Beam Transfer (Waldo MacKay)

- Description of the ATR beam line (AGS to RHIC)
- Status
  - Magnets
  - Other components
  - AGS
- Flag measurements
- Beam steering
- Commissioning strategy for next fall
- Conclusions

ATR Injection Line Description

I U-line:

A. Match beam from AGS into W-line

B. Stripping foil: $Au^{+77} \Rightarrow Au^{+79}$

II W-line:

A. Vertical drop of 1.7m

B. 20° bend to reach 6–12 o'clock symmetry line (Requires zero dispersion upstream and downstream of the 20° arc.)

C. 6 Quads at end of W-line match into the 90° arcs.

III Y-line:

A. Bend almost 90° into the Yellow (ccw) ring.

B. 6 Quads at end of Y-line match into RHIC.

C. Vertical injection into RHIC with lambertson.

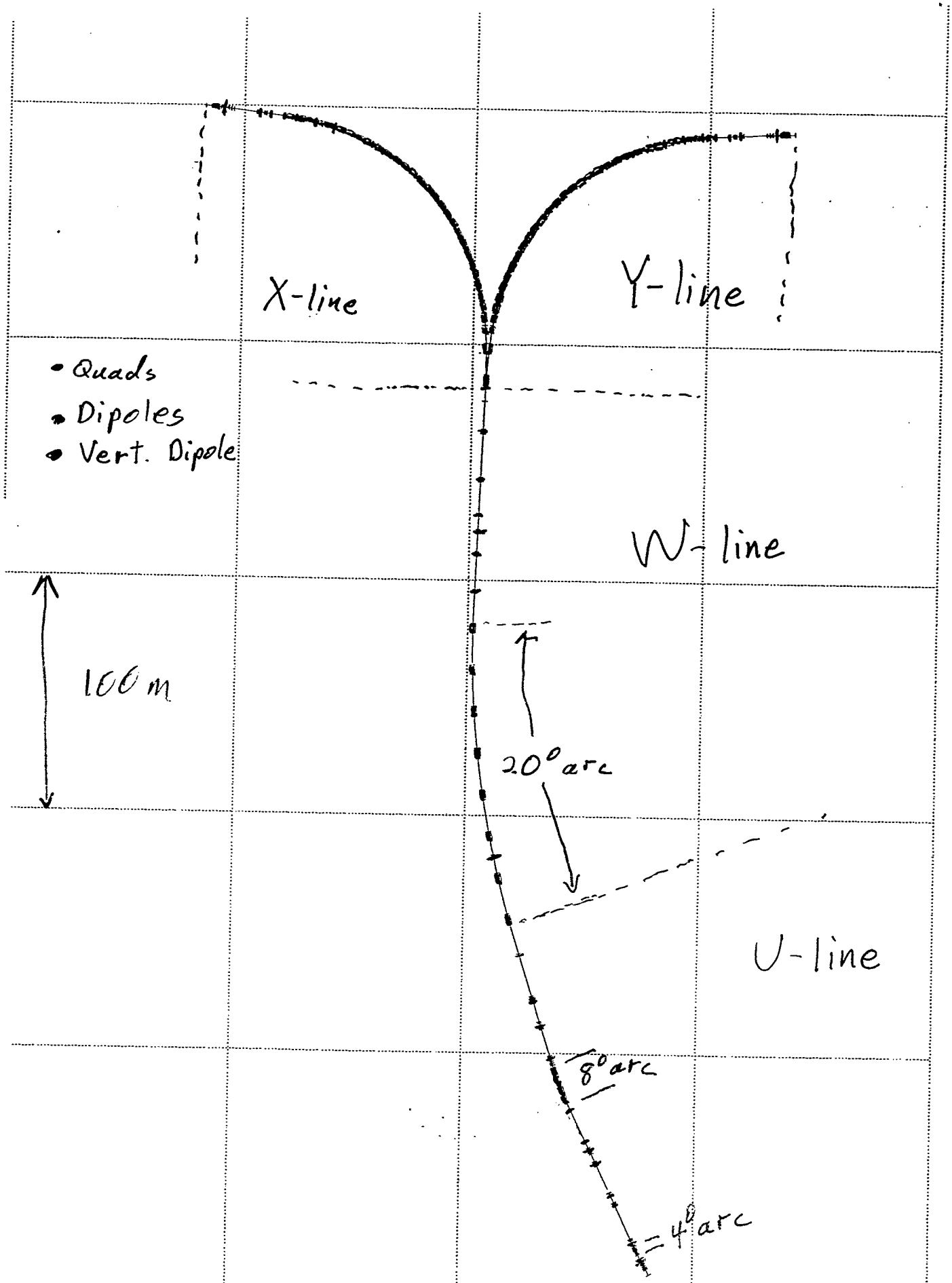
IV X-line:

A. Bend almost 90° into the Blue (cw) ring.

B. 6 Quads at end of X-line match into RHIC.

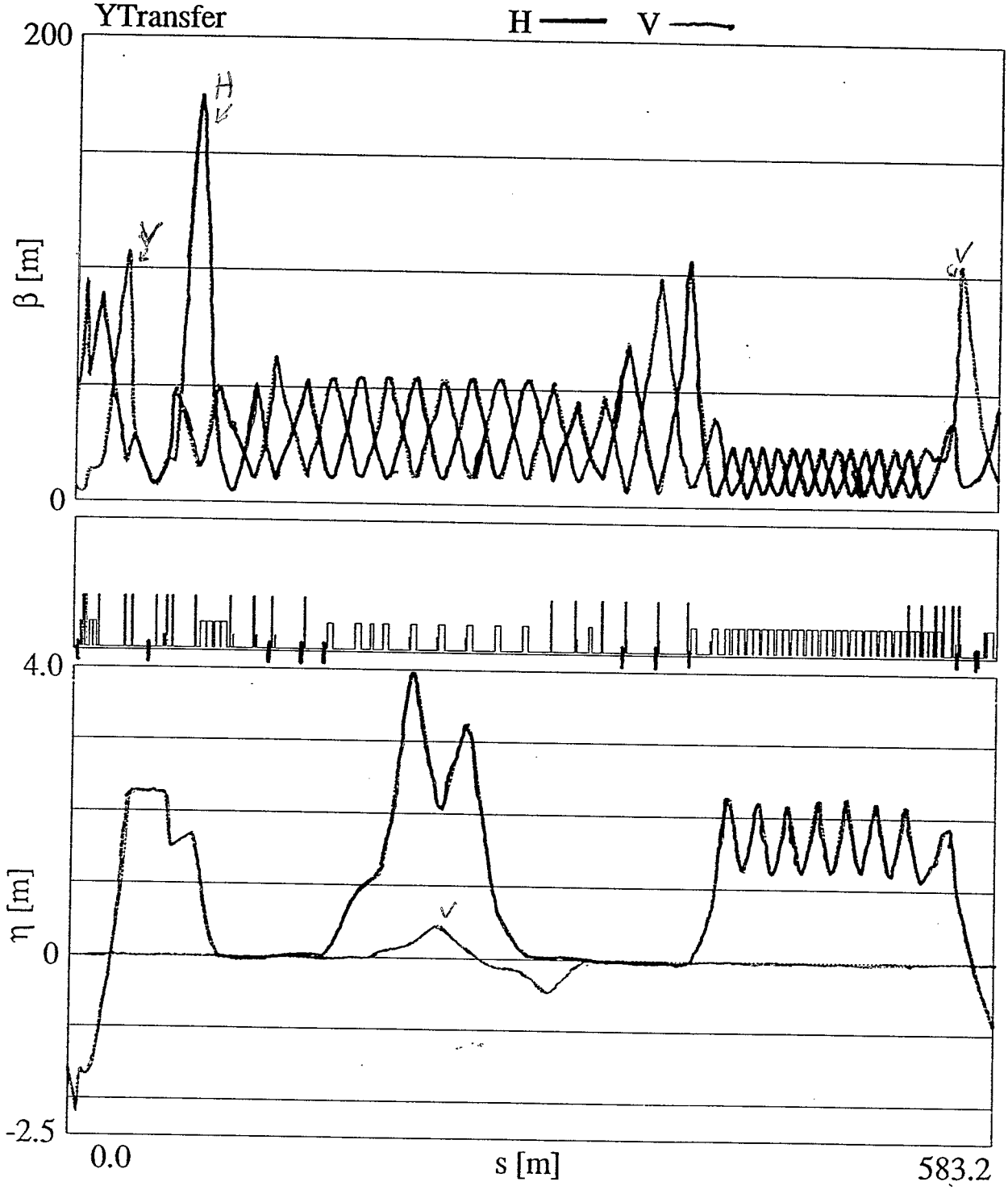
C. Vertical injection into RHIC with lambertson.

V Injection kickers inside each ring.

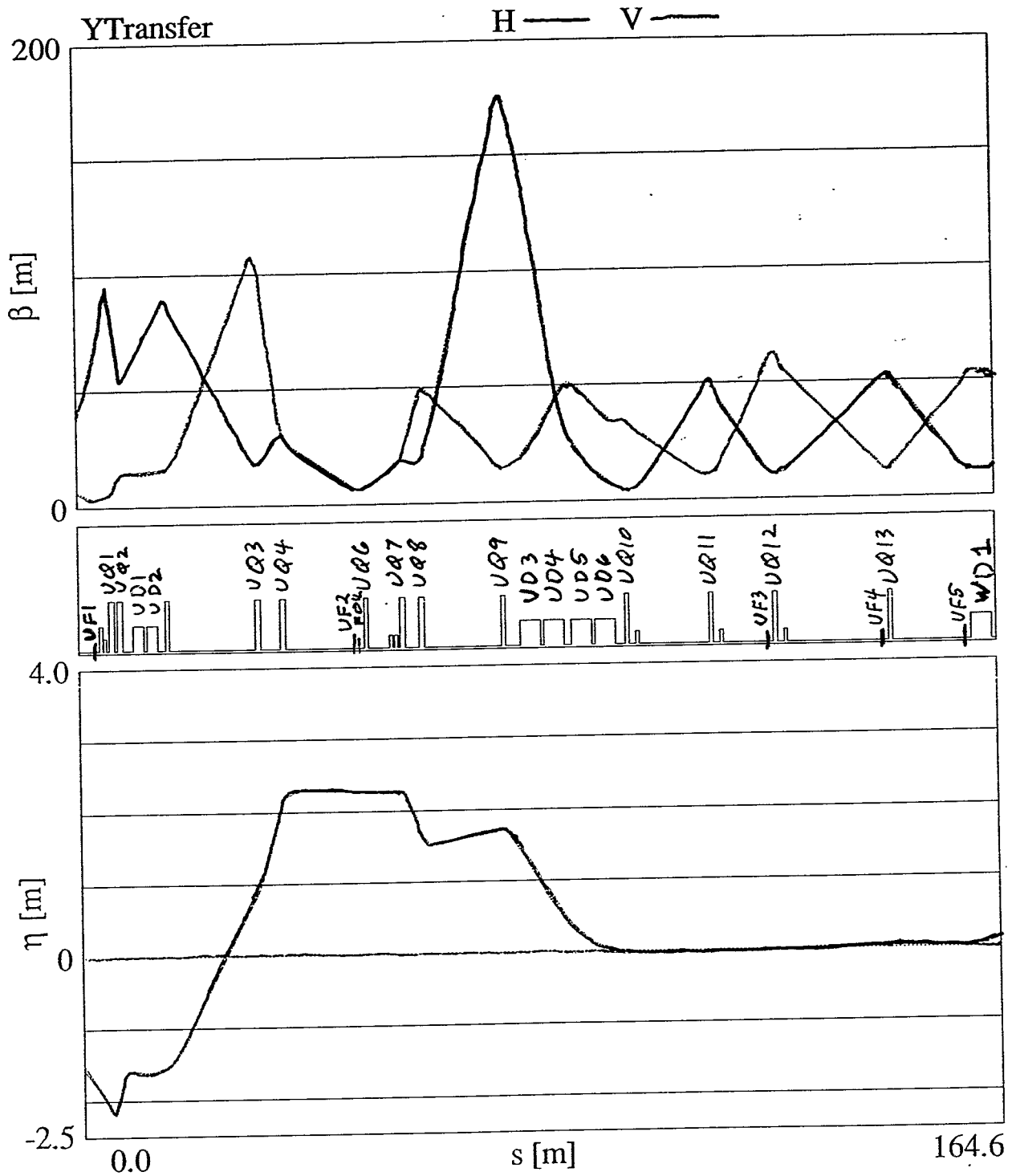

X-line
Y-line
• Quads
• Dipoles
• Vert. Dipole
W-line
100 m
20° arc
U-line
8° arc
4° arc

U, W, + Y - lines

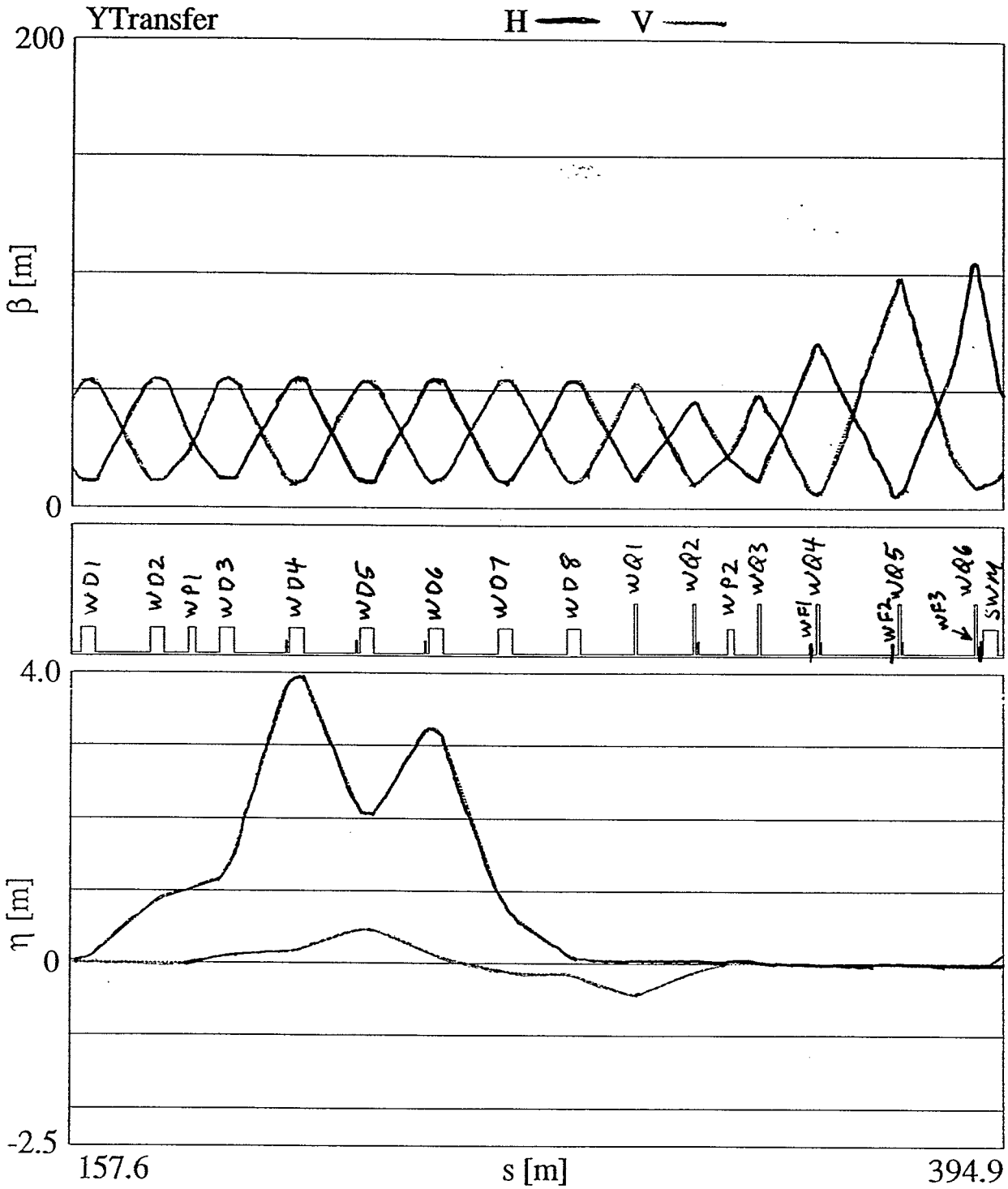
1 : flag



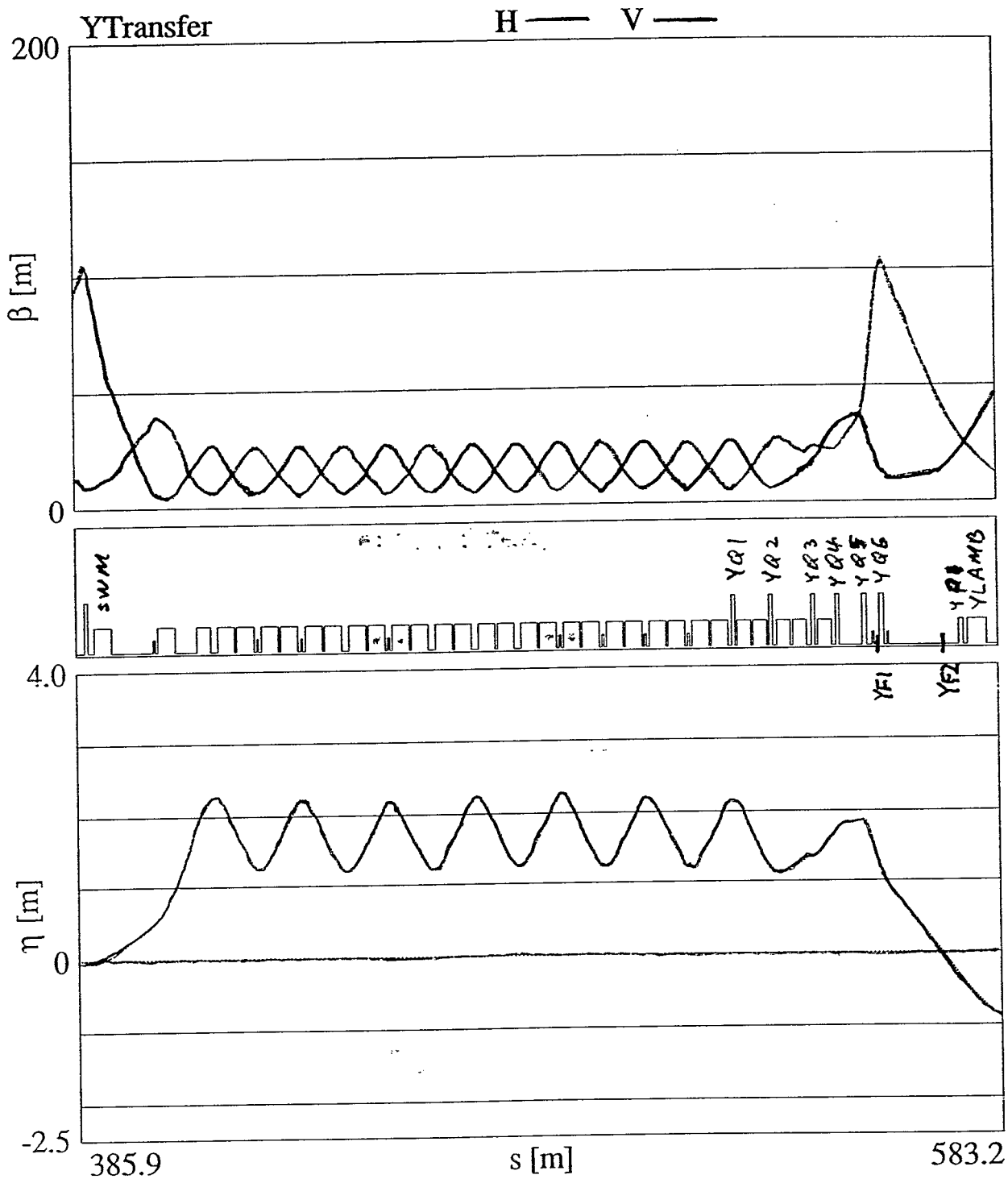
U-line


YTransfer
H
V
200
β [m]
0
UF1
UQ1
UQ2
UD1
UD2
UQ3
UQ4
UF2
UQ6
UQ7
UQ8
UQ9
UD3
UD4
UD5
UD6
UQ10
UQ11
UF3
UQ12
UF4
UQ13
UF5
WD1
4.0
η [m]
0
-2.5
0.0
s [m]
164.6

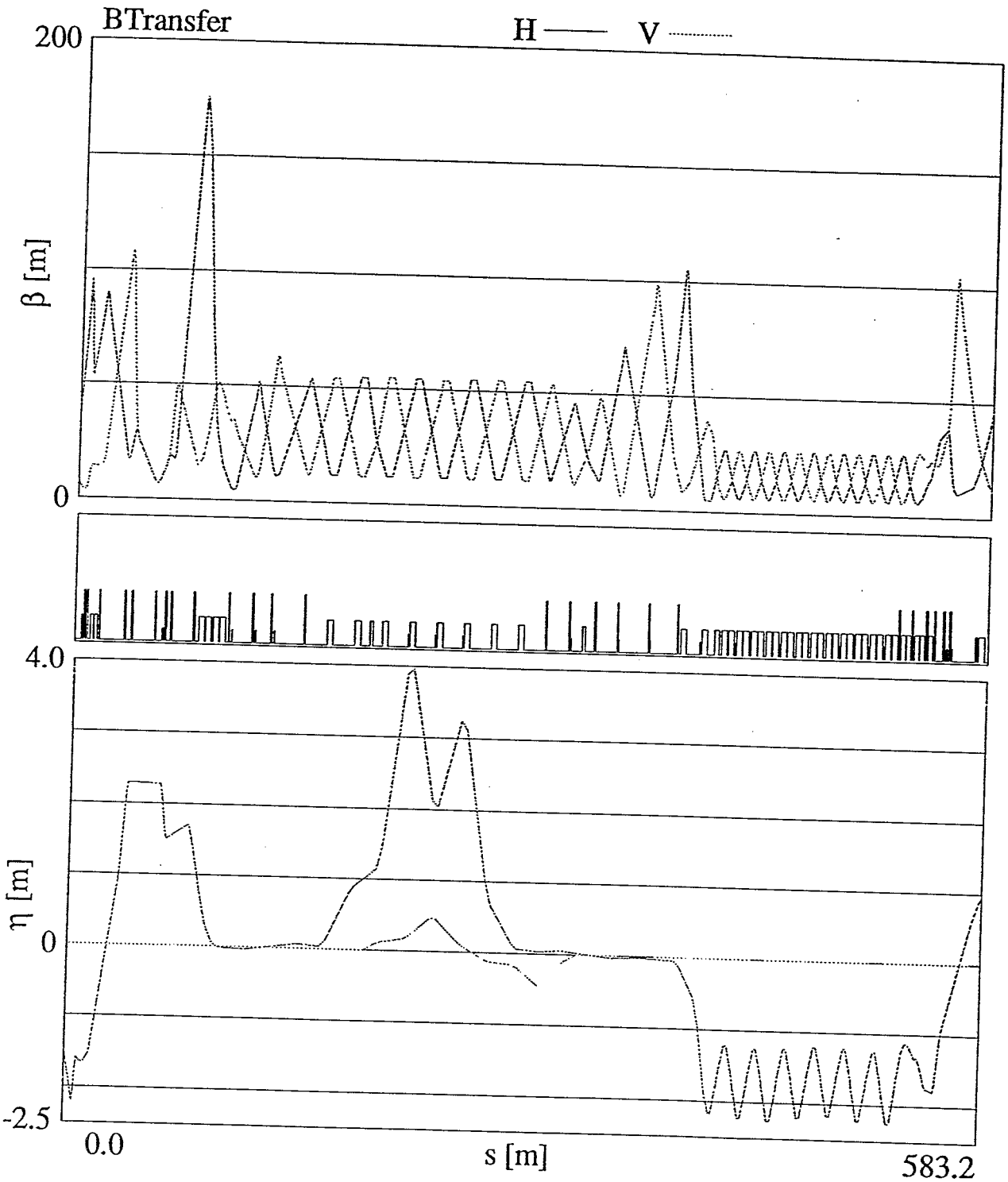
W-line


YTransfer
H
V
200
β [m]
0
WD1
WD2
WP1
WD3
WD4
WD5
WD6
WD7
WD8
WQ1
WQ2
WP2
WQ3
WF1
WQ4
WF2
WQ5
WF3
WQ6
SWM
4.0
η [m]
0
-2.5
157.6
s [m]
394.9

Y-line


YTransfer
H
V
200
β [m]
0
SWM
YQ1
YQ2
YQ3
YQ4
YQ5
YQ6
YLAMB
YF1
YF2
4.0
η [m]
0
-2.5
385.9
s [m]
583.2

D, W & X - lines

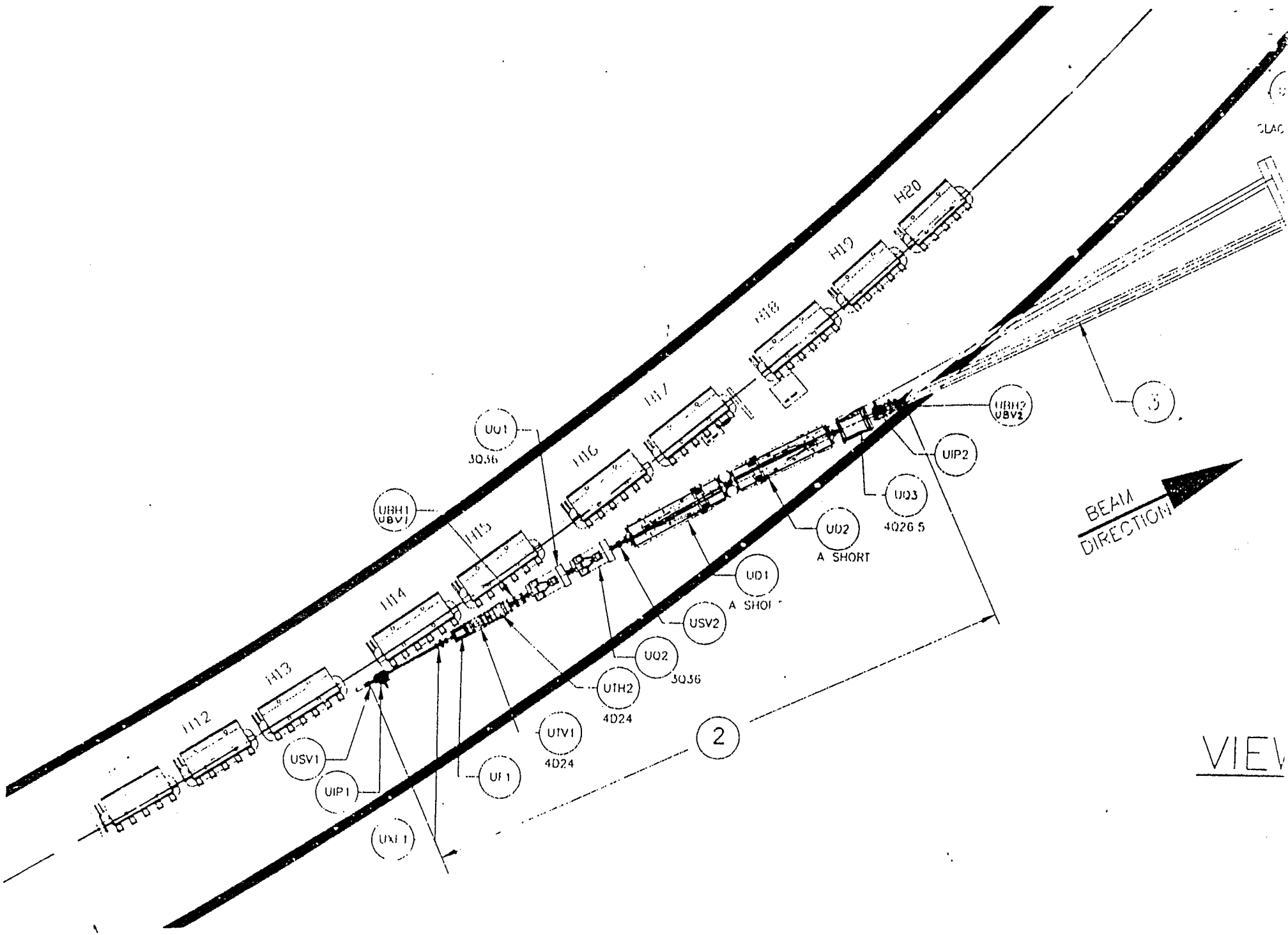


Changes since 1993 Review

- Dipoles UD1 and UD2 changed to longer magnets with smaller gaps.

$$B \sim 2\text{T} \rightarrow 1.28\text{T}$$
$$|\Delta B/B| \sim 1/800 \rightarrow 1/4000 \quad \text{at} \quad x = \pm 0.025\ \text{m}.$$

- 9 new planes of BPM's for better steering.
- Moved 2 flags and added 2 new ones.
  (Better emittance measurements.)
- BLM's allocated.
- AGS extraction and transfer to RHIC to be line-locked (30 Hz).
  - BPM electronics.
  - Frame grabbers for flags.


H12
H13
H14
H15
H16
H17
H18
H19
H20
UBH1
UBV1
UQ1
3Q36
UIP1
USV1
UF1
UTV1
4D24
UTH2
4D24
UQ2
3Q36
USV2
UD1
A SHORT
UD2
A SHORT
UQ3
4Q26.5
UIP2
UBH2
UBV2
3
2
BEAM
DIRECTION
VIEW

Field Quality

- Quads OK.
  - All on separate power supplies.

- Dipoles OK.
  - Random errors $\left|\frac{\Delta B}{B}\right| < 0.002$ can be corrected.

    Measured $\sigma \simeq 0.1\%$
  - Random errors $\left|\frac{\Delta k_1}{k_1}\right| < 0.005$ can be corrected.

    Measured $\sigma \simeq 0.1\%$
  - 8 type-C dipoles have been measured and sorted for the 20° arc.
  - The 7 type-B dipoles with old steel are being placed on either side of horizontal trims in the X- and Y-lines. Additionally, these trims are 180° degrees apart in phase.

Magnet Status as of 21 Sept., 1994

Type of magnet	Number	Location	Constructed	Measurements	In Tunnel	Left to install
Type-A dipoles thin	2	End of X and Y arcs	yes	no	0	2
Type-A dipoles fat	2	4° arc in U line	no	no	0	2
Type-B dipoles long	50	Large X and Y arcs	almost	1 left	24	26
Type-B dipoles short	10	Large X and Y arcs	none	1 to do	0	10
Type-C dipoles	12	8° and 20° bends	done	done	1	11
Quads of 4 types	31	all lines	done	done	20	11
Old trims	7	U line	done	no	4	3
New trims	26	W, X, and Y lines	done	no	0	26
W-line pitch	2	W line	done	no	0	2
Lambertson pitch	2	Ends of X and Y lines	done	no	0	2
Lambertsons	2	Ends of X and Y lines	done	soon	0	2
Switch magnet	1	begining of X and Y arcs	done	no	0	1

Status of other components

I Flags (12 total)

A. Working prototype in BTA line between Booster and AGS

B. Construction proceeding.

C. Cameras have been ordered.

D. Frame grabbers (4 channels) should be ordered soon.

E. Working software application.

II BPM's

A. Type 1 and 2 assembled.

B. Type 3 should be finished by November. (Upstream U-line)

C. Electronics – 1 working module by November.

III Collimators being constructed.

IV Current transformers ordered (4 to 8 weeks).

V Beam loss monitors

A. First ion chamber being received this week.

B. Circuit boards are being stuffed.

VI Stripping foil

A. Drive will be a duplicate of the Flag drives.

AGS and Extraction

I Bump windings should be completed in Nov.

A. Should do machine studies with bumps during next proton run.

II G10 kicker is ready (install in Nov.)

A. Kicker will be used to extract beam into the B2 test beam line in December.

III H10 septum should be finished by Feb. 1995.

A. Installation will be next summer.

IV Upstream U-line inside AGS tunnel.

A. Hopefully, most of this will be completed in Nov.
   1. UD1 and UD2 dipoles should be ready by Nov.
   2. The last bit UQ3 onward will be installed next summer, since shielding must be removed.

V At present, AGS BPM's can't see ion beams!

A. The upgrade of electronics was scheduled for 1996.

B. We will identify a minimum set of electrodes to instrument with more sensitive electronics for the 1995 test.

Flags

I Locations

A. 1 at beginning of U-line near AGS.

B. 1 near stripping foil.

C. 3 upstream of 20° arc.

D. 3 downstream of 20° arc near switch magnet.

E. 2 at end of X-line.

F. 2 at end of Y-line.

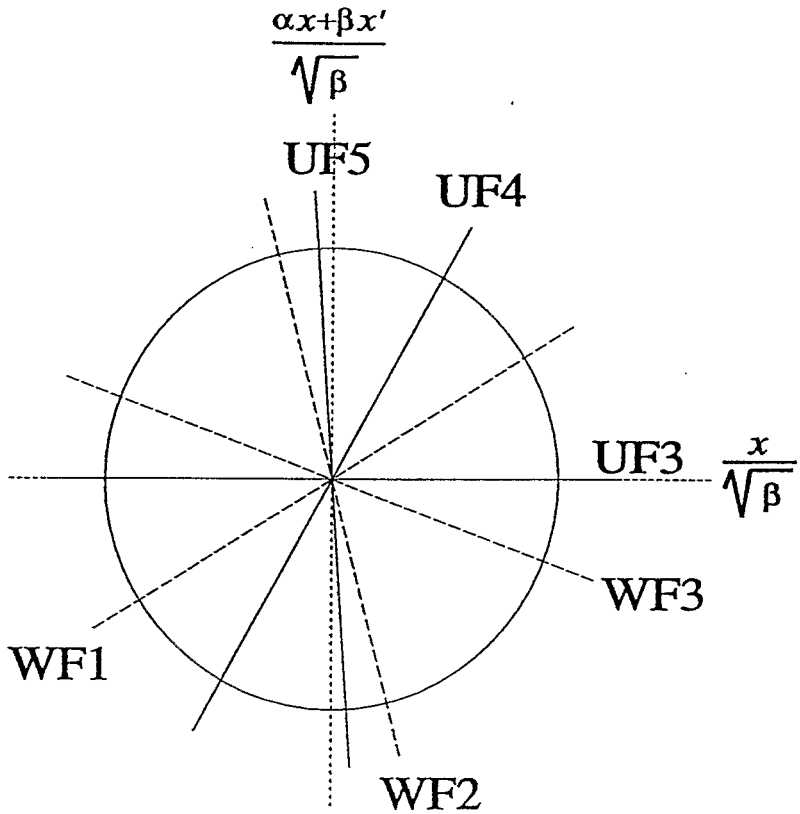
II Emittance measurement

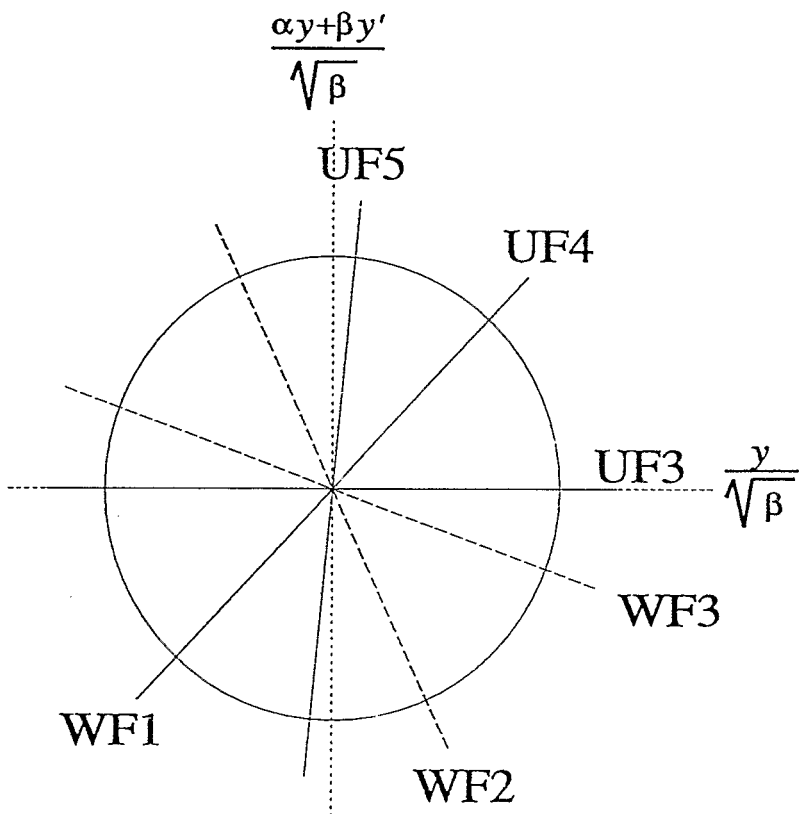
A. UF3, UF4, UF5, WF1, WF2, and WF3.

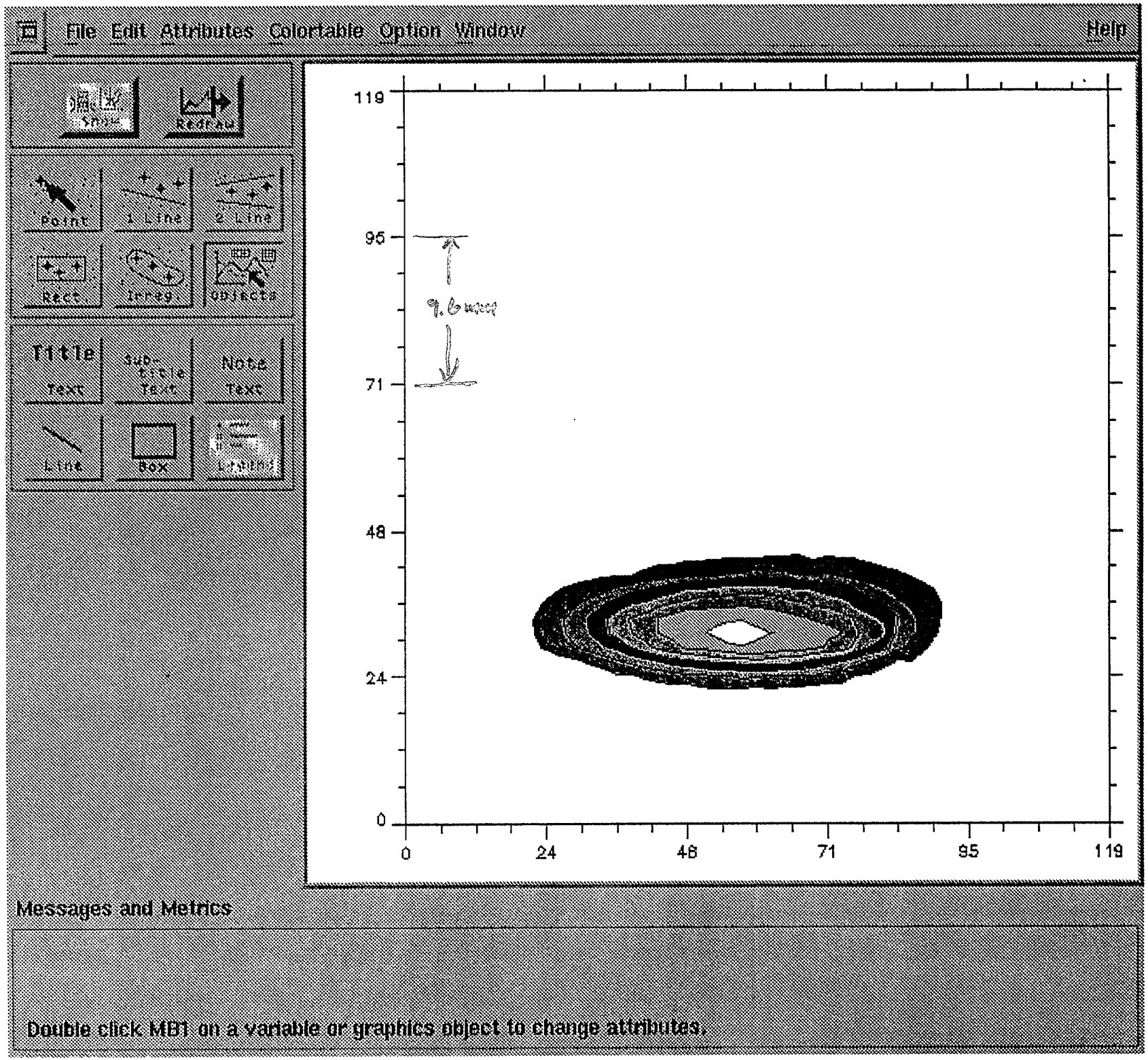
B. Zero dispersion.

C. Resolution: $\sim 0.1\,\mathrm{mm}$.

D. Estimated accuracy of emittance with 6 flags: $\sim 5\%$.

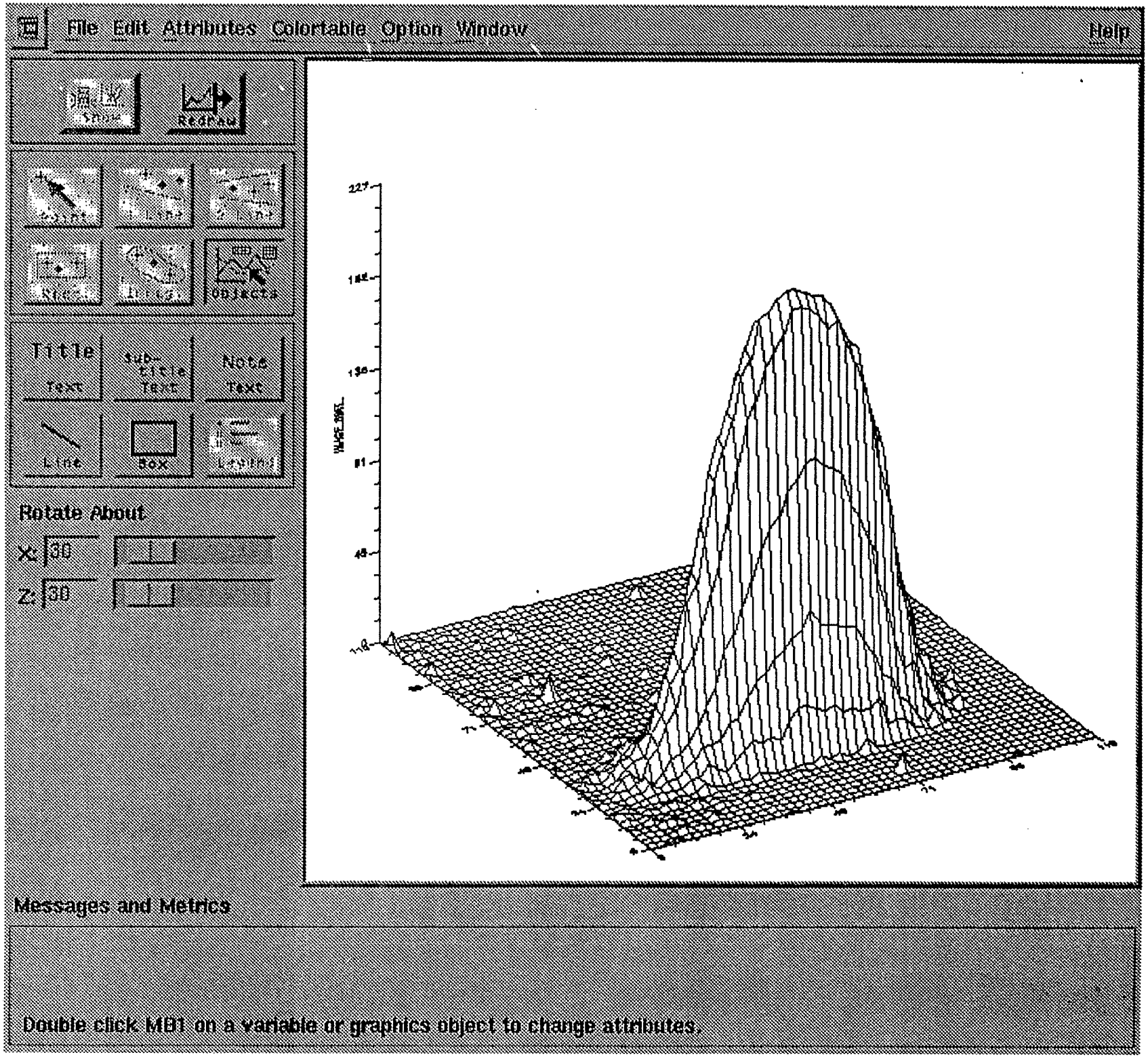

$\frac{\alpha x+\beta x'}{\sqrt{\beta}}$
UF5
UF4
UF3
$\frac{x}{\sqrt{\beta}}$
WF3
WF1
WF2


$\frac{\alpha y+\beta y'}{\sqrt{\beta}}$
UF5
UF4
UF3
$\frac{y}{\sqrt{\beta}}$
WF3
WF1
WF2



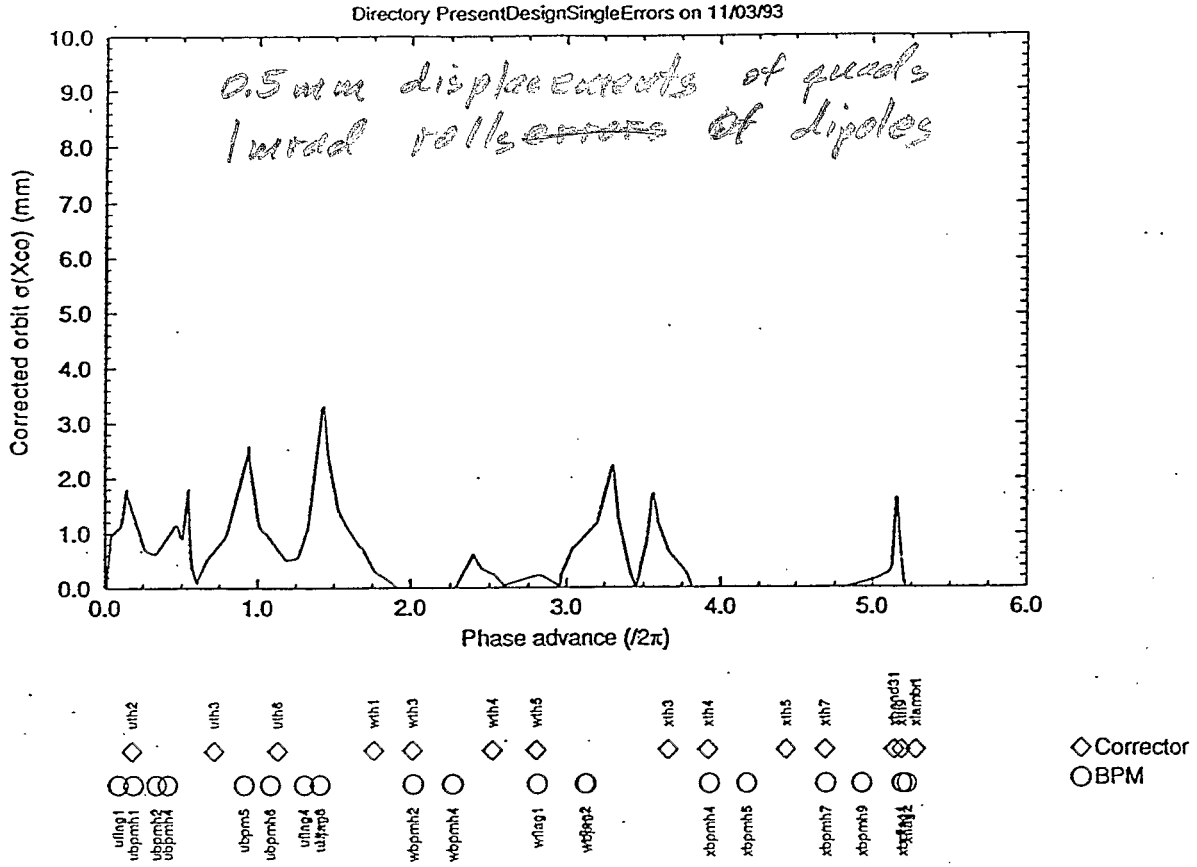
← Pixels

~ 0.4 mm / pixel


File Edit Attributes Colortable Option Window
Help
Redraw
Objects
Title Text
Sub-Title Text
Note Text
Line
Box
Rotate About
X: 30
Z: 30
Messages and Metrics
Double click MB1 on a variable or graphics object to change attributes.

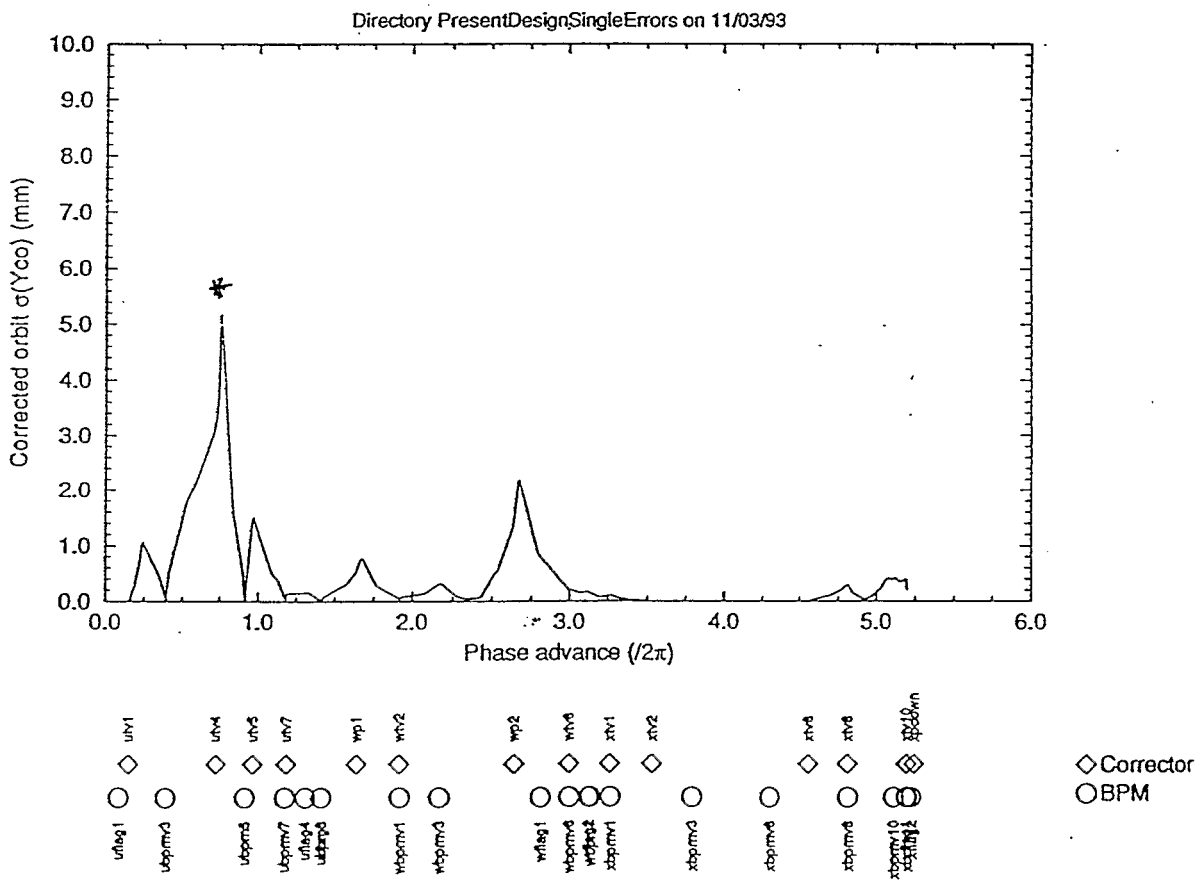
Horizontal closed orbit sigma, 76 single errors, after correction

Directory PresentDesignSingleErrors on 11/03/93



Vertical closed orbit sigma, 76 single errors, after correction

Directory PresentDesignSingleErrors on 11/03/93



*~4" ID at this point

Vertical Aperture at Injection

I Aperture limits

A. injected beam

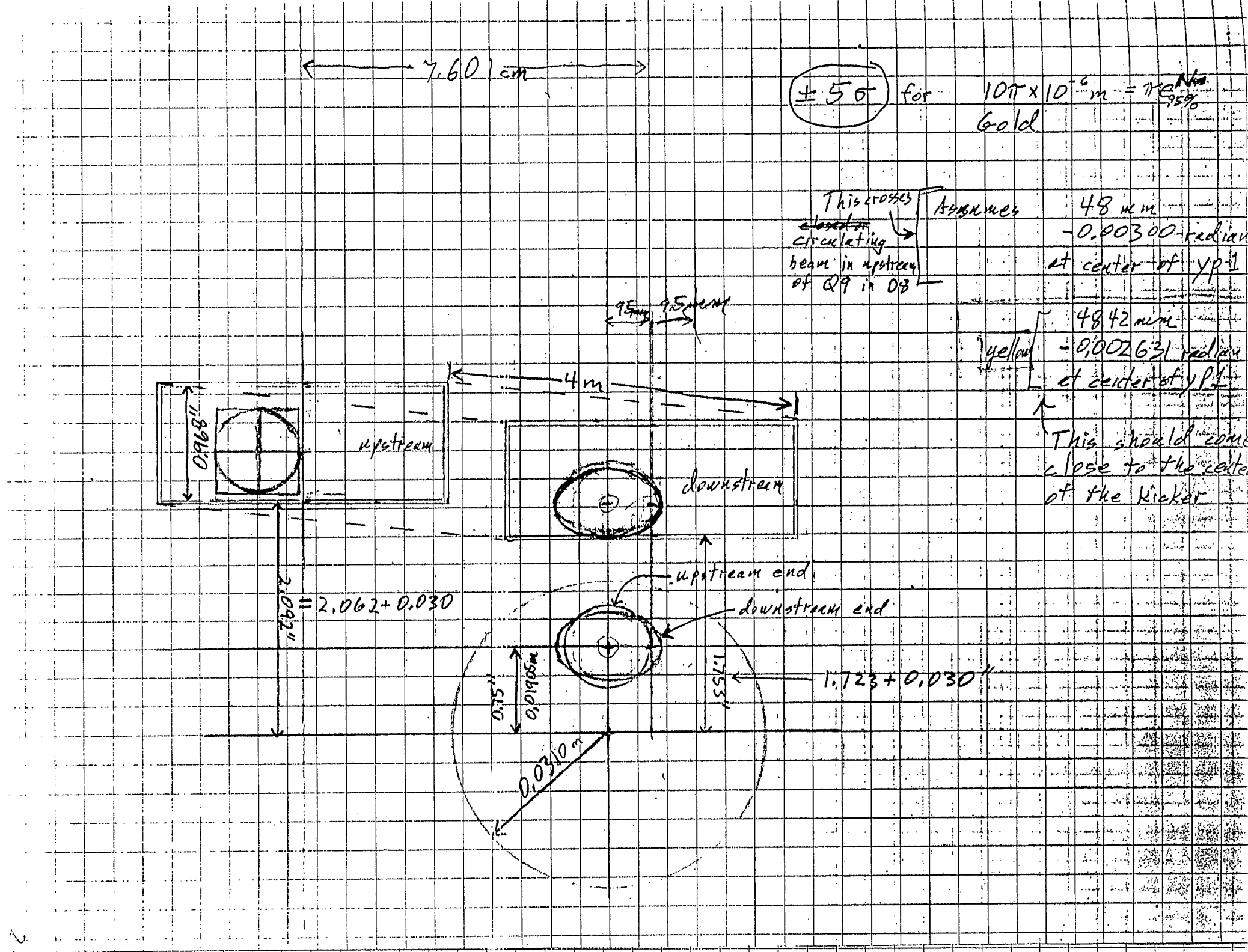
1. Lambertson: $\sim \pm 3.5\sigma$ at 30π
2. 24.5 mm vertical height

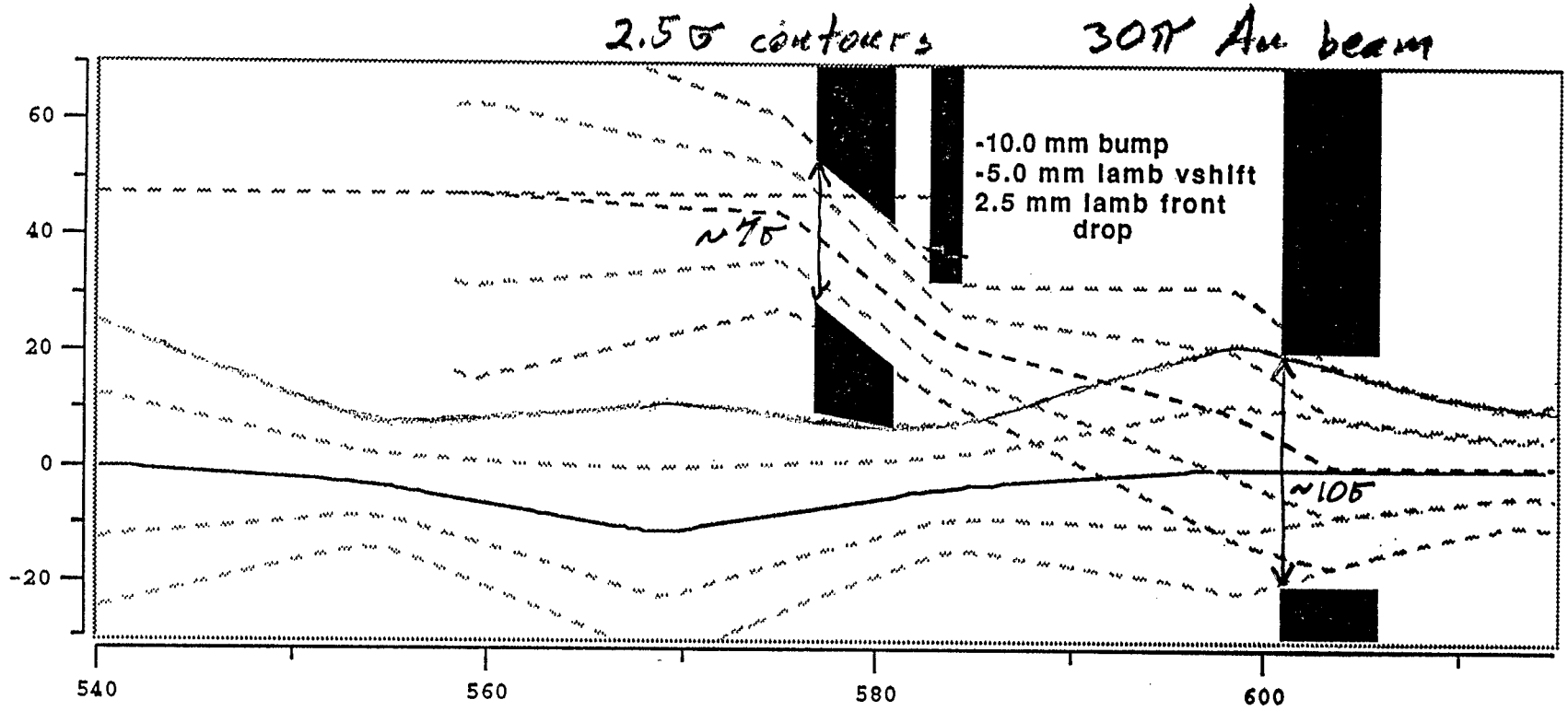
B. Circulating beam

1. Kicker: $\sim \pm 5\sigma$ at 30π
2. 41.2 mm ID

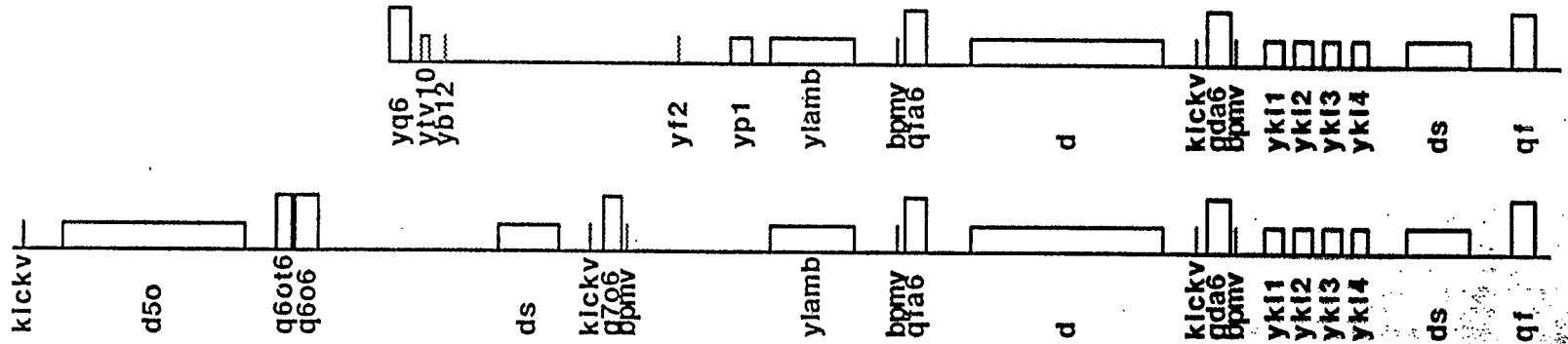
C. Warm-to-cold transition after lambertson

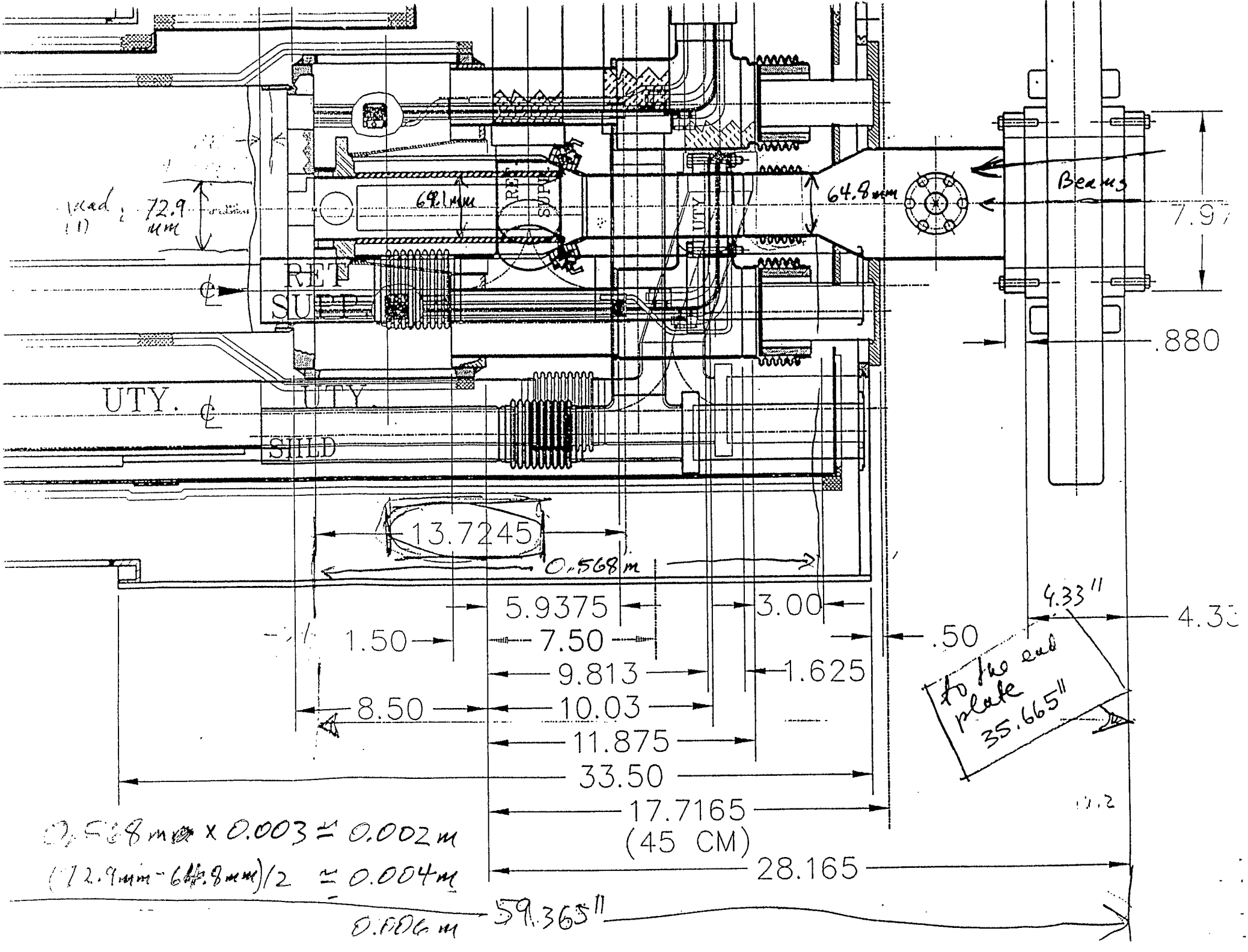
1. Constricts ID 8 mm more than quadrupole.
2. Length subtracts another 2 mm.
3. Net result: clip top of aperture by 6 mm.
4. $\Rightarrow$ We need to hone the design.


7.601 cm
±5σ for 10π × 10⁻⁶ m = πe N 95%
Gold
This crosses ~~closed or~~ circulating beam in upstream of Q9 in D8
Assumes 48 mm
-0.00300 radian
at center of YP-1
yellow
48.42 mm
-0.002631 radian
at center of YP-1
This should come close to the center of the kicker
9.5 mm
9.5 mm
4 m
0.968"
upstream
downstream
upstream end
downstream end
2.092" = 2.062 + 0.030
0.75"
0.01905 m
1.753"
1.723 + 0.030"
0.0310 m

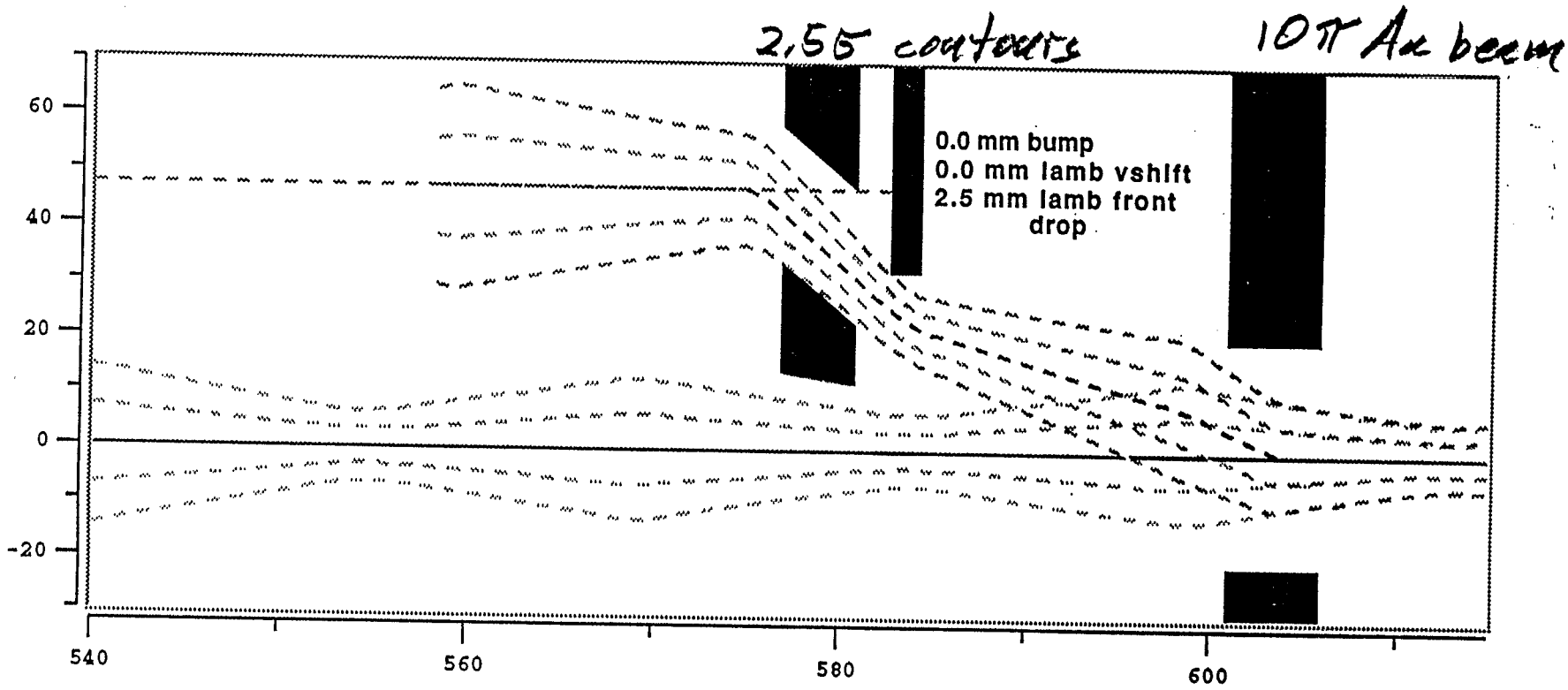


Kick ∠ 1.86 mradian

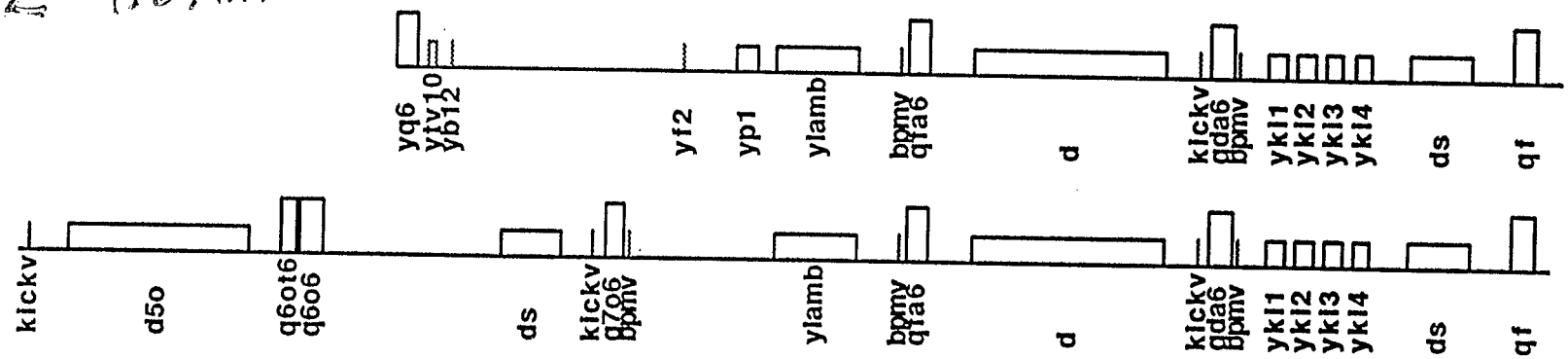




Beams
64.8 mm
69.1 mm
72.9 mm
RET SUPP
UTY.
SHLD
7.97
.880
13.7245
0.568 m
5.9375
3.00
1.50
7.50
.50
9.813
1.625
8.50
10.03
11.875
33.50
17.7165
(45 CM)
28.165
59.365"
4.33"
to the end plate 35.665"
0.568 m x 0.003 ≃ 0.002 m
(72.9 mm - 64.8 mm)/2 ≃ 0.004 m
0.006 m



Kick ∠ 1.67 mradian



Commissioning Strategy for Fall 1995

I Things to do before beam tests

II With beam

A. Sept. $\rightarrow$ Nov. 1995 with Heavy Ions.
   1. Two weeks dedicated running.
   2. Two months of parasitic running.

B. Jan. 1996: protons to $g-2$ experiment (U- and V1-lines).

I Things to do before beam tests

A. check cooling water on magnets

B. ramp magnets

C. check polarities of magnets

D. pump down line and check vacuum

E. check interlocks

F. check other hardware
   1. BPM's: cables and electronics
   2. BLM's (with a radioactive source)
   3. Flags: read back pictures with calibration lights
   4. Collimators: check motor control and location read-backs.
   5. Current transformers and electronics
   6. Timing system: check signals
      a. to transformers
      b. to BPM's
      c. eventually to injection kicker system

G. Test connection to RHIC abort system

II With beam ($\sim 10^{10}$ charges of some species, hourly average 1pulse/30sec)

A. Thread beam down the U- and W-lines.
   1. Steer the beam onto the flags.
   2. Measure the location with the BPM's.
   3. Verify magnet and BPM polarities with beam.
   4. After reaching a flag with a reasonable trajectory, remove the flag and go on to the next one.

B. Measure the pulse stability from the AGS.
   1. Current
   2. Position
   3. Profile on flags

C. Do fault studies.
   1. Check for radiation leaks when the beam hits certain key elements. Of particular interest are:
      a. Access doors, particularly in the split region.
      b. Penetrations for ventilation shafts and cables.
      c. Thin shielding areas.
      d. The top of the berm where Thompson road crosses the beam line.

D. Measure the transverse matrix elements (C, S, C', S') for both x and y.
   1. Measure the beam location at all BPM's.
   2. Change UTV1 by a small amount and remeasure the trajectory.
   3. Reset UTV1 to previous value and remeasure the trajectory.
   4. Change UTH2 by a small amount and remeasure the trajectory.
   5. Calculate the expected deviations and compare with data.

E. Measure the dispersion elements of the beam line (D, D').
   1. Measure the trajectory.
   2. Simulate a -0.1% momentum change by ramping all magnets up by 0.1%.
   3. Remeasure the trajectory.
   4. Calculate the values of D and D' at the BPM locations.
   5. Compare with the expected values.

F. Measure the beam shape (hyperellipsoid)
   1. Measure the profile at flags UF3, UF4, and UF5
   2. Measure the profile at flags WF1, WF2, and WF3
   3. Attempt to measure momentum spread with collimator UC1.
   4. Calculate emittances, betas, and alphas (horiz and vert) at the flag locations.
   5. Measure dispersion of the beam.
      a. Change the momentum of the AGS extracted beam.
      b. Remeasure the trajectory.
      c. Calculate the values of η and η' at the BPM locations.
   6. Compare with the expected values.

G. Tune the U-line quads to best match the desired values going into the W-line.
   1. Note that the dispersion should be zero at the entrance to the W-line (20° arc).

H. Tune the W-line quads to best match the desired values just upstream of SWM (switch magnet).

I. Scan aperture

Conclusions

I Design and Construction

A. Magnets:

1. Magnet construction almost complete.
2. At least 50 (as of 23 Sept.) are already installed in tunnel.
3. Field quality is good.

B. Minor changes to beam line (more flags and BPM's)

C. BLM's laid out.

D. Installation progressing well.

II Applications

A. Two major application codes well under development:

1. Beam threading
2. Emittance measurement: flag data has been read from BTA line.

III Sticky points

A. Design of warm-to-cold transitions near lambertsons need work.

B. Upgrade AGS BPM's to see ions.

IV Beam test in 1995

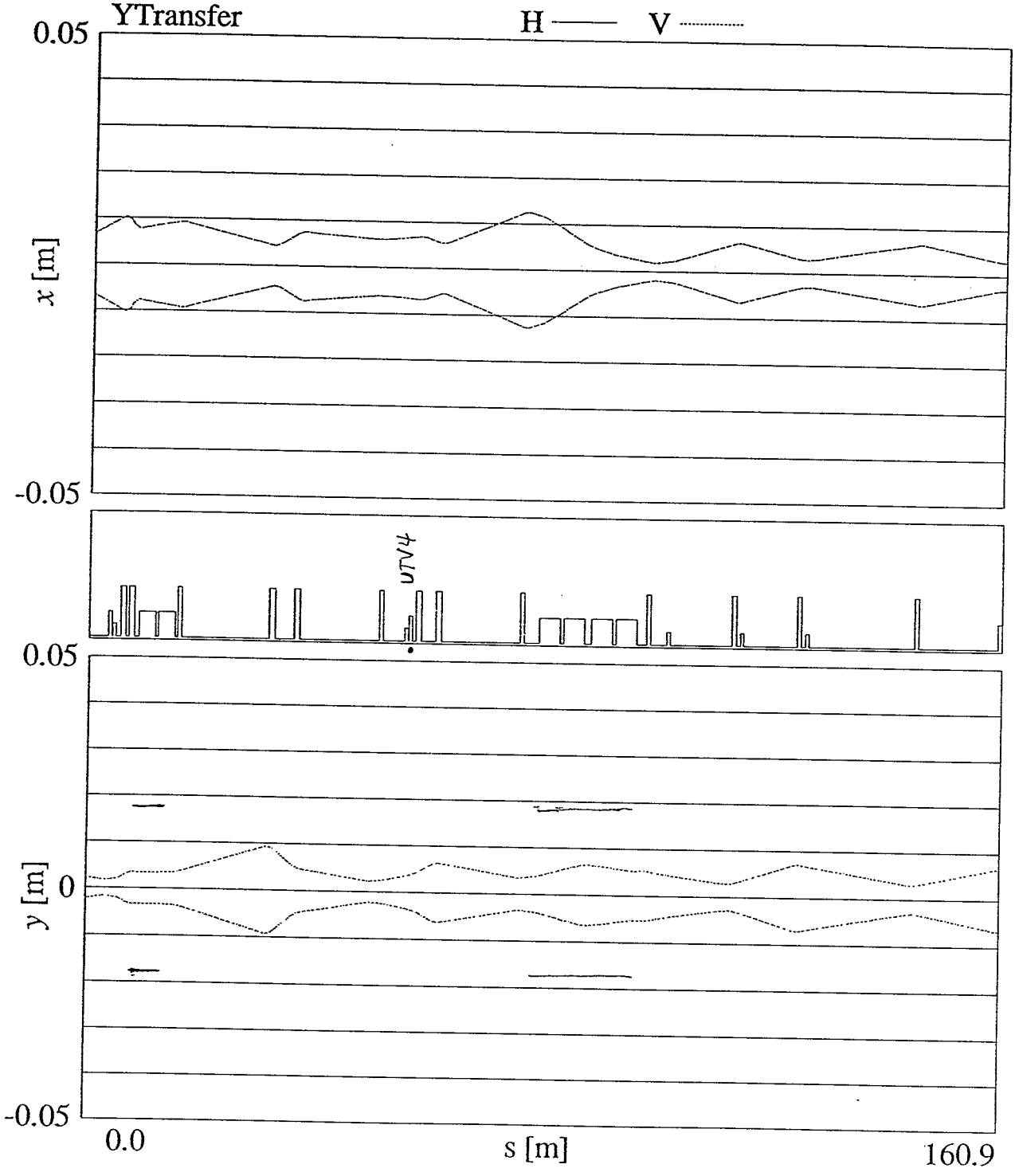
A. Strategy fairly well planned.

U-line

$10\pi \times 10^{-6}$ Au

95%

$\frac{\sigma_\rho}{\rho} \sim 10^{-3}$

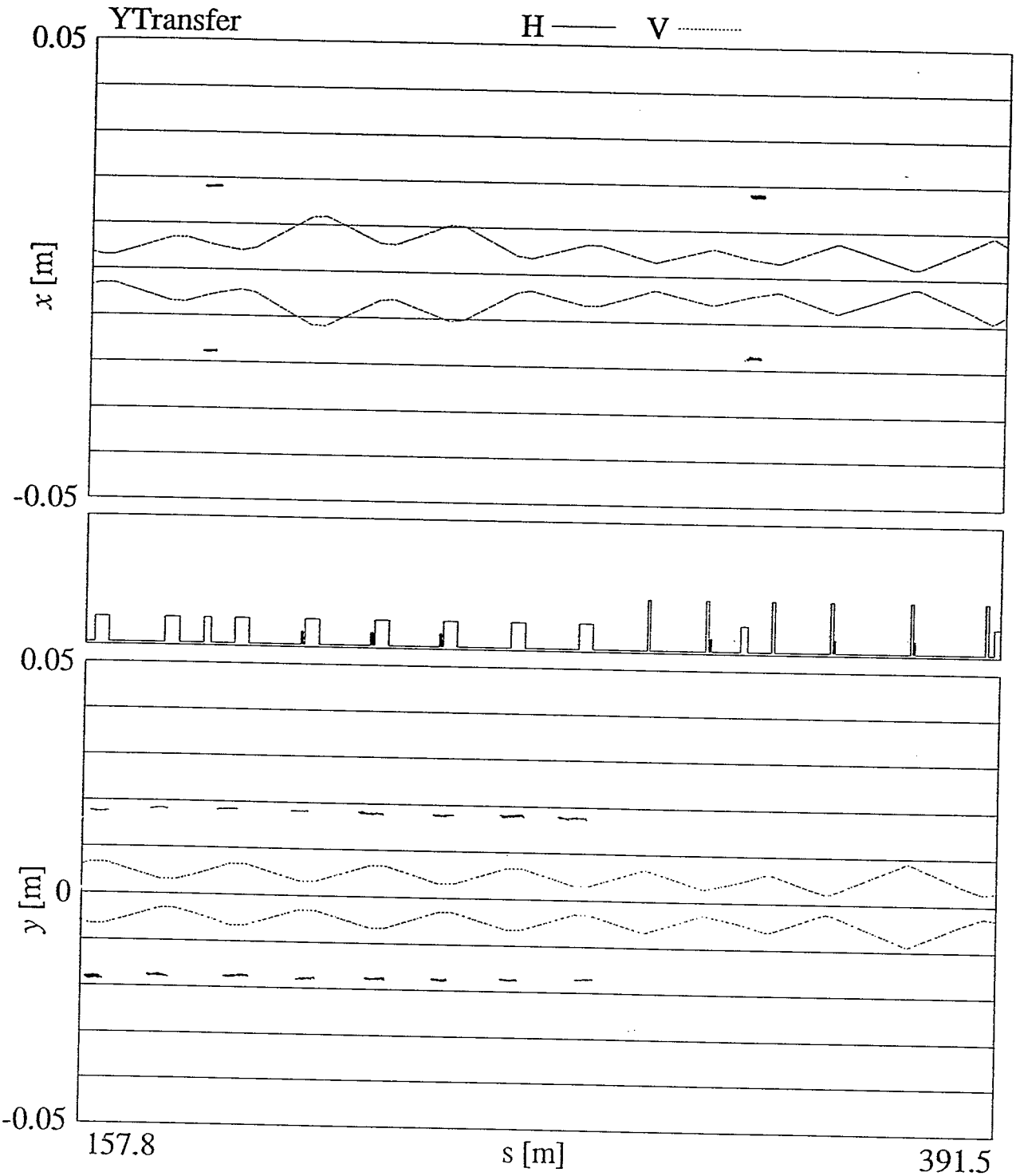


W-line

$10\pi \times 10^{-6}$ Au

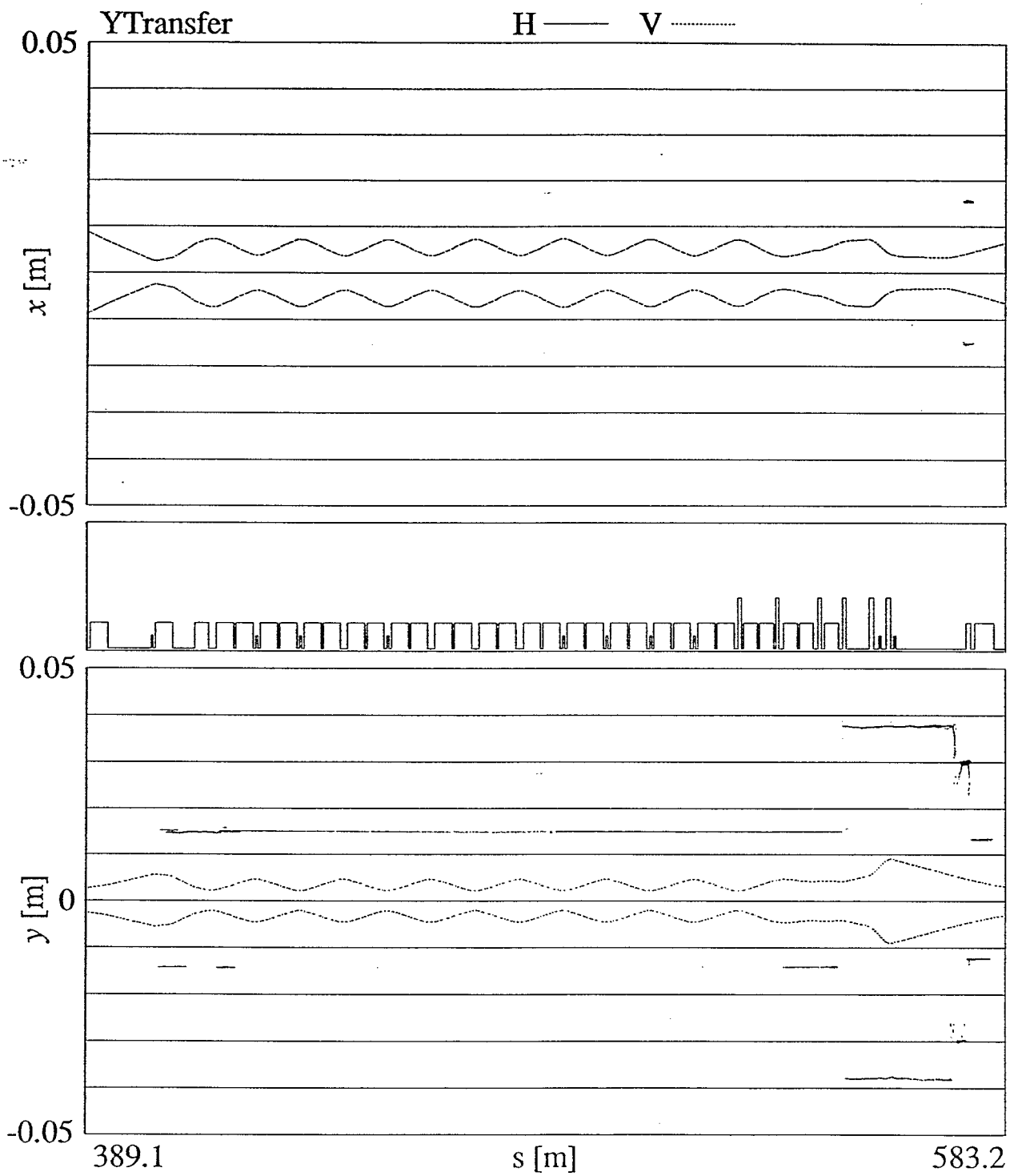
95%

$\frac{\Delta p}{p} \sim 10^{-3}$



Y-line

$10\pi \times 10^{-6}$ Acc

95%

$\frac{\sigma_p}{p} \sim 10^{-3}$