GSI2: ^{16}O (200 MeV) on C_2H_4 Charge Measurement in Section2

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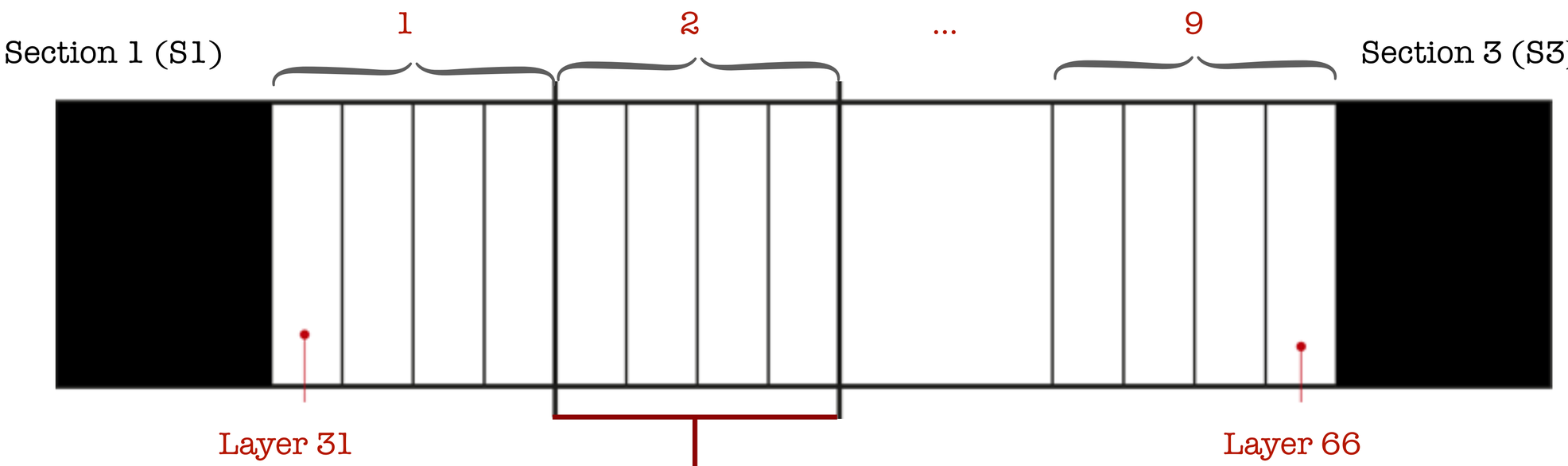
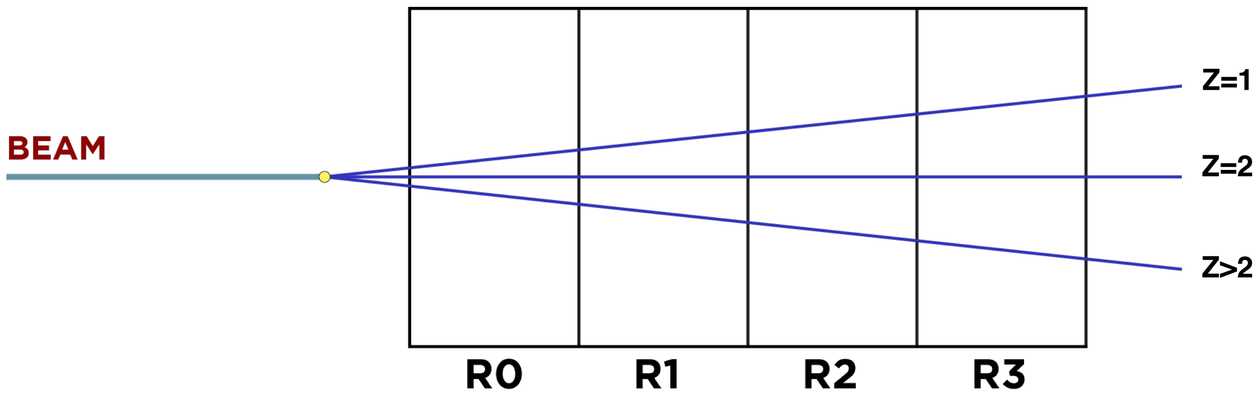
ZOOM General meeting, 11 June 2020

STRUCTURE OF SECTION 2 (S2)

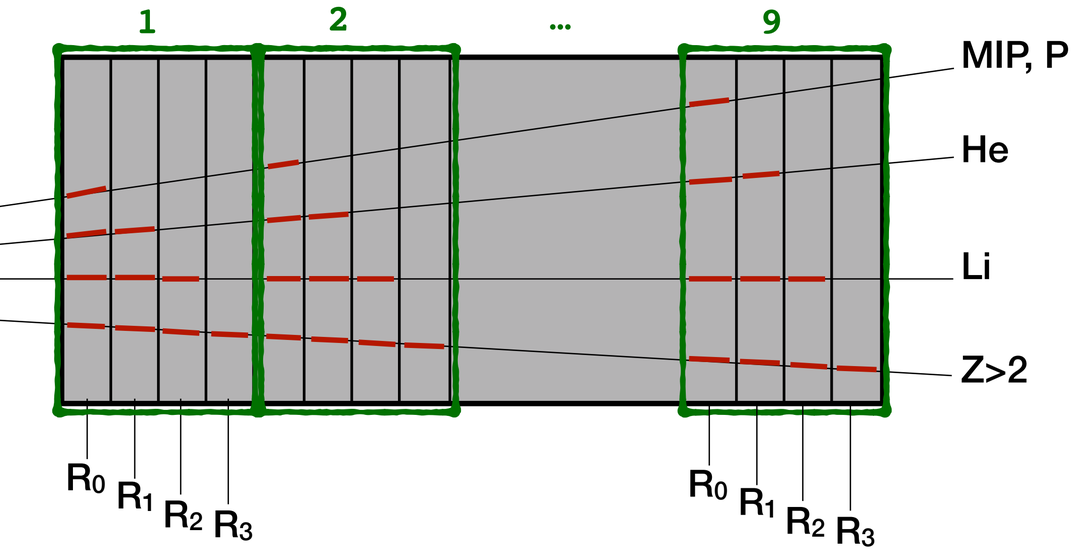


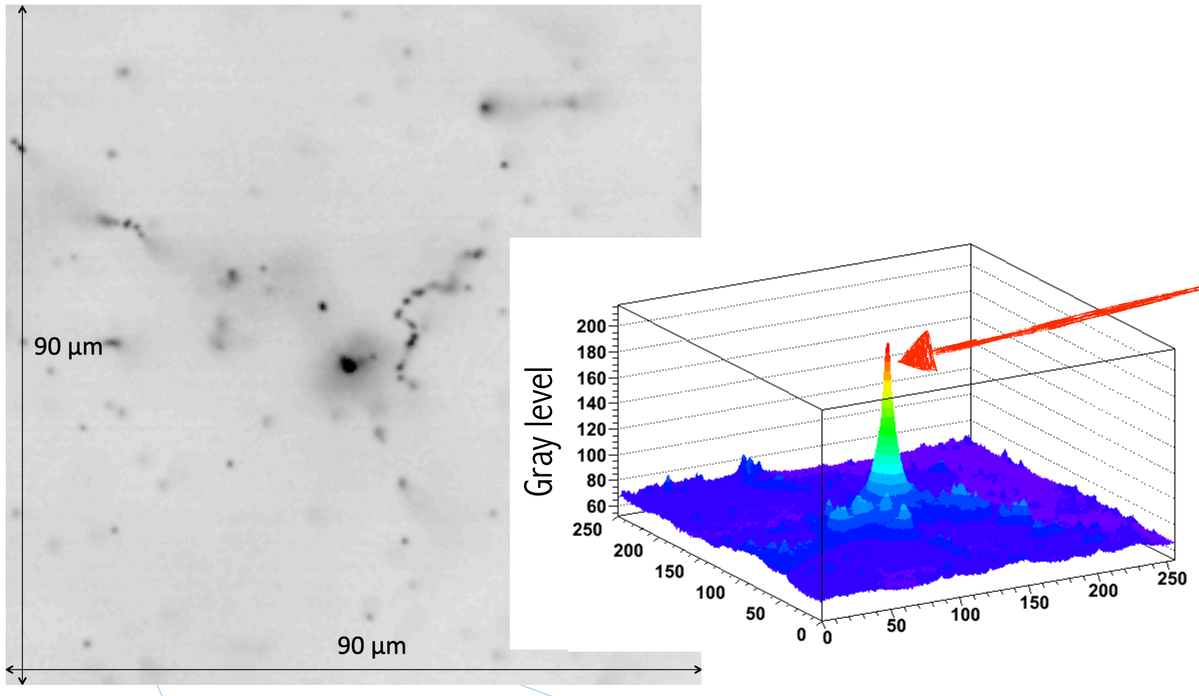


Emulsions in S2 underwent to **different thermal treatments**

- **R0:** Not thermally treated
- **R1:** 24 h at **T1=28°C** and RH = 95%
- **R2:** 24 h at **T2=34°C** and RH = 95%
- **R3:** 24 h at **T3=36°C** and RH = 95%

VARIABLES USED



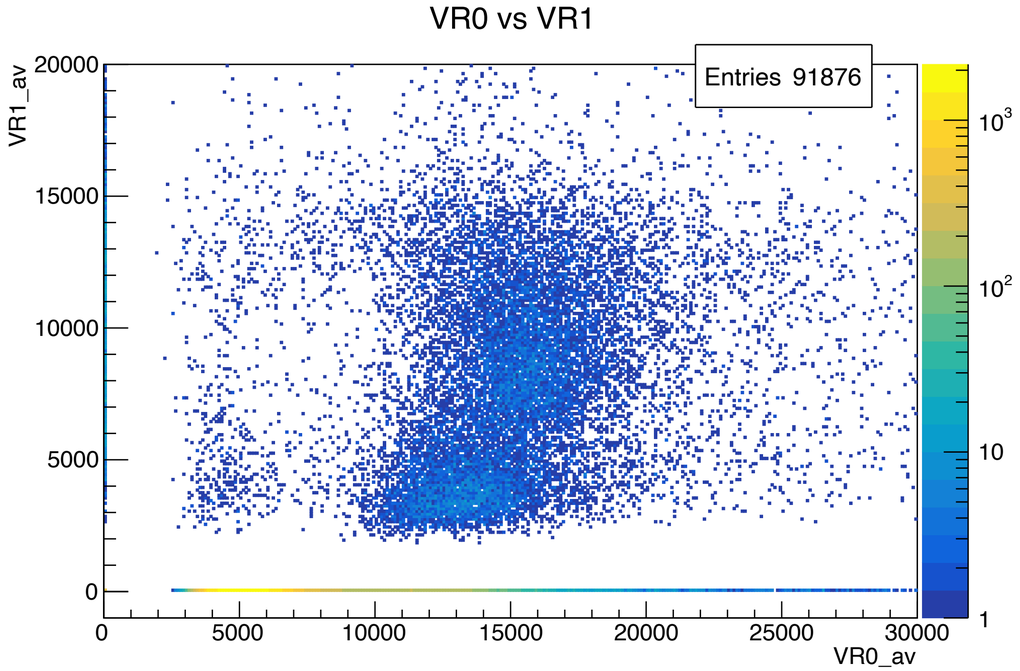


Each thermal treatment erase totally or partially the track's segments, depending on its ionization.

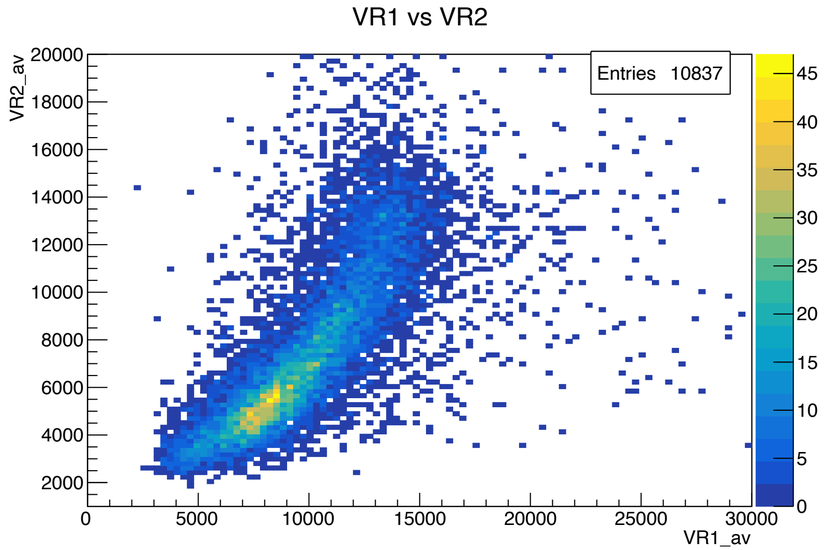
For each track the following variables are evaluated:

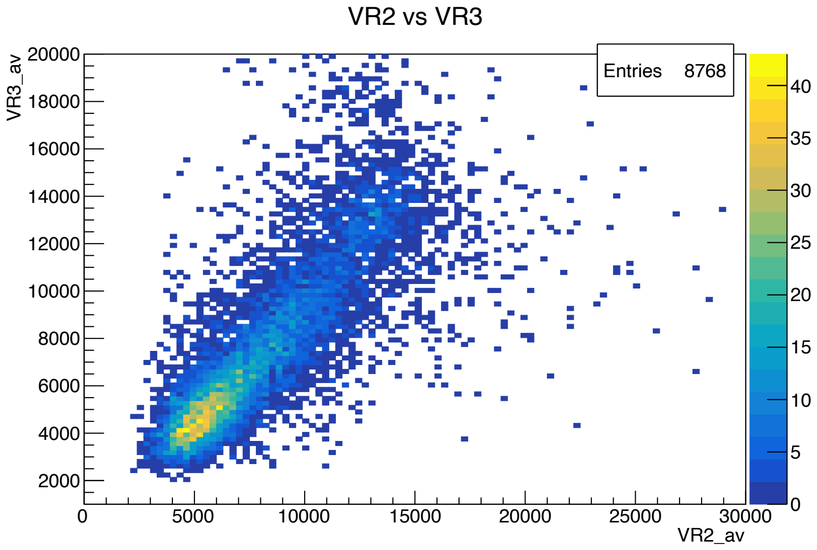
- nsegx: number of the segments in Rx
- Volume VRx: ionization in each layer
- VRx_av: $\frac{\sum_{\text{nsegx}} \text{VRx}}{\text{nsegx}}$ *(evaluated also if nsegx=1)*

Charge Measurement

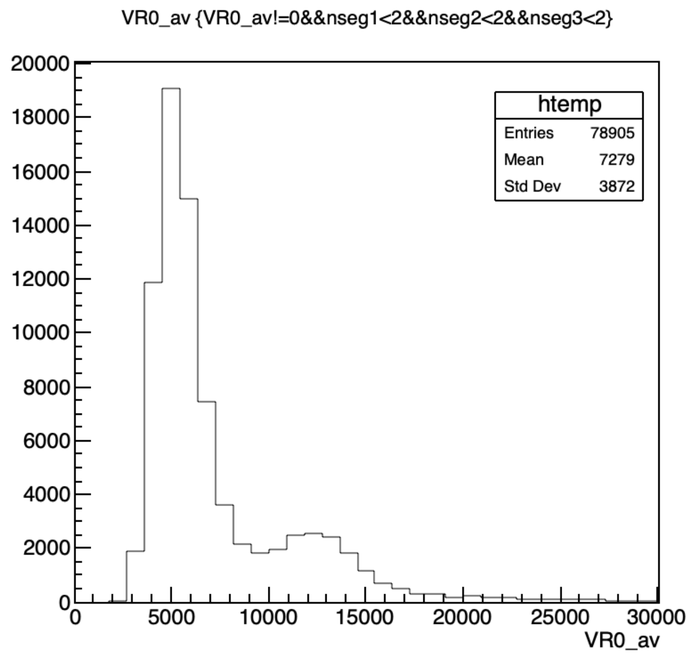


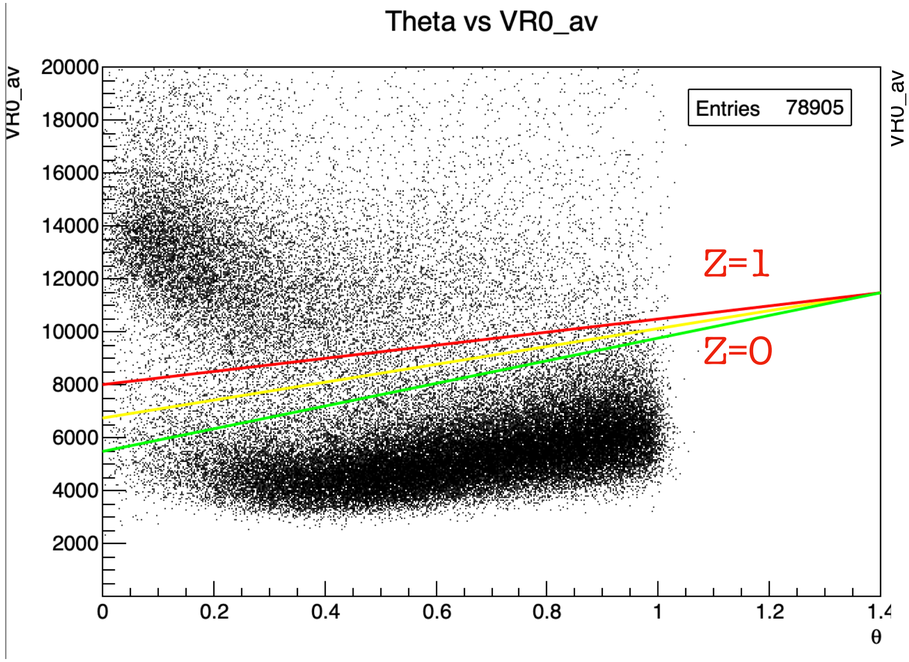
- Combining the four VRx_av variables we can distinguish the particles' charge:
  - ➡ Z≤2: sharp cuts on VR0 and VR1
  - ➡ Z≥2: Principal Components Analysis

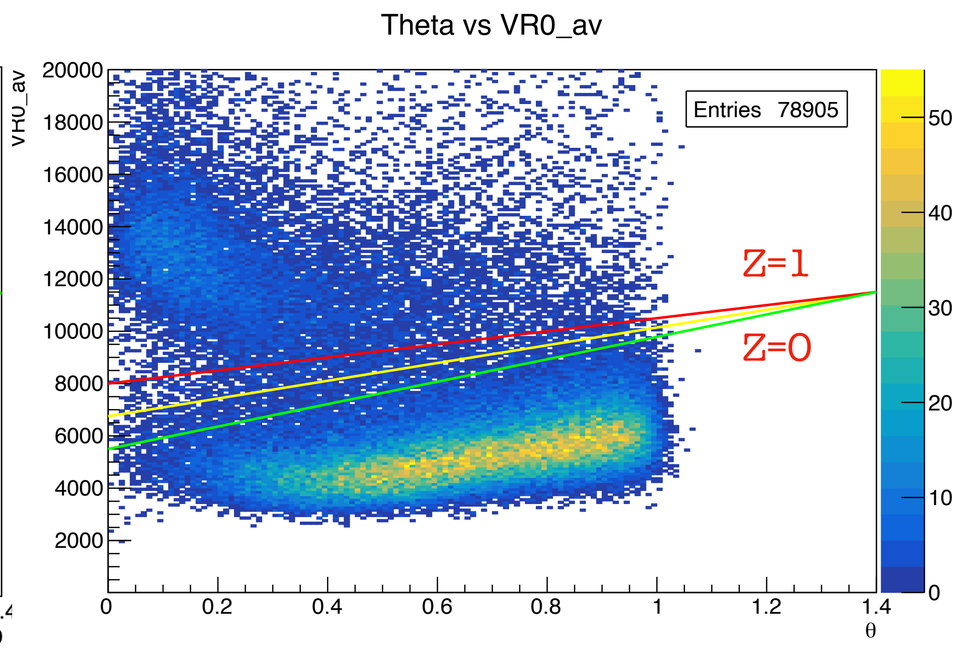




COSMIC RAYS AND HIGH ENERGY Z=1



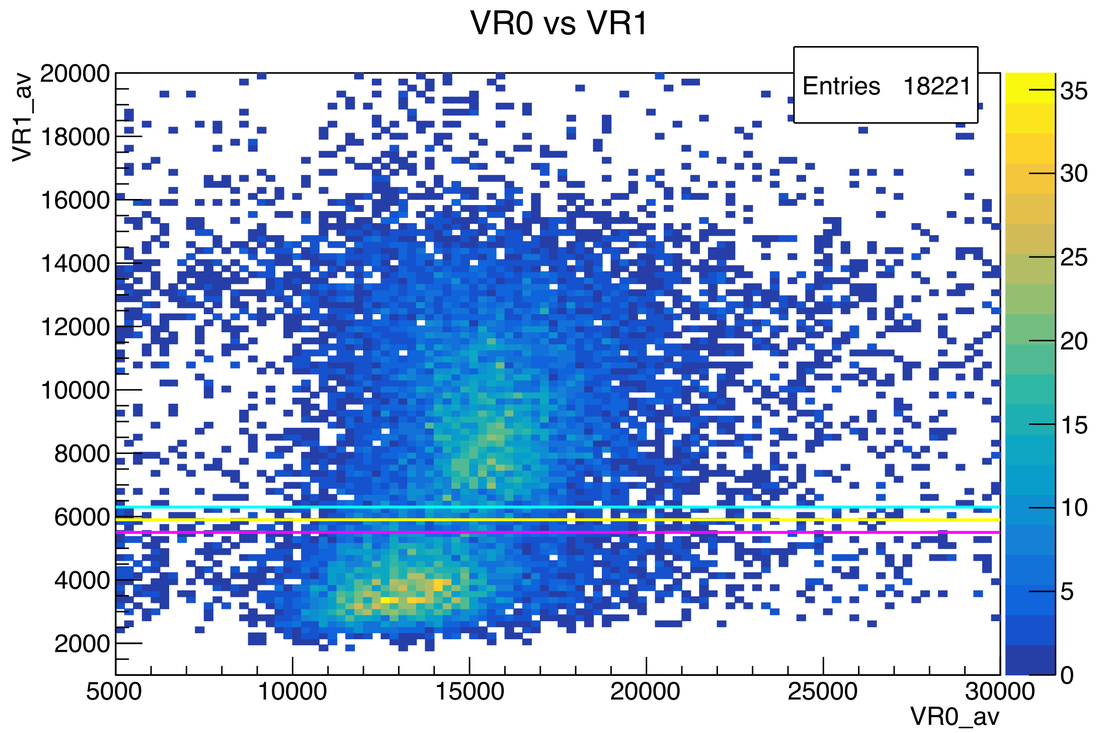


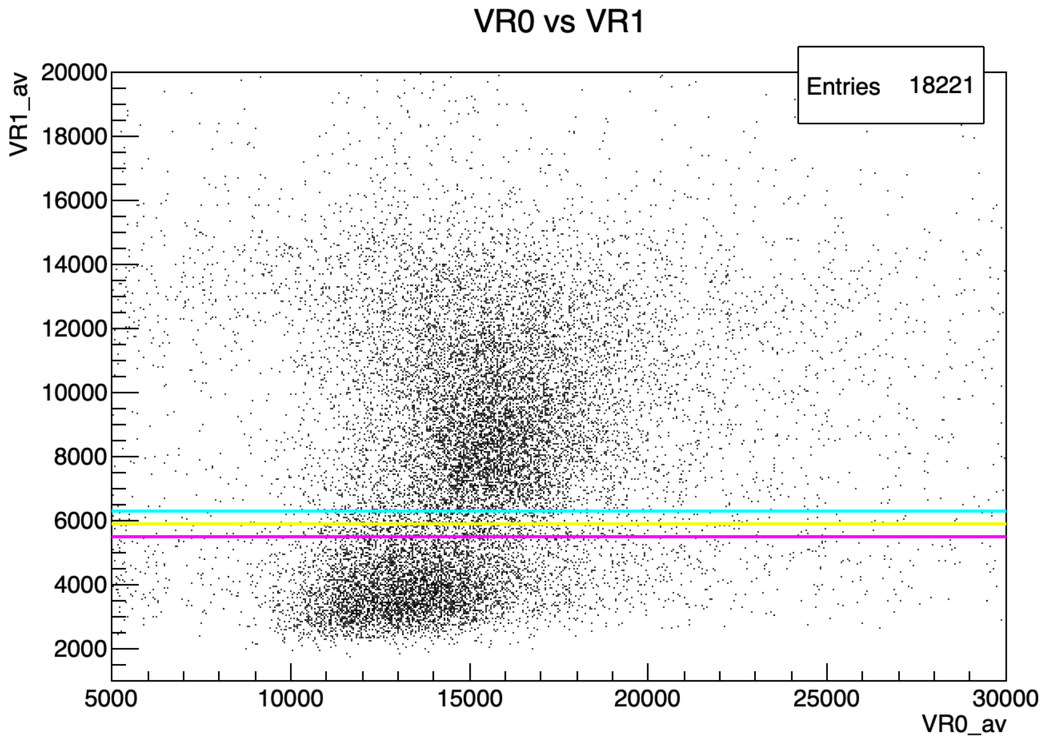


- **Cosmic Rays:**
  - **line0a:** VR0<4285.71*Theta+5500 & VR0_av!=0&nseg1<2&nseg2<0&nseg3<0 → **58486**
  - **line0b:** VR0< 3392.86*Theta+6750 & VR0_av!=0&nseg1<2&nseg2<0&nseg3<0 → **60126**
  - **line0c:** VR0< 2500*Theta+8000 & VR0_av!=0&nseg1<2&nseg2<0&nseg3<0 → **61462**

- **High energy Z=1**: VR0_av≥line0* &&nseg1<2&&nseg2<2&&nseg3<2

Z=1 Low energy





- **<u>Low energy Z=1:</u>**
  - **line1a**: VR0_av≥0&&0<**VR1_av≤5500**&&nseg2<2&&nseg3<2
  - **line1b**: VR0_av≥0&&0<**VR1_av≤5900**&&nseg2<2&&nseg3<2
  - **line1c**: VR0_av≥0&&0<**VR1_av≤6300**&&nseg2<2&&nseg3<2
- **<u>High energy Z=2</u>**: VR1_av≥line1*&&nseg2<2&&nseg3<2

Error Evaluation for Sharp Cuts

line0a / line1a		
Z	**# trks**	**% on total**
Cosmic Rays	58486	69.7%
1	22664	27.0%
2	2713	3.2%
Tot	83863	

line0c / line1a		
Z	**# trks**	**% on total**
Cosmic Rays	61462	73.3%
1	19688	23.5%
2	2713	3.2%
Tot	83863	

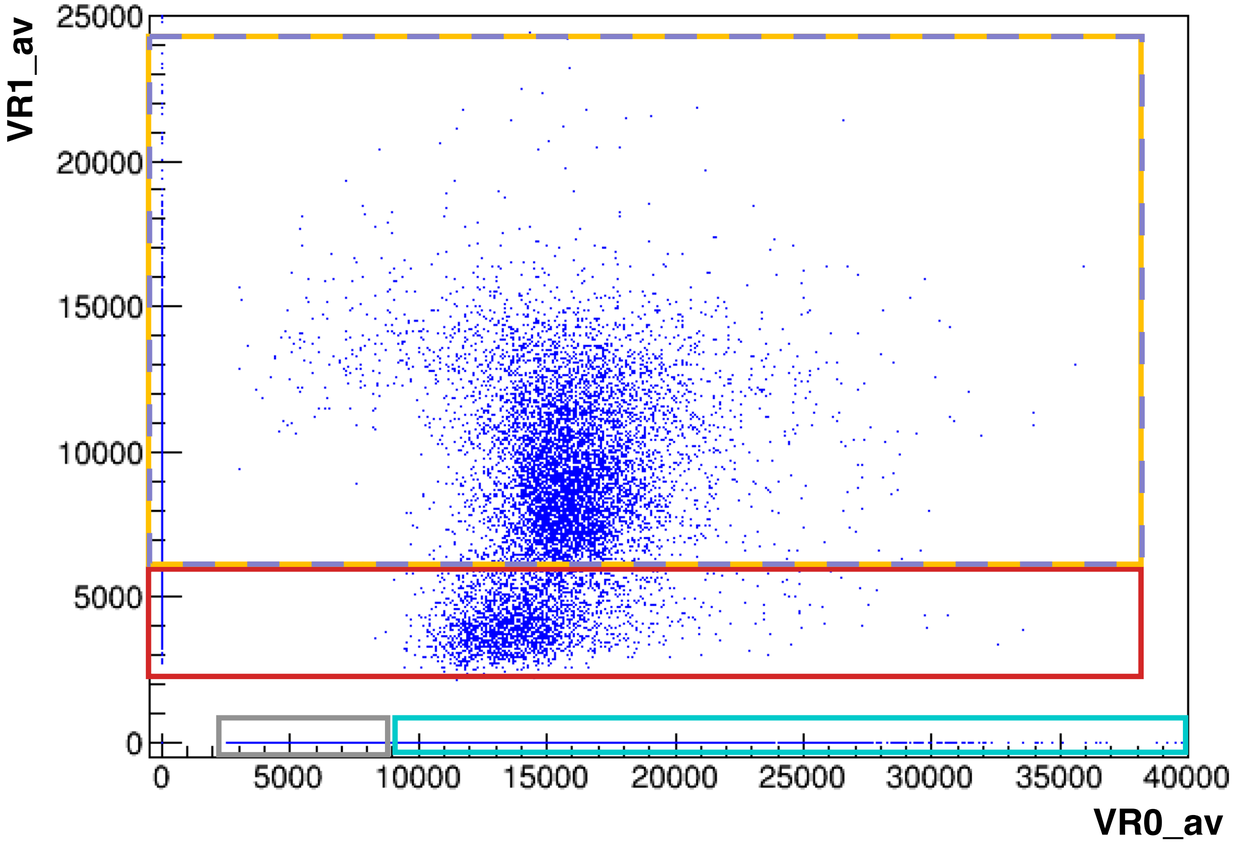
line0a / line1c		
Z	**# trks**	**% on total**
Cosmic Rays	58486	69.8%
1	22985	27.4%
2	2299	2.7%
Tot	83770	

line0c / line1c		
Z	**# trks**	**% on total**
Cosmic Rays	61462	73.4%
1	20009	23.9%
2	2299	2.7%
Tot	83770	

Result

	MEAN line0b / line1b		ERROR (Max-Min)/2	
Z	**# trks**	**% on total**	**# trks**	**% on total**
Cosmic	60126	72%	1488	2%
Z=1	21199	25%	1649	8%
Z=2	2494	3%	207	8%
TOT	83819			

SUMMARY CHARGE MEASUREMENT Z<2



- **Z=0:** 0<VR0< 3392.86*Theta+6750 & nseg1<2 & nseg2<2 & nseg3<2
- **High energy Z=1:** VR0_av≥4285.71*Theta+5500 & nseg1<2 & nseg2<2 & nseg3<2
- **Low energy Z=1:** VR0_av≥0 & 0<VR1_av≤5900 & nseg2<2 & nseg3<2
- **High energy Z=2:** VR1_av>5900 & nseg2<2 & nseg3<2
- **Z≥2: at least 3 VRx → Principal Components Analysis**

Principal Components Analysis (PCA)

Ref: https://root.cern.ch/doc/master/classTPrincipal.html

- Request: at least 3 VRx_av
- Four different variables have been created:
  - VP_123 = a·VR1_av + b·VR2_av + c·VR3_av
  - VP_023 = d·VR0_av + e·VR2_av + f·VR3_av
  - VP_013= g·VR0_av + h·VR1_av + i·VR3_av
  - VP_012= l·VR0_av + m·VR1_av + n·VR2_av

Given the value of VP_xxx we assign Z according to the probability provided by the three gaussian distributions (see next slide)

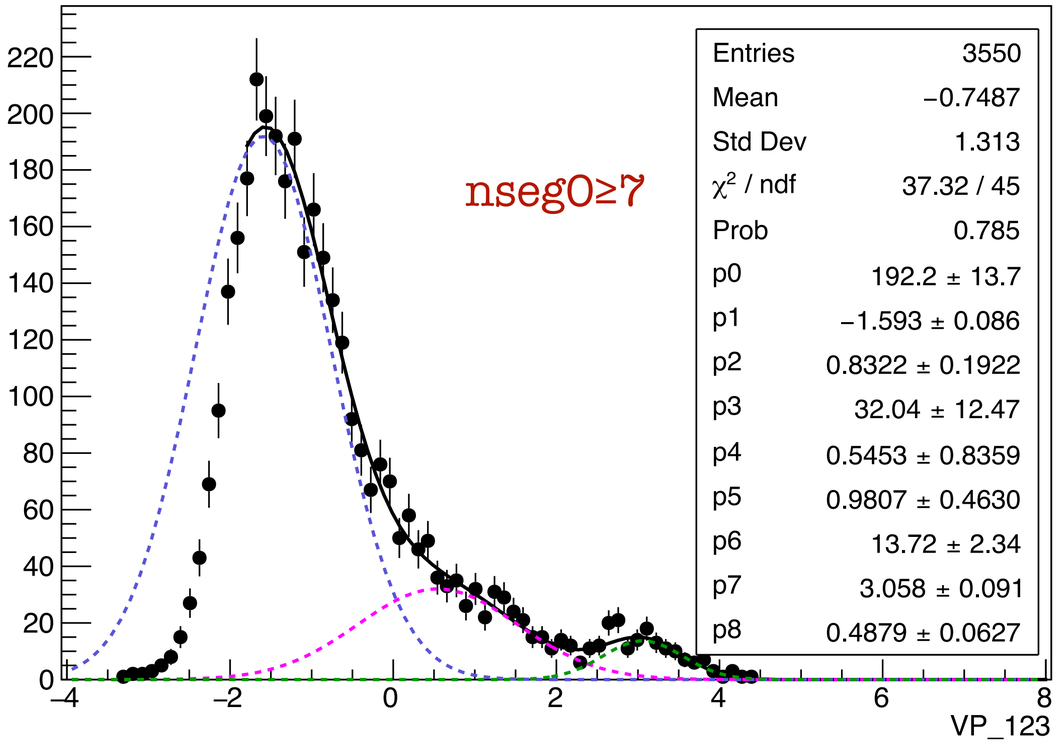
Assigned with PCA

Z	#	%
VP_123	6796	90.3%
VP_012	546	7.3%
VP_013	111	1.5%
VP_023	71	0.9%

VP_xxx Fits

Our fit model is characterized by:

- 3 gaussians
- Z=2 gaussian is partially erased
- Mean of Z=2 gaussian > Mean of Z=3 gaussian > Mean of Z≥4 gaussian
- Heigh of Z=2 gaussian > Heigh of Z=2 gaussian ≥ Heigh of Z≥4 gaussian

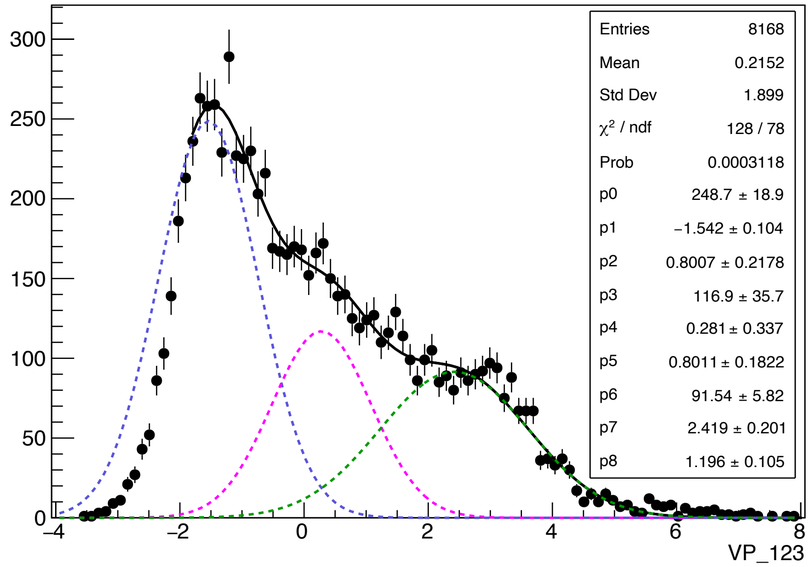


Model was qualitatively inferred by the analysis with a “cleaner” sample (requirement of 7 nseg0)

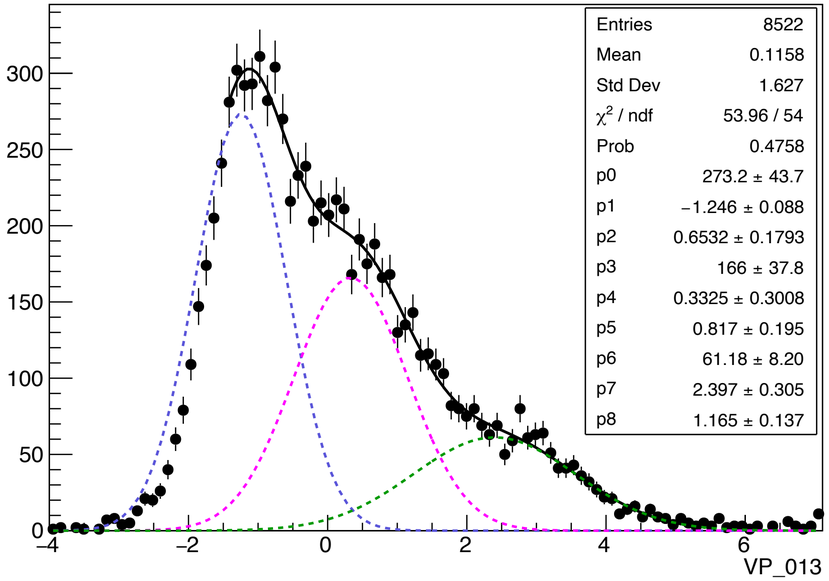
(see Adele Lauria’s presentation on 4/3/2020)

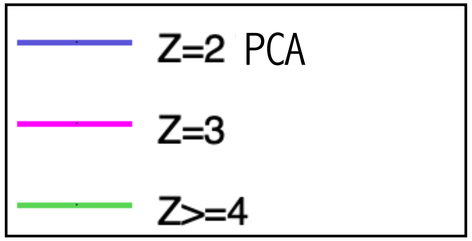
FIT VP_XXX

VP_123

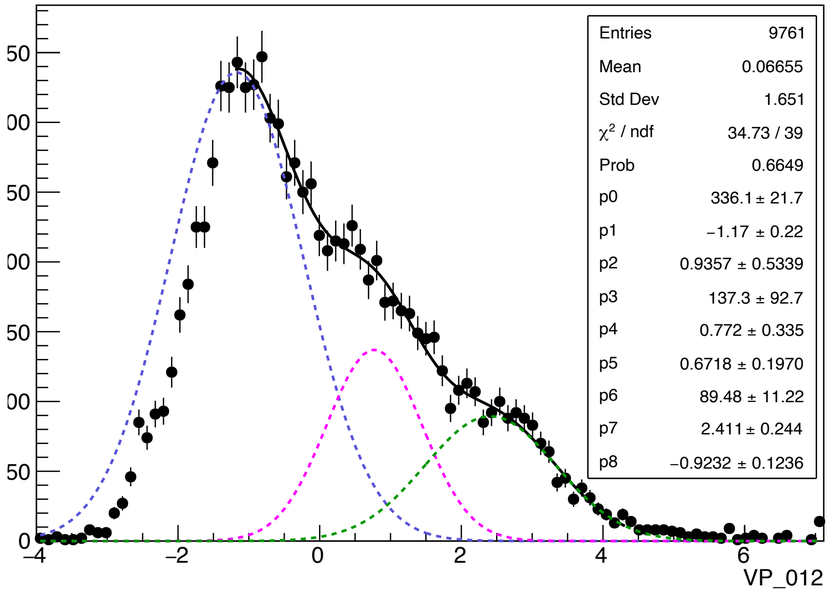


VP_013

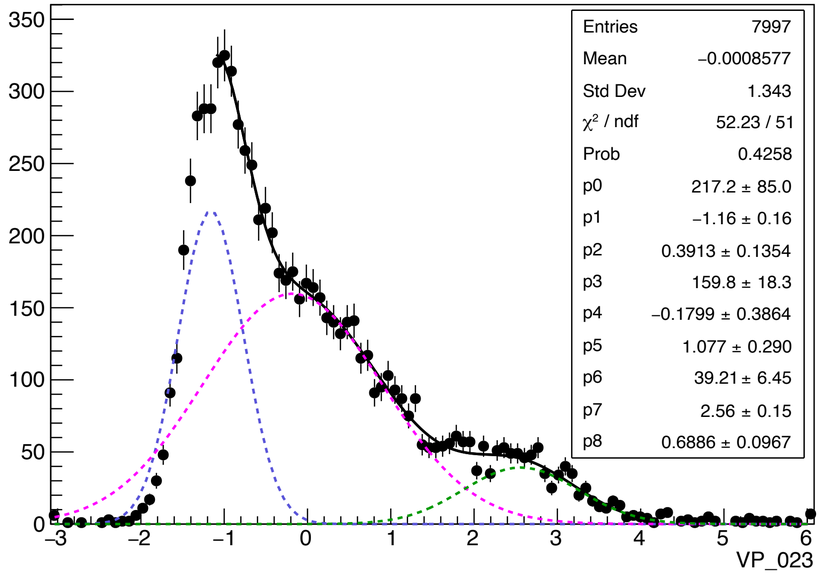




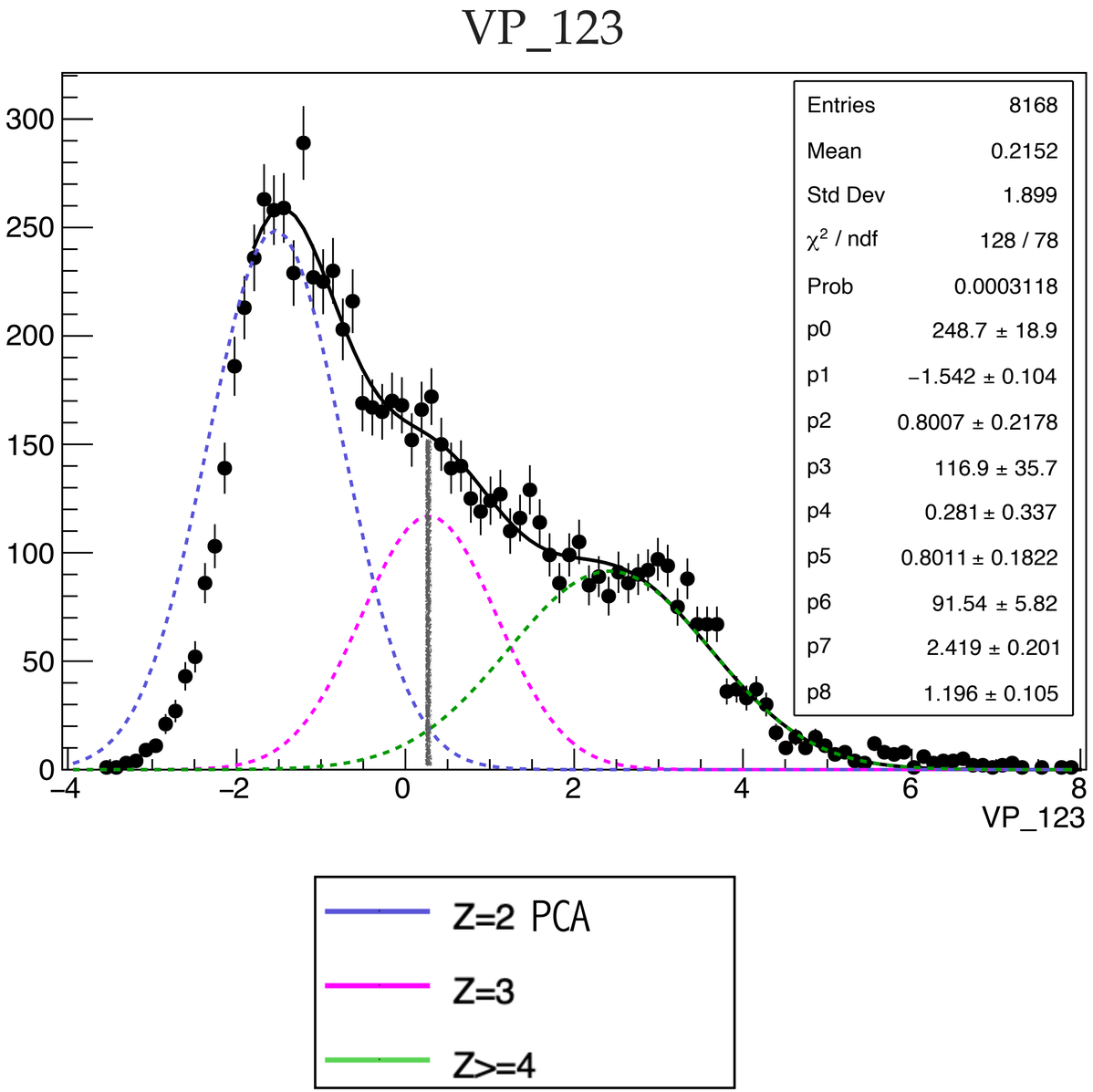
VP_012



VP_023



CHARGE ASSIGNMENT



Example of charge assignment VP_123=0.3:

➡ Total heigh: 140

➡ heigh Z=2: 15 → probability of being Z=2: 15/140 = 10.7%

➡ heigh Z=3: 110 → probability of being Z=2: 15/140 = 78.6%

➡ heigh Z=4: 15 → probability of being Z≥4: 15/140 = 10.7%

Error Evaluation PCA

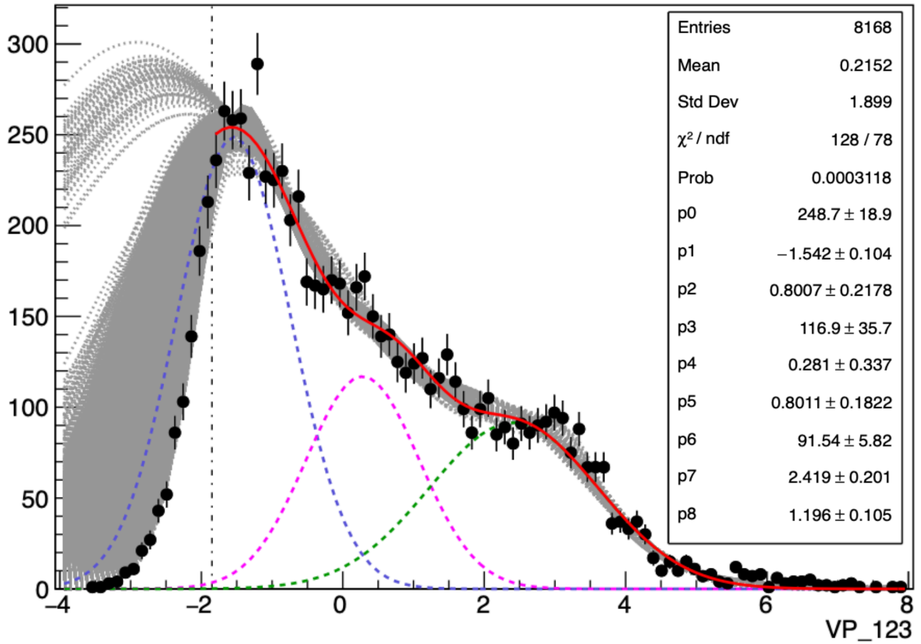
- Systematic error: due to the chosen fit (fits can differ because of different binning, lower limit…)

- Gauss parameters error: due to the errors of fit parameters
  - ➡ Each gaussian has its “mean” value and its error
  - ➡ Random generation of 3 new gaussian means, normally distributed around the mean within 1 sigma
  - ➡ 3-gaussian fit fixing the 3 mean parameters
  - ➡ Evaluation of fit probability to describe data. If larger than 0.02% the fit is considered good
  - ➡ Charge assignment and evaluation of relative fractions for each Z ($Z \geq 2$)
  - ➡ Mean and Standard Deviation evaluated on 10000 good fits

We consider only the error on VP_123 (90% contribution)

FIT - ERROR EVALUATION

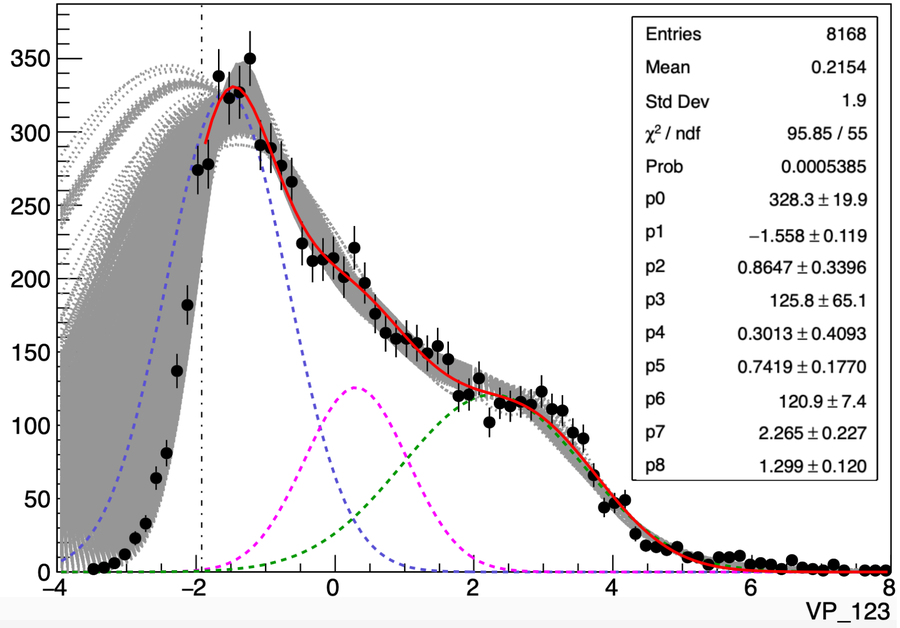
1



Chi2	128/77
Prob	0.03%
N trials	15259

Z TPr	Mean	St. Dev
2	49.51%	0.11%
3	29.08%	0.12%
4	21.41%	0.04%

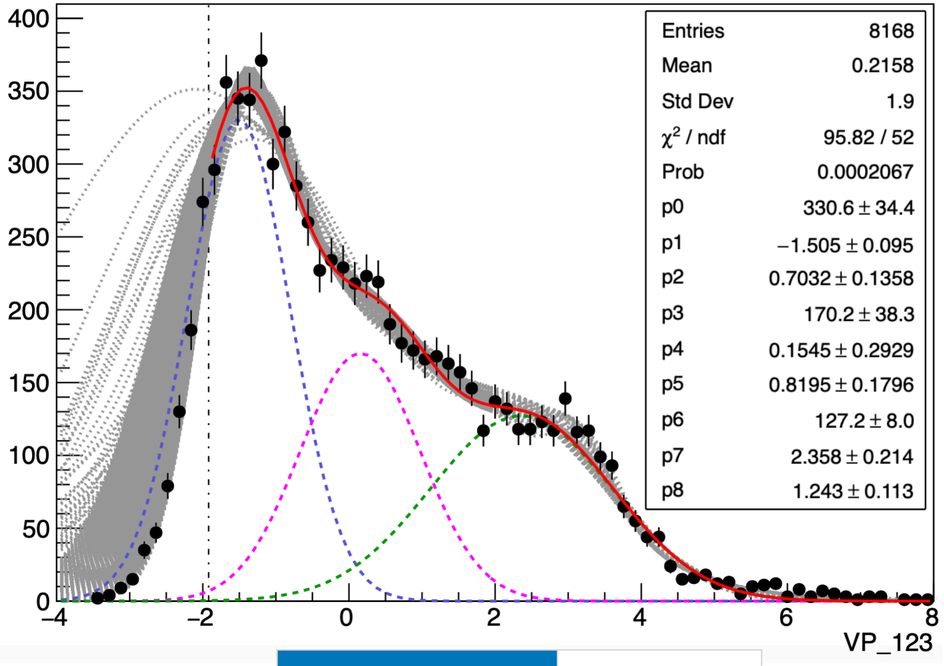
2



Chi2	98.85/55
Prob	0.05%
N trials	15398

Z TPr	Mean	St. Dev
2	48.75%	0.13%
3	26.80%	0.14%
4	24.46%	0.05%

3



Chi2	95.82/52
Prob	0.02%
N trials	19915

Z TPr	Mean	St. Dev
2	44.39%	0.09%
3	32.67%	0.11%
4	22.93%	0.04%

FIT - GAUS PAR + SYSTEMATIC ERROR

Tot trks VP_123	6801

Fit #	Z=2		Z=3		Z≥4	
	Mean	Dev.St	Mean	Dev.St	Mean	Dev.St
1	49.5%	0.1%	29.1%	0.1%	21.4%	0.04%
2	48.7%	0.1%	26.8%	0.1%	24.5%	0.05%
3	44.4%	0.1%	32.7%	0.1%	22.9%	0.04%

RESULT:

	Z=2			Z=3			Z≥4		
	Mean	Syst	Gaus Par	Mean	Syst	Gaus Par	Mean	Syst	Gaus Par
# trks	3251	174	4	1993	200	5	1569	104	2
%	47.8%	2.6%	0.06%	29.3%	2.9%	0.07%	23.1%	1.5%	0.02%

weighted average

(Max-Min)/2

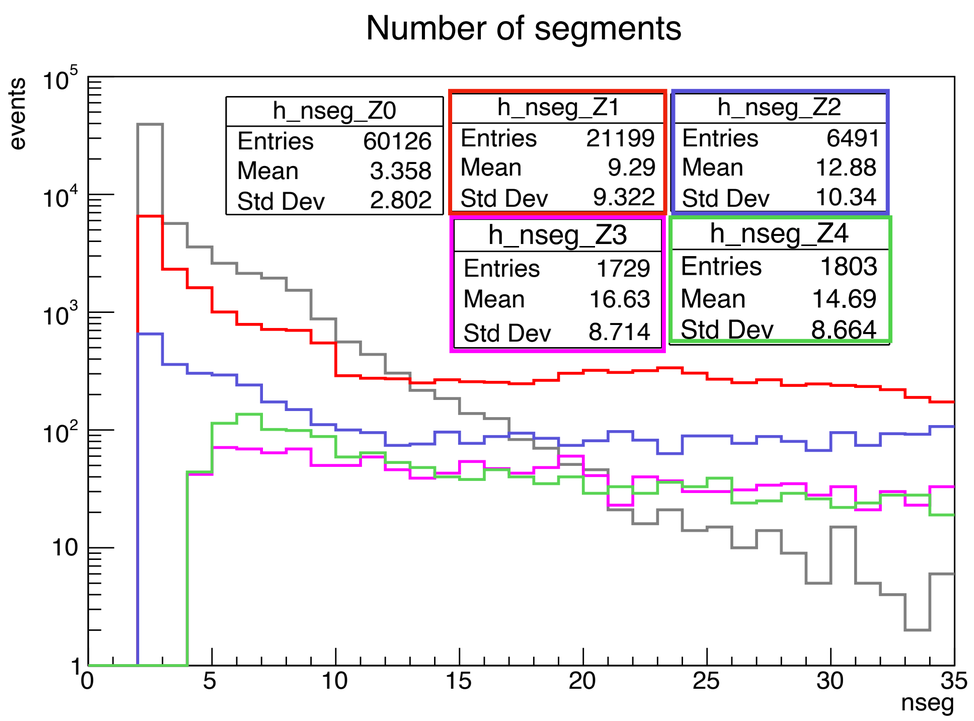
Dev. st. on weighted average

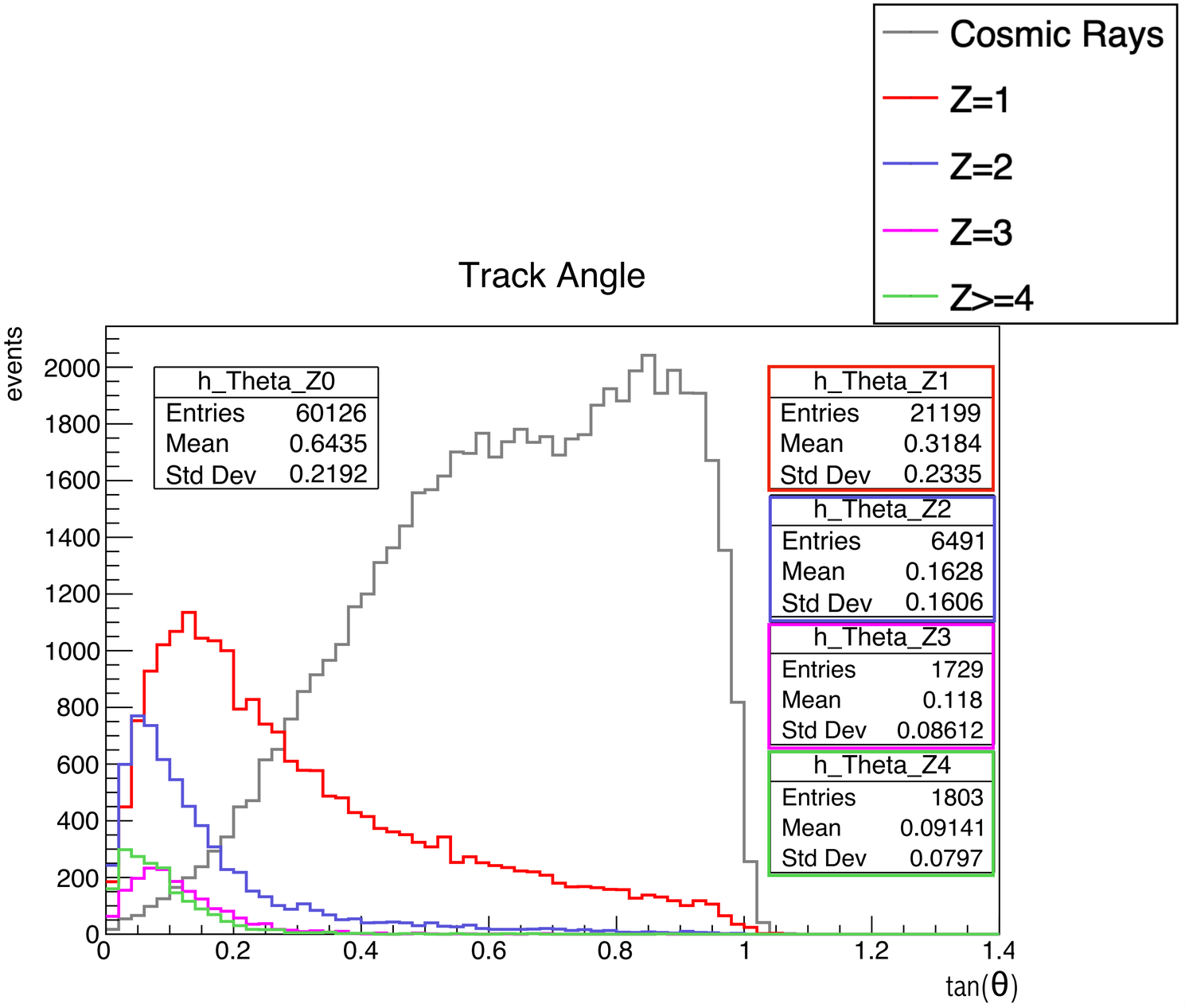
Charge Measured (DATA)

Z	% on total charged			
	Result	Systematic err	Gauss Param err	Statistic err
1	67.9%	5.3%	/	0.5%
2	19.9%	1.2%	0.01%	0.4%
3	6.9%	0.6%	0.02%	0.2%
≥4	5.3%	0.3%	0.01%	0.2%
Not assigned	528			
Total assigned	91361			
Total trks	91889			

(A more detailed table is in back up slide #21)

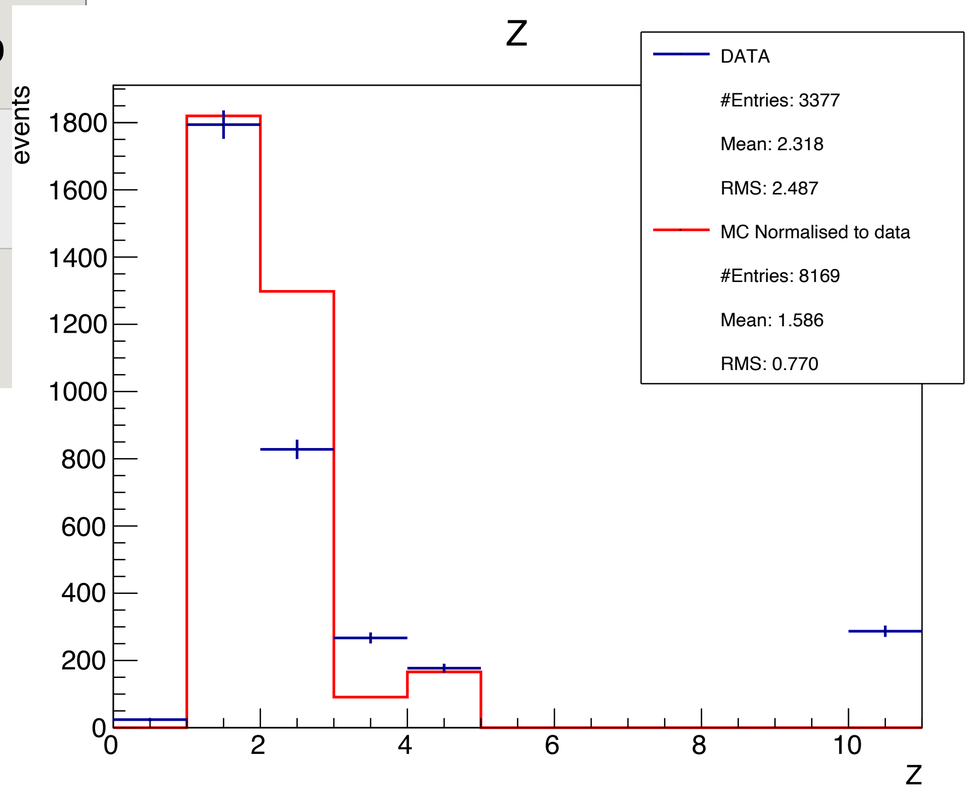
DISTRIBUTIONS TAGGED PARTICLES





CHARGE OF TRACKS ATTACHED TO VERTICES (DATA AND MC)

Z	DATA		MONTE CARLO	
	#tracks	% on total assigned	#tracks	% on total
1	1794	58.5%	1820	59.4%
2	828	27.0%	1298	42.3%
3	267	8.7%	91	3.0%
≥4	177	5.8%	166	5.4%
Total assigned	3066		3375	
Not assigned	287		/	
Total trks	3353		3375	



CONCLUSIONS

- Charge assigned combining the four VRx_av:
  - ➡ Z≤2: sharp cuts on VR0 and VR1
  - ➡ Z≥2: Principal Components Analysis
- Charge assigned for 99.4% of reconstructed tracks
- Charge assigned for 91.4% of tracks attached to a vertex

BACK UP SLIDES

CHARGE MEASURED (DATA)

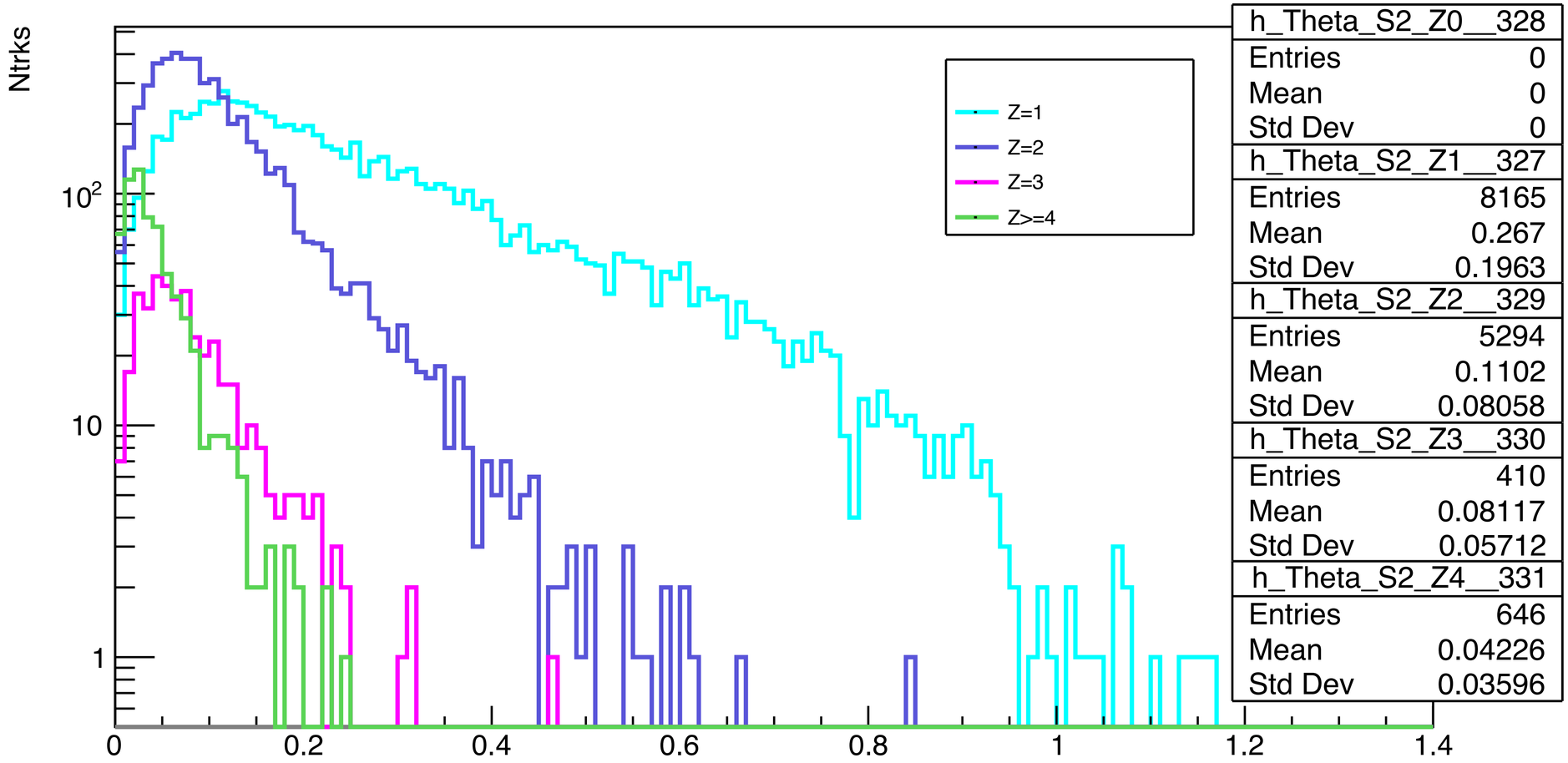
Z	cut sharp		VP_123			other VP	TOT	% on total assigned				% on total charged			
	#trks	err max	#trks	err sys	err stat	#trks		Result	Err syst	Err par gaus	sample err	Result	Err sys	Err par gaus	sample err
Cosmic Rays	60126	1488					60126	65.8%	1.6%	/	0.3%				
1	21199	1649					21199	23.2%	1.8%	/	0.2%	67.9%	5.3%	/	0.5%
2	2494	207	3251	174	4	460	6205	6.8%	0.4%	0.00%	0.1%	19.9%	1.2%	0.01%	0.4%
3			1993	200	5	177	2170	2.4%	0.2%	0.01%	0.06%	6.9%	0.6%	0.02%	0.2%
≥4			1569	104	2	91	1660	1.8%	0.1%	0.002%	0.05%	5.3%	0.3%	0.01%	0.2%
Total w/o comics	23693		6814			728	31235								
Not assigned							528								
Total assigned	83819		6814	477	11	728	91361								
Total trks							91889								

MC Charged Particles Produced in S1 Arriving in S2

	MC "true"		MC "reco"	
	# trks	%	# trks	%
Z=1 nseg0+nseg1≥2	8083	56.8%	15801	62.6%
Z=2 nseg0+nseg1+nseg2+nseg3≥3	5117	36.5%	7961	31.5%
Z=3 nseg0+nseg1+nseg2+nseg3≥3	397	2.8%	567	2.2%
Z≥4 nseg0+nseg1+nseg2+nseg3≥3	472	3.9%	925	3.7%
Total	14069		25254	

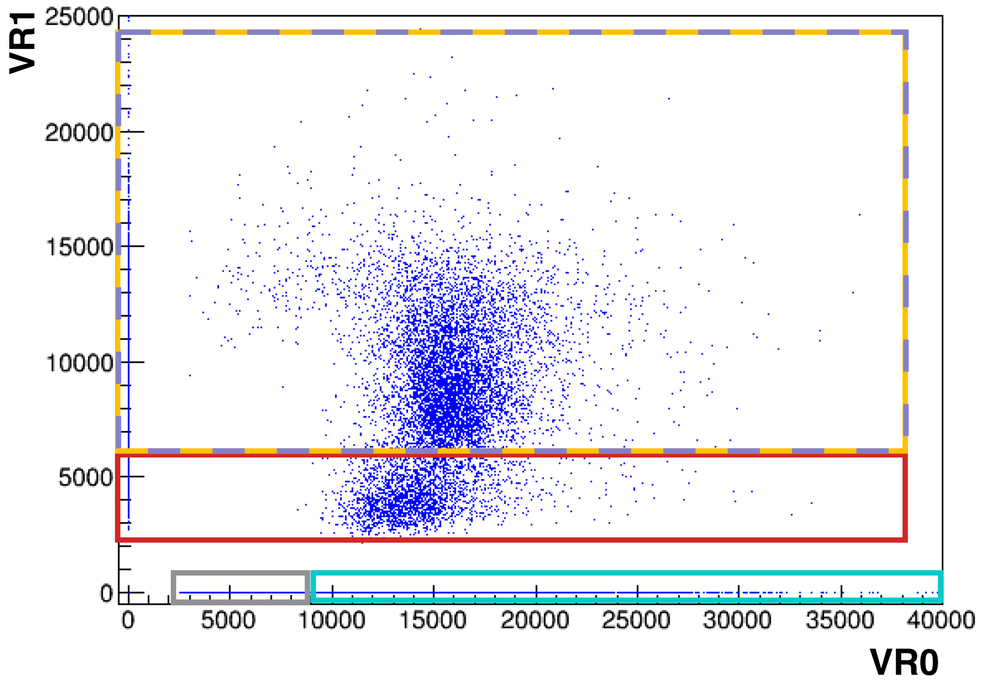
Beam: Oxygen@200MeV/n - Target: S1 Polyethylene

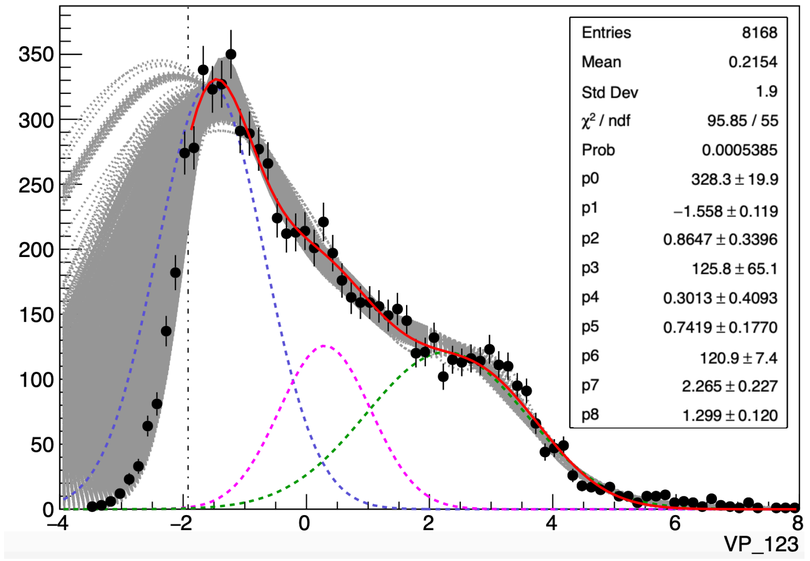
THETA DISTRIBUTION (MC TRUE)

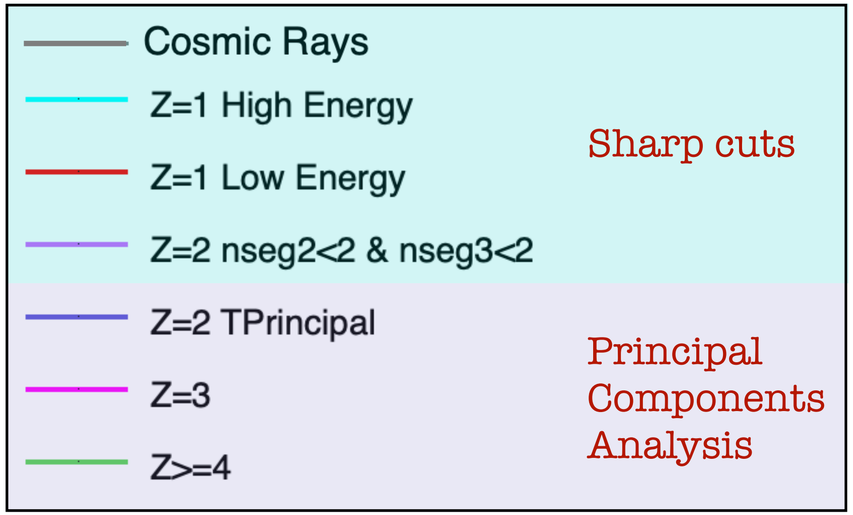


SUMMARY SLIDE

Charge Measure in S2







- Charge assigned for 99.4% of reconstructed tracks
- Charge assigned for 91.4% of tracks attached to a vertex

Z	% on total charged reconstructed tracks			
	Result	Systematic err	Gauss Par err	Statistic err
1	67.9%	5.3%	/	0.5%
2	19.8%	1.2%	0.02%	0.4%
3	7.0%	0.6%	0.03%	0.2%
≥4	5.3%	0.3%	0.01%	0.2%