Precise Measurement of Pion Cross-section

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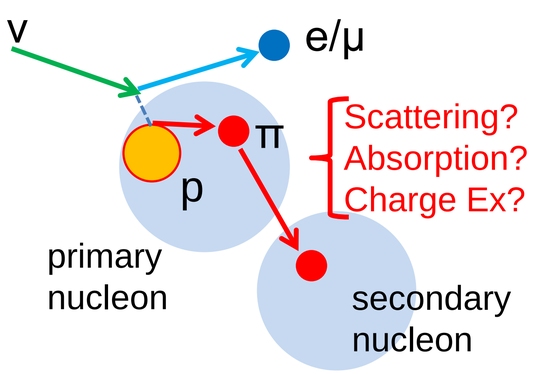
Pion detector for analysis of ν-oscillation — PiaVo

HAdron Reconstruction Performance Studies In CH On Reduced Detector — HaRpsi CHord

1. Motivation : Why Pion interaction ?

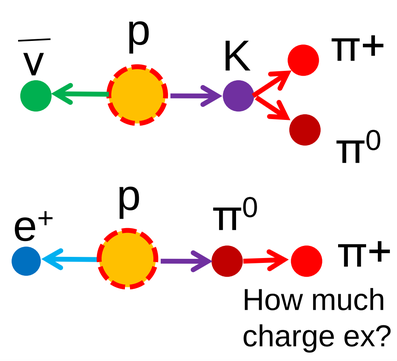
For neutrino experiment:

If a secondary π generated by neutrino interaction is absorbed by nuclei, such π is not detected. This becomes major backgrounds for ν_e appearance, and the energy spectrum of CCQE ν events would be distorted. Thus, precise measurements of π interaction is necessary for the precise measurement of the oscillation parameters.

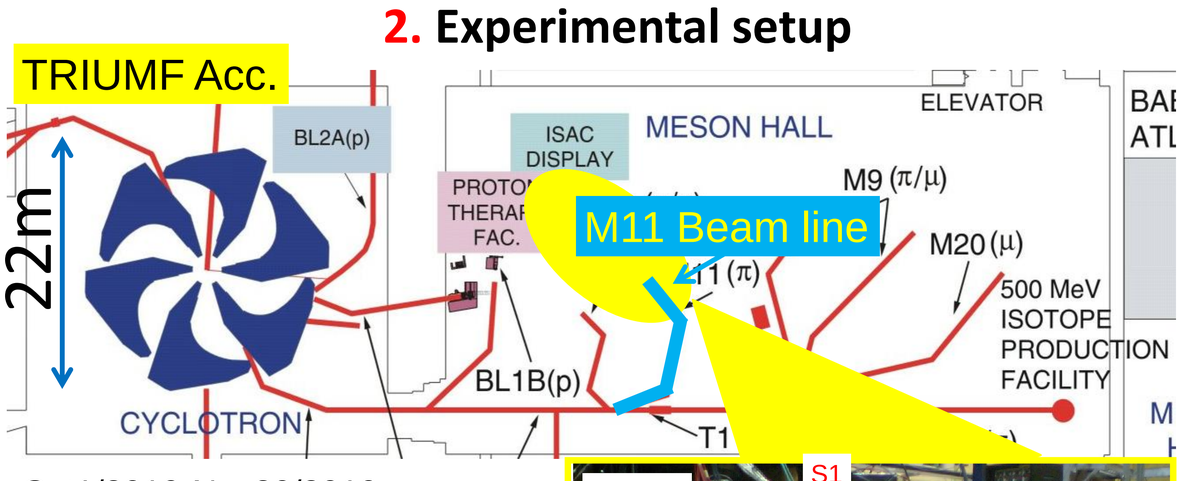


For nucleon decay experiment:

π interaction also plays a key role to nucleon decay. This is because that for Kν mode, most Ks are detected via $K^+ \rightarrow \pi^+\pi^0$ channel. Also our result is very useful to evaluate the MC simulation of e π^0 mode, and could determine how much fraction of the π^0 should interact in the nucleus.



2. Experimental setup



Oct1/2010-Nov30/2010

>480MeV/c proton from cycl.

>π+/π- beam at M11

>P_π: 150-375MeV/c

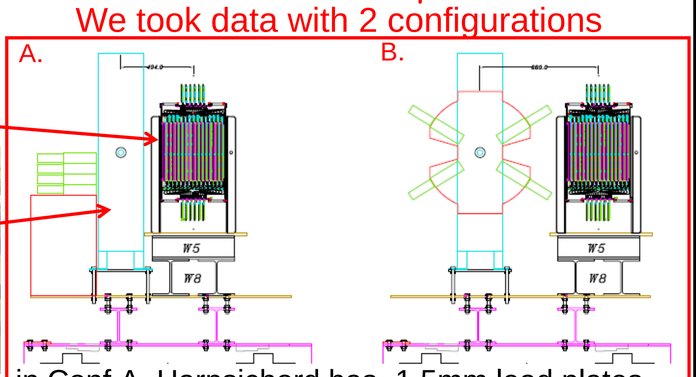
>Trig rate(S0&S1): <30Hz

>Config A: More eff. for Cx

Config B: Angular dist. of π^0

We took data with 2 configurations

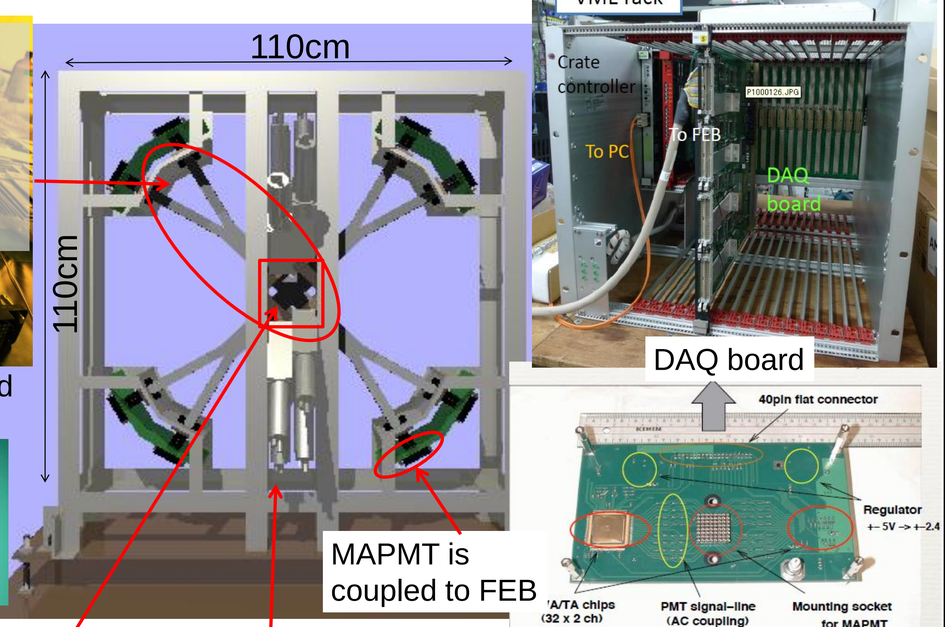
Harpsichord:
Miniature of T2K FGD consists of 1cm square scintillator with WLS coupled to MPPC.
15layers of 32(x) ×32(y) channels

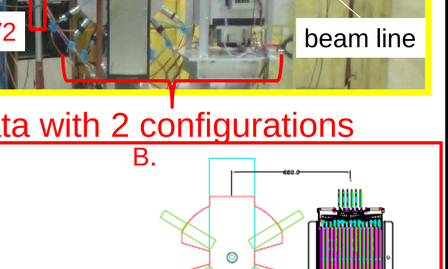


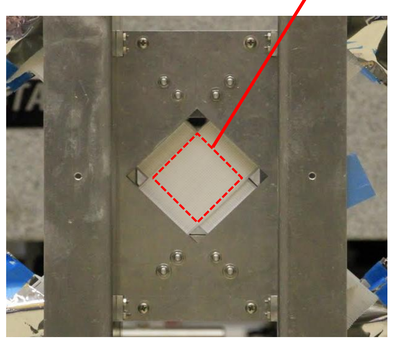
in Conf.A, Harpsichord has~1.5mm lead plates in between each layer.

3. PIAvO detector

8×8 fib. coupled to 1 MAPMT

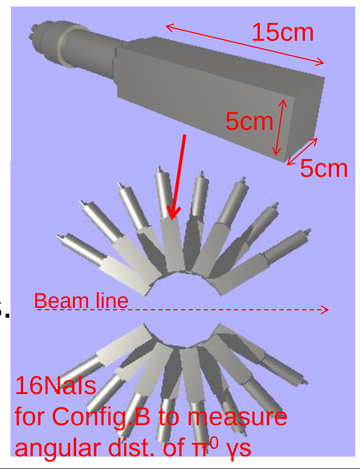






Main volume of the detector is 1.5mm×32 cubic $=(48)^3 mm^3$

To measure absorption and charge exchange cross-section separately, NaI (crystal size : 5cm×5cm×15cm) detectors are installed to detect γs from π^0 decays.
15NaIs for Config.A
16NaIs for Config.B



4. Hit level analysis

Before track reconstruction is implemented, we needed to verify our data. Also, the result of this study will be compared with the result with track reconstruction, and check the systematic uncertainty on both results.

Selection of Absorption/Cx candidate

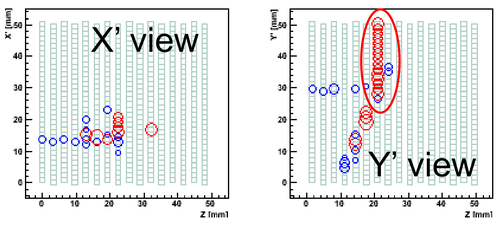
1 Incoming mip particle should be in inside 20 fiber (out of 32)

2 Clean event selection

These large charge hits (red circles) are difficult to say if the particle is mip or not without track reconstruction, since the angle of the track is not clear.

$$-0.25 < \frac{Nx - Ny}{Nx + Ny} < 0.25$$

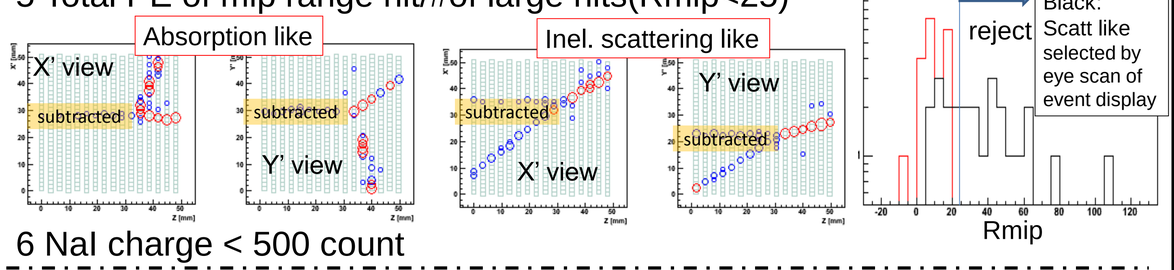
Nx= #of large hit in X'
Ny= #of large hit in Y'



3 Number of layers which incoming mip particle went straight: $3<N_{layer}<13$

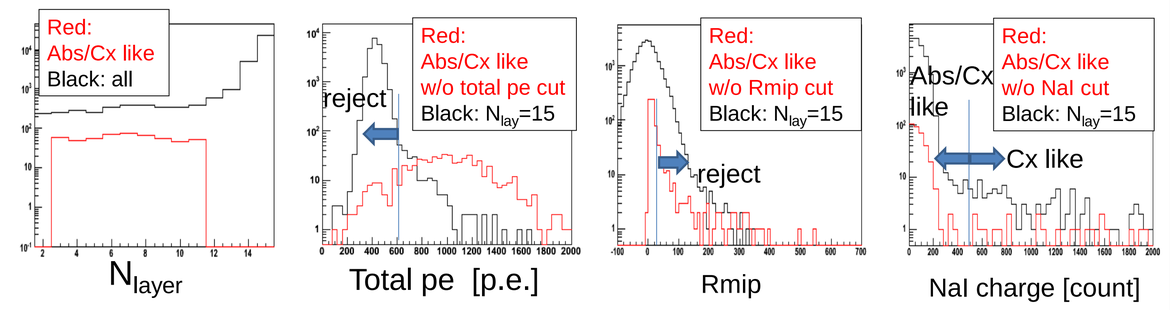
4 Total PE > 600 p.e. (mip hit ~12p.e.)

5 Total PE of mip range hit/#of large hits(Rmip<25)



6 NaI charge < 500 count

Example of distributions for 250 MeV/c mode



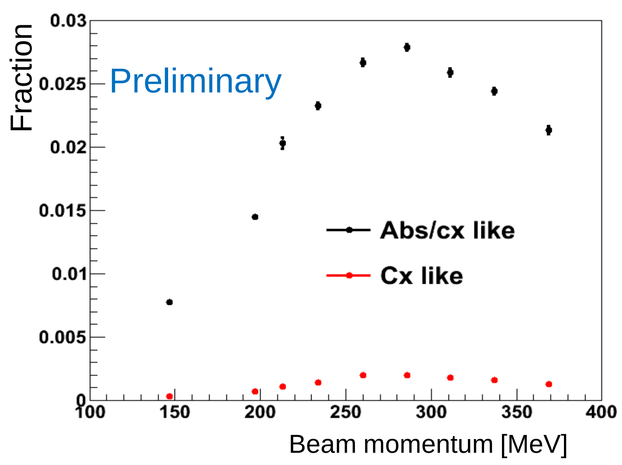
5. Status and TO DO

>Fraction of selected events and penetrated events as a function of incoming π momentum (right plot).

※ Selection/Detection efficiency is not corrected. (Need MC simulation)

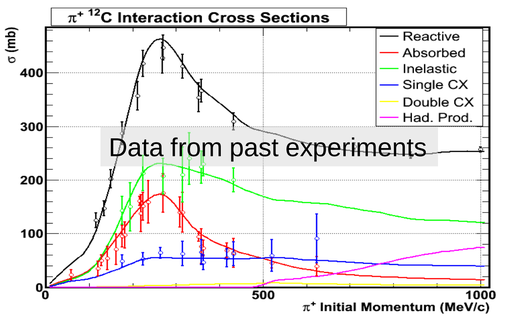
※ Fraction of π in each momentum setting is corrected by fitting tof distributions. (Need to develop better method using Cherenkov detector)

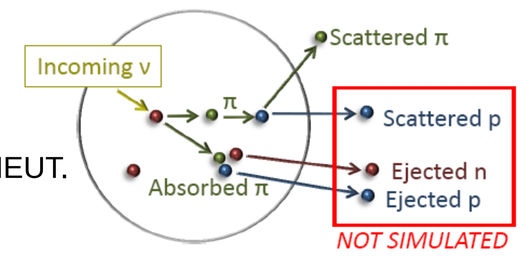
※ After the robust selection cuts, the statistical uncertainty is ~5% for Cx like events. Cf. Past exp. data have >20% uncertainty.



>Next things to do

- Use Harpsichord data to see Cx event
- MC development
  - ・MC based on G4
  - ・Implement NEUT π interaction into G4 code
  - ・Develop PIAvO-Harpsichord integrated MC
- Efficiency check for the hit-level analysis
- Track reconstruction and Analysis
- Get cross section
- Systematic uncertainty study
- Analysis of number of ejected nucleon after absorption which is not simulated in current NEUT.
- Prepare for next beam test in May/Jun 2011
  - ・Install water layer





6. Summary

>Precise measurements of π interaction are necessary for the precise measurement of the oscillation parameters since the uncertainty of pion interaction is one of major sources of systematic uncertainty for neutrino beam flux and spectrum measurement.

>This measurement also contribute verification of MC simulation to nucleon decay experiment.

>From Oct.1 to Nov.30, 2010, we performed an experiment to measure the pion interaction cross section at TRIUMF M11 beam line.

>For the experiment , two new detectors are developed: one in Kyoto and the other one in TRIUMF.

>Hit level analysis is performed to check data quality. Even after the strict cuts, we still have enough statistics (statistical uncertainty ~5%)

> We will summarize the result within 1year including the result from next beam time from May 2011.