

A new neutron monitor for high flux neutron beams

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ESS Requirements for *next-gen* monitors

High Flux
High rate

Strong Gamma
environment

Minimal
material budget
and
perturbations of
the beam

Stable over
time (< 5 %
variations)

Absolute flux
accuracy

Uranium monitors

Pros

Best neutron/gamma discrimination

Good stability over time

Fast signals / high counting rate

Low voltage operation

Cons

Efficiency specifications not reliable

Bad uniformity over the active area

High beam perturbations / attenuation

One major supplier

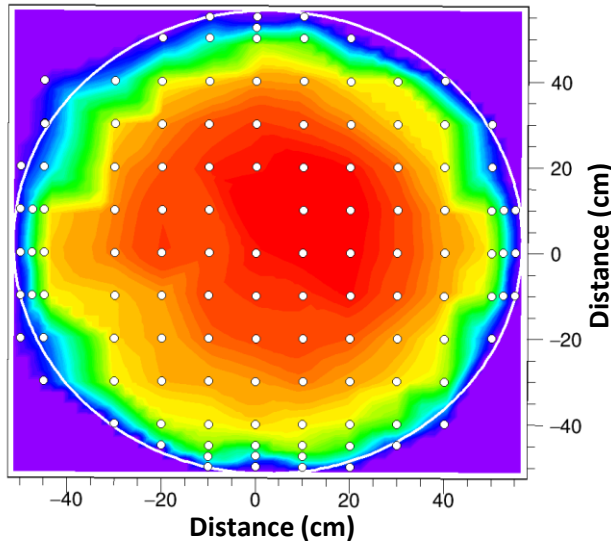
Long delivery time
After-sales service
Radioactive sources regulations

Uranium monitors

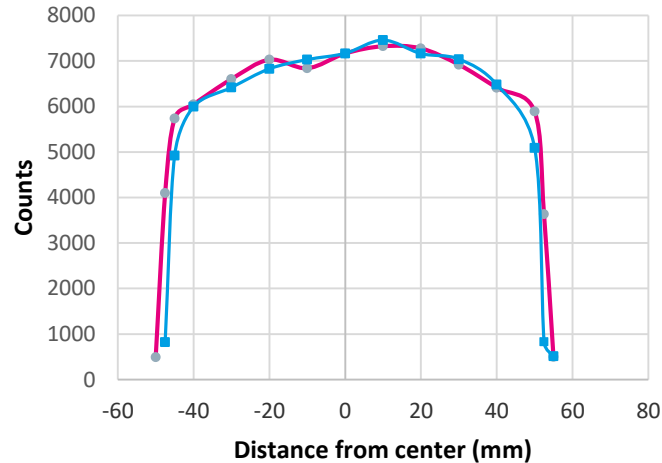
Uniformity issues

Measured with a collimated (2.5 mm × 2.5 mm) 2.5 Å- neutron beam

Uniformity of LND monitor n 926

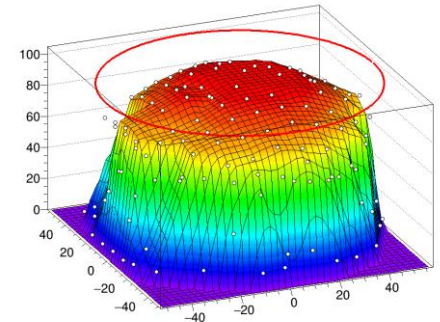


Axial Uniformity of 926 (Mod. 3053)



—●— Hor. Diameter —■— vert. Diameter

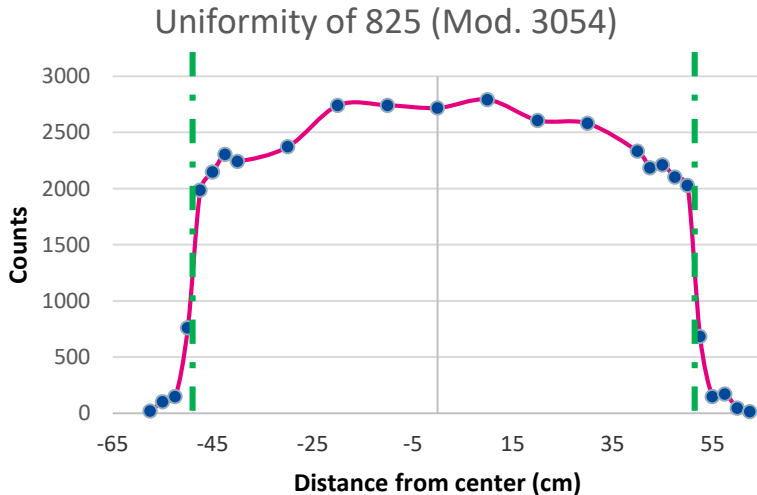
Uniformity of LND monitor n 926



Uranium monitors

Uniformity issues

Even worse with a low efficiency one (3×10^{-4})

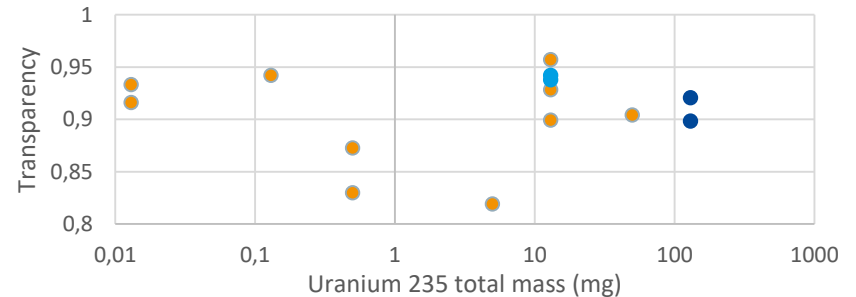


Uniformity : up to 20-25 % deviations

Active area : ≈ 100 mm (108 mm in specs.)

Measured transparency : 89 - 96 %

Average 91% (12 LND monitors tested)



ILL proposal

A multitube gas-filled monitor

Initially designed for SHARP instrument for **operation in vacuum**

Additional features compared to Uranium monitors

Efficiency can be tuned

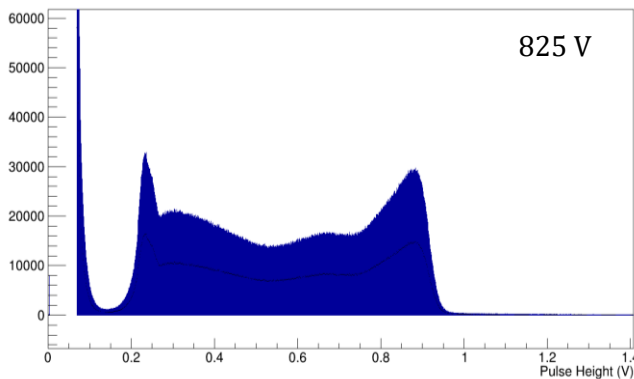
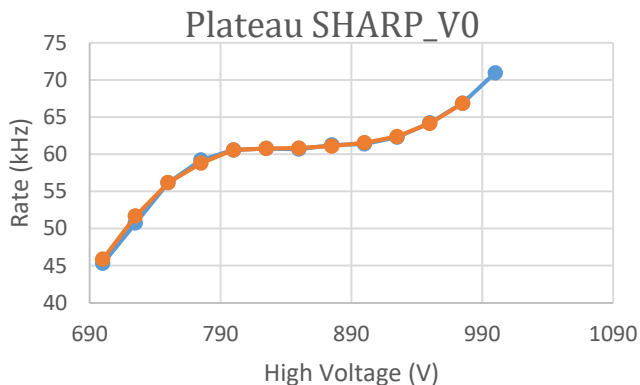
Excellent uniformity

Better transparency (0.5 mm windows / 0.4 mm inner walls)

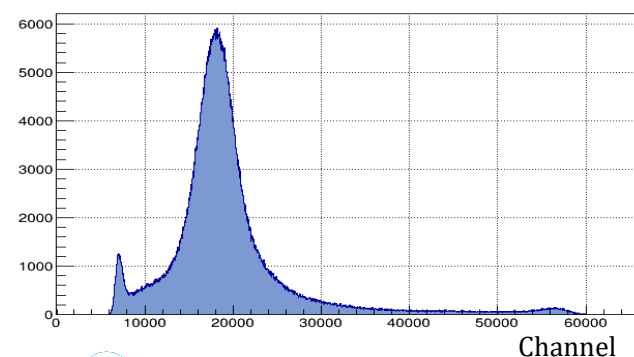
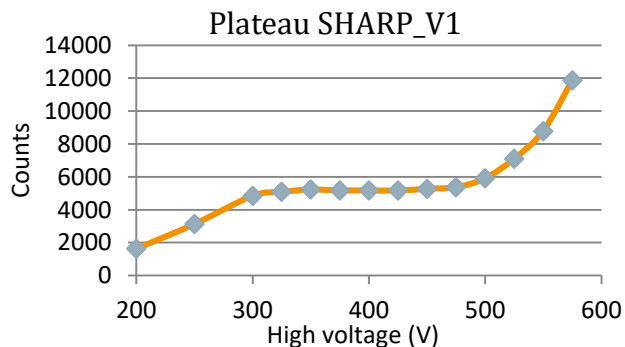


Multitube Monitor

Pulse height spectra



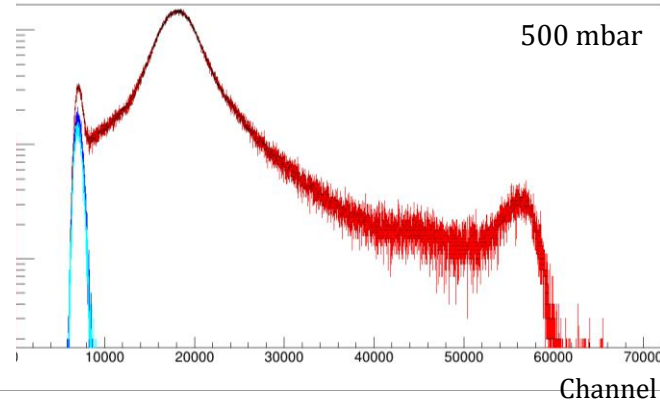
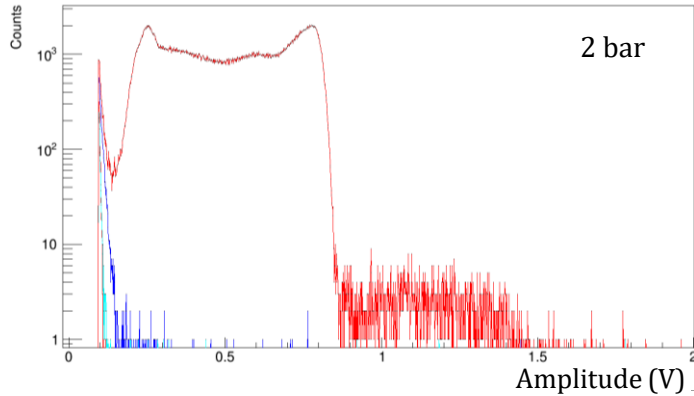
2 bar $Ar - CO_2$
4 mbar 3He
(also tested with Nitrogen)



500 mbar $Ar - CO_2$
10 mbar 3He

Multitube Monitor

Gamma discrimination



1. Beam On
2. Beam On with B_4C shielding
3. Beam Off

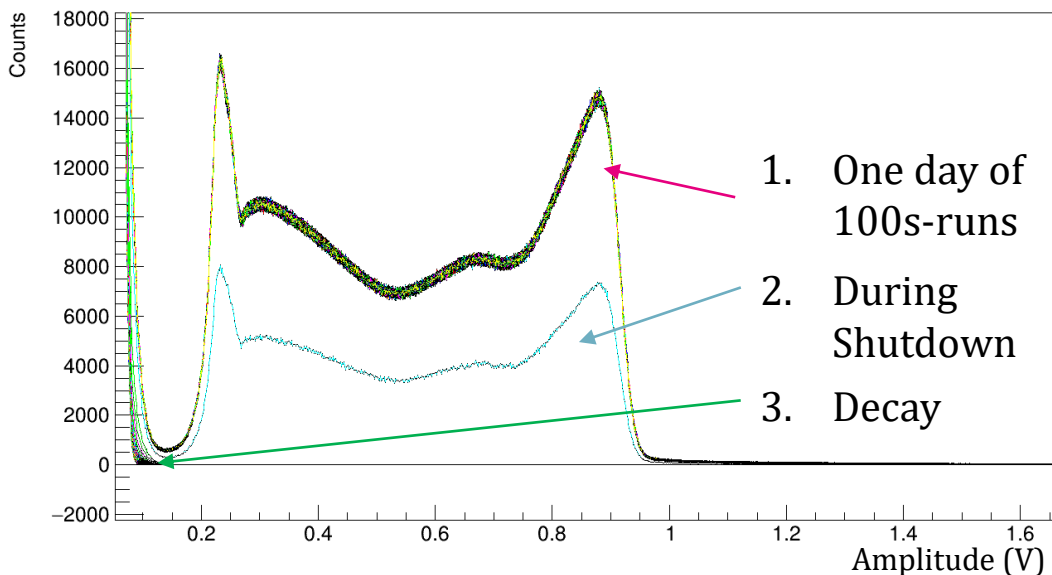
Excellent gamma discrimination @ 2 bar
Even better @ 500 mbar

Multitube Monitor



Stability

P.H. Spectra over time



60 kHz on 2 cm² over a day
On H523/SuperSUN @ ILL

inc. flux : $\sim 2 \times 10^7 \text{ n.cm}^{-2}.\text{s}^{-1}$

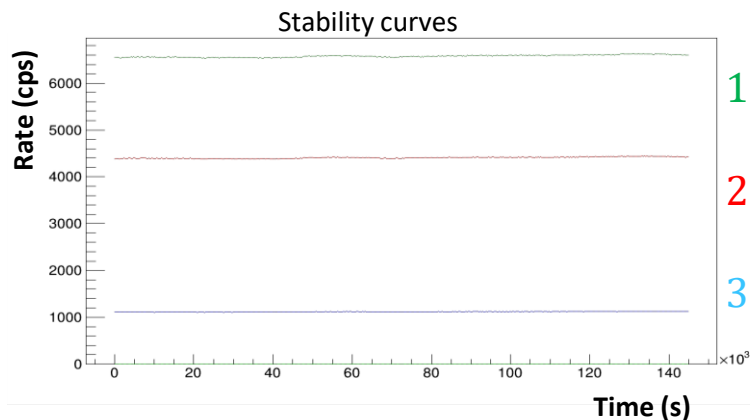
Good stability – No charging effect
No shift on PH spectra

Multitube Monitor



Stability

Two day of measurements with 3 monitors



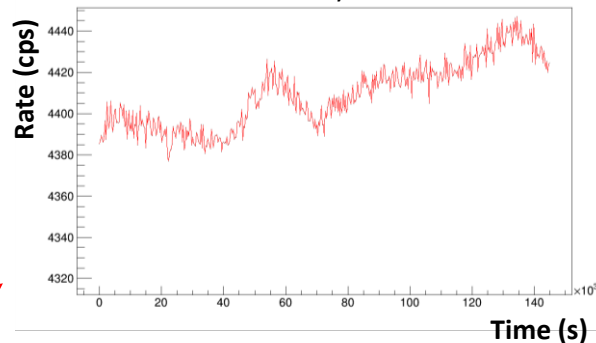
1. U - monitor 1

2. Sharp_V1

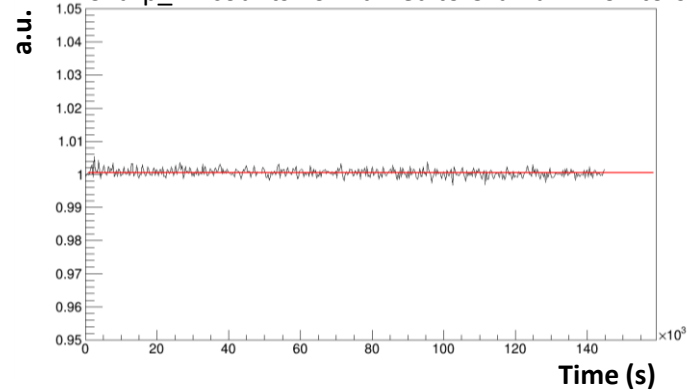
3. U - monitor 2

$\approx 0.2\%$ counting rate variations
(stat. err. $1.6 \times 10^{-1}\%$)

Beam intensity variations



Sharp_V1 counts normalized to Uranium monitors



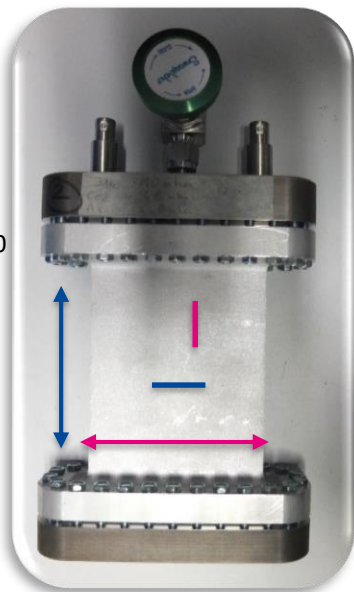
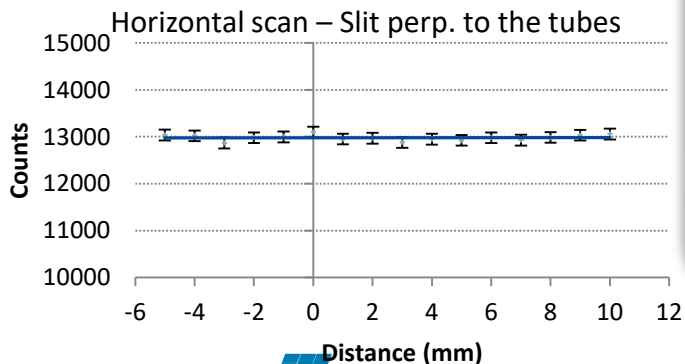
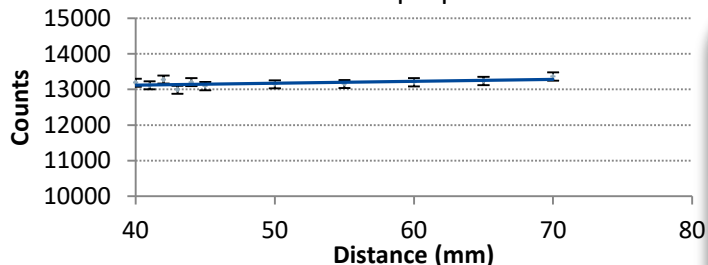
Multitube Monitor

Uniformity

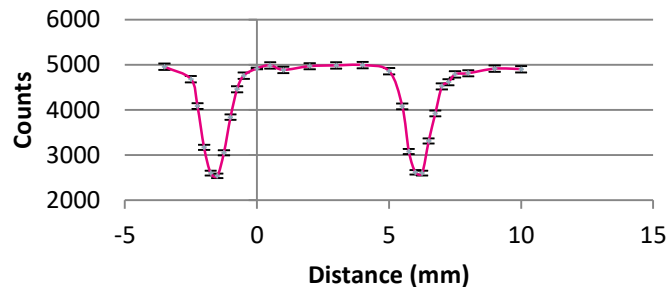


Beam collimated with a slit (0.5 mm x 12 mm)

Vertical scan – slit perp. to the tubes



Horizontal scan – slit parallel to the tubes



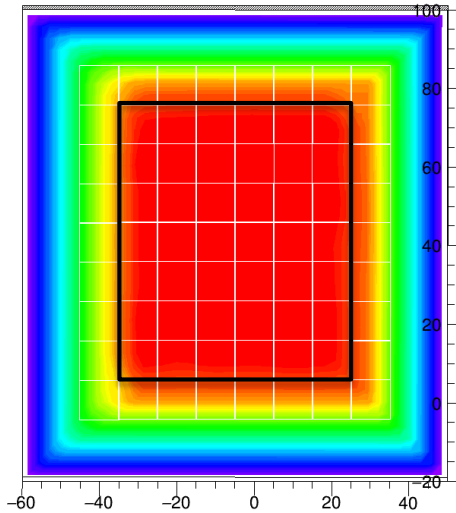
In the normal case of use with slit apertures, uniformity is great (std. dev. < 0.5 % hor. / < 0.8 % vert.)

Multitube Monitor

Uniformity



Beam collimated with a mask (20 mm x 20 mm)



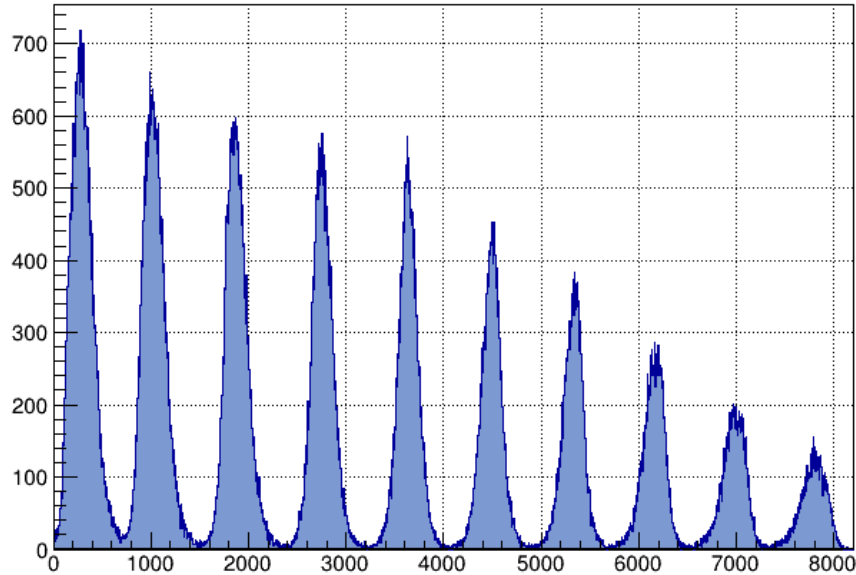
-Efficiency mapping within the active area shows a very uniform detector all over the surface

- Statistical uncertainty : 0.4 %
- Std deviation : **0.6 %**

Multitube Monitor



Optional 1D or 2D localization



This monitor could also be filled so that it allows **absolute beam flux measurements** (as hexacomb detector but with larger and more channels)

More measurements still needed to evaluate the accuracy

Conclusions

Good neutron/gamma discrimination

Tested on instrument with strong gamma background

Fast signals / high counting rate

Tested at 60 kHz - 300 Hz/mm² -- Achievable 250 kHz ?

Efficiency from 10⁻⁶ to ~0.9

Excellent uniformity

Small beam perturbations / attenuation

Optional 1D-2D localization and beam absorption profile



Thank you for your attention



INSTITUT LAUE LANGEVIN

NEUTRONS
FOR SOCIETY

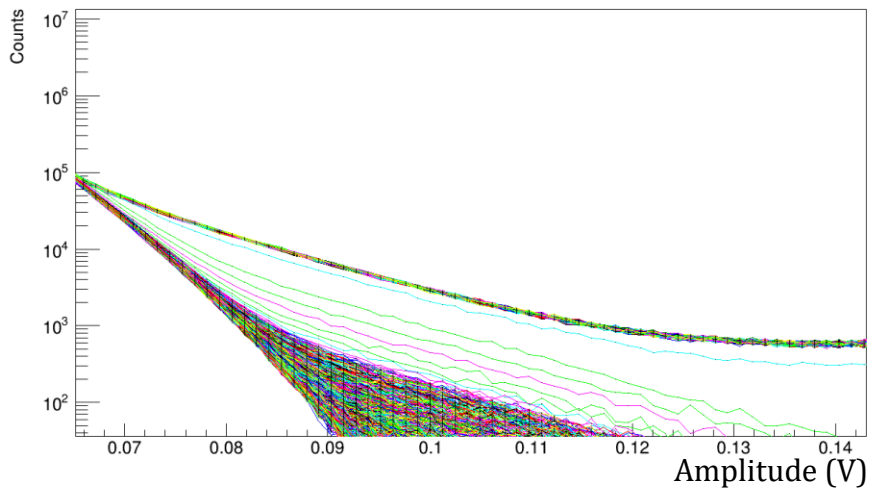


EUROPEAN
SPALLATION
SOURCE

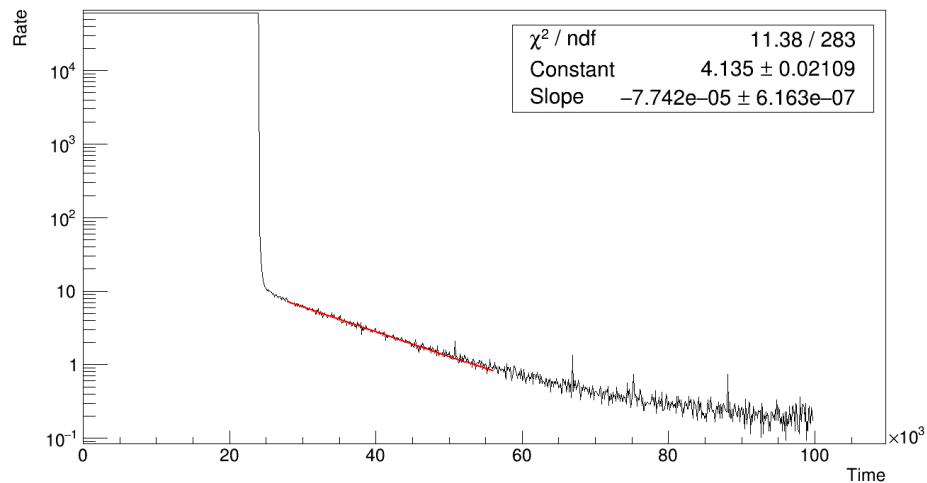
Back-up slides

Decay after shutdown

Multi-graph

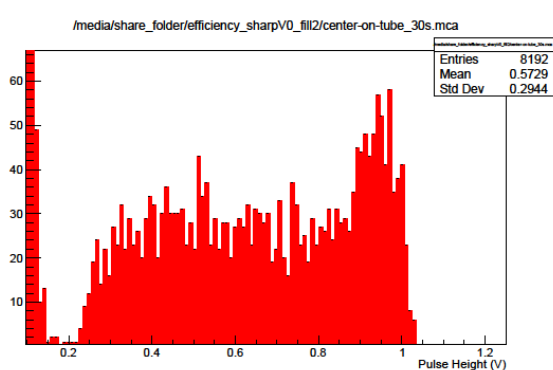


Stability curve

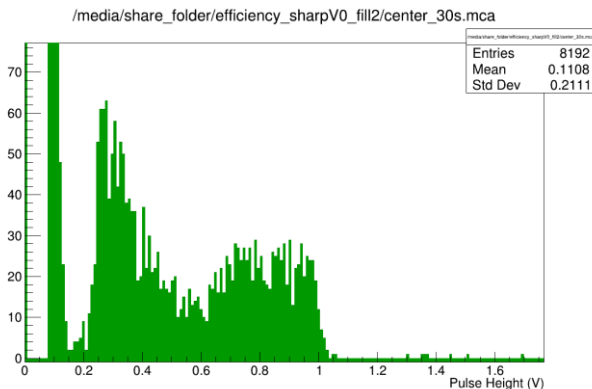


Backup slides

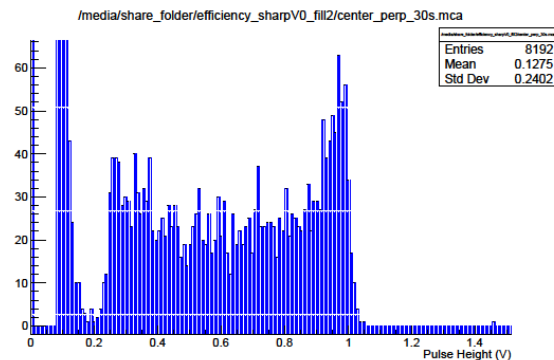
Pulse height spectra structure



2.5 mm slit
centered on tube



2.5 mm slit centered on
detector (Al wall)



2.5 mm slit perpendicular
to the tubes

Structure observed in the spectrum seems to be due to the presence of Al walls

Backup slides

Signals

