Protecting STAR from Abort Kicker Pre-fires

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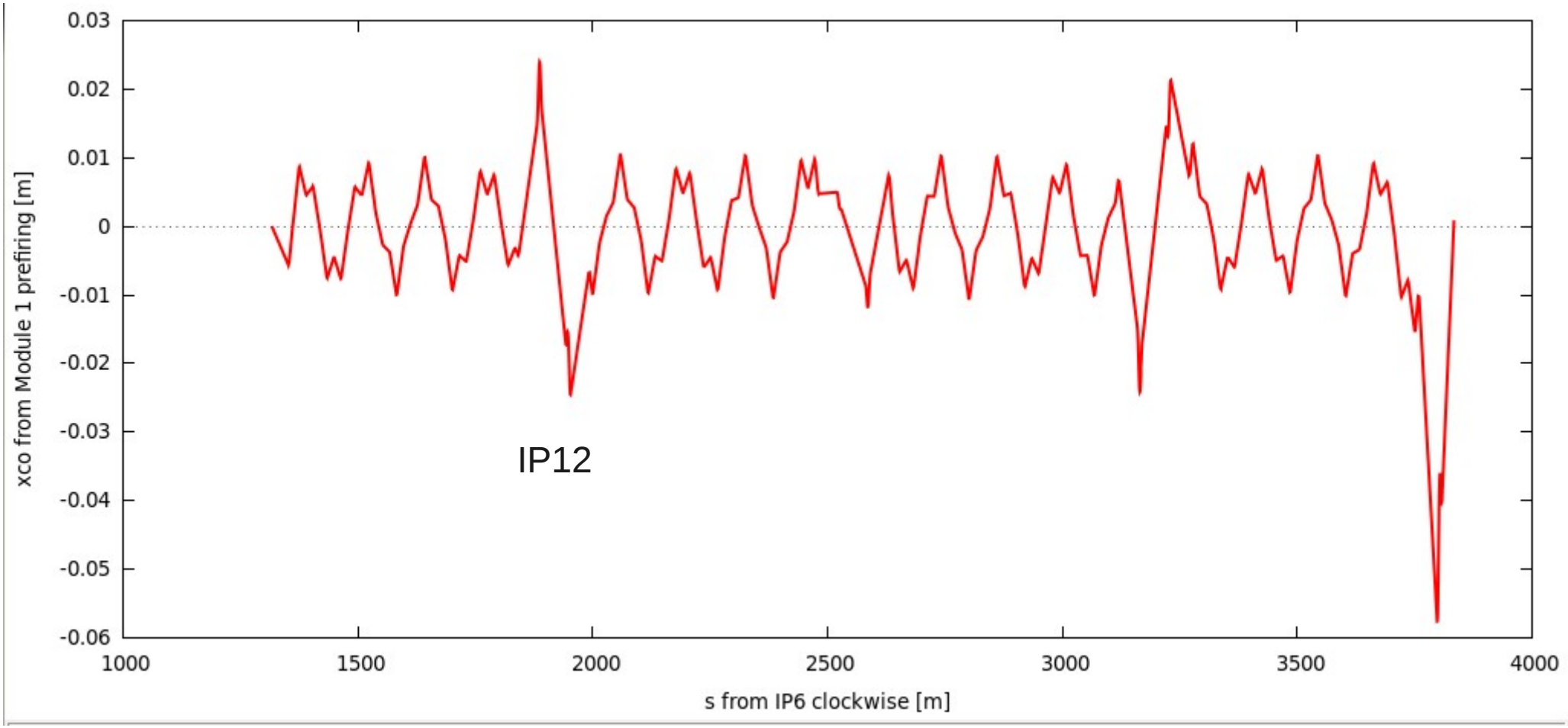
- In previous years, the first BLUE pre-fire has always resulted in major damage to the wire chamber electronics at STAR
- Pre-fires cannot be prevented, but we can reduce their impact
- This requires an aperture limitation far upstream of STAR where the kicked beam gets lost

Orbit from Blue Pre-fire

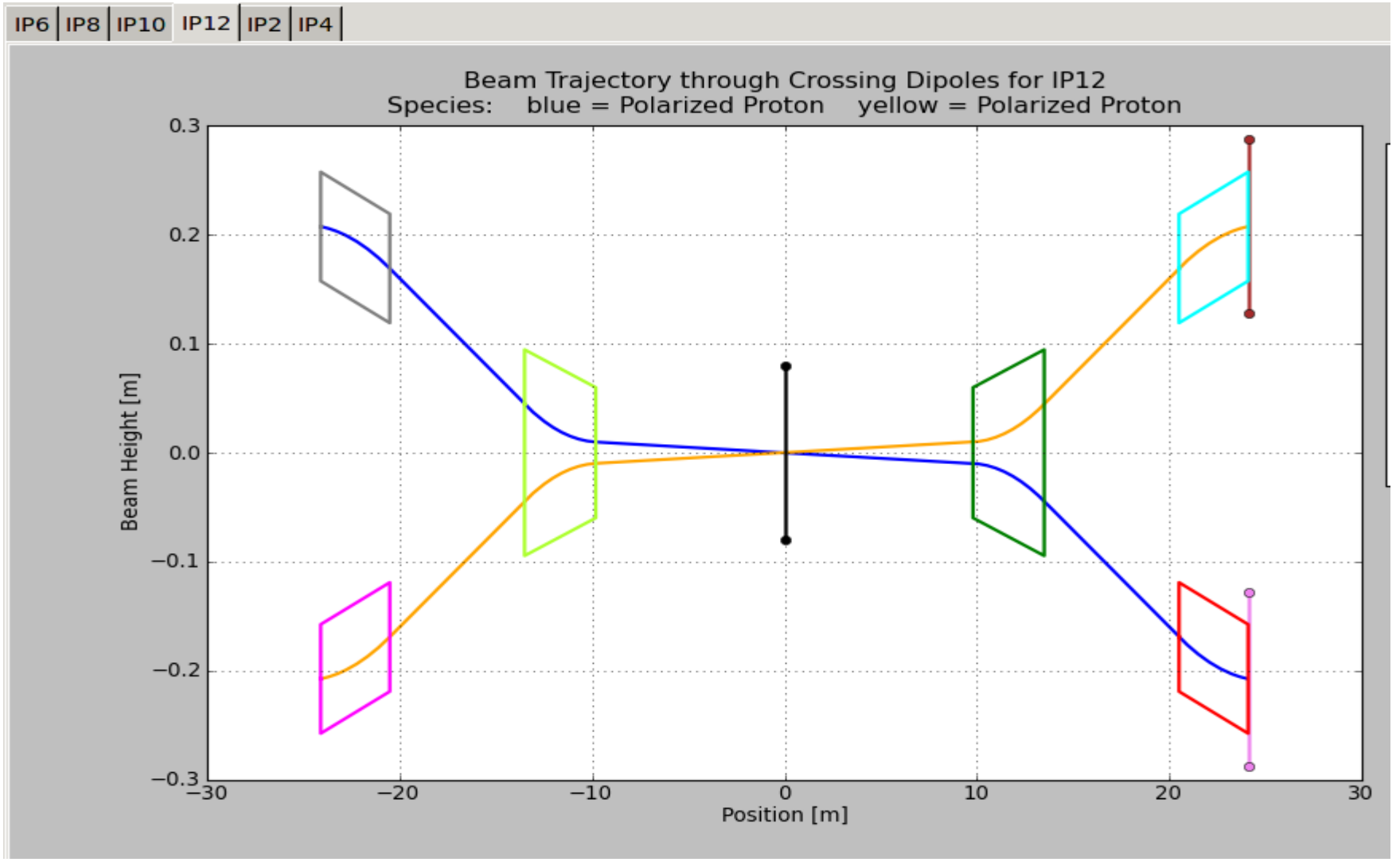


Largest orbit excursion occurs in the triplet upstream of STAR

Basic Idea

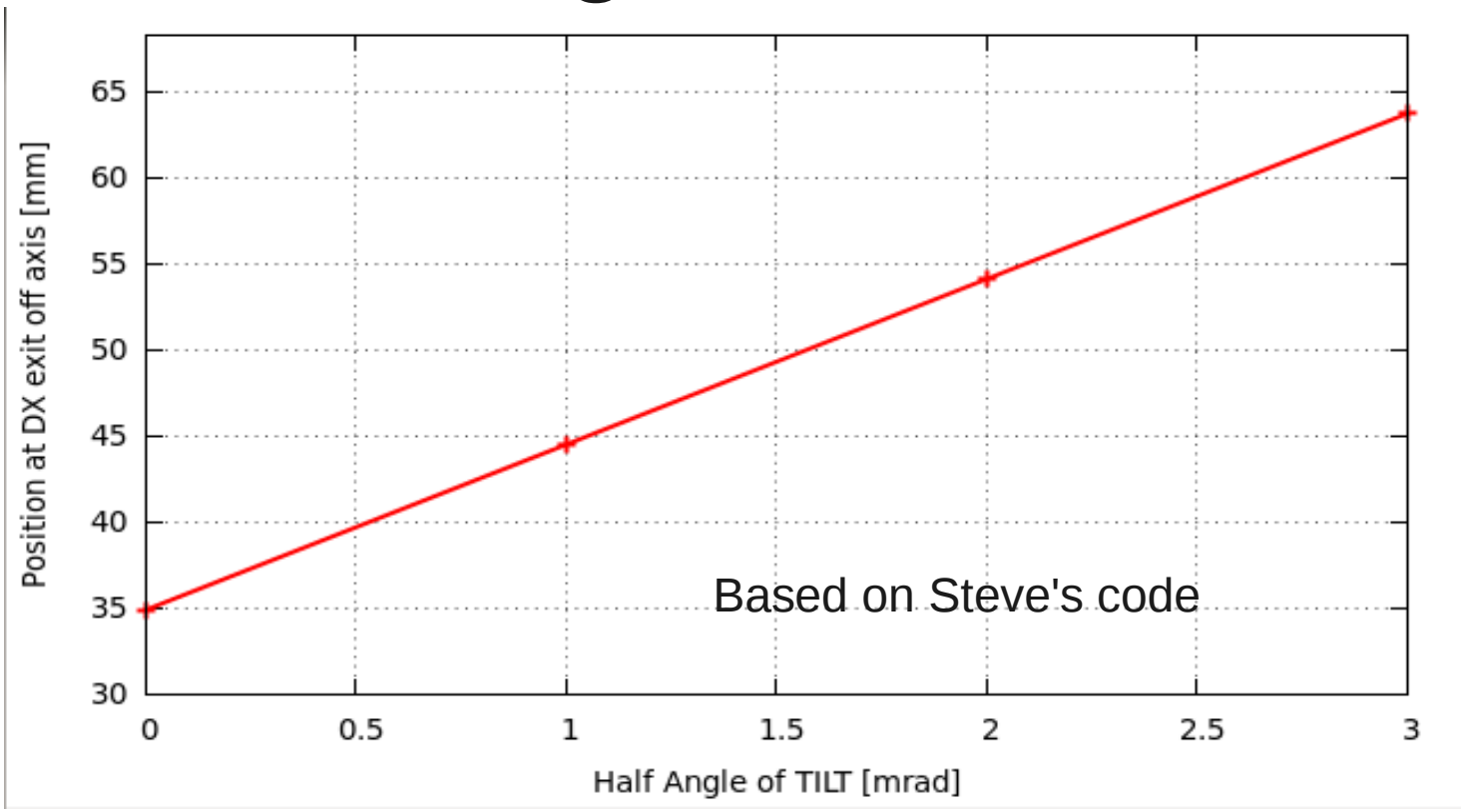
- Generate a large crossing angle in IP12, using DX and D0 magnets
- This will result in a tight aperture at the downstream ends of the DX separator dipoles
- The additional kick from the pre-firing abort kicker module will then push the beam into that aperture limit
- This will likely quench the DX magnet, but pre-fires result in quenches anyway

Crossing angle at IP12



Apply a large crossing angle in IP12 to minimize the aperture at DX (outer end)

Physical Aperture vs. Crossing Angle at IP12

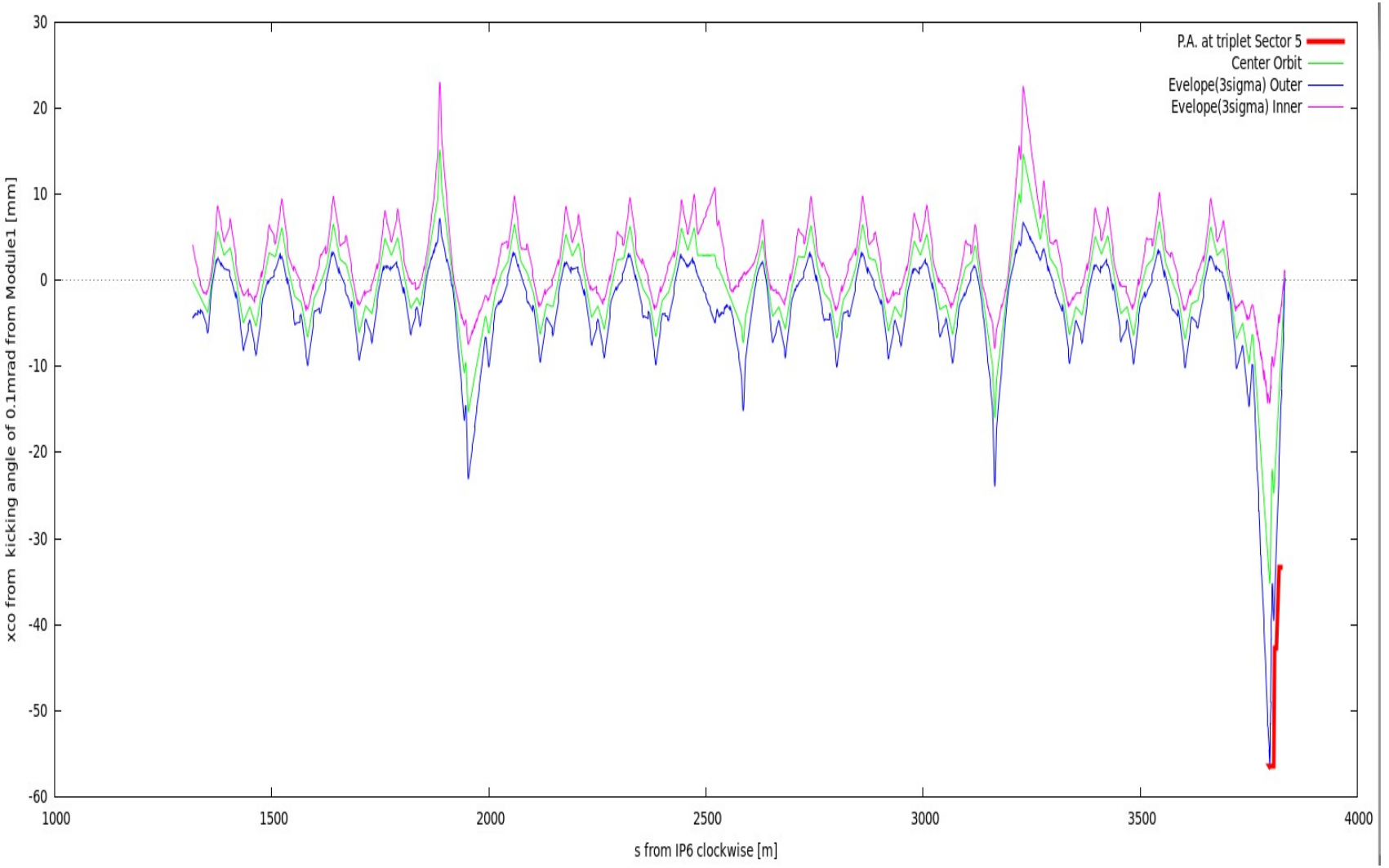


Beam pipe aperture at DX is 68.326mm
Maximum feasible crossing angle is 2.3mrad
-> **This gets us within 11mm of the aperture limit**
-> Need an additional IR orbit bump of a few millimeters to get us close enough

Geometric Considerations

- Ideally, the entire beam should hit the emergency absorber if the kick is large enough for the 3sigma envelope to otherwise hit the STAR triplet
- With a triplet aperture radius of 68mm, the 3sigma beam hits the STAR triplet if the pre-fire kick exceeds 0.12mrad (Module 1) to 0.14mrad (Module 5)

Kick Angle to hit IR6 Triplet



- Resulting orbit (green) with 3sigma envelope

Resulting orbit shift at DX in IR12

- The minimum kick results in an orbit excursion of 5.3 (Module 1) to 6.1mm (Module 5)
- The 3sigma beam size at the DX ends is 3sigma=3.1mm, which means that the minimum kick results in an orbit shift of 5 to 6sigma
- The circulating beam needs a minimum aperture of 5sigma
- At the minimum kick, only **half** the beam gets lost in IR12 DX

- If one bunch receives just the minimum kick, the next bunch gets a kick that is about 15 percent larger, resulting in a larger loss at the IR12 DX
- Kicks increase bunch-by-bunch until the resulting kick is large enough to abort the remaining bunches into the beam dump
- Without the orbit angle in IR12, 10 to 15 bunches would hit the STAR triplet
- With the orbit angle, only very few bunches hit the STAR triplet, and none of them with its full intensity

Summary

- Pre-fires are not preventable, but we can minimize the damage to STAR
- A large crossing angle (plus some orbit bump) in IR12 would make the DX magnets there the limiting aperture for most of the bunches in the event of a pre-fire
- This solution is not perfect, but it reduces the amount of beam hitting the STAR triplet significantly
- We will work on a better solution for future runs