Linac4 accelerating structures

status and installation plan

F. Gerigk, PIMS collaboration meeting, 26/27 Feb 2013

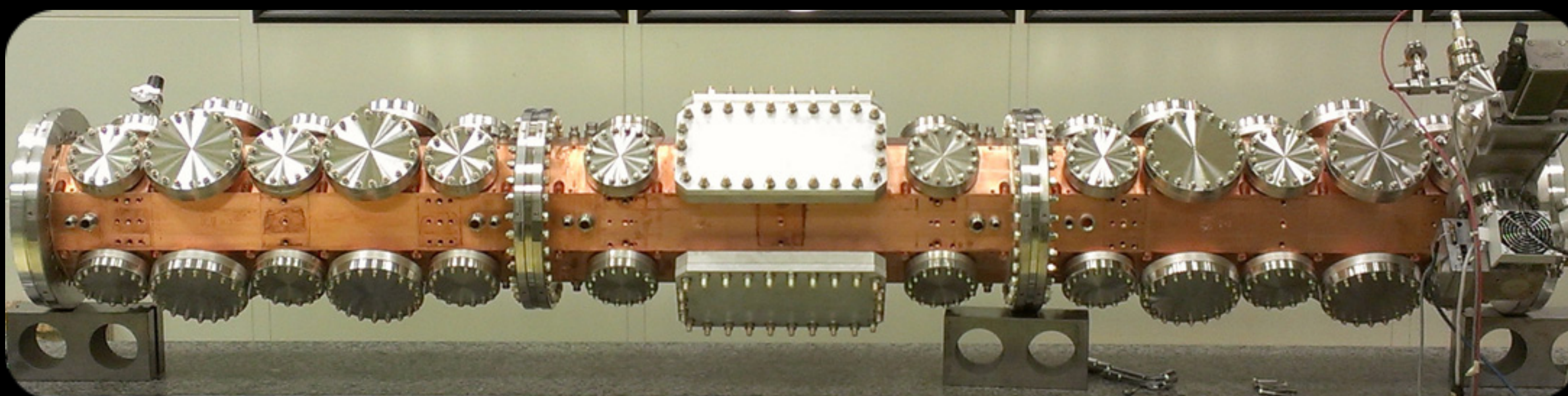
RFQ

(project eng: C. Rossi)

design (CEA/CERN) and construction (CERN): 2009 - 2012

Parameter	Value
frequency	352.2 MHz
length	3.06 m
vane voltage	78.27 kV
maximum aperture a	1.8 mm
maximum modulation	2.36
average aperture r_0	3.3 mm
ρ/r_0	0.85

Parameter	Value
min. longitudinal radius	9 mm
max field on pole tip	34 MV/m
Kilpatrick	1.84
focusing parameter	5.7
acceptance at I=0 mA	1.7 π mm mrad
final synchronous phase	-22 deg



High-power conditioning has started last week at the CERN 3 MeV test stand.

DTL

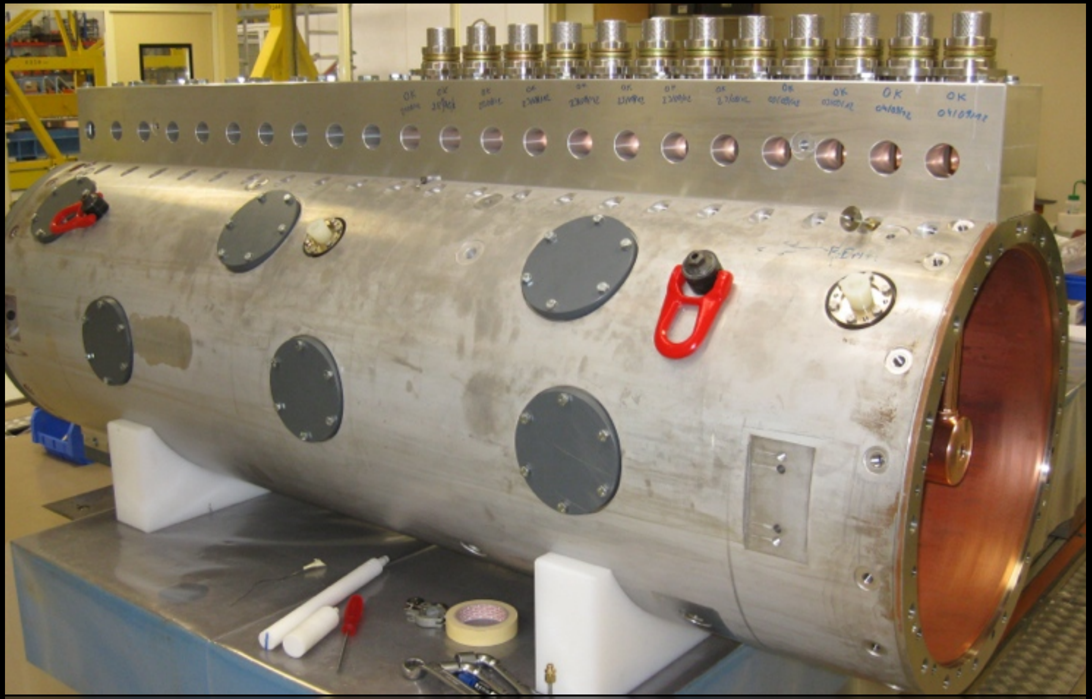
Drift Tube Linac

project eng: S. Ramberger

construction: industry + collaboration (ESS Bilbao)

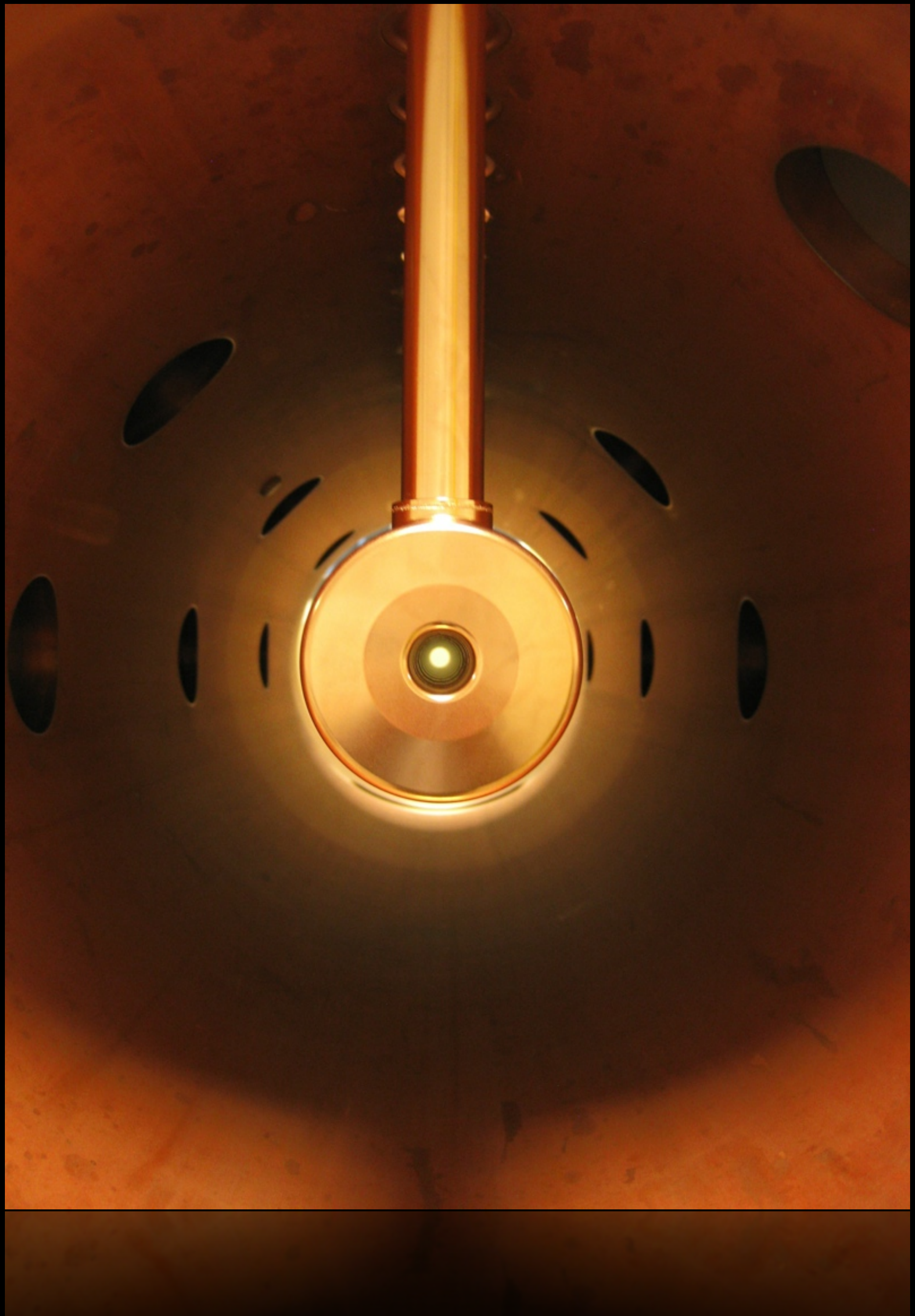
Parameter	Value
frequency	352.2 MHz
energy range	3 - 50.3 MeV
E_0T	2.65 - 2.95 MV/m
synchronous phase	-30 → -26 deg
ZT^2 (linac def., operational value)	44 - 52 MΩ
Q_0 (measured, av. p. module)	~39000 - 43000
cavity length	3.8 - 7,3 m
number of cavities	3
total number of drift tubes	108
peak power/cavity	1/2/2 MW
Kilpatrick	< 1.6

DTL highlights



- Rigid (5 cm thick) steel tanks assembled from <2 m long segments.
- PMQs in vacuum for streamlined drift tube assembly (SNS technology).
- Adjust & Assemble: Tightly toleranced Al girders w/o adjustment mechanism.
- Design for zero maintenance (no diagnostics/steering/EMQs inside DTs).
- Spring loaded metal gaskets for vacuum sealing and RF contacts.
- Easy-to-use mounting mechanism filed for patent.
- Increased gap spacing in first cells to reduce peak fields and potential breakdowns in PMQ fields.

DTL assembly status



- The first tank segment is copper plated and assembled with girder and drift tubes.
- Drift tube installation takes 10 min/ item thanks to metal gaskets and (“automatic”) alignment.
- Vacuum leak tight.
- First tank completed by summer 2013 to be high-power tested.
- Tank 2&3 to be assembled and tested in 2013.

timeline DTL:

2004	start of a collaboration with VNIIEF and ITEP (Russia) for the design and construction of Linac4 DTL tank
2005	decision to use PMQs
2006-7	start of mechanical design at CERN
2008	**construction of DTL prototype in collaboration with INFN Legnaro**
2009	**successful high-power testing of the CERN/INFN prototype**
2010	filing of patent on the "mounting mechanism" to position drift tubes
2008-10	purchase of **30 tons of raw material (~3000 pieces** of stainless steel cylinders, Cu drift tubes/stems, Al girders, flanges, etc)
2011	**start of construction of tanks (industry) and drift tube parts (collaboration with ESS-Bilbao)**
2012	start of girder construction in industry
autumn 2012	first tank segment assembled
2013	completion of first tank and high-power testing, assembly and tuning of tank 2,3, low-power testing of tank 2,3
2014	**installation in Linac4 tunnel and high-power testing of tank 2,3**

CCDTL

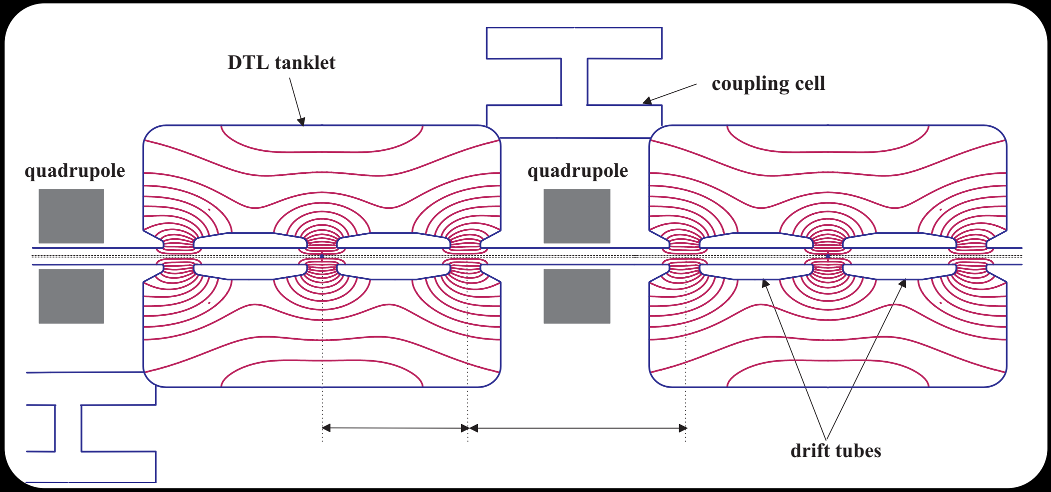
Cell-Coupled Drift Tube Linac

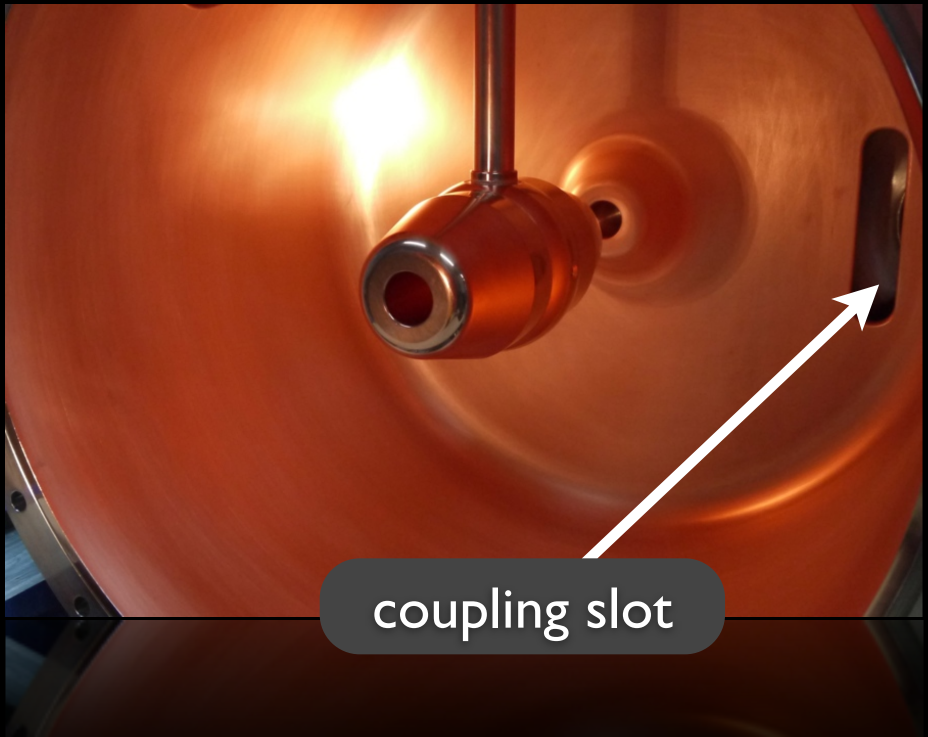
Parameter	Value
frequency	352.2 MHz
energy range	50.3 - 102.9 MeV
E_0T	3.6 - 2.7 MV/m
synchronous phase	-20 deg
ZT^2 (linac def., operational value)	40 - 33 MΩ
Q_0 (measured, av. p. module)	~41000 - 44000
cavity length	0.7 - 1.04 m
number of modules	7
cavities per module	3
accelerating gaps per cavity	3
total number of drift tubes	42
peak power/cavity	950 - 1000 kW
Kilpatrick	<1.8

design & construction: BINP, VNIITF

project eng: A. Tribendis (BINP)

CCDTL highlights

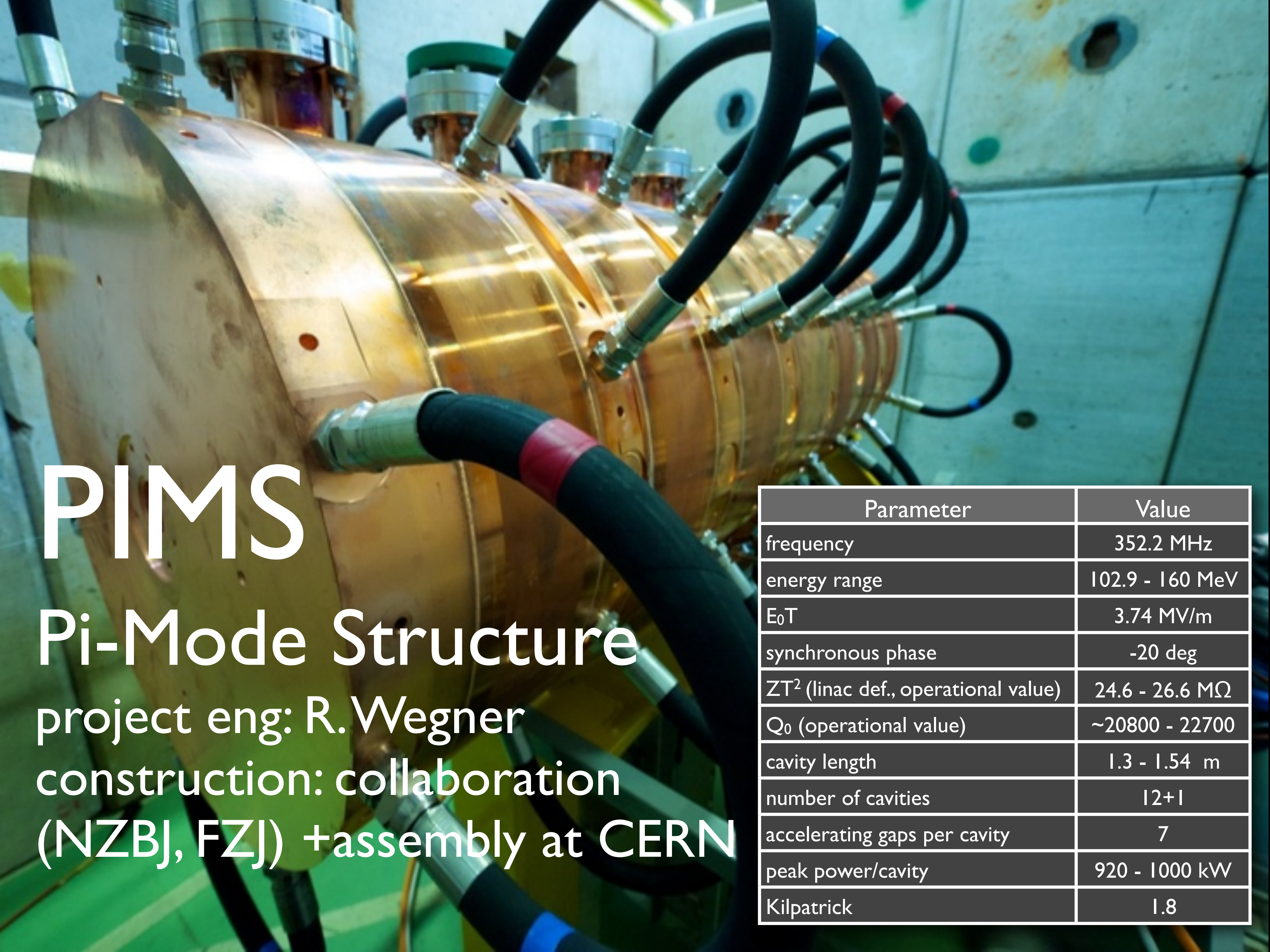




- **First ever use of a CCDTL in an operational machine!**
- 3 tanks/9 gaps per module
- **Alignment** of quads outside of RF structure (easy access),
- **Alignment** of complete module (3 cavities) on support (beam apertures within ±0.3 mm) via mechanical means (successfully tested).
- coupling cell dimensions remain constant for all modules,
- 8 technical meetings (5 in Russia, 3 at CERN),
- France - CERN - Moscow - VNIITF (Snezhinsk) - BINP - Moscow - CERN: **13000 km** until the raw steel has been transformed into cavities,

timeline CCDTL:

1994	J. Billen, F. Krawczyk, R. Wood, L. Young: "A new RF structure for Intermediate Velocity particles"
2000	Conceptual CCDTL design for new proton linac at CERN
2001	13-cell **cold model** in aluminum
2004/5	design/construction of **CERN prototype**: 2 half tanks + 1 coupling cell
2006	successful high-power testing of CERN prototype
2006	construction of **prototype** with 2 complete tanks + coupling cell in Russia (BINP/VNIITF) within **ISTC** contract
2007	**successful high-power testing** of ISTC prototype at CERN
2009	**start of** ISTC **contracts** to construct 7 CCDTL modules for Linac4
Jan. 2010	shipping of **46 tons of raw material (in ~1500 pieces) to Russia**
Nov. 2011	successful vacuum and low-power tests of first complete module at BINP
autumn 2012	**delivery and assembly of first 2 modules to CERN + high power test of first module**
March 2013	assembly of module 3 and 4, high-power test of module 2
May 2013	delivery and assembly of remaining modules to CERN, installation of first module(s) in the Linac4 tunnel



PIMS

Pi-Mode Structure

project eng: R. Wegner
construction: collaboration (NZBJ, FZJ) +assembly at CERN

Parameter	Value
frequency	352.2 MHz
energy range	102.9 - 160 MeV
E_0T	3.74 MV/m
synchronous phase	-20 deg
ZT^2 (linac def., operational value)	24.6 - 26.6 MΩ
Q_0 (operational value)	~20800 - 22700
cavity length	1.3 - 1.54 m
number of cavities	12+1
accelerating gaps per cavity	7
peak power/cavity	920 - 1000 kW
Kilpatrick	1.8

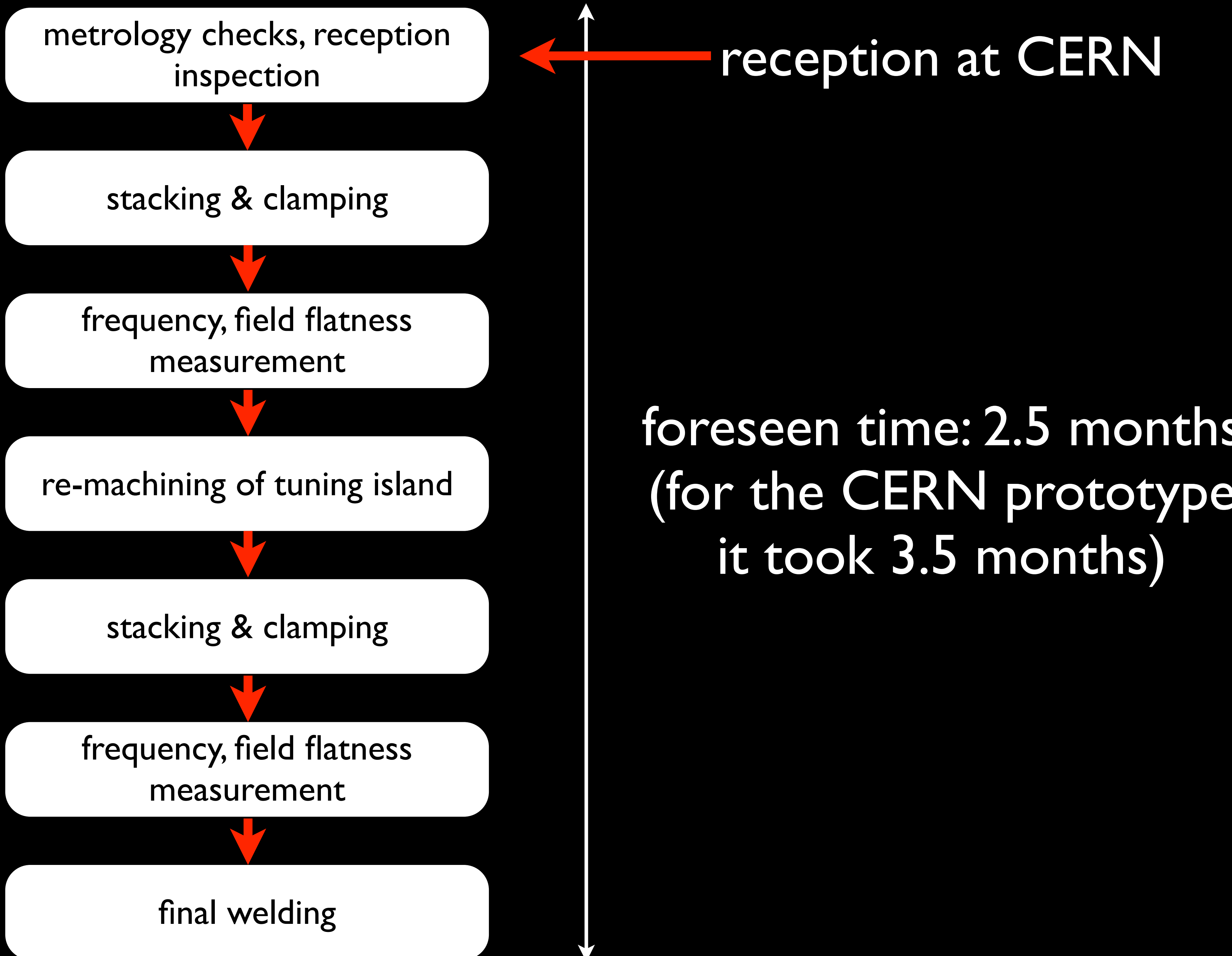
PIMS highlights

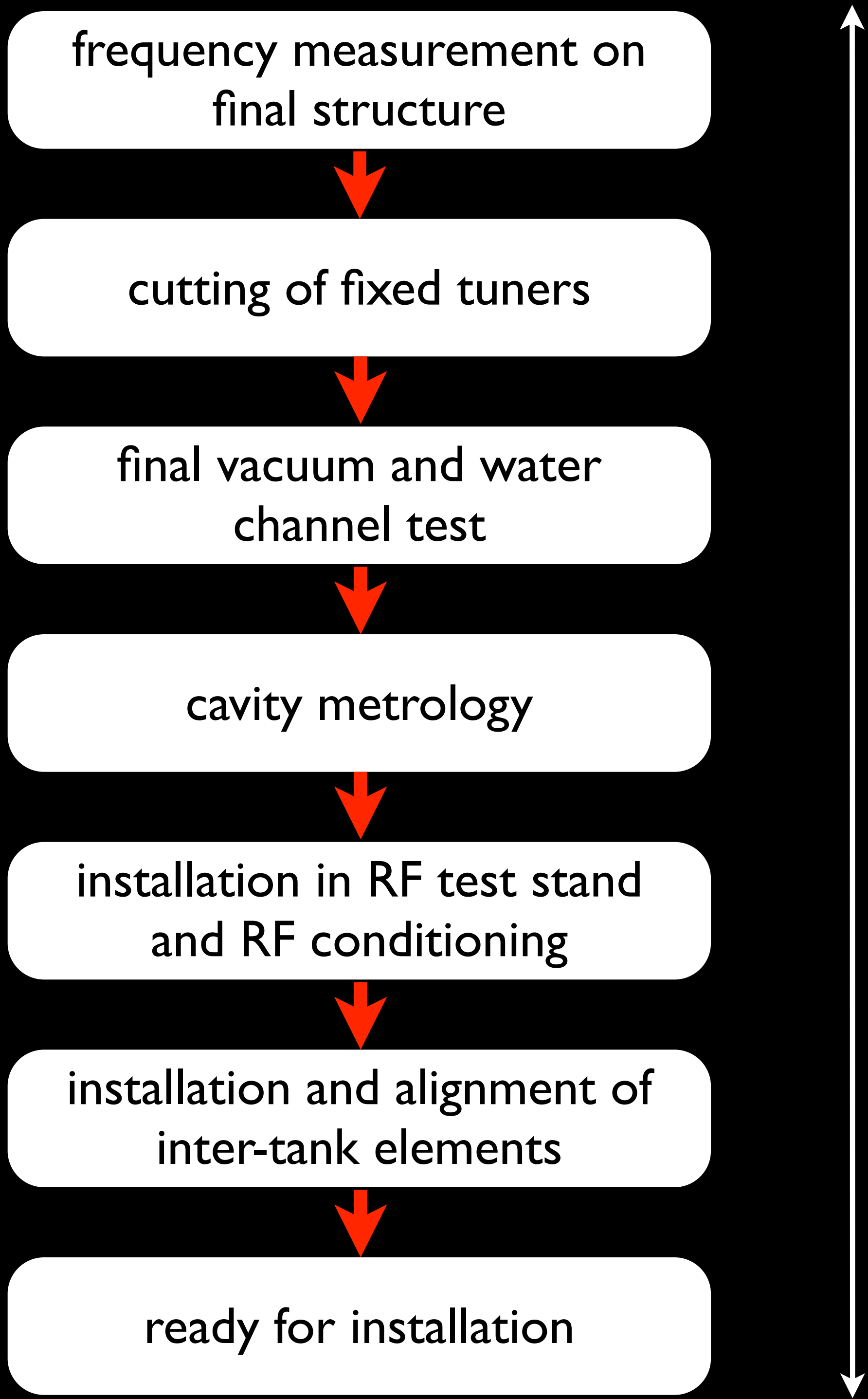
- same RF frequency (352.2 MHz) as the rest of Linac4,
- 7 cell pi-mode design with strong cell-to-cell coupling (~5%),
- **first-ever use of PIMS in proton linac,**
- coupling slot design optimized for high shunt impedance,
- high power tested 60% above nominal peak fields!
- assembly of discs and rings via EBW to avoid loss of material rigidity during brazing,

timeline PIMS:

1977	5-cell pi-mode structure used in PEP storage ring (electrons) at SLAC (353.2 MHz)
1989	5-cell pi-mode structure used in LEP (electrons) at CERN (352.2 MHz)
2007	**Decision to use PIMS to replace the Side-Coupled Linac (704 MHz)** between 100 - 160 MeV in Linac4 for **low-β proton acceleration**
2007	tendering for 3D forged OFE copper for PIMS construction
2007/8	construction and measurements on scaled **aluminum cold model**
2008	order of 26 t of 3D forged OFE copper (last piece delivered: Nov 2011)
2009/10	design and construction of full size **PIMS prototype at CERN**
2010	**successful high-power testing** at CERN and decision to use prototype as first PIMS cavity in Linac4
Nov. 2010	collaboration with **NCBJ** (National Centre for Nucl. Research, **Poland**, formerly Soltan Inst.) and **FZJ** (Forschungszentrum Jülich, **Germany**) for the construction of 12 PIMS cavities.
Jan. 2011	first shipment of altogether **31 tons of raw material (~1500 pieces)** to Poland
Aug. 2012	most machining and welding operations are qualified, ~half of the discs and rings are rough-machined
summer 2013	**delivery of first series cavity to CERN**, assembly (EBW), tuning and subsequent high-power testing at CERN,
October 2014	delivery of last PIMS cavity to CERN

BINP, Novosibirsk	**CCDTL:** design & construction
CEA, Saclay	**RFQ:** mech. design & measurements
ESS, Bilbao	**DTL, jacks, RF coupler:** production of DTL drift tubes, support for market survey of Spanish industry,
FZJ, Jülich	**PIMS:** port weldings (EBW)
INFN, Legnaro	**DTL**: collaboration on prototype construction, **movable tuners:** construction
ISTC, Moscow	**CCDTL:** contract framework with BINP/VNIITF, financing, customs procedures in Russia
KACST, Riyadh	**DTL:** construction of cold model
NCBJ, Swierk	**PIMS:** machining of all pieces
RRCAT, Indore	**RF coupler**: prototyping & construction
VNIITF, Snezhinsk	**CCDTL**: design & construction
VNIIEF, Sarov	**DTL:** preliminary mechanical design
ITEP, Moscow	**DTL:** preliminary designs

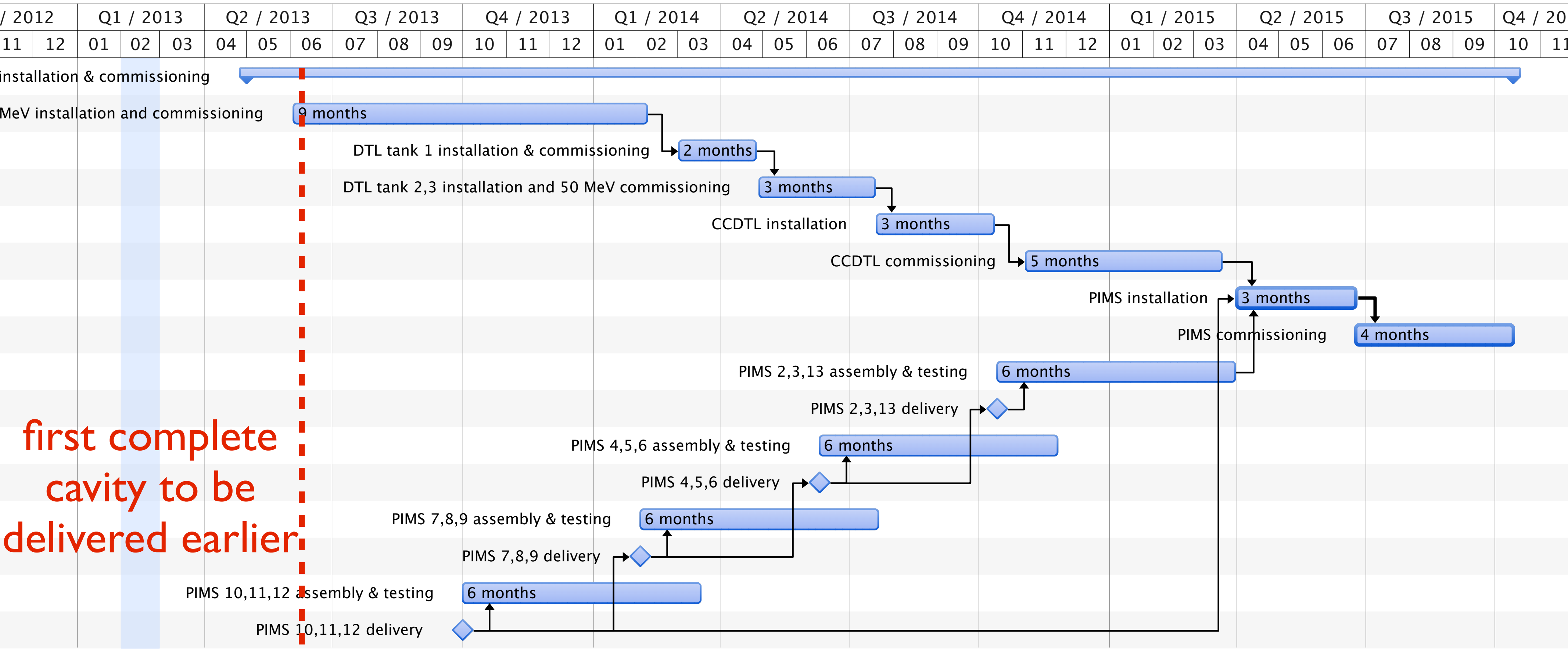

metrology checks, reception inspection
stacking & clamping
frequency, field flatness measurement
re-machining of tuning island
stacking & clamping
frequency, field flatness measurement
final welding
reception at CERN
foreseen time: 2.5 months
(for the CERN prototype
it took 3.5 months)



foreseen time:
2 months

If we receive batches of 3 cavities, we assume that they can be assembled and tested within ~6 months at CERN.

Installation schedule



The first 3 cavities have to be at CERN by 1. September 2013 to be followed by **1 cavity/1.5 months**.
First cavity to be completed by 1. June 2013!