CXRS at W7-X - Current status and OP2 plans

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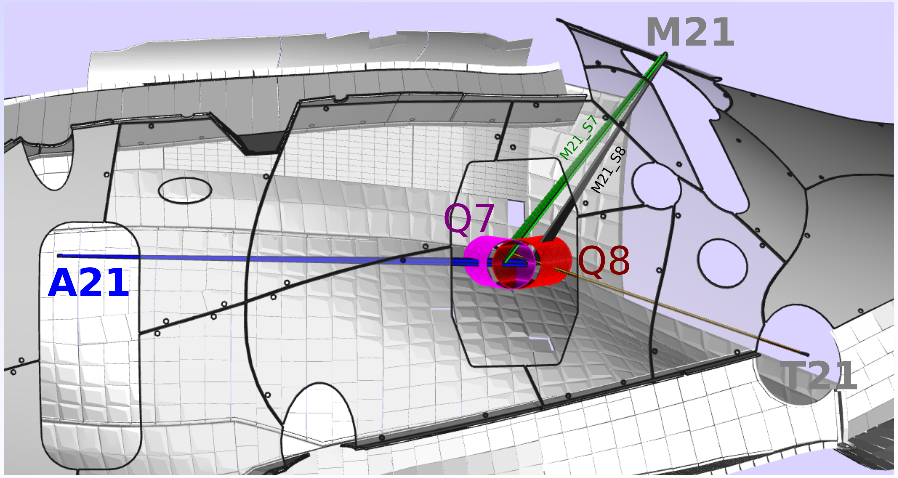
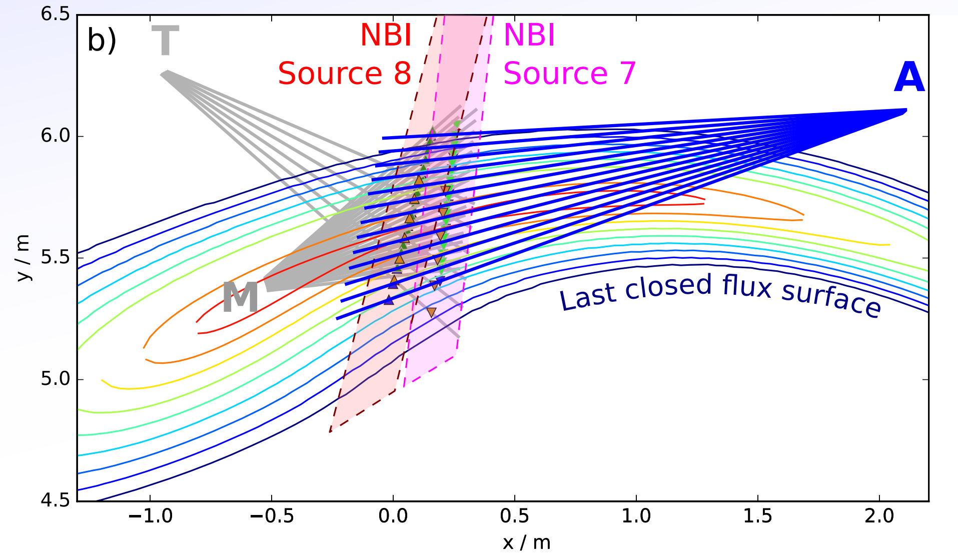
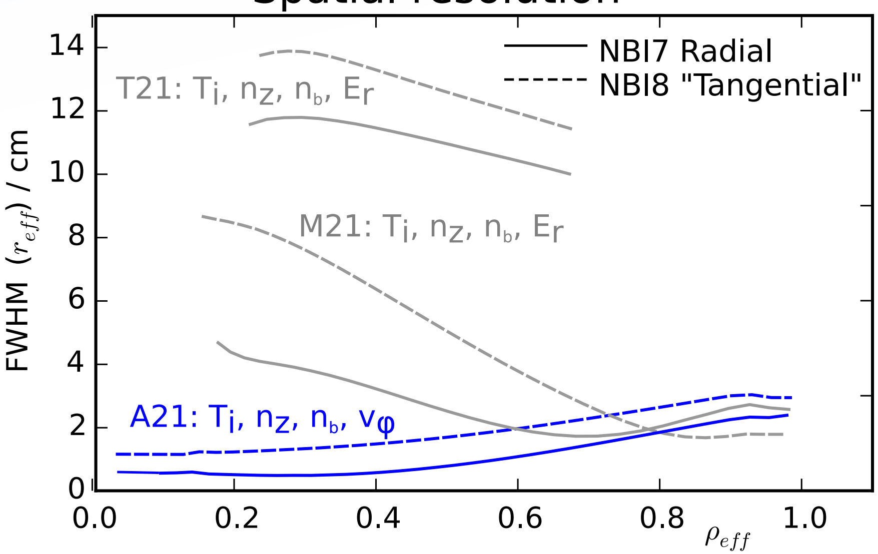
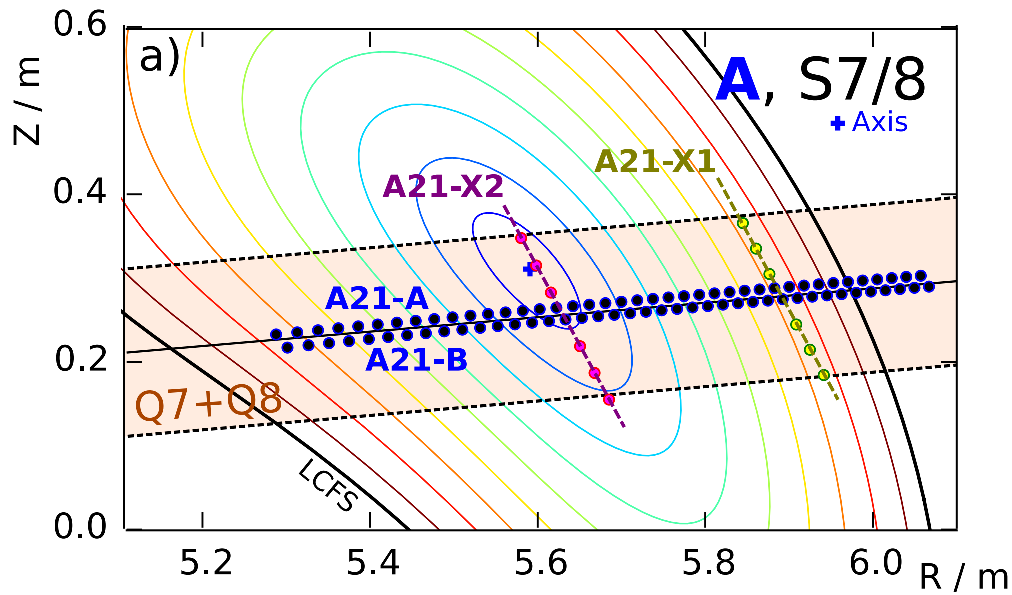
Observation Systems





Spatial resolution





AEA21: High resolution, toroidally viewing system.
AEM21: 45° to toroidal. Primarily for Er.
AET21: Low resolution overview/cross-check. -45° to toroidal.

O. Ford
L.Vanó

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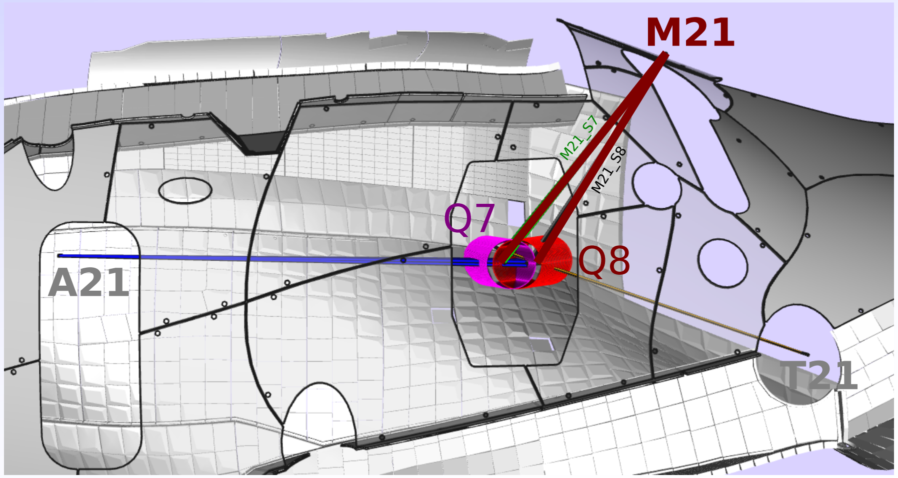

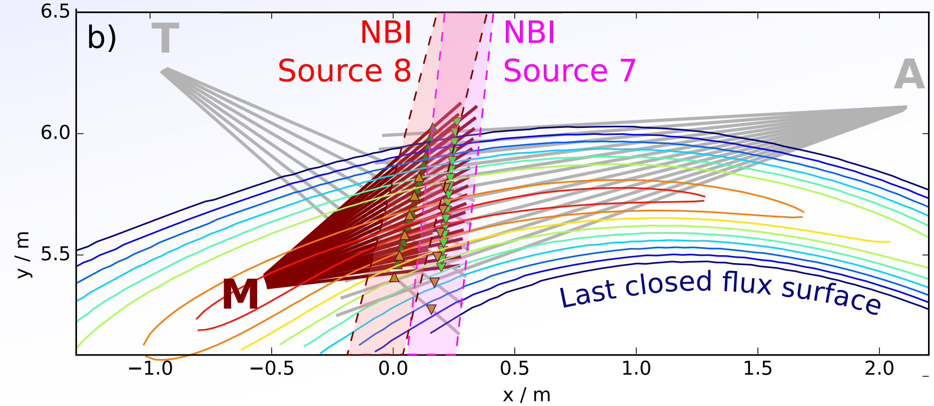

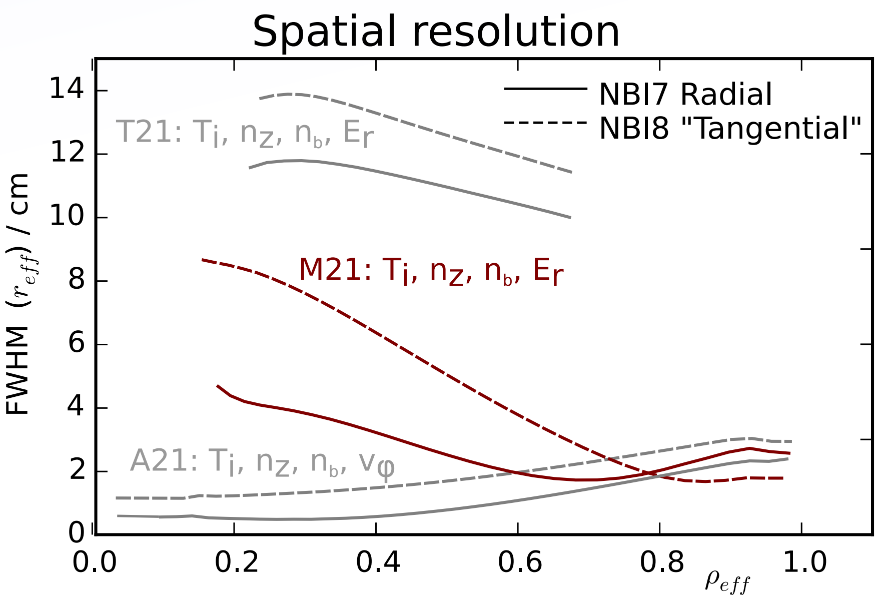

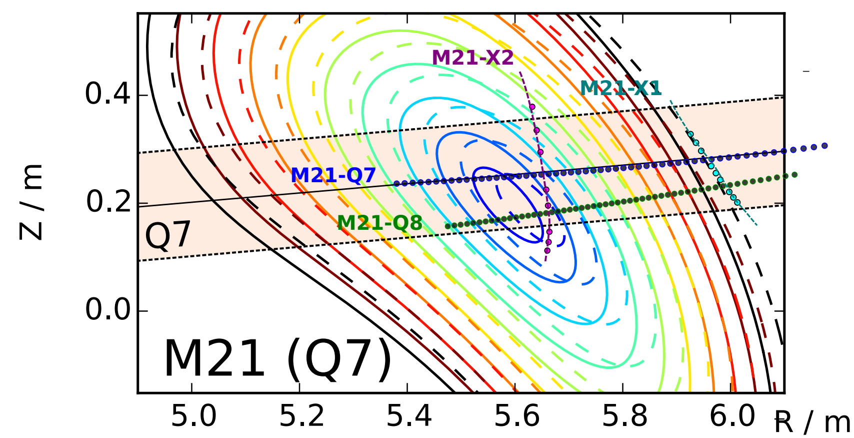

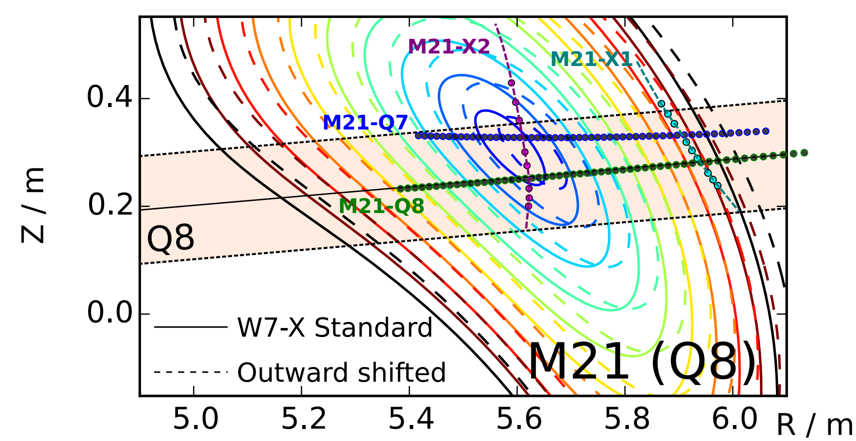

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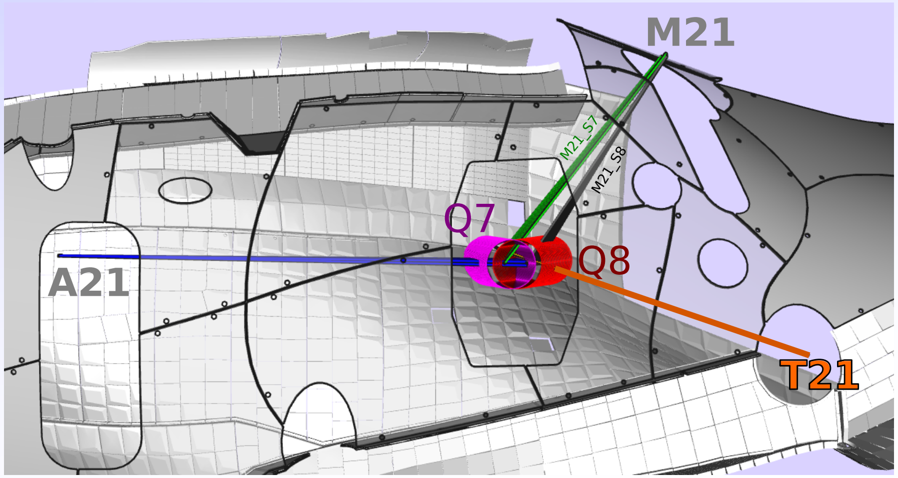

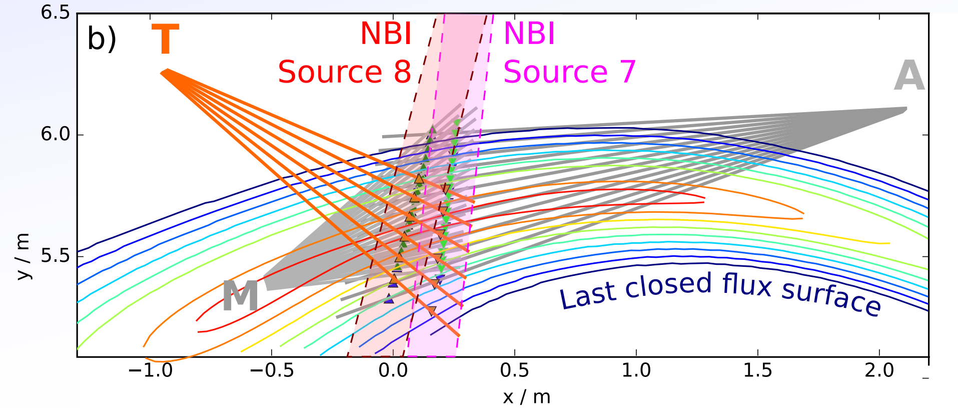

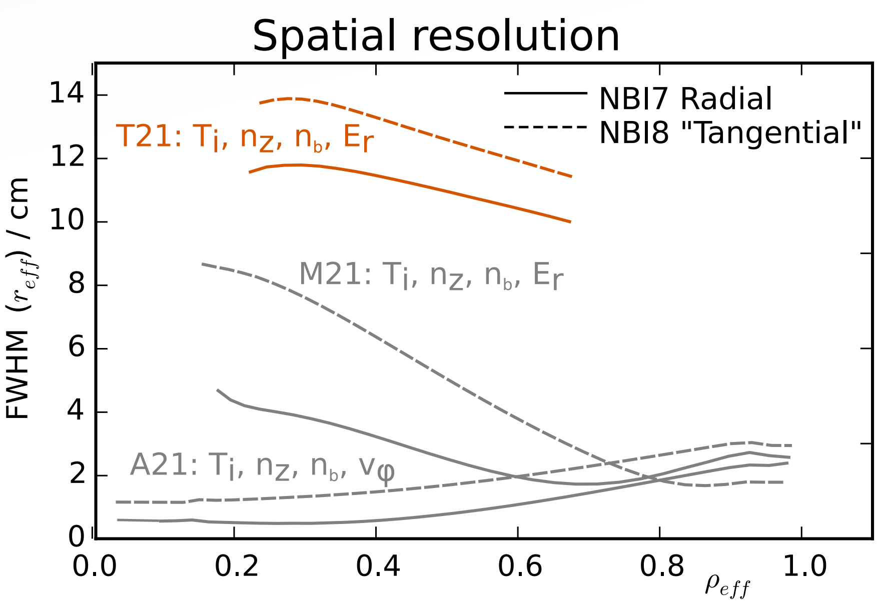

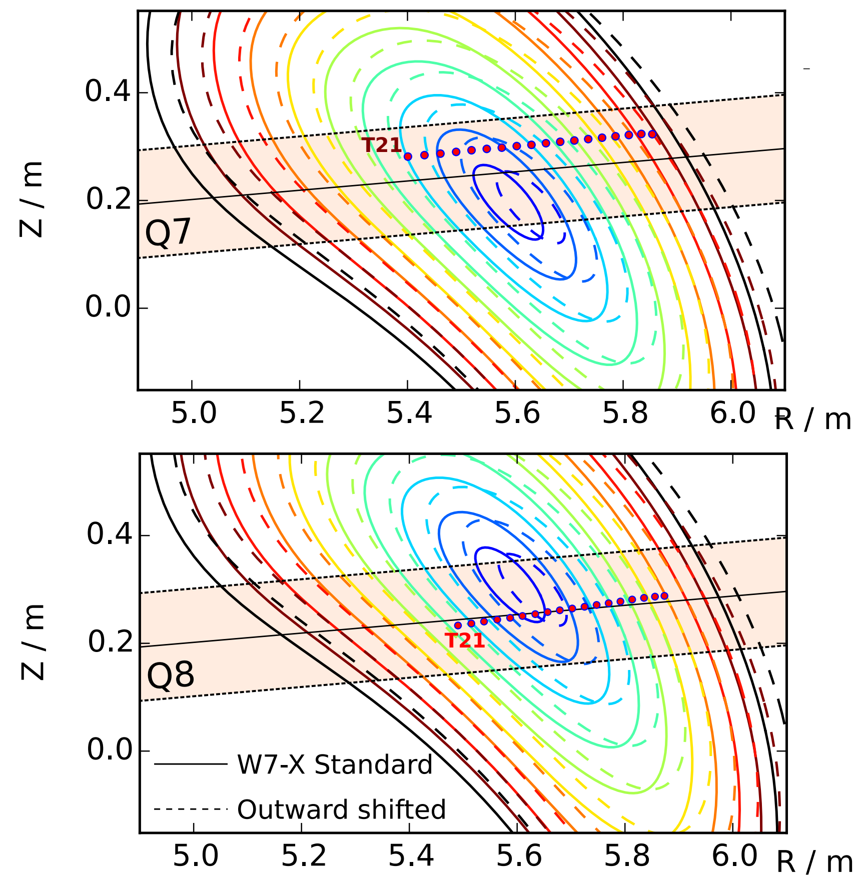

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Spectrometers

5 Spectrometers provide 300 measurements, each a mix from A, M and T ports:

ITER-Like Spectrometer (ILS) - Base system, **52 channels**:
Red (Halpha) --> n_b and FIDA, maybe one day T_H, n_H, n_e
Green (529nm) --> T_i, n_C, E_r
Blue (468nm) --> n_{He}

Always available

AUG1 - Secondary impurities 1: **43 channels**
Mainly n_O, n_B, n_C and more T_i, E_r.

AUG2 - Secondary impurities 2: **37 channels**
Injected impurities: B, N, Fe^{23+}, Fe^{24+}, Ar

Variable settings

NIFS He/H - **30 channels**.
High resolution Halpha for He/H ratio.
But also for BES --> n_b, FIDA, n_H, T_H ...

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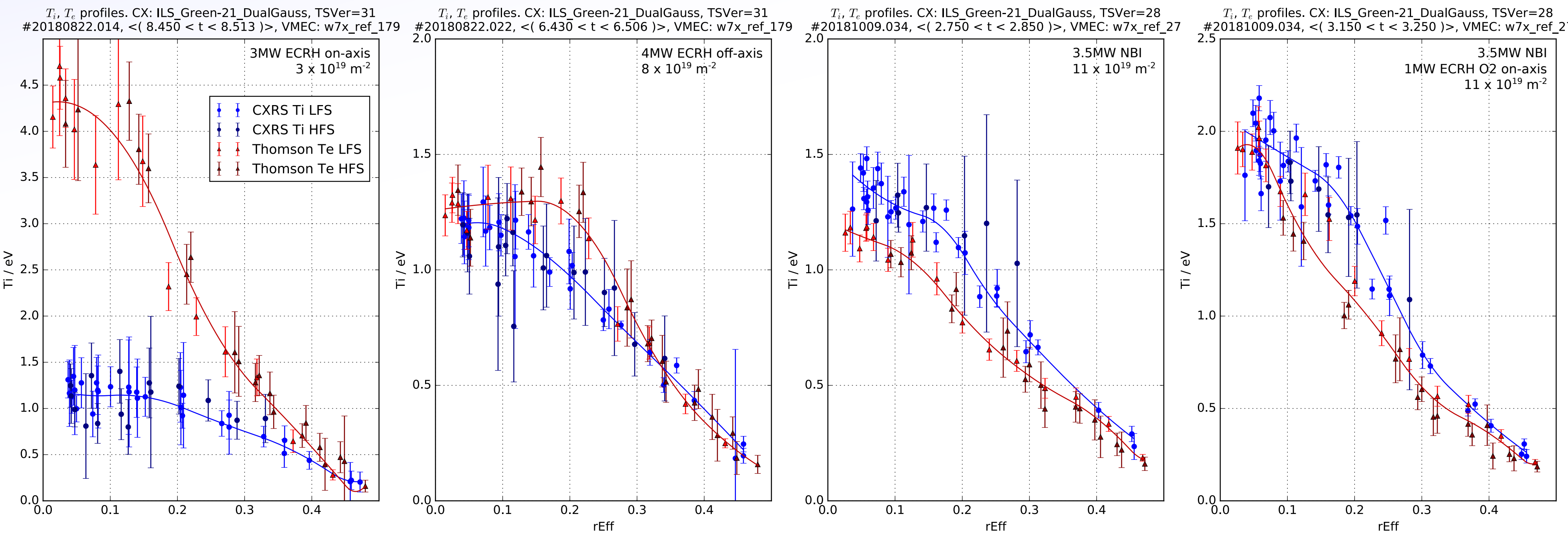
L.Vanó

Ti Profiles

- Ti profiles now available for almost all OP1.2b NBI shots.
- Generally good agreement with Thomson Scattering and expectations.

- Processed with simple Gaussian fitting program.
- Good for blips but long NBI shots difficult.
  - Only forward modelling of whole profiles will solve this --> Minerva

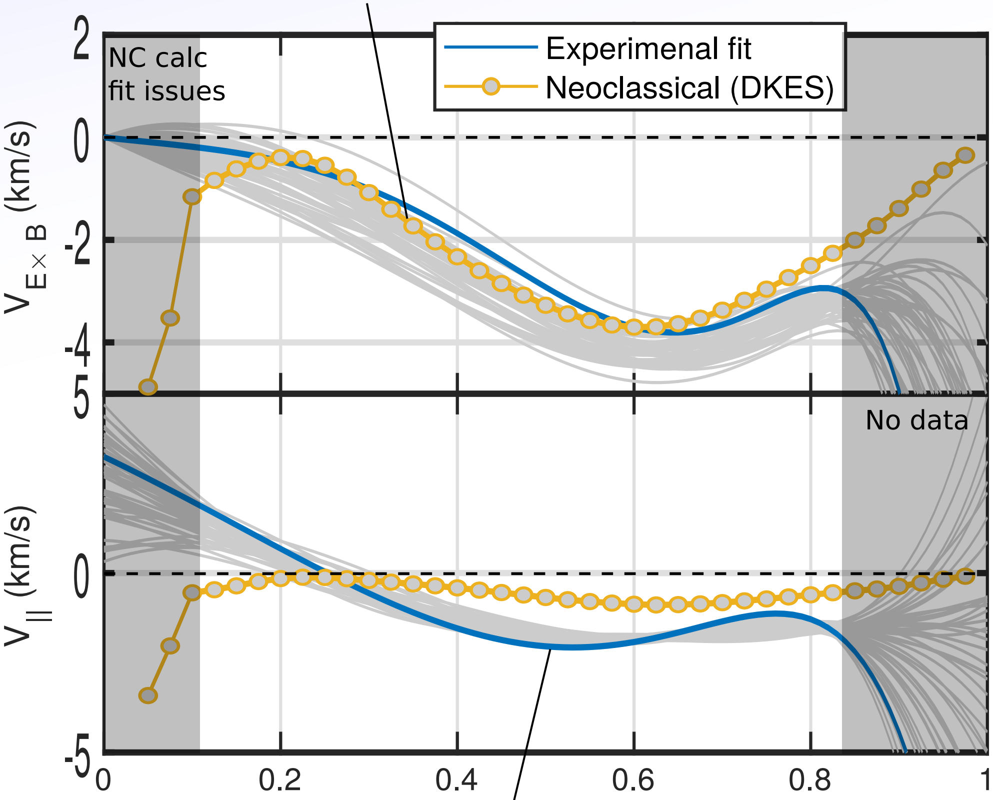


- Good quality profiles produced for normal uses.
- Special mode for high resolution gradient measurements (all spectrometers on C_VI)

E_r Profiles (A.Alonso)

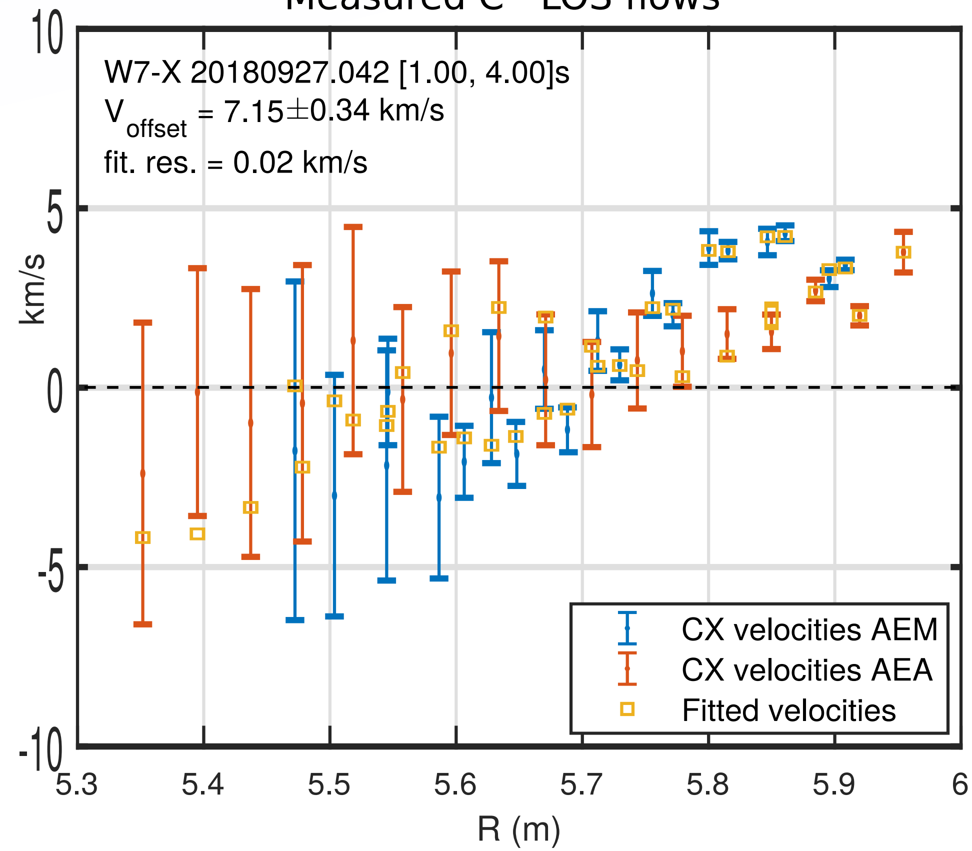
- Work is on-going to produce Er profiles (A. Alonso):
  - Measured flows into magnetic coordinates --> Potential + Toroidal flow
  - Correction of CX cross-section effects and finite lifetime orbit effects

NC predicted Er strongly affected by choice of fits of profiles



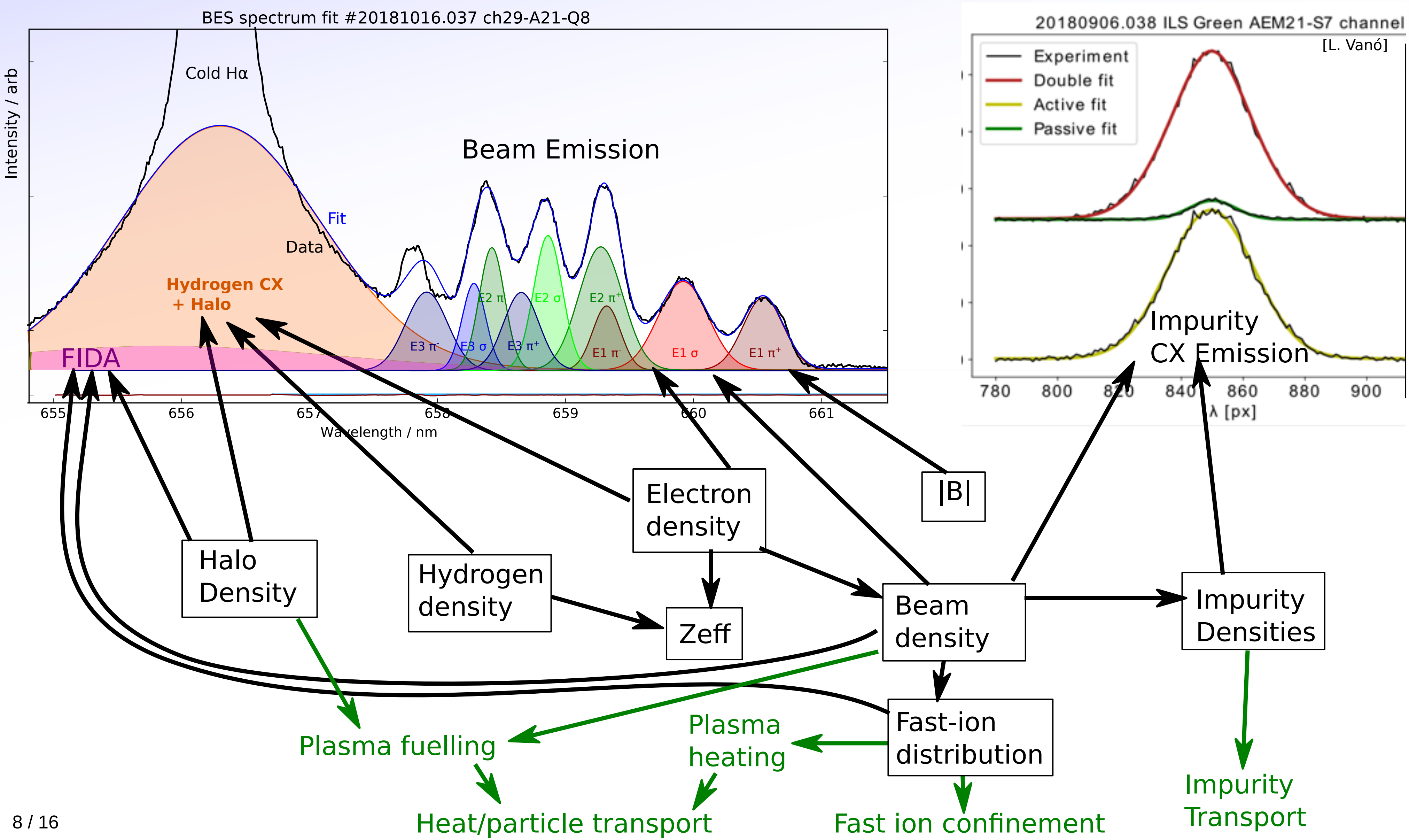
Parallel flows strongly affected by assumed NBI energy component fractions.

Measured C^{VI} LOS flows



OP1.2b: BES Measurements

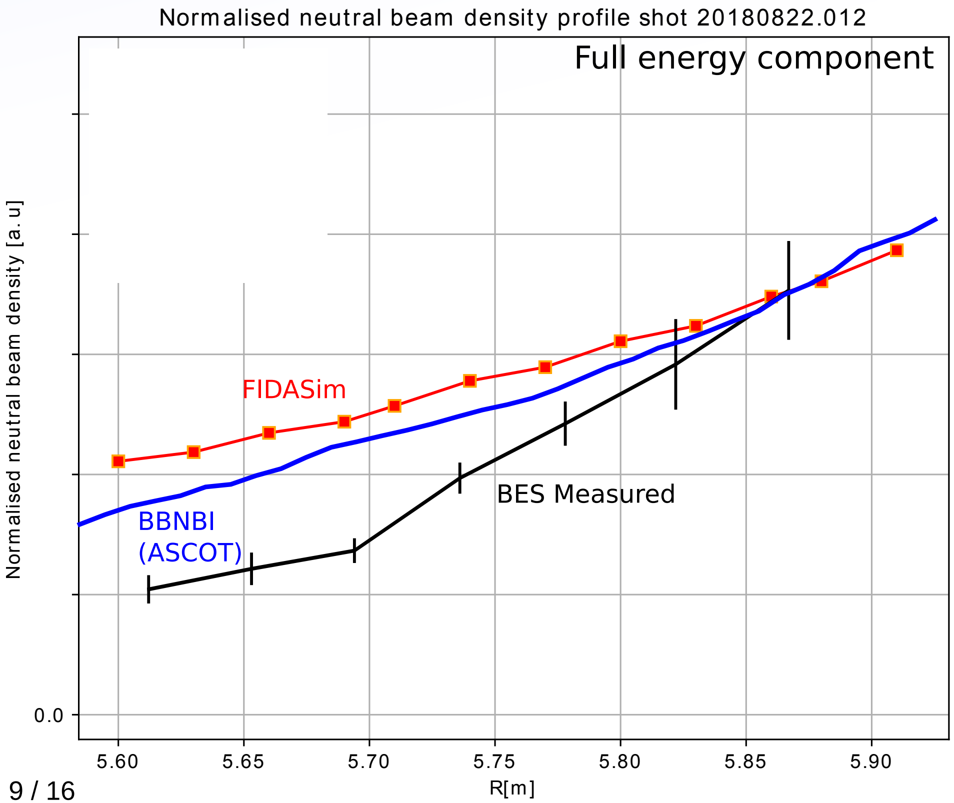
BES (Beam Emission Spectroscopy) and Halpha spectrum can deliver lots of information

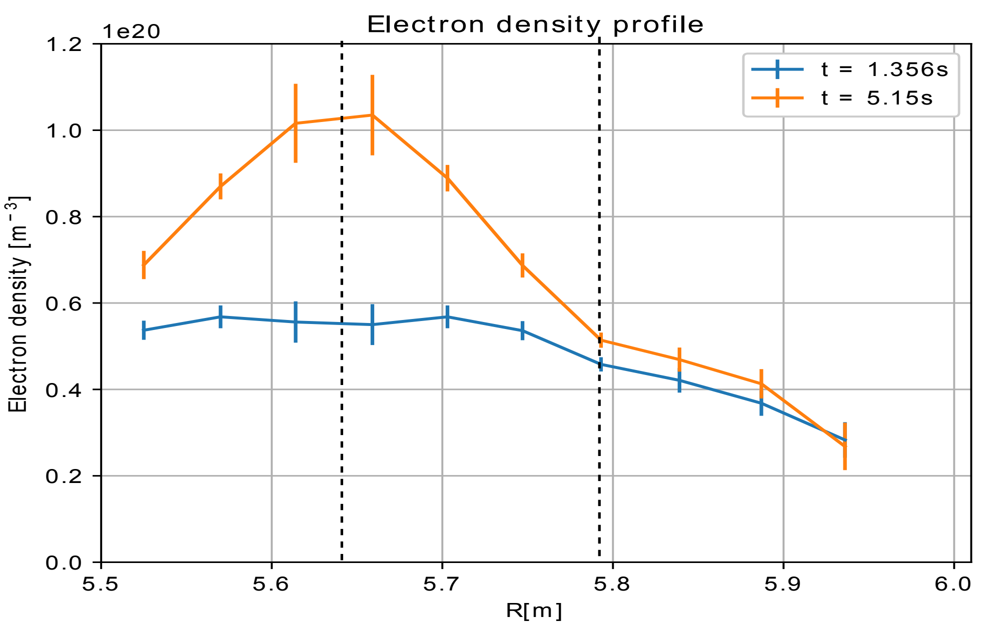


Beam deposition (T.W.C.Neelis)

Measured beam deposition (ignoring Halo CX broadening) now calculated.

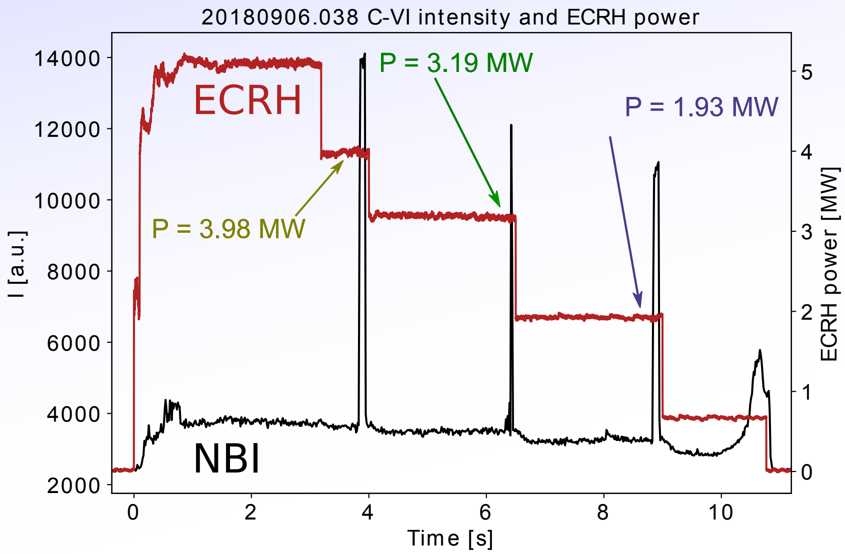
- Comparison to models (see talk S. Äkäslompolo)
- Fast ion birth profile
- Particle source profile

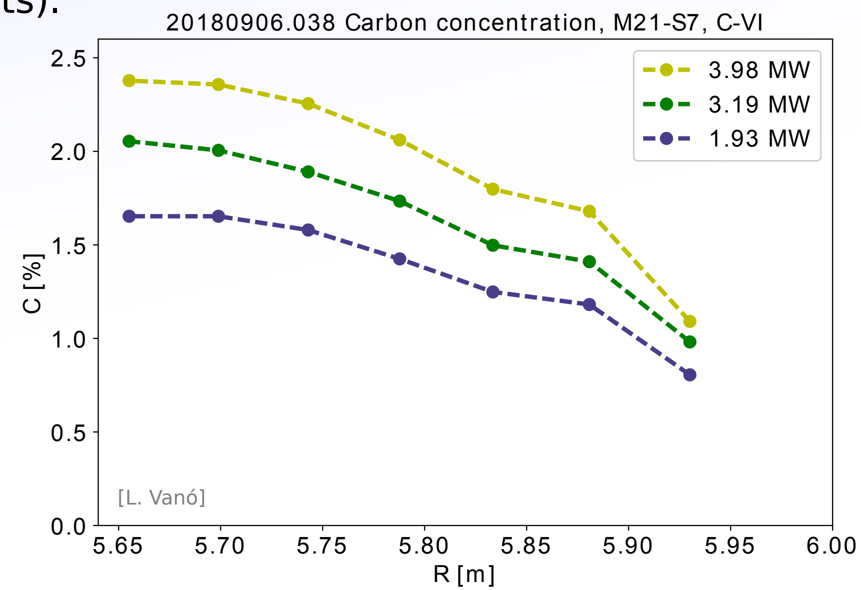




Carbon Profiles (L. Vanó)

- Now able to produce carbon concentration profiles for NBI blips.
- Very soon somewhat routinely (Requires accurate BES fits).





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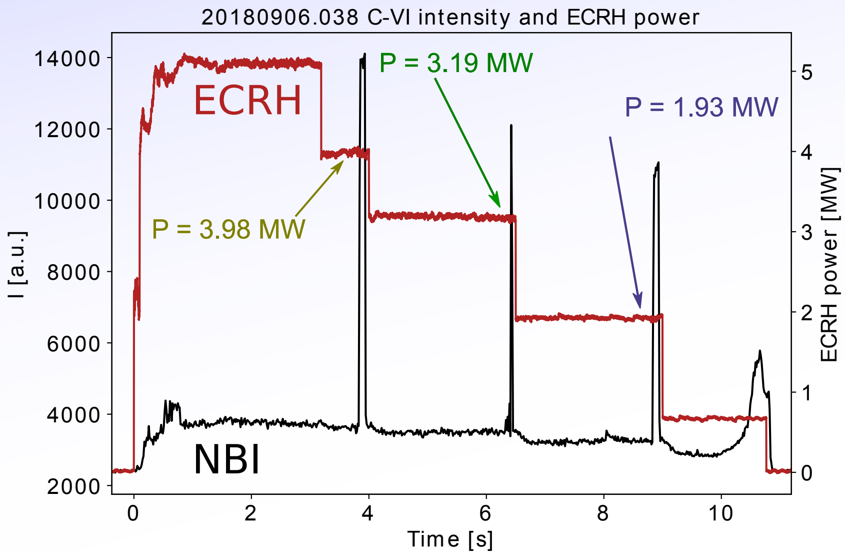
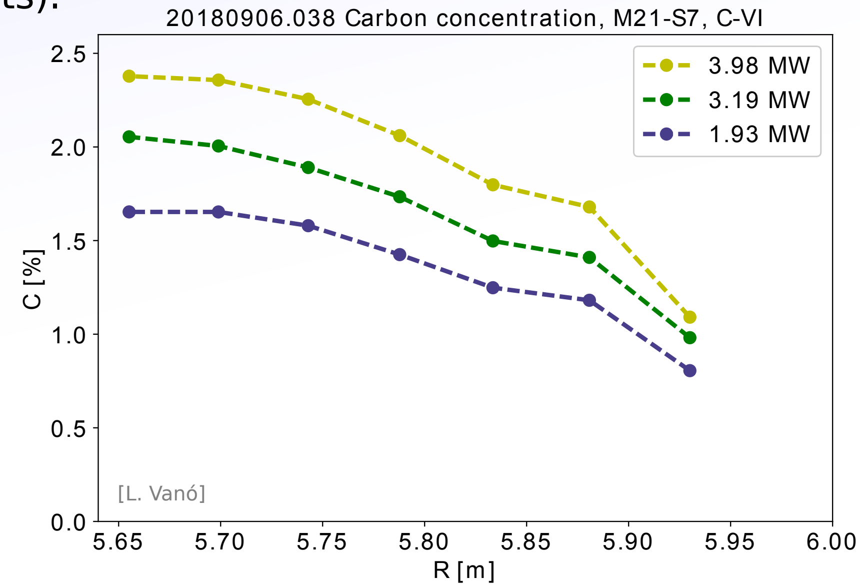
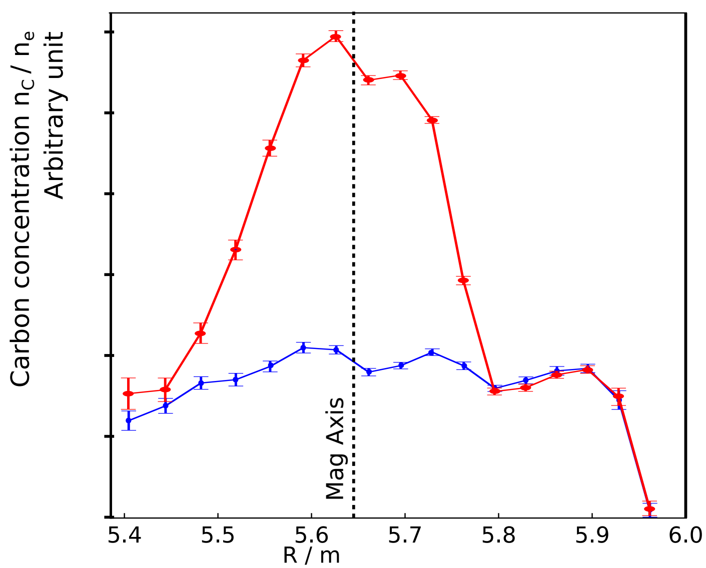
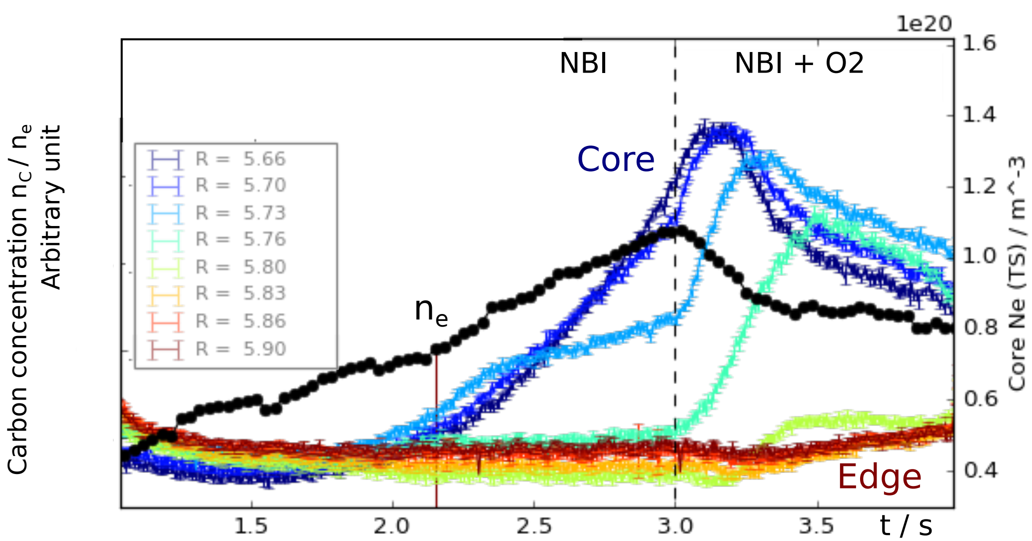




Strongly peaked carbon concentrations seen in pure NBI shots:





OP1.2b: FIDA

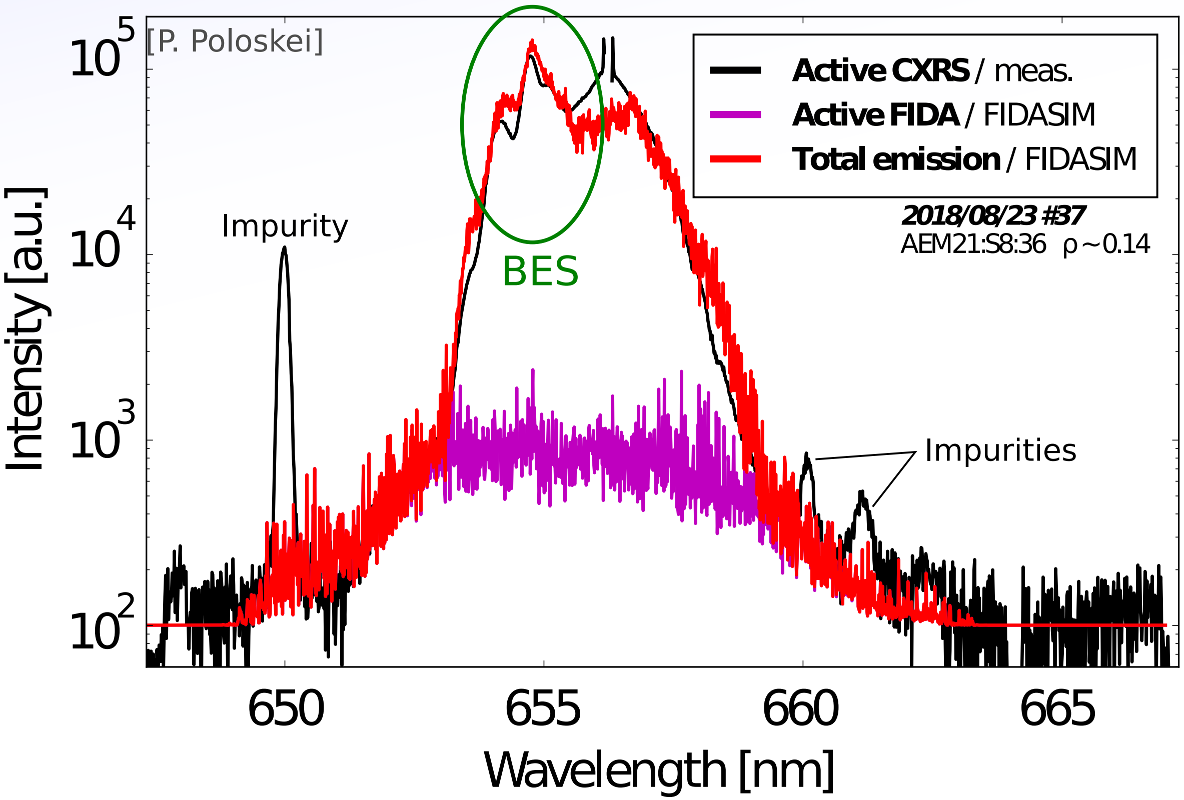
- FIDA Measurements planned with 'AUG' variable wavelength spectrometers:
  Unsucessful due to insufficient dynamic range but ILS Hα channel fortunately sees FIDA signal very well.

- Comparisons with ASCOT / FIDASIM underway
(P. Poloskei, S. Äkäslompolo)

- Bachelor Student (~Summer, with S. Bozhenkov) to look systematically at data and consider FIDA options for OP2.

- Dedicated spectrometer?, but unlikely to improve on ILS.

- ILS Hα can be optimised for much higher speed (~2ms)



- Offered use of very high speed spectromter for OP2 (~µs, but 1-channel) for FIDA from Garching (B.Geiger, A. v. Vuuren). Passive FIDA mesaurements planned.

OP2 Plans

- CXRS produces good high resolution data up to 2.5keV and 1.5 x 10^{20} m^{-2},
  - **No upgrades in coverage or resolution are planned** (or budgeted).

- Front-end optics need cooling to meet OP2 requirements:
  In-progress and expecting to be ready for OP2 vacuum closing.

- Currently only 6-channels available on NI20 box using T-port (low resolution).
  Upgrade here will require more fibres (~400€ / channel)

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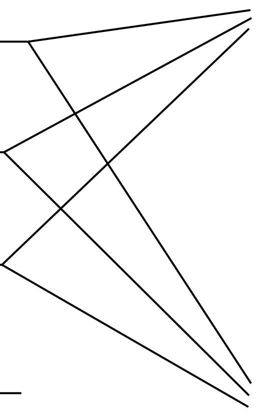
- We can add/upgrade spectrometers at the back-end at any time (i.e. right up to start of OP2.1).

	Observation		Transfer Fibres
NI21	A: Toroidal	120	80
	M: 45° view	120	80
	Low res	20	8
NI20	Low res	20	~~8~~ 6
			176



Spectrometers	
52	ILS
43	AUG1
43	AUG2
30	NIFS
168	

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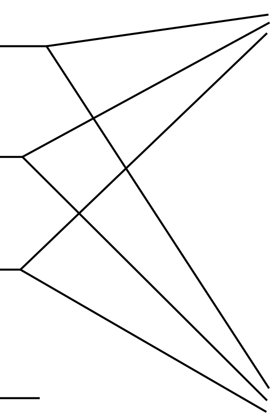
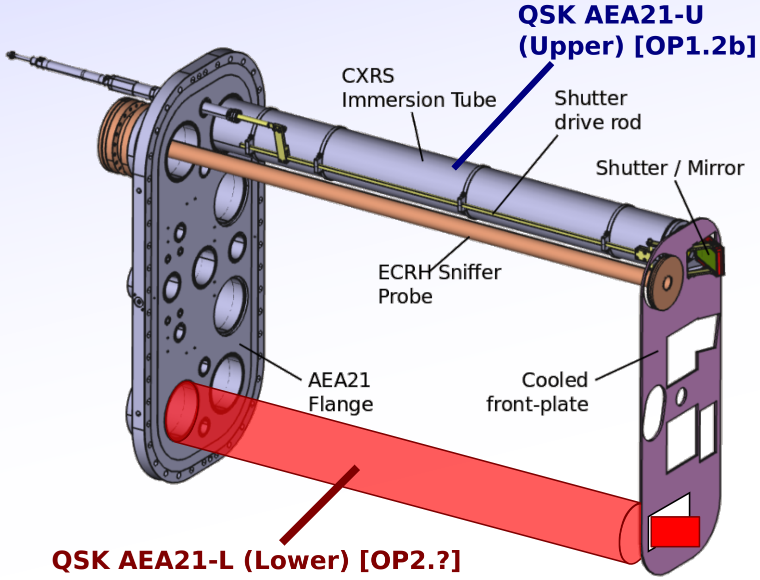
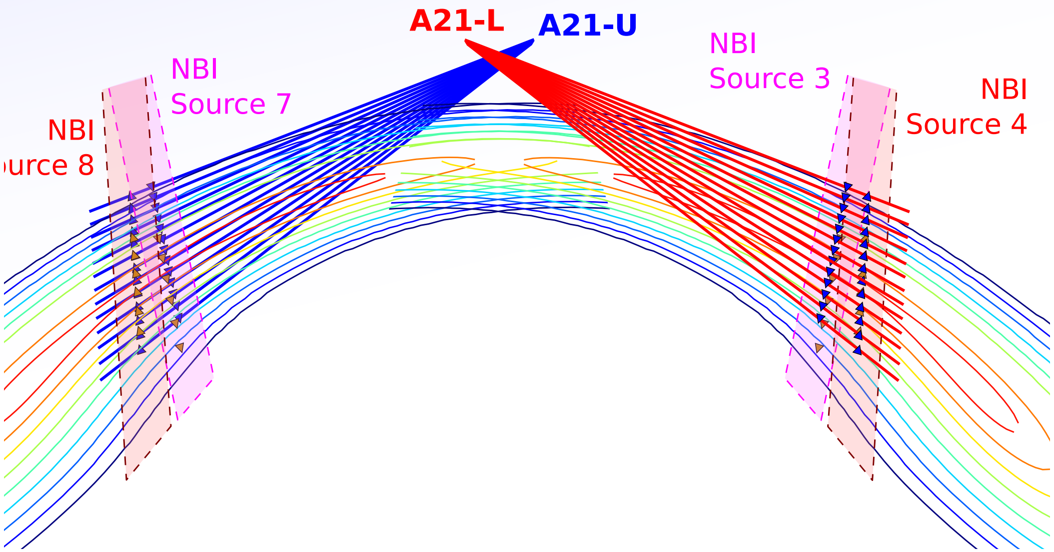
RuDiX	-	t.b.d	-		???
			176	**168**	



OP2 Possibilities

1) Add vacuum components for toroidal (A) observation of NI20:





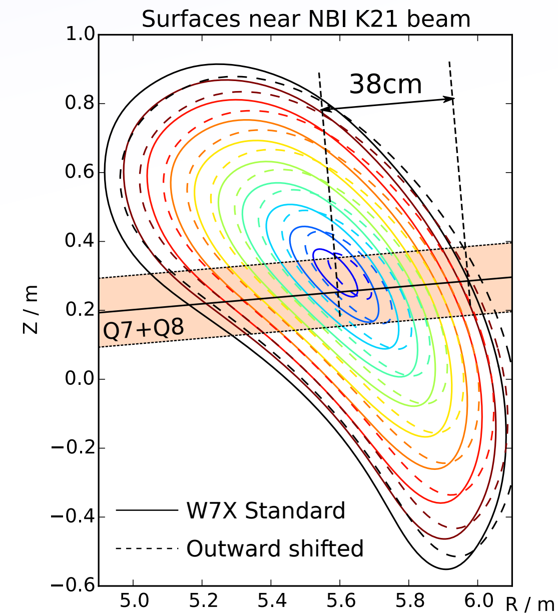
- 10 - 15k€ for in-vacuum and barrier components.
- Optics can be decided later (and purchased).
- Could be shared (time or light) between:
    CXRS - But we would need more channels and spectrometers!
    CXRS CIS (Experimental)
    MSE / IMSE
    CIS (E4),
    Video (E4),
    BES (E5)

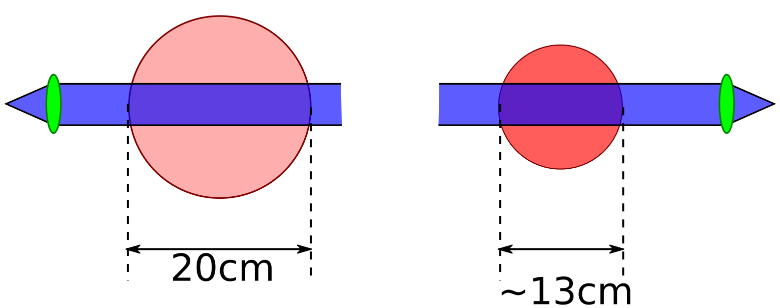
OP2 Possibilities

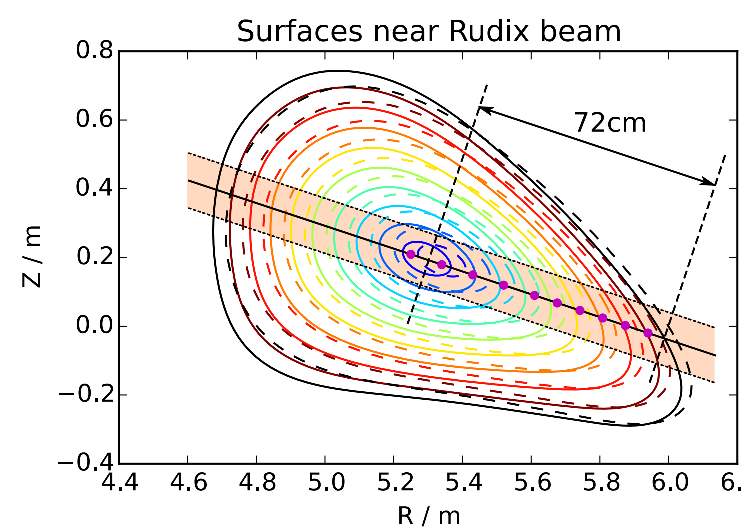
2) CXRS on RuDiX

- CXRS on RuDIX baseline design currently limited (12 channels, f/6 spectrometer, no CCDs!)
- If RuDIX is installed, we could move large part of transfer/back-end over to RuDIX easily, but...

Beam	**NBI**	**RuDIX**
Current	25 A	2.2 A
Diameter	20cm	13cm
Power	1.8MW	360kW
Energy	55 kV	60 kV
Divergence	0.8°	0.7°
Plasma ½ width	40cm	90cm
Signal (edge)	**125 Am^{-1}**	**17 Am^{-1} (14%)**
Signal (core)	**60 A/m^{-1}**	**4 Am^{-1} (6%)**







Much lower core S/N due to:
1) Lower beam current (8%)
2) Longer path in plasma (stronger attenuation)

OP2 Possibilities

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- Resolution same as poloidal system in core, better than both at edge.

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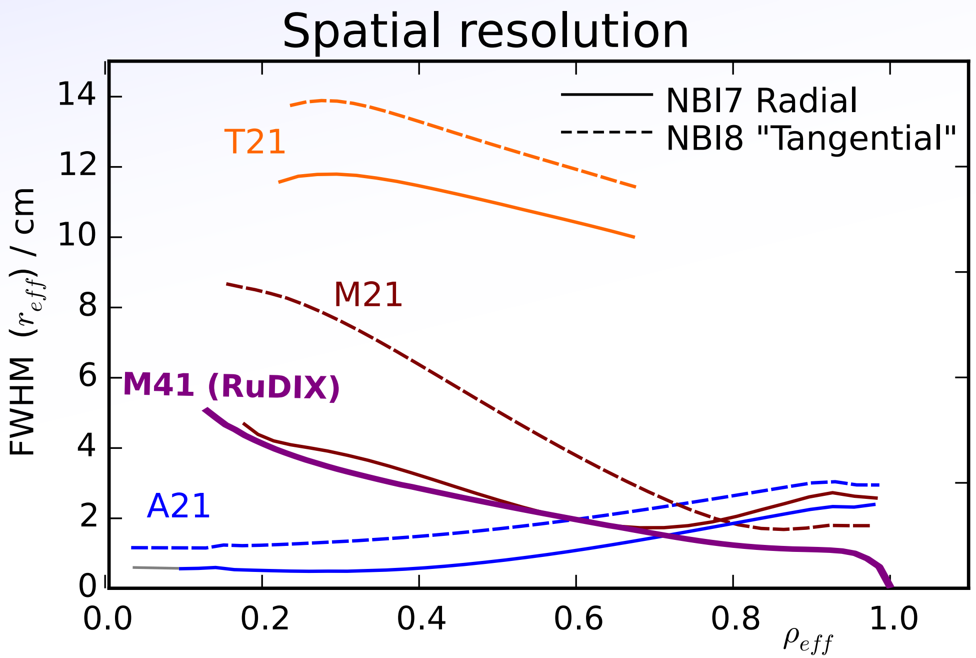
Resolution (c)	**1 cm**	**5 cm**
Resolution (e)	**3 cm**	**1 cm**



Pros:
- More than 10sec coverage.
  (Do we require CXRS in long pulse experiments?)
- Less perturbative
  (Lower power, no current drive)
- Better edge resolution

Cons:
- Resources / reliability (see talk P. McNeely)
- No toroidal flow measurement
- Much lower S/N
- Lower core resolution

Summary

- Very successful campaign for CXRS. Good data available or expected for: T_i, E_r, v_φ, n_C, n_O, n_b

- Need good strategy for exploiting BES data and dealing with CXRS passive background:

  - Minerva would be very powerful here - Student in Minerva group?

  - *Possibility* of 3cm resolution $\Delta t \sim 10$ms n_H/n_e profile information! (P. Poloskei, FIDASIM)

- **No changes/upgrade to base system planned.**
  - Do we want more spectrometers (e.g. for Spectral-MSE, CXRS)?
  - Would need more transfer fibres to match.

- FIDA: Explore possibilities with existing hardware? Dedicated spectrometer?

- Proposal: Install 2nd immersion tube for OP2.1:
  - Low cost, low effort, opens possibilities for OP2 diagnostic development.

- Do we need RuDIX?
  - CXRS looks to be worse on RuDIX.
  - Do we really need long pulse measurements?
  - Is NPA good enough reason alone to have it?