Darkside Masterclass
Instruction – Excel Part A

Istituto Einaudi, Siracusa, 17-03-2025

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Purpose

Analysis via **Excel event display** for 3 different events (Ev): number 4, number 474, number 19383

You can move between these events selecting the corresponding tab (see the bottom of your excel file)

Final goal: learn how to reconstruct the **position** (x,y,z,r) of the particle and when to reject an event (based on the position).

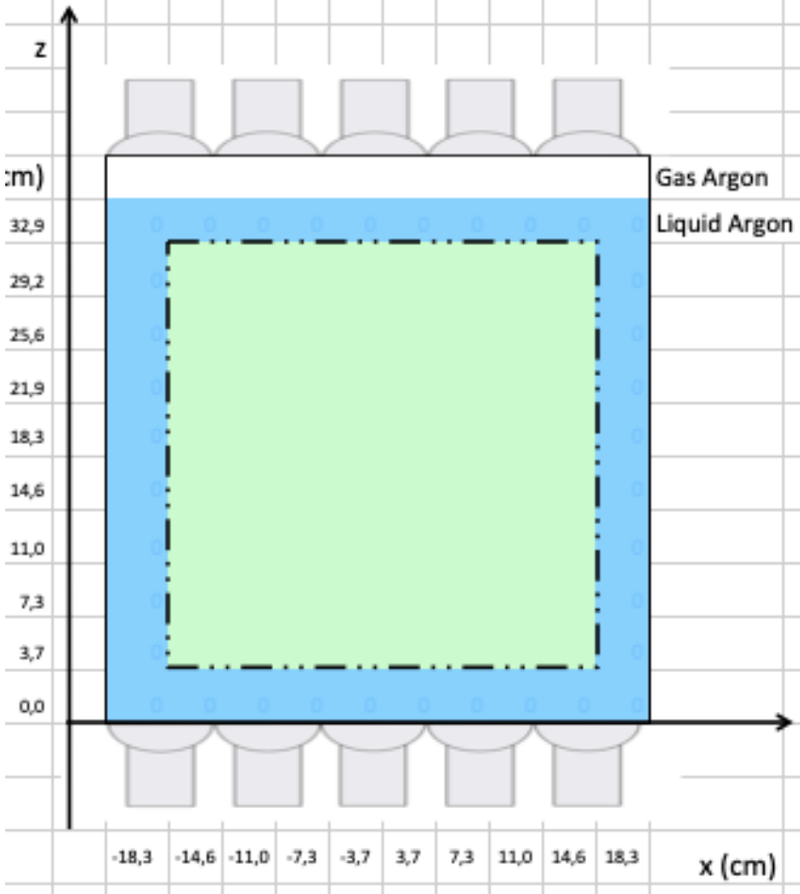
Excel View

Data	
Event	0
x (cm)	0,000
y (cm)	0,000
t_drift (µs)	0,000
v_drift (cm/µs)	0,093
Ztot (cm)	35,600

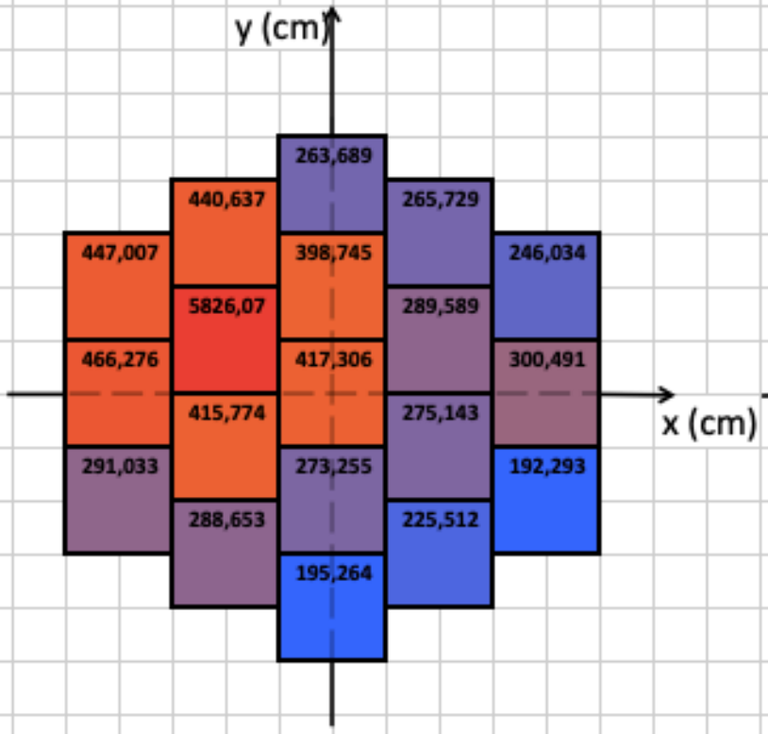
1: Calculate the quantities in red		
r (cm)	0,000	Fiducial Volume definition
Drift Distance (cm)	0,000	0 cm < r < 15 cm
z (cm)	0,000	4,4 cm ≤ z ≤ 31,9 cm

2: Using the PMT maps fille the table (use PMTs with S2 > 400 pe)

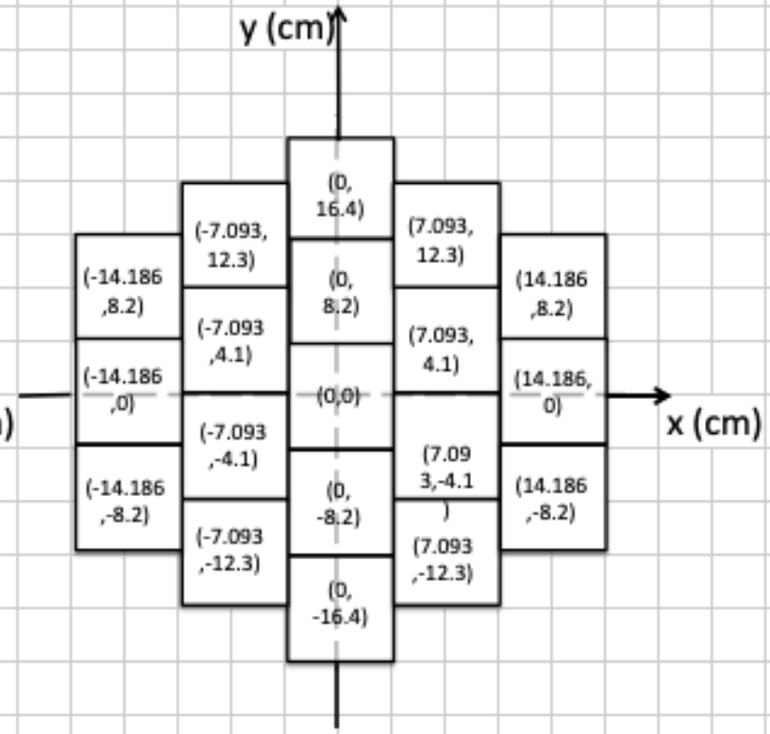
x	y	S2 (pe)	x*S2	y*S2
-7,0893	4,1	5826,070		
0	8,2	398,745		
0	0	417,306		
-7,093	12,3	440,637		
-7,093	-4,1	415,774		
-14,184	8,2	447,007		
-14,186	0	466,276		
	SUMS	8411,815	0,000	0,000
	X_Mean (cm)	0,000		
	Y_Mean (cm)	0,000		



S2 PMT distribution



PMT Position



Excel View

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1: Calculate the quantities in red		
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2: Using the PMT maps fille the table (use PMTs with S2 > 400 pe)

x	y	S2 (pe)	x*S2	y*S2
-7,0893	4,1	5826,070		
0	8,2	398,745		
0	0	417,306		
-7,093	12,3	440,637		
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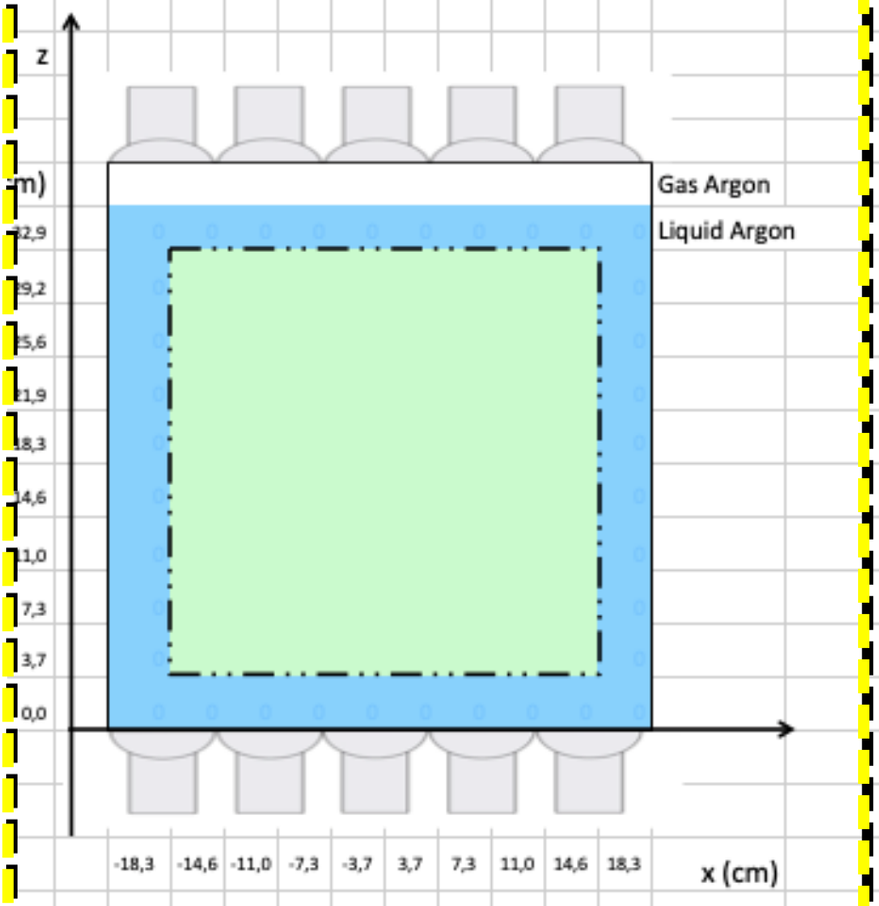
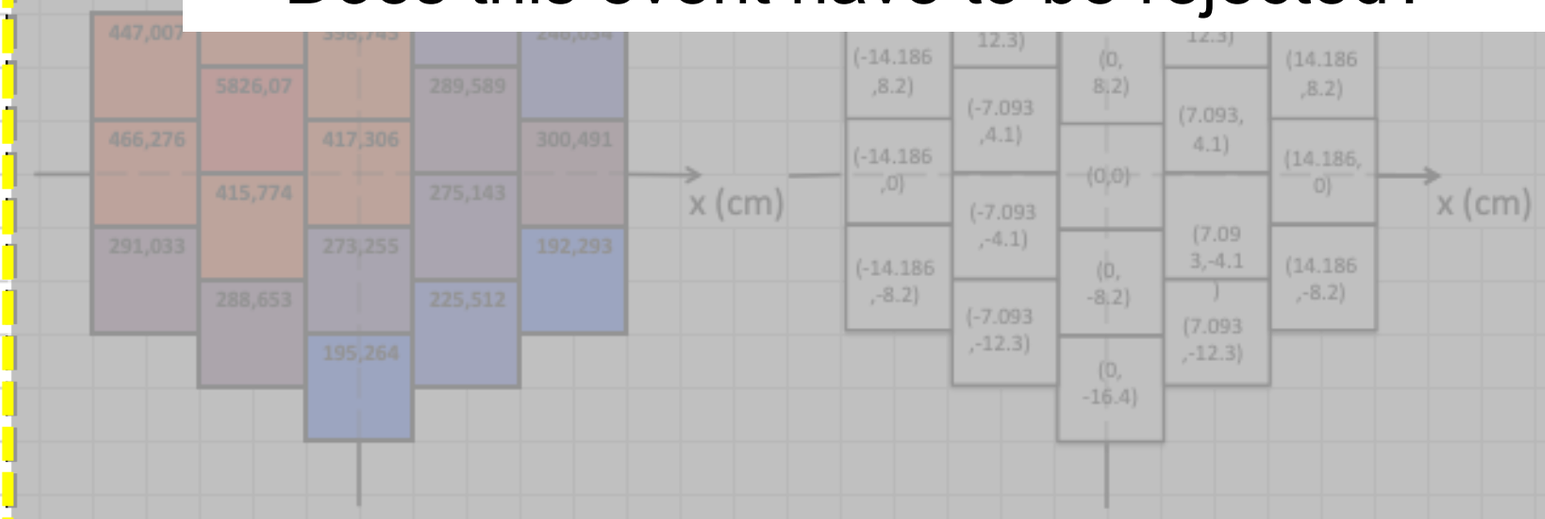
-14,184	8,2	447,007		
-14,186	0	466,276		
	SUMS	8411,815	0,000	0,000
	X_Mean (cm)	0,000		
	Y_Mean (cm)	0,000		



PART 1:

- Calculate the radius (**r**) and the **z** position of the particle
- Does this event have to be rejected?



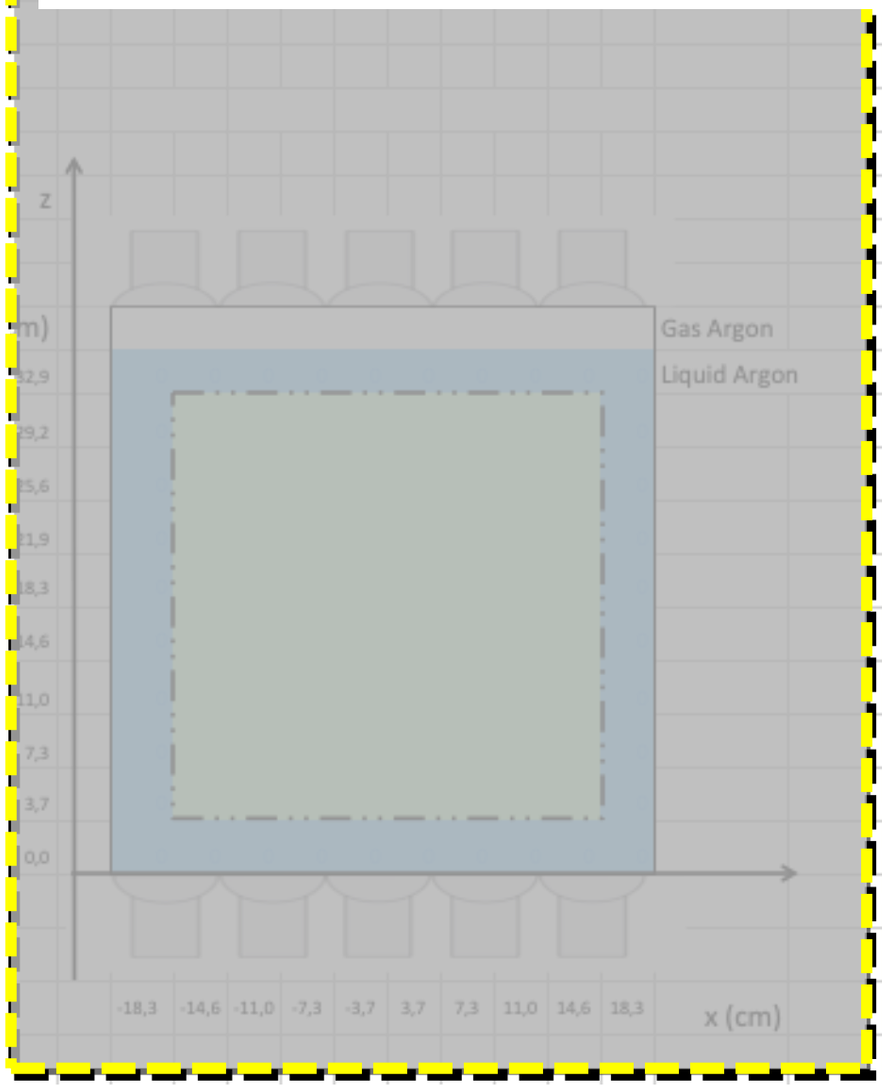
Excel View

PART 2:

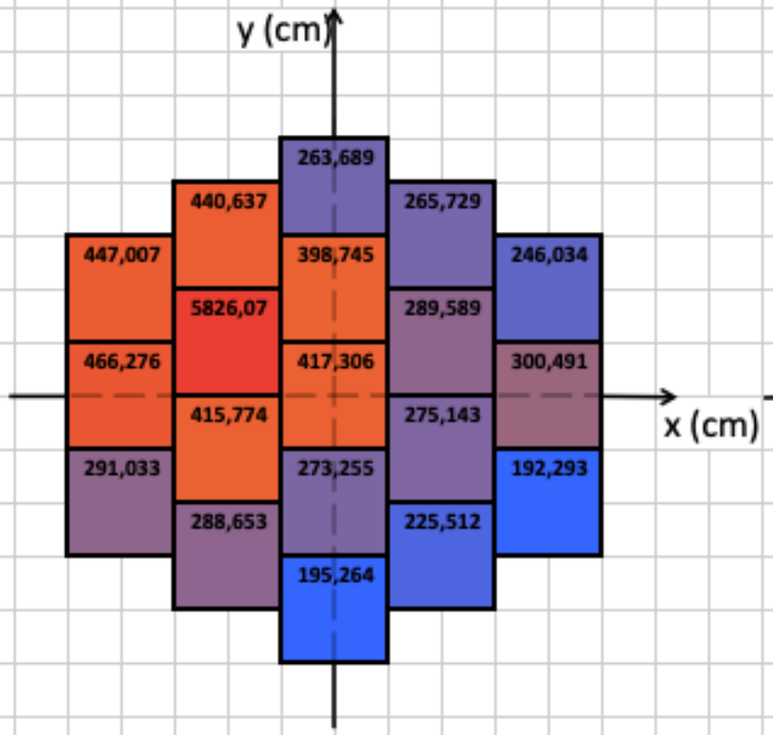
- **To be done only if the event has NOT been rejected in PART 1**
- Calculate the x and y position of the particle and compare them with the original Data

2: Using the PMT maps fille the table (use PMTs with S2 > 400 pe)

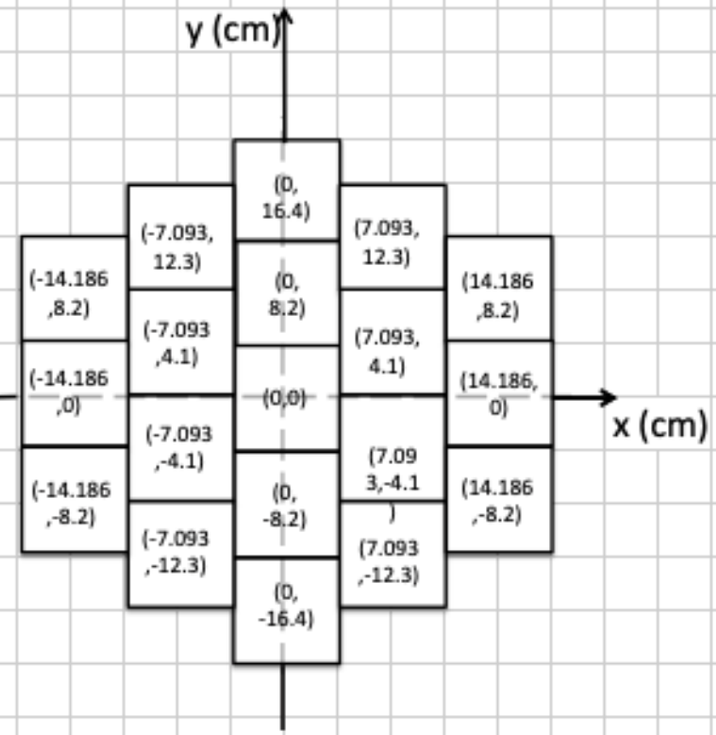
x	y	S2 (pe)	x*S2	y*S2
-7,0893	4,1	5826,070		
0	8,2	398,745		
0	0	417,306		
-7,093	12,3	440,637		
-7,093	-4,1	415,774		
-14,184	8,2	447,007		
-14,186	0	466,276		
	SUMS	8411,815	0,000	0,000
	X_Mean (cm)	0,000		
	Y_Mean (cm)	0,000		



S2 PMT distribution



PMT Position

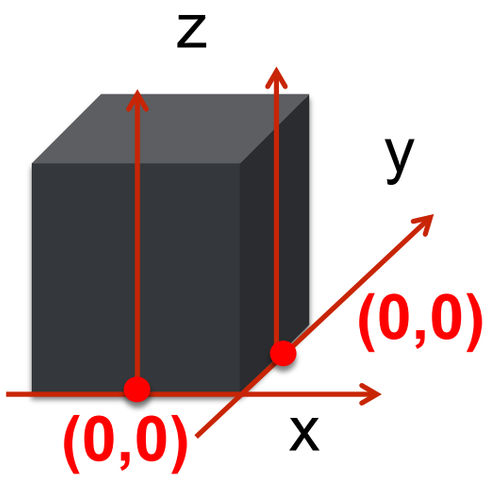


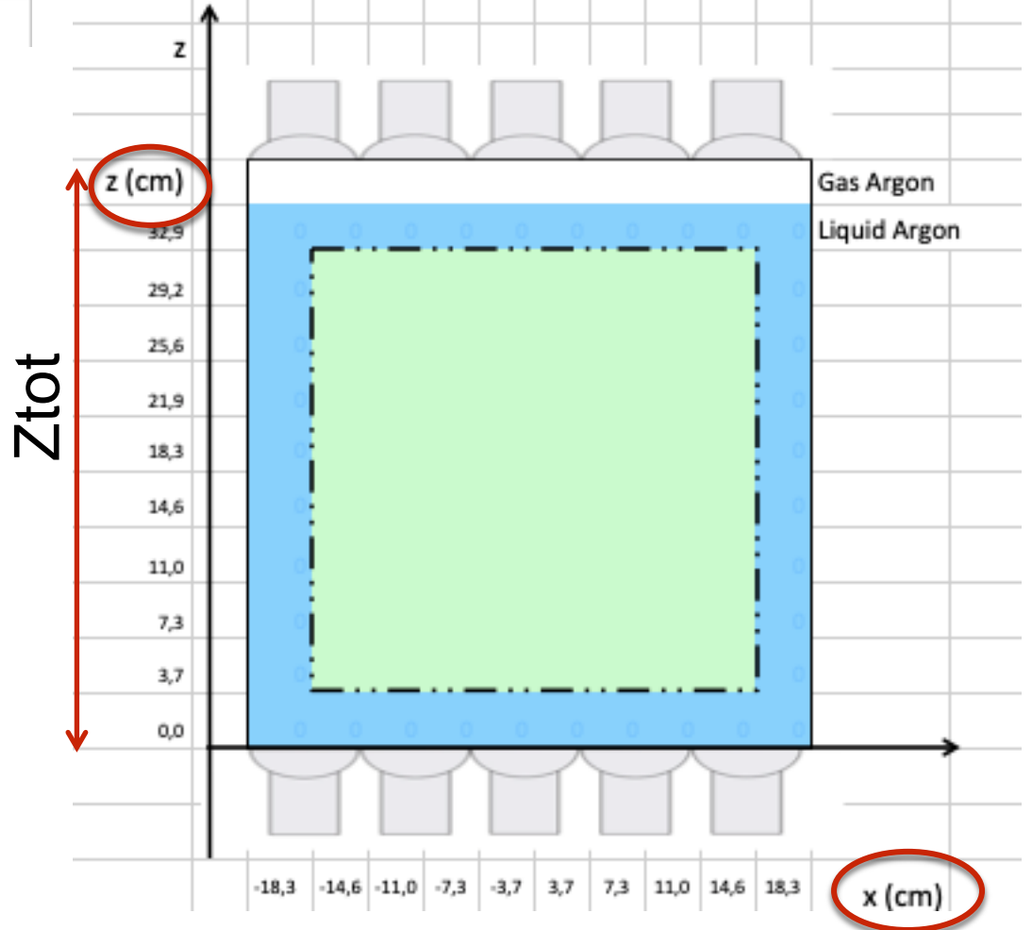
PART 1

Data	
Event	70000
x (cm)	-1,000
y (cm)	3,573
t_drift (µs)	170,000
v_drift (cm/µs)	0,093
Ztot (cm)	35,600

You will start with the following data:

- The number (ID) of the event
- x position of the particle in the TPC in centimetre (cm)
- y position of the particle in the TPC in cm
- Time between S1 and S2 in microsecond (µs=10^{-6} s)
- Velocity of an electron in Liquid Ar in cm/µs
- Total height of the TPC in cm





PART 1

To calculate the radius (r), which means the distance from the center in x and y of the TPC, you simply use the Pythagorean theorem:

$$r=\sqrt{x^2+y^2}$$

Which, translate in excel is:
=SQRT(G7^2+G8^2)

Where G7 and G8 correspond to excel cells containing the value of the x and y position, as you can see from the screenshot

You can insert them in your excel formula by simply clicking on the respective cells

PART 1

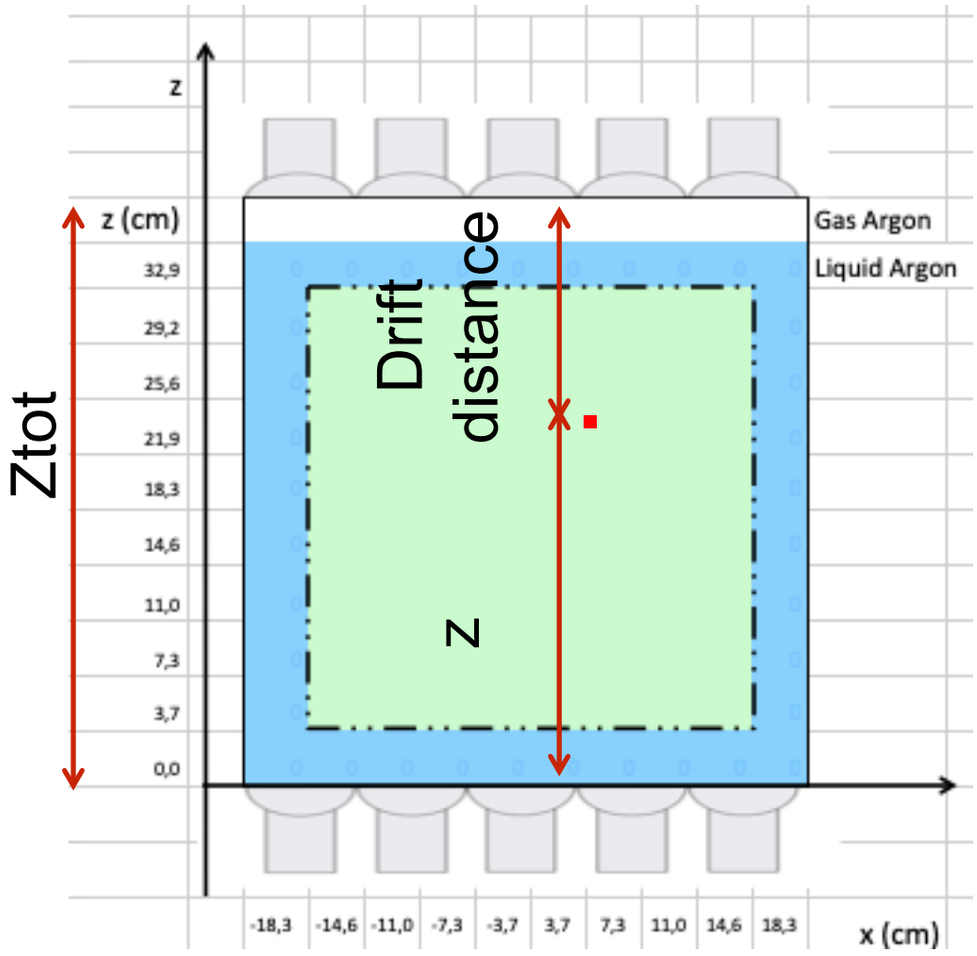
To calculate the z axis, you can then apply the following formula:

Space (Drift distance)= Velocity (v_drift) * time (t_drift)

The drift distance is not equal to z, indeed it has been calculated starting from the t_drift = $t_{S2} - t_{S1}$, which means top – bottom

We can then get the final z position in our frame of reference:

z = Ztot - Drift distance



When you finished, you can see the x-z position highlighted in a yellow square

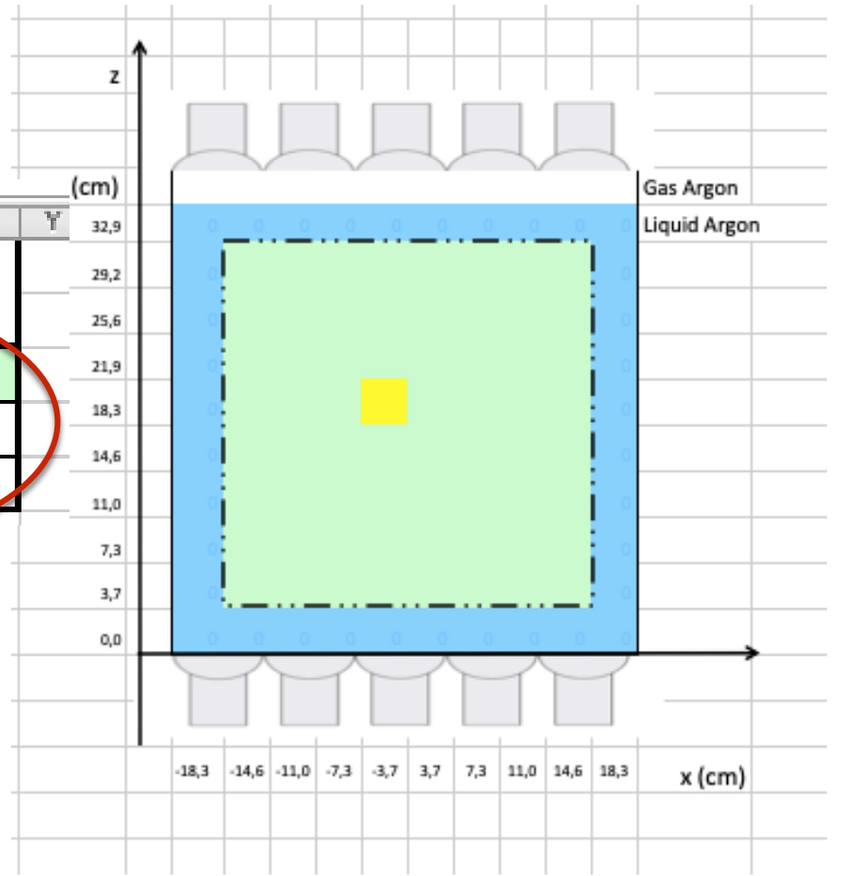
PART 1

Considering then the fiducial volume, expressed in r and z positions and highlighted in the screenshot, and with the help of the **green** square highlighted in the TPC, you have to decide to reject or not this event.

M	N	O	P	Q	R	S	T	U	V	W	X	Y

1: Calculate the quantities in red

r (cm)	3,710	Fiducial Volume definition
Drift Distance (cm)	15,810	0 cm < r < 15 cm
z (cm)	19,790	4,4 cm ≤ z≤ 31,9 cm

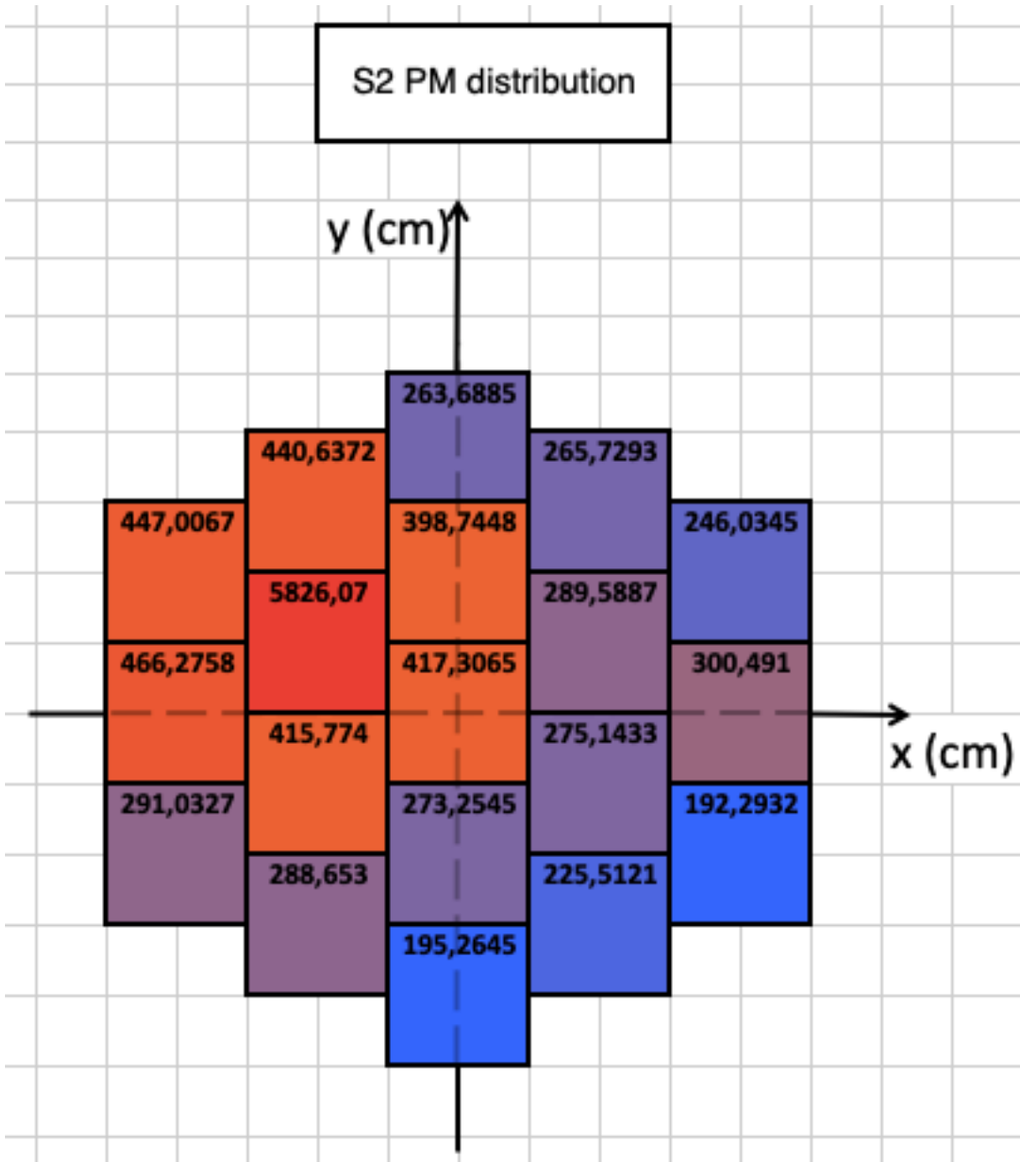


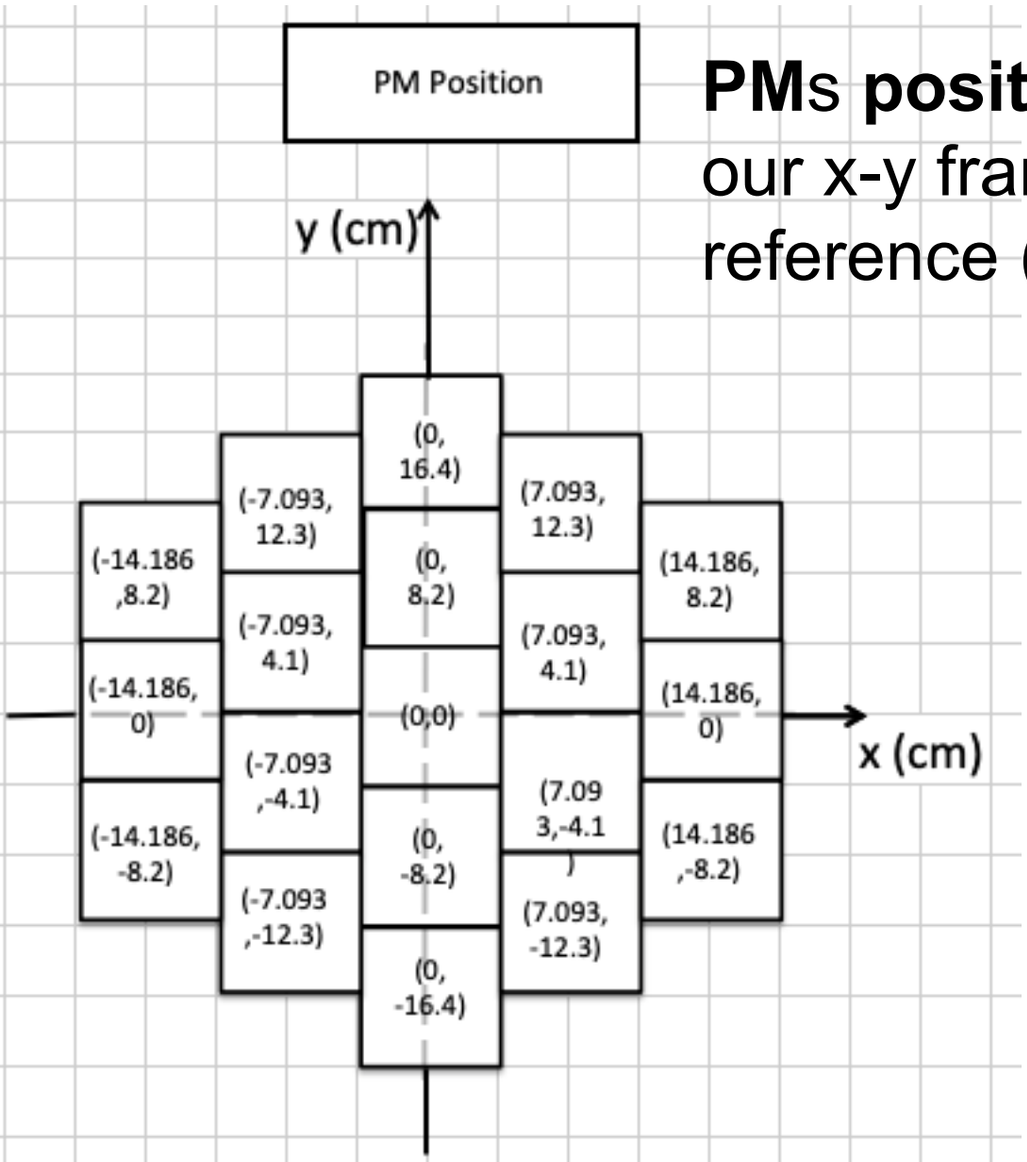
The event has to be in between the value of r and z**. Why?**
As you can notice, both from the z-x plot and, in particular directly from the r (3,71 cm) and z (19,79 cm) value of the example, this event has to be accepted.

PART 2

If the event has been accepted in PART 1, otherwise skip

Now we can see how to get an approximation of the x and y position (in PART 1 given), starting from the **S2** charge **distribution** in the top PhotoMultipliers (**PM**s) of the TPC (on the left in the screenshot) expressed as a number of photon electrons (pe)





PMs **position** in our x-y frame of reference (cm)

PART 2

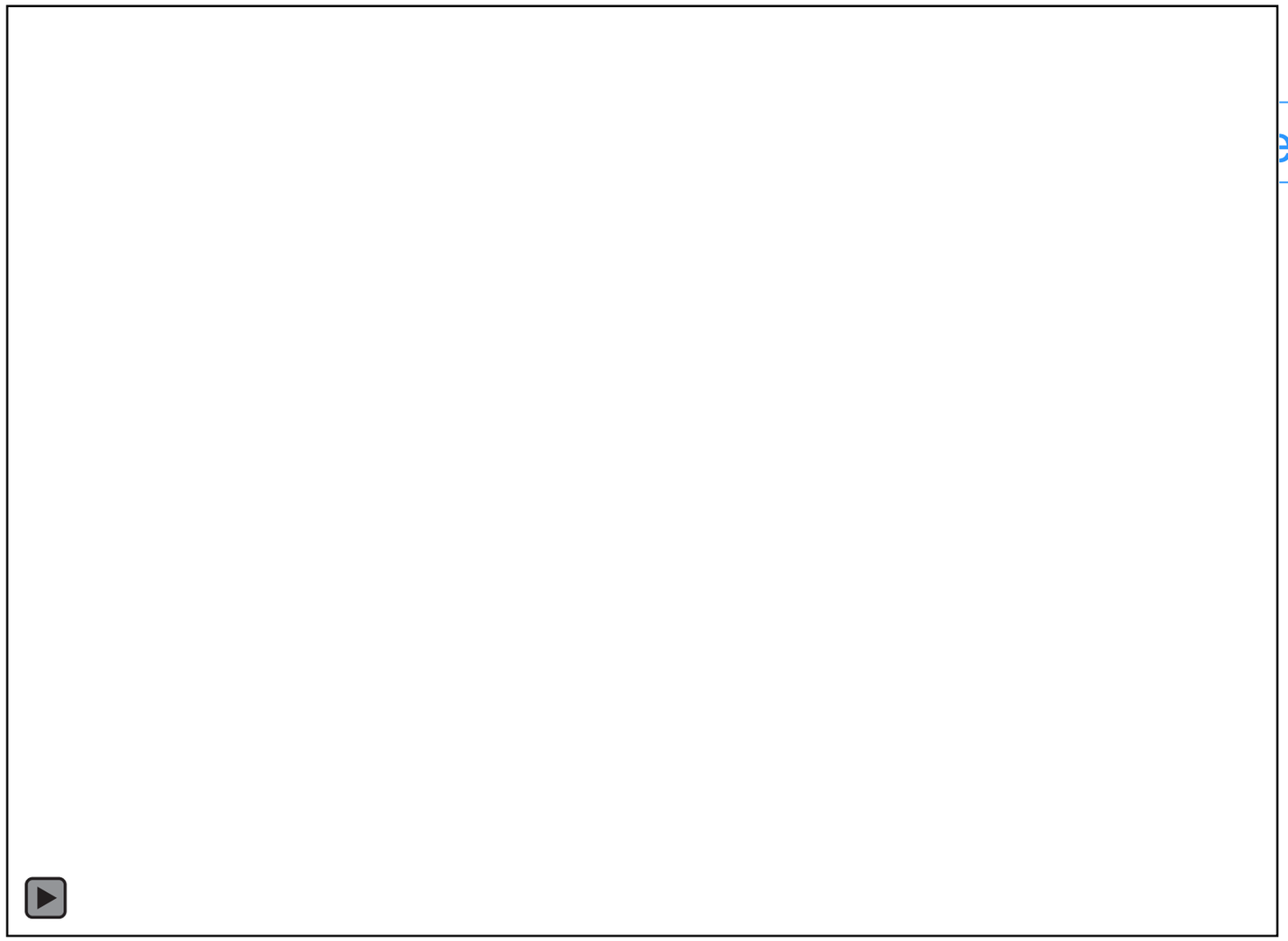
We can then perform a weighted average in both x and y between the 7 PM with the highest number of photons in S2, using as weight (w) the number of photonelectrons (pe)

position *w

$$X\_mean = \frac{x_{PM1}{}^{*}\, pe_{PM1} + x_{PM2}{}^{*}\, pe_{PM2} + x_{PM3}{}^{*}\, pe_{PM3} + x_{PM4}{}^{*}\, pe_{PM4} + x_{PM5}{}^{*}\, pe_{PM5} + x_{PM6}{}^{*}\, pe_{PM6} + x_{PM7}{}^{*}\, pe_{PM7}}{pe_{PM1}+pe_{PM2}+pe_{PM3}+pe_{PM4}+pe_{PM5}+pe_{PM6}+pe_{PM7}}$$

Σw

Σw== SUMS



The same for the y position