Overall Complex and Parameters including Injectors, Damping Rings and Beam Delivery System

Hans-H. Braun, CLIC ACE, June 20, 2007

- Parameter history and driving forces
- New nominal parameters
- Subsystem parameters in comparison with other projects
- Civil engineering studies and overall layout

CLIC product specifications

- E_{CM} should cover range from ILC to highest energies accessible for LHC
  $\Rightarrow$ E_{CM} =0.5-3 TeV, (some physicist keep saying that 5 TeV would be better)
- L > few 10^{34} cm^{-2} for acceptable background and energy spread

  E_{CM} and L will need revision once LHC physics results are available

- Design compatible with construction in Geneva region
- Affordable
- Power consumption < 500 MW
- Time scale for required R&D efforts compatible with CDR by 2010, TDR by 2015

Short history and near future of CLIC parameters

1986 (last CLIC advisory committee) - 2004, CLIC Palaeolithicum

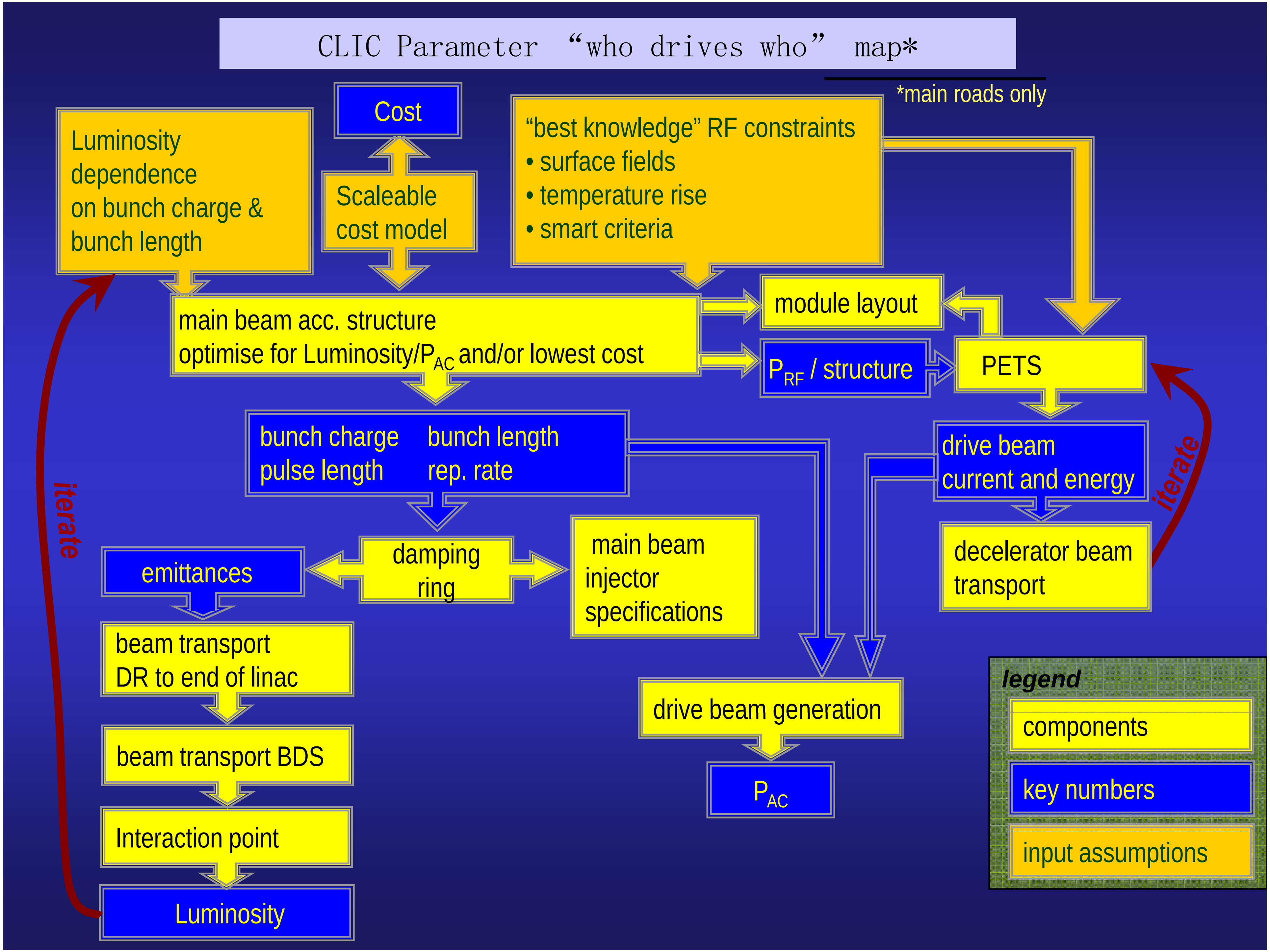
2005 parameter set, assuming G=150 MV/m and ν_{RF} =30 GHz
Key input: 2005 assumptions on maximum structure performance
Key optimization criterion: maximize Luminosity / P_{AC}
Design of subcomponents adjusted and described (CLIC note 627)

Present parameters, phase I (2006), search optimum G and ν_{RF}
Key input: revised assumptions on maximum structure performance & cost model
Key optimization criteria: minimize cost and maximize Luminosity / P_{AC}
$\Rightarrow$ 100 MV/m and 12 GHz, (other motives NLC/JLC experience & test facilities, 2010 feasibility proof)

Present parameters, phase II (until now), adjust and make design more robust
Key input and criteria : gut feeling and comparison with others, in particular NLC/JLC
Design of subcomponents adjusted. Elimination of scary numbers where possible.

Present parameters, phase III (now until end 2007 ?), fine adjust and document
Key input : final round of structure optimisation, re-iterate subsystems
Describe resulting overall design in appropriate document

Wait for new experimental data and start over again if necessary


CLIC Parameter "who drives who" map*
*main roads only
Cost
Luminosity dependence on bunch charge & bunch length
Scaleable cost model
"best knowledge" RF constraints
• surface fields
• temperature rise
• smart criteria
module layout
main beam acc. structure
optimise for Luminosity/P_AC and/or lowest cost
P_RF / structure
PETS
bunch charge
bunch length
pulse length
rep. rate
drive beam current and energy
emittances
damping ring
main beam injector specifications
decelerator beam transport
beam transport DR to end of linac
drive beam generation
beam transport BDS
P_AC
Interaction point
Luminosity
iterate
iterate
legend
components
key numbers
input assumptions

CLIC Note 627

UPDATED CLIC PARAMETERS 2005

H. Braun, R. Corsini, A. De Roeck, A. Grudiev, S. Heikkinen, E. Jensen, M. Korostelev, D. Schulte, I. Syratchev, F. Tecker (editor), W. Wunsch, F. Zimmermann, CERN, Geneva

for the CLIC study team

Abstract

This note presents the CLIC parameter set as of mid 2005 and describes the different sub-systems, stressing how the design of the different components is driven.
This design emerged from a better understanding of limitations for normal conducting accelerating structures, which led to a new optimised design for the CLIC 30 GHz accelerating structure. The structure parameters and improvements in other sub-systems have resulted in a major revision of the parameters. The overall layout and efficiencies for CLIC with this updated parameter-set are presented.

1. Surface electric field [9]: $E_{\mathrm{surf}}^{\mathrm{max}} < 380$ MV/m.
2. Pulsed surface heating [10]: $\Delta T^{\mathrm{max}} < 56$ K.
3. Power [11]: $P_{\mathrm{in}}\sqrt{\tau_p} < 1200\ \mathrm{MW}\sqrt{\mathrm{ns}}$.

[11] V. Dolgashev, "Effect of Rf Magnetic Fields and Input Power on Rf Breakdown Limit", Workshop on High-Gradient RF, Argonne, October 2003

It has to be noted that this optimisation procedure is based on a number of assumptions that are the best knowledge as of mid 2005. In the future, these assumptions may well change when new data becomes available. The RF power constraint [11] is the most uncertain number. It is based on X-band data for copper structure, whereas the number we need is for molybdenum structures at 30 GHz. The two other RF constraints, pulsed surface heating and surface electric field, are also not known with any certainty. Finally, since breakdown behaviour is theoretically not well understood, there is no guarantee that there are no other RF constraints.

Recent changes of key CLIC parameters

Main Linac RF frequency	**30 GHz ⇒ 12 GHz**
Accelerating field	**150 MV/m ⇒ 100 MV/m**
Overall length @ E_{CMS}= 3 TeV	**33.6 km ⇒ 48.3 km**

Why ?

Very promising results of earlier 30 GHz Molybdenum test structures (190 MV/m) not reproduced for test conditions closer to LC requirements (i.e. long RF pulses, low breakdown rate, structures with HOM damping)

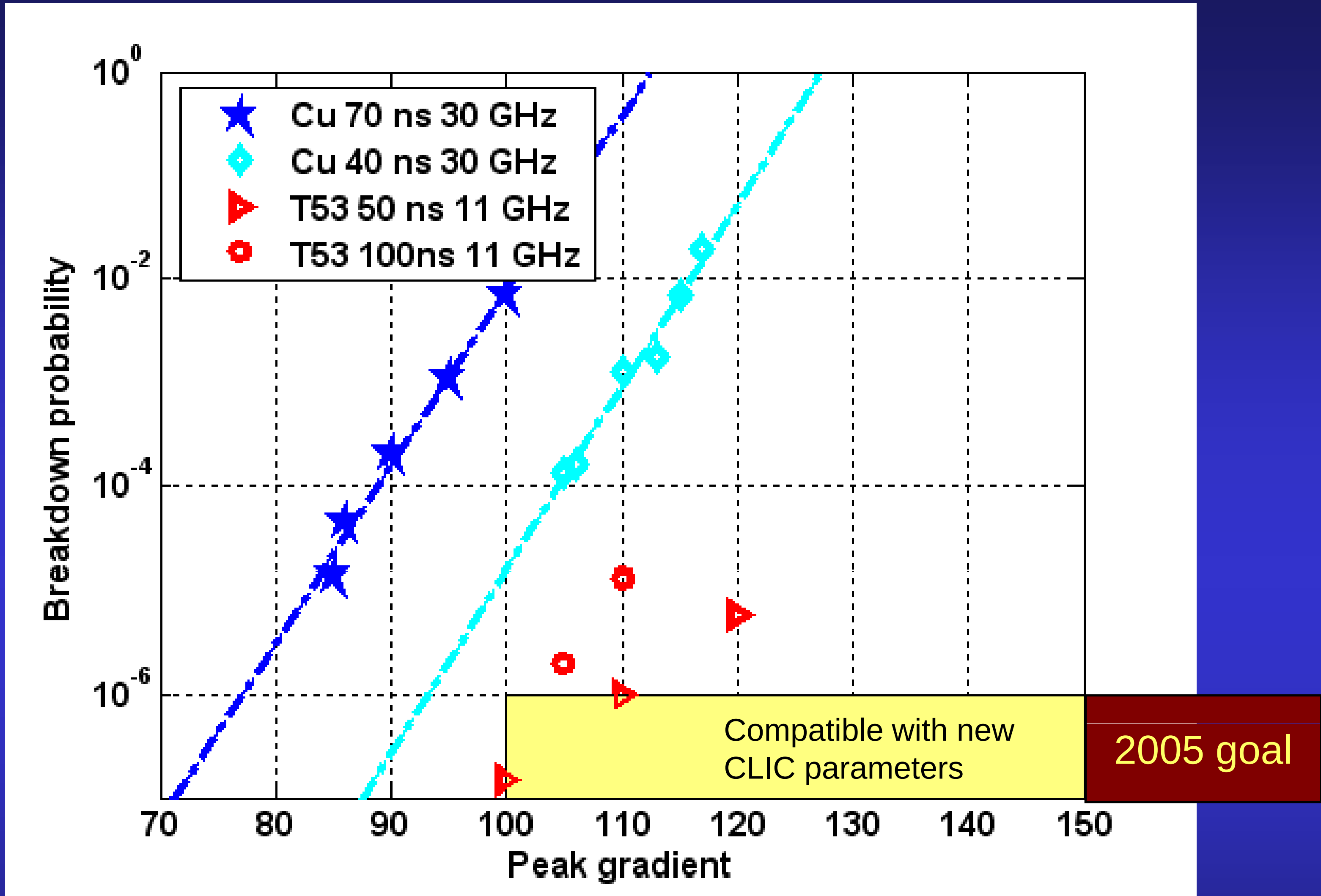
Copper structure tests don't indicate advantage of frequencies>12 GHz for achievable gradient

Parametric cost model indicates substantial cost savings for 12 GHz/100 MV/m (flat minimum for this parameter range)

Allows RF structure testing in existing SLAC and KEK facilities

Increase chance of feasibility demonstration by 2010

100 MV/m is lowest permissible gradient for a 3 TeV machine in Geneva region

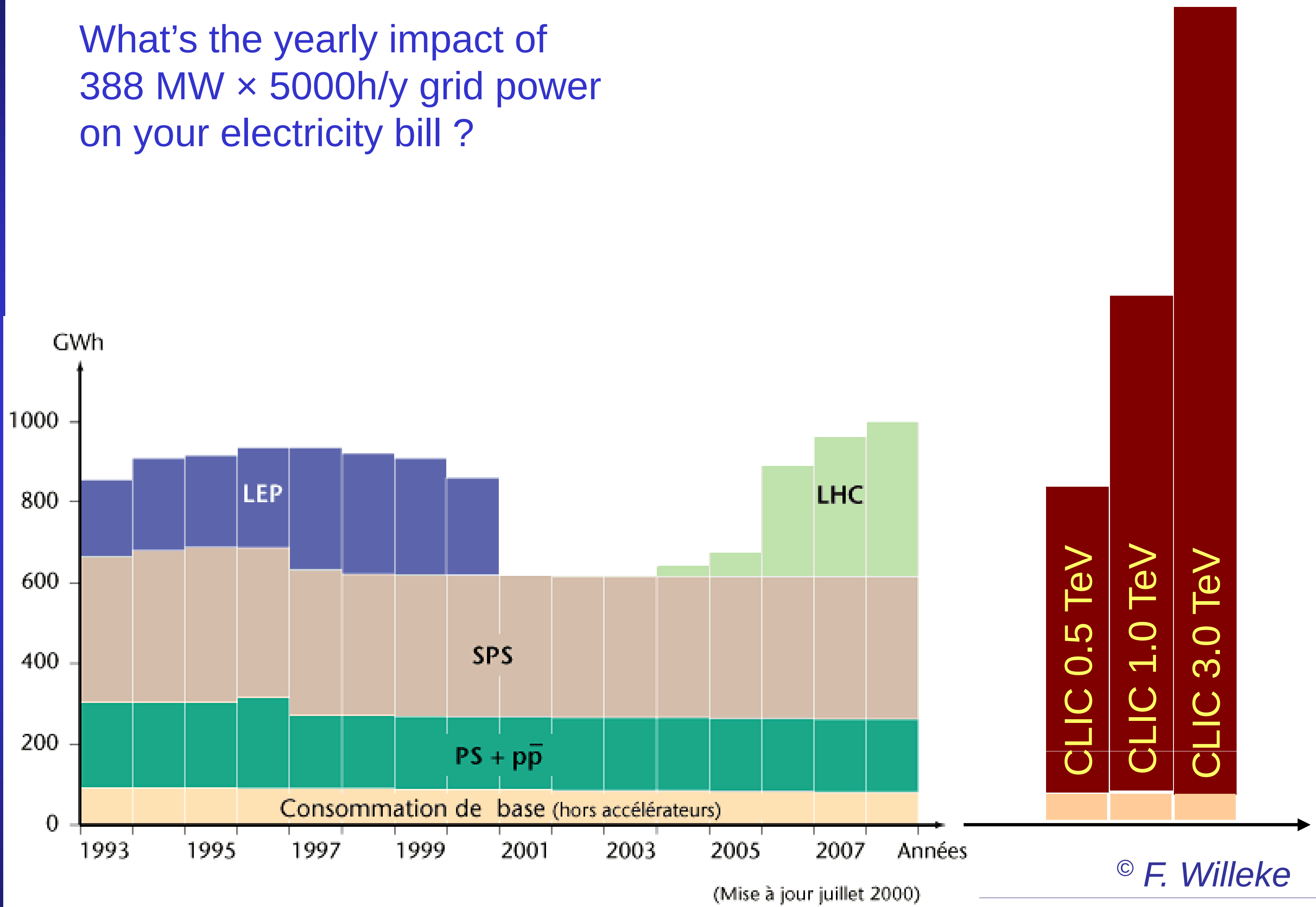


To achieve 300 ns pulse length at 100 MV/m still a lot of progress required.
Improvements expected from new shorter structures with less peak power flow.
Alternatively pulse length can be reduced at expense of power efficiency.

CLIC for E_{CM} = 0.5 / 1.0 / 3.0 TeV

Parameter	Symbol	3 TeV	1 TeV	0.5 TeV	ILC	Unit
Center of mass energy	E_{cm}	3000	1000	500	500	GeV
Main Linac RF Frequency	f_{RF}	12	12	12	1.3	GHz
Luminosity	**L**	**7**	**2.7**	**2.1**	**2**	**10^{34} cm^{-2} s^{-1}**
Luminosity (in 1% of energy)	$L_{99\%}$	2	1.5	1.4		10^{34} cm^{-2} s^{-1}
Linac repetition rate	f_{rep}	50	75	100	5	Hz
No. of particles / bunch	N_b	4.0	4.0	4.0	20	10^9
No. of bunches / pulse	k_b	311	311	311	2670	
No. of drive beam sectors / linac	N_{unit}	26	9	5	-	-
Overall two linac length	l_{linac}	41.7	14.4	8.0	22	km
Proposed site length	**l_{tot}**	**48.25**	**20.55**	**14.15**	**31**	**km**
DB Pulse length (total train)	τ_t	139	48	27	-	μs
Beam power / beam	P_b	15	5	5	10.8	MW
Total site AC power	**P_{tot}**	**388**	**~250**	**158**	**230**	**MW**

What’s the yearly impact of
388 MW × 5000h/y grid power
on your electricity bill ?



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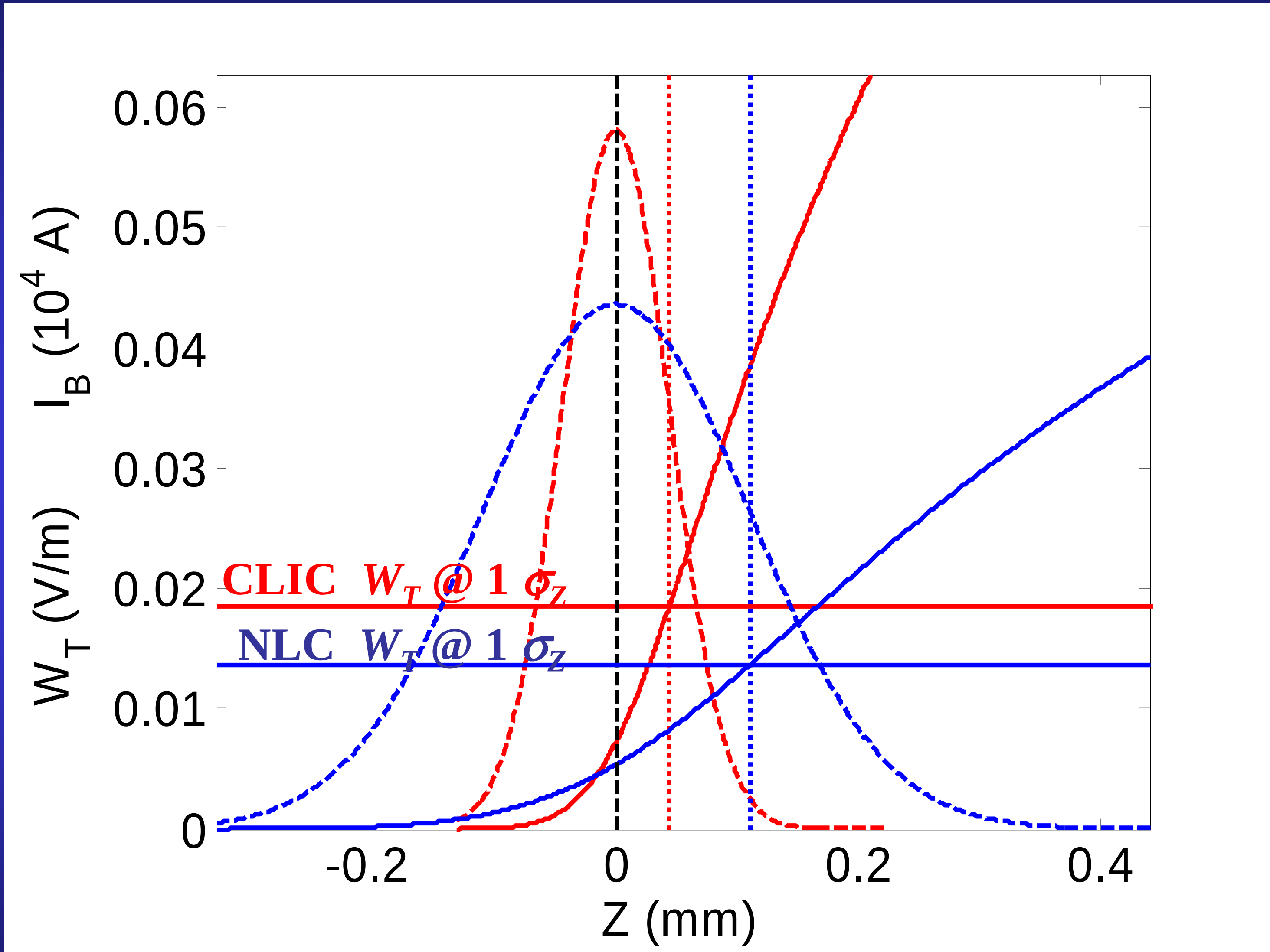
CLIC Linac parameters vs. NLC

Parameter	CLIC 3 TeV	NLC 500 GeV, TRC values	comments
Accelerating Gradient, loaded (MV/m)	100	50	Mandatory for 3 TeV
Frequency (GHz)	12	11.4	Compatibility with CTF3
Phase advance per cell	120	150	Structure optimisation
Iris radius a/λ	0.155 - 0.085	0.21 - 0.148	Reduce power flow for given gradient
Structure length (mm)	229	900	Consequence of reduced power flow
Structure input power (MW)	64.9	75	similar
Pulse length (ns)	297	400	similar
$P/C \times T^{1/3}$ (MW/m $s^{1/3}$)	17.8	15.9	similar
Bunch charge (e_0)	4×10^9	7.5×10^9	Reduced to compensate for stronger W_T
Bunch separation (rf cycles)	8	16	Strong HOM damping
Beam current (A)	1.07	0.86	similar
Bunches per train	146	192	similar
σ_z (μm)	44	110	Higher gradient, lower charge
$\varepsilon_X^* / \varepsilon_Y^*$ (nm)	680 / 20	3600 / 40	Smaller to get comparable Lumi. & background for reduced bunch charge
RF to beam efficiency %	23.8	31.5	Smaller because of high gradient
Rep. rate (Hz)	50	120	Higher E_{cm} (similar for same E_{CM})
No. Klystrons per TeV (E_{CMS})	265	8256	Drive beam vs. distributed klystrons
Average power per klystron (kW)	215	14.4	Drive beam vs. distributed klystrons

Short range transverse wake, CLIC vs. NLC



If Linac parameters approach NLC, why retain drive beam concept ?

CLIC with klystrons vs. CLIC with drive beam

Present CLIC X - band structure parameters are

$L_{eff} = 0.229\text{m}, P_{in} = 69\text{ MW}, Tpulse = 297\text{ ns}, G_{loaded} = 100\text{ MV/m}$

CLIC with $E_{cms} = 3$ TeV needs a total loaded RF voltage of $V_{RF} = 3.3$ TV (with 10% overhead for BNS etc.). The total number of accelerating structures is therefore

$$N_{Acc} = \frac{V_{RF}}{G_{loaded} L_{eff}} = 144106$$

And the instantentenous 12 GHZ RF power for both linacs is

$$P_{Inst} = N_{Acc} P_{In} = \frac{V_{RF} P_{In}}{G_{loaded} L_{eff}} = 9.94\text{ TW}$$

A NLC RF unit consisting of 2 klystrons (75 MW each and 1.6 μs pulselength) provide with SLED II compression 475 MW during 400 ns. For the shorter RF pulse of CLIC we assume for the sake of simplicity that the peak power can be raised by the ratio of pulse length

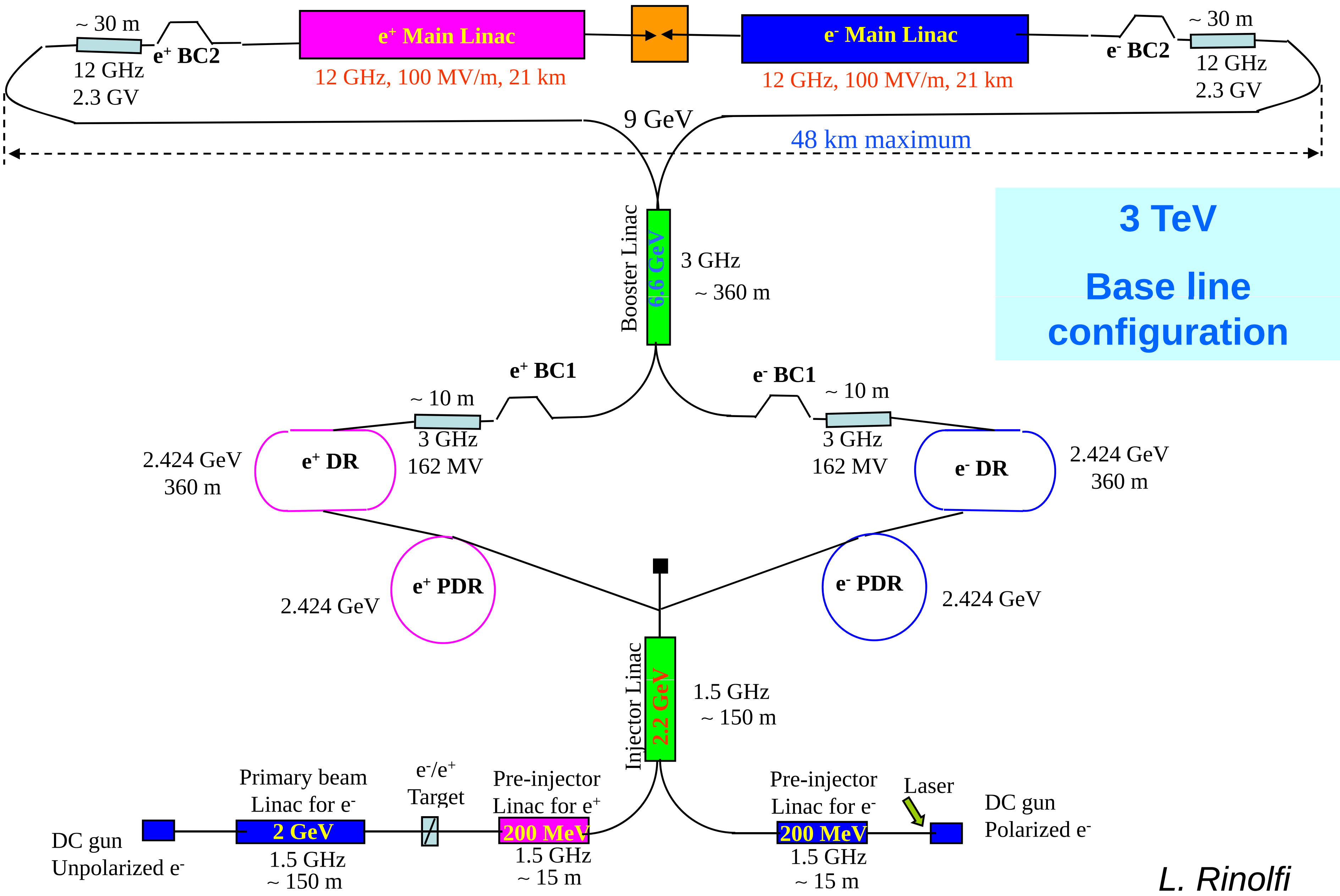
$$P_{RFunit} = 475\text{ MW} \frac{400\text{ ns}}{297\text{ ns}} = 640\text{ MW}$$

Therefore the number of NLC RF units required to feed CLIC is

$$N_{RFunit} = \frac{P_{Inst}}{P_{RFunit}} = \frac{V_{RF} P_{In}}{G_{loaded} L_{eff} P_{RFunit}} = 15538$$

The 2004 NLC cost estimate assumed that a RF unit with two klystrons and SLED II accounts for roughly 0.5 M$. Therefore the RF source costs for a klystron driven CLIC are estimated as 7.8 B$.

CLIC main beam injector complex



L. Rinolfi

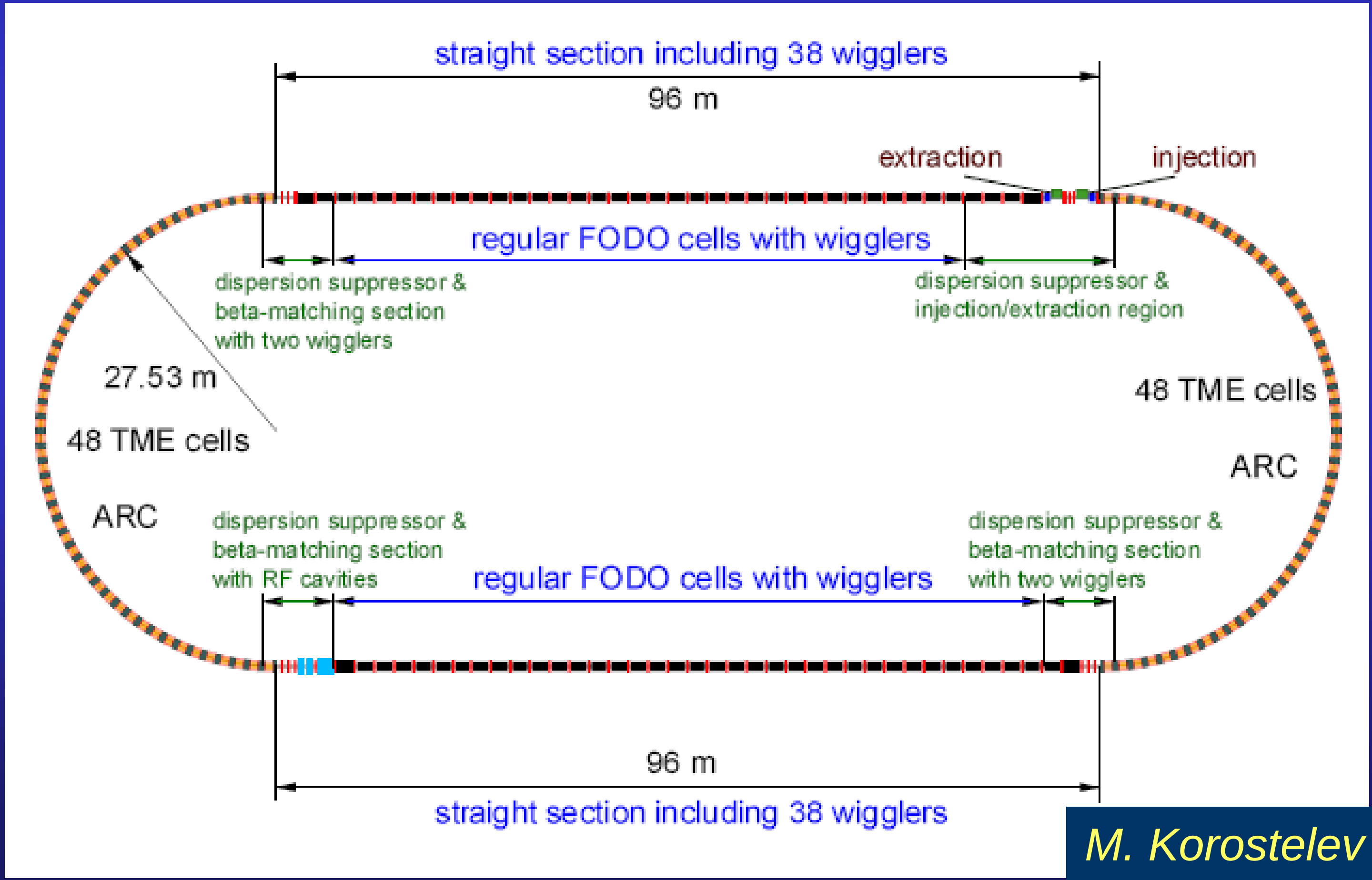
Beam parameters comparison
at entrance of main linac

		NLC (1 TeV)	CLIC 2007 (3 TeV)	ILC (Nominal)
Energy E	GeV	8	9	15
Bunch population N	10^9	**7.5**	**4**	**20**
Bunches per train n_b	-	190	311	2625
Bunch spacing Δt_b	ns	1.4	0.667	369
Train length t_{pulse}	ns	266	207	968625
Emittances $\gamma\varepsilon_x$, $\gamma\varepsilon_y$	nm	3300, 30	600, 10	8400, 24
rms bunch length σ_z	µm	90-140	44	300
rms energy spread σ_E	%	0.68	1.5	1.5
Repetition frequency f_{rep}	Hz	120	50	5
Train population $N \times n_b$	10^{12}	**1.43**	**1.24**	**52.5**
Average beam power P	kW	219	90	630

L. Rinolfi

Damping rings

- Emittance IBS dominated
- Very fast damping with 2.5 T s.c. wiggler $\tau_x / \tau_y / \tau_z$ = 1.5 / 1.5 / 0.75 ms
- Only one machine pulse stored at a time, filling ~ one quarter of the ring
- Issues: Wiggler technology, e-cloud, orbit & optics control, dynamic aperture
- Predamping ring mandatory for both DR's
- Extraction / Injection simpler than for ILC



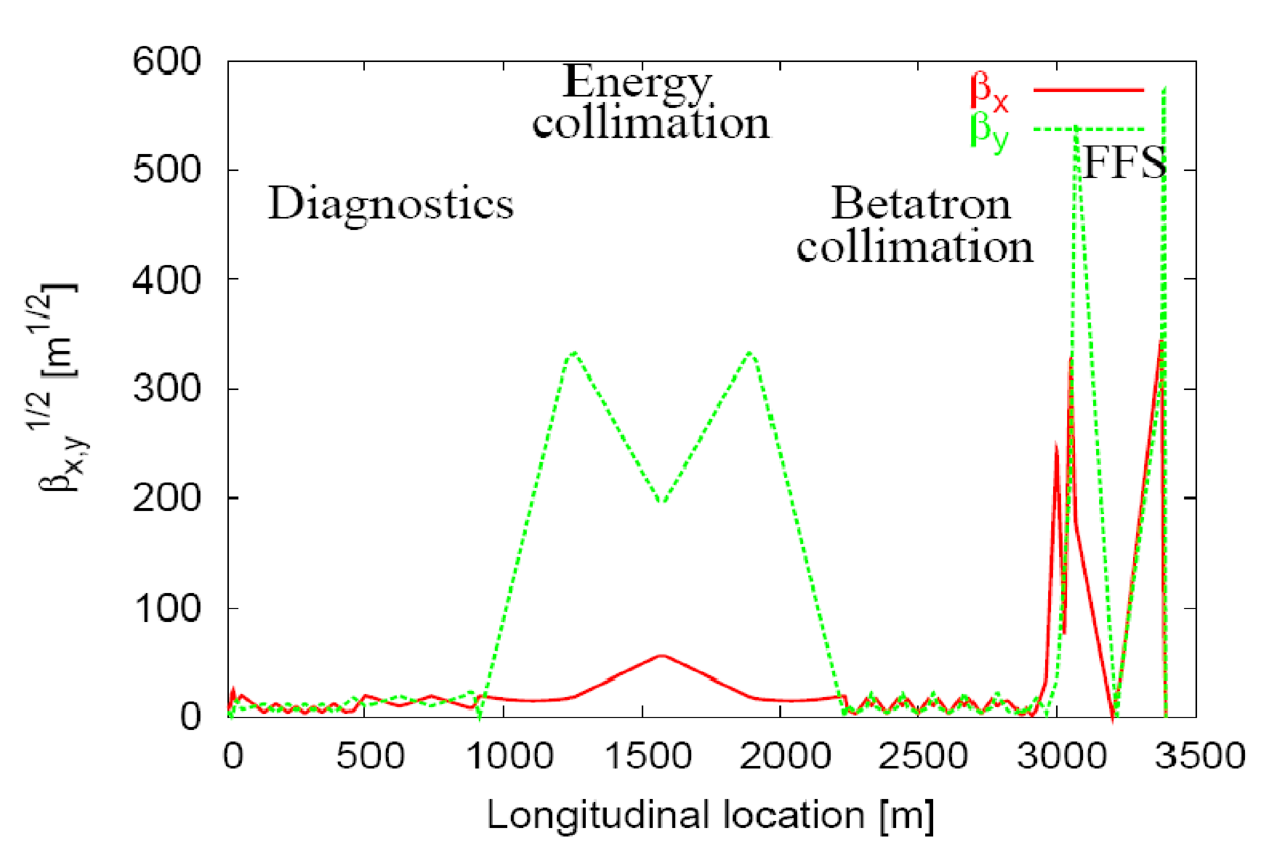
M. Korostelev

Damping and storage rings emittances

PARAMETER	NLC	ILC	CLIC	ATF	ALS	SLS
energy [GeV]	1.98	5.00	**2.424**	1.3	1.9	2.4
Bunch charge [10^9]	7.5	<20	**4.4**	10	4	6
circumference [m]	299.79	6695.1	**365.2**	139	197	288
hor. normalized emittance [nm]	2370	5600	**395**	2798	25656	23483
ver. normalized emittance [nm]	20	20	**4.2**	25	19	70

Y. Papaphilippou

Full BDS



length values not up-to-date

R. Tomás

	ILC	NLC	ATF2	CLIC	unit
General					
Energy	250/500	250/500	1.28	1500	GeV
$\epsilon_x \gamma$	800	360	300	68	10^{-8}m
$\epsilon_y \gamma$	4	4	3	2	10^{-8}m
e^-/bunch	20	7.5	8	4	10^9
bunches/train	2670	192	1900	311	1
bunch spacing	363	1.4	0.09	0.66	ns
β_x **at IP**	21	8	4	7	mm
β_y **at IP**	0.4	0.1	0.1	0.09	mm
σ_x **at IP**	0.65	0.24	2.2	0.053	μm
σ_y **at IP**	5.7	3	35	1	nm
Energy bandwidth σ_x	0.8		0.8	0.5	%
Energy bandwidth σ_y	0.6		0.3	0.5	%
BDS lengths					
Diagnostics	550	335	50	250	m
Collimation	0.9	1.46	0	2	km
FFS	700	500	40	450	m
L*	3.5	3.5	1	3.5	m
Total BDS	2.15	2.3	90	2.7	km

Comparison of different BDS systems.
Energy bandwidth is defined as energy offset required to double beamsize

R. Tomás

More details about energy bandwidth

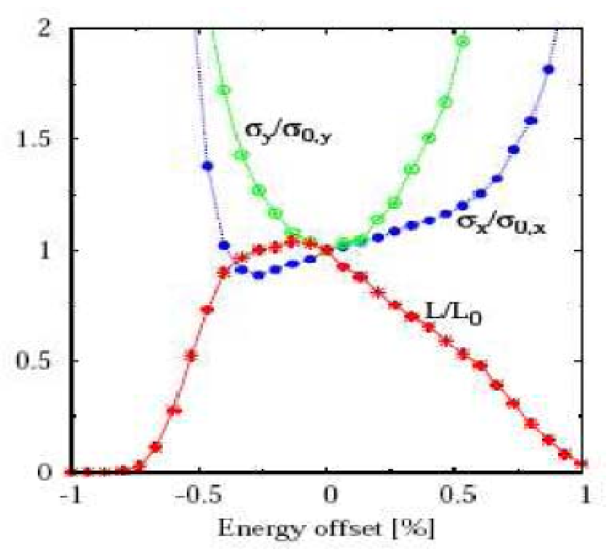


Figure 1: CLIC BDS bandwidth

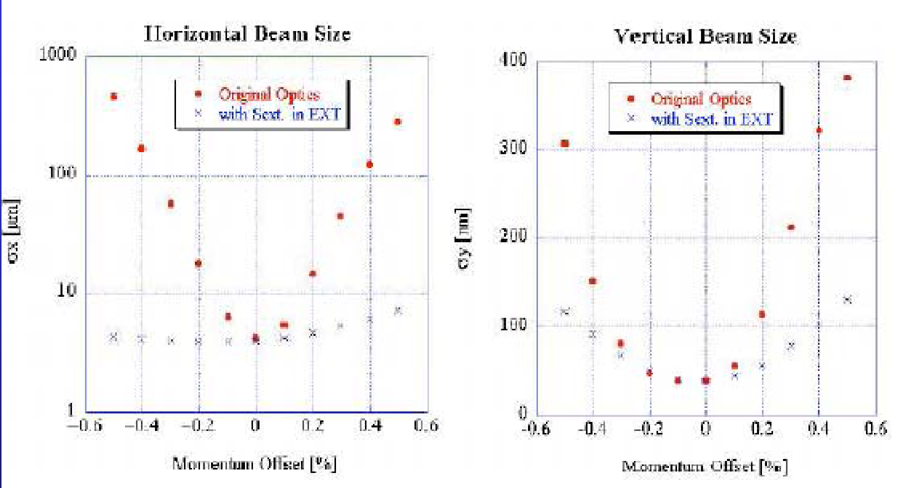


Figure 2: ATF2 bandwidth

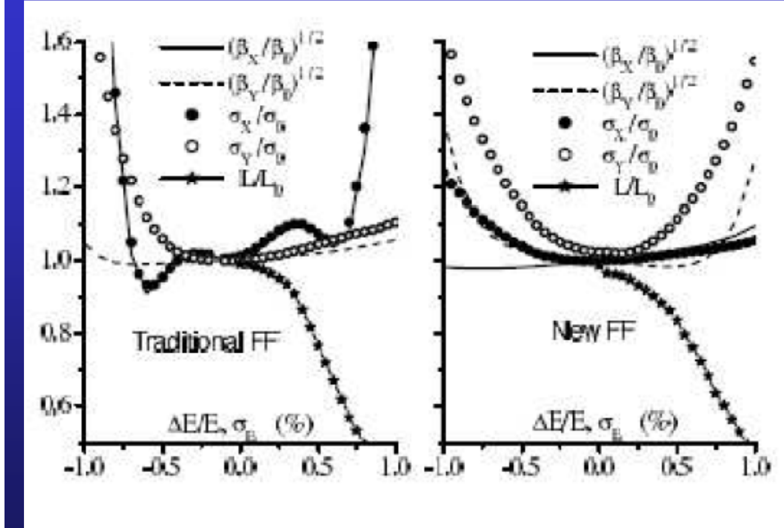


Figure 3: ILC FFS bandwidth

How we get to total length (for 3 TeV)

14-Jun-07

component	Length	comments
R turnaround	120 m	GLC Project report, KEK Report 2003-7 Rarc=87m for 8.25GeV. $\Delta\varepsilon$~E^5/R^3 gives R=100m for 9 GeV +20m margin
spin Rotator	105 m	ILC spin rotator length EUROTeV-Report-2006-068
BC2 energy correlation cavities	40 m	Assuming 2.3 GV of X band cavities at ~60 MV/m
Bunch Compressor 2 chicane	40 m	CLIC BC2 design, EUROTeV report 2007-9
Matching and diagnostics	60 m	What remains after all other distances are substracted from maximum site length
Linac-sector × Nsector	21060 m	26 sectors * 810m, assumes 10% voltage overhead and 78% filling factor
BDS-diagnostics	250 m	Assuming laser wire with 1 micron resolution able to resolve 20 nm vert. emittance Scales L~vert emittance x Sqrt(laser resolution)
BDS-collimation	2000 m	Determined by robustness requirement for energy collimator
BDS final focus	450 m	assuming L*=3.5m
Half total length	24125 m	
Total	**48250 m**	About maximum site length available with IP on CERN unfenced (J.L. Baldy, 27Apr'07)

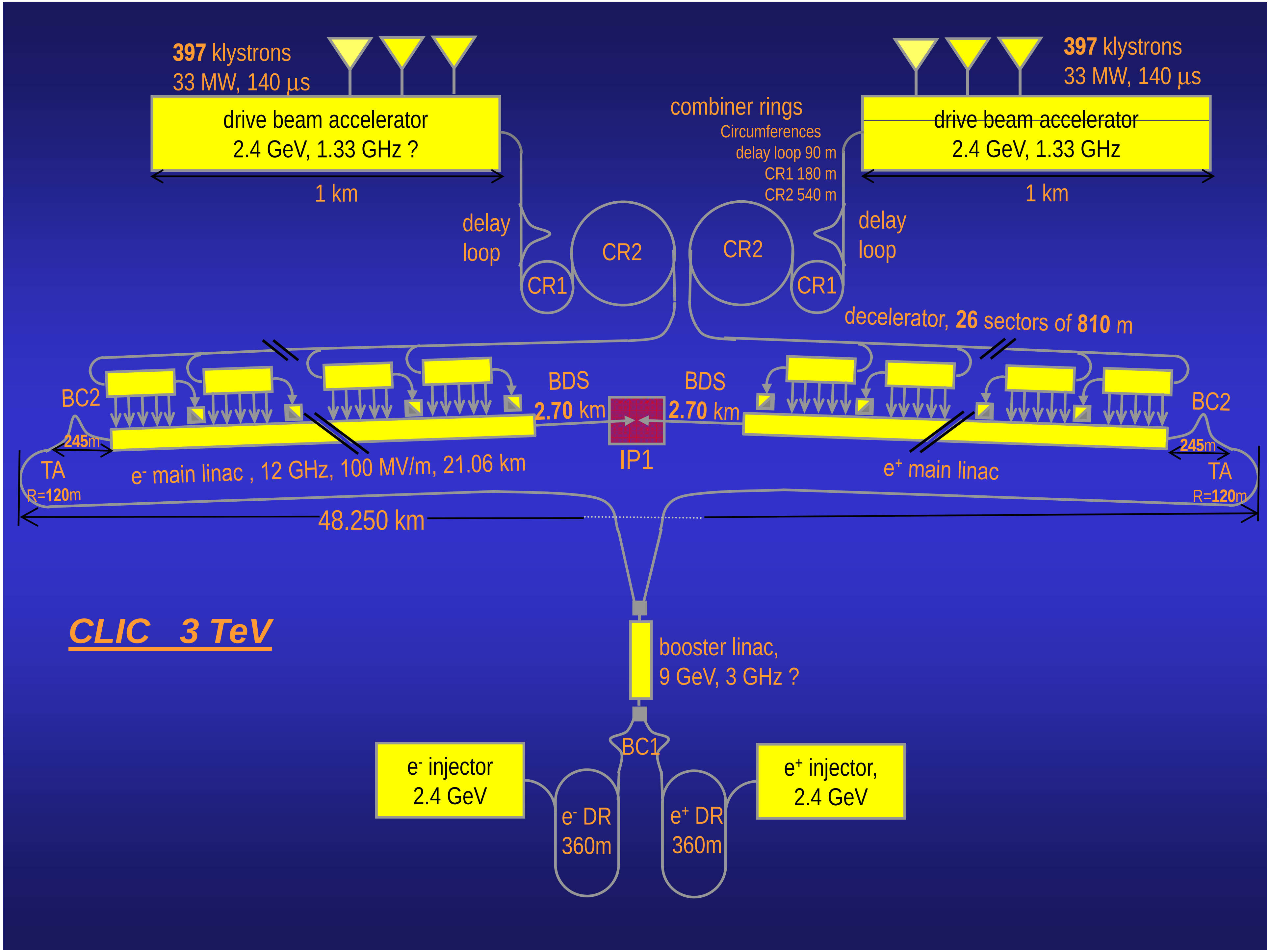
Belongs all to BC2
Total Length
BC2=245m

provided by
Rogelio Tomás

CLIC PROJECT

Civil Engineering Layouts

- Bases For The CE Layouts
- General layouts
- Underground layouts



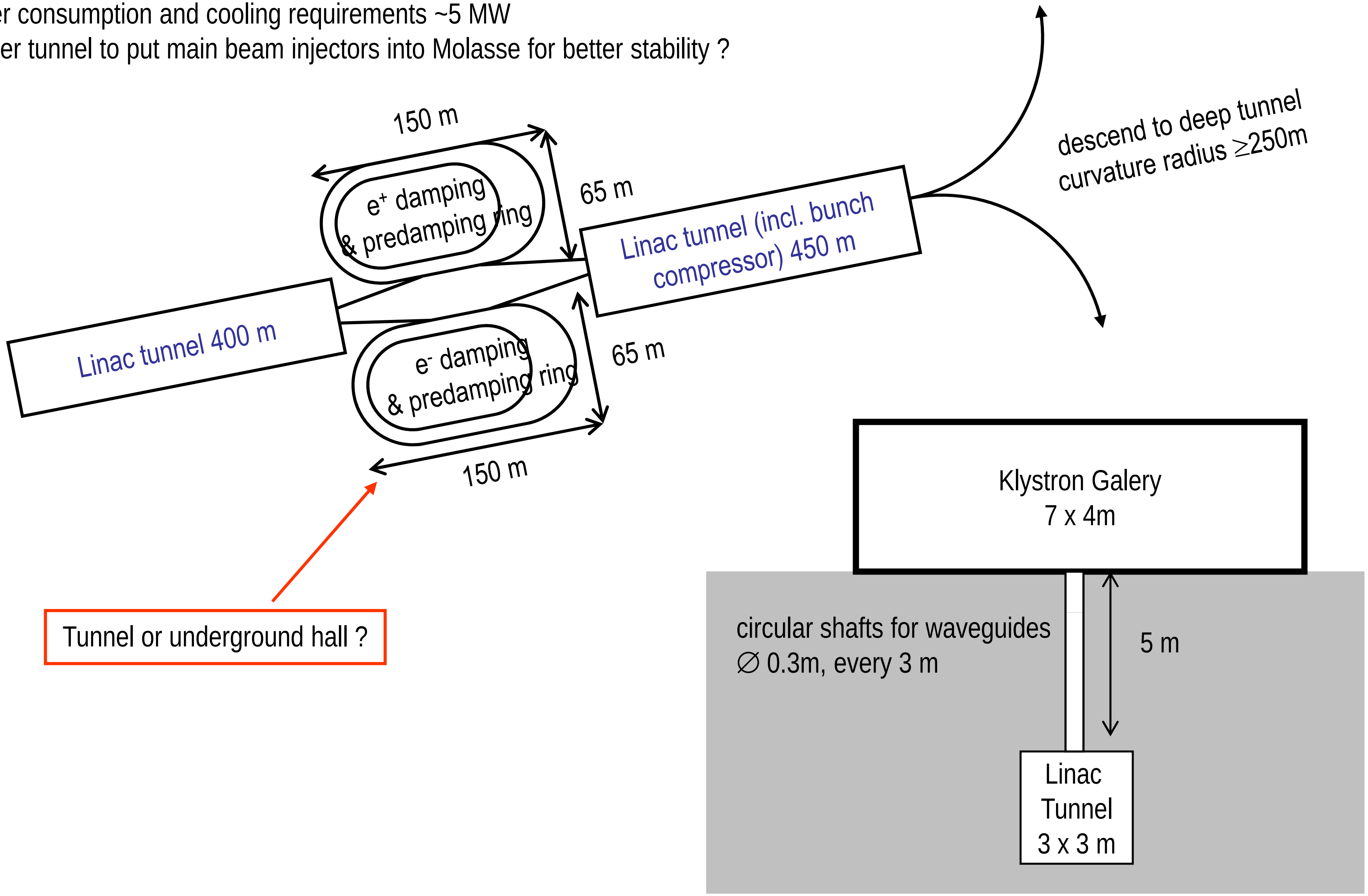
397 klystrons
33 MW, 140 μs
drive beam accelerator
2.4 GeV, 1.33 GHz ?
1 km
combiner rings
Circumferences
delay loop 90 m
CR1 180 m
CR2 540 m
397 klystrons
33 MW, 140 μs
drive beam accelerator
2.4 GeV, 1.33 GHz
1 km
delay
loop
CR2
CR1
CR2
CR1
delay
loop
decelerator, 26 sectors of 810 m
BC2
245m
TA
R=120m
BDS
2.70 km
BDS
2.70 km
IP1
BC2
245m
TA
R=120m
e- main linac , 12 GHz, 100 MV/m, 21.06 km
e+ main linac
48.250 km
CLIC 3 TeV
booster linac,
9 GeV, 3 GHz ?
BC1
e- injector
2.4 GeV
e- DR
360m
e+ DR
360m
e+ injector,
2.4 GeV

Some basic features

- Layout compatible with E_{CMS} = 3 TeV
- IP and injectors located on the CERN Prevessin site (incl. unfenced areas)
  In this case topolgy limits total length to L_{total} < 48.25 km
- Detector size and configuration assumed to be same as for ILC (two detectors in push pull)
- Single tunnel with ∅ 4.5 m. This diameter is kept not only throughout the linac but also in the BDS systems.
- The two linac tunnels are laser-straight with an angle of 20 mrad between them.
- The plane containing the tunnels may have a slope of up to 1% in order to optimize the location of the tunnels considering the underground and surface conditions.
- The maximum spacing between main access shafts is 5 km.
  For 3 TeV this leads to 5 shafts on either site of IP plus three shafts for the IP area.
  For 1 TeV this leads to 2 shafts on either site of IP plus three shafts for the IP area.
- For surface buildings only technical buildings in central region and at access shaft areas are considered.
- For all other surface buildings the existing CERN infrastructure is considered to be sufficient.

Main beam injector linacs

Total length ~1 km
If possible on CERN Prevessin site close to power substation
Power consumption and cooling requirements ~5 MW
Deeper tunnel to put main beam injectors into Molasse for better stability ?

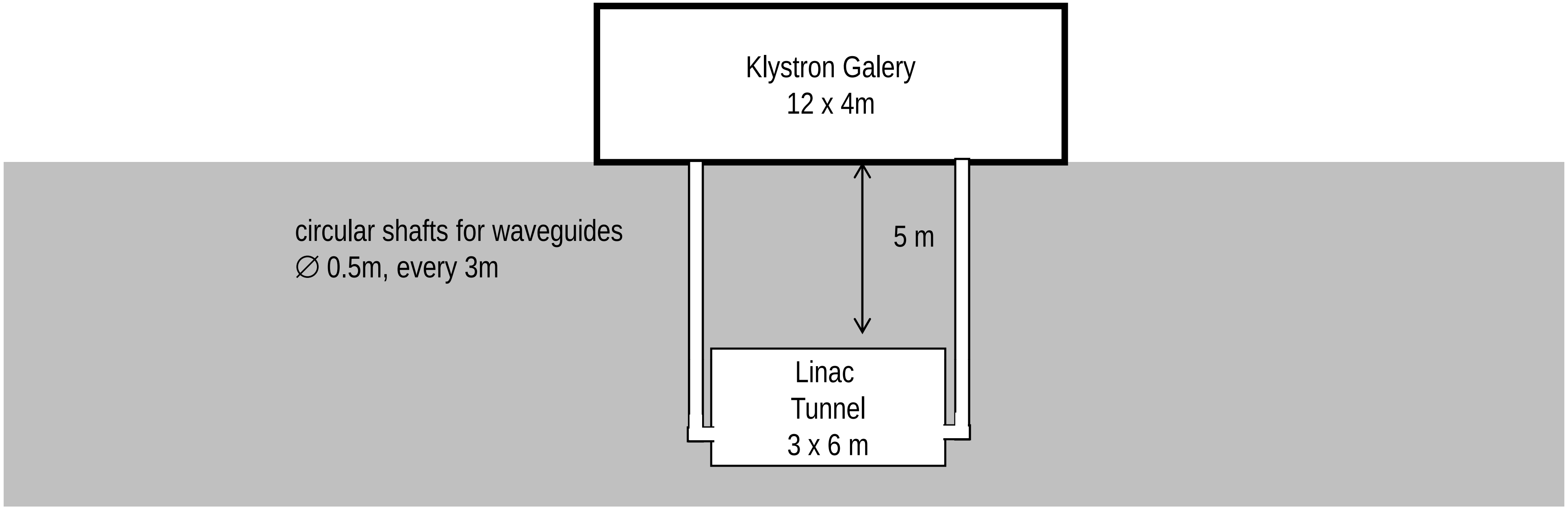


Drive beam accelerator

Total length ~ 1 km
On CERN Prevessin site close to power substation
Power consumption and cooling requirements **~300 MW**

The two drive beam accelerators are alongside in the same 6 m wide tunnel

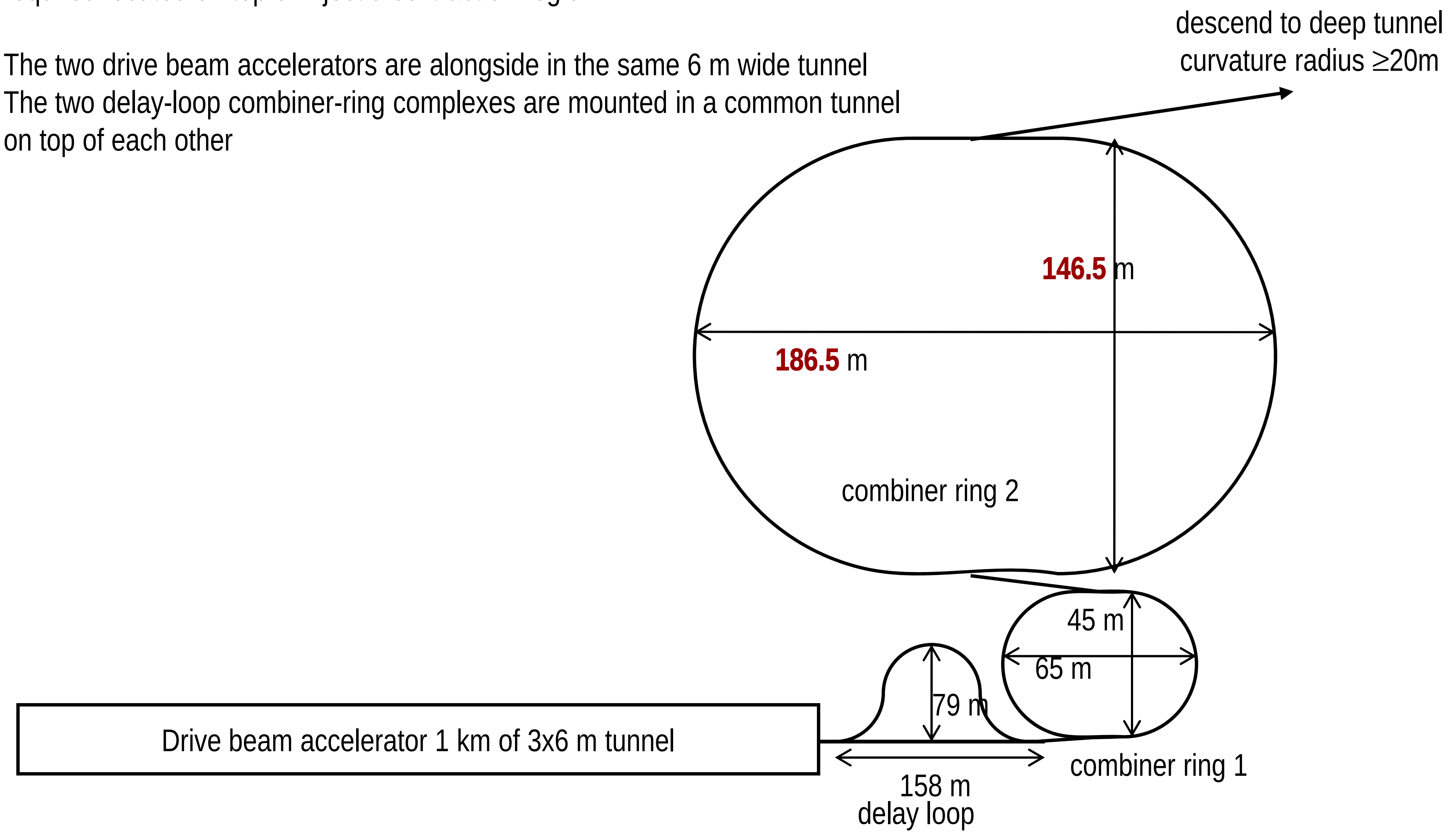
available surface per Klystron ~ 15 m^2



Drive beam injector complex

>= 5 m under ground.
4 m wide tunnels for beamlines and rings.
Transfer between rings can be adapted to topological constraints.
Total of ~ 300 m^2 of surface buildings for klystrons and power supplies required located on top of injection/extraction region

The two drive beam accelerators are alongside in the same 6 m wide tunnel
The two delay-loop combiner-ring complexes are mounted in a common tunnel on top of each other



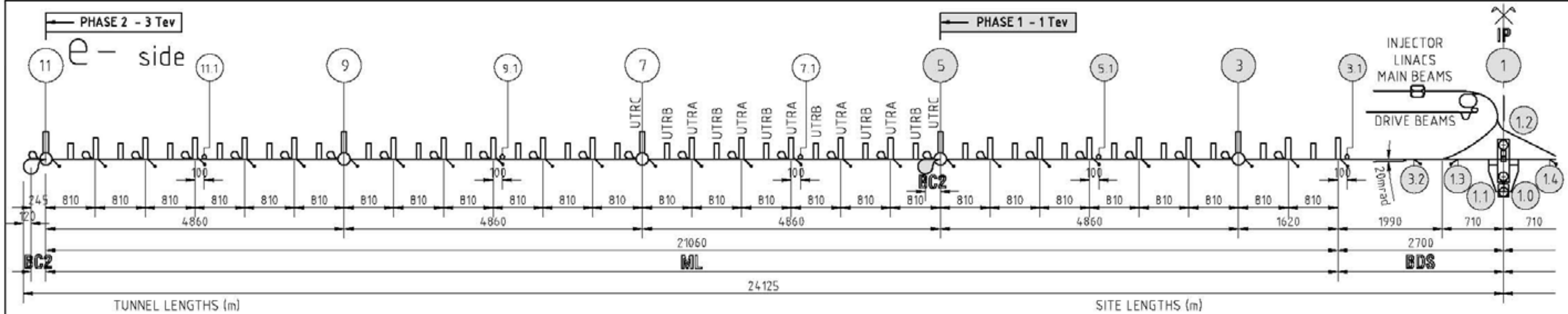
Bases For The CLIC Civil Engineering Layouts and Drawings :

- All information received from AB Department up to 25.06.07
  - Follows many discussions between AB and TS representatives
  - Takes into account all Decisions made since January 2007
- LEP, LHC and the project proposals for TESLA and ILC
- Geological / Geotechnical / Hydrological data know to us from various sources (no additional borings or tests)
- Preliminary environmental investigations (all foreseen sites visited)
- Permanent view on CE feasibility and optimization in term of cost and time schedules
- Input from very Experienced CE Consultants (AMBERG Ing. Zurich)

Notes :

- The Surface buildings list and layouts still to be drawn up (in the coming weeks)
- The TS Systems other than CE are still to be looked into (they are likely to have some impact on the CE drawings)

J.-L. Baldy



TUNNEL LENGTHS (m)

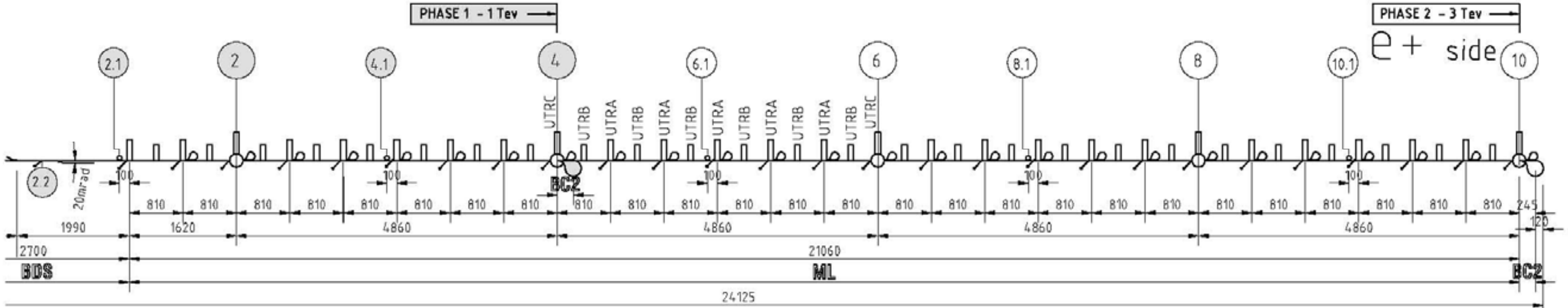
	main beam turn-around	BC2	e− side ML	BDS	e+ side ML	drive beam accelerator +DL+CR1+CR2+ links	e− e+ injectors + DR +link +booster linac	main + drive beam transfer tunnels	TOTAL
Phase 1	1508	490	6 480	5 400	6 480	2 216	1430	2 516	26 520
Phase 2	1508	490	14 335	-	14 335	-	-	-	30 668
Total	3016	980	20 815	5 400	20 815	2 216	1430	2 516	57 188

SITE LENGTHS (m)

	main beam turn-around	BC2	e− side ML	BDS	e+ side ML	TOTAL
Phase 1	240	490	6 480	5 400	6 480	19 090
Phase 2	240	490	14 215	-	14215	29 160
Total	480	980	20 695	5 400	20 695	48 250

TUNNELS SECTIONS

Area	beam turn-around	e− e+ sides ML	BDS	main/drive beam transfer tunnels	main/drive beam common transfer tunnel
section dims.	Ø3 m	Ø4.5 m	Ø4.5 m	Ø3.8 m	Ø4.5m



SHAFTS

Point	1.0	1.1	1.2	2	3	4	5	6	7	8	9	10	11
Øm	9	16	16	9	9	9	9	9	9	9	9	9	9

SURVEY BORINGS

Point	2.1, 3.1, 4.1, 5.1	6.1, 7.1, 8.1, 9.1, 10.1, 11.1
Øm	1.50	

SHAFT BASE CAVERNS (10 UTRC)

Point	2, 3, 4, 5	6, 7, 8, 9, 10, 11
(LxWxH) m	49 x 16 x 18 3 storeys	

UTRA CAVERNS

Nombre	14 x	30 x
(LxWxH) m	26 x 9 x 7.2	

UTRB CAVERNS

Nombre	16 x	36 x
(LxWxH) m	20 x 9 x 7.2	

DETECTORS HALL + SERVICE HALL

Point	1.1, 1.2	1.0
(LxWxH) m	120 x 25 x 39	40 x 16 x 15

MAIN BEAM DUMP CAVERNS & SERVICE HALLS (↗)

Point	BDS CAVERNS 1.3, 1.4, 2.2, 3.2	BDS SERVICE HALLS 1.3, 1.4, 2.2, 3.2
(LxWxH) m	20 x 8 x 14 + 1 storey	38 x 16 x 10

MUON WALL WIDENINGS

Point	1.3, 1.4
(LxWxH) m	25 x9x7.2 +15x9x7.2

CONNECTION CAVERNS

Point	1.3, 1.4
(LxWxH) m	18 x 9 x 7.2

DRIVE BEAM DUMP CAVERNS (↘)

Nombre	At each UTRAs and UTRCs 18 x	36 x
(LxWxH) m	6 x 9 x 5	

DRIVE BEAM RETURN LOOP

Nombre	16 x	36 x
(LxWxH) m	63 x 2.4 x 3	

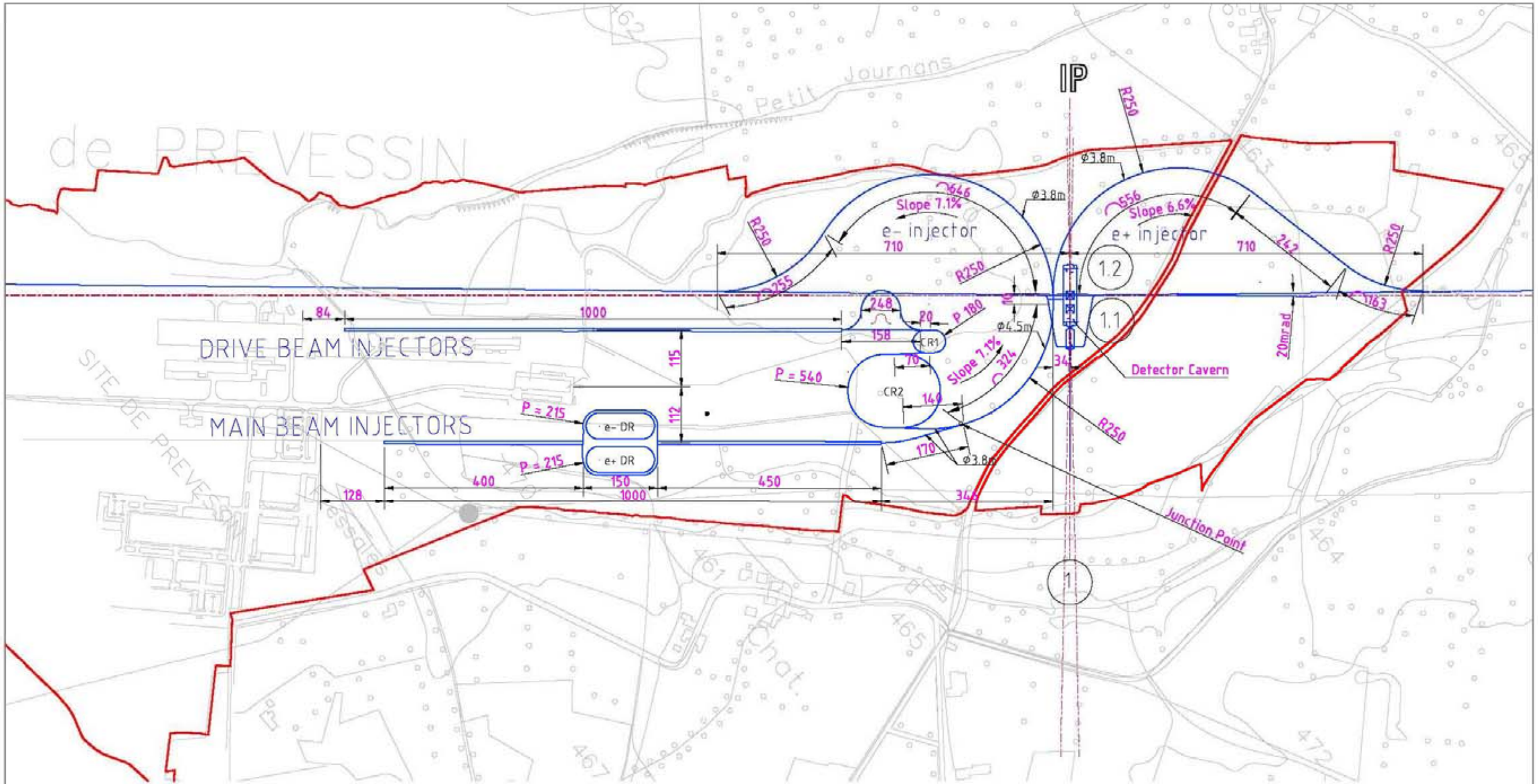
UTR = Underground Technical Room

CLIC - UNDERGROUND STRUCTURES SCHEMATIC LAYOUT

GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISOR : JL.BALDY
DESIGNER : N.BADDAMS

SCALE : 1/62500(A3_FORMAT) DATE : 13_JUNE_2007

CLIC.CE-1.1749.0001 SIZE 3 INDICE G



INJECTORS TUNNELS	DRIVE BEAM INJECTORS COMPLEX					MAIN BEAM INJECTORS COMPLEX						COMMON & FINAL TRANSFER TUNNELS (after Junction Point)		
	LINAC	DELAY LOOP	CR 1	CR 2	TT to Junction Point	LINAC 1	e- DR	e+ DR	DR Link	LINAC 2 + BC 1	TT to Junction Point	COMMON	e- TT	e+ TT
Length (l) m	1000	406	180	540	140	400	215	215	150	450	170	334	901	971
Section (l x h) m	6 x 3	4 x 3	4 x3	4 x 3	Φ 3.8	3 x 3	6 x 3	6 x 3	14 x 3	3 x 3	Φ 3.8	Φ 4.5	Φ 3.8	Φ 3.8

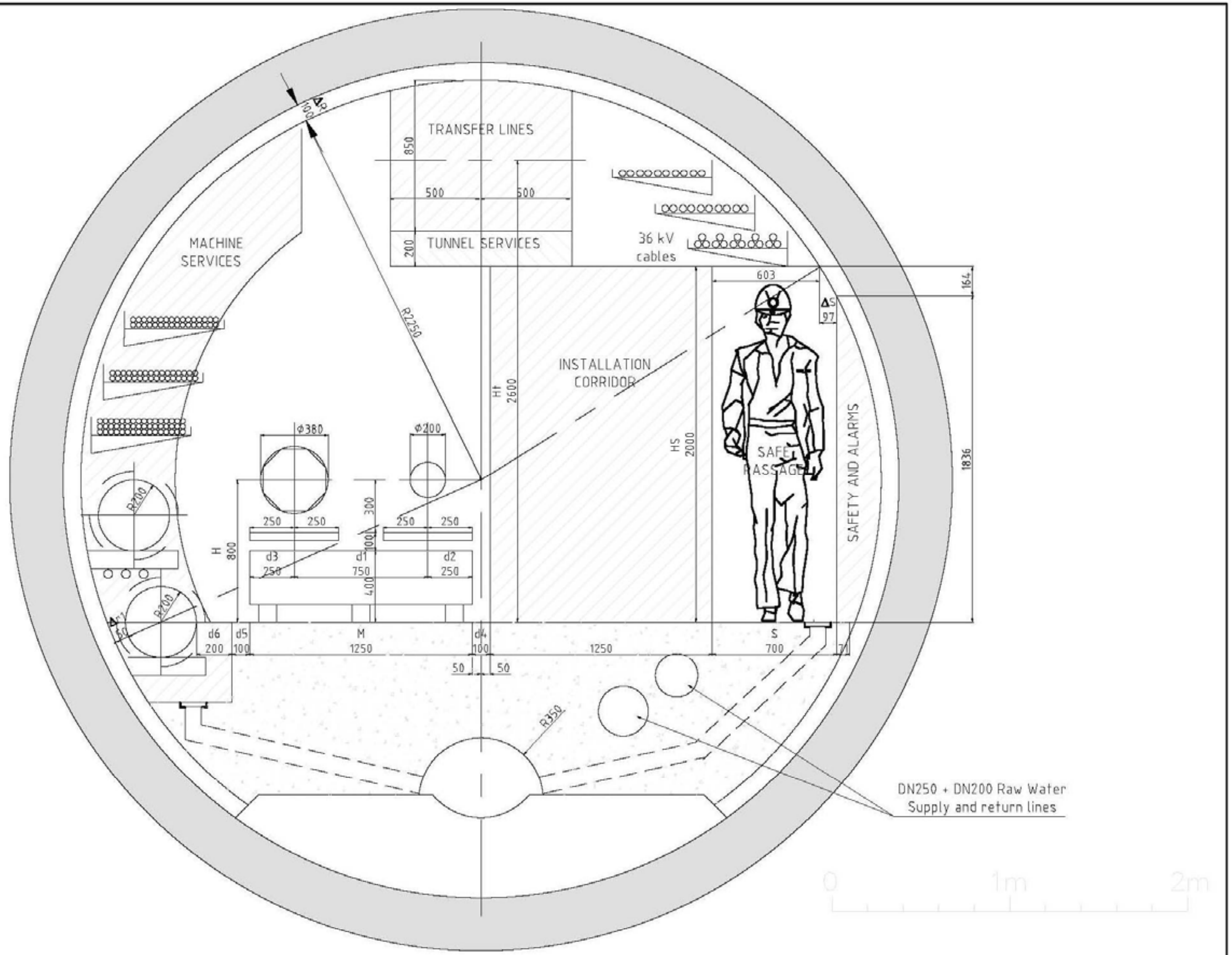
CLIC- MAIN / DRIVE BEAM INJECTORS AND EXPERIMENTAL AREA LAYOUT

CERN

GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISOR : JL.BALDY
DESIGNER : N.BADDAMS

SCALE : 16500(A3_FORMAT) DATE : 12_JUNE_2007

CLIC.CE-1.1799.0002 SIZE 3 INDICE D



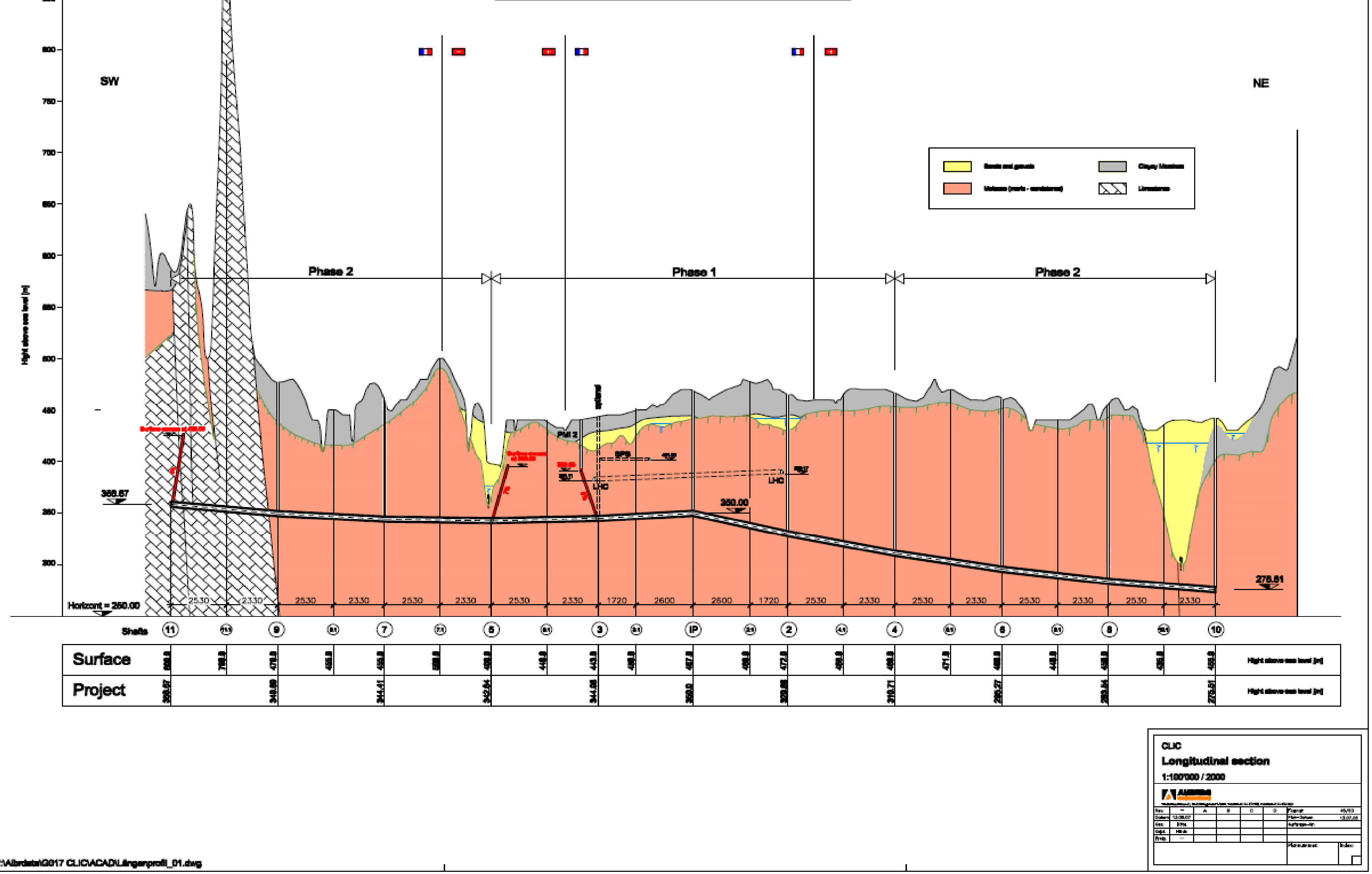
CLIC TUNNEL TYPICAL CROSS SECTION

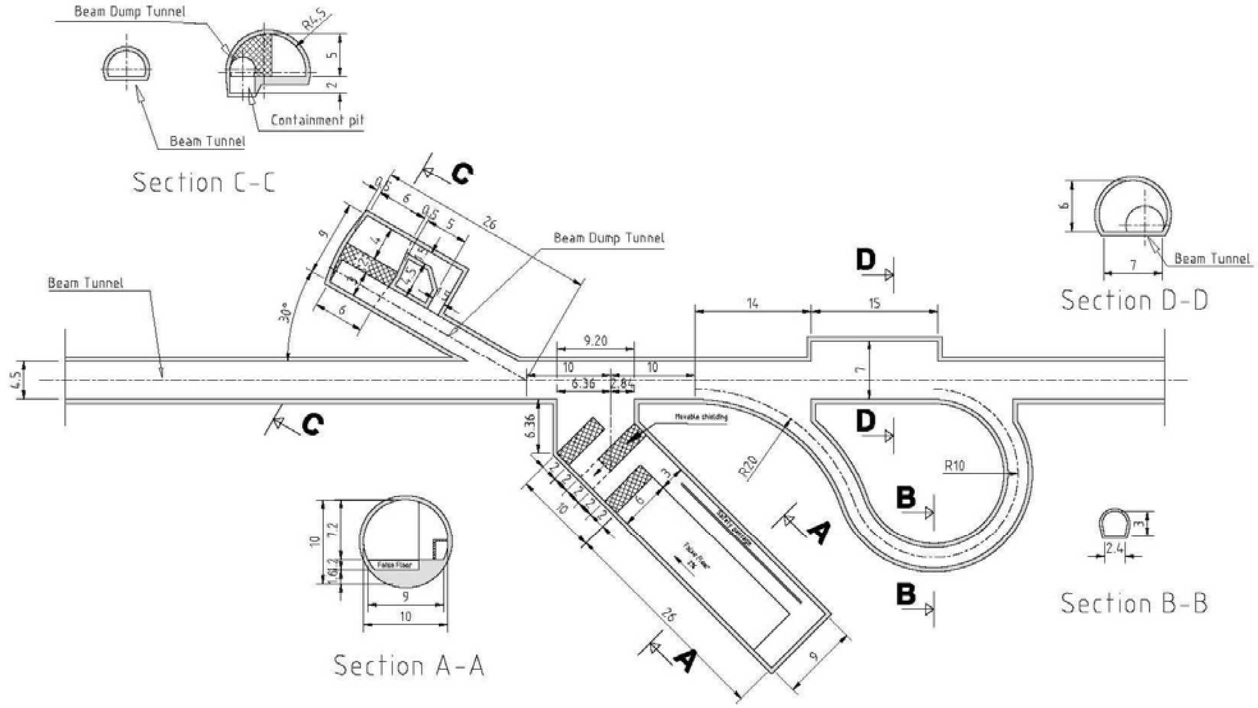
GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISEUR : C.WYSS
DESIGNER : N.BADDAMS

SCALE : 1/20(A3_FORMAT) DATE : 14_MAY_2007

CLIC.CE-1.1710.0004 SIZE 3 INDICE -

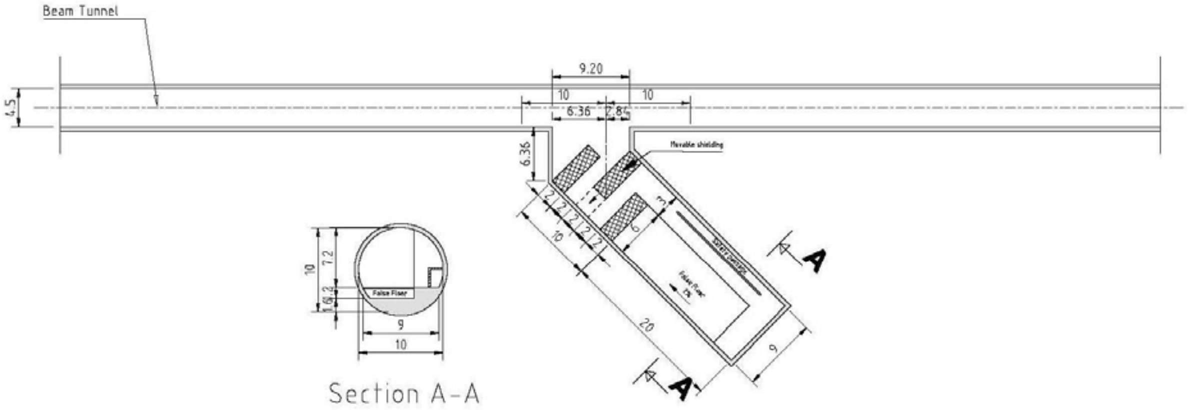
Longitudinal section 1:100'000 / 2000





CLIC - UTRA CAVERN, DRIVE BEAM LOOP AND BEAM DUMP

GROUP : TS-CE CIVIL ENGINEERING SUPERVISEUR : JL.BALDY DESIGNER : N.BADDAMS	SCALE : 1/500(A3_FORMAT) DATE : 22_MAY_2007 CLIC-.CE-1.1710.0002	SIZE 3	INDICE A

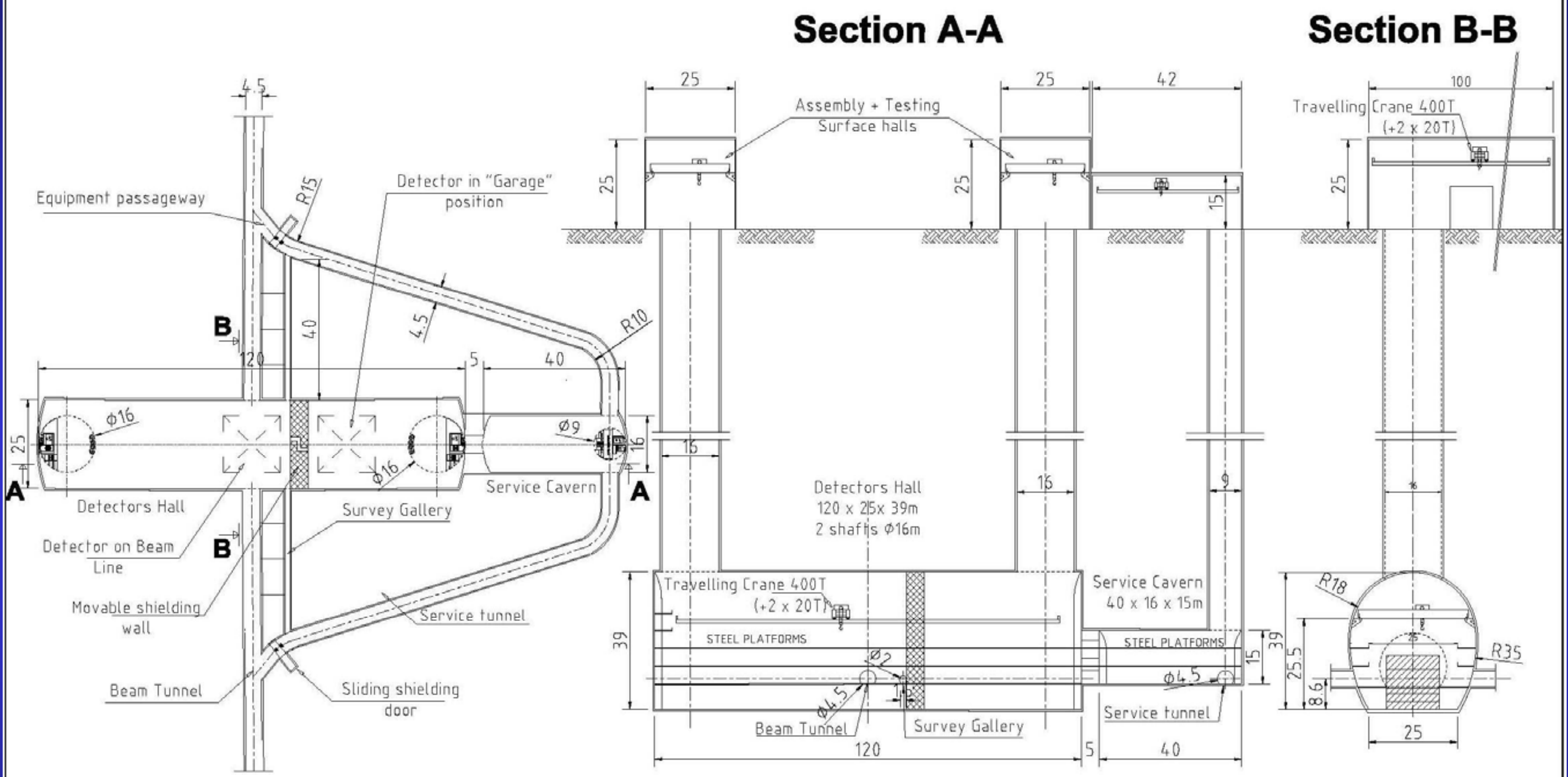


CLIC - UTRB CAVERN

GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISEUR : JL.BALDY
DESIGNER : N.BADDAMS

SCALE : 1/500(A3_FORMAT) DATE : 14_MAY_2007

CLIC-.CE-1.1710.0003 SIZE 3 INDICE -



CLIC- DETECTORS HALL AREA (SURFACE AND UNDERGROUND)

GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISOR : J.L.BALDY
DESIGNER : N.BADDAMS

SCALE : 1/750(A2 FORMAT) DATE : 21 MAY 2007

CLIC.CE-1.1700.0001 | 2 | B

Conclusions

New parameters set established driven by
- Disappointing results of RF tests
- Better (but far from perfect) insight in RF constraints
- Cost model
- Desire for more robust design and chance for feasibility demonstration by 2010

CERN TS study advances civil engineering and infrastructure studies to same level as ILC

Good suggestions to reduce CLIC maximum length from 48 to 42 km (increased gradient, reduced E_{CM} range, smarter collimation scheme, less energy overhead…) are welcome.
This would simplify tunnel construction in Geneva region substantially.