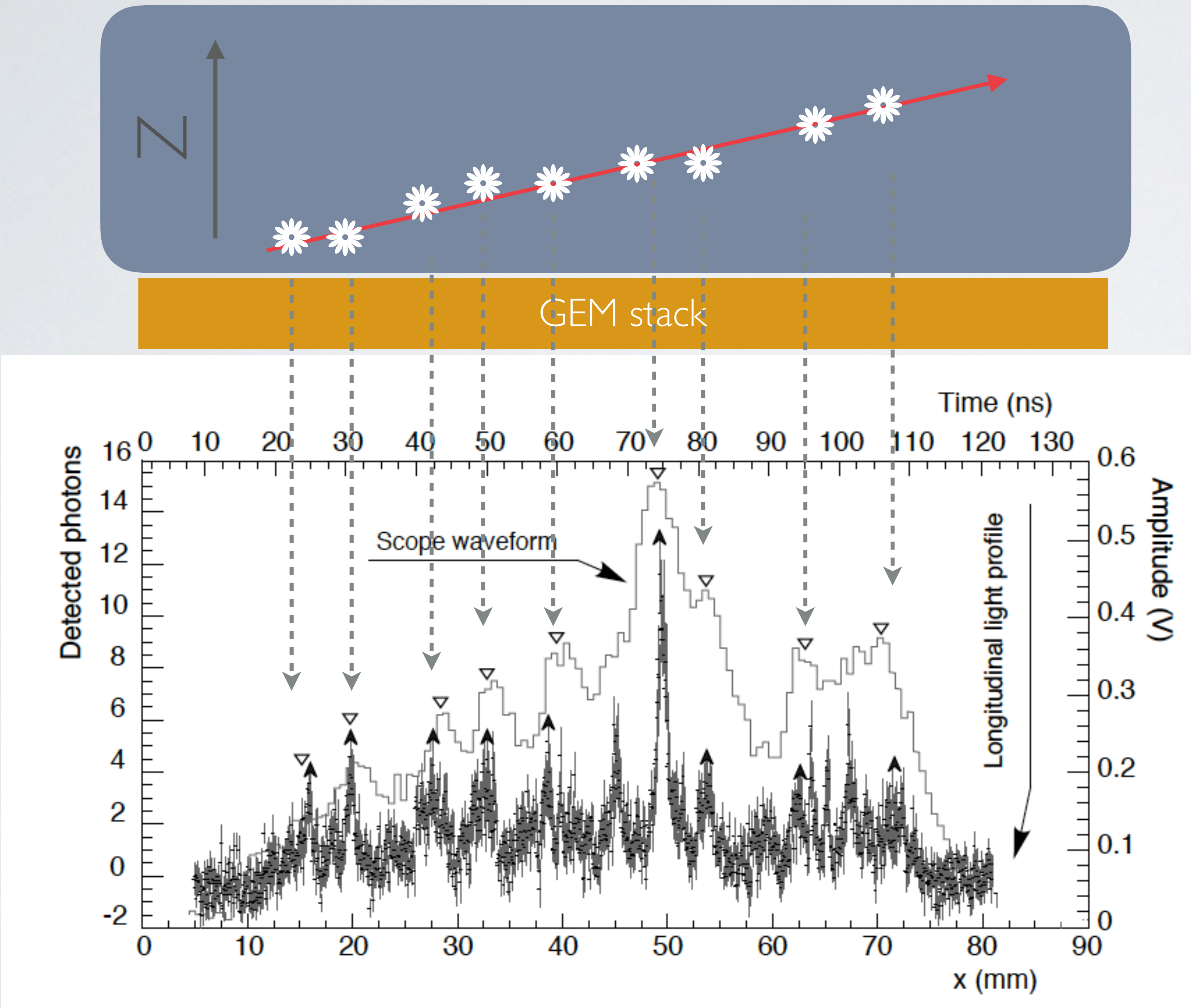
PMT SIMULATION

- Principle of operation

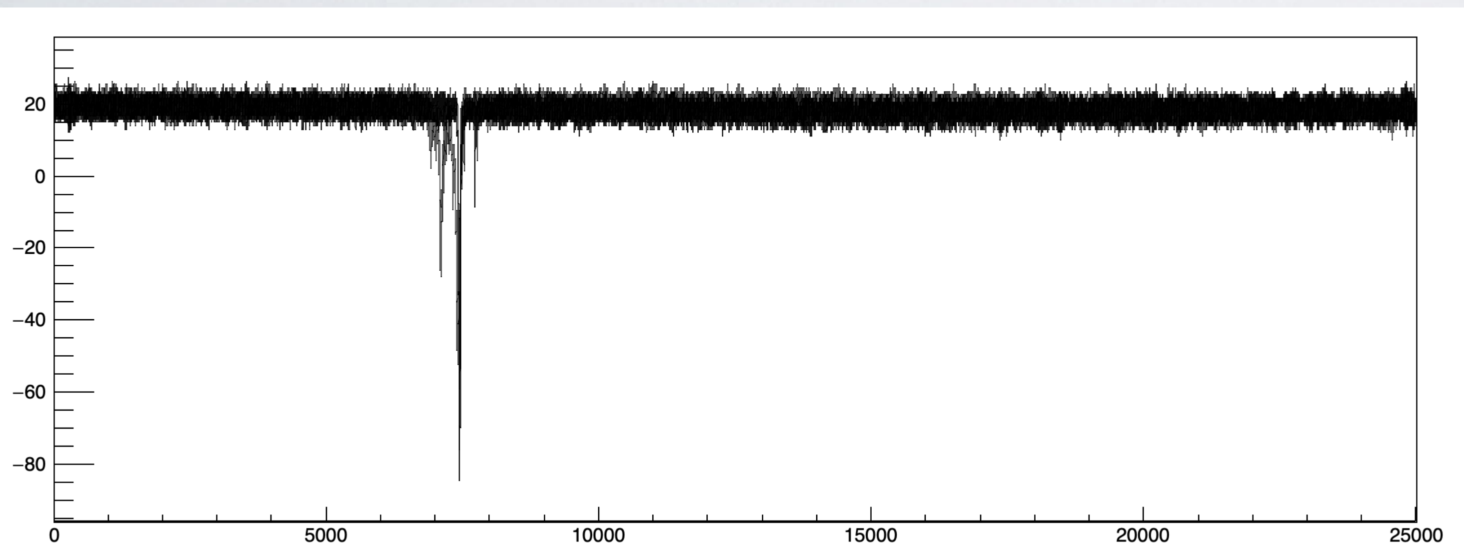


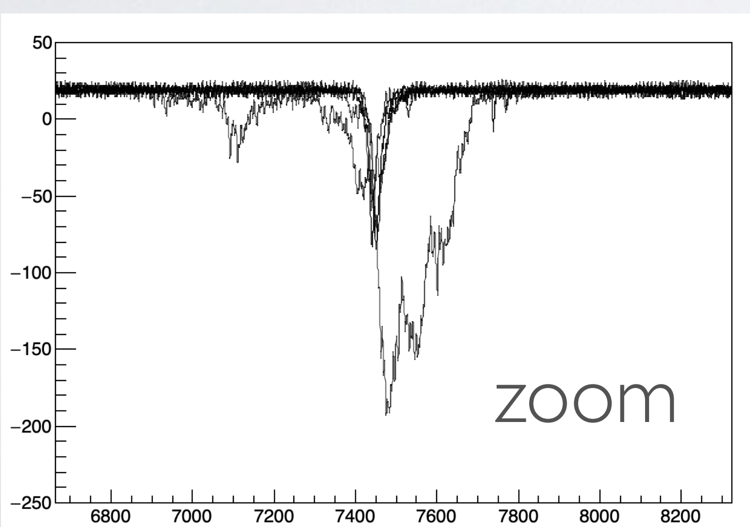
ArXiv ePrint: 1803.06860

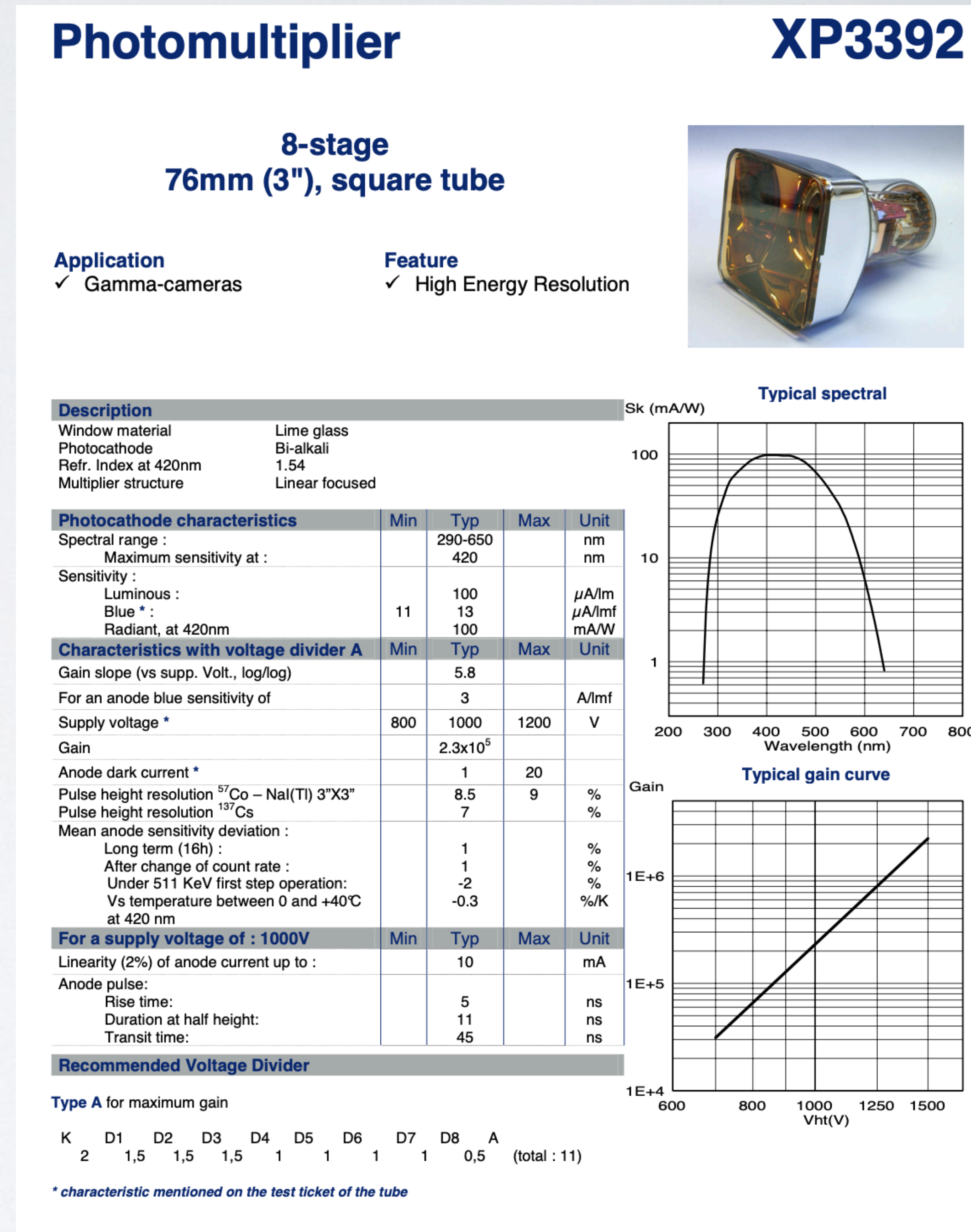
- PMT is able to detect the arrival time of each single cluster

- In LEMON, LIME, CYGNO we have PMT or SiPM to reconstruct Z information ("TPC mode");

- In LEMON we are acquiring an XP3392, with a 4 GS/s digitiser for 2.5 us







Photomultiplier **XP3392**

8-stage
76mm (3"), square tube

Application
✓ Gamma-cameras

Feature
✓ High Energy Resolution

Description	
Window material	Lime glass
Photocathode	Bi-alkali
Refr. Index at 420nm	1.54
Multiplier structure	Linear focused

Photocathode characteristics	Min	Typ	Max	Unit
Spectral range :		290-650		nm
Maximum sensitivity at :		420		nm
Sensitivity :				
Luminous :		100		μA/lm
Blue * :	11	13		μA/lmf
Radiant, at 420nm		100		mA/W
Characteristics with voltage divider A	**Min**	**Typ**	**Max**	**Unit**
Gain slope (vs supp. Volt., log/log)		5.8		
For an anode blue sensitivity of		3		A/lmf
Supply voltage *	800	1000	1200	V
Gain		2.3×10^5		
Anode dark current *		1	20	
Pulse height resolution ^{57}Co – NaI(Tl) 3"X3"		8.5	9	%
Pulse height resolution ^{137}Cs		7		%
Mean anode sensitivity deviation :				
Long term (16h) :		1		%
After change of count rate :		1		%
Under 511 KeV first step operation:		-2		%
Vs temperature between 0 and +40℃ at 420 nm		-0.3		%/K
For a supply voltage of : 1000V	**Min**	**Typ**	**Max**	**Unit**
Linearity (2%) of anode current up to :		10		mA
Anode pulse:				
Rise time:		5		ns
Duration at half height:		11		ns
Transit time:		45		ns

Recommended Voltage Divider

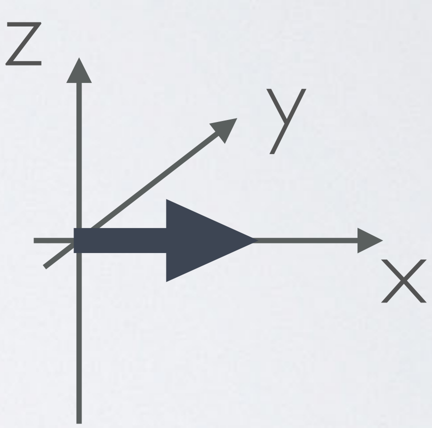
Type A for maximum gain

K	D1	D2	D3	D4	D5	D6	D7	D8	A	
2	1,5	1,5	1,5	1	1	1	1	0,5		(total : 11)

** characteristic mentioned on the test ticket of the tube*

- We should simulate what we'll happen in LIME and CYGNO;
- The idea is to start from text files we have with the simulation of energy release in gas per different particles (He and e^-) and different energies;
- For nuclear recoils they are on Trello https://trello.com/c/mkuEa29O

Recoil	Clusetr	X (mm)	Y (mm)	Z (mm)	Energy Loss (keV)
1	1	0.079257	-0.001156	0.001034	12.590000
1	2	0.140500	-0.006131	0.000210	6.980000
1	3	0.252980	-0.010680	-0.000333	13.920000
1	4	0.329070	-0.014320	0.002628	6.240000
1	5	0.467630	-0.022250	-0.009407	12.440000
1	6	0.650650	-0.047180	-0.044910	17.830000
1	7	0.722480	-0.061920	-0.058290	6.090000
1	8	0.760040	-0.072660	-0.068510	3.080000
1	9	0.783380	-0.079120	-0.073660	1.610000
1	10	0.806480	-0.084330	-0.074880	2.530000
1	11	0.817190	-0.084370	-0.072470	0.710000
1	12	0.827720	-0.083380	-0.070110	1.200000
1	13	0.847760	-0.082170	-0.065510	1.340000
1	14	0.880940	-0.085640	-0.050740	3.597000



- For each energy loss:
  - evaluate the number of electrons created (1e$^-$/40eV);
  - evaluate the time of arrival on the GEM with right drift velocity (5 cm/us);
  - evaluate the "longitudinal dispersion" with the right diffusion coefficient:
    - $\sigma_T = \frac{1}{v_d}\sqrt{(110\mu m \times Z)}$
  - evaluate the PMT signal by using an experimental calibration factor (mV/e$^-$) and the PMT transfer function (at some point we'll measure it for all PMT-SiPM we want to simulate);
  - Digitise the signal with different sampling rate according to DAQ designs;

- Once ready:
  - Develop tools for waveform analysis to check the expected performance and compare them with LEMON (and then LIME) data.