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Results Review

Control of Neutral Fueling and Helium Exhaust to NSTX-Upgrade Plasmas by Three-Dimensional Magnetic Control Fields

DoE grant DE-SC00012315

Oliver Schmitz

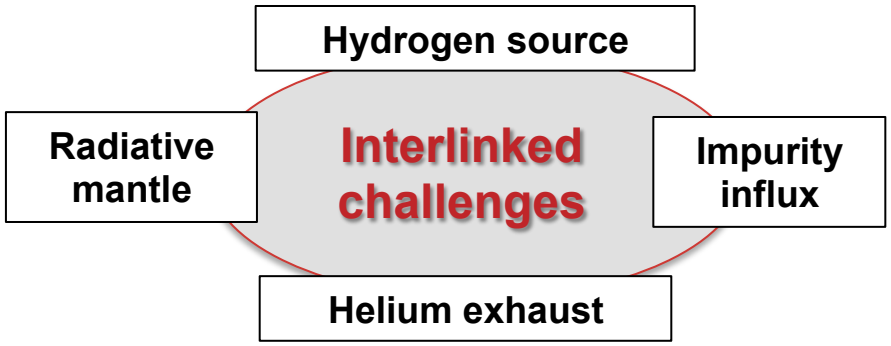
University of Wisconsin – Madison,
Department of Engineering Physics, Madison, WI, USA

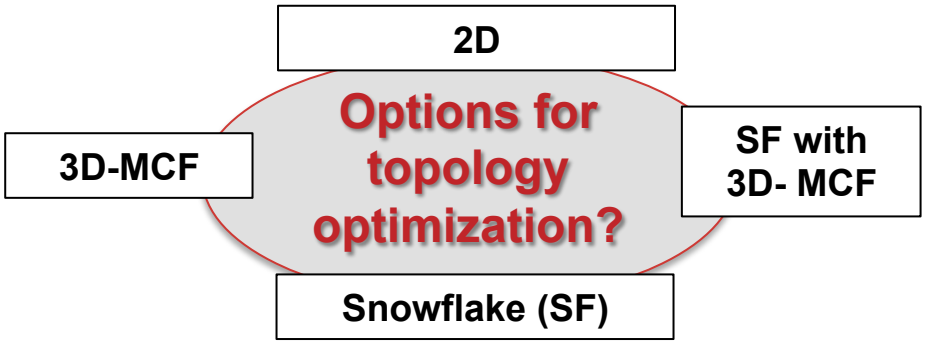
Participants

- Heinke Frerichs, Numerical Scientist
- Kurt Flesch, PhD student (experiment), behind Qual, soon 100% research
- Ian Waters, PhD student (numerical), behind Qual, soon 100% research

The research scheme in a nutshell – change notes

Focus: enhanced discharge duration in NSTX-Upgrade requires governance of neutral exhaust and fueling including heat exhaust by radiation





Goal: Explore topology optimization for improved neutral fueling and exhaust control to generate stable, high density conditions in NSTX-U

Method I: Reliable experimental approaches

He line ratio spectroscopy — PhD K. Flesch

Penning gauge spectroscopy — PhD K. Flesch

Method II: State of the art 3D MHD and edge & neutral transport modeling

EMC3-Eirene ⟷ M3D-C1

PhD I. Waters, H. Frerichs

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Predictive capability: development and validation of combined EMC3-Eirene and M3D-C1 code package

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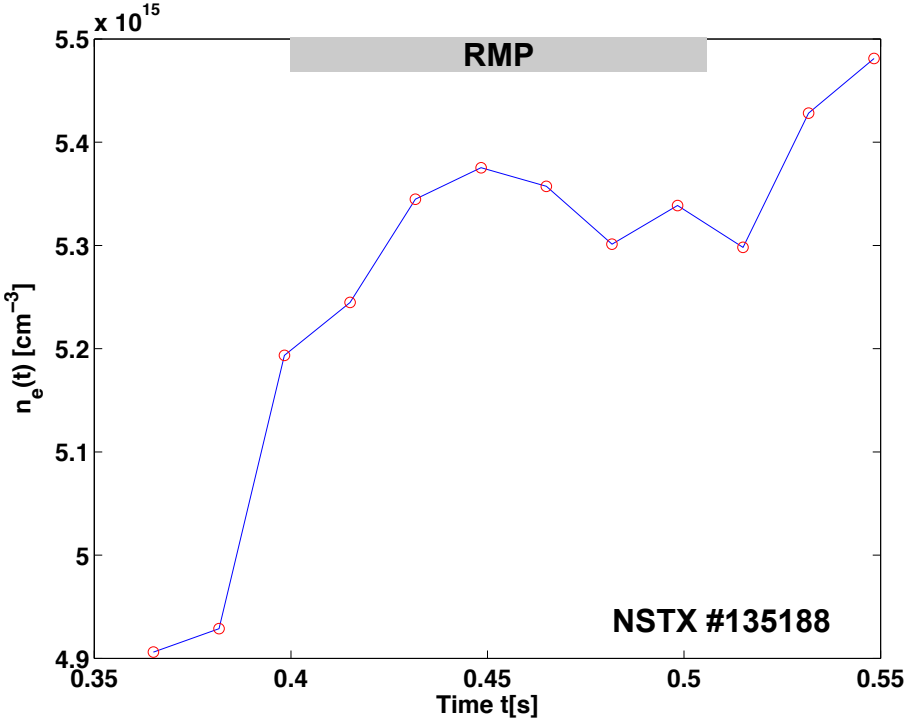
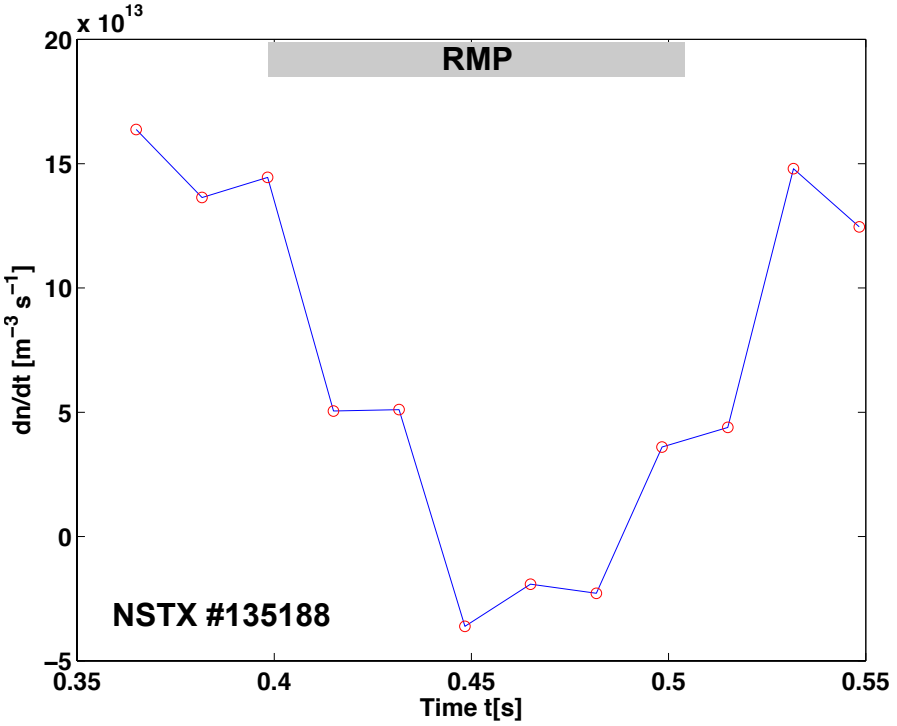
Analysis of NSTX data provided first time evidence for manipulation of particle balance by RMP fields – reduction of neutral fueling!

Research goal in grant: use RMP fields to improve density control

Density $n_e(t)$



dn_e/dt (t)



Initial, suggestive result for reduction of neutral fueling efficiency as means to control density raise!

Analysis conducted by K. Flesch in collaboration with J.-W. Ahn

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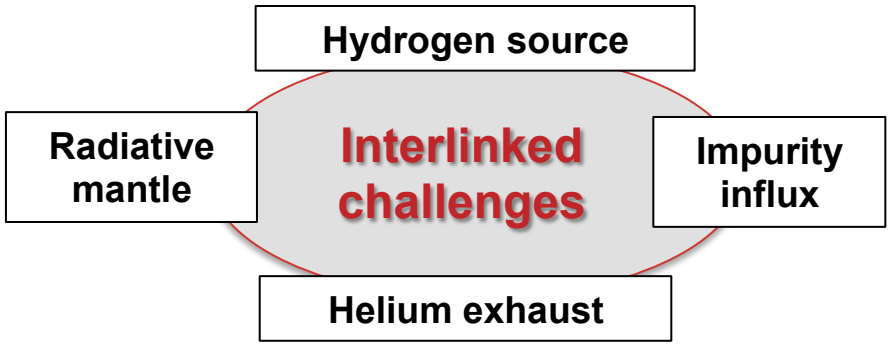

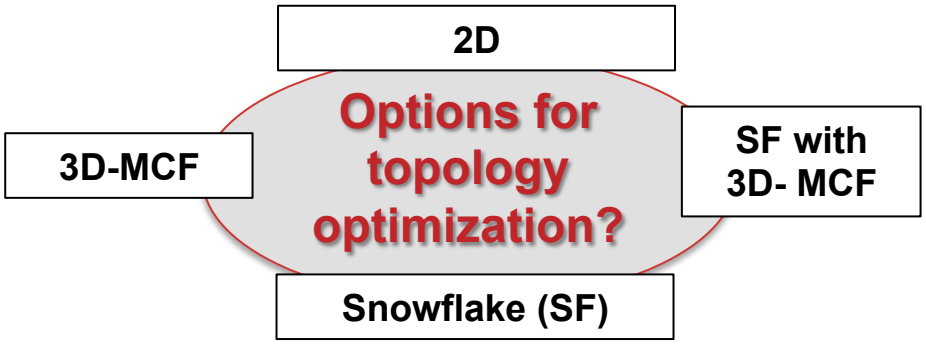

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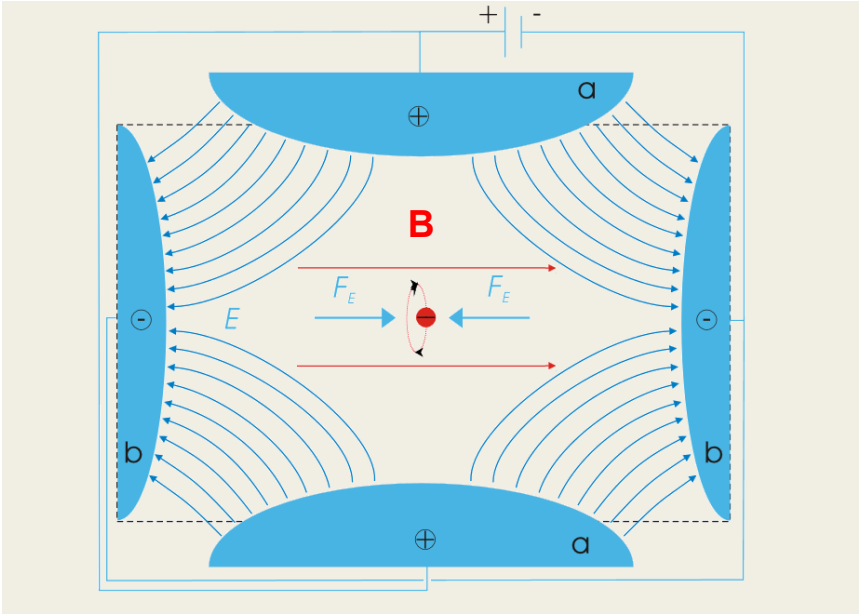
Penning gauge allows to differentiate He & H2 spectroscopically

Goal: understand discharge behavior and optimize light output for optically assisted Penning gauge which uses the local magnetic field of the device

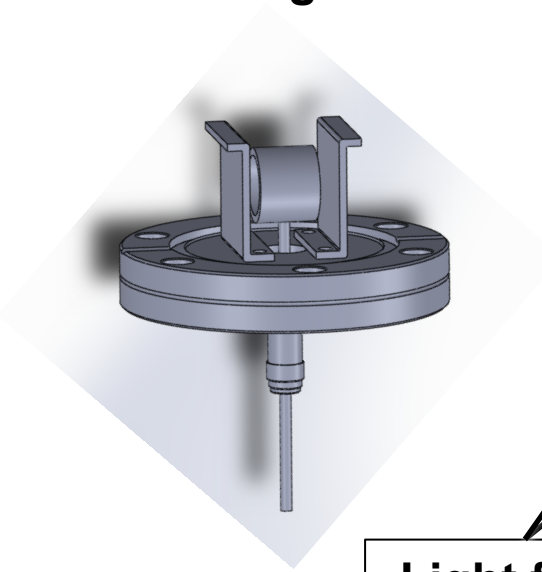
Penning trap principle



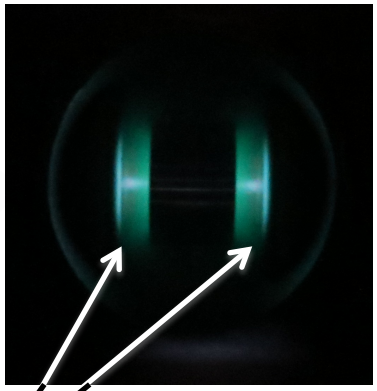
Existing penning trap

[R. Raman et al., RSI **74** (2003) 1900]

mounted at NSTX-U has been rebuild for testing



1 x 10^{-3} mbar, 3 kV



Light for spectroscopy

➡ Ion current ~ n_n

Quite low intensity ➡ **Low sensitivity**

Approach: evaluated existing setup and try to change anode configuration for better light throughput

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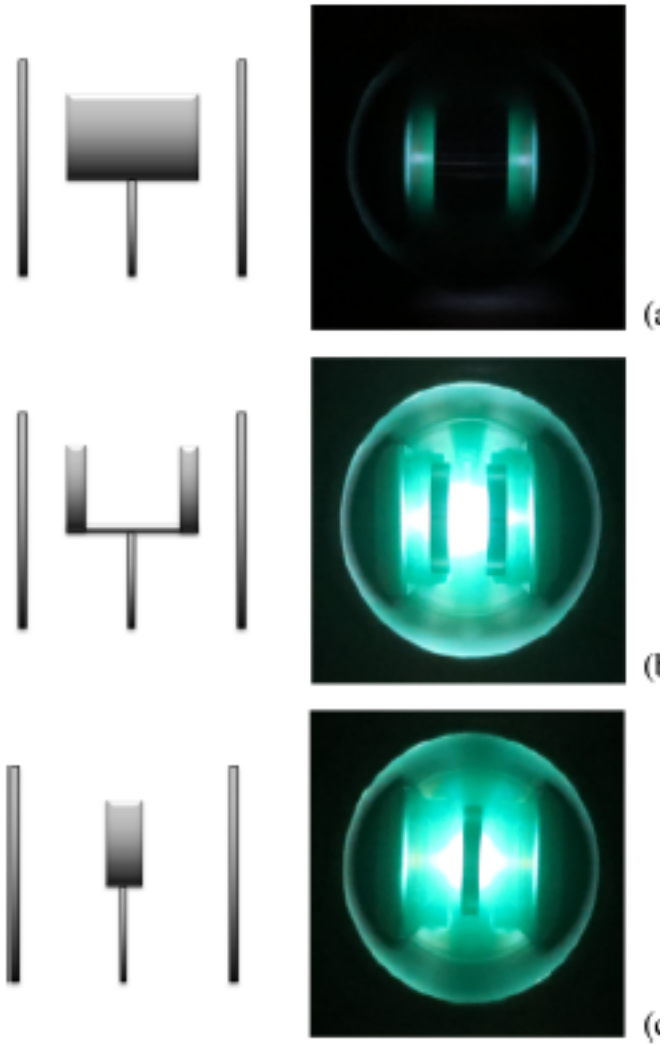
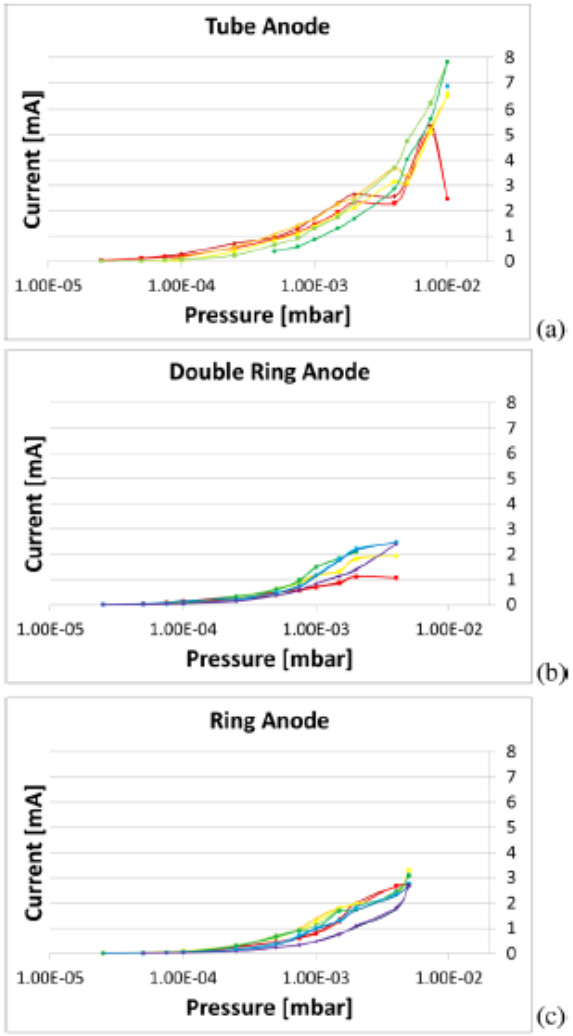
New anode designs have been tested and modeled to improve light output at same neutral pressure sensitivity

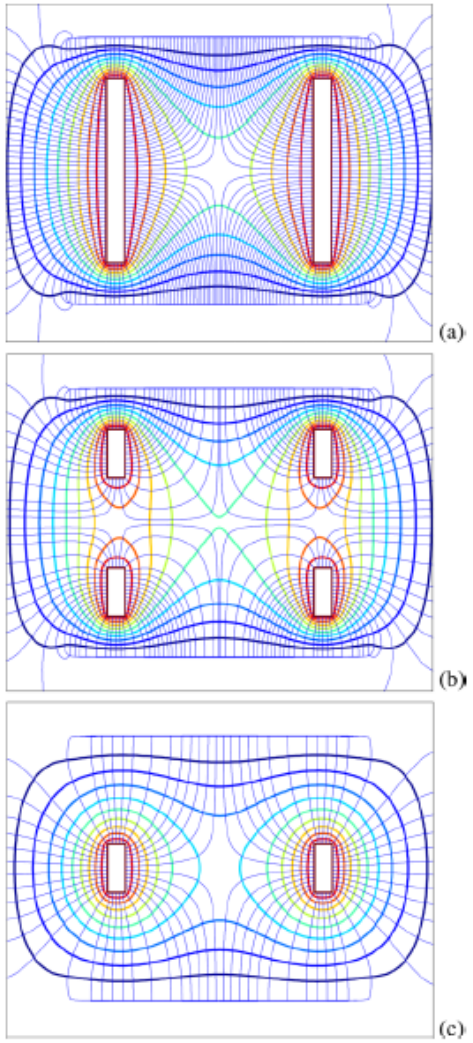
Three anode designs



$I(p_n)$ curve



Modeled planar E-field



[K. Flesch, T. Kremeyer et al., RSI **87** (2016) 11E529]

Next step: reactivate existing setup and use new observation – possibly later new anode design

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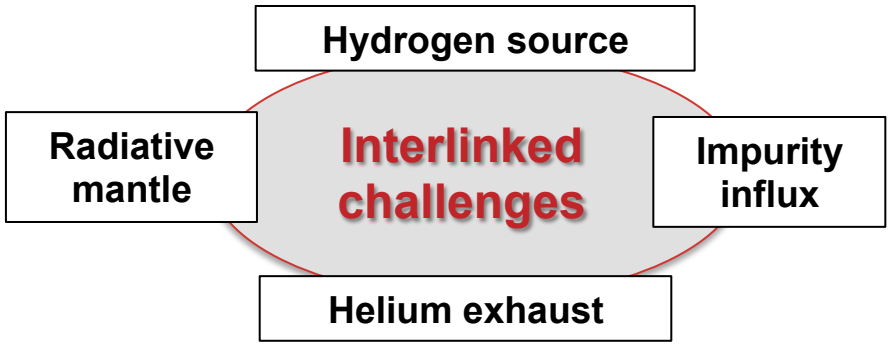

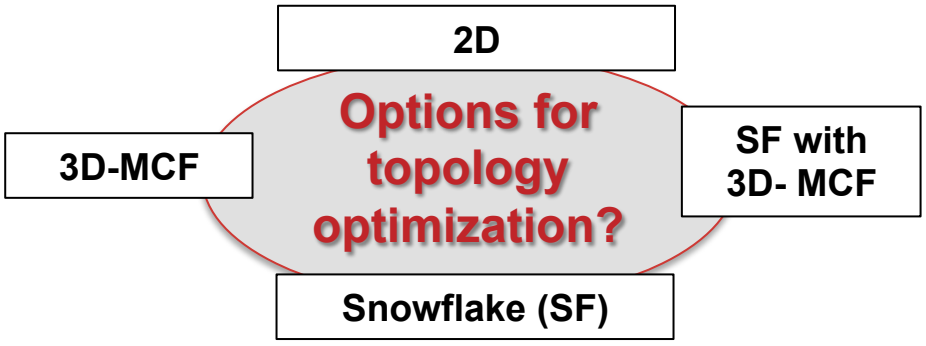

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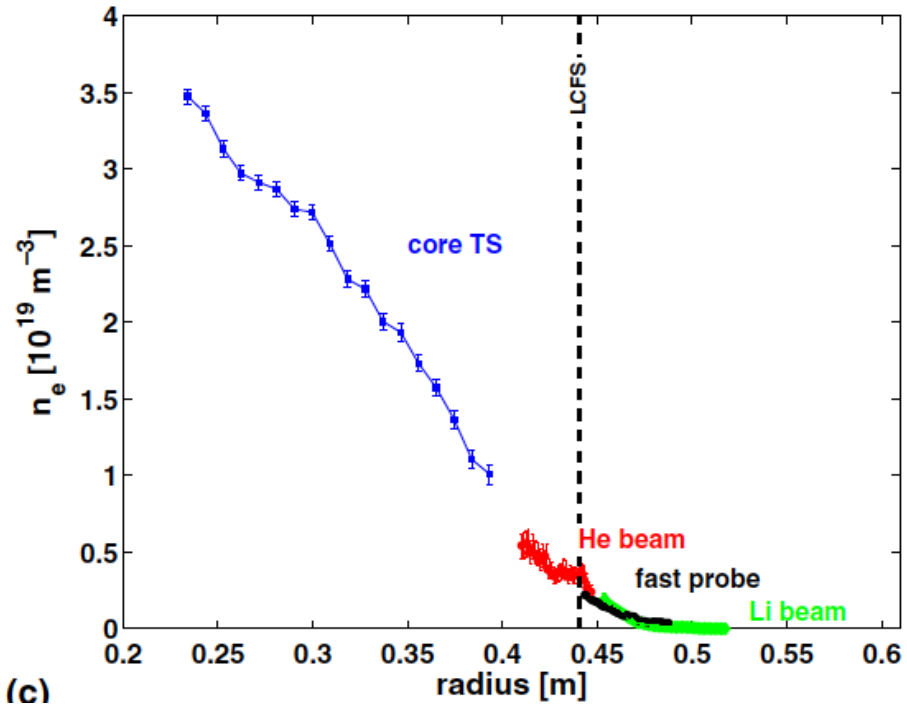
Line ratio spectroscopy on He is a reliable method for plasma edge characterization

Available parameter range: $2.0 \times 10^{18} m^{-3} < n_e < 5.0 \times 10^{19} m^{-3}$, $10\ eV < T_e < 350\ eV$

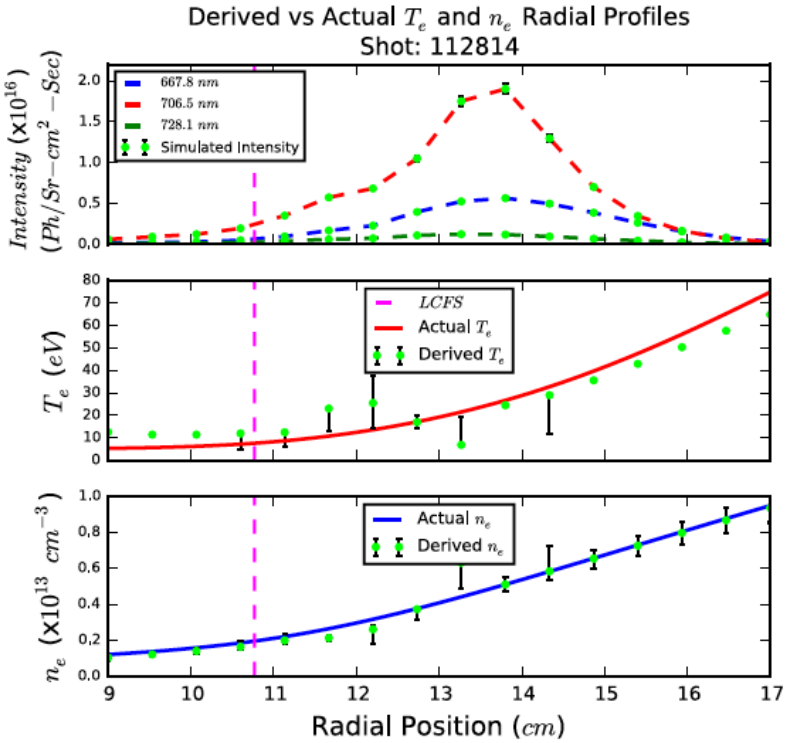
Regularly applied on several device

- **TEXTOR** [O. Schmitz et al., PPCF **50** (2008) 115004]



Used as standard diagnostic at RFX
(see talk by M. Agostini in June 2015)

Feasibility study for NSTX-U promising



[J. Munoz-Burgos et al., PoP **23** (2016) 053302]

Advanced He CRM is ready to be deployed!

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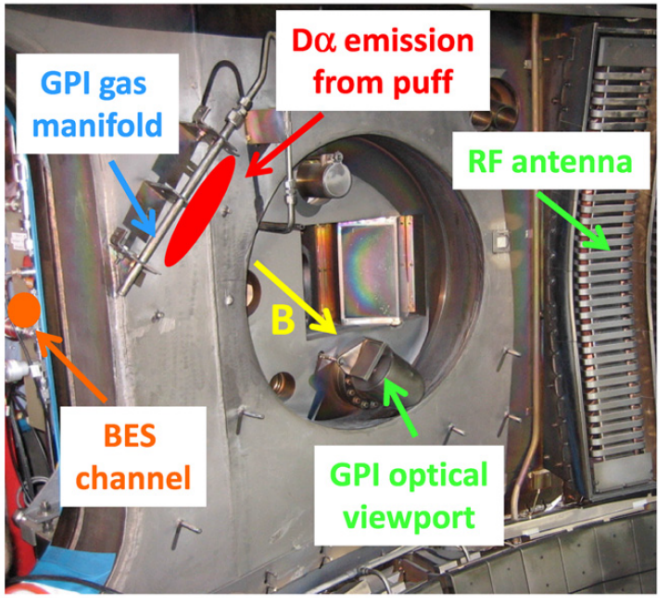
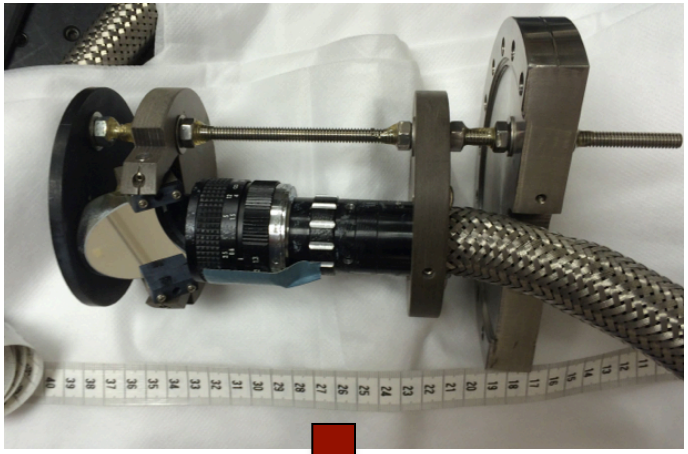
Plan for use of existing hardware (GPI) and spectrometer from UW Madison is being implemented to otbain proof of principle

GPI gas injection

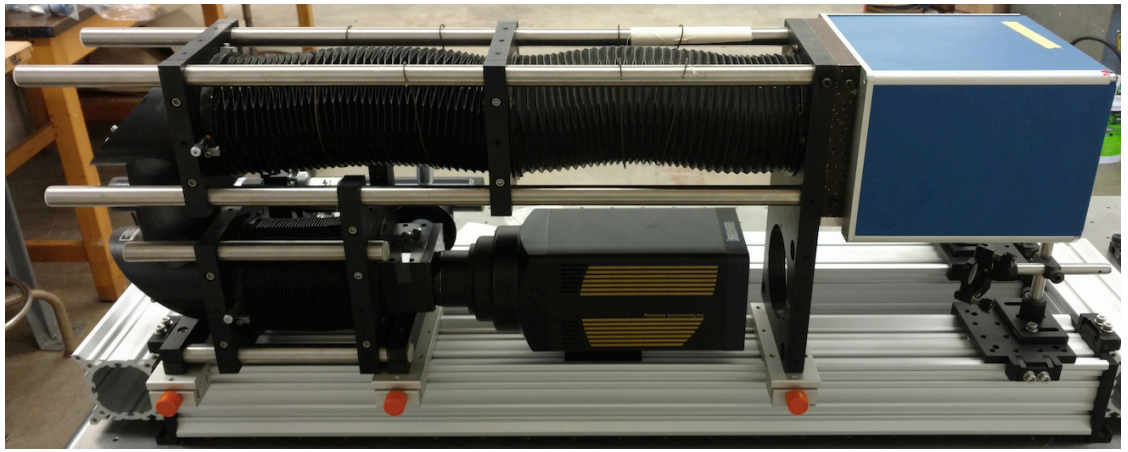


[S. Sweben et al., PPCF **56** (2014) 095010]

GPI observation



UW Madison spectrometer



High spectral resolution:

- CII line separation from He triplet line
- Good survey for spurious background signal
- New camera gives time resolution in 100Hz-1kHz range
- Setup and calibration ongoing in lab

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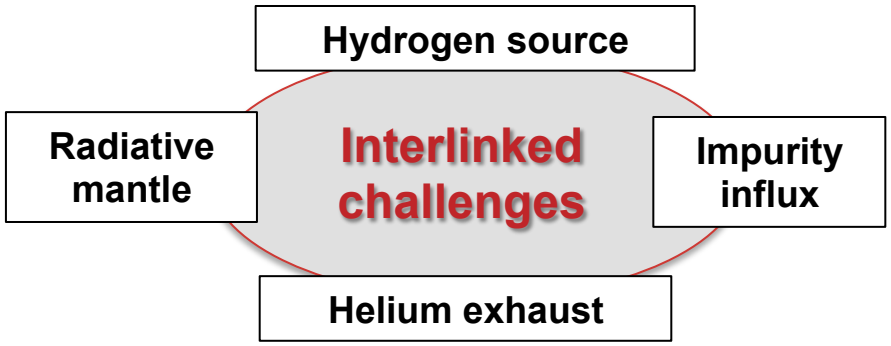

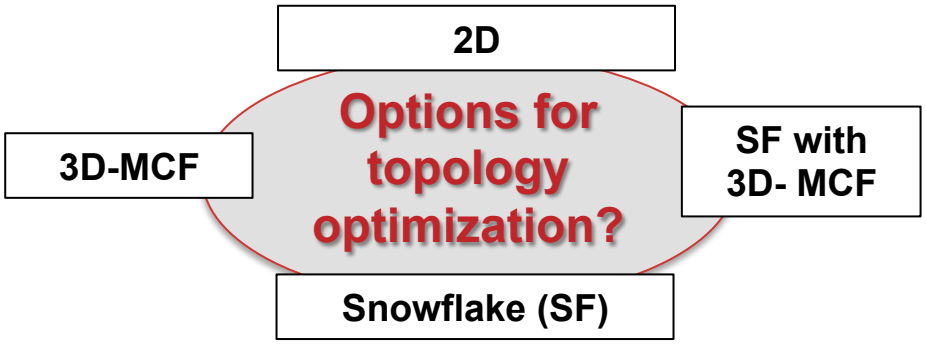

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Overview on results obtained so far (technical and preparation)

- **Experimental preparations for dedicated improvement of particle balance analysis and 3-D edge physics are on schedule**

- **First evidence for manipulation of particle balance found in NSTX data**

- **NSTX-U repair schedule is an issue for progress of experimental student**

- **Numerical work is progressing very well using EMC3-EIRENE (I. Waters)**
- First time study of NSTX-U snowflake configuration was recently published
- Particle balance analysis from synthetic diagnostic in EMC3-EIRENE established
- RMP current threshold for reduced fueling efficiency seen
- Close collaboration with T.E.Evans and G.Canal

- **Two journal papers published, 3APS posters, 1 invited talk on TTF workshop**
- **Collaboration with MAST to understand RMP pump out in STs initiated**