

PEGASUS EXPERIMENT

Ohmic Coupling and Sustainment of LHI-Produced Plasmas in the PEGASUS Experiment

Chris Pierren

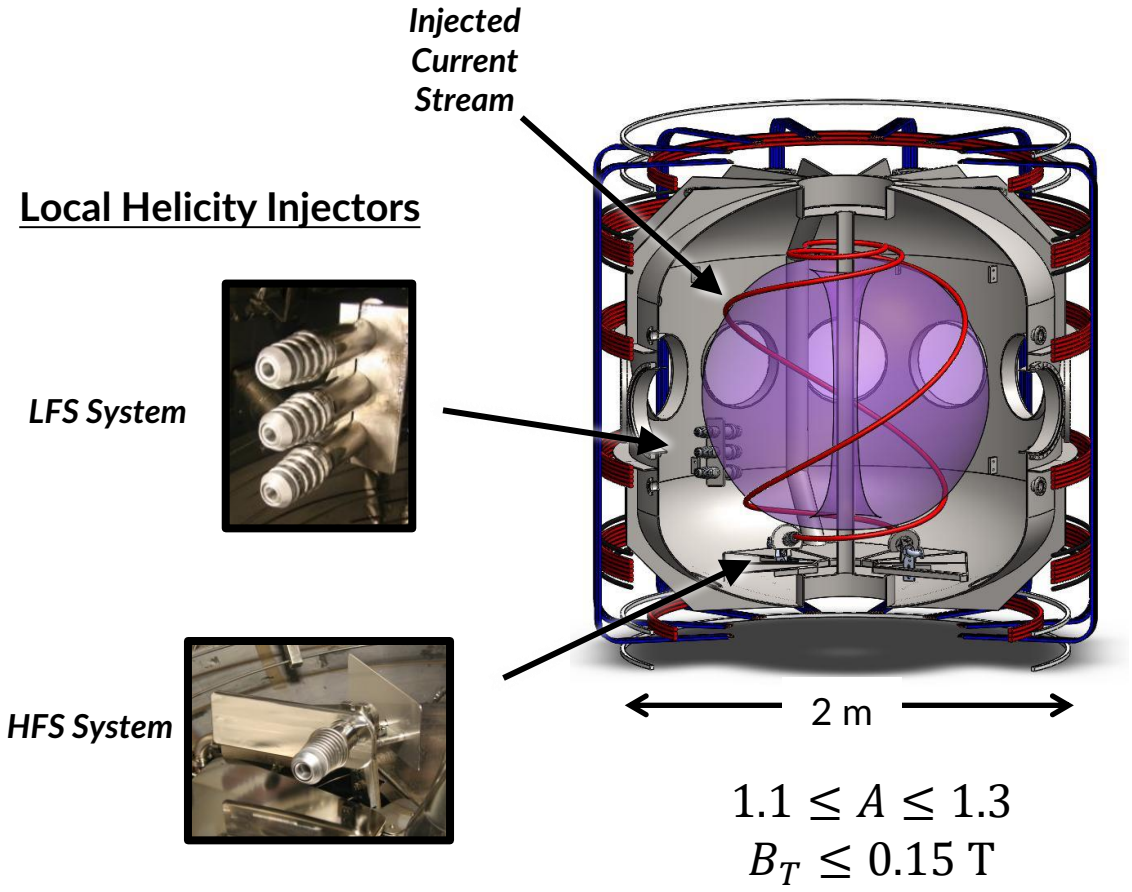
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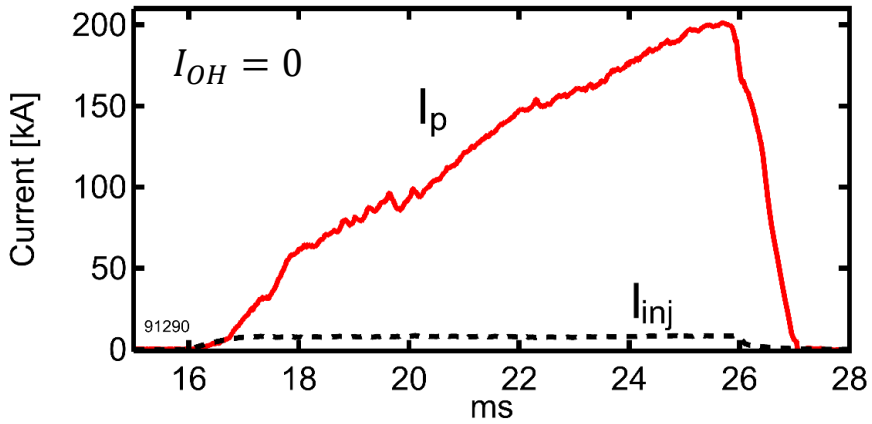
STs Likely Require Solenoid-free Startup and Local Helicity Injection (LHI) is a Promising Technique



$1.1 \leq A \leq 1.3$

$B_T \leq 0.15$ T

Non-Solenoidal $I_p = 0.2$ MA via LHI startup ($I_{inj} \leq 8$ kA)



- Current injected at plasma boundary
- Relaxation via helicity-conserving instabilities
- Hardware retractable after startup

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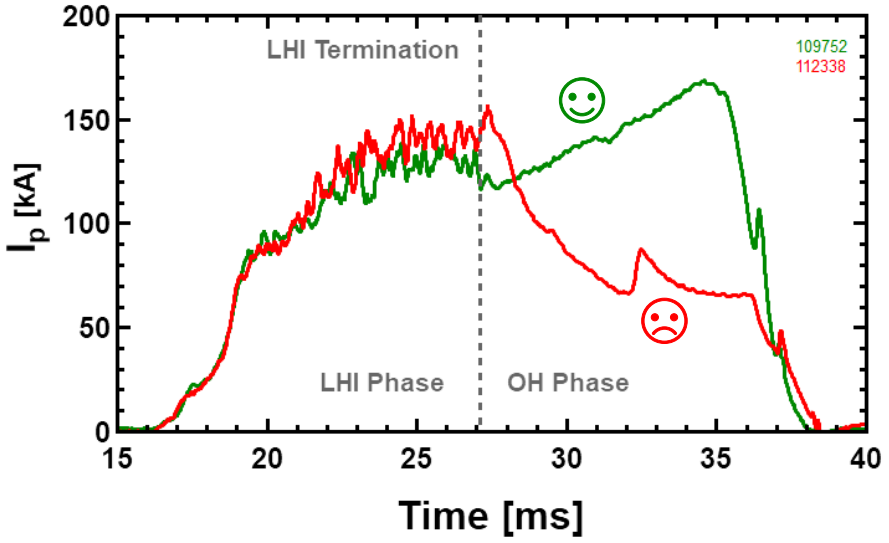
Does LHI Produce Viable Startup Targets?



Requirements of Viable Startup Plasmas

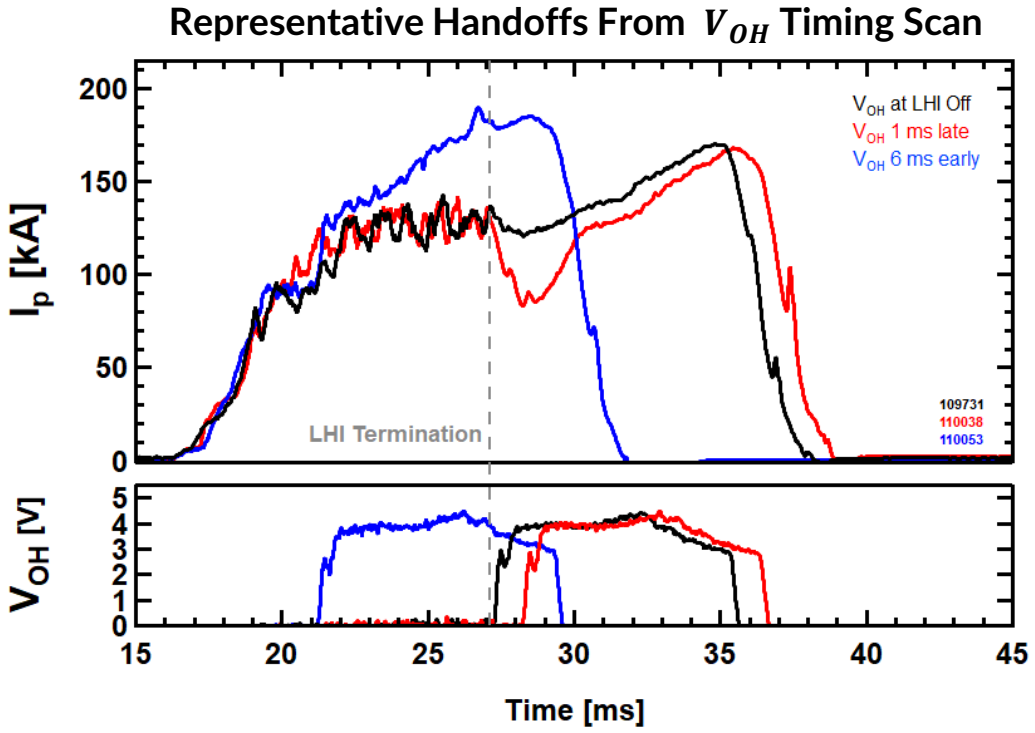
1. Readily conservable poloidal flux
2. Low impurity content
3. Profiles compatible with sustainment CD
4. Attractive MHD stability properties

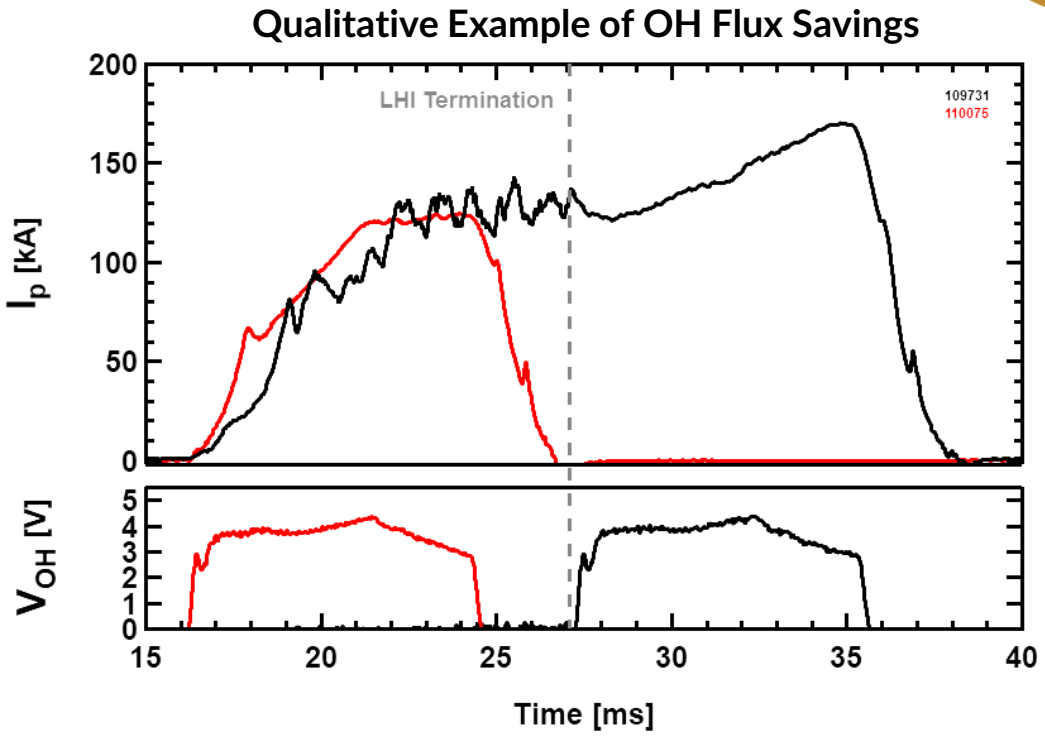
Test via Handoff to OH-CD



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LHI Flux: Robustly Conserved & Provides OH Flux Savings





- V_{OH} late: similar levels of I_p
- V_{OH} early: increased I_p
  - LHI compatible with simultaneous OH-CD

- OH flux savings is indicative of target viability
  - Metric used in CHI→OH-CD studies on NSTX [1]
- Savings: Higher I_p when OH flux coupled to LHI startup plasma then when used alone

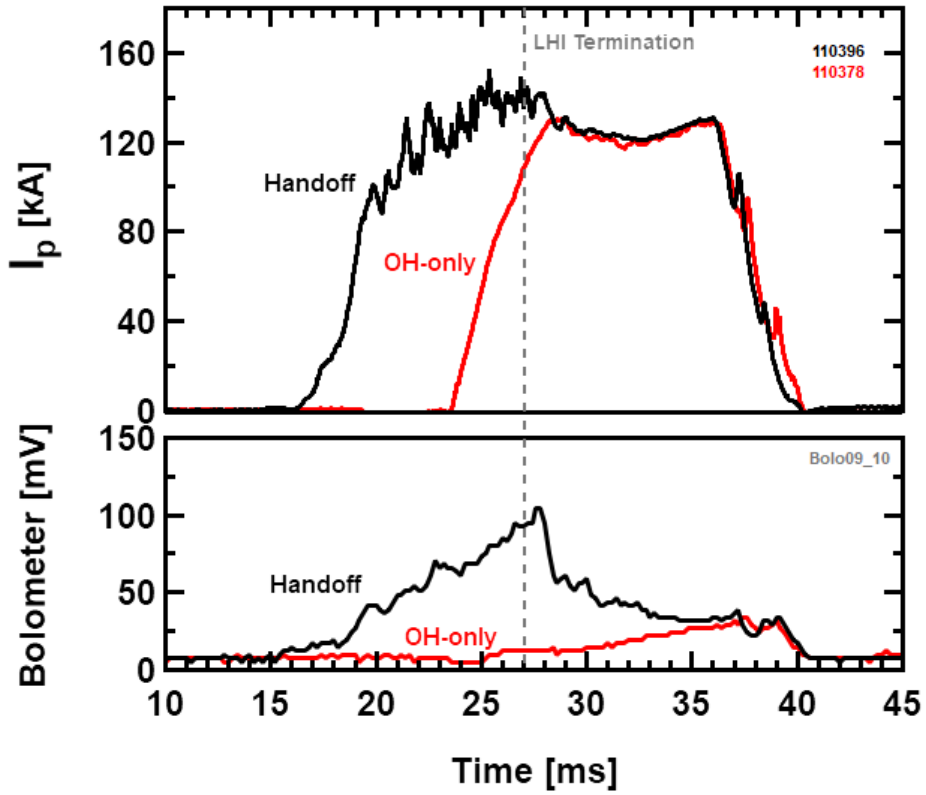
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[1] R. Raman et al., Phys. Rev. Lett. **104**, 095003 (2010)

LHI Impurities: Sufficiently Low for Reliable OH Sustainment

- No symptoms of excessive impurities:
  - OH sustainment failure
  - Elevated radiated power across handoff
- Bolometers: decay to typical OH-levels across handoff
- Similar decay in SPRED VUV spectra
- Could be pump-out, could also be burn-through
- More detailed study of impurities on PEGASUS-III

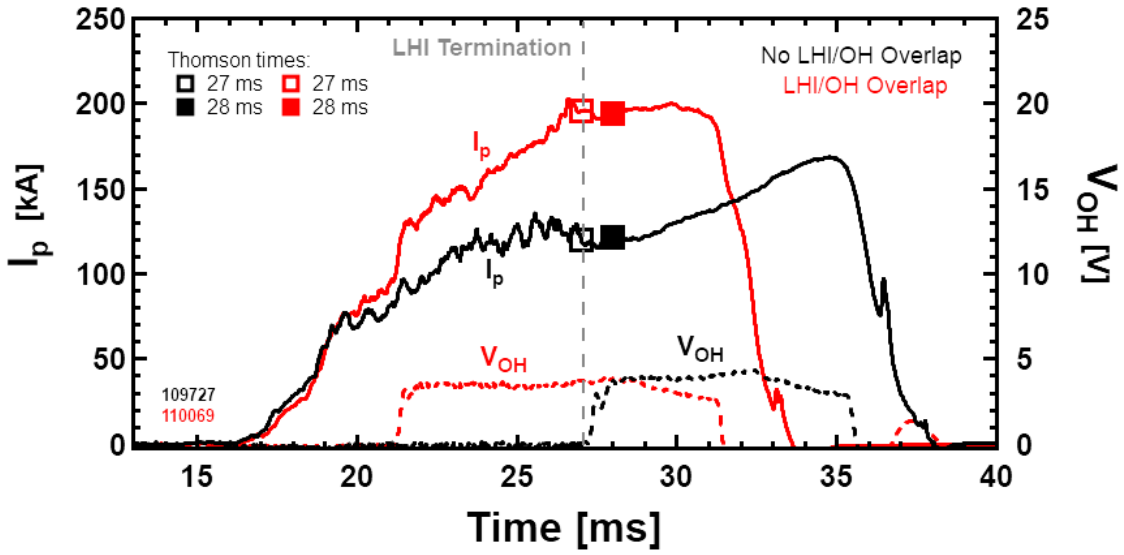
Representative Comparison of I_p and Core Bolometer Between Handoff and OH-only



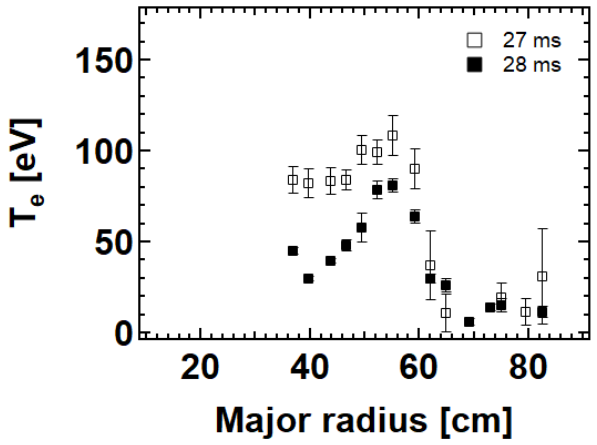
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LHI T_e: Simultaneous LHI & OH-CD Improved T_e Evolution

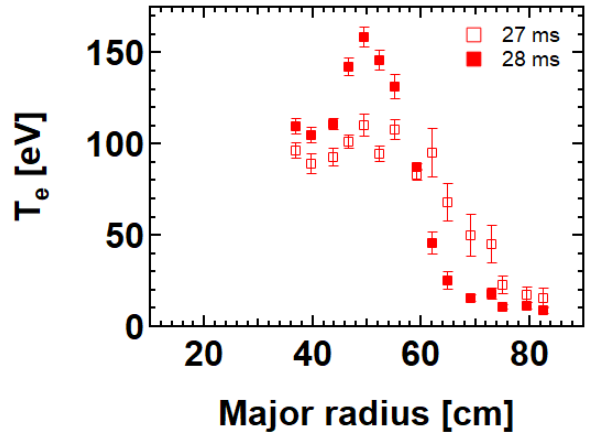
- V_{OH} applied at LHI termination: core $T_e \downarrow \sim 50\%$, I_p & n_e maintained
- V_{OH} applied during LHI: core T_e maintained across handoff
- Result suggests favorable LHI compatibility with P_{aux}
- Potential P_{aux} augmentation of T_e if needed as LHI scaled to higher B_T
  - Scaling to higher B_T and LHI synergies with RF topics for PEGASUS-III



No LHI/OH overlap, T_e decreases



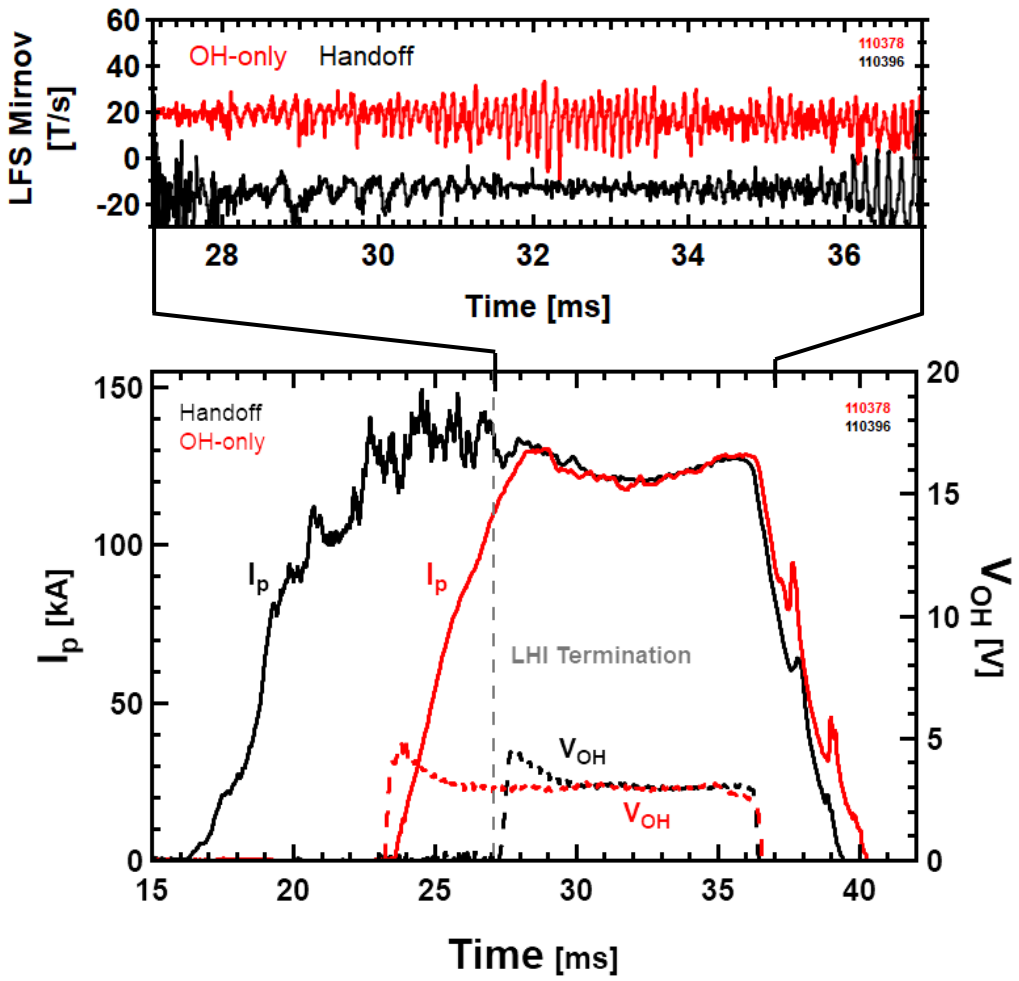
LHI/OH overlap, T_e maintained



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LHI MHD: Targets Have Favorable MHD Properties

- Many OH discharges in PEGASUS limited by strong low-m, $n = 1$ tearing modes as $j(R)$ evolves, $\uparrow \ell_i$ [1]
  - Appear as q profile flattens, reduction in magnetic shear
- LHI establishes MHD attractive, low ℓ_i targets [2]
  - Can LHI target $j(R)$ improve OH MHD stability?
- Test by replacing OH front-end with LHI, effectively reducing/delaying OH-phase $\ell_i(t)$
- LHI→OH: quiescent period terminated by $n = 1$ mode
  - Interpretation: $j(R)$ growing more peaked due to OH drive
  - In principle, LHI-produced $j(R)$ could be frozen via P_{aux}
- Estimated resistive diffusion time: $\tau_R = \frac{\mu_0 a^2}{\eta} \lesssim 12$ ms



[1] A.C. Sontag et al., Nucl. Fusion **48**, 095006 (2008)
[2] J.M. Perry et al., Nucl. Fusion **58**, 096002 (2018)

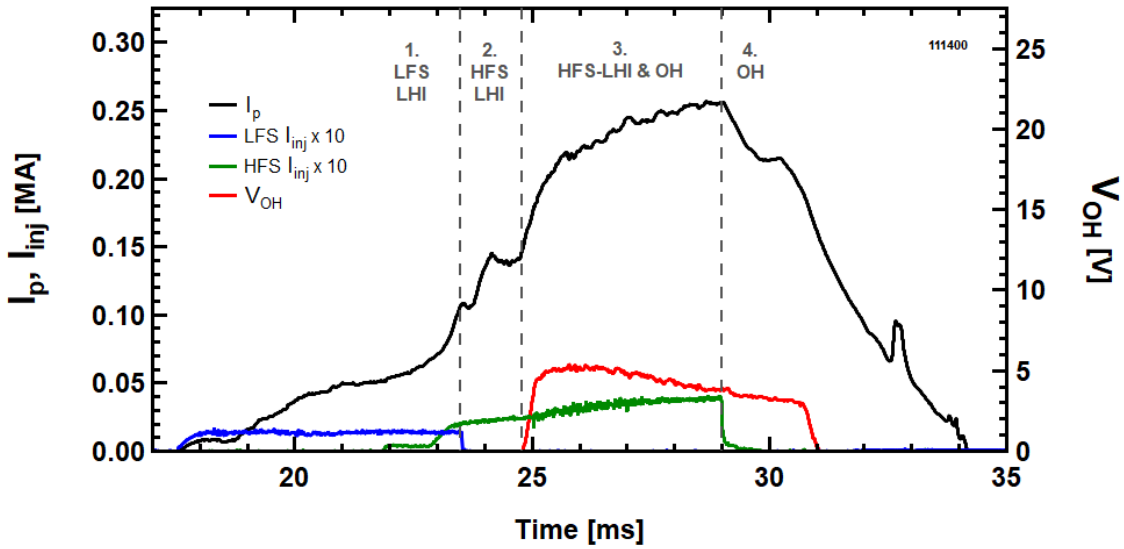
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Successful LHI→OH Indicates Viable LHI Startup Plasmas



- LHI poloidal flux readily conserved
- Impurities sufficiently low for OH sustainment
- T_e evolution improved by simultaneous OH-CD
  - LHI compatibility with P_{aux}?
  - Enables T_e augmentation if required?
- Generates MHD attractive, low ℓ_i targets
- Optimistic about LHI prospects and excited to investigate scaling to ↑ B_T on PEGASUS-III

Record I_p achieved with HFS-LHI and OH co-drive with different CD regions identified



1. Discharge initiated with LFS-LHI
2. LFS-LHI target coupled to and grown with HFS-LHI
3. HFS-LHI and OH co-drive to an $I_p = 0.25$ MA.
4. Insufficient OH flux for continued sustainment

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