GRIPS Innovation, Science and Technology Policy Program

第126回 GIST セミナー

フュージョン(核融合)エネルギーの商業化を促進するために

-技術課題への挑戦と官民連携の在り方

KYOTO FUSIONEERING

FUSION for the FUTURE

Satoshi Konishi

KYOTO FUSIONEERING

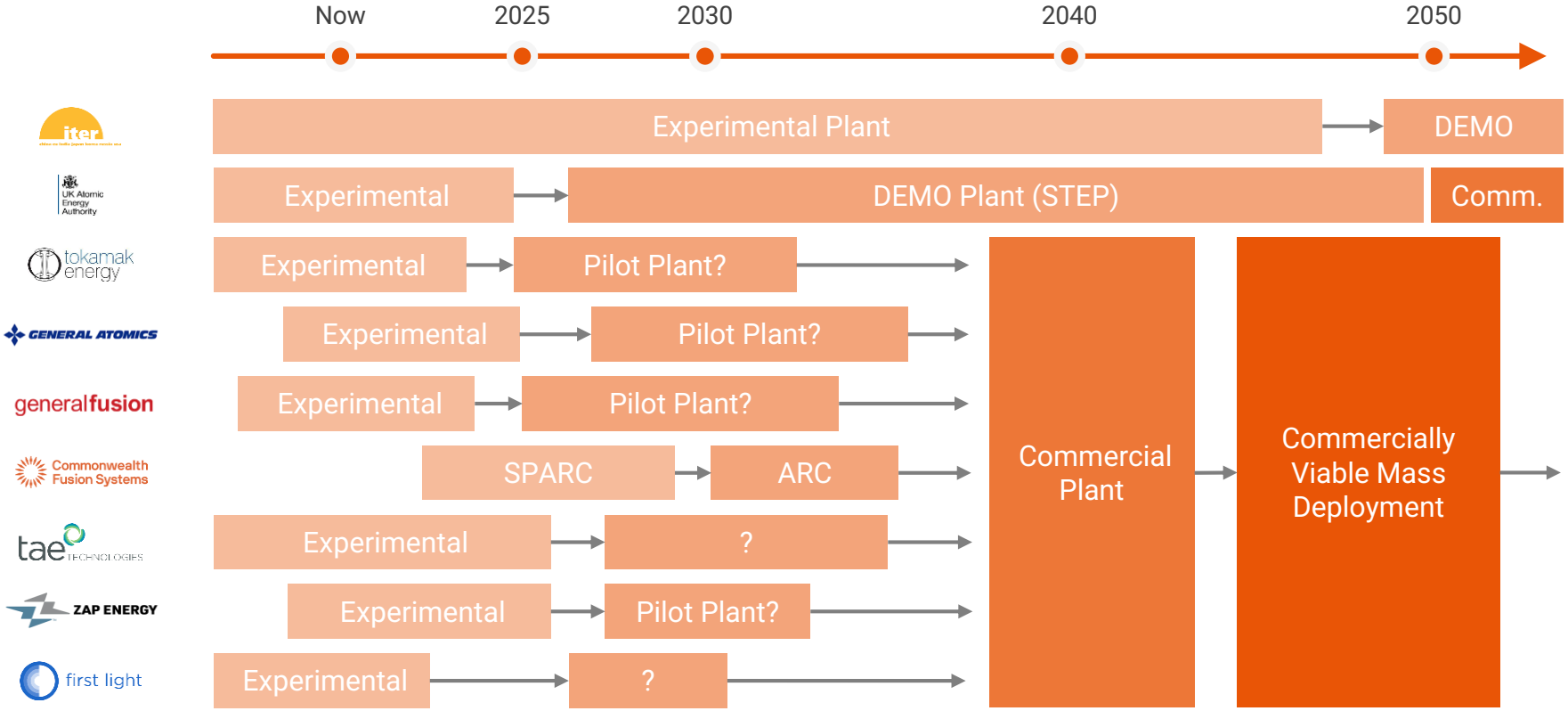
Fusion Energy Market: A Snapshot

フュージョンの市場は、エネルギー実用化以前に始まっている。

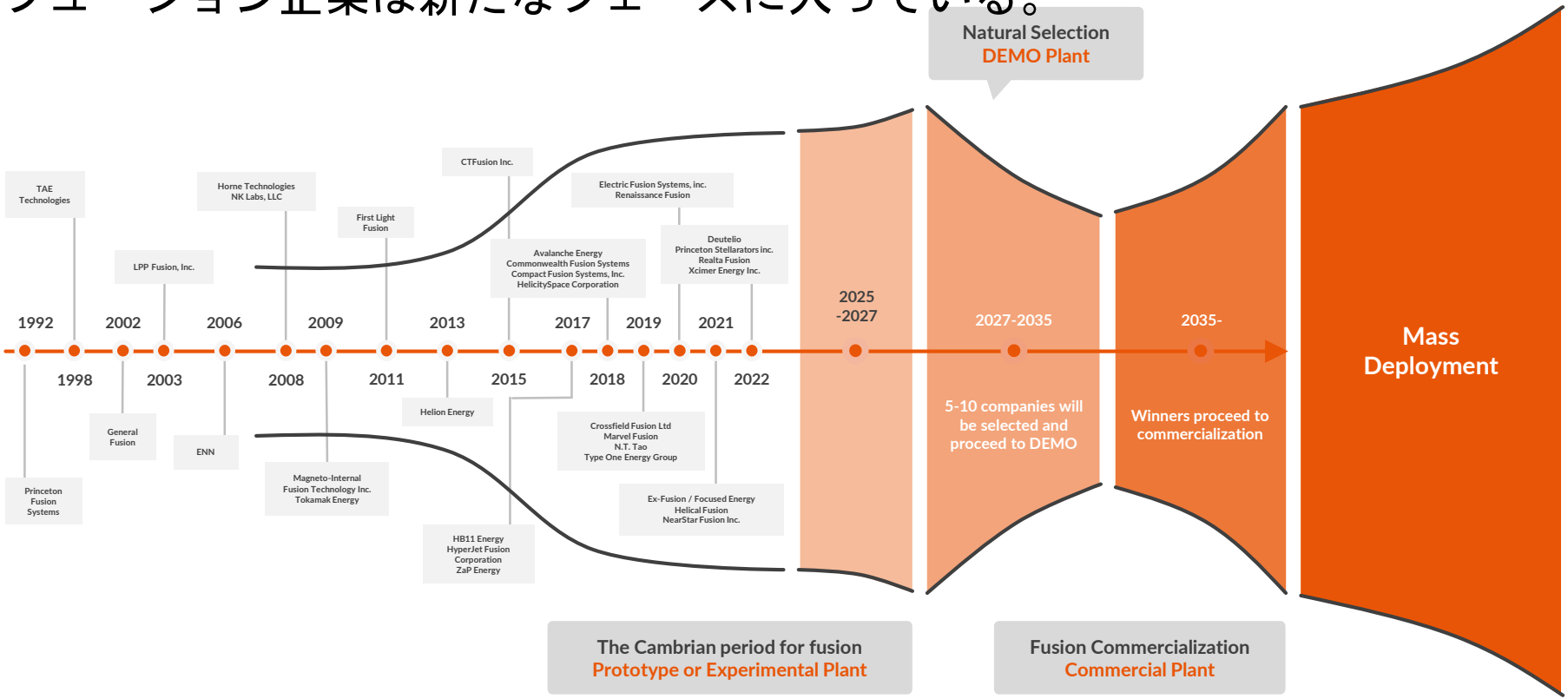
	Now-2027	2027-2035	2035-2040	2050
	Experimental Plant	Demonstration Plant	Commercial Plant	Mass Deployment
# of Plants	Public: 35-50 Private: 20-25	5-10	2-5 per year	30-50+ per year
Per Plant budget (M USD)	100 - 1,000 M (ITER: 20B)	1,000-5,000 M	1,000-5,000 M	3,000-5,000+ M
Market size (Global, M USD)	5,000 M	30,000 M	15,000 M per year	150,000 M per year
Major Challenge	Experimental verification of conceptual approach	Continuous operation Integrated testing Heat extraction Tritium breeding	Cost reduction Efficiency improvement	Commercial Continuous technology improvement

Fusion Commercializagion in 2030's

世界のフュージョン開発は様々な戦略に展開し始めた



Selection will occur next
-while the market continues to grow
フュージョン企業は新たなフェーズに入っている。



Kyoto Fusioneering Company Profile

会社概要—京大発スタートアップ

Founded: 0ct 2019

Funding: ($80M+ 122億円)

Shareholders:

JIC VENTURE GROWTH INVESTMENTS, DBJ 日本政策投資銀行グループ, JAFCO, CORAL CAPITAL, Mitsubishi Corporation, MITSUI&CO., MUFG, SMBC, THE KANSAI ELECTRIC POWER CO., INC.

Location: Kyoto, Tokyo
Seattle, Reading (Oxford)

Employees: Total 95+

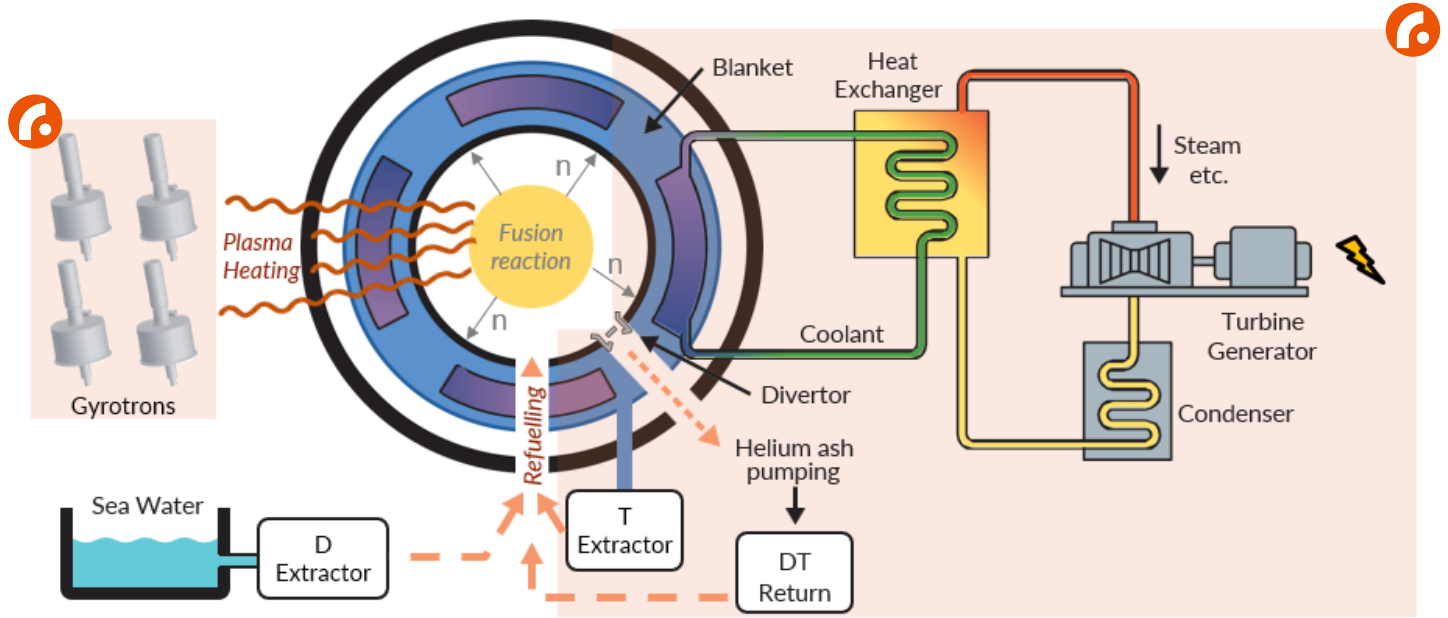
Kyoto Fusioneering offices and business

京都フュージョニアリングは世界的展開を必要とし、実践している

Kyoto Fusioneering provides fusion supply chain

フュージョンエネルギーには複雑で高度なサプライチェーンが必要

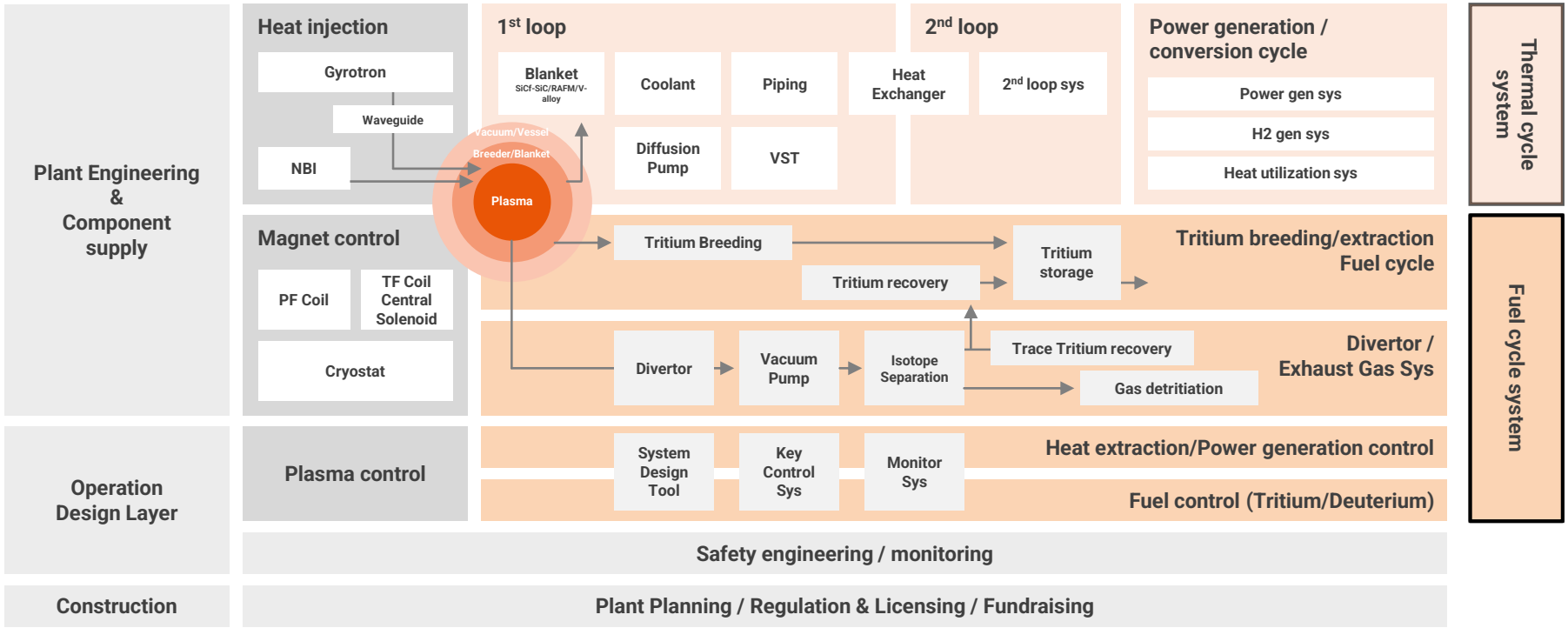
Other fusion companies focus on developing a power-producing fusion reaction…



… KF focuses on key fusion power plant integrated systems and components, principally: plasma heating systems, power production, fusion fuel cycle.

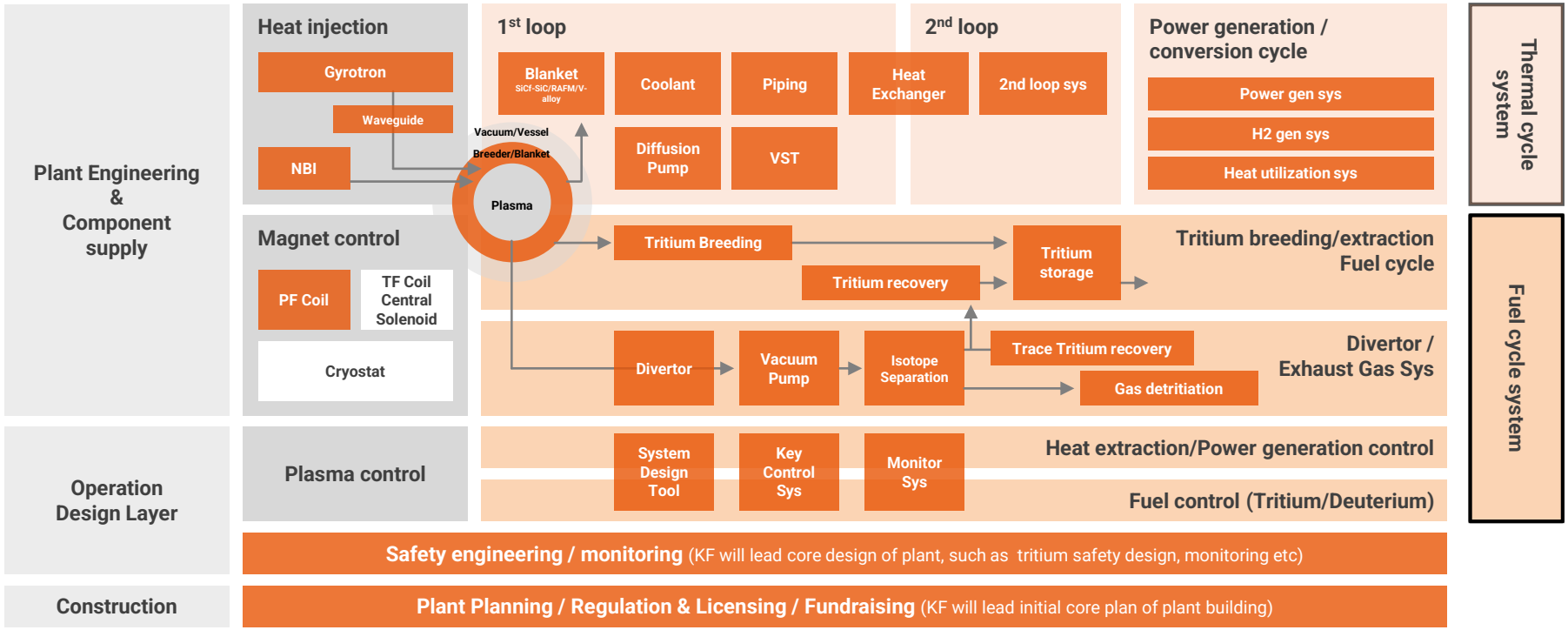
Key Systems in a Fusion Power Plant

現在、世界の主要な計画はプラズマ中心に開発が進められているが…



Kyoto Fusioneering's Capability and Coverage

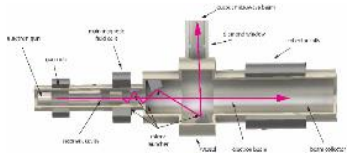
京都フュージョニアリングのフュージョンプラント技術



Product & services

京都フュージョニアリングの主要な炉工学機器技術

Plasma Heating (Gyrotron)



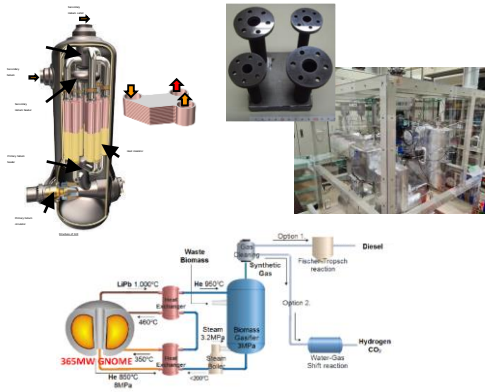
World-record high-frequency (236 GHz)

High power, high stability, high efficiency

9.5T magnet, root-sound superconducting material (under fabrication)

World-leading engineering service and support

Thermal Cycle System



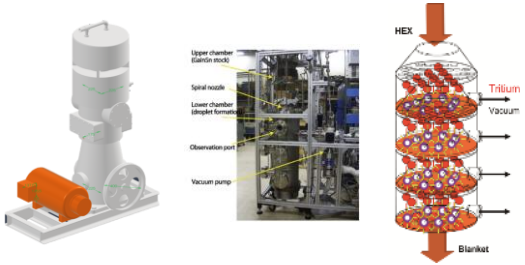
1,000°C heat management with advanced materials SiCf/SiC (nuclear: ~300℃)

Tritium (fuel) breeding blanket, heat exchanger

Plant for hydrogen generation from biomass and carbon fixation from fusion

Next generation high efficiency power cycle engineering (high-temperature helium gas turbine)

Fuel Cycle System



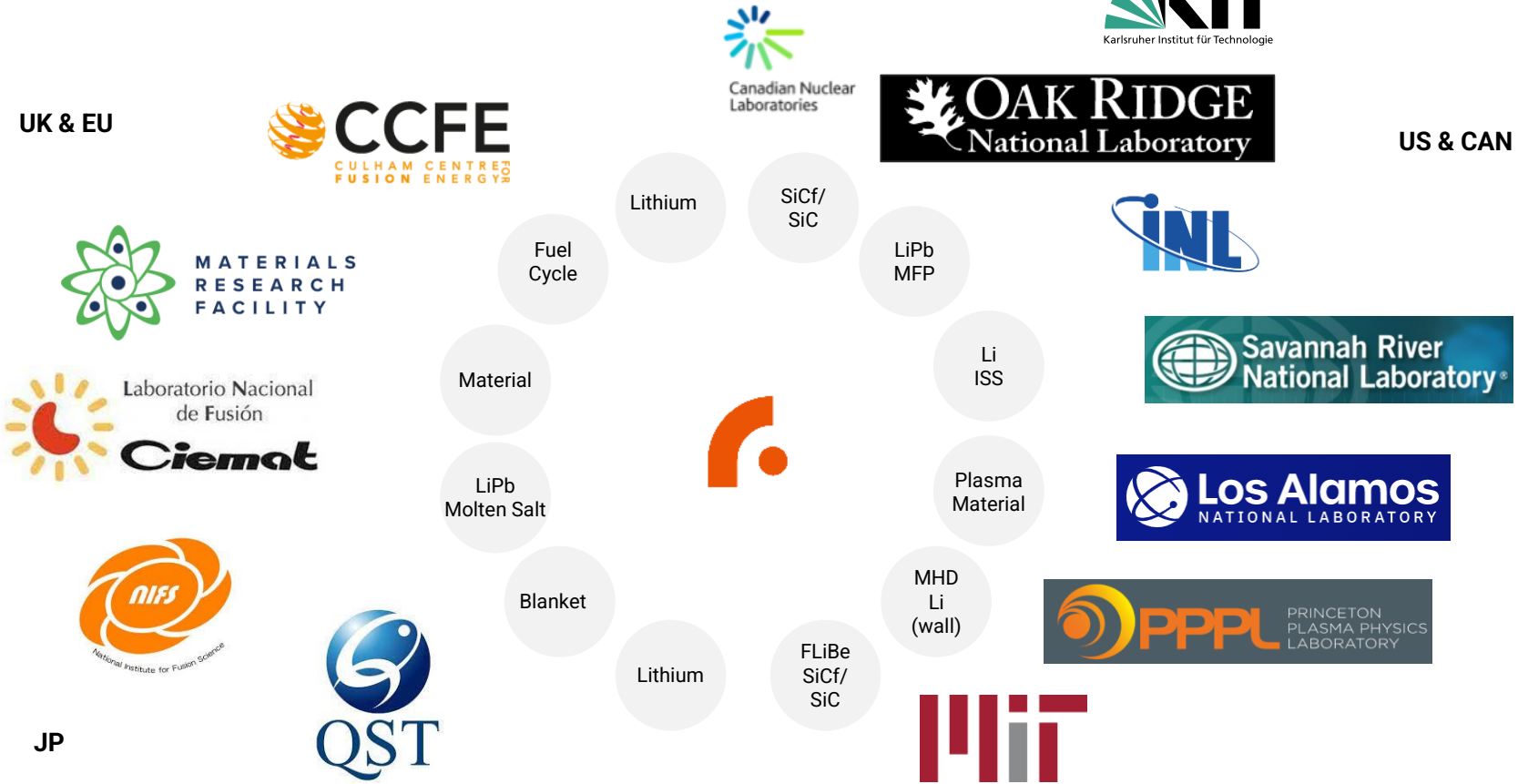
Innovative tritium fuel cycle design (Direct Internal Recycling)

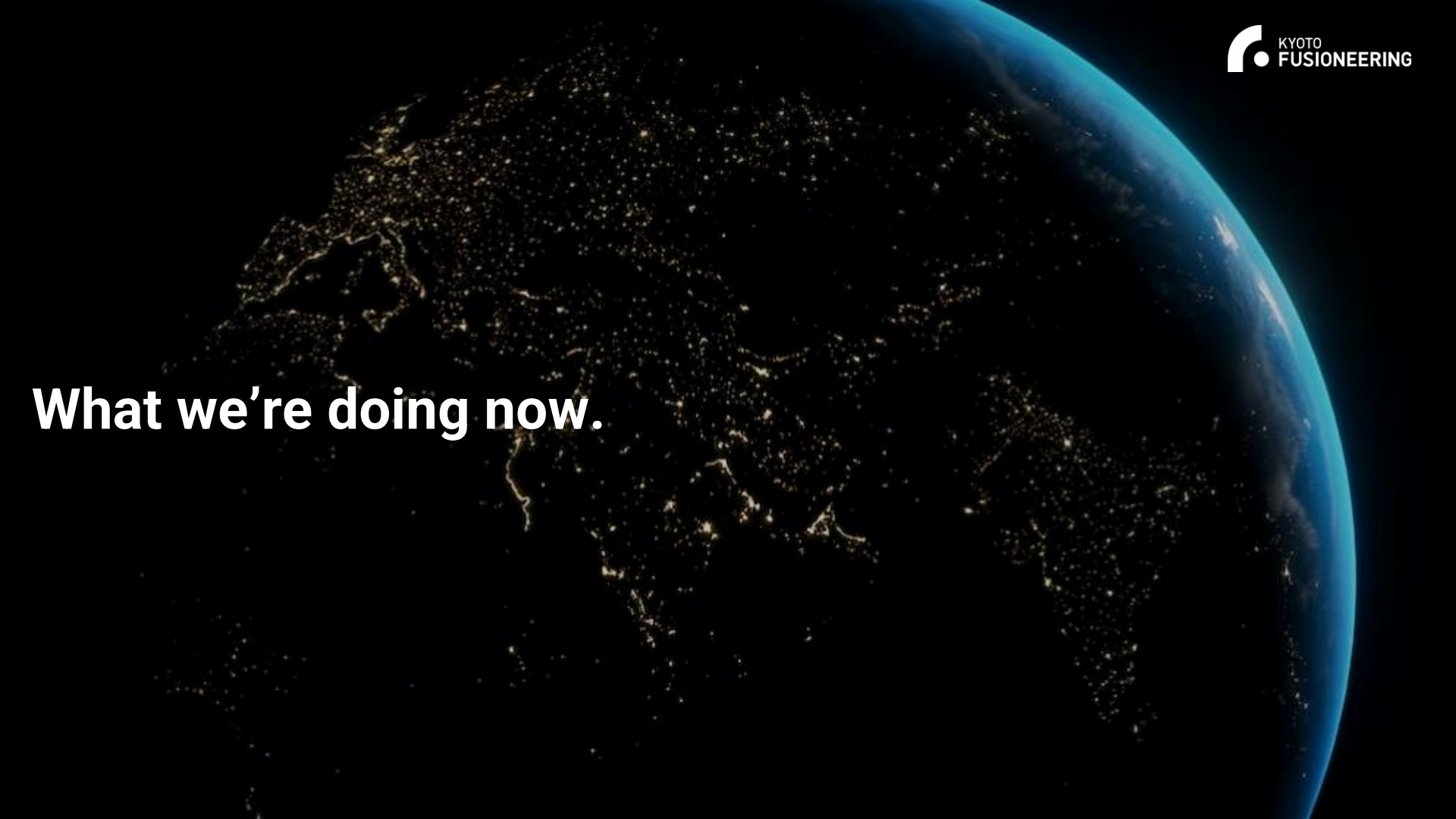
Tritium and deuterium transport equipments (tritium compatible pumps)

Cutting-edge tritium separation systems

Taking a Collaborative Approach

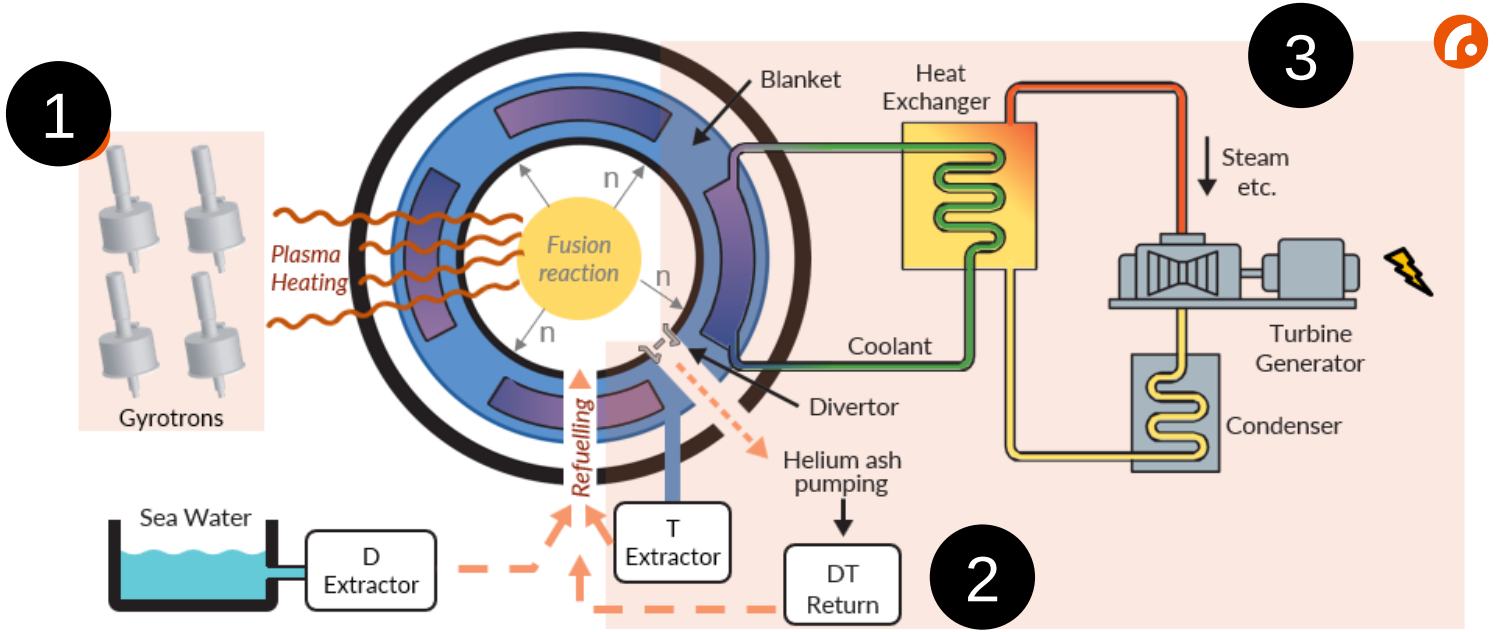
京都フュージョニアリングと公的機関の協力



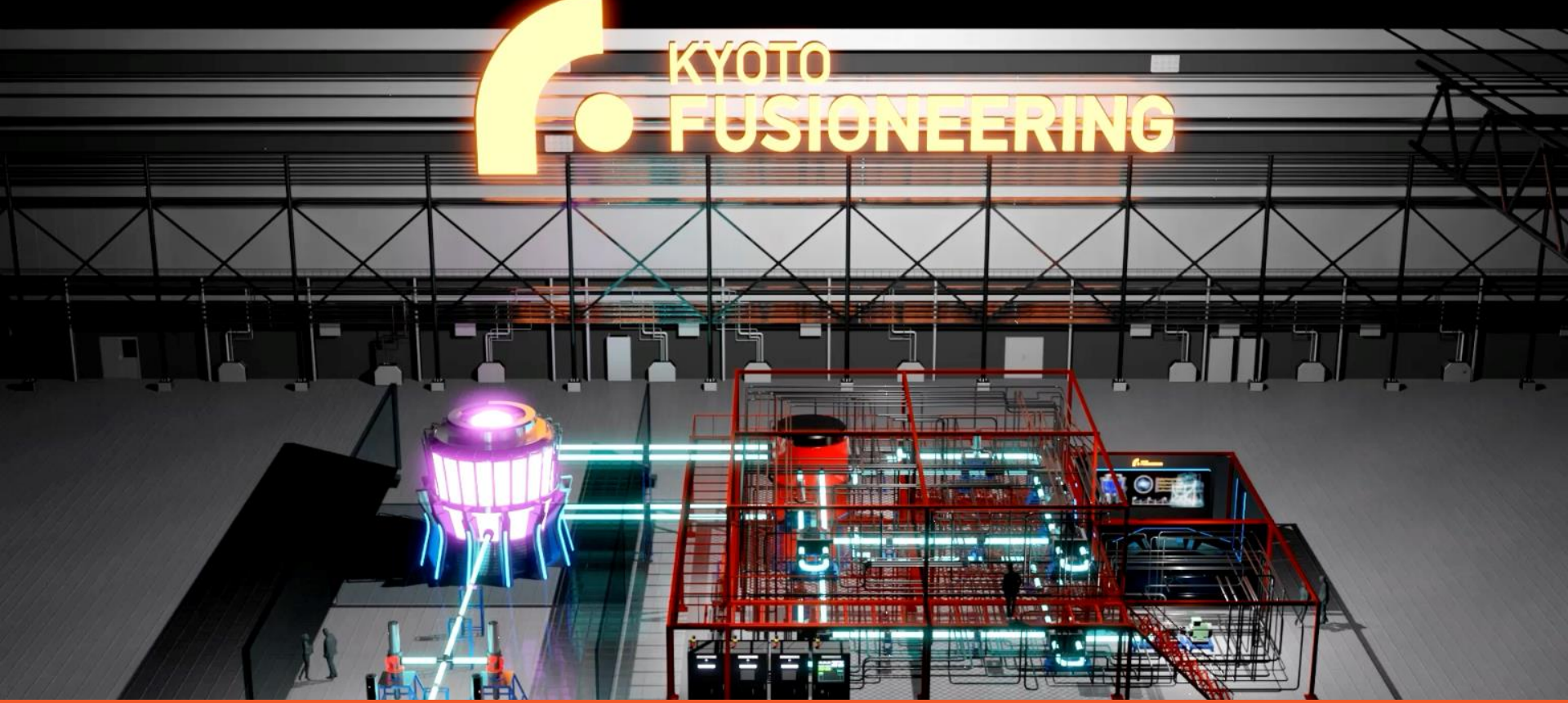

KYOTO
FUSIONEERING
What we’re doing now.

Business of Kyoto Fusioneering: enabling technology

京都フュージョニアリングによるフュージョン技術の開発



… KF focuses on key fusion power plant integrated systems and components, principally: plasma heating systems, power production, fusion fuel cycle.

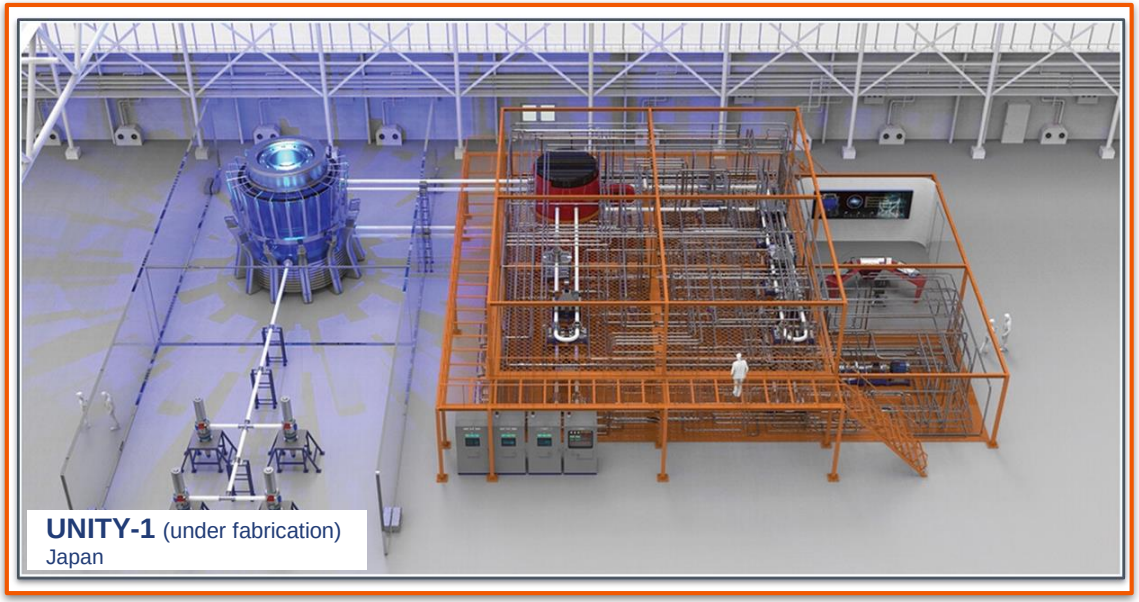


UNITY-1 (UNique Integrated Testing facilitY)

World-first integrated testing facility for fusion power plant equipment. Electricity generation with fusion relevant technologies; operational from 2024.

UNITY-1 Facility

京都フュージョニアリングによるエネルギー変換開発



Location: Japan (under construction)

Thermal Cycle and Blanket System:

- Blanket test section (1000°C LiPb, Li, FLiBe)
- 250 L LiPb inventory
- 4T NbTi magnet
- IH heating and surface heating for blanket module 30x30x70 cm
- Two heat exchangers and power conversion (first electricity generation from a blanket module)

Fuel Cycle:

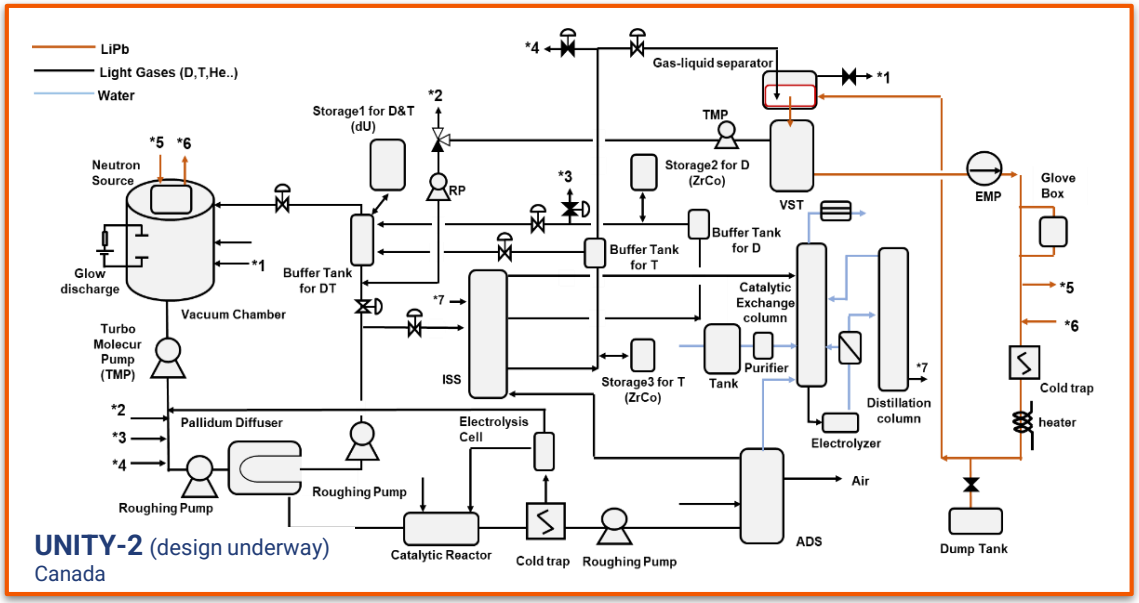
- Deuterium injection as proxy for tritium
- Tritium extraction via VST, electrochemical
- Exhaust pumping from vacuum vessel (pump train)
- DIR testing with proton conductor pump

Materials:

- Compatibility in flow conditions (up to 50 L/min via 3 EMPs)
- FLiBe and Li piping material tests
- MHD testing with SiCf/SiC insulators

UNITY-2 Facility 京都フュージョニアリングによる燃料サイクル開発

Focused on demonstrating fusion power plant relevant tritium fuel cycle technologies in an integrated fashion



UNITY-2 (design underway)
Canada

Location: Chalk River, Ontario

Components:

- Tritium Extraction System to be tested with Tritium (~50 L Li-Pb loop)
- Fusion Plant conditions for vacuum chamber (including PEG gases)
- Dual storage system (dU, ZrCo)
- Dual ISS (TCAP, CD)
- Outer cycle included (WDS, ADS)
- Centrifugal Pellet Injection

Tritium:

- Under review, 10 to 40 g inventory
- Fuelling of vacuum chamber at ~2.6 Pa m^3 / s

Modelling:

- Dynamic fuel cycle modelling
  - Coolant/breeder inventory
  - Pumps, Pd diffuser, getter beds, DT delivery mechanism

2023
Initiation:
Design and individual component testing

2024
Procurement:
Key systems and components

2025
Installation:
Integration of systems. Planned commissioning

Recent Fusion Programs:最新の核融合計画

KYOTO FUSIONEERING

Company	Location	Funds raised	Type of reactor	Fuel cycle	Power plant concept	blanket	temp (°C)
Commonwealth Fusion Systems	MA, USA	$ 2,000M	Tokamak	D-T	ARC reactor	FLiBe	630°C
Tokamak Energy	Oxford, UK	$ 250M	Spherical tokamak	D-T	ST-E1	Li/Agnostic	~600°C
Focused Energy	USA / Germany	$ 82M	ICF (direct drive)	D-T	SuperNova	Li/Agnostic	-
Realta Fusion	WI, USA	$ 12M	mirror	D-T	HAMMIR	Agnostic	-
Xcimer Energy	CA, USA	$ 12M	ICF	D-T	HYLIFE-III	FLiBe/Agnostic	-
ZaP Energy	WA, USA	$ 208M	Z-pinch	D-T		LiPb	-
Type One Energy	WI, USA	$ 30M	Stellarator	D-T		-	-
Helion Energy	WA, USA	$ 577M	FRC	D-He3	Polaris	-	-
General Fusion	BC, Canada	$ 300M	Acoustic implosion	D-T	Yes?	LiPb	-
UKAEA STEP	UK	$ 222M	Tokamak	D-T	STEP	Li/Agnostic	550-600°C
Kyoto Fusioneering	Japan,UK,US	$ 90M	not specified	D-T	Yes?	LiPb,Li,FLiBe	500-1000°C

民間核融合の弱点と課題

Private programs have weak points.
現在の民間主導核融合には明確に足りないものがある

- Designing nuclear compatible devices and plants
- Material qualification for nuclear testing
- Regulation, license and safety
- Supply of special materials (tritium, lithium-6, Be, etc..)
- Waste disposal and tritium emission
- Public understanding and acceptance

Fusion Nuclear Technology and ppp

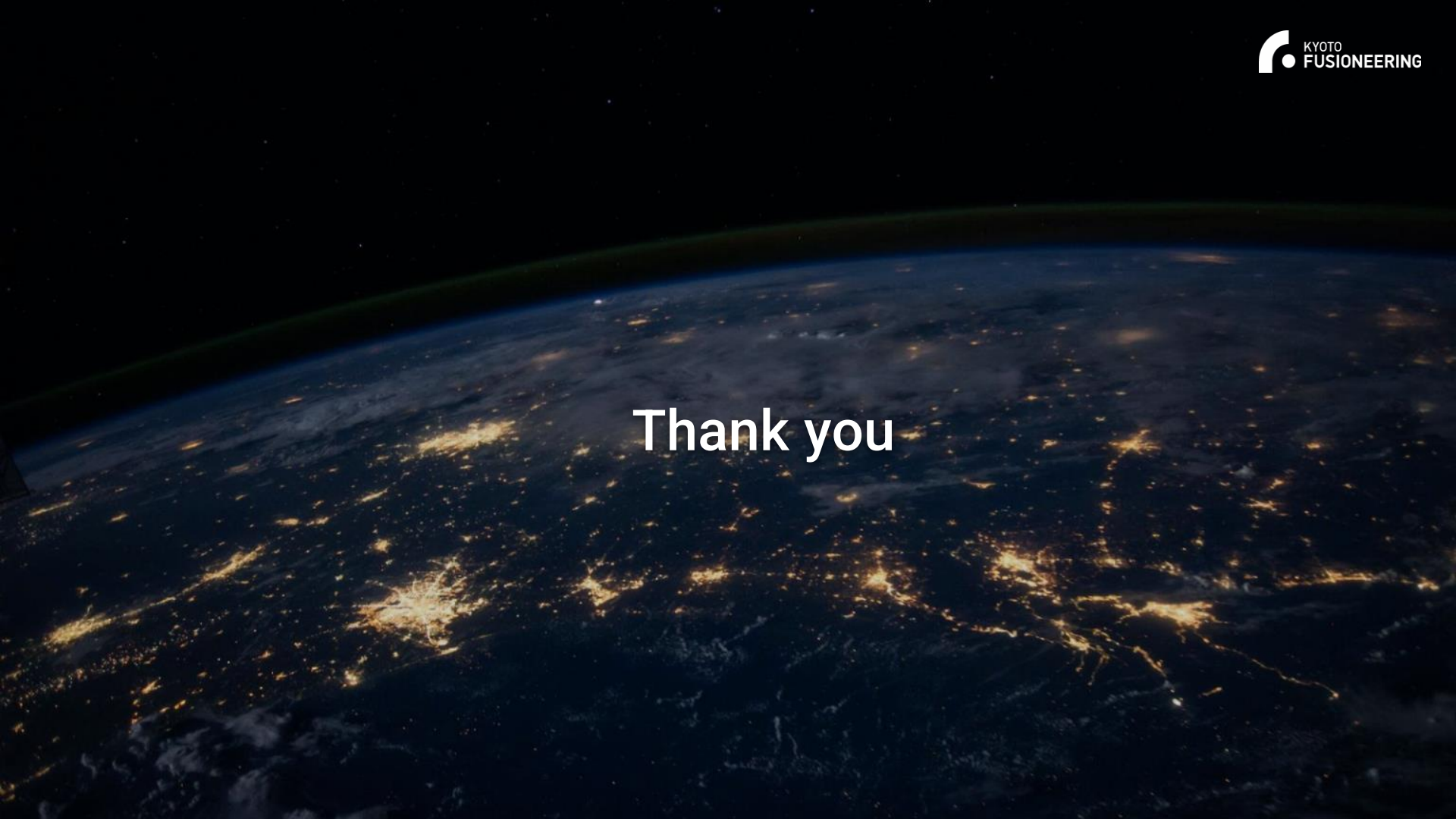
KYOTO FUSIONEERING

官民協力でなければ成立しないFusionの課題

- Nuclear technology is week in most of private programs
- Demands for Fusion Nuclear Technology appears significantly earlier than private programs (~2030 for DT!)
- Previous programs do not take private activities into account
- …This is the time to reconsider the public programs to involve privates.
- Effective private-public partnership is the only way to make Fusion energy possible

….and respond to the world expectations for the real innovative energy.

Confidential | 19


KYOTO
FUSIONEERING
Thank you