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XP 1003: Combined X-point Height and Strike Point Control

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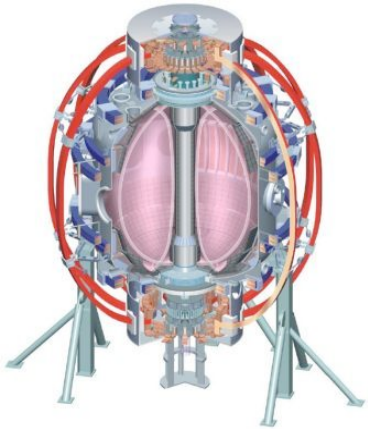
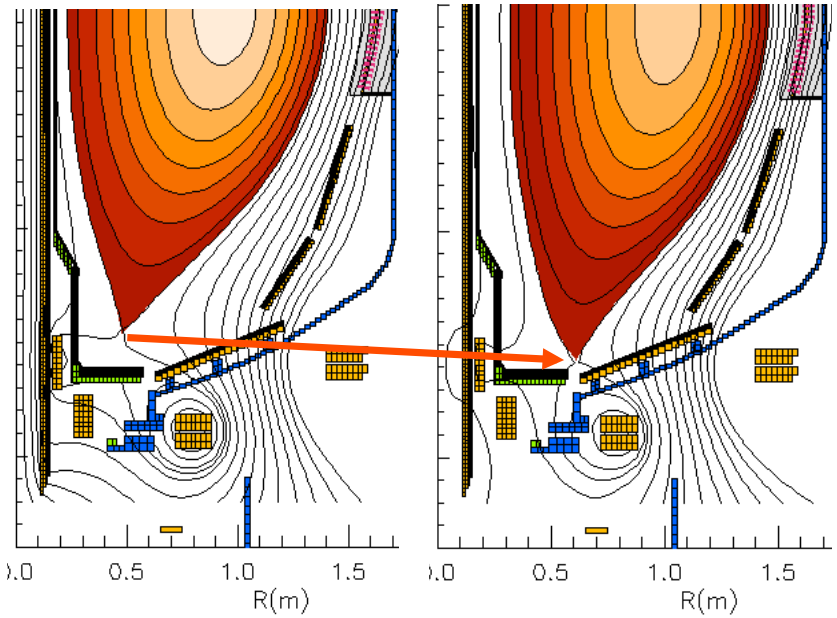
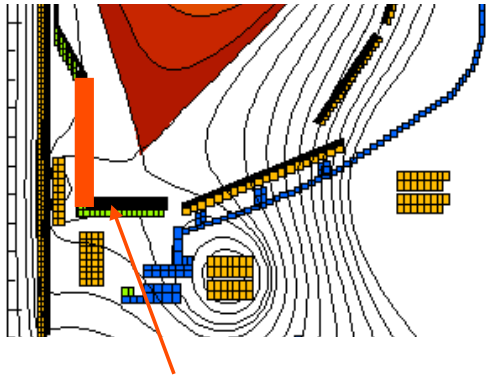
2010 NSTX XP Review, ASC
Room B-252
March 14th, 2010



Previous Year: Inner Strike Point Control



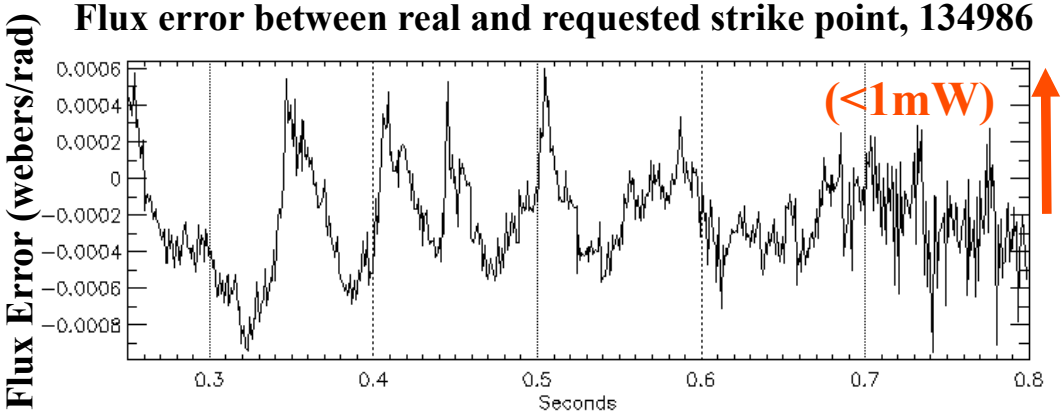
X-points bifurcation



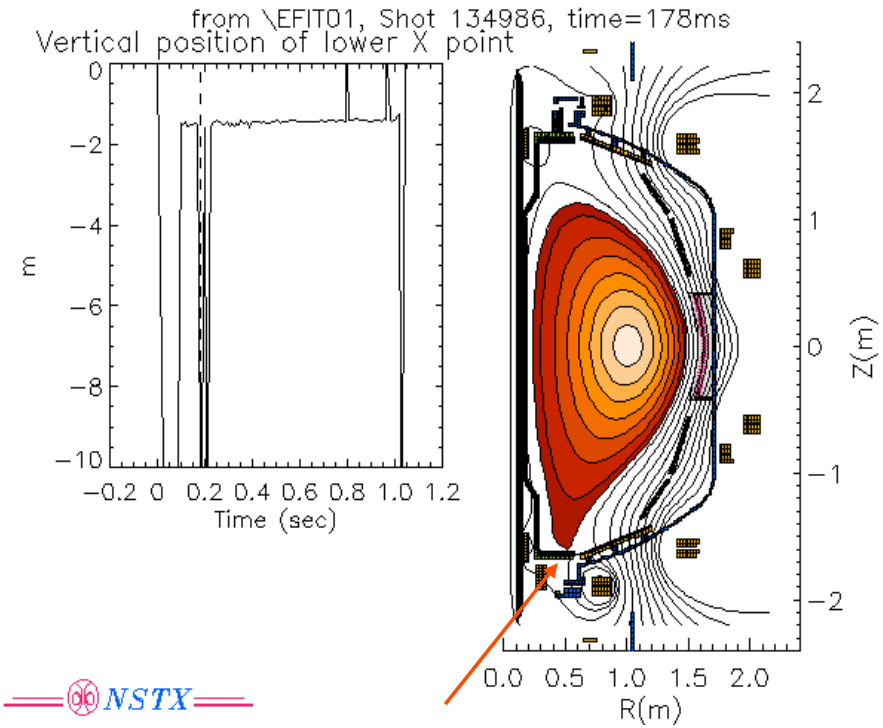
Segment to control inner strike point

- The OSP controller kept the controller at requested position but problems during the transition
- During the transient phase of the discharge, equilibrium bifurcated to a nearby solution with a low X-point.
- Algorithm was jumping from one solution to the other one.
- To make more stable plasma: Added inner strike point controller.

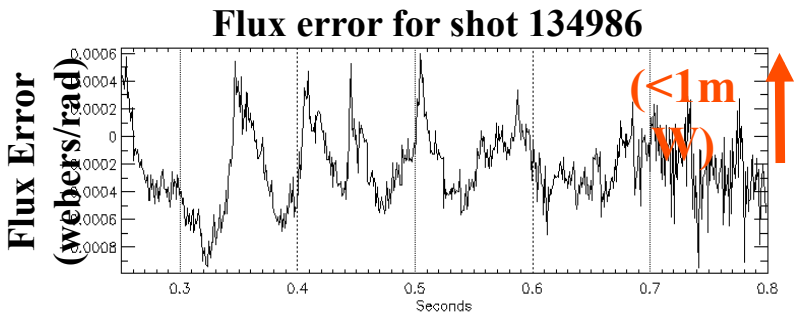
Flux error between real and requested strike point, 134986



Improvement Needed for Transient Phase: X-point Height Control

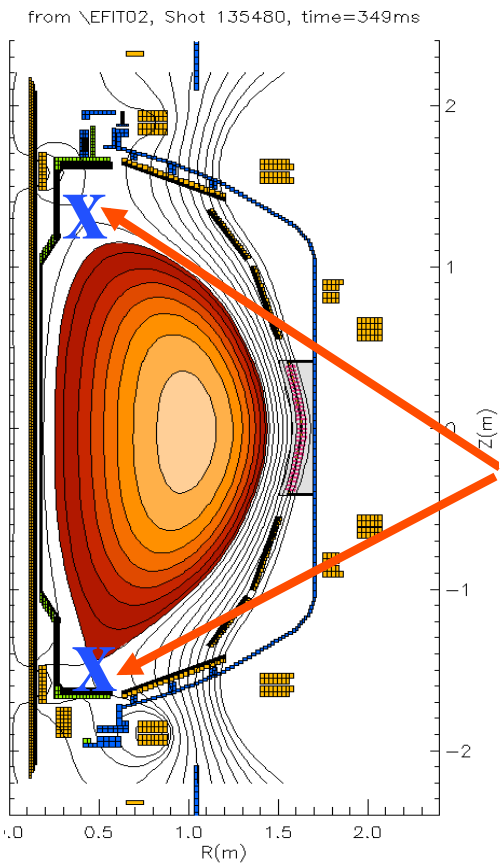


Plasma touching the vessel During transient

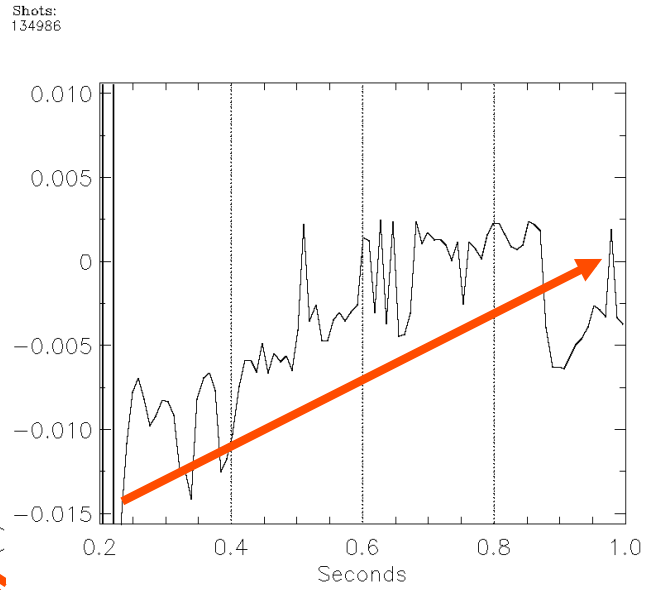


- Problems with the transient phase of the shots with the outer strike point controller on.
- The X-point was touching the vessel wall.
- Last year, inner-strike point control instead of X-point control
  - insufficient run time to implement X-point controller
- Use PF1AL to control X-point height
  - System Id: Relay Feedback
  - Include MIMO controller including PF2L
  - Tune PID
- Time Requested: 1 day

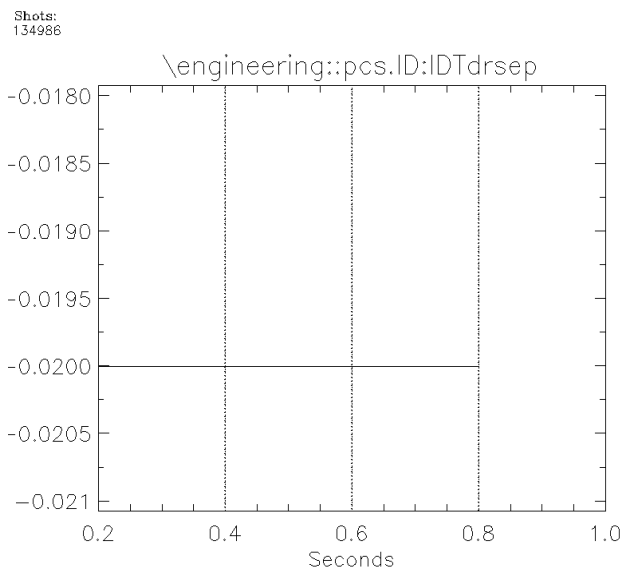
Improvement Need: Drsep Drifts When SP is Controlled



Control Drsep drift via X-point controls.



Dr_sep EFIT02 (cm)



Dr_sep request (cm)

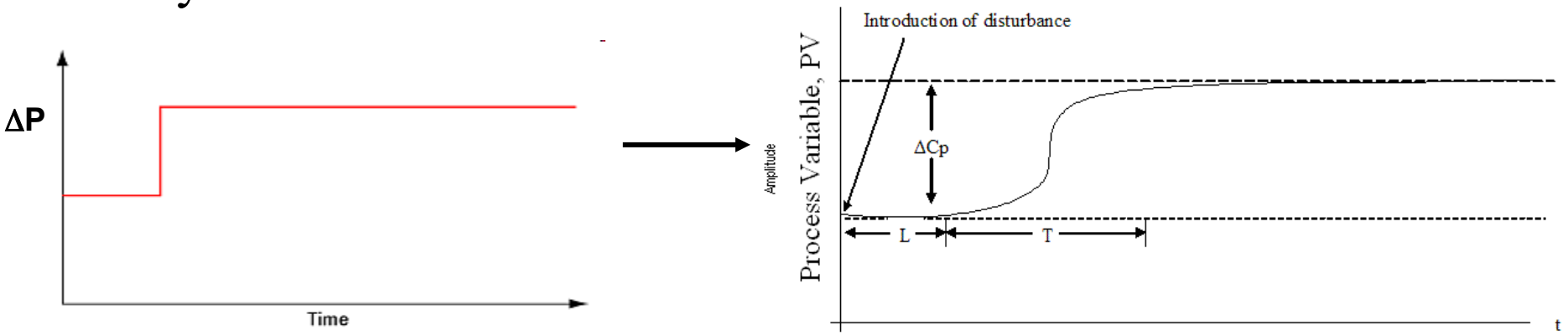
- Problems with the drsep drifting to zero when SP control is on.
- If we can control both upper and lower X-point, drsep can be kept constant.

Current System ID

- System Id: Identify the effect of these coils on the boundary shape.

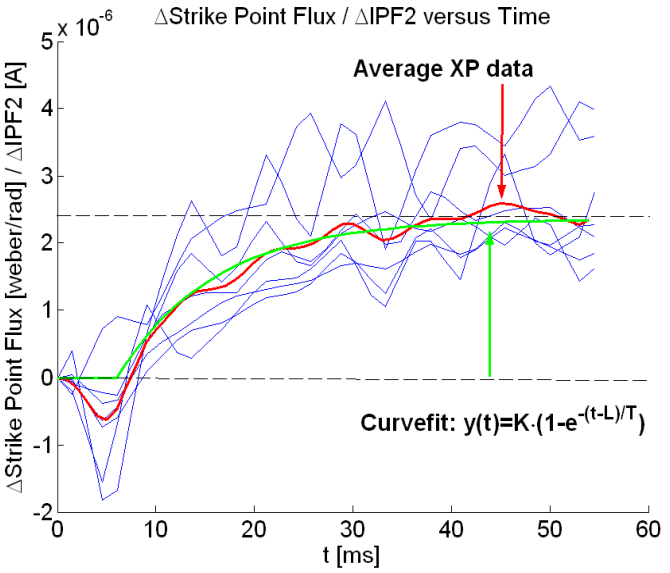
$$\dot{y}(t)T + y(t) = Ku(t - L)$$

- Last year: Reaction Curve Method



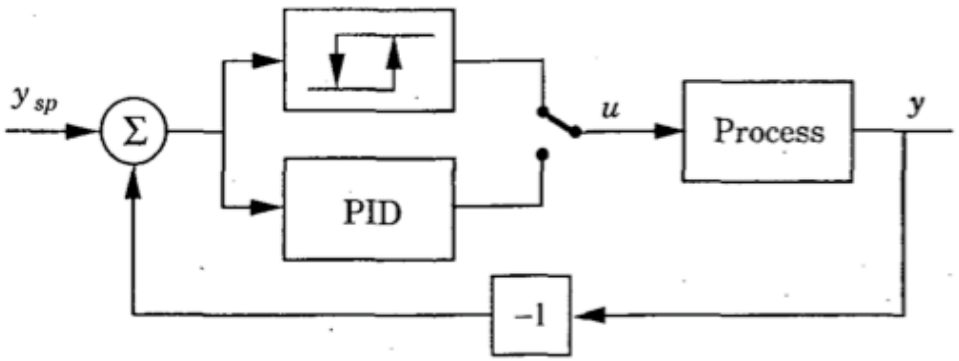
- Results from last year:
- Problem:
  - Many shots needed
  - Not precise

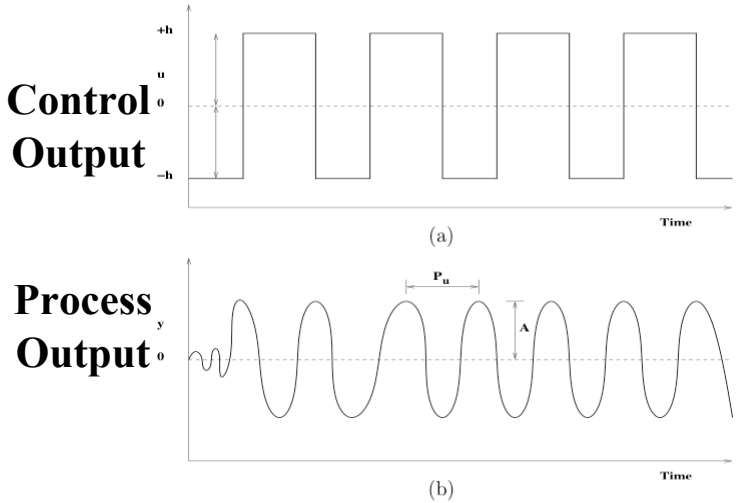
	K_p	K_i	K_d
P	$(\Delta P/\Delta C_p)\bullet(T/L)$	-	-
PI	$0.9\bullet(\Delta P/\Delta C_p)\bullet(T/L)$	$(\Delta P/\Delta C_p)\bullet(3.3\bullet T/L^2)$	-
PID	$1.2\bullet(\Delta P/\Delta C_p)\bullet(T/L)$	$(\Delta P/\Delta C_p)\bullet(2\bullet T/L^2)$	$(\Delta P/\Delta C_p)\bullet(T/2)$



This Year: Experimental Closed Loop System ID

- This year: **Auto-tuning with Relay Feedback Method**





- When we reach this closed-loop plant response pattern the oscillation period (P_u) and the amplitude (A) of the plant response can be measured and used for PID controller tuning.

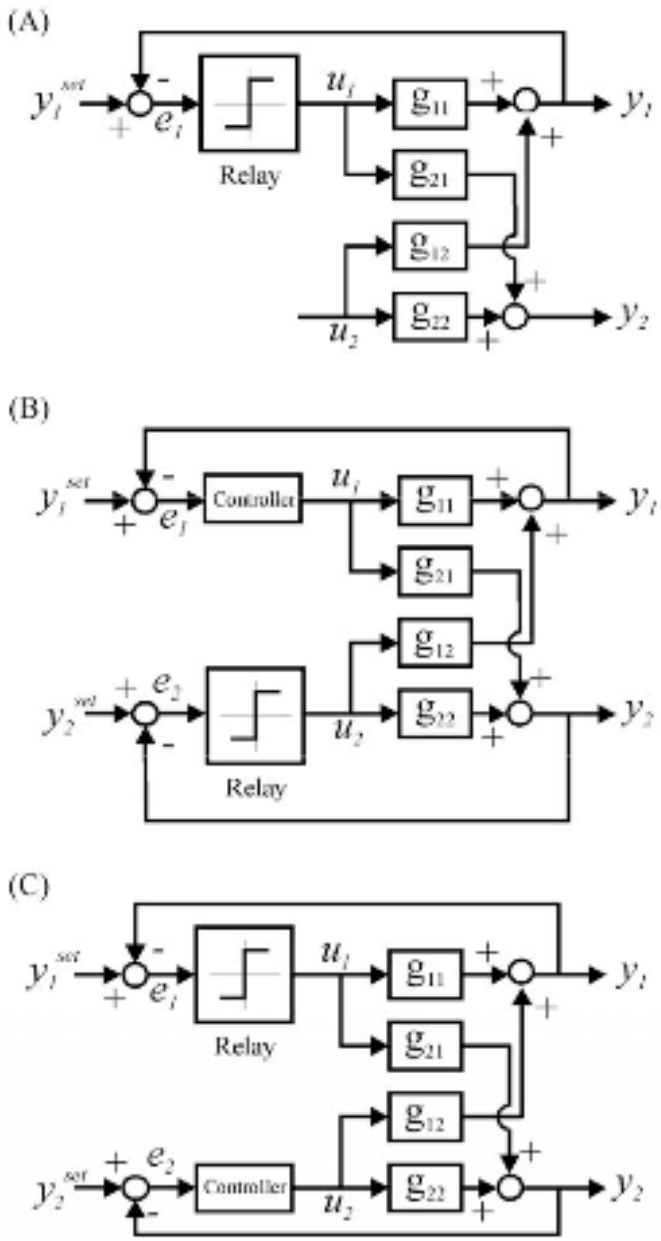
	K_c	τ_I	τ_D
P	$0.5K_{cu}$		
PI	$0.45K_{cu}$	$P_u/1.2$	
PID	$0.6K_{cu}$	$P_u/2$	$P_u/8$

where $K_{cu} = \frac{4h}{\pi A}$

- Only a single experiment is needed.
- Closed loop: More stable

  – Relay Feedback is almost implemented on PCS.

Sequential SISO



1. Perform relay-feedback for y1-u1 while loop 2 is on manual (Figure A)
2. Design the PI/D for u1 for based on on K_{cu} and P_u.
3. Perform relay-feedback for y2-u2 while loop 1 is on automatic (Figure B)
4. Design PI/D for u2.
5. Perform relay-feedback for y1-u1 while loop 2 is on automatic (Figure C)
6. Redesign PI/D for u1.

Experimental Plan for X-point Height/SP controller

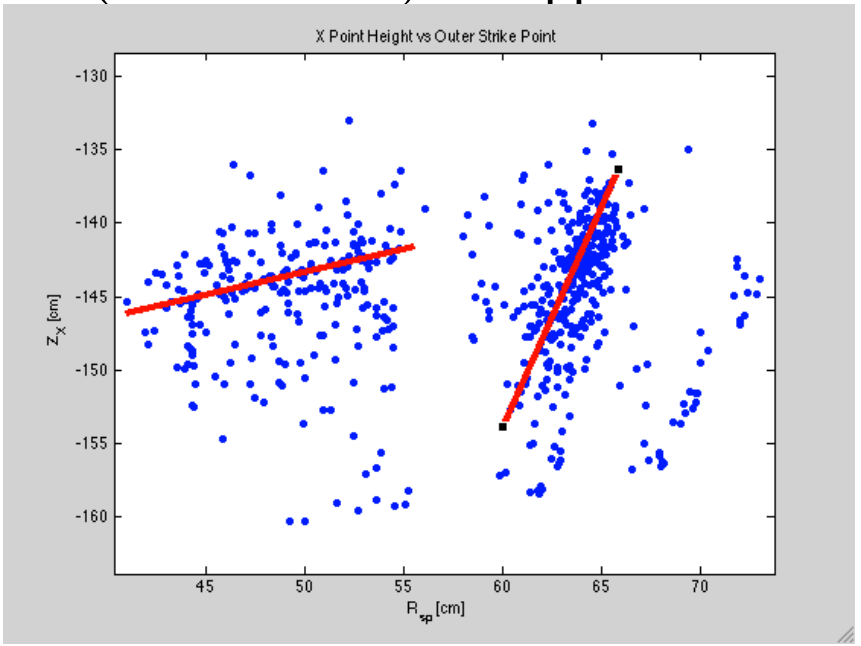
- Time request: 1day
- Load shot 134986 and see if the shot is still the same and SP controllers are working (2 shot)
- Relay Feedback Test (5 shots)
  - First time use. Need to test the software before use.
  - Start with a h value of ~200 Volts. If this is not appropriate scan h.
  - Set the hysteresis value to 2*RMS measurement ~0.1 mWebers/rad. Test.
  - Run relay-feedback on OSP with PF2L. Compare the results with already running control for OSP with PF2L (sanity check).
  - Start with a small P only control for X-point (based on the found K_{cu} and P_u). Test the controller is behaving as expected (correct sign and relative magnitude).

Experimental Plan for X-point Height/SP controller

- Sequential PID Tuning (8 shots)
  - Set PID based on K_{cu} and P_u. Manually tune for stability and performance.
  - Relay-feedback on PF1AL to X-point while OSP control is on.
  - Set PID for PF1AL. Manually tune for stability and performance.
  - Relay-feedback for PF2L to OSP while X-point control is on.
  - If needed repeat this process for PF1AL again.
- Upper/lower combined control for enhanced control (5 shots).
  - Make the changes to the control matrix and PID gains.
  - Tune the requests for the X-point and OSP (if needed F7) for upper to achieve the desired Drsep and stability.
- Scan X-point/OSP with various strike point locations (8 shots).

  <u>R-SP vs. Z-Xpoint</u>

  [44,-146], [47,-145], [50,-144], [53,-143], [55,-142], [61,-153], [62,-150], [63,-147]



Experimental Plan for X-point Height/SP controller

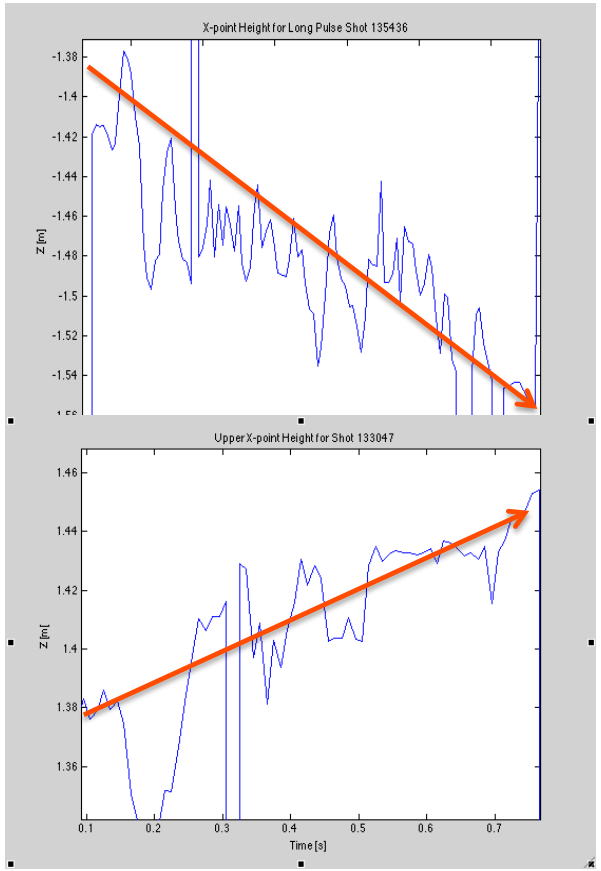
- Decision Point: If the control works without problems and time permits:

  Use the controller for the long pulse shots.
- X-point drifts in long pulse shots.
- We expect the results from control XMP-66 (including better axisymmetric control) and X-point/OSP

  control will enhance performance

- Shot list (6-8 shots).
  - Load shot 135445
  - Implement the XMP-66 improvements in PCS.
  - Add the X-point/OSP controller for this shot
  - Scan X-point from 142 to 152 along

    with OSP [142, 145, 148, 152]
  - Choose the best, add upper/lower X/OSP control



- Backup Slides