report for analysis

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Contents

1 beam line detector analysis

1.1 timing calibration for TDC at RF,plastic scintillator,PPAC

1.1.1 summary

We should get physical information from the obtained data,digital data taken by the data acquisition system. In this section, I analyze timing calibration of F2PL,RF and PPAC.

1.1.2 ch⇔ns

In following a picture, this is a raw data of timing signals which correspond to the time arranged to the 20 ns.

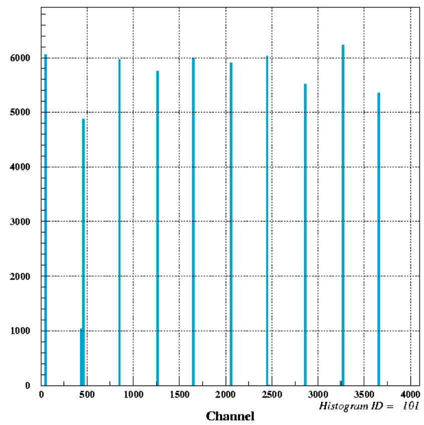


Figure 1: tdc ch

To convert obtained digital data to ns, I used following function.

$$T(ns) = aX(ch) + b \tag{1}$$

h

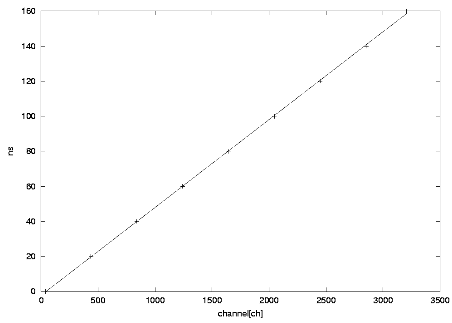


Figure 2: tdc ch

h

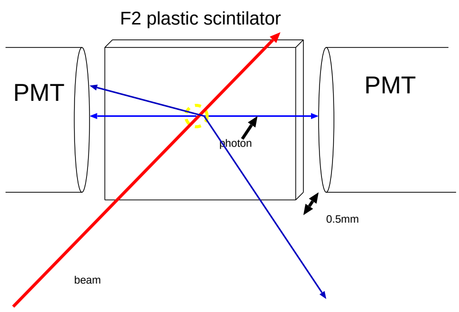


Figure 3: tdc ch

1.2 RIPS and plastic scintillator

1.2.1 summary

F2PL has mainly purpose of two parts. One part is for particle identity of the beam from RIPS. And another part is to measure TOF ,time of flight for calculating a momentum of the beam. The relay of this TOF is that of from F0 to F2.

1.2.2 principle

This section is an introduction for how to do a particle identity. In magnetic filed ,D1 and D2 ,the motion of charged particle is Lorenz motion and thus, following equation is concluded for charged particle.

- B:value of magnetic filed
- ρ:radius of curvature

- Z:number of proton of charged particle
- A:number of mass of charged particle

$$B\rho \propto \frac{A}{Z} \tag{2}$$

This shows that the particle is separated if $\frac{A}{Z}$ of the particle is different. The equation of the energy loss of a charged particle which passes though a matter is given by following .

- v:velocity of charged particle
- TOF: time of flight of certain section

$$\Delta E \propto \frac{Z^2}{v^2} = Z^2 \mathrm{tof}^2 \tag{3}$$

This shows that I can separate the particles which are different number of Z.This part is done by Al degrader which is between D1 and D2. If I modify the magnetic filed value of D2 which is fits to the particle which is used in this experiment, the particle far from ones is rejected because of different proton number by using degrader composed of Al between D1 and D2 which caused different energy loss ,thus changing particle velocity. So I can select particles which are around the ones which is used in this experiment. But this mixes other particles around that which is not to be able to separate in Rips. To reject that, I use a F2PL.This gives me timing signal and pulse height caused by charged particle passing though that material. I can do the identify the particle by equation 3.

1.2.3 calibration beam ^{25}Ne and particle identity

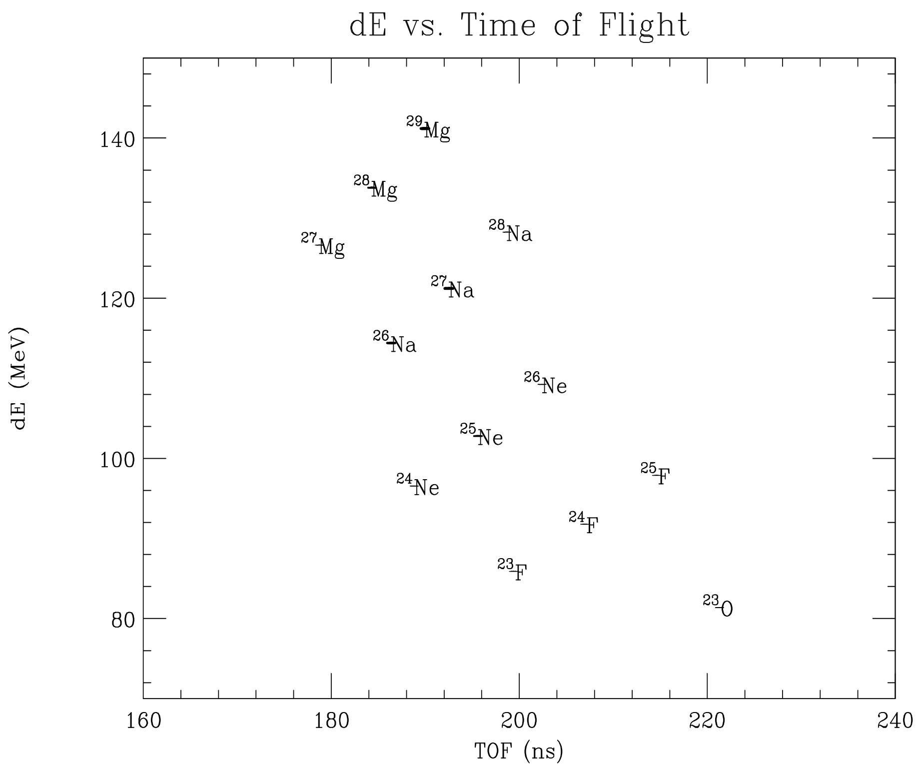
For purpose of following calibration, I used the run which is ^{25}Ne. That has $\Delta p/p = \pm 0.1\%$,the momentum of distribution. Before calibration, I must select ^{25}Ne by using the correlation between pulse height of F2PL and TOF from F0 to F2PL. To identify the particle. I reefer the simulation code ,Intensity. This gives me intensity of various fragment which goes from RIPS and above correlation on simulation.

1.2.4 slew correction of the plastic scintillator

By the threshold of a discriminator, the timing of low pulse height on analog signal is delayed compared to other region of energy. To correct the slew signal, I used following equation.

$$< A >= \frac{a}{T^b} \tag{4}$$

Figure 4: TOF vs ΔE from calculation of Intensity



1.2.5 To calibrate RF1 and RF2 and to select real event

After RF signal is thinned because of high count rate, these are divided into two signals of RF1 and RF2 in order to get the data efficiently. These signals correspond to one cycle by one cycle. Thus, if the timing signal include proper range on one TDC, another TDC must be out of range. So, I have to reject the unproper signal.Following picture shows that and proper pulses set to come about 200ns.

calculation of intensity

Fragment	Rate (particle/s)	TOF(F0-F2) (ns)
^{25}Ne	6.223*10^3	201.4
^{26}Na	6.761*10^3	191.1
^{27}Na	8.963*10^3	197.4
^{28}Mg	5.013*10^3	189.0
^{29}Mg	9.808*10^3	194.8

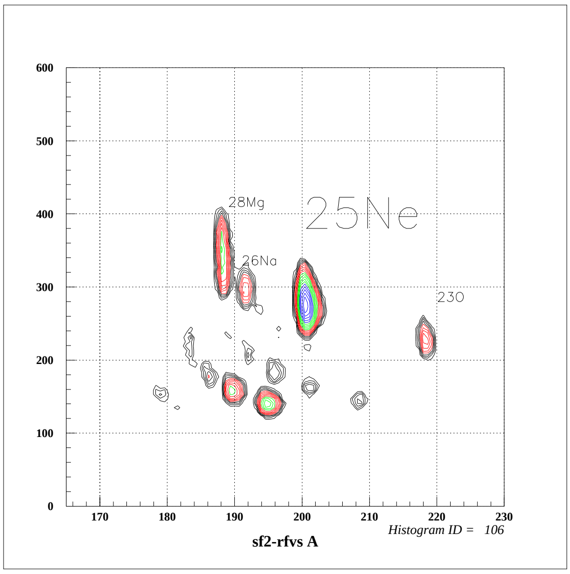


Figure 5: tof(ns) vs ΔE from experiment data

1.2.6 determination momentum of beam

Firstly, I introduce simply physics calculation to determine a beam momentum and β from measuring value in this experiment.

- B:the value of magnetic filed from NMR
- C:the velocity of the light
- ρ:the radius of curvature,3.6m at RIPS
- Z:the proton number of charged particle
- AMU:atomic mass unit
- P:momentum

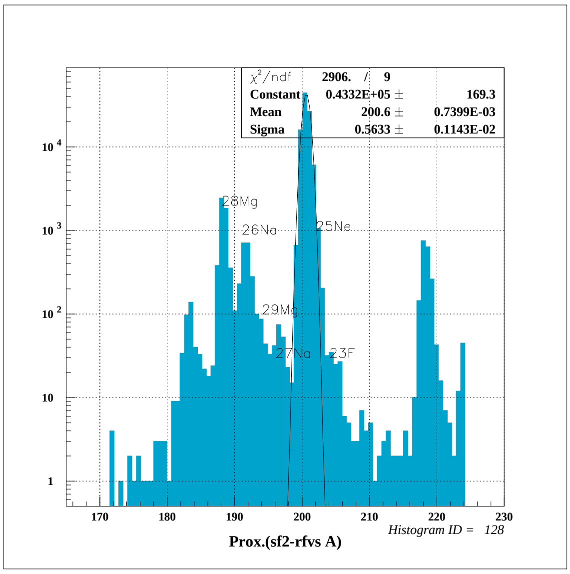


Figure 6: TOF (ns)

- E_{kin}:kinetic energy of the charged particle
- E_{total}:total energy of the charged particle

There are two NMR systems at D1 and D2 each other and this give me precise value of the magnetic field.

$$P = \frac{cB\rho Z}{A} \tag{5}$$

From momentum, you calculate kinetic energy.

$$E_{\text{kin}} = \frac{P^2}{\sqrt{P^2 + AMU^2} + AMU} \tag{6}$$

$$E_{\text{total}} = E_{\text{kin}} + AMU \tag{7}$$

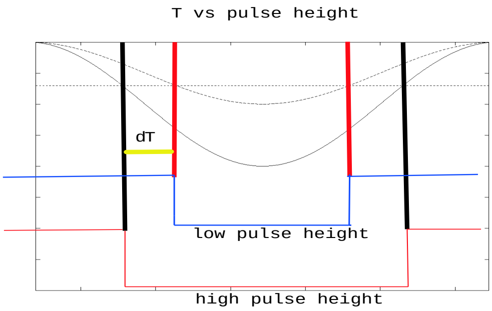


Figure 7: pulse height vs timing

$$\beta = \frac{P}{E} \tag{8}$$

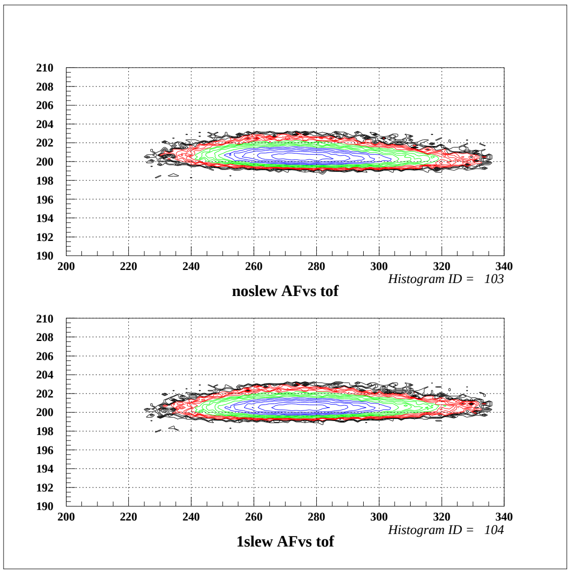
From that, TOF is calculated in following.

- L: flight length

$$\mathrm{TOF} = \frac{\mathrm{L}}{\beta \mathrm{c}} \tag{9}$$

In above procedure, I calculate TOF from F0 to F2.Thus I determine absolute value. And I calculate beam momentum and β at D1,D2 by using magnetic filed value of NMR .

So, by using this value,I can select the real event on the experiment data .That is to say,the beta of unreal event is less than real beta in this set. Because this event is out of range at TDC and delayed about 80ns. In the next step,I analyze the momentum before the target. Though the beam line,many matter,F2PL, two PPACs,kapton miler and air which included from the end of the beam pipe to the target, included on that. I explain how to get this value in following sentence. The value after calculating above equation is corresponded to the central value of what I obtain from experimental data.To be from central value to outside that on a momentum distribution of that data, I can approximate β distribution on following equation.



TOF(RF-SF2)

	σ
no slew	0.5061
one slew	0.4953

$$\beta_{\rm D2} = a + b{\rm TOF}_{\rm F0-F2} + {\rm cTOF}^2_{\rm F0-F2} \tag{10}$$

Similarly momentum is calculated. a,b,c is obtained by the calculation.

$$P_{\rm aftermaterial} = a + bP_{\rm beforematerial} + cP^2_{\rm beforematerial} \tag{11}$$

I check the value obtained from experiment data compared to the calculated value.

comparison

^{25}Ne

	calculation	exp
$\beta_{\rm D2}$	0.3427	0.3425
$\frac{\rm P_{afttgt}}{A}$	316.75[MeV]	316.7[MeV]
$\beta_{\rm afttgt}$	0.32194	0.3220
$\frac{\rm E_{afttgt}}{A}$	52.3803[MeV]	52.41[MeV]

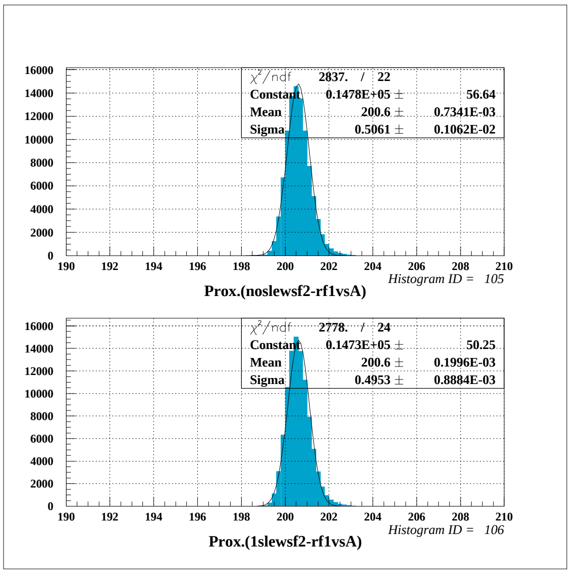


Figure 8: before slew correction and after correction

After rejecting unreal event by using comparison β between real event or not, I check the beam rate compared between before rejecting rate or after that. And I calculate the purity of ^{25}Ne of beam.

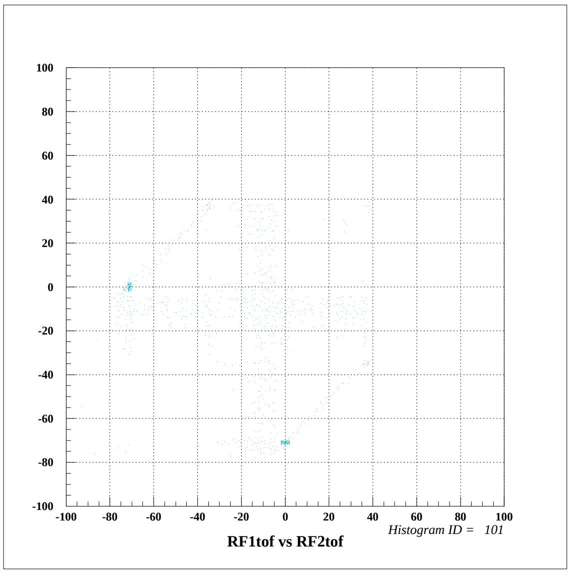
	count rate
RF1*^{25}Ne	47824
RF2*^{25}Ne	48146
βRF after selecting*^{25}Ne 60MeV/A at D2	95441
$(RF1+RF2)\approx RF$	

$$purity = \frac{N_{^{25}\mathrm{Ne}}}{N_{\mathrm{total}}} = 79.6\%$$

N: all particle count rate at F2

1.2.7 particle identity of ^{26}Ne,$\Delta p/p = \pm 2\%$

This procedure of ^{26}Ne is same that of ^{25}Ne.



$$purity = \frac{N_{^{26}\mathrm{Ne}}}{N_{\mathrm{total}}} = 77.3\%$$

N:All particle count rate at F2

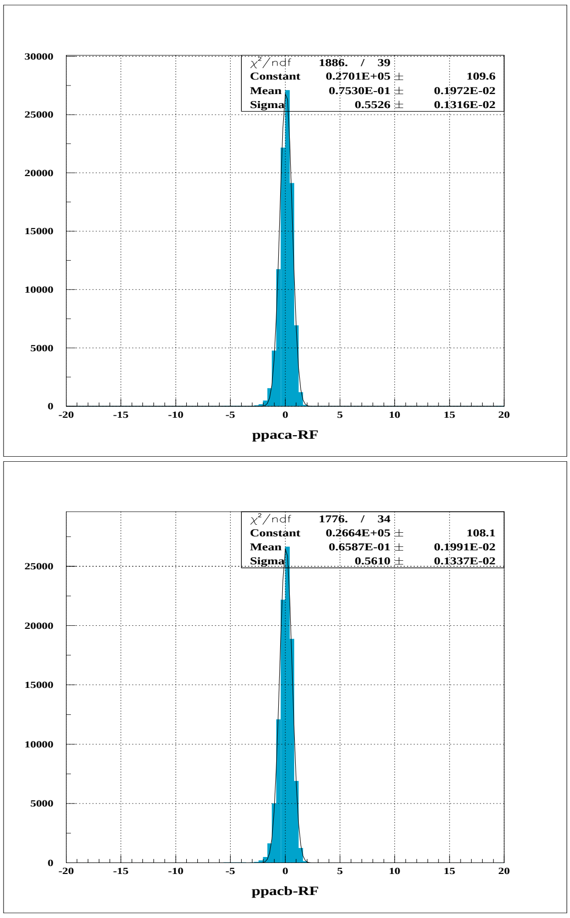


Figure 9: RF-SF2(TOF) and RF-PPACA,B(TOF)

1.2.8 momentum distribution of ^{26}Ne,$\Delta p/p = \pm 2\%$

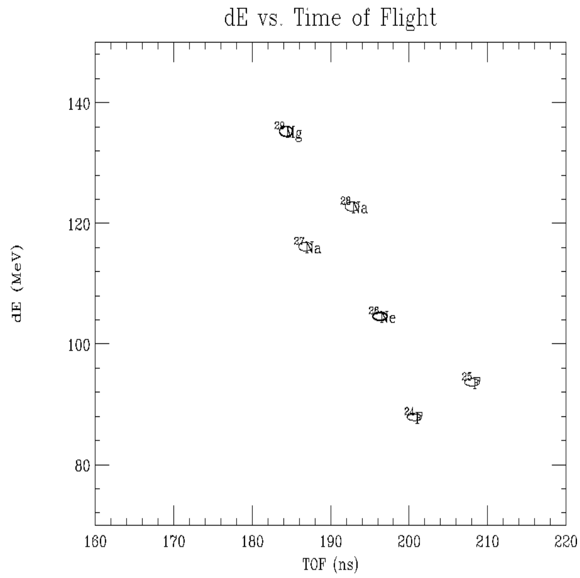


Figure 10: XIntensity TOF vs ΔE

calculation of intensity

Fragment	Rate (particle/s)	TOF (ns)
^{25}Ne	$6.223*10^3$	201.4
^{26}Na	$6.761*10^3$	191.1
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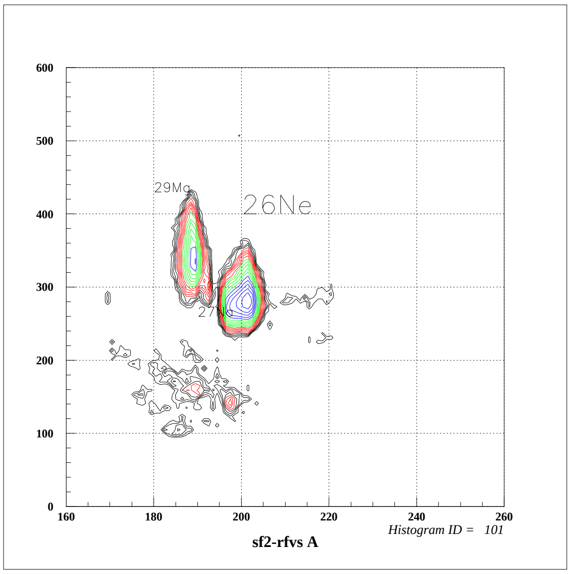

Figure 11: RF-SF2(TOF) VS A

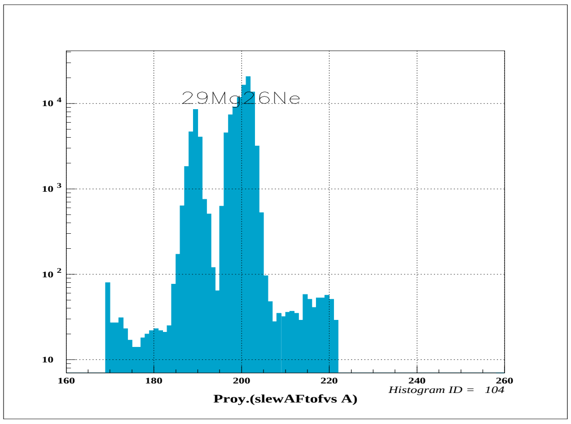

Figure 12: projection of timing

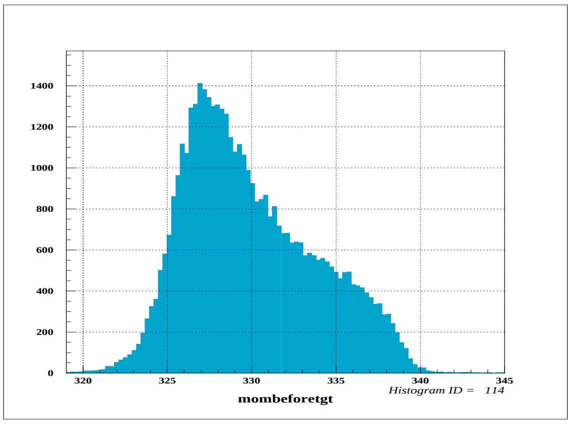

Figure 13: 26Ne momenutum before tgt