Cooling Experiment Simulations

K.Hanke CERN/PS

88 MHz option

- possible scenarios: 8 cavities and 4 cavities
- status of hardware design

scenario using 8 cavities

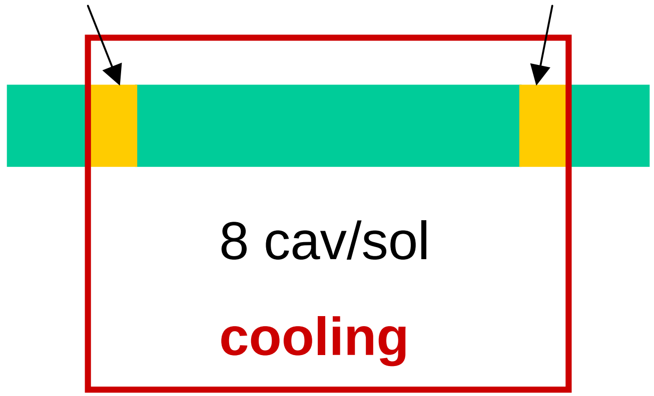
- beam dynamics (*PATH*)
- cross check with *ICOOL* (E.-B. Holzer)
- parameter scan (E.-S. Kim)

scenario using 4 cavities

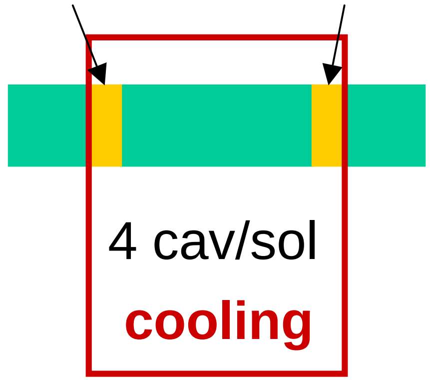
- beam dynamics and parameter scan

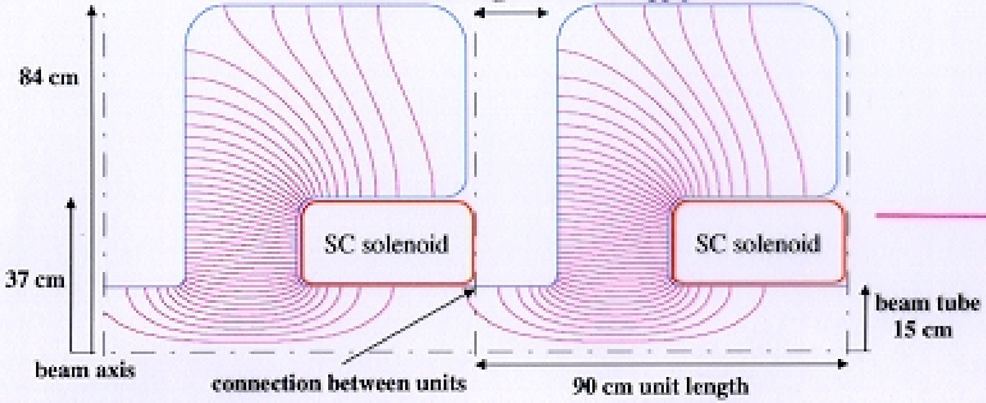
88 MHz Option: Lay-Out

a)

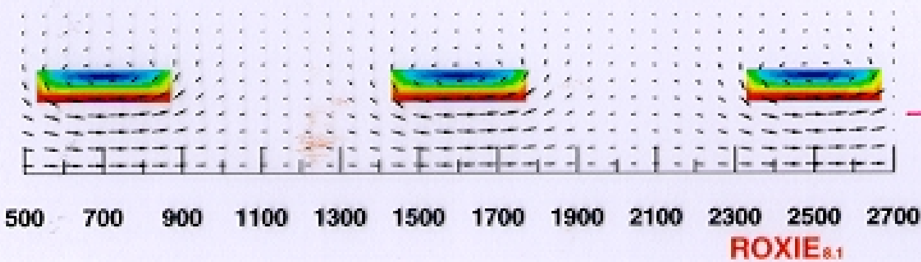


b)





1.) 88 MHz cavities (F.Gerigk)



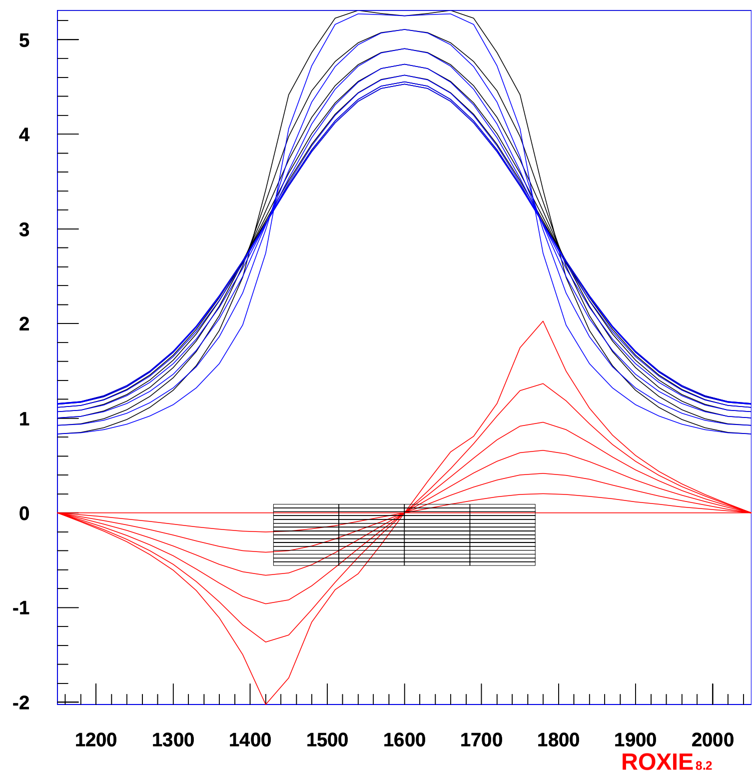
2.) sc solenoids (S.Russenschuck, M.Aleksa)

gradient
dimensions
electric field map

tracking code

magnetic field map

Solenoids for 88 MHz Cavities



quench limit for *NbTi* at 4.5 K: 9 T

maximum B_z on axis: 4.5 T if at 60% on load line

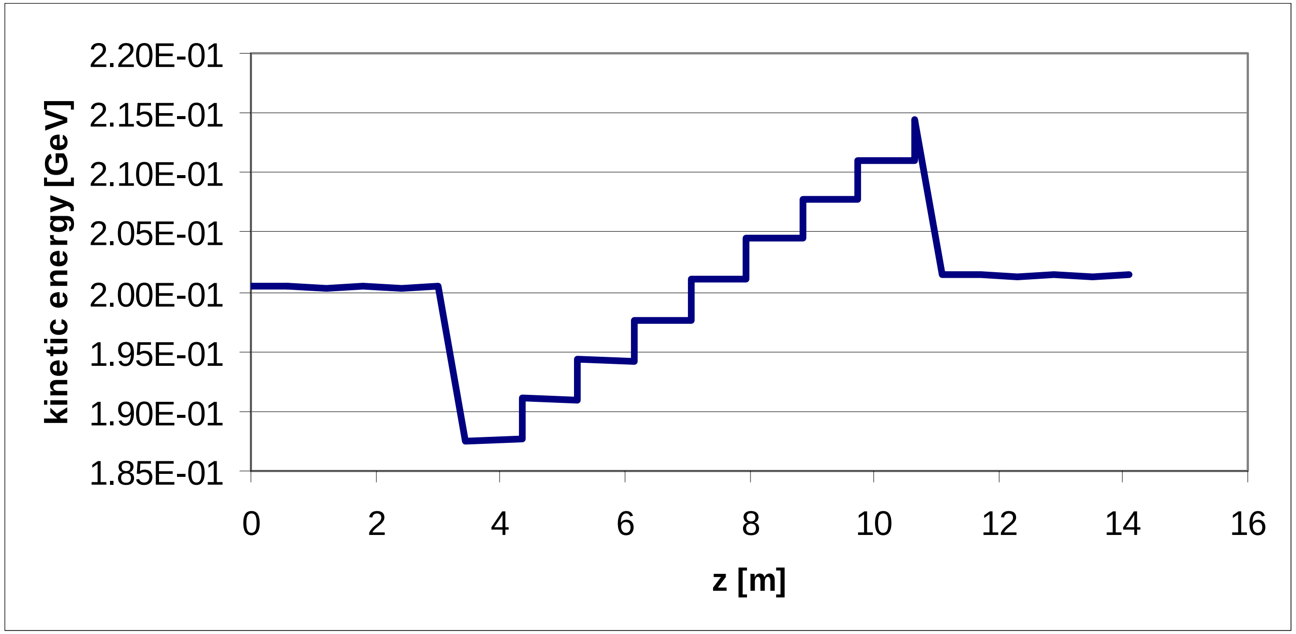
6.0 T if at 80% on load line

present settings stay well below 4.5 T

88 MHz Option (8 Cav.): Beam Dynamics

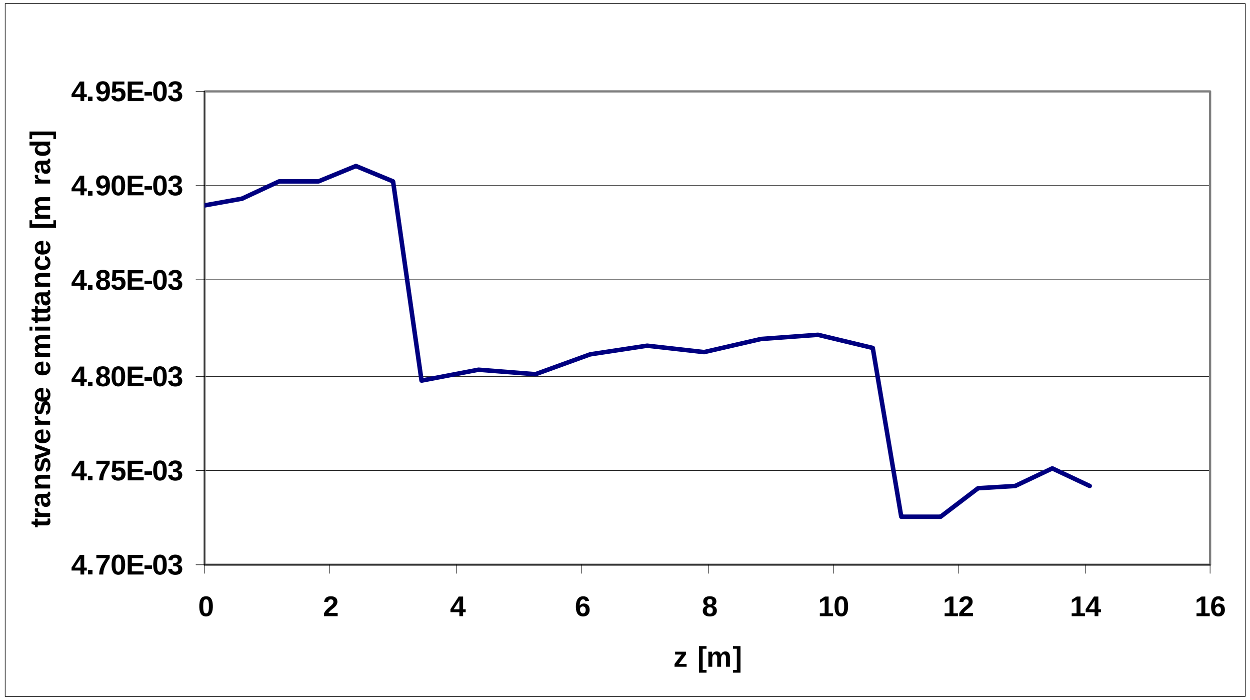
typical input beam parameters:
input energy: 200 MeV (variable)
energy spread +- 15 MeV
α = 0, β = 1 m, ε variable

settings of the channel:
solenoid settings: ~ 3 T
cavity phase: 0 deg



kinetic energy vs z for 88 MHz cooling experiment (8 cav.) computed with *PATH*

88 MHz Option (8 Cav.): Beam Dynamics



transv. emittance (r.m.s., norm.) vs z for 88 MHz cooling experiment (8 cav.) computed with *PATH* (50.000 particles)

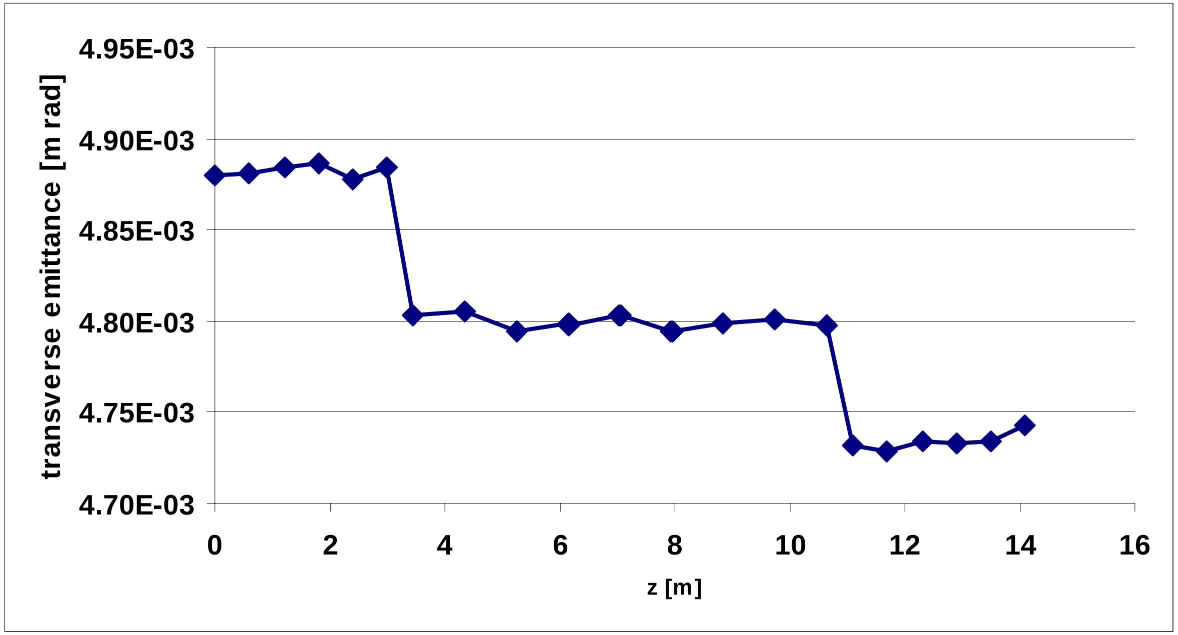
<u>performance for example optics:</u>

transv. emittance reduction: - 3.7%

particle gain in acceptance: + 9.1 %

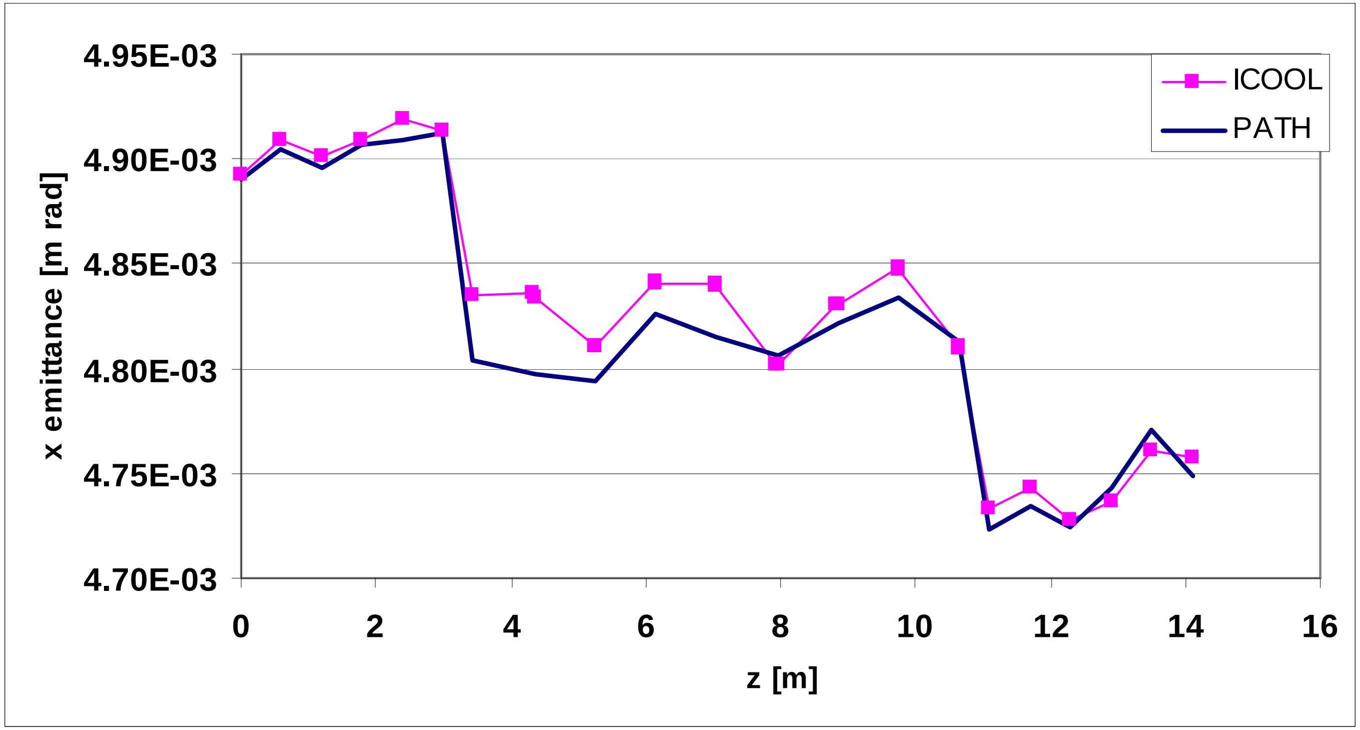
Cross-Check of *PATH* vs *ICOOL*

- for the same input beam (50.000 particles) and the same channel optics, the results could be reproduced in *ICOOL*



transv. emittance (r.m.s., norm.) vs z for 88 MHz cooling experiment (8 cav.) computed with *ICOOL* (50.000 particles)

Cross-Check of *PATH* vs *ICOOL*



x - emittance (r.m.s., norm.) vs z for 88 MHz cooling experiment (8 cav.) computed with *PATH* and *ICOOL* (50.000 particles)

Cross-Check of *PATH* vs *ICOOL*

y - emittance (r.m.s., norm.) vs z for 88 MHz cooling experiment (8 cav.) computed with *PATH* and *ICOOL* (50.000 particles)

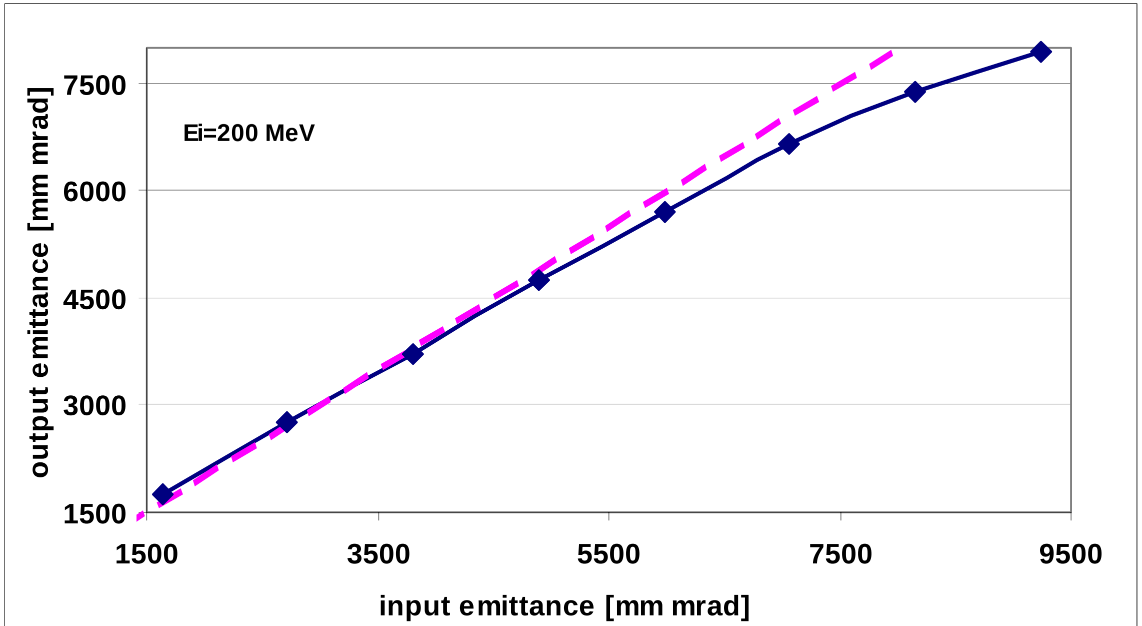
Cross-Check of *PATH* vs *ICOOL:* Conclusion

simulations started from the same input distribution,
used the same set-up, optics and field maps

	PATH	ICOOL
transmission	100 %	100 %
transv. emittance reduction	-3.7 %	-3.2 %
particle gain in acceptance (1.5 cm rad norm. and 0.1 eVs)	+9.1 %	+ 7.6 %

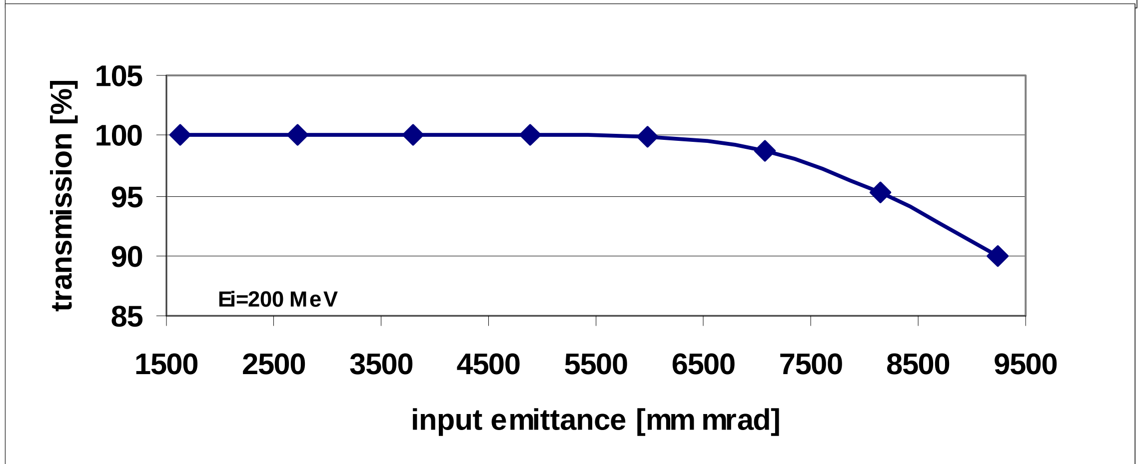
both runs done with same input distribution (50.000 particles)

88 MHz Option (8 Cav.): Parameter Scan



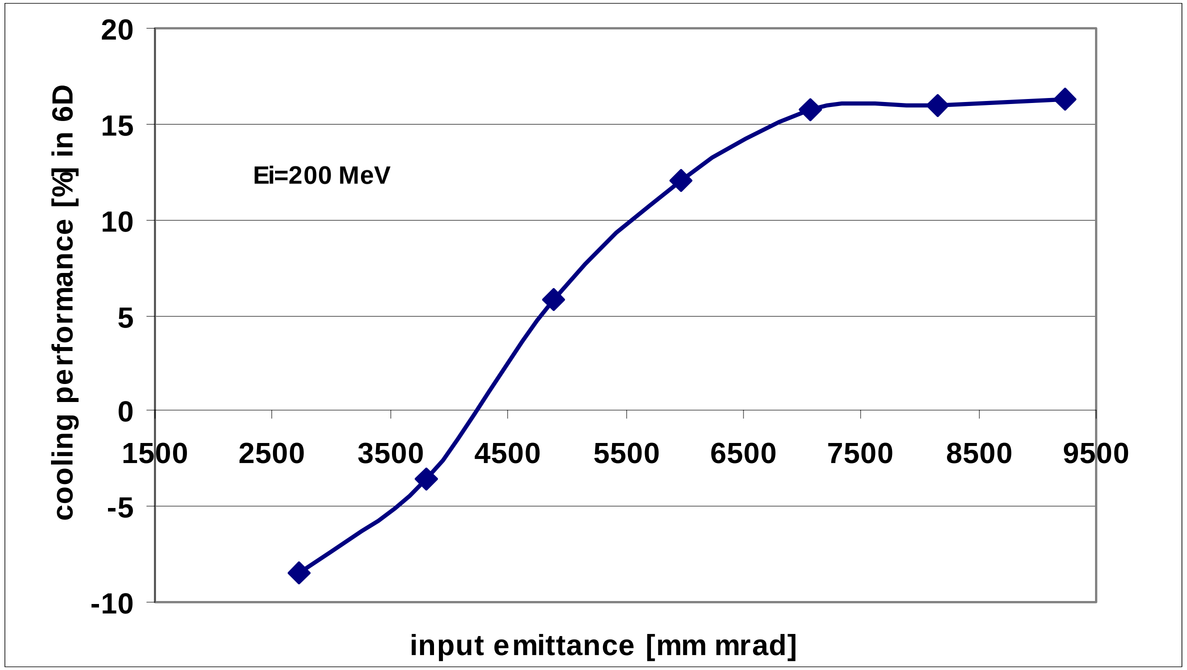
8 cavities,
E = 200 MeV

output emittance vs input emittance (r.m.s., norm.)



transmission vs input emittance (r.m.s., norm.)

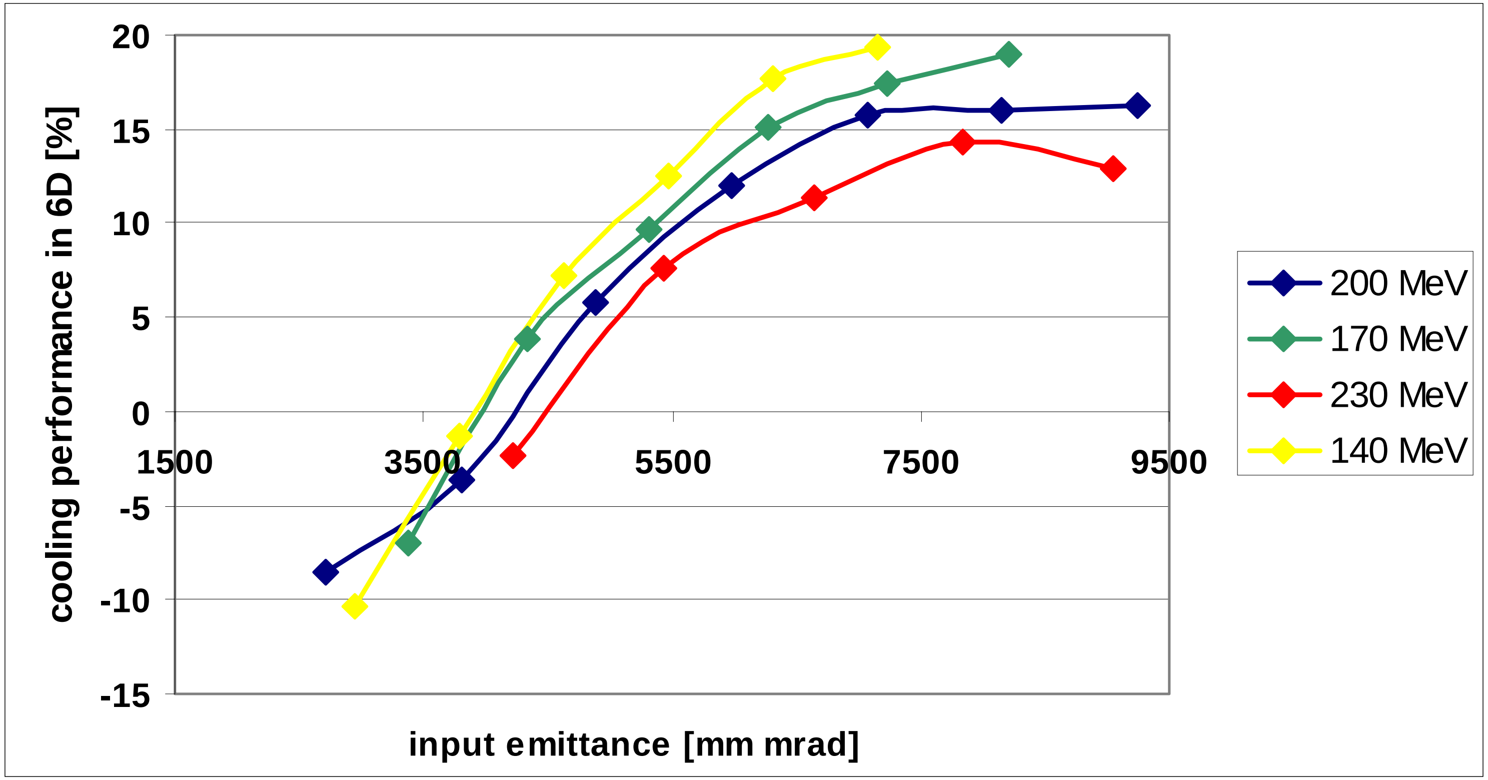
88 MHz Option (8 Cav.): Parameter Scan



cooling efficiency is measured as number of muons inside an acceptance of 0.1 eVs and 1.5 pi cm rad (norm.)

depending on input emittance, cooling efficiency up to 15%

88 MHz Option (8 Cav.): Parameter Scan



cooling efficiency for various input beam energies

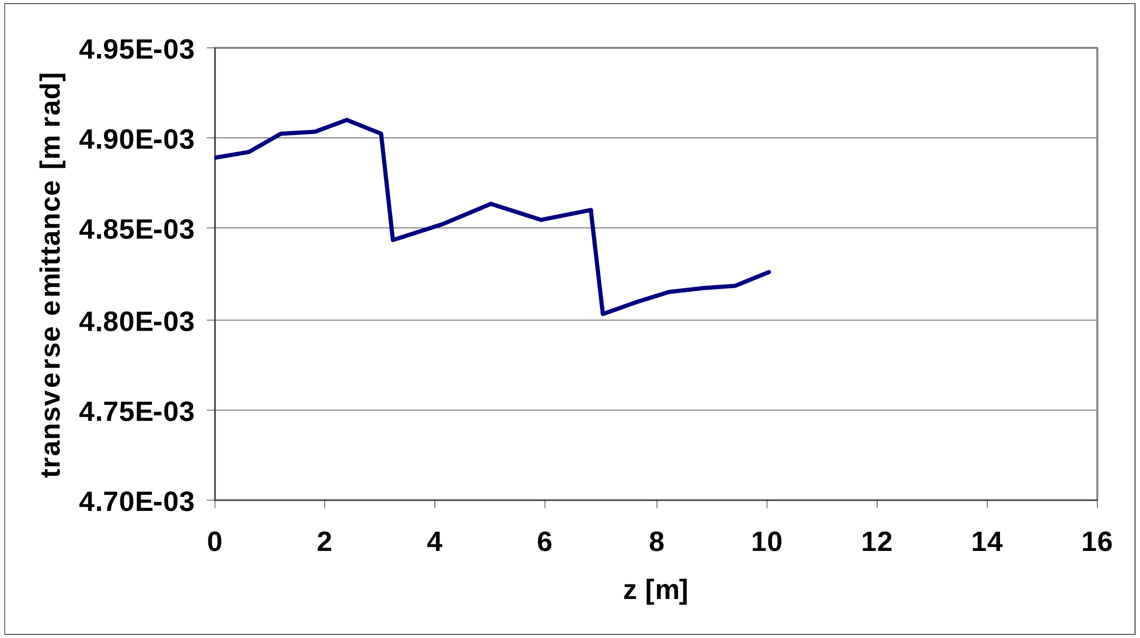
88 MHz Option (8 Cav.): Parameter Scan

various input beam energies used:
230, 200, 170, 140 MeV (kinetic)
for each energy: ε_{out} vs ε_{in}, cooling efficiency, transmission
see NF Note 90
for lower energy, the cooling performance goes up

E_{in} [MeV]	cooling efficiency[%]	solenoid field [T]
230	7.5	2.7
200	10.0	2.7
170	11.5	2.7
140	12.5	2.7

comparison of cooling efficiency for ε_{in} = 5500 mm mrad and various input beam energies

88 MHz Option (4 Cav.): Beam Dynamics



cooling performance of a system with only 4 cavities (50.000 particles)

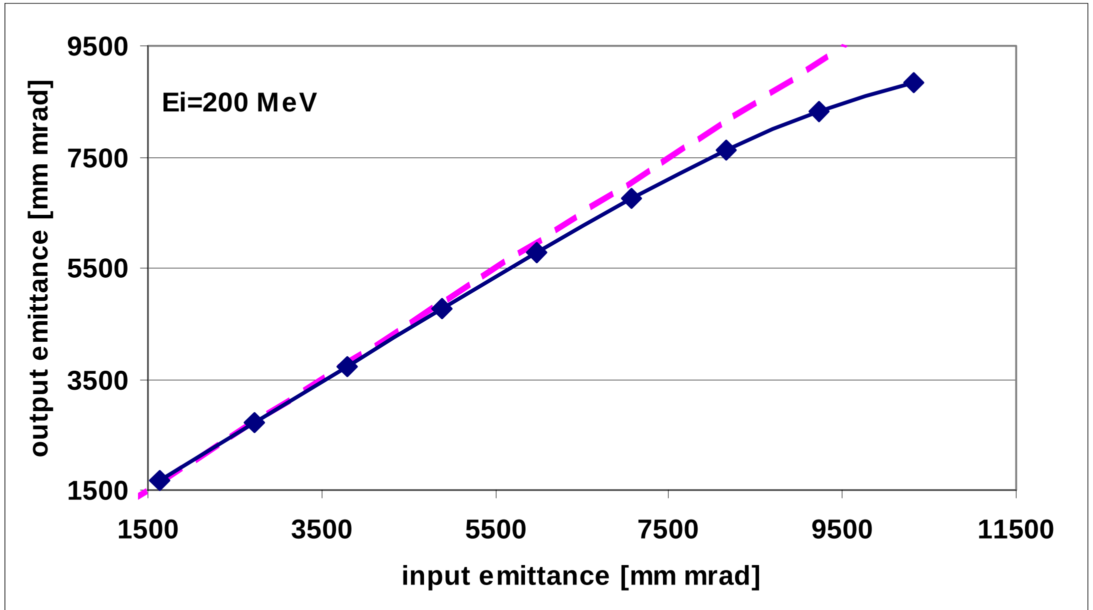
<u>performance for example optics:</u>

transv. emittance reduction 2%

particle gain in acceptance: +3.5 %

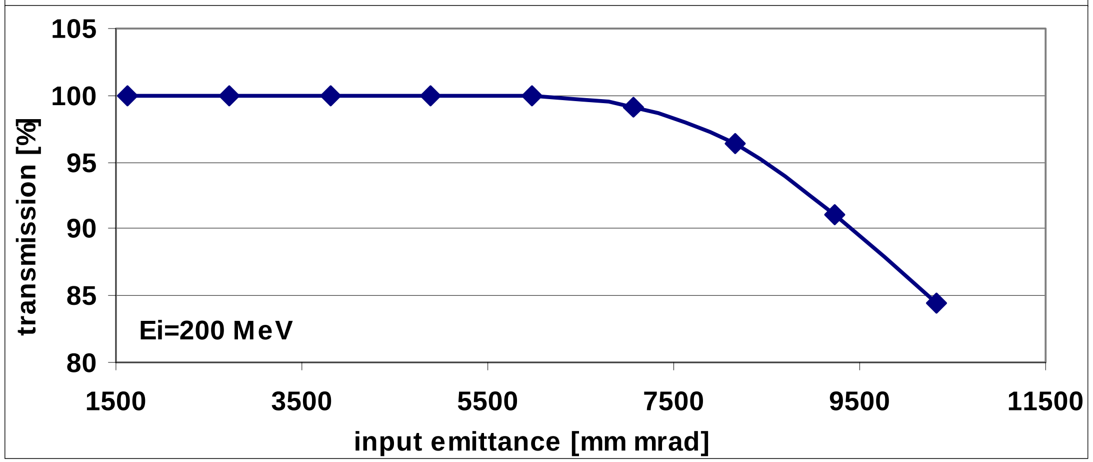
performance drops down roughly in proportion

88 MHz Option (4 Cav.): Parameter Scan



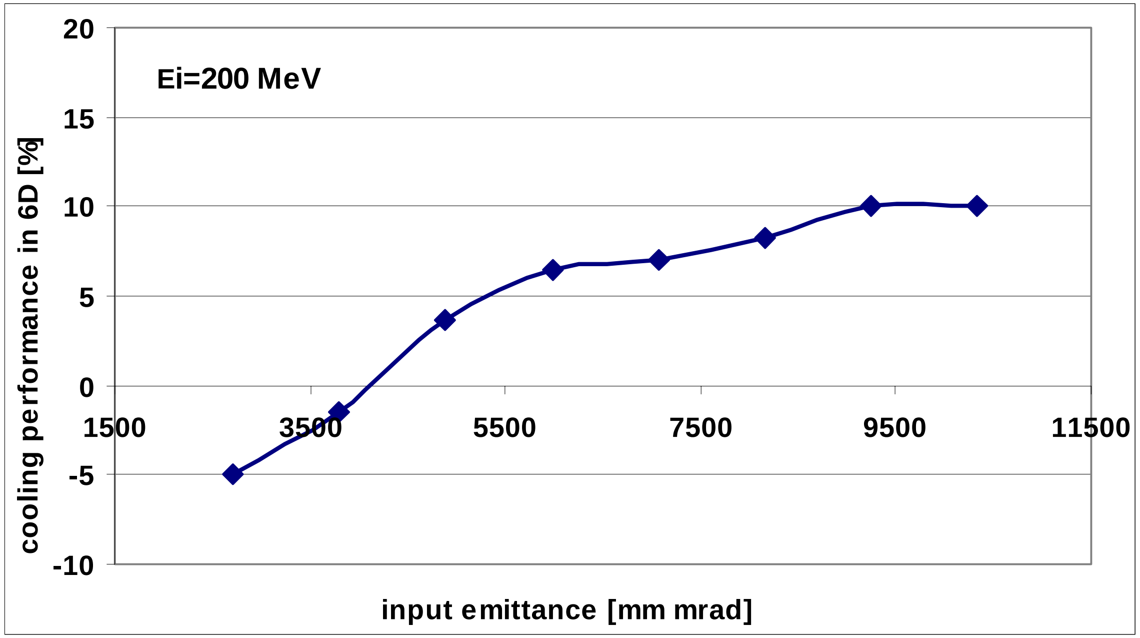
4 cavities,
E = 200 MeV

output emittance vs input emittance (r.m.s., norm.)



transmission vs input emittance (r.m.s., norm.)

88 MHz Option (4 Cav.): Parameter Scan



cooling efficiency is measured as number of muons inside an acceptance of 0.1 eVs and 1.5 pi cm rad (norm.)

depending on input emittance, cooling efficiency up to 10%

88 MHz Option (4 Cav.): Parameter Scan

input energies used: 200 MeV and 140 MeV (kinetic)
the hope is to compensate reduced cooling performance by going to lower energy

E_{in} [MeV]	cooling efficiency [%]	solenoid field [T]
200	4.5	2.7
140	6.5	2.5

comparison of cooling efficiency for ε_{in} = 5000 mm mrad and two different input beam energies

Conclusion

a cooling experiment, which is a subsection of the CERN 88 MHz cooling channel, has been simulated with *PATH* based on engineering designs for cavities and solenoids

the cooling performance is about 3.7 % in transverse (r.m.s) emittance reduction and about 9.1 % increase of muons inside a given acceptance; the performance of a system of only 4 cavities goes down in proportion

the results have been confirmed with a second code (*ICOOL*)

a detailed parameter scan has been performed to evaluate the performance of the channel for various input beams, settings etc. (E.-S.Kim, K.Hanke, NF Note 90)

simulation of a 200 MHz option under way