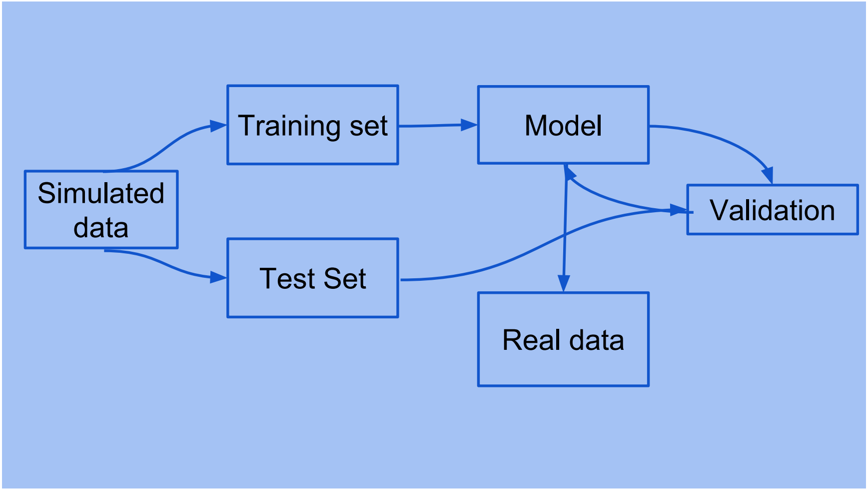
Machine Learning techniques applied to cosmological problems.

Martín de los Rios

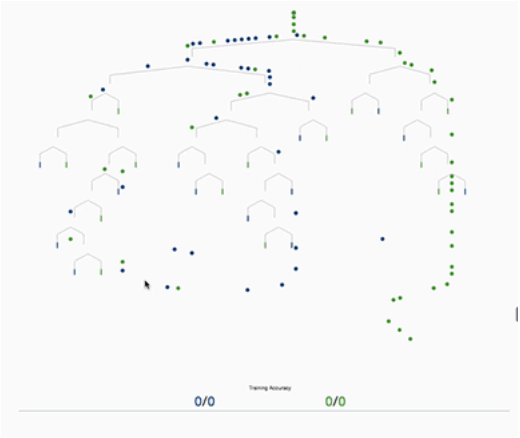
Director: Dr. Mariano Domínguez

Resumen

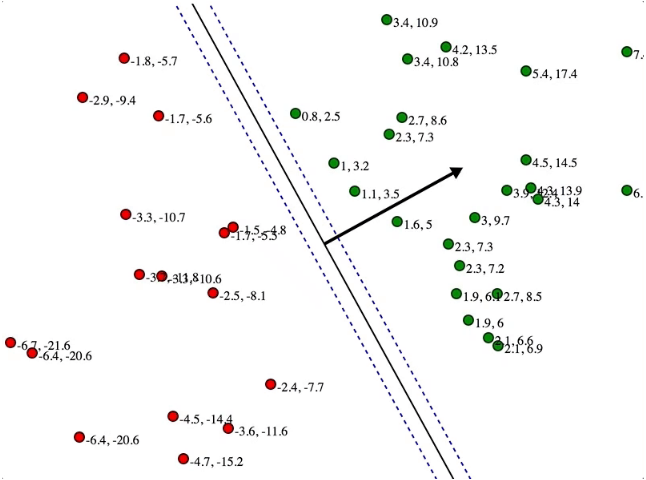
Supervised Learning.



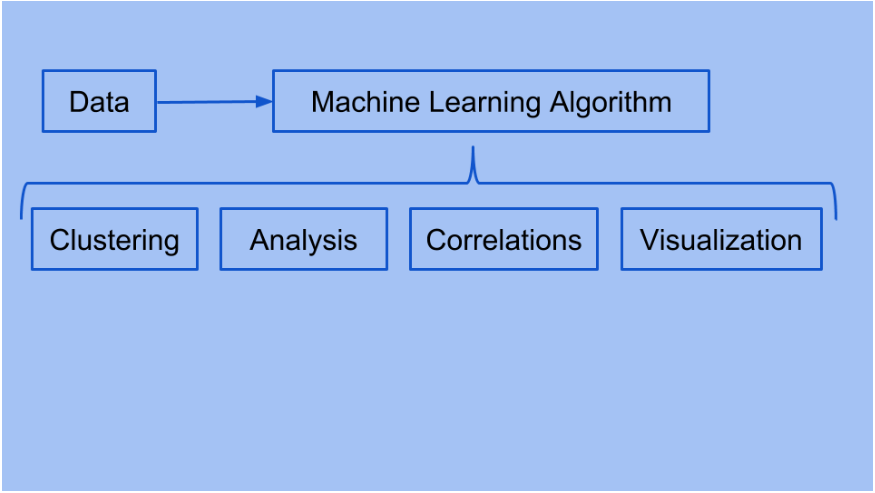
Random Forest



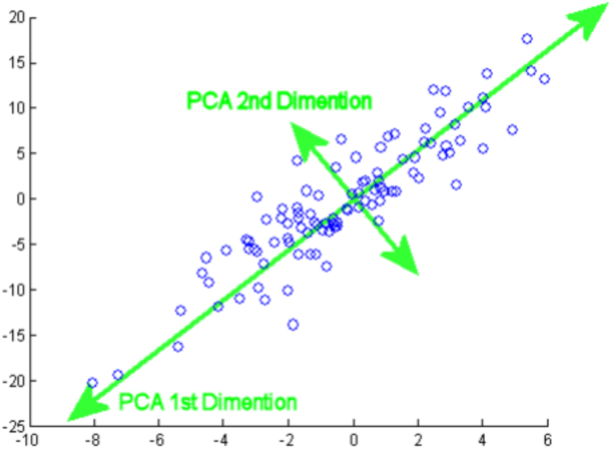
Support Vector Machines



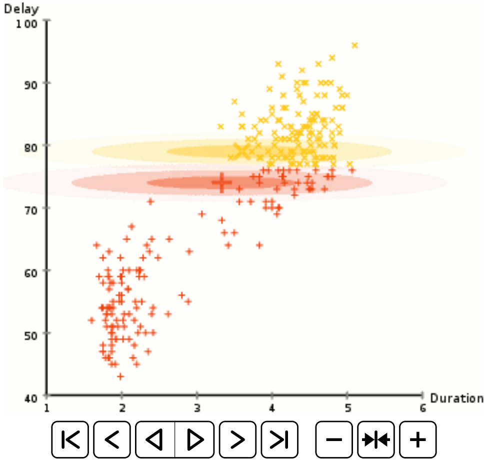
Unsupervised Learning.



Principal Components Analysis.



Mixture of Gaussians



Mon. Not. R. Astron. Soc. **000**, 1–7 (2015) Printed 17 December 2015 (MN LaTeX style file v2.2)

The MeSsI (Merging Systems Identification) Algorithm & Catalogue.

Martín de los Rios⋆, Mariano J. Domínguez R.⋆, Dante Paz, Manuel Merchán [1,2,3].
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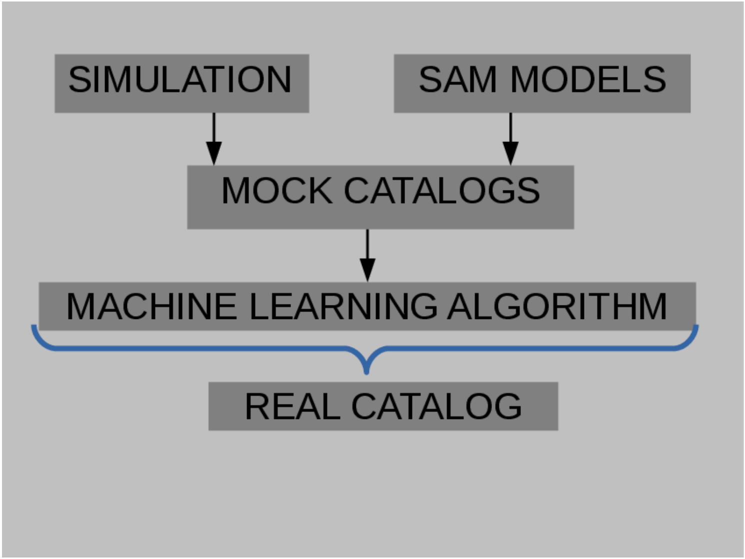
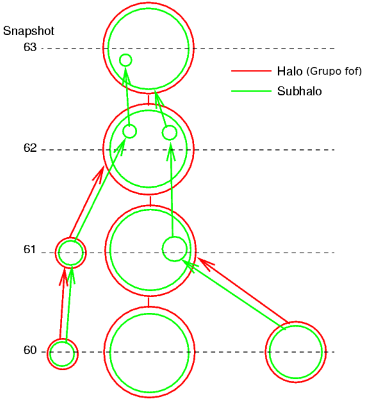
[2] *Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.*
[3] *Consejo Nacional de Investigaciones Científicas y Técnicas, Rivadavia 1917, C1033AAJ Buenos Aires, Argentina.*

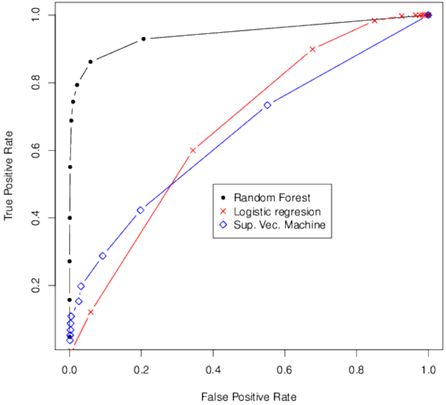

SIMULATION
SAM MODELS
MOCK CATALOGS
MACHINE LEARNING ALGORITHM
REAL CATALOG

Study of the merger trees.

- Based on the subhalos merger trees, we construct the merger tree for every fof group in the simulation.



- Dressler-Shectman test.
- Non gaussianity test.
- Color.
- Number of galaxies.



- We found 61 candidates to merging clusters.
- In 32 of these we were able to identify the colliding substructures.
- 21 of these were previously classified as merging clusters by other authors.

Name	M_1 [$10^{14} M_{\odot}$]	RA_1[°]	DEC_1 [°]	z_1	M_2 [$10^{14} M_{\odot}$]	RA_2[°]	DEC_2[°]	z_2
Abell 1991	5.7	223.58	18.53	0.0583	2.6	223.67	18.67	0.0586
	±1.2	±0.05	±0.09	±0.0003	±1.02	±0.6	±0.1	±0.0003
Abell 1424	4.9	179.38	5.08	0.0760	5.1	179.19	5.01	0.0746
	±2.3	±0.09	±0.02	±0.0004	±1.4	±0.1	±0.04	±0.0005
Abell 1589	5.5	190.25	18.53	0.0721	1.1	190.34	18.22	0.0716
✓	±0.4	±0.01	±0.02	±0.0001	±0.5	±0.01	±0.005	±0.0002
31170	25.4	255.63	34.06	0.0993	13.3	255.76	33.90	0.0989
	±0.8	±0.05	±0.05	±0.0001	±1.3	±0.005	±0.005	±0.0002
Abell 2029/33	24.3	227.73	5.68	0.0796	13.4	227.81	6.13	0.0805
	±4.6	±0.05	±0.1	±0.0004	±1.8	±0.1	±0.2	±0.0009
Abell 2069	22.6	230.99	29.94	0.1146	32	231.07	29.86	0.1146
✓	±6.8	±0.05	±0.04	±0.0002	±10	±0.05	±0.09	±0.0004
Abell 2142	18.3	239.61	27.23	0.0901	11.3	239.33	27.5	0.0893
✓	±0.6	±0.005	±0.005	±0.0004	±1.8	±0.005	±0.005	±0.0001
Abell 1913	5.5	216.73	16.75	0.0530	2.1	216.84	16.62	0.0533
	±1.1	±0.02	±0.06	±0.0004	±1.4	±0.04	±0.1	±0.0013
Abell 2399	5.1	329.29	−7.81	0.0576	2.4	329.49	−7.79	0.0581
	±0.3	±0.02	±0.02	±0.0001	±0.3	±0.04	±0.02	±0.0002
Abell 85	7.4	10.425	−9.25	0.0559	1.8	10.47	−9.51	0.0573
✓	±0.3	±0.005	±0.01	±0.0001	±1.1	±0.01	±0.05	±0.002
55731	1.9	244.72	24.21	0.0661	2.05	244.63	24.32	0.0656
	±0.4	±0.06	±0.08	±0.0004	±0.3	±0.07	±0.08	±0.0005
Abell 1750	8.7	202.80	−1.89	0.0868	7.5	202.82	−1.73	0.0848
✓	±1.1	±0.02	±0.02	±0.0009	±1.6	±0.04	±0.1	±0.0016
Abell 3158	37.24	55.75	−53.63	0.0633	4.6	55.37	−53.48	0.0622
✓	±1.5	±0.07	±0.004	±0.0001	±0.2	±0.007	±0.001	±0.0001
Abell 376	19.7	41.46	36.89	0.0478	4.01	41.72	36.94	0.0489
	±1.4	±0.006	±0.005	±0.0001	±1.09	±0.003	±0.007	±0.0002
Abell 3490	44.76	176.42	−34.37	0.0688	116.5	176.1	−34.39	0.0727
	±4.3	±0.02	±0.01	±0.0001	±40.4	±0.1	±0.1	±0.001
Abell 2382	77.7	327.90	−15.66	0.0676	6.12	328.167	−15.62	0.0642
	±10.2	±0.006	±0.006	±0.0003	±1.1	±0.003	±0.01	±0.0002
Abell 689	32.3	129.39	14.99	0.2788	9.9	129.29	15.06	0.2791
	±7.9	±0.02	±0.04	±0.0002	±8.5	±0.1	±0.1	±0.0007
Abell 1758N	59.3	203.07	50.59	0.2768	29.1	203.25	50.57	0.2783
✓	±9	±0.02	±0.01	±0.0002	±15.8	±0.02	±0.03	±0.0007
Abell 1758S	43	203.21	50.42	0.2742	15.8	202.96	50.39	0.2739
✓	±4	±0.005	±0.001	±0.0002	±1.6	±0.001	±0.001	±0.0001
Abell 2631	84.9	354.36	0.26	0.2762	77.1	354.60	0.269	0.2766
✓	±2.1	±0.001	±0.001	±0.0001	±4.3	±0.005	±0.01	±0.0002
Abell 2055	20.02	229.68	6.23	0.1013	3.9	229.71	6.19	0.0997
	±7.6	±0.04	±0.06	±0.0007	±2.2	±0.08	±0.1	±0.0018
Abell 2261	65.8	260.60	32.06	0.2253	13.4	261.10	32.27	0.2232

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December 4, 2017

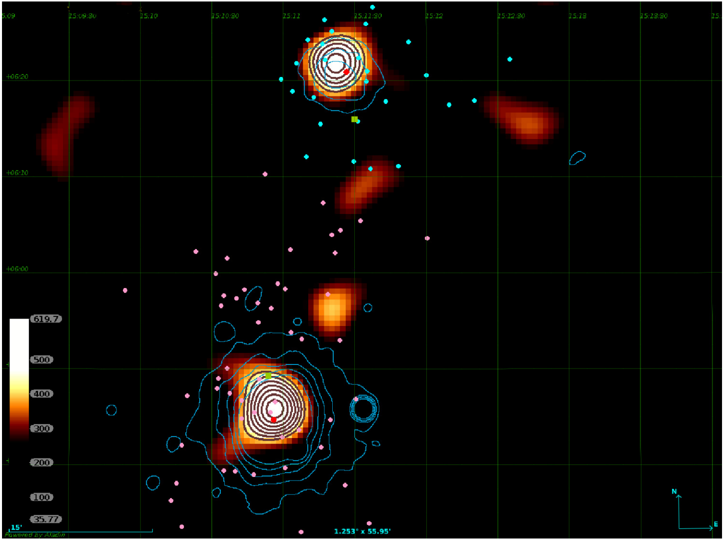
I. Analysis of candidates for interacting galaxy clusters

A1204 and A2029/A2033

Elizabeth Johana Gonzalez ⋆[1,2], Martín de los Rios[1,2], Gabriel A. Oio[1,2], Daniel Hernández Lang[4], Tania Paez Tagliaferro[1,2], Mariano J. Domínguez R.[1,2], José Luis Nilo Castellón[3,4], Héctor Cuevas L.[4], and Carlos A. Valotto[1,2]

[1] Instituto de Astronomía Teórica y Experimental, (IATE-CONICET), Laprida 854, X5000BGR, Córdoba, Argentina.
[2] Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.
[3] Instituto de Investigación Multidisciplinario en Ciencia y Tecnología, Universidad de La Serena. Benavente 980, La Serena, Chile.
[4] Departamento de Física y Astronomía, Facultad de Ciencias, Universidad de La Serena. Av. Juan Cisternas 1200, La Serena, Chile.

A2029/2033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15:10
15:10:30
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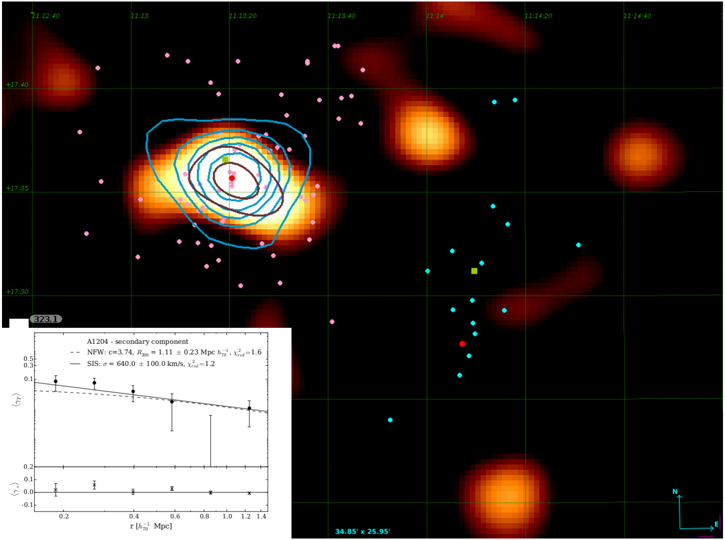
15:11:30
15:12
15:12:30
15:13
15:13:30
+06:20
+06:10
+06:00
619.7
500
400
300
200
100
35.77
15'
Powered by Aladin
1.253° x 55.95'
N
E

A1204



11:12:40
11:13
11:13:20
11:13:40
11:14
11:14:20
11:14:40
+17:40
+17:35
+17:30
323.1
A1204 - secondary component
NFW: c=3.74, R_{200} = 1.11 ± 0.23 Mpc h_{70}^{-1}, χ^2_{red}=1.6
SIS: σ = 640.0 ± 100.0 km/s, χ^2_{red}=1.2
$\langle\gamma_T\rangle$
$\langle\gamma_\times\rangle$
r [h_{70}^{-1} Mpc]
34.85' x 25.95'
N
E

II. Analysis of candidates for interacting galaxy clusters:

A267, a merging fossil group.

Elizabeth Johana Gonzalez ⋆[1,2], María Jose Kanagusuku[1,2], Martín de los Rios[1,2], Gabriel A. Oio[1,2], Daniel Hernández Lang[4], Tania Aguirre Tagliaferro[1,2], Mariano J. Domínguez R.[1,2], José Luis Nilo Castellón[3,4], Héctor Cuevas L.[4], and Carlos A. Valotto[1,2]

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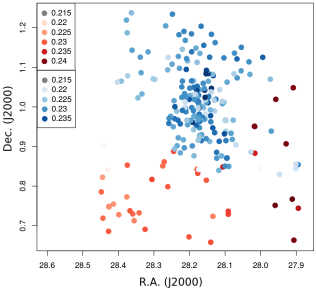
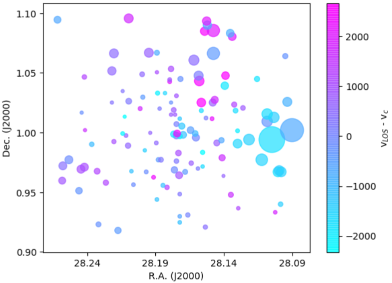
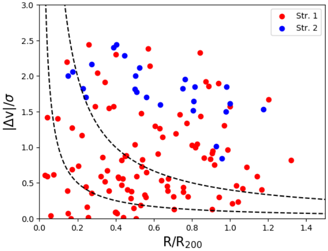
[2] Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.
[3] Instituto de Investigación Multidisciplinario en Ciencia y Tecnología, Universidad de La Serena. Benavente 980, La Serena, Chile.
[4] Departamento de Física y Astronomía, Facultad de Ciencias, Universidad de La Serena. Av. Juan Cisternas 1200, La Serena, Chile.


0.215
0.22
0.225
0.23
0.235
0.24
0.215
0.22
0.225
0.23
0.235
Dec. (J2000)
R.A. (J2000)
28.6
28.5
28.4
28.3
28.2
28.1
28.0
27.9
0.7
0.8
0.9
1.0
1.1
1.2


Dec. (J2000)
R.A. (J2000)
28.24
28.19
28.14
28.09
0.90
0.95
1.00
1.05
1.10
2000
1000
0
−1000
−2000
$v_{LOS} - v_c$



- $\approx 40\%$ Fossil groups have a major merger $z < 0.8$.
- $\approx 15 - 25\%$ Fossil groups have a major merger $z < 0.3$.

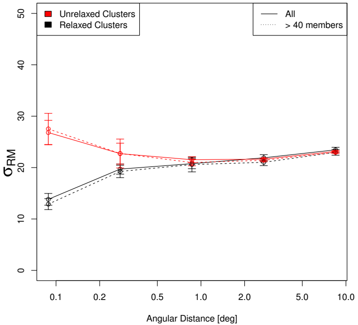
Faraday Rotation Measure dependence with galaxy clusters dynamics

F.A. Stasyszyn[1,2★] & M. de los Rios[1,2,3]

[1] *Instituto de Astrofísica Teórica y Experimental (IATE), Laprida 854, Córdoba, Argentina*

[2] *Observatorio Astronómico de Córdoba, Universidad Nacional de Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina.*

[3] *Consejo Nacional de Investigaciones Científicas y Técnicas, Rivadavia 1917, C1033AAJ Buenos Aires, Argentina.*


Unrelaxed Clusters
Relaxed Clusters
All
> 40 members
σ_{RM}
0
10
20
30
40
50
0.1
0.2
0.5
1.0
2.0
5.0
10.0
Angular Distance [deg]
Unrelaxed Clusters
Relaxed Clusters
All
> 40 members
σ_{RM}
1
2
5
10
Projected Distance [Mpc]

CosmoML: Machine Learning techniques applied to the Cosmic Microwave Background.

Martín de los Rios⋆, Mariano J. Domínguez R.⋆ [1,2,3].
[1] *Instituto de Astronomía Teórica y Experimental (CCT Córdoba, CON ICET, UNC), Laprida 854, X5000BGR, Córdoba, Argentina.*
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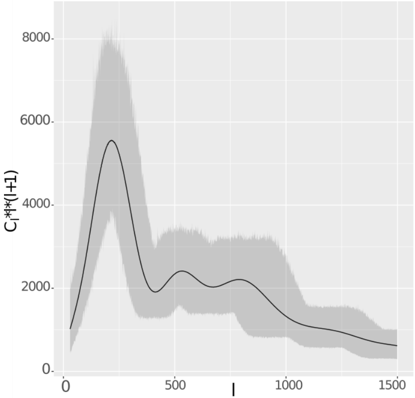
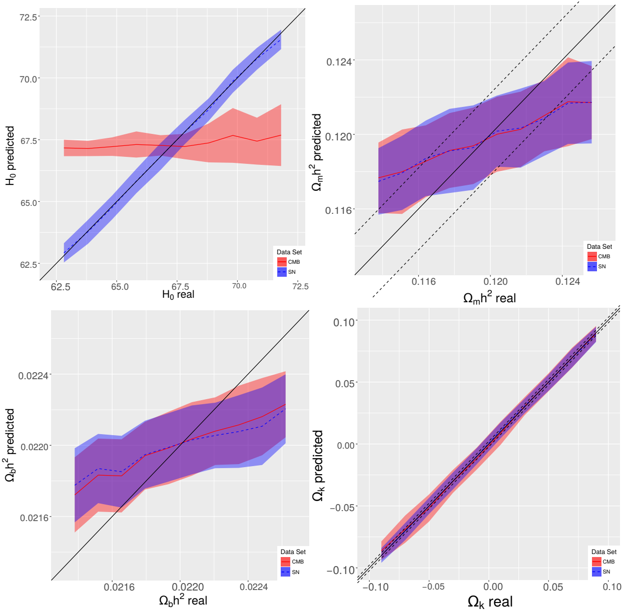
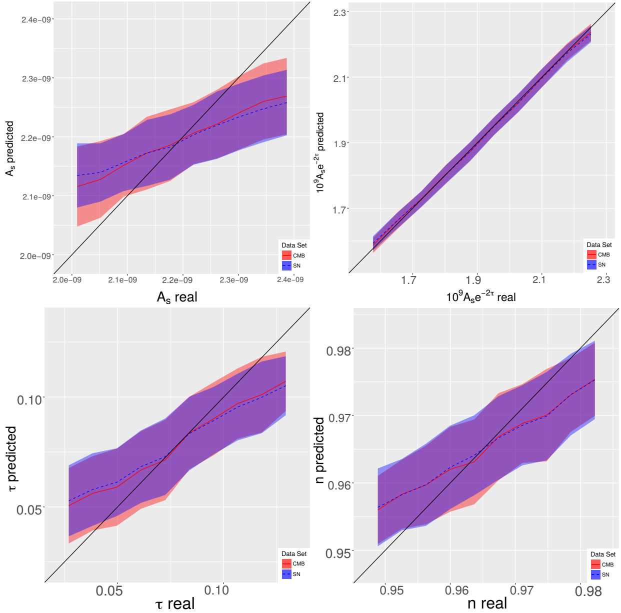
Parameter	Minimum	Maximum	Planck
$\Omega_m h^2$	0.1131	0.1263	0.1197
$\Omega_b h^2$	0.02131	0.02269	0.022
Ω_k	–0.1	0.1	0
H_0	62.31	72.31	67.31
n	0.9469	0.9841	0.9655
A_s	$1.988 * 10^{-9}$	$2.408 * 10^{-9}$	$2.198 * 10^{-9}$
τ	0.021	0.1349	0.078

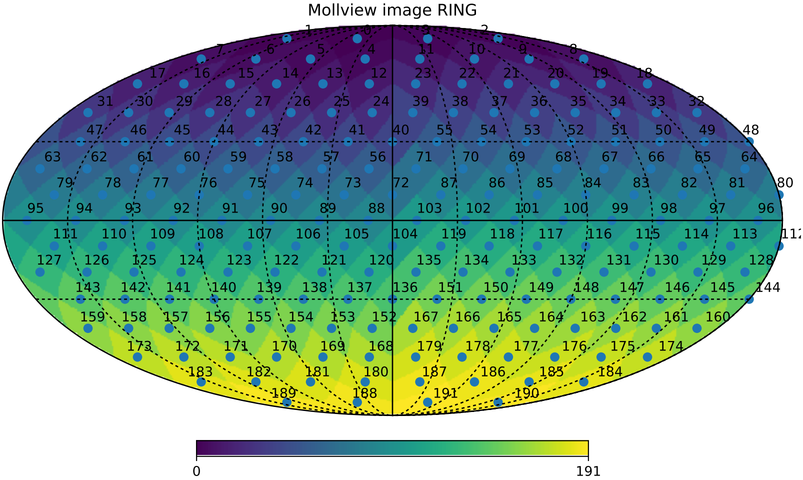




H_0 predicted
H_0 real
$\Omega_m h^2$ predicted
$\Omega_m h^2$ real
$\Omega_b h^2$ predicted
$\Omega_b h^2$ real
Ω_k predicted
Ω_k real
Data Set
CMB
SN



A_s predicted
A_s real
10^9 A_s e^{-2τ} predicted
10^9 A_s e^{-2τ} real
τ predicted
τ real
n predicted
n real
Data Set
CMB
SN


Mollview image RING
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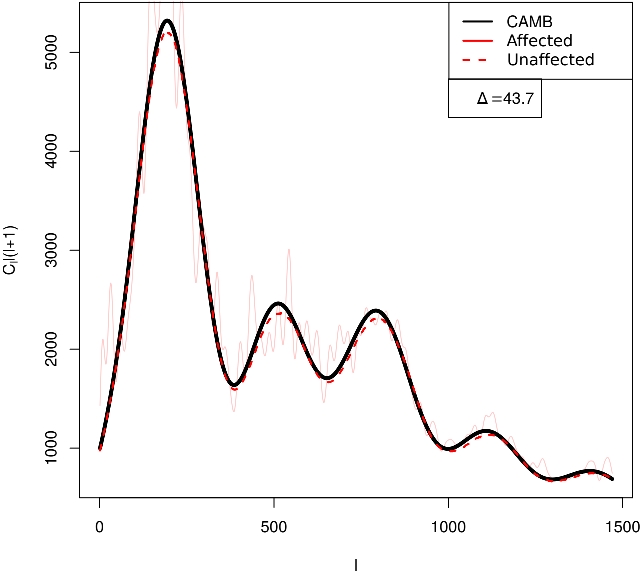
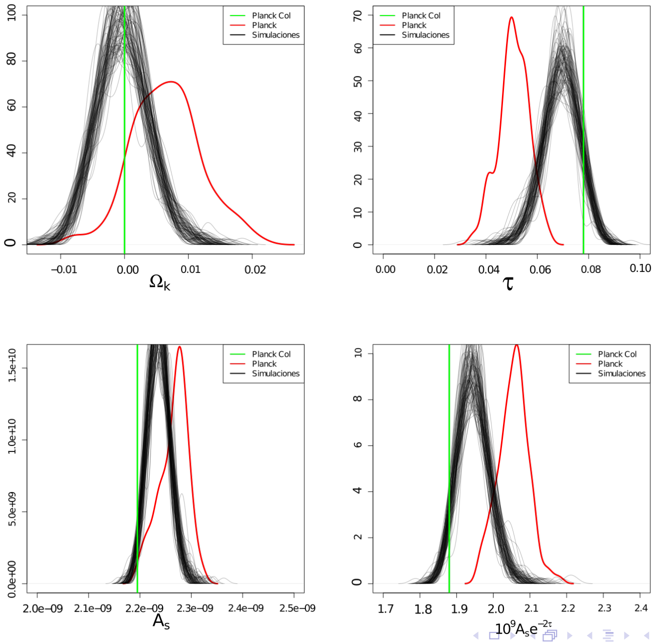
63 62 61 60 59 58 57 56 71 70 69 68 67 66 65 64
79 78 77 76 75 74 73 72 87 86 85 84 83 82 81 80
95 94 93 92 91 90 89 88 103 102 101 100 99 98 97 96
111 110 109 108 107 106 105 104 119 118 117 116 115 114 113 112
127 126 125 124 123 122 121 120 135 134 133 132 131 130 129 128
143 142 141 140 139 138 137 136 151 150 149 148 147 146 145 144
159 158 157 156 155 154 153 152 167 166 165 164 163 162 161 160
173 172 171 170 169 168 179 178 177 176 175 174
183 182 181 180 187 186 185 184
189 188 191 190
0
191


CAMB
Affected
Unaffected
Δ =43.7
5000
4000
3000
2000
1000
Cl(l+1)
0
500
1000
1500
l


Planck Col
Planck
Simulaciones
Ω_k
τ
A_s
$10^9 A_s e^{-2\tau}$

- We developed a method for the automatic classification of galaxy clusters dynamical state.

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- Using this technique wee build a catalogue of merging clusters candidates.

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- We performed individual analysis of 3 of this clusters.
- We performed an Statistical analysis comparing the magnetic fields in relaxed and unrelaxed clusters.
- We studied the cosmic microwave background using Machine Learning techniques.
- We studied the angular distributions of the cosmological parameters without finding anything unexpected in the standard cosmological model, with the possible exception of the parameter $10^9 A_s e^{-2\tau}$.

- Machine Learning techniques are very powerful tools to study in an independent and agnostic way any data set.

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- They can be very useful for classification and regression problems, achieving, in most of the problems, better results than the traditional methods in lower computational time.

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- They can be very useful for classification and regression problems, achieving, in most of the problems, better results than the traditional methods in lower computational time.
- Taking into account the large amount of data that will be recorded by the future surveys, this technique will be essential for their analysis.


THANK YOU