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FAIR

Investigations on Pick-Up and Kicker Electrodes for Stochastic Cooling

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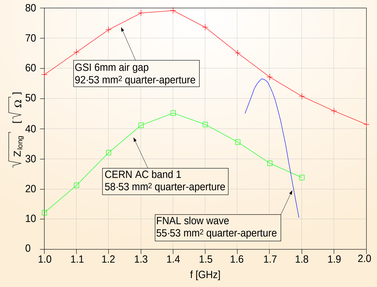
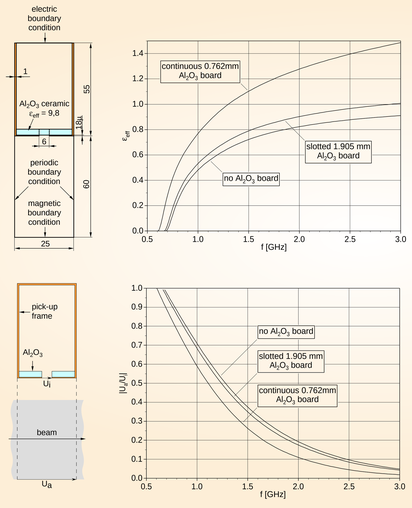
Slotline Pick-Up

The main task of the FAIR collector ring (CR) is stochastic cooling of RIBs and antiprotons. The CR should achieve a phase space volume reduction of $1.6 \cdot 10^4$ in 5 s for antiprotons and $1.3 \cdot 10^6$ in 1 s for RIBs. The pick-ups must have a large bandwidth, a high S/N ratio and a large aperture of 120·120 mm^2. A new planar electrode is developed to meet these requirements.

The figure shows the square root of the longitudinal impedance (beam in center, longitudinal kicker mode) of a 2 m long array of 80 slotline electrodes, a 2 m long array of 23 CERN AC band 1 superelectrodes and a scaled FNAL slow-wave structure with 80 cells with a length of 32.5 cm without coupler.



Properties of Different Slotline Types



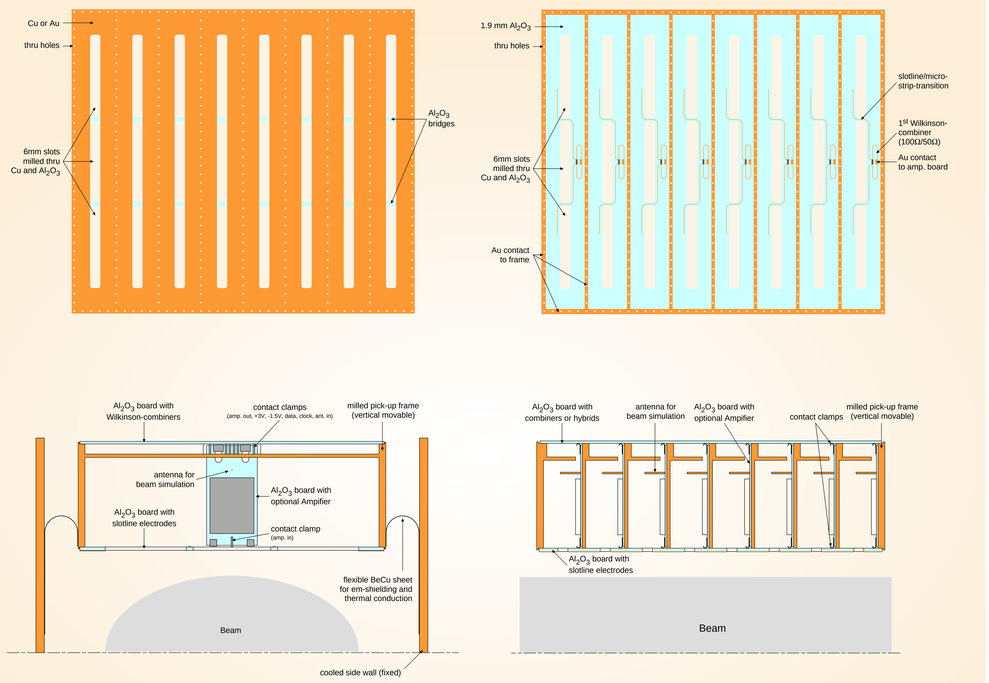
An ideal slotline consists of a narrow gap in the conductive coating of an infinitely wide dielectric substrate.

In reality, the conductors are finite and the rear side of the electrode has to be shielded. This line acts more like a dielectric loaded waveguide with a cut-off frequency and a higher dispersion.

The numeric calculations were done using the Microwave Studio eigenmode solver. The line is built into a rectangular frame with a height of 55 mm. With a smaller box, the cut-off frequency would be in the operating frequency range (1-2 GHz). Below the slotline is 60 mm space to the center of the beam pipe. Symmetrically driven electrodes on each side of the beam pipe are simulated by a magnetic boundary condition at the bottom.

The first type of slotline has no substrate. The second type uses a continous 0.76 mm Al_2O_3-substrate. The third type is a compromise and uses a 1.91 mm substrate with a slot through the substrate.

Pick-Up Module



The figures above show a possible layout of a pick-up module.

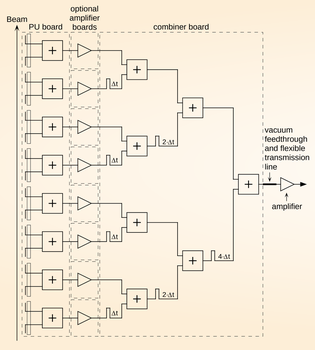
At the bottom of the module is the pick-up board with eight slotlines and the first combiner stages.

The board above establishes the connection between the pick-up board and the combiner board on top of the module. It also contains a small antenna for signal injection into each slot. This can be used to check the whole circuit of the module without a beam. The connection board can optionally contain the first stage of the low noise amplifier.

The pick-up module will be vertically movable to follow the cooled beam. This will be neccesary to get enough signal when the beam gets colder. Two BeCu springs establish the thermal connection to the fixed cooled side walls. These springs are also responsible for the electromagnetic shielding. An alternative to the mechanical complicatad long springs could be an simple gap with damping material on the sidewall and short springs for the thermal conduction.

A whole pick-up or kicker tank will probably consist of eight modules. Both ends will be closed with damping material and a thermal shielding.

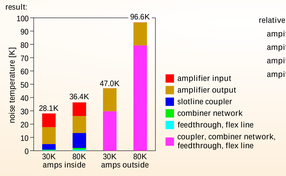
Signal Combination and Noise Temperature



assumptions:

• transmission of slotline coupler:	-0.92 dB	= 0.9
• transmission of one Wilkinson combiner:	-0.2 dB	= 0.977
• transmission of a feedthrough with flexible transmission line:	-0.5 dB	= 0.944
• transmission of the amplifiers:	10 dB	= 3.162
• noise figure of the amplifiers:	0.25 dB	≙ 17.2 K
• electrode spacing:	25 mm	
• frequency range:	1…2 GHz	

result:



relative signal to noise ratio:

amplifiers inside, T=30K:	5.4 dB
amplifiers inside, T=80K:	4.6 dB
amplifiers outside, T=30K:	3.1 dB
amplifiers outside, T=80K:	:= 0.0 dB

To fulfill the signal-to-noise ratio requirements, one has to combine the signals of an array of electrodes. Due to the two different velocities it is necessary to use switchable delay lines for the phase consistent combination. A group of eight electrodes will be combined with fixed delays and the combination of the groups will be done with switchable delay lines. With an electrode distance of 25 mm and eight electrodes, the amplitude degradation compared with switchable delays on every electrode is only 4.6 % at 1.5 GHz.

One possibility to bring down the noise is to cool the pick-up modules to 80 K or 30 K.

Another possibility is to terminate the slotlines with electrically cold loads. A single electrode with the first combiner has a high reflection factor. An amplifier is therefore terminatad with its own cold input. Due to the different delays in the combiner network, an amplifier behind the module is terminated by the resistors of the combiners instead of the cold input.