Abort Gap Population measurement in ALICE

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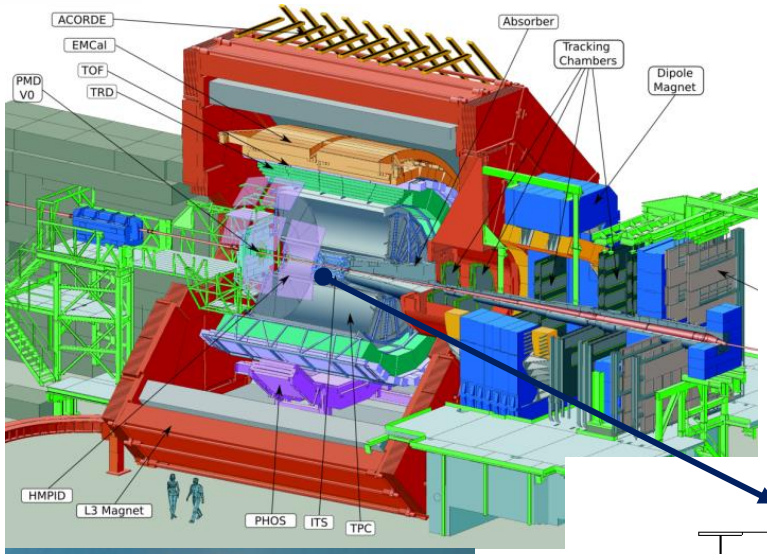
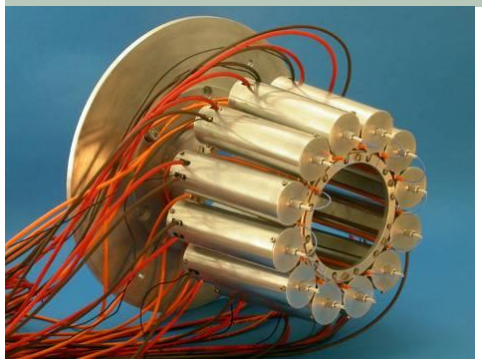
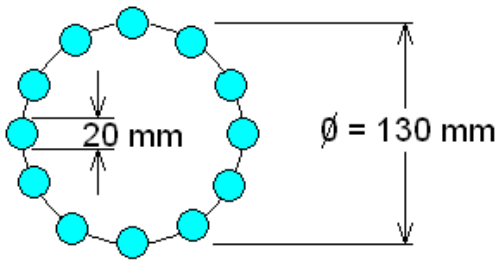
AGP measurement using T0 detector

- Basic idea: since we were able to run with main-satellite collisions, we would have enough sensitivity to “see” main-AG collisions
- T0 trigger (T0VX) bunch-by-bunch info stored in Central Trigger Processor (CTP) Interaction Record (IR), collision rate corresponding to crossings of Main buckets with AG protons can be calculated
- From b-by-b Luminosity + known number of protons in main bucket -> **nr. of protons in the 1 RF bucket in the AG**
- Average the numbers of protons in all available RF buckets in the AG and scale to the number of ALL RF buckets in the AG (**Assumption: distribution of charge in the AG is more or less uniform**)

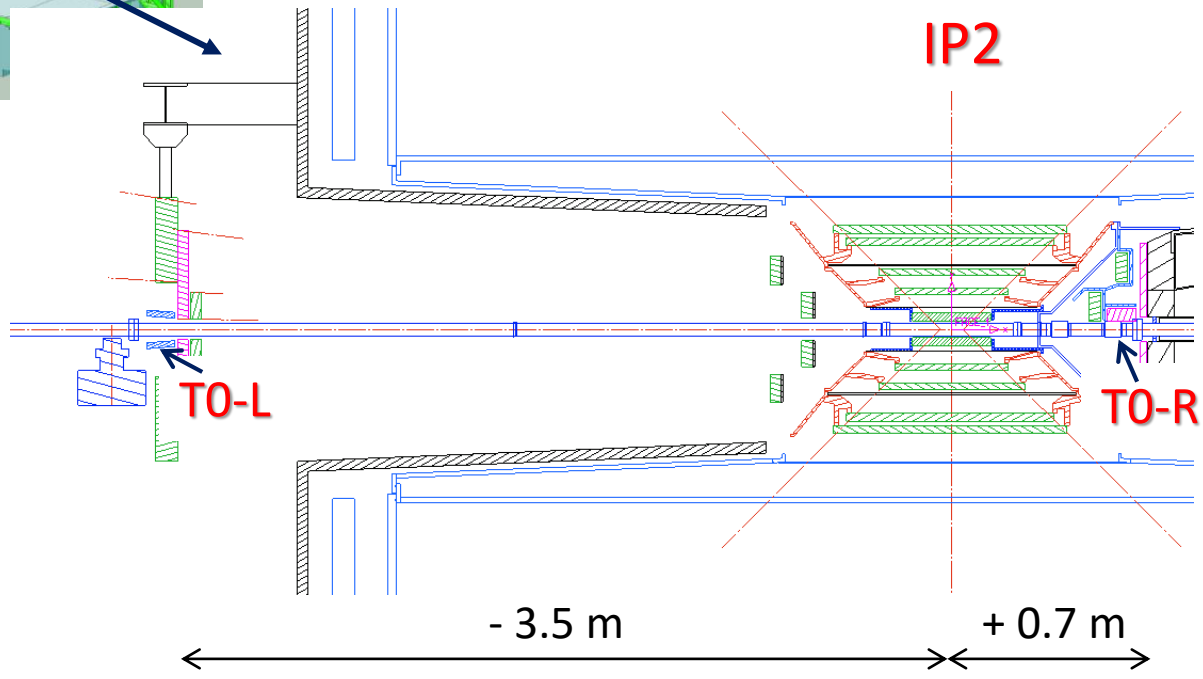
T0 detector







- Two arrays of 12 PMTs with Cherenkov quartz radiators
- Time resolution better than 50 ps
- It provides level 0 trigger and vertex position below 7.5 mm
- Very small acceptance, high rejection of background



Abort Gap seen in ALICE

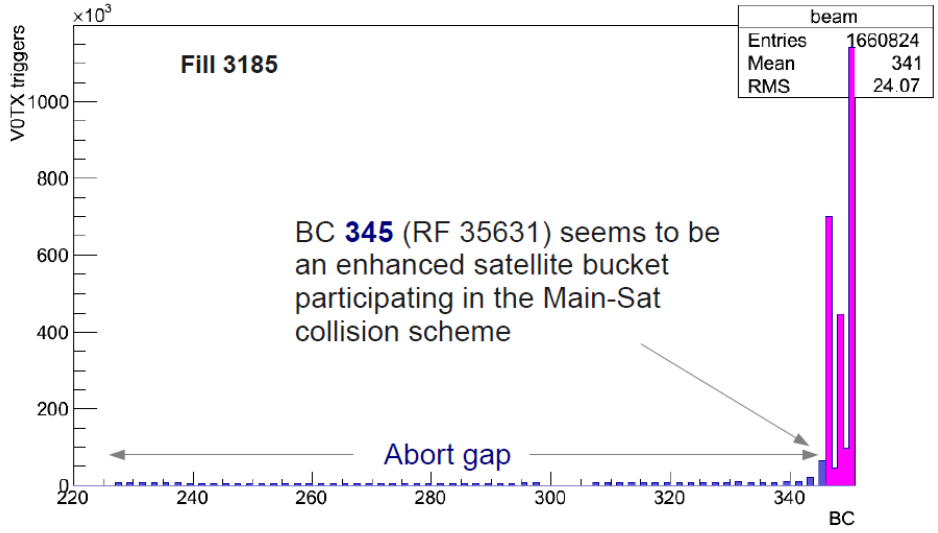
- RF buckets: **34440 to 35640**
- (LHC-OP-ES0024-rev1.2)

Beam	Abort Gap RF bucket	ALICE BC	Filled bucket of the other beam
A	34441	226	C: 7711
A	35631	345	C: 8901
C	34441	2899	A: 25531
C	35631	3018	A: 26721

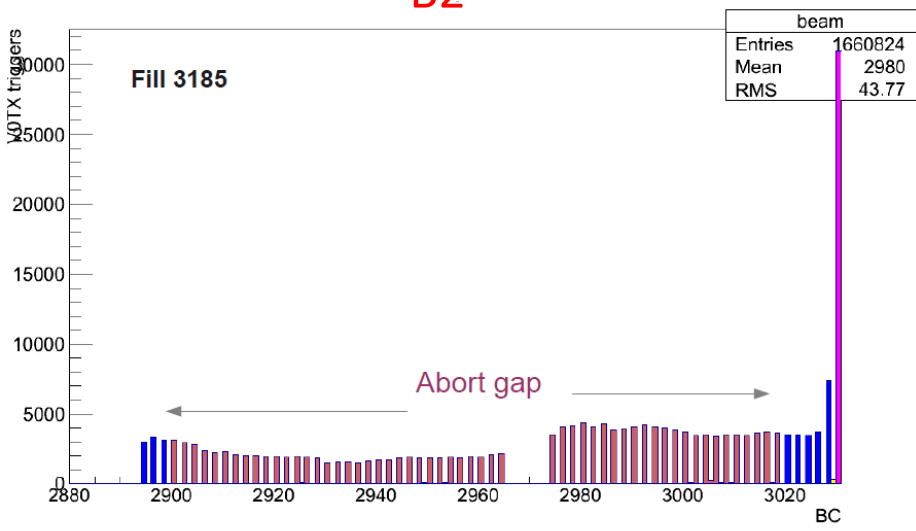
A= Beam-1 C=Beam-2

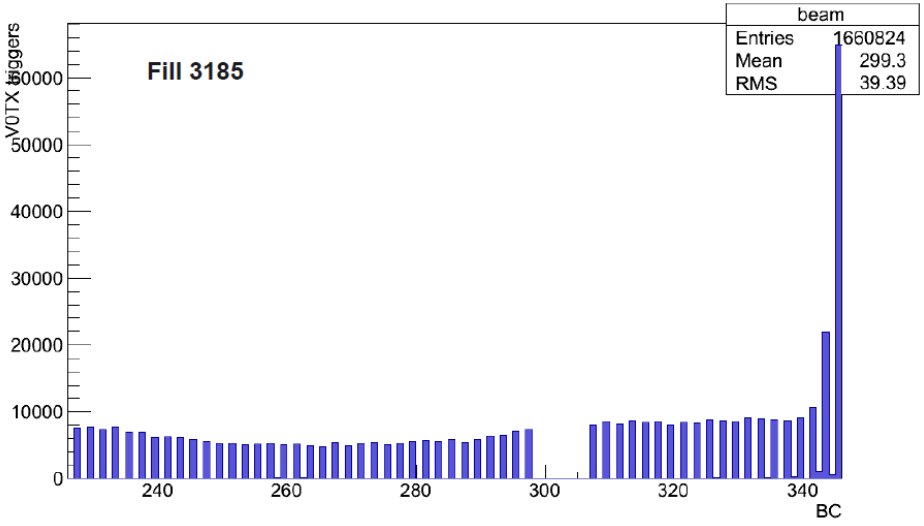
B1 last bunch issue

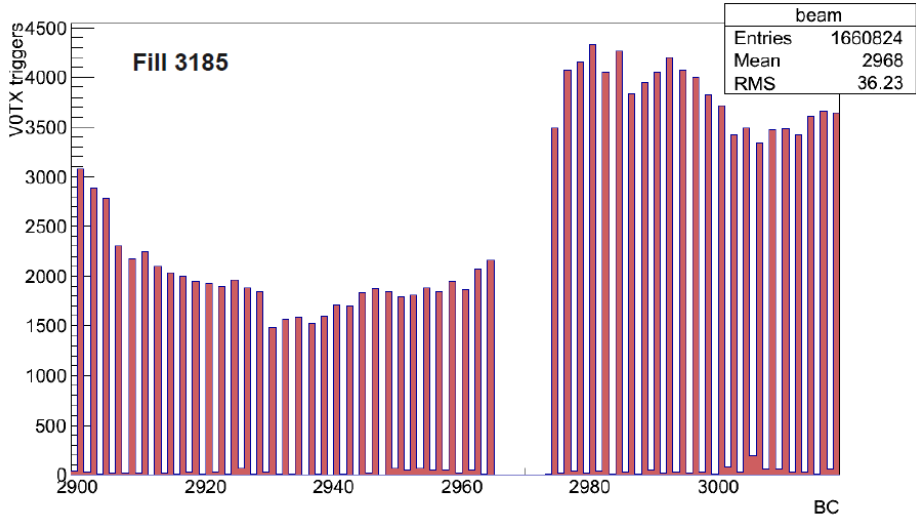
B1



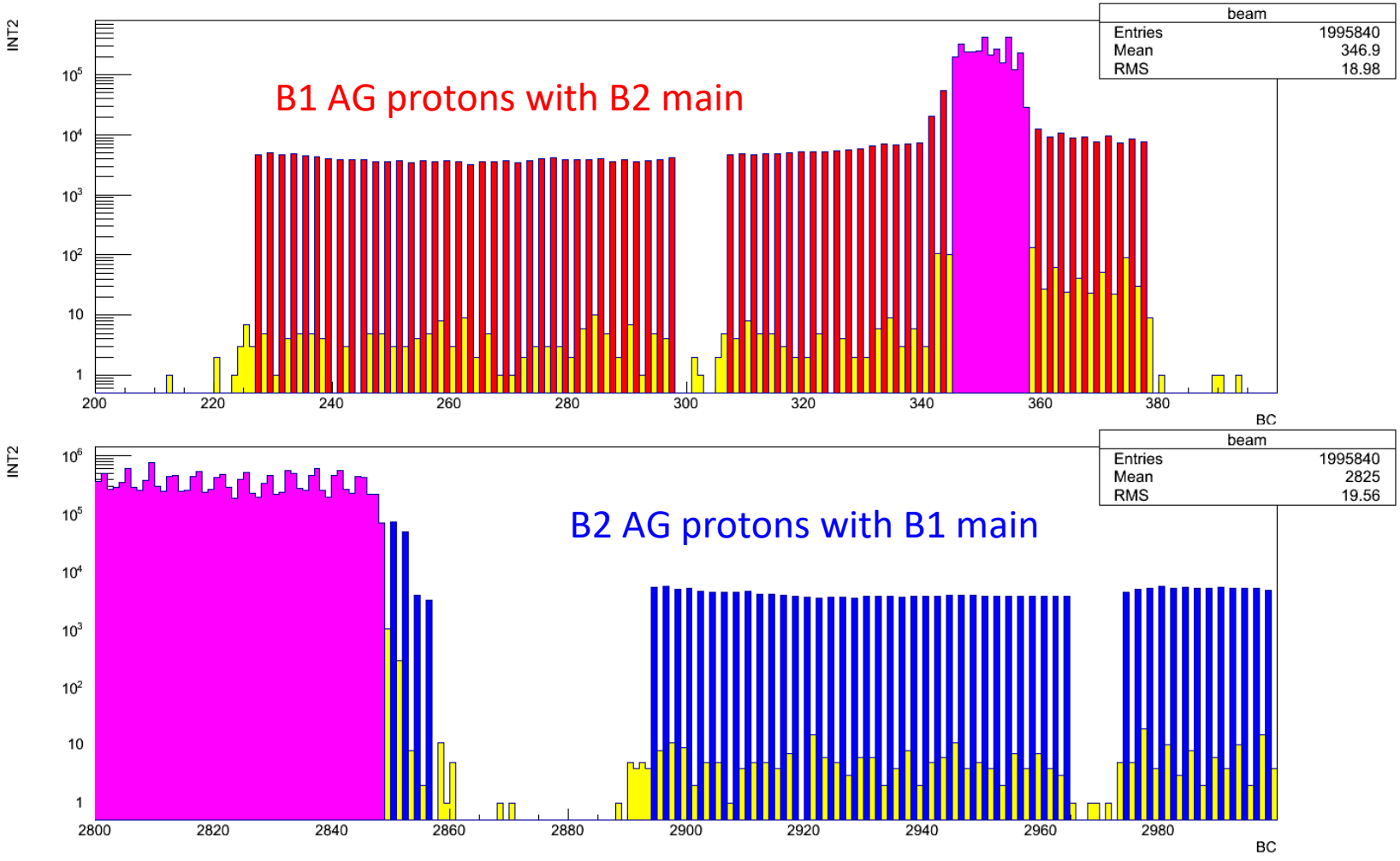
B2







An example of T0VX IR around AG



Official main-satellite collisions

"Noise" in not filled bunches

Beam parameters

B-by-b luminosity: $L_{bb} = f_{rev}\, N_1 N_2 \cos^2(\alpha/2)\, S\, F / (4\pi\sigma_x\sigma_y)$

where:

- $L_{bb} = R_{T0}/\sigma_{T0}$ *is measured from T0VX rate (R_{T0}) using T0 normalization cross section*
- f_{rev}= 11246 Hz
- N_1, N_2 = *no. of protons in a given bunch, for B1 and B2*
- α = *total crossing angle in yz plane*
- $S = 2^{1/2}\, \sigma_y / \Sigma_y$ *geometric factor*
- $F = \exp(-d^2 / 2\Sigma_x^2)$ *separation factor*
- $\sigma_x\sigma_y = \varepsilon\, \beta^*$ *transverse beam size at IP ($\sigma_x = \sigma_y$)*
- $\Sigma_x^2 = 2\sigma_x^2$ *effective area y-size at IP2*
- $\Sigma_y^2 = 2\sigma_y^2\cos^2(\alpha/2) + 2\sigma_z^2\sin^2(\alpha/2)$ *effective area y-size at IP2*

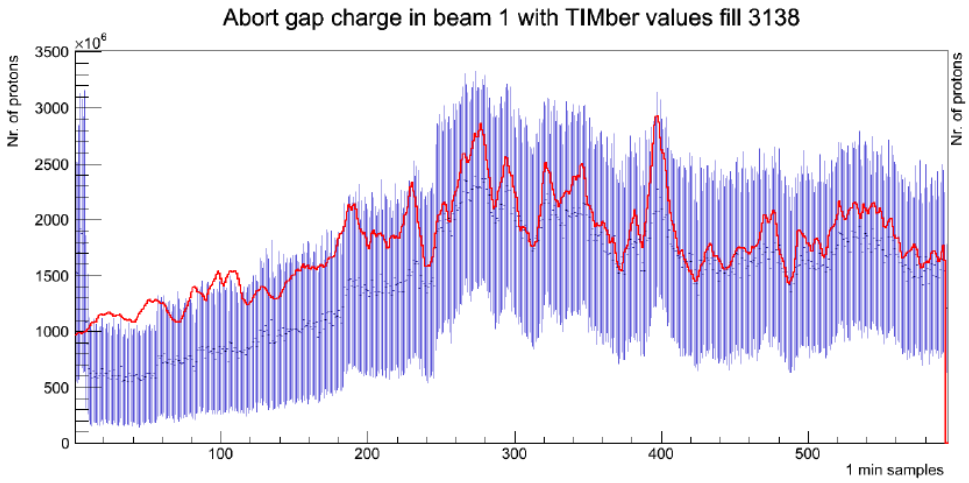
During a fill the collision rate (hence L_{bb}) can change due to variations of N1, N2, beam separation d (due to lumi levelling) and beam transverse size, not all are known online. Various procedures have been tested….

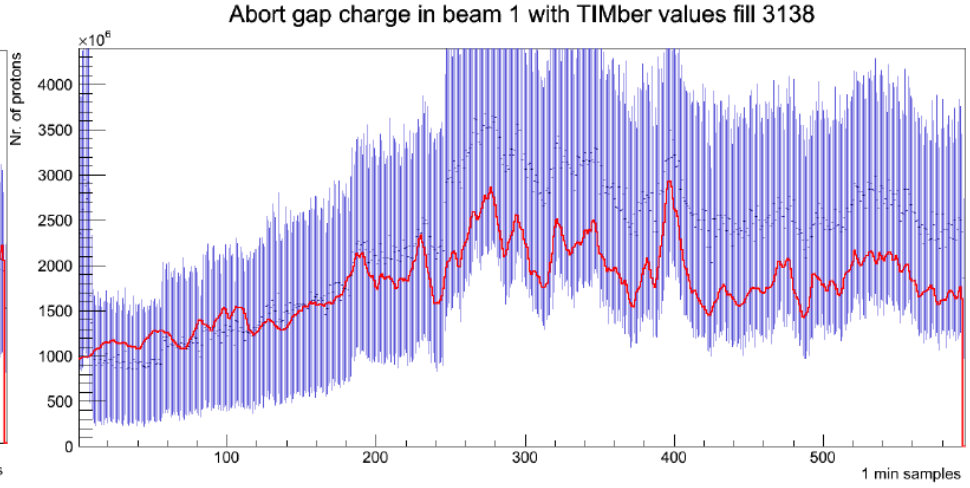
First attempt of AGP measurement (offline)

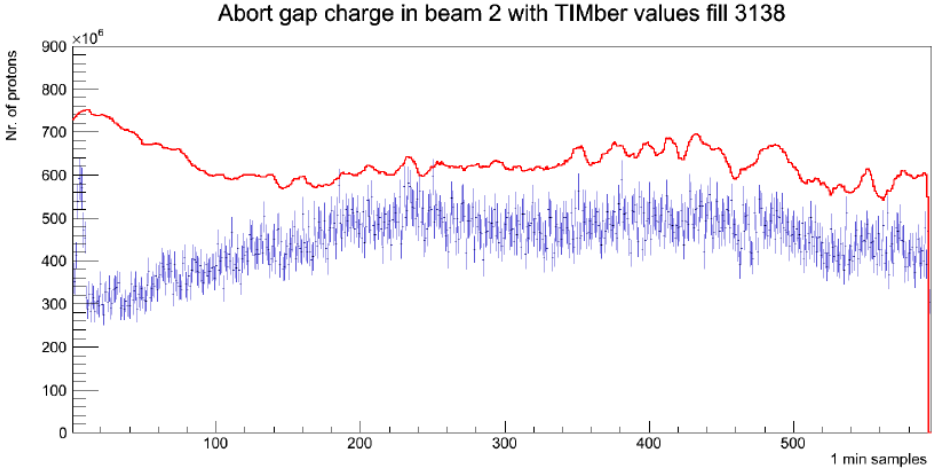
- Fills with the abort gap charge values from LHC: 3138, 3178, 3182, 3185, 3188, 3192, 3194, 3200 (7-18/10/12)
- No. of protons in 1 BC calculated for each seen BC in the AG and extrapolated to the number of the RF buckets in the AG (1200)
- All beam parameters considered constant
- Mean values with error on mean of each fill plotted and compared with the TIMBER values (1 min averages).
  - R.M.S. spread can be rather large due to BC 345
  - low trigger count per BC per minute also contribute to the BC-to-BC fluctuations
- Plots on the right include an ad-hoc re-scaling of 0.65 for better matching

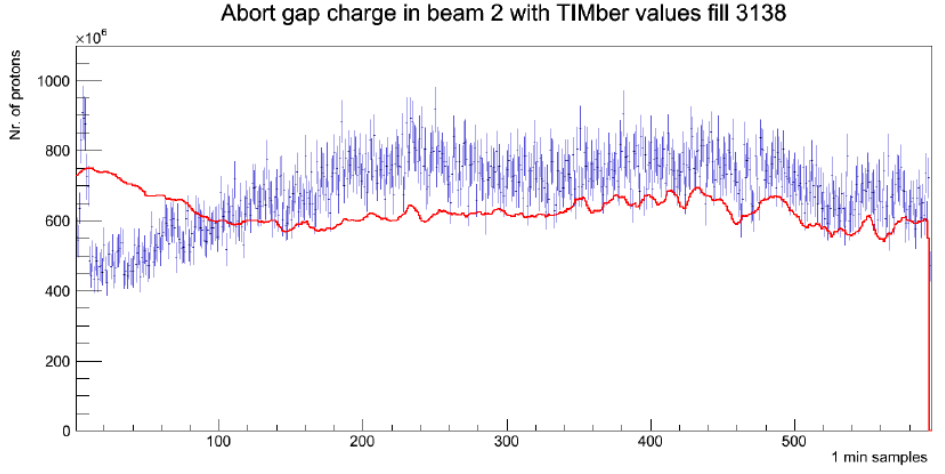
First attempt – FILL 3138

with 0.65 rescaling



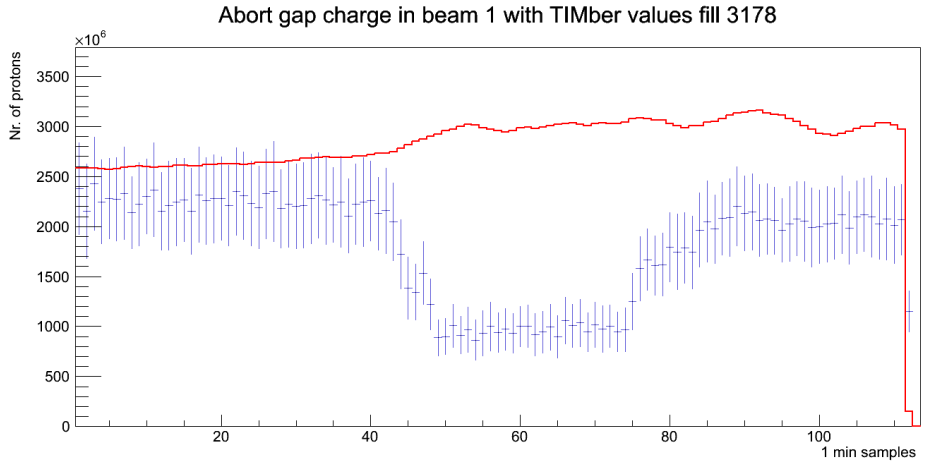


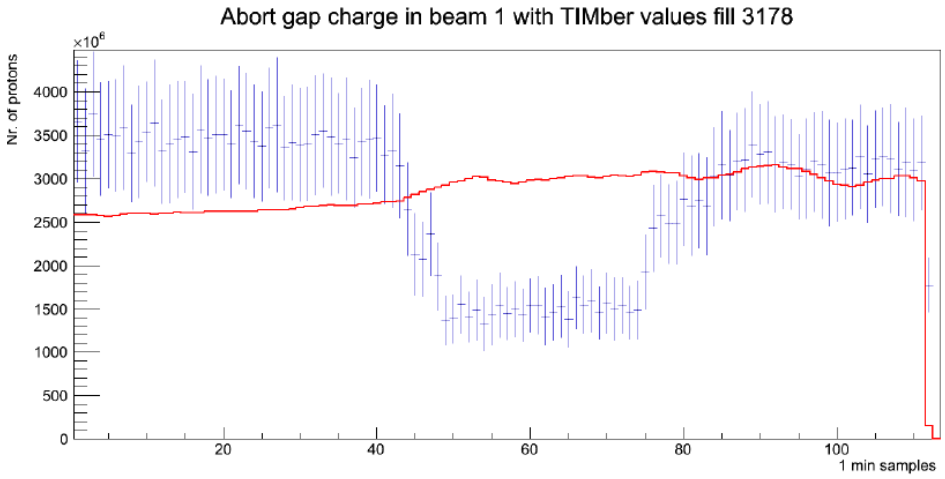


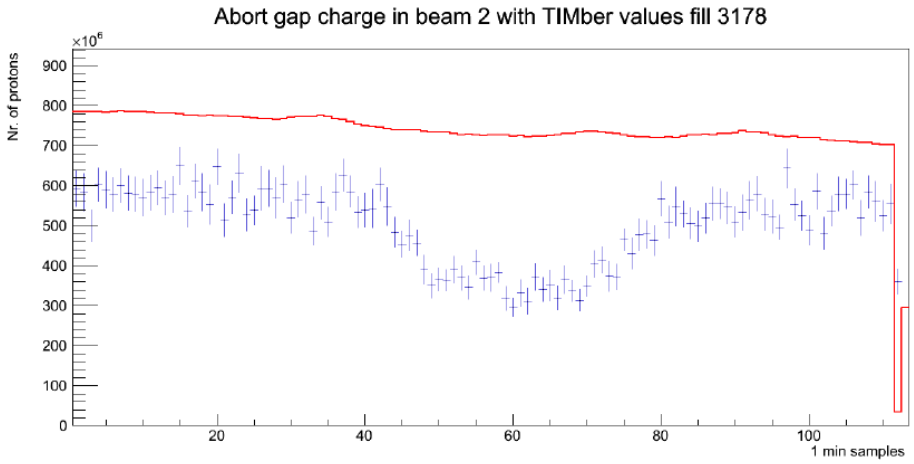


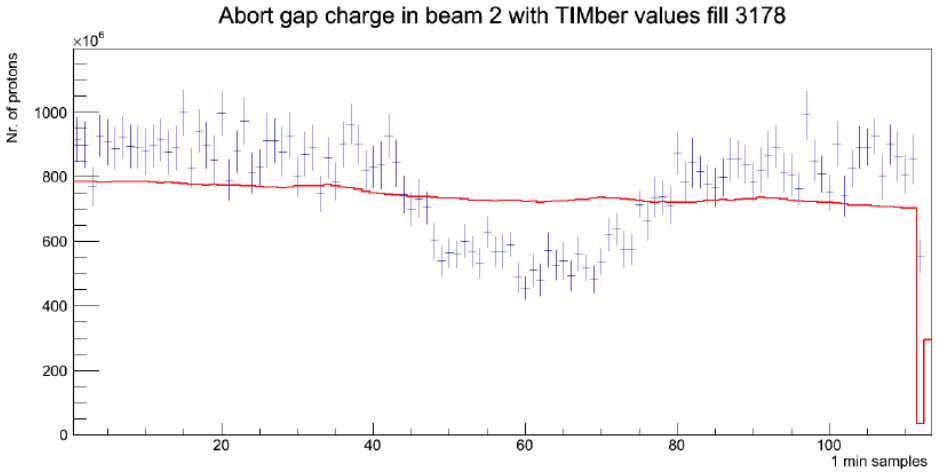
First attempt – FILL 3178

with 0.65 rescaling



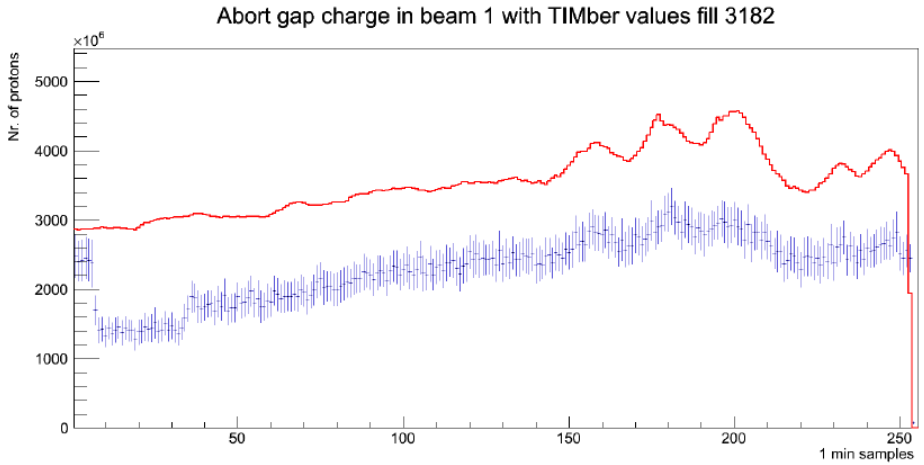


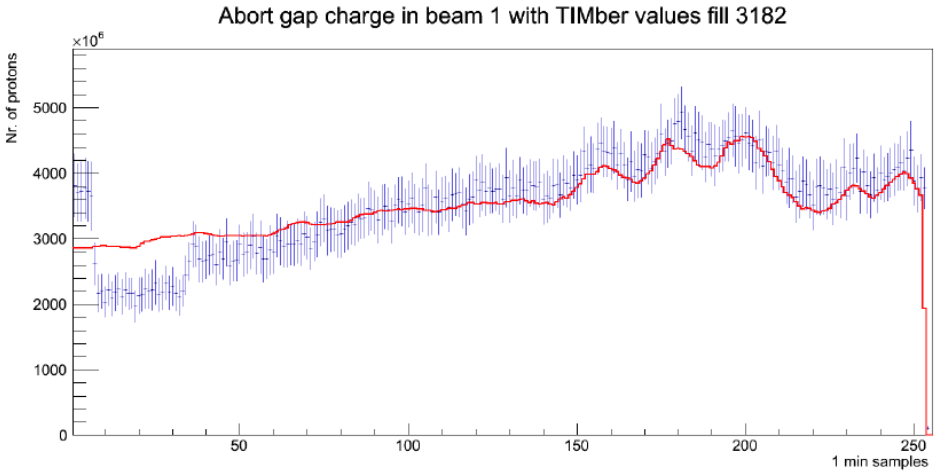


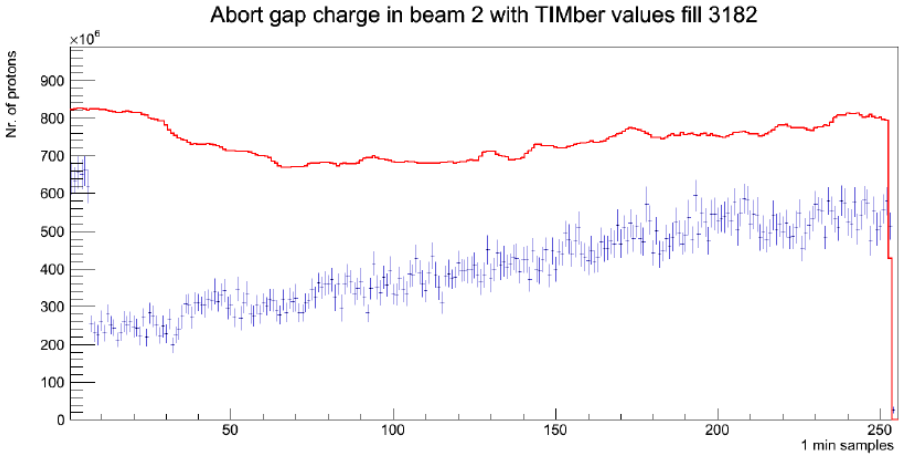


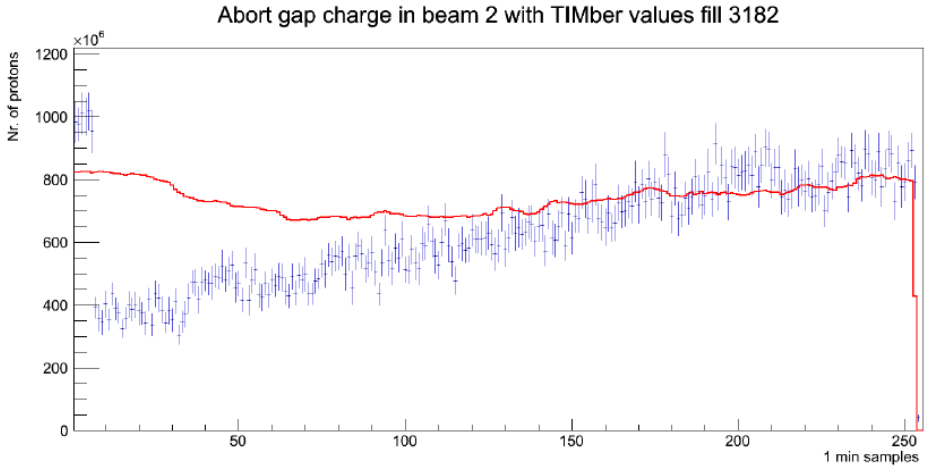
First attempt – FILL 3182

with 0.65 rescaling



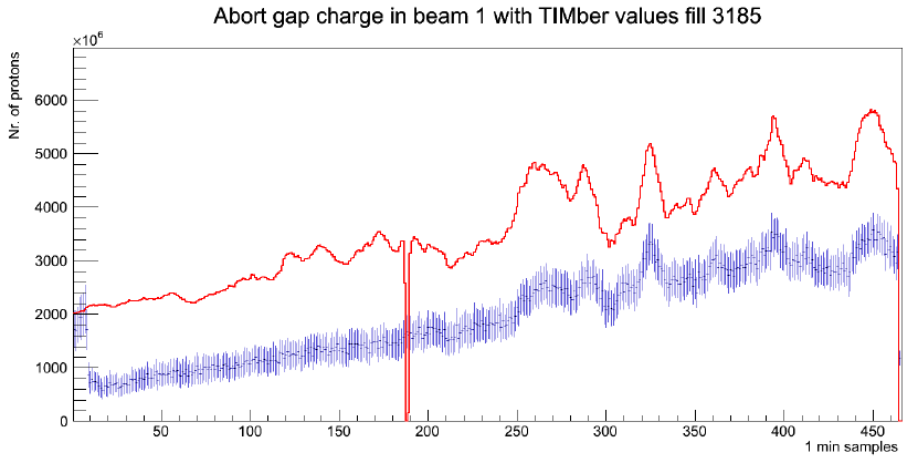


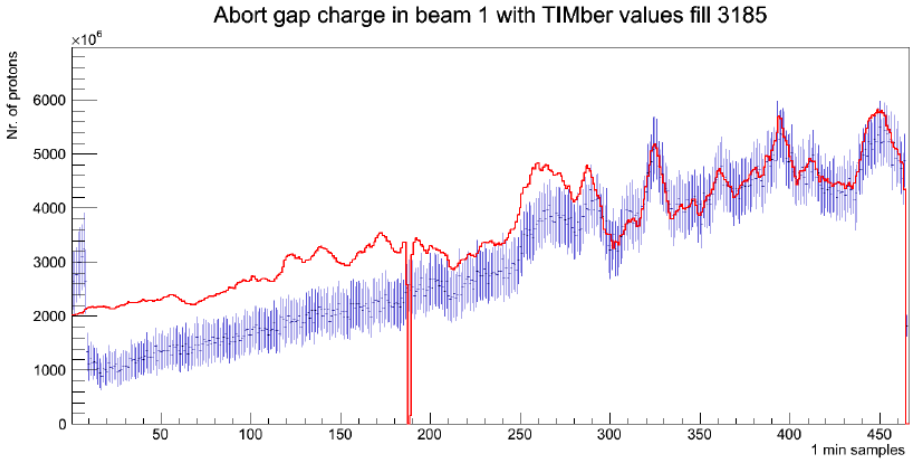


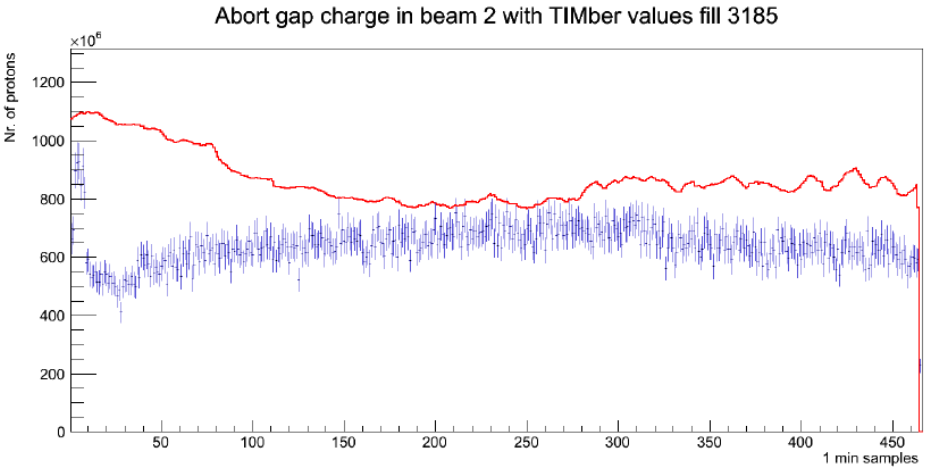


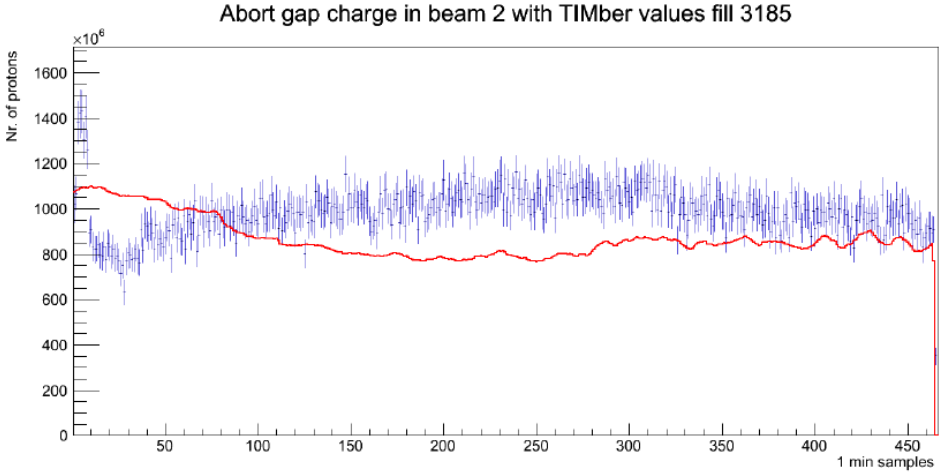
First attempt – FILL 3185

with 0.65 rescaling



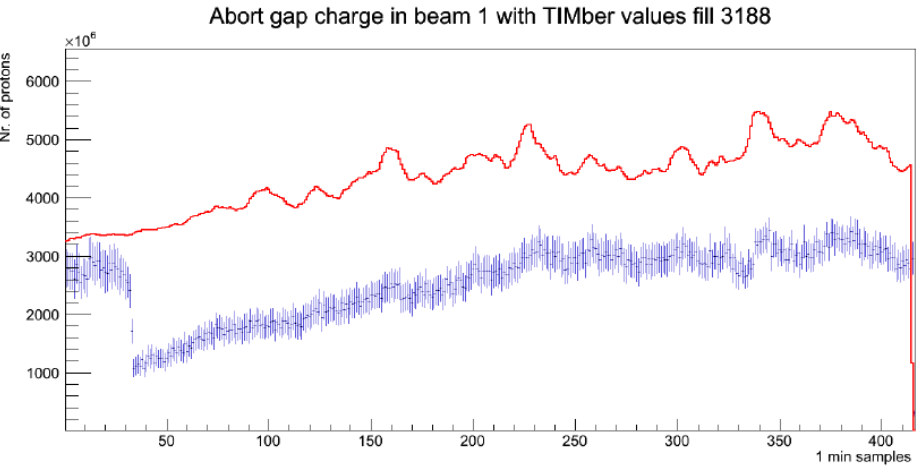


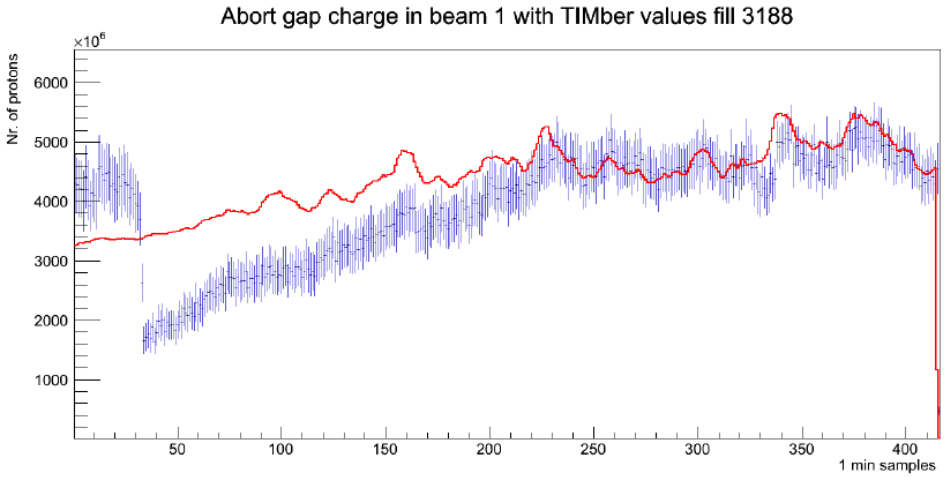


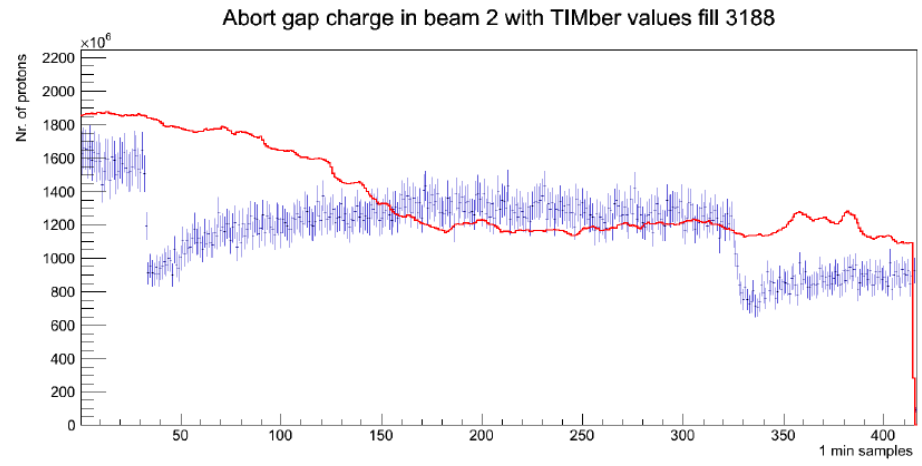


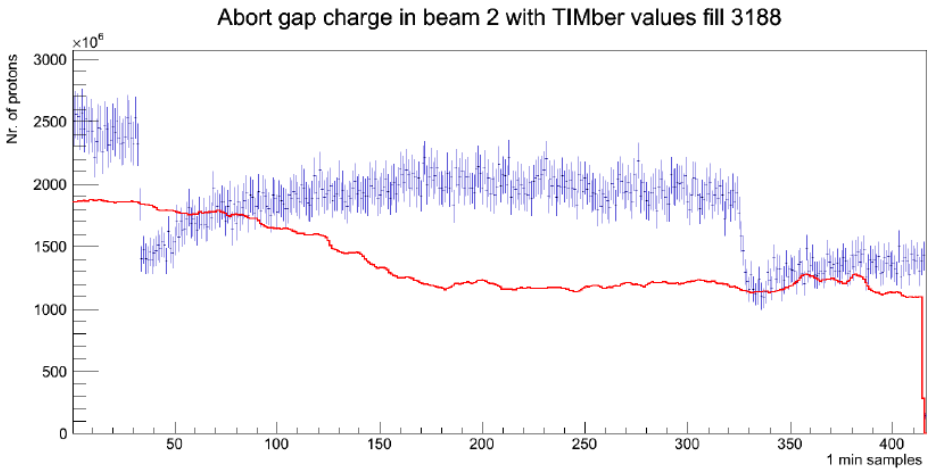
First attempt – FILL 3188

with 0.65 rescaling



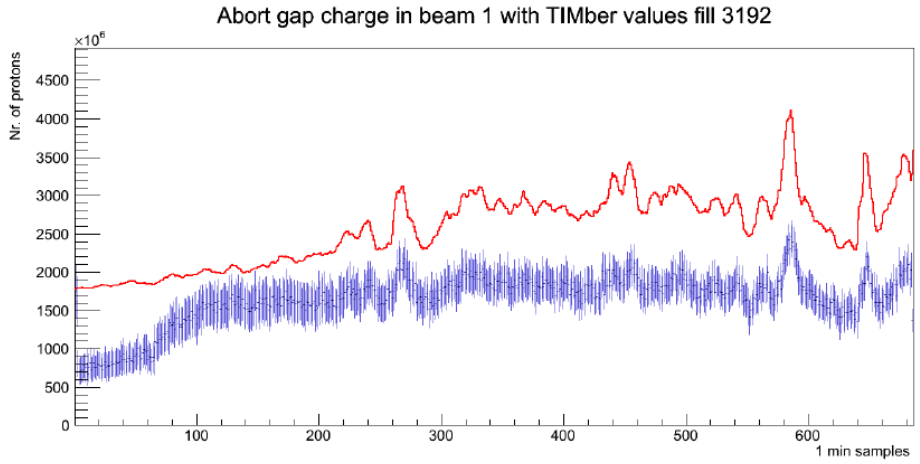


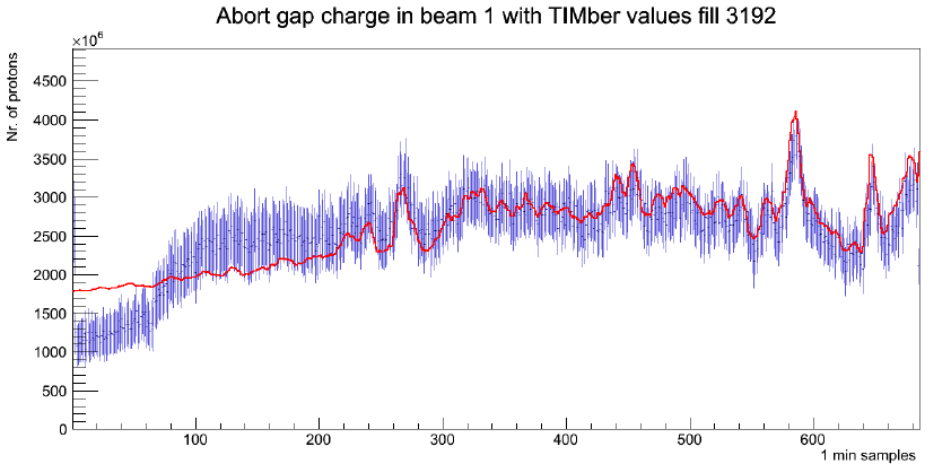


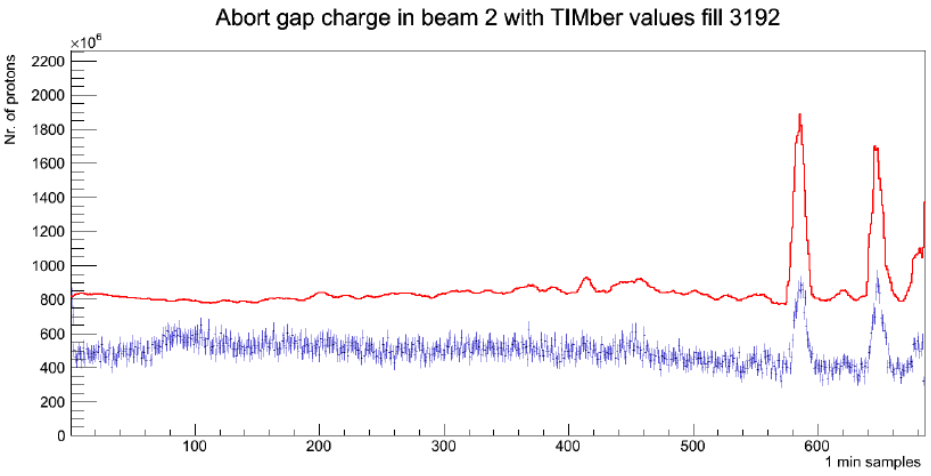


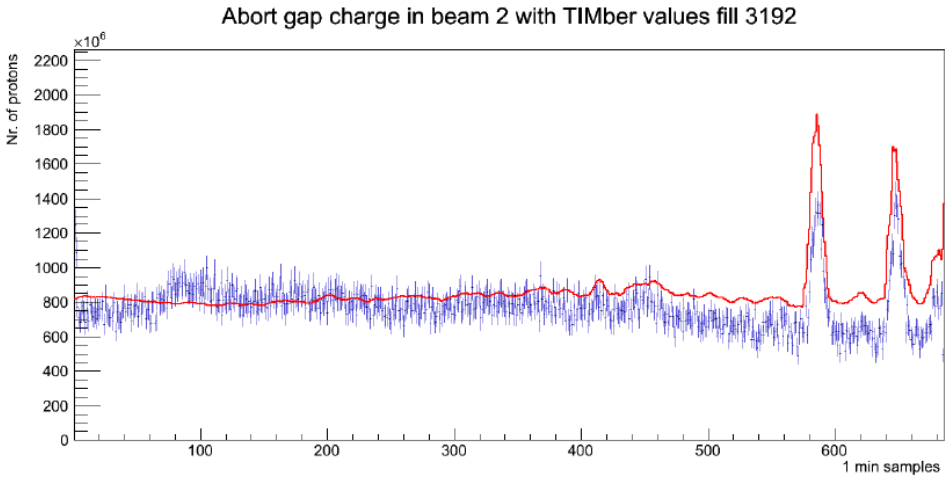
First attempt – FILL 3192

with 0.65 rescaling



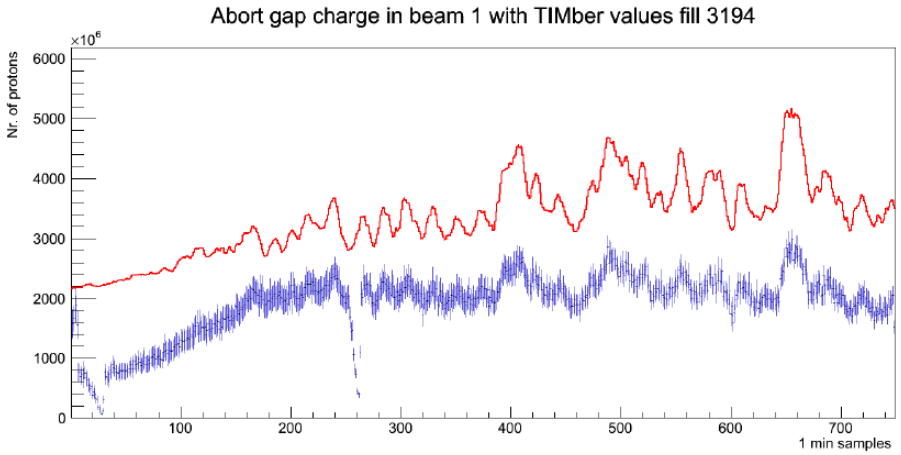


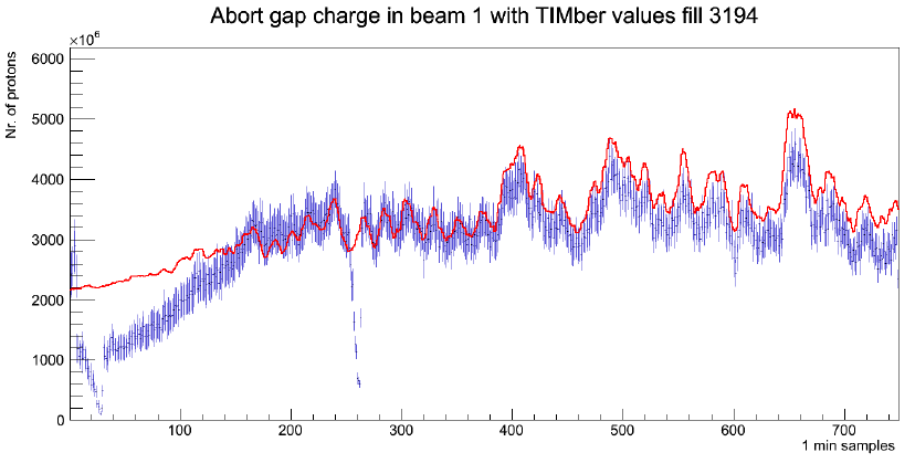


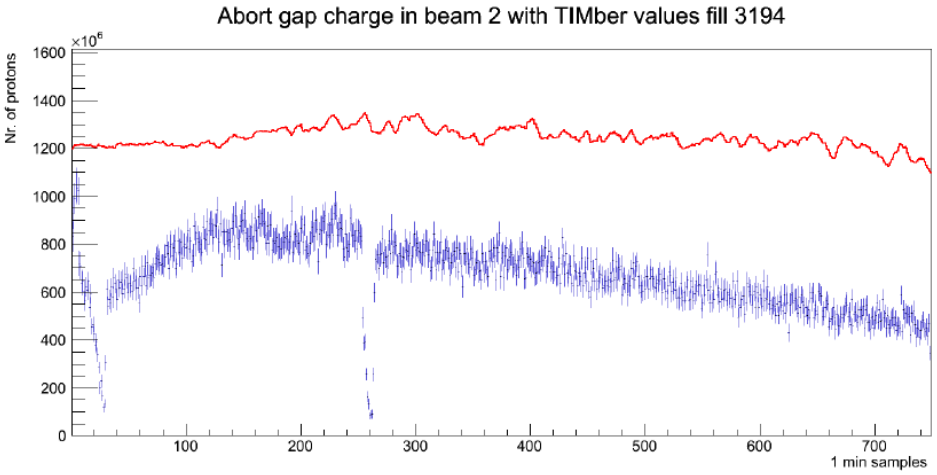


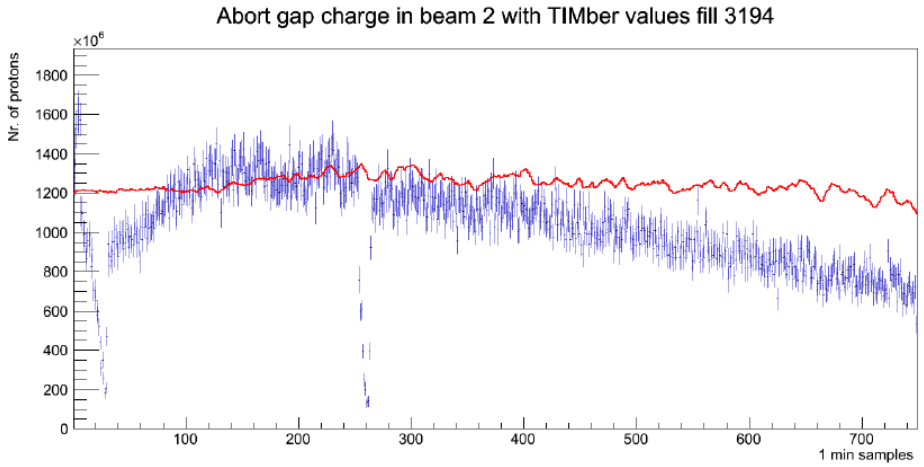
First attempt – FILL 3194

with 0.65 rescaling



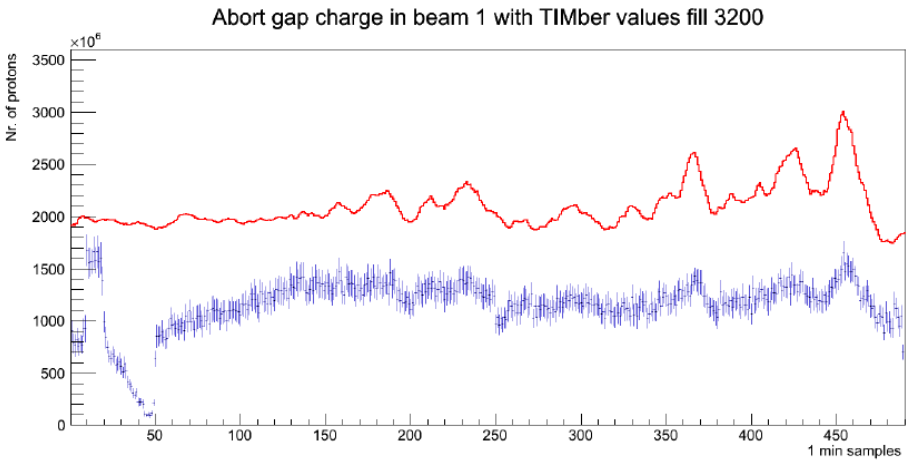


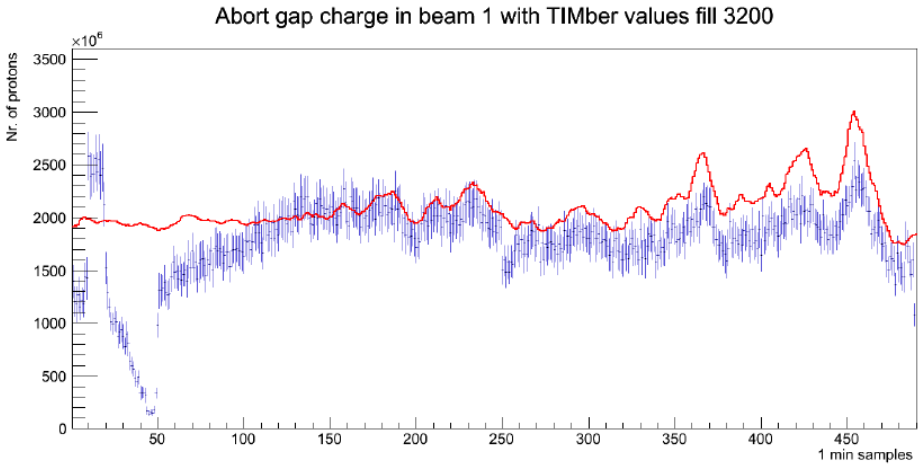


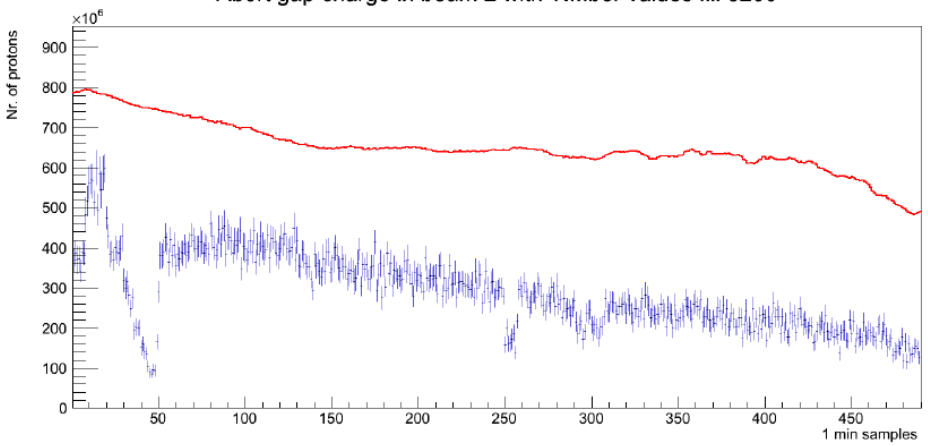


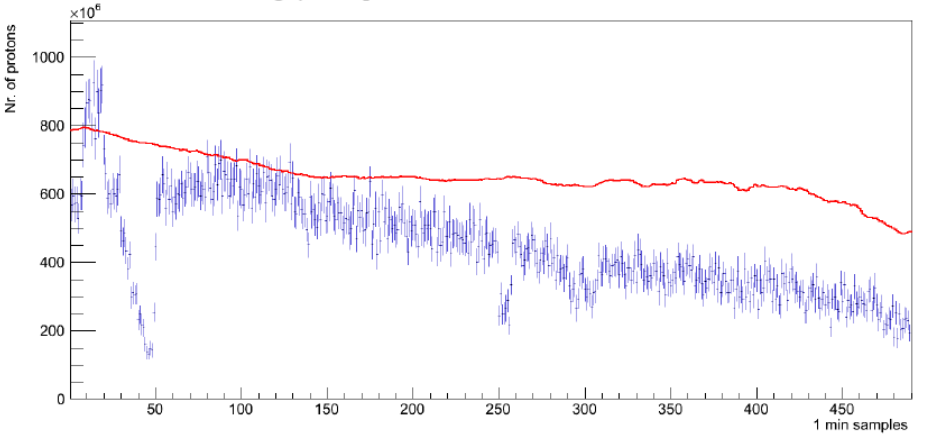
First attempt – FILL 3200

with 0.65 rescaling









Summary of observations on first procedure

- Rescaled AG charges calculated from IR match the TIMBER data better, especially in the second half of the fill (beam params more stable?)
- Some discrepancies remain, in particular for B2 (due T0 or BSRT?)
- In some cases B1 and B2 rates have different trend

Second attempt of AGP measurement (offline)

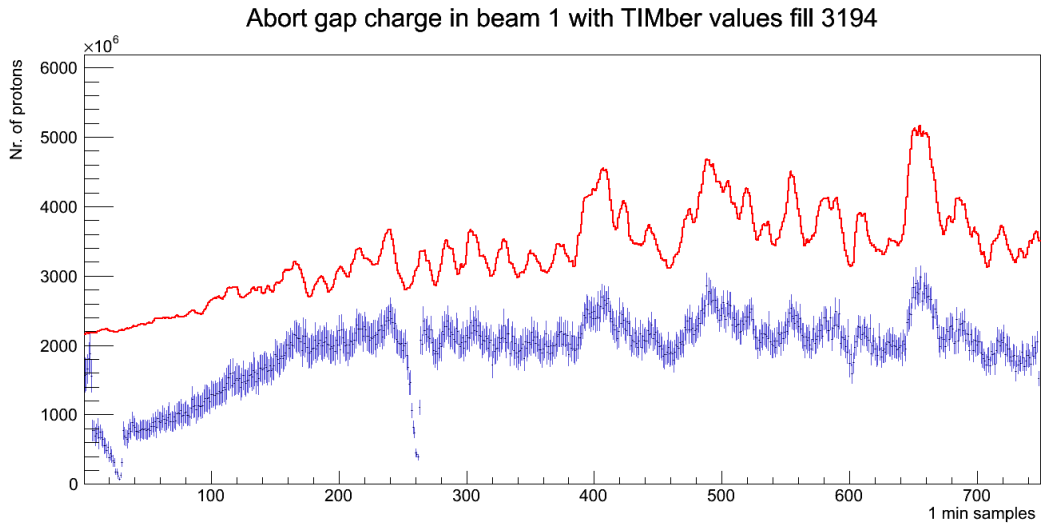
- Try to improve the calculation taking into account separation and beam lifetime (but constant emittance)
- Values of R sampled every minute, when $R > R_{max} \rightarrow R_{max} = R$, after a couple of minutes R_{max} is set at the beginning of SB
- From R and R_{max} calculate the beam separation as

$$d^2 = 2\,\Sigma_x \ln(R_{max}/R)$$

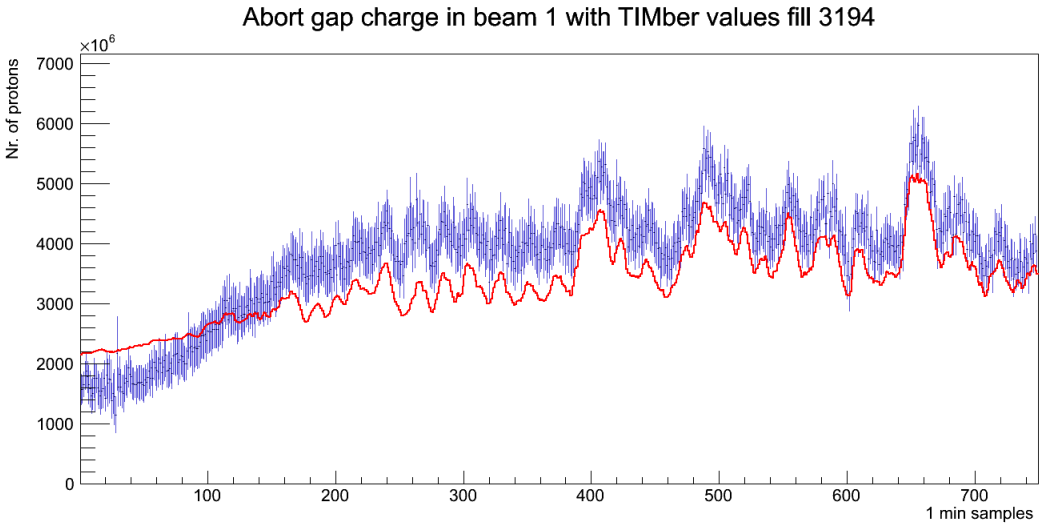
- L decreases with time so the beam separation is decreased to keep L = const
- Due to lifetime, R_{max} at a given time fill cannot be the same as at the beginning -> R_{max} scaling: when R_{max} is set, time t_{max} is stored and at time t we correct R_{max} (assuming $\lambda = 0.0017\ min^{-1}$ i.e. 10h beam lifetime)

$$R_{max} \rightarrow R_{max}\, e^{-\lambda\,(t - tmax)}$$

FILL 3194 - comparison of two procedures

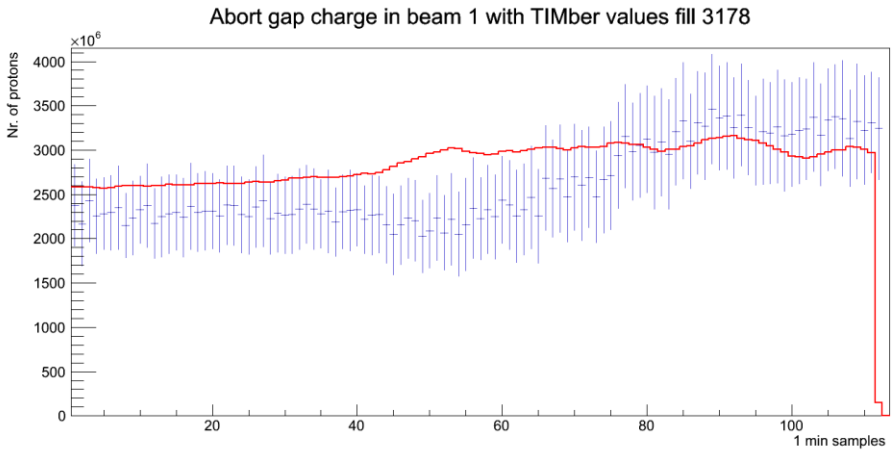


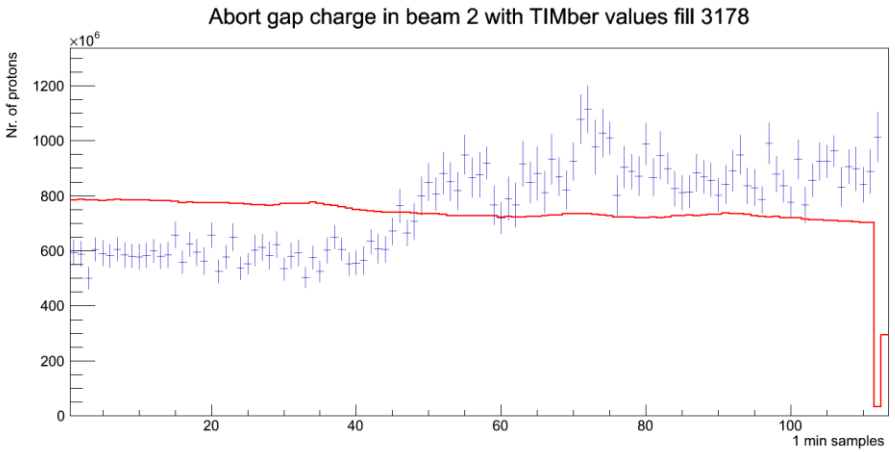
d=0 , no corrections

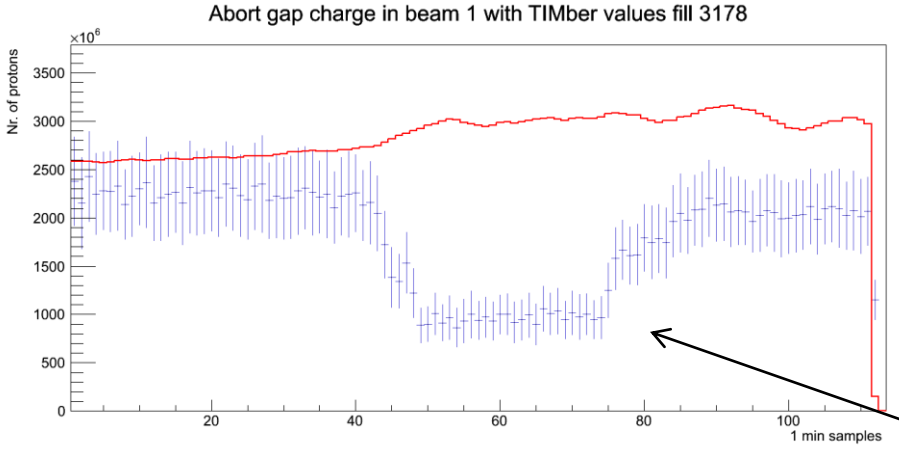


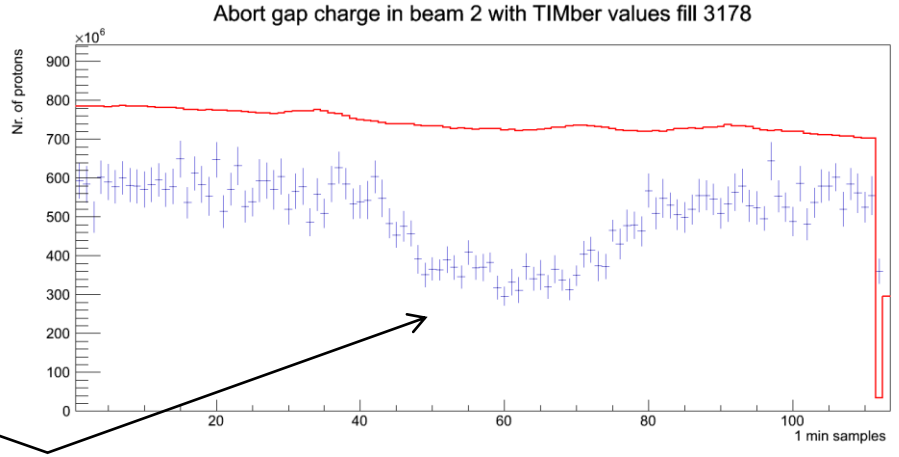
corrected for lumi levelling and beam lifetime

Second attempt – FILL 3178



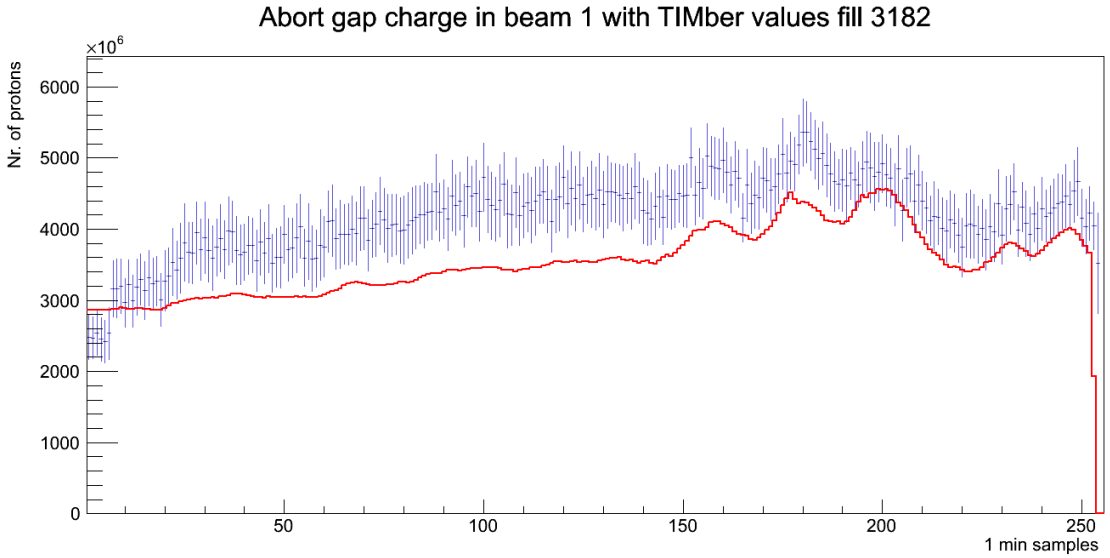


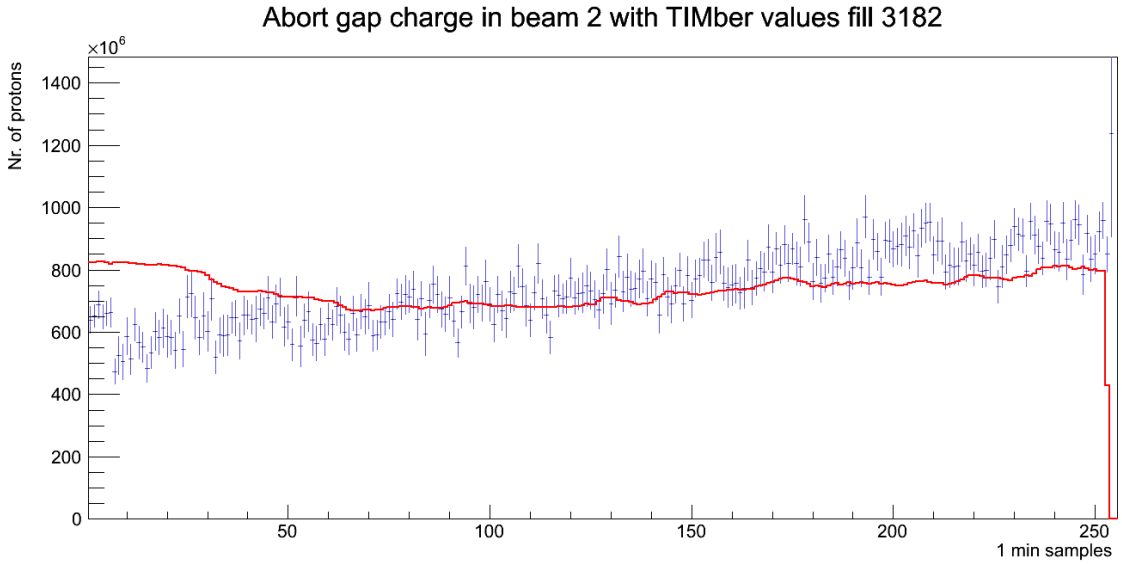




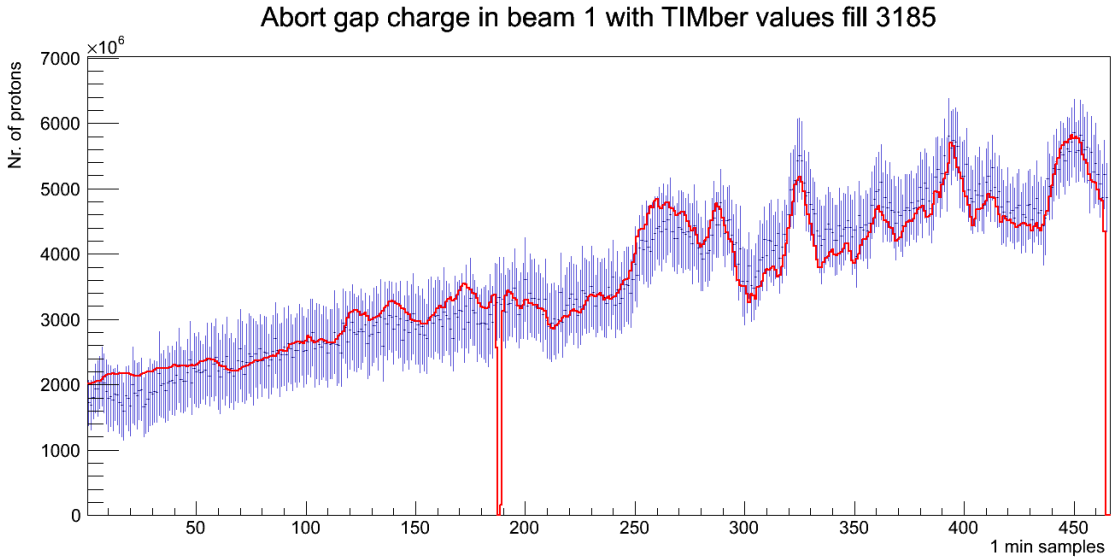
w/o lumi levelling correction

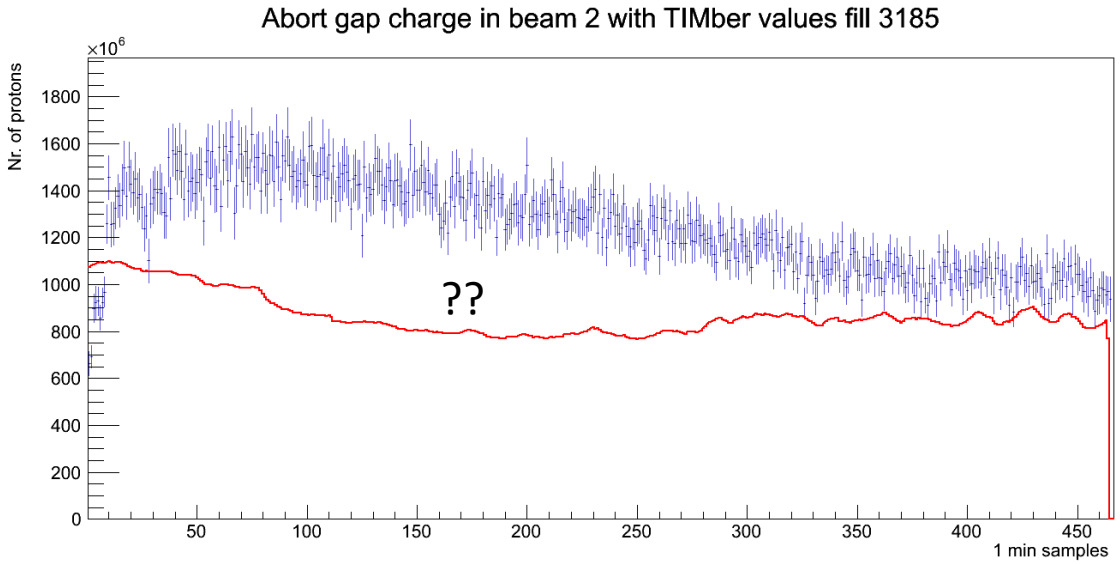
Second attempt – FILL 3182



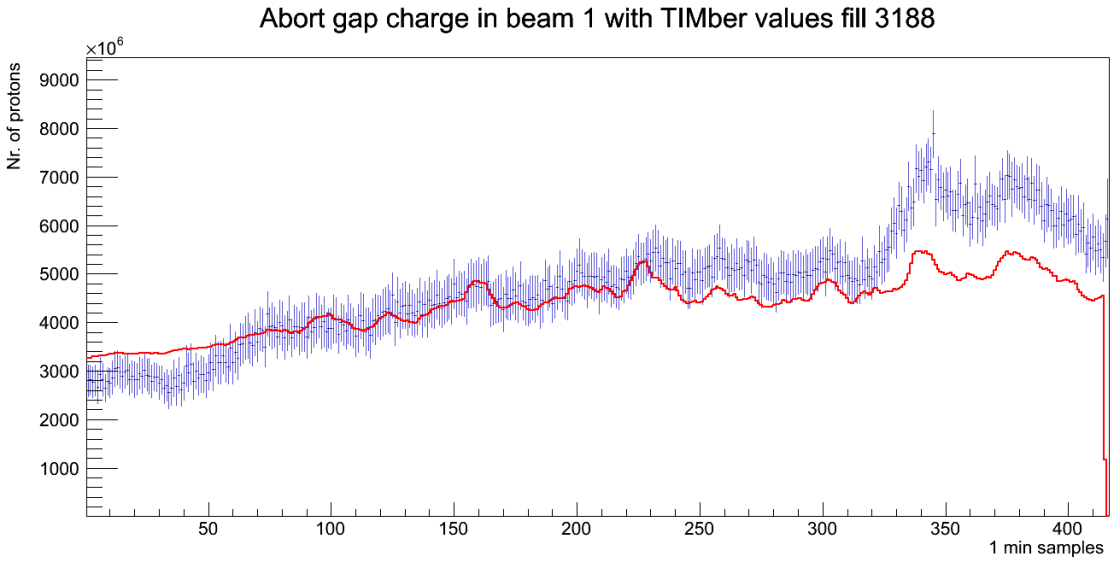


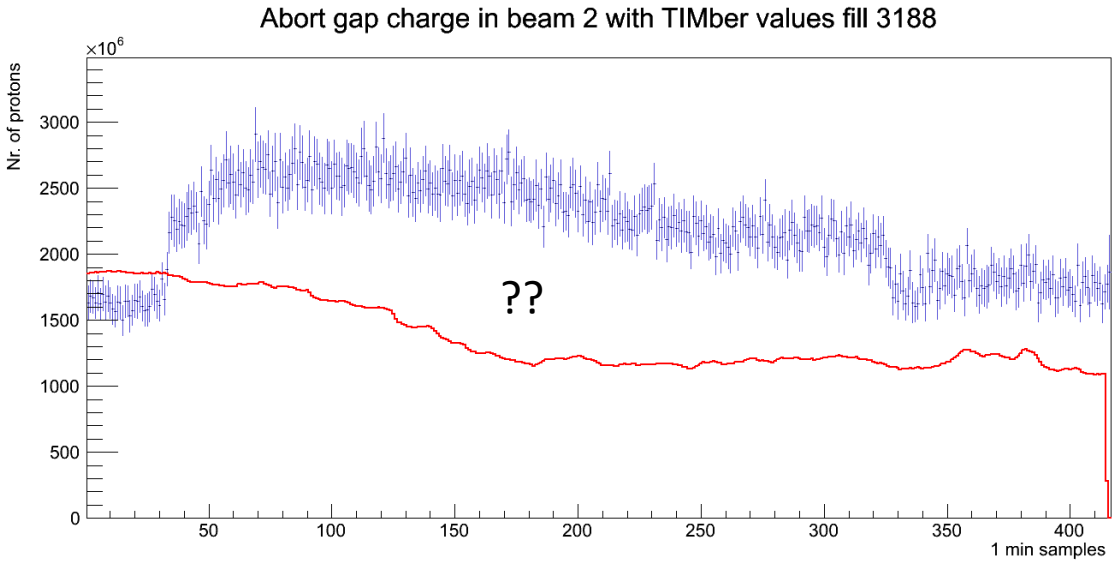
Second attempt – FILL 3185



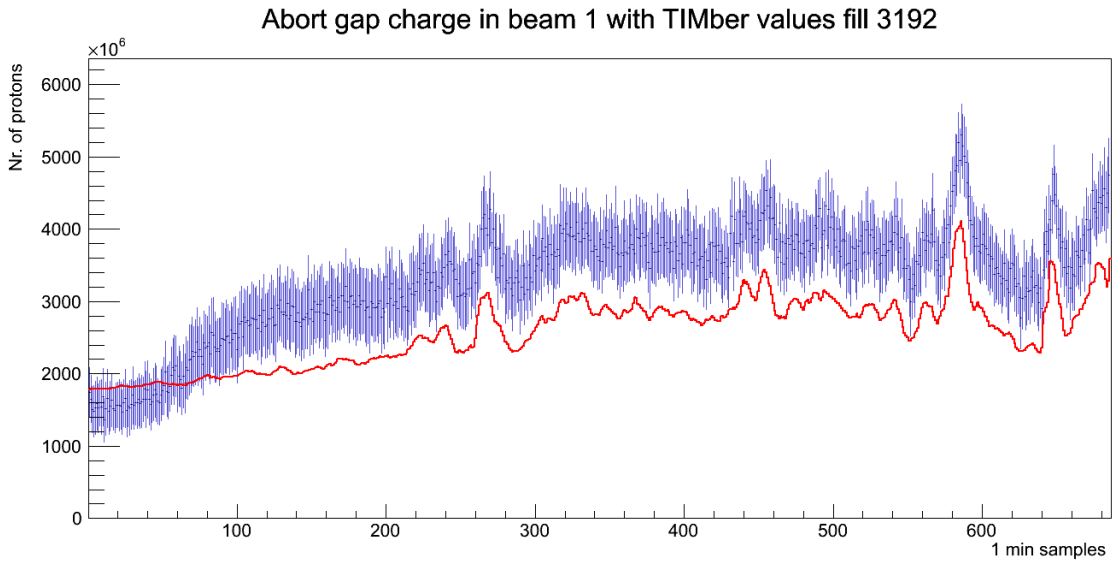


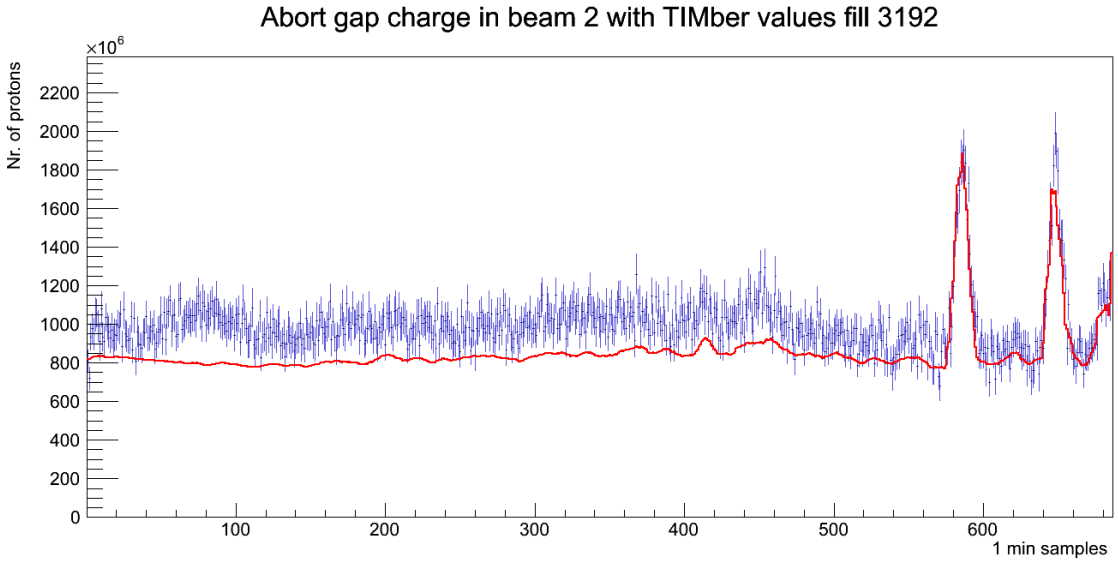
Second attempt – FILL 3188



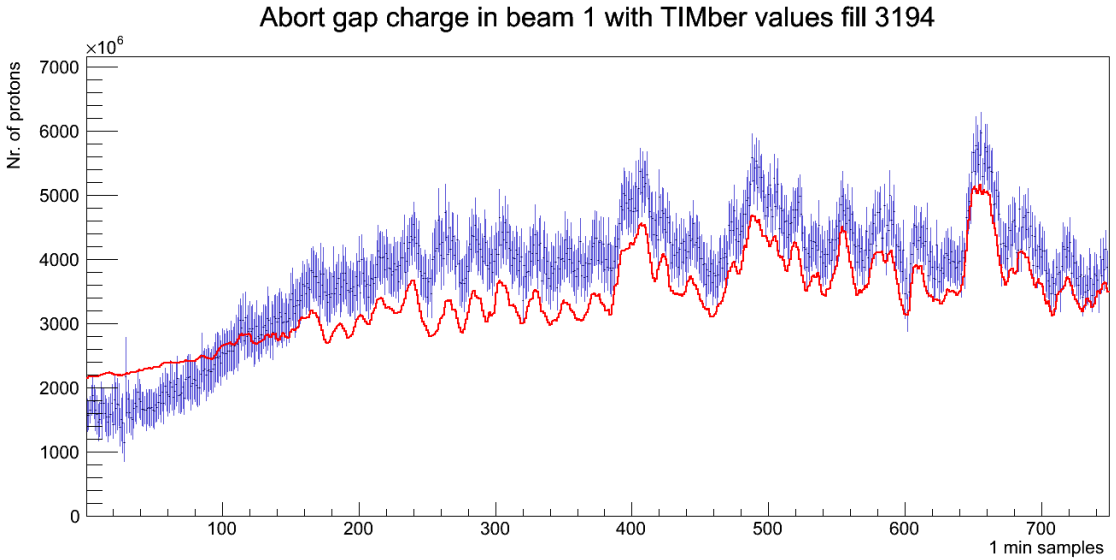


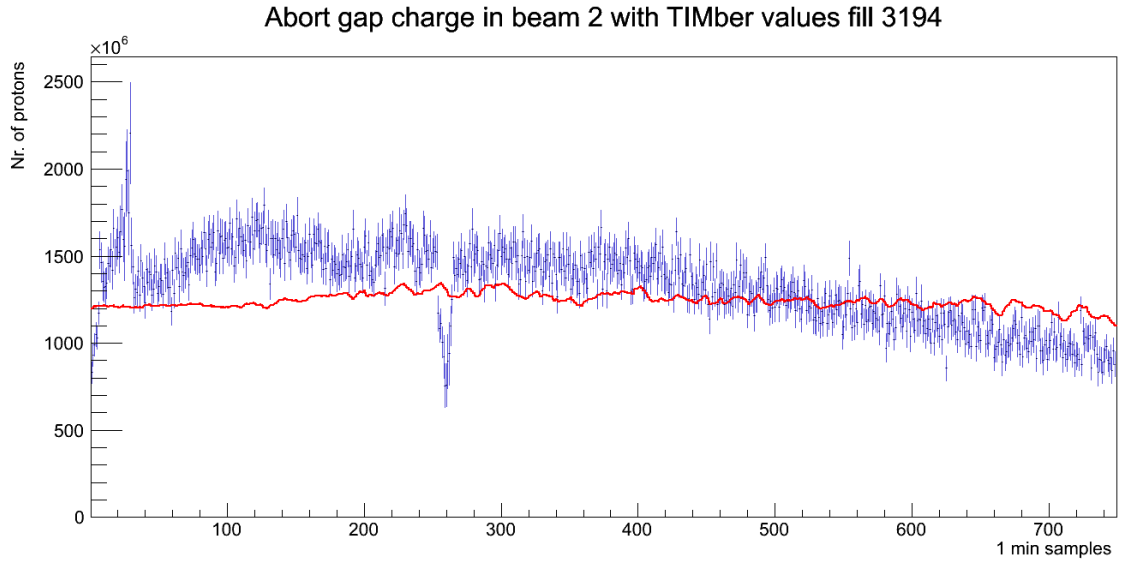
Second attempt – FILL 3192



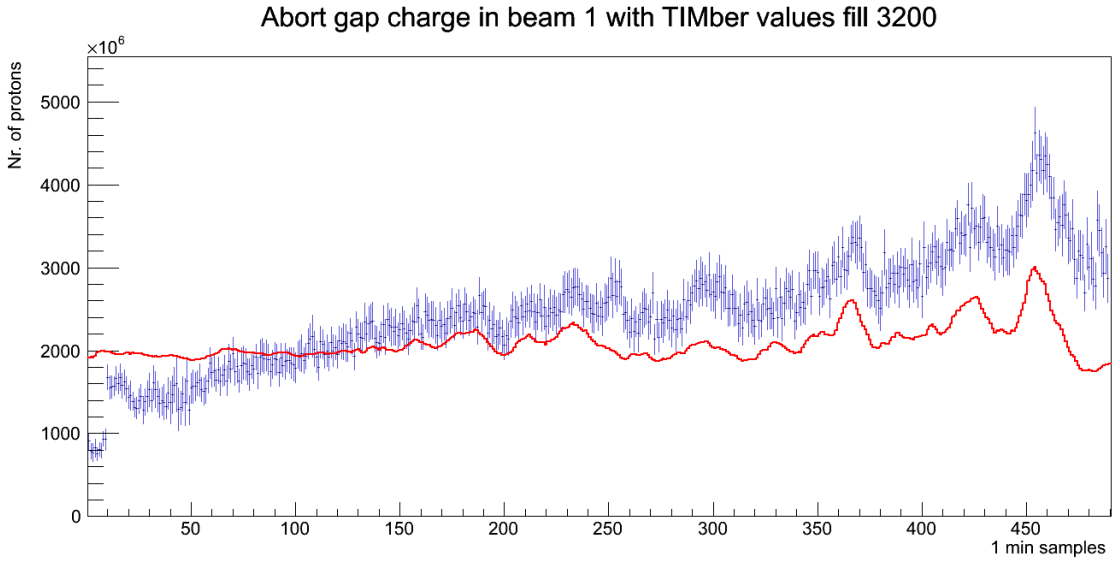


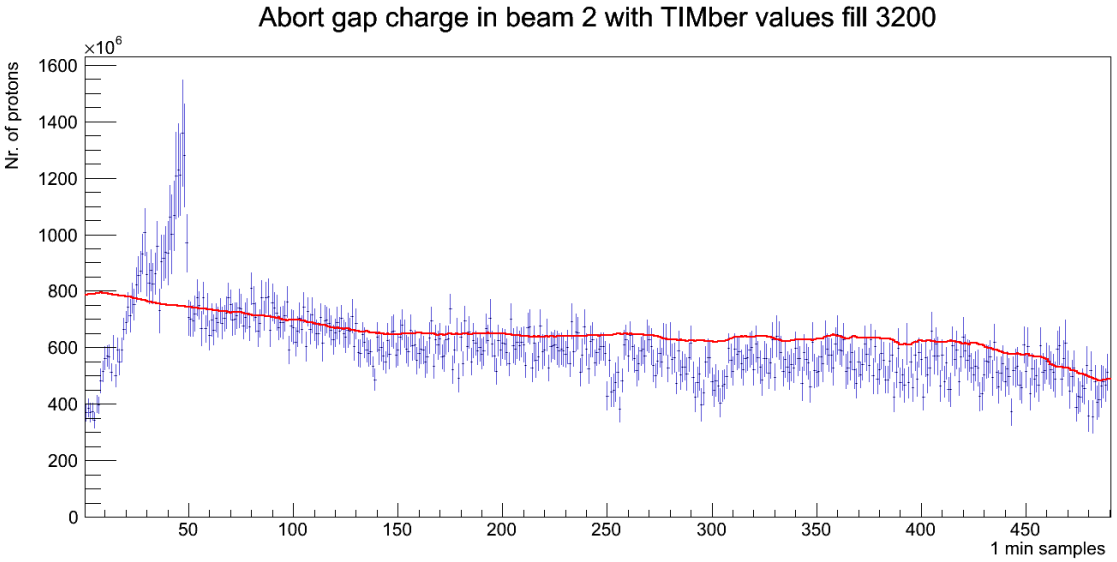
Second attempt – FILL 3194





Second attempt – FILL 3200





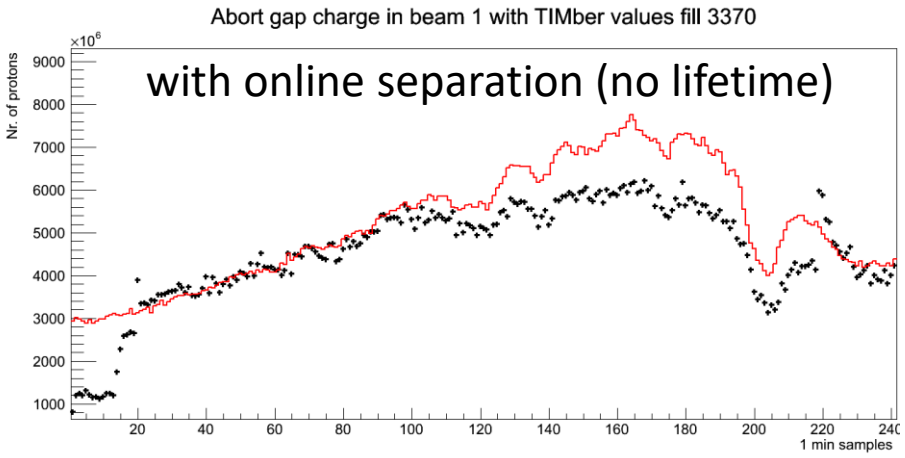
Third attempt of AGP measurement (online)

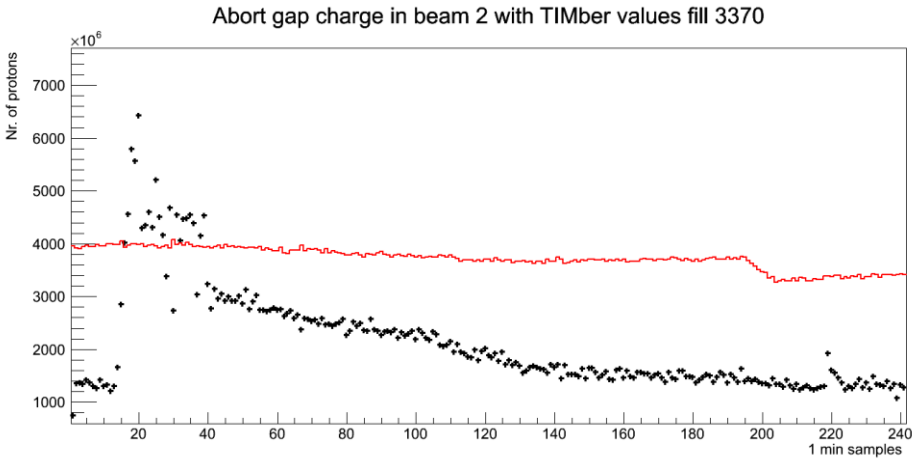
- Around mid November the four values of IP2 separation knobs were made available on dip (dip/acc/LHC/Beam/SepKnob/….)
- Beam separation calculated from the LHC knob values, maximum luminosity marks the reference knob values (trigger rates are checked every 2 sec):

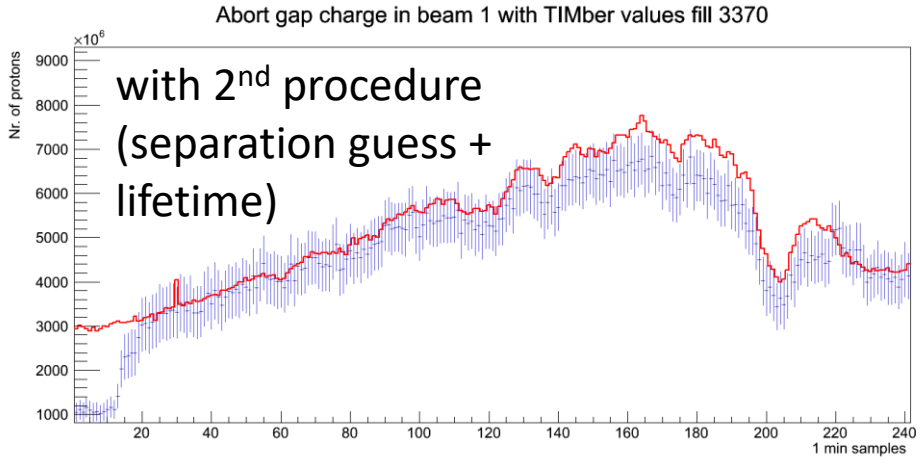
$$d^2 = \left[\left(B1X - B1X_{ref}\right) - \left(B2X - B2X_{ref}\right)\right]^2 + \left[\left(B1Y - B1Y_{ref}\right) - \left(B2Y - B2Y_{ref}\right)\right]^2$$

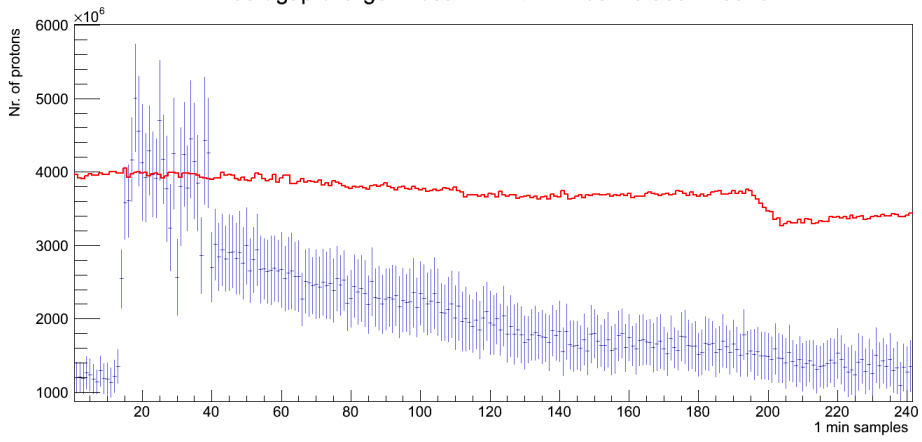
- Unfortunately not many useful fills available for checking: 3370, 3374, 3375, 3378.

Third attempt – FILL 3370

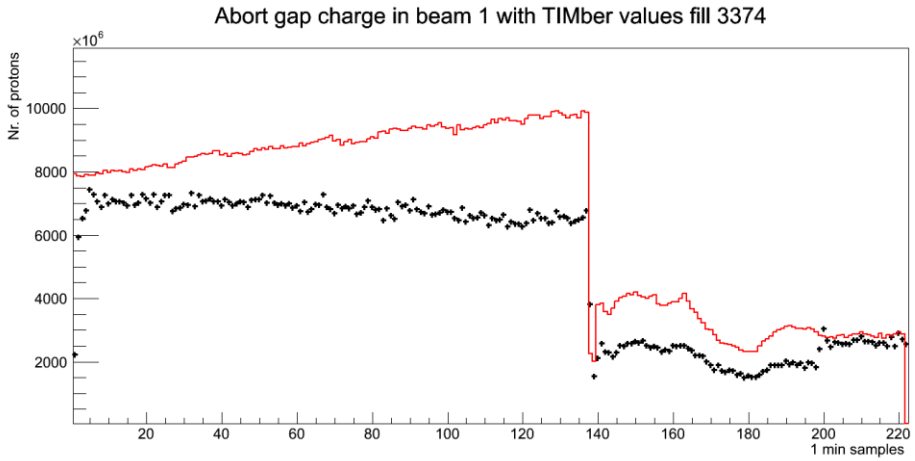


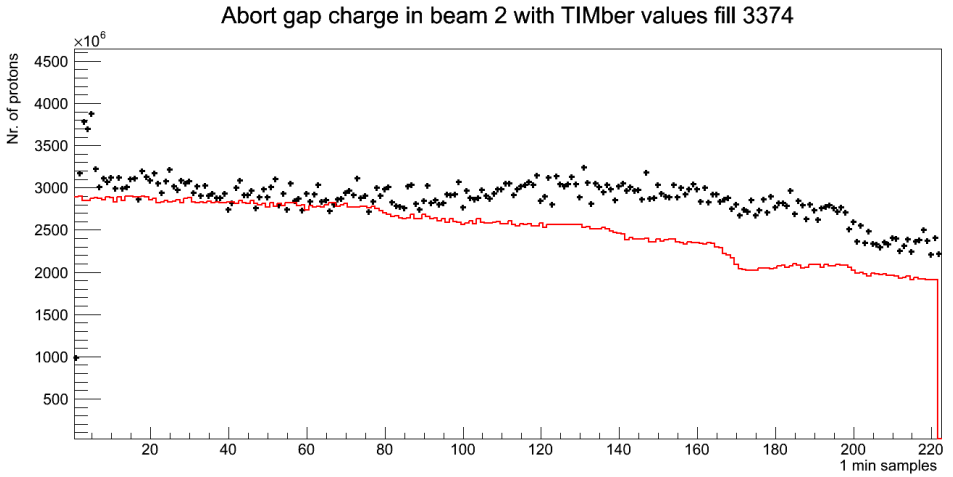


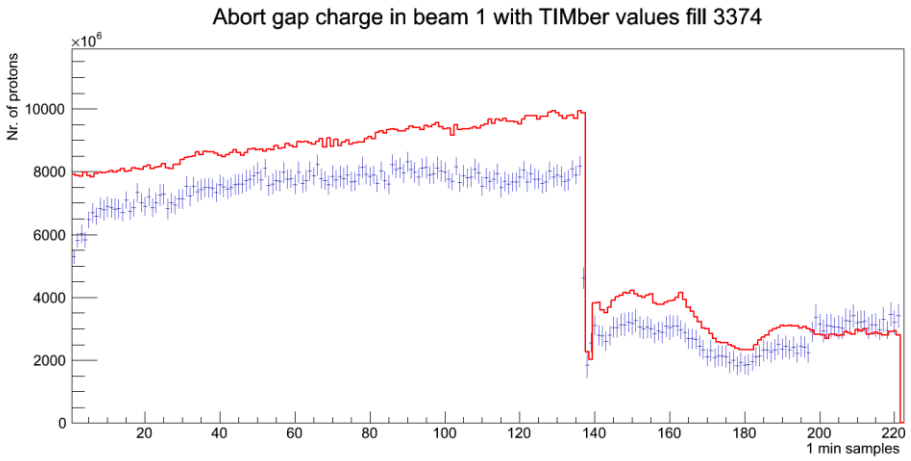


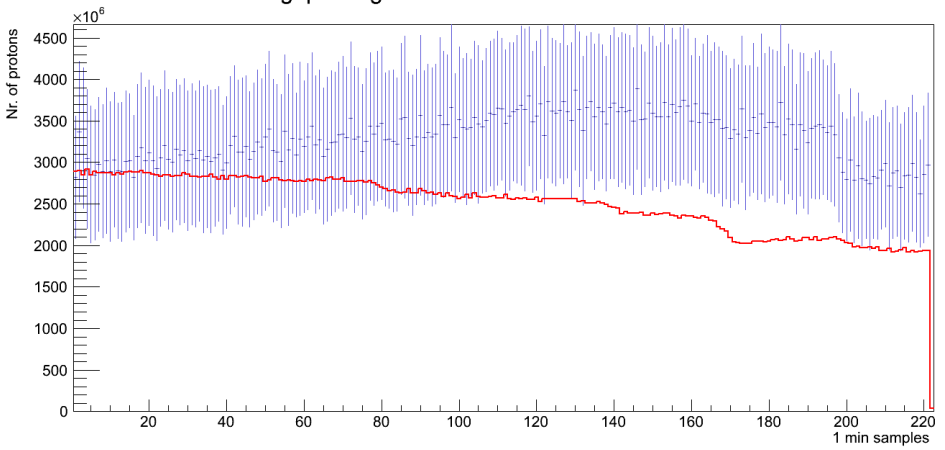


Third attempt – FILL 3374

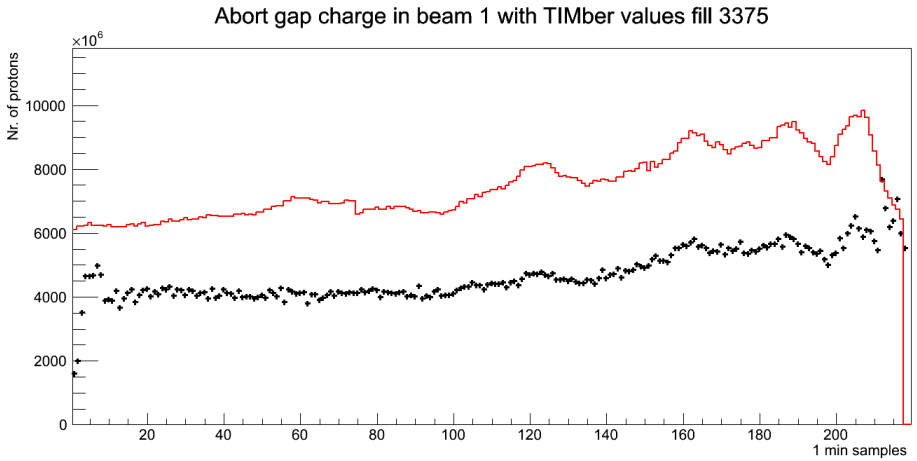


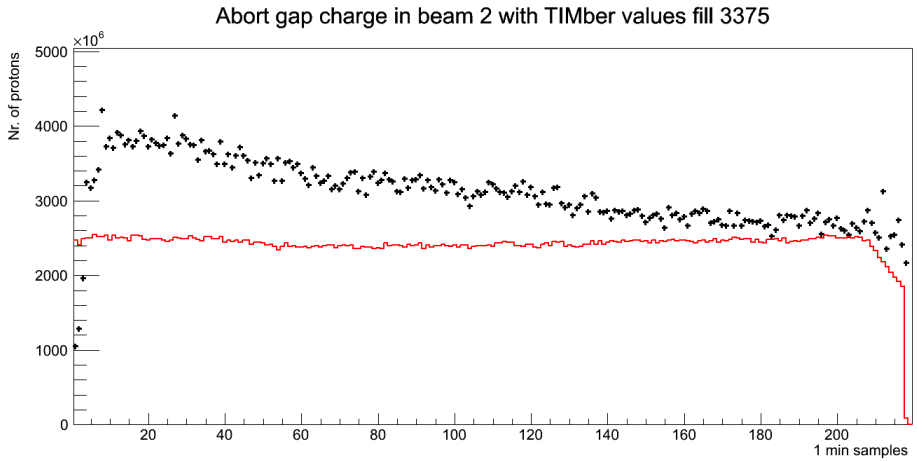


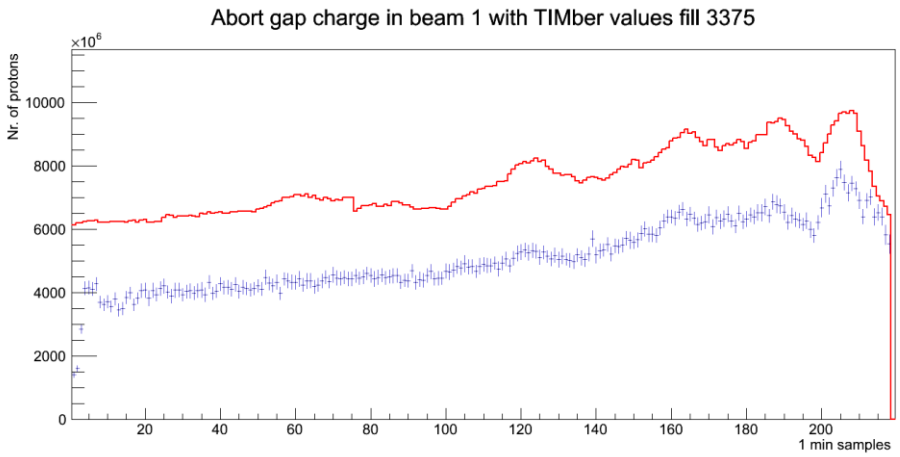


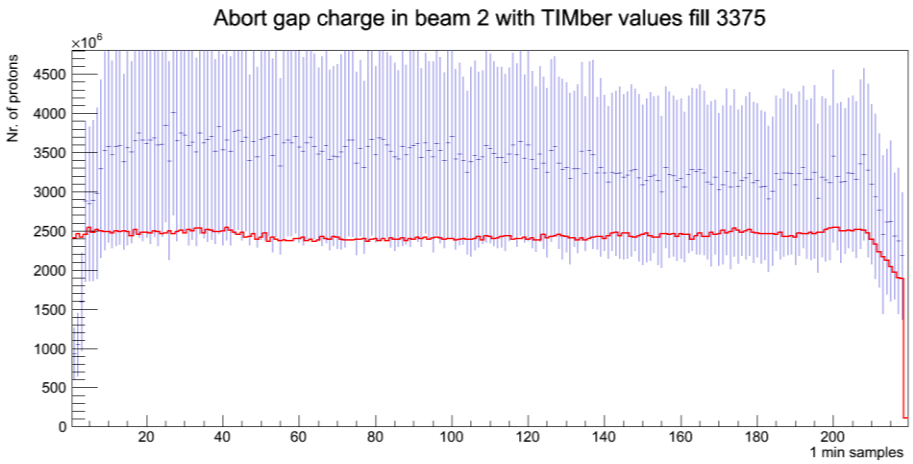


Third attempt – FILL 3375

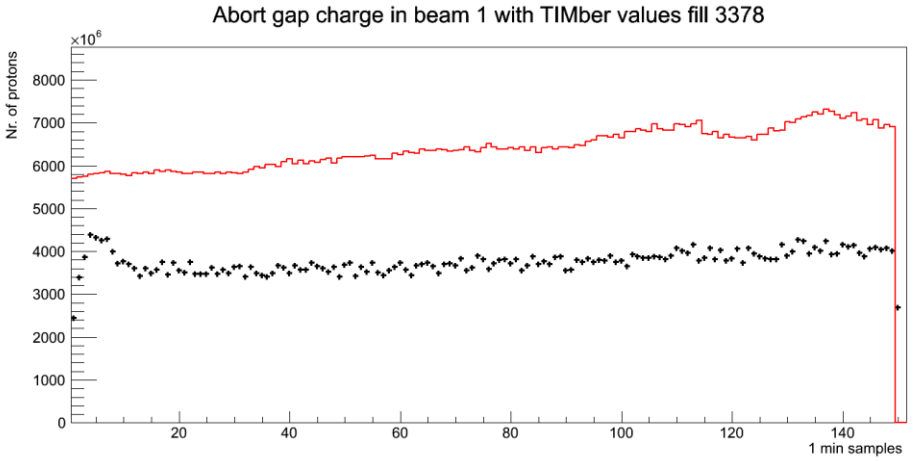


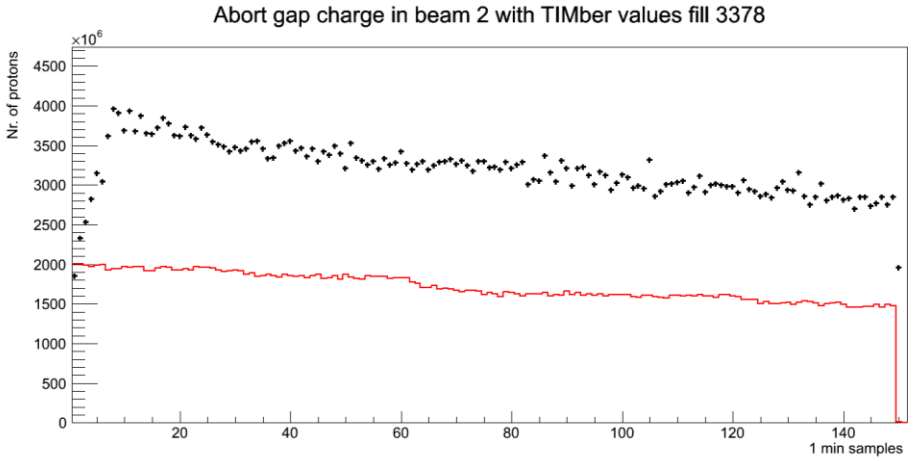


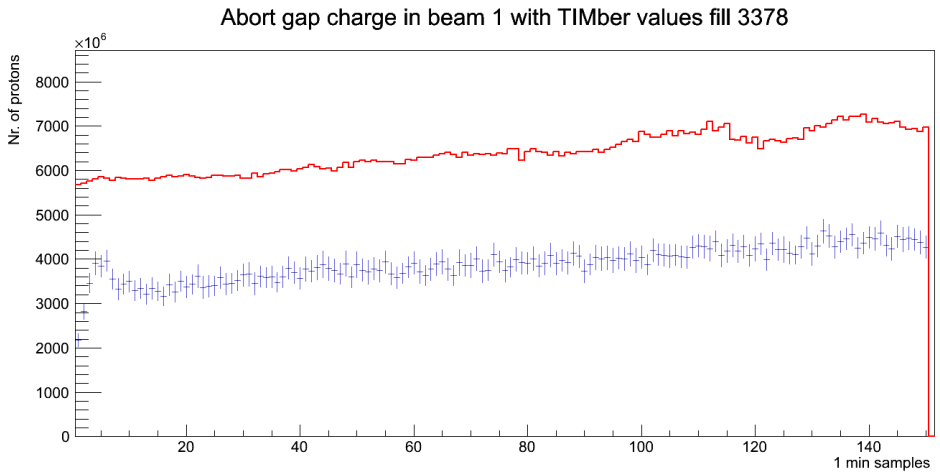


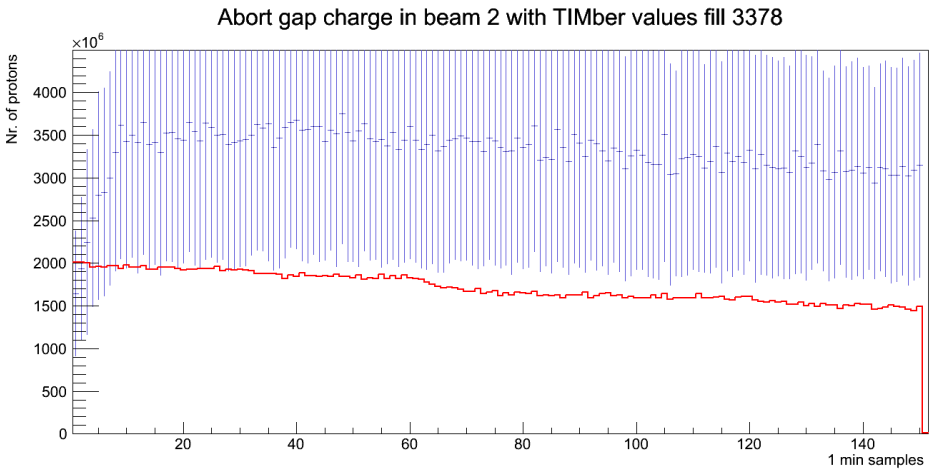


Third attempt – FILL 3378









Summary and outlook

- Various procedures have been tried, the best one using separation from guess and lifetime (fixed at 10h), probably similar results could be obtained implementing lifetime correction also in third procedure
- In general trend and order of magnitude of AGP from BSRT is reproduced, exact matching quite difficult, larger discrepancies observed for B2
- The method could be improved with larger statistics, i.e. more fills to be checked
- In perspective, with main-main collisions a better tuning would be possible by comparison with interaction rates from main colliding bunches (both charges known, precise estimation of lifetime, emittance,…)