CERN Super-Beam
(SPL)

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new very fresh document

CERN–2006–006
12 July 2006

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Conceptual design of the SPL II

A high-power superconducting H$^-$ linac at CERN

F. Gerigk (Editor), M. Baylac[1], E. Benedico Mora, F. Caspers, S. Chel[2], J.M. Deconto[1], R. Duperrier[2], E. Froidefond[1], R. Garoby, K. Hanke, C. Hill, M. Hori[3], J. Inigo-Golfin, K. Kahle, T. Kroyer, D. Kuechler, J.-B. Lallement, M. Lindroos, A.M. Lombardi, A. López Hernández, M. Magistris, T.K. Meinschad, A. Millich, E. Noah Messomo, C. Pagani[4], V. Palladino[5], M. Paoluzzi, M. Pasini, P. Pierini[4], C. Rossi, J.P. Royer, M. Sanmarti, E. Sargsyan, R. Scrivens, M. Silari, T. Steiner, J. Tückmantel, D. Uriot[2], M. Vretenar

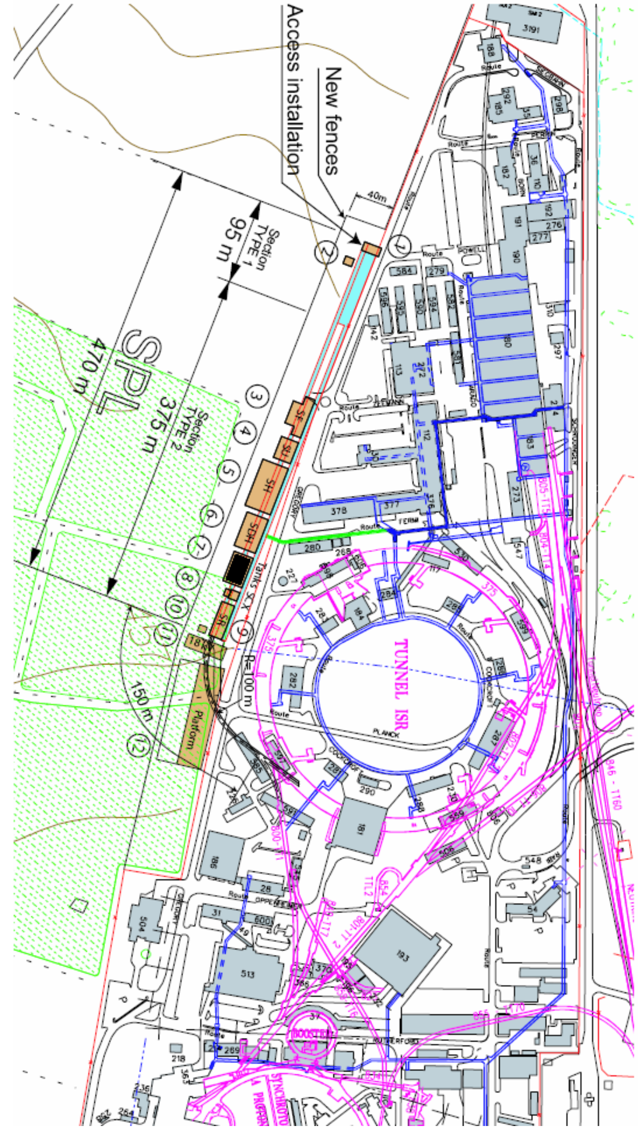

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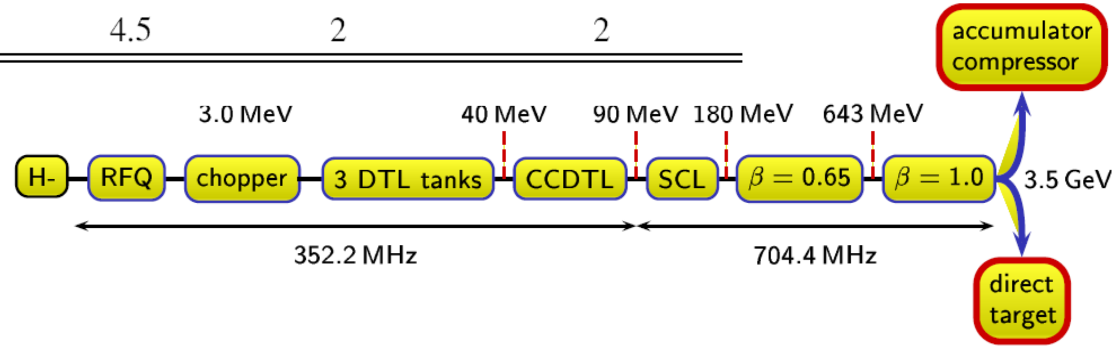
Table 2.2: Main linac parameters and changes from CDR1 to the revised design (CDR2)

	CDR1	CDR2 (neutrino)	CDR2 (ISOL)
Energy [GeV]	2.2	3.5	3.5
Length [m]	690	430	430
Average beam power [MW]	4	4	5
Average RF power† [MW]	24	17	21
Average cryogenics power [MW]	9.6	3.6	4.4
Repetition rate [Hz]	75	50	50
Beam pulse length [ms]	2.2	0.57	0.71 + 0.014
Average pulse current (after chopping) [mA]	11	40	40
Peak bunch current (after 3 MeV) [mA]	18.4	64	40
Beam duty cycle (after chopping) [%]	16.5	2.9	3.6
Injection turns (into ISR)	660	176	–
Peak RF power [MW]	32	162	162
No. of 352.2 MHz tetrodes (0.1 MW)	79	3	3
No. of 352.2 MHz klystrons (1 MW)	44	14	14
No. of 704.4 MHz klystrons (5 MW)	–	44	44
Cryo-temperature [K]	4.5	2	2

† Without 30% margin for Lorentz detuning.



Possible energy upgrade to 5 GeV could be the subject of a 3rd CDR (CDR3)

CERN Super-Beam (SPL)

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CERN–2006–005
ECFA/06/242
22 May 2006

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Beams for European Neutrino Experiments (BENE)
Midterm scientific report

CARE

BENE

Edited by the (extended) BENE Steering Group

A. Baldini (Pisa), R. Bennett (RAL), A. Blondel (Geneva), J. E. Campagne (LAL), C. Cavata (Saclay), A. Donini (Madrid), M. Dracos (Strasbourg), J. Dumarchez (Paris VI), R. Edgecock (RAL), I. Efthymiopoulos (CERN), R. Garoby (CERN), P. Huber (Madison), K. Long (IC London), M. Lindroos (CERN), F. Méot (Saclay & Grenoble), M. Mezzetto (Padua), V. Palladino (Naples), G. Rees (RAL), P. Sievers (CERN), P. Strolin (Naples), C. Volpe (IPNO)

Also a lot of information inside the BENE Midterm scientific report

Collection system for future neutrino beams
horn and target integration

- 2 LoI's in BENE (CARE)
  - CERN
  - Strasbourg

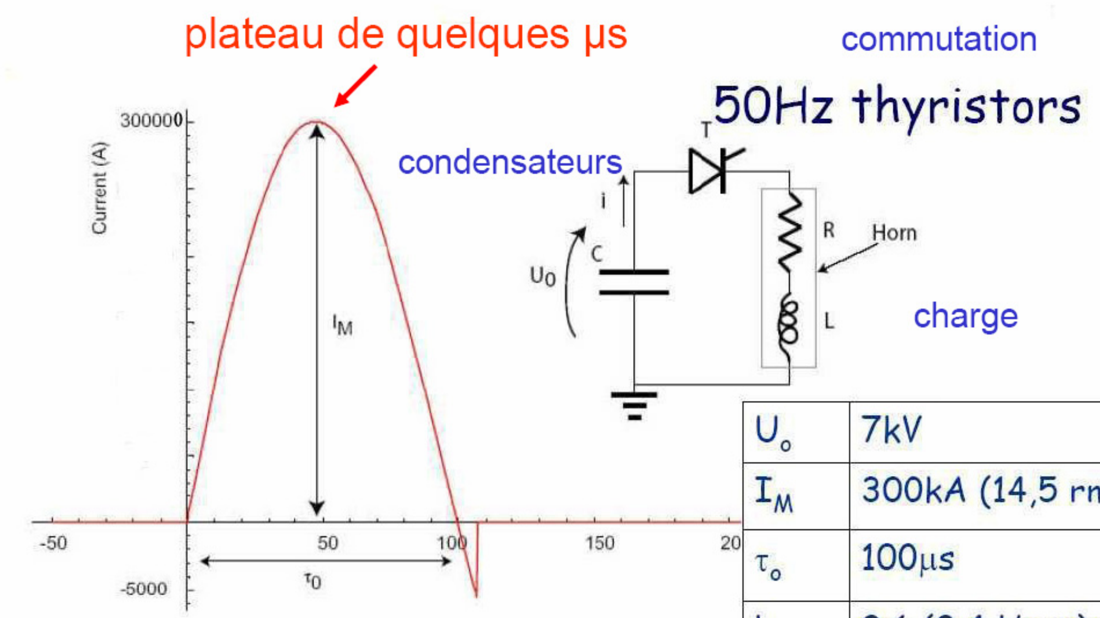
CERN LoI

- Target R&D
- Horn and solid target integration

1. Improve existing infrastructure (at BA7) to allow realistic tests of a NuFact prototype horn at nominal conditions. Analysis of fatigue tests and possible corrective actions.
2. Investigation of the material structure of the existing Nufact horn (480 k€, available) with a 50 Hz power supply (300 kA, 5 kV, <100 μs). The investigation will be based on laser vibrometer (100 k€, available) measurements of the horn's resonance frequencies and of their damping constants with increasing number of cycles. A mechanical analysis (mechanical engineers from Poland/Krakow via T. Kurtyka) should be derived to assess the fatigue of the system (horn and strip line) and its life time (expected to be few month of operations at nominal parameters).
3. Development of a test bench using the NuFact horn and the 50Hz power supply to validate multi-physics simulations in order to reduce the experimental working load and costs (collaboration with Strasbourg).
4. Address the integration issues of the horn. Complete the design of the existing horn including possibly the studies for a target station located in the inside. Investigate the cooling issues involved. (collaboration with BNL).

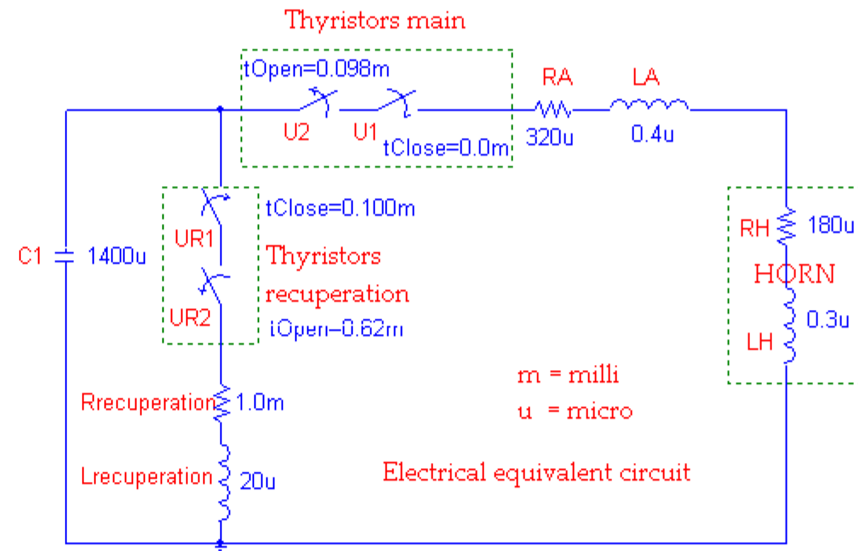
total cost for the collector: 1.35 M€

Power Supply for horn pulsing (major issue)

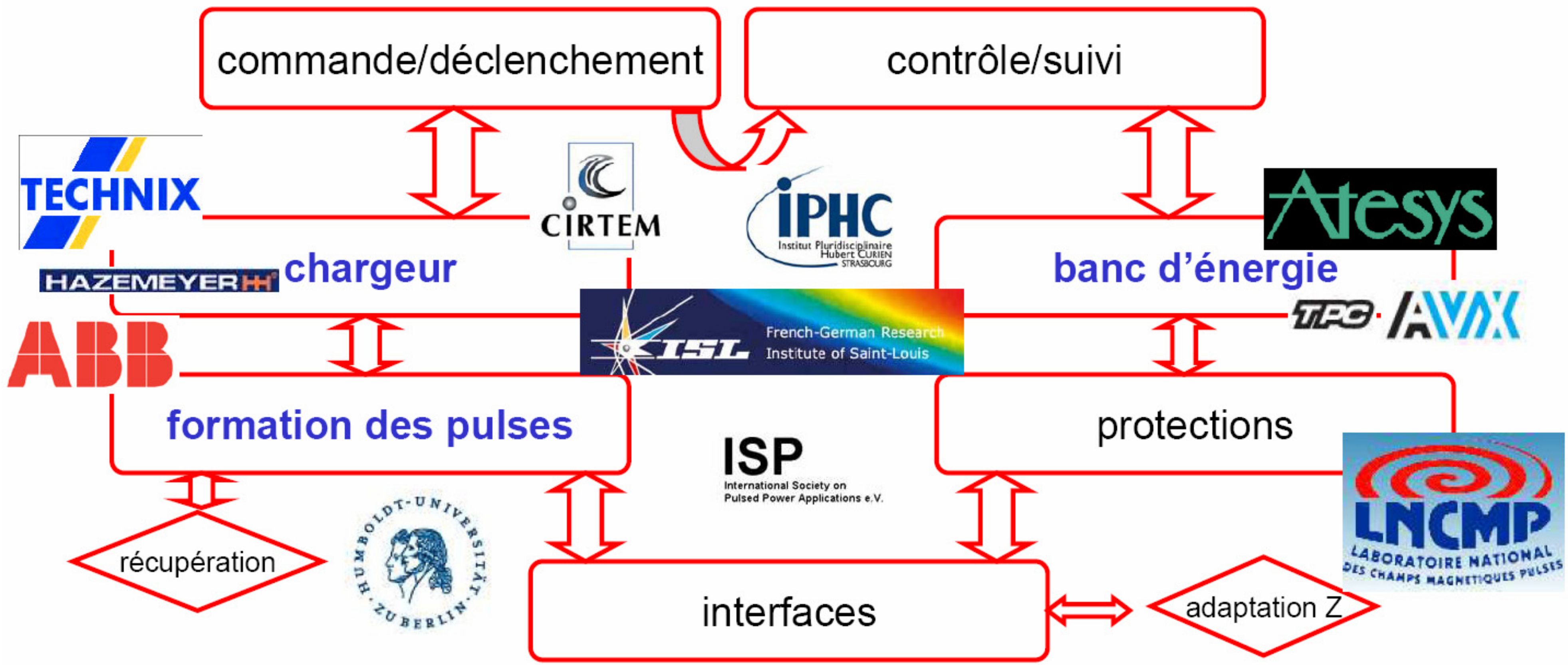


values considered by CERN

U_o	7kV
I_M	300kA (14,5 rms)
τ_o	100µs
L	0.6 (0.4 Horn)µH
R	500 (180 Horn) µΩ
C	1500µF

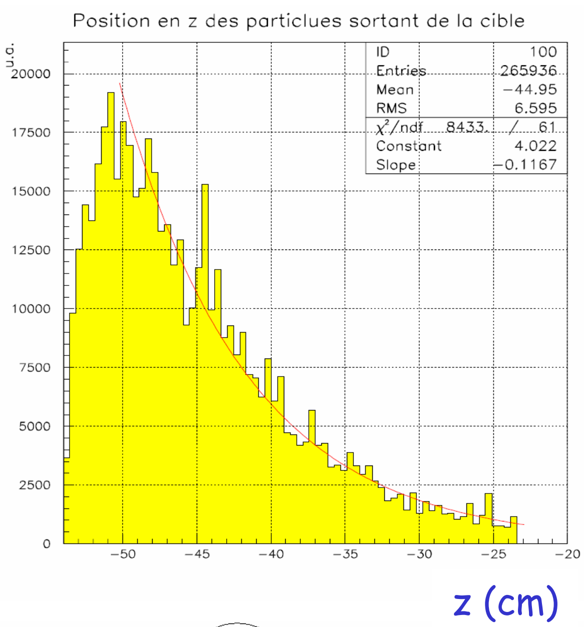


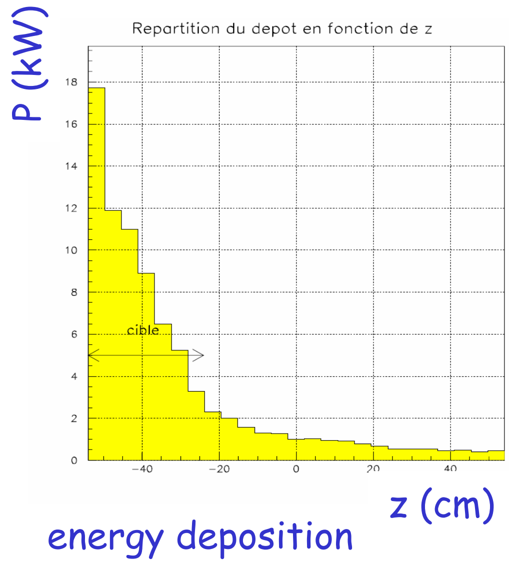
the power supply

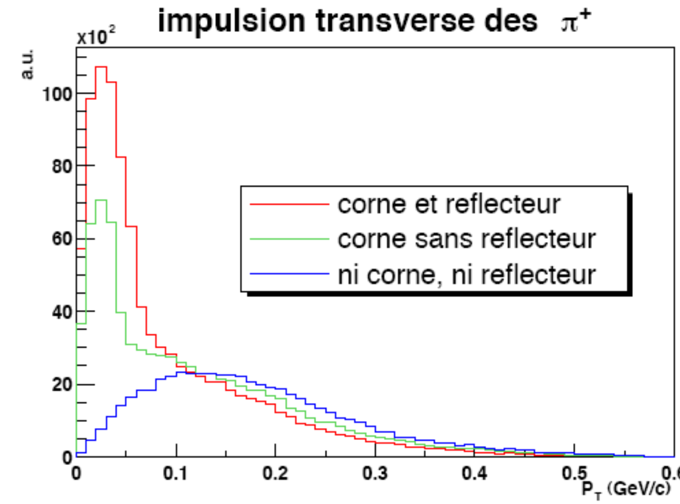


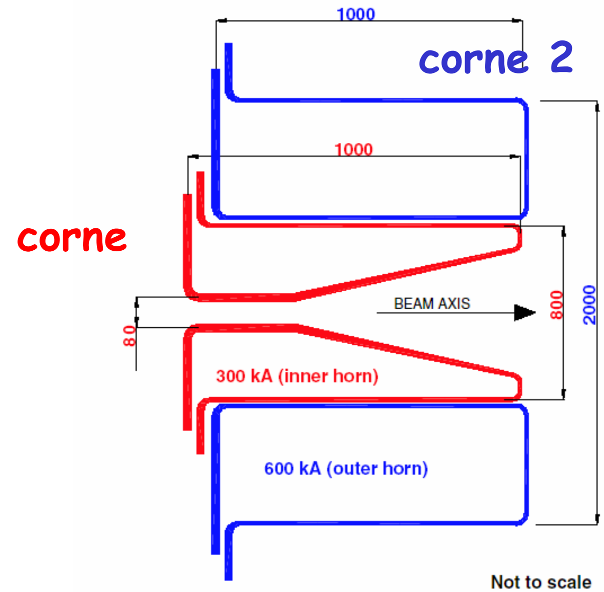
Due to the high price go to a modular system and increase small by small the current

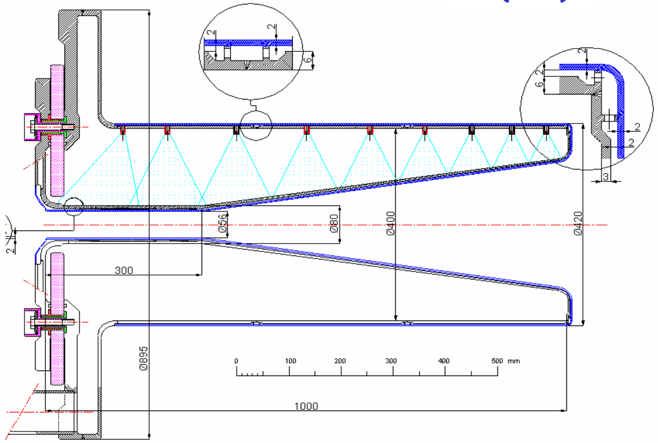
"Physics" studies to be restarted







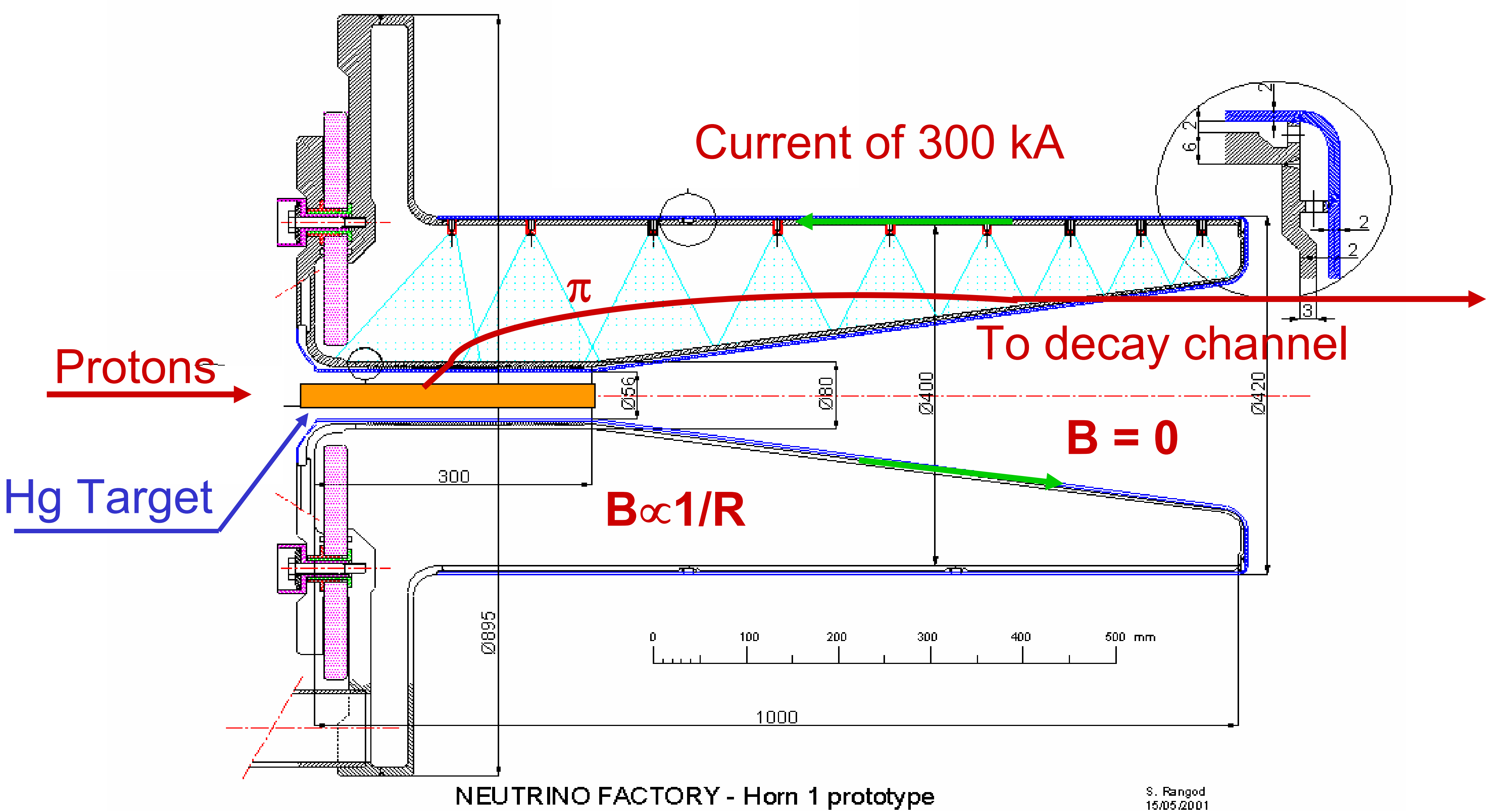




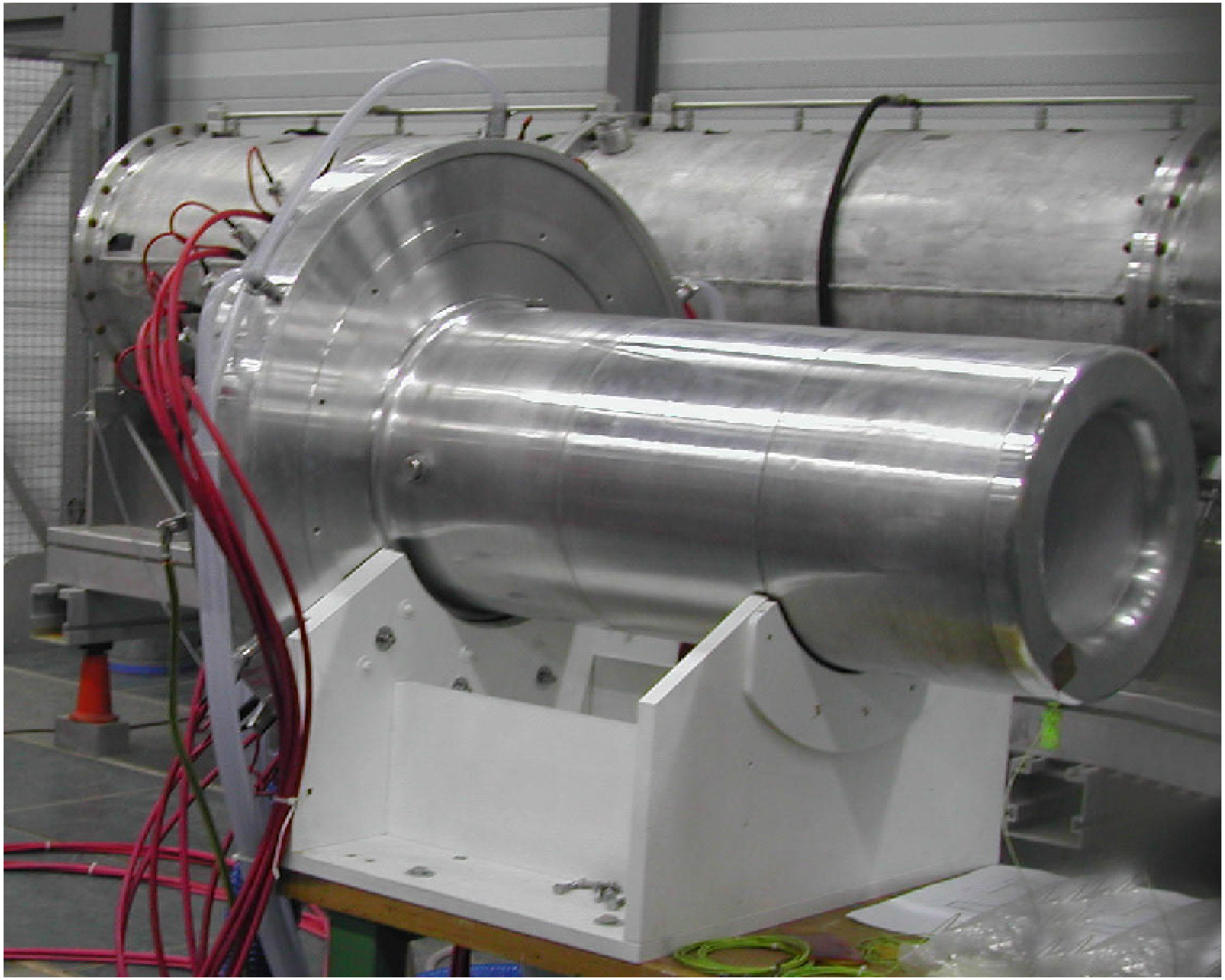
Previous Studies

- S. Gilardoni: Horn for Neutrino Factory and comparison with a solenoid
  - http://doc.cern.ch/archive/electronic/cern/preprints/thesis/thesis-2004-046.pdf
  - http://newbeams.in2p3.fr/talks/gilardoni.ppt
- A. Cazes: Horn for SPL
  - http://tel.ccsd.cnrs.fr/tel-00008775/en/
  - http://slap.web.cern.ch/slap/NuFact/NuFact/nf142.pdf
  - http://slap.web.cern.ch/slap/NuFact/NuFact/nf-138.pdf

Focusing system: magnetic horn

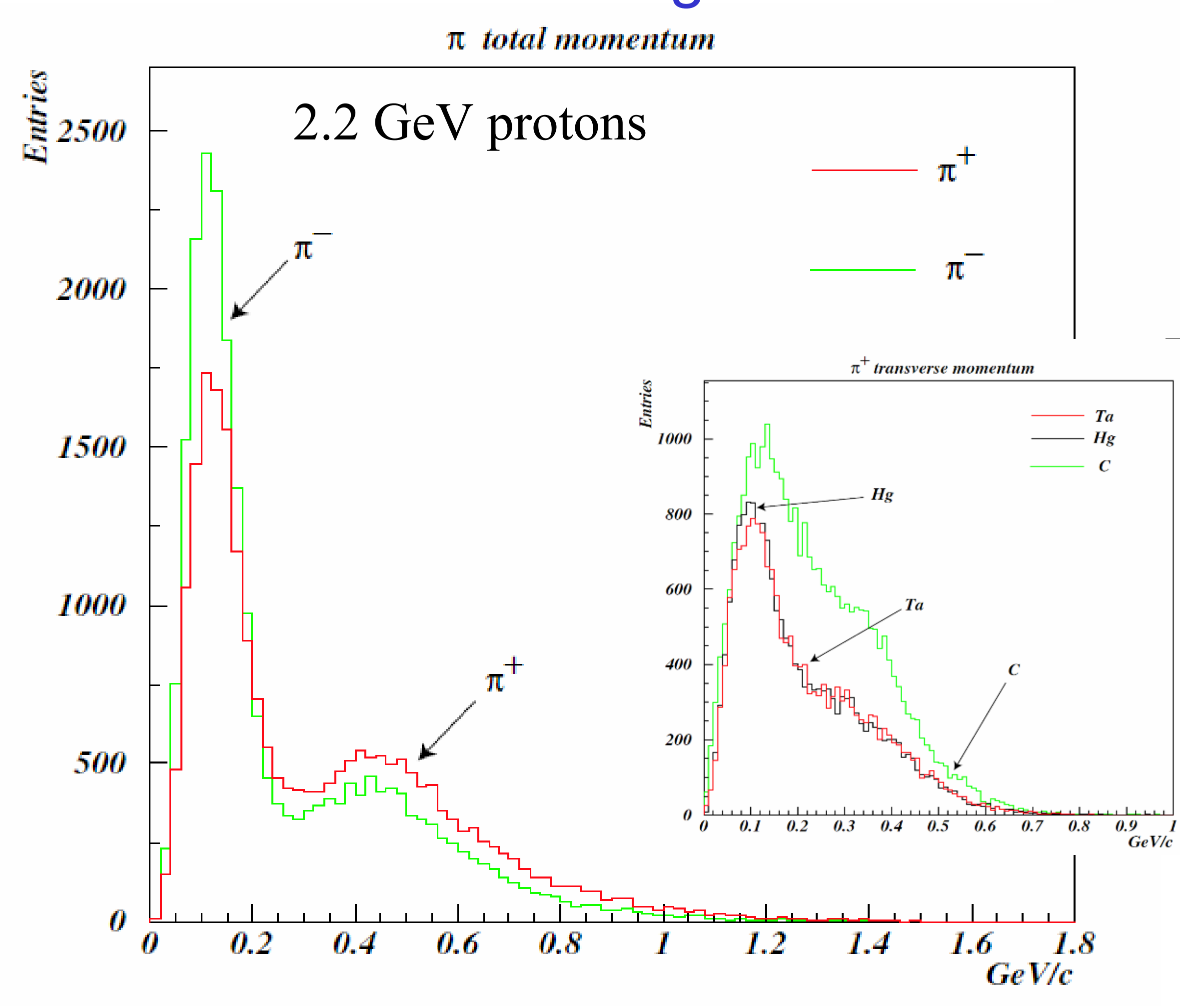


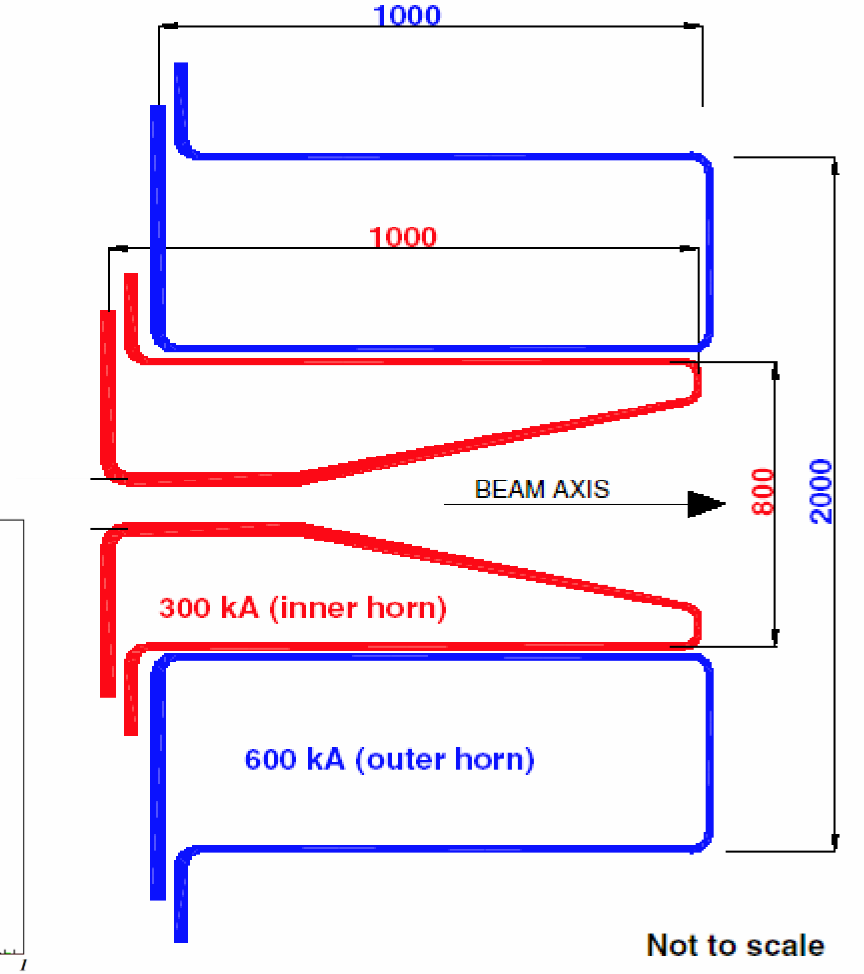
Horn prototype ready for tests



Proposed design

Particle at target

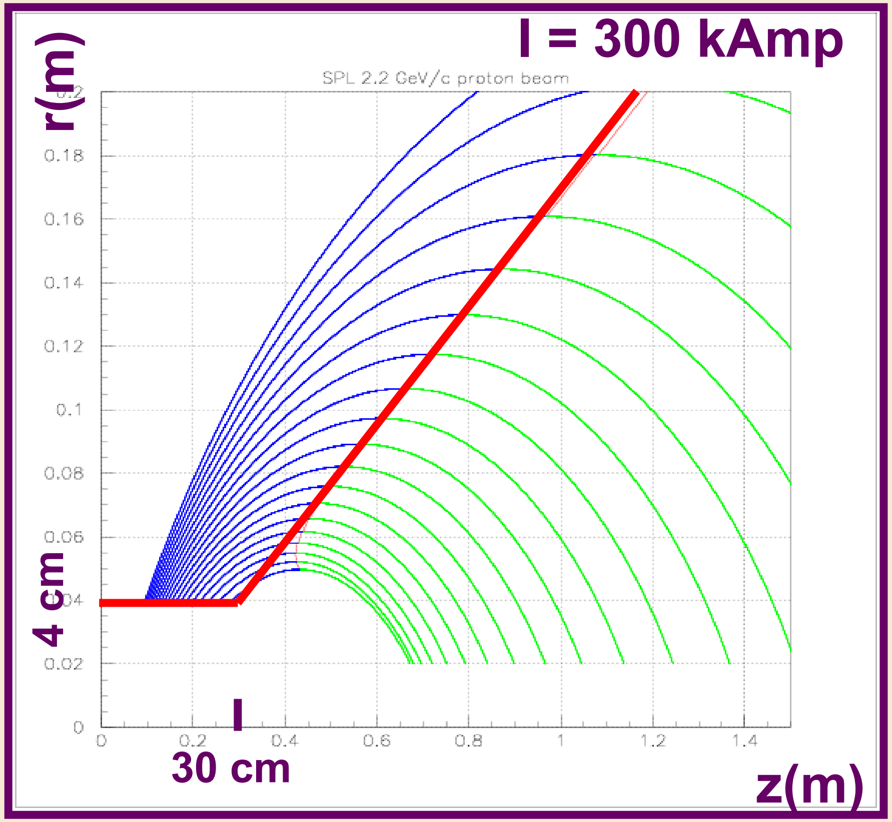


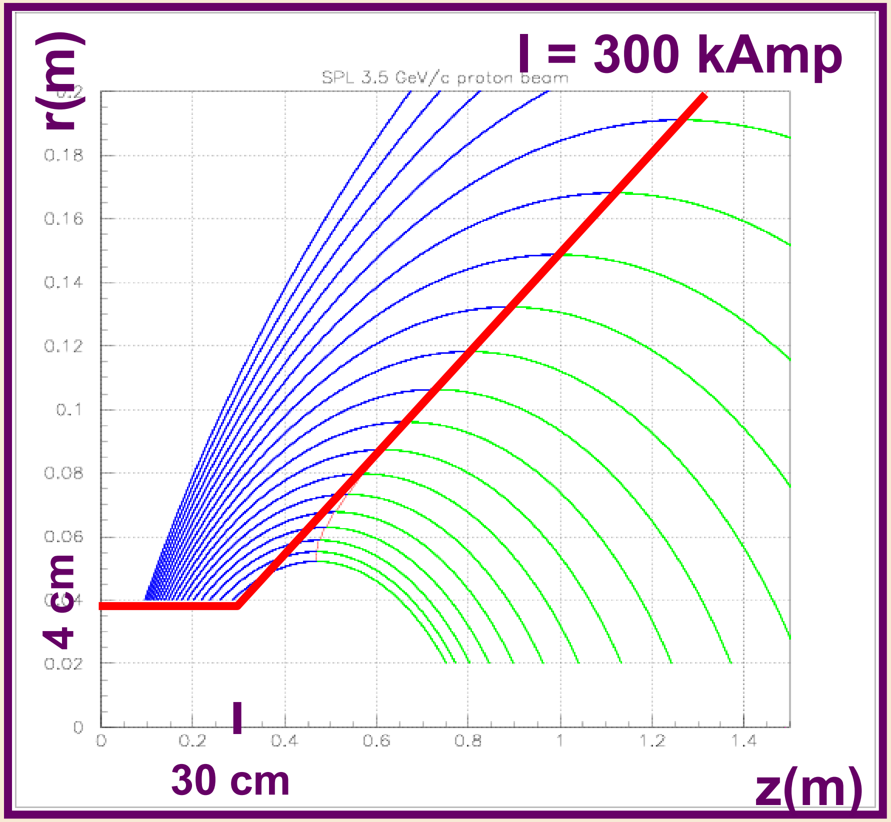


In collaboration with LAL

New Geometry

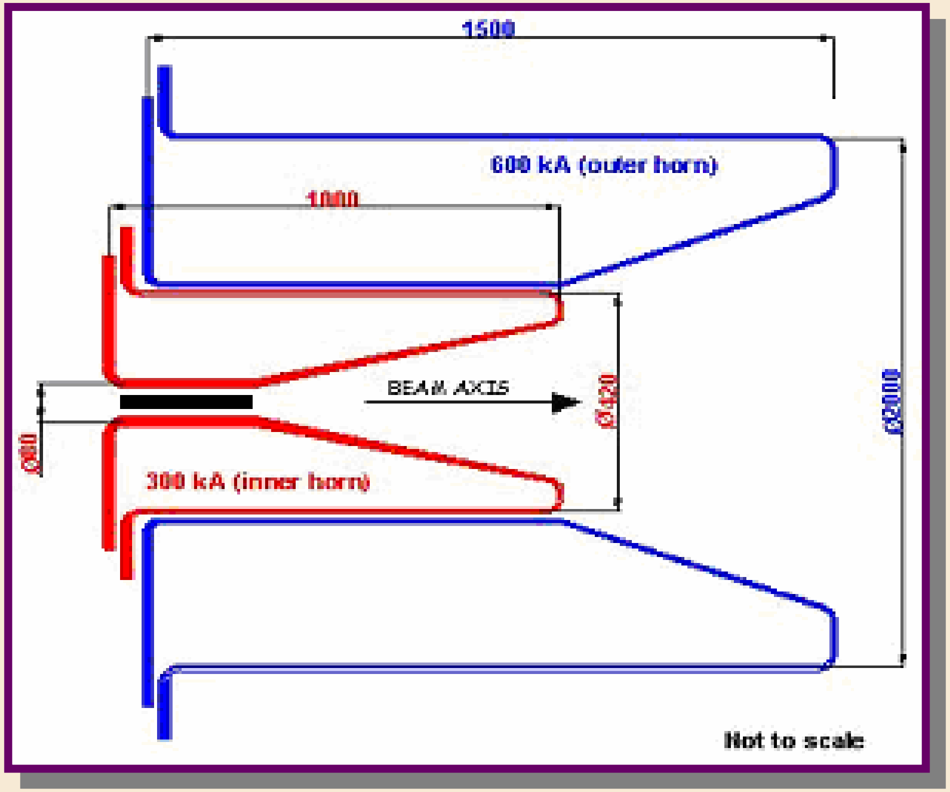
- 2.2 GeV proton beam :
  - $\langle p_\pi \rangle$ = 405MeV/c
  - $\langle \theta_\pi \rangle$ = 60°
- 3.5 GeV proton beam :
  - $\langle p_\pi \rangle$ = 492MeV/c
  - $\langle \theta_\pi \rangle$ = 55°





Reflector

- A reflector has been included
- It is not optimized yet
- diameter : 2m
- length :1.5m
- I = 600kAmp



Flux summary, 2.2 GeV

		positive focusing		negative focusing	
		Flux (/100m^2/y)	Majoritary composition	Flux (/100m^2/y)	Majoritary composition
Decay tunnel :20m	ν_μ	3.89 10^{13}	π^+ (99%)	5.08 10^{12}	π^+(99%)
	$\bar{\nu}_\mu$	3.19 10^{12}	π^- (99%)	2.93 10^{13}	π^- (99%)
	ν_e	1.77 10^{11}	$\pi^+\to\mu^+$(80%)	2.85 10^{10}	$\pi^+\to\mu^+$(38%); K^+ (37%) ;K^0 (25%)
	$\bar{\nu}_e$	1.24 10^{10}	K^0 (55%); $\pi^-\to\mu^-$(45%)	8.14 10^{10}	$\pi^-\to\mu^-$(90%)
Decay tunnel :80m	ν_μ	4.21 10^{13} (+8%)	π^+ (99%)	5.06 10^{12} (-0.4%)	π^- (99%)
	$\bar{\nu}_\mu$	3.38 10^{12} (+6%)	π^- (99%)	3.18 10^{13} (+8.5%)	π^+ (100%)
	ν_e	2.66 10^{11} (+50%)	$\pi^+\to\mu^+$(90%)	3.09 10^{10} (+8.5%)	$\pi^+\to\mu^+$(40.%) K^+ (35%) ;K^0 (25%)
	$\bar{\nu}_e$	1.42 10^{10} (+14.5%)	K^0 (50%) $\pi^-\to\mu^-$(50%)	1.14 10^{11} (+40%)	$\pi^-\to\mu^-$(95%)

Antoine Cazes

LABORATOIRE DE L'ACCELERATEUR LINEAIRE

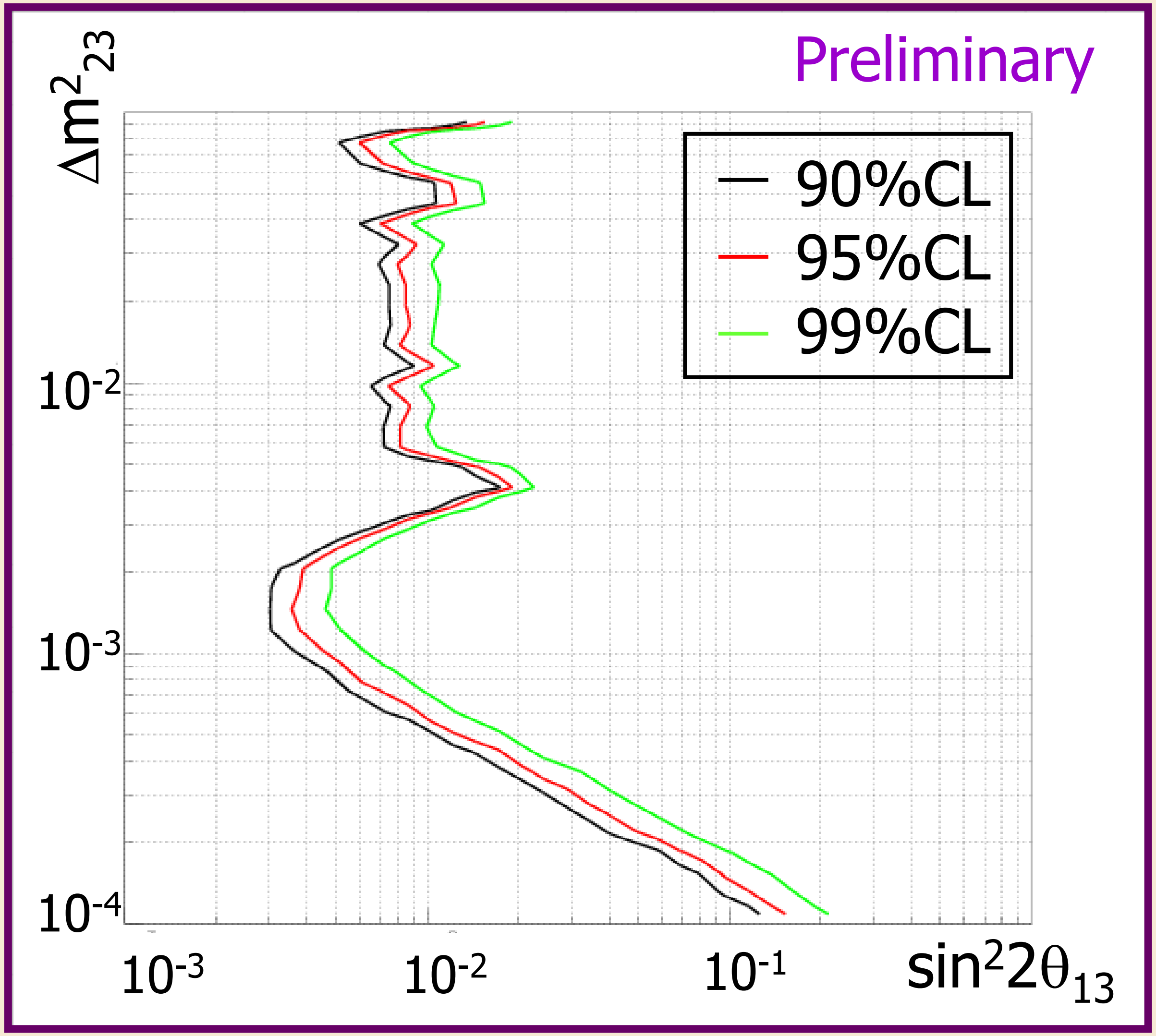
Flux summary, 3.5 GeV

		positive focusing		negative focusing	
		Flux (/100m2/y)	Majoritary composition	Flux (/100m2/y)	Majoritary composition
Decay tunnel :20m	ν_μ	$7.82\ 10^{13}$	π^+ (100%)	$1.42\ 10^{13}$	π^- (98%)
	$\bar{\nu}_\mu$	$1.10\ 10^{13}$	π^- (99%)	$6.65\ 10^{13}$	π^+ (99.5%)
	ν_e	$4.07\ 10^{11}$	$\pi^+ \rightarrow \mu^+$(84%)	$1.19\ 10^{11}$	K^+ (50%);K^0 (30%) $\pi^+ \rightarrow \mu^+$(20%)
	$\bar{\nu}_e$	$5.34\ 10^{10}$	K^0 (70%) $\pi^- \rightarrow \mu^-$(30%)	$1.87\ 10^{11}$	$\pi^- \rightarrow \mu^-$(80%)
Decay tunnel :80m	ν_μ	$8.32\ 10^{13}$ (+6%)	π^+ (99%)	$1.56\ 10^{13}$ (+10%)	π^- (98%)
	$\bar{\nu}_\mu$	$1.19\ 10^{13}$ (+8%)	π^- (98%)	$7.03\ 10^{13}$ (+6%)	π^+ (100%)
	ν_e	$5.60\ 10^{11}$ (+38%)	$\pi^+ \rightarrow \mu^+$(89%)	$1.30\ 10^{11}$ (+9%)	K^+ (45%);K^0 (30%) $\pi^+ \rightarrow \mu^+$(25%)
	$\bar{\nu}_e$	$5.93\ 10^{10}$ (+11%)	K^0 (60%) $\pi^- \rightarrow \mu^-$(40%)	$2.59\ 10^{11}$ (+38.5%)	$\pi^- \rightarrow \mu^-$(85%)

θ_{13} Sensitivity

- Use Mauro Mezzetto code.
- detector:
  - Water Cerenkov
  - 440 kt
  - at Fréjus (130 km from CERN)
- Run:
  - 2 years with positive focussing.
  - 8 years with negative focussing.
- Computed with δ_{CP}=0 (standard benchmark) and θ_{13} = 0
- parameter…
  - $\Delta m_{23} = 2.5\ 10^{-3} eV^2$
  - $\Delta m_{12} = 7.1\ 10^{-5} eV^2$
  - $\sin^2(2\theta_{23}) = 1$
  - $\sin^2(2\theta_{12}) = 0.8$

Sensitivity 2.2GeV



Minimum:
$\theta_{13} = 1.6°$
(90%CL)

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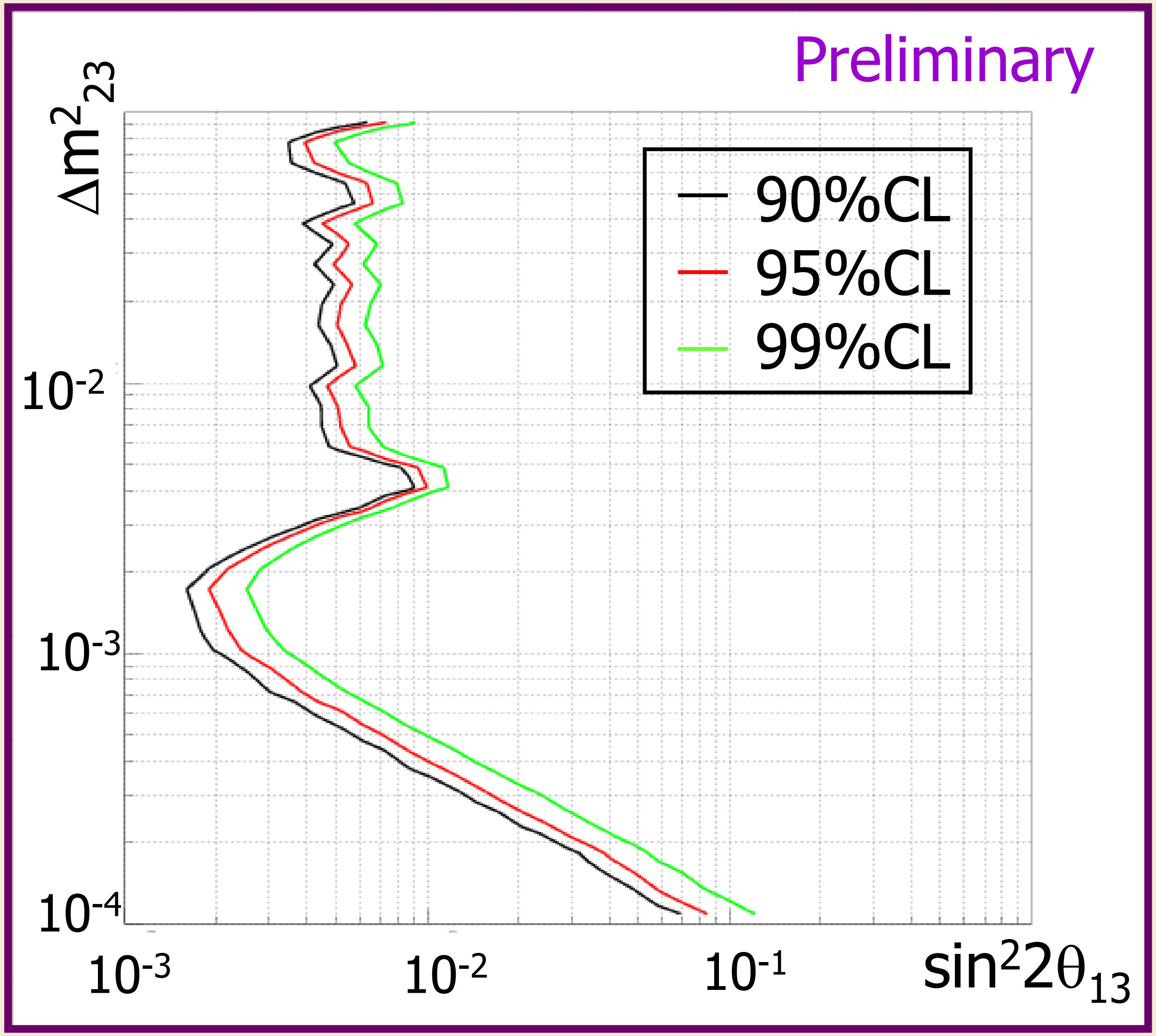
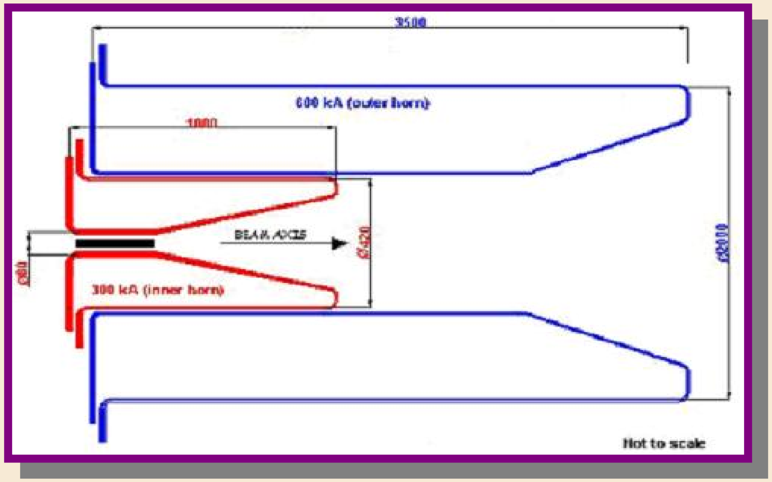
Sensitivity 3.5GeV

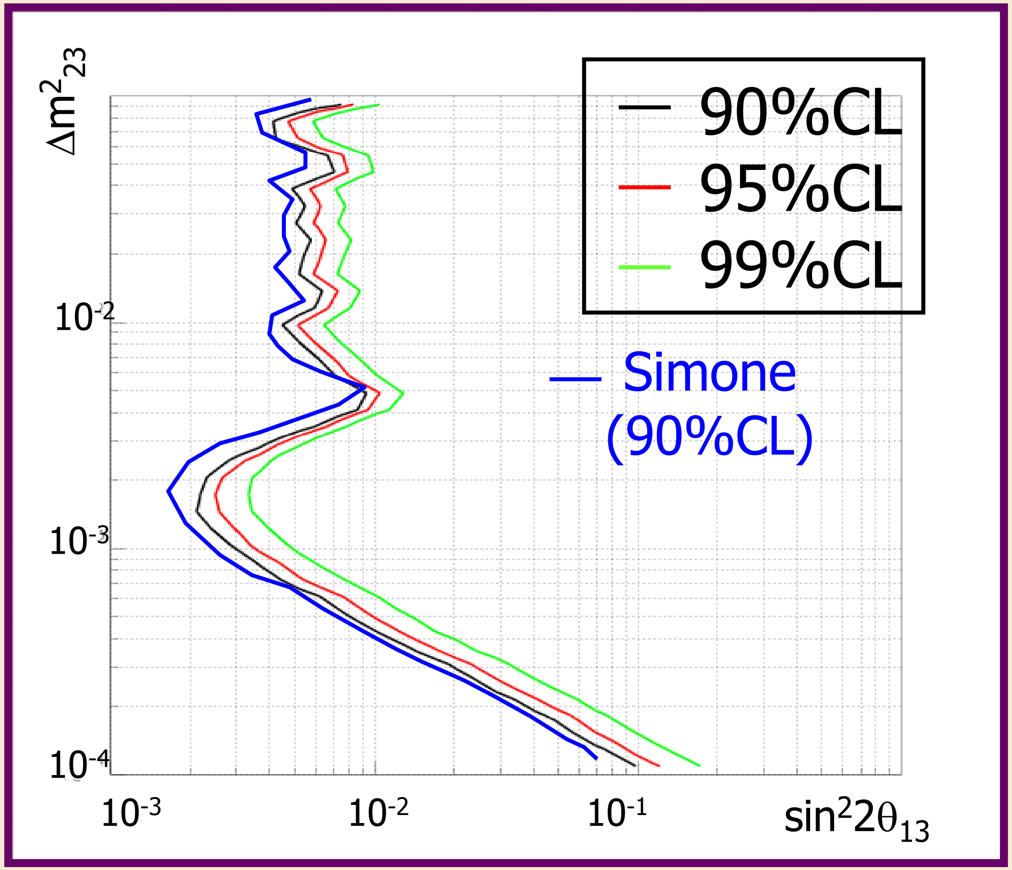


Minimum:
θ_{13}= 1.2°
(90%CL)

Other reflector design (S. Gilardoni Thesis)

- Reflector length 3.5m
- Reflector inner conductor cylindrical length : 2.5m
- Proton Beam 2.2GeV





Minimum:
θ_{13}= 1.3° (90%CL)

Conclusion

- New CDR for SPL
- Restart hardware activity around the:
  - collector
  - power supply
  - target integration
- Restart optimization studies of the collector
- Strengthen the collaboration with other super-beams
- Be ready for FP7