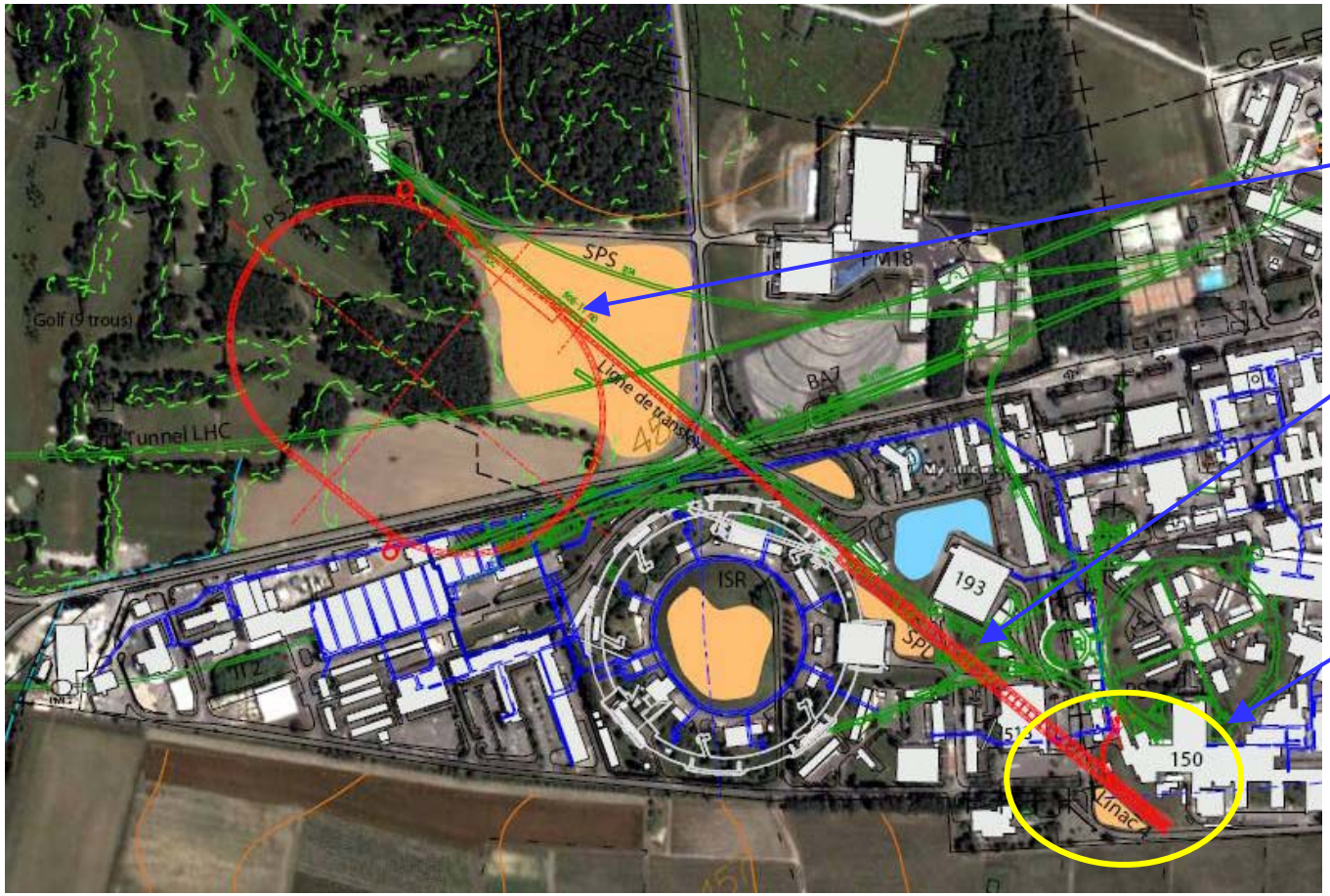
Introduction to Linac4: parameters, layout, challenges

M. Vretenar 09.05.2007 BI Review

Linac4 and the new injectors



Linac4 will first inject into the PSB and then can be the first element of a new LHC injector chain. It will increase the beam brightness for the LHC, provide more beam to ISOLDE, increase the reliability.

Linac4 parameters

Ion species	H−	
Output Energy	160	MeV
Bunch Frequency	352.2	MHz
Max. Rep. Rate	2	Hz
Beam Pulse Length	400	μs
Max. Beam Duty Cycle	0.08	%
Chopper Beam-on Factor	62	%
Chopping scheme:		
222 transmitted /133 empty buckets		
Source current	80	mA
RFQ output current	70	mA
Linac pulse current	40	mA
N. particles per pulse	1.0	$\times 10^{14}$
Transverse emittance	0.4	π mm mrad

Max. rep. rate for accelerating structures 50 Hz

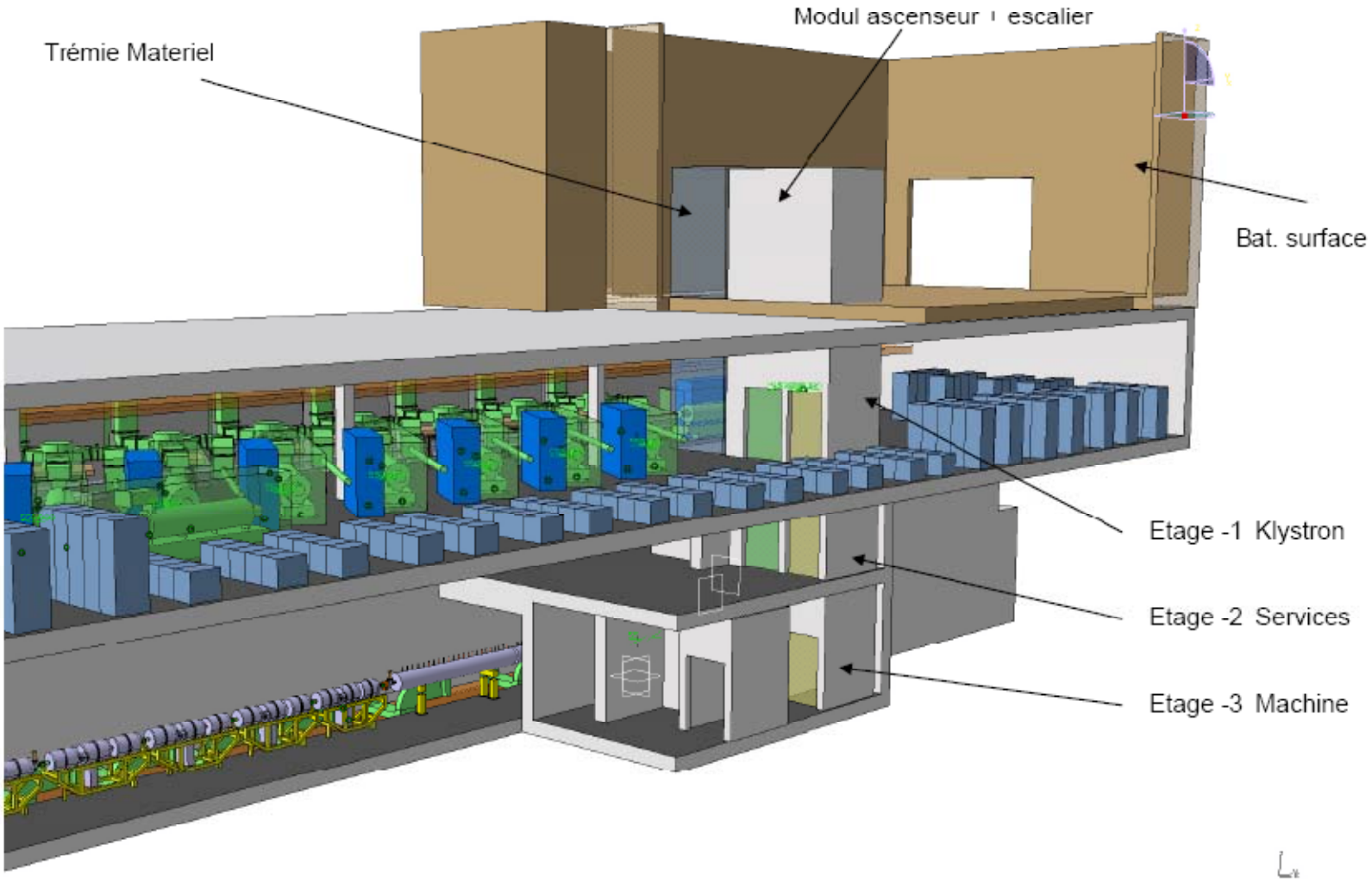
H- particles and higher energy than Linac2 (160/50 MeV, factor 2 in $\beta\gamma^2$) allow accumulating more particles in the PSB.

Will re-use 352 MHz LEP RF components: klystrons, waveguides, circulators.

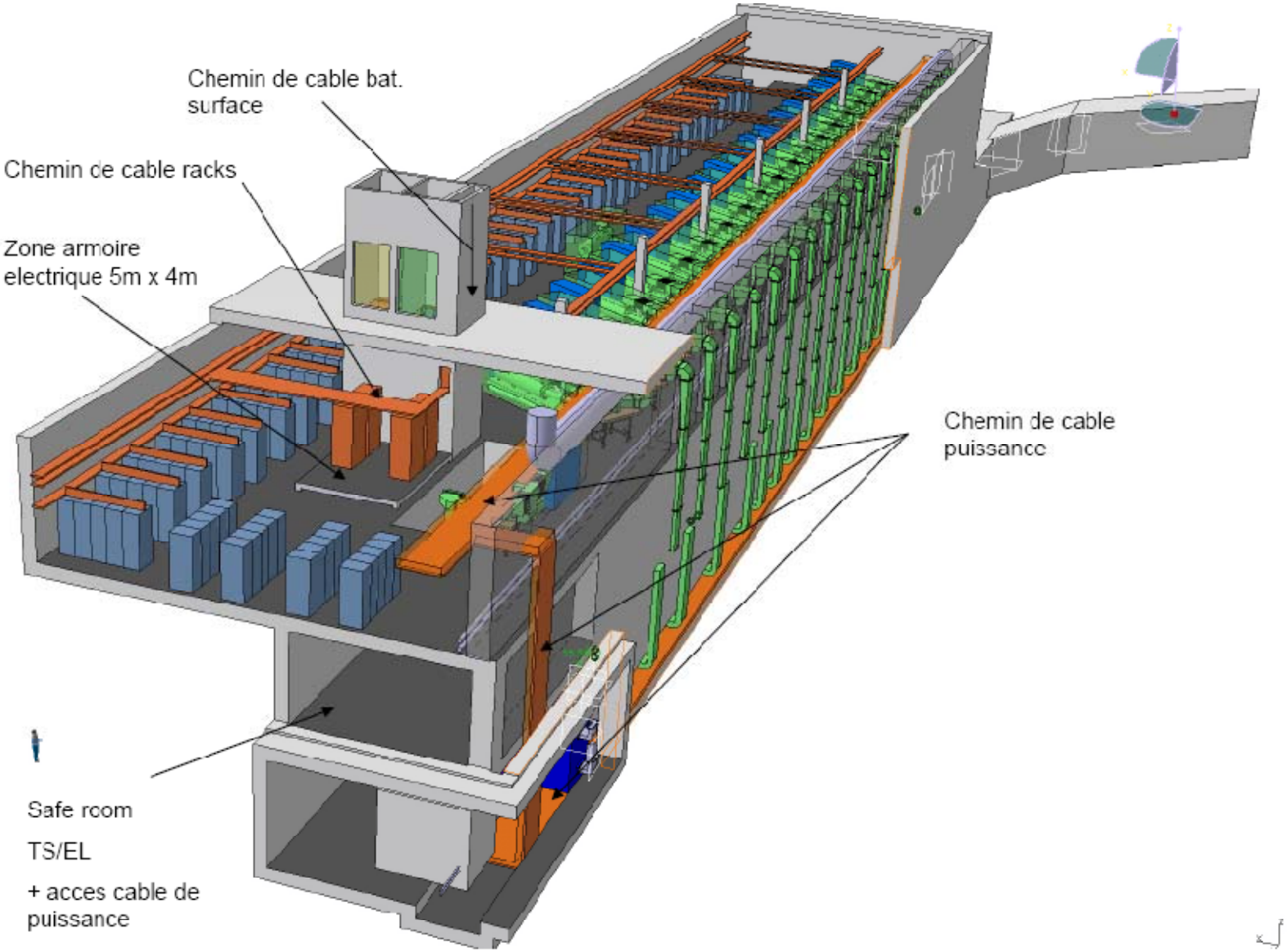
2 operating modes: low duty for LHC, high duty for a high-power SPL for neutrino physics in a second phase.

- Structures and klystrons dimensioned for 50 Hz
- Power supplies and electronics dimensioned for 2 Hz.

Linac4 in the new building - 1

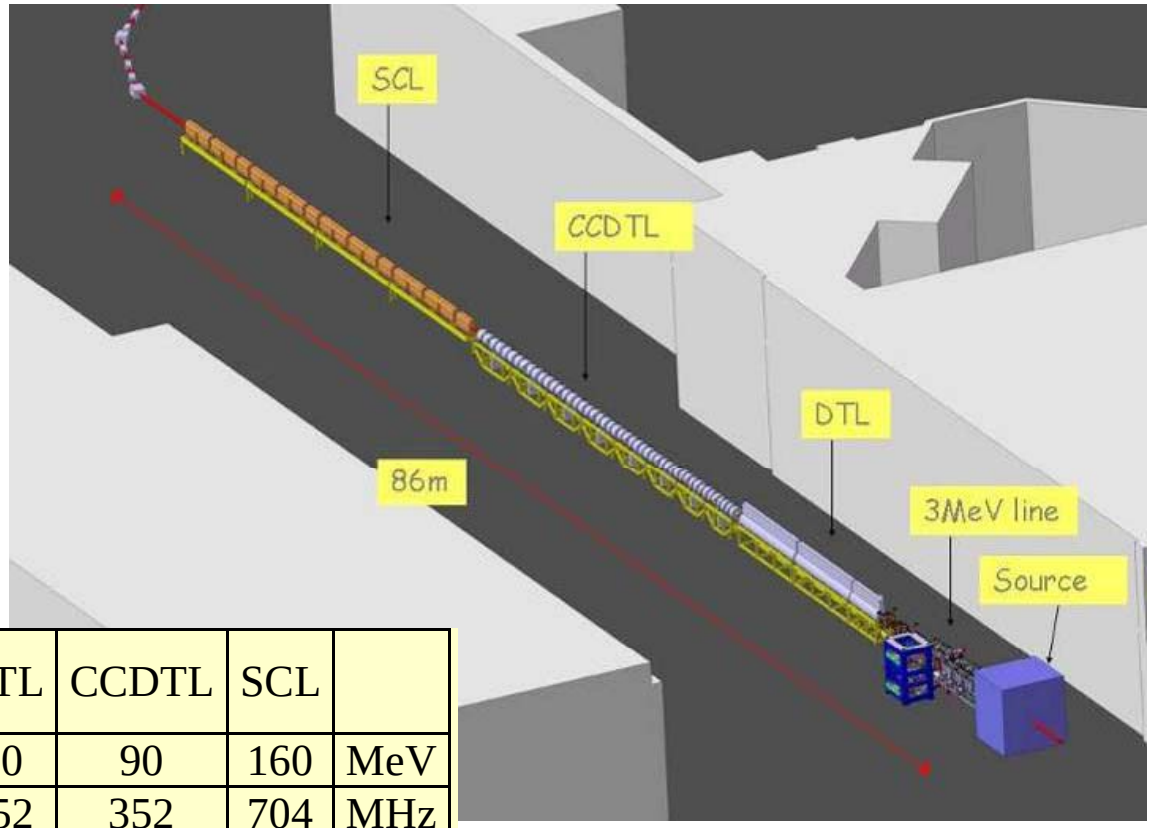


Linac4 in the new building - 2



The Linac4 accelerator

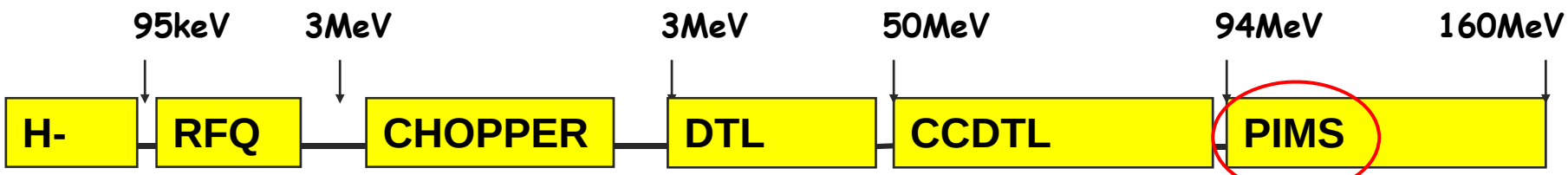
The linac (86 m) is made of an ion source followed by a sequence of accelerating structures, with focusing quadrupoles and diagnostics.



	RFQ	Chopper line	DTL	CCDTL	SCL	
Energy	3.0	3.0	40	90	160	MeV
Frequency	352	352	352	352	704	MHz
Current	70	40	40	40	40	mA
RF Power	1.0	-	3.9	6.4	12.5	MW
Klystrons	1	-	5	8	4	-
No. tanks	1	-	3	24	20	-
Length	5.95	3.7	13.4	25.2	28.0	m

Three structures are required for the main acceleration (3-160 MeV), to keep high RF efficiency.

Linac4 Layout



H-	RFQ	CHOPPER	DTL	CCDTL	PIMS
RF volume source (DESY) 35 kV Extrac. +60kV Postacc.	Radio Frequency Quadrupole (IPHI) 352 MHz 6 m 1 Klystron 1 MW	Chopper 352 MHz 3.6 m 11 EMquad 3 rf cavity	Drift Tube Linac 352 MHz 13.4 m 3 tanks 5 klystrons 4 MW 82 PMQuad	Cell-Coupled Drift Tube Linac 352 MHz 25.3 m 24 tanks 8 klystrons 6.5 MW 24 EMQuads	Pi-Mode Structure 352 MHz 27 m 12 tanks 6 klystrons ~12 MW 12 EMQuads

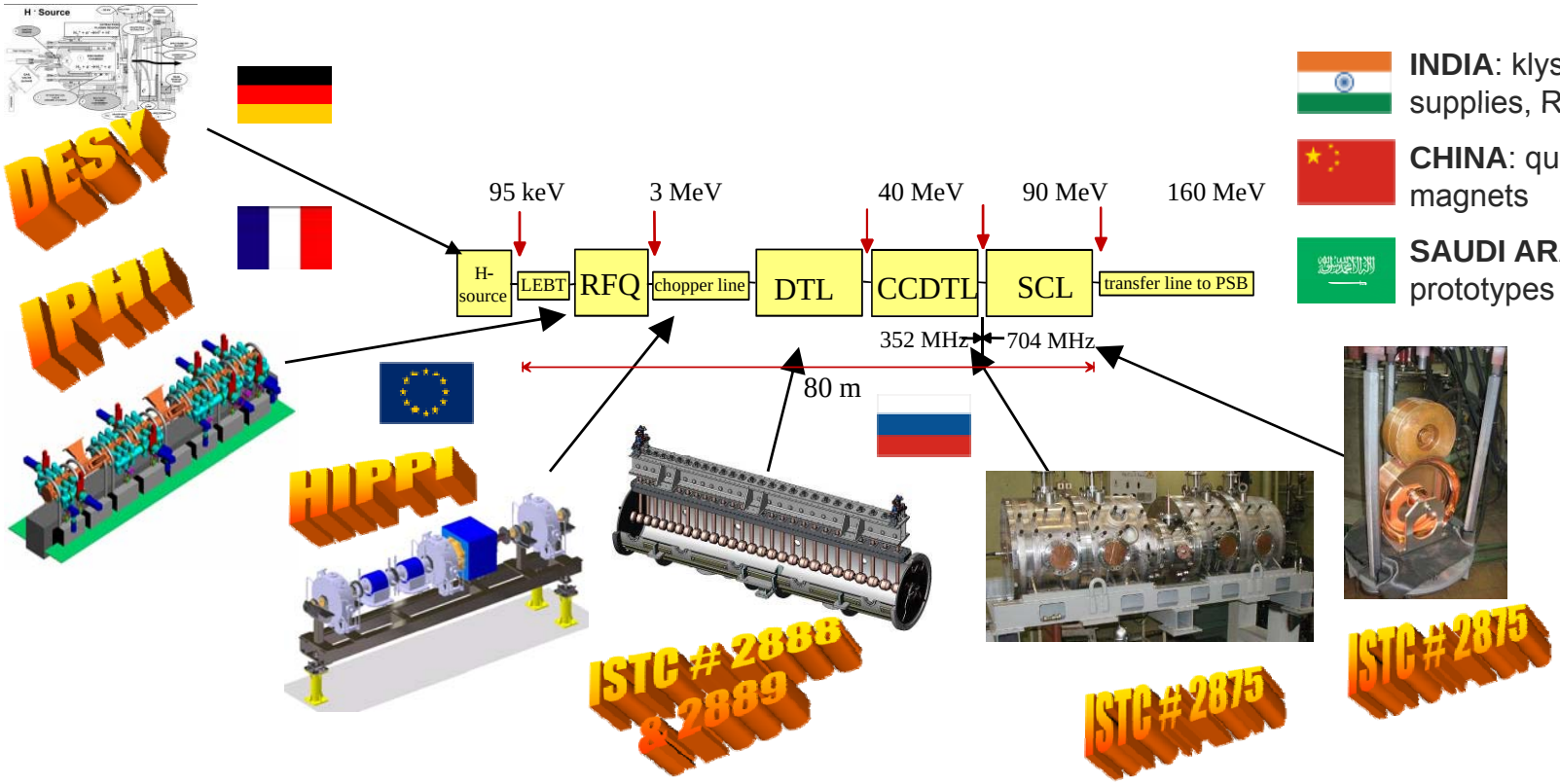
Total Linac4:
80 m,
18 klystrons

RF Duty cycle:
0.1% phase 1 (Linac4)
3-4% phase 2 (SPL)
(design: 10%)

4 different structures,
(RFQ, DTL, CCDTL, PIMS)

Ion current: 40 mA (avg. in pulse), 65 mA (bunch)

Linac4 R&D collaborations (2004-2007)



Network of collaborations for the R&D phase, via EU-FP6, CERN-CEA/IN2P3, ISTC (CERN-Russia), CERN-India and CERN-China agreements.

Preparation in view of future international participation to the construction of Linac4

Linac4 Schedule

- Preparation (contracts, material): 6/2007 – 6/2008
- Construction: 6/2008 – 12/2010
- Installation and commissioning: 2011
- PSB upgrade: 11/2011 – 3/2012
- Start-up with the new injector: 4/2012

After the latest information on the building, will probably move by 1 year → Linac installation and commissioning 9/2010-12/2011
PSB upgrade 10/2011-3/2012
Start-up 4/2012

The 3 MeV test stand in construction will be extended and used to test critical components.

1st critical deadline: building design (dimensions, electrical and cooling requirements) to be frozen by end September 2007 → preliminary definition of all components on the machine!

Linac4 challenges

1. Main challenge of Linac4 is RELIABILITY (~6000 hours/year with fault rate comparable to Linac2, ~1.5% of scheduled beam time).
2. Control of EMITTANCE GROWTH is of paramount importance for clean PSB injection.
3. Careful LOSS CONTROL is important to prepare for the SPL mode of operation $\rightarrow$ for 1 W/m distributed loss in SPL mode, losses lower than 0.1 W/m in PSB injection mode (at 160 MeV, $1.5*10^{-5}$/m loss rate).

Linac4 challenges for BI

2 conflicting requirements:

- Space charge (the main beam dynamics concern for a proton linac) imposes short distances between focusing elements.
- Control of emittance growth and of beam losses requires sophisticated diagnostics in the main part of the linac.

→ Need of SPECIAL DIAGNOSTICS elements that fit in the short distances allowed by the beam dynamics.