Progress and Next Steps at TAE

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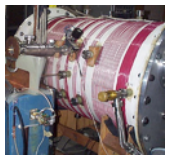
Historical and future program overview

Continual progress towards advanced beam-driven FRC fusion

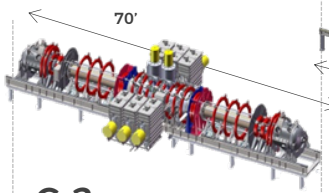
Major development platforms integrate then best design

- incremental bases for rapid innovation

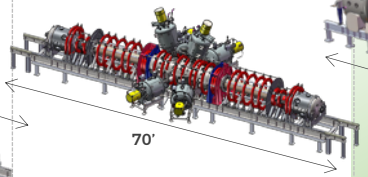
Copernicus entering phased sequence of reactor performance experiments



A, B, C-1
Early development
1998 – 2000s



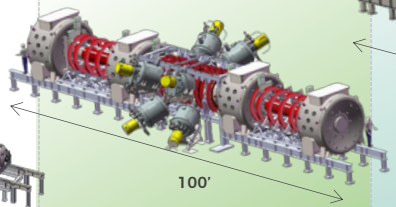
C-2
First full-scale machine
2009-2012



C-2U
Plasma Sustainment
2013-2015

TAE's current machine

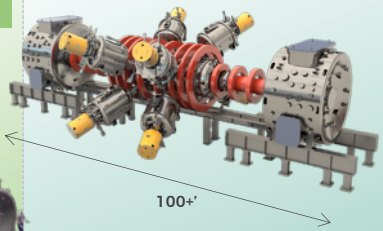
- First plasma July 2017
- One year construction
- On time, on budget
- Scaling studies ongoing



Norman (C-2W)
Collisionless Confinement Scaling
2016-2020

TAE's next machine

- In final design
- Construction to start 2021
- First operation in early 2023



Copernicus
Reactor Performance operating on hydrogen plasma
2021+

Norman Program Update

Norman Goals

Explore beam driven FRCs in fully collisionless regime

- Principal physics focus on
  - scrape off layer and divertor behavior
  - ramp-up characteristics
  - transport regimes
- Specific programmatic goals
  - demonstrate ramp-up and sustainment for times well in excess of characteristic confinement and wall times
  - explore energy confinement scaling over broad range of parameters
    - core and edge confinement scaling and coupling
    - consolidated picture between theory, simulation and experiment
  - develop and demonstrate first order active plasma control

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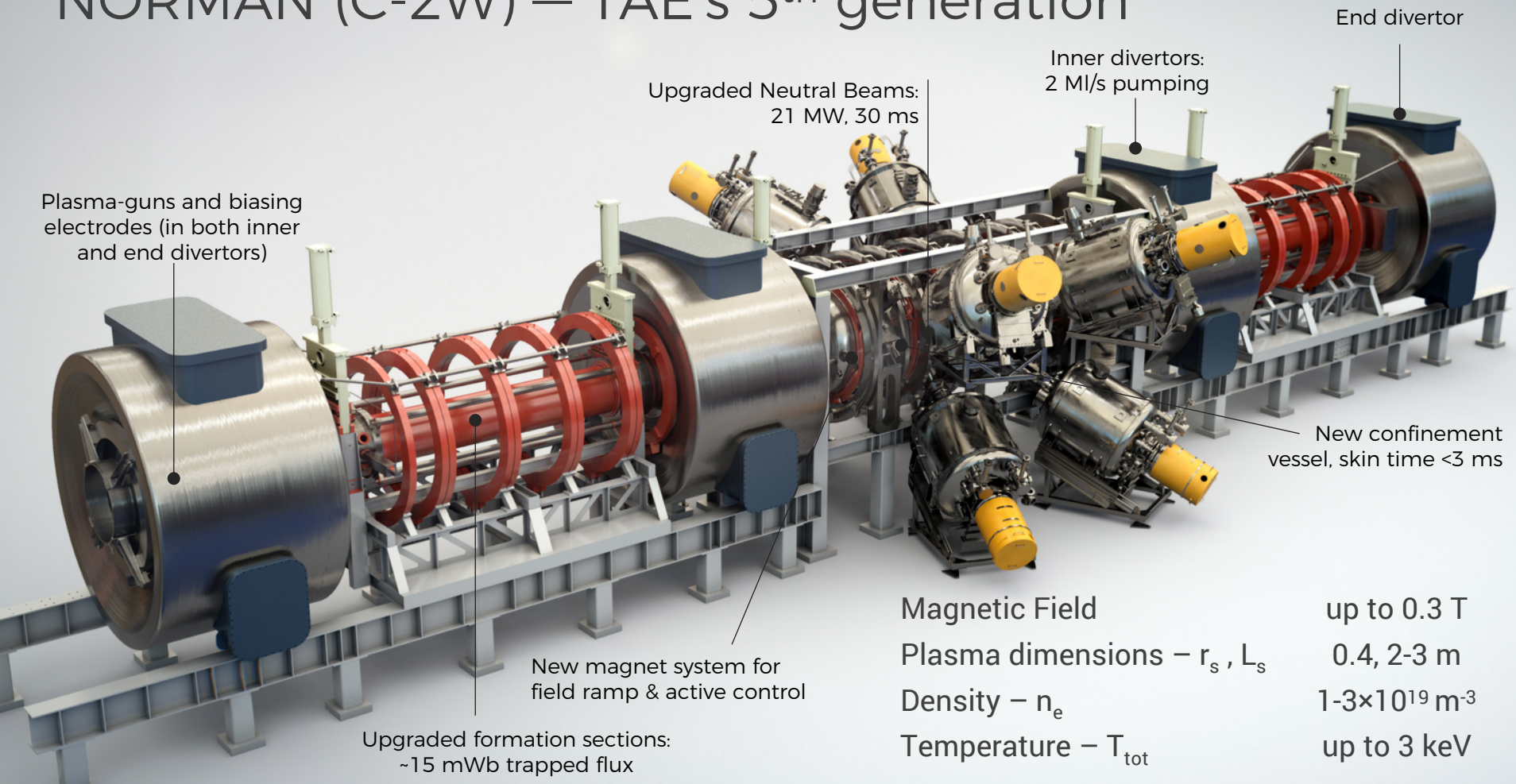
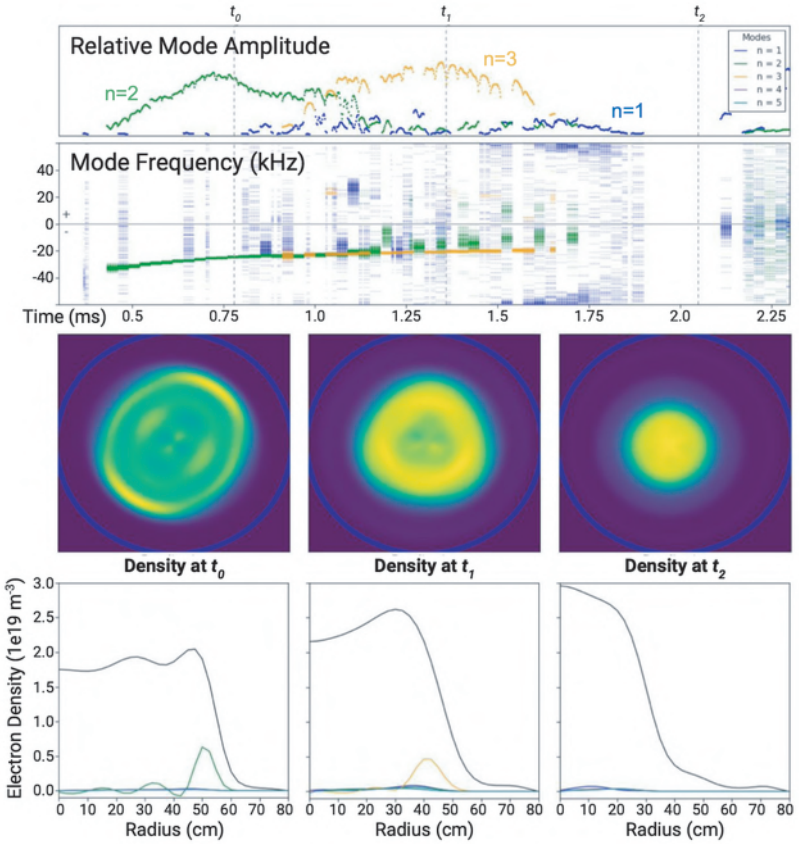
NORMAN (C-2W) — TAE's 5th generation



Magnetic Field	up to 0.3 T
Plasma dimensions – r_s , L_s	0.4, 2-3 m
Density – n_e	1-3×10^{19} m^{-3}
Temperature – T_{tot}	up to 3 keV

Google collaboration on diagnostics post processing

Allows study of internal plasma perturbations



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- High fidelity holistic 3-D plasma reconstruction
- Plasma perturbations up to toroidal mode number 5
- Mode amplitude < 3 G
  - experimentally benign
  - consistent with theory
- Global modes suppressed and not distractive

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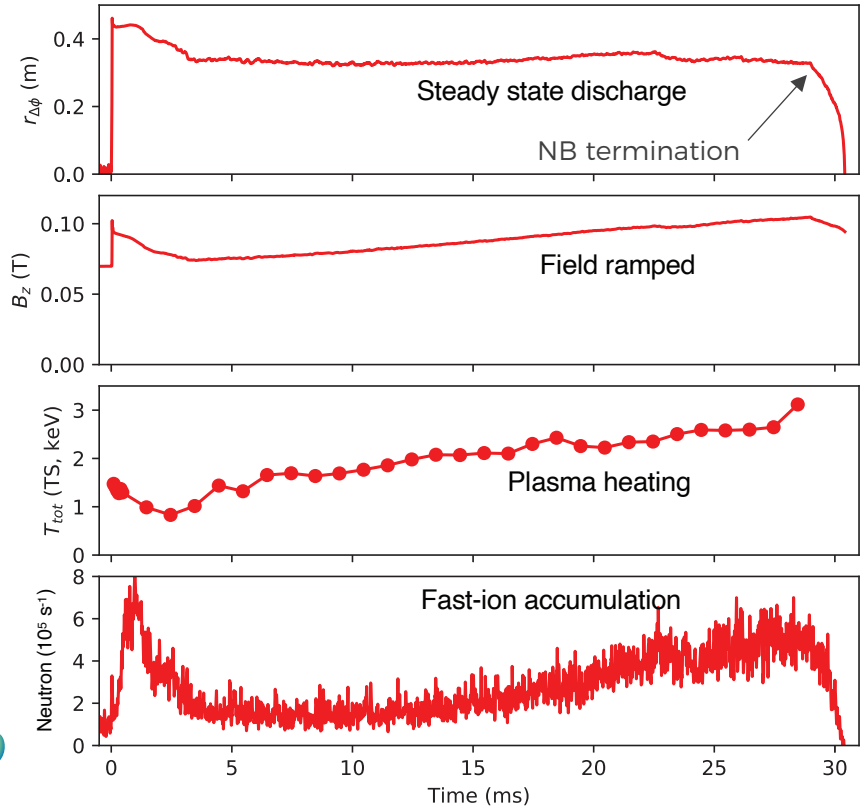
Typical steady-state FRC discharges

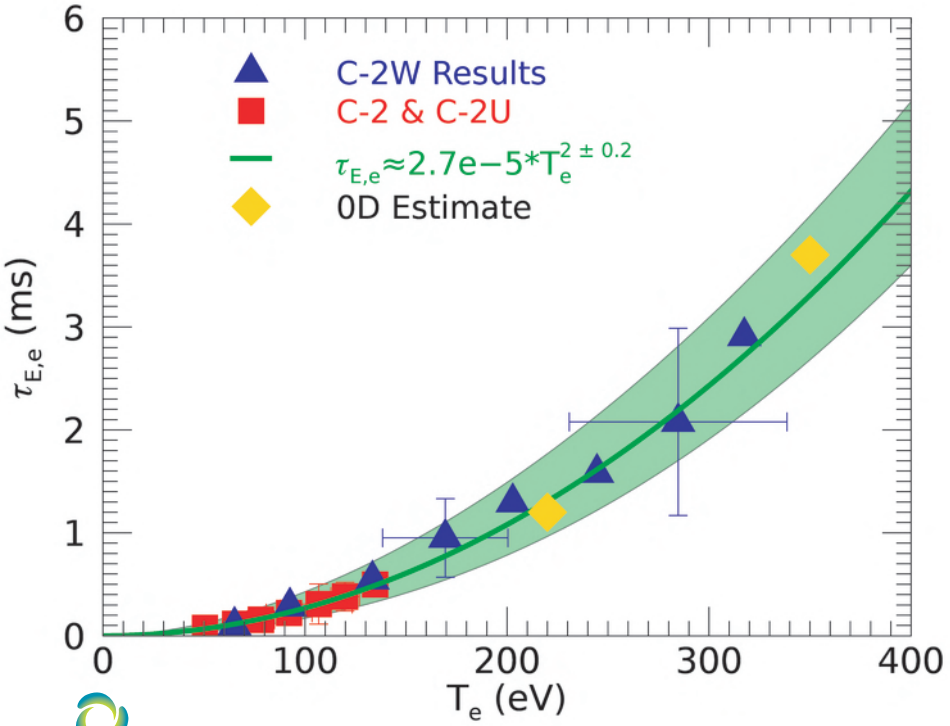
Sustainment with active feedback of beam-driven FRCs



- Duration up to 30 ms (limited by energy storage)
- Plasma heating and ramp-up clearly observed
- Neutron signal indicates fast-ion accumulation (up to and exceeding thermal pressure)
- Active external field and shape control as plasma pressure builds up

TAE electron confinement scaling confirmed

New C-2W regime shows same trend up to 3x T_e of C-2U



- Electron energy confinement time correlates positively with T_e
- Transport rates inferred from model using experimental inputs and constraints
- Multiple methodologies agree
- Variance due to model uncertainties, not variation of mean values
- Further analysis under way

Next Steps

Copernicus

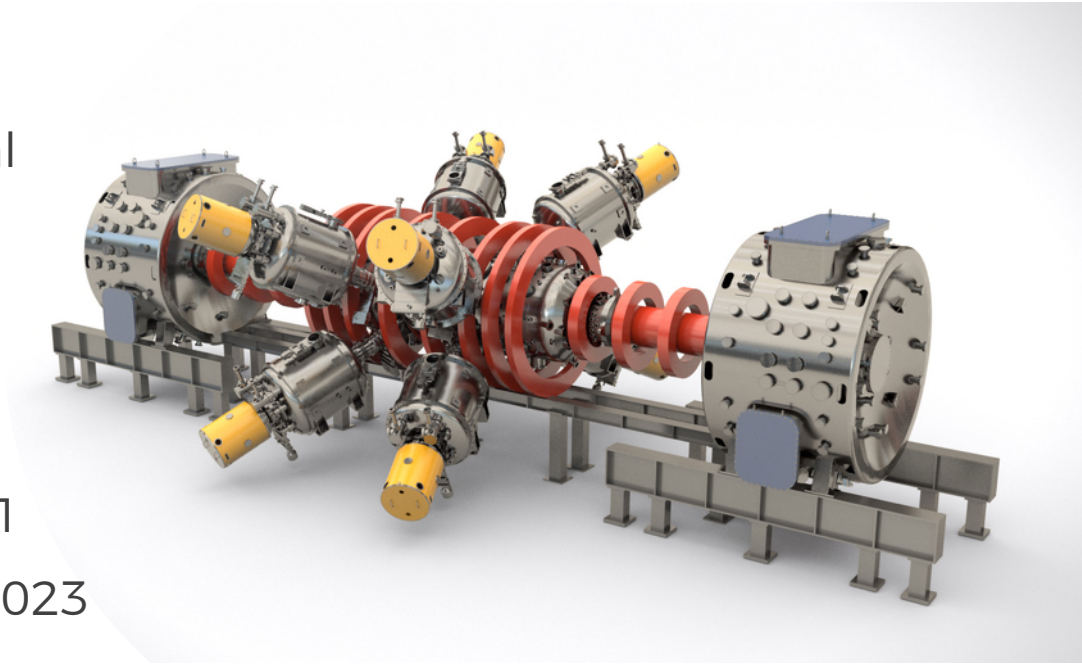
Reactor scale plasma performance platform

Design development ongoing

- 10+ keV ion temperature goal
- Hydrogen only operation

Budget and timing

- $250 MM cap-ex
- Construction to begin in 2021
- Commissioning and ops by 2023



Beyond Fusion

Spin-off technologies


Thank You