MUSIC tuning-fork

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February 13, 1997

Contents

1 Safety instructions

- The housing of the detector must be connected to the ground of the "Messnetz".
- Don't apply the high voltage to the MUSIC as long as the grey plastic shieldings are removed (except during experiments) !
- Remove shieldings only directly before the cave will be closed and only when the high voltage is switched off !
- Don't switch off or disconnect the power supply of the preamplifiers as long as a signal is applied to the input "Test" or "Detector" !
- Avoid more than 1000 ions/sec. penetrating through the MUSIC when the high voltage is applied ! A higher rate will cause damage of the preamplifiers !

2 Checks before the beam time starts

- Test whether all supplies are properly connected. Check the voltage for the preamplifier and the high-voltage for anodes and cathodes (don't apply more than about 50V to the latter for this test purpose!) The best way to test a proper gas flow is by means of soap bubbles at the gas outlet of the MUSIC.
- Test that the preamplifiers work properly. Apply a pulser signal from the "Messhütte" via the test wires to the preamplifier test input and check the returning signals of the energy branch.

3 Introduction

The MUltiple Sampling Ionization Chamber (MUSIC) [1] is an ionization chamber filled with P10 gas (90% Ar, 10% CH_4) at about room temperature and normal pressure. When an ionizing particle penetrates through the gas, a cloud of electrons and ions is generated and by means of an applied electric field the charged particles drift towards the cathode (positive ions) and to the six-fold segmented anode (electrons). Using charge-sensitive preamplifiers, the charge of the electron cloud arriving at each anode is converted into a voltage which is proportional to the number of electrons. Since the number of generated electrons is roughly proportional to the square of the charge of the penetrating particle, the output voltage of the preamplifier is a measure for the atomic number of this particle. The preamplifier output signal is gained and shaped by a main amplifier and digitized by an ADC and furtheron handled by the data-acquisition system GOOSY. From the six available anodes only the signals of the middle four anodes are used (the first and the last anode serve for homogenity of the electric field and are only connected to the high voltage).

Using an additional, fast detector as a start trigger for a TAC, the drift time of the

[1] M. Pfützner et al., Nucl. Instr. and Meth. B in press,

H. Geissel et al., GSI report 90-1 (1990), 255

M. Pfützner et al., GSI report 91-1 (1991), 288

M. Pfützner et al., GSI report 92-1 (1992), 338

C. Scheidenberger et al., GSI report 93-1 (1993), 193

electron cloud provides information of the x-position of the passing particle. The stop signal for the TAC can be derived from the timing output of the preamplifier, or, like we do usually, from the energy signal of each anode.
Since the amplitude of the energy signal also depends on the atomic density of the gas, which may vary with temperature and pressure of the surroundings, sensors are installed inside the MUSIC in order to monitor those parameters.

4 Setup

All components required for a proper use of the MUSIC and a schematic view of the setup and the electronical components is given if fig. 1.

5 Operation

- gas supply:
  about 30 to 40 hours before the beam-time start a gas flow of about 0.15...0.20 l/min. of P10 gas should be applied to the MUSIC.

- removal of ~~shieldings:~~ protective covers
  the grey shieldings of the MUSIC entrance and exit window should be removed only directly before the cave will be closed. The high voltage must be switched off at this time due to safety reasons.

- power supply:

– preamplifiers: they are supplied from the NIM crate mounted on the S4 support.

– high voltage: the HV is taken from the CAEN crate in the Messhütte of the FRS. The following values should be used to achieve highest drift velocities of the electrons of about $5 cm/\mu s$:

	old MUSIC	new MUSIC
U_{Anode}	+650 V	+650 V
$U_{Cath.}$	−4000 V	−4200 V

- signal processing and adjustment of the electronics:
  ionization-energy loss (ΔE) generates free charge carriers (their number per anode will be n_e) which are collected by the anodes and their total charge (Q) is converted to a voltage (U_{preamp}). For a preliminary adjustment before the beamtime the following equations are helpful:

$$\Delta E \simeq 2073\, eV \times \frac{{Z_1}^2}{\beta^2} \times \left[8.6008 + \ln\left(\beta^2\gamma^2\right) - \beta^2\right] \quad (1)$$

$$n_e \simeq 76.77 \quad \times \frac{{Z_1}^2}{\beta^2} \times \left[8.6008 + \ln\left(\beta^2\gamma^2\right) - \beta^2\right] \quad (2)$$

$$Q \simeq 1.2283 \cdot 10^{-17} As \times \frac{{Z_1}^2}{\beta^2} \times \left[8.6008 + \ln\left(\beta^2\gamma^2\right) - \beta^2\right] \quad (3)$$

$$U_{preamp} \simeq -\frac{0.012283\, mV}{C_{preamp}\langle pF\rangle} \times \frac{{Z_1}^2}{\beta^2} \times \left[8.6008 + \ln\left(\beta^2\gamma^2\right) - \beta^2\right] \quad (4)$$

Here Z_1 is the atomic number of the penetrating ion, β its velocity relative to the speed of light, $\gamma = (1-\beta^2)^{-1/2}$, and C_{preamp} is the capacity of the coupling capacitor of the preamplifier, and U_{preamp} is the peak voltage of the energy signal.

With a gauge capacitor ($C_{gauge} = 8.2\,pF$), see fig. 1, plugged on the input "Detector" of the preamplifier and a pulser ($t_{rise} \simeq 200ns, t_{fall} \geq 10\mu s, U_{pulser}$) the charge of the generated electrons can be simulated according to the following equation:

$$U_{pulser} = \frac{Q}{C_{gauge}} = n_e \times 2 \times 10^{-5} mV \sim 0.012 mV \times \frac{Z_1^2}{\beta^2} \qquad (5)$$

For the adjustment of the electronics in the Messhütte the following parameters of the devices should be noted:

- preamplifier:
  $C_{preamp} \simeq 1 \; or \; 2\,pF$,
  $U_{preamp,max} = 5V$
- main amplifier (e·m 1003):
  bipolar output (+10/−8 V), shaping time 0.5 μs ;
  within an accuracy of 10% the amplitudes of the energy signals of the four anodes should be equal; for this purpose the fine gain of the main amplifiers must be adjusted.
- fast linear amplifier (FL8000):
  input terminated by 50Ω
  unipolar output (-11 ... 0 V), $t_{rise} \simeq 200ns$, $t_{fall} \simeq 600ns$;

serial number 8060: gain = 200

serial number 8061: gain = 20

– ADC (energy):

input terminated by $1k\Omega$,

input range: 0 ... +8V, 2048 channels

– TDC (timing):

input range: 0 ... 10 μs, 2048 channels

Figure 2 shows how the signals should look like for the primary beam (e. g., 500 MeV/u Ti ions). Please note especially the timing of the signals for the ADC gates !

– Sensors for temperature and pressure:

The sensor for the gas pressure works in a range of 800 ... 1300 mbar and delivers an output voltage of 0 ... +5V and a slope of 1V/100mbar. The output voltage of the temperature sensor amounts to 2.2V at 22°C and has a slope of 0.1V/°C.

- data aquisition and analysis:

  Several spectra and pictures are available, for example:

  – spectrum MUSiE(1–4): energy spectrum from each anode (no. 1–4) of MUSIC no. i

  – picture DE_MUSIC(i): geometrical mean of the four energy signals of MUSIC no. i

- spectrum MUSiT(1–4): time spectrum from each anode (no. 1–4) of MUSIC no. i

- Example:

  For example it is desired to observe the energy deposition of a primary-beam Au ion with 700 MeV/u at channel 1200. The adjustment works like the following:

  700 MeV/u corresponds to $\beta = 0.82, \gamma = 1.75$; so according to equation (3) per each anode a total charge $Q = 9.9 \cdot 10^{-13} As$ is generated. So apply a pulser peak voltage of 120mV to the gauge capacitor and connect it with the input "detector" of the preamplifier, terminated by 50Ω. You should measure about 500mV preamplifier-output voltage when a preamlpifier with a 2pF capacitor is used. Since the inputs of the fast amplifiers for the timing are terminated by 50Ω, the energy signal is decreased by a factor of about two. This yields about 250mV at the mainamplifier input in this case. The ADC(energy) has a full range of about 2000 channels corresponding to 8V. Thus $8V \times \frac{1200}{2048} = 4.8V$ should be the output voltage of the main amplifier according to a gain of $4800mV/U_{preamp} = 4800/250 \simeq 20$. Using an adequate trigger for the data-acquisition system you should detect the pulser line as well as the primary beam centered at channel 1200.

For the timing branch only the TAC range has to be adjusted keeping in mind that the maximum drift time of the electrons is less than $5\mu s$.

6 Appendix

6.1 Mechanical dimensions

In the following table all important mechanical dimensions of the available MUSICs are listed according to fig. 3. All dimensions are given in "mm".

Detector	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	window size
A,B(old)	420	90	25	204	23	227	240	80	2	420	575	200 x 200 mm^2
C,D(new)	530	100	60	276	23	299	280	35	2	530	600	450 mm diamete

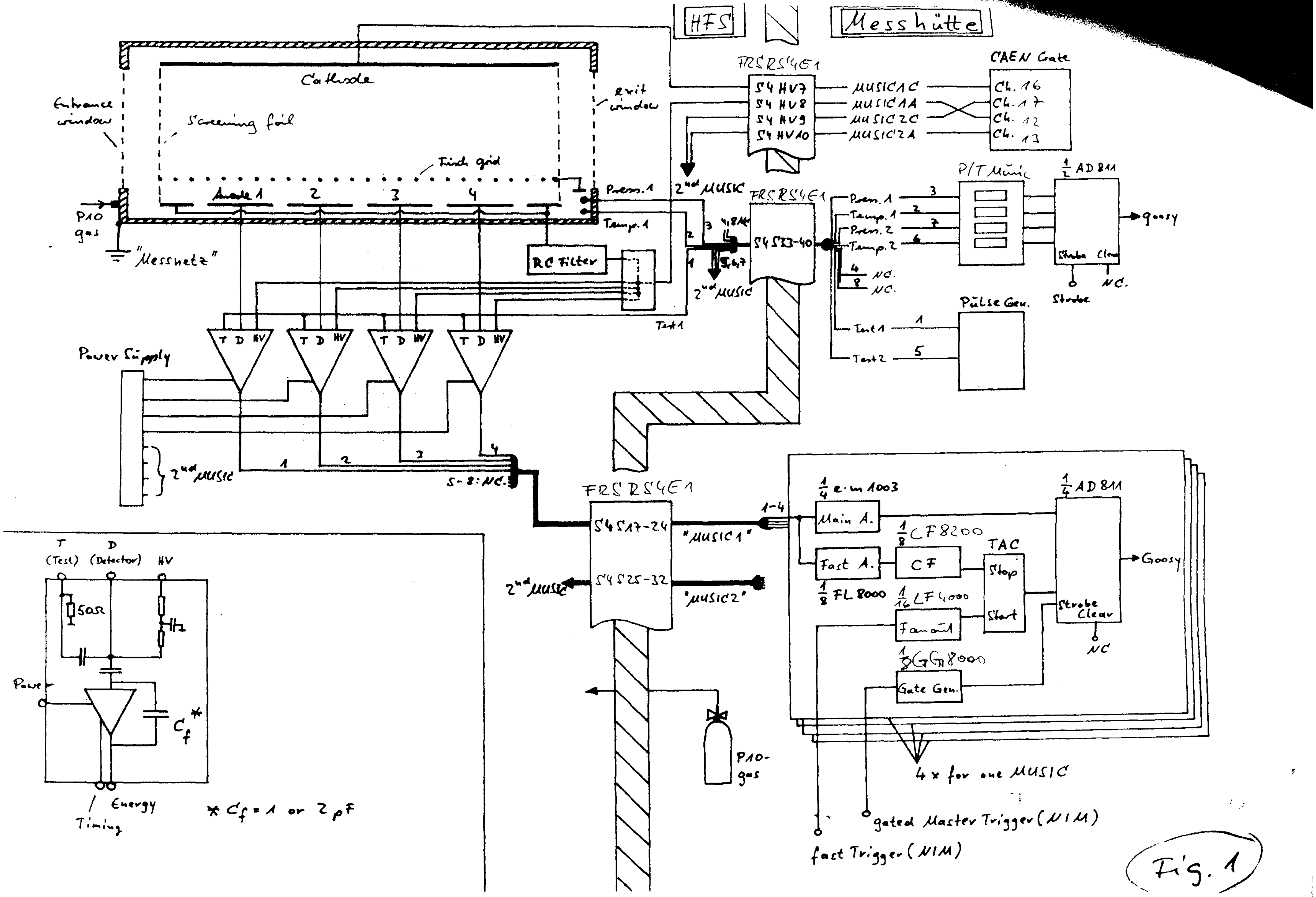
height of anodes: 240 mm (A,B=old); 280 mm (C,D=new);

wire spacing of Frisch grid: 1 mm

wire diameter: 50 μm

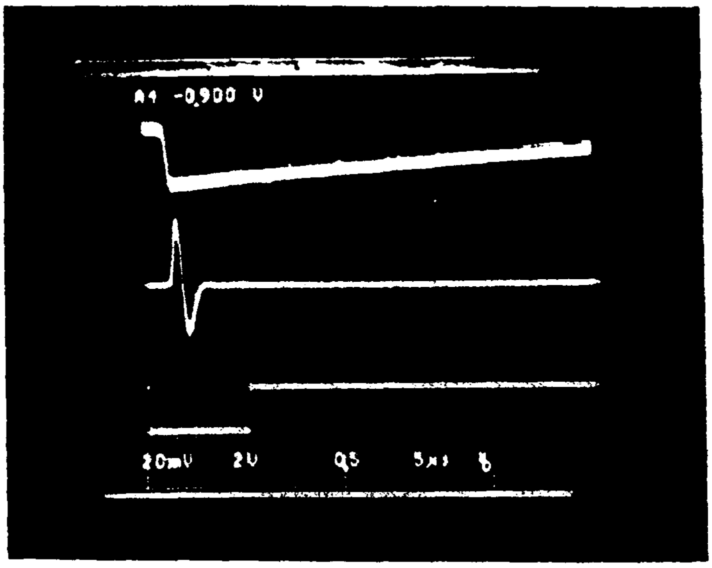
Composition and thickness of materials:

- entrance and exit window:
  25 μm capton ($[C_{22}H_{10}O_5N_2]_n$), $\rho = 1.4 g/cm^3$ coated with $40 \mu g/cm^2$ Al
- screening foil:
  25 μm capton coated with 40 and $80 \mu g/cm^2$ Al, respectively
- gas:
  the "thickness" of the gas corresponds to X11 of the table above;
  the "active thickness" of the gas corresponds to about 4·X2 of the table above.



HFS
Messhütte
Cathode
Entrance window
Screening foil
exit window
Frisch grid
Anode 1
2
3
4
P10 gas
"Messnetz"
Press. 1
Temp. 1
RC Filter
Test 1
Power Supply
T D HV
2nd MUSIC
5-8: NC.
FRS RS4E1
S4 HV7
S4 HV8
S4 HV9
S4 HV10
MUSIC1C
MUSIC1A
MUSIC2C
MUSIC2A
CAEN Crate
Ch. 16
Ch. 17
Ch. 12
Ch. 13
S4 S33-40
Press. 2
Temp. 2
NC.
P/T Music
1/2 AD 811
Strobe
Clear
goosy
Pulse Gen.
Test 2
S4 S17-24
S4 S25-32
"MUSIC1"
"MUSIC2"
P10-gas
1/4 e.m 1003
Main A.
Fast A.
1/8 FL 8000
1/8 CF 8200
CF
TAC
Stop
Start
1/16 LF 4000
Fan out
1/8 GG 8000
Gate Gen.
1/4 AD 811
Goosy
4 x for one MUSIC
gated Master Trigger (NIM)
fast Trigger (NIM)
T (Test)
D (Detector)
HV
50Ω
Power
Energy
Timing
C_f *
* C_f = 1 or 2 pF

Fig. 1

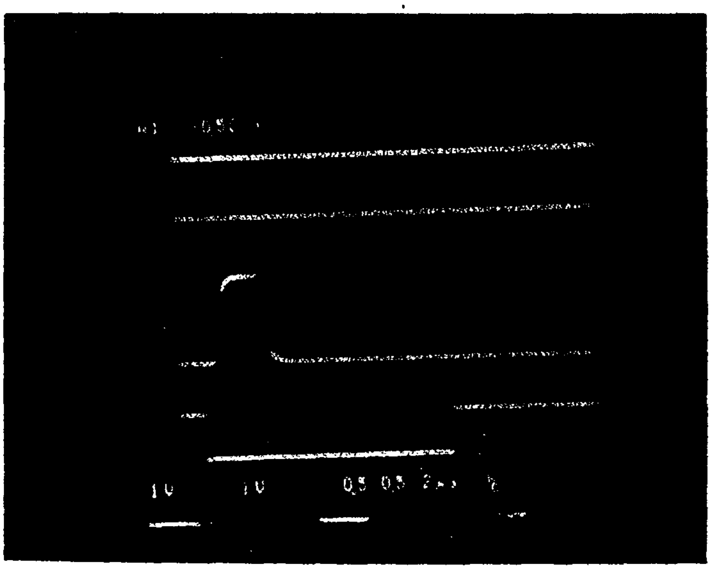


Pre-amp. output

Main-amp. output

ADC strobe

Fig. 2a) Energy branch



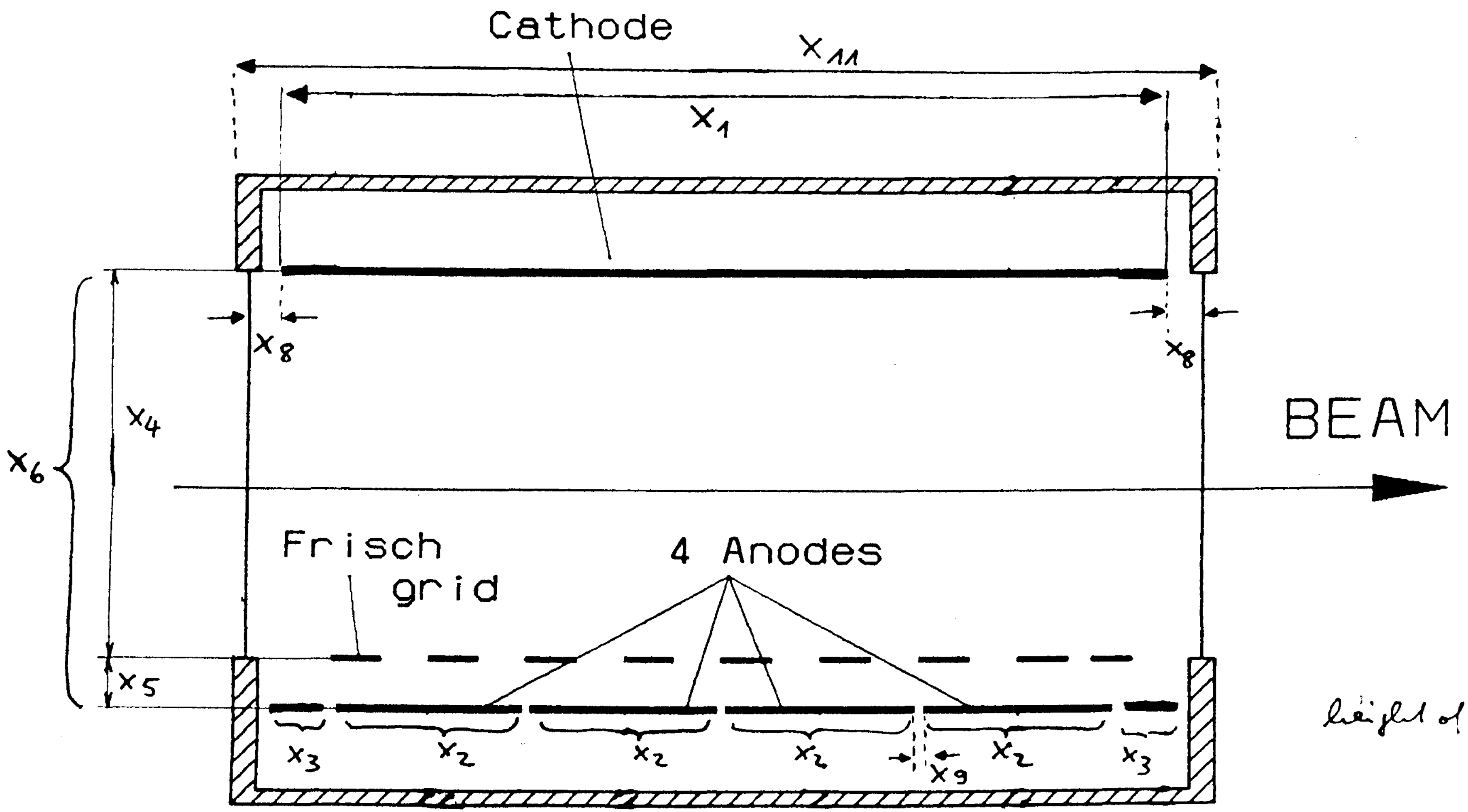
TAC start (from Scint.

TAC stop (from MUSIC

TAC output

ADC strobe

Fig. 2b) Timing branch



height of anodes: x_7

Fig. 3