Summary of progress towards CLIC goals and next steps for structure testing

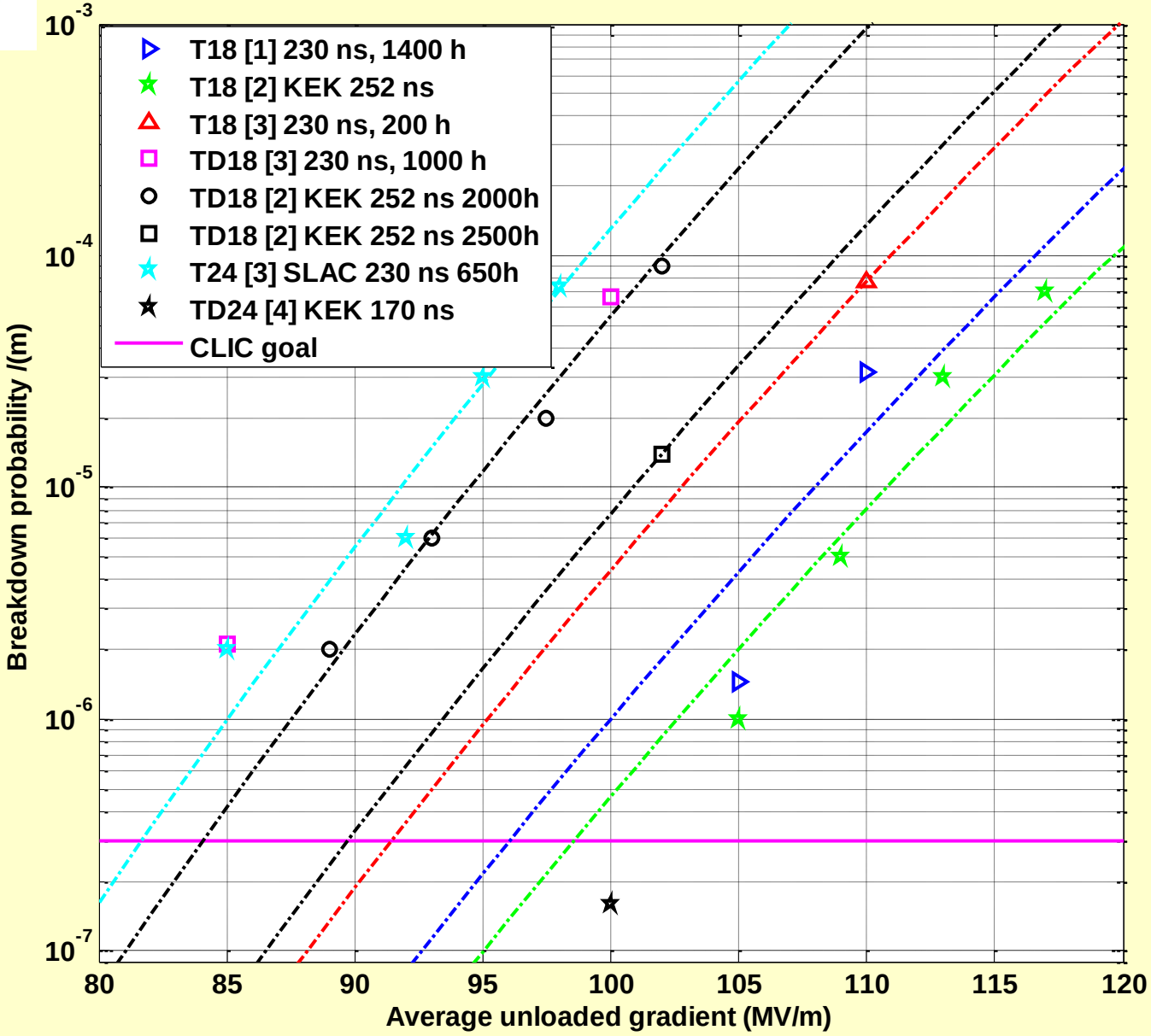
- Where we are: CDR - summary
- Testing goals for the next phase (2012-2016)
- Facilities and plans for structure testing
- Tentative testing program for 2012-2013

Steffen Döbert, BE-RF

CDR published but where are we now ?

Structure name	Unloaded gradient [MV/m]	Flat top pulse length [ns]	Breakdown rate [1/pulse/meter]	conditioning hours	Expected gradient for a trip rate of 3×10^{-7} and 180 ns flat top [MV/m]
T18 #1 SLAC	105	230	1×10^{-6}	1400 h	105
T18 #1 SLAC	106	230	3.1×10^{-7}	1200 h	110
T18 #2 KEK	105	252	1×10^{-6}	3900 h	107
T18 #3 SLAC	110	230	7.7×10^{-5}	288 h	95
T18 #5 CERN/SLAC	90	230	1.3×10^{-6}	560 h	89
TD18 #1 SLAC	100	230	7.6×10^{-5}	1300 h	87
TD18 #2 KEK	102	252	1.4×10^{-5}	2500 h	95
T24 #4 SLAC	98	230	7.4×10^{-5}	650 h	85
T24 #3 KEK	120	252	1.6×10^{-6}	1700 h	120
TD24 #3 KEK 12 GHz TBTS	100	160	1.6×10^{-7}	3200h	103

Breakdown rates



CDR published but where are we now ?

- Successfully tested T24 and TD24 with CLIC pulse shape to CDR specifications (one of each, unloaded)
  100 MV/m, > 170 ns flat top, < 3×10^{-7} BDR/m
- Breakdown rate dependencies and theories seem to describe the experiments
- Fabrication procedure existing
- We have a baseline CLIC structure: TD26 (not tested yet)
- Wake field control bench market in the past, new tests planned
- Very long testing time needed > 2000 hours
- Lack of testing capabilities !

What to do next ?

- More statistics for TD24, fabrication yield ?
  (9 x TD24_R05 under preparation)

- Advance towards TD26 with compact coupler and SiC
  (structure in the pipe line, spring 2013)

- Test with beam loading
  (test under preparation in CTF3,early 2013)

- Understand breakdown kicks
  (more measurements are under way in CTF3, TBTS)

What to do next ?

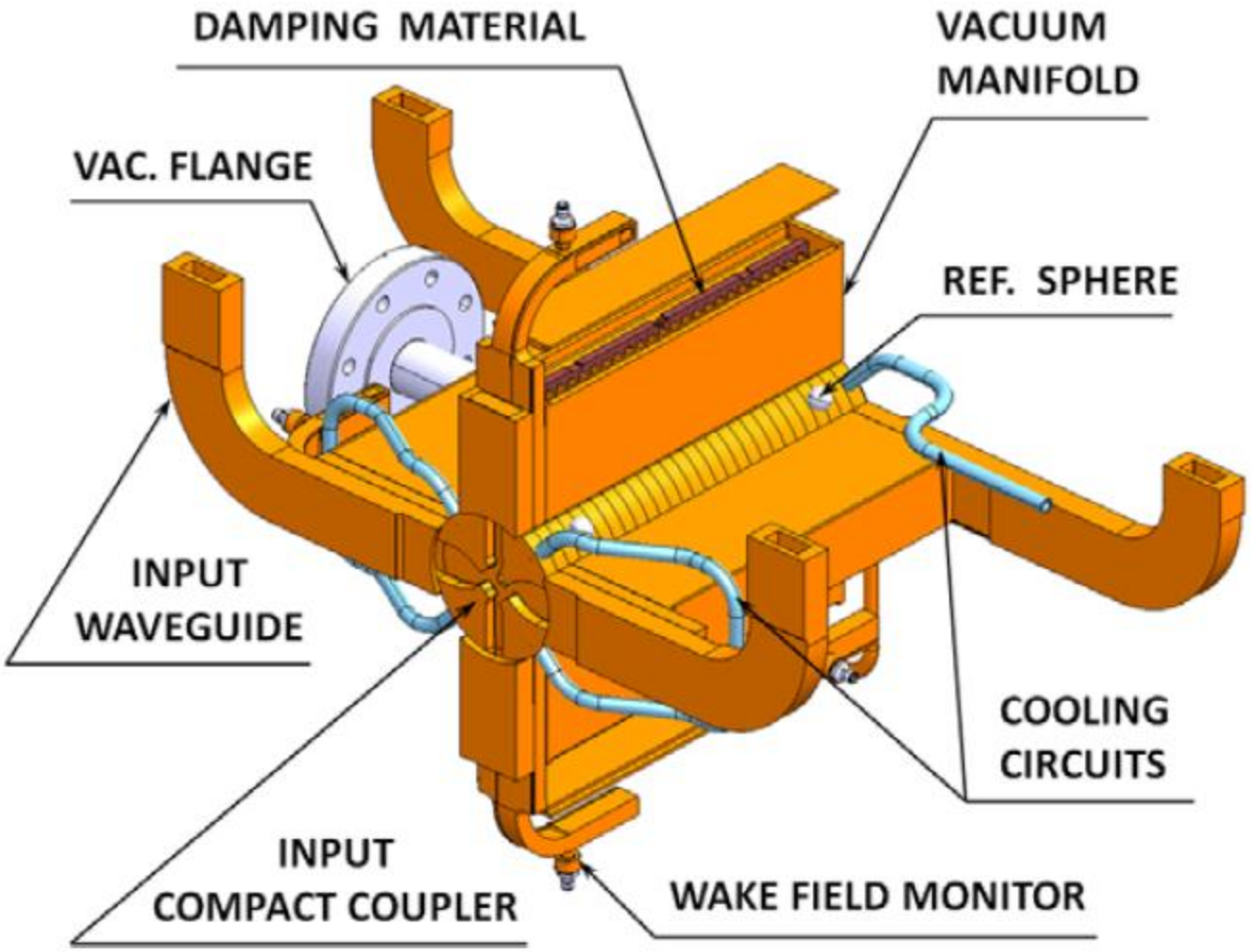
- Understand conditioning time / learn to predict from early results
- Vary structure fabrication to improve performance and/or reduce cost
- Understand beam conditioning, some experience needed (TBL+)
- How about dark current, do we need more data (in principle yes but simulation effort pending)
- 'Super-structures' and 'rf-units'
- Alternative designs (DDS, Choke Mode, Crab cavity)

TD26 parameters

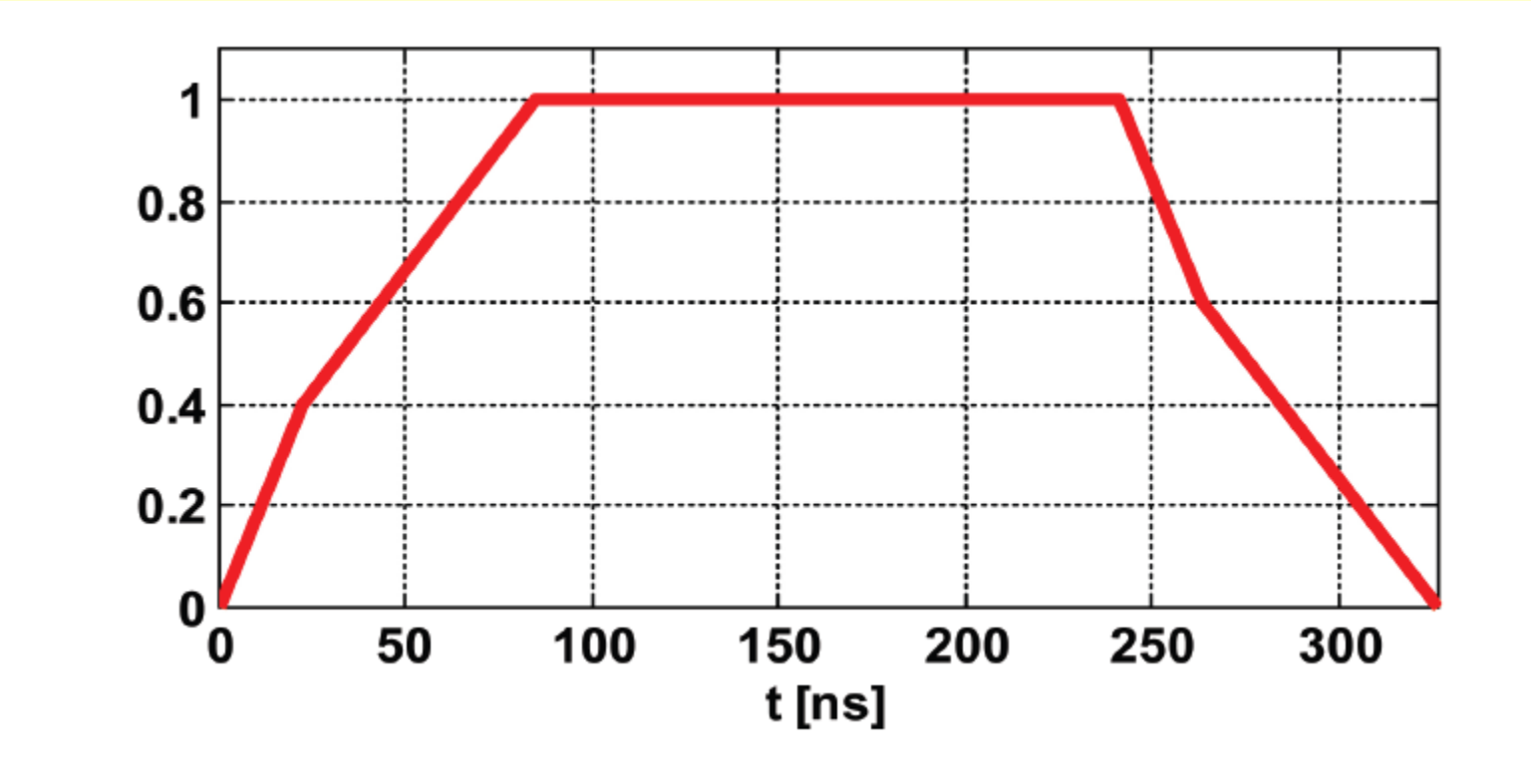
Table 5.23: Structure Parameters.

Average loaded accelerating gradient	100 MV/m
Frequency	12 GHz
RF phase advance per cell	$2\pi/3$ rad.
Average iris radius to wavelength ratio	0.11
Input, Output iris radii	3.15, 2.35 mm
Input, Output iris thickness	1.67, 1.00 mm
Input, Output group velocity	1.65, 0.83 % of c
First and last cell Q-factor (Cu)	5536, 5738
First and last cell shunt impedance	81, 103 MΩ/m
Number of regular cells	26
Structure length including couplers	230 mm (active)
Bunch spacing	0.5 ns
Bunch population	3.72×10^9
Number of bunches in the train	312
Filling time, rise time	67 ns, 21 ns
Total pulse length	243.7 ns
Peak input power	61.3 MW
RF-to-beam efficiency	28.5 %
Maximum surface electric field	230 MV/m
Maximum pulsed surface heating temperature rise	45 K

Full equipped TD26 structure



CLIC design pulse shape with 170 ns flat top

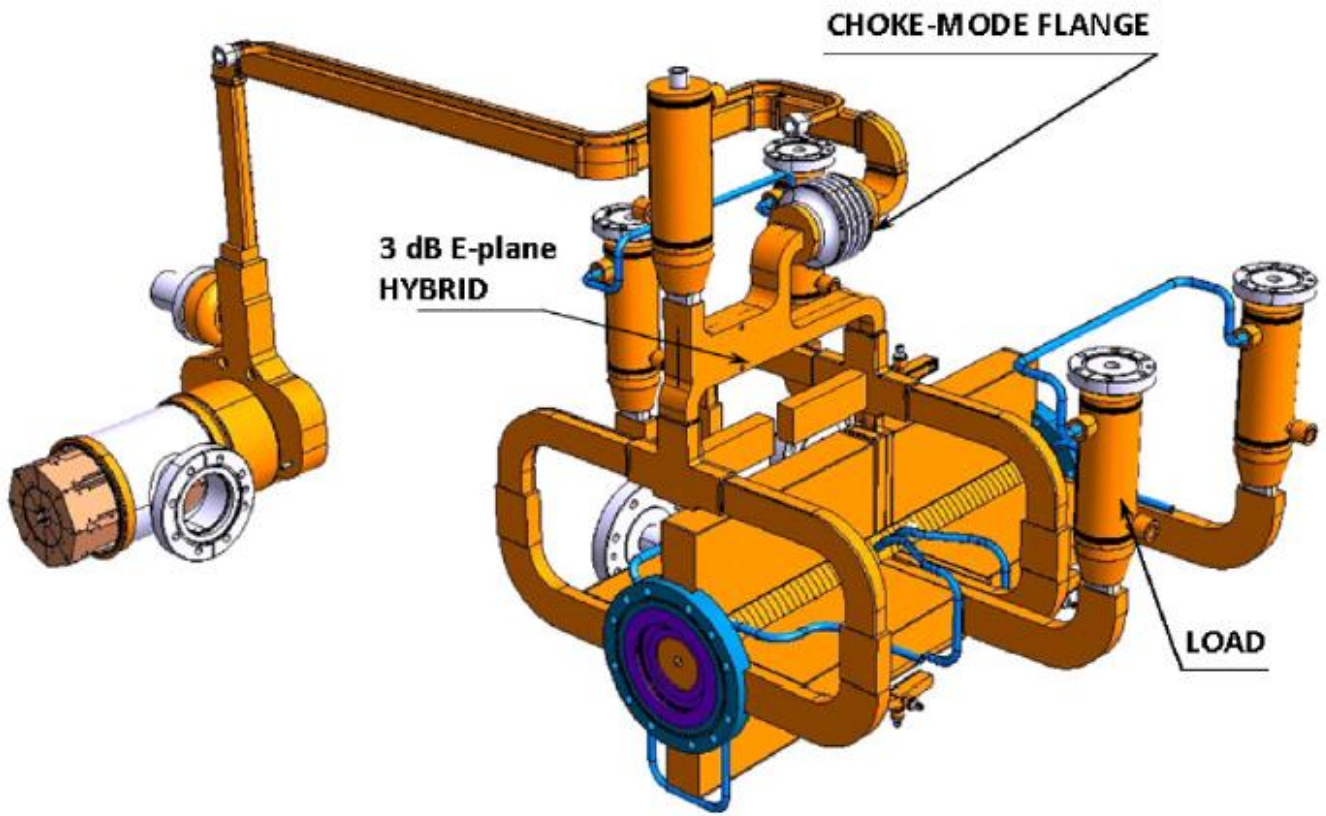


We should try to use this pulse shape for high power testing as the reference in the future

What about PETS testing and accelerating structure wake field damping verification?

- New ASSET test in preparation, sufficient ?
- Will have ~ 20 PETS structure tested in CTF3 until 2016
  Plan to test at least one more CLIC PETS with better statistics at low BDR, CERN test stand ?

CLIC rf unit



Will be tested in CTF3 within the modules,
prepare to test as well in the stand alone test stand wit additional PETS input coupler

Testing facilities existing and planned

- **KEK**, NEXTEF, only facility available right now
- **SLAC**, ASTA and NLCTA,

  basically unavailable for CLIC related studies
- **CERN**, first X-band test stand

  Construction finally finished

  Ready for commissioning (50 MW+ PC)

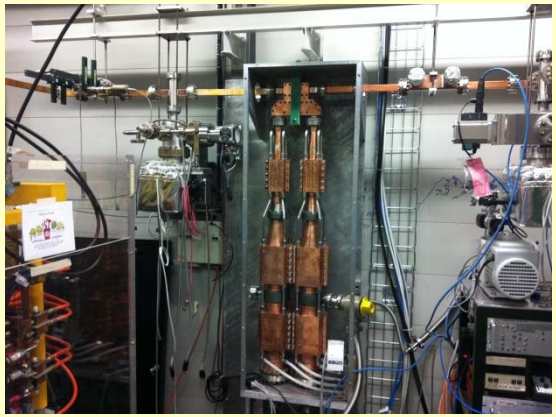
CERN plan to create more x-band testing capability

Test stand	2012	2013	2014	2015	2016
KEK, NEXTEF					
CERN 50 MW (1)					
CERN 50 MW (2)					
Collaborator 50 MW					
CERN 5 MW (3)					

In addition some beam based testing in TBTS and TBL

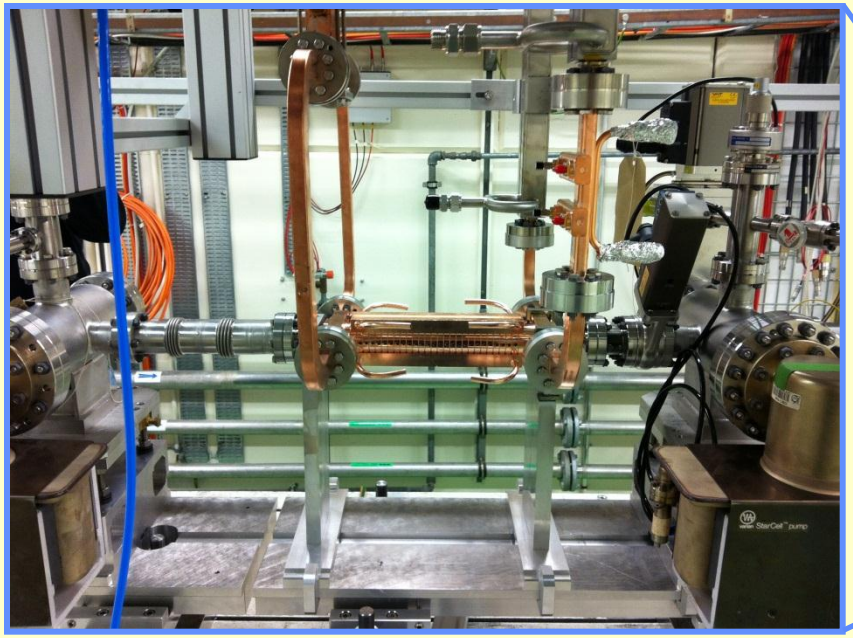
12 GHz stand alone test stand

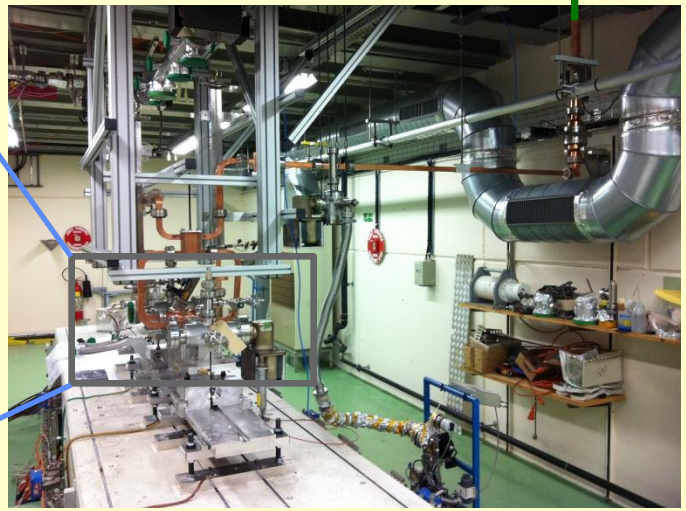
- WG network and LLRF finished
- Klystron conditioned up to 40MW, 500ns, 50Hz with loads
- Next step is conditioning of WG network and pulse compressor



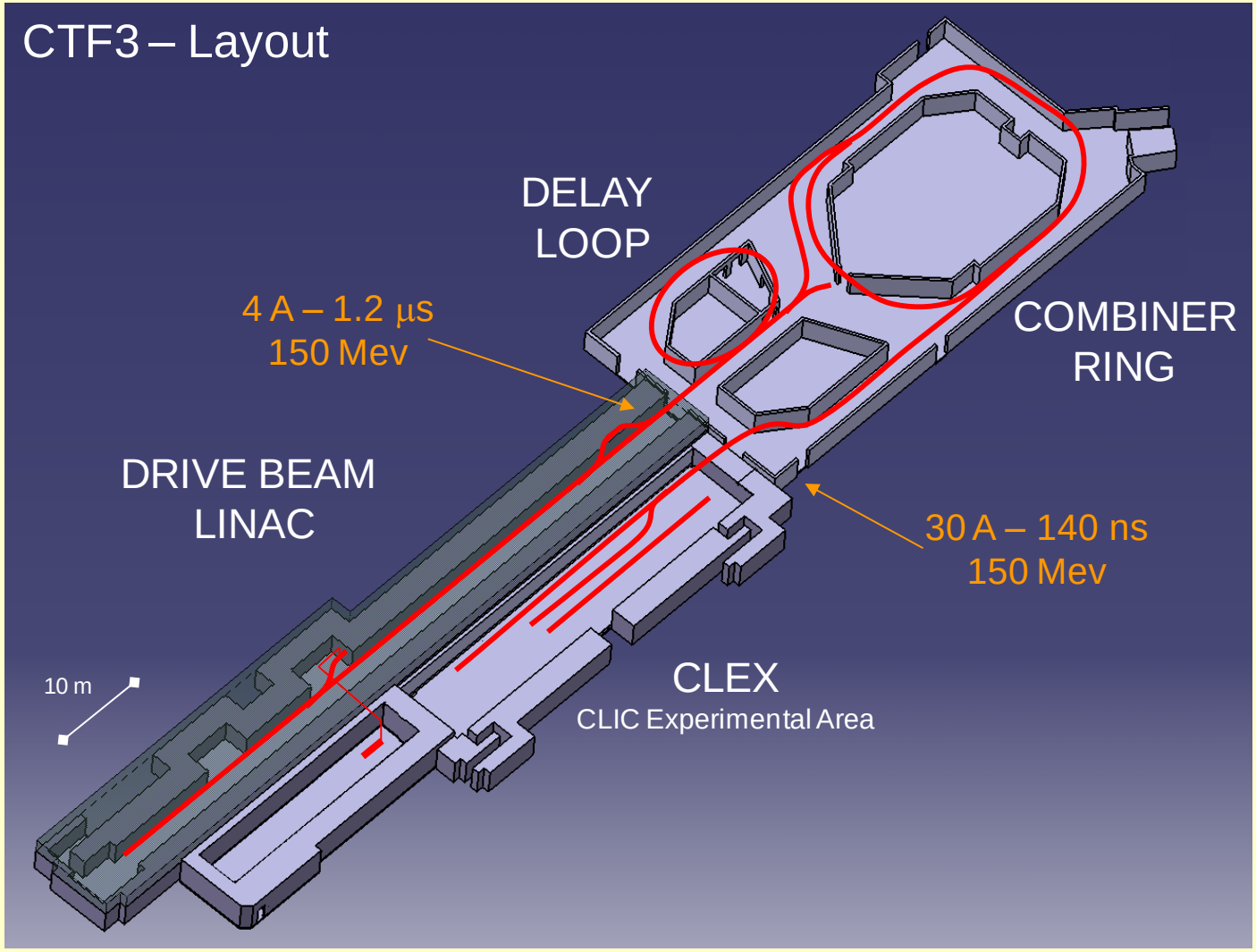
Gallery

Bunker



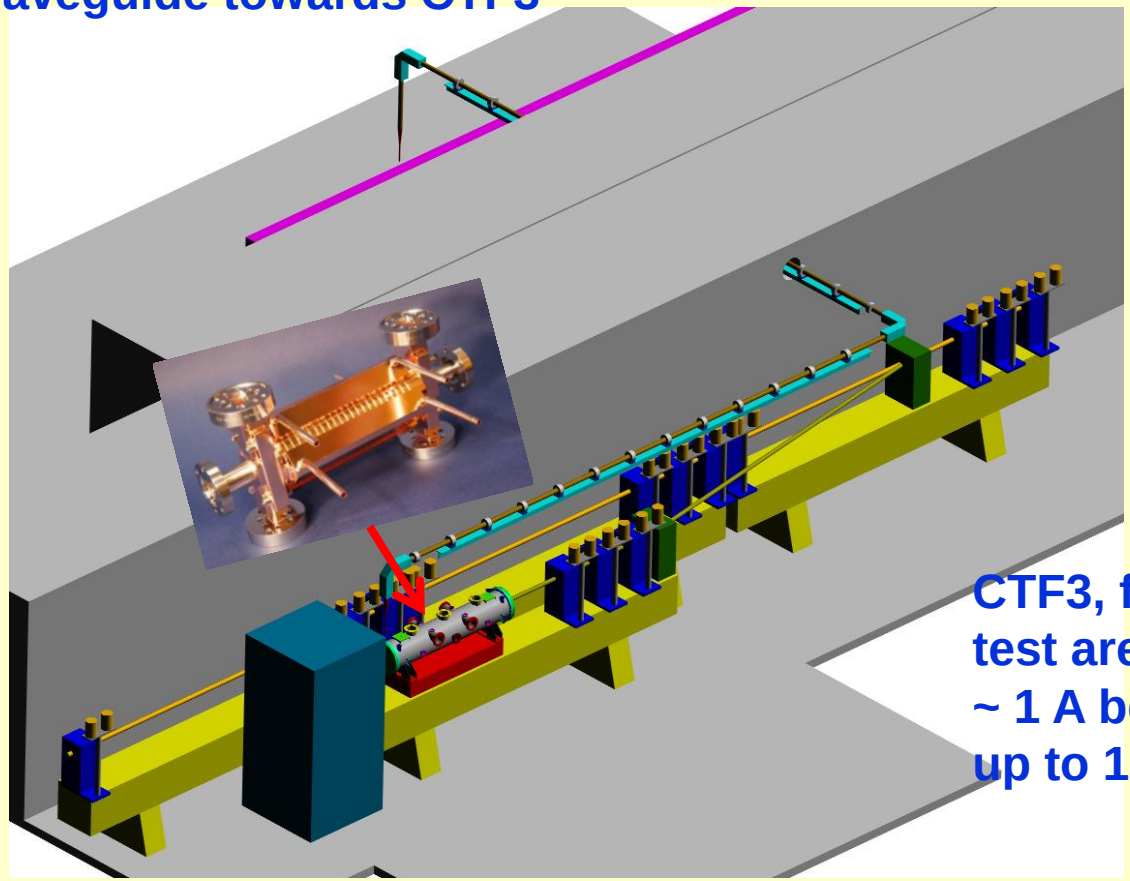


CTF3


CTF3 – Layout
DELAY
LOOP
4 A – 1.2 μs
150 Mev
COMBINER
RING
DRIVE BEAM
LINAC
30 A – 140 ns
150 Mev
10 m
CLEX
CLIC Experimental Area

Beam loading experiment in CTF3

CTFII, 12 GHz test area, circular waveguide towards CTF3



CTF3, former 30 GHz test area
~ 1 A beam for 156 ns up to 100 MeV

Main goal: compare breakdown rate with and without beam loading

TBL beam line in CTF3

12 PETS tanks installed, 3 from CIEMAT, up to 21 A beam

Maximum power per PETS in 2011: 70 MW (630 MW in total)

Tentative 2012 program

Test stand	#1 1 Q/2012	#2 2 Q/2012	#3 3 Q/2012	#4 4 Q/2012
NEXTEF	TD24[4] →		TD24_r05[2] →	
CERN 12 GHz		T24[1]	TD24_r05 →	
TBTS	TD24[1] →		TD24 wake monitor →	

Request to test DDSA and crab-cavity at CERN

Tentative 2013 program

Test stand	#1 1 Q/2013	#2 2 Q/2013	#3 3 Q/2013	#4 4 Q/2013
NEXTEF	TD24_r05[x] →			
CERN 12 GHz (1)	Beam loading experiment (CTF3)	TD26_CC	DDSA	TD24_SiC
CERN 12 GHz (2)			Crab-cavity	TD26_SiC super-structure
TBTS	TD24 wake monitor →			

Need to agree on longer term program, which structure for statistics and studies (TD24_r05 ?)

Conclusion

- CDR published and major milestones demonstrated
- Unfortunately very few x-band testing possibilities right now, but working hard to improve the situation
- Establish a solid baseline for structure industrialization

Many thanks to everybody involved in this activities at

KEK, CEA, SLAC, PSI, Trieste, CIEMAT, Uppsala, CERN

The END

Key structures
near term 2011-12

T24: CLIC baseline with higher efficiency and less tapering, done ?

TD24: CLIC baseline with damping, should start now

TD24_12GHz: First 12 GHz structure powered by PETS, ongoing

TD24_R05: Modified radius to improve surface quality

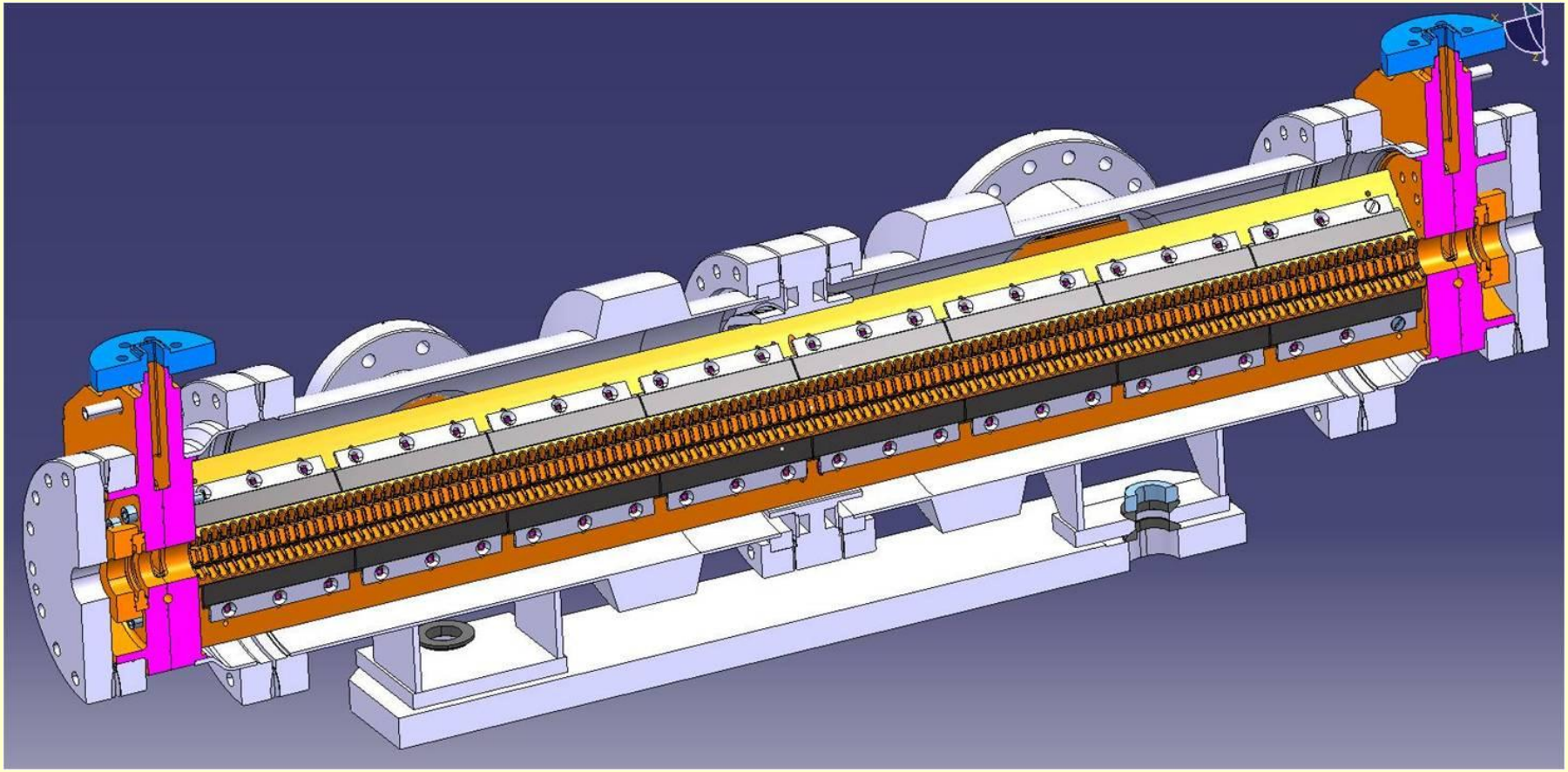
TD24_R05_SiC_CC: Compact coupler and HOM load integrated

PETS 11.4 GHz damped: PETS with damping material, done ?

PETS 12 GHz: Beam based power production, ongoing

TBL+

to test structures and two beam conditioning strategy



Plans for TBL beyond 2012

How could it look like