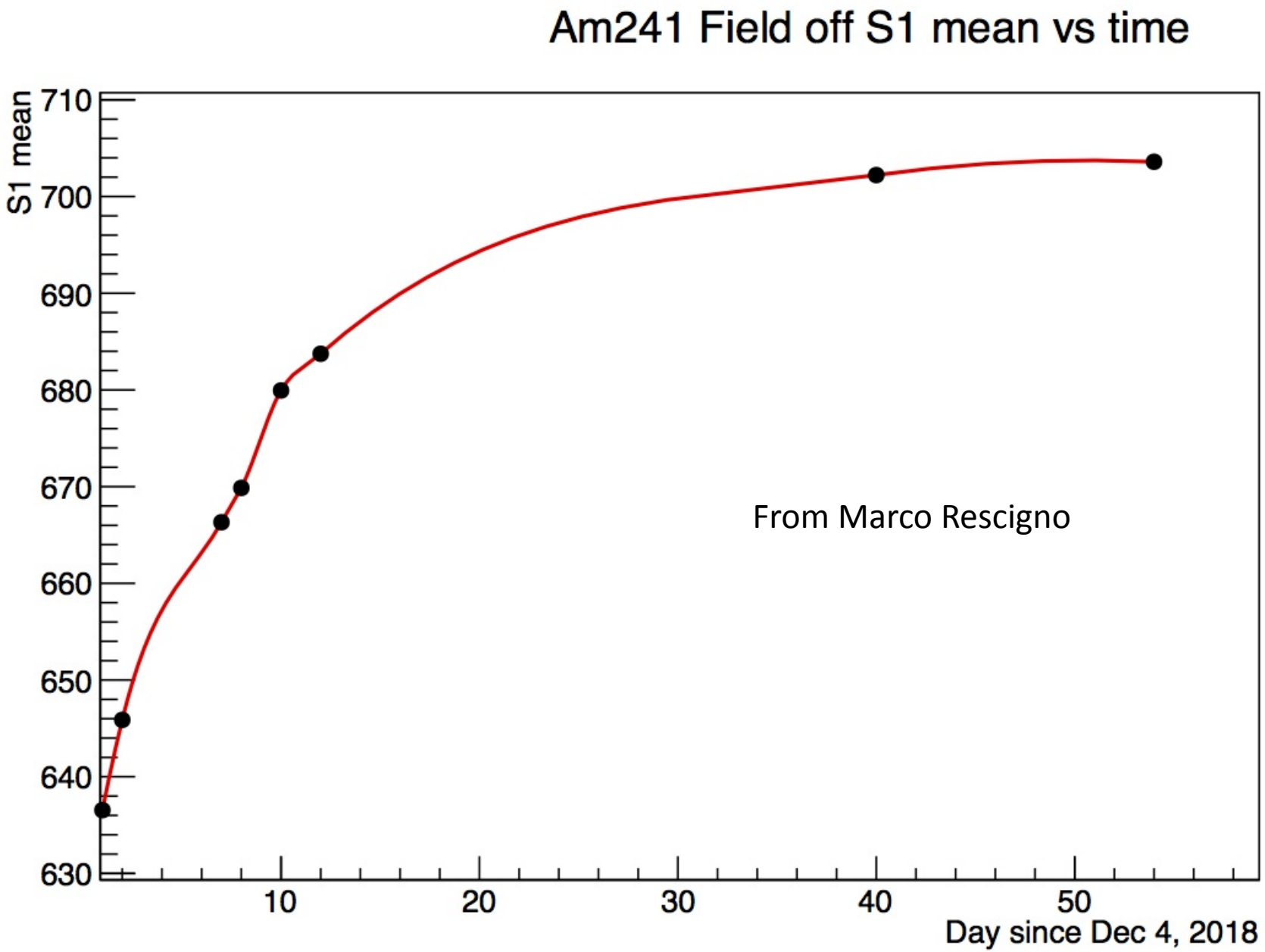
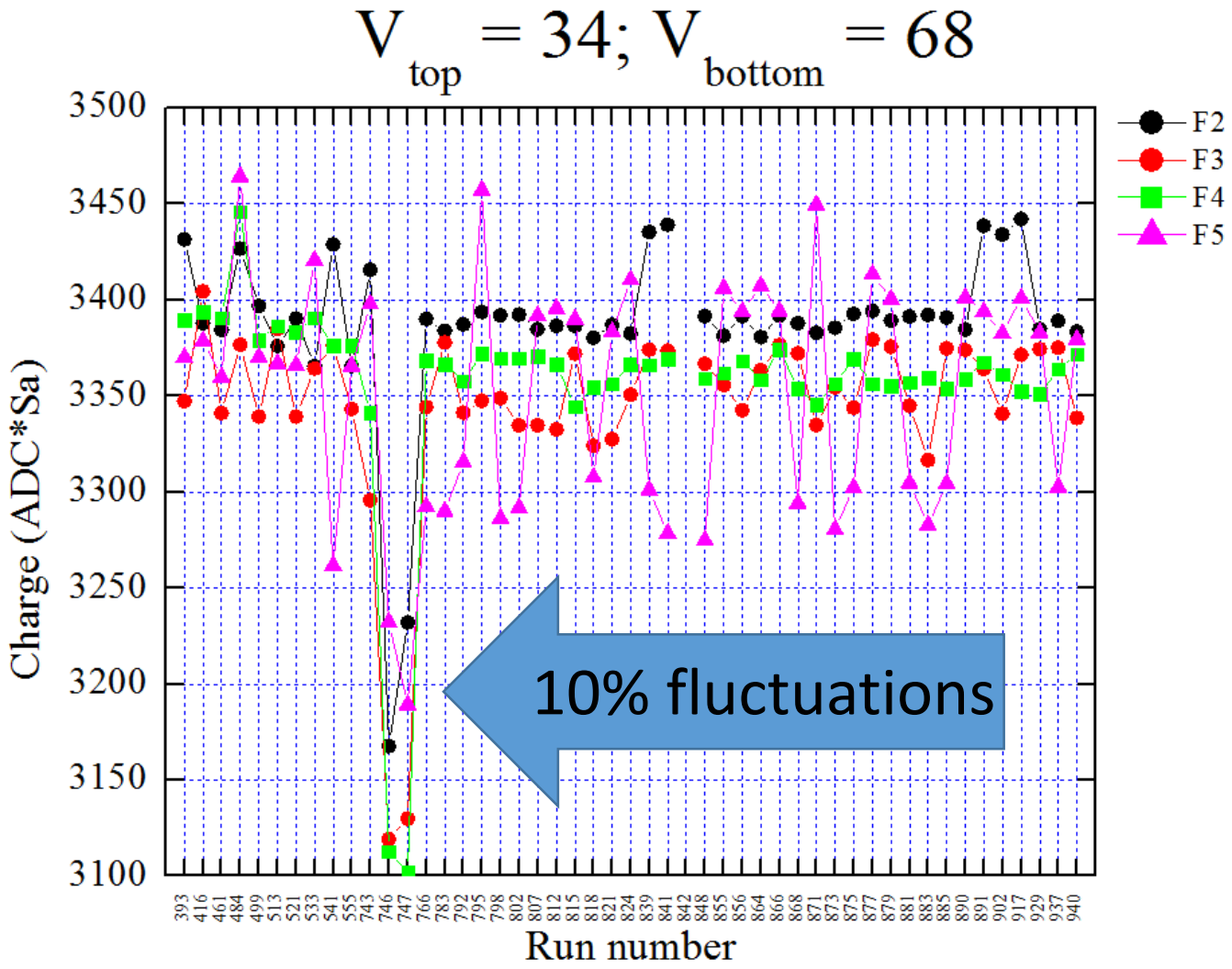
Why do S1 light yield increase with time?

ReD call 1 April 2019

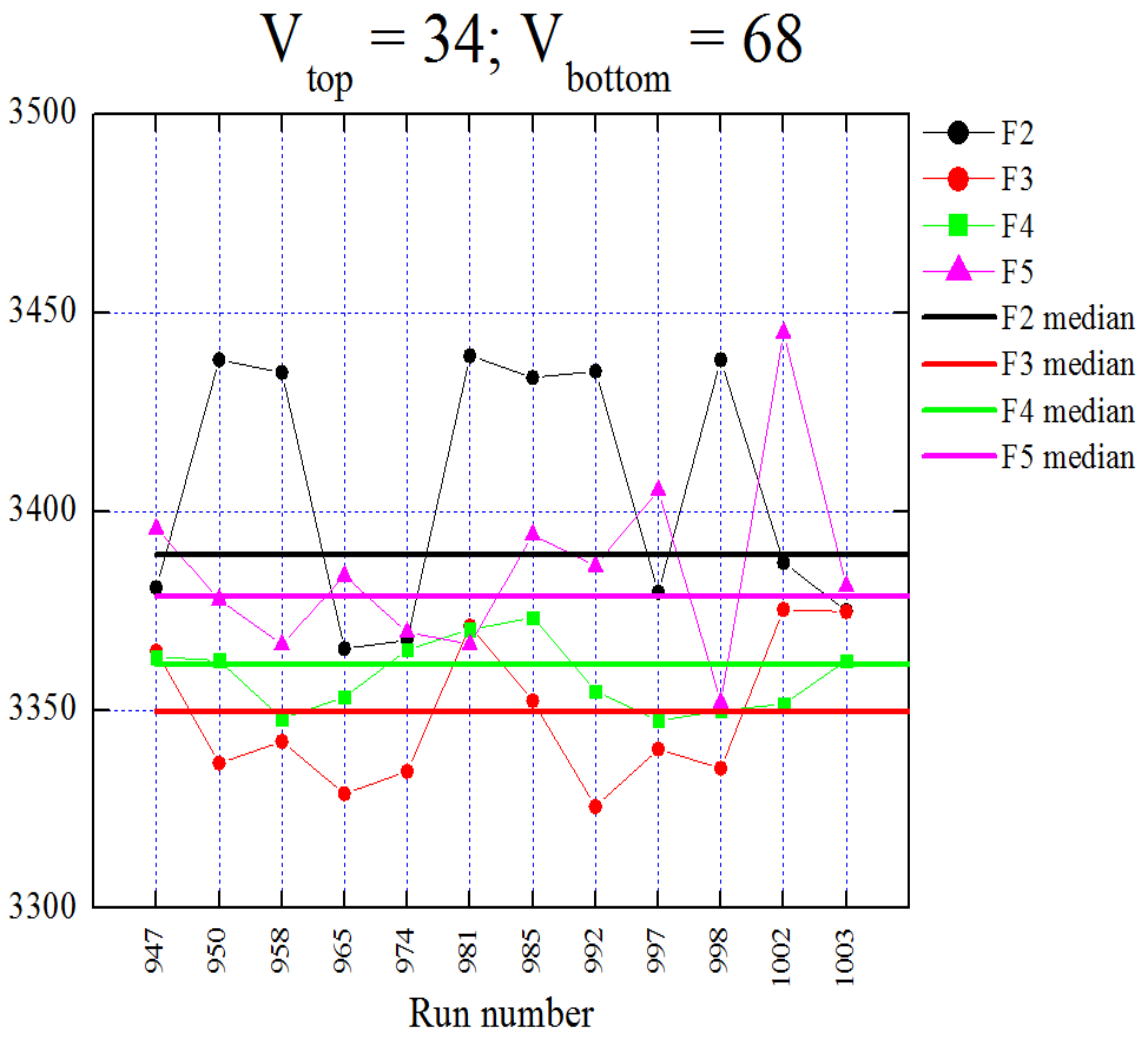
Oleynikov Vladislav


Am241 Field off S1 mean vs time
S1 mean
710
700
690
680
670
660
650
640
630
10
20
30
40
50
Day since Dec 4, 2018
From Marco Rescigno

SERs are ~ 1% stable, except 10% fluctuations

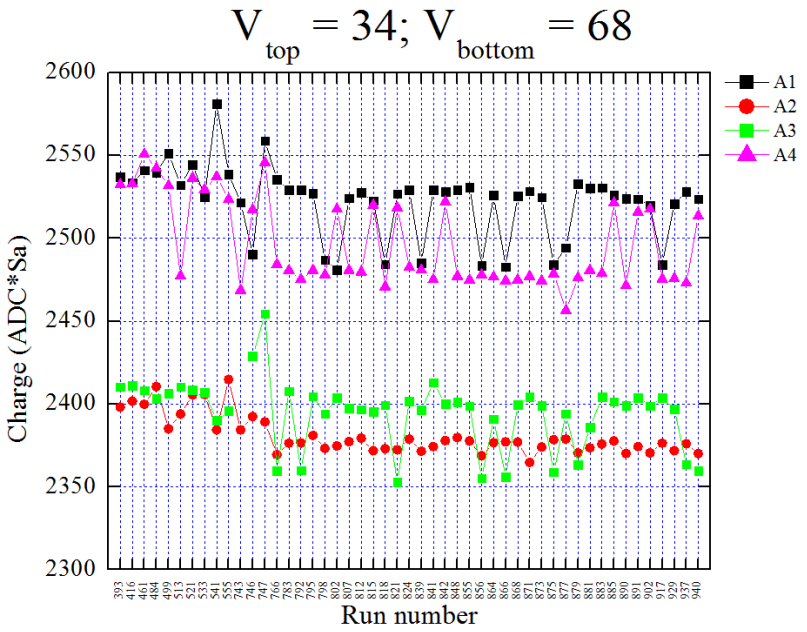


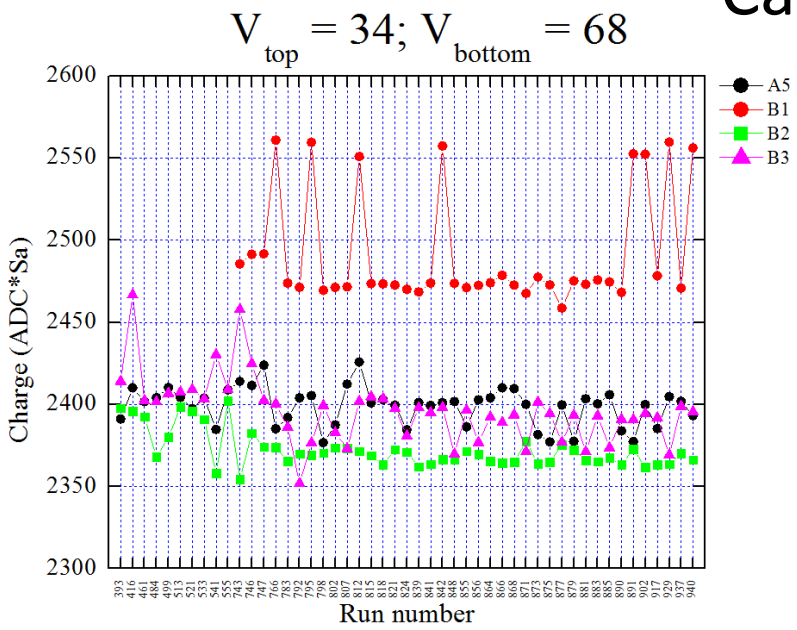
Camp-VII



Camp-VII-2, Camp-VII-3

Camp-VII


V_{top} = 34; V_{bottom} = 68
Charge (ADC*Sa)
Run number
A1
A2
A3
A4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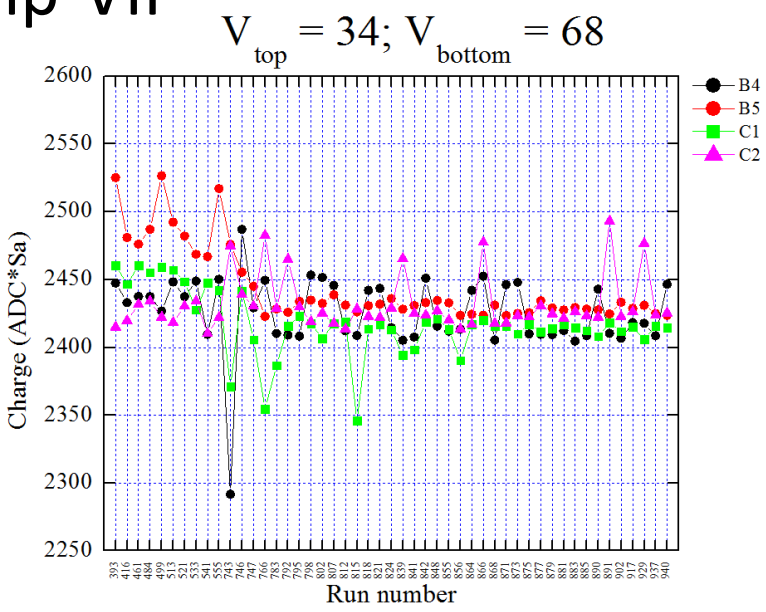
Charge (ADC*Sa)
Run number
A5
B1
B2
B3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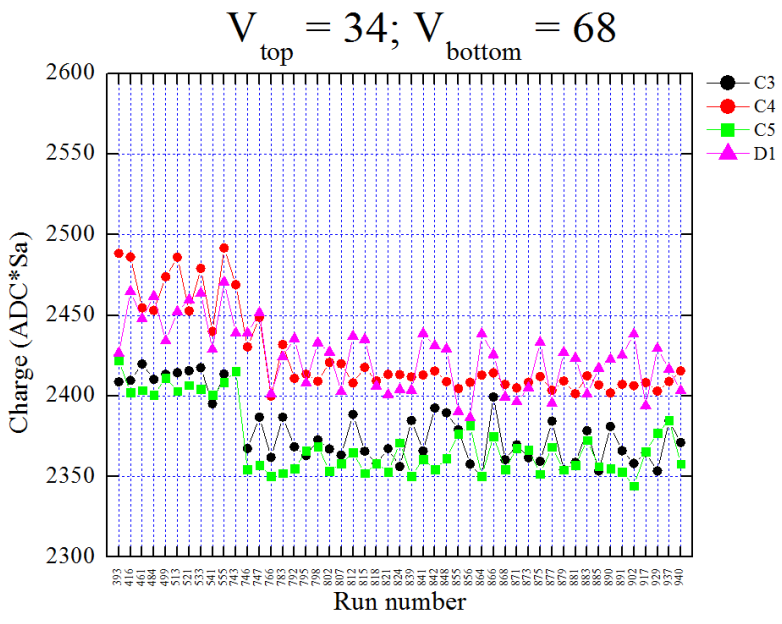
Charge (ADC*Sa)
Run number
B4
B5
C1
C2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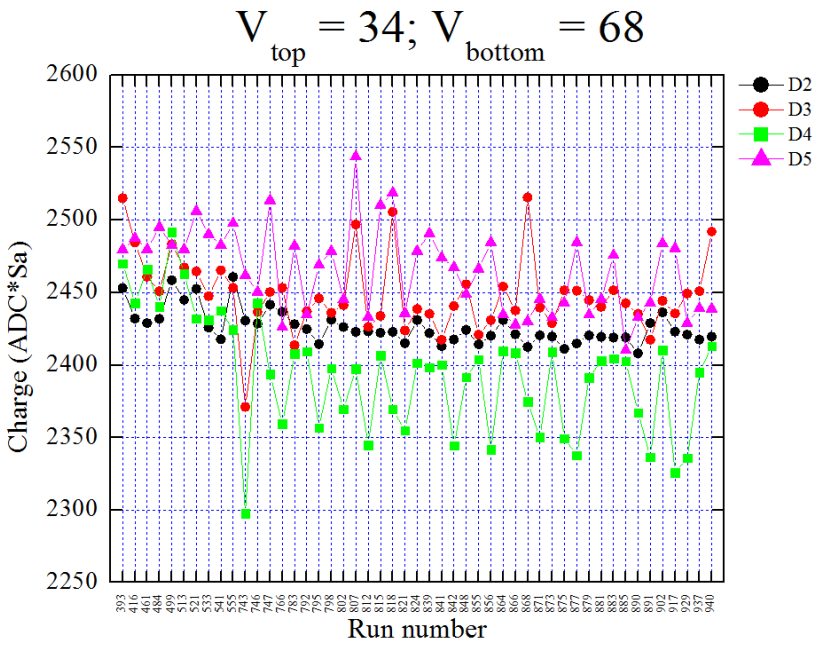
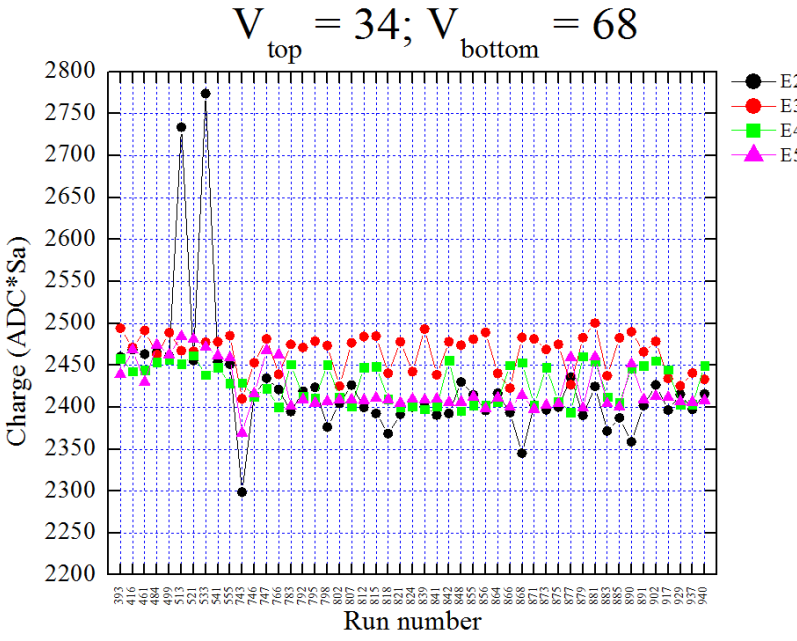
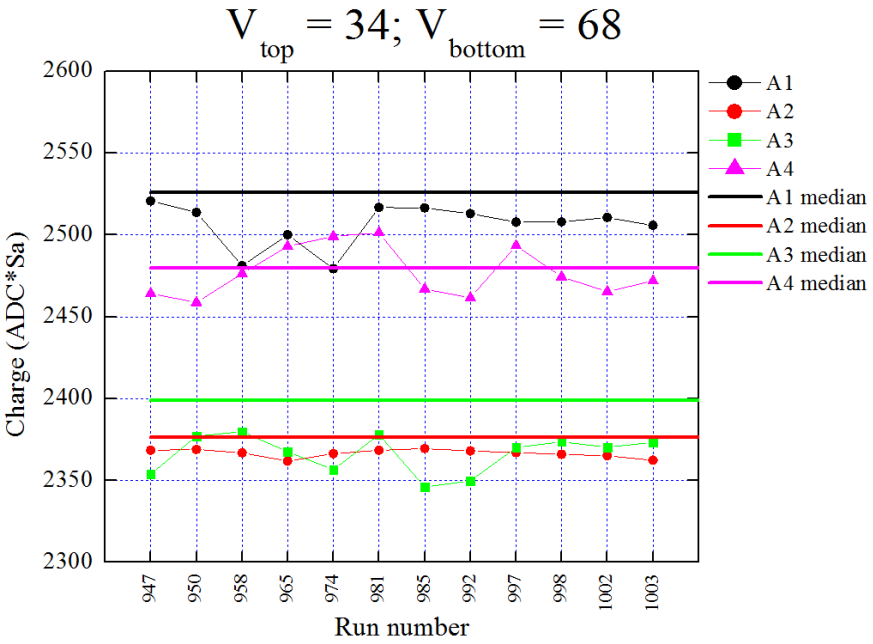
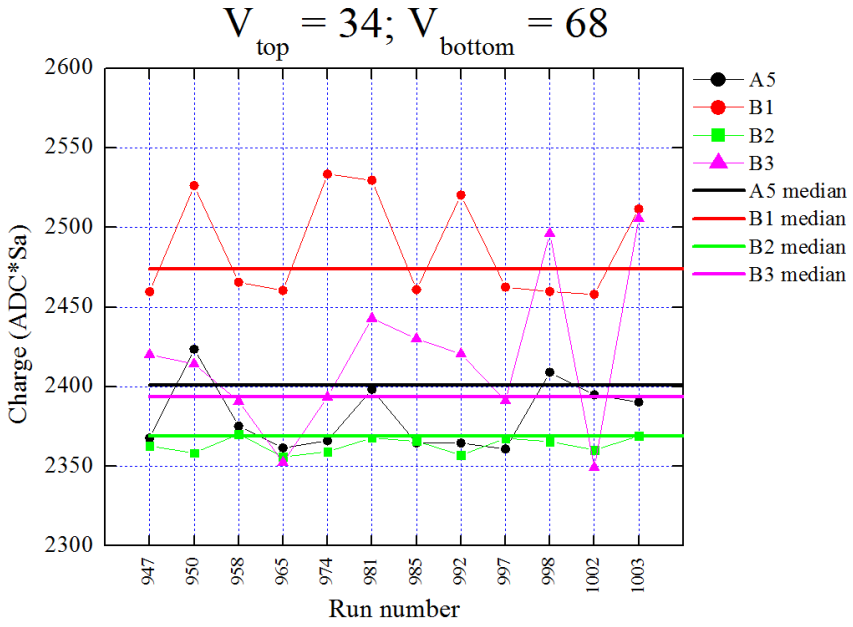
Charge (ADC*Sa)
Run number
C3
C4
C5
D1

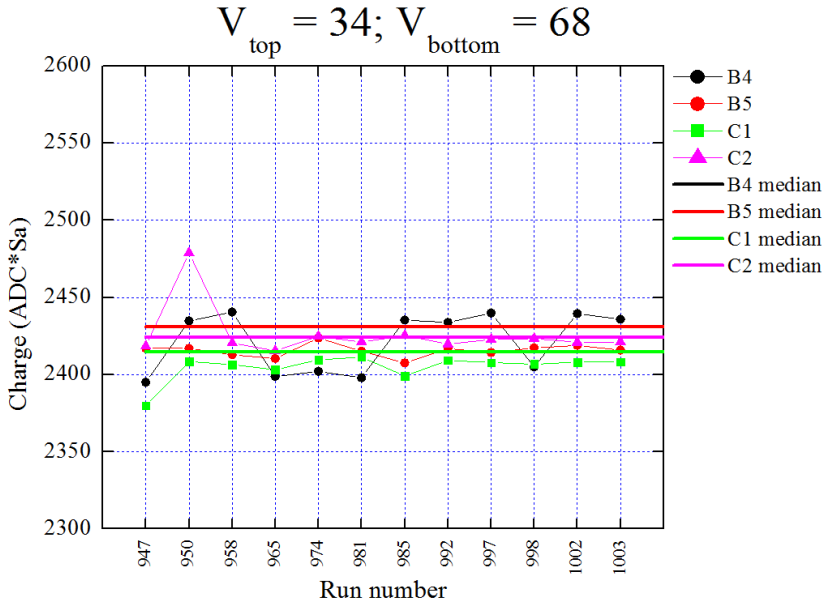

V_{top} = 34; V_{bottom} = 68
Charge (ADC*Sa)
Run number
D2
D3
D4
D5

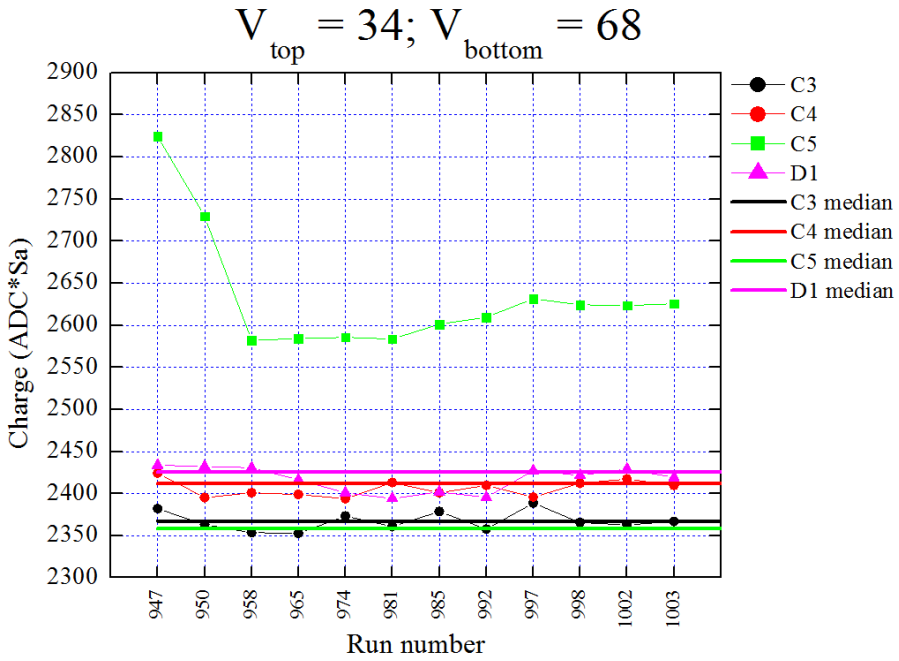

V_{top} = 34; V_{bottom} = 68
Charge (ADC*Sa)
Run number
E2
E3
E4
E5

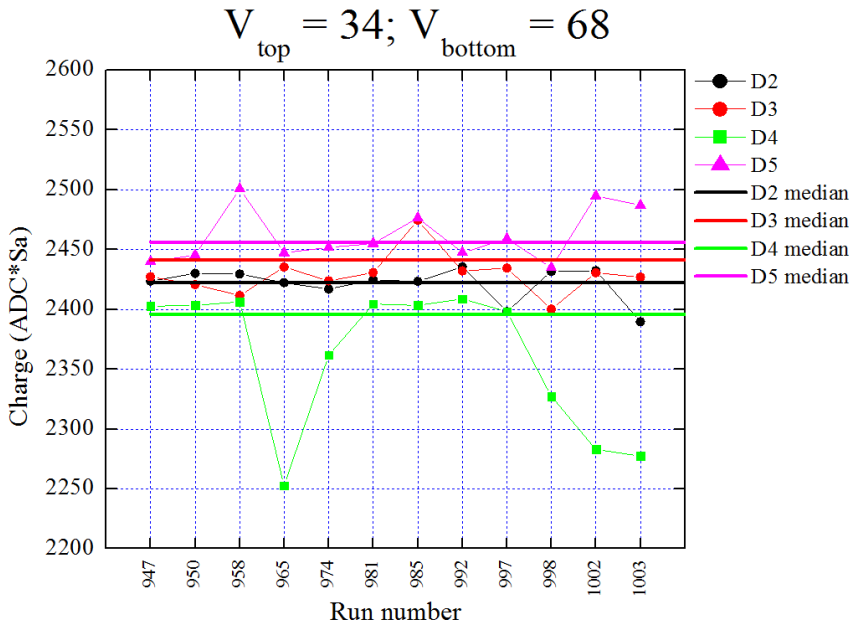
Camp-VII-2, Camp-VII-3

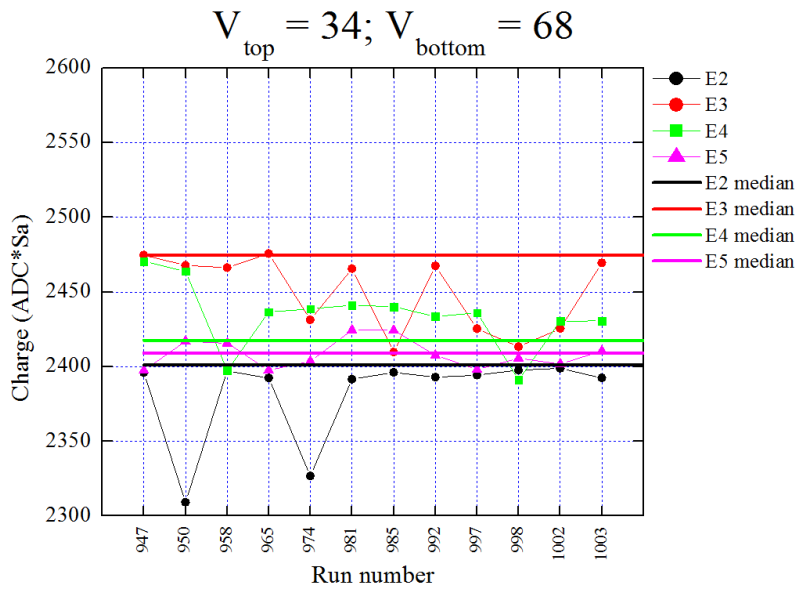


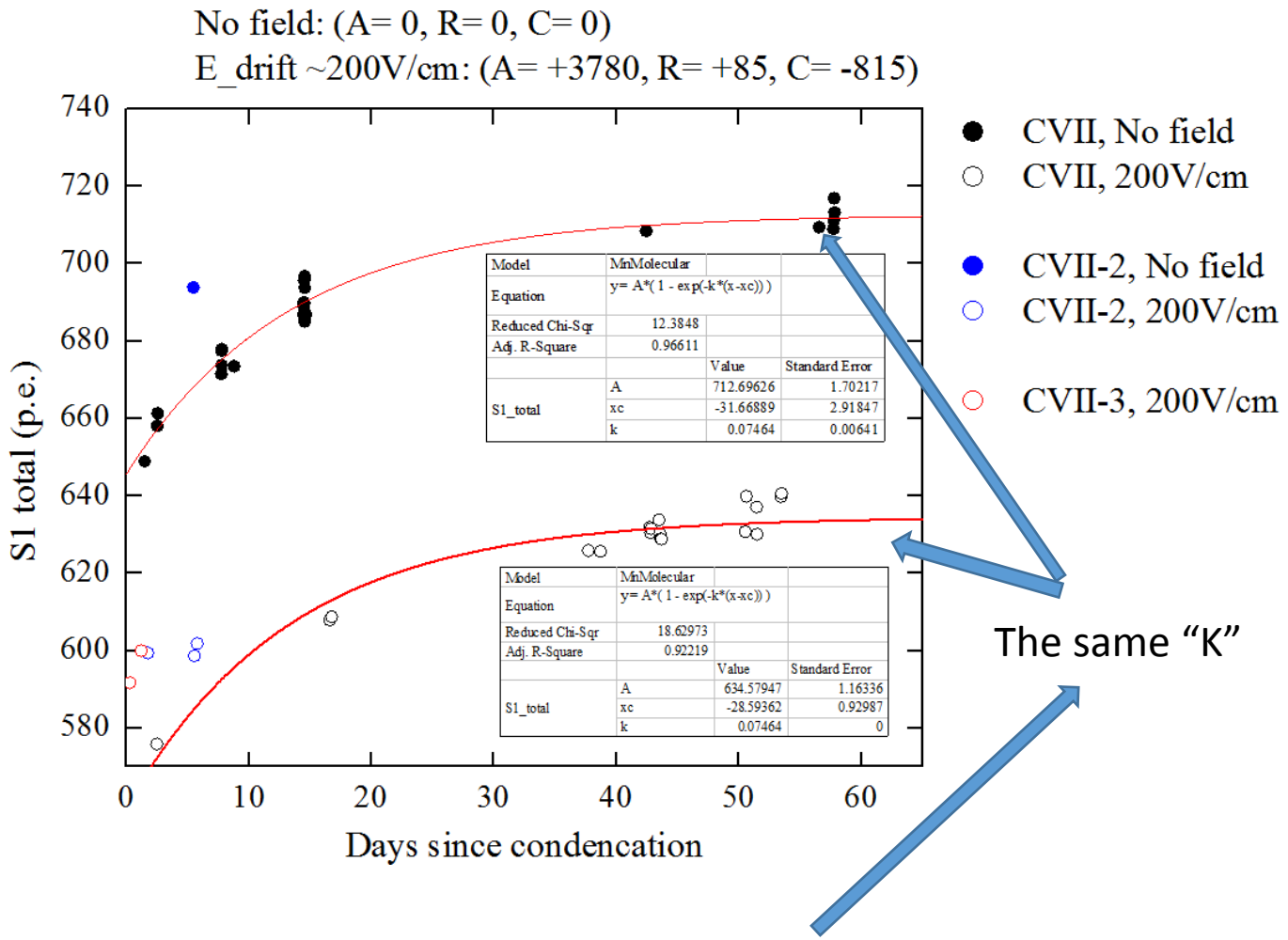












The same “K”

Fit: $y = A*(1 – \exp[-k*(x-xc)])$

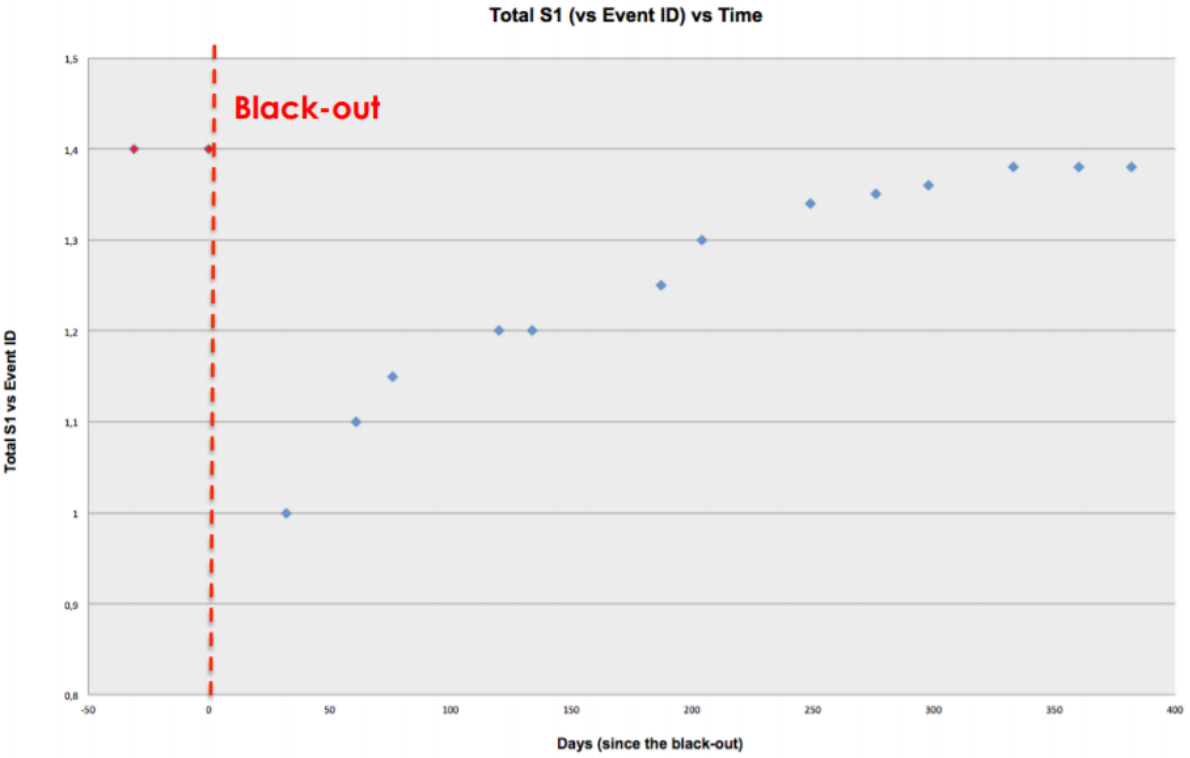
Such dependency with time looks like to some physical process.

630 PE -> 710 PE (12.7%) in 60 days

S1 increases with time in Ds-50 too.

DS-50 UAr – Data Taking

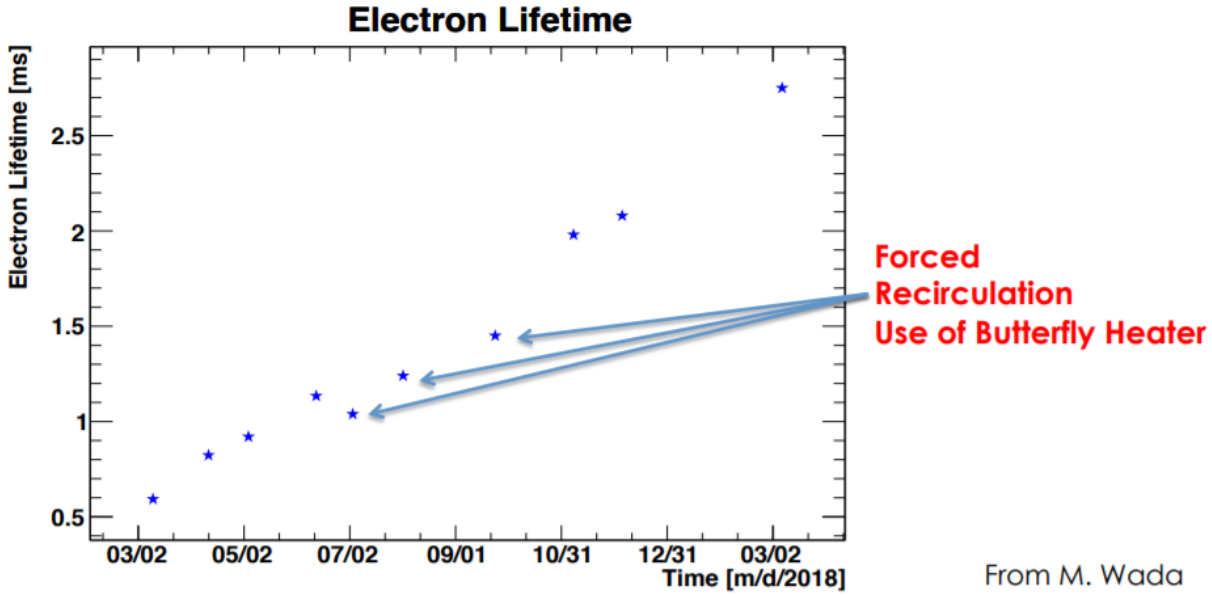
Data Taking – S1 vs Event Id Time Evolution



DS-50 UAr – Data Taking

Time Evolution of the Electron Lifetime

- Two different behaviors
- Slow improvement over 1 year operations
- Far from >10 ms extrapolated value



From M. Wada

From Nicola Canci's talk

https://agenda.infn.it/event/17634/sessions/6720/attachments/61732/73763/canci_2019_03_18_ds_gm.pdf

First hypothesis: S1 increases with time because [O2] and [N2] decreases.

R Acciarri *et al* Nuclear Physics B (Proc. Suppl.) 197 (2009) 70–73 doi: 10.1016/j.nuclphysbps.2009.10.037

R Acciarri *et al* 2010 *JINST* **5** P05003 doi:10.1088/1748-0221/5/05/P05003

http://www.bo.infn.it/sm/sm08/presentations/10-02m/Acciarri_IPRD08.pdf

2.2 Scintillation light quenching

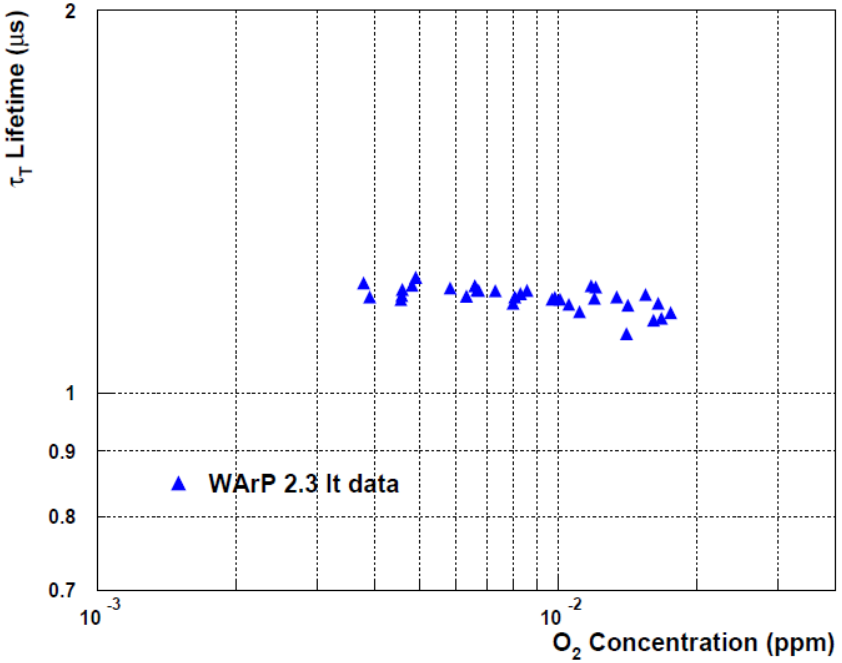
Residual O_2 contamination leads also to a substantial reduction of the scintillation light intensity. This may be attributed to a quenching process in two-body collision of O_2 impurities with Ar_2^* excimer states:

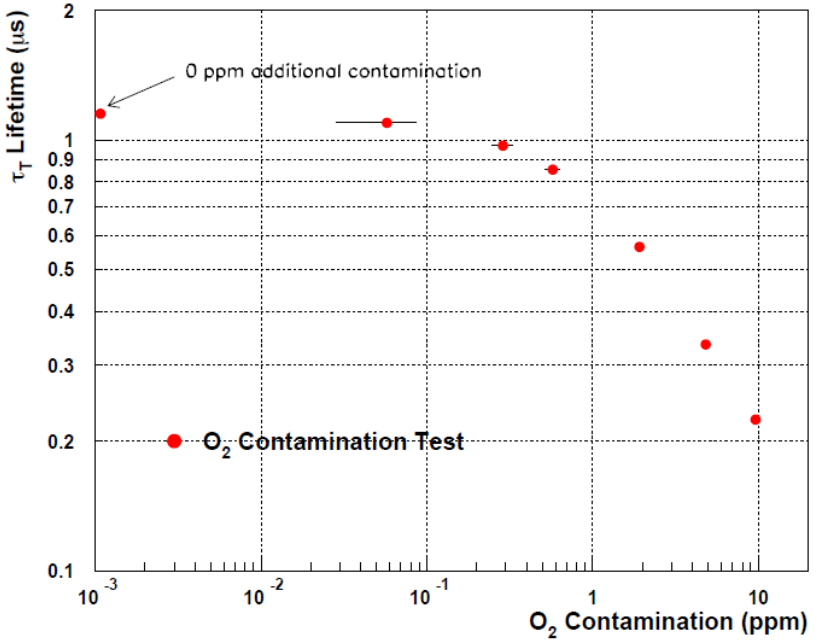
$$\frac{1}{\tau_T'} = \frac{1}{\tau_T} + k_Q\,[O_2] \qquad Ar_2^* + O_2 \rightarrow 2Ar + O_2 \qquad (4)$$

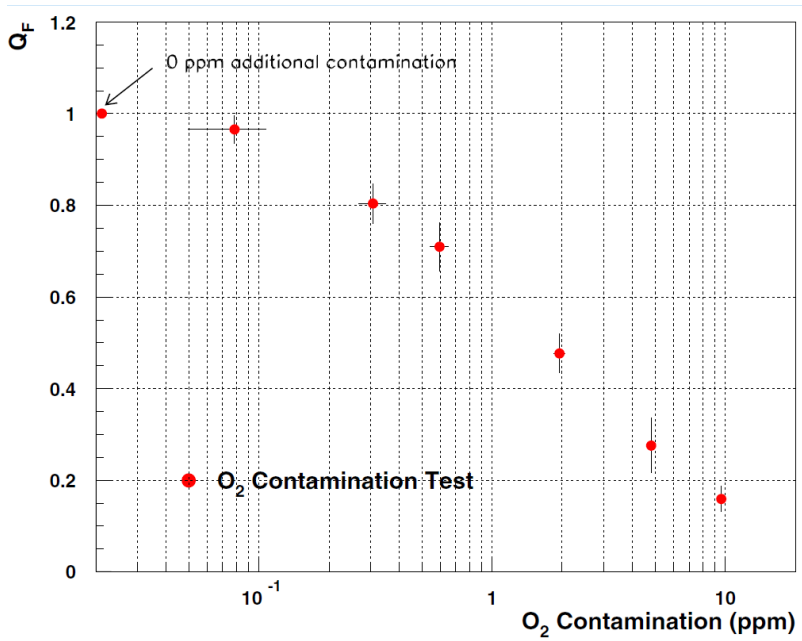
2.3 Scintillation light absorption

Scintillation photons have energy lower than the atomic Ar first excited state, therefore pure LAr is transparent to its own scintillation radiation.[6] However, absorption mechanisms should be taken into consideration in presence of contaminations of photo-sensitive molecules potentially diluted in LAr. In this case emitted photons may be absorbed regardless from the type of precursors, singlet or triplet excimer states, they originate from. This implies that the *total* light yield available for detection can be reduced, depending on the concentration of the photo-sensitive impurity, but no modification of the time constants of the scintillation signal is expected.

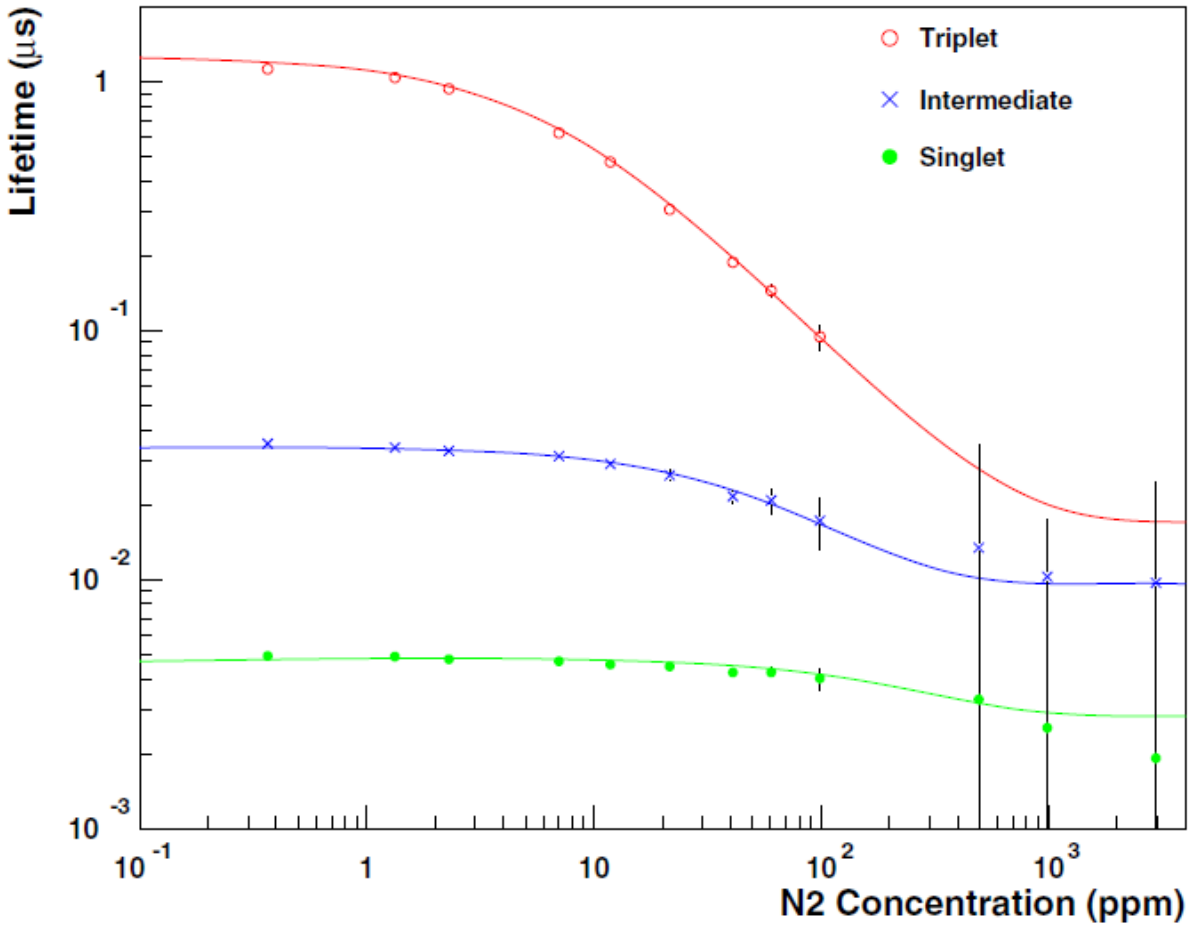
$$\gamma + O_2 \rightarrow O(^3P) + O(^1S)$$

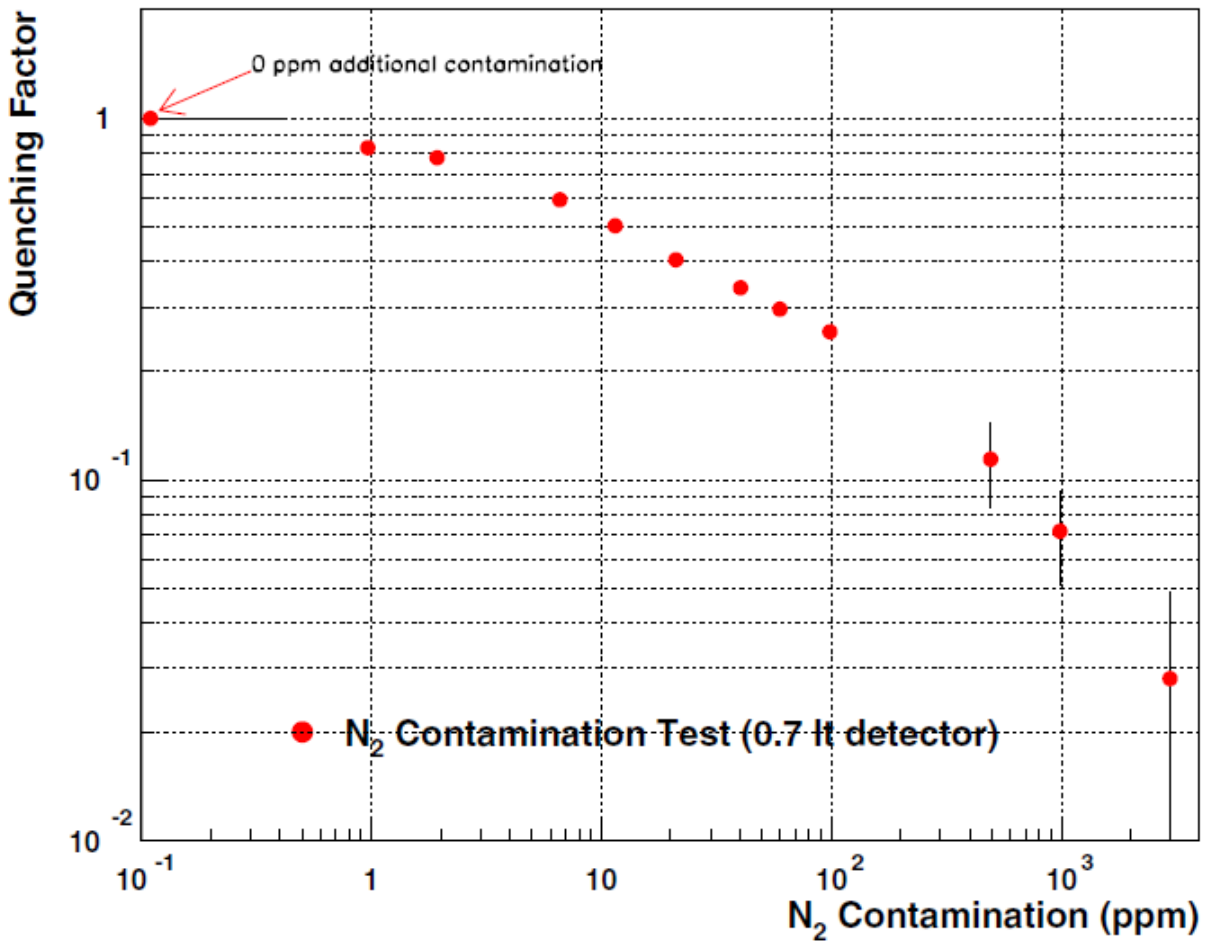






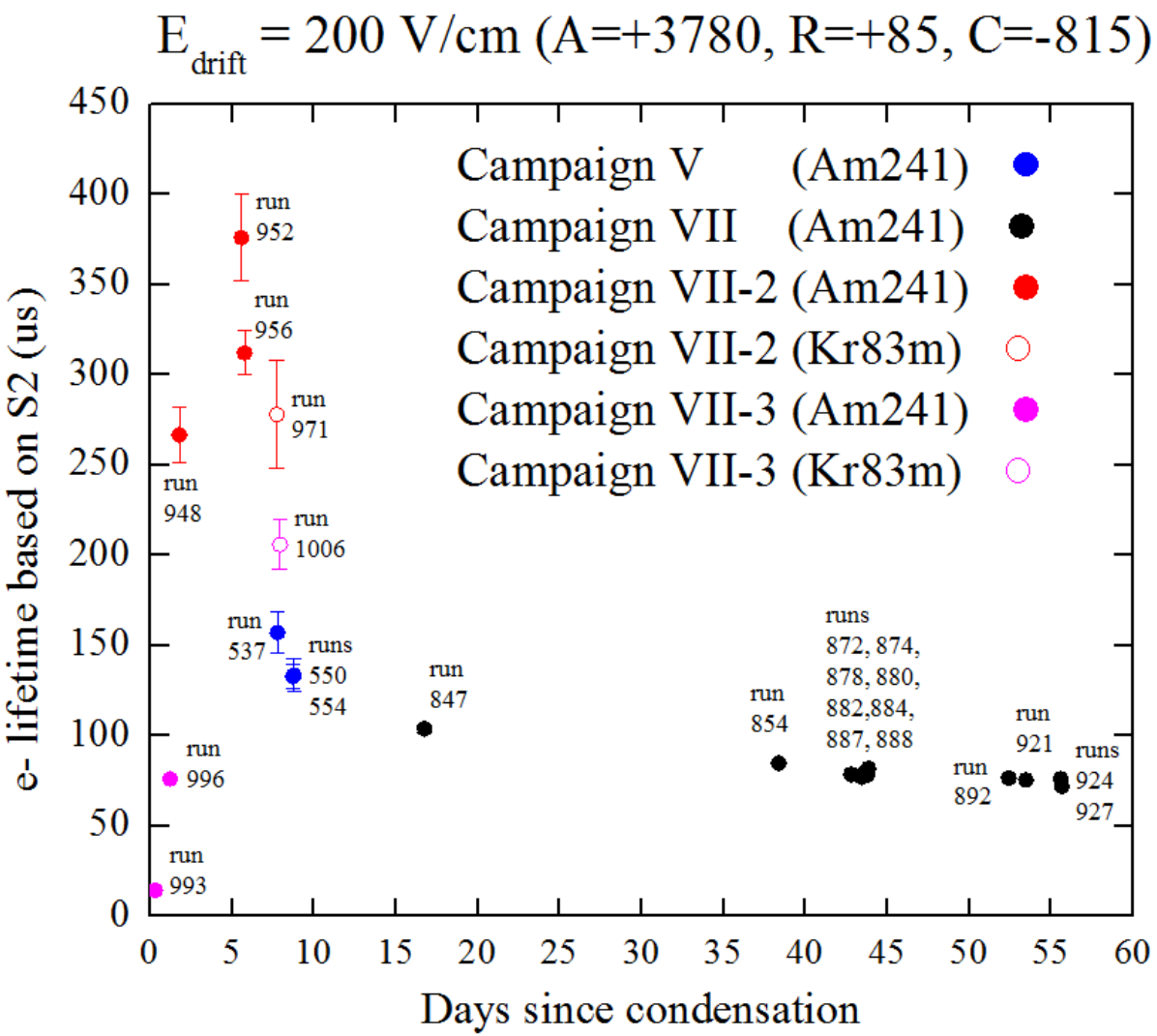
First hypothesis: S1 increases with time because [O2] and [N2] decreases.

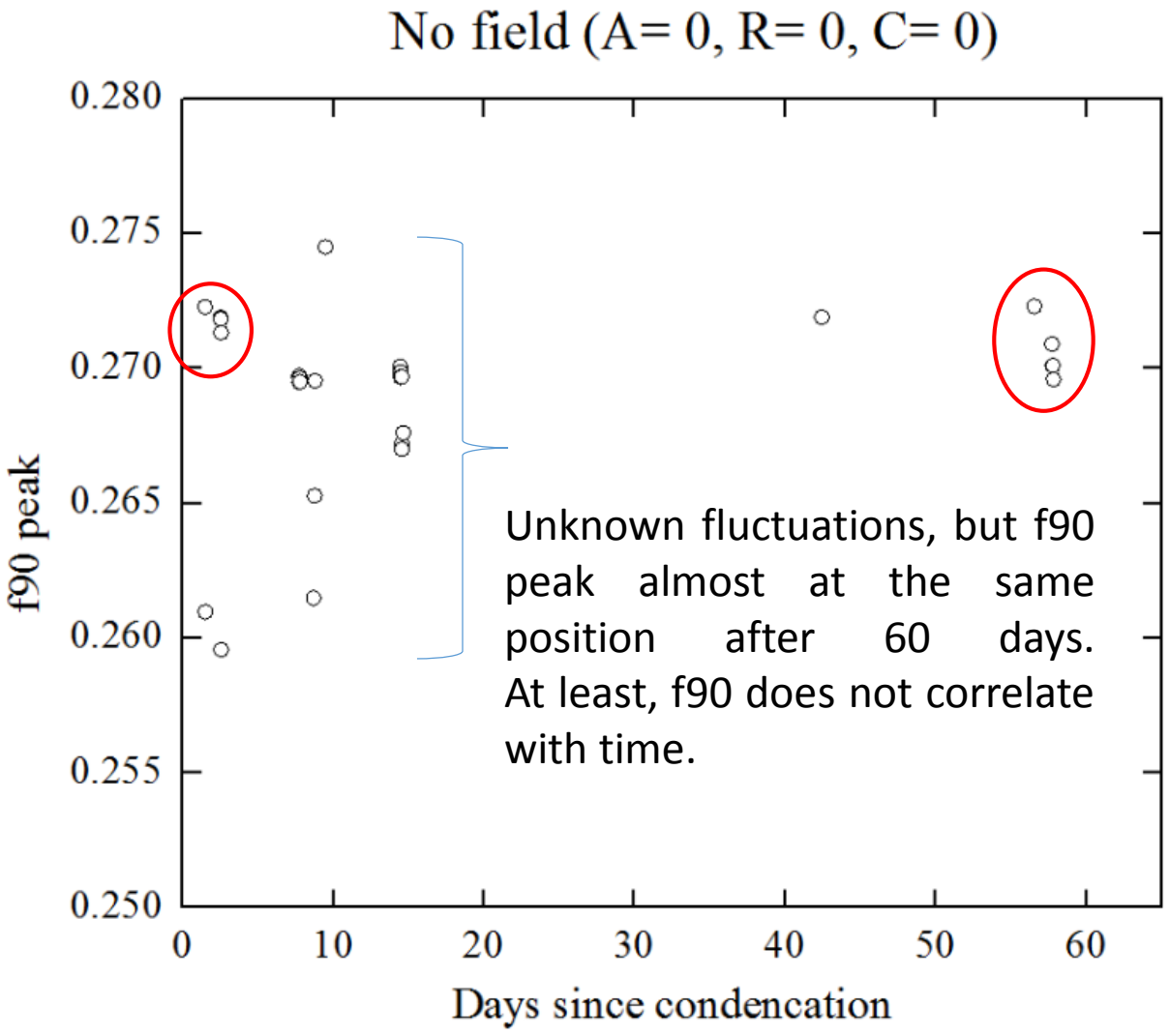




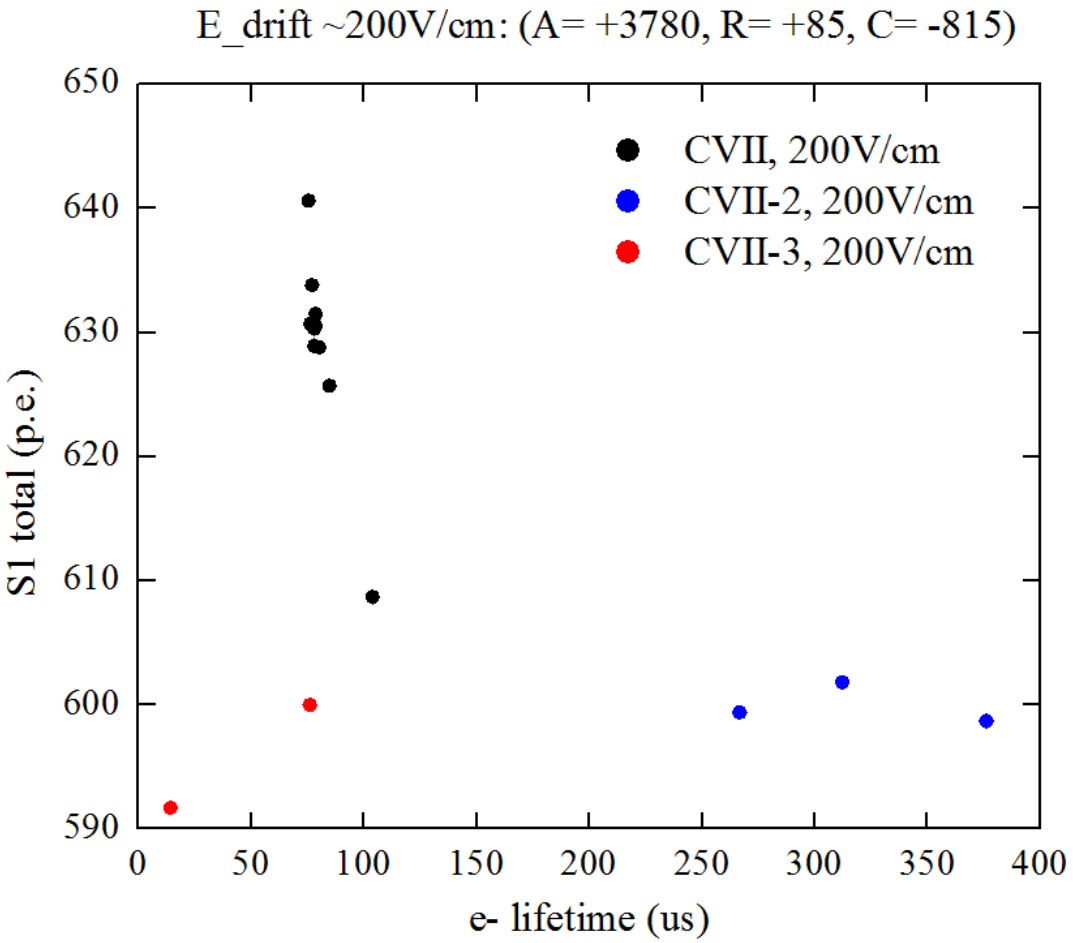
“An intermediate component is also found to be present (as sometimes reported in literature), whose origin could presumabily be ascribed to PMT instrumental effects”.

First hypothesis: S1 increases with time because [O2] and [N2] decreases.





First hypothesis: S1 increases with time because [O2] and [N2] decreases.

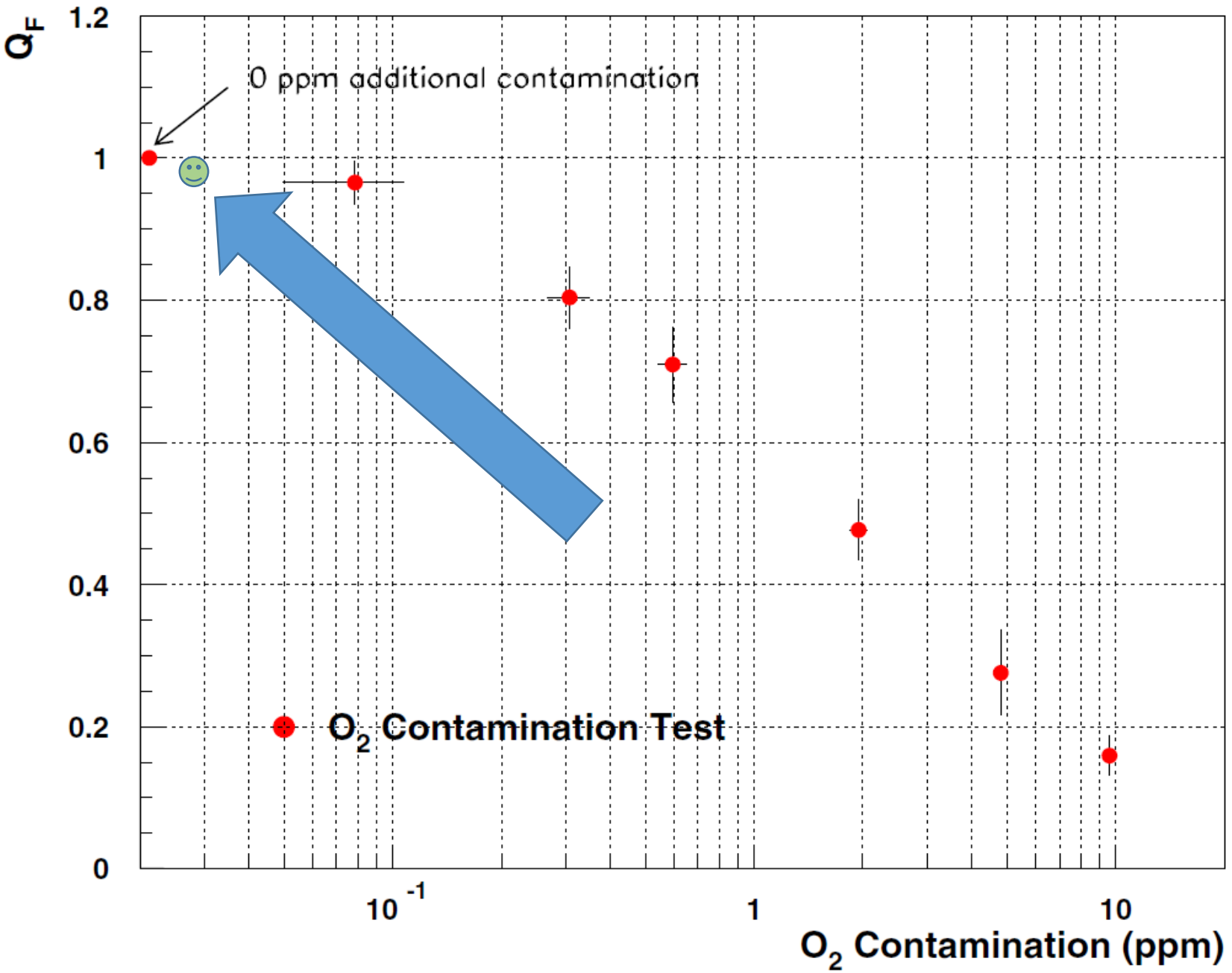


S1 correlate, anticorrelate and doesn't correlate with e- lifetime. So, I would conclude, that there are no dependency between S1 and e- lifetime in our experiment.

Vd ~ 50 mm / 62 us = 0.81 mm/us
Ed ~ 0.2 kV/cm
K [ppm * mm]^-1 = 0.95/E^0.8 ~ 3.44 (at 87 K)
(from Barabash, Bolozdynya. ISBN 5-283-04049-6)
C [ppm] = (Vd * tau_e * K)^-1

C (15 us) ~ 24 ppb
C (400 us) ~ 0.9 ppb

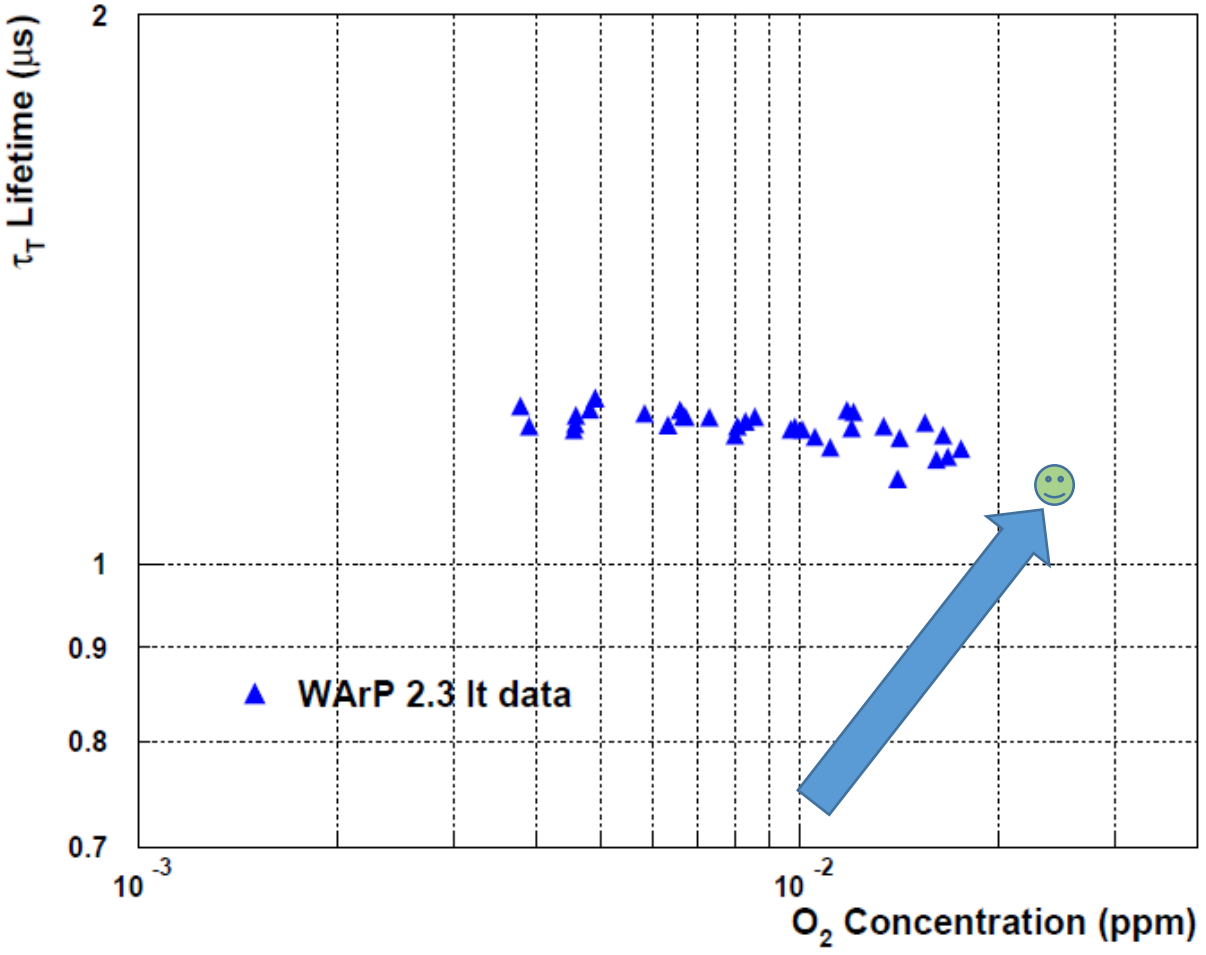
First hypothesis: S1 increases with time because [O2] and [N2] decreases.

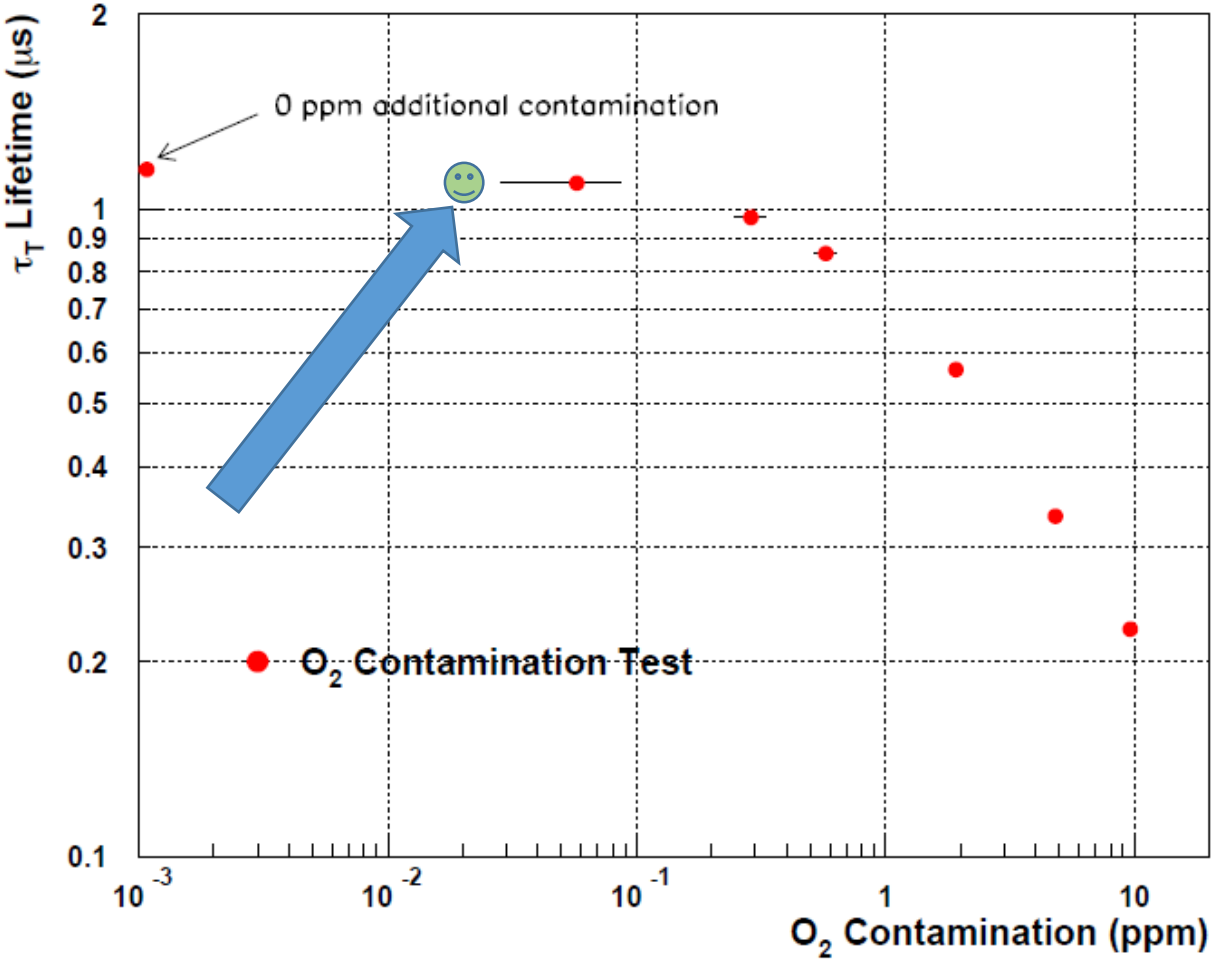


15 us ~ 24 ppb [O2]

S1 * 0.95

First hypothesis: S1 increases with time because [O2] and [N2] decreases.

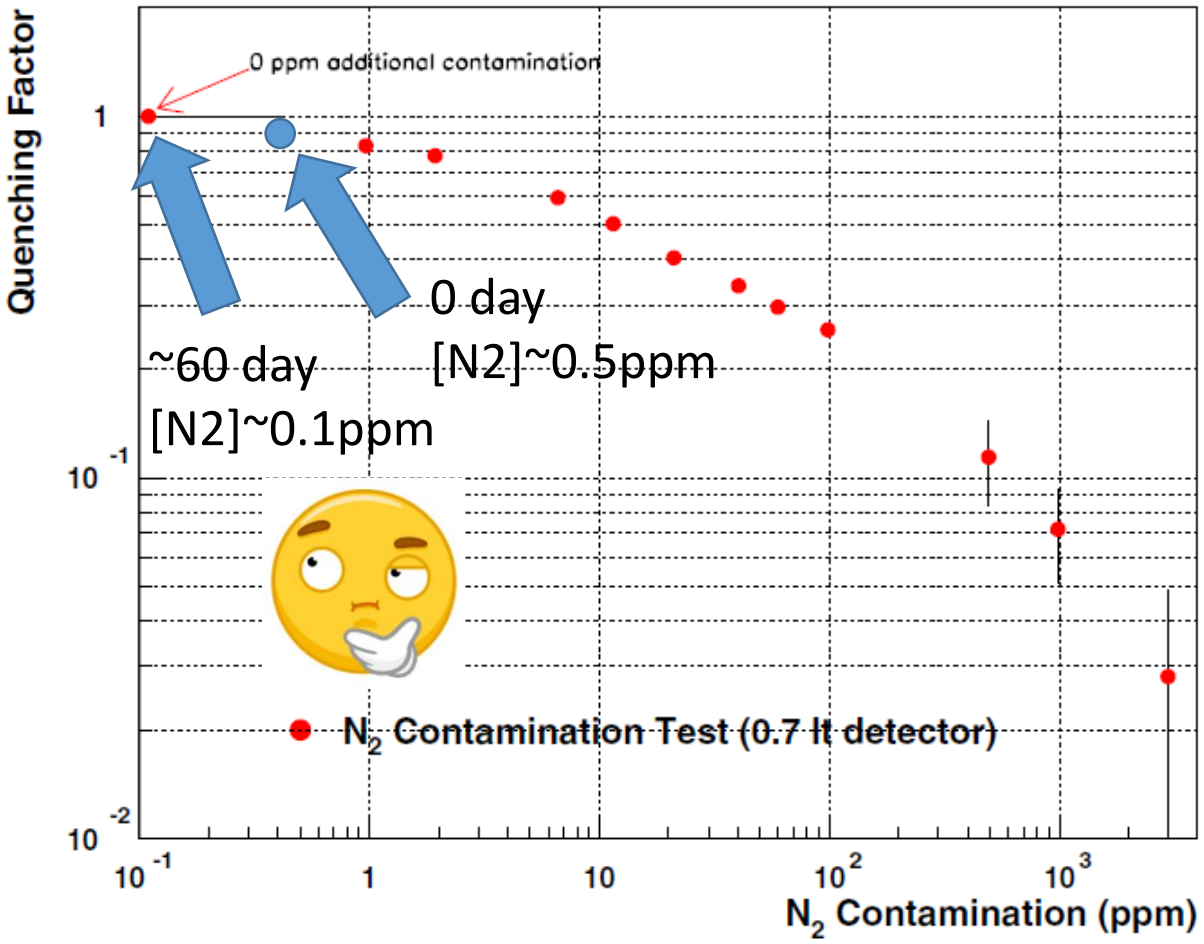


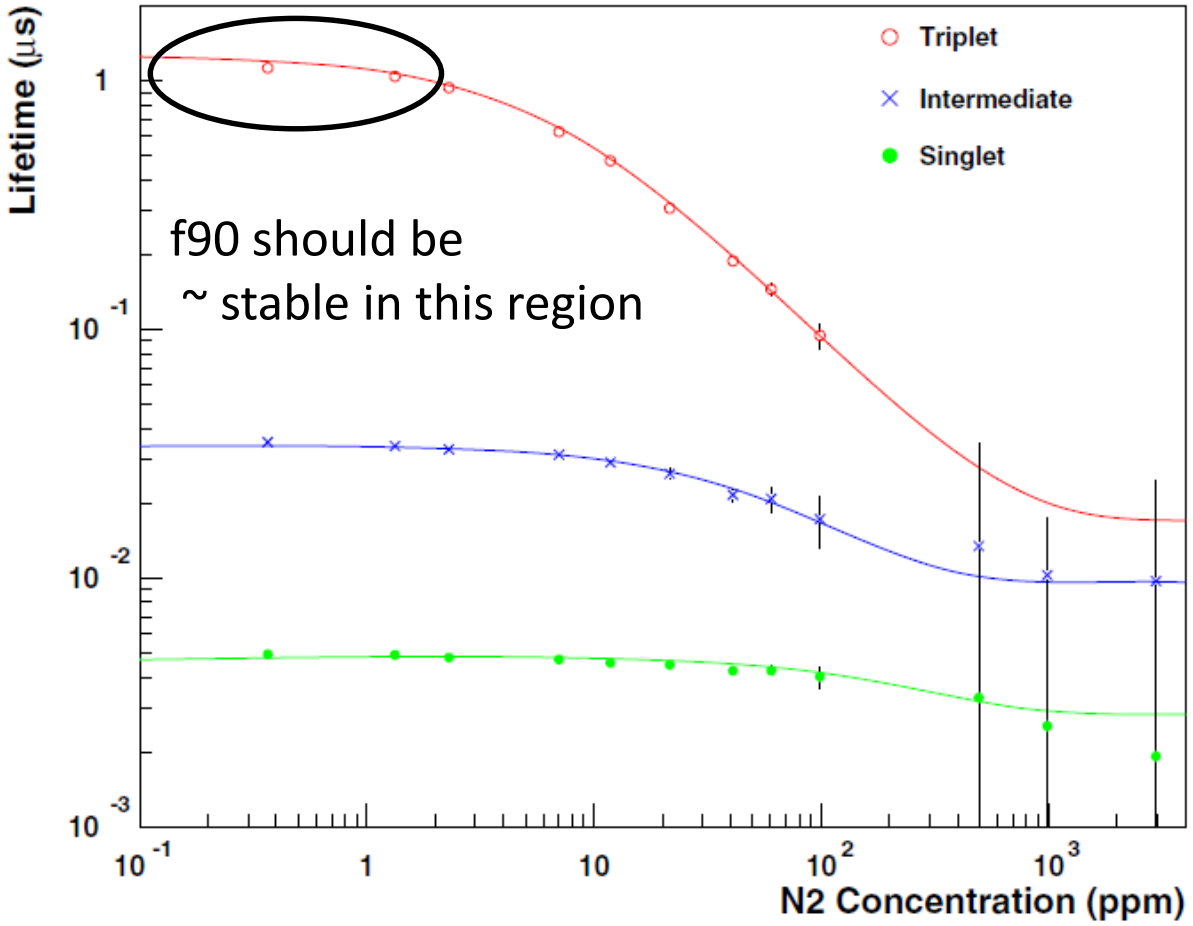


15 us ~ 24 ppb [O2]

very small changes of tau_triplet -> f90 is stable

First hypothesis: S1 increases with time because [O2] and [N2] decreases.





S1 can increase with time if [N2] decreases with time.

Second hypothesis: S1 increases with time because of TPB dehydration.

10.1016/0168-583X(96)00318-7

A number of the TPH and TPB samples were repeatedly retested over a six month period. During this time they were sealed in petri dishes and kept in a dark cupboard (to avoid the large degradation which would result from a continuous exposure to sunlight). Fig. 8a, b shows the ageing effects at the end of this period due to oxidation and hydration for the two fluors, random errors are shown only. The deterioration occurred steadily and is worse at the optimum thickness of the WLS and corresponds to a decrease in efficiency of 10–15%. It should be noted that,

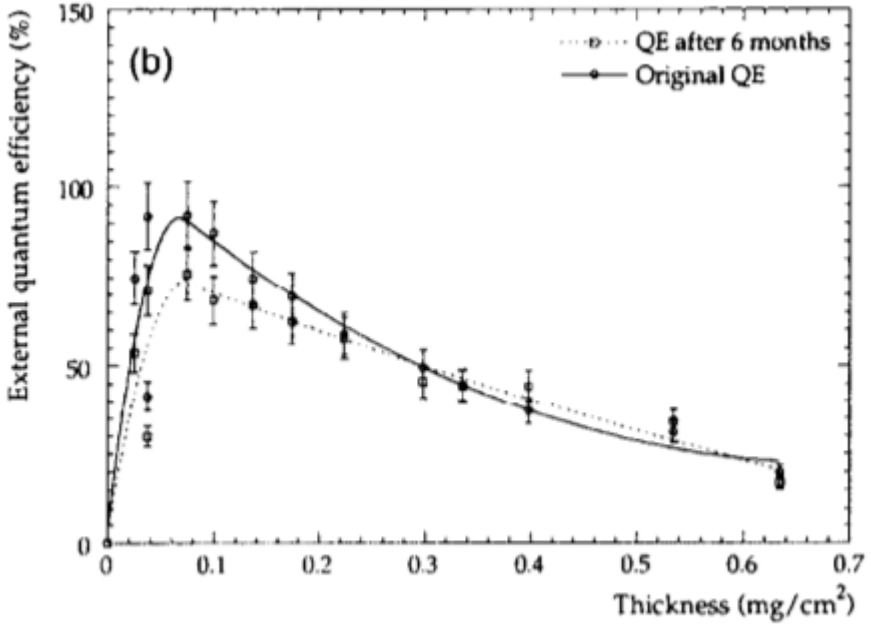


Fig. 8. Deterioration in efficiency of TPH and TPB after a six month period (175 nm incident light).

http://darkmatter.ethz.ch:8080/Plone/meetings/ardm-meeting-jul-30-2012/120730-TPB-Degradation.pdf/at_download/file

http://microboone-docdb.fnal.gov/cgi-bin/RetrieveFile?docid=1797&filename=ignarra_tpb_degradation_9Dec2011.pdf&version=1

WArP and CERN CCS Study

TPB hygroscopicity + mechanical stability to thermal cycles

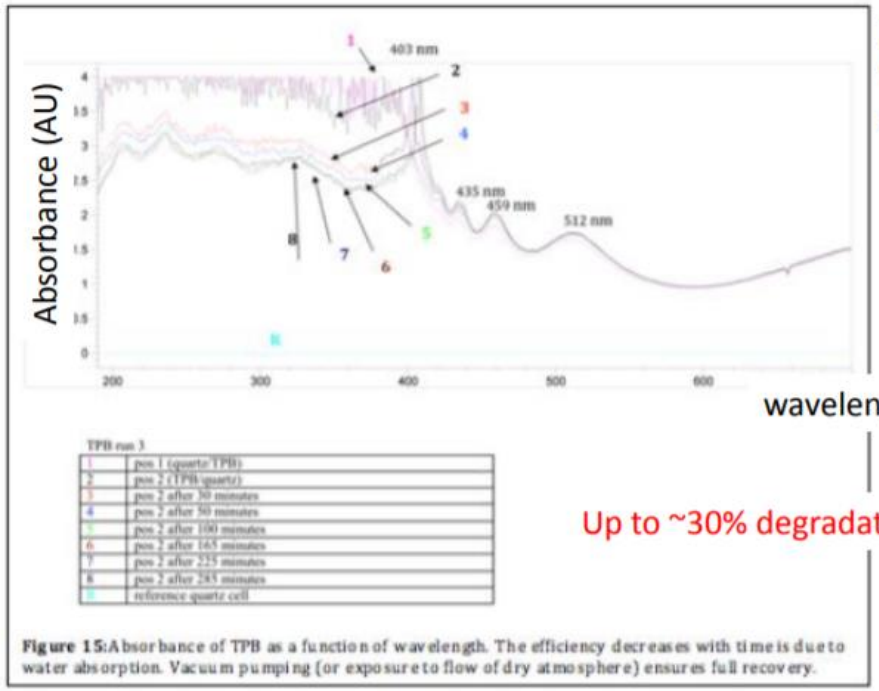


Figure 15: Absorbance of TPB as a function of wavelength. The efficiency decreases with time is due to water absorption. Vacuum pumping (or exposure to flow of dry atmosphere) ensures full recovery.

From:
"The WArP Programme"
R. Acciarri et al.

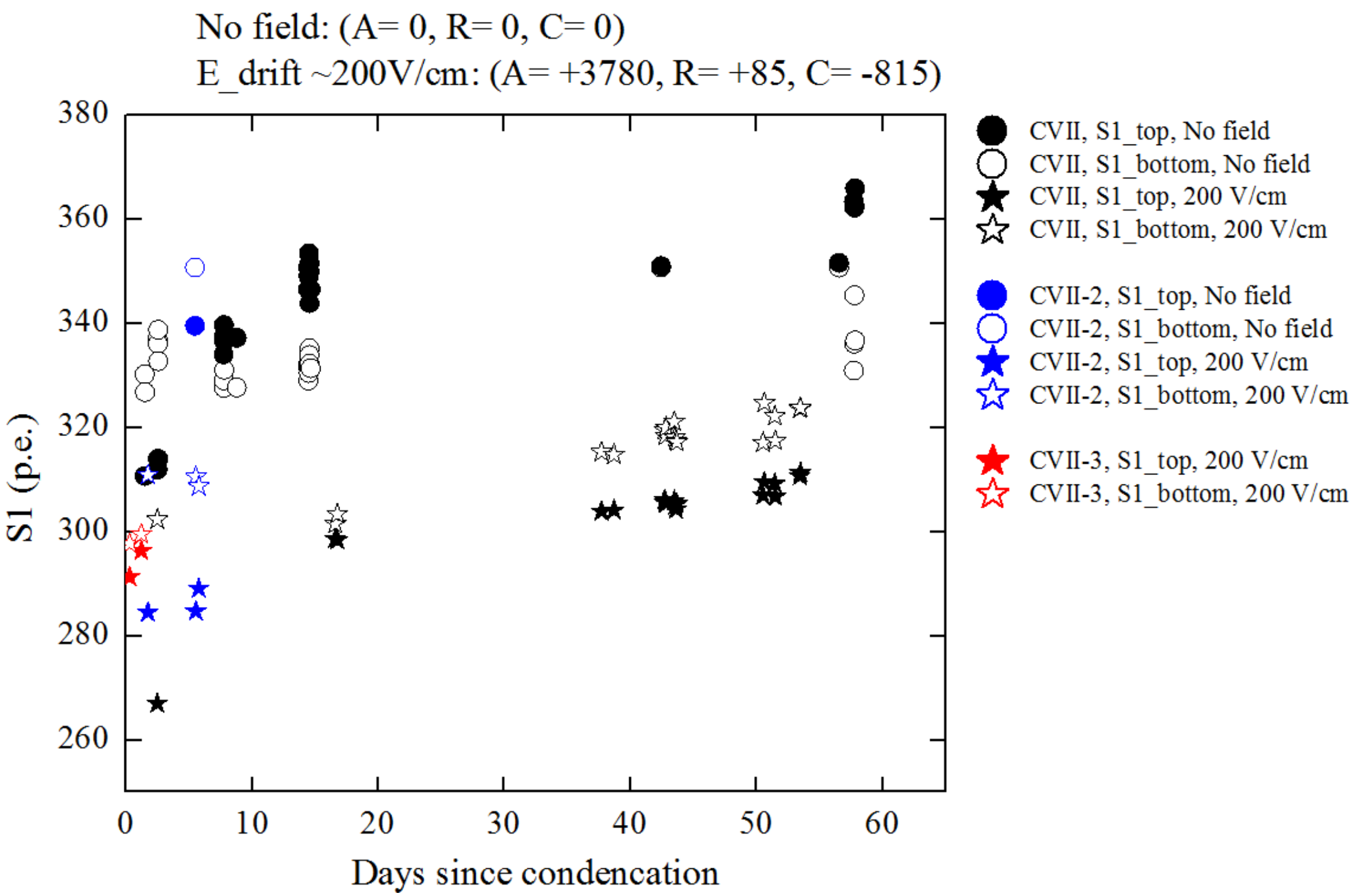
Up to ~30% degradation in light absorbance

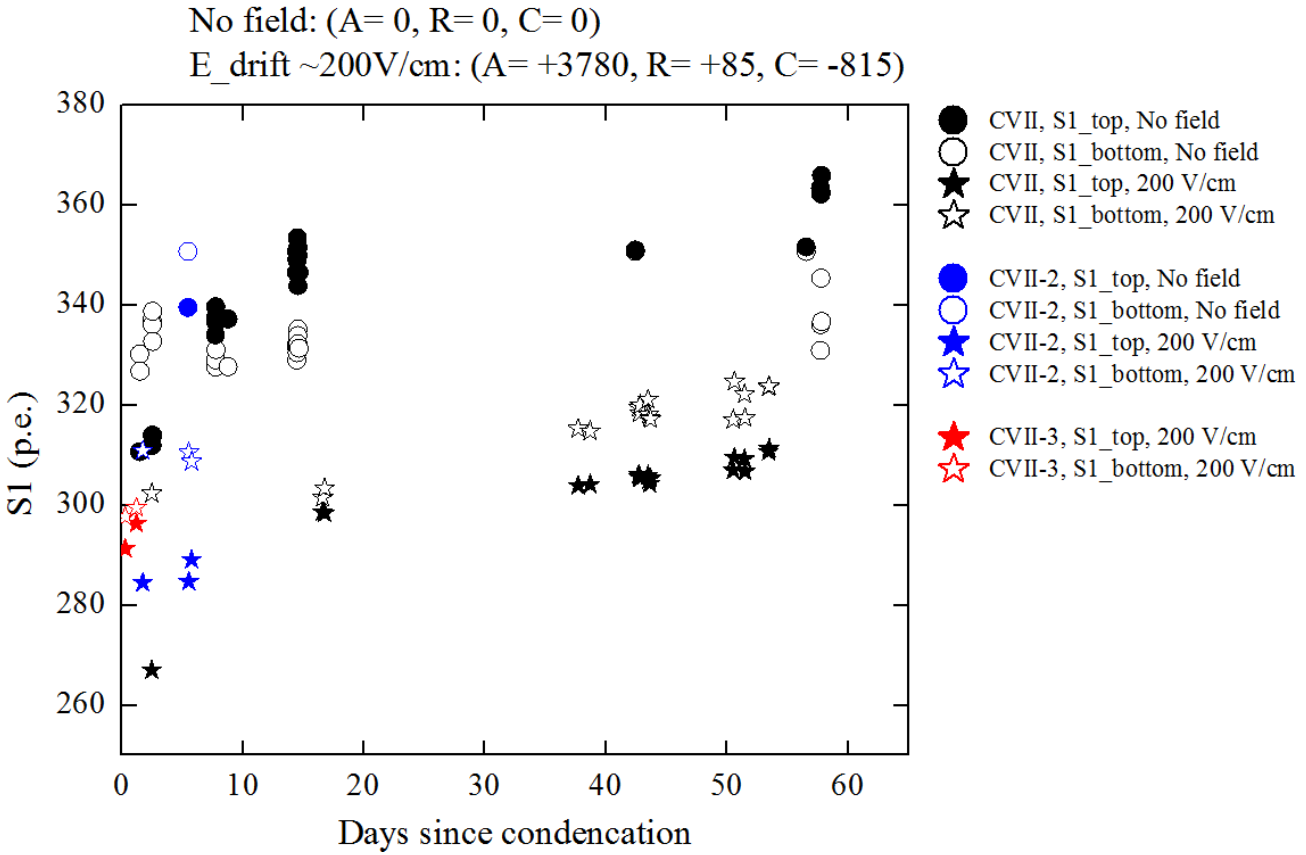
Conlusion:

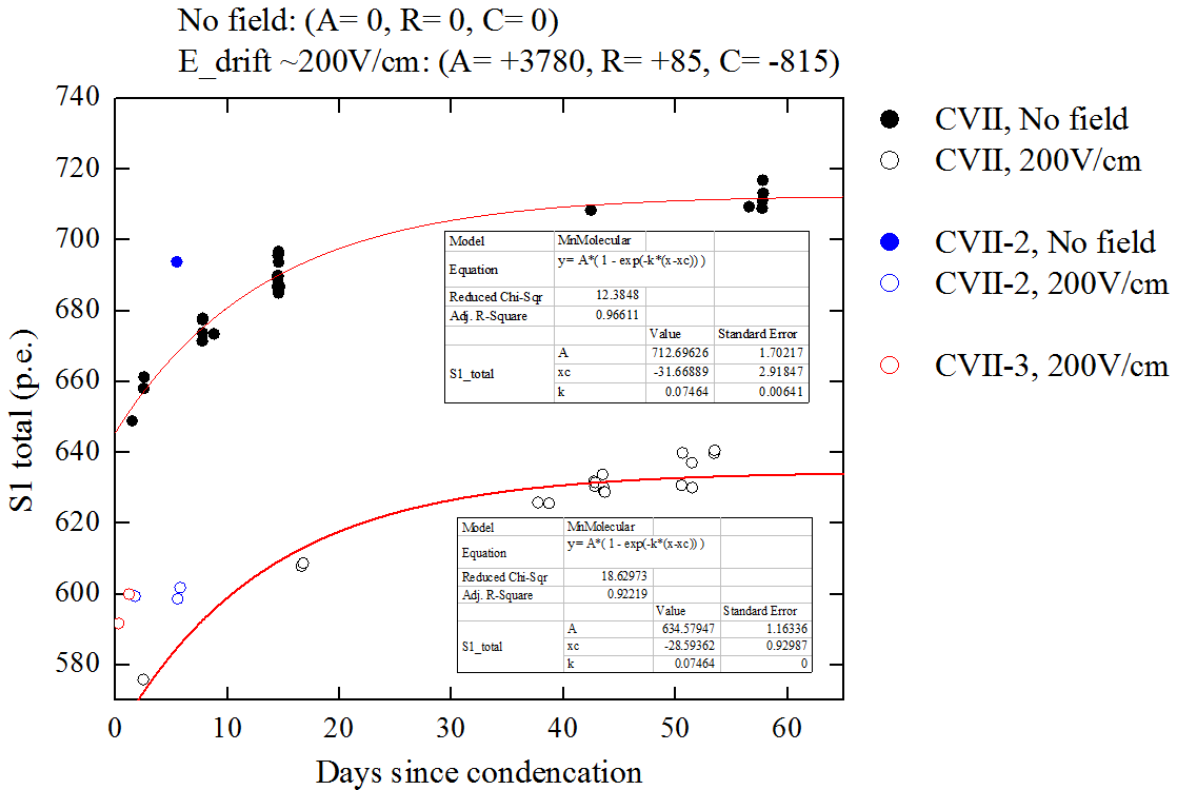
- Efficiency decreases with water absorption
- Vacuum pumping ensures full recovery

Good news: Reversible effect !

9


No field: (A= 0, R= 0, C= 0)
E_drift ~200V/cm: (A= +3780, R= +85, C= -815)
S1 (p.e.)
Days since condencation
380
360
340
320
300
280
260
0
10
20
30
40
50
60
CVII, S1_top, No field
CVII, S1_bottom, No field
CVII, S1_top, 200 V/cm
CVII, S1_bottom, 200 V/cm
CVII-2, S1_top, No field
CVII-2, S1_bottom, No field
CVII-2, S1_top, 200 V/cm
CVII-2, S1_bottom, 200 V/cm
CVII-3, S1_top, 200 V/cm
CVII-3, S1_bottom, 200 V/cm





CVII:

Why S1_top increase, but S1_bottom ~ stable (field ON and OFF)?

Hypothesis: after LAr condensation TPB in the liquid quickly returned most part of the water, so S1_bottom was almost stable with time, when we started to measure.

TPB in the gas returned water too, but slowly.

Conclusions:

- Changes in [O2] can't explain ~13% increasing of S1 light yield with time.
  Even in the worst case O2 can change S1 only by 5%.
  And, what is most important, there no correlation between S1 and [O2].

- Changes in [N2] can explain 13% increasing of S1 light yield with time.
  For example, at t=0 [N2]~0.5ppm and at t=60 [N2]~0.1ppm.
  But is it possible to decrease [N2] if [O2] increases or doesn't changes?
  And, what is most important, why S1_top and S1_bottom have different dependencies with time?

- TPB dehydration can explain increasing of S1 light yield with time too.
  It can explain different dependencies of S1_top and S1_bottom with time.

- May be S2(purity corrected) vs time can clarify TPB or [N2] responsible for S1 changes.

Thank you for your attention!