Proposal for 2009 NSTX Run

TAEs studies in L-mode, center-stack limited deuterium plasmas

XP 916

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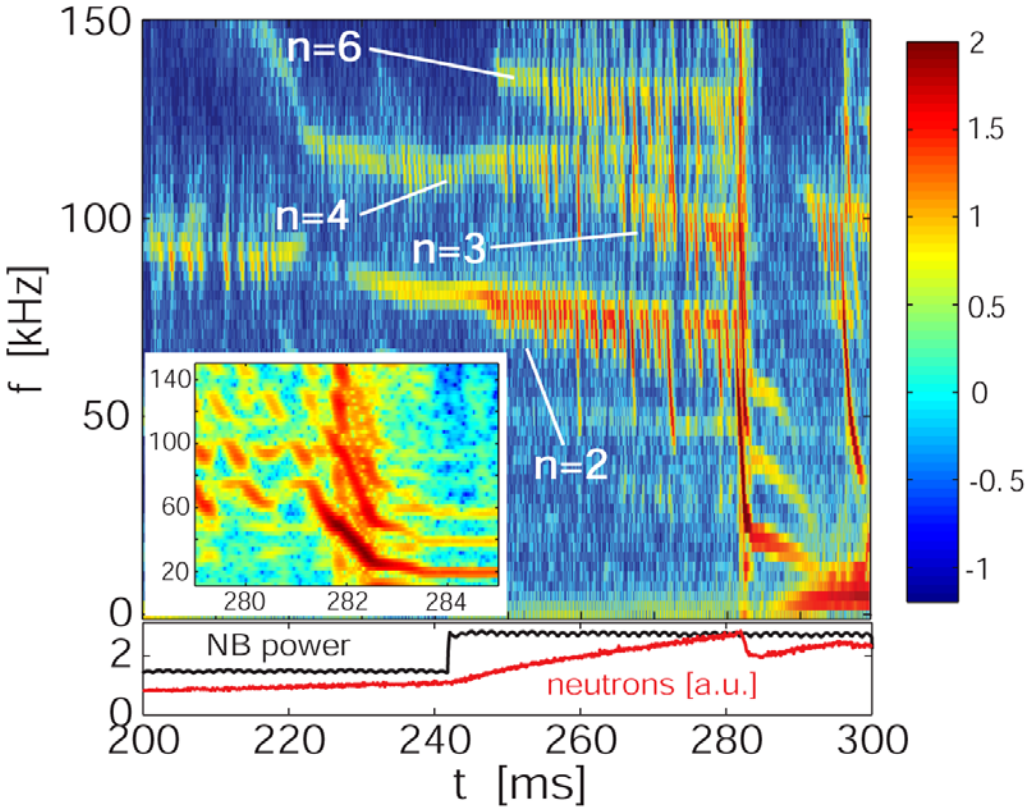
Good results from past years motivate (even more) detailed studies

- TAE avalanches and induced fast-ion transport characterized so far in L-mode, lower-single-null *helium* plasmas
- More quantitative information available from deuterium plasmas
- TAE dynamics still poorly understood
  - Need synergetic effort between experiments and theory/modeling
  - Code validation is a necessary step

This year: more focus on TAE dynamics leading to avalanches & loss

- Example: sh#128455



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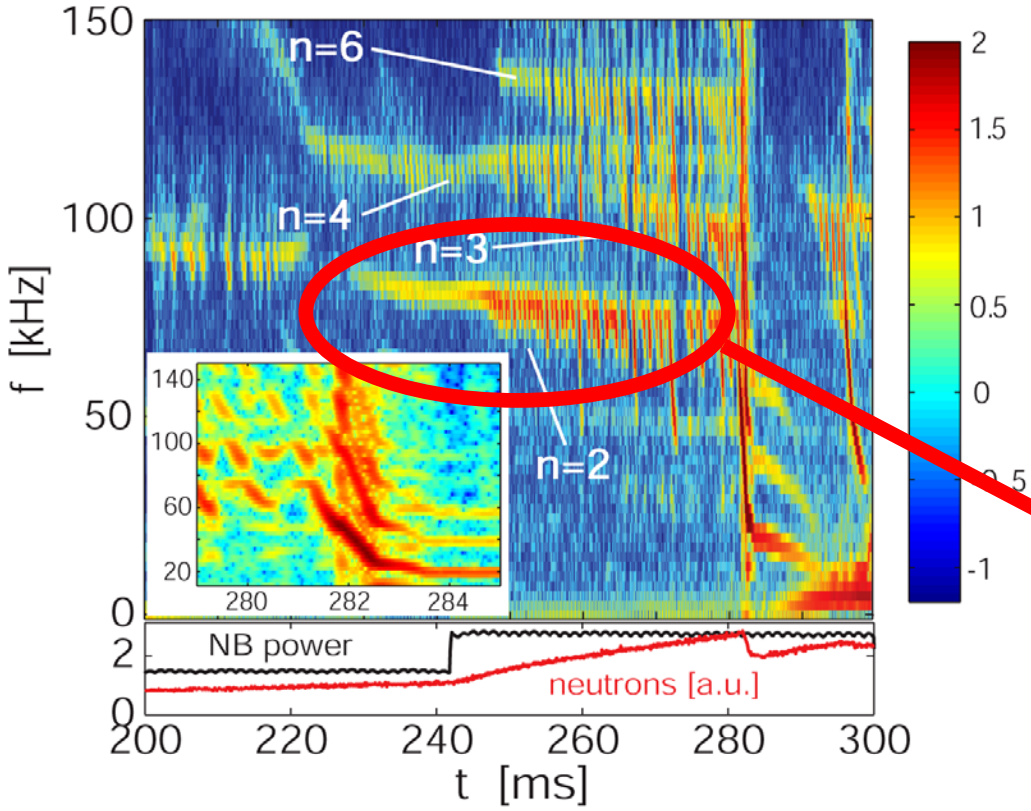
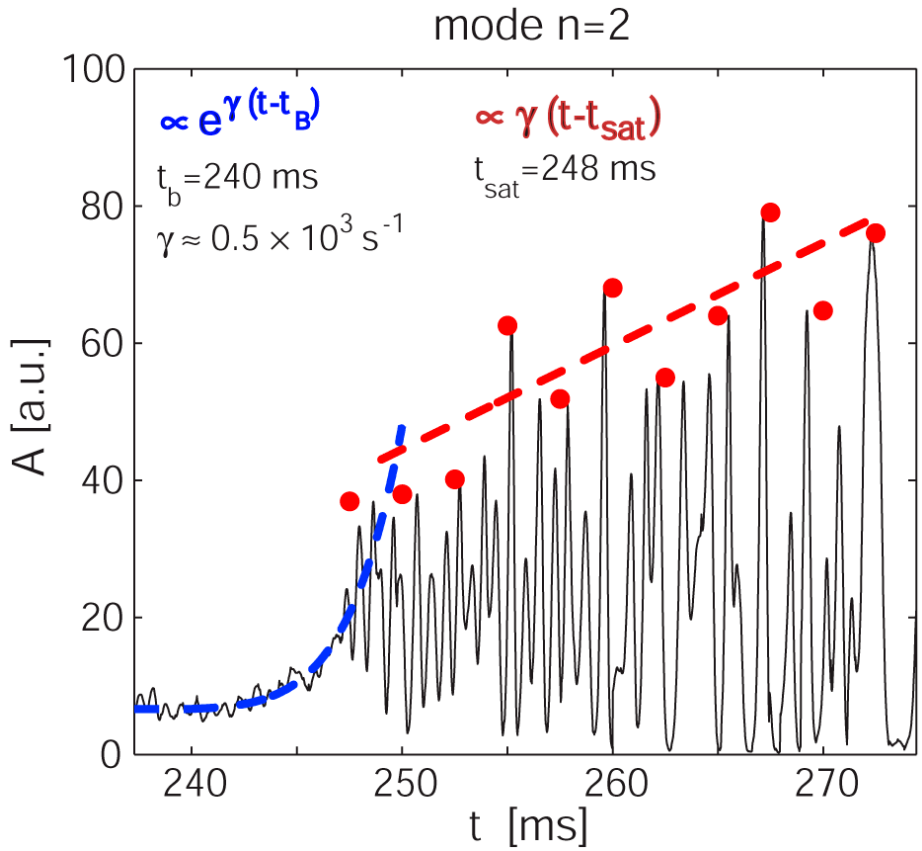


- Multiple TAEs destabilized by ~2.3MW of NB power
- Complex dynamics:



Three major goals for 2009 XP

- Develop target plasma
  - Deuterium L-mode, center-stack limited with presence of TAEs and TAE avalanches
- Study dependence of TAE dynamics and induced fast-ion transport on plasma parameters
  - Plasma rotation, shape, B_{tor}, q-profile, n and T_e, ...
- Provide “ideal” case for code validation (M3D-k, et al. ?) and extensive theory-experiment comparison

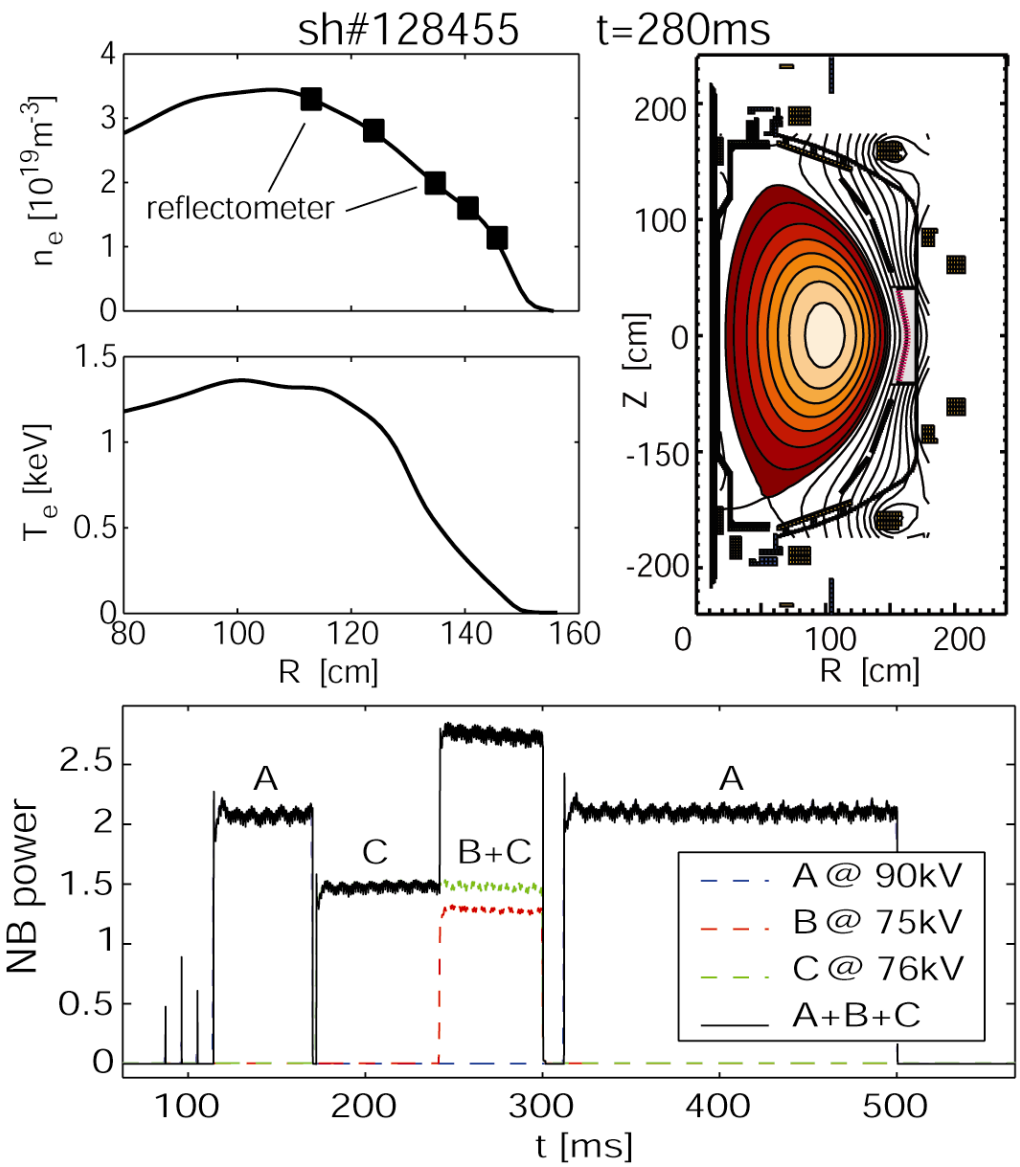
Two days allocated for this XP, divided into two parts

- Part#1: target plasma development 1/2 day
- Part#2: parameter scan 1+1/2 day

- Part#1 can be run early (beginning of March?)
- Part#2 requires 8-channel reflectometer (April?), possibly HHFW (at least 2MW)

Target plasma: modify sh#128455

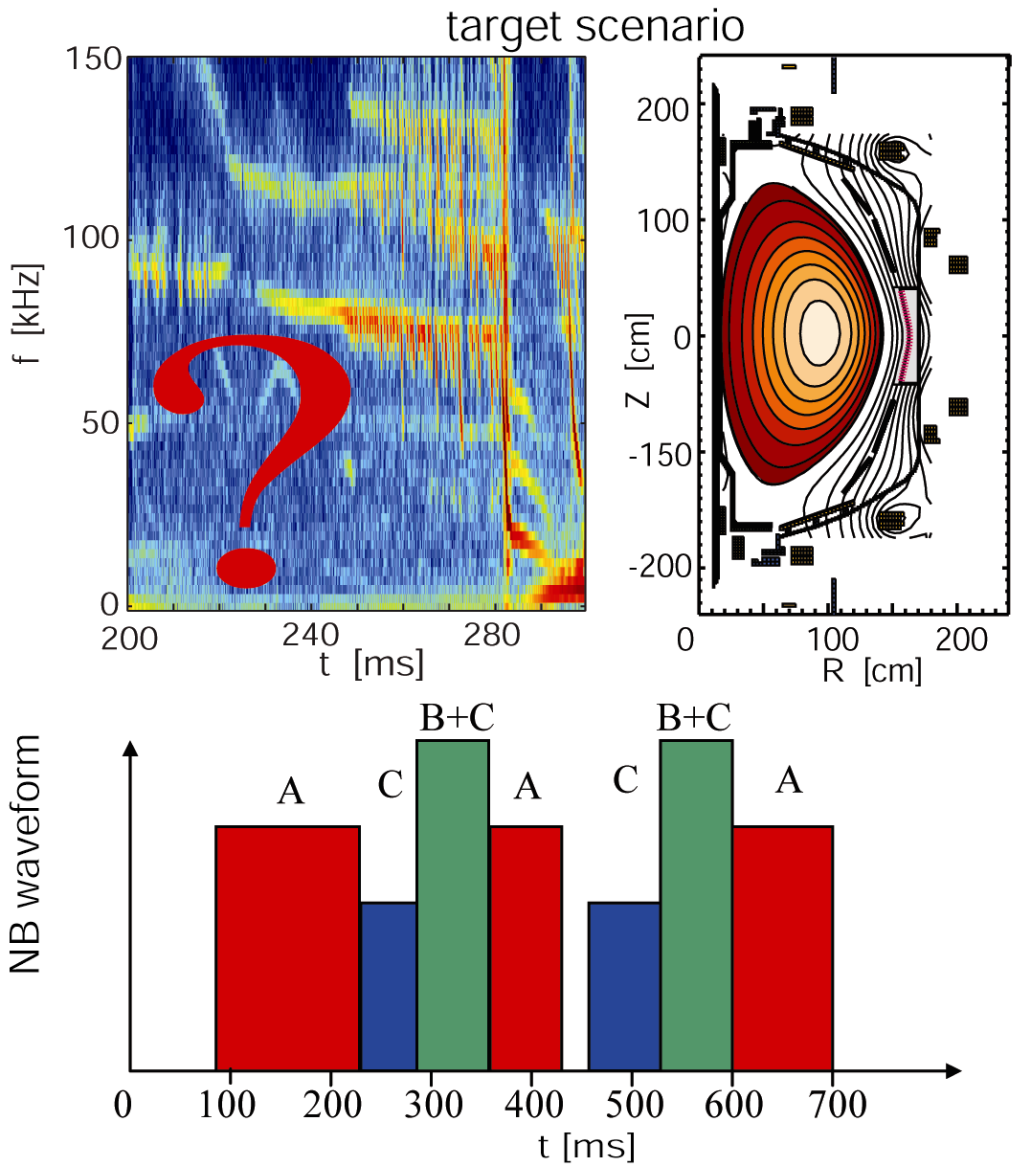
- I_p=0.9MA, B_{tor}=4.5kG
- kappa ~ 2



- Backup: sh#121522, 123862

Target plasma: modify sh#128455

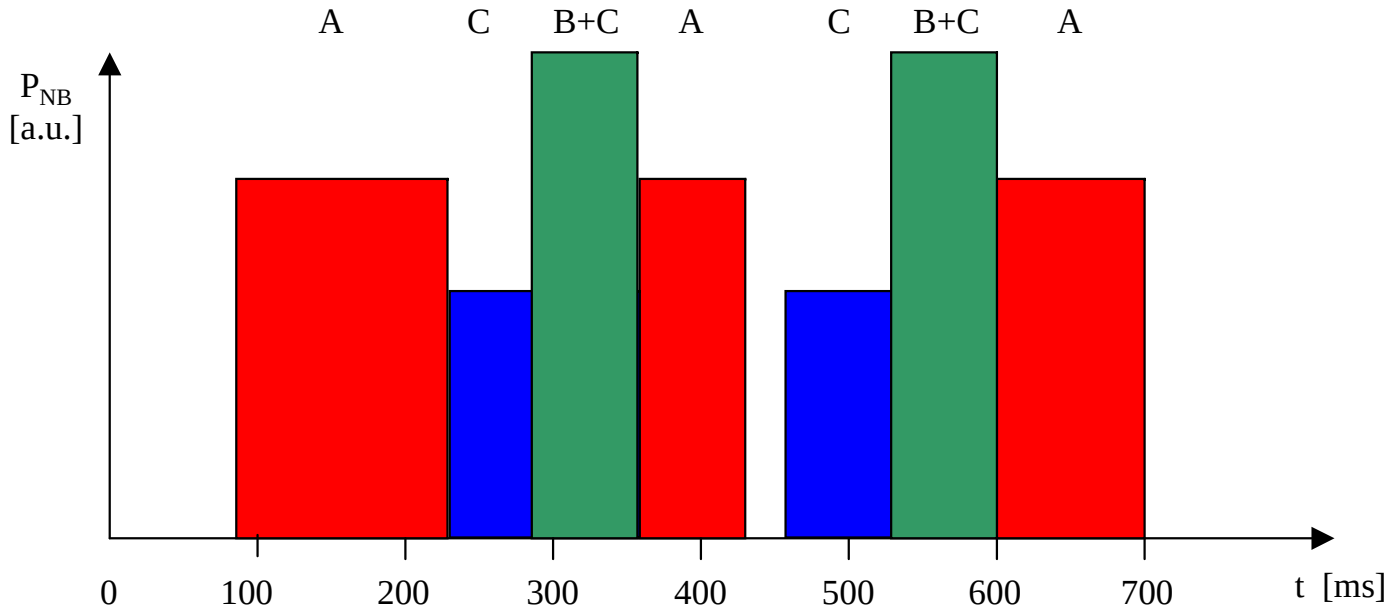
- I_p=0.9MA, B_{tor}=4.5kG
- kappa ~ 2
- Use deuterium, LFS injection
- Reduce inner gap
- Extend NB phase
- Check for TAEs
- Backup: sh#121522, 123862



Target plasma optimization

- Optimize density for reflectometer measurements
  - $n_0 \sim 3.2 \times 10^{19}$ m^{-3} at t ~ 350 ms
- Keep plasma in L-mode (at least up to ~400ms)
  - Center-stack limiter and LFS fueling should be enough
- Look for TAE activity: adjust NB timing, power
- NB power scan to determine threshold for TAEs and avalanches
  - Source C voltage primary knob, change B voltage if needed

NB timing modified with respect to model shot



- Source A still ON at beginning of flat top for MSE data
- Delay B turn-on (extend “linear” phase of TAEs?)
- Add second sequence A, C, B+C after 450ms
- Beam notch 430 → 450ms to decrease fast-ion drive, prevent EPMs, avoid H-mode, diagnostics check
- NB timing modified as required during target development

Parameter scan, priority

- Priority of scans:
  - (i) Plasma rotation: minimize v_{tor}
  - (ii) Shape (elongation)
  - (iii) B_{tor}
  - (iv) Code validation shots
  - (v) NPA + f-FIDA scan [option]
  - (vi) T_e, through HHFW [option]
  - (vii) Density [option]

top priority

lower priority

- NB power scan for (ii) → (iv) and (vii)

If (i) successful and no noise on NPA, ssNPA: EFC coils ON at optimum I value for (ii) → (vii)

Parameter scan: Plasma rotation

- EFC coils turn on at 200 ms
  - Configuration: n=3 braking
- Optimize current
  - Binary search, max current t.b.d. (any hints?)
  - Minimize rotation, but...
  - Avoid plasma collapse, mode locking
  - If TAEs disappear: adjust beam voltage (source C)
- Need CHERS, possibly pCHERS
- Max 8 shots

Parameter scan: Elongation (& q-edge)

- Start from target plasma (kappa ~ 2)
  - Keep EFC coils ON with “optimum” current, if previous scan successful
- Change kappa to 1.8 and 2.2
- For each value perform NB power scan
  - If TAEs/avalanches disappear: increase source C voltage by 5kV, repeat
  - If TAEs/avalanches still present: decrease source C voltage by 5kV, repeat
- Max 8 shots

Parameter scan: Toroidal field

- Start from target plasma (B_{tor}=4.5kG)
  - Keep EFC coils ON if ...
- Change B_{tor} to 3.5kG and 5.5kG
  - Adjust plasma current to ~match *q* from ref. shot
- For each value perform NB power scan
  - If TAEs/avalanches disappear: increase source C voltage by 5kV, repeat
  - If TAEs/avalanches still present: decrease source C voltage by 5kV, repeat
- Max 8 shots

Decision point: what's next?

- If duration of "linear" TAE phase not long enough [to get mode structure] in previous shots, optimize discharge for *code validation*
- If good signal on NPA and ssNPA, move to *NPA and f-FIDA scan*
- If HHFW is available, move to T_e *scan*, else
- If no TAEs/avalanches observed after t=450 ms, move to *density scan*

Optimized discharges for code validation

- Start from target plasma
- Remove source B: extend duration of “linear” phase of TAEs to ~50ms
  - Check quality of mode structure measurements from reflectometer
- Adjust source C voltage to vary amplitude of TAEs (steps og 5kV)
- Max 4 shots

NPA vertical scan, f-FIDA filter scan

- Repeat target plasma, good reproducibility needed for first 400ms [at least]
- Perform NPA vertical scan
  - Tangency radii t.b.d. based on results from previous scans
- Perform f-FIDA filter angle scan
  - Focus on different portions of fast-ion spectrum
  - Change angle from shot to shot: 0, 10, 2, 8, 6, 4 deg.
- Max 8 shots

Parameter scan: Electron temperature

- Start from target plasma (T_0~1.2keV at 300ms)
- Keep same NB timing/power as in reference shot
- Perform HHFW power scan
  - HHFW turn ON after ~30ms from onset of TAE
  - Two RF pulses, duration ~150 ms
  - Increase P_{RF} up to 2MW, step of 250kW
- Max 6 shots

Parameter scan: Density

- Start from target plasma (n_0~3.2x$10^{19}$$m^{-3}$ at 350ms)
- Increase density: n_0~4.2x$10^{19}$$m^{-3}$ at 350ms
- Perform NB power scan
  - If TAEs/avalanches disappear: increase source C voltage by 5kV, repeat
  - If TAEs/avalanches still present: decrease source C voltage by 5kV, repeat
- If time permits: decrease density: n_0<2x$10^{19}$$m^{-3}$ at 350ms
- Max 6 shots

Shot list

- Part#1, target plasma development 16 shots
- Part#2, parameter scan ~ 45 shots
  - Plasma rotation 8 shots
  - Elongation 8 shots
  - Toroidal field 8 shots
  - Code validation discharges 4 shots

Top priority

***options**

  - Density* 6 shots
  - Te through HHFW* 8 shots
  - NPA/f-FIDA* 8 shots

lower priority

Required diagnostics

- Plasma equilibrium
  - MPTS, CHERS, MSE
- MHD activity
  - Magnetics
- Mode structure
  - Reflectometers, USXR, TOSXR (FIRETIP? High-k?)
- Fast ions
  - Neutrons, sFLIP, NPA, ssNPA, FIDA