LIU-PSB, technical progress (RCS)

Operational aspects & performance:

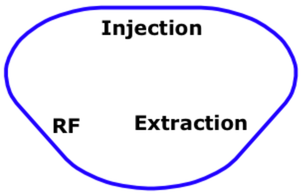
No time to work on it – meeting with PS (Rende) Monday

RCS Design & Parameters

Baseline scenario completed.

lattice consists of 21 cells – 5 per arc and 2 per straight section - with a cell length of 5.6993 m; FODO lattice chosen; QH= 4.205 and QV= 3.572

Circumference	119.68 m
Number of cells	21
Number of cells per straight section	2
Length of straight section	4×2.35 m
Distance QF-Bend	0.65 m
Phase advance per cell (hor.)	72.1°
Phase advance per cell (vert.)	61.2°
Q_H	4.20505
Q_V	3.57156
Gamma transition	3.60
$\beta_{H,max}$	8.73 m
$\beta_{V, max}$	12.06 m
$D_{x, max}$	3.73 m



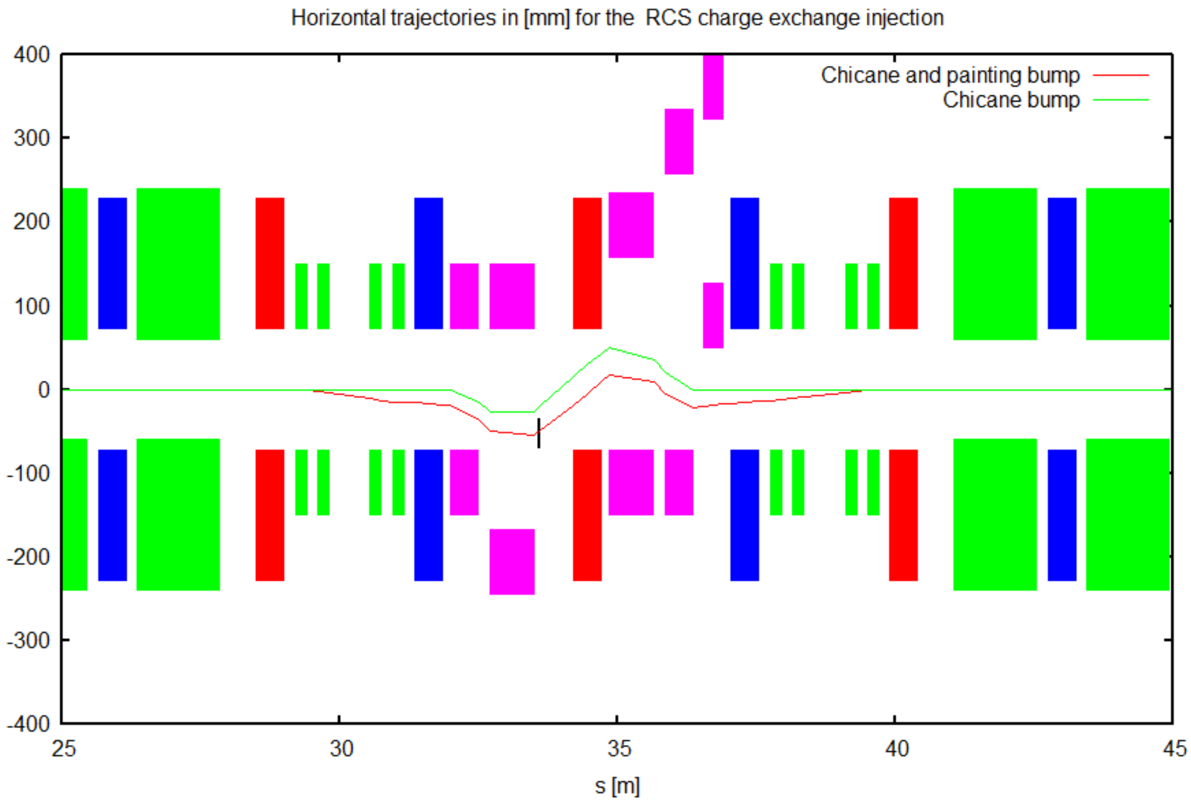
The RCS is confronted with conflicting requirements between injection and extraction; main issue is the longitudinal emittance of the h=1 bunches.

PS requests 2 eVs; emittance blow-up by an additional rf cavity in the VHF range to be Studied

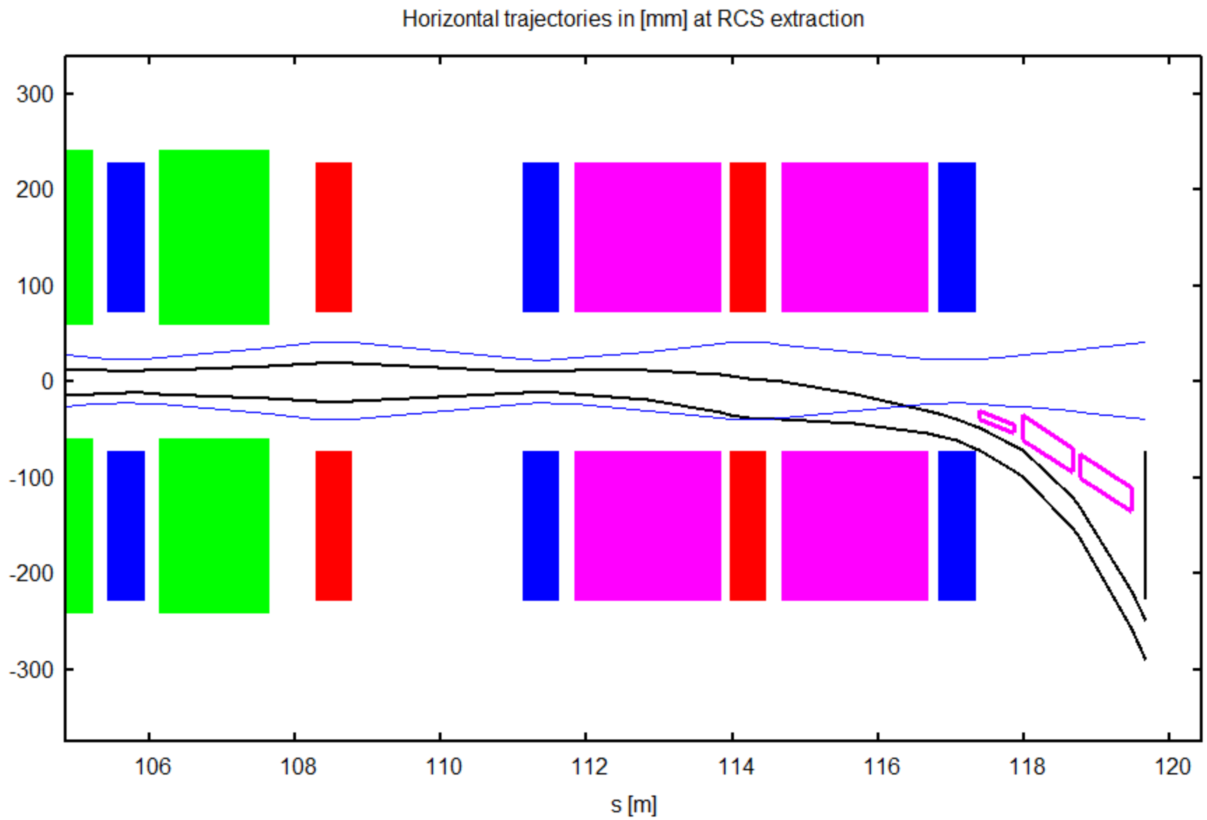
At injection longitudinal painting (improved scheme)

Injection and Extraction:

The charge exchange injection comprises a horizontal 4 magnet chicane bump, a 4 magnet painting bump per plane and 3 stripping foils



The extraction is a fast bunch-to-bucket transfer with a kicker and septum system placed around a defocusing quadrupole. The kicker system consists of 2 tanks filling two adjacent half cells. The required rise time is 40 ns



Missing: budget estimate and planning

RCS2PS Transfer Line and PS Injection:

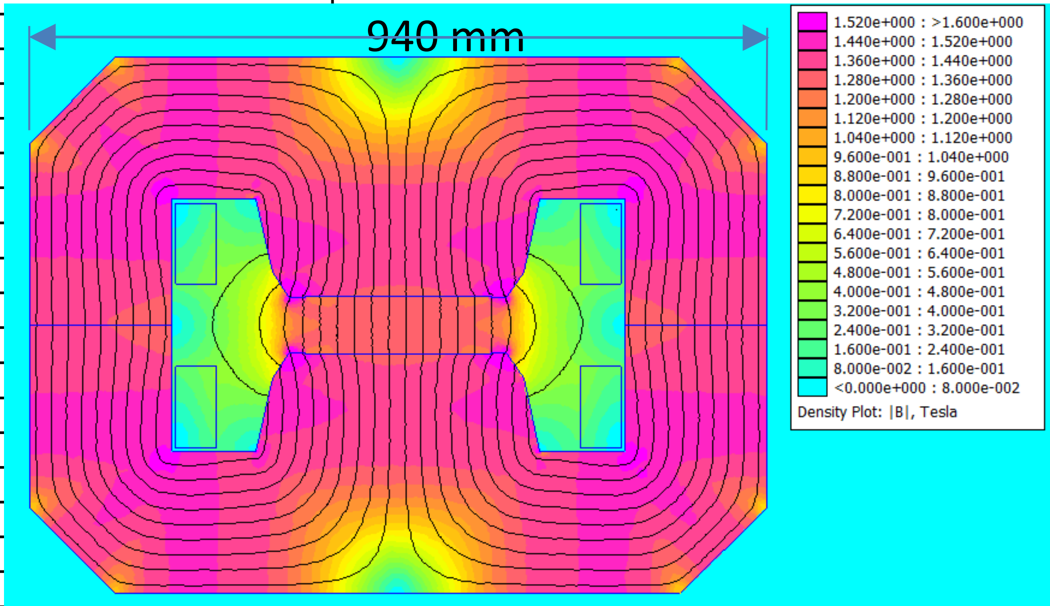
In preparation; expect major contribution to the cost (re-build the line designed for 160 MeV)

Magnets:

Consider only main bends and quads (main contributors to the cost); transfer line magnets to be included in Transfer Line chapter

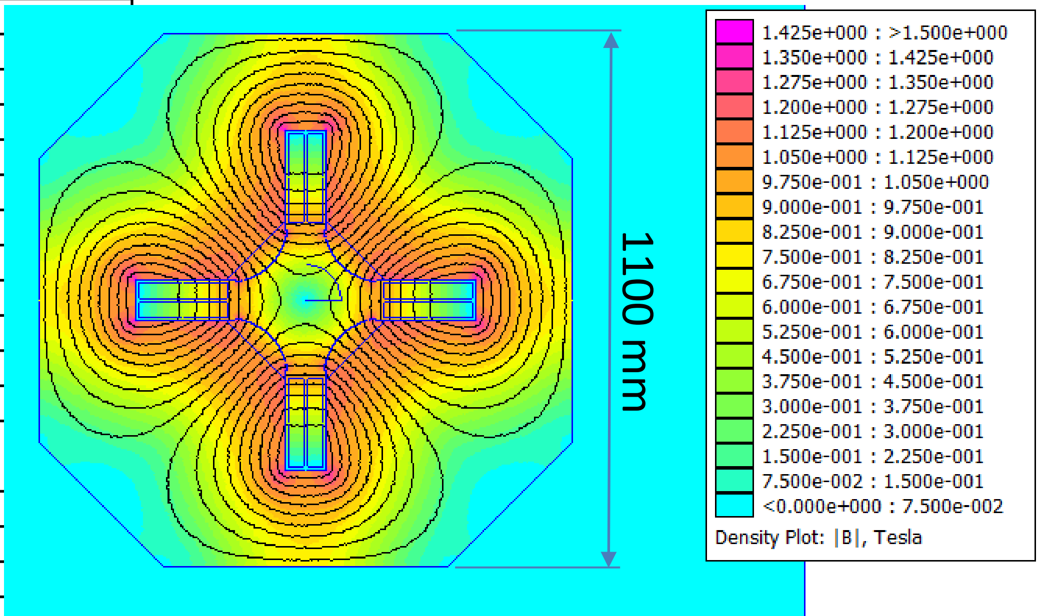
Main bends

Approx. Magnet Dimension	
Iron length (m)	1.426
Total length (m)	1.626
Iron Width (m)	0.94
Iron Height (m)	0.66
Aperture height (m)	0.071
Aperture width (m)	0.27
Approximate weight (kg)	6000
Magnetic Parameters	
Magnet type	H – laminated, water cooled
Field (T)	1.3
Magnetic length (m)	1.5
Integrated field (Tm)	1.946
# turns per pole	6
# turns total	12
Electrical Parameters	
Current at peak field (A)	6106
Current at Injection (A)	1256
Current r.m.s. (A)*	3793
Resistance @ 20 °C (m□)	1.08
Resistance warm [□T = 30°C] (m□)	1.14
Inductance (mH)	1.36
Max. Volt-drop (V)**	226
Copper Losses, warm (kW)	16.4
Iron Losses (kW)	1.7
Total Dissipated Power (kW)	18.1
Cooling parameters	
Flow [□T = 20K] (l/min)	12
Required Pressure Drop (bar)	8
RCS Machine - Bending	
# Magnets in series (incl. Ref. magnet)	31
Total magnet resistance warm (m□)***	35
Total magnet inductance (mH)	42
Total dissipated power (kW)	562
Total volt drop (kV)	7.0



Main quads

Approx. Magnet Dimension	
Iron length (m)	0.433
Total length (m)	0.6
Iron Width (m)	1.1
Iron Height (m)	1.1
Inscribed Radius (m)	0.1
Approximate weight (kg)	2950
Magnetic Parameters	
Magnet type	Tapered pole - laminated, water cooled
Gradient (T/m)	8.0
Magnetic length (m)	0.5
Integrated Gradient (T)	4
# turns per pole	8
# turns total	32
Electrical Parameters	
Current at peak field (A)	3979
Current at Injection (A)	815
Current r.m.s. (A)*	2470
Resistance @ 20 °C (m□)	1.79
Resistance warm [□T = 30°C] (m□)	1.89
Inductance (mH)	1.46
Max. Volt-drop (V)**	155
Copper Losses, warm (kW)	11.5
Iron Losses (kW)	0.7
Total Dissipated Power (kW)	12.2
Cooling parameters	
Flow [□T = 20K] (l/min)	8.5
Required Pressure Drop (bar)	8
RCS Machine – Quadrupole***	
# Magnets in series	21 QF or 21 QD
Total magnet resistance warm (m□)****	40
Total magnet inductance (mH)	31
Total dissipated power (kW)	257
Total volt drop (kV)	3.4



Magnet Interlocks:

Warm magnet Interlock Controller (WIC) solution is proposed. This system is currently deployed in LEIR, in Linac3, in the SPS-LHC-CNGS transfer lines and is also protecting the normal conducting magnets of the LHC.

Power Supplies:

Only Ring power supplies considered; transfer line power supplies in the corresponding Chapters

Main bending power supply:

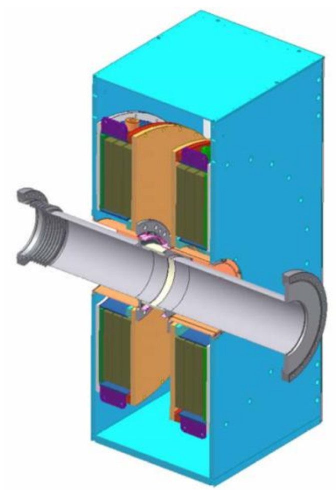
- A resonant system also called a White circuit is often used in fast cycling accelerators with a repetition rate of 10Hz to 50Hz (ESRF, SRS, J-PARC,...). This topology is highly cost effective but does not allow any freedom on the current waveform for operation.

- A semiconductor based 4-quadrant converter with local capacitive energy storage as developed for the PS. This topology is significantly more expensive but allows more freedom on the current waveform and is well known and understood at CERN.

Power supplies for main quads and correctors

RF System:

The wide frequency range, the fast cycling and the limited available space in the straight sections, suggest the use of high-permeability materials; Finemet® is the magnetic alloy of choice



Parameter	Value
Energy range	160 MeV to 2 GeV
Repetition rate	~10 Hz
RF voltage	60 kV
Revolution Frequency	1.1? MHz to 3.3? MHz
Harmonic numbers	h = 1 to 4
Frequency range	1.?? MHz to 10.?? MHz
Available length	4.5 m ??
Beam intensity	1e13 ppp
Energy increase	~ 3 kJ
Required power	60 kW (acceleration in 50 ms)

Parameter	Value
Cavity Gap Voltage	8 kV
Frequency range	1. to 10.0 MHz
Cavity power	26 kW
Cavity length	0.5 m
HV supply voltage	8 kV
HV supply current	~20 A
Plate power dissipation	55 kW
Driving power	250W
Repetition rate	~10 Hz
Number of cavities	8

Beam Instrumentation:

Instrument	Location
Pick-ups	RCS + transfer line
Wide band pick-up	RCS
Q measurement	RCS
DCCT + Fast BCT	RCS
Beam loss monitors	RCS + transfer line
Fast wire scanners	RCS
Scintillating screens	RCS + transfer line
SEM grids	transfer line

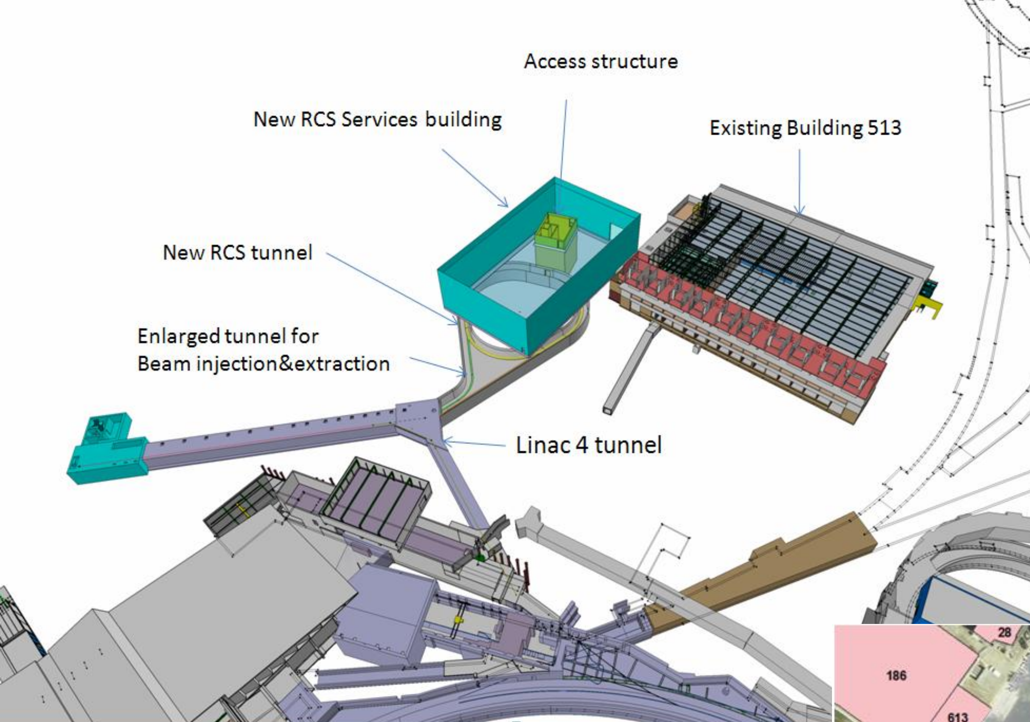
Beam Interlocks

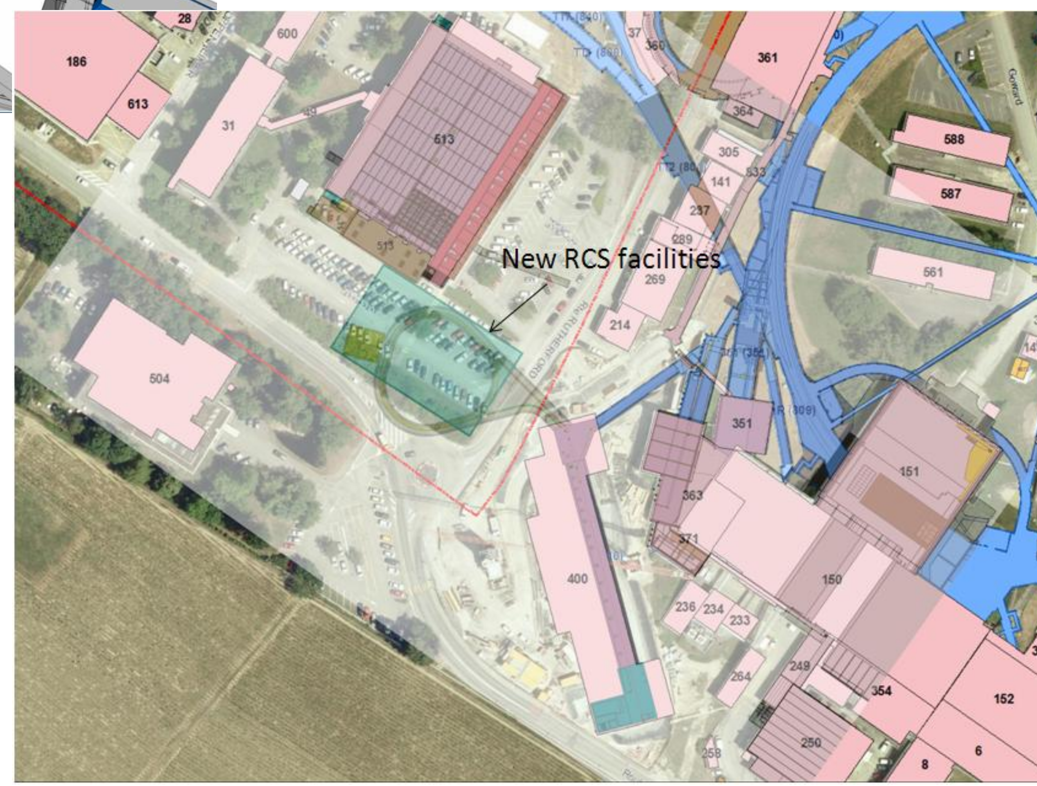
Civil Engineering:

The civil engineering to be carried out is at the CERN site of Meyrin and consists of one tunnel (approx 127 m long), situated 13m below finished ground level, and one surface building (approx 54 m long by 32 m wide).

Several concrete ducts will connect the tunnel and the building and a concrete structure will provide access for personnel and equipment at the tunnel by means of a lift shaft and stairwell.

The existing Linac4 tunnel will be modified to allow for connection of the new RCS tunnel.


Access structure
New RCS Services building
Existing Building 513
New RCS tunnel
Enlarged tunnel for
Beam injection&extraction
Linac 4 tunnel


New RCS facilities
186
613
28
600
31
513
361
588
587
561
504
400
351
363
151
150
152
354
250
214
269

Cooling & Ventilation:
Entirely missing.

Transport Systems:
OK

Radiological Protection:
Entirely missing.

Compared to the 2 GeV Booster Study: What is covered, what is not covered

Work-Package	Responsible	Unit
2.Beam Dynamics	C. Carli	BE/ABP
3.Magnets	D. Tommasini, A. Newborough	TE/MCS
4.RF Systems	A. Findlay, M. Paoluzzi, M.E. Angoletta, A. Blas, A. Butterworth	BE/RF
5.Power Converters	S. Pittet, D. Nisbet	TE/EPC
6.Instrumentation	J. Tan	BE/BI
7.Beam Intercepting Devices	O. Aberle, A. Massi	EN/STI
8.Vacuum System	J. Hansen	TE/VSC
9.L4-PSB Transfer and PSB Injection	W. Weterings, C. Carli	TE/ABT, BE/ABP
10.PSB Extraction and PSB-PS Transfer	Borburgh, W.Bartmann	TE/ABT
11.Controls	S. Jensen	BE/CO
12.Electrical Systems	D. Bozzini, S. Olek	EN/EL
13.Cooling and Ventilation	M. Nonis	EN/CV
14.Installation, Transport and Handling	Ruehl, C. Bertone	EN/HE
15.Civil Engineering	L.A. Lopez-Hernandez	GS/SE
16.Radiation Protection	M. Widorski	DGS/RP
17.Interlock Systems	B. Puccio, P. Dahlen, B. Todd	TE/MPE
18.Alarms		--/---
19.Access Systems - Doors		--/---
20.Survey	T. Dobers	BE/ABP
21.Commissioning and Operation	B. Mikulec	BE/OP
22.Dismantling		--/---

Budget and Time Lines (so far)

system	cost estimate [kCHF]	time estimate (from project approval)
Operational Aspects	-	-
Design & Paramters	-	-
RCS injection and extraction	xxx	xxx
RCS2PS Transfer Line	xxx	xxx
PS Injection	xxx	xxx
Magnets	8856	36 m
Magnet interlocks	300-500	12 m
Power supplies	22000 (resonant) 26000 (POPS type)	2 y study & design 3 y production, installation, commissioning
RF Systems	13000	2 y development 2 y production/installation
Beam Intercepting Devices	800	2 y
Beam Instrumentation	2883	-
Beam Interlocks	200	12 m
Civil Engineering	23130	4 y 2 m
Cooling & Ventilation	xxx	xxx
Transport Systems	890	3 m
Radiological Protection	xxx	xxx
Linac4 Modifications	xxx	xxx

Missing:
- OP aspects
- inj./extr. cost
- RCS2PS transfer
- PS injection
- beam instr. Time
- CV
- RP
- vacuum
- EL

Σ kCHF 76259