CONSIDERATIONS ON A KLYSTRON MODULE LAYOUT

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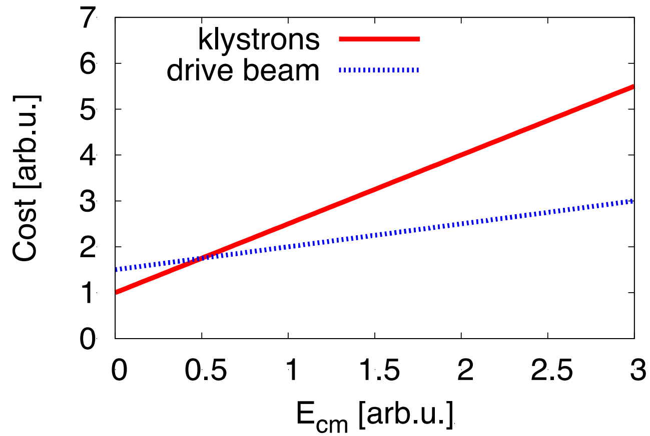
Considerations on a Klystron-based Option at 380 GeV

With the increase of the klystron and modulator efficiencies, the interest for the option is growing



Two tunnels or one large tunnel (with shielded separation between the modulator area and the beam) ?

- **Solutions exist to keep attenuation low in long waveguides**
- **Access to modulators is required during operation**

In principle, k-modules do not need to be moved if CLIC is upgraded, however different BDS length for the 380 GeV and the 3 TeV options.

380 GeV Module Sequence - Klystron Option

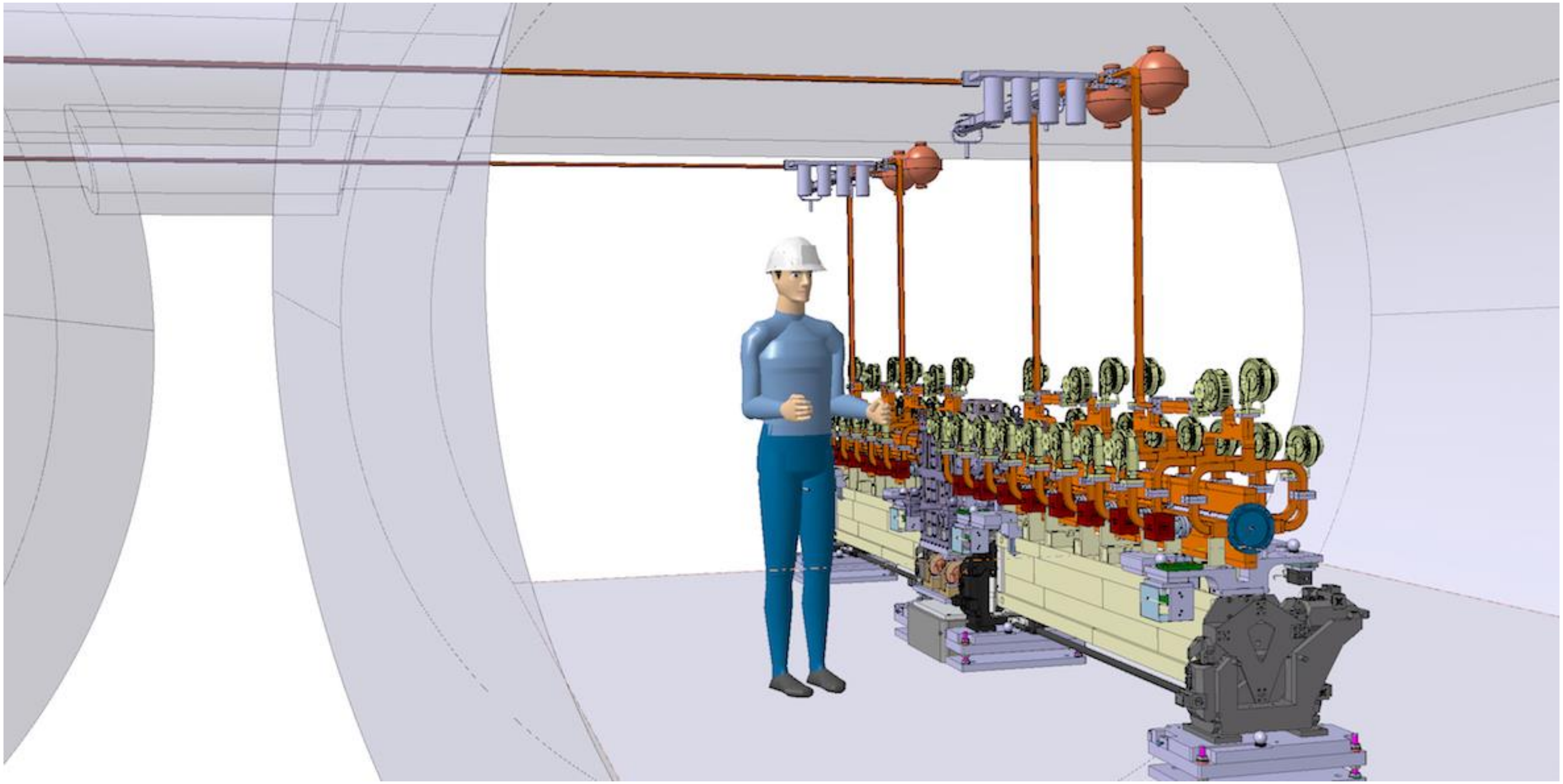
Sectors of the MB FODO lattice for one Linac

FODO Sector	T0	Q1	Q2	Totals	AS with 28 cells
1	148	148			sequence: 148 x T0Q1
2	276	138			sequence: 138 x T0T0Q1
3	228	76			sequence: 76 x T0T0T0Q1
4	300		100		sequence: 100 x T0T0T0Q2
5	504		126		sequence: 126 x T0T0T0T0Q2
Totals	1456	362	226		
Quads	0	362	226	588	362 x 0.4 + 226 x 0.65
AS	11648			11648	

T0 Module is made of 8 x AS

One Linac length = 3334 m

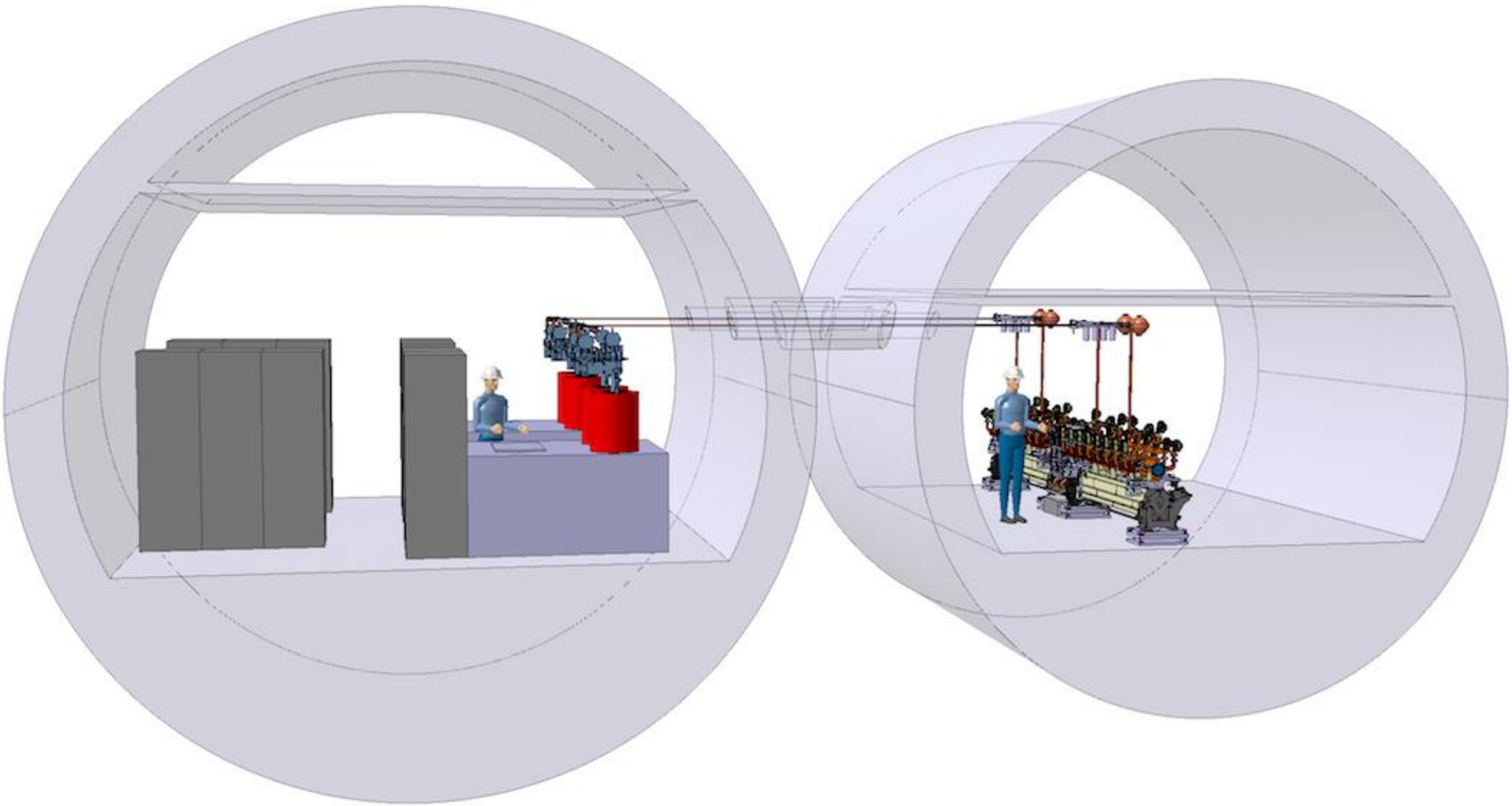
380 GeV Klystron Tunnel View



The module layout is still at a draft stage

3D Integration and Design Y. Cuvet

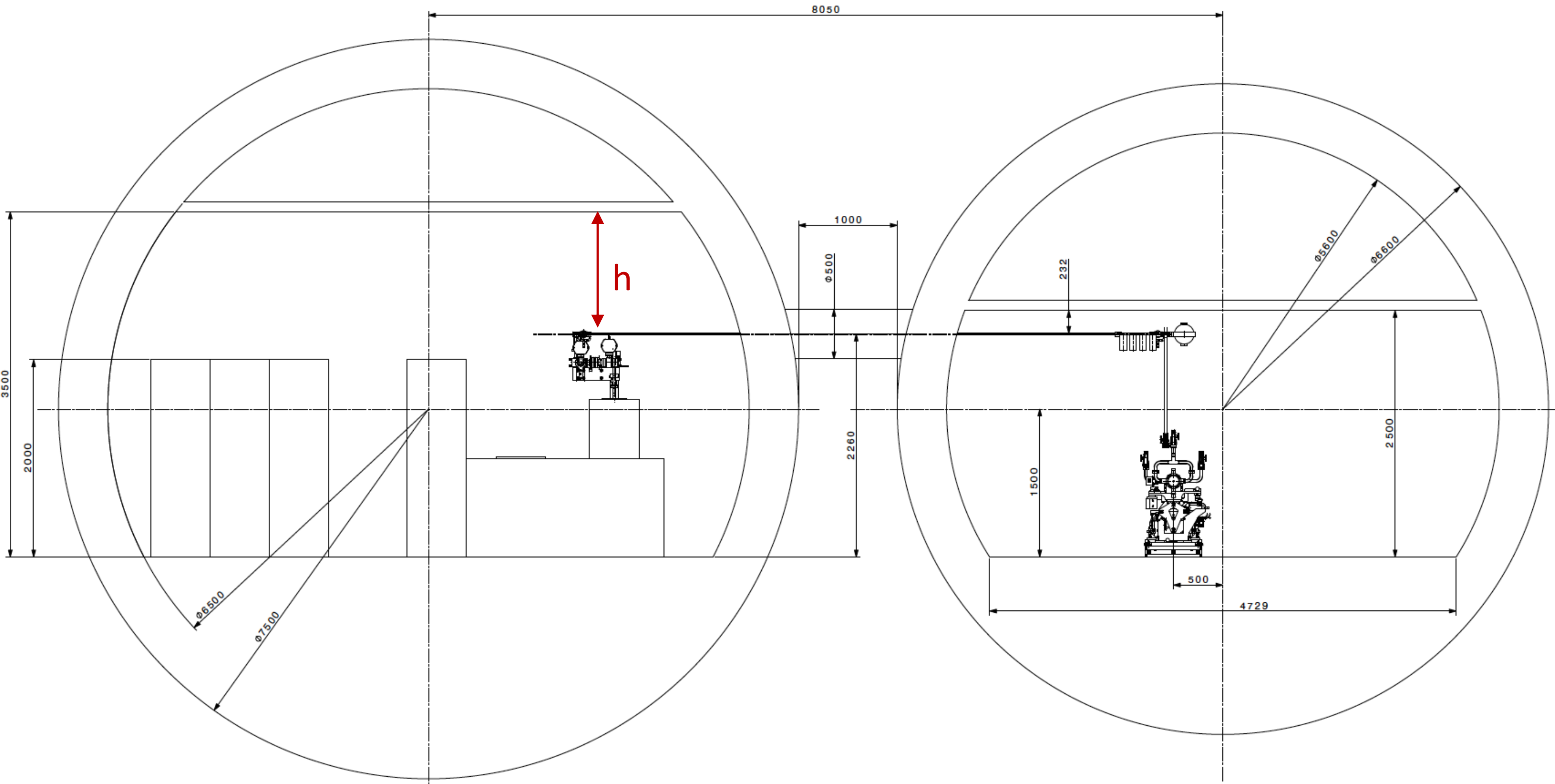
380 GeV Klystron Tunnel View



The modulator layout comes from the revisiting of a Scandinova draft proposal.

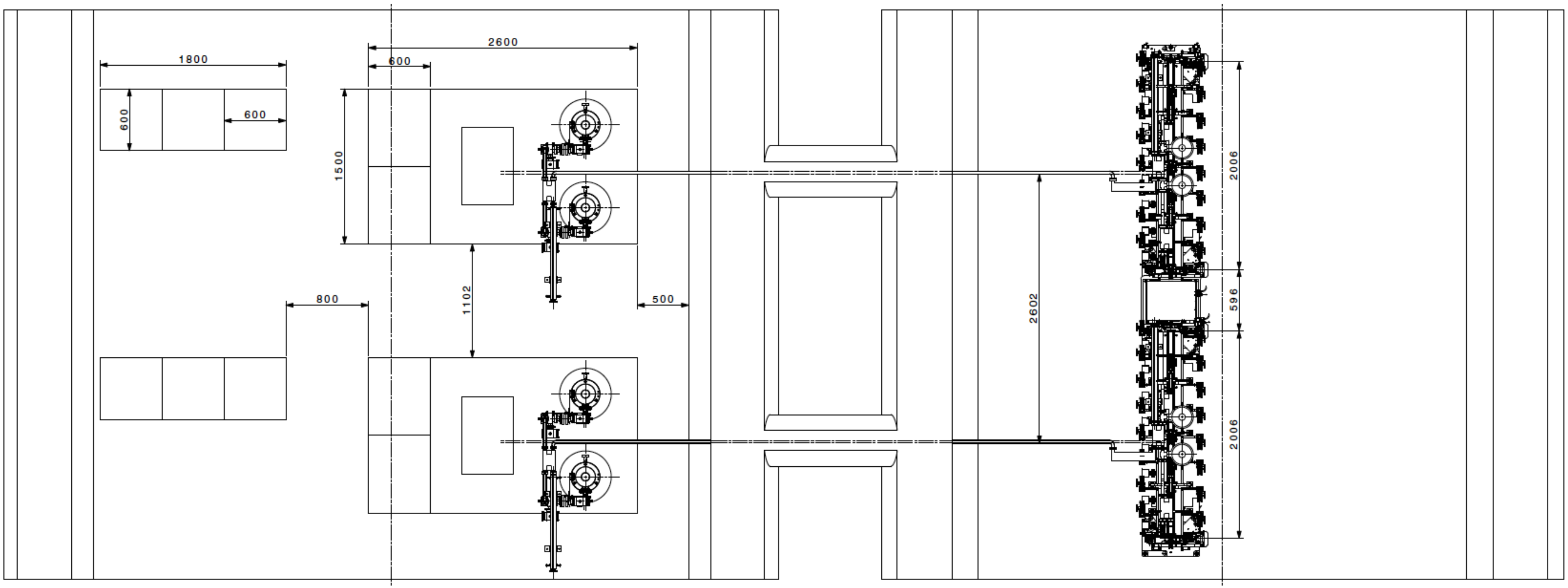
The distance between tunnels remains to be defined and the number of interconnections as well.

380 GeV Klystron Tunnel Cross-sections

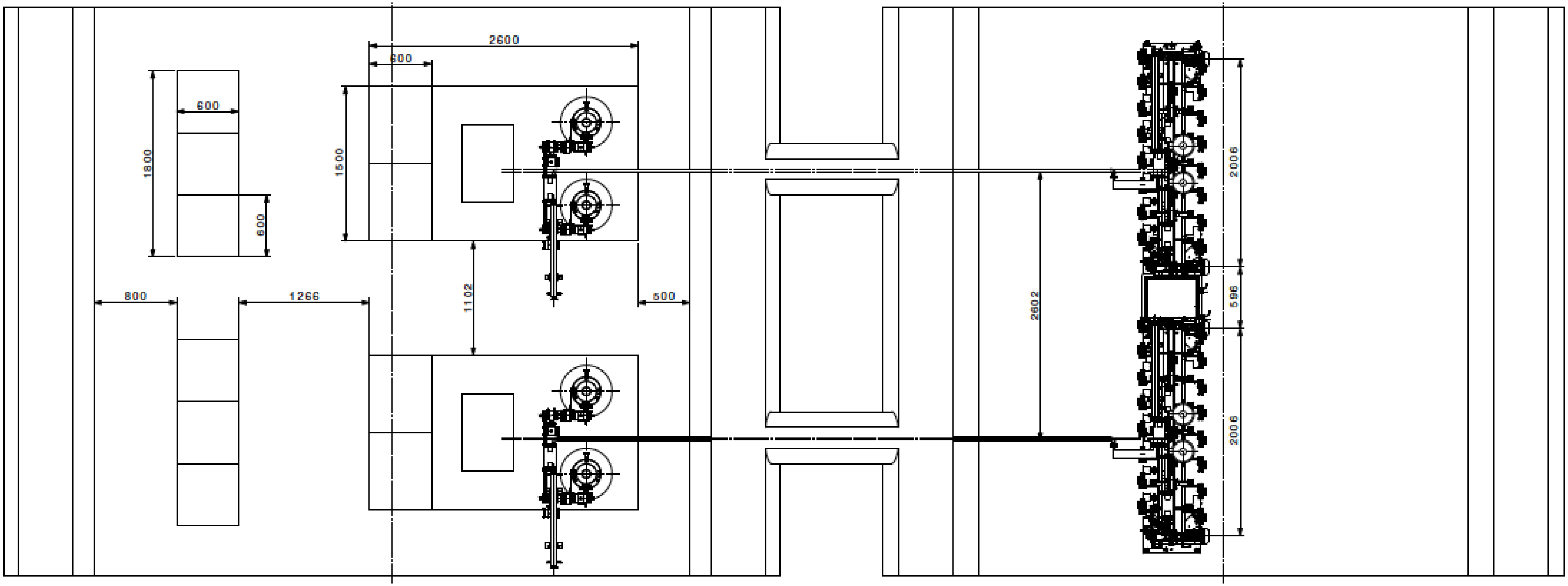


Klystron replacement needs space under the ceiling and a crane

380 GeV Klystron Tunnel Plan View



380 GeV Klystron Tunnel Plan View



380 GeV choice of RF Strcuture

Optimization of RF structure design – D. Schulte 21/01

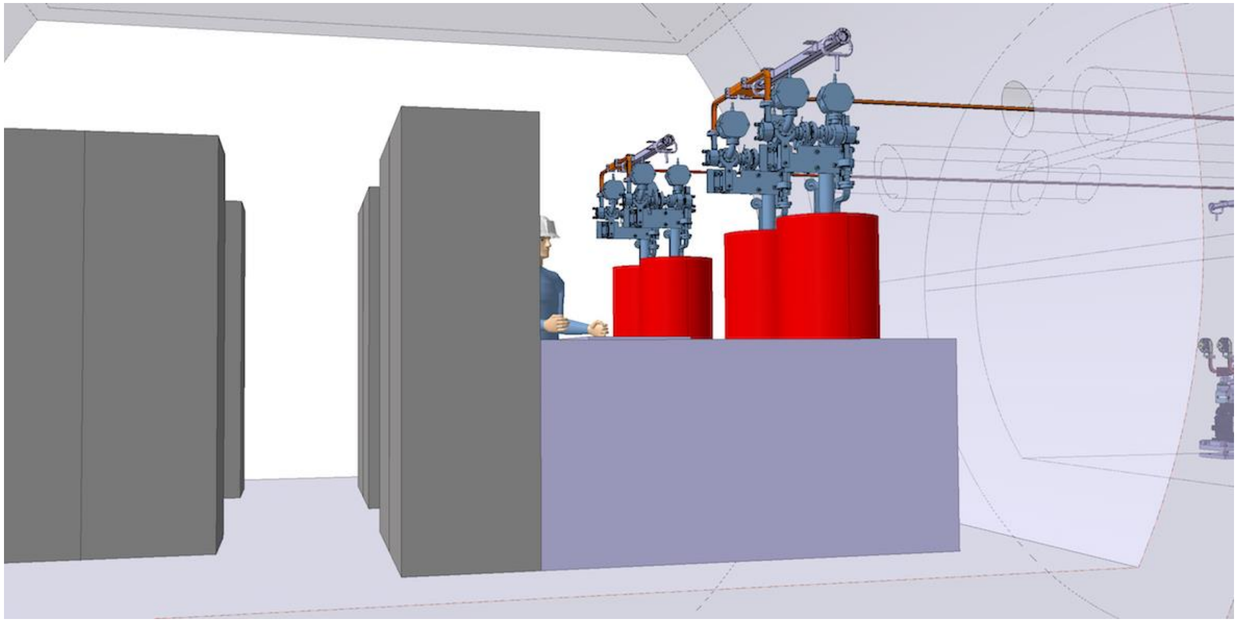
Parameter	Symbol	Unit	DB	K	DB244	K244
Frequency	f	GHz	12	12	12	12
Acceleration gradient	G	MV/m	72.5	75	72	79
RF phase advance per cell	$\Delta\phi$	°	120	120	120	120
Number of cells	N_c		36	28	33	26
First iris radius / RF wavelength	a_1/λ		0.1525	0.145	0.1625	0.15
Last iris radius / RF wavelength	a_2/λ		0.0875	0.09	0.104	0.1044
First iris thickness / cell length	d_1/L_c		0.297	0.25	0.303	0.28
Last iris thickness / cell length	d_2/L_c		0.11	0.134	0.172	0.17
Number of particles per bunch	N	10^9	3.98	3.87	5.2	4.88
Number of bunches per train	n_b		454	485	352	366
Pulse length	τ_{RF}	ns	321	325	244	244
Peak input power into the structure	P_{in}	MW	50.9	42.5	59.5	54.3
Cost difference (w. drive beam)	$\Delta C_{w.\ DB}$	MCHF	-50	(20)	0	(20)
Cost difference (w. klystrons)	$\Delta C_{w.\ K}$	MCHF	(120)	50	(330)	240

RF Power Dissipation

Structure	CLIC-G	CLIC-G*	CLIC380	Klystron (K)
f_{rep} [Hz]	50	50	50	50
Efficiency: η [%]	27.7	28.5	39.8	38.7
Rise time: tr [ns]	22.4	22	13.1	20.3
Filling time: tf [ns]	62.9	65.5	55.4	62.7
Efficient beam loading time: tb [ns]	155.5	155.5	175.5	242
Pulse length: tp [ns]	240.8	243	244	325
P_{in} [MW]	63.8	62.3	59.7	41.7
$P_{out}^{unloaded}$ [MW]	29.7	26.5	27.6	17.9
P_{out}^{loaded} [MW]	11.9	9.76	6.2	4.5
P_{beam} [MW]	27.367	27.747	33.035	21.673
Thermal dissipation [W]: $\langle P_{dissipated}^{unloaded} \rangle$, $\langle P_{dissipated}^{loaded} \rangle$	410.564, 336.181	434.970, 349.394	391.620, 289.526	386.750, 286.649
Mean power in the load [W]: $\langle P_{load}^{unloaded} \rangle$, $\langle P_{load}^{loaded} \rangle$	357.588, 219.193	321.975, 191.822	336.720, 148.935	290.875, 128.735
Mean power to the beam: $\langle P_{beam} \rangle$ [W]	212.778	215.729	289.879	262.241

X. X. Huang 5/04/17

380 GeV Klystron option – Power Dissipations in Main Tunnel



The following power levels and efficiencies have been considered for the evaluation of the power dissipation:

AS input	**42.5 MW with 325 10^{-9} s @ 50 Hz**
Klystron output	**57 MW peak with 1.625 10^{-6} s @ 50 Hz**
Efficiencies	**modulator 95%, klystron 70%, RF network (including the pulse compression) 60%**

380 GeV – Power Dissipations in the Main Tunnel

Component	unit	3 TeV DB	380 GeV DB	380 GeV K
Alignment	W/m	1.9	1.8	0.8
BPM	W/m	13.9	13.0	2.3
Vacuum	W/m	51.1	43.9	31.7
Magnets (air)	W/m	46.1	45.7	17.5
Magnets (water)	MW	16.8	2.7	1.4
MBQ stabilization	W/m	8.7	14.3	15.7
RF System$_{unloaded}$ (air)	W/m	195	167	255
RF System$_{unloaded}$ (water)	MW	107	15	25
RF System$_{loaded}$ (air)	W/m	137	98	181
RF System$_{loaded}$ (water)	MW	79	9	19

To be checked

M. Aicheler

380 GeV – Power Dissipations in the Main Tunnel

Totals	unit	3 TeV DB	380 GeV DB	380 GeV K
Unloaded case (air)	W/m	307	1.8	0.8
Unloaded case (water)	MW	124	13.0	2.3
Loaded case (air)	W/m	249	42.3	17.5
Loaded case (water)	MW	96	1.1	0.7
Klystron (air)	W/m	-	-	87
Klystron (water)	MW	-	-	11

Estimates assume 95% power dissipated in water and 5% in air.

M. Aicheler

380 GeV – Concluding remarks

A refinement of the information concerning klystron efficiency and modulator topology can produce relevant changes in this preliminary proposal.

The Klystron 3D layout can rapidly progress, as soon as feedback on the draft proposal becomes available.

We will work to refine the RF design and the layout in parallel.

At this moment what looks as a useful input to the CEIS WG is:

- Deliver a realistic layout of the klystron-based machine
- Identify the operational conditions (and transitions)
- Evaluate the interfacing to the infrastructure and services
  - Power consumption
  - Power dissipation and heat load on air and water
  - Needs for specific ancillary systems (BOC temp control, for ex.)