Ar experiments and analysis

Francisco Guzmán

ADAS-EU
University of Strathclyde

ADAS-EU course – 26 – 30 Mars 2012

Outline

Outline

Outline

Outline

Outline

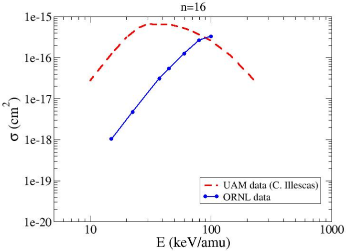
ADAS-EU
ADAS for fusion in Europe

ADAS sets comparison

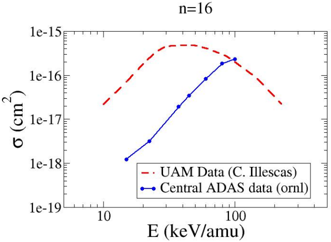
ADAS-EU
ADAS for fusion in Europe

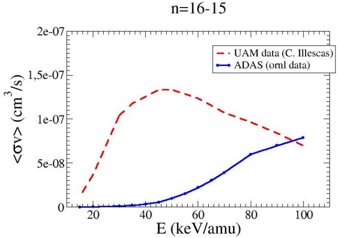
Ar^{16+} + H

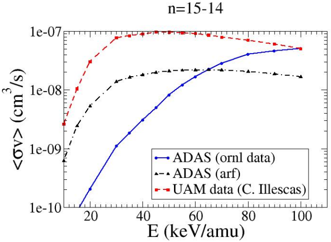
$Ar^{18+} + H \Longrightarrow Ar^{17+}(n) + H^{+}$



$Ar^{16+} + H \Longrightarrow Ar^{15+}(n) + H^{+}$

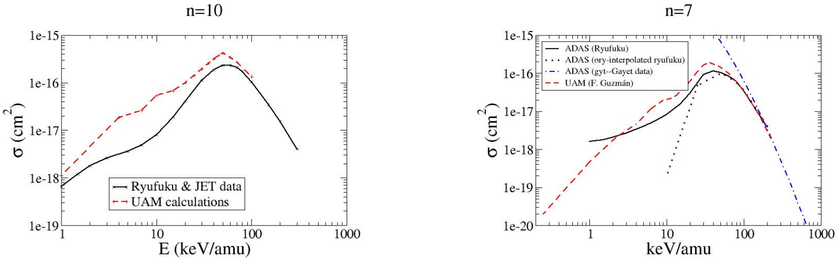






not only Ar!

$Ne^{10+} + H \Longrightarrow Ne^{9+}(n) + H^+$ $\qquad$ $B^{5+} + H \Longrightarrow B^{4+}(n) + H^+$



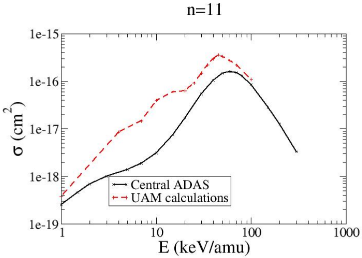
UAM: Errea *et al.* Nucl Inst. & Meth. Phys. Res. B **235**, 315 (2005)

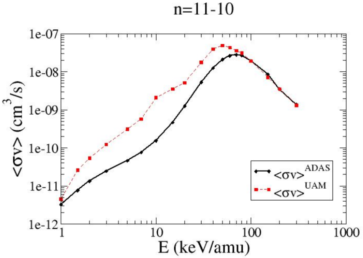
ADAS: Ryufuku JAERI-M-82-03 and JET data base (Summers and Horton) (n>10 extrapolated)

Differences on Ne

ADAS-EU
ADAS for fusion in Europe

Differences in cross section are reflected in effective coefficients





Plasma Parameters:

$$\begin{aligned} n_i &= 4{*}10^{13}\text{cm}^{-3} \\ T_i &= 3\text{ keV} \\ Z_{eff} &= 1.7 \\ B &= 3\text{T} \end{aligned}$$

Outline

ADAS-EU
ADAS for fusion in Europe

Using CHEAP

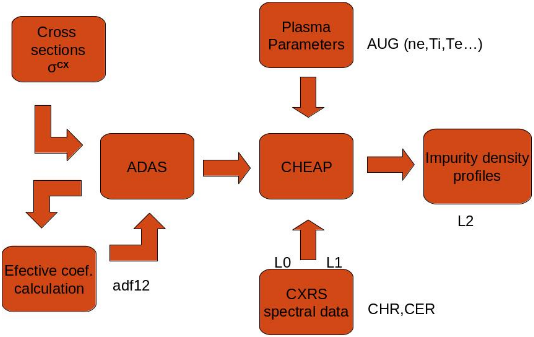
- CHarge Exchange Analysis Package (CHEAP) calculates iteratively impurity and beam density in plasmas from a spectral line photon flux and effective rates.

$$n_Z = \frac{\phi_{CX}^{Z}}{q_{eff}^{CX} n_{beam}}$$

- Flux will be fitted using CXFIT.
- CHEAP has been developed by M. von Hellerman and others in JET.

Using CHEAP

- CHarge Exchange Analysis Package (CHEAP) calculates iteratively impurity and beam density in plasmas from a spectral line photon flux and effective rates.



What does CHEAP do?

ADAS-EU
ADAS for fusion in Europe

- $(T_i, T_e, n_e, \phi_{CX})$ profiles $\Longrightarrow$ beam density attenuation $\Longrightarrow$ calculated photon flux $\Longrightarrow$ impurity densities.
- CHEAP can use several background impurities to calculate beam attenuation.
- $q_{eff}(Z, H(n = 1, 2)$ CX data is used to calculate beam attenuation.
- Z_{eff}^{CX} could be calculated from impurity profiles and can be implemented.

What does CHEAP do?

- $(T_i, T_e, n_e, \phi_{CX})$ profiles $\Longrightarrow$ beam density attenuation $\Longrightarrow$ calculated photon flux $\Longrightarrow$ impurity densities.
- CHEAP can use several background impurities to calculate beam attenuation.
- $q_{eff}(Z, H(n = 1, 2)$ CX data is used to calculate beam attenuation.
- Z_{eff}^{CX} could be calculated from impurity profiles and can be implemented.

What does CHEAP do?

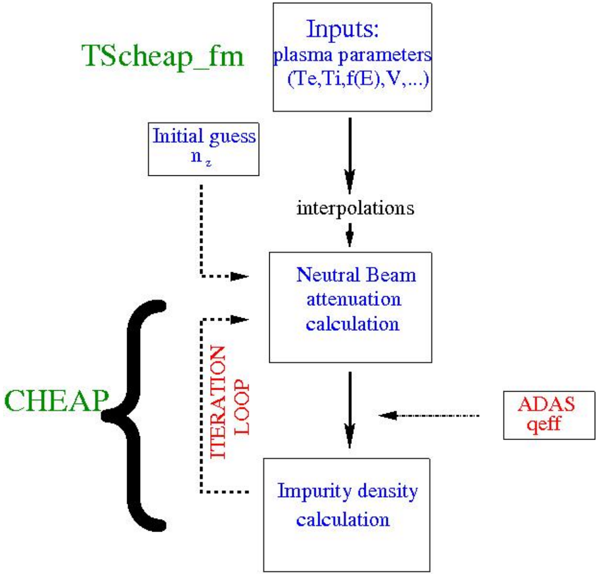
ADAS-EU
ADAS for fusion in Europe

- $(T_i, T_e, n_e, \phi_{CX})$ profiles $\Longrightarrow$ beam density attenuation $\Longrightarrow$ calculated photon flux $\Longrightarrow$ impurity densities.
- CHEAP can use several background impurities to calculate beam attenuation.
- $q_{eff}(Z, H(n = 1, 2)$ CX data is used to calculate beam attenuation.
- Z_{eff}^{CX} could be calculated from impurity profiles and can be implemented.

What does CHEAP do?

- $(T_i, T_e, n_e, \phi_{CX})$ profiles $\Longrightarrow$ beam density attenuation $\Longrightarrow$ calculated photon flux $\Longrightarrow$ impurity densities.
- CHEAP can use several background impurities to calculate beam attenuation.
- $q_{eff}(Z, H(n = 1, 2)$ CX data is used to calculate beam attenuation.
- Z_{eff}^{CX} could be calculated from impurity profiles and can be implemented.

CHEAP structure

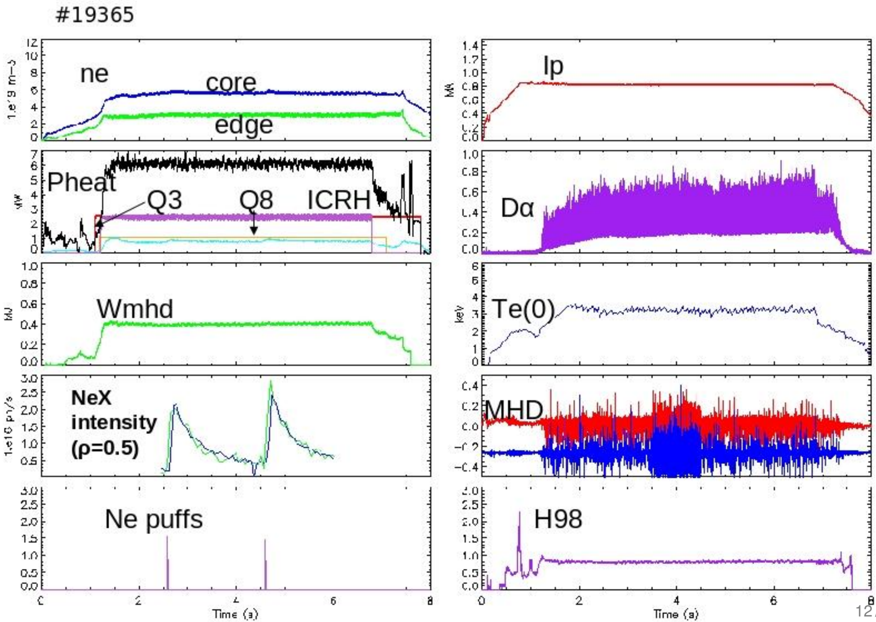


Outline

ADAS-EU
ADAS for fusion in Europe

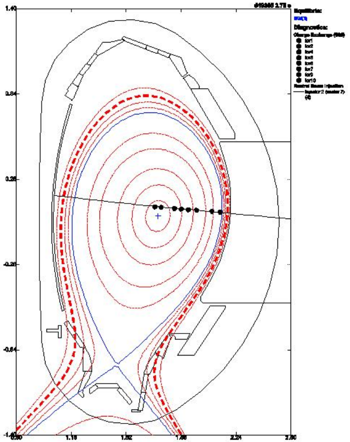
ASDEX-U shot 19365

ADAS-EU
ADAS for fusion in Europe

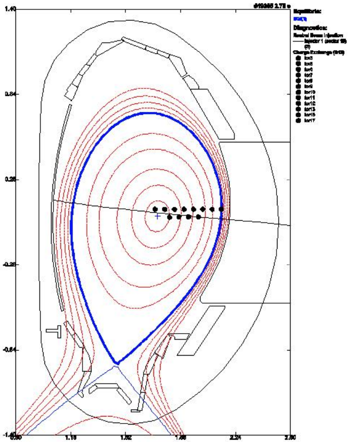


Experimental set-up

CHR (S09)



CER (S13)



Measured NeX lines

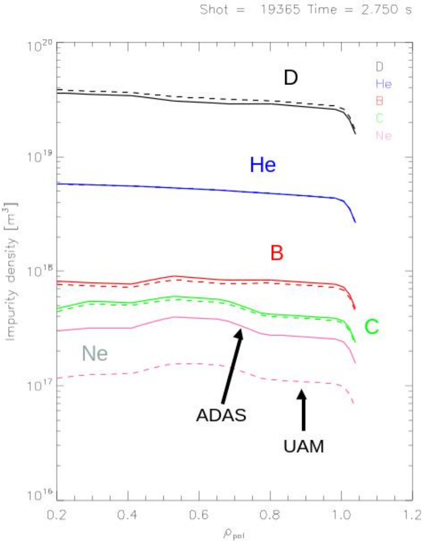
ADAS-EU
ADAS for fusion in Europe

1	n=11-10	λ=524.92 nm	
2	n=10-9	λ =388.37 nm	Problems of calibration
3	n=13-11	λ=388.095 nm	Too weak
4	n=14-12	λ=494.46 nm	B^{4+} λ=494.47nm stronger line
5	n=15-13	λ=618.577 nm	complicated spectra
6	n=12-11	λ=690.16 nm	complicated spectra

CHEAP impurity densities

Shot #19365

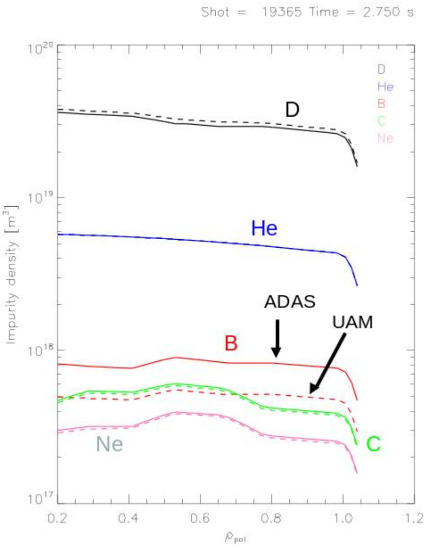
ADAS-EU
ADAS for fusion in Europe

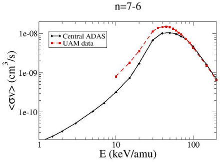


- D: Compensating ion
- He: fix concentration n_{He}/n_e=0.1
- B: fitted from BV(7-6) λ= 494.47 nm
- C: fitted from CVI(8-7) λ=529.07 nm
- Ne: fitted from NeX(11-10) λ=524.92nm

Boron checked as well!

ADAS-EU
ADAS for fusion in Europe





- D: Compensating ion
- He: fixed concentration $n_He/ne = 0.1$
- B: fitted from BV(7-6) λ= 494.47 nm
- C: fitted from CVI(8-7) λ=529.07 nm
- Ne: fitted from NeX(11-10) λ=524.92nm

Outline

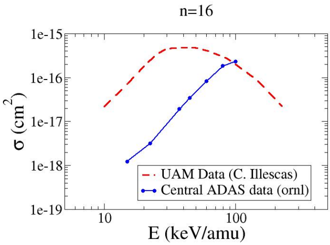
ADAS sets comparison

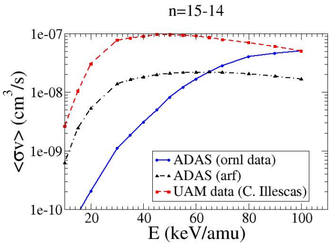
Ar^{16+} + H

ADAS-EU
ADAS for fusion in Europe

$Ar^{16+} + H \Longrightarrow Ar^{15+}(n) + H^{+}$

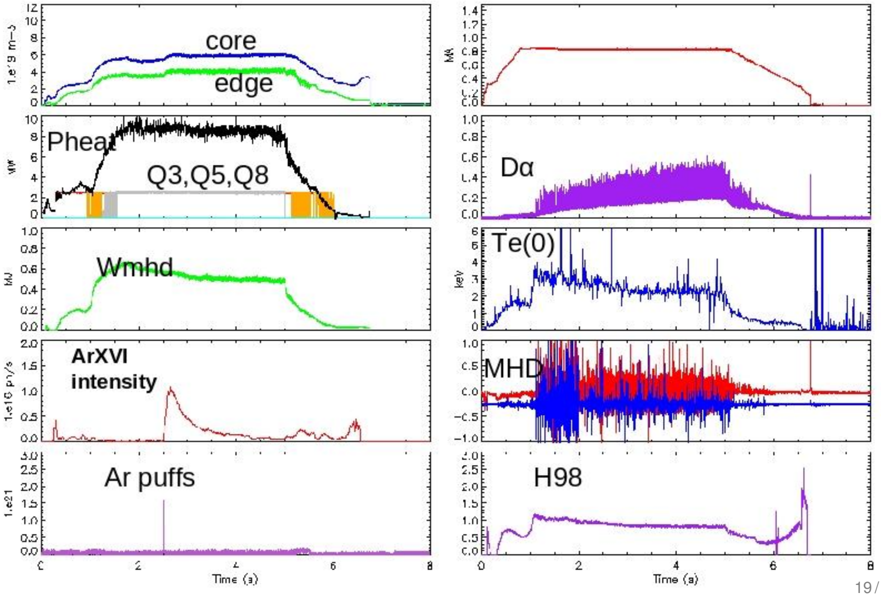
- Factor between 5 and 25 of difference in the T_i relevant ranges.
- Energy NB ASDEX = 30keV and 45keV





ASDEX-U shot 22301-22303

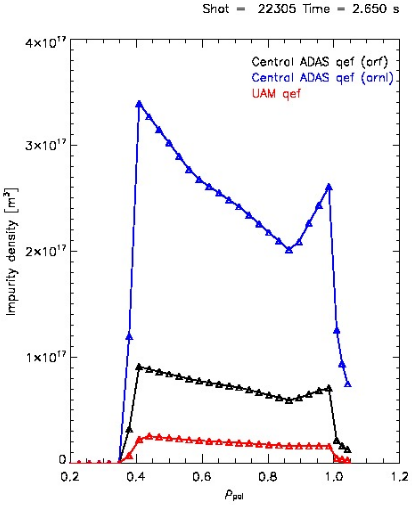
ADAS-EU
ADAS for fusion in Europe



Preliminary comparisons for ArXVI

ADAS-EU
ADAS for fusion in Europe

Shot 22305; ArXVI profile



Radial density profile obtained from the fitting of calculated line intensity to the experimental one using the CHEAP code in ASDEX-U.ρ_{pol} =0.5; t=2.65

Data	ORNL	UAM	ARF	X ray
Conc. Ar	0.02123	0.00104	0.00482	0.001

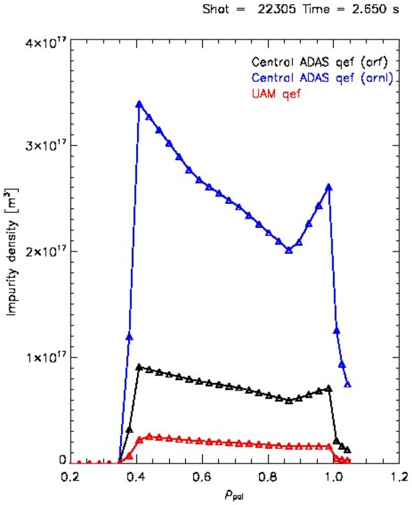
F Guzmán and C. Maggi (Spring 2009).

X ray data provided by M. Sertoli

Preliminary comparisons for ArXVI

ADAS-EU
ADAS for fusion in Europe

Shot 22305; ArXVI profile



Radial density profile obtained from the fitting of calculated line intensity to the experimental one using the CHEAP code in ASDEX-U.ρ_{pol} =0.5; t=2.65

Data	ORNL	UAM	ARF	X ray
Conc. Ar	0.02123	0.00104	0.00482	0.001

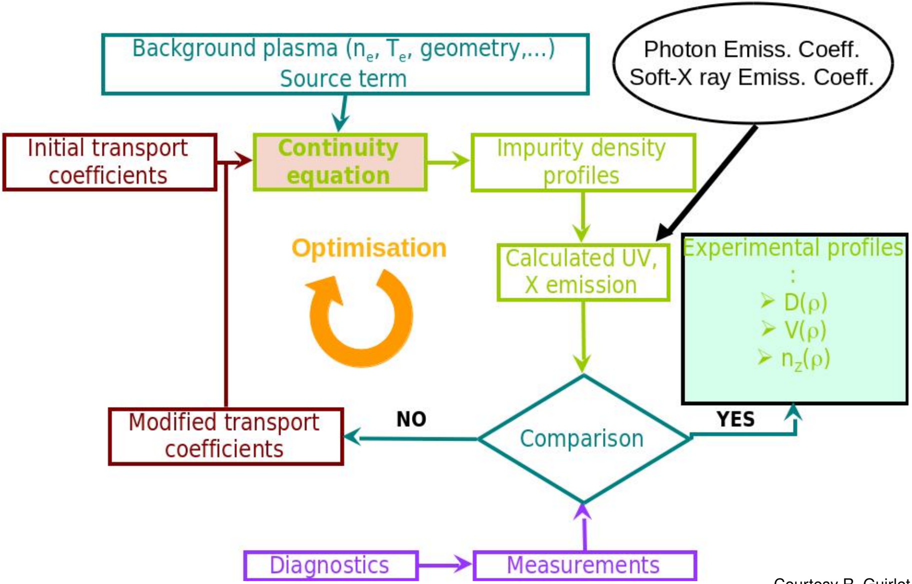
UAM data seems to agree with Soft X-ray

F Guzmán and C. Maggi (Spring 2009).

Johann spectrometer data provided by M. Sertoli

Soft X-ray profiles

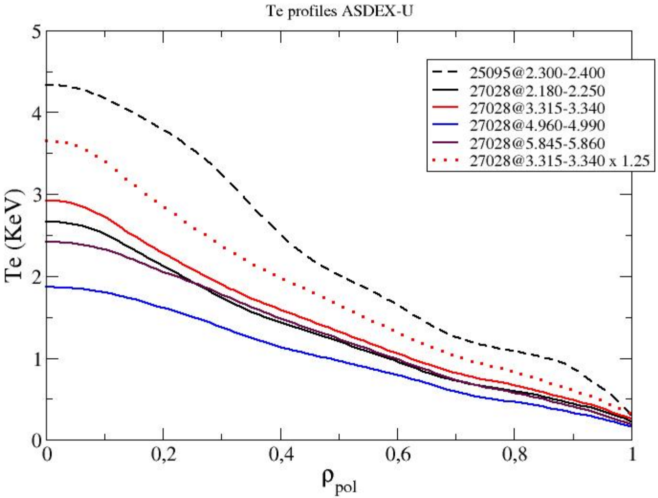
ADAS-EU
ADAS for fusion in Europe



Courtesy R. Guirlet

Ar experiment preparation in ASDEX

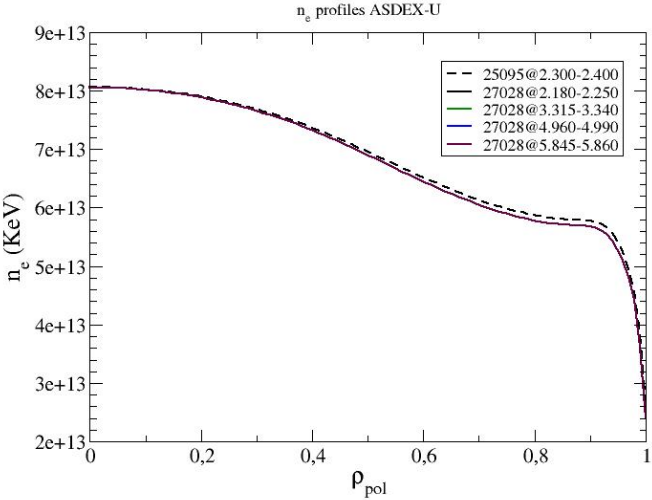
Temperature profiles



Ar experiment preparation in ASDEX

Density profiles

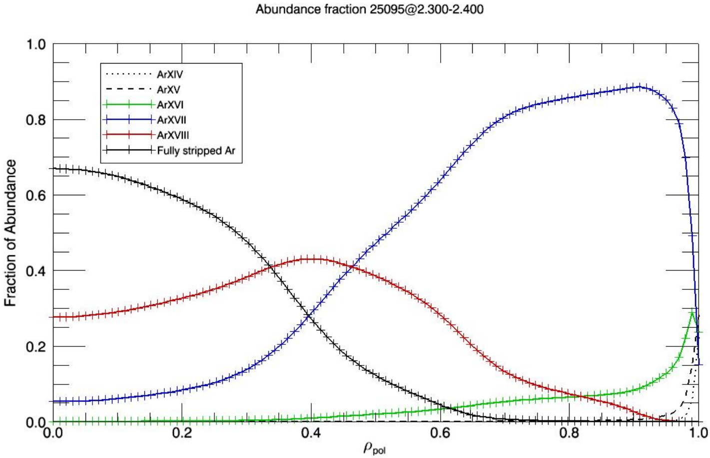
ADAS-EU
ADAS for fusion in Europe



Ar profiles 25095@2300-2400

ADAS 405 ion. eq. balance

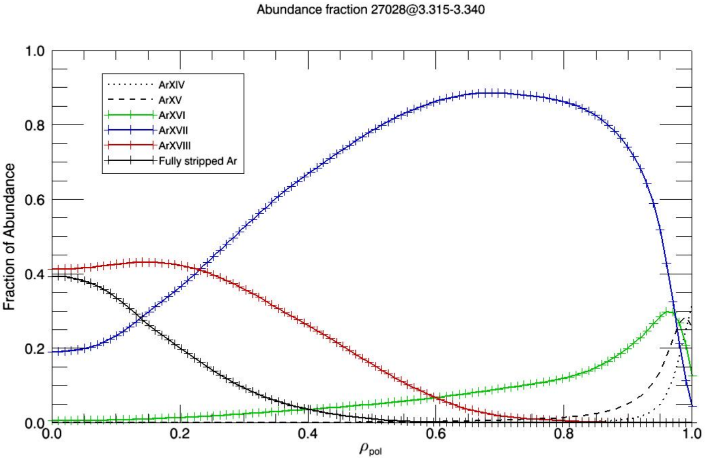
ADAS-EU
ADAS for fusion in Europe



Ar profiles 25095@3315-3340

ADAS 405 ion. eq. balance

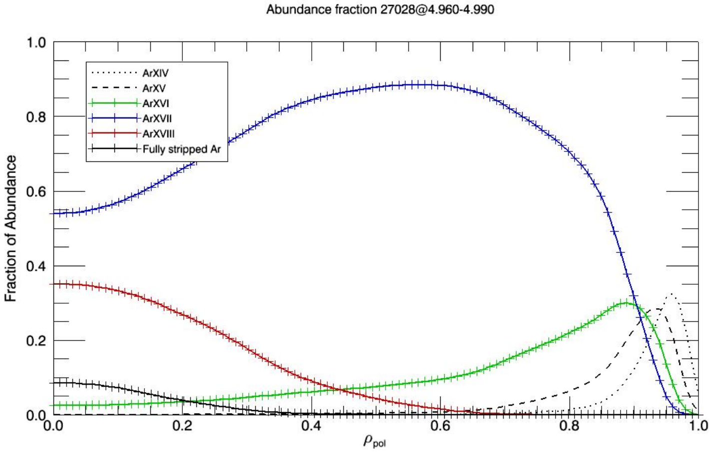
ADAS-EU
ADAS for fusion in Europe



Ar profiles 25095@4960-4990

ADAS 405 ion. eq. balance

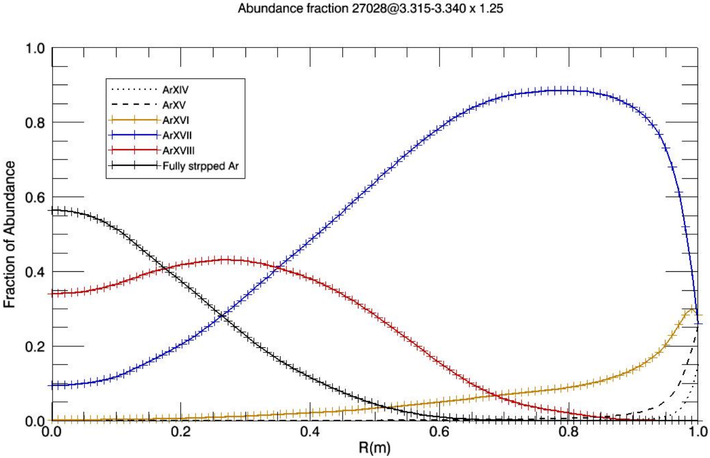
ADAS-EU
ADAS for fusion in Europe



Ar profiles 25095@3315-3340

ADAS-EU
ADAS for fusion in Europe

ADAS 405 ion. eq. balance



Summary

ADAS-EU
ADAS for fusion in Europe

- Cross sections accuracy is fundamental to obtain impurities densities by CXRS. There are big differences between the different calculations in cross sections.
- Experimental methods feedback in providing recommended cross sections.
- By comparison of diagnostic profiles two data sets are compared:
  1. Electron-impact excitation data with small uncertainties
  2. Ion-impact CX data
- Inconsistencies will be detected and the quality of data evaluated.

Summary

- Cross sections accuracy is fundamental to obtain impurities densities by CXRS. There are big differences between the different calculations in cross sections.
- Experimental methods feedback in providing recommended cross sections.
- By comparison of diagnostic profiles two data sets are compared:
  1. Electron-impact excitation data with small uncertainties
  2. Ion-impact CX data
- Inconsistencies will be detected and the quality of data evaluated.

Summary

- Cross sections accuracy is fundamental to obtain impurities densities by CXRS. There are big differences between the different calculations in cross sections.
- Experimental methods feedback in providing recommended cross sections.
- By comparison of diagnostic profiles two data sets are compared:
  1. Electron-impact excitation data with small uncertainties
  2. Ion-impact CX data
- Inconsistencies will be detected and the quality of data evaluated.

Summary

- Cross sections accuracy is fundamental to obtain impurities densities by CXRS. There are big differences between the different calculations in cross sections.
- Experimental methods feedback in providing recommended cross sections.
- By comparison of diagnostic profiles two data sets are compared:
  1. Electron-impact excitation data with small uncertainties
  2. Ion-impact CX data
- Inconsistencies will be detected and the quality of data evaluated.