Cooling Experiment Simulations in Europe

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Collaboraton with INFN/Frascati

88 MHz option

- possible scenarios: 8 cavities and 4 cavities
- hardware design and simulation results

a) scenario using 8 cavities

- beam dynamics (*PATH*)
- cross check with *ICOOL*
- parameter scan

b) scenario using 4 cavities

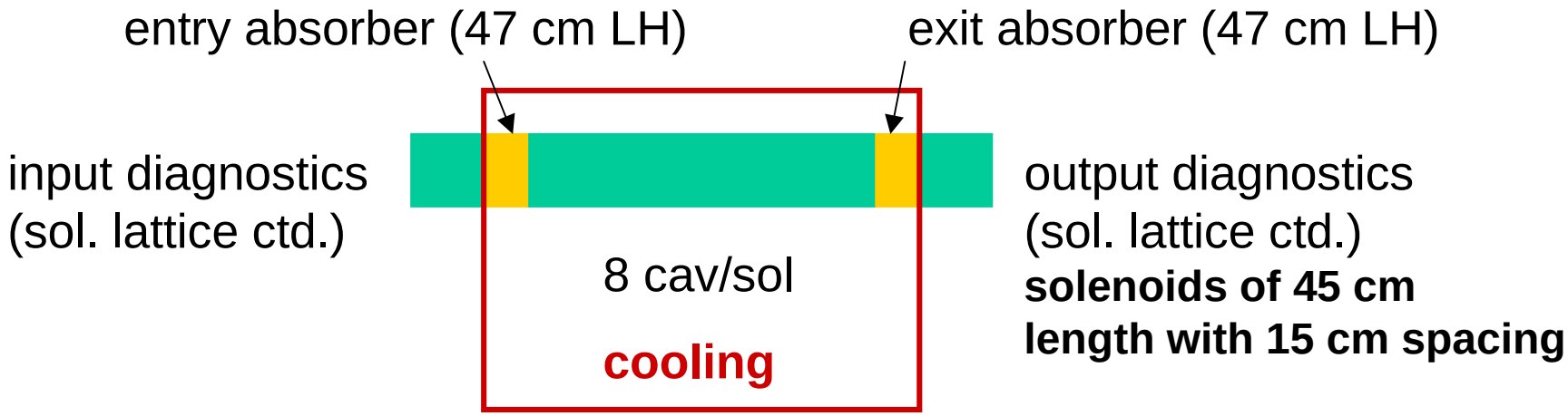
- beam dynamics and parameter scan

200 MHz option

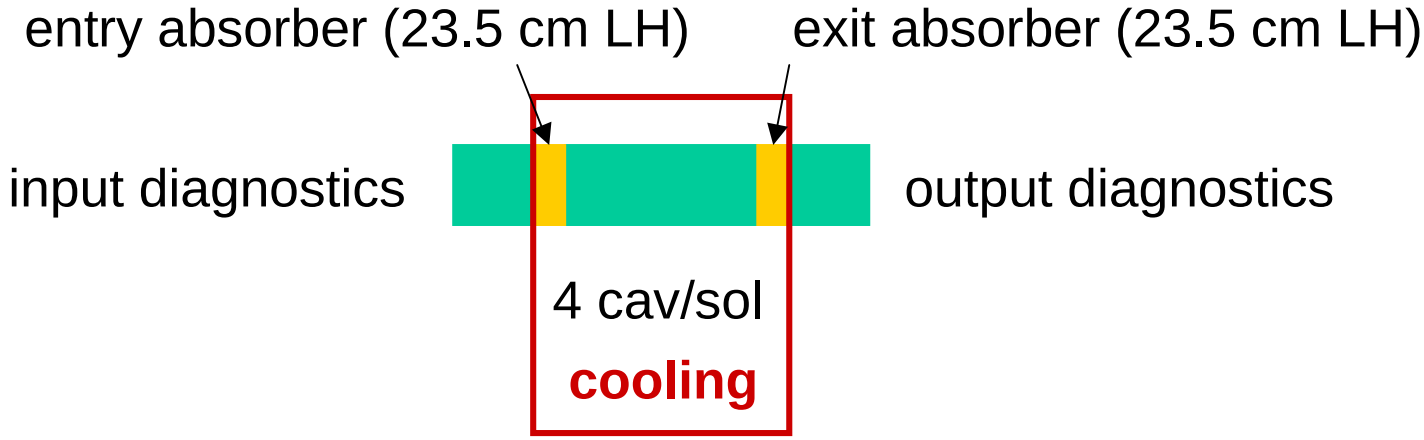
- simulation results (INFN collaboration)

88 MHz Option: Lay-Out

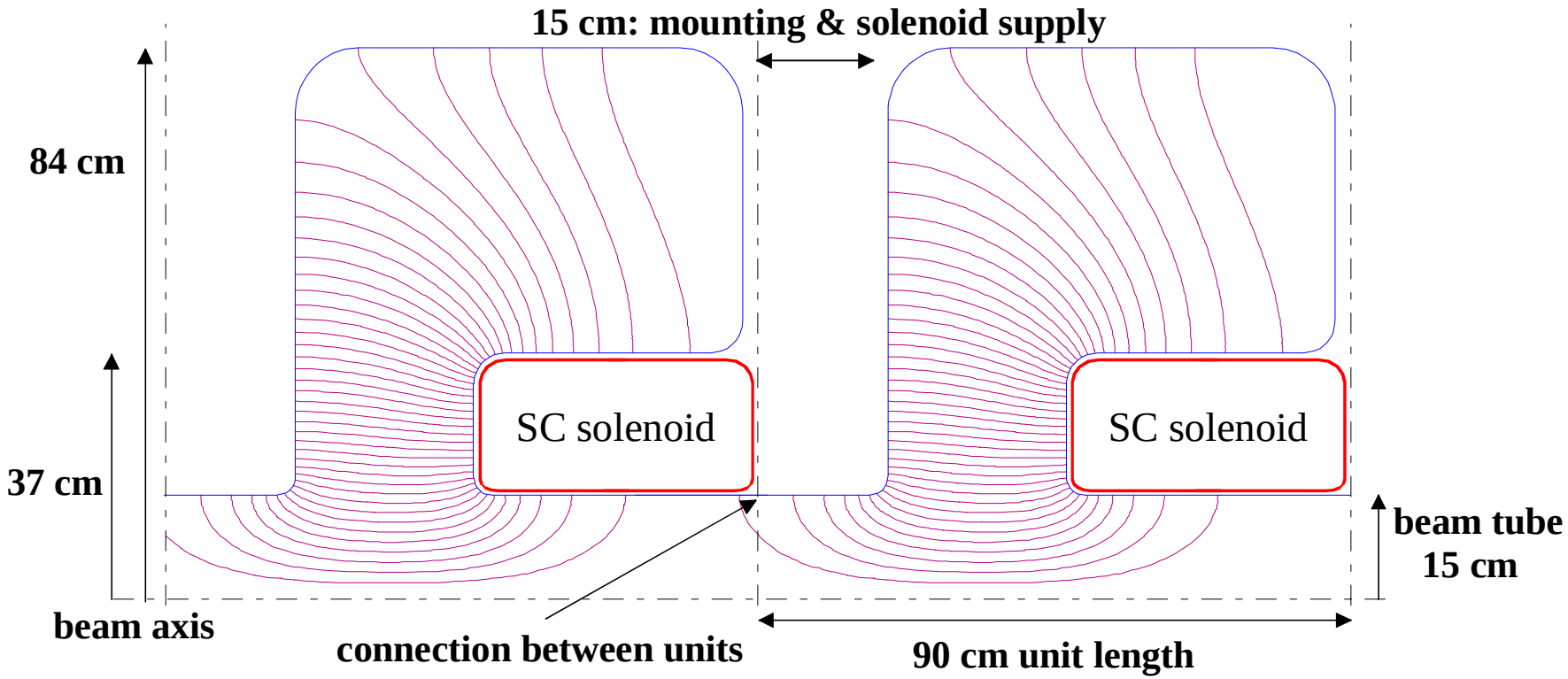
a)



b)

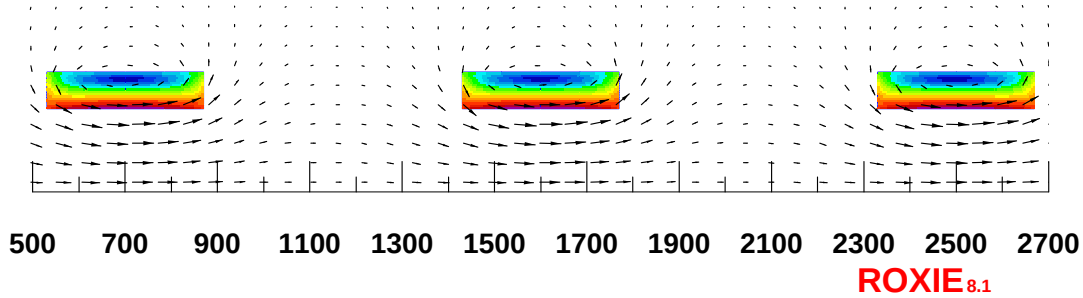


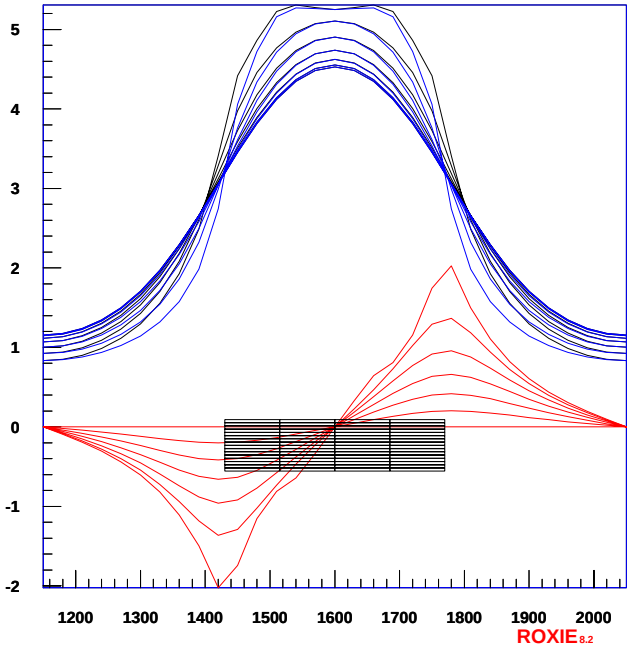
88 MHz Cavities



88 MHz cavities for muon cooling
SuperFish design, F.Gerigk

Solenoids for the 88 MHz Cavities





solenoids designed according to boundary conditions imposed by cavities
take into account cryogenics, forces etc.

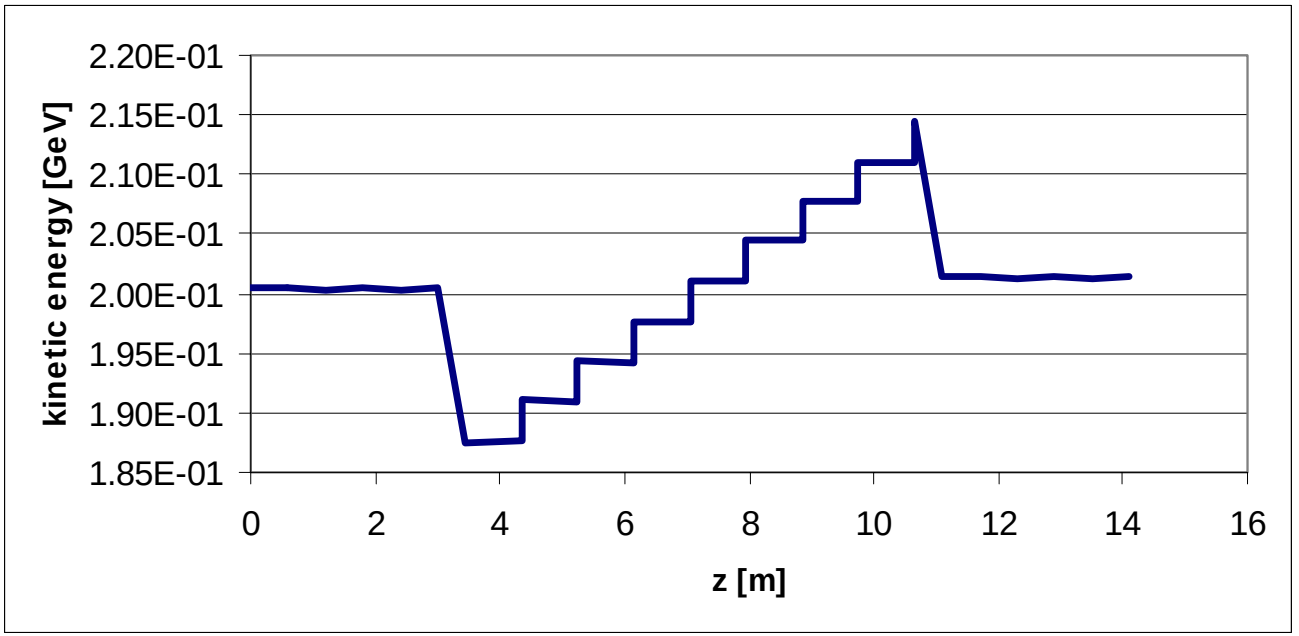
<u>maximum B_z on axis:</u>
quench limit for *NbTi* at 4.5 K: 9 T

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

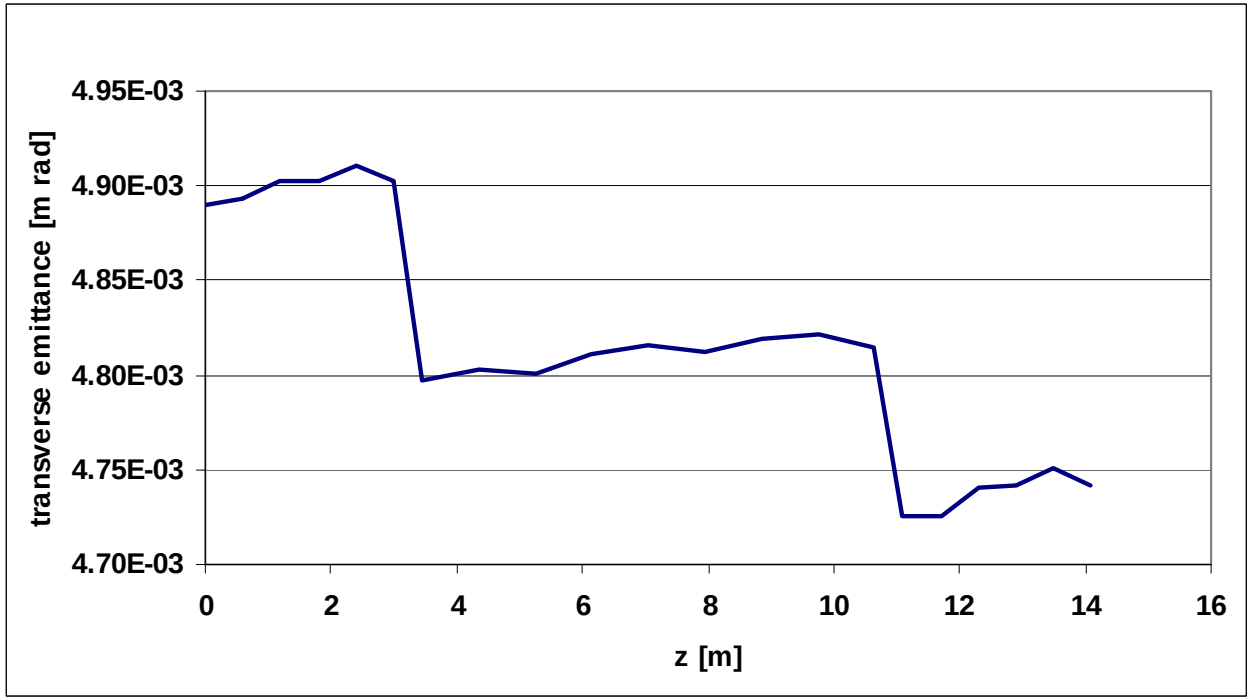
typical input beam parameters:
input energy: 200 MeV (variable)
energy spread +- 15 MeV
α = 0, β = 1 m, ε variable

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 %

88 MHz Option (8 Cav.): Beam Dynamics

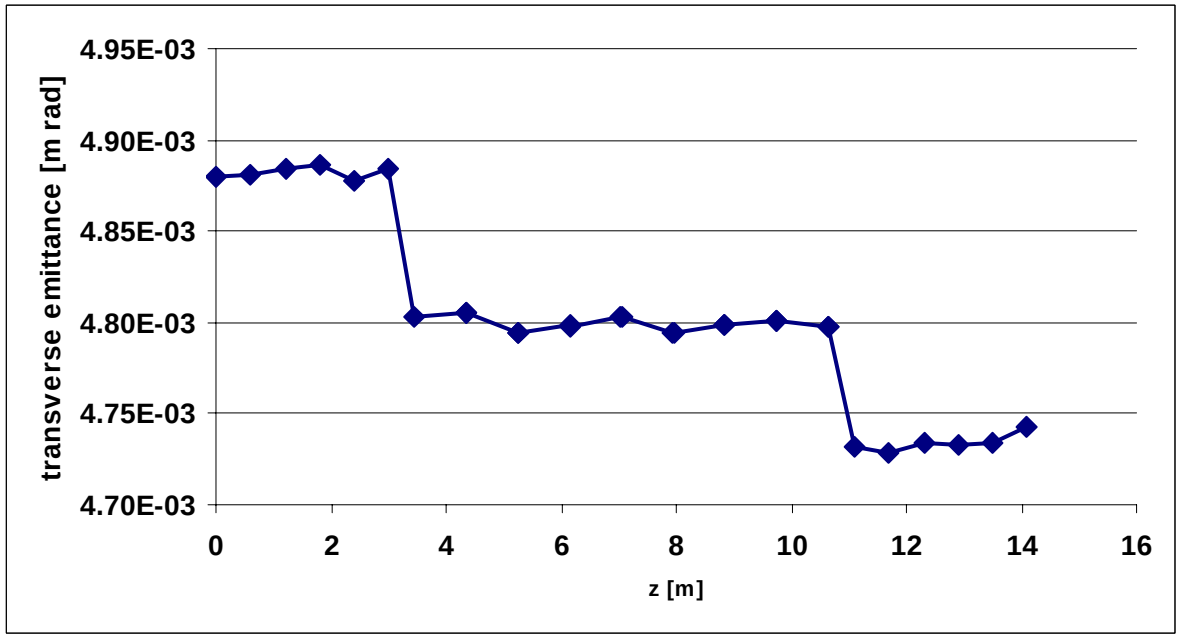
have recently included in the simulations:

-absorber windows (150 μm):
essentially no effect

-field flip:
does not change cooling performance

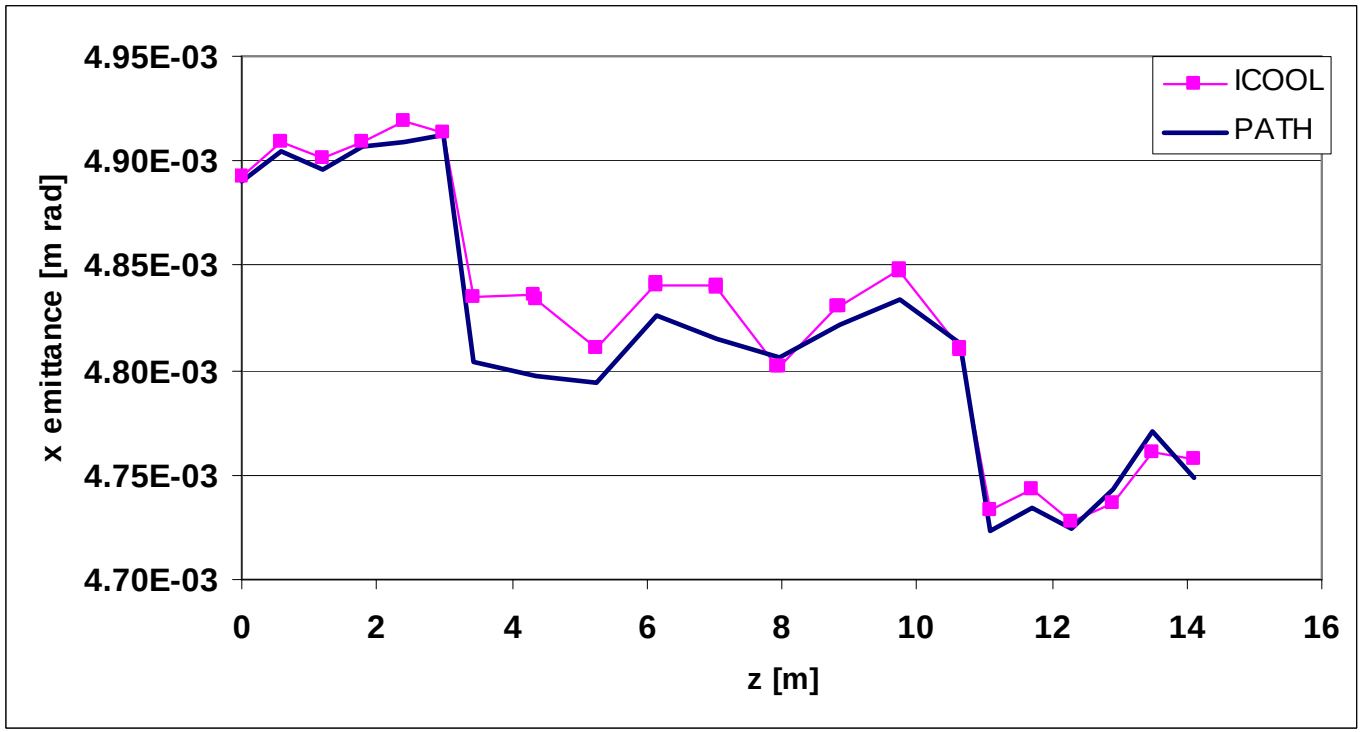
Cross-Check of *PATH* vs *ICOOL*

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



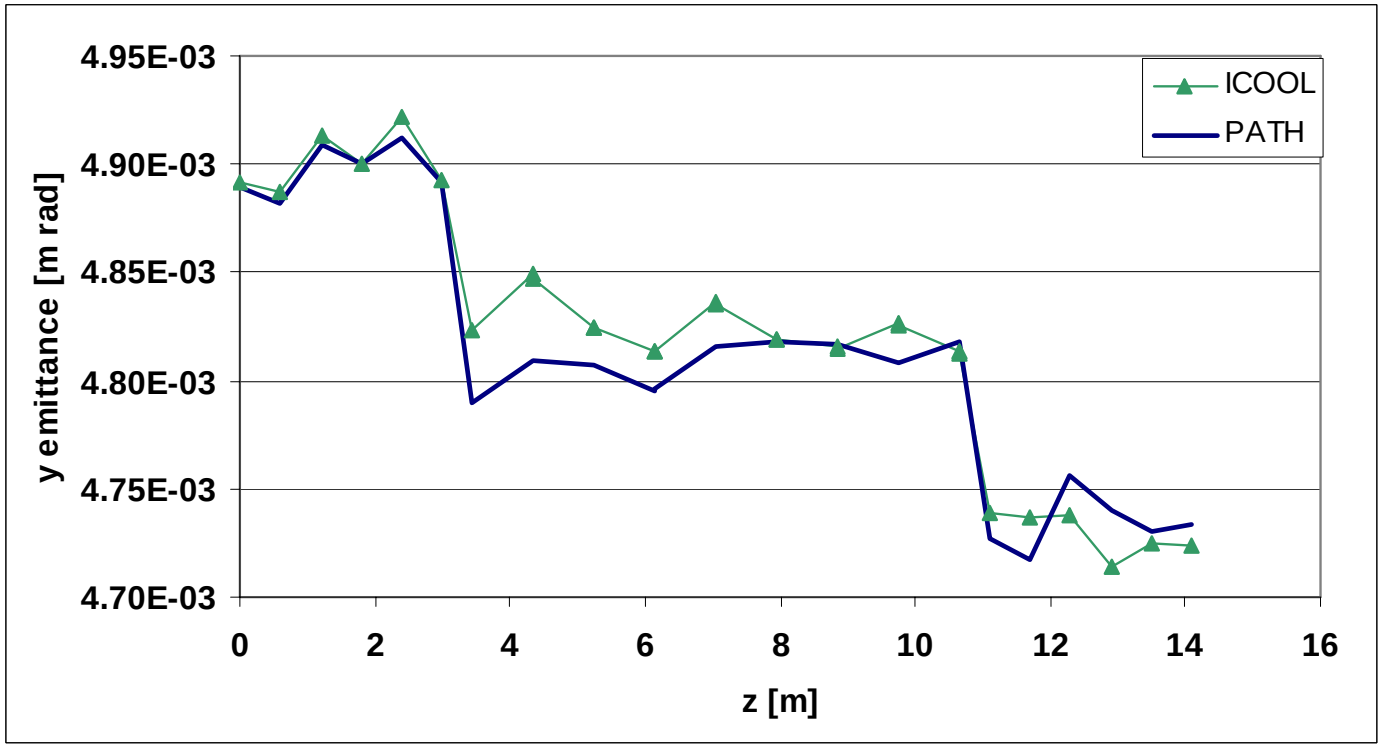
transv. emittance (r.m.s., norm.) vs z for 88 MHz cooling experiment (8 cav.) computed with *ICOOL* (50.000 particles)

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)

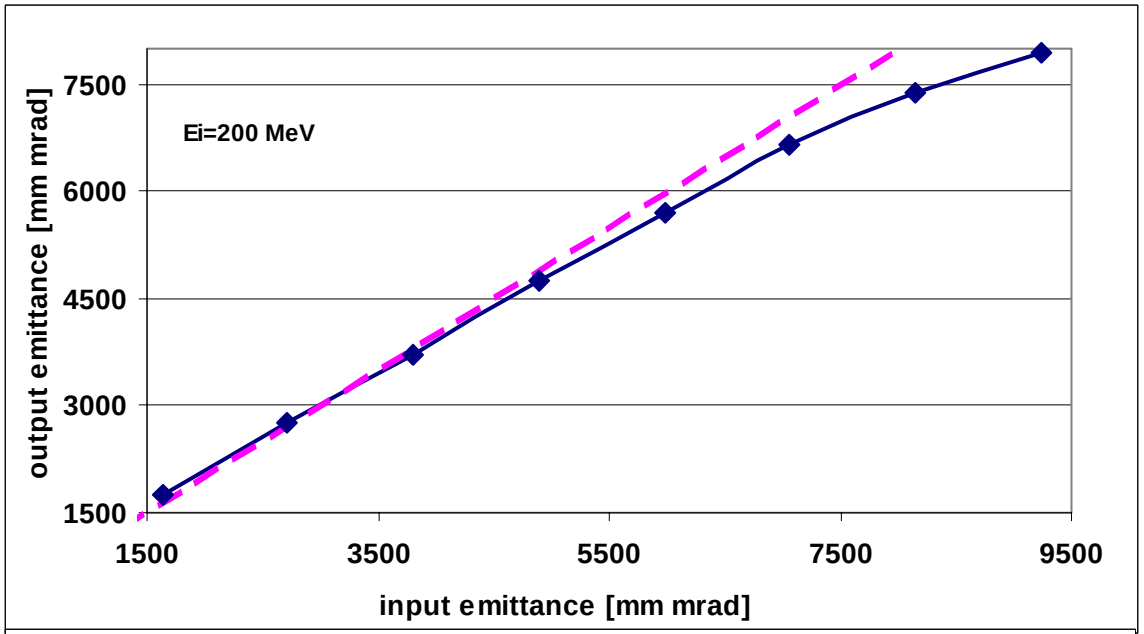
Cross-Check of *PATH* vs *ICOOL:* Conclusion

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 %

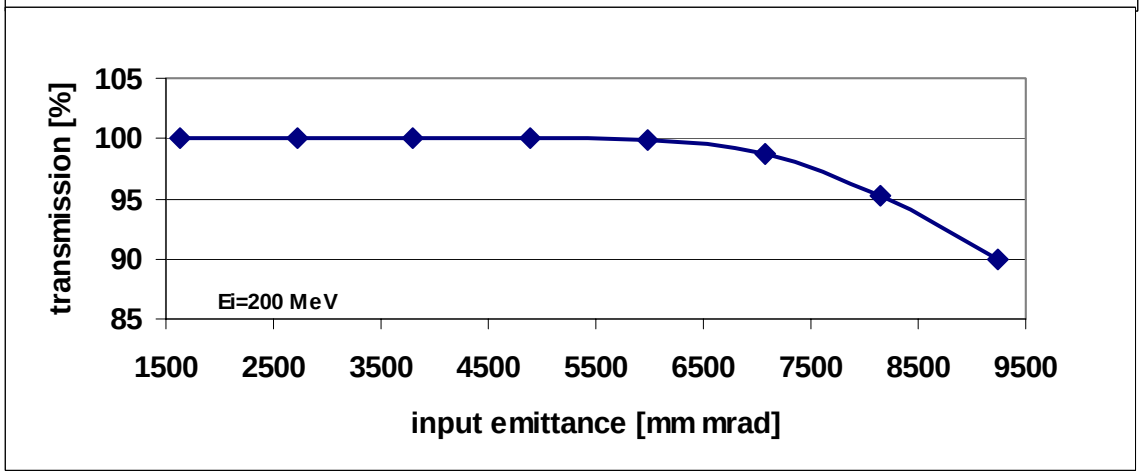
both runs done with same input distribution (50.000 particles)

88 MHz Option (8 Cav.): Parameter Scan



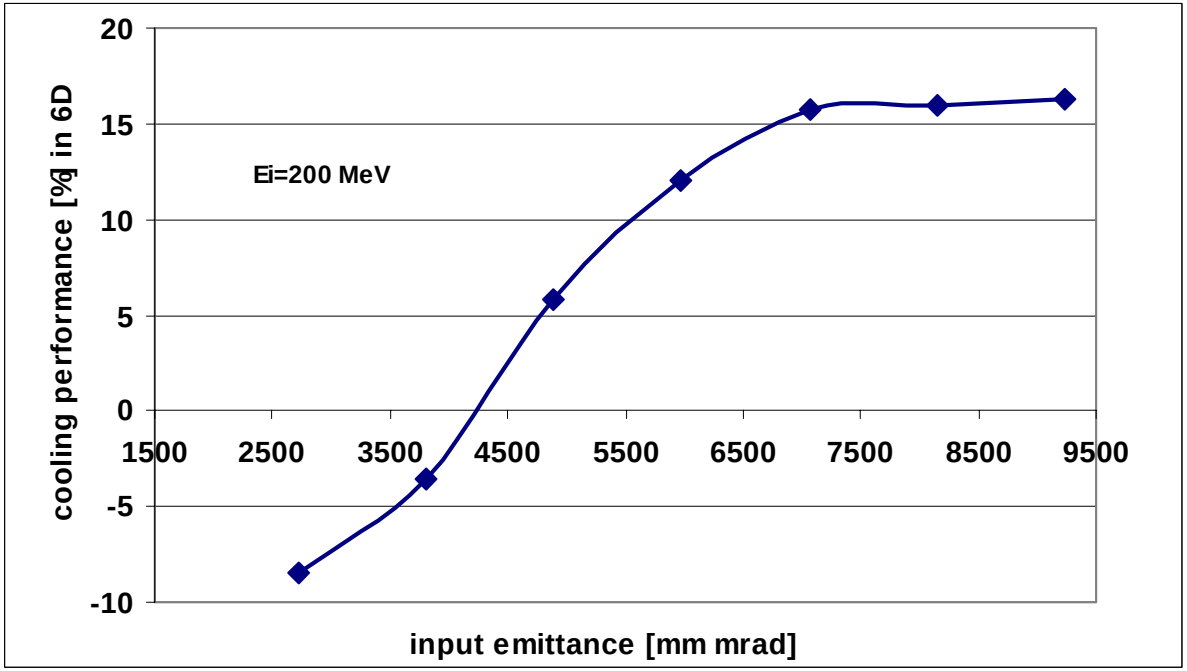
8 cavities,
E = 200 MeV

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



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

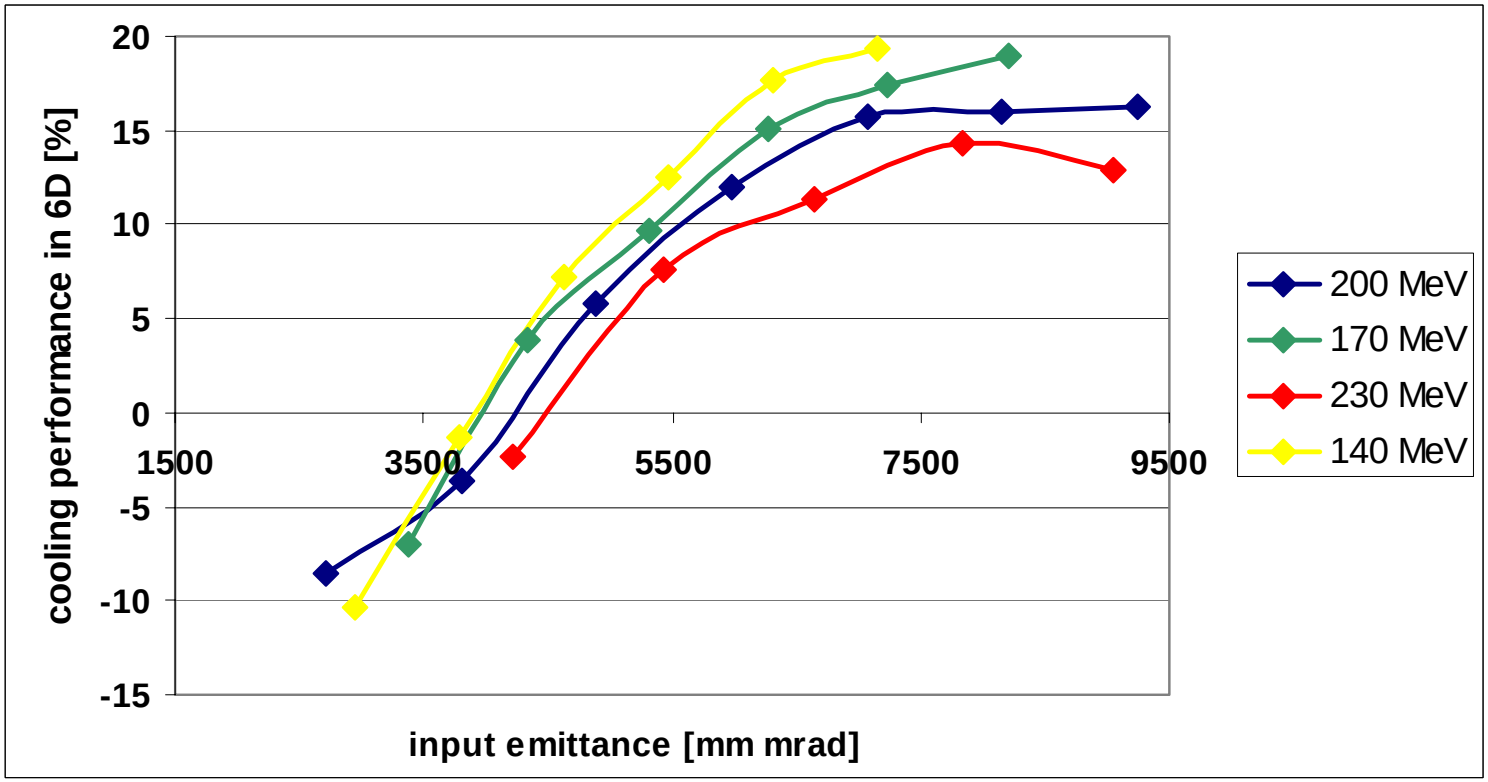
88 MHz Option (8 Cav.): Parameter Scan



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

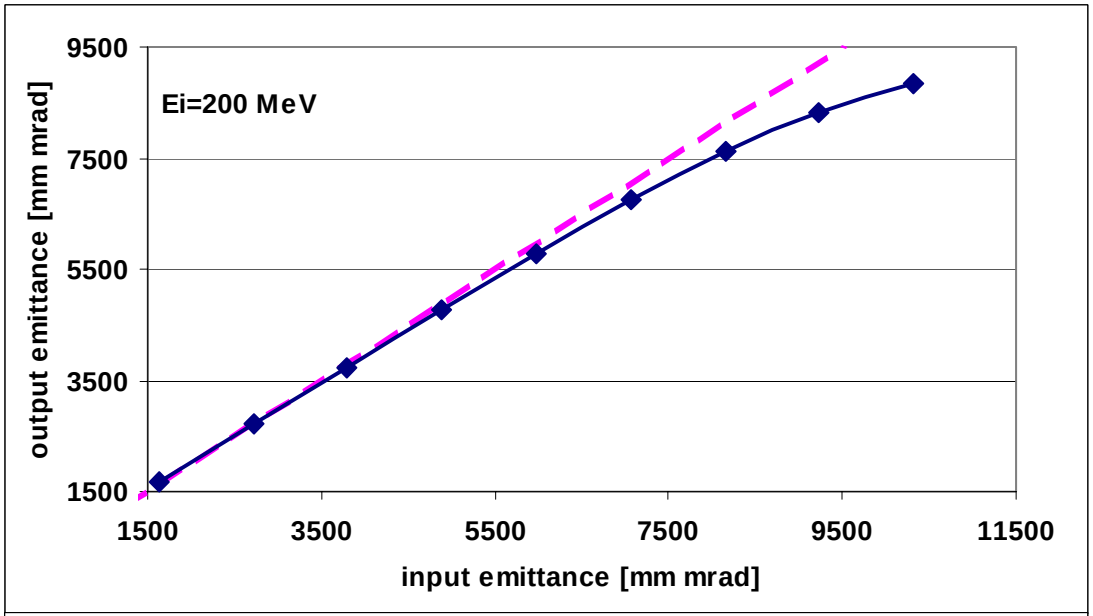
E_{in} [MeV]	cooling efficiency[%]	solenoid field [T]
230	7.5	2.7
200	10.0	2.7
170	11.5	2.7
140	12.5	2.7

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

88 MHz Option (4 Cav.): Beam Dynamics

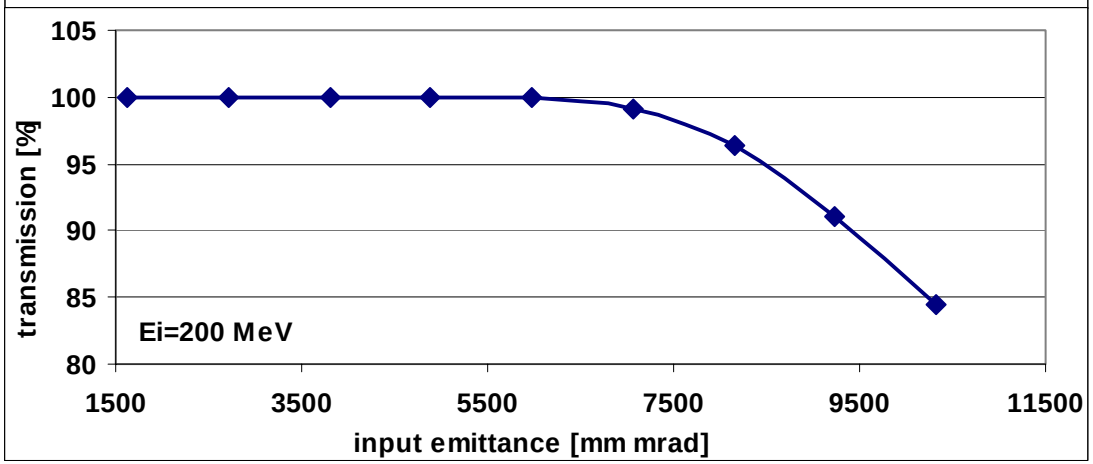
cooling performance of a system with only 4 cavities (50.000 particles)
performance for example optics:
transv. emittance reduction 2%
particle gain in acceptance: +3.5 %
performance drops down roughly in proportion

88 MHz Option (4 Cav.): Parameter Scan



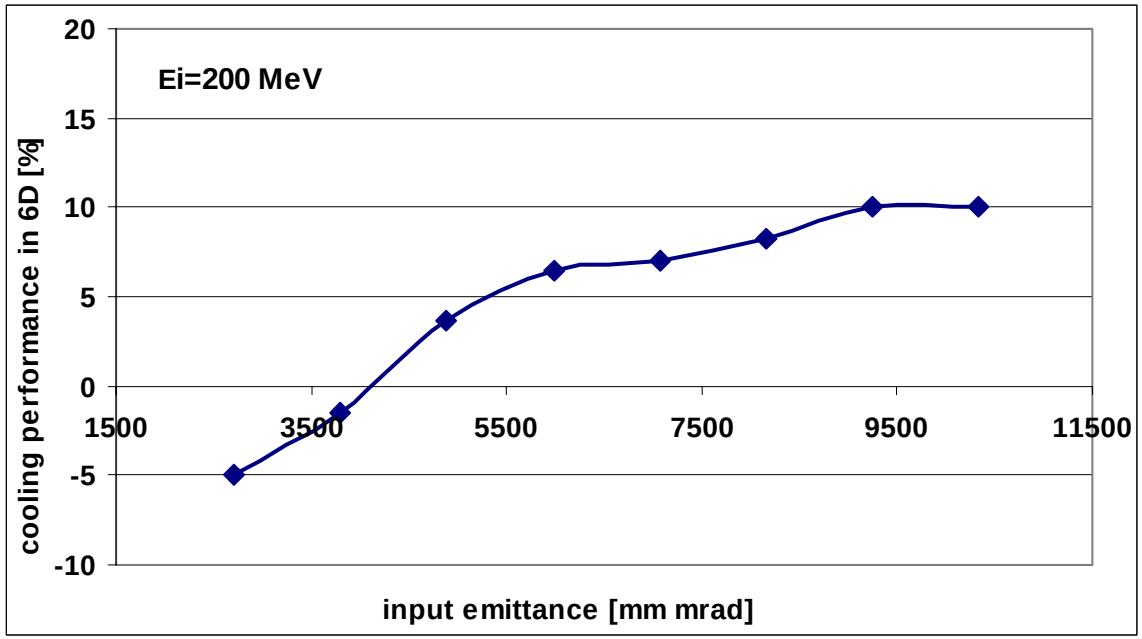
4 cavities,
E = 200 MeV

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 $\boldsymbol{e}_{in}$ = 5000 mm mrad and two different input beam energies

200 MHz Simulations at INFN Frascati

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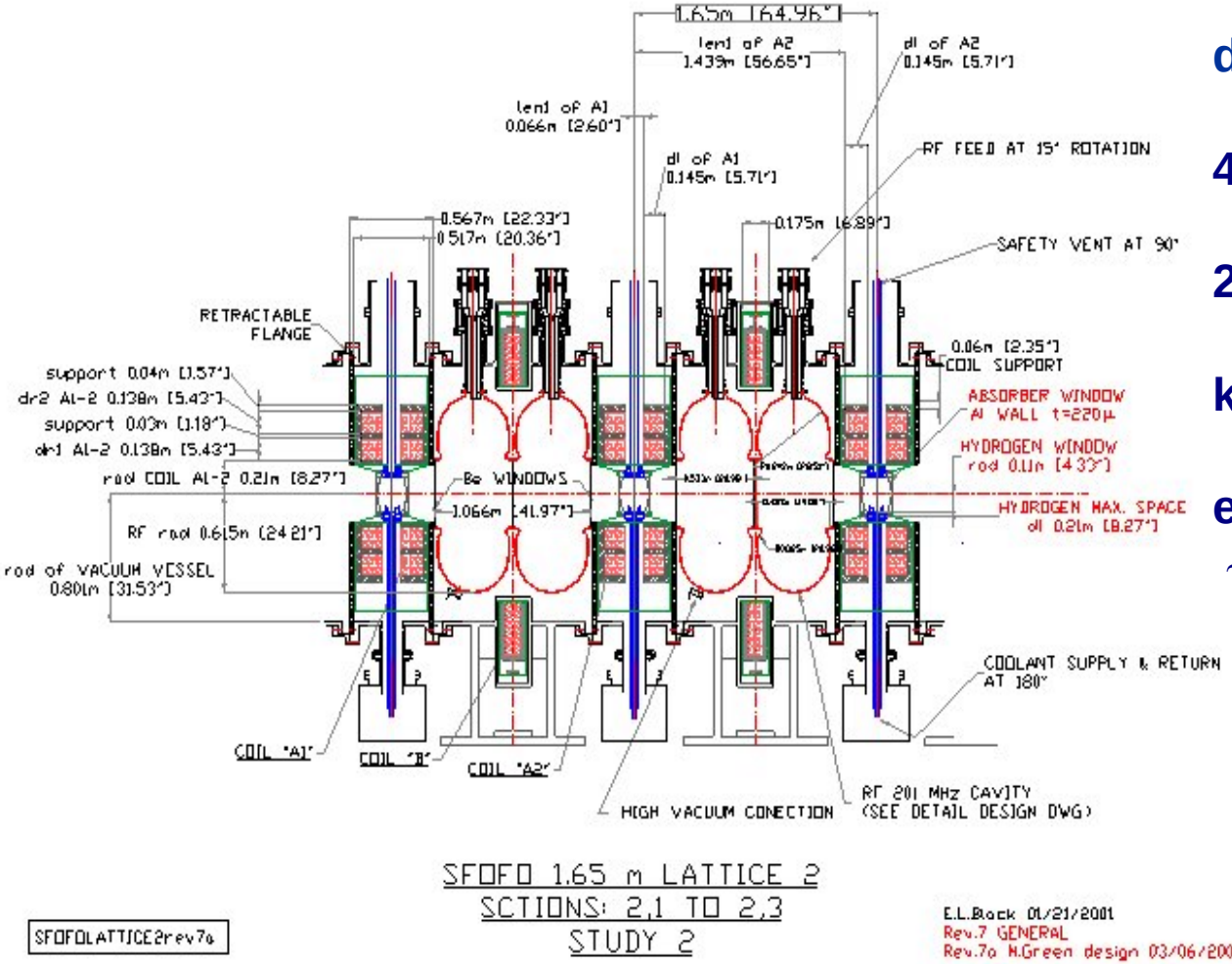
Luciano Catani
Alessandro Cianchi
Massimo Ferrario
Valeria Fusco
Mauro Migliorati
Luigi Palumbo
Bruno Spataro
Franco Tazzioli
Cristina Vaccarezza
Victor Verzilov

Collaboration with NFWG at CERN

Aim:
Design a Test Facility for μ-cooling
Prepare a proposal by the end of June 2002

Task of INFN group:
Study the 200 MHz scheme in comparison with the 88 MHz scheme proposed at CERN

Components & Parameters



diagnostic solenoids ~2m

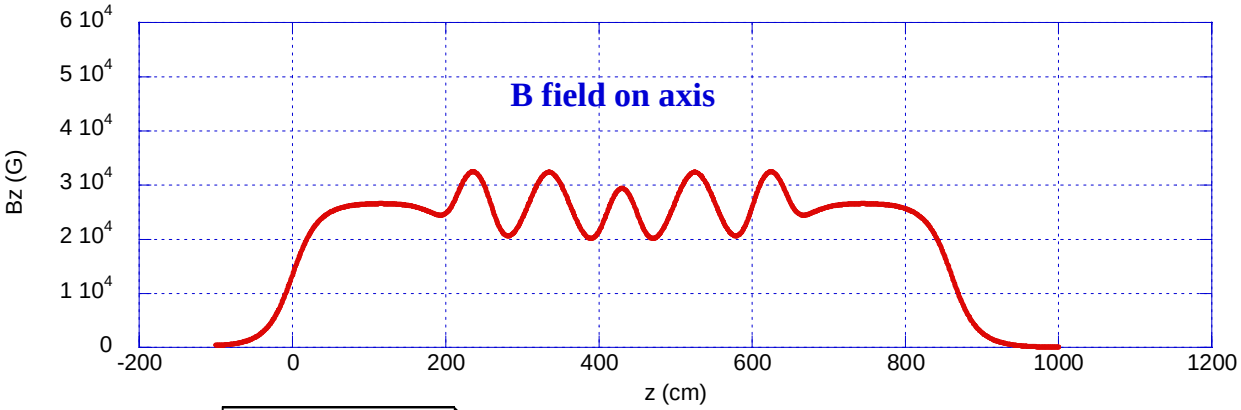
4 RF 200MHz cells, 7.6 MV/m

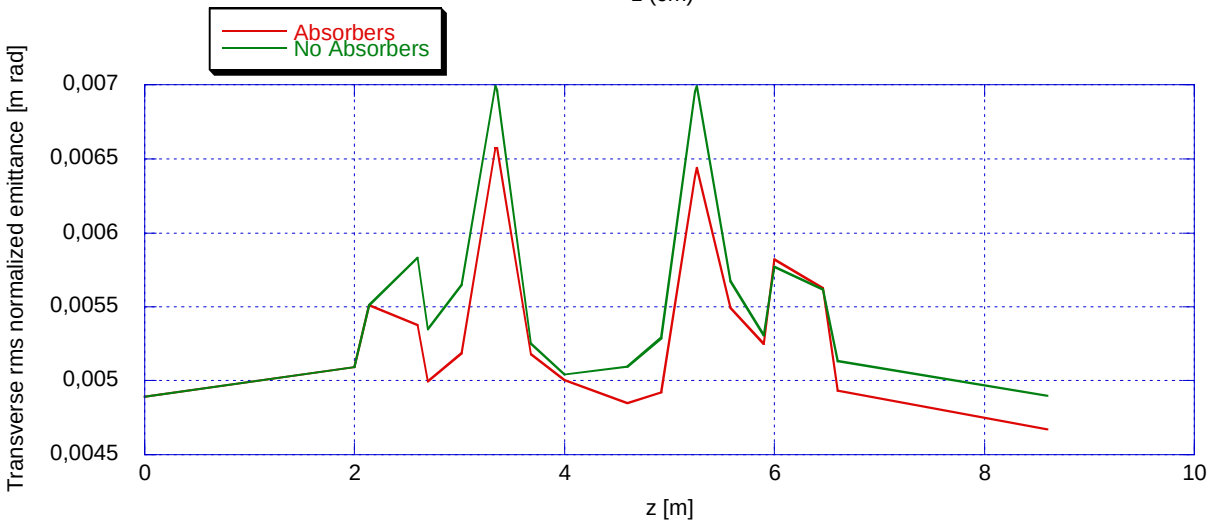
2 absorbers of 46 cm LH

kinetic energy: ~ 200 MeV

emittance (rms, norm.):
~ 3 – 10 mm rad

200 MHz Option: Simulation Results





particle gain in acceptance:
+ 9%
as in 88 MHz case

PATH simulation of 2 × 2 cell 200 MHz cavity with 2 × 46 cm LH absorber

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 the RLA acceptance (for nominal optics)
the performance of a system of only 4 cavities drops 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)

a 200 MHz system has been simulated and shows a cooling performance comparable to the 88 MHz option

Summary paper in preparation