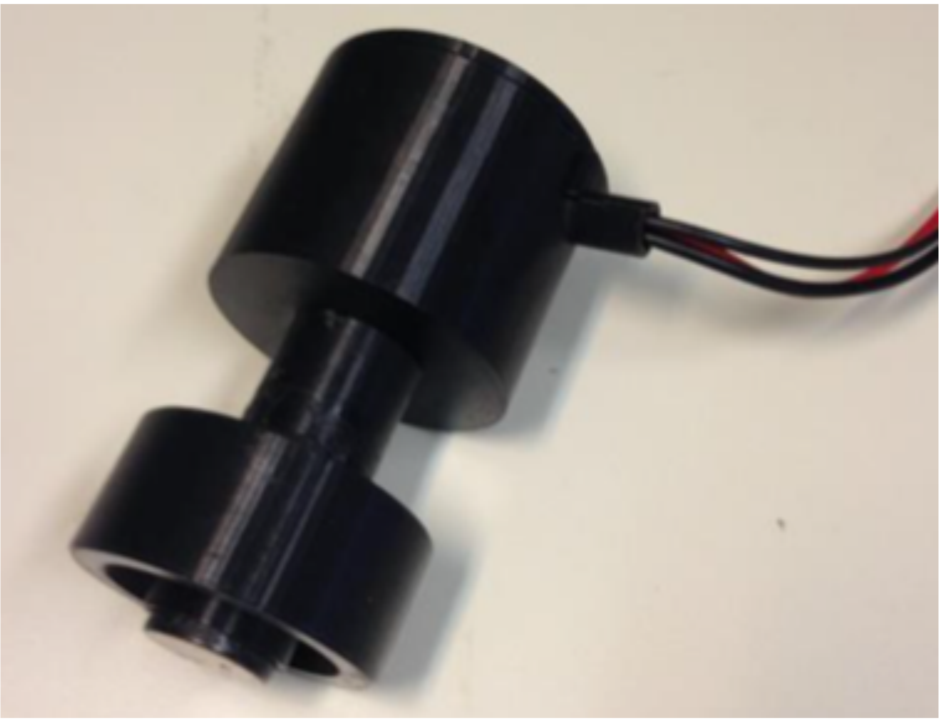
The small PMT : operation and performances

Antonella Castellina
INFN and INAF - Torino



Contributions from
INFN-Catania
INFN-Napoli
INFN-Torino
IPN-Orsay
Malargüe staff

AugerPrime electronics Operation Readiness Review, April 14, 2024

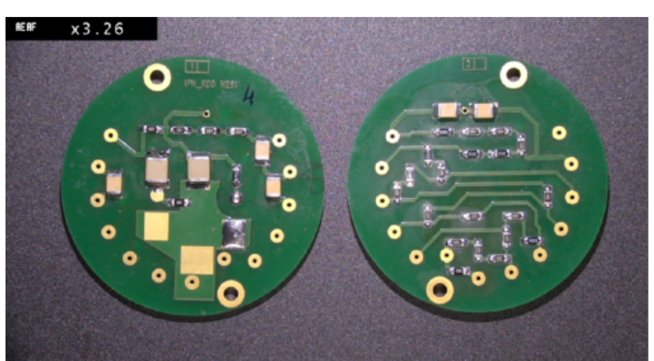
Small PMT unit

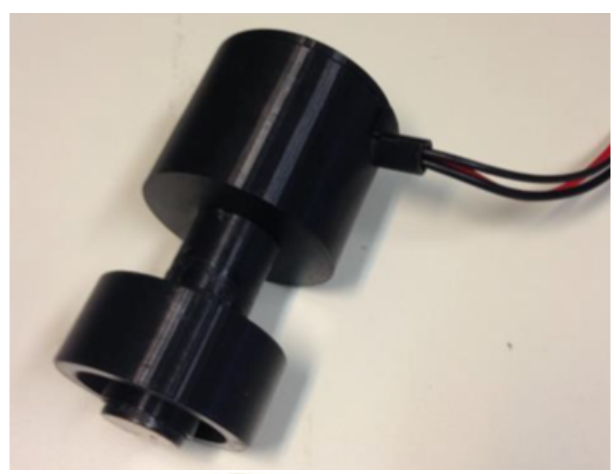
1510 units to be installed (excluding the external border of 150 stations)

- 1477 already installed
- 33 missing (25 in forbidden areas, 8 due to problematic installation)

1 unit =

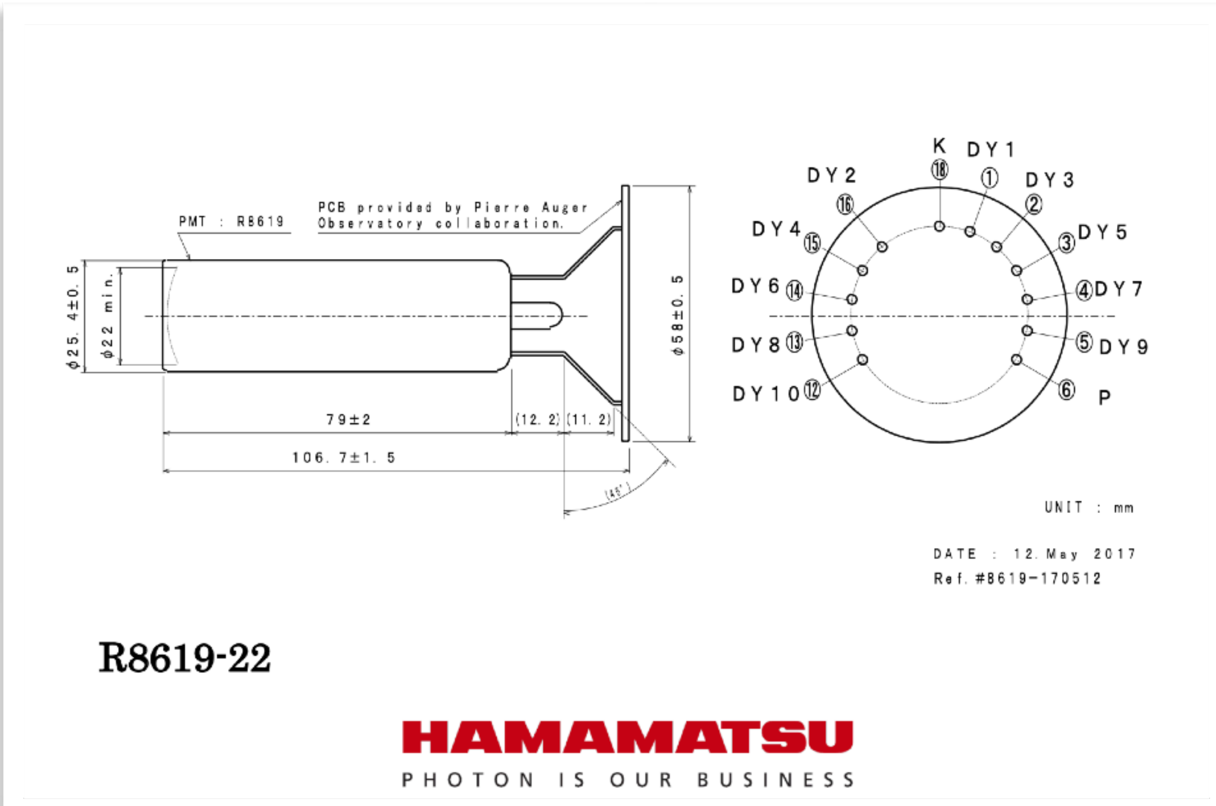
- sPMT R8619
- HVPS A7501
- mechanics
- cables



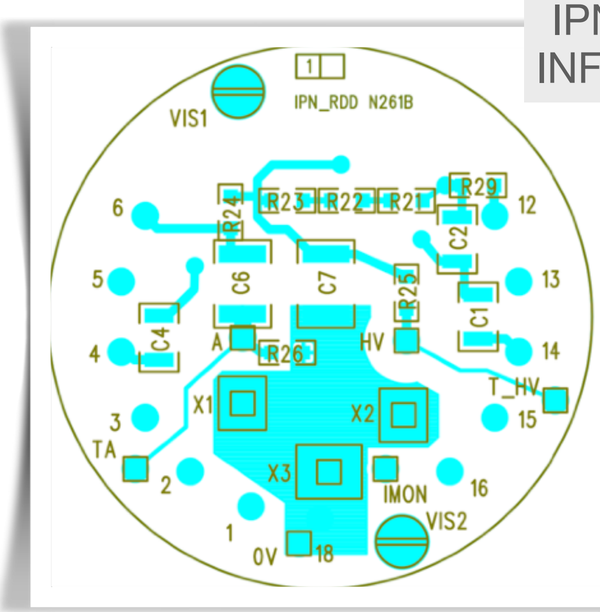


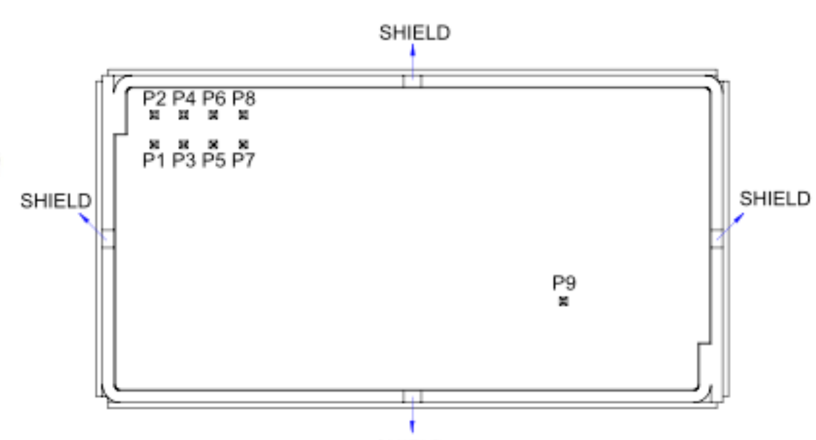
sPMT - production

- All specifications for production collected in *EDMS PAO-000273-ProductionsPlan*
- Datasheets, descriptions and tools collected in *EDMS PAO-000274-ProductionDocuments*



IPN-Orsay
INFN-Torino

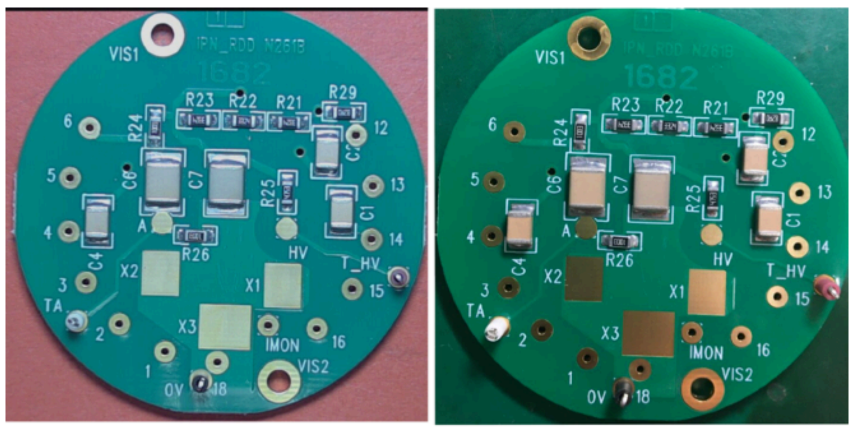




Pin #	Description	Direction
P1	Enable (on >+2.8V)	In
P2	OVC Status	Out
P3	Vmon	Out
P4	Vset	In
P5	Iset	In
P6	Imon[2]	Out
P7	+12V (±10%) Input	In
P8	RTN ground - shield	
P9	HV Output	Out

1- Tests before shipping - by providers

- All parts of the SPMT units have been tested
- Documentation in *EDMS PAO-000275-TestAssemblyProcedures*
- Results in *EDMS PAO-000276 and PAO-000267—TestReports and Link to test results*



@ NeOhm before shipment @ Hamamatsu

Dividers

- tested by NeOhm Co. before delivering to Hamamatsu
- some gold plated soldering points discolored : defective bases discarded by Hamamatsu, NeOhm agreed to replace them
- reason: thickness of deposition under specs

SPMT with flying leads

- tested by Hamamatsu (requirements checked)

HVPS

- tested by CAEN

Required converter specification	Range & accuracy	
Main voltage supply	$V_{cc} = 12V \pm 5\%$	✓
Temperature range	-20°C < T < 60 °C	✓
Output voltage V_{out}	$V_{min} = 0V < V_{out} < V_{max} = 2100V$	✓
Input command V_{cin}	$0 < V_{cin} < 2.5V$ ($V_{cin} = 2.5V$ at V_{max})	✓
Output voltage monitor V_{mon}	$0 < V_{mon} < 5V$ ($V_{mon} = 5V$ at V_{max})	✓
Power absorption	$P_{abs} < 500$ mW at V_{max}	✓
Uniformity of output voltage V_{out} for a constant V_{cin} command	$< 10^{-3}$	✓
$\triangle V_{out}/V_{out}$ fluctation vs V_{cc}	$\triangle V_{out}/V_{out} < 1‰$ at $V_{out} > 500\,V$	✓
Integral non linearity for V_{out} vs V_{cin}	$< 2 \cdot 10^{-3}$ at $V_{out} > 500V$	✓
Integral non linearity for V_{mon} vs V_{out}	$< 2 \cdot 10^{-3}$ at $V_{out} > 500V$	✓
Termal stability $\triangle V_{out}/V_{out} \cdot$ T	$< 10^{-4}$ °C^{-1}	✓

CAEN Tools for Discovery

Costruzioni Apparecchiature Elettroniche Nucleari C.A.E.N. S.p.A.
Via Vetraia, 11 - 55049 Viareggio (LU) - Italy
+39.0584.388.398 - fax +39.0584.388.959
info@caen.it - www.caen.it

Viareggio, March 30th 2018

Ricci Giacomo

A7501PB – s/n 159

Vset (V)	Vout (V)	Vmon (V)	Imon (V)	Iin (mA)	PWR_in (mW)	Vout/Vset	Vout/Vset INL	Vout/Vmon	Vout/Vmon INL	Imon/Vset	Imon/Vset INL
0,0011	14,4174	0,0256	0,0088	4,5361	56,0845	12826,8786	54,28%	562,6702	-8,14%	7,8158	65,33% *
0,0980	86,1153	0,1959	0,0570	7,4485	92,0941	878,2884	-2,26%	439,6410	-1,23%	0,5818	-1,72% *
0,2017	174,4525	0,4054	0,1166	8,6631	107,1110	865,1081	-0,39%	430,3298	-0,47%	0,5781	-0,20% *
0,3034	260,1415	0,6087	0,1743	9,6186	118,9258	857,4322	-0,20%	427,4017	-0,23%	0,5745	-0,13% *
0,4037	344,7160	0,8095	0,2313	10,4990	129,8108	853,8597	-0,07%	425,8555	-0,13%	0,5729	-0,05% *
0,5008	426,5719	1,0037	0,2865	11,3259	140,0342	851,7964	0,00%	425,0046	-0,06%	0,5721	0,00%
0,6008	510,6580	1,2033	0,3431	12,1854	150,6619	850,0144	0,01%	424,3774	-0,02%	0,5712	-0,02%
0,7044	597,9467	1,4103	0,4020	13,1063	162,0482	848,8811	0,04%	423,9839	0,02%	0,5706	-0,01%
0,8026	680,5937	1,6066	0,4577	13,9784	172,8304	847,9418	0,05%	423,6166	0,03%	0,5702	-0,01%
0,9004	762,8796	1,8020	0,5132	14,8608	183,7412	847,2995	0,06%	423,3631	0,05%	0,5699	0,00%
0,9967	843,6253	1,9938	0,5676	15,7408	194,6211	846,4304	0,03%	423,1190	0,05%	0,5695	-0,04%
1,1039	934,0836	2,2087	0,6287	16,7468	207,0589	846,1454	0,06%	422,9037	0,06%	0,5695	0,01%
1,2037	1017,2762	2,4075	0,6851	17,6903	218,7254	845,1461	-0,01%	422,5429	0,02%	0,5692	-0,01%
1,2960	1093,9935	2,5915	0,7374	18,5764	229,6805	844,1621	-0,08%	422,1473	-0,04%	0,5690	-0,02%
1,4007	1182,0961	2,8012	0,7970	19,6010	242,3491	843,9222	-0,07%	421,9978	-0,05%	0,5690	-0,01%
1,5041	1269,3130	3,0083	0,8558	20,6230	254,9846	843,9121	-0,04%	421,9399	-0,03%	0,5690	0,02%
1,5985	1348,9342	3,1974	0,9095	21,5661	266,6461	843,8549	-0,02%	421,8890	-0,02%	0,5689	0,03%
1,7005	1434,6796	3,4011	0,9673	22,5933	279,3461	843,6637	-0,02%	421,8265	-0,02%	0,5688	0,02%
1,8007	1519,0240	3,6016	1,0242	23,6157	291,9877	843,5578	-0,01%	421,7680	-0,01%	0,5688	0,03%
1,9049	1606,4866	3,8093	1,0832	24,6864	305,2255	843,3651	-0,01%	421,7305	0,00%	0,5686	0,02%
2,0023	1688,5989	4,0044	1,1386	25,7006	317,7649	843,3313	0,00%	421,6861	0,00%	0,5686	0,02%
2,1049	1774,7725	4,2093	1,1966	26,7732	331,0272	843,1796	0,00%	421,6362	0,00%	0,5685	0,01%
2,2042	1858,3829	4,4081	1,2528	27,8214	343,9875	843,1134	0,01%	421,5869	0,00%	0,5684	0,00%
2,3005	1939,4036	4,6007	1,3069	28,8512	356,7198	843,0262	0,01%	421,5484	0,01%	0,5681	-0,04%
2,3962	2019,8343	4,7919	1,3613	29,8707	369,3250	842,9308	0,01%	421,5077	0,01%	0,5681	-0,03%
2,5017	2108,9869	5,0036	1,4216	31,0193	383,5261	843,0249	0,03%	421,4944	0,01%	0,5683	0,00%

Interpolation line slope "m"			840,497123	420,476459	0,56728114
Interpolation line intercept "q"			5,64754198	4,81687131	0,00240774

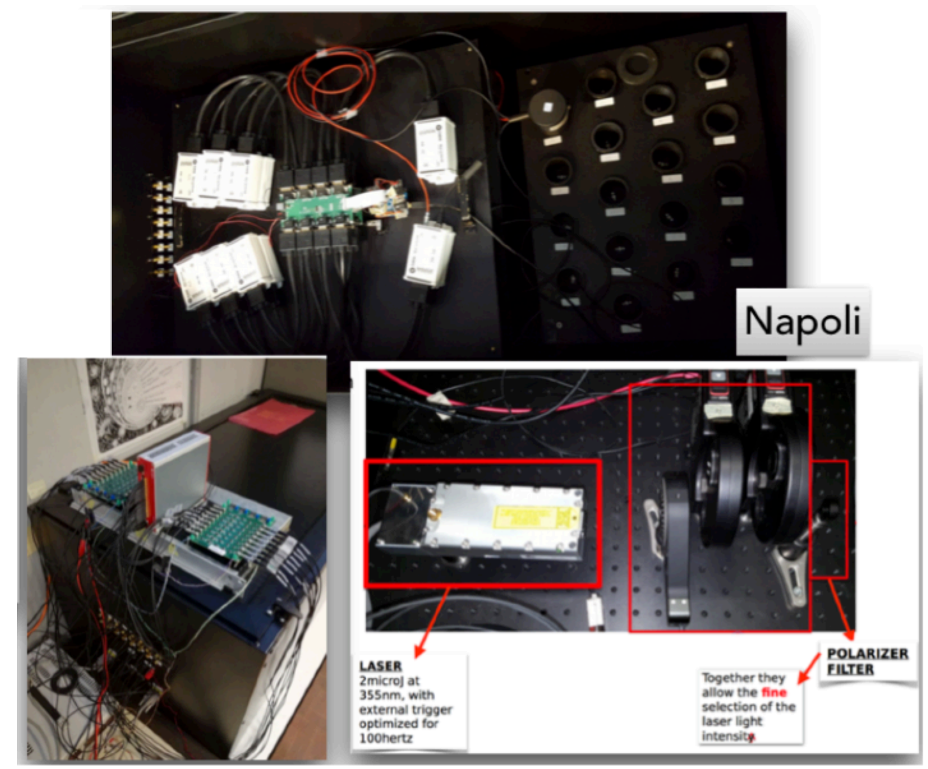
* step out of relevant range (Vout<400V). This step has been discarded for statistics.

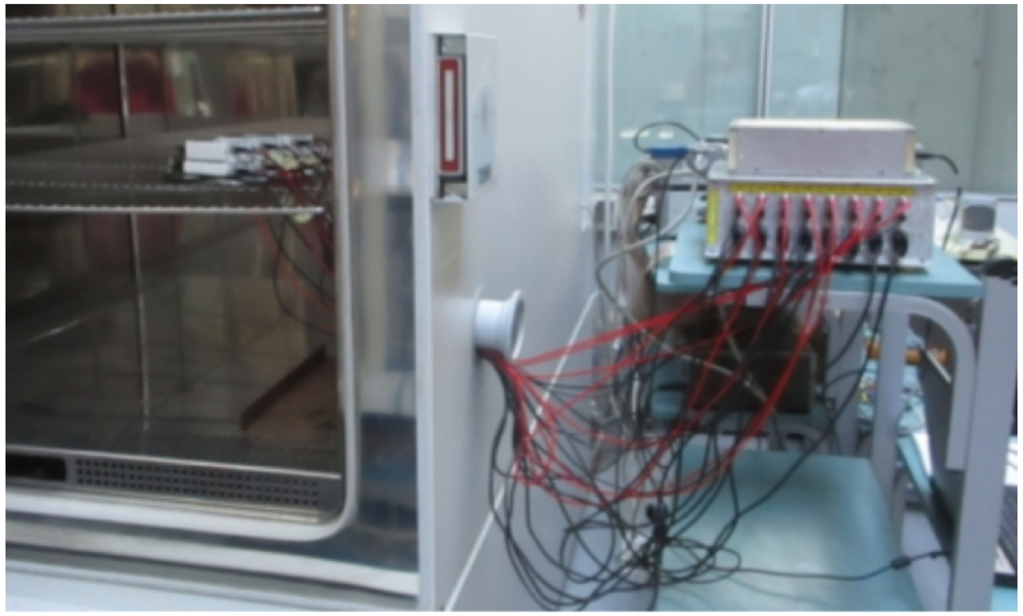
1- Tests before shipping - at INFN labs

PMT test (INFN-Napoli)

- 16 sPMT tested in one shot
- Double dynamics front-end: x12 amplifier for SPE/MIP measurements, /7 attenuator for linearity
- results in MySQL database ansd ascii

[M.Buscemi et al., JINST 15 (2020) 07, P07011]





HVPS test (INFN-Torino & Catania)

- two identical test systems
- tests at room temperature and in climatic chamber
- results in https://pandora.infn.it/public/b4022a

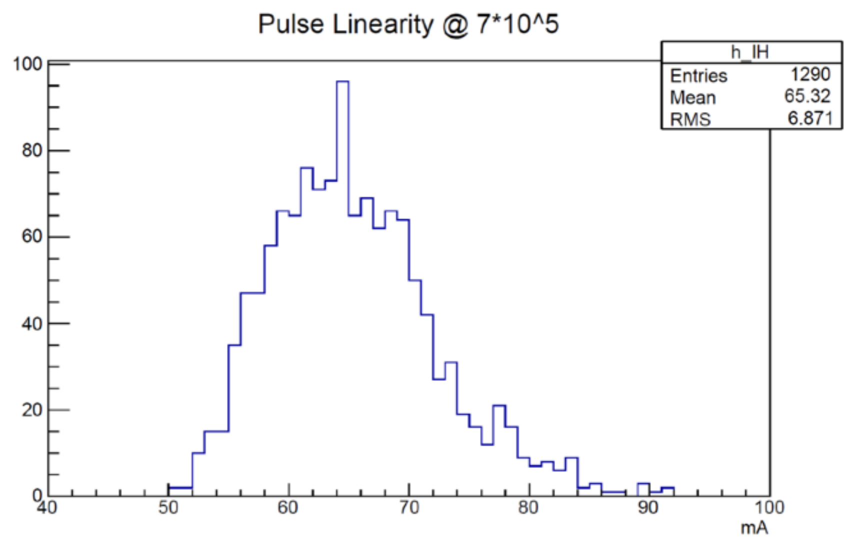
[G.Anastasi et al., JINST 17 (2022) T04003]

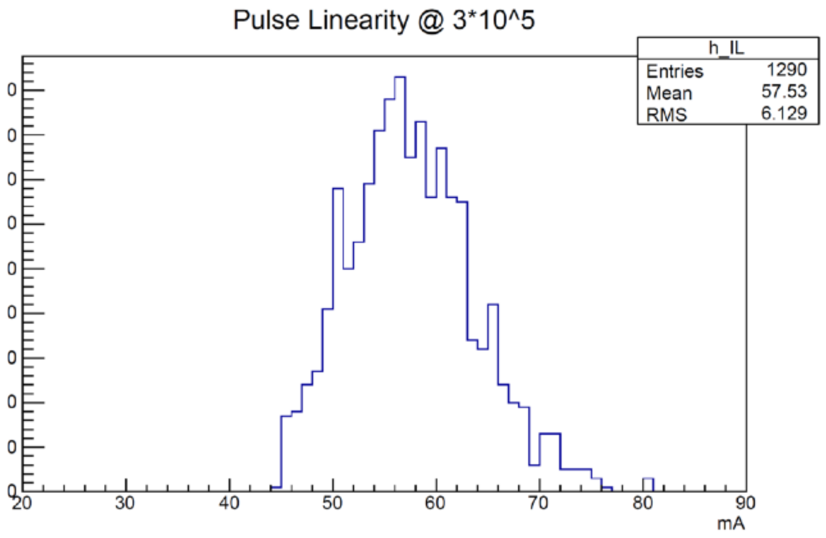
EDMS PAO-000275-Test and assemby procedures

1- Tests before shipping - at INFN labs

PMT test (INFN-Napoli)

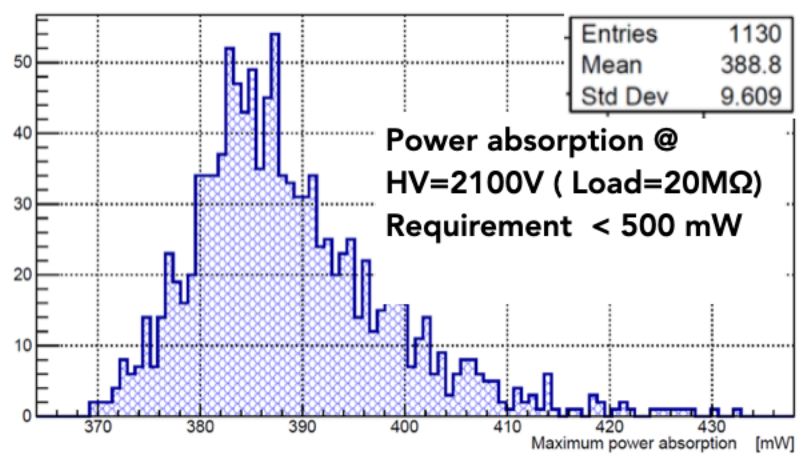
- Only 2 out of 1290 discarded

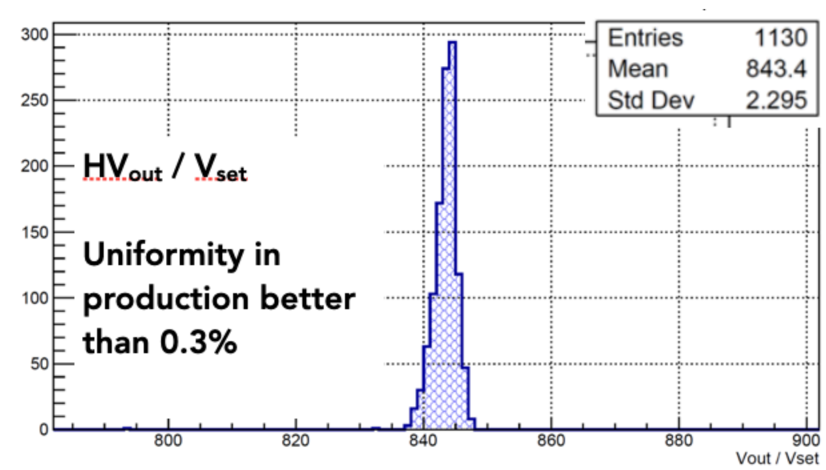




HVPS test (INFN-Torino & Catania)

- ~150 HVPS rejected and replaced (bad soldering for one pin+one bad component identified)
- All modules in agreement with specifications





More tests: sPMT dependence on Temperature

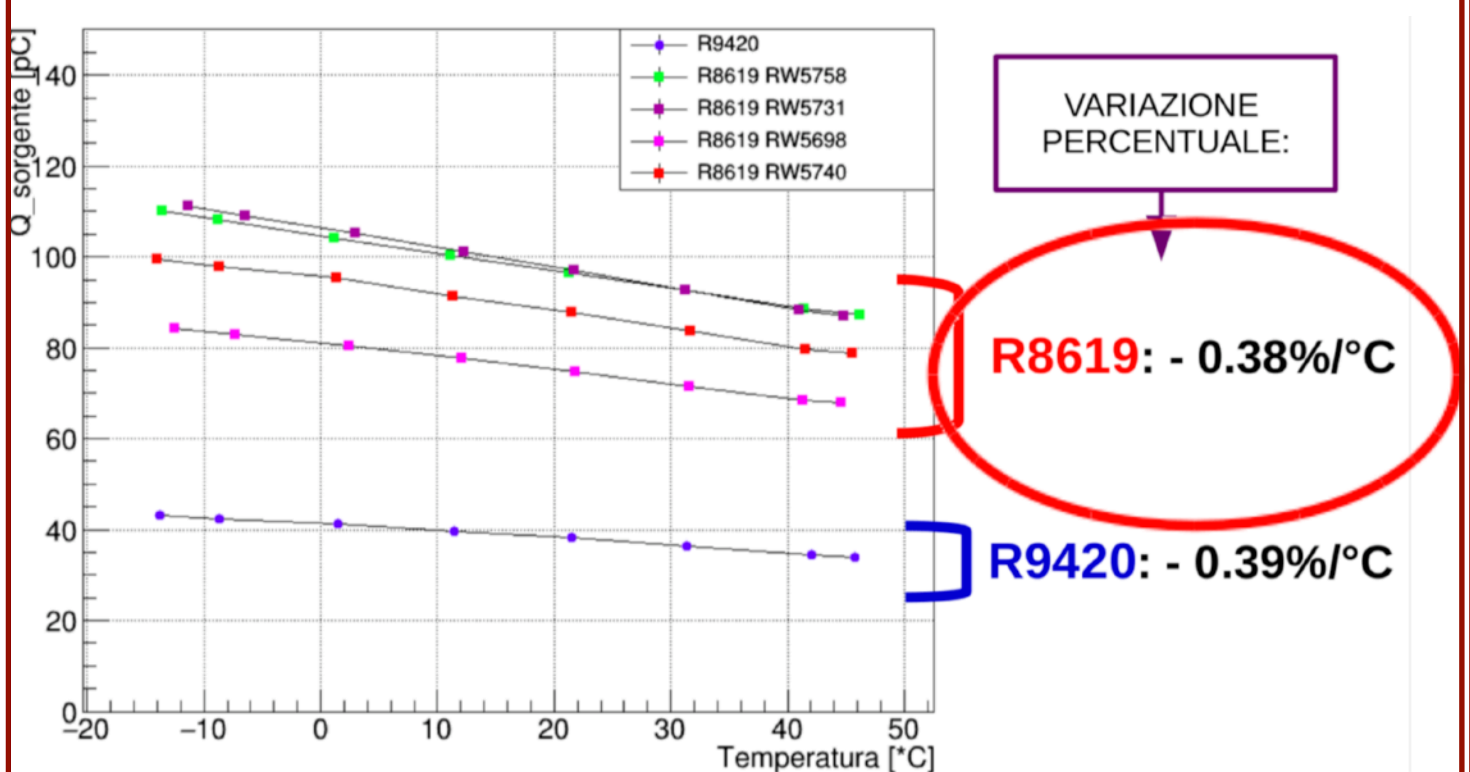
[GAP2016-078]

Components sensitive to temperature

➡ High Voltage Power Supply $$\frac{|\Delta HV_{out}|}{HV_{out}\Delta T} = 2.5\ 10^{-5}/°C$$

➡ PCB + Divider $$\left(\frac{\Delta G}{G\Delta T}\right) < 3\%$$

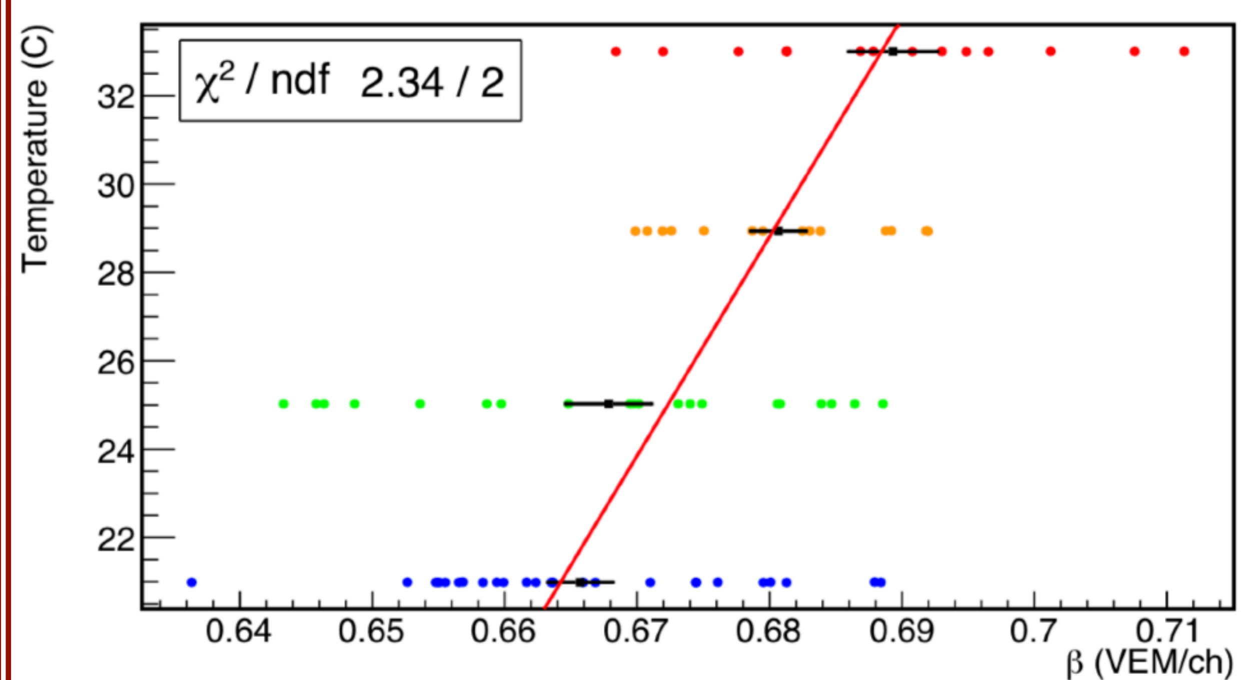
➡ Photomultipliers [contributions from dynode multipliers and Photocathode Quantum Efficiency]



$$\beta = \frac{S_{LPMT}(VEM)}{S_{SPMT}(ch)}$$

$$\Delta\beta = 0.38\% \cdot \Delta T$$

expected

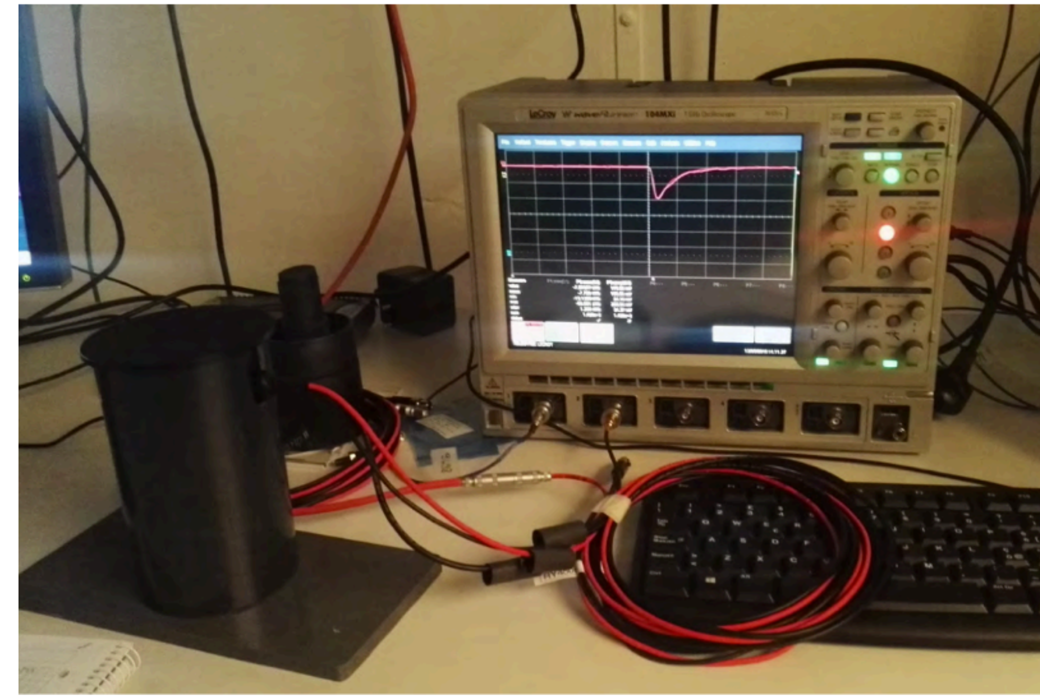


$$\Delta\beta = (0.37 \pm 0.05)\% \cdot \Delta T$$

measured (6 hrs cross-calib)

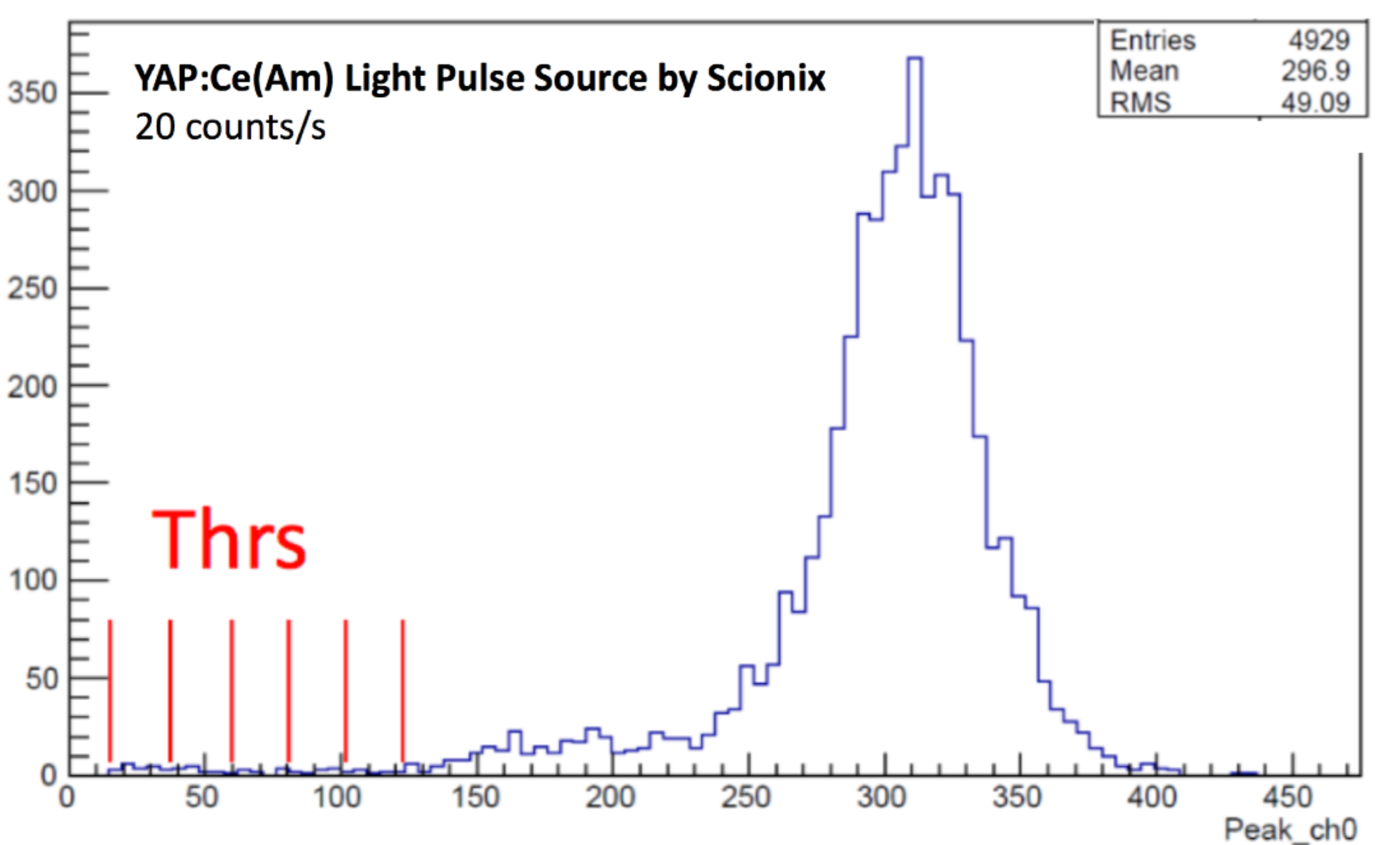
2- Test before deployment - at SDEco

EDMS PAO-000275-Test and assemby procedures



Light source (Scionix ^{241}Am-YAP:Ce), ~22 Bq, providing pulses of constant intensity at ~15 Hz.

- fast and simple checks by oscilloscope at the required SPMT gain: <P> and <Q> averaged over 512 pulses
- result largely independent of acquisition threshold: robust technique to monitor the gain at % accuracy in few mins
- database with results available at SDECo



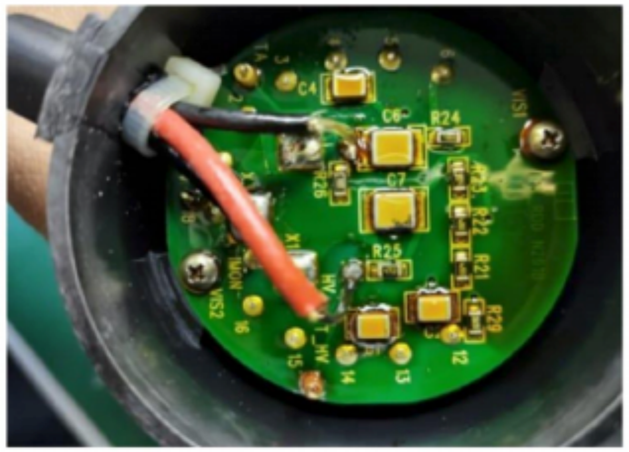
THRs [mV]	<Peak>$_{512}$ [mV]	<Q>$_{512}$ [nV/s]
20	284	10.6
40	291	10.9
60	292	10.9
80	294	10.9
100	293	11.0
120	293	11.0
140	295	11.0

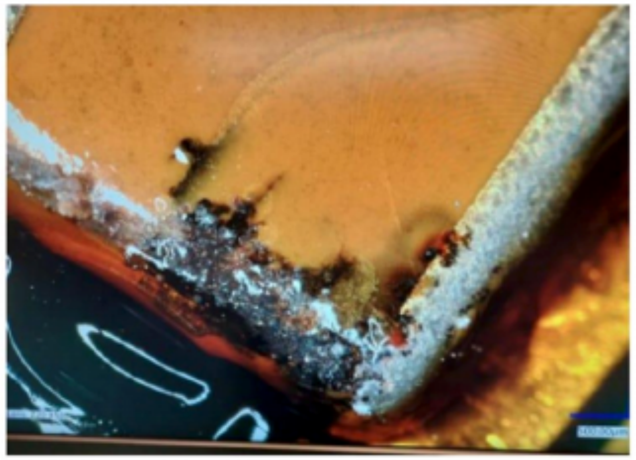
sPMT - problems from the field

Only 16 SPMTs since their deployment experienced problems affecting their performances.

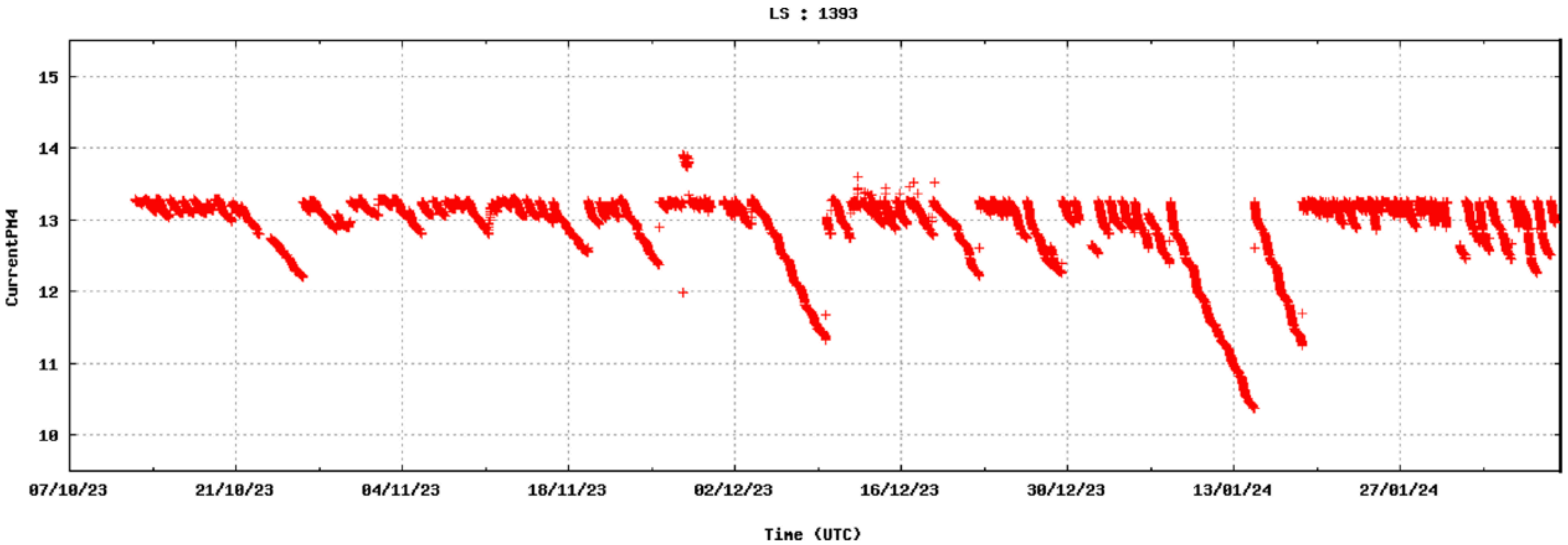
EDMS PAO-000276-SPMT Problems at test and field

- Water/humidity damage to the divider components
  - cause: incomplete sealing due to missing silicone application at production (Zener)
  - All SPMT deployed after November 2022 properly sealed by the local staff





- Unstable Imon
  - cause: probably originated by humidity
  - almost always solved by changing the base



- Transmission problems in monitoring data
  - cause: still unknown, under study

sPMT - problems from the field

Only 16 SPMTs out of 1547 installed units experienced problems affecting their performances.
In 12 out of 16 cases, the SPMT was installed prior to November 2022 —> no correct sealing

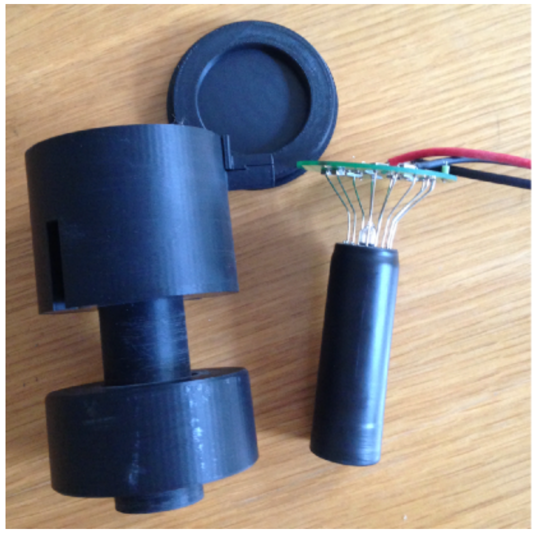
No failures found on SPMT tube or HVPS up to now (~1 year)
Malfunctioning in the field difficult to solve: either sporadic or due to environmental causes that disappear in lab
However, checking contacts and/or replacing the divider solves most problems

Note that
— the dividers have only passive components
— low cost ~15€/unit
— a large batch of spares is available (>370)

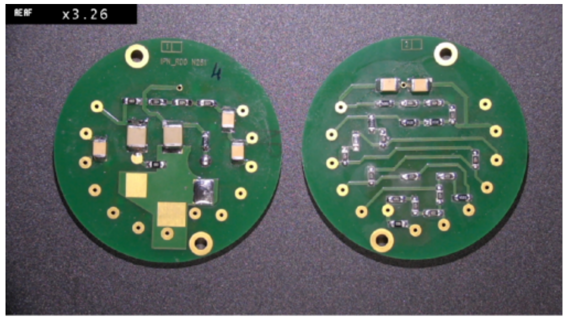
➡ No need for a dedicated test system in SDEco

sPMT - spare parts

- photomultipliers+base+cables+mechanics
  - 1477 installed, 33 still missing
  - ***148 spare units***



- Dividers
  - 66 remaining from the production
  - other two batches of 150+160 bases have been produced
  - ***376 spare units***



- HV modules
  - ***185 spare units***

- Control cables (HV to UUB)
  - ***129 spare units***
- Clamps
  - ***400***

EDMS PAO-000276-SPMT Spare parts

Documentation

Technical docs

Procedures

Test results

Maintenance

- Productions Plans PAO-000273
  - 2491602 (v.1) Agreement between the Pierre Auger Collaboration and Hamamatsu for the furniture of up to 1700 photomultiplier
  - 2491603 (v.1) Hamamatsu PHOTOMULTIPLIER TUBE R8619 Data Sheet
  - 2491604 (v.1) Hamamatsu and INFN Torino activity for Pierre Auger upgrade
  - 2491605 (v.1) Requirements for 1700 High Voltage Power Supply modules for the Pierre Auger Observatory
  - 2491606 (v.1) Technical Requirements for the supply of up to 1700 photomultipliers model R8619SEL-10 MOD3
  - 2491607 (v.1) SPMT Bases production Plan
  - 2491608 (v.1) Specifiche per la fornitura di 1700 schede partitore di tensione per il fotomoltiplicatore Hamamatsu R8619
- Productions Documents PAO-000274
  - 2491845 (v.1) SPMT Production Documents
  - 2491846 (v.1) SPMT Bases Production documents
  - 2491847 (v.1) SPMT HVPS Production documents
  - 2491848 (v.1) SPMT Mechanics Production documents

- Tests_&_Assembly_Procedures PAO-000275
  - 2491612 (v.1) A facility to validate photomultipliers for the upgrade of the Pierre Auger Observatory
  - 2491613 (v.1) Hamamatsu R8619 Base Measurements
  - 2491614 (v.1) SPMT Bases Tests Procedures
  - 2491841 (v.1) Specifiche per la procedura di assemblaggio di 800 fotomoltiplicatori Hamamatsu R8619SEL-10 MOD3.
  - 2491843 (v.1) Test bench and validation for the CAEN A7501PB HV-boxes of AugerPrime
  - 3071162 (v.1) Validation of high voltage power supplies for the small PMT
  - 3071263 (v.1) Procedure for the test of SPMT with YAP light source
- Deployement PAO-000263
  - 2175217 (v.1) SPMT INSTALLATION PROCEDURE
  - 2804588 (v.2) SPMT Sealing procedure

- Tests Reports PAO-000276
  - 2491610 (v.1) Quantum Efficiency for R8619 PMT
  - 2491611 (v.1) CAEN Test report on HVPS A7501PB
- Link to the Tests Results repository in Italy PAO-000267
  - 2273463 (v.1) Link to the Tests Results repository

- Maintenance PAO-000276
  - 3071612 (v.1) Small PMT Spare Parts
  - 3071614 (v.1) SPMT problems at test and field

The local staff is fully trained to perform all activities related to the SPMT

Reference person : Juan Pablo Gongora

sPMT - setting and calibration

[GAP2022-018]

Only ~1 phe/muon, due to small area

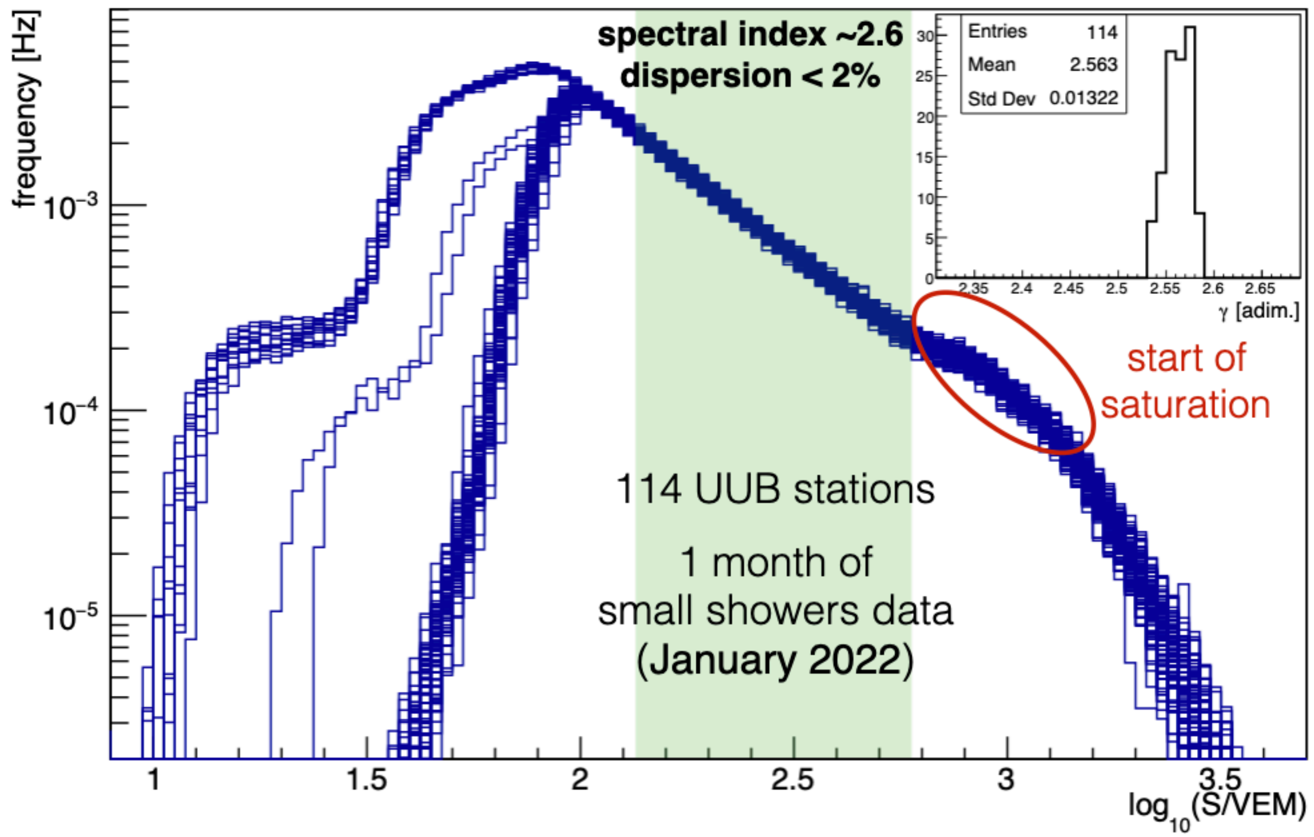
Exploit *local small showers* (~200/hour) : T1 events selected requiring a 2-fold coincidence among the LPMTs signals above a threshold S_{peak}(LPMTs) changing with the individual LPMTs counting rates.

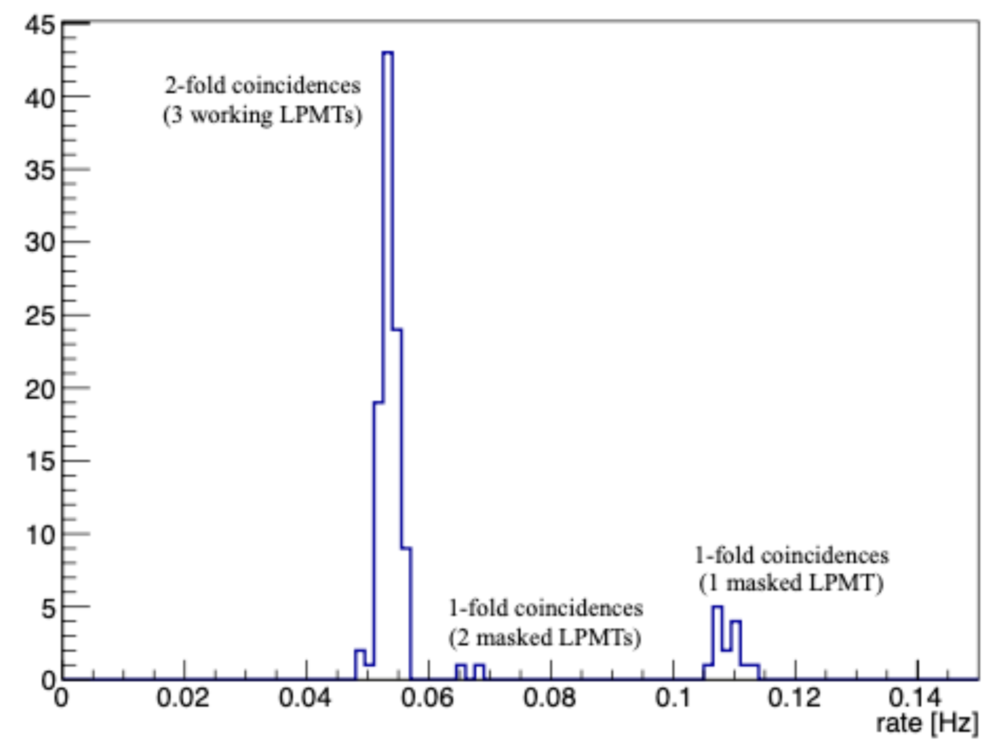
Small showers are used to:

➡ Set the HV allowing to measure signals without saturation at least up to 20,000 VEM

➡ Cross-calibrate the SPMT against calibrated signals from the LPMTs

…and they can provide a continuous monitoring of the LPMTs





sPMT - HV setting

GOAL : set the HV allowing to measure S_{target}= 22,500 VEM (±10%)

Saturation determined by the FADC dynamic range

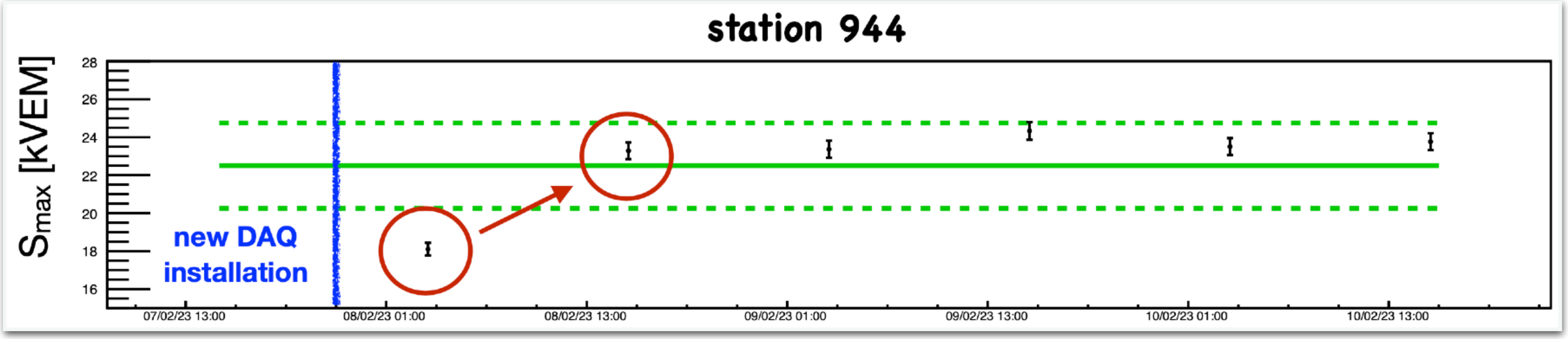
DR = 4095 - baseline ~ 3845 FADC counts

In first approximation $$Q_{max} = AoP_{ref} \times DR$$

Thus, for the SPMT signal $$S_{max} = AoP_{ref} \times DR \times \beta$$

where AoP_{ref} is the signal width and β the calibration factor

Procedure performed on-tank using small showers in 12h blocks and comparing S_{max} to S_{target}
Optimal result reached after 12 hours (one HV change)



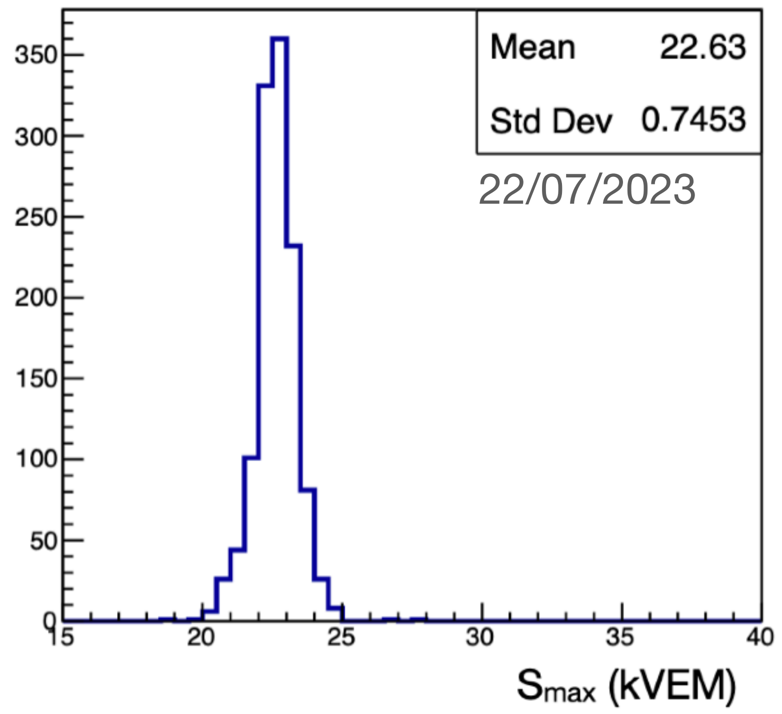
➡ Automatic procedure activated in July 2023

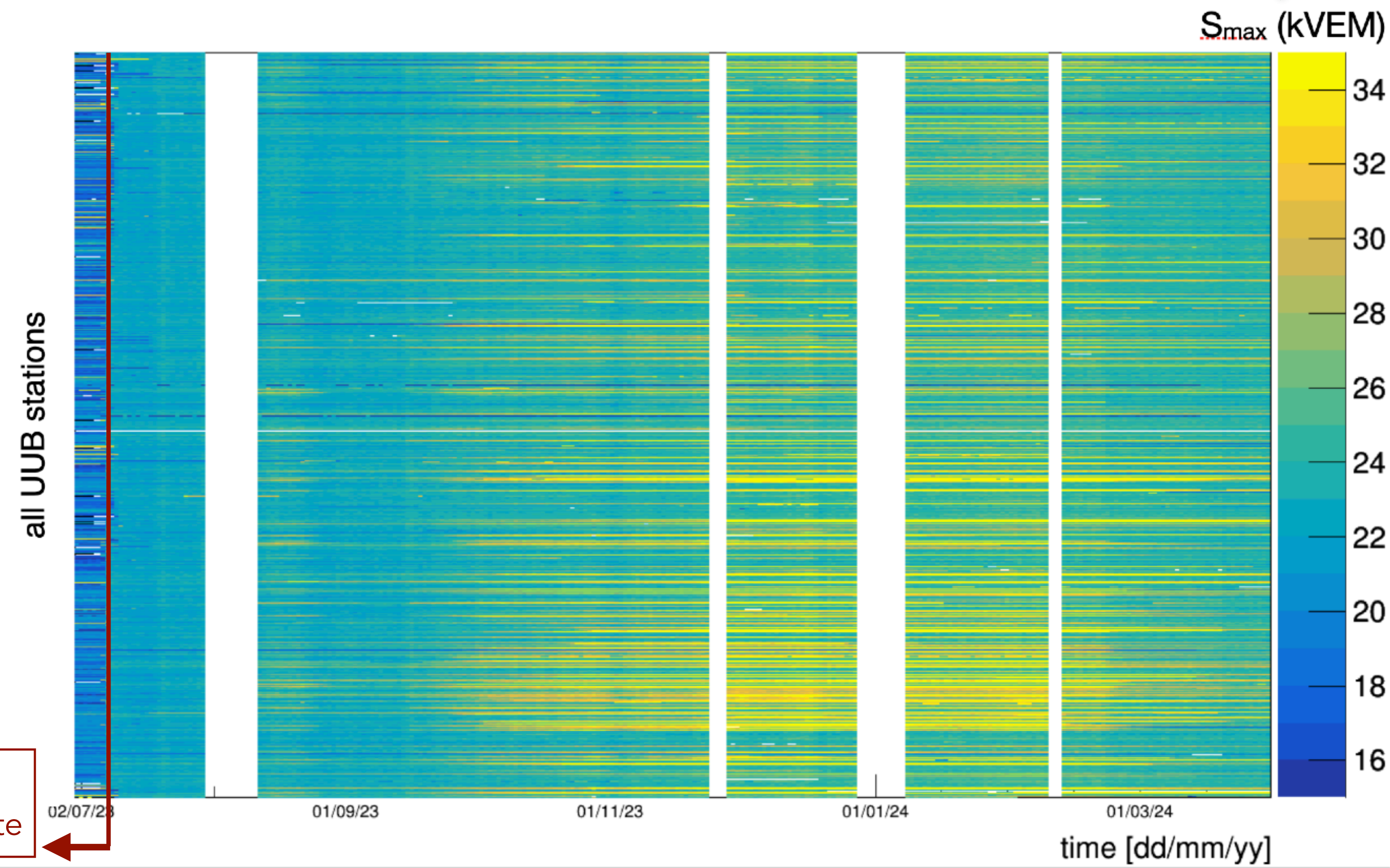
➡ code maintained in the SDE/UUB/DAQ gitlab repository

sPMT - Dynamic range

Maximum signal without saturation S_{max} estimated using small showers data

GOAL : set the HV allowing to measure signals without saturation at least up to 20,000 VEM





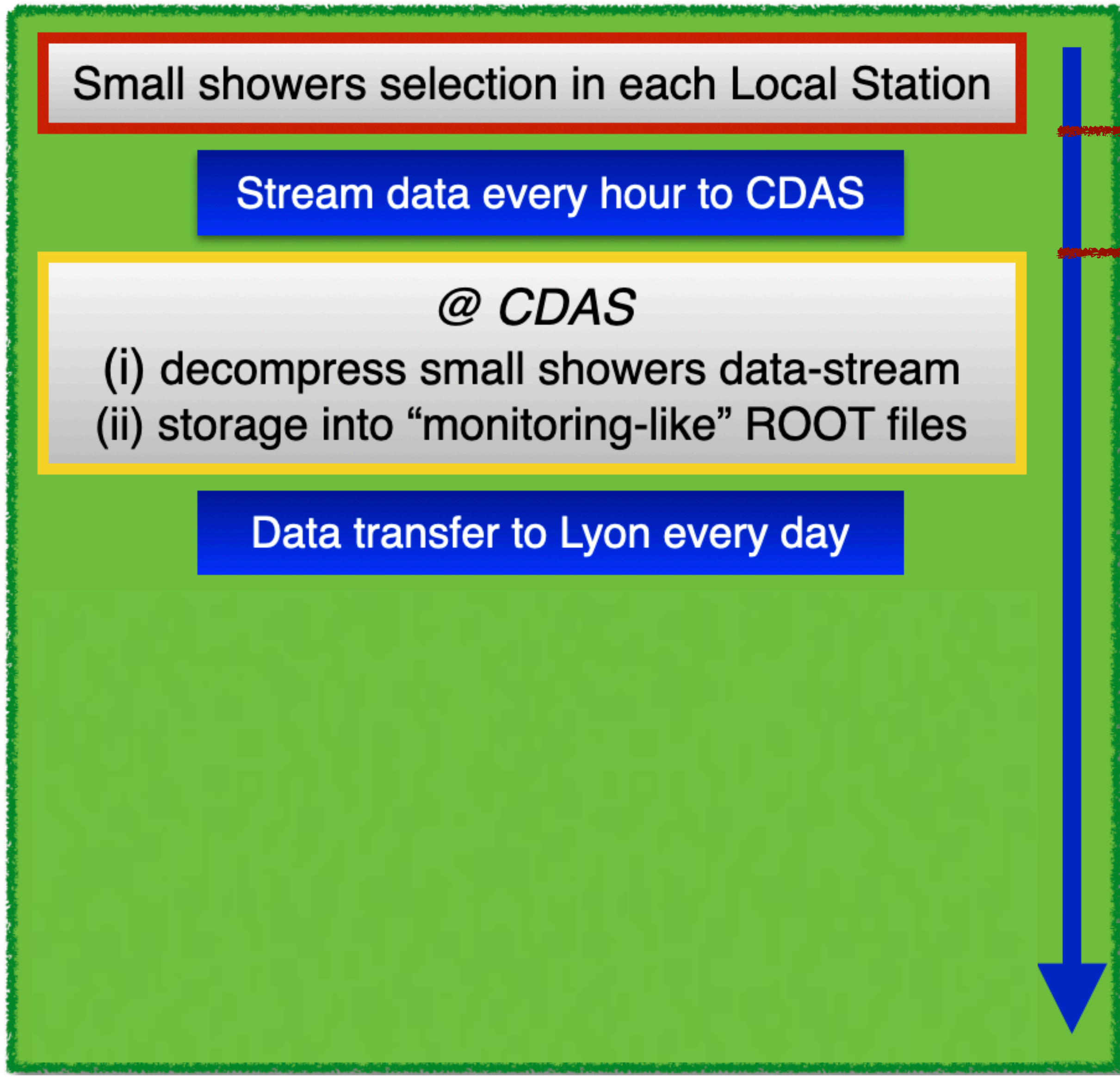
07/07/2023
UUB-DAQ software update

➡Procedure succesful in almost all SPMTs (~1% failure)

➡Bad periods are due to loss of small shower files

sPMT - calibration

[GAP2022-018]



HV setting

	Variables	Freq.
EVENT info	GPS time	**~ 200/h** (~ 400/h with a masked LPMT)
	event enumerator	
	AREA_PEAK_SATUR x 6 (LPMT1-2-3 / sPMT / SSD LG-HG)	
MUON info	GPS sec	~ 1 / min
	LPMT VEM charge x 3 (from histograms, custom process)	
	SSD MIP charge	
DAQ info	GPS sec	~ 1 / 5 min
	LPMTs masked status	
	HG/LG ratio x 3	
	LPMT threshold x 3	
	online VEM (peak) x 3	

Small showers stored by CDAS-DAQ in one spmt_yyyy_mm_dd.root file per day with data from ~00:00 to ~23:59 of dd/mm/yyyy from the whole array (< 300 MB/day)

Codes in the SDEU/UUB/daq and CDAS-DAQ repositories

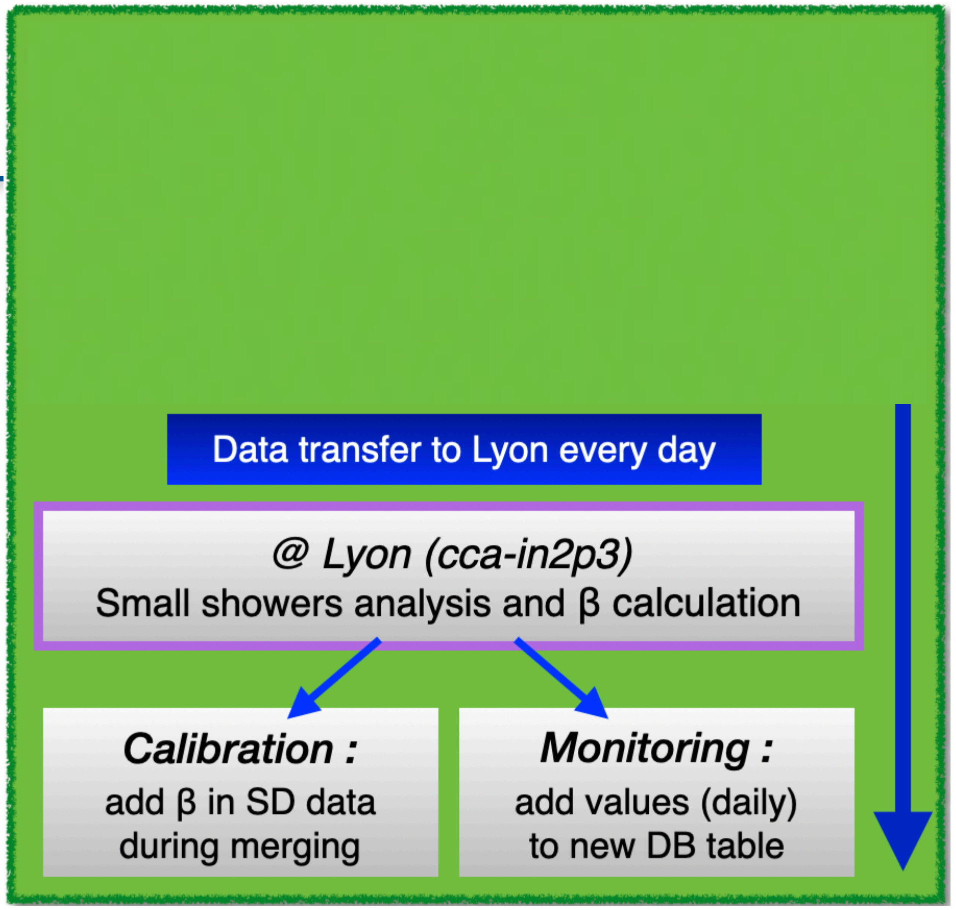
sPMT - calibration

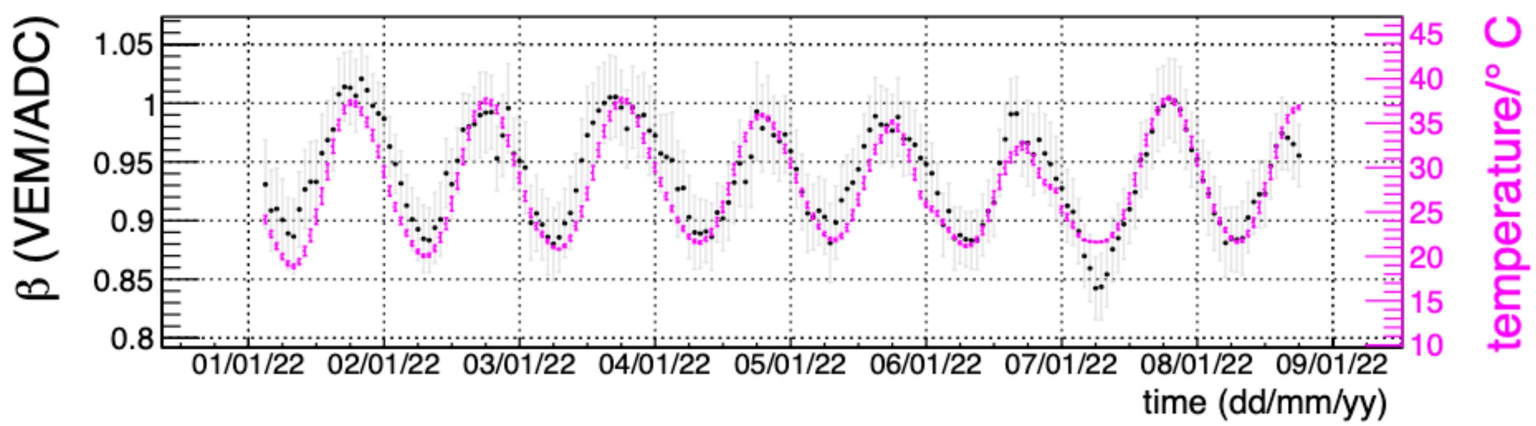
Only ~1 phe/muon, due to small area
Cross-calibration against LPMT calibrated
signals using local small showers (~200/hour)

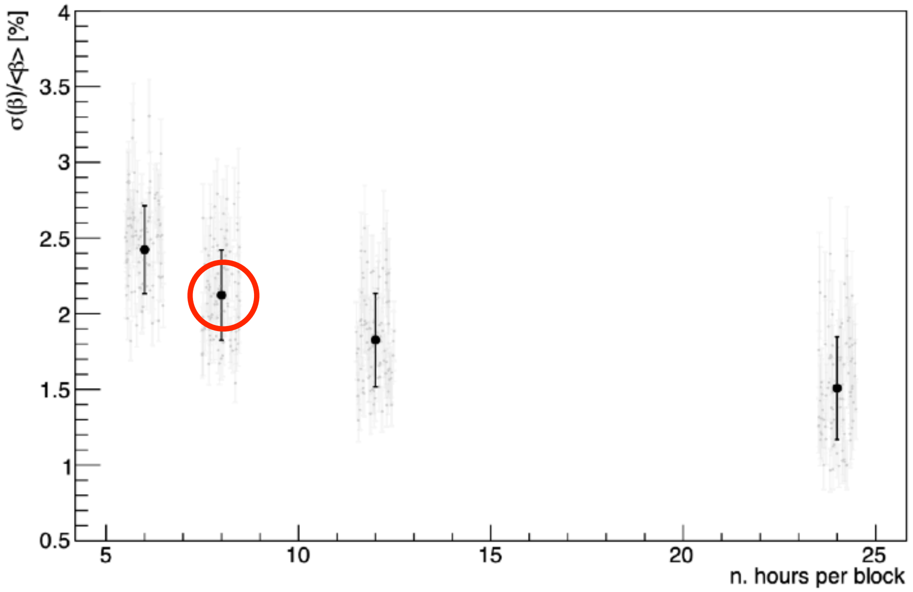
$$S_{\mathrm{SPMT}}[\mathrm{VEM}] = \beta \times Q_{\mathrm{SPMT}}[\mathrm{FADC\ counts}]$$

➡ Calibration parameter β determined every hour with ***~2.2% precision*** using data from 8 hour sliding windows

➡ Daily evolution in β : ±8% (anode sensitivity from lab measurements -0.38%/^{0}C, daily excursion ~20^{0}C)







Calibration running on CC-IN2P3 (code in the gitlab repository) producing 1 ROOT file per day for the whole array, stored in /sps/pauger/users/ganastasi/SPMTcalibration_results/v2r0/

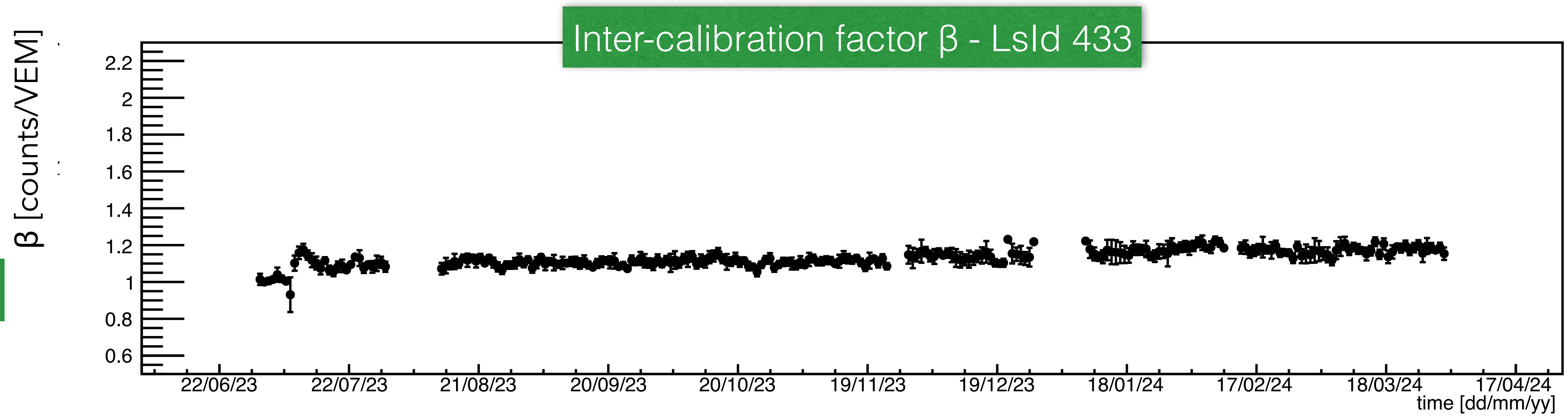
[GAP2022-018]

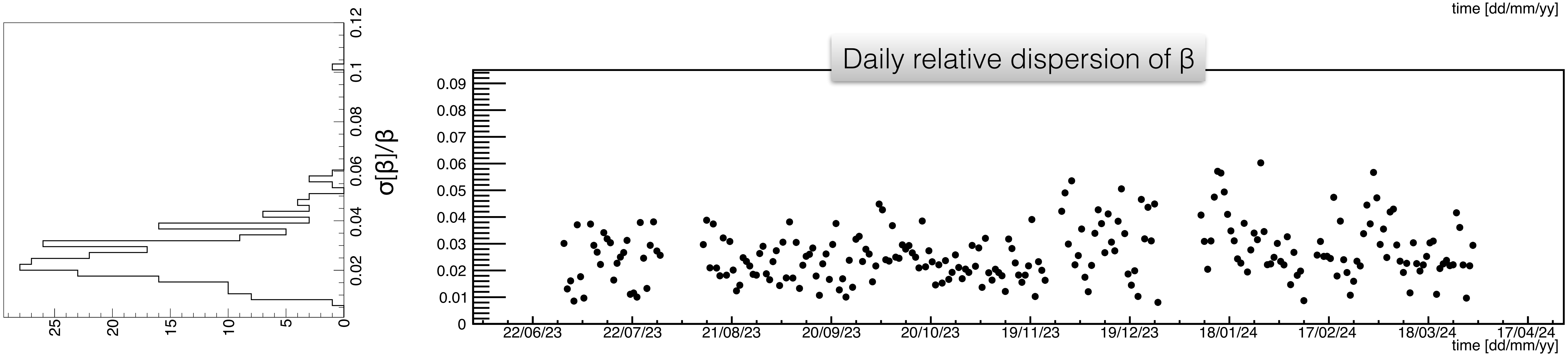
Stability of cross-calibration

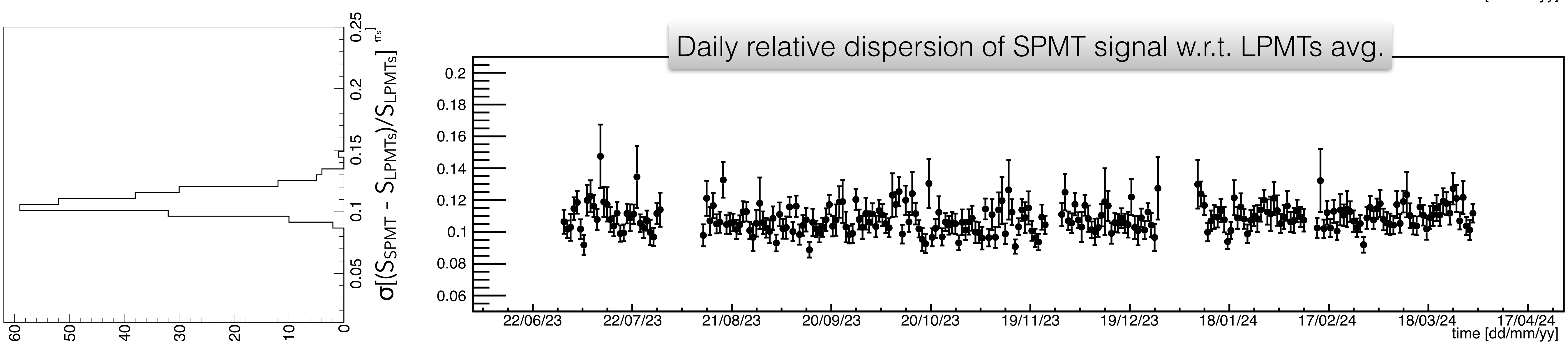
σ[β]/β < 5%

σ[(S_{SPMT} - S_{LPMTs})/S_{LPMTs}]

~ 10-12%



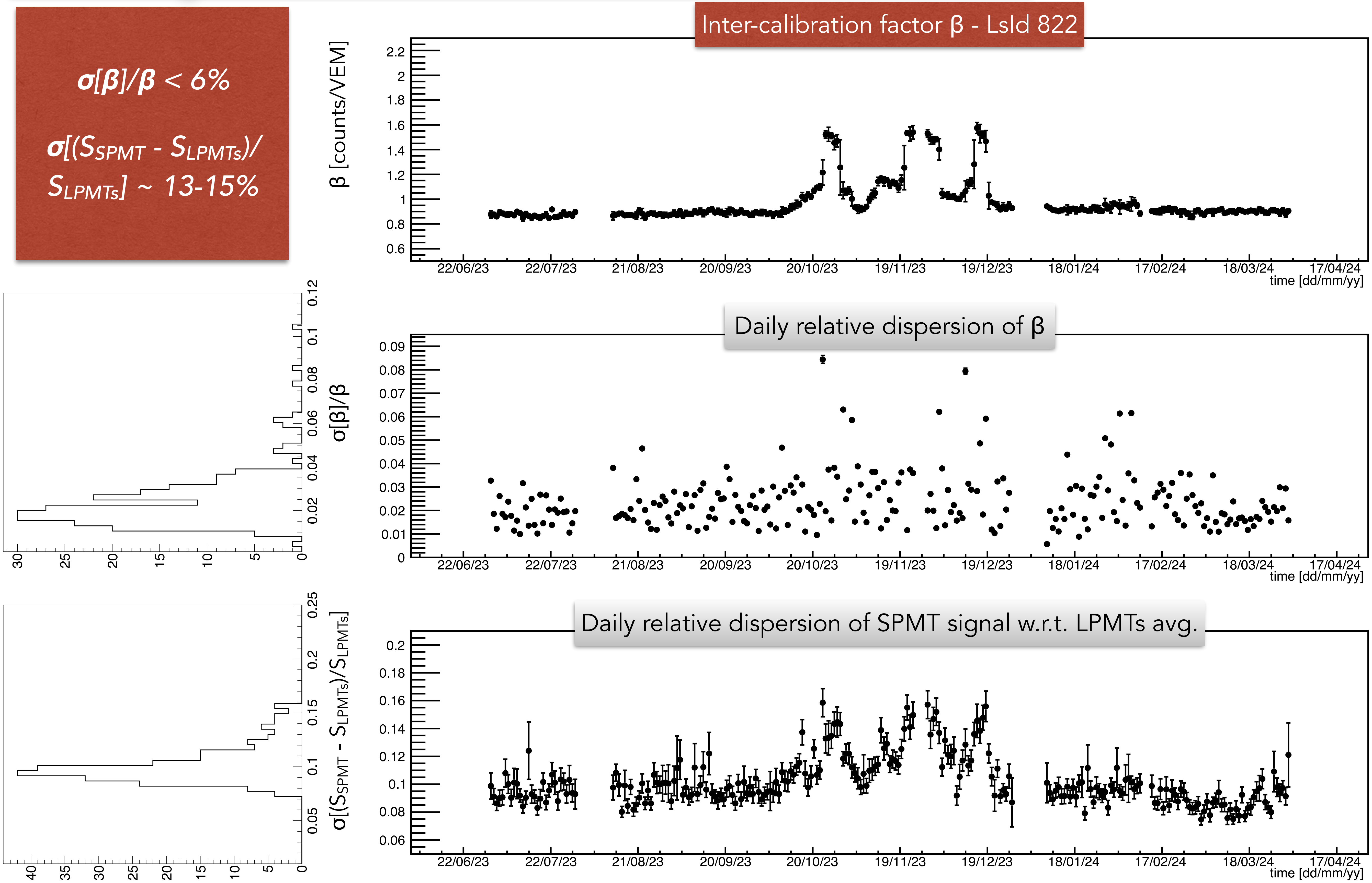




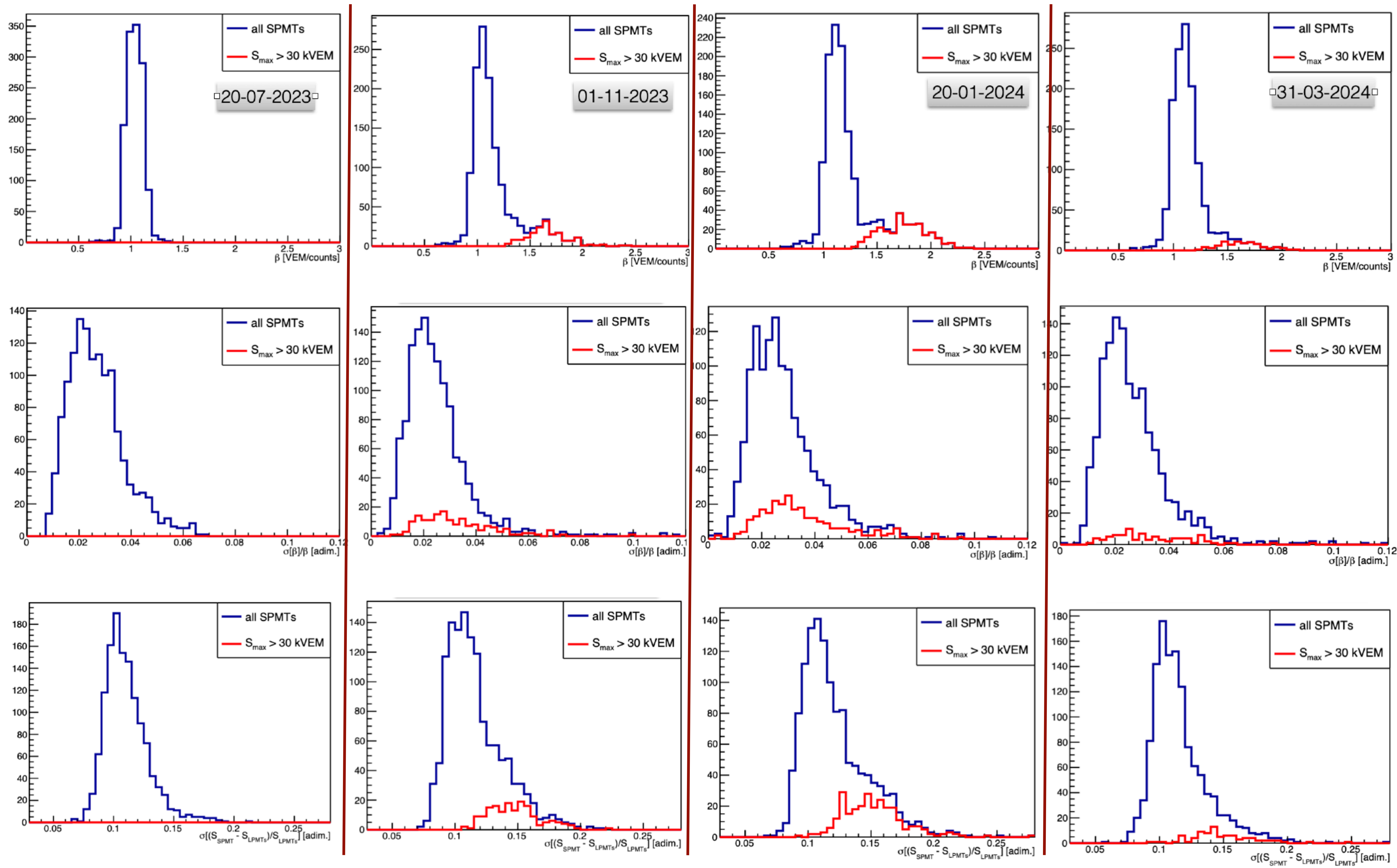
Stability of cross-calibration

σ[β]/β < 6%

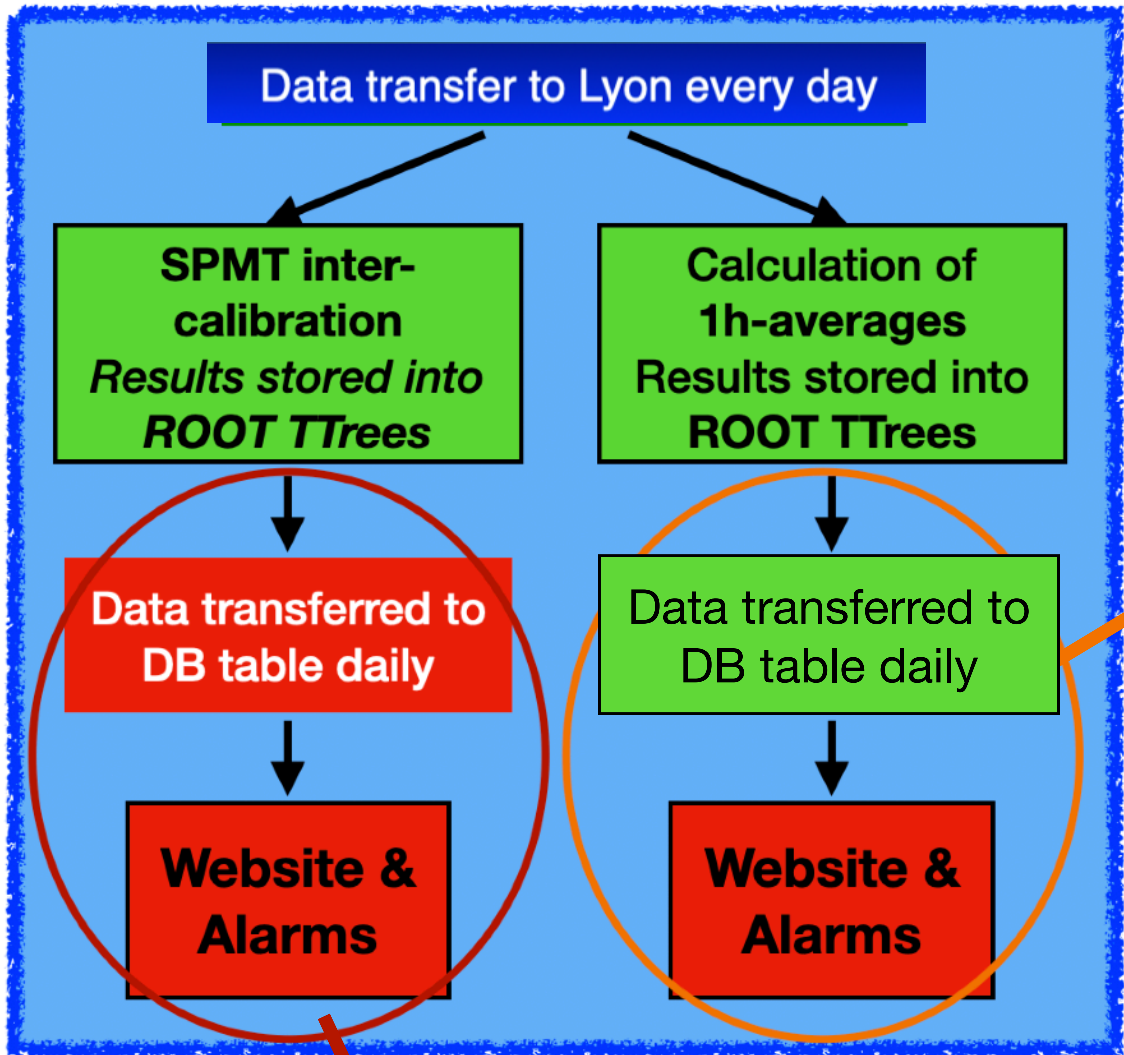
σ[(S_{SPMT} - S_{LPMTs})/S_{LPMTs}] ~ 13-15%



Evolution with time



sPMT - monitoring



Monitoring of small showers acquisition partially implemented

- ➡ codes under augermonitoring
  - calculation of 1h-averages
  - filling of the MonitSmallShowers table (see also next slide)
- ➡ alarms under development

Monitoring of **SPMT inter-calibration & dynamic range extension** performed manually (codes not in public repositories).

"*Hardware*" (i.e. SlowControl) monitoring in common with the other components.

- ➡ alarms missing for all AugerPrime detectors
- ➡ should add check of SPMT *V_{mon}/I_{mon} ratio*

Conclusion

Failures

- ➡ All failures during production and tests in labs identified. Bad units replaced by providers
- ➡ No SPMTs discarded after delivery to Malargüe

Maintenance

- ➡ 16 out of 1477 SPMTs inspected due to suspect malfunctioning in the field. None due to the tube, solved by replacing the PMT base.
- ➡ failures in cross-calibration: <5% due to LPMTs

Spares

- ➡ Sufficient number of spares for all parts of the SPMT units

Software

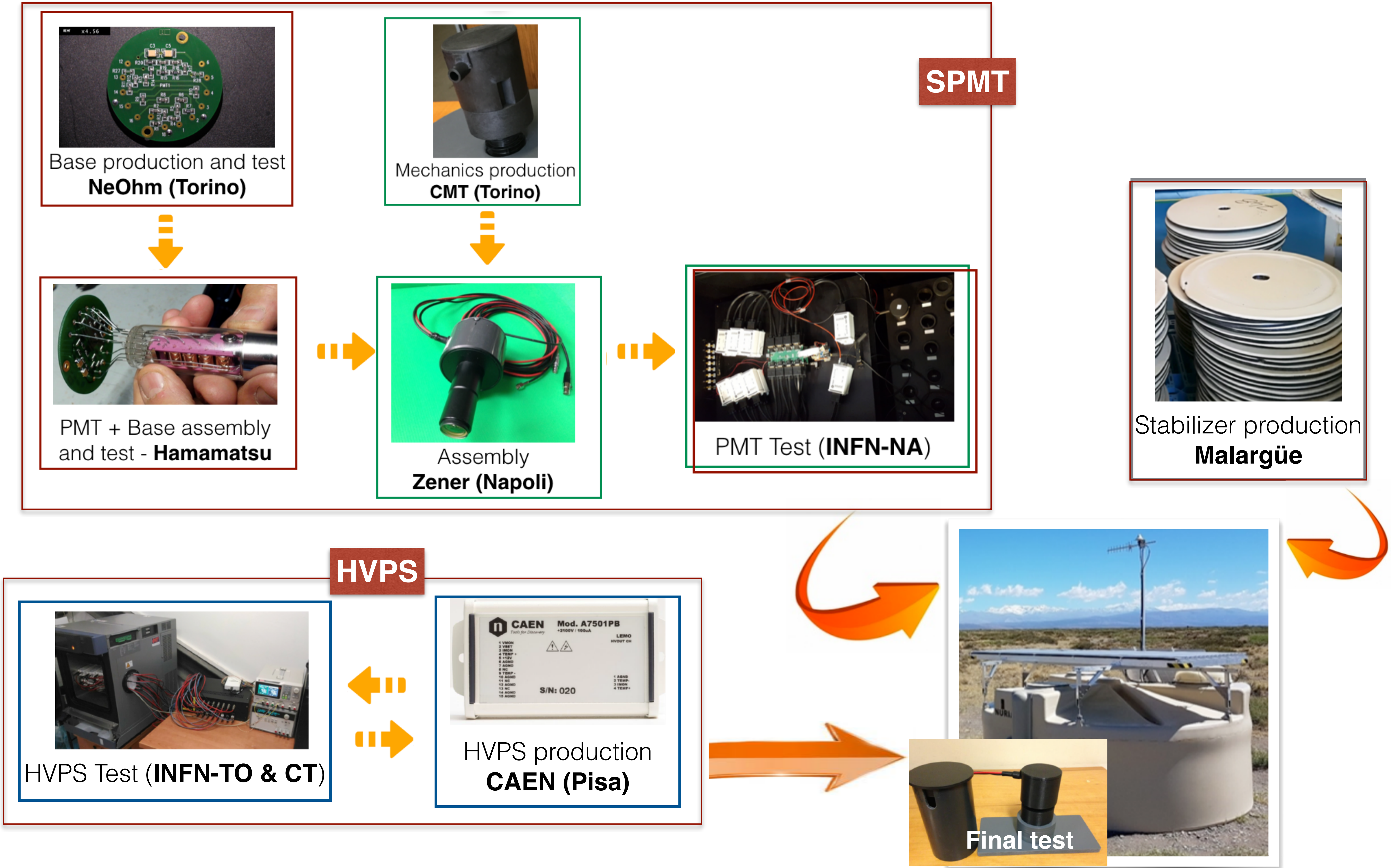
- ➡ Cross-calibration software chain in place
- ➡ <8% failures in custom VEM evaluation
- ➡ Monitoring to be completed

Documentation and training

- ➡ Docs and procedures available in EDMS
- ➡ Local staff trained and expert

Backup

sPMT production organization



Ground connections for the HV CAEN A7501PB module

Fig. 5 A7501PB Front panel, LEMO HV and 4-pin Mini XLR connectors for Auger IMON

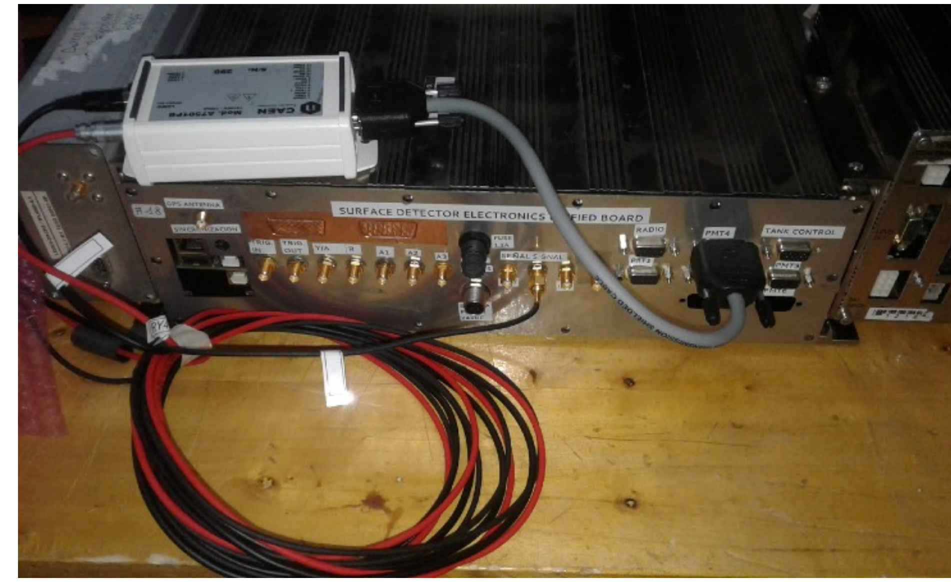
Fig. 6 A7501PB Back panel with DB15 connector

Mini XLR

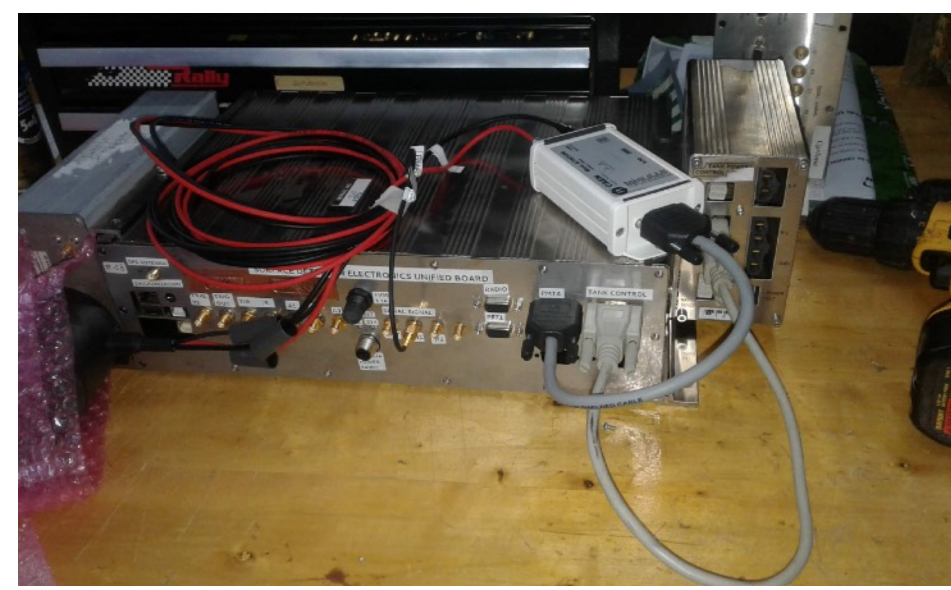
- Pin1: GND
- Pin2: n.c
- Pin3: Imon
- Pin4: n.c
- Not the entire metal enclosure of the HV module is electrically connected to GND. Only the panel housing the Mini XRL and Lemo HV connectors is wired at GND, anyway the white paint must be removed to have a good contact.

DB15

- Pin1: Vmon
- Pin2: Vset
- Pin3: Imon
- Pin4: n.c
- Pin5: +12V
- Pin6: GND
- Pin7: GND
- Pin8: n.c.
- Pin9: n.c
- Pin10: GND
- Pin11: n.c.
- Pin12: GND
- Pin13: n.c
- Pin14: n.c.
- P1n15: n.c.



HVPS attached with the same screw used for radio (SU), possible even when radio is present



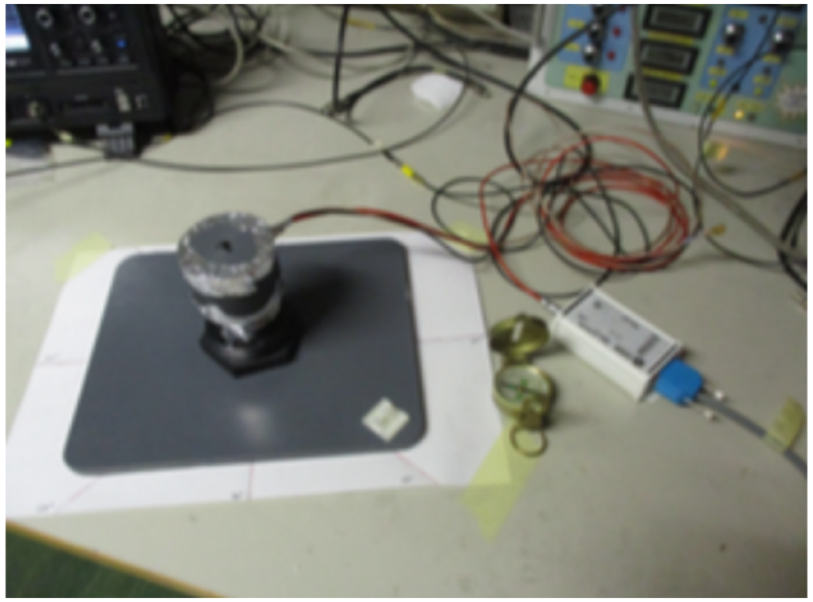
Another solution: attach it in the TPCB side, moving back the TPCB box and thus releasing a screw as the module cannot be fixed due to the height of the TPCB box which interferes with the cables outlet of the HV module

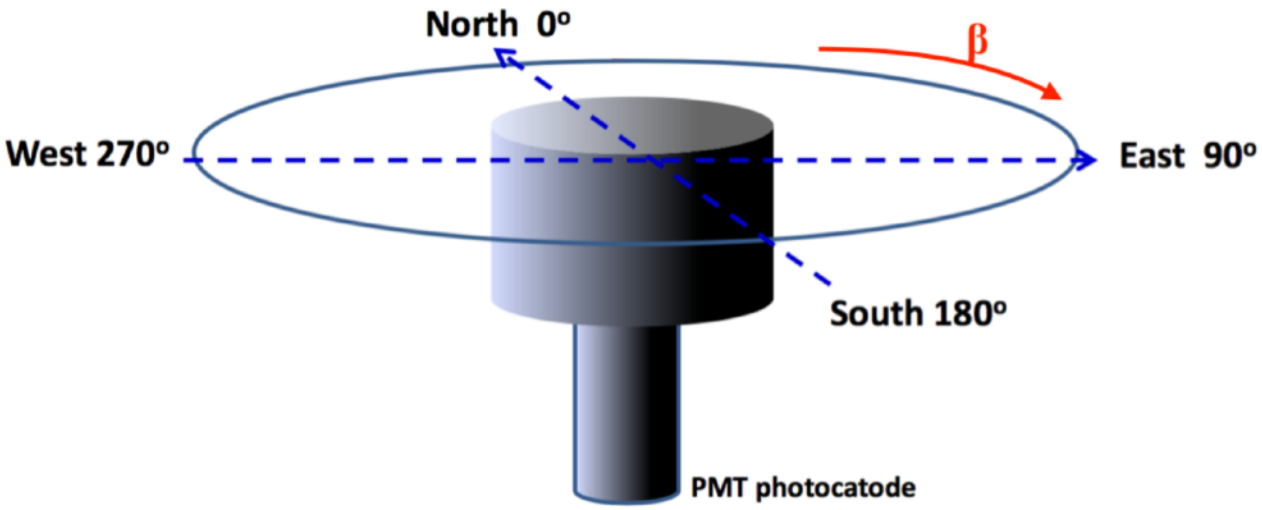
More tests: sPMTdependence on magnetic field

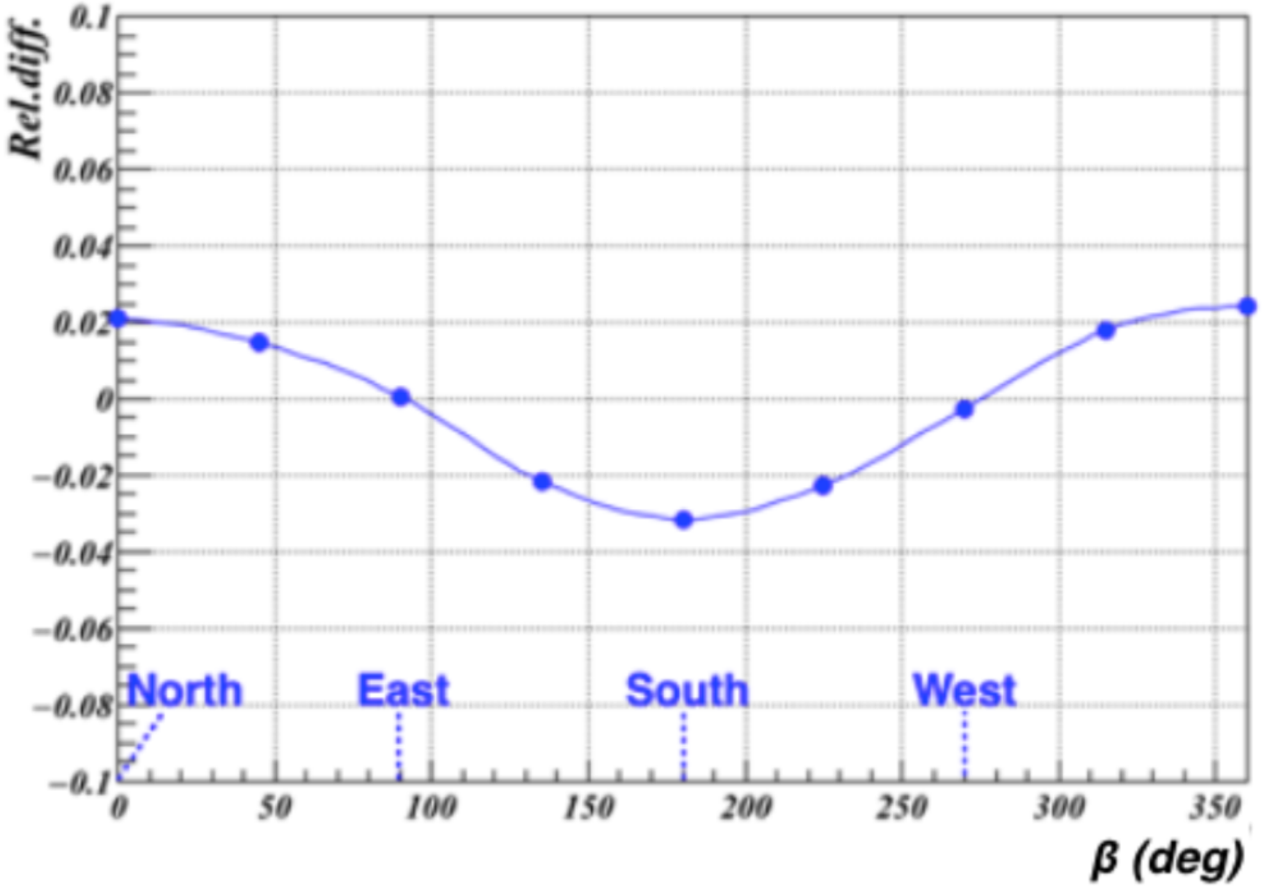
[GAP2016-007]

the Earth magnetic field can affect the performances of PMTs depending on their orientation :

- deflections in phe trajectories drifting from photocathode to first dynode
- deflection of secondary e⁻ in the dynode chain

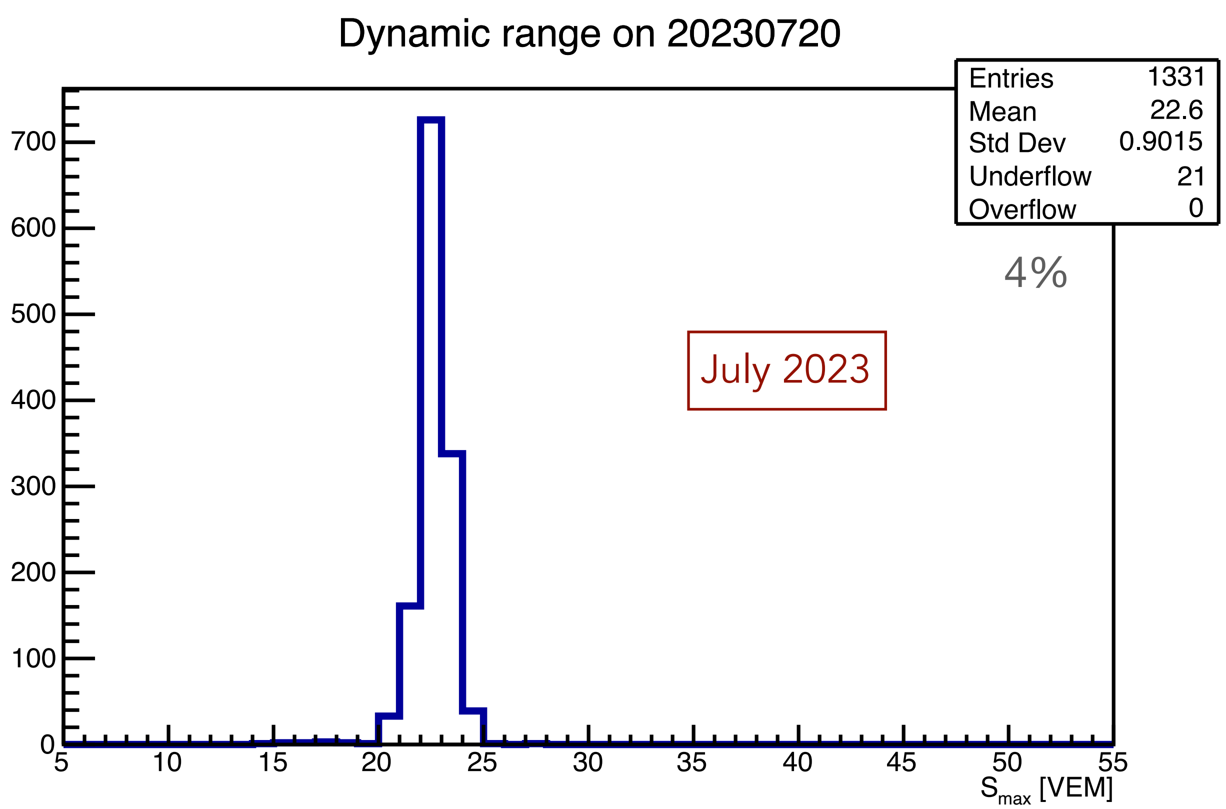


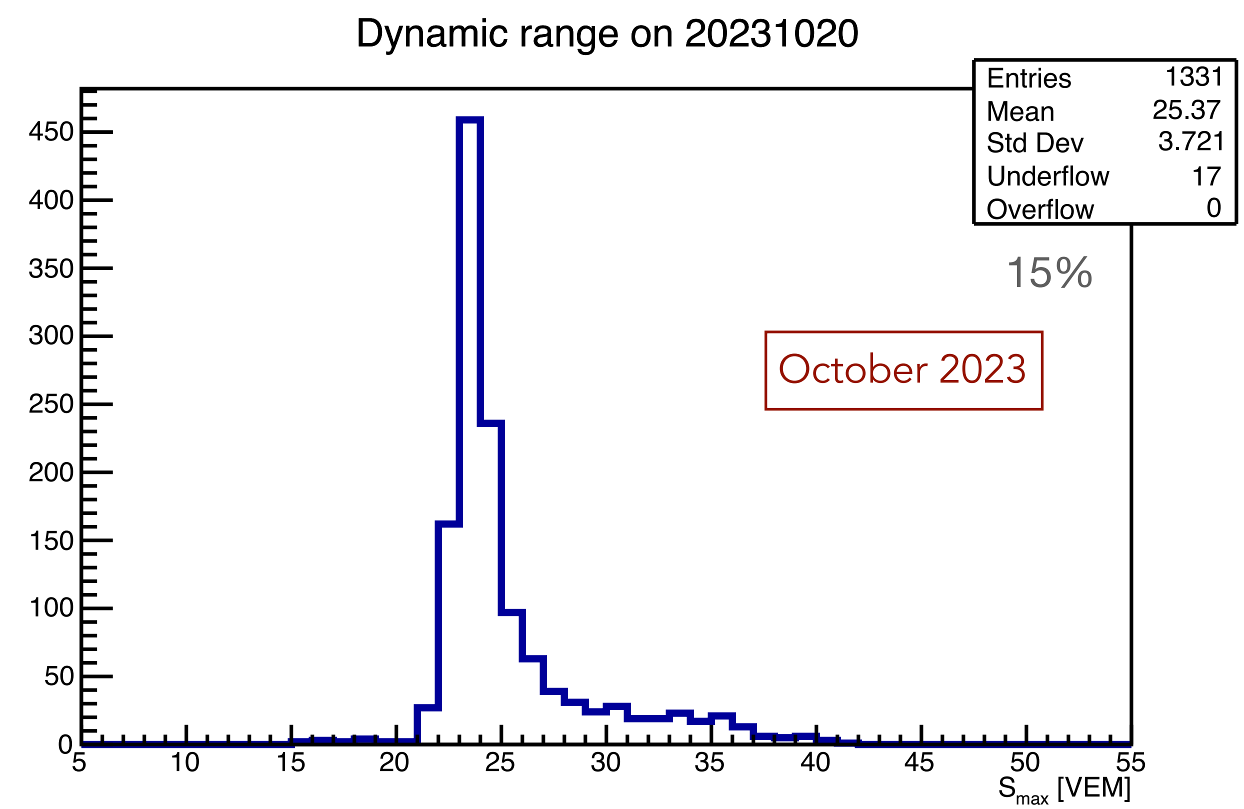


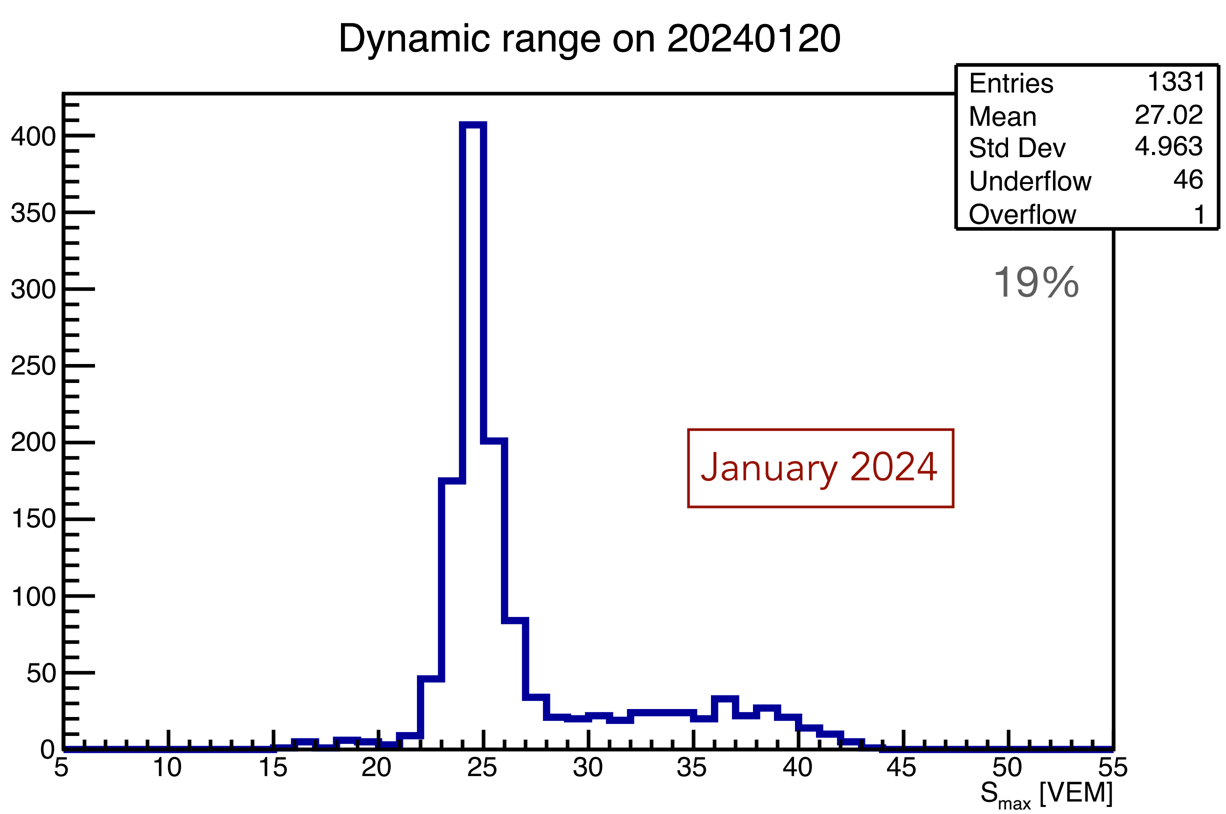


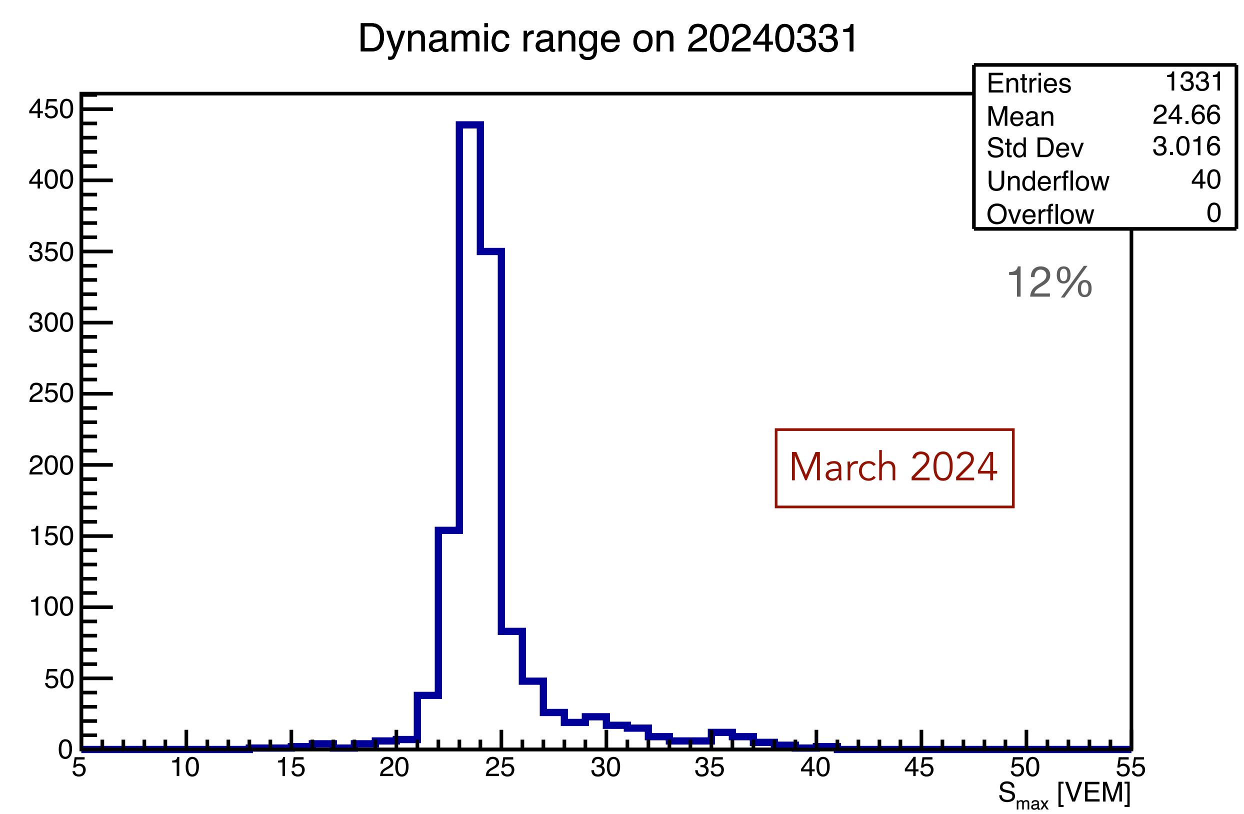
max deviation ~2-3%
no need for a magnetic field shielding

sPMT - Dynamic range





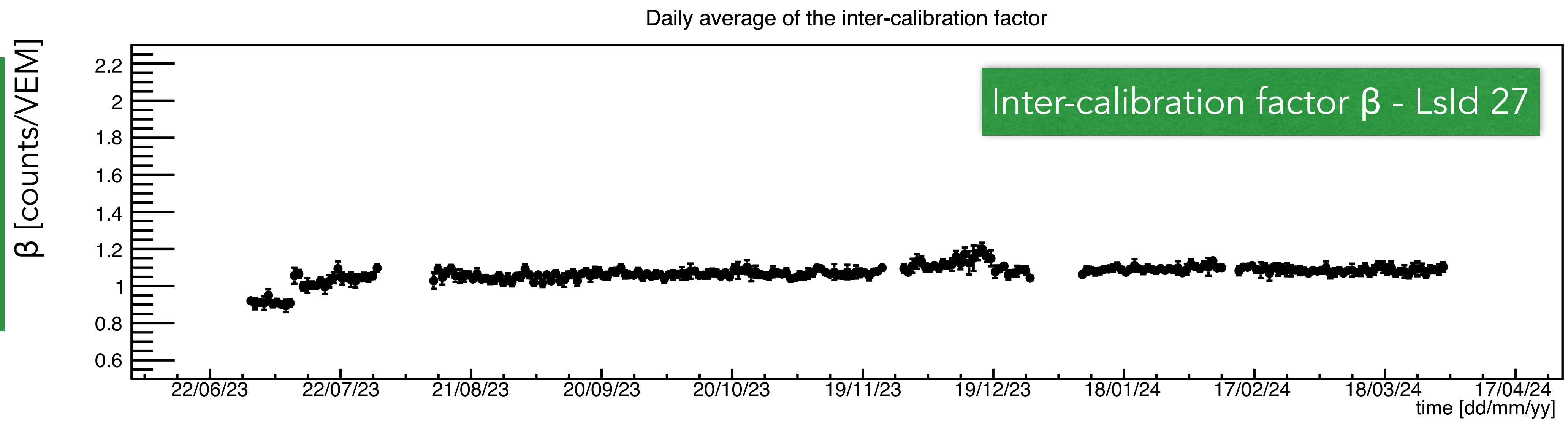


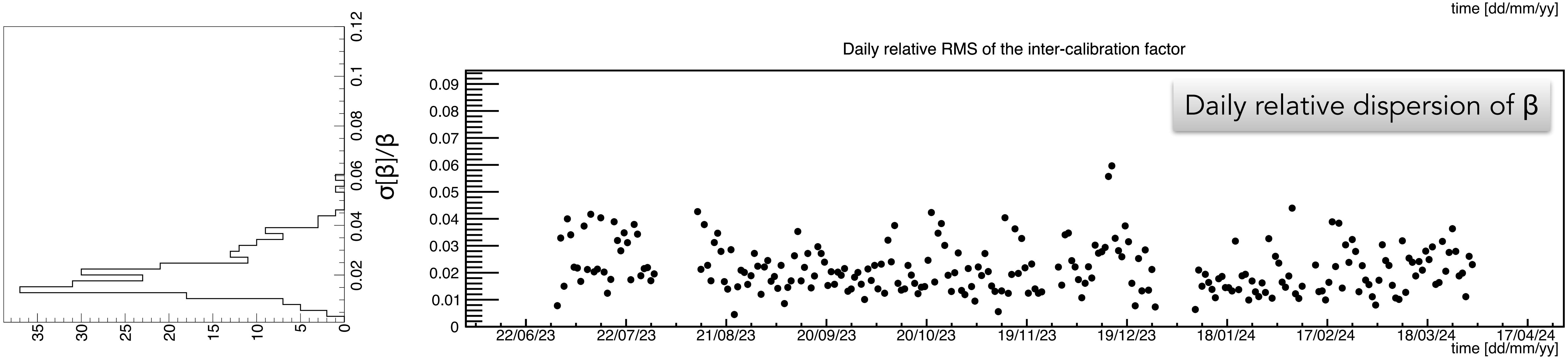


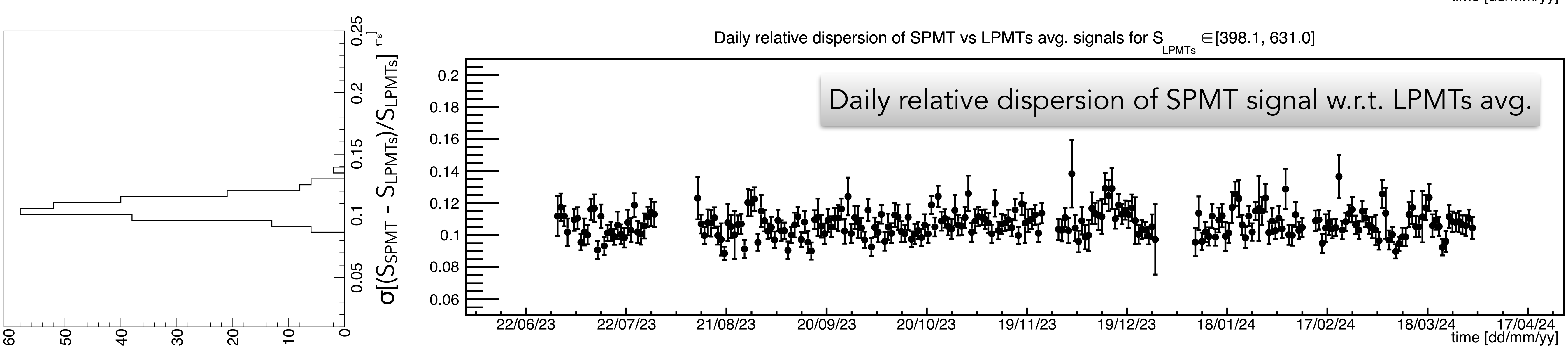
Stability of cross-calibration

σ[β]/β < 4%

σ[(S_SPMT - S_LPMTs)/S_LPMTs] ~ 10-12%



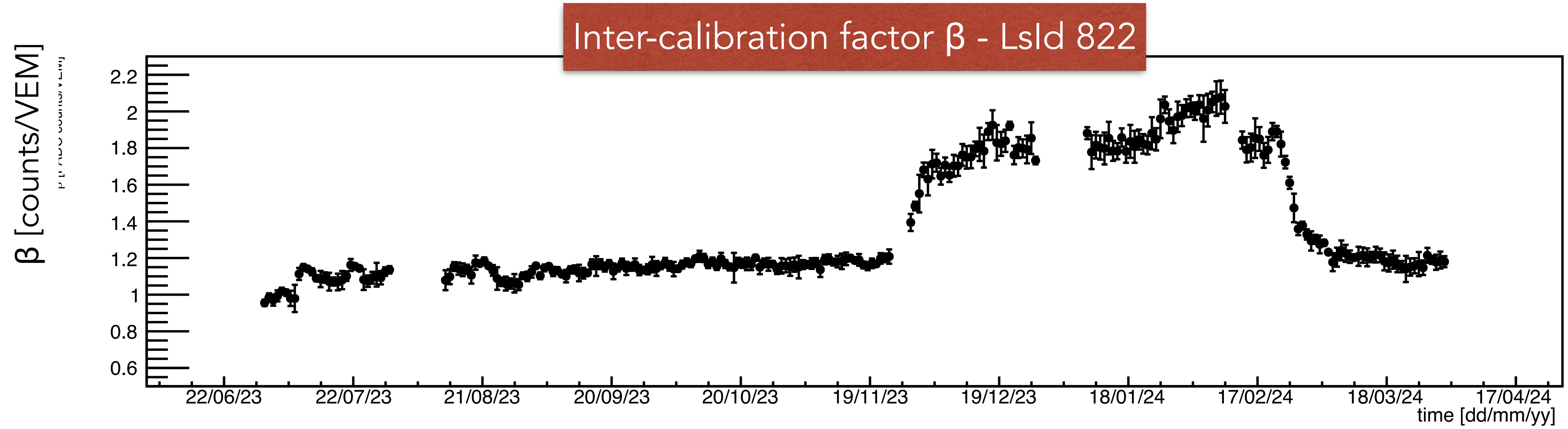


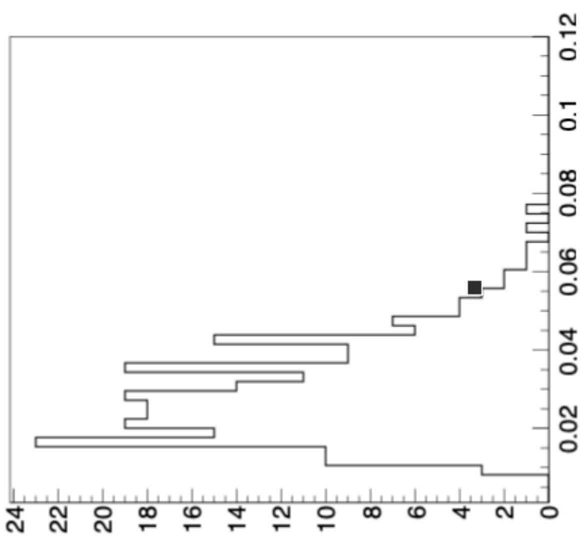


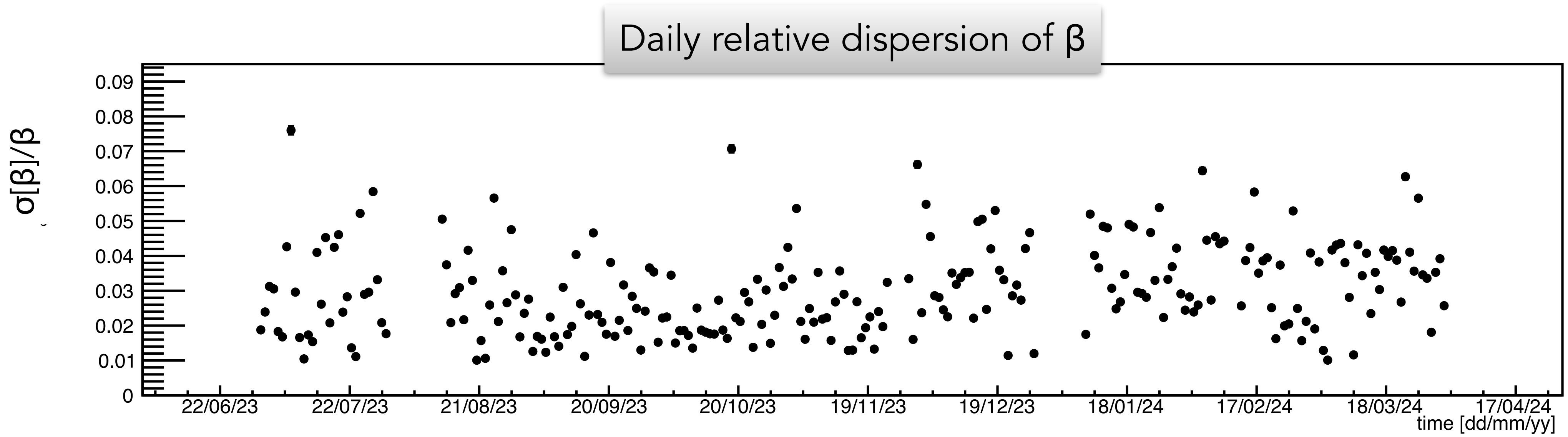
Stability of cross-calibration

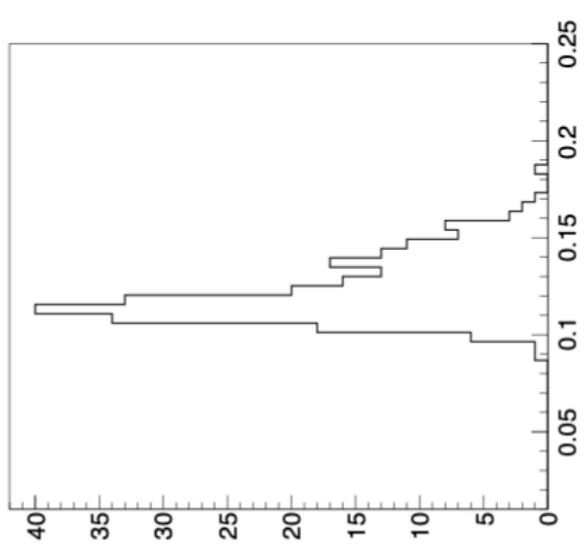
σ[β]/β < 6%

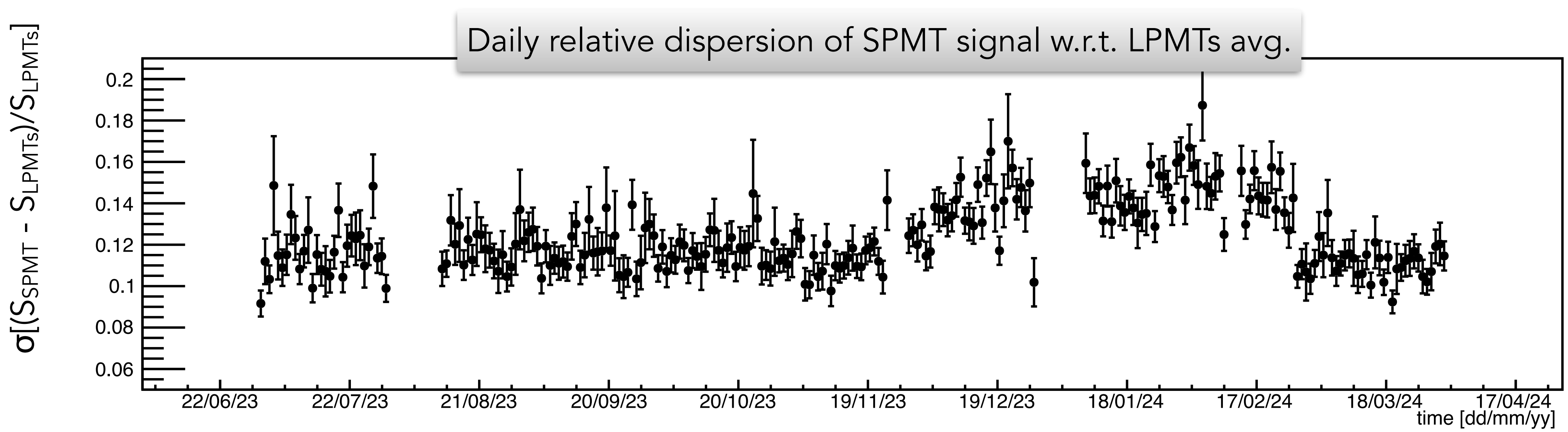
σ[(S_{SPMT} - S_{LPMTs})/ S_{LPMTs}] ~ 13-15%





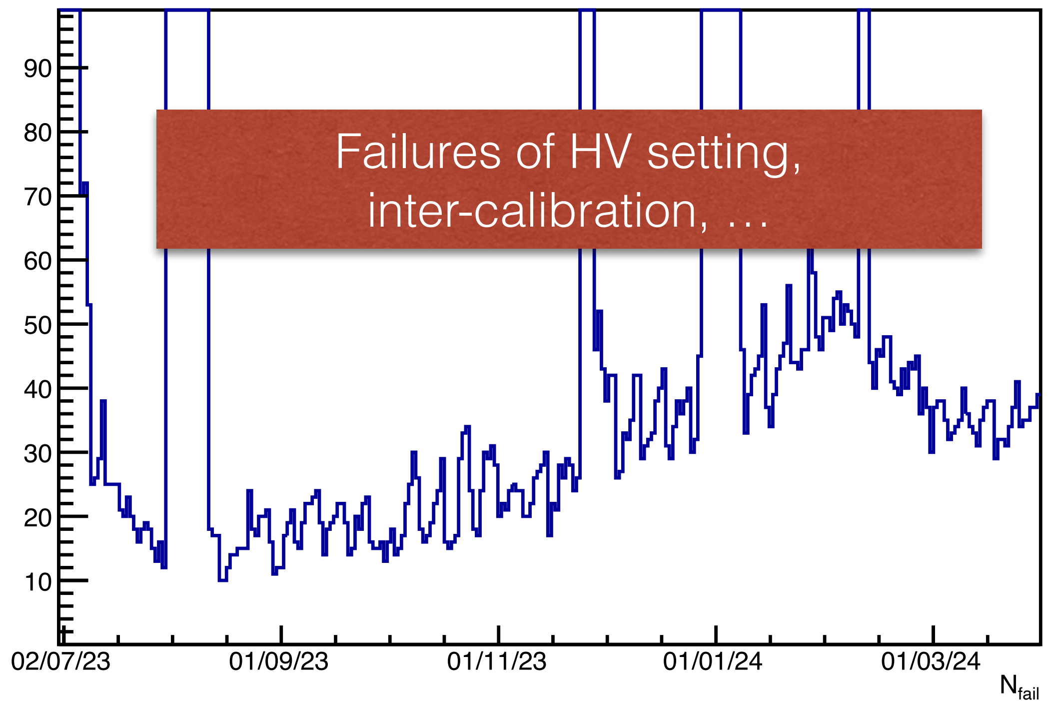




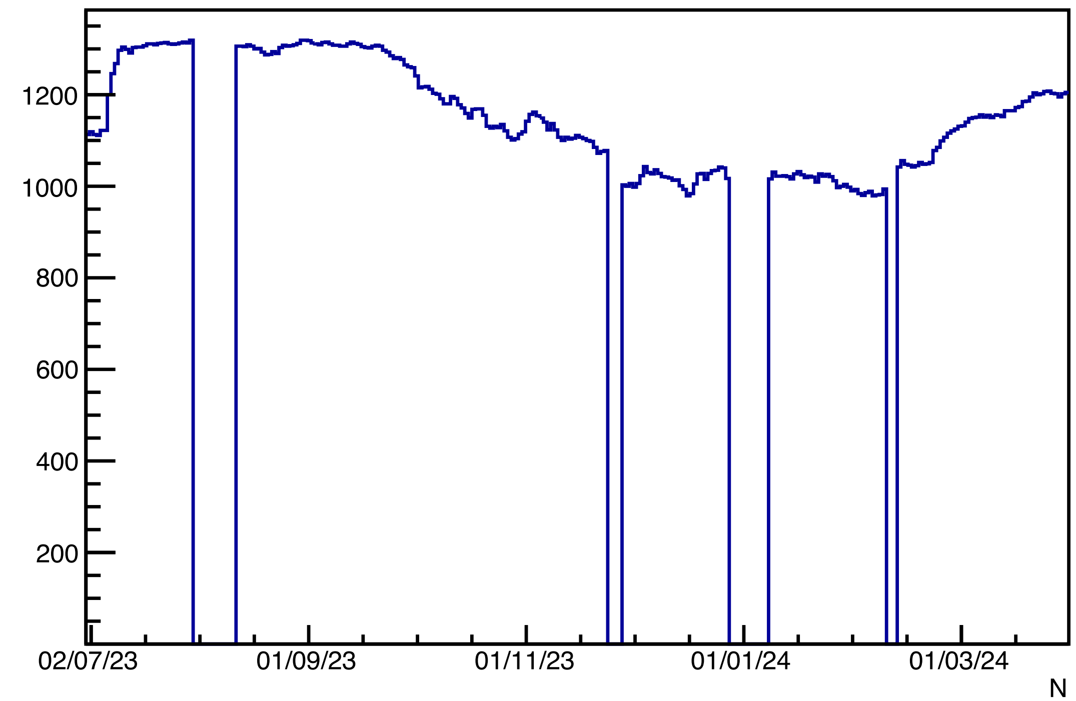


Instabilities over time

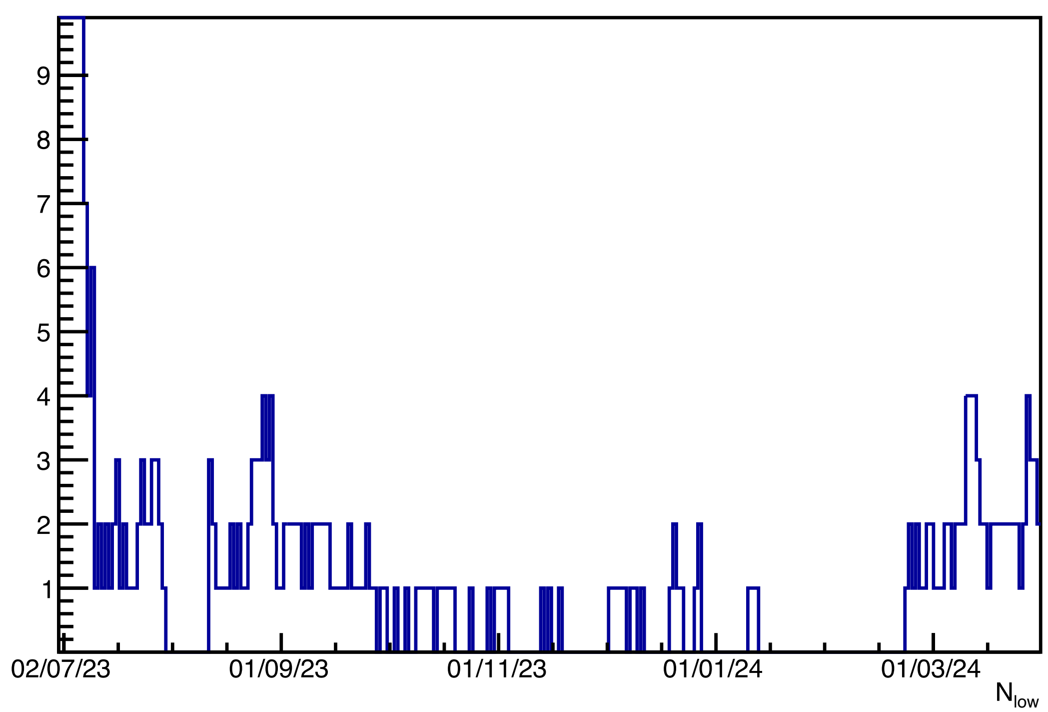
Number of tanks where $\beta \approx 0$ (failures)



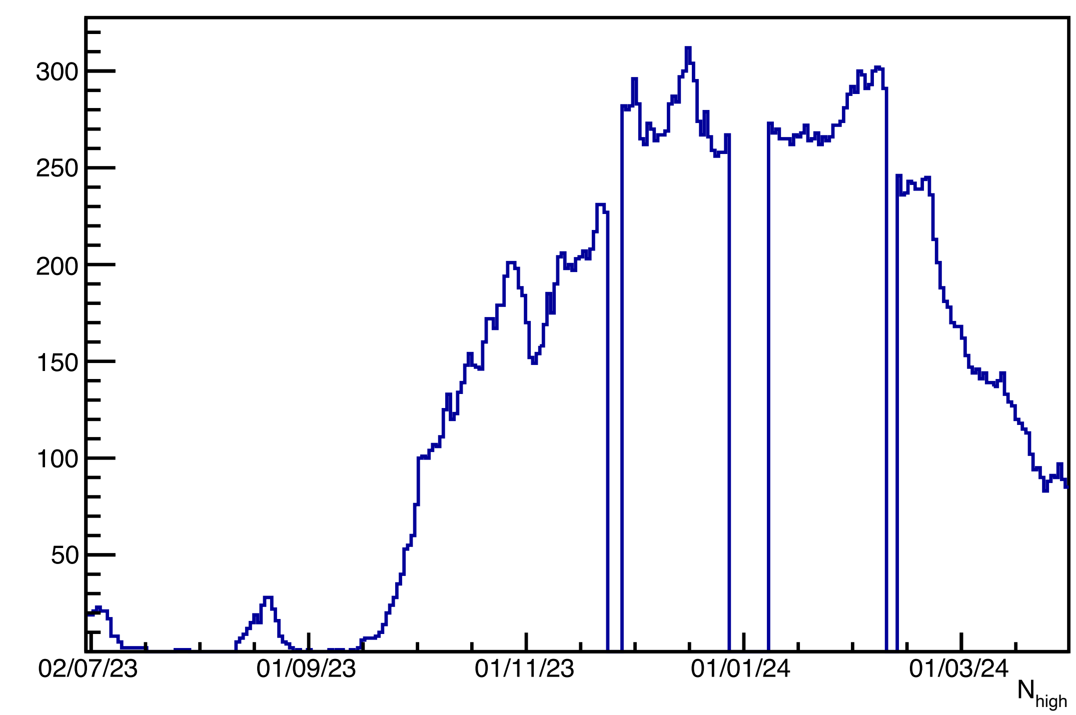
Number of tanks with $S_{max} \in [15, 30]$ kVEM



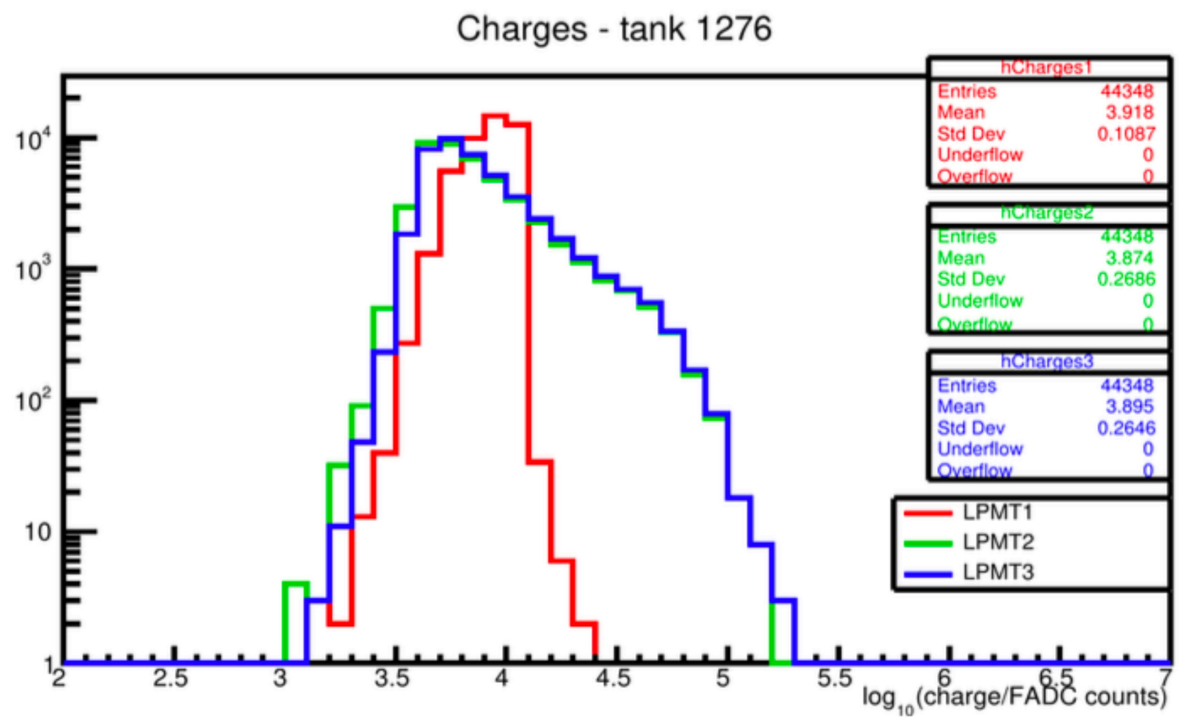
Number of tanks with $S_{max} < 15$ kVEM

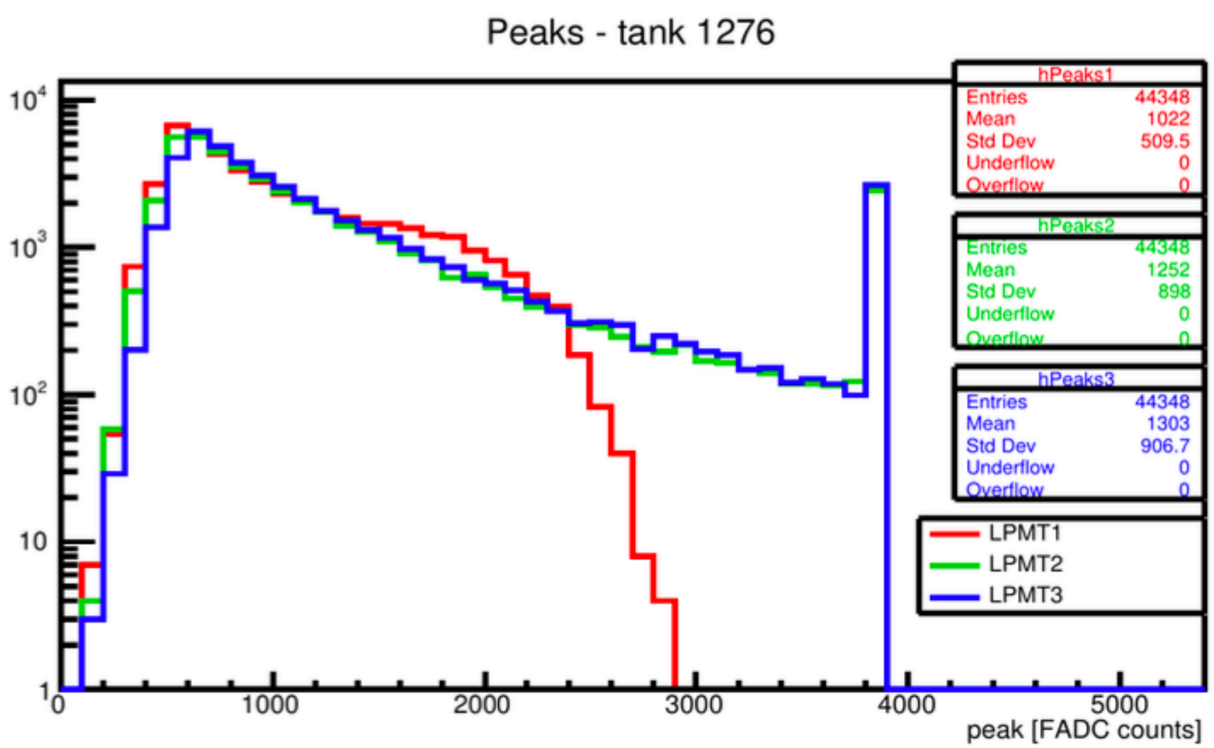


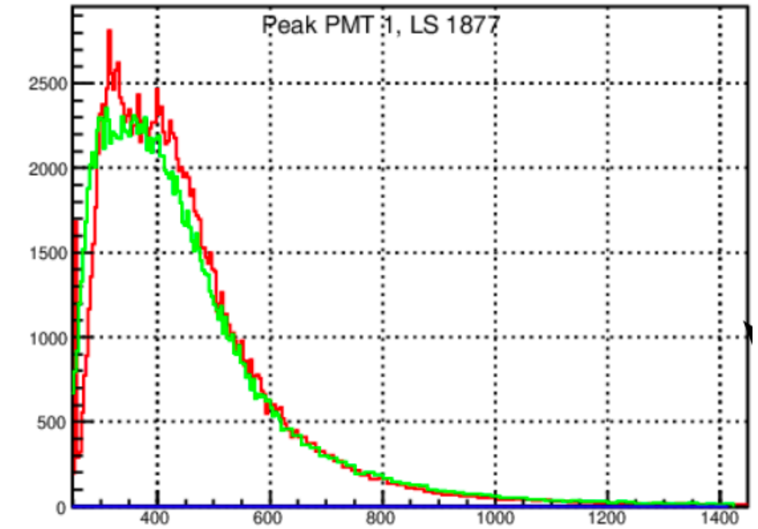
Number of tanks with $S_{max} > 30$ kVEM

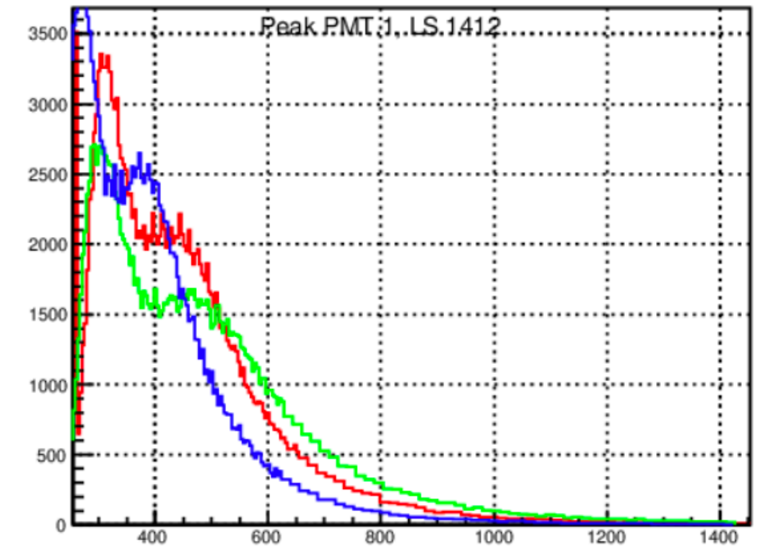


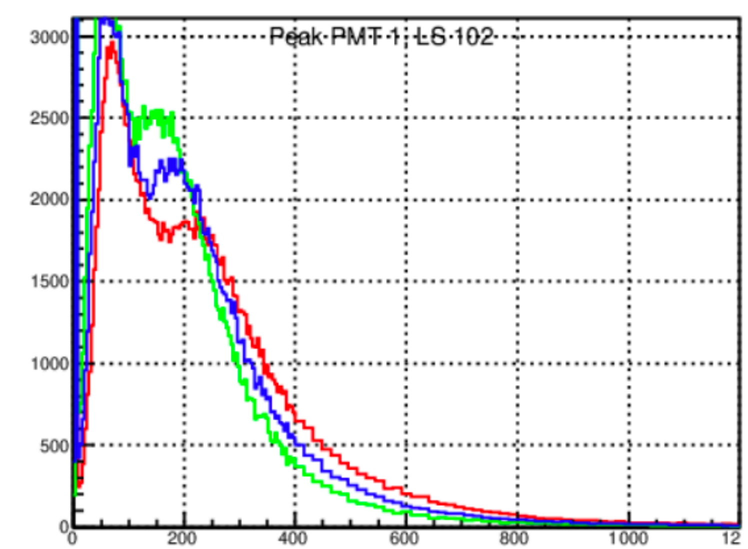
sPMT - problems











sPMT - problems from the field

ChicaBlu - no I_{mon}

Bad contact between the connector from PMT(I_{mon}) and the one of the HVPS. Reconnection solved the problem

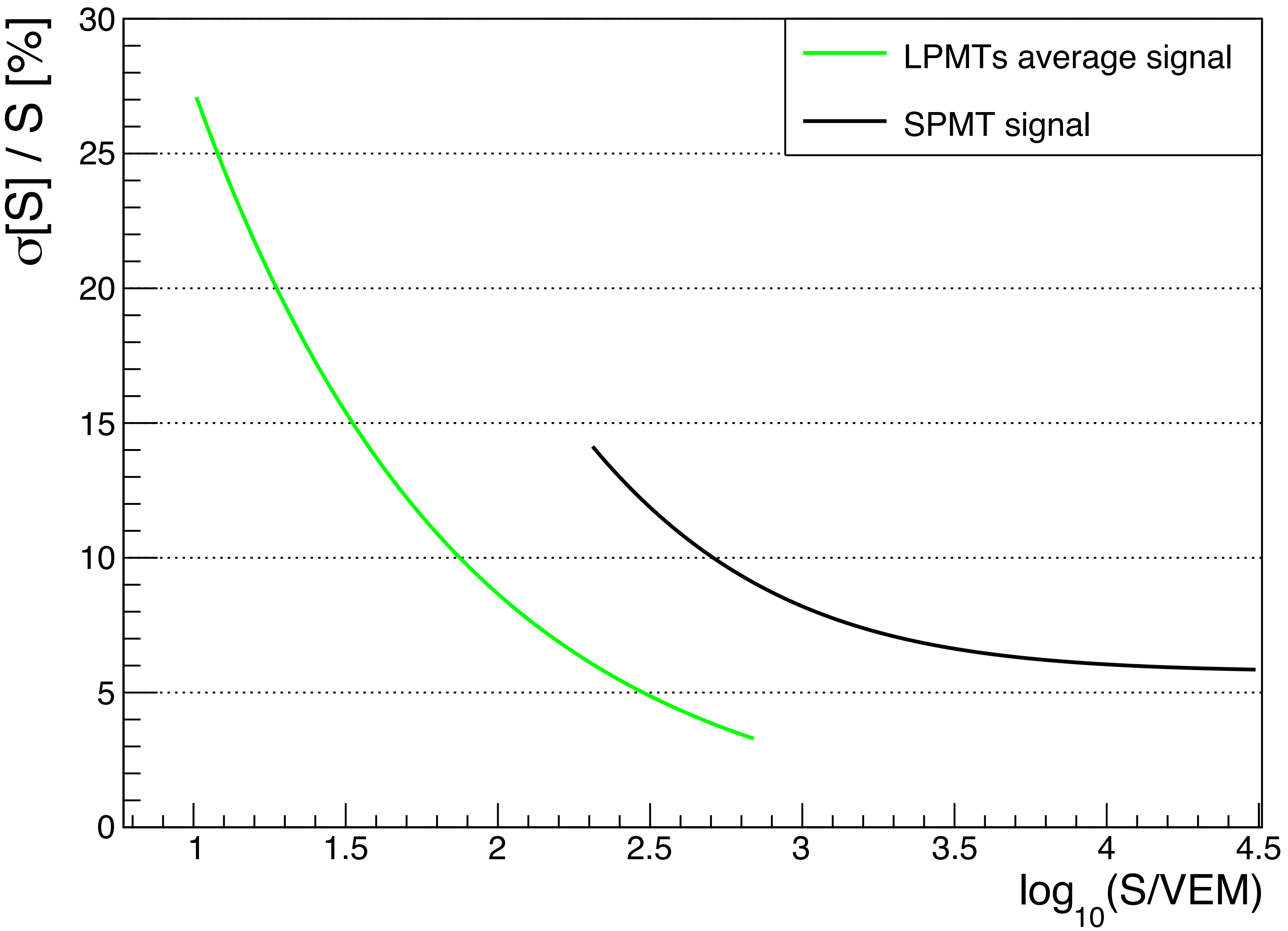
Base n.0589

Base n.1851

Chiron - unstable I_{mon}

- PMT changed
- Removed PMT retested in SDEco -OK
- Divider changed even if found clean
- Insulating acrylic paint applied and sPMT container resealed

sPMT - signal accuracy



SPMT signal (relative) accuracy:

- ~10% @ LPMTs saturation
- ~6% @ highest signals

★ Extrapolated maximum bias at highest signals: (2.8 ± 2.0)%

Relative SPMT signal accuracy

$$\frac{\sigma_{S_{SPMT}}}{S_{SPMT}} = \sqrt{a^2 + \frac{b^2}{S_{SPMT}}}$$

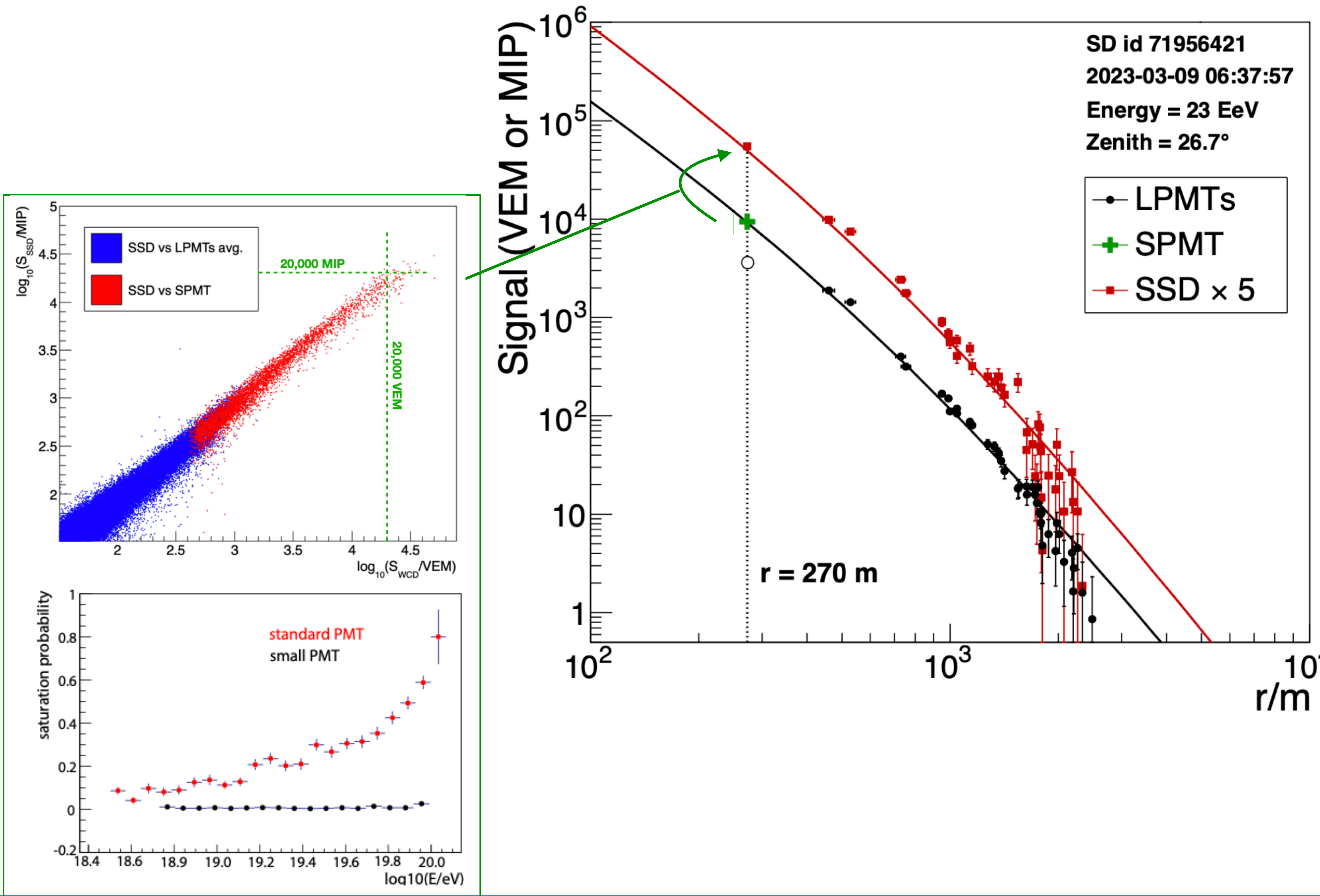
- evaluated using 1 month of small showers data from 300 SPMTs:

$$a = (5.8 \pm 1.1)\,\%$$

$$b = (1.8 \pm 0.2)\ \text{VEM}^{1/2}$$

✓ consistent results obtained with simulations of UHE p/Fe-initiated showers in UUB twin stations

sPMT - perfomances



sPMT - codes

- ➡ Small showers acquisition
  - Local station DAQ: SDEU/UUB/daq
  - CDAS-DAQ: Apps/SPMT
  - example code to read small showers files: spmt_example

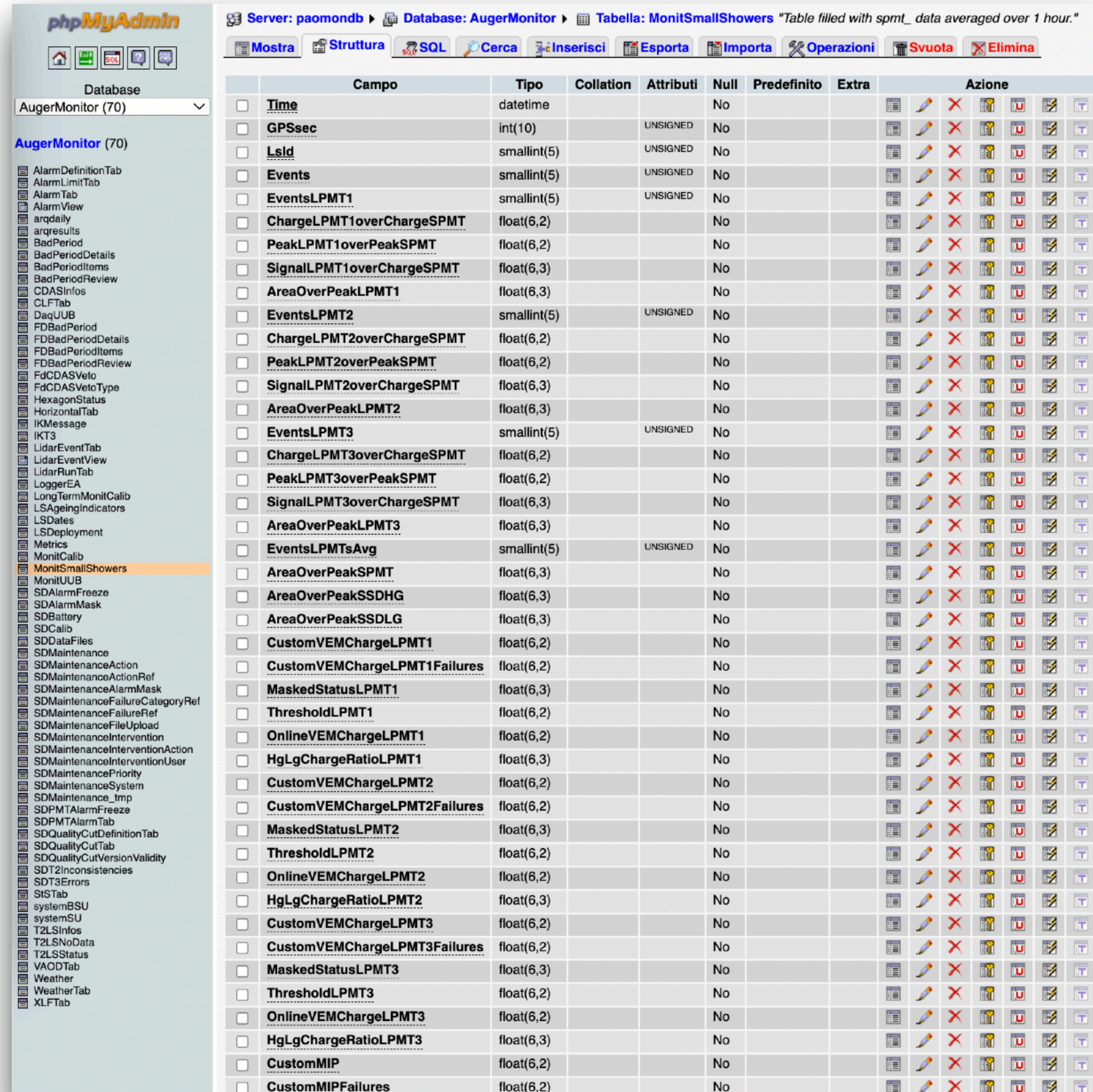
- ➡ SPMT HV setting

- ➡ Small showers acquisition monitoring (running in Lyon)
  - calculation of 1h-averages
  - filling of the MonitSmallShowers table

- ➡ SPMT inter-calibration (running in Lyon)

- ➡ SPMT inter-calibration inclusion in the SD files production (running in Lyon)
  - IoSdCalibSPMT class in IoSdData.h & IoSdData.cc
  - SdExtraData.cc & SdExtraData.h

sPMT - monitoring



Campo	Tipo	Collation	Attributi	Null	Predefinito	Extra	Azione
Time	datetime			No			
GPSsec	int(10)		UNSIGNED	No			
LsId	smallint(5)		UNSIGNED	No			
Events	smallint(5)		UNSIGNED	No			
EventsLPMT1	smallint(5)		UNSIGNED	No			
ChargeLPMT1overChargeSPMT	float(6,2)			No			
PeakLPMT1overPeakSPMT	float(6,2)			No			
SignalLPMT1overChargeSPMT	float(6,3)			No			
AreaOverPeakLPMT1	float(6,3)			No			
EventsLPMT2	smallint(5)		UNSIGNED	No			
ChargeLPMT2overChargeSPMT	float(6,2)			No			
PeakLPMT2overPeakSPMT	float(6,2)			No			
SignalLPMT2overChargeSPMT	float(6,3)			No			
AreaOverPeakLPMT2	float(6,3)			No			
EventsLPMT3	smallint(5)		UNSIGNED	No			
ChargeLPMT3overChargeSPMT	float(6,2)			No			
PeakLPMT3overPeakSPMT	float(6,2)			No			
SignalLPMT3overChargeSPMT	float(6,3)			No			
AreaOverPeakLPMT3	float(6,3)			No			
EventsLPMTsAvg	smallint(5)		UNSIGNED	No			
AreaOverPeakSPMT	float(6,3)			No			
AreaOverPeakSSDHG	float(6,3)			No			
AreaOverPeakSSDLG	float(6,3)			No			
CustomVEMChargeLPMT1	float(6,2)			No			
CustomVEMChargeLPMT1Failures	float(6,2)			No			
MaskedStatusLPMT1	float(6,3)			No			
ThresholdLPMT1	float(6,2)			No			
OnlineVEMChargeLPMT1	float(6,2)			No			
HgLgChargeRatioLPMT1	float(6,3)			No			
CustomVEMChargeLPMT2	float(6,2)			No			
CustomVEMChargeLPMT2Failures	float(6,2)			No			
MaskedStatusLPMT2	float(6,3)			No			
ThresholdLPMT2	float(6,2)			No			
OnlineVEMChargeLPMT2	float(6,2)			No			
HgLgChargeRatioLPMT2	float(6,3)			No			
CustomVEMChargeLPMT3	float(6,2)			No			
CustomVEMChargeLPMT3Failures	float(6,2)			No			
MaskedStatusLPMT3	float(6,3)			No			
ThresholdLPMT3	float(6,2)			No			
OnlineVEMChargeLPMT3	float(6,2)			No			
HgLgChargeRatioLPMT3	float(6,3)			No			
CustomMIP	float(6,2)			No			
CustomMIPFailures	float(6,2)			No			

43 variables - 24 entries per day per UUB tank

MonitSmallShowers table added to the AugerMonitor database

Daily and separately for each tank with a sPMT, check of :

- presence of acquired data (i.e. *number of entries in the table*);
- number of small showers (*Events*);
- And separately for each LPMT :
  - masked status (*MaskedStatusLPMT1-2-3*);
  - percentage of failed VEM calibrations using the custom algorithm (CustomVEMCharge LPMT1-2-3Failures);
  - number of events above 200 VEM (EventsLPMT1-2-3);
  - LPMT signal over SPMT charge ratio (SignalLPMT1-2-3over ChargeSPMT).