PIERRE AUGER OBSERVATORY

Surface Detector Electronics Upgrade Critical Design Review

WP7 – Calibration and control tools

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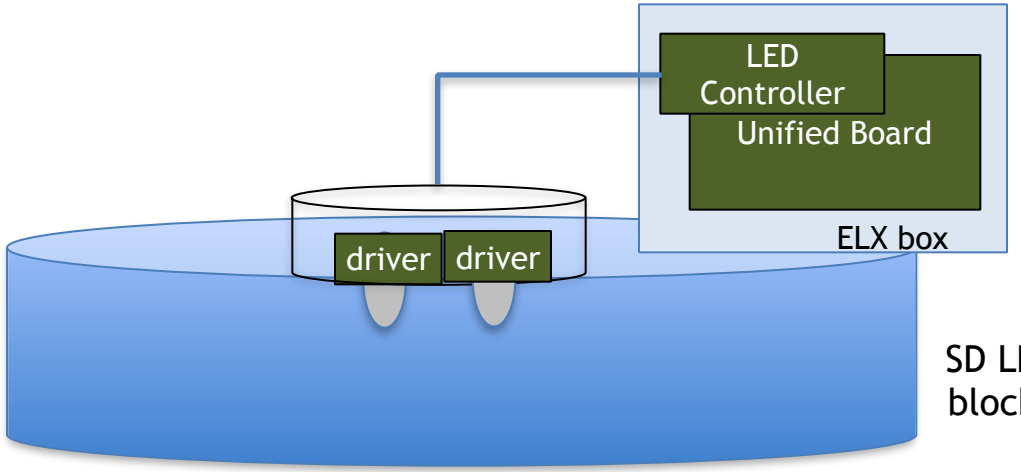
LED system overview

- Requirements
  - Measure PMT linearity over full dynamic range (~20 bits)
  - Cross calibrate readout channels
    - ANODEx1, ANODEx32, SmallPMT
  - Create artificial EAS events on the SD array

- *Nota Bene* - the LED system:
  - does NOT perform ALL necessary calibrations for science data acquisition
  - supports, does NOT replace, routine calibrations

Design concept

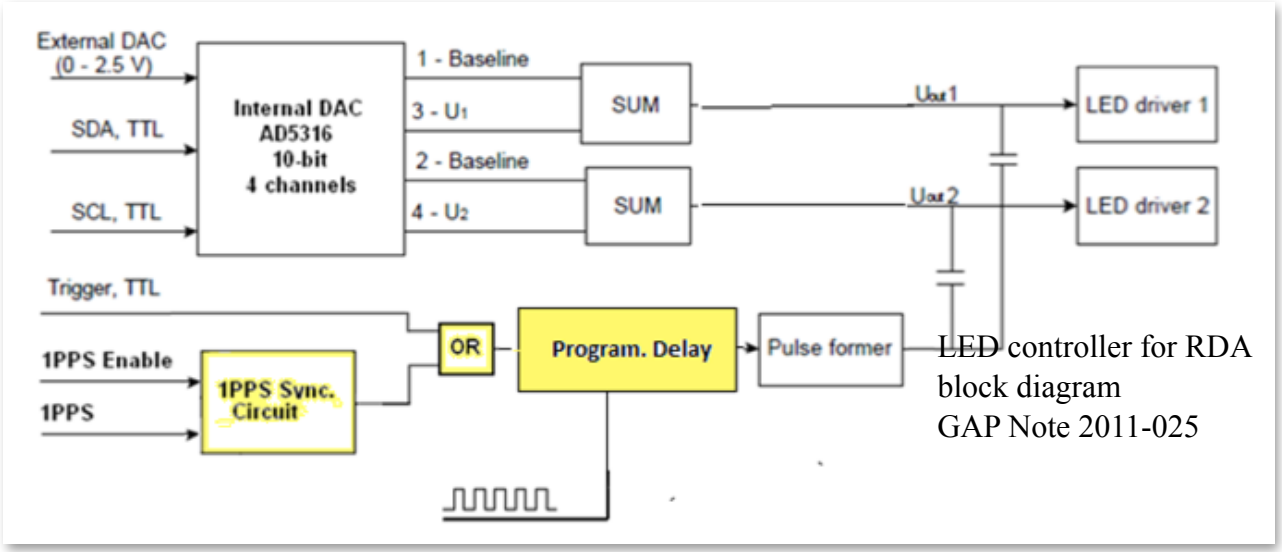
- two LED that can be triggered simultaneously and independently
  - for linearity and cross-calibrations
- pulse shape similar to CR and determined by tank
- GPS trigger with arbitrary delay



SD LED system block diagram

Design implementation

- Use existing LED on tanks
  - flashers, driver, mechanics
  - working on ~90% of SD array, missing on InFill
- New LED controller
  - Add GPS synchronization with programmable delay

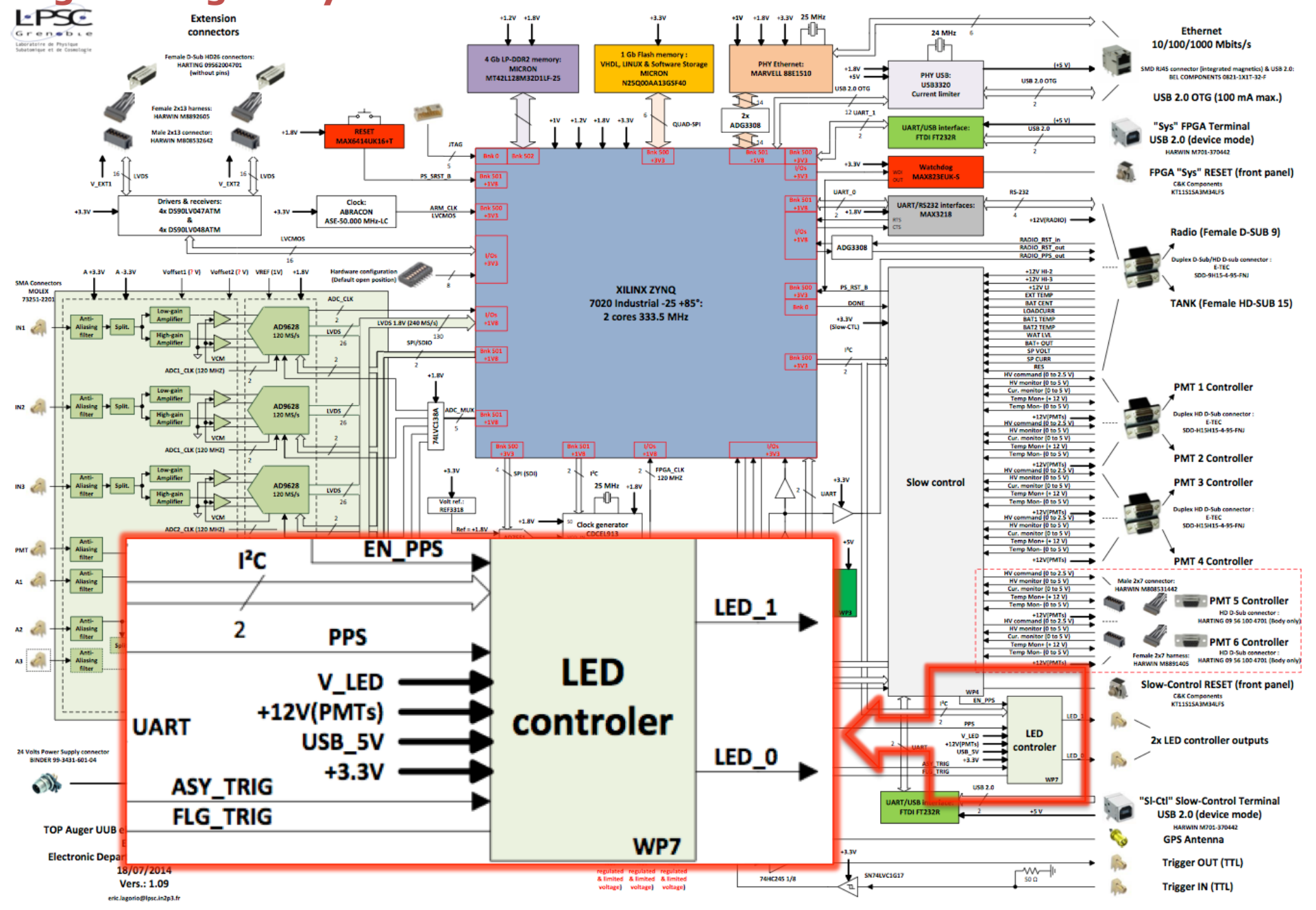


LED controller for RDA block diagram
GAP Note 2011-025

Design implementation

- Increased LED bias
  - smallPMT dynamics sampled in the field with 19V
  - UUB will provide unregulated DC line, limited to 24V, for further extension
- GPS trigger synchronization
  - via a hardware gate around GPS-PPS
  - via FPGA timing with arbitrary delay

Upgraded Unified Board and LED connections
Engineering Array Production

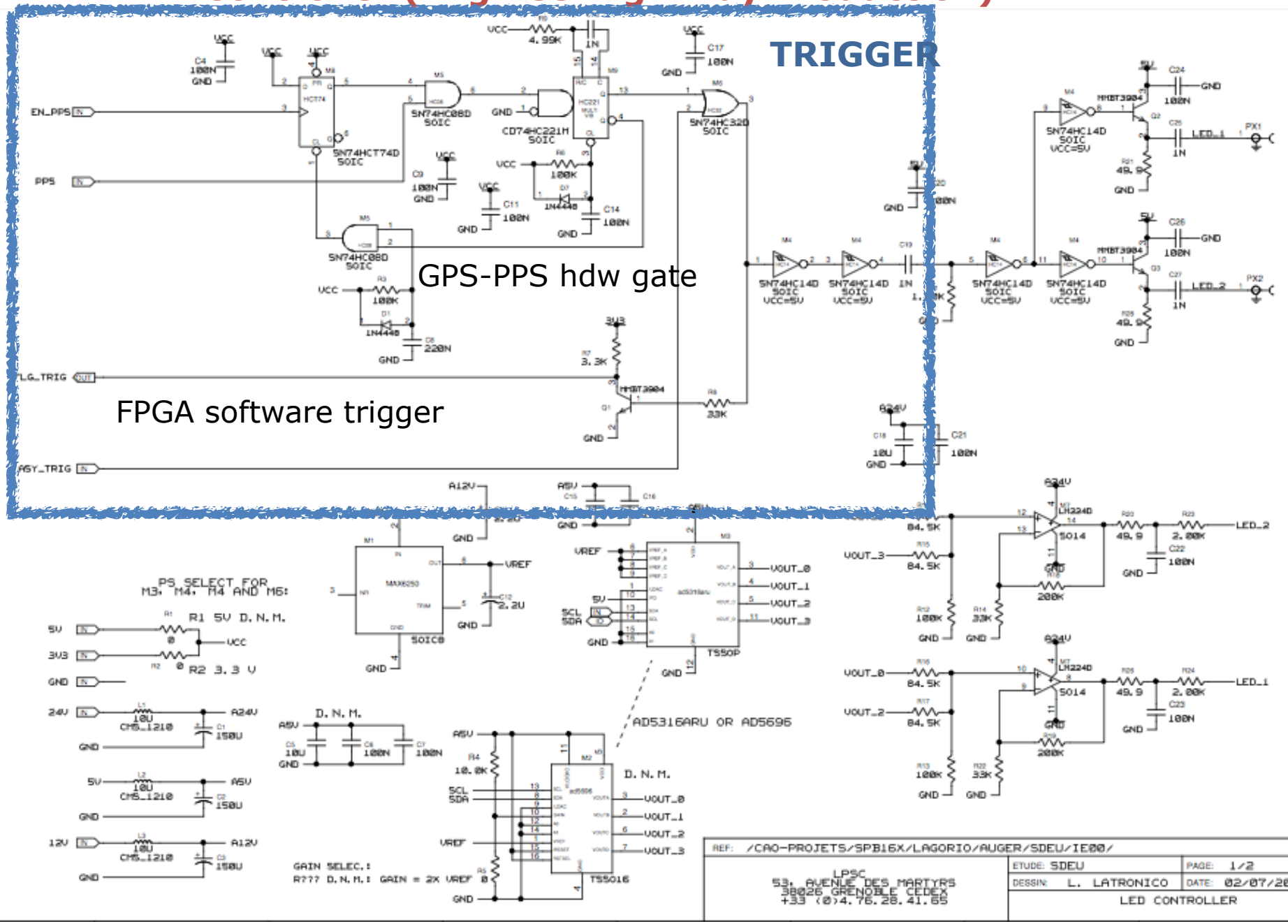


LED Controller - connections

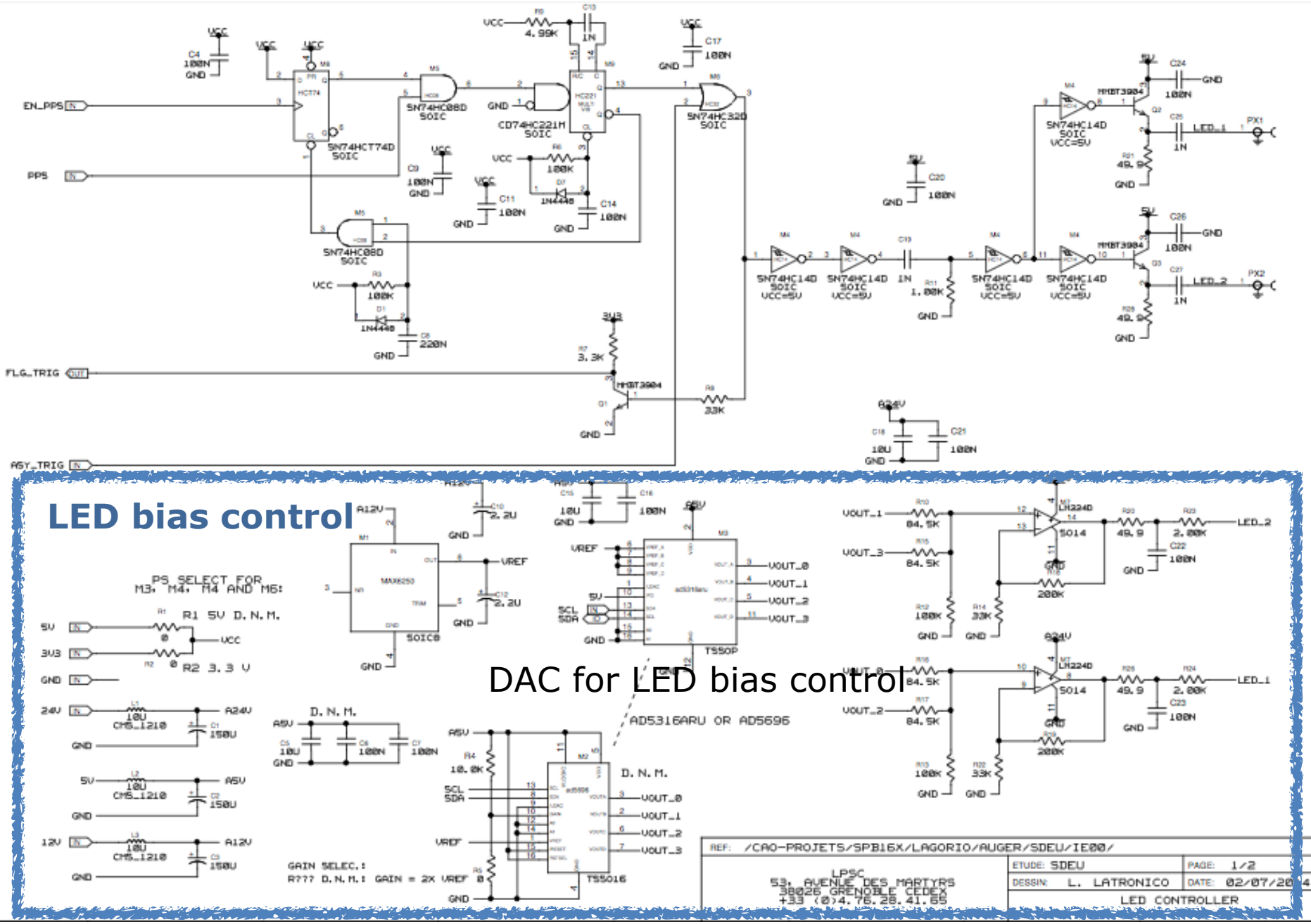
Connection	*Direction*	*Function*
EN_PPS	INPUT	Enable PPS signal from Slow Control (WP4)
PPS	INPUT	GPS PPS signal directly from GPS
ASY_TRG	INPUT	software trigger from UUB FPGA
FLG_TRG	OUTPUT	LED trigger flag to UUB FPGA
5V		For digital circuit
3.3V		For digital circuit
19-32V (unregulated)		Analog bias to LED, limited to 24V

Control through I2C bus via Linux drivers (per WP6 recommendations)

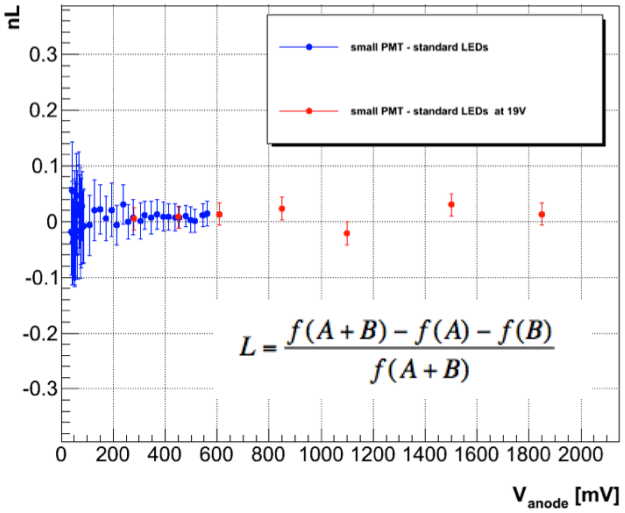
NEW LED Controller (Engineering Array Production)



NEW LED Controller (Engineering Array Production)

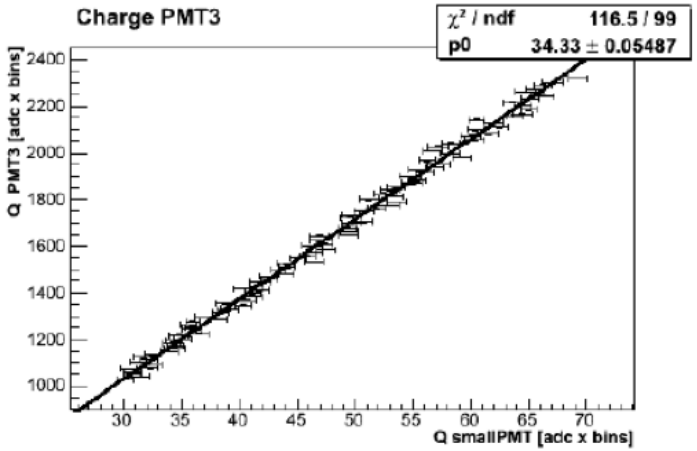


Test reports - past examples

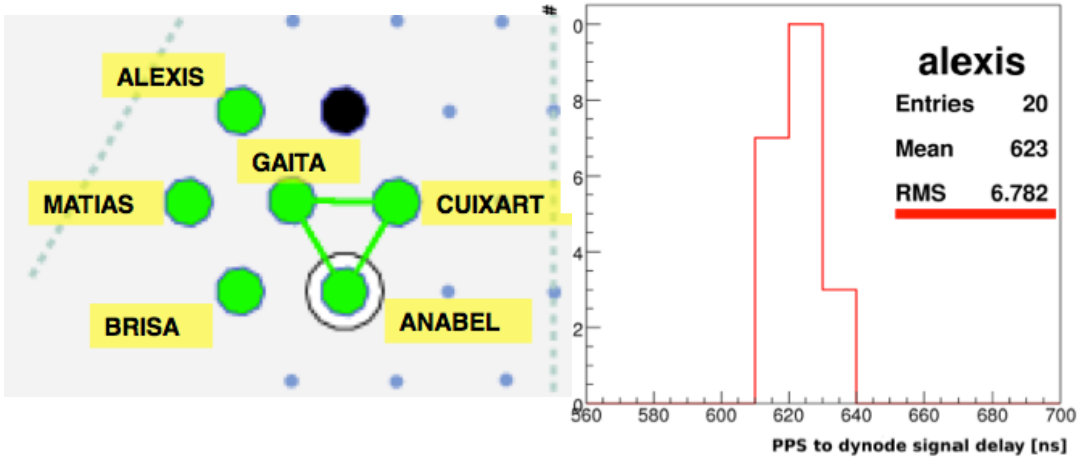


1. Non linearity
   - does not probe SMPT saturation

2. Inter-range calibration (PMT3-Anode vs SPMT)



3. Artificial EAS patterns on the array (LED modified controllers for RDA, GAP 2011-25)
   - time dispersion of PPS aligned pulses on one tank



Test strategy

- Laboratory Tests for early prototypes
  - basic functional tests of the electrical connections
  - verify control of the bias DAC
  - run full linearity tests without PMTs
  - develop and tune test protocol
- Field tests (Engineering Array)
  - functional tests
  - GPS timing
  - linearity and cross-calibrations

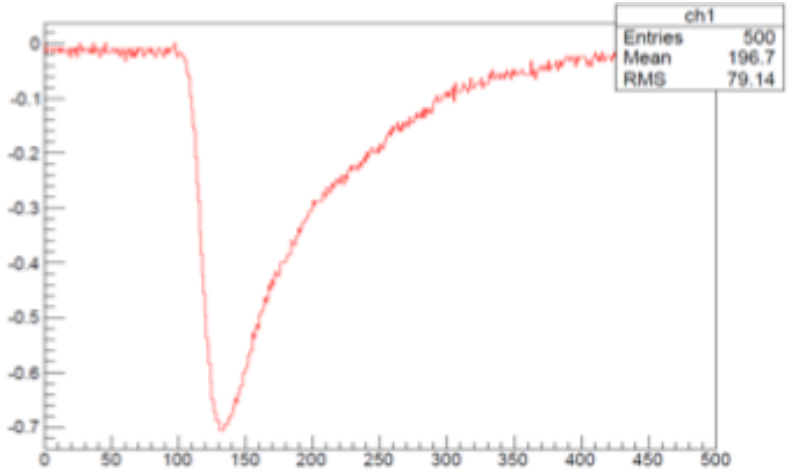
Conclusions

- Status
  - system design complete and flown down to WP5
  - final layout to be validated
  - ready for pre-production
- References
  - SDE Upgrade Plan
  - SDE Upgrade Specifications
  - GAP 2011-25

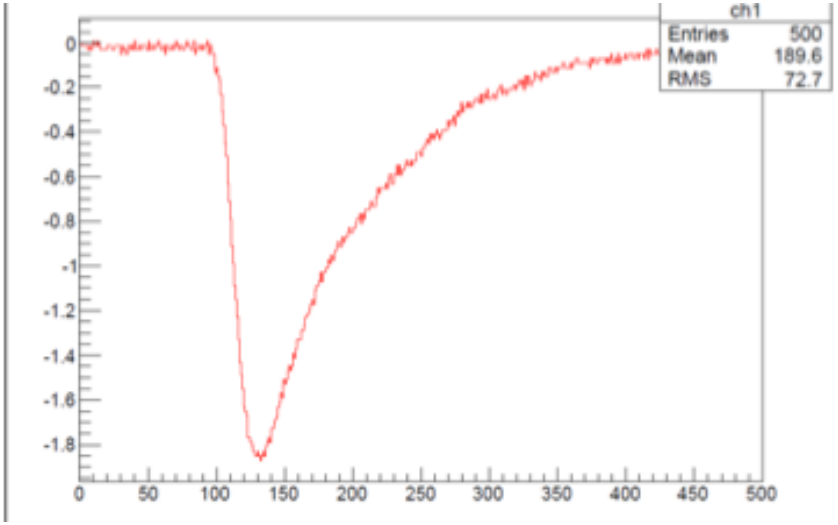
BACKUP

Small PMT linearity

Standard LED – 10 V



Standard LED – 19 V

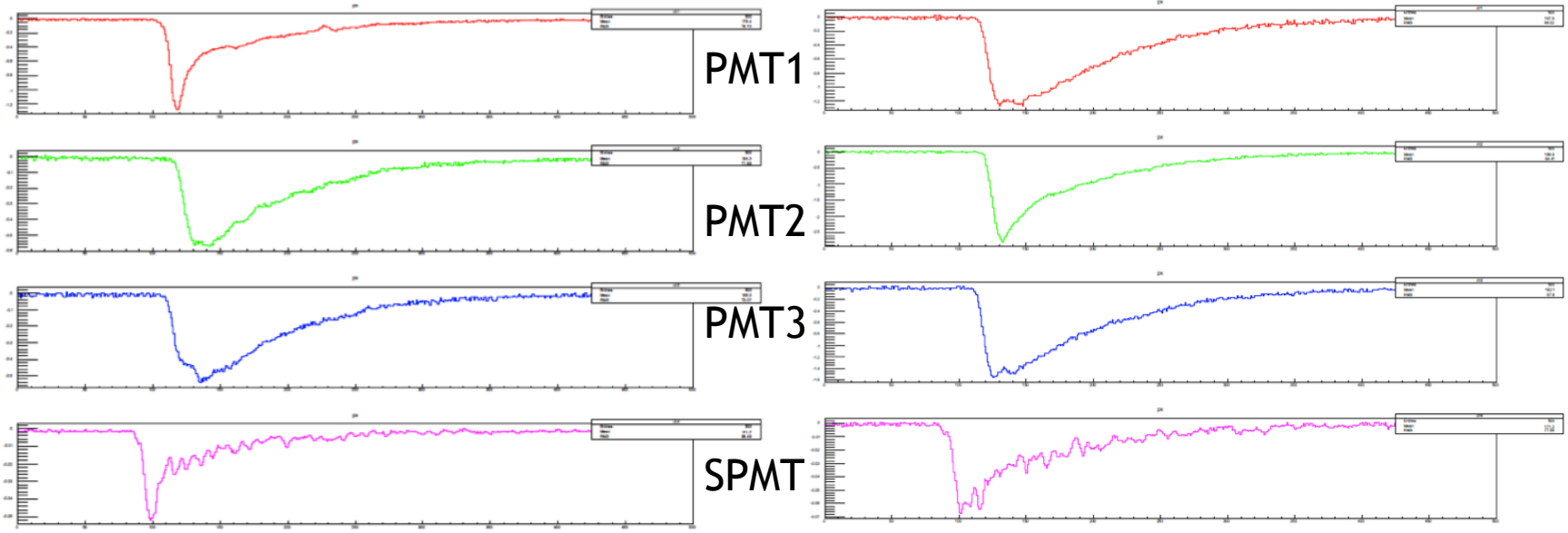


Higher input voltage can generate more light, similar signal shape

Signal shape

CR Event A

Standard LED (12º light cone)



WP7 WBS

WBS	Activity	Quant	Base Unit	Est Code	Contin gency	Cost / Unit	Total Cost with Cont.	Total WP cost	Total FTE-M over 4 Y
1.7	**Calibration and control tools - WP7**							136987.5	96.(
1.7.1	Calibration and control design H/W and S/W		hours	EE	30%	35	**0**	**22522.5**	
1.7.1.1	Prototype Board	2	each			4550	**9100**		
1.7.1.1.1	Design Prototype	60	hours	EE	30%	35	2730		
1.7.1.1.2	CAD Layout	60	hours	EE	30%	35	2730		
1.7.1.1.3	Procure Parts	2	each	EE	30%		0		
1.7.1.1.4	Prototype PCB's	2	each	EE	30%		0		
1.7.1.1.5	Assemble prototype PCB's	80	hours	EE	30%	35	3640		
1.7.1.2	S/W integration	80	hours	EE	30%	35	**3640**		
1.7.1.3	Functional testing of prototype	80	hours	EE	30%	35	**3640**		
1.7.1.4	Test on UUB Prototypes (E. Array) and pre-production	5	days	EE	30%	35	**227.5**		
1.7.1.5	Integration on UUB design	80	hours	EE	30%	35	**3640**		
1.7.1.6	Reports and documentation	50	hours	EE	30%	35	**2275**		
1.7.2	Light generator design	80	hours	EE	30%	35	**3640**	**114465**	
1.7.2.1	Prototype design	2	each			1365	**2730**		
1.7.2.1.1	Procure Parts	2	each	EE	30%		0		
1.7.2.1.2	Fabricate prototype	40	hours	EE	30%	35	1820		
1.7.2.1.3	Assemble prototype	20	hours	EE	30%	35	910		
1.7.2.2	Functional testing of prototype	40.0	hours	EE	30%	35	**1820**		
1.7.2.3	Production	2000	each			14.56	**29120**		
1.7.2.3.1	Procure Parts for production	2050	each	EE	30%		0		
1.7.2.3.2	Fabricate production	320.0	hours	EE	30%	35	14560		
1.7.2.3.3	Assemble production	320.0	hours	EE	30%	35	14560		
1.7.2.4	Functional testing and validation of production	160.0	hours	EE	30%	35	**7280**		
1.7.2.5	Onsite shipment	2000	each	EE	30%	5	**13000**		
1.7.2.6	Receive/Inspect	80.0	hours	EE	30%	35	**3640**		
1.7.2.7	Onsite integration	125	days	EE	30%	280	**45500**		
1.7.2.8	Validation	160	hours	EE	30%	35	**7280**		