Stellarator database

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Outline

- **Where are we?**
  - ISHPDB (**I**nternational **S**tellarator and **H**eliotron **P**rofile **D**ata**B**ase)
  - ISHCDB (**I**nternational **S**tellarator and **H**eliotron **C**onfinement **D**ata**B**ase)
  - Empirical scaling ISS04
- **Physics questions**
  - What happens for stellarators at high beta, low collisionality?
  - Why does W7-X not follow ISS04 and what does that mean for fusion?
- **Which data do we need?**
  - More than we have.
- **Additional considerations**
  - Open science / open data
  - Stakeholder interests
  - Interests of EUROfusion

ISHPDB (profile database)

- **Profile database for selected physics topics**
  - Easy to navigate and high relevance of the data
  - Small number of profiles per topic and highly individualized data sets

International Stellarator-Heliotron Profile Database

Public Data

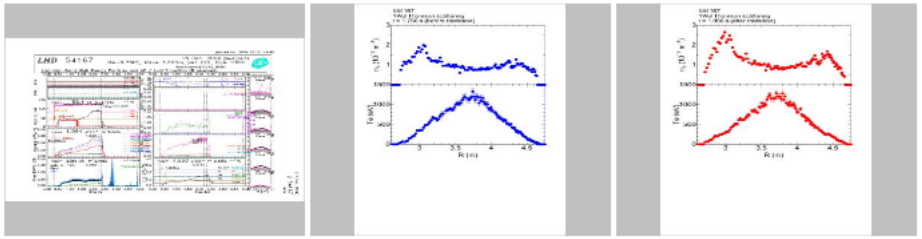
Disclaimer

The International Stellarator-Heliotron Database is pursued under the auspices of IEA Implementing Agreement for Cooperation in Development of the Stellarator-Heliotron Concept (2.10.1992).
The content of this web-site is the intellectual property of the International Stellarator-Heliotron Profile Database collaboration.
Any publication from material stored on this web-site requires agreement from the collaborators.
As for the access to LHD data, **LHD_DataUsageAgreement**, **ResearchProposal**, should be sent to yokoyama @ lhd.nifs.ac.jp.

- Information
- Confinement Data
- CERC
- High Beta
- Validation of Neoclassical Transport
- High Performance
- High Ti
- H-Mode
- Edge Turbulence
- Plasma Flows
- Pellets
- Modeling and code verification
- Update Information
- How to access?
- Software
- Stellarator Turbulence

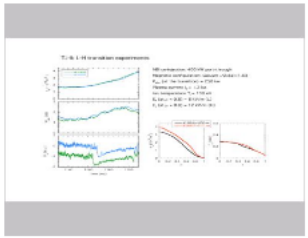
LHD H-Mode data

054167
shot info
txt
UFILE
lhd_054167_001756_v0001_0d.dat
lhd_054167_001756_v0001_2d.dat
lhd_054167_001856_v0001_0d.dat
lhd_054167_001856_v0001_2d.dat
xml
Confinement Data

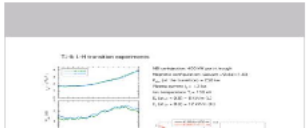


TJ-II H-Mode data

018998
shot info
txt
UFILE
tjii_018998_001150_v0001_2d
Configuration Data
018998.zip
xml
Confinement Data



019002
shot info
txt
UFILE
tjii_019002_001171_v0001_2d
Configuration Data

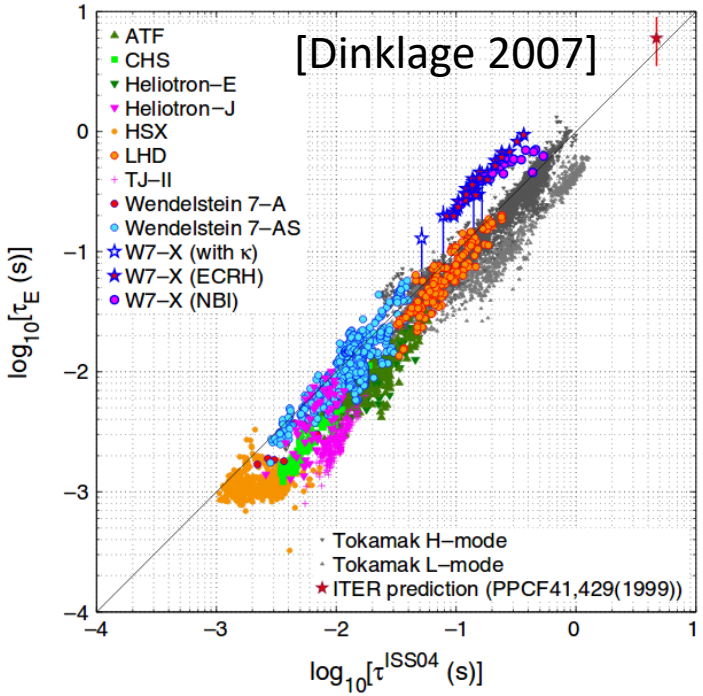


Confinement database

- **ISHCDB (International Stellarator and Heliotron Confinmenet DataBase)**
  - Extensive data set from many different stellarators
- **Empirical cross-machine scaling ISS04**
  - [Yamada2005]

$$\tau_{\mathrm{ISS04}} = 0.134 a^{2.28} R^{0.64} P^{-0.61} \bar{n}_{\mathrm{e}}^{0.54} B^{0.84} \iota_{2/3}^{0.41}$$

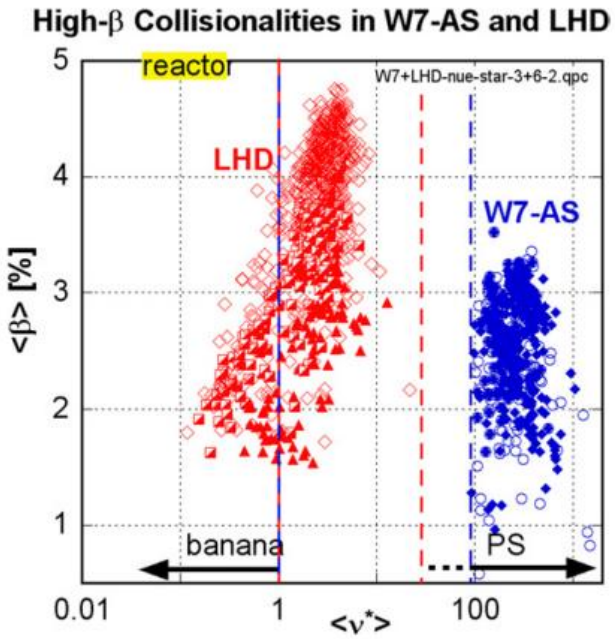
  - (very) different stellarators show a similar scaling behavior
  - **BUT** with different prefactors (configuration or renoarmlization factor)
  - $\tau_E = f_r \cdot \tau_{ISS04}$
  - Indications that ISS04 **not** valid at high beta



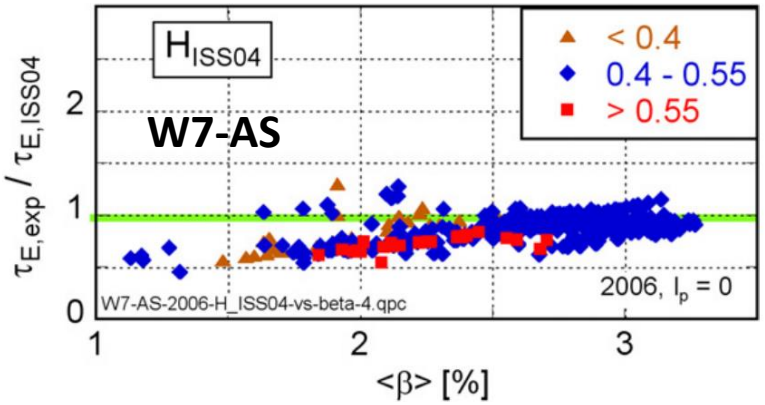
- **The two most important questions:**
  - What determines f_r (optimization!)?
  - What happens at high beta / low collisionality?

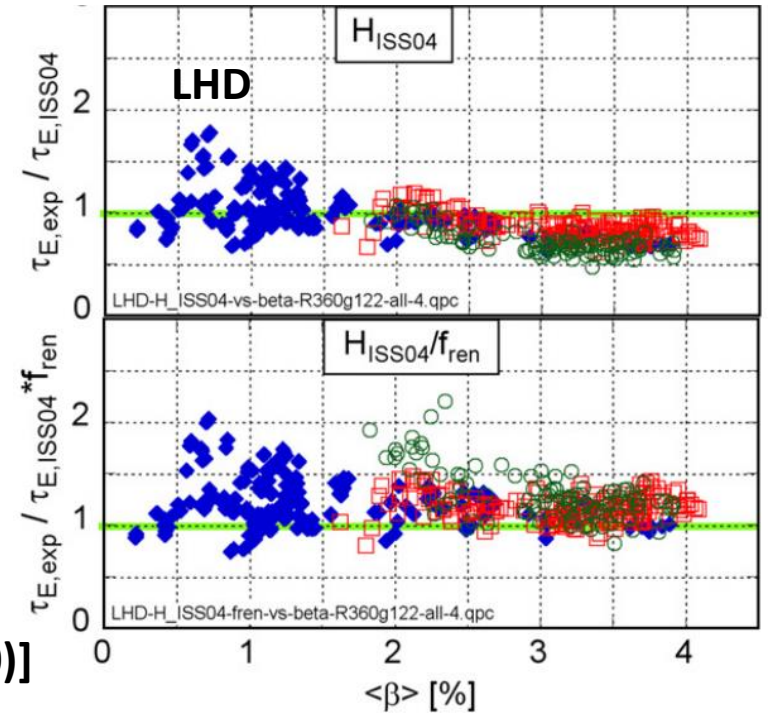
High-beta scaling

- **W7-AS data inconclusive**
  - No strong degradation in global performance
- **LHD sees a high-beta degradation**
- **Collisionalities not yet reactor-relevant**
  - Great importance of W7-X



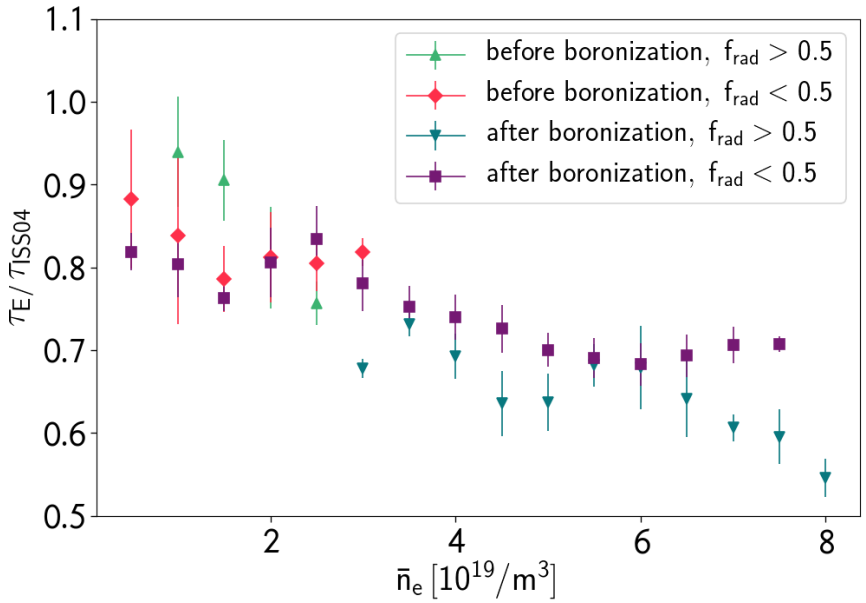
[Weller, NF (2020)]



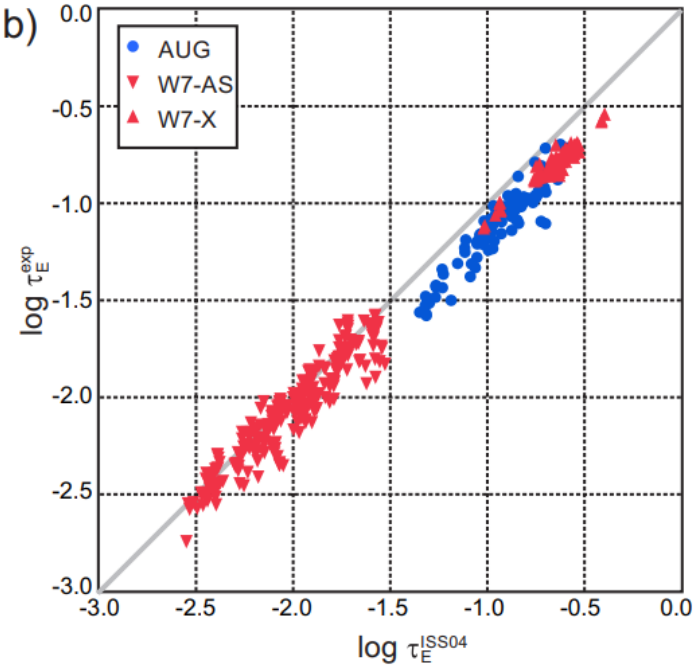


Results from W7-X

- **Global energy confinement time**
  - Essentially in line with ISS04 for low densities.
  - Weaker density scaling for higher densities (not yet high beta).
  - Probably due to electron-heating together with turbulent transport.
  - No sufficient database for a high-beta scaling, yet.



[Fuchert, NF (2020)]



[Stroth, PPCF (2020)]

Which data do we need?

- **The current database is rather old and lacks important data**
  - Especially from LHD (high-beta experiments) and W7-X (anything).
  - There were efforts in the past few years to extend the database.
  - But the „data providers“ were not too collaborative (including me…).

- **BUT**
  - We know that the „boring plasmas“ (meeting the selection cirteria for ISS04) in essentially all devices, including W7-X, roughly follow ISS04.
  - Reactor-relevant regimes are not meeting the selectrion criteria (especially high radiation).
  - **My personal opinion: There is little value in just adding W7-X to the old database, derive „ISS2X“ and find that it is „roughly the same“. We will not learn anything that we don‘t know already!**

Structural requirements

- **ISHCDB is lacking crucial data to answer the relevant questions**
  - „Geometric“ quantities (elongation, effective helical ripple,…).
  - Reduced profile information (Te/Ti, density peaking,…).
- **The data structure requires flexibility**
  - Not all data may be available for every experiment.
  - Important quantities may have to be added later on, reflecting new insight.
- **Ideally, the data could be traced back to the „raw data set“**
  - „Manually“ possible for the ISHCDB
- **Unified structure with the tokamak universe?**

  → see next slide

Open science / open data

- **Open science / open data topics are becoming increasinlgy important**
  - Data of fusion experiments is complex: Many different physical quantities, different dimensionality, only meaningful with meta data.

- **Funding agencies and authorities will likely establish requirements**
  - **FAIR** principles: **F**indable, **A**ccessible, **I**nteroperable, **R**eusable
  - Challenge: It is unclear how these requirements will look like.
  - It seems foolish not to be prepared, especially if we set up an extended database.

- **Prepare the data set for automated analysis**
  - Possibly part of the FAIR principles.
  - Probably even in our own interest.

→ Who defines the requirements and who is implementing them (external input to minimze additional work load?)

Stakeholder interests

- **Collaborators: Can all data be gathered and stored?**
  - „political clearance“ for existing (and legacy) experiments in different countries
- **EUROfusion**
  - Input for the EUROfusion roadmap and „Mission 8“
  - Benchmark cases for theory support (TSVV)
- **Fusion community**
  - Comparison of different reactor concepts:
    - Tokamaks and stellarators
    - Different stellarator concepts

Summary

- **Reactor-relevant questions cannot be answered with the current database**
  - Important data is missing.
  - The scaling-approach itself needs to be revisited.
- **New data has to be added**
  - Just expand the old data structure?
  - Or setup a more modern structure?
  - Possibly even covering tokamak and stellarator data?
  - Metadata not meeting FAIR principles.
- **Stakeholder interests**
  - Realizing projects with many international partners cumbersome
  - EUROfusion goals require a comprehensive database