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On the path to a Pilot Plant

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TAE's path towards commercial fusion

Major development platforms integrate then best design

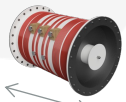
- incremental bases for rapid innovation

Copernicus entering phased sequence of experiments in 2025/26

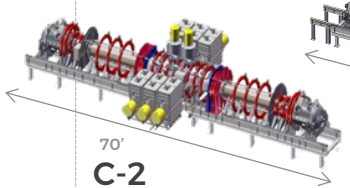
DaVinci demo plant in early 2030's

TAE's next machine
- In final design
- Construction 2023+
- First ops in 2025
- Viability of net

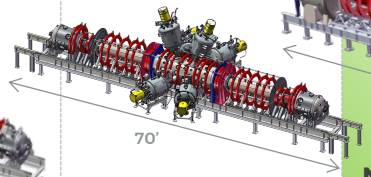
Proof of Concept
- up to 6 keV total T
- Full active feedback
- Macro-stability



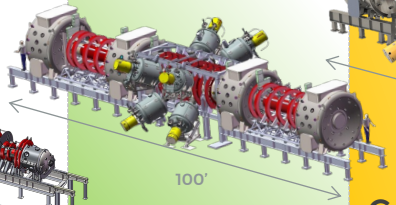
A, B, C-1
Early development steps
1998 – 2000s



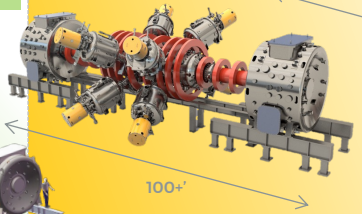
C-2
First full-scale machine
2009-2012



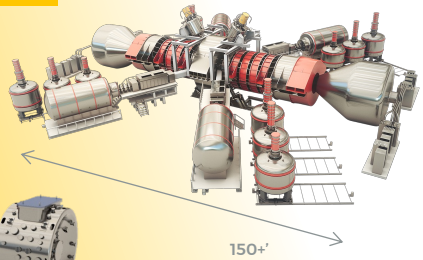
C-2U
Plasma sustainment
2013-2015



Norman (C-2W)
Collisionless Confinement Scaling
2016-2024



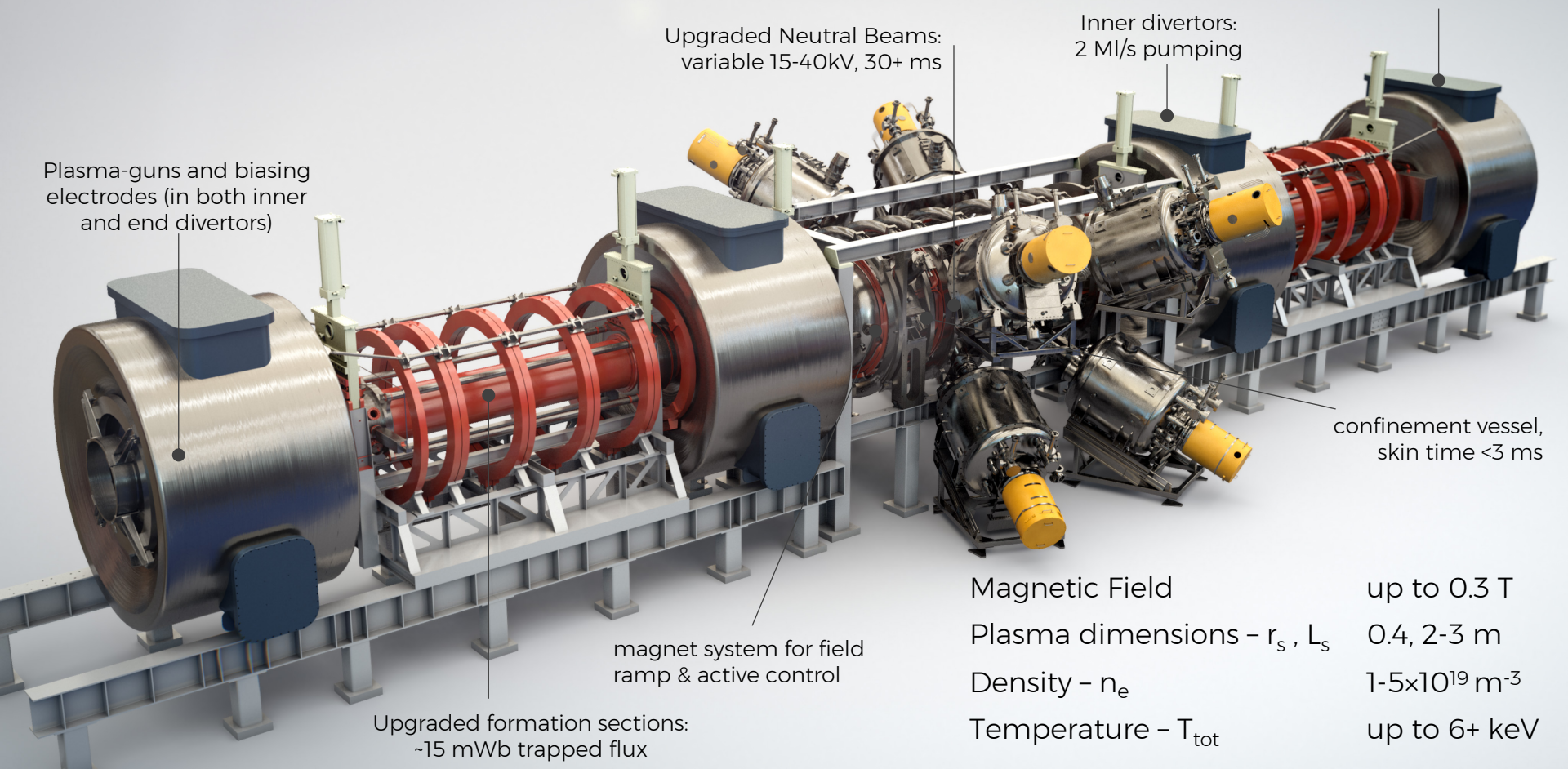
Copernicus
Reactor performance operating on hydrogen plasma
2023-2027



Da Vinci
First integrated Demo Plant to begin ops in late 20's and fueled with H-B[11]
2026 onward

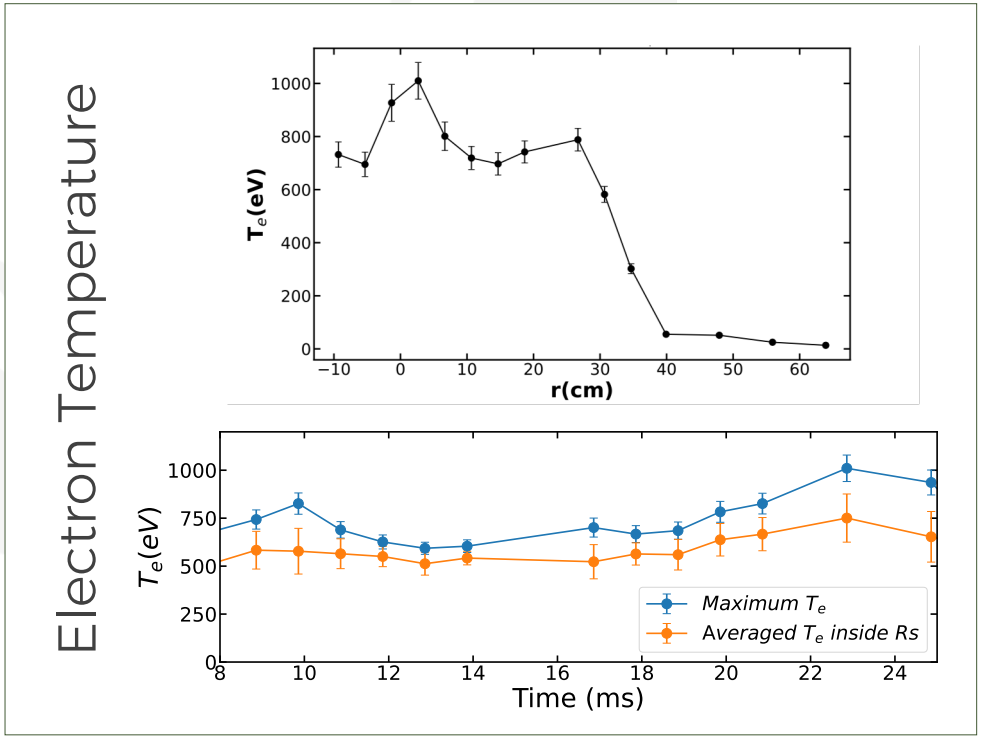
Recent Highlights on Norman

NORMAN — 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	$1\text{-}5\times10^{19}\ m^{-3}$
Temperature – T_{tot}	up to 6+ keV

High performance beam driven FRCs demonstrated

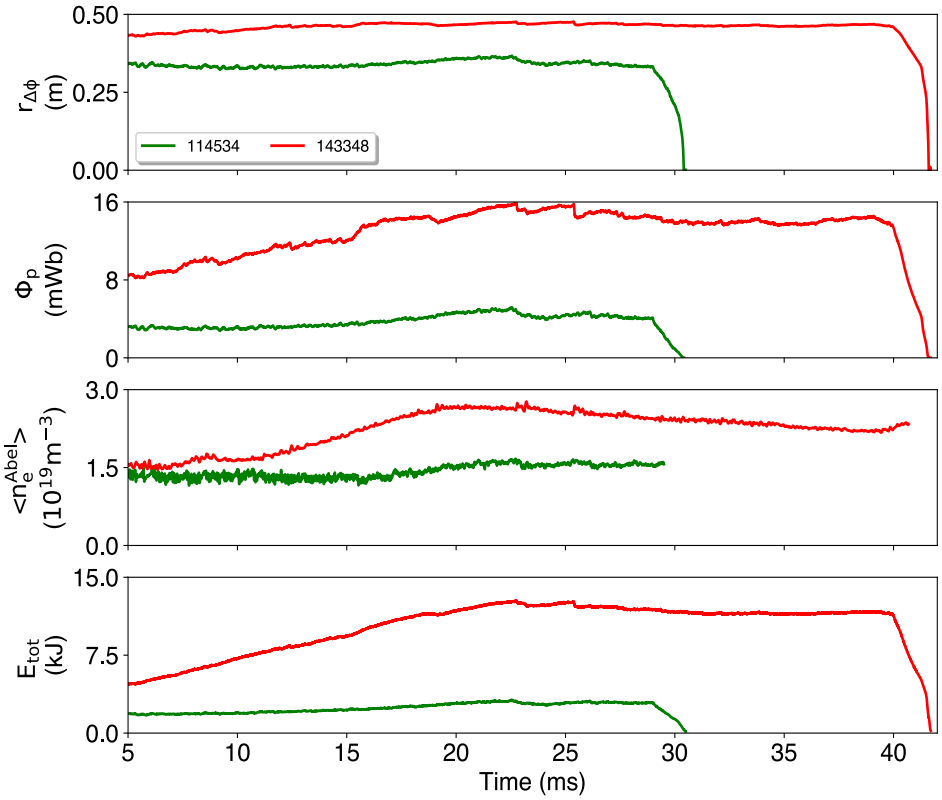


- Record plasma parameters
  - T_e up to 1 keV
  - T_{tot} up to 6+ keV
  - density up to 3×10^{19} m^{-3}
- Plasma ramp-up (flux build-up) clearly observed
  - indicative of current drive
- Performance optimized by using ML and active feedback control for
  - magnetic fields
  - edge biasing
  - fueling
  - neutral beam injection

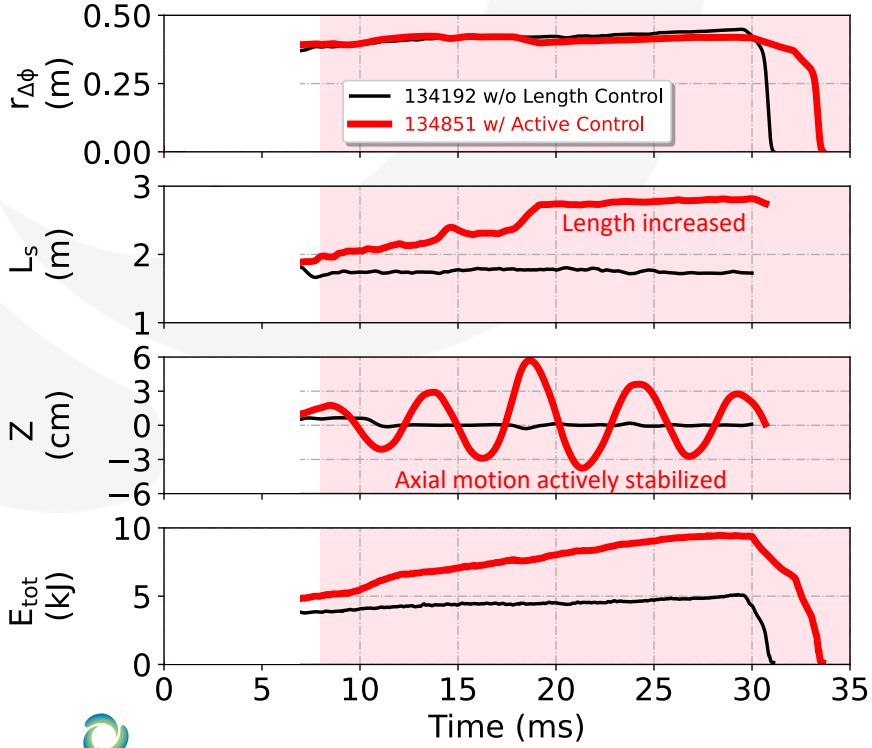
Beam-driven FRCs sustained in steady state

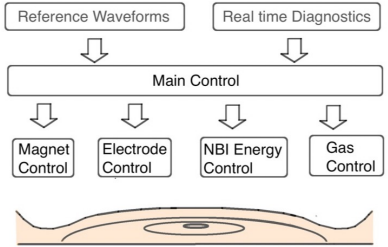
Key accomplishments on Norman:

- Stable FRCs via edge biasing and NB injection
- Pulse length ~40 ms in steady state (limited by on-site stored energy)
- Effective plasma ramp-up and heating
- Energy and temperatures drastically increased
- Active plasma control and improved FRC stability demonstrated



Active-feedback expands reactor design space





- Beam injection helps to break an intrinsic coupling between FRC density and length ($S^*/E < 3$)
- Active-feedback, real-time magnetic control implemented to independently control plasma shape
- Improves operating flexibility and enables broader options for reactor

Norman legacy

Beam driven FRCs demonstrated in collisionless regime

Physics performance goals achieved

- Macro-stability & sustainment for up to 50 ms, limited by stored energy
- Total temperature over 6 keV, electron temperature up to 1 keV
- Confinement scaling confirmed in collisionless regime
- Excellent edge insulation – energy loss per ion/electron pair ~6-7 T_e

Technology development goals demonstrated

- Millisecond-scale ramp-up and heating
- Real-time active feedback with
  - tunable beam system – 15-40 keV within 100s of micro-seconds
  - stability and transport control via end-biasing
  - position and shape control via trim and saddle-coils

Next Step — Reactor Scale Operation

Copernicus

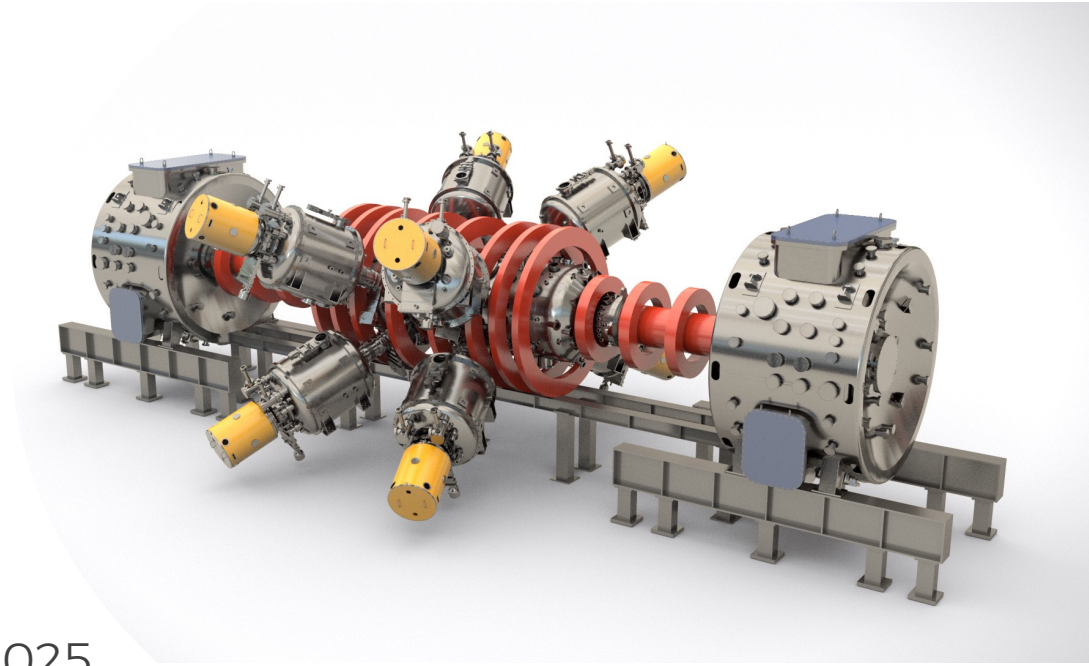
D-T reactor scale plasma performance

Design finished

- 10+ keV ion temperature
- Hydrogen only operation
- 2-3 sec pulse length

Budget and timing

- $250+ MM cap-ex
- Fabrication under way
- Commissioning and ops by 2025



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Copernicus lab core and shell construction completed

Facility installations and inner buildout just started

- 100,000 sqft lab site in Irvine
- Building completed 9/2023
- Interior installations and machine construction under way
- New offices occupied 7/2023

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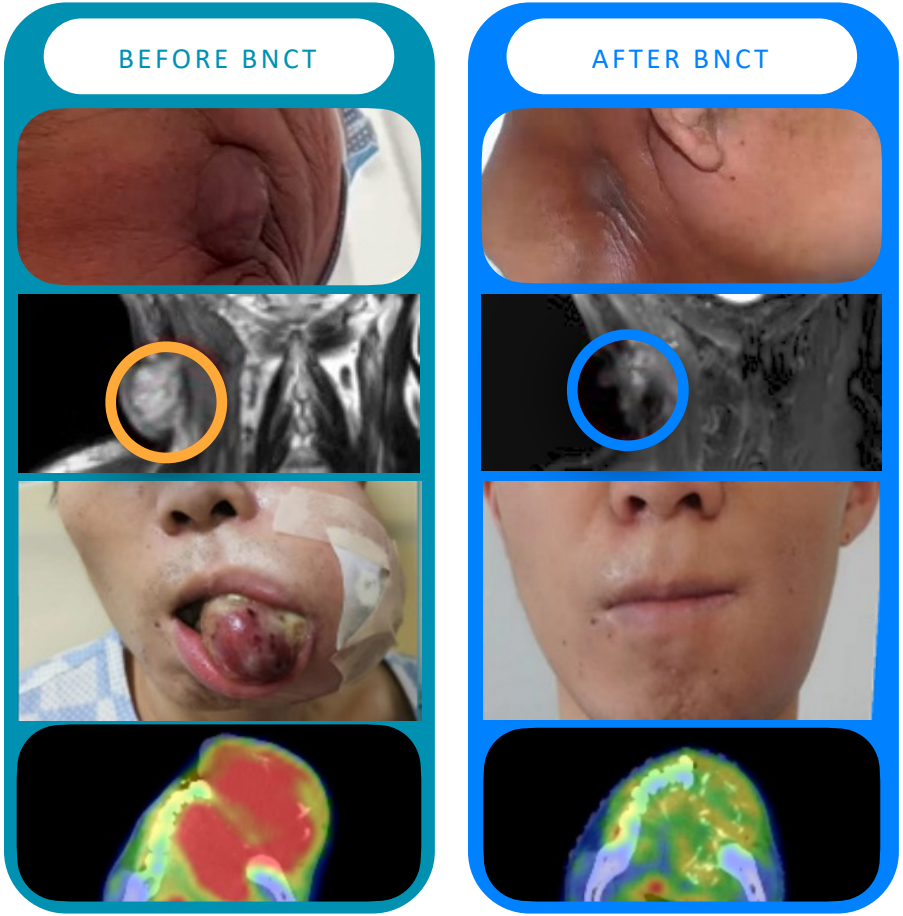
Beyond Fusion

Spin-off technologies

First patients treated with our neutron beam system

- 15 patients / 19 treatments (Head/Neck and Glioma cases)
- Patients treated starting October 2022 through July 2023
- All treatments considered safe with good tumor control
- Glioma patients responding as early as 10 days post-treatment



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Thank You