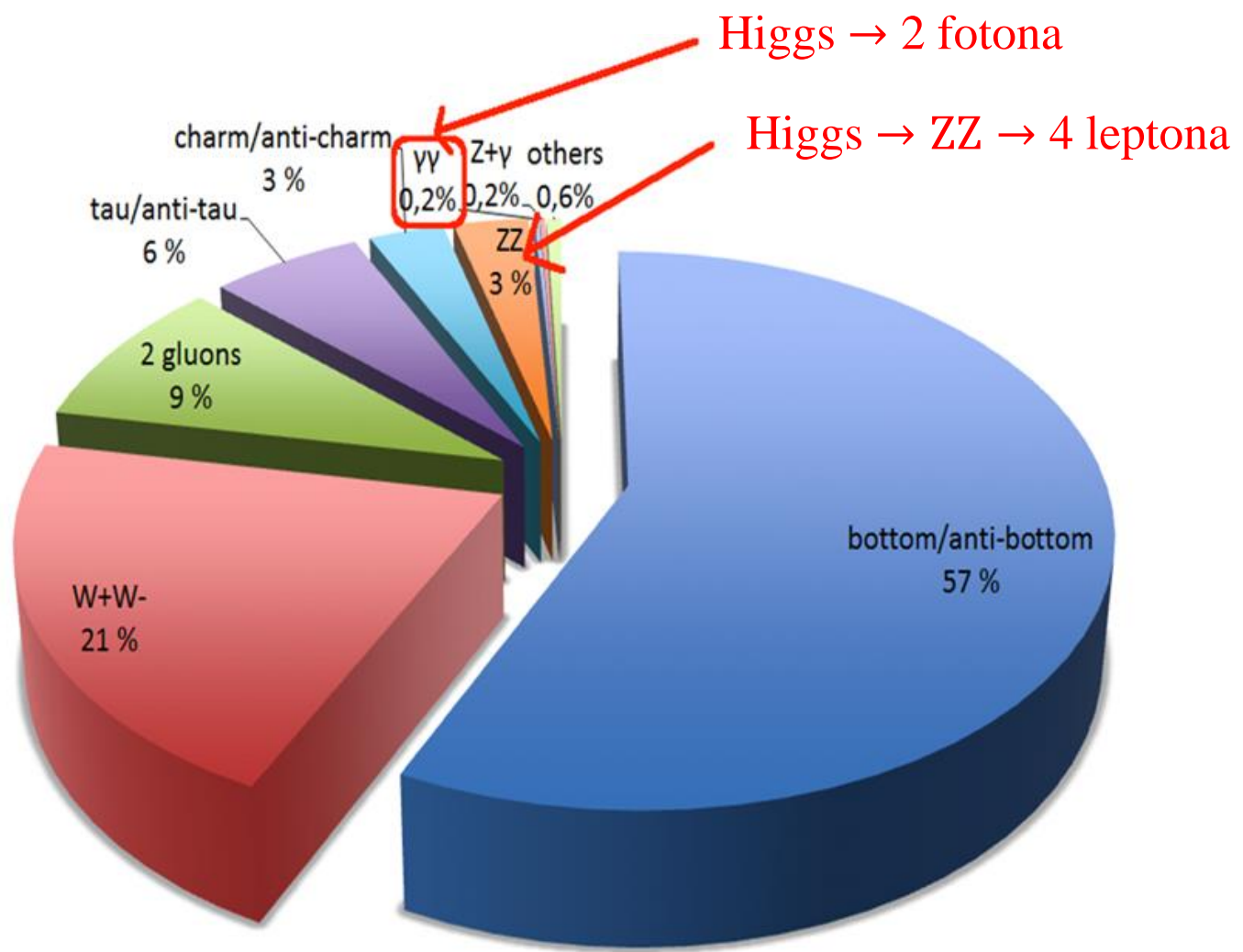
Z 0 bozon



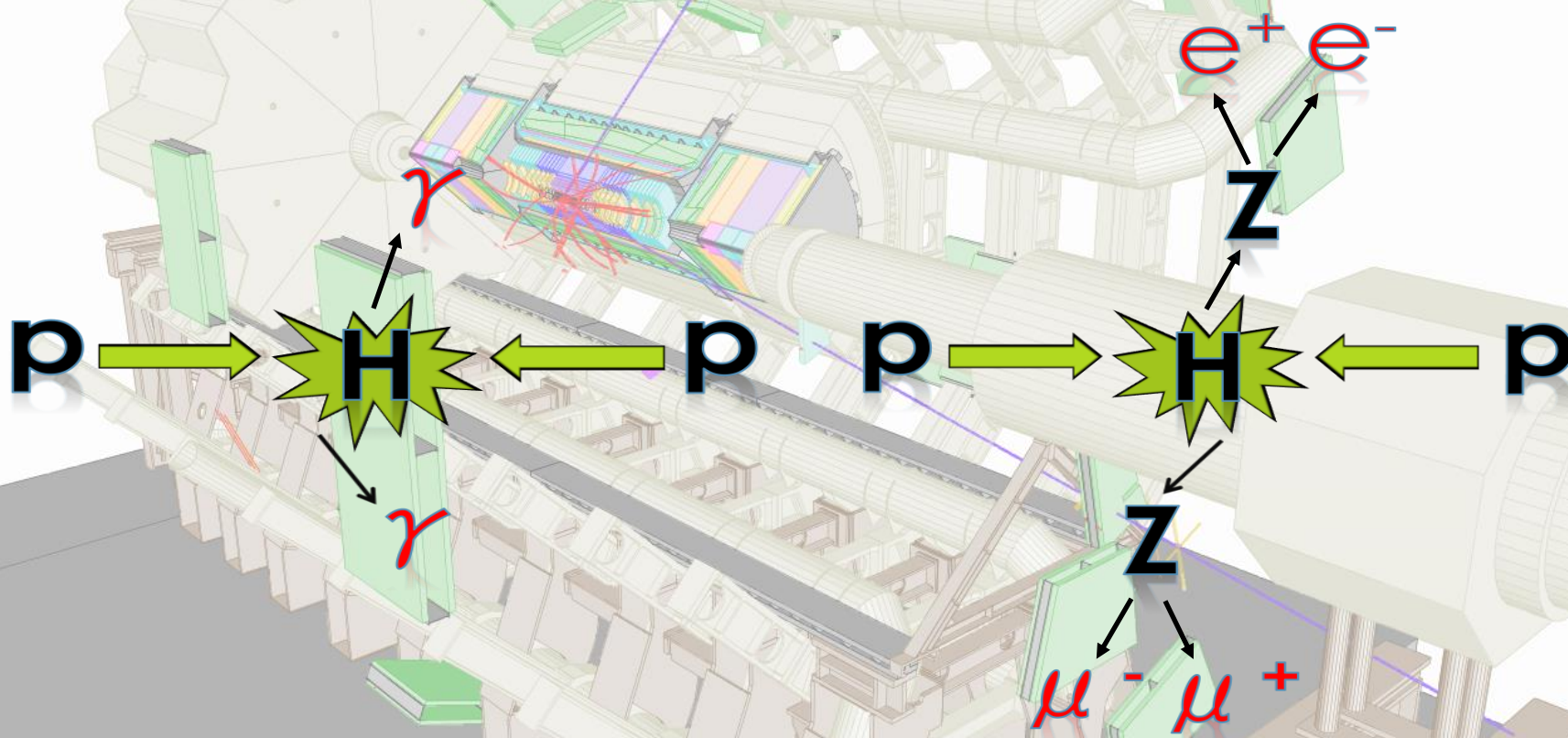
Raspad Higgs bozona



Raspad Higgs bozona

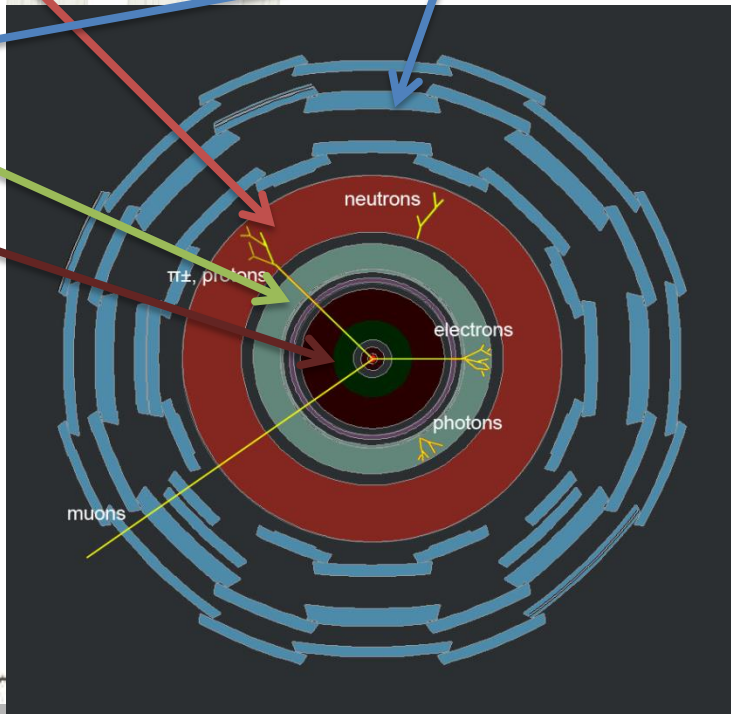
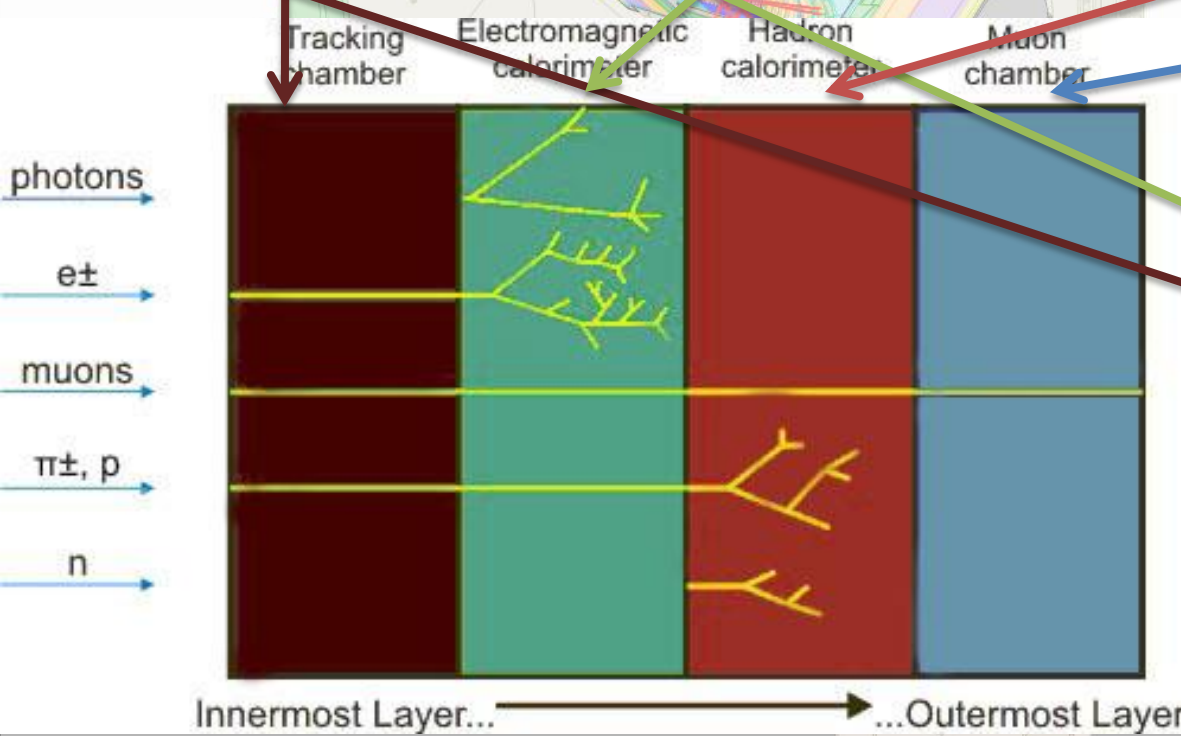


Higgs bozon



Osnovni koncepti detekcije čestica

- Različite čestice ostavljaju specifičnu kombinaciju signala u različitim komponentama



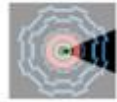
ELEKTRON

Trag u unutrašnjem detektoru

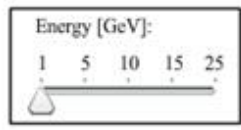
Deponovana energija u elektromagnetnom kalorimetru

ATLAS

animation

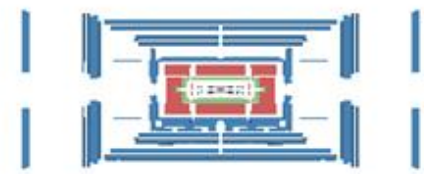
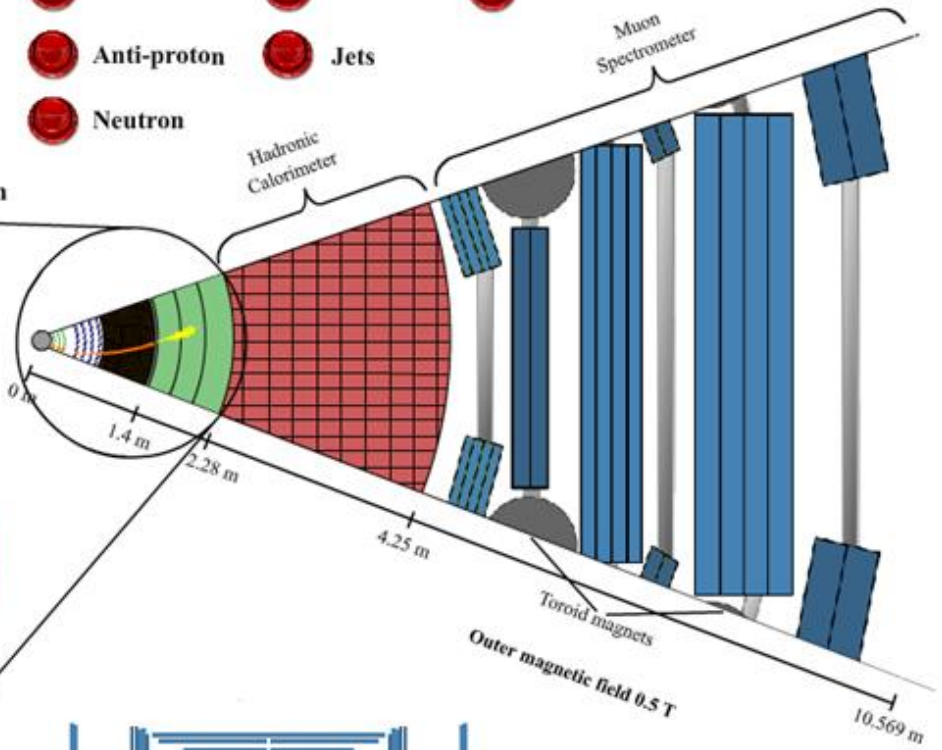
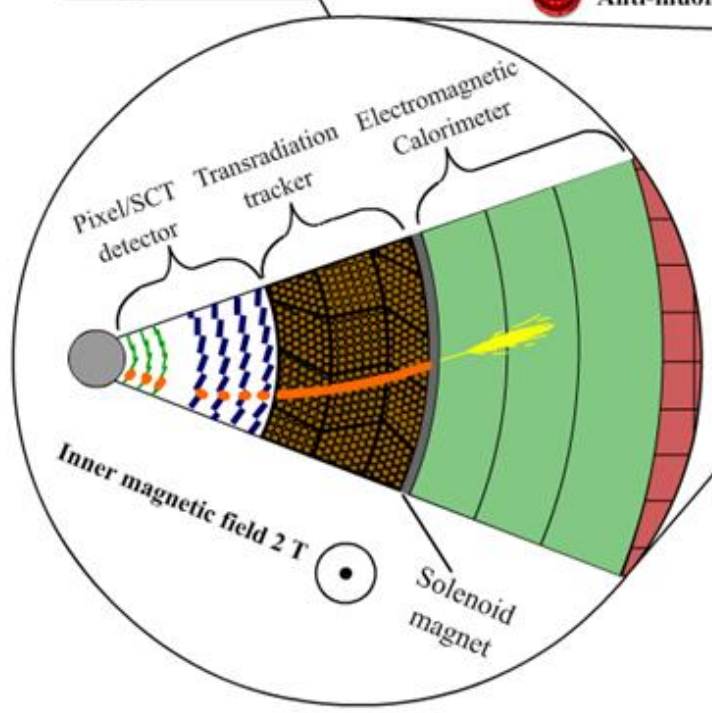


display instantly



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

Magnification 3x



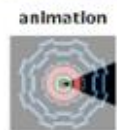
Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

POZITRON

Trag u unutrašnjem detektoru

Deponovana energija u elektromagnetnom kalorimetru

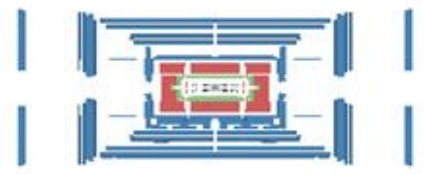
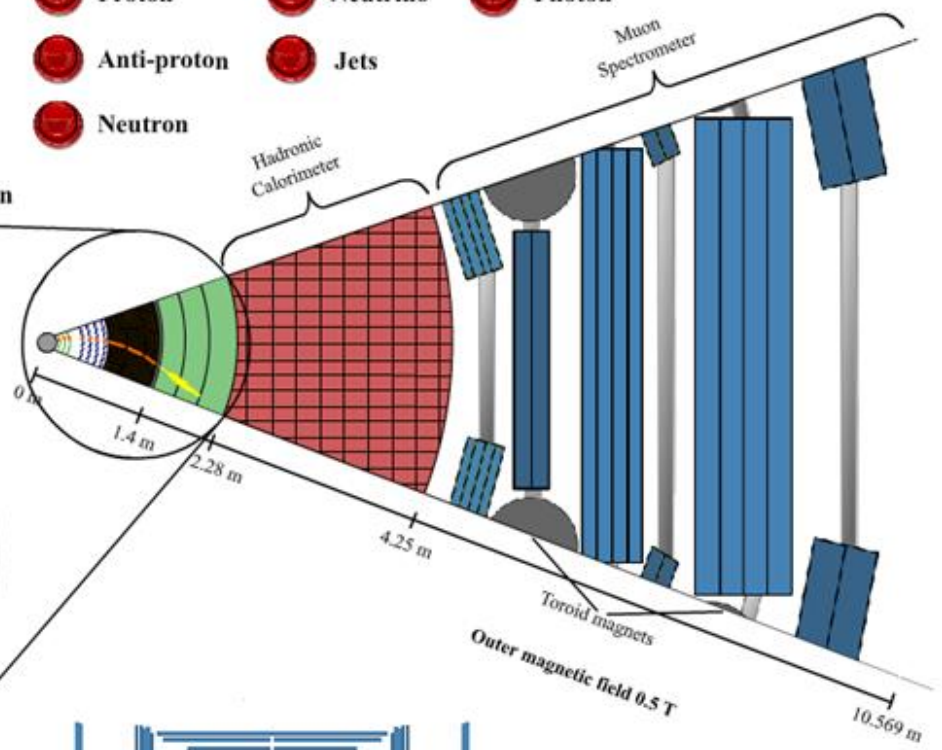
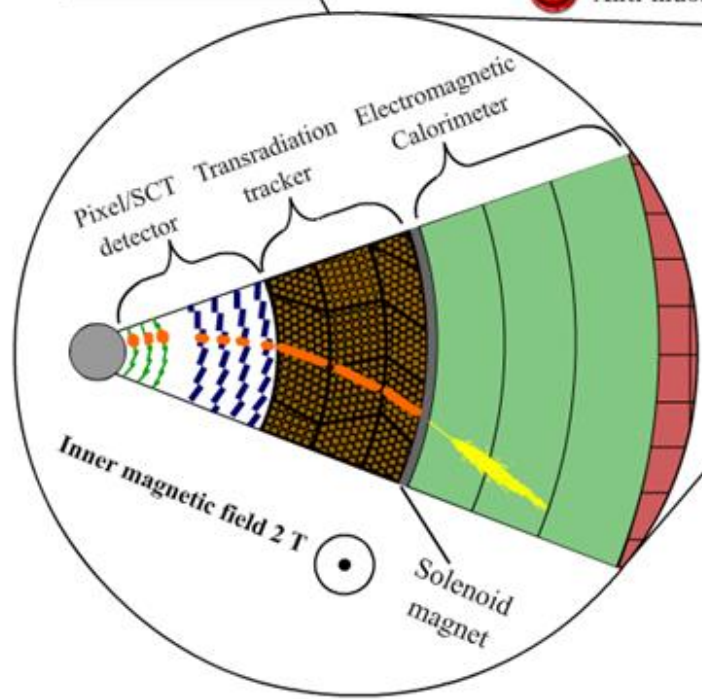
ATLAS



display instantly

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

Magnification 3x



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

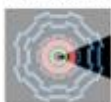
MION

Trag u unutrašnjem detektoru

Trag u mionskom spektrometru

ATLAS

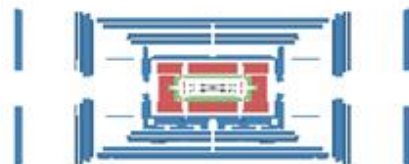
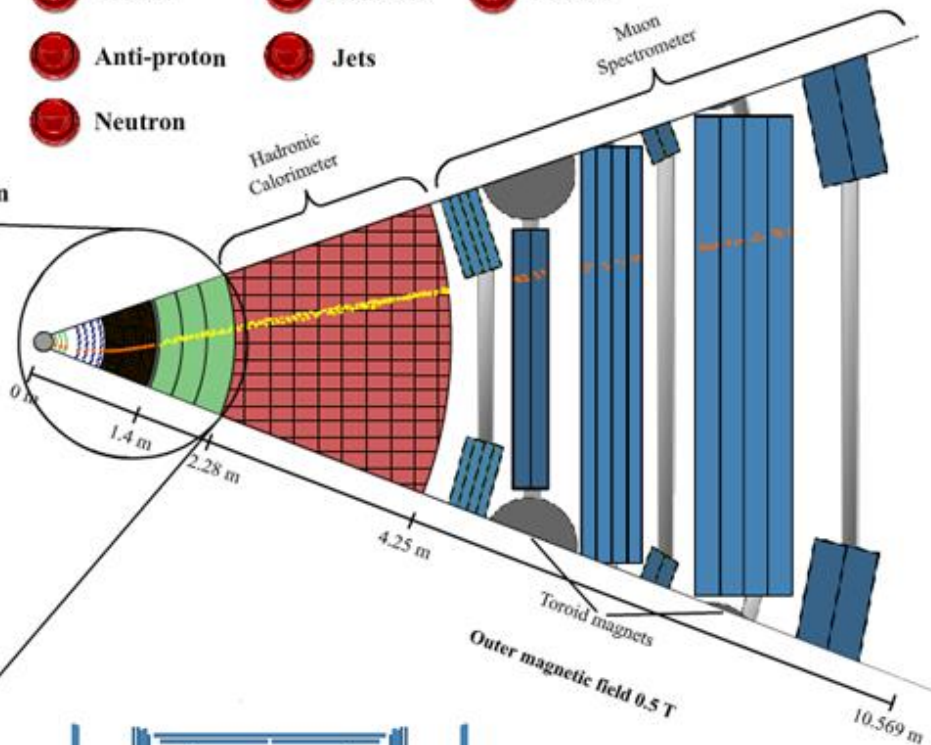
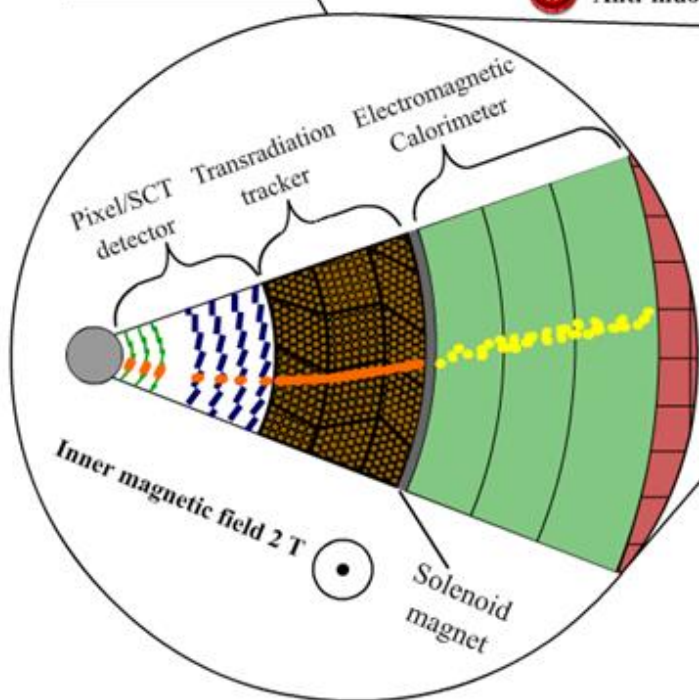
animation



display instantly

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

Magnification 3x



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

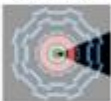
ANTIMION

Trag u unutrašnjem detektoru

Trag u mionskom spektrometru

ATLAS

animation



display instantly

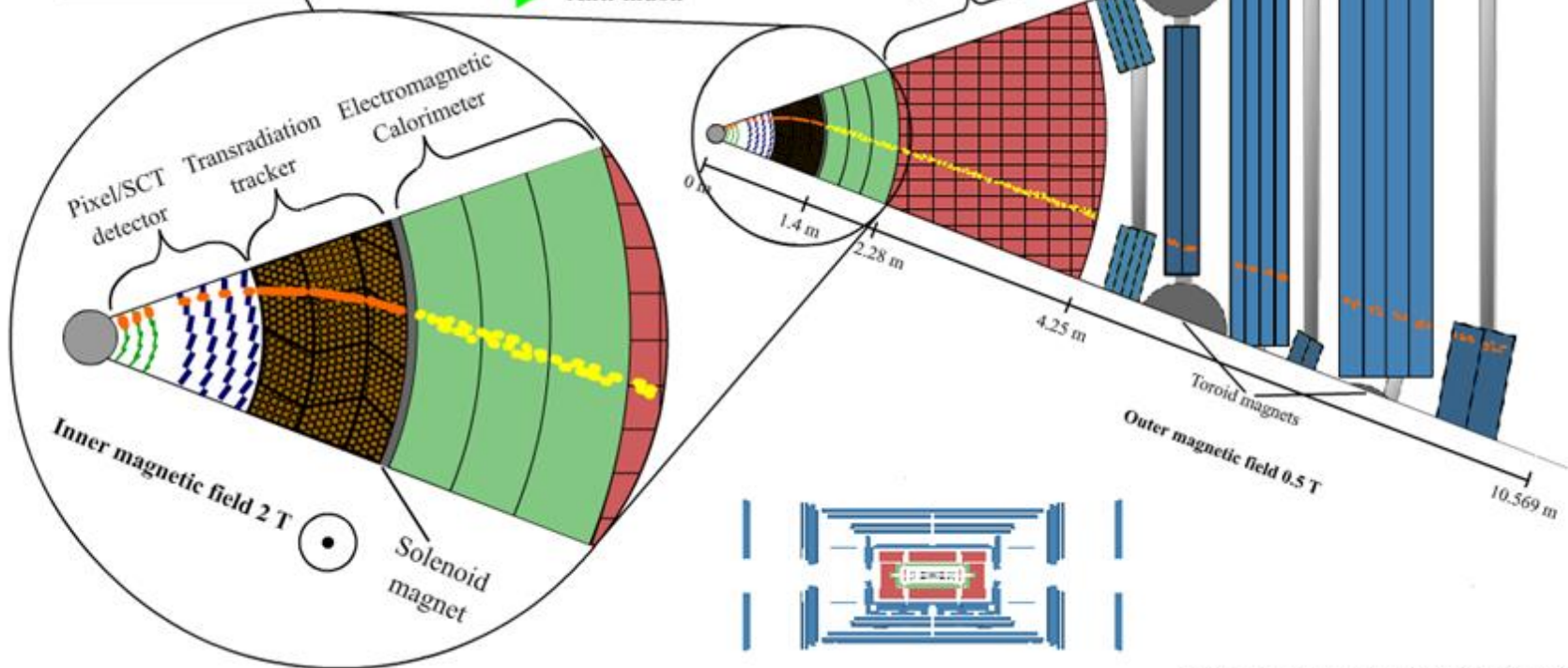
Energy [GeV]:

1 5 10 15 25



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

Magnification 3x



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PROTON

Trag u unutrašnjem detektoru











Deponovana energija u hadronskom kalorimetru

ATLAS

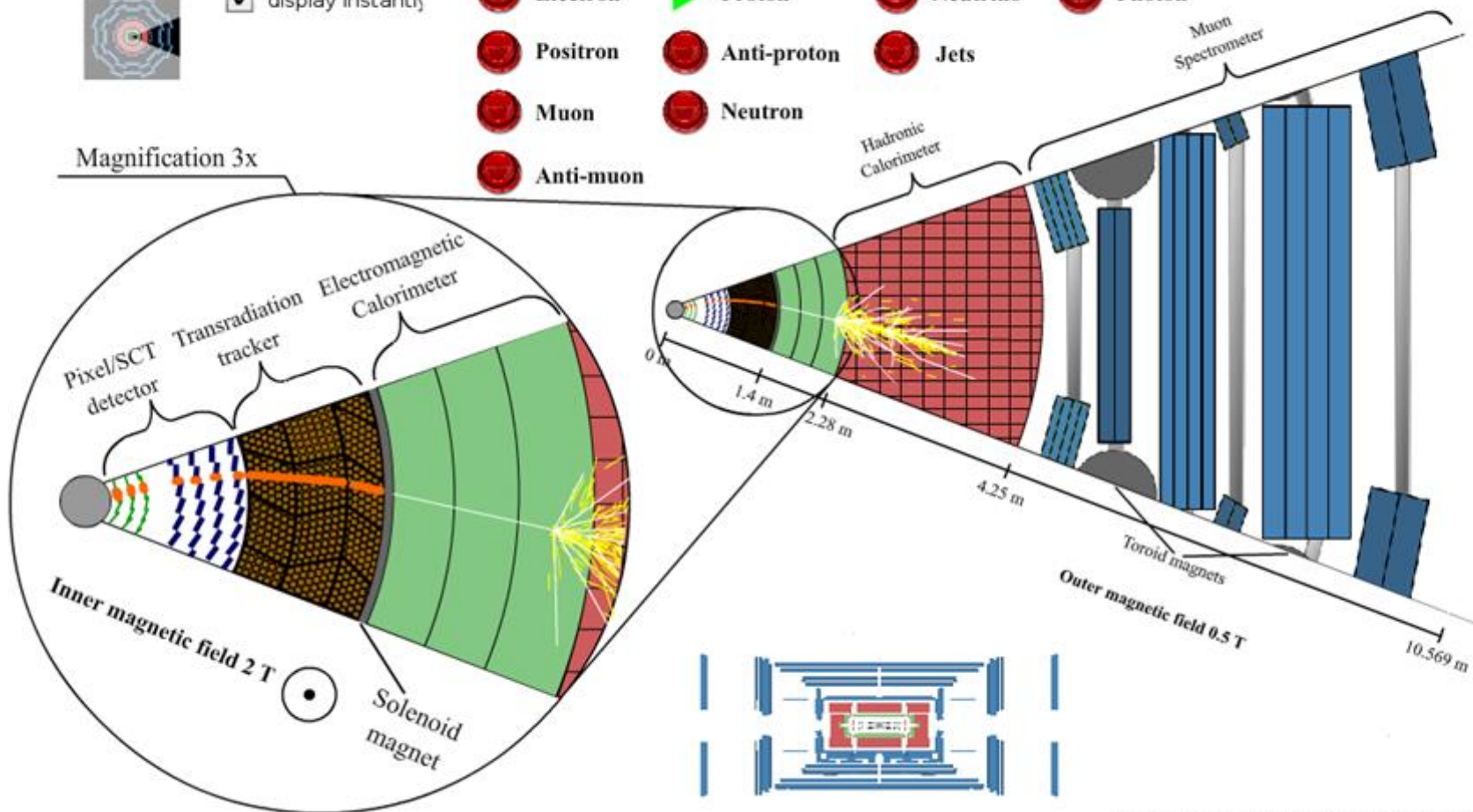
animation



display instantly

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

Magnification 3x



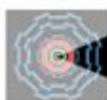
Created by T. Herrmann, O. Jeřábek, K. Jende, M. Kobel

NEUTRON

Deponovana energija u hadronskom kalorimetru

ATLAS

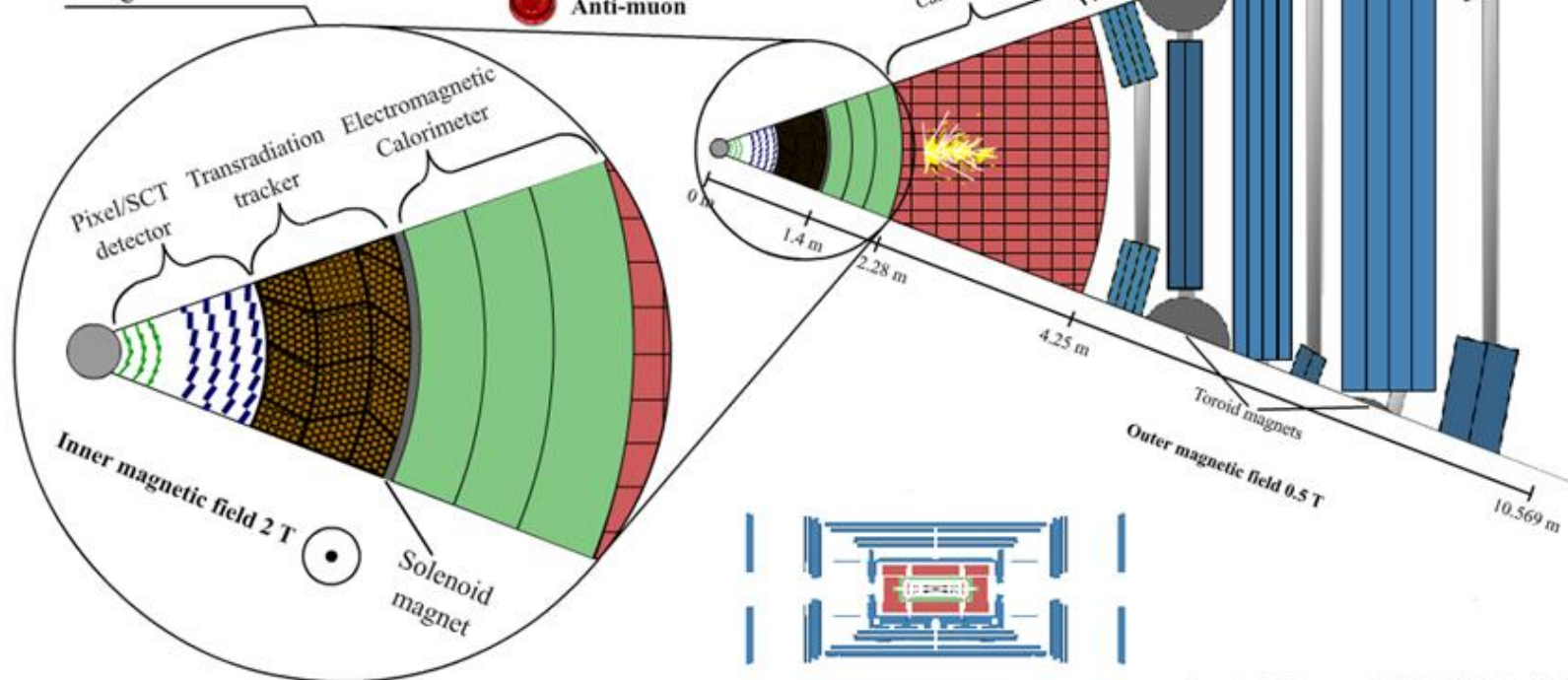
animation



display instantly

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

Magnification 3x



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

FOTON

Deponovana energija u elektromagnetnom kalorimetru

ATLAS

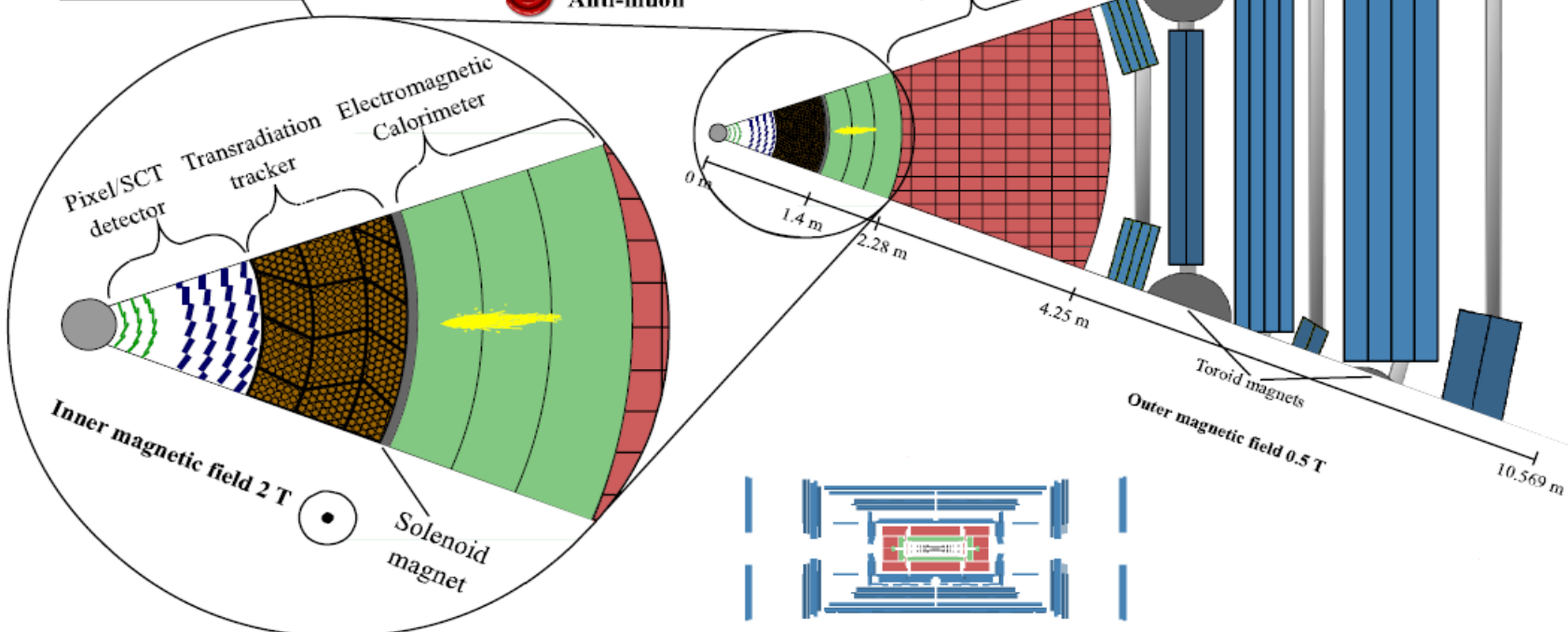
animation

display instantly



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

Magnification 3x



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

Invarijantna masa

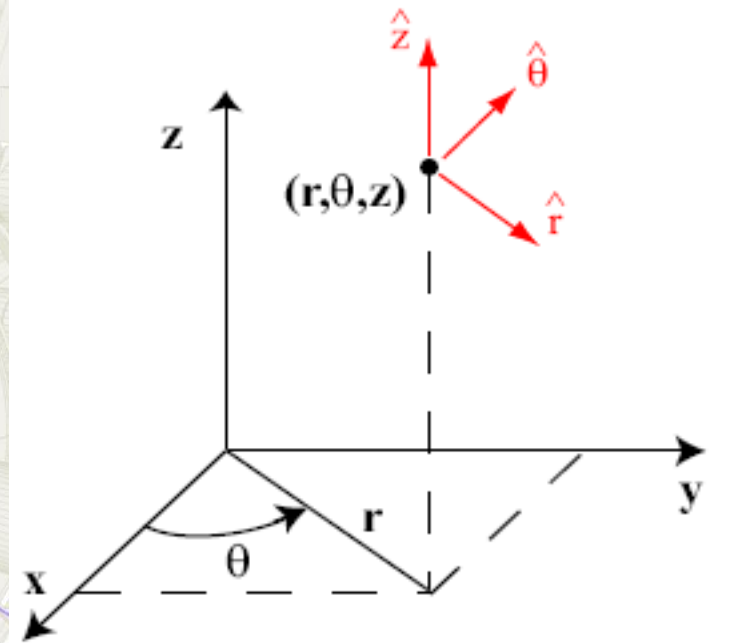
Z → μμ candidate in 7 TeV collisions
Run Number: 154822, Event Number: 14321500
Z: Minv=87 GeV, Pt=26 GeV
Pt(μ+) = 45 GeV, η=2.2
Pt(μ-) = 27 GeV, η=0.7

Veza mase, energije i impulsa:

$$(mc^2)^2 = E^2 - (pc)^2$$

Masa Z bozona se može izračunati iz produkata njegovog raspada:

$$(m_0^{(Z)})^2 = \left(\sum_{i=1}^n \frac{E_i}{c^2} \right)^2 - \left(\sum_{i=1}^n \frac{\vec{p}_i}{c} \right)^2$$

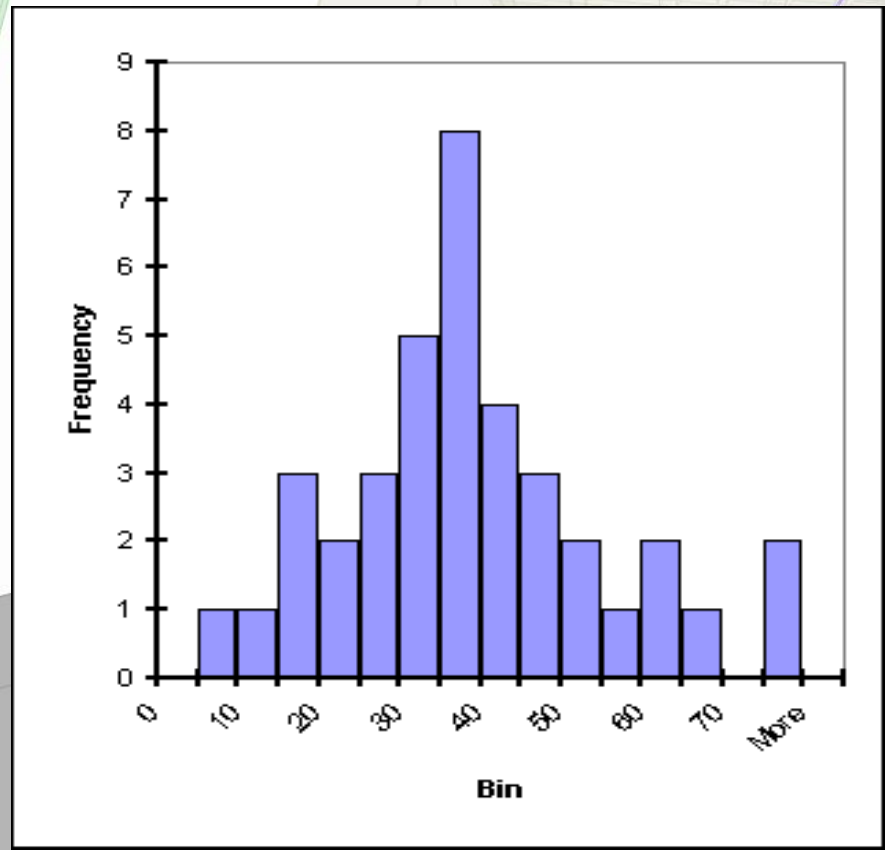


$$m_0^{(Z)} = \sqrt{(m_0^{(1)})^2 + (m_0^{(2)})^2 + 2 \left(\frac{1}{c^4} \cdot E_1 \cdot E_2 - \frac{1}{c^2} \cdot \vec{p}_1 \cdot \vec{p}_2 \right)}$$

Masa leptona (elektroni i mioni) zanemarljiva
Energija/impuls leptona iz kalorimetra/spektrometra
Impuls leptona: transverzalni impuls/energija i položaj u prostoru

Mali matematički podsetnik:

HISTOGRAMI



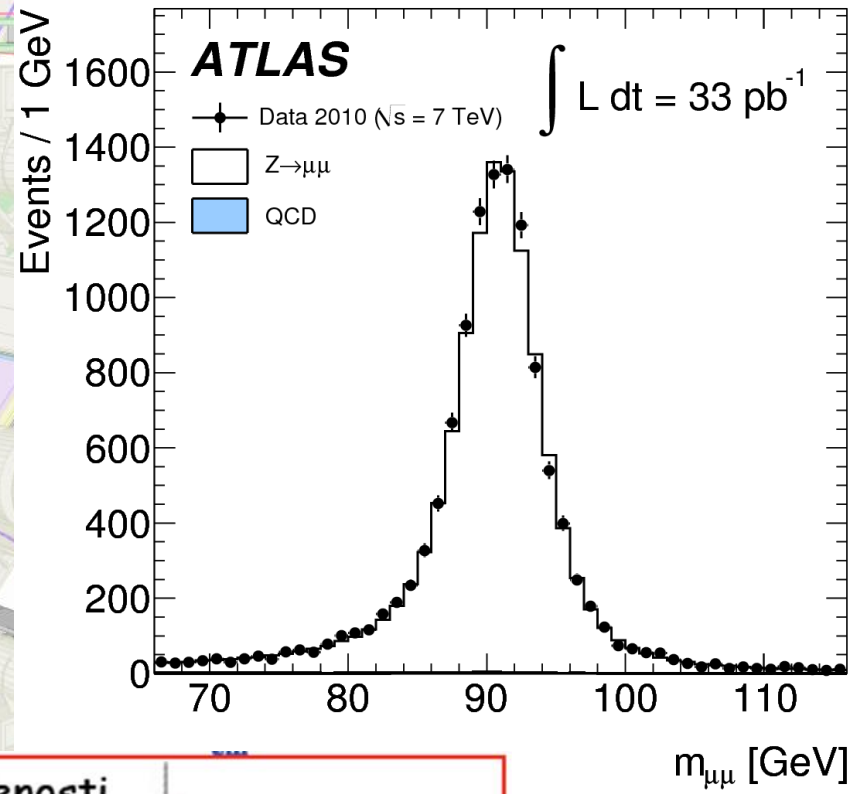
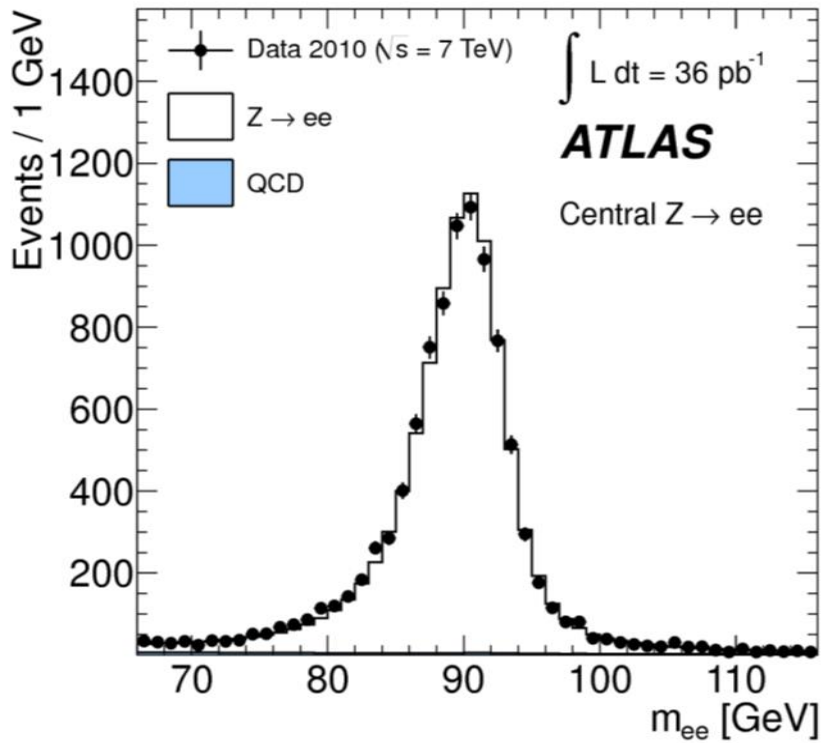
- Vrh raspodele ukazuje najverovatniji proces
- Repovi – fonski procesi
- Srednja vrednost:

$$\Sigma (fN) / \Sigma (f)$$

- Širina – rastur oko srednje vrednosti

Frequency = učestalost pojavljivanja

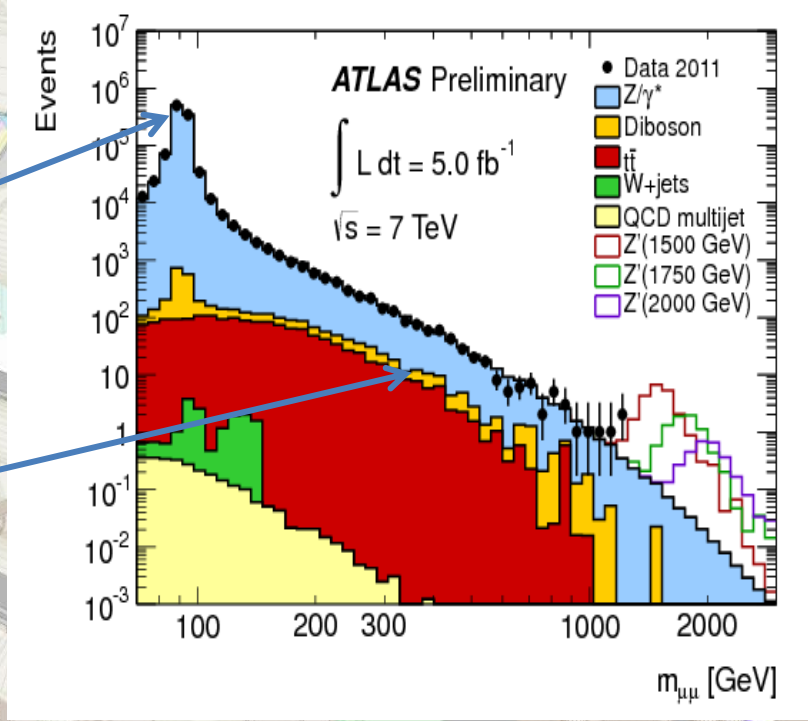
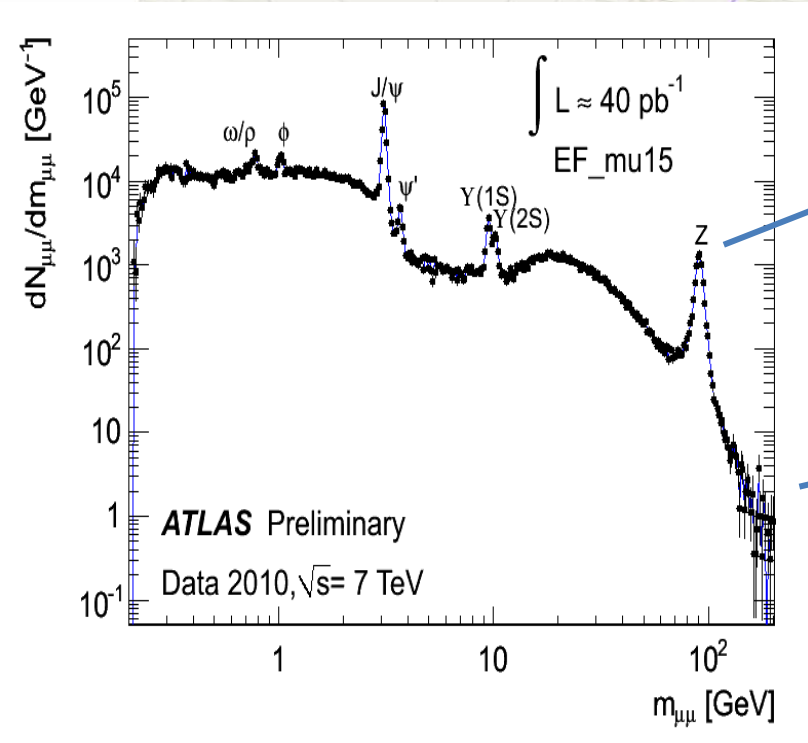
Histogrami invarijantne mase (ATLAS)



Usled principa nedodređenosti energija (invarijantna masa) kratkoživeće čestice ima konačnu preciznost. Vrh distribucije uvek ima istu vrednost (oko nominalne vrednosti). Γ = širina na poluvisini.

$$\Delta E \Delta t \gtrsim h,$$

Mogućnost za otkriće novih čestica u raspodeli invarijantne mase dva leptona

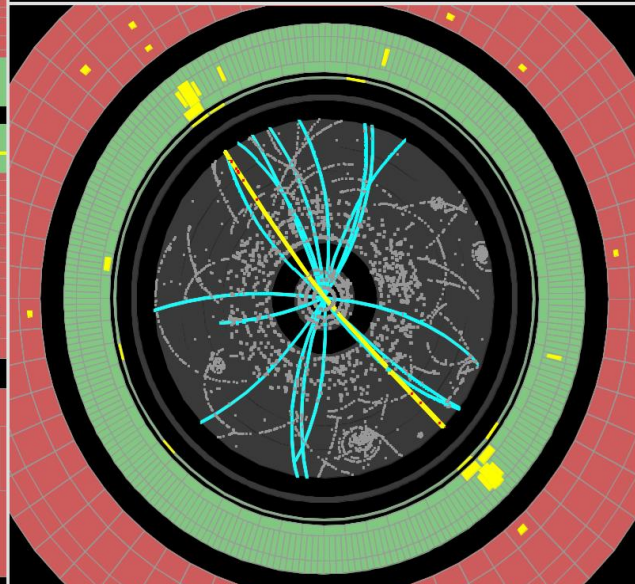
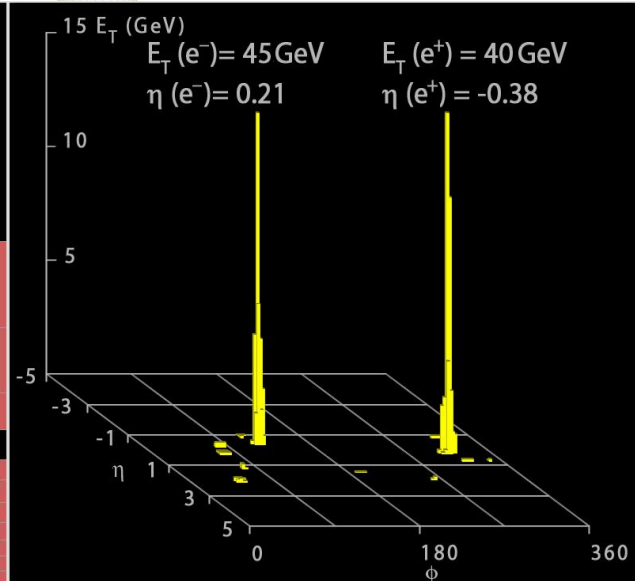
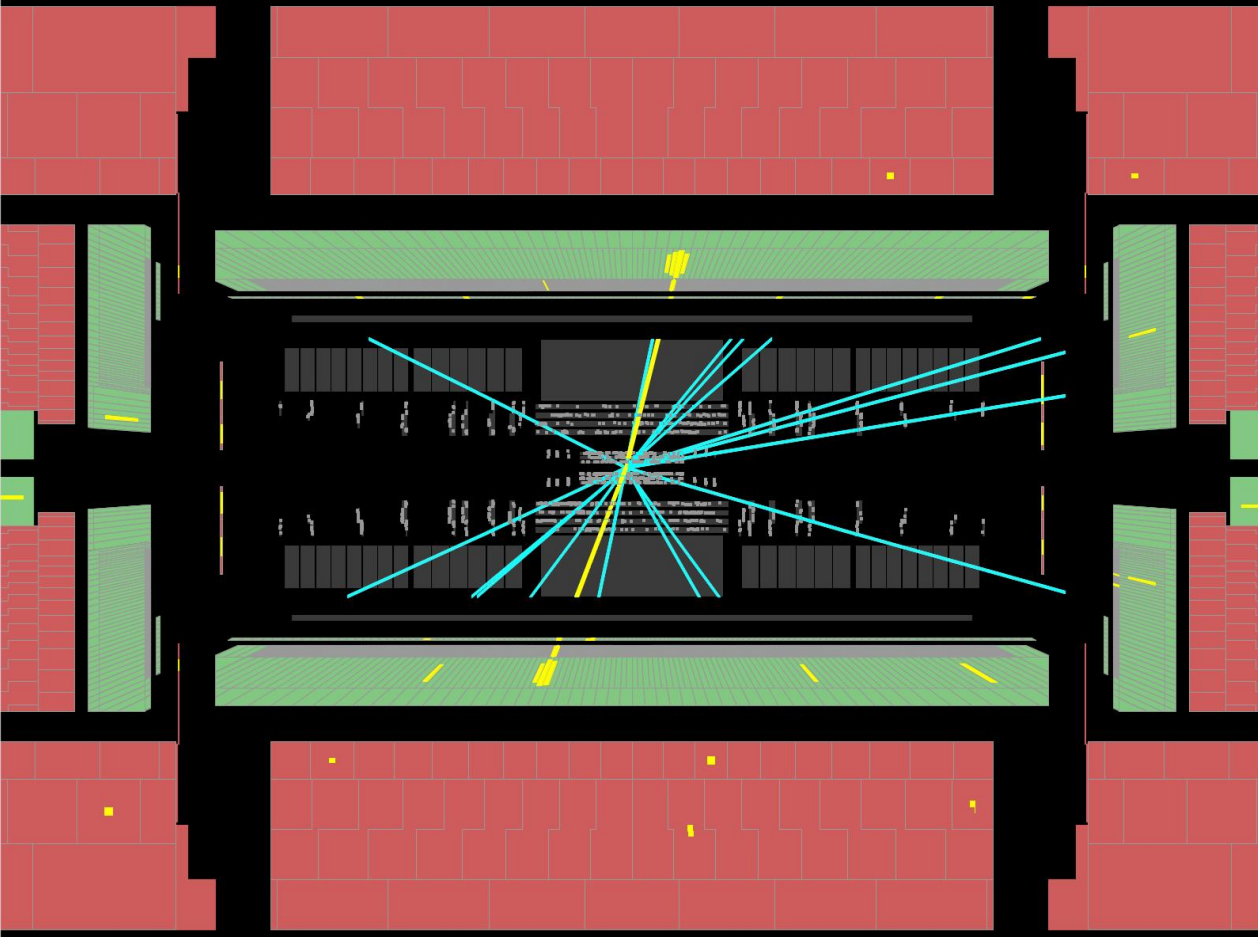


Eksperimentalni potpis Z bozona na LHC-u (e+e-)

Z → μμ candidate in 7 TeV collisions
Run Number: 154817, Event Number: 14321500
L_{int} = 37.1 fb⁻¹, Pt = 26 GeV
Pt(μ⁺) = 45 GeV, η = 2.2
Pt(μ⁻) = 27 GeV, η = 0.7



Run Number: 154817, Event Number: 968871
Date: 2010-05-09 09:41:40 CEST
M_{ee} = 89 GeV
Z → ee candidate in 7 TeV collisions



Eksperimentalni potpis Higgs bozona na LHC-u ($\mu+\mu-\mu+\mu-$)

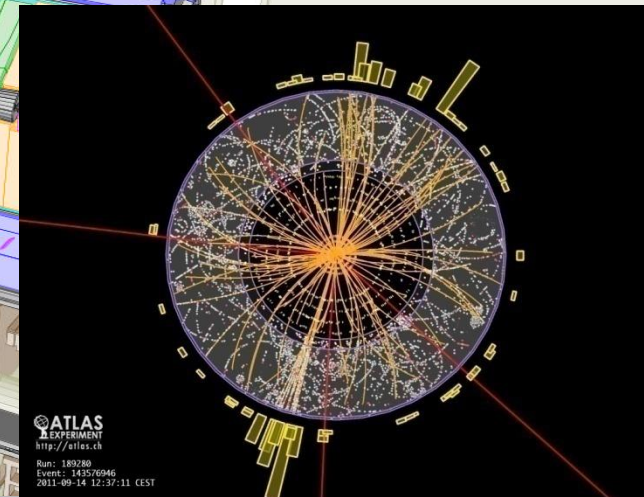
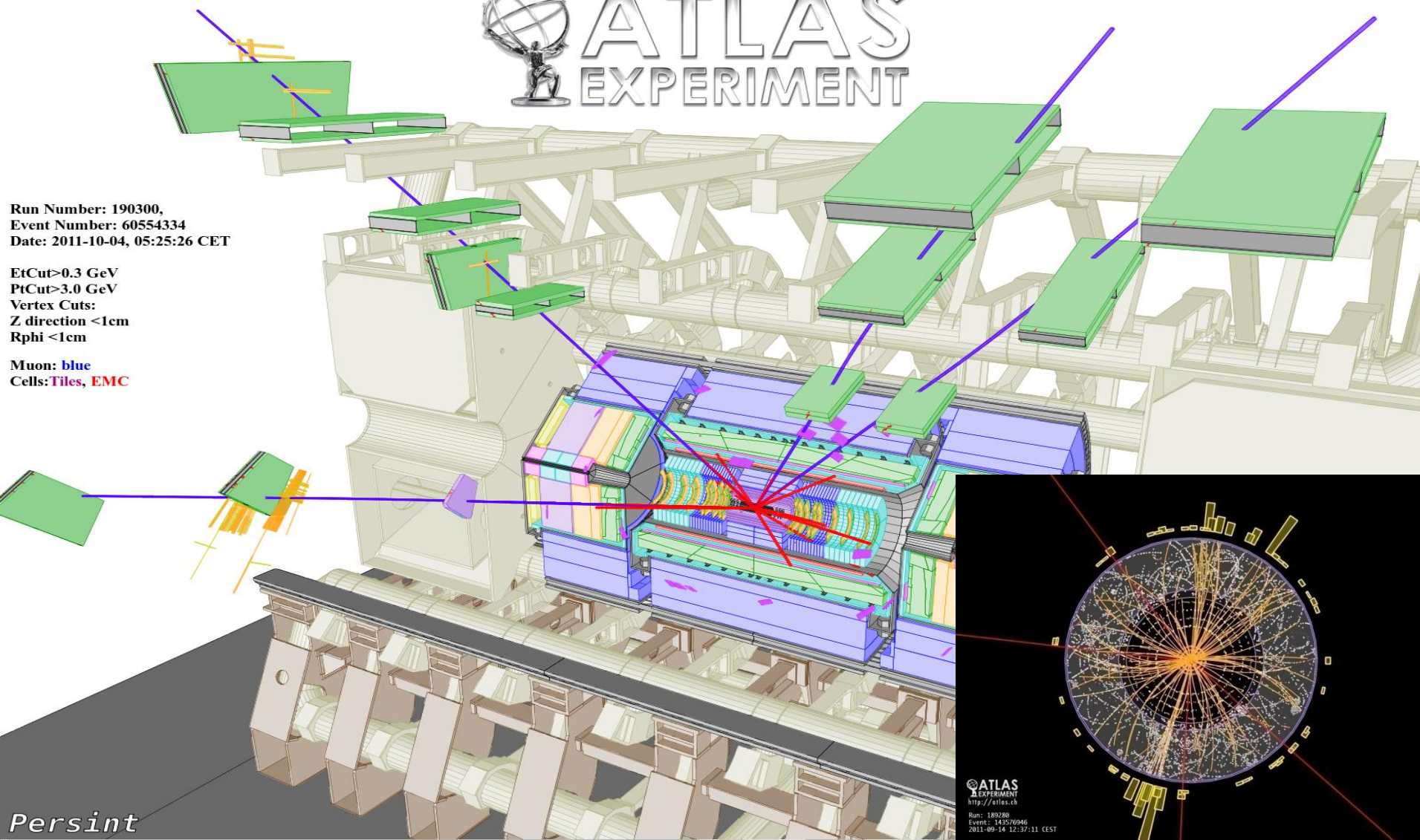
Z-> $\mu\mu$ candidate in 7 TeV collisions
Run Number:154822, Event Number: 14321500
Z: Minv=87 GeV, Pt=26 GeV
Pt(μ^-) =27 GeV, $\eta=0.7$



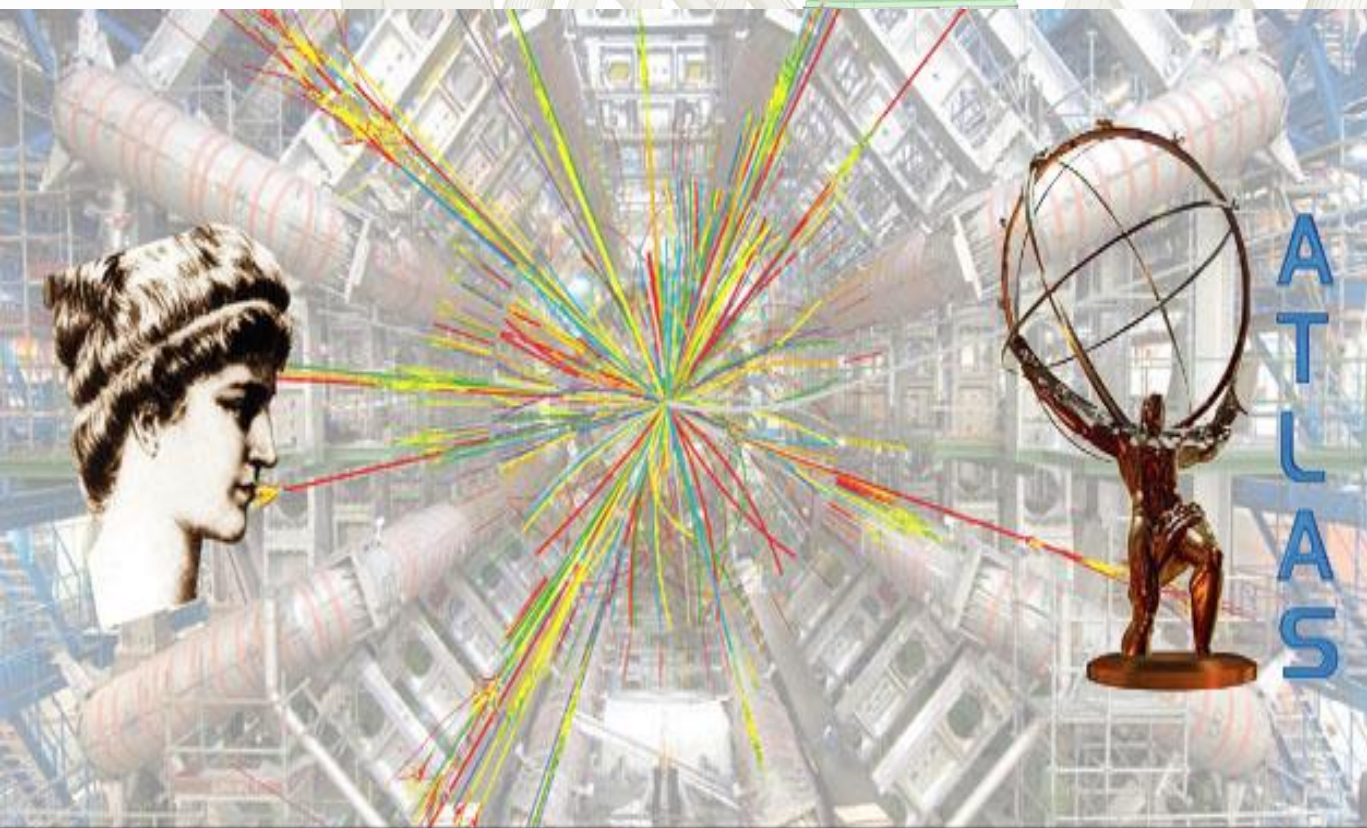
Run Number: 190300,
Event Number: 60554334
Date: 2011-10-04, 05:25:26 CET

EtCut>0.3 GeV
PtCut>3.0 GeV
Vertex Cuts:
Z direction <1cm
Rphi <1cm

Muon: blue
Cells:Tiles, EMC



Analiza događaja sa ATLAS eksperimenta



UNIVERSITY
OF
ATHENS



INSTITUTE
OF PHYSICS
BELGRADE

H Y P A T I A

HYbrid Pupil's Analysis Tool for Interactions in ATLAS

Analiza događaja sa ATLAS eksperimenta

- LHC akcelerator: proton – proton sudari na energiji od 13 TeV
- Edukativni program za vizuelizaciju događaja: HYPATIA

ZADATAK 1:

Rekonstrukcija događaja i potraga za raspadima J/ψ i Y mezona, Z i Z' bozona na:
elektron – pozitron par
mion – antimion par

Rekonstrukcija događaja i potraga za raspadima Higgs bozona na:

dva fotona

dva para leptona ($\mu^-\mu^+\mu^-\mu^+$, $\mu^-\mu^+e^-e^+$, $e^-e^+e^-e^+$)

ZADATAK 2:

Snimanje masenog spektra za događaje sa jednim bozonom.

ZADATAK 3:

Upoređivanje rezultata sa vrednostima izmerenim na ATLAS eksperimentu.

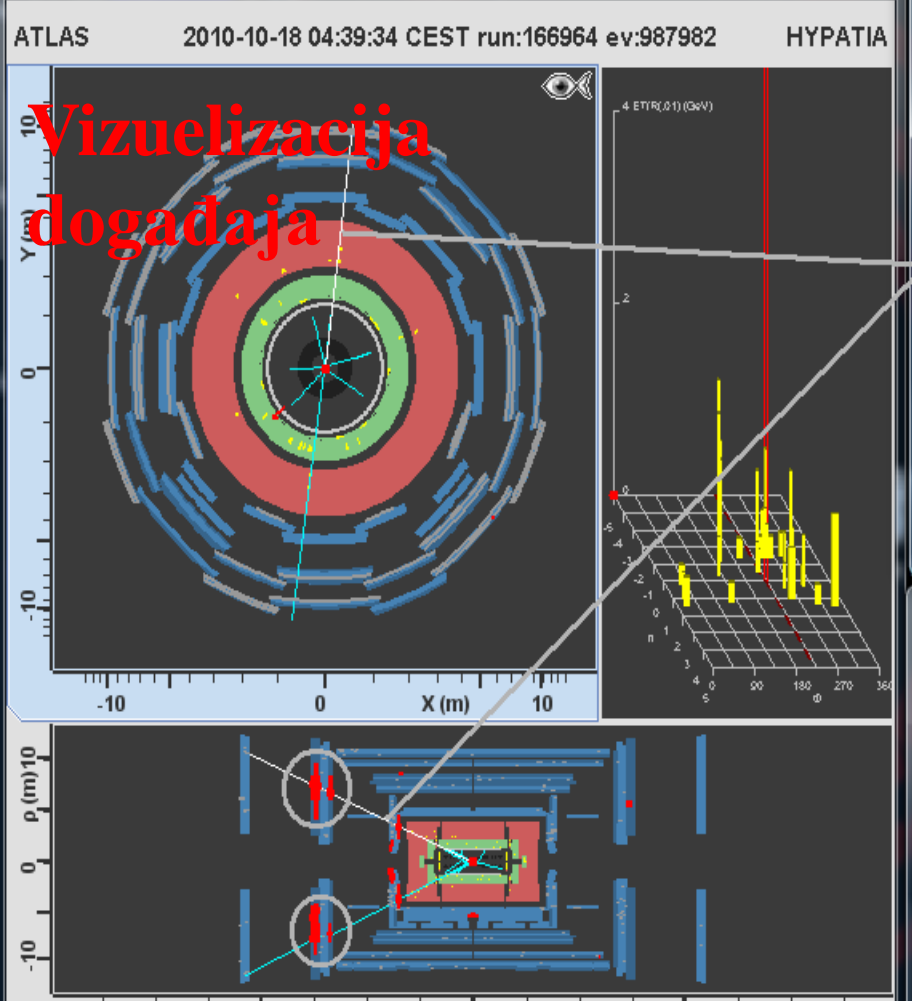
HYPATIA – Osnovni elementi

Hybrid pupils' analysis tool for interactions in ATLAS - version 6.0 - Invariant Mass Window

File Name	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(Z ν) [GeV]	M(4l) [GeV]	e/ μ
00036_JiveXML_166964_987982.xml	19.626	Tracks 3	112.57	+	49.4	1.441	-1.464	95.325		μ
		Tracks 69	96.83	-	45.88	-1.720	-1.378			μ

Invarijantna masa

Canvas Window - File: 00036_JiveXML_166964_987982.xml Run: 166964 Event: ...



HYPATIA - Track Momenta Window

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

ETMis: 20.808 GeV ϕ : -2.415 rad Collection: MET RefFinal

C:\installers\HYPATIA\groupA\00036_JiveXML_166964_987982.xml

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 3	+	112.57	49.42	1.441	2.687
Tracks 69	-	96.83	45.88	-1.720	2.648
Tracks 127	-	37.93	30.81	1.803	0.948
Tracks 128	+	25.73	12.70	0.303	2.625
Tracks 134	+	14.19	8.35	-2.346	2.315
Tracks 136	-	14.18	8.63	-3.123	0.255
Tracks 154	+	14.19	8.35	-2.346	2.513
Tracks 176	-	13.53	12.74	0.259	1.915

Tragovi čestica

HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data **Cuts** InDet Calo MuonDet Objects Geometry

	Name	Value
InDet		
Calo	<input checked="" type="checkbox"/> Pt	> 5.0 GeV
MuonDet	<input type="checkbox"/> d0	< 2.5 mm
Objects	<input type="checkbox"/> z0	< 20.0 cm
ATLAS	<input type="checkbox"/> d0 Loose	< 2.5 cm
	<input type="checkbox"/> z0-zVtx	< 2.5 mm

Kontrolni prozor

PODACI

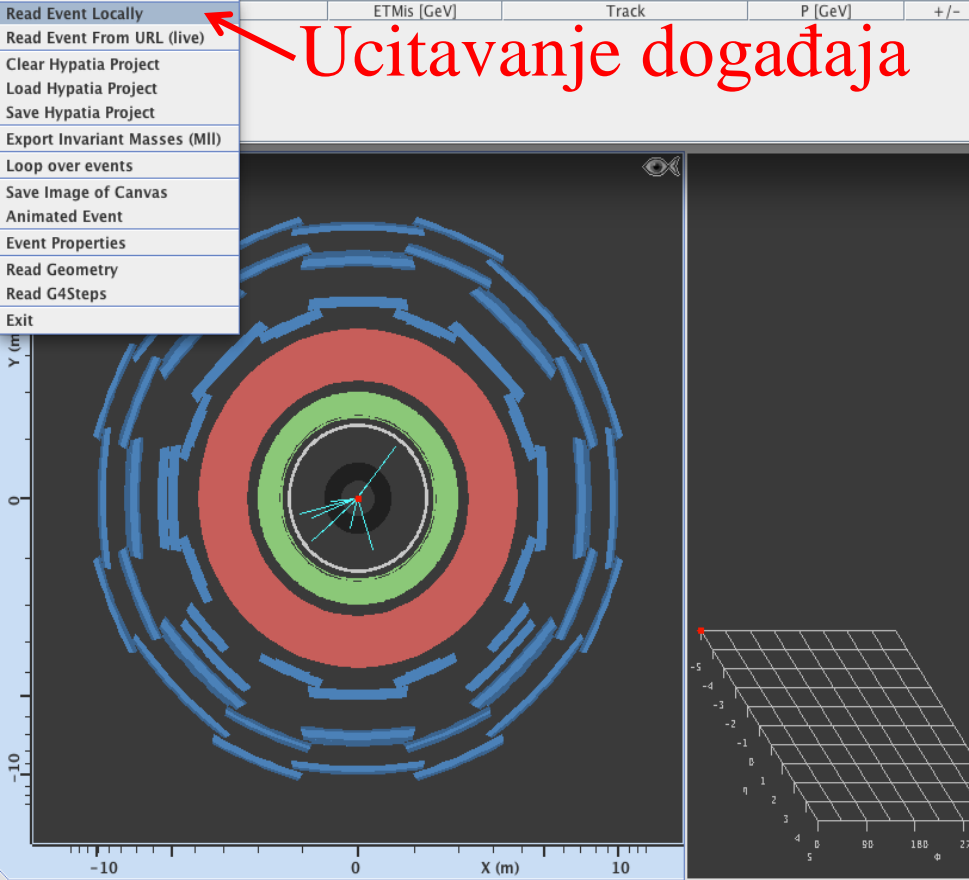
Z-> $\mu\mu$ candidate in 7 TeV collisions
 Run Number:154822, Event Number: 14321500
 Z: Minv=87 GeV, Pt=26 GeV
 Pt(μ^+) =45 GeV, $\eta=2.2$
 Pt(μ^-) =27 GeV, $\eta=0.7$

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

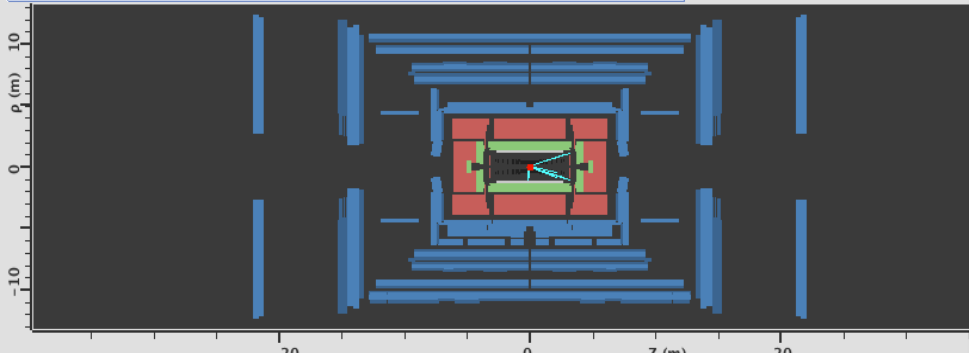
Ucitavanje događaja



File Previous Event Next Event Insert Electron Insert Muon Delete Track Reset Canvas
 ETMis: 13.877 GeV ϕ : 0.785 rad Collection: MET_RefFinal
 events/events4.zip/jiveXML_106051_1950731.xml

Reconstructed Tracks

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 0	-	11.68	4.28	-1.319	0.375
Tracks 1	+	126.06	39.41	-2.413	0.318
Tracks 2	+	4.57	4.56	-2.783	1.649
Tracks 3	-	167.90	53.01	0.906	0.321
Tracks 4	-	1.34	1.33	-2.949	1.475
Tracks 5	-	1.75	1.74	-3.090	1.645
Tracks 6	+	18.61	3.94	-1.818	0.214



HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

Data	Name	Value
<input checked="" type="checkbox"/>	Status	
<input checked="" type="checkbox"/>	InDet	
<input checked="" type="checkbox"/>	Calo	
<input checked="" type="checkbox"/>	MuonDet	
<input checked="" type="checkbox"/>	Objects	

File

Previous Event

Next Event

Insert Electron

Insert Muon

Delete Track

Reset Canvas

ETMis: 8.041 GeV

 ϕ : 0.114 rad

Collection: MET_Reffinal

/Users/nenadv/Downloads/groupA-1/event038.xml

Reconstructed Tracks

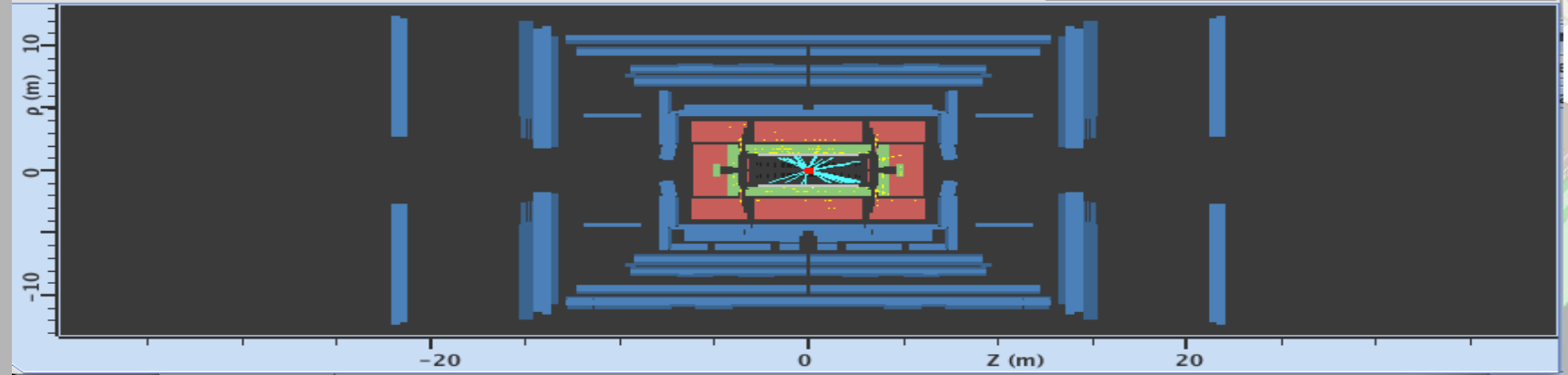
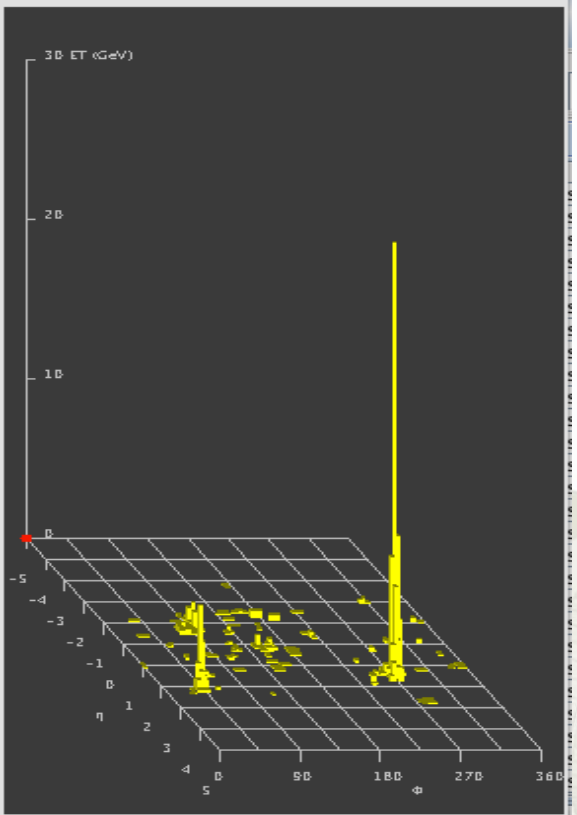
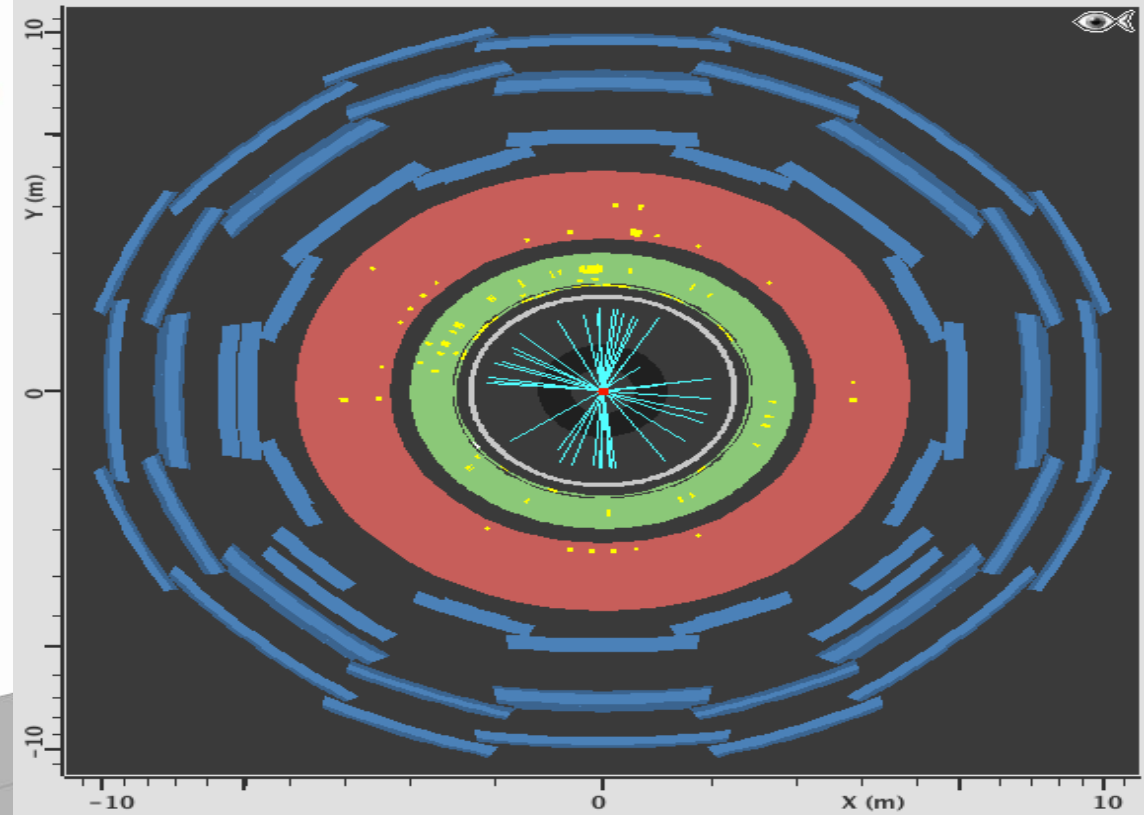
Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 3	+	15.84	3.66	1.084	0.233
Tracks 4	+	10.56	3.53	-1.450	0.341
Tracks 5	-	2.47	1.70	1.567	2.381
Tracks 6	-	3.00	1.86	-0.471	2.473
Tracks 7	-	2.50	1.64	2.576	2.422
Tracks 10	+	2.29	2.19	2.950	1.286
Tracks 11	-	2.99	2.82	-2.609	1.908
Tracks 12	-	3.53	2.17	-0.245	0.661
Tracks 13	-	5.91	2.27	-1.572	0.395
Tracks 14	-	2.60	1.50	-0.038	2.525
Tracks 18	+	4.35	1.66	-1.689	0.392
Tracks 19	-	7.66	2.53	-1.761	0.337
Tracks 20	-	2.95	1.61	2.838	2.563
Tracks 22	+	8.67	7.38	1.640	2.124
Tracks 23	+	140.85	57.41	-1.547	0.420
Tracks 25	+	8.50	7.13	1.487	2.146
Tracks 30	+	2.06	1.69	1.406	2.185
Tracks 35	-	12.39	10.15	1.544	2.183
Tracks 40	-	2.75	2.63	2.861	1.276
Tracks 41	+	2.53	2.53	-0.878	1.615
Tracks 43	+	2.33	1.61	2.188	2.380
Tracks 44	+	2.78	2.43	2.501	2.075
Tracks 45	+	2.61	2.29	1.618	2.070
Tracks 47	-	2.31	2.12	0.917	1.985
Tracks 48	-	4.33	3.26	2.512	0.853
Tracks 56	-	3.74	1.61	-2.151	2.698
Tracks 59	+	3.10	1.85	2.707	2.502

HYPATIA prozor vizuelizacije događaja

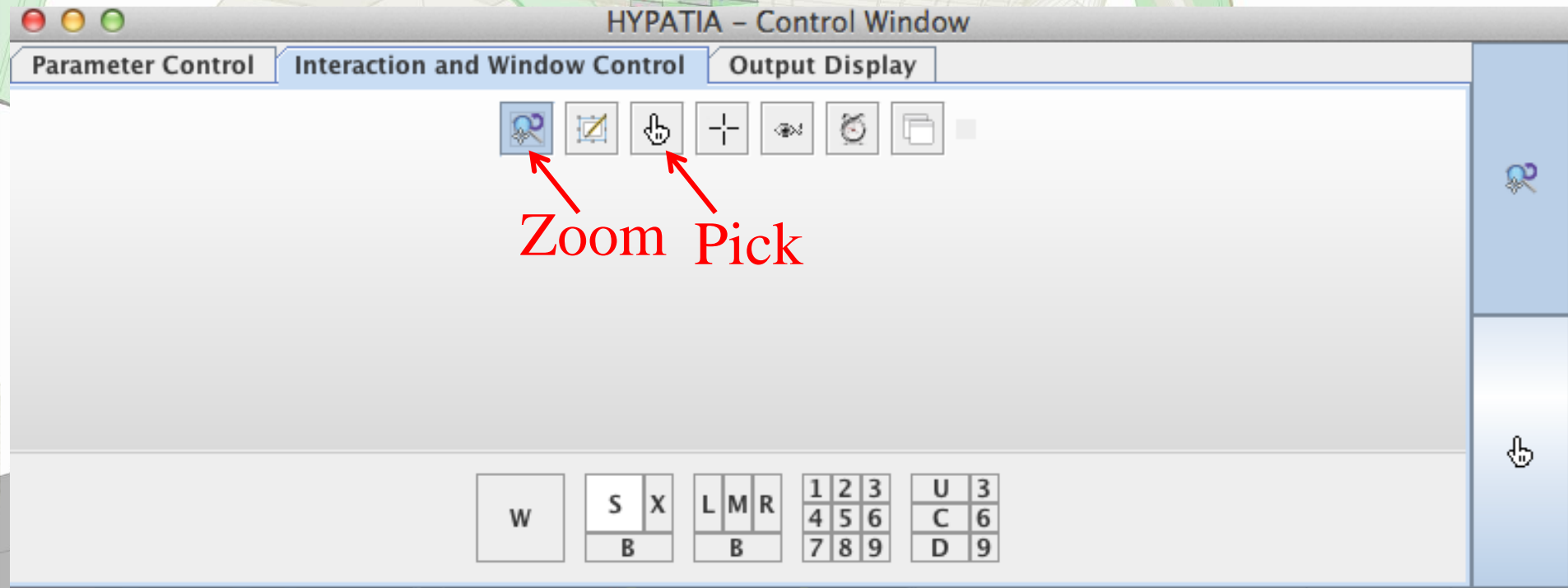
Z- $\mu\mu$ candidate in 7 TeV collisions
Run Number:154822, Event Number: 14321500
Z: $M_{inv}=87$ GeV, $P_t=26$ GeV
Pt: 15.5 GeV, 22.2 GeV
Pt: 15.5 GeV, 22.2 GeV

Canvas Window - File: event038.xml Run: 180636 Event: 12562630

ATLAS 2011-04-30 14:37:53 CEST source:event038 run:180636 ev:12562630 lumiBlock:117 HYPATIA



HYPATIA kontrolni prozor



HYPATIA kontrolni prozor

$Z \rightarrow \mu\mu$ candidate in 7 TeV collisions
 Run Number: 154822, Event Number: 14321500
 Z: Minv=87 GeV, Pt=26 GeV
 $\eta_{\mu 1} = 45$ GeV, $\eta = 2.2$
 $\eta_{\mu 2} = 27$ GeV, $\eta = 0.7$

HYPATIA - Control Window

Parameter Control | Interaction and Window Control | Output Display

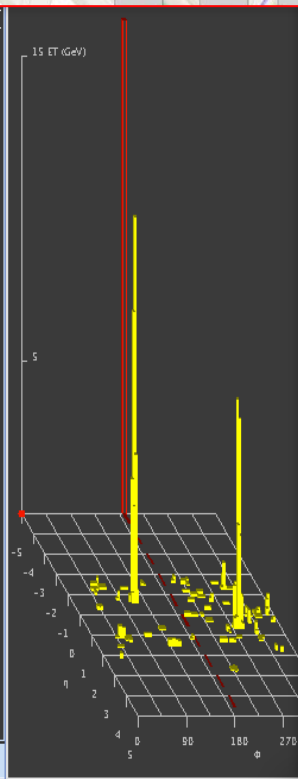
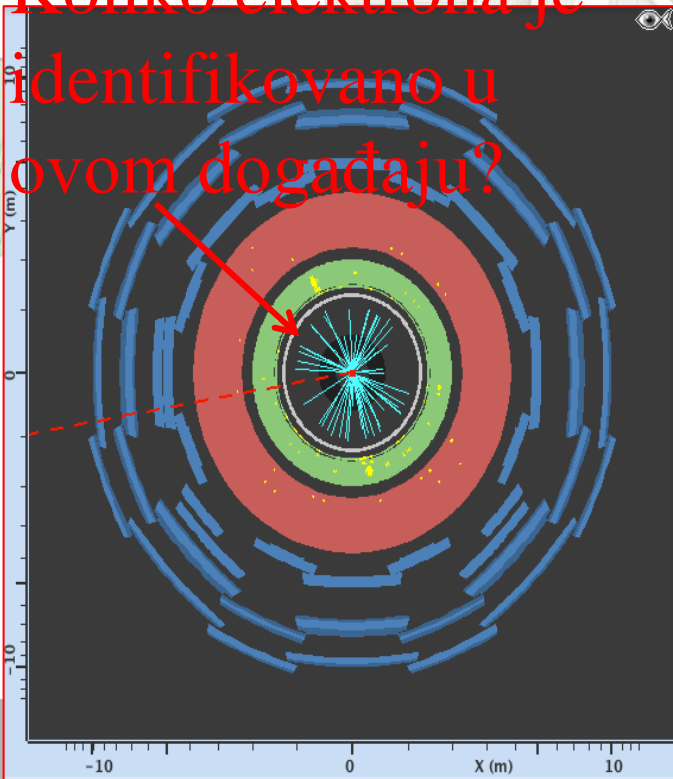
Projection | Data | Cuts | InDet | Calo | MuonDet | Objects | Geometry

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

HYPATIA

Z $\rightarrow\mu\mu$ candidate in 7 TeV collisions
Run Number:154822, Event Number: 14321500
Z: Minv=87 GeV, Pt=26 GeV
Pt(μ^+) =45 GeV, $\eta=2.2$
Pt(μ^-) =27 GeV, $\eta=0.7$

Koliko elektrona je
identifikovano u
ovom događaju?



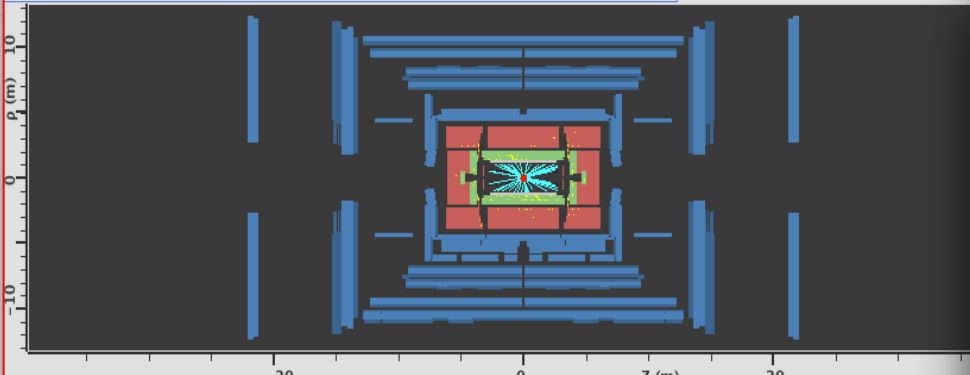
File Previous Event Next Event Insert Electron Insert Muon Delete Track Reset Canvas

ETMis: 16.187 GeV ϕ : -2.974 rad Collection: MET_Reffinal

/Users/nenadv/Downloads/groupA-1/event001.xml

Reconstructed Tracks

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 0	+	6.95	1.64	-0.749	0.238
Tracks 2	+	40.57	33.41	-1.366	0.968
Tracks 3	-	5.00	1.07	1.283	0.216
Tracks 6	-	1.55	1.40	-1.368	2.013
Tracks 7	+	7.23	1.50	1.901	0.209
Tracks 8	+	7.08	1.73	0.054	0.247
Tracks 9	+	5.86	3.01	1.369	2.603
Tracks 10	-	2.32	1.72	2.779	2.307
Tracks 11	+	4.21	2.01	-2.064	2.644
Tracks 13	-	2.89	1.08	2.567	0.384
Tracks 15	-	4.67	4.66	-0.707	1.512
Tracks 16	+	1.48	1.37	-1.110	1.948
Tracks 17	-	5.78	1.24	0.509	0.217
Tracks 19	+	9.18	1.43	1.673	2.985
Tracks 20	-	4.87	1.09	-0.573	0.225
Tracks 22	-	3.82	1.08	-1.000	0.285
Tracks 23	-	1.53	1.27	1.382	0.978
Tracks 24	-	1.93	1.02	0.498	2.586
Tracks 26	+	1.90	1.11	2.997	2.519
Tracks 34	-	1.79	1.79	-0.493	1.560
Tracks 35	-	1.56	1.56	-1.995	1.517
Tracks 38	+	6.00	1.22	0.896	2.937
Tracks 42	-	4.01	4.01	-0.727	1.572
Tracks 47	-	4.64	1.43	2.561	0.313
Tracks 53	-	2.80	2.78	-0.616	1.429
Tracks 55	+	4.26	4.18	-1.121	1.770
Tracks 56	-	3.19	1.53	0.857	0.499



HYPATIA - Control Window

Parameter Control Interaction and Window Control Output Display

Projection Data Cuts InDet Calo MuonDet Objects Geometry

Data

Data	Name	Value
<input checked="" type="checkbox"/>	Objects	
<input type="checkbox"/>	Jet Collections	
<input checked="" type="checkbox"/>	ETMis Collections	
<input type="checkbox"/>	BJet Collections	
<input type="checkbox"/>	Electron Collections	
<input type="checkbox"/>	Muon Collections	
<input type="checkbox"/>	Photon Collections	
<input type="checkbox"/>	Taujet Collections	

HYPATIA - Track Momenta Window

7-cm candidate in 7 TeV collisions

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

ETMis: 8.041 GeV ϕ : 0.114 rad Collection: MET_Reffinal

 /Users/nenadv/Downloads/groupA-1/event038.xml 

Reconstructed Tracks

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 3	+	15.84	3.66	1.084	0.233
Tracks 4	+	10.56	3.53	-1.450	0.341
Tracks 5	-	2.47	1.70	1.567	2.381
Tracks 6	-	3.00	1.86	-0.471	2.473
Tracks 7	-	2.50	1.64	2.576	2.422
Tracks 10	+	2.29	2.19	2.950	1.286
Tracks 11	-	2.99	2.82	-2.609	1.908
Tracks 12	-	3.53	2.17	-0.245	0.661
Tracks 13	-	5.91	2.27	-1.572	0.395
Tracks 14	-	2.60	1.50	-0.038	2.525
Tracks 18	+	4.35	1.66	-1.689	0.392
Tracks 19	-	7.66	2.53	-1.761	0.337
Tracks 20	-	2.95	1.61	2.838	2.563
Tracks 22	+	8.67	7.38	1.640	2.124
Tracks 23	+	140.85	57.41	-1.547	0.420
Tracks 25	+	8.50	7.13	1.487	2.146
Tracks 30	+	2.06	1.69	1.406	2.185
Tracks 35	-	12.39	10.15	1.544	2.183
Tracks 40	-	2.75	2.63	2.861	1.276
Tracks 41	+	2.53	2.53	-0.878	1.615
Tracks 43	+	2.33	1.61	2.188	2.380
Tracks 44	+	2.78	2.43	2.501	2.075
Tracks 45	+	2.61	2.29	1.618	2.070
Tracks 47	-	2.31	2.12	0.917	1.985
Tracks 48	-	4.33	3.26	2.512	0.853
Tracks 56	-	3.74	1.61	-2.151	2.698
Tracks 59	+	3.10	1.85	2.707	2.502

HYPATIA - Track Momenta Window

7-cm candidate in 7-TeV collisions

File Previous Event Next Event e^- μ^- X \leftrightarrow
 Insert Electron Insert Muon Delete Track Reset Canvas

ETMis: 8.041 GeV ϕ : 0.114 rad Collection: NET_Reffinal

 /Users/nenadv/Downloads/groupA-1/event038.xml 

Reconstructed Tracks

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 3	+	15.84	3.66	1.084	0.233
Tracks 4	+	10.56	3.53	-1.450	0.341
Tracks 5	-	2.47	1.70	1.567	2.381
Tracks 6	-	3.00	1.86	-0.471	2.473
Tracks 7	-	2.50	1.64	2.576	2.422
Tracks 10	+	2.29	2.19	2.950	1.286
Tracks 11	-	2.99	2.82	-2.609	1.908
Tracks 12	-	3.53	2.17	-0.245	0.661
Tracks 13	-	5.91	2.27	-1.572	0.395
Tracks 14	-	2.60	1.50	-0.038	2.525
Tracks 18	+	4.35	1.66	-1.689	0.392
Tracks 19	-	7.66	2.53	-1.761	0.337
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Tracks 22	+	8.67	7.38	1.640	2.124
Tracks 23	+	140.85	57.41	-1.547	0.420
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Tracks 30	+	2.06	1.69	1.406	2.185
Tracks 35	-	12.39	10.15	1.544	2.183
Tracks 40	-	2.75	2.63	2.861	1.276
Tracks 41	+	2.53	2.53	-0.878	1.615
Tracks 43	+	2.33	1.61	2.188	2.380
Tracks 44	+	2.78	2.43	2.501	2.075
Tracks 45	+	2.61	2.29	1.618	2.070
Tracks 47	-	2.31	2.12	0.917	1.985
Tracks 48	-	4.33	3.26	2.512	0.853
Tracks 56	-	3.74	1.61	-2.151	2.698
Tracks 59	+	3.10	1.85	2.707	2.502

HYPATIA prozor invarijantne mase

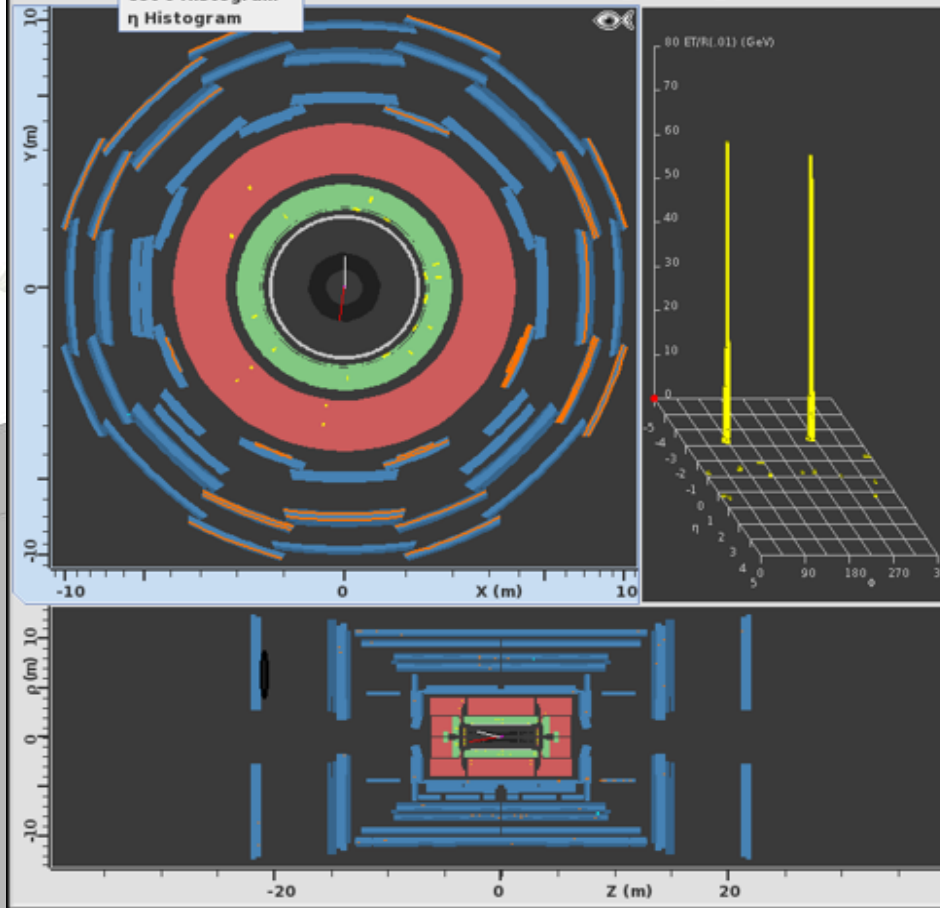
Hybrid pupils' analysis tool for interactions in ATLAS - version 6.0 - Invariant Mass Window

File View **Histograms** Preferences Help

	ETMis [GeV]	Track	P [GeV]	+/-	Pt [GeV]	ϕ	η	M(2l) [GeV]	M(4l) [GeV]	e/ μ
JiveXML_165732	3.007	Tracks 2	186.3	+	39.9	1.563	-2.224	86.559		e
		Tracks 1	251.5	-	47.0	-1.720	-2.361			e

M(Iv) Histogram
M(II) Histogram
M(III) Histogram
M(ee) Histogram
M($\mu\mu$) Histogram
ETMis Histogram
P Histogram
Pt Histogram
 ϕ Histogram
cot θ Histogram
 η Histogram

Canvas ATLAS XML_165732_97381580.xml Run: 165732 Event: 97381580
:48:51 CEST source:jiveXML_165732_97381580 HYPATIA



HYPATIA - Track Momenta Window

Previous Event Next Event Insert Electron Insert Muon Delete

ETMis: 3.007 GeV ϕ : 1.057 rad Collection: MET RefFinal

fasterClass/zpath/Els/jiveXML_165732_97381580.xml

Reconstructed Tracks

Track	+/-	P [GeV]	Pt [GeV]	ϕ	θ
Tracks 1	-	251.45	47.01	-1.720	2.954
Tracks 2	+	186.30	39.85	1.563	2.926

HYPATIA - Control Window

Interaction and Window Control Output Display

Parameter Control

Event Data

W S X L M R 1 2 3 U 3
B B 4 5 6 C 6
7 8 9 D 9

Za razmišljanje

- ✓ **Vaš posao se ne završava kada dobijete rezultate**
- ✓ **Analizirajte raspodelu koju ste dobili**
- ✓ **Da li vidite razlike između e^+e^- i $\mu^+\mu^-$ raspodela?**
- ✓ **Koliko često se Z bozon raspada na e^+e^- a koliko često na $\mu^+\mu^-$?**
- ✓ **Kolika je srednja vrednost mase Z bozona? Zašto ne postoji samo jedna vrednost mase Z bozona? Kolika je njegova širina?**
- ✓ **Da li primećujete neke druge rezonance na manjim vrednostima invarijantne mase leptonskih parova? Možete li da se setite njihovih imena?**
- ✓ **Da li ste otkrili novu česticu na velikoj vrednosti invarijantne mase? Kolika je masa / širina te čestice?**
- ✓ ***Ne zaboravite, radite sa realnim podacima iz proton-proton sudara prikupljenih na ATLAS eksperimentu 2015. godine. Zato, UŽIVAJTE !!!***