PRELIMINARY STUDIES OF A COMPACT VHEE LINEAR ACCELERATOR SYSTEM FOR FLASH RADIOTHERAPY

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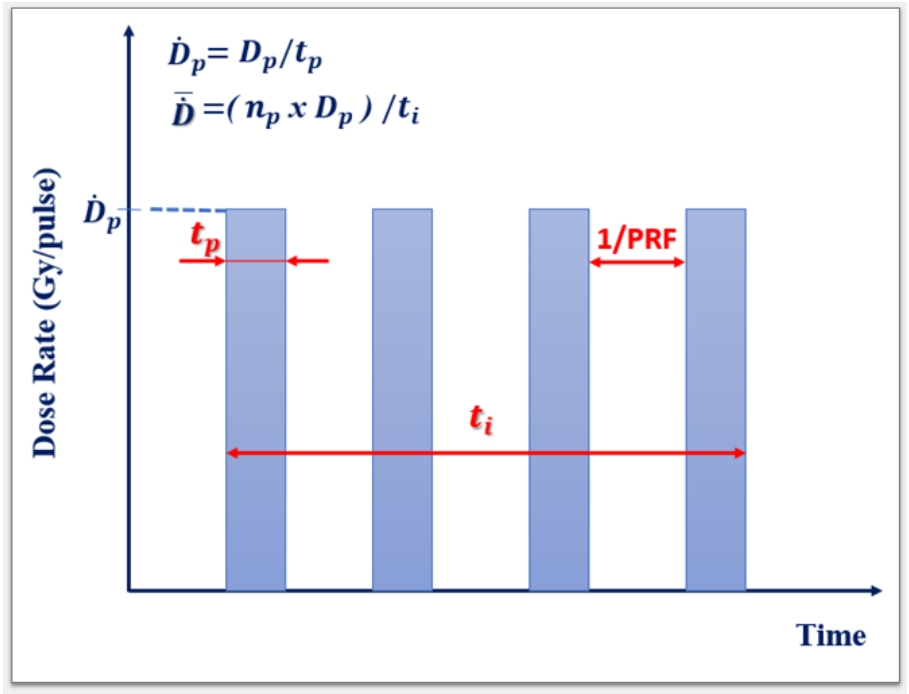
FLASH PARAMETERS

- The FLASH Radiotherapy is a new technique in the cancer cure: it spares healthy tissue from the damage of the ionizing radiation maintaining the efficient of the cancer cure.
- In order to translate the FLASH effect in clinical use and to treat deep tumors, Very High Electron Energy (VHEE) irradiations could represent a valid technique.



Symbol	Description	Value
PRF	Pulse repetition frequency	> 100 Hz
t_p	Pulse width	< 0.1-4.0 μs
t_i	Total irradiation time	< 100 ms
$\bar{\dot{D}}$	Time-averaged dose rate	> 100 Gy/s
$\dot{D}_p$	Dose-rate in a single pulse	> 10^6 Gy/s
D_p	Dose in a single pulse	> 1 Gy

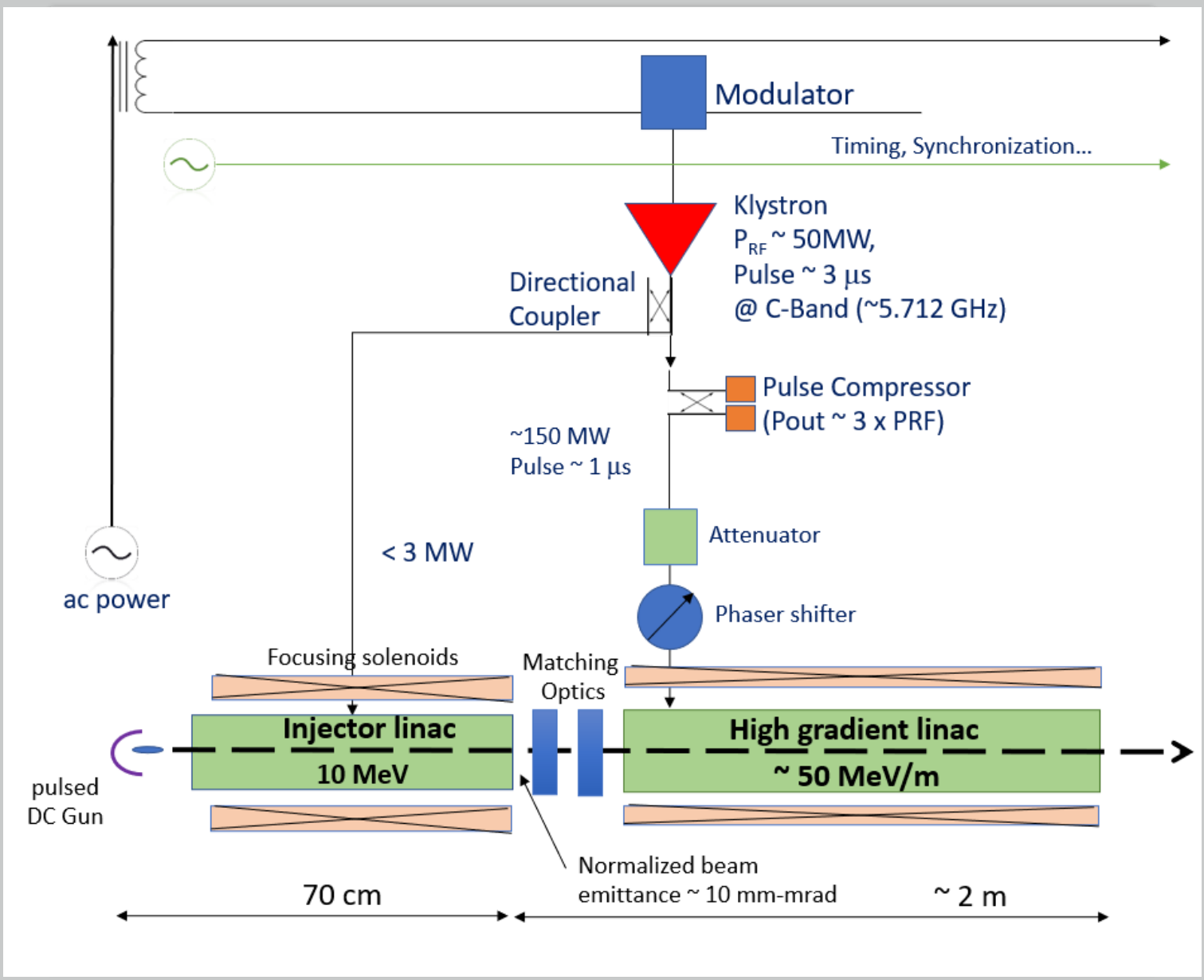
VHEE LINAC LAYOUT

Our linear accelerator comprises three main parts:

1. Electron beam injector with high current and low energy (10MeV)

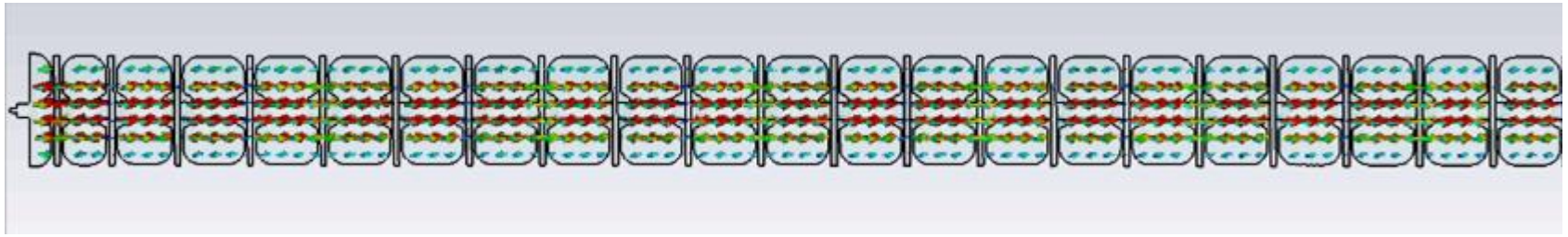
2. High gradient acceleration structure (50MeV/m)

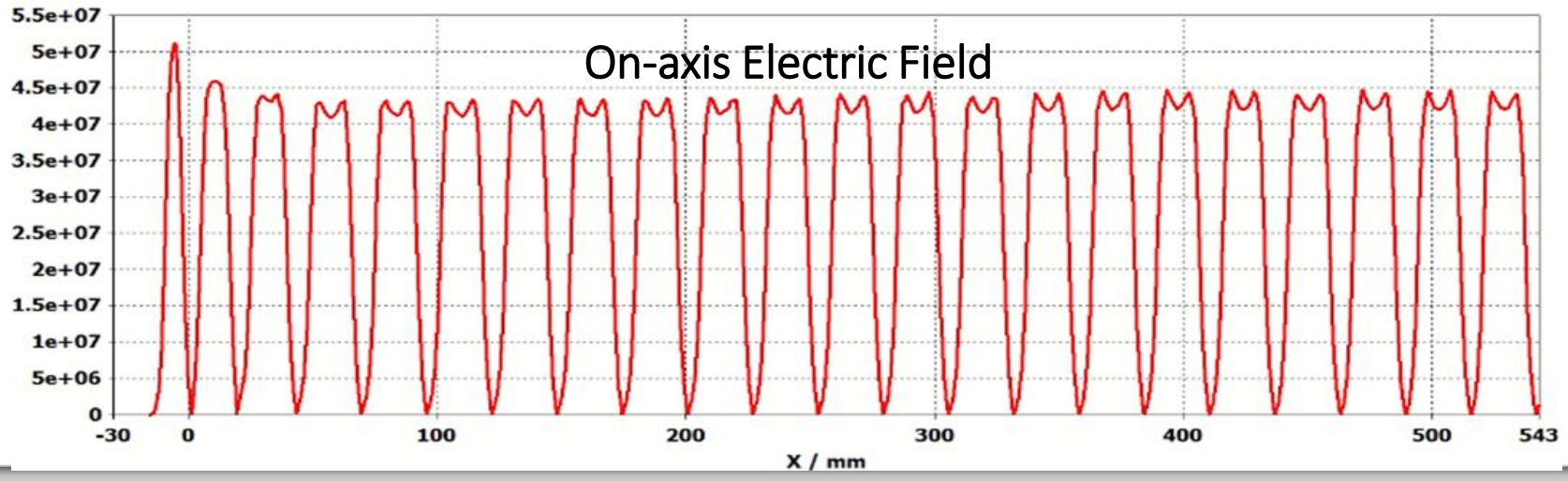
3. RF power distribution system (klystron power 50MW).



Electron beam injector

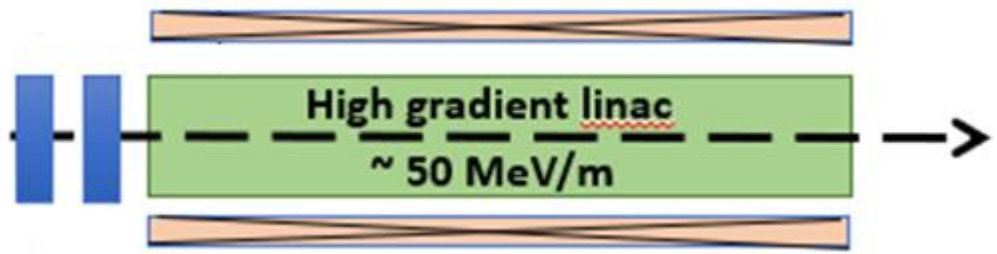
- Low energy 10MeV
- High current 200mA

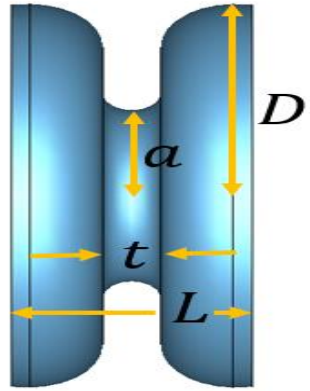




Parameter	Value
Frequency of operation	5.712 GHz
Effective shunt impedance	110 MΩ/m
Quality factor	~ 10000
Pulse length	1.0-3.0 μs
Linac length	~ 60 cm
Output Energy	10 MeV
Peak Beam Current	~ 200 mA
RF Input Power	< 3 MW

High gradient accelerating structure

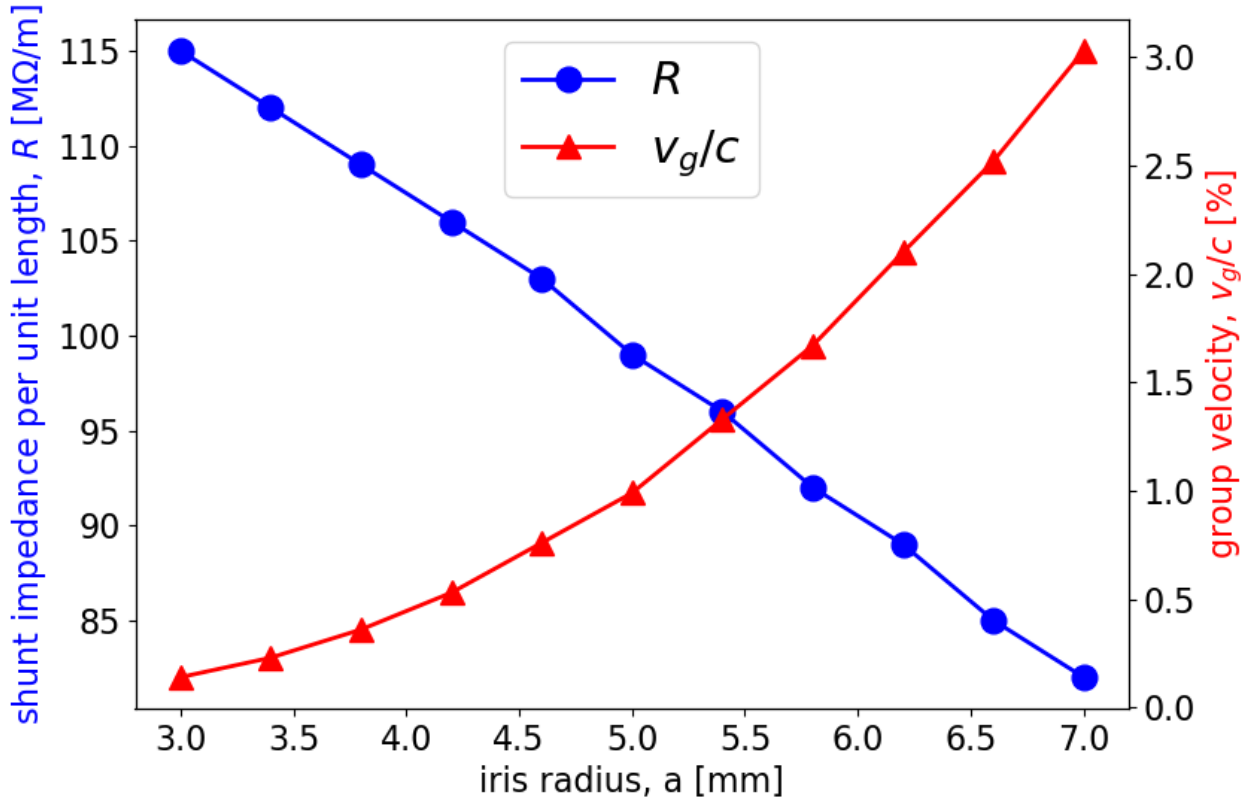




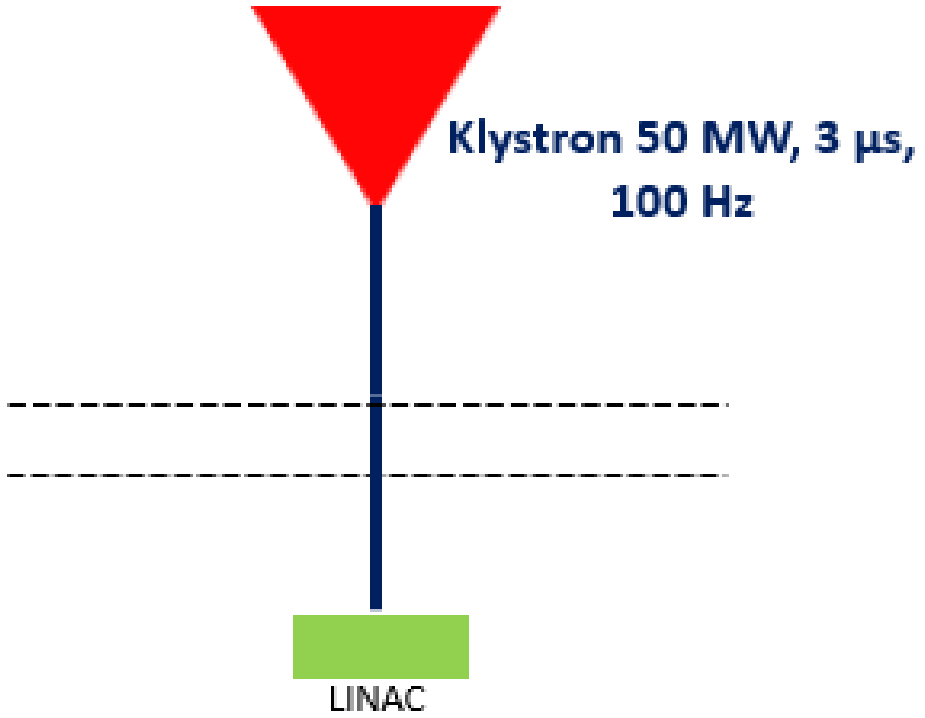
Parameters VHEE FLASH LINAC

Parameter	Value
Frequency of operation	5.712 GHz
Output Energy	> 60 MeV
Output Beam Current	200 mA
Pulse width	3.0 μs
PRF	100 Hz
Klystron RF Power	50 MW
Effective shunt impedance	> 110 $M\Omega/m$
Quality factor	~ 10000
High gradient structure length	~ 180 cm
Total Linac length	~ 300 cm

Preliminary study for high gradient cell



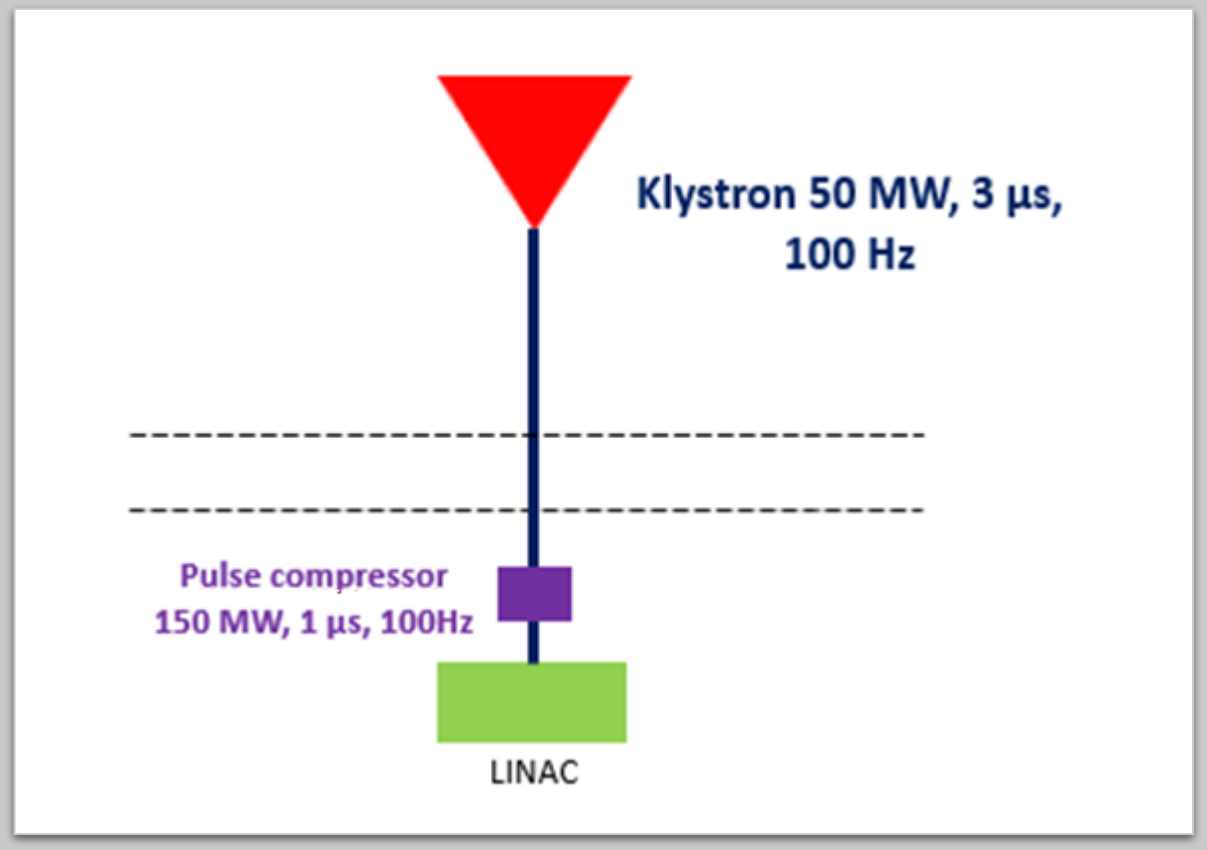
Power supply with klystron



Parameter	Value
Frequency of operation	5.712 GHz
Output Energy	> 60 MeV
Output Beam Current	200 mA
Pulse width	3.0 μs
PRF	100 Hz
Klystron RF Power	50 MW
Effective shunt impedance	> 110 $M\Omega/m$
Quality factor	~ 10000
High gradient structure length	~ 180 cm
Total Linac length	~ 300 cm
Pulse charges	600 nC
$\overline{\dot{D}}$	> 100 Gy/s
$\dot{D}_p$	> 10^6 Gy/s
DPP	12 Gy in ∅10 cm

Pulse compressor option

To reach a higher energy, the system is equipped with a pulse compressor
(SLED type from SLAC or BOC from PSI)



Parameter	Value
Frequency of operation	5.712 GHz
Output Energy	100 MeV
Output Beam Current	200 mA
Pulse width	$1.0\mu s$
PRF	100 Hz
RF Power	~ 150 MW
Pulse charges	200 nC
$\overline{\dot{D}}$	$> 100\ Gy/s$
$\dot{D}_p$	$> 10^6\ Gy/s$
DPP	4 Gy in ⌀10 cm

Conclusion

- The VHEE Linac parameters suitable to satisfy FLASH criteria were investigated.
- Preliminary results of compact C-band system allow to obtain:
  - maximum energy of 60-100MeV,
  - peak current of 200 mA,
  - charge in 1-3 μs pulse of 200-600 nC,
  - dose of 4-12 Gy in a single pulse in Ø10 cm
  - dose rate $>10^6$ Gy/s
- Further studies are ongoing to complete the characterization of the machine and manufacture and test of RF prototypes

Thank you for joining!