

Technical Manual

Ionisation Chamber MUSIC80



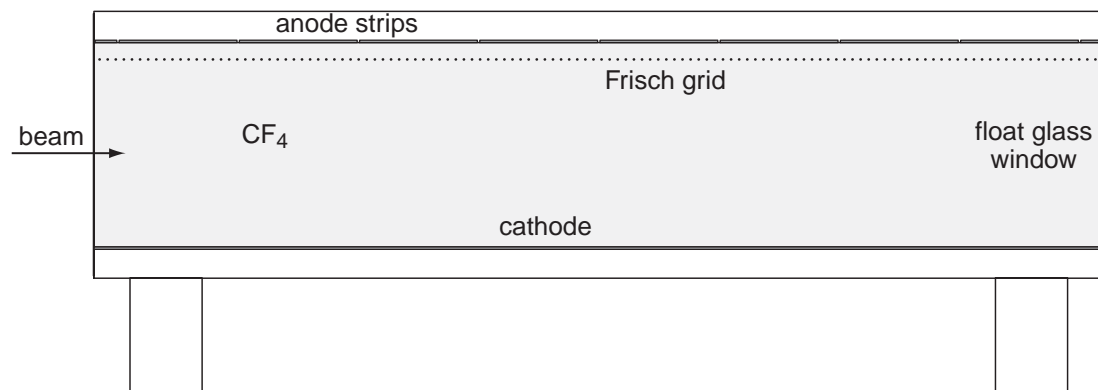
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General Description

The ionisation chamber MUSIC80 is a fast, multiple sampling ionisation chamber with 8 anode strips and a vertical drift length of 80 mm. It is operated with pure CF_4 at room temperature and atmospheric pressure as counting gas. The homogenous entrance windows consisting of thin float glass with integrated field homogenization enable a compact setup. The field homogenization consist of aluminium strips (thickness $1 \mu\text{m}$) deposited on the float glass by photolithography and a voltage divider with resistors glued directly onto the glass plate. The anode strips are read out with an optimised charge sensitive preamplifier and shaper combination for particle rates up to 200 kHz. Since the number of generated electrons in the counting gas is roughly proportional to the square of the charge of the penetrating particle, the output voltage of the shaper is a measure for the atomic number of this particle.

Using an additional fast start signal (e.g. a scintillator signal) the drift time of the electron cloud provides information about the vertical position of the passing particle. The stop signal can be derived from the common timing output of the shaper module.



Specifications

Geometry

active area:	200 mm × 80 mm
active length:	400 mm
anode:	8 anode strips with 50 mm active length each
total gas length:	420 mm
entrance windows:	float glass D263 (DESAG), thickness 210 μm
distance anode – grid:	7 mm
grid wire diameter:	100 μm
grid wire spacing:	1 mm

Gas supply

counting gas:	CF_4 (tetrafluoromethane)
counting gas pressure:	atmospheric pressure (≈ 1 bar)
maximum differential pressure:	± 5 mbar to atmospheric pressure
total gas volume:	8.6 l
recommended gas flow:	4 – 6 l/h
typical drift velocity:	10–12 cm/ μs @ 1kV/cm for electrons
gas supply connectors:	Swagelok tube fittings, 8 mm

High voltage supply

maximum input voltage:	-10 kV
operating input voltage:	-8 kV – -10 kV
field homogenization current:	32 μA @ 10 kV
high voltage connector:	SHV connector

Environmental conditions

storage temperature:	10 – 40 °C
operating temperature:	10 – 40 °C

Layers of matter in beam direction

material	length	mass thickness
air	5 mm	0.64 mg/cm ²
mylar foil, aluminium coated	25 μ m	3.48 mg/cm ²
air (in chamber housing)	15 mm	1.93 mg/cm ²
float glass D263 with field homogenization	210 μ m	52.71 mg/cm ²
CF ₄ , inactiv	10 mm	3.93 mg/cm ²
CF ₄ , anode 1	50 mm	19.63 mg/cm ²
CF ₄ , anode 2	50 mm	19.63 mg/cm ²
CF ₄ , anode 3	50 mm	19.63 mg/cm ²
CF ₄ , anode 4	50 mm	19.63 mg/cm ²
CF ₄ , anode 5	50 mm	19.63 mg/cm ²
CF ₄ , anode 6	50 mm	19.63 mg/cm ²
CF ₄ , anode 7	50 mm	19.63 mg/cm ²
CF ₄ , anode 8	50 mm	19.63 mg/cm ²
CF ₄ , inactiv	10 mm	3.93 mg/cm ²
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air	5 mm	0.64 mg/cm ²

ATIMA target file

0.64300 1 air
 3.48000 1 Mylar
 1.93000 1 air
 52.7100 1 glass
 3.92600 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 19.6300 1 CF4
 3.92600 1 CF4
 52.7100 1 glass
 1.93000 1 air
 3.48000 1 Mylar
 0.64300 1 air

Electronic Frontpanel

- Power control LED ($\pm 12\text{V}$)
- Power connector: NIM-Standard, sub-D, 9 pin
 - pin 1 ground
 - pin 2 ground
 - pin 3 not connected
 - pin 4 $+12\text{V}$
 - pin 5 not connected
 - pin 6 not connected
 - pin 7 not connected
 - pin 8 not connected
 - pin 9 -12V

Supply limits: voltage $\pm 11\text{V}$ to $\pm 13\text{V}$

current $\pm 80\text{mA}$ (0Hz particle rate) to $\pm 300\text{mA}$ (200kHz particle rate)

- Test input
 - use only to test cable connections. Calibrate amplitudes with beam.
 - Internally terminated with 50Ω .
 - The capacity to the preamp inputs varies from 0.1pF to 1.5pF .
 - Negative tailpulses, 1V corresponds to about $1.3\text{E-}13\text{ C}$.
- Preamp output
 - Each of the 8 preamps has a negative and positive BNC-Lemo output.
 - Connect (+)-output to the shaper (+)-input and (-)-output to shaper (-)-input.
- High voltage input: SHV connector
 - maximum voltage: -10kV

Gas supply Frontpanel

- gas in connector
 - 8mm Swagelok tube fitting
- gas out connector
 - 8mm Swagelok tube fitting

Both tube fittings and the assembly thread rods (metric thread M8) are electrically isolated from the chassis ground. The chassis ground is connected to the signal ground of the peamplifiers. Avoid interfering ground connections during the installation of the chamber (e.g. caused by electrically conductive gas supply tubings).

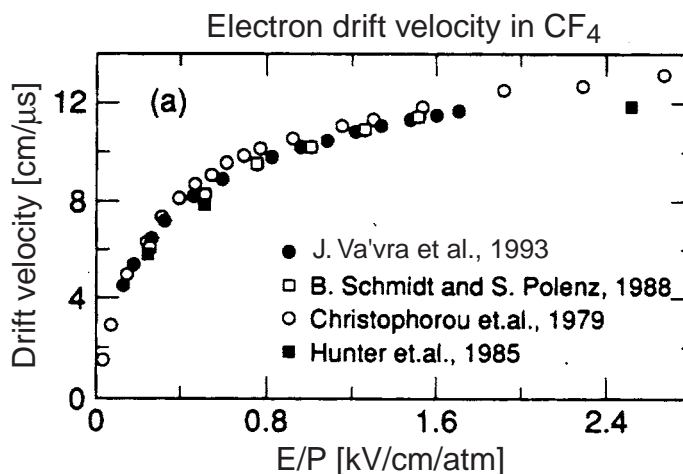
The cross marker on the two front panels mark the center of the active chamber volume and can be used for alignment of the ionisation chamber. The chamber is centered in beam direction in respect to the chamber chassis. The bottom plate is aligned in parallel to the cathode and anode plane.

Counting gas

Tetrafluoromethane (CF_4) is used as counting gas. To ensure correct operation of the chamber use only gas with less impurities than 10 ppm. The use of a purifier filter (e.g. MicroTorr Model PS11-MC1- CF_4) is highly recommended.

Properties of CF_4

density @ STC	$\rho = 3.93 \text{ mg/cm}^3$
lowest excitation potential	$E_x = 12.5 \text{ eV}$
lowest ionization potential	$E_i = 15.5 \text{ eV}$
average energy per ion pair	$W_i = 54 \text{ eV}$
radiation length	$l = 92.4 \text{ m}$
electron drift velocity	$v_d = 10 \text{ cm}/\mu\text{s} @ 1.0 \text{ kV/cm/atm}$
longitudinal diffusion	$\sigma_L = 80 \mu\text{m}/\sqrt{\text{cm}} @ 1.0 \text{ kV/cm/atm}$
electron diffusion	$\sigma_x = 220 \mu\text{m}/\sqrt{\text{cm}} @ 1.0 \text{ kV/cm/atm}, T=25^\circ\text{C}$



Remove the filter mesh in the Swagelok fittings of the chamber before the assembly of the gas supply tubing. Don't turn the Swagelok tube fittings of the chamber during tube installation to avoid leakage.

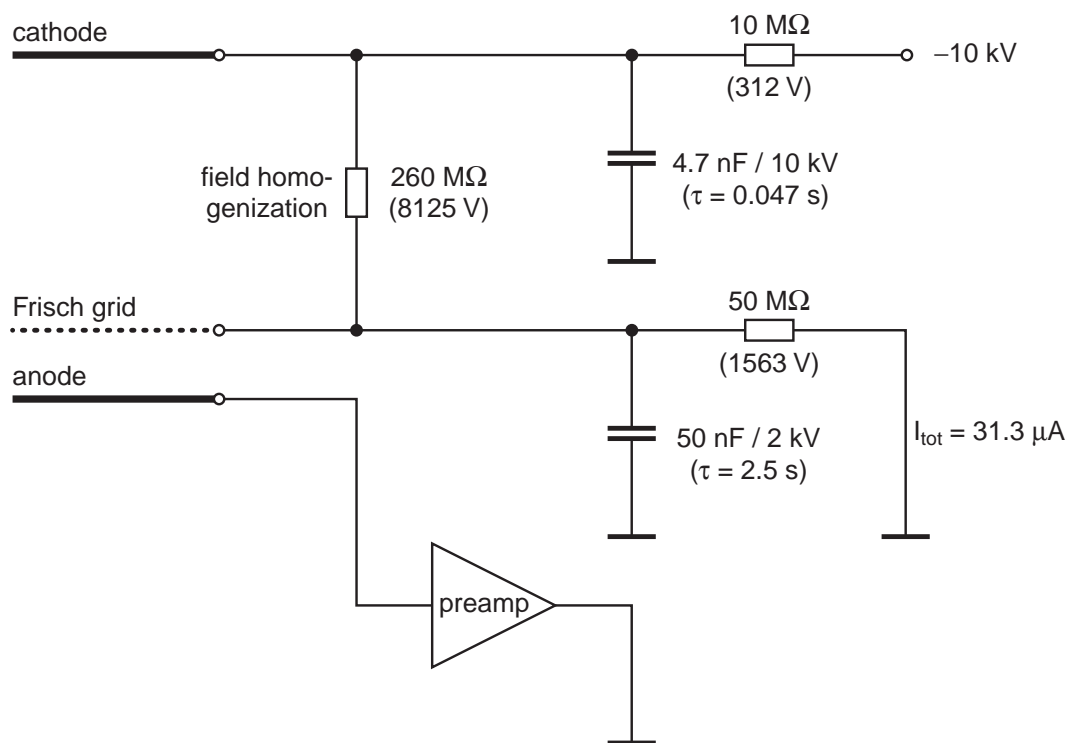
The pressure differential between the internal chamber pressure and the external atmospheric pressure cannot exceed ± 5 mbar. A higher pressure differential can destroy the glass entrance windows. Avoid pressure shocks in any case.

Start the gas flow (2 – 5 l/h) approximately 24 hours before the use of the chamber in a beam-time. The gas purity can be checked by measuring the deposited energy loss signal in dependency of the drift length.

Electric circuit diagram

The high voltage input is used to supply the cathode and the Frisch grid. A voltage divider circuit build up by the field homogenization resistors and the Frisch grid filter circuit ensures correct electric field intensities for maximum efficiency of the Frisch grid. A filter circuit for the cathode voltage is included in the chamber chassis.

The effective potential over the active drift distance is equal to 81.25% of the HV input voltage (see schematic circuit diagram).

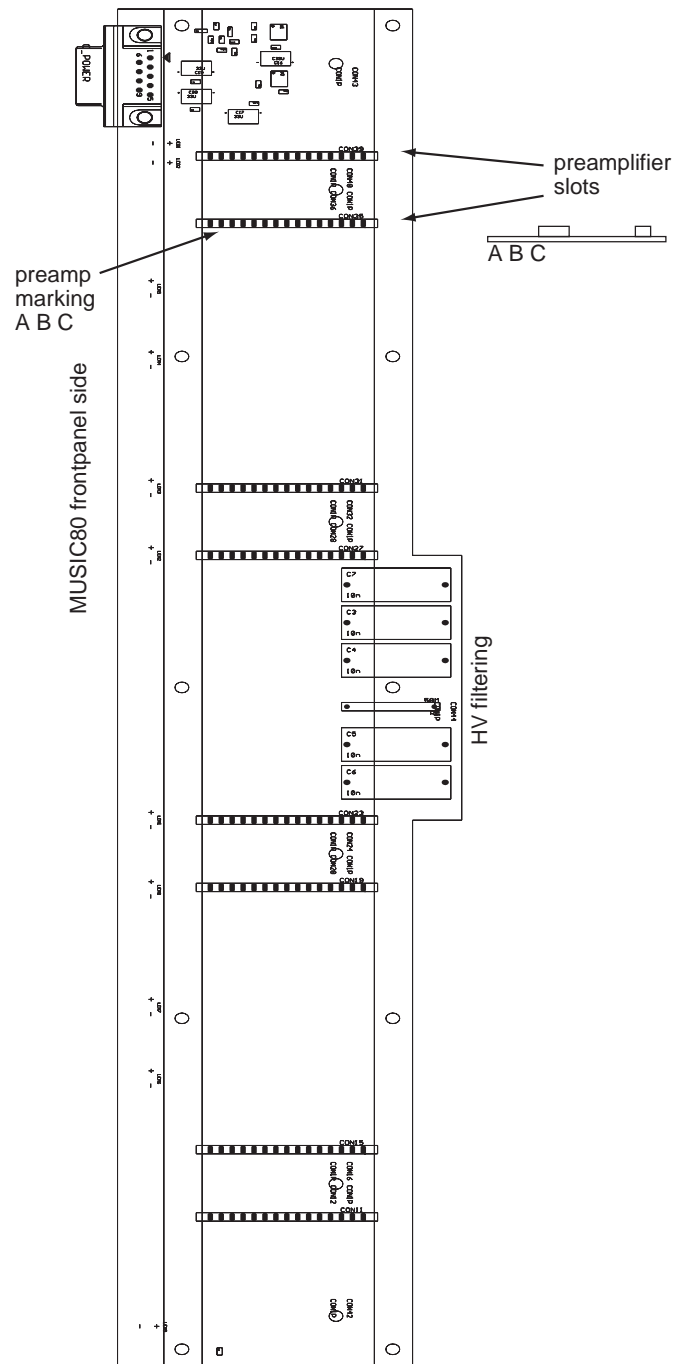


Danger! High Voltage!

Never exceed the maximum allowed input voltage of -10kV . Don't open the chamber chassis if the high voltage is applied. Even after switching off the high voltage the capacitors of the Frisch grid filter circuit still stores high voltage. Please wait several minutes before opening the chamber chassis.

MUSIC80 Motherboard

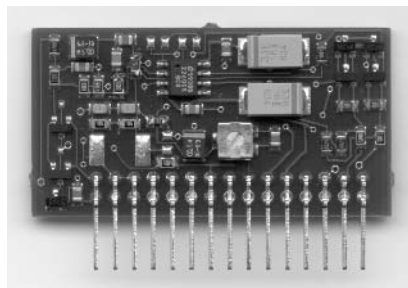
The motherboard is located inside the MUSIC 80 case. After opening the two brass screws the top cover can be removed. The motherboard includes the voltage control and regulation and the high voltage filtering for the Frisch grid. There are eight slots for the preamplifier modules. Please note the correct orientation of the preamplifier modules. After closing the top cover fasten the brass screws to ensure good electric contact to the chassis.



Preamplifiers

Common specifications

Output amplitude:	used max range $\pm 1.1\text{V}$ @ 50Ω headroom for high rate stacking: max $\pm 4\text{V}$ @ 50Ω
Risetime:	$< 100\text{ ns}$
Falltime	$\approx 10\ \mu\text{s}$



To cover the dynamic range of all particles, three different sensitivities are necessary:

Preamplifier, sensitivity A

lower limit:	$2.5\text{E-}14\text{ C} = 1\text{V}$, (maximum sensitivity of shaping amplifier)
upper limit:	$2\text{E-}12\text{ C} = 10\text{V}$, (minimum sensitivity of shaping amplifier)
typical nuclear range:	$Z=92$ to $Z=25$
typical pulser input:	input amplitude for $Z=92$: -10V (risetime 100 ns)

Preamplifier, sensitivity B

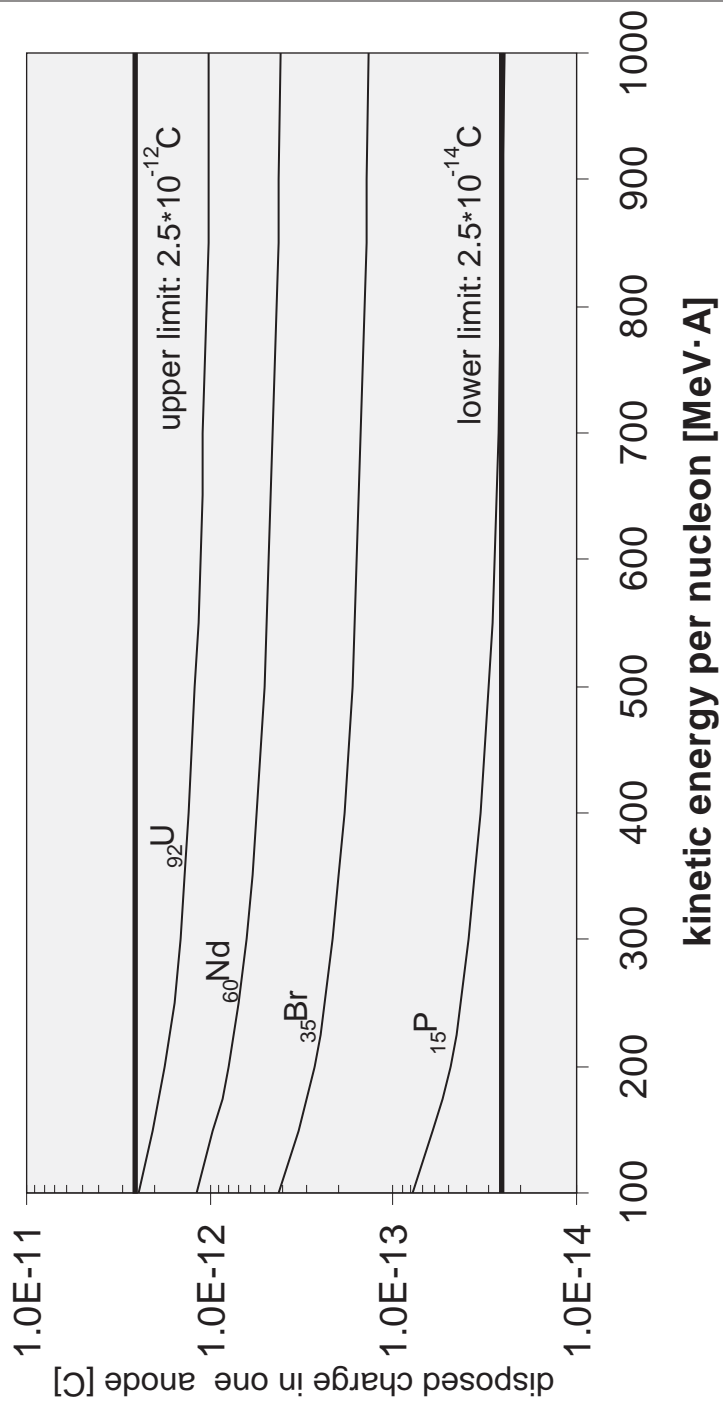
lower limit:	$5\text{E-}15\text{ C} = 1\text{V}$, (maximum sensitivity of shaping amplifier)
upper limit:	$4\text{E-}13\text{ C} = 10\text{V}$, (minimum sensitivity of shaping amplifier)
typical nuclear range:	$Z=50$ to $Z=12$
typical pulser input:	input amplitude for $Z=50$: -2V (risetime 100 ns)

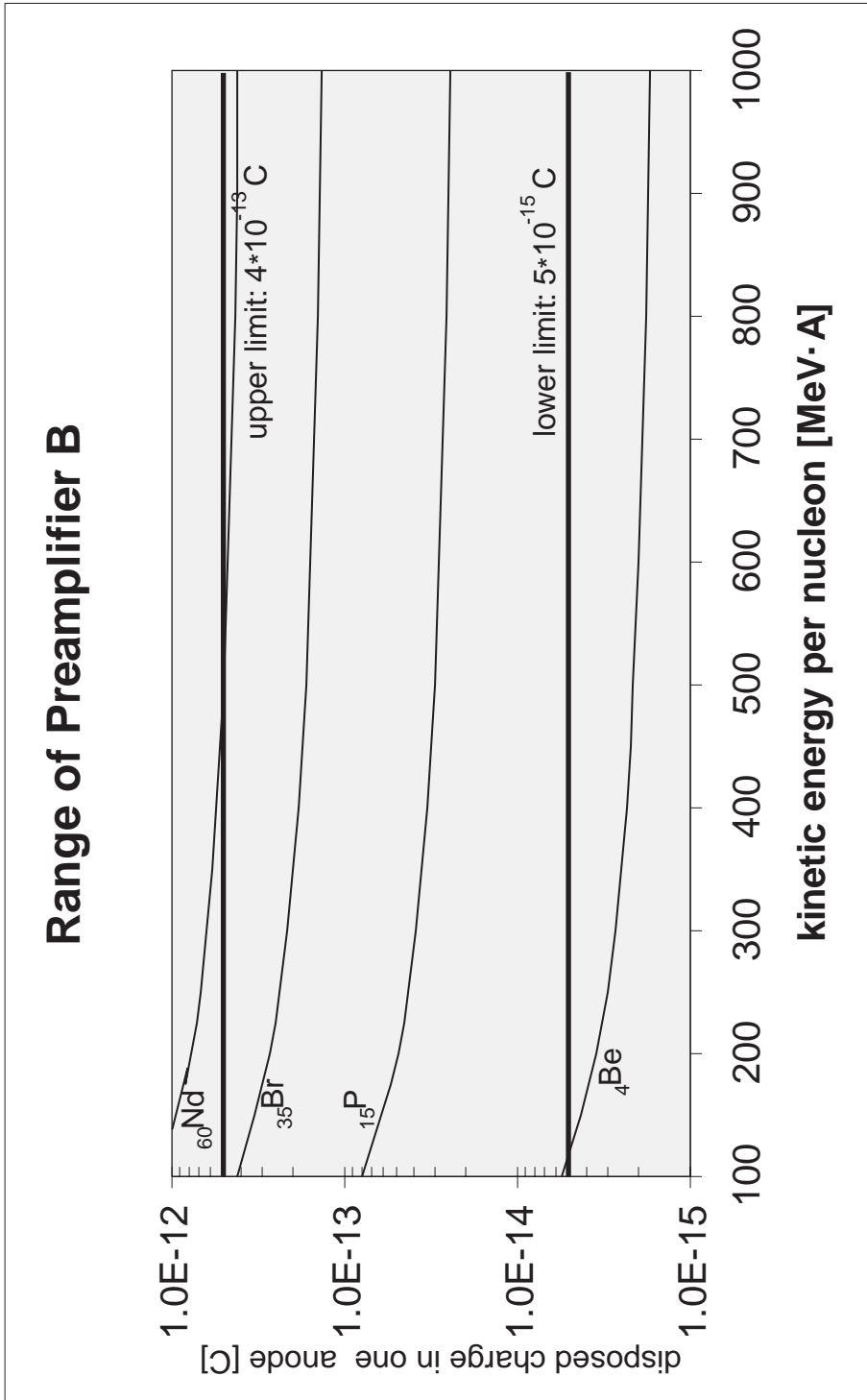
Preamplifier, sensitivity C

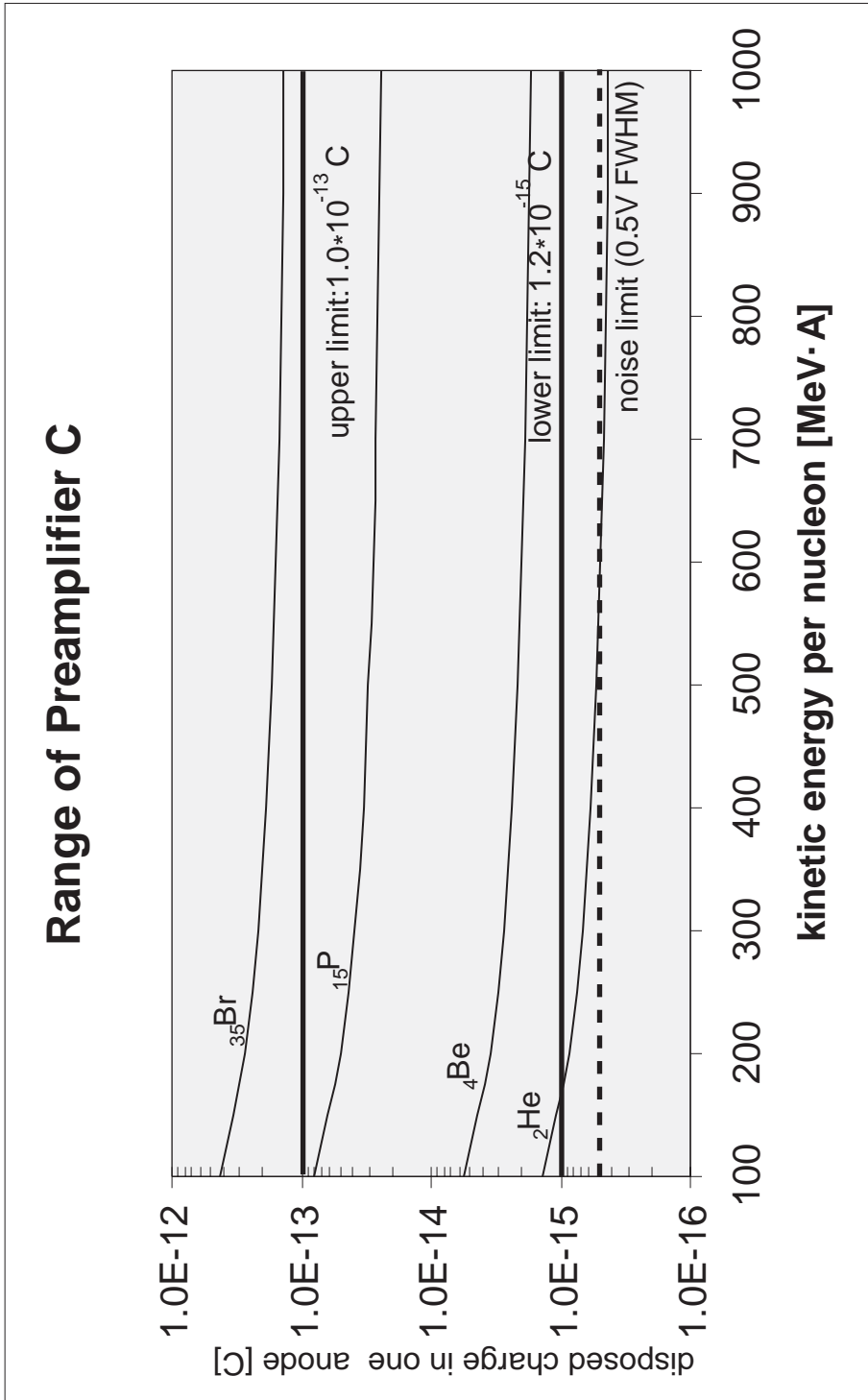
lower limit:	$1.2\text{E-}15\text{ C} = 1\text{V}$, (maximum sensitivity of shaping amplifier)
upper limit:	$1.0\text{E-}13\text{ C} = 10\text{V}$, (minimum sensitivity of shaping amplifier)
typical nuclear range:	$Z=25$ to $Z=3$
typical pulser input:	input amplitude for $Z=25$: -0.5V (risetime 100 ns) remove pulser in run to avoid additional noise.

The preamplifiers have a factor of 3.5 of headroom at their upper range limit. Nevertheless, for very high particle rates avoid to use preamplifiers at the upper range (problem of pile down).

Range of Preamplifier A



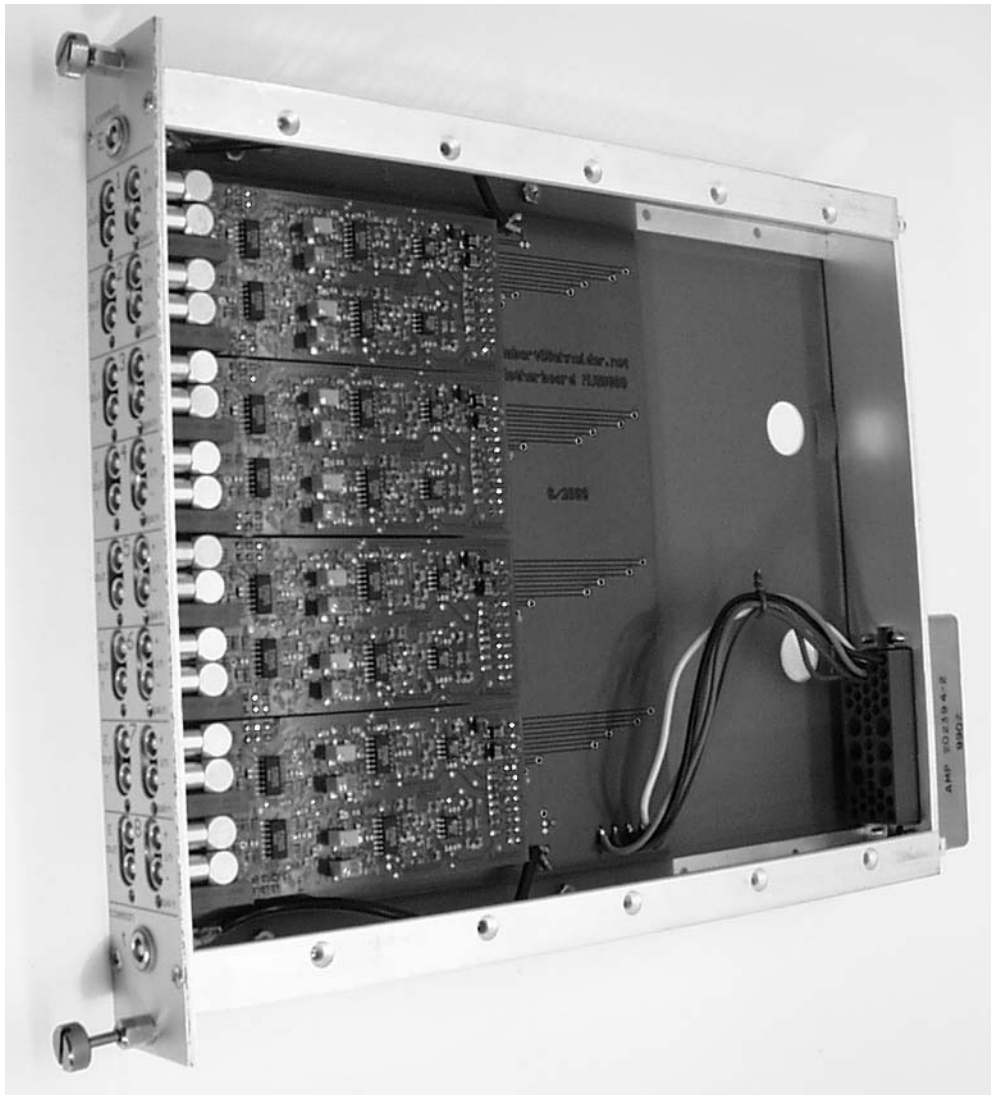




Shaping Amplifiers

Each channel has a negative and a positive input. This helps to reduce 50 Hz noise signals which can be caused by a bad measurement ground connection between Messhütte and the electronics at the FRS focal planes. Connect shaper (+)-inputs to the MUSIC-preamp (+)-outputs. Therefore 16 BNC connections are needed. If the number of cables is critical, it is also possible to use only the (+) or the (-)-inputs. In this case the output amplitude is reduced by a factor of 2 and the 50 Hz noise signals are not cancelled out.

8 shaper channels are placed in one NIM module.



Shaping Amplifiers Specifications

Shaper inputs

internally terminated with 50Ω
positive and negative input
adjustable range (10V output) $\pm 0.15V$ to $\pm 1.15V$
Headroom for preamp signal stacking: $\pm 4V$

Energy outputs for each channel

shaping time 550ns FWHM
signal rise of timing output to shaping peak: 750ns
Amplitude: max 10V (for standard ADC-inputs, typ. $1k\Omega$)
(For special applications shaping times from 250ns to $1\mu s$ can be ordered.)

Timing outputs for each channel

output voltage -100mV per 1V shaper output
risetime: 100ns

Common Timing output

mean value of all channels \Rightarrow noise reduced by a factor 3.
Use this signal for trigger generation. Terminate with 50Ω .
(Data: see single channel)

Common Energy output

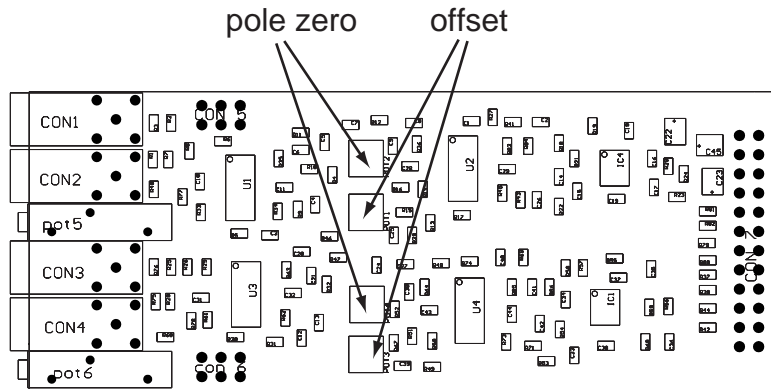
mean value of all channels \Rightarrow noise reduced by a factor of 3.
Useful if you study very light nuclei at the noise limit of preamp type C.
(Data: see single channel)

Power consumption

+12V	+150mA
+6V	+100mA
-6V	250mA
total power	4W

Adjustment of offset and pole zero

- Both parameters were adjusted before delivery. Change only if necessary. An offset value of 0.3V is acceptable.
- Power up the MUSIC preamps and shaper units at least thirty minutes before adjusting or measuring.



Hints for Data Acquisition

Measuring the Y-Position (drifftime)

- Start TDC or TAC with a scintillator signal.
- Use the common timing output of the shaper module for discriminator input. A good threshold is about 50mV.
- Stop TDC or TAC with the discriminator signal.
- The produced electron cloud drifts in upward direction. A short drift time correspond to a high vertical position of the passing particles.

Measuring energy deposition

- Connect the 8 energy signals (and optional the common energy signal if you measure at the preamplifier noise limit) to the ADC.
- Use the discriminator signal with a gate generator to create the ADC gate with proper delay and width.
- Do not use a scintillator signal to create the gate for the ADC.
- The shaping signals can jitter in time by the total drifftime, which is about 800ns.

