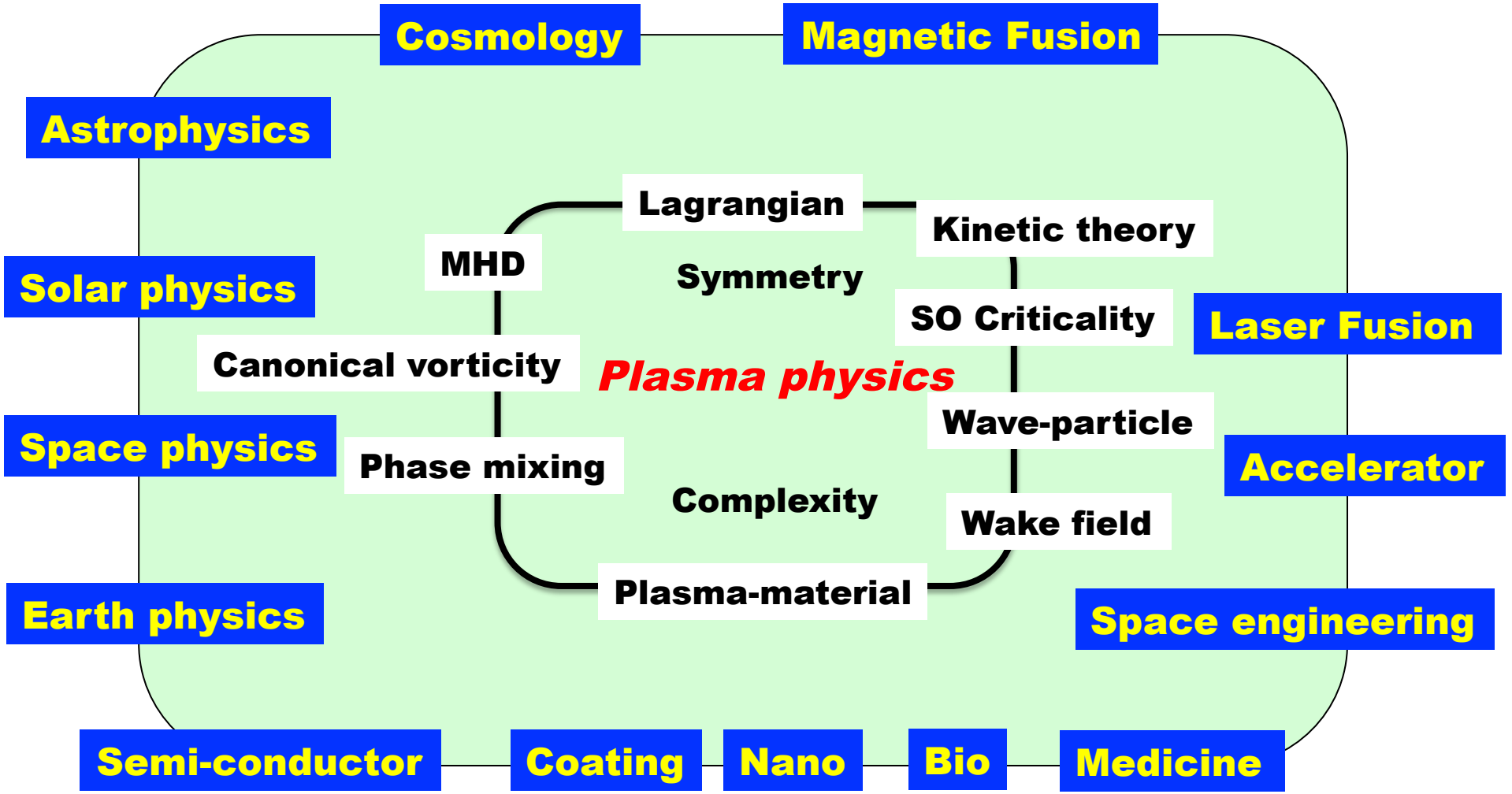
35 AAPPS Council, April 7-8, 2017 Xi'an, China

Introduction of DPP activity
Magnetic Fusion Facilities in Asia

M. Kikuchi

Chairman, AAPPS-DPP

Plasma Physics as a frontier in science of matter



Asia-Pacific Physical Societies *Division of plasma physics*

Fundamental
Basic
Applied
Laser
Space
Solar/Astro
Magnetic Fusion ← This time

Contributions
China; SWIP, ASIPP, HUST, Peking, Tsinghua, Jejiang, Daliang,--
Japan: NIFS(Odachi), Kyoto, Kyushu, U. Tokyo, Nagoya, Tsukuba, --
Korea: NFRI, KAIST, SNU, POSTECH, UNIST
Taiwan: NCKU
Australia: ANU, --

Executive Committee, Division of plasma physics, AAPPS

Applied plasma physics : Prof. M. Shiratani

Plasma agriculture: an emerging research field

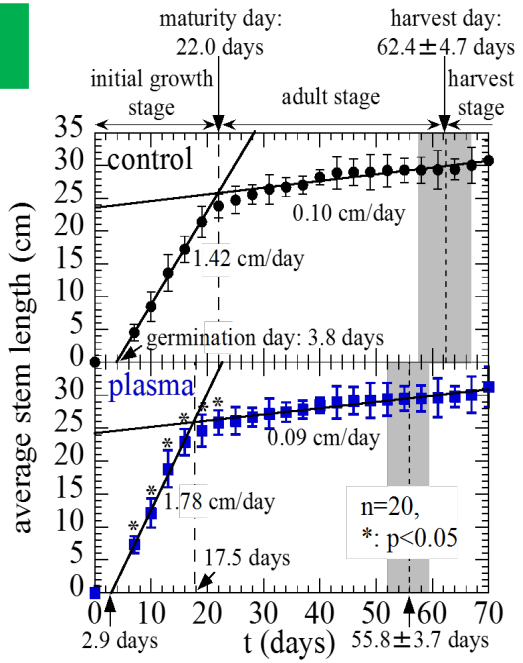
Plasma induced effects:

1. **Increase in germination rate (10% up),**
2. **Growth rate enhancement,**
3. **Reduction in harvest period (11% down),**
4. **Increase in seed yield (56% up).**

News in American Vacuum Society, IEEE, German Physical Society, Japanese Society of Applied Physics.
>2000 downloads per year.
K. Koga, et al., APEX, 9 (2016) 016201.

Atmospheric DBD plasma was irradiated to seeds of Arabidopsis for 3 min.

Growth of plants from seeds with plasma irradiation was compared with control plants for weeks.



3 replication, *: p<0.05

	control	plasma
harvest day (days) n=20	62.4±4.7	55.8±3.7 **(89 %)**
total seed weight (mg) n=20	26.4	41.1* **(156 %)**
average weight of one seed (mg/seed) n=100	0.0201±0.0024	0.0225±0.0016* (112 %)
number of seeds n=20	1313	1826* **(139 %)**

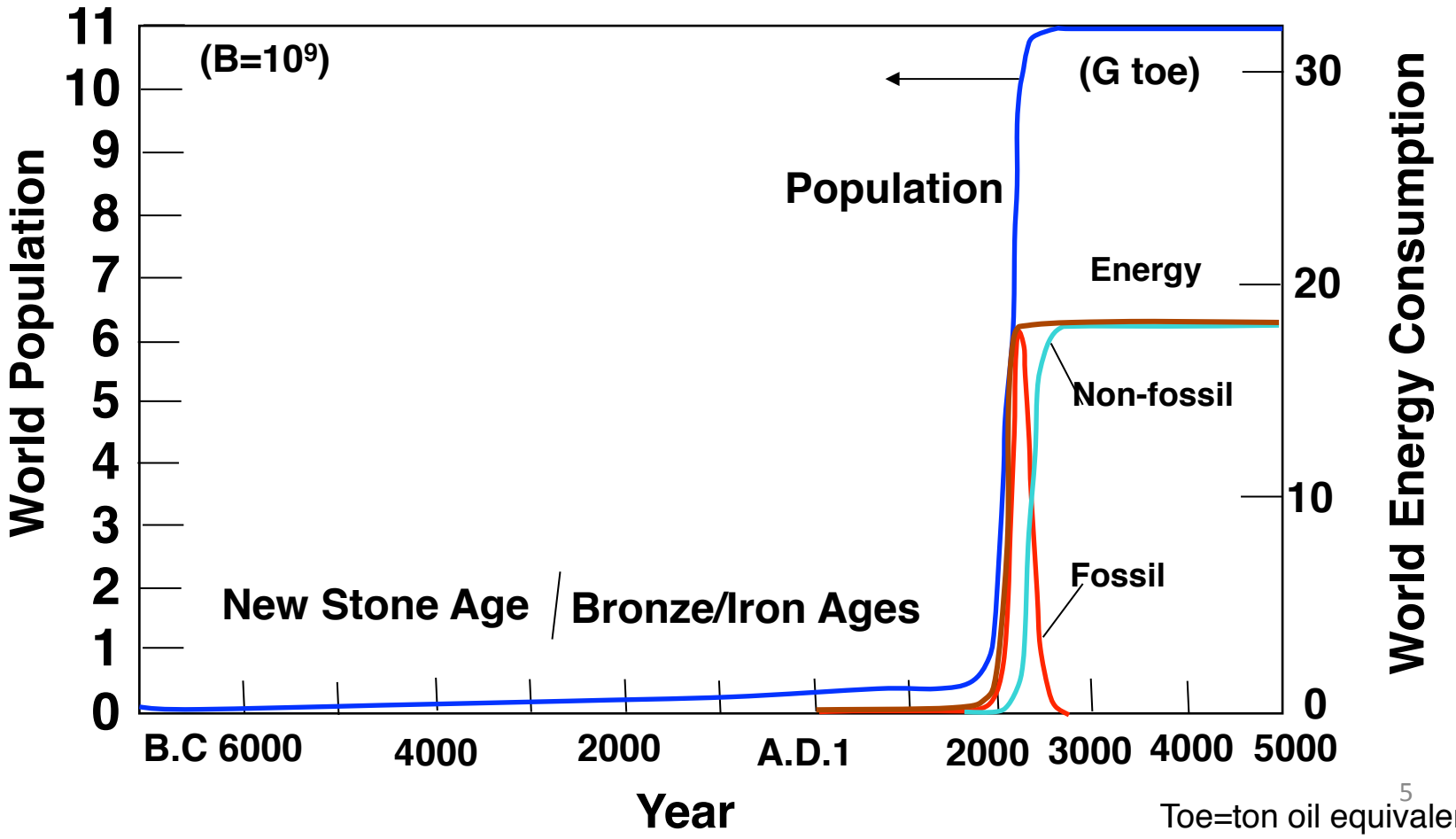
1. Fusion Energy : Pros and Cons (1)

BIG transition in both human population and energy consumption.

Fossil resources will expire in a moment

Energy security :Multiple energy resources for many 1000 years (Renewables, fission and fusion)

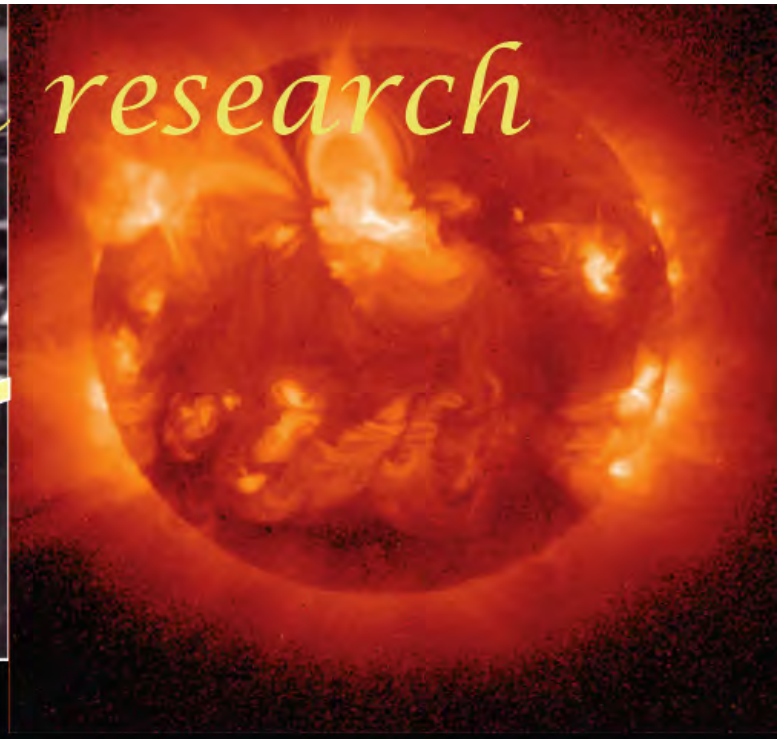
Fission is also inexhaustible (Uranium in Sea water)

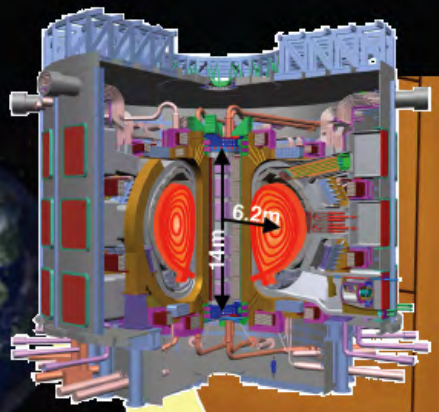


Toe=ton oil equivalent

50 years of Fusion research

2nd Geneva Conference
1958, Prof. Yukawa





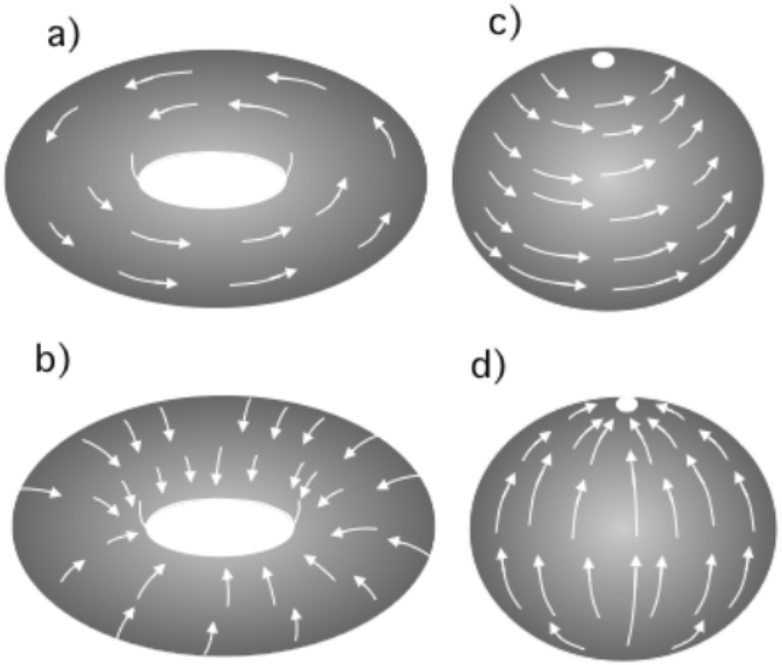
22nd Fusion Energy Conference at Geneva 2008, 2nd from left

2. Why are toroidal devices used? (2)

French mathematician **Henri Poincare** (1854-1912) proved a theorem "**Closed surface that can be covered with vector field without fixed point is restricted to a torus**." This is called "**Poincare theorem**"

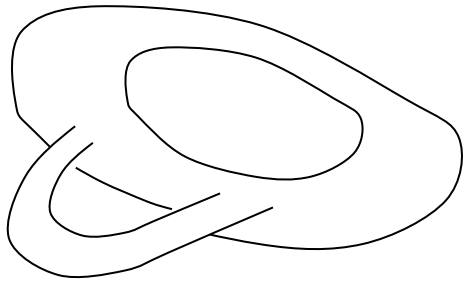
For the magnetic fusion, plasma must be confined inside the closed surface. If the magnetic field on this surface has some null point (fixed point), the plasma will leak through that region.

Hair whorl on the head



See my book for proof of Poincare theorem

i)

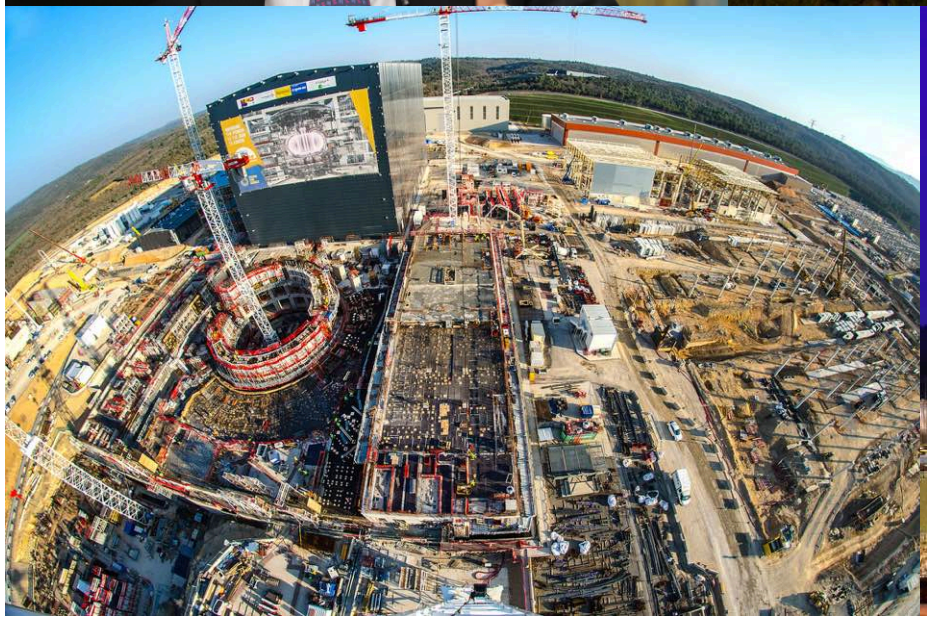


Bundle divertor is topologically not a torus.
So, it necessarily includes null point of vector field.

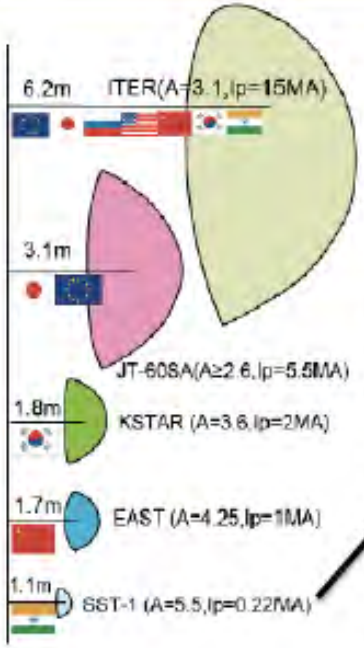
J.B. Taylor, Bundle divertors and topology,
CLM-R 132 (1974)

Sun on the Earth is under construction: day and night

ITER DDG GS Lee



Asian Fusion : Largest population and energy consumption



b

China Fusion Research (1) : SWIP

Southwestern Institute of Physics

Chengdu, Sichuan province

Welcome to 1st Asia-Pacific Conference on Plasma Physics

AAPPS-DPP executive committee (M. Kikuchi, chair) decided to organize the 1st Asia-Pacific Conference on Plasma Physics (AAPPS-DPP2017 in short). This conference will be the general plasma physics conference in Asia-Pacific region, similar to the APS-DPP and EPS-DPP conferences on plasma physics.

Scope of the AAPPS-DPP2017

AAPS-DPP2017 is a plasma physics conference under the authority of AAPPS-DPP for scientific discussions on plasma physics. This conference should be physics oriented and provide interdisciplinary and in-depth discussions among and in various fields of plasma physics and application.

International organizing Committee Chair: Liu Chen

Co-chair: M. Kikuchi

Local organizing Committee Chair: Yong Liu

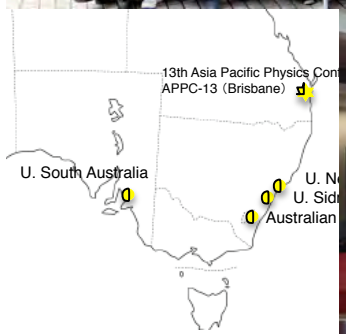
Welcome to Chengdu

Registration New!

Start: 20 January 2017

Abstract Submission New!

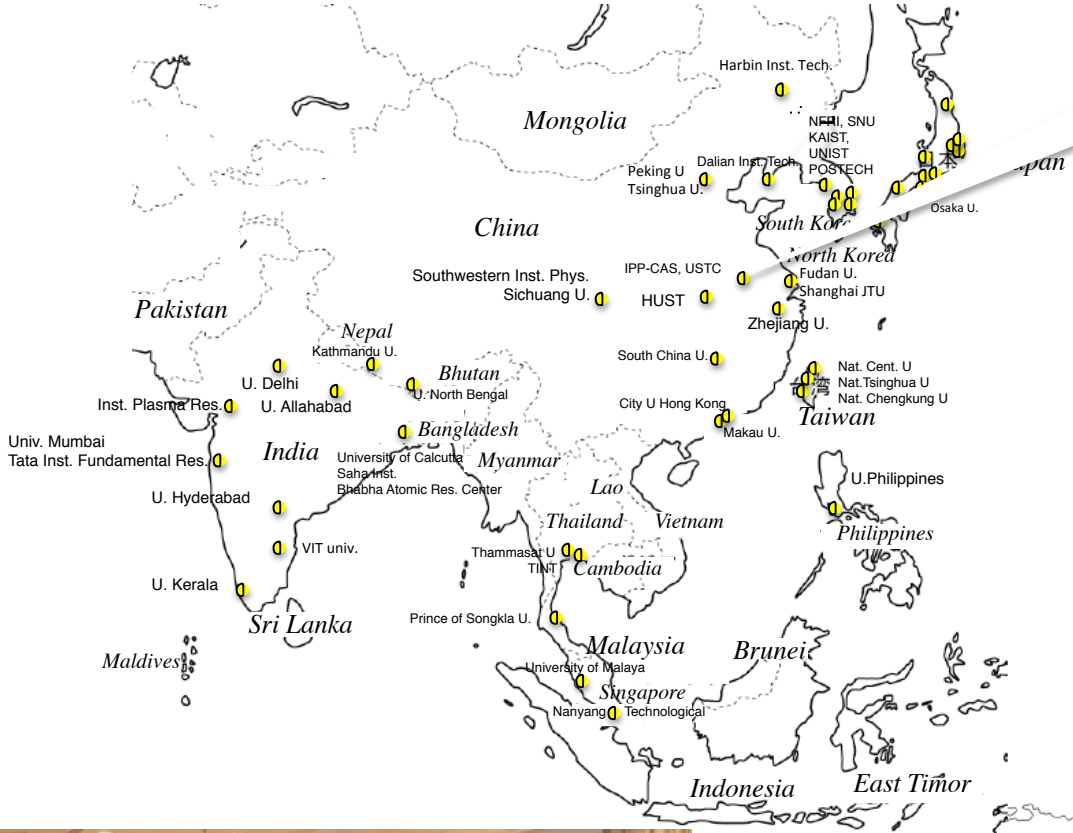
Deadline: 30 April 2017



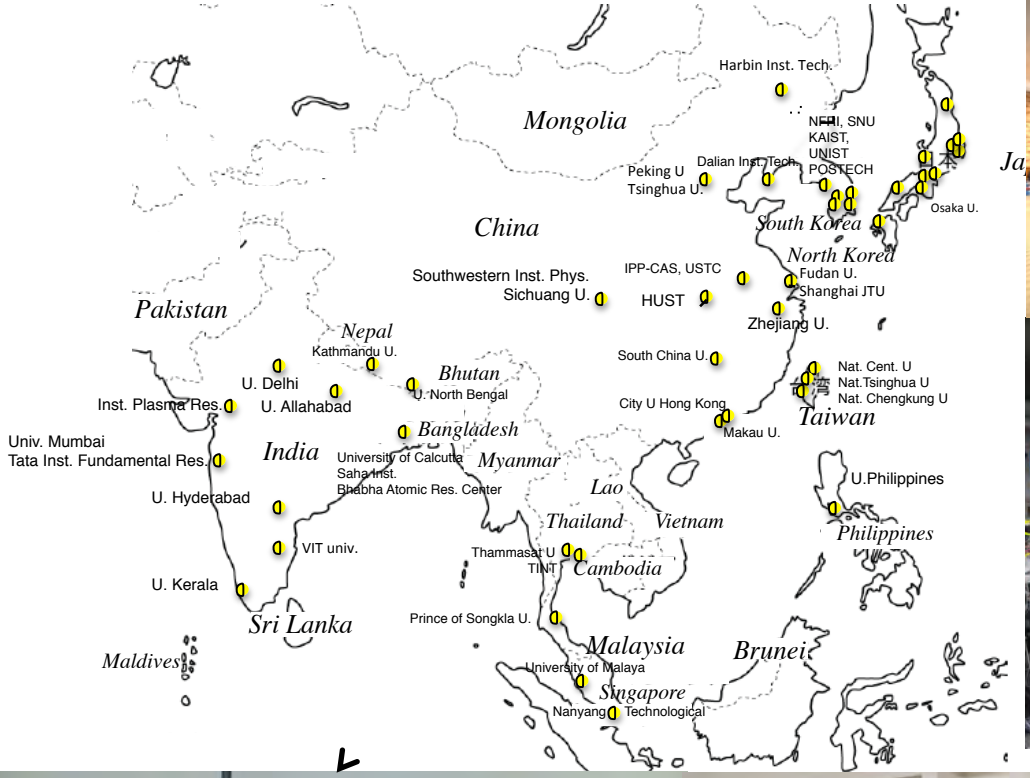
China Fusion Research (2) : ASIPP

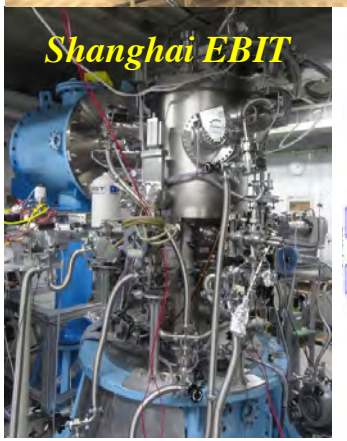
Institute of Plasma Physics, CAS

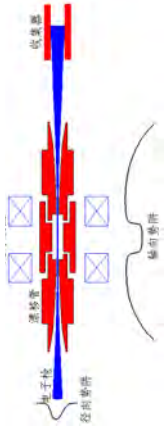
Hefei



China Fusion Research (3) : HUST (J-TEXT), Fudan University (A&M)







New Zealand

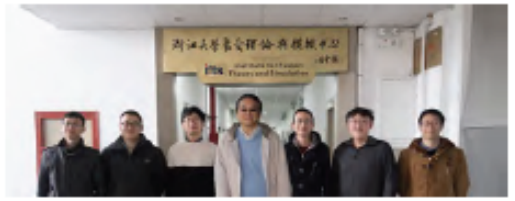
China Fusion Research (5) : Zhejiang U (Hangzhou), Dalian University of Technology

Dalian University of Technology

Dalian

Institute for Fusion Theory and Simulation, Zhejiang University

Hangzhou

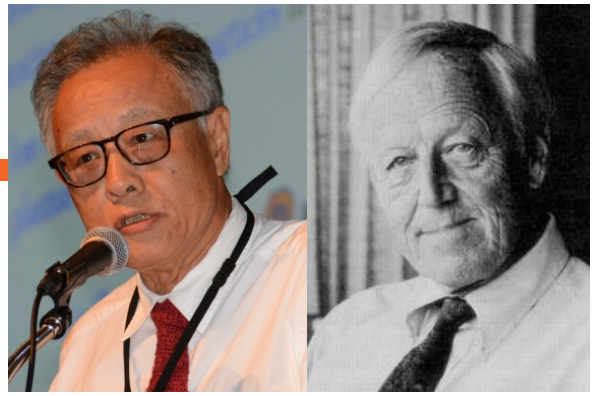


APTWG in Dalian

West Lake Symposium in Hangzhou

Discrete and Continuous Spectrum

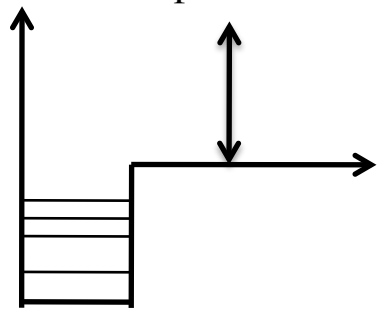
Physics of " Phase Mixing "



L. Chen APPC-12 H. Alfven

Quantum mechanics

Continuous spectrum



Discrete spectrum

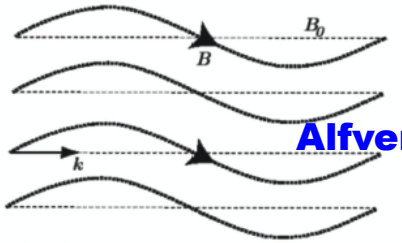
Functional theory

Linear operator having continuous spectrum

$$(x-\lambda)f = 0 \qquad \lambda : \text{eigen value}$$

Solution ; $f = c\delta(x-\lambda)$.

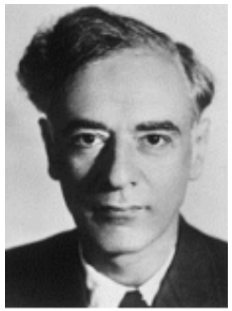
λ can be arbitrary !!
f is non square integrable.



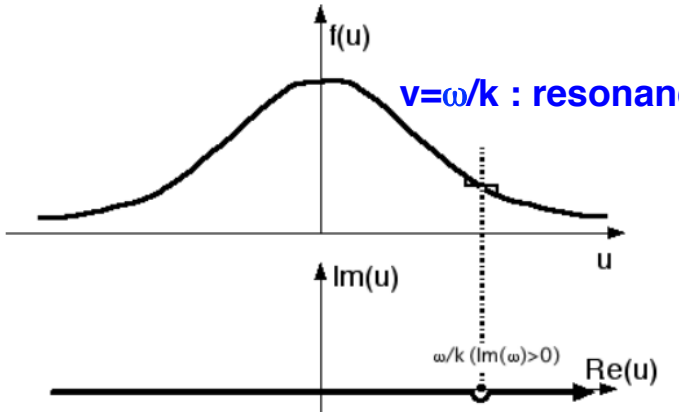
Alfven Wave

Plasma Physics : Two types of continuous spectrum leads to collisionless damping.

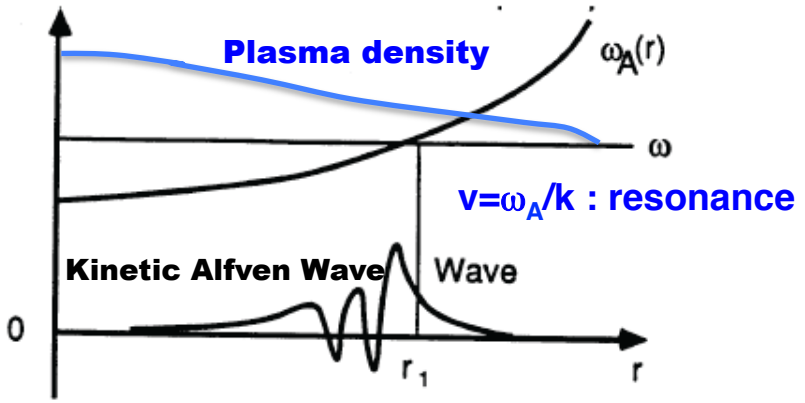
Velocity space : Landau damping



L.D. Landau



Spatial non-uniformity : Alfven continuum damping



A. Hasegawa, L. Chen: PRL1974,75

L. Chen, Reviews of Modern Physics (2016)

Courtesy of Prof. Kaneko, Mutoh

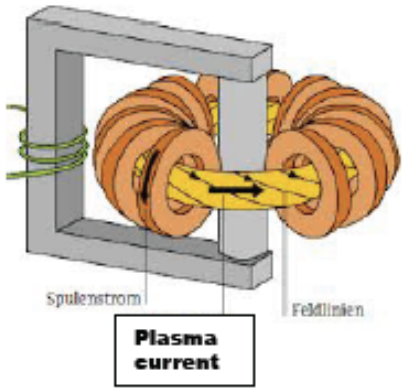
Japanese Fusion Activities

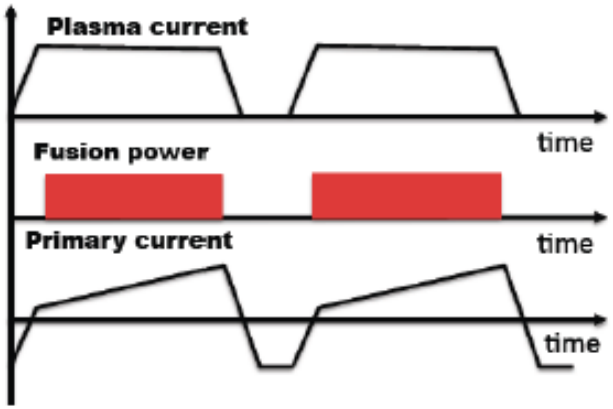
Total Univ. labs and Institutes under collaboration with NIFS: 170

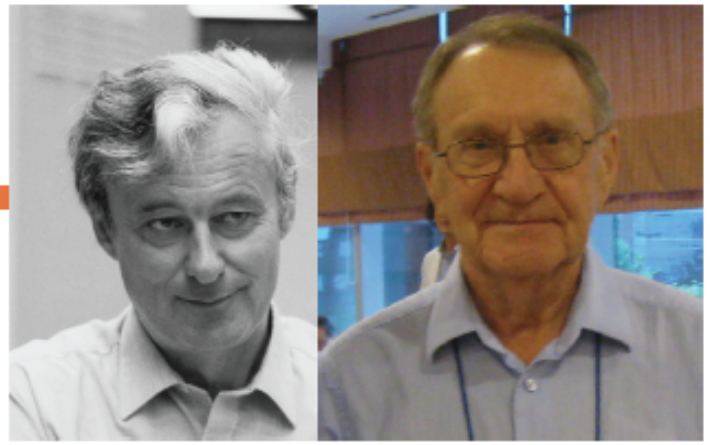
Self-generated current

Bootstrap current

Tokamak is a front runner in Fusion Research.
But, it uses transformer action to drive plasma current.
So it will operate in pulse.

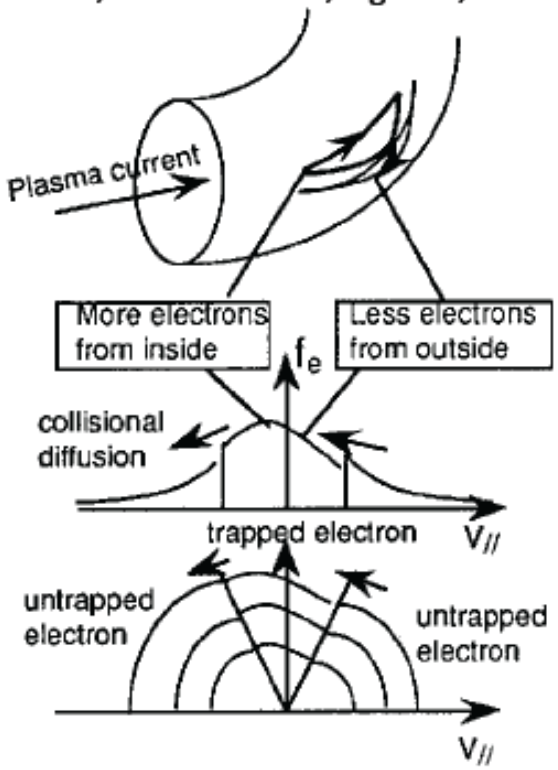






R. Bickerton R. Sagdeev

Nature,1971 Galeev,Sagdeev, IAEA1971



Plasma itself will drive plasma current !!

- **Force comes from trapped particle – Velocity space diffusion**

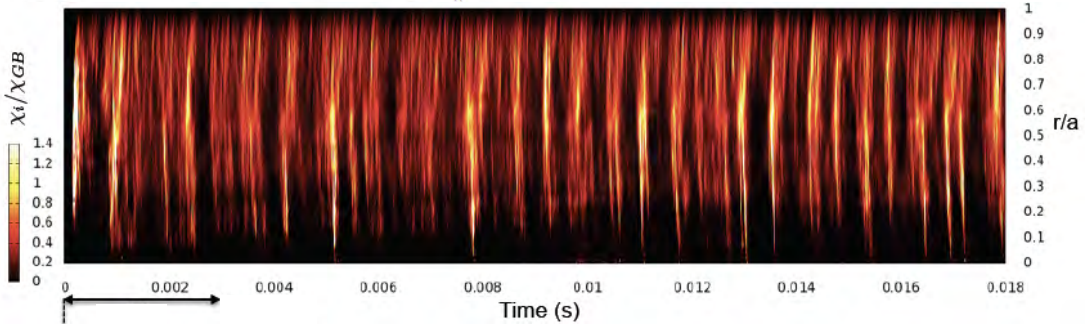
Called "bootstrap current"

M. Kikuchi, Reviews of Modern Physics (2012), Springer 2011, 2015.

First principle 5D Gyro-phase averaged kinetic simulation

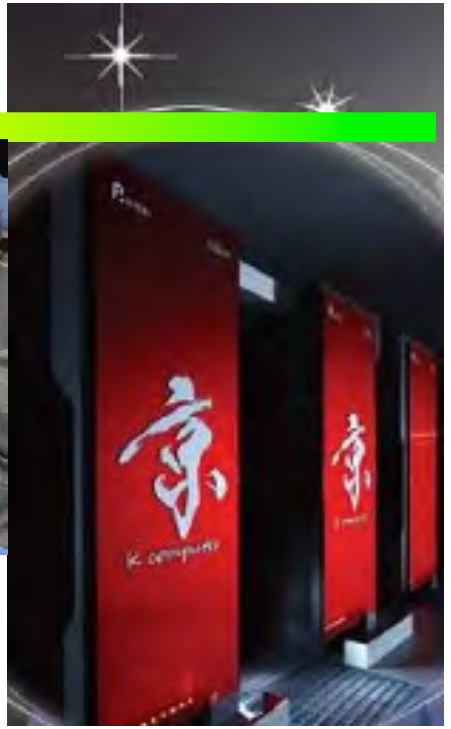
$$\frac{\partial f}{\partial t} + \{f, H\} = C(f) + S \qquad C(f): \text{collision} \quad S: \text{source}$$

$$\frac{\partial \mathcal{J} f}{\partial t} + \nabla \cdot (\mathcal{J} \dot{\boldsymbol{R}} f) + \frac{\partial}{\partial v_\parallel}(\mathcal{J} \dot{v}_\parallel f) = \mathcal{J} C(f) + \mathcal{J} S_{\mathrm{src}} + \mathcal{J} S_{\mathrm{snk}}$$



τ_{ii}

Y. Idomura
EPS2013



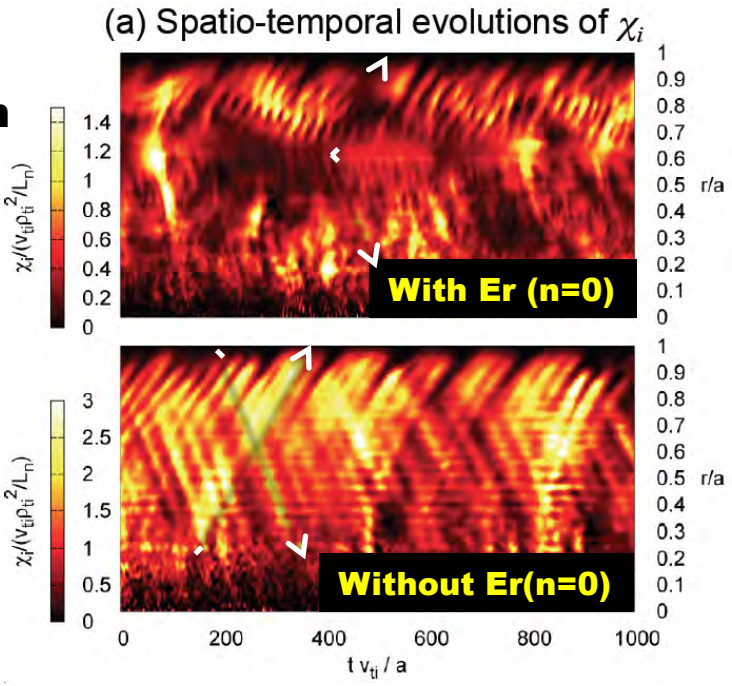
Radial force balance equation

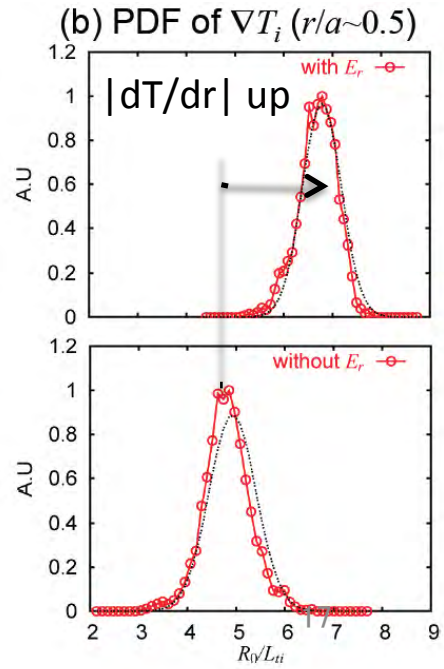
$$u_{\zeta i} = \frac{1}{B_\theta}\left[E_r - \frac{1}{eZ_i n_i}\frac{dP_i}{dr} - \frac{K_1}{eZ_i}\frac{dT_i}{dr}\right]$$

is an important constraint for avalanche propagation.

Er(n=0):
global Er and Zonal flow Er

Diamond et al., PPCF2004

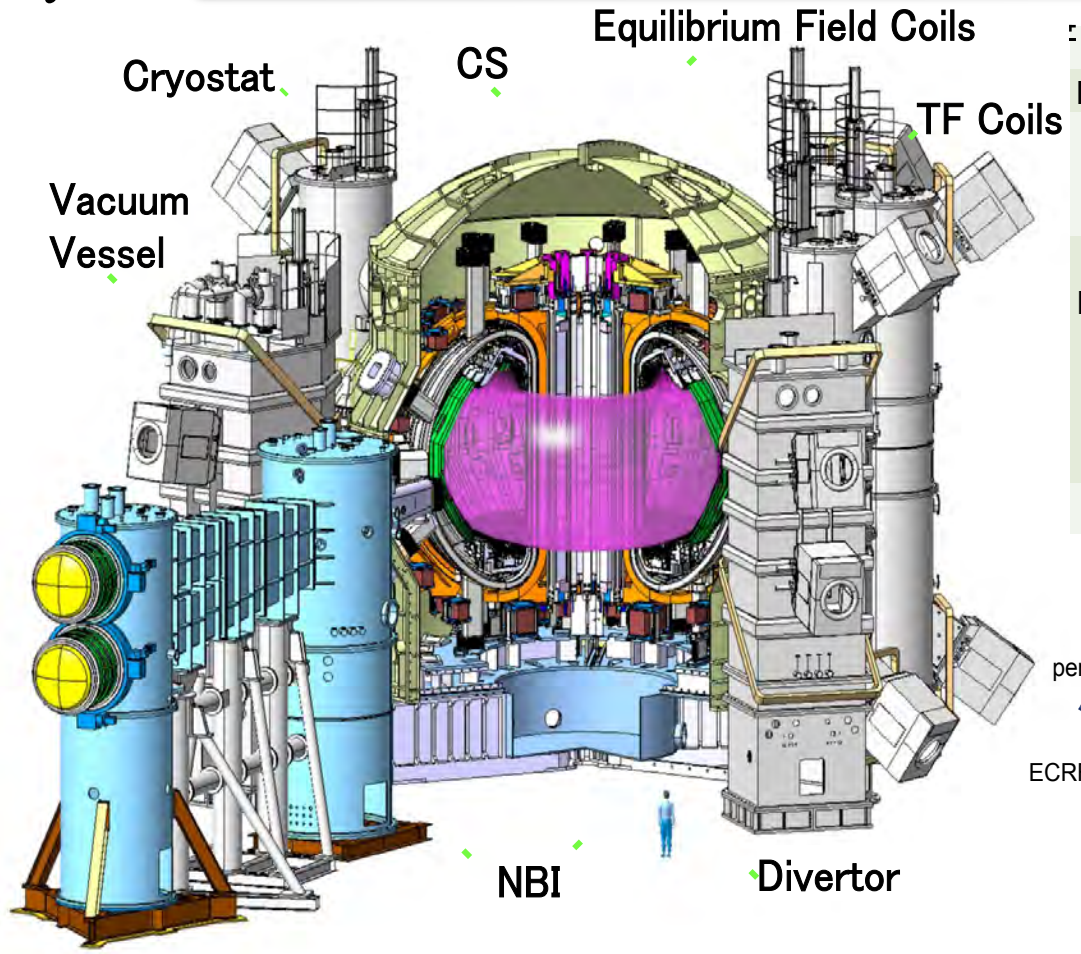




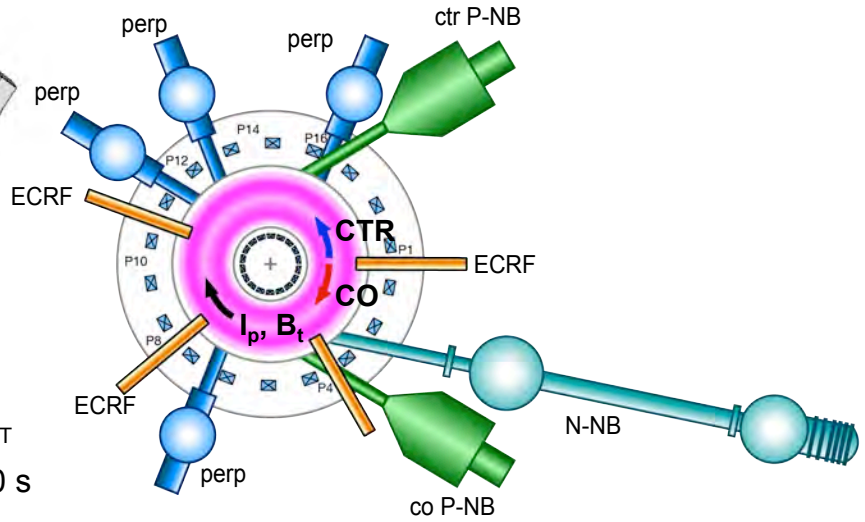
Asian program : EU-Japan JT-60SA tokamak (NAKA)

QST

JT-60SA Advanced Superconducting Tokamak BA-Satellite Tokamak Program



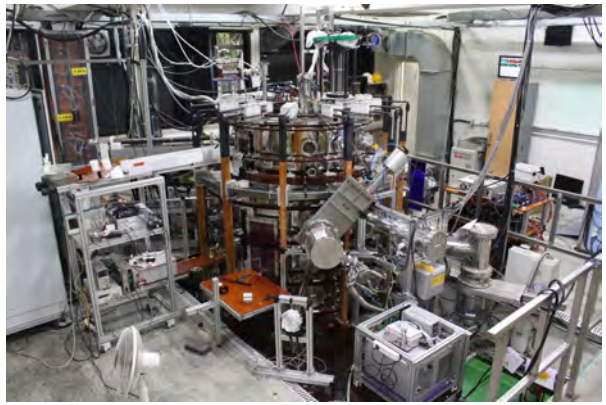
NB		ECRF
N-NB: 500keV	P-NB: 85keV	
cox2 10MW	cox2 4MW ctrx2 4MW perpx8 16MW	7 MW 110 & 138 GHZ
functions: heating (N-NB: more e⁻ heating, P-NB: more ion heating) current drive toroidal torque drive fueling		functions: heating (pure e⁻ heating) current drive
duration 100s		



I_p	B_t	R_p	a_p	κ_x	δ_x	q_{95}	V_p	τ_{FT}
5.5MA	2.25T	2.97m	1.18m	1.93	0.5	3	133m^3	100 s

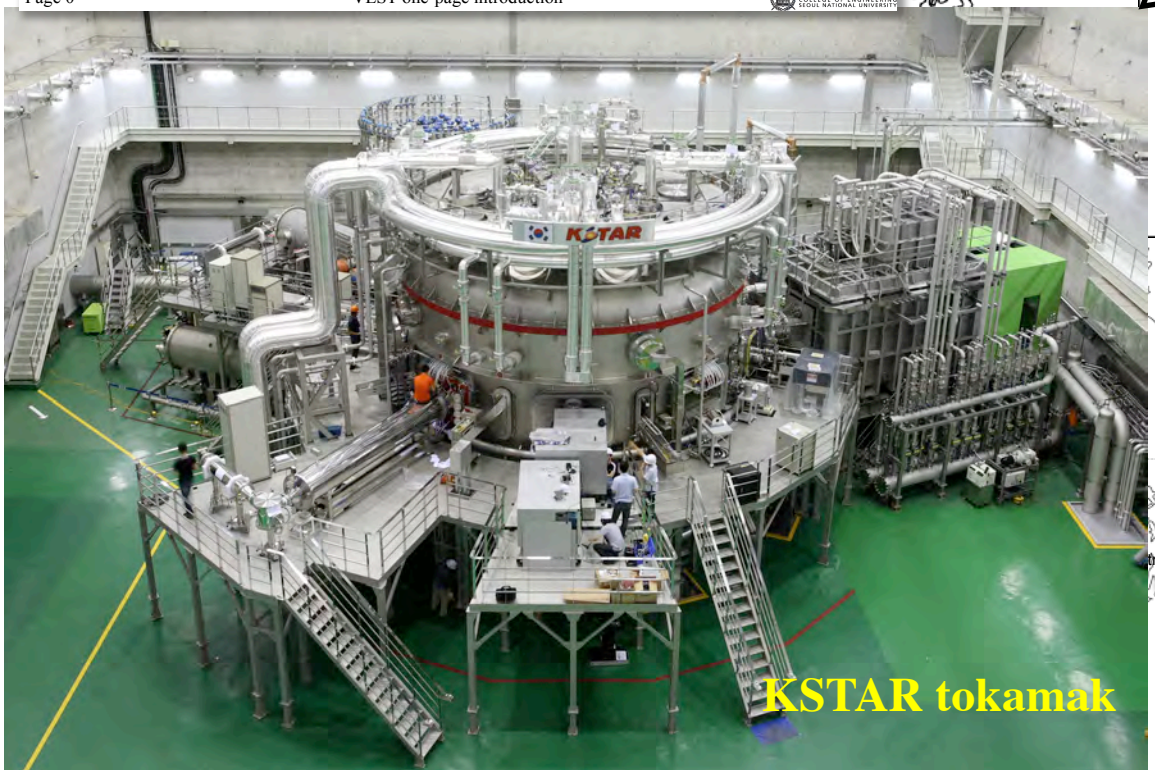
Korea Fusion Research:

VEST (Versatile Experiment Spherical Torus)



Chamber radius		
(main chamber)	0.8	m
(upper & lower)	0.6	m
Chamber height	2.4	m
Major radius	0.43	m
Minor radius	0.33	m
Aspect ratio	> 1.3	
Toroidal field	0.1	T
Plasma current	0.1	MA
Elongation	< 2	
Safety factor (edge)	< 7	

Page 0 VEST one-page introduction



KSTAR tokamak

SNU (YS Hwang, TS Hahm)

★ Seoul

Incheon

Ulung Island

NFRI (K. Kim, M. Kwon, YK. Oh)

Postech (G. Yun

Daejeon

Pohang

KAIST(W. Choe)

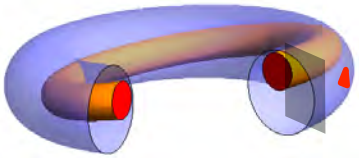
Daegu

UNIST
(H. Park)

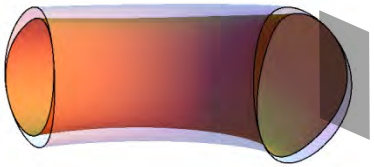
Ulsan

Busan

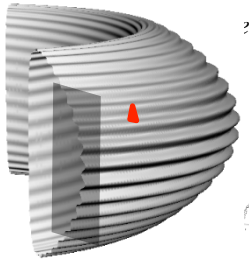
Gwangju



Internal Kink



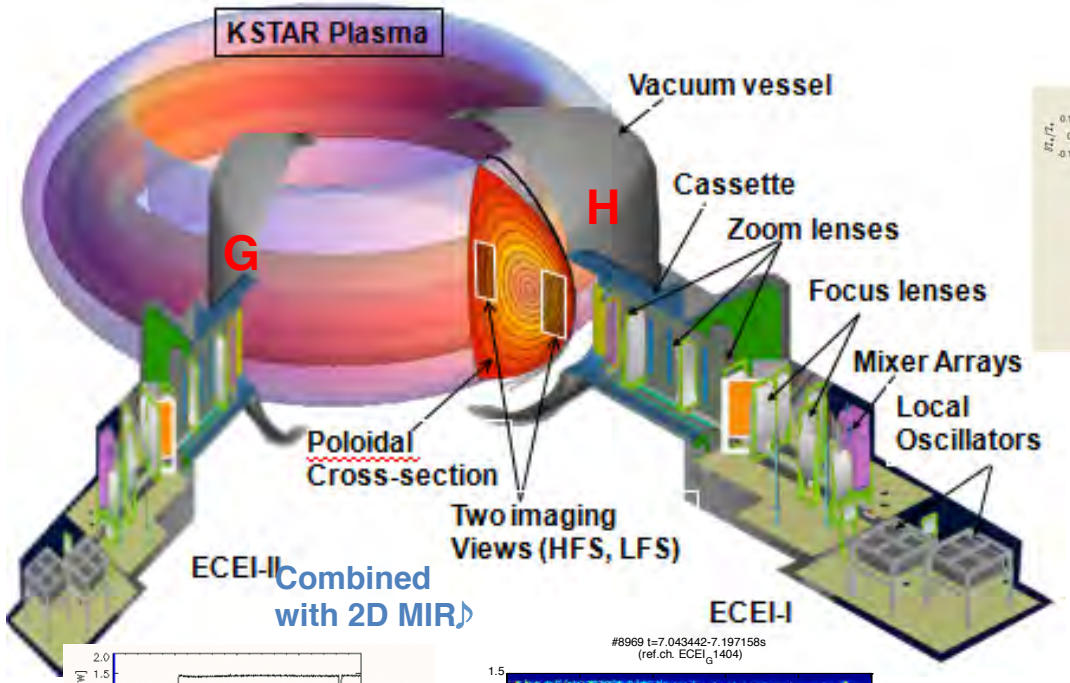
Tearing



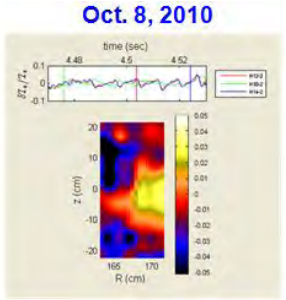
Ballooning
(ELMs)

Advanced diagnostic capabilities of KSTAR

Courtesy of Prof. H. Park

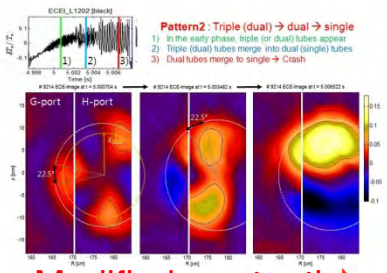


Combined with 2D MIR♪



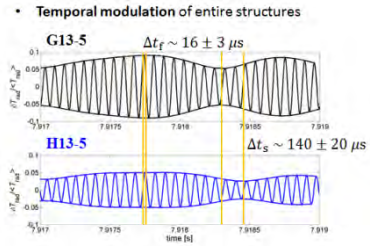
at 23rd FEC Daejeon Korea♪

G. Yun♪



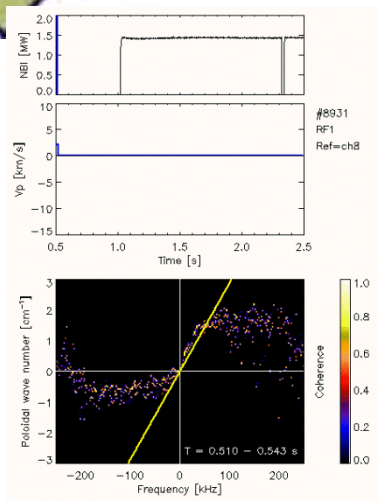
Modified sawtooth♪

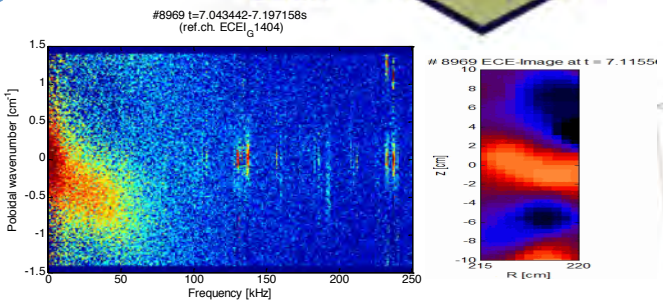
Multimode mode



M. Kim♪

m/n=2/1 mode♪

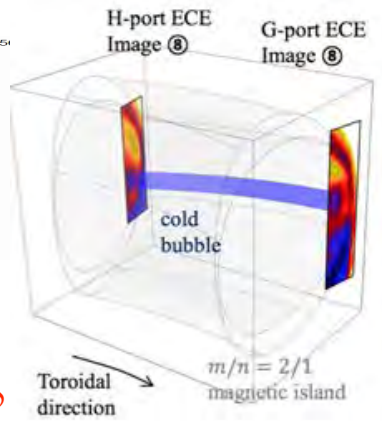




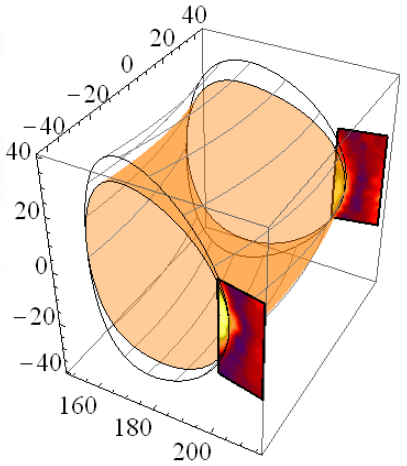
Te fluctuation (k vs. ω)♪

J. Lee♪

2D Te fluctuation (30-50 kHz)♪



Cold bubble Leads to disruption♪

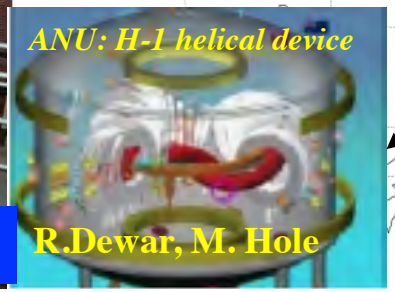


M. Choi♪

2D Density fluctuation ♪ W. Lee♪

Activities in India, ASEAN and Australia

SST-1: Indian superconducting tokamak



ASEAN plasma and fusion school

13th Asia Pacific Physics Conference
APPC-13 (Brisbane)