πE3 secondary beam line

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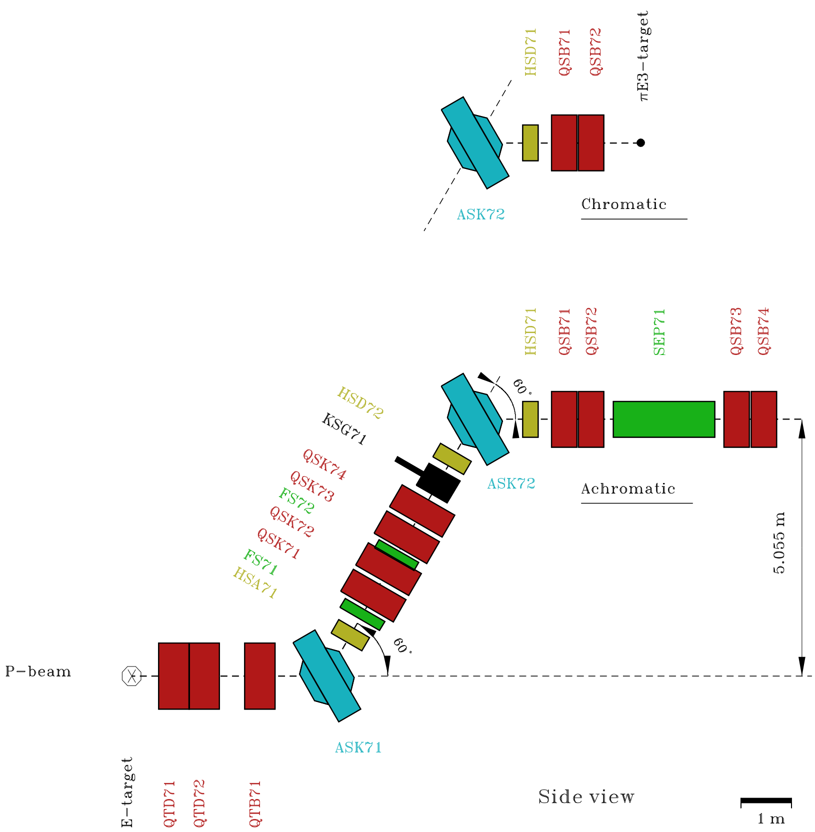
PSI october 1997

πE3



πE3

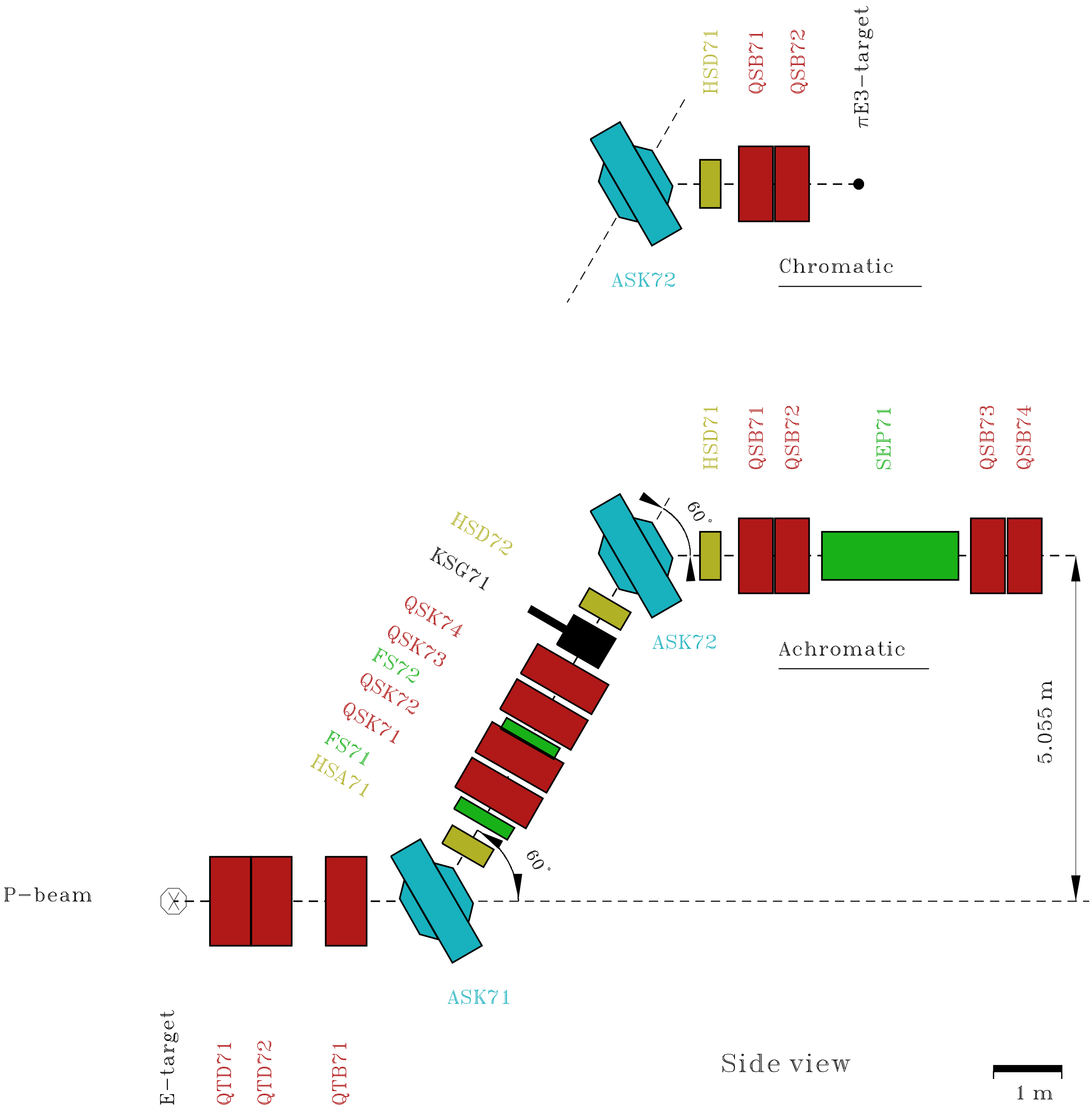


Figure 1: πE3 beam line

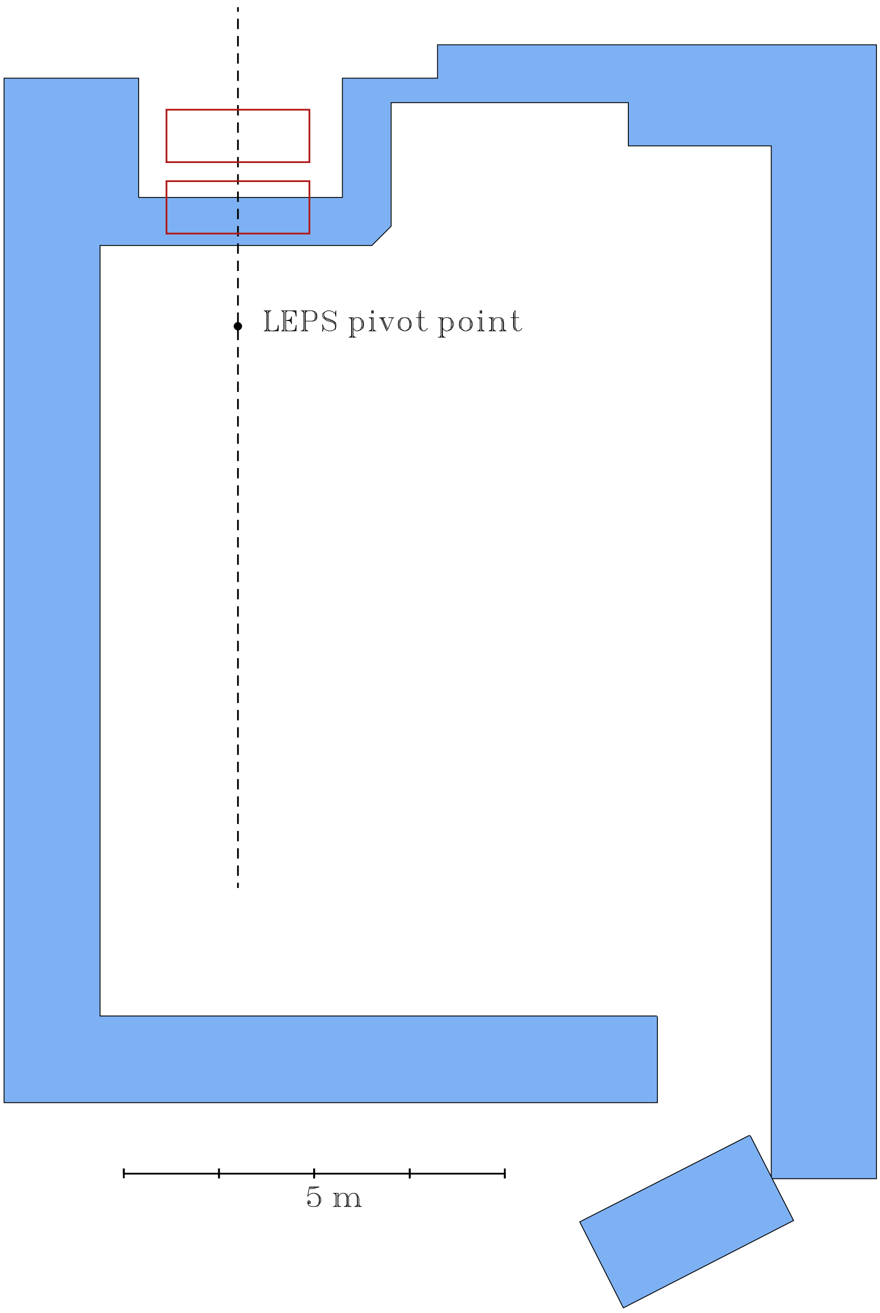
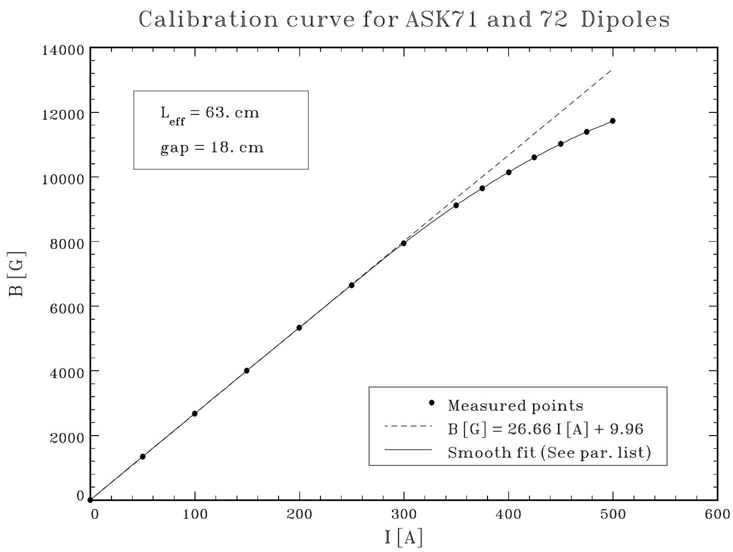
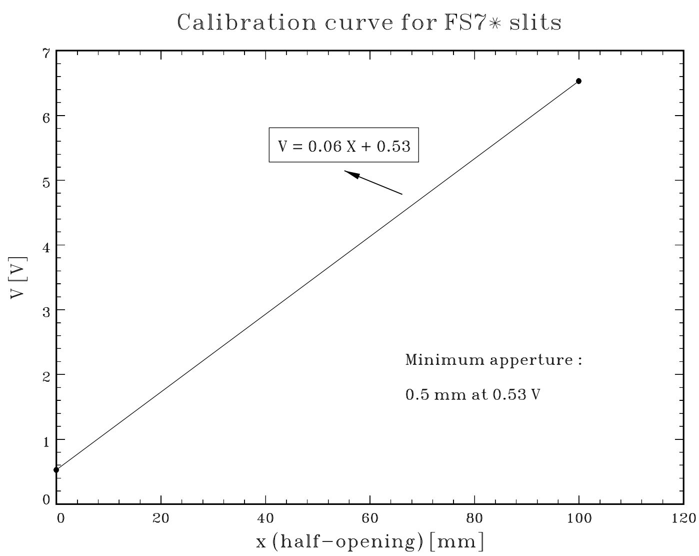


Figure 2: Lyout of the πE3 area

1 πE3 beam line

The **πE3** beam line was specially designed to match the optical characteristics of the low energy pion spectrometer LEPS. It is the only beam line with vertical bending plane, the experimental area being 6 m above the ground ! Two optical version have been worked out : a hight resolution **chromatic** mode and a large acceptance **achromatic** one. The beam line contains two non standard ASK bending magnets with non symmetric with extremely curved pole faces. Corresponding excitation is given below. In order to correct for some optical abberations three sextupoles are included in the beam line.
There are two pair of slits (in bending and non bending plane) allowing to either reduce the beam intensity or the accepted momentum range. Both have the same calibration given in a figure.
For low energy μ or π, the power supplies of the quadrupoles can also be set to 20 % ,in order that for low excitation to not be in the lower part of the current range.





1.1 Chromatic mode

The corresponding characteristic are given in the following table. The dispersion plane is the vertical one (y direction) !

Beam line characteristics for **chromatic** version							
Dispersion	L	$\frac{\Delta p}{p}$	$\Delta x'$	Δy	$\Delta y'$	Δp	$\Delta\Omega$
-5 cm/%	13 m	< 0.3 %	50 mrad	12 mm	65 mrad	$\simeq \pm$ 3.4 %	7 msr

In this mode there is a dispersive focus at the position of the second slits (FS72 up-down) in order to reduce the accepted momentum domain ($\simeq 8$ %), otherwise the slits allowed to reduce the intensity. A typical setting is given at the end.

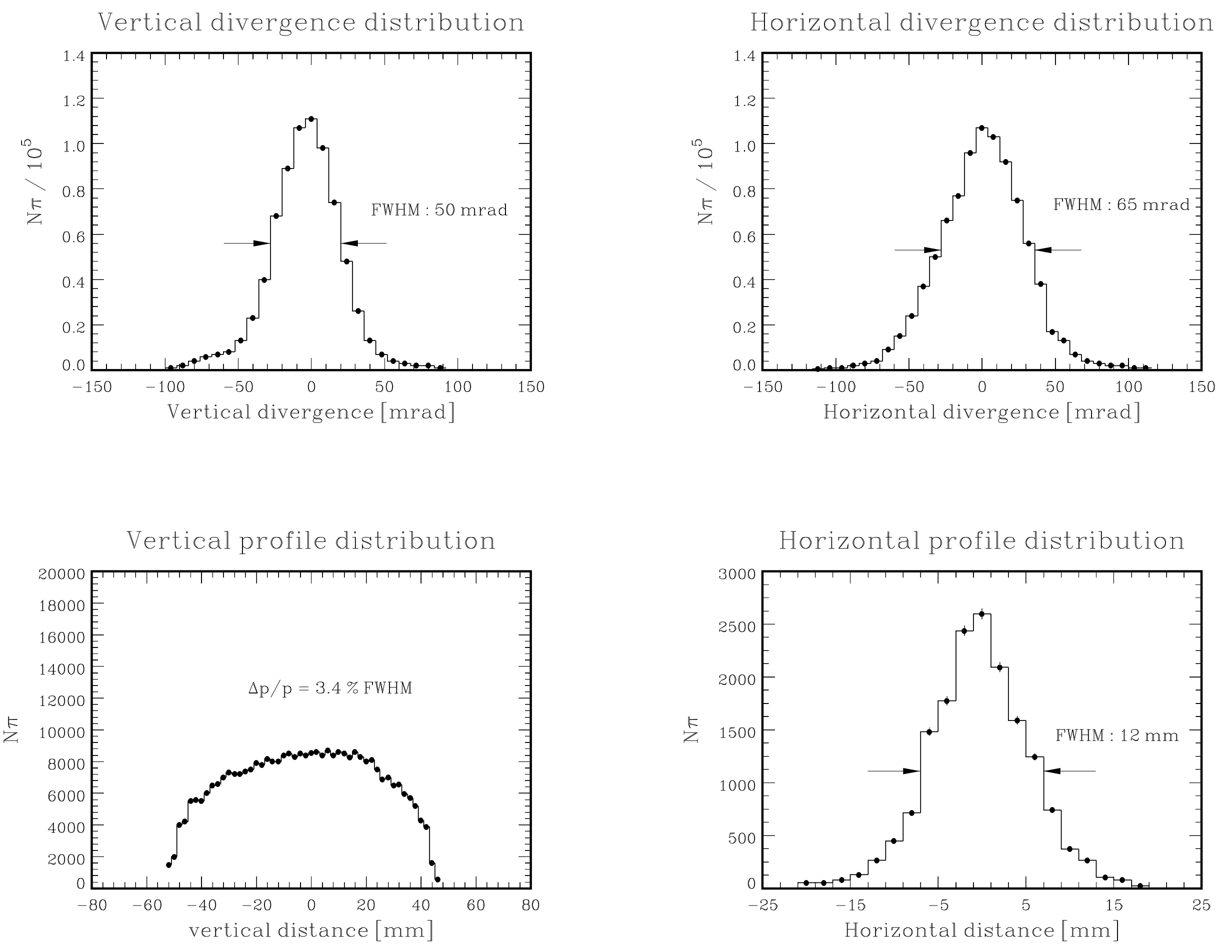


Figure 3: Achromatic phase space in πE3 beam line

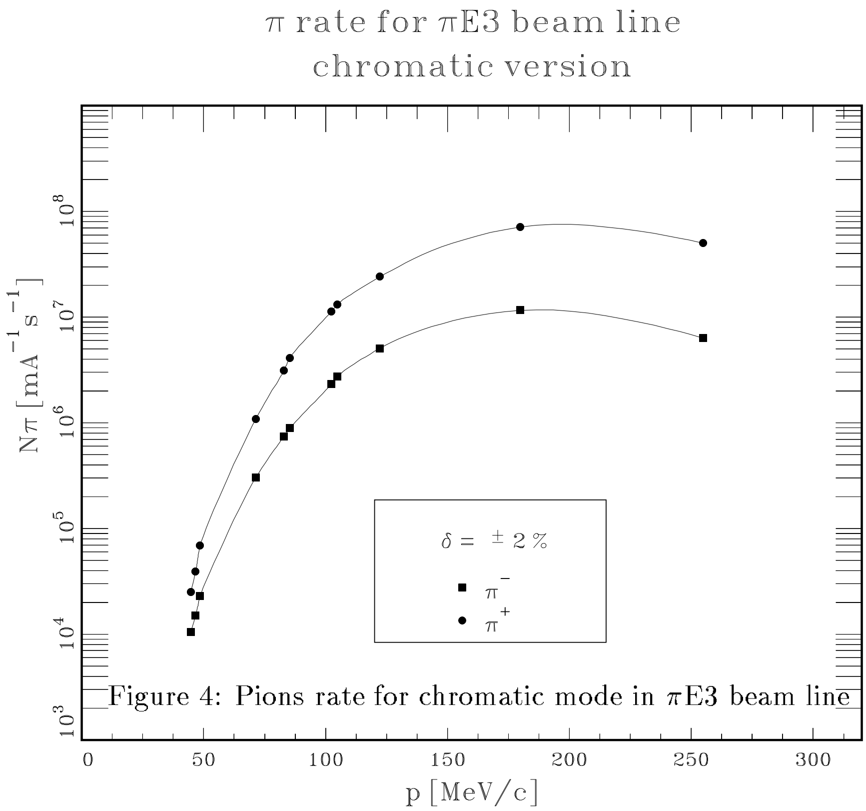


Figure 4: Pions rate for chromatic mode in πE3 beam line

1.2 Achromatic mode

This mode can as well be tuned to produce μ^+ and μ^-. The corresponding measured intensity are given figure 5.

The characteristics at the same target position as for the chromatic mode is given in a table, however usually this mode is used with an extension comprising a separator, a quadrupole doublet and a solenoid. A typical setting is given at the end. There is a possibility to have an **achromatic** mode with a dispersive focus at the position of the first slits, in order to reduced the momentum domain. Otherwise in this mode the slits are only reducing the intensity.

Beam line characteristics for **achromatic** version						
L	Δx	$\Delta x'$	Δy	$\Delta y'$	Δp	$\Delta\Omega$
13 m	15 mm	80 mrad	30 mm	20 mrad	$\simeq$ 8 %	13 msr

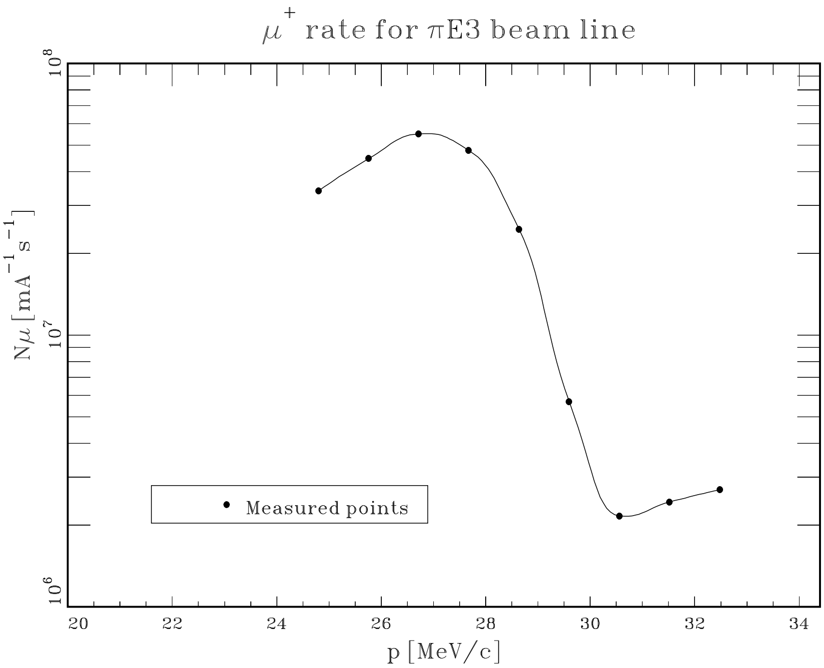


Figure 5: Muon rate for achromatic mode in πE3 beam line

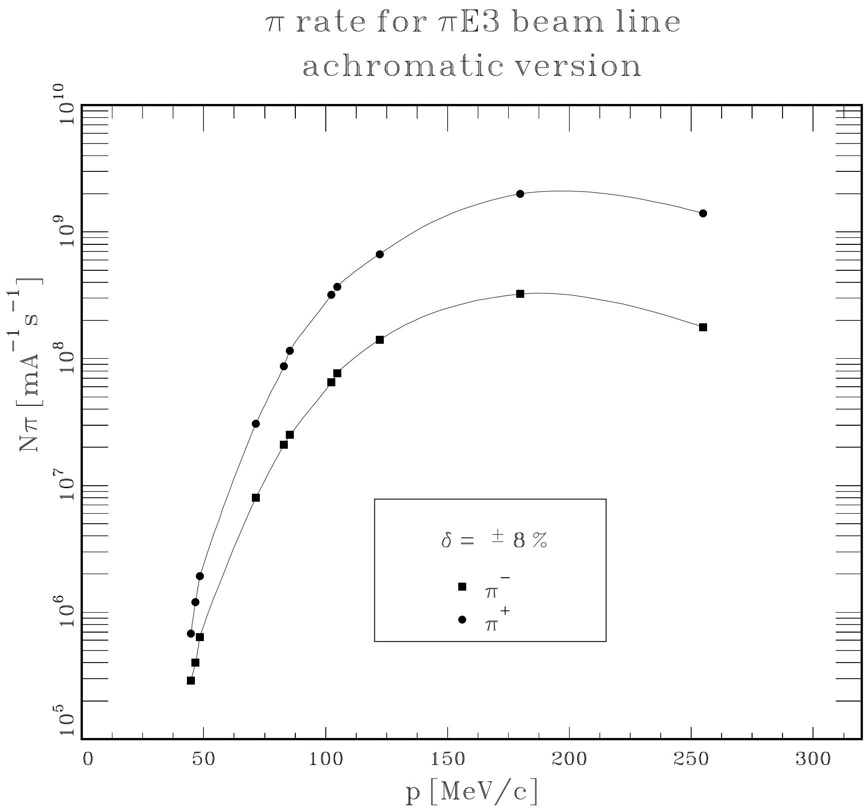


Figure 6: Pion rate for achromatic mode in πE3 beam line

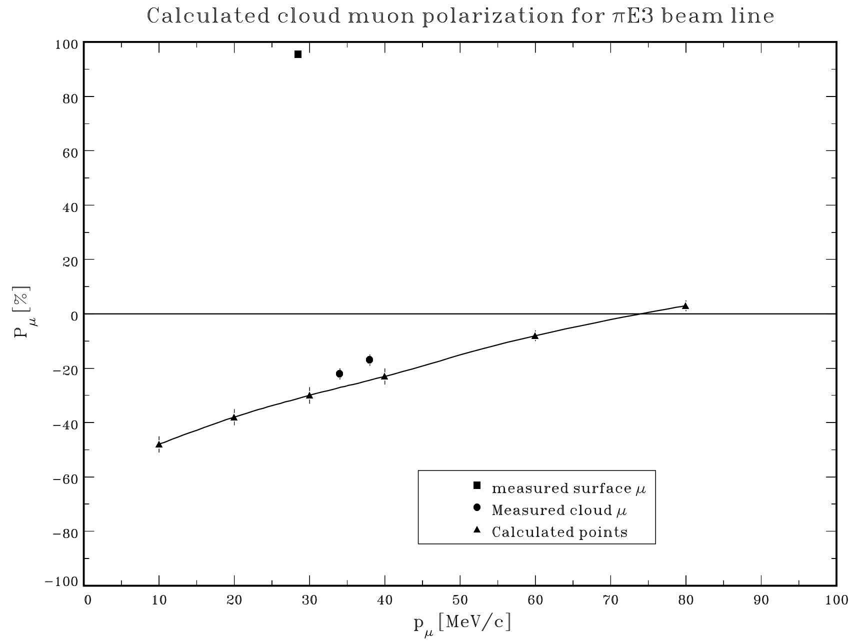


Figure 7: Muon polarization in πE3 beam line

1.3 Some other informations

- At **Leps** pivot point the beam's hight is 150.5 cm
- Down stream the pivot it is 155.5 cm
- There is a possibility of inserting one or two Mylar degrader foils. This degrader is just before the FS71 slits. The available thickness are 200 μm and 400 μm
- If an end beam window is needed, it is of Mylar and has usually 150 μm
- The standard beam pipe diameter is 320 mm
- The DAC values for the slits run from 0 to 600

In case of problems contact :

- for **electricity** : A Widmer , M Horvat
- for **cooling water** : Markus Koller
- for **beam setting** : U Rohrer
- for **vacuum system** : U Kalt
- for **separator** : P Gheno
- for **Experimental hall** : H Vetterli
- for **SU** : W Wittwer

1.4 On beam setting

There are **two** PC available for πE3 beam line :

$$\begin{cases} \text{PC 278} & \text{located in the } \pi\text{E3 barracq} \\ \text{PC 144} & \text{located on the gallery in a CAMAC crate} \end{cases}$$

You work with the PC 278, using mainly the **SETPOINT** facility.
The corresponding CAMAC address and magnet identification are in the : **device.lis** file (in OPTIMA).If you change the device.lis, start SETPOINT again. You might have setting saved in a **.set** file (in SETPOINT) , which can be loaded, or created.

However :

If you have to change the **device.lis** file, you have to do it **in** the **PC144**

More information are to be found in :

http://www.psi.ch/verb+ +Rohrer/secblctl.html

For this go into the PSI home page : http://www.psi.ch and click on Departments and Projects , and then on Experimental Facilities (AEA) and finally on Control system for secondary beam lines.

There is possibility to have a scaling factor of 20 % for the quadrupoles. On the gallery where the power supplies are, you have on each quadrupole power supply a button which can be set either to 100 % or to 20 %. This allows a better setting of the quadroples when you work with low momenta particles. However if you change this scaling factor you have to do it also in the **device.lis** file, otherwise the conversion DAC-ADC will be wrong !!

To convert from DAC value to Field value you can use the **Itune** programme. There is a manual for the **Tune** , **Itune** , **DAC_to_B** and **B_to_DAC** programme by F Foroughi.

Examples are given at the end.

The structure of the **device.lis** file is :

Device name	DAC-special	ROAD add	CAMAC station Nb	DAC min	DAC max	DAC-type	ADC-parameter	ROAD add	CAMAC station Nb	ADC-channel	Range	ADC-type	Scale (normal=1.0)	Precision DAC-ADC
QTD71	0	1	3	-4095	4095	2	1	1	3	0	0	2	0.200	0.100
QTD72	0	2	3	-4095	4095	2	1	2	3	0	0	2	0.200	0.100
QTB71	0	3	3	-4095	4095	2	1	3	3	0	0	2	0.200	0.100
ASK71	0	9	5	-4095	4095	2	1	9	5	0	0	2	1.000	0.100
HSA71	0	1	5	- 750	750	5	1	1	5	0	0	5	1.000	0.100
QSK71	0	9	3	-4095	4095	2	1	9	3	0	0	2	0.200	0.100
QSK72	0	10	3	-4095	4095	2	1	10	3	0	0	2	0.200	0.100
QSK73	0	11	3	-4095	4095	2	1	11	3	0	0	2	0.200	0.100
QSK74	0	12	3	-4095	4095	2	1	12	3	0	0	2	0.200	0.100
HSA72	0	4	5	-4095	4095	2	1	4	5	0	0	2	1.000	0.100
ASK72	0	10	5	-4095	4095	2	1	10	5	0	0	2	1.000	0.100
HSD71	0	3	5	-4095	4095	2	1	3	5	0	0	2	1.000	0.100
QSB71	0	4	3	-4095	4095	2	1	4	3	0	0	2	0.200	0.100
QSB72	0	5	3	-4095	4095	2	1	5	3	0	0	2	0.200	0.100
QSB73	0	6	3	-4095	4095	2	1	6	3	0	0	2	0.200	0.100
QSB74	0	8	3	-4089	4095	2	1	8	3	0	0	2	0.200	0.100
*														
SEP	0	11	5	-2047	2047	5	1	11	5	0	0	5	1.200	0.100
FS71-O	0	0	6	0	1000	9	1	0	6	0	0	9	4.095	0.100
FS71-U	0	1	6	0	1000	9	1	1	6	0	0	9	4.095	0.100
FS71-L	0	0	8	0	1000	9	1	0	8	0	0	9	4.095	0.100
FS71-R	0	1	8	0	1000	9	1	1	8	0	0	9	4.095	0.100
FS72-O	0	0	9	0	1000	9	1	0	9	0	0	9	4.095	0.100
FS72-U	0	1	9	0	1000	9	1	1	9	0	0	9	4.095	0.100
FS72-L	0	0	10	0	1000	9	1	0	10	0	0	9	4.095	0.100
FS72-R	0	1	10	0	1000	9	1	1	10	0	0	9	4.095	0.100

A * means newpage.

For more informations see the corresponding WWW pages !

1.5 Separator 1

When all connections are done and the vacuum is : $\leq 2\,10^{-6}$ mbar then you can start the conditioning of the sparator **1** (0.7m).

- If you need gas (He-Ne) change the position of the setting from **cond** to Betr[1] and with the setting point enter gas at about $2\,10^{-4}$ mbar pressure
- If you don't want gas, check that the setting is on **cond**

When this has been done, proceed in the following way :

- Set the voltage to 10 KV and the current to 17 μA (See the table) and wait until the current stabilizes to this value
- Continue to increase the voltage in 10 KV or 5 KV step (see table) by adjusting correspondingly the current, and always **wait** until the current stabilizes to the given value
- Continue until you reach the wanted value for your high voltage.
- If you need more than 100 KV, go to a higher value, and then go back to the wanted one

> Don't go too fast, the reward could be **no** separator

The maximum electric potential is 150 kV, and the maximum magnetic field is 500 G

> For the moment only **negative** electric field is applicable
> (see next page)

[1] **Cond**itionning and **Betr**ieb

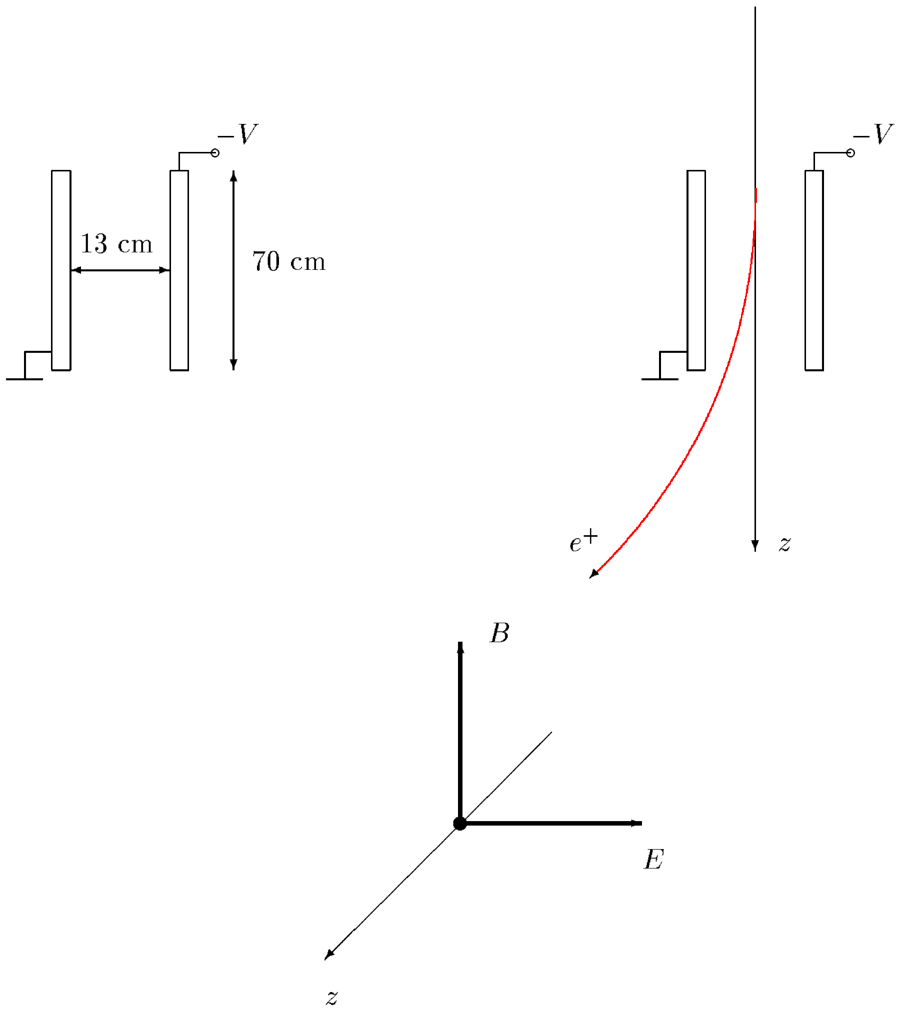


Figure 8: Electrodes arrangement and fields for **positively** charged particles

The hight of the electric electrode (polished Al) is : 22 cm

Note that the μ^+ helicity turns anti-clockwise in the above configuration !!

In a direct coordinate system the angular deflection is given by

$$\frac{dy}{dz} = \frac{1}{p}\left\{ \frac{E}{\beta} L_e - 0.3\, B\, L_m \right\} \qquad \text{[mrad]}$$

With :

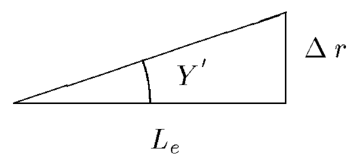
- p — The momentum in MeV/c in the z direction
- E — The electric field in kV/m, in the y direction (here the horizontal one)
- L_e — The effective length of the electric field in m, in the z direction
- B — The magnetic field in Tesla, in the x direction (here the vertical one)
- L_m — The effective length of the magnetic field in the z direction
- β — The velocity : $\beta = \dfrac{p}{\sqrt{m^2 + p^2}}$,where m is the mass of the particle

For two different types of particle, with mass $m_1 > m_2$ and thus $\beta_1 < \beta_2$ but with the same momentum, the angular separation Y' is :

$$Y' = \frac{E}{p} L_e \left\{ \frac{1}{\beta_1} - \frac{1}{\beta_2} \right\} \qquad \text{[mrad]}$$

and the separation in radial direction is :

$$\Delta r = L_e \,\mathrm{tg}\,\left(\frac{180\, Y'}{1000\, \pi}\right) \qquad \text{[m]}$$



If the applied potential is V (in kV) and the gap g (here 0.13 m) then

$$E = \frac{V}{g} \qquad \text{[kV/m]}$$

When working with the separator you have two main valves :

VSD71 After the last dipole ASK71

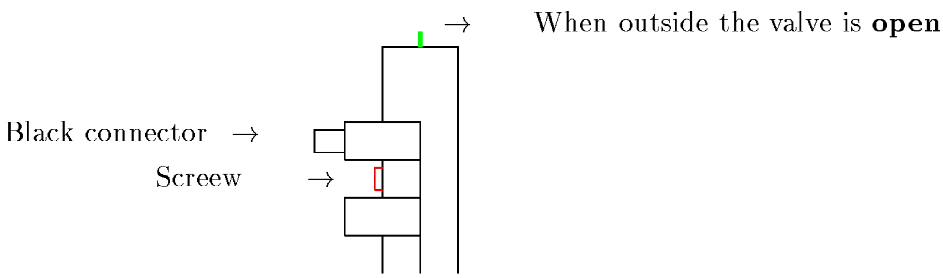
VSD72 After the QSB72 quadrupole and before the separator

which close are open **together with** the KANALVERSCHLUSS.
If for some reason you find out that they don't and remain closed, you have to go on the galeri, to the set point of VSD71 and VSD72 , and there :

- Change the button position from **F** (fern) to **L** (local)
- Push the button **Sv** (sharf)
- Push the button back from **L** to **F** (fernt)

The indication should go from VG_g to VG_o[2]

if you want to close the valve after the separator, you have to do it per hand. On top of the valve, bellow the black connector (see figure) there is a screew, which when turned to the left closes the valve and open it when turned to the right !!



[2]**o** for open, and **g** for closed (geschlossen)

Table of $I = I(V)$ for the separator 1

E KV	I μA
10	17
20	34
30	50
40	70
45	78
50	86
55	94
60	103
65	111
70	120
75	129
80	137
85	147
90	155
95	164
100	173
105	181
110	189
115	120
120	207

πE3 slits in Achromatic mode

FS71

Reduces beam **intensity**

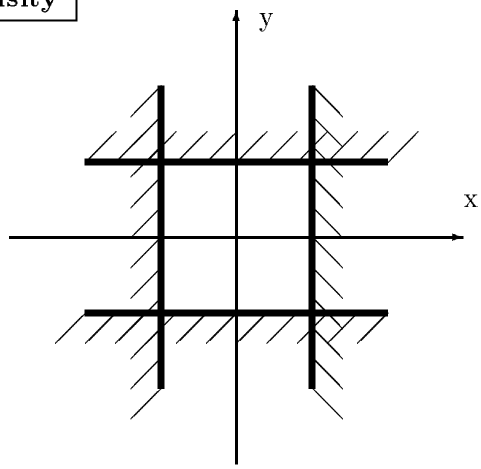
Located between HSA71 and QSK71 (see fig 1)

Maximal opening ± 10 cm (i.e, 20 cm)

Calibration :

$$x \text{ or } y = \pm 10 \times \frac{\text{DAC} - 53}{600} \; cm$$

The four jaws move indepentently .



FS72

Reduces beam **intensity**

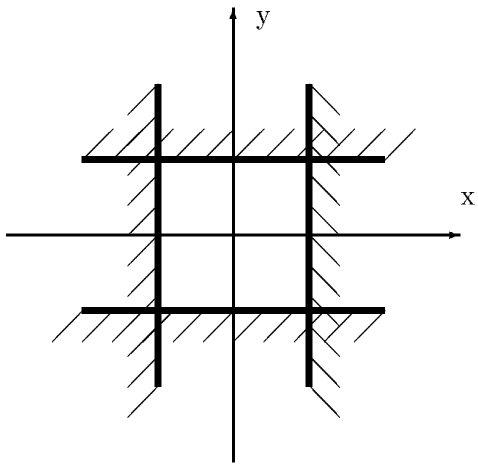
Located between ASK72 and ASAK73 (see fig 1)

Maximal opening ± 10 cm (i.e, 20 cm)

Calibration :

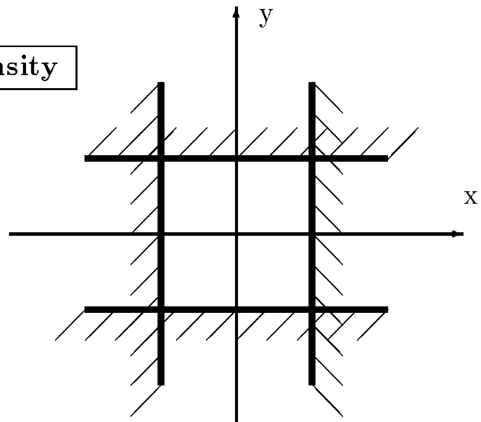
$$x \text{ or } y = \pm 10 \times \frac{\text{DAC} - 50}{600} \; cm$$

The four jaws move indepentently .



πE3 slits in Chromatic mode

FS71 — Reduces beam **intensity**

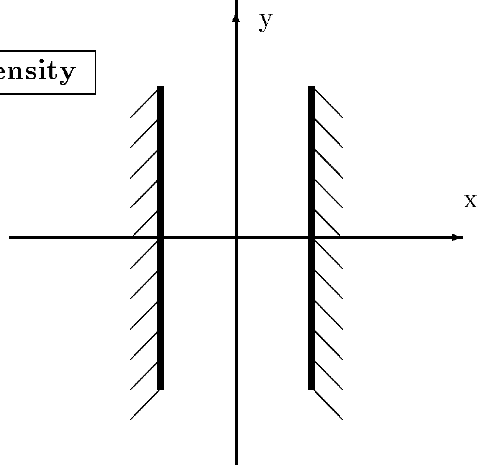


Located between HSA71 and QSK71 (see fig 1)
Maximal opening ± 10 cm (i.e, 20 cm)
Calibration :

$$x \text{ or } y \;=\; \pm 10 \times \frac{\text{DAC} - 53}{600}\; cm$$

The four jaws move indepentently .

FS72 (L/R) — Reduces beam **intensity**

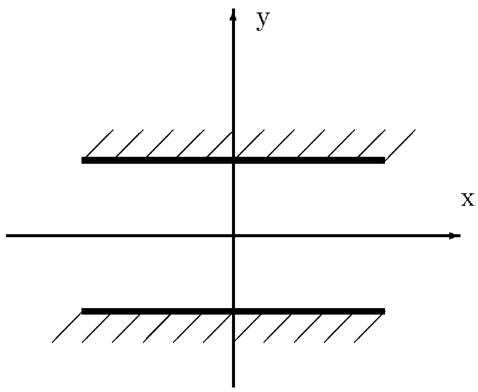


Located between QSK72 and QSK73 (see fig 1)
Maximal opening ± 10 cm (i.e, 20 cm)
Calibration :

$$x \;=\; \pm 10 \times \frac{\text{DAC} - 53}{600}\; cm$$

The two jaws move indepentently.

FS72 (O/U) — Reduces beam **momentum** bite



Located between ASK72 and ASK73 (see fig 1)
Maximal opening ± 10 cm (i.e, 20 cm)
Calibration :

$$y \;=\; \pm 10 \times \frac{\text{DAC} - 53}{600}\; cm$$

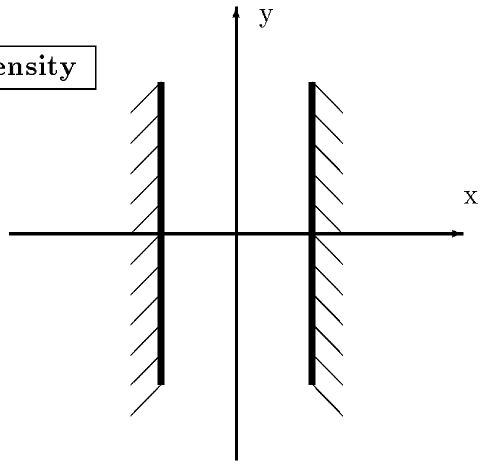
Beam[3] dispersion $\simeq\; -5$ cm/%
E,g DAC = 353 ; X = $\pm$ 5 cm ;

$$\frac{\Delta p}{p} \;=\; 1\,\%\ (2\ \%\ \text{FWHM})$$

The two jaws move independently.

[3] Here the bending plane is the vertical one !!

πE3 slits in Mixt mode



FS71 (L/R)

Reduces beam **intensity**

Located between HSA71 and QSK71 (see fig 1)
Maximal opening ± 10 cm (i.e, 20 cm)
Calibration :

$$x = \pm 10 \times \frac{\text{DAC} - 53}{600} \; cm$$

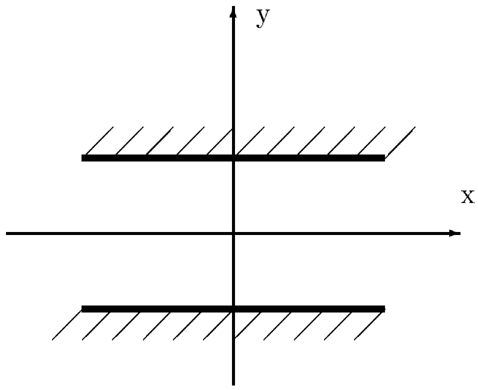
The two jaws move indepentently.

FS71 (O/U)

Reduces beam **momentum** bite

Located between HSA71 and ASK71 (see fig 1)
Maximal opening ± 10 cm (i.e, 20 cm)
Calibration :

$$y = \pm 10 \times \frac{\text{DAC} - 53}{600} \; cm$$

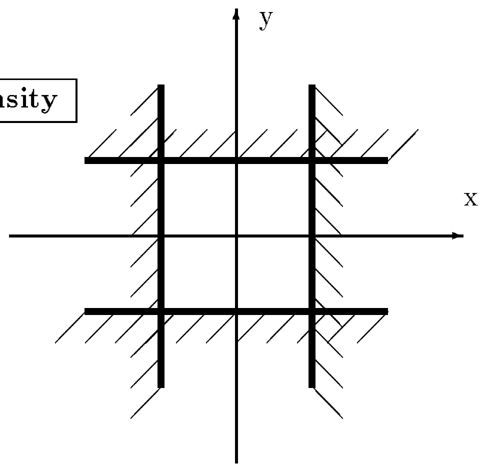


Beam[4] dispersion $\simeq -2.5$ cm/%

E,g DAC = 353 ; X = $\pm$ 2.5 cm ;

$\frac{\Delta p}{p} = 1\,\%$ (2 % FWHM)

The two jaws move independently.



FS72

Reduces beam **intensity**

Located between QSK72 and QSK73 (see fig 1)
Maximal opening ± 10 cm (i.e, 20 cm)
Calibration :

$$x \text{ or } y = \pm 10 \times \frac{\text{DAC} - 53}{600} \; cm$$

The four jaws move independently.

[4] Here the bending plane is the vertical one !!

Table I. Coefficients for the calibration of magnetic elements

$B = a_0 + a_1 I + a_2 I^2 + a_3 I^3 + a_4 I^4$ [B] = G ; [I] = A

	Coefficients				
Element	a_0	a_1	a_2	a_3	a_4
QTA	12.00	25.113	$-.2946\ 10^{-1}$	$+.182\ 10^{-3}$	$-.36\ 10^{-6}$
QTB	1.933	16.011	$-.7186\ 10^{-2}$	$+.432\ 10^{-4}$	$-.63\ 10^{-7}$
QTD	1.933	16.011	$-.7186\ 10^{-2}$	$+.432\ 10^{-4}$	$-.63\ 10^{-7}$
QTH	7.647	18.10	$-.4520\ 10^{-2}$	$+.333\ 10^{-4}$	$-.61\ 10^{-7}$
QSB	0.	17.066	$+.9412\ 10^{-2}$	$-.361\ 10^{-4}$	$+.10\ 10^{-7}$
QSE	.1541	14.125	$+.4991\ 10^{-2}$	$-.132\ 10^{-4}$	
QSF	.8402	9.1893	$-.3735\ 10^{-2}$	$+.254\ 10^{-4}$	$-.32\ 10^{-7}$
QSL	0.	18.092	$+.4228\ 10^{-3}$		
QSK	7.135	18.2460	$-.9022\ 10^{-2}$	$+.528\ 10^{-4}$	$-.79\ 10^{-7}$
HSA	13.47	62.384	$-.2505\ 10^{+0}$	$-.225\ 10^{-2}$	
HSB	13.47	62.384	$-.2505\ 10^{+0}$	$-.225\ 10^{-2}$	
HSC	1.145	9.2268			
HSD	12.33	9.6336	$+.4849\ 10^{-1}$	$-.279\ 10^{-3}$	$+.37\ 10^{-6}$
ASK*	10.02	25.722	$+.1256\ 10^{-1}$	$-.341\ 10^{-4}$	
ASK**	7.51	19.291	$+.9420\ 10^{-2}$	$-.256\ 10^{-4}$	
ASL	0.	32.256	$-.3116\ 10^{-2}$		
ASM	7.31	25.967			
ADT	1.83	12.445			
ASX	3.91	21.382	$+.1040\ 10^{-1}$	$-.223\ 10^{-4}$	
ASY	20.8	23.974	$-.1655\ 10^{-2}$		
ASZ	7.31	25.967			

* ASK 61,62,71,72,81 and 82 ; ** ASK 31 and 32

Setting for πE3

P = 28. MeV/c Particle : μ^+ Mode : **Achromatic**

Elements	B [KG]	I [A]	DAC	$\frac{I}{Imax} \cdot \frac{100}{r}$	r Range factor	Imax [A]
QTD 71	0.5642	35.76	1464	0.358	20	500
QTD 72	-0.3669	-23.21	-950	0.232	20	500
QTB 71	0.1195	7.47	306	0.075	20	500
ASK 71	1.5994	59.34	486	0.119	100	500
HSA 71	0.0966	1.37	56	0.027	100	50**
QSK 71	0.4951	27.35	448	0.109	100	250
QSK 72	0.022	0.83	68	0.017	20	250
QSK 73	-0.5577	-30.85	-1263	0.309	20	500
QSK 74	0.6221	34.46	1411	0.345	20	500
HSD 72	-0.2016	-18.12	-371	0.091	100	200*
ASK 72	1.5017	55.68	456	0.111	100	500
HSD 71	-0.3828	-33.67	-689	0.168	100	200
QSB 71	0.257	14.49	593	0.145	20	500
QSB 72	-0.081	-4.57	-187	0.046	20	500
SEP 71	1.	0.1	4	0.002	100	50
QSB 73	-0.6187	-34.91	-1429	0.349	20	500
QSB 74	0.7058	39.83	1631	0.797	100	50**

Example for QTD 71 : $\frac{I}{Imax} \frac{100}{r} = \frac{35.76}{500} \times \frac{100}{20} = 0.358$

$\frac{35.76}{500} \times \frac{100}{20} = 0.3576 \rightarrow \text{DAC} = 0.3576 \times 4095 = 1464$

* : HSA72 is the name of its power supply **2048 instead of 4095 !!

Setting for πE3

P = 130. MeV/c Particle : $\boldsymbol{\pi^+}$ Mode : **Leps**

Elements	B [KG]	I [A]	DAC	$\frac{I}{Imax} \cdot \frac{100}{r}$	r Range factor	Imax [A]
QTD 71	-3.1407	-198.63	-1627	0.397	100	500
QTD 72	1.5678	99.84	818	0.2	100	500
QTB 71	-0.0157	-0.88	-36	0.009	20	500
ASK 71	6.8938	258.95	2121	0.518	100	500
HSA 71	0.0771	1.05	43	0.021	100	50**
QSK 71	-0.13	-6.89	-564	0.138	20	250
QSK 72	0.5005	27.65	453	0.111	100	250
QSK 73	0.9707	53.97	442	0.108	100	500
QSK 74	-0.2292	-12.45	-510	0.124	20	500
HSD 72	-0.2687	-24.29	-497	0.121	100	200*
ASK 72	6.4313	241.37	1977	0.483	100	500
HSD 71	-1.4995	-123.78	-2534	0.619	100	200
QSB 71	-0.4577	-25.81	-1057	0.258	20	500
QSB 72	0.9814	55.46	454	0.111	100	500

Example for QTD 71 : $\frac{|I|}{Imax} \times \frac{100}{r} = \frac{|-198.63|}{500} \times \frac{100}{100} = 0.397$

$\frac{-198.63}{500} \times \frac{100}{100} = -0.3973 \rightarrow \text{DAC} = -0.3973 \times 4095 = -1627$

* : HSA72 is the name of its power supply **2048 instead of 4095 !!