05 Oct 2020

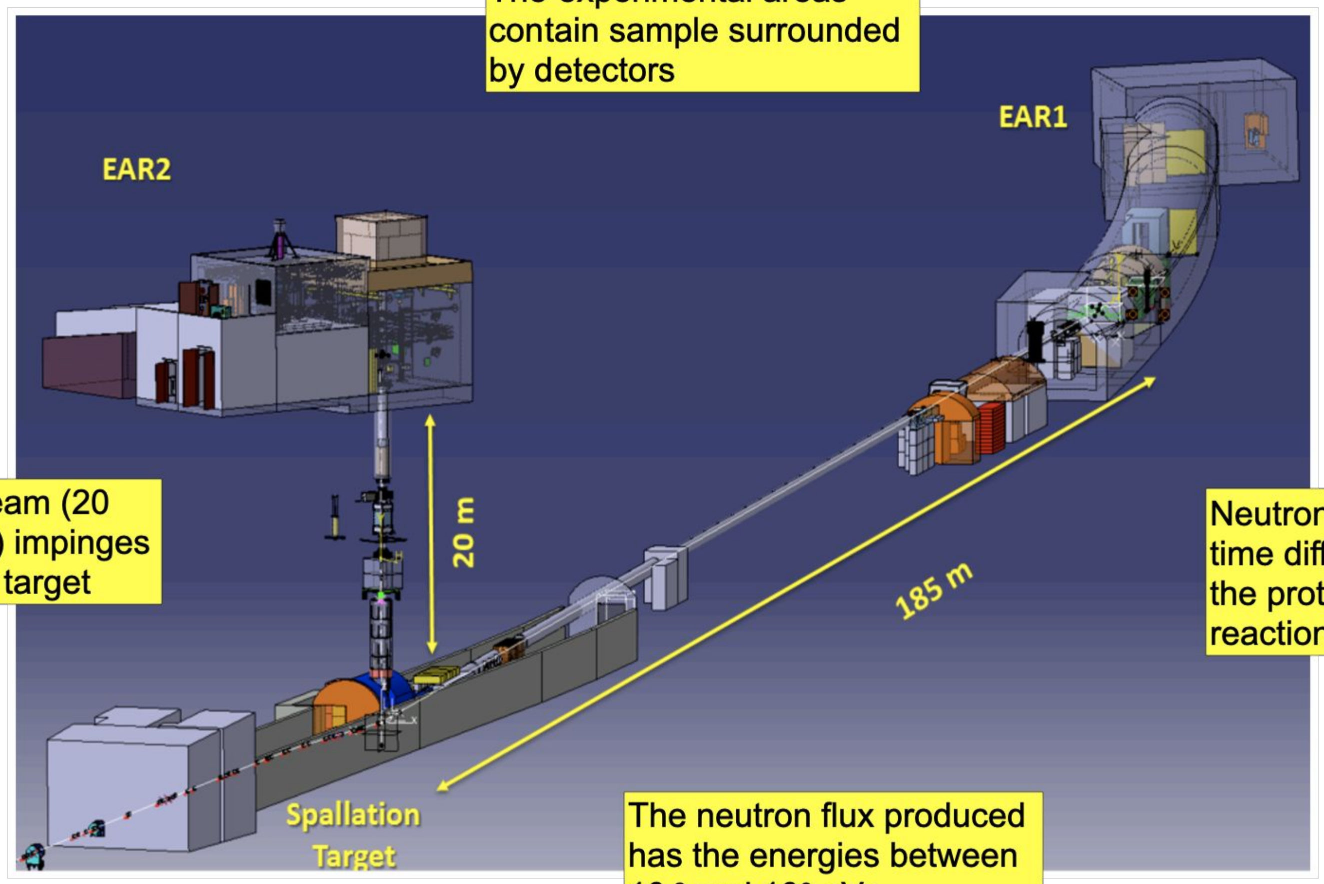
Motivation

- $^{77,78}Se$ abundances produced in massive stars are most sensitive to nuclear reaction rate uncertainties of:
  - $^{77}Se(n,\gamma)^{78}Se$
  - $^{78}Se(n,\gamma)^{79}Se$
  - $^{68}Zn(n,\gamma)^{69}Zn$

- Big uncertainties and discrepancies (10-50%) in the previous measurements of these reactions in relevant energy range.

Experiment - n_TOF facility

The experimental areas contain sample surrounded by detectors



Pulsed proton beam (20 GeV, 7×10^{12} pps) impinges on the spallation target

Neutron energy given by time difference between the proton pulse and the reaction at the sample

The neutron flux produced has the energies between 10^{-2} and 10^{8} eVs

Experiment - Detector setup

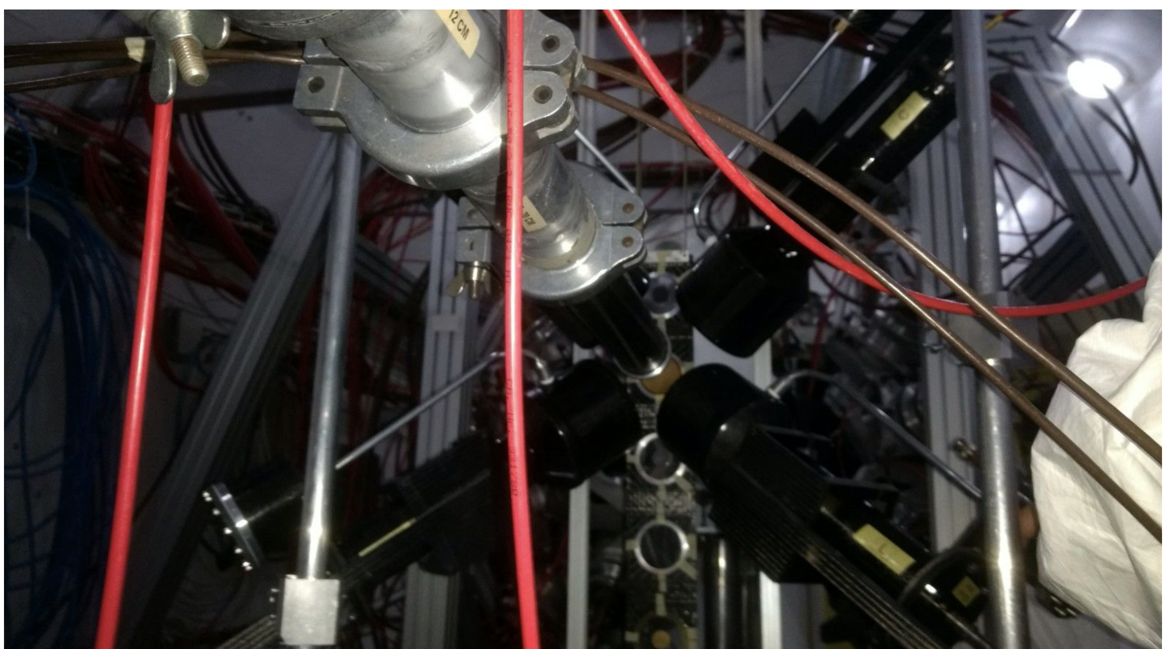
Four C6D6 liquid scintillator detectors.

Measurements on samples:

- Au (for normalisation to known resonance)
- Empty frame (for beam-induced sample-independent BG)
- Neutron filters (for beam-induced sample-dependent BG)
- C (for delayed γ from scattered neutron BG)

Beam-off runs for ambient BG.

Highly enriched samples prepared at PSI (by S. Heinitz) as pressed cylindrical pellets from elemental powder



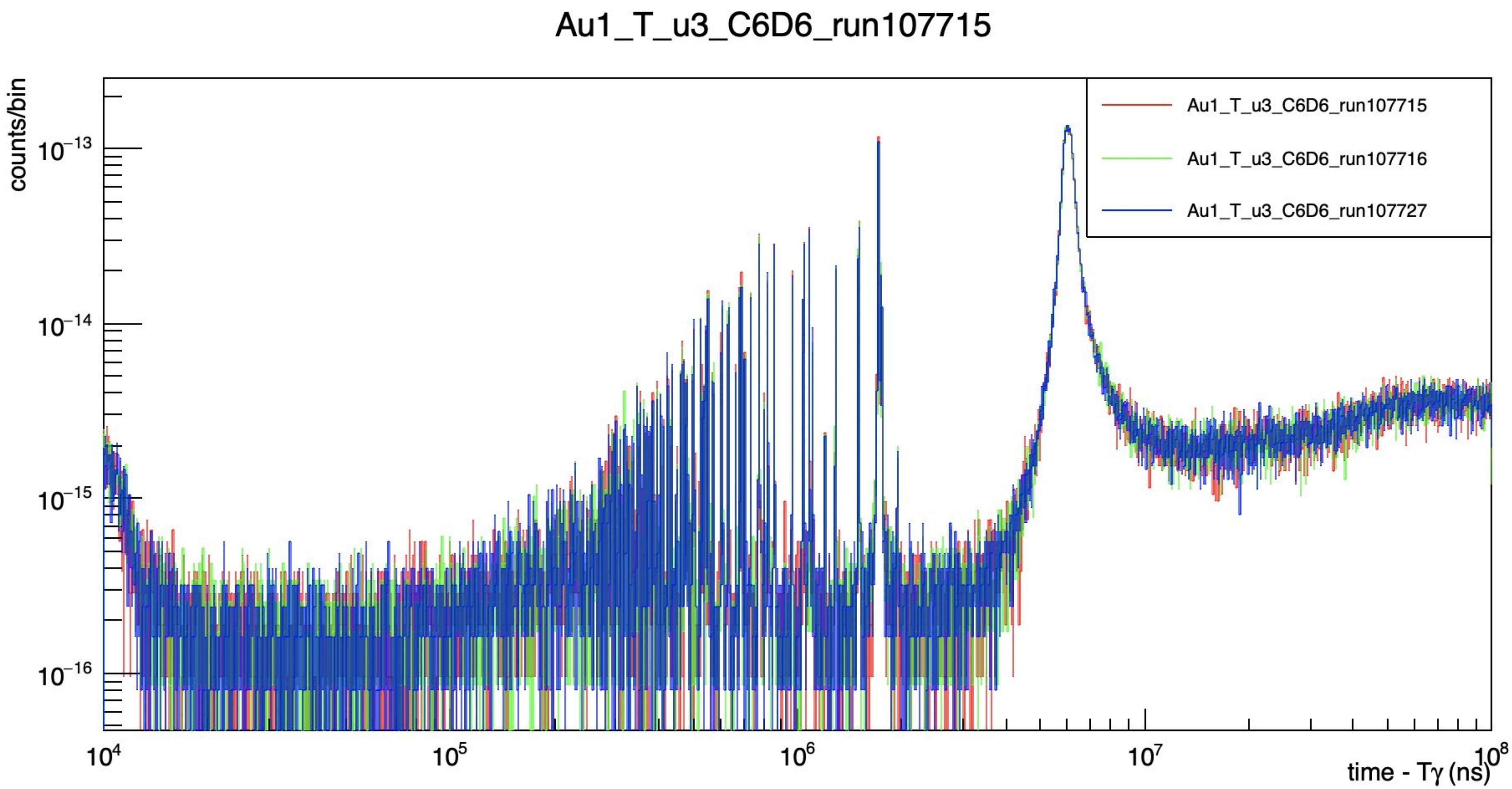
n_TOF data

- Events from n_TOF DAQ are recorded as full (digitised) waveforms.
- The raw data is processed into root files using Pulse Shape Algorithm (PSA) routine to identify the gamma signals and record their corresponding TOF, amplitude, and other relevant information.
- TTOFSort library for streamlined analysis of data from various n_TOF setups.
- It sorts the data into a range of useful histograms.

Data analysis - Checking sample in each run

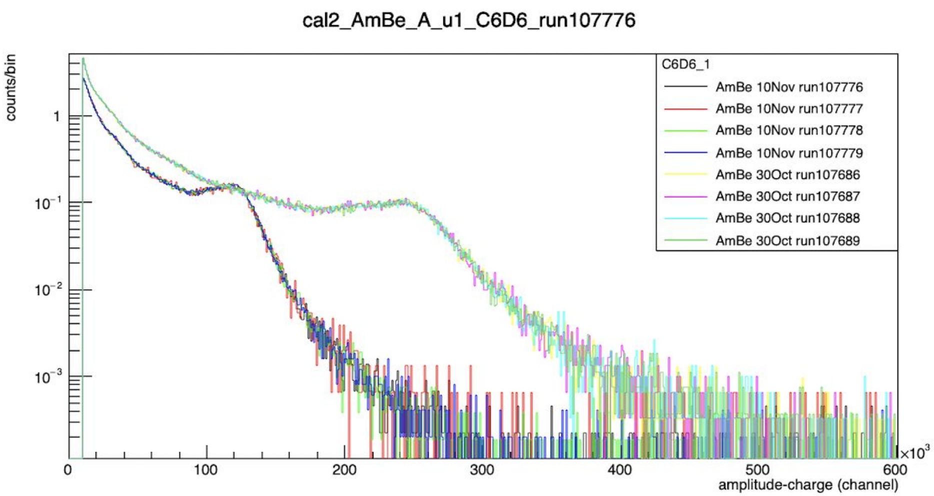
Checking TOF histogram of each run to cross check the sample in logbook.

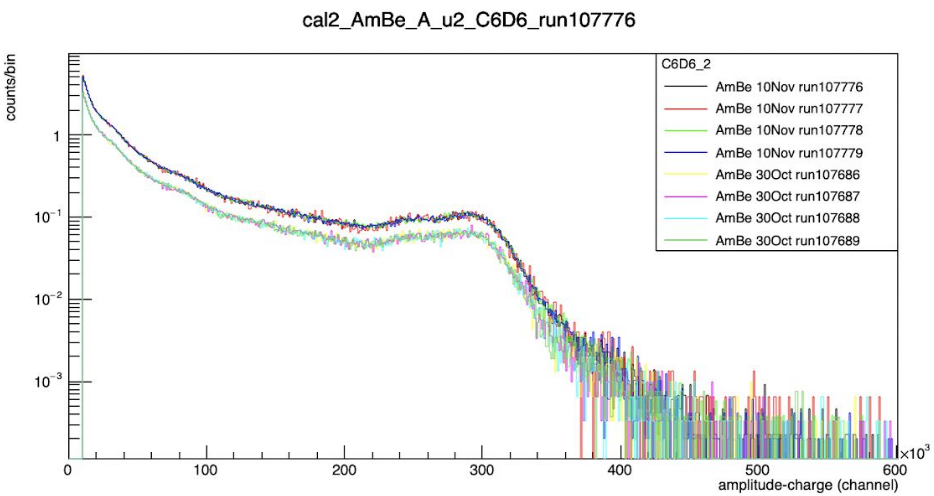
Example shown: Gold runs, calibration 1 set, histograms normalised for number of protons, rebin factor 10.

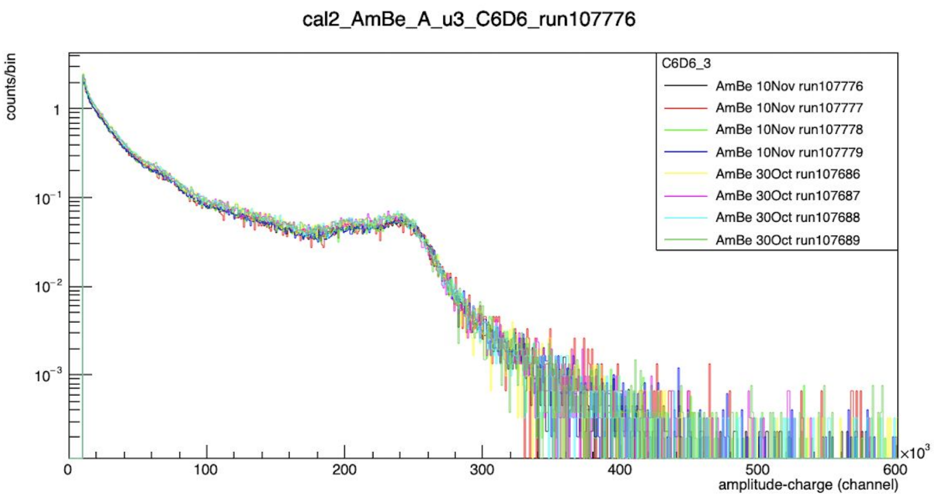


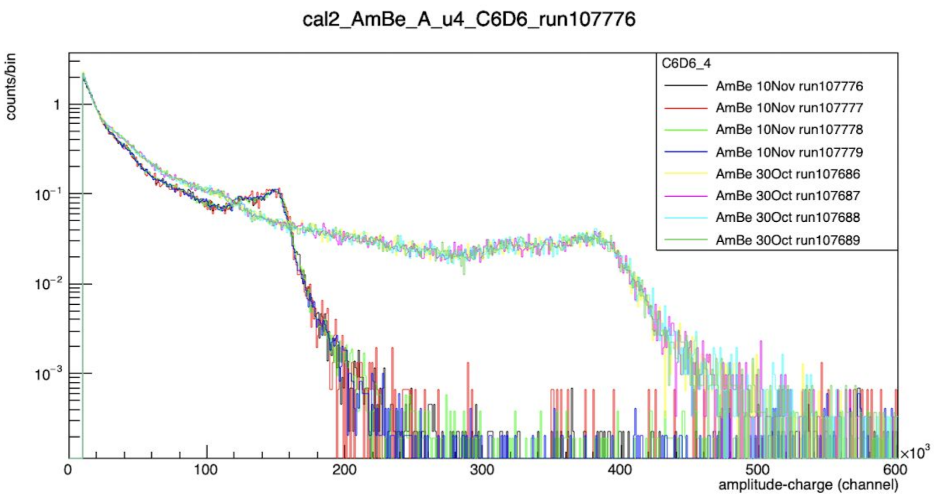
Data analysis - Gain stability check (AmBe runs)

Normalised for number of bunches









Data analysis - Proton counting consistency

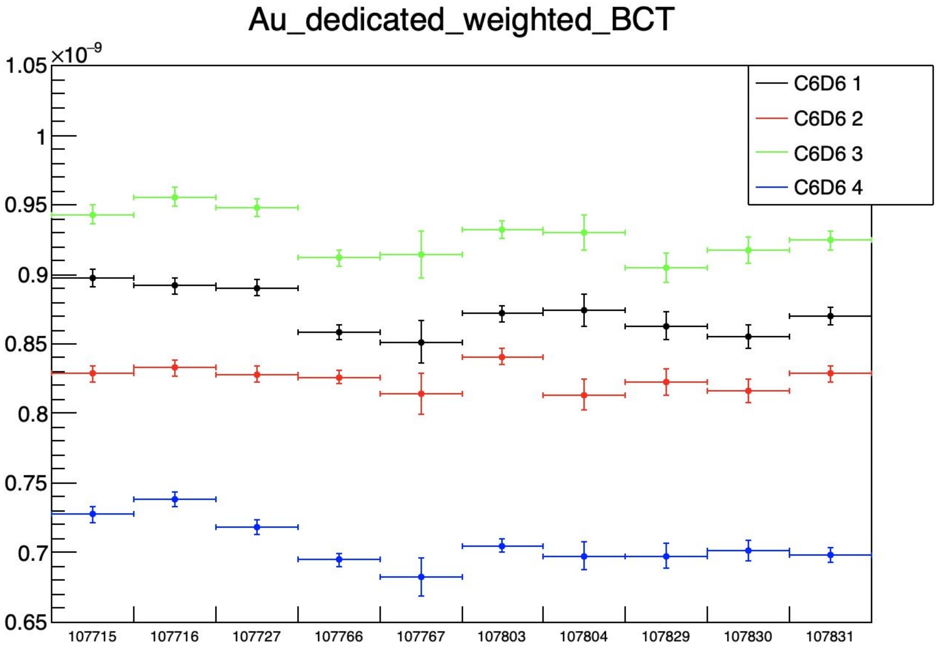
- Proton counting:
  - BCT (Beam Current Transformer) at the PS
  - SiMon - Counting 6Li(n,t)4He reaction events in silicon detectors upstream.

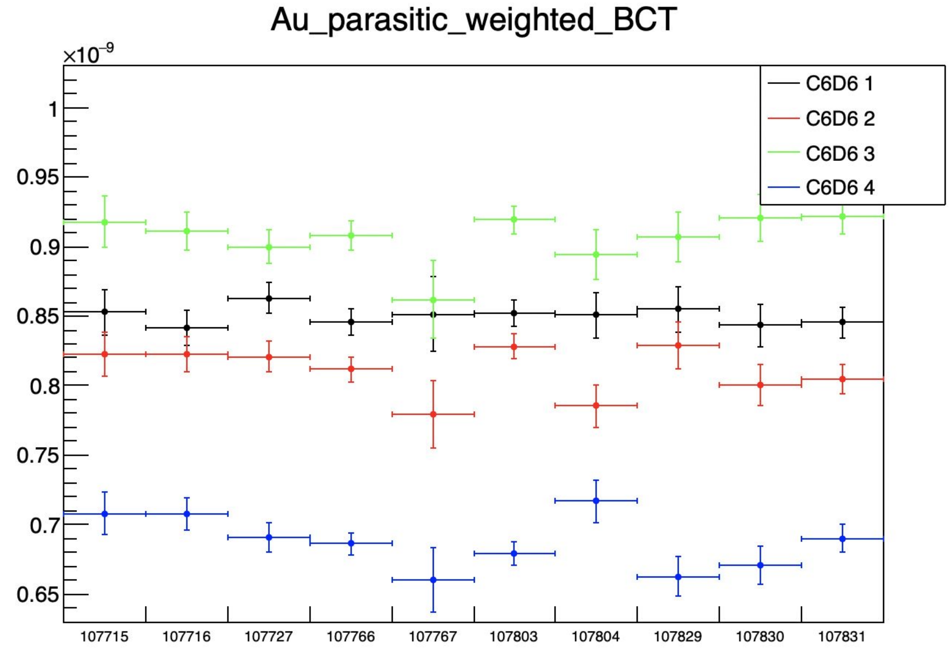
- Two types of proton pulses sent to n_TOF: dedicated ($\sim 7 \times 10^{12}$ pps), parasitic ($\sim 3 \times 10^{12}$ pps). More on this later.

- The quantity ‘number of counts in a resonance / protons’ should be same throughout the campaign.

Proton consistency test
Au, weighted, BCT

Deadtime = 60
coincidence time = 60
htof deadtime corrected
Au resonance = 55e5 - 65e5 ns.

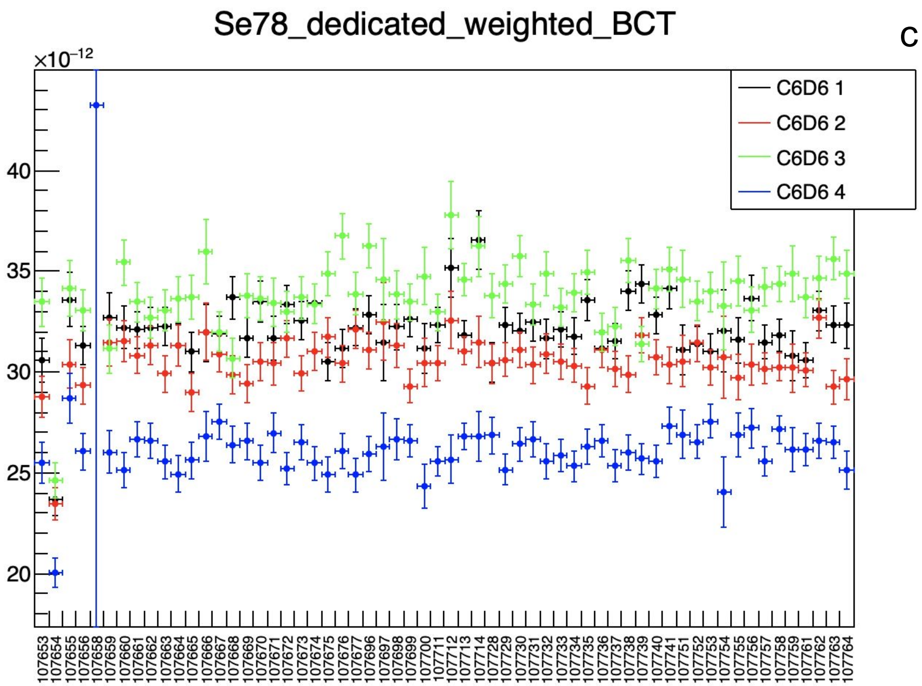




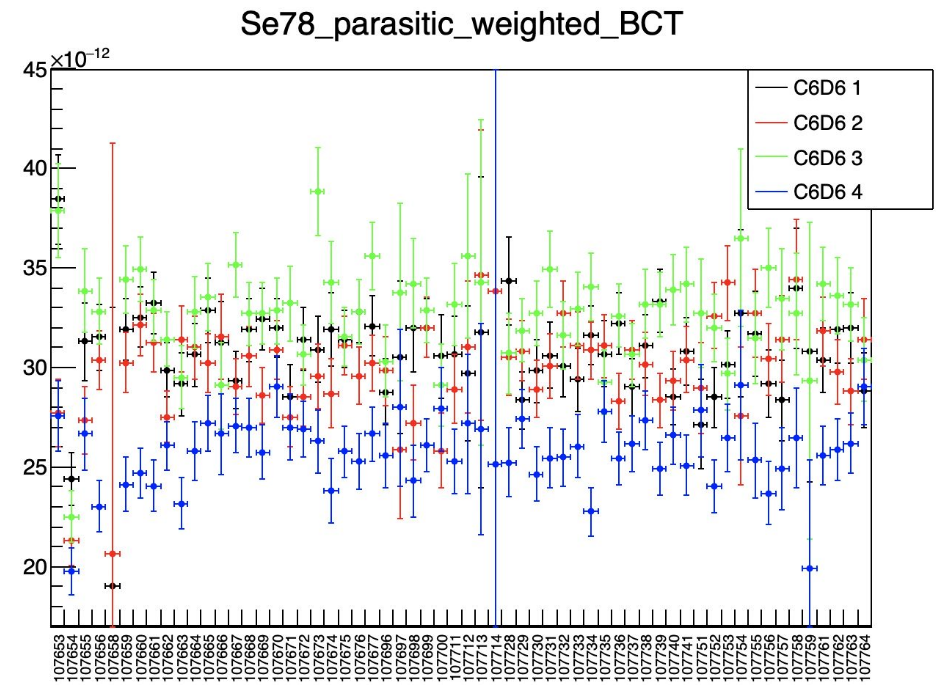
Proton consistency test
Se78, weighted, BCT

Deadtime = 40
coincidence time = 40
htof deadtime corrected
resonance = 63e4 - 70e4 ns.

107654: uncertain sample position, low stat in tof spectrum
107658: low stat (4 events)



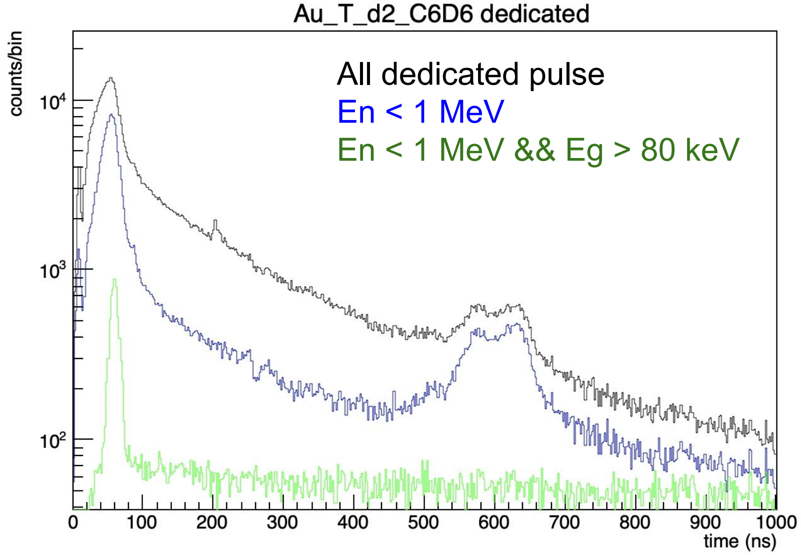
c

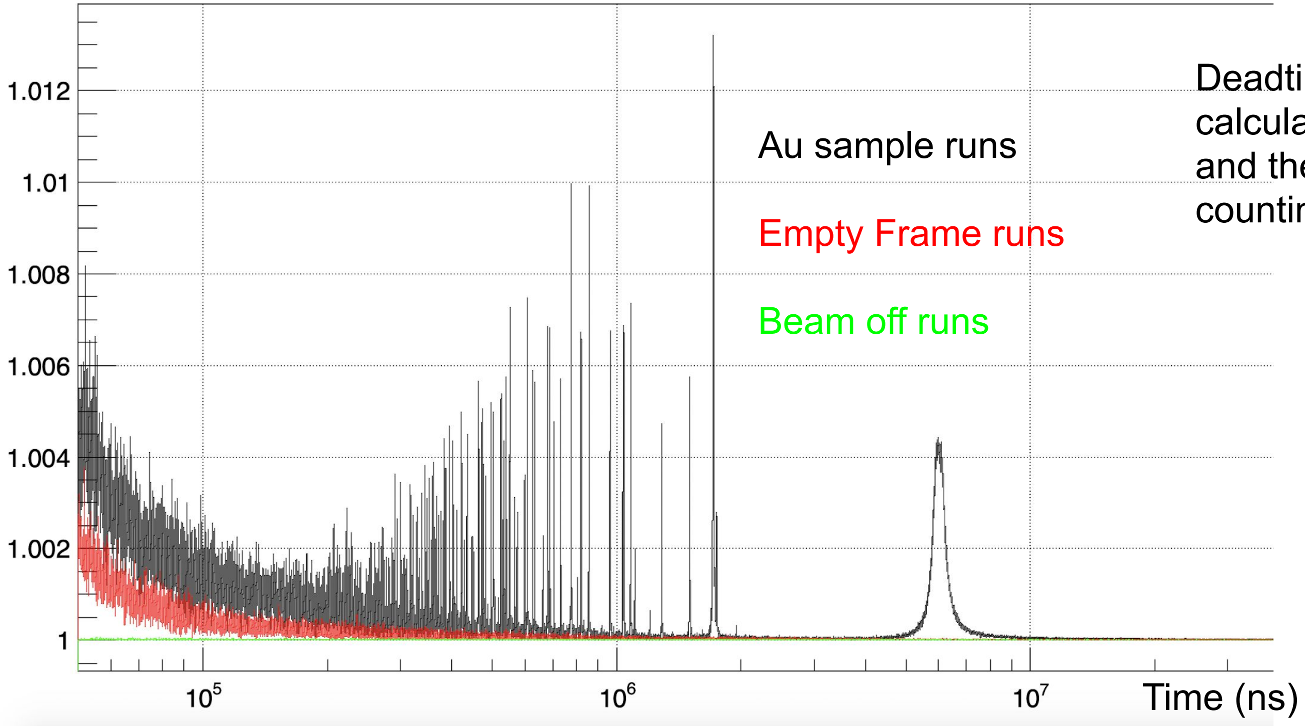


Data analysis - Deadtime correction

$C' = C / (1 - C*\tau_d)$
where,
C' = true count rate
C = Measured count rate
τ_d = Fixed dead time

τ_d is estimated by looking at histogram of time difference between consecutive events:

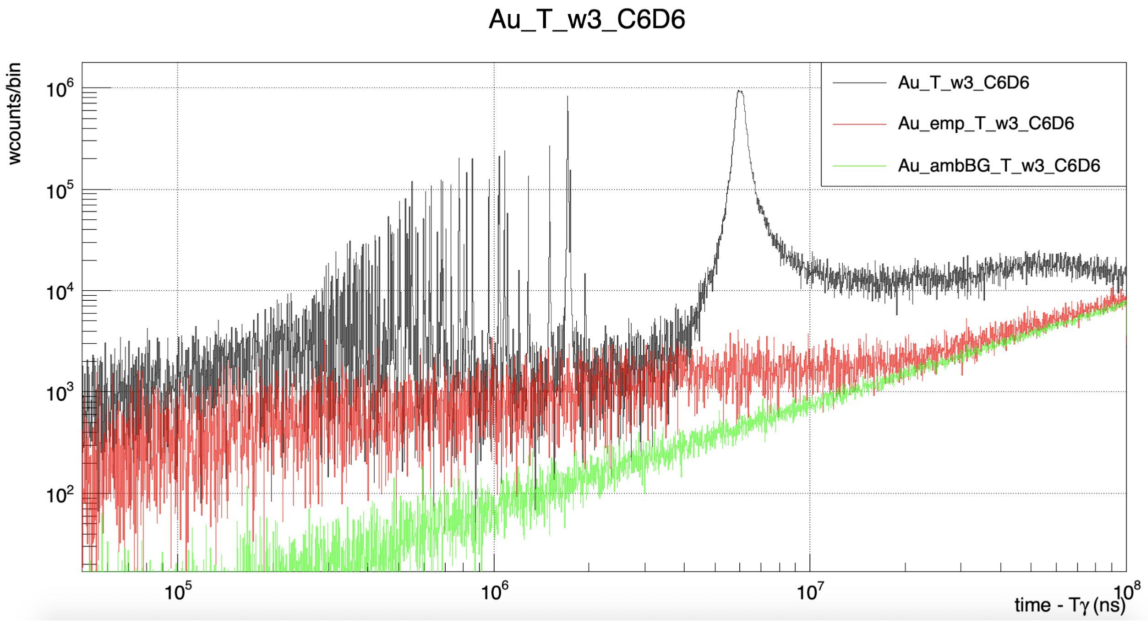


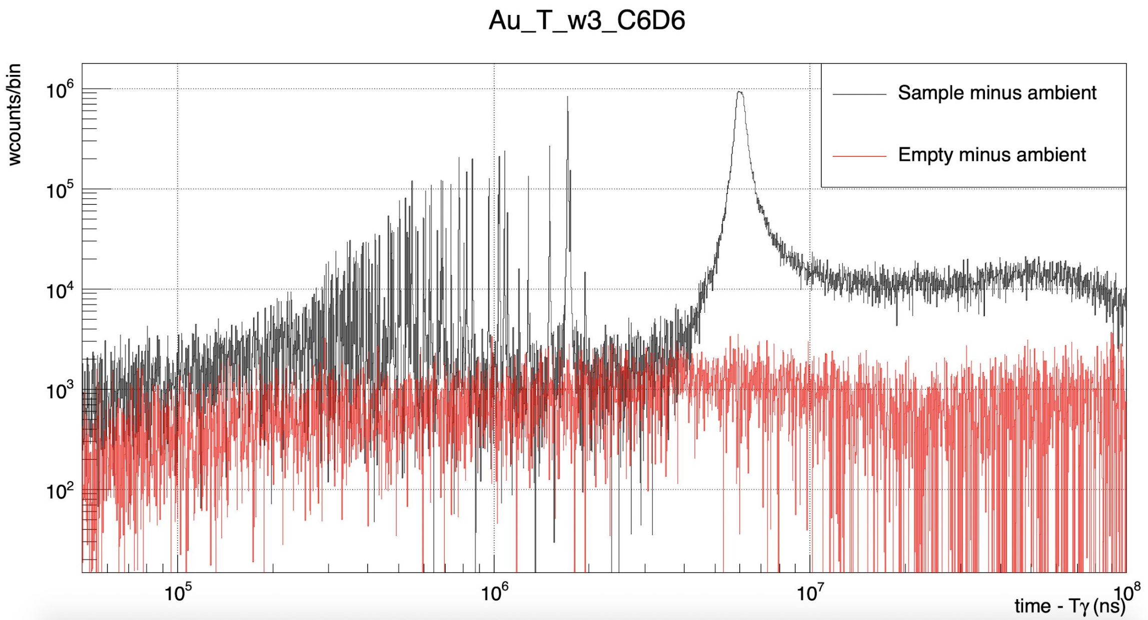


Deadtime correction factor: calculated using the above formula and the zero-threshold raw counting spectra

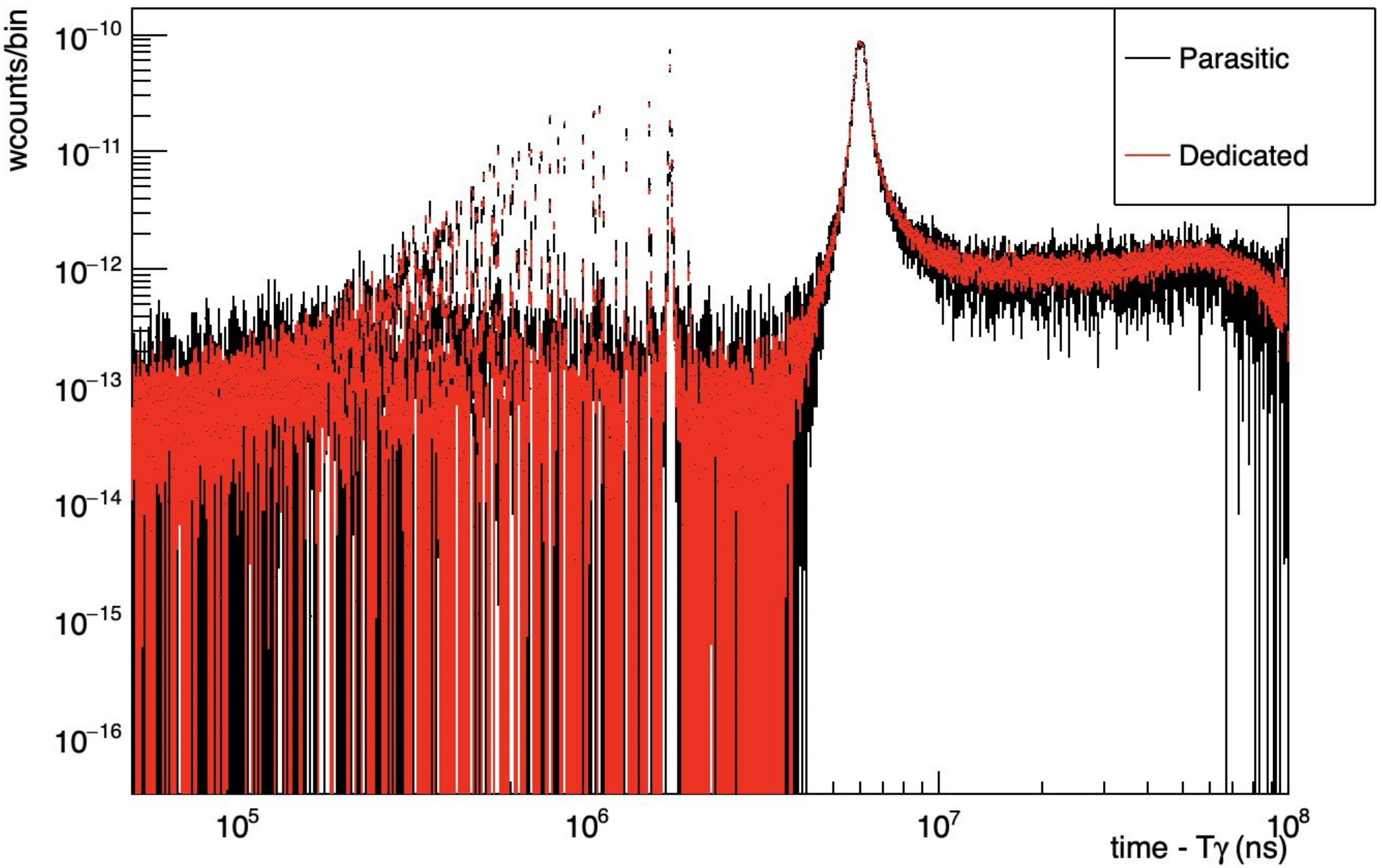
Data analysis - Background subtraction

1. Deadtime correction on sample, empty frame, and amb BG.
2. Normalise empty frame histogram to number of protons in sample run.
3. Normalise ambient background histogram to number of bunches in the sample run.
4. Subtract scaled ambBG from sample hist and from emptyFrame hist.
5. Subtract emptyFrame hist from sample hist.



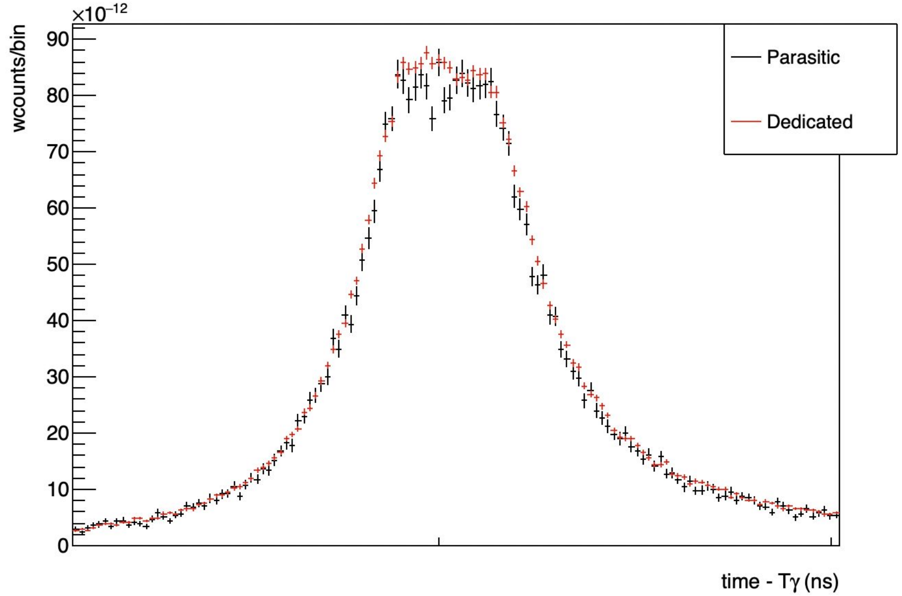


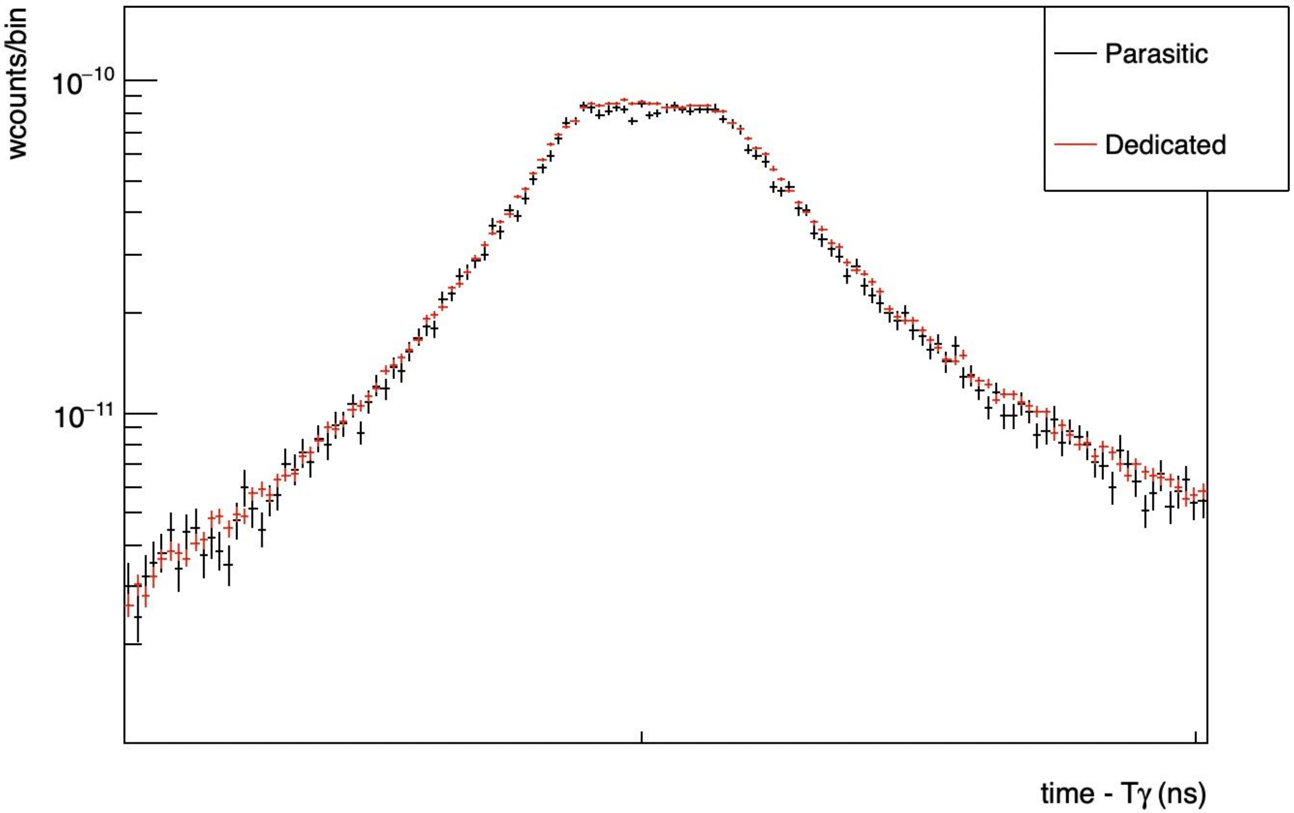
Data analysis - Dedicated and parasitic comparison



Data analysis - Dedicated and parasitic comparison

Rebin 10





Data analysis - Dedicated and parasitic comparison

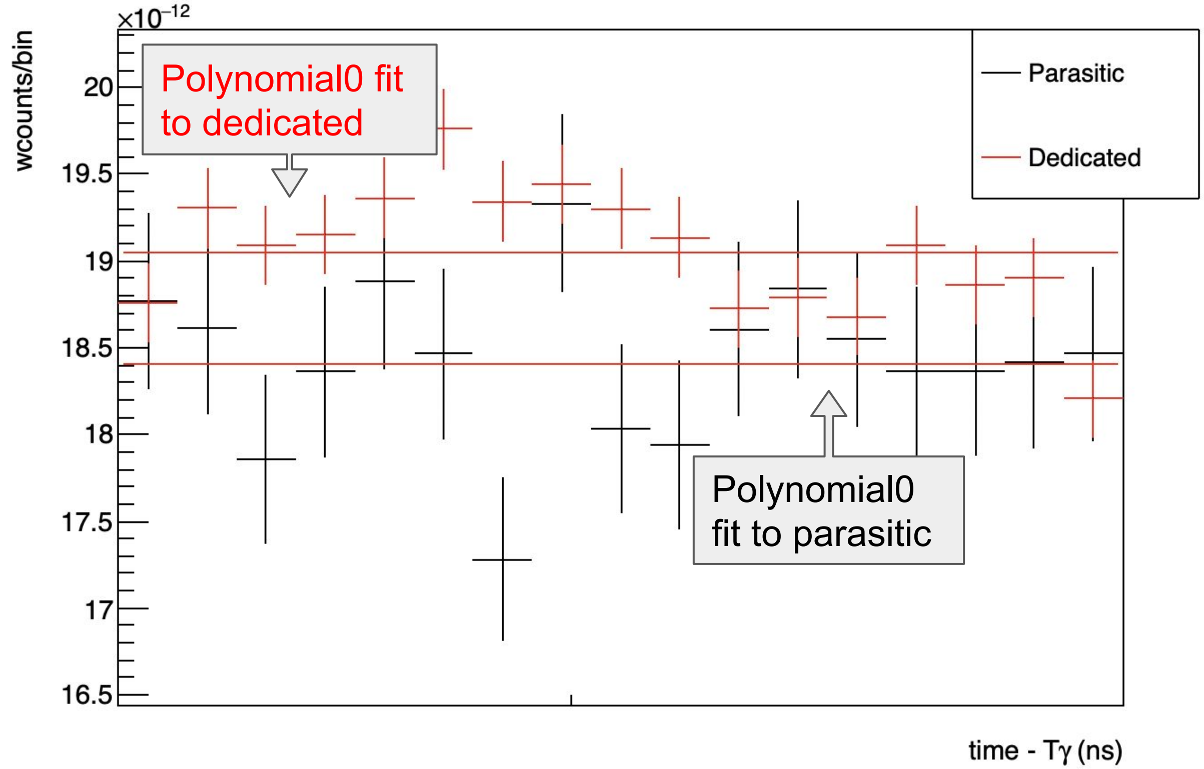
Rebin 10

Sum WF

Calculated plateau avg (x 10^{-14})

- Ded = 1910 ± 06.0 ± 30.2 (SD)
- Par = 1840 ± 12.8 ± 47.8 (SD)

SE (par) = 0.70%
SD (par) = 2.6%
Discrepancy = 3.8%




```
c1 | c1 | 330,453 | x=6.00373e+06, y=1.59993e-11
ded avg = 1.90536e-11 ¬± 5.54956e-14
par avg = 1.842e-11 ¬± 1.20402e-13
root [1] TFitEditor::DoFit - using function PrevFitTMP  0x7fc55b4a5970

****************************************
Minimizer is Linear / Migrad
Chi2                      =      41.7179
NDf                       =           16
p0                        =   1.90444e-11   +/-   5.54765e-14
Warning in <FlushXOROps>: No CrosshairWindow found to draw into
TFitEditor::DoFit - using function PrevFitTMP  0x7fc55b4aceb0

****************************************
Minimizer is Linear / Migrad
Chi2                      =      14.3163
NDf                       =           16
p0                        =   1.84023e-11   +/-   1.203e-13
Warning in <FlushXOROps>: No CrosshairWindow found to draw into
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