FOOT General Meeting, 2020 December 10^{th}

Neutron Detection at CNAO

FOOT collaboration awareness campaign: stop with the positives!

Michela M. for the FOOT_neutrons

State of the Art

- Nice overviews of the existing neutrons cross section data has been presented by Cristian Massimi during this year. He will present this afternoon an ***"Updates on neutron data in the literature and possible setup for the CNAO and GSI test".***
- The idea is: became familiar with neutron measurements repeating a measurement present in the literature and then in the future try to fill the gaps in the production cross sections in element of interest - i.e. C,H,O. *[A FOOTnote PRIN/something would help!]*
- When the calorimeter will be completed, interesting analysis can be performed exploiting the data collected by the calorimeter (Cristian presented some ideas in the past). However for the moment the size of the calorimeter probably do not allows for this scope.
- For the moment.. we have to think something else.. **Few ideas in this talk.** Remember that:

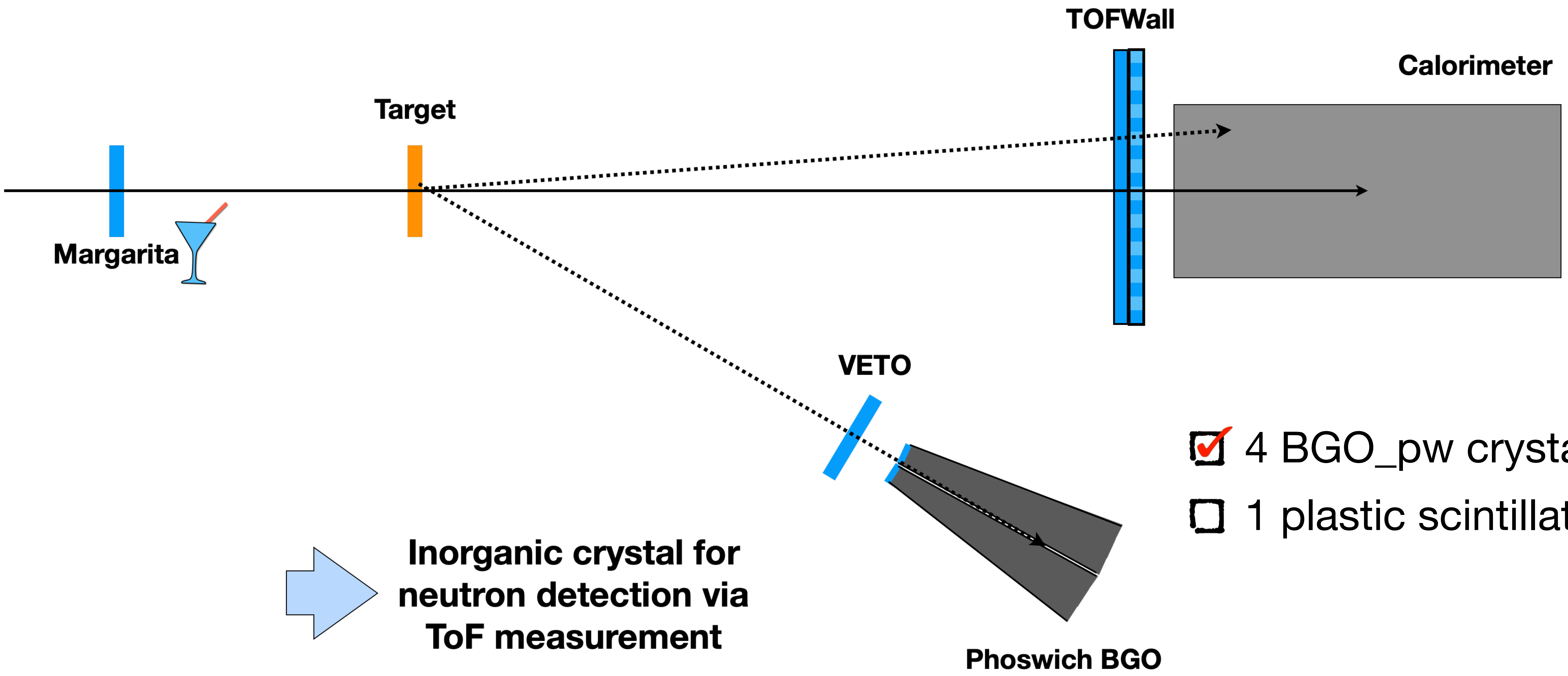
☑ CNAO and GSI we can target double differential inclusive cross sections for the production of neutron in p+(C/O/H) and ^{12}C+(C/O/H) reactions and ^{16}O+(C/O/H) respectively.

☐ Statistics with neutrons is a nightmare.. detection efficiency is low: special runs at high beam intensity are required to make a strong measurement.

UltraFast neutrons

TOF MEASUREMENTS

- A dedicated extra detector can be added to the FOOT setup: we want be sure to do not perturb the standard setup..



- [x] 4 BGO_pw crystals
- [ ] 1 plastic scintillator veto

Inorganic crystal for neutron detection via ToF measurement

UltraFast neutrons

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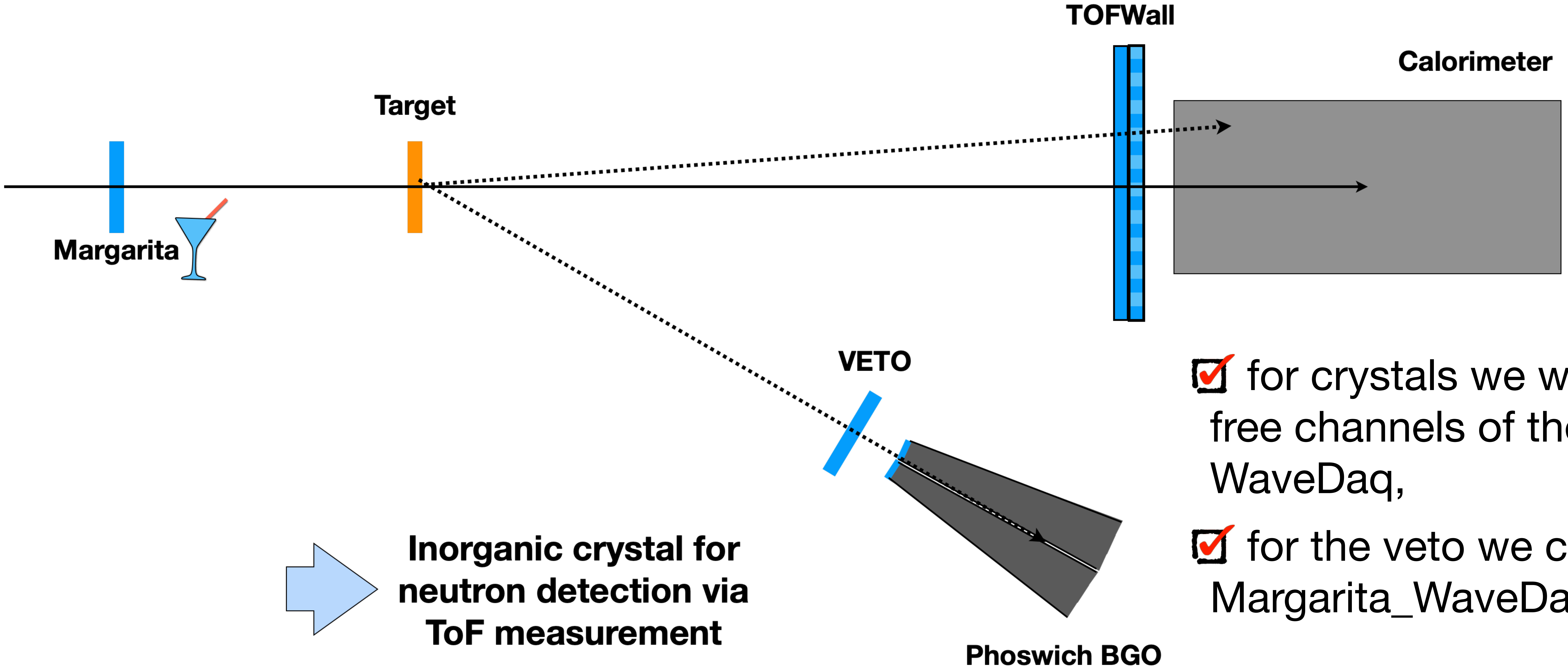

Inorganic crystal for neutron detection via ToF measurement

- ☑ for crystals we want to exploit the free channels of the calorimeter WaveDaq,
- ☑ for the veto we can exploit the Margarita_WaveDaq free channels

UltraFast neutrons

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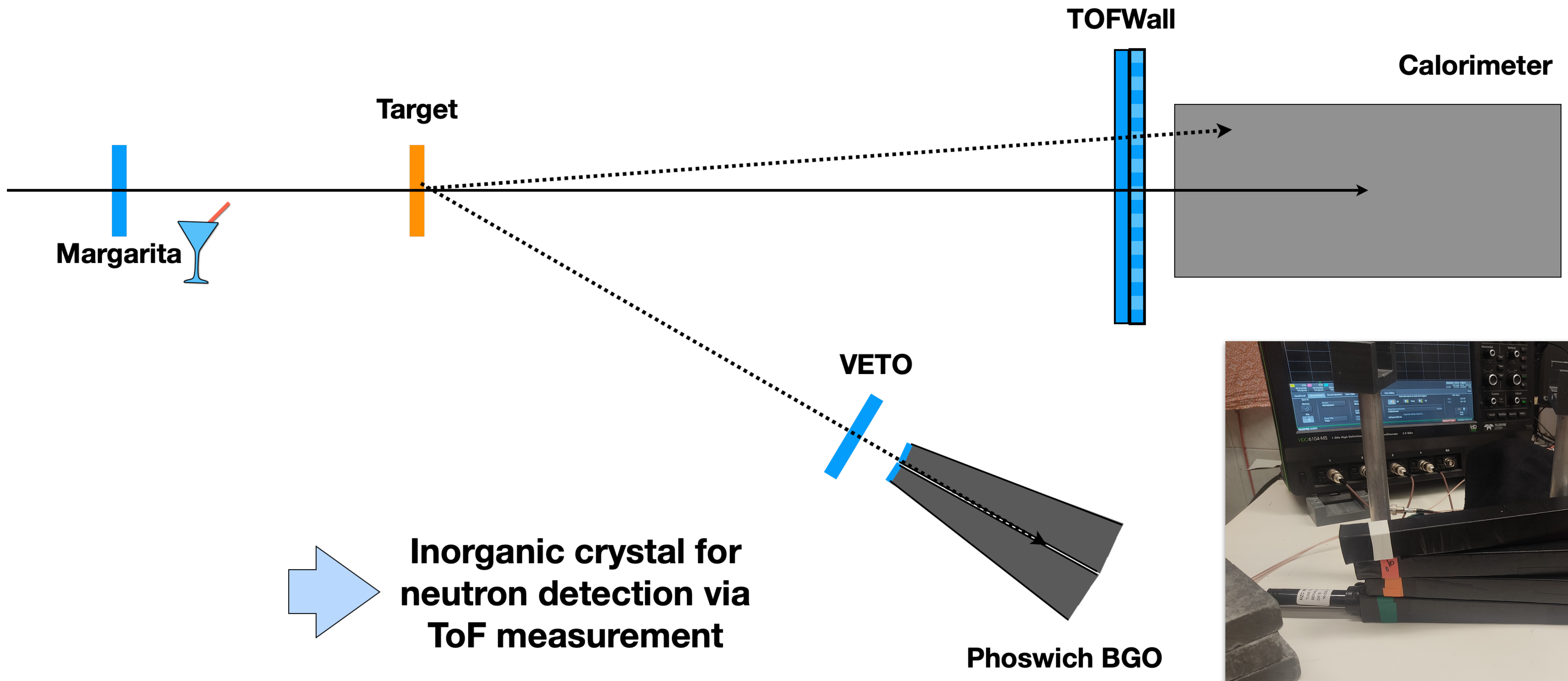
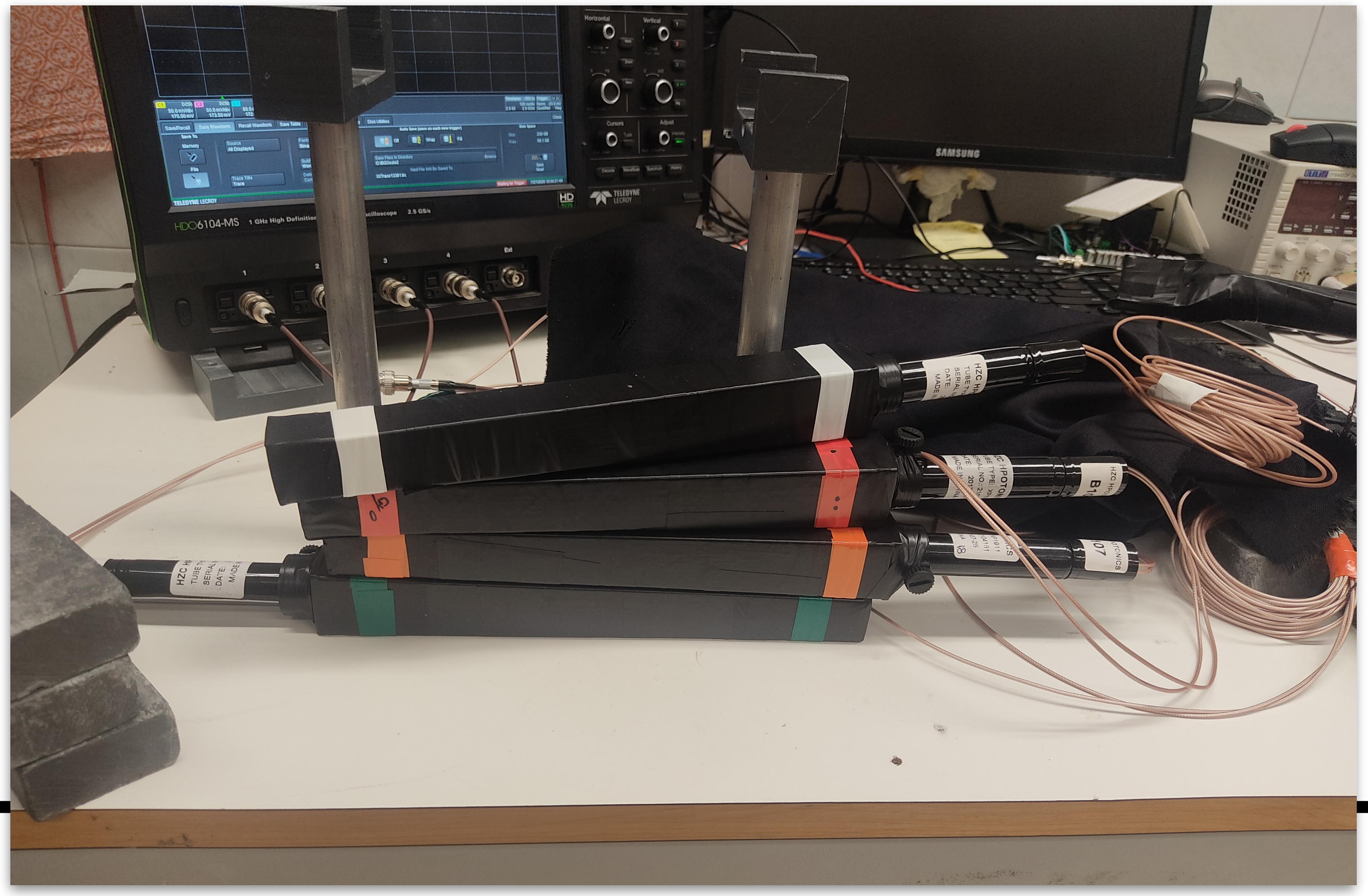
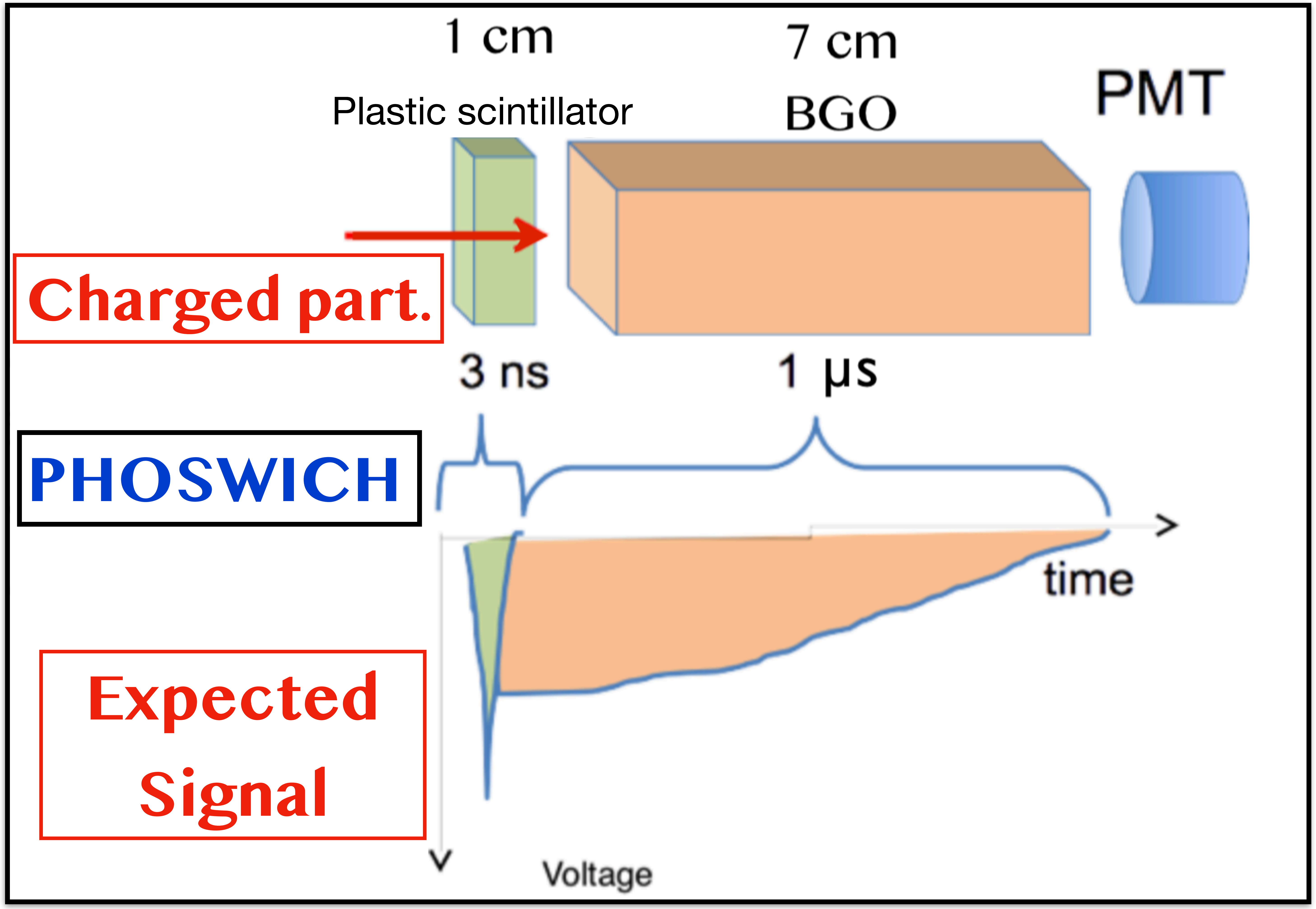
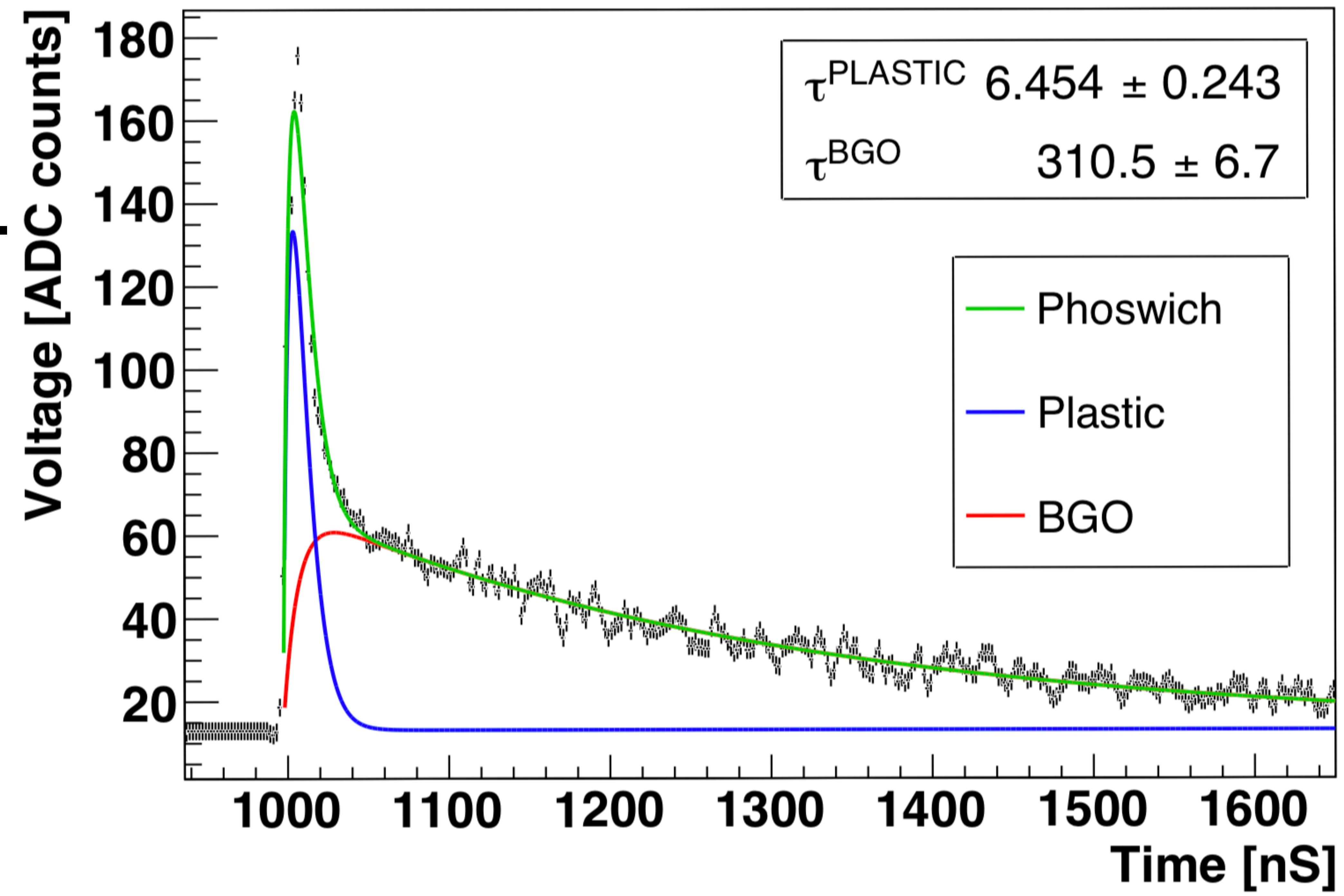


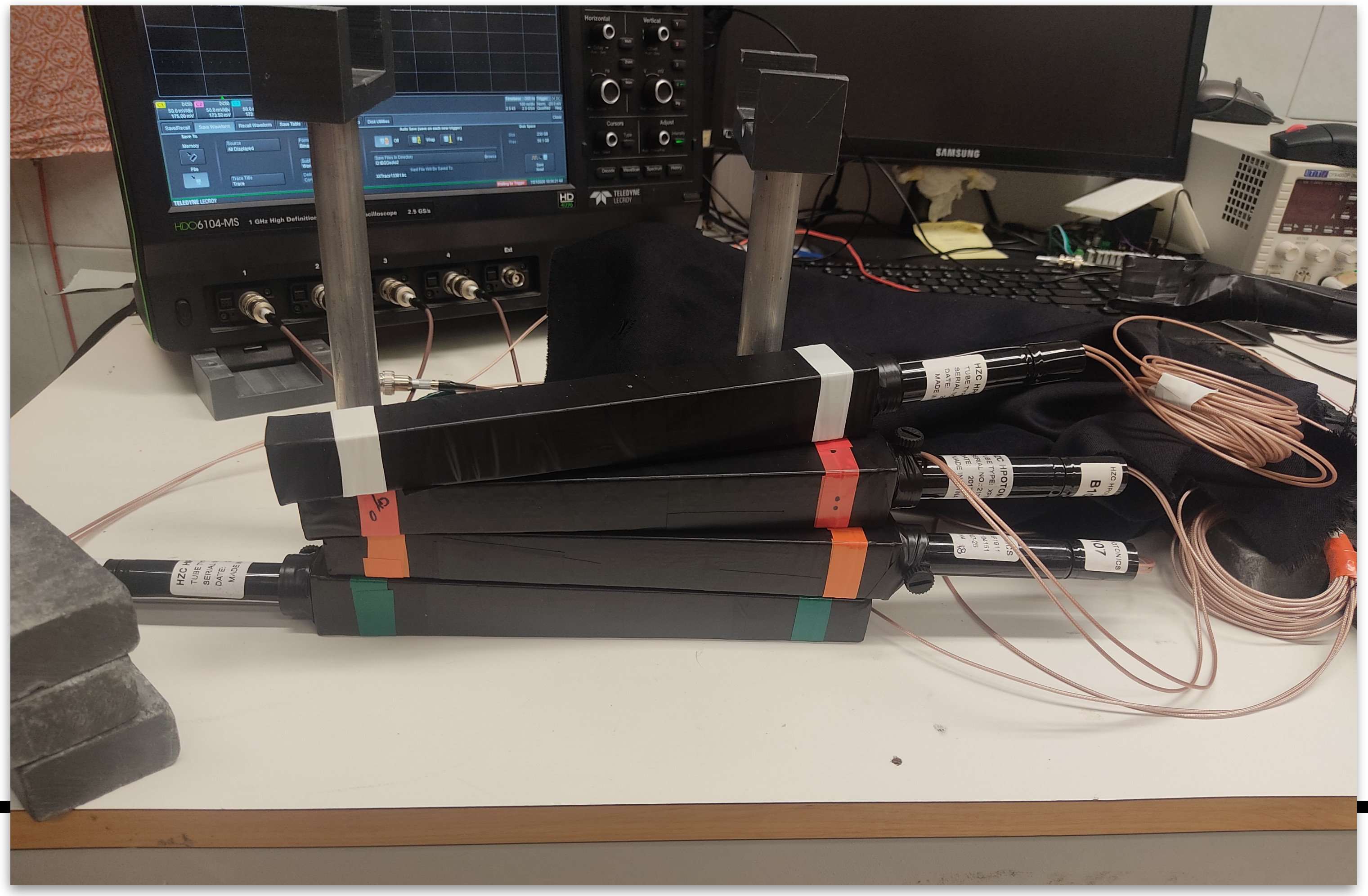
Inorganic crystal for neutron detection via ToF measurement



UltraFast neutrons



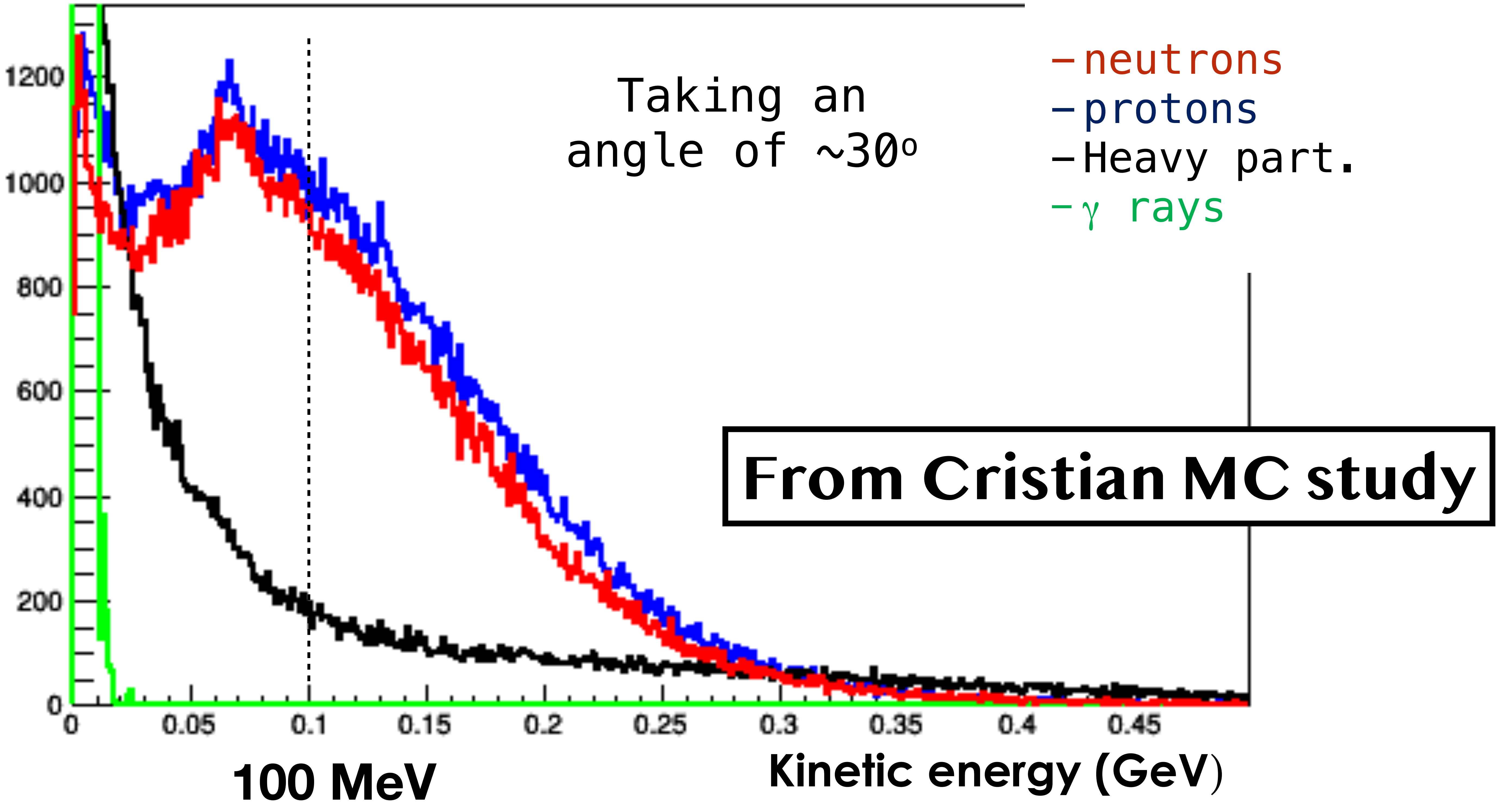




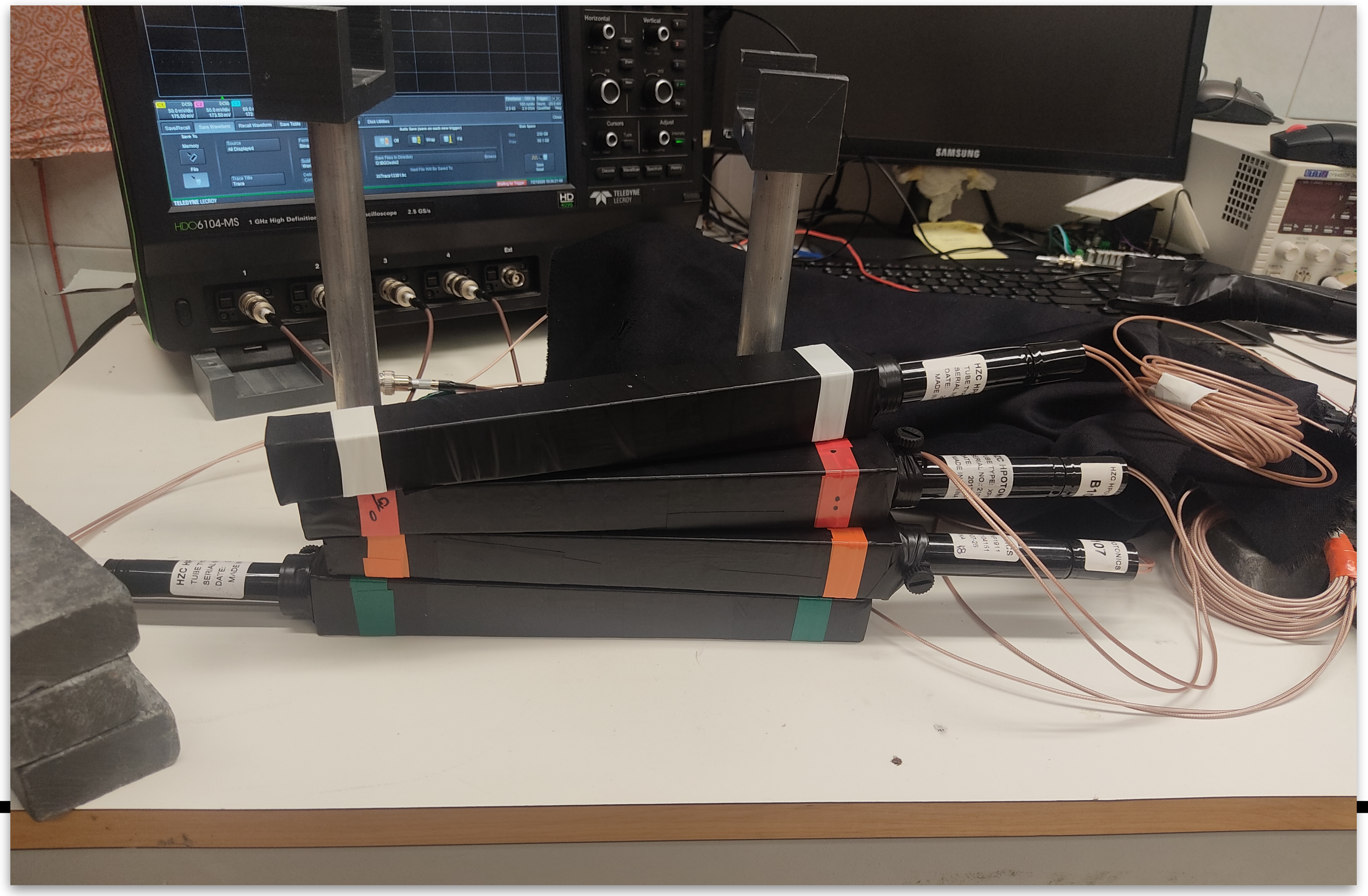
UltraFast neutrons

TOF MEASUREMENTS

- Charged particles are a large background that can be suppressed ‘easily’ looking at the veto and the crystals: the phoswich setup allows for a nice separation between charged and neutral particles with a good time resolution for the charged ones.



- The main source of irreducible background comes from the neutron produced in the calorimeter.. to be studied!!!



UltraFast neutrons

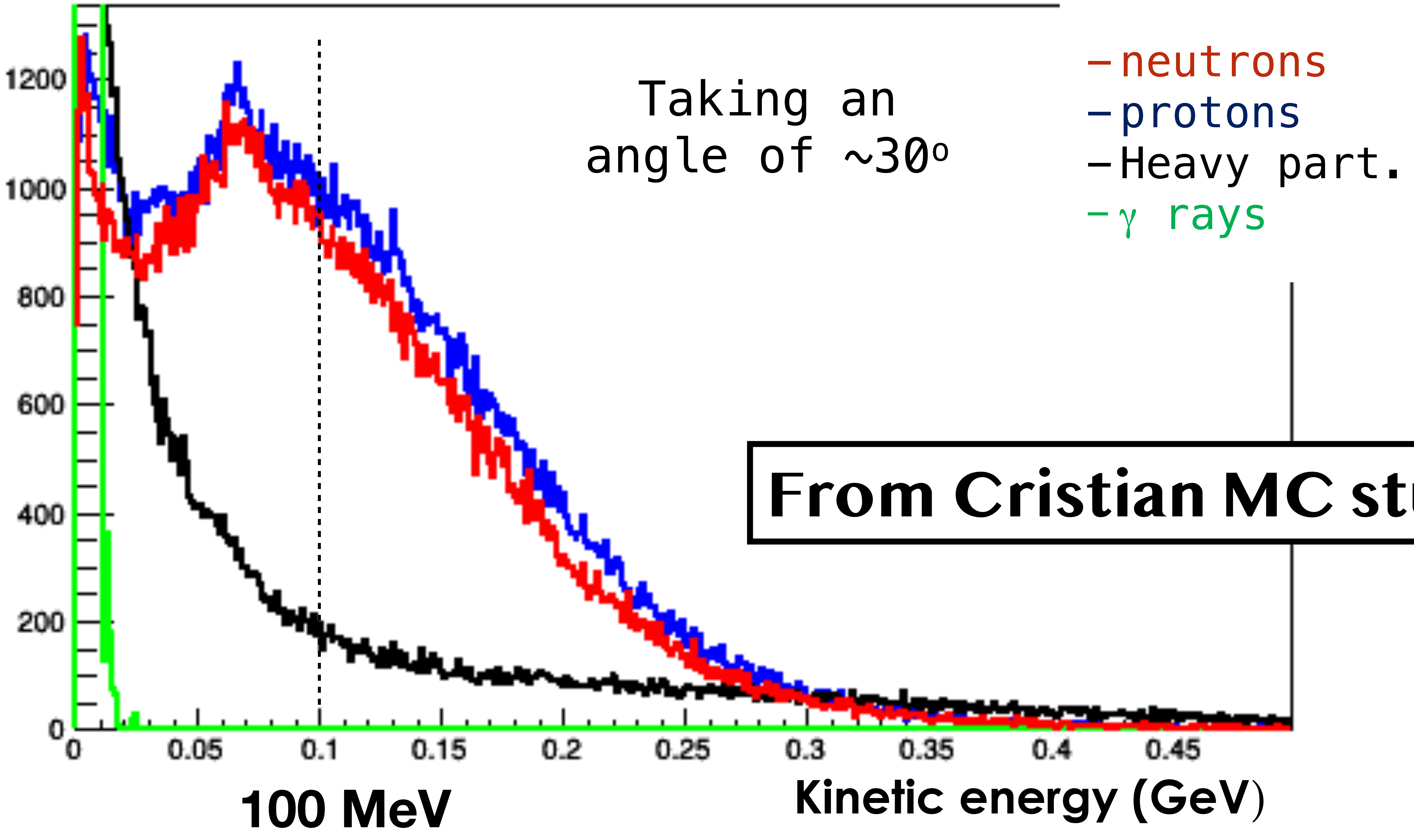
...NTS

- Charged particles are a large background that can be s... ...he veto and the crystals: the phoswich setup allows for a nice sepa... ...eutral particles with a good time resolution for the charged or...

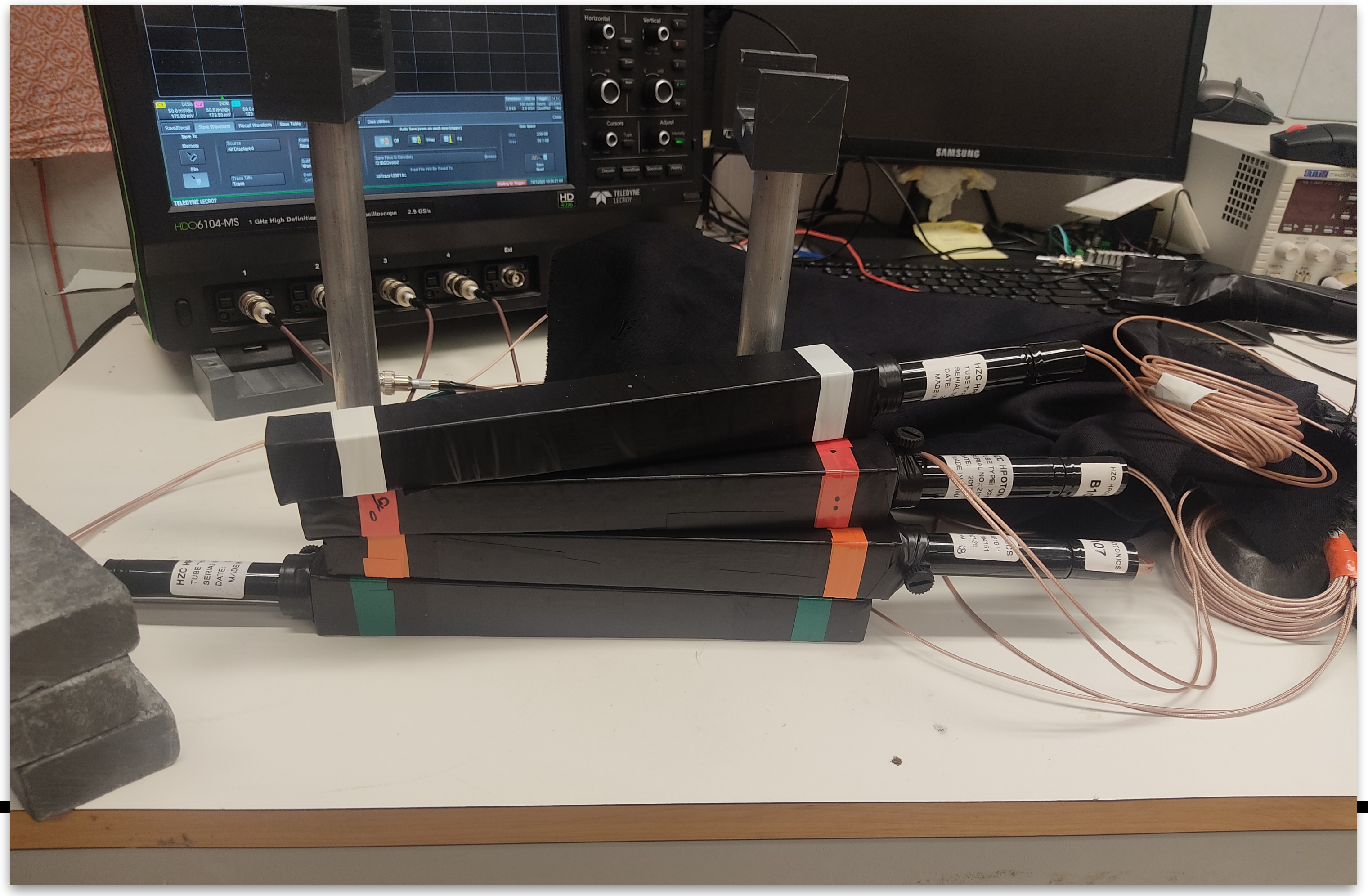
~ 181000 neutrons
Geometric efficiency ~ 1%
Detection efficiency ~ 10 %
→ **181 events in the detector for 5x10^{7} primaries**

=> 0.3 hours for ~10 neutrons
(3 hours for 100 neutrons)
(beam 1kHz)

...ucible ... the neutron ...ter.. to be studied!!!



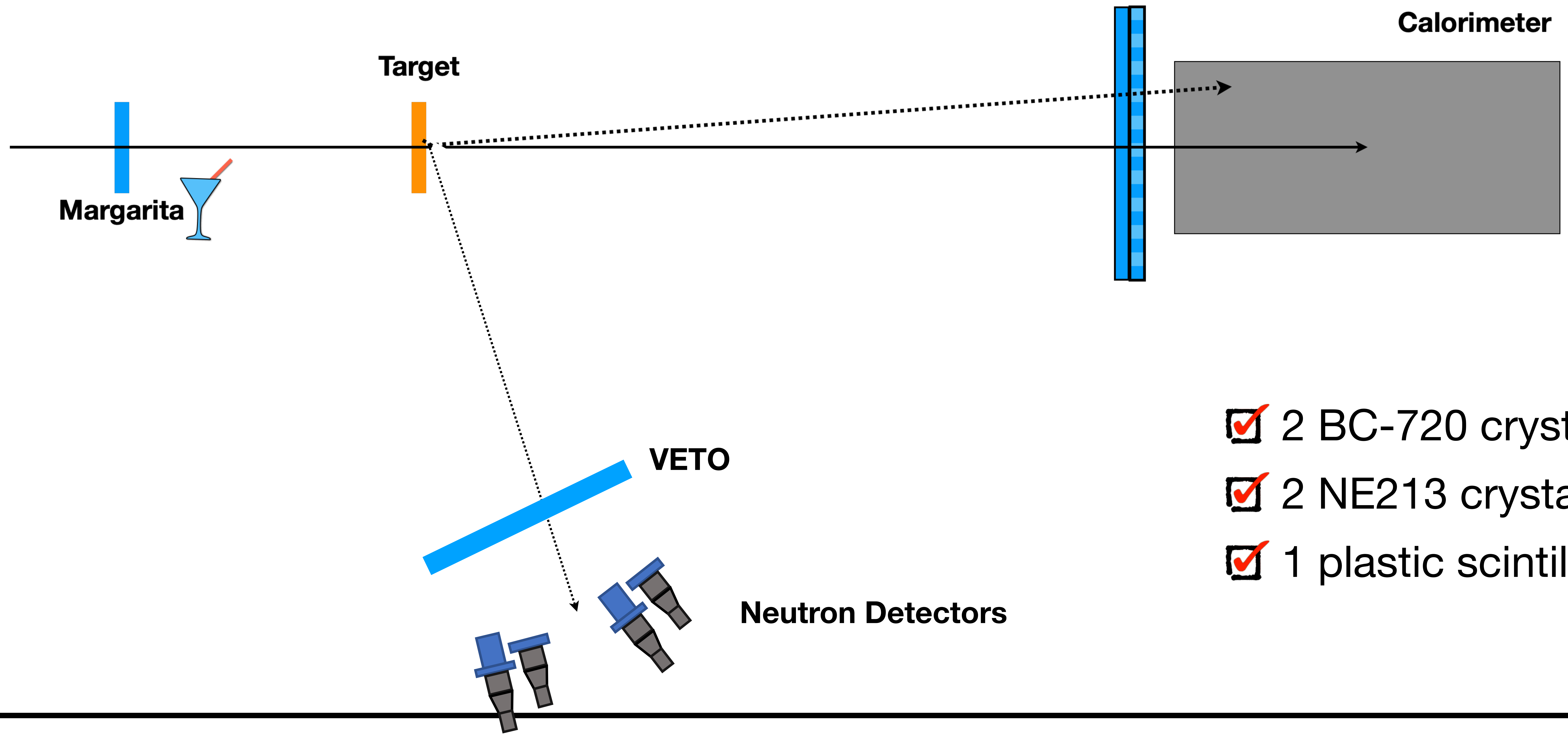
From Cristian MC study



Fast neutrons

TOF MEASUREMENTS

- A dedicated second extra detector can be added to the FOOT setup: we want be sure to do not perturb the standard setup..



- ☑ 2 BC-720 crystals
- ☑ 2 NE213 crystals
- ☑ 1 plastic scintillator veto

Fast neutrons

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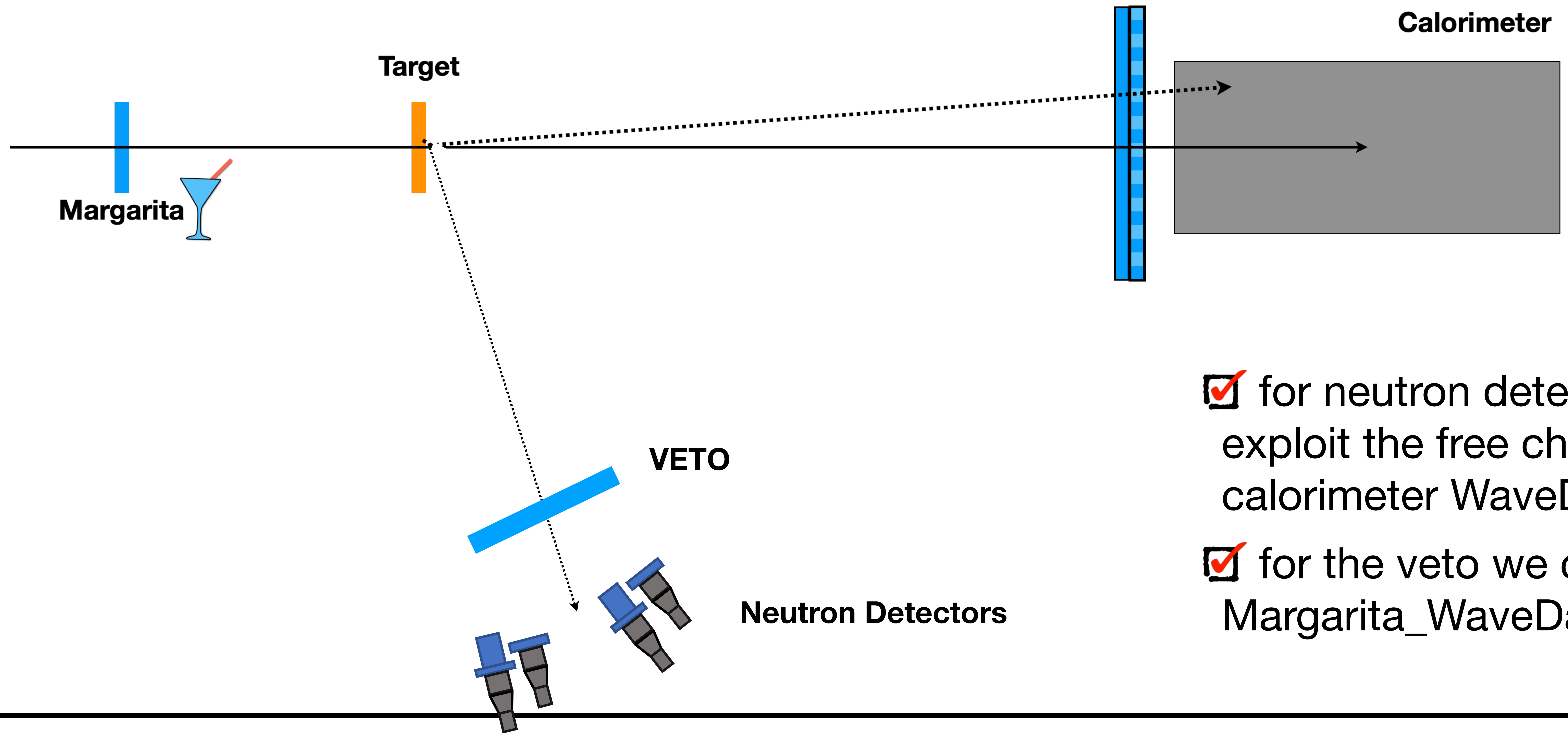


☑ for neutron detector we want to exploit the free channels of the calorimeter WaveDaq,

☑ for the veto we can exploit the Margarita_WaveDaq free channels

Fast neutrons

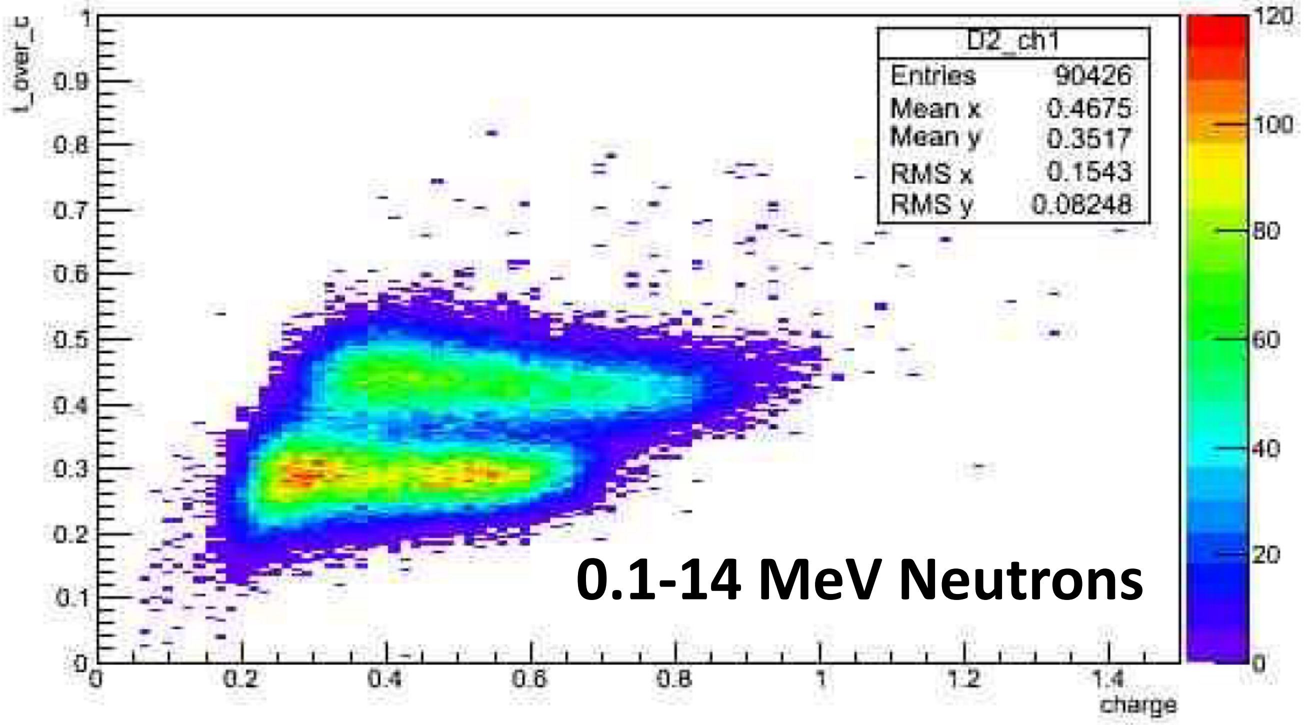
TOF MEASUREMENTS

- A dedicated second extra detector can be added to the FOOT setup: we want be sure to do not perturb the standard setup..
- these detectors work on neutron-proton scattering and are therefore more **efficient at low energy** (fast neutrons, order of MeV) than high energy neutrons. There is no break in physics, but high-energy neutrons interact little due to the collapse of the cross section.

NE232

Liquid scintillator optimised for:

☑ neutron/gamma separation



BC-720

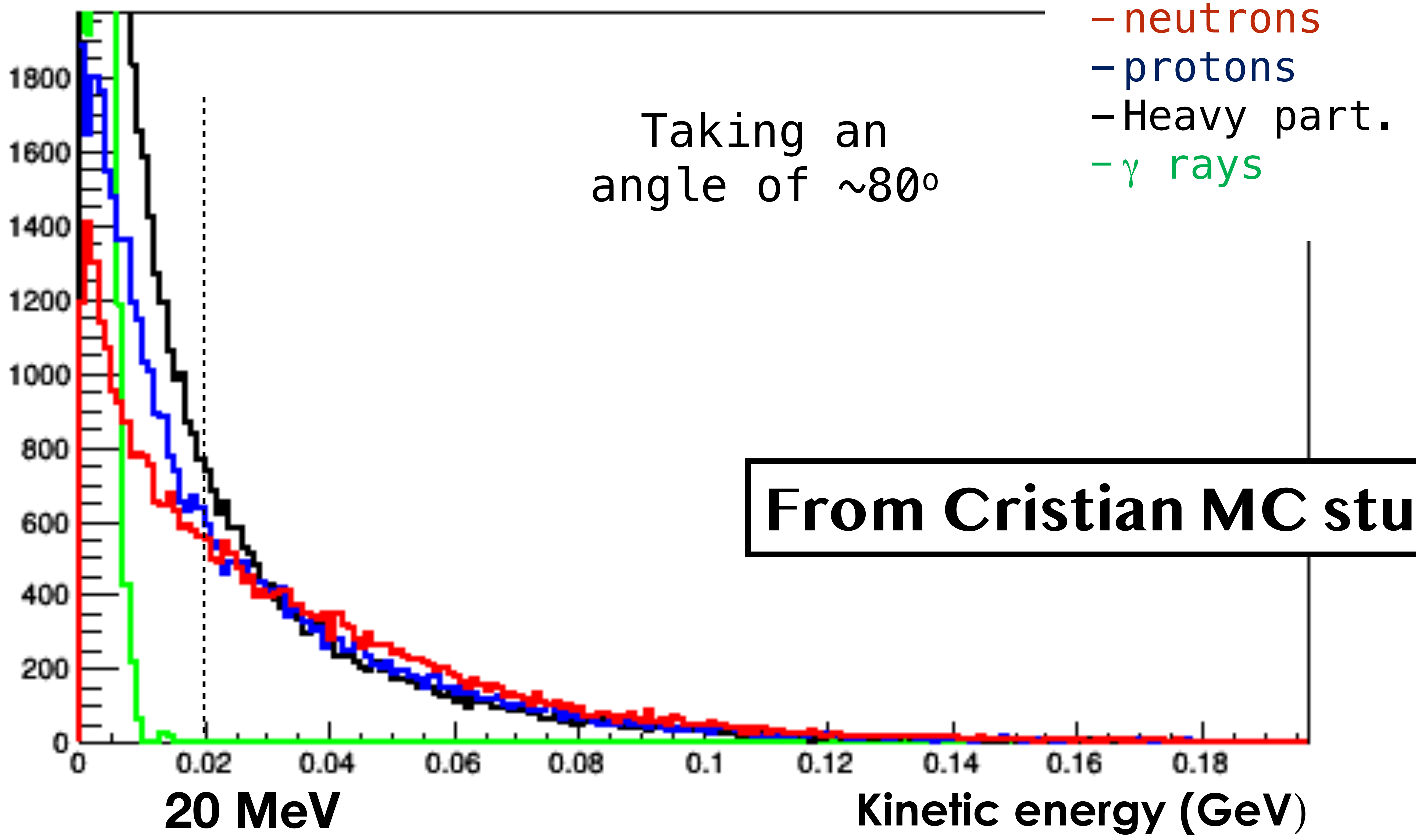
ZnS(Ag) phosphor embedded in a clear hydrogenous plastic: detection of the proton recoil interaction in the plastic (the proton being detected by the ZnS).

☑ insensitive to gamma radiation

UltraFast neutrons

TOF MEASUREMENTS

- Photons are a background in NE213 but can be discriminated by PSD while the BC 720 iis gamma insensitive.



- The charged particles will be veted by an external plastic scintillator veto.

~ 36000 neutrons
Geometric efficiency ~ 1%
Detection efficiency ~ 10 %
→ **36 events in the detector for 5x10⁷ primaries**

=> 3 hours for ~30 neutrons
(beam 1kHz)

Summarising

- We have two possible setup, one dedicated to high energy (>10 MeV) and an other more efficient for low energy (<10 MeV).

DAQ Channels

- CaloWDaq (6 free channels)
- MargWDaq (8 free channels)

- 4 BGO_pw => 4 CaloWDaq
- 1 Veto. => 1 MargWDaq

and/or

- 2 BC-720 + 2 NE213 => 4 CaloWDaq
- 1 Veto. => 1 MargWDaq

Trigger Channels

- "Luca" allows for a couple of dedicated triggers
- LE and HE neutron setups can run in parallel but we are limited by the number of free channels in the CaloWDaq
- Efficiency runs have to be scheduled
- High rate runs are largely suggested

TO DO

A dedicated MC of the setup to study the expected number of events and the expected outcome.

Altro?