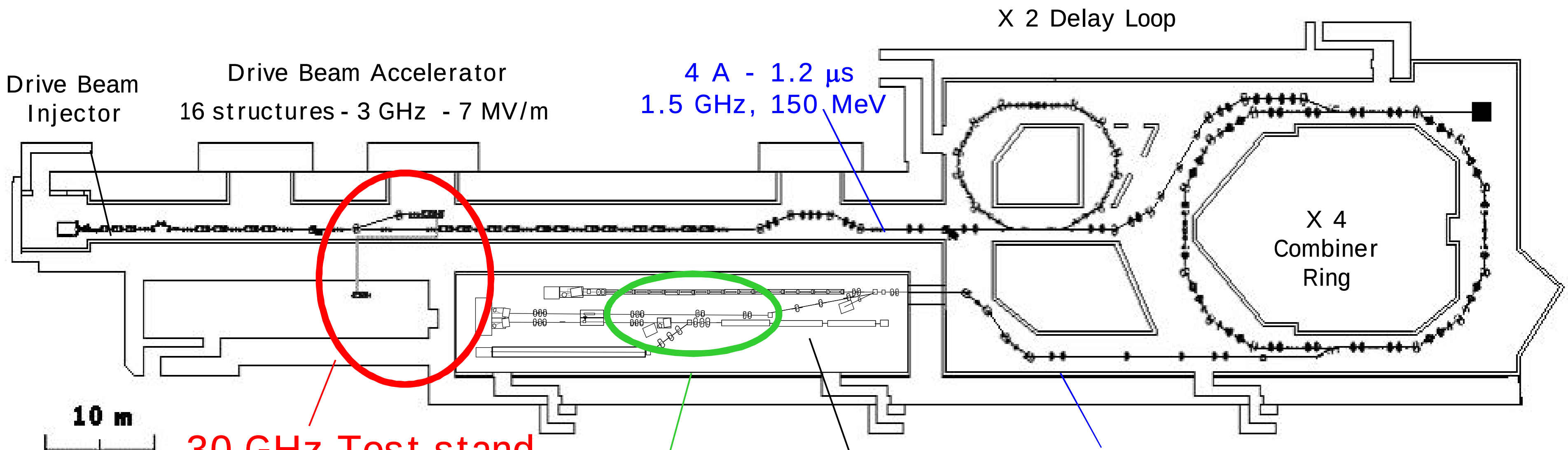
RF Power production at CTF3

- 30 GHz power production
- 12 GHz power production in the Two Beam Test Stand (TBTS)
- 12 GHz power using the Test Beam Line (TBL)
- 12 GHz stand alone power source

Steffen Döbert, BE-RF

Rf power production with CTF3



30 GHz Test stand

65 MW, 100 ns

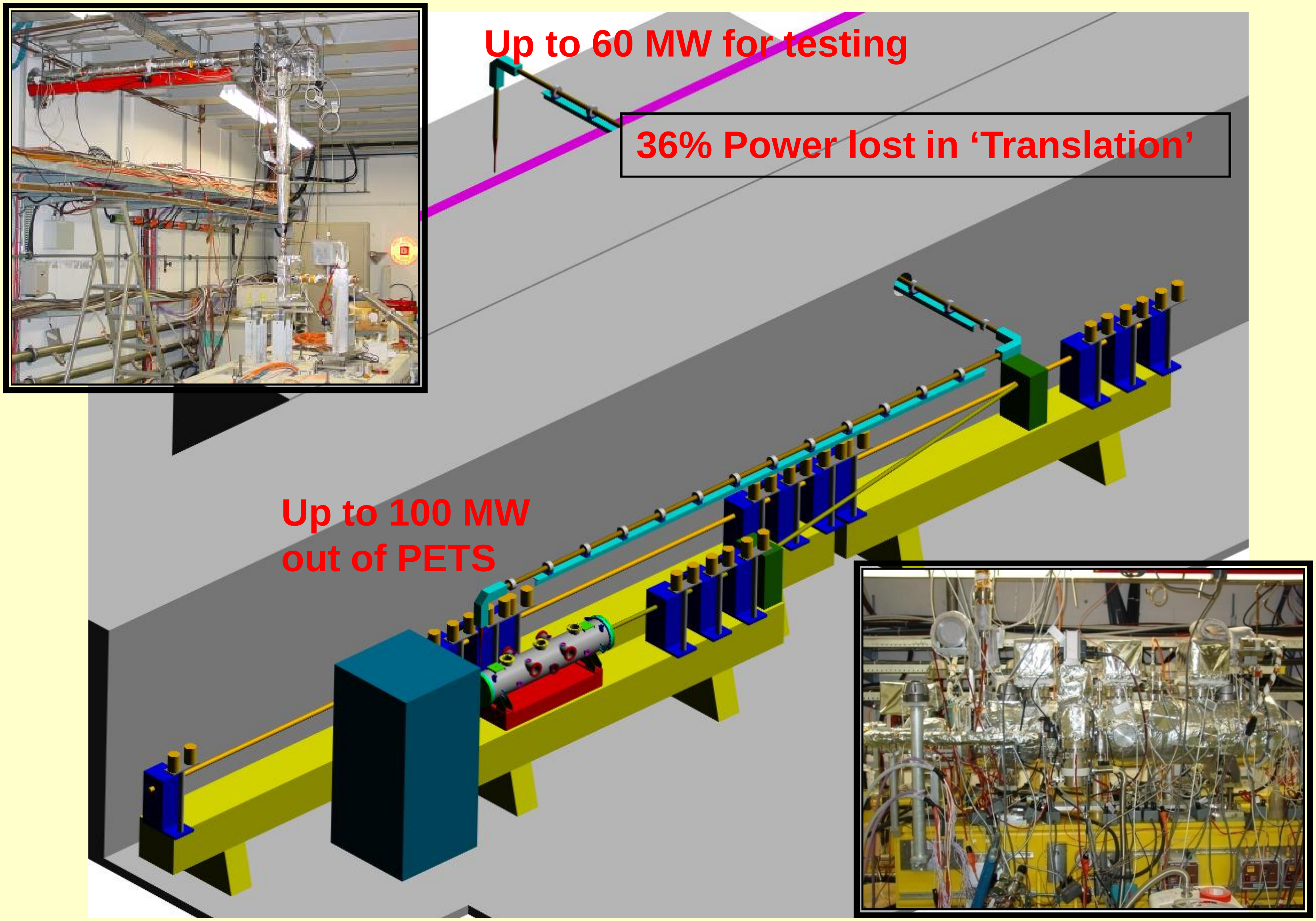
Two Beam Test stand 12 GHz

200 MW, 140 ns

TBL, 16*150 MW, 140 ns

Stand alone 12 GHZ test stand in CTF2, 50 MW klystron + pulse compressor

30 GHz Power Production



Automatic conditioning

Pulse to pulse data acquisition for history and waveforms for trips

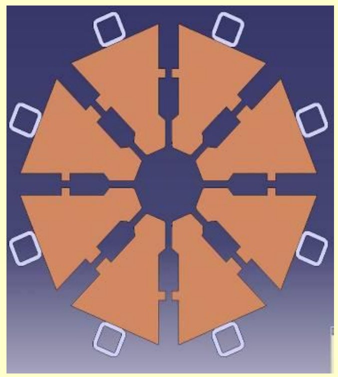
Automatic conditioning, strategy and interlocks

Enable / Name	Number events	Pulse length	Stepping Motor	Wait	Threshold	Enable Threshold	Incid. Power Threshold
[x] FC	1	60.00 %	100.00 %	10.00 sec	-0.50		
[ ] Missing energy	1	50.00 %	50.00 %	0.00 sec	25.00 %		0.10
[ ] Reflected energy	0	50.00 %	50.00 %	0.00 sec	25.00 %		0.10
[x] Vacuum AST		55.00 %	100.00 %	10.00 sec		50.00 %	
[x] Vacuum PT		55.00 %		10.00 sec		50.00 %	
[x] Vacuum FB		55.00 %		10.00 sec		50.00 %	
[x] Vacuum SB		55.00 %		10.00 sec		50.00 %	
[x] Vacuum TB		55.00 %		10.00 sec		50.00 %	
[x] CPI Loss		100.00 %	100.00 %	180.00 sec			
[ ] Gun Inhibit		100.00 %	100.00 %	30.00 sec			
[ ] Pulse OFF		100.00 %	100.00 %	5.00 sec			
[ ] No pulses		100.00 %	100.00 %	60.00 sec	10.00 sec		

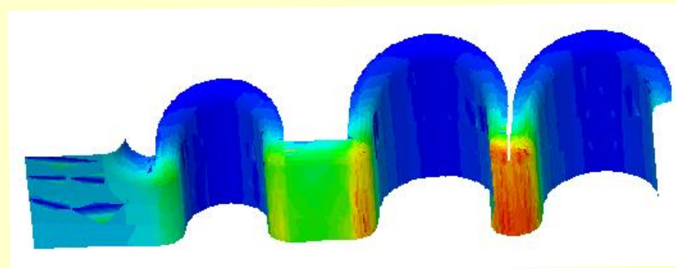
Programmable trip detection method and switch on procedure

The 12 GHz PETS

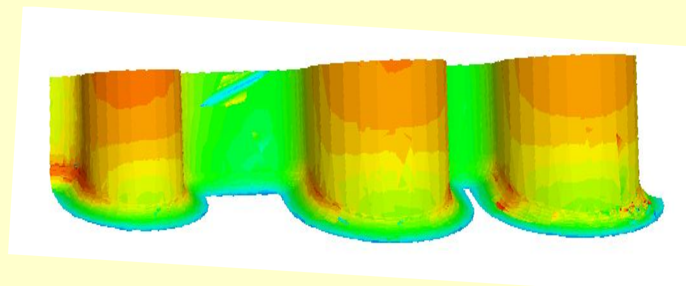
$$P = I^2 L^2 F_b^{\,2} \omega_0 \frac{R/Q}{V_g 4}$$

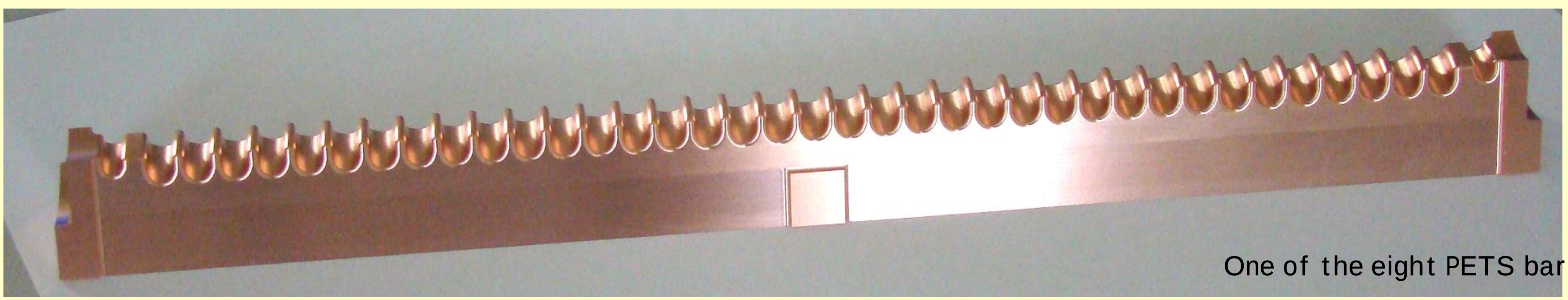


E max (135 MW)=56 MV/m



H max (135 MW)=0.08 MA/m

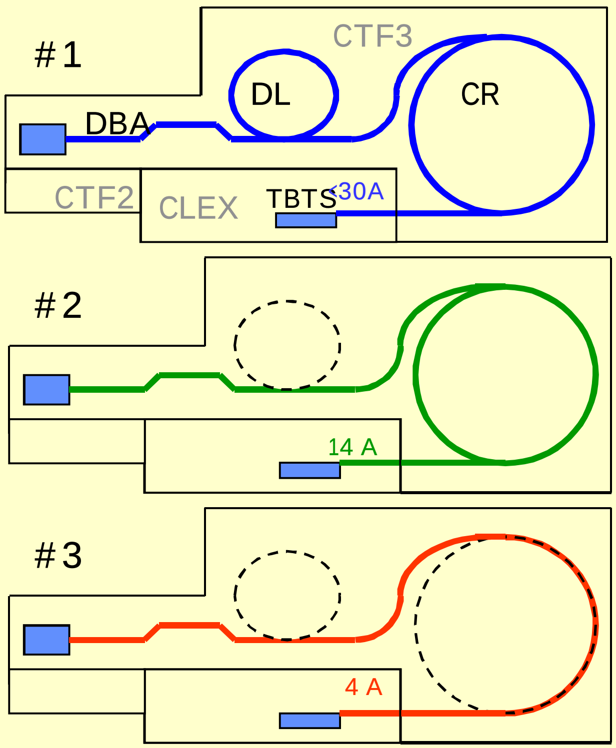




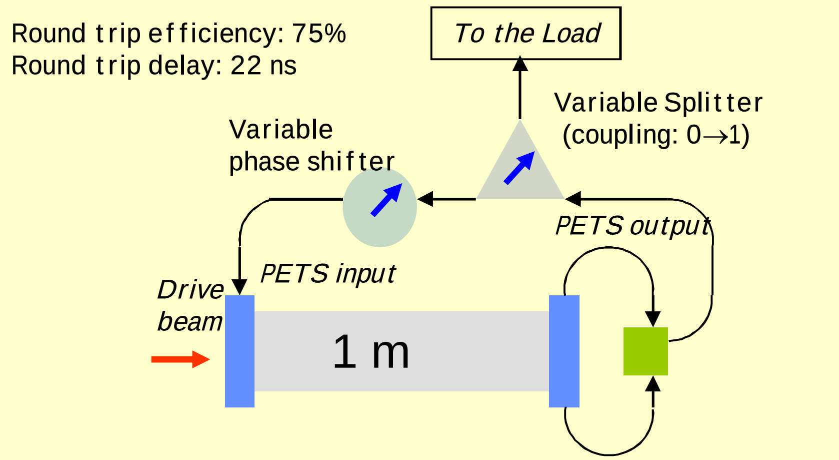
One of the eight PETS bar

PETS high power test in the TBTS

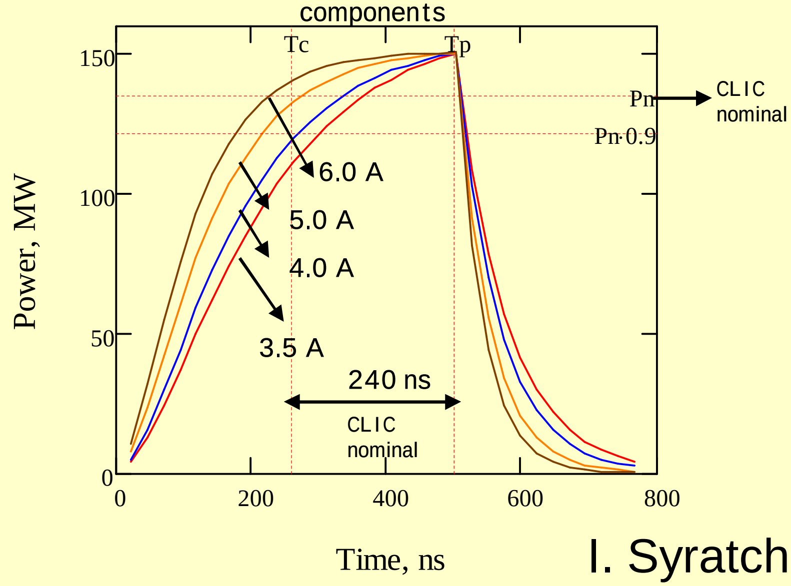
- Different drive beams generated in the CTF3



Operation mode	#1	#2	#3	CLIC
Current, A	<30	14	4	101
Pulse length, ns	140	<240	<1200	240
Bunch Frequency, GHz	12	12	3	12
PETS power (12 GHz), MW	<280	61	5	135



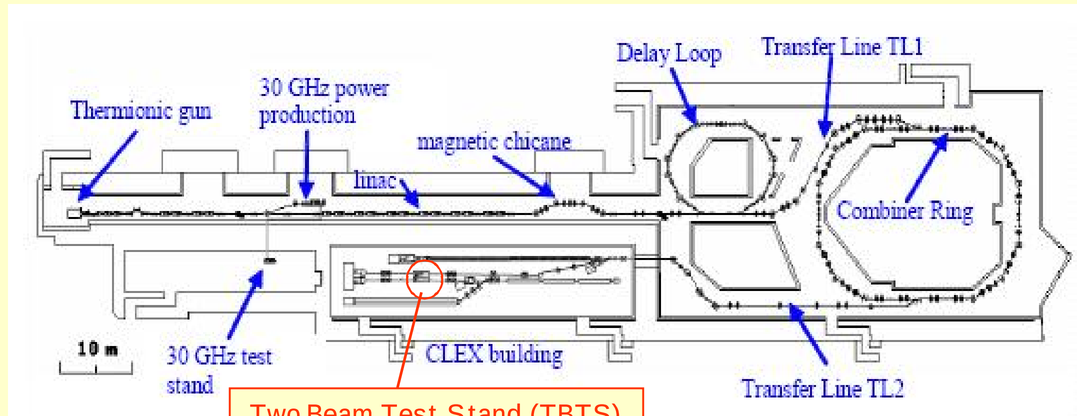
Expected PETS power production with re-circulation.
The calculation followed the measured performance of all the components



I. Syratchev

1 m long TBTS PETS

Fully equipped 1 m long TBTS PETS



Two Beam Test Stand (TBTS)

Variable high power RF power splitter

Variable high power RF phase shifter

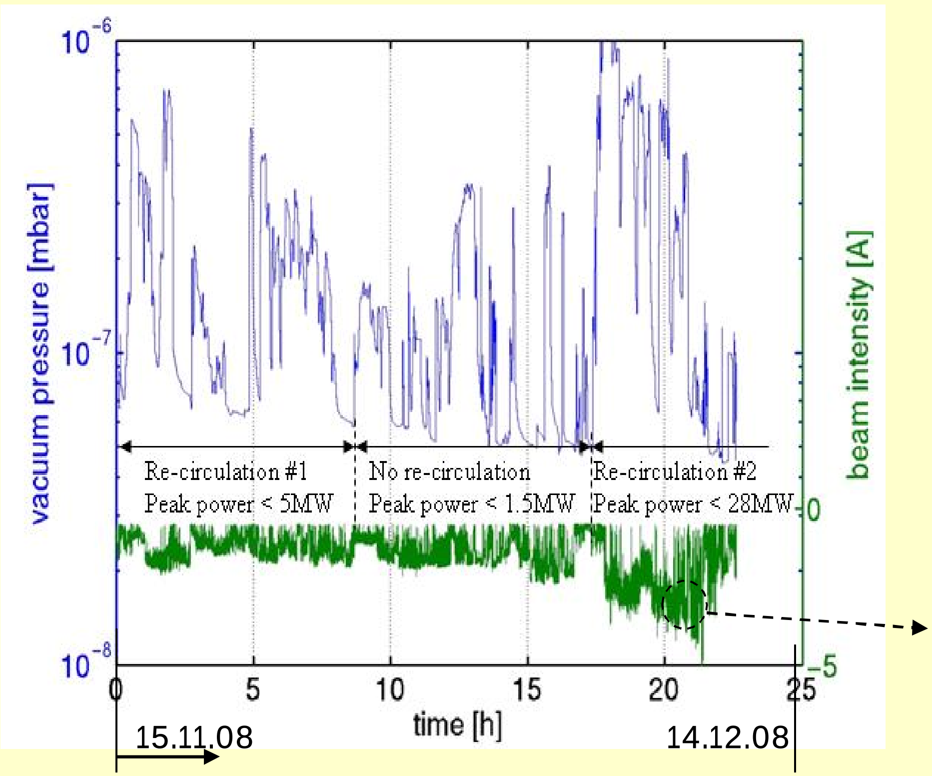
Drive beam

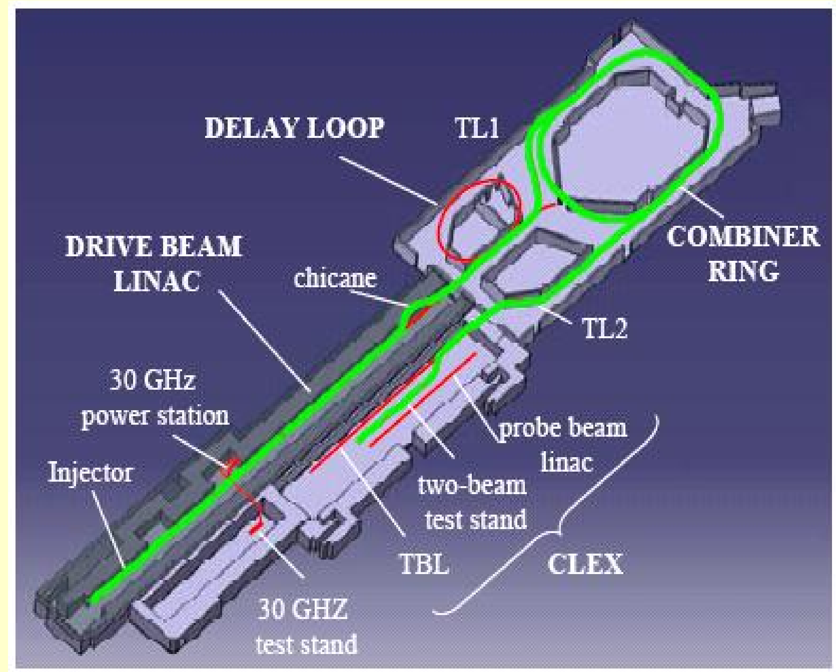
PETS tank with re-circulation RF circuit installed in TBTS test area (October 2008)

I. Syratchev

PETS processing

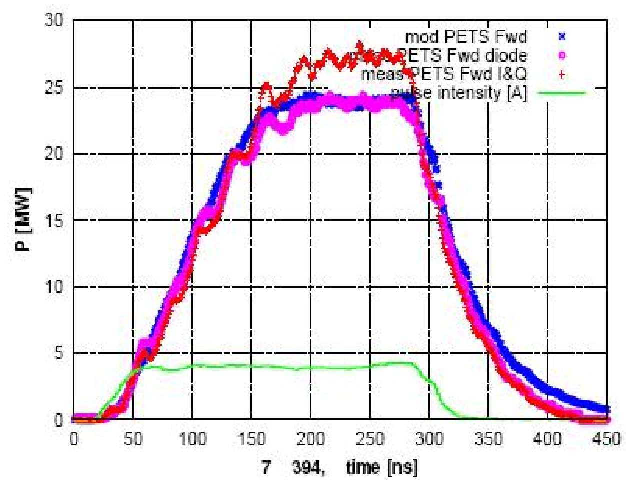
PETS processing history in 2008

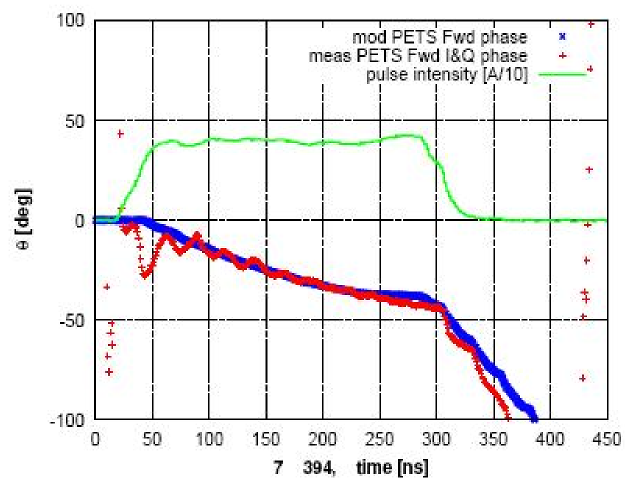




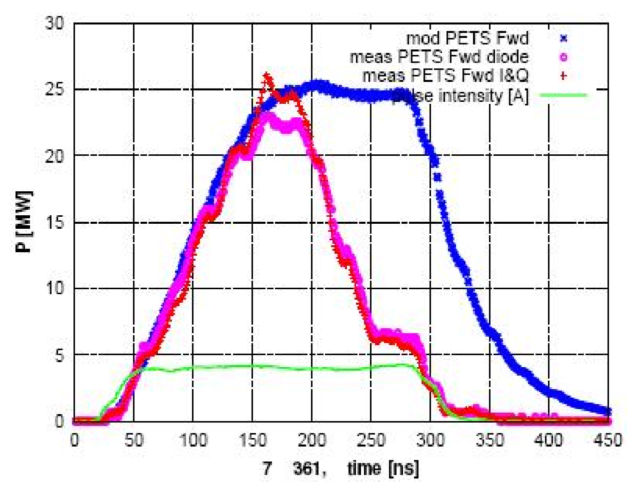
Conditioned to about 30 MW, 150 ns flat top

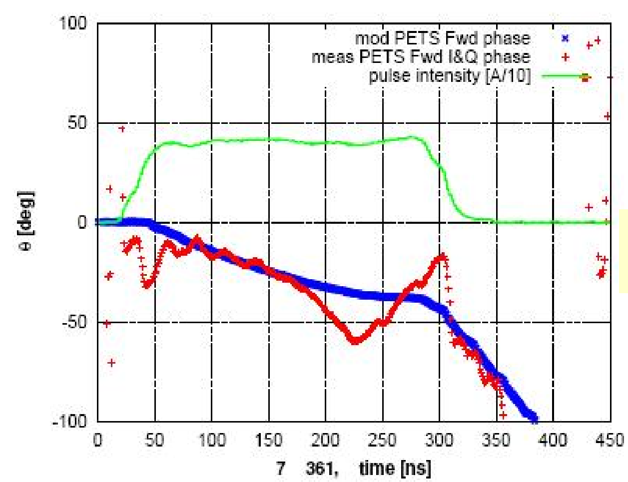
High power test, first results





Model with constant coupling and phase





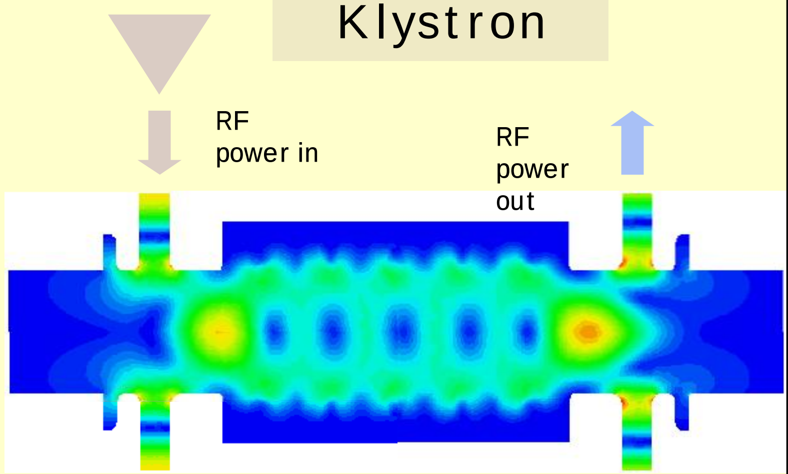
Event with breakdown

$P_{mod} = c^2 P_{meas} = (0.78)^2 P_{meas}$ (bunch length 2.8 mm rms)

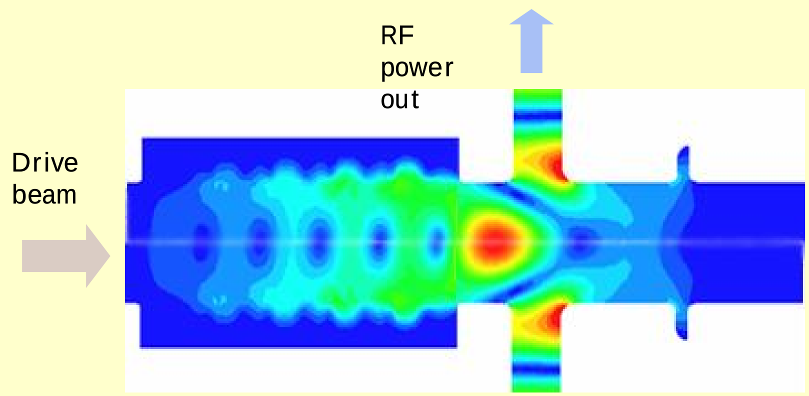
E. Adli

PETS testing

Klystron



Drive beam



ASTA (SLAC)

Objective: to understand the limiting factors for the PETS ultimate performce

What matters is the output section !

CTF3 (CERN + Collaborations)

Two beam test stand (CERN + Collaborations)

Objective: to demonstrate design rf parameters at the output of the PETS

Test beam line (CERN + Collaborations)

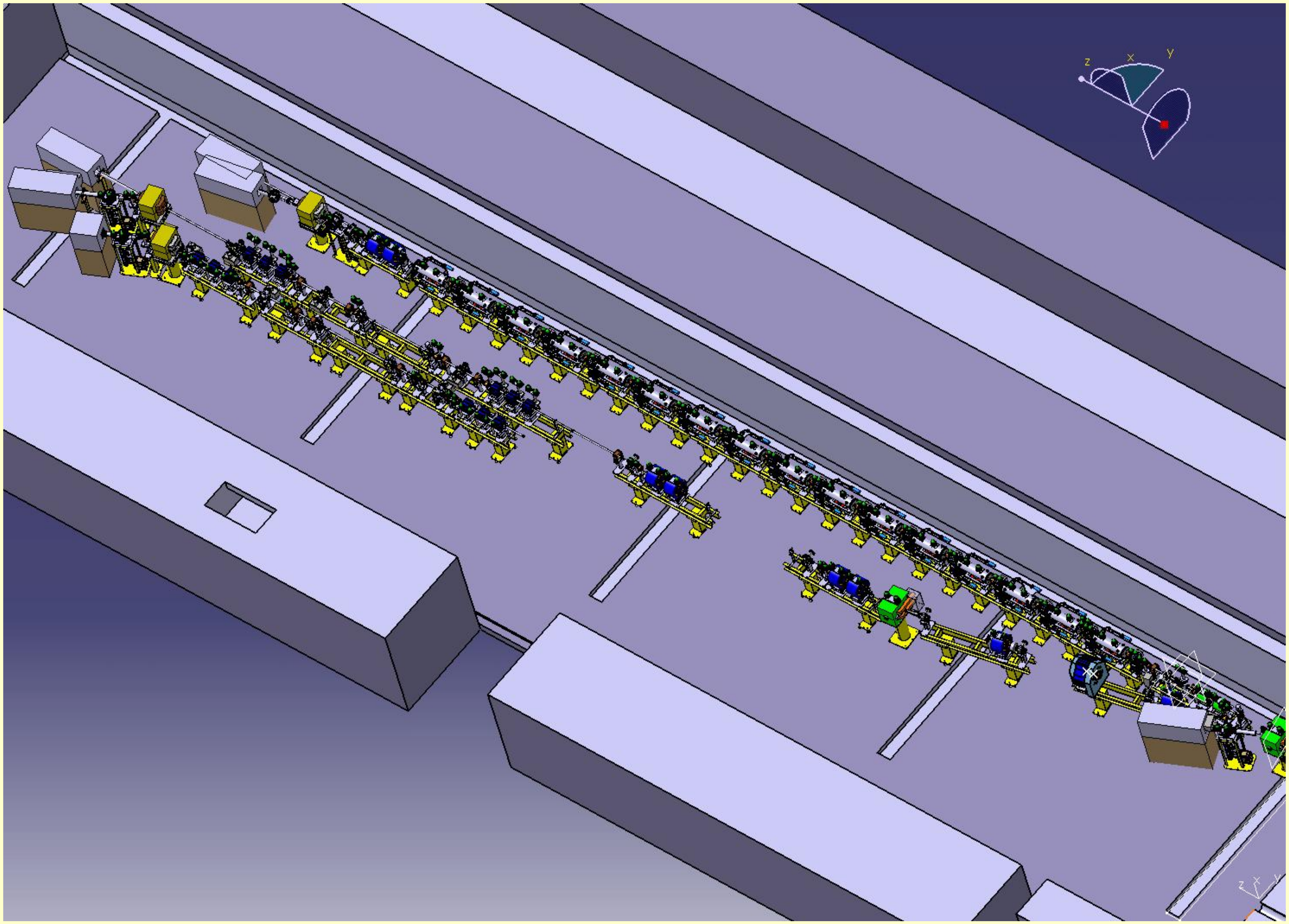
Objective: to demonstrate the beam transportation without looses and ~ 50% deceleration.

I. Syratchev

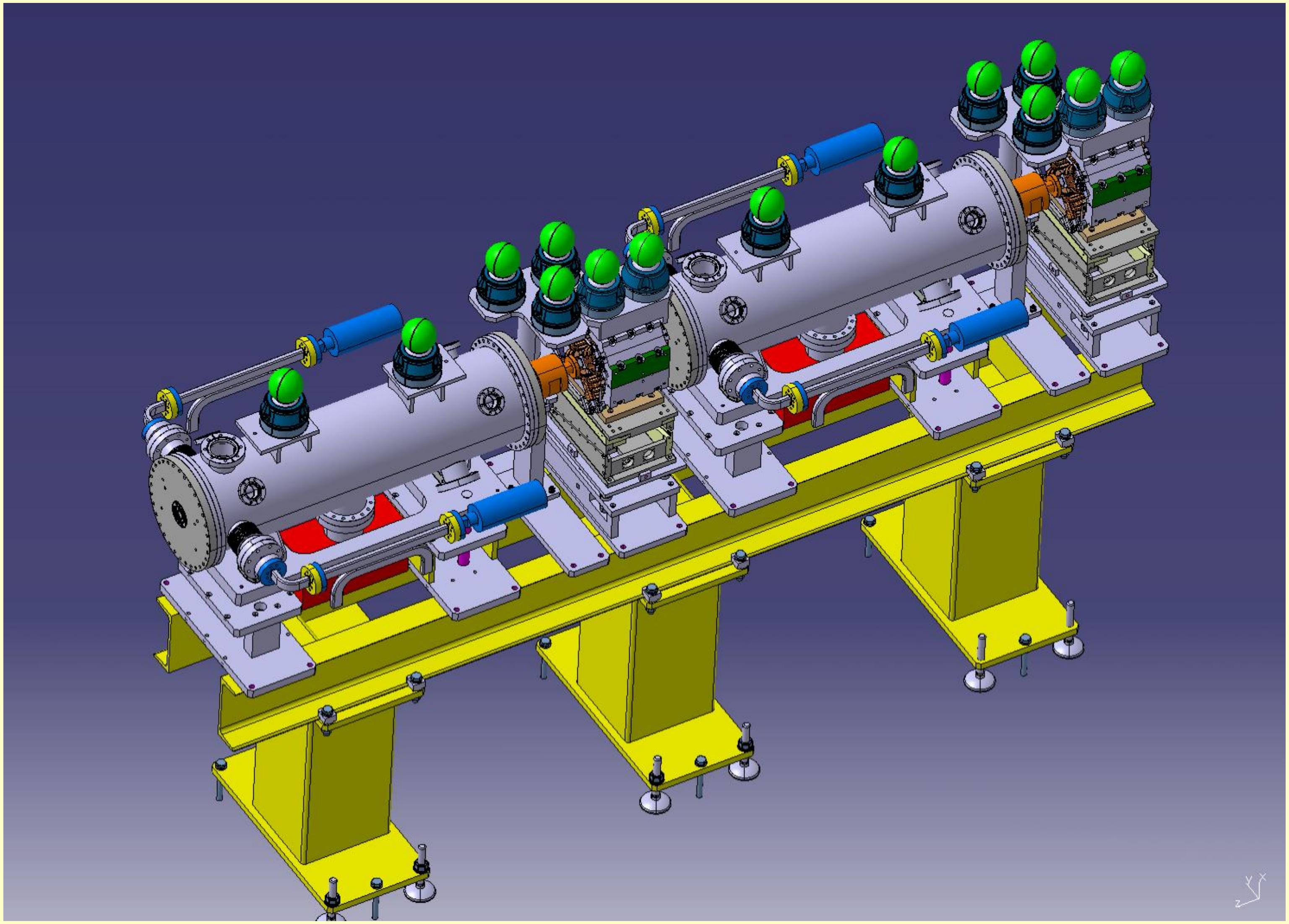
Test Beam Line Goals

- o High energy spread beam transport, low losses
  (Bench mark simulations)
- o RF Power Production, Stability
  (End Energy <50%, 2.4 GW of RF power)
- o Alignment
  Active Quad alignment with movers
  (Test procedures for BBA, DFS)
  100 microns pre-alignment for PETS
- o Drive Beam Stability, Wake fields
  (no direct measurement of the wake fields)
- o 'Realistic' show case of a CLIC decelerator
- o Industrialization of complicated RF components

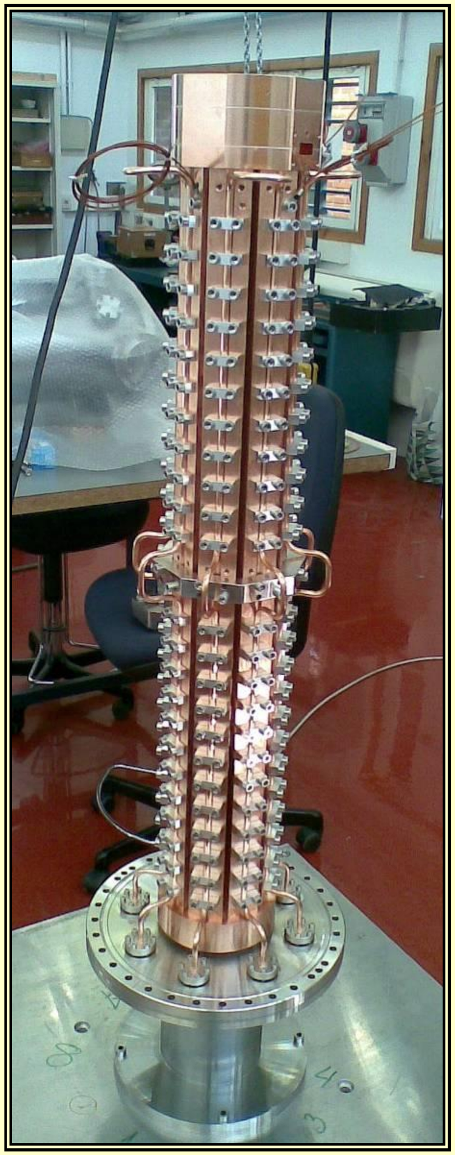
TBL in CLEX

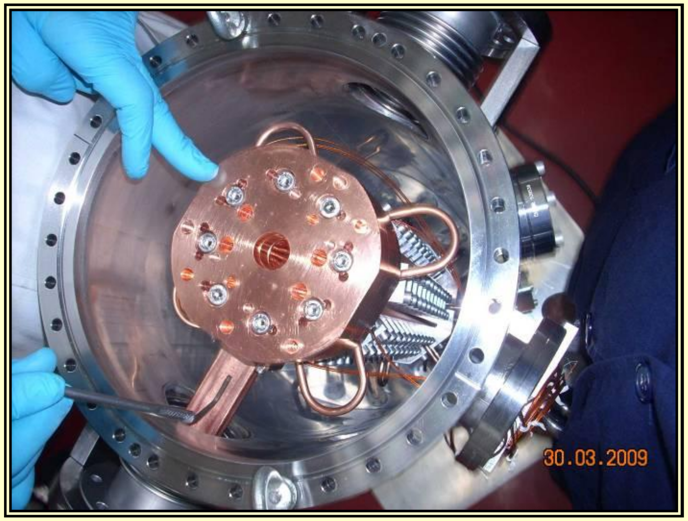


TBL cell



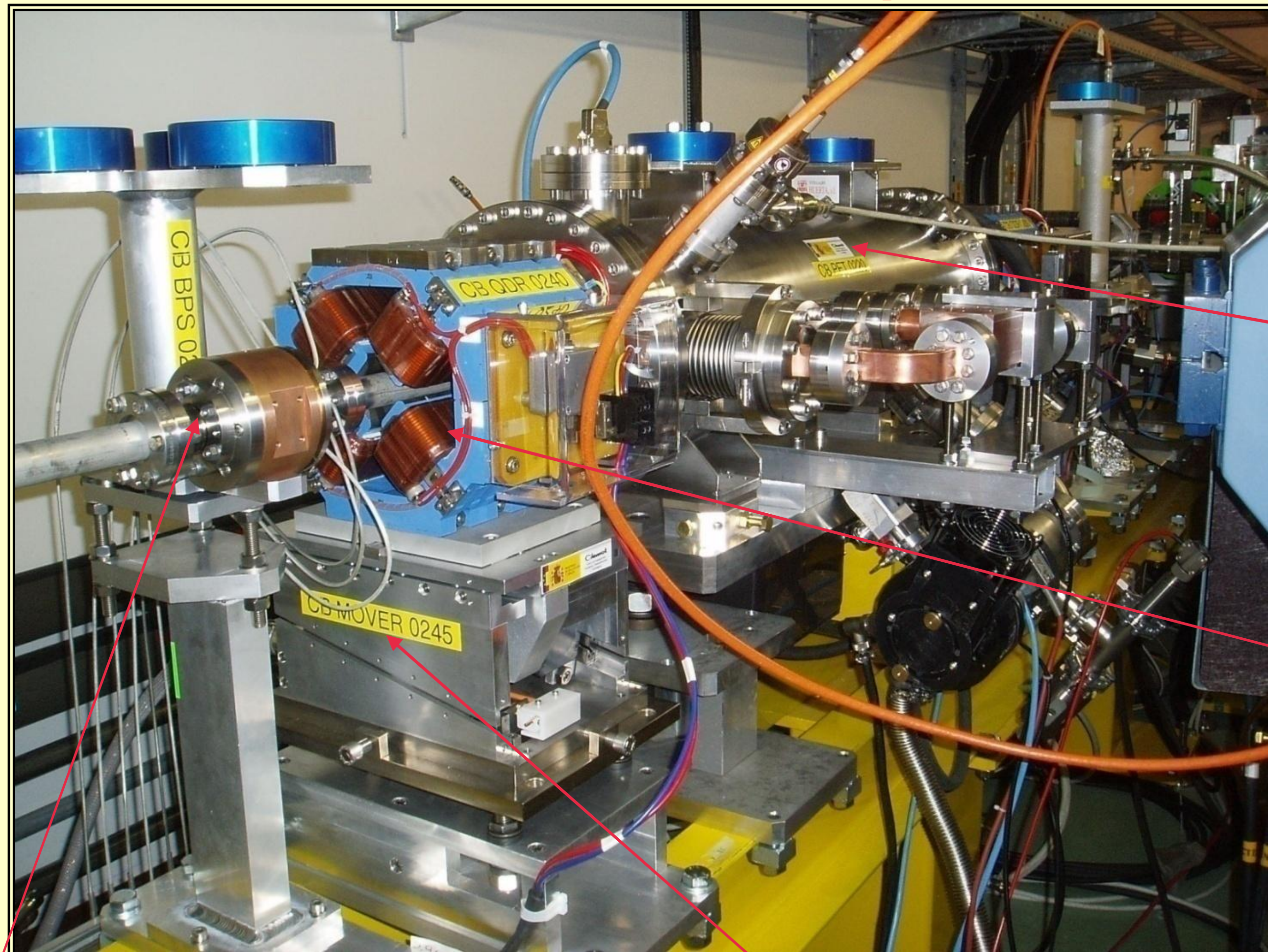
PETS tank assembly, CIEMAT





Happy Team after finishing the first tank

Prototype module installed in April 2009



PETS-tank, CIEMAT

Quad, BINP

BPM, IFC, UPC, LAPP

Quad Mover, CIEMAT

TBL planning

- Organize and launch production of at least 7 more PETS with our collaborations to be commissioned with beam in 2010.
  Approach: parallel fabrication at CIEMAT and CERN
  using multiples vendors
- CDR demonstration measurement milestones at the end of 2010
- Complete TBL with 16 PETS in 2011
- Full demonstration of drive beam decelerator end of 2011
- > 2012 use TBL as a 12 GHz power source, rf conditioning with beam (up to 16 testing slots would be possible)

TBL energy profile

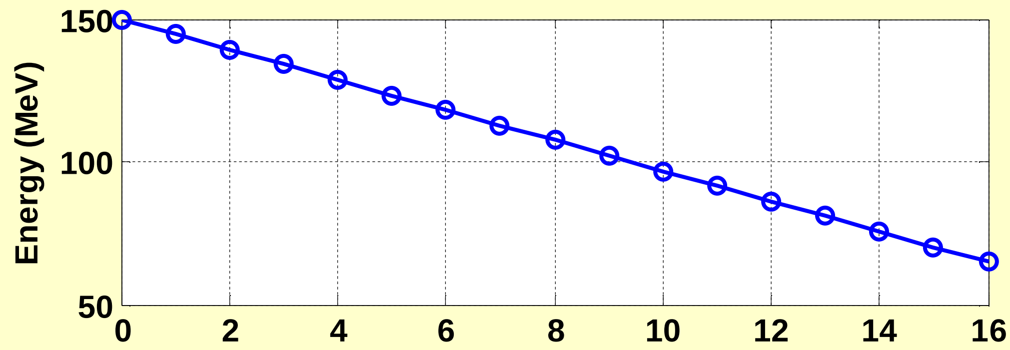
16 PETS

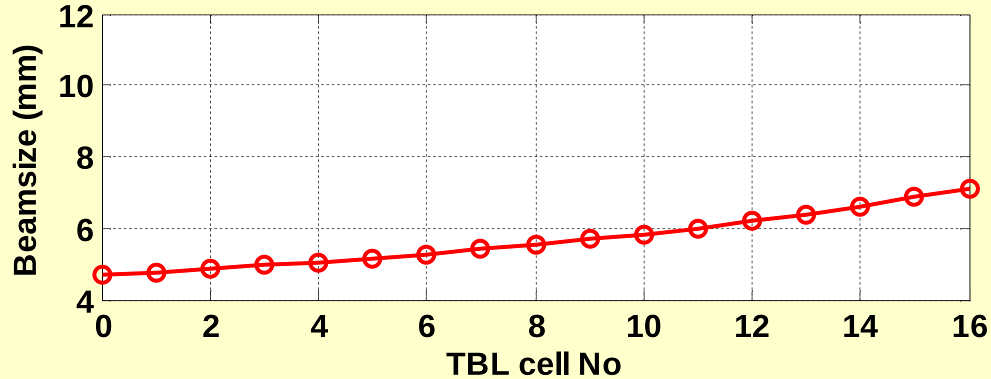
E_0 = 150 MeV

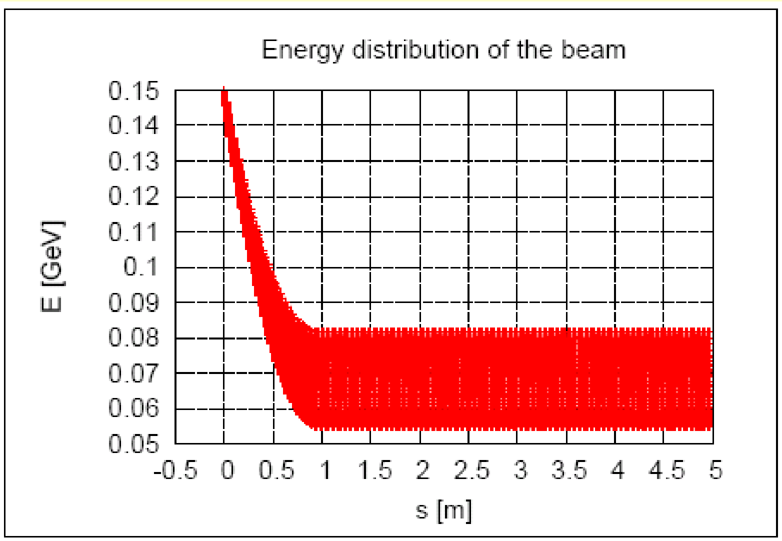
I=28 A

Energy extraction: 56 %

2.2 GW of rf power

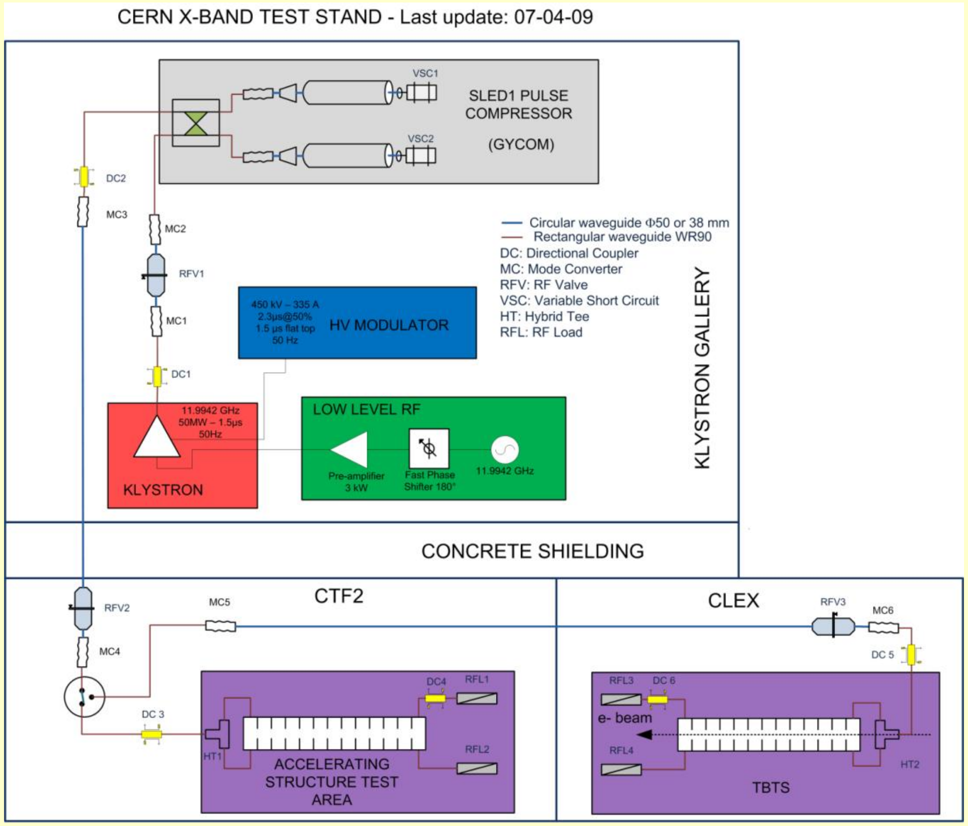






Beam energy after lattice

12 GHz Test-Stand at CERN

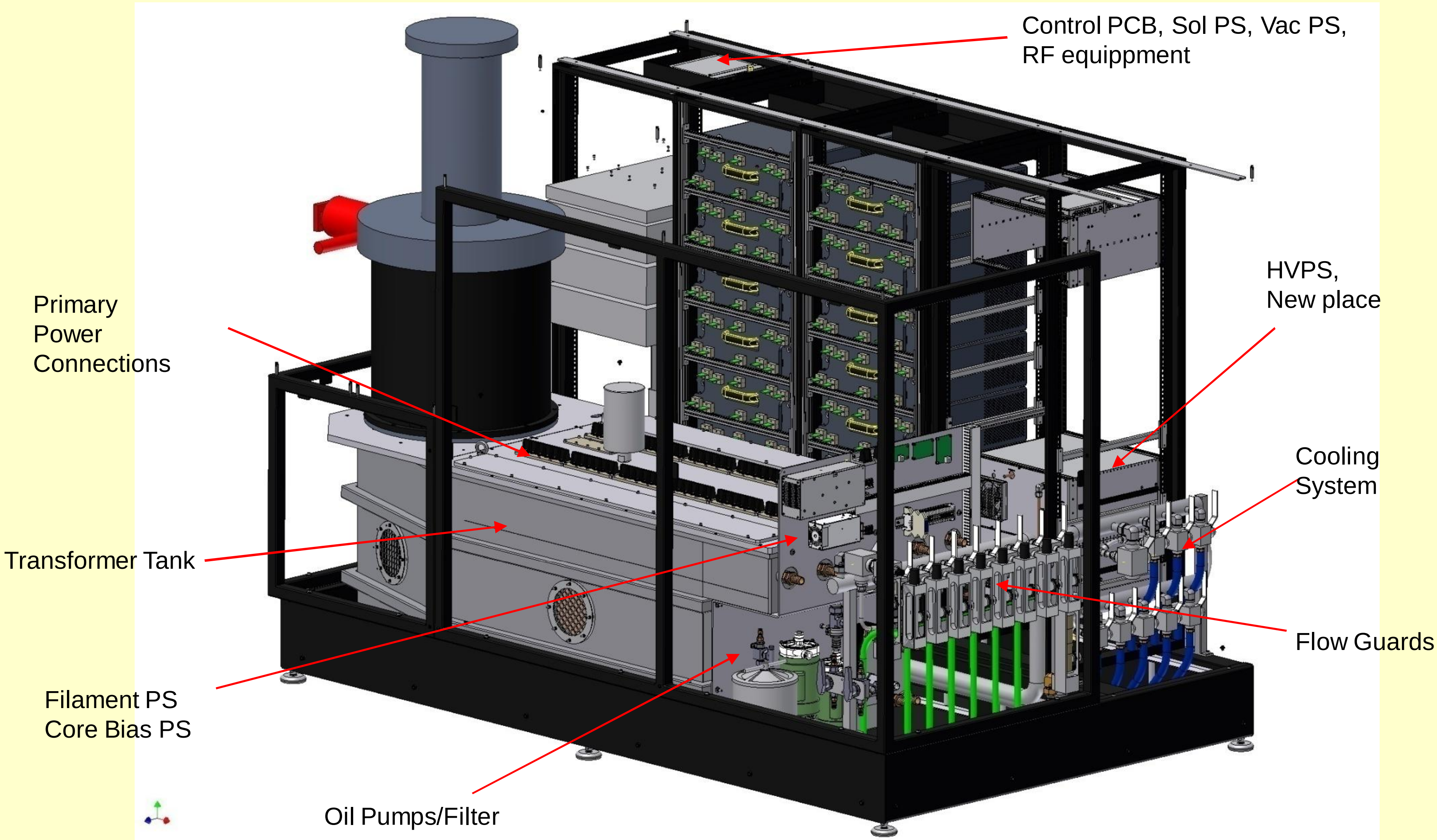


Stand alone 12 GHZ test stand with independent bunker (CTF2) and option to use the power synchronized with beam in CTF3

50 MW klystron form SLAC, pulse compressor from the beginning

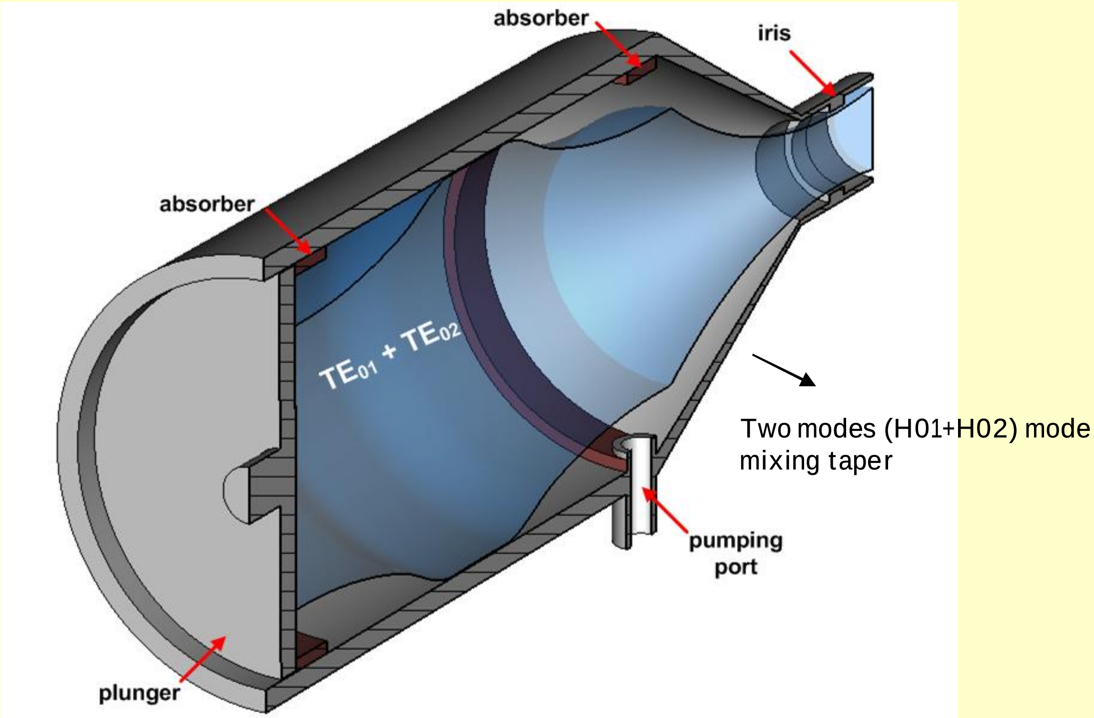
K. Schirm, F. Peauger

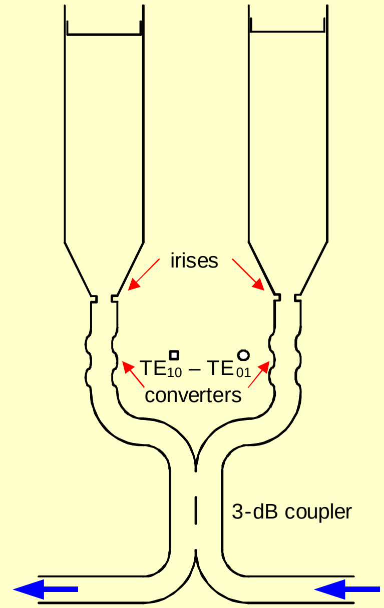
Modulator



Status: ordered

Pulse Compressor: Gycom

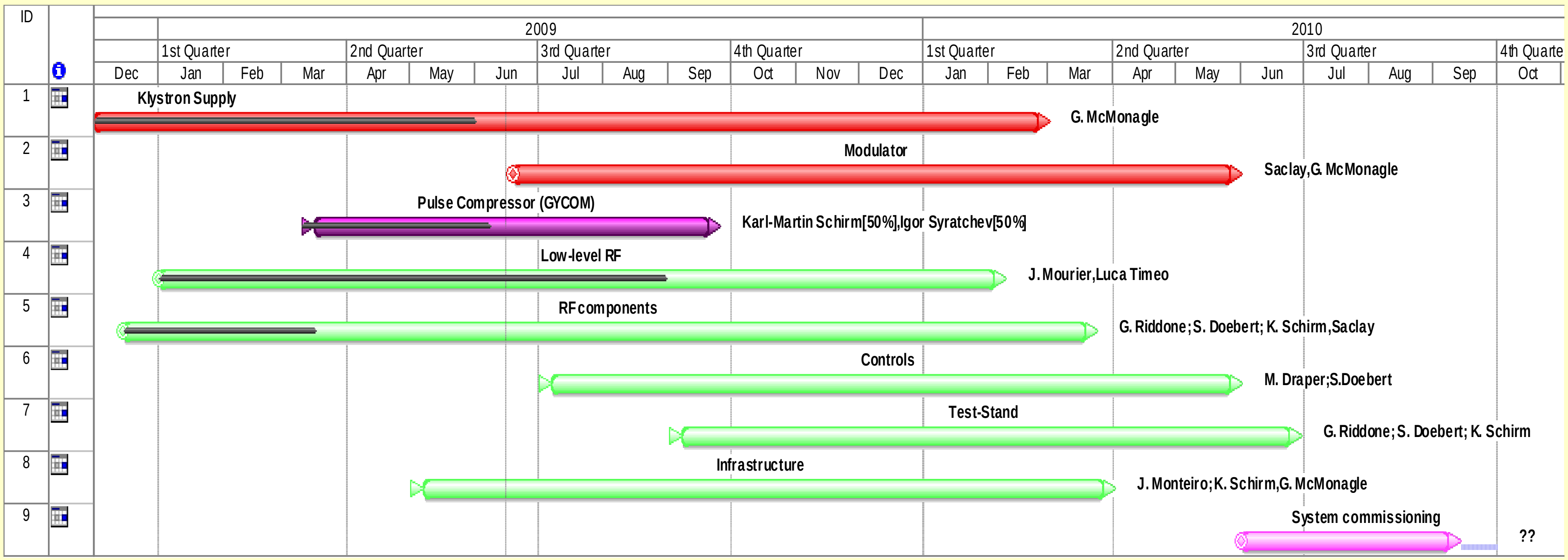




Courtesy: I. Syratchev

Status: ordered

Schedule



Goal is to be operational in Summer 2010

Conclusion

- 30 GHz power source will stop operating at the end of this year
  We basically finished our testing program at 30 GHz
- TBTS will come online in fall with a first 12 GHz structure test and two beam acceleration experiments.
  It will be challenging to operate at the beginning
- TBL should produce power soon and is effectively a test for PETS but the power will be used only after 2012 for accelerating structure testing
- The 12 GHz klystron based test stand should be available in summer 2010 and is considered as the new work horse for CLIC structure testing. We are already thinking of a klystron based structure testing plant with of the order of 10 testing slots

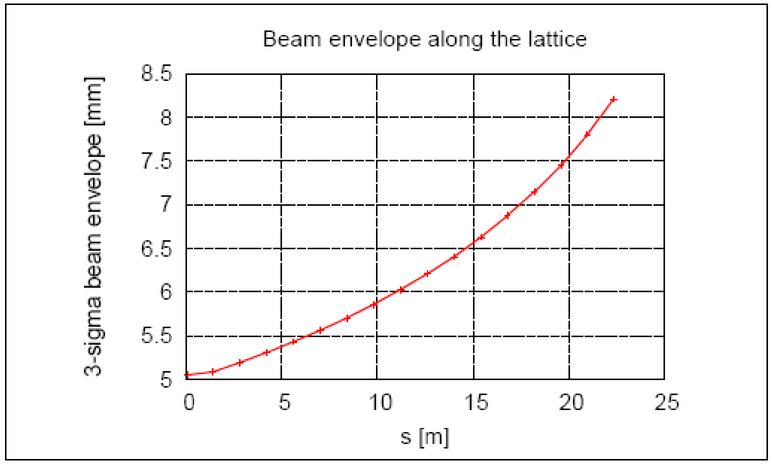
Outlook on CERN structure testing

Up to 2010: CLIC feasibility testing, rely on collaboration
with SLAC and KEK at 11.4 GHz

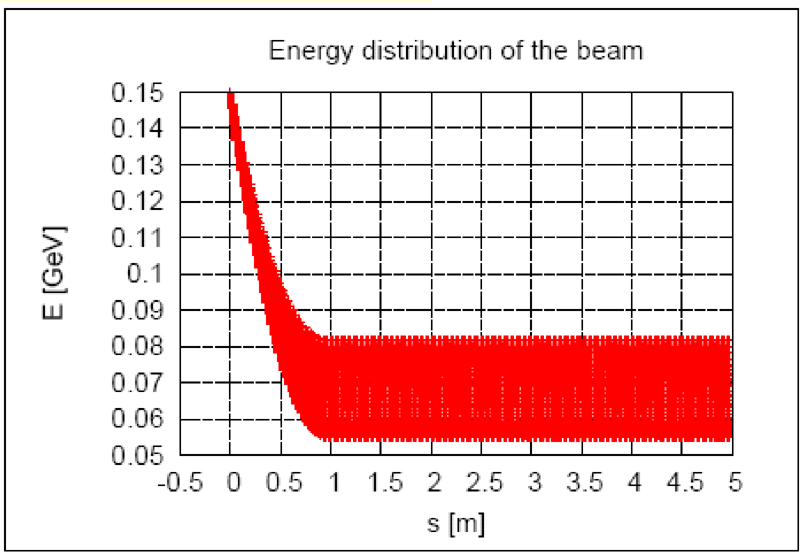
2011 -2012: ~ 6 structure tests/year at 12 GHz, stand alone test stand
+ a few in the TBTS

2013 -2016: In case we enter into the TDR phase
TBL as power source
Klystron base structure testing plant
Goal: ~ 50 structure tests/year

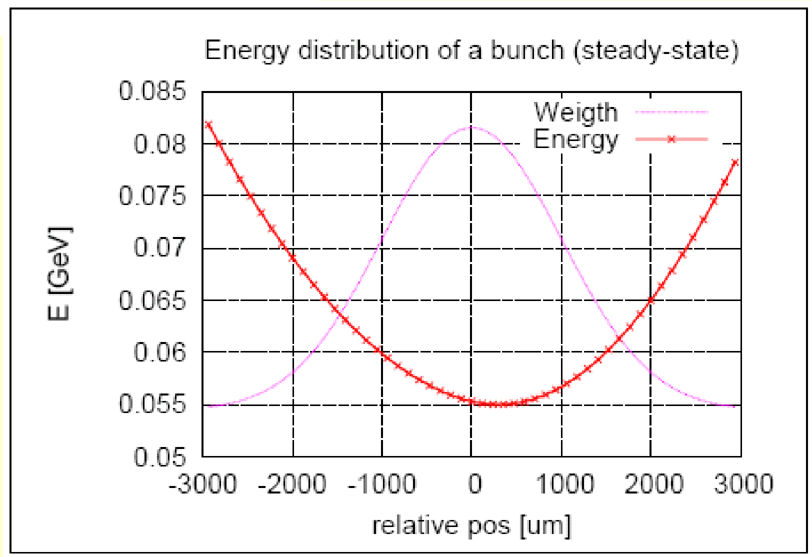
TBL beam dynamics



3-σ beam envelope along lattice (adiabatic effects alone)



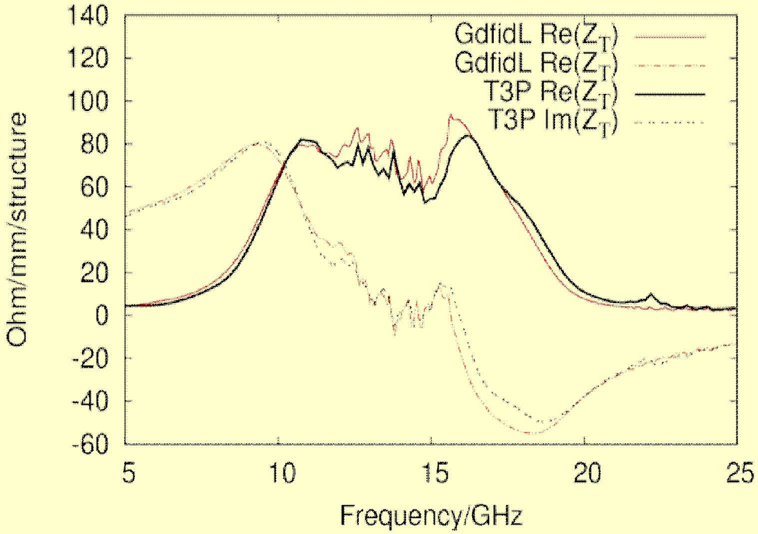
Beam energy after lattice



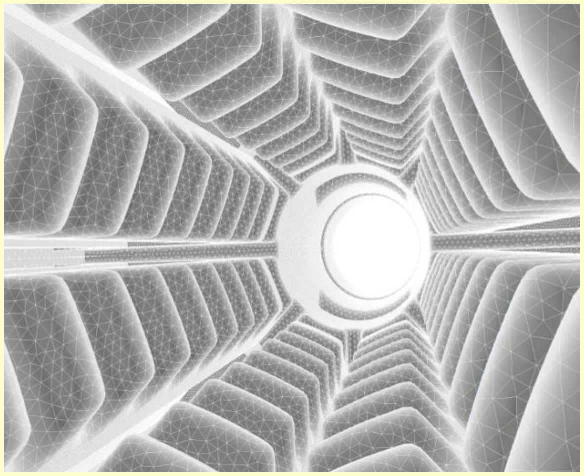
Steady state bunch energy profile

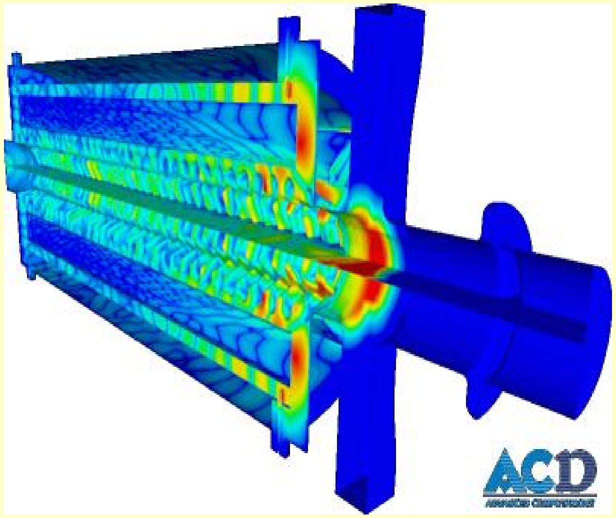
1m ~ 3 ns

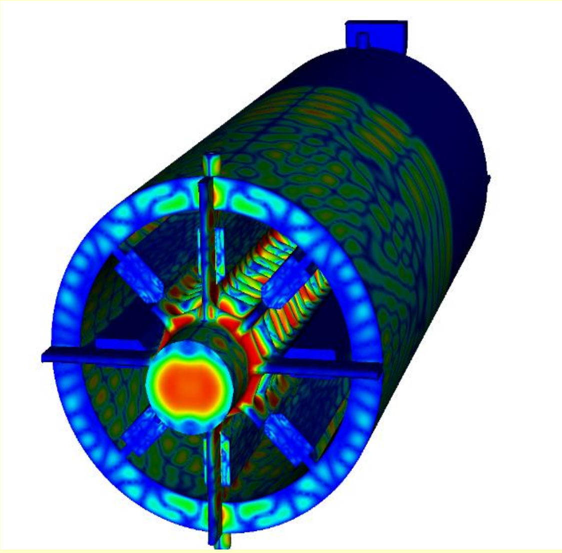
HOM damping in PETS



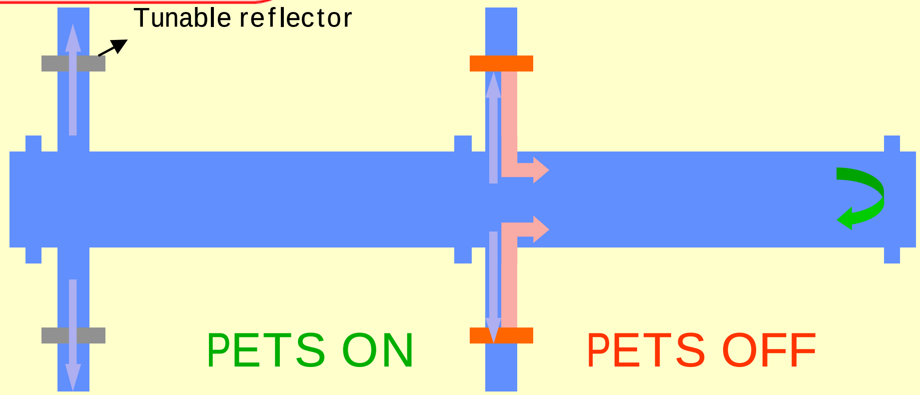
T3P

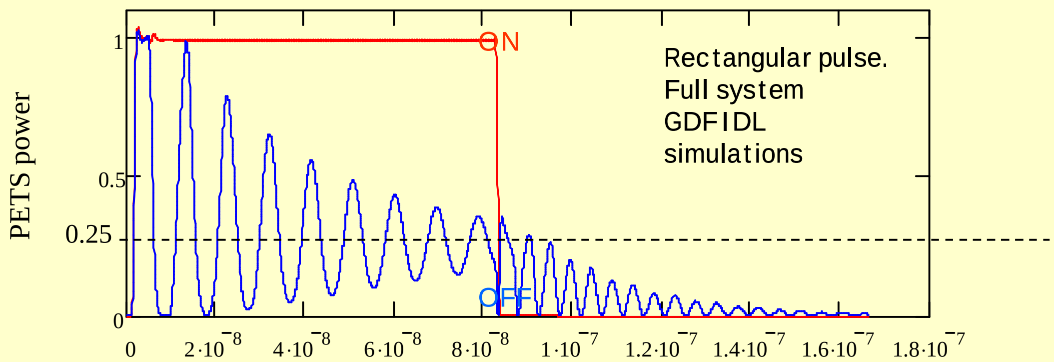


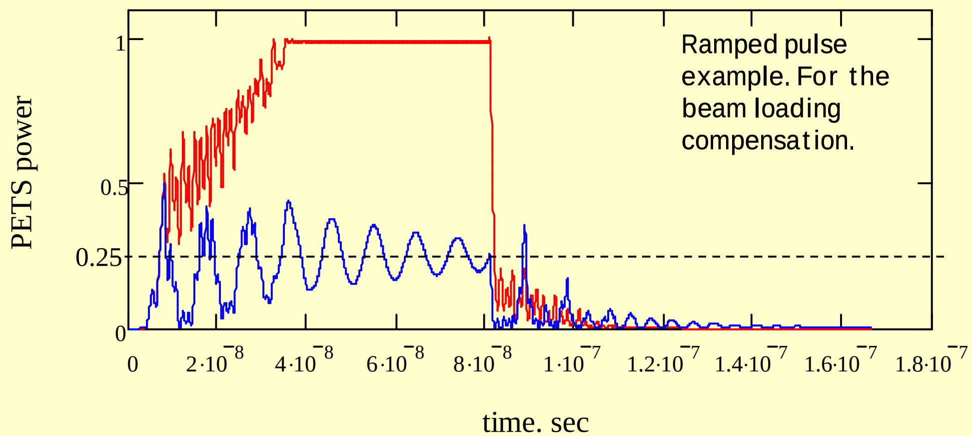




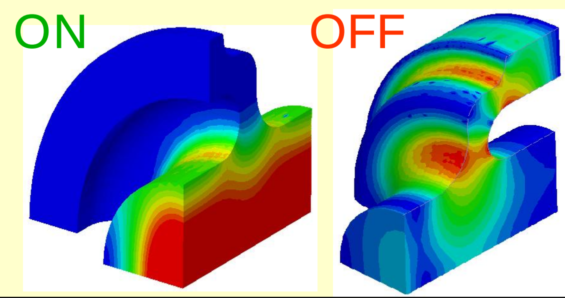
PETS ON/OFF







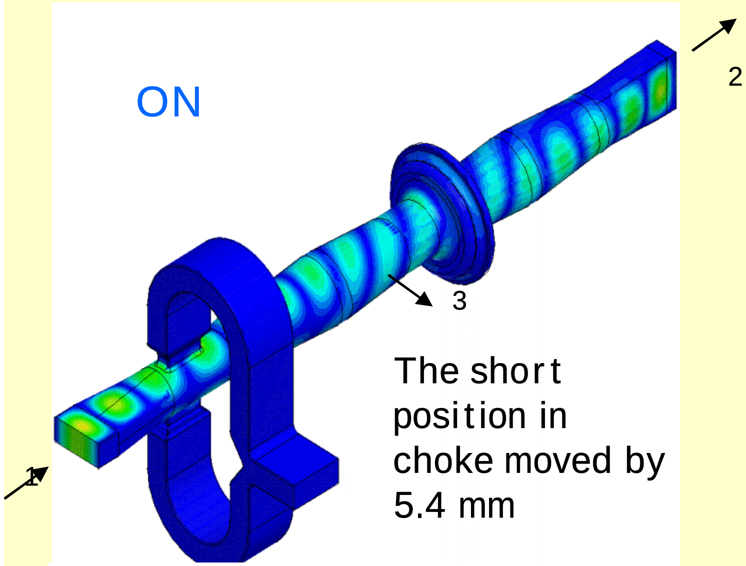
The choke-based reflector concept.



1. With proposed scheme we can guarantee the strong (< -20 dB) suppression of the RF power delivery to the accelerating structure.
2. In a case of the breakdown in PETS the RF pulse time structure and 25% saturated power allow to expect the PETS safe behavior.

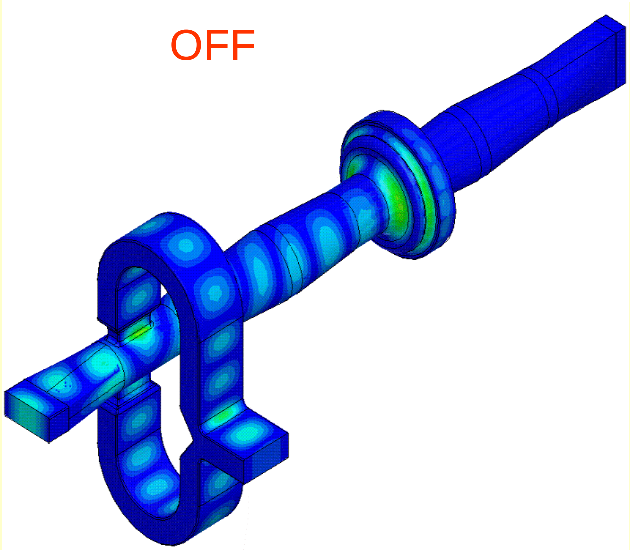
PETS ON/OFF

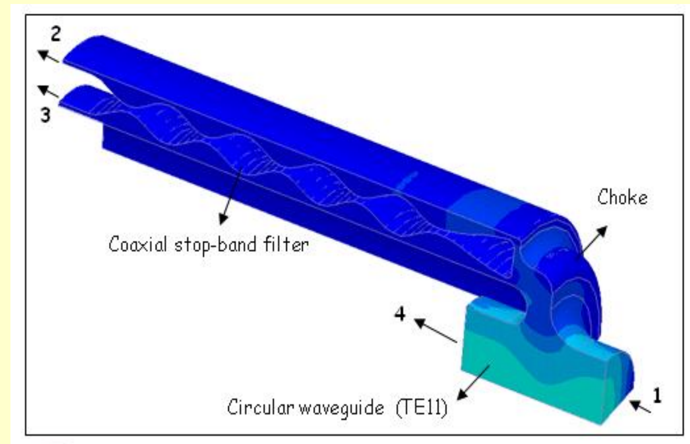
ON

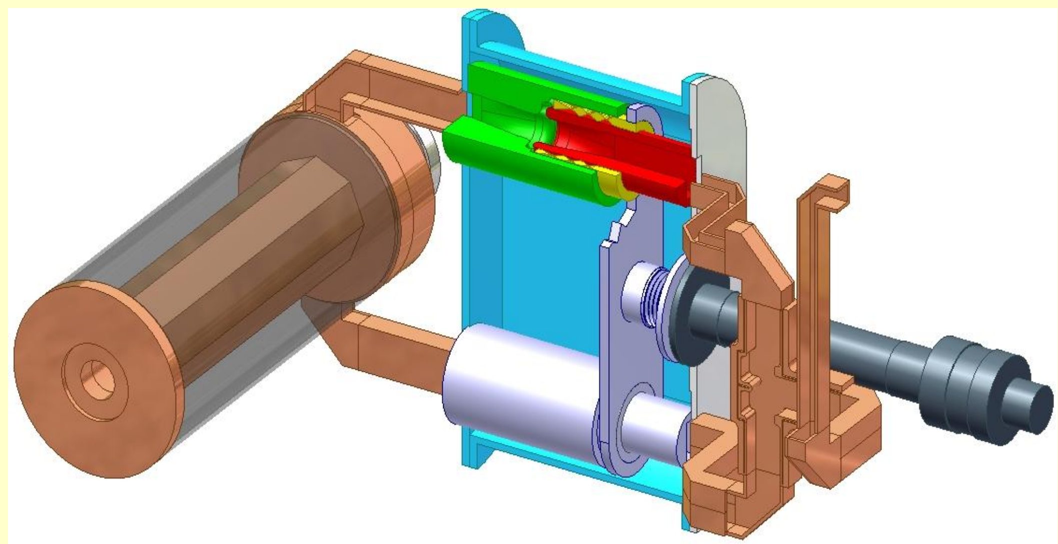


The short position in choke moved by 5.4 mm

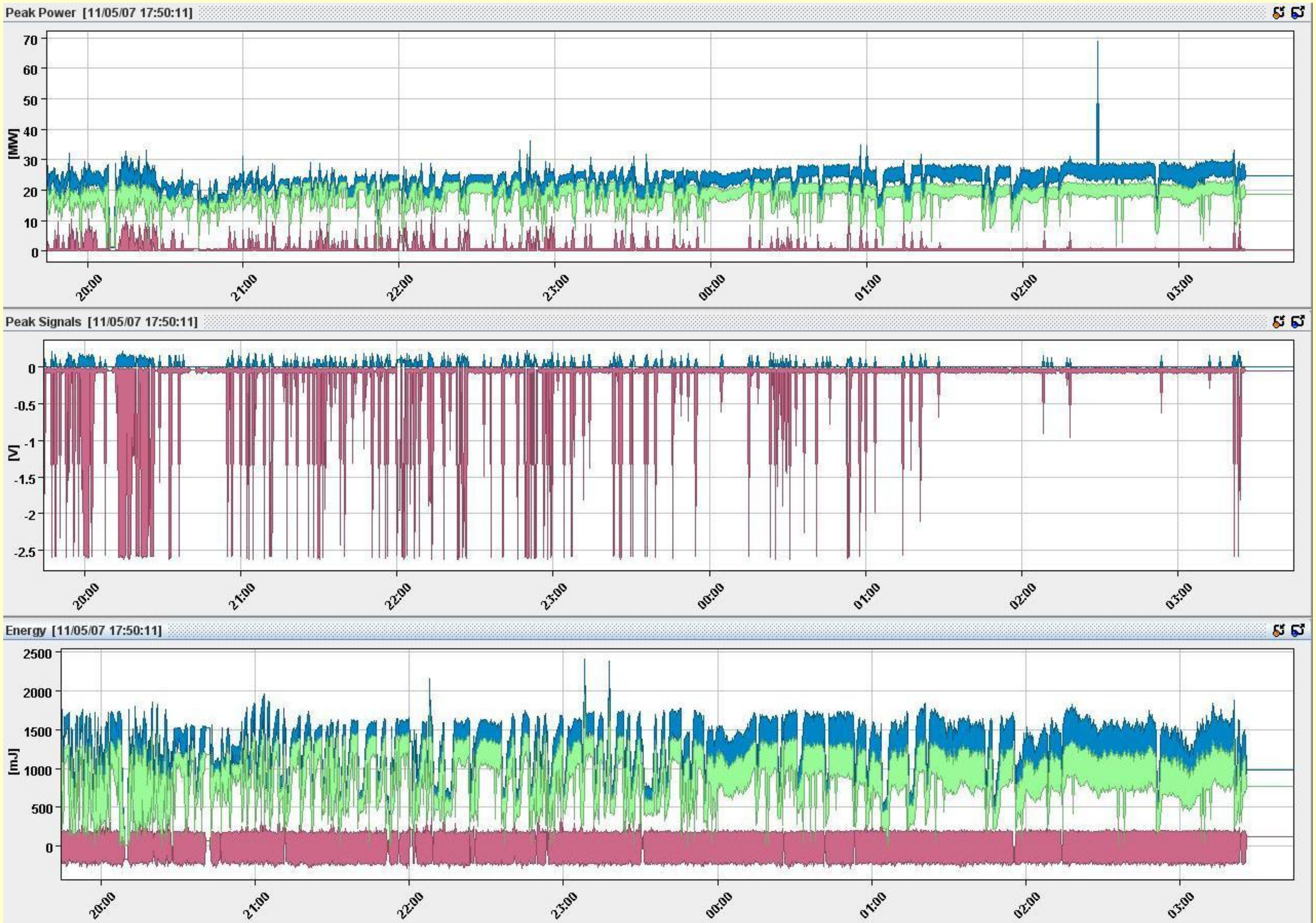
OFF







Conditioning history

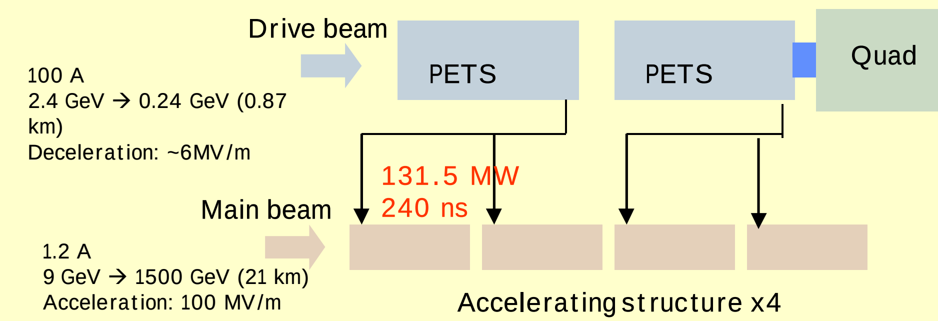


PETS design

$$P = I^2 L^2 F_b^{\,2} \omega_0 \frac{R/Q}{V_g 4}$$

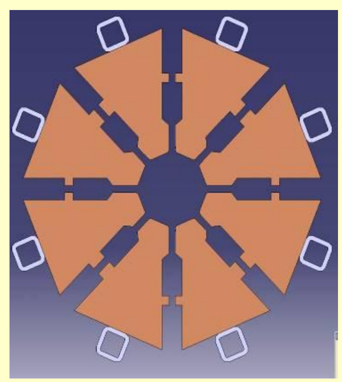
P – RF power
I – Drive beam current
L – Active length of the PETS
F_b – single bunch form factor (≈ 1)

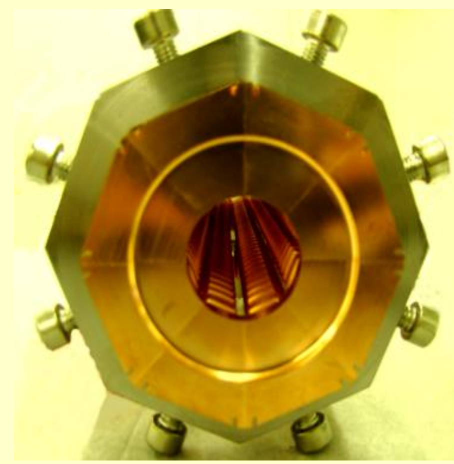
As a result of multiple compromises, the PETS aperture a/λ = 0.46 (m = 2) was chosen.



The PETS are large aperture, high-group velocity and overmoded periodic structures. In its final configuration, PETS comprises eight octants separated by 2.2 mm wide damping slots.

PETS cross-section





Status

- Installation of prototype beam line completed, waiting for beam
  (3 Quads on movers, 3 BPM's and 1 PETS tank with undamped PETS)
- Beam line without PETS tanks will be finished this fall

Prototyping:

- PETS tank: engineered and manufactured by CIEMAT
  (low level measurements performed and accepted)
- BPM's: smaller version of CTF3 type BPM, made by IFC Valencia
  Electronics from UPC Barcelona and LAPP Annecy
  (basic tests with beam done)
- Quads: Designed at CERN and manufactured by BINP Russia
- Quad-Movers: engineered and manufactured by CIEMAT
  (tests demonstrated the micron level accuracy)

Experiments in TBL

- Produce nominal 28 A beam and nominal CLIC power (135 MW) with at least 8 PETS and 100% transmission (120 MeV from CTF3) This corresponds to 35 % power extraction
- Beam based quad alignment with movers to optimize transmission and transverse beam parameters
- Detailed energy and energy spread measurements to verify deceleration.
- Streak camera measurements before and after TBL
- Monitor rf power production stability, amplitude and phase (% level in amplitude, 1 degree in phase)
- Measure beam properties and compare with simulations
- Controlled misalignment of quads, measure effect ?
- Controlled beam offset in PETS, measure effect ?