Status of CTF3

G.Geschonke
CERN

CLIC Test Facility CTF3

Provide answers for CLIC specific issues

➔ Write CDR in 2010

Two main missions:

Prove CLIC RF power source scheme:
- bunch manipulations, beam stability,
- Drive Beam generation
- 12 GHz extraction

Demonstration of “relevant” linac sub-unit:
- acceleration of test beam

Provide RF power for validation of CLIC components:

accelerating structures,

RF distribution,

PETS (Power extraction and Transfer Structure)

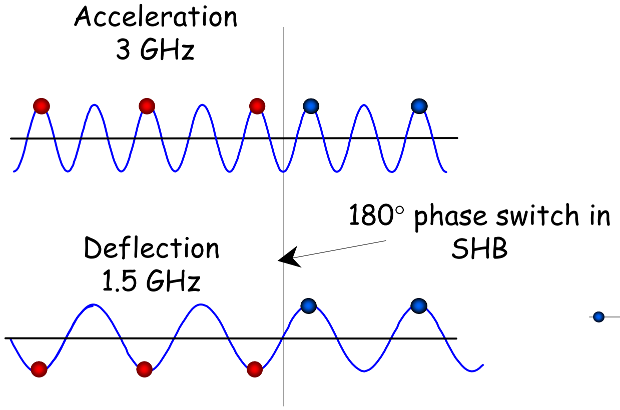
Drive Beam generation in CTF3

Principle: A long high intensity bunch train (1.4 μs) is accelerated with 3 GHz

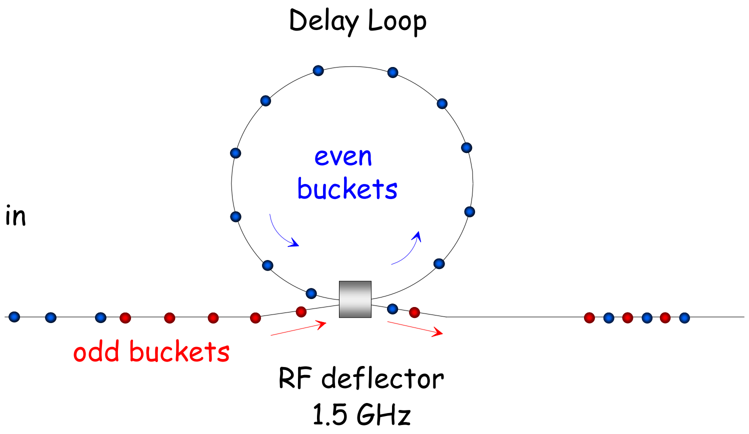
Bunch manipulations increase bunch repetition frequency

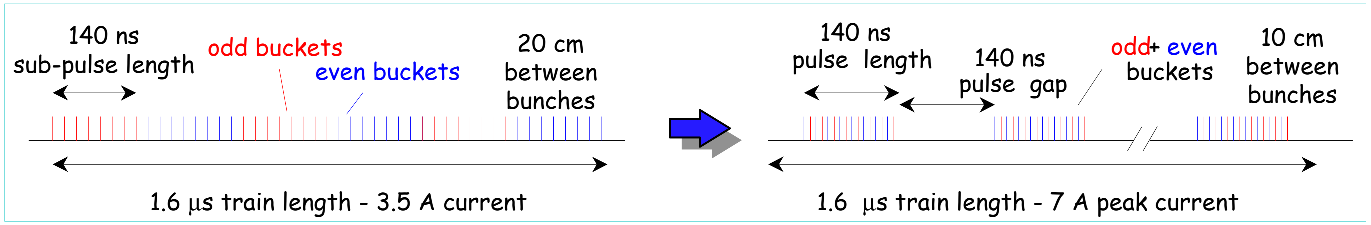
and increase peak current

"Phase-coding" of bunches



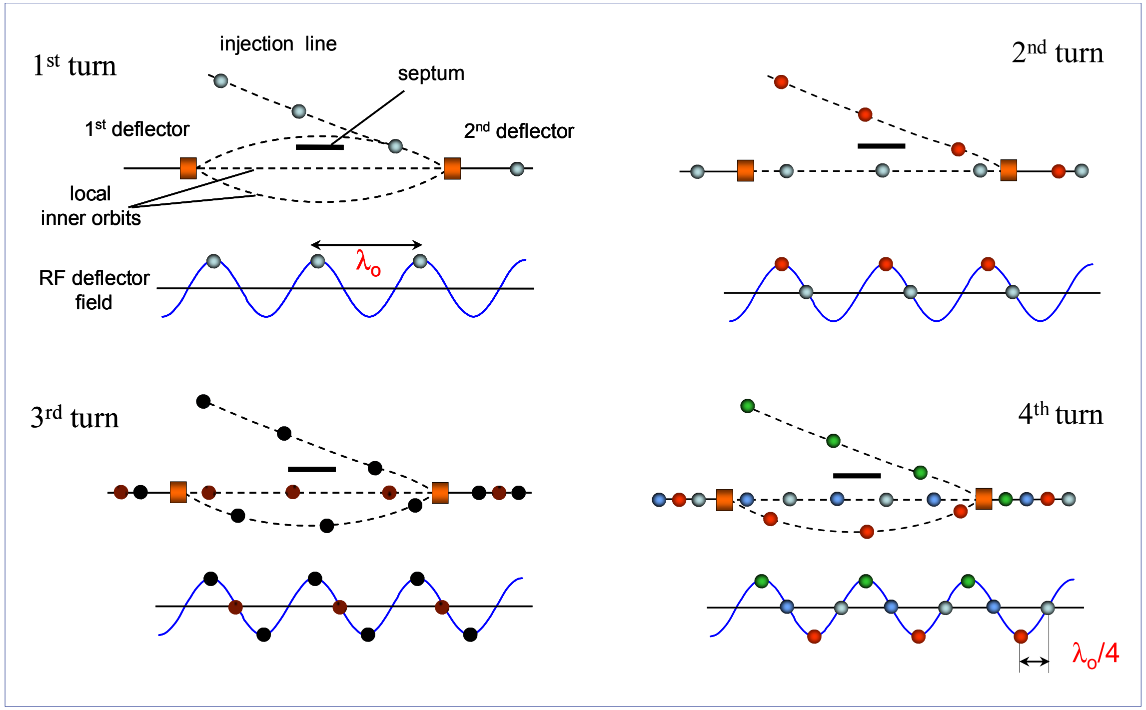
bunch interleaving with **Delay Loop**

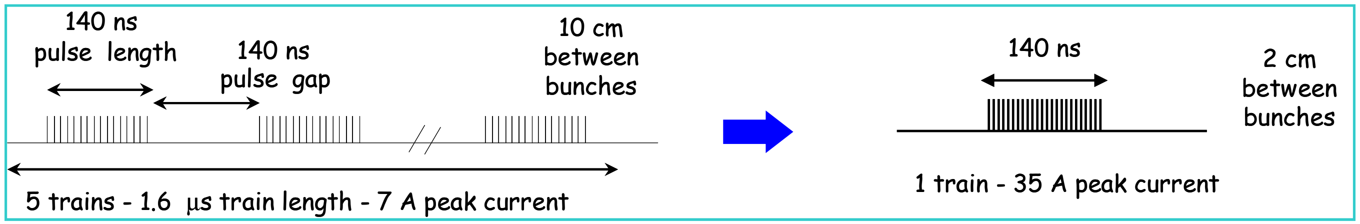




Drive Beam generation

successive injection of 4 bunch trains into **Combiner Ring**





CTF3 - CLIC

CTF3 is scaled down from CLIC:

	CLIC	CTF3
Drive Beam energy	2.4 GeV	150 MeV
compression / frequency multiplication	24 (Delay Loop + 2 Combiner Rings)	8 (Delay Loop + 1 Combiner Ring)
Drive Beam current	4.2 A*24 → 101 A	3.5 A*8→ 28 A
RF Frequency	1 GHz	3 GHz
train length in linac	139 μs	1.5 μs
energy extraction	90 %	~ 50 %

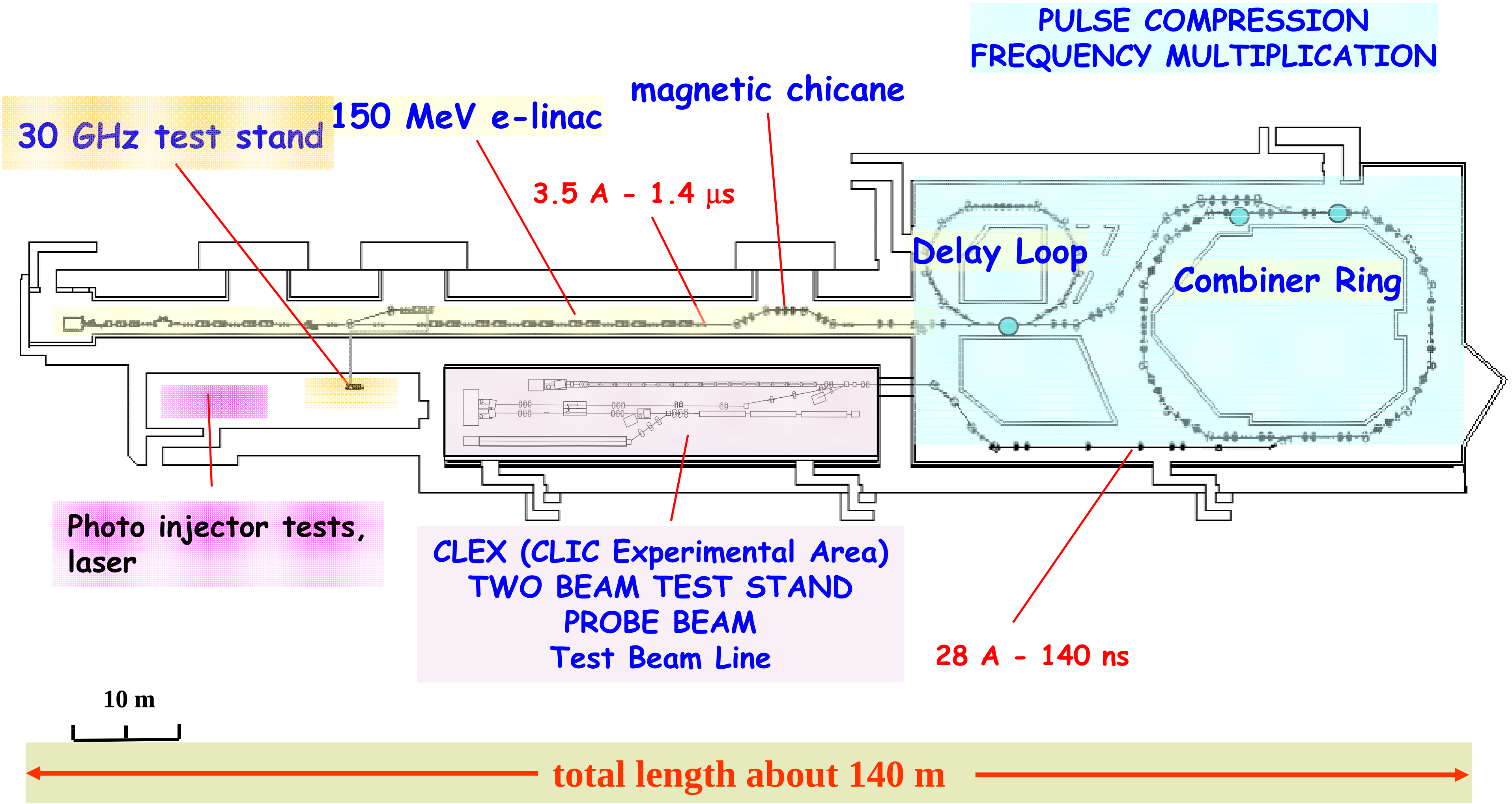
CTF3 uses existing infrastructure from LEP injector:

Building, infrastructure,

3 GHz RF power plant,

CTF3 building blocks

Infrastructure from LEP



Present CTF3 status

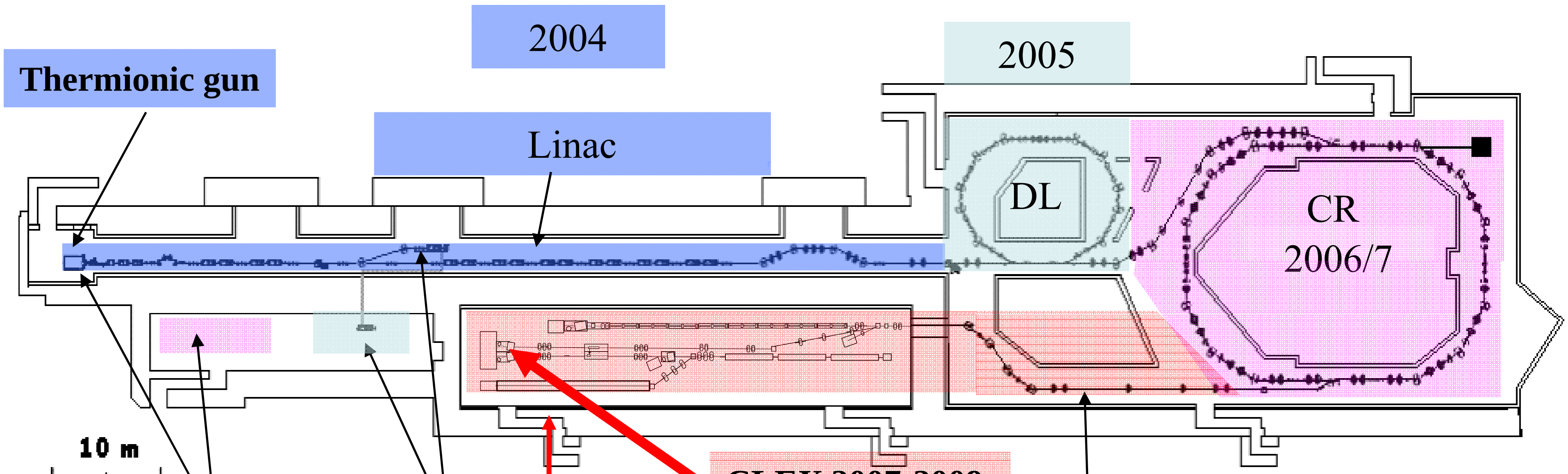


Photo injector / laser tests from Oct. 2008

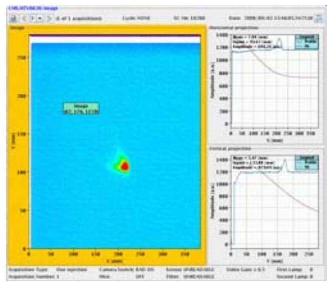
30 GHz production (PETS line) and test stand

CLEX 2007-2009 building in 2006/7

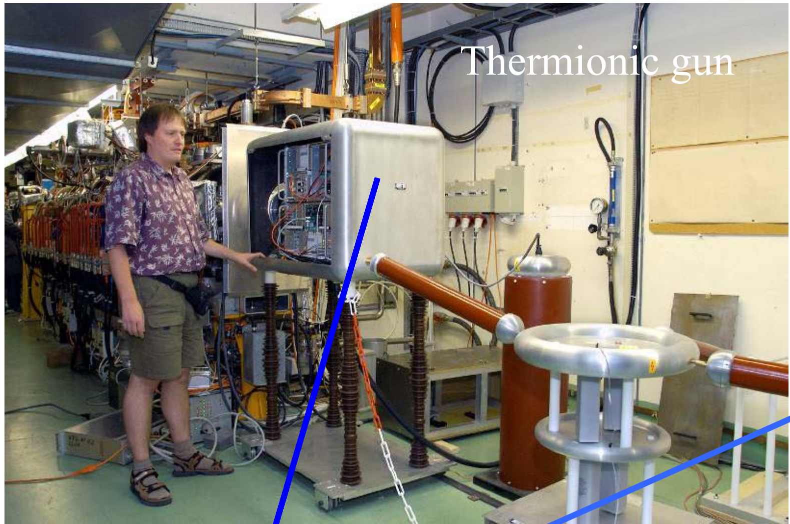
TL2 2008

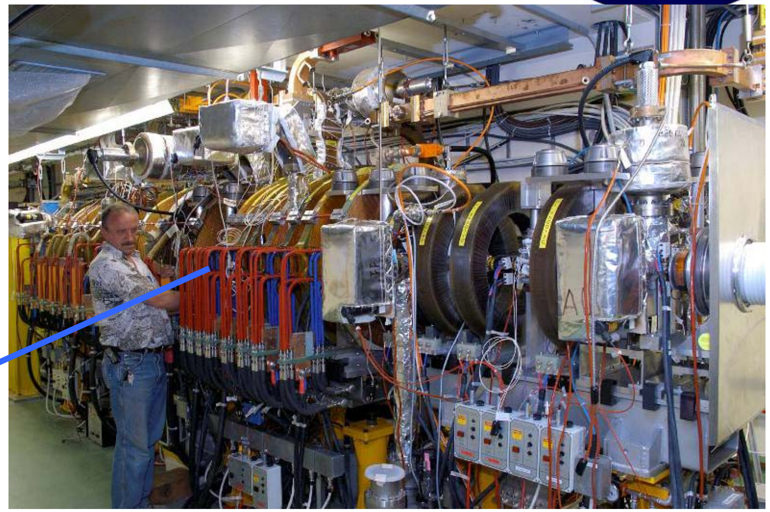
CLEX building:
Everything installed (except TBL)
Commissioning started

Beam up to here

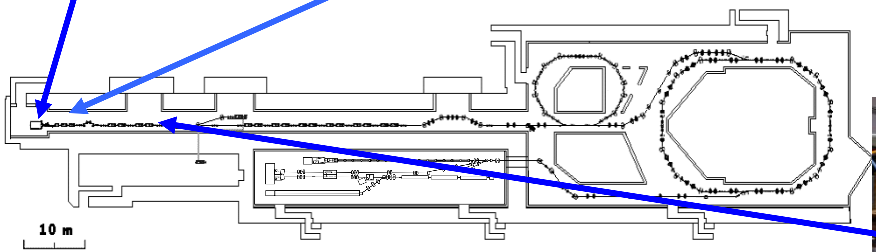


CTF3 Installation





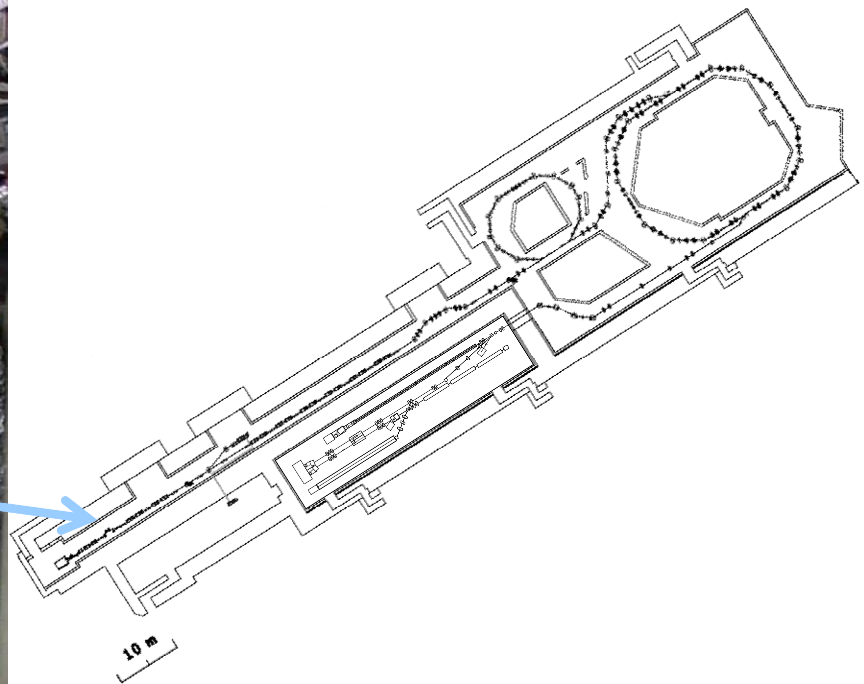
Injector solenoid



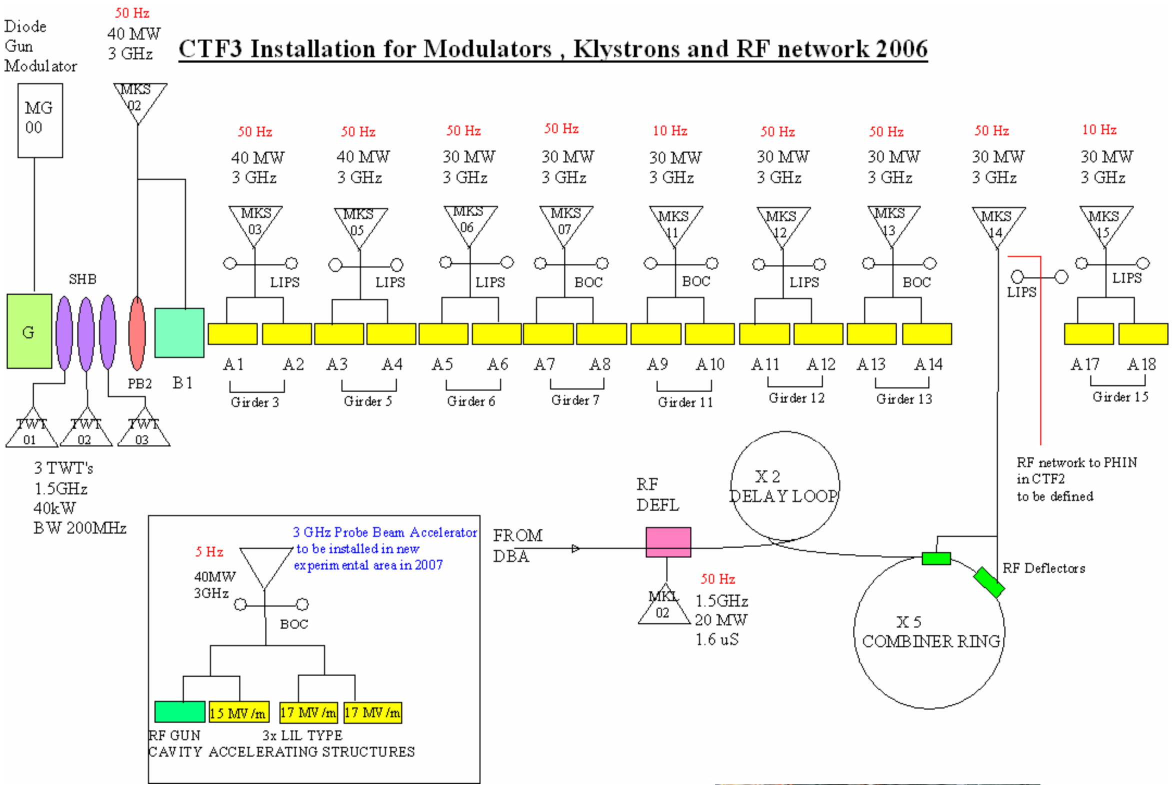
Thermionic gun
- 10 A max,
- after bunching
  - 3.5 A nominal, max. 7 A
- one sw and one tw buncher
- three 1.5 GHz bunchers

Magnetic chicane

Injector and Linac



RF power plant



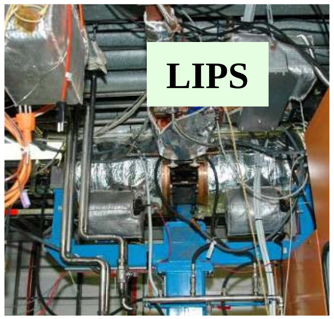
11 s-band klystrons 3 GHz
35 – 45 MW, 5.5 µs

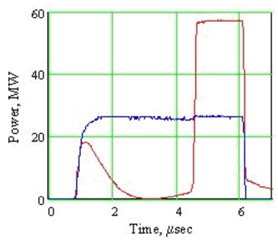
9 with pulse compressors:
factor 1.9 – 2 (1.6 µs)

3 L-band travelling wave tubes
40 kW, 3 µs
1.5 GHz BW >200 MHz

1 L-band klystron
22 MW, 5.5 µs

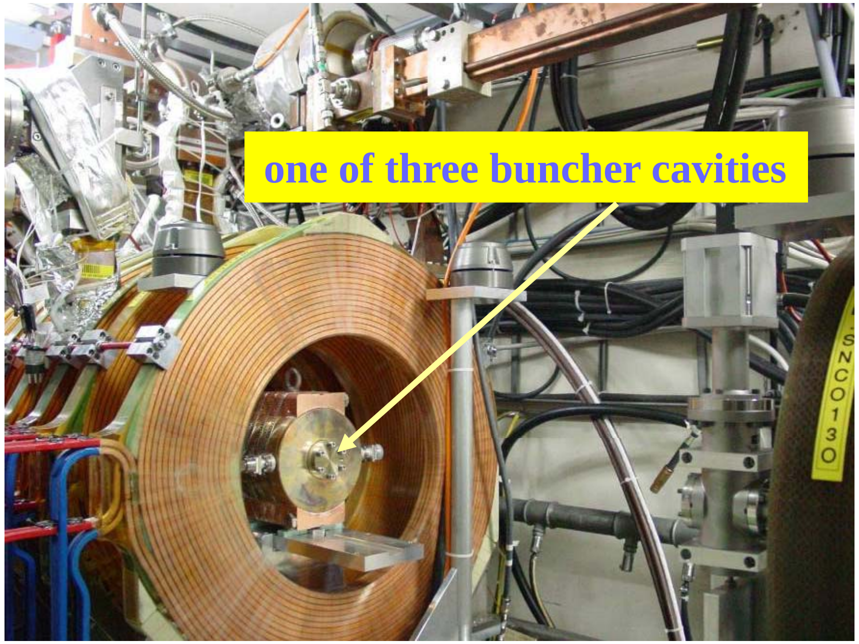
RF Pulse compression

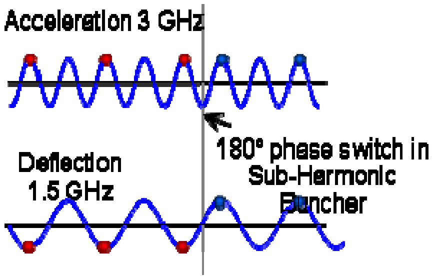


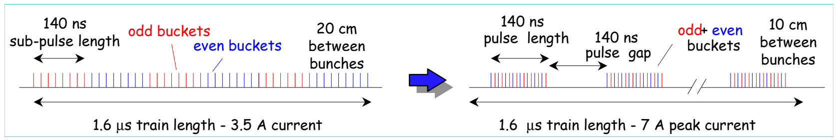


phase error: 6 deg
amplitude: ±1%

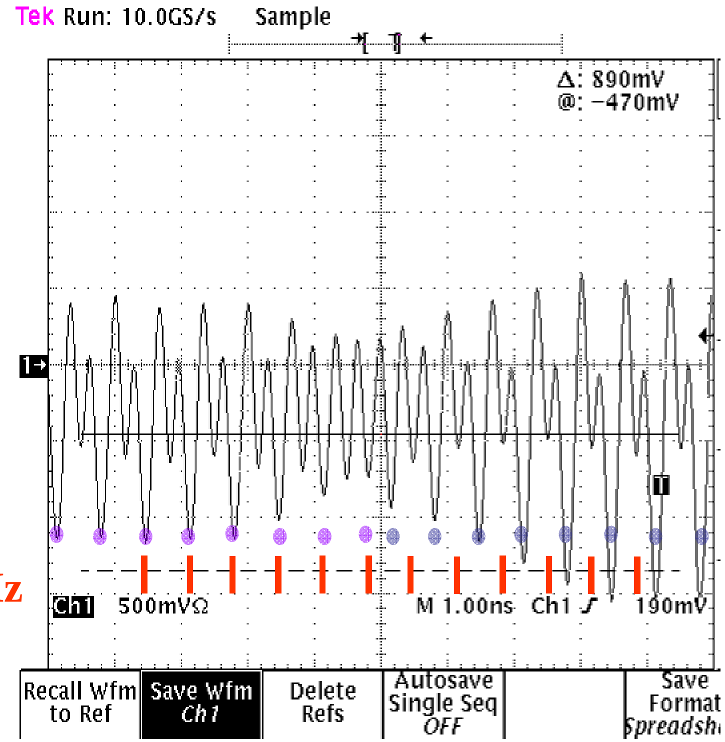
Sub-harmonic bunching / phase coding







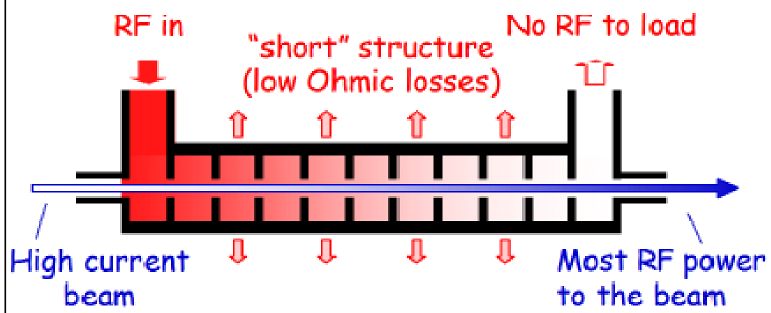
1.5 GHz



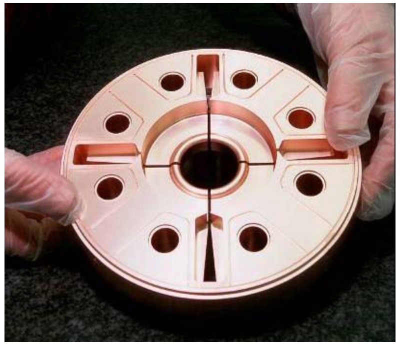
Switching transient about 7 bunches

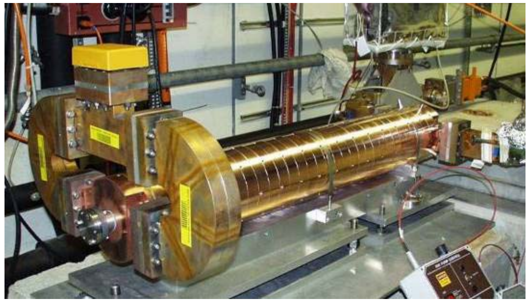
Full Beam loading

Proof of one of the major CLIC features:
Full Beam Loading

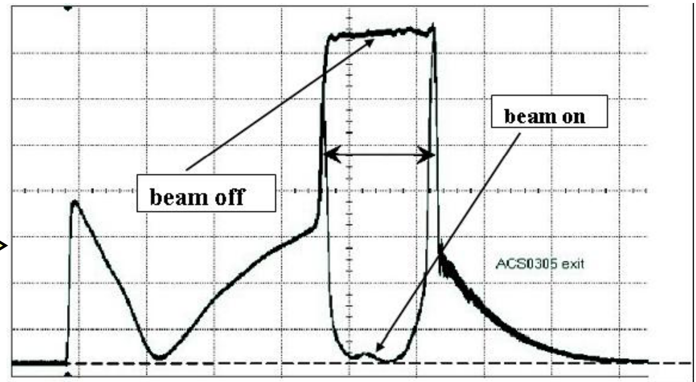


Drive Beam accelerating structure:





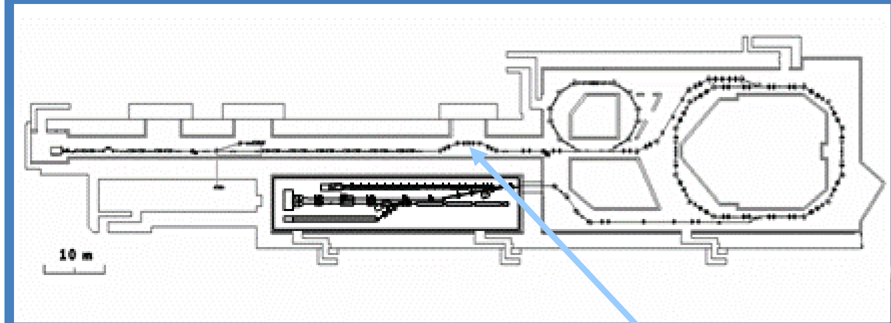
RF to beam transfer:
95.3 % measured



RF power at output of accelerating structure

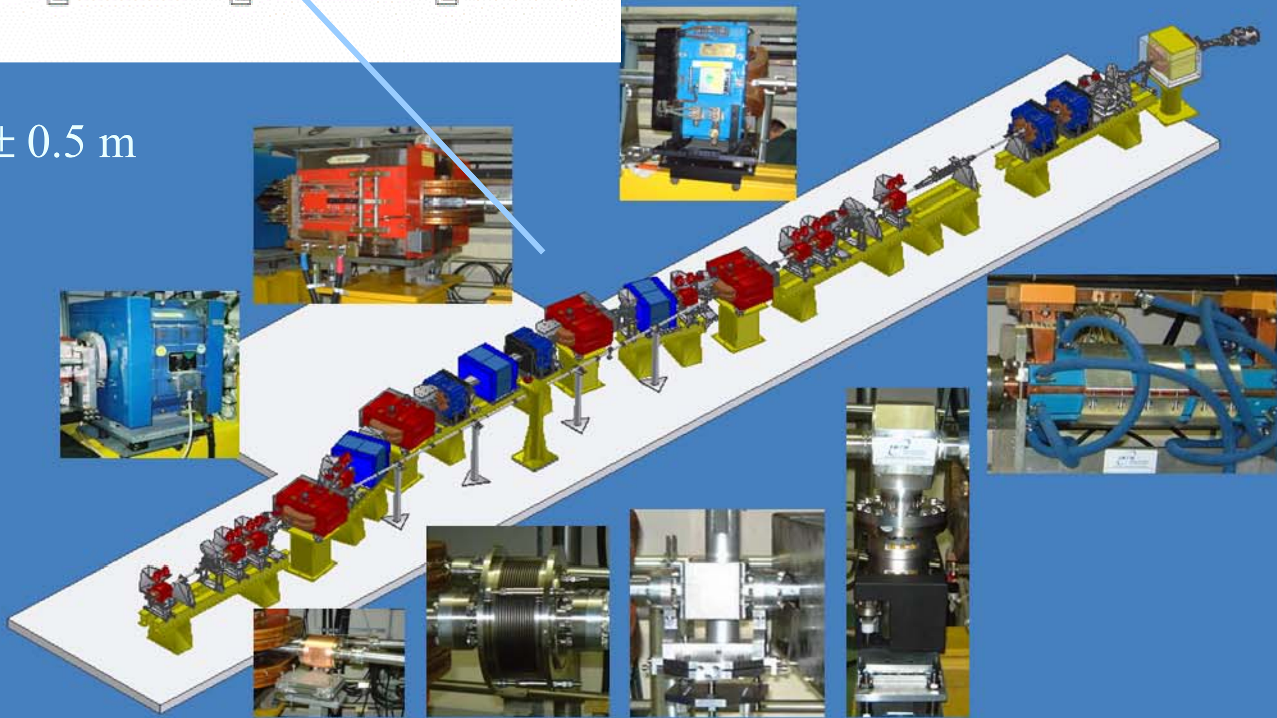
Linac routinely operated with full beam loading

Bunch Stretcher – Compressor Chicane



Built by INFN Frascati

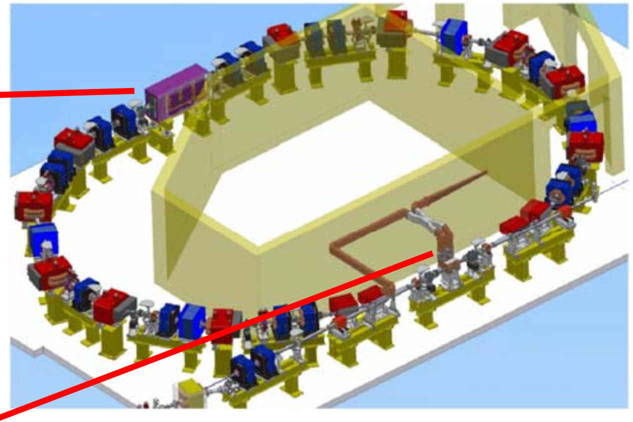
R_{56} between ± 0.5 m

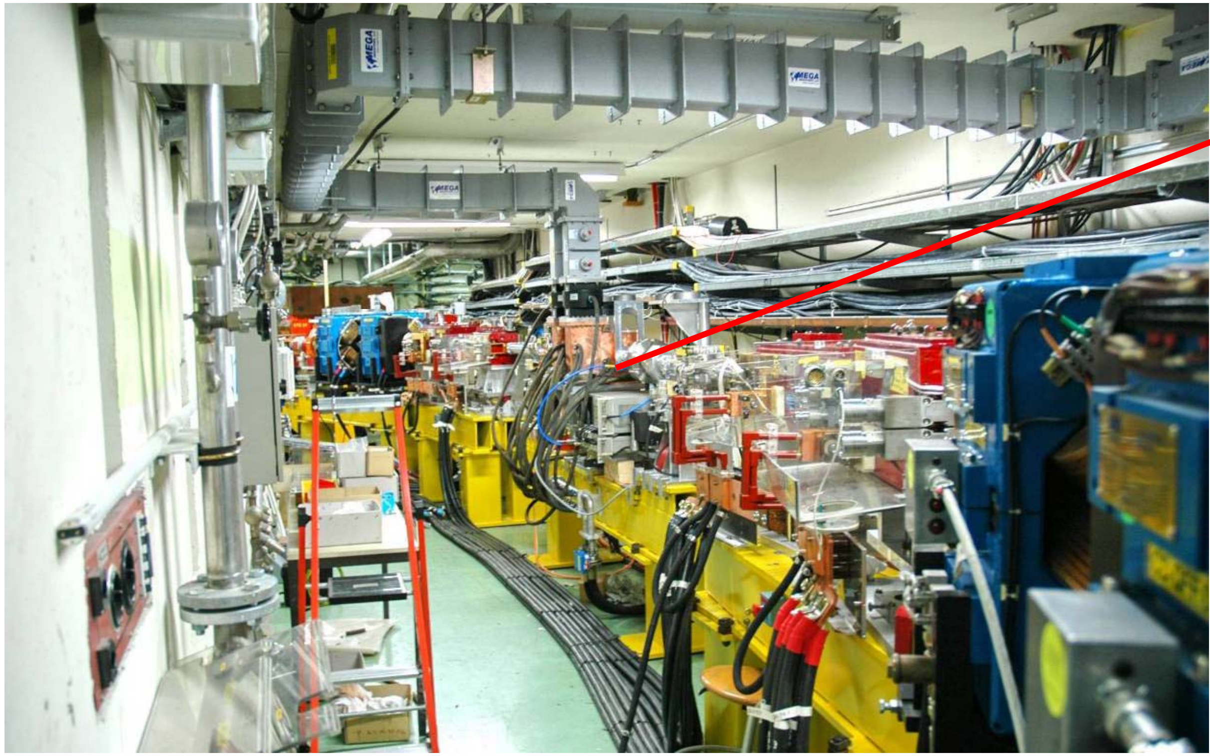


Delay Loop

Designed and built by INFN Frascati

circumference 42 m (140 ns)
isochronous optics
wiggler to tune path length
(9 mm range)

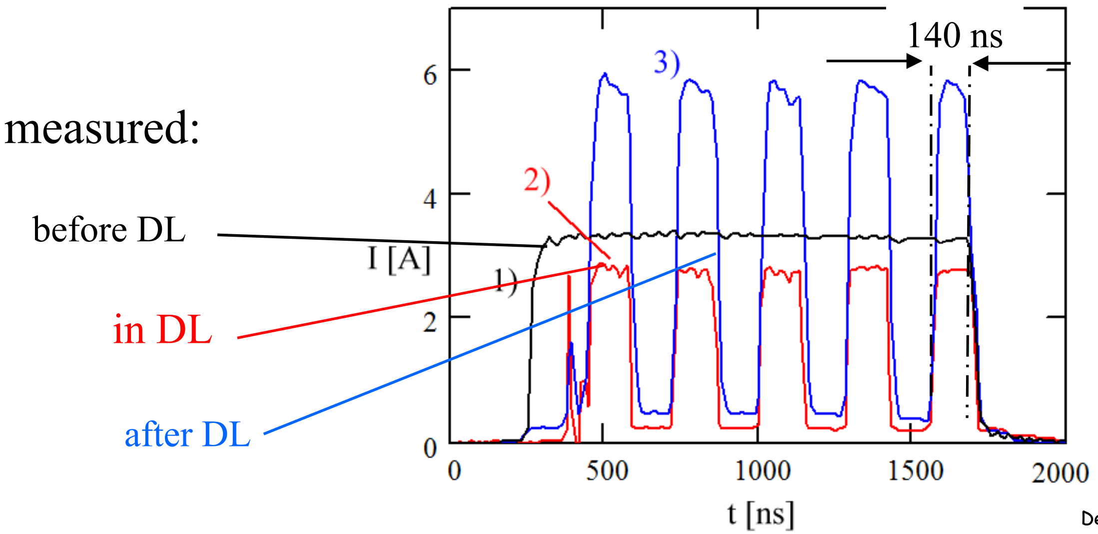


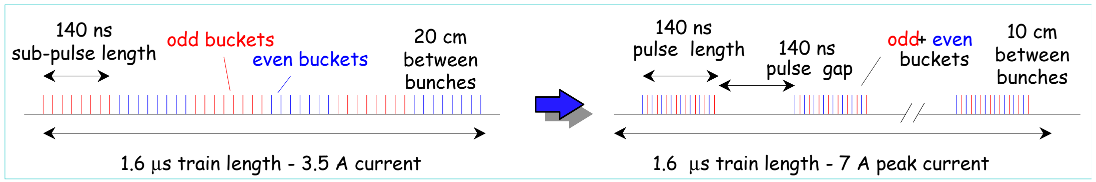


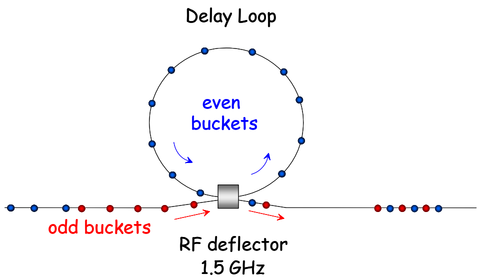
1.5 GHz RF deflector

Bunch interleaving in Delay Loop

Beam current measured:

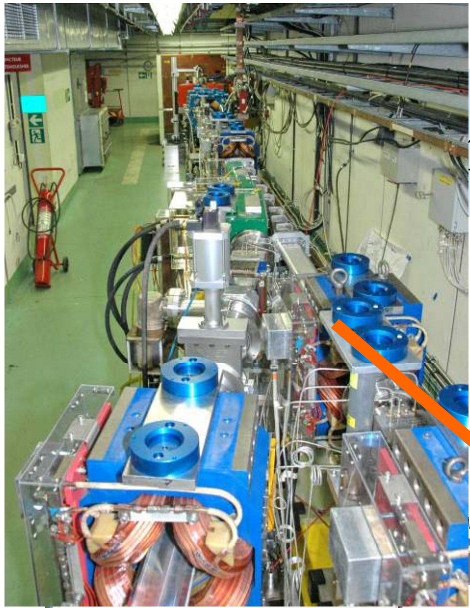


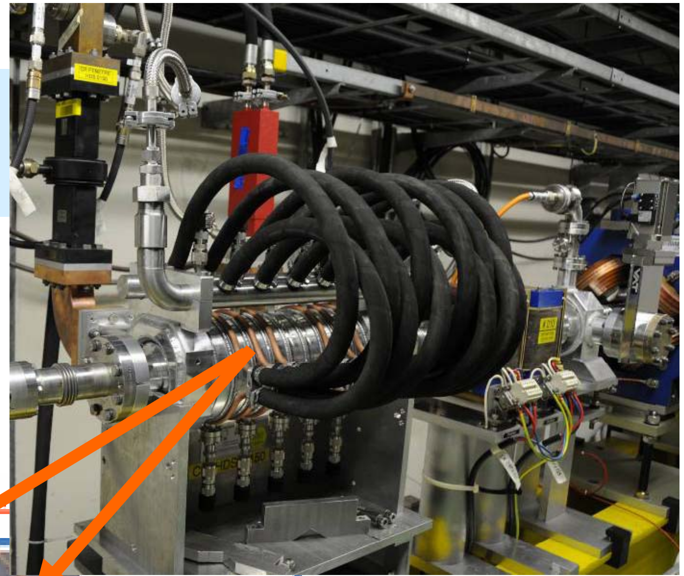


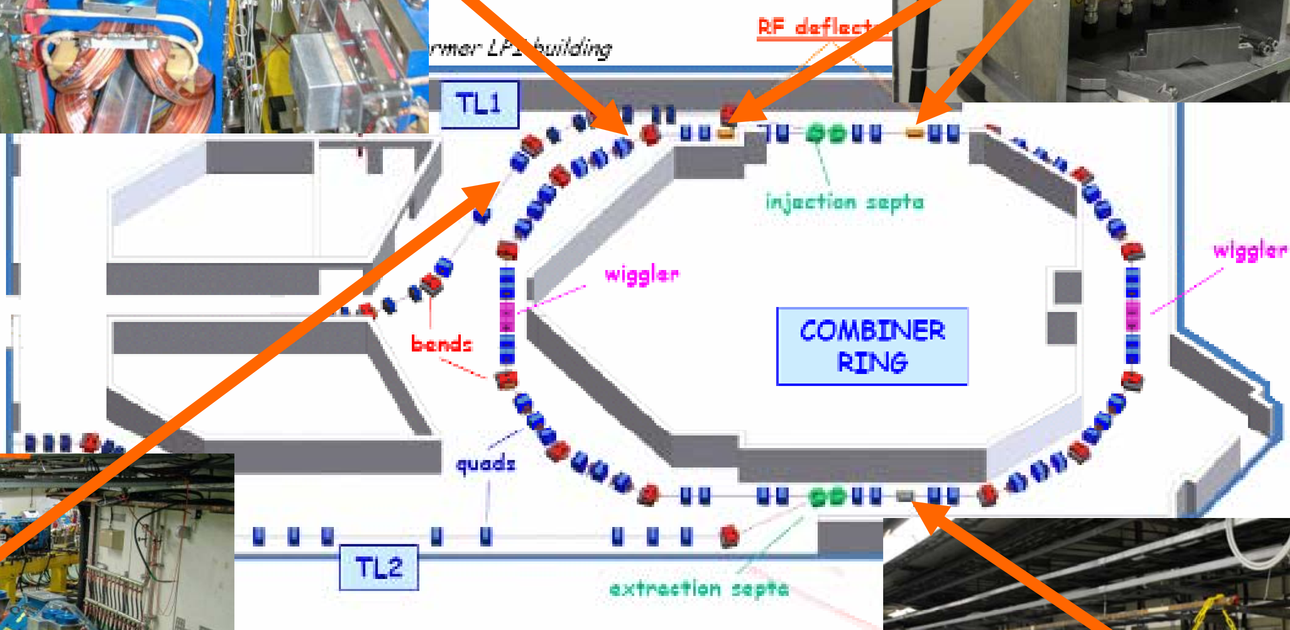


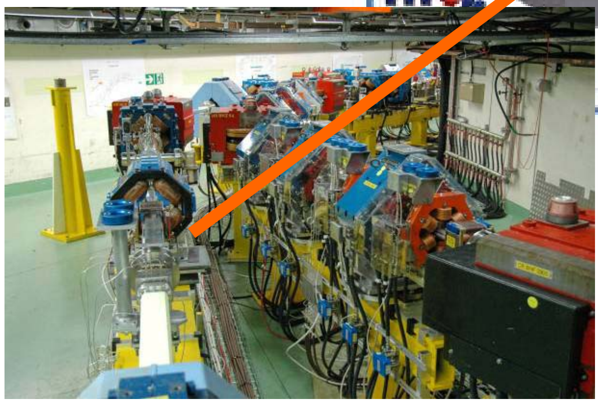
Successful demonstration of Delay Loop operation !

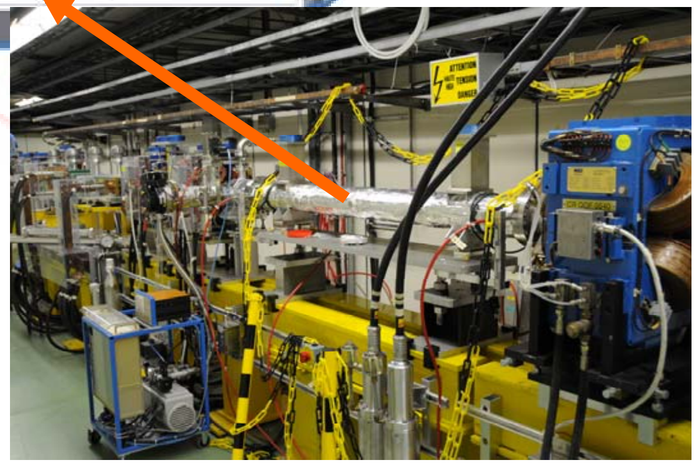
mbiner Ring






TL1
injection septa
wiggler
wiggler
bends
COMBINER RING
quads
TL2
extraction septa

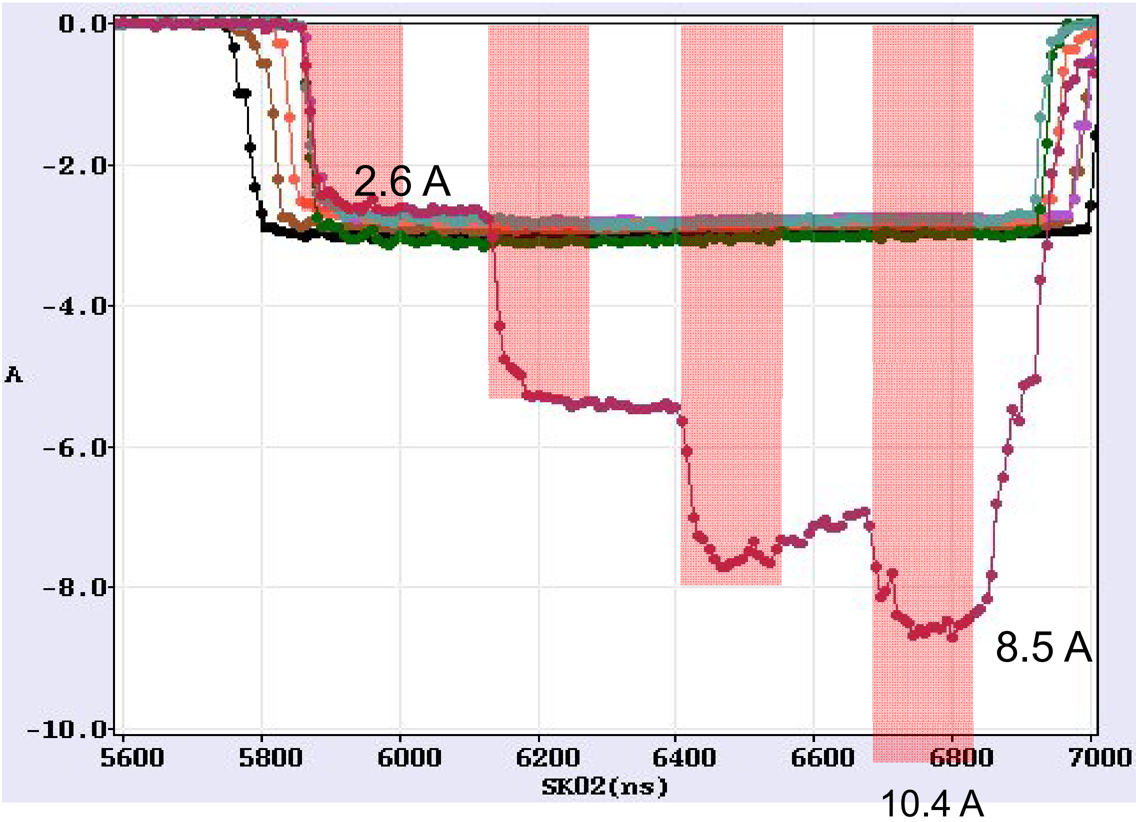




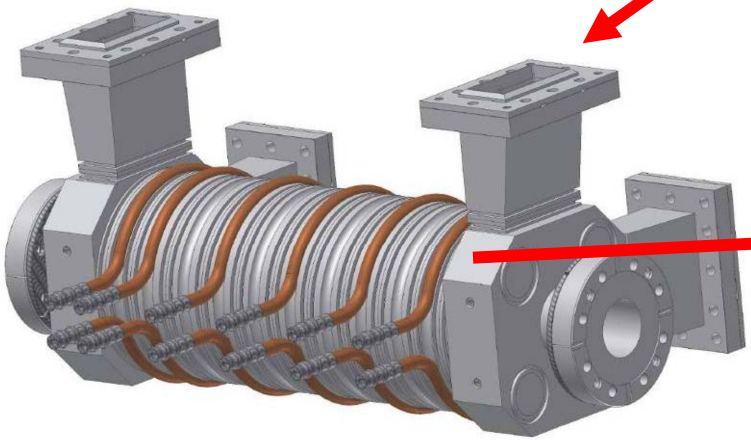
Combiner Ring commissioning

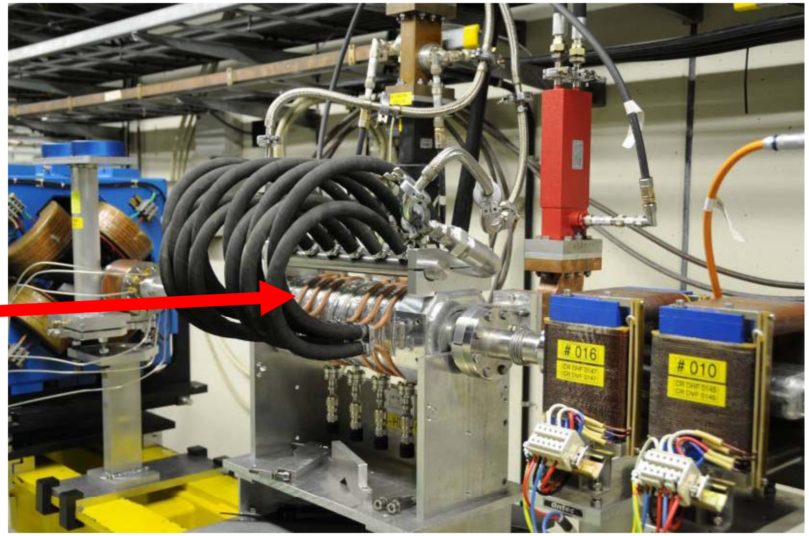
Achieved recombination:

- Linac current lower than nominal
- DL bypassed (no holes, missing factor 2)
- Losses during recombination (**instability**…)



Instability in CR

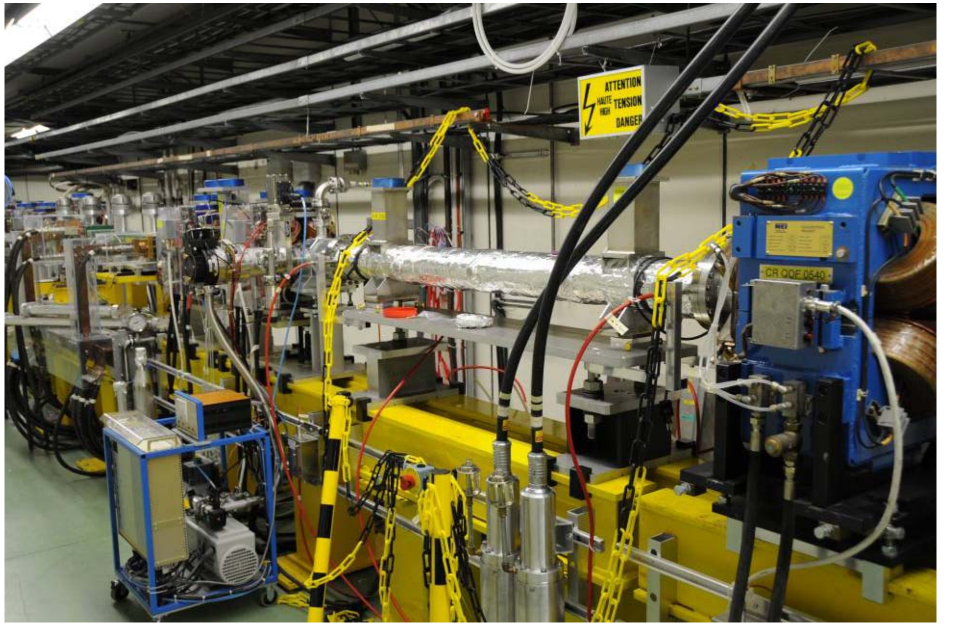




New Installation: Strip-line kicker

Strip-line kicker from CIEMAT installed in the Combiner Ring and tested:

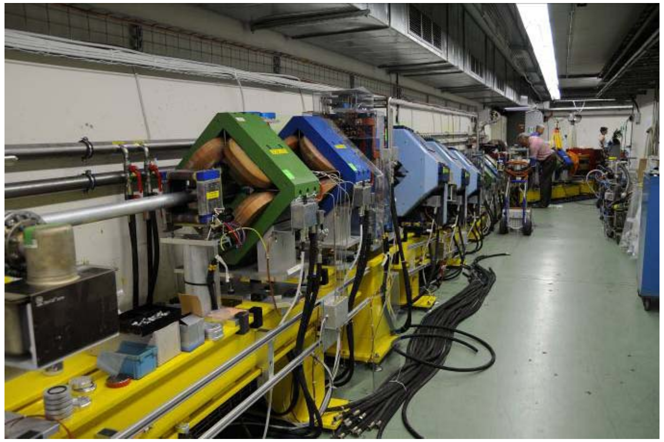
works according to specifications

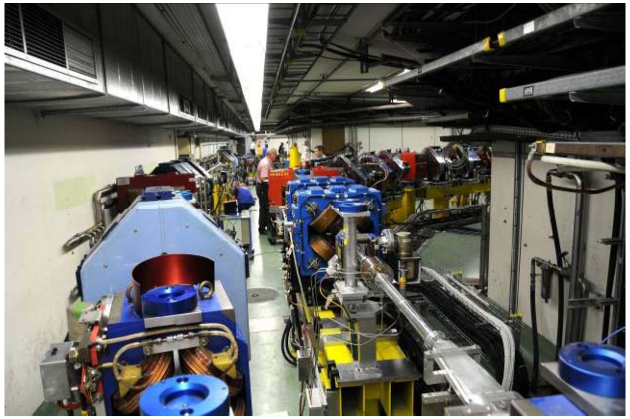


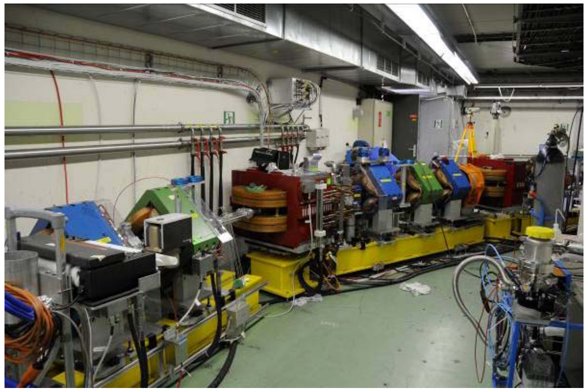
Transfer line TL2

large part been done by RRCAT:

- Optics design
- Aluminium vacuum chambers
- Bending magnets

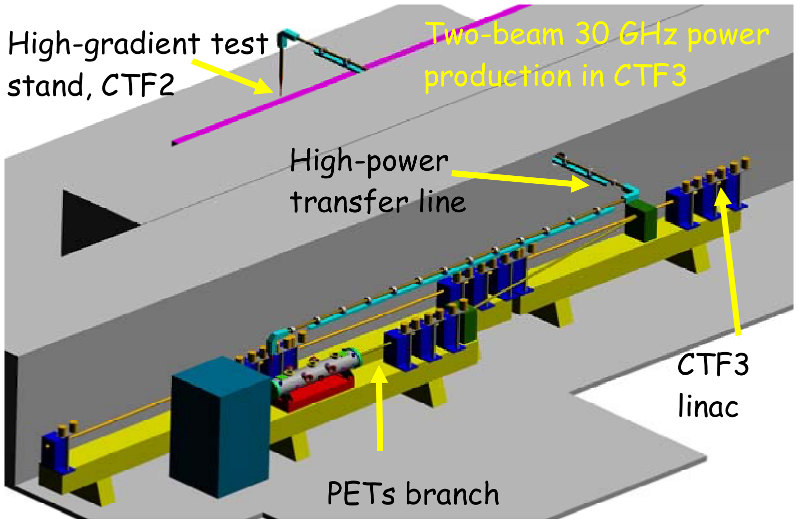






Accelerating structure testing

Tests at 30 GHz still continuing

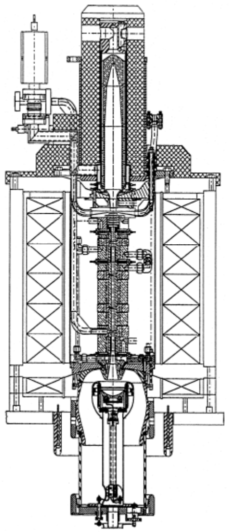


100 MW produced at 30 GHz,
Transmission via circular
TE_{01} line (17 m) with 65 % efficiency

operation for 30 GHz now routine,
largely automatic.
24 hour operation

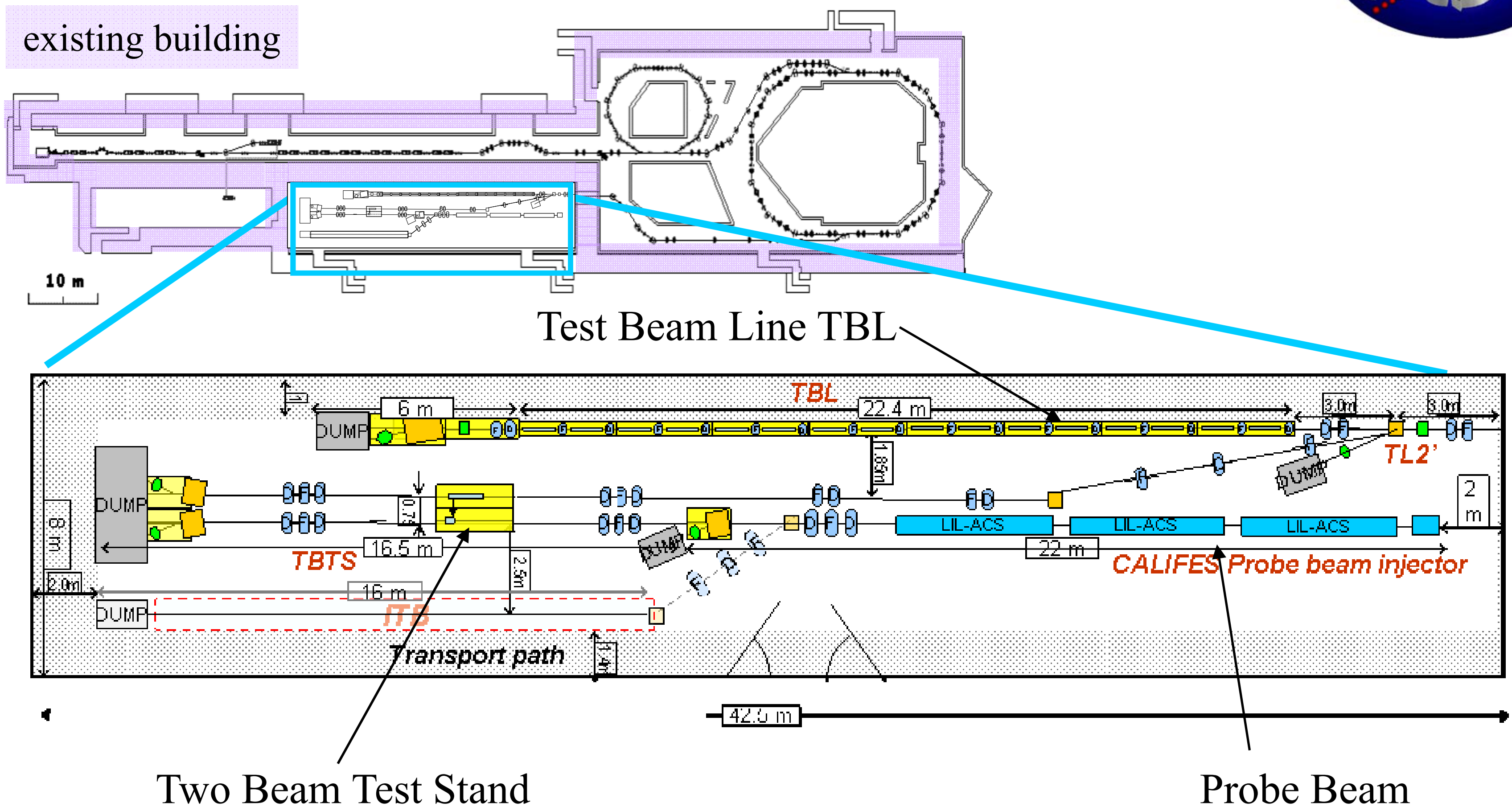
12 GHz work:
Collaboration with SLAC and KEK,
presently no test facility at CERN

Stand-alone power source in preparation



Klystron with
pulse compressor

CLEX (CLIC Experimental Area)



All Beam lines installed, except TBL !
(ITB is not part of the base-line programme)

Probe Beam

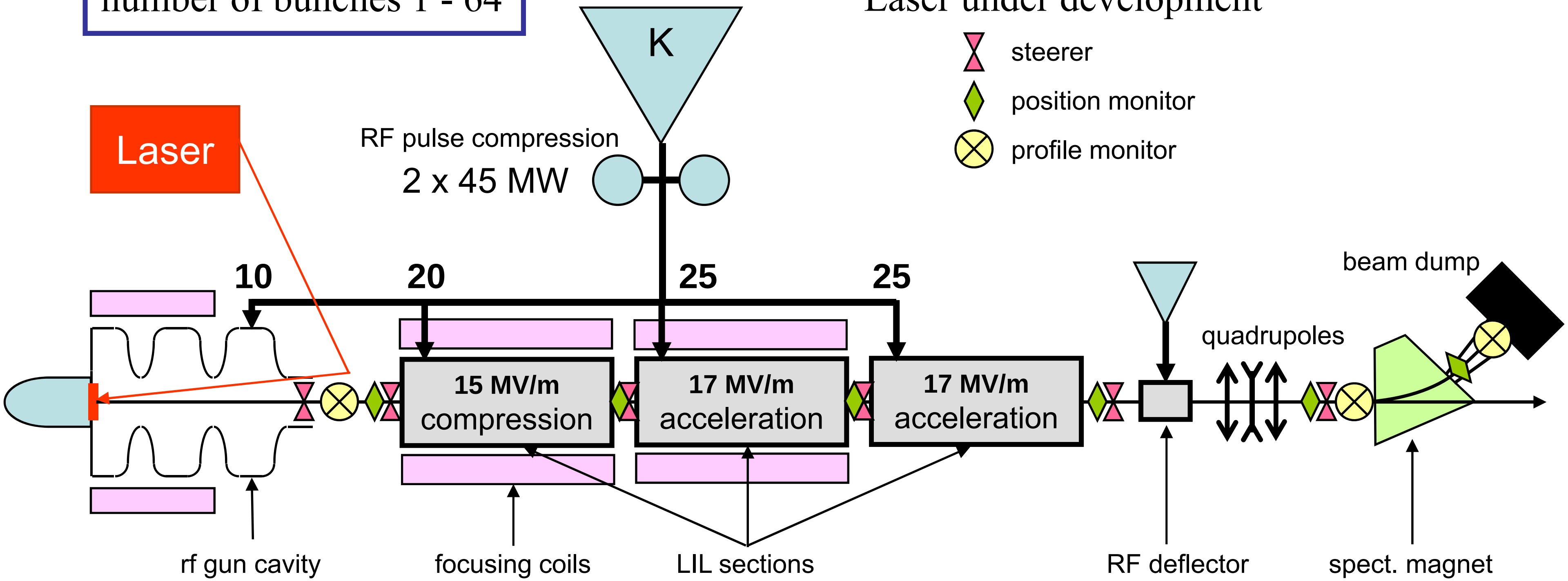
Responsibility of IRFU (DAPNIA), CEA, Saclay

200 MeV
bunch charge 0.5 nC
number of bunches 1 - 64

Status:

Installed, RF conditioning in June

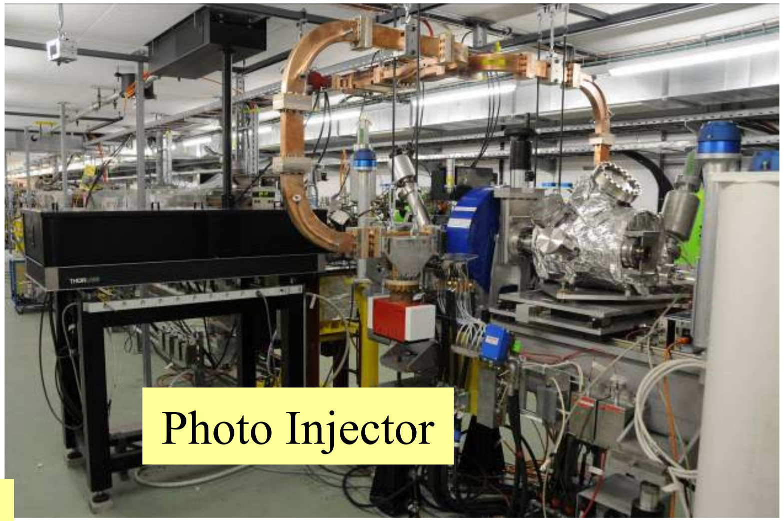
Laser under development

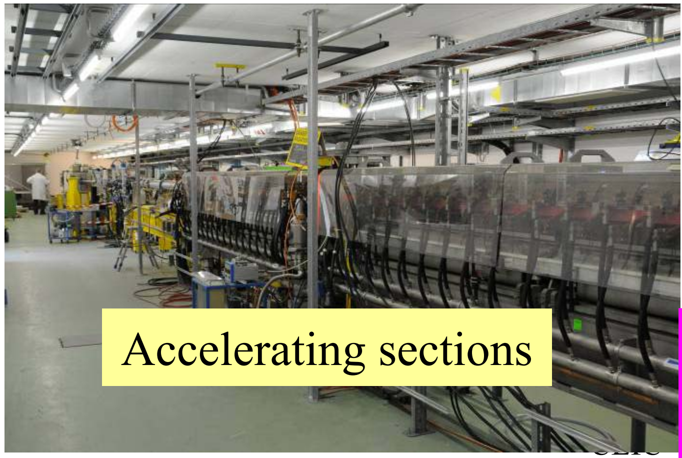


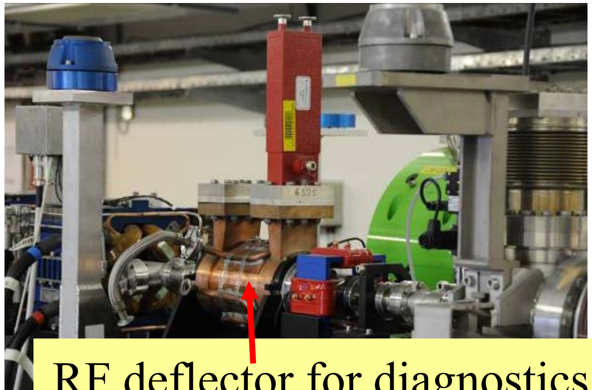
CALIFES

A. Mosnier, CEA Dapnia

Califes

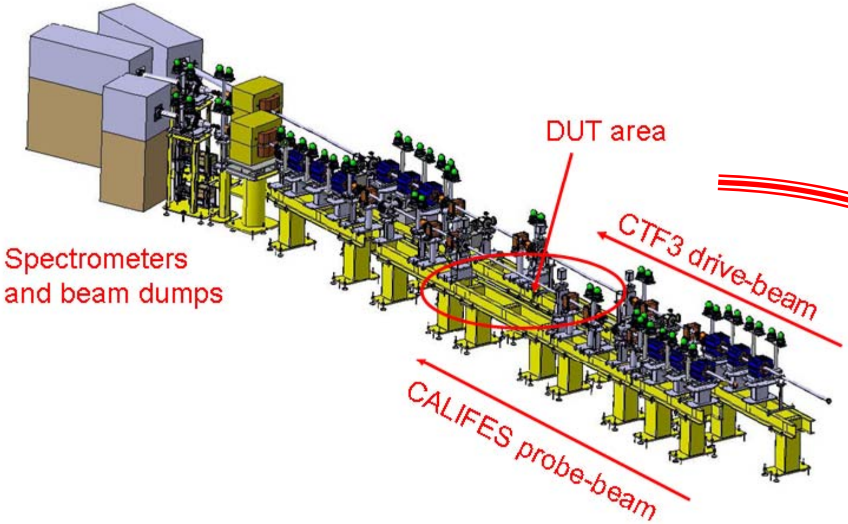




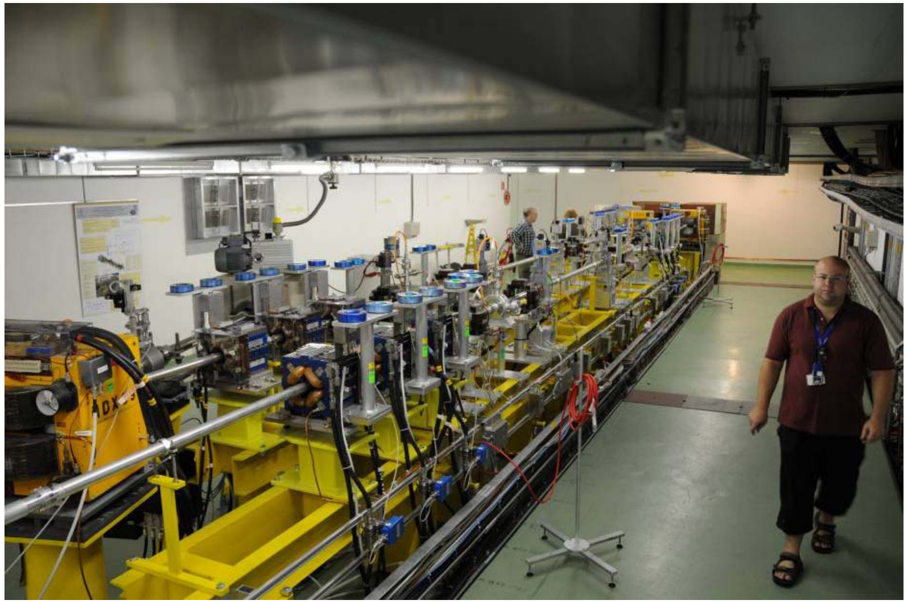


Klystron and modulator installed
Waveguides installed, Phase shifter is late
RF conditioning starts now

TBTS Design



From Dream to reality!



UPPSALA UNIVERSITET

TBTS
- intro
- design
- status

Summary

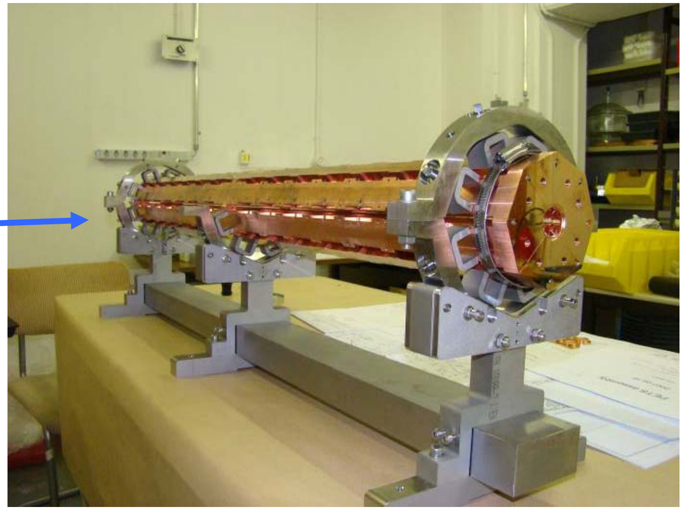
Roger Ruber

CTF3 Meeting

Two Beam test Stand

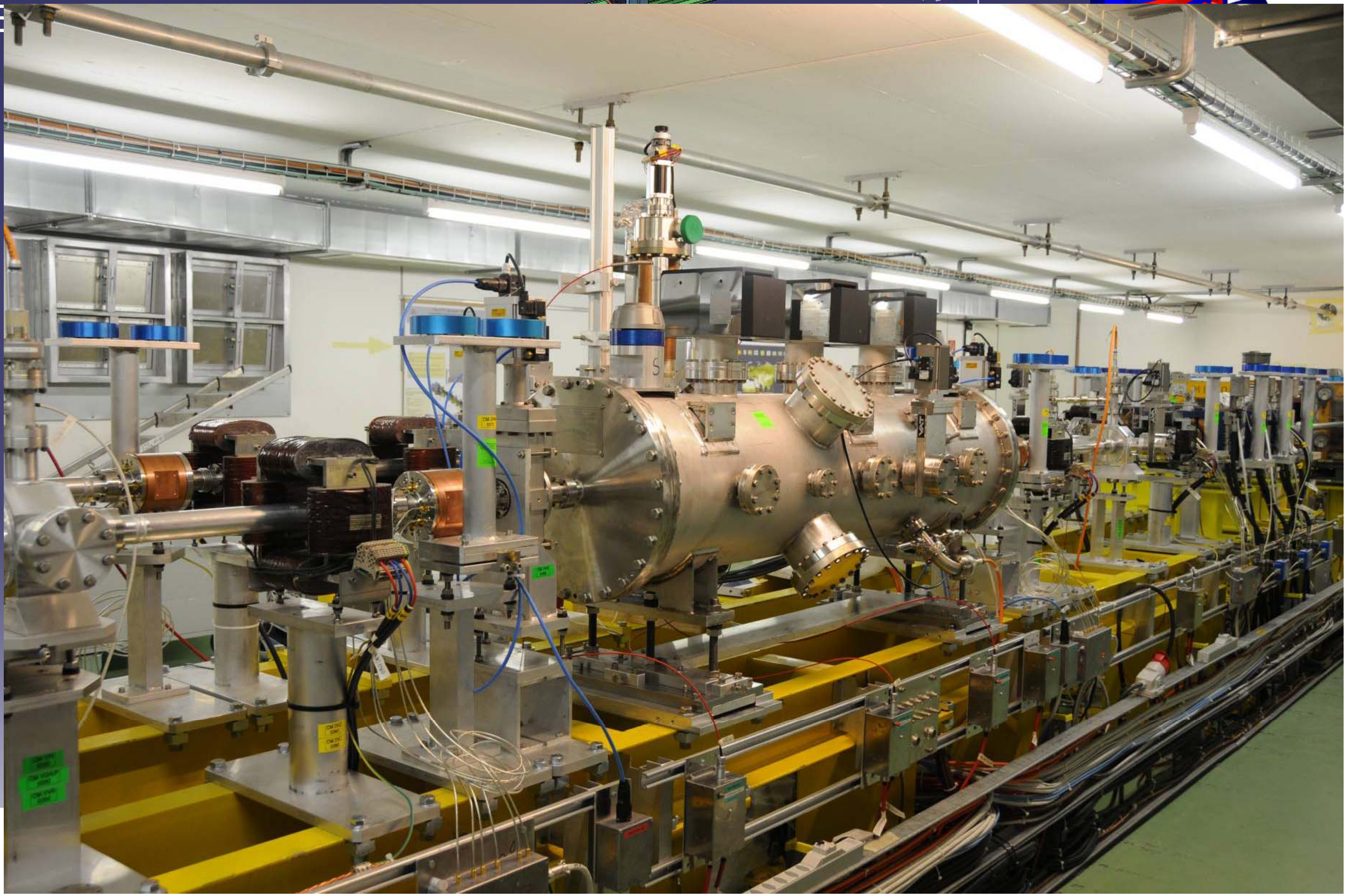
All hardware installed !
(Uppsala University)
Commissioning with beam starting

PETS (CERN) will be installed in October,
first accelerating structure in 2009



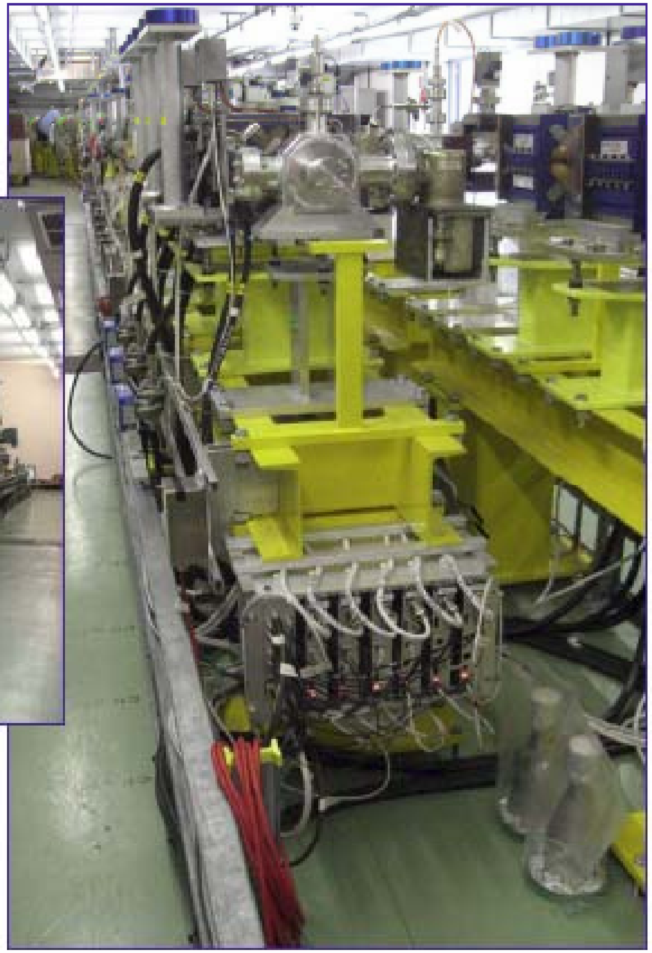
Phase #1

PE



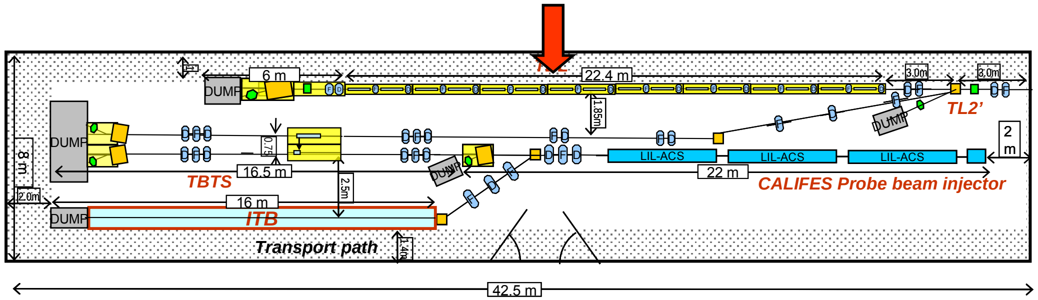
CLEX

Uranus



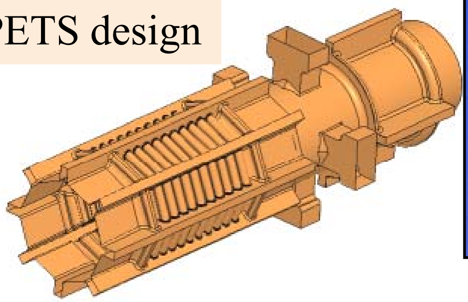
Neptune

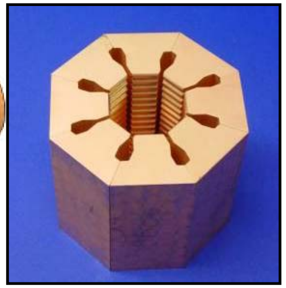
Test Beam Line TBL



- High energy-spread beam transport
  decelerate to 50 % beam energy
- Drive Beam stability
- Stability of RF power extraction
  total power in 16 PETS: 2.5 GW
- Alignment procedures

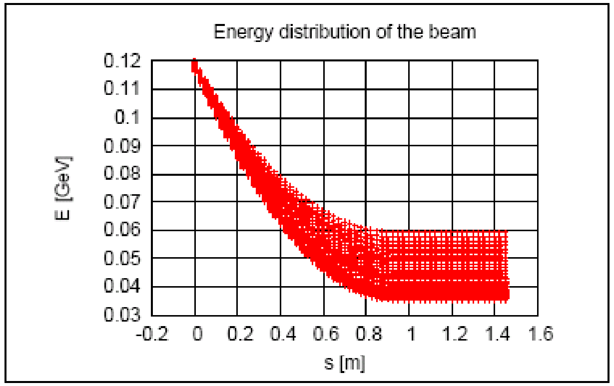
PETS design

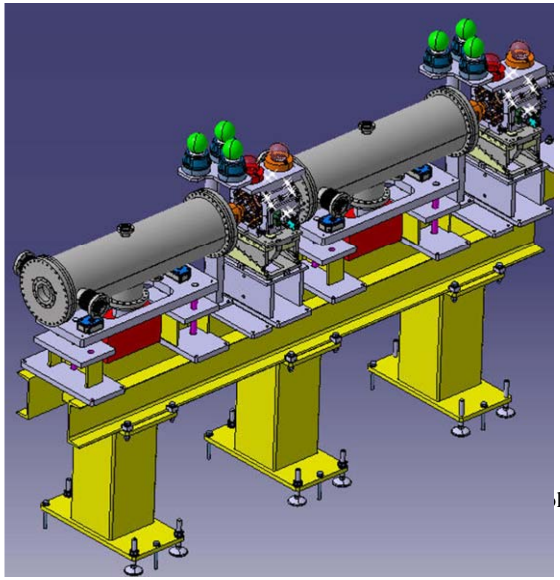




5 MV/m deceleration (35 A)

165 MV output Power





2 standard cells, 16 total

PETS development: CIEMAT

BPM: IFIC Valencia

and UPC Barcelona

TBL

• Prototype PETS + vacuum tank being built by CIEMAT

• Precision quadrupole movers are being built by CIEMAT, prototype has been successfully tested

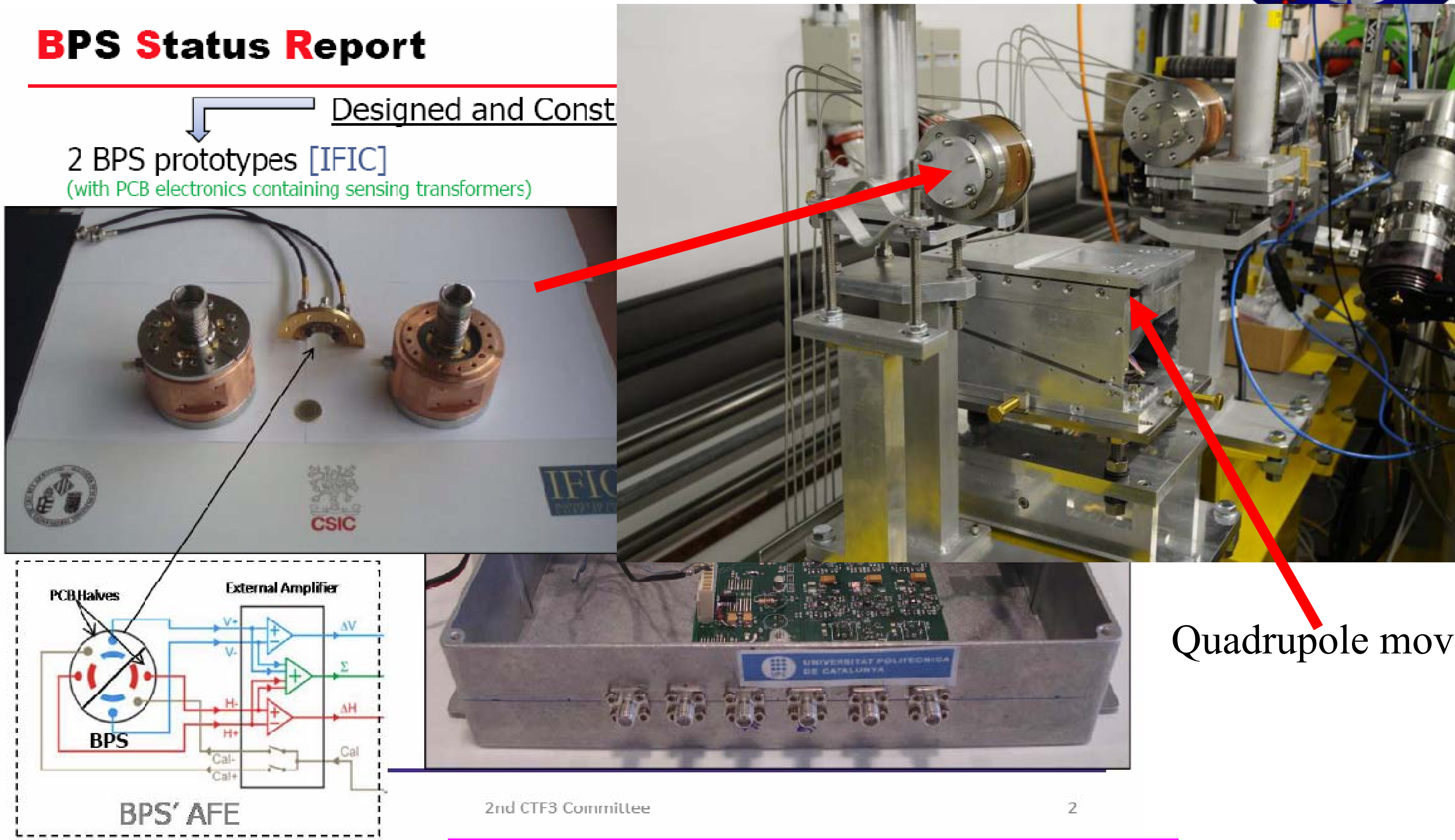
• All quadrupole magnets are being built by BINP, delivery end 2008

• Beam Position monitor prototype was built by IFIC Valencia, front-end analogue electronics is being developed by UPC Barcelona

• Vacuum components built by CERN

• Beam line will be installed with all quadrupoles and PETS replacement chambers during winter shut-down.

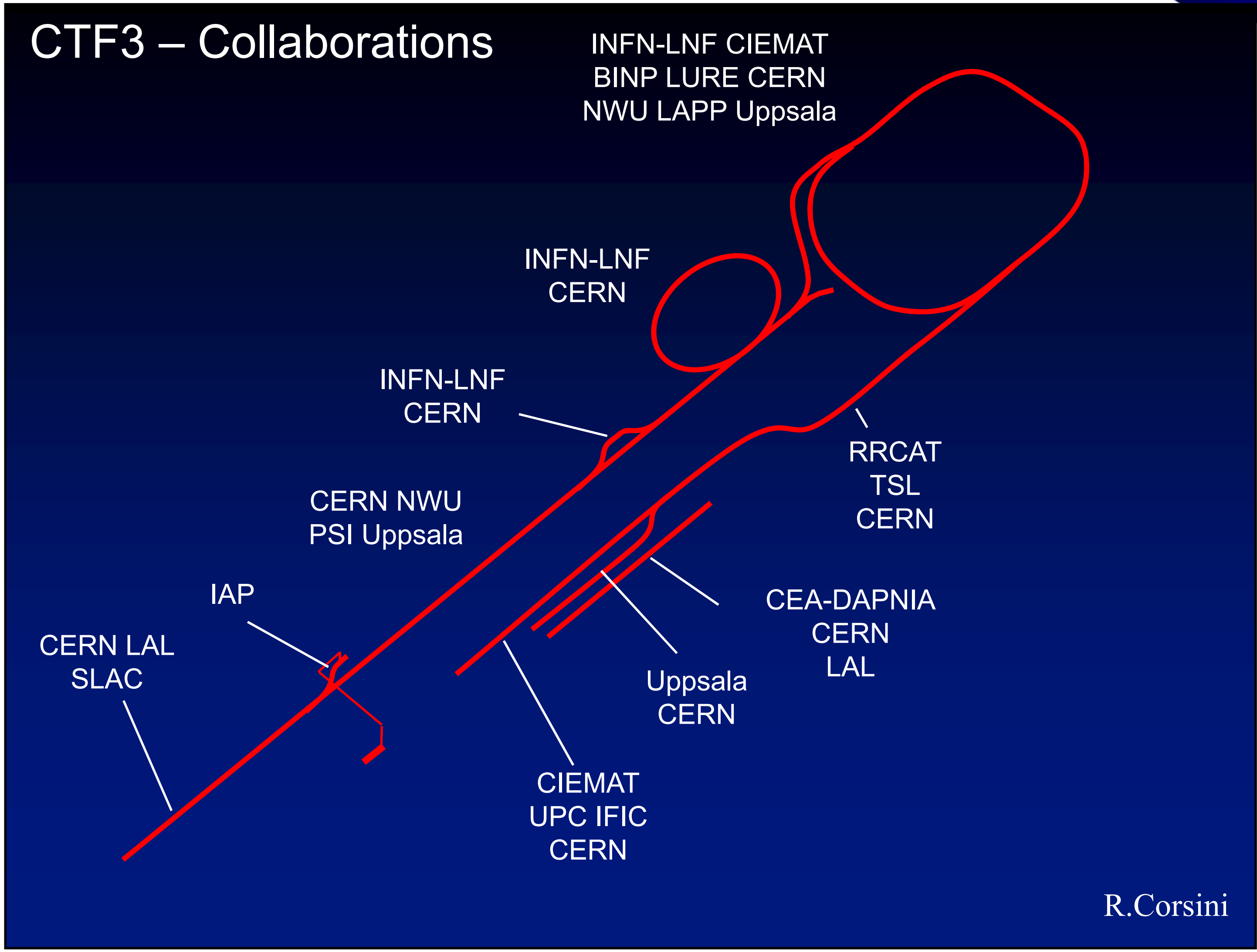
BPS for TBL (IFIC Valencia and UPC Barcelona)



Quadrupole mover

Series of 15 start in October!

CTF3 Collaboration



CLIC / CTF3 collaboration

27 collaborating institutes

Ankara University (Turkey)
Berlin Tech. Univ. (Germany)
BINP (Russia)
CERN
CIEMAT (Spain)
Finnish Industry (Finland)
Gazi Universities (Turkey)

IRFU/Saclay (France)
Helsinki Institute of Physics (Finland)
IAP (Russia)
IAP NASU (Ukraine)
Instituto de Fisica Corpuscular
(Spain)
INFN / LNF (Italy)
J.Adams Institute, (UK)

JASRI (Japan)
JINR (Russia)
JLAB (USA)
KEK (Japan)
LAL/Orsay (France)
LAPP/ESIA (France)
LLNL/LBL (USA)
NCP (Pakistan)
North-West. Univ. Illinois (USA)

PSI (Switzerland),
Polytech. University of Catalonia (Spain)
RAL (England)
RRCAT-Indore (India)
Royal Holloway, Univ. London, (UK)
SLAC (USA)
Svedberg Laboratory (Sweden)
University of Oslo
Uppsala University (Sweden)

Goals & milestones 2008 run

- 1st run (April - June)
  - Injector & Linac: establish stable & documented working point, automatic beam steering & steering algorithm studies, diagnostics consolidation, stability studies, EUROTeV BPMs
  - Delay Loop: complete beam optics measurements (dispersion, orbit, kick measurements, matching), re-establish combination
  - TL1 & combiner ring: complete optics studies (dispersion, closed orbit correction, matching, tunes, kick measurements, quad displacement evaluation), tune and β function dependence of vertical instability, factor four combination with DL bypass (≥ 10 A)
  - DL, TL1 & CR: factor 8 combination (≥ 15 A)
- 2nd run (July - September)
  - Complete DL + CR, new RF deflectors (20 A ?)
  - TL2 commissioning
  - First CALIFES commissioning
  - TBTS commissioning (no PETS)
- 3rd run (September - December)
  - Complete above program
  - Coherent Diffraction Radiation tests
  - TBTS, PETS running in

CDR Experiment

Royal Holloway University of London

CERN

Coherent Diffraction Radiation experiment

Maximilian Micheler, Grahame Blair, Stewart Boogert, Pavel Karataev
John Adams Institute at Royal Holloway

David Howell
John Adams Institute at Oxford University

Nicolas Chritin, Roberto Corsini, Thibaut Lefevre, Patrick Lelong
CERN

We also would like to acknowledge help of Dr. V.Antonov for target manufacturing and J. Taylor for the workshop efforts

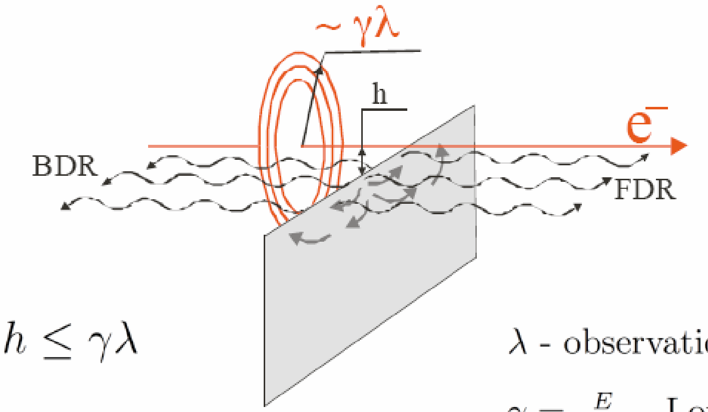
June 19, 2008

CDR Experiment

Basic Principle:

• Diffraction radiation (DR) appears when a charged particle moves in the vicinity of a medium

• Impact parameter, h, is the shortest distance between the target and the particle trajectory



$h \leq \gamma\lambda$

λ - observation wavelength

$\gamma = \frac{E}{mc^2}$ - Lorentz factor

CDR Experiment after Combiner Ring

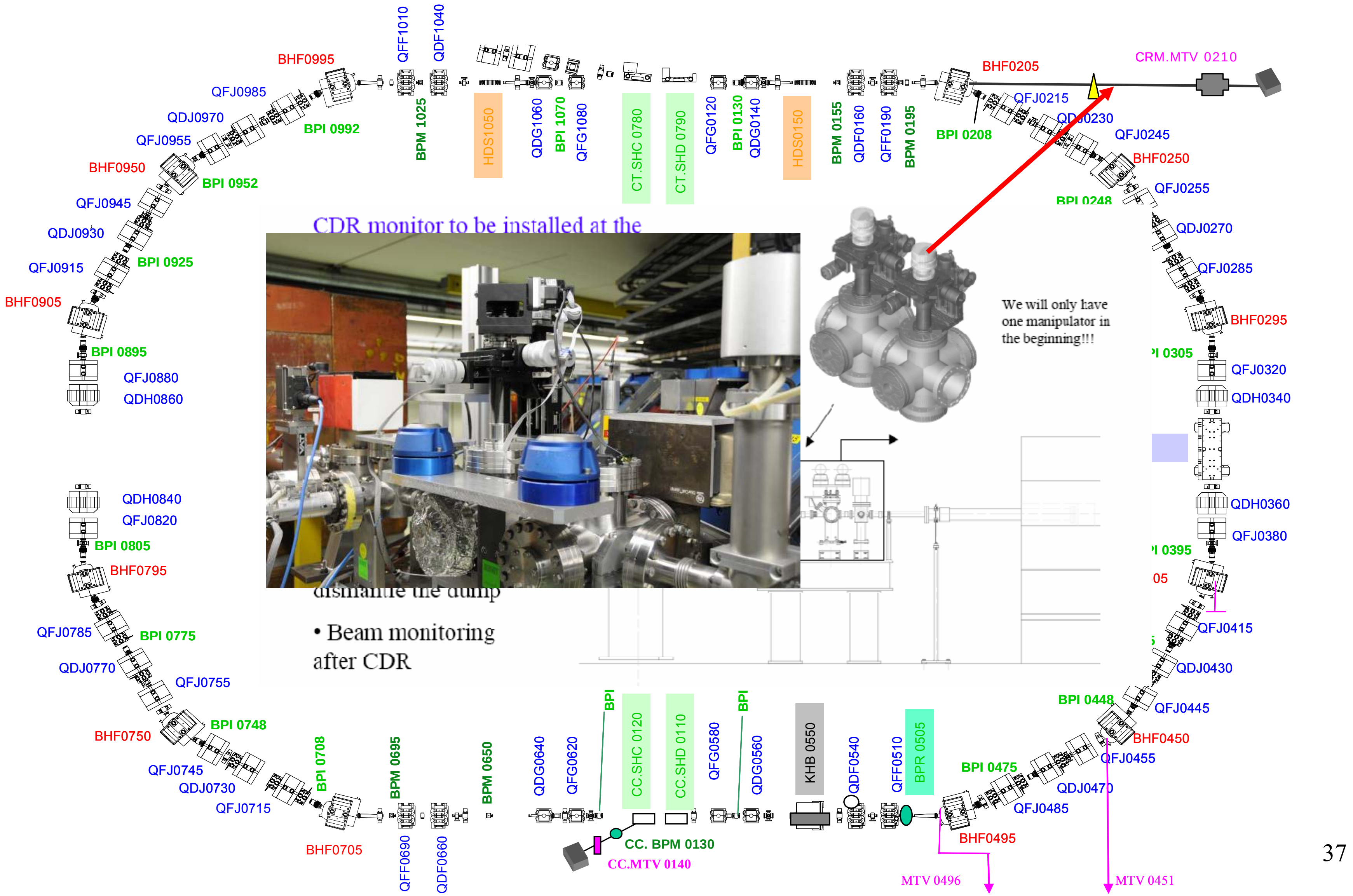
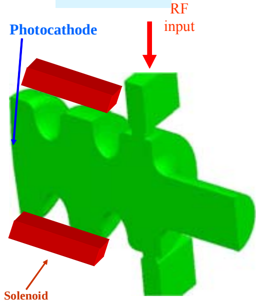


Photo Injector

smaller emittance, faster phase coding, no "satellite bunches"

LAL

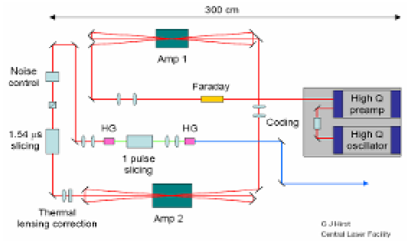


CERN

Cs_2Te photo cathode
3% QE
40 hours life time
pulse train: 1.5 µs,
charge per bunch: 2.33 nC
bunch spacing 0.67 ns
number of bunches: 2332

RAL

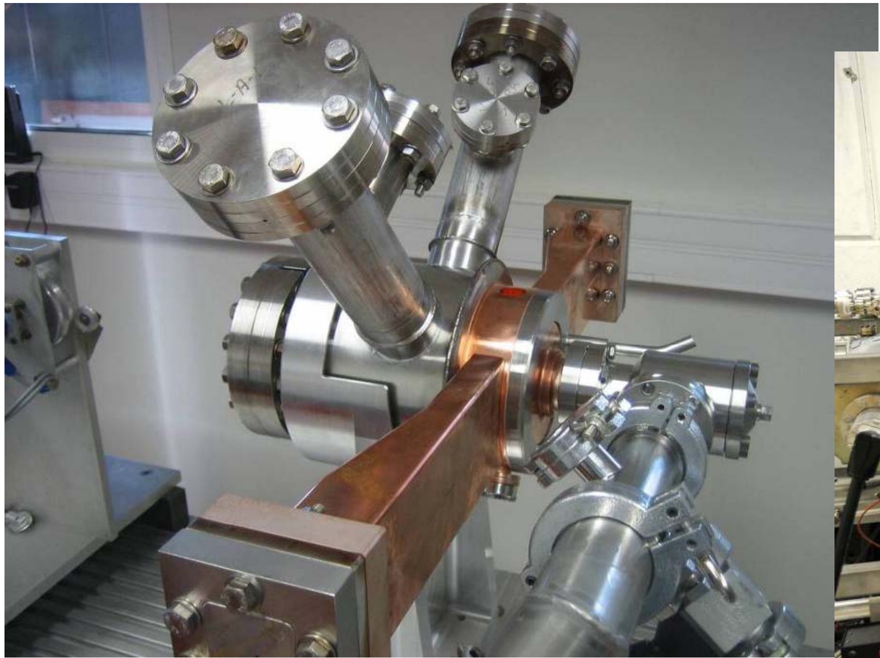
diode pumped
Nd:YLF laser
10 µJ IR / bunch
0.37 µJ UV on
cathode /bunch

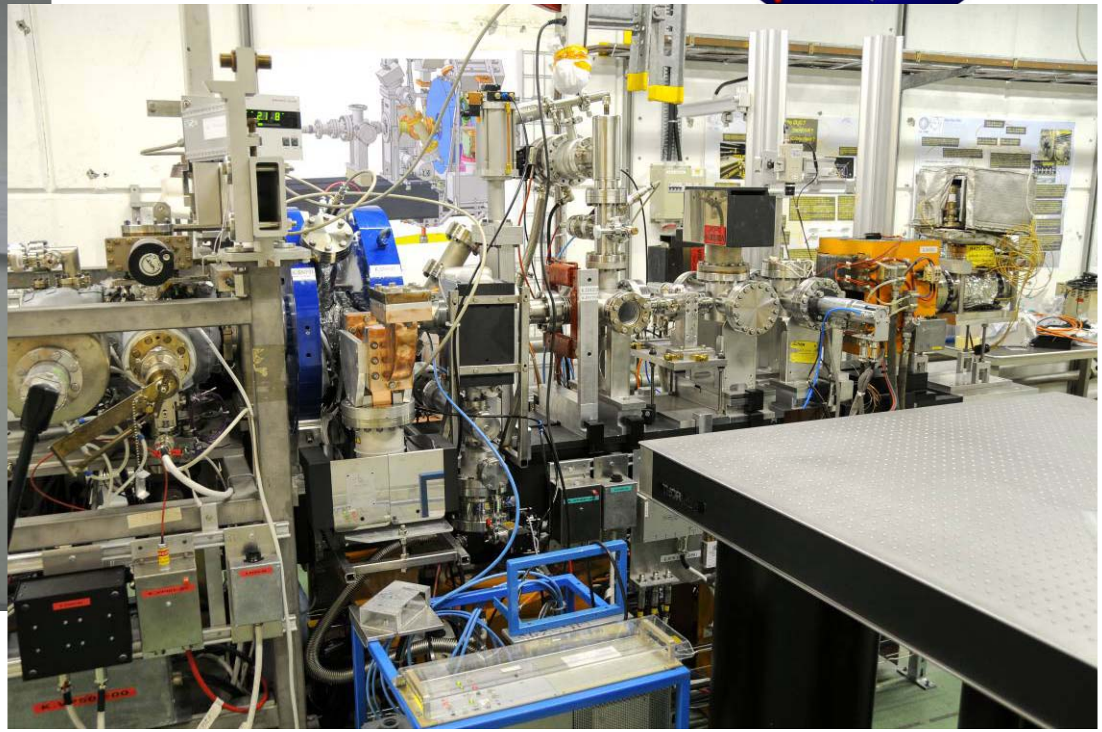


RF gun installed.

Laser: needs to be finished , new diagnostics available,
➔ much more optimistic now

Status of the PHIN photoinjector





PHIN-2 gun brazed at LAL – tested o.k. -

delivery of PHIN-2 gun from LAL to CERN: 20 May
preparation for bake-out, installation + assembly
(with help from LAL – MERCI!), waveguides, etc.

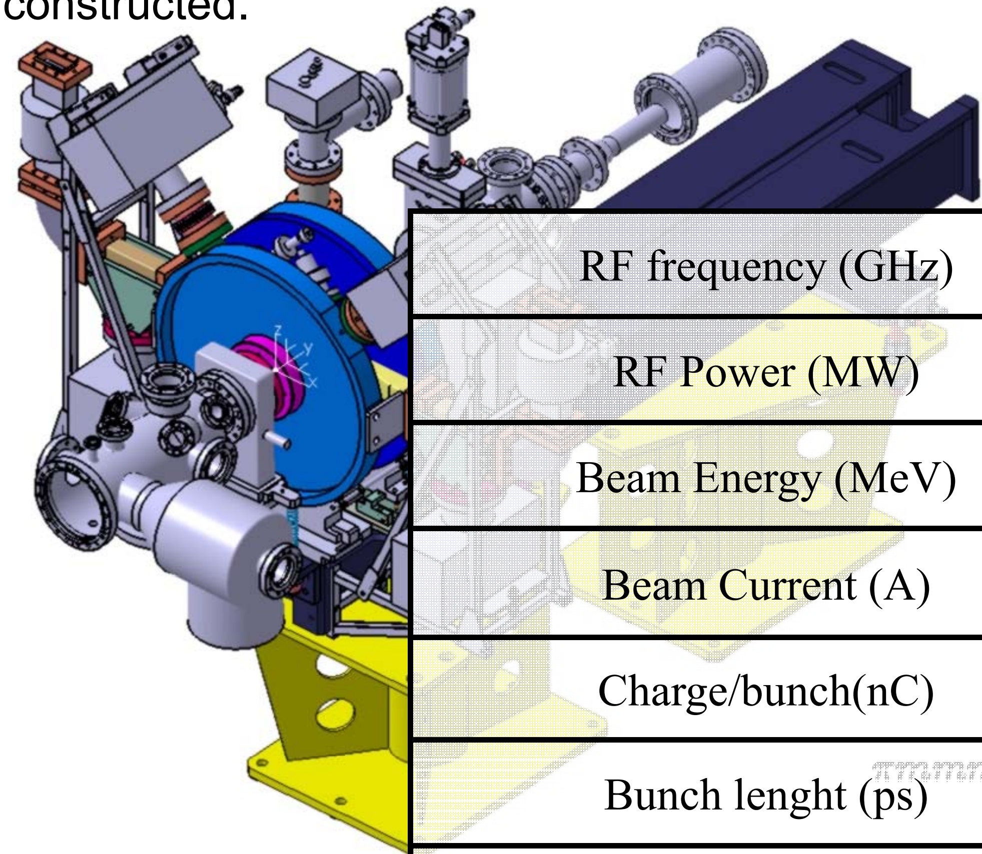
? ready in September ? – **yes !**

RF conditioning:
start in October shutdown

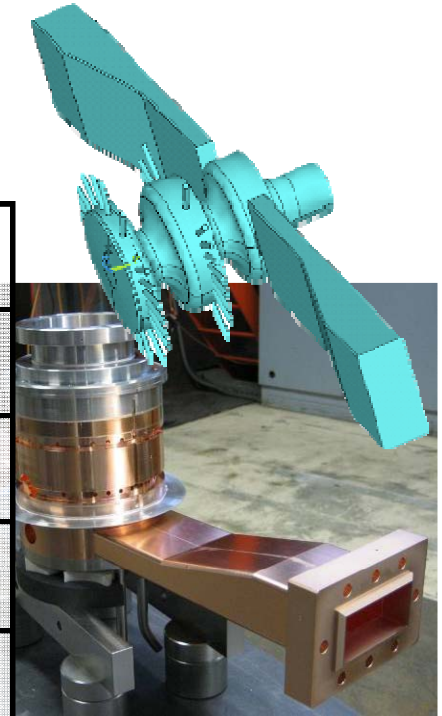
(klystron shared with
Combiner Ring deflectors)

PHIN photo injector prototype

Within the framework of second Joint Research Activity PHIN of the European CARE program a new photo injector for CTF3 drive beam has been designed and being constructed.



RF frequency (GHz)	2.99855
RF Power (MW)	30
Beam Energy (MeV)	5-6
Beam Current (A)	3.51
Charge/bunch(nC)	2.33
Bunch lenght (ps)	10
Energy Spread (%)	<2
Normalized emittance ( )	<25
Pulse train duration (μs)	1.548



2-1/2 rf gun

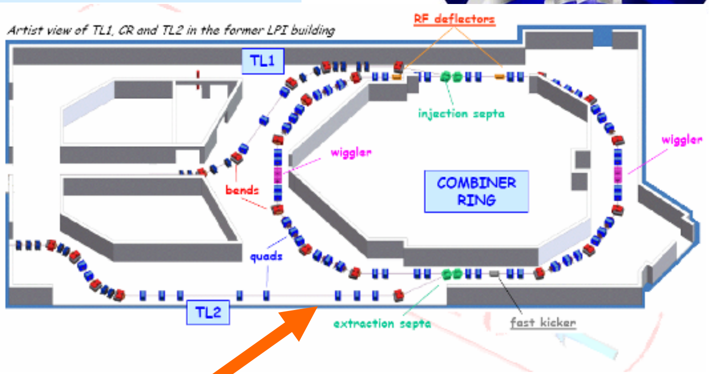
References:

1) Steffen Doebert, Integration of the PHIN rf gun into the CLIC Test Facility, proceedings of EPAC 2006, Edinburgh, Scotland

2) R. Roux, et al, Design of a RF gun, CARE Note-2004-034-PHIN

3) I. N. Ross, Feasibility study for the ... Laser System ... Note 462

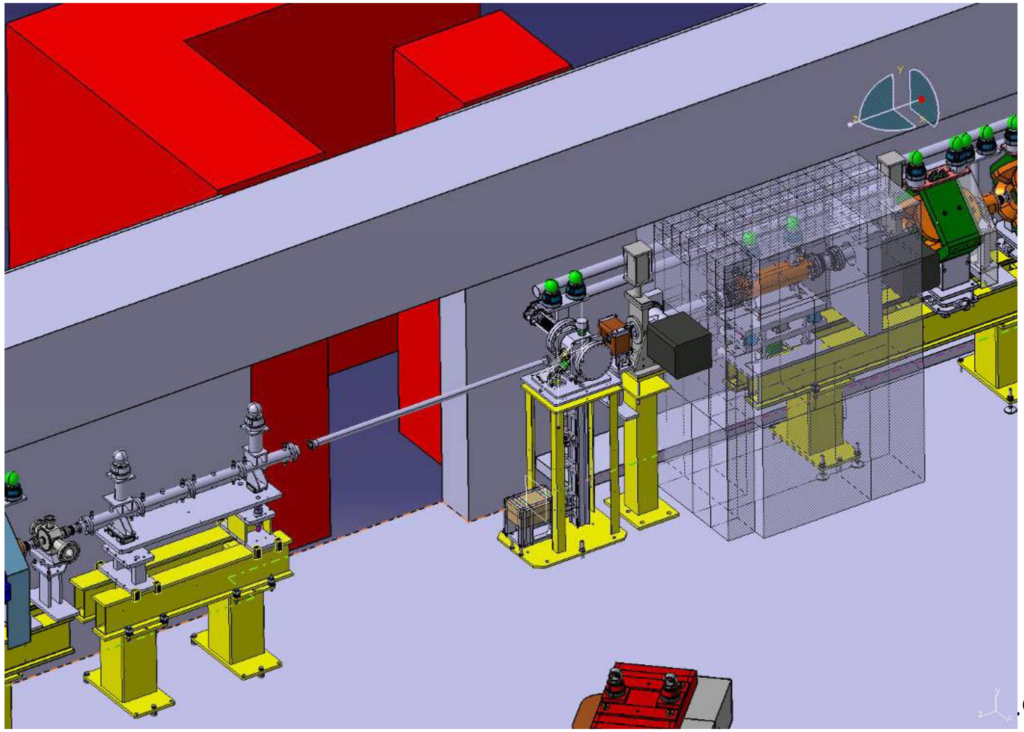
Next steps: Tail clipper

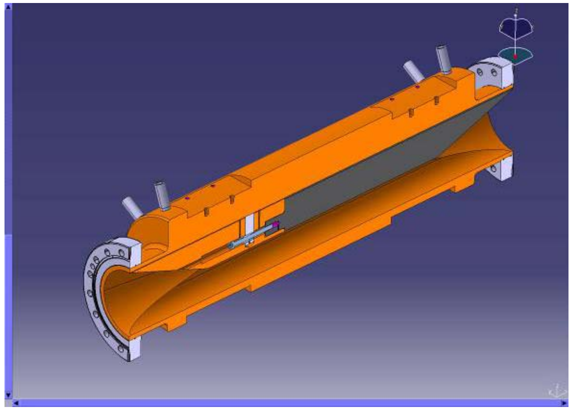


change length of bunch train going into CLEX
with fast transverse kickers – collimator/dump

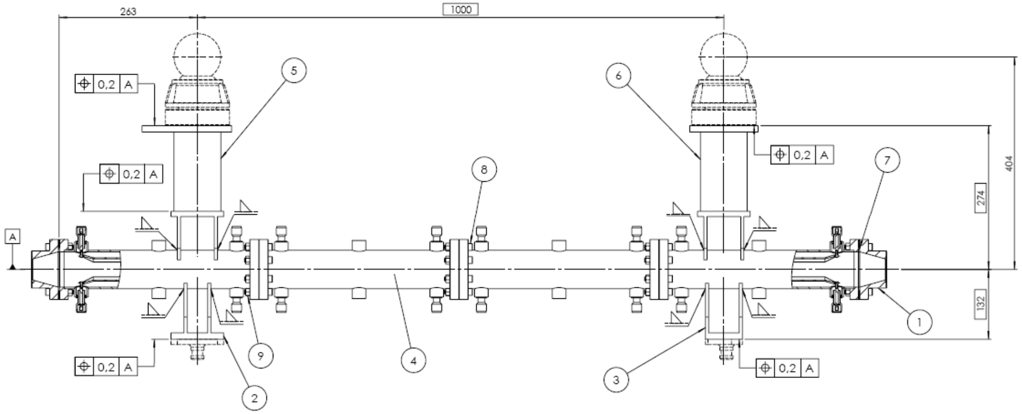
Strip-line kickers from CIEMAT,

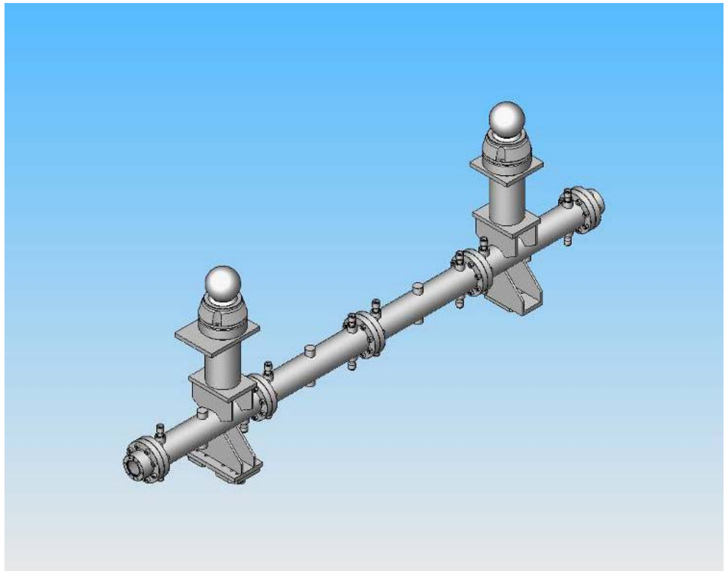
Collimator / dump (CERN):
serves also as safety element to inhibit beam into CLEX





CTF3 KICKER STATUS (CIEMAT)





- Design is already finished.
- Practically all the materials & components have been acquired.
- Electrodes have been manufactured
- Test devices have been received or will be soon at CIEMAT (Including the pulsed power supply).
- Still waiting for the reception of some more CERAMASEAL feedthroughs.
- Delivery will depend on the reception of the feedthroughs and the ability to achieve 10^{-8}mbar

Tentative long-term CLIC scenario

Shortest, Success Oriented, Technically Limited Schedule

Technology evaluation and Physics assessment based on LHC results for a possible decision on Linear Collider funding with staged construction starting with the lowest energy required by Physics

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Feasibility issues (Accelerator&Detector)																	
Conceptual design and cost estimation																	
Design finalisation and technical design																	
Engineering optimisation																	
Project approval & final cost																	
Construction accelerator (poss. staged)																	
Construction detector																	

CDR

TDR

Project approval ?

First Beam

Conclusion II

Well advanced programme

Consistent parameter set

Technical programme is on track

- **CTF3 on schedule**

  full beam loading

  bunch phase coding and Delay Loop operation

  First results on recombination on Combiner Ring

Progress is only possible because we have a very prosperous collaboration between 27 international institutes