

*LHC Beam Operation Committee meeting*

*October 10<sup>th</sup>, 2011*

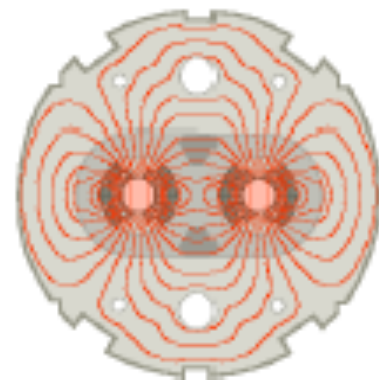
*CERN, Geneva, Switzerland*

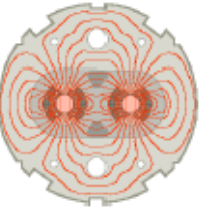
# **Combining ramp and squeeze at the LHC**

***G. Müller, S. Redaelli, N. Ryckx***

***CERN - BE department - OP group***

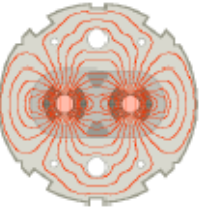
*Input/discussion: Beta-beat team (Rogelio), FiDeL  
(Ezio), OP (Mike), Orbit team (Jörg), CO (Greg)*



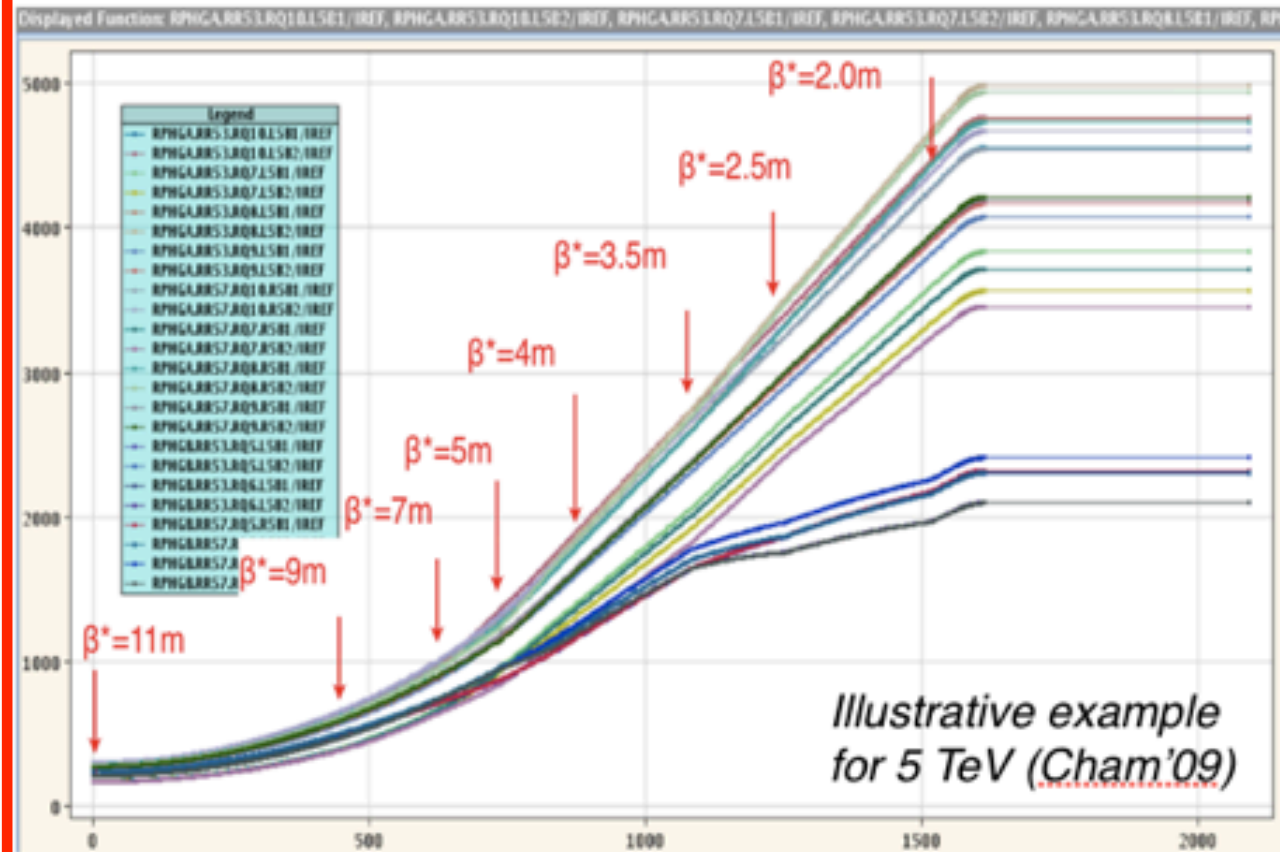
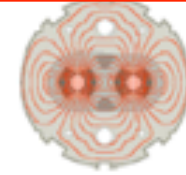


# Outline

- Motivation**
- Recap. of OP cycle**
- Combined Ramp&Squeeze**
- Proposal for beam tests**
- Conclusions**



## Combined ramp&squeeze

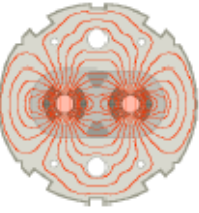


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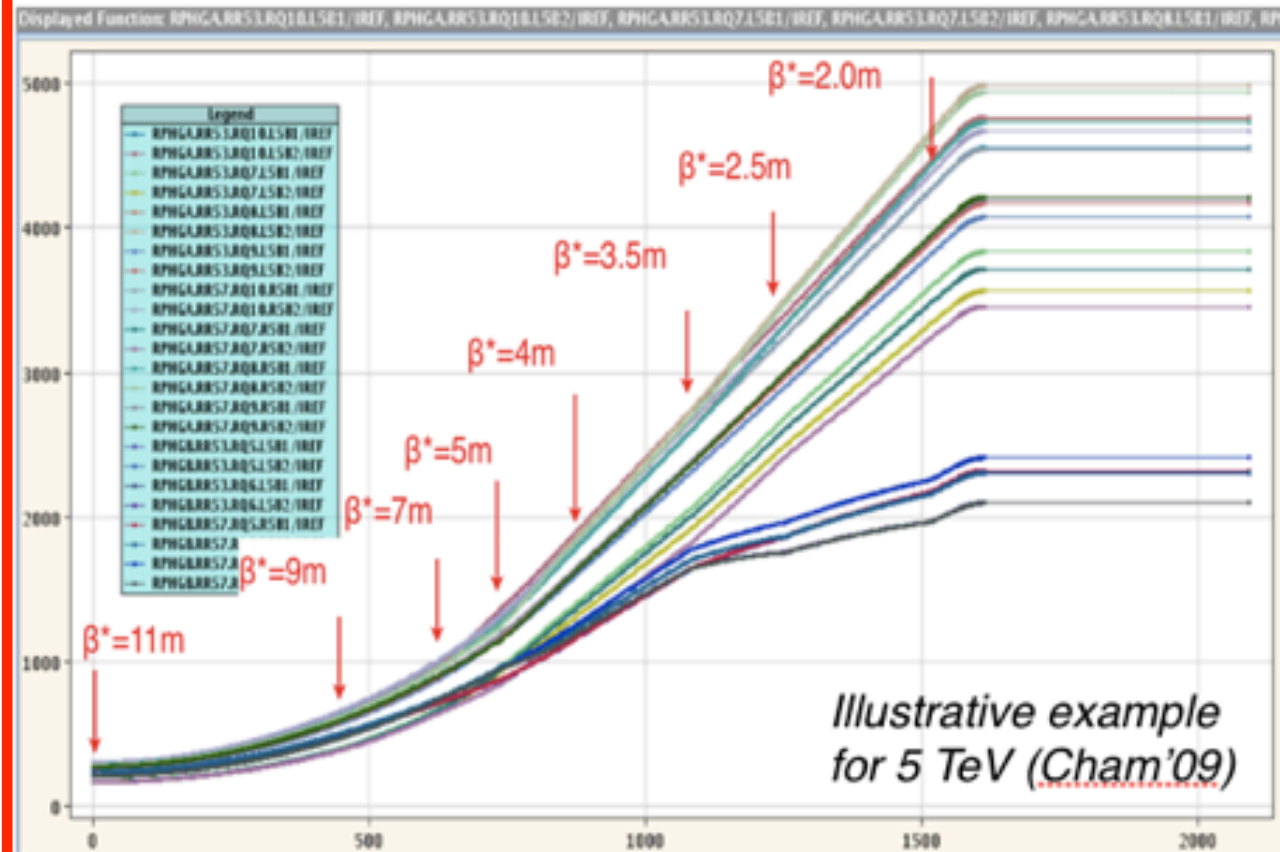
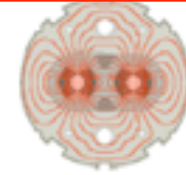
- Reduced cycle duration;
- Minimize human errors;
- Some steps done at lower stored energy (less critical).

### CON's

- Loose the possibility to stop at intermediate betas: No flexibility!  
*Difficult to measure/correct optics.*  
*No verification of collimators/loss maps at intermediate optics.*
- Commissioning of crossing schemes becomes more complex;
- Aperture limitations at lower energies: critical steps remains at top-energy;  
*Realistically: beta\* < 7 m to be done at top energy.*
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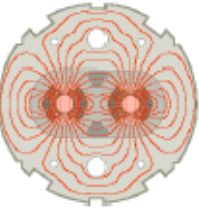
**At Chamonix 2011, it was concluded that the investment of work was not yet justified**

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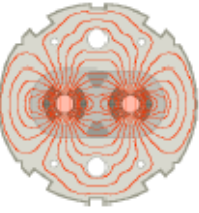
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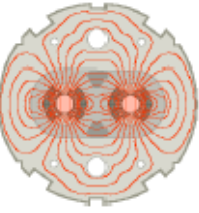


## Improved optics commissioning experience than in 2010

- Smoother squeeze commissioning than in 2010
- New challenging optics commissioned without problems (ATS, 90m)



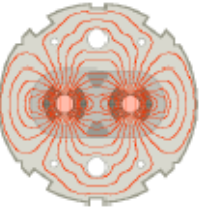
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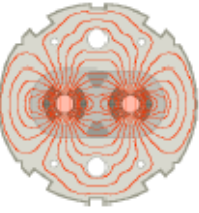


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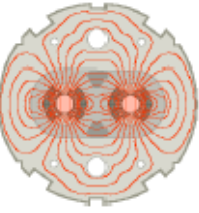
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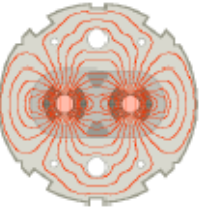
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  - The rest of the squeeze will follow afterwards, as done now.



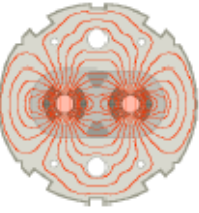
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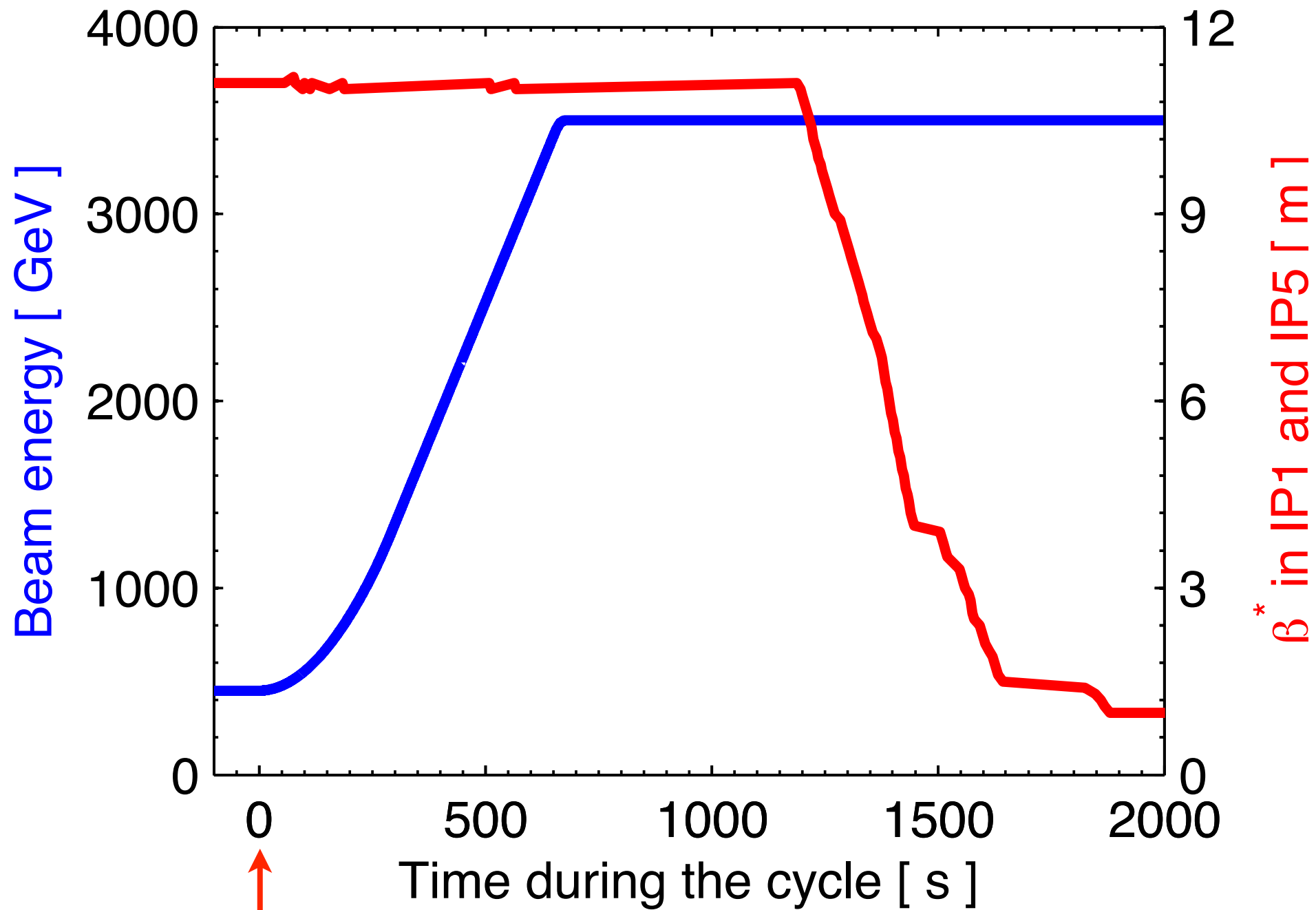
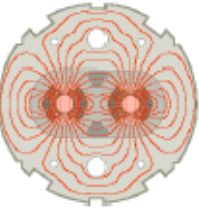
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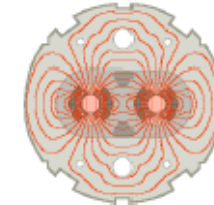
**It is now a good timing to test this with beam for possible implementation in 2012**

# Recap. of present operational cycle

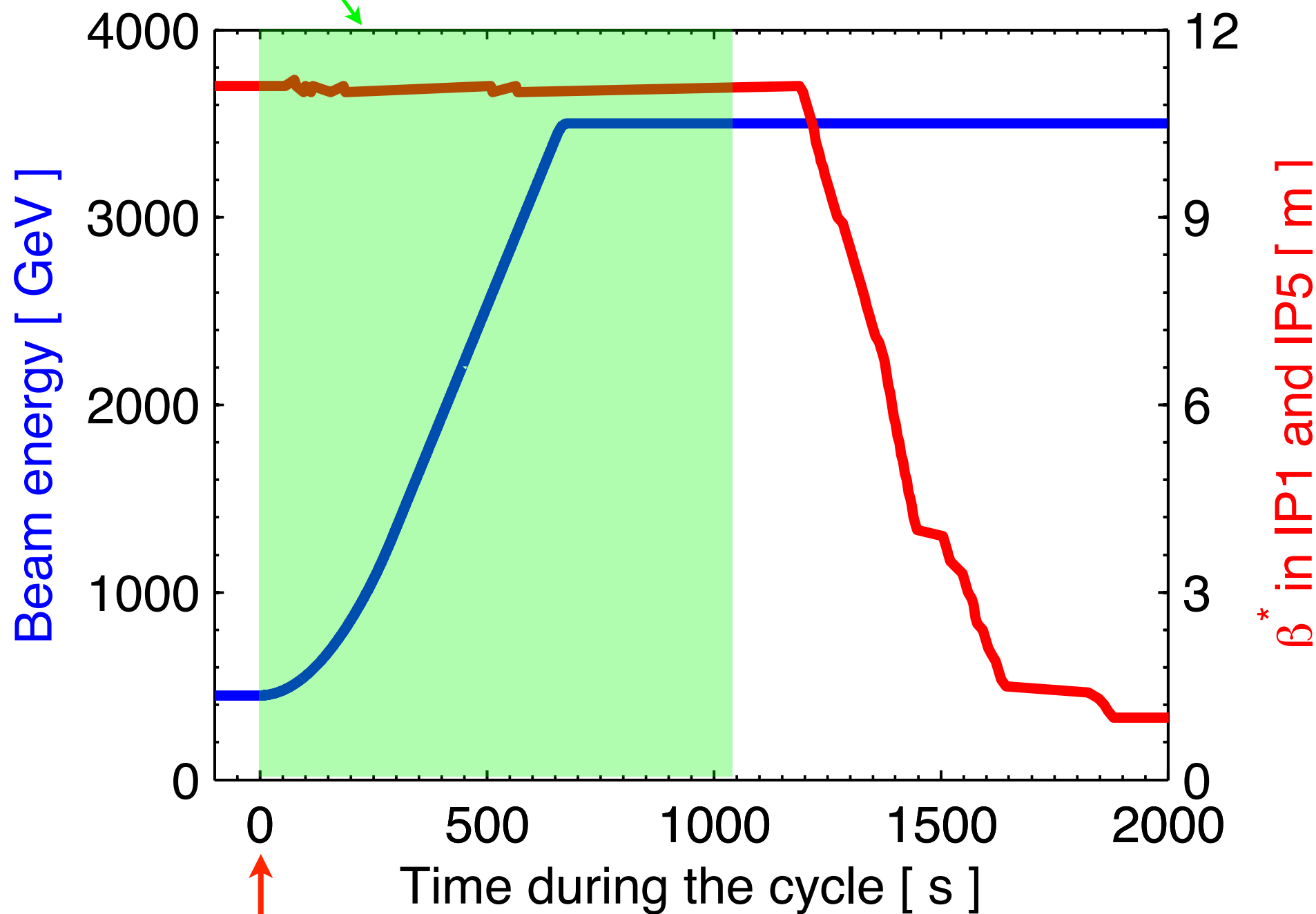


$t=0$ : start of ramp

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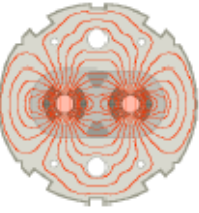
Ramp:  
680s + 340s = **1020s**



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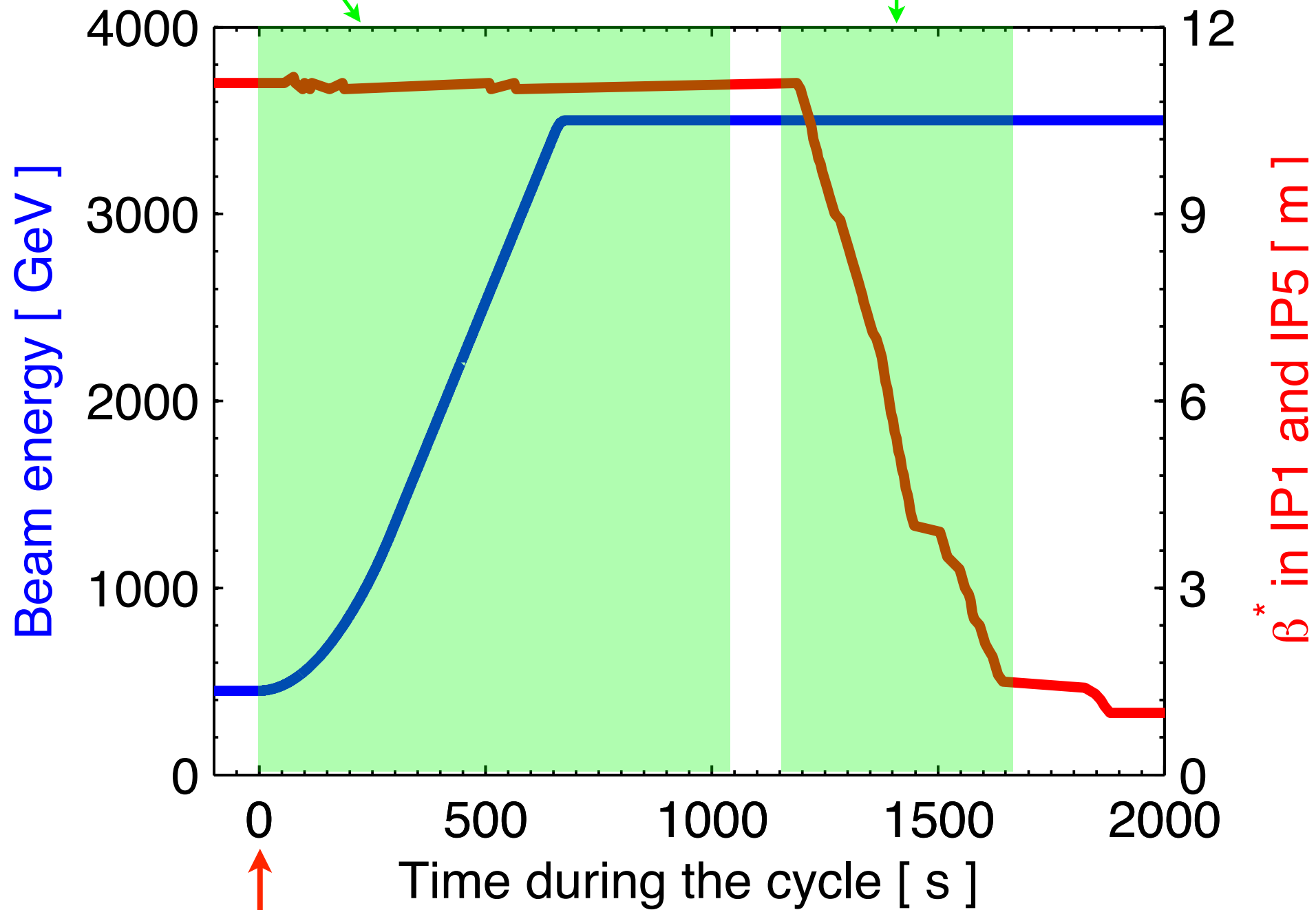


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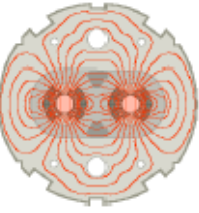
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**475s**



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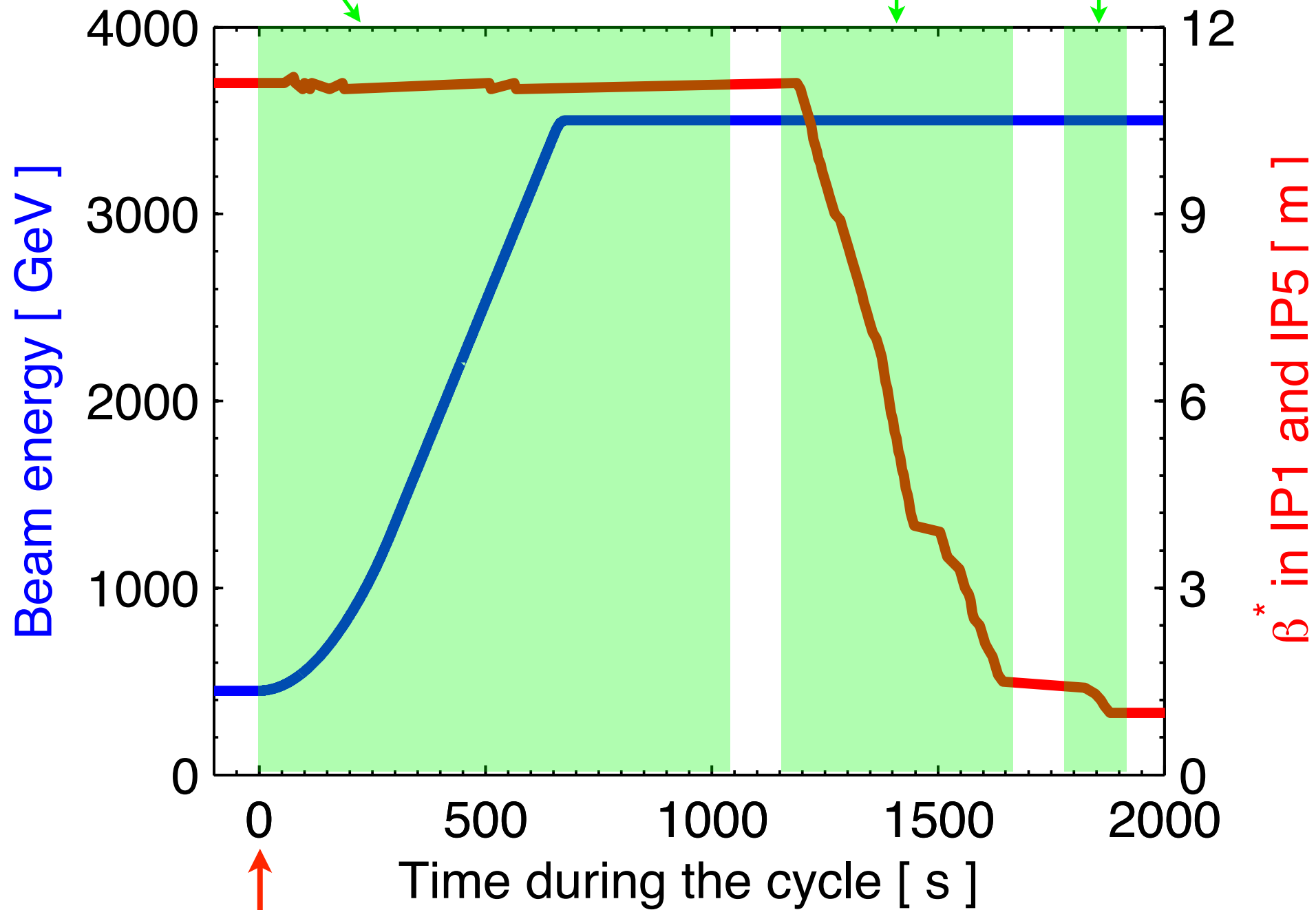
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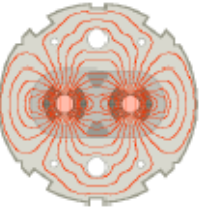
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Squeeze (2) to 1.0 m :  
**73s**



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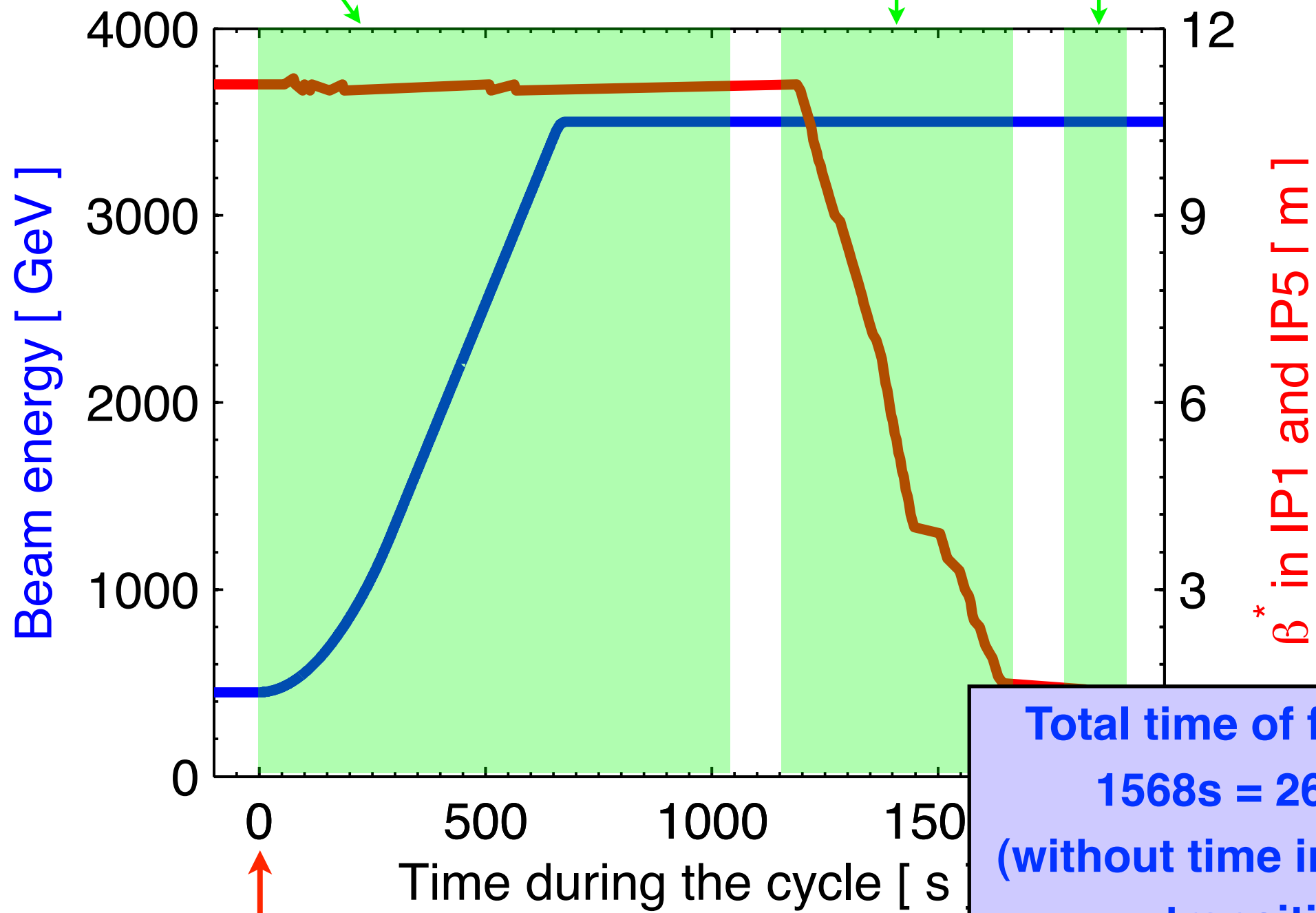
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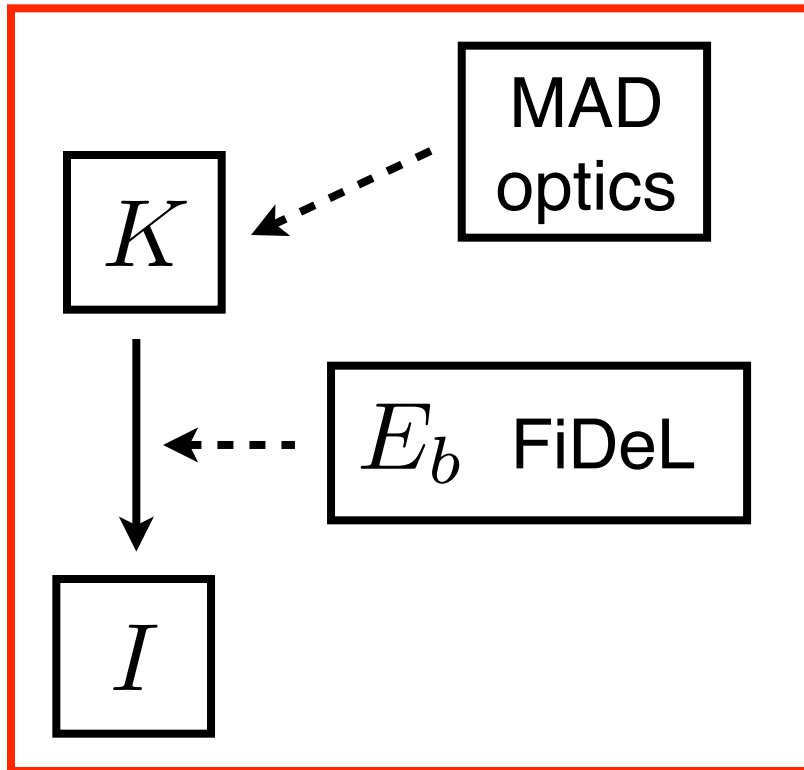
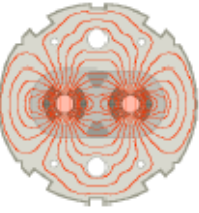
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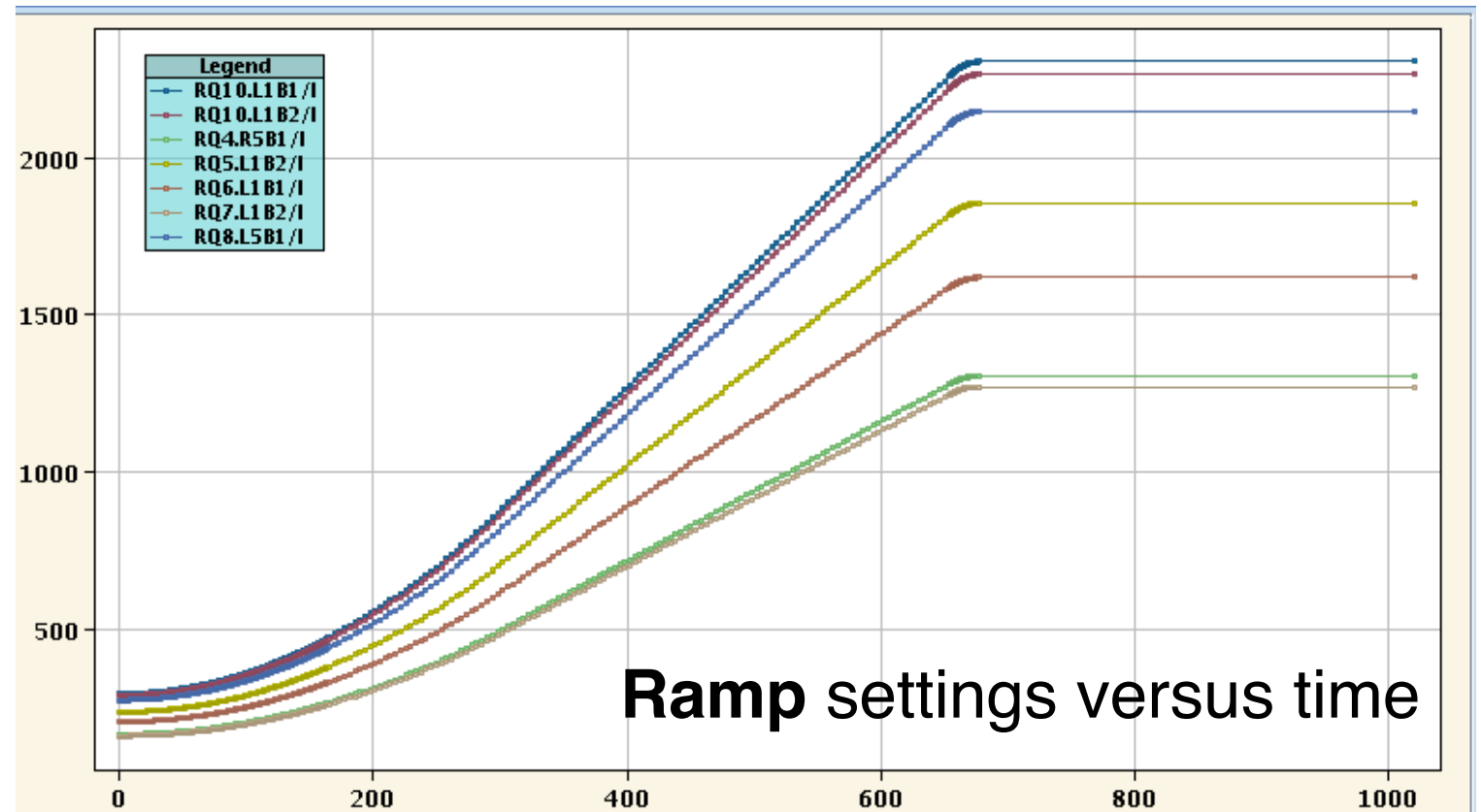
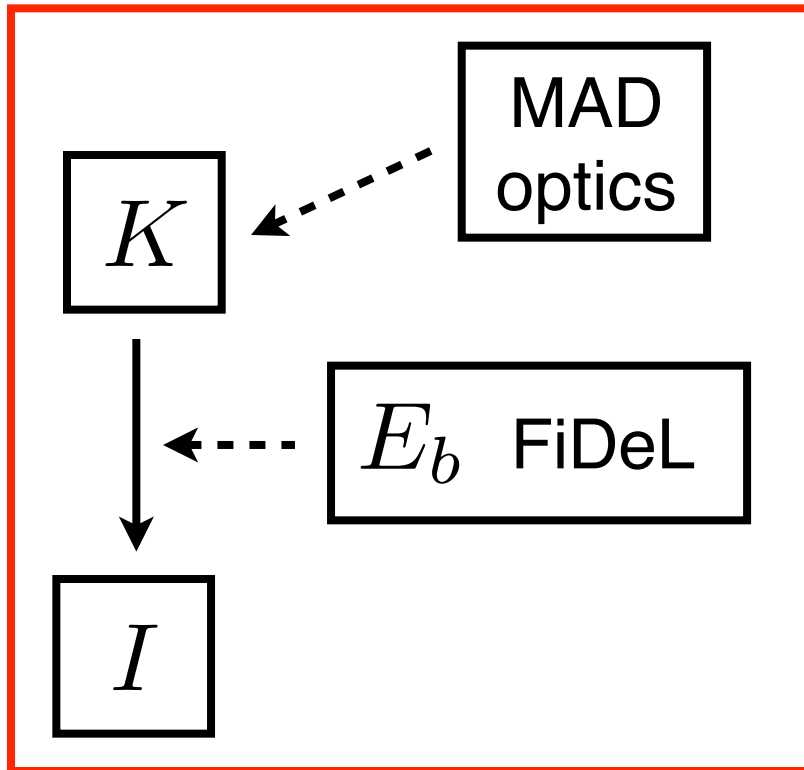
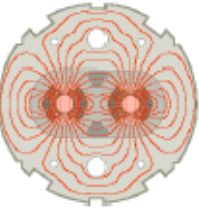
**Total time of functions:  
1568s = 26.1 min  
(without time intervals for  
transition)**

t=0: start of ramp

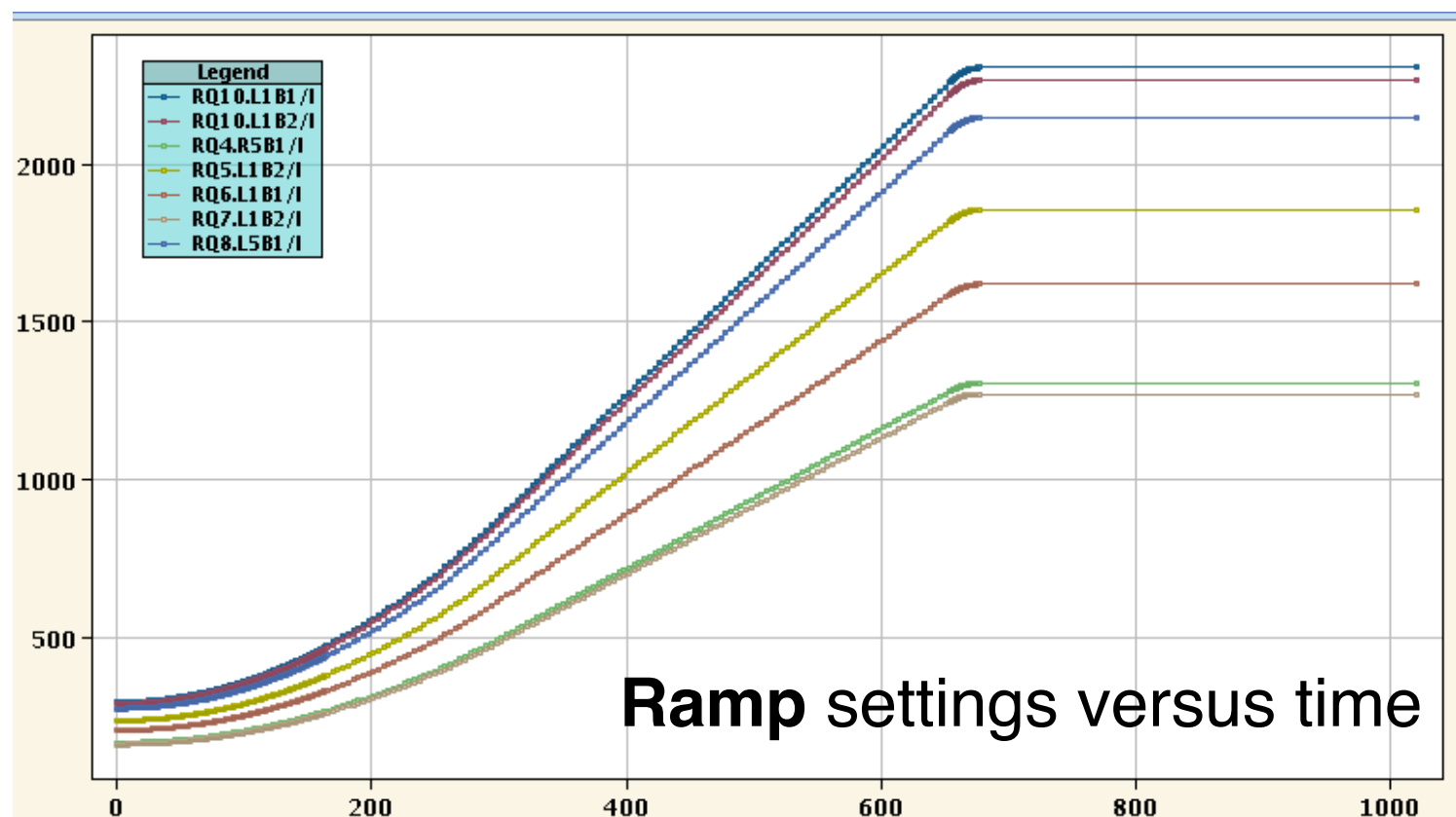
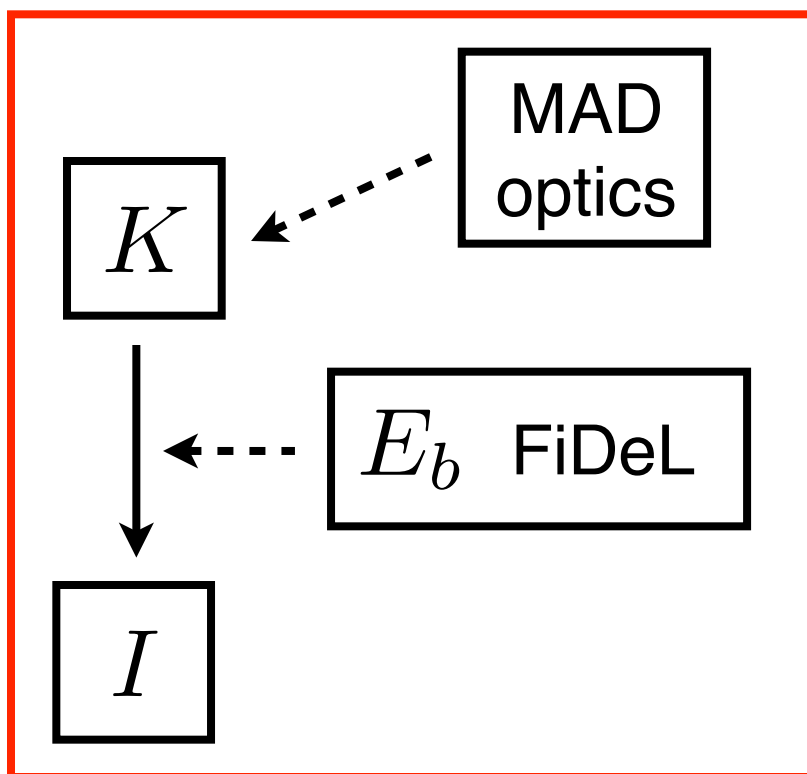
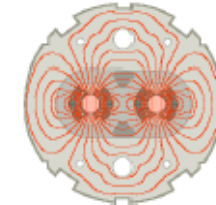
# Recap. of settings generation



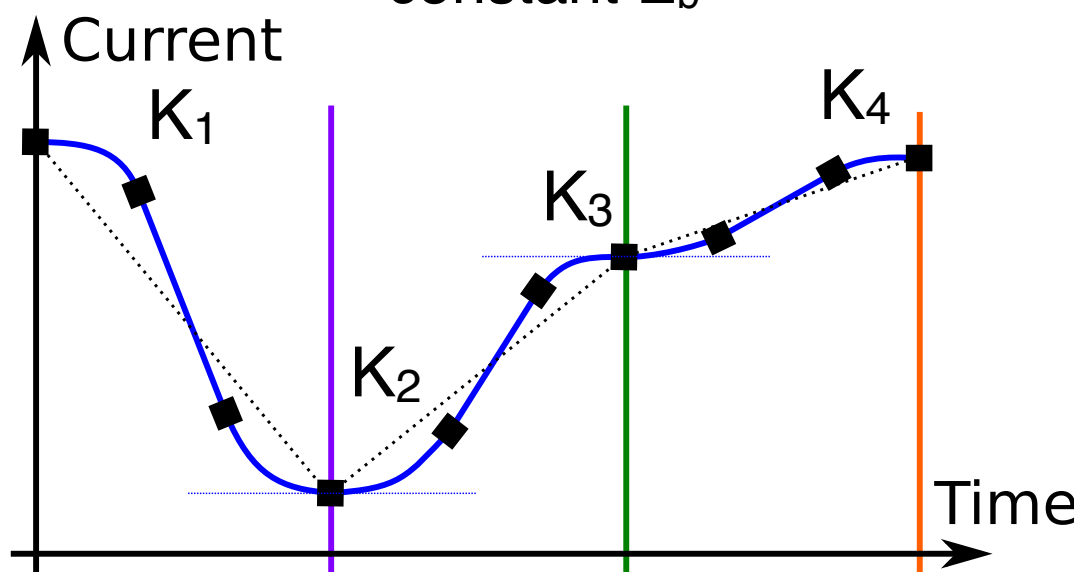
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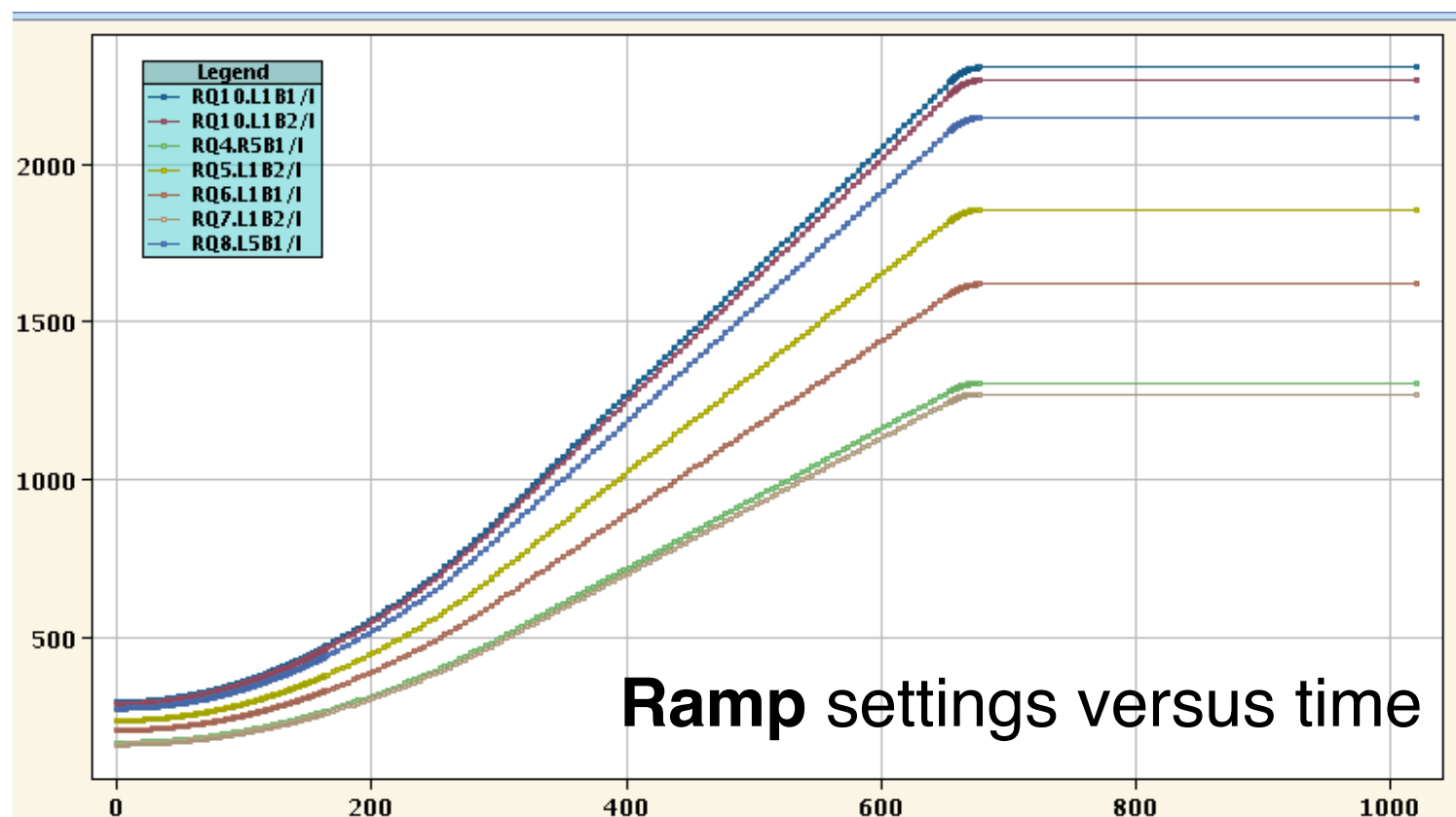
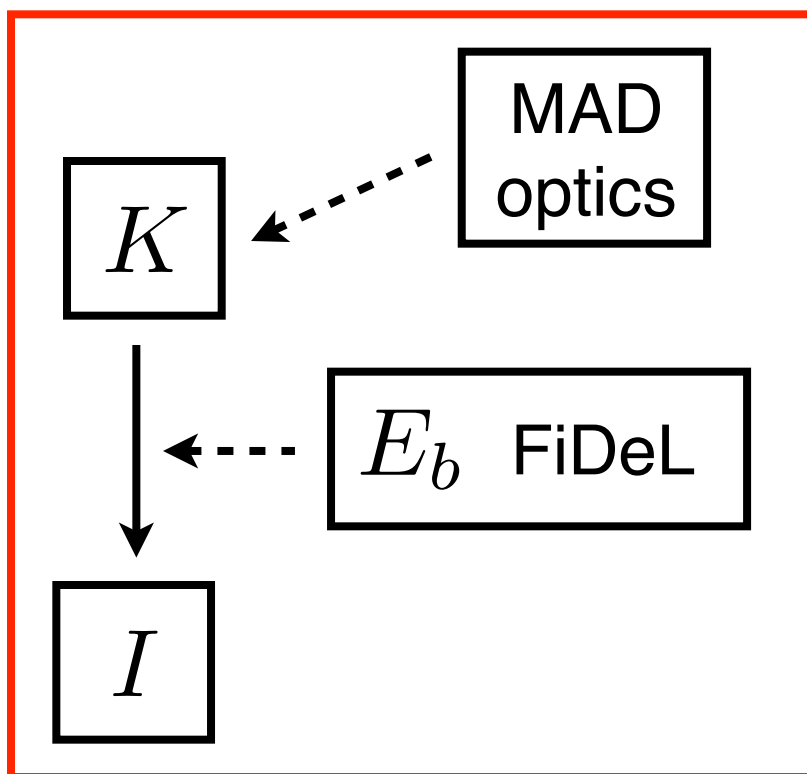
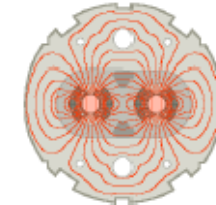
Squeeze: generation at constant  $E_b$



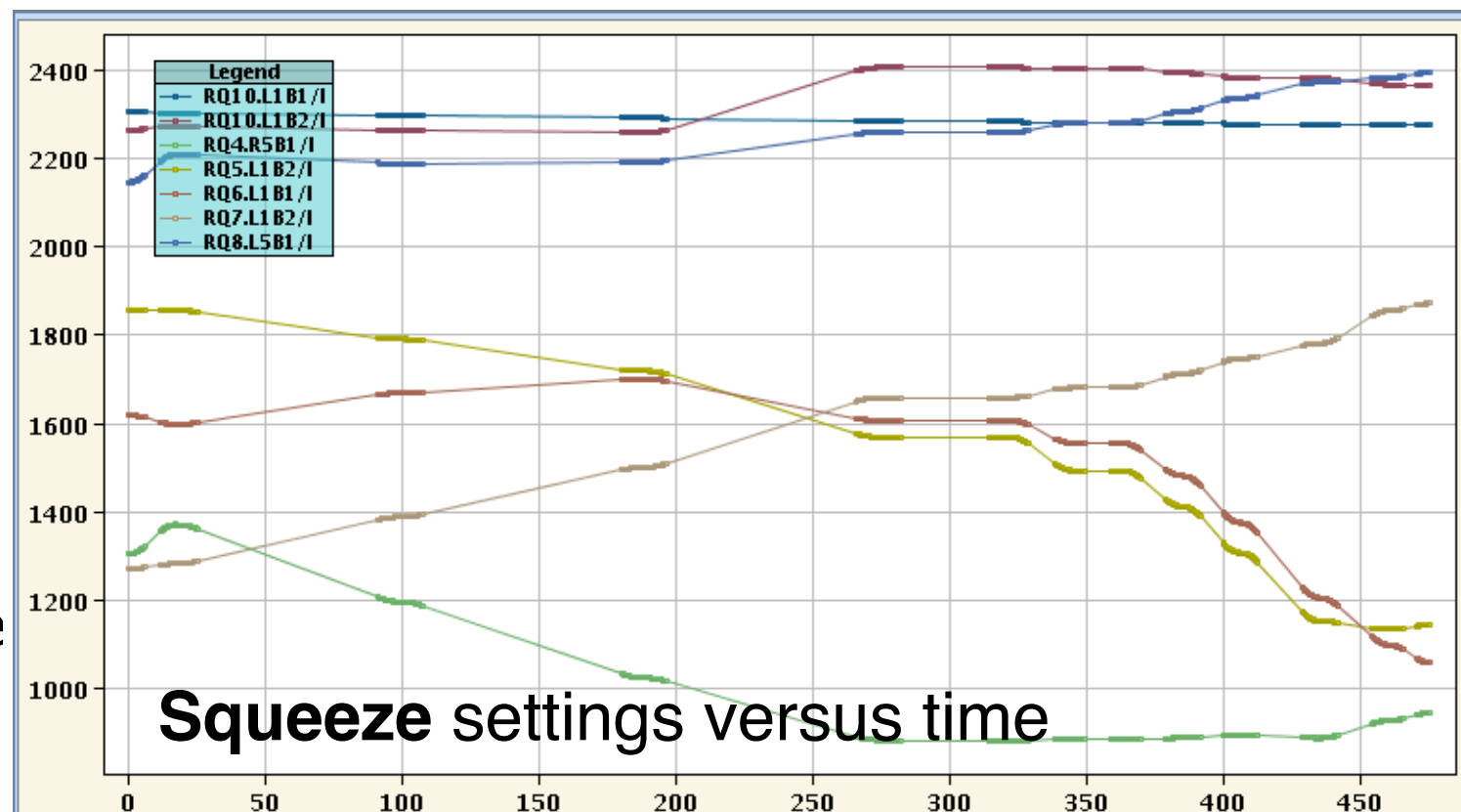
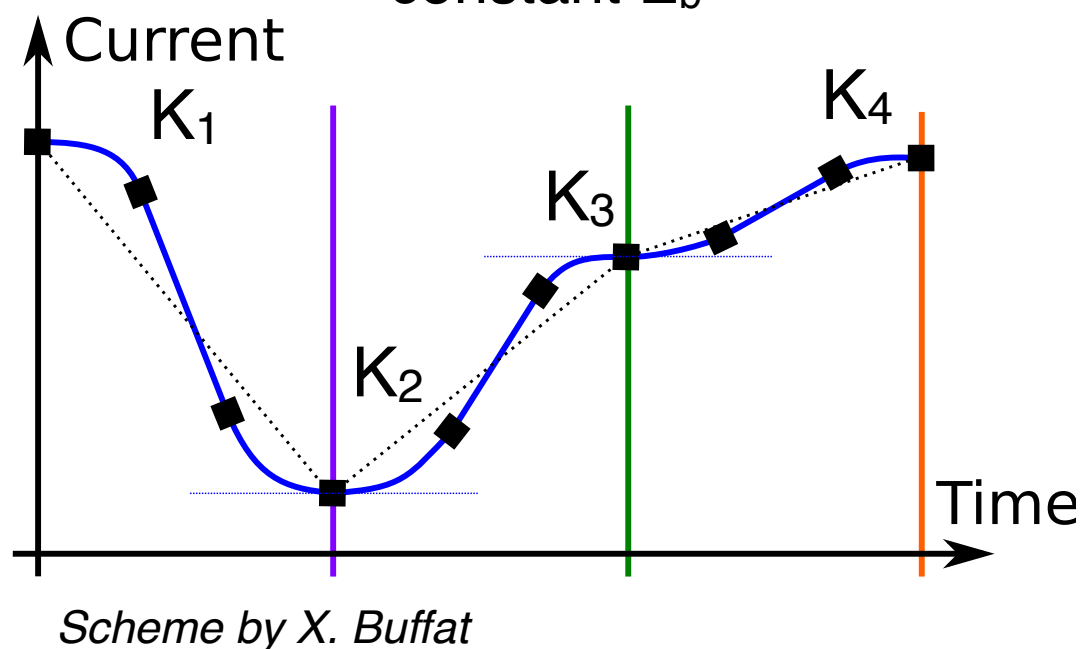
Scheme by X. Buffat

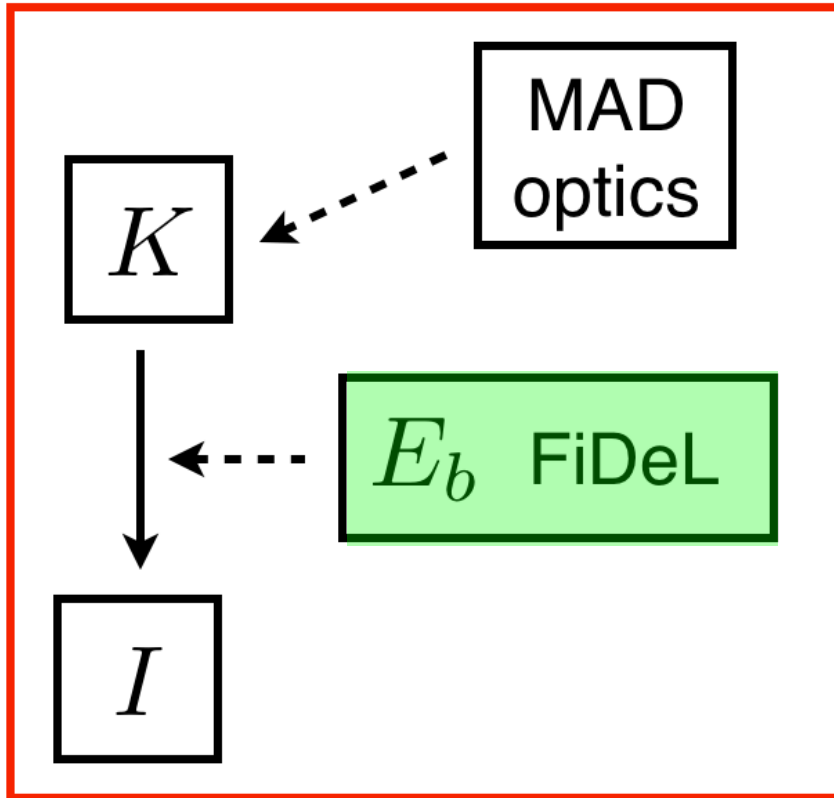
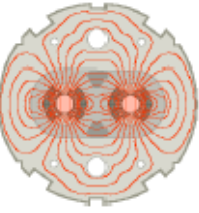


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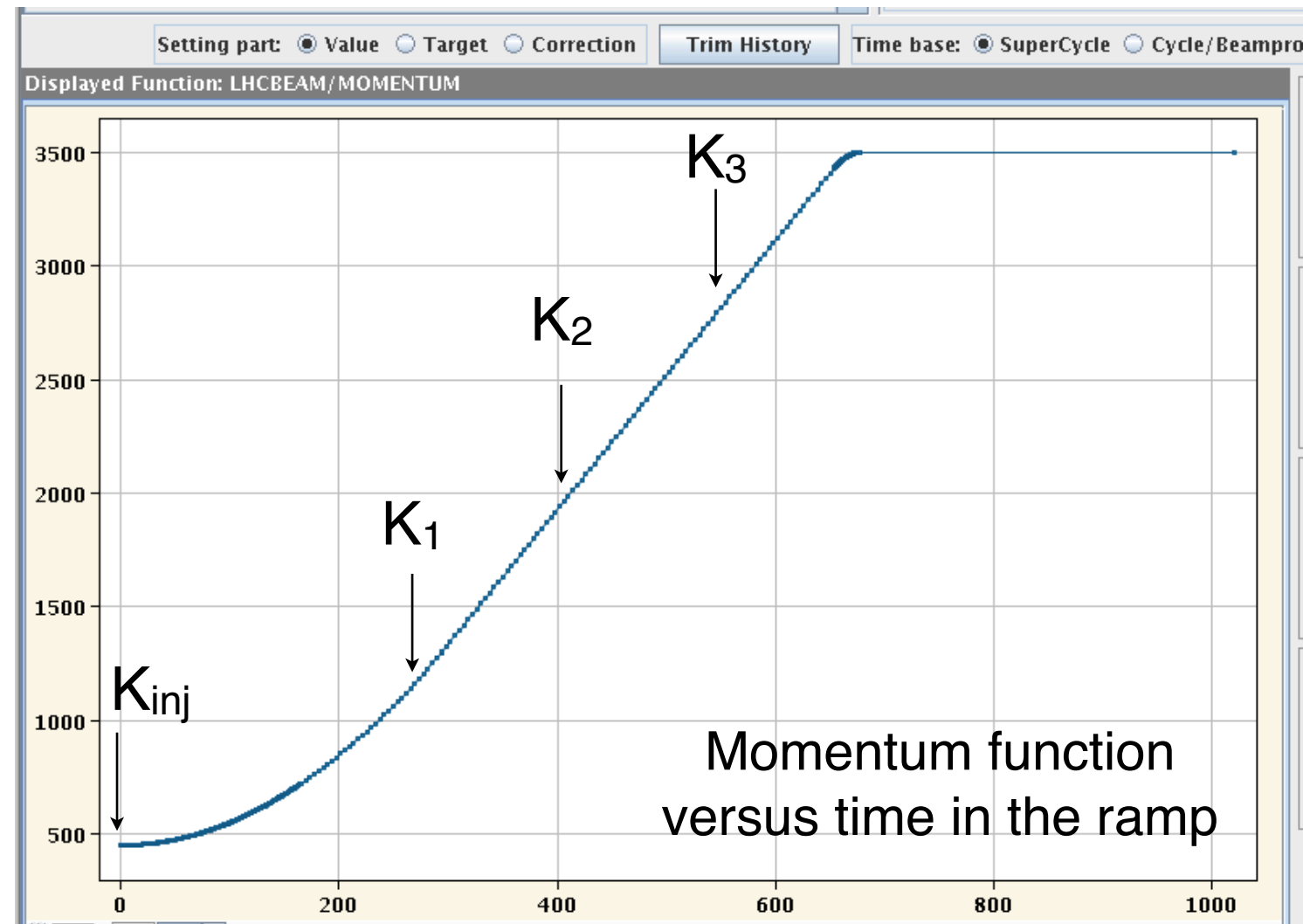
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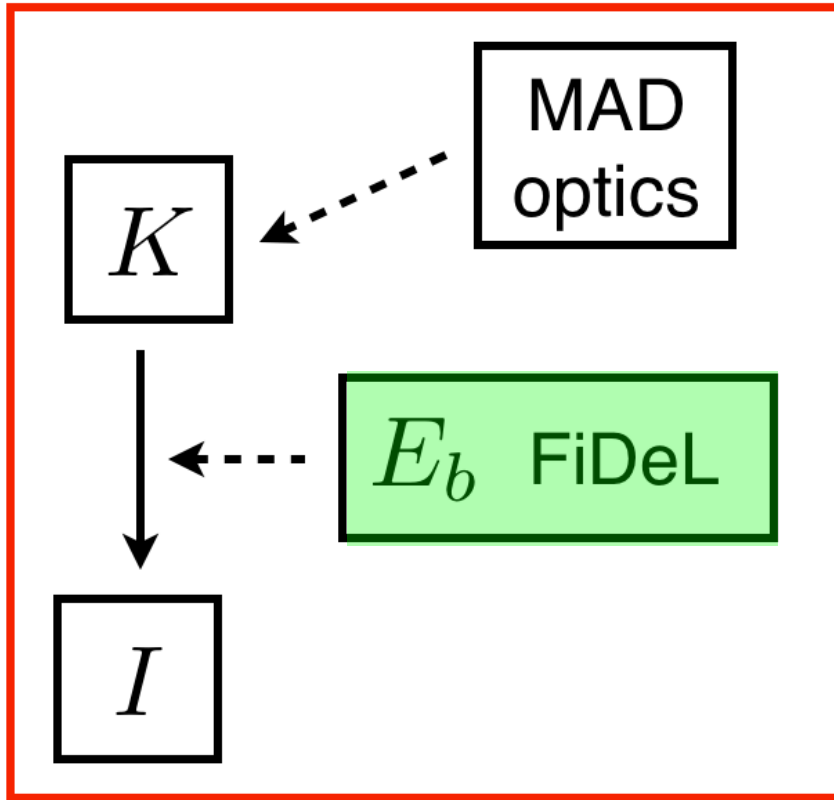
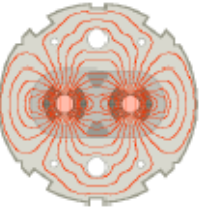
For each magnet:  $K = K(t, E_b)$

The currents are then calculated for the good  $E_b$ .

Optic Name	Energy	Time
A1100C1100A1000L1000_2011	450.0	0
A1100C1100A1000L1000_2011	986.0897	233
A900C900A1000L900_0.00949_2011	1655.8375	354
A700C700A1000L700_0.00923_2011	2224.2585	450
A500C500A1000L500_0.00900_2011	2958.4691	574
A400C400A1000L400_0.00893_2011	3313.7322	634
A350C350A1000L350_0.00882_2011	3500.0	680
A350C350A1000L350_0.00882_2011	3500.0	1020

*Smoothing of current functions provided by the energy scaling*





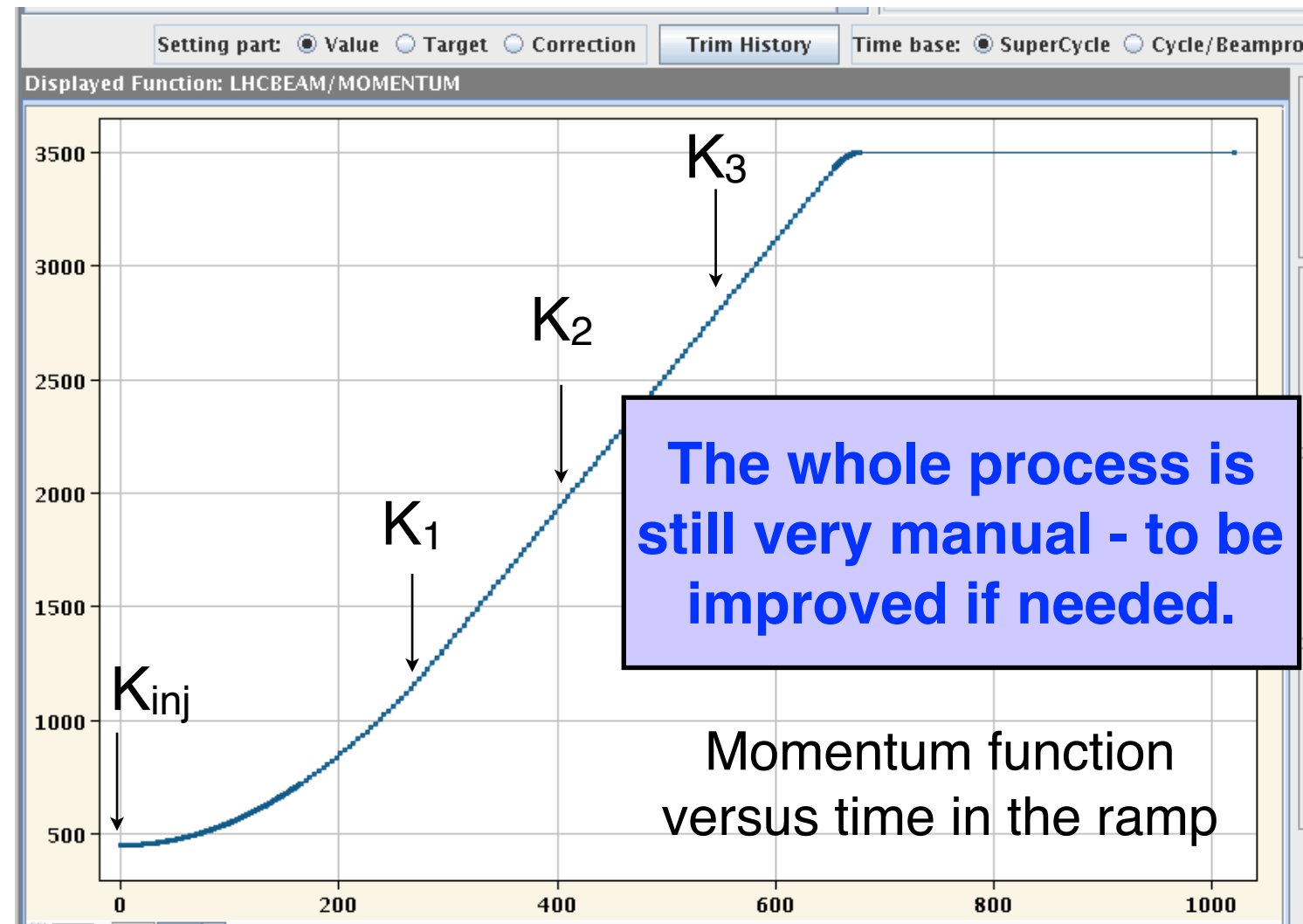
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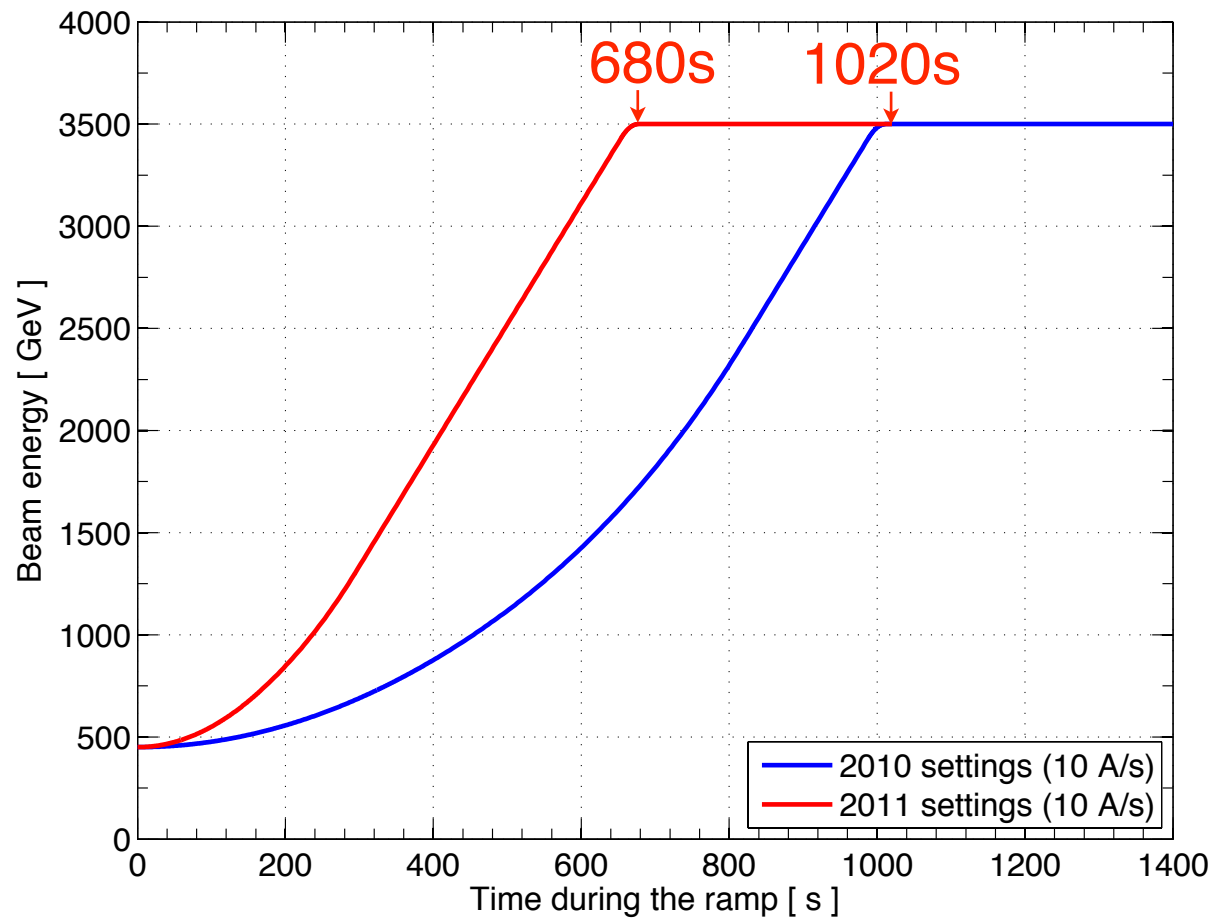
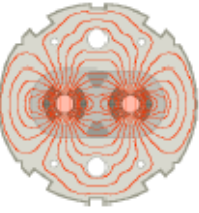
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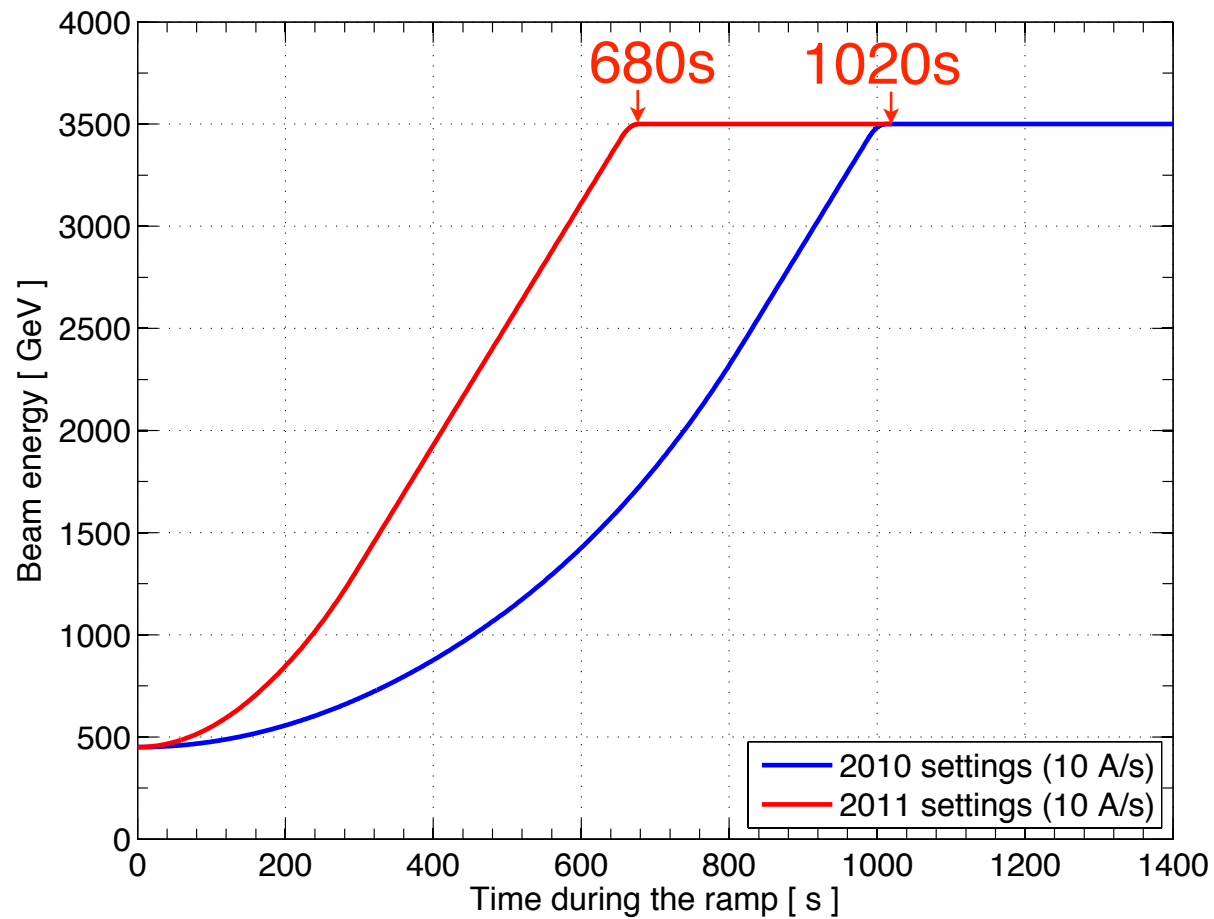
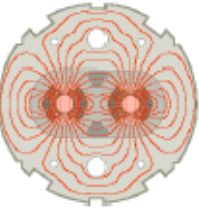


**The whole process is still very manual - to be improved if needed.**

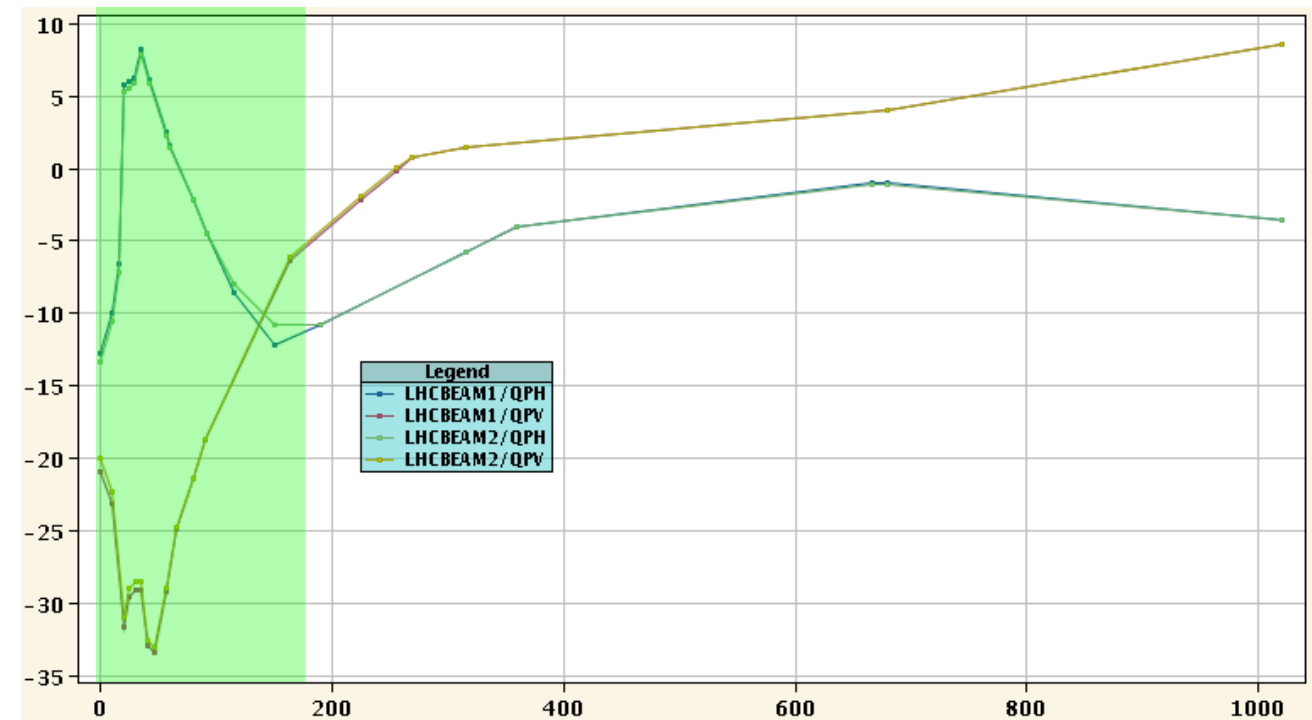
Momentum function versus time in the ramp



- Respect the total ramp length of 680 s
- Wait for decay of dynamics effect (first optics change > 200s)
- Fit optics changes in the linear part of the current ramp rate ( $t > 200$  s)
- Final  $\beta^*$  target value larger than where optics corrections take place ( $> 3.0$  m)
- For a given configuration, push  $\beta^*$  changes to highest  $E_b$  to gain in aperture
- Adjust functions  $K(t, E_b)$  to minimize the dynamic beta-beat
- Avoid sharp changes of superconducting magnet currents (dry-runs needed)

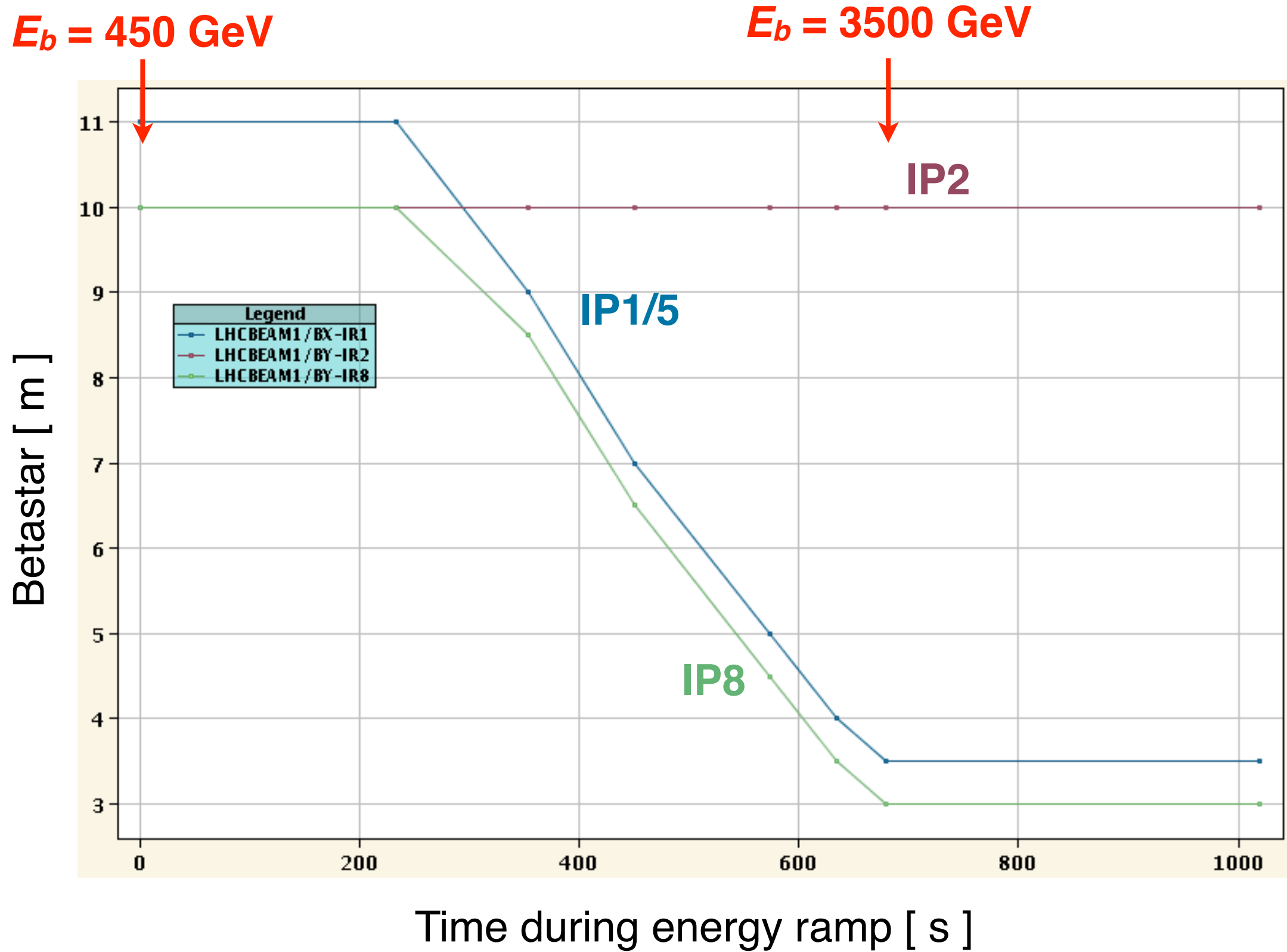
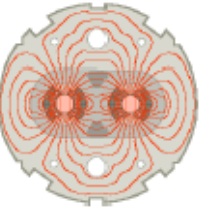


Present chromaticity settings during ramp



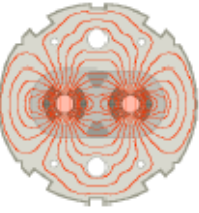
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# Configuration for beam tests



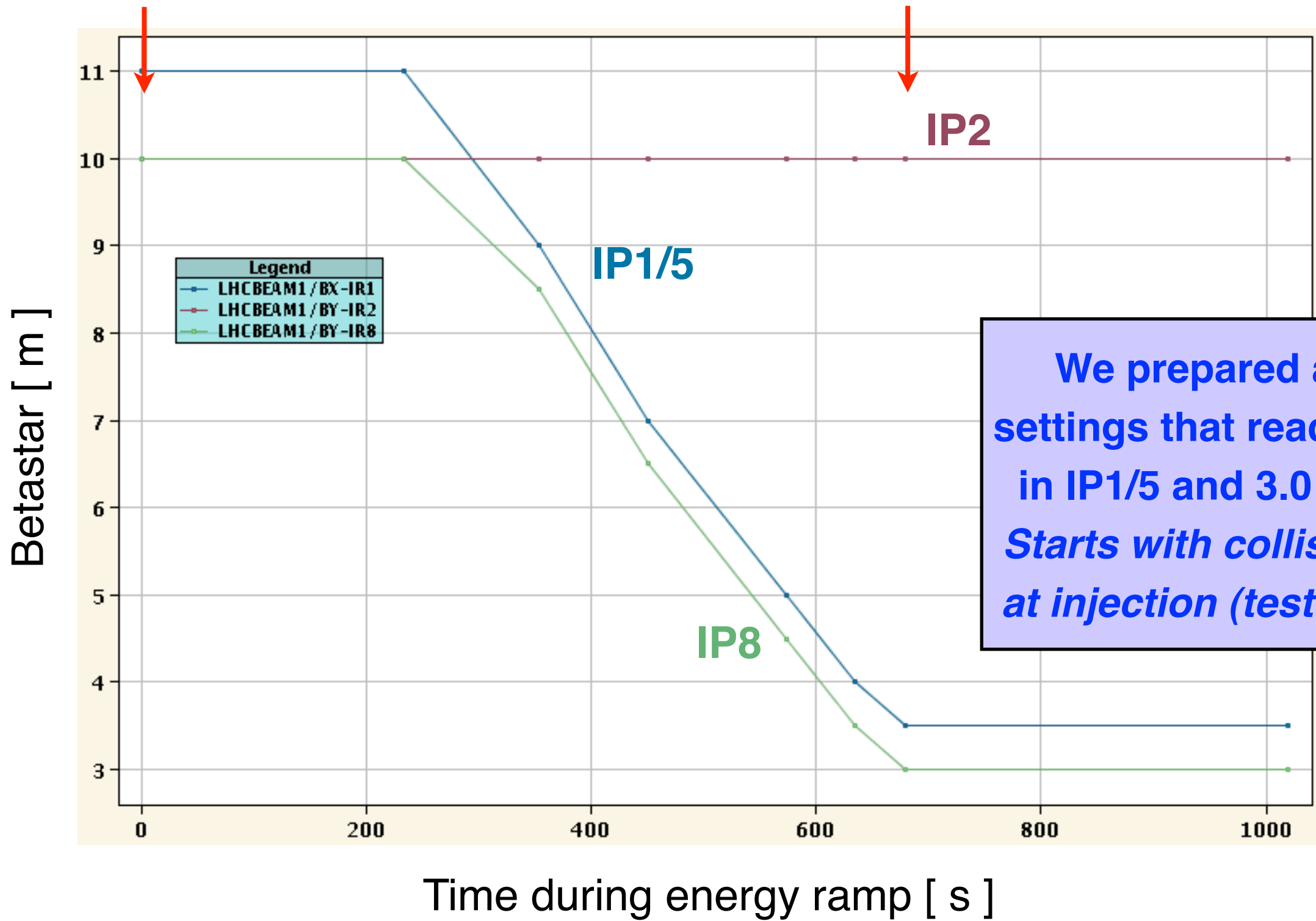


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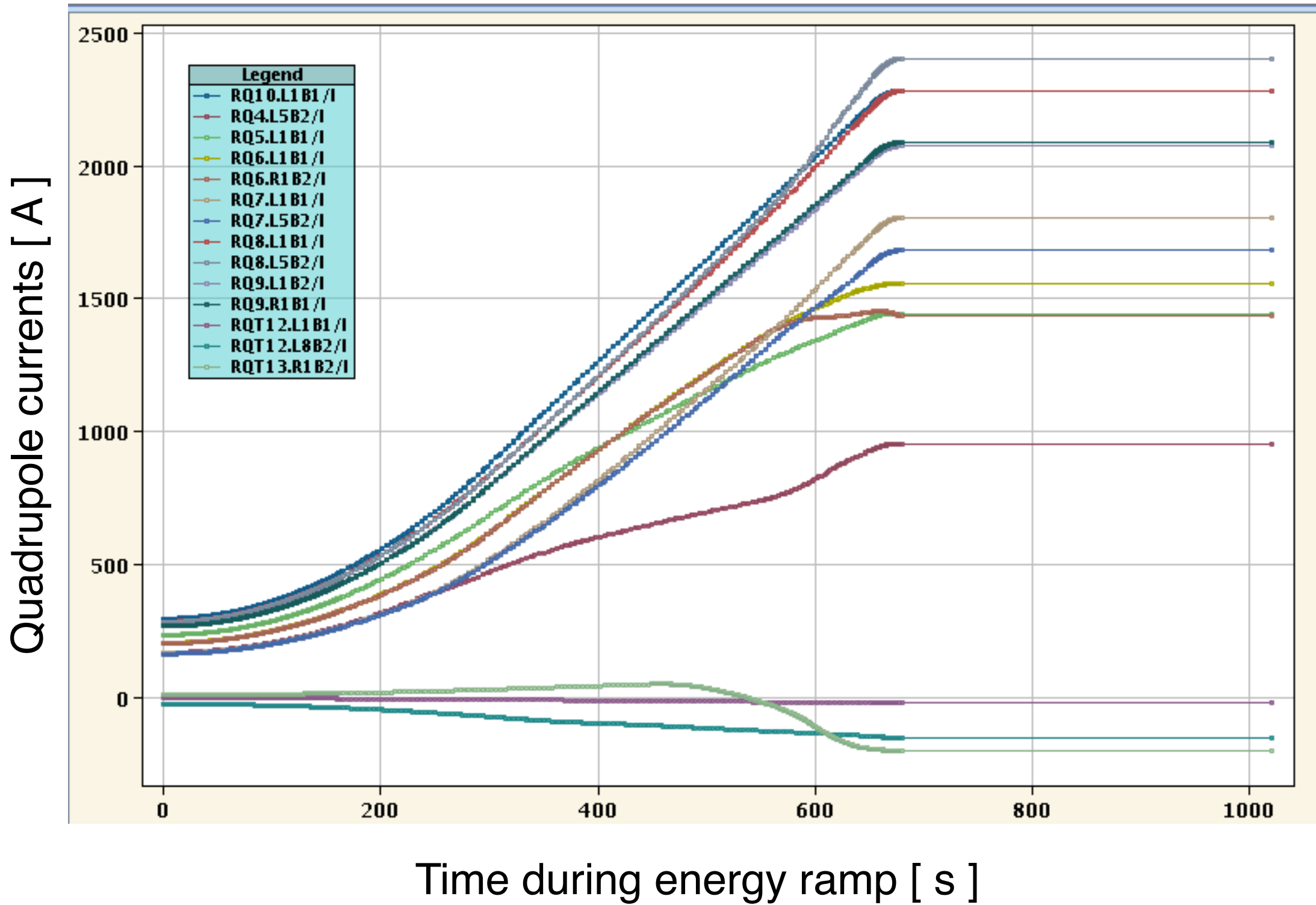
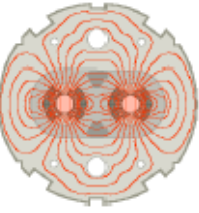
$E_b = 450 \text{ GeV}$

$E_b = 3500 \text{ GeV}$

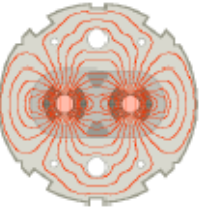


We prepared a set of settings that reaches 3.5 m in IP1/5 and 3.0 m in IP8. Starts with collision tunes at injection (tested in MD).

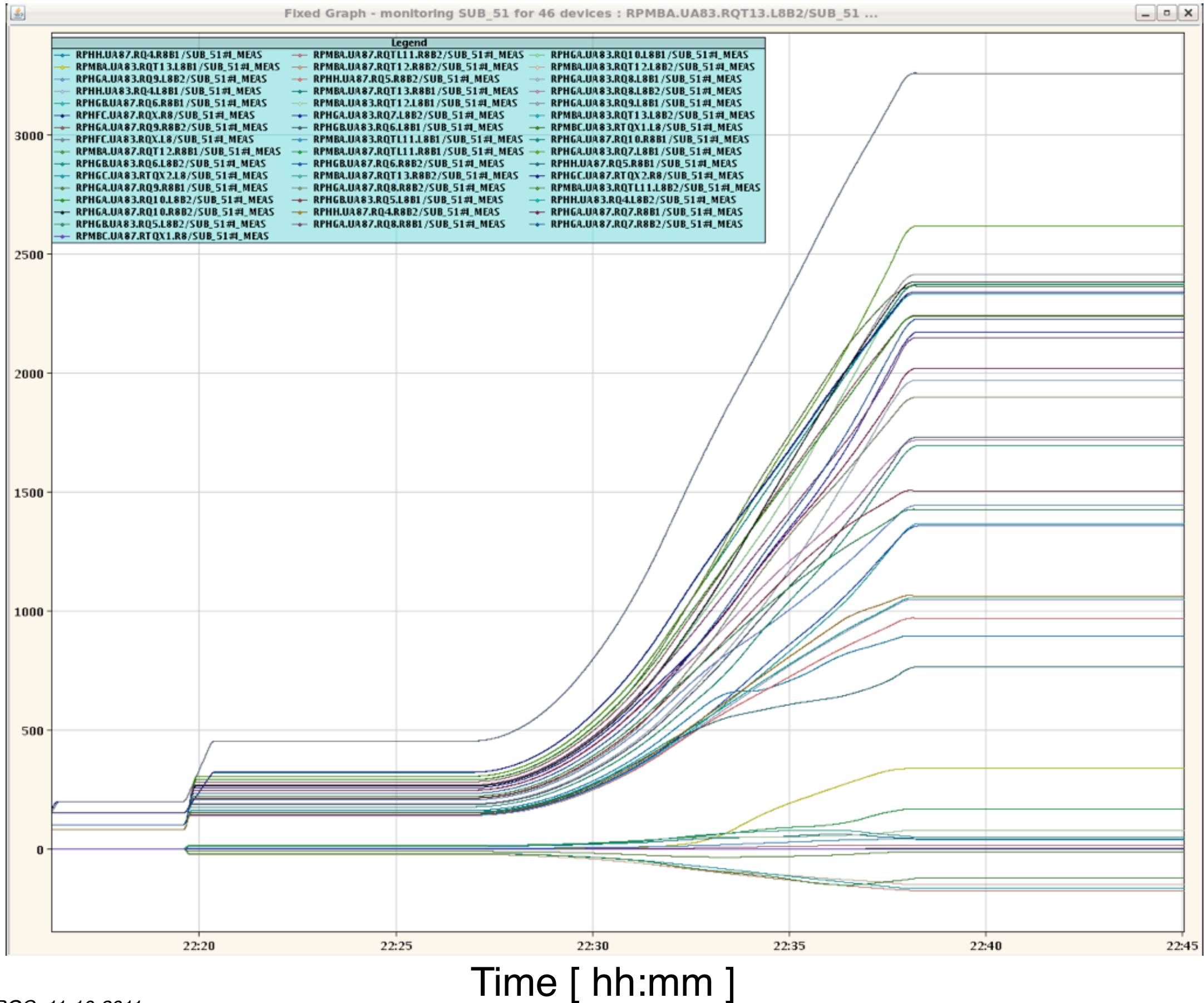
# Example of quadrupole settings



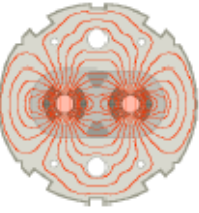
# Results of dry-runs - Quadrupoles



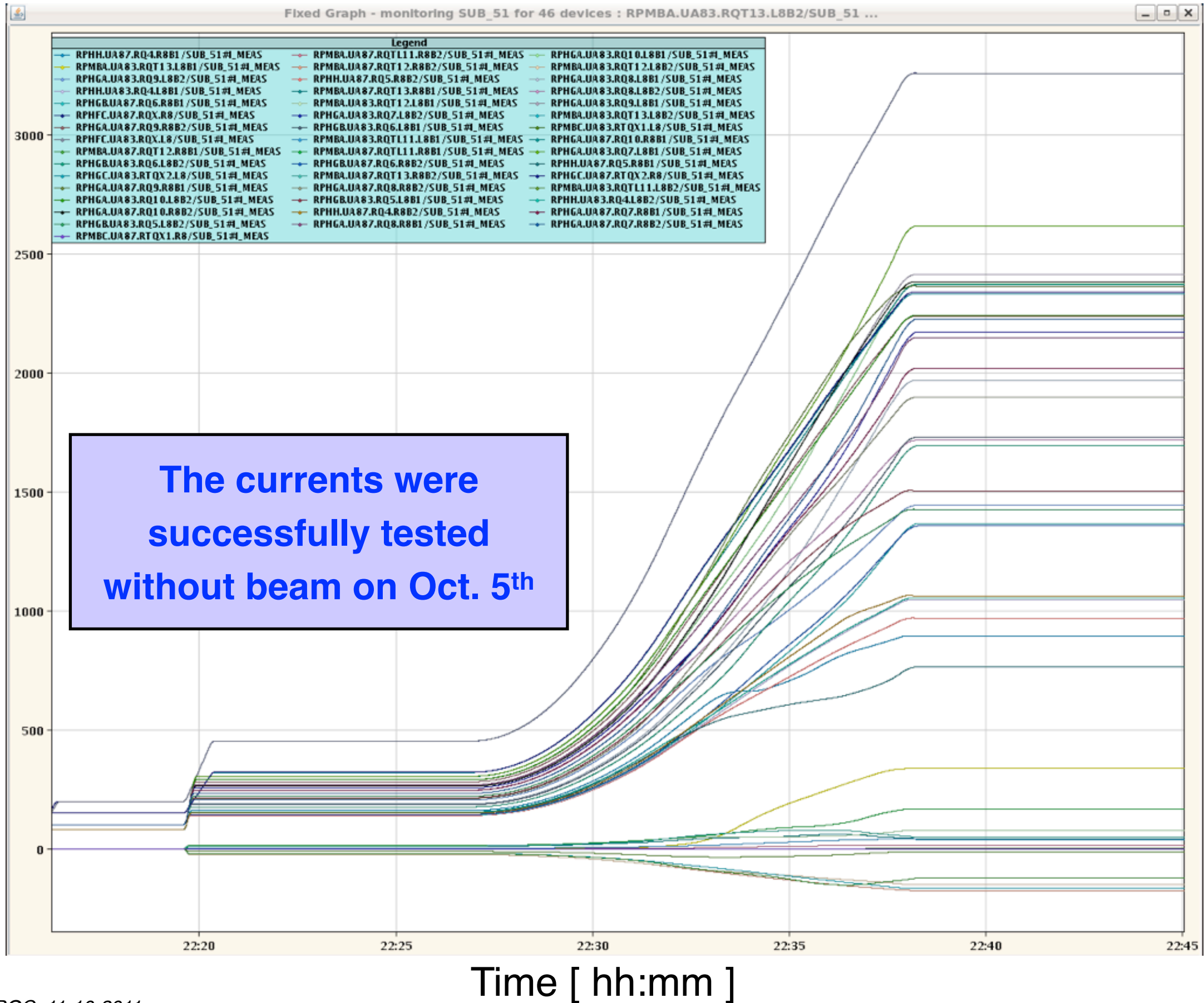
Measured quadrupole currents [ A ]



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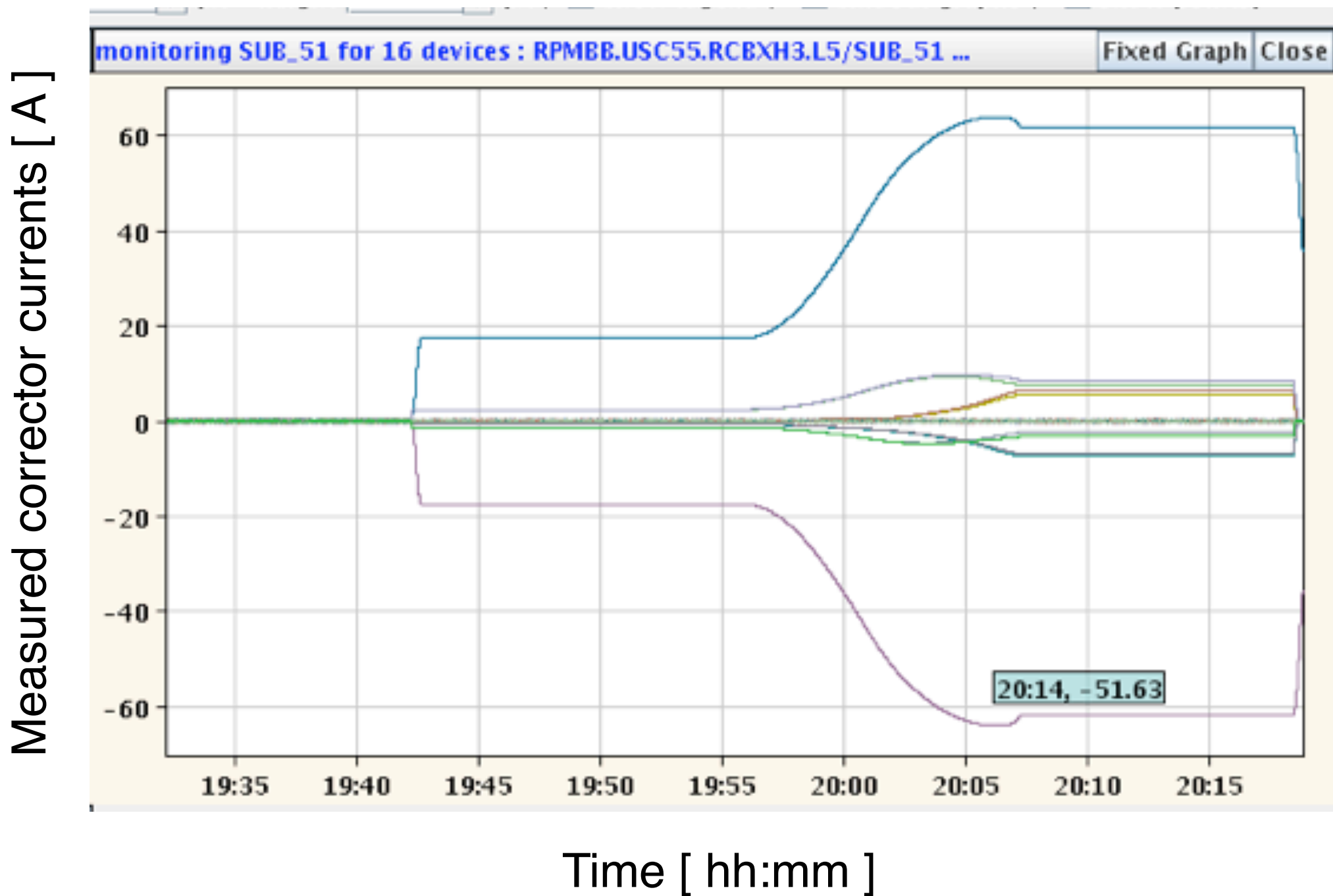
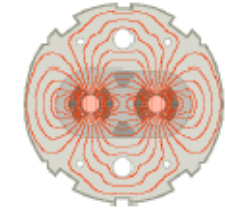


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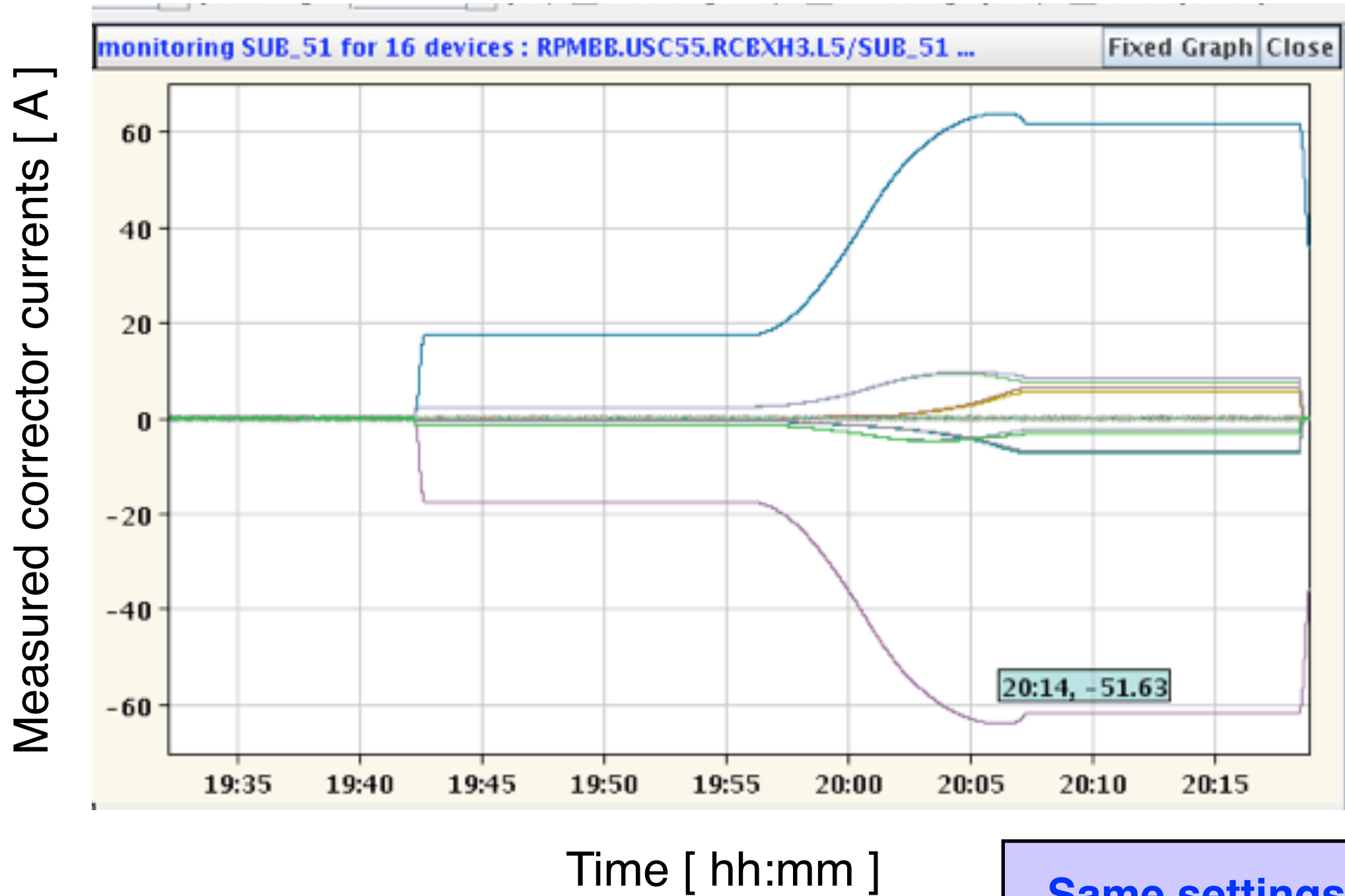
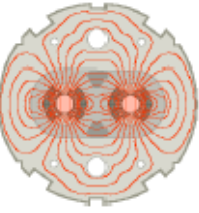




# Results of dry-runs - Orbit correctors



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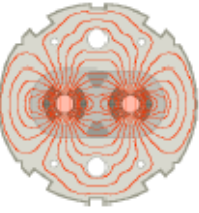


**Same settings in mm as standard operation:  
170 → 120 urad**

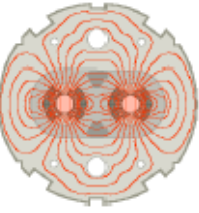




# Simulation of dynamic errors

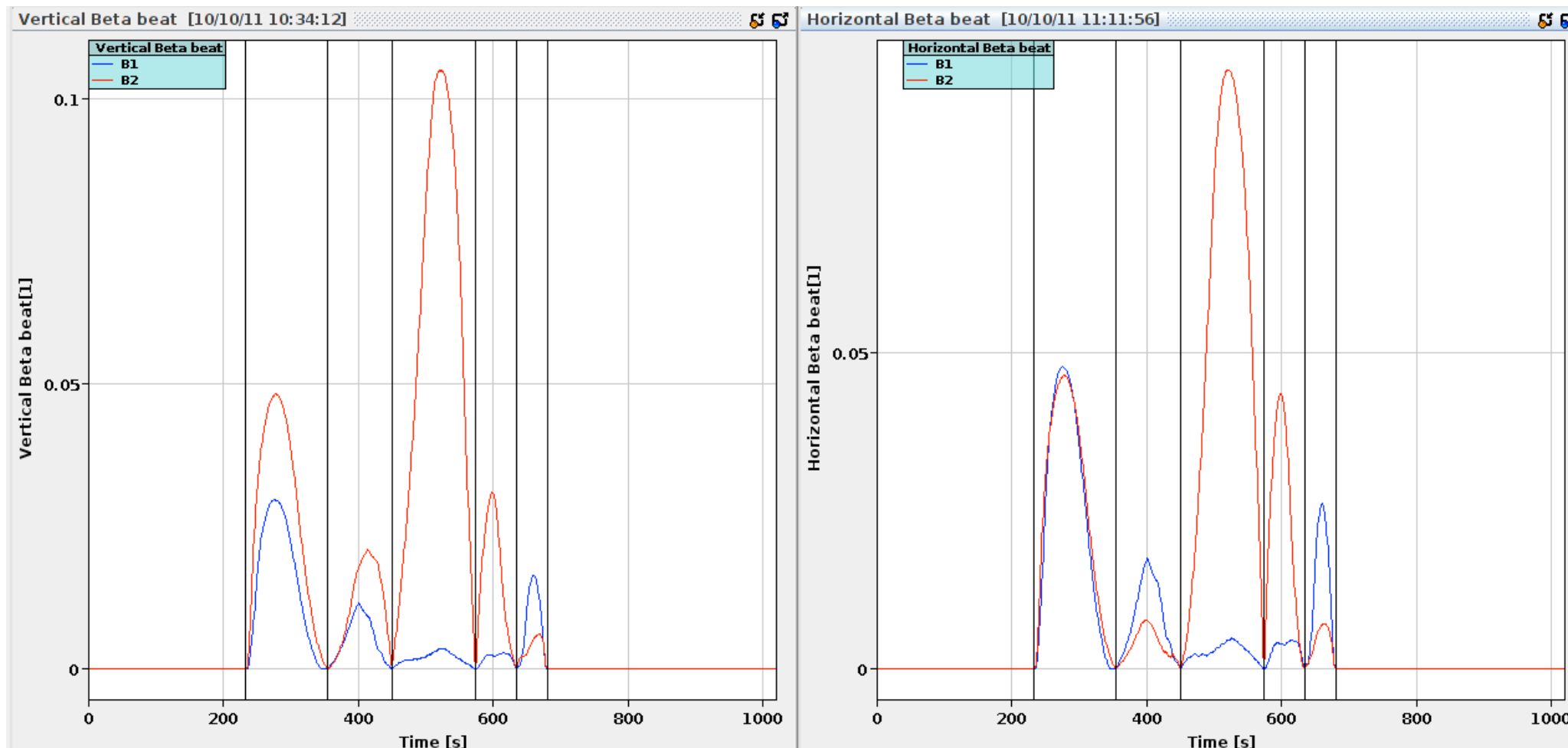


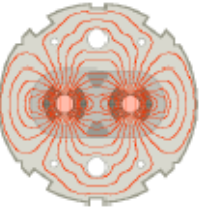
Generated settings are validated with simulations done with MADX online →  
Check if linear parameters are respected,  
compute the dynamics betabeat between matched points,  
calculated the variation of Xing/Sep bump shapes.  
Tools used for the optimization of the present squeeze, see X. Buffat thesis.



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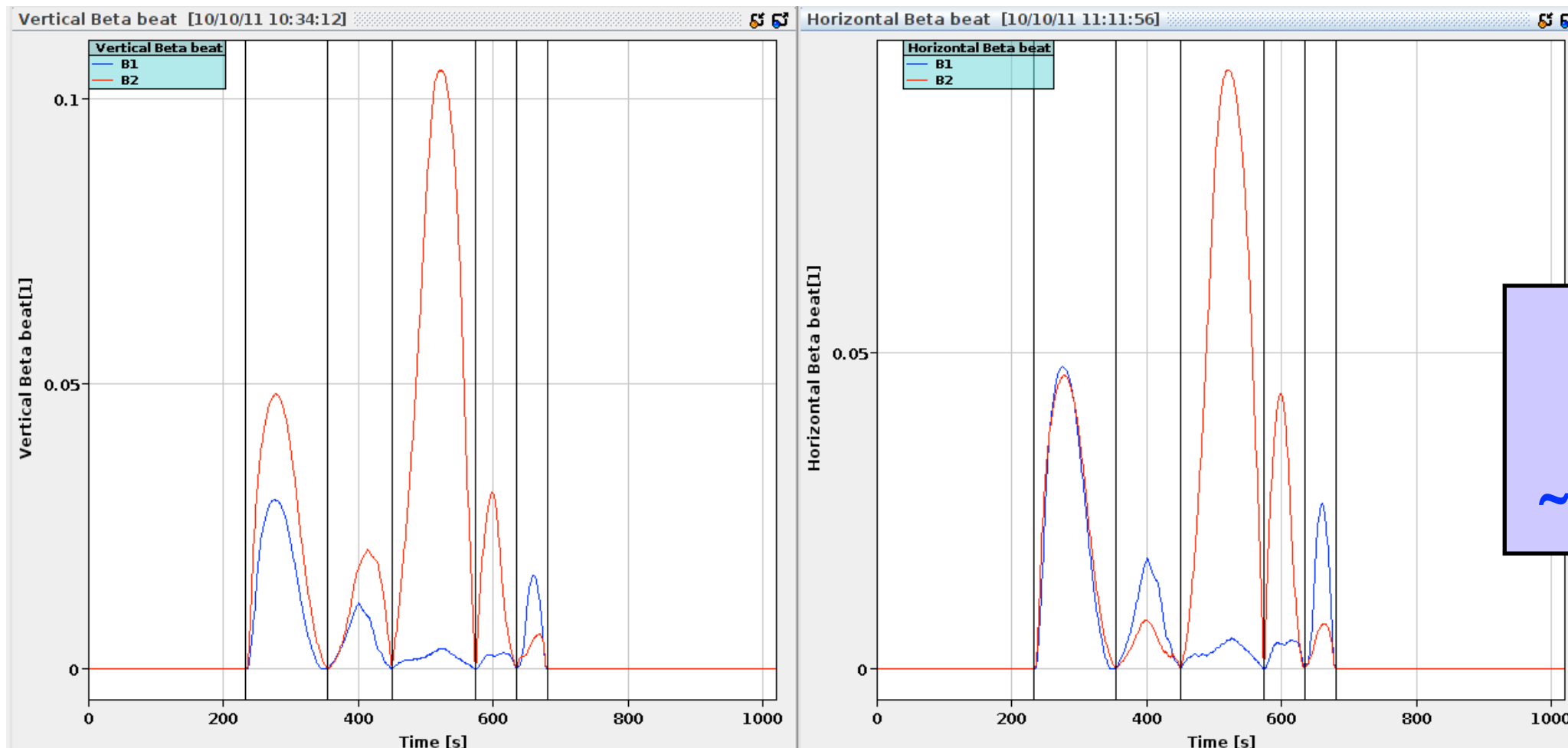
## Simulated dynamics beta-beating





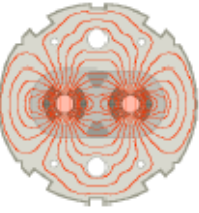
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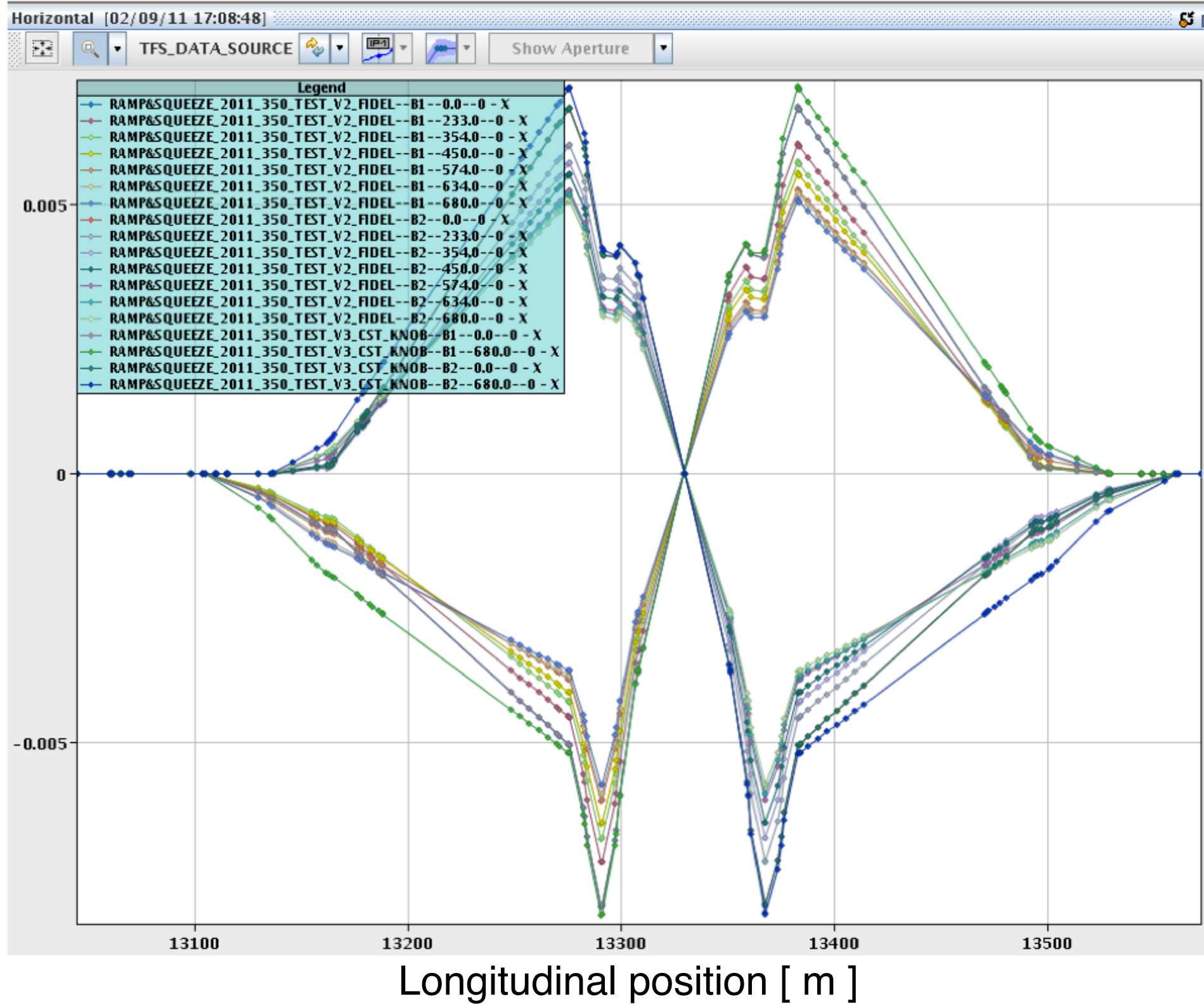


**Present settings  
 have a beta-beat  
 ~10% at around 5m**

# Simulation of beam orbit



Simulated beam position [ m ]

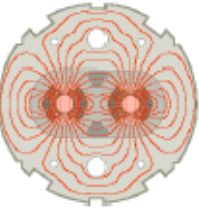


*Simulation of  
beam process  
scan by N.  
Ryckx*

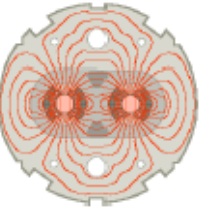
Prepared simulations of crossing angle shapes  
versus time that will be needed for the orbit feedback.



# Conclusions and outlook



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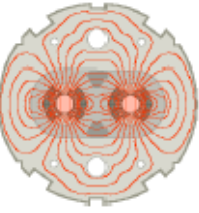


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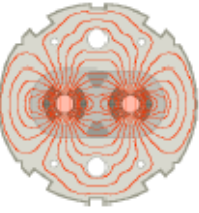
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*Diploma thesis work in collaboration with EPFL.*



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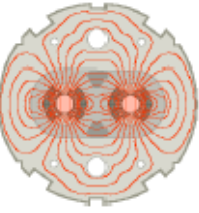
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R&S down to 3.5 m in IP1/5 and 3.0 m in IP8**

*This would give a gain of more than 400 s per fill!*

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- ☑ **Much detailed preparation still ongoing**

*10% beta beating under investigation.*

*Preparing feedforward corrections based on simulations.*

*Check of settings by FiDeL team required.*

*Collimator settings not yet prepared, but possible in principle.*

*Detailed aperture calculations needed: left for after first beam tests.*

# Tune decay during ramp

