*LHC Beam Operation Committee meeting*

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# LHC Cycle for Proton Physics Operation

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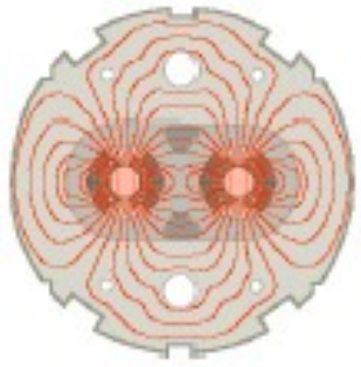
*Acknowledgments: FiDeL team, G. Kruk, M.Strzelczyk,*

*L. Ponce, M. Solfaroli, R. Tomas, ABP optics team*



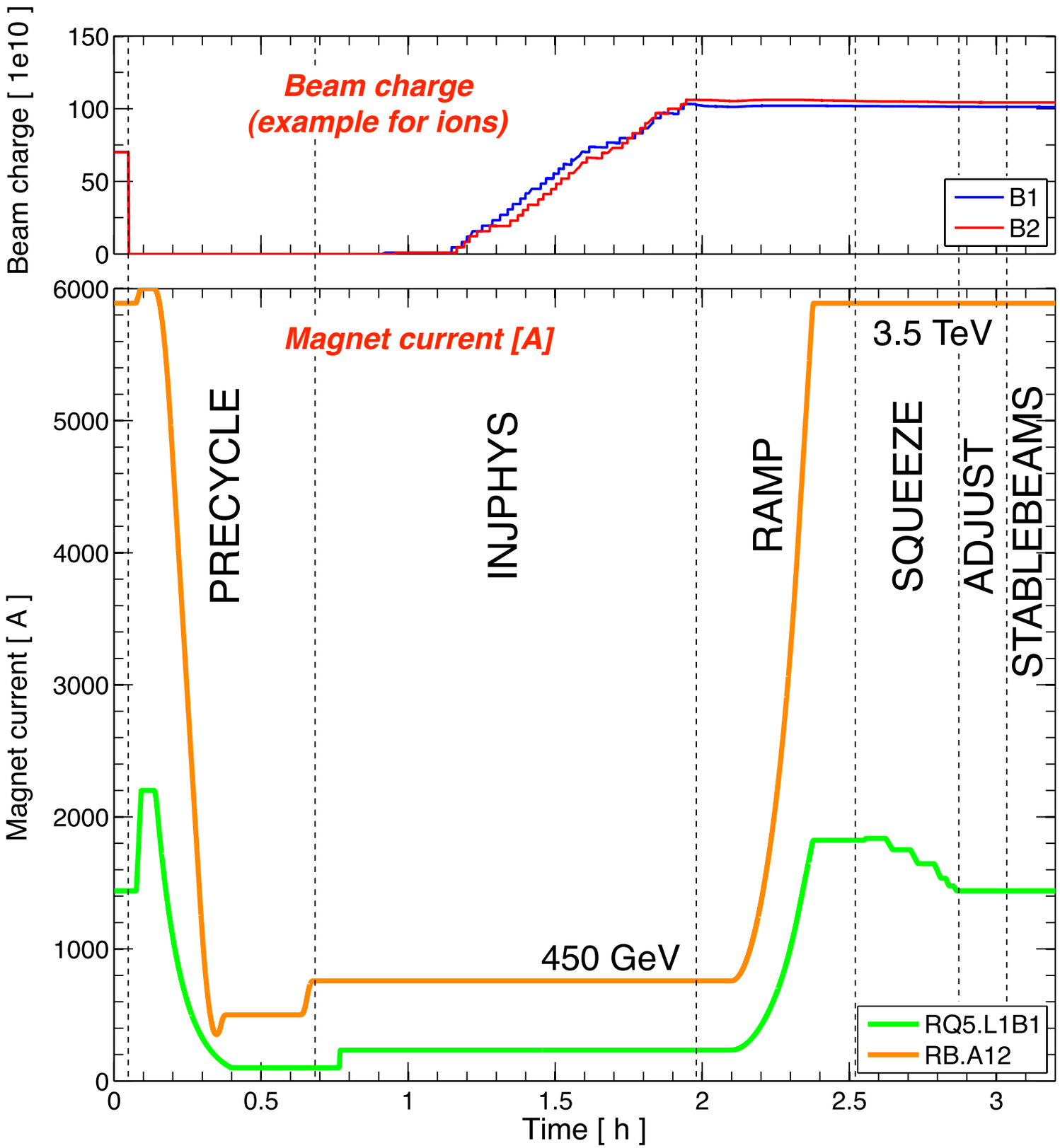
# Introduction

- **Machine parameters will be discussed at Chamonix2012**
  - After Christmas, we started working on a “best guess” parameter set
- **Main parameter changes:**
  - It looks likely that we will operate at **4 TeV**
  - The commissioning will be focused on a target **beta* = 60** cm in IP1/5
- **“Smaller” but significant other changes:**
  - Partial squeeze in IP2 (3m), together with the other IPs
  - Collisions with V angle in IP8
- **Also, fold in some turnaround improvements:**
  - Try to get rid of the 6 minute decay plateau at flat-top!
  - Faster pre-cycle to reduce time with no beam (Walter’s talk at Evian)
  - Unfortunately, no combined ramp and squeeze
- **This talk: ramp and squeeze settings**
  - Will say what is there already
  - Will stress what is still missing
  - MD optics and high-beta optics not discussed here.

# Outline

- ☑ Introduction
- ☑ Recap of 2011
- ☑ 2012 configuration
- ☑ Ramp and squeeze
- ☑ Conclusions

# Modes within the LHC cycle

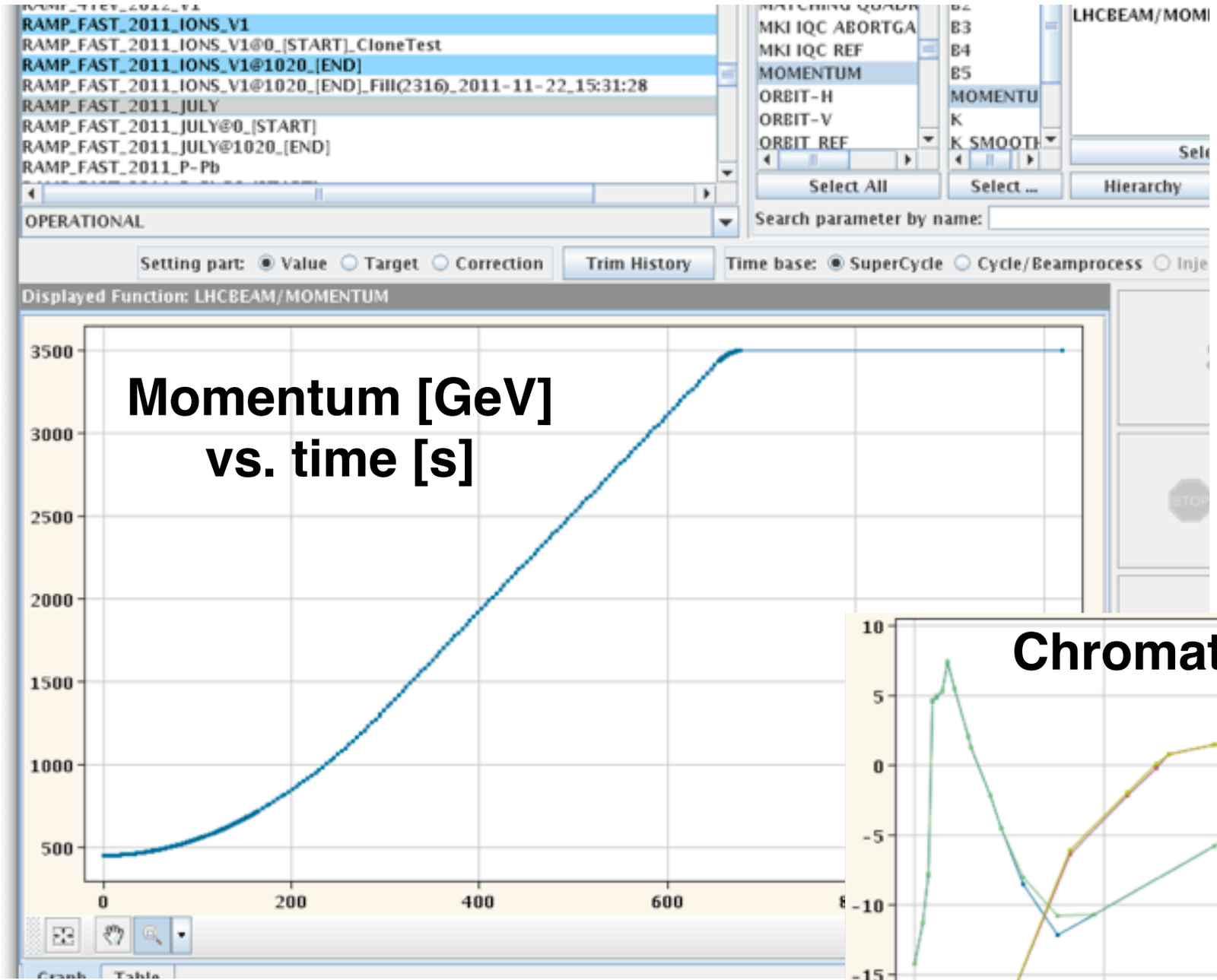



*Time-functions for settings of*
*(1) ramp,*
*(2) squeeze(s),*
*(3) collisions,*
*(4) pre-cycle (without beam).*

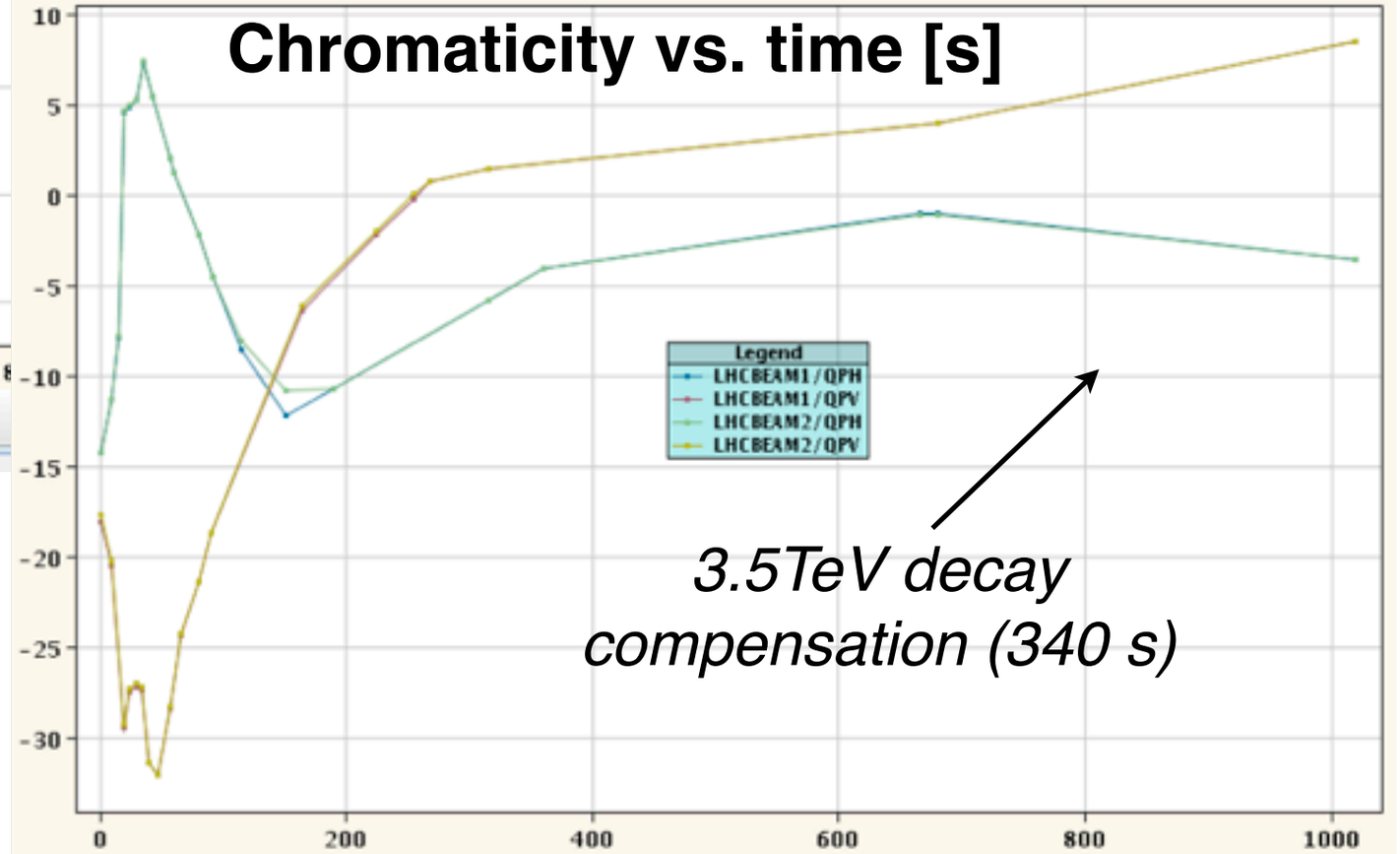
*Discrete ("actual") settings for:*
*(1) injection,*
*(2) prepare ramp,*
*(3) flat-top,*
*(4) adjust (end of squeeze),*
*(5) stable beams.*

*Focus here: setting functions, no human factor of discrete phases.*

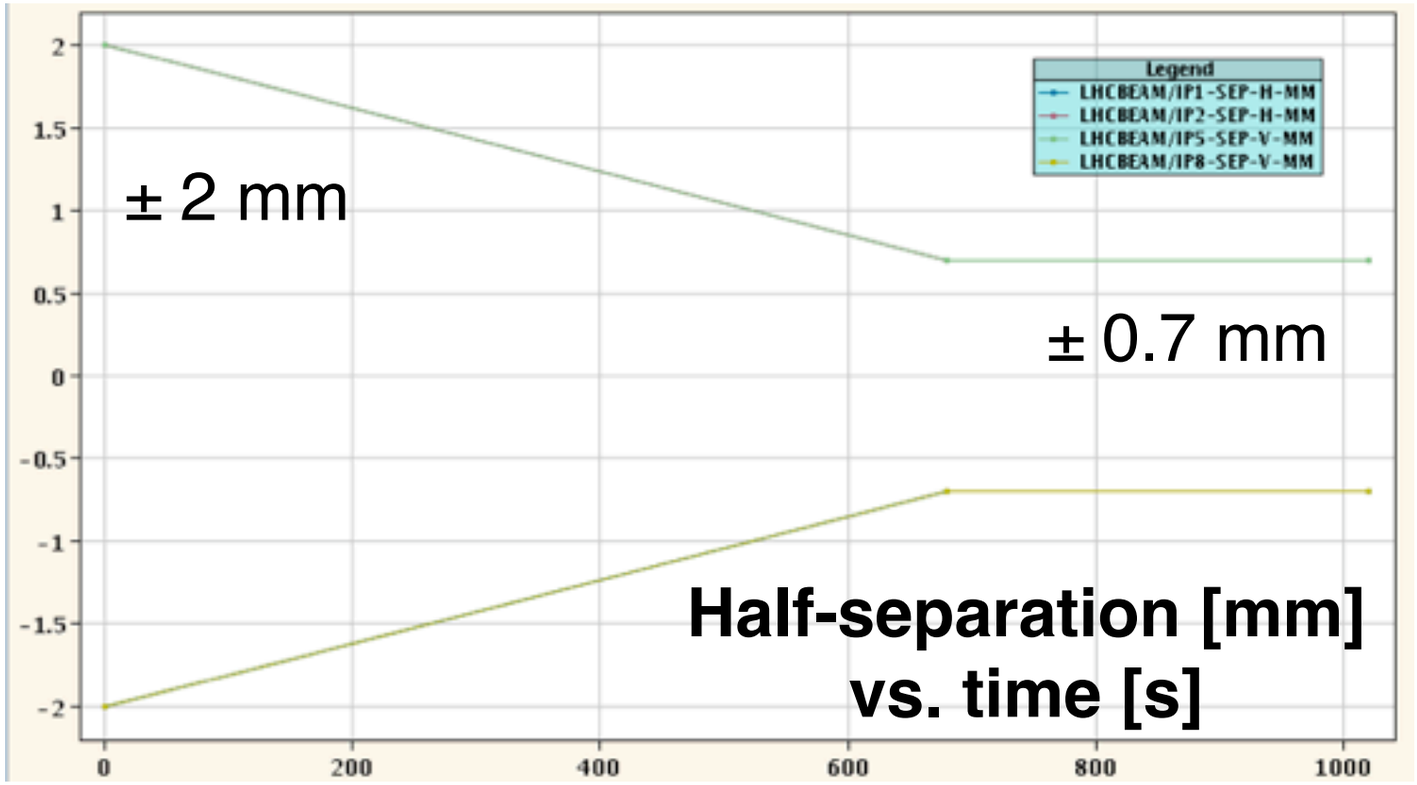
# Ramp in 2011

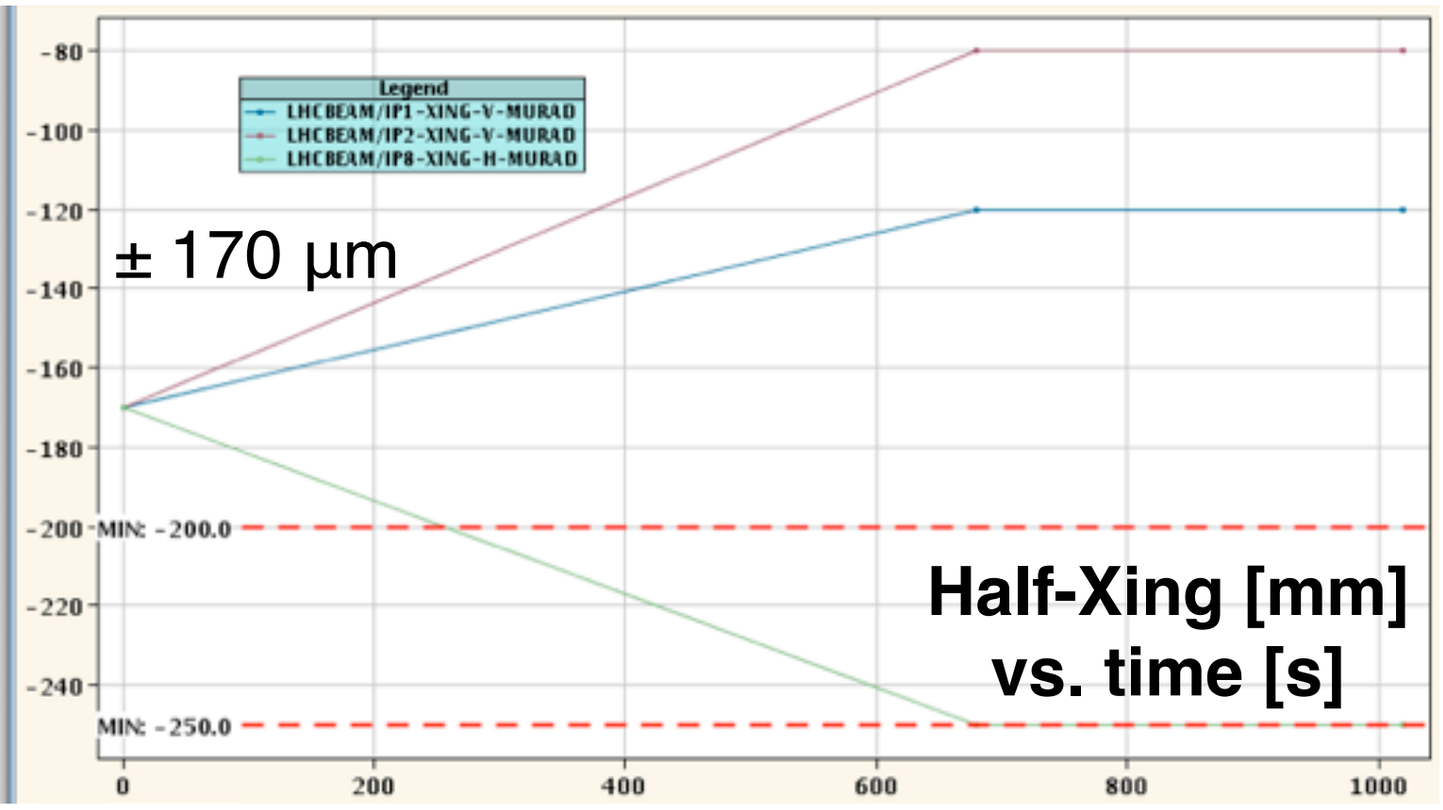



- Nominal ramp rate of 10 A/s
- Optics and tune constant
- Duration = 1020 s (680+340)
- 3.5 TeV decay compensation
- Separation and crossing changed during the ramp!



# Separation and crossing



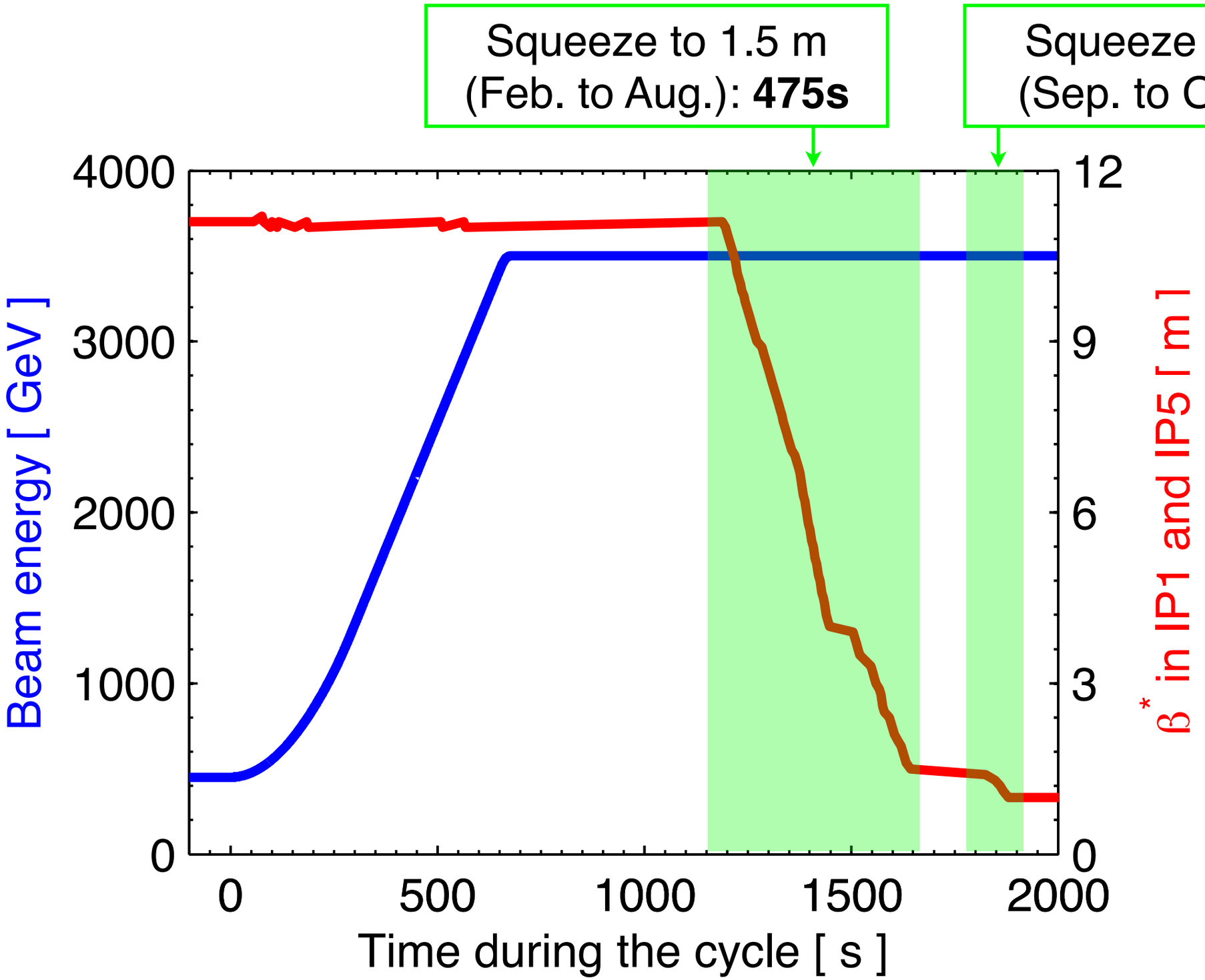




Possibility to change OFB reference with linear functions of time → Xing adjusted to final values and separation reduced during ramp!

Crucial improvement of the operational robustness compared to 2010!

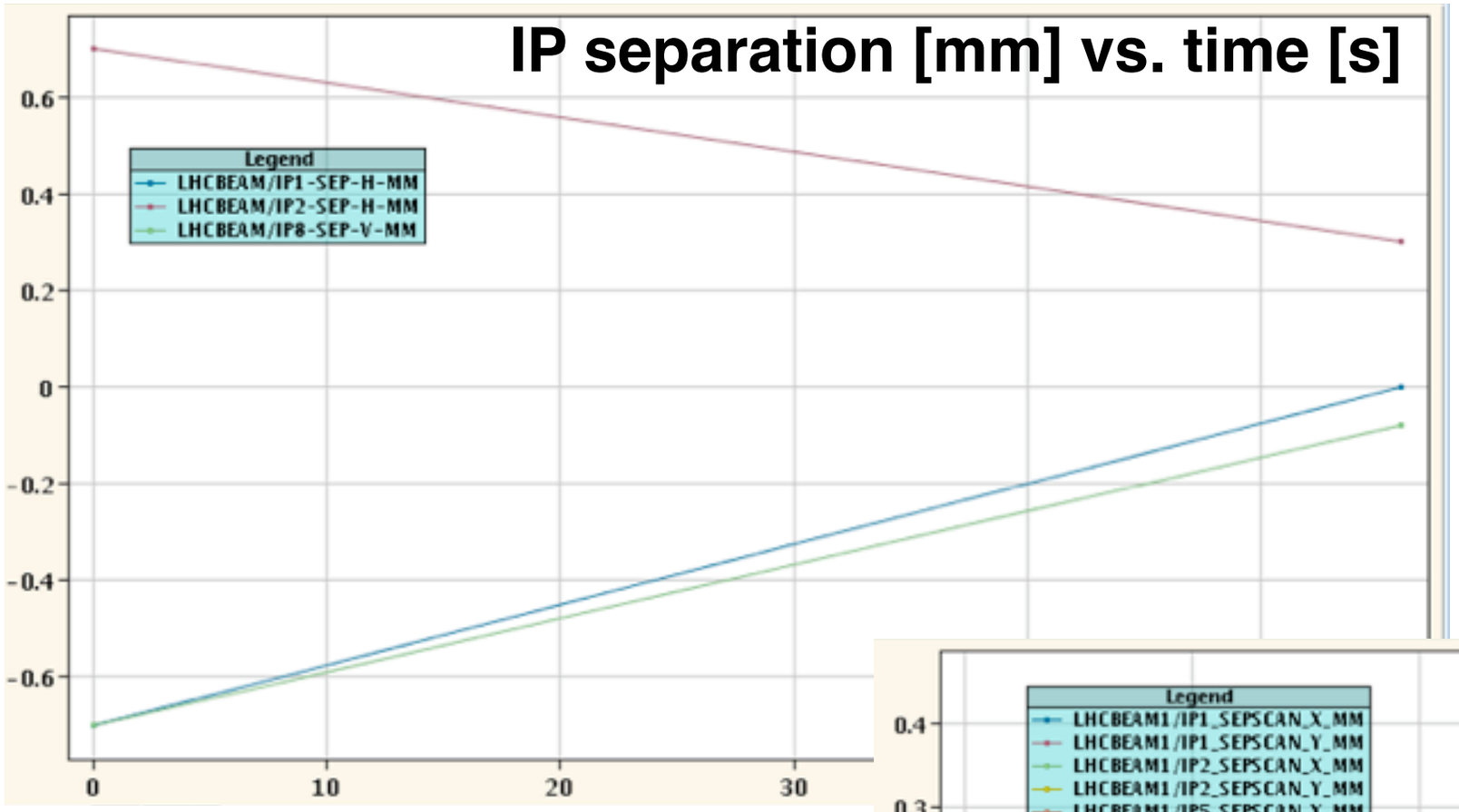
Can we have more sophisticated functions of time?

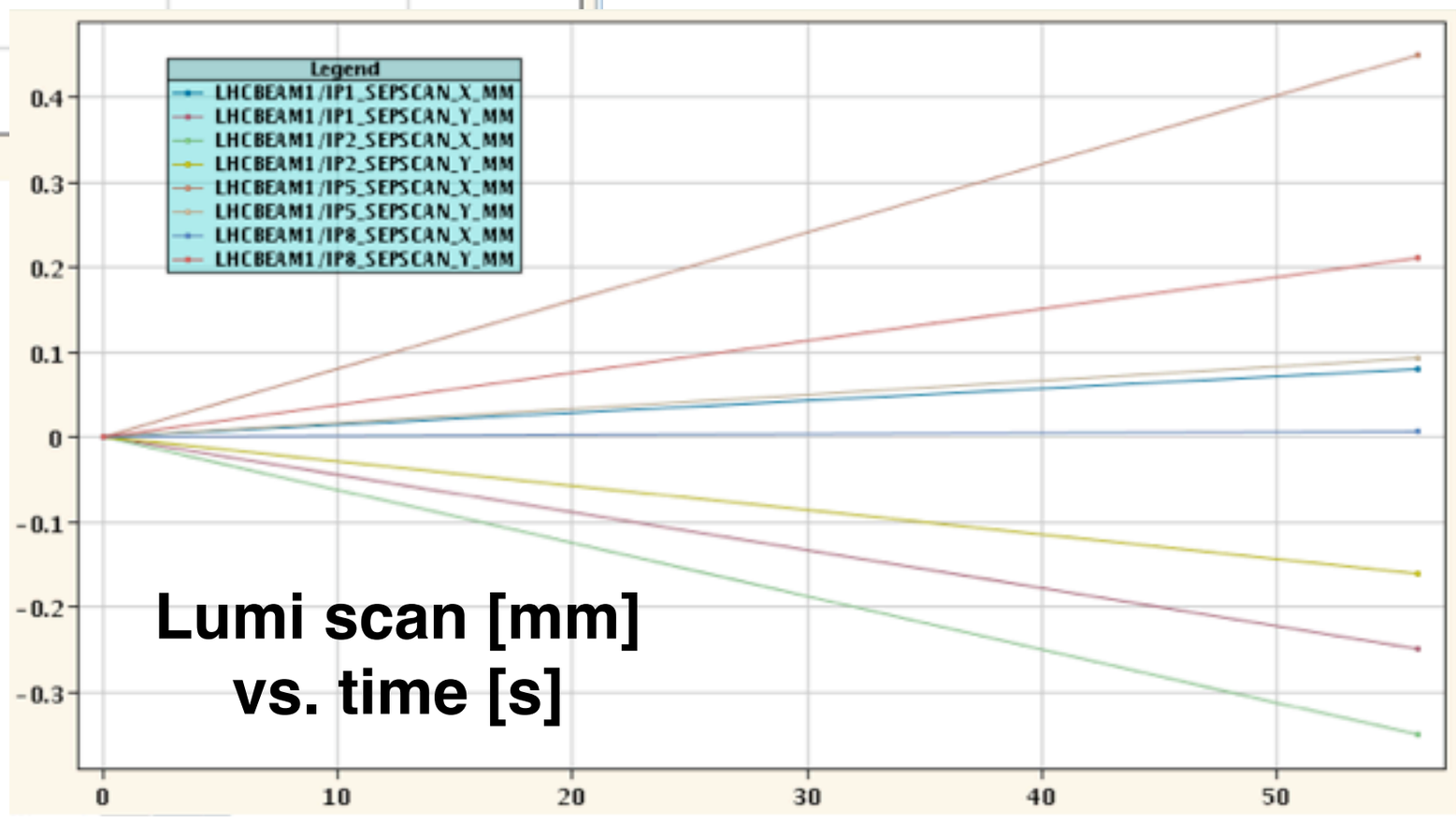
# Squeeze in 2011




Ions: IP2 squeeze to 1m took **771 s** and was performed with other IPs squeezed.

# “Collision” functions in 2011




*Duration: **56 s** (p): factor 2 faster than in 2011 (smaller separation at flat-top!)*
*Ions: **260 s***
*Lumi-scans feed-forwarded fill after fill → good convergence!*

# 2011 parameter table

| Parameter | Value at 450 GeV | Value at top energy |
|---|---|---|
| Energy [ GeV ] | 450 | 3500 |
| Beta* IP1/5 [ m ] | 11.0 | 1.5 → 1.0 |
| Beta* IP8 [ m ] | 10.0 | 3.0 |
| Beta* IP2 [ m ] | 10.0 | 10.0 (p); 1.0 (Pb) |
| Parallel separation [ mm ] | 2.0 | 0.70 |
| Crossing angle IP1/5 [ μrad ] | 170 | 120 |
| Crossing angle IP2 [ μrad ] | 170 | 80 |
| Crossing angle IP8[ μrad ] | 170 | 250 |
| Ramp duration [ s ] | 1400 → 1020 | |
| Squeeze duration [ s ] | 1041 (3.5 m) → 548 (1.0 m), | |
| Collision BP duration [ s ] | 108 → 56 | |

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- ☑ **2012 configuration**
- ☑ Ramp and squeeze
- ☑ Conclusions

# Baseline for 2012

- **Operation energy = 4 TeV**
- **Target $\beta^*$ = 60 cm in IP1 and IP5**
  - At the limit of 2011 aperture: need to address early on in 2012 the aperture!
  - Detailed commissioning in the range 1.0 m to 0.6 m (intermediate points) to allow "easy" fall-back to larger $\beta^*$
- **Partial squeeze of IP2 to 3 m, in parallel to other IPs**
  - Improve rates for main-satellite collisions
  - Will speed-up squeeze for ions
- **Remove the 6 minute decay plateau at flat-top**
  - Move chromaticity decay compensation to the spools, where
- **New pre-cycle functions for faster turnaro**
  - Requires validation of hardware, only possib
- **Vertical crossing in IP8** - *see last LBC*

Working assumptions for the moment, waiting for the official decision at Chamonix2012

# 2012 parameter table (protons)

| Parameter | Value at 450 GeV | Value at top energy |
|---|---|---|
| Energy [ GeV ] | 450 | **4000** |
| Beta* IP1/5 [ m ] | 11.0 | **0.6** |
| Beta* IP8 [ m ] | 10.0 | 3.0 |
| Beta* IP2 [ m ] | 10.0 | **3.0** |
| Parallel separation [ mm ] | 2.0 | **0.67** |
| Crossing angle IP1/5 [ μrad ] | 170 | **145** |
| Crossing angle IP2 [ μrad ] | 170 | **90+** |
| Crossing angle IP8 [ μrad ] | 170 | **100#** |
| Ramp duration [ s ] | 2010: 680+340 | → **770** |
| Squeeze duration [ s ] | 2010: 548 (1.0 m) | → **819** (0.6 m) |
| Collision BP duration [ s ] | 2010: 56 | → **56** |

*+: Preliminary estimate by J. Jowett, R. Versteegen, assuming 2.5 micron emittance*
*#: assumed crossing in V plane (W. Herr)*

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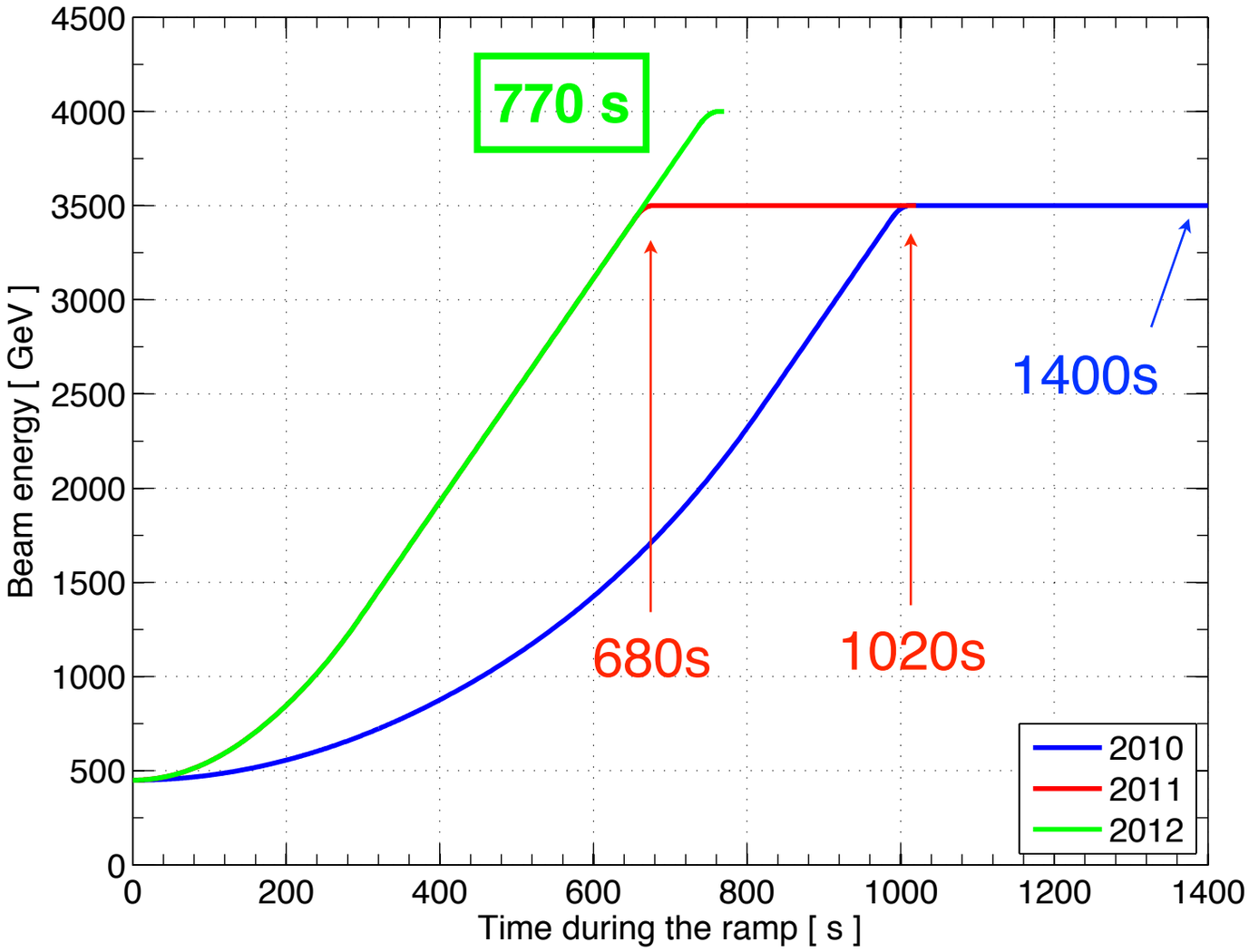
# Ramp to 4 TeV in 2012

- ☑ Same optics and dipole parameters as 2011 give a duration of 770 s (4 TeV)
- ☑ Linear variation in t of Sep/Xing during energy change
- ☑ Same strategy as in 2011 for decay/snapback handling
- ☑ Remove decay *plateau* at top energy




***M. Lamont***

How do we remove the decay *plateau*?

# Removal of decay *plateau* at flat-top

## Operation in 2010 and 2011:

*- Decay of **tune** and **chromaticity** after ramp corrected with Q and Q' knobs*

*- Functions of all PC's were stretched in t, but not changing → machine frozen!*

## Proposal for 2012:

*- Move Q' corrections to RCS's*

*- Longer functions for RCS only → can continue the squeeze with all other PCs!*

*- Let QFB take care of small Q changes*

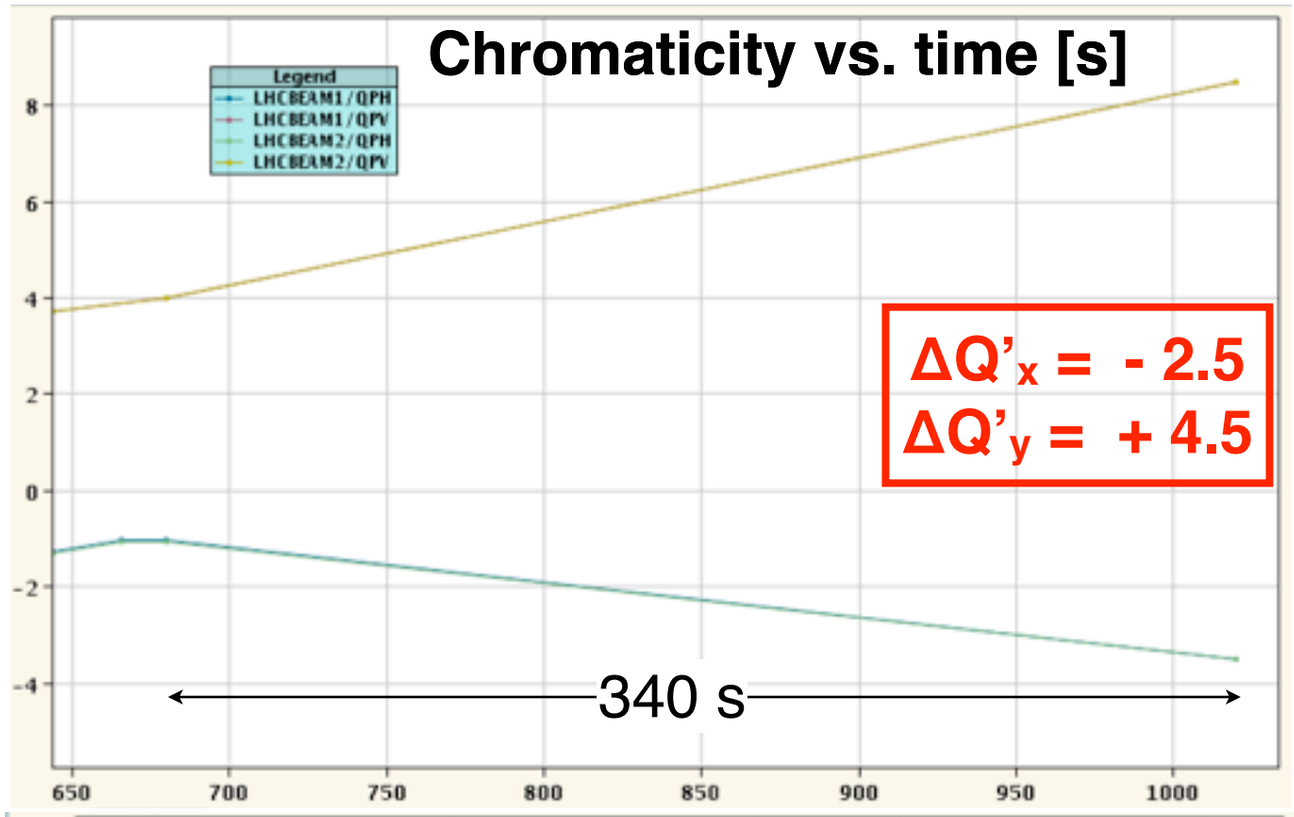
## Requirements:

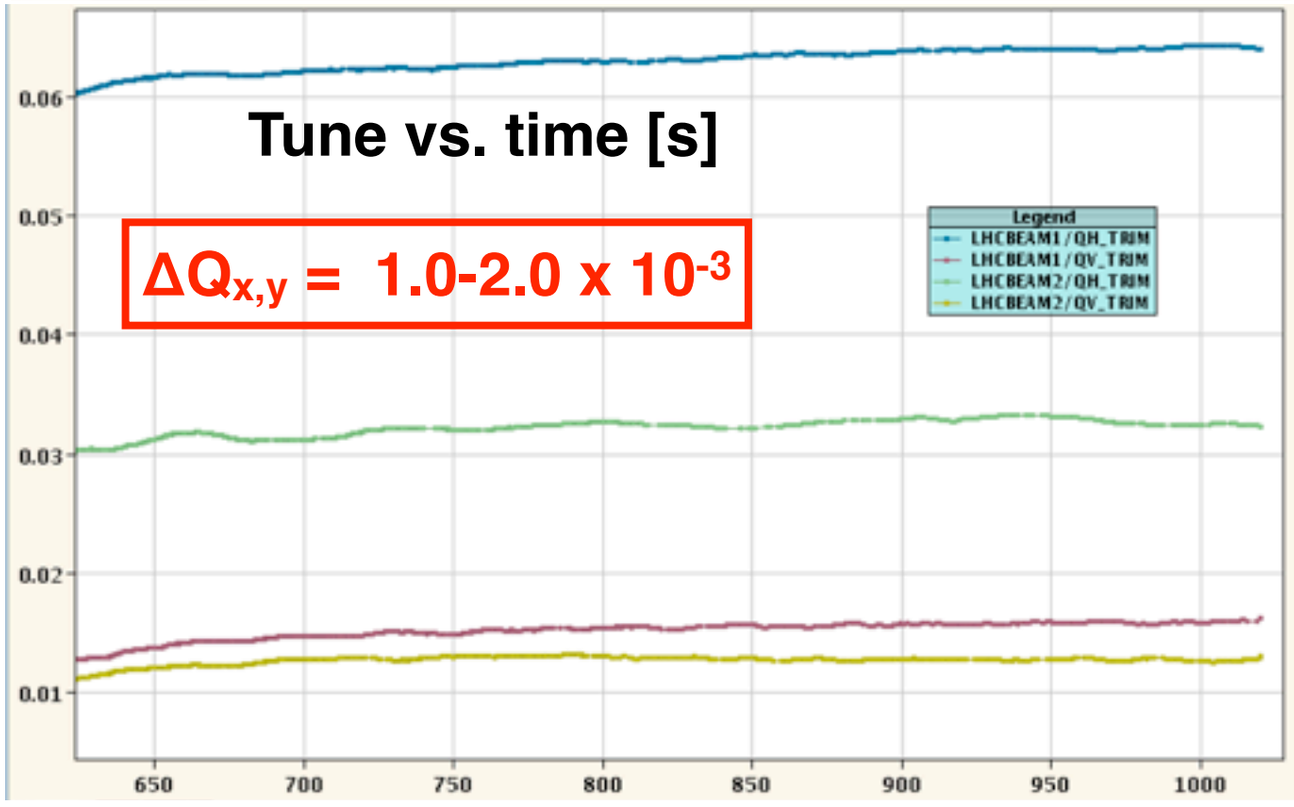
*- Calculate currents in RCSs for ΔQ'*

*- 2 beam processes: one only for RCSs, with the same ramp and longer plateau*

*- A bit of gymnastics with the sequencer:*
*RCSs moved into new complementary HWG's*
*Separated sub-sequences for loading settings at injection, additional LSA users*

*- Tuning based on early measurements in 2012 (Ex. longer plateau needed?)*



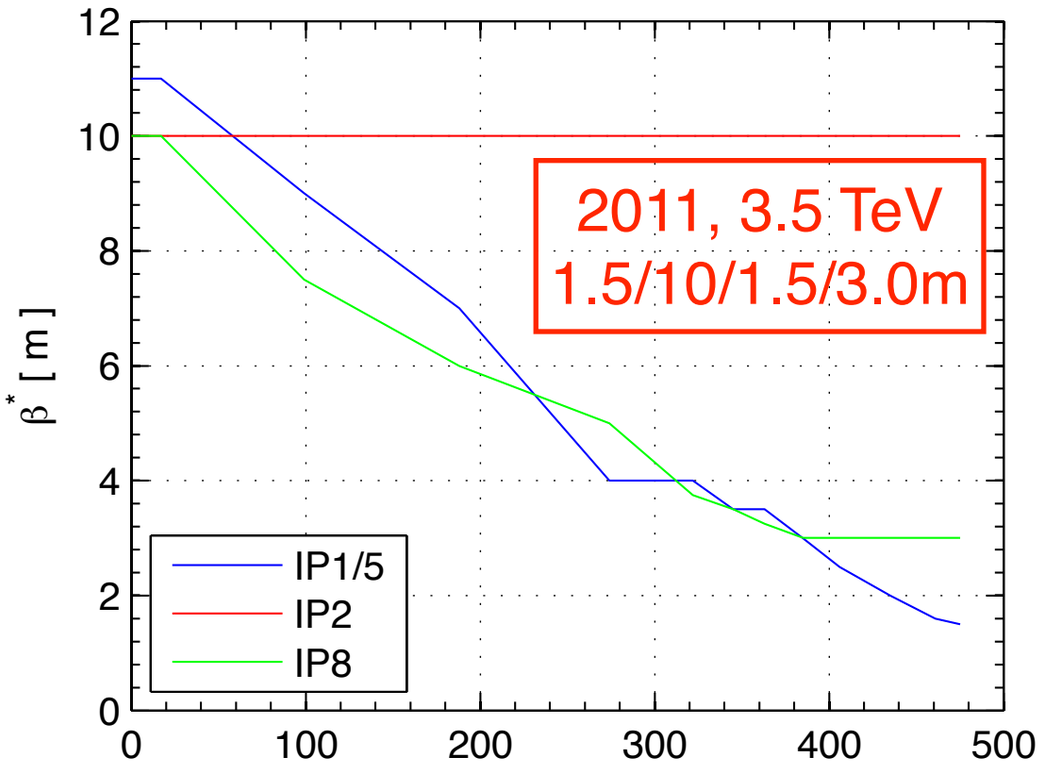
# Squeeze in 2011 and 2012

## Recap of strategy for 2011:

1. *Optimized duration down to 3m (based on 2010)*
2. *No optimization in new territory below 3m*
3. *Keep ~same $\beta^*$ in all IPs (better for protection)*

## Strategy for 2012:

1. *Optimized duration in known range above 1.5m*
2. *Same matched points below 1.5m*
3. *Allow different $\beta^*$ values in IPs (ok in 2011!!)*
   *Ex.: no repeated points in IP1/5; IP2 slower...*
4. *Keep all matched points in IP8*




## Achieved parameters:

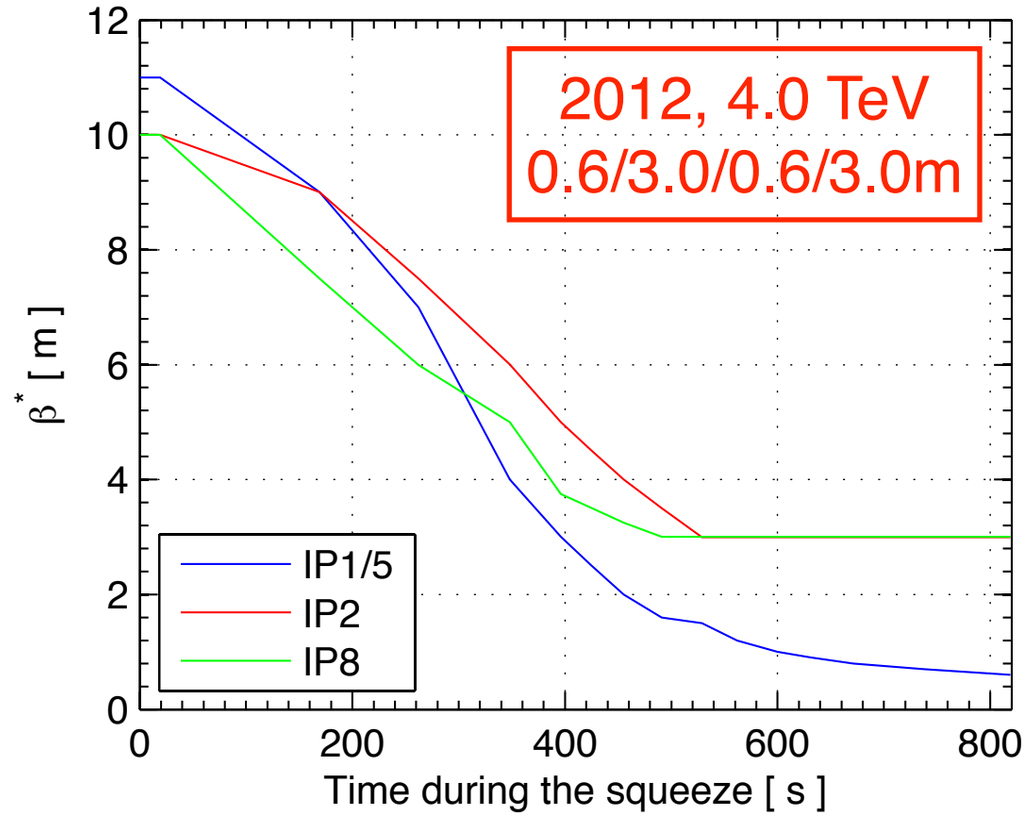
*Duration = **819 s** (lost 48s due to IP2)*
*Settings preparation/validation ongoing (M. Solfaroli)*

## Improved feed-forward strategies

*Tunes, beta-beat and orbit based on simulations!*

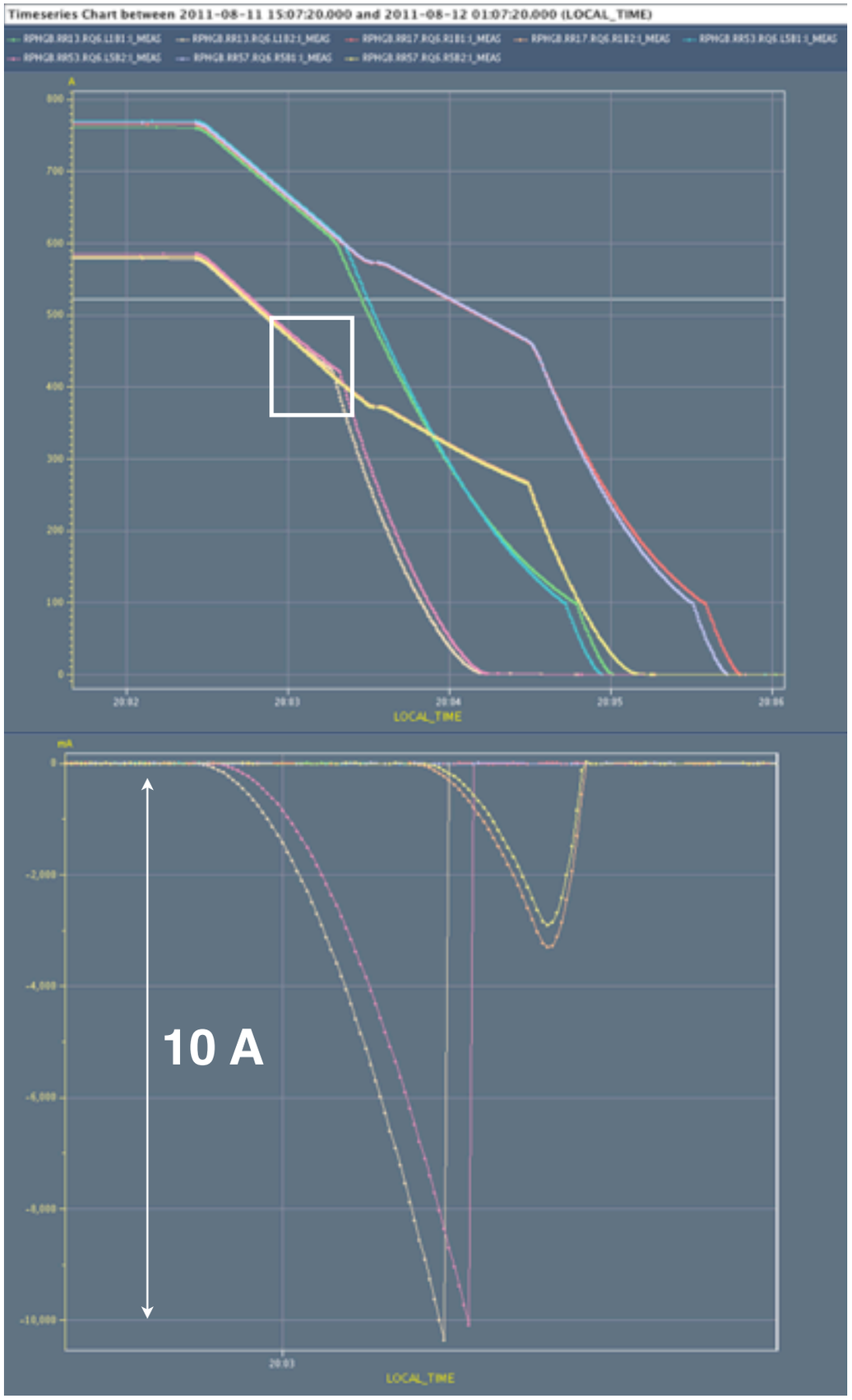
*First guess of beam process type for 2012 squeeze*

| Optic Name | Energy | Time | Parabolic Fraction |
|---|---|---|---|
| A110C1100A1000L1000_INJ_2011 | 4000.0 | 0 | 0.0 |
| A110C1100A1000L1000_2011 | 4000.0 | 19 | 0.314056 |
| A900C900A900_0.00915L750_0.00932_2011 | 4000.0 | 169 | 0.066667 |
| A700C700A750_0.00897L600_0.00909_2011 | 4000.0 | 262 | 0.107527 |
| A400C400A600_0.00889L500_0.00900_2011 | 4000.0 | 348 | 0.096116 |
| A300C300A500_0.00889L375_0.00888_2011 | 4000.0 | 396 | 0.168406 |
| A250C250A450_0.00889L350_0.00882_2011 | 4000.0 | 425 | 0.221224 |
| A200C200A400_0.00889L325_0.00878_2011 | 4000.0 | 455 | 0.215405 |
| A160C160A350_0.00889L300_0.00875_2011 | 4000.0 | 491 | 0.206602 |
| A150C150A300_0.00889L300_0.00875_2011 | 4000.0 | 529 | 0.185064 |
| A120C120A300_0.00889L300_0.00875_2011 | 4000.0 | 562 | 0.194409 |
| A100C100A300_0.00889L300_0.00875_2011 | 4000.0 | 600 | 0.167657 |
| A90C90A300_0.00889L300_0.00875_2011 | 4000.0 | 631 | 0.18177 |
| A80C80A300_0.00889L300_0.00875_2011 | 4000.0 | 671 | 0.13051 |
| A70C70A300_0.00889L300_0.00875_2011 | 4000.0 | 738 | 0.088383 |
| A60C60A300_0.00889L300_0.00875_2011 | 4000.0 | 819 | 0.10219 |



# Outstanding issues

- **NEED AN OFFICIAL 2012 SEQUENCE RELEASE**
  *Under validation by ABP → available end of this week for settings preparation after Cham2012*
- **New optics in 2012**
  *New phase advance in IP6 - see previous talks*
  *Improved optics available for IP2*
- **Improved setting generation**
  *Trips of Q4, Q5, Q6 from incorrect inductance*
  *2011: problems with ATS, 90m, low-beta <1.0m*
  *Will affects the duration of 2012 squeeze!*
- **Improved strategy for trim knobs**
  *OP/LSA agree on strategy for round-off of knobs during squeeze (Q, Q', C)*
  *Issue revealed in ATS MDs + orbit around matched points*
- **Chasing setting problems in IP8**
- **Start dry-runs of squeeze asap!**
  *Problems last year in dry-runs to < 1.0m (Q6)*



# Conclusions

- ☑ **Proposal for the 2012 configuration was presented**
- ☑ **New settings for ramp and squeeze being prepared**

  *Energy ramp to 4 TeV*

  *Squeeze in IP1/5 to 60 cm; IP2 also squeeze*

  *Removing flat-top decay plateau*

- ☑ **Ramp + squeeze + collision duration (protons):**

  ***2010**: 1020 + 548 + 56 s = **1624 s** (27.1 min)*

  ***2011**: 770 + 819 + 56 s = **1645 s** (27.4 min)*

  *Additional 11 minute gain in the precycle!*

- ☑ **Several new improvements/changes on the table**

  *Need validation early on in the commissioning*

- ☑ **Looking forward to start the beam commissioning!**