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# Suppression of counter-propagating GAE with outboard neutral beam injection

#### Author list

Meeting name Meeting location Meeting date





#### Outboard sources suppress ctr-propagating GAE

 More than 60 examples show a clear correlation of ctrpropagating GAE amplitude reduction/growth with turn on/off time of outboard sources,

- no (clear) exceptions have been found.

- In many cases, complete suppression is seen, however, particularly with source 2a, the GAE may be only reduced in amplitude, or may reappear.
- Observations are consistent with model of cyclotronresonant drive of GAE.



## Typical 1 MA, 6 MW NSTX H-mode

- (to be compared with NSTX shot)
- Note extensive hfAE activity.

- 4 kG; lower field.
- H-mode.
- All 90 kV beams.





### 'Similar' 1MA, 6MW NSTX-U H-mode

- 6.5 kG(?) toroidal field.
- One 90 kV beam, 3 70 kV beams
- Two outboard sources.
- Density similar

Note minimal hfAE activity





#### So, are outboard beams prime cause?

• GAE is suppressed when source 2c comes on.



- Dominant mode is n=13, ctr-propagating.
- Lowest frequency n=13 CAE is 2.22 MHz (see eigenmode on right).
- Assumption is that these are GAE.



#### Otherwise kind of similar NSTX-U shots

• With 1a, 1b, 1c: 3.1MW

• With 1b,1c, 2c: 3.1MW



**NSTX-U** 

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## More examples: suppression with 2a

- Top panel shows GAE excited by inboard sources 1b and 1c (blue and cyan, lower panel).
- Injection of outboard source 2a starting at 0.192s results in suppression of GAE.
- Complete suppression takes about 10 ms.





#### More examples: suppression with 2b

- Top panel shows GAE excited by inboard sources 1b and 1c (blue and cyan, lower panel).
- Injection of outboard source 2b starting at 0.192s results in suppression of GAE.
- Complete suppression takes about 10 ms.





#### More examples: suppression with 2c

- Top panel shows GAE excited by inboard sources 1b and 1c (blue and cyan, lower panel).
- Injection of outboard source 2b starting at 0.192s results in suppression of GAE.
- Complete suppression takes about 5 ms.





## GAE grows during 2a beam block

- Top panel shows GAE excited by inboard sources
  1b and 1c (blue and cyan, lower panel).
- Outboard source 2a has block from 0.437s to 0.454s.
- GAE amplitude grows during 2a off-time, suppressed after.





#### BL-2 sources deposit pitch≈1 fast ions

- The top figure shows the TRANSP fast ion distribution function calculated just before source 2a injection, the lower figure is just after.
- Change in fast ion distribution mostly for pitch > 0.8.
- Consistent with drive predominantly from perpendicular fast ion energy.





#### High frequency Alfvénic activity lower in NSTX-U

 Mode frequencies higher (expected and found), means resonance conditions are different

- Possibly will see more with higher voltage beams.

Outboard sources suppress counter-propagating GAE.

- Both time correlations and shot-to-shot variations confirm this.

 Observations are consistent with model of cyclotronresonant drive of GAE

- no perpendicular fast ion energy, no drive.

