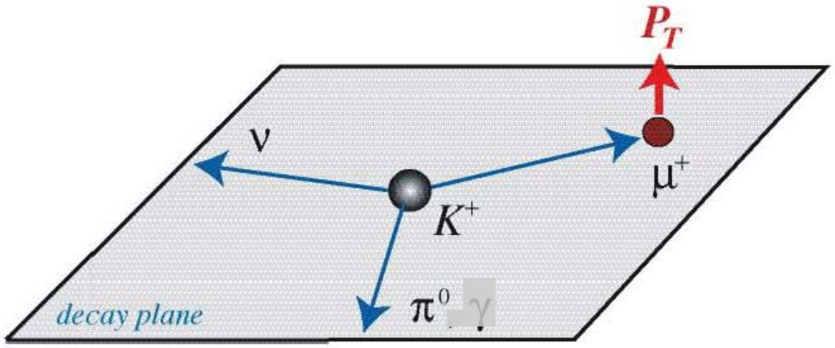
ミュオン横偏極

$K^+ \rightarrow \pi^0 \mu^+ \nu$ decay

$$P_T = \frac{\sigma_\mu \cdot (p_{\pi^0} \times p_{\mu^+})}{|(p_{\pi^0} \times p_{\mu^+})|}$$



- P_T is T-odd and spurious effects from final state interaction are small.
  Non-zero P_T is a signature of T violation.
- Standard Model contribution to P_T : $P_T(SM) < 10^{-7}$
- Spurious effects from final state interactions : $P_T(FSI) < 10^{-5}$
- There are theoretical models which allow sizeable P_T without conflicting with other experimental constraints.

KEK-PS E246 experiment

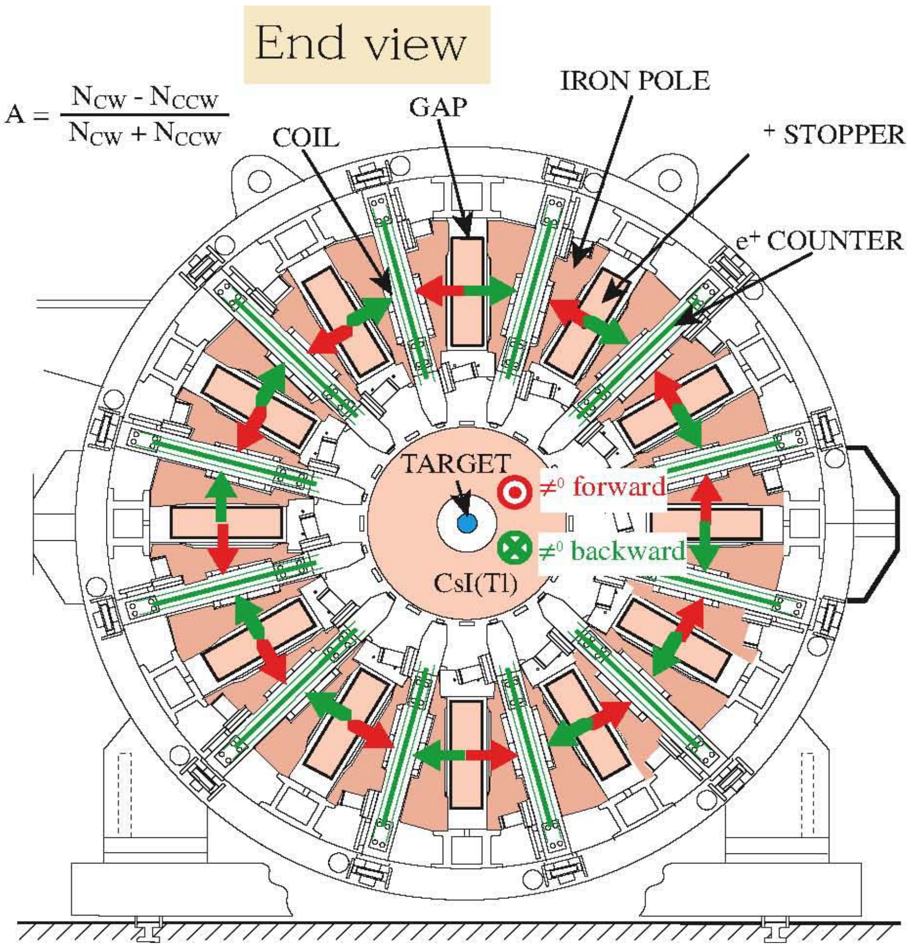
$P_T = -0.0017 \pm 0.0023(stat) \pm 0.0011(syst)$

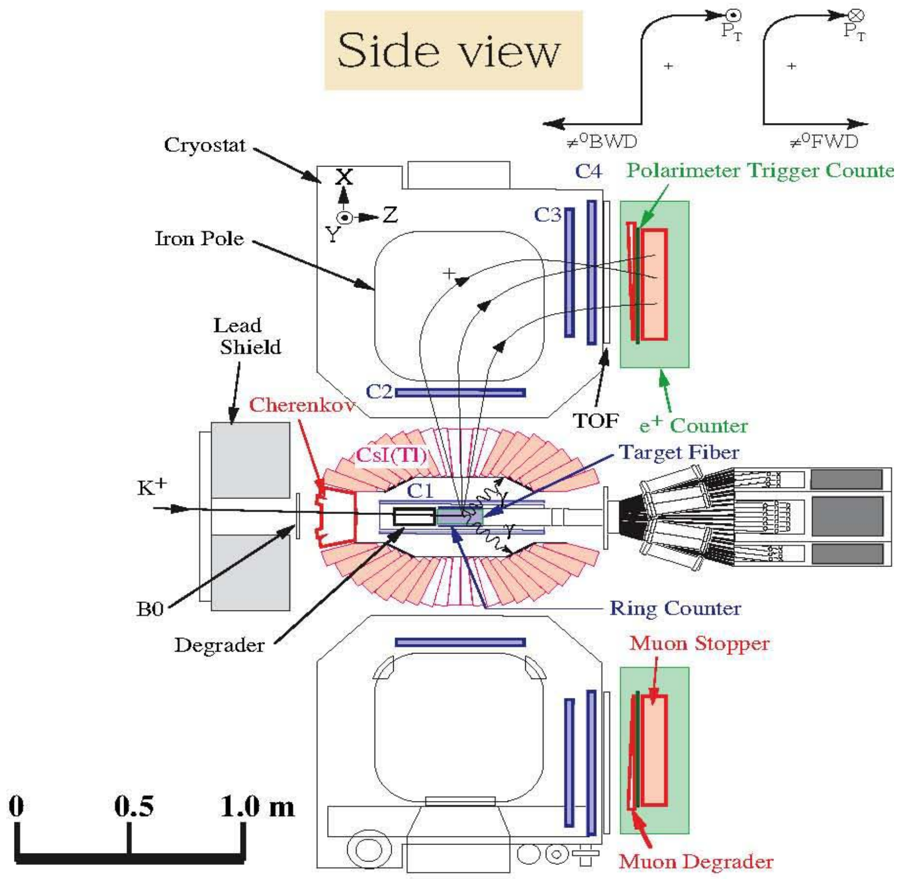
($|P_T| < 0.0050$: 90% *C.L.*)

$\mathrm{Im}\xi = -0.0053 \pm 0.0071(stat) \pm 0.0036(syst)$

($|\mathrm{Im}\xi| < 0.016$: 90% *C.L.*)

E06 (TREK) 実験

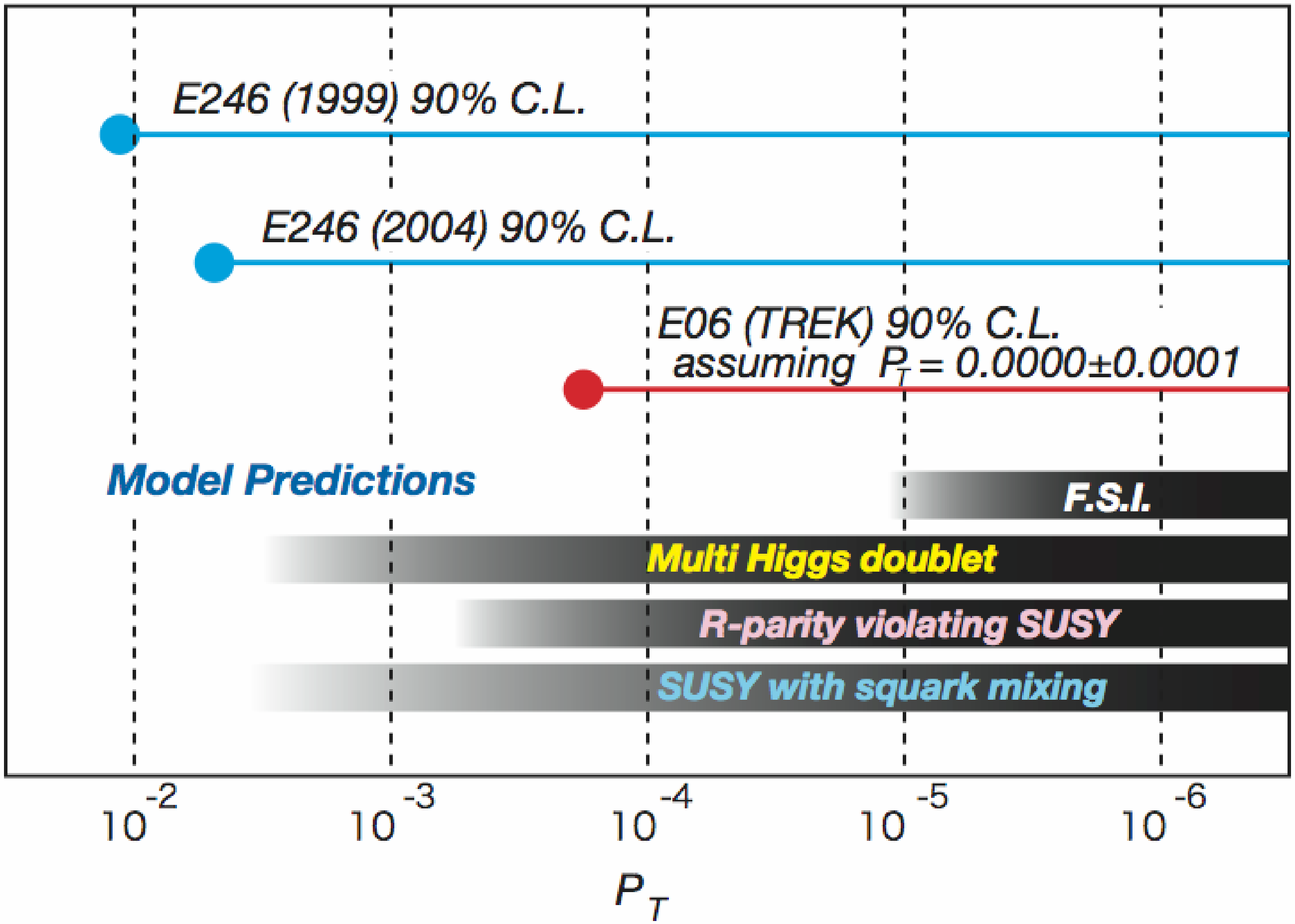




- **Stopped K^+ decay**
- SC Toroidal spectrometer

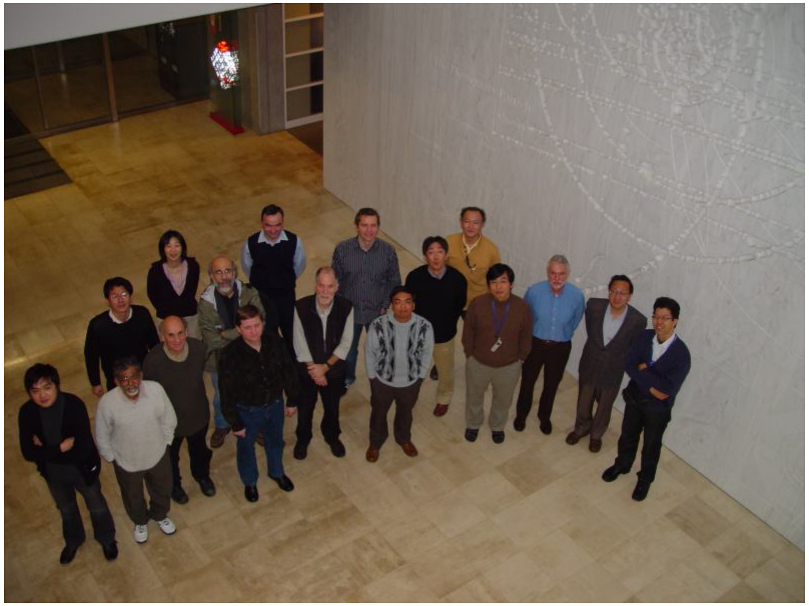
- Measurement of e^+ emission *cw/ccw* asymmetry when π^0 in *fwd/bwd* directions

E06 (TREK)目標感度



- 10^{-4}の感度で幾つかの理論モデルが射程内
- ε'/ε が New Physics とすると、K^+のP_T~10^{-4} (I.Bigi)

TREK実験の現状とスケジュール

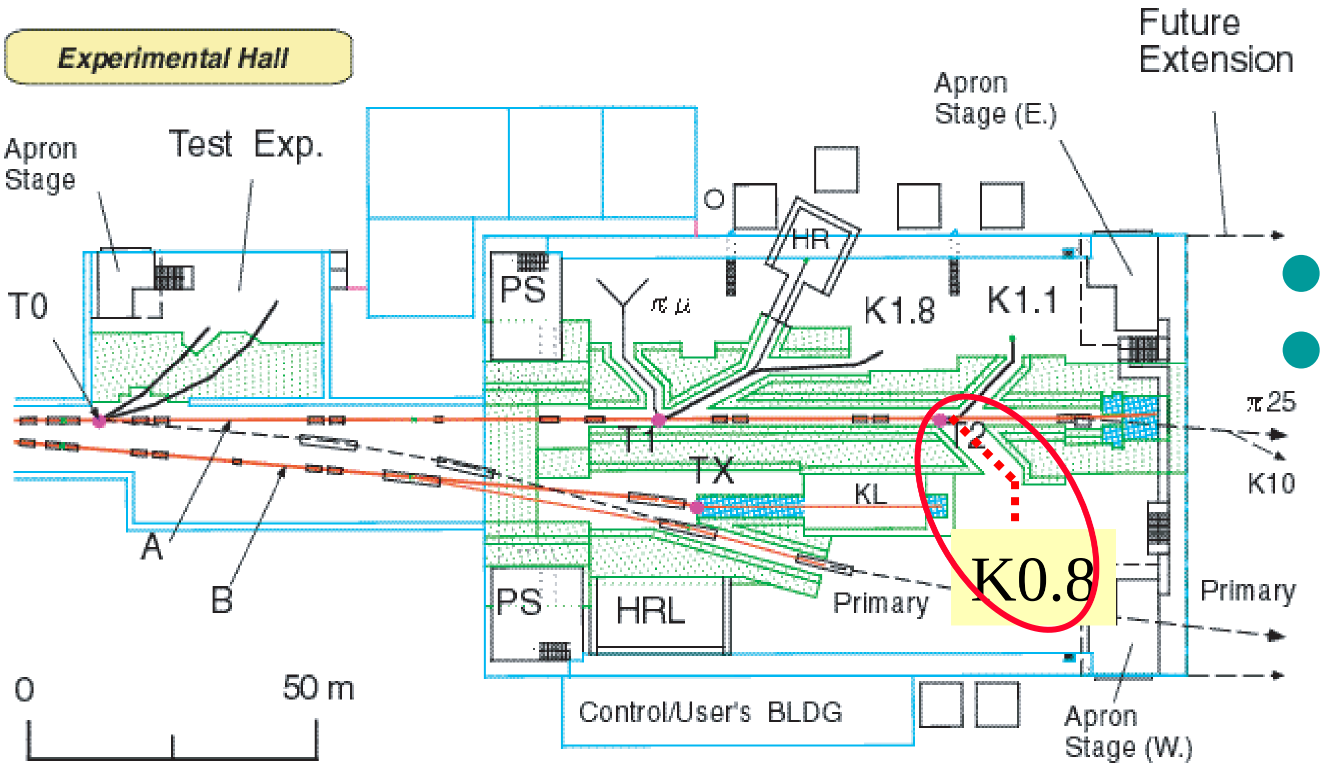


TREK collaboration
5カ国（カナダ、米国、ロシア
ベトナム、日本）の13大学/研究
所

<===
2007年2月のKEKミーティング

- 2006年夏にStage-1 Approval
- 2006~2007 測定器要素のR&D
- 2007年6~7月；FIFC審査と第３回PACへの報告
  - 測定器のアップグレード方針、系統誤差の評価 etc が認められる。
- Stage-2を要求中：ビームラインが一つのネック
- 2011~2012の実験実施を目標

J-PARCでの理想的静止K^+用ビーム



- 第2標的 T2 から
- しかし第2期

• KEK-PS

–K3 (東カウンターホール) 0.5~1.1 GeV/*c*

•Single stage ESS ; 14.5 m

–K5 (北カウンターホール) < 0.65 GeV/*c*

•Single stage ESS ; 12.5 m

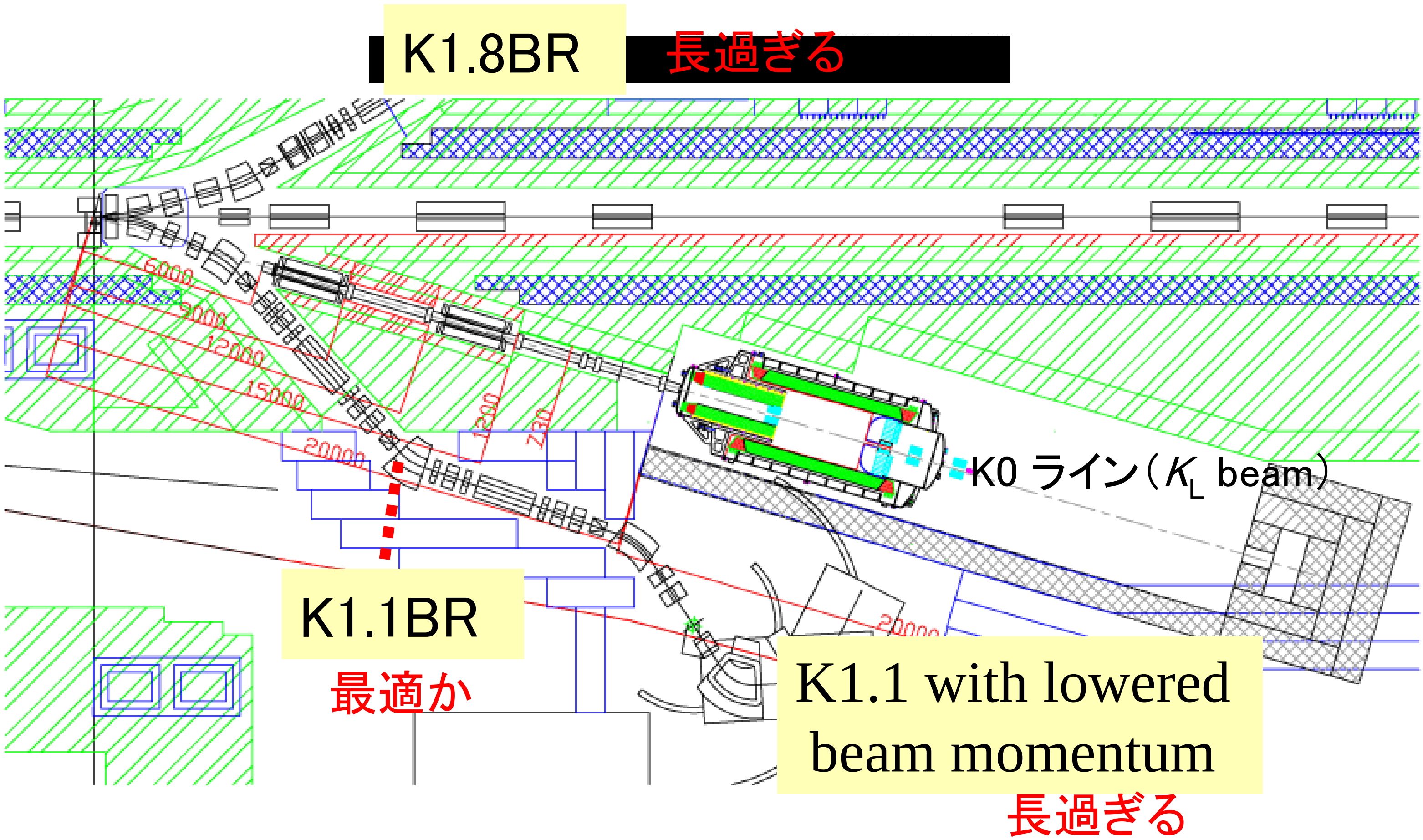
•BNL-AGS

–C4-LESBIII < 0.83 GeV/*c*

•Double stage ESS ; 19.6 m

第1期での K0.8 の可能性

- T1 標的の最大限有効利用



K1.1-BR レイアウト

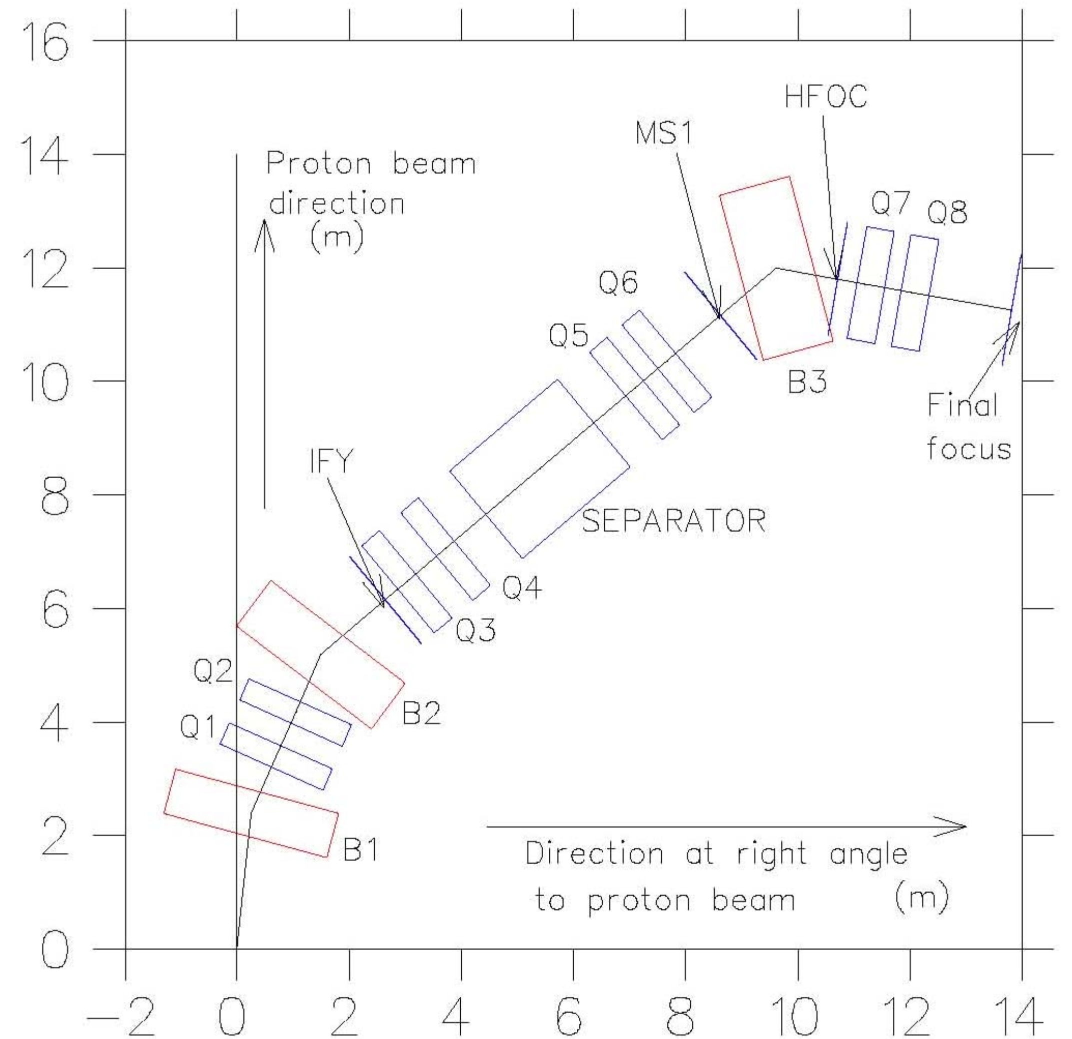


Figure 1: Layout of the 0.8 GeV/c beam.

Doornbos氏の設計

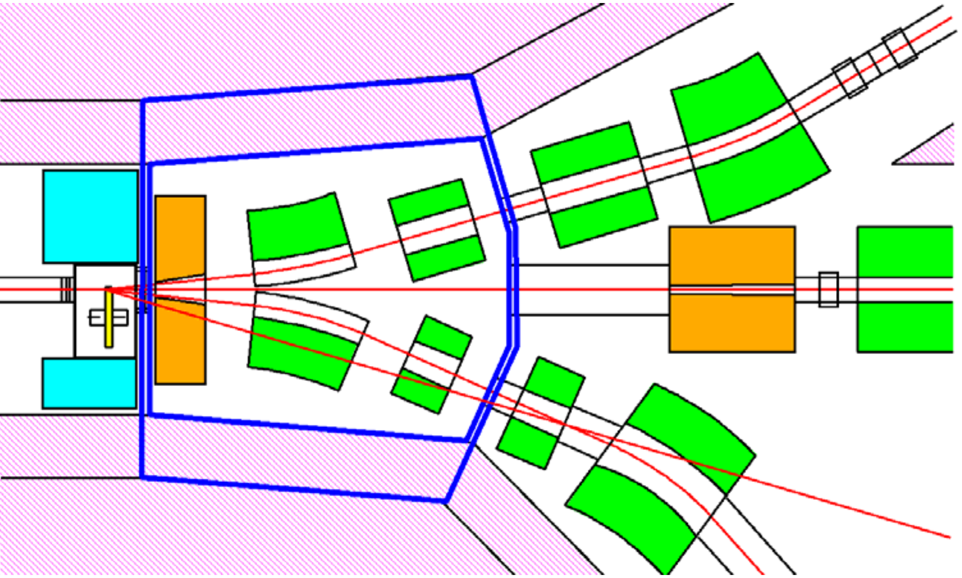
- K1.8-BR の考え方と全く同じ

- A branch of K1.1
- Common use of the upstream part up to MS1
- Macroscopic time sharing with K1.1
- Effective use of IFY
- Moderate K/π ratio with a single-stage ESS

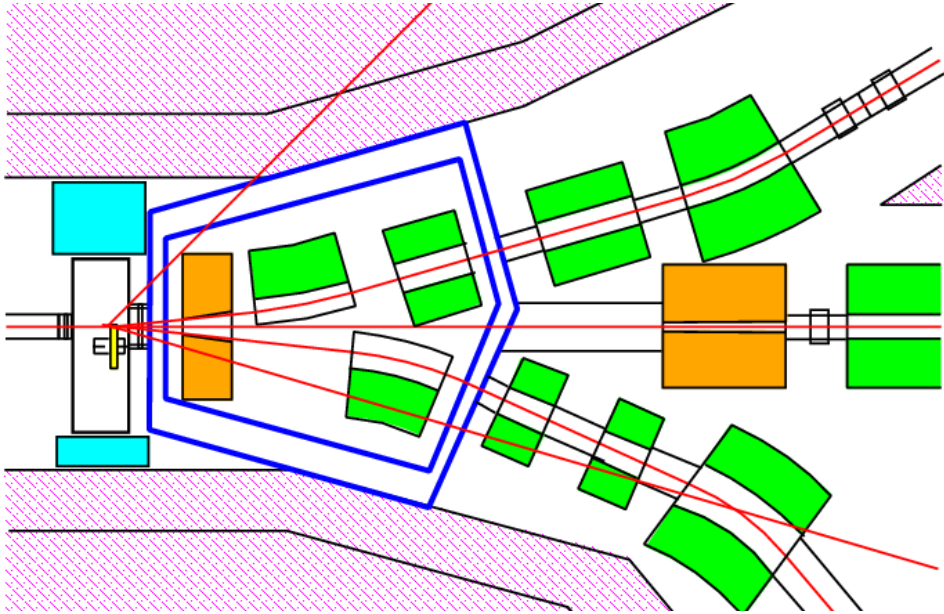
- 2005年当時のK1.1光学設計に基づいてK1.1BRの比較的詳細な光学設計
（2007年にビーム光学の修正があったが基本的なところは変更がない。）

K1.1 new beam optics

- Due to the conflict between K1.8B1 and K1.1B1
  Distance to B1 from T1= 2.0 m (1.2 m before)
- New optics calculation done



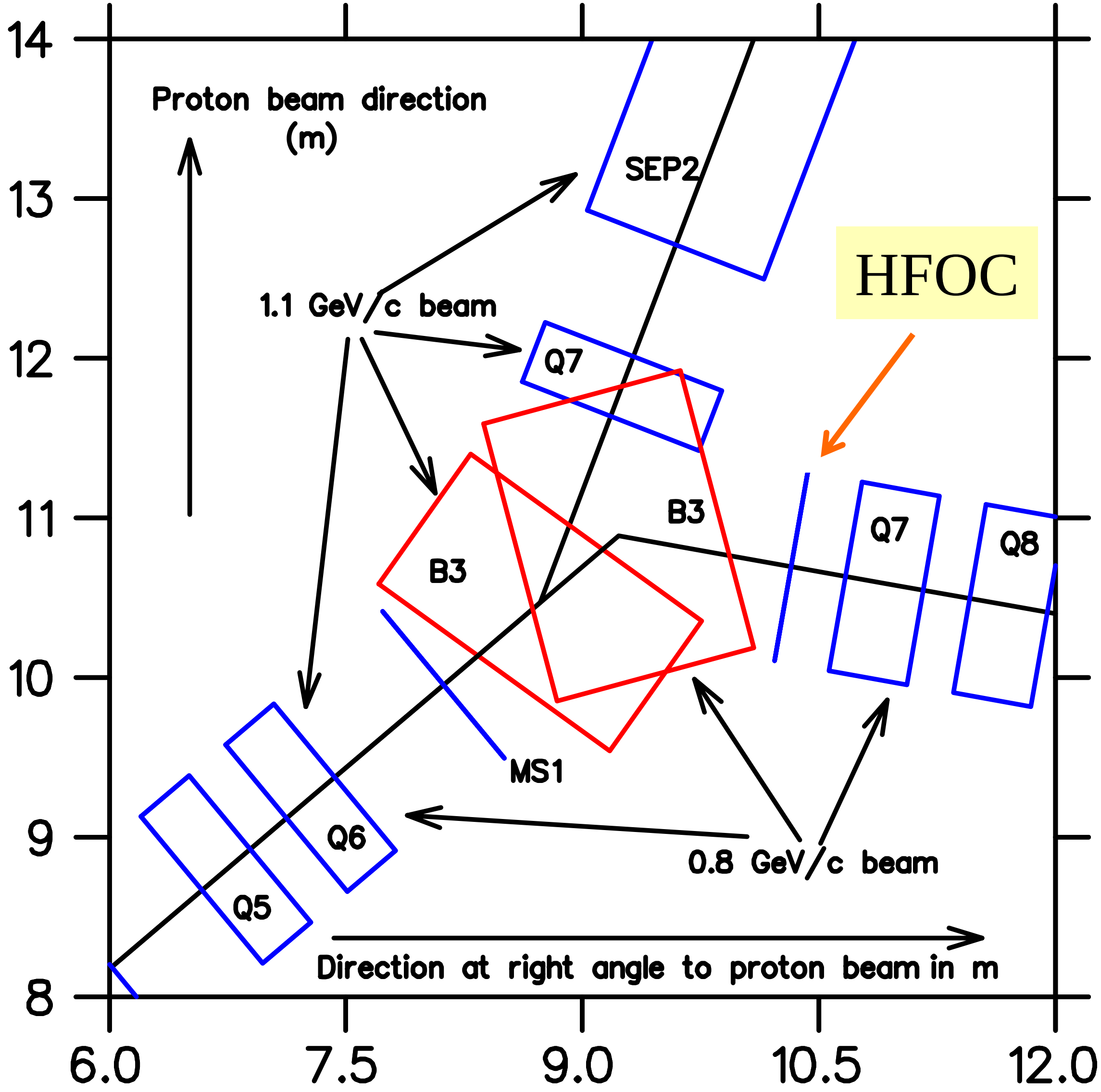
Ω(K1.1-BR) = 6.0 msr%(Δp/p)



Ω(K1.1-BR) = 4.5 msr%(Δp/p)

K1.1のアクセプタンスが小さくなったのは残念であった。

Replacement of B3



- Macroscopic time sharing between K1.1 and K1.1BR
- B3 replacement
- Removal of Q7

K1.1-BR Design principle

- Effective use of wedge focus to make HFOC
- Suppression of slit-scattered pions at HFOC
- Suppression of muons also at HFOC

以上K1.8BRと異なる部分

- Cloud pion source definition by IFY

K1.1-BR Beam envelop

@ 0.8 GeV/c

x'=35 mr

y'= 9 mr

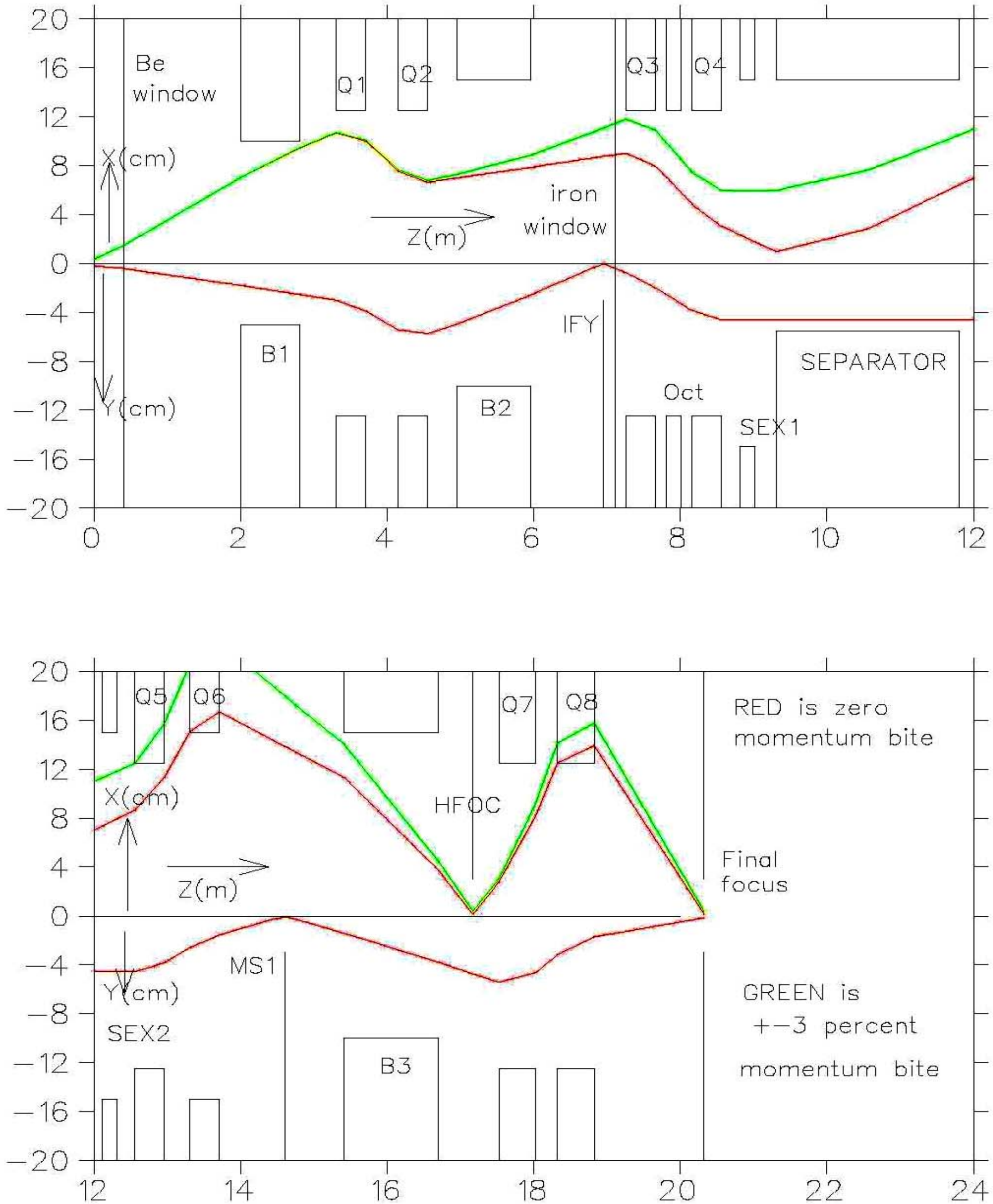
x = 3.5 mm

y = 2.0 mm

$\Delta p/p$ = 0, ±3%

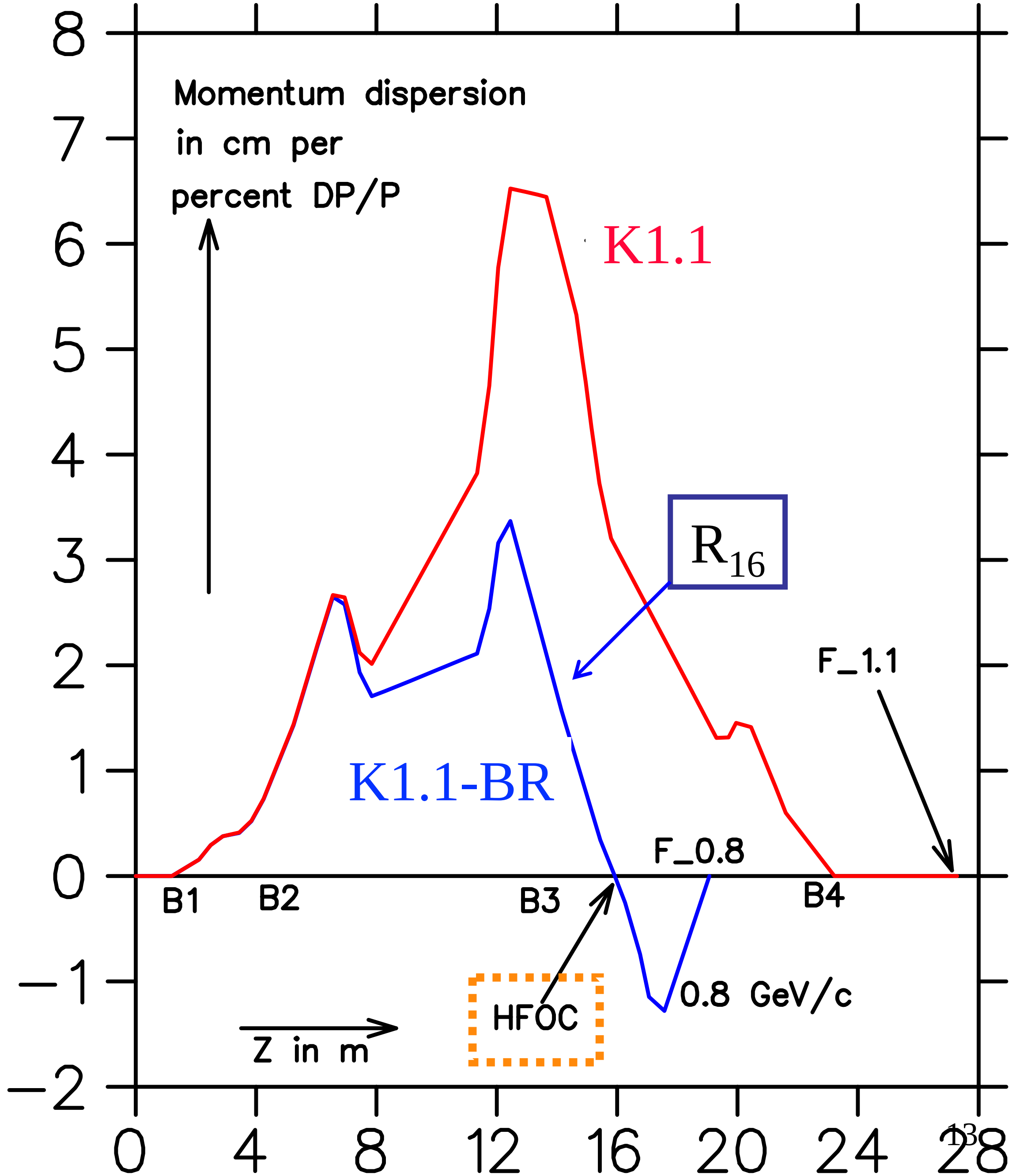
Length = 20.3 m

Acc = 4.5 msr % $\Delta p/p$



Momentum dispersion

$R_{16}(FF) = 0$
$R_{26}(FF) \neq 0$



IFY profile

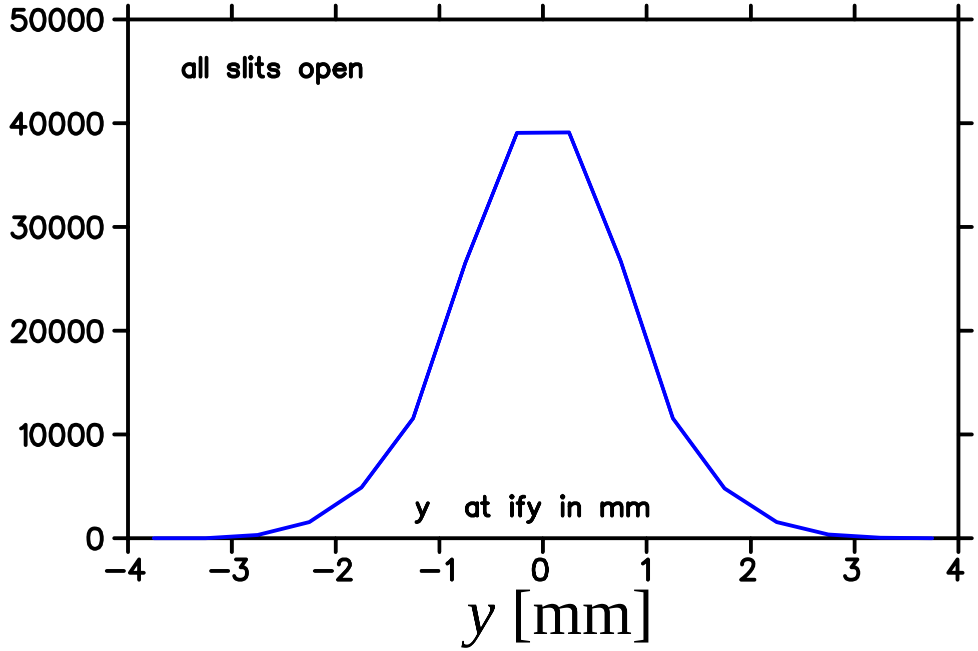
ZGOUBI calculation

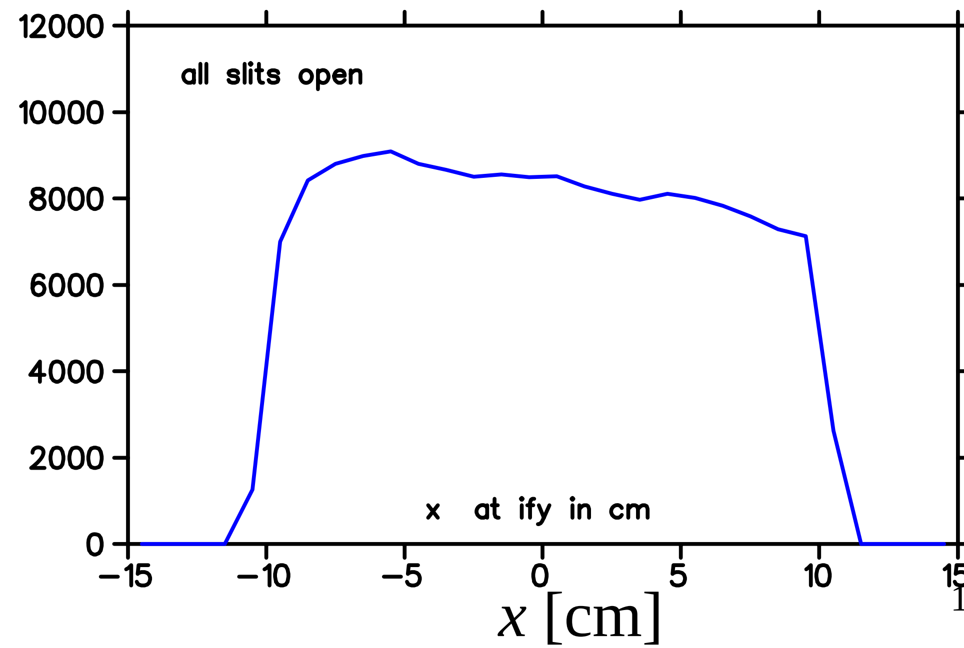
Source size

$\Delta x = 2$ mm

$\Delta y = 2$ mm

ZGOUBI:
- Q fringing field
- Up to 5th order

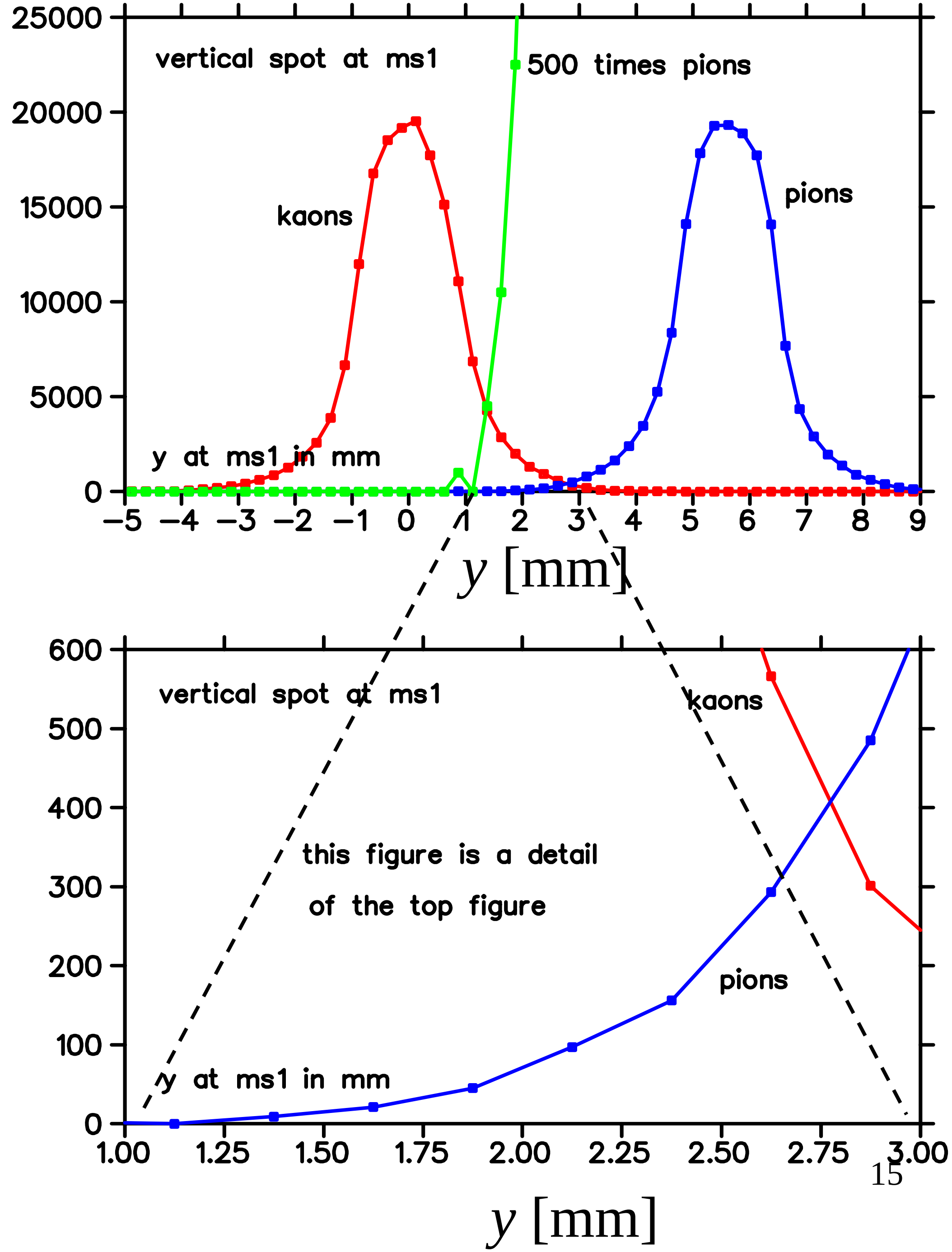




MS1 profile

DCS = 550 kV/10cm
Pion kick = 2.2 mr

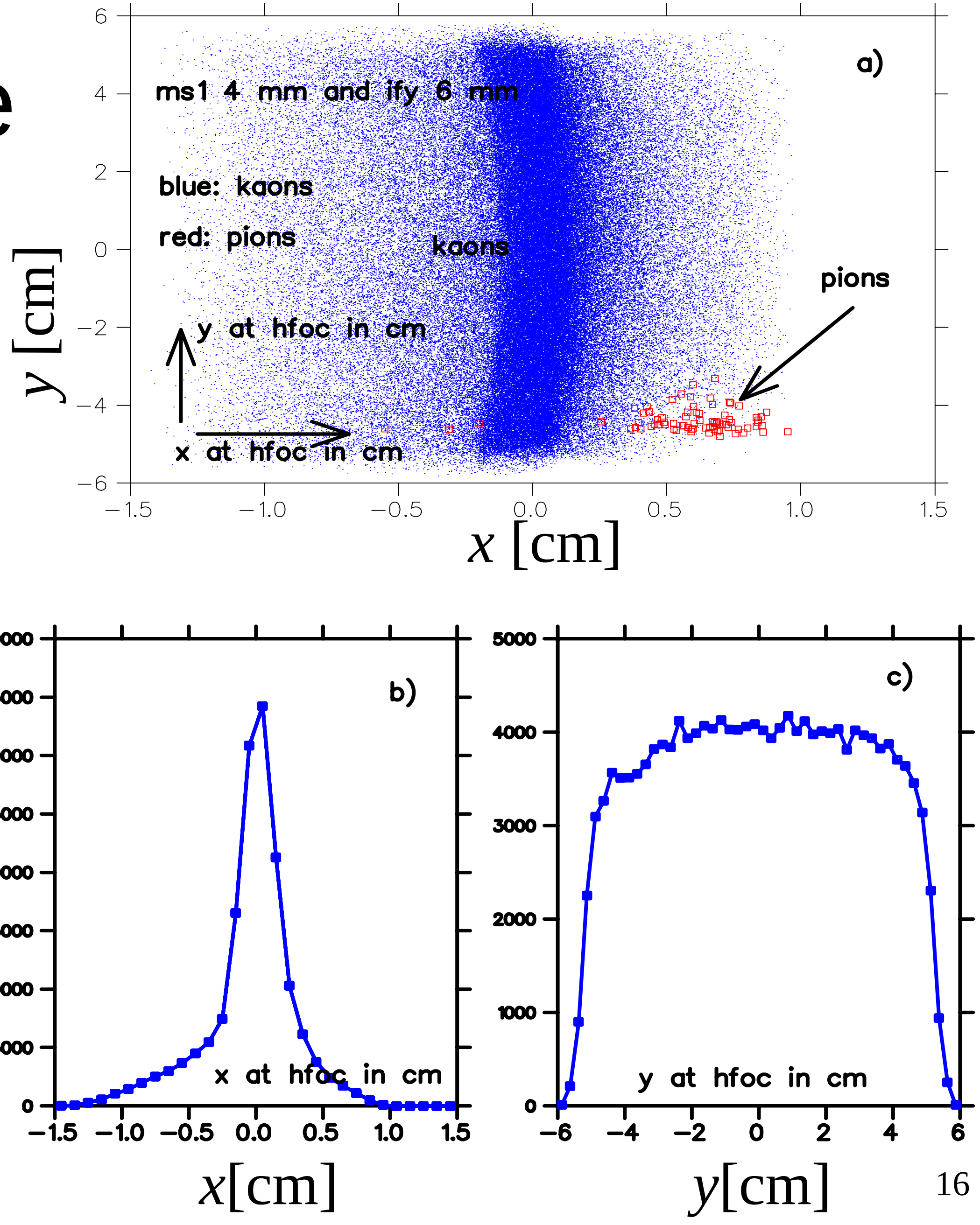
ZGOUBI calculation



HFOC profile

ZGOUBI calculation

Pions =
direct pions
from the target



Final focus

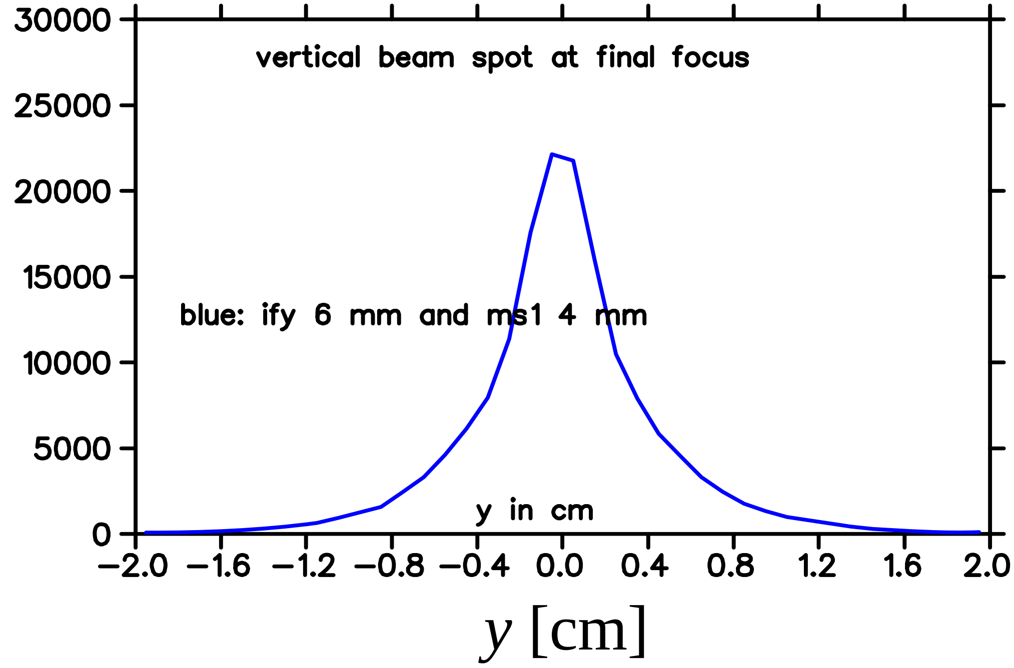
ZGOUBI calculation

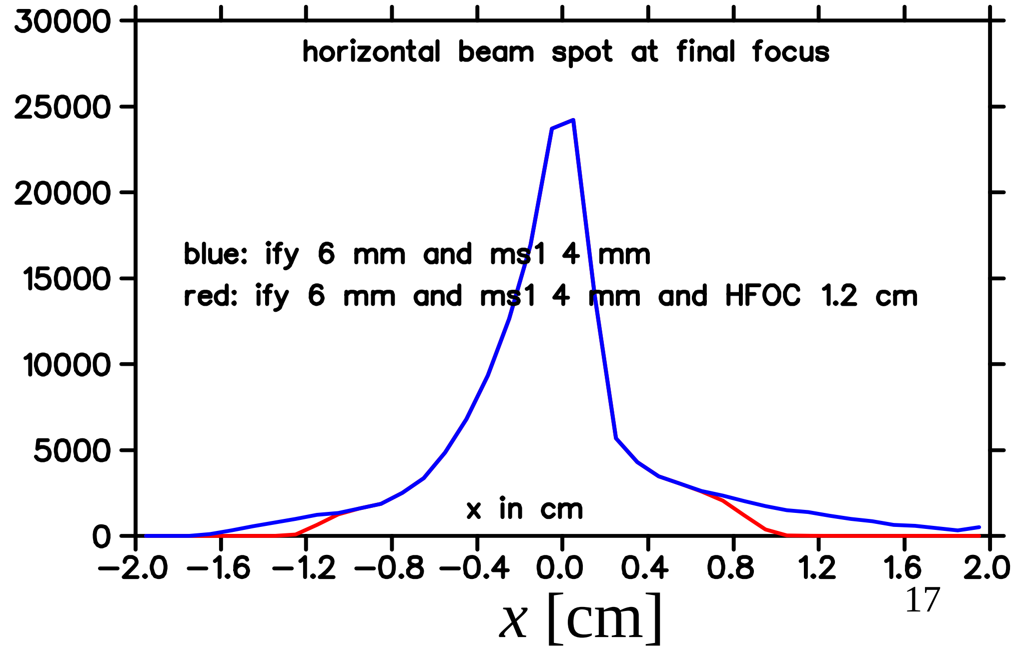
$R_{16} = 0$

cf. $R_{16} \neq 0$
@ K5
→ source of
systematic errors

$R_{26} \neq 0$

- less problematic
- longer target





Pion contamination

Three sources:

1. Higher order aberration
   simulation by ZGOUBI
2. Slit scattering
3. Cloud pions from *Ks* ($c\tau$ =2.7 cm)
   simulation by REVMOC

Aberration:

$$y = R_{33} y_0 + R_{34}\,\phi + A_1\phi\theta + A_2\phi\theta^2 + B_1\phi\delta + B_2\phi\delta^2 + \cdots$$

A_1, B_1 = 0 by adjusting the sextupoles S1 and S2
A_2, B_2 were minimized by optimizing the octupole O1

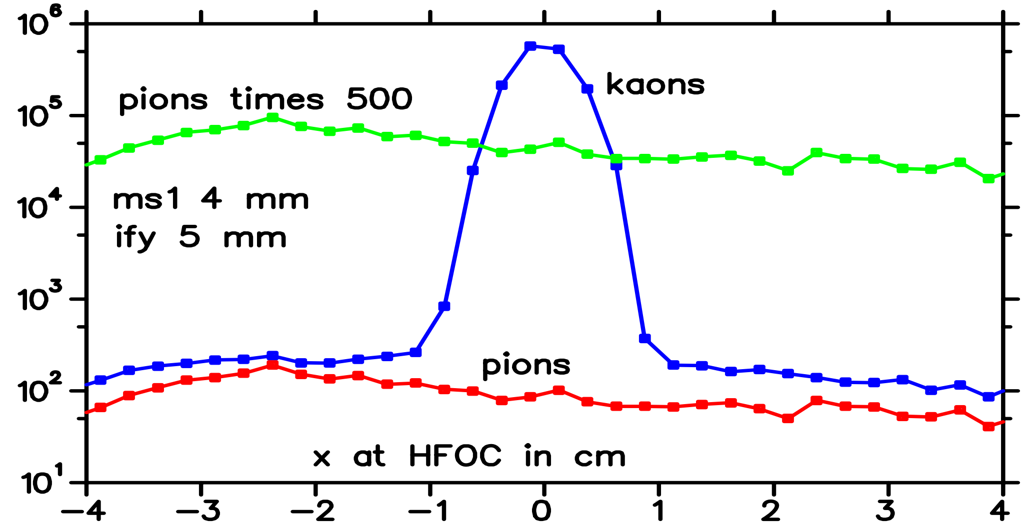
Rejection of slit-scattered pions

x-profile at HFOC

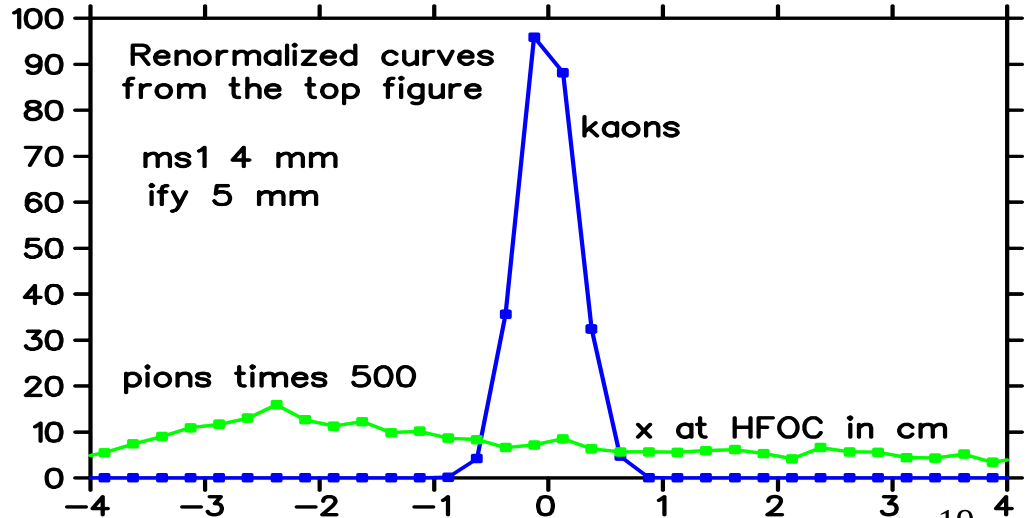
- Slit scattering simulation with REVMOC from IFY and MS1

- with 30 cm thickness tapered (20 mr at both ends)

HFOC is effective !



x[cm]



x[cm]

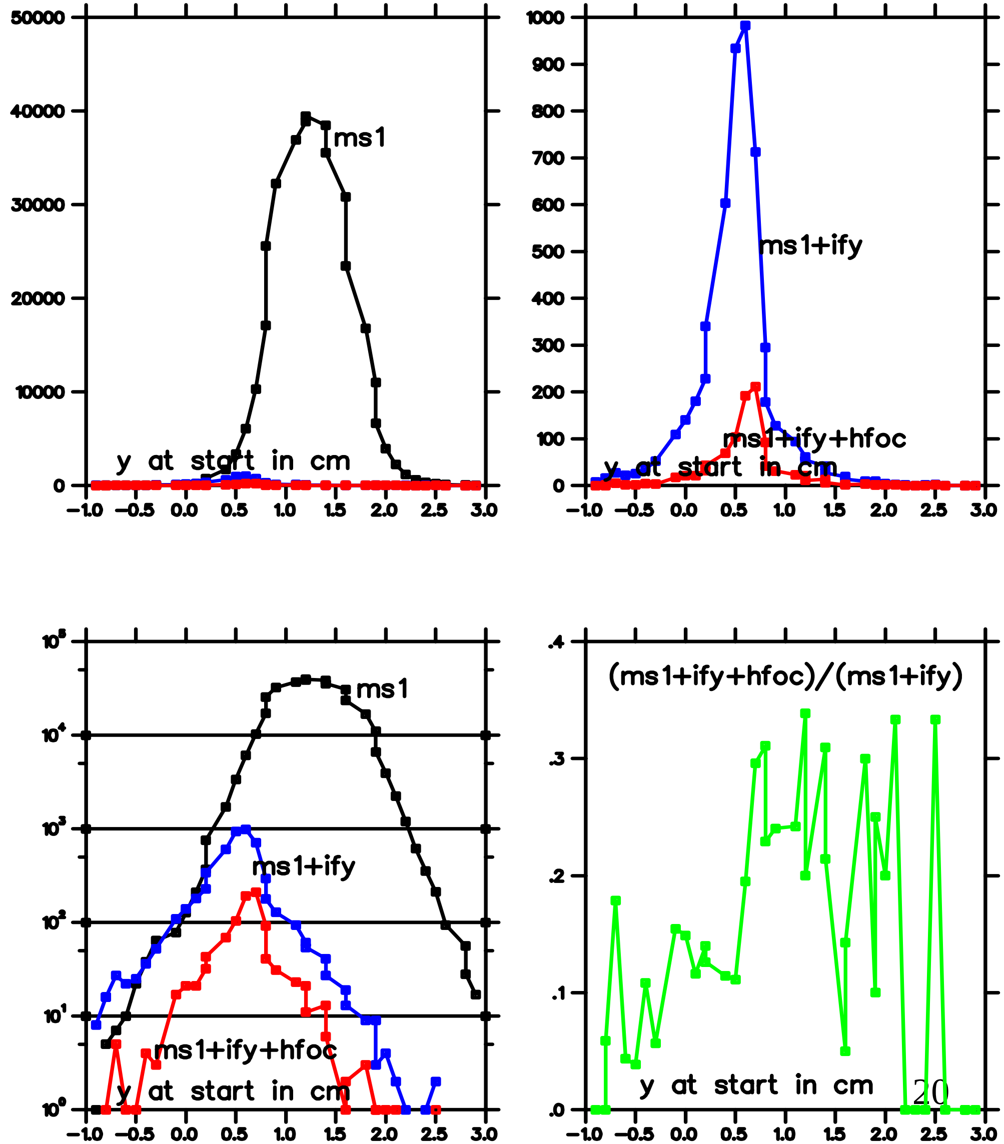
Rejection of cloud pions

Accepted *y* region at the production target

Pion source of
x = ±2 cm
y = ±2 cm
was assumed.
(c.f. $c\tau = 2.7$ cm)

IFY = 5 mm
MS1 = 4 mm
HFOC = 1.6 cm

HFOC is effective !



Kaon yield and π/K ratio

Table 3: Kaon acceptance and pion contamination as function of slits for a gaussian vertical source with σ=1.3 mm. All widths are full width.

MS1 (mm)	HFOC (cm)	N(kaons)	N(pions)	pi/K	acceptance (msr.percent)
5	open	52,348	40	0.46	4.7
5	1.2	46,107	26	0.33	4.1
4.5	open	51,263	24	0.28	4.6
4.5	1.4	46,862	19	0.24	4.2
4	open	49,631	15	0.18	4.5
4	1.2	43,688	8	0.11	3.9

Scattered pions

Table 8: Contamination due to scattering as function of slit apertures.

IFY (mm)	MS1 (mm)	HFOC (cm)	Y at HFOC (cm)	N(K))	N(PI)	Accep tance	Pi/K
open	4	open	open	86536	178	5.2	1.23
6	4	open	open	80866	262	4.9	1.94
6	4	1.6	open	79630	38	4.8	0.29
6	4	1.2	open	76407	26	4.6	0.20
6	4	1.2	+5,-15	74342	9	4.5	0.07
open	5	open	open	91557	316	5.5	2.07
6	5	open	open	85043	451	5.1	3.18
6	5	1.6	open	83978	56	5.0	0.40
6	5	1.2	open	80034	38	4.8	0.28
6	5	1.2	+5,-15	77557	17	4.7	0.13

Cloud pion contamination

Table 4: Cloud pions as function of slit apertures

MS1 (mm)	IFY (mm)	N(pions)	
5	open	14,994	
5	6	902	
4	open	11,563	Pi/K~5
4	6	364	Pi/K~0.16

Muon contamination

Table 7: Muon contamination as function of slit apertures.

IFY (mm)	MS1 (mm)	HFOC (cm)	N(pions)	K/Mu
open	5	open	1970	2.33
open	5	1.2	684	0.81
6	5	open	695	0.82
6	5	1.2	190	0.22
open	4	open	1477	1.75
open	4	1.2	588	0.70
6	4	open	544	0.64
6	4	1.2	145	0.17

Summary of the K1.1BR beam

- Acc = 4.5 msr % $\Delta p/p$

  c.f. Acc (K1.1) ~ 2 msr % $\Delta p/p$
  Acc (LESB3) ~ 50 msr % $\Delta p/p$

- $I_{K^+} \sim 2.1 \times 10^6$/s

- $\pi^+(\mu^+)/K^+ \sim 0.6$ assuming $\sigma_\pi/\sigma_K = 600$

- Beam spot : $d_x \sim d_y \sim 1$ cm << @K5
  (old calculation)

n-value in B1

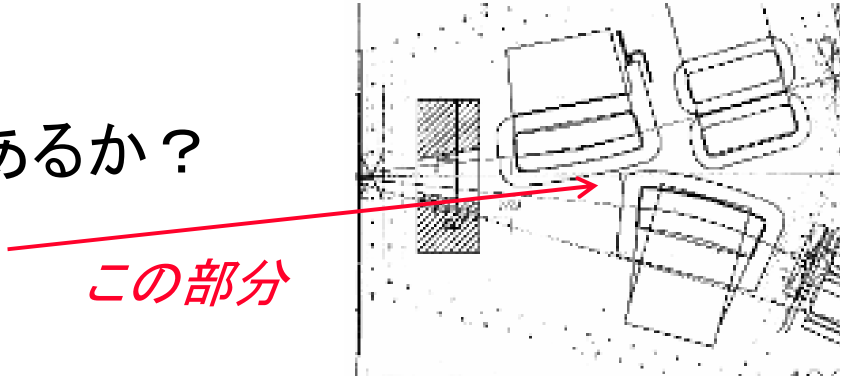
最近の検討で、第一エレメントをCombined-function magnet とすると
アクセプタンスが大幅に改善されることが判明。

- BY(x,0)=BY(0,0)*(1-*n*x/rho)

- TRANSPORT input
  4.000 'B1 ' 0.80000 10.47709 -6.74614;
  Q2 is turned off

アクセプタンス Ω＝8.0 msr%(Δp/p)
1.75 倍の増加！

チェックすべき課題:
1）K1.1ビーム光学が可能であるか？
2）構造的、技術的問題



K1.1-BR 今後の進め方

- FIFCレビューア Phil Pile氏の助言の検討
  - 2~3のスリットの追加の可能性
  - 更なるK/π比改善の努力

- 検討結果を”K0.8 beam design progress report” として次回のPACへ報告する。

- 素核研/J-PARCにはビームライン設置の計画(年次計画、予算計画)をPACに示すことをお願いする。

第3回PACの助言

- To: E06

The PAC is also concerned that there are several conflicts and interferences between the K0 beamline and K1.1-BR beamline designs, as mentioned in the FIFC report. The discussion on the stage-2 recommendation will be made after we hear from the IPNS/J-PARC management on the realistic plan of the beamline.

- To : IPNS/J-PARC

The PAC considers that it is important for the IPNS/J-PARC management to develop a realistic plan for the completion of the beam lines.

……………………..

まとめ

- E06 (TREK) 実験のためのK1.1-BRの詳細な検討が進んでいる。K1.1-BRとして理想的な光学はほぼ固まっている。

- ビームラインの早期の実現のためには、K1.1ビームも含めた全体の計画が１日も早くできている必要。K1.1の実験提案が早く出てくることを望みたい。

- PACからの宿題であるK0とK1.1干渉問題の解決と、K1.1先頭部の設置時期の計画策定は、ハドロンビームライングループに依存している。宜しくお願いします。