Analysis note 32 : FS run plan studies.

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by

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Introduction

The purpose of the note is to write down a summary of my investigations on (anti–)proton acceptance and rates in the forward spectrometer.

Simulating performance

The acceptance have been calculated with *gbrahms*. Single protons with a flat distribution in momentum, θ, and ϕ were used as input. The distribution was made wide enough to enclose the acceptance. All protons were thrown from the nominal interaction point.
The total time of flight resolution (IP + hodoscopes) was set to $\sigma_{tof} = 0.120$ns for both H1 and H2. Requiring a 4 σ_{tof} resolution between protons and kaons (2 sigmas on each side) allows p–K separation as shown in Table 1.

Detector	Angular coverage	Time of flight (ns)	σ_{tof}(ns)	p–K separation (GeV/c)
H1	2.3-30°	30	0.120	4.5
H2	2.3-15°	64	0.120	6.4

Table 1: Summary of proton identification in FS with time of flight.

If we want to go to higher momentum we need the RICH. Figure 1 from the CDR illustrates that we can use the rich to reject kaons and pions in the range 10–16 GeV/c and have proton identification from 16–30 GeV/c, so that the identification will be from 10–30 GeV/c. The clever reader will note that there is a gap from 6.4–10 GeV/c where no proton id is possible, but that could change with improvement of the effective time of flight resolution [1] and if the refractive index of the RICH gas turns out to be different. The angular coverage of the RICH is 2.3-15°.
The information have been summarised in Figure 2. It has been demanded that a track has at least one hit in all detectors before the ID detector, the list being (T1, T2, H1, T3, T4, T5, H2, RICH).

Calculating rates

The total acceptance can be calculated as

[1] small effect as the contribution to $(\frac{\sigma_m}{m})^2$ is $\gamma^4 \times (\frac{\sigma_{tof}}{\mathrm{TOF}})^2$ and $\gamma \propto p$ when as here, $p \gg m$.

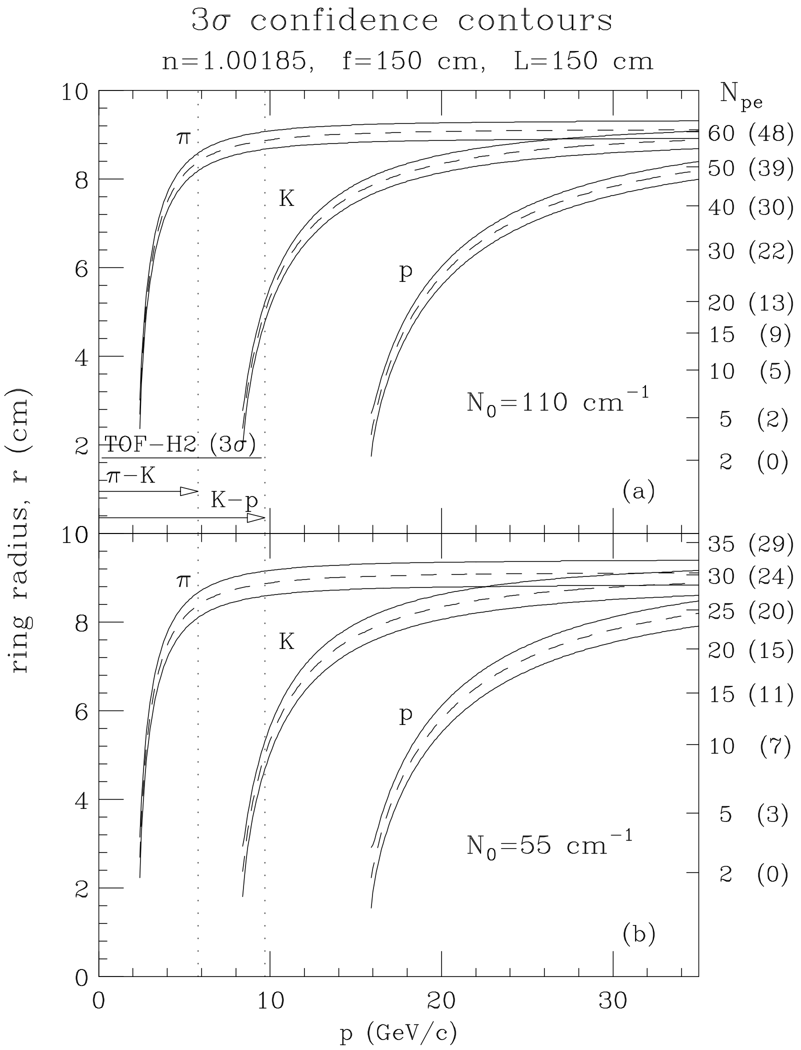

Figure 1: RICH performance taken from CDR.

$$Acc(y, p_t) = \frac{N_{ID}}{N_{TRIED}} \times \frac{\Delta\phi}{360^\circ}$$

Where $\Delta\phi = 20^\circ$ at $\theta = 2.3^\circ$ and $\Delta\phi = 8^\circ$ at $\theta = 10^\circ$.
Using a histogram with normalised HIJING and Fritiof predictions for 40 % central events, NO WEAK DECAYS, an estimate of the counts pr event can be obtained

$$Counts(y, y + \Delta y, p_t, p_t + \Delta p_t) = Acc(y, p_t) \times Model(y, p_t) \times \Delta y \times \Delta p_t$$

Using this equation, HIJING data provided by Djamel, and the GEANT calculations for the

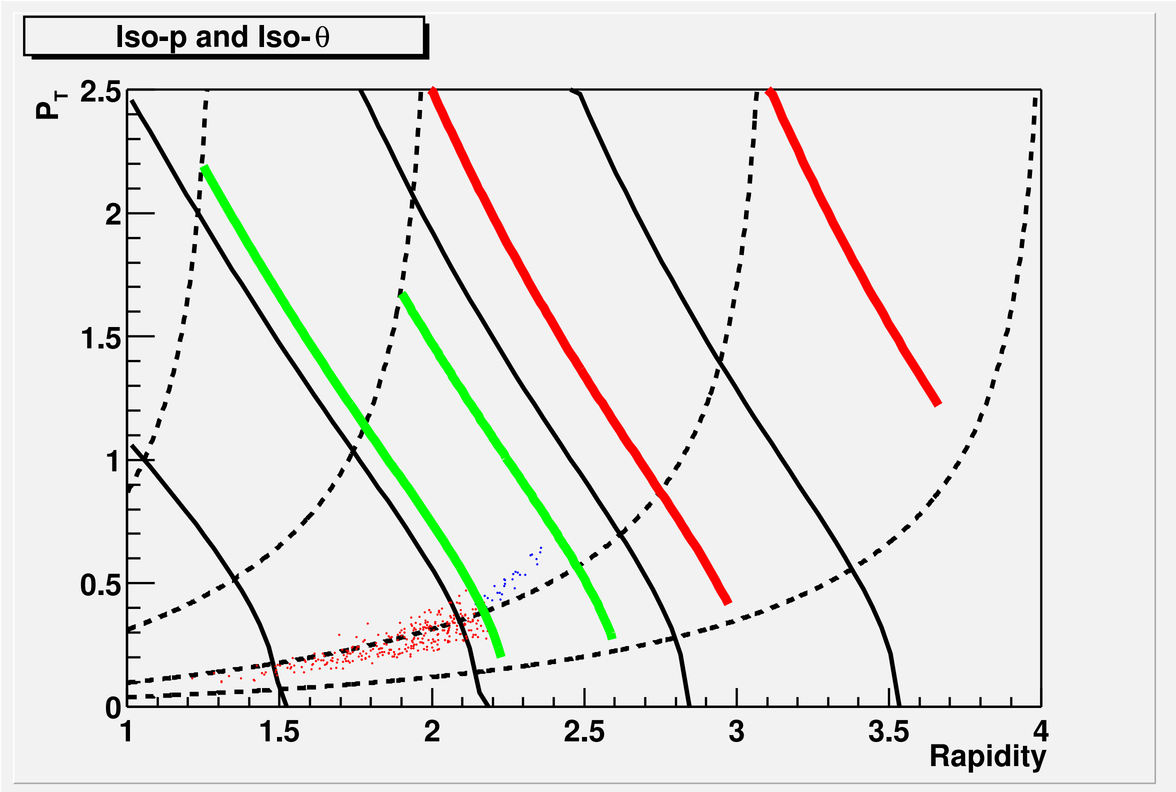

Figure 2: Proton acceptance with fields as in run 2525. The red dots are protons identified by H1 and the blue dots are protons identified by H2. The green lines shows maximum proton identification with H1 and H2. The red lines shows the limits of the RICH proton identification. The dashed black lines are isoangles of 30, 15, 5, 2°, and the solid black lines are isomomentum of 2, 4, 8, 16 GeV/c.

2525 setting, Figure 2, an estimate of 1 proton for every 50 40% central event is obtained, see Figure 3.
The final rate of (anti-)protons pr second can depend on

- Beam luminosity. Design luminosity is 1200 Hz.
- Centrality. I have used a centrality cut of 40% $= 0.4$
- Vertex distribution. For the FS we win something in rates with a narrower vertex and loose some in acceptance. A narrower vertex would make these estimates better.
- Efficiency. No detector efficiencies have been folded into these calculations.
- Dead time. This have not been taken into account.

To get the final rate in the above example I multiply by $0.4 \times 1200 = 480$, so that we get the rate of 10 Hz.

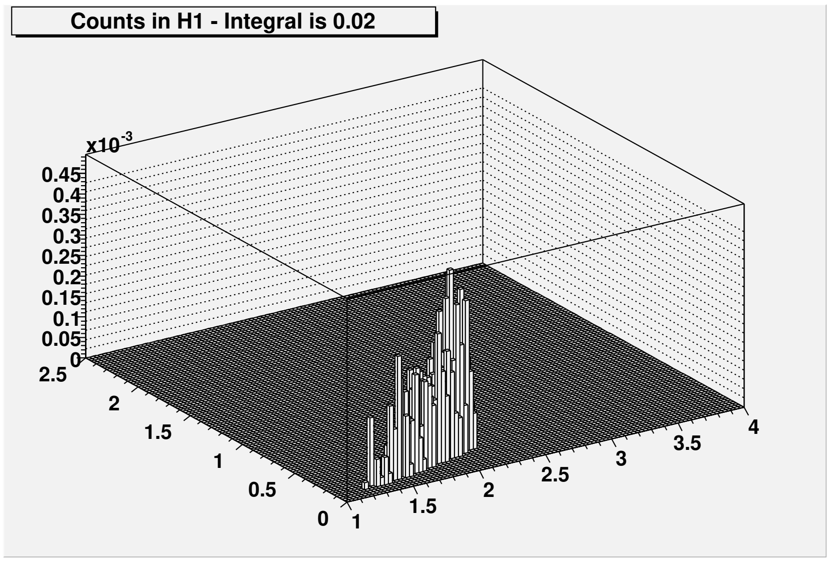

Figure 3: Rates as a function of rapidity y and transverse momentum p_t. The integral gives the total yield pr 40% central event (0.02). The peak is at $y \sim 2$ and $p_t \sim 0.3$.

A sample at the smallest angle $\theta = 2.3°$

Different settings at low angles and high fields were tested. It was found that 5 settings could cover the highest rapidities, see Figure 4.
Calculations for the black setting shows that the count rate of protons in the defined rapidity region is 19 Hz at *full luminosity* and *no dead time*. This gives 70K/hour. Anti–protons are scaled down by a factor of 7 in this setting.
To estimate the acceptance correction for the black sample I tried to scale it to the HIJING spectra. This is shown in Figure 5. The acceptance correction seems to be flat and fall of only at the ends.

A sample at rapidity $y \sim 2$.

To get an idea of how many settings were needed to cover a small band in rapidity around 2 and get a good p_t spectrum i tested different angular settings. The plots are shown in Figure 6 and the rates are estimated in Table 2.
There was a lot of talk here at NBI about measuring protons at high p_t ($p_t \geq 2$) around $y \sim 2$, to look for the same jet quenching (?) signals as observed by Phenix and Star at mid rapidity, i.e, "Particle composition is observed to be a strong function of p_t" (especially there are more protons than pions at $p_t \geq 2$GeV/c, $y \sim 2$).
It has to be tested that we can get a reasonable sample at the same rapidity for at least pions and protons to make sense.

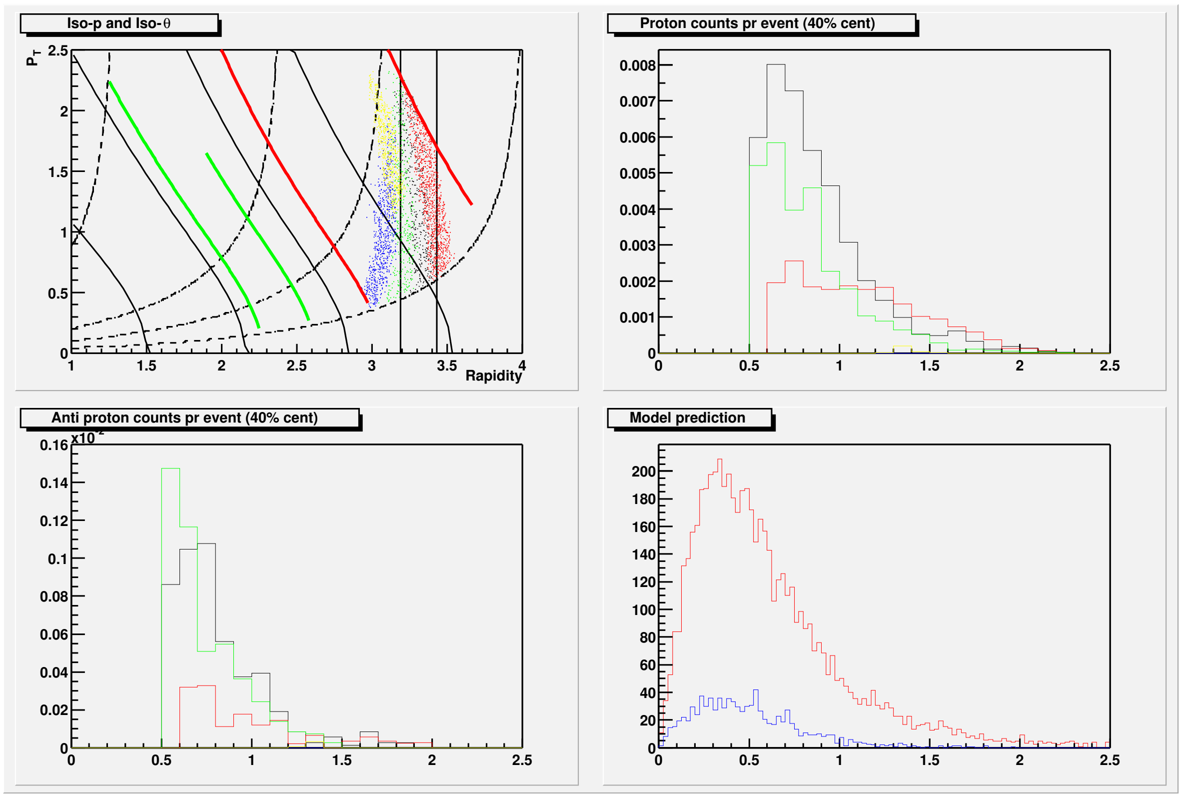

Figure 4: (Top Left) 4 settings at 2.3° $\frac{1}{2}$(blue),$\frac{2}{3}$(green),$\frac{5}{6}$(black), and $\frac{1}{1}$(red) field. 1 setting at 4° $\frac{1}{1}$(yellow) field. Notice that for the rest of the plots only the data in the rapidity region from ~ 3.2 to ~ 3.4, in between the vertical black lines is used. (Top Right + Bottom Left) (Anti–)proton counts pr event vs p_t. (Bottom Right) The shape of the HIJING proton (red) and anti–proton (blue) data. The spectra are unnormalized, but mutually comparable.

Conclusions

- Protons can be identified in the FS with H2 (H1) up to $\sim$ 6.4GeV/c ($\sim$ 4.5GeV/c) using hodoscopes in the angular range $2.3 < \theta < 15$ ($2.3 < \theta < 30$) and using the RICH $10 < p_{proton} < 30$ in the angular range $2.3 < \theta < 15$.
- Only a few settings is needed to cover the very forward rapidities and the rates are quite high.
- Many settings are needed to cover the lower rapidity spectra and the rates are lower, even though we are at the peak of the (anti–)proton distribution.

I hope the note can provide input to the run plan.

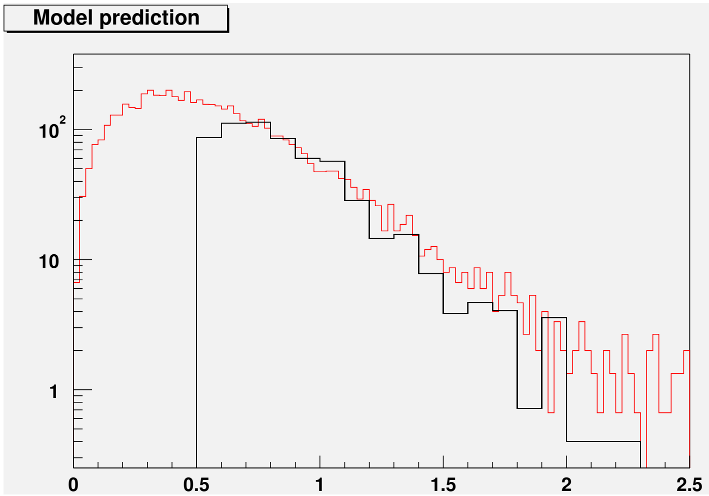

Figure 5: Unnormalized HIJING distribution (red) and scaled black setting distribution.

Colo(u)r	θ	H1 p (Hz)	H1 $\bar{p}$ (Hz)	H2 p (Hz)	H2 $\bar{p}$ (Hz)
Black	2.3	5	3	NA	NA
Red	4	5	3	0.4	0.3
Green	6	2	1	0.5	0.3
Blue	8	0.5	0.4	1.5	0.5
Yellow	10	NA	NA	0.5	0.3

Table 2: Summary of (anti–)proton rates in hodoscopes. All fields are $\frac{1}{2}$. The blue numbers from H2 probably reflects statistical error in the HIJING prediction.

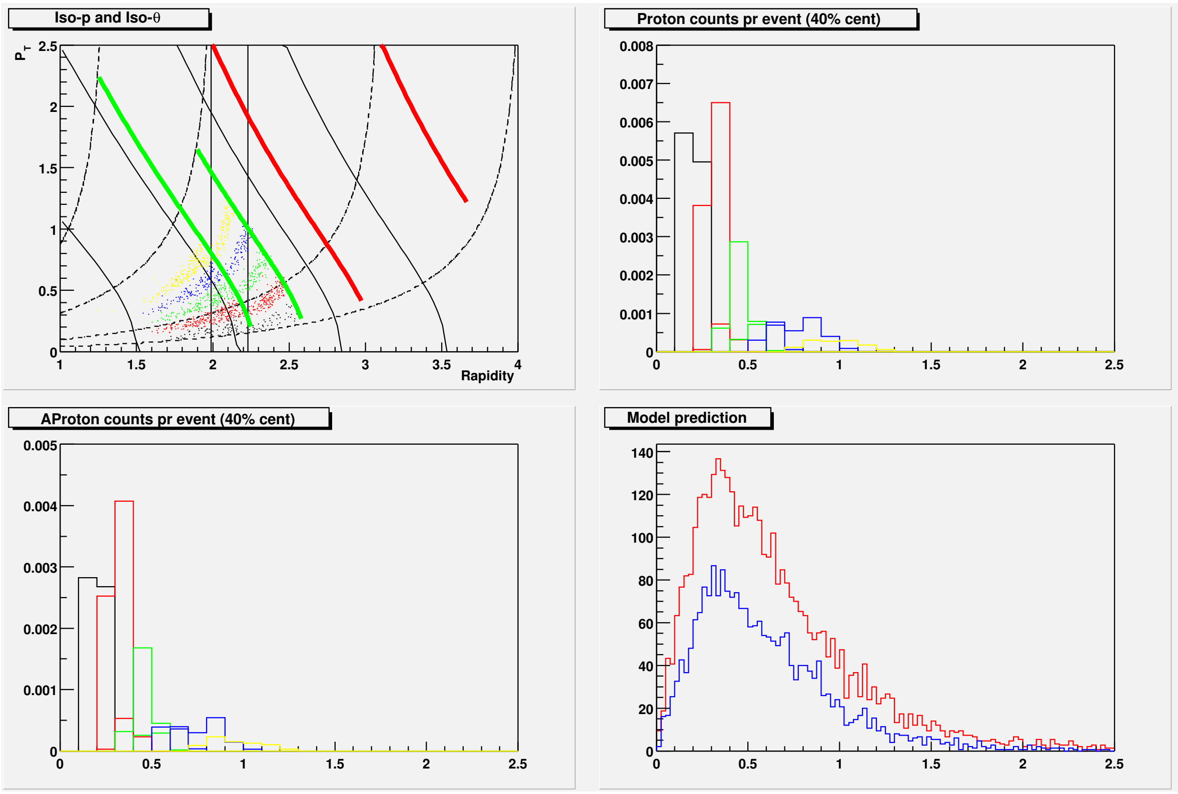

Figure 6: (Top Left) 5 settings at $\frac{1}{4}$ field. $\theta = 2.3$ (black), 4 (red), 6 (blue), and 10° (yellow). Notice that for the rest of the plots only the data in the rapidity region from ~ 2.0 to ~ 2.2, in between the vertical black lines is used. (Top Right + Bottom Left) (Anti–)proton counts pr event vs p_t. (Bottom Right) The shape of the HIJING proton (red) and anti–proton (blue) data. The spectra are unnormalized, but mutually comparable.