Update about SiPMs and readout electronics

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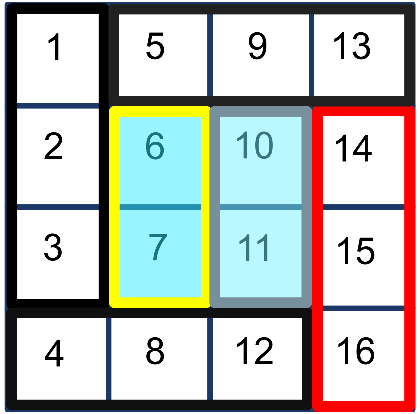
Thanks to : Antonio Vanzanella , Lucca Pagliuso and Roberto Ferreira dos Santos

Photon Detection Unit in PoWER

- It should be designed in order to detect converted photons by PEN (420 nm) and **also to directly detect VUV photons** produced by interactions in LAr buffer
- Demonstration of VETO capabilities of PoWER PDS is very important and it will be the main goal of next small scale prototypes
- PoWER photon sensor should be composed by SiPMs densitive down to VUV region and to standard Visible sensitive SiPMs giving **two output channels**
- Unbalance of two channel signals allow to disentangle background events from internal detector events

Design of the first PoWER light detection prototype

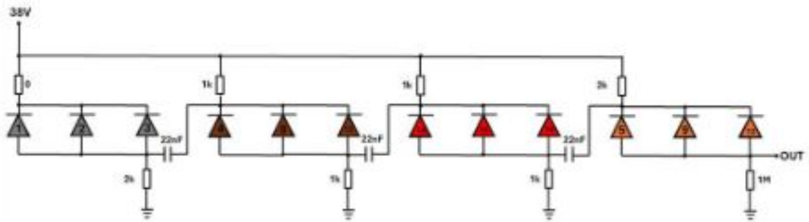


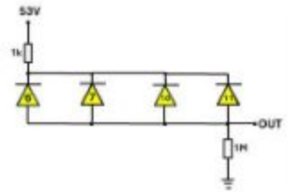
- Assembly and test of a 4×4 matrix with central 2×2 made by Hamamatsu **VUV4 S13370** and 12 lateral **S14160 visible SiPMs**
- Each SiPM is 6 mm × 6 mm and can be directly soldered on PCB
- Development of a primary PCB for SIPMs housing and a second connected to first one for the implementation of the ganging schema
- The SiPMs order executed by Campinas, waiting to receive the samples

Setup Ganging

12 VIS SiPMs: 3 SiPMs are passively parallel-ganged; each triplet is then passively series-ganged.

4 VUV SiPMs: 4 SiPMs are passively parallel-ganged



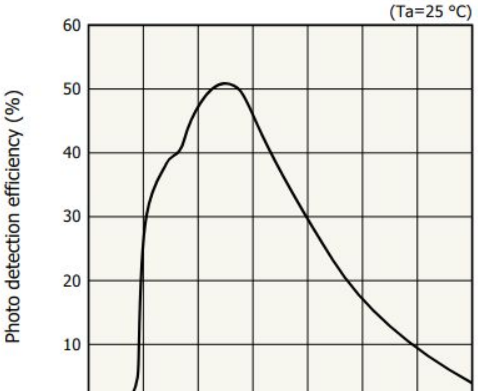


S14160-6050HS for visible light detection

Parameter		Symbol	S14160/S14161 -3050HS-04, -08	S14160/S14161 -4050HS-06	S14160/S14161 -6050HS-04	unit
Spectral response range		λ	270 to 900			nm
Peak sensitivity wavelength		λp	450			nm
Photon detection efficiency at λp*3		PDE	50			%
Breakdown voltage		V_{BR}	38			V
Recommended operating voltage*4		Vop	V_{BR} + 2.7			V
Vop variation between channels in one product*5	Typ.	-	0.1			V
	Max.		0.2			
Dark current	Typ.	I_D	0.6	1.1	2.5	μA
	Max.		1.8	3.3	7.5	
Crosstalk probability		-	7			%
Terminal capacitance		Ct	500	900	2000	pF
Gain		M	2.5×10^6			-
Temperature coefficient of recommended reverse voltage		ΔTVop	34			mV/°C

N pixels: 14331

Capacitance per pixel ~ 150 fF, Total Capacitance = 2000pF



S13370-6050VN for VUV detection

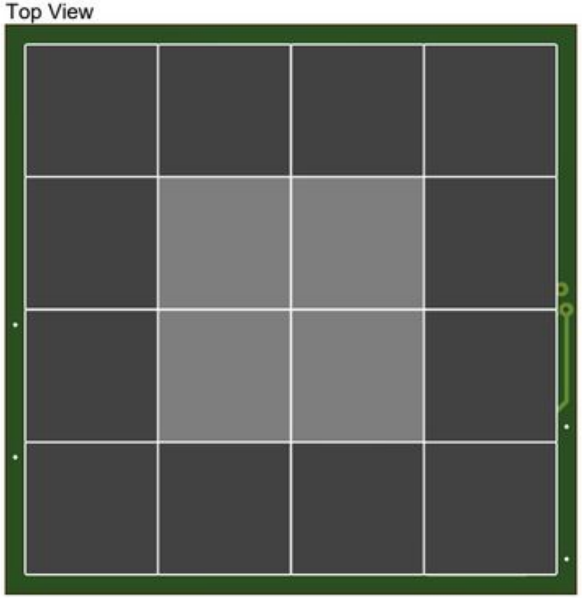
■ **Electrical and optical characteristics**
(Typ. Ta=25 deg C, Over voltage=4.0V Unless otherwise noted)

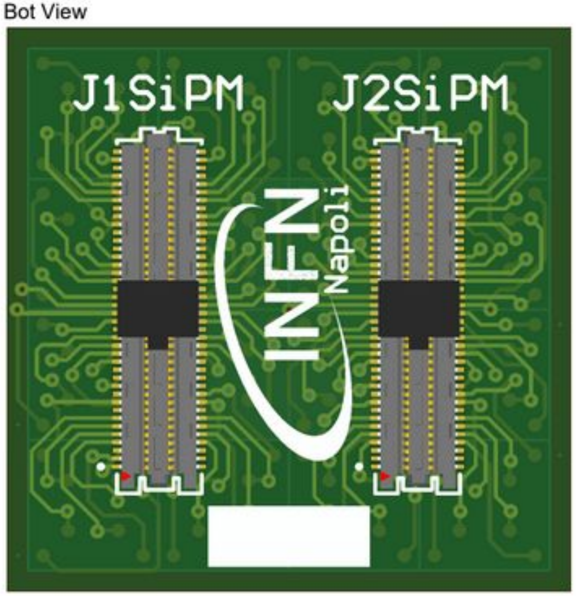
Parameters		Symbol	S13370 -3050CN	S13370 -3075CN	S13370 -6050CN	S13370 -6075CN	unit
Spectral response range		λ	120 to 900				nm
peak sensitivity wavelength		λp	500				nm
Photon detection efficiency at λp *2		PDE	35	40	35	40	%
Break down Voltage		VBR	53 +/-5				V
Recommended operating voltage *3		Vop	VBR + 4				V
Dark count	typ.		1.0		4.0		Mcps
	max.		3.0		12.0		Mcps
Crosstalk probability		-	3	5	3	5	%
Terminal capacitance		Ct	320		1280		pF
Gain		M	2.55×10^6	5.8×10^6	2.55×10^6	5.8×10^6	-
Temperature coefficient of recommended reverse voltage		ΔTVop	54 (around the room temperature)				mV/℃

N pixels: 14336

Capacitance per pixel ~ 100 fF, Total Capacitance = 1300pF

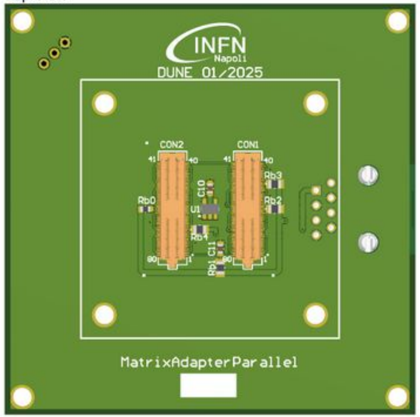
SiPM matrix board to host SiPMs



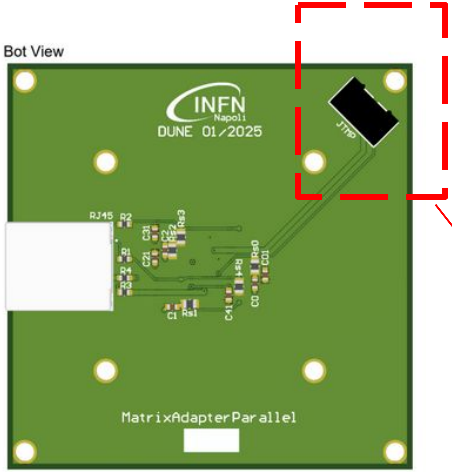


Ganging board

Top View



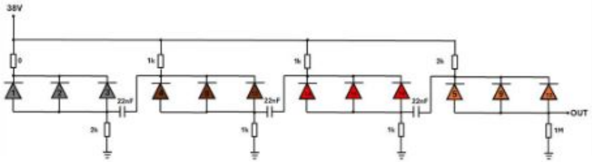
Bot View



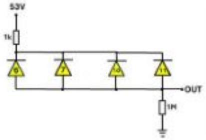
→2 output channels: one VUV and other VIS

Capacitance per channel:
VIS: ~ 1500pF
VUV: 3840

Temperature sensor: TMP37

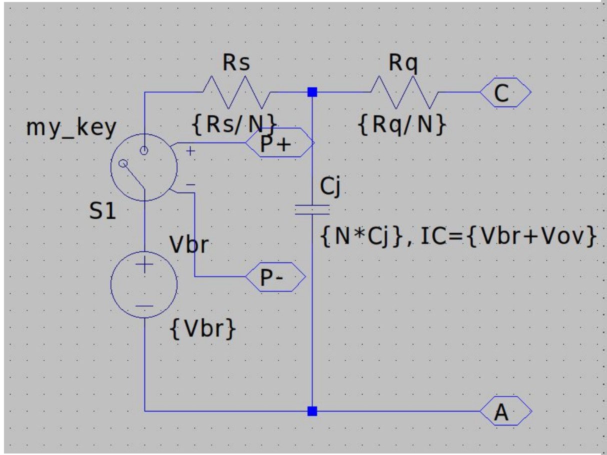


1	5	9	13
2	6	10	14
3	7	11	15
4	8	12	16

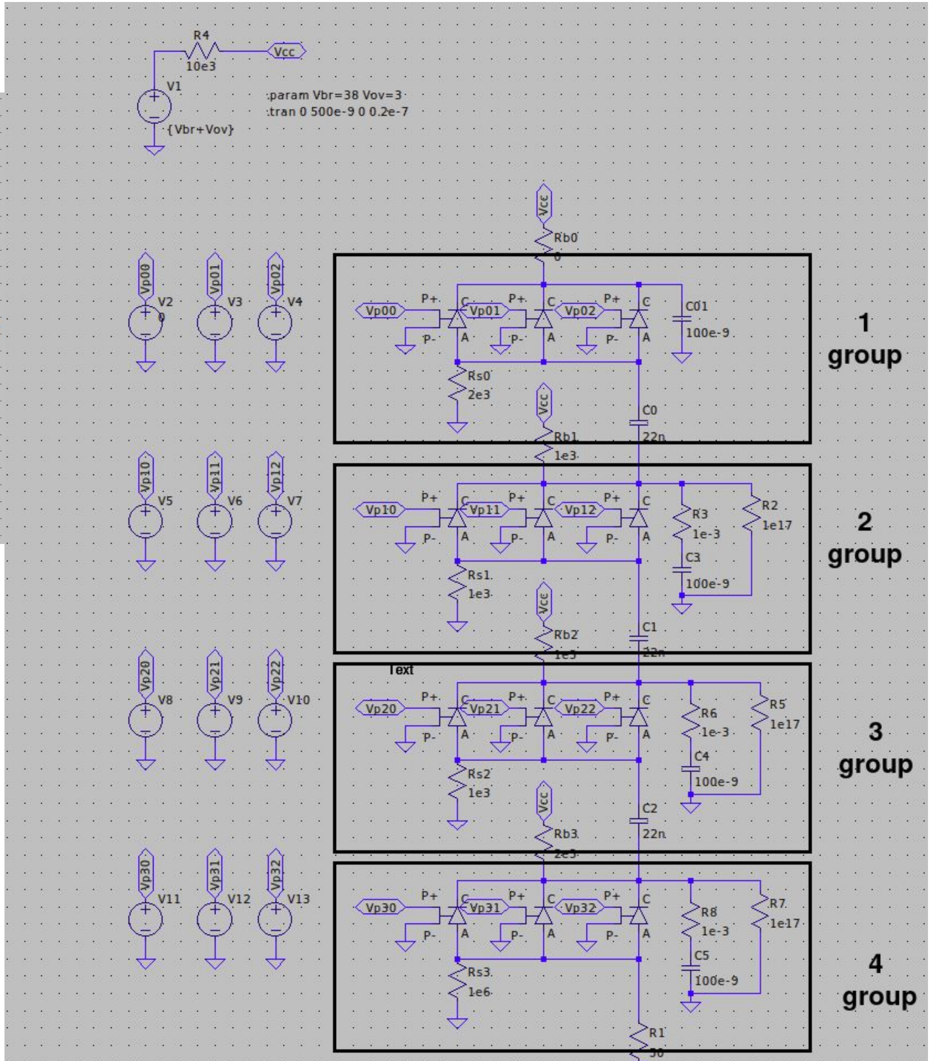


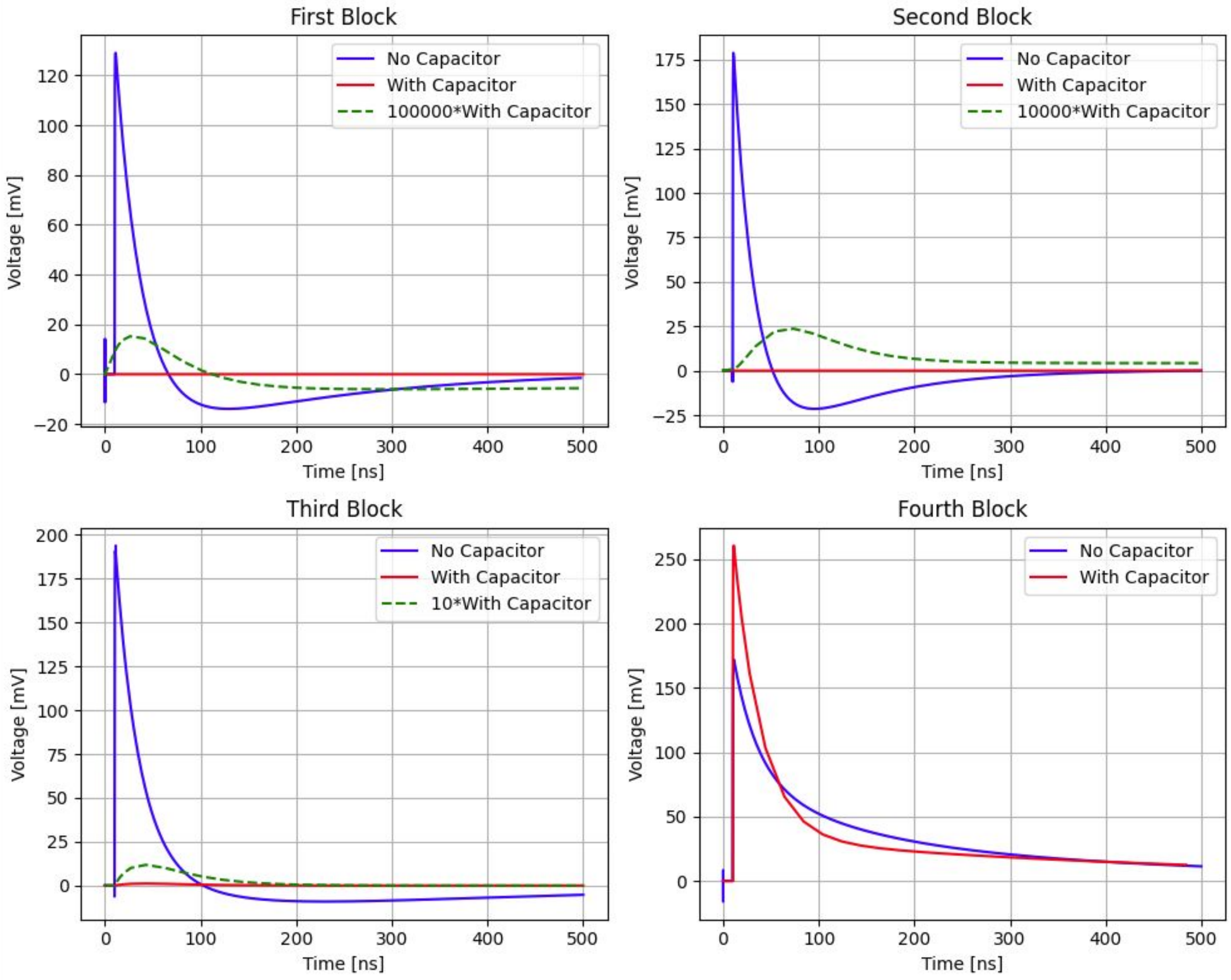
Spice Simulation

SiPM model:



Rq (quenching resistor) = 150kΩ for Hammamatsu 50 um pixel pitch
Cj = Junction Capacitence
Rs (SiPM conducting resistance) ~ 1kΩ
Rk (Non conducting resistance) ~ 1MΩ

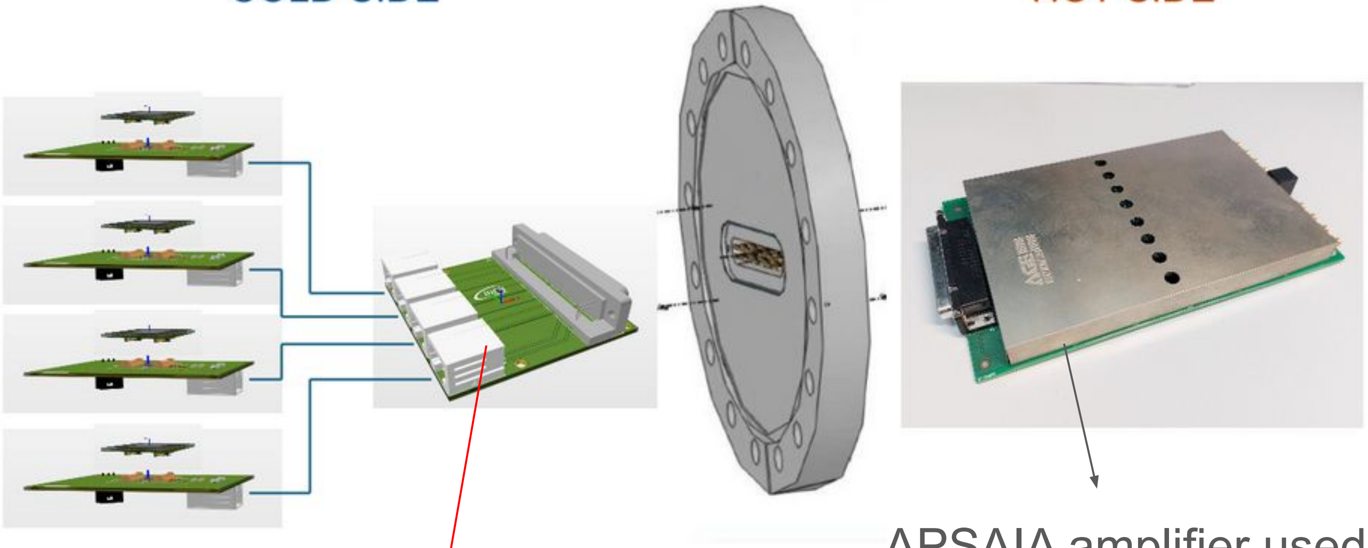



First Block
No Capacitor
With Capacitor
100000*With Capacitor
Voltage [mV]
Time [ns]
Second Block
No Capacitor
With Capacitor
10000*With Capacitor
Voltage [mV]
Time [ns]
Third Block
No Capacitor
With Capacitor
10*With Capacitor
Voltage [mV]
Time [ns]
Fourth Block
No Capacitor
With Capacitor
Voltage [mV]
Time [ns]

Full Chain to read-out four 4×4 matrices (8 channels)

COLD SIDE

HOT SIDE



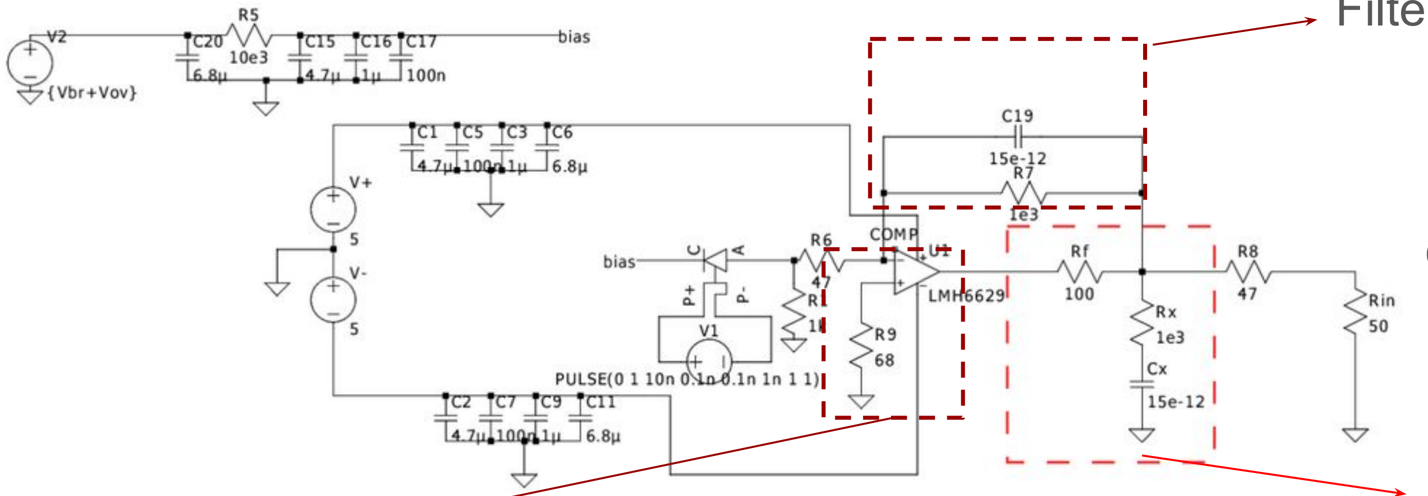
Converter from
RJ45 TO DB37

APSAIA amplifier used in SBND experiment:
GAIN from 20x or 40x
Output → MCx
Can provide the bias to the SiPMs
(from 20V up to 60V)

In alternative: test of cold amplifier in Naples

In case of high noise with APSAIA configuration, we are developing a cold-amplifier and we are going to test it with VUV SiPMs

Filter: fc = 10MHz



Gain: ~ 20

Fast AmpOP, with resistor at non inverting input, to compensate the polarization current

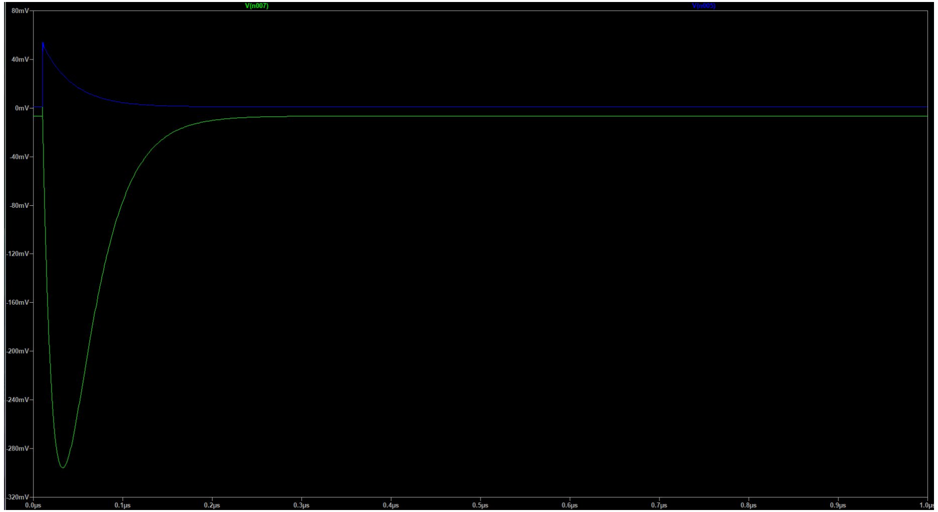
Compensator to stabilize the fast AMP-OP (can be not mounted)

Summary

- Designed electronics for a 4×4 PoWER prototype tile (PCB production in next month)
- Order of Hamamatsu SiPMs done,
- First test of electronics this summer
- Assembly of matrices as soon we will receive Hamamatsu SiPMs
- Alternative cold amplifer is under test
- Alternative light readout with FBK SIPMs

The compensator

w/COMPENSATOR



n/COMPENSATOR