MUCOOL experiment- Plans

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Charge from Fermilab

Sep 13, 2000 letter from John Cooper to me states "I am asking you to lead the work at Fermilab on the following tasks:

1. Design of a muon testbeam that can be used to study the performance of a cooling section.
2. Simulation of the response of a cooling test section to the test beam. Hence determine what properties of the cooling channel can and cannot be tested in a muon beam.

I would like a short report on these items to be given to Mike Shaevitz, Steve Holmes and myself by April 1st, 2001".

We have had 3 meetings on this topic. I will summarize the ideas generated therein.

Muon Test beam-Targetry

1 Targetry and Primary Focusing

(N.Holtkamp, N.Mokhov)

- 8 GeV proton beam (FNAL Booster)
- Active target
- Li lens for primary focusing

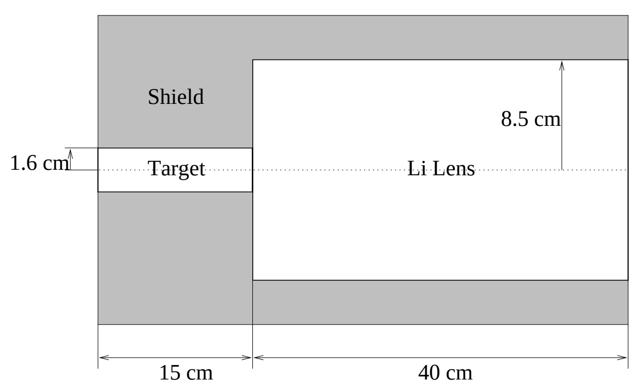

Figure 1: Schematic of the target station.

Proton Beam: 8 GeV, $\sigma_x = \sigma_y = 6$ mm, $\sigma_z = 30$ cm, 750,000 protons
Target: Copper, $L = 15$ cm, $R = 1.6$ cm, $G = 4.39$ T/cm, $B_{max} = 7.0$ T, $J = 560$ kA
Li Lens: $L = 40$ cm, $R = 8.5$ cm, $G = 0.158$ T/cm, $B_{max} = 1.34$ T, $J = 570$ kA

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Muon Test beam-Decay channel

2 Beam Characteristics after Li Lens

Yield: $\pi^-/p = 0.119, \quad \mu^-/p = 0.0022$

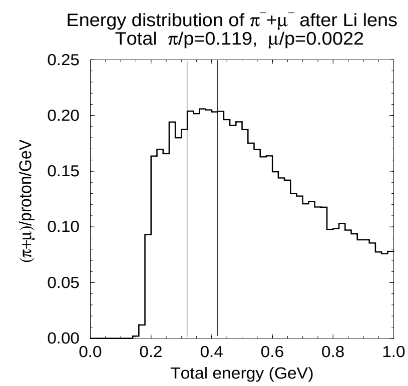


Figure 2:

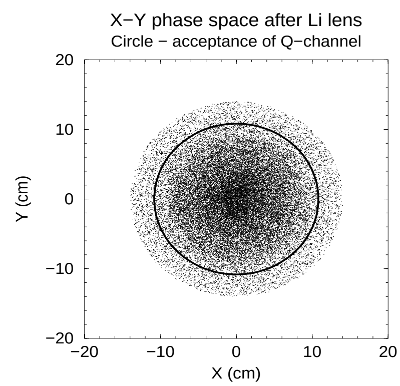
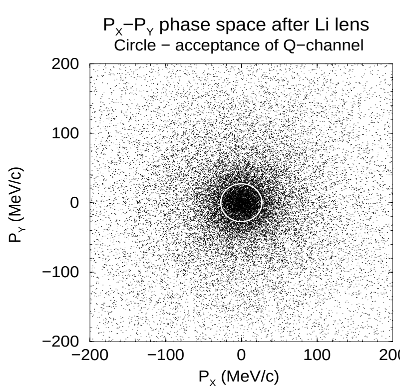


Figure 3:



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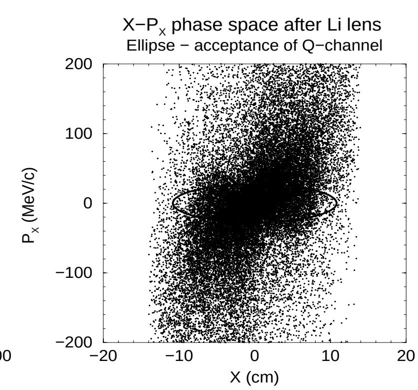

Figure 5:

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Muon test beam – Decay channel

3 Q-Decay Channel: Lattice and β-functions

- Quads: $L = 36$ cm, $G = 0.059$ T/cm, $R = 13.7$ sm
- Drift 36 cm
- No RF

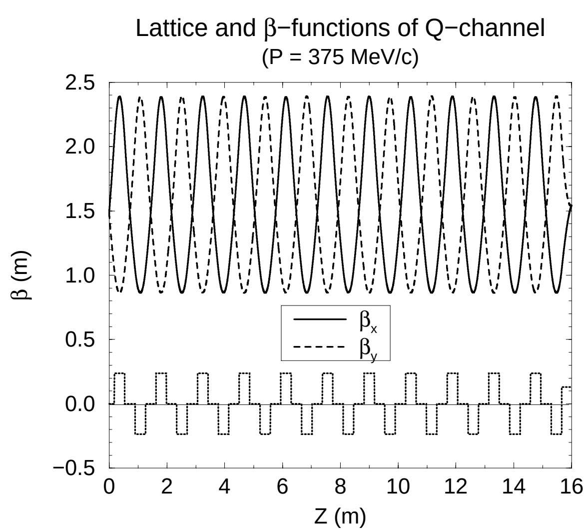

Figure 6:

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Muon test beam –Decay channel

4 Muon Beam Characteristics in Q-Channel

- Radius of aperture 13.7 cm
- E-window 255-355 MeV • T-window ±75 cm

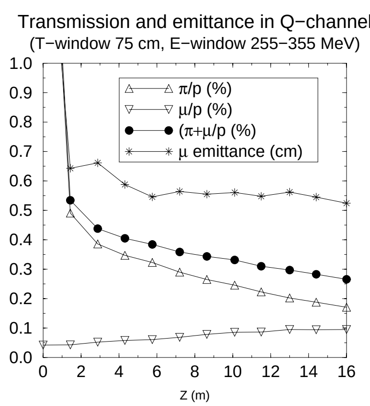
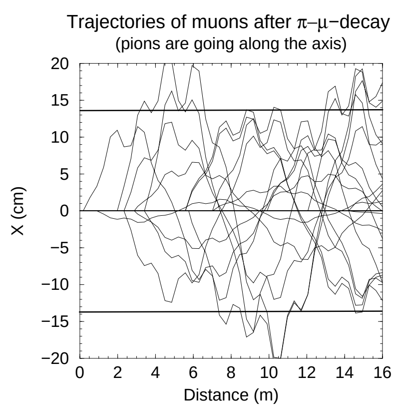


Figure 7:



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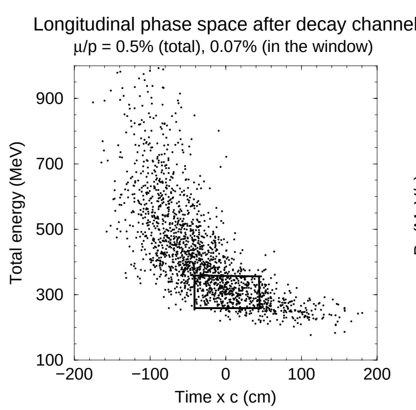

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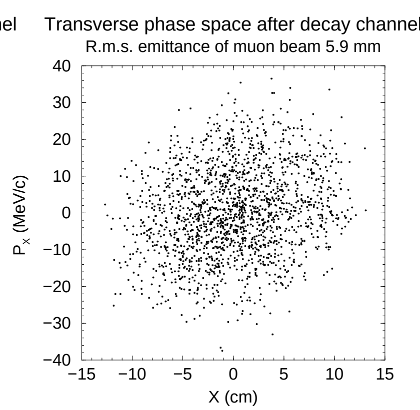

Figure 10:

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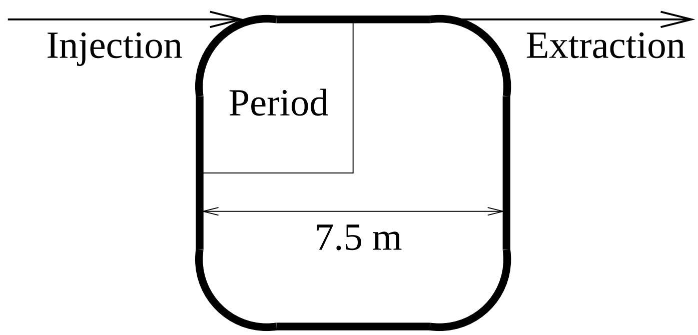
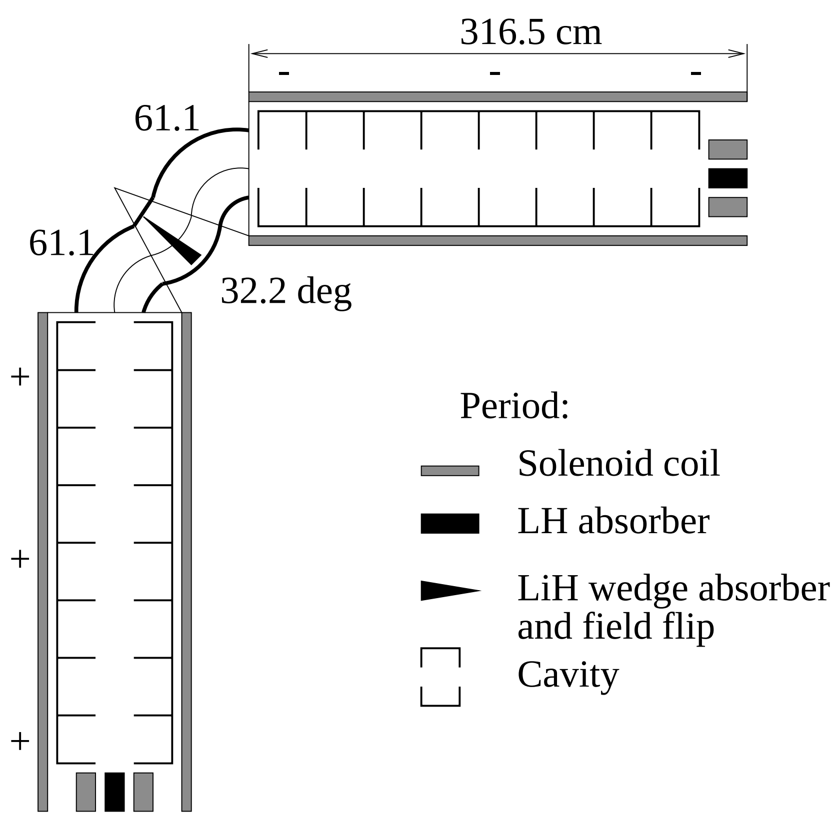
Ring Cooler ideas

- Initial scheme from V.Balbekov





Ring Cooler –New scheme from Balbekov

5 Ring Cooler

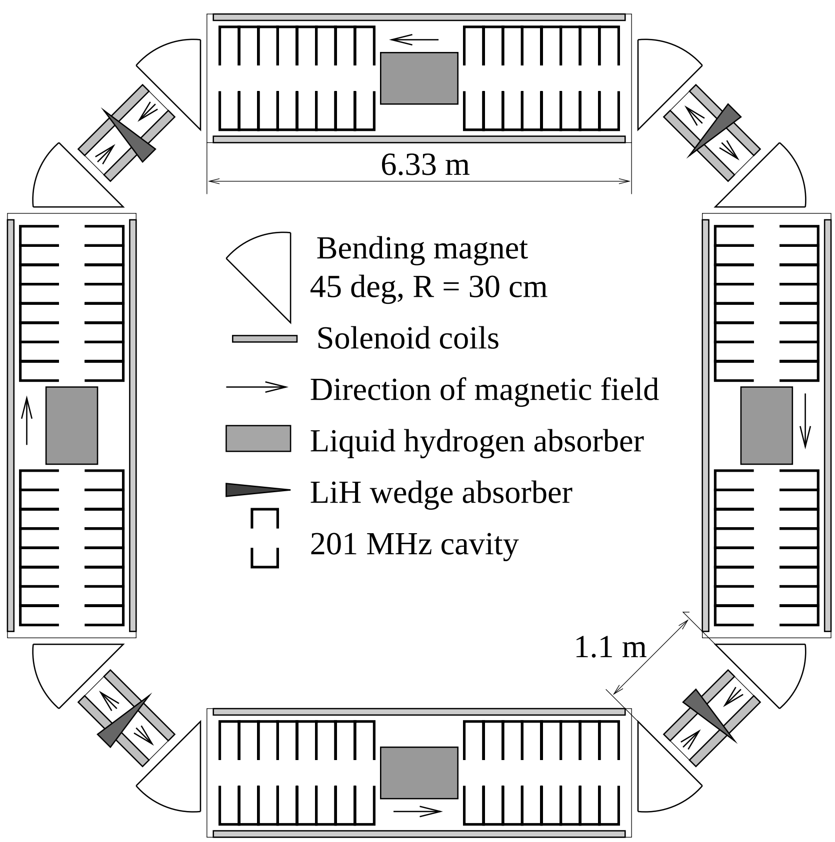


Figure 11: Schematic of ring cooler

Ring Cooler - Parameters

Ring cooler: list of parameters

1.	Circumference	32.4 m
2.	Kinetic energy of muons	125-164 MeV
3.	Revolution frequency	8.4 MHz
4.	Bending radius	30 cm
5.	Bending field	2.52 T
6.	Solenoid field	± 3.56 T
7.	RF frequency	201.25 MHz
8.	Accelerating gradient	15 MeV/m
9.	RF harmonic number	24
10.	Main absorber	LH, 120 cm
11.	Wedge absorber	LiH, $dE/dy = 0.8$ MeV/cm
12.	β-function	42 cm

Necessary conditions:

- Field flip
- Ho dispersion at SS

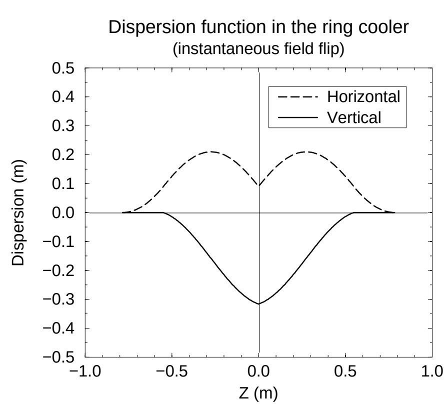


Figure 12:

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Ring Cooler-Performance

6 Cooling in the Ring

Injected beam:	$\sigma_X = \sigma_Y = 4.87$ cm
	$\sigma_{P_x} = \sigma_{P_y} = 26$ MeV/c
	$\sigma_Z = 8.5$ cm, $\sigma_E = 18.8$ MeV
	$\varepsilon_X = \varepsilon_Y = 1.2$ cm, $\varepsilon_Z = 1.5$ cm
After 15 revolutions:	$\varepsilon_X = 0.32$ cm
	$\varepsilon_Y = 0.37$ cm
	$\varepsilon_Z = 0.68$ cm
Transmission:	68% with decay
	49% without decay

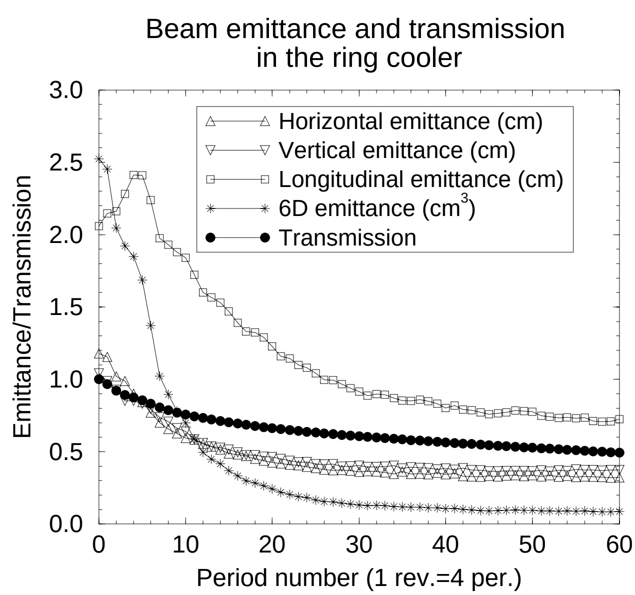

Figure 13:

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Ring Cooler -Performance

7 Phase Space of the Beam

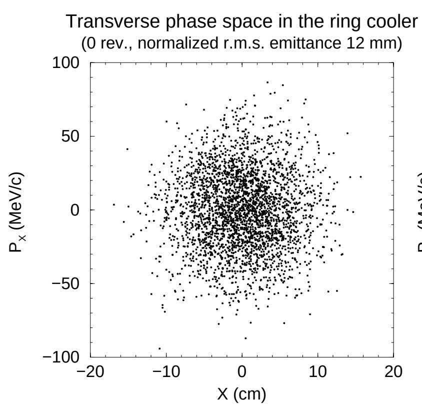


Figure 14:

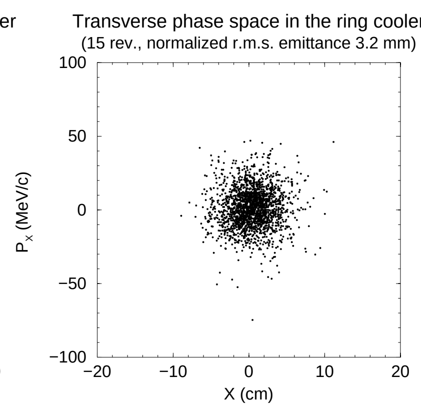


Figure 15:

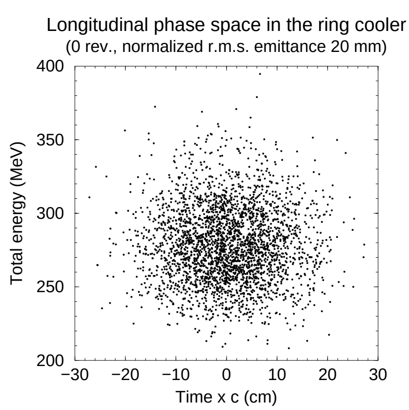


Figure 16:

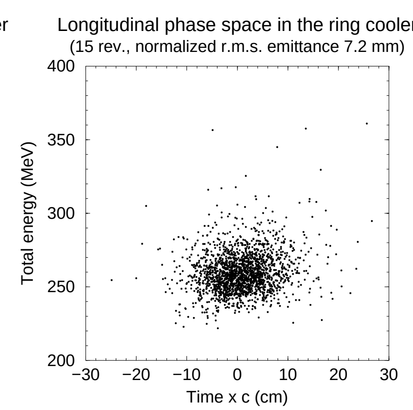
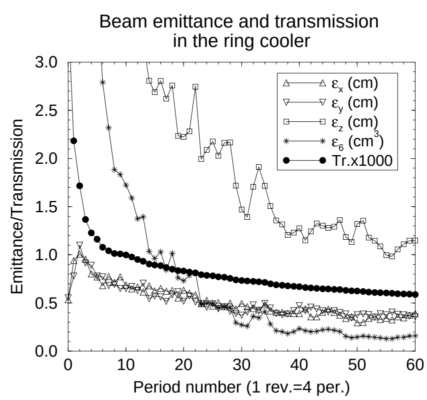


Figure 17:

Ring Cooler-Performance

8 Bunching in the Ring (Q-Decay channel)

$$N_\mu = 6 \cdot 10^{10} \times 6 \cdot 10^{-4} = 3.6 \cdot 10^{7}$$



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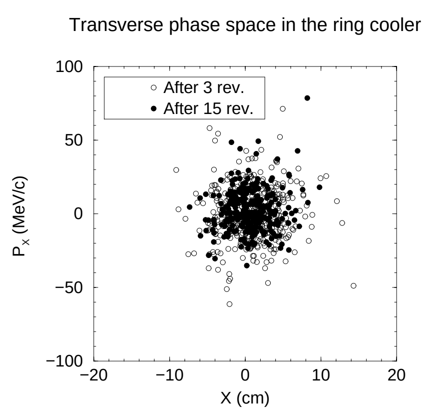

Figure 19:

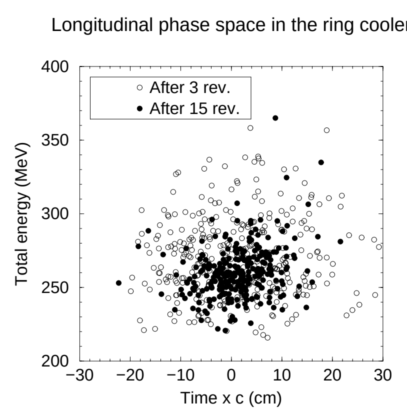

Figure 20:

Q-decay channel is a bottleneck

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Ring Cooler-Performance

Solenoidal channel $B = 3.56$ **T,** $R = 15$ **cm,** $L = 16$ **m** provides 2.5 times more muons at the same window. After the bunching:

$$N_\mu = 6 \cdot 10^{10} \times 1.2 \cdot 10^{-4} = 7.2 \cdot 10^7$$

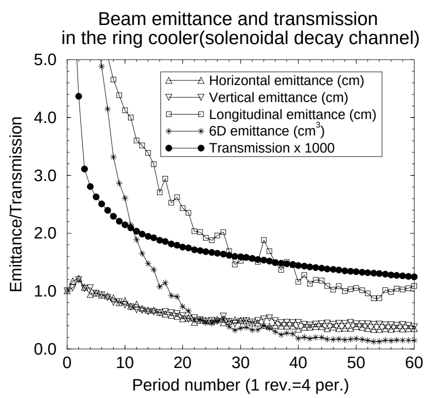

Figure 21:

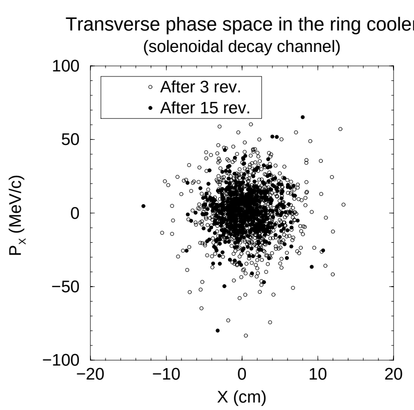

Figure 22:

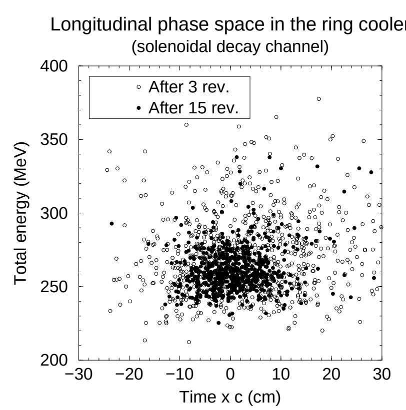

Figure 23:

Injection ideas

- It is difficult to inject beam of either pions or muons into the ring cooler.
- Try injecting protons (8GeV-1-3ns bunch) and hit one of the wedge targets. Simulation of pion production and capture at 90 degrees is being conducted by N.Mokhov
- Muon Collider/Neutrino factory fellow –Z.Usubov will help in simulating this setup in Geant4/DPGeant.
- If we can show that it is possible to capture sufficient number of muons this way, then we need to go into an engineering study that will put the design onto a more realistic basis. This can be followed by cost estimates etc.
- The beauty of this scheme (if it works) is that it would demonstrate cooling (6D) on modules that are used by the regular cooling channel. Reusing the modules turn by turn (20 turns foreseen) would reduce the cost of a cooling demonstration channel by that factor.