SC Linac Optimisation

- (70) 200 MeV up to 1334 MeV
- Cost, Performance Dependence from
  Power,
  Energy,
  Current,
  Number of cells/cavity
  .....

Optimisation Procedure

- Input Data
- Longitudinal Beam Dynamics
  -> Cells/Cavity & Cavities Grouping
- Transverse Beam Dynamics
  -> Lattice structure & Focusing Methode
- Design of Cryogenics, Magnets, Mechanics
- Building, Infrastructure, Cost
- Performance Analysis (not yet done)

Cost dependence from main parameters

Superconducting Linac 70 to 1334 MeV			
Parameter	from	to	cost decrease/increase
Number of cells per cavity	5 cell	6 cell	-10 %
Peak Field*	25 MV/m	40 MV/m	-21 %
power doubling by energy increase	1334 MeV	2700 MeV	59 %
Energy doubling at constant power*	1334 MeV	2700 MeV	10 %
total cost superconducting part of Linac (reference)			**202 M€**

* Peak Field of 40 MeV/m is state of the art based on DESY work
low energy structures are limited by the magnetic field to lower values

** Estimation done on peak field of 40 MV/m

Cost general

cells per cavity	**5**	6	6	6	6	6	
E min	70	70	70	70	70	70	MeV
E max	1341	1345	1337	**2666**	**2666**	**2673**	MeV
beam current	3.75	3.75	3.75	3.75	1.87	1.87	mA
Power beam	5	5	5	**10**	5	**5**	MW
E peak	25	25	**40**	25	25	**40**	MV/m
system length	445	391	278	655	655	444	m
Accelerator	103.4	91.0	74.0	147.7	135.8	101.3	M€
Mains,RF	75.4	63.0	48.8	104.4	92.9	70.4	M€
Building	26.1	29.5	18.5	43.7	43.7	29.6	M€
infrastructure	13.3	13.3	12.5	14.9	14.9	13.6	M€
Cooling,water	5.1	4.9	4.9	9.2	6.3	6.2	M€
Total invest SC	**223.3**	**201.8**	**158.7**	**320.1**	**293.8**	**221.2**	**M€**
cost per length	**501**	**516**	**572**	**488**	**448**	**498**	**K€/m**
cost per MeV	**175.6**	**158.2**	**125.3**	**123.3**	**113.2**	**85.0**	**k€/Me**

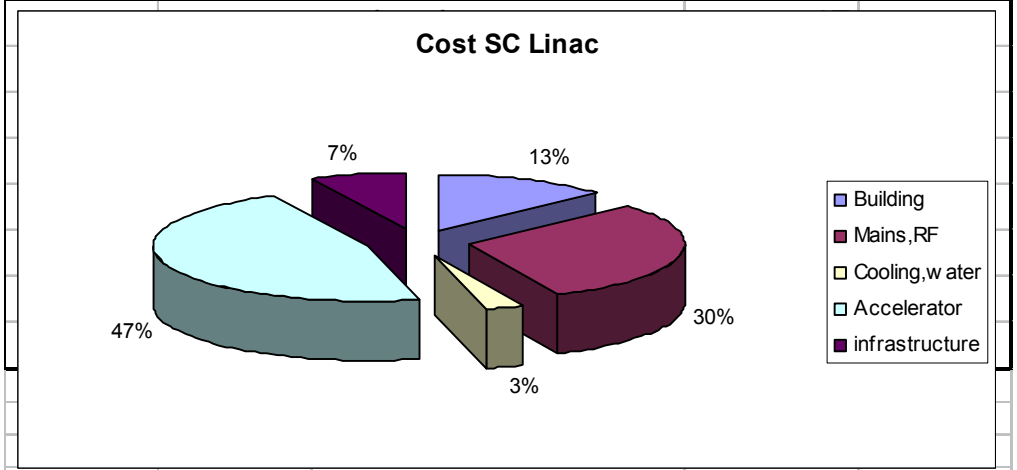
CONCERT

Cost - Man Power - Proto Typing - Operation

man power planning	60	53	53	85	78	59	my
cost planning	4.5	4.0	4.0	6.4	5.9	4.4	M€
man power prototyping	74	66	66	107	98	74	my
cost prototyping	11.2	9.9	9.9	16.0	14.7	11.1	M€
man power constr.	1488	1319	1319	2134	1958	1475	my
cost man power constr	95.3	84.4	84.4	136.6	125.3	94.4	M€
man power operation	112	99	99	160	147	111	my/y
cost operation	**25.3**	**24.0**	**24.0**	**43.3**	**32.0**	**29.4**	**M€/y**
man power total	**1622**	**1438**	**1438**	**2326**	**2135**	**1607**	**my**
man power total cost	**110.9**	**98.3**	**98.3**	**159.0**	**145.9**	**109.9**	**M€**

SC linac
Parametric Cost level2

Parametric cost calculation SC linac 70 to 1340 MeV			
1.1	Building	23.2	M€
1.2	Mains,RF	53.2	M€
1.3	Cooling,water	4.9	M€
1.4	Accelerator	81.7	M€
1.5	infrastructure	12.7	M€
	Total invest SC linac	175.7	M€

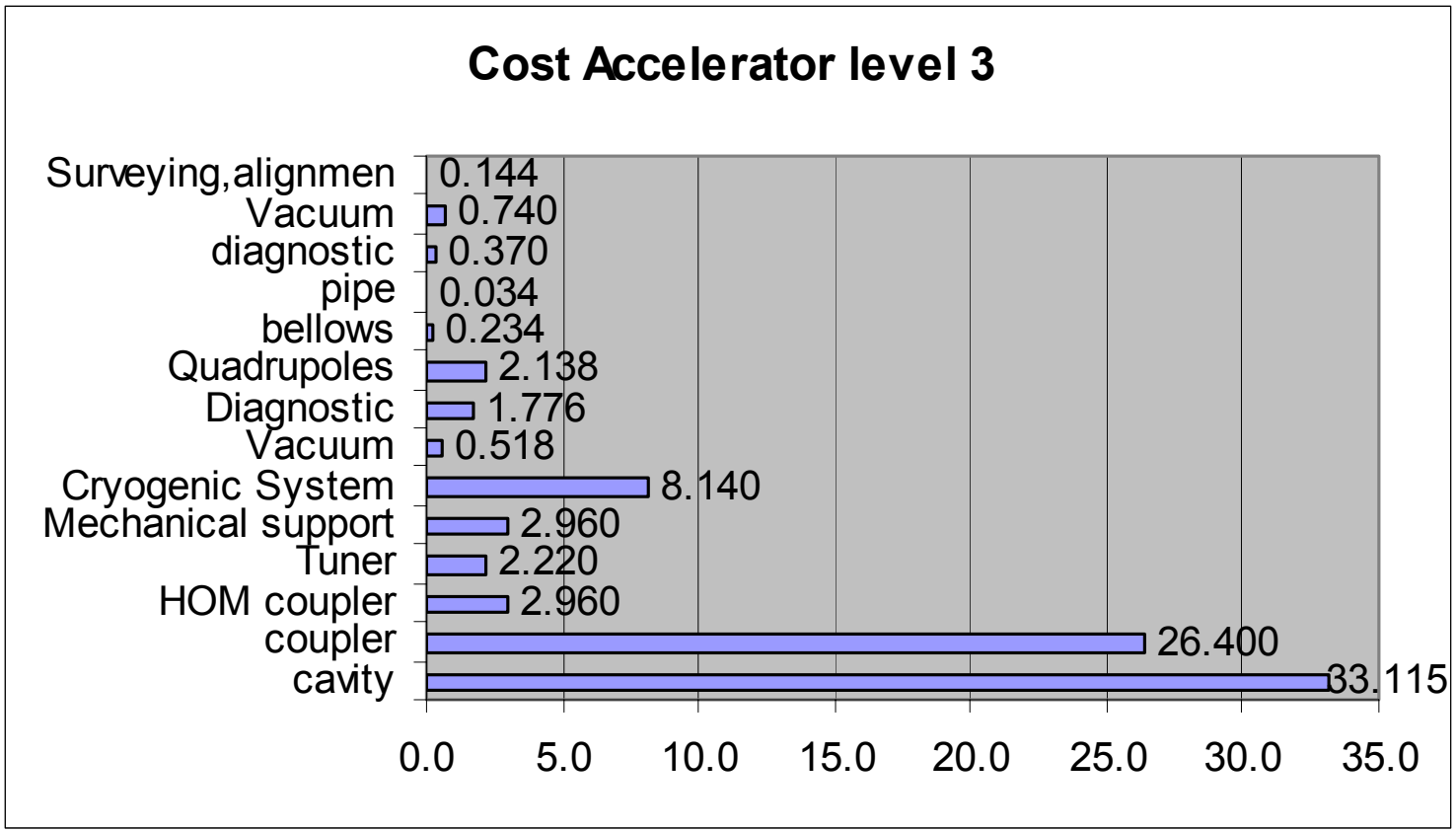


	1.2.1	RF		

Cost: RF - Cooling

Mains,RF		
cost klystrons	45.080	M€
cost circulators	11.280	M€
cost RF piping	1.748	M€
Power installation accelerator		
cost installed power accelerator	4.922	M€
Cooling		
cost installation cooling water	4.922	M€

Cost – Accelerator level 3



Cost Accelerator Infrastructure

cryo infrastructure		
Chemical Lab	4.000	M€
Clean tunnel	3.000	M€
Cryostats test	3.200	M€
RF infrastructure		
RF maintenance hall	0.450	M€
RF Laboratory	0.100	M€
Water,Air systems		
air conditioning	2.503	M€

Input Data SC Linac Sytems

Energy max	***T max***	***1334***	MeV
Energy inj.	***T inj***	***70***	MeV
Beam Power	P beam	5	MW
Current av.	***i av***	***3.75***	mA
Pulse length	***t puls***	***1.20***	ms
Repetition rate	rep rate	50	Hz
Duty cycle	***d.c.***	***6***	%
Accumulator revolution frequency	***f rev accu***	***1.2416***	MHz
"Chopping cycle"	Chopping factor	70	%
	t rev accu	805	ns
Chopping: Beam on	t on micro puls	564	ns
Chopping: Beam off	***t off micro puls***	***242***	ns
Ring switching time	***t switch accu***	0.1	ms
bunch distance normalised to lambda RF	b dist lambda RF	1	
Peak current	i peak	89	mA
	i peak makro puls	***62***	mA
Frequency high beta linac structure	***f RF HEL***	***700***	MHz
Number of cells per cavity	***cells per cavity***	***6***	
	cavities per cryostat	***2***	
	cavities per clystron	***1***	
	Number of families	***6***	
Couplers Power	***RF window Power trans***	***500***	kW
Cryogenics	static heat loss	2	W/m

Input Data for Building & Shielding

Tunnel		
Tunnel CpCubicMeter	**0.50**	**k€/m^3**
Tunnel width	**8**	**m**
Tunnel height	**4**	**m**
RF Galery		
RF Galery CpCubicMeter	**0.30**	**k€/m^3**
RF Galery width	**15**	**m**
RF Galery height	**4**	**m**
Shielding		
Reinforced concrete large shielding blocks	**0.300**	**k€/m^3**
Thickness Shielding side	**4**	**m**
Thickness Shielding top	**4**	**m**
Thickness Shielding bottom	**2**	**m**

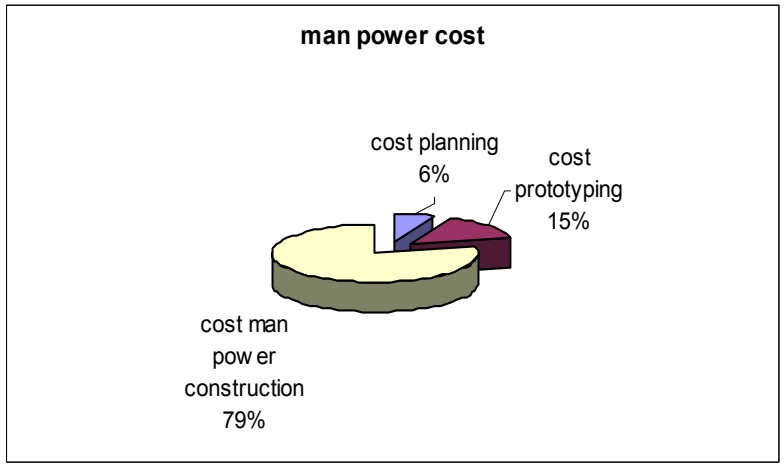
Input Data for Building & Shielding 2

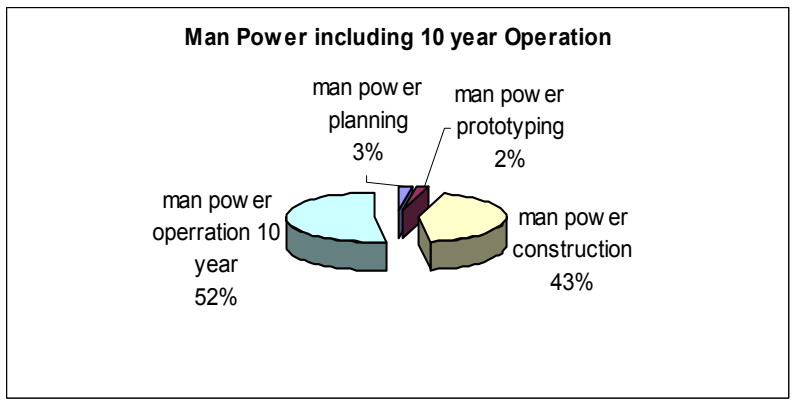
real estate preparation		
cost real estate	0.060	k€/m^2
real estate area to building	5	
Earth movement	0.020	k€/m^3
Rough machined steel	0.450	k€/t
Parking area	0.065	k€/m^2
Unit cost for a 10 m wide road	120	€/m
Road cost per m^2	12	€/m^2
ground preparation thickness	2.000	m
ground preparation CpCubicMeter	0.040	k€/m^3
Light Ind.	0.600	k€/m^2
Heavy Ind.	0.750	k€/m^2
workshop compressor	0.643	k€/m^2
Workshop mechanical, electrical	0.793	k€/m^2
Experimental Hall	0.900	k€/m^2
Compressor hall incl. Soundproofing	0.990	k€/m^2
Laboratories	1.095	k€/m^2
RF medium rise A/C	1.350	k€/m^2
Cooling plant	0.840	k€/m^2

Input Man Power

engineers	man power E CpYear	80	K€/y
Technicians	man power T CpYear	70	K€/y
Work	man power W CpYear	60	K€/y
LINAC			
capital spend per staff member	Cap spend pStm	245	K€/m
Rings and Beam Transport lines			
capital cost per staff member	Cap cost pStm	152	K€/Sy
planning effort in units of total capital invest	planning C to totLinacCost	2	%
Prototyping	Prototyp C to totLinacCost	5	%
Operation	man power per totLinacCost	0.5	man/M€
Machine usage yearly operation time	operation hours per year	5000	h
	Number of working day's per Year	230	d

Man power cost

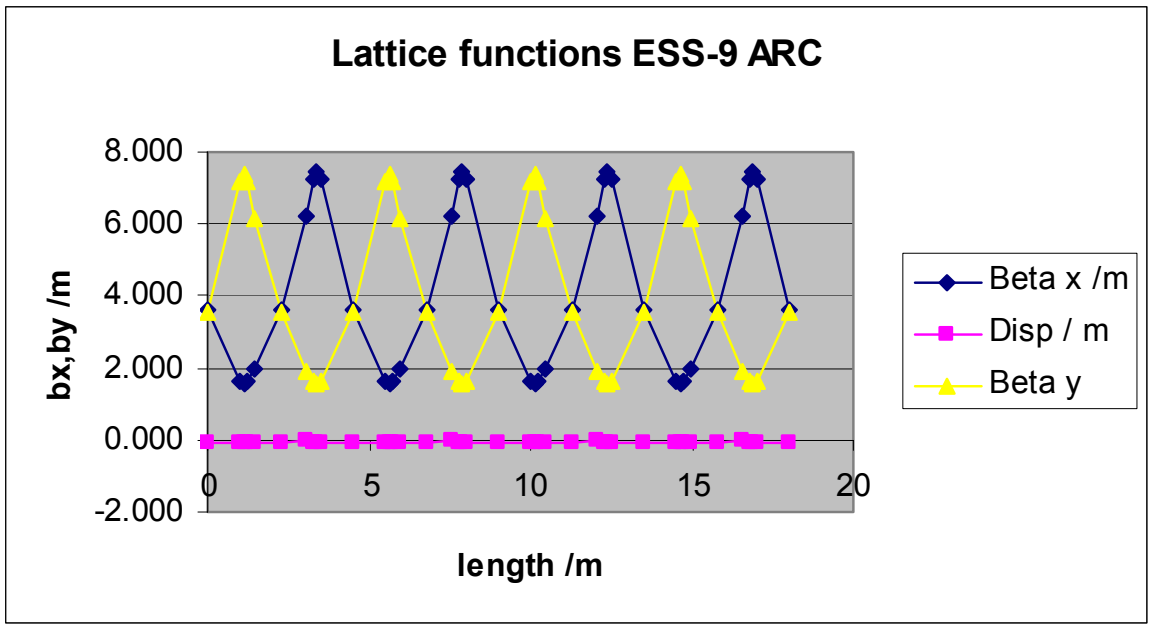




Ring: Emittance for $4*10^{14}$ Particles

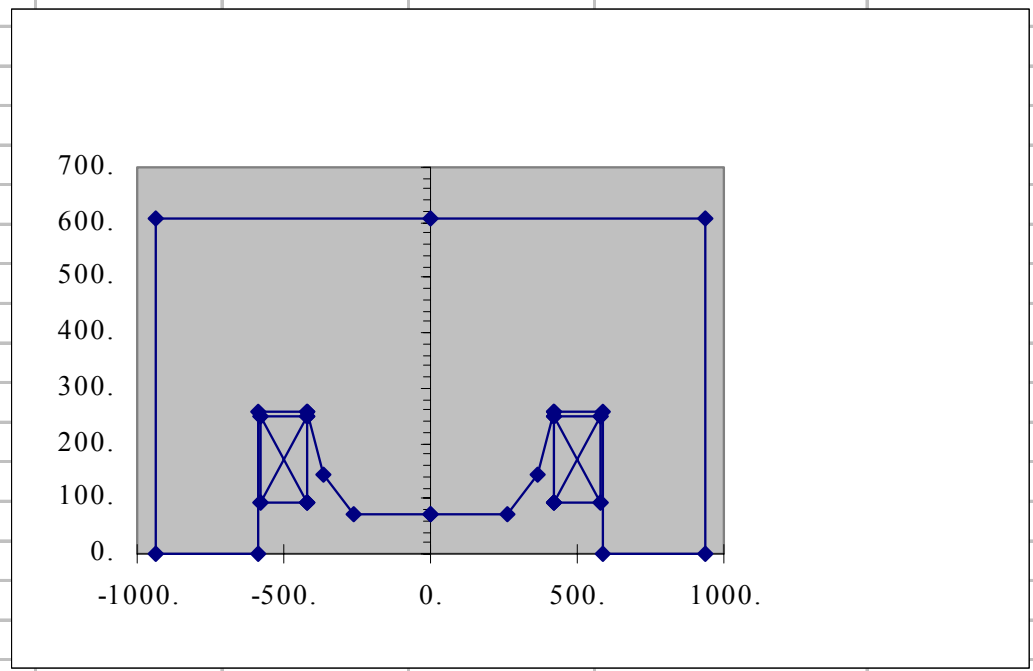
Emittance for sp. ch.eps sp.ch.		299.943698	mm mrad		No_Part_accum	**4.00E+14**		
	Beta-function	beta_x_max	7.44	m	Bunching factor	B_f	0.5	
		beta_y_max	7.42	m	Tune shift	DQ_Laslett	0.15	
	beam size	b_vert	45.00	mm	vacuum gap	two_h	137	mm
		a_hor	45.07	mm	vacuum horiz.	two_w	305	mm
		w/h	2.23	like parallel p	magnet gap	two_v	147	mm
		Formfactor	2.75		eps1	0.206		
					eps2	0.617		
max. Number of parti	No Part 1.ste	3.64E+14						
corrected emittance	eps 1.step	**300**	**mm mrad**					
	b_vert_correc	**47**	**mm**		vac_ch_vert	two_h_1.step	133	mm
	a_hor_correct	**47**	**mm**		vac_ch_hor	two_w_1.step	293	mm
					magnet gap 1.step	two_v_1.step	143	mm

Lattice Function for SNS like Ring

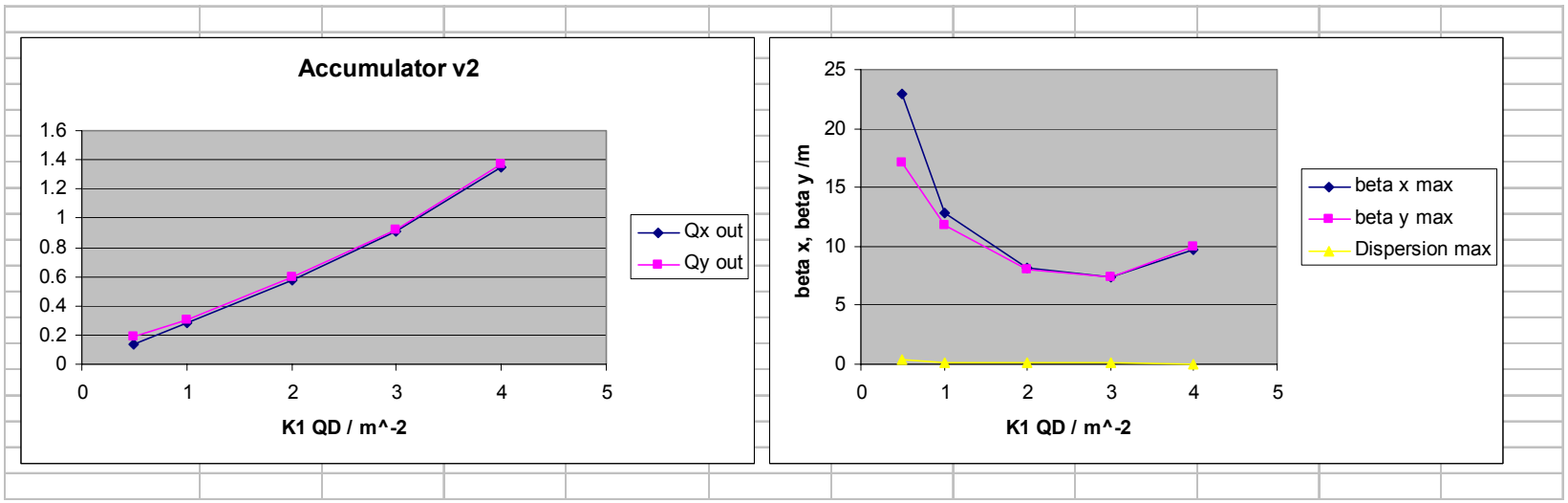


Ring bending magnets

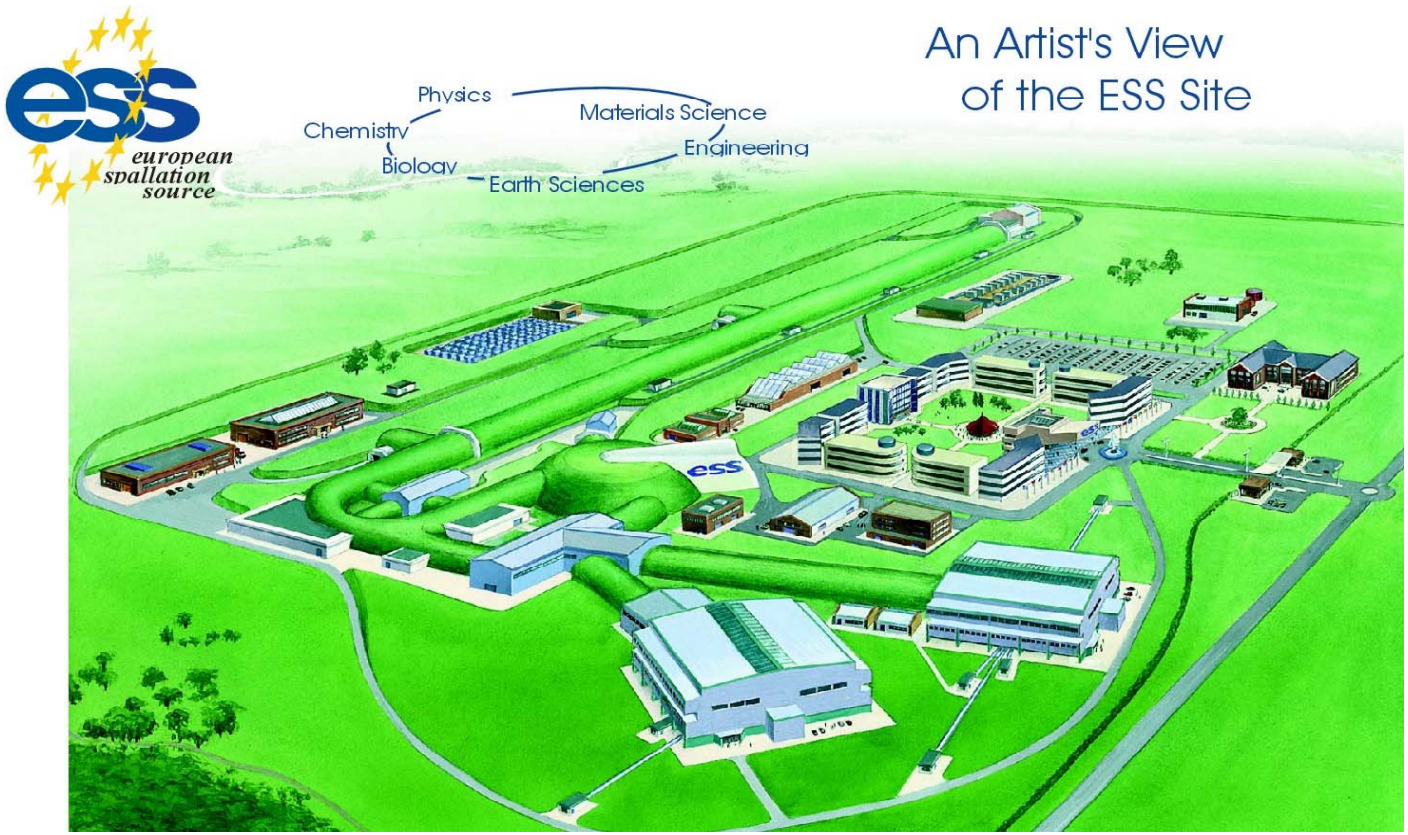
cost copper	72.986	TDM		-421.989701	247.5		
cost FE	88.137	TDM					
cost power	57.956	TDM					
cost water inst.	52.956	TDM					
cost invest total	272.035	TDM					
ann. cost renew	27.203	TDM					
ann. cost water	9.532	TDM					
ann. cost power	13.239	TDM					
ann. cost operatic	49.974	TDM					
cost inv.+oper.	772	TDM					
cost 33 magnets	25469	TDM					



Quad strength Optimisation



First costing

- 2 ring < - > 1 ring
- 200 < - > 130

Neutron City