THE TULIP (p) AND CABOTO (C, p) PROJECTS OF THE TERA FOUNDATION

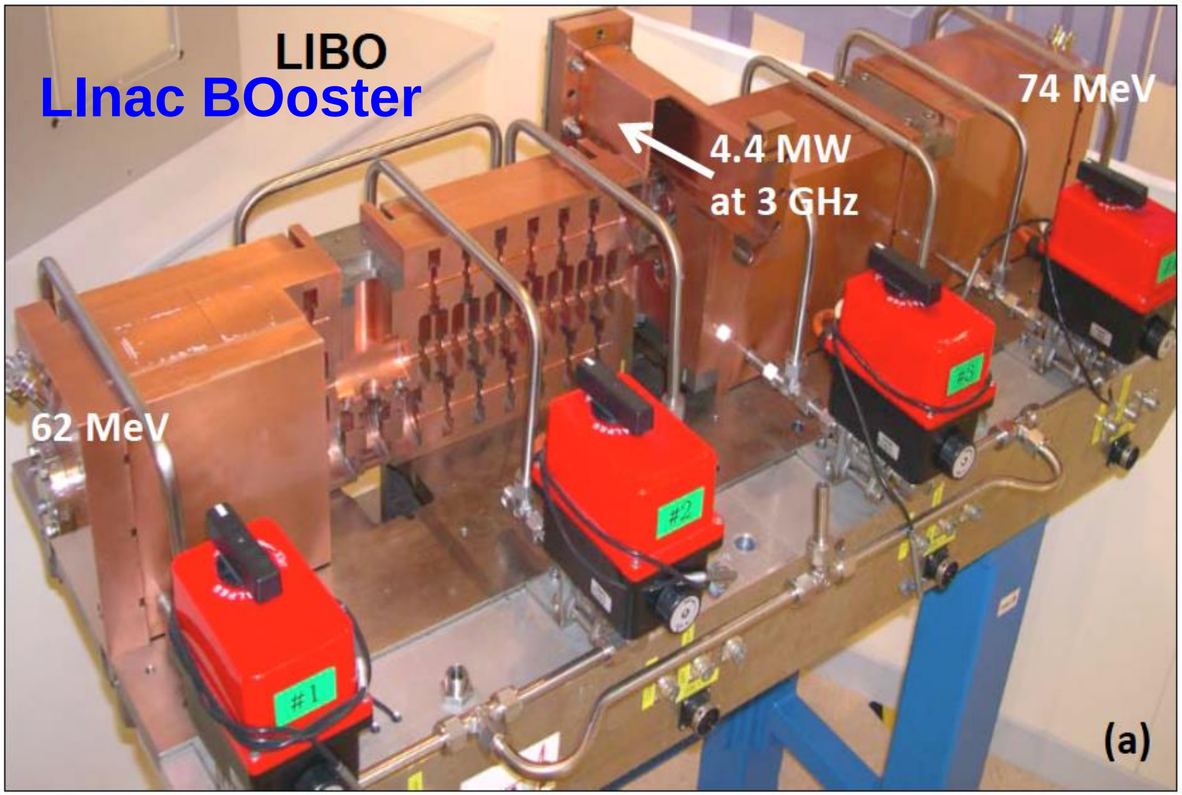
Ugo Amaldi

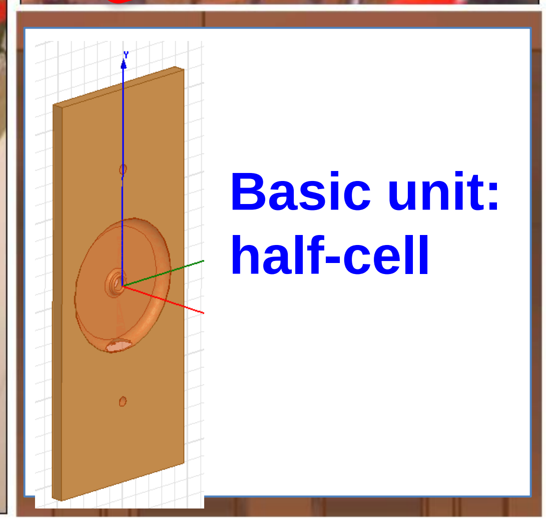
TUrning **LI**nac for **P**rotontherapy
CArbon **BO**oster for **T**herapy in **O**ncology

TULIP

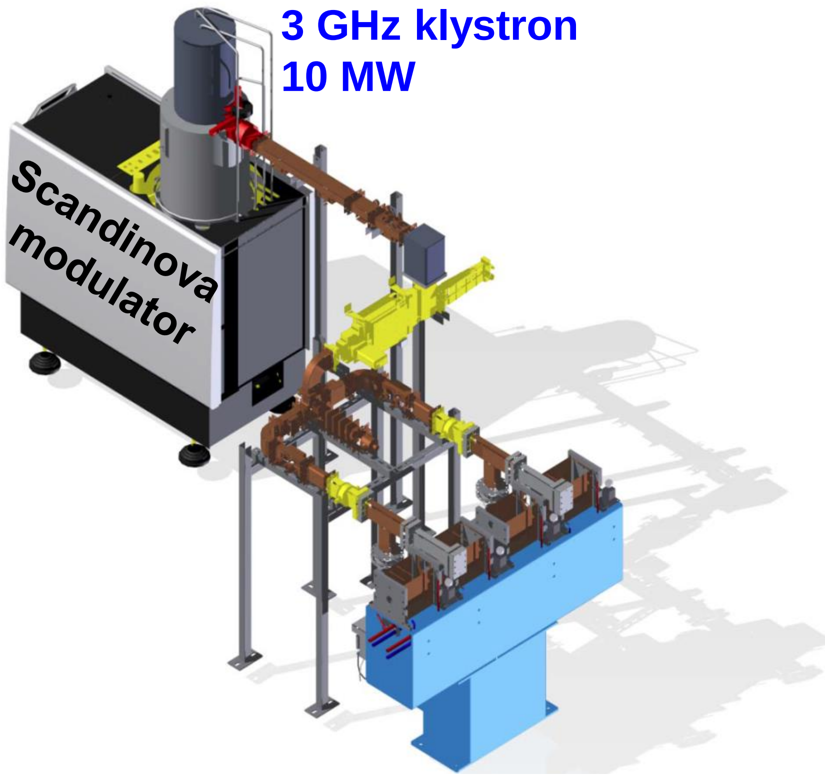
Accelerating Unit built and tested by TERA – CERN - INFN

This Unit has accelerated protons from 62 to 74 MeV at the same 3 GHz frequency of electron linacs

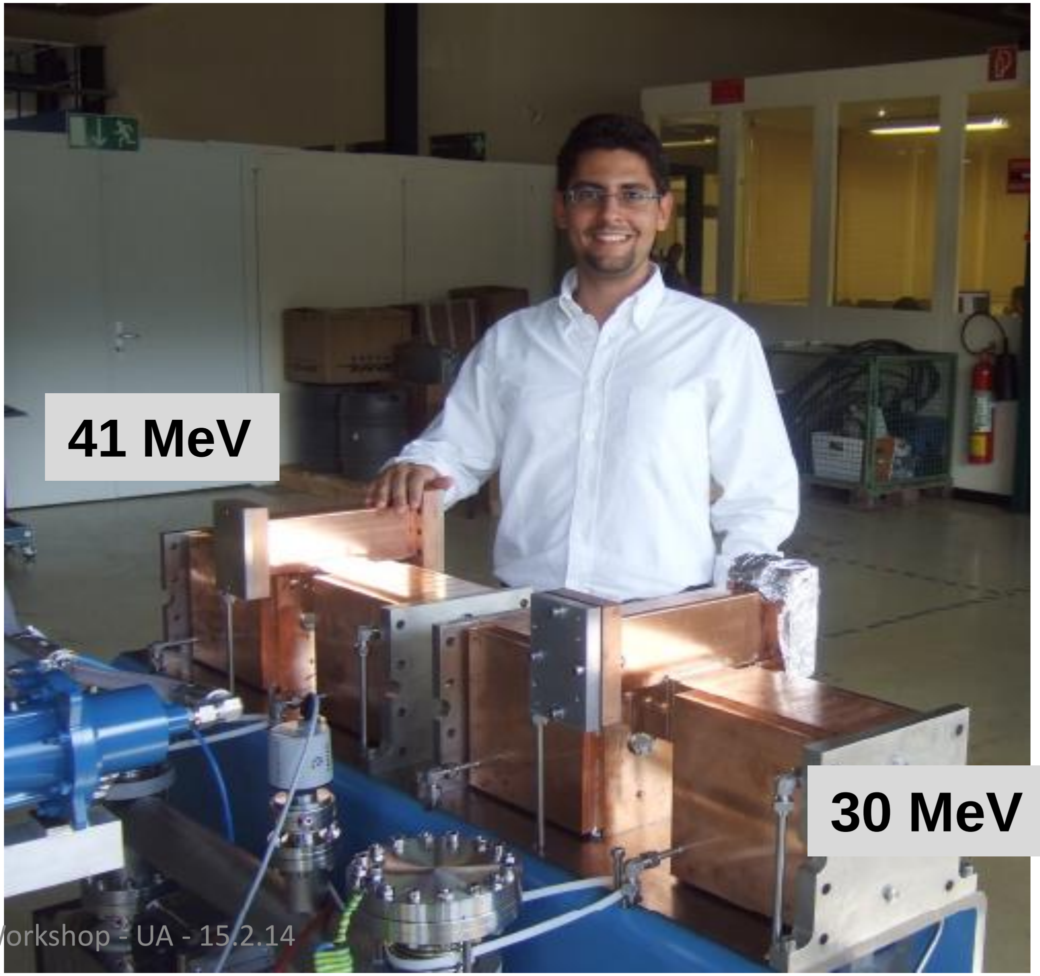




Commercial prototype built and power tested by A.D.A.M.: 2011



A.D.A.M. = Applications of Detectors and Accelerators to Medicine



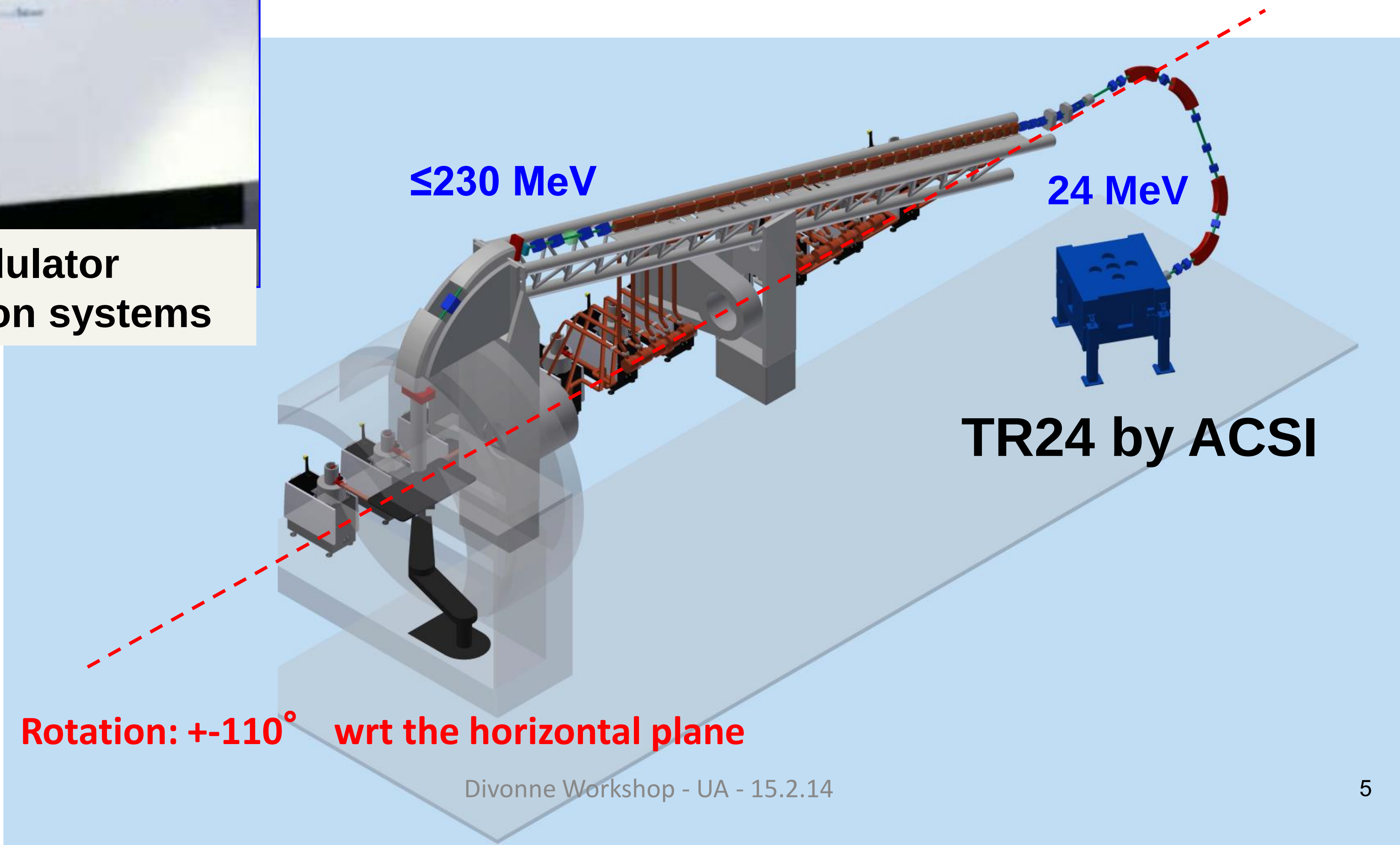
First Unit of LIGHT

Linac for Image Guided Hadron Therapy

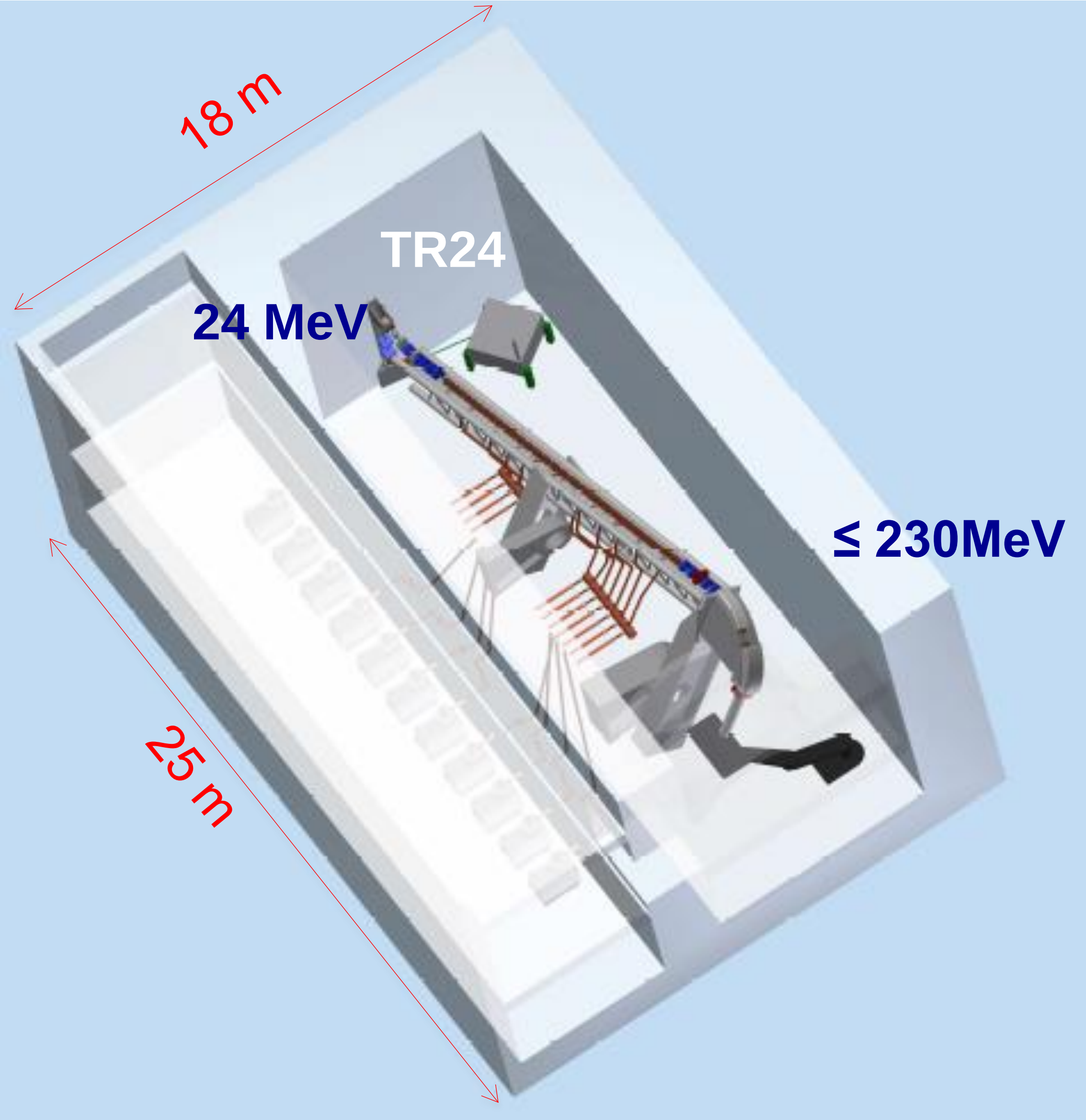
TULIP at 3 GHz with E_0 = 30 MV/m

11 modulator -klystron systems

10 MW klystron

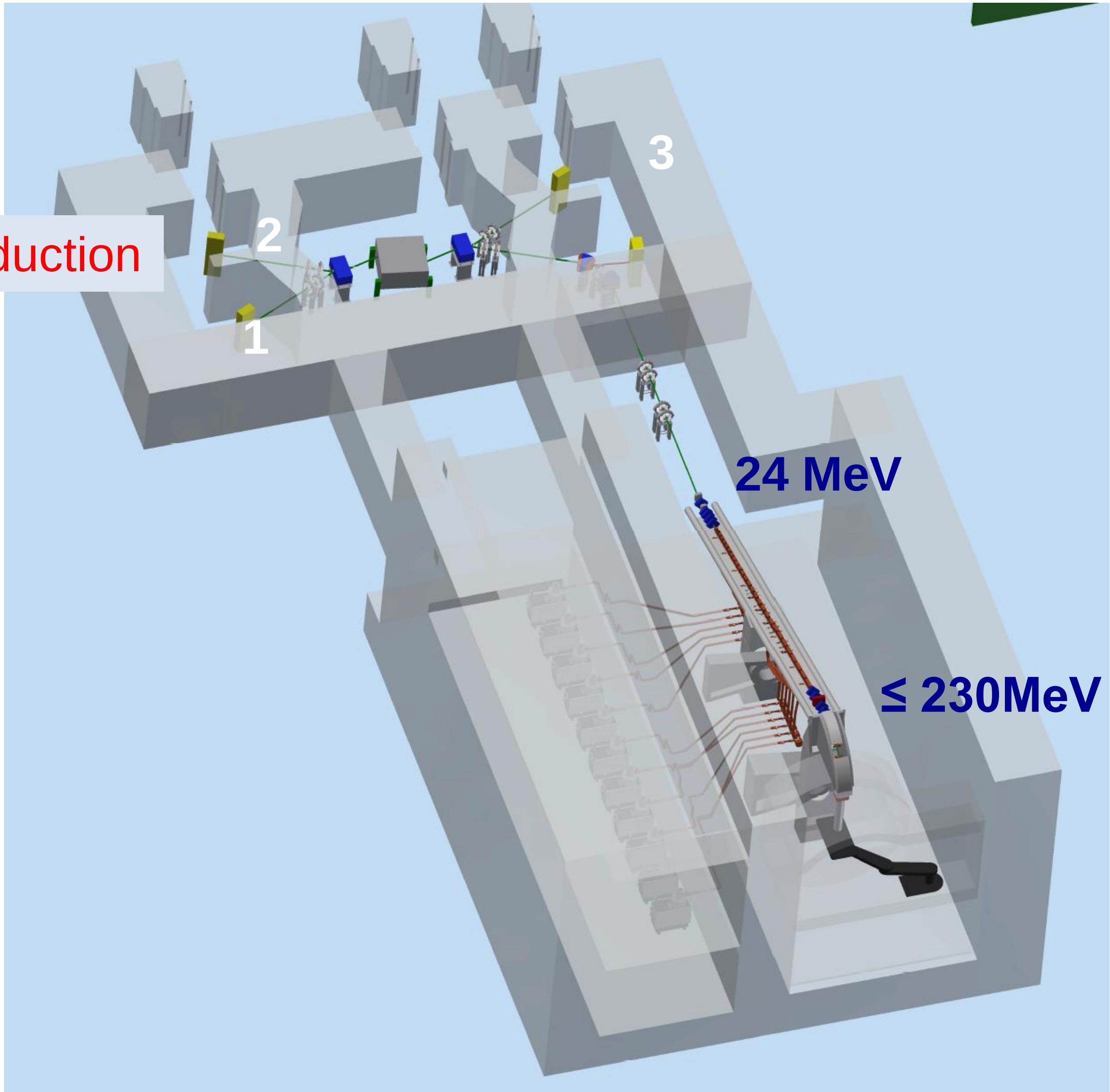


TULIP

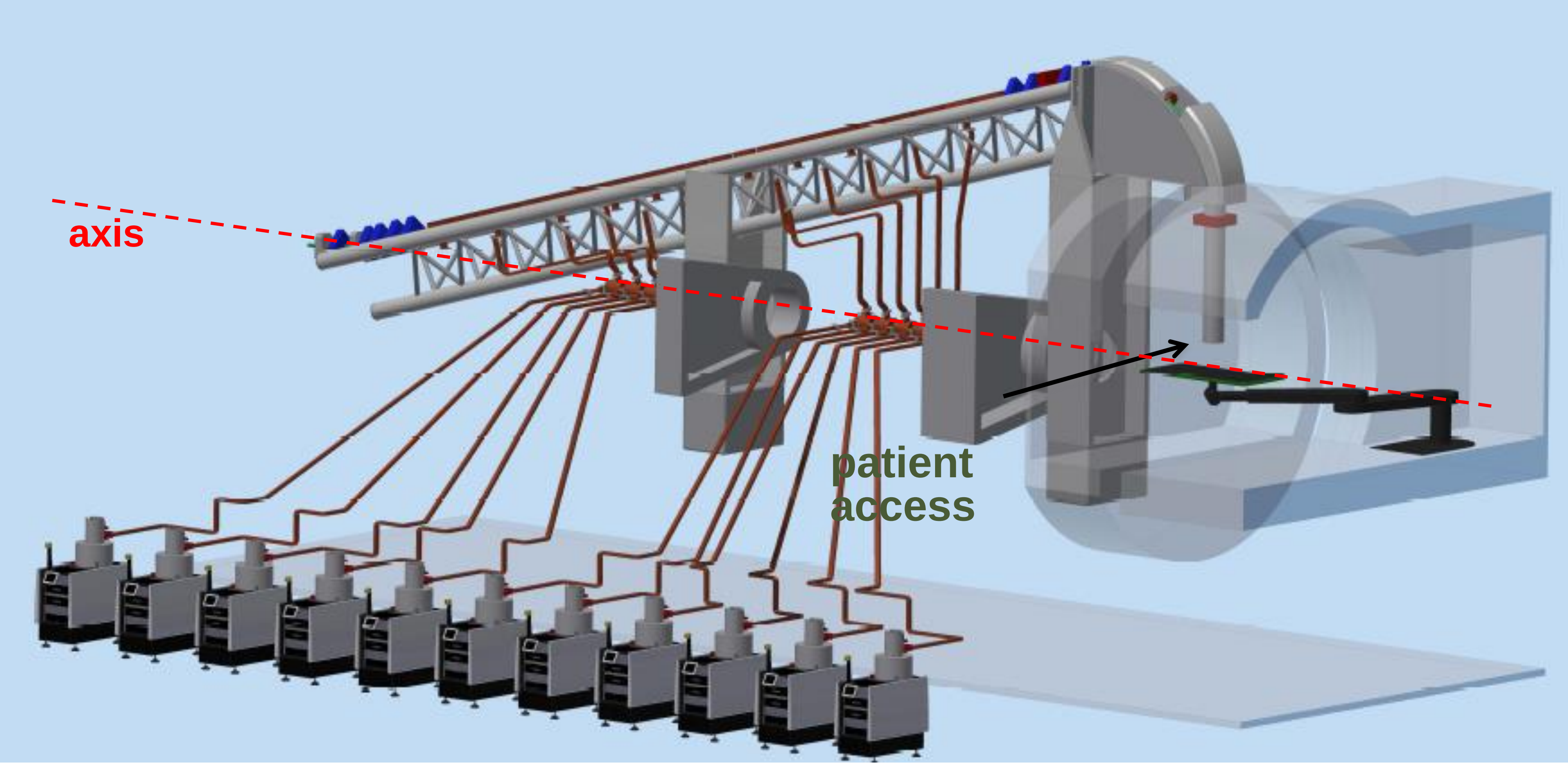


TULIP-RI

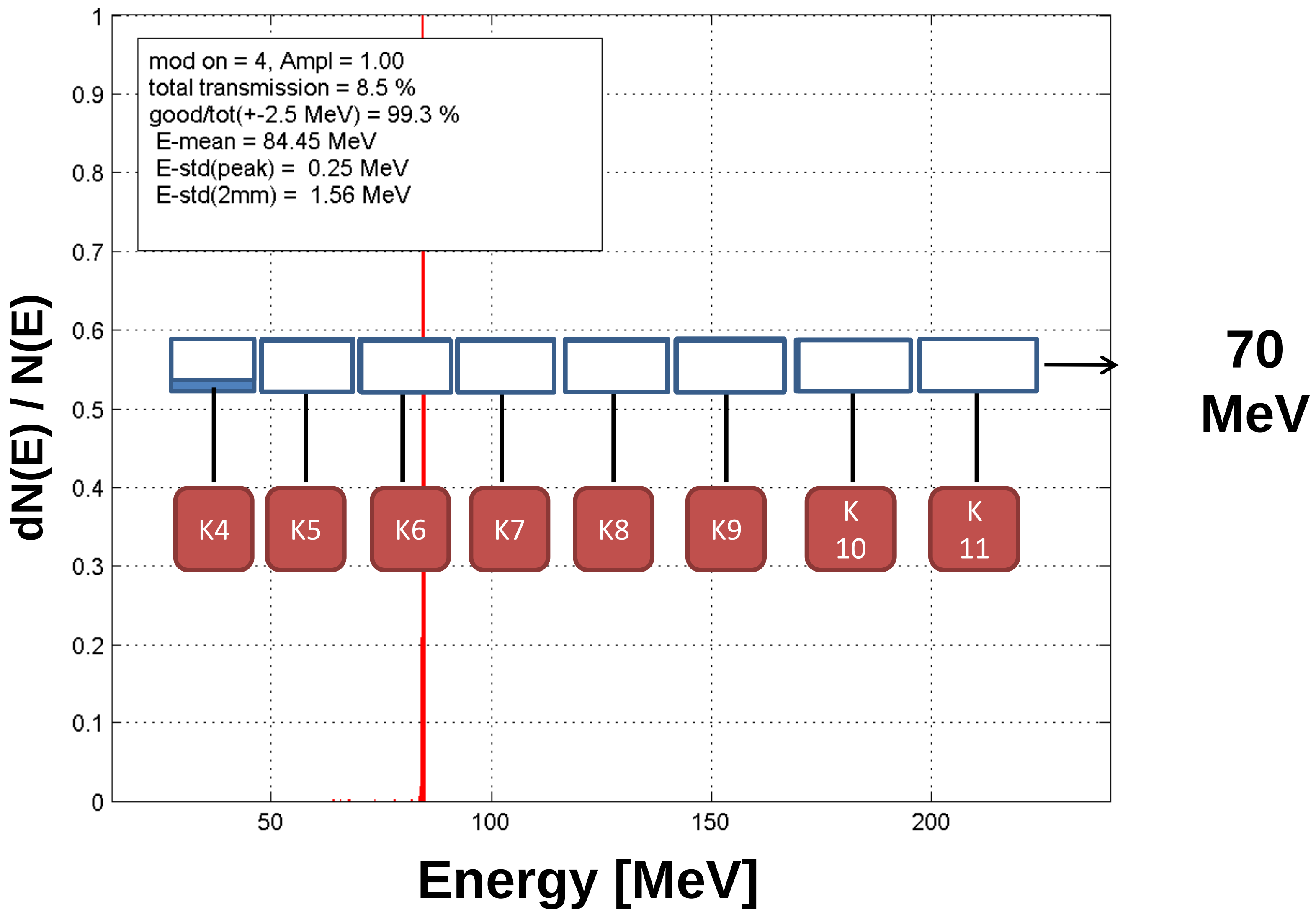
Radio-isotope production



TULIP at 3 GHz with E_0 = 30 MV/m

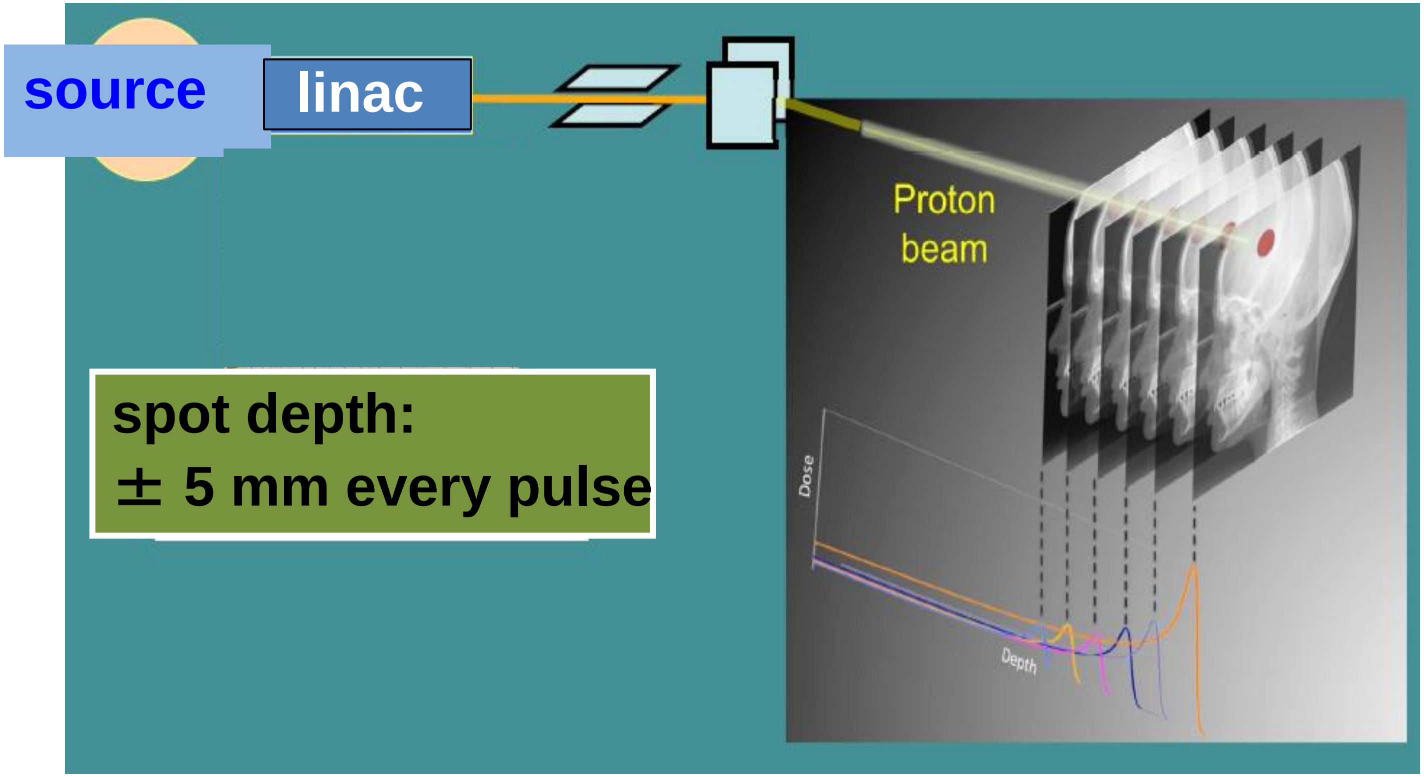


Fast and active energy variation



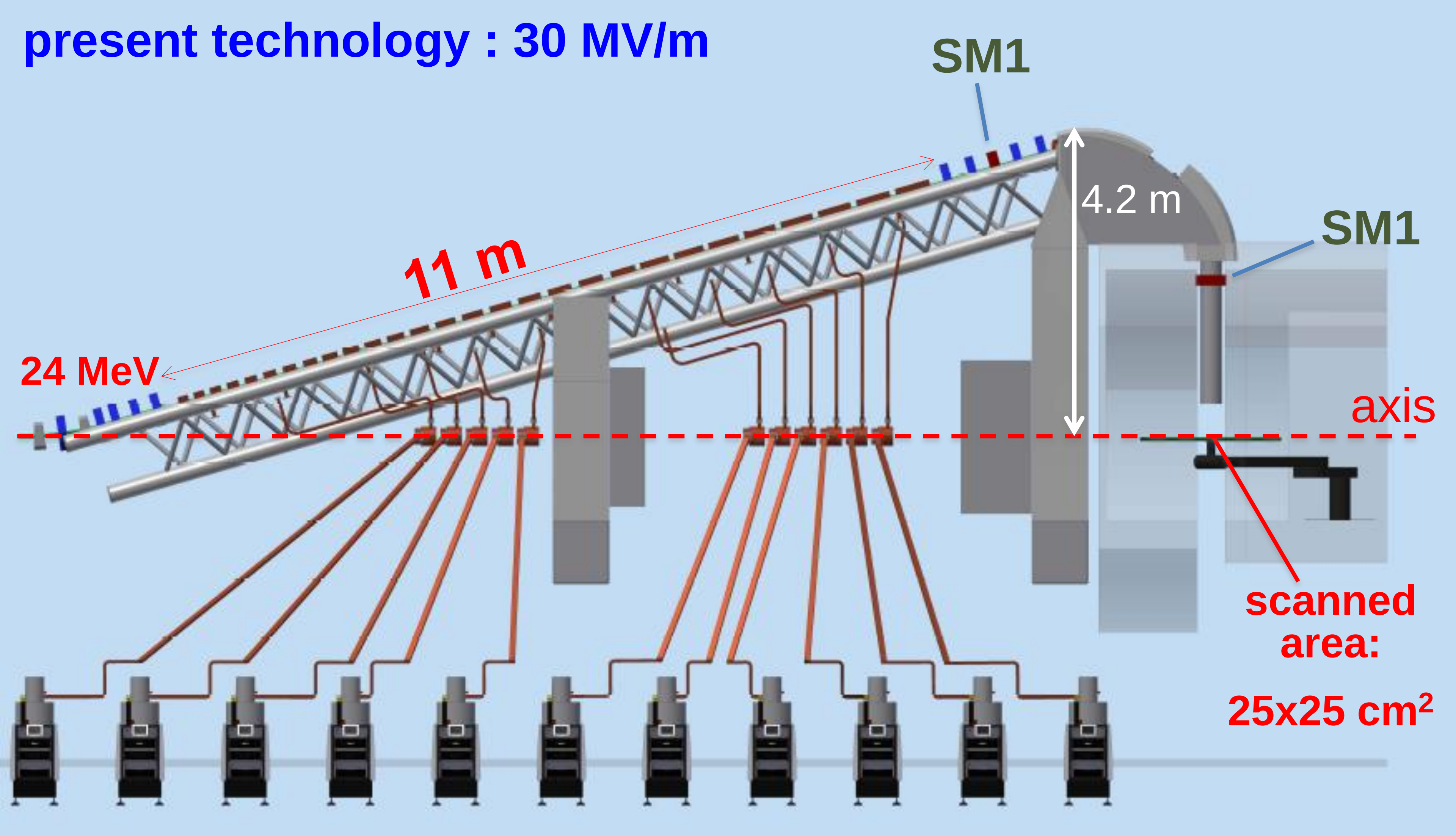
The deposition depth can be adjusted every 5 ms

The linac pulses 120-200 times per second



To follow moving organs in 4D the beam time structure is better than the ones of cyclotrons and synchrotrons

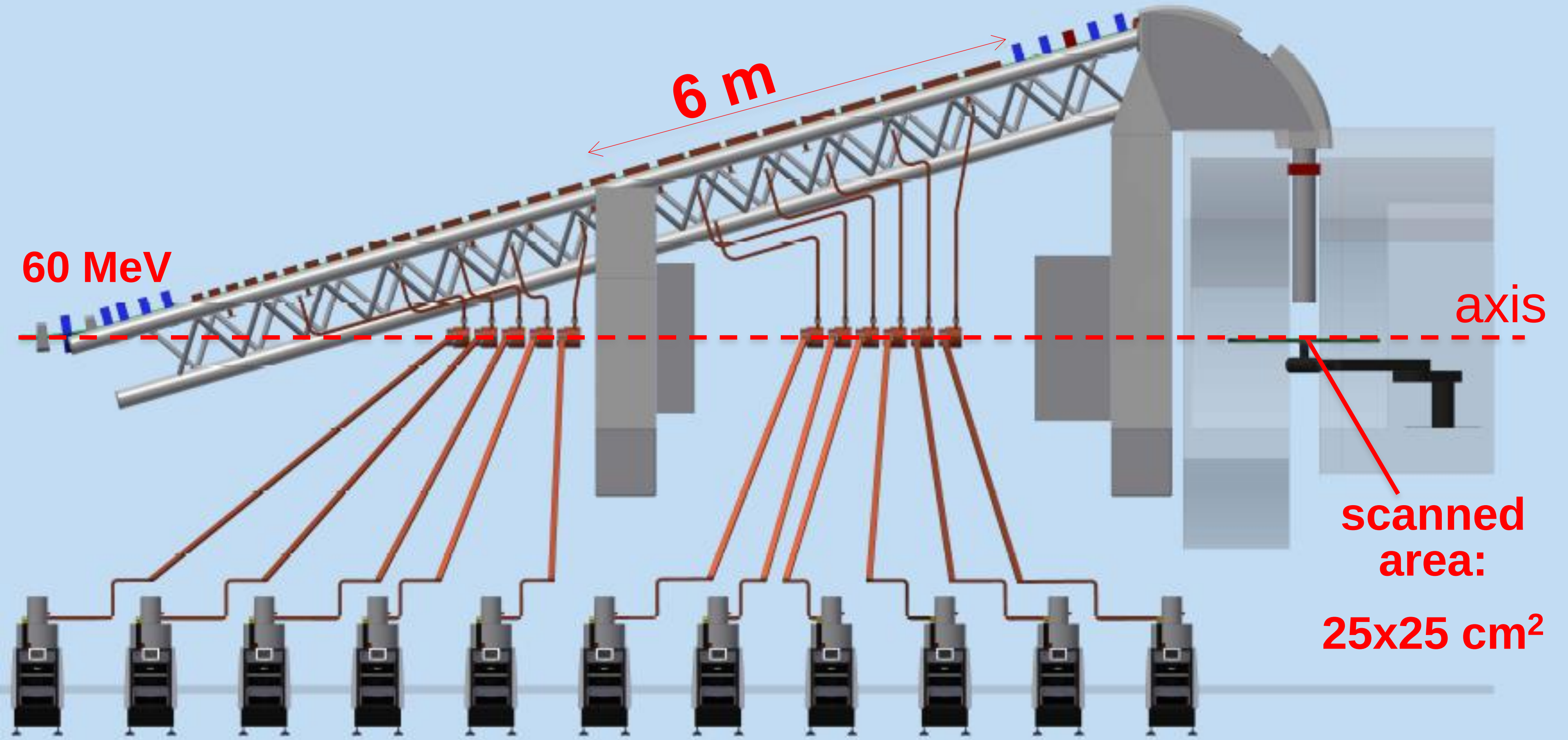
TULIP at 3 GHz with E_0 = 30 MV/m



TULIP 2.0

CLIC technology : 50 MV/m

prototype is being built by CERN and TERA



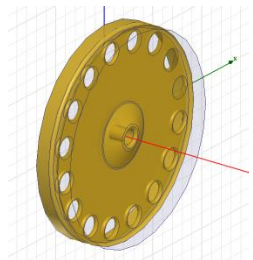
New high-gradient “backward” TW structure

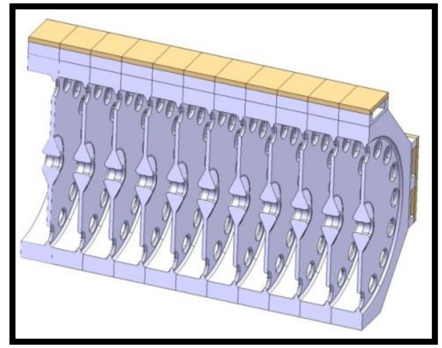
‘NEW’ bwTW

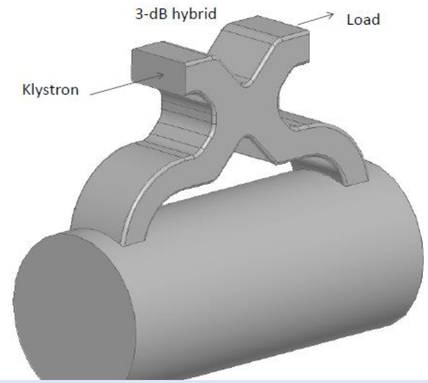
<u>50 MV/m</u>

BDR = 10^{-6} m^{-1}

(20% more power for same gradient)

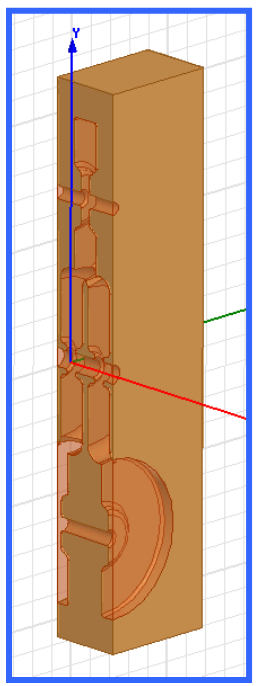


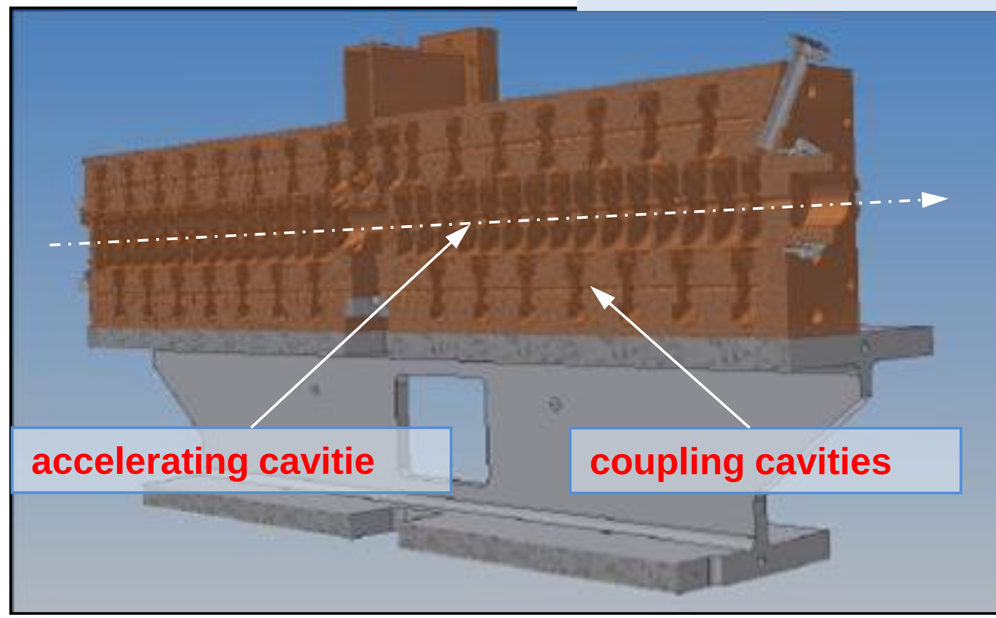




With recirculation: I. SYRATCHEV

DESIGNED with A.GRUDIEV /CLIC financed by KT



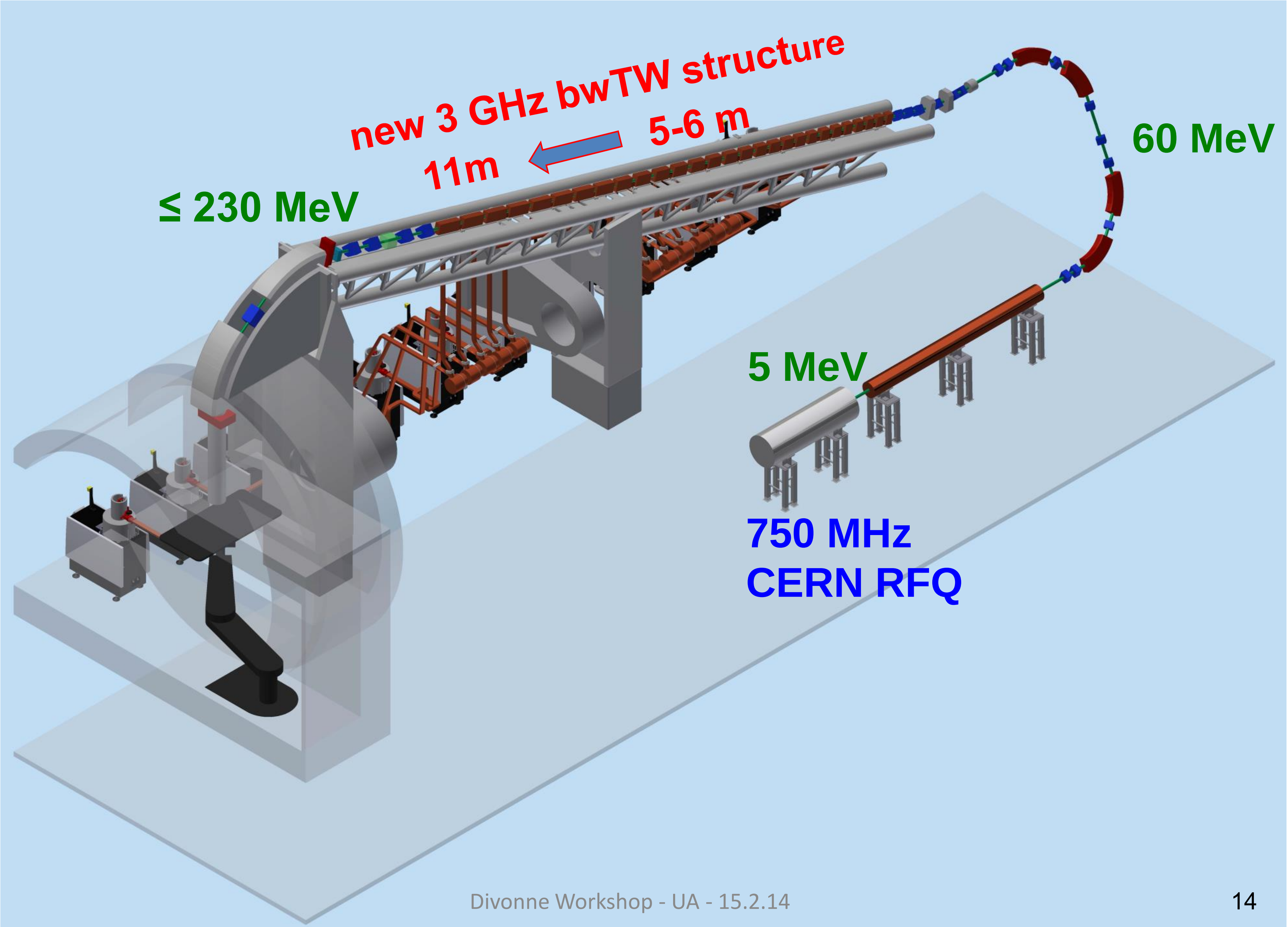


‘OLD’ SW CCL

<u>30 MV/m</u>

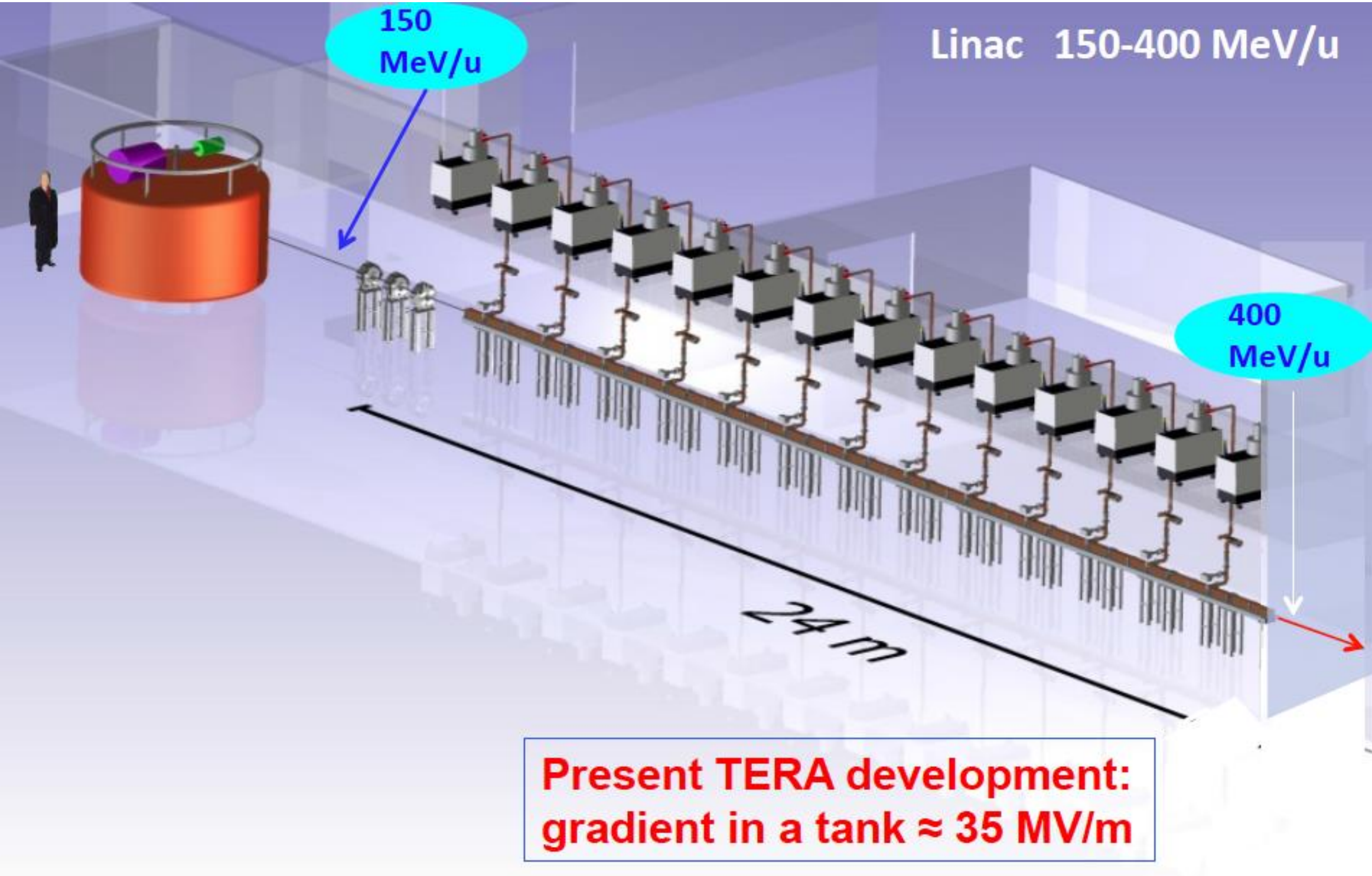
BDR = 10^{-6} m^{-1}

PROPOSAL TO BE WORKED ON: TULIP 2.0

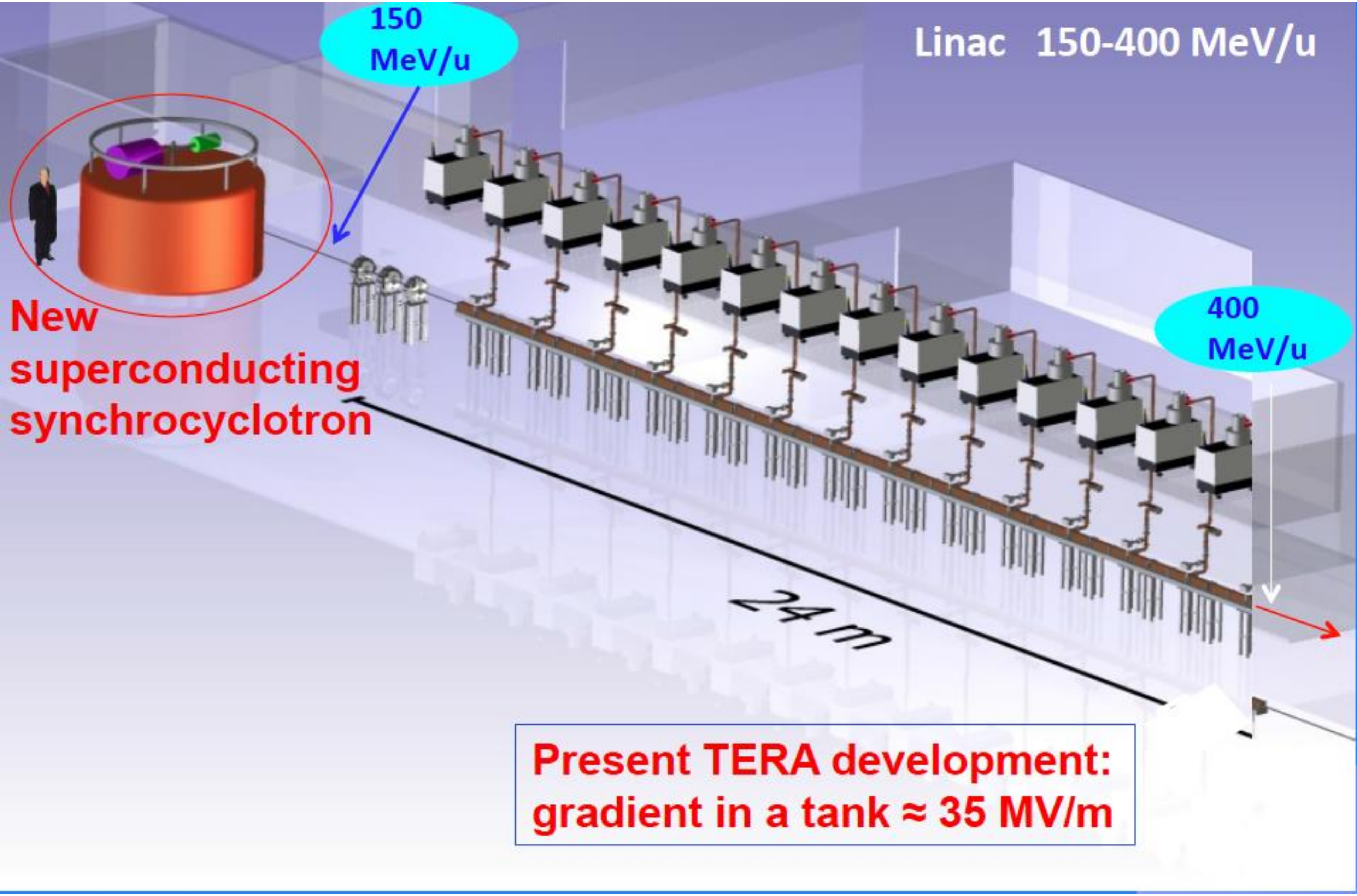


CABOTO

CABOTO @ 400 MeV/u

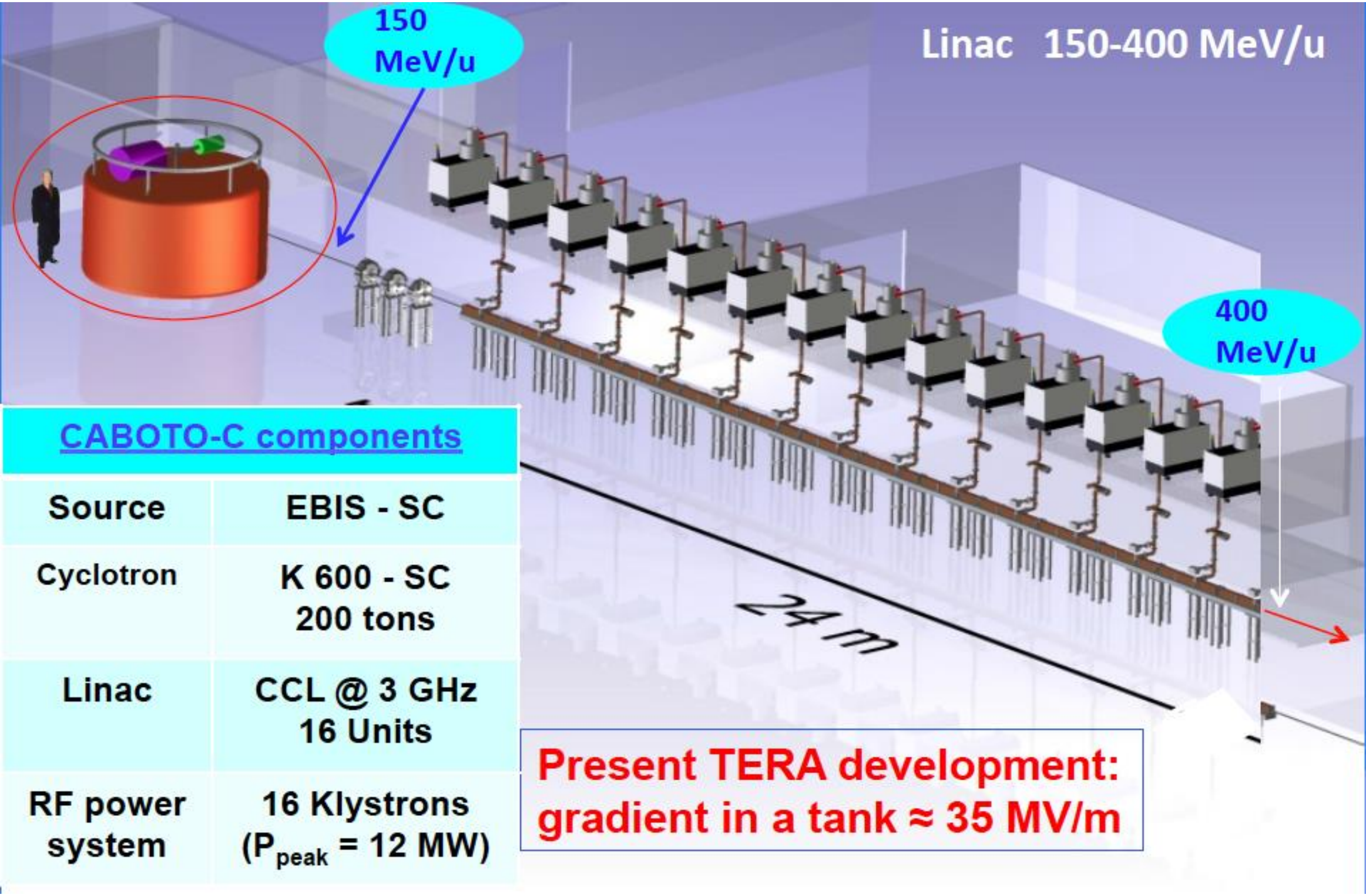


CABOTO @ 400 MeV/u



Present TERA development:
gradient in a tank ≈ 35 MV/m

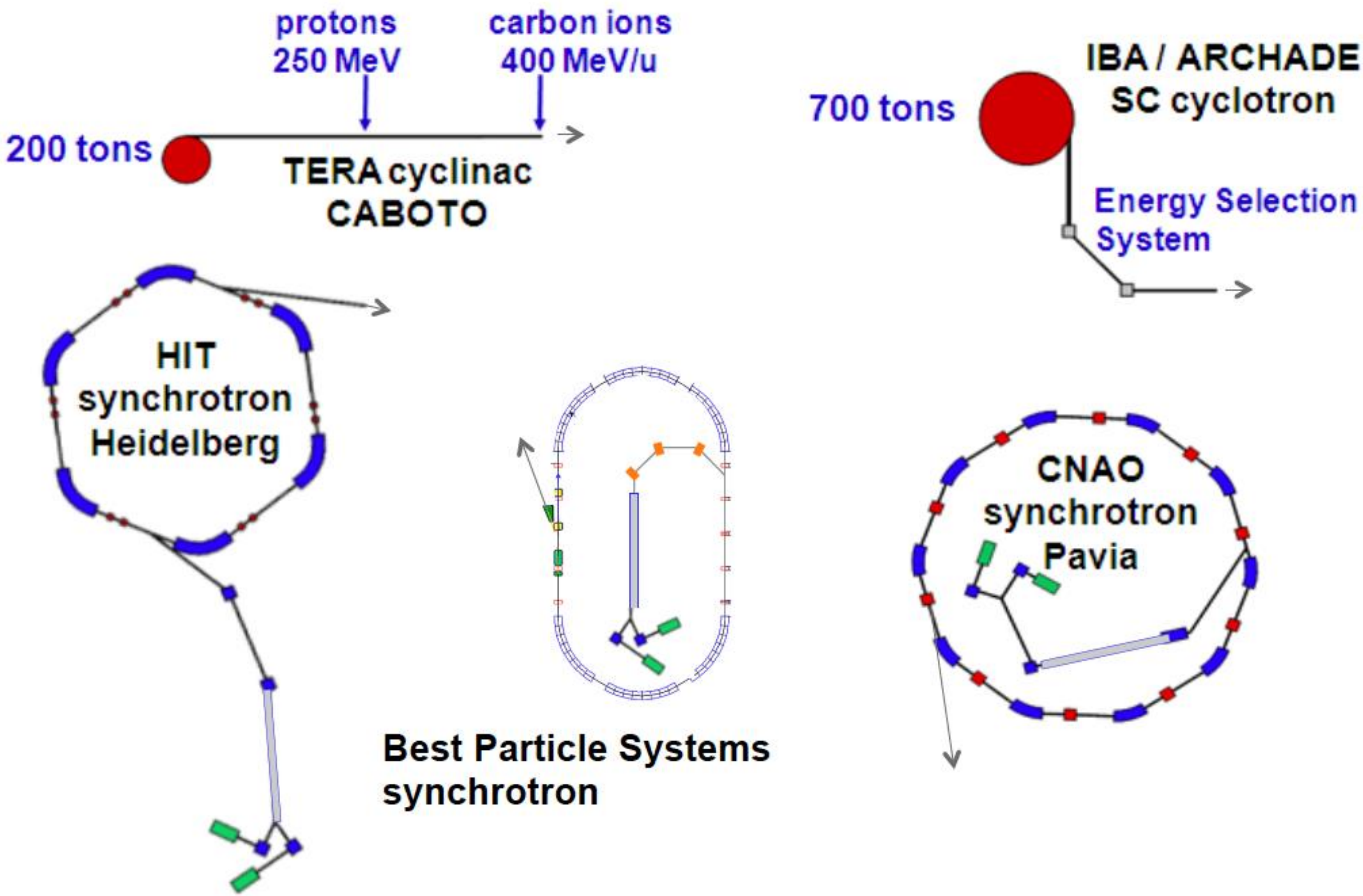
CABOTO @ 400 MeV/u



CABOTO-C components	
Source	EBIS - SC
Cyclotron	K 600 - SC 200 tons
Linac	CCL @ 3 GHz 16 Units
RF power system	16 Klystrons (P_{peak} = 12 MW)

**Present TERA development:
gradient in a tank ≈ 35 MV/m**

Comparison of C ion facilities



RESERVE SLIDES

The reasons for proton single-room facilities

Radiation treatment	Patients per year in 10^7	Number of session per patient	Sessions/d in 1 room (d = 12 h)	Patients/y in 1 room (y=230 d)	Rooms per 10 million people (1)	Relative ratio ≈
Photons (1)	20'000	30	48	370	54	**8^2**
Protons (12%)	2'400	20	36	380	6.3	**8**
C ions (3%)	600	10	36	760	0.8	**1**

ENLIGHT results

1 single-room p-facility every 8 X-ray rooms in 3-4 close-by hospitals serving 1-1.5 million people

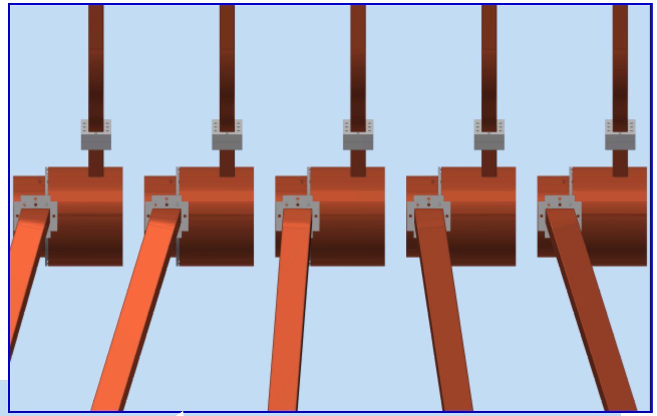
Accelerators for hadrontherapy: From Lawrence cyclotrons to linacs ☆

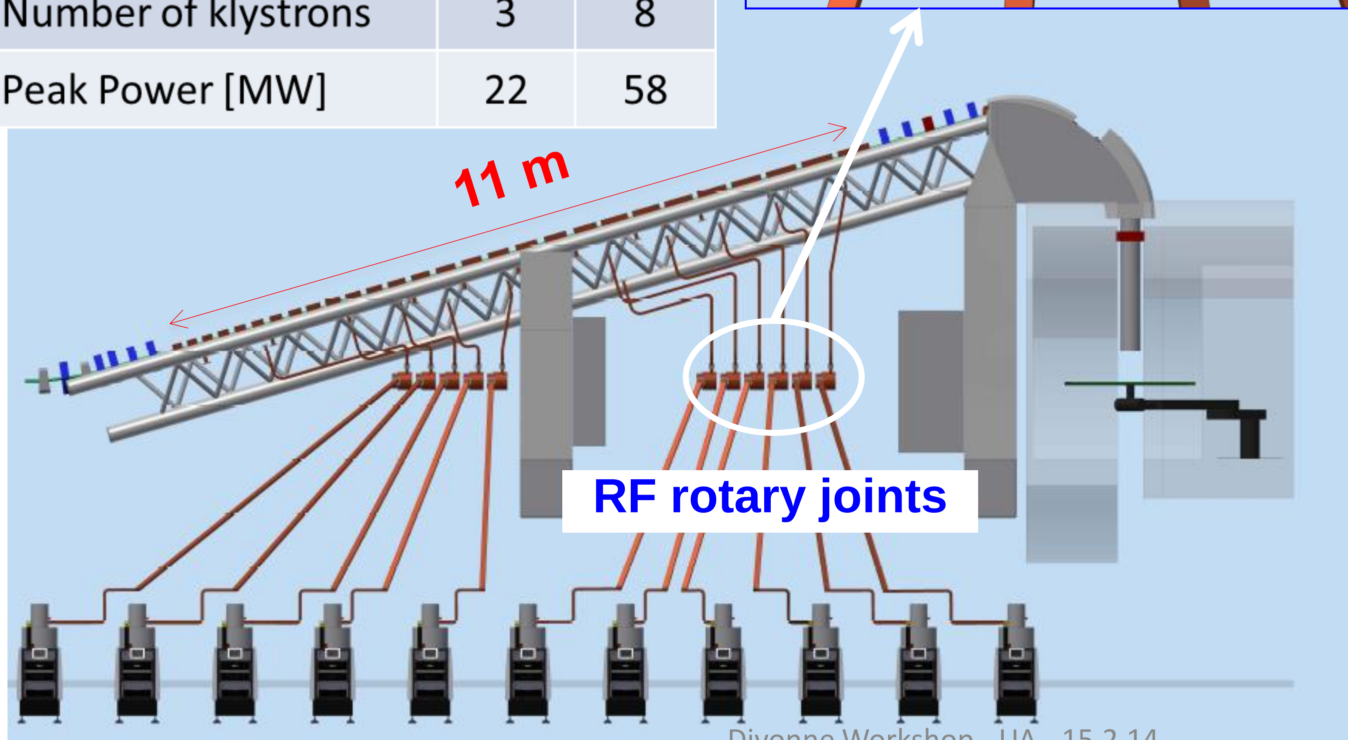
U. Amaldi[1], R. Bonomi, S. Braccini[*,2], M. Crescenti[3], A. Degiovanni, M. Garlasché, A. Garonna, G. Magrin[4], C. Mellace[4], P. Pearce[4], G. Pittà[4], P. Puggioni[4], E. Rosso, S. Verdú Andrés[5], R. Wegner[6], M. Weiss[7], R. Zennaro[8]

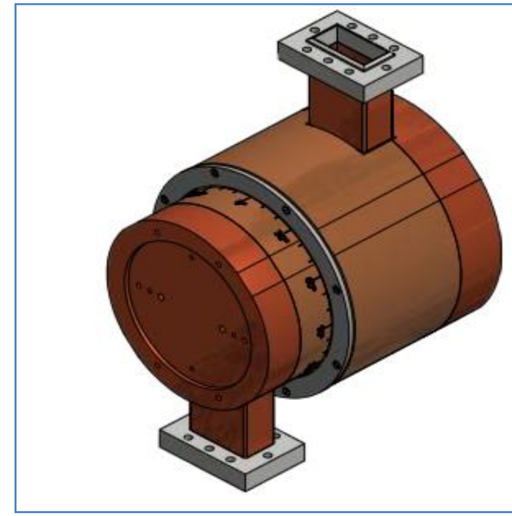
Nuclear Instruments and Methods in Physics Research A 620 (2010) 563–577

TULIP linac at 3 GHz with RF rotary joints

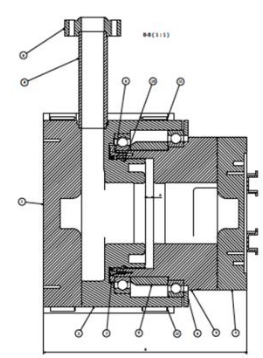
Quantity [unit]	Sec.1	Sec. 2
Total length [m]	3.4	7.9
Output energy [MeV]	70	230
Avg. axial field [MV/m]	22.8	29.4
Max. surf. field [MV/m]	150	170
Number of klystrons	3	8
Peak Power [MW]	22	58

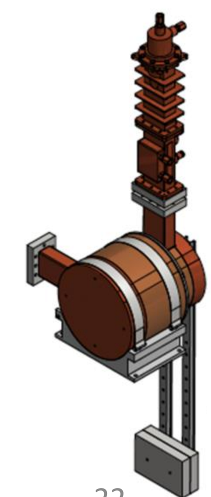






1st prototype under construction at CERN





Mechanical design by Paolo Magagnin - TERA

NOTE:
- For production steps refer to TLPRJ_001;
- (final gap after spacer remachining A=11.24± 0.04 mm)