CTF3 Status

R. Corsini for the CTF3 Team

Talk Outline:

1. News since last Project Meeting
2. Status of feasibility benchmarks in CTF3
   - Drive beam generation
   - PETS & RF Structures
   - Two-beam issues

Program for the rest of the year - I

- PHIN run

☺

  - Completed, good measurements on cathode lifetime

- TERA experiment

☺

  - Done within schedule, other 3 weeks planned at the beginning of 2012

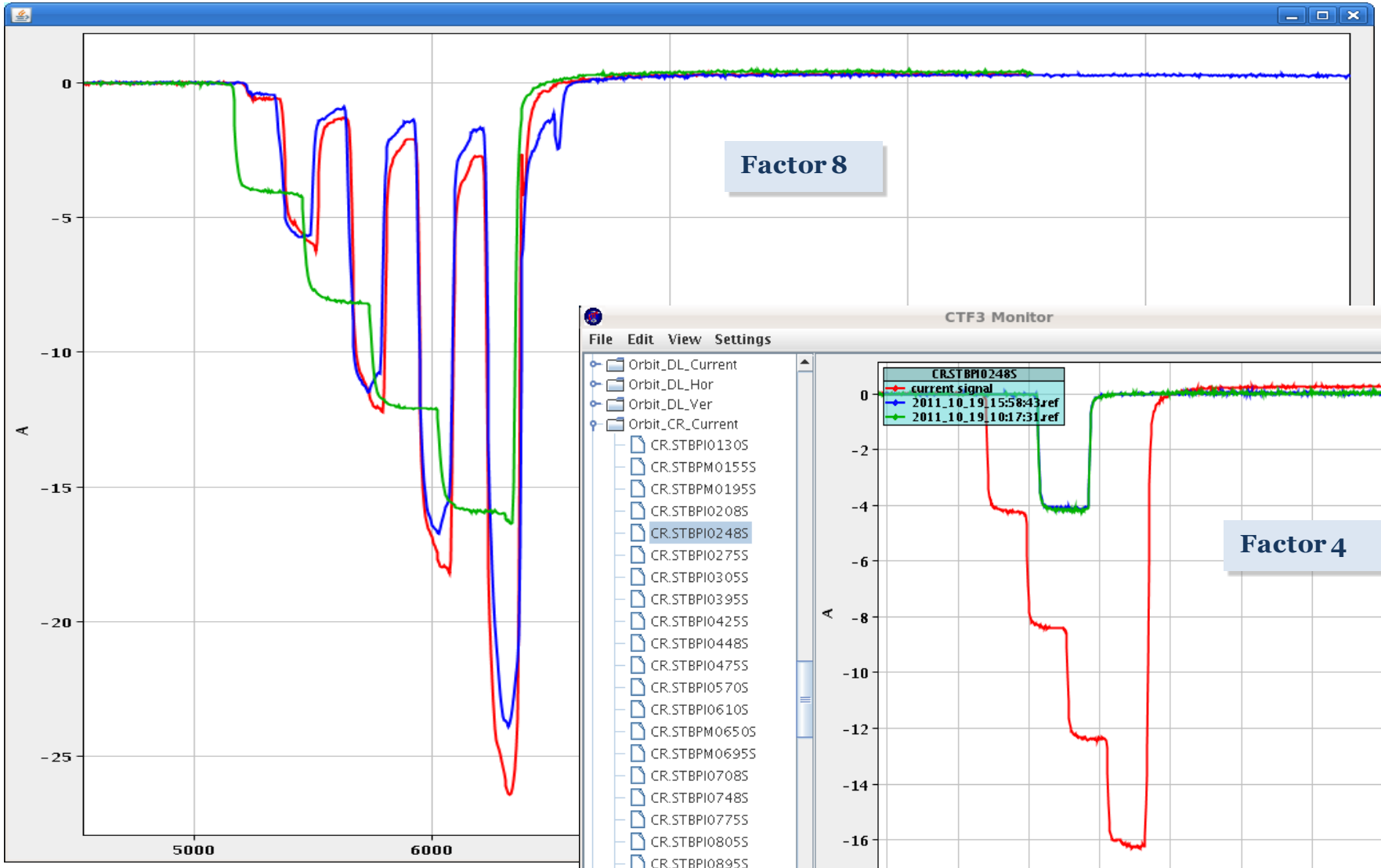
- Improve 1.5 GHz factor 8 beam

😐

  - Delayed by manpower (LCWS 11 Granada), gun & klystron troubles, TWT availability
  - Good improvements on beam current flatness from gun, compensation of phase switches, injector set-up
  - Optics studies to increase acceptance under way. Improvements in DL &CR optics, CR closed orbit

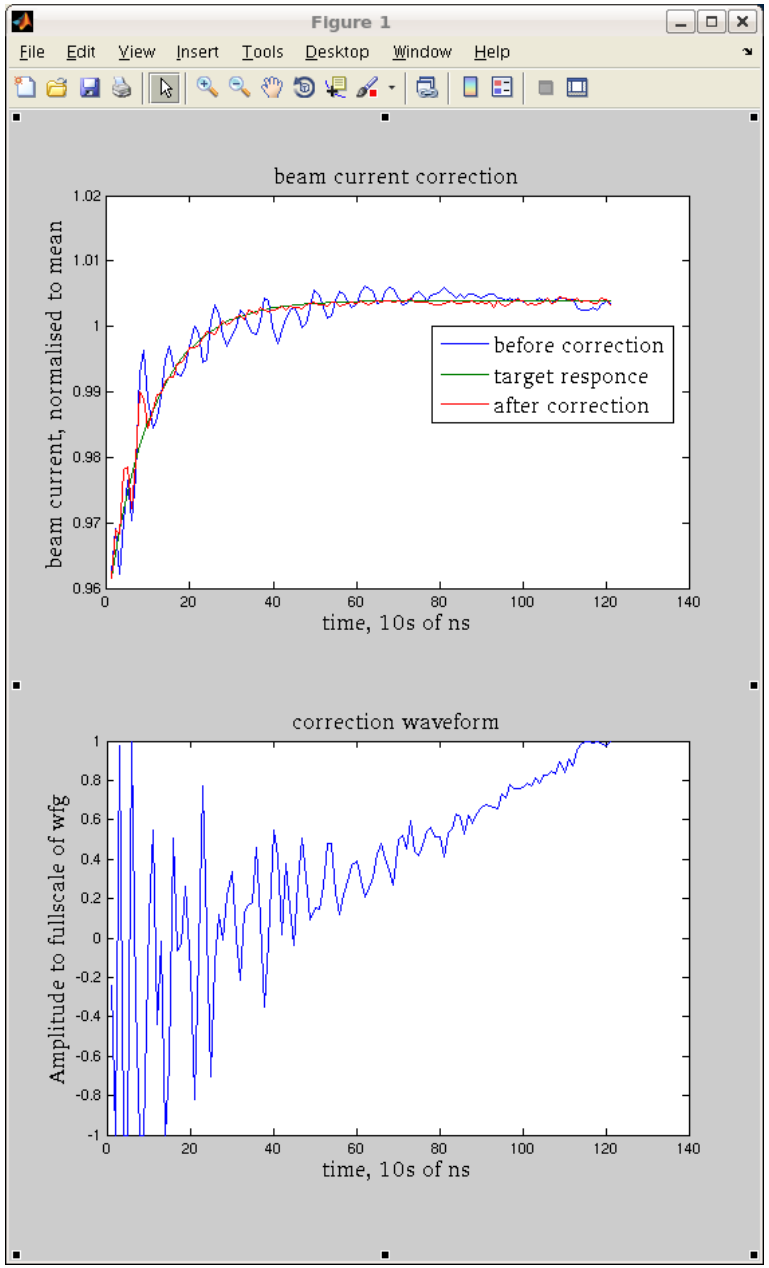
Beam Recombination

R. Corsini,
CLIC Project Meeting, 21 October 2011

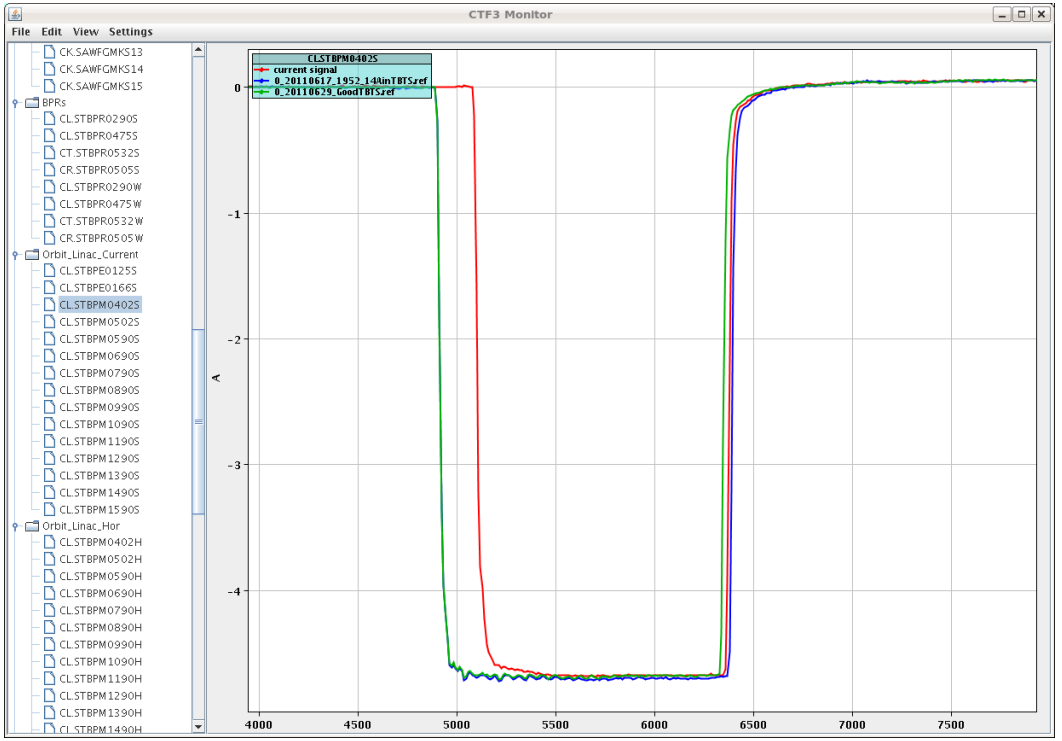


Gun current Correction

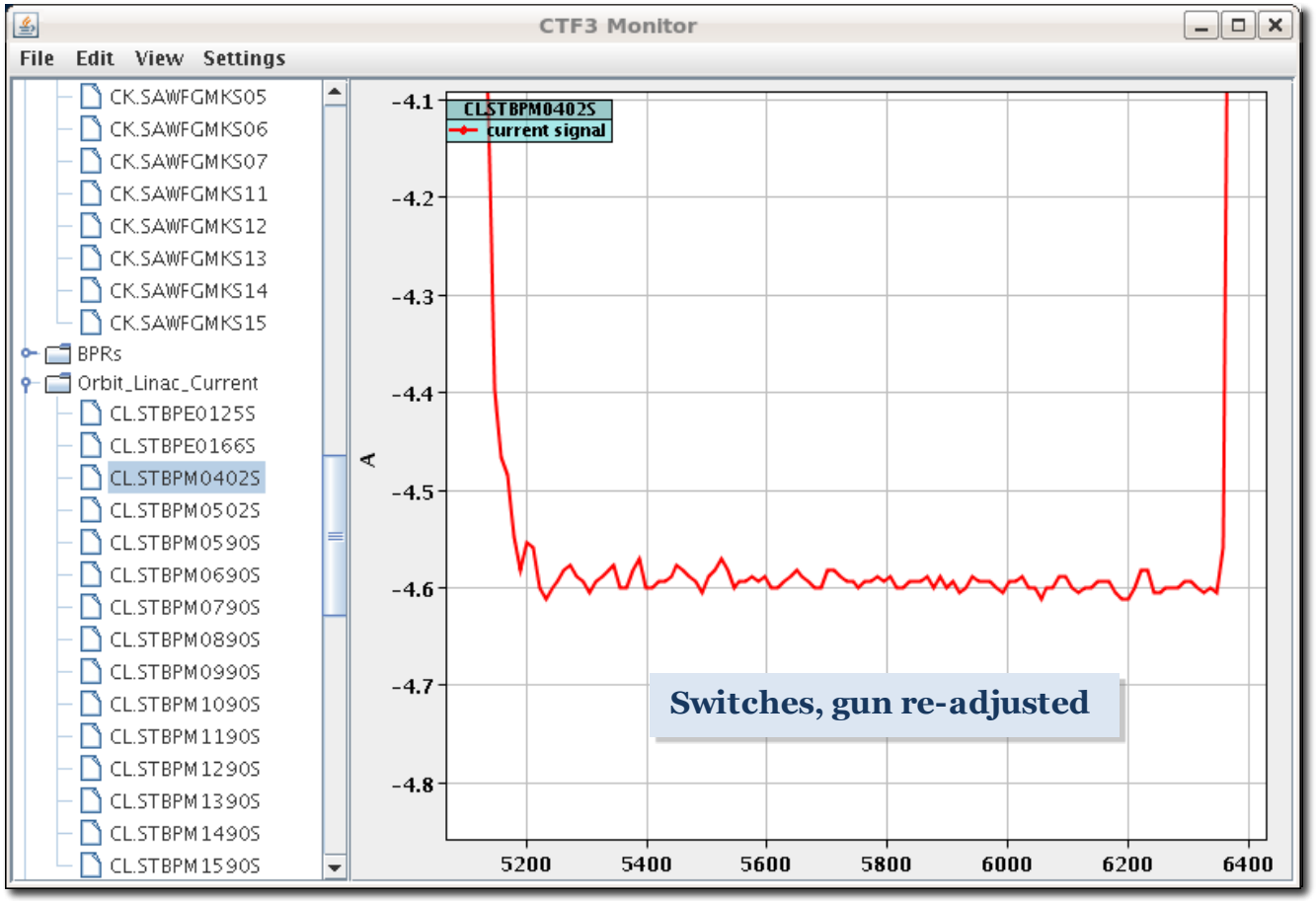
R. Corsini,
CLIC Project Meeting, 21 October 2011



Alexandra Andersson



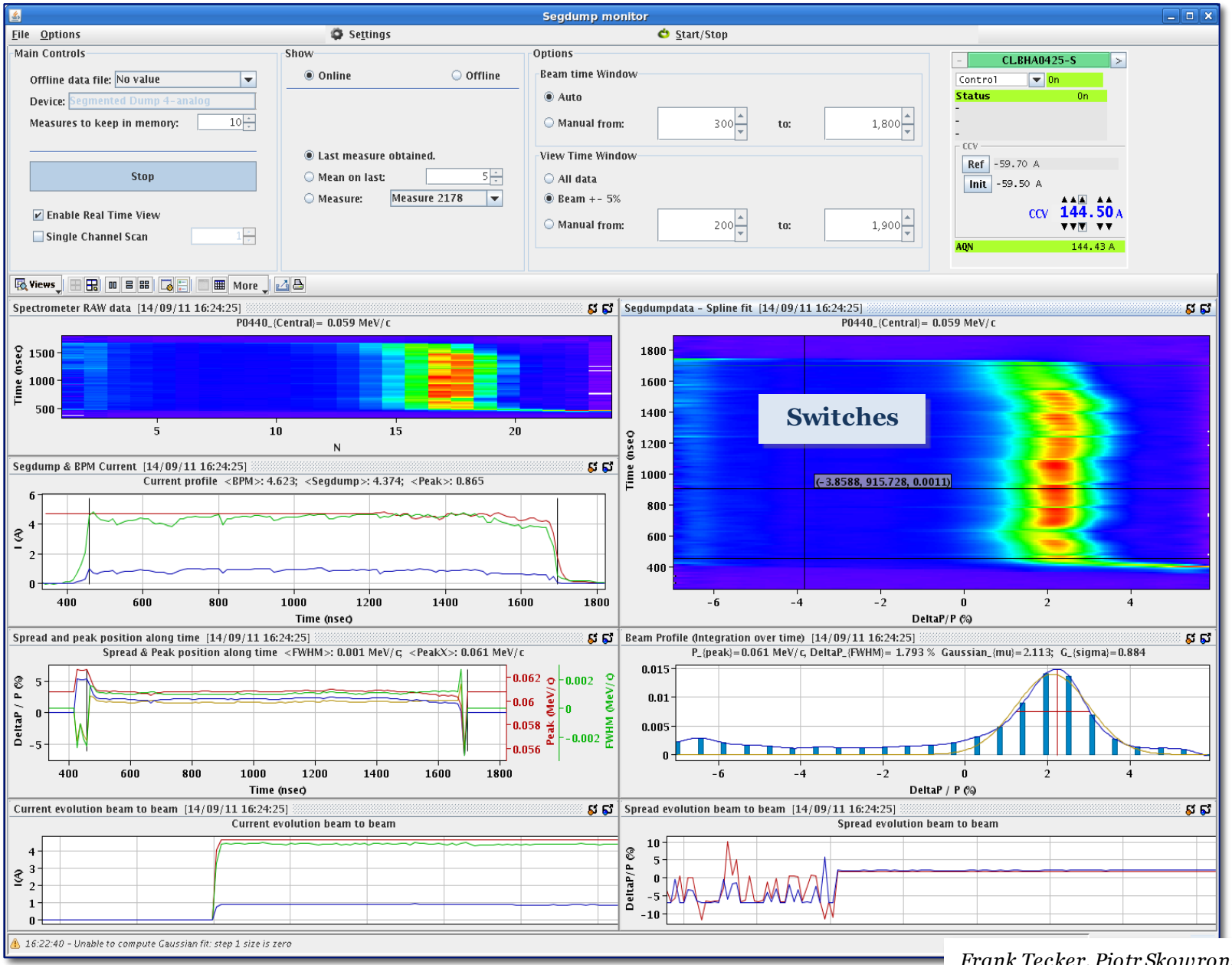
Compensation of phase switches



Alexandra Andersson, Frank Tecker, Piotr Skowronski

Compensation of phase switches

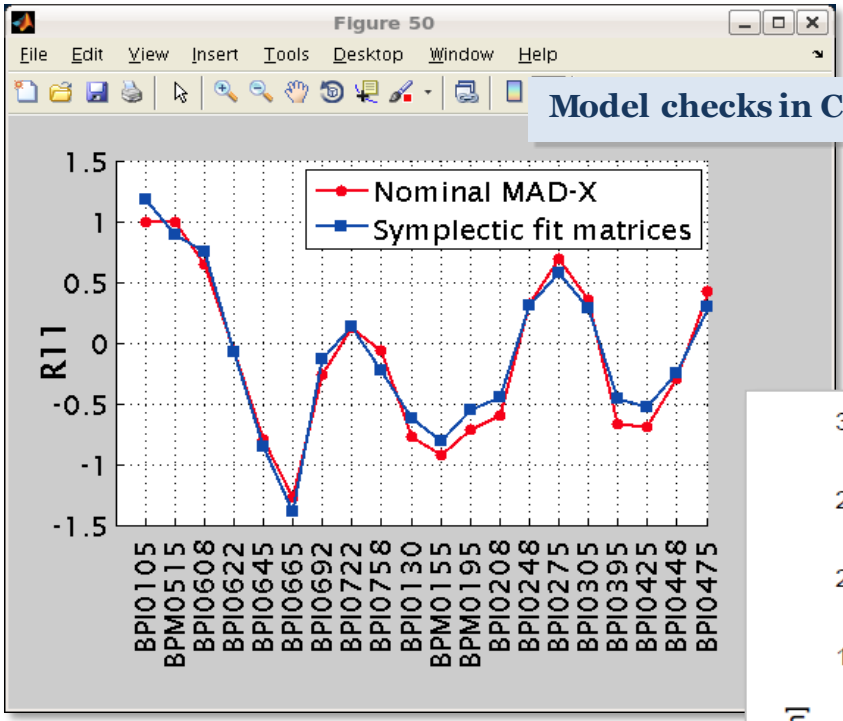
R. Corsini,
CLIC Project Meeting, 21 October 2011



Frank Tecker, Piotr Skowronski

Optics studies, orbit correction

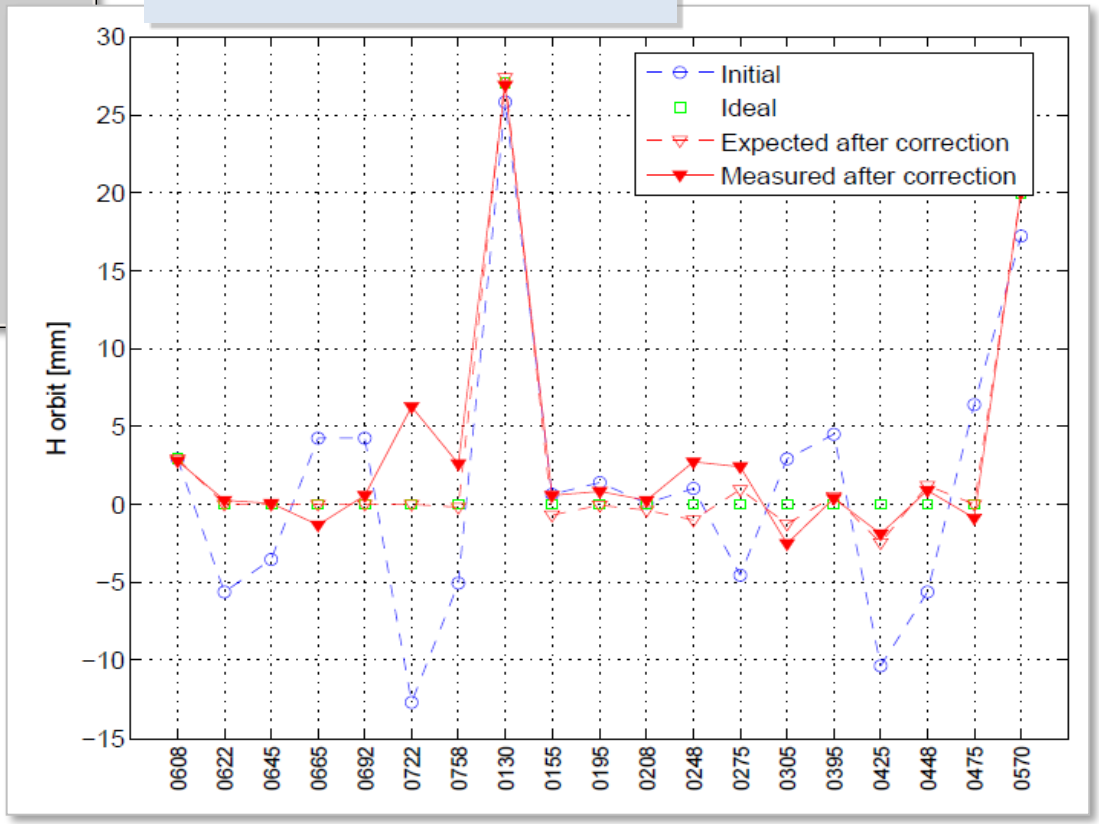
Model checks in CR



Ben Constance

Orbit correction in TL1 - CR

Guido Sterbini, Ben Constance

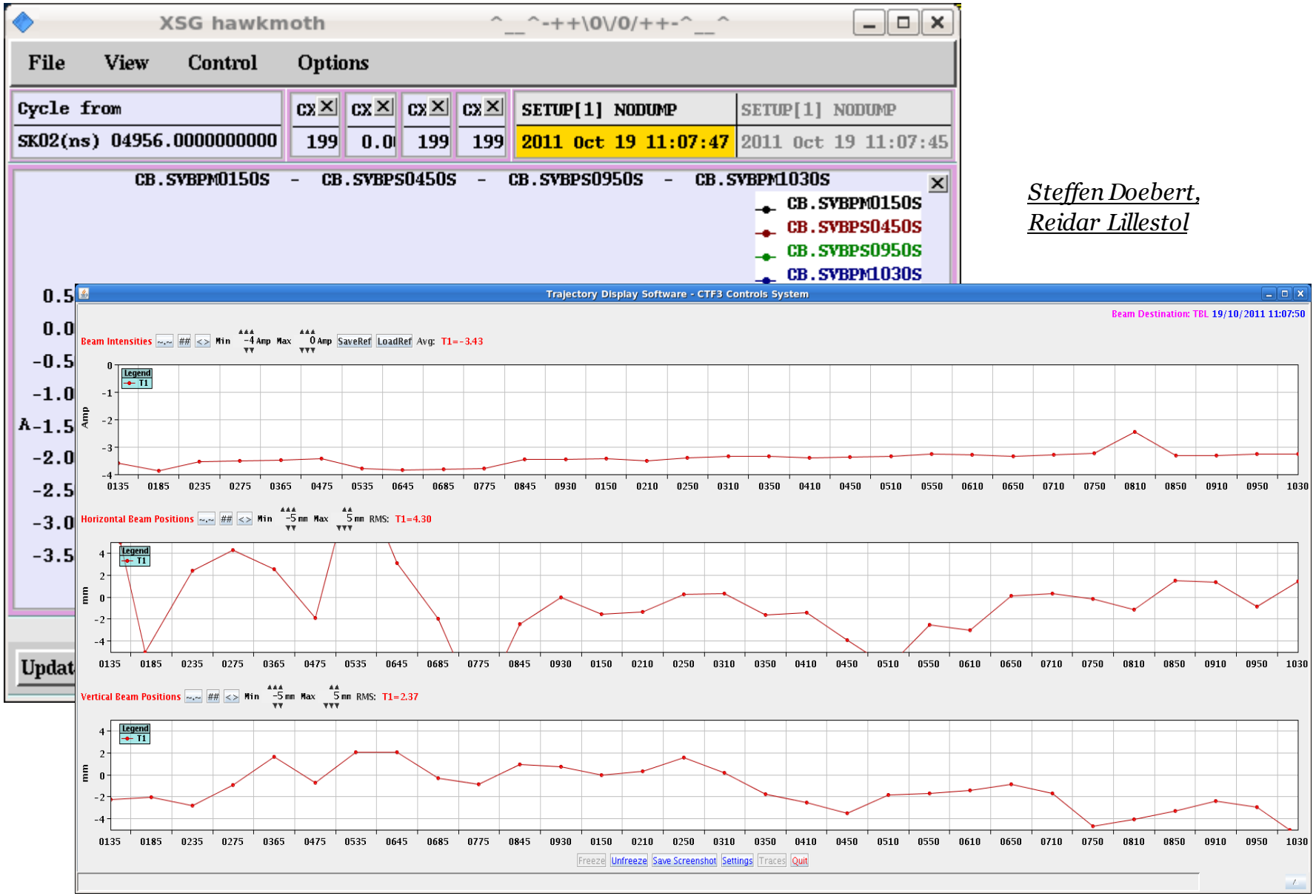


Program for the rest of the year - I

- PHIN run ☺
  - Completed, good measurements on cathode lifetime
- TERA experiment ☺
  - Done within schedule, other 3 weeks planned at the beginning of 2012
- Improve 1.5 GHz factor 8 beam 😐
  - Delayed by manpower (LCWS 11 Granada), gun & klystron troubles, TWT availability
  - Good improvements on beam current flatness from gun, compensation of phase switches, injector set-up
  - Optics studies to increase acceptance under way. Improvements in DL &CR optics, CR closed orbit
- TBL deceleration with 8 PETS for CDR ☺
  - 9 PETS installed instead of 8, first beam (3-4 A) transported – no major issues – start higher current tests today.
- PETS On-Off ☺
  - Installed – first tests (low current) positive, work as recirculation, fast conditioning > more later

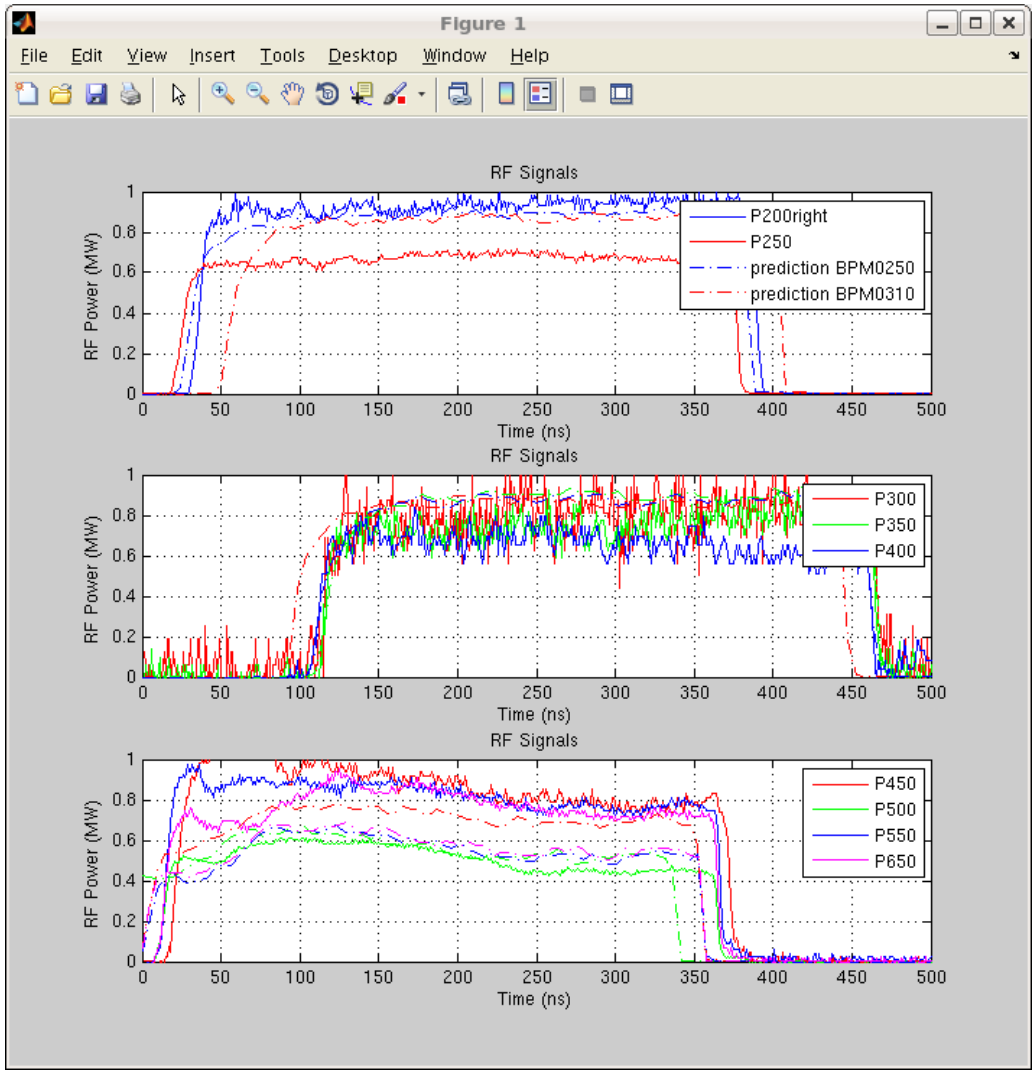
TBL with 9 PETS tanks

R. Corsini,
CLIC Project Meeting, 21 October 2011



Steffen Doebert, Reidar Lillestol

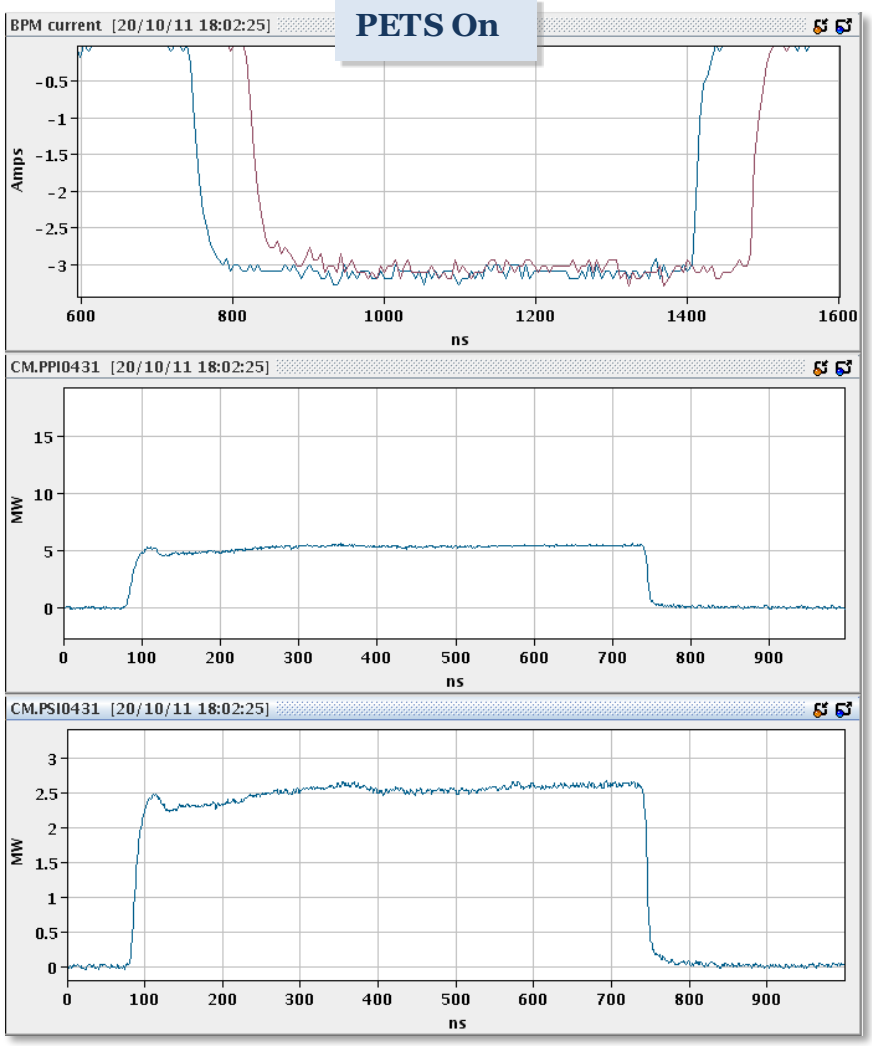
TBL with 9 PETS tanks



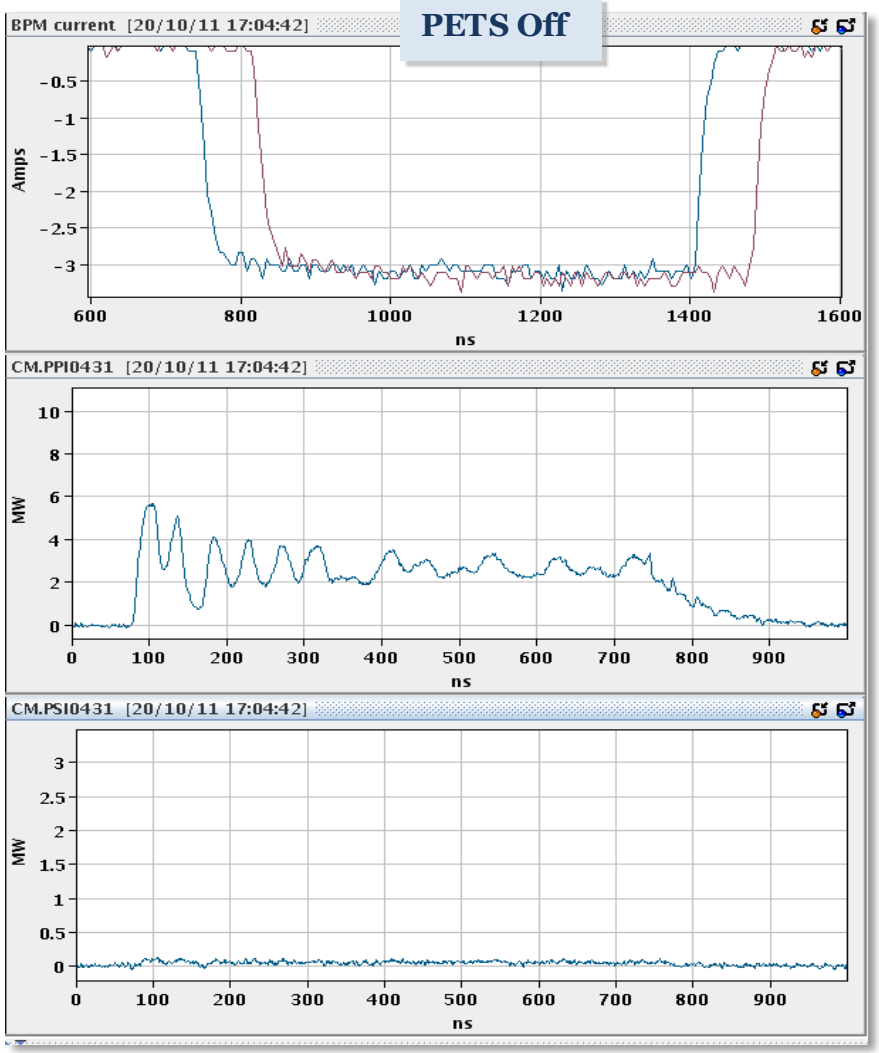
Reidar Lillestol

TBTS first operation with Petsonov

PETS On



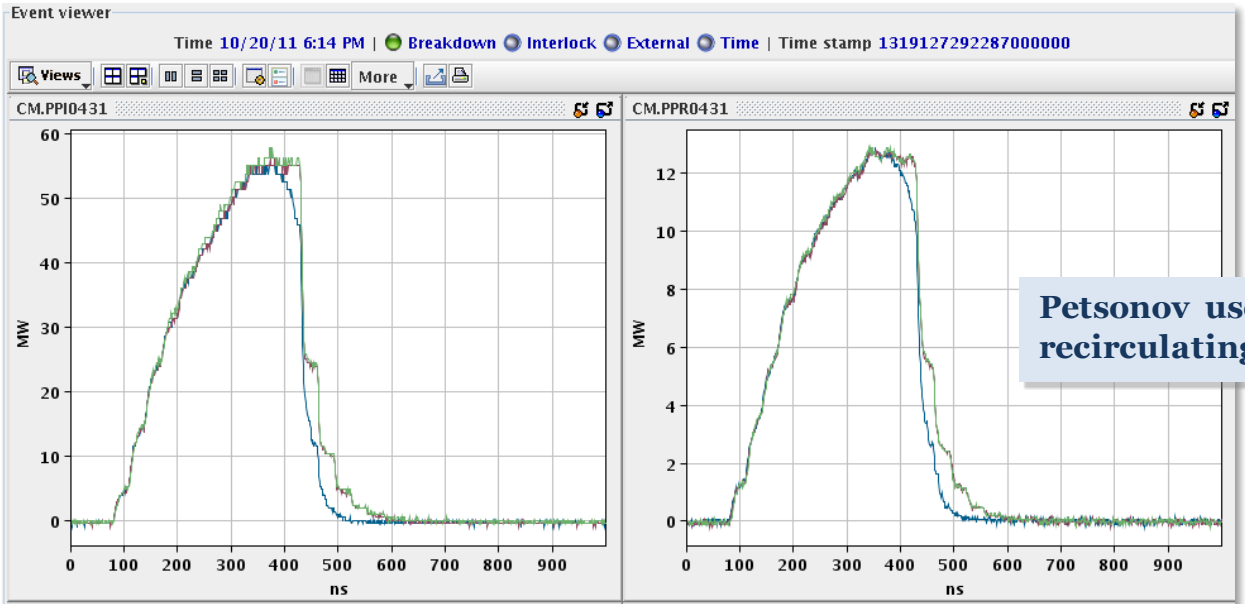
PETS Off



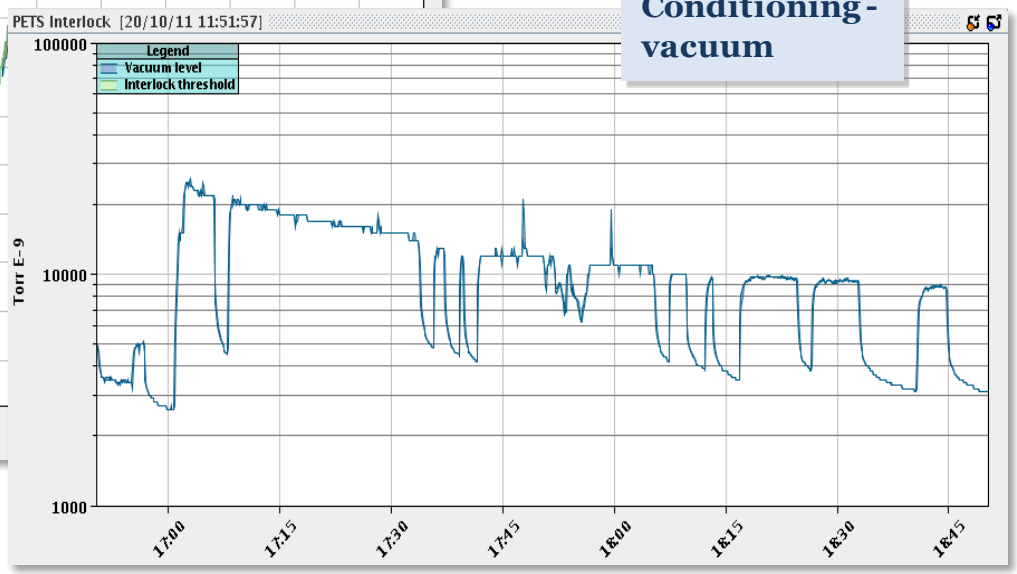
Igor Syratchev, Alexei Dubrowski

TBTS first operation with Petsonov

Igor Syratchev,
Alexei Dubrowski



Petsonov used in recirculating mode



Conditioning - vacuum

Program for the rest of the year - II

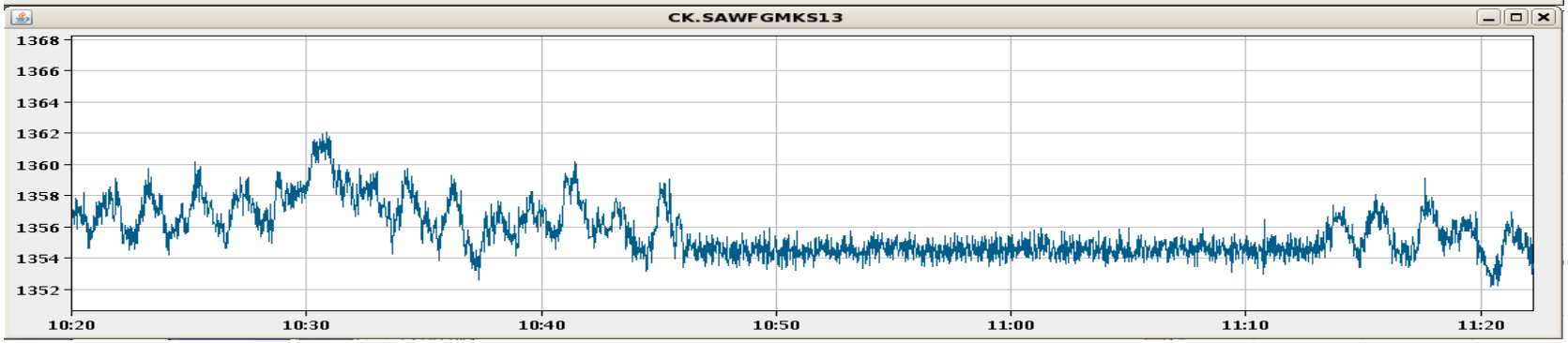
- Beam stability measurements at 3 GHz and 1.5 GHz 😐
  - Several improvements in "slow" feed-backs, some more under way
  - Still miss factor 8
- Emittance and bunch length control 😐
  - Will profit from optics/operational improvements, measurements still to be performed (December?)
- Breakdown kick measurements 😐
  - Preliminary results based on screen, BPM upgrade needed (measurements in December – continued in 2012)
- Beam loading compensation for main beam ☹
  - First tests, need good set-up before real tests

Feed-backs, stability

RF power feedback, MKS 13

[MW]

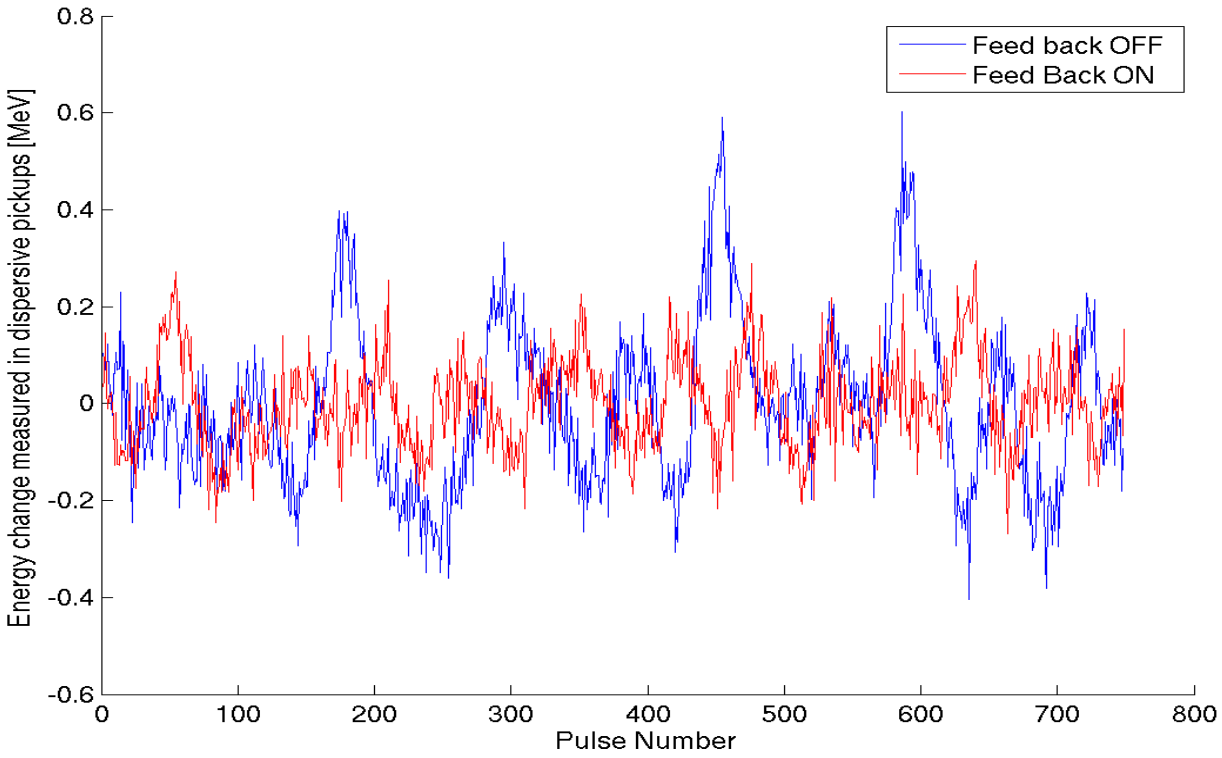
[arb]



Tobia Persson,
Piotr Skowronski

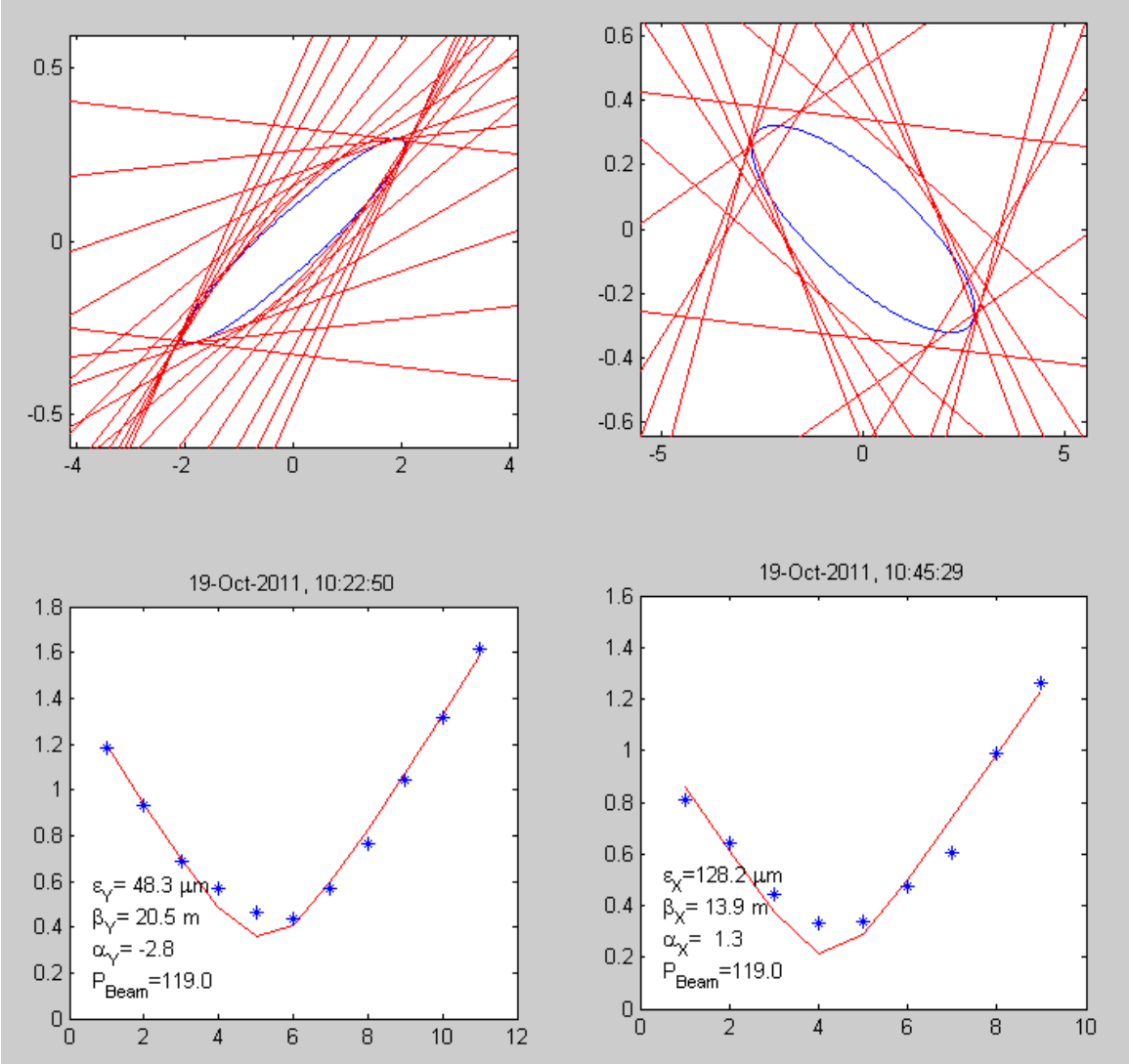
Feed-backs, stability

RF power feedback, effect on beam



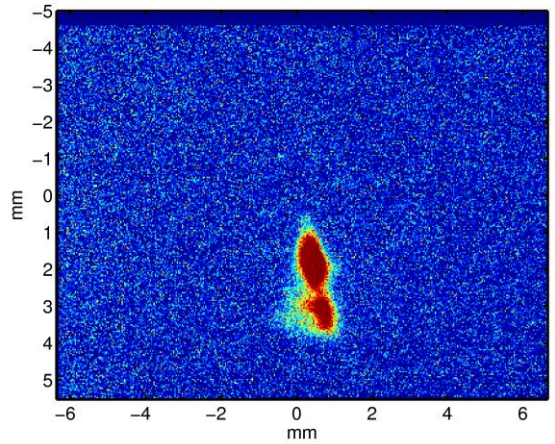
Tobia Persson, Piotr Skowronski

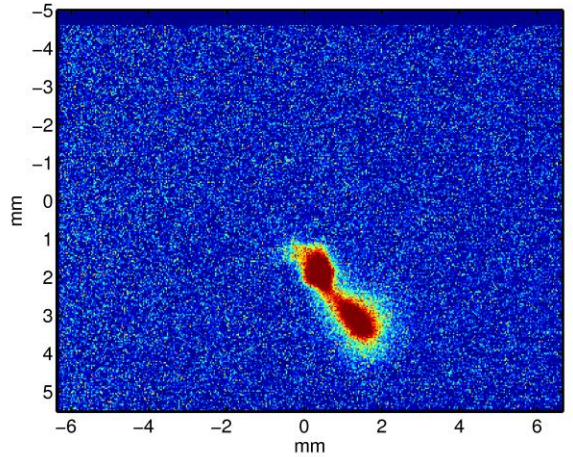
Emittance at TBL entry



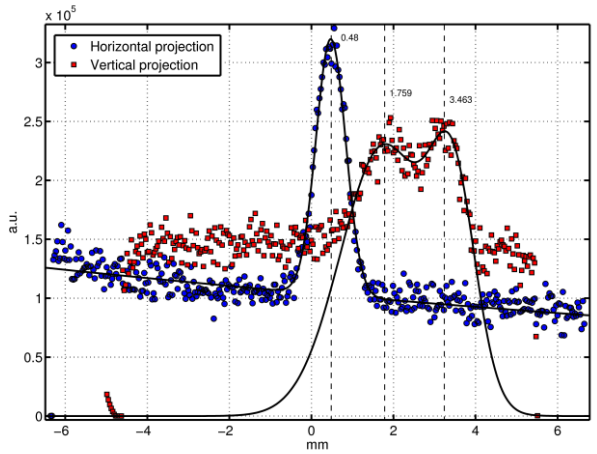
Reidar Lillestol

Break-down kicks

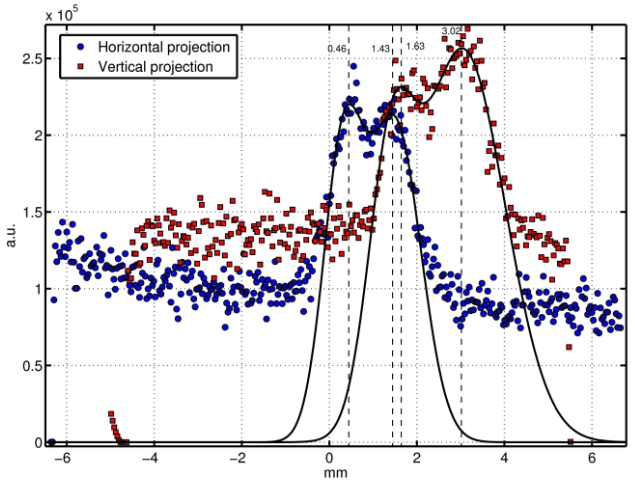




Measured on OTR screen CA.MTV0790 (~4.9 m from the accelerating structure).



kick angle = 340 µrad



kick angle = 400 µrad

Andrea Palaia, Wilfrid Farabolini, Javier Barranco

CLIC Feasibility Benchmarks

CTF3

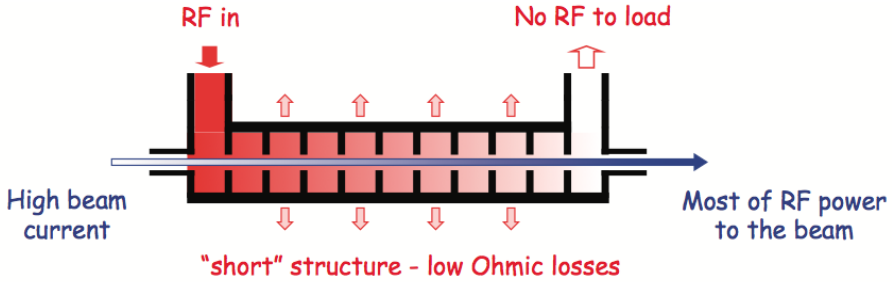
System	Item	Feasibility Issue	Unit	Nominal	Achieved	How	Feasibility	Comments
Two Beam Acceleration	Drive beam generation	Fully loaded accel effic	%	97	95	CTF3	✓	Novel scheme fully demonstrated in CTF3 in spite of lower current since beam dynamics more sensitive than nominal due to lower energy (250MeV/2Gev)
		Freq&Current multipl	-	2*3*4	2*4	CTF3	✓	
		Combined beam current (12 GHz)	A	4.5*24=100	3.5*8=28	CTF3	✓	
		Combined pulse length (12 GHz)	nsec	240	140	CTF3	✓	
		Intensity stability	1.E-03	0.75	< 0.6	CTF3	✓	End of DeA. To be demonstrated for combined beam in 2011
		Drive beam linac RF phase stability	Deg (1GHZ)	0.05	0.035	CTF3, XFEL	✓	Achieved in CTF3, XFEL design
	Beam Driven RF power generation	PETS RF Power	MW	130	>130	TBTS/SLAC	✓	BD rate at nominal power and pulse lenght, measured on Klystron driven PETS. Beam driven tests under way in CTF3
		PETS Pulse length	ns	170	>170	TBTS/SLAC	✓	
		PETS Breakdown rate	/m	< 1-10-7	≤ 2.4 10-7	TBTS/SLAC	✓	
		PETS ON/OFF	-	@ 50Hz	-	CTF3/TBTS	2011	Prototype under fabrication for tests with beam
		Drive beam to RF efficiency	%	90%	-	CTF3/TBL	2012	TBL with 8 (16) PETS in 2011(12) for 30(50%) efficiency. Benchmark beam simulation for safe extrapolation of high efficiency at high drive beam energy(2GeV).
		RF pulse shape control	%	< 0.1%	-	CTF3/TBTS	2011-2012	
	Accelerating Structures (CAS)	Structure Acc field	MV/m	100	100	CTF3 Test Stand, SLAC, KEK	✓	Nominal performances of 3 structures without damping. 1 structure equipped with damping features under RF conditionning to reduce breakdown rate.
		Structure Flat Top Pulse length	ns	170	170		✓	
		Structure Breakdown rate	/m MV/m.ns	< 3-10-7	5-10-5(D)		2011	
		Rf to beam transfer efficiency	%	27	15		2011	
	Two Beam Acceleration	Power producton and probe beam acceleration in Two beam module	MV/m - ns	100 - 170	106 - 170	TBTS	✓ 2011	Power production in Two Beam Test Stand (TBTS)
								Probe beam acceleration by Two Beam Test Stand(TBTS)
		Drive to main beam timing stability	psec	0.05	-	CTF3	2012	
		Main to main beam timing stability	psec	0.07	-	XFEL?	2012	
Ultra low beam emittance & sizes	Ultra low Emittances	Emittance generation H/V	nm	500/5	3000/12	ATF, NSLS/SLS + simulation	✓	Damping Ring design nom perf. Relax emitt achieved ATF
		Emittance preservation: Blow-up	nm	160/15	160/15		2011-12	Simulation + alignment/stability
	Alignment	Main Linac components	microns	15	10 (princ.)	Alignement & Mod.Test Bench	2011	Principle demonstrated in CTF2, to be adapted to long distances and integrated in Two Beam Module in 2010
		Final-Doublet	microns	2 to 8			2011	
	Vertical stabilisation	Quad Main Linac	nm>1 Hz	1.5	0.13 (principle)	Stabilisation Test Bench	2011-12	Adaptation to quad prototype and detector environment in 2010. Integrated in Two Beam Module with beam till 2012.
		Final Doublet (assuming feedbacks)	nm>4 Hz	0.2				
Operation and Machine Protection System (MPS)		72MW@2.4GeV main beam power of 13MW@1.5TeV				CTF3 simulations	2011	Report integrating LHC experience under preparation

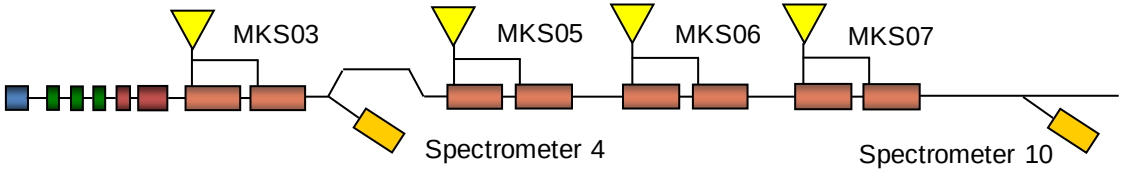
RF Test Stands
SLAC – KEK -CERN

Technical system tests and simulations

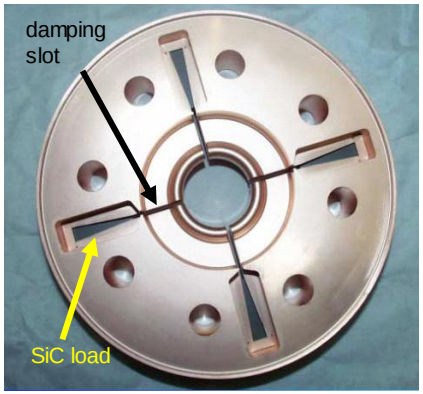
CTF3 Achievements – Drive Beam Generation

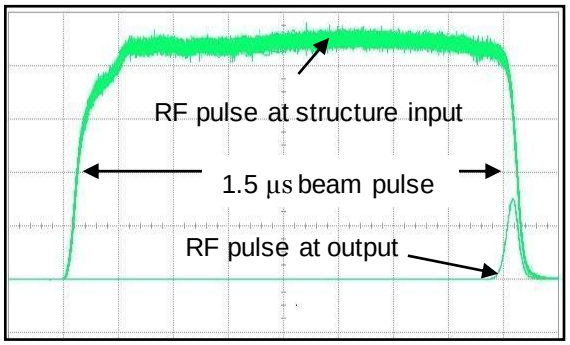
Item	Feasibility Issue	Unit	Nominal	Achieved	How	Feasibility	Comments
Drive beam generation	Fully loaded accel effic	%	97	95	CTF3	✓	Novel scheme fully demonstrated in CTF3 in spite of lower current since beam dynamics more sensitive than nominal due to lower energy (250MeV/2Gev)
	Freq&Current multipl	-	2*3*4	2*4	CTF3	✓	
	Combined beam current (12 GHz)	A	4.5*24=100	3.5*8=28	CTF3	✓	
	Combined pulse length (12 GHz)	nsec	240	140	CTF3	✓	
	Intensity stability	1.E-03	0.75	< 0.6	CTF3	✓	End of DBA. To be demonstrated for combined beam in 2011
	Drive beam linac RF phase stability	Deg (1GHZ)	0.05	0.035	CTF3, XFEL	✓	Achieved in CTF3, XFEL design





Dipole modes suppressed by slotted iris damping (first dipole's Q factor < 20) and HOM frequency detuning



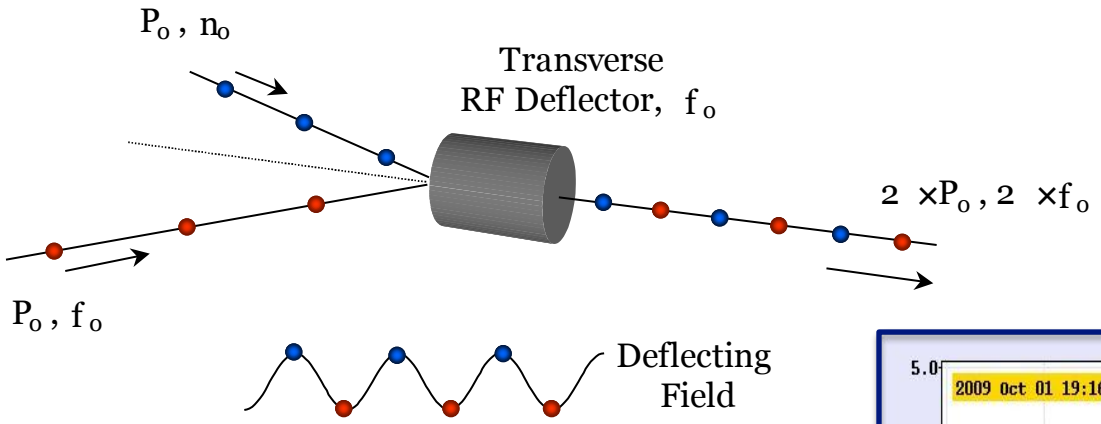


High current, full-loaded linac operation

- 95 % RF to beam efficiency measured
- No instabilities

CTF3 Achievements – Drive Beam Generation

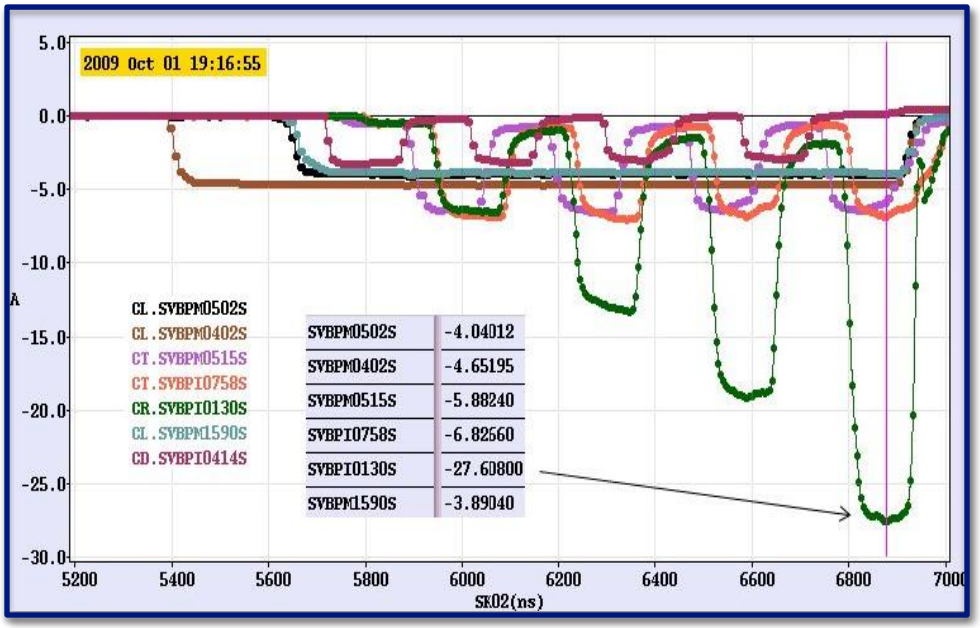
Item	Feasibility Issue	Unit	Nominal	Achieved	How	Feasibility	Comments
Drive beam generation	Fully loaded accel effic	%	97	95	CTF3	✓	Novel scheme fully demonstrated in CTF3 in spite of lower current since beam dynamics more sensitive than nominal due to lower energy (250MeV/2Gev)
	Freq&Current multipl	-	2*3*4	2*4	CTF3	✓	
	Combined beam current (12 GHz)	A	4.5*24=100	3.5*8=28	CTF3	✓	
	Combined pulse length (12 GHz)	nsec	240	140	CTF3	✓	
	Intensity stability	1.E-03	0.75	< 0.6	CTF3	✓	End of DBA. To be demonstrated for combined beam in 2011
	Drive beam linac RF phase stability	Deg (1GHZ)	0.05	0.035	CTF3, XFEL	✓	Achieved in CTF3, XFEL design



Beam recombination

- Factor 8 recombination by RF deflector injection

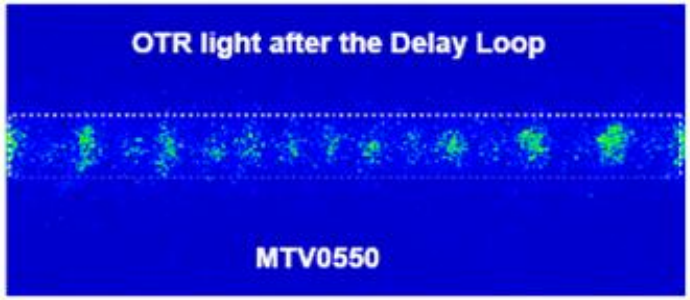
November 2011

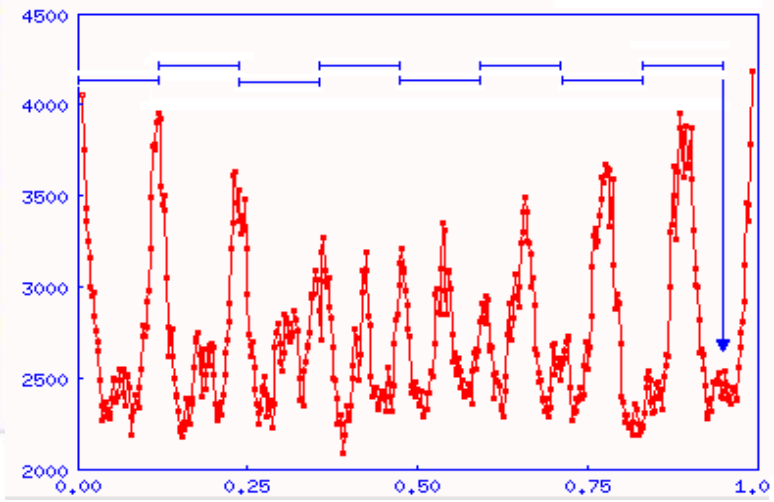


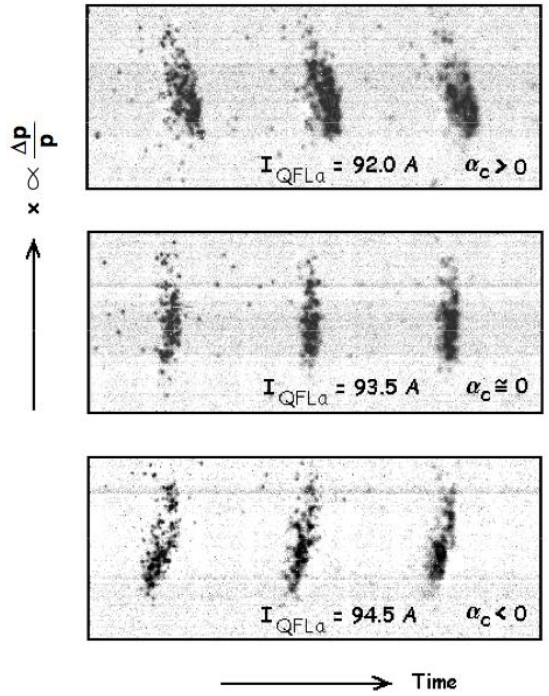
CTF3 Achievements – Drive Beam Generation

Beam recombination

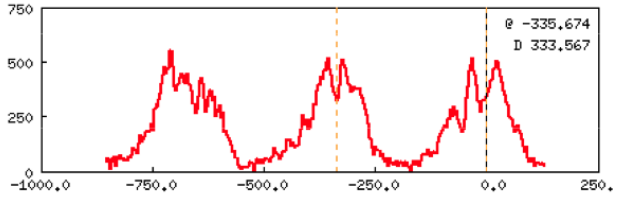
- Fast bunch phase switch in SHB system
- Operation of isochronous rings and beam lines



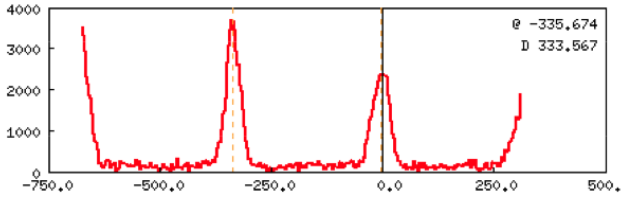




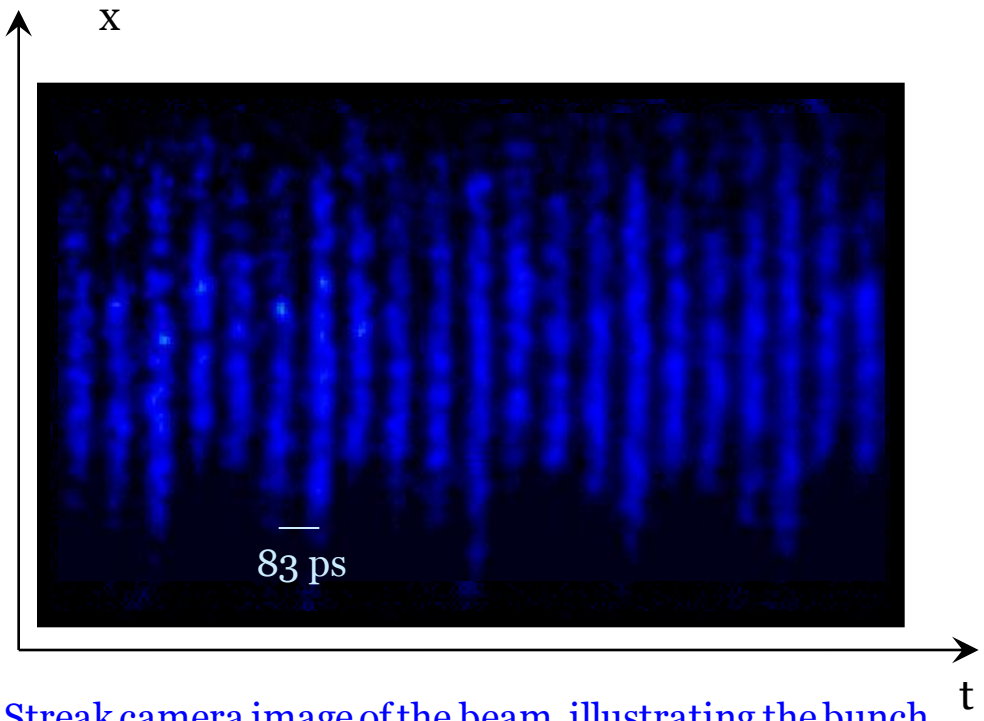
non-isochronous – 2nd turn



isochronous – 60th turn

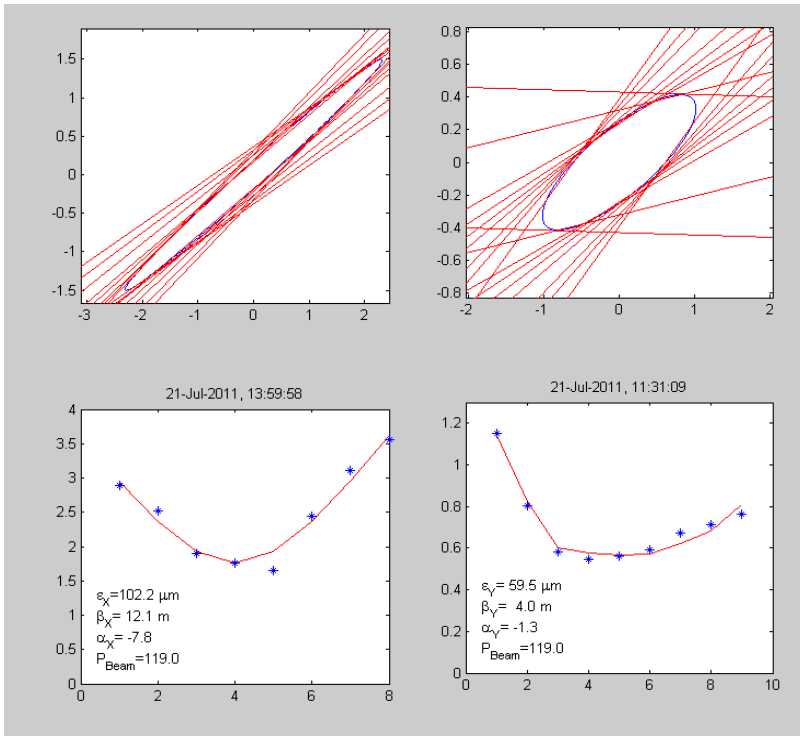


CTF3 Achievements – Drive Beam Generation



Streak camera image of the beam, illustrating the bunch combination process

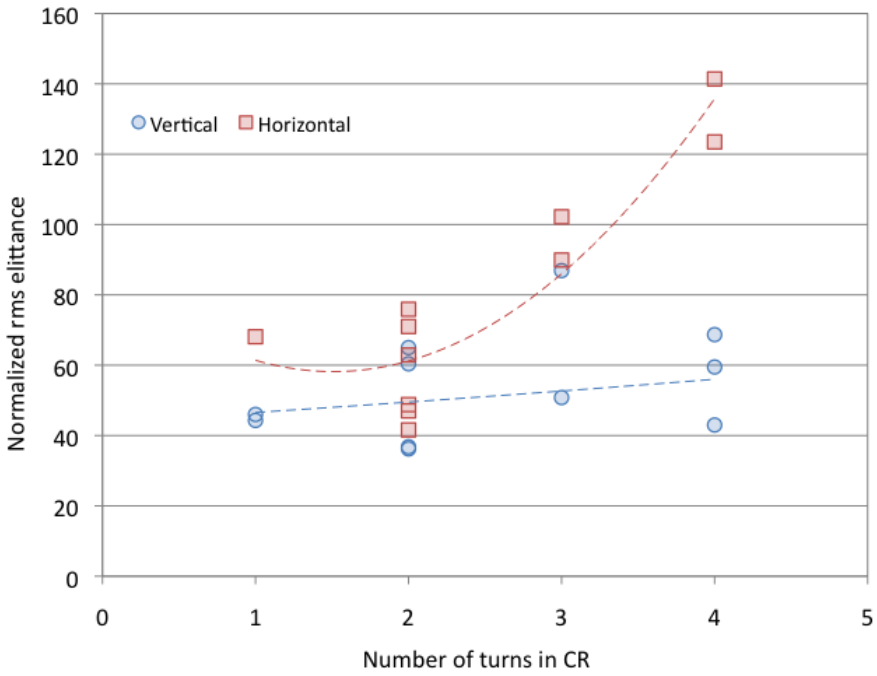
CTF3 Achievements – Drive Beam Generation



Beam recombination - Emittance

Different turns are ~ ok, no unknown effects
Some emittance increase due to non perfect combination

Best results in CLEX
for factor 4: ε_H= 250 um ε_V= 150 um
for factor 8: ε_H= 250 um ε_V= 150 um



- Improve measurements
- Correct dispersion (linear, nonlinear)
- Correct multi-turn orbit
- Control beta-beating

End 2011 ?

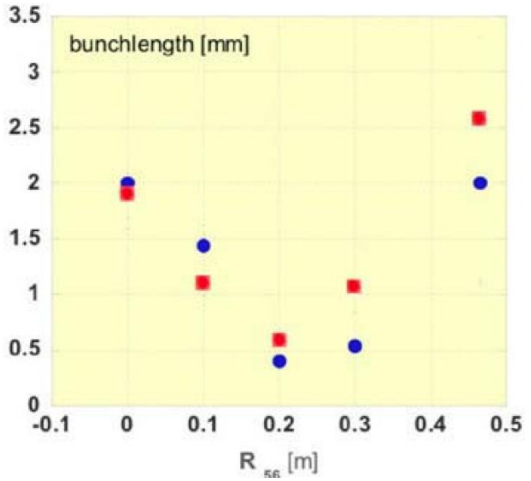
CTF3 Achievements – Drive Beam Generation

Beam recombination – Bunch lenght

nominal in CLEX 1 mm sigma

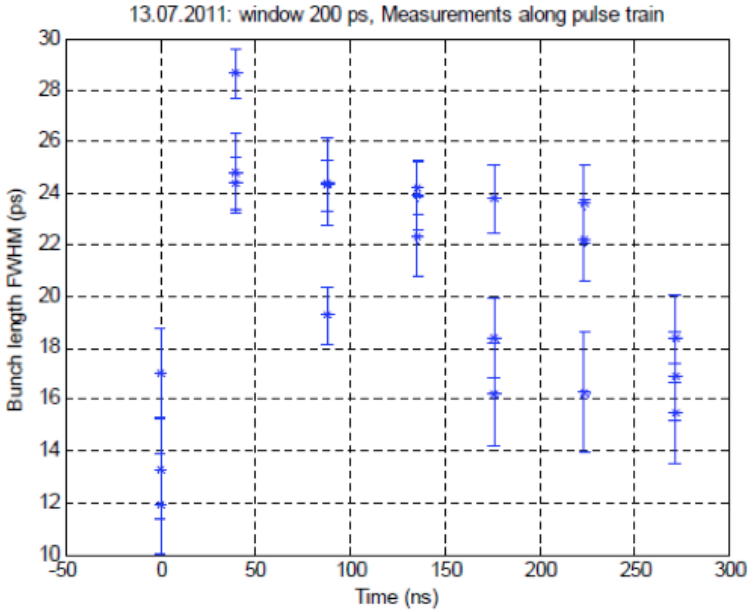
In the past, well below 1 mm sigma measured at the end of the linac (tuned chicane)

Recent results (preliminary): 1.5 to 4 mm sigma for CR and CLEX (natural chicane)



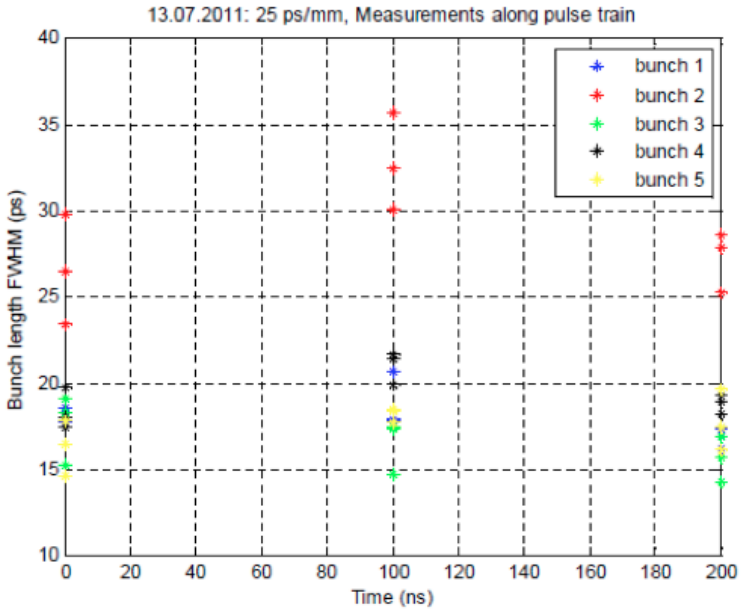
Combiner ring

turn 1, 3 data for each timing



CLEX

5 bunches per measurement, 3 data for each timing



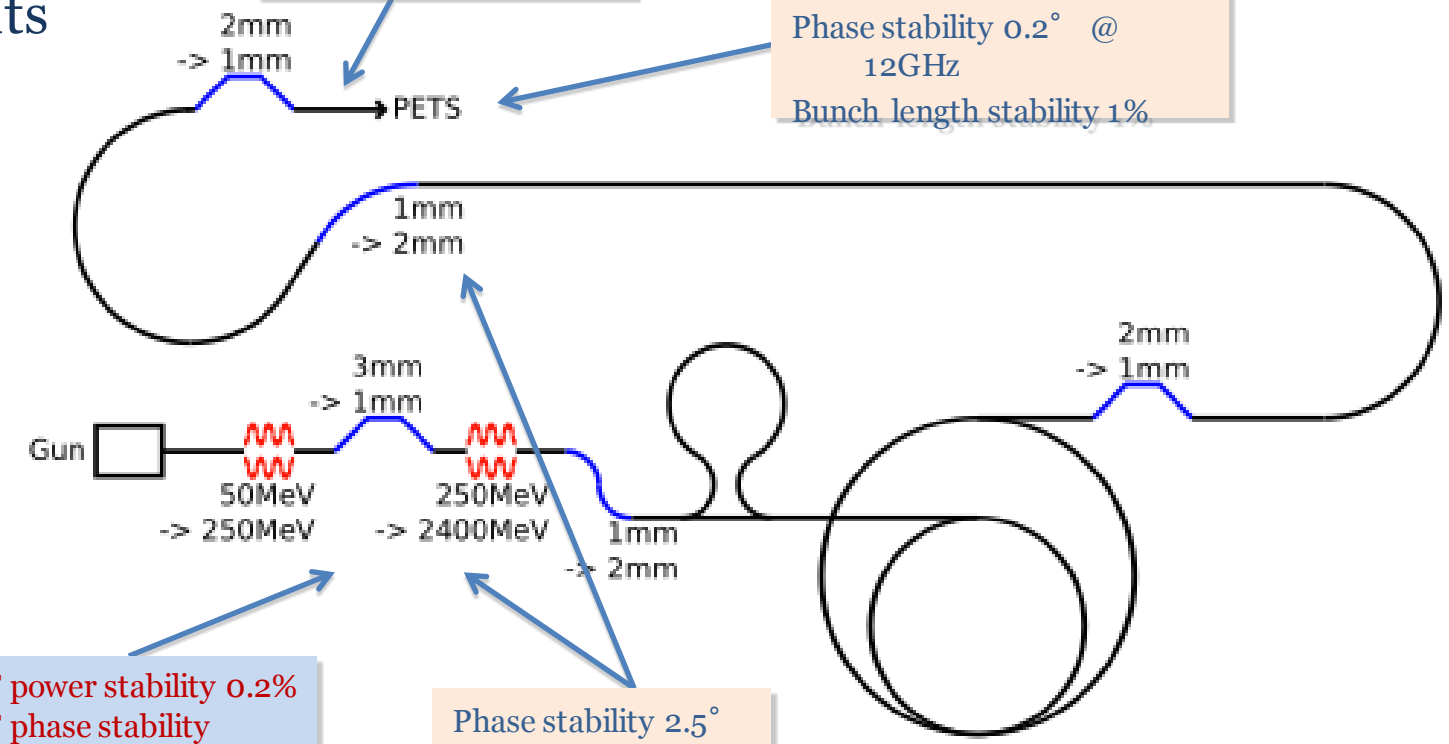
CTF3 Achievements – Drive Beam Generation

Item	Feasibility Issue	Unit	Nominal	Achieved	How	Feasibility	Comments
Drive beam generation	Fully loaded accel effic	%	97	95	CTF3	✓	Novel scheme fully demonstrated in CTF3 in spite of lower current since beam dynamics more sensitive than nominal due to lower energy (250MeV/2Gev)
	Freq&Current multipl	-	2*3*4	2*4	CTF3	✓	
	Combined beam current (12 GHz)	A	4.5*24=100	3.5*8=28	CTF3	✓	
	Combined pulse length (12 GHz)	nsec	240	140	CTF3	✓	
	Intensity stability	1.E-03	0.75	< 0.6	CTF3	✓	End of DBA. To be demonstrated for combined beam in 2011
	Drive beam linac RF phase stability	Deg (1GHZ)	0.05	0.035	CTF3, XFEL	✓	Achieved in CTF3, XFEL design

CLIC Drive Beam requirements

Emittance $\varepsilon_{x,y} \leq 150\mu m$
Transverse jitter $\leq 0.3\sigma$

Current stability $0.75 \cdot 10^{-3}$
Phase stability 0.2° @ 12GHz
Bunch length stability 1%



RF power stability 0.2%
RF phase stability 0.05°
Current stability 0.1%

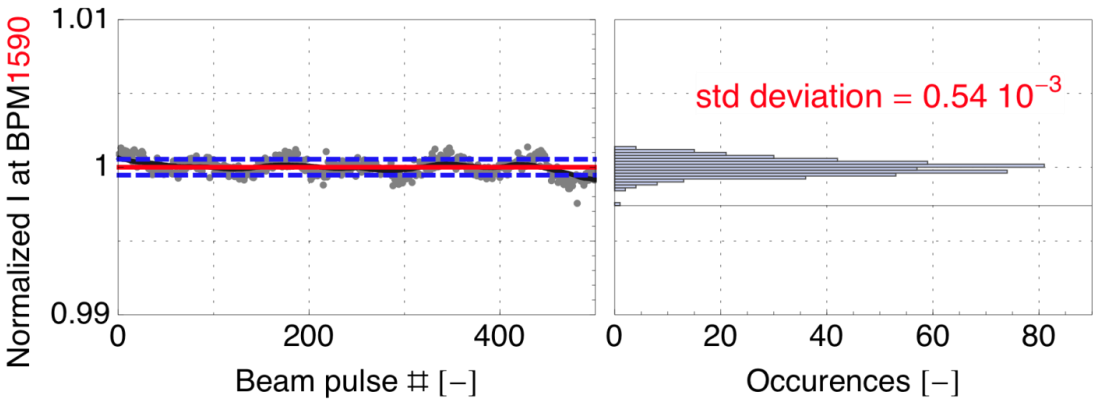
Phase stability 2.5° @ 12GHz
0.2° @ 1GHz

CTF3 Achievements – Drive Beam Generation

Item	Feasibility Issue	Unit	Nominal	Achieved	How	Feasibility	Comments
Drive beam generation	Fully loaded accel effic	%	97	95	CTF3	✓	Novel scheme fully demonstrated in CTF3 in spite of lower current since beam dynamics more sensitive than nominal due to lower energy (250MeV/2Gev)
	Freq&Current multipl	-	2*3*4	2*4	CTF3	✓	
	Combined beam current (12 GHz)	A	4.5*24=100	3.5*8=28	CTF3	✓	
	Combined pulse length (12 GHz)	nsec	240	140	CTF3	✓	
	Intensity stability	1.E-03	0.75	< 0.6	CTF3	✓	End of DBA. To be demonstrated for combined beam in 2011
	Drive beam linac RF phase stability	Deg (1GHZ)	0.05	0.035	CTF3, XFEL	✓	Achieved in CTF3, XFEL design

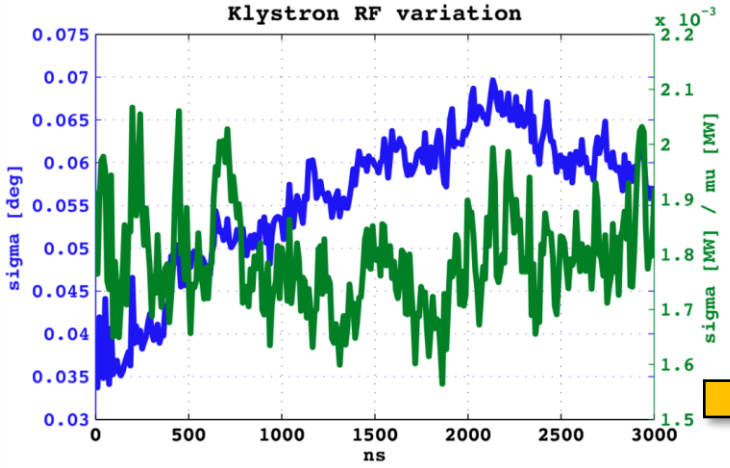
Pulse charge measured at end of the linac

After factor 8 combination
~ 1% jitter



"Good" CTF3 klystron

- pulse-to-pulse jitter
- 10 ns time slices along the RF pulse
- with respect to local phase reference



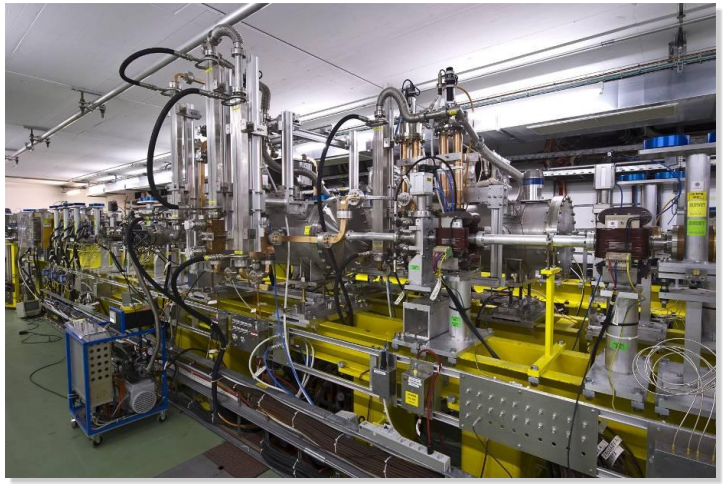
- Improve and document current stability for combination factor 4
- Improve stability for combination factor 8 at the permil level
- Means: improve acceptance (dispersion, orbit, beta-beating)
- Reduce energy spread – bunch length

	Tolerance	Measured
Beam current	0.75%	0.54%
RF Power	0.2%	0.16% - 0.21%
RF Phase	0.05°	0.035° - 0.07°

End 2011 – Mid 2012

CTF3 Achievements – Beam driven RF power generation

Beam Driven RF power generation	PETS RF Power	MW	130	>130	TBTS/SLAC	✓	BD rate at nominal power and pulse lenght, measured on Klystron driven PETS. Beam driven tests under way in CTF3
	PETS Pulse length	ns	170	>170	TBTS/SLAC	✓	
	PETS Breakdown rate	/m	< 1·10-7	≤ 2.4 10-7	TBTS/SLAC	✓	
	PETS ON/OFF	-	@ 50Hz	-	CTF3/TBTS	2011	Prototype under fabrication for tests with beam
	Drive beam to RF efficiency	%	90%	-	CTF3/TBL	2012	TBL with 8 (16) PETS in 2011(12) for 30(50%) efficiency. Benchmark beam simulation for safe extrapolation of high efficiency at high drive beam energy(2GeV).
	RF pulse shape control	%	< 0.1%	-	CTF3/TBTS	2011-2012	



PETS rapidly (~ 3 x 10^5 pulses) reached record >**200 MW** peak RF power level,

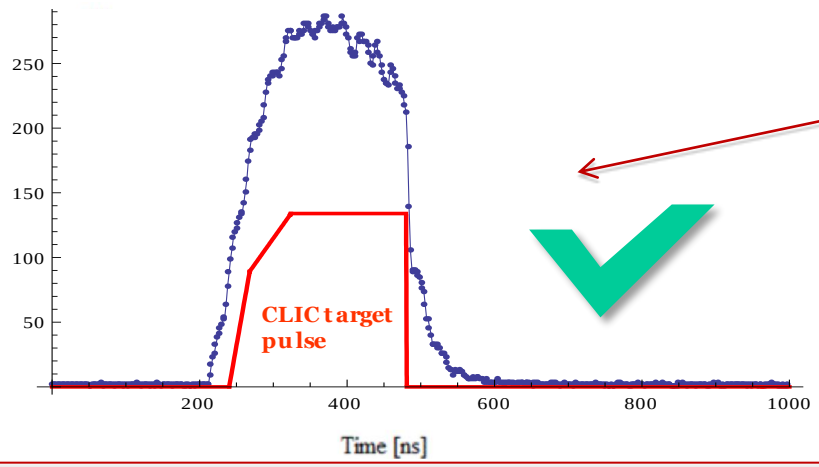
providing reliably pulses ~160 MV peak to accelerating structure.

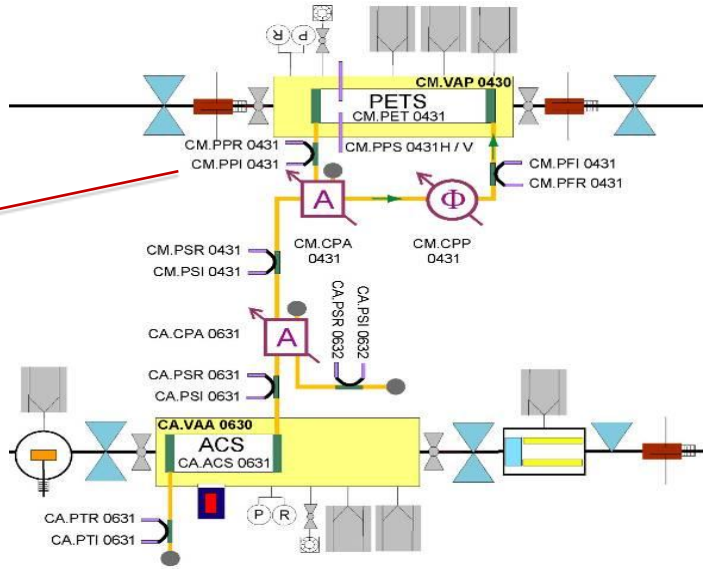
About twice the power needed to demonstrate 100 MV/m acceleration in a two-beam experiment with TD24 structure.

- Analyze data for evaluation of present break-down rate
- Dedicated measurement at high powers – increased rep rate
- Document

Breakdown rate?

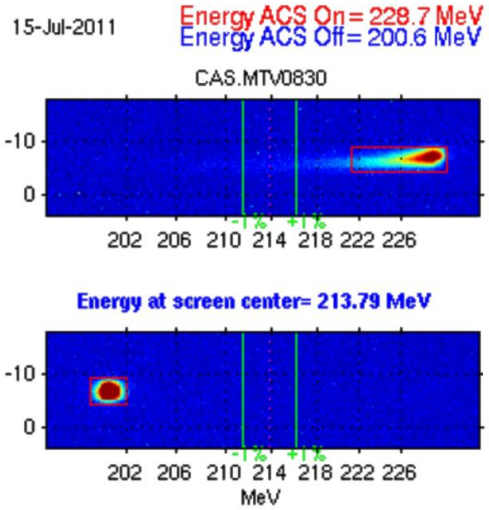
End 2011 – Mid 2012





CTF3 Achievements – Two-Beam Acceleration

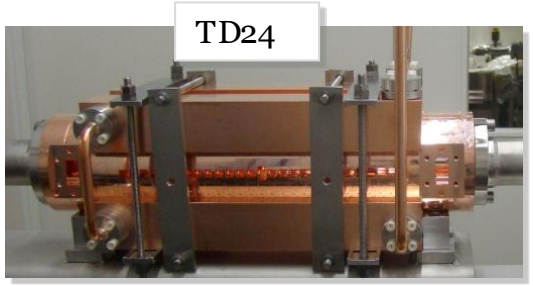
Accelerating Structures (CAS)	Structure Acc field	MV/m	100	100	CTF3 Test Stand, SLAC, KEK	✓✓	Nominal performances of 3 structures without damping. 1 structure equipped with damping features under RF conditionning to reduce breakdown rate.
	Structure Flat Top Pulse length	ns	170	170		2011	
	Structure Breakdown rate	/m MV/m.ns	< 3·10-7	5·10-5(D)		2011	
	Rf to beam transfer efficiency	%	27	15			
Two Beam Acceleration	Power producton and probe beam acceleration in Two beam module	MV/m - ns	100 - 170	106 - 170	TBTS	✓	Power production in Two Beam Test Stand (TBTS)
							Probe beam acceleration by Two Beam Test Stand(TBTS)
	Drive to main beam timing stability	psec	0.05	-	CTF3	2012	
	Main to main beam timing stability	psec	0.07	-	XFEL?	2012	

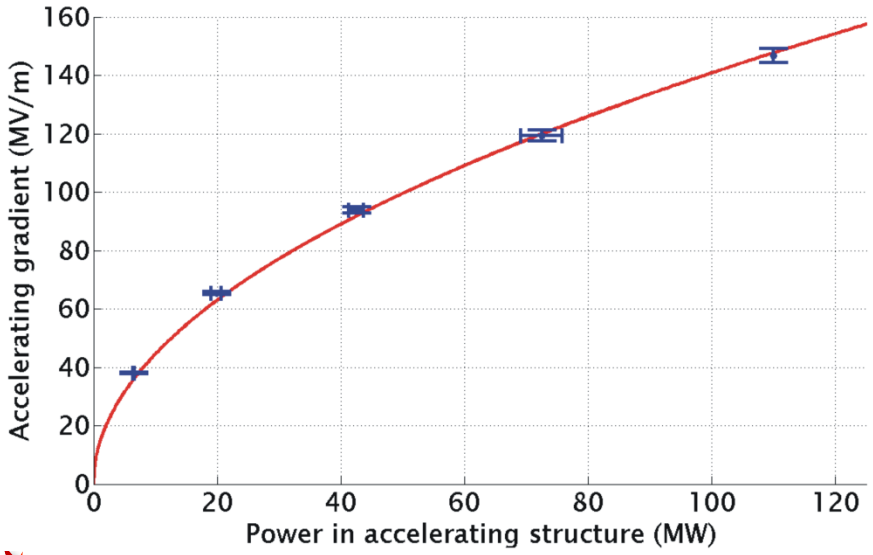


Drive beam ON

Drive beam OFF

Two-Beam Acceleration demonstration in CTF3 Two-Beam Test Stand





Maximum probe beam acceleration measured: 31 MeV

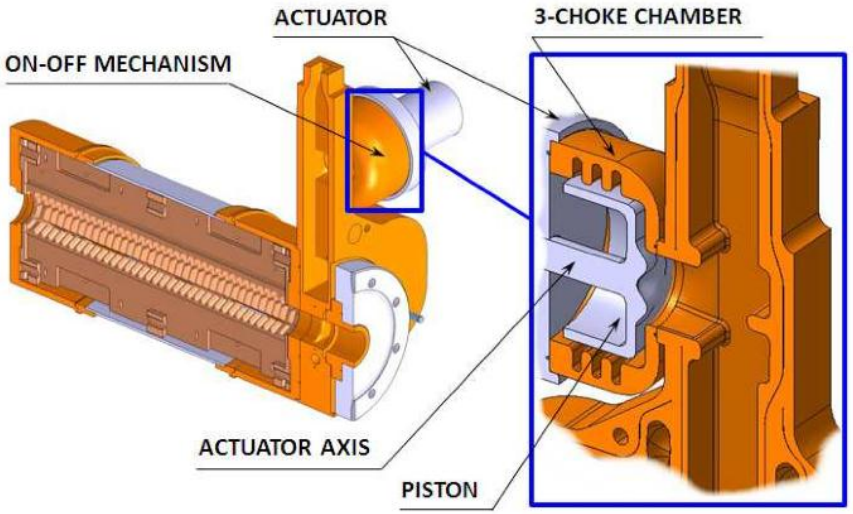
⇒ Corresponding to a gradient of **145 MV/m**

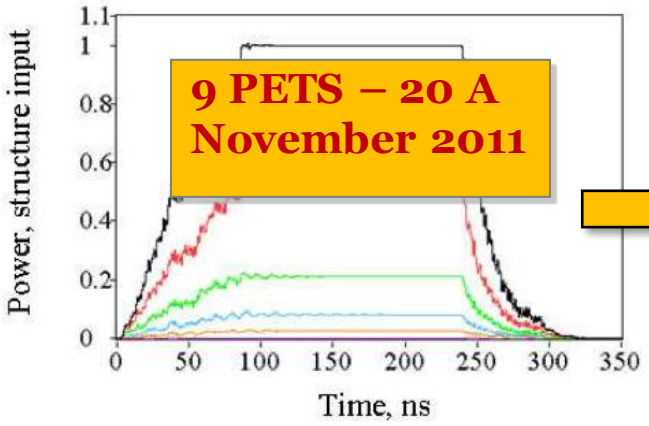
CTF3 Achievements – Beam driven RF power generation

Beam Driven RF power generation	PETS RF Power	MW	130	>130	TBTS/SLAC	✓	BD rate at nominal power and pulse lenght, measured on Klystron driven PETS. Beam driven tests under way in CTF3
	PETS Pulse length	ns	170	>170	TBTS/SLAC	✓	
	PETS Breakdown rate	/m	< 1·10-7	≤ 2.4 10-7	TBTS/SLAC	✓	
	PETS ON/OFF	-	@ 50Hz	-	CTF3/TBTS	2011	Prototype under fabrication for tests with beam
	Drive beam to RF efficiency	%	90%	-	CTF3/TBL	2012	TBL with 8 (16) PETS in 2011(12) for 30(50%) efficiency. Benchmark beam simulation for safe extrapolation of high efficiency at high drive beam energy(2GeV).
	RF pulse shape control	%	< 0.1%	-	CTF3/TBTS	2011-2012	

Issues:

- Reliable power production
- Ability to control output power





- Conditioning
- Initial test – no structure connected
- Connect structure
- Full test, including use as recirculation loop

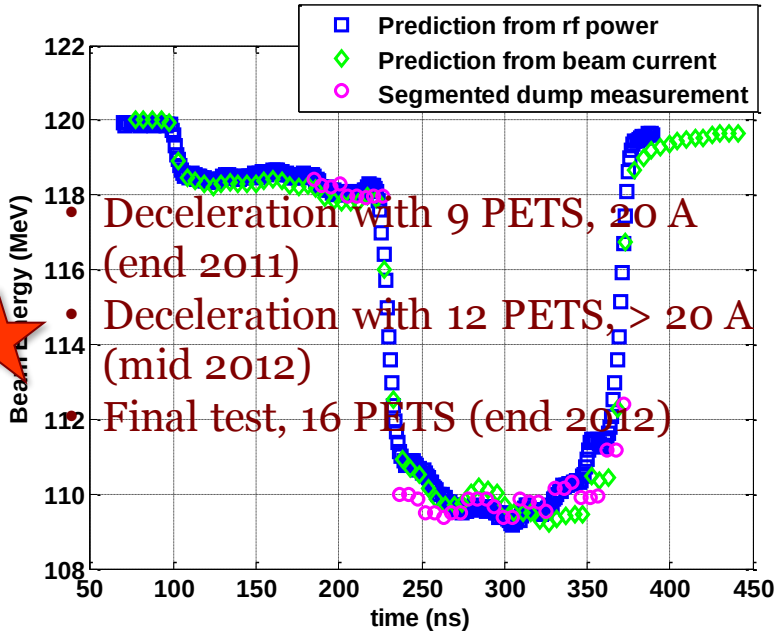
On-off mechanism

Installation in CTF3 TBTS under way now.
Test starting from next week.
End 2011 ?

CTF3 Achievements – Beam driven RF power generation

Beam Driven RF power generation	PETS RF Power	MW	130	>130	TBTS/SLAC	✓	BD rate at nominal power and pulse lenght, measured on Klystron driven PETS. Beam driven tests under way in CTF3
	PETS Pulse length	ns	170	>170	TBTS/SLAC	✓	
	PETS Breakdown rate	/m	< 1·10-7	≤ 2.4 10-7	TBTS/SLAC	✓	
	PETS ON/OFF	-	@ 50Hz	-	CTF3/TBTS	2011	Prototype under fabrication for tests with beam
	Drive beam to RF efficiency	%	90%	-	CTF3/TBL	2012	TBL with 8 (16) PETS in 2011(12) for 30(50%) efficiency. Benchmark beam simulation for safe extrapolation of high efficiency at high drive beam energy(2GeV).
	RF pulse shape control	%	< 0.1%	-	CTF3/TBTS	2011-2012	

9 PETS – 20 A November 2011



- Deceleration with 9 PETS, 20 A (end 2011)
- Deceleration with 12 PETS, > 20 A (mid 2012)
- Final test, 16 PETS (end 2012)

16 PETS maximum

4 PETS installed and tested
~~4~~ 5 ~~being~~ installed in September
12 to 16 next year

Up to 19 A current

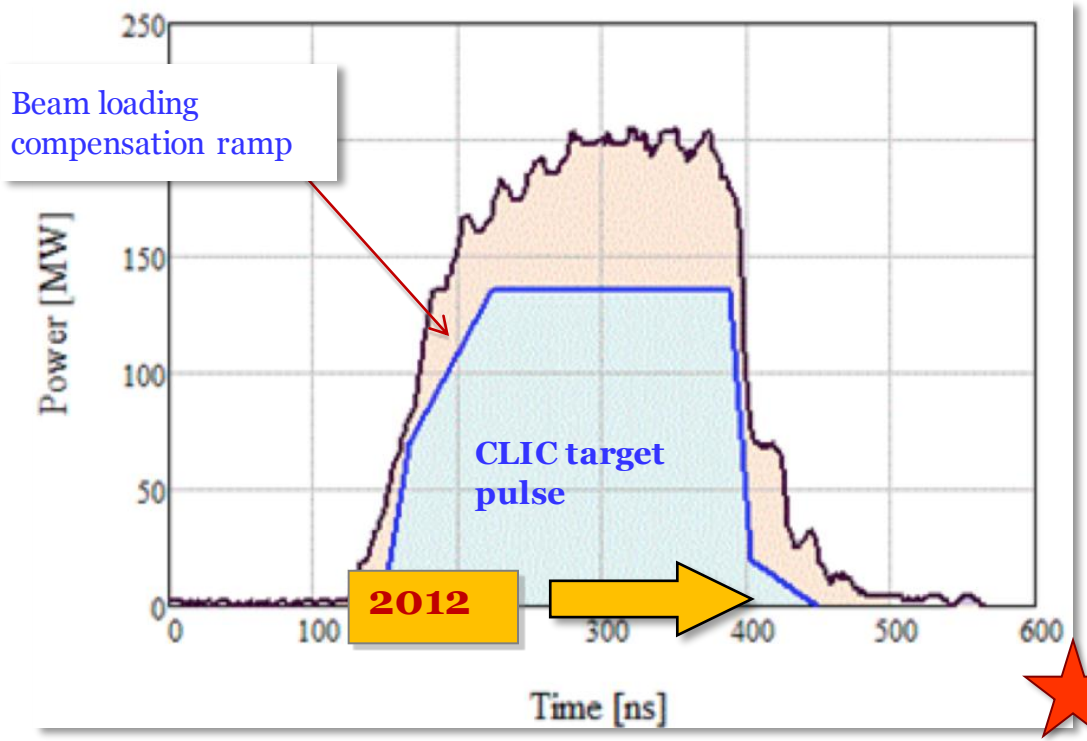
- optics understood
- no losses in TBL

Good agreement

- power production
- beam current
- beam deceleration

CTF3 Achievements – Beam driven RF power generation

Beam Driven RF power generation	PETS RF Power	MW	130	>130	TBTS/SLAC	✓	BD rate at nominal power and pulse lenght, measured on Klystron driven PETS. Beam driven tests under way in CTF3
	PETS Pulse length	ns	170	>170	TBTS/SLAC	✓	
	PETS Breakdown rate	/m	< 1·10-7	≤ 2.4 10-7	TBTS/SLAC	✓	
	PETS ON/OFF	-	@ 50Hz	-	CTF3/TBTS	2011	Prototype under fabrication for tests with beam
	Drive beam to RF efficiency	%	90%	-	CTF3/TBL	2012	TBL with 8 (16) PETS in 2011(12) for 30(50%) efficiency. Benchmark beam simulation for safe extrapolation of high efficiency at high drive beam energy(2GeV).
	RF pulse shape control	%	< 0.1%	-	CTF3/TBTS	2011-2012	



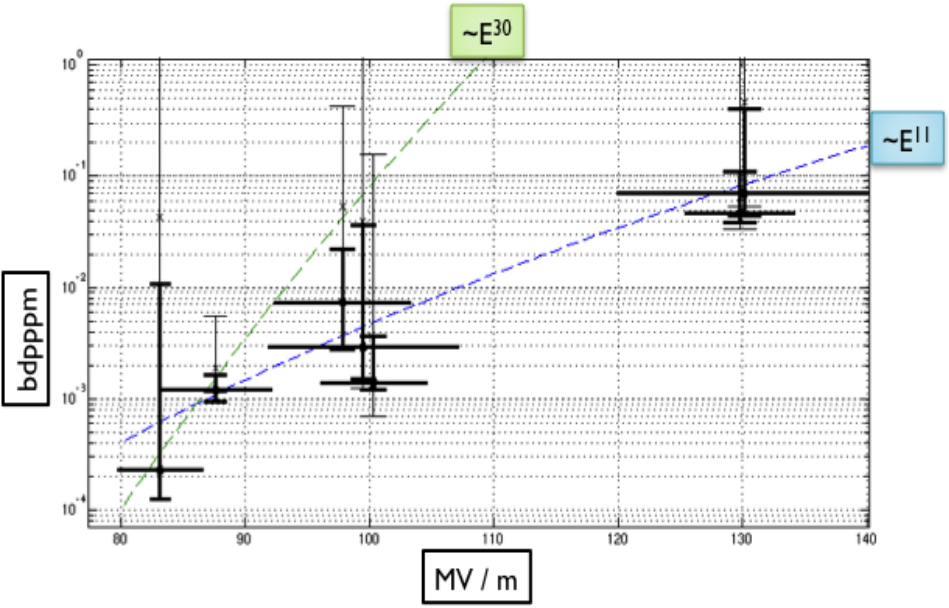
- Create precise ramp by fine tuning of phase switches timing
- Show control of ramp to the desired degree (limited by number of free parameters)
- Eventually test acceleration with probe beam (short pulse, scan method)

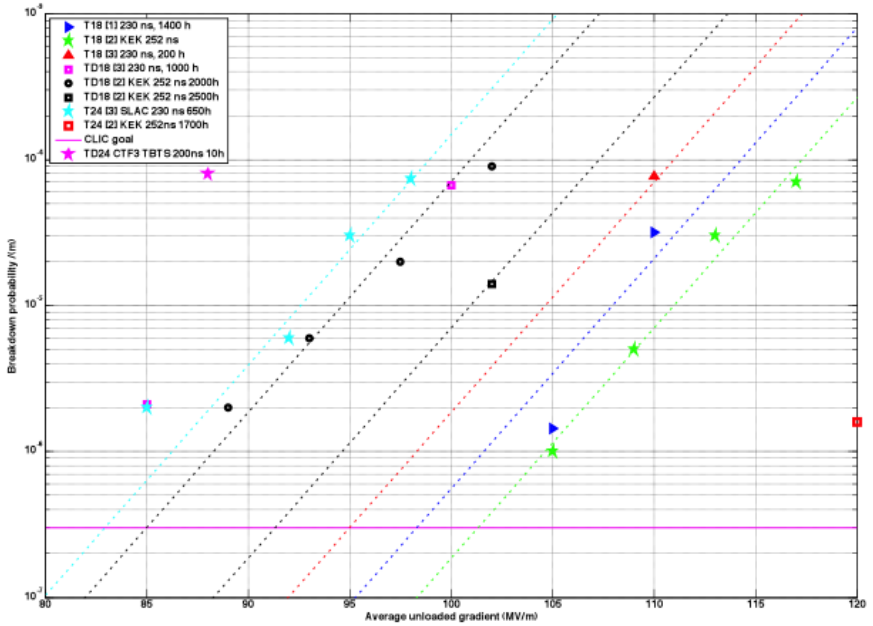
- Initial tests, end 2011
- Eventual improvements/upgrades, shut down 2011/2012
- Full test, including probe beam acceleration, mid/end 2012

CTF3 Status

CTF3 Achievements – Accelerating Structures

Accelerating Structures (CAS)	Structure Acc field	MV/m	100	100	CTF3 Test Stand, SLAC, KEK	2011	Nominal performances of 3 structures without damping. 1 structure equipped with damping features under RF conditionning to reduce breakdown rate.
	Structure Flat Top Pulse length	ns	170	170		2011	
	Structure Breakdown rate	/m MV/m.ns	< 3·10-7	5·10-5(D)			
	Rf to beam transfer efficiency	%	27	15			
Two Beam Acceleration	Power producton and probe beam acceleration in Two beam module	MV/m - ns	100 - 170	106 - 170	TBTS	2011	Power production in Two Beam Test Stand (TBTS)
							Probe beam acceleration by Two Beam Test Stand(TBTS)
	Drive to main beam timing stability	psec	0.05	-	CTF3	2012	
	Main to main beam timing stability	psec	0.07	-	XFEL?	2012	

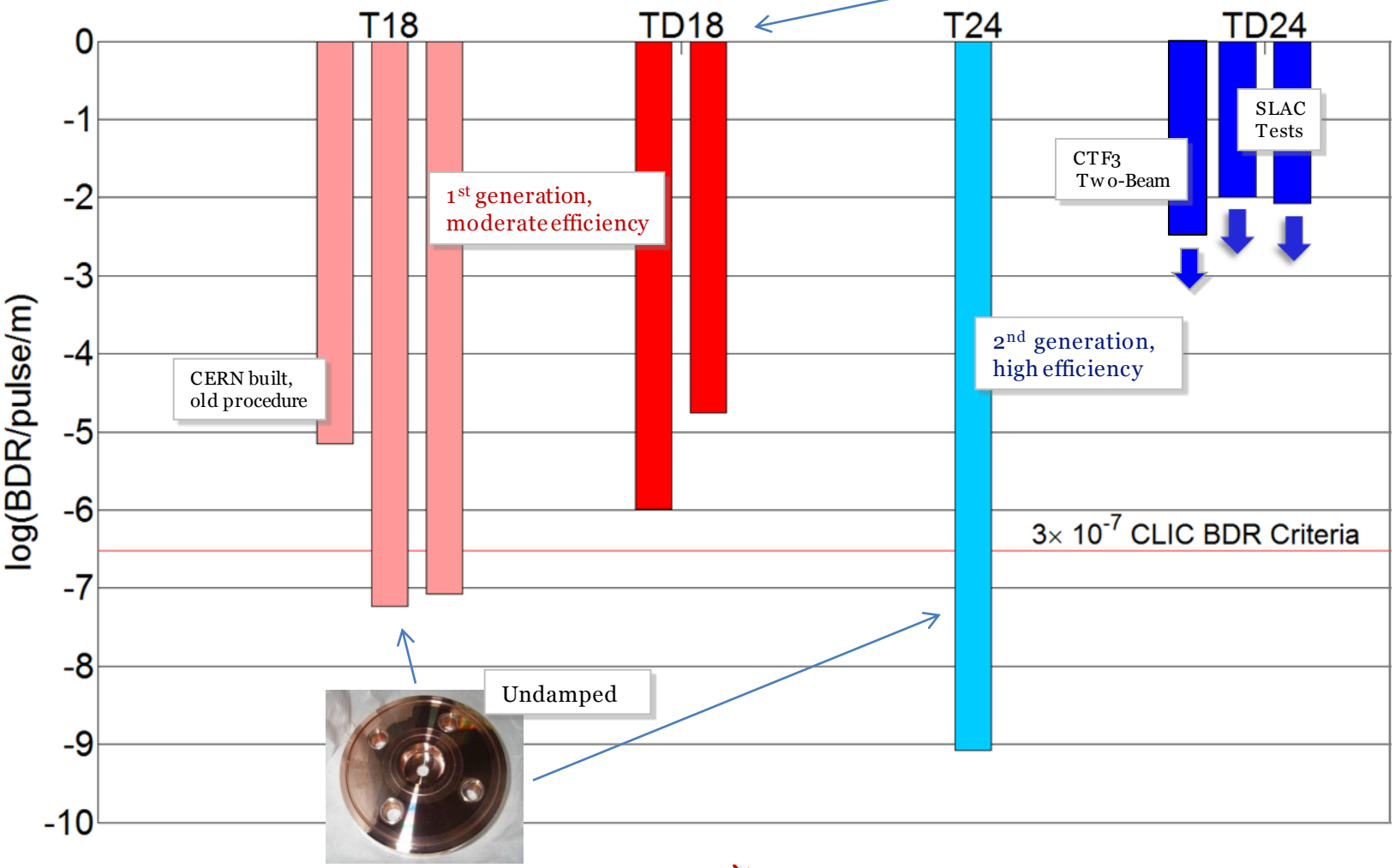




Accelerating Structure - Experimental results

Breakdown rate at 100 MV/m (unloaded) accelerating gradient and scaled to 180 ns pulse length

Measurements scaled according to ➡ $p \propto G^{30}\tau^{5}$



CTF3 Achievements – Accelerating Structures

Accelerating Structures (CAS)	Structure Acc field	MV/m	100	100	CTF3 Test Stand, SLAC, KEK	✓✓	Nominal performances of 3 structures without damping. 1 structure equipped with damping features under RF conditionning to reduce breakdown rate.
	Structure Flat Top Pulse length	ns	170	170			
	Structure Breakdown rate	/m MV/m.ns	< 3·10-7	5·10-5(D)		2011	
	Rf to beam transfer efficiency	%	27	15		2011	
Two Beam Acceleration	Power producton and probe beam acceleration in Two beam module	MV/m - ns	100 - 170	106 - 170	TBTS	2011	Power production in Two Beam Test Stand (TBTS)
							Probe beam acceleration by Two Beam Test Stand(TBTS)
	Drive to main beam timing stability	psec	0.05	-	CTF3	2012	
	Main to main beam timing stability	psec	0.07	-	XFEL?	2012	

- Continue conditioning/BDR measurements of TD24 in the shadow of other experiments
- Profit to improve power production stability/availability/rep rate
- Continue BD kick measurements
- Install couple of new structures, TD24 with wake-field monitors in winter shut-down 2011-2012
- First module should go in during winter shut-down 2012-2013

CTF3 Achievements – Two-Beam Acceleration

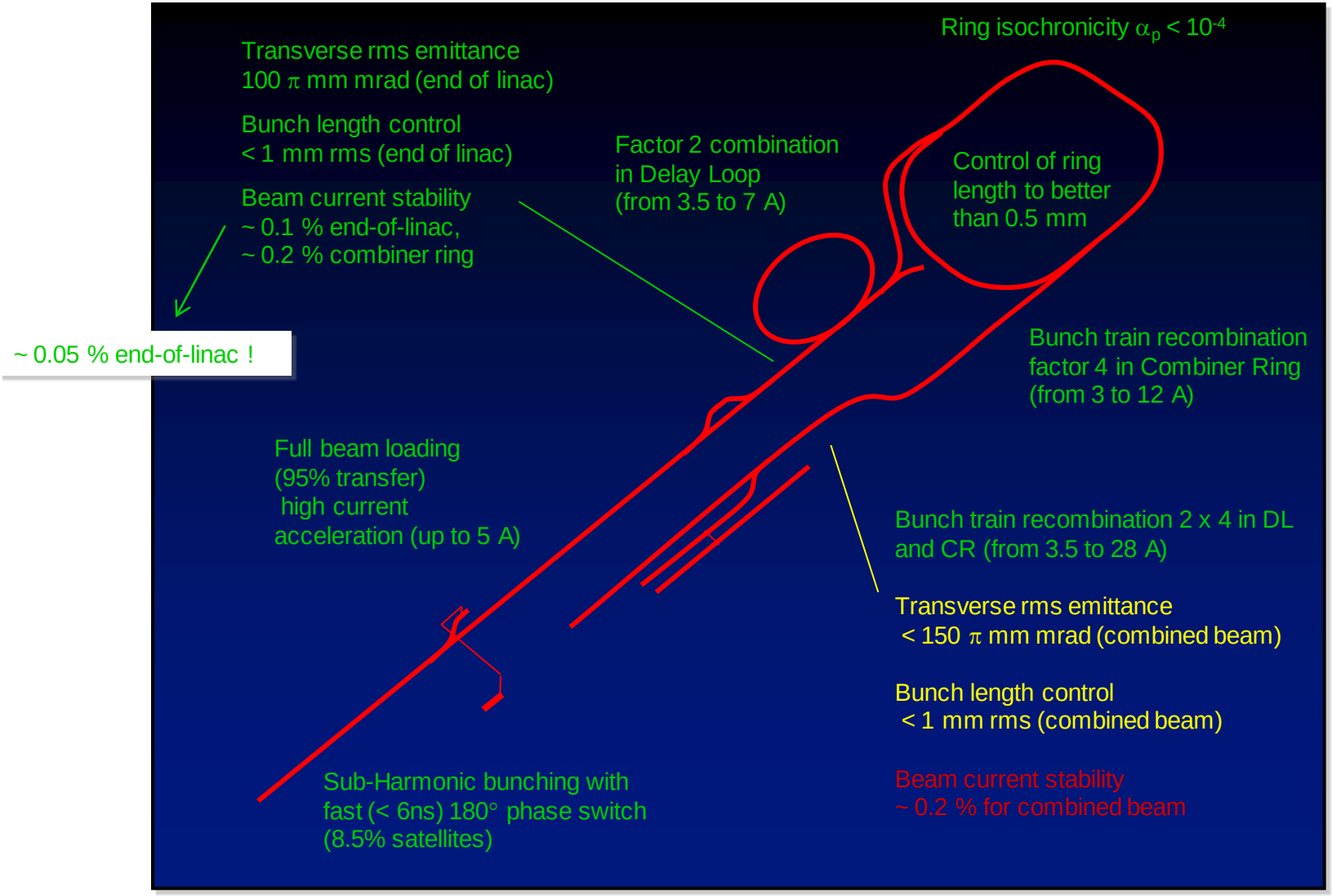
Accelerating Structures (CAS)	Structure Acc field	MV/m	100	100	CTF3 Test Stand, SLAC, KEK	✓✓	Nominal performances of 3 structures without damping. 1 structure equipped with damping features under RF conditionning to reduce breakdown rate.
	Structure Flat Top Pulse length	ns	170	170		2011	
	Structure Breakdown rate	/m MV/m.ns	< 3·10-7	5·10-5(D)		2011	
	Rf to beam transfer efficiency	%	27	15			
Two Beam Acceleration	Power producton and probe beam acceleration in Two beam module	MV/m - ns	100 - 170	106 - 170	TBTS	2011	Power production in Two Beam Test Stand (TBTS)
							Probe beam acceleration by Two Beam Test Stand(TBTS)
	Drive to main beam timing stability	psec	0.05	-	CTF3	2012	
	Main to main beam timing stability	psec	0.07	-	XFEL?	2012	

See the previous WG session

(common AWG6-AWG8)

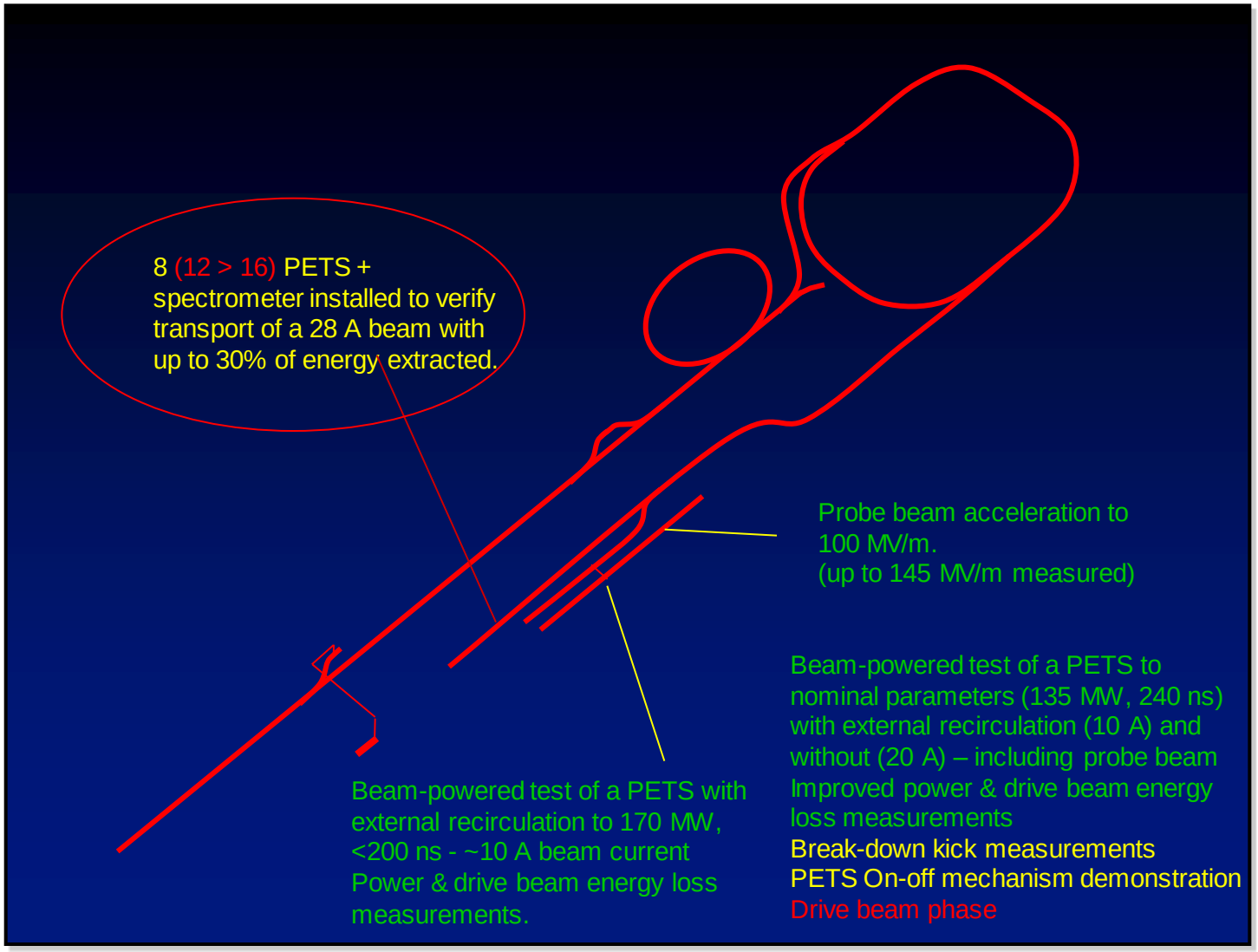
CTF3 achievements – Drive Beam

CTF3 Achievements – What is still missing for feasibility – Drive Beam Generation



CTF3 achievements – Two-Beam issues

CTF3 Achievements – What is still missing for feasibility – TBL / TBTS / CALIFES

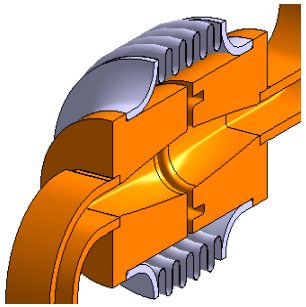


Two-Beam RF components

Two-Beam RF layout

Waveguide network

- high power
- precise phase length

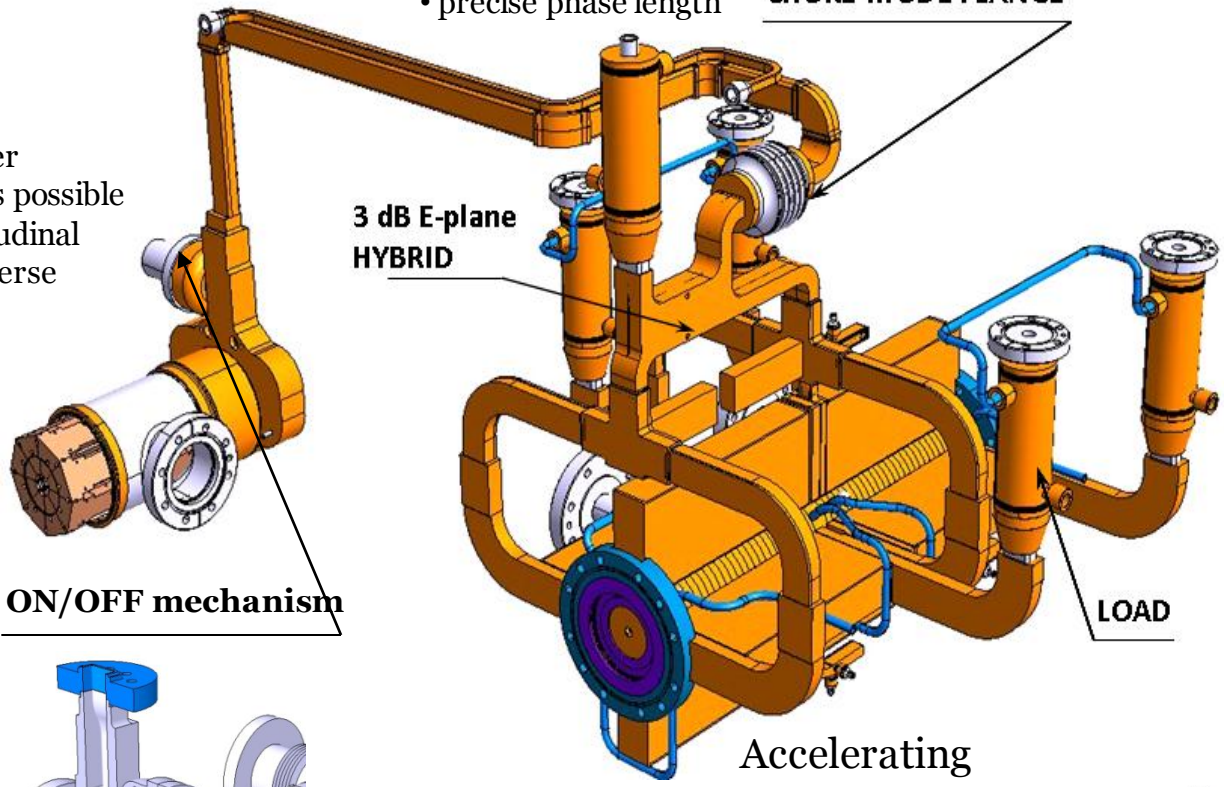


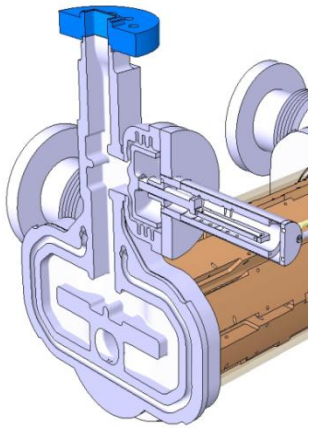
Choke mode flange

- independent alignment of main and drive beam

PETS

- high-power
- as short as possible
- low longitudinal and transverse impedance



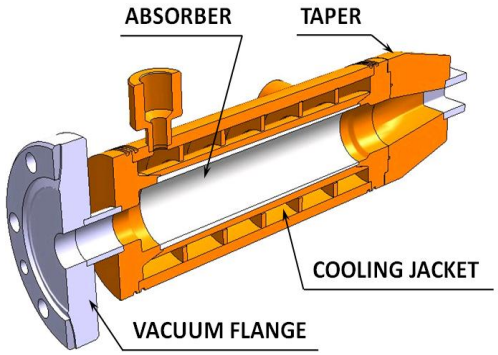


On/ramp/off

- necessary (?) to react to breakdown and/or failure

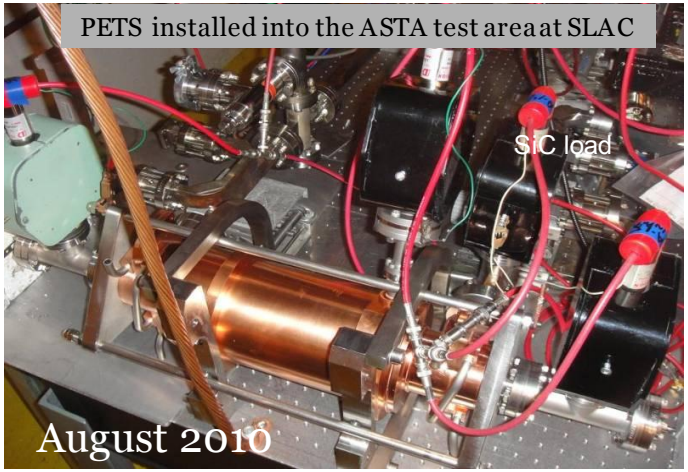
Accelerating structure

- high-gradient
- as long as possible
- micron precision
- transverse wake-field suppression

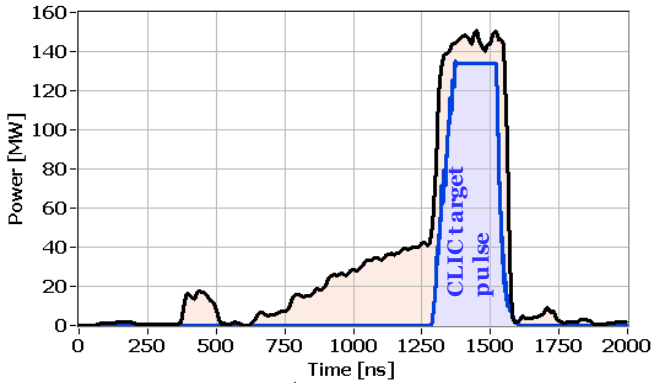


Power Extraction and Transfer Structure (PETS)

High power tests of the full PETS prototype (with damping material) at ASTA/SLAC

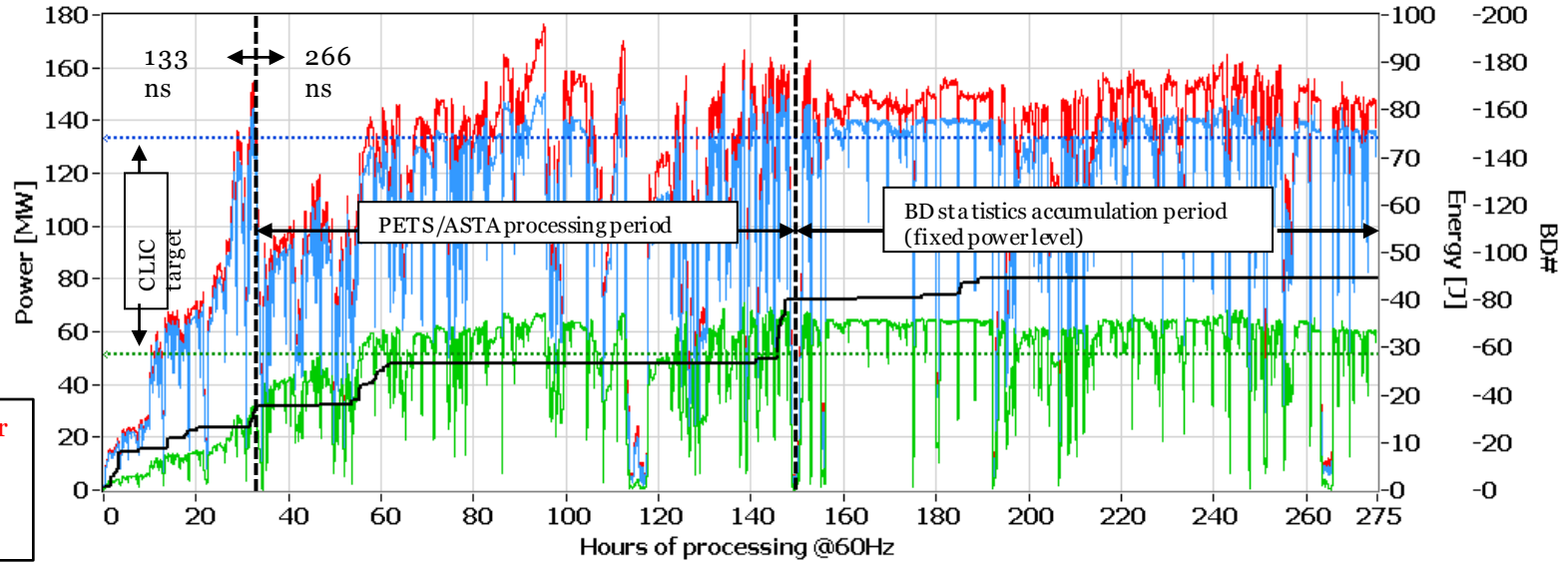


Typical RF pulse shape in ASTA during the last 125 hours of operation



No breakdown during the last 80 hours

BDR <2.4 10-7/pulse/m



Key Design Issues

Main linac gradient	– Accelerating structure
Drive beam scheme	– Drive beam generation – Power extraction and drive beam deceleration – Two beam module
Luminosity	– Main beam emittance generation and preservation – Focusing to nanometer size – Alignment and stabilisation
Operation and Machine Protection System (robustness)	
Detector (experimental conditions)	

Design and feasibility issues will be covered in

CLIC Conceptual Design Report

In time for European strategy group

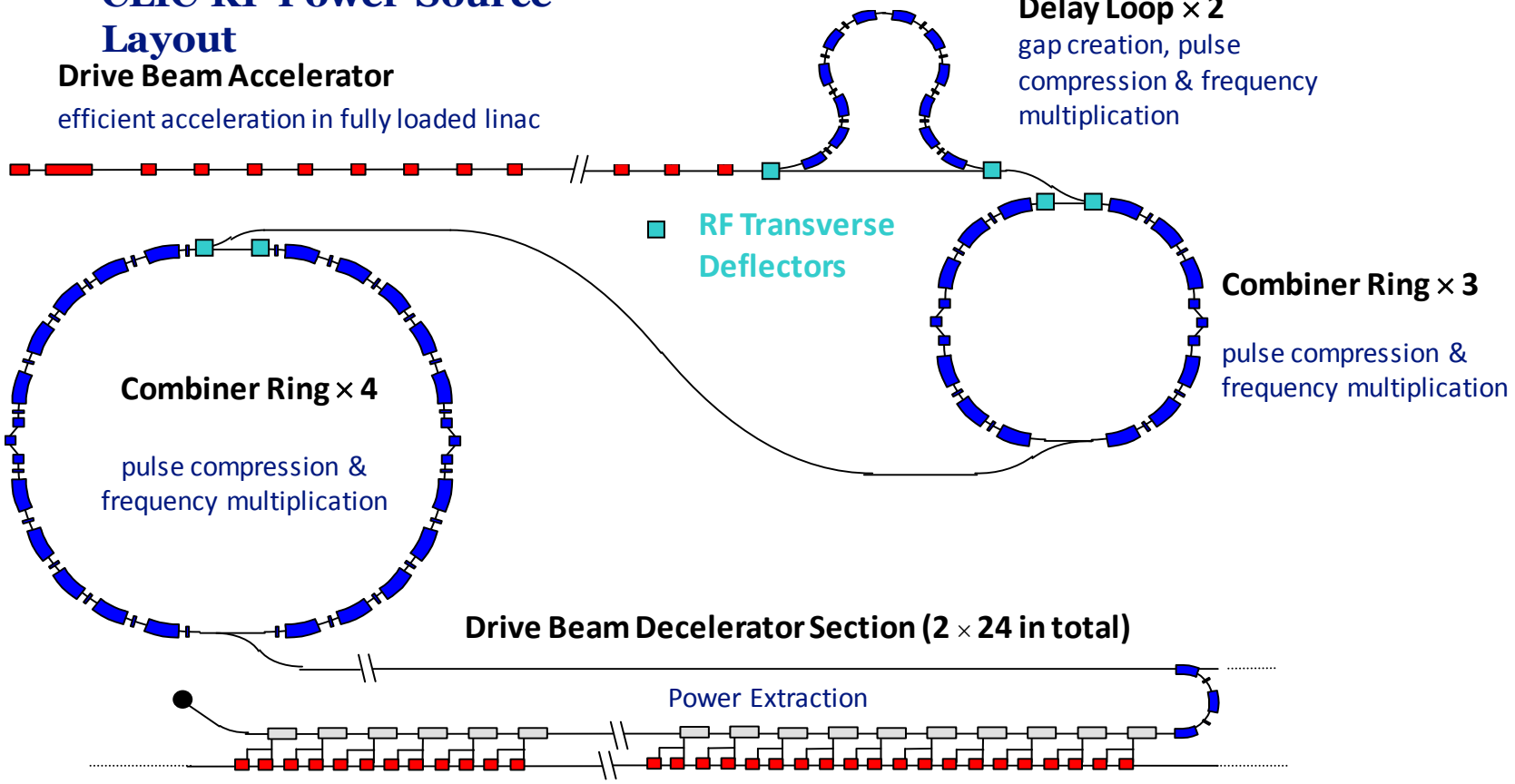
Volume 1: Accelerator

Volume 2: Physics and experiments

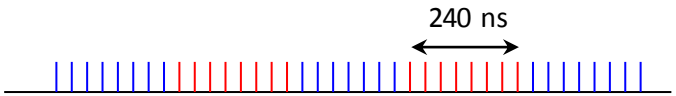
Volume 3: Executive summary

The CLIC RF Power Source Concept

CLIC RF Power Source Layout

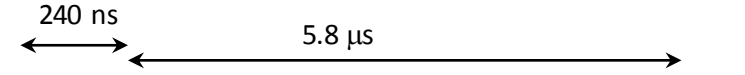


Drive beam time structure - initial



140 μs train length - 24 × 24 sub-pulses
4.2 A - 2.4 GeV – 60 cm between bunches

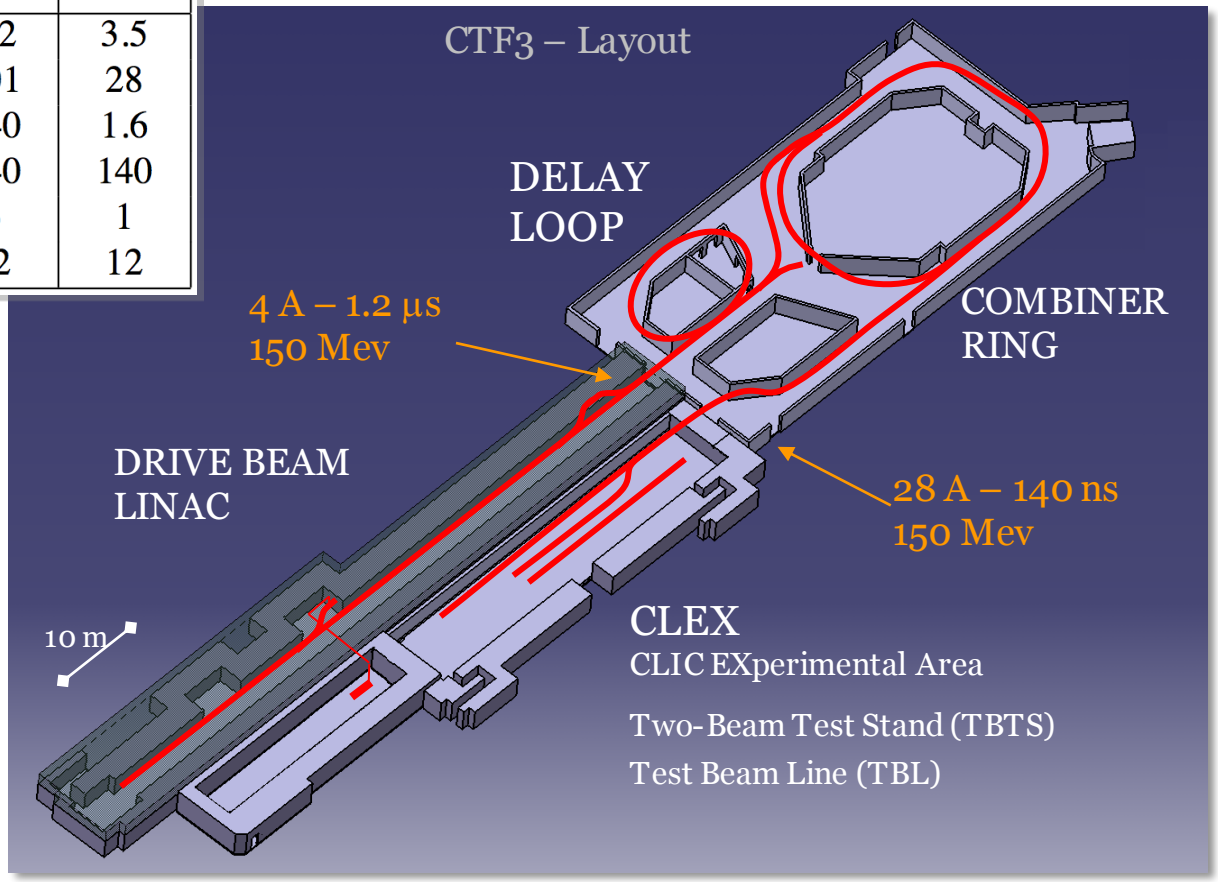
Drive beam time structure - final



24 pulses – **101 A** – 2.5 cm between bunches

CLIC Test Facility (CTF3)

parameter	unit	CLIC	CTF3
accelerated current	A	4.2	3.5
combined current	A	101	28
accelerated pulse length	μs	140	1.6
final pulse length	ns	240	140
acceleration frequency	GHz	3	1
final bunch frequency	GHz	12	12



Scaled model of CLIC RF power source - built partly re-using existing infrastructure

- Made it affordable
- Different parameters – in some cases issues more difficult than in CLIC

CLIC Test Facility (CTF3)

What do we learn in CTF3, relevant for the CLIC RF power source ?

A non-exhaustive list ☺ easier ☹ more difficult

System	quantity/issue	CTF3	CLIC
Injector/linac	bunch charge	2-3 nC	7.7 nC
	current	3.5 - 4.5 A	4.2 A
	pulse length	1.4 μs	140 μs
	phase coding	same	
	frequency	3 GHz	1 GHz
	transverse stability	about the same - CTF3 ``too stable´´	
Delay loop/ring	final current	30 A	110 A
	beam energy	150 MeV	2.4 GeV
	combination	2 - 4	2 - 3, 4
	CSR, wakes	worse in CTF3 (lower energy)	
	Deflector instability	about the same	
Power production (PETS)	Aperture	23 mm	23 mm
	Length	≈ 1 m	23 cm
	Power	> 135 MW	135 MW
	Pulse length	140 ns (240 with recirculation)	240 ns
Decelerator	Fractional loss	50-60 %	90%
	Final energy	70 MeV	240 MeV
	wakes, stability	somehow ``masked´´ in CTF3	
	beam envelope	much larger in CTF3	

In general, most of unwanted effects are equivalent or worse in CTF3 because of the low energy, however in CLIC the beam power is much larger (heating, activation, machine protection)
Needed tolerances on the final drive beam parameters (phase, current, energy stability...) are more stringent in CLIC – some could be demonstrated in CTF3 as well