LHC Machine Protection Meeting
September 13th, 2013
CERN, Geneva, Switzerland

Redundant collimator position limits versus IP separation

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Acknowledgments: R. Bruce, G. Valentino, J. Wenninger

Outline

- ☑ Introduction
- ☑ Status of implementation
- ☑ Strategy for new limits
- ☑ Conclusions

Introduction

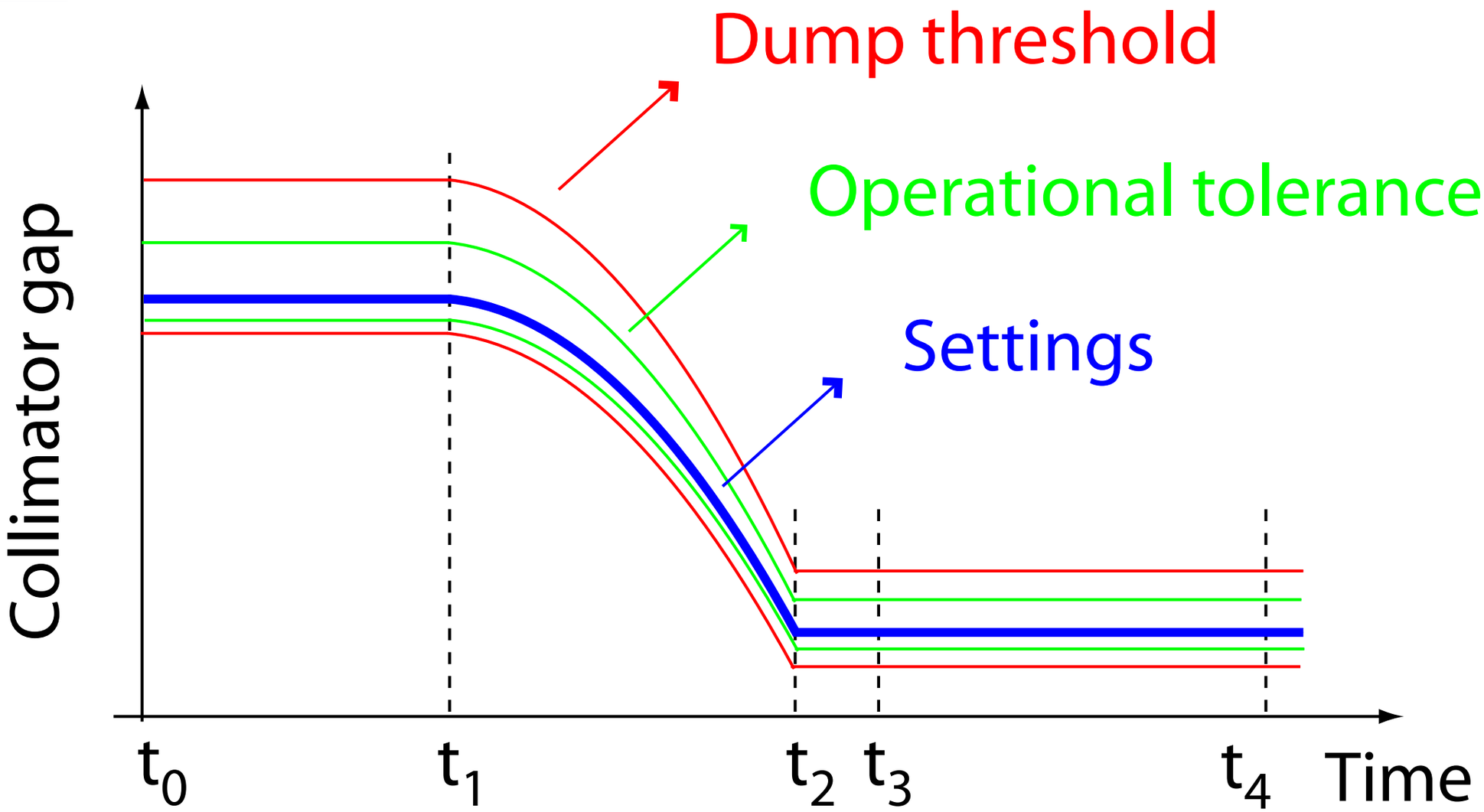
	N	Team	Step. motors	Discrete settings	Function settings	Timing card	Time limits	Energy limits	Beta* limits	"Redundant" limit	Temp. intrlck
LHC coll	96	STI	X	X	X	X	X	X	X		X
TCDQ	2	ABT		X	X	X	X	X	X		
TDI	2	STI	X	X		X	X				
XRP	32	PH / ICE	X	X			X			X	

There is an impressive amount of interlocks used for the collimators in the LHC!

Aim: Minimized the risk of damage by dumping the beams if the system(s) detects incorrect positions.
"Internal system interlocks" are mandatory because beam measurements (individual BLMs, beam loss patterns, ...) often CANNOT detect dangerous situations.
E.g.: collimator at wrong position only hit in case of asynchronous dump.

Why are we considering new redundant limits?

Preset interlock strategy



- Two regimes: discrete ("actual") and time-functions *(internal clock at 100 Hz)*
- **Inner** and **outer thresholds** as a function of **time** for each motor **axis** and **gap** (24 functions per collimator). Triggered by timing event (e.g. start of ramp).
  "Double protection" → BIC loop broken AND jaw stopped
- Redundancy: **maximum allowed gap versus energy** (2 per collimator: OUT)
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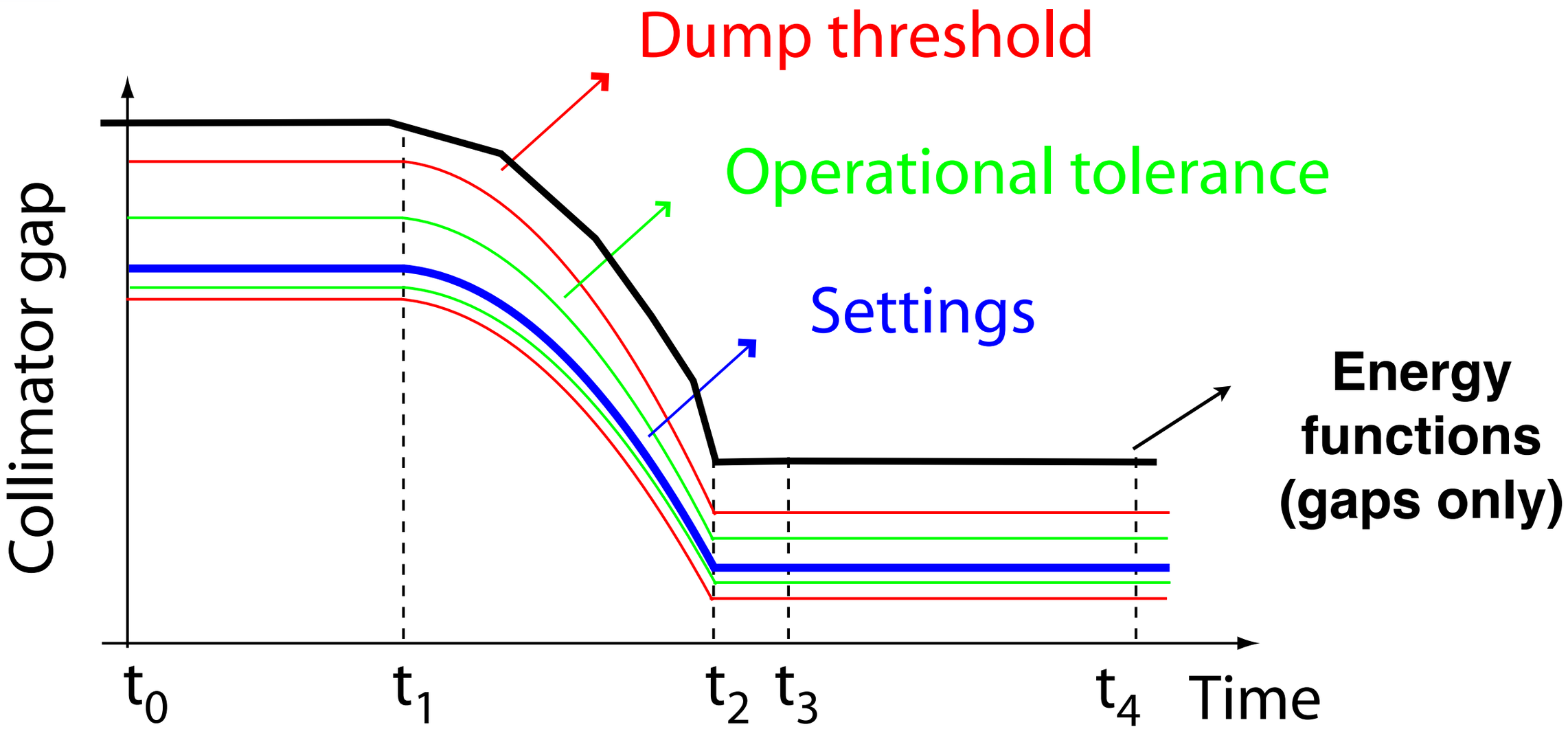

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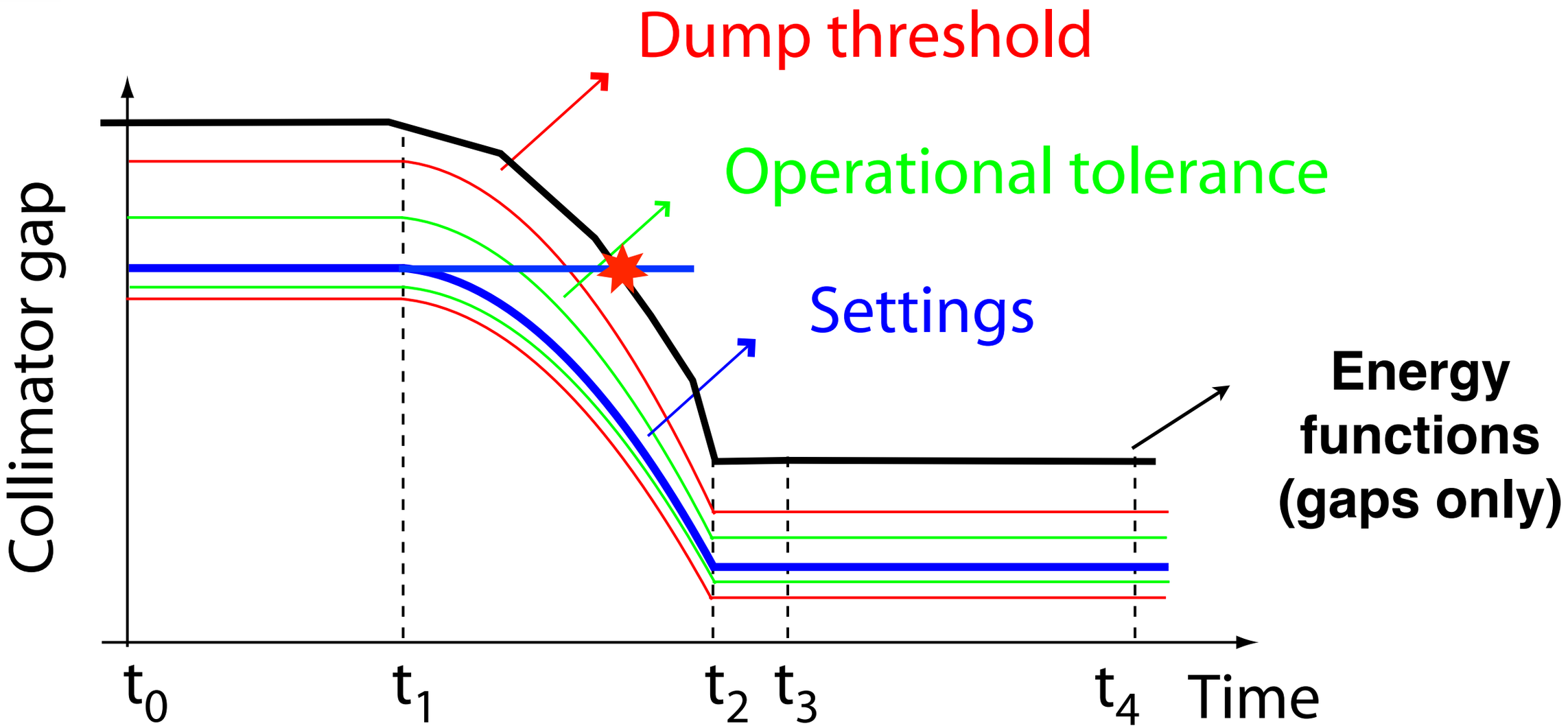

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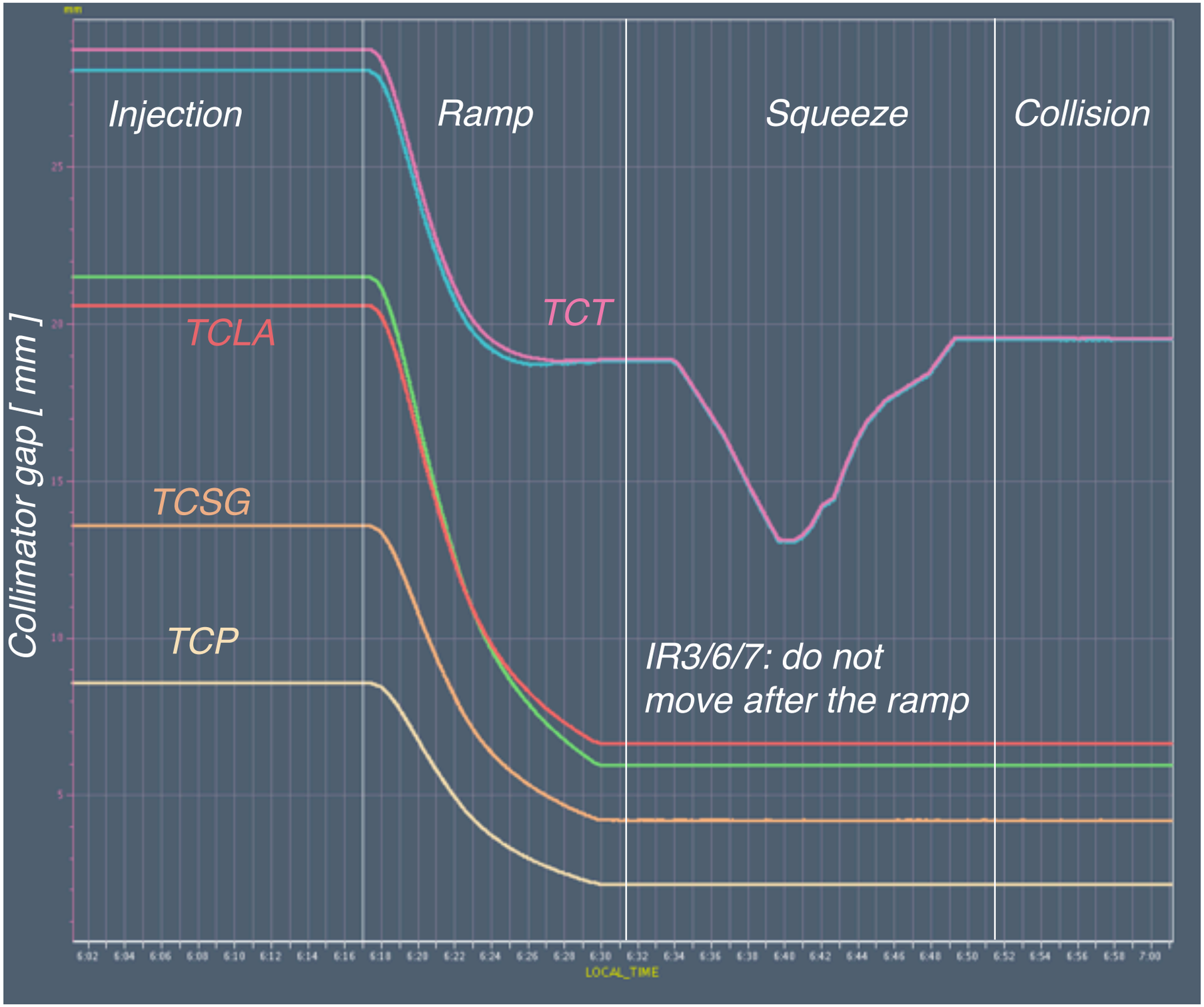
Collimator settings per family



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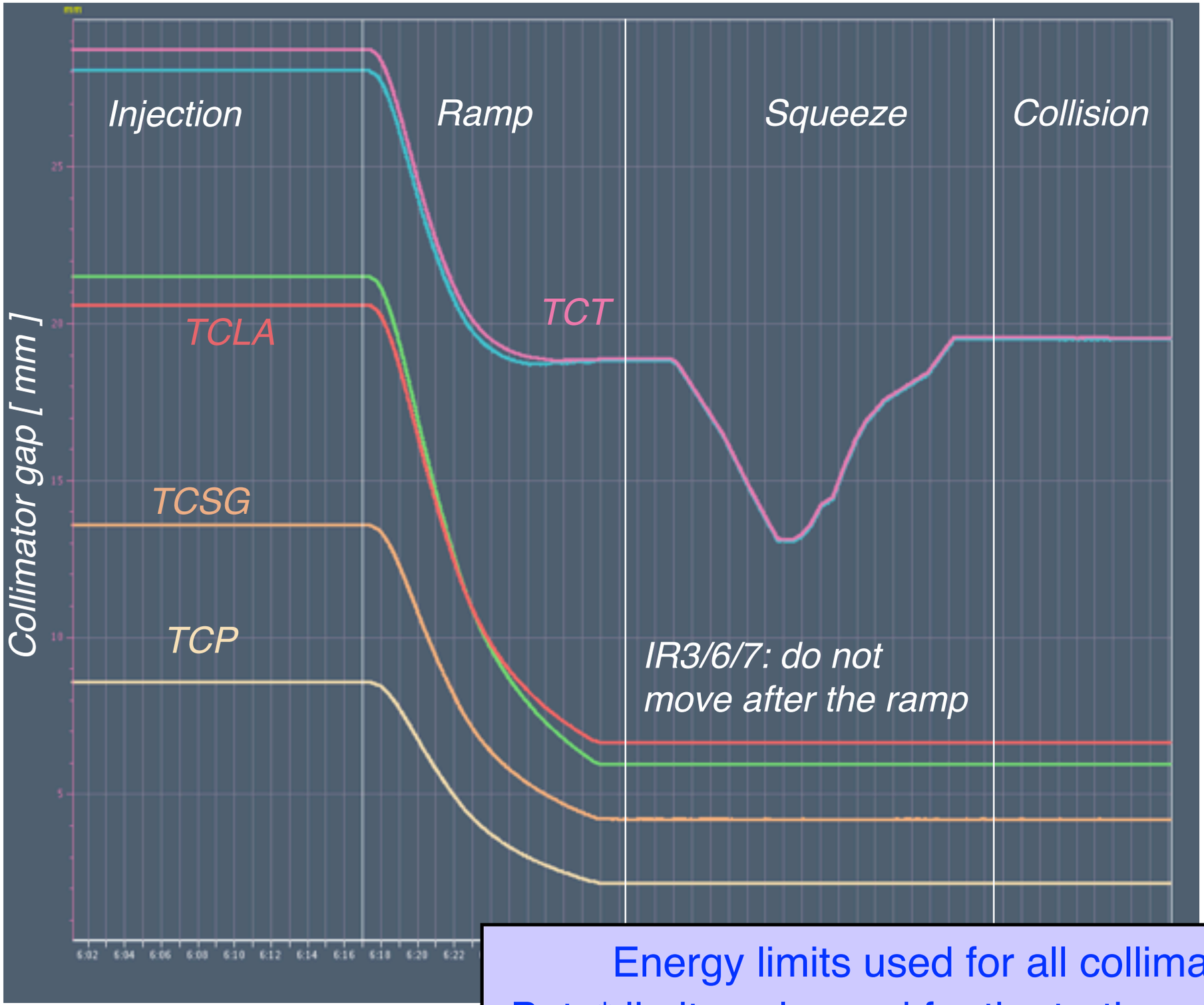
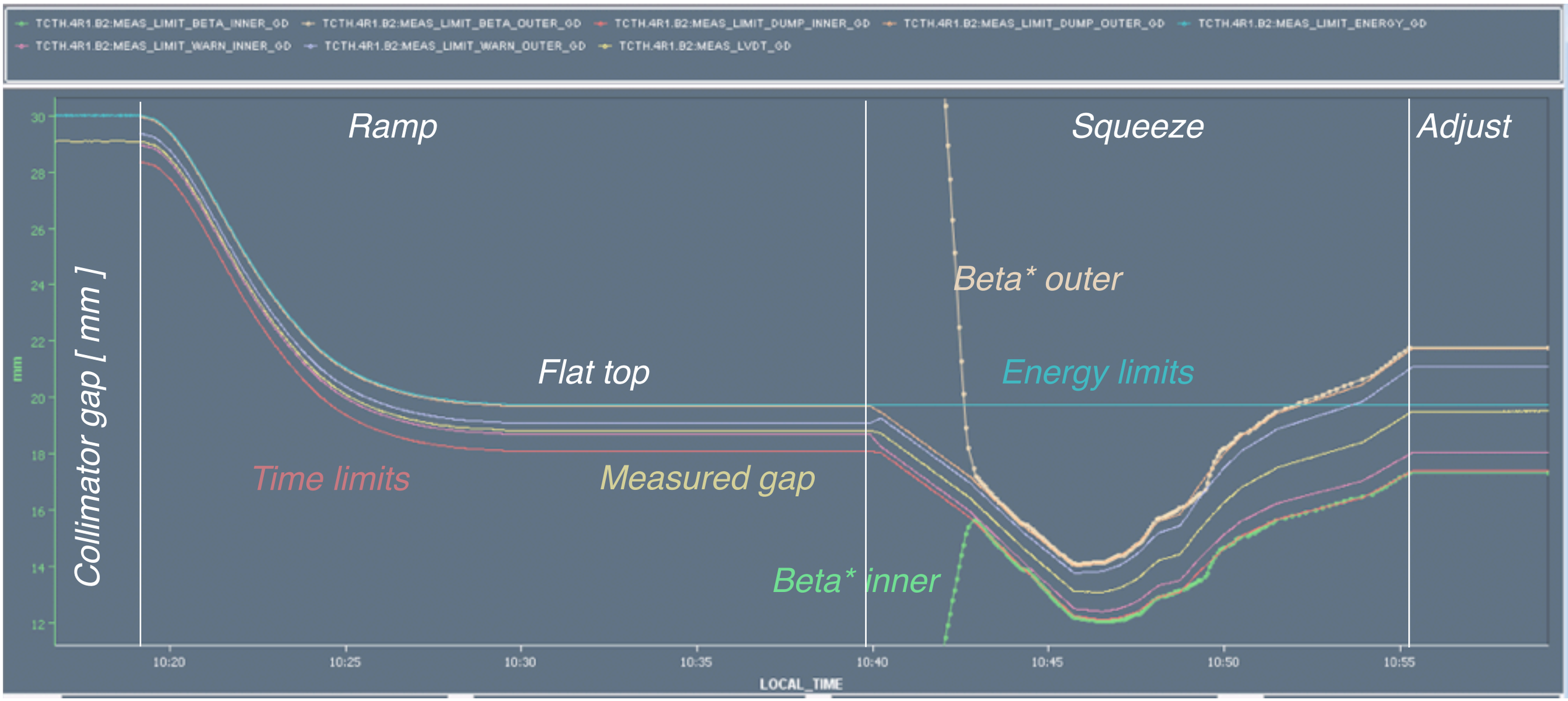


Energy limits used for all collimators.
Beta* limits only used for the tertiary collimators
(active but set to parking for other families).

Interlock limits in practice...



Energy limits active already at injection:

- Prevent injection of unsafe beams if collimators are open!
- Test at every fill the interlock chain, when collimators go to parking.
- They dump the beams if a collimator does not start ramp functions.

Beta* limits became active for the TCTs at the first squeeze step to 9m.

Physics: 3 redundant limits (vs time, energy and beta*active at the same time!!

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  Interpolations of limits vs. E and beta are used to compute limits vs time.*

  Independent and safe inputs: if a collimator does not start ramp functions, it will sit happily within its discrete injection limits -> no interlock!

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- As opposed to the standard functions versus time that evolve during each cycle, these limits are **very rarely changed in the hardware** (1-3 controlled changes per year if really necessary).
  - *They do not stop collimator movements if violated: system remains fully operational if these limits are masked (safe intensity MD’s and setups)*
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  - *Protection by reducing of dependance on operational sequences: important because dynamics changes of settings is a weak point of the settings management.*
- To work, this equires a reliable way to compute inputs E(t), beta*(t).
  - *Energy straightforward. Beta* already required much more thinking.*
  - *So far, the reliability of the present system is very good - it must not get worse!*

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  1. *Issue with local timing in IR1 - TCTs did not move as no trigger was received. Standard high intensity proton fill.*
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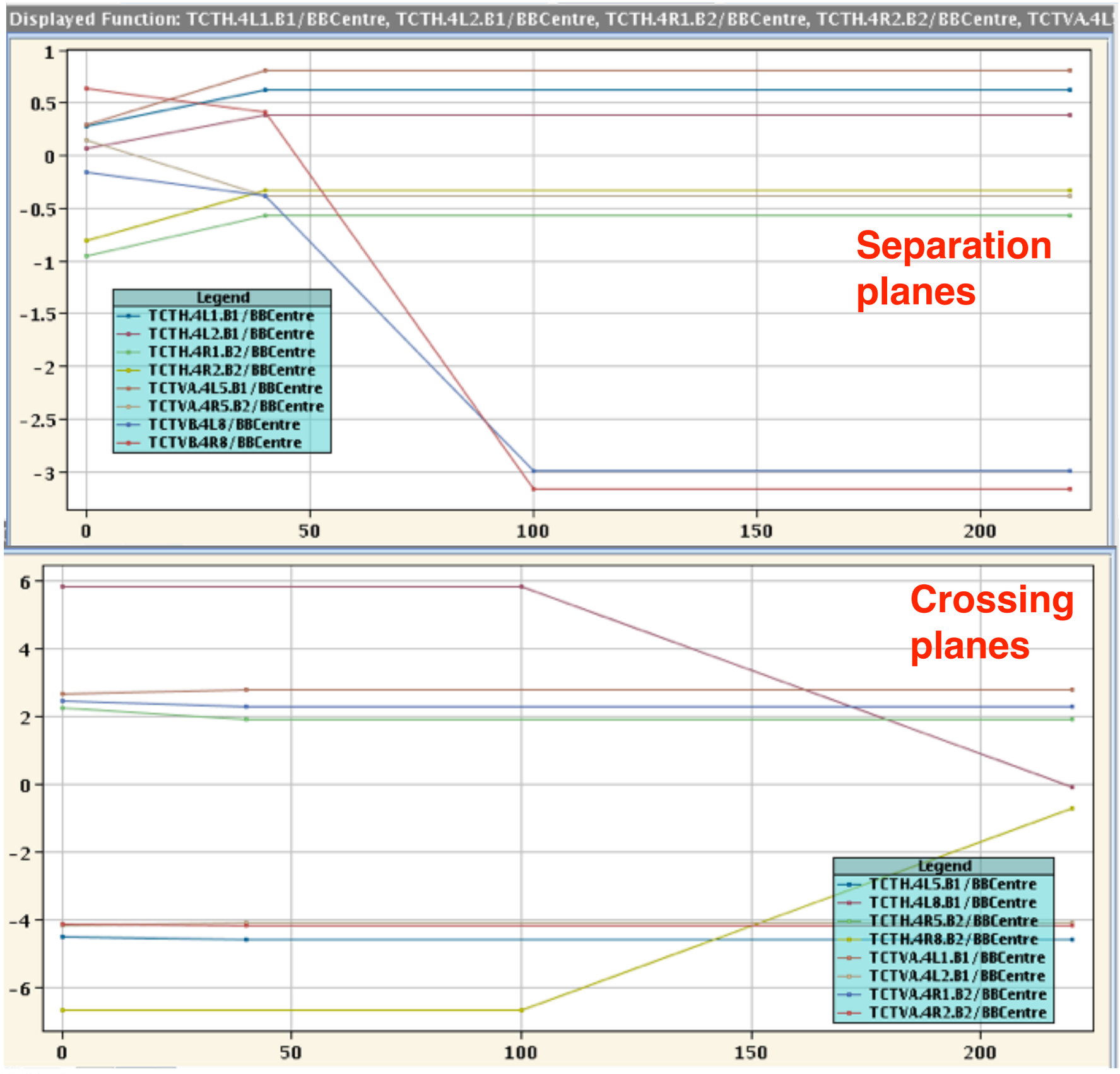
Examples


Displayed Function: TCTH.4L1.B1/BBCentre, TCTH.4L2.B1/BBCentre, TCTH.4R1.B2/BBCentre, TCTH.4R2.B2/BBCentre, TCTVA.4L
Separation planes
Legend
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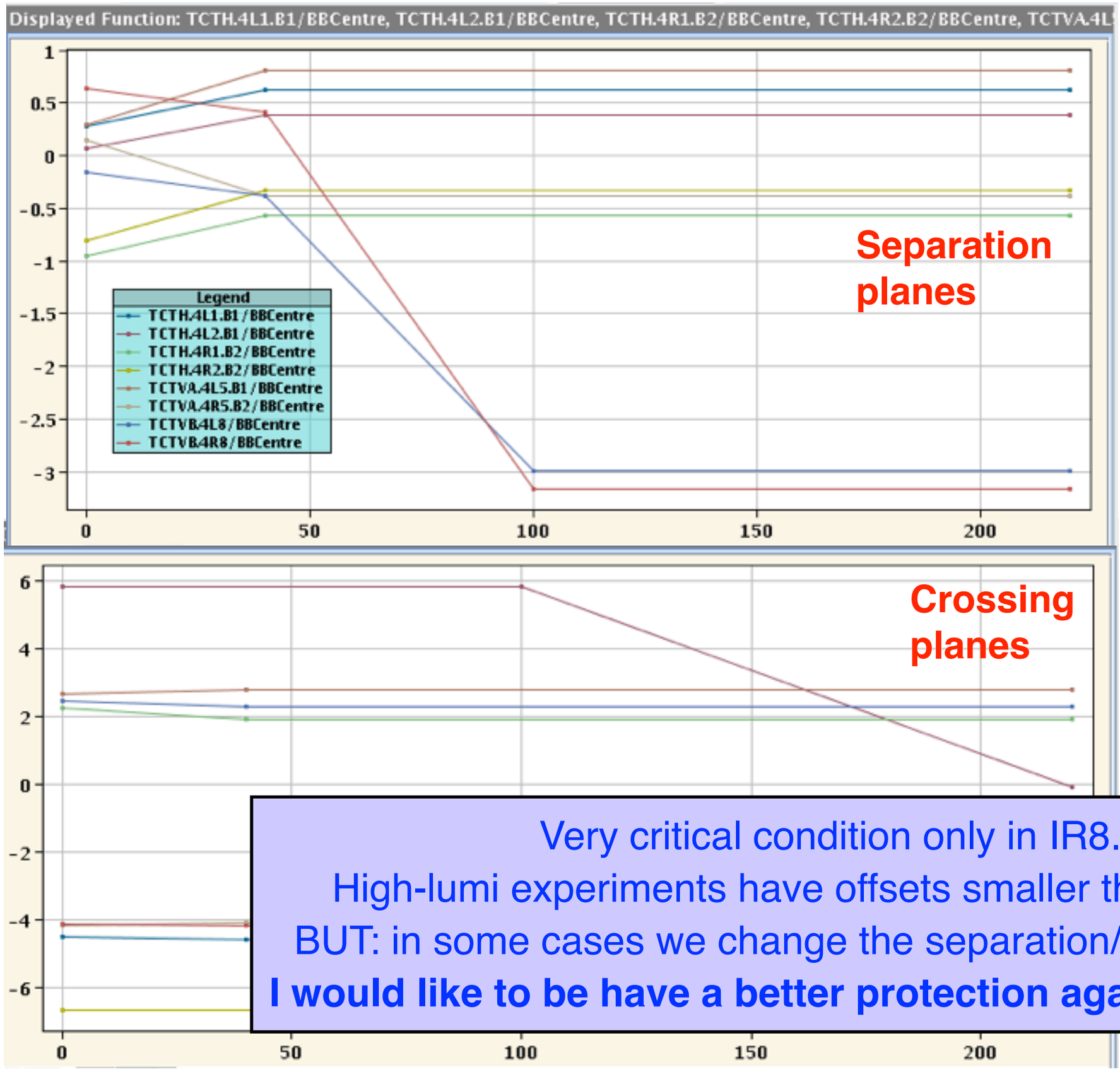

Very critical condition only in IR8.

High-lumi experiments have offsets smaller that 1 sigma.

BUT: in some cases we change the separation/crossing a lot!

I would like to be have a better protection against this case.

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- **Add redundant limits versus separation / crossing**

  Identical redundancy concept as for energy and beta limits*

  Requirements to other systems:

  Need reliably the distribution of separation in the timing.

  Issue with the number of telegrams!

  *Calculation of separation must be independently on the beam process and settings management by the sequencer -> **to be developed***

The implementation does not come for free: new settings parameters, updated machine protection sequences, more commissioning time...

Present strategy

- **We decided to implement the limits in the collimator controls.**
  - *Properties at FESA level for inner and outer limits for 4 jaw corners.*
  - *Assumed a distribution in the timing at 10 Hz.*
  - *Similar interpolation as done for the other energy and beta* limits.*
  - *This was done to freeze the FESA classes in the transition to V3.*
- The limits will be activated by a configuration options.
  - *Only activate them for collimators concerned.*
  - ***Keep one single version of software for cleaning and inj. prot. collimators.***
- We can decide later on about the real deployment:
  - *Status of collimator production: will we have BPM-collimators in all IR's*
  - *News from the timing team...*
  - *News from the reliable calculation of the new required parameters.*
- Obviously, during HW commissioning, the machine protection sequences will be done after configuration of the system in order to exclude wrong configurations.

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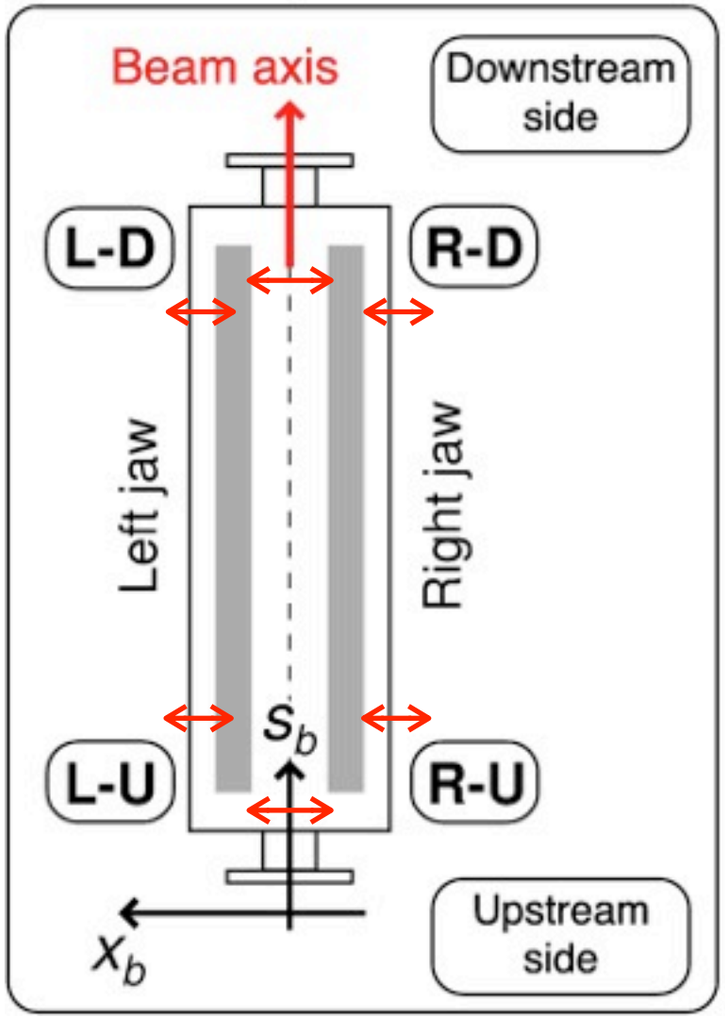
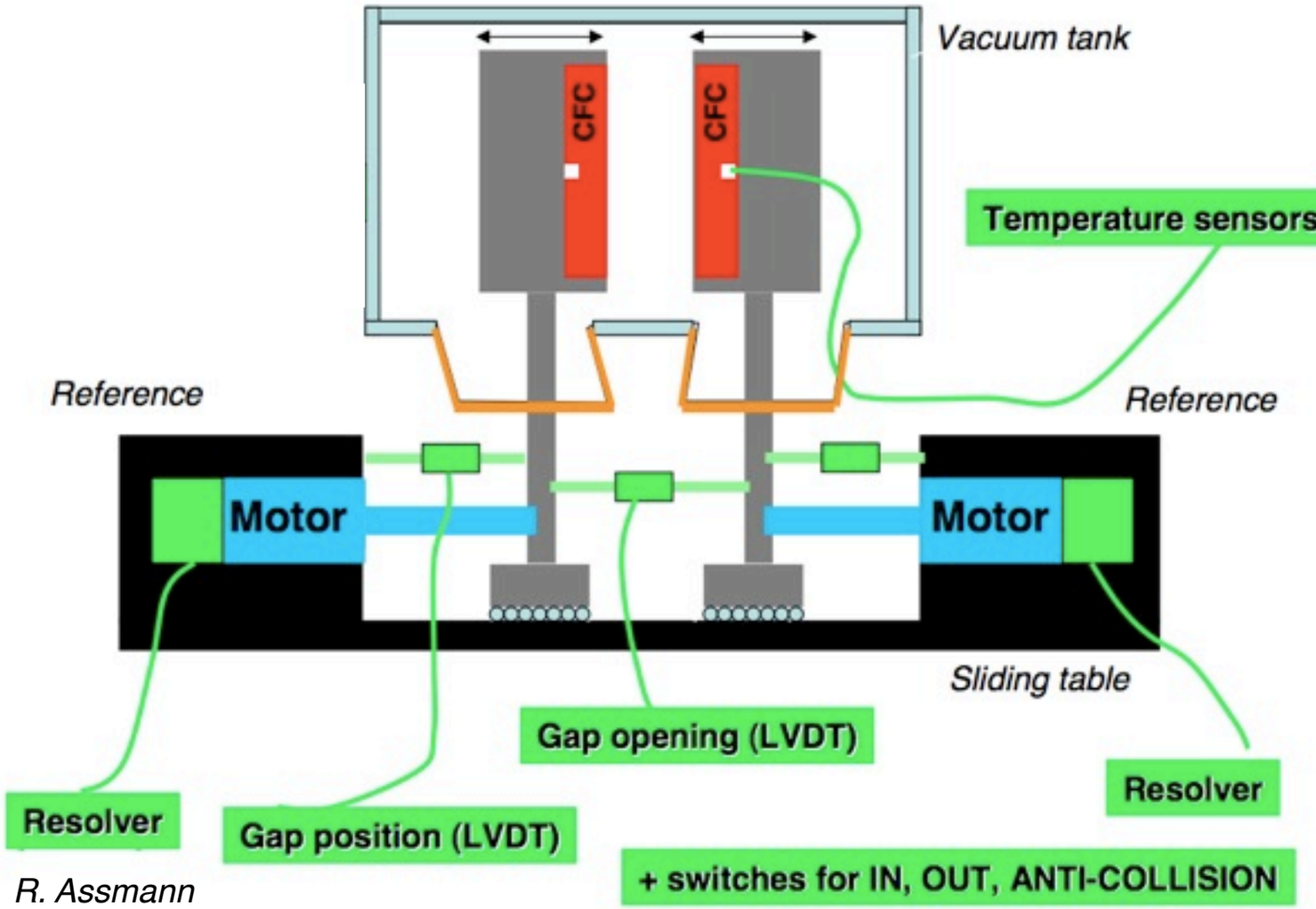
- We propose to take the final decision before the end of the year!

Reserve slides

Collimator controls





R. Assmann

Settings: **4 stepping motors** for jaw corners - 1 motor for tank position.

Survey: 7 direct measurements: **4 corners** + **2 gaps** + tank

4 resolvers that count motor steps

10 switch statuses (full-in, full-out, anti-collision)

Redundancy: motors+resolvers+LVDT's (*Linear Variable Differential Transformer*) =

14 position measurements per collimator

Recap. of settings management

Hypercycle

Users	Beam process
INJ	Injection-BP
RAMP	RampFunction-BP
FLATTOP	FlatTop-BP
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PHYSICS	StableBeam-BP

A simplified view for illustration purposes.

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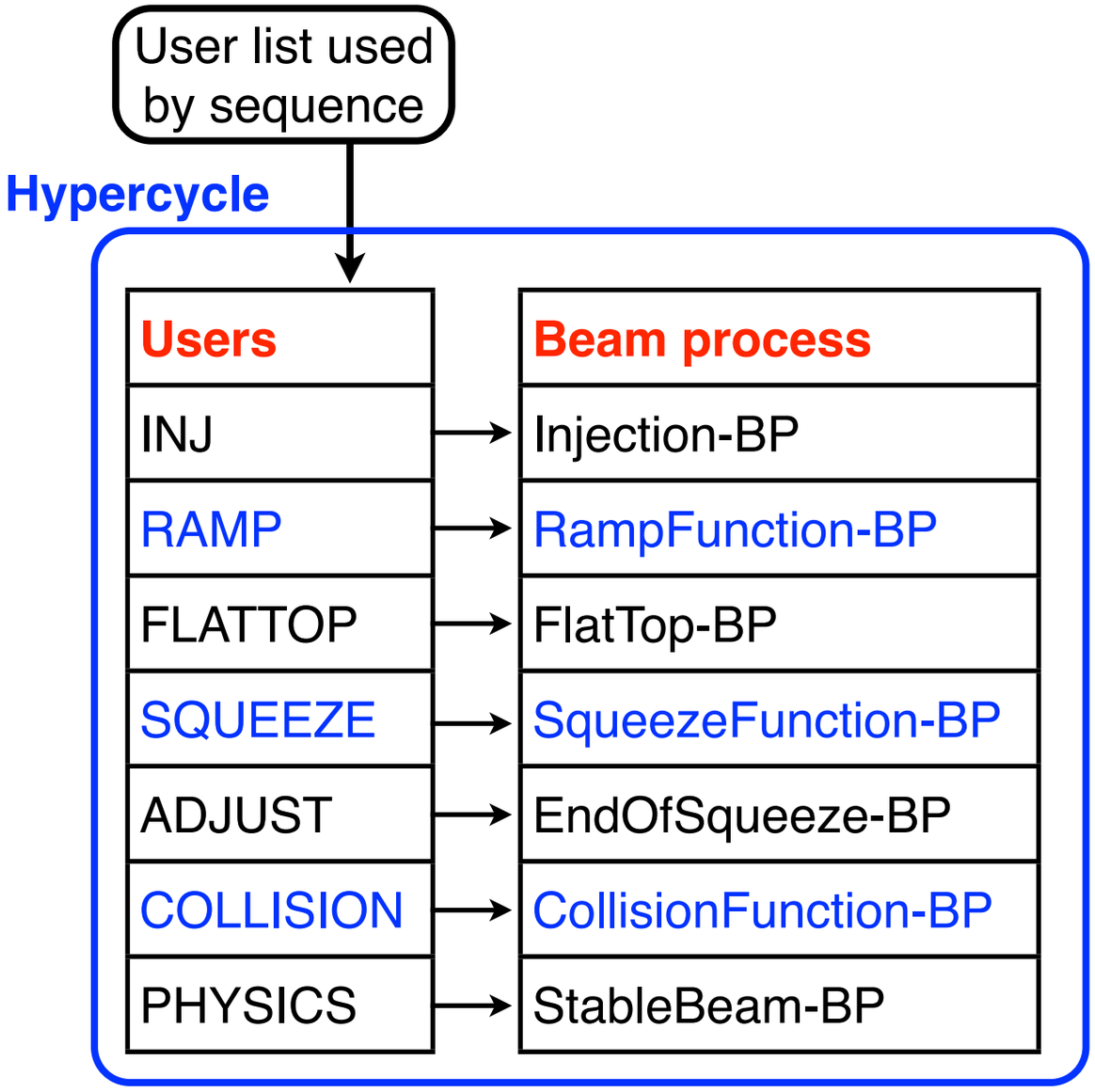

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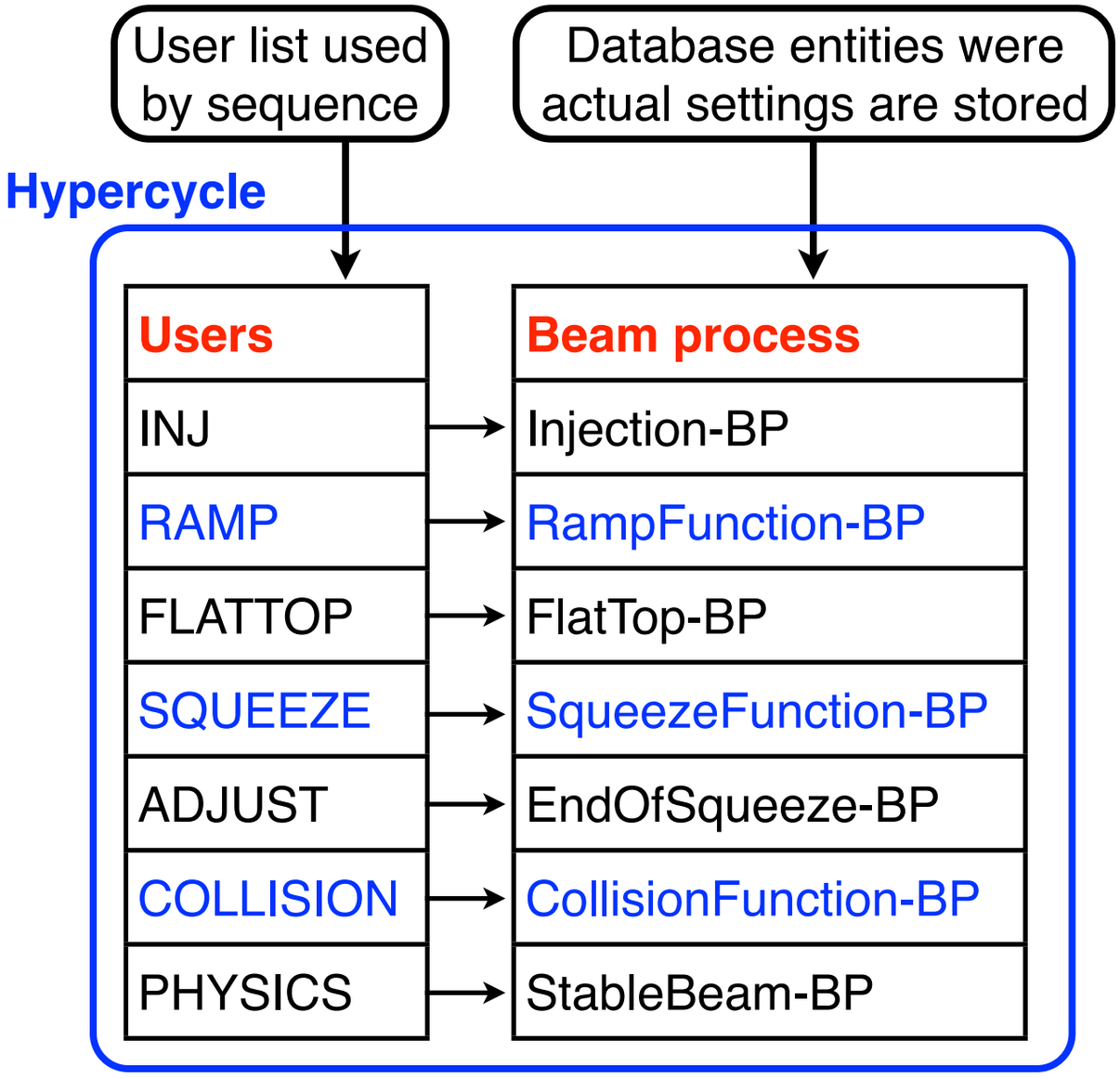

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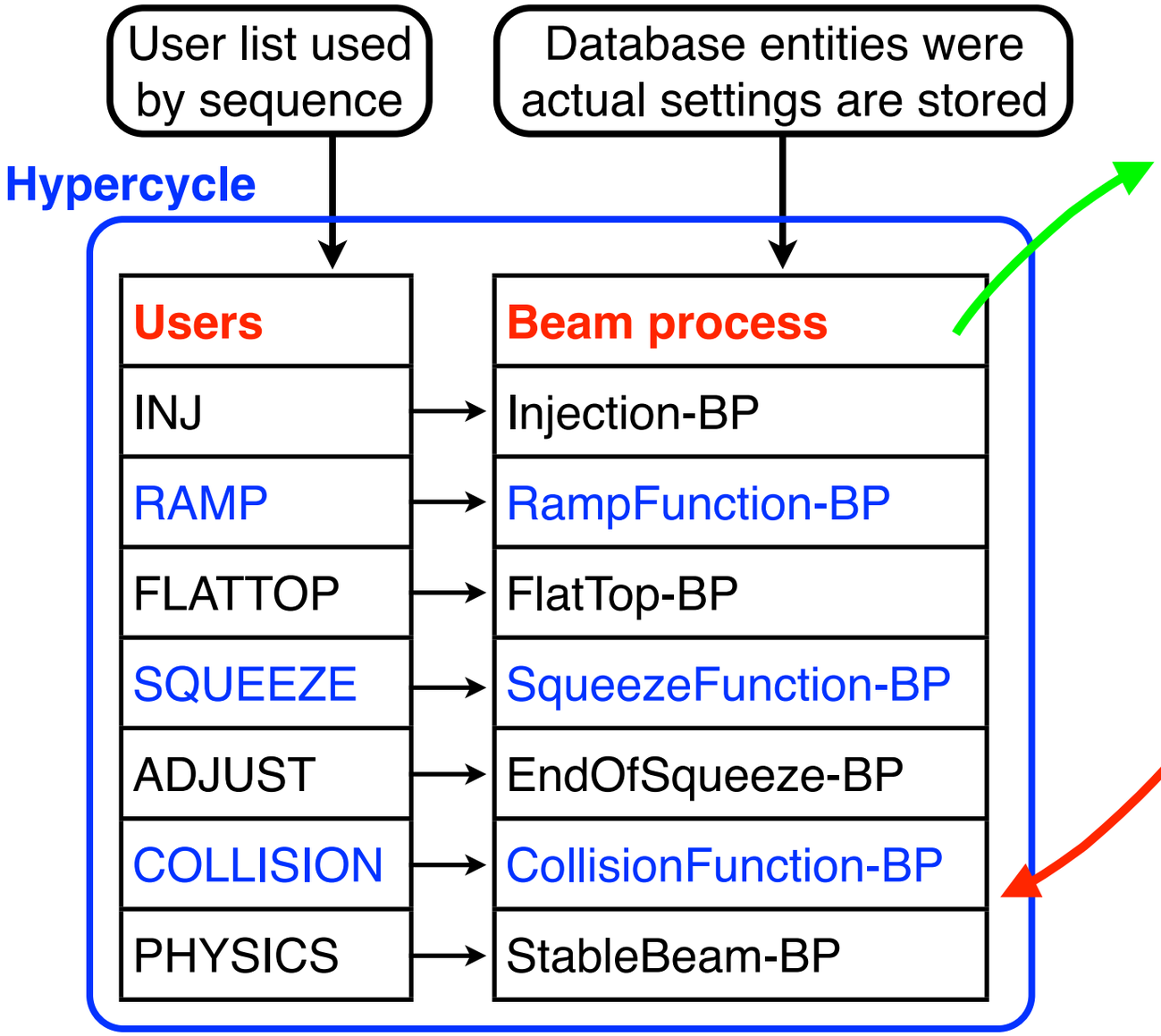

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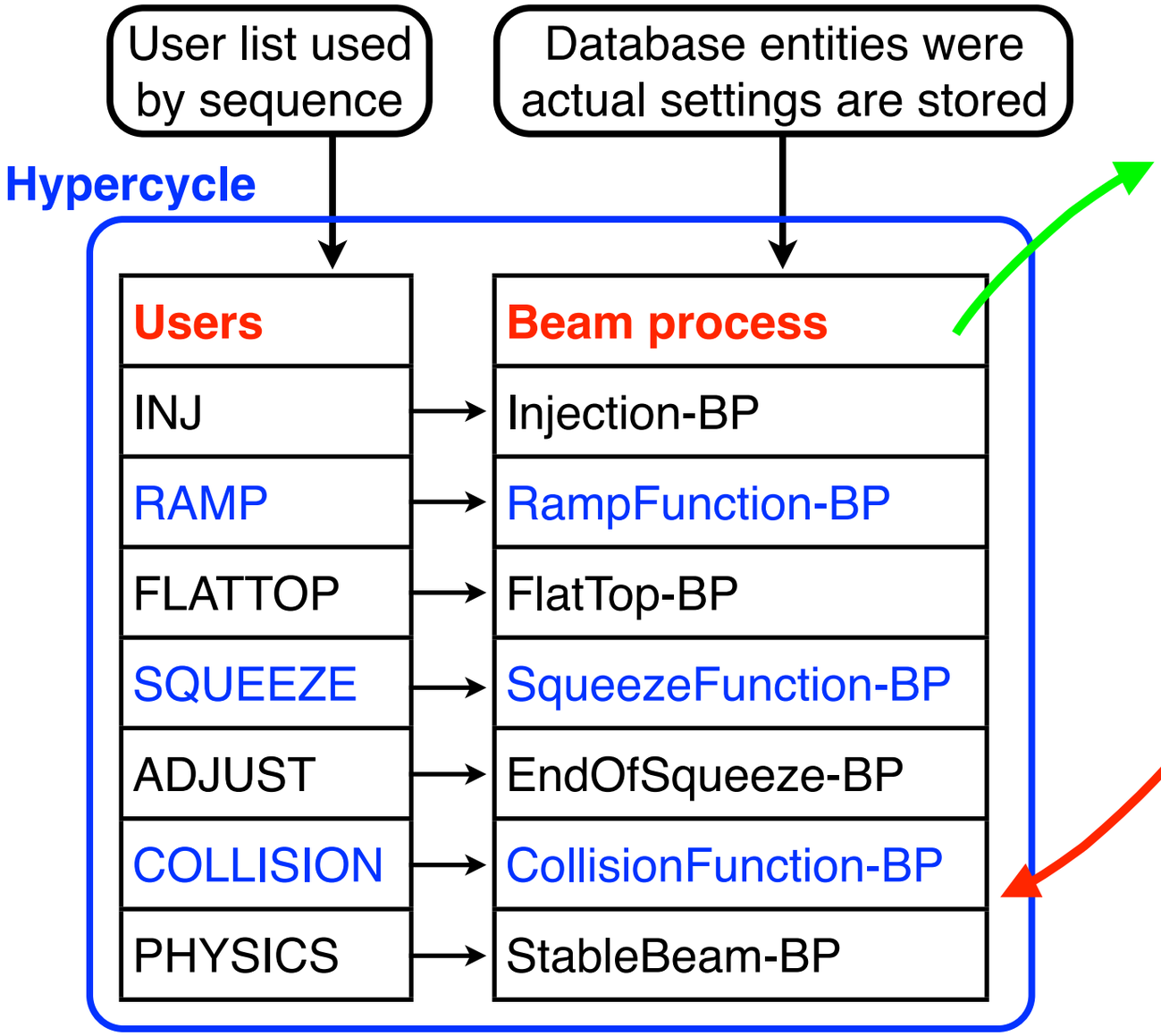

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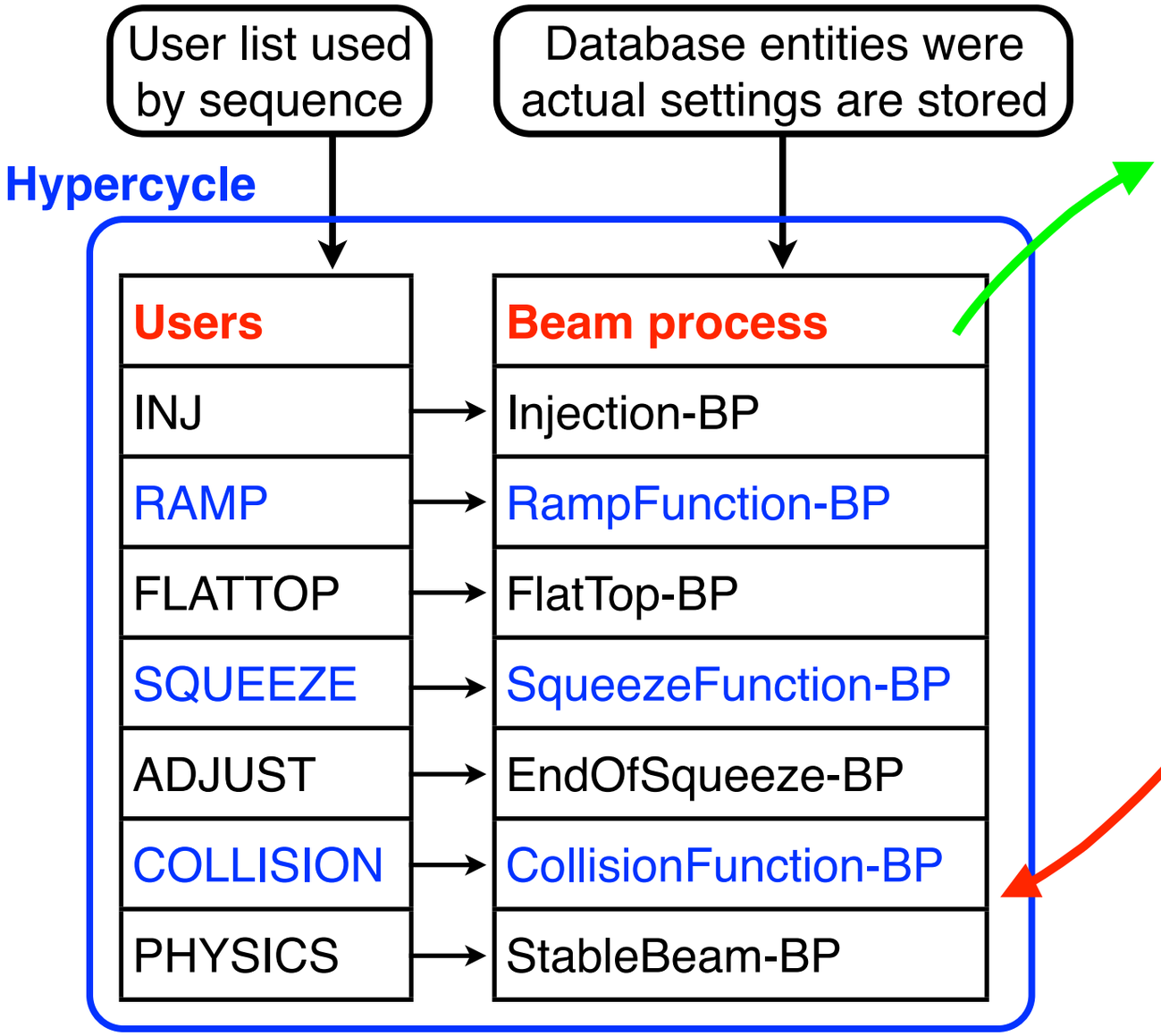

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FlatTop-BP'	FlatTop-BP''
SqueezeFunction-BP'	SqueezeFunction-BP''
EndOfSqueeze-BP'	EndOfSqueeze-BP''
CollisionFunction-BP'	CollisionFunction-BP''
StableBeam-BP'	StableBeam-BP''

Time-dependent settings and limits are stored in beam processes (BPs).

4 people on the world can change the settings of a BP (MCS protected), but...

At any given time, 3-4 people in the CCC can changes the assignment BP↔ user!

"Protection by complexity" for ring collimators, more issues for **injection protection**.

Proposal to add RBAC protection for some BP's - not deployed in 2012.

Redundant limits versus energy and beta* are always resident in the hardware ("discrete BP") and are not changed during the OP cycle (1-3 changes per year!).

This scheme works for ramp and squeeze but it is not in place for collision functions.