Beam loss experience from CTF3

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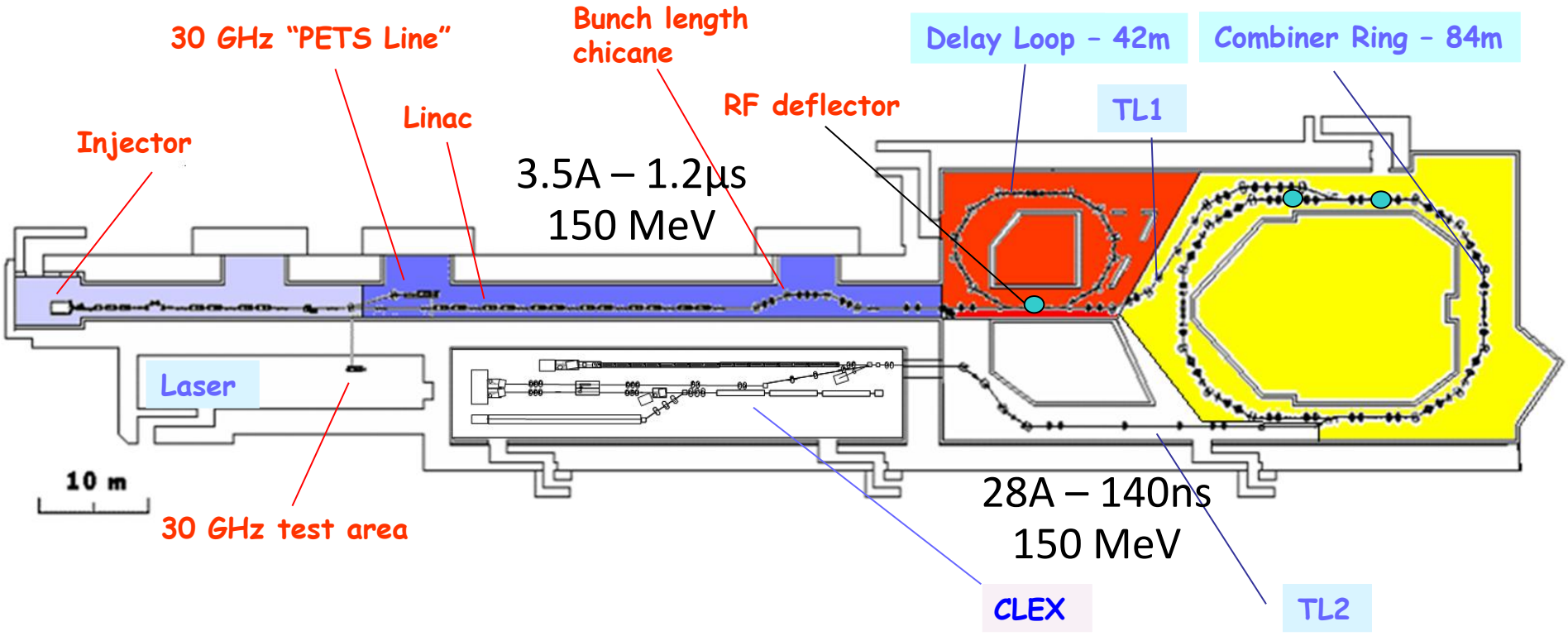
for the CTF3 Team

- Introduction
- Transient/steady state/accidental losses
- Radiation issues
- Interlocks
- RF breakdown kicks

CTF 3 – CLIC Test Facility

- demonstrate CLIC RF power source Drive Beam generation (fully loaded acceleration, bunch frequency multiplication 8x)
- Test CLIC accelerating structures
- Test power production structures (PETS)



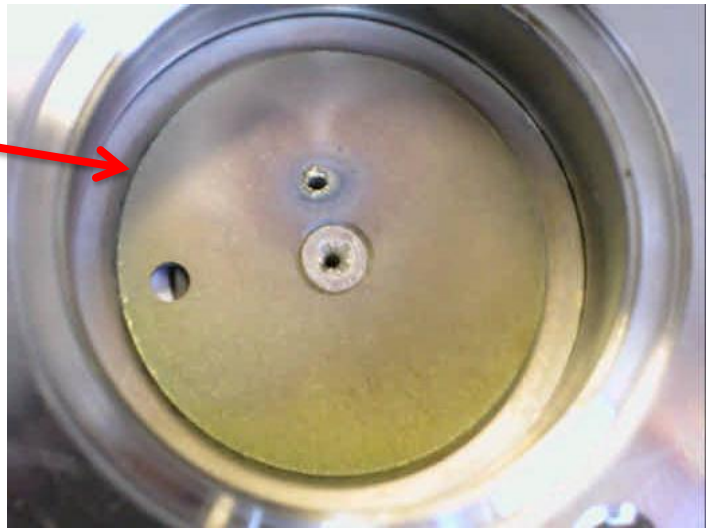
Comparison CLIC - CTF3

	CTF3	CLIC
Energy	0.150 GeV	2.4 GeV
Pulse length	1.2 µs	140 µs
Multiplication factor	2 x 4 = 8 (DL + 1 CR)	2 x 3 x 4 = 24 (DL + 2 CR)
Linac current	3.5 A	4.2 A
Final current	28 A	100 A
RF frequency	3 GHz	1 GHz
Deceleration	to ~50% energy	to 10% energy
Repetition rate	up to 5 Hz	50 Hz
Energy per beam pulse	0.7 kJ	1400 kJ
Average beam power	0.6 kW (@ 0.8Hz)	70 MW

- CTF3 covers well the CLIC drive beam generation scheme
- Still considerable extrapolation to CLIC parameters
- Especially total beam power (loss management, machine protection)
- CTF3 entry in HHGG: **MOSTLY HARMLESS!**
  (Hitch Hiker's Guide to the Galaxy)

Accidental losses

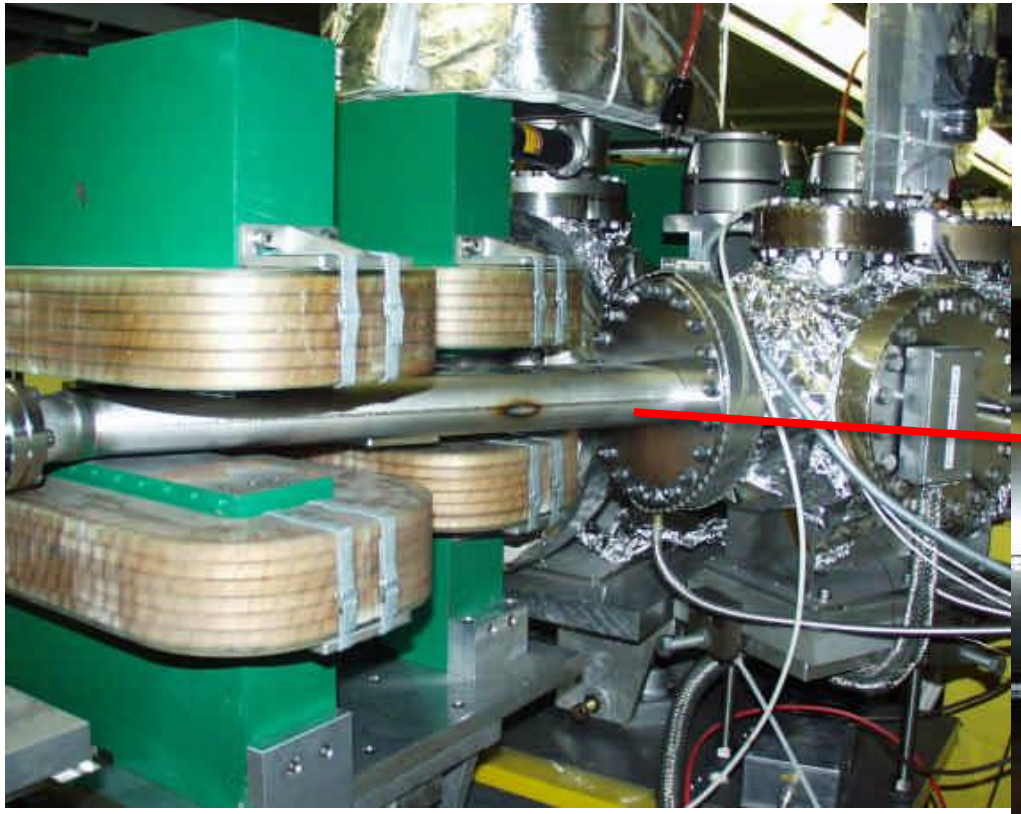
- running at higher beam power with up to 50Hz lead to some damage in the past (several kW of beam power)
- here a vacuum valve (CL.VVS0412)

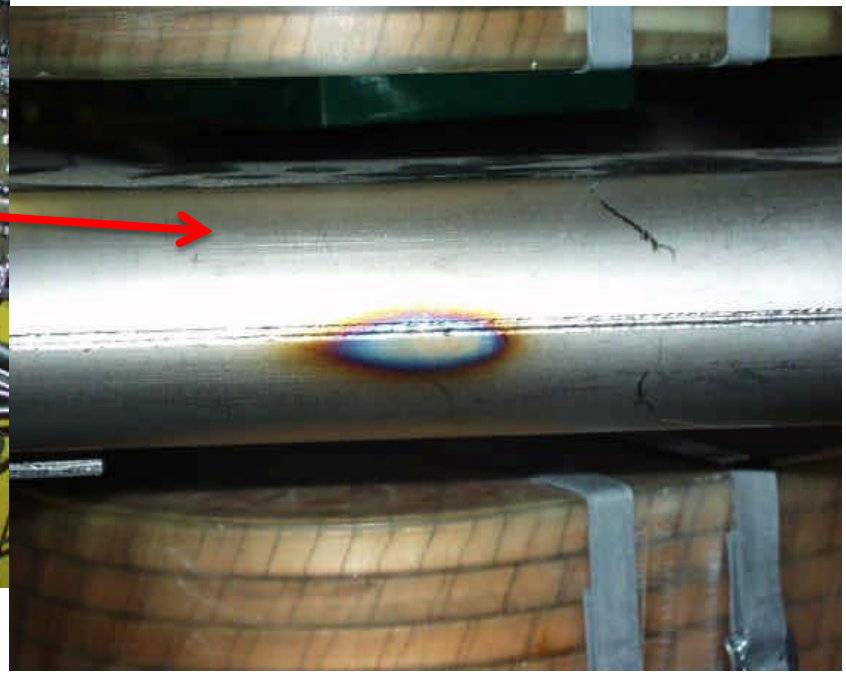


Accidental losses (2)

- Damaged a bellow with high dark current from the gun

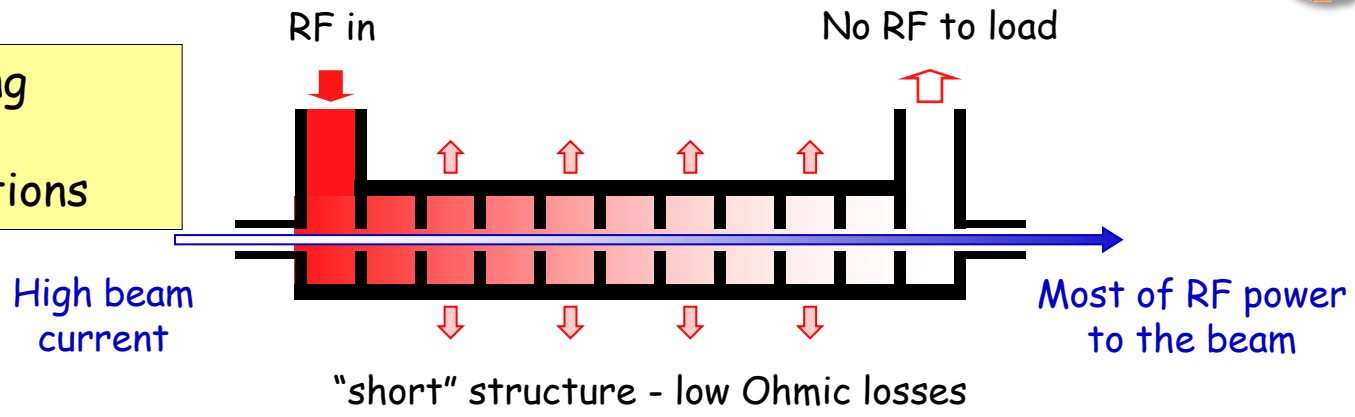
- Signs of heating the vacuum chamber in the spectrometer line



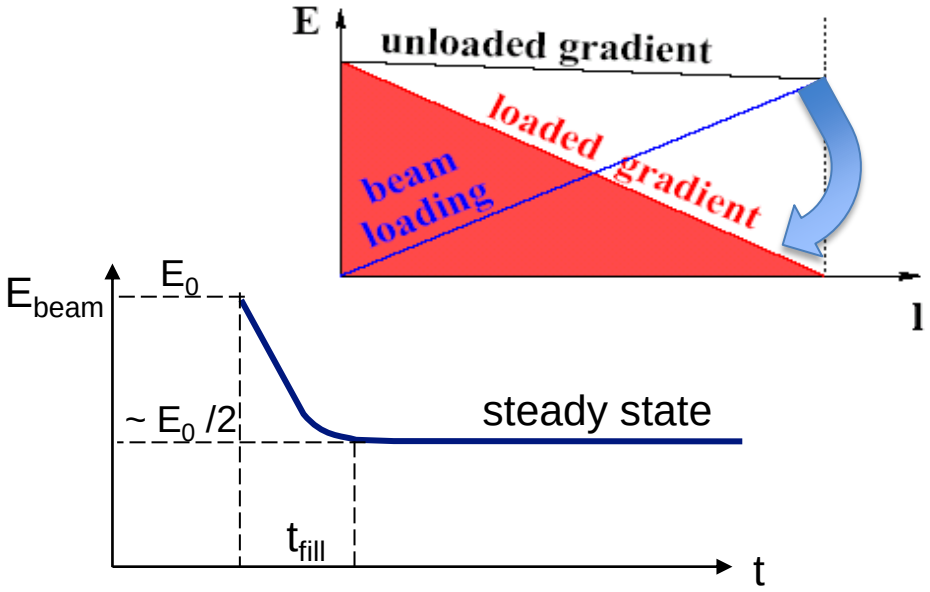


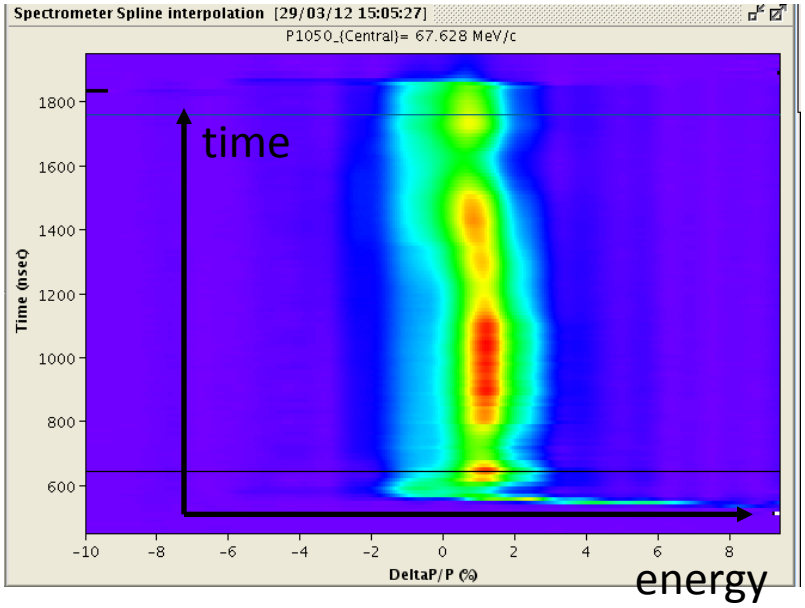
Fully loaded linac operation

Full beam-loading acceleration in traveling wave sections



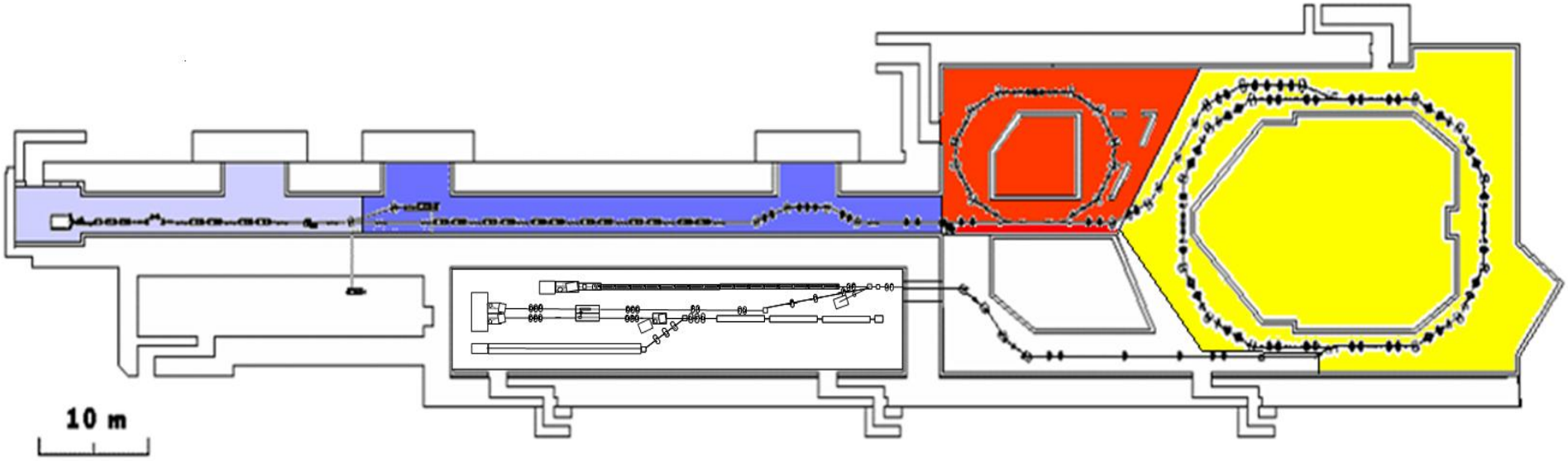
- The start of the beam pulse receives a different energy gain
- Steady state after ~cavity fill time





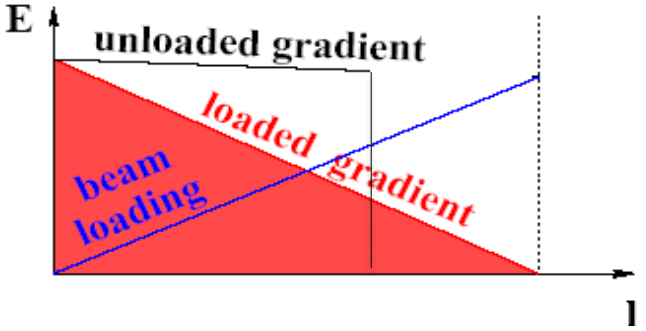
Loss of transient

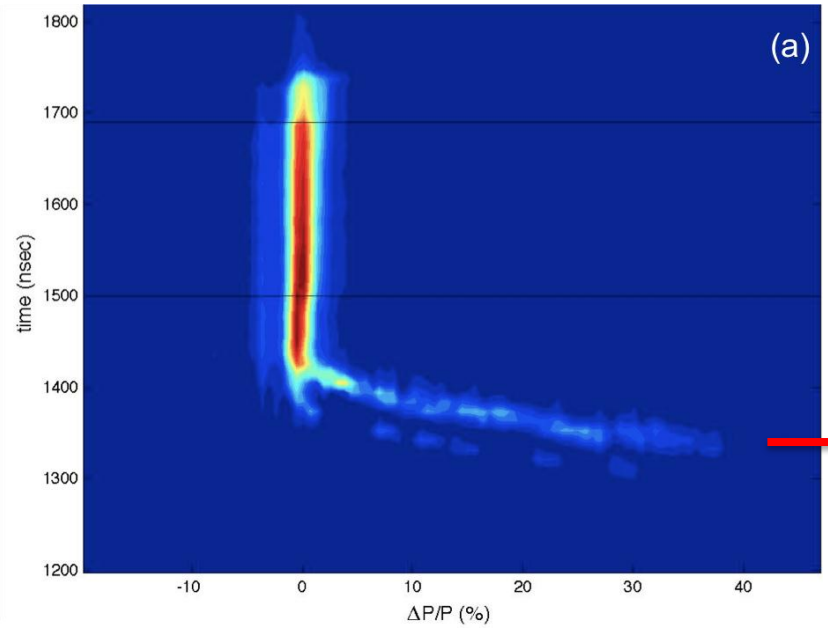
- Transient gets lost mainly at dispersive sections (chicanes, DL,…)
- Some losses along the linac when collimator wide open (not default)
- No collimator in the end-of-linac (Frascati) chicane
  => gradual losses of the transient in the DL or TL1
- CLIC needs proper ‘cleaning’ of the transient (kicker, collimators)

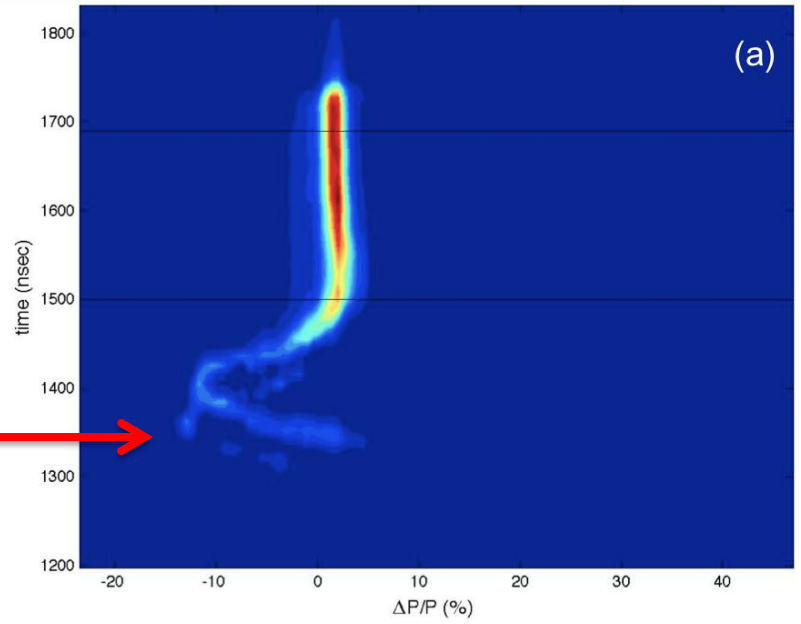


Transient reduction

- 'Delayed filling' of the RF structures can reduce the transient
- Principle: the travelling wave accelerating structure is only partially filled with RF when the beam passes
- energy gain can be shaped
  => transient efficiently reduced

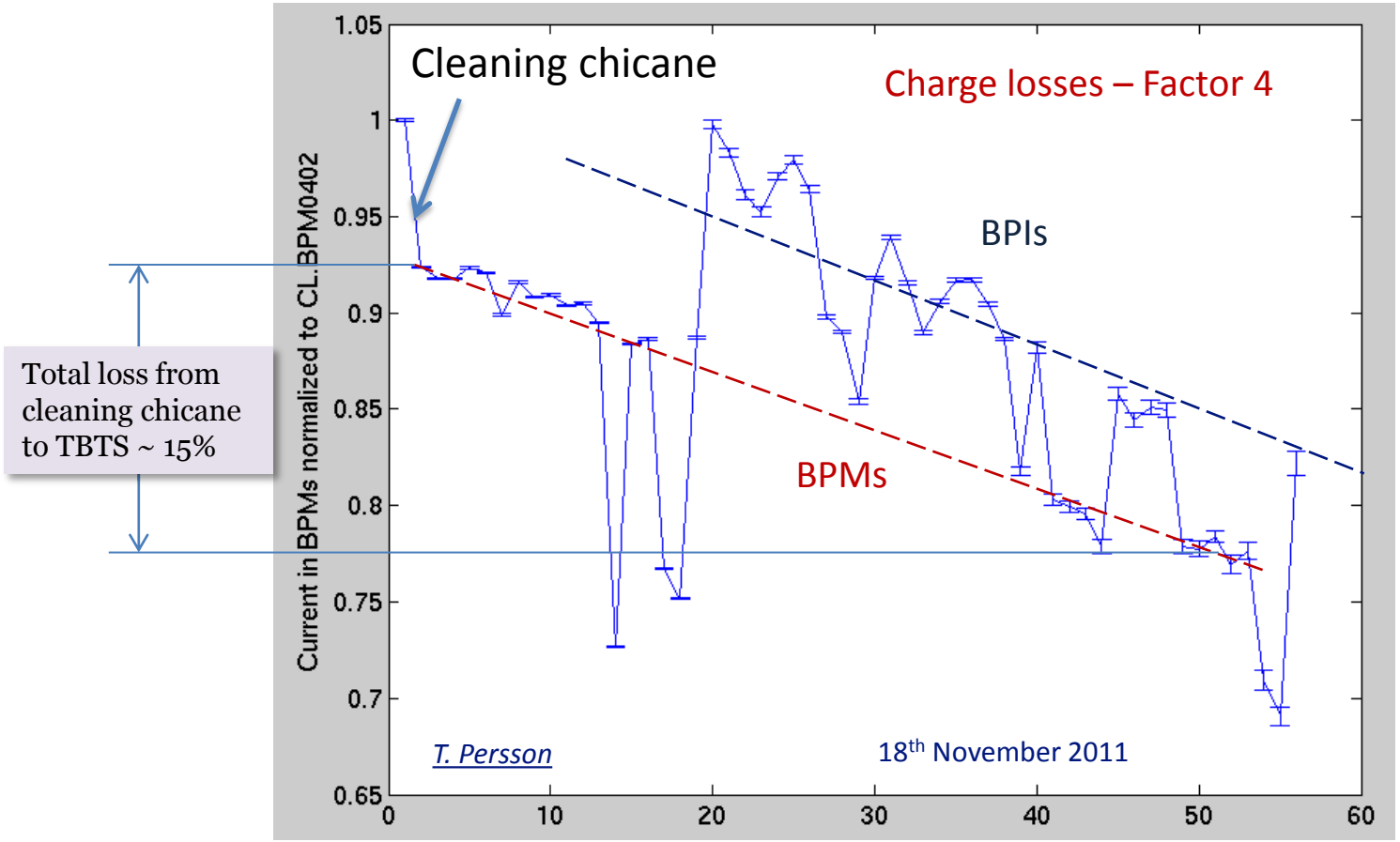




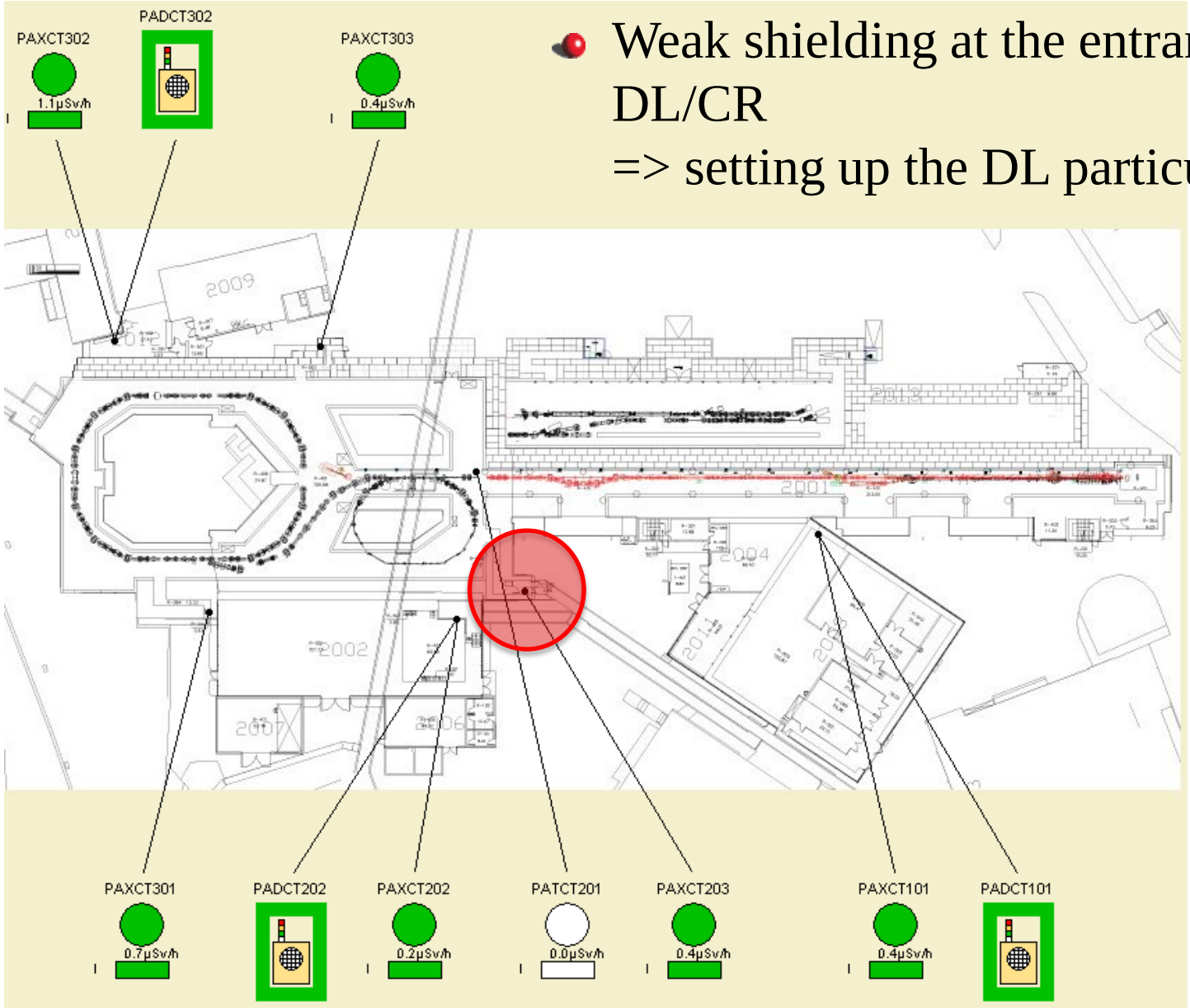


Steady state beam losses

- Also steady state losses along the machine
- Estimation not precise (different BPM types/electronics)

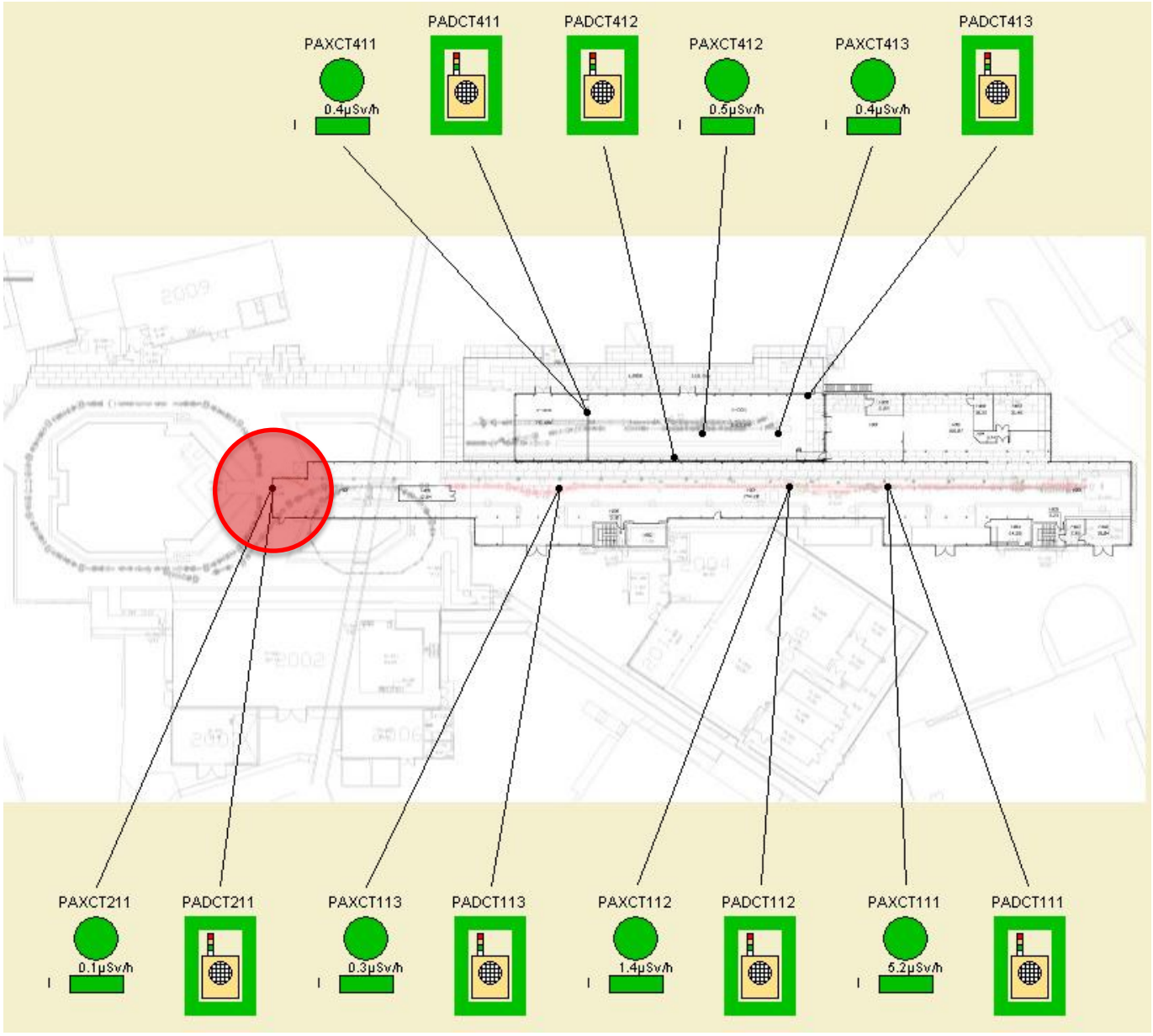


Radiation issues



- Weak shielding at the entrance door of the DL/CR
  => setting up the DL particularly difficult
- => shorter beam pulse for setting up the DL
- Remarks:
- using existing buildings
- radiation limits went down over the years

Radiation issues



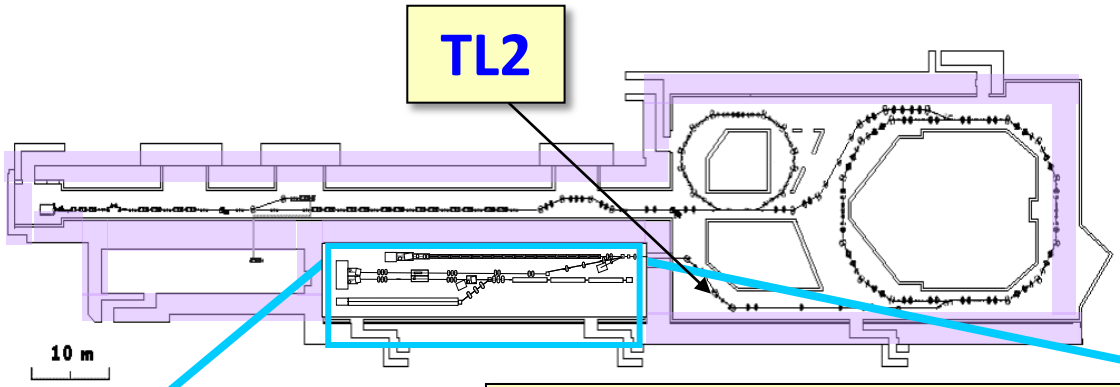
- Weak shielding at the end of the klystron gallery => setting up the DL/CR/TL2 can be difficult
- Limits the repetition rate for CTF3 operation

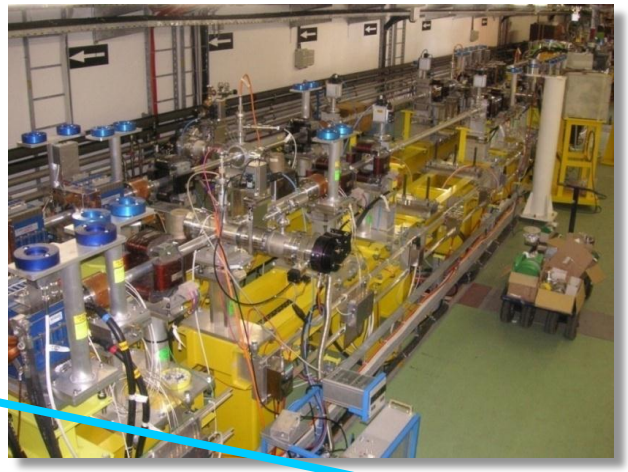
Beam Interlocks

- Beam losses are in general not critical
- no intra-pulse interlocks
- interlocks to reduce beam losses and radiation (mostly software):

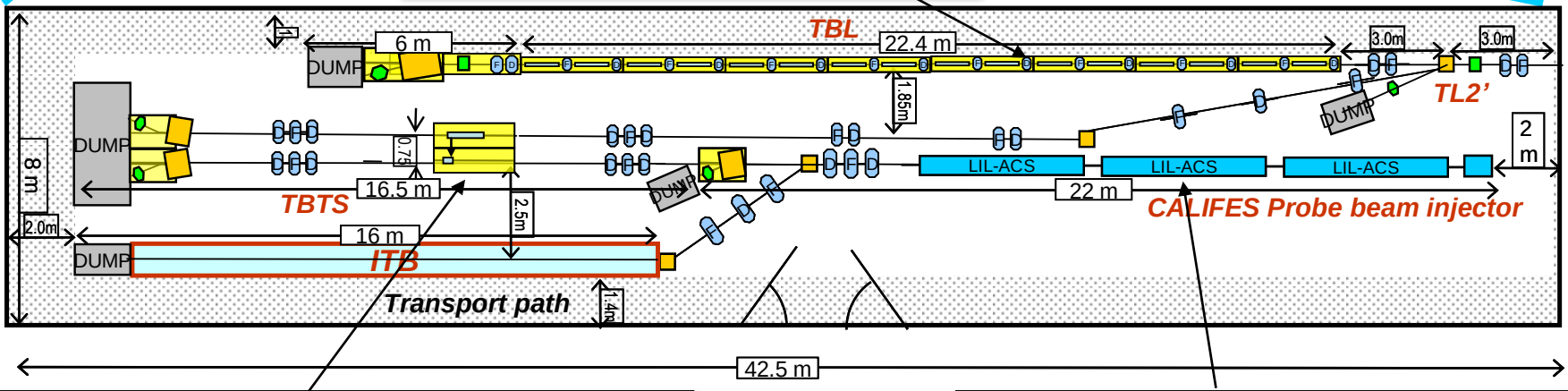
- RF -> Gun interlock (PLC)
  - when a klystron is not pulsing, the gun trigger is disabled
- Radiation level interlock
  - when a radiation level is above a certain threshold, the gun is disabled
- Beam current interlock
  - when the beam current falls below a give threshold, the gun is disabled
- Vacuum valve interlock (HW)
  - when a valve in the beam path is closed, no beam is possible
- Repetition rate interlock
  - rate limit based on beam destination

CLEX (CLIC Experimental Area)





Test Beam Line - TBL

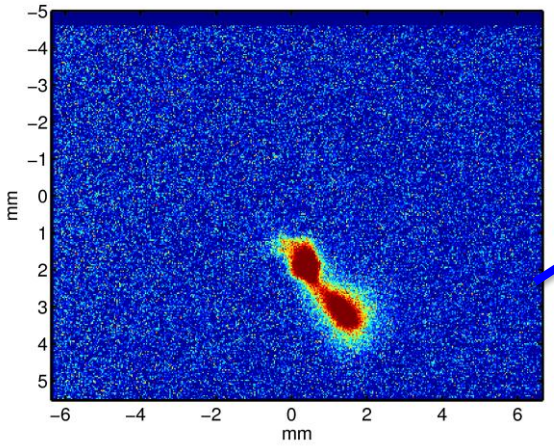


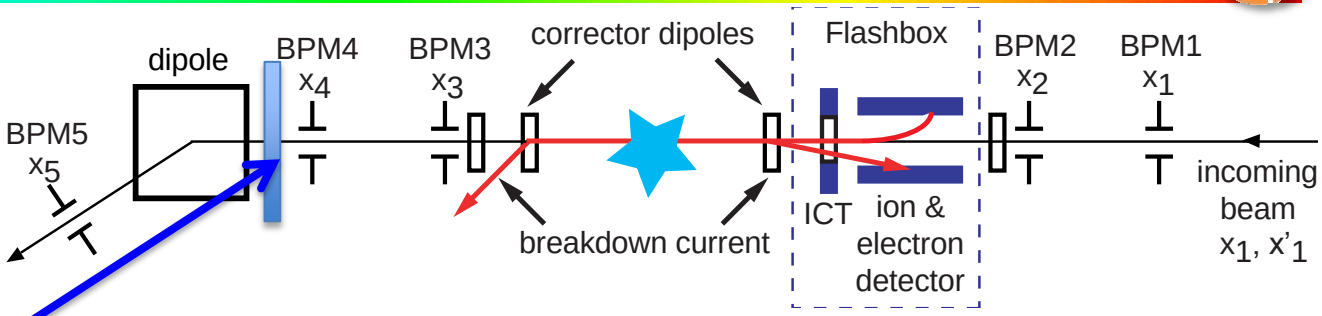
Two Beam Test Stand - TBTS

Probe Beam - CALIFES

- tests for power production, deceleration and two-beam studies

TBTS beam kick measurements





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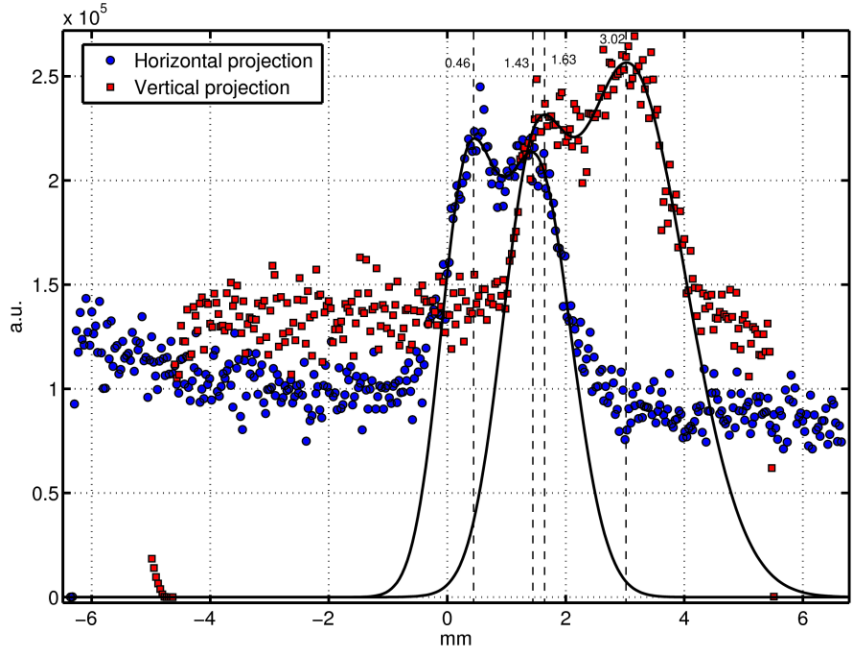
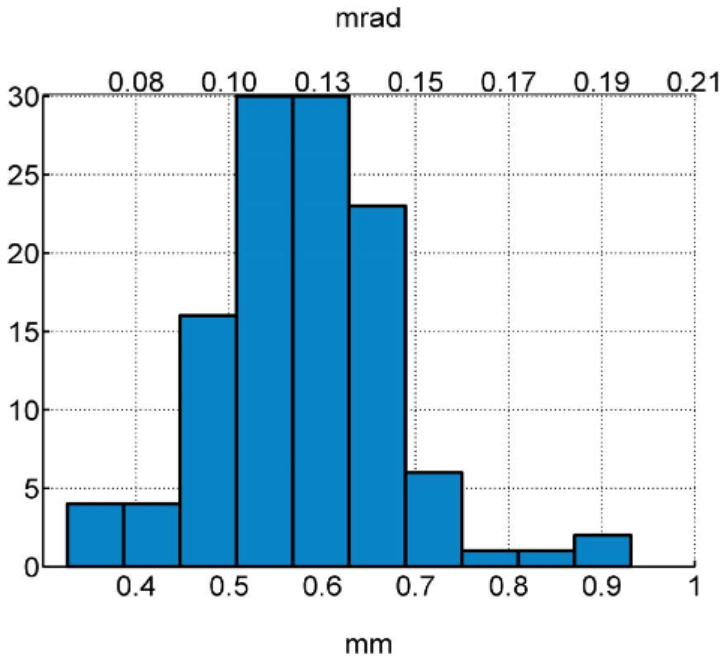


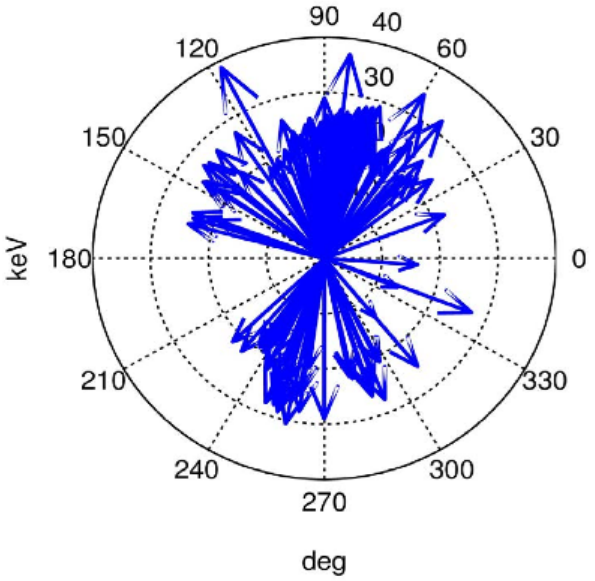
- Measured on OTR screen CA.MTV0790 (~4.9 m from the accelerating structure).
- 2-Gaussian fit on the screen
- Analysis on ~170 BD events

TBTS beam kick measurements

kick magnitude
(typically 0.13 mrad)



transverse electric field
(typically 25 keV)



- kicks corresponding to transverse momentum between 10 and 40 keV/c
  (measurements at NLCTA < 30 keV/c)
- more data with BPMs this year…

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- Thank you very much!

- Further questions?