SOME RESULTS FROM M13 TESTS AND TUNING

G.M. Marshall
TRIUMF

January 26, 2001

M13 tests and tuning for *TWIST*

http://stoney.phys.ualberta.ca/ e614/Projects/E614-S2/

Outline

- Problems encountered
- Pion tuning
- Surface muon tuning
- Test of fiber light guide muon counter
- Rates for horizontal scans of 1AT1 graphite and Be targets
- Recommendations

Problems encountered

- cyclotron instabilities (inflector)
- BL1A tuning
- production target
  - ▷ horizontal alignment
    (with respect to beam)
  - ▷ vertical alignment
    (with respect to secondary beam line)
  - ▷ graphite target longevity
- M13 beam line
  - ▷ alignment as indicated by quadrupole steering
  - ▷ vertical alignment inconsistency with M11
  - ▷ bending magnet instability
  - ▷ monitoring of power supply currents (solution expected soon)
- rate inconsistency with graphite target
  - ▷ edge scans of November 13 and 20 differ by ~ 2
  - ▷ rate measurements on November 20 differ by 13%

Pion tuning at 120 MeV/c

- beam and detectors
- quadrupoles off
- quadrupole steering: Q7 and summary of Q3-Q7
- emittances following optimization
  in x: $\pi \cdot (10 \text{ mm}) \cdot (10 \text{ mr})$
  in y: $\pi \cdot (7 \text{ mm}) \cdot (15 \text{ mr})$
  (B2 0.9% higher)

Element	Set Point (DAC)	Current (A)	Field (G)
B1	10690	164.	3540.6
B2	11999	135.	3860.7
Q1	2587	633.	
Q2	31513	239.	
Q3	2820	513.	
Q4	3113	374.	
Q5	2930	511.	
Q6	1680	206.	
Q7	1760	209.	

Table 1: M13 beam line settings for approximately 120 MeV/c pions, determined in beam tests of November and December 2000. Currents are estimates from the channel control system only, and are neither precise nor reproducible. Fields are NMR values for B1 and B2.

Beam and detectors

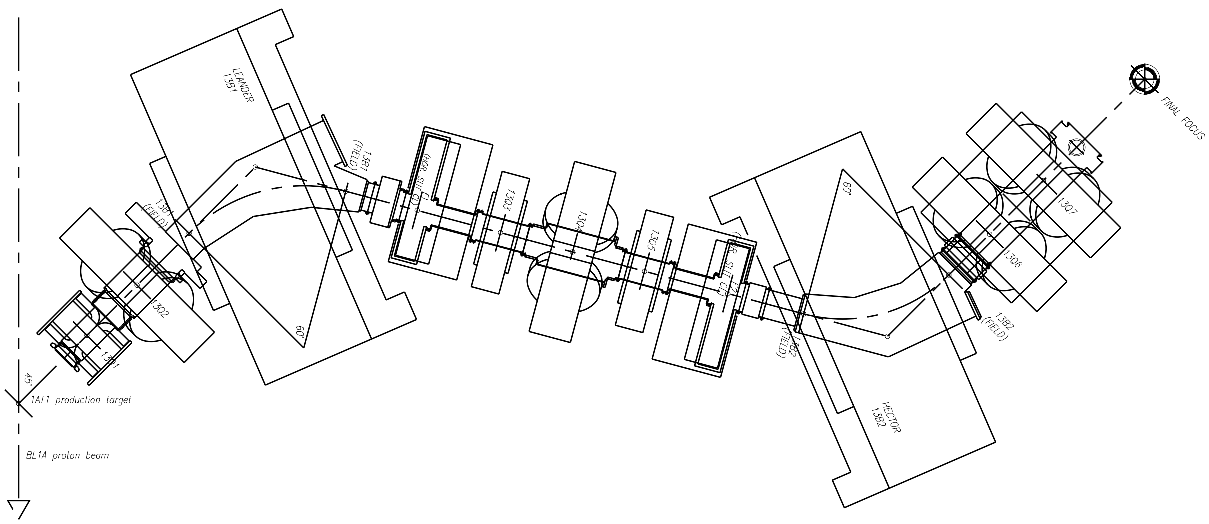

Figure 1: Diagram of elements of M13.

Figure 2: Arrangement of chambers (C64 and C96) and scintillators (M, P, E1, and E2), showing end of beam pipe and an absorber (abs).

Quadrupoles off

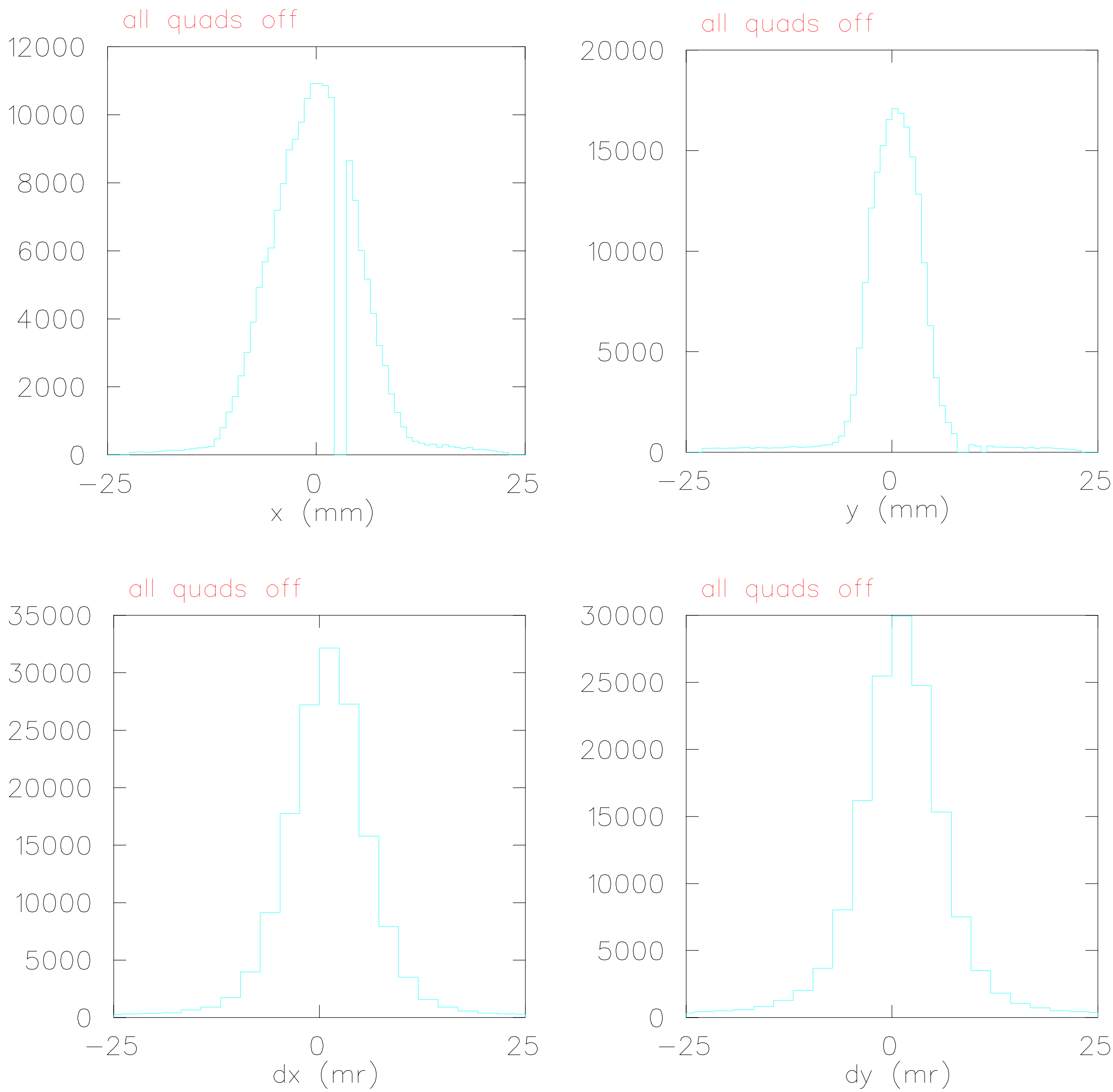

Figure 3: Beam position and divergence distributions for 120 MeV/c pions, with no quadrupoles turned on.

Steering by Q7

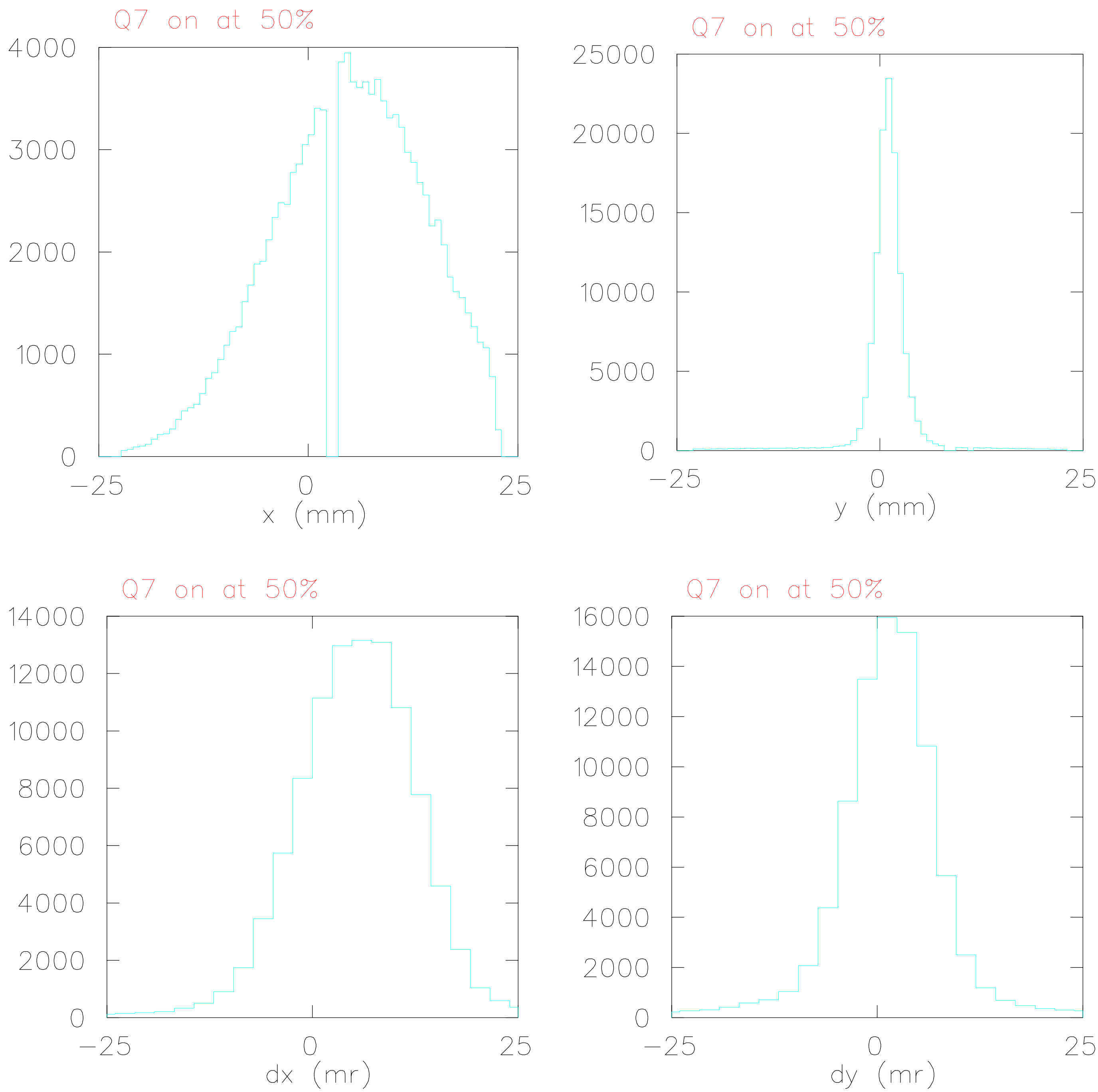

Figure 4: Beam position and divergence distributions for 120 MeV/c pions, with Q7 only turned on at 50% of nominal current. Note the shifts compared to Fig. 3, especially in x and dx.

Steering by quadrupoles

Quad	% of nominal	x (mm, mean)	y (mm, mean)	dx (mr, mean)	dy (mr, mean)
F1HS = 5 mm, F2HS = 5 mm					
-		-0.7	+0.4	+0.8	+0.8
Q7	50%	+5.4	+1.0	+5.3	+1.4
Q6	50%	-7.8	-1.8	-3.2	-0.8
F1HS = 5 mm, F2HS = 50 mm					
-		+0.8	+0.3	+0.3	+0.3
Q5	20%	-3.2	+0.6	-0.7	+0.7
Q4	10%	+1.2	-0.1	+0.3	+1.0
Q3	20%	+0.9	+0.8	-0.1	-0.9

Table 2: Summary of beam steering for individual quadrupoles energized separately to a percentage of nominal current.

Emittances following optimization

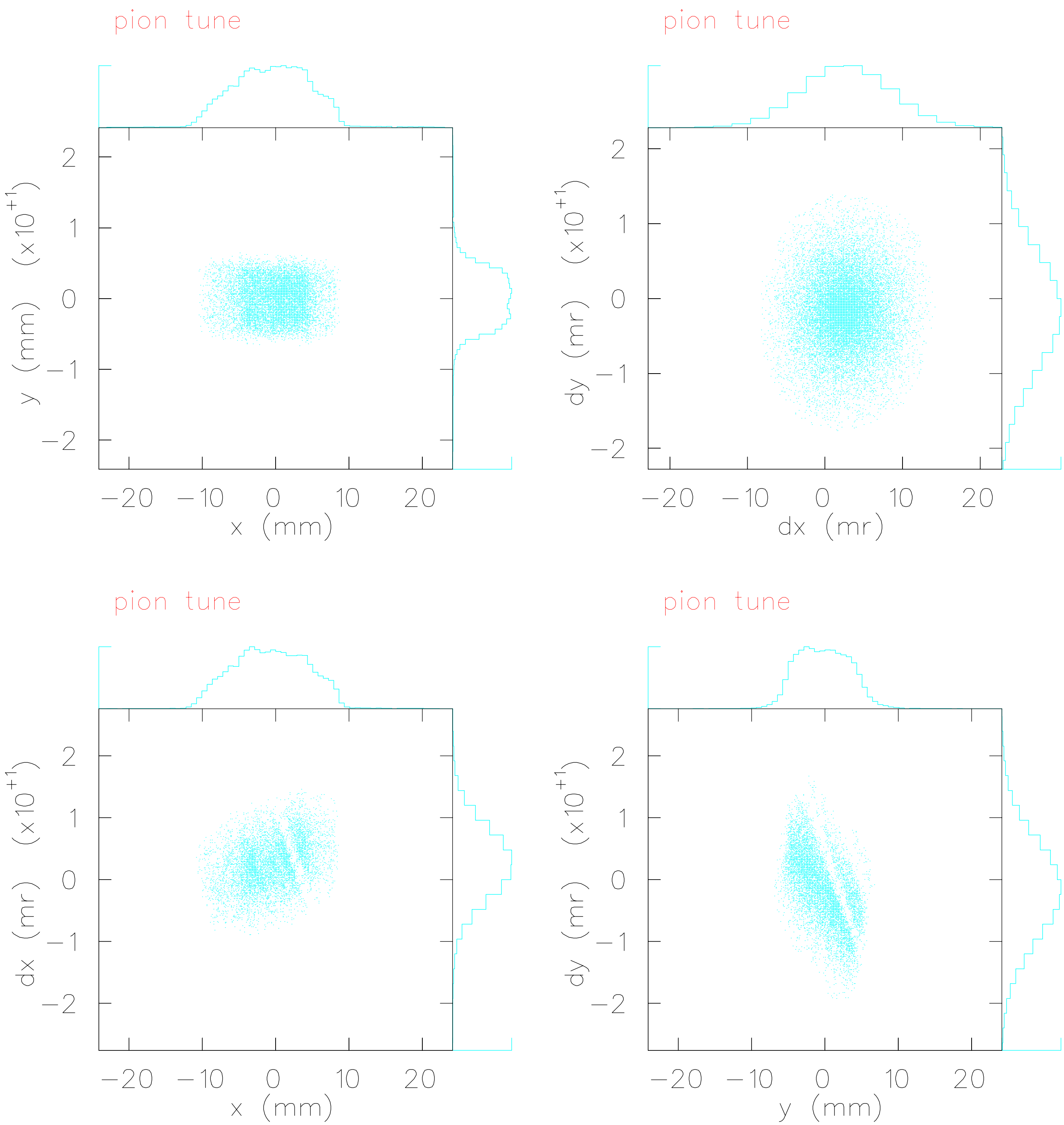

Figure 5: Beam emittance plots following tuning for 120 MeV/c pions.

Surface muon tuning

- Q2 optimization
- edge scans:
  $\Rightarrow$ positron consistent with muon to 0.1%
- surface muon rates
- surface muon tune
- surface muon beam profile:
  non-uniform behavior at edge

Q2 optimization

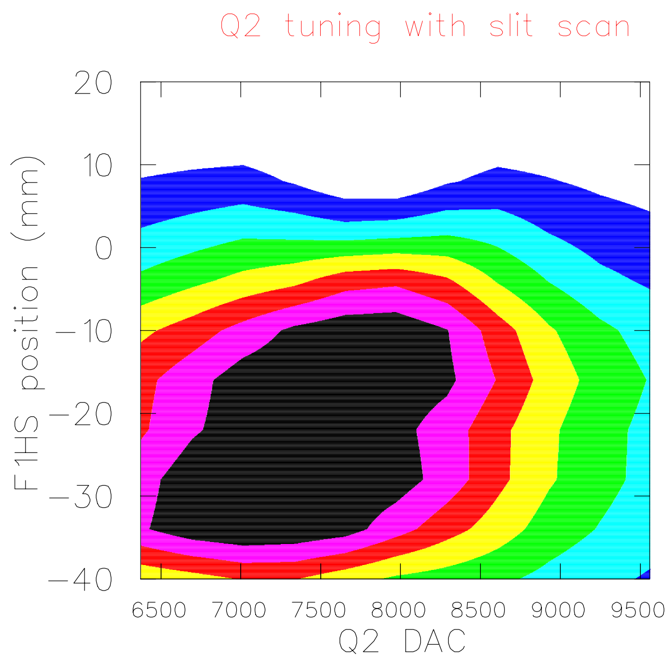

Figure 6: Muon rate contours for a grid of settings of F1HS position and Q2 DAC. The close contour lines indicate a steep gradient at the surface muon edge, a requirement for a dispersed focus at F1.

Surface muon rates

F0HS width (mm)	F0VJ width (mm)	μ^+ rate $\times 10^{+3}\ s^{-1}$	e^+ rate $\times 10^{+3}\ s^{-1}$
80	25	18.6	107.
40	25	9.0	52.
40	15	5.0	30.

Table 3: Muon and positron rates for different settings of F0 slit and jaw, for 29.4 MeV/c (B1 set to 864.3 G). F1HS was 10 mm, and the proton beam current was 140 μA on a 12 mm Be target in a stainless steel water jacket.

- beam size(FWHM) for muons 24 mm (x) by 11 mm (y)
  for pions 16 mm (x) by 13 mm (y)
- tails on x distribution
- rate observed to be 33% higher from graphite target than from Be

Surface muon tune

Element	Set Point (DAC)	Current (A)	Field (G)
B1	2631	40.	876.0
B2	3049	34.	956.3
Q1	639	156.	1040.9
Q2	7795	59.	900.4
Q3	697	127.	1376.5
Q4	769	93.	1419.5
Q5	786	123.	1340.3
Q6	420	53.	800.8
Q7	540	63.	959.4

Table 4: M13 beam line settings for 29.79 MeV/c, the edge of the surface muon momentum distribution, determined in beam tests of November and December 2000. Currents are estimates from the channel control system only, and are neither precise nor reproducible. Fields are NMR values for B1 and B2, and estimated pole tip fields derived from the currents and the activation specifications for all quadrupoles. Note that these are not final *TWIST* settings, but still require modifications for transport into the solenoidal field, for specific slit and jaw settings, and following any changes or upgrades to M13 beam elements and monitoring.

Surface muon beam profiles

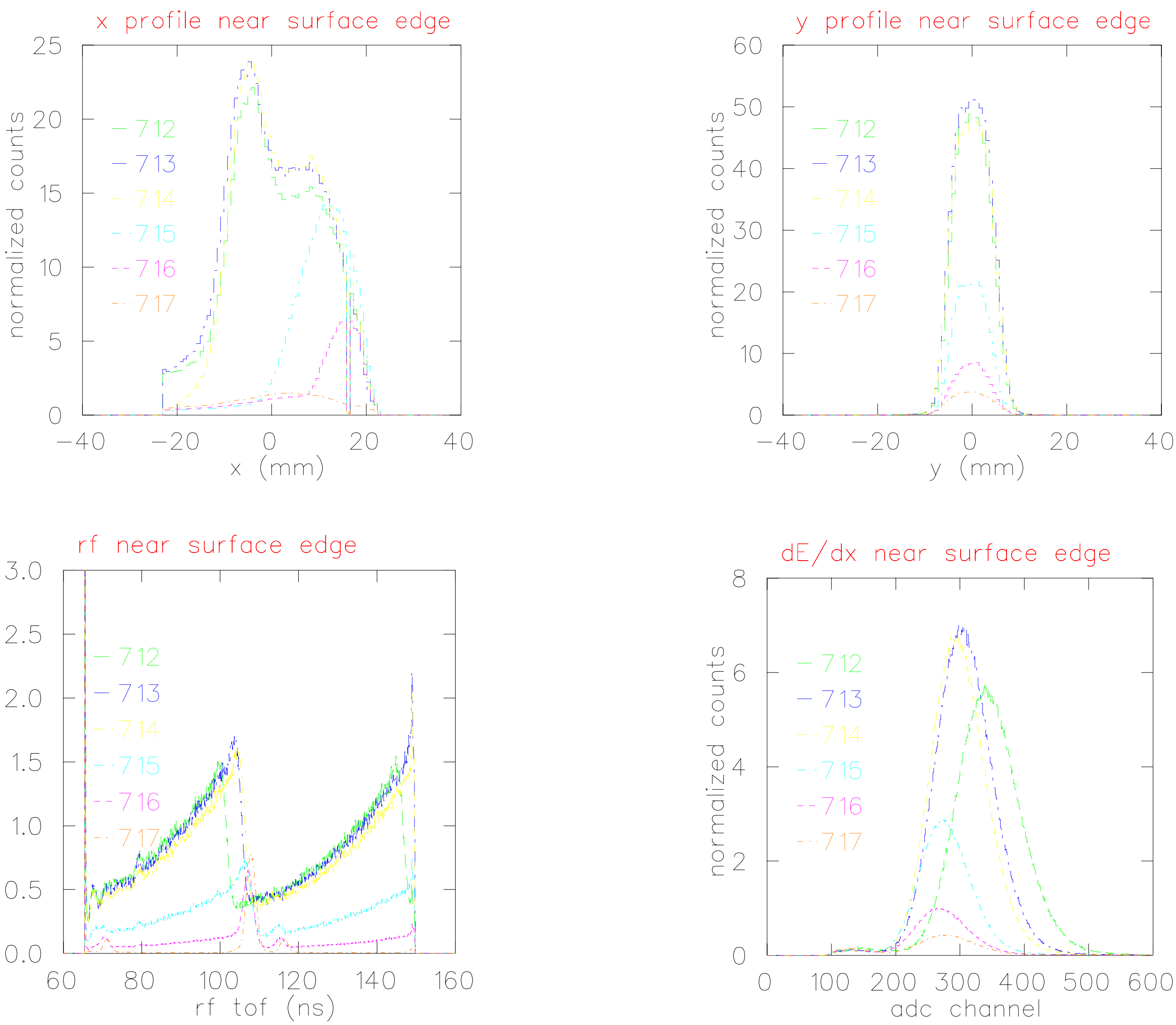

Figure 7: Beam profiles in x and y, with time of flight and muon energy loss distributions, for beam momenta near the surface muon edge. The legend indicates a sequential run number, for B1 NMR values of 835.0, 864.3, 870.5, 878.8, 883.0, and 889.2 gauss respectively.

Muon x distributions

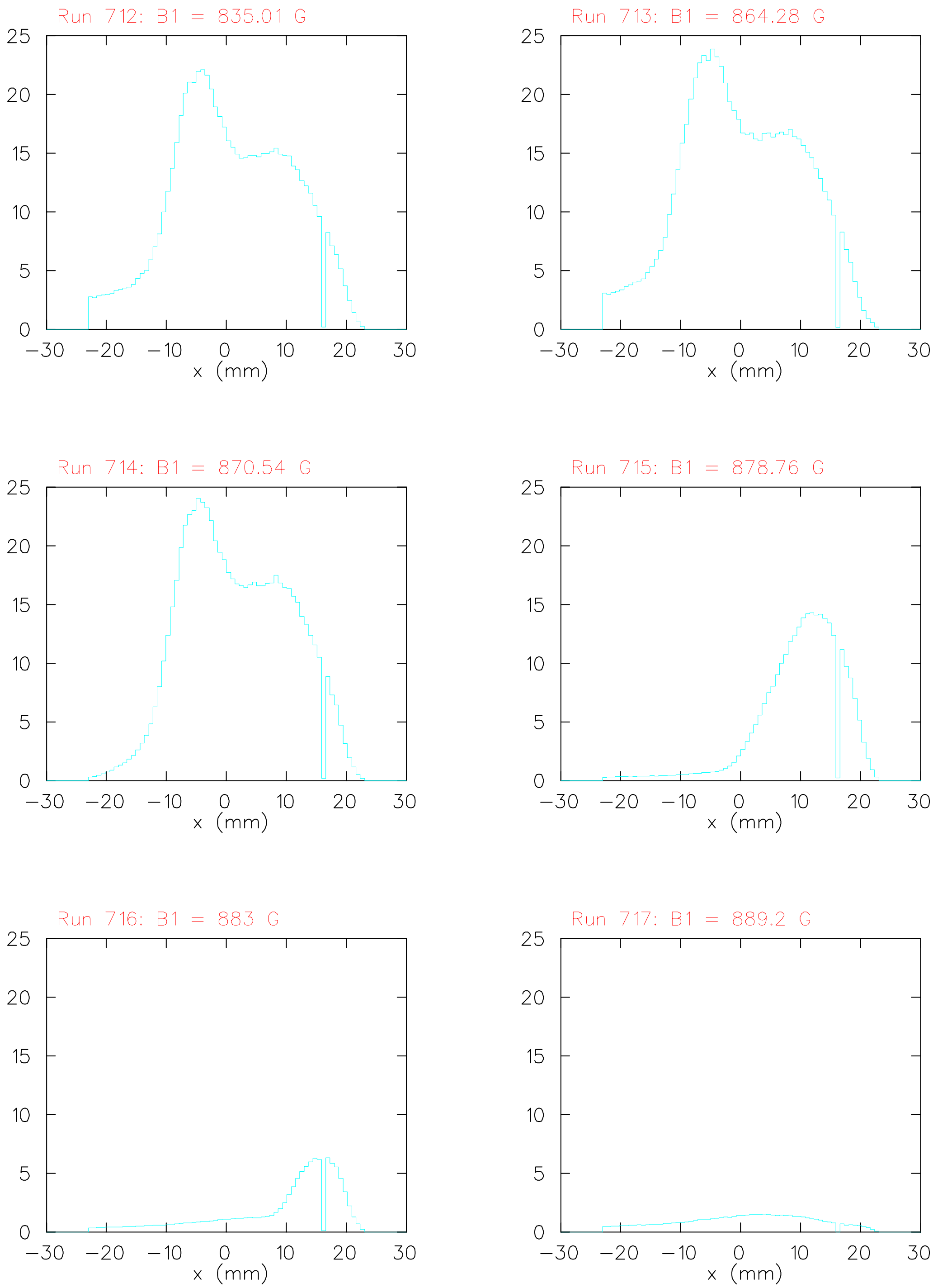

Figure 8: Beam profile in x as in first plot of Fig. 7, normalized to muon rate, for different runs at different momenta near surface muon edge.

Test of fiber light guide muon counter

- FLG scintillator placed between C64 and M muon counter
- pulse heights recorded for both FLG phototubes for events triggered by M counter and one x-y coordinate in C64, for two voltages
- plot fraction of events with ADC values above pedestal vs position for muons and positrons (determined by M ADC)
- muon efficiency reasonably uniform, approximately 95%
- positron efficiency much lower

FLG efficiencies for muons

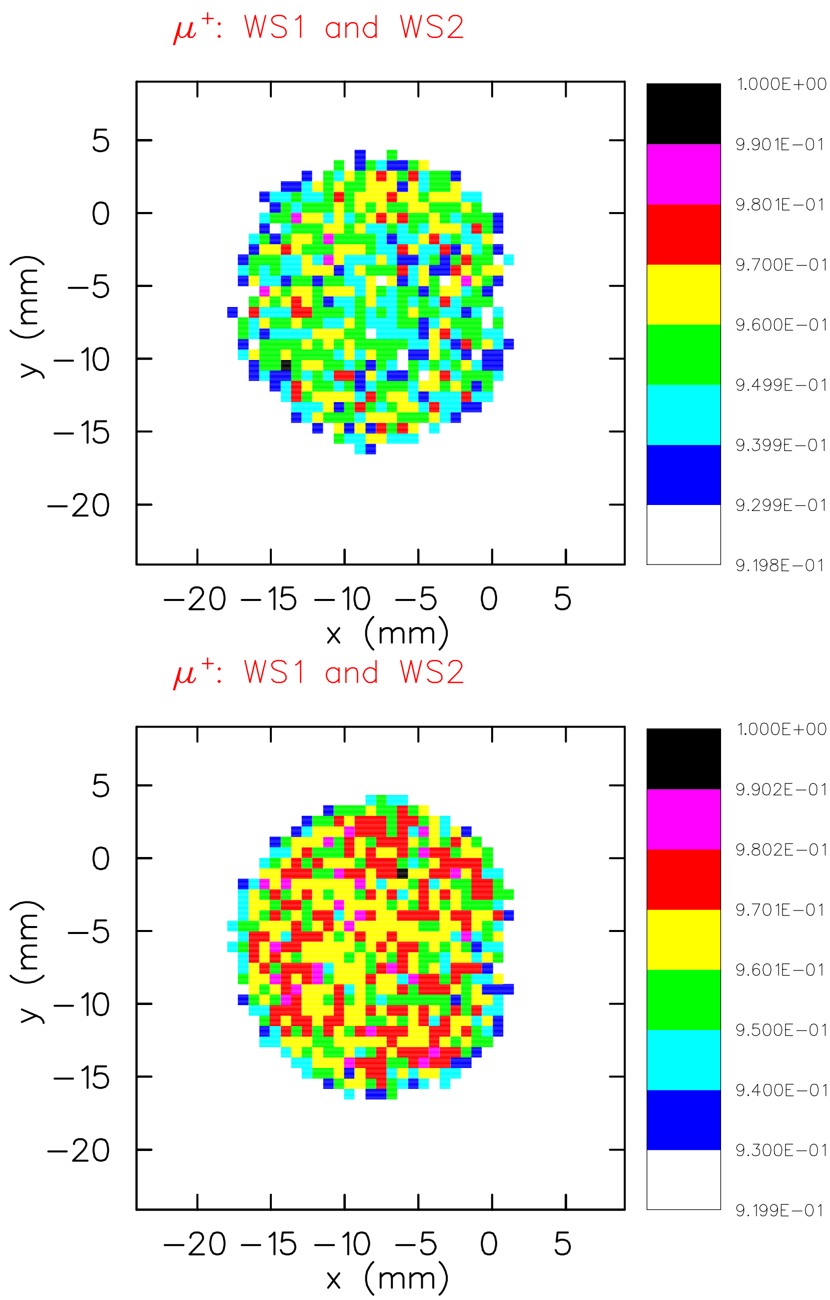

Figure 9: Plots of fiber light guide scintillator efficiency versus position for surface muons, for photomultiplier high voltages of 1750 V (upper) and 1850 V (lower). Note that the range displayed is from 92% to 100% only.

FLG efficiencies for positrons

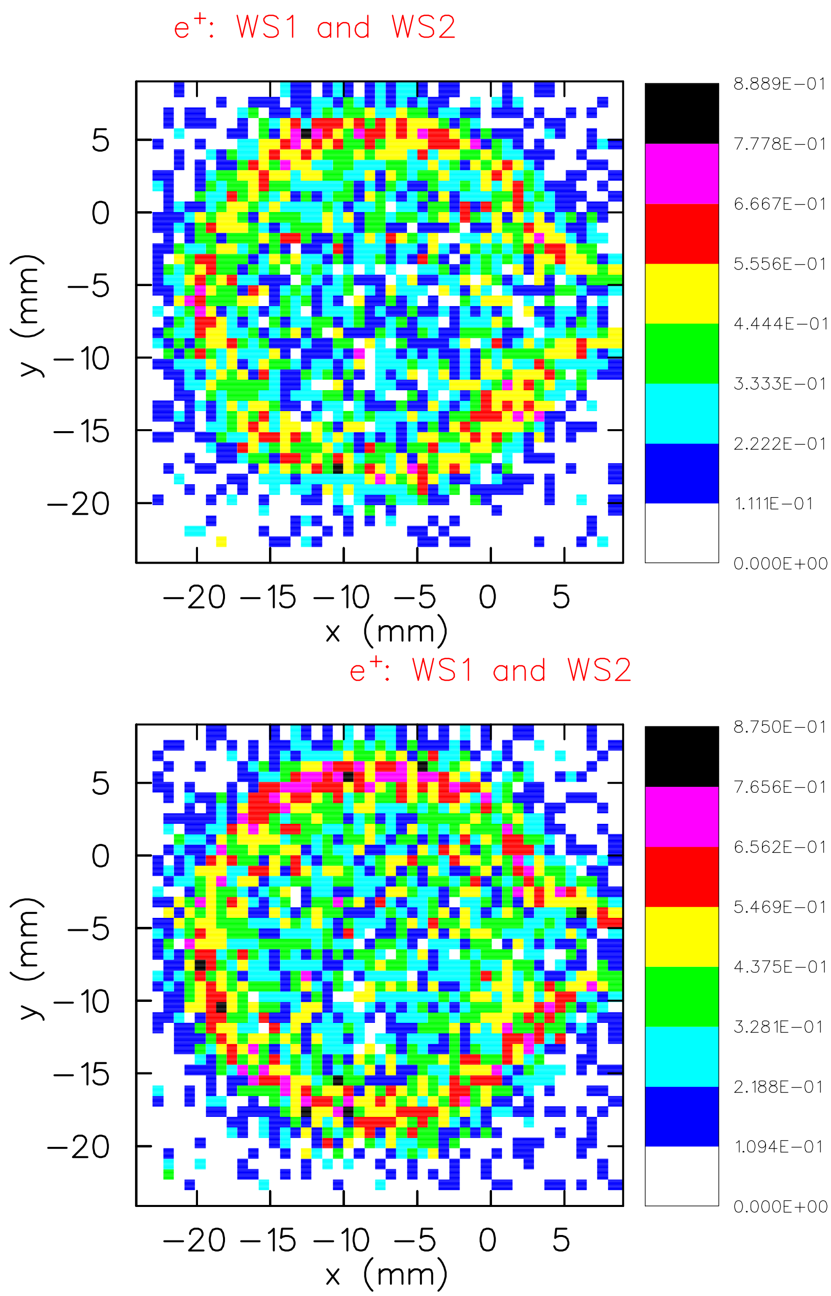

Figure 10: As Fig. 9, except for beam positrons rather than surface muons. In this case, the range is from 0% to almost 90%. The fiber path to the photomultipliers can be seen on the right side.

1AT1 horizontal target scans

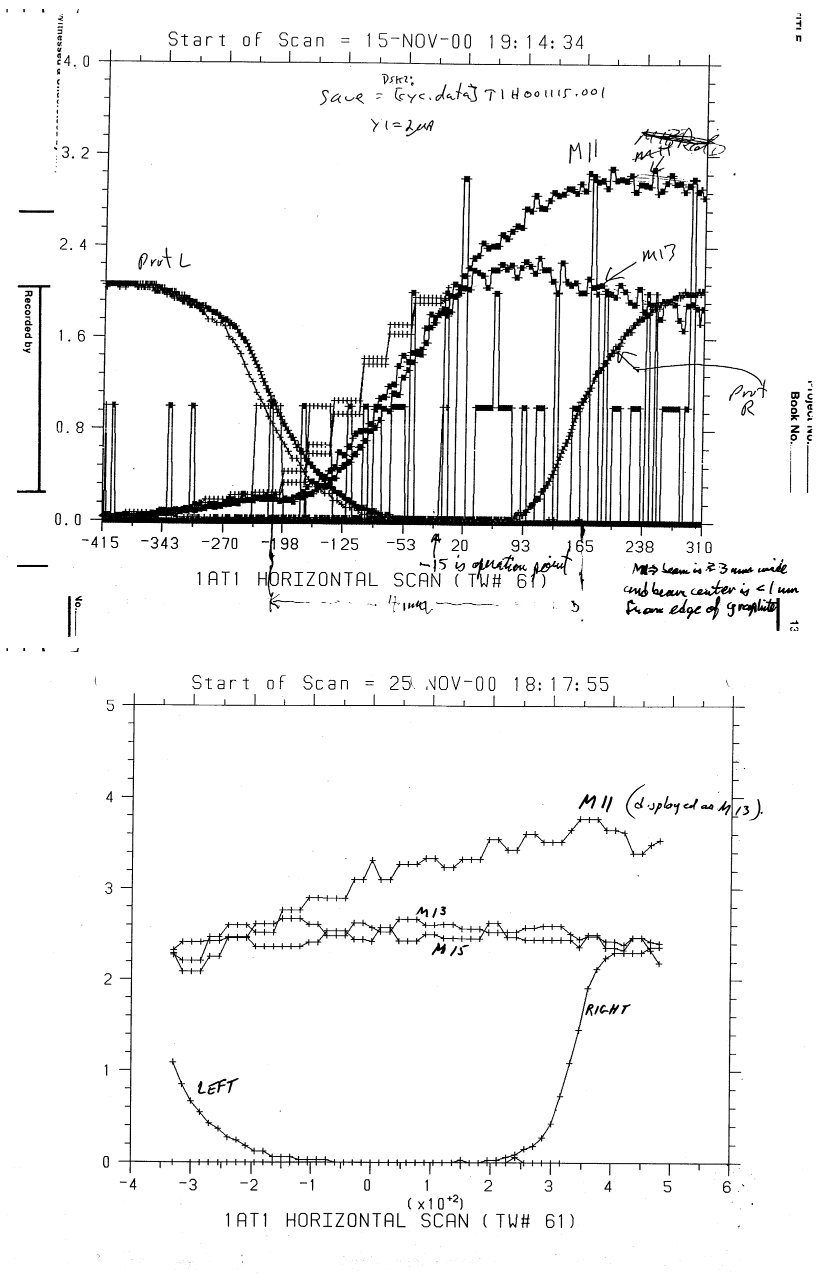

Figure 11: Horizontal target scans from the graphite target on November 15 (top) and the Be target on November 25 (bottom). Rates from M13 and M11 are indicated. Note the M13 surface muon rate drops as beam moves to the right across the nominal center of the beam in the top figure.

Recommendations

New items which should be seriously considered:

- surface muon emittance monitor which can be used easily at any time:
  $\Rightarrow$ TEC?
  $\Rightarrow$ steering after Q7?
  $\Rightarrow$ F3HS, F3VS?
- F2VS for $\mathcal{TWIST}$ tune
- survey and check of Q6 and Q7 alignment and field symmetry
- independent 1AT1 position monitoring

Developments which were already anticipated:

- power supply current transformers
- controls system isolation transformers
- slow monitoring of all power supply currents
- installation of Hall probes in all magnets, including dipoles
- replacement for secondary channel control system (TICS)
- testing and manufacture of graphite targets