

USTC SNST 2014 Autumn Semester Lecture Series

Title: Introduction to Tokamak Fusion Energy Nuclear Science and Technology Research and Development (R&D)

L8-A: Putting it all together: the box and thinking beyond

L8-B: 2014秋季学期系列讲座同学反馈问卷

Lecturer: YKM Peng
Assistant: Guoliang Xu

Room 1617, 930-1130, January 17, 2015

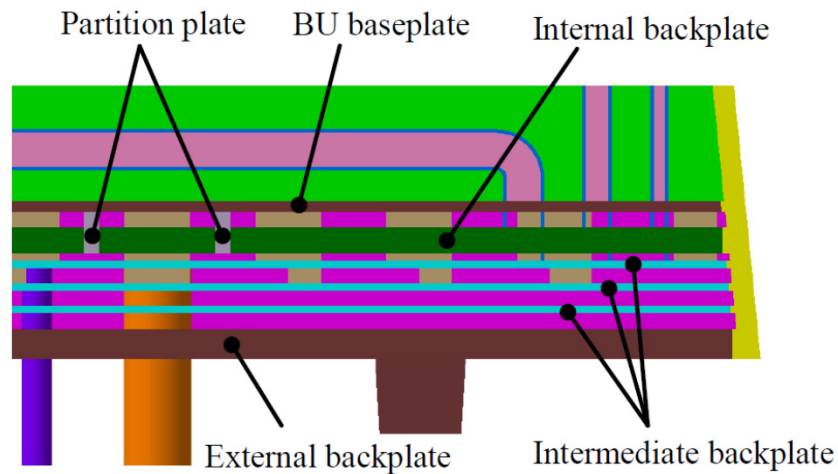
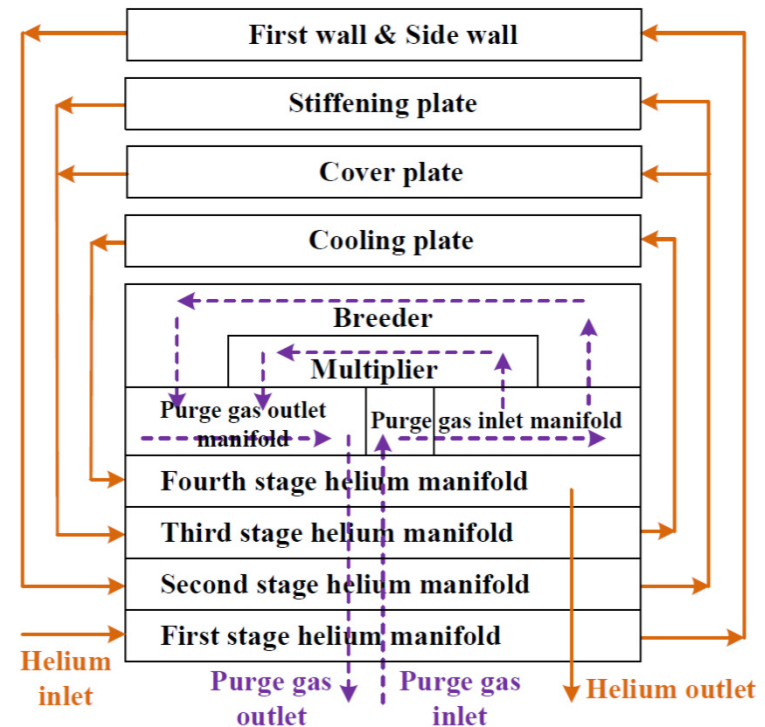
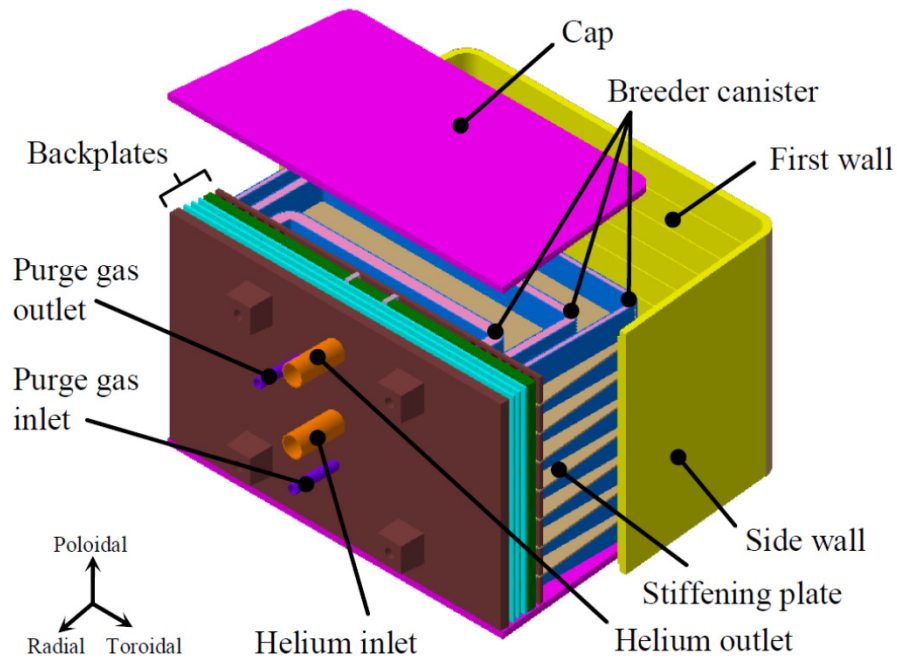
What to Carry with You?

- Fusion energy R&D topics are framed (i.e., boxed) within science and technology assumptions.
- The nearest “box” frames the ITER design and CFETR concepts: plasma and fusion nuclear science and technology assumptions commonly adopted today.
- Potential improvements to CFETR may exist just beyond this “box”.
- This “box” is in turn framed within scientific models in place for the past ~100 years, such as Maxwell’s electro-magnetics, model of atoms, Einstein’s special relativity, quantum mechanics, nuclear science.
- Wouldn’t it be beneficial to monitor development beyond this big “box”, and think about implications to fusion energy?

ITER technical objectives and S&T assumptions

| | ITER Project (2009) | Some S&T Assumptions |
|---------------------------------------|--|---|
| Fusion gain (Q) | <ul style="list-style-type: none"> • Q = 10 (short pulse); 5 (steady state) • Ignite and maintain burn for 480 s | <ul style="list-style-type: none"> • H-mode plasma confinement • Strongly coupled electrons and ions • Global MHD stability with margin • Divertor edge scrape-off layer with high recycling and impurity entrainment |
| Burning plasma condition & techniques | <ul style="list-style-type: none"> • To be experimentally tested in ITER | <ul style="list-style-type: none"> • Deep fueling of deuterium and tritium • Mitigation of plasma disruption impact via massive gas puff, killer pellets, etc. • Partial non-inductive hybrid long pulse operation |
| Fusion core technology | <ul style="list-style-type: none"> • S/C magnets • Remote handling (RH) | <ul style="list-style-type: none"> • Nb-Sn in Cu strains and cable-in-conduit conductors • Articulated arm for in-vessel maintenance and repair |
| Tritium fuel | <ul style="list-style-type: none"> • Verify breeding concept | <ul style="list-style-type: none"> • 6 TBM designs containing paths for tritium migration and loss? (\Rightarrow CFETR blanket) |
| Neutron shield & heat conversion | <ul style="list-style-type: none"> • Refine techniques | <ul style="list-style-type: none"> • Explore DEMO blanket options |

Helium cooled solid breeder blanket – framed in thermal hydraulics



Goals: to optimize

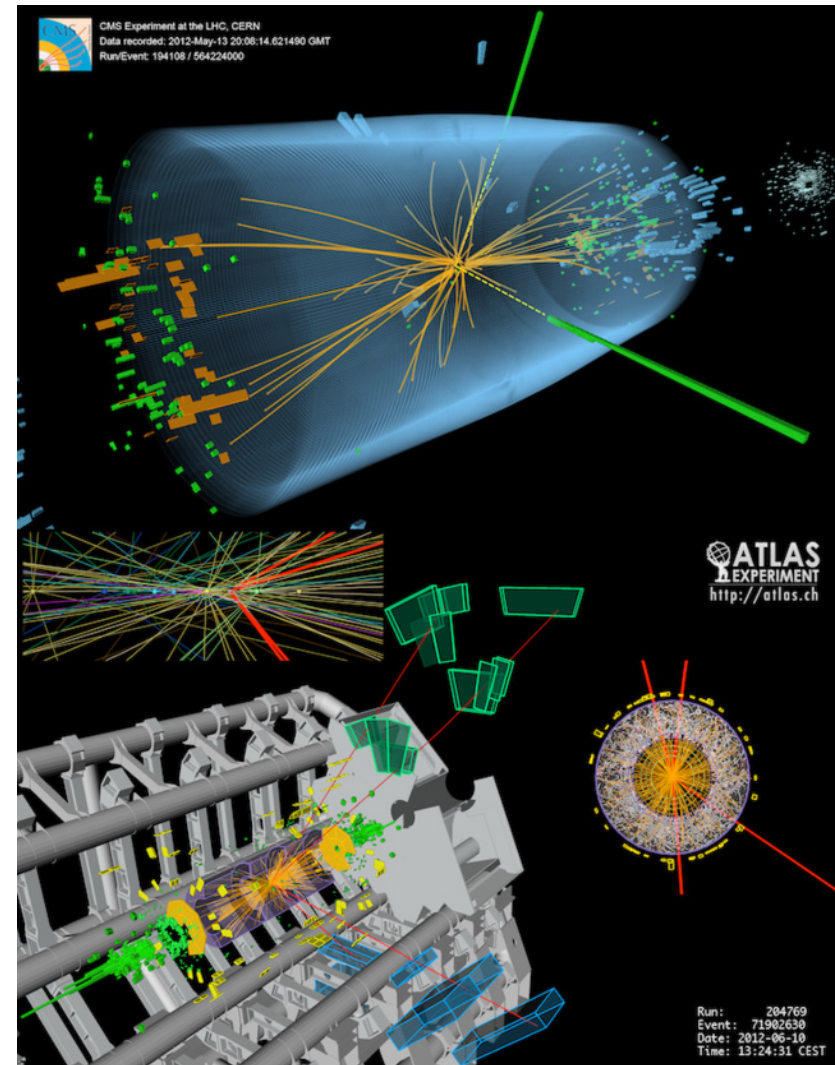
- Tritium breeding ratio
- Energy conversion
- How to minimize tritium loss?
- Additional helium “flush”?
- Reduced permeation surface?

Quantum tunneling to overcome Coulomb force to reach nuclear force has framed D-T fusion since 1929

- James Clerk Maxwell's equations of electric and magnetic fields – 1861-1862
 - Atoms, electrons, and subatomic particles – Thompson 1897
 - Becquerel, Curies' discovery of nuclear radiation – ~1900
 - Albert Einstein's special theory of relativity – 1905
 - Quantum mechanics: Heisenberg, de Broglie, Schrödinger, Pauli, Bose, etc. – 1920's
 - Hund, Atkinson's quantum tunneling + nuclear reactions:1929
-
- Bethe's C-N-O cycle of fusion in Sun, $4p \Rightarrow \alpha$ – 1939
 - Test of Teller-Ulam's hydrogen bomb – 1952

Could there be some update to Modern Physics and Cosmology that affect our fusion model?

- Modern physics continues its growth apace since 1929.
- Large Hadron Collider (LHC) in Europe confirmed the existence of Higgs' boson, the "God particle", in 2012.
- Nobel Price in Physics: Englert & Higgs for 1964 theory on the origin of mass of subatomic particles, in 2013.



Any implications to the framework of nuclear fusion?

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Next session: discussion on joint evaluation of this lecture series on
January 17, 2015

20150117-L8-B, 2014 秋季学期系列讲座同学反馈问卷:

同学姓名: _____

1. 如何平衡讲座的深度和广度, 或者如何在深度和广度中做选择? How should the depth and width of the lecture series be balanced? That is, how would you choose between depth and width?

答/Answer:

2. 对下学期课程的内容有什么建议? 是否需要加强关于某个课题的研发经验的内容? 是否可以课前给出参考文献? What would you suggest regarding the content of the lectures for the next semester? Should the R&D experience and content of chosen topics be strengthened? Should key references be provided before a lecture?

答/Answer:

3. 系列讲座间的内容、思路和逻辑是否需要加强? Should the conception, logic, and content of the entire lecture series be strengthened?

答/Answer:

4. 是否应该适当加一些聚变科学家的小故事? Should some interesting episodes of fusion scientists and researchers be included, when appropriate?

答/Answer:

5. PPT 里面是否可以加入一些小视频(videos)? Should some videos be included in the PPT lectures?

答/Answer:

6. 有无什么改良课堂讨论形式的建议? How should the style and form of the discussion sessions be improved?

答/Answer:

7. 是否要有必须做的作业? 如果是的话, 应如何实现? Should mandatory homework be implemented? And if so, how?

答/Answer:

8. 上课的频率应该是多少? 最想在那个时间段上课(周几, 上午还是下午)? How frequent should the lectures be? Which time period would be most desirable (which weekday, morning or afternoon)?

答/Answer:

9. 如何让更多的人更好的使用课程的资源平台? 例如, 我们是否应该给问卷的反馈一个活动的链接? How to help more usage of the information website for the lecture? For example, should the questionnaire like this one be actively linked to enable online feedback?

答/Answer:

10. 听完系列讲座之后，個人的收获是什么？ What benefits have you realized from this lecture series?

答/Answer:

11. 对下学期系列讲座，希望個人的收获是什么？ What benefits would you hope to realize with regard to the lecture series for the next semester?

答/Answer: