TBL experimental program, evolution to RF power testing in TBL

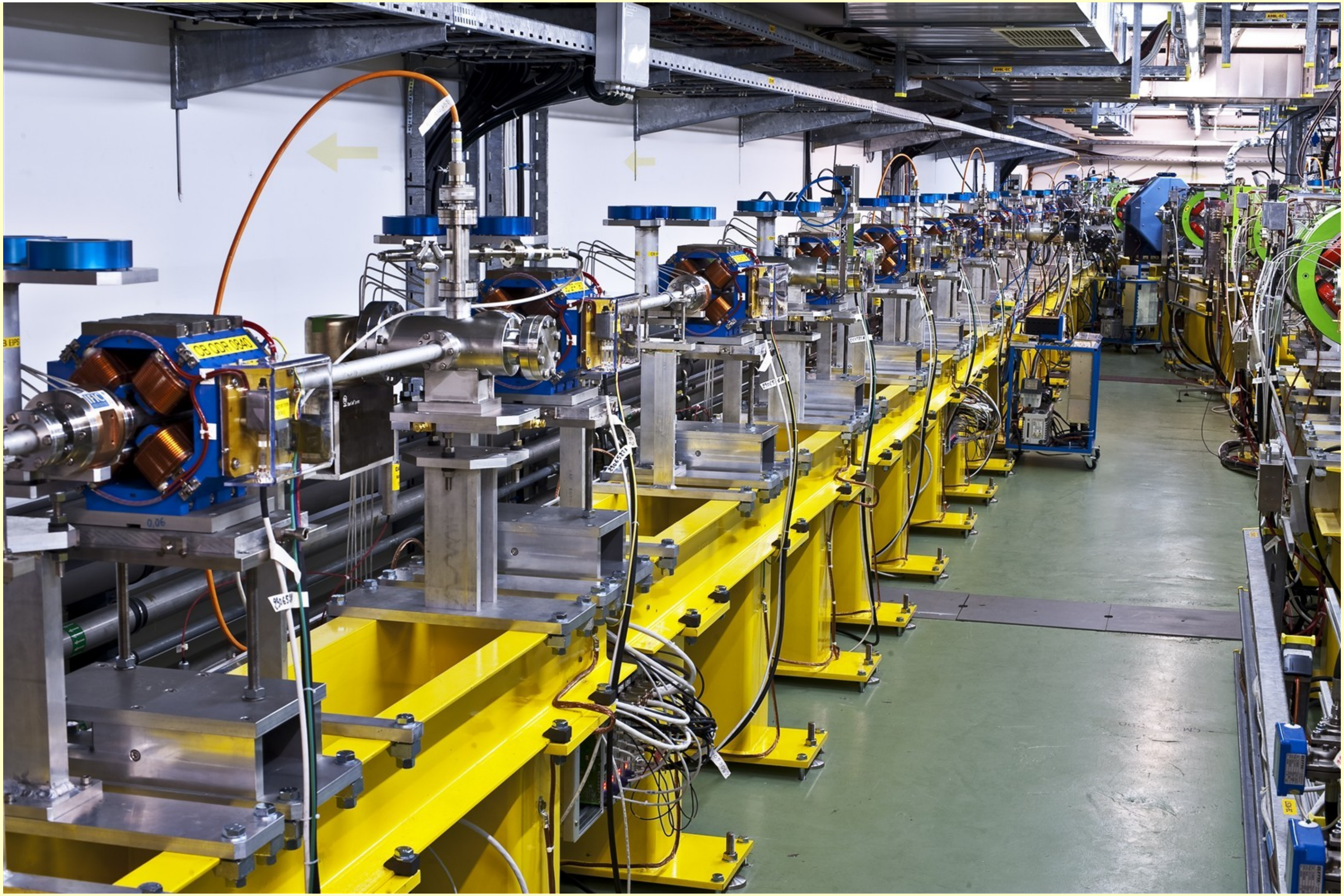
- Current status of TBL
- Experimental program and first results
- Plan for completion
- TBL as a power source for structures

TBL status

- Beam line including PETS prototype installed
  all Quads on movers,
  BPM's with new read out electronics,
  diagnostic section with emittance meter and time resolved spectrometer

- First commissioning and measurements performed
  PETS qualified and found consistent up to 50 MW
  beam matching and transport performed
  end of line spectrometer tested
  BPM resolution measured
  Magnet movers tested

TBL in CLEX



Experimental program

TBL: a high-power test facility

power production, energy balance, power stability,

rf pulse shaping

TBL: demonstration of stable beam transport for heavily decelerated beam – CLIC feasibility

no losses, alignment studies, emittance growth

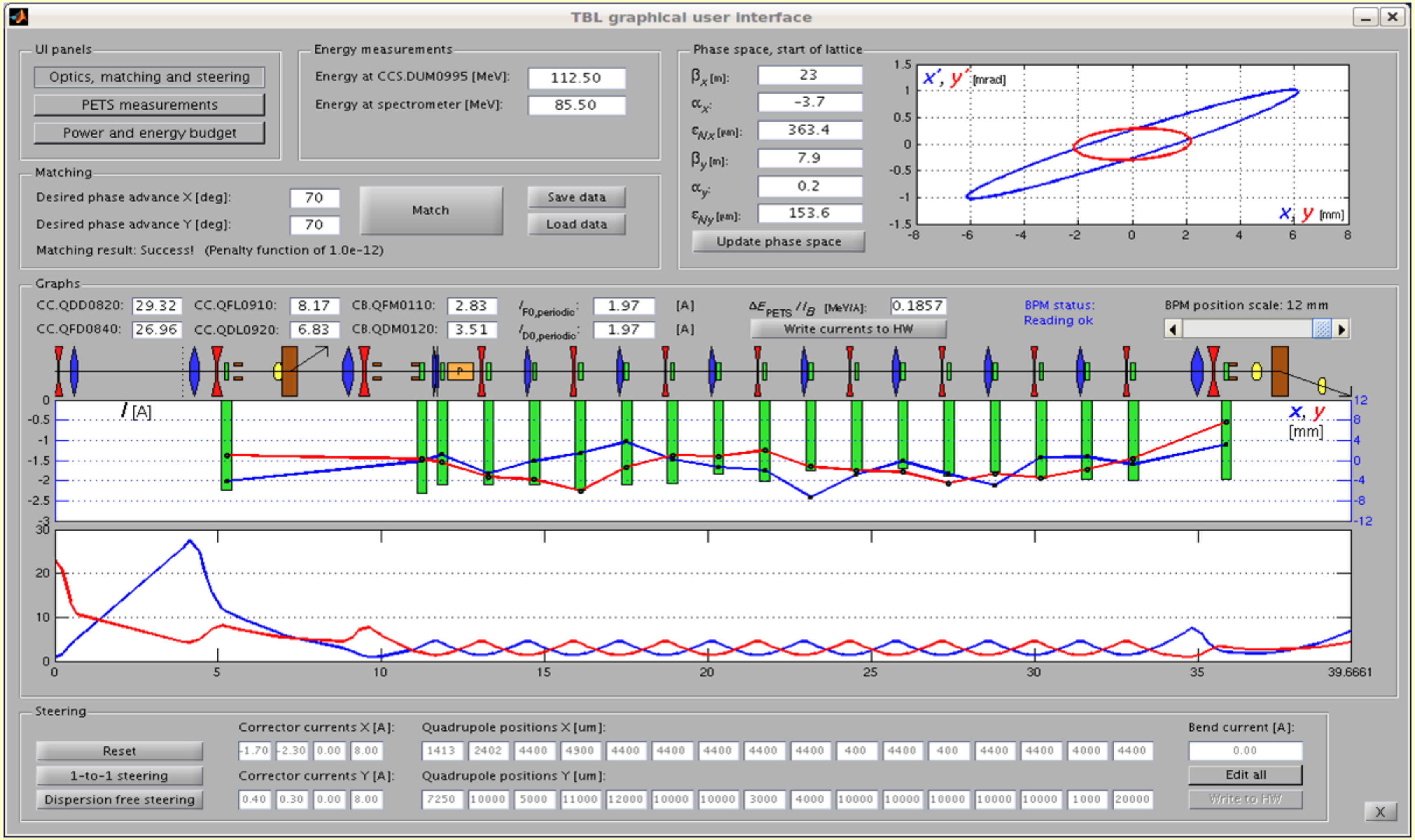
TBL: first prototype for the CLIC decelerator - test-bench and benchmarking

detailed energy spectrum and beam parameters

engineering test bed

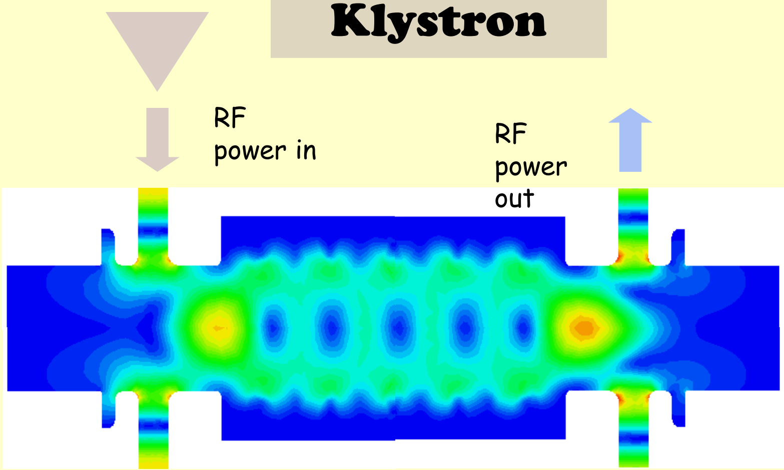
TBL commissioning

Panel to measure beam parameters and perform the matching

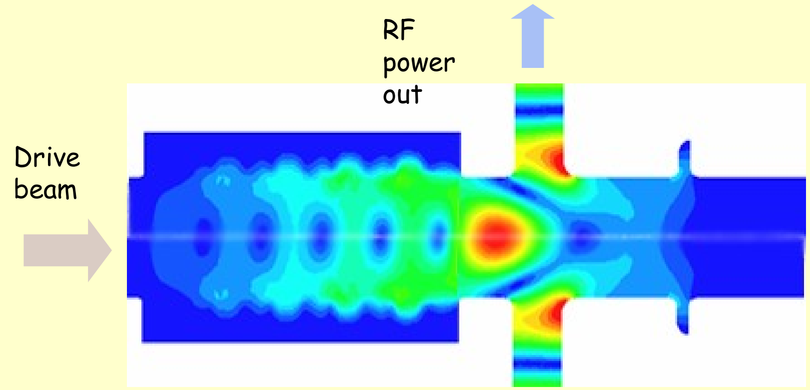


PETS testing

Klystron



Drive beam



ASTA (SLAC)

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

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)

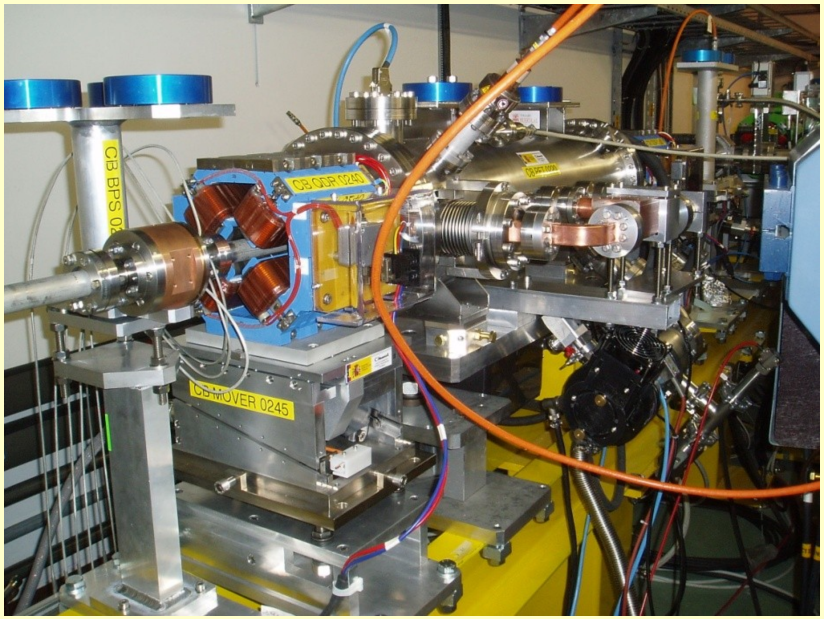
Objective: to demonstrate the beam transportation without looses and ~ 50% deceleration.

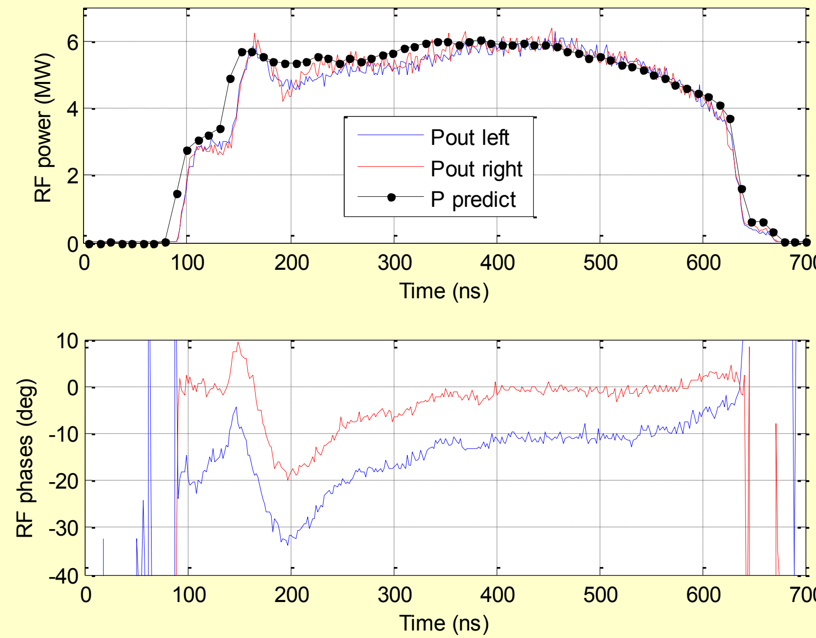
What matters is the output section !

I. Syratchev

Test Beam Line commissioning results

TBL installation in CTF3 and example of 12 GHz power production

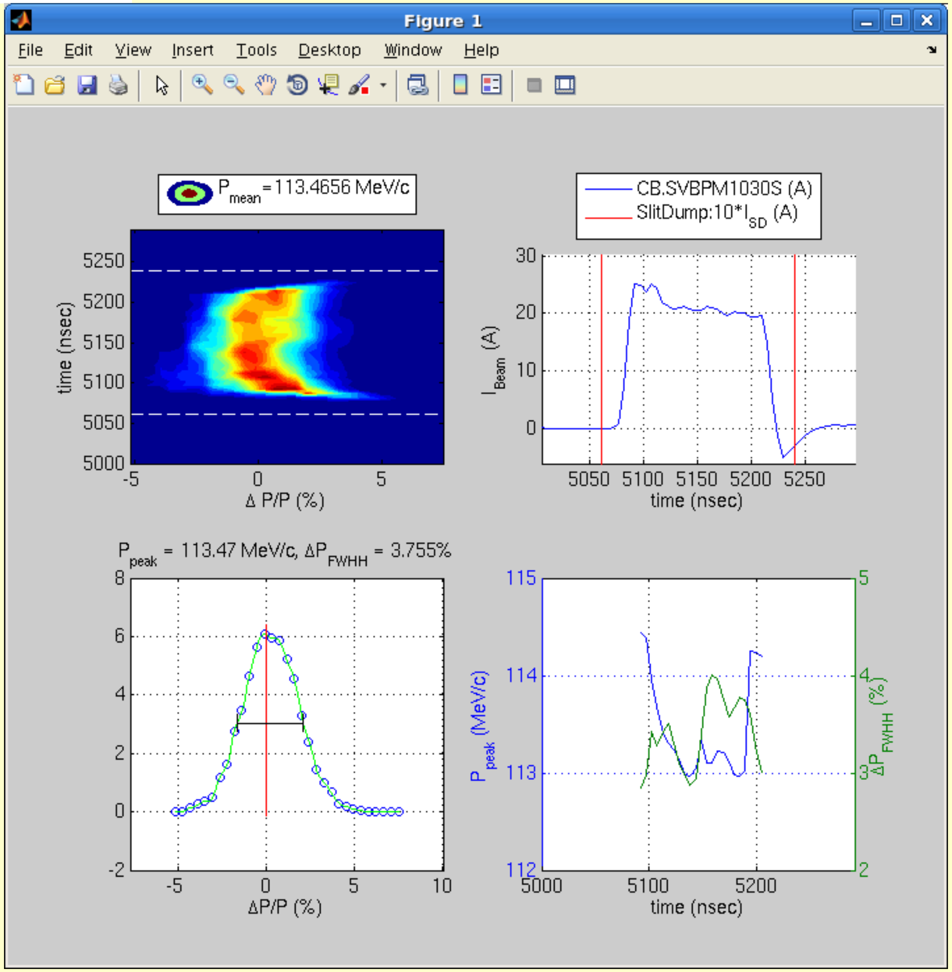


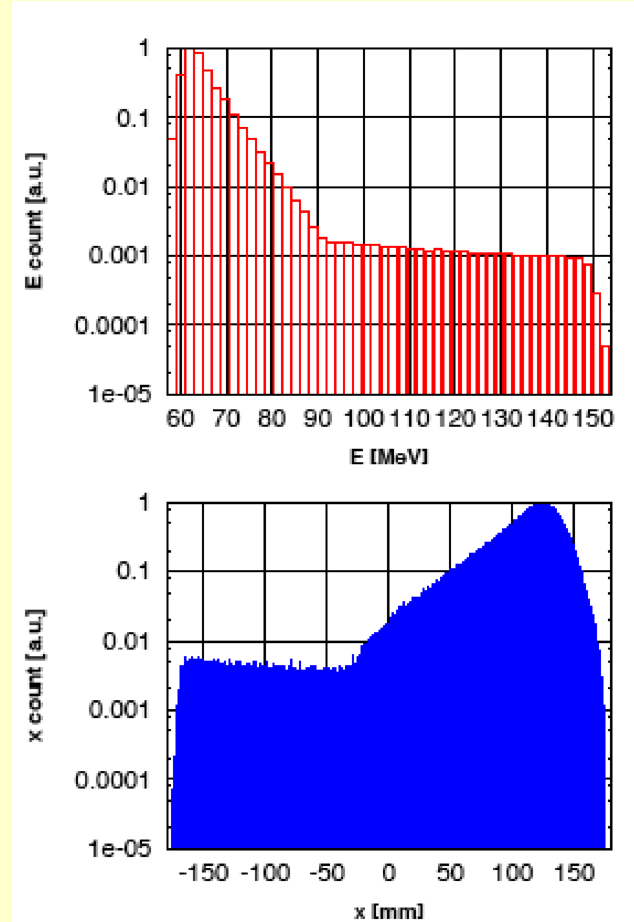


Successful commissioning of the TBL beam line, > 50 MW of 12 GHz power generated with a 17 A drive beam in agreement with theoretical predictions
Turned out to be a nice diagnostics to optimize the drive beam

Steffen Döbert, BE-RF

Energy and Energy spread

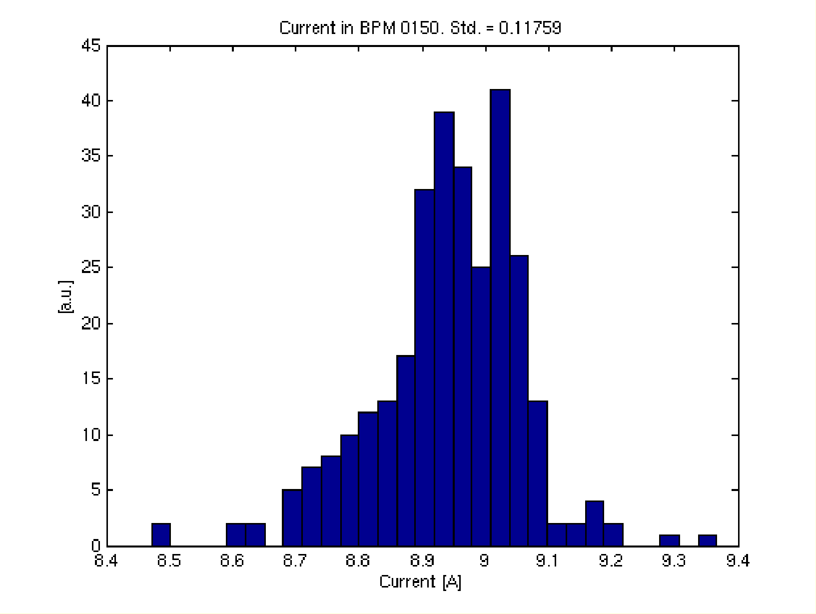


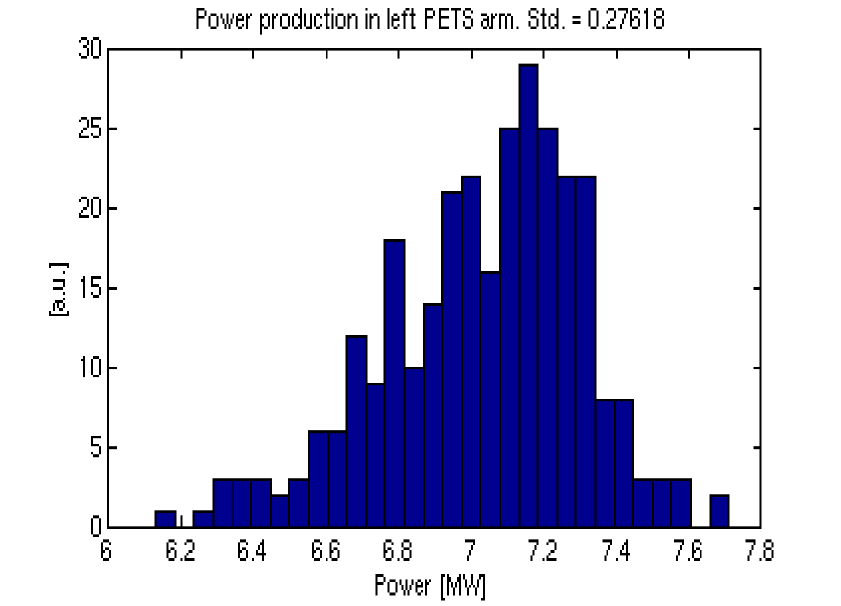


Simulation for 16 PETS

Time resolved energy spread with 50 MW in one PETS

PETS, power production stability

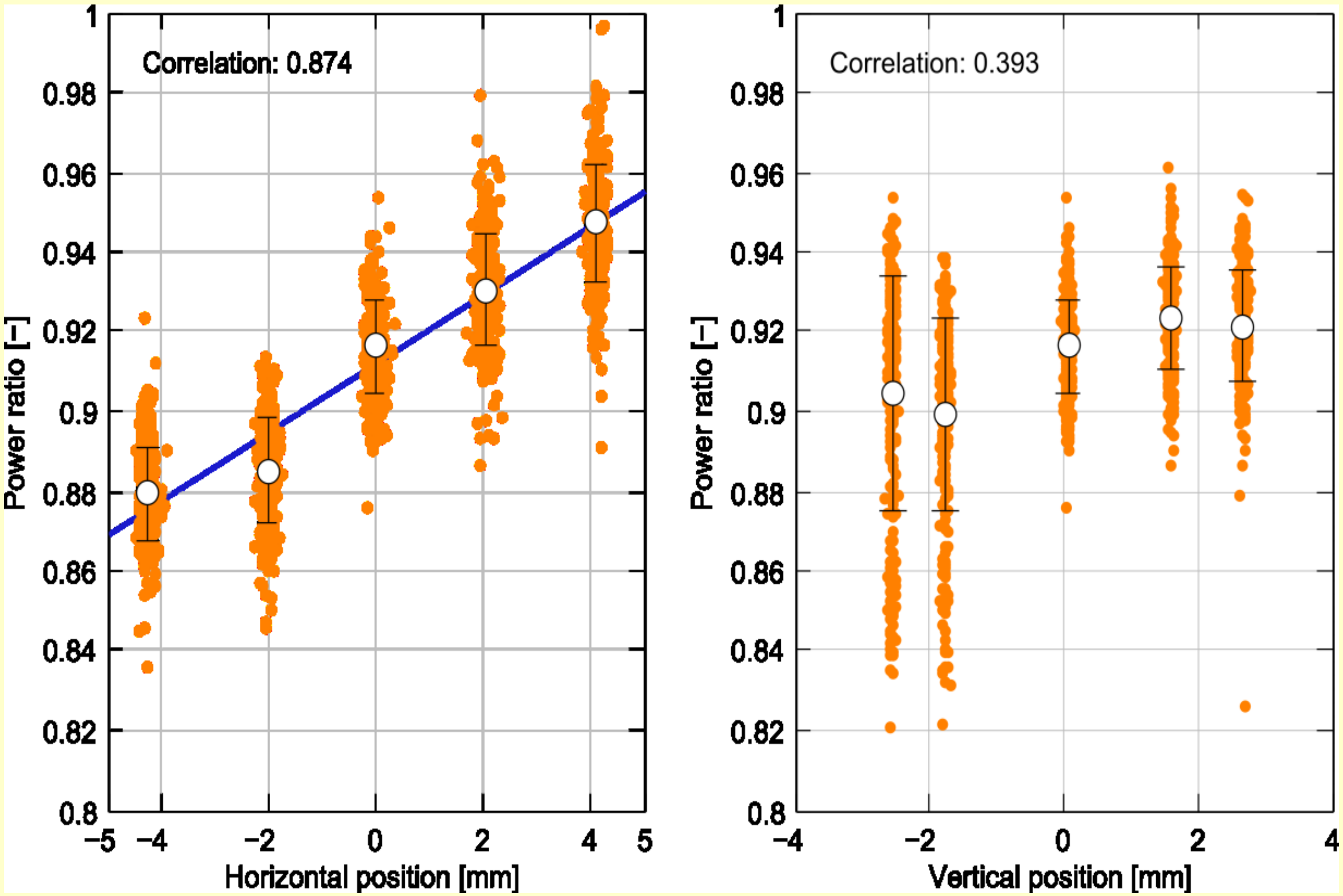




Current stability ~ 1.3%; P ~ I^2

Measured current stability in the CTF3 linac 9×10^{-4}

PETS, power production position correlation

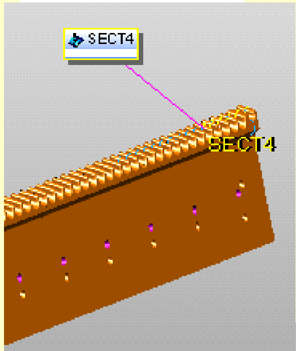


Correlation of beam position and output power

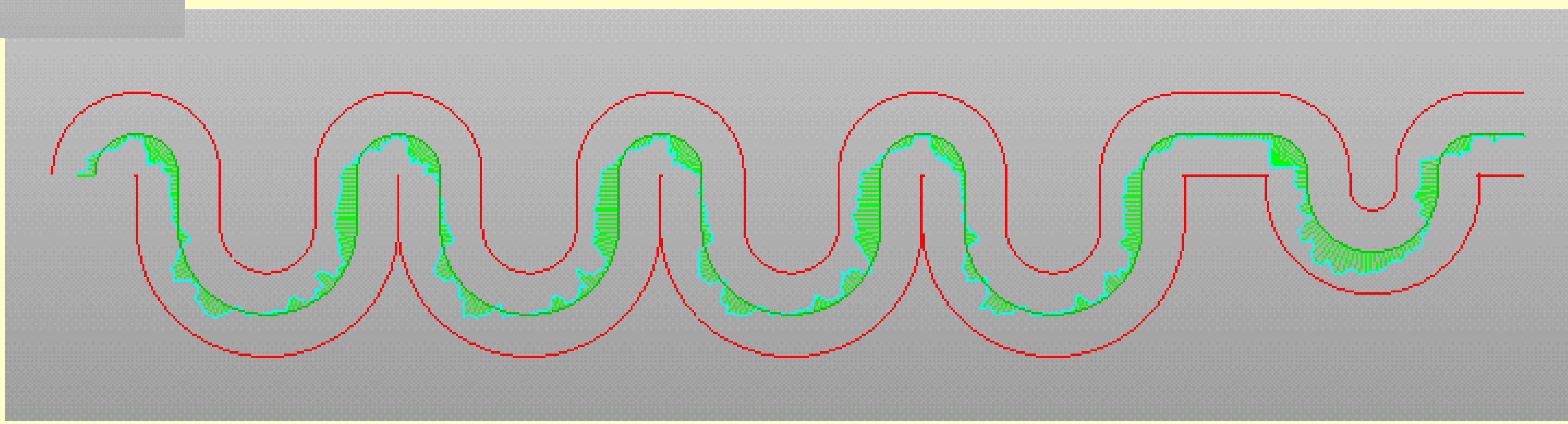
Status of series production

- In the process to produce next 8 tanks
  3 by CIEMAT, 5 by CERN
- Pacing item is the PETS itself
- At CERN we prepared for clean room assembly
- Aim to have 4 tanks installed in February,
  8 tanks in summer 2011, 12 in 2012
- Recently decided to order 4 more tanks now
- India and BINP both made PETS prototypes as well
  (option for second series)

Status of series production



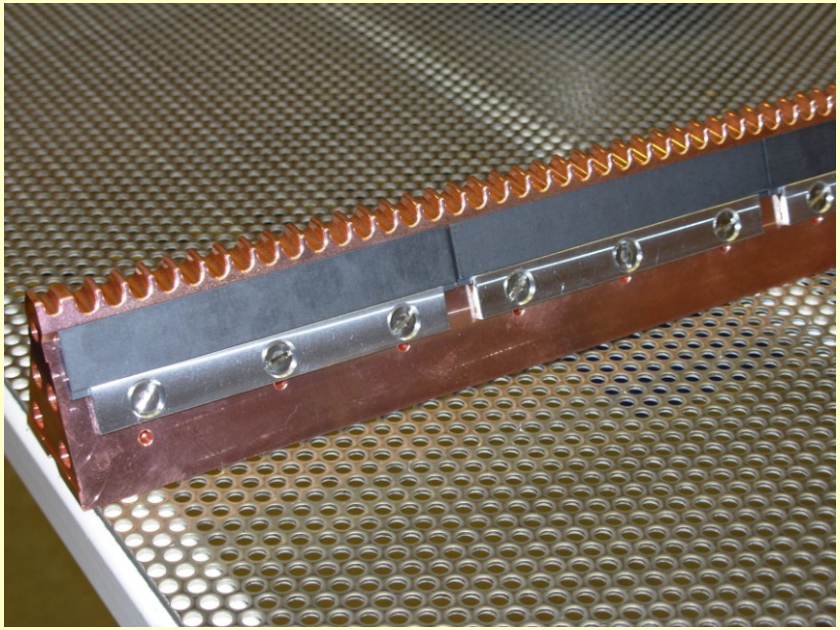
First conform PETS bar for series production,
We will have made 96 of this high precisions objects at the end of this year



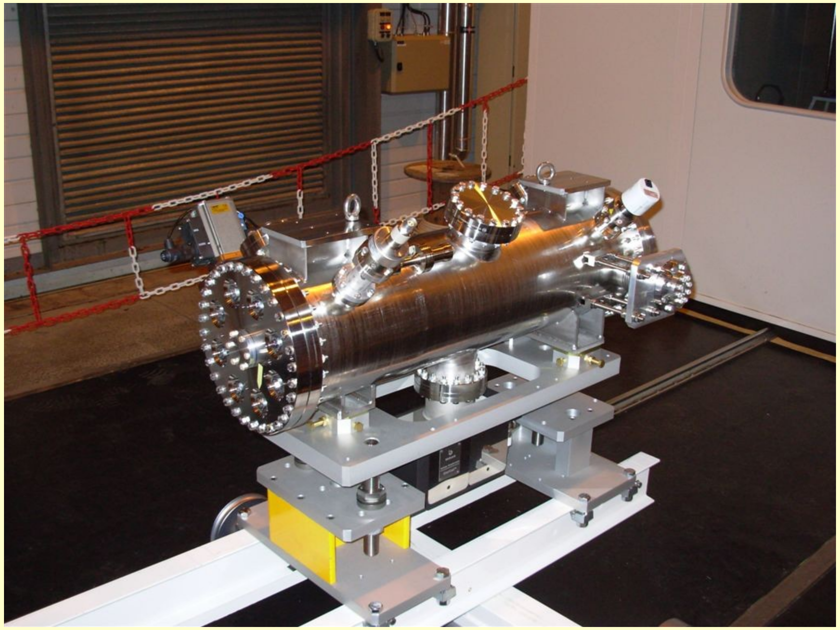
		Mesuré	Nominal	Iso	Tol -	Tol +	Ec.	Tendance	Hors tol.
✓	MAX	0.014	0.000		-0.020	0.020	0.014		
✓	MIN	-0.016	0.000		-0.020	0.020	-0.016		
✓	MoyS	-0.000					-0.000		
✓	MoyA	0.005					0.005		
✓	E.F.	0.029					0.029		

Status of series production

PETS bar with damping ceramic

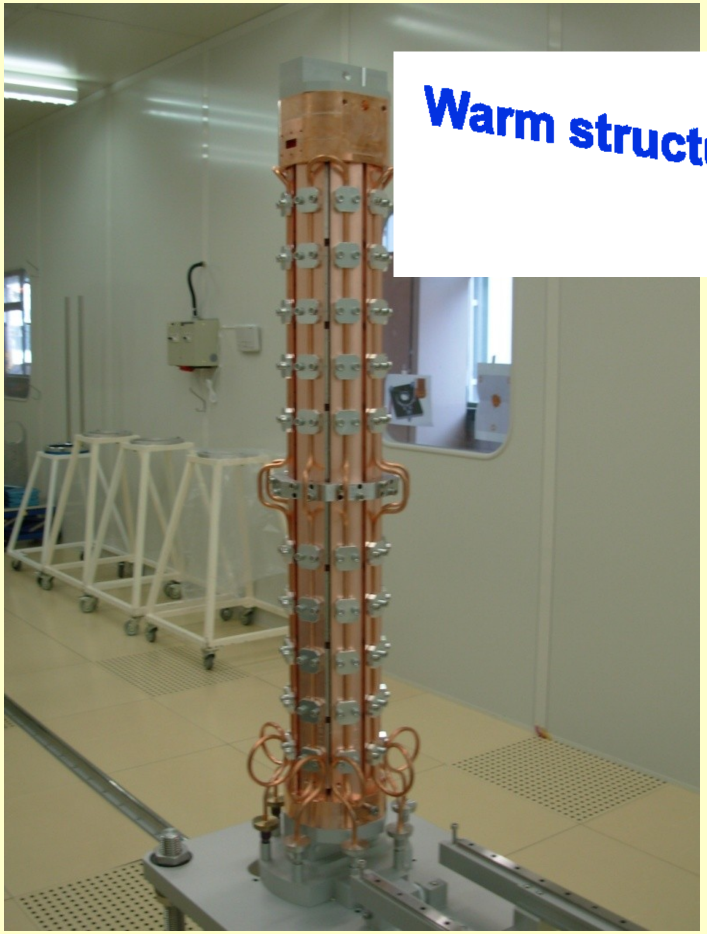


Finished tank out of the clean room



TBL decelerator production

Warm structures using cold technology



TBL PETS assembly in the SM18 clean room
(first out of 5 tanks)

Plans for completion and feasibility demonstration

- Demonstration with 8 in summer 2011,

  >30% deceleration
- TBL with 12 PETS in 2012
- Perform full experimental program afterwards
- Develop modified tanks optimized for structure

conditioning

Plans for TBL beyond 2012

- Upgrade TBL to a test facility relevant for CLIC TDR work
- 12 GHz power production for structure conditioning
- Working experience with a real decelerator
- Beam dynamics studies, pulse shaping, feedbacks, etc

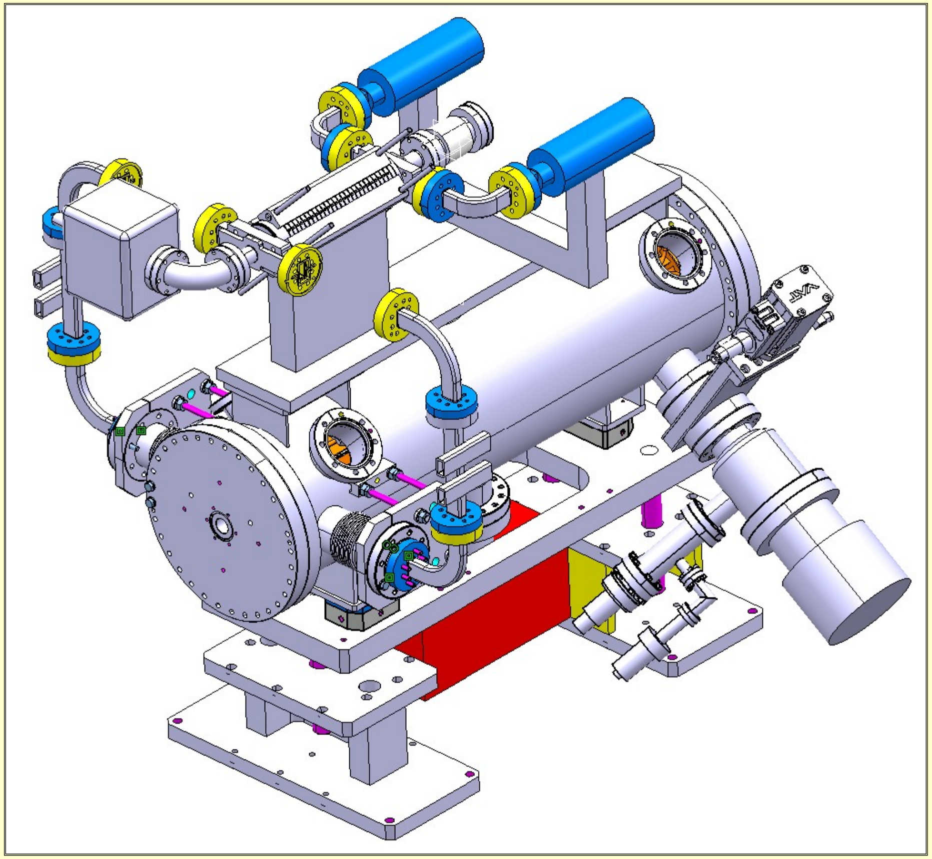
<u>CTF3 dilemma:</u>
Can produce high current > 14 A with 140 ns pulse length
Need > 20 A to power one structure with a TBL PETS

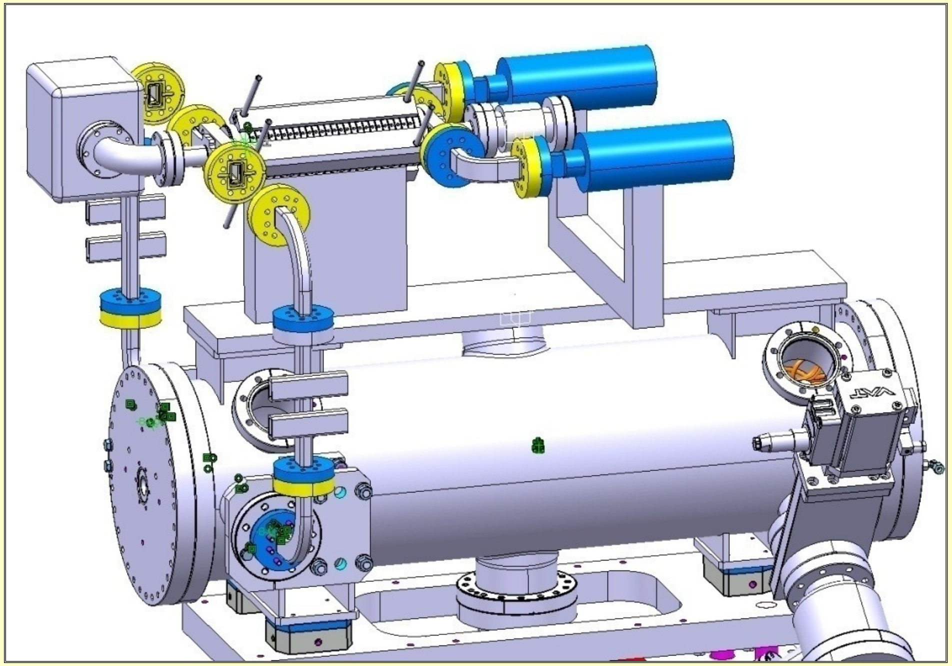
Or combination factor 4 only, < 14 A but 280 ns
Need to chain two TBL-PETS to power a structure

Many constraints due to building, space and radiation (rep. rate limit 10Hz ?)

Plans for TBL beyond 2012

How could it look like





Plans for TBL beyond 2012

What can be done with TBL+

- **Develop conditioning scenario for CLIC**

  conditioning with beam / use of ON/OFF mechanism of PETS

  precondition with klystron and then with beam

  conditioning of PETS

- **Test bed for PETS development, ON/OFF, new designs, etc**

- **Power production as a function of beam parameters**

  alignment, stability, pulse shape, phase stability, beam loses, failure modes

- **Continue decelerator beam dynamics studies**

Conclusion

- TBL commissioning ongoing, feasibility demonstration can be started in 2011 with 8 PETS and finished with 12-16 in 2012
- TBL+ upgrade useful as a facility dedicated to conditioning experiments, essential for CLIC TDR phase Plan to create a limited number (4 ?) of testing slots
- Working horse conditioning facility based on klystrons is needed in addition to support the structure development

TBL vs CLIC

Parameter	Symbol	TBL	CLIC
Number of PETS [-]	N_{PETS}	16	1492
Length of PETS [m]	L_{PETS}	0.80	0.21
Initial average current [A]	I_0	28	101
Power per PETS [MW]	P	$\sim$138	135
Initial energy [MeV]	E_0	150	2400
Mean energy extracted [%]	η_{extr}	$\sim$54	84
PETS sync. freq. [GHz]	f_{rf}	12	12
Number of FODO cells [-]	N_{FODO}	8	524
Length of FODO cells [m]	L_{FODO}	2.82	2.01
Pulse length [ns]	t_{pulse}	140	240
Transient length [ns]	t_{fill}	3	1
Bunch rms length [mm]	σ_{z}	1.0	1.0
Init. norm. emittance [μm]	$\epsilon_{\mathrm{N\,x,y}}$	150	150
Beam pipe radius [mm]	a_0	11.5	11.5

PETS are designed to produce nominal CLIC power of 135 MW for nominal 28 A CTF3 current

Plans for TBL beyond 2012

TBL versus klystrons, additional value of TBL

	Klystron	Klystron	TBL+	TBL+
Rep rate (Hz)	50	100	10	5
slots	2	2	1	1
Number of units	2	2	16	8
hours/day	24	24	24	12
days/year	300	300	300	180
Rf-pulses/year	5E+09	1E+10	4E+09	3E+08

TBL: Test of PETS and structure possible
Closer to CLIC situation
Less flexible for frequent changes in the set up

28 A needed for 135 MW/PETS
20 A for 70 MW/PETS
15 A for 70 MW/ for two PETS

PETS, power production

- 50 MW produced in agreement with theoretical prediction
- nice diagnostics to optimize the drive beam