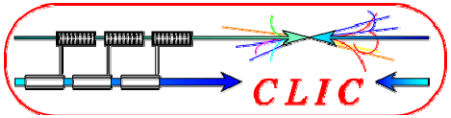
Piotr Krzysztof Skowroński

Status and plans for CTF3

What is needed for the operation, the resources, infrastructure issues and plans for 2009 and beyond.
Impact of short shutdown in 2010

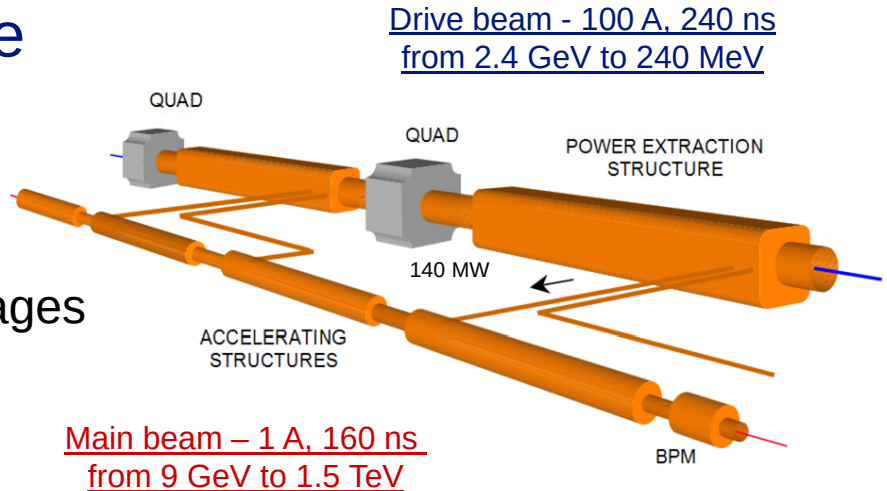
The Accelerator Technical, Operation & Performance Days
6 March 2009



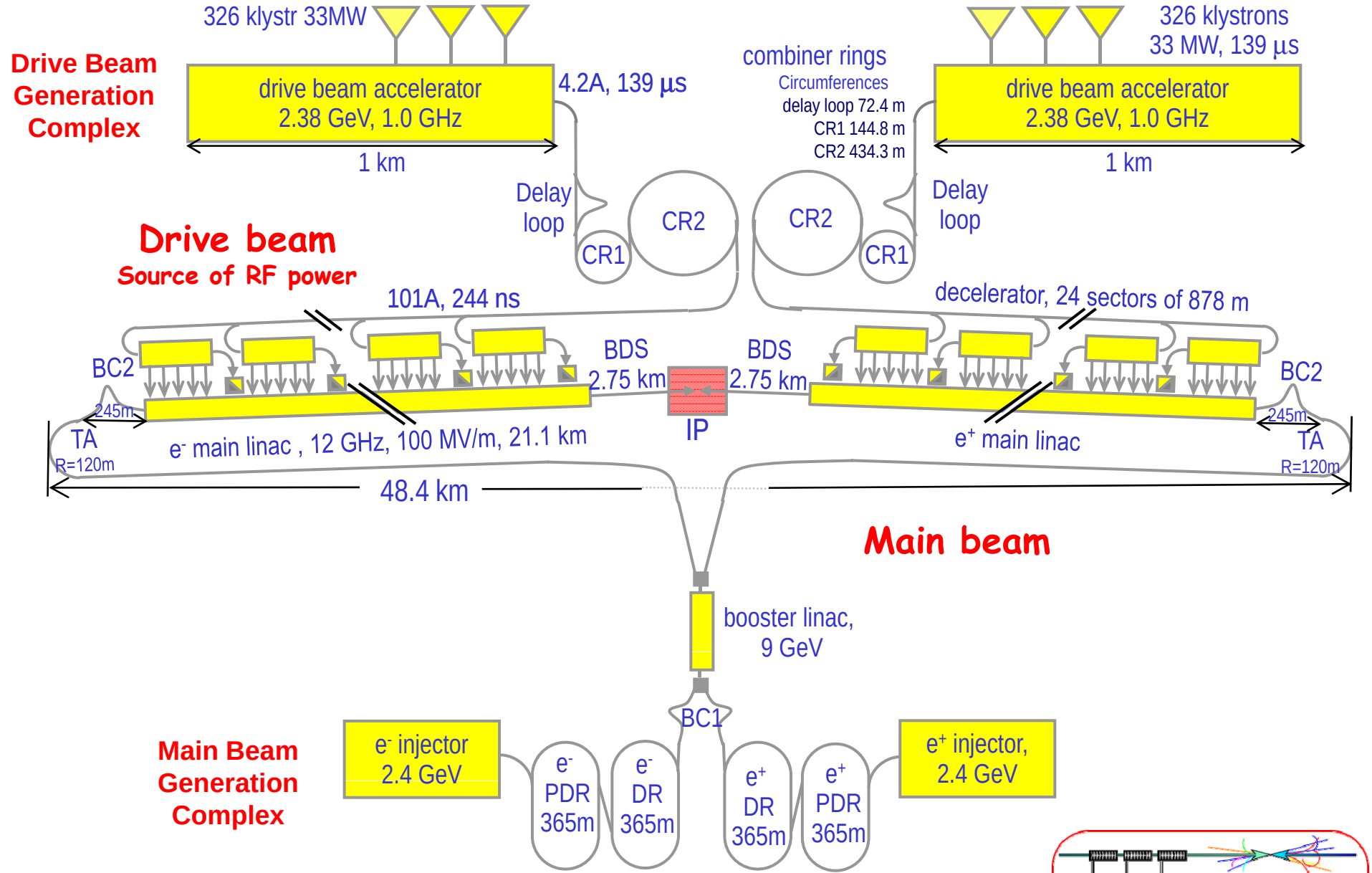
The CLIC way to a multi TeV collider

Basic features

- High acceleration gradient (100 MV/m)
  - ✓"Compact" collider - overall length @ **3 TeV** < **50 km**
  - ✓**Normal conducting** accelerating structures
  - ✓High acceleration frequency (**12 GHz**)
- Two-Beam Acceleration Scheme
  - ✓Cost effective, reliable, efficient
  - ✓Simple tunnel, no active elements
  - ✓Modular, easy energy upgrade in stages

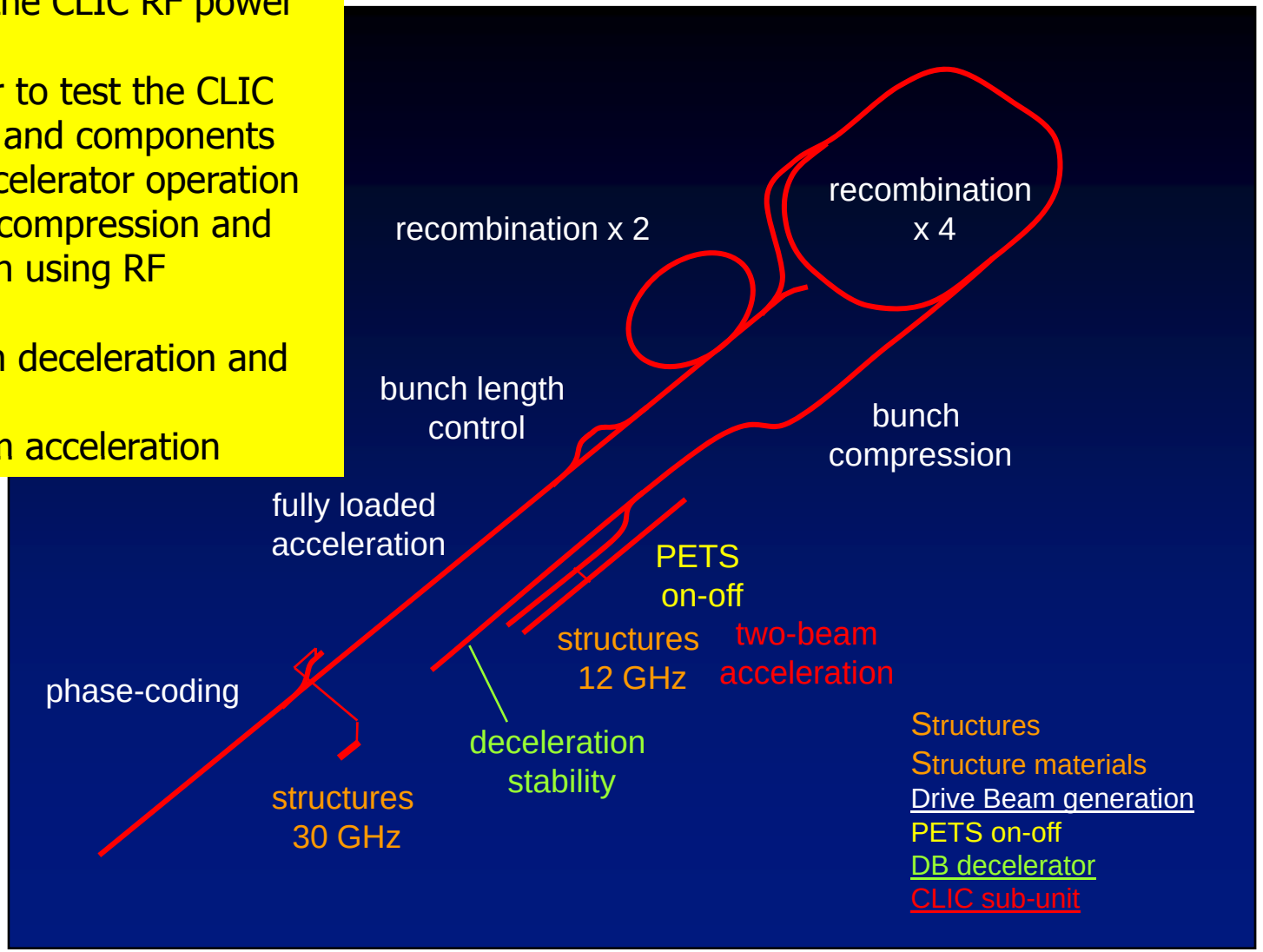


CLIC Layout 3 TeV



CTF3: CLIC R&D Issues – WHERE?

Small scale version of the CLIC RF power source
✓Provide the RF power to test the CLIC accelerating structures and components
✓Full beam-loading accelerator operation
✓Electron beam pulse compression and frequency multiplication using RF deflectors
✓Safe and stable beam deceleration and power extraction
✓High power two beam acceleration

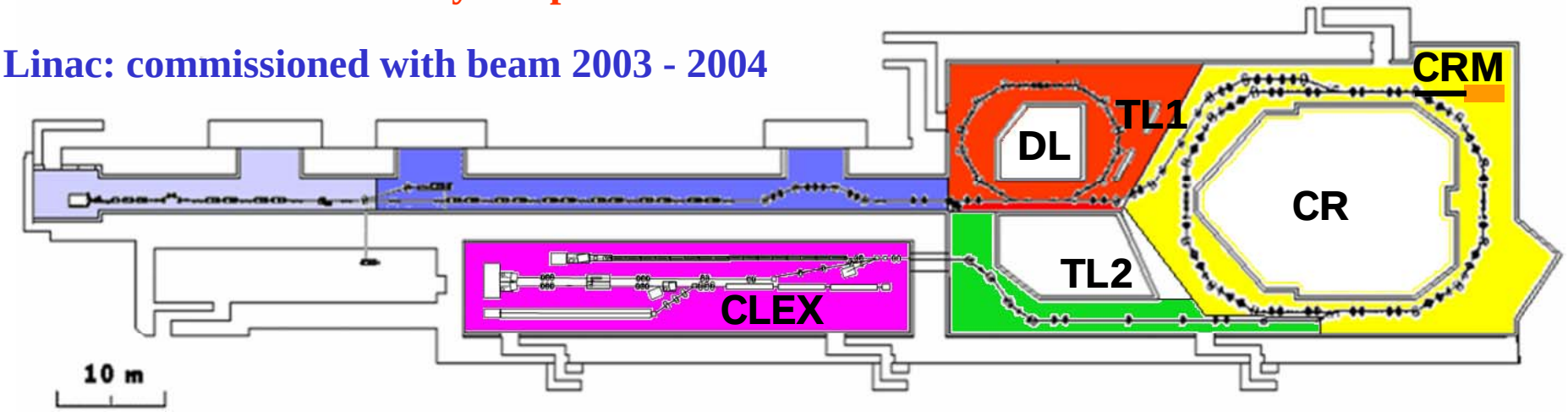


CLIC Test Facility 3

TL1 & CRM commissioned fall 2006

Delay Loop: commissioned with beam 2005-2006

Linac: commissioned with beam 2003 - 2004



TL2 and TBTS commissioning started August 2008

CR commissioning since 2007

Operations & Performance

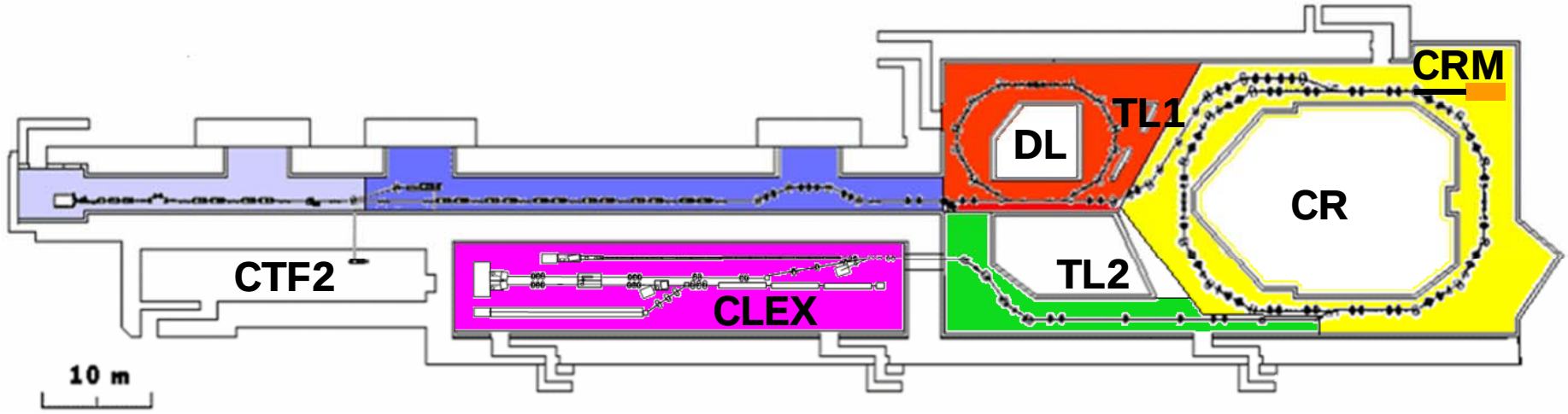
CTF3 is special since it is an ACCELERATOR test facility

Only part of the operations is routine,
most of the time we are in „Machine Developement”

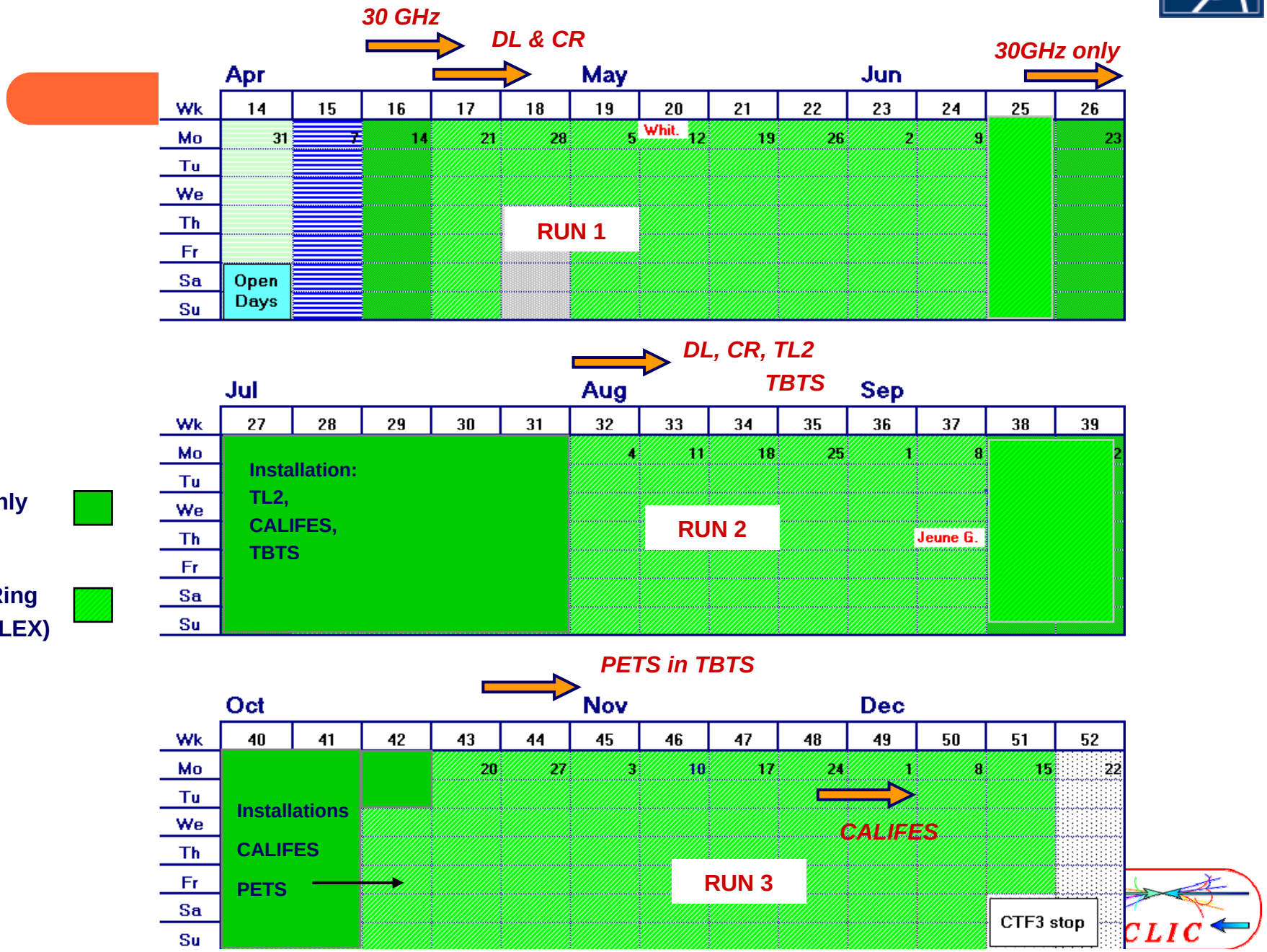
Performance is measured in terms of
the achieved experimental results

Operations

- The machine is operated in two modes
  - PETS beam for 30GHz structures tests
    - From Friday to Monday morning
    - Setup is done by CTF3 team
    - Night and weekend supervision from CCC by PS operators
  - Commissioning beam
    - From Monday to Thursday
    - Two overlapping shifts (voluntary)
      - From 8AM to 2PM
      - From 2PM to 8PM
      - It increases productivity since everyday machine startup takes up to 3 hours to reach previous evening status



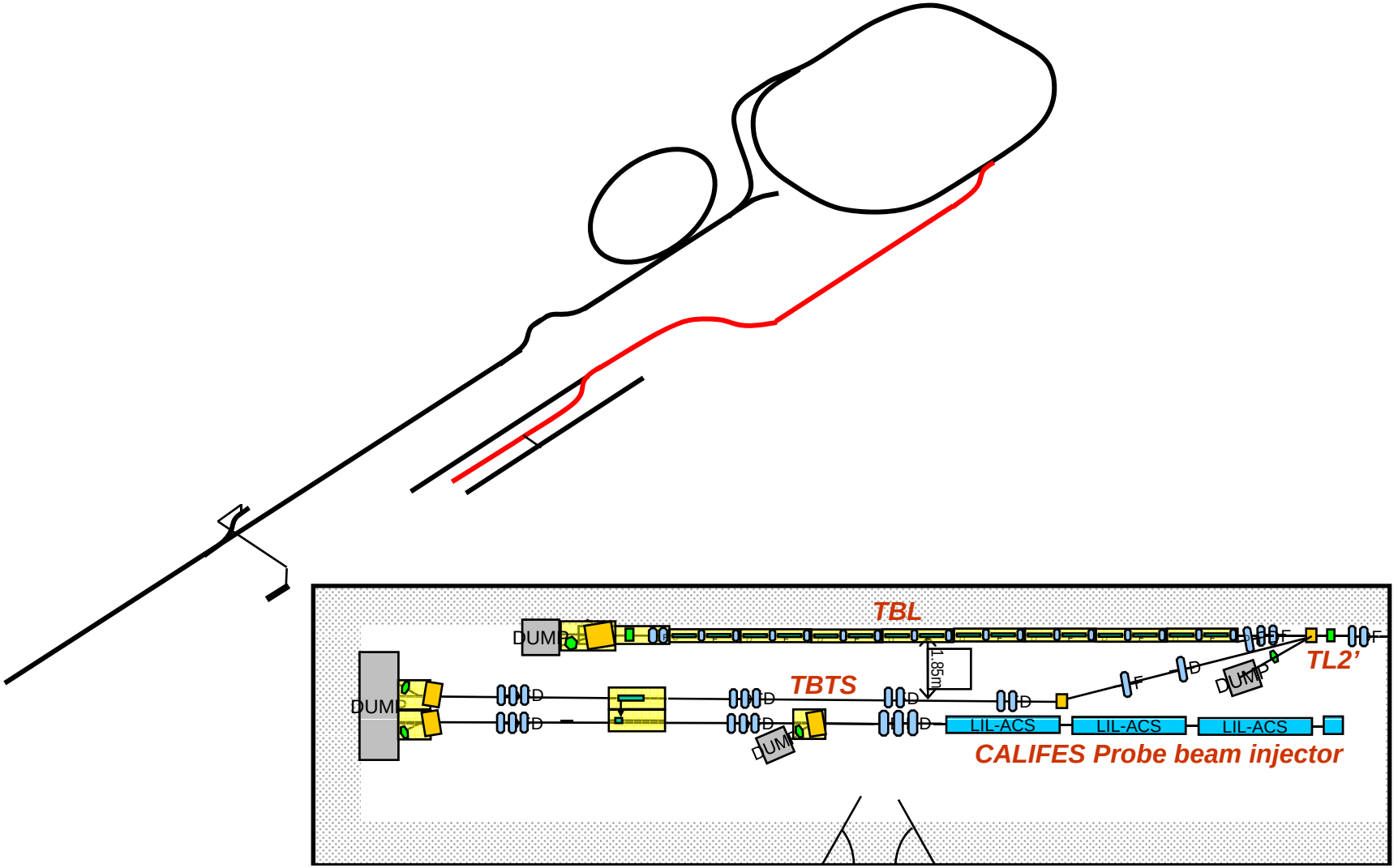
2008 Schedule



2008 program

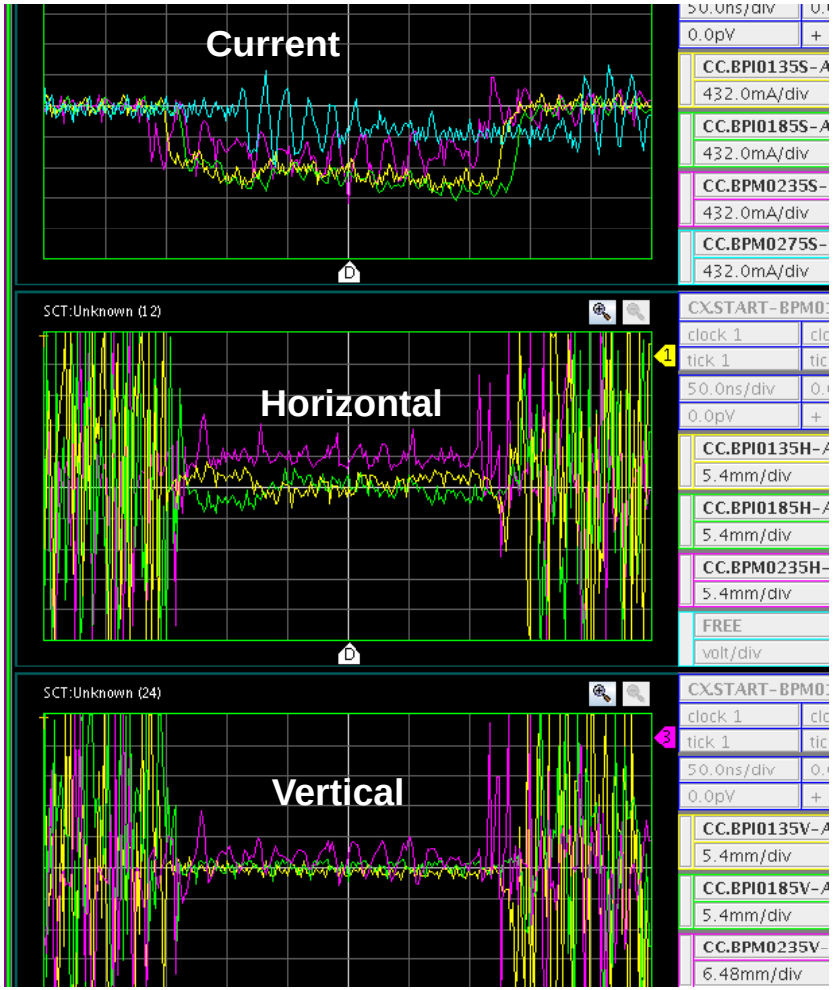
- Run 1
  - Very difficult run
  - Problems with the gun stability (eventually fixed in August)
  - Issues with vacuum, timing, frequent klystron trips, water temperature stability, overloaded DSCs
  - Consolidated beam diagnostic in Linac
- Shut-down for installations of TL2 and in CLEX
- Run 2&3
  - Improved running conditions
  - Short shutdown between runs 2&3 for installations of PETS and CALIFES
  - RF deflectors installed (Sept 26)
  - Satisfactory running conditions achieved only in autumn
  - Completion of CR commissioning
  - TL2 and CLEX lines commissioning started
  - RF Power Extraction experiments started

TL2 and TBTS Commissioning



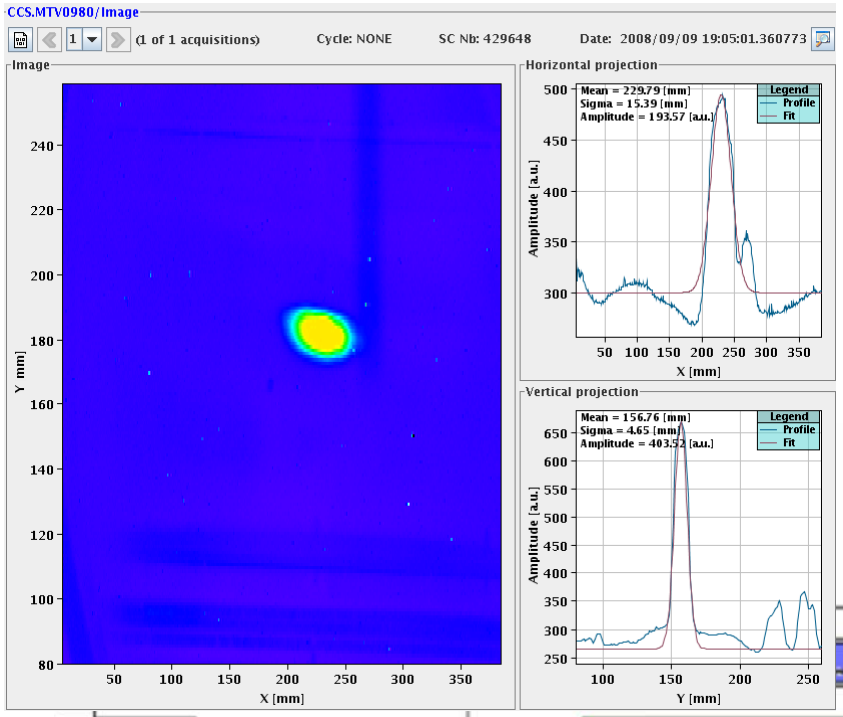
TL2 and TBTS Commissioning

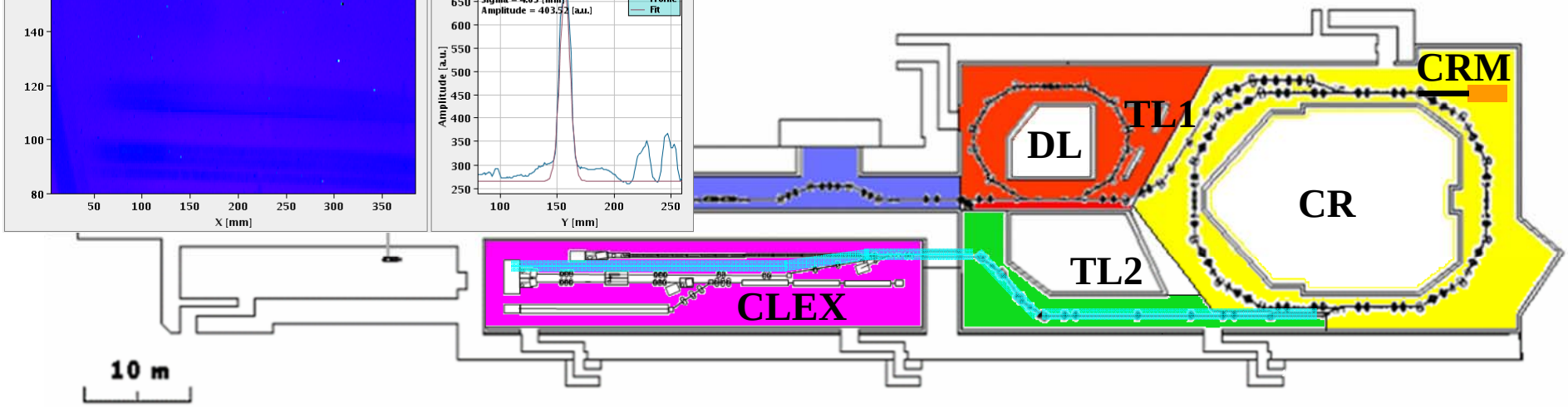
- Strip-line kicker works well
- BPMs based on the new electronics developed by our colllaborator LAPP (Annecy) in principle work, but
  - 30ns time jitter
  - Big problems with OASIS viewer
    - The traces are digitized in-situ and analog signals are not available so we are forced to use this application to get them
  - Swapped vertical with horizontal for one type of pickups, OK for the other
  - Front-end task often crashing
  - Constant improvement in making them stably operational
- No MTV suitable for quad scans
- The beam setup was very, very, very difficult



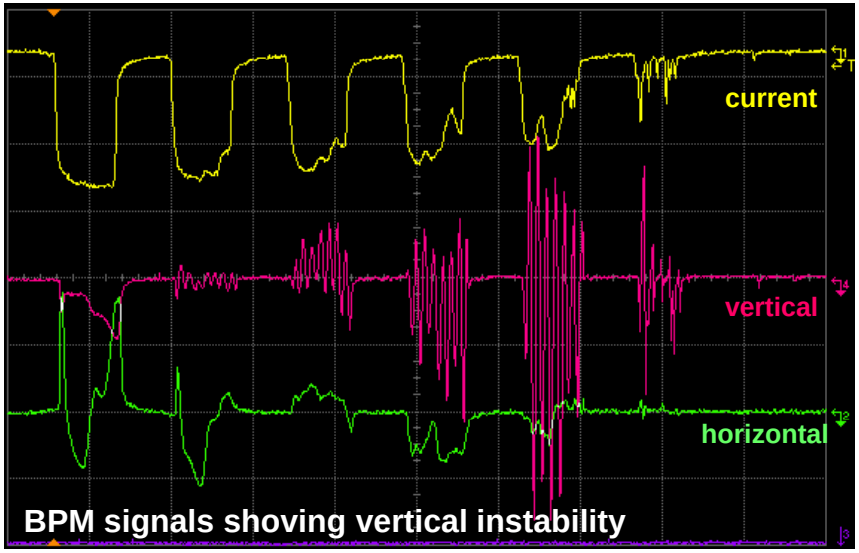
TL2 and TBTS Commissioning

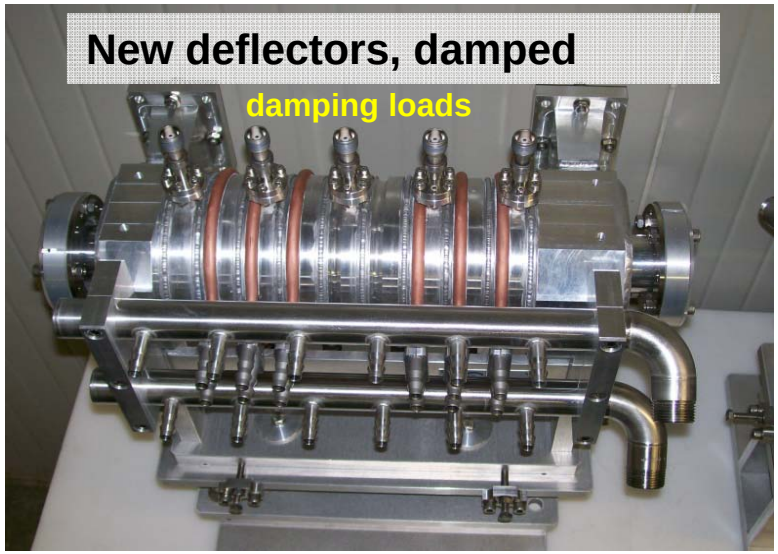
- Despite the problems we have managed to transport the beam till the end of Two Beam Test Stand
  - However, with 20% current loss
  - We had some problem with the optics, which was not diagnosed yet





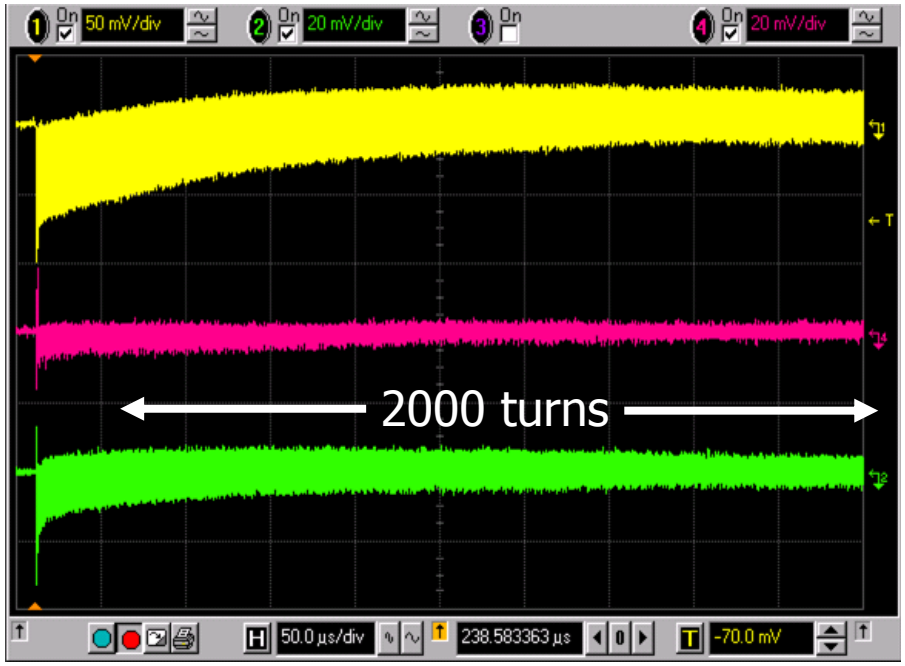
New deflectors in Combiner Ring
The Instability Gone

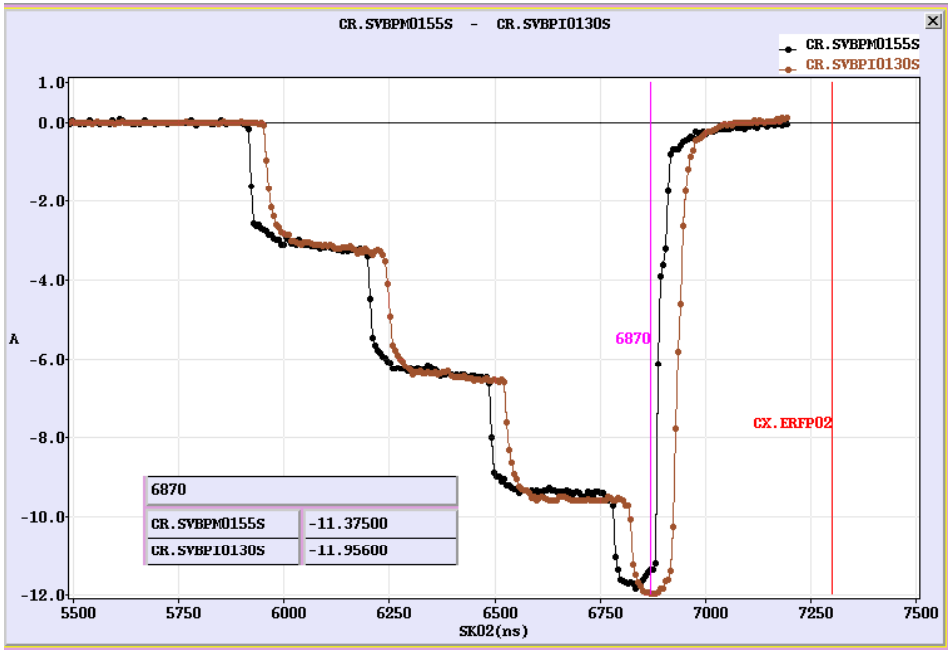




New deflectors in Combiner Ring
The Instability Gone

- Stable beam circulating for miliseconds
- Recombination factor 4
- Since then all the measurements were much easier to do and much more precise

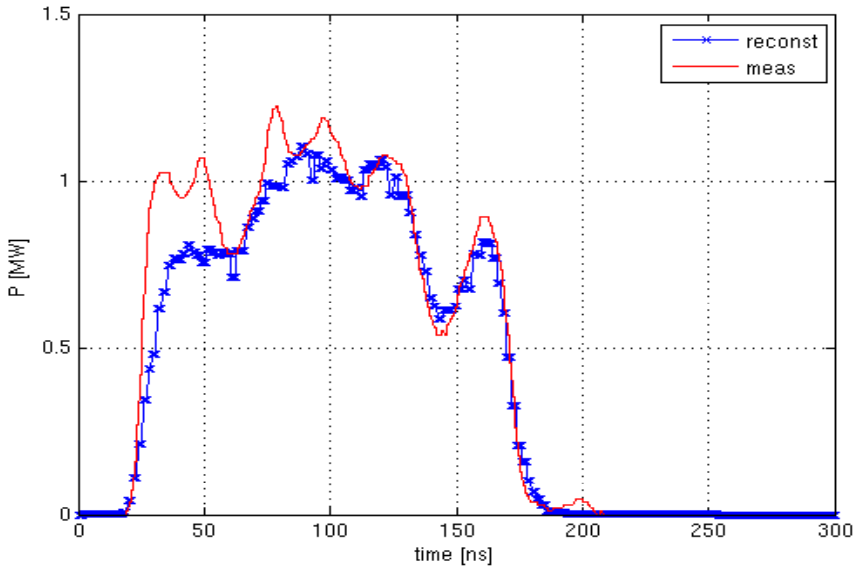




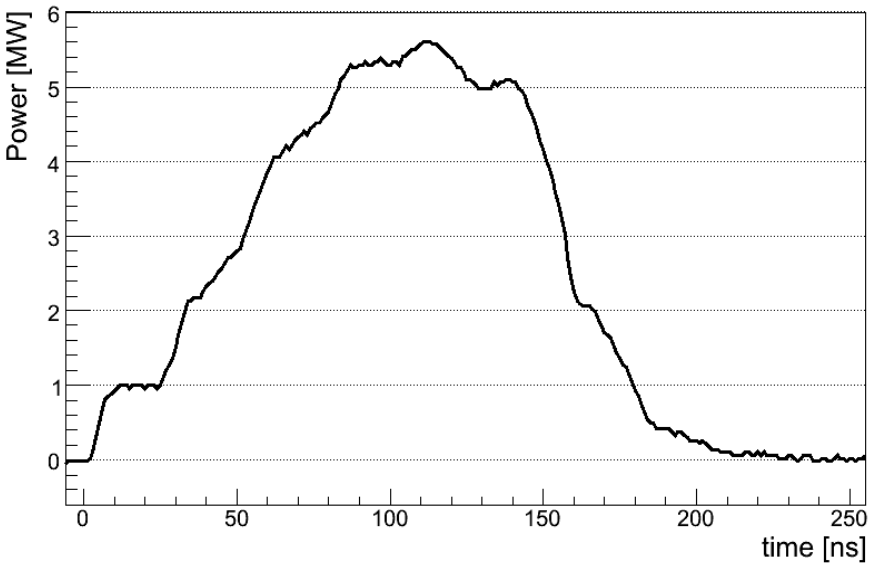
RF power from PETS in TBTS

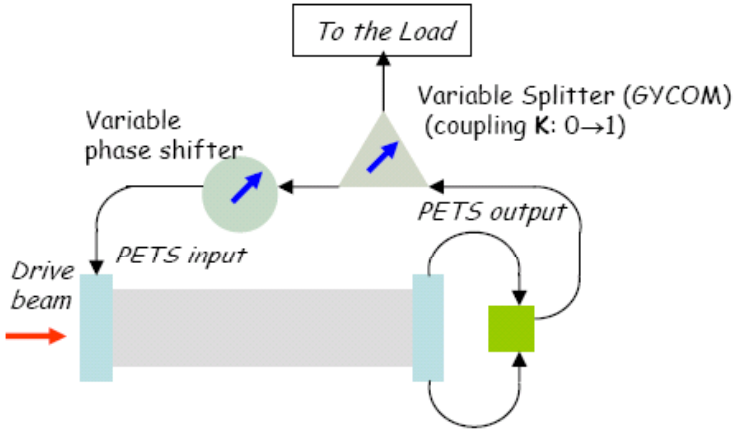
Power produced by PETS (I_{beam}=2A)

without



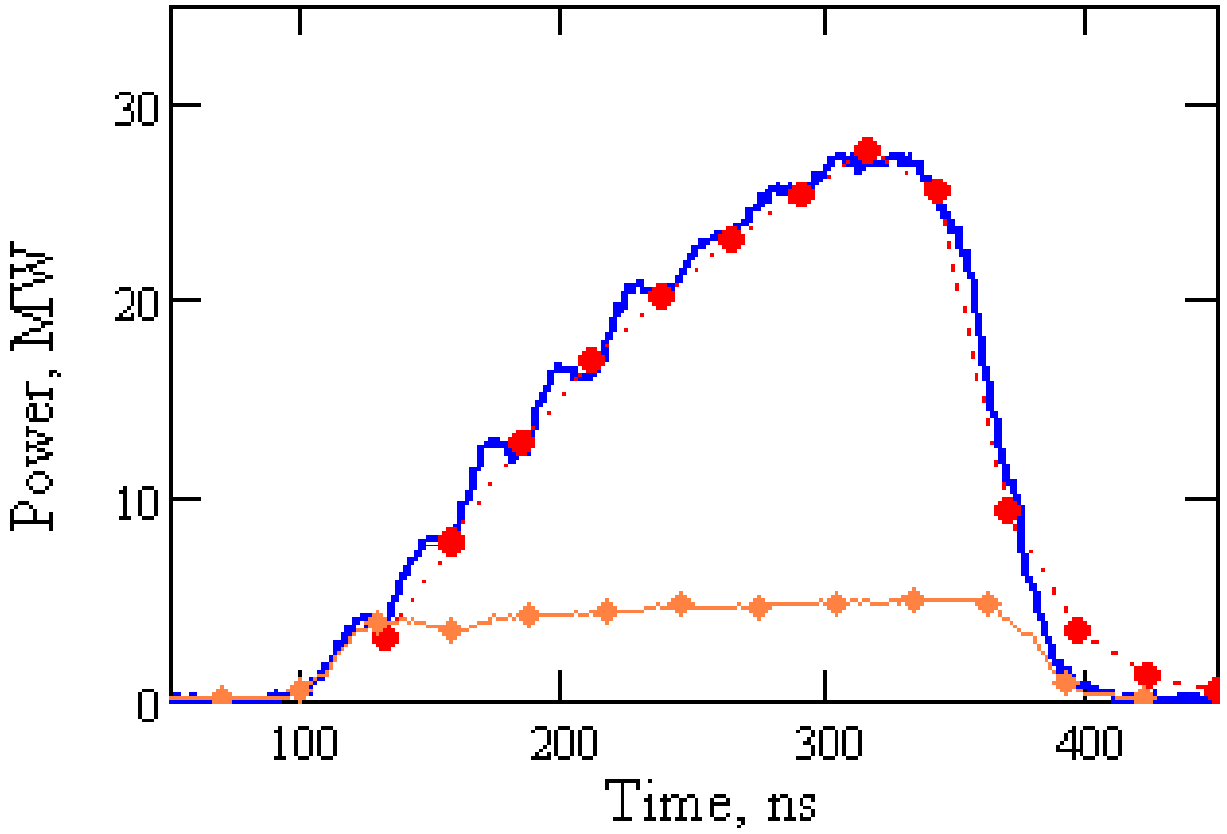
and with recirculation



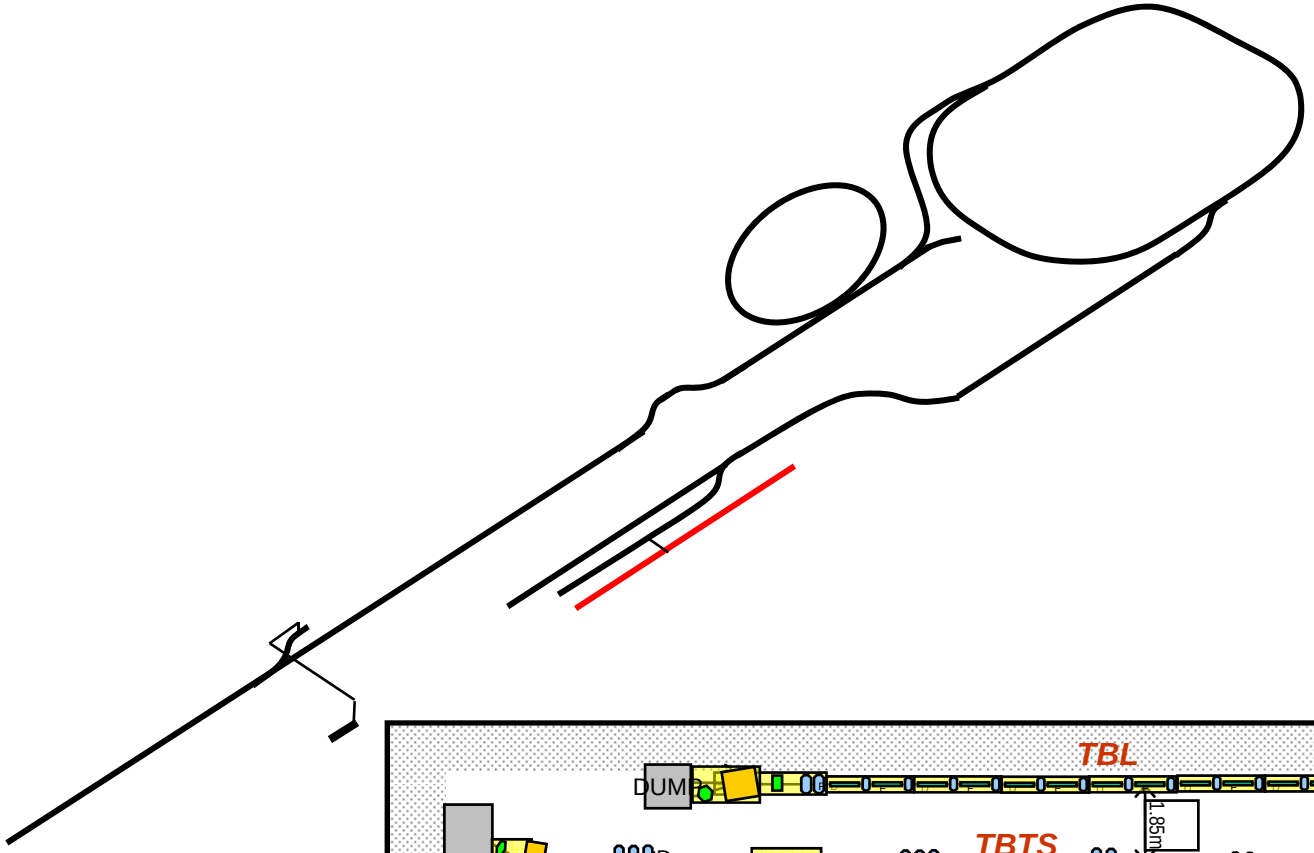


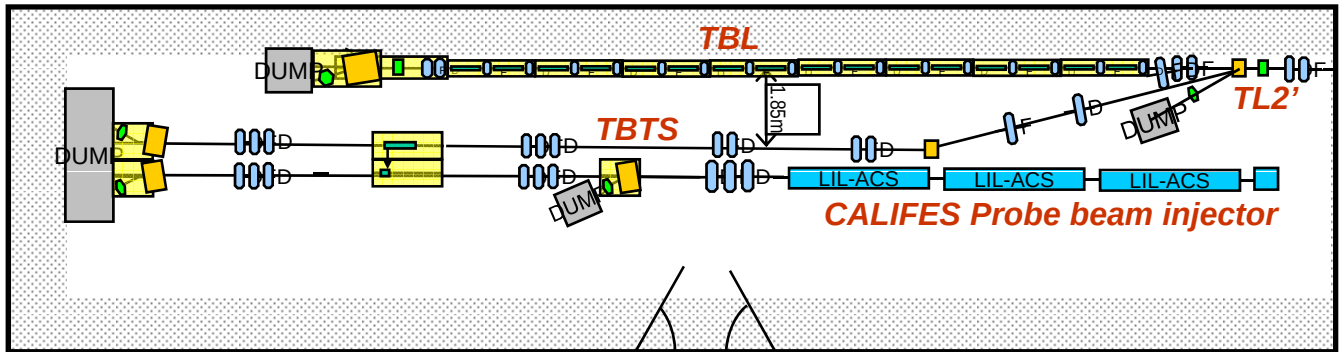
Recombined beam to PETS

- 6A through PETS
- Almost 30MW obtained



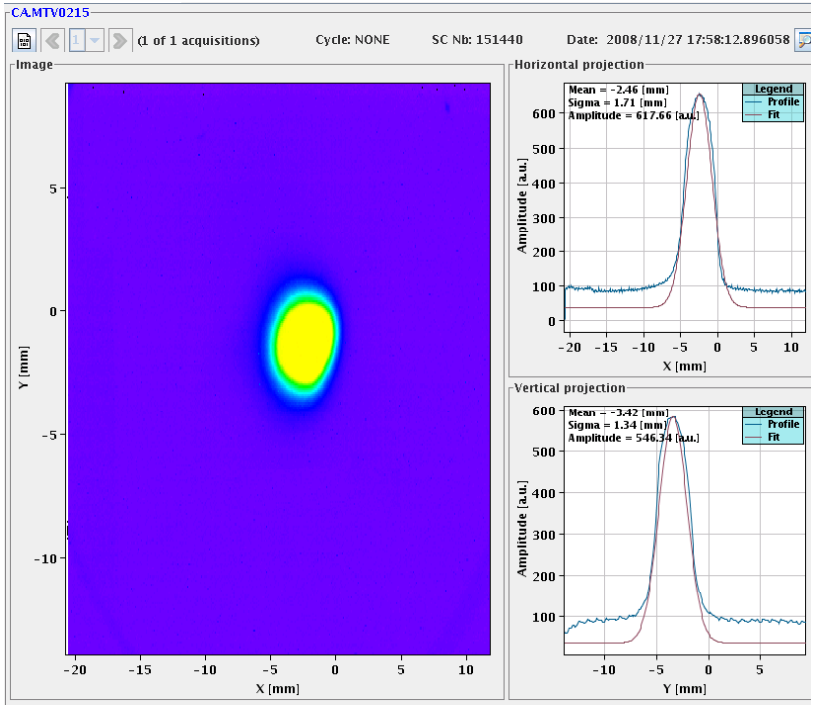
CALIFES Commissioning





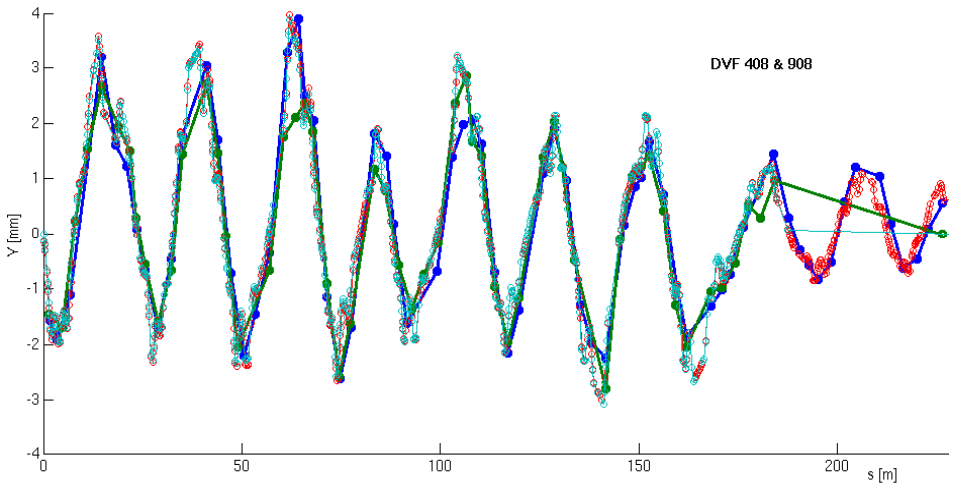
CALIFES Commissioning

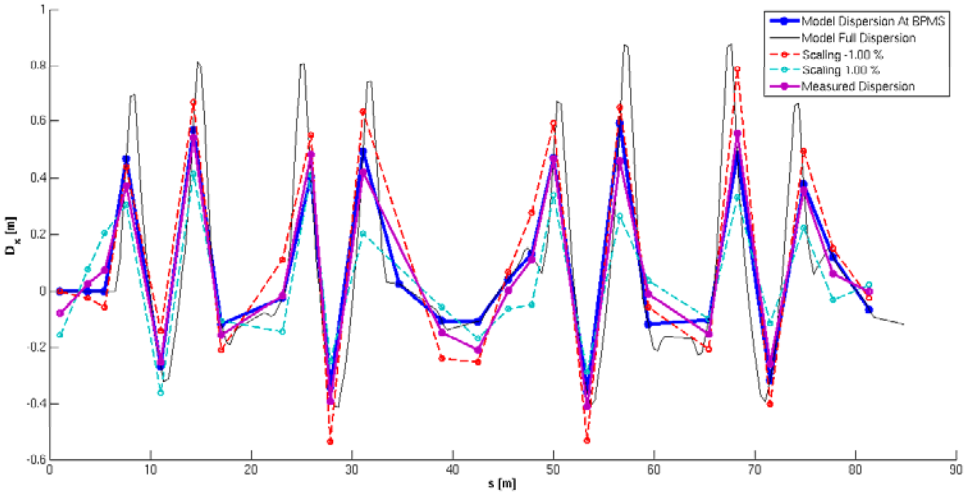
- Started on Dec 1
  - Earlier the laser was used by PHIN
- The beam with laser pulse train of 100 ns length (150 bunches)
  - 100% transmission thru the 1st cavity
  - Problems with RF phase adjustment
- Finished on Dec 11
  - Laser broken
    - Device sent to manufacturer for reparation, came back previous month
- Ready to restart commissioning next week



Optics Errors

- We have discovered several optics errors
  - e.g. swapped cables, wrong calibration factors in the model
- At the end of last run we have obtained quite good agreement between the model and measurements
  - Precise measurements finally possible thanks to achieved beam stability
  - Large improvement for Combiner Ring
  - Still several issues need to be clarified





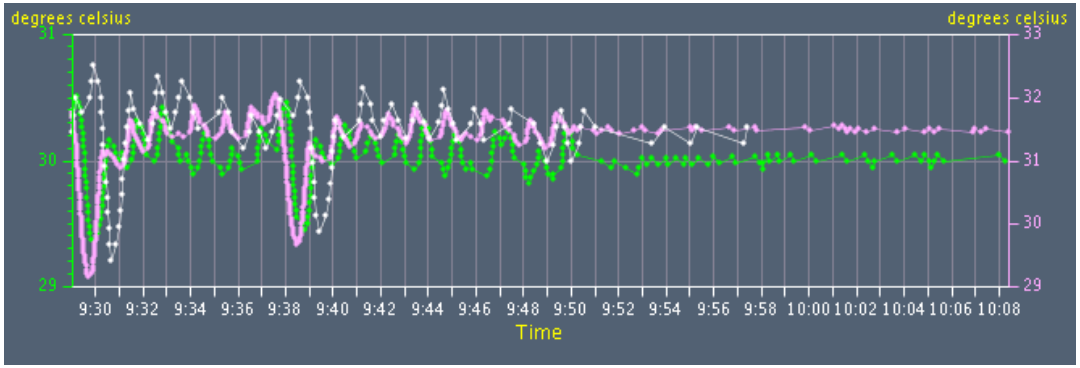
Technical & Infrastructure Issues

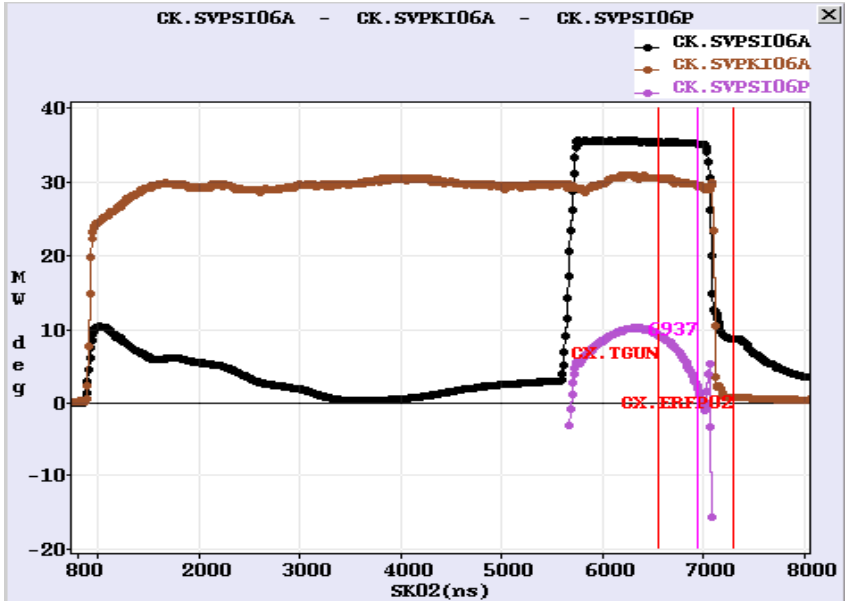
Controls Issues

- Many front-ends are at the limit of their capability (mainly memory)
  - This severely affects the operation
  - According to CO there is no upgrade from RIO2 to RIO3 CPUs possible at the moment (HW not available). CO plans to distribute some tasks from these front-ends to other ones as a temporary solution
- We had many problems with the OASIS viewer
  - Impossible to connect signals
  - Wrong signals got connected
  - Connection read-only
  - Signals automatically disconnected...)
  - This has been improved significantly over the run
- There are timing problems due to badly functioning TG8 cards
  - This lead to trips of the klystrons
  - Upgrade of the system to new timing cards foreseen
- The JAVA console manager has improved significantly
- We had many problems with the control of a new BPM system
  - This is under the responsibility of a CTF3 collaborator from LAPP Annecy

Cooling Water

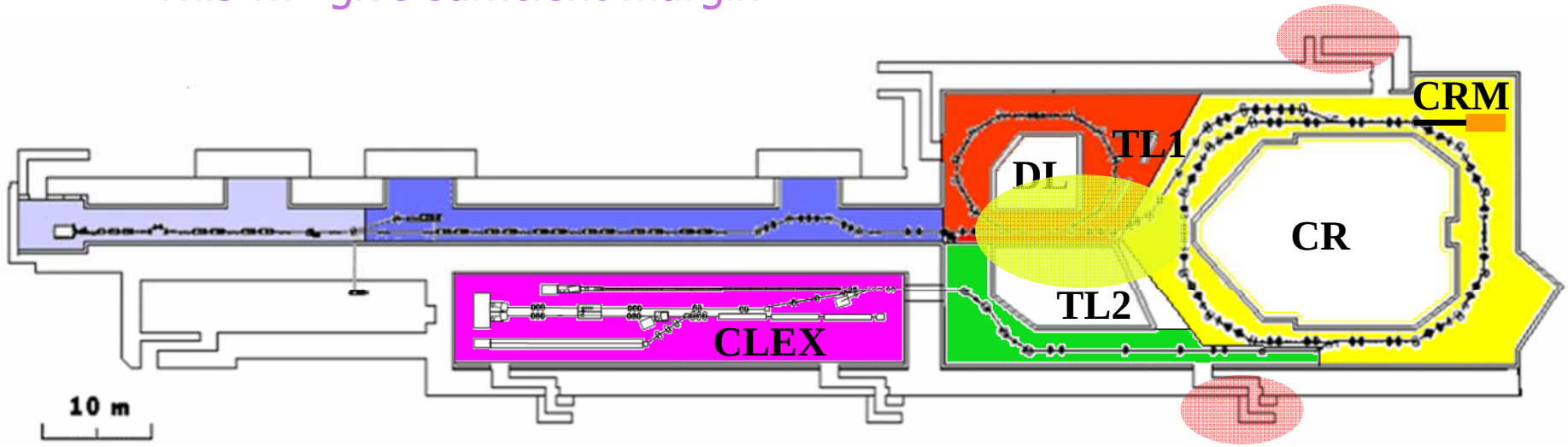
- New pump was installed in 2008 in order to cover the demand of the new CLEX devices
- Water temperature stability was an issue for 2 weeks in May
  - RF compression cavities are very sensitive to cooling water temperature
  - The fine adjustment is done be a heater that is too powerfull
    - It was operating at its minimum range what lead to the instability in the feed-back loop
    - Set point was adjusted lower what fixed the issue





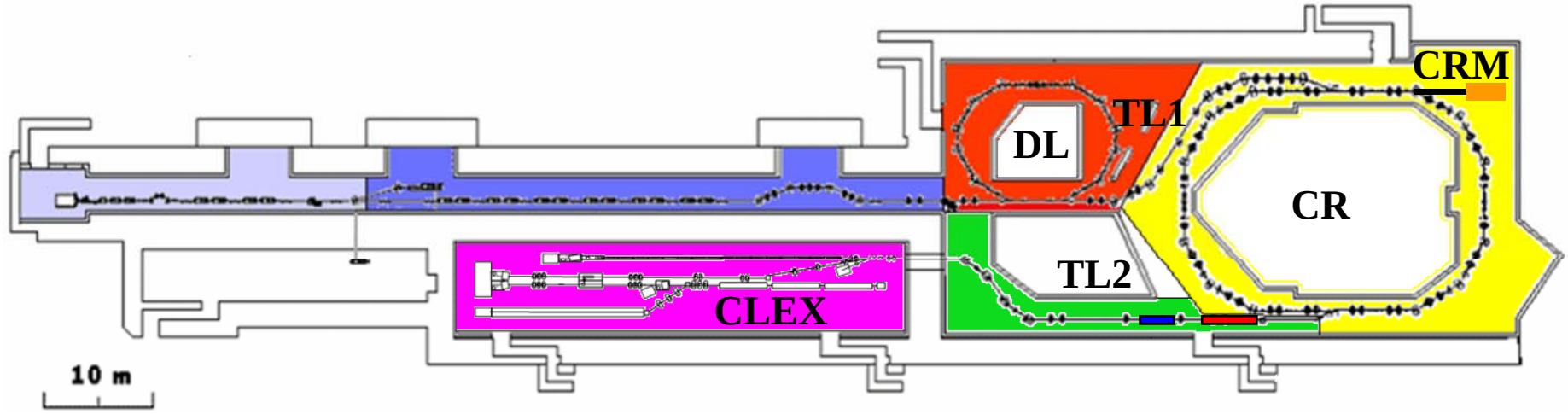
Radiation

- The biggest infrastructure issue represents not sufficiently thick floor at the end of the klystron gallery
  - It prevents us from running at higher then 1Hz rep. rate
    - All the other hardware is capable to run at 10Hz
    - The high rep rate is strongly desirable for RF tests
- During this shutdown 2 exit chicanes were extended
  - Even the smallest losses at injection and ejection regions of Combiner Ring were leading to alarm levels outside
  - This will give sufficient margin



3 zones
Tail clipper

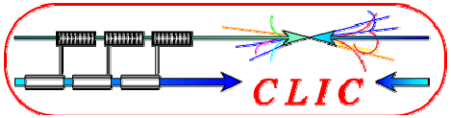
- We have installed Tail Clipper
  - It is made of kicker ▬ and dump ▬ that sits just above the beam
- It allows to regulate recombined train length
  - Kicker rump-up time is below 5ns
- The dump serves as a beam stopper to protect CLEX
  - It is on pneumatic suspension and blocks completely the beam if CLEX has to be secured
  - It makes possible simultaneous operation of DL/CR and installations in CLEX



Resources

CTF3 is a collaboration
Almost half of resources come from outside CERN
(excuding pre-existing infrastructure)

- Gun – LAL Orsay / SLAC
- Delay Loop, str. chicane – Frascati
- Probe Beam Injector – CEA Saclay
- Two Beam Test Stand – Uppsala Univ.
- RF Deflectors – Frascati
- Kickers – CIEMAT
- BPMs in Test Beam Line – Valencia
- its electronics – UPC Barcelona
- Magnets in TL2 – India
- BPM RO system in TL2 & CLEX – LAPP
- Septa in CR – CIEMAT
- Vacuum Chamber in CR – India
- Wigglers – Frascati
- Photoinjectors – LAL Orsay
- TL1 quads – BIP Novosibirsk
- BPMs in CT, CR – Frascati
- Tanks for MTVs – Pakistan
- Movers for quads in TBL – CIEMAT
- BLMs – NW Univ. Chicago
- CDR pickup – RHUL / JAI
- etc, etc, etc, ...

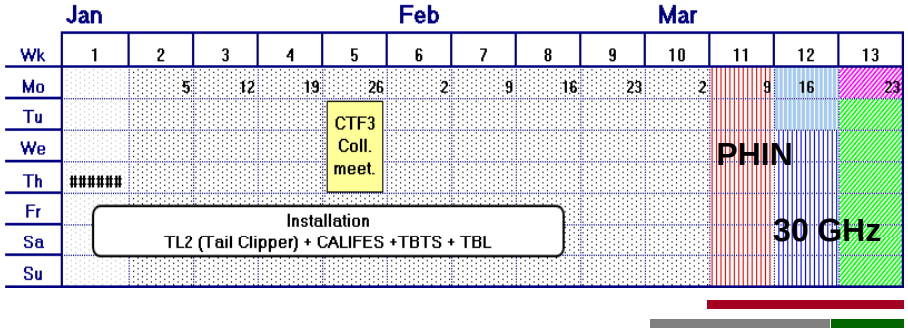


Resources

- „Work packages" agreed in the past with all the groups involved
  - Define detailed commitments and assignments between the CTF3 Collaboration and CERN groups
  - Review with the new management ongoing
- The most urgent HR issues
  - Post for the gun engineer filled previous week
  - 4-6 people fully capable to run the machine alone
    - Roberto Corsini
      - Became ABP/CC3 section leader
      - Will have even less time to spend in the control room
    - Frank Tecker
    - Simona Bettoni (Fellow)
    - Piotr Skowronski (PJAS)
      - Contract ends in May
    - Steffen Doebert
      - His main responsibility are structure tests
    - Django Manglunki
      - 50% for CTF3

Plans for 2009

2009 CTF3 experimental program Schedule



Sections in operation

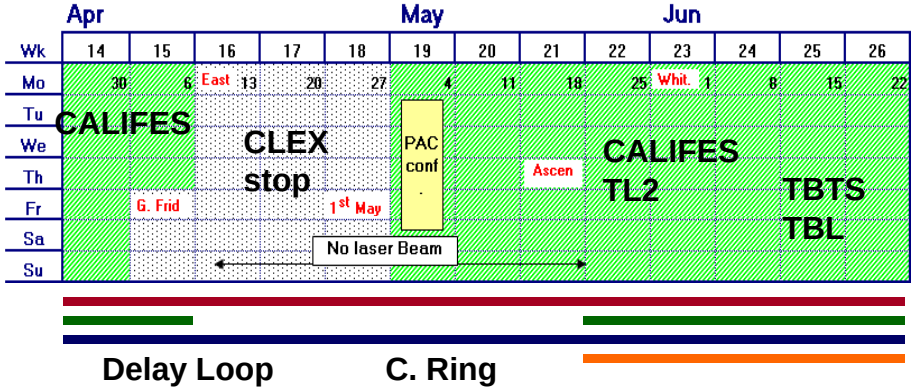
Linac

PHIN

CALIFES

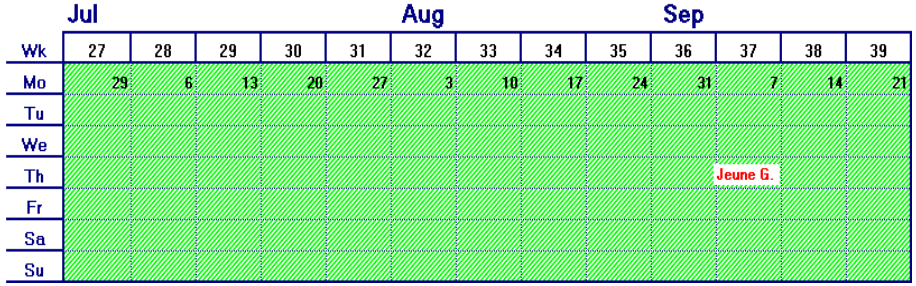
DL & Ring

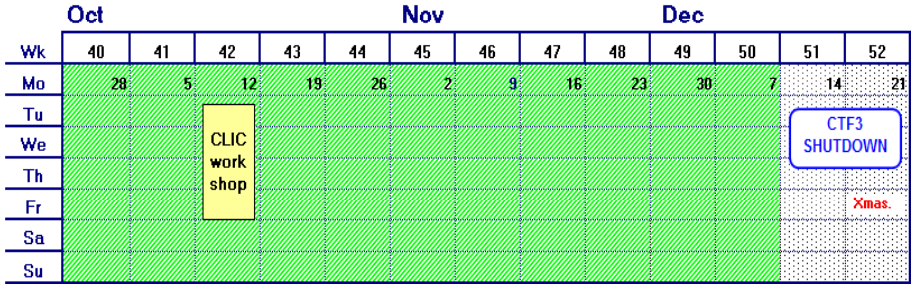
TL2, TBL, TBTS (DB)



Delay Loop

C. Ring



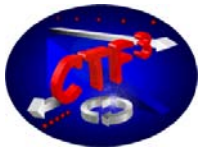


2009 CTF3 experimental program Goals

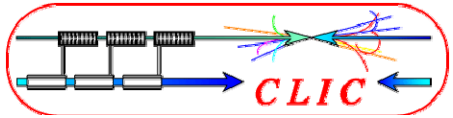
- 30 GHz: Two structure test (TM02) + breakdown studies
- CALIFES: Beam characterization, beam to TBTS (most likely still reduced current)
- Delay Loop: Back in operation, retrieve combination x 2 (~ 7 A)
- Combiner Ring: Final optics checks, isochronicity, put together with DL (> 24 A)
- TL2: Complete commissioning, bunch length control, > 20 A transported to users
- TBTS: PETS to nominal power/pulse length (15 A, recirculation)
  Beam commissioning of probe beam line
  First accelerating structure tests (one structure ? – CLIC G)
  Two-beam studies (deceleration/acceleration), initial breakdown kicks studies
- TBL: PETS validation (100 MW, need > 20 A), beam line studies (2-3 PETS ?)
- PHIN: Beam characterization, reach ½ of nominal bunch charge ?
- Others: CDR studies in CRM, beam dynamics benchmarking, stability studies, control of beam losses…

No winter shutdown in 2010

- It can only help us to achive all the goals before the end of 2010
- No other machine or user depends on us
  - There is no harm if we decide to make a shutdown
- Klystrons must undergo maintanance
  - **We have to have some shutdown**
  - At the moment it takes 10 weeks (1 week per klystron)
  - It can be shortened if additional manpower is assigned or we decide to run at lower energy and have one klystron disconnected at a time



Plans for 2010 and beyond



2010 CTF3 experimental program

- Finish whatever was not possible to complete
  - full parameters (~ 30 A in CLEX)

- PHIN nominal bunch charge, **phase coding, long term test** ?
- CALIFES nominal parameters
- TBL running in with many (8?) PETS, deceleration experiment
- TBTS test a few ACS, **nominal gradient with beam**
  complete breakdown kicks, beam loading compensation demonstration ?

CTF3 after 2010

- Proposal for CTF3 program after 2010 is under preparation
  - At present, CTF3 experimental program officially stops in 2010
  - Note some commitments made for FP7 activities
- **Almost for sure CTF3 will be used for further** CLIC studies in the next few years
  - The current results are very promising
  - Or even longer: CTF3 as X-band testing plant
    - One can consider to condition CLIC structures with RF from CTF3 before installing them in the tunnel

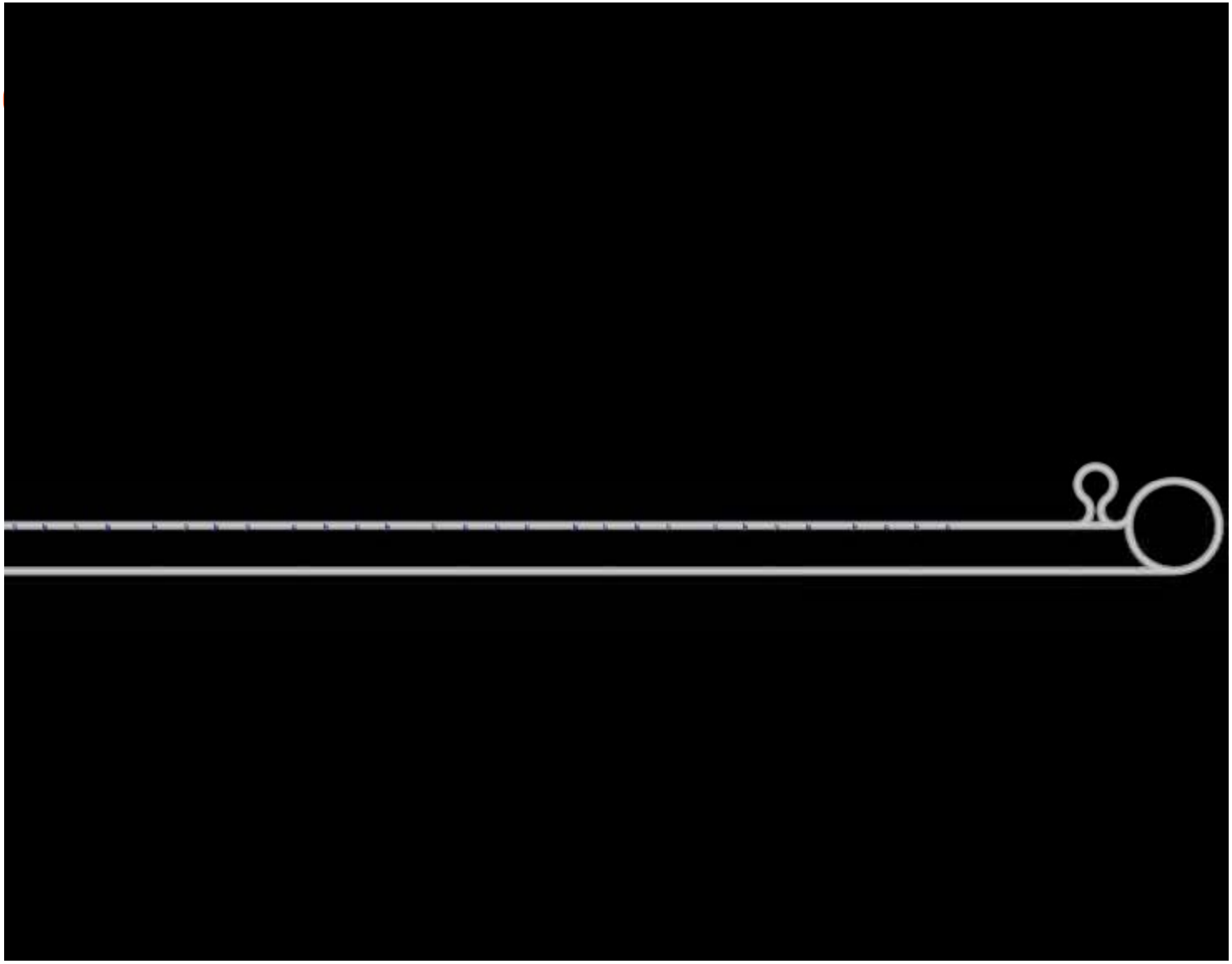
CTF3 after 2010

- Beam loading compensation
  - experiment (control of RF pulse shape)
  - Full demonstration
    - need CALIFES upgrade – 1 klystron
- Phase stability / measurements / feed-forward
- Photo-injector option full implementation (?)
- CTF3 "reasonable upgrade" with 3 more klystrons
  - CALIFES,
  - Tests + CALIFES defl. + PHIN
  - girder 14
- CTF3 upgraded to X-band testing plant
  - 1/2 nominal current
  - 2 PETS chained
  - DB dump in DL
- Rep. rate upgrade, up to 50 Hz
  - Additional Shielding needed
  - Control of beam losses
- One, then several modules in TBTS, with ~ nominal parameters
  - need PETS priming or recirculation
- Instrumentation development for LC
  - Instrumentation Test Beam Line (?)

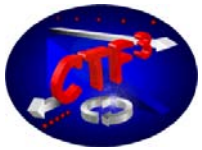
Conclusions

- Comparing to '07, '08 runs went relatively smoothly without any major disasters like
  - Vacuum leaks (2 in 2007)
  - Klystrons down for good (2 in 2007)
- The problem with the unstable gun solved
  - A Specialist hired
    - Should ensure reliable operation and improve performance
- New RF deflectors installed in the Combiner Ring
  - The instability gone
  - Immediately got recombination factor 4
- TL2 and TBTL need more reliable diagnostic for precise optics measurements
- CALIFES commissioning postponed to the next run
- Manpower situation for the machine operation is tight

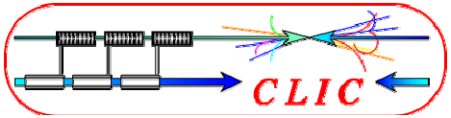
Thank you!



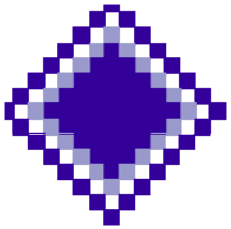
Lemings recombination by Alexandra Andersson


CTF3


CERN


CLIC

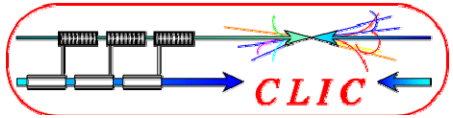
BACKUP Slides



BACKUP


CTF3

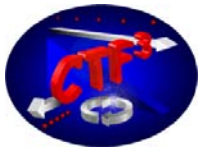

CERN


CLIC

Tentative schedule for CLIC R&D 2010-2016

Year		2010	2011	2012	2013	2014	2015	2016
CTF3+	module test	design	build	commision				
	TBL+	finish TBL program	modify	X RF test	X RF test	X RF test	X RF test	X RF test
	phase feedforward	design	build	commision & run				
	general	consolidation						
Next facility towards CLIC	DBA Injector		Design		build	commission		
	Nominal DBA modules		Design		build		commission	
	Economy DBA modules				build			commission
	combiner rings		Design		build			commission
	TBA		Design		build			commission
	civil engineering	Design	build					
Stand alone X-band sources		build & commission additional test ports						
		RF test program						
X-band structure development		continuation						
Design & beam dynamics studies		continuation						
LC Detector R&D		continuation						

+ possibly other R&D programs to be defined…



CERN DG's talk to Staff
3 October '08

Projects for Scientific Activities over the Period 2012 - 2016

To be decided in 2010-2011 in light of first physics results from LHC, and designed and R&D results from the previous years. This programme could most probably comprise:

- An LHC luminosity increase requiring a new injector (SPL and PS).

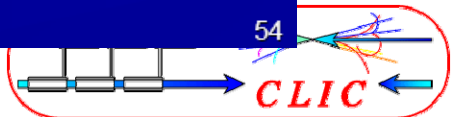
  The total cost of the investment over 6 years (2011-2016: 1000-1200 MCHF + a staff of 200-300 per year. Total budget: ~200-250 MCHF per year.

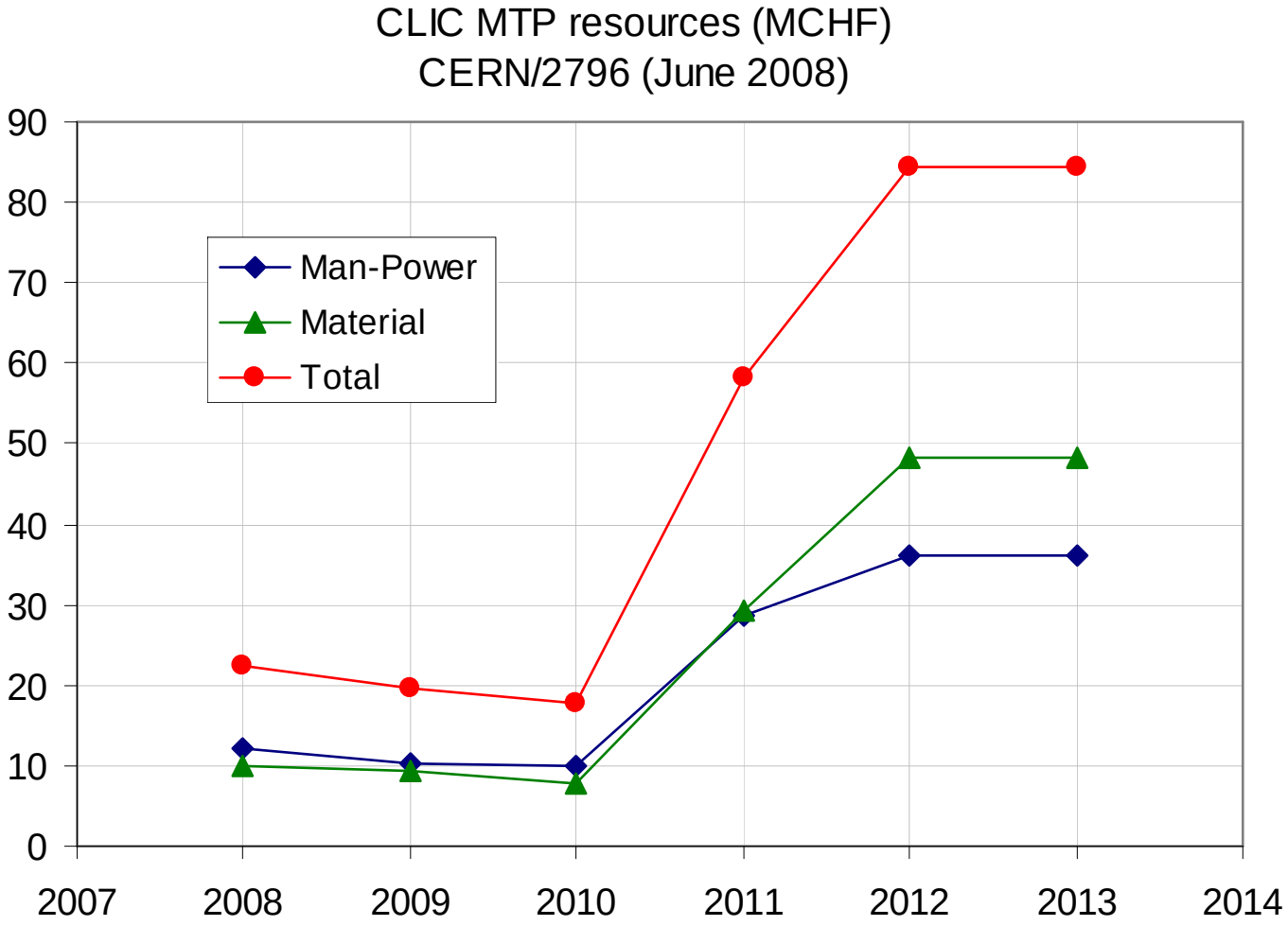
- Preparation of a Technical Design for the CLIC programme, for a possible construction decision in 2016 after the LHC upgrade (depending on the ILC future).
  Total CERN M + P contribution + ~250 MCHF + 1000-1200 FTE over 6 years.

- Enhanced infrastructure consolidation: 30 MCHF + 40 FTEs from 2011.

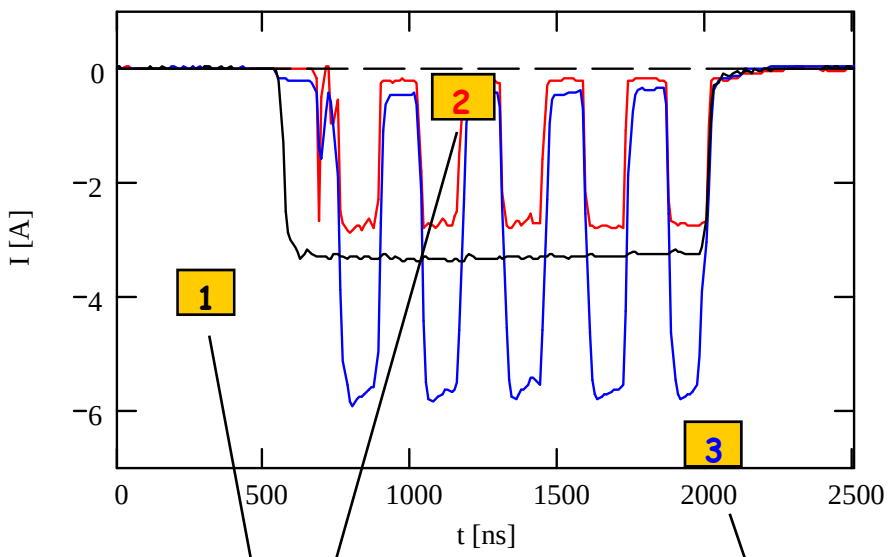
NB: Over the period 2012-2016. Effective participation of CERN in another large progra… …cted resou… …l Design. This s… …*proved* or if a new, more ambitious level of activities and support is envisaged in the European framework.

N.B.: Expect additional significant contribution from outside CERN, up to the same level

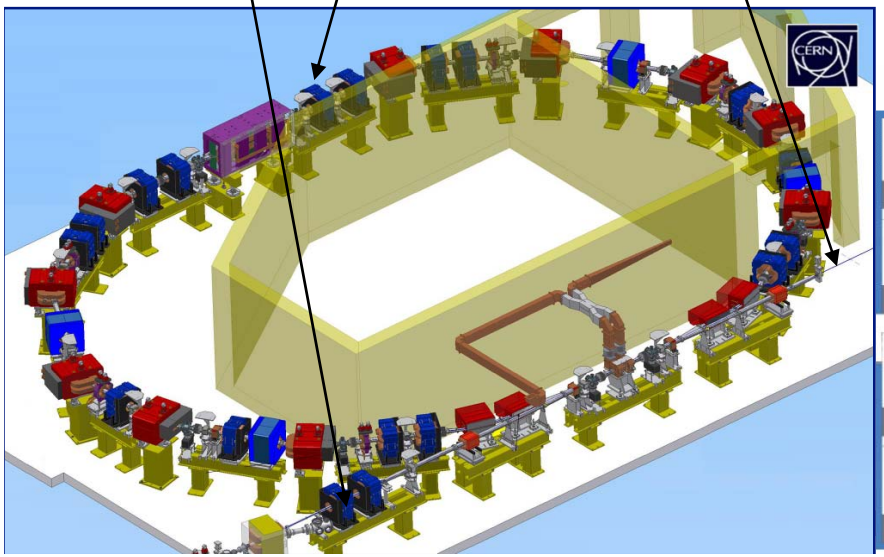


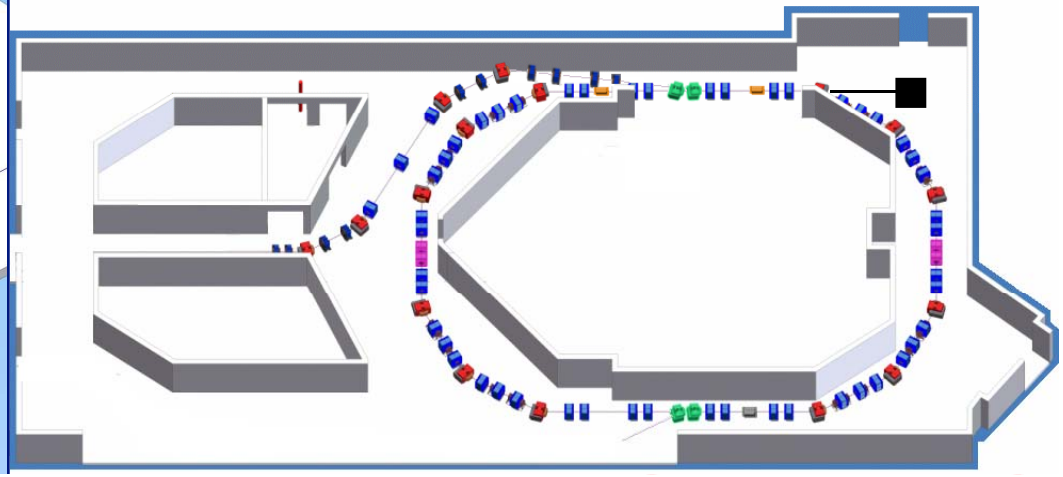

CLIC MTP resources (MCHF)
CERN/2796 (June 2008)
90
80
70
60
50
40
30
20
10
0
2007
2008
2009
2010
2011
2012
2013
2014
Man-Power
Material
Total

Main Points of 2006



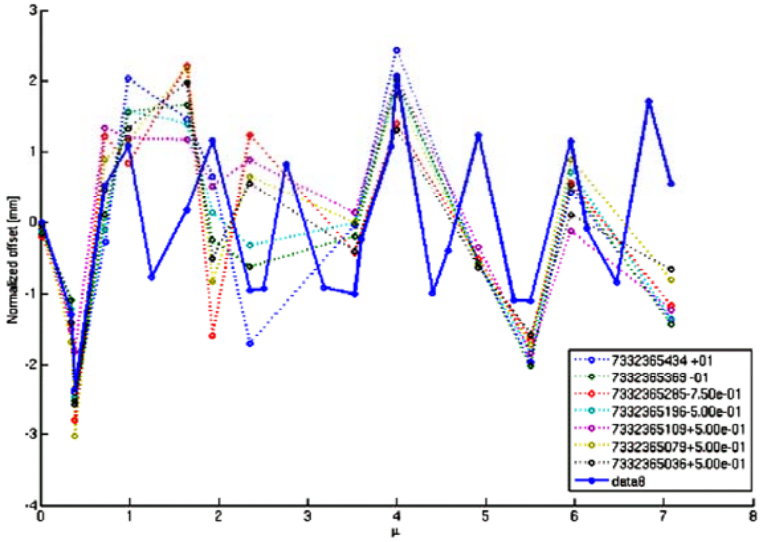
- Delay Loop Commissioned
  - 7A after DL
  - 1400 ns pulse length
- TL1 and CR injection Commissioned
  - 3.2A in TL1, 3A in CRM
  - RF injection to CR

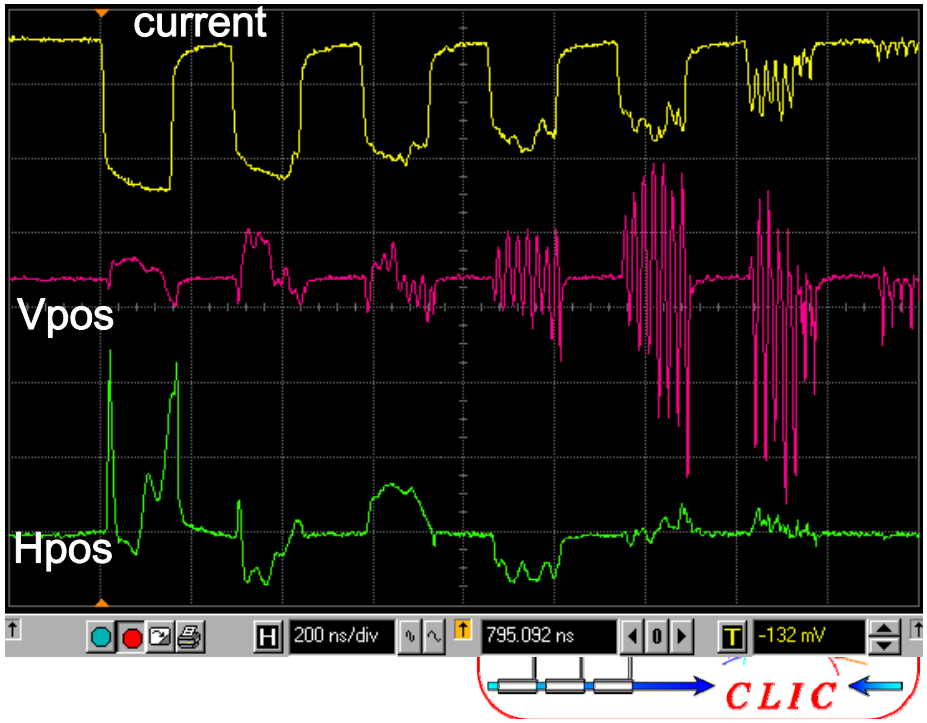




Main Points of 2007
TL1 and CR

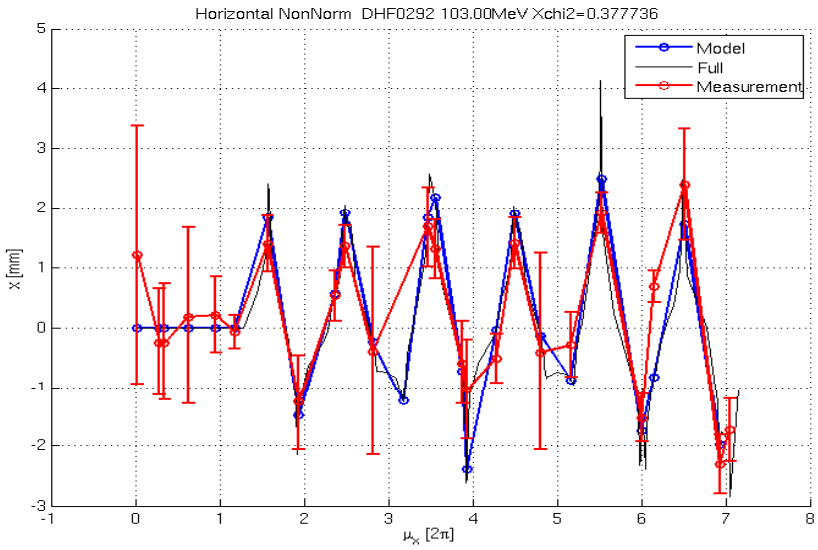
- Transfer Line 1 relatively quickly commissioned
- No major problems with establishing injection to CR
- Long and painful CR commissioning being finished only now
  - Fast Vertical Instability caused by the deflectors
  - Bad cabling of quadrupoles
  - Wrongly calibrated BPMs
  - Unstable gun
  - Inaccurate model of the ring

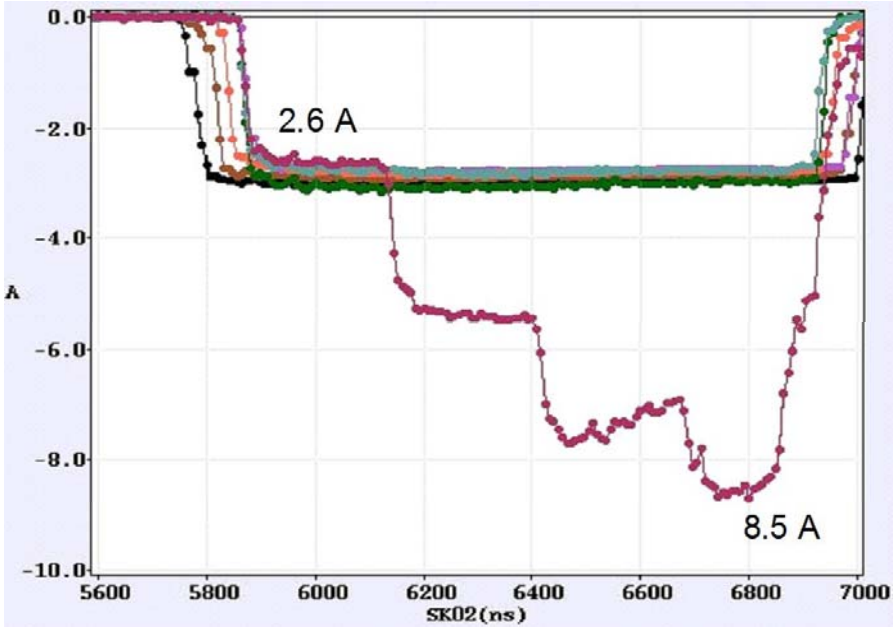




Main Points of 2007
CR results

- Besides all the problems
  - We have managed to recombine the train factor 4
    - OK, almost 4, but the principle was shown to be valid
  - Perform the optics studies which enabled gradual debugging and validation of the machine model

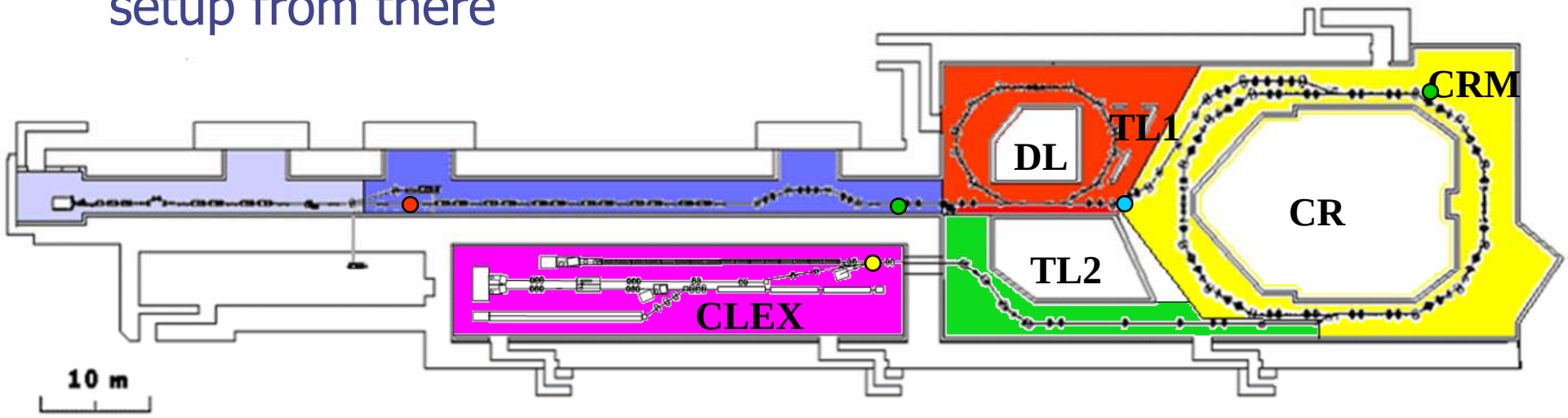




ıg

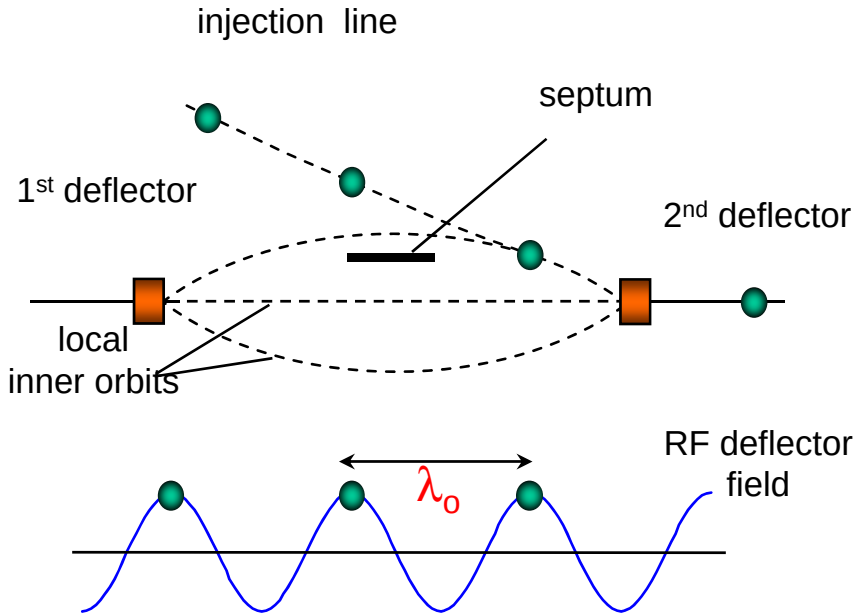
Machine Setup on one slide

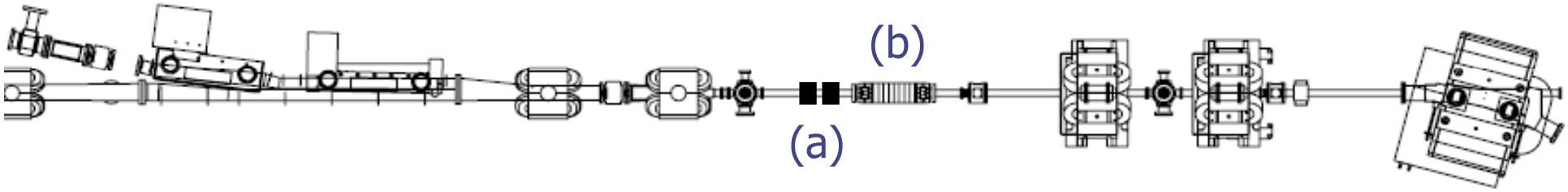
- Machine setup is based on quad scans
  - Beam is set-up to the screen on girder 10
    - Phases of acc-structures up to girder 10 are adjusted to get full loading
  - Twiss parameters are measured and whole linac is rematched
    - Phase adjustment for the rest of the structures
    - Energy profile is measured at girder 10 and elsewhere is calculated
  - Another quad scan is made at CTS
  - TL1 and is matched to the CR closed solution at this given energy
- If something changes at given point, we must redo the setup from there



CR Injection

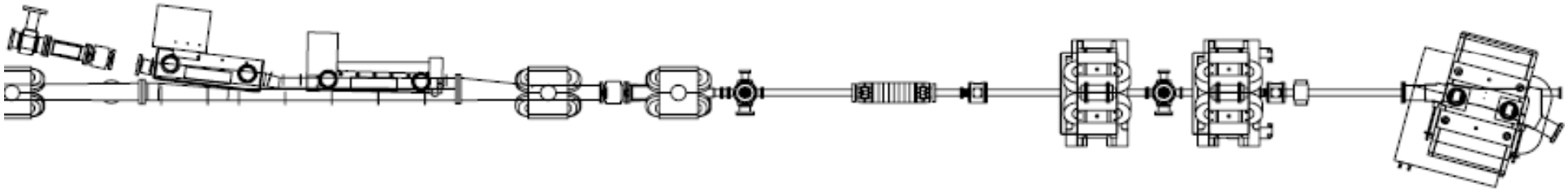
- Beam recombination in CR is made with time variable bump





Long circulating CR beam

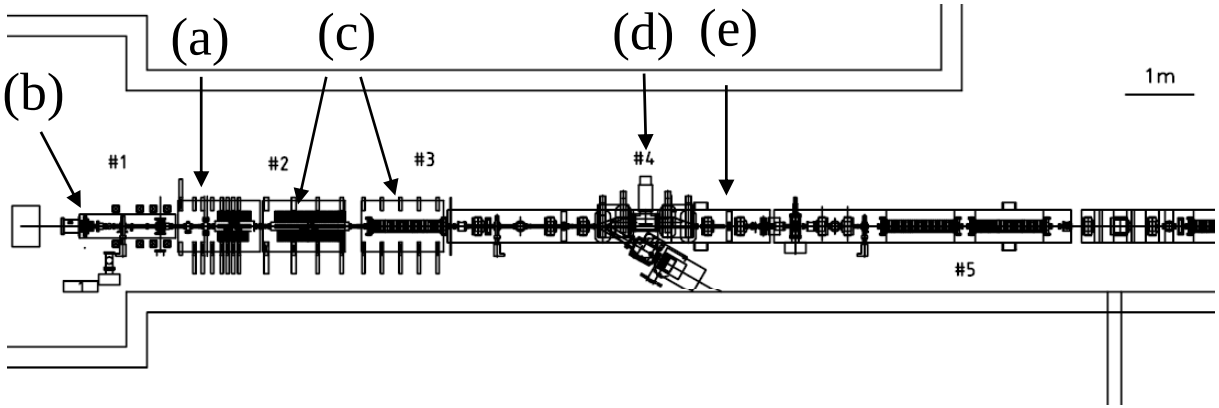
- Many measurements require long circulating beam in CR
  - Tune
  - Closed orbit correction
  - Closed orbit length measurement
- The beam is injected to the ring RF deflectors
  - The klystron timing is adjusted so the RF pulse ends when the last bunch of the train leaves the deflector
  - Since those are travelling wave cavities with short filling time the RF is gone before the first beam of the train comes back to the deflector
  - This way beam makes several hundreds turns before it irradiates too much energy thru synchrotron radiation to be fitted in the acceptance



Beam setup procedure
Linac to girder 4

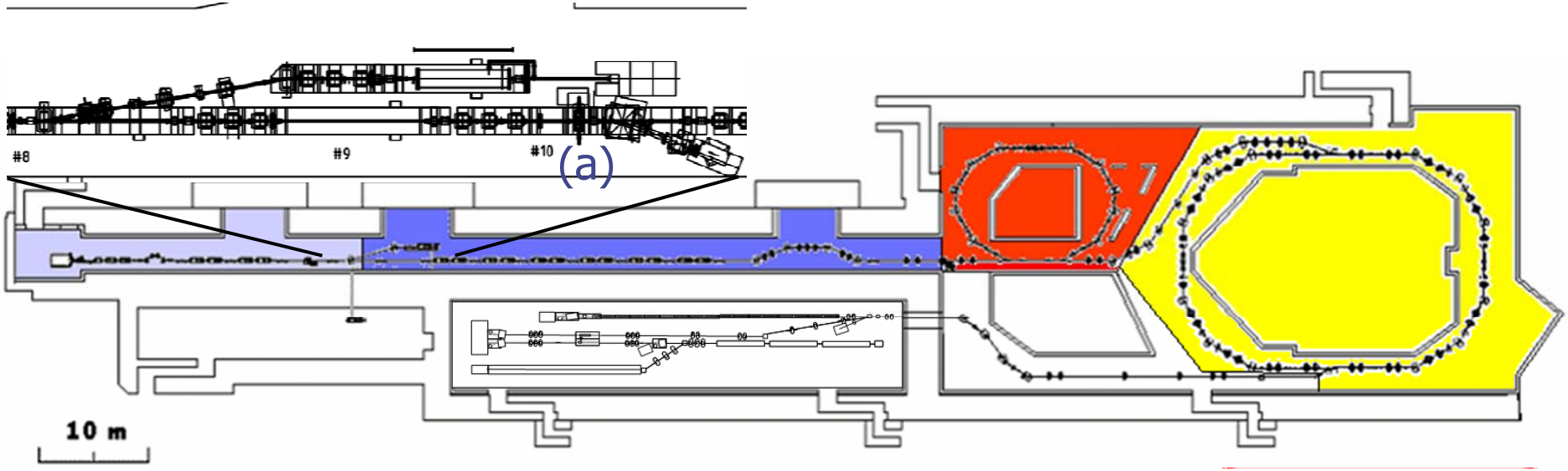
- We start with 3GHz (more stable) beam
  - Traveling Wave Tubes (TWTs) off (a)
- Adjust
  - The gun (b)
  - Phases of klystrons 2 and 3 (c)
  - The compressor chicane (d)
    - Current in bends
    - The slit gap

  to get 4-5 A beam after the chicane (e)



Beam setup procedure
Linac to girder 10

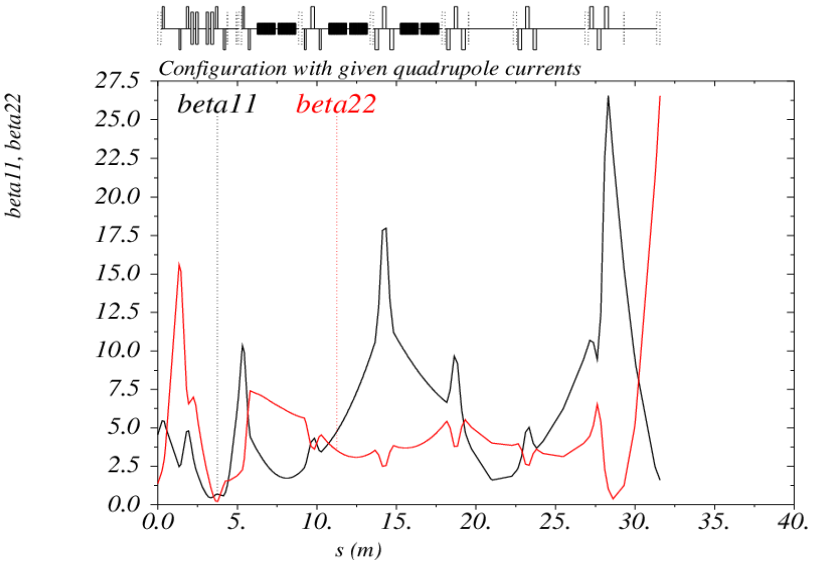
- Adjust the phase of MKS05
- Get somehow the beam up to spectrometer 10 (a)
  - Usually by scaling up and down all the quadruples together
- Beam measurements at spectrometer 10
  - Energy with the slit dump
    - Vary the bend current to get maximum signal
    - Having current-momentum coefficient for this angle one gets energy
  - Twiss parameters using quad scan
    - We vary quad strengths and measure beam profiles at screen MTV1026



Beam setup procedure
Optics Calculation

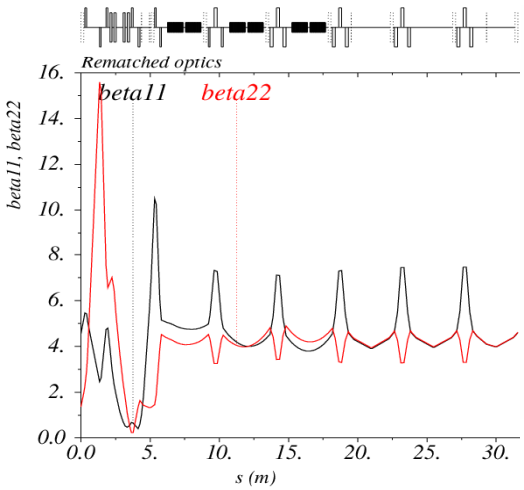
- Having
  - The energy profile along the whole linac
    - Having input power to each of the accelerating structures and knowing beam current one calculates acceleration in each cavity
  - Twiss parameters at certain location

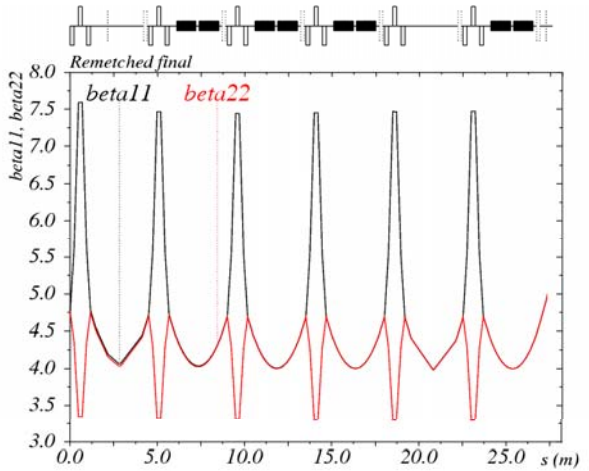
    we can calculate the optics along the machine
- We have the design optics however the exact magnet setting depends on
  - Beam provided by the injector
  - Energy profile that depends on the klystrons power

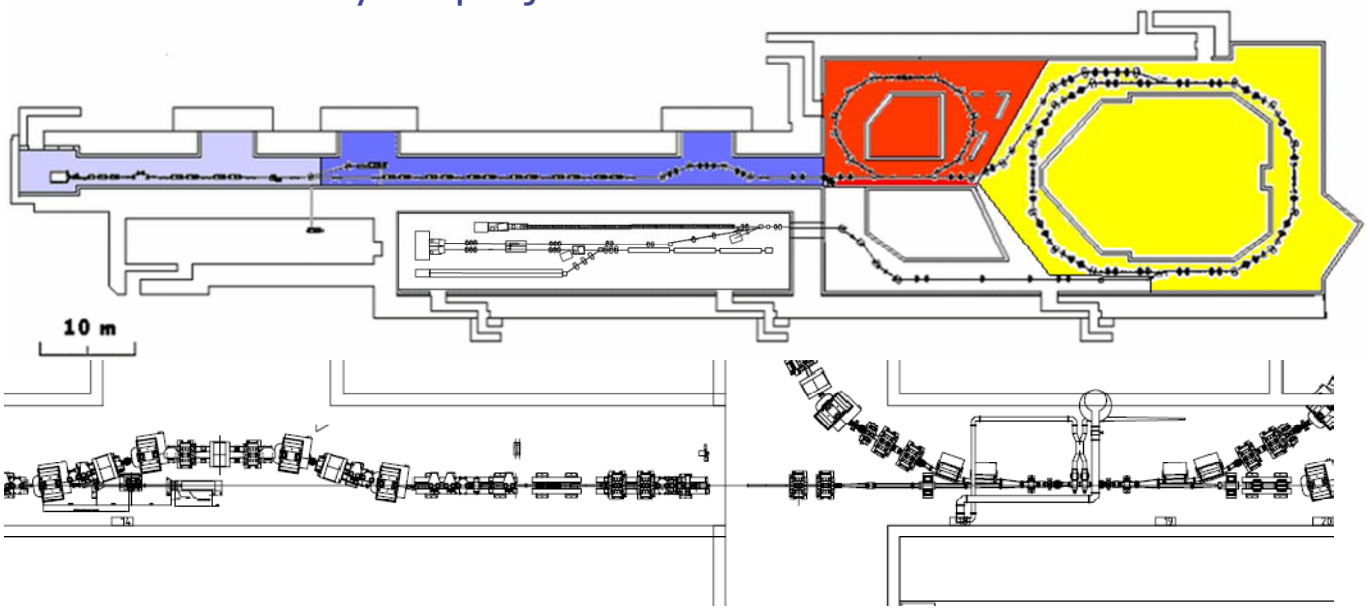


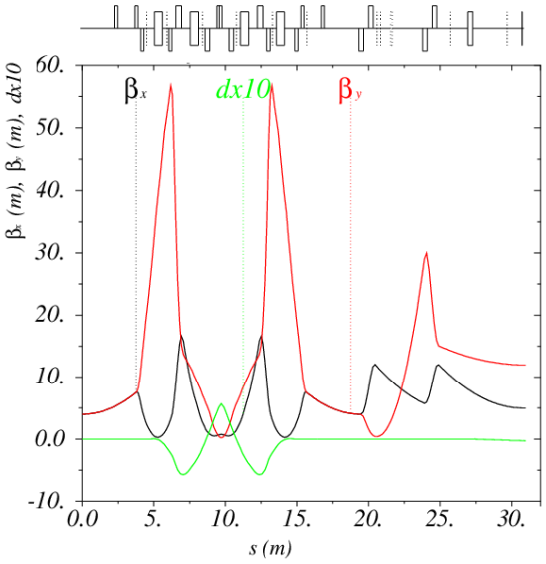
Beam setup procedure
Linac rematch

- Knowing Twiss parameters at the end of the buncher rematch the whole linac up to the Delay Loop to the nominal optics
- Adjust
  - phases of klystrons from 11 to 15
  - bends in
    - The stretcher chicane
    - Delay Loop injection



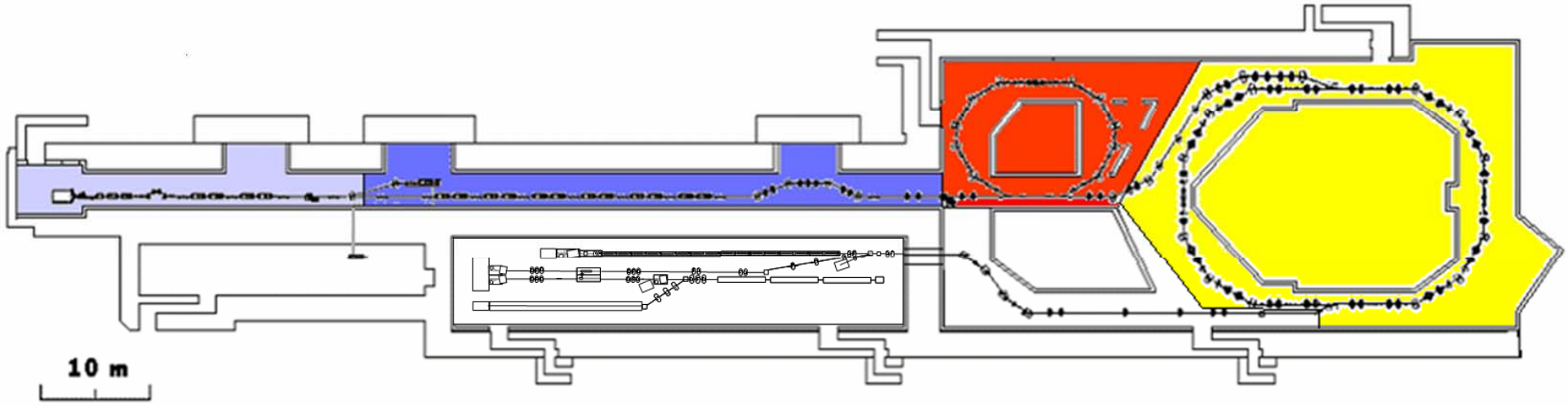






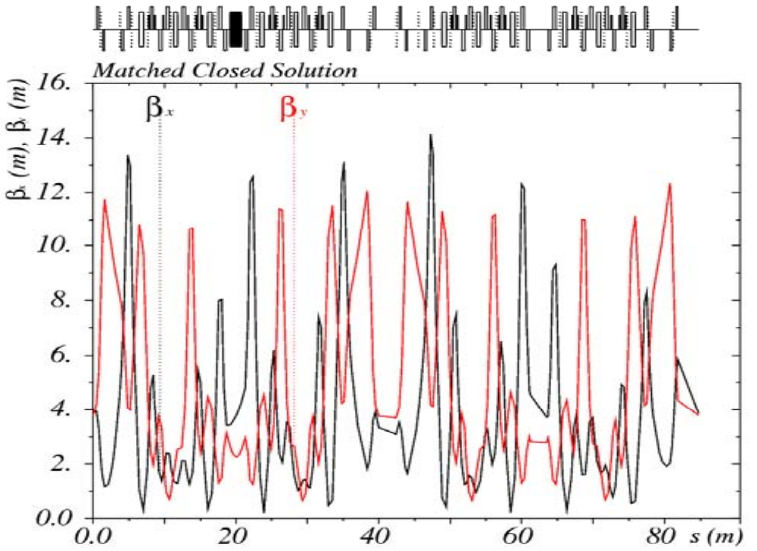
Beam setup procedure
Optics Verification

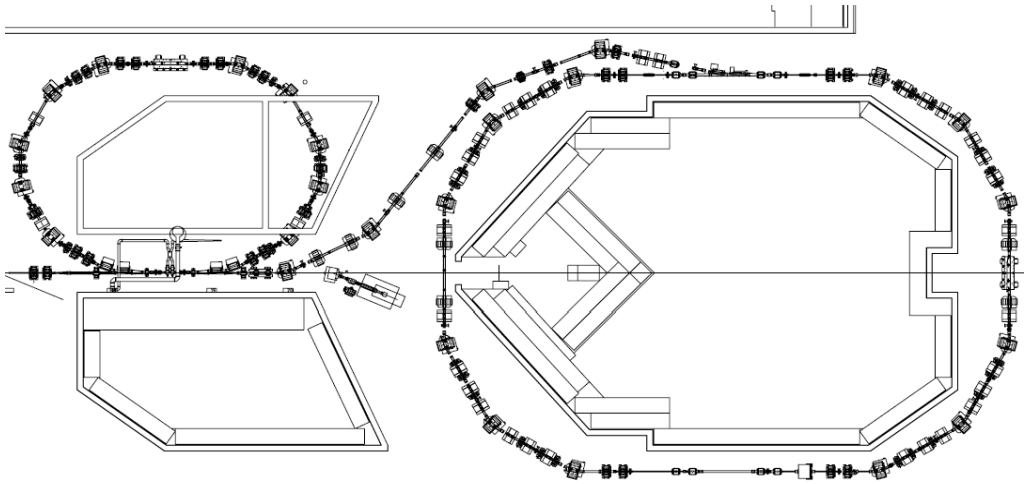
- Perform quad-scans at
  - Spectrometer 10
    - To verify the rematch
  - Beginning of TL1
- Depending on the obtained results rematch whole or part of the linac
- Check if the obtained energy agrees with the bends settings

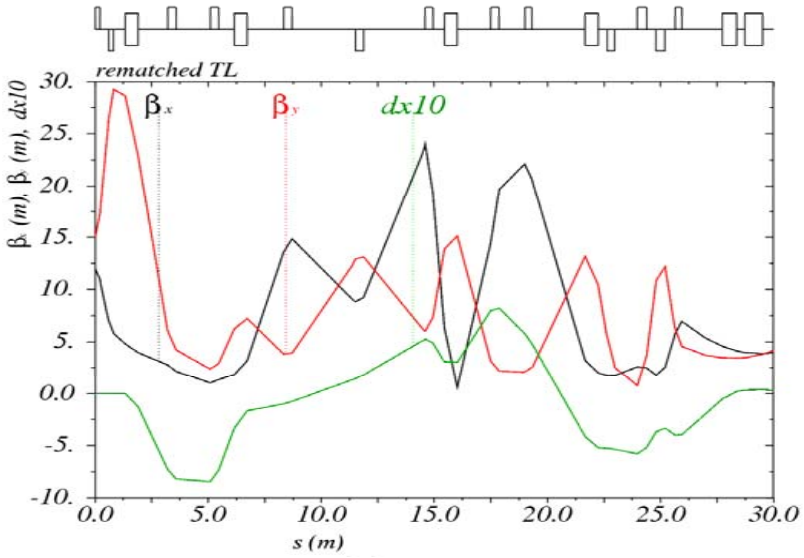


TL1 and CR optics

- Adjust the optics in the Combiner Ring to
  - The beam energy
  - Wiggler current
- Calculate isochronous optics in TL1 to match CR

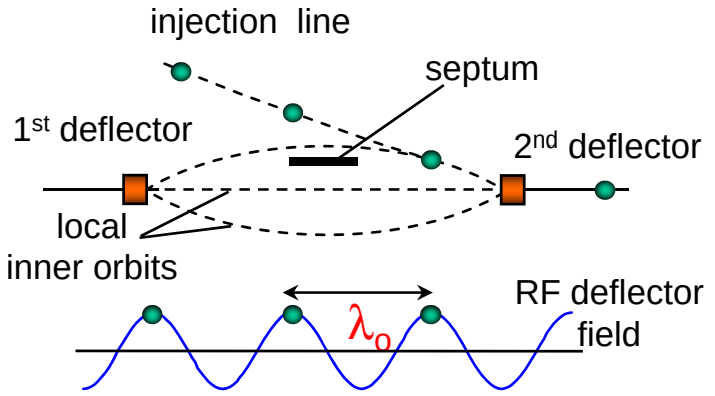


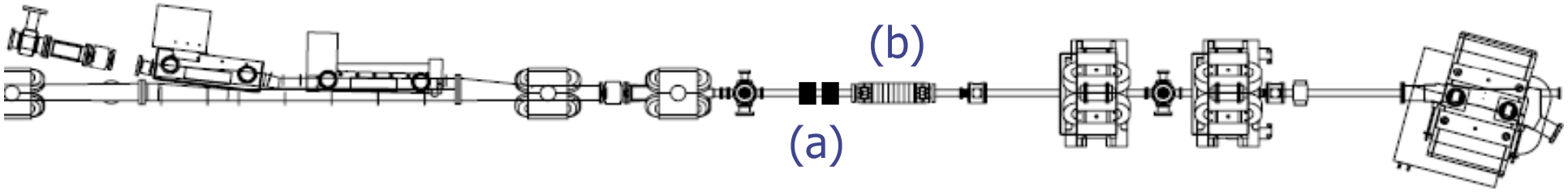




Beam setup procedure
CR Injection

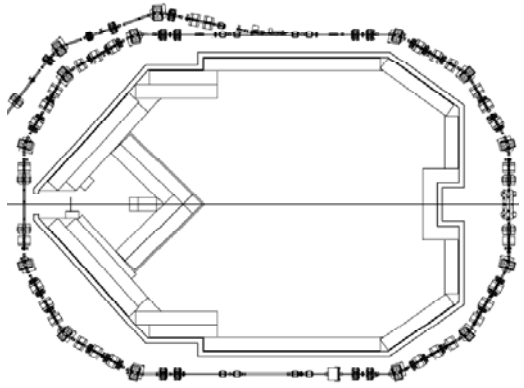
- We start with static magnetic injection using two horizontal correctors (a)
  - It allows for only one turn in CR
- Setup the septa and the orbit
- Switch to the injection with the RF deflector (b)
  - It is an iterative procedure that involves the following steps
    - Set RF power (amplitude)
    - Find zero crossing phase of the RF deflector
      - It leaves the orbit unchanged
    - Set the phase +/- 90 and switch off the correctors
    - If kick is too weak or to strong adjust the power
      - It changes the phase

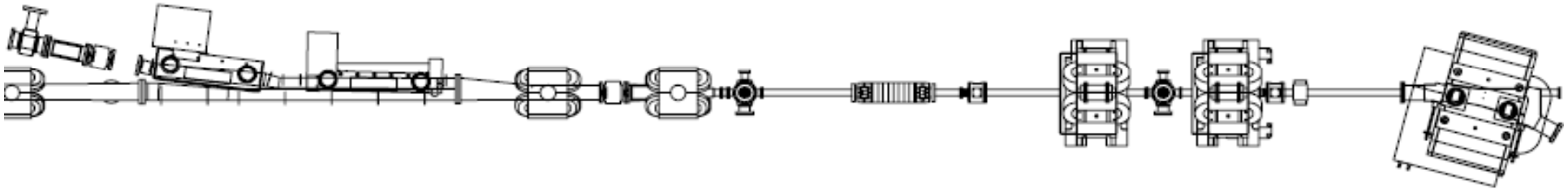




Beam setup procedure
CR Injection

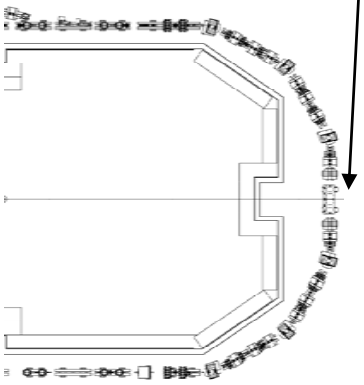
- To setup a good injection and orbit
  - Short train is injected (~140ns)
  - RF is switched off just after the last bunch is injected
- It allows for long lasting beam circulation in the ring
  - Then it is easier to find a closed orbit
  - It makes possible to apply orbit correction procedures more efficiently
  - Allows to measure the tunes precisely

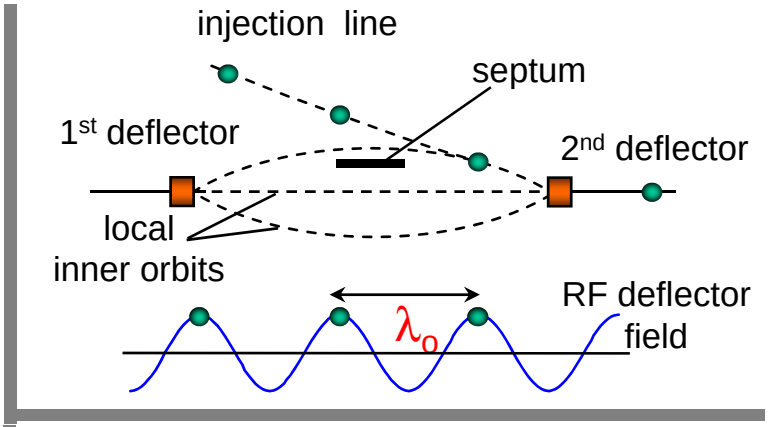


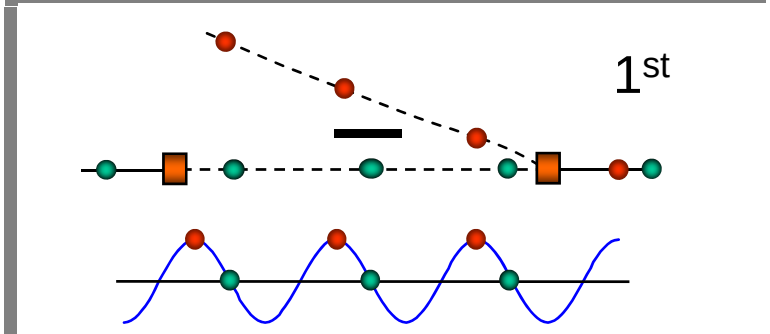


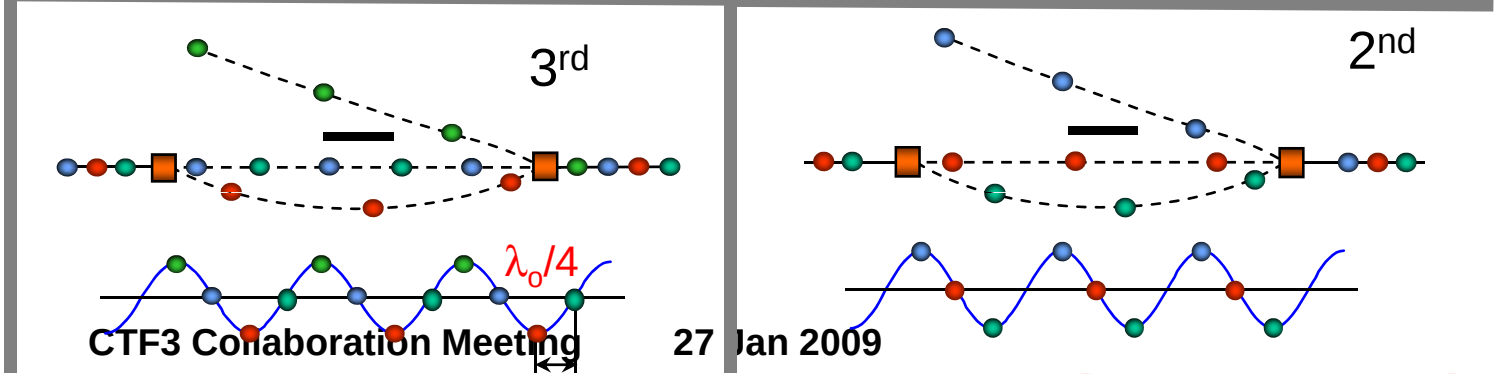
Orbit length in CR

- The orbit must have the length $C_r = (n_t \quad ¼)\ \lambda$ *(it is „-" in our case)*
  so the beam arrives exactly
  - 1st turn: at zero crossing phase
  - 2st turn: at the crest
    - But opposite amplitude than at the injection
  - 3st turn: at zero crossing again
- Adjust the length with the wiggler









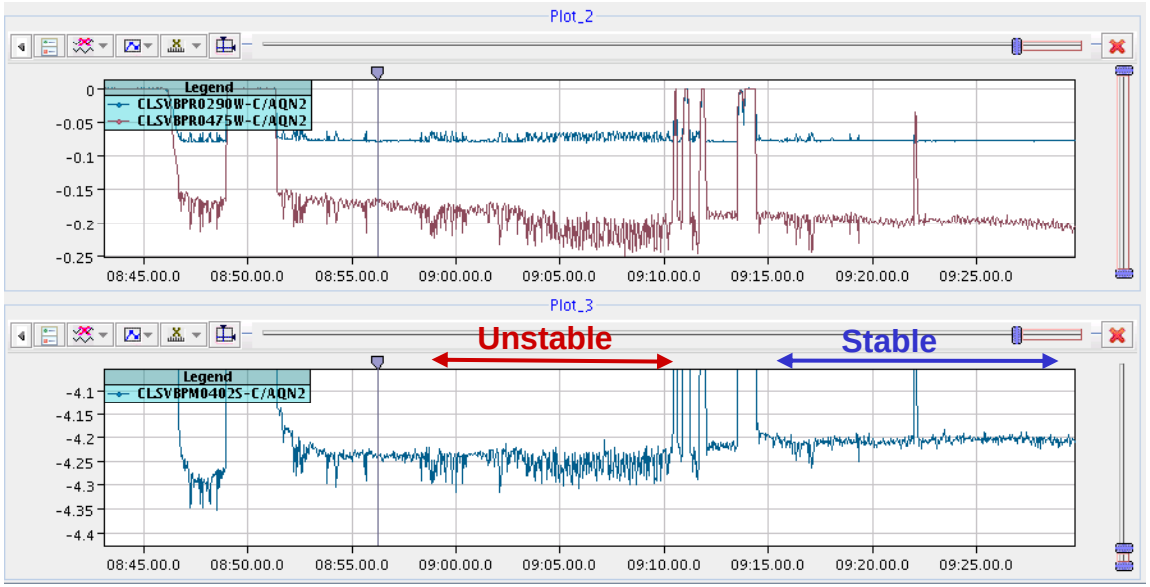
Beam Setup

- In theory the whole procedure could be completed within a couple of weeks
  - If, and only if, the machine is
    - Stable
    - Reliable
- Whenever any device changes its parameters the procedure needs to be restarted from the point the device sits!

Unstable gun

- Already since the first run of 2007 we observed large beam jitter that originates from the gun instability
  - The current is slightly different from shot to shot
  - Since we operate in the fully loaded mode
    - phases are adjusted so all the RF energy is transferred to the beam

    bunches with different current are accelerated differently
  - It leads position jitter in the dispersive regions
    - What made the setup and measurements very hard!



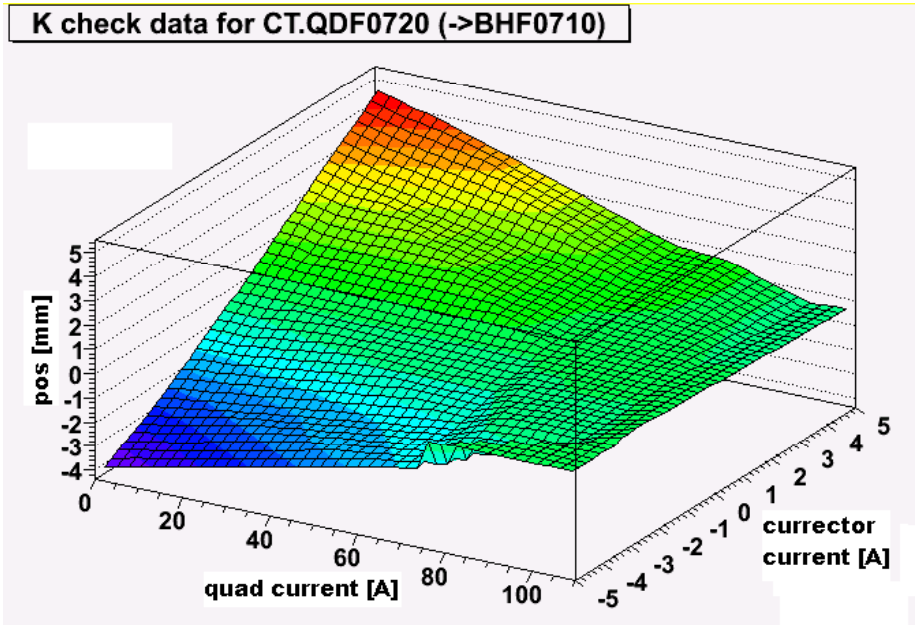
Unstable gun
Problem Solved

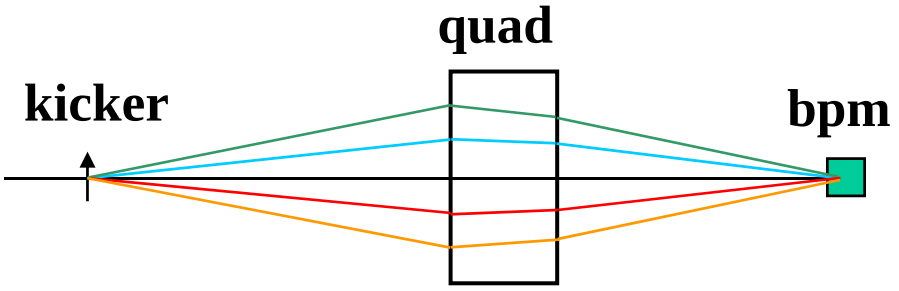
- Finding the problem was difficult and tedious
  - The device is constructed by LAL and the designer is retired
  - It was finally found that the high voltage power converter produces chainsaw-like signal
    - however according to the manufacturer the device itself was OK
  - After inspection in-situ one of resistors was found cracked
    - connecting capacitor bank to the ground
      - at low voltage the resistance was inf, but when 150kV applied than it was conducting thru arcing
  - And later another resistor found cracked
    - between capacitor bank and the high voltage deck
  - Since than (end of September 2008) the gun behaves OK

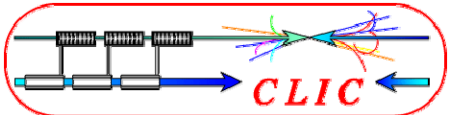
- FOTO of broken resistors

K1 measurement

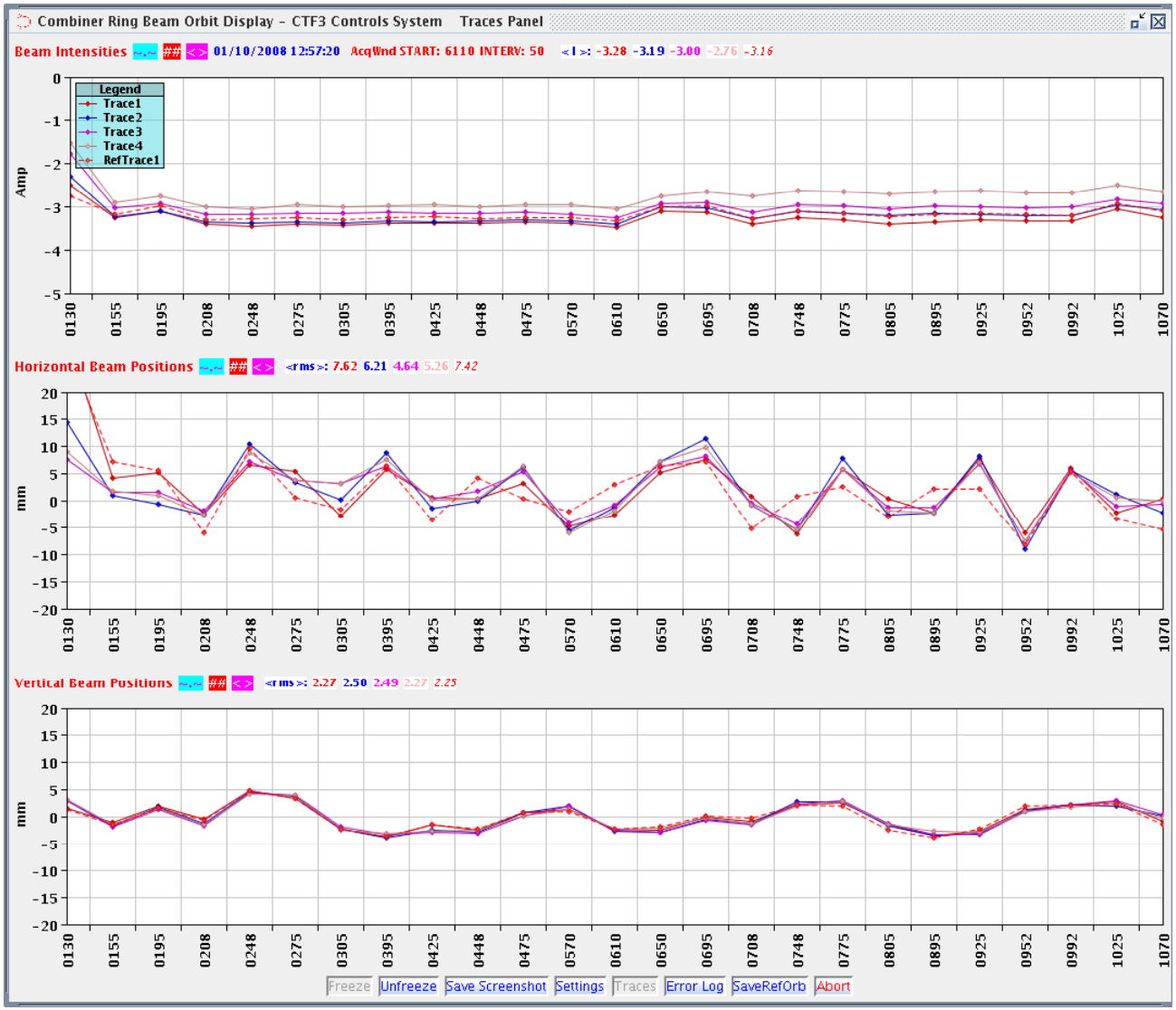
- We have attempted to measure focusing strength of combined function magnets
  - We look for the magnet current that gives 180 phase advance between kicker and BPM
    - Knowing energy and distances we get k1
- Unfortunately when we did it the gun was still unstable and the result was not precise enough



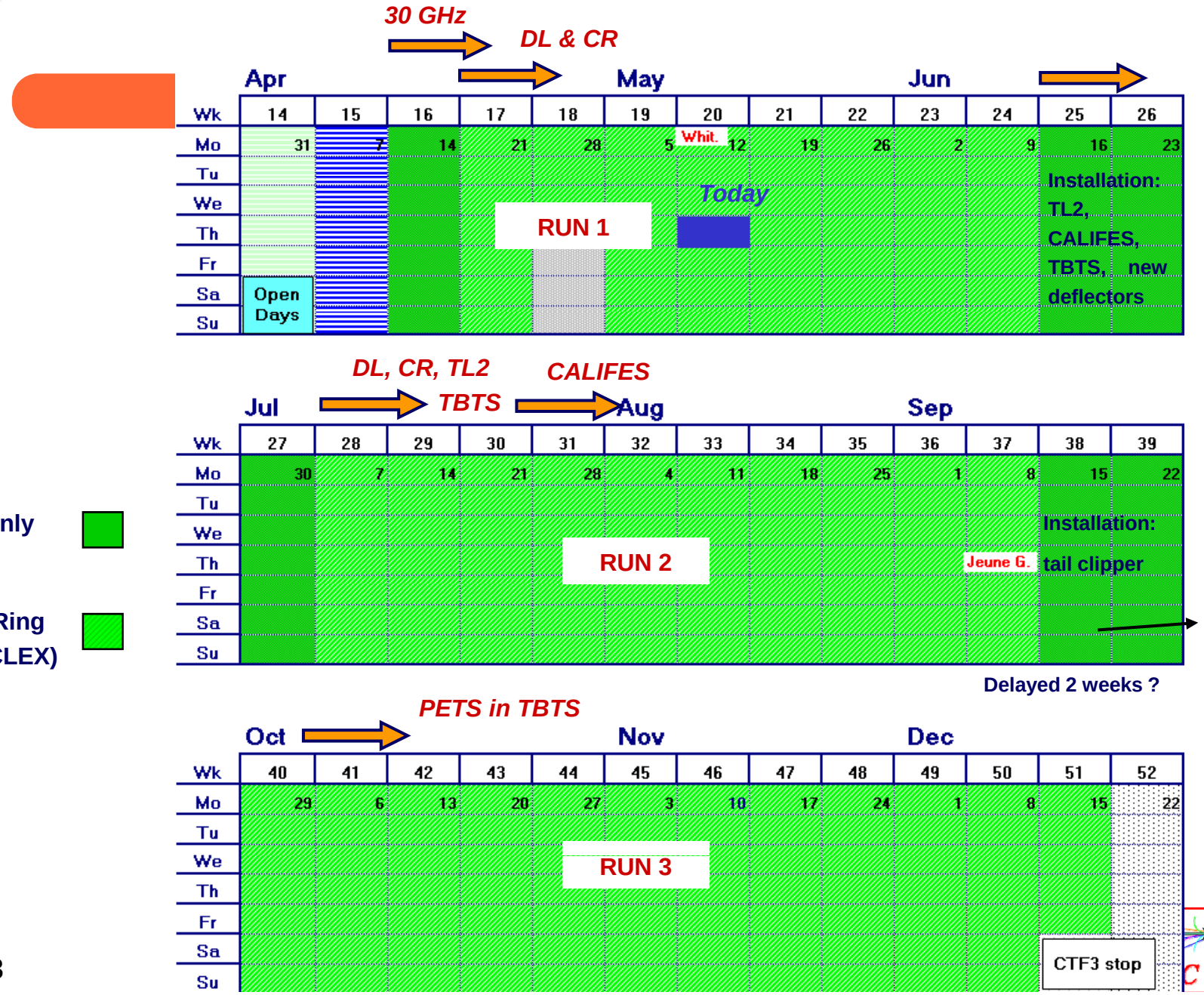




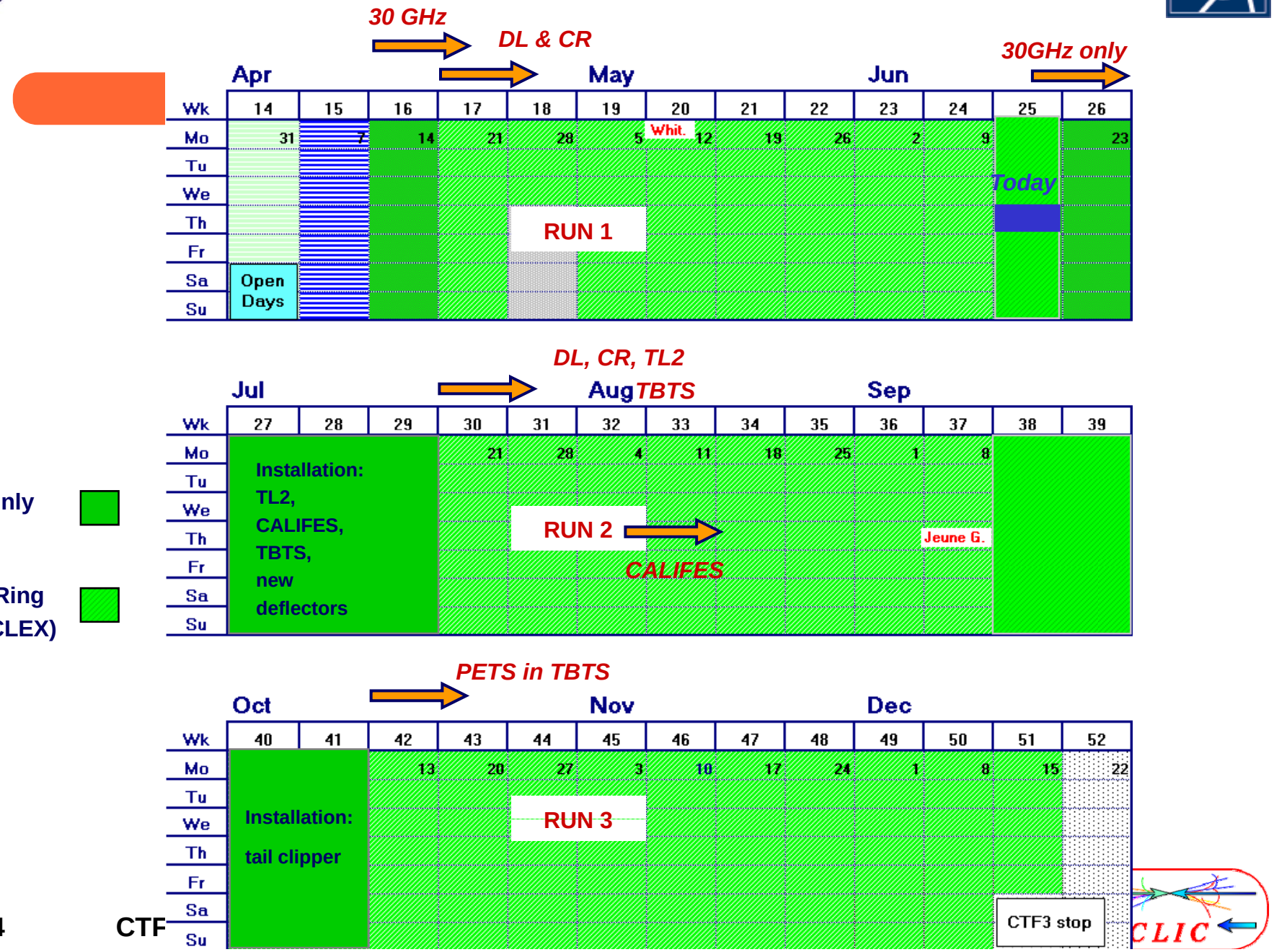
CR Orbit Closure



Schedule 2008 v1

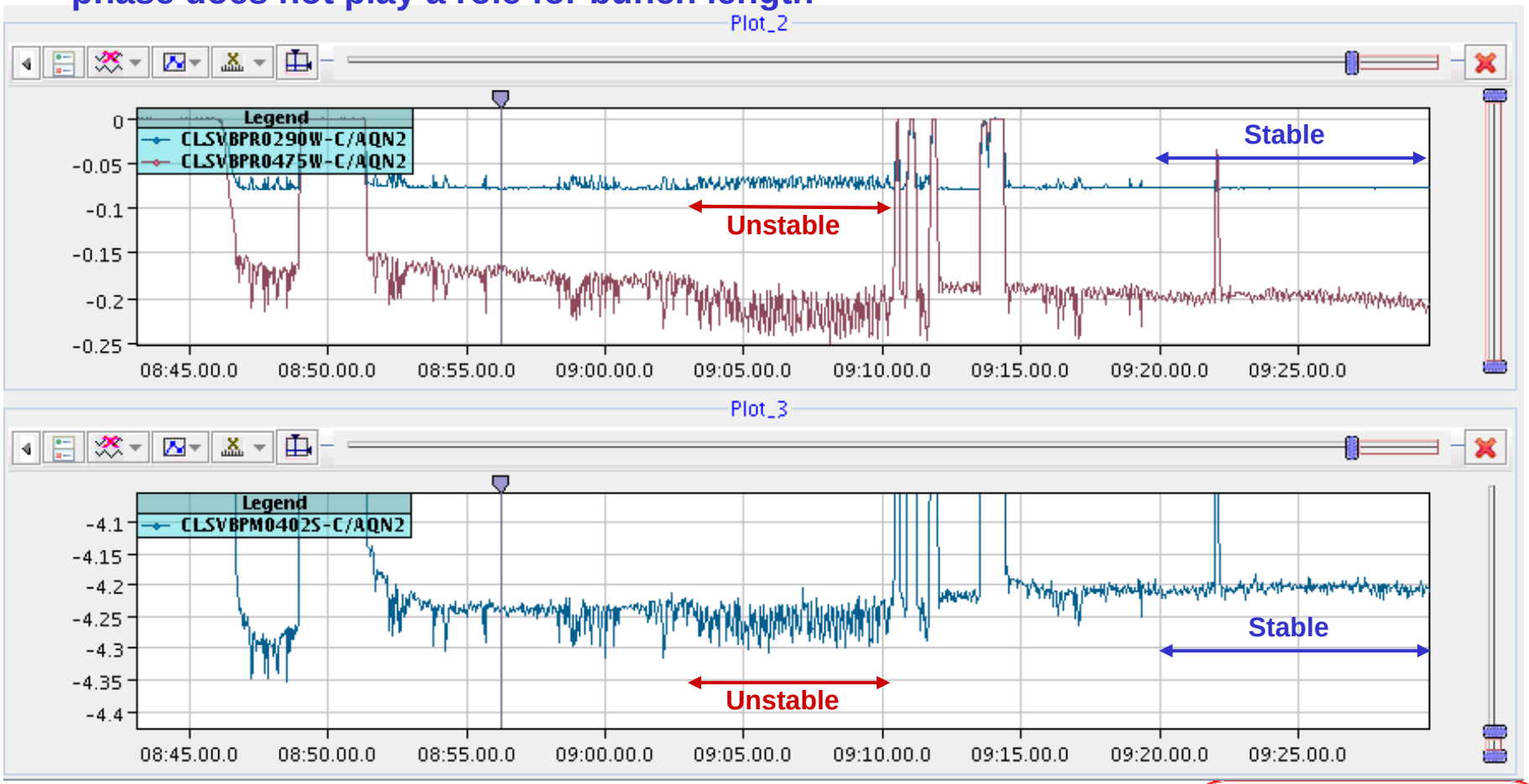


Schedule 2008 v2

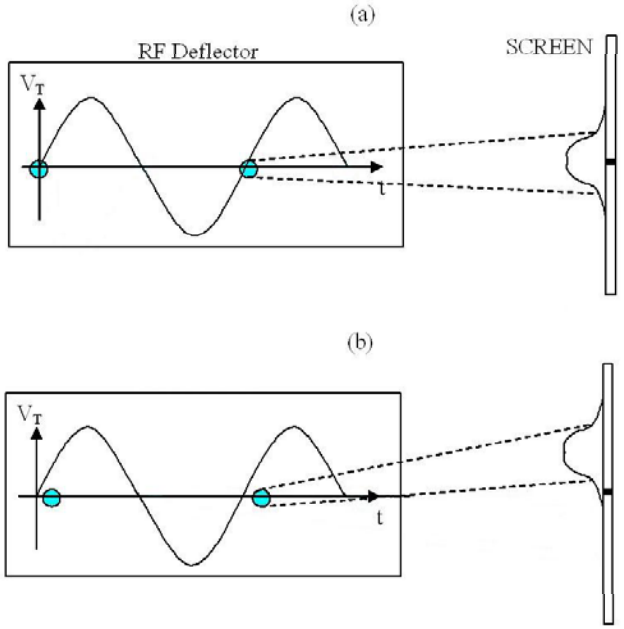


Gun HV stability

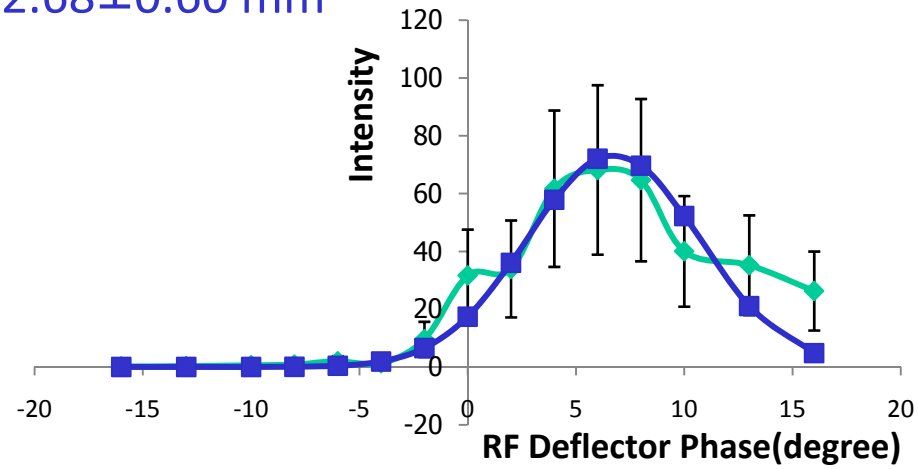
It must be the Gun HV instability since 0290 is only after buncher, whichs phase does not play a role for bunch length



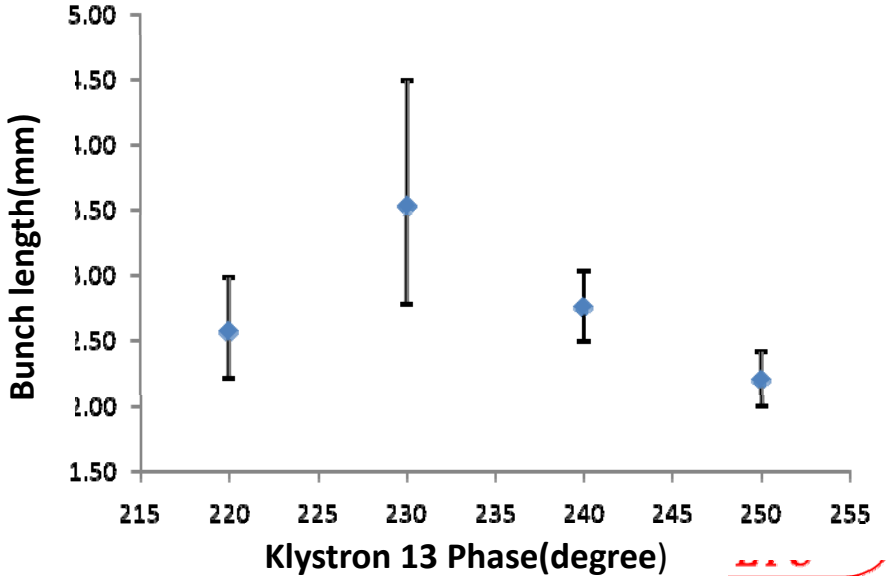
Bunch length



l_b= 2.68±0.60 mm

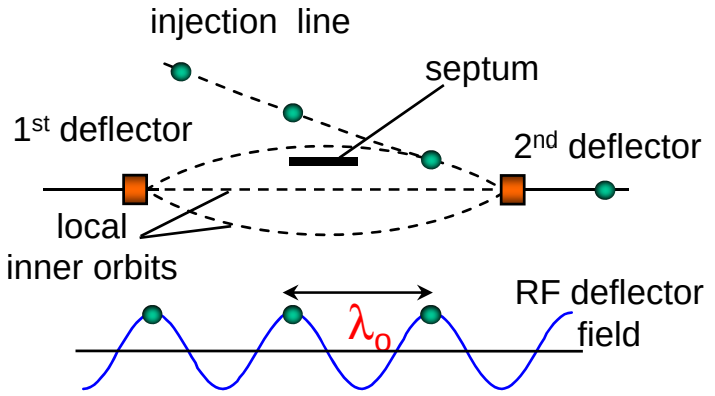


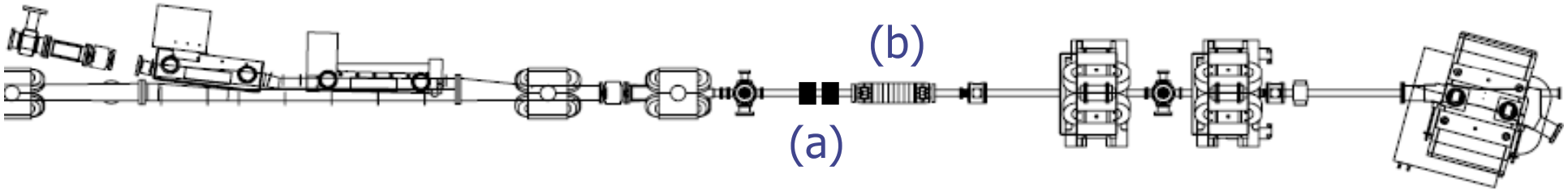
The bunch length achieved by measuring the intensity of a thin band at middle of screen for each RF deflector phase and fitting a Gaussian distribution. The standard deviation of this chart is related to bunch length by c/f constant. c is speed of light and f=1.5 GHz is frequency of RFD. The errors are large due to the beam jitter but is good for first measurement by this method



Machine setup – 2nd slide
CR Injection

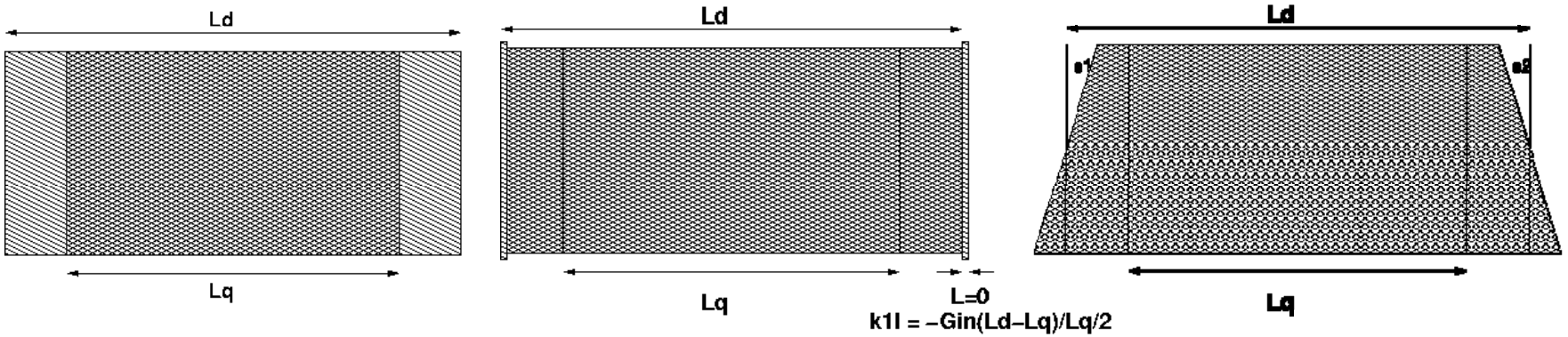
- We start with static magnetic injection using two horizontal correctors (a)
  - It allows for only one turn in CR
- Setup the septa and the orbit
- Switch to the injection with the RF deflector (b)
  - It is an iterative procedure that involves the following steps
    - Set RF power (amplitude)
    - Find zero crossing phase of the RF deflector
      - It leaves the orbit unchanged
    - Set the phase +/- 90 and switch off the correctors
    - If kick is too weak or to strong adjust the power
      - It changes the phase

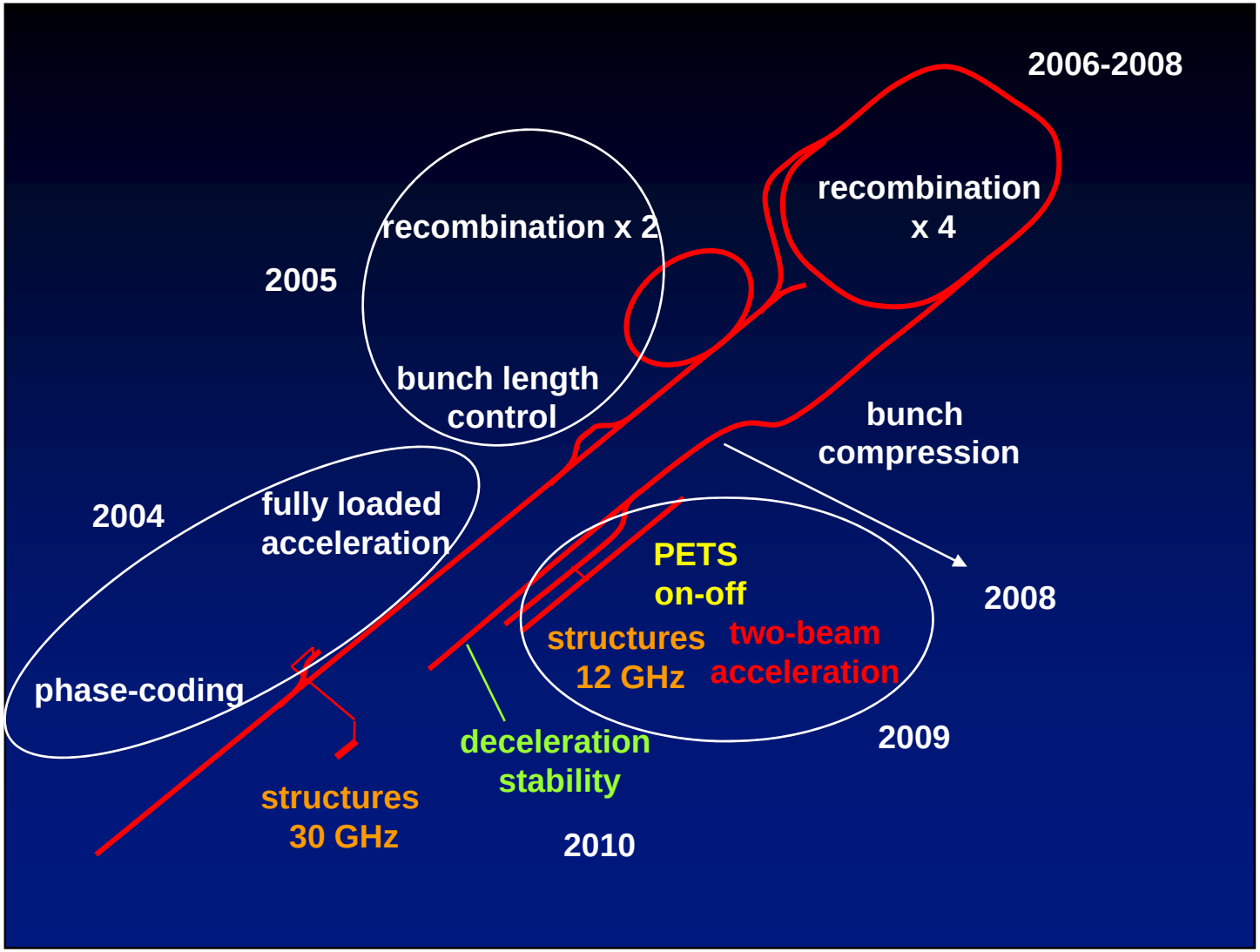




CR Model Validation
Focusing of combined function bends

- Insufficiently precise modeling of combined function magnets for magnetic lengths for quadrupolar component is shorter then for dipolar one
  - We inherited the model of those magnets from EPA in which the 3rd way of the magnet modeling was chosen
    - However EPA had 16 of them in the ring, and CR has 12
    - Although all parameters were scaled accordingly and it should work for CR equally well as for EPA
- The modeling with the straight forward (1st) way give slightly better results
- Lowering k1 by 10% compares better with the model




2006-2008
recombination x 2
2005
recombination
x 4
bunch length
control
bunch
compression
2004
fully loaded
acceleration
PETS
on-off
2008
structures
12 GHz
two-beam
acceleration
phase-coding
2009
deceleration
stability
structures
30 GHz
2010

Plans beyond 2009

- Prove CLIC RF power source scheme:
  - Drive Beam acceleration
    - Full beam loading – 95% efficiency
  - Bunch recombination
    - Reach nominal current ~ 30 A
    - Combination factor 2 x 4
  - Two-beam acceleration of test beam in relevant sub-unit
    - 100 MV/m with beam
    - TBTS in CLEX
  - Power production in PETS
    - 12 GHz, 135 MW, 240 ns, TBTS & TBL
- Provide RF power to validate CLIC components (less important after frequency change to 12 GHz):
  - Accelerating structures, RF distribution, PETS
    - Stand-alone 12 GHz power source