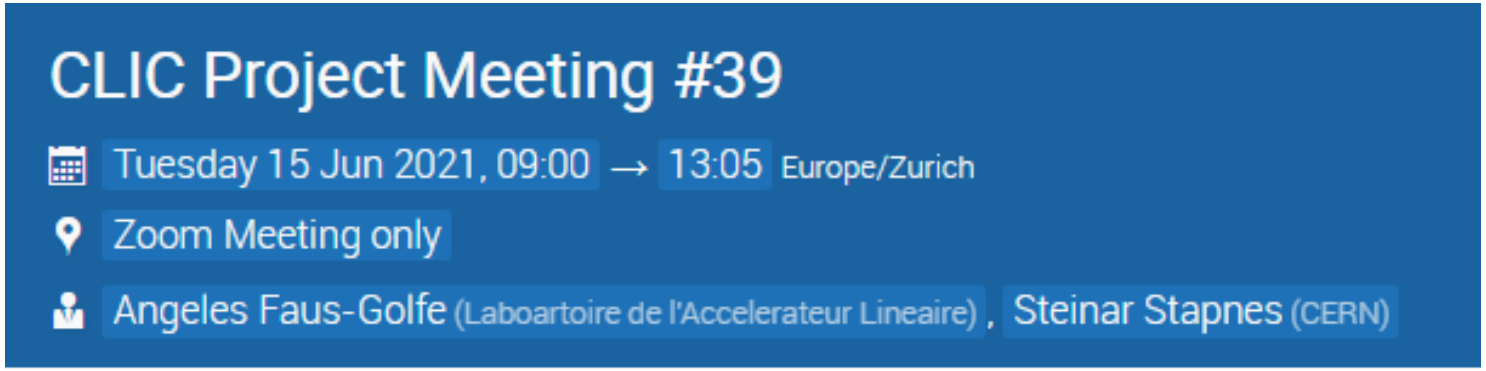
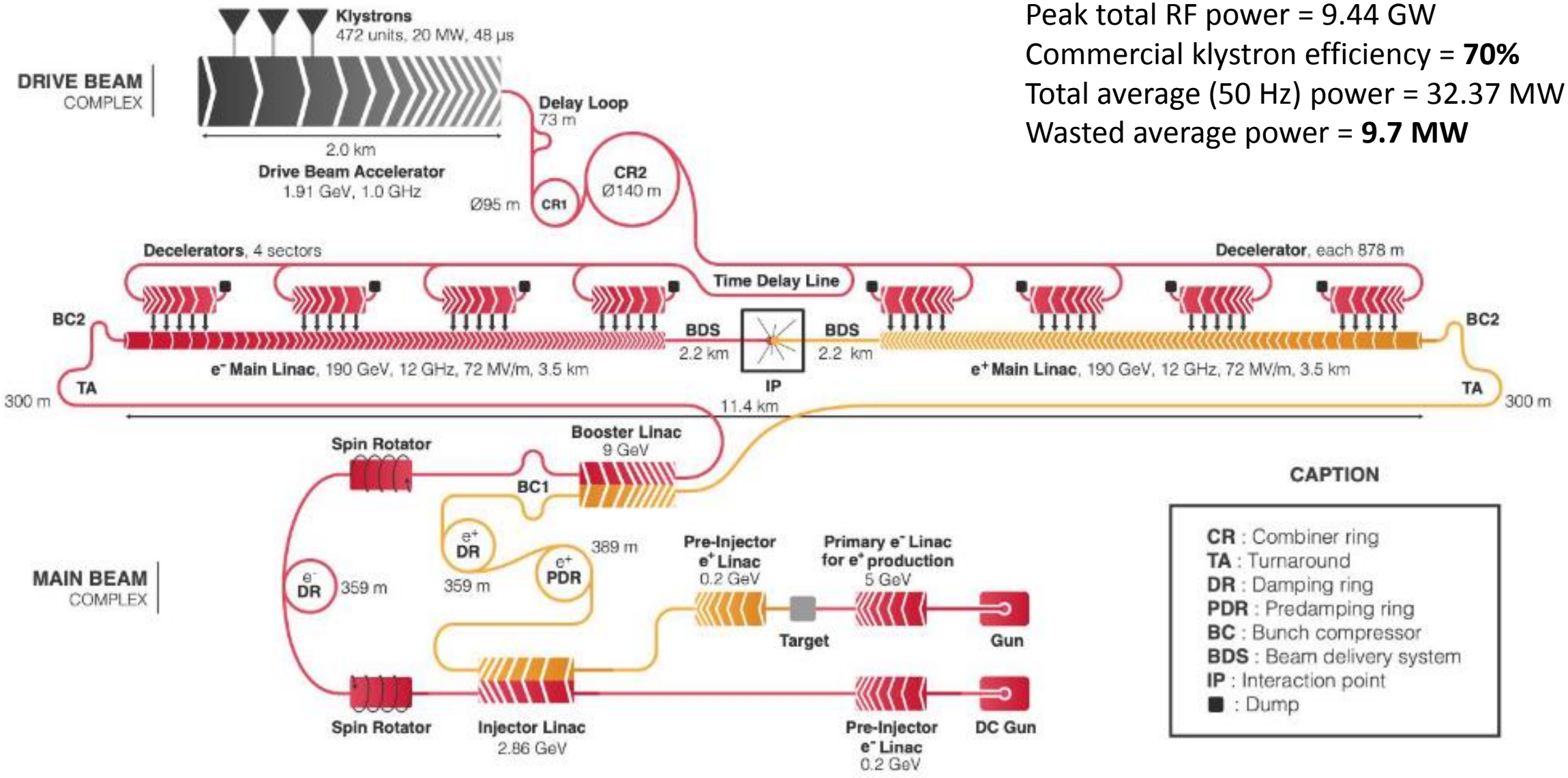


DBA RF power source efficiency considerations for CLIC.

I. Syratchev

CLIC 380 GeV

DB Accelerator RF power source:
DBA # klystrons = 472
RF power/ klystron = 20MW
Peak total RF power = 9.44 GW
Commercial klystron efficiency = **70%**
Total average (50 Hz) power = 32.37 MW
Wasted average power = **9.7 MW**



CAPTION

CR : Combiner ring
TA : Turnaround
DR : Damping ring
PDR : Predamping ring
BC : Bunch compressor
BDS : Beam delivery system
IP : Interaction point
■ : Dump

Two-Stage Multi Beam Klystron (TS MBK) technology.

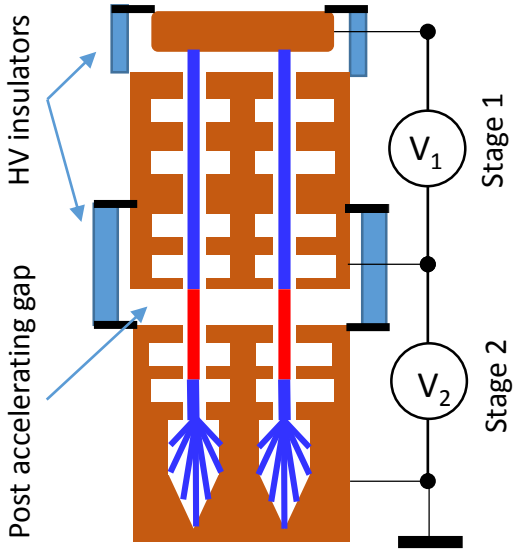
Specific features

1. Bunching at a low voltage (high perveance). Very **compact RF bunching circuit.**
2. Bunched beam acceleration and cooling (reducing $\Delta p/p$) along the short DC voltage post-accelerating gap.
3. Final power extraction from high voltage (low perveance) beam. **High efficiency.**

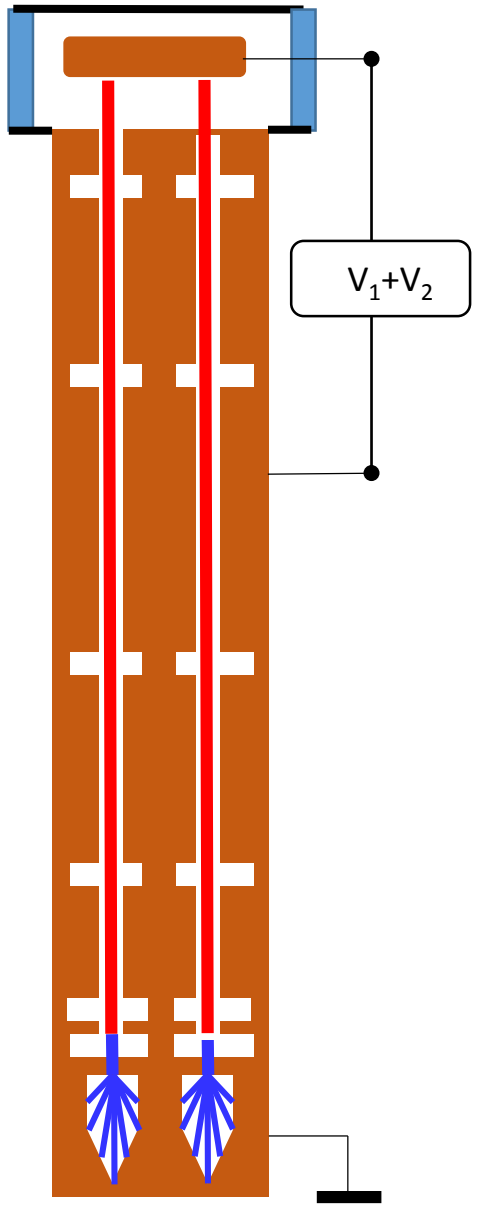
Additional advantages:

1. The second HV stage can be operated in DC mode. Thus simplifying the modulator topology (cost/volume) and increasing the modulator efficiency (in pulsed mode).
2. Simplified feedback for the first stage pulsed voltage. Improved klystron RF phase and amplitude stability.
3. Gap's accelerating DC voltage is a natural barrier for reflected electrons. Improved tube stability.

TS HE MBK
Efficiency 85%



Commercial HE MBK
Efficiency 70%



High Efficiency 24 MW, 1 GHz, CLIC TS MBK performance summary (PIC CTS/3D)

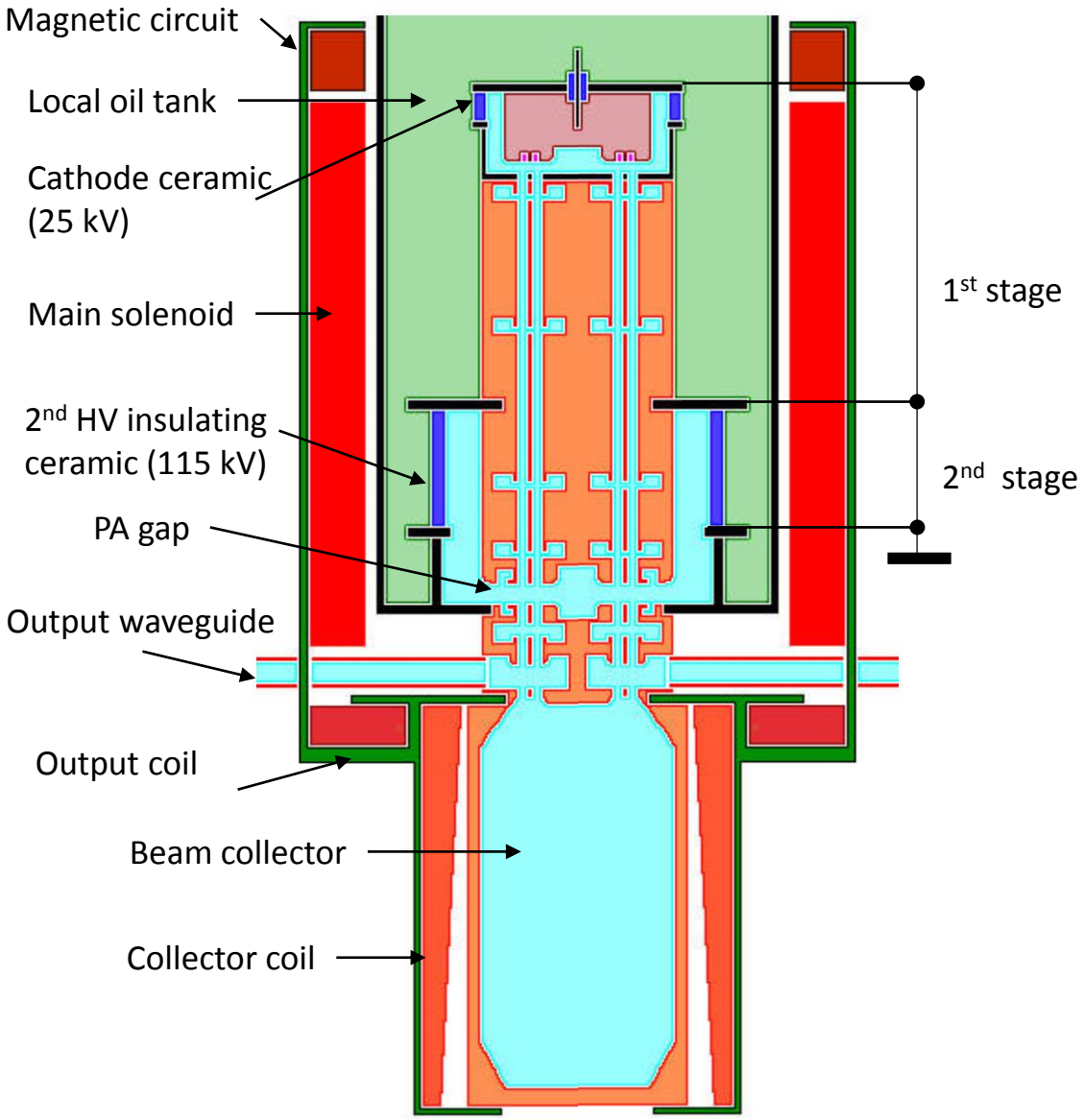
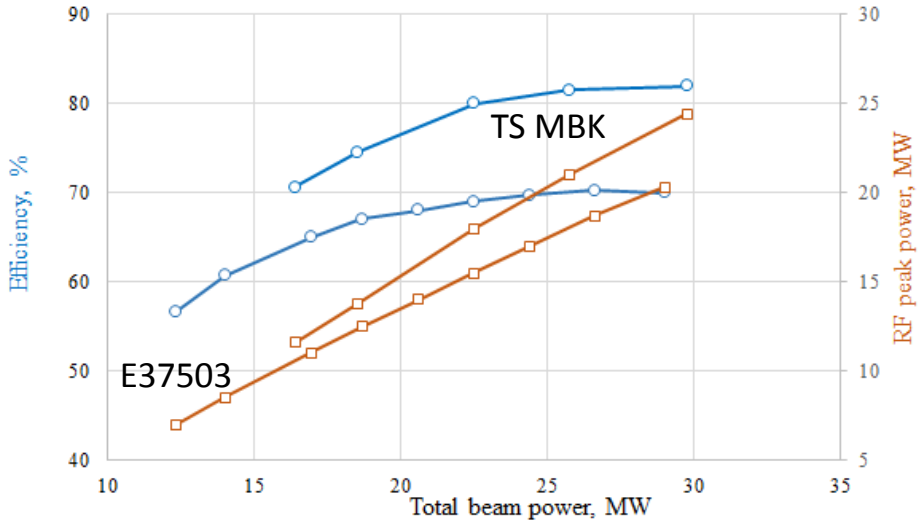


TABLE I. DESIGN AND SIMULATED PARAMETERS (CST/3D) OF THE CLIC TS MBK AND CANON MBK E3750 CATALOGUE DATA

Parameter	TS MBK	E37503	Unit
Operating frequency	1000	1000	MHz
Voltage at the 1st stage	25	160	kV
Voltage at the 2nd stage	140		
Total beam current	212	180	A
Number of beamlets	30	6	
Number of cavities	6	6	
Perveance at the 1st stage	1.77	0.47	$\mu A/V^{3/2}$
Perveance at the 2nd stage	0.133		
Output RF power	24.1	20	MW
Saturated power gain	52	54	dB
Saturated efficiency	82	70	%
Length of RF circuit	900	1500	mm



RF power source

Commercial CLIC MBK

DBA # klystrons = **472**
RF power/ klystron = 20MW
Peak total RF power = 9.44 GW
Klystron efficiency = **70%**
Total average (50 Hz) power = 32.37 MW
Wasted average power = **9.7 MW**

Novel TS CLIC MBK

DBA # klystrons = 394: Direct saving on the cost of **78 tubes**
RF power/ klystron = 24MW
Peak total RF power = 9.44 GW
Klystron efficiency = **85%**
Total average (50 Hz) power = 26.65 MW: **5.72 MW** reduction
Wasted average power =4 MW: **60%** saving on water cooling

Modulator

Current = 180A
Voltage = 160 kV
Flat top efficiency = 96%
Temporal efficiency
(3 μsec rise/fall time) = 94%
Total efficiency = 90%

Total Grid power: 37 MW

Current = 215A
Total voltage = 140 kV
Flat top efficiency (DC 2nd stage 115kV) = 100%
Temporal efficiency (1st stage pulsed at 25kV,
0.5 μsec rise/fall time) = 97%
Total efficiency = **97%**

Total Grid power: 27.2 MW; 9.8 MW (26.5%) on Electricity cost

DB Accelerator

Each accelerating structure will be longer by 10%, but overall number of structures will be reduced by 20%. Thus investment cost of the accelerator will be reduced be about 15%. Another savings will come from the overall reduction of the accelerator tunnel length by about 10% (1.8km instead of 2 km).

Finally, with implementation of the novel TS klystron technology, the power savings in the CLIC BDA complex will be about 26.5% and the investment cost reduction will be at a level of 15%.