

Optimization for Energetic Particles

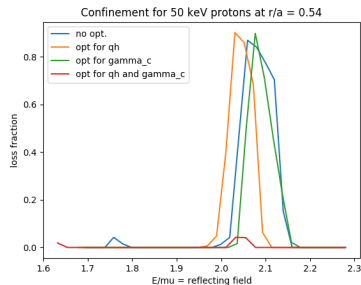
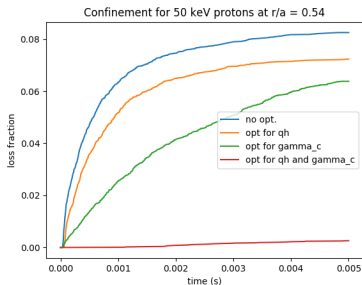
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Wistell Meeting, Oct 5, 2018

Metrics for energetic particle optimization are now working

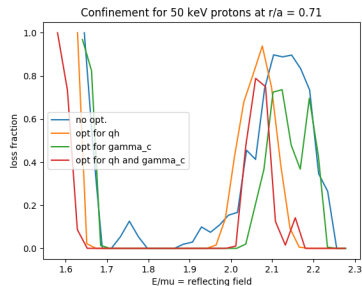
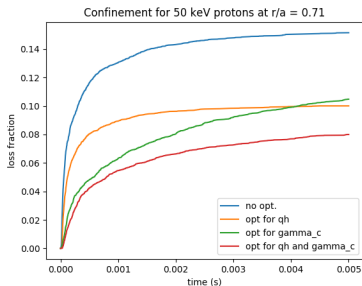
- Key metric: $\gamma_c = \arctan(v_r/v_\theta)$: the ratio of the bounce average radial drift over the poloidal drift - want to minimize
- Can minimize by either reducing radial drift - ensuring $dJ/d\theta$ is small
- Can minimize by increasing poloidal drift - ensuring dJ/dr is large
- Standard neoclassical optimization, ϵ_{eff} optimizes mainly for deeply trapped particles
- For energetic particles, many losses occur at the trapped passing boundary
- Caveat: ripple trapping from finite coils is another source of EP losses and is completely ignored in these configurational optimizations

Optimizing for γ_c and qhs completely eliminate all losses at the mid radius for 50 keV protons



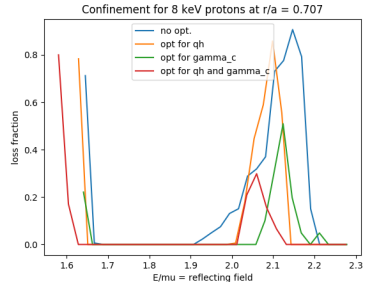
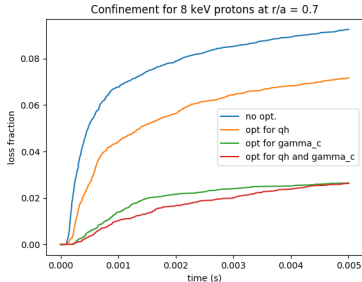
γ_c metric performs better by eliminating losses at the trapped-passing boundary.

Further out, 50 keV protons are lost in all configs



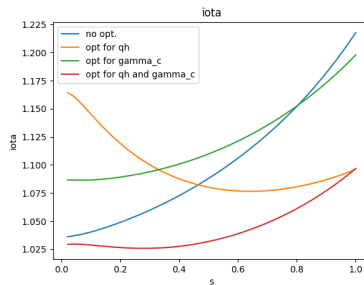
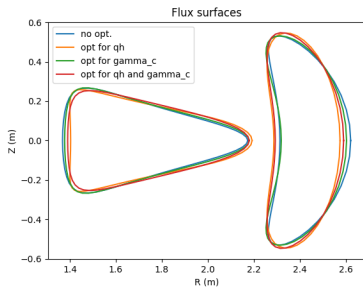
- All deeply trapped particles are lost, along with most particles near the trapped passing boundary
- All configurations do well with particles away from these loss regions

For 8 keV protons, γ_c optimization does much better than qhs alone

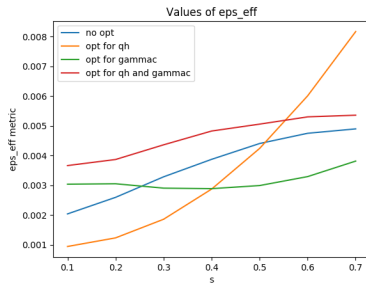
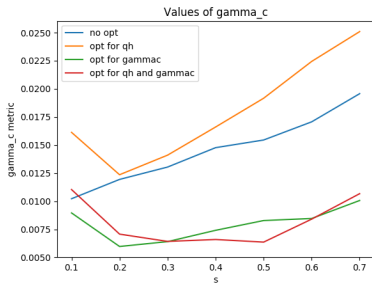
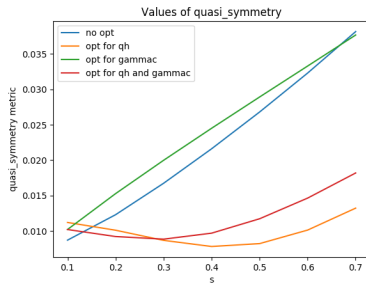
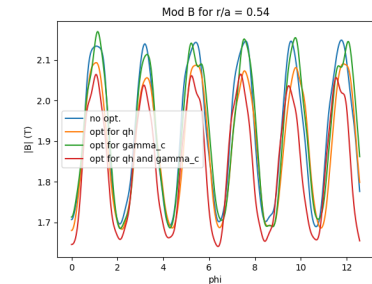


An 8 keV proton has similar normalized gyroradii in a 2.5 T, 0.25 m minor radius device to a 3.5 MeV alpha in a 5 T, 2 m minor radius reactor.

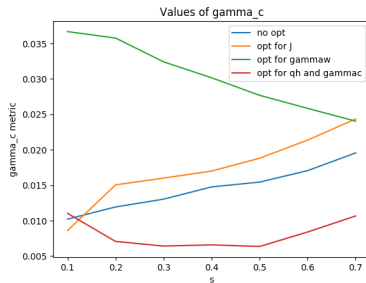
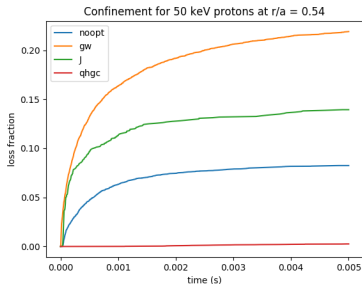
Flux surfaces and rotational transform look reasonable



ϵ_{eff} not the metric for FIs

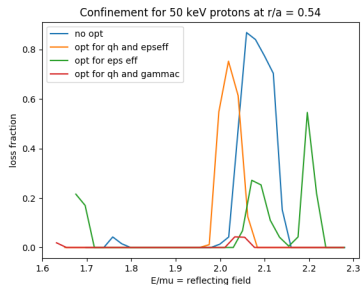
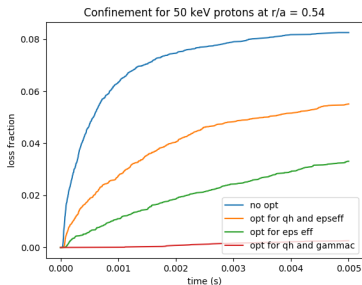
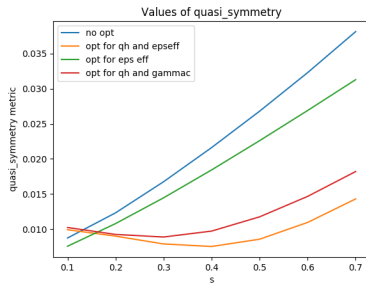
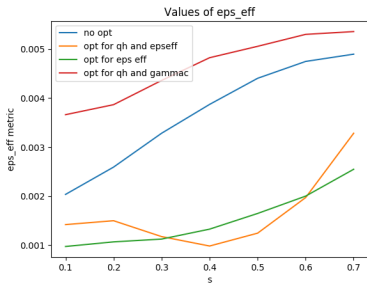


Other metrics, J and γ_w do not work as well



- Optimizing for J targets $dJ/d\theta$. Minimizing this should reduce radial drift
- Maximizing γ_w should target increasing poloidal drifts
- It appears it's better to target both simultaneously with γ_c
- Just targeting one appears to come at the expense of the other!

Targeting ϵ_{eff} also not as good as γ_c



Next steps

- The confinement of qhs with γ_c looks too good to be true. Why does this configuration have such good confinement properties?
- Rerun the γ_w and J optimizations, or both simultaneously. They should perform better than they do (in progress)
- Get $B_{\max}$ optimization which might help with trapped passing boundary (in progress)
- Get better diagnostic information on pitch angles, specifically deeply trapped particles
- Write up for publication