Drive Beam Linac , surface building and equipment

B. Jeanneret, G. McMonagle
August 2010
With material thanks to
E.Jensen, R. Wegner, A. Aksoy, D. Siemaszko & D. Nisbet, J. Osborne, N. Baddams

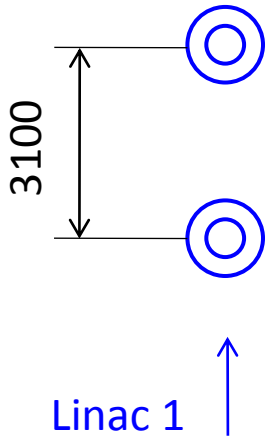
parameters

Beam energy	2.370E+09	eV	E			**DB Linac**	**Ref :**	**Erk ACE Feb10**			
Rep rate	5.000E+01		f			**BJ may 2010**		**Rolf BDyn Aug09**			
Total pulse length	1.403E-04	s	tau			**improved 'April10' version**		**Avni xls 14apr10**			
pulse length	2.450E+02	ns	tau_train								
Beam current	4.210E+00	A	I								
Klystron power	**1.500E+07**	W	Pk			OPTICS					
module yield	9.500E-01		Ym								
loss between klys/cells	9.500E-01		Yt			Quad assembly	6.000E-01	m			
						(Q+BPM+other)					
Acc volt/module	3.216E+06	V	Ym*Yt*Pk/I			Quadrupoles					
accelerating phase phia	1.900E+01	deg				Integrated normalised nom gradient		4.950E-01	kL m^-1	(2.75x0.18)	
cos(phia)	9.455E-01		cphia			Integrated gradient + 10% margin		4.302E+00	GL Tm/m	from Avni	
						length		2.500E-01	L m		
Installation margin	1.050E+00		imargin			Gradient		1.721E+01	G T/m		
nb modules , 1 linac	**819**		imargin*E/Vm/cphia			Radius		5.000E-02	R = 49 mm + 1mm pipe		
nb modules , 2 linac	**1638**					Pole tip field		8.603E-01	T		
RF length	2.500E+00	m				**Total nb Q , 2 linac**		**1638**			
(20cells 0.1m +0.5m couplers+interconnect)								L & G can be varied, GL is constant			
1 Module + 1 Q	**3.100E+00**	m				variant for quad	L=0.2m, G=21.5T/m,Bpole=1.08T				
						CO dipole corrector	L=0.2m, 0.03T				
RF length	2.048E+03	m						**Total plug power**			
Optics	4.914E+02	m									
Total Linac L	**2.539E+03**	m				RF	287.3				
						Solenoid	4.9				
Klys+mod yield	6.000E-01					Quadrupoles	3.8	**296.0**			
Total peak RF power/linac	1.229E+10	W				BEAM POWER					
Average total RF power/linac	8.618E+07	W									
Total plug power/linac	1.436E+08	W				P1 = I*tau*fr*E	6.999E+07	1 Linac			
RF plug power , 2 Linac	**2.873E+08**	W				**P = 2P1**	**1.400E+08**	W			
FODO cell	Q + RF + Q + RF		6.200E+00								
Klystron spacing / linac			3.100E+00								

Cell structure

R. Wegner, E. Jensen, A, Aksoy, D. Schulte

- RF active section : 20 cells × 0.1m = 2m
- Coupler, interconnect : 0.5 m
- Quad, MBCO, BPM : 0.6 m
- TOTAL : 3.1 m
- May need adjustement (Vacuum equip. for pressure p ~ 5 10^{-11} Torr, …)



15 MW klystrons
Acc. V/module 3.2 MV
819 cells / linac
Total length 2540 m

Plug-power for RF (2 linacs):
290 MW
(→ 0.115 MW/m)

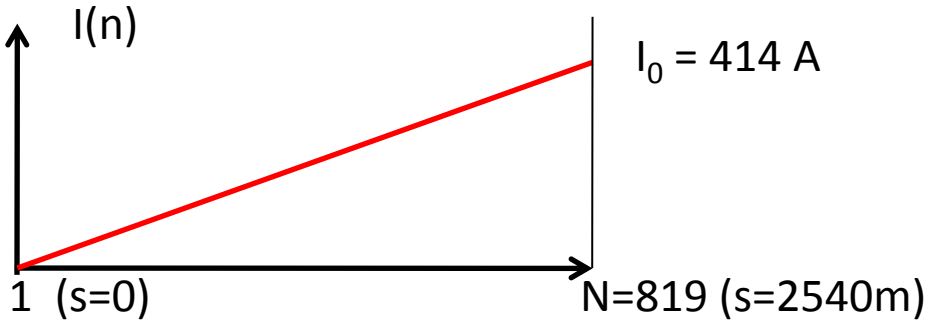
Magnets – quadrupoles

- N=819 Q, spaced by 3.1m for each Linac (total Linac length 2540m)
- R = 3.7 10^{-2} Ω, $I_{max} = I_0 = 414$ A, $p_{max} = 6.3$ kW
- Gradient must follow the beam energy increase

  → $I(n) = nI_0/N$

→ Power scheme similar to DECEL_Q advisable

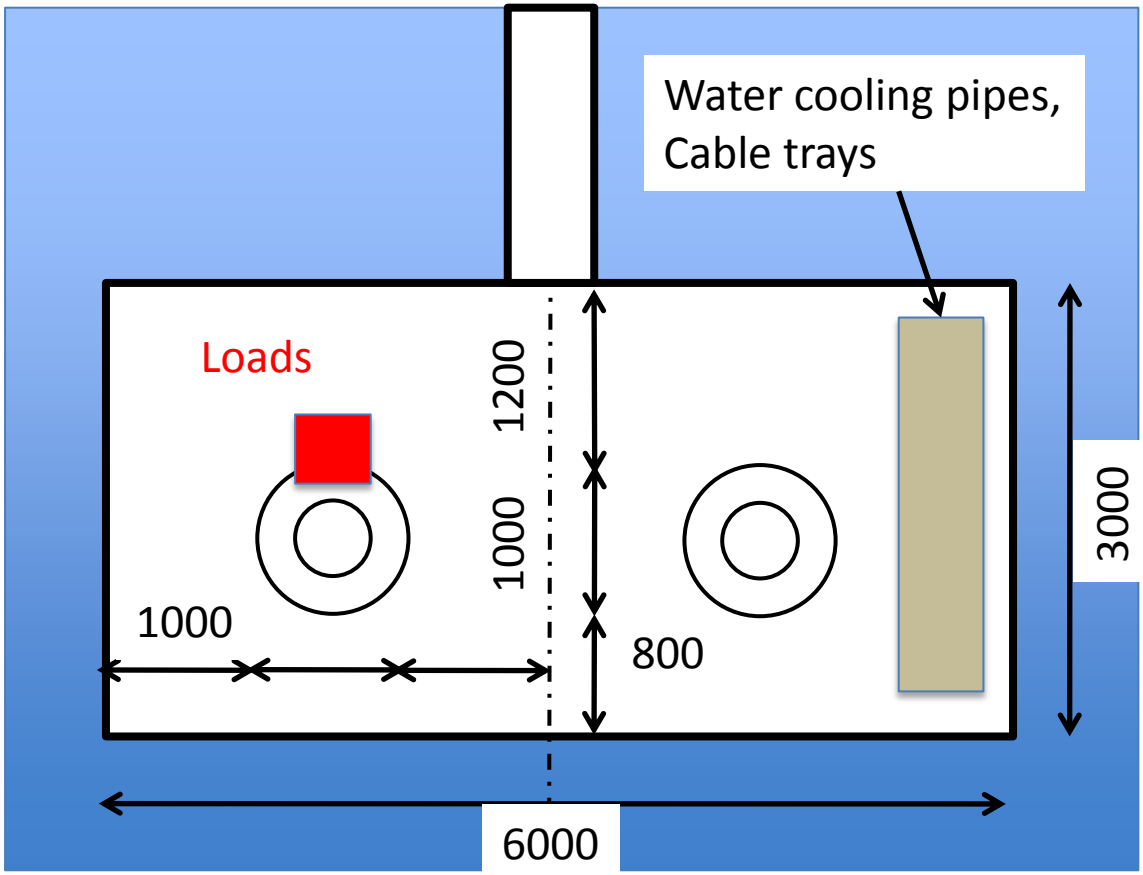
→ Total power : $P = Np_{max}/3 = 4$ MW



Power & Cooling

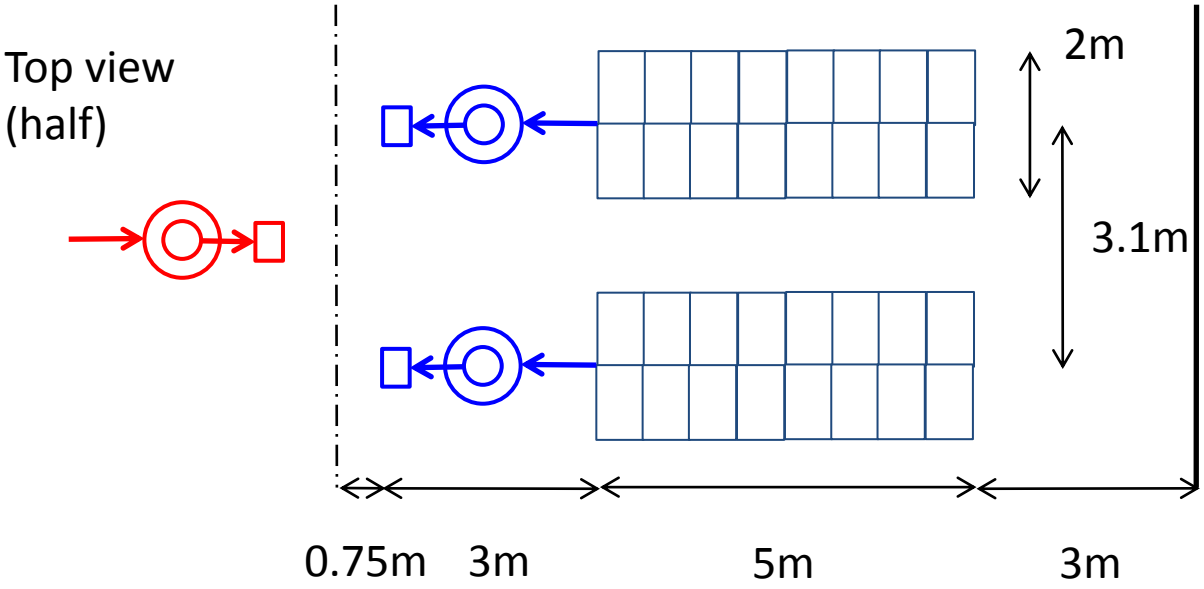
- Total plug power for RF : P_{tot} = 290 MW
  - 140 MW to beam → 150 MW to heat
- Total power for magnets (Quad + Sol): 9 MW to heat
- Total installed power :
  - $P_{installed} = (1+ \varepsilon) \times (290 + 9)$
  - with ε the 18kV conversion yield (see with Daniel/Cesary)
  - Add for light, cranes, safety systems, …
- Total cooling power (tunnel & surf. Blg) :
  - $P_{cool} = (1+ \varepsilon) \times (150 + 9)$

DB Linac, tunnel

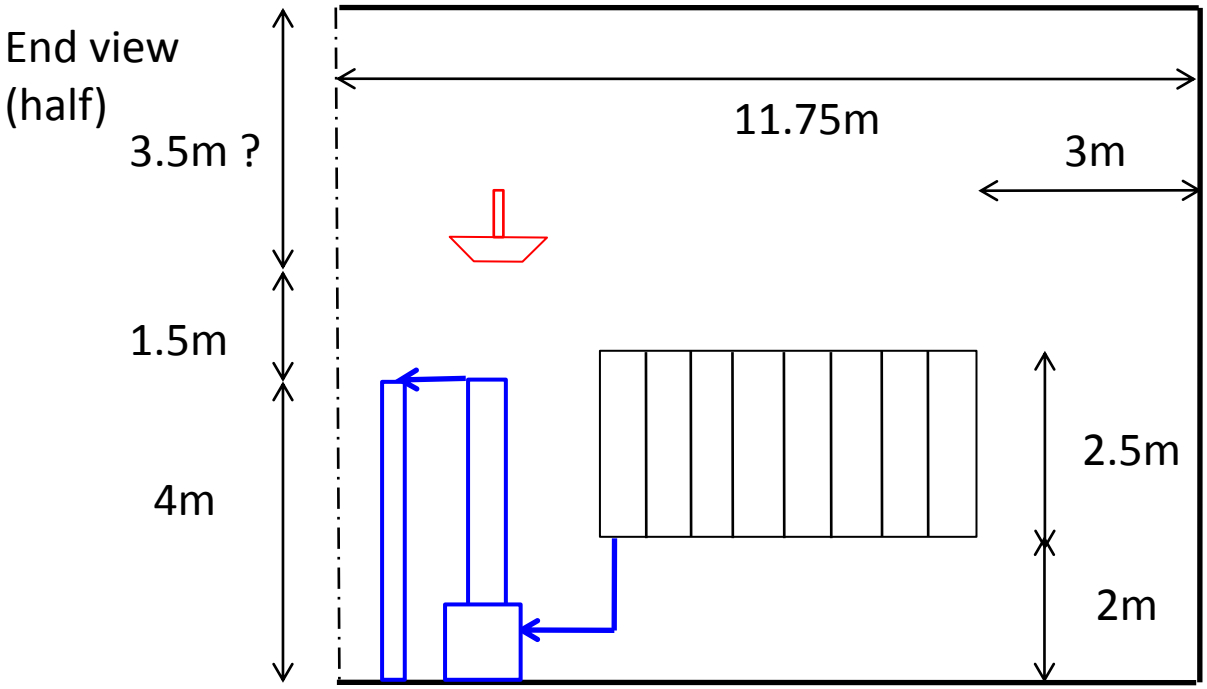


- Total length now : 2540 m
- → conflict with EHN1
- → move towards top of the drawing, see below

DB Linac building

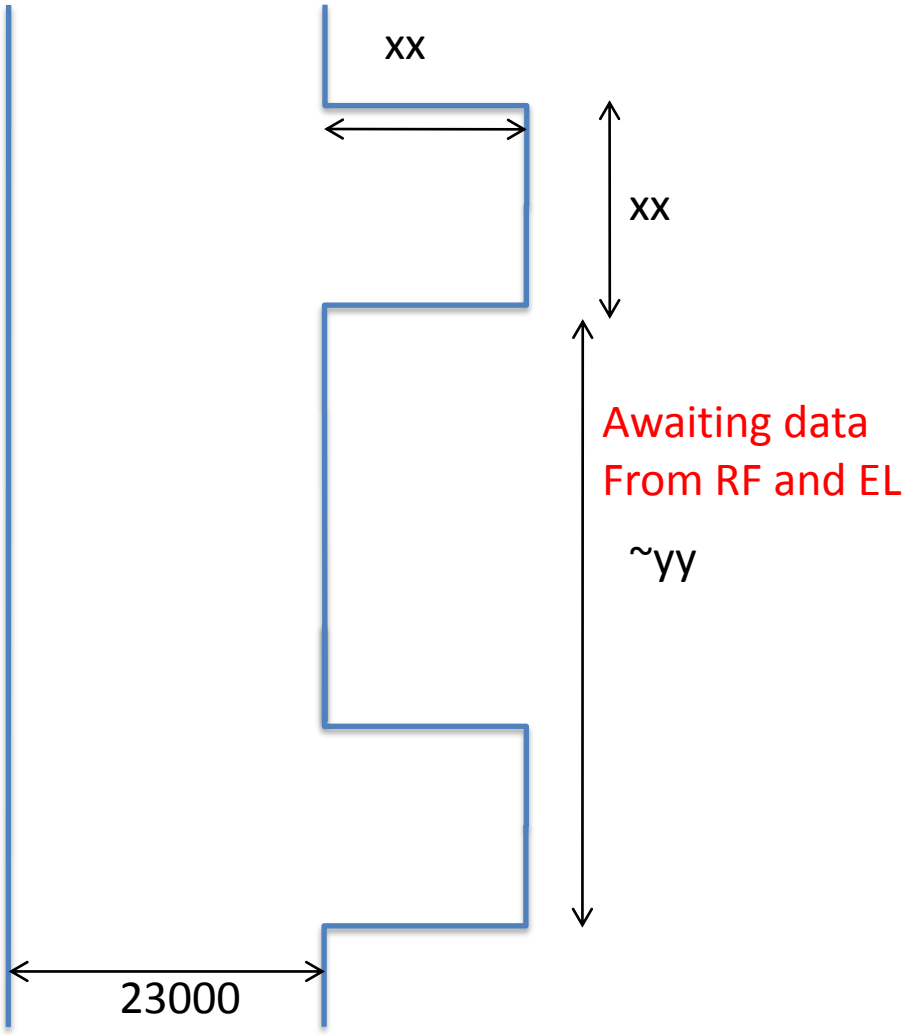


Width: 23.5m
Height: 9m ?
Length : 2540 m



Klystrons are transported along the central path.
A technical area without RF must be foreseen at crane extremities

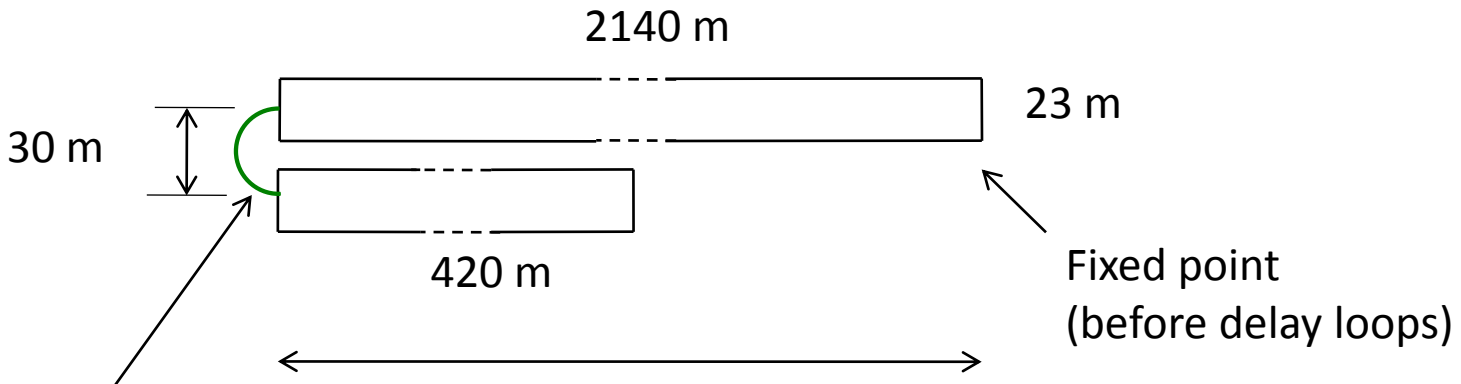
Top View of DB Linac



- A small building is needed for 18kV station ~ every yy = 40 m ?
- Size : xx by xx , xx = ?
- Installed power

  4.6 MW/40m

Top view of DB Linac buildings



Underground,
Same section as in slide 6
(CDR, to be revised for TDR)

Site implementation

DB Linac (undergroud and surface)
- Long segment : 2140 m
- Short segment : 420 m

Loop : underground
- radius : 30 m

Axis separation of the segments :
- 30 m

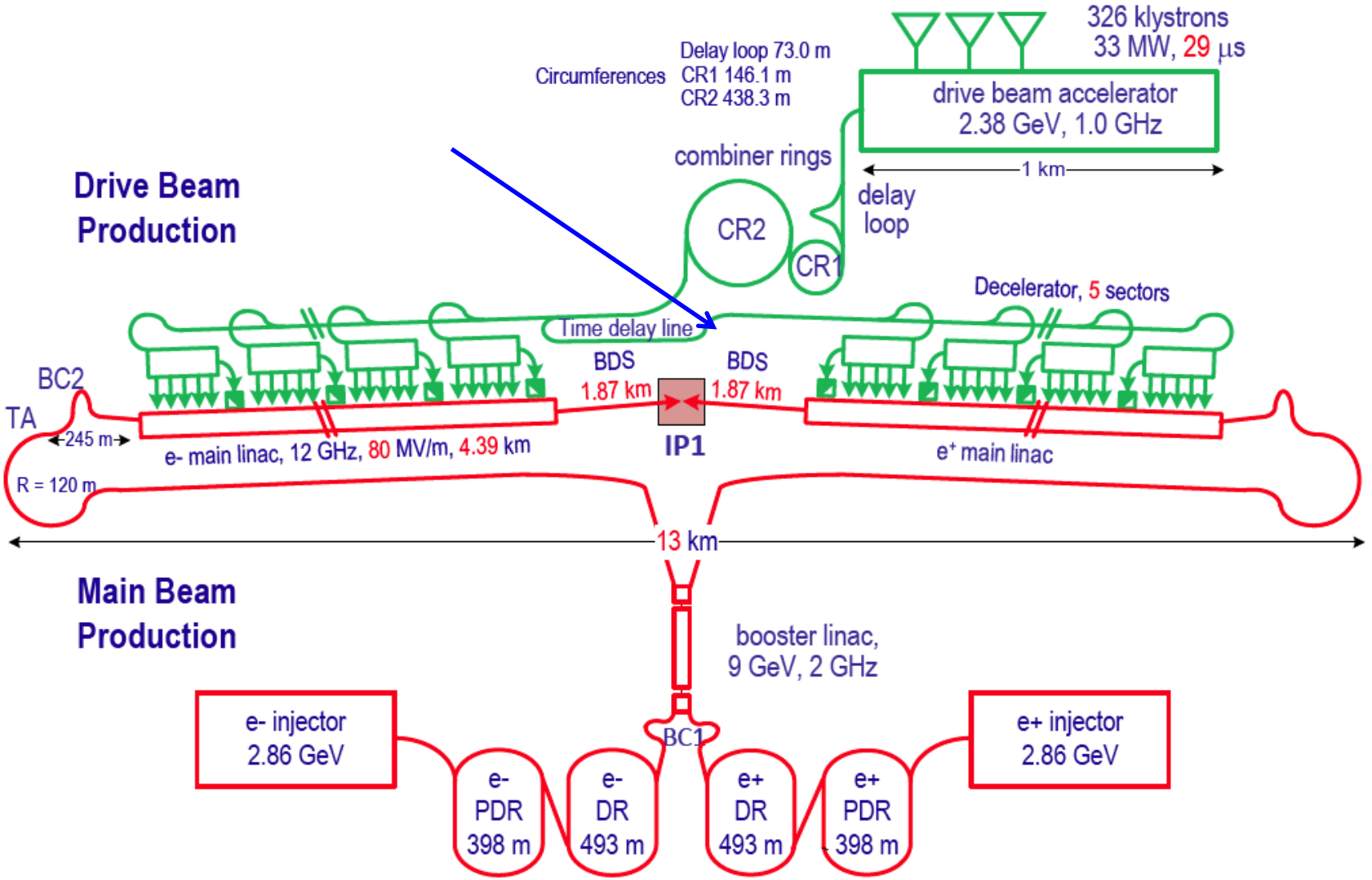
500 GeV delayed transfer for the drive beam

B.Jeanneret , July 2010

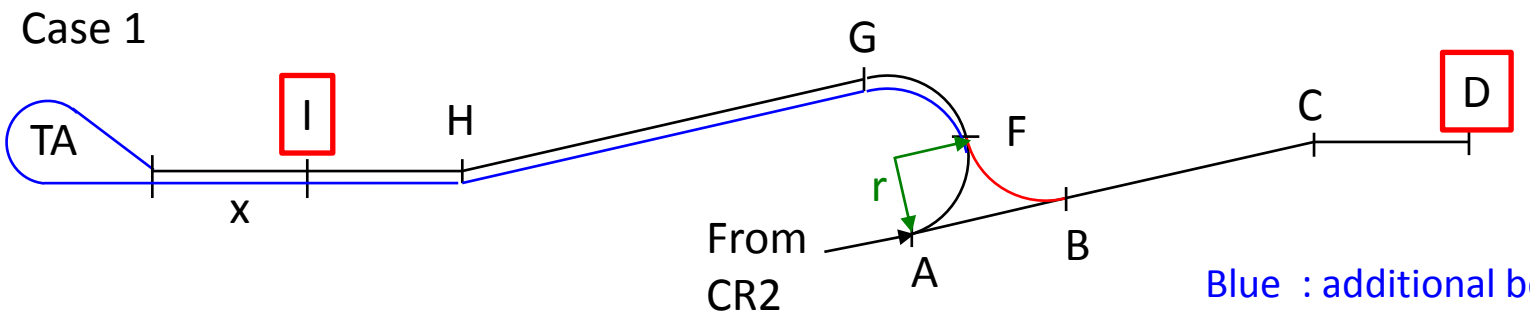
Input data

- Time delay between e+ & e- DB train :
  - The two sets of 5 trains each 240 ns are produced one after the other with a single Linac
  - $\Delta t = 5 \times 24 \times 240$ ns = 28800 ns → Δ = 8640 m
- The trains must be synchronous when passing along the end of the Main Linac

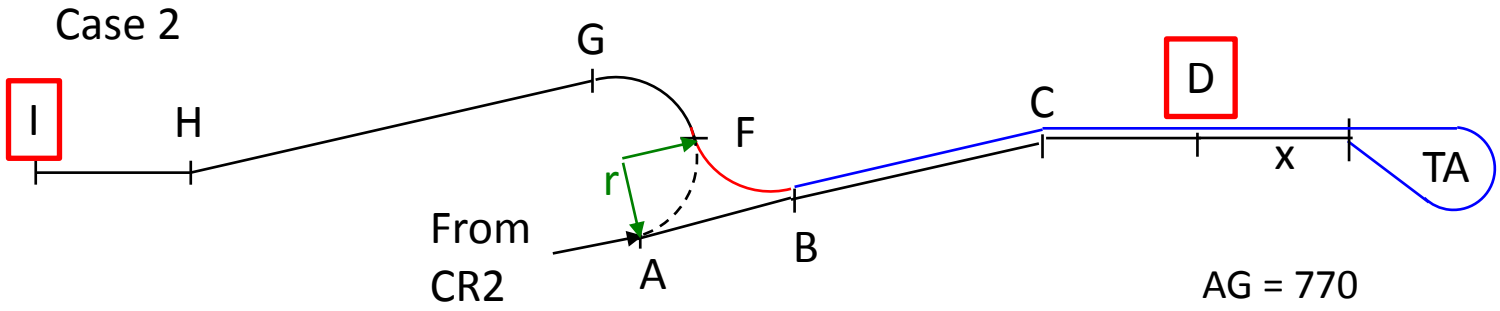
CLIC overall layout – 500 GeV



Coming back to surface



Blue : additional beam line
Red : additional tunnel
D,I : end of ML



- Case 1 :
  - e+ trains come first and go through : AFGHI-TA-IHGFBCD
  - e- trains go through : AFGHI
- Case 2 :
  - e- trains come first and go through : ABCD-TA-DCBFGHI
  - e+ trains go through : ABCD

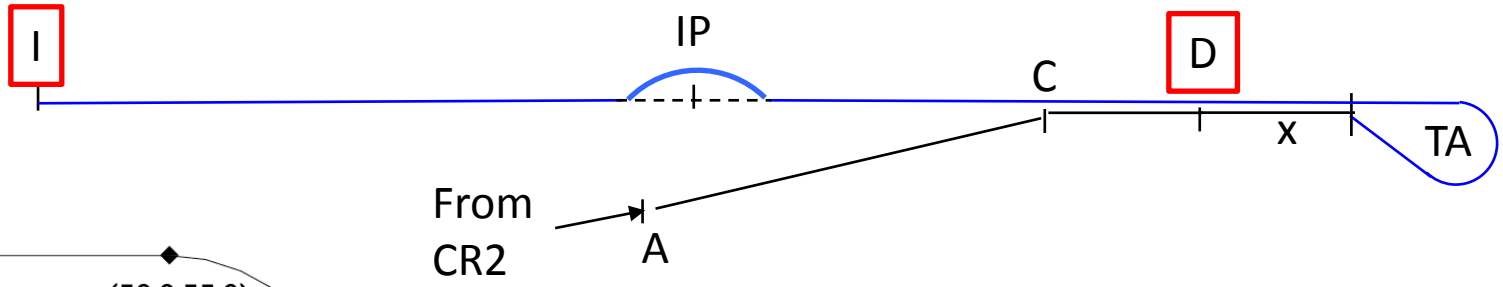
AG = 770
GH = 1449
HI = CD = 25 (500GeV)
AC = 2117
AB = 2r = 524
TA = 146
With y = AG+GH+AC+2*HI
→$x = (\Delta + 2r - y - TA)/2$
$x(case1) = x(case2) = 2316$ m

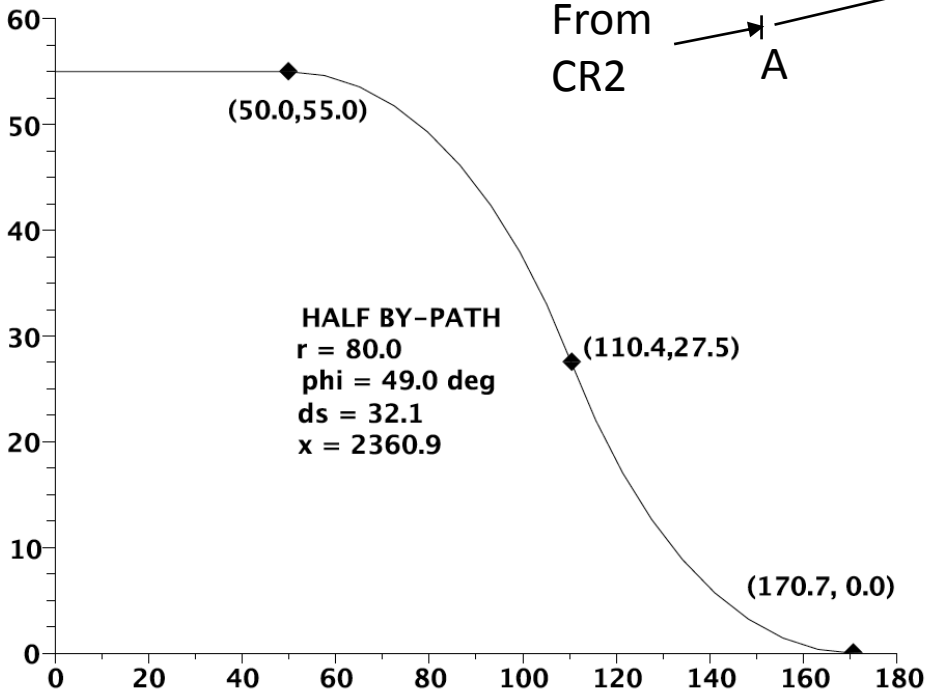
See ~/clic/CDR/500gev/bypath.sce

Impact for hardware / through surface

- Case 2 simpler
- $x / L_{sector} = 2316/877 = 2.64$ sectors
  - one extra DB line to be housed in the main tunnel
- Civ. Eng. :
  - one-quarter circle of surface tunnel to be added
  - Line e^+ down to tunnel :
    - wide enough to accomodate a 3rd beam line.
    - 1 additionnal turn-around , of type 'DB'
- Additional beam lines:
  - 3909 m (AC-2r+x) of type 'DB-LTL'
  - 1 dedicated turn-around , of type 'DB'

Use a by-path around IP





- D,I : end of ML (500 GeV)
- e^+ in D & e^- in I : synchronous
- Δ_{db} = 8640
- ID = 2×1870 , TA = 146
- δ_{bp} = 14
- $x = (\Delta_{db} - \delta_{bp} - ID - TA)/2 = 2361$ m
- $x / L_{sector} = 2361/877 = 2.70$ sectors

see :/Users/Bernard/clic/CDR/500gev/bypath_ugnd.sce

Impact for hardware / underground by-path

- $x / L_{sector} = 2361/877 = 2.7$ sectors
  - one extra DB line to be housed in the main tunnel
- Civ. Eng. :
  - 374 m of tunnel to be added for by-path
  - 1 additionnal turn-around , of type ‘DB’
- Additional beam lines:
  - 3740 m (DI) of type ‘DB-LTL’
  - 1 dedicated turn-around , of type ‘DB’
- Beam lines not needed :
  - Surface loop & descent down (2460 m)
- Advantage : disconnected from surface changes for Main Beam