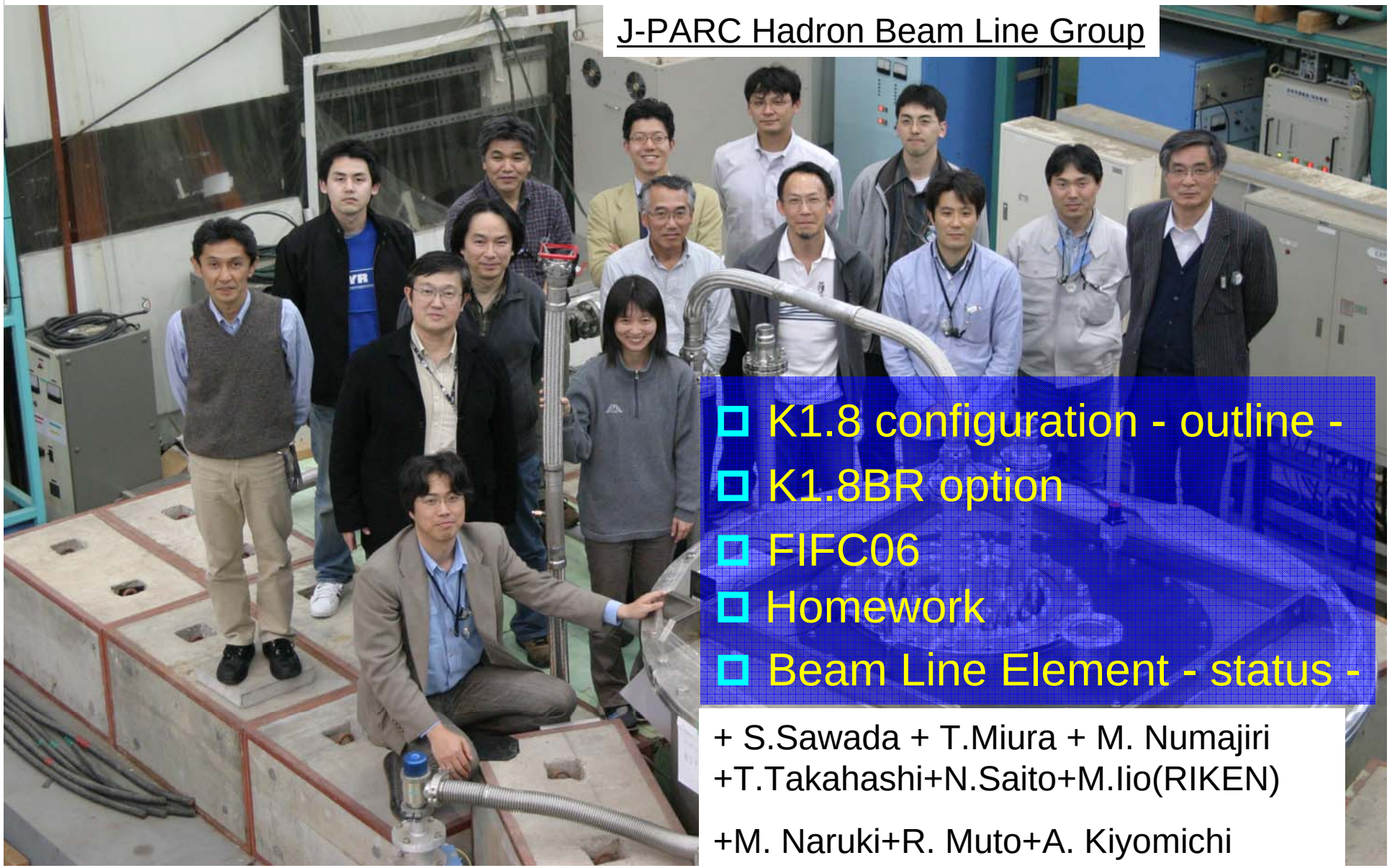
K1.8 and K1.8BR beam lines

J-PARC Hadron Beam Line Group



- K1.8 configuration - outline -
- K1.8BR option
- FIFC06
- Homework
- Beam Line Element - status -

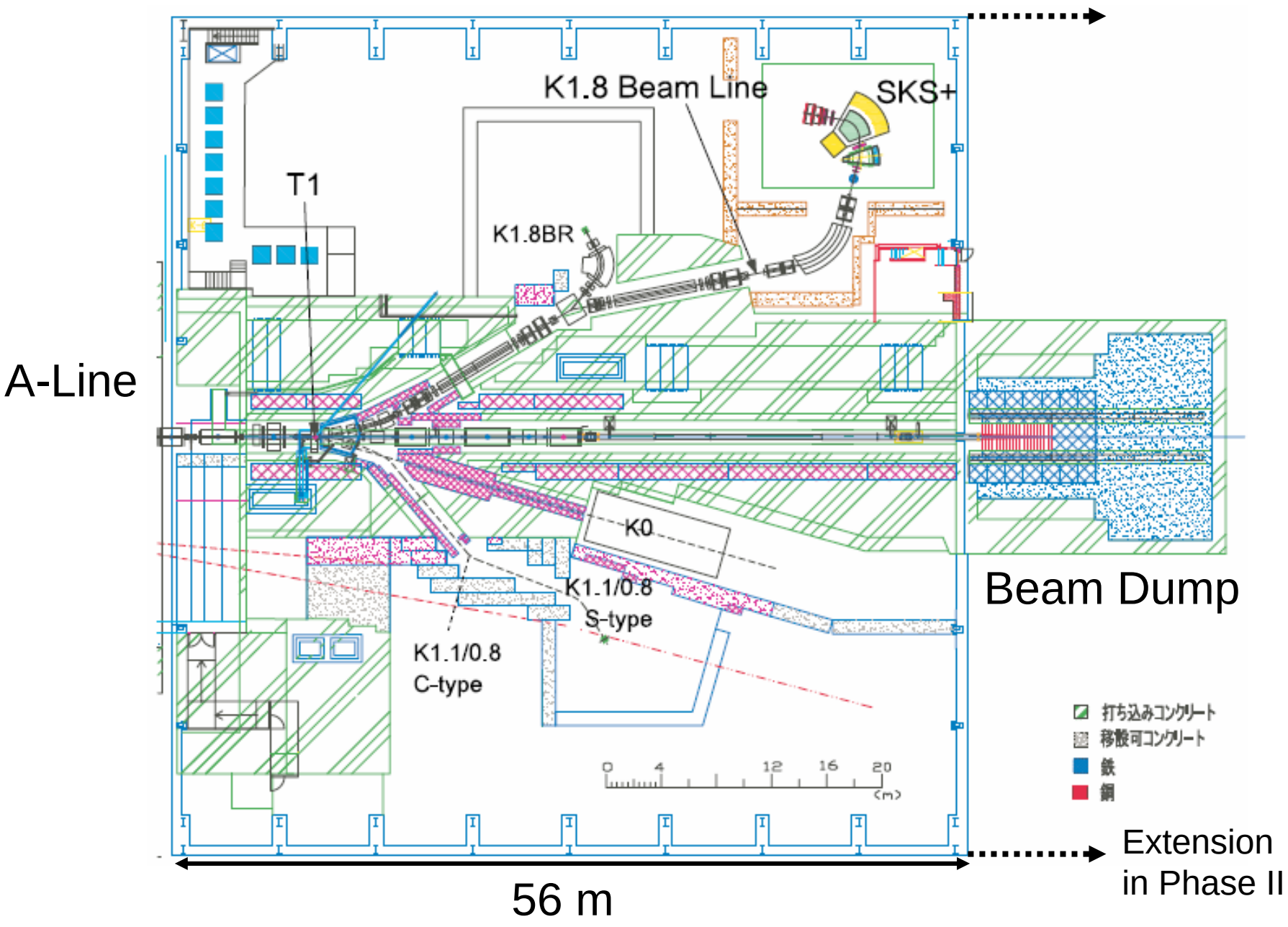
+ S.Sawada + T.Miura + M. Numajiri
+T.Takahashi+N.Saito+M.Iio(RIKEN)

+M. Naruki+R. Muto+A. Kiyomichi

K1.8 configuration
- outline -

- Design
  Design goal/Layout and Concept
- Optics
  Beam envelope/Beam analyzer/Profile@FF

Hadron Experimental Hall (Phase I)



K1.8 design

Design Goal

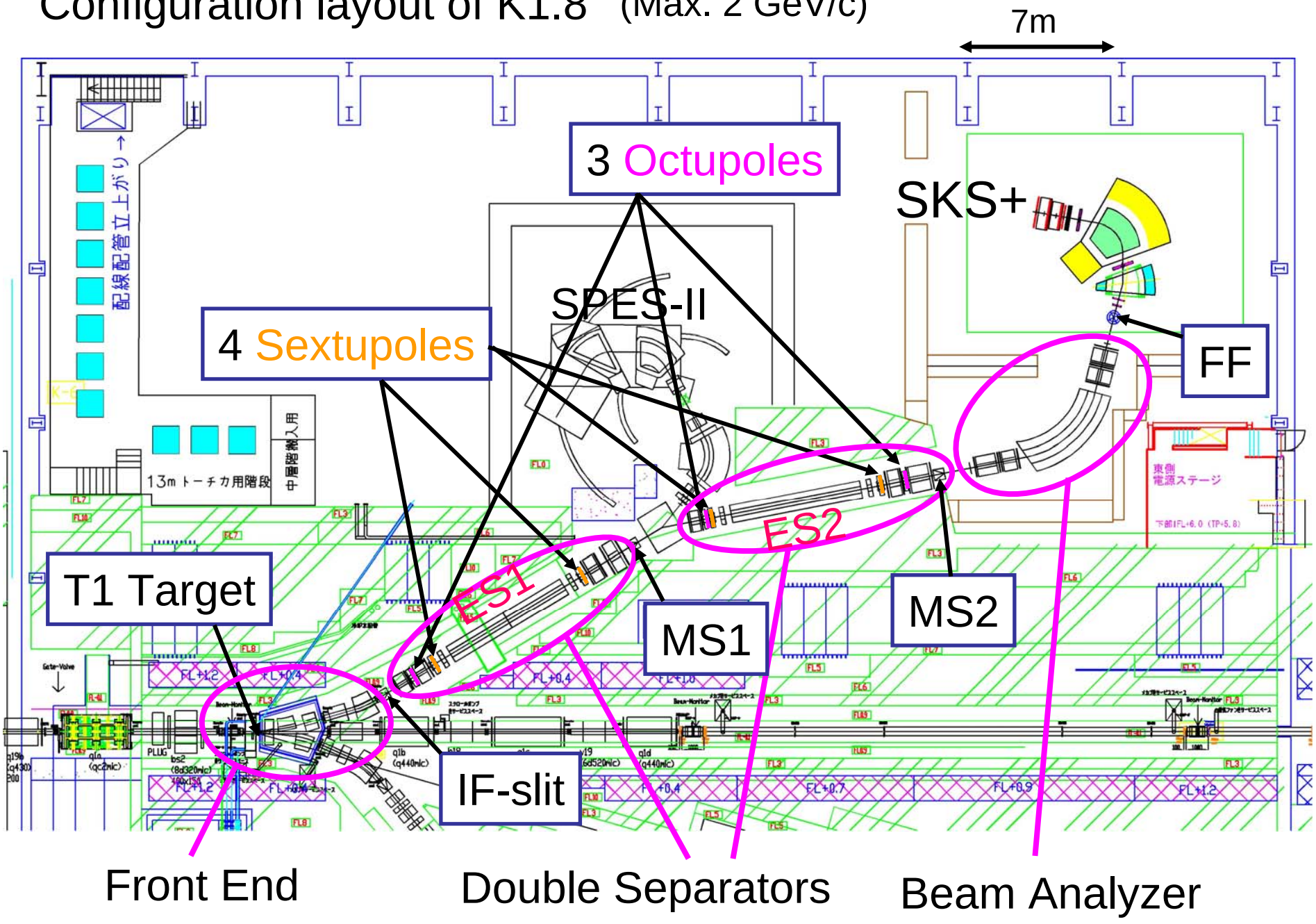
- ✓ Optimized for Ξ hypernuclear spectroscopy
- ✓ Max. Central Momentum of K1.8: ~ 2 GeV/c
  since the Ξ production is a max. at 1.8 GeV/c
- ✓ Intense K- at 1.8 GeV/c: $\sim 10^7$ ppp for 50GeV-15μA
  30 GeV-9μA is a target specification in Phase I
- ✓ Pure K- at 1.8 GeV/c: K/π>>1 at FF
  Better K/π even at MS2 for beam line counters
- ✓ Required a High Res. Beam Analyzer
  for Precision Spectroscopy of Ξ hypernuclei

K1.8 design

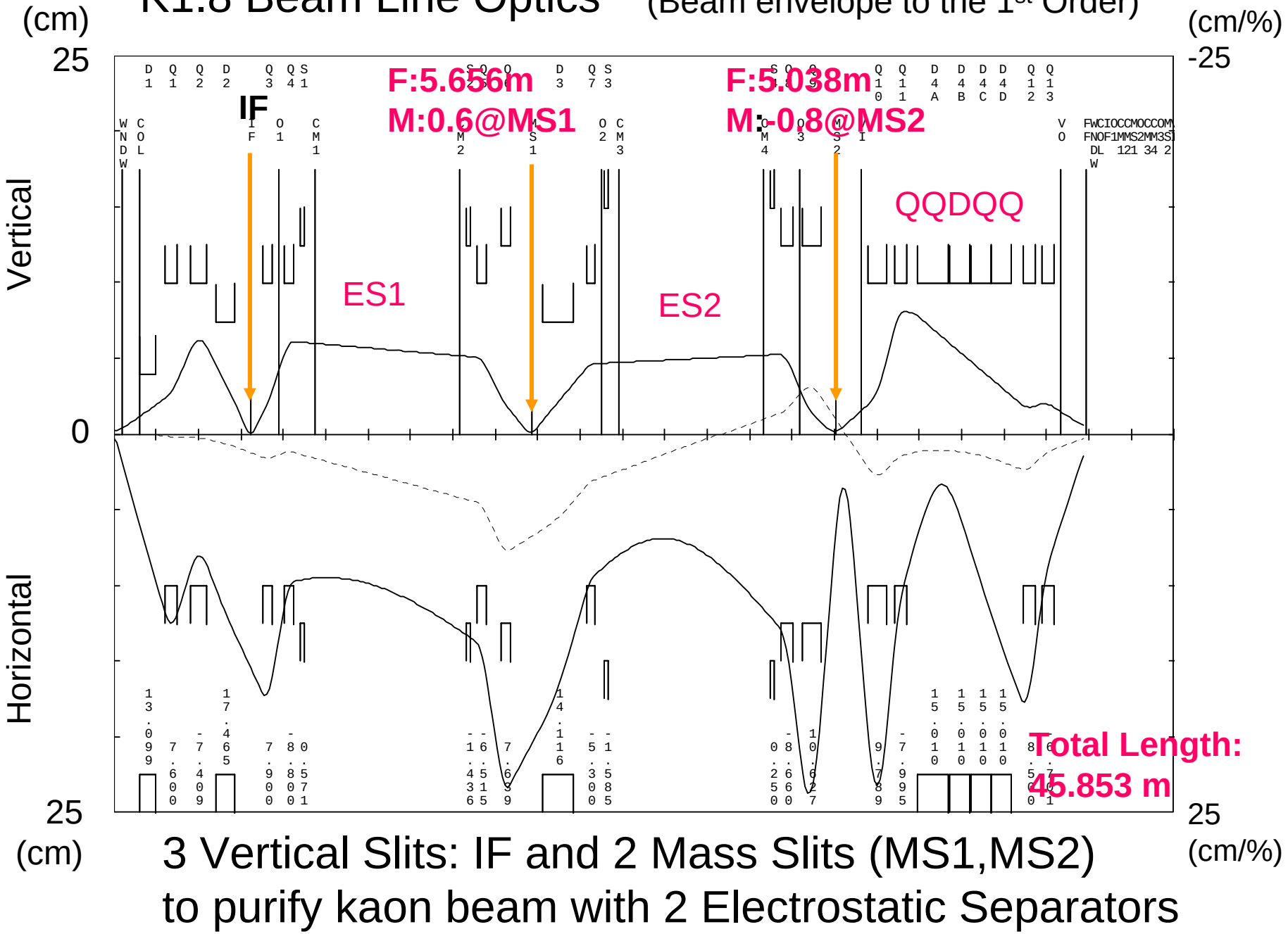
Layout and Concept

- ✓ Front End Section
  - 2ndary Beam Extraction at 6 deg.
  - Thermal protections/ Rad-Hard Equipments
    - Cu collimator before D1
    - Magnet Operation in a Vacuum Chamber
- ✓ 1st and 2nd Separation Sections
  - Double Stage Separation:
  - 3 vertical Slits for Kaon purification
  - Higher order corrections to the 3rd order
    - 4 6-poles & 3 8-poles for vertical focus at MS1 & MS2
- ✓ Beam Analyzing Section
  - Point-to-point Optics btwn entrance & exit of a QQDQQ
    - eliminate the multiple scattering effect to the 1st order
  - Focus on FF: R12~R34~R16~0

Configuration layout of K1.8 (Max. 2 GeV/c)



K1.8 Beam Line Optics (Beam envelope to the 1st Order)



3 Vertical Slits: IF and 2 Mass Slits (MS1,MS2)
to purify kaon beam with 2 Electrostatic Separators

Beam Analyzer

For Ξ hypernuclear Spectroscopy by (K^-,K^+) [E05]

ΔE~3 MeV (FWHM) together w/ SKS+

VO → VI (Point to Point Optics)

1st Order Resolution :

R11=-0.44, R12=0, R16=1.57 cm/%

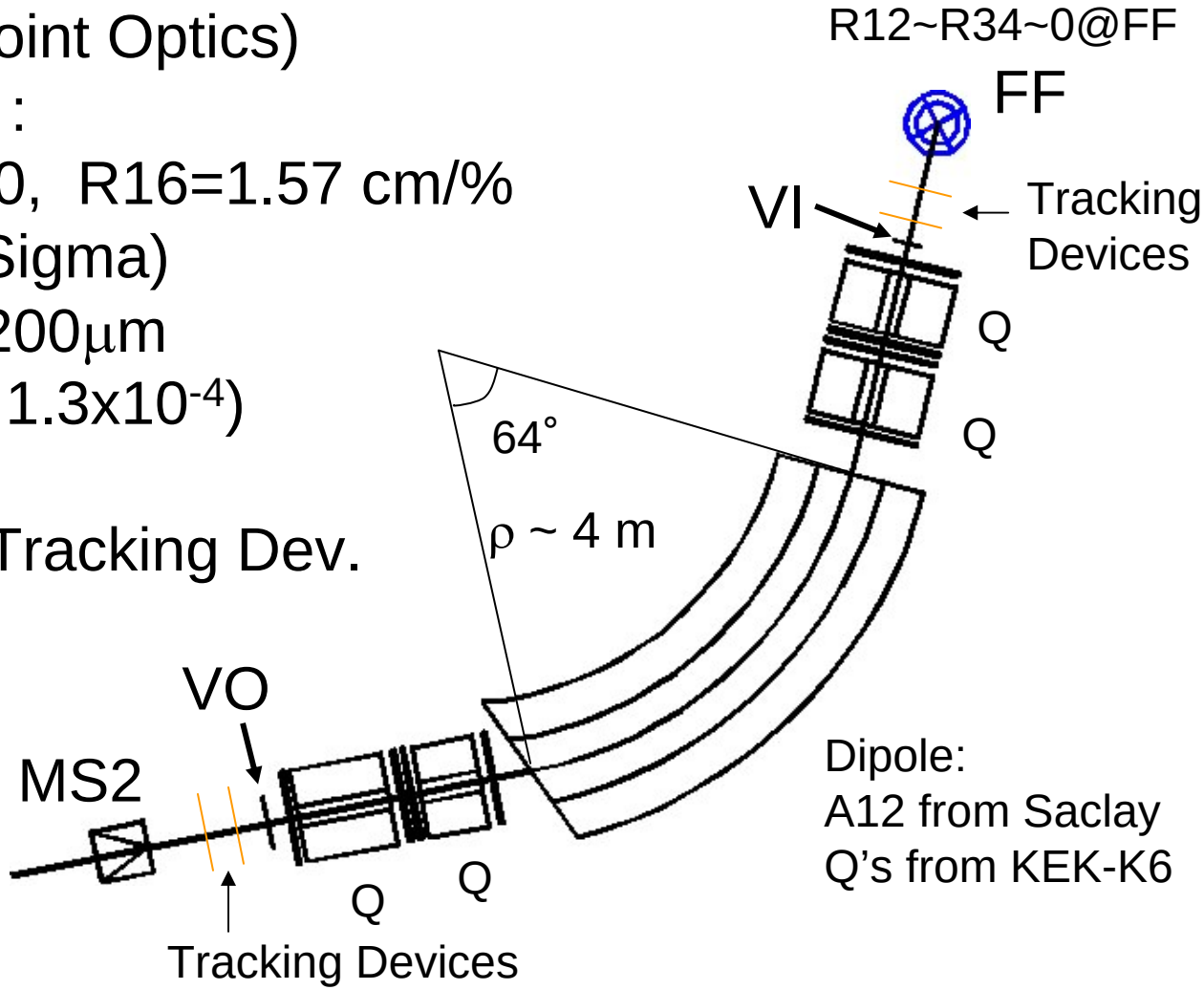
dp/p~1.4×10^{-4} (in Sigma)

assuming σ_x~200μm

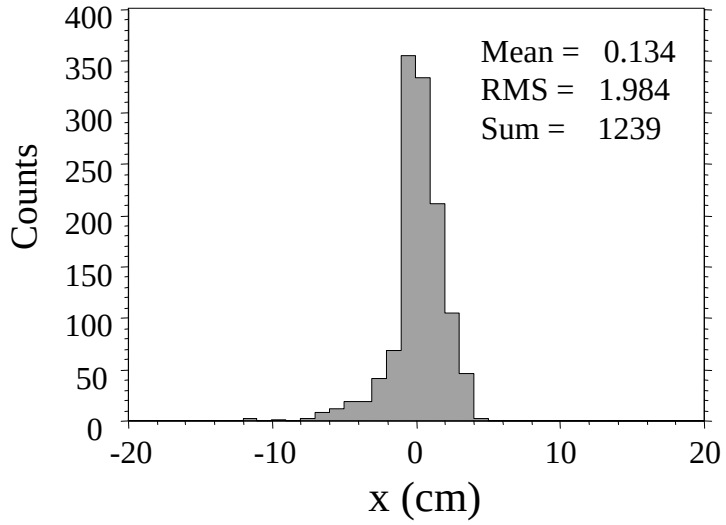
(c.f. in case of K6: 1.3×10^{-4})

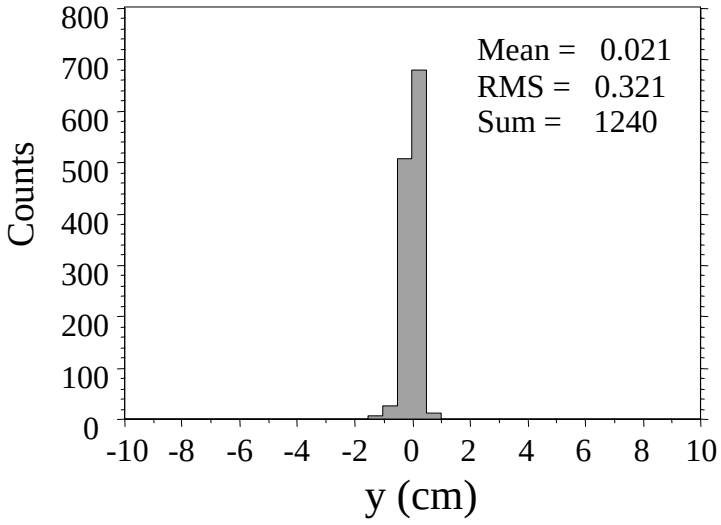
→h.o. correction:

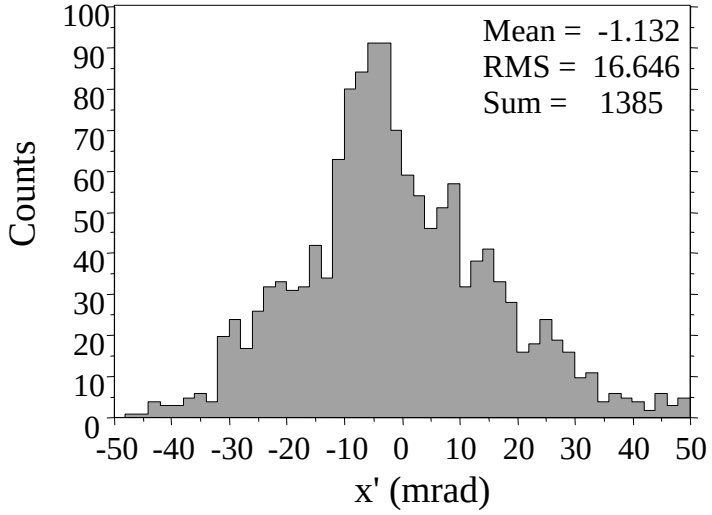
orbit analysis w/ Tracking Dev.

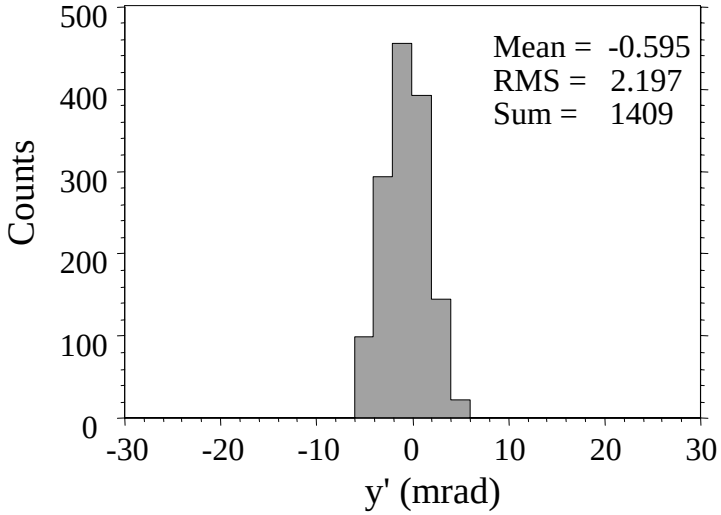


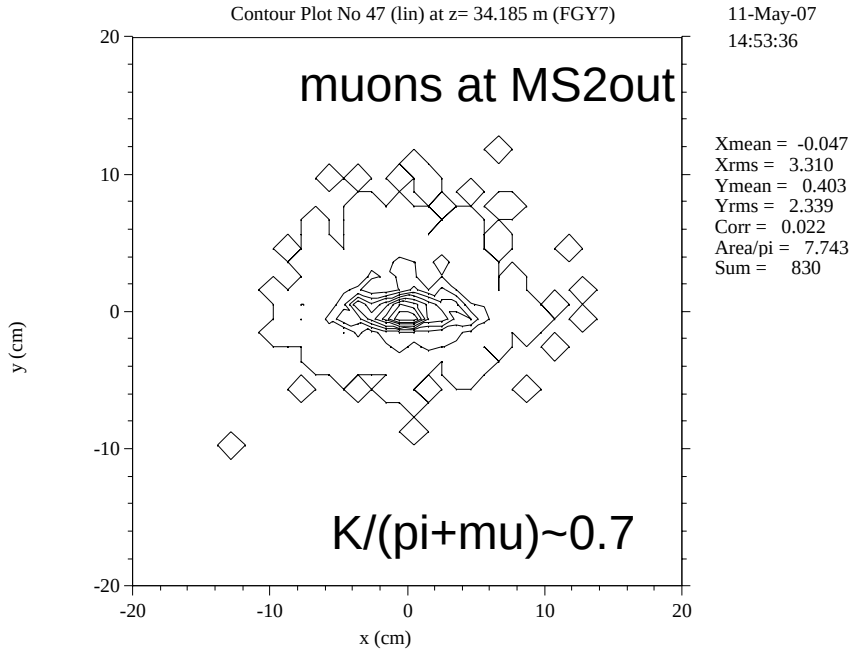
Kaon Beam Profile at FF of K1.8

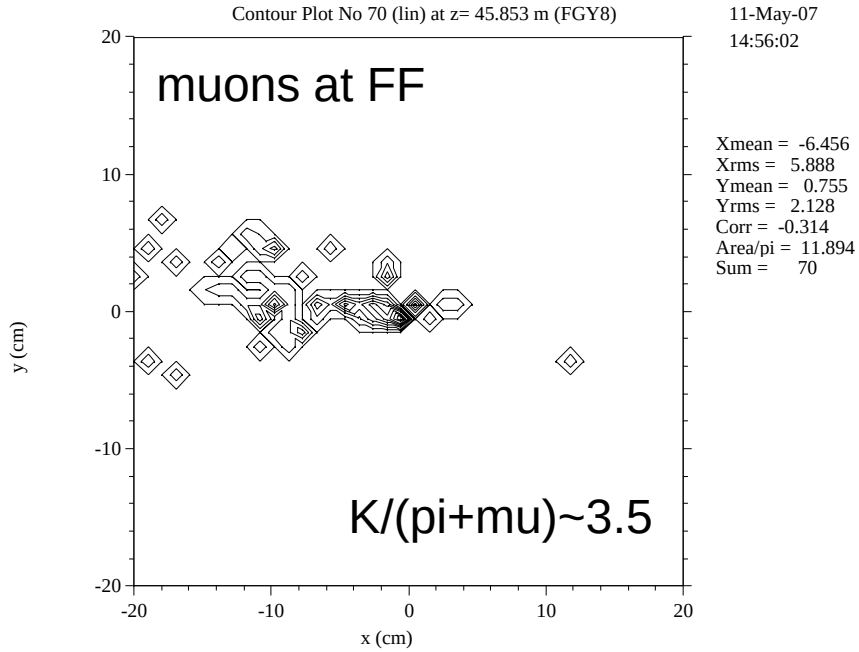


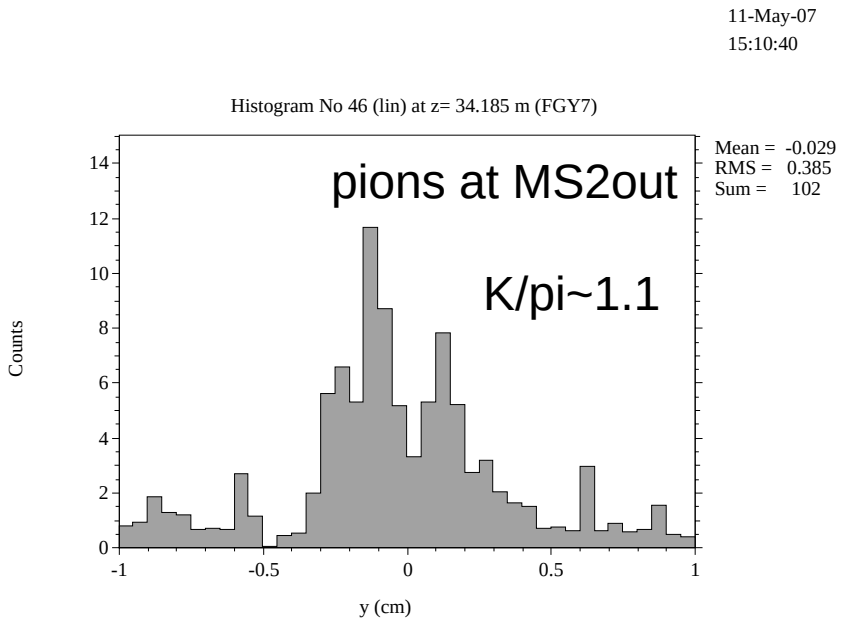


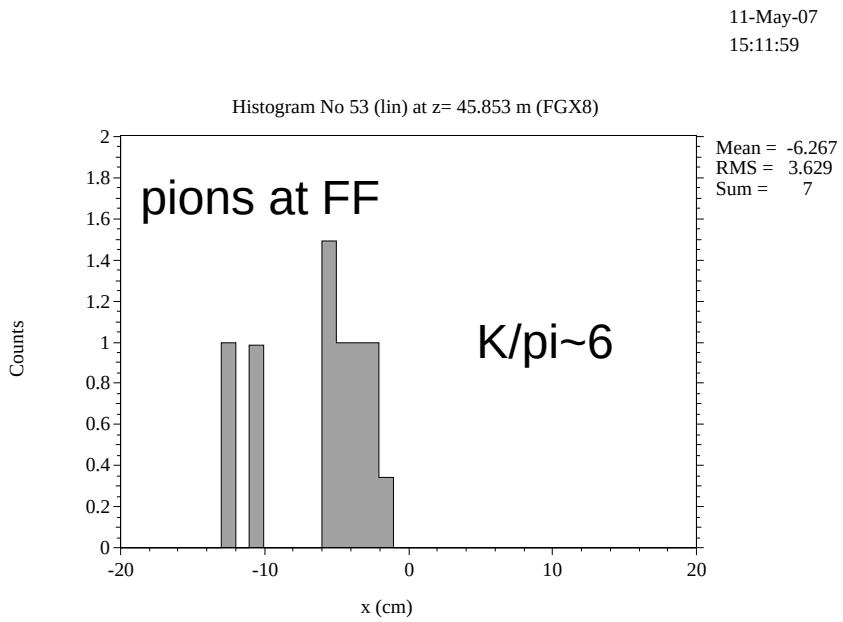





Contour Plot No 47 (lin) at z= 34.185 m (FGY7)
11-May-07
14:53:36
muons at MS2out
Xmean = -0.047
Xrms = 3.310
Ymean = 0.403
Yrms = 2.339
Corr = 0.022
Area/pi = 7.743
Sum = 830
K/(pi+mu)~0.7
y (cm)
x (cm)


Contour Plot No 70 (lin) at z= 45.853 m (FGY8)
11-May-07
14:56:02
muons at FF
Xmean = -6.456
Xrms = 5.888
Ymean = 0.755
Yrms = 2.128
Corr = -0.314
Area/pi = 11.894
Sum = 70
K/(pi+mu)~3.5
y (cm)
x (cm)


11-May-07
15:10:40
Histogram No 46 (lin) at z= 34.185 m (FGY7)
pions at MS2out
Mean = -0.029
RMS = 0.385
Sum = 102
K/pi~1.1
Counts
y (cm)


11-May-07
15:11:59
Histogram No 53 (lin) at z= 45.853 m (FGX8)
pions at FF
Mean = -6.267
RMS = 3.629
Sum = 7
K/pi~6
Counts
x (cm)

K1.8 Performance Summary

051011

	K1.8 (50 GeV-15μA)	(30 GeV-9μA)
Max. Mom. (GeV/c)	2	
Length (m)	45.853	
Acceptance (msr.%)	1.4	
$K^-(\pi)$ Intensity (ppp)#		
1.8 GeV/c	6.6E+06	1.4E+06
1.5 GeV/c	2.7E+06	0.54E+06
1.1 GeV/c	0.38E+06	0.08E+06
Electro-static Separator	750kV/10cm 6m×2	
Single Rate @ MS2 @ 1.8 GeV/c$	＞33E+06	＞8E+06
K^-/π^- @ FF @ 1.8 GeV/c	8	6.9
X/Y(rms) size @ FF (mm)	19.8/3.2	

using Sanford-Wang formula, assuming 1pulse=3.53s（0.7s flat top)

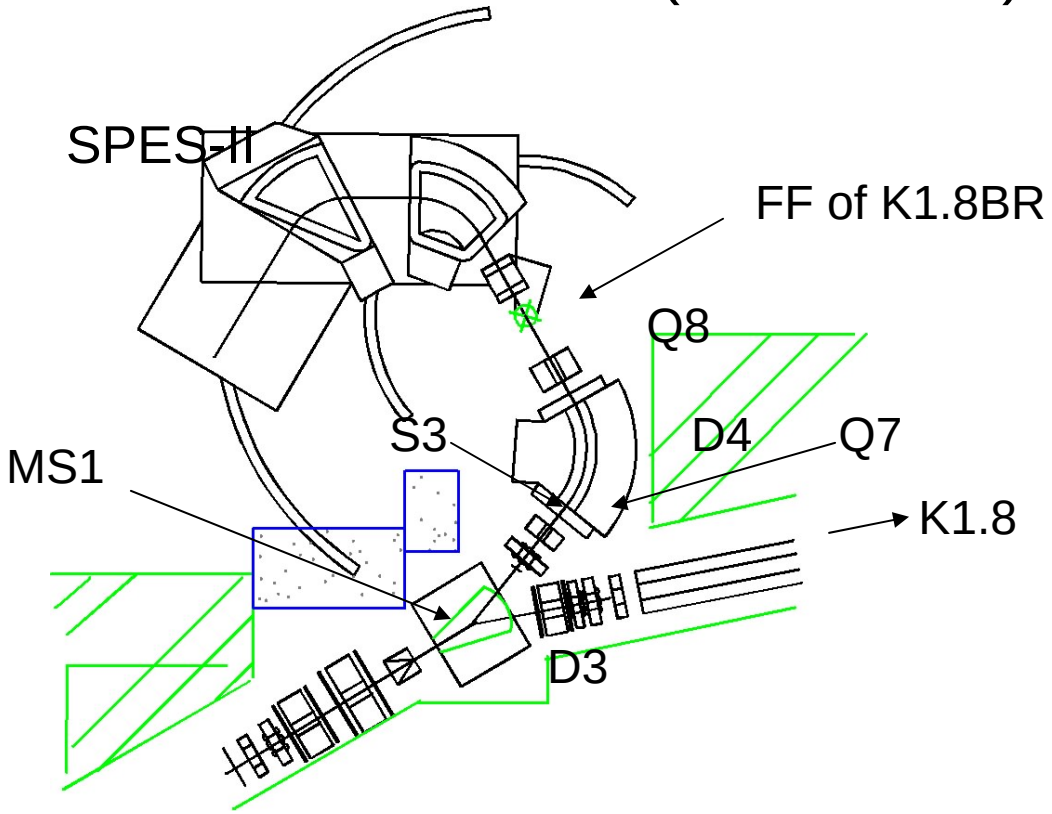
$ Signle Rate Estimation for Trigger/Tracking Devices to be placed just after MS2

K1.8BR option

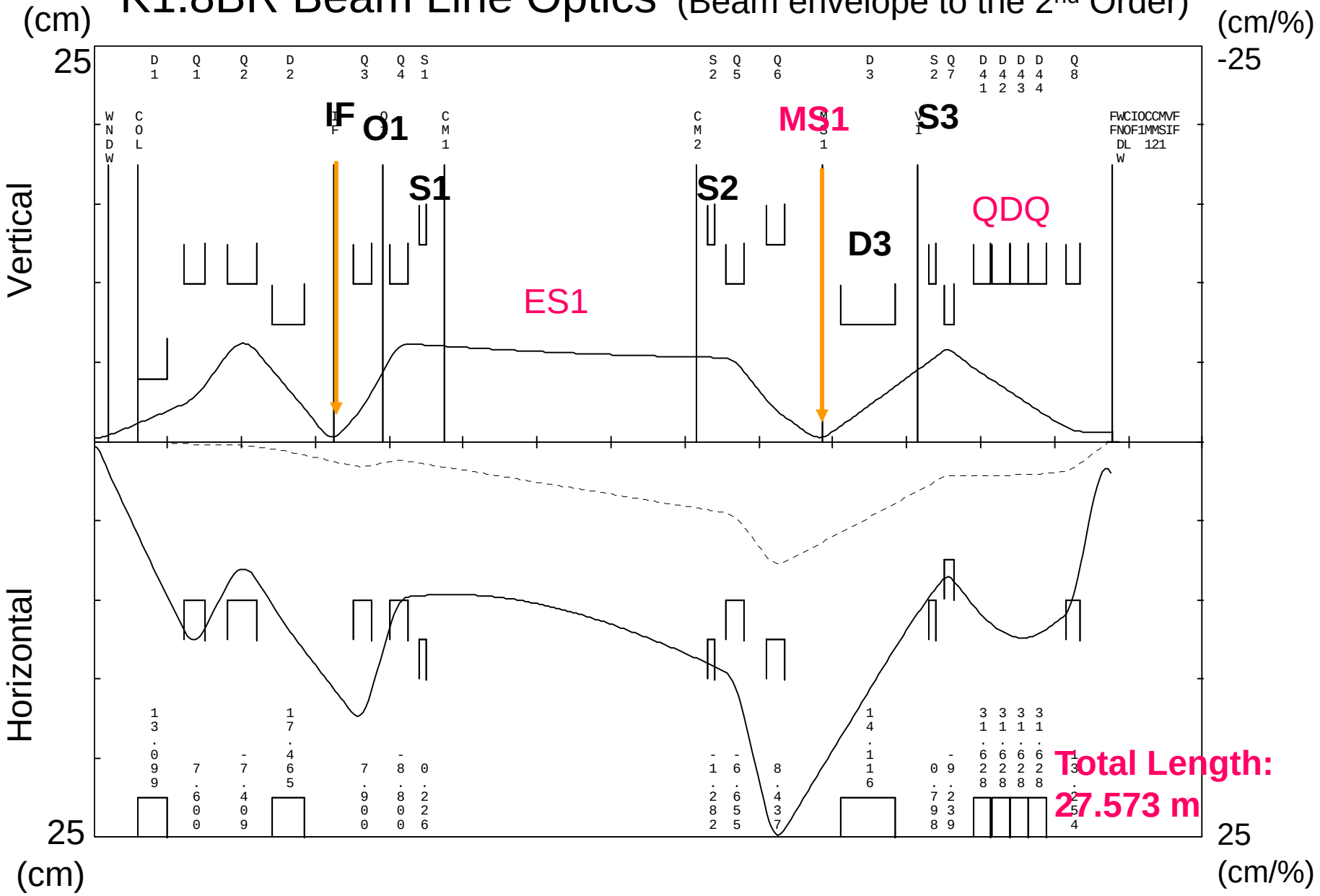
- Concept
- Optics
  Beam envelope/Profile@FF
- K1.8BR performance summary

K1.8BR Beam Line

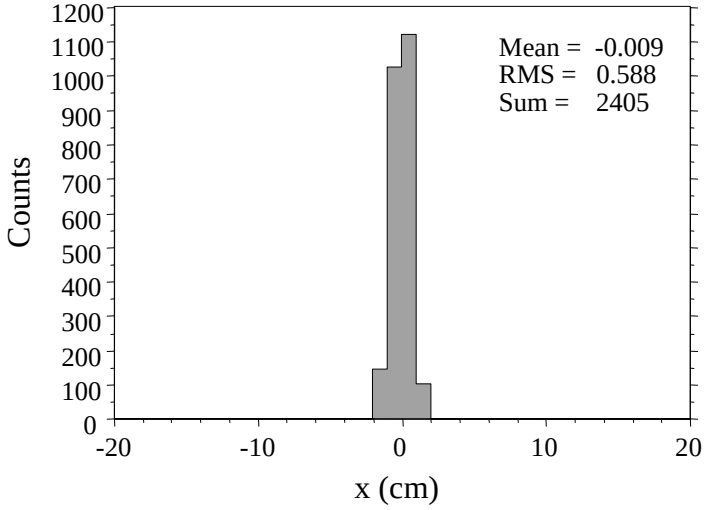
- Branch at D3 of K1.8
  Beam bent opposite side at D3, +SQDQ to focus at FF
  Time sharing with K1.8
  helpful for efficient experimental execution/coordination
- Single ES Stage, Shorter BL (27.6m)
  Intensity of K- at 1.1 GeV/c:~15 times > K1.8
  Intense Low Momentum Kaon (<1.2 GeV/c)

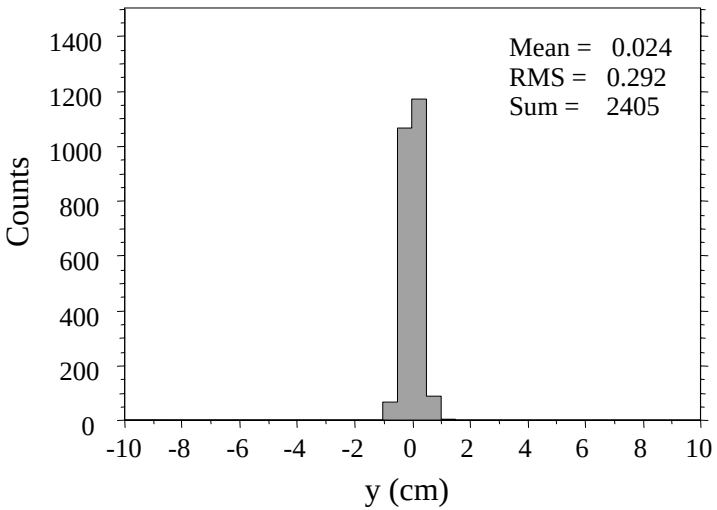


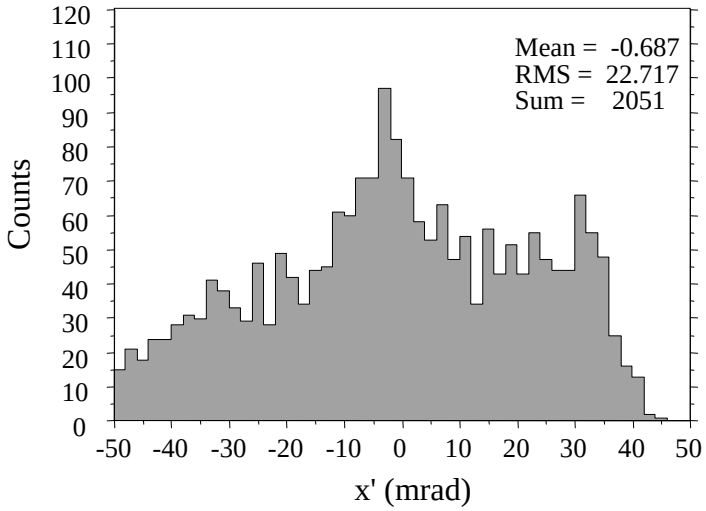
K1.8BR Beam Line Optics (Beam envelope to the 2nd Order)

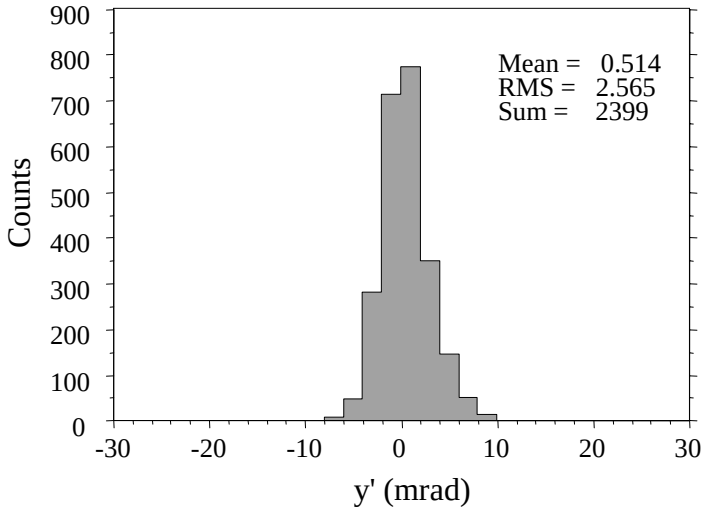


Beam Profile at FF of K1.8BR （S3 on)









K1.8BR Performance Summary

2005.10.11

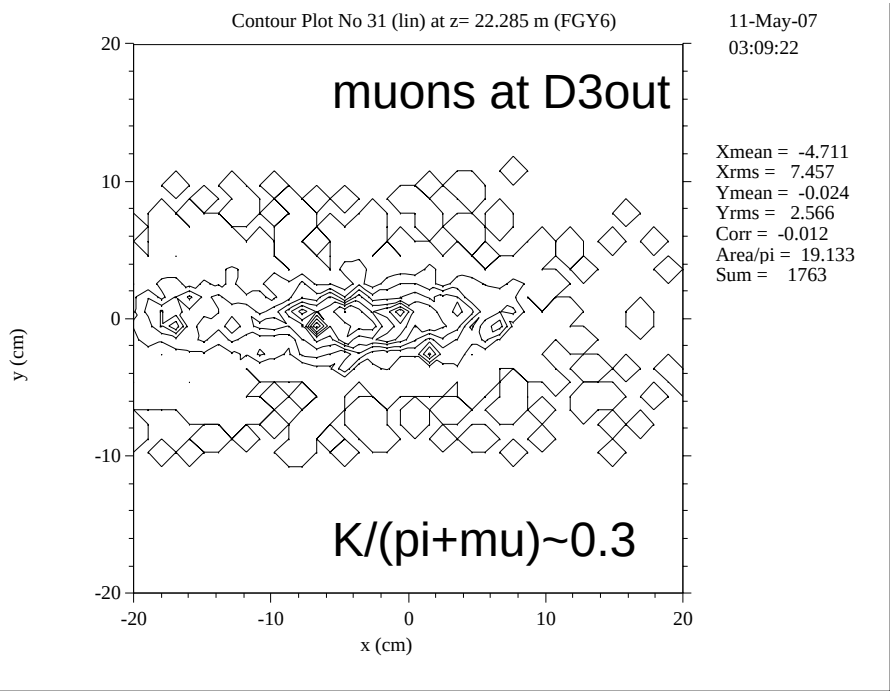
	K1.8BR (50 GeV-15μA)	(30 GeV-9μA)
Length (m)	27.573	
Acceptance (msr.%)	2.5¥	
K^- Intensity (ppp)#		
1.1 GeV/c	5.5E+06	1.2E+06
0.8 GeV/c	1.0E+06	0.2E+06
0.6 GeV/c	0.1E+06	0.02E+06
Electro-static Separator	500kV/10cm 6m	
Single Rate@D3out @1.1 GeV/c$	＞30E+06	＞7E+06
K^-/π^- @ FF@1.1 GeV/c&	7.5	6.8
X/Y(FWHM) size @ FF (mm)	5.9/2.9	

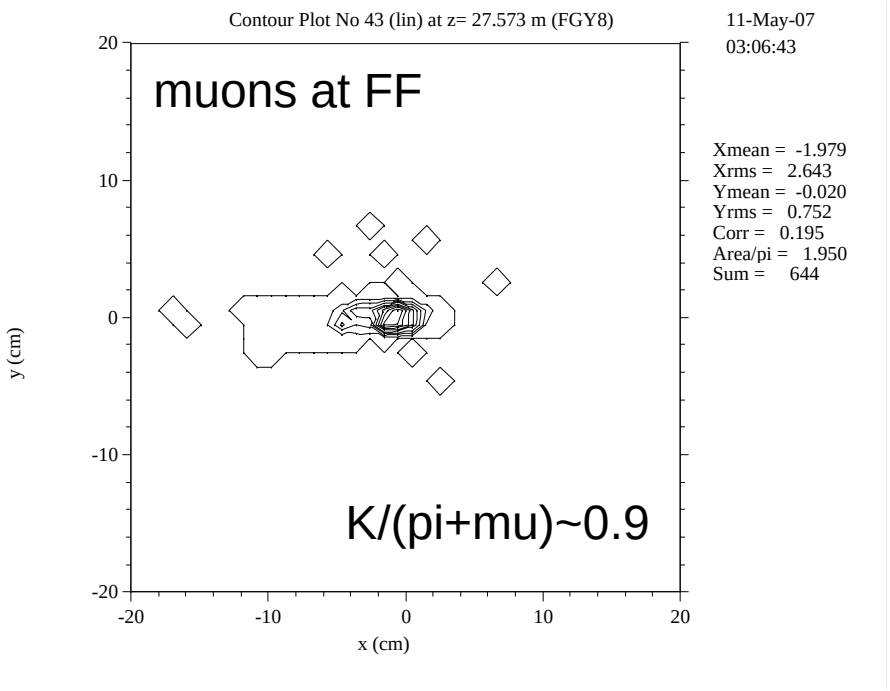
¥ IF/MS1 Heavy Alloy: IF opening 4 mm, MS1 opening 4.66 mm

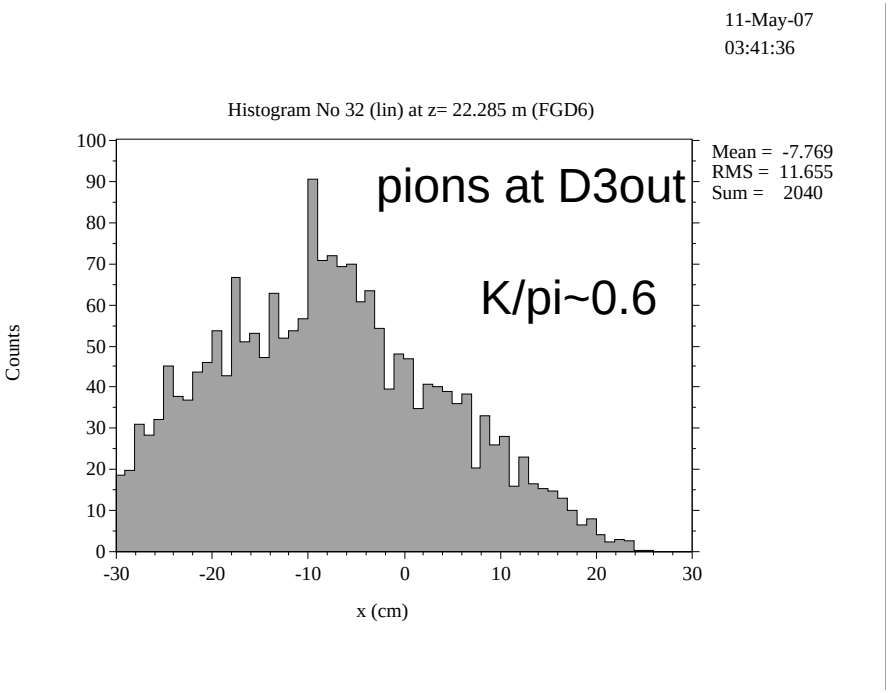
using Sanford-Wang formula, assuming 1pulse=3.53s（0.7s flat top)

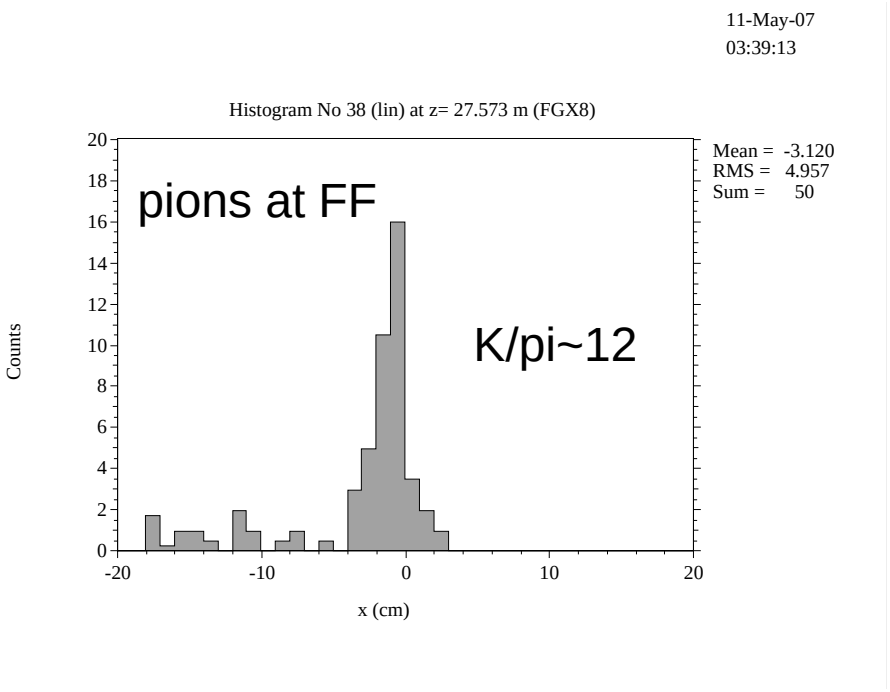
$ Signle Rate Estimation for Trigger/Tracking Devices to be placed just after D3

& cloud π not included


Contour Plot No 31 (lin) at z= 22.285 m (FGY6)
11-May-07
03:09:22
muons at D3out
Xmean = -4.711
Xrms = 7.457
Ymean = -0.024
Yrms = 2.566
Corr = -0.012
Area/pi = 19.133
Sum = 1763
K/(pi+mu)~0.3
y (cm)
x (cm)


Contour Plot No 43 (lin) at z= 27.573 m (FGY8)
11-May-07
03:06:43
muons at FF
Xmean = -1.979
Xrms = 2.643
Ymean = -0.020
Yrms = 0.752
Corr = 0.195
Area/pi = 1.950
Sum = 644
K/(pi+mu)~0.9
y (cm)
x (cm)


11-May-07
03:41:36
Histogram No 32 (lin) at z= 22.285 m (FGD6)
pions at D3out
Mean = -7.769
RMS = 11.655
Sum = 2040
K/pi~0.6
Counts
x (cm)


11-May-07
03:39:13
Histogram No 38 (lin) at z= 27.573 m (FGX8)
pions at FF
Mean = -3.120
RMS = 4.957
Sum = 50
K/pi~12
Counts
x (cm)

FIFC in October, 2006

- FIFC report
- report to FIFC by J. Doornbos

FIFC report → http://j-parc.jp/NuclPart/pac_0701/FIFC_report_submitted.pdf

(1) Front end part

…does not find any essential problems

(2) ES and MS

…no significant concern about its performance. It is remarked that the experience at KEK-PS is very useful and important in the operation fo these separators.

(3) BA and Final Focusing system

…convinced with this performance of momentum resolution from the beam optical point of view. …essential for the chamber to work properly in high hit-rate…

(4) Optics design and K-pi separation

…agrees with the presented performance as a whole, although it wants to reserve some uncertainty in the estimate of the K/pi ratio.

(5) K1.8BR

…accepts the proposed performance… the K/pi which had better to be regarded with some ambiguity. …was concerned about the muon contamination in the beam, since it could influence on the exp condition…

… recommends ... to evaluate it seriously soon.

(6) Conclusion

…found no problem in the prospect that K1.8 and K1.8BR will be operational with sufficient performance for the experiments, in general. It is remarkable that the high K/pi presented …has been supported by an independent check by an external reviewer (J.D.). However, the ambiguity of the estimate has to be taken to be large.

Report to FIFC by J. Doornbos → attached in the FIFC report

Individual check by using ZGOUBI and REVMOC

K1.8 : 1.8 GeV/c, 750 kV/10cm double stage ES, σ ~1.3mm at T1
~45 m, 1.4 msr%, pion/kaon at FF~570 if ES1=ES2=0

(1) Direct pions
pion/kaon ~ 0.1 at FF, even no octupoles

(2) Cloud pions
no problem, MS1 & 2 reduce by a factor 5, IF further reduce by a factor 3

(3) Muons
muon/kaon ~ 0.1

(4) Slit scattering of pions (at IF)
pion/kaon ~ 0.2 at most

(5) In total, Kaon/(pi+mu) ~ 3 at FF

K1.8BR : 1.1 GeV/c, 500 kV/10cm single stage ES
~27 m, 2 msr%, pion/kaon at FF~1200 if ES1=ES2=0

(1) Direct pions will be negligible

(2) Cloud pions can be reduced by an order of magnitude by IF and MS1

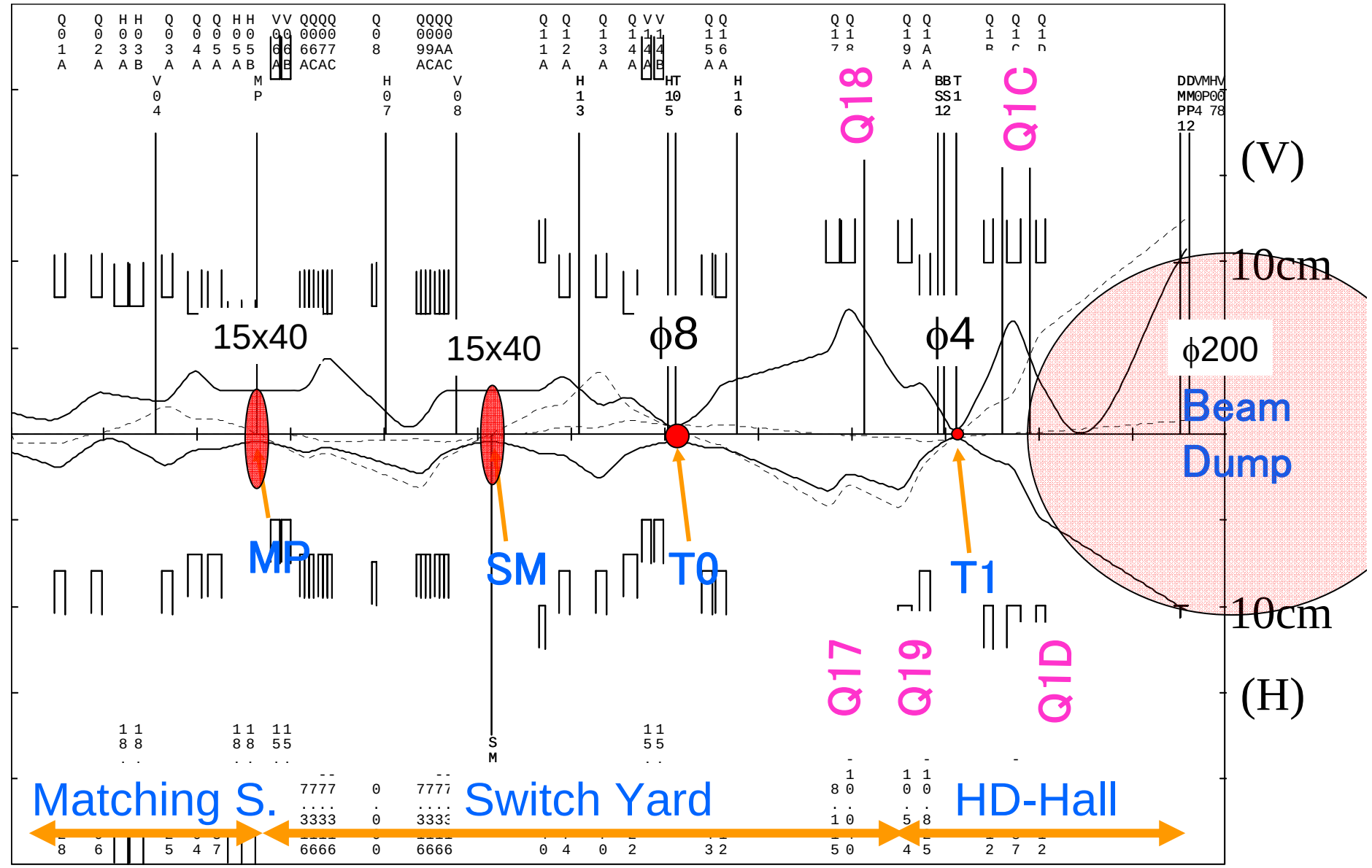
(3) Slit scattering at IF: pion/kaon ~ 0.3

(4) Muons: muon/kaon ~ 1.75 at FF

Homework

given on 22/Dec/2006

Beam Envelope（30 GeV SEB:ε_H=4.4π / ε_V=10.4π mm･mr）



Tracking Simulation for Slow Extraction Beam

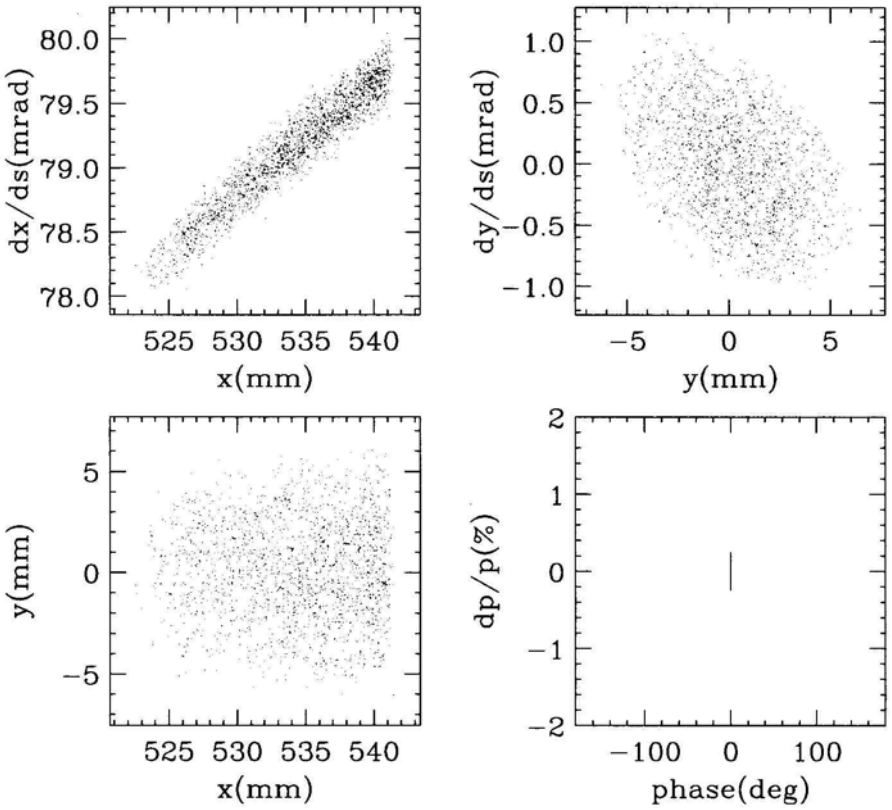
by M. Tomizawa

メイン取り出しビーム　50GeV　(エミッタンス6.1pi,　dp/p 0.25%)

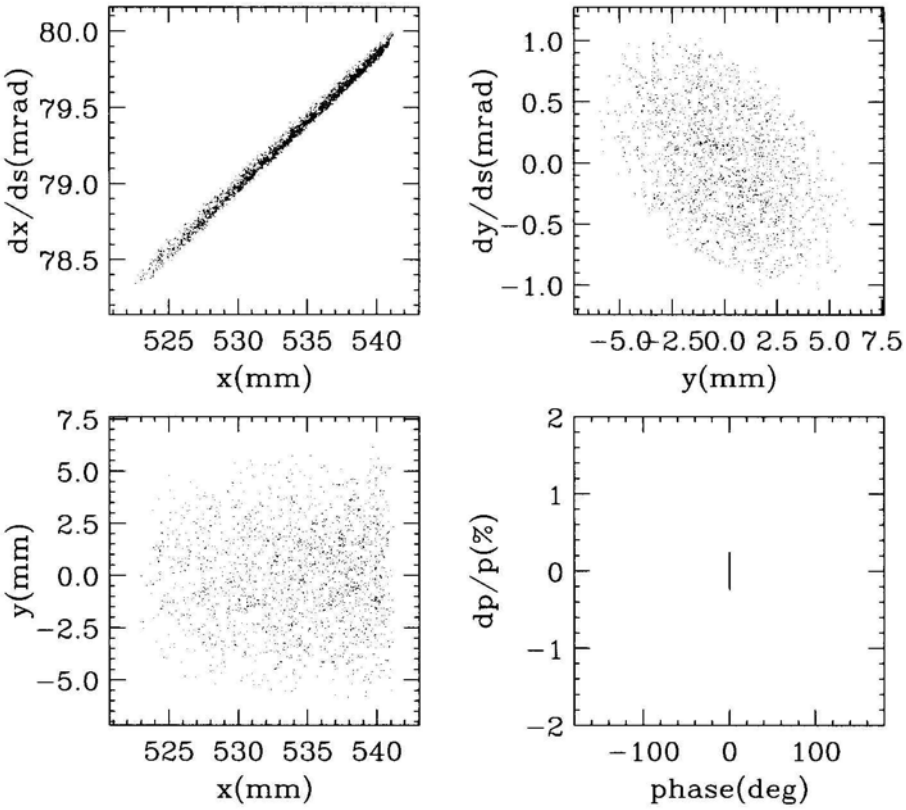
Q、D磁石共multipole 成分　ON　ステップサイズ約20mm@ESS

プロット:ビーム分布@QFP入口

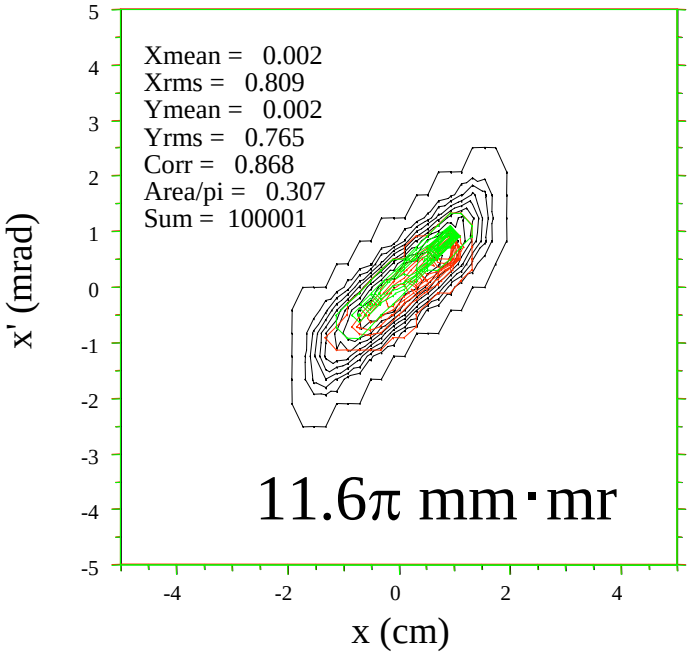
Fixed Bump

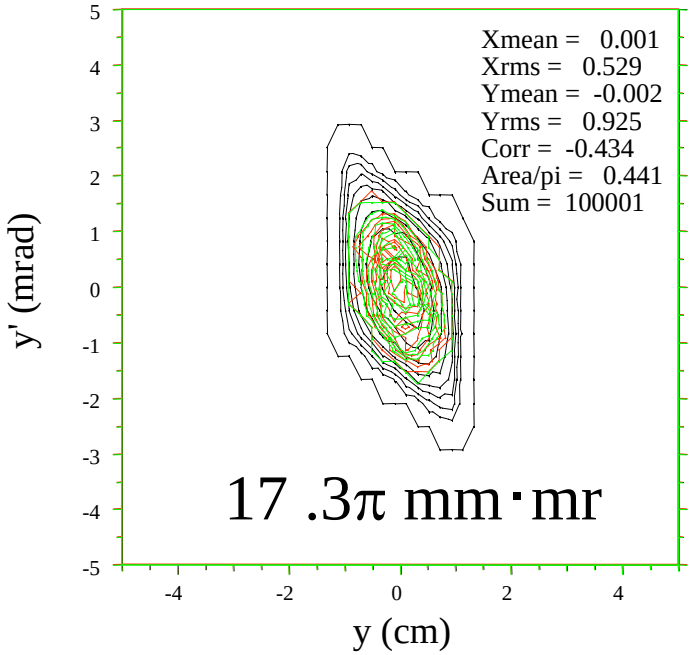


Dynamic Bump

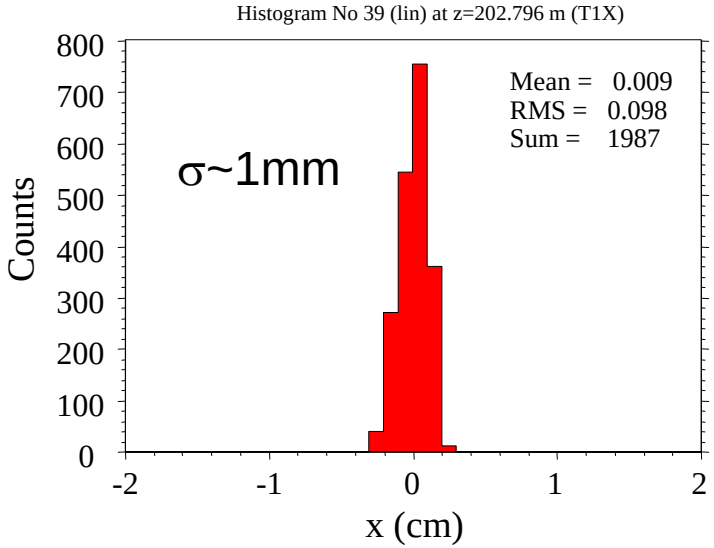


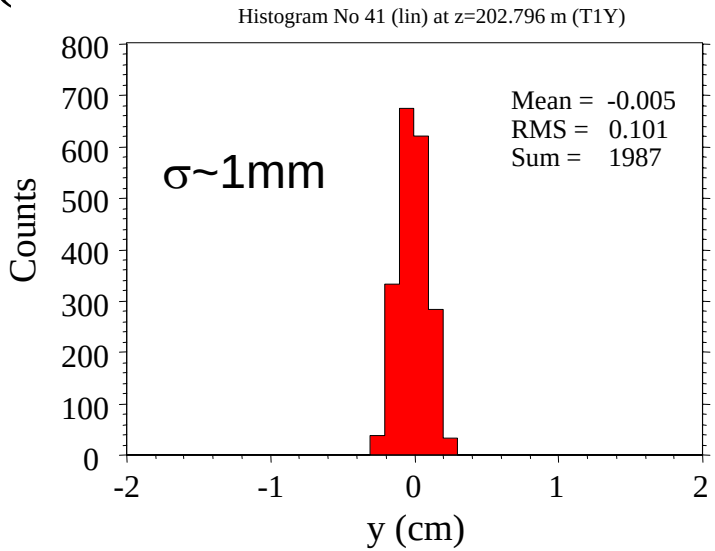
Beam Emittance (color) and Acceptance (black)



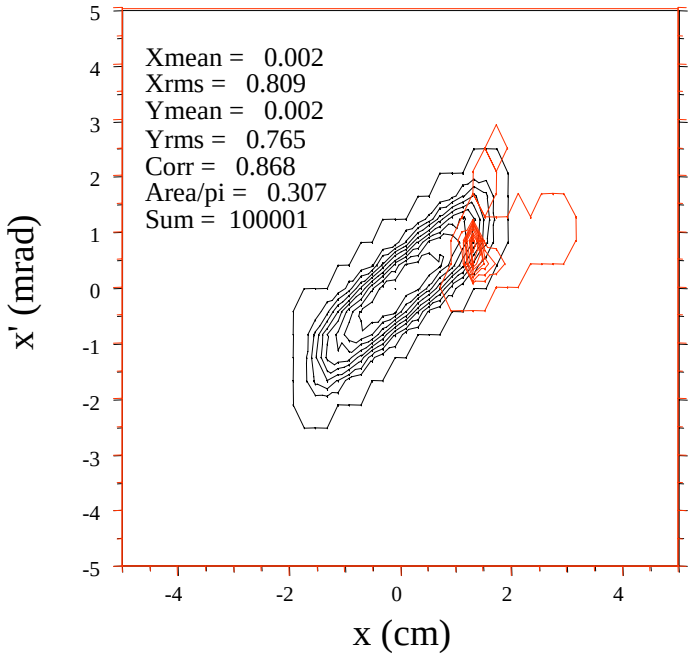


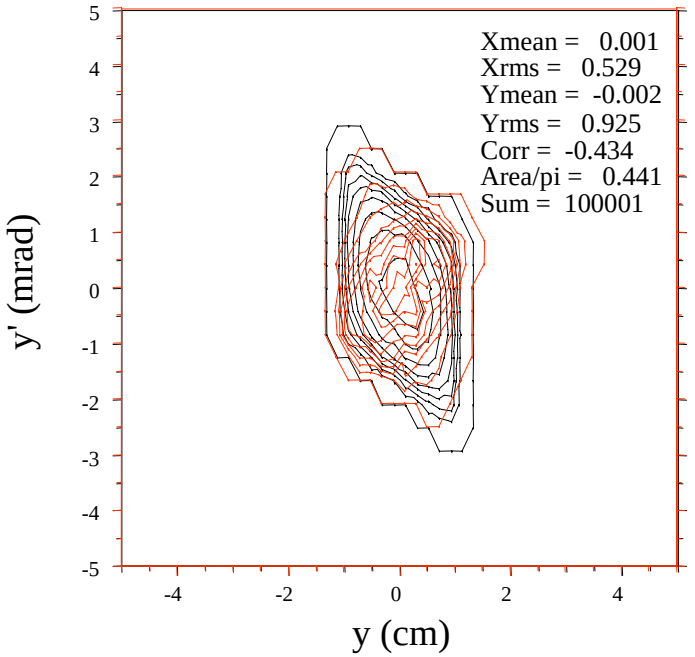
Beam Profile @ T1(30 GeV)



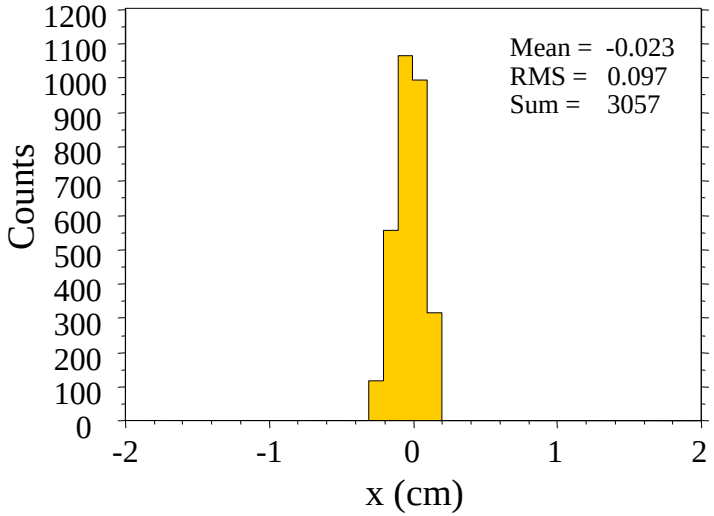


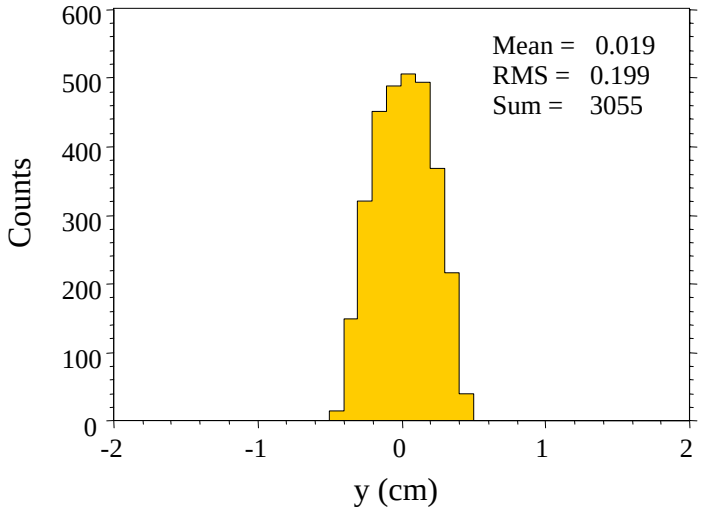
seb8f1tu.dat



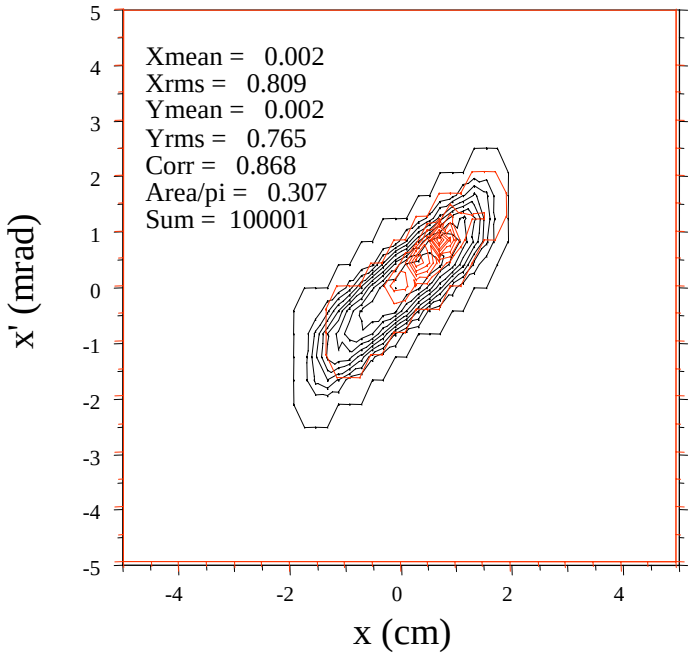


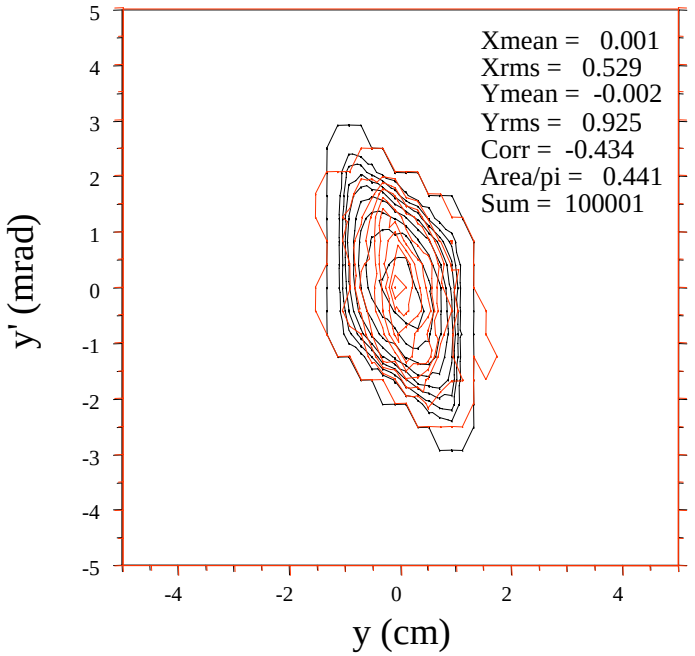
30 GeV scattered at ESS(1.39kW)　Loss:18W@q17,18/ 229W@q1D



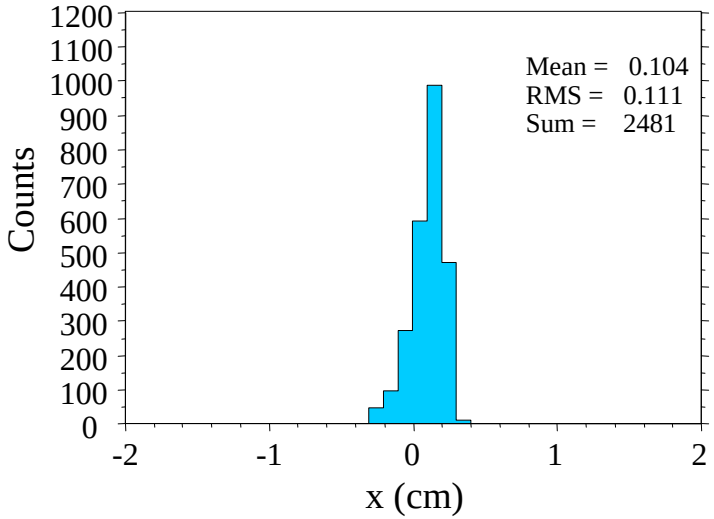


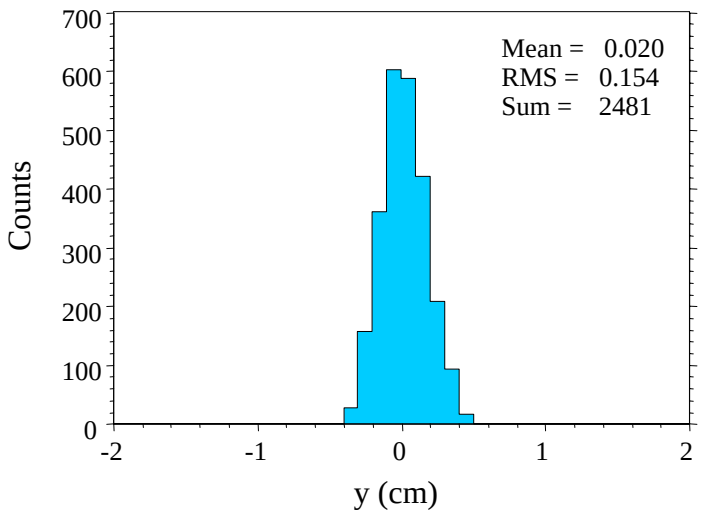
seb8f1tu.dat

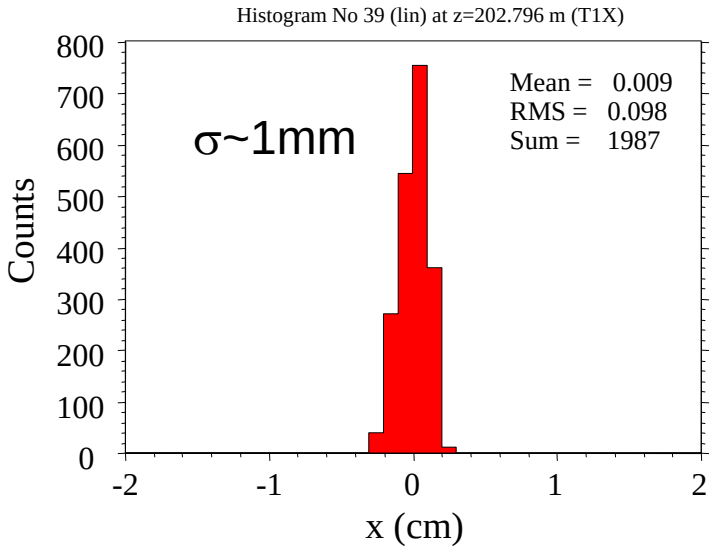


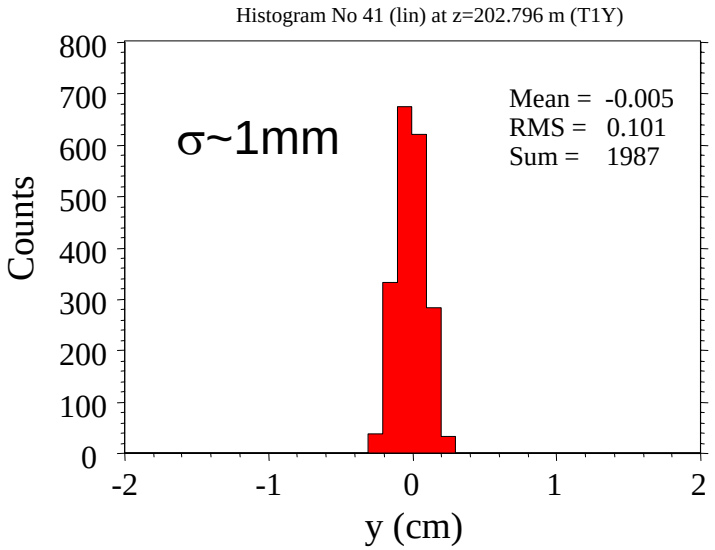


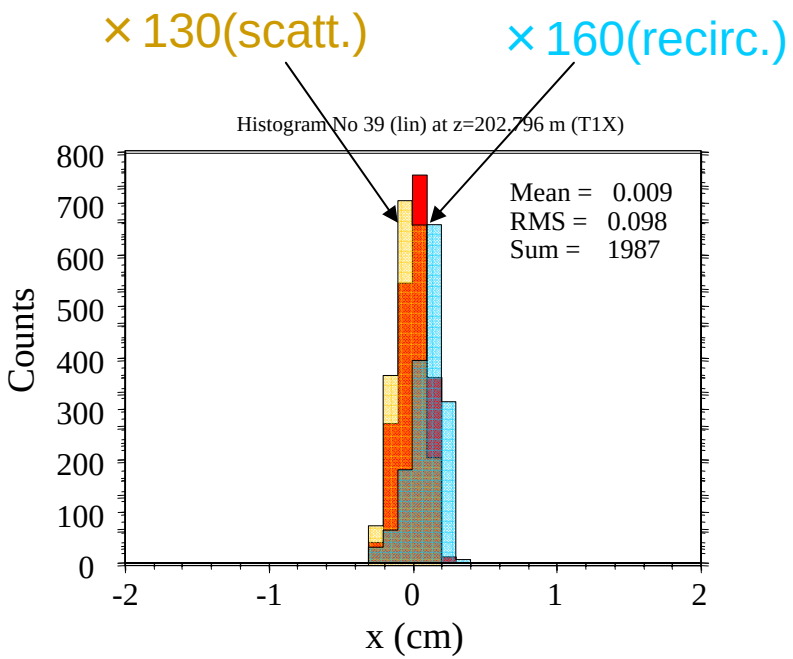
30 GeV scattered, recirculated (1.12kW) No Loss

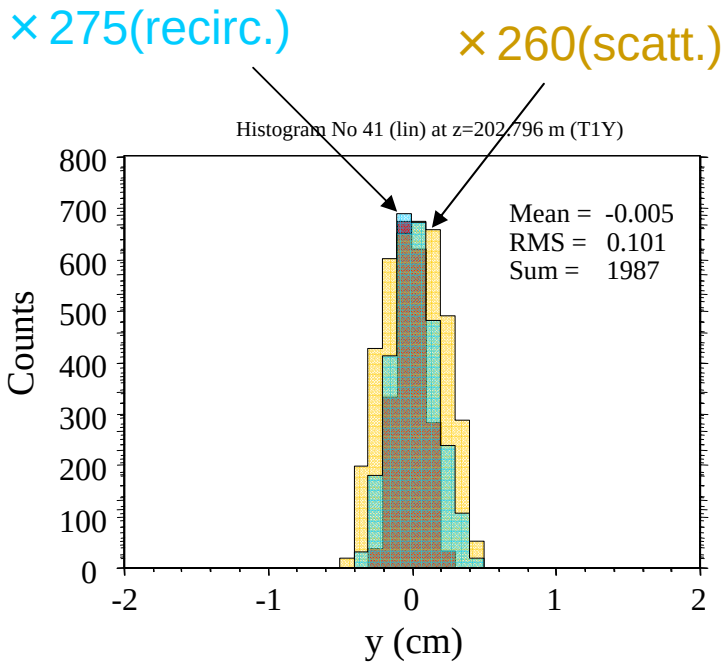





Histogram No 39 (lin) at z=202.796 m (T1X)
σ~1mm
Mean = 0.009
RMS = 0.098
Sum = 1987
Counts
x (cm)


Histogram No 41 (lin) at z=202.796 m (T1Y)
σ~1mm
Mean = -0.005
RMS = 0.101
Sum = 1987
Counts
y (cm)


×130(scatt.)
×160(recirc.)
Histogram No 39 (lin) at z=202.796 m (T1X)
Mean = 0.009
RMS = 0.098
Sum = 1987
Counts
x (cm)


×275(recirc.)
×260(scatt.)
Histogram No 41 (lin) at z=202.796 m (T1Y)
Mean = -0.005
RMS = 0.101
Sum = 1987
Counts
y (cm)

- Slow Extraction Beam :
  - 30 GeV, 9μA (270 kW) in Phase 1
  - Tracking Simulation for Extraction Beam by M. Tomizawa

    Extracted Beam Power normalized to be 270 kW

    Scatterred by ESS

    Kicked & Extracted……1.39kW (0.5%)

    Horizontally shifted

    Vertically broadened

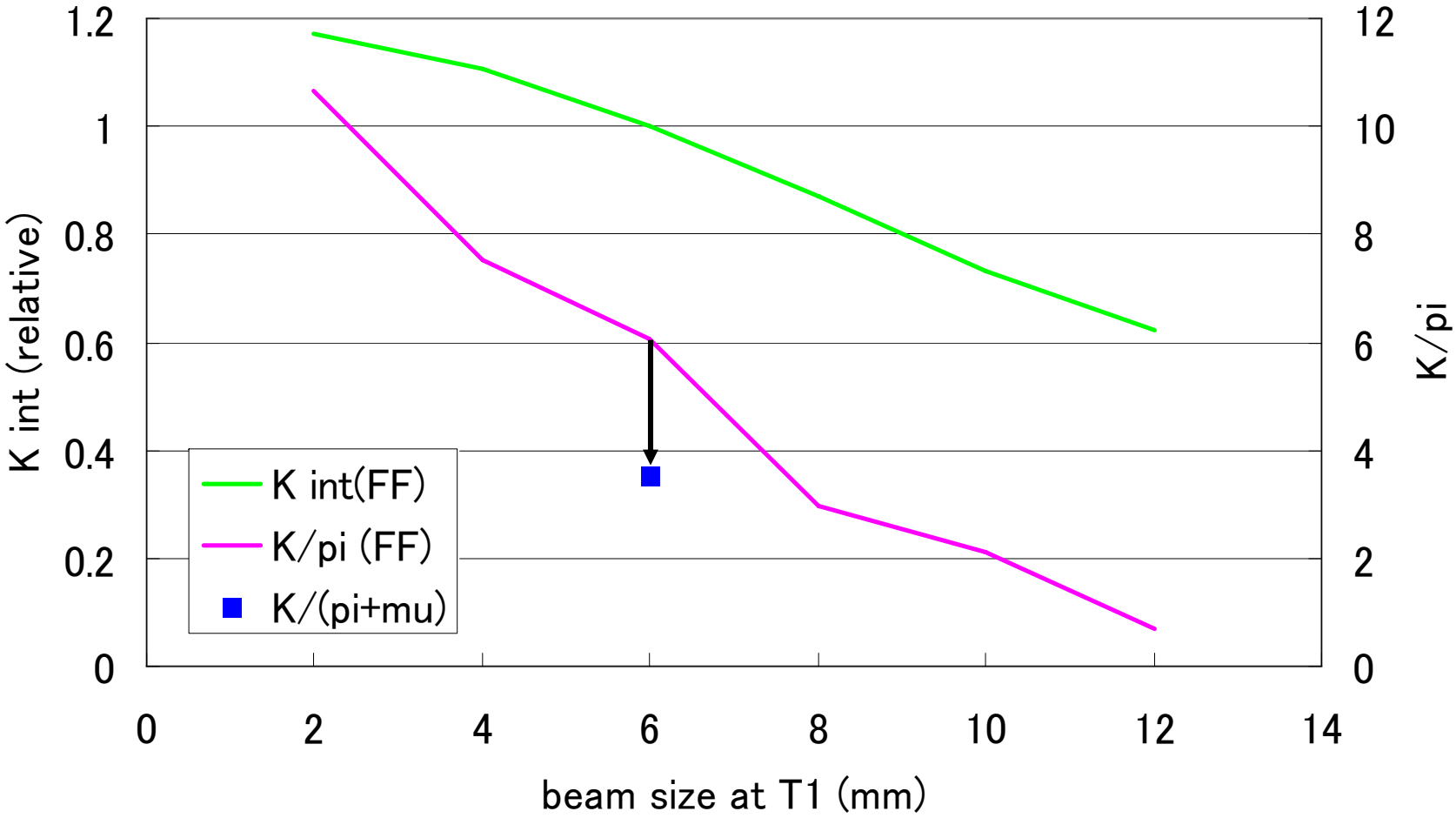
    Recirculated & Extracted……..1.29 kW (0.5%)

    Vertically broadened

- Beam Loss along the Beam Line
  - ✓ Kicked & Extracted……..18W Loss at q17,18 (<200W)
  - ✓ Recirc. & Extracted……..no loss till T1

- Beam Profile at T1
  - ✓ Kicked & Extracted……..Vertically broad tail (small fraction)
  - ✓ Recirc. & Extracted……..Vertically broad tail (small fraction)

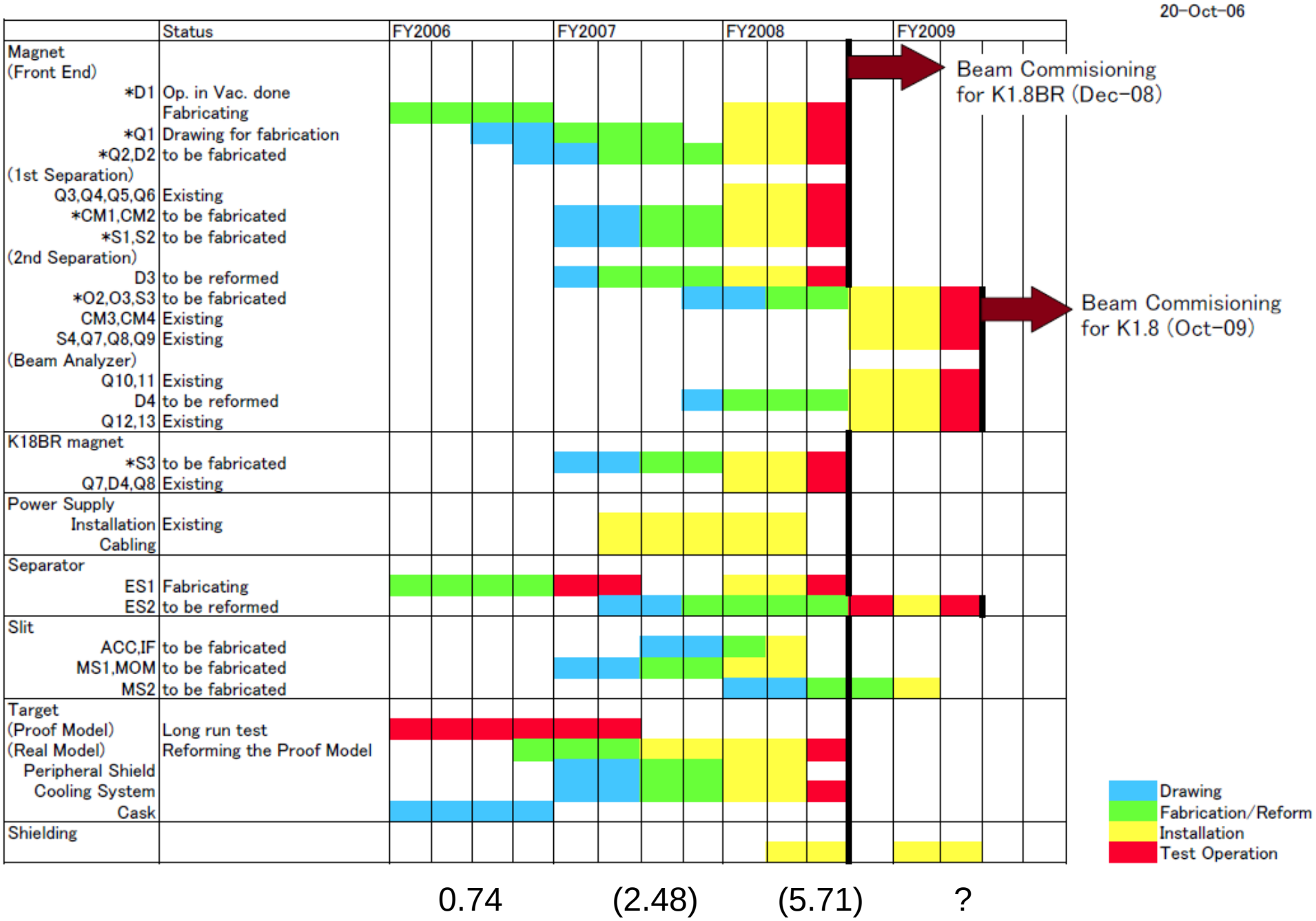
Kaon intensity and K/pi as a function of the beam spot size at T1



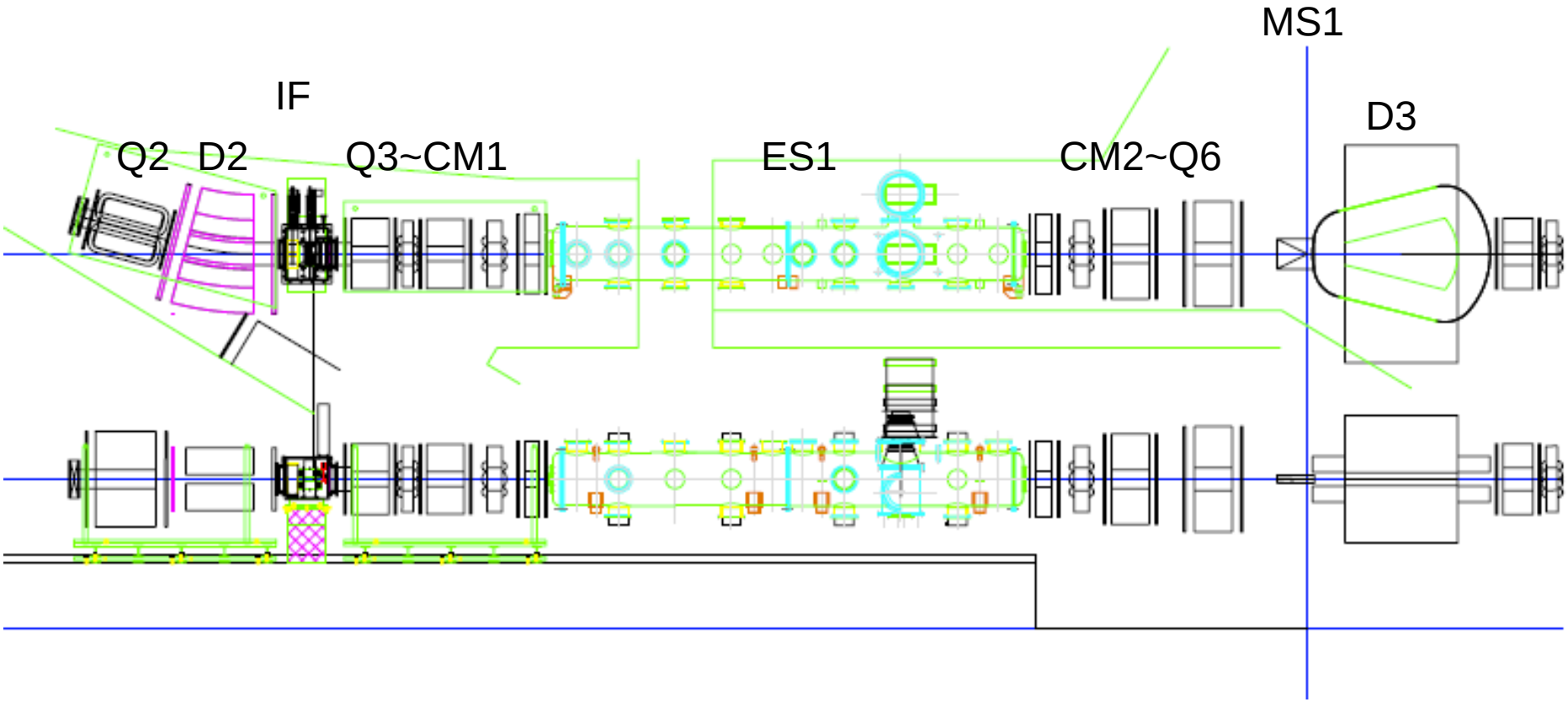
Beam Line Element
- status -

- Schedule
- IF Slit
- Magnet Layout
  Q3~CM1
- Mass Slit

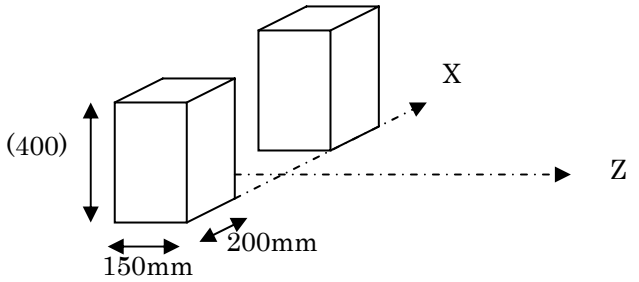
Construction Schedule of K1.8 and K1.8BR



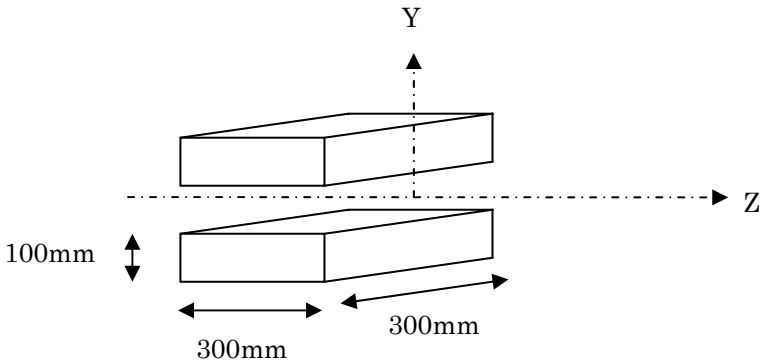
K1.8 upstream configuration



IF slit (brass)

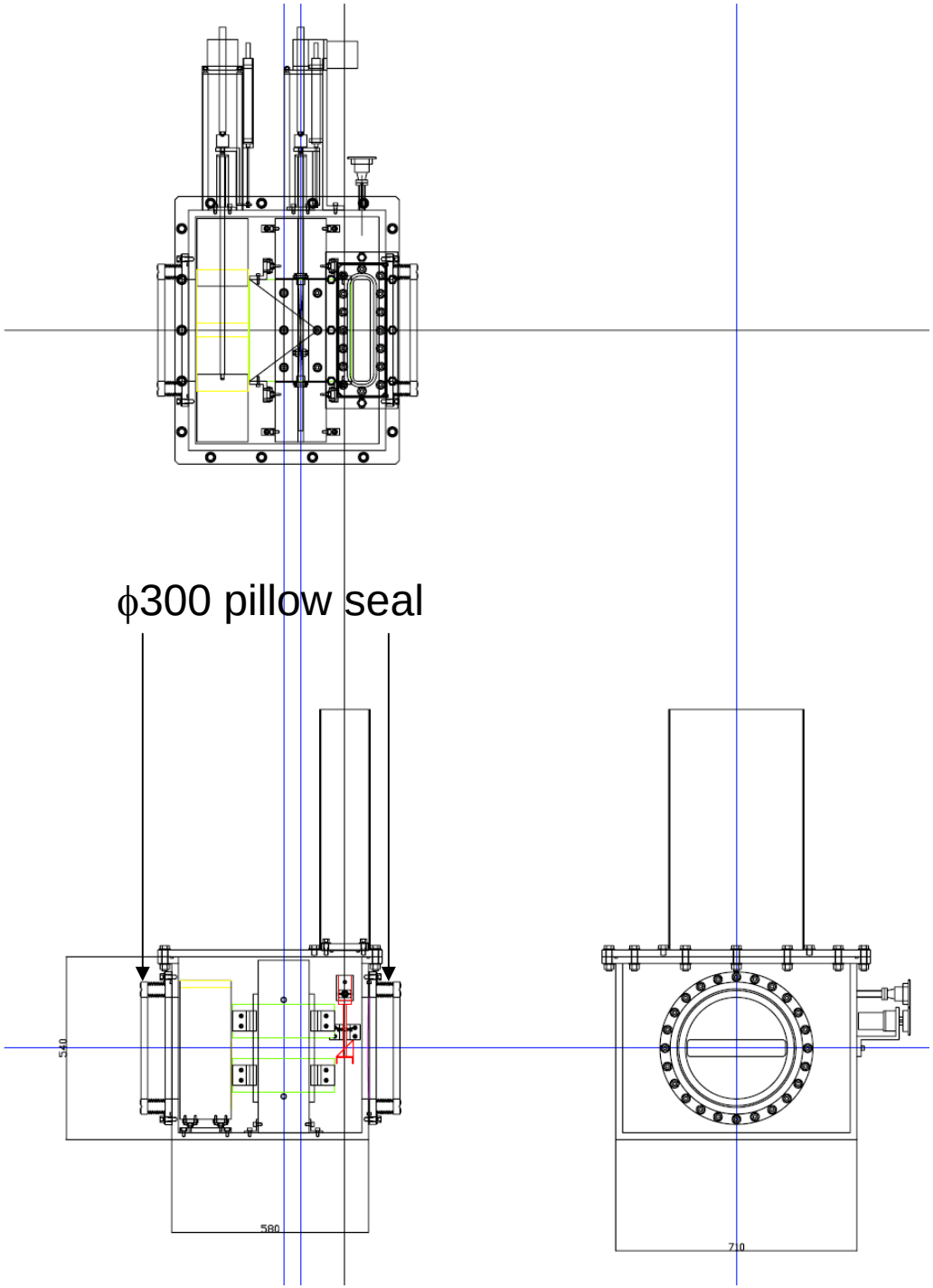


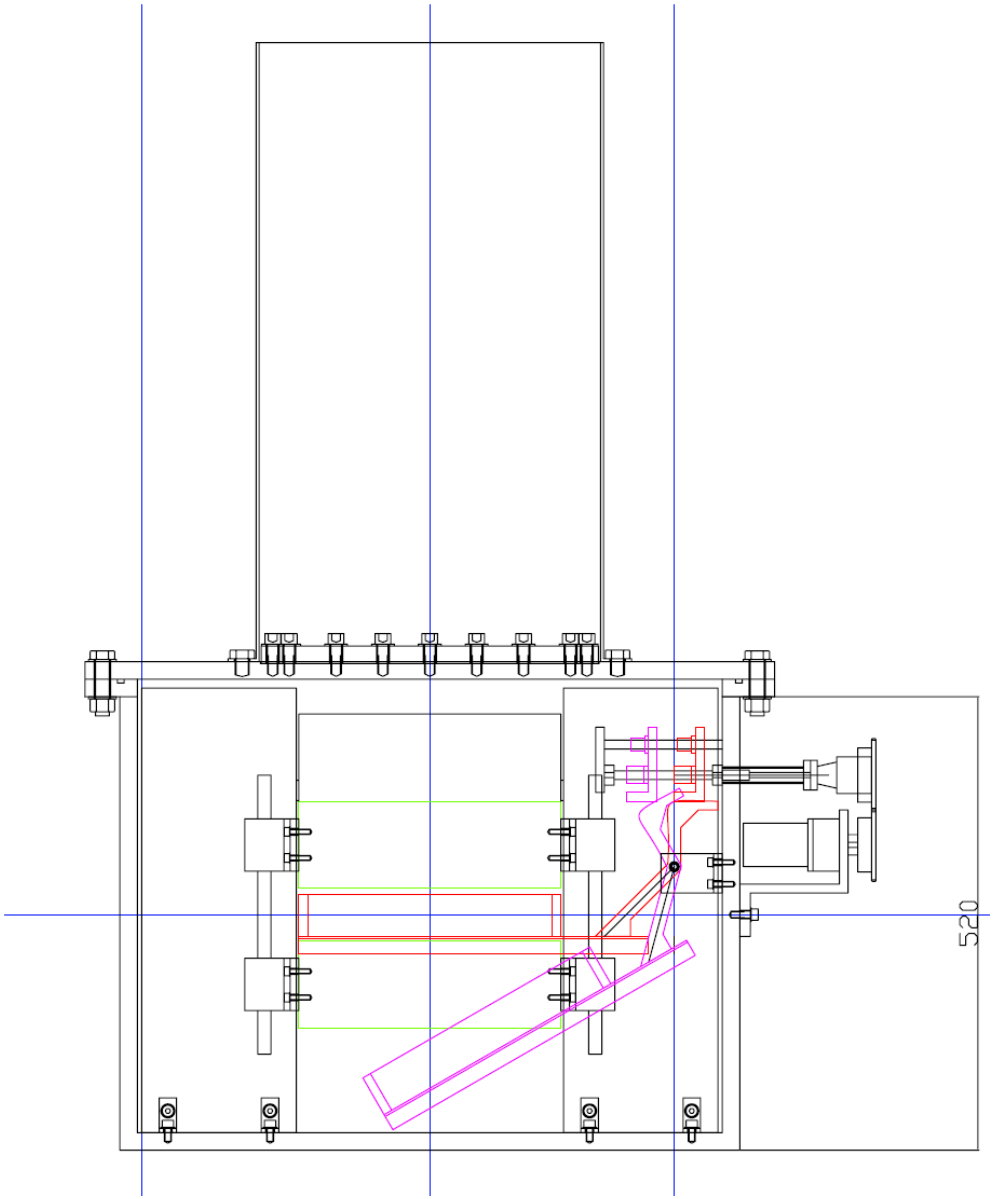
水平方向可動スリット

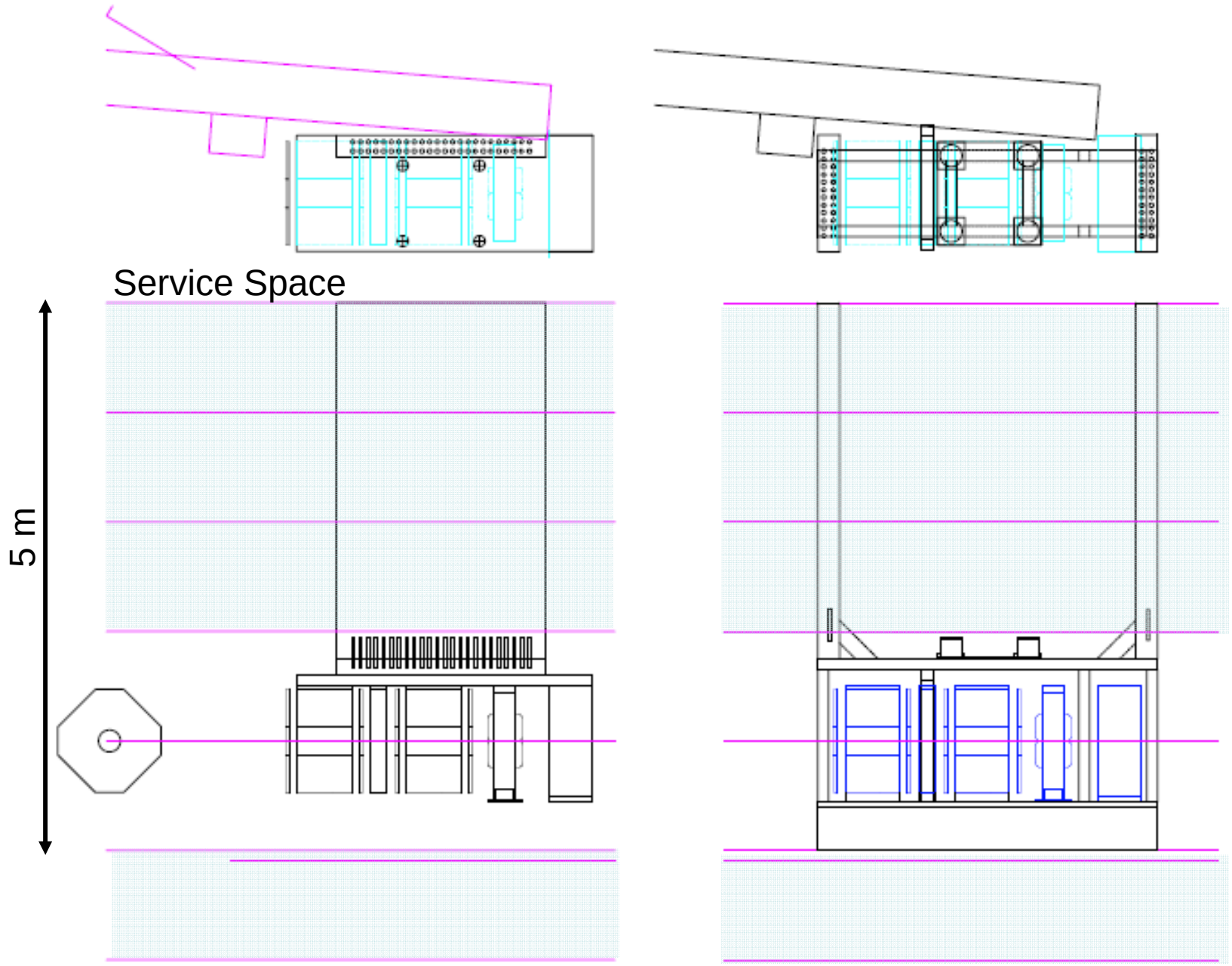


鉛直方向可動スリット

ϕ300 pillow seal



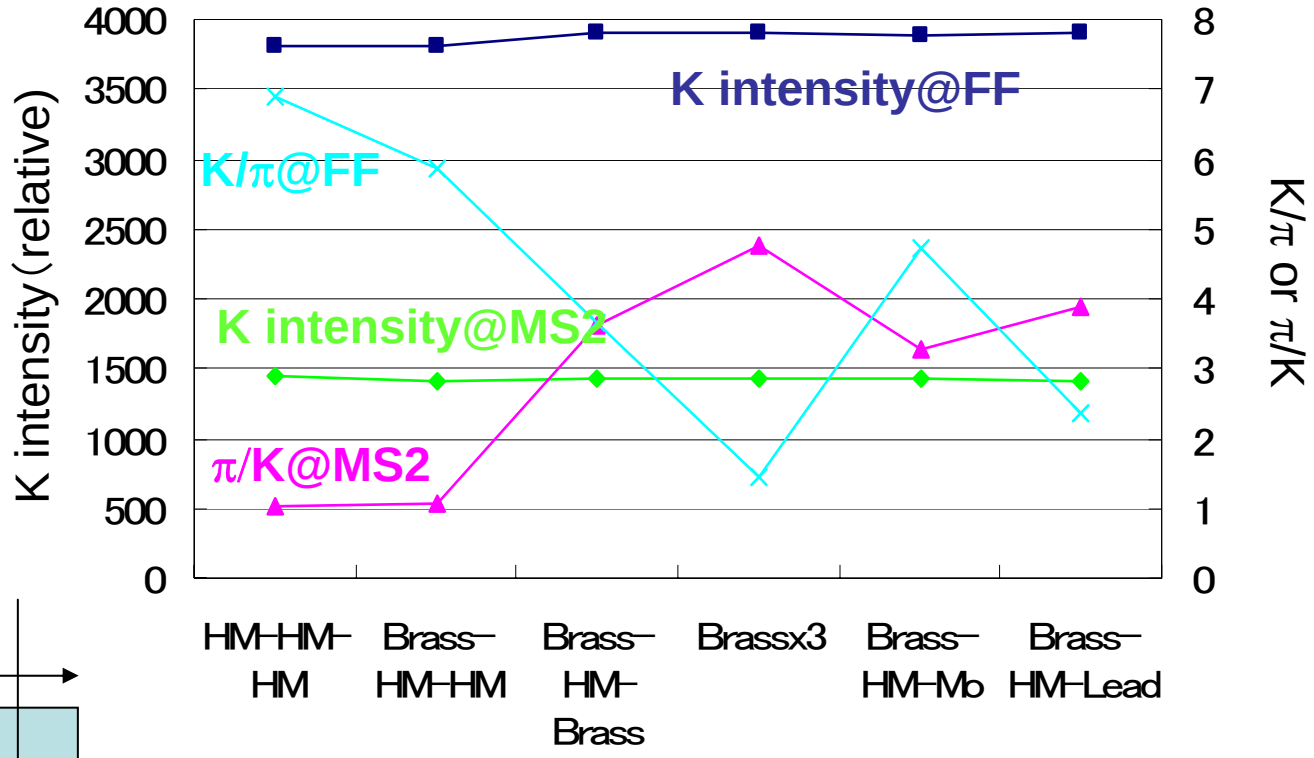

520



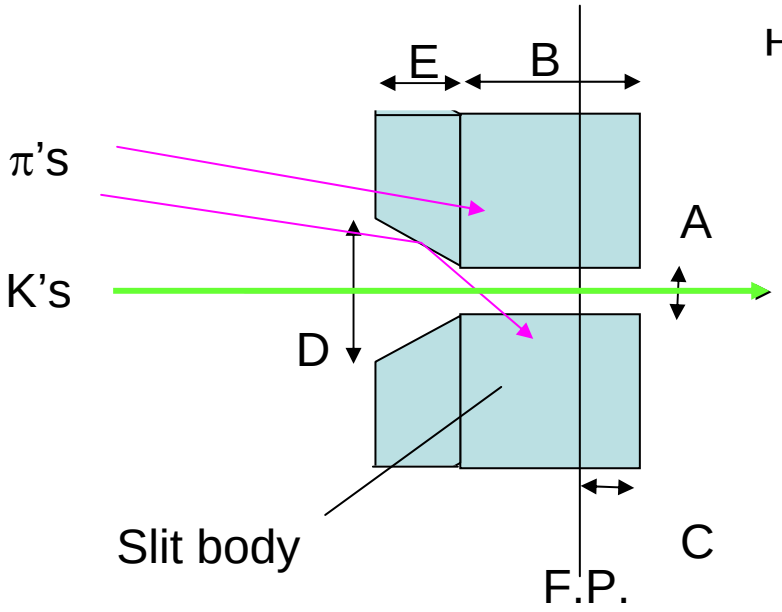
Drawn by M. Naruki

Design of the mass slit

Choice of Materials for Three Vertical Slits

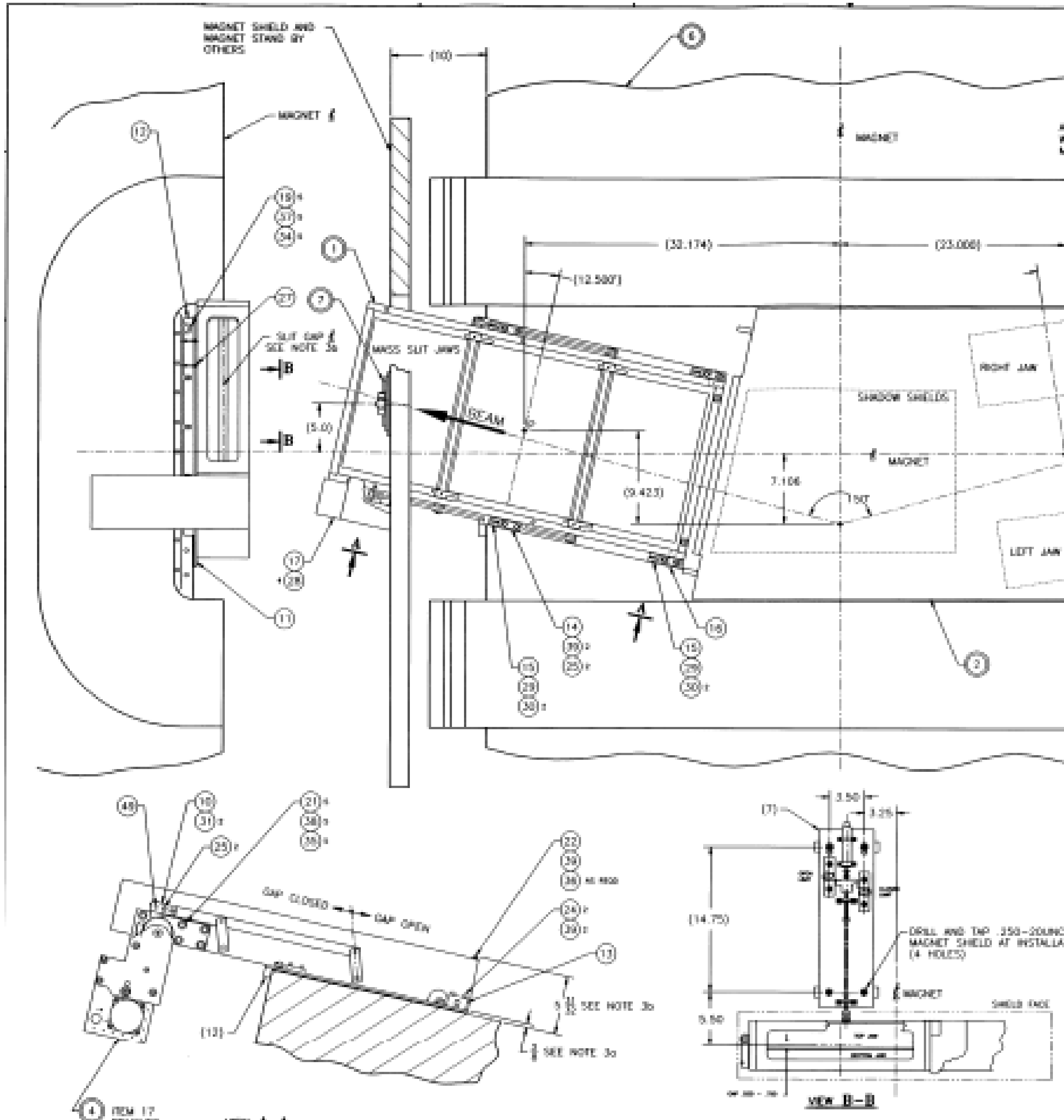


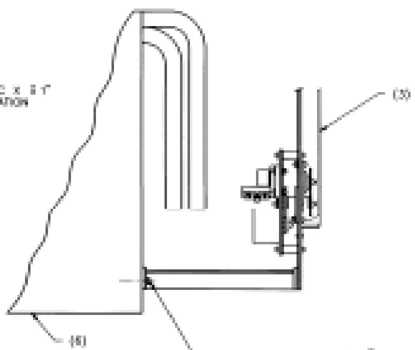
Optimizing
the slit opening/shape



	A	B	C	D	E	
IF	4	300	100	-	-	Brass
MS1	4.5	300	100	10.9	200	HM
MS2	4.8	400	100	9.2	100	HM

Unit:mm





ITEM NO.	QTY.	DESCRIPTION		MFG. PART NO. OR DWG. NO.
1	1	FIRST MASS SLIT ASSEMBLY		D13-M-6227-5
2	1	FIRST VARIABLE COLLIMATOR ASSY.		D13-M-6024-5
3	1	FIRST VARIABLE COLL. DRIVE ASSY.		D13-M-6025-5
4	1	MASS SLIT DRIVE ASSEMBLY		D13-M-6157-5
5	1	VACUUM BOX FLANGE		D13-M-6027-5
6	1	30D72 MAGNET ASSEMBLY		D12-M-234-5
7	1	LINEAR POTENTIOMETER ASSEMBLY		D13-M-6490-4
8				
9	1	FLANGE BLANK-OFF		D13-M-6151-3
10	1	DRIVE LINK SUPPORT		D13-M-6164-2
11	1	SUPPORT PLATE		D13-M-6171-4
12	1	PLATE SUPPORT		D13-M-6172-3
13	2	BLOCK LONG		D13-M-6173-2
14	2	BLOCK SHORT		D13-M-6174-2
15	4	LOCK PLATE		D13-M-6175-2
16	2	PIN		D13-M-6176-2
17	1	DRIVE ENCLOSURE		D13-M-6165-3
18				
19	5	SCR HEX HD 3/8-16 x 1 1/2	SST	T-12816
20	26	SCR HEX HD 5/16-18 x 1 1/4	SST	T-12724
21	9	SCR HEX HD 5/16-18 x 1"	SST	T-12716
22	2	SCR HEX HD 1/4-20 x 1/2	SST	T-12612
23				
24	4	SCR SOC HD 1/4-20 x 1 1/2	SST	T-95692
25	6	SCR SOC HD 1/4-20 x 3/4	SST	T-95686
26				
27	8	SCR FLT HD 1/4-20 x 7/8	SST	T-55620
28	4	SCR RND HD #10-32 x 3/8	SST	T-58760
29	4	SETSCREW 5/16-18 x 1"	SST	----------
30	8	SETSCREW #10-32 x 1/2	SST	T-64129
31	2	SETSCREW #8-32 x 5/16	SST	T-64097
32				
33				
34	5	WASHER FLT #3/8	SST	T-84132
35	35	WASHER FLT #5/16	SST	T-84128
36	AS REQ.	WASHER FLT #1/4	SST	T-84124
37	5	WASHER LOCK #3/8	SST	T-88736
38	35	WASHER LOCK #5/16	SST	T-88732
39	10	WASHER LOCK #1/4	SST	T-88728
40				
41				
42				
43	1	O-RING #1/8 x 3 1/4 I.D.	VITON	H-30547
44	1	O-RING #1/4		VITON ROPE
45	1	COPPER GASKET #1 1/3 CONFLAT		I-05360
46	1/4	BOLTS #1 1/3 CONFLAT		I-05380
47				
48	1	ELECTRICAL FEEDTHROUGH		[illegible]
49	1	DOWEL PIN #5/16 x 1 1/4	SST	[illegible]

NOTES:

1- LOCATIONS P AND J ARE COMPONENT CENTER POSITIONS. THESE DESIGN POINTS ARE INCLUDED FOR INFORMATIONAL REFERENCE ONLY, AND ARE AUTOMATICALLY ATTAINED BY MECHANICAL CONSTRAINTS. EXCEPT FOR THE MASS SLIT HEIGHT ADJUSTMENT, NO POSITIONAL SURVEYING IS REQUIRED.

2- ADJUSTMENT OF THE FIRST VARIABLE COLLIMATOR ASSY (ITEM 2) AND ITS DRIVE (ITEM 3) IS FULLY DESCRIBED ON DRAWING D13-M-6025-5.

3- POSITIONING AND ADJUSTMENT OF THE MASS SLIT (ITEM 1) AND ITS DRIVE (ITEM 4) IS AS FOLLOWS:
   a. INSTALL SUPPORT PLATE (ITEM 11) AND ITS COMPONENTS. ADJUST ITS UPPER SURFACE INTO A PLANE APPROX. 3/8 INCH ABOVE THE MAGNET CORE FACE.
   b. CRADLE THE MASS SLIT ASSY (ITEM 1) INTO THE ABOVE, AND ADJUST THE SLIT GAP CENTERLINE ONTO THE MAGNET CENTERLINE PLANE BY MEANS OF JACK SCREWS (ITEM 29) AND LOCKING HARDWARE. SET ANTI-TIPPING SCREWS (ITEM 22) TO 5 31/32 INCH DIMENSION NOTED.
   c. INSTALL THE MASS SLIT DRIVE ASSY (ITEM 4) AND CONNECT IT TO THE MASS SLIT LINKAGE.
   d. ADJUST THE JAW GAP AND THE SWITCHES OF ITEM 7 TO .030 CLOSED LIMIT, .750 OPEN LIMIT.
   e. RECORD THE POTENTIOMETER READING OF ITEM 7 AT BOTH LIMITS.
   f. RUN AND TEST. COMPLETE ASSEMBLY.

TRANSFER DR. AND TAP 4X 5/16-18UNC-2B ▽ 3/4 IN MAGNET CORE (2 PLACES IN BOTTOM CORE) (2 PLACES IN TOP CORE)

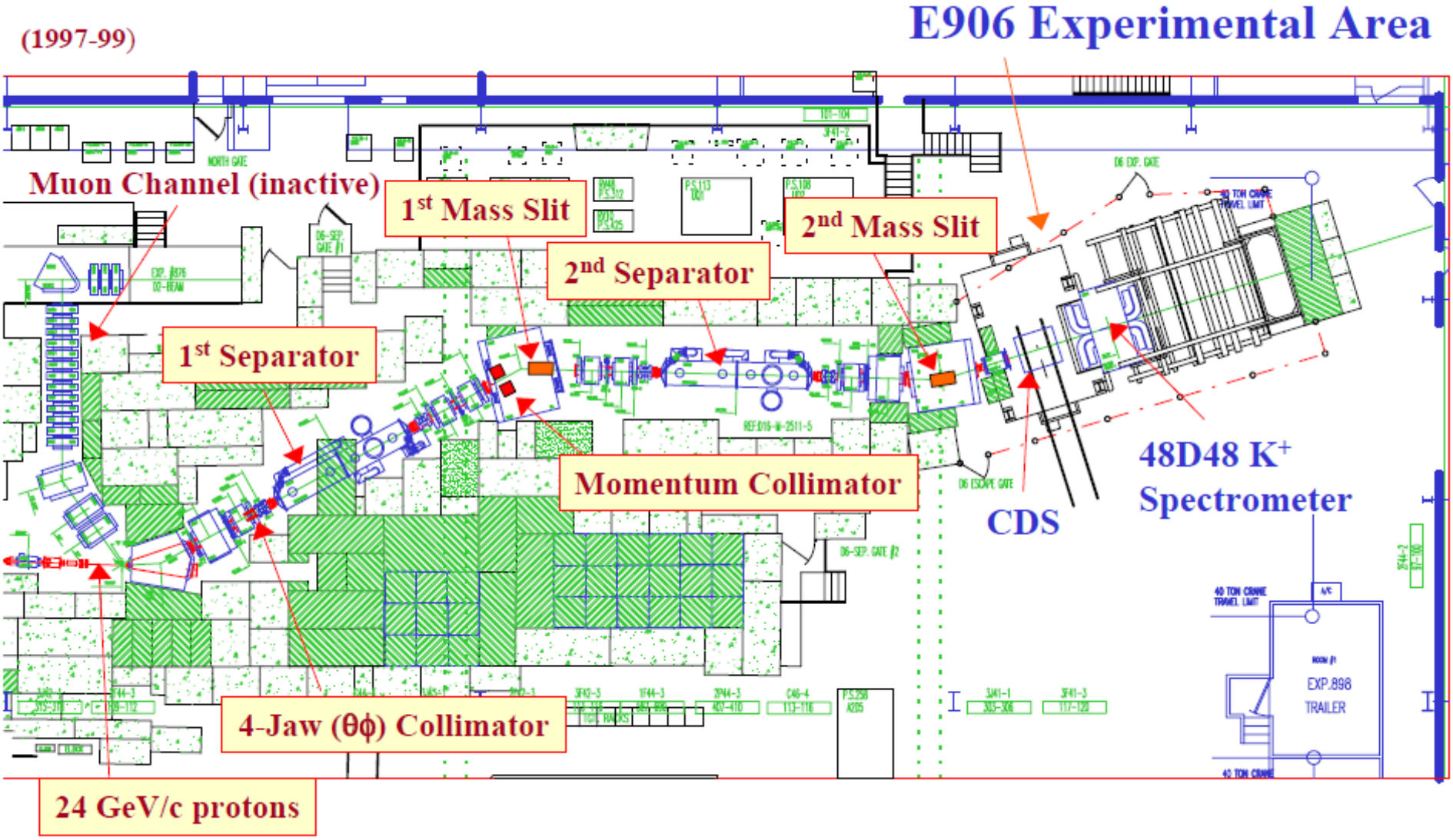
QA CATEGORY A-3

BROOKHAVEN NATIONAL LABORATORY
UPTON, N.Y. 11973
A.G.S. GENERAL EXPER. EQUIP.
Σ SHAVUL BEAM ASSEMBLY
30D72/COLLIMATOR, MASS SLIT, INSTALLATION

D12-3M-93	D15-M-2511-5	1		
.XX ±.005	.X ± 1/2"	± 1/32	± 1/64	
1/64	1/32	1/16	125 √	
1-10-91	SEE P/L	1/4		
[illegible]	J.W.	J.M.	K.DAMM	D12-M-3673-5 B

D12-M-3673-5

D6 at BNL-AGS


(1997-99)
E906 Experimental Area
Muon Channel (inactive)
1st Mass Slit
2nd Mass Slit
2nd Separator
1st Separator
Momentum Collimator
48D48 K+
Spectrometer
CDS
4-Jaw (θϕ) Collimator
24 GeV/c protons
EXP.898
TRAILER

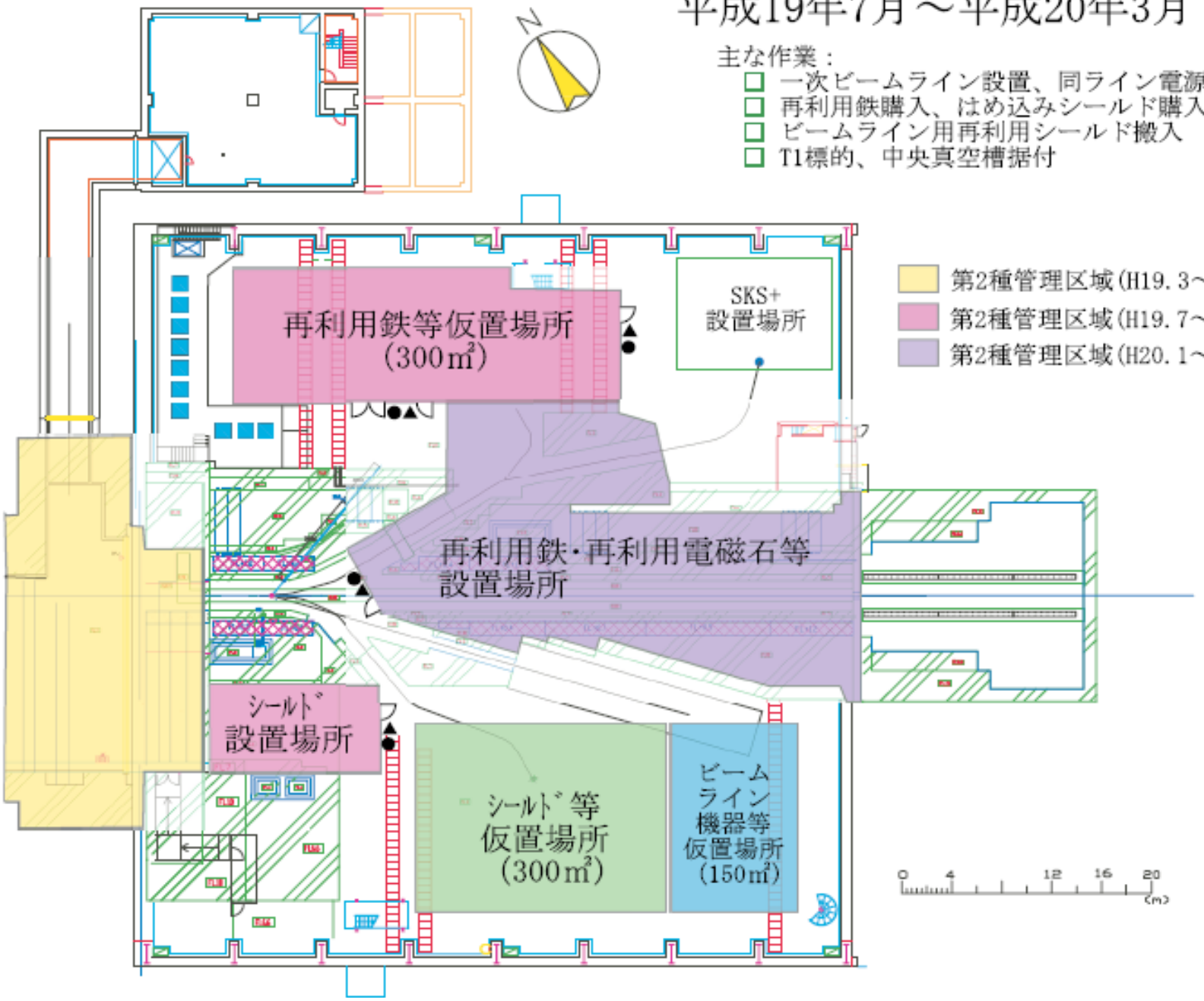
Beam Line Magnet Installation

2007. 6 HD-Hall Civil Construction Complete
→ Survey, Beam Line Marking will start

平成19年7月～平成20年3月

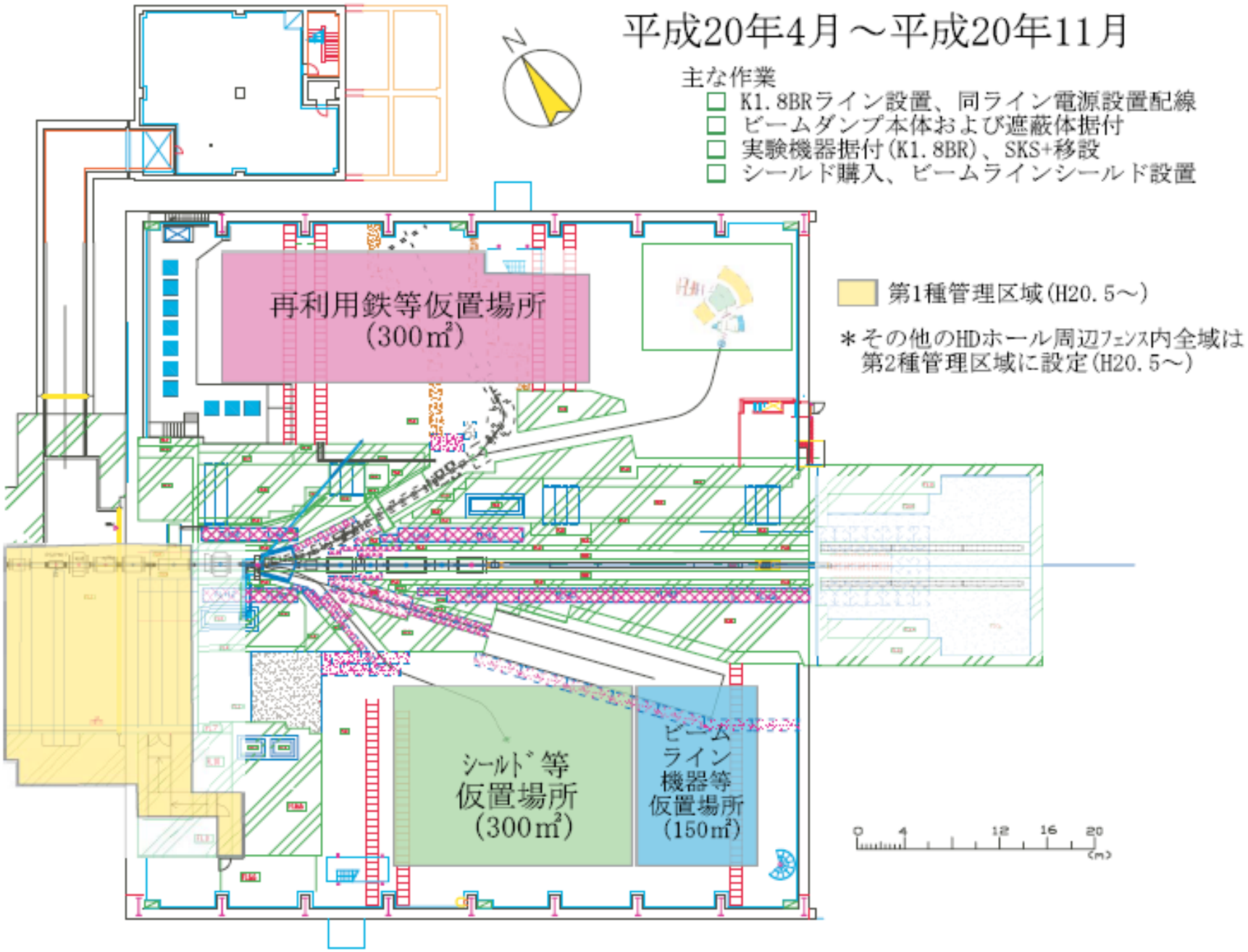
主な作業：

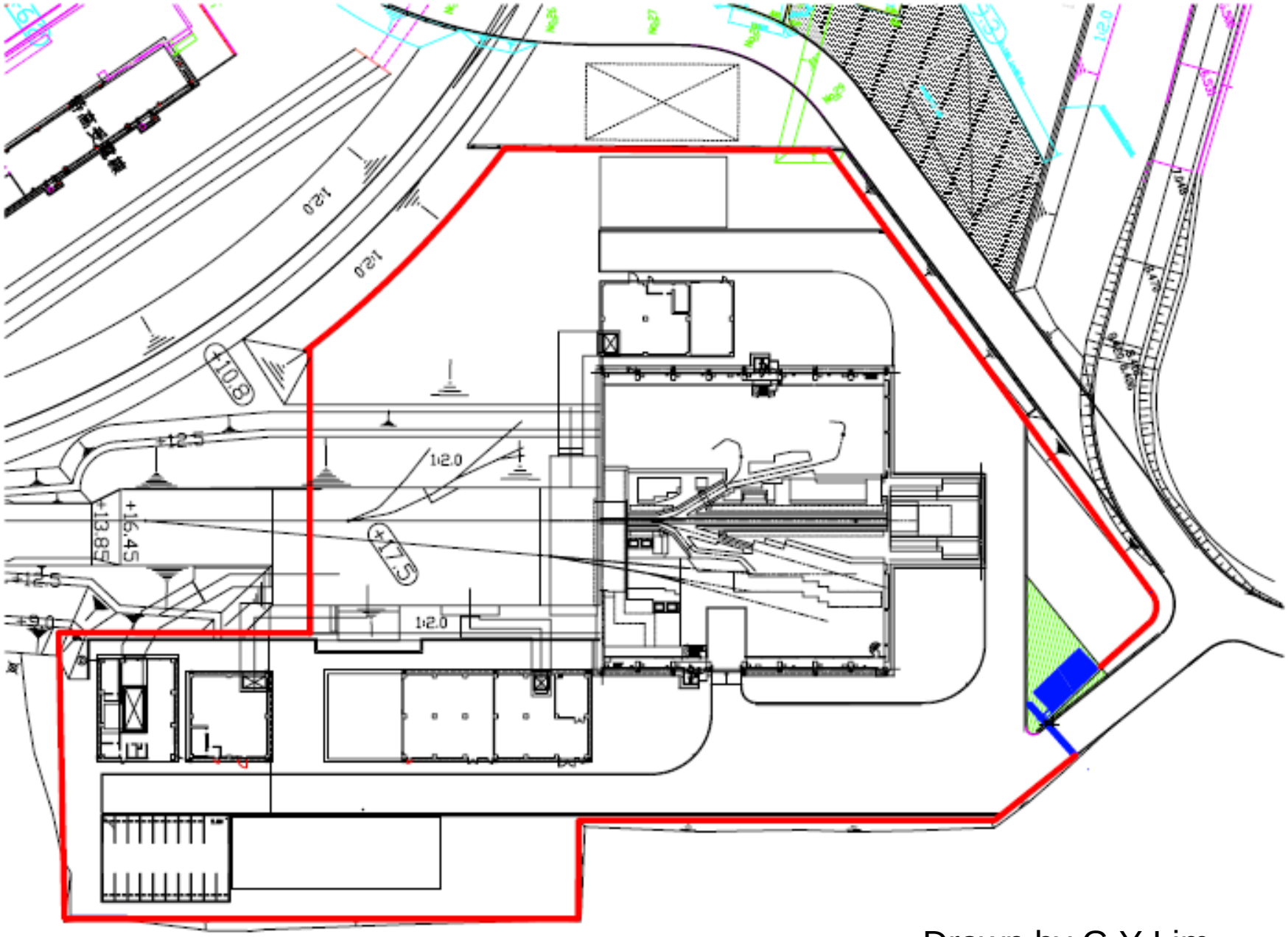
- □ 一次ビームライン設置、同ライン電源設置配線
- □ 再利用鉄購入、はめ込みシールド購入
- □ ビームライン用再利用シールド搬入
- □ T1標的、中央真空槽据付



平成20年4月～平成20年11月

主な作業
- K1.8BRライン設置、同ライン電源設置配線
- ビームダンプ本体および遮蔽体据付
- 実験機器据付(K1.8BR)、SKS+移設
- シールド購入、ビームラインシールド設置




Drawn by G.Y.Lim

平成20年12月～平成21年10月

主な作業
- □ K1.8ライン下流部設置、同部電源設置配線
- □ 実験機器据付(SKS+、BAほか)
- □ K1.8ラインシールド設置