Motional Stark Effect Imaging on ASDEX Upgrade:

Analysis Notes from Jan 2015

O. P. Ford,[1] A. Burckhart [1]

1: Max-Planck Institut für Plasmaphysik, Greifswald/Garching, Germany
2: Plasma Research Laboratory, Australian National University, Canberra

Equilibrium Stuff

Oliver Ford
IPP Greifswald

Polarisation Angle --> Pitch

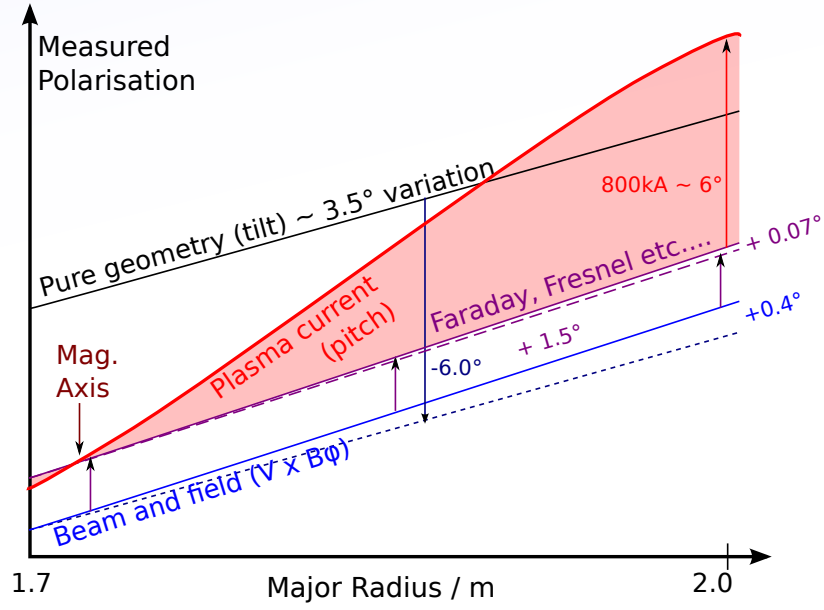
Measured θ is directly related to pitch (Bz/Bφ), but lots of things effect both the real and theoretical relationship:

0) Offset

- Diagnostic geometry
- Mirror position
- Vessel movements
- Plate temperatures
- Beam geometry
- Faraday rotation
- ....

Should not be required, if the edge field is known (and Er).

(with the new system, we need to make sure we see nearer the edge)



1) Linear in (R,Z)

- View geometry
- Beam geometry
- Mirror angle
- ...

The linear change needs calibrating. In vessel calibration not possible for prototype system so currently trying to calculate it from Equilibrium. This requires knowing Ip and **Axis position.**

2+) Non-linear in (R,Z)

- Intrinsic contrast (Crystal plate deformations)

2nd+ order instrument effects need eliminating or calibrating where possible!

Current setup suffers from crystal plate deformations (manufacturing).
Ordered better crystals to solve this but they did not arrive in time for this campaign.

Effect depends on light cone so we need illumination as if from the beam (in-vessel work)

Oliver Ford
IPP Greifswald

Equilibrium

What would we need in the equilbrium to believe we are perfectly predicting the angles?
How much do these things really effect it?

- Good magnetics data:
  - TF Correction.
  - Remove Drifts
  - Take care of vessel currents near pickups during fast changes.
  - No mismatch to pre-ignition PF ramps.
  - No non-axisymmetry (Error fields, RMPs?)

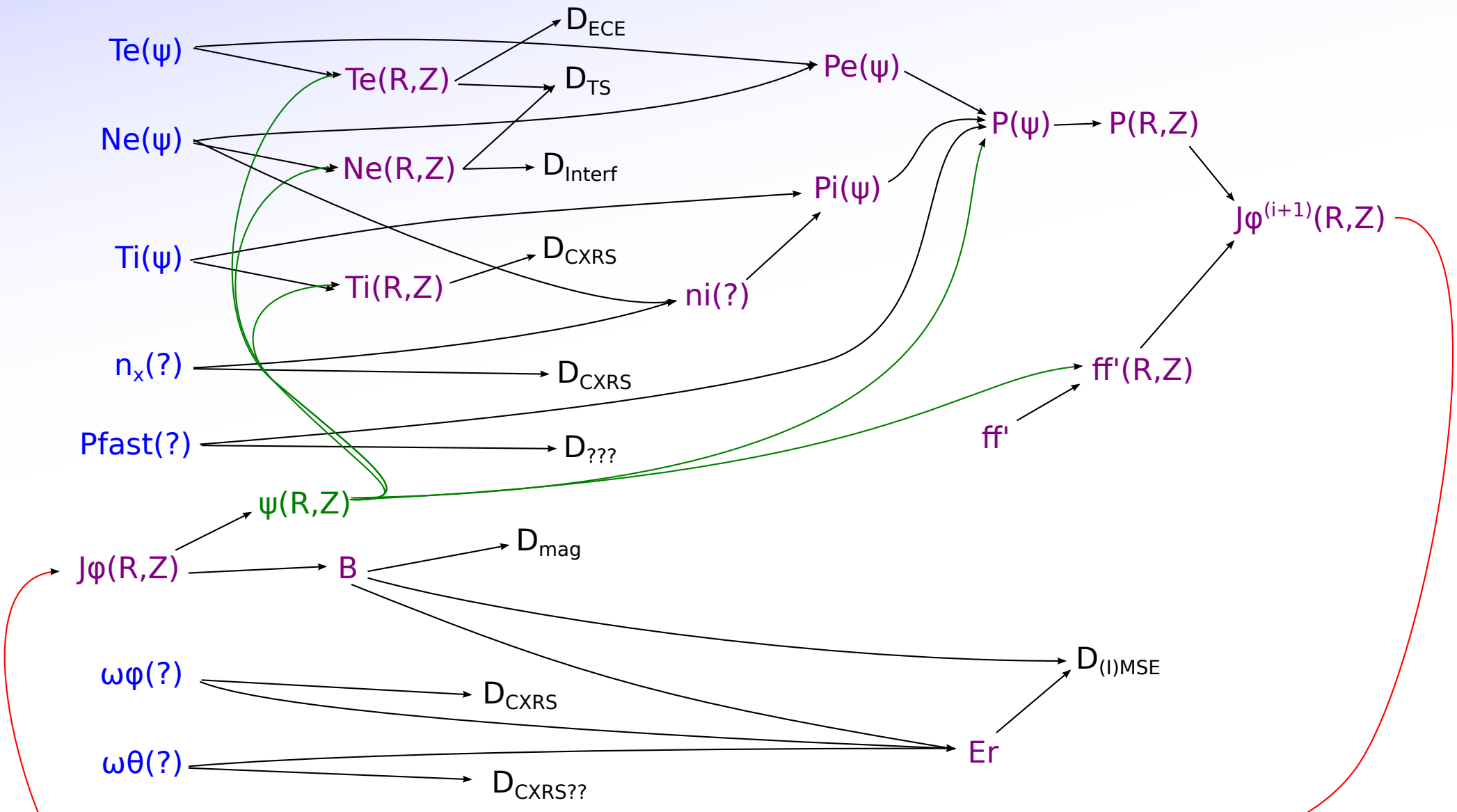
- Pressure:
  - Good ne/Te into the core.
    - Relaible from TS but not into centre.
    - Checked Good ECE (Optically thick, good calibration etc)
    - Interferometry in model.
  - Good Ti. CXRS seems good but needs checking.
  - ni ... Zeff???
  - Fast ion pressure (low, or measured)
  - Anisotropy (low fast ions or handled correctly)

- Electric Field
  - Needs vφ (Ok from CXRS) and vθ into the core + terms from dP/dρ
  - Needs Bθ too (so couples into equi)

All diagnostic input info is in R,Z not ρ so needs to be remapped consistently.

Oliver Ford
IPP Greifswald

Required Model



Oliver Ford
IPP Greifswald

Electric Field

Is the electric field important?

Fields are:
- Eφ = From loop voltage, usually a few V / m - not important.
- Eθ = Not sure this should exist. Certainly integral around θ loop is 0, so should be small.
- Er = Radial electric field - can be very large.

Er comes equates to (for a given species):

$$E_r = \frac{1}{n_i q_i}\frac{dp_i}{dr} - v_\theta B_\phi + v_\phi B_\theta$$

Small
Big

Diamagnetic — Poloidal Rotation — Toroidal Rotation

AUG has routine measurements for vφ but not vθ.

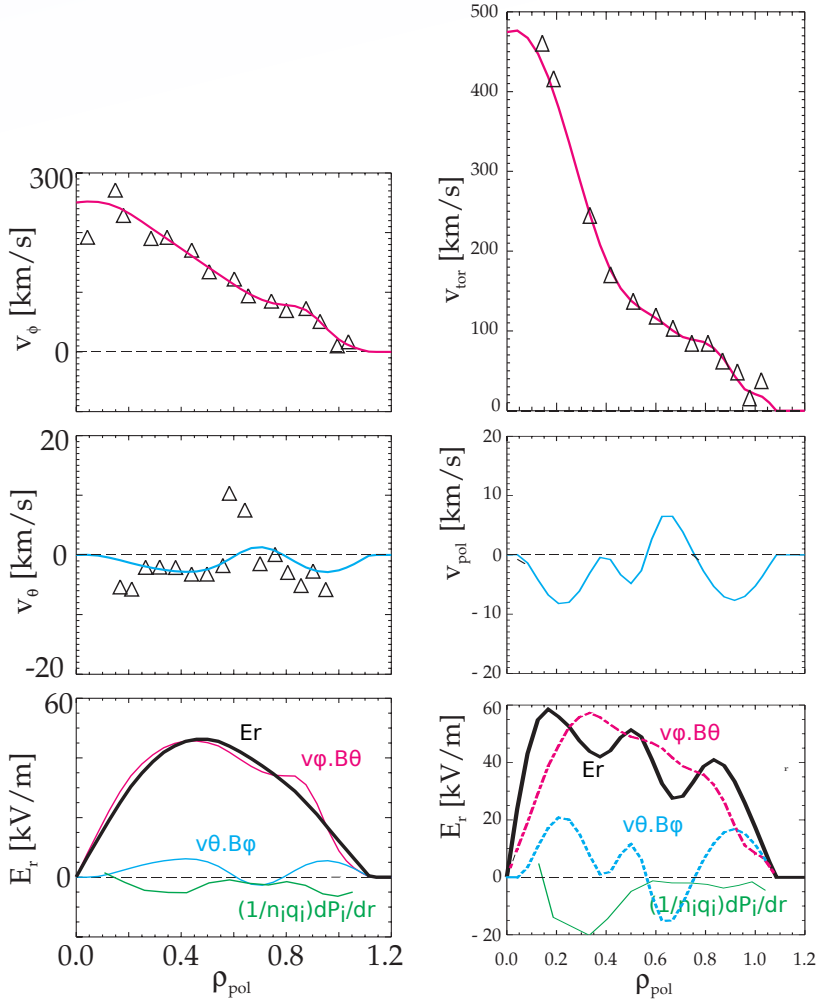
Upper typical values:
Bφ ~ 2.5T
Bθ ~ 500mT
vφ ~ 200km/s
vθ ~ 20km/s
(but can be much larger for ITBs)

Er ~ 50kV/m
(up to few 100s kV/m for ITBs)

We need to worry most about vφ.Bθ and that alone should be enough to estimate the magnitude, but maybe not to remove it by calculation from the CXRS measured vφ.

Obviously everything is always 0 at the axis.

Also... are ωφ and ωθ constant(ish) on surfaces??



'Improved' H-Mode Ti~8keV

L-Mode with ITB . Ti~15keV

[H.Meister. Nucl. Fus. 2001]

Oliver Ford
IPP Greifswald

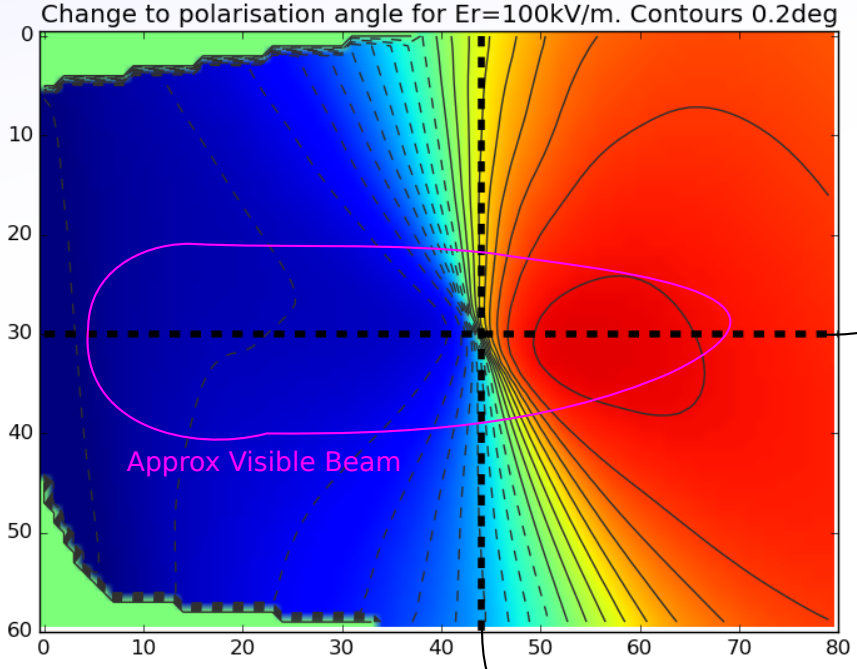
Electric Field

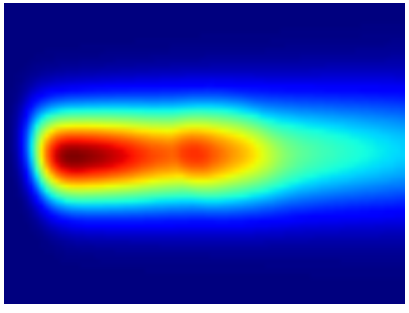
What does 100kV/m Er do to the polarisation angle?

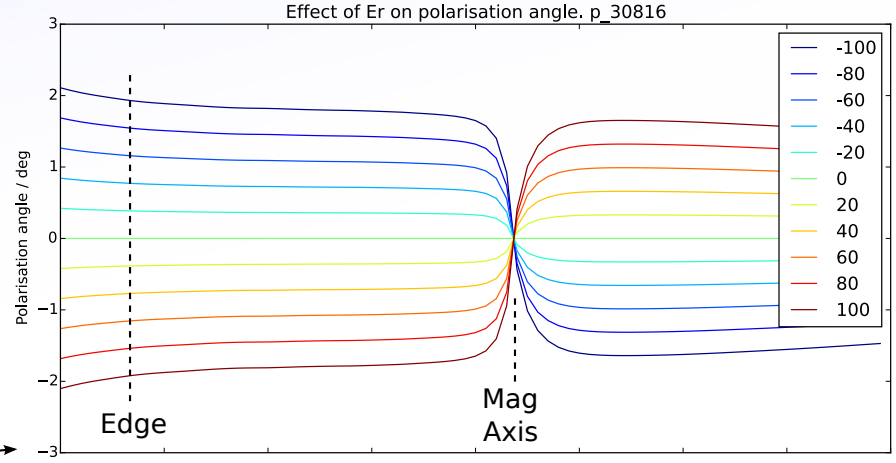
Lorenz field is typically E = v x B = sqrt(2*60keV / m_p) * 2T ~ 7MV/m, mostly from Bφ, so approx vertical.
On midplace, Er is approx radial (major R)

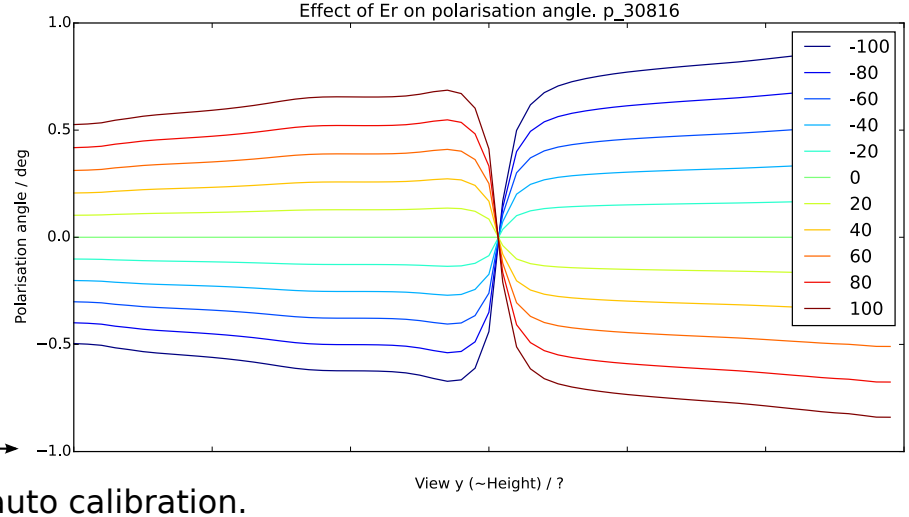
100kV / 7MV ~ 0.8° - Very significant!!!
Actual angles reduce this a little, but not by more than a factor of 2.

How does it look? For Q3 (IMSE 2013/14) simulation (minerva/IMSELosFan):









So, it's a big enough effect to mess up the auto calibration.
It also shows Er should be just visible in the vertical variation.
At the core it's strong, but Er will be small.
Off-axis (~mid radius), the vertical variation for Er=60kV/m is about 0.1°, magnitude 1°.

Conclusion:
Expect ~1° changes due to Er!