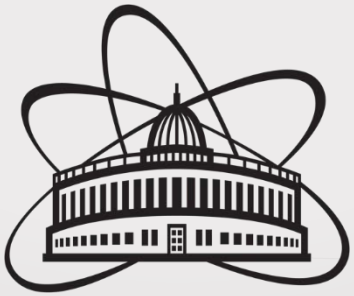
Suppression of a slow component of a BaF_2 crystal luminescence with a thin multilayer filter

Yuri Davydov,

for Dubna and St. Petersburg (“Ural-GOI”- Branch of JSC «PA «UOMP», LLC “Optech”, INCROM ltd, State Polytechnic University) groups



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2. Thin multilayer filter
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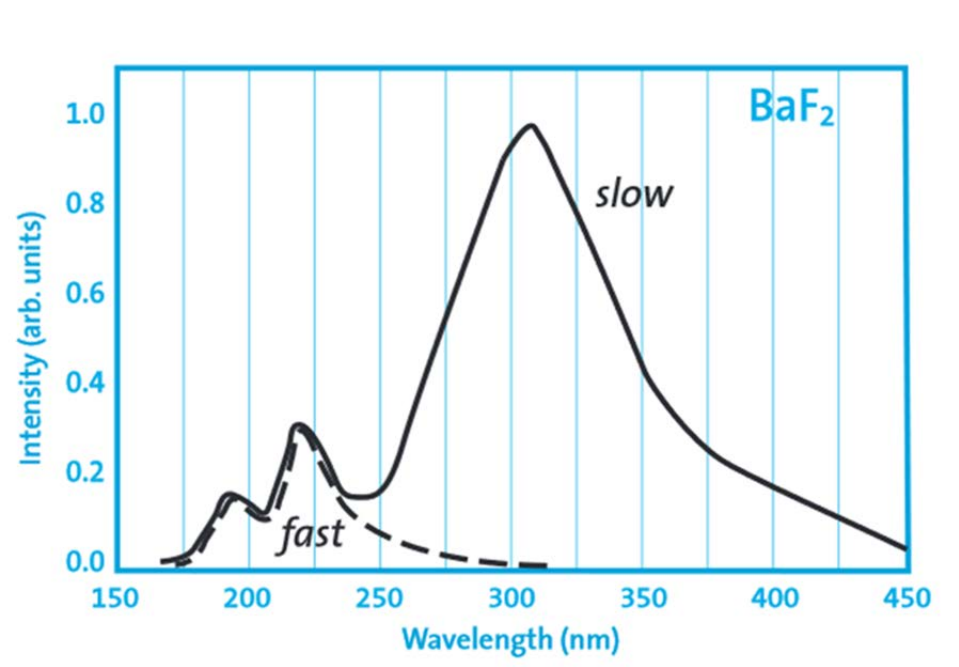
4. Conclusions and plans

Introduction



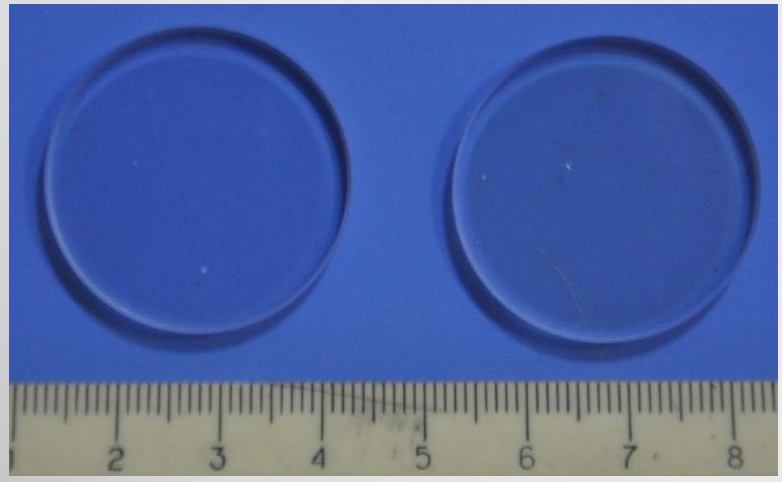
Fast components (195, 220 nm)
- Decay time <1 ns
Slow component (310 nm)
- Decay time ~620 ns

BaF_2 crystals are natural choice for the Mu2e-II calorimeter to use at the intensity frontier

A slow component of the BaF_2 luminescence could cause a problems at high rate and needs to be suppressed

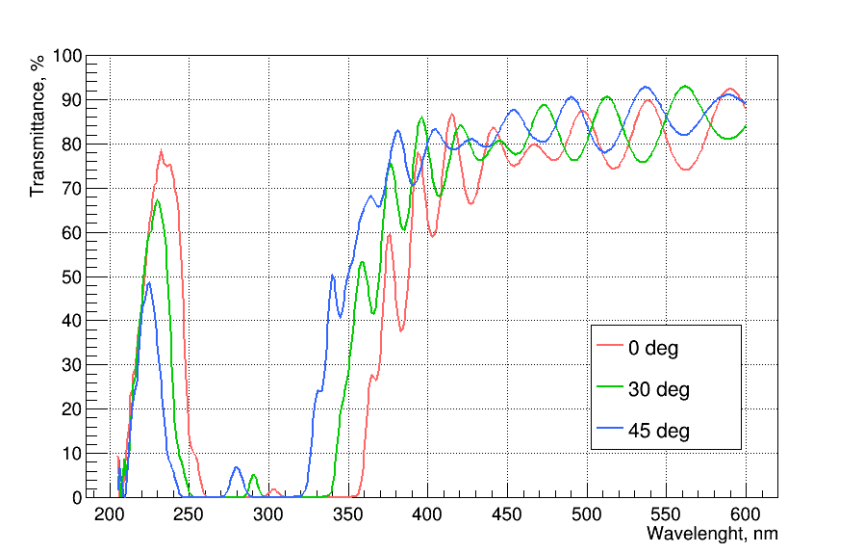
Thin multilayer filter for a BaF_2 slow component suppression

- Thin multilayer filters made of rare earth oxides can suppress luminescence in the range about from 250 nm to 400 nm
- Calculation of the filter design, selection of film-forming materials and complex analysis of a sprayed filter was carried out by the special developed program
- Filters are made by spraying thin layers of rare earth oxides on the substrate
- Thin layers are made by electron-beam evaporation of materials
- Typically filters comprise up to 200-220 layers depending of optical range and suppression level



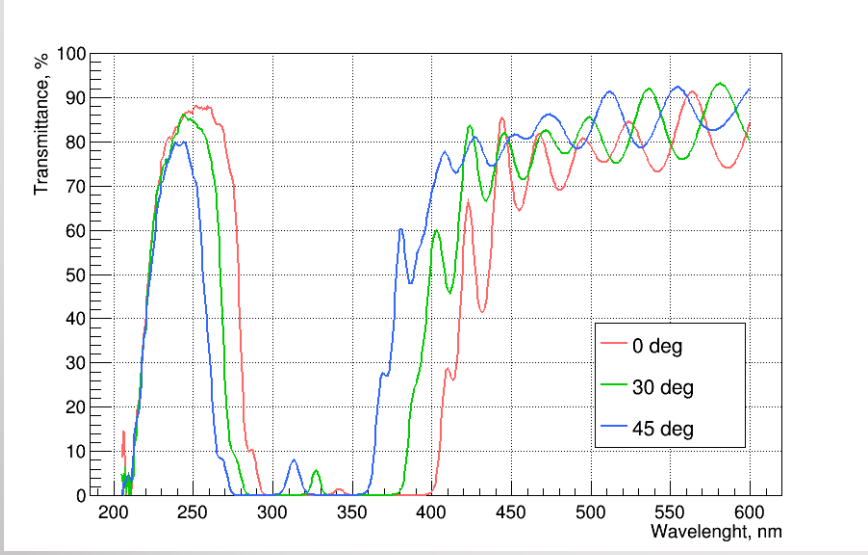
We have a few samples of a multilayer filters sprayed on the quartz glass substrate (KU-2 type)
Quartz glass substrates are 30 mm in diameter and 3 mm thick
Quartz glass is optimal material for the multilayer filter evaporation

Transmittance of single filters



Transmittances of filters were measured with Shimadzu SolidSpec-3700 DUV photo spectrometer

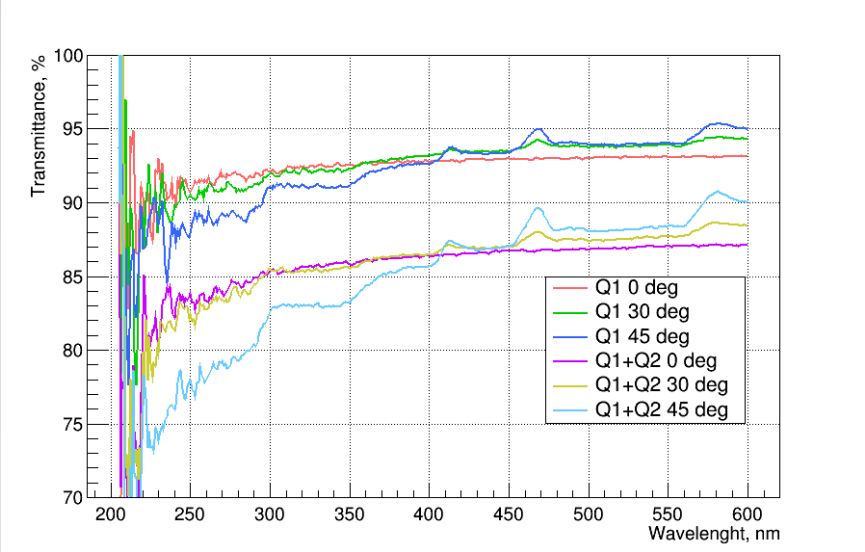
Filter: type1



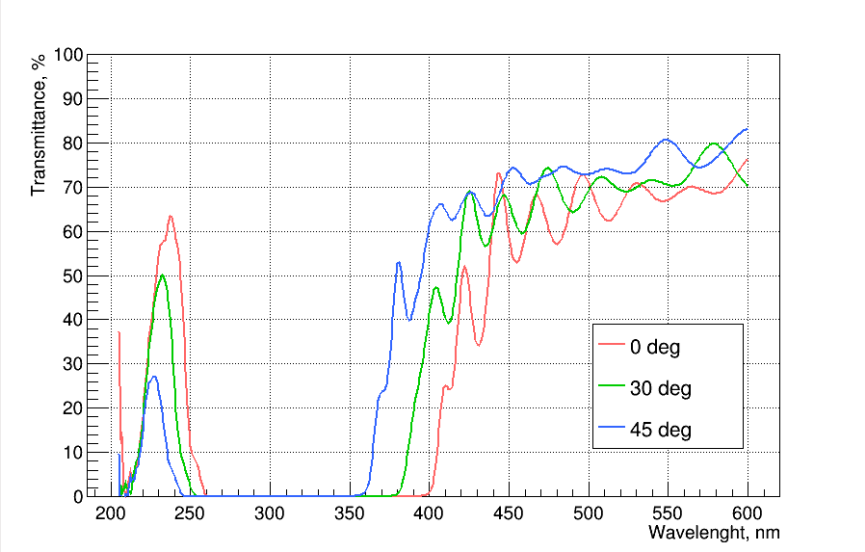
One can see that single filter type1 or type2 is not enough to significantly suppress the slow component. Two filters together should provide essential suppression of the slow component. However, fast component will be suppressed as well

Filter: type2

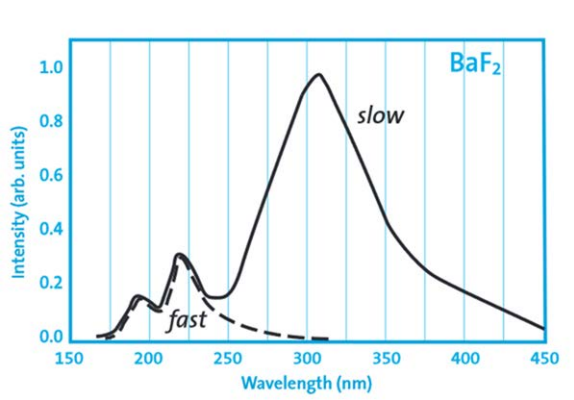
Transmittance of pair of filters



Single or two quartz windows



Two filters together: type1+ type2



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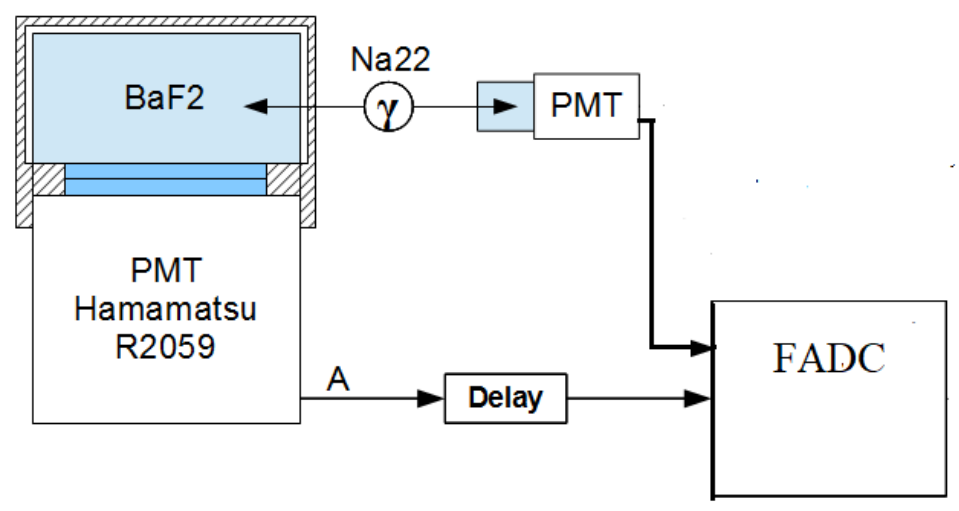
Tests of the BaF_2 with filters

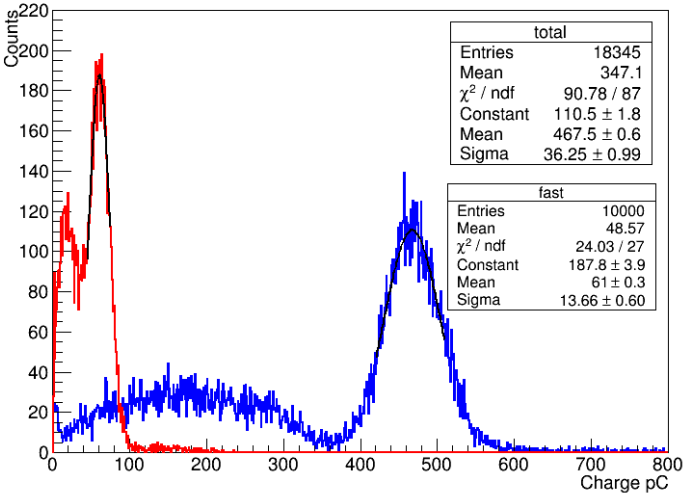


The block diagram of setup

- We tested BaF_2 crystal with pair of filters (type1+type2)
- Crystal has dia. 30 mm and height 30 mm
- Hamamatsu R2059 PMT was employed for measurements
- Data were digitized with CAEN digitizer
- Triggers were provided by two back-to-back emitted 511 keV gammas
- No optical grease was used between PMT-filters-crystal

BaF_2: Fast/Total ratio

A.



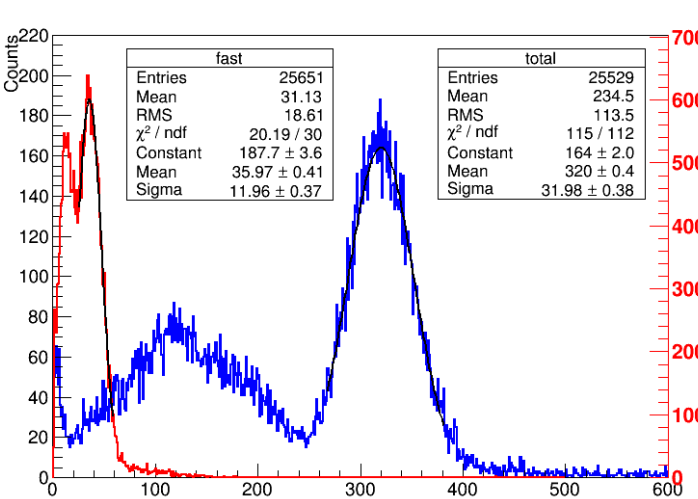
A. BaF_2 directly coupled to photocathode
F/T = 0.13.

B. BaF_2 coupled to photocathode with two quartz windows F/T = 0.11.

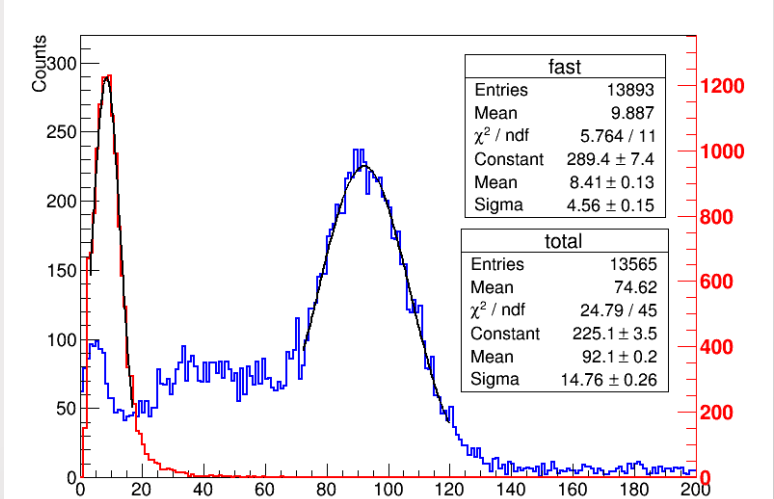
C. BaF_2 coupled to photocathode with two filters (quartz). The total signal is suppressed approximately 3.5 times.

Unfortunately, the fast component is also suppressed
F/T = 0.9.

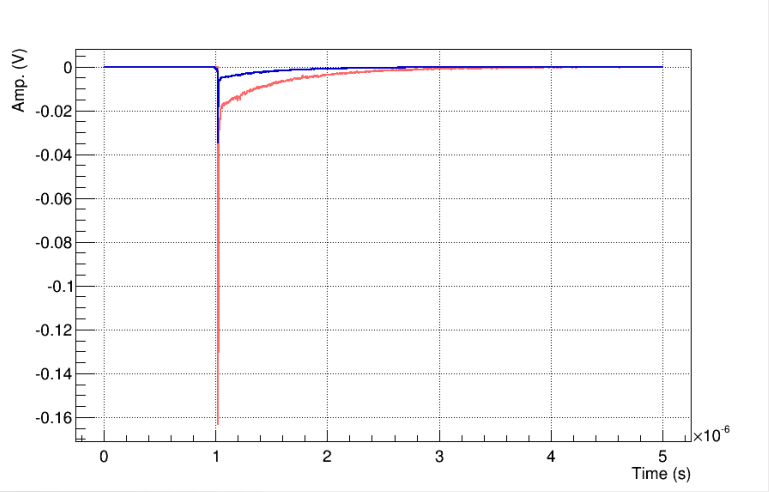
B.



C.

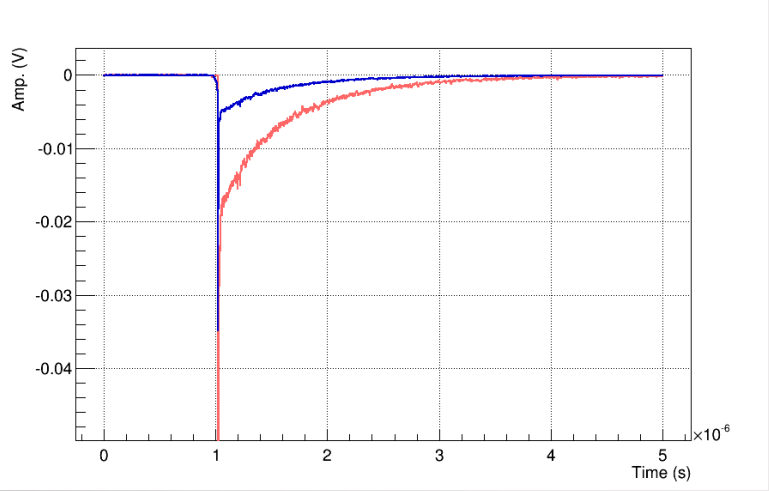


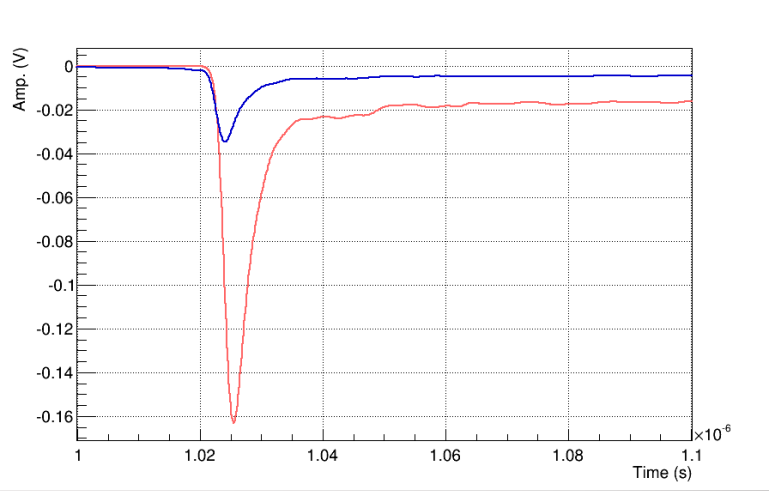
BaF_2 signals



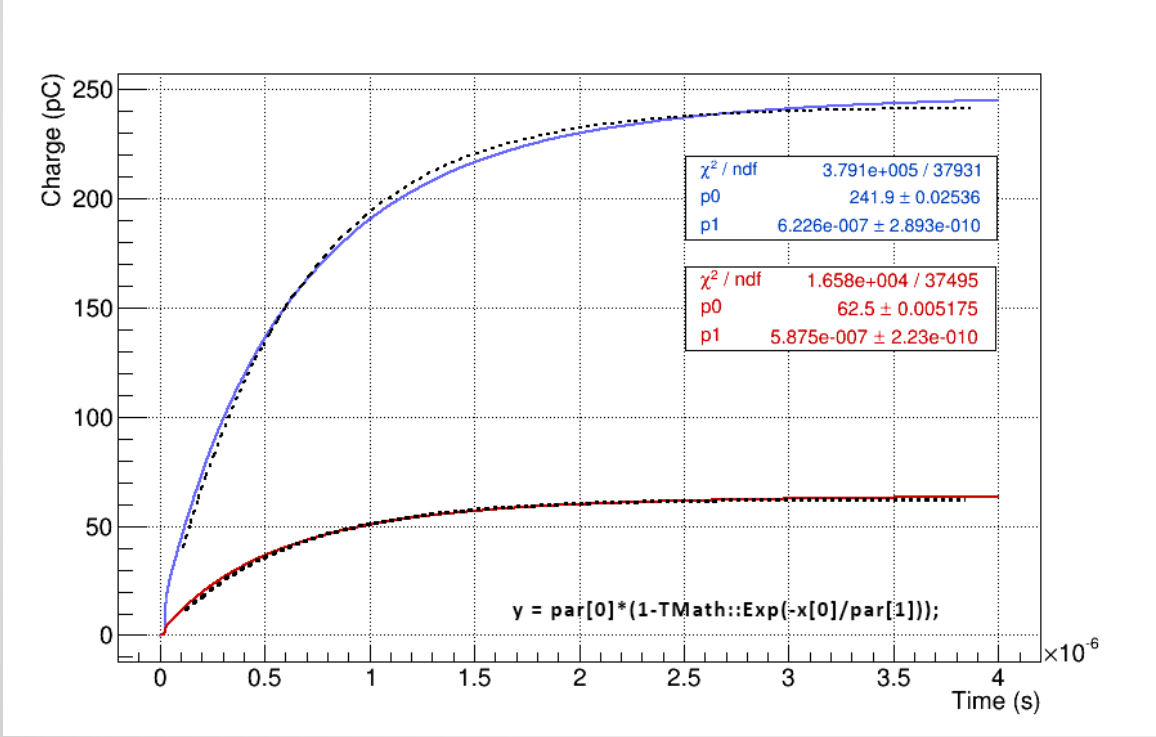
Averaged signals from the crystal with and with no filter:
Left, top – full scale
Left, bottom – with details in amplitudes
Right, bottom – with fast component details

Two bottom frames demonstrate that both slow and fast components are suppresses about 4 times





Charge integral

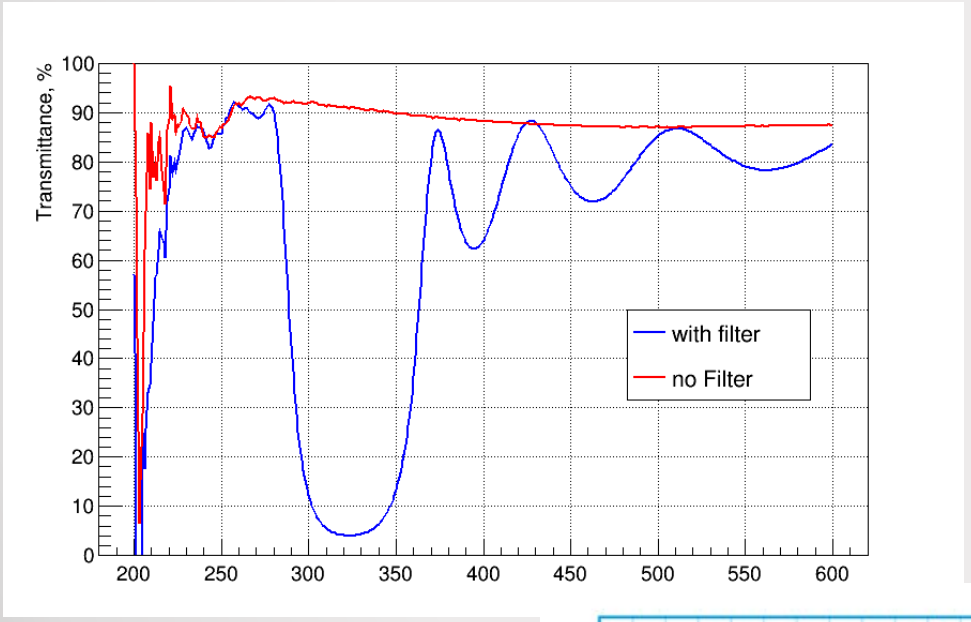


The averaged signal charges were calculated for the full range of digitization for a crystal with no and with a filter

The total charge indicates the suppression of the signal from the crystal with the filter about 4 times

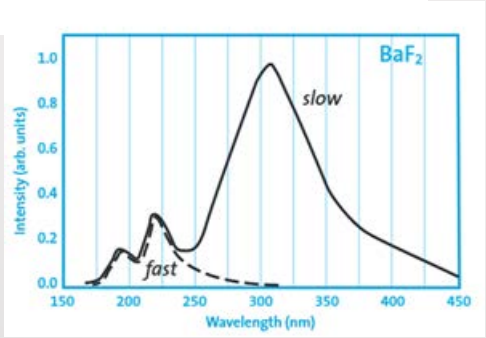
Filter sprayed on the BaF_2 crystal

Crystal is 30 mm in diameter and 30 mm in height. All surfaces are polished.
It was one of the first attempts to spray a filter on the crystal:
multilayer filter was sprayed on one BaF2 crystal end



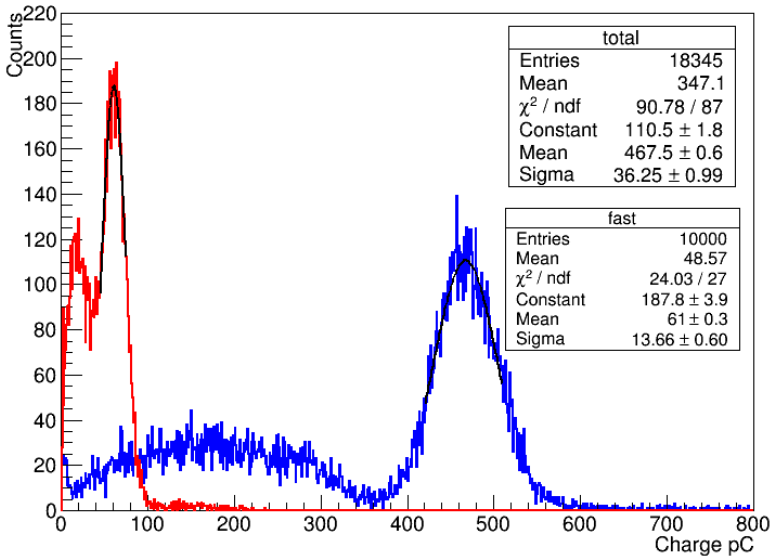
Transparencies:
blue - BaF_2 with a filter
Red - BaF_2 without filter

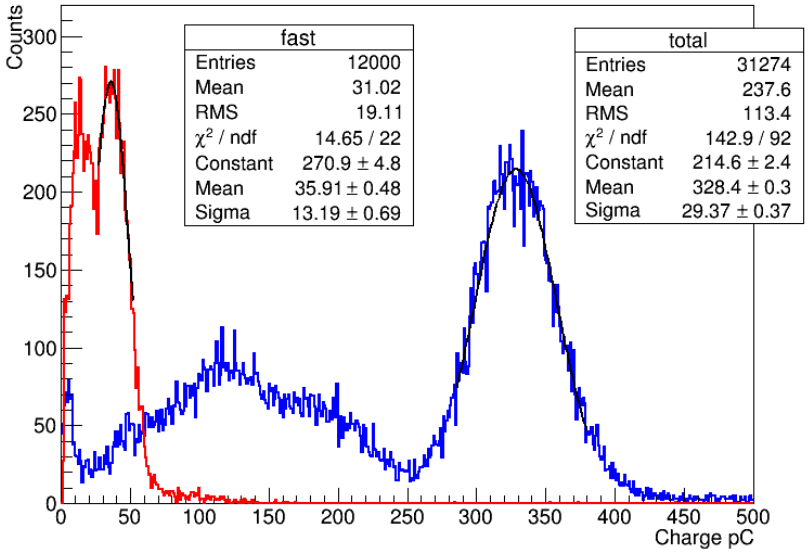
The filter quality is much worse than that one sprayed on the quartz window



One can see that filter will suppress only a fraction of a slow component luminescence

Signals from BaF_2 crystal with a sprayed filter





Data taken with FADC:

- Trigger: two back-to-back emitted 511 keV gammas from ^{22}Na

Top frame – ^{22}Na spectra from the BaF_2 without a filter
Bottom frame – ^{22}Na spectra from the BaF_2 with evaporated filter

Blue - total signal
Red - fast signal

Data shows that suppression of a total signal is about 1.5 times

Conclusion …

- Thin multilayer filters made of up to 200 layers of rare earth oxides can suppress a luminescence in the range about from 250 nm to 400 nm and could be used for suppression of a slow component in the BaF_2 crystals
- Filters made by spraying thin layers of rare earth oxides on a quartz glass substrate suppress the total signals from the BaF_2 4 times
- Filter sprayed directly on the BaF_2 surface allowed to suppress the total signal about 1.5 times
- Certainly, it is necessary to continue research to improve the quality of multilayer filters

… and future plans

We plan to continue R&D on that direction in order to improve the quality of filters (increasing suppression of a slow component and improving transparency of filters in the 190-230 nm range).

Participating groups:

JINR, Dubna, Russia
Ural-GOI, Branch of JSC PA UOMP, St. Petersburg, Russia
LLC Optech, St. Petersburg, Russia
INCROM ltd, St. Petersburg, Russia
St. Petersburg State Polytechnic University, St. Petersburg, Russia

Welcome to join u for this R&D!