ChemiX

Science motivation for Another solar Bragg crystal spectrometer

J. Sylwester

for the

SRC PAS Solar Physics Division Team

Please note the poster

Content

- State of the art in X-ray spectroscopy
- Why Bragg & bent spectrometer?
- What we can learn?
- What drives selection of spectral ranges & resolution (crystals & detectors)?
- What we have to compromise?
- Why we need to be close to the Sun?
- Present state of development?
- Funding perspectives in Poland?

Spectroscopy: the mother of (solar) plasma dignostics

- Well recognized early on (60ties) by several groups:
  - in Russia - Prof. Mandels'tam group (FIAN)
  - In UK- Prof. Pounds and Prof. Culhane
  - In US – Prof. Neupert, Doschek (our competitor?)
- Excellent theory tools from atomic physics
  - Prof. L.A. Vainshtein, Safronova, I. Beigman, A. Urnov, A. Gabriel,C. Jordan, J. Dubau, P. McWhirter
  - Now all included in CHIANTI SolarSoft

Just an example

1974

ANALYSIS OF THE INTENSITIES AND PROFILES OF THE SPECTRAL LINE Mg XII 8.42 Å IN THE SOLAR X-RAY SPECTRUM

J. JAKIMIEC
Wrocław University, Wrocław, Poland
V. V. KORNEEV, V. V. KRUTOV, and I. A. ZHITNIK
Lebedev Physical Institute, Moscow, U.S.S.R.
and
S. PŁOCIENIAK, B. SYLWESTER, and J. SYLWESTER
Polish Academy of Sciences, Solar-Terrestrial Relations Laboratory, Wrocław, Poland

Thermal (Tion) & turbulent width, intensity prop. to abundance

Doppler component

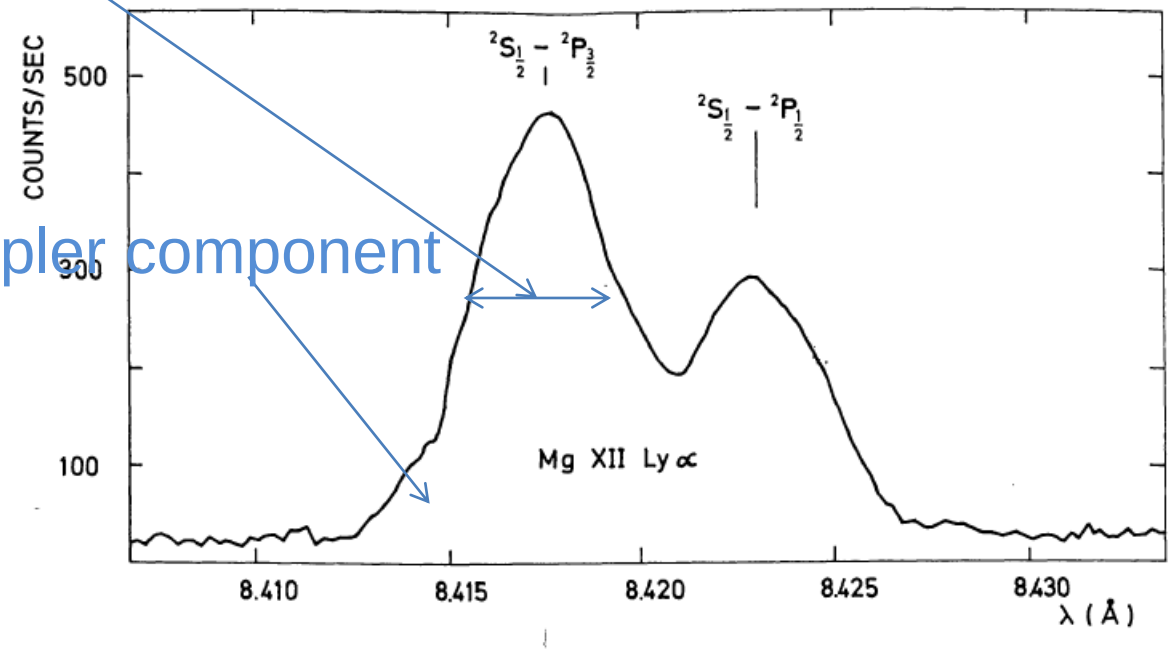
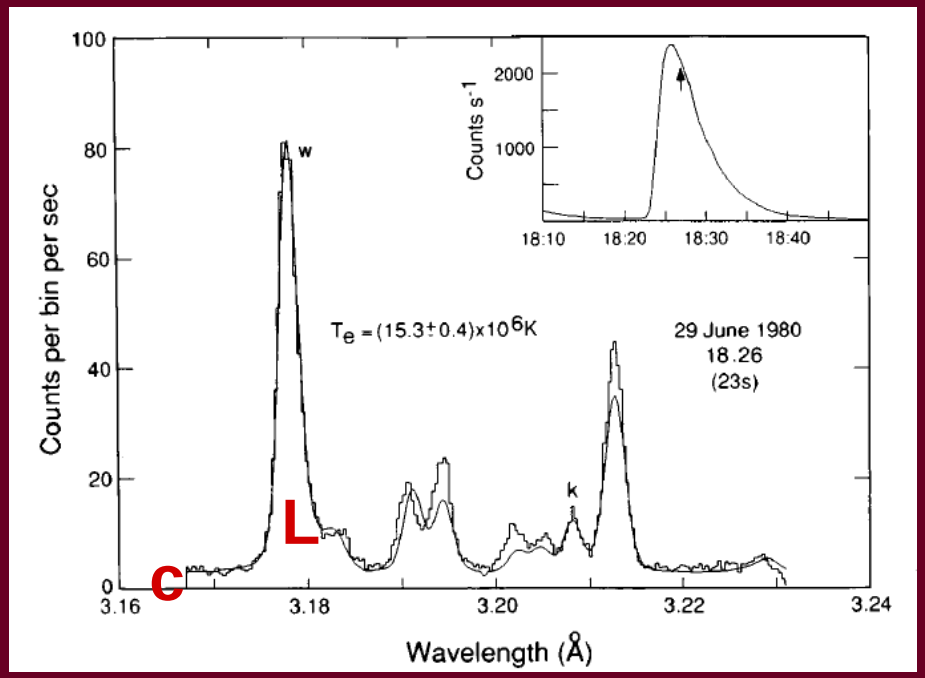


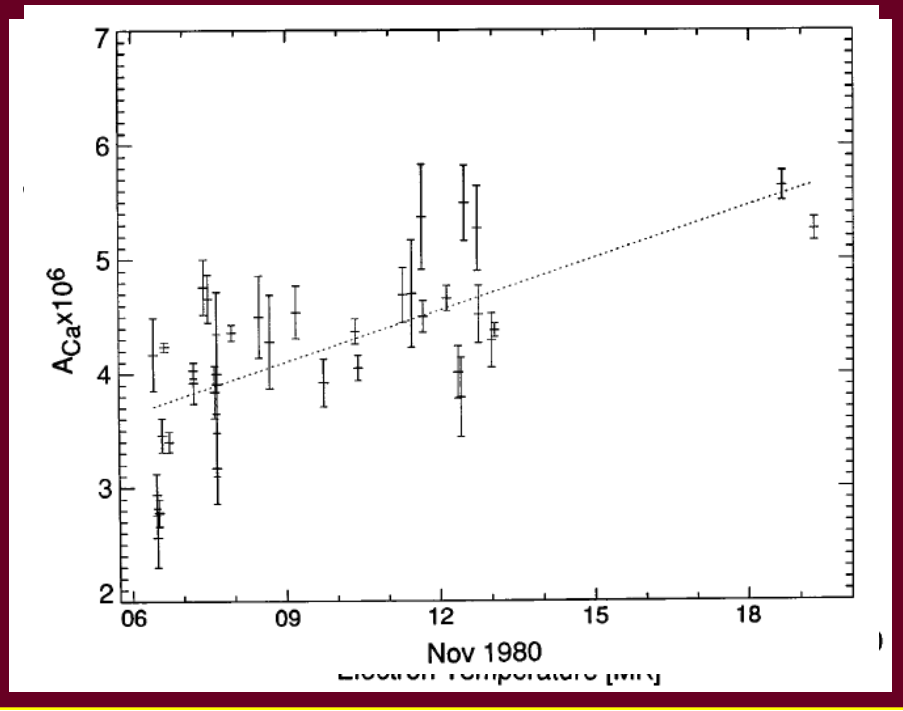
Fig. 1b.

The construction and operation of the satellite and of the spectrometer were analogous as in the case of Intercosmos 4 satellite (cf. Grineva *et al.*, 1972). The satellite was launched on 30 June 1972 and the present investigation is mainly based on the

Golden Age of Bragg solar spectroscopy 1970-1995,

Intercosmos-4,7,16, P-78, Hinotori, SMM-FCS, BCS, Yohkoh BCS



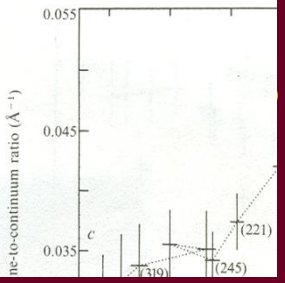


Reprinted from Nature, Vol. 310, No. 5979, pp. 665-666, 23 August 1984

Variation in observed coronal calcium abundance of X-ray flare plasmas

J. Sylwester*, J. R. Lemen† & R. Mewe‡

* Space Research Centre, Polish Academy of Sciences, Kopernika 11, Wroclaw, Poland
† Mullard Space Science Laboratory, Holmbury St Mary, Dorking, Surrey RH5 6NT, UK
‡ Laboratory for Space Research, Beneluxlaan 21, Utrecht, The Netherlands



THE ASTROPHYSICAL JOURNAL, 501:397–407, 1998 July 1

DETAILED EVIDENCE FOR FLARE-TO-FLARE VARIATIONS OF THE CORONAL CALCIUM ABUNDANCE

J. SYLWESTER
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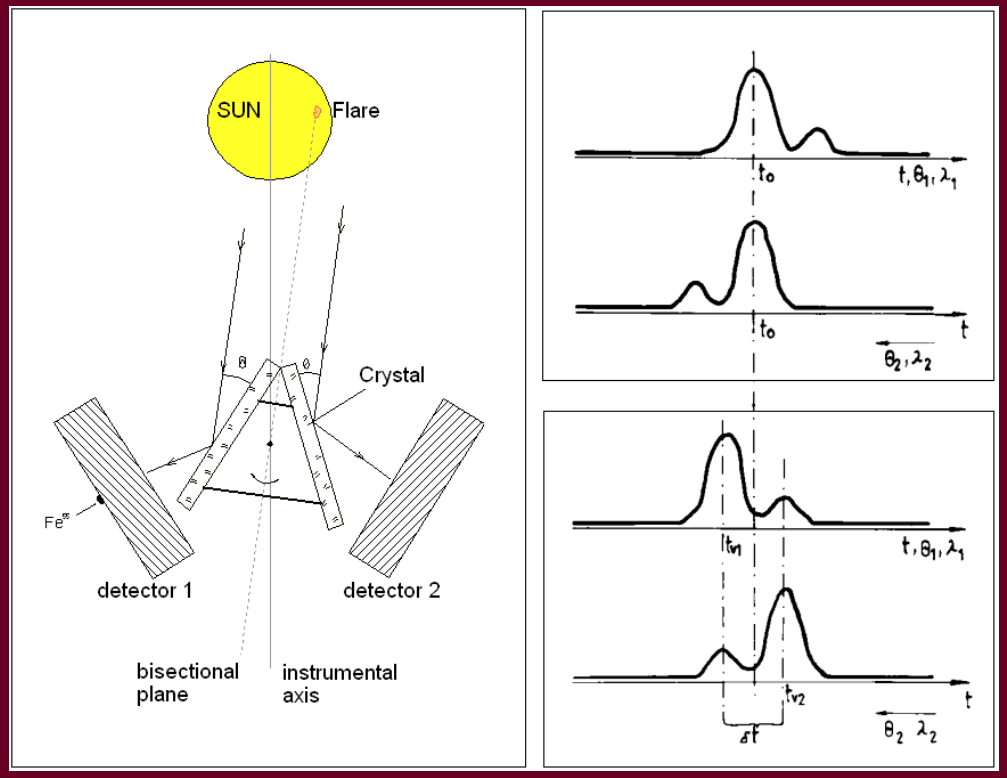
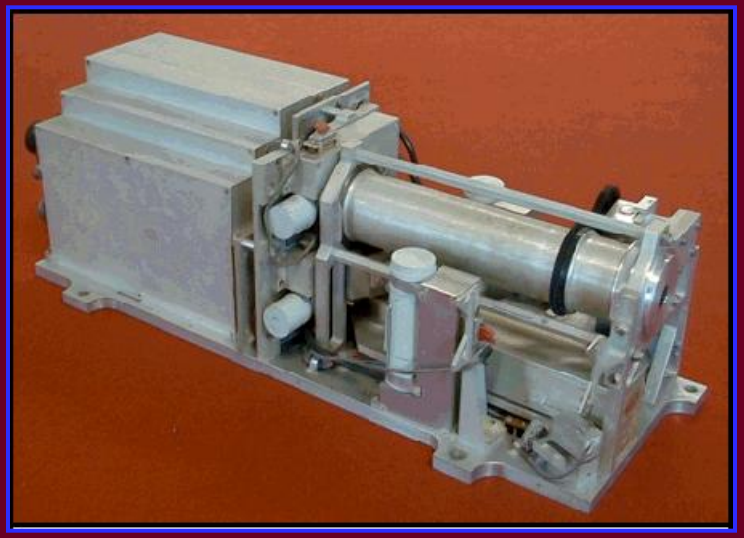
Received 1997 September 2; accepted 1998 February 9

New experience - new designs

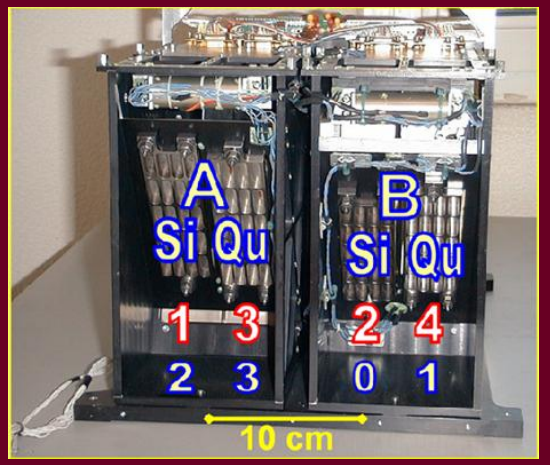
- X-ray Dopplerometer (~1980): absolute measurements of line shifts





RDR – Rocket Dopplerometer flown aboard Vertical-11 sounding rocket
Made in one year, launched in 1983

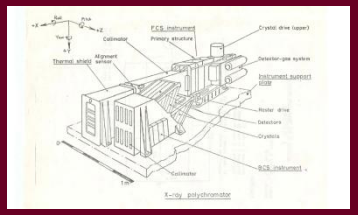
RESIK, by now the ultimate solar spectrometer aboard CORONAS-F (IZMIRAN)



- Unprecedented sensitivity
- Continuum is clearly visible
- Line-to-continuum provides
  elemental abundances
  first evers: K, Ar, Cl, S
- Bent crystal geometry: instant intensity measurements in all wavelengths

Privilages of being aboard IHZ

- Proximity to the Sun: fluxes x 20
  crystal sizes can be smaller
  2 m size 200 kg



SOLAR MAXIMUM MISSION

X-RAY POLYCHROMATOR

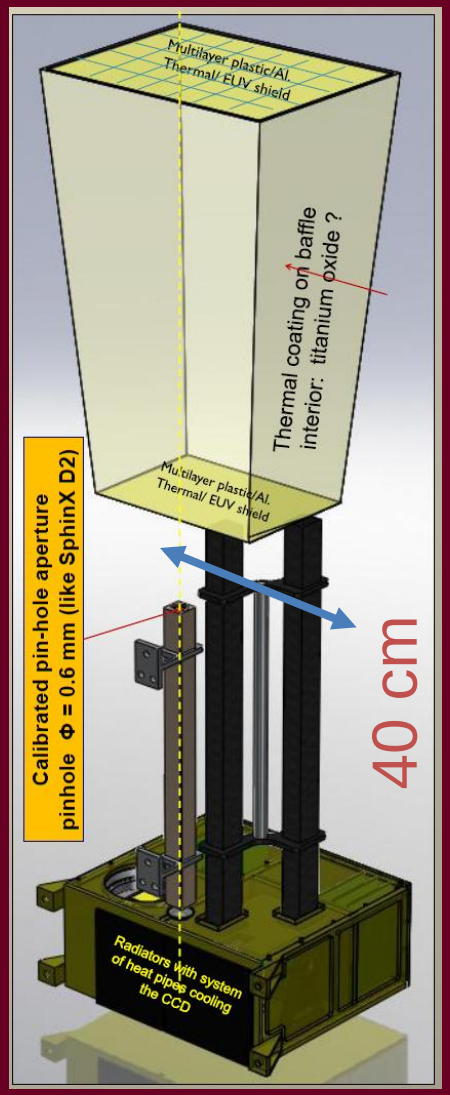
USER'S GUIDE

- Easy follow of particular AR due to co-rotation – pin-hole imaging option

So, what is ChemiX

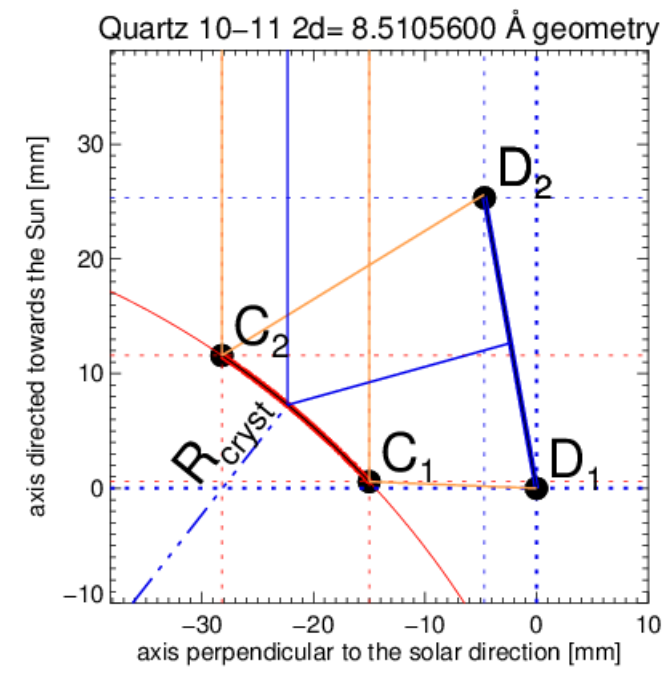
- Two CCD back illuminated detectors like these used in TESIS ~2000 position resolution
- 5 crystals illuminating the detectors:
  - 2 larger areas with crystal radiai ~50-70 cm
  - 3 smaller areas for specific physical tasks
- Smaller area crystals working in Dopplerometer orientation

Just a view on ChemiX



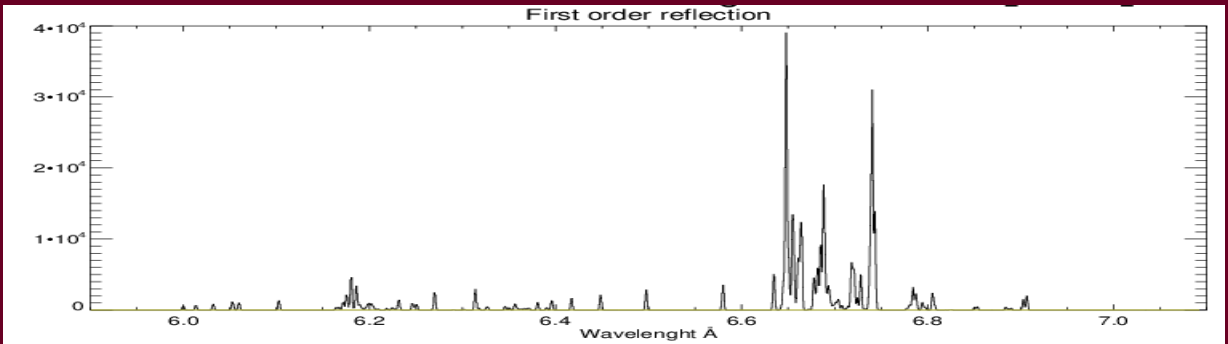
- Thermal & EUV blocking section (from 250C to 90C)
- Stationary Pin-hole X-ray Camera
- Moving slit collimatots
- Two crystal and detector sections (5pieces of the illuminating crystals) oriented in the opposite sense of dispersion

Spectral Coverage 6 - 7 Å

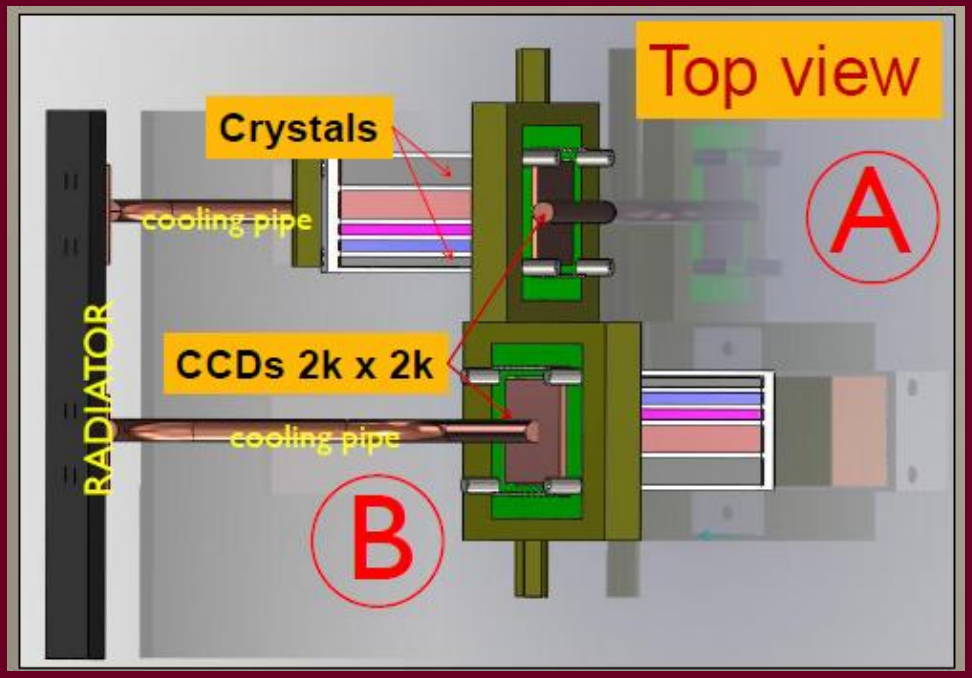


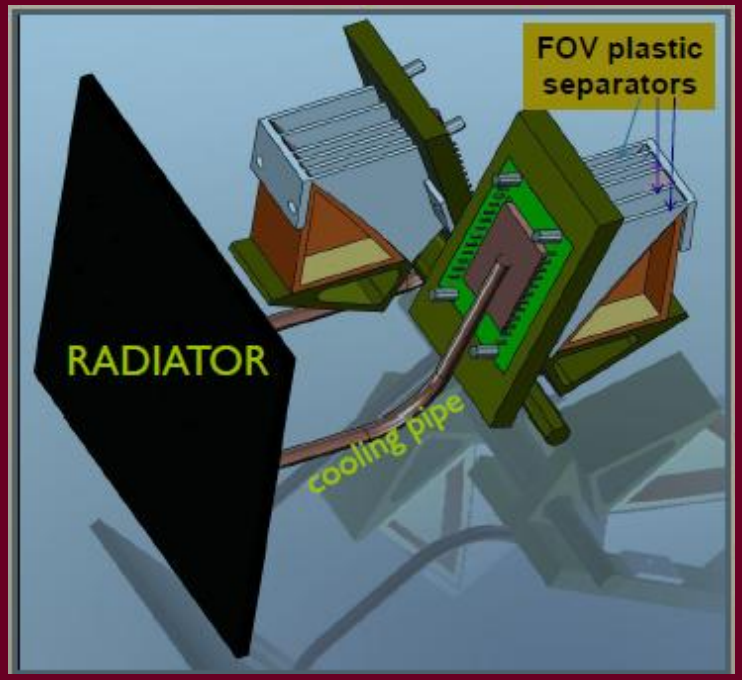
[5.900, 7.092] Å

$theta_{1(min)}$	:	43.888 [deg]
$theta_{2(max)}$	:	56.539 [deg]
det. angle	:	79.573 [deg]
R_{cryst}	:	78.000 [mm]
C_{length}	:	17.221 [mm]
$C_{1[x,y]}$:		[−15.000, 0.582] [mm]
$C_{2[x,y]}$:		[−28.207, 11.580] [mm]
$D_{1[x,y]}$:		[0.000, 0.582] [mm]
$D_{2[x,y]}$:		[−4.661, 11.580] [mm]
D_{length}	:	25.753] [mm]
D_{angle}	:	79.573 [deg]
$D_{pixel\ No.}$	:	2048
$D_{pixel\ size}$	:	12.575 [microns]
$D_{av\_resolution}$	:	0.00058 [A/pixel]
$D_{av\_dlamb/dthet}$	:	0.09361 [A/degree]



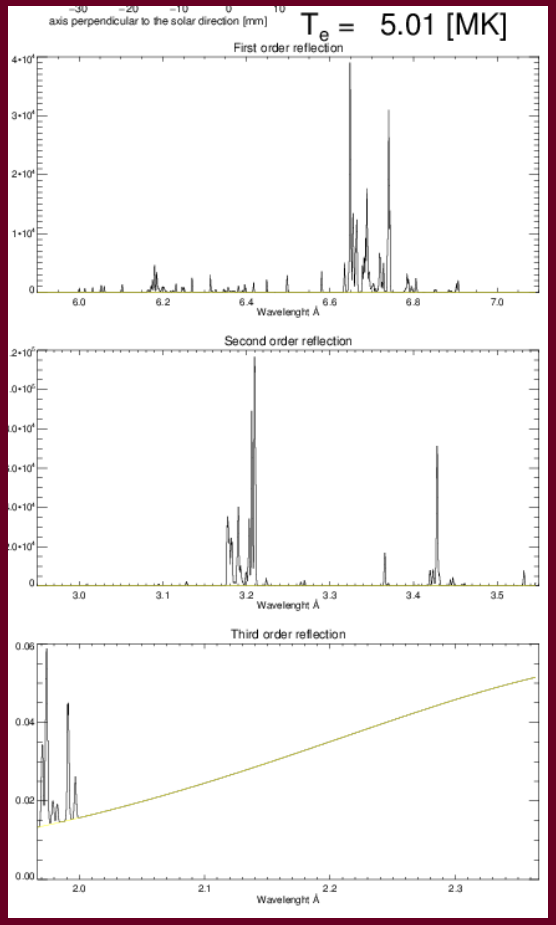
Crystal-detection sections

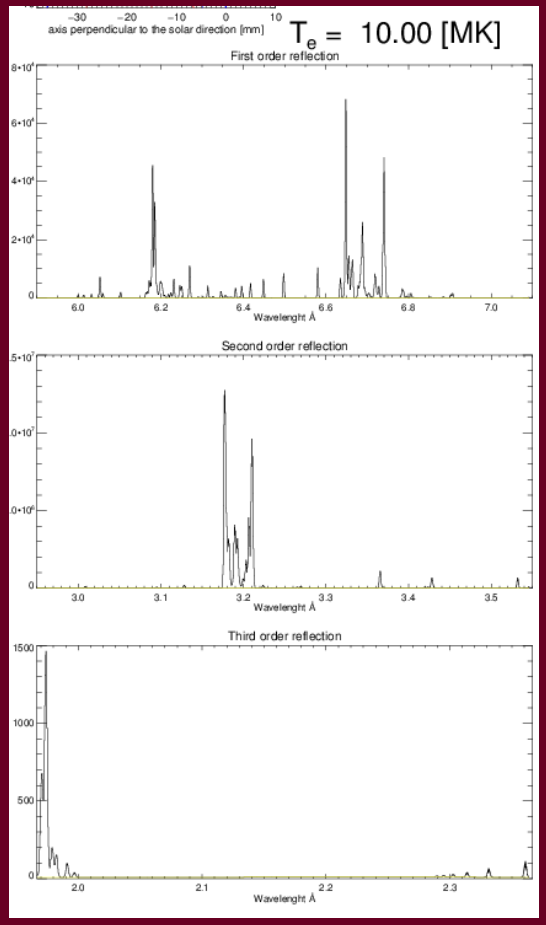


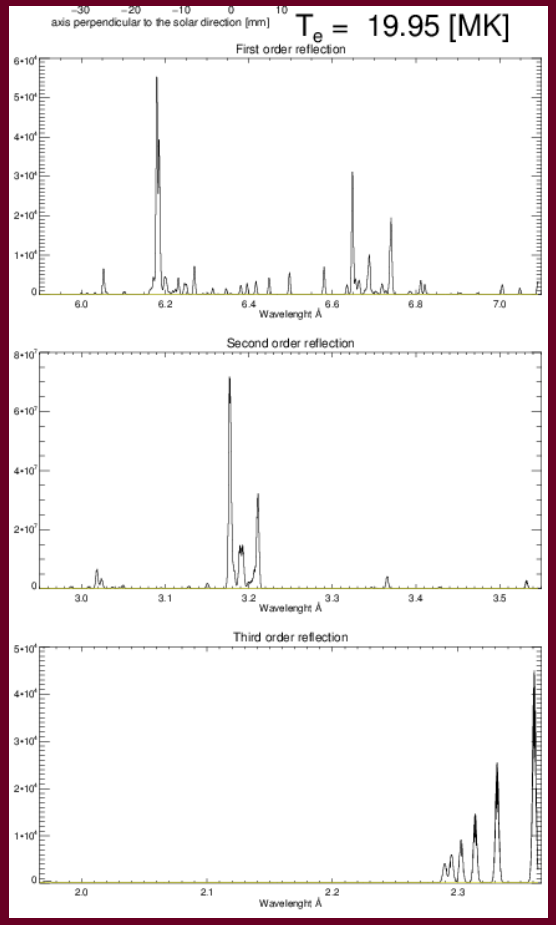


CCD: e2v 2048 x 2048 pixels like in TESIS MgXII channel
High efficiency active colling pipes – gas/condensation
5 spectral ranges on each CCD, 3 in the Dopplerometer configuration;
Recccomendations are being asked forom the community: FIAN, Ken Phillips, Helen Mason, Giulio del Zanna

Higher orders of reflection..





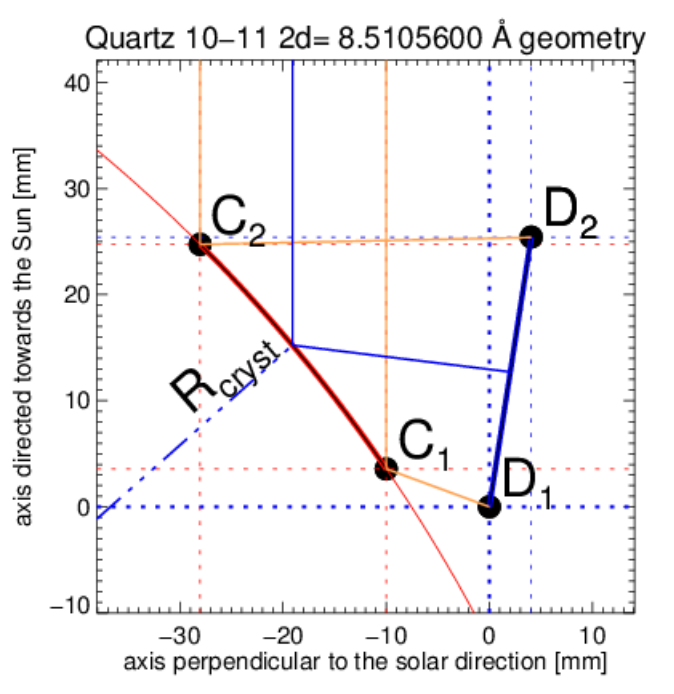


5 MK

10 MK

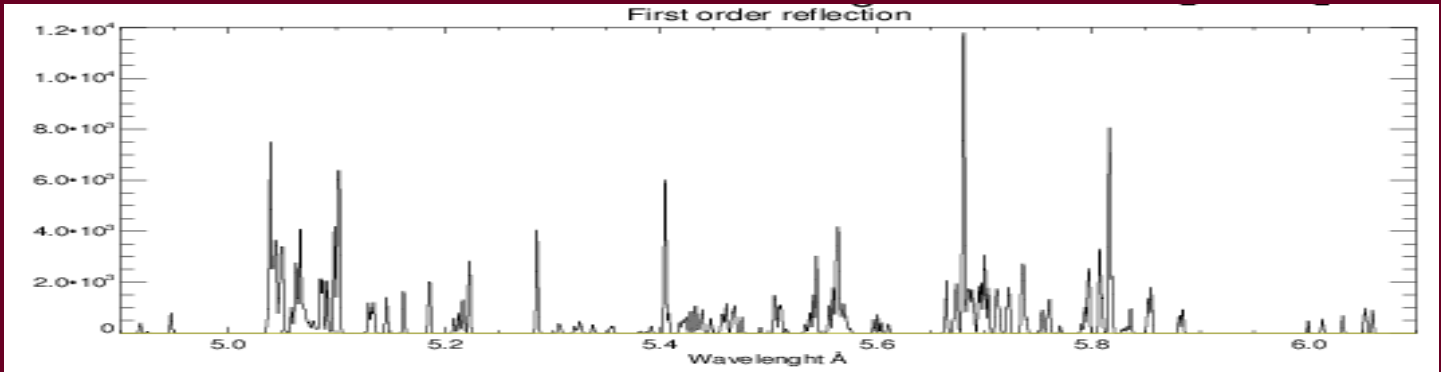
20 MK

Spectral Coverage 5 - 6 Å

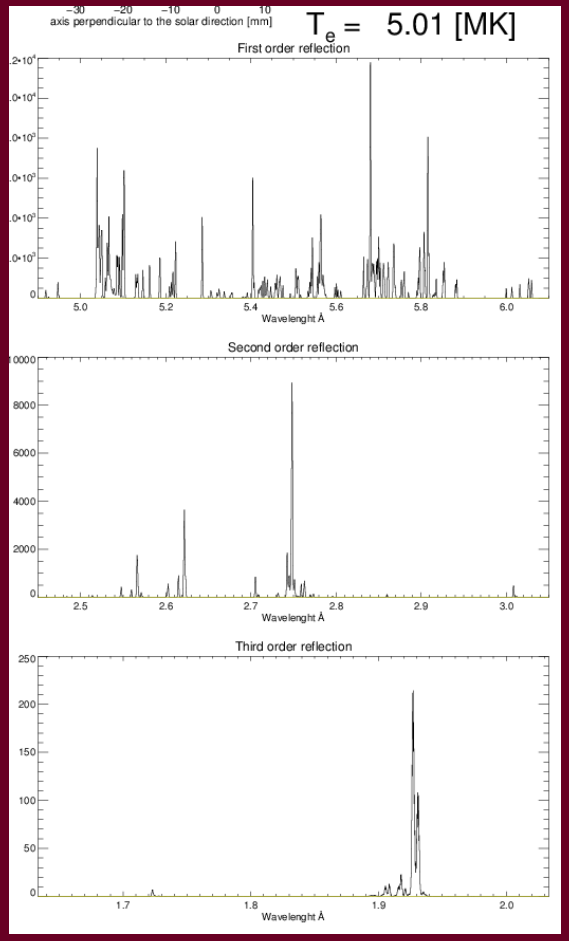


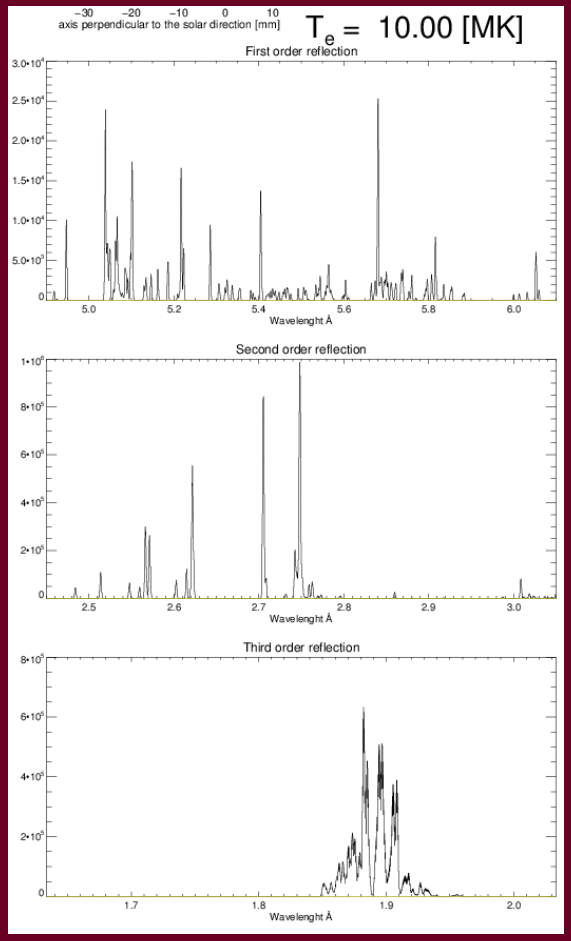
[4.900, 6.102] Å

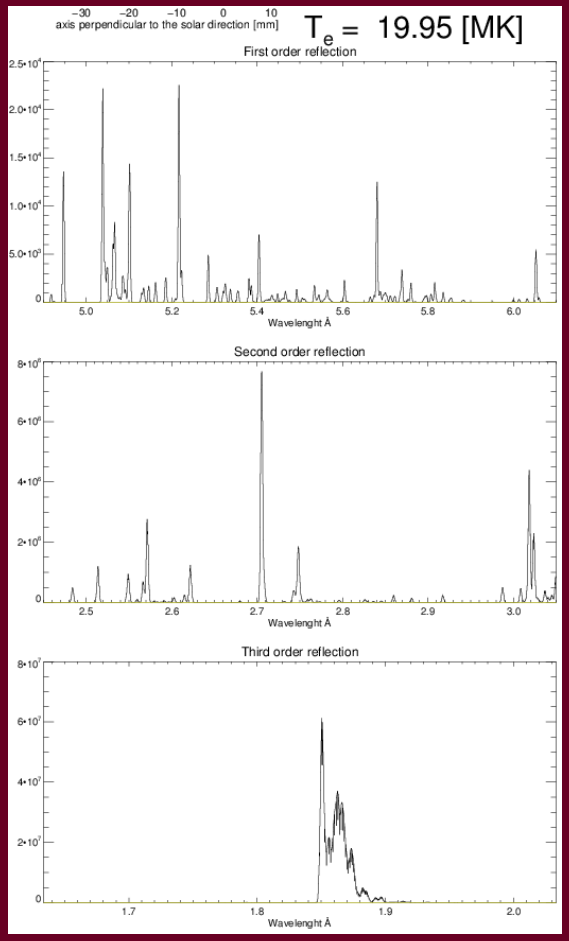
$theta_{1(min)}$	:	35.153 [deg]
$theta_{2(max)}$	:	45.787 [deg]
det. angle	:	99.060 [deg]
R_{cryst}	:	150.000 [mm]
C_{length}	:	27.842 [mm]
$C_{1[x,y]}$:		[−10.000, 3.580] [mm]
$C_{2[x,y]}$:		[−28.045, 24.730] [mm]
$D_{1[x,y]}$:		[0.000, 3.580] [mm]
$D_{2[x,y]}$:		[4.055, 24.730] [mm]
D_{length}	:	25.753] [mm]
D_{angle}	:	99.060 [deg]
$D_{pixel\ No.}$	:	2048
$D_{pixel\ size}$	:	12.575 [microns]
$D_{av\_resolution}$	:	0.00059 [A/pixel]
$D_{av\_dlamb/dthet}$	:	0.11246 [A/degree]



Higher orders of reflection..





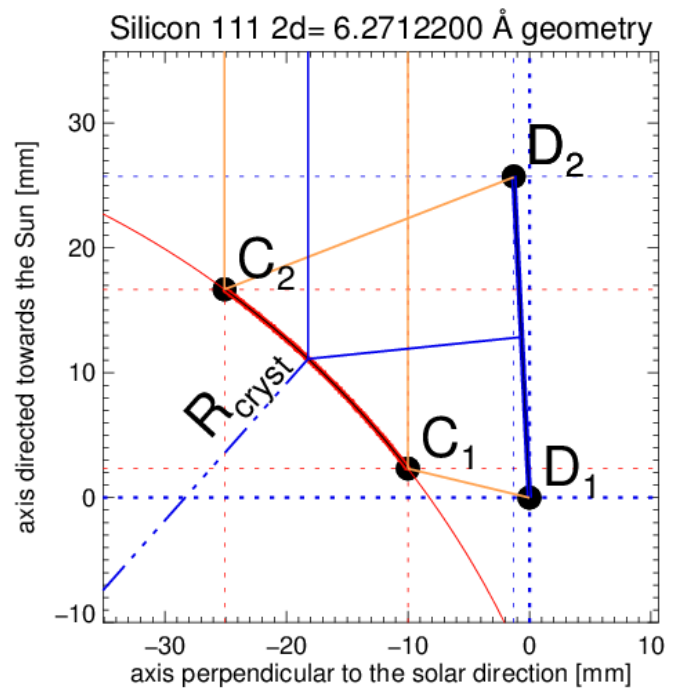


5 MK

10 MK

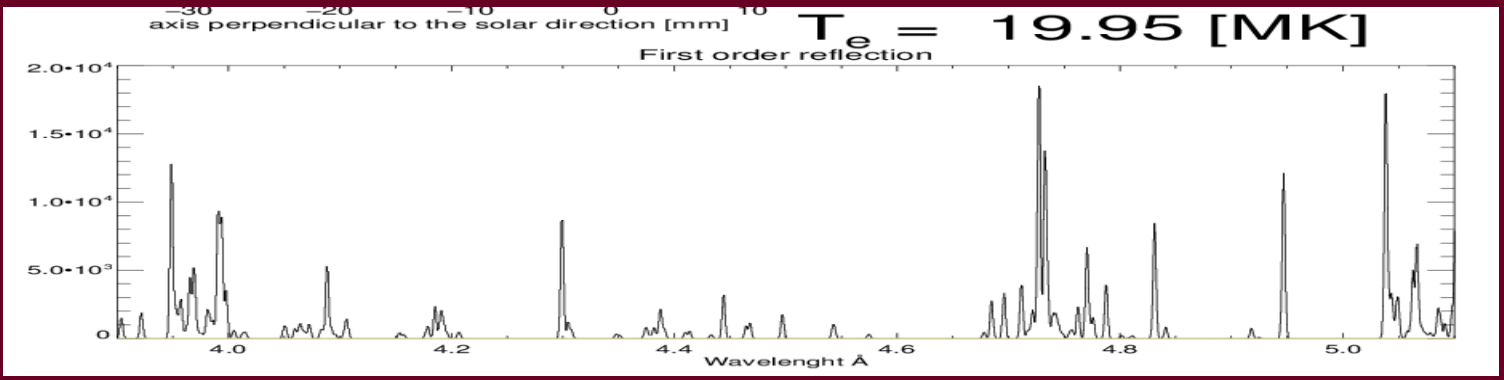
20 MK

Spectral Coverage 4 - 5 Å

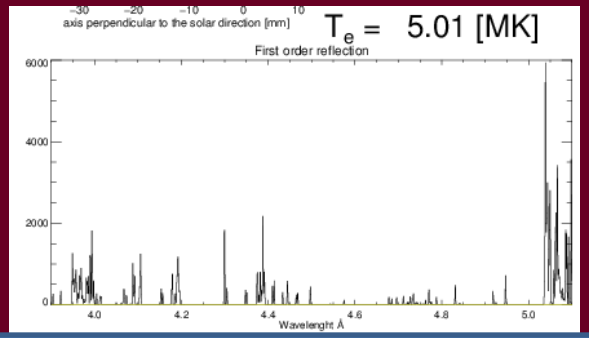


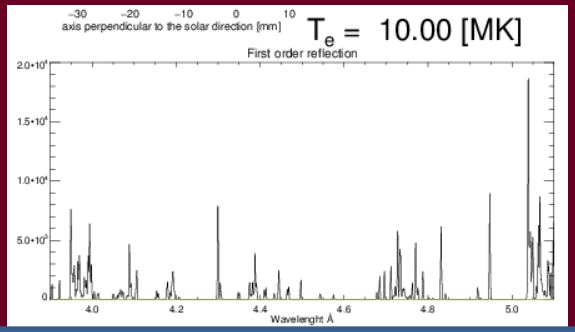
[3.900, 5.102] Å

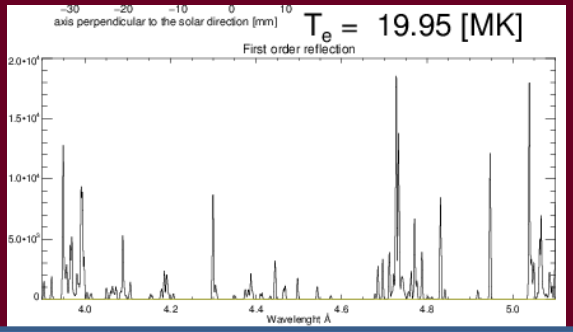
$theta_{1(min)}$	:	38.454 [deg]
$theta_{2(max)}$	:	54.414 [deg]
det. angle	:	87.132 [deg]
R_{cryst}	:	75.000 [mm]
C_{length}	:	20.891 [mm]
$C_{1[x,y]}$:		[−10.000, 2.326] [mm]
$C_{2[x,y]}$:		[−25.088, 16.677] [mm]
$D_{1[x,y]}$:		[0.000, 2.326] [mm]
$D_{2[x,y]}$:		[−1.288, 16.677] [mm]
D_{length}	:	25.753] [mm]
D_{angle}	:	87.132 [deg]
$D_{pixel\ No.}$	:	2048
$D_{pixel\ size}$	:	12.575 [microns]
$D_{av\_resolution}$	:	0.00059 [A/pixel]
$D_{av\_dlamb/dthet}$	:	0.07405 [A/degree]



Higher orders of reflection..Si 111







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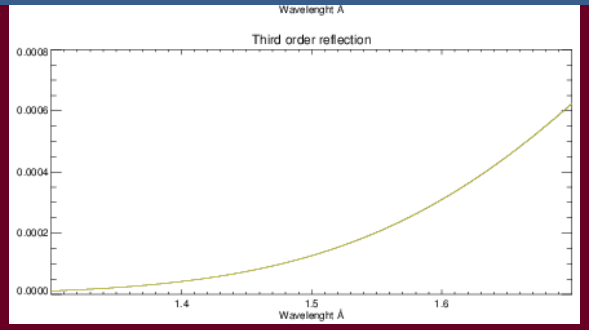
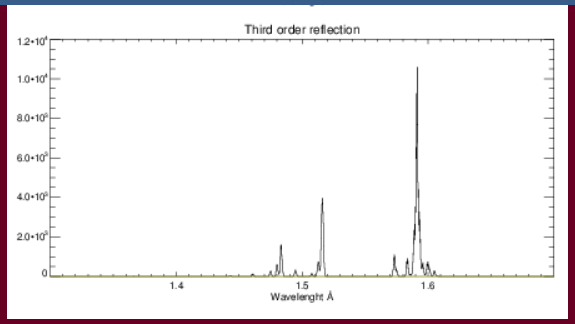
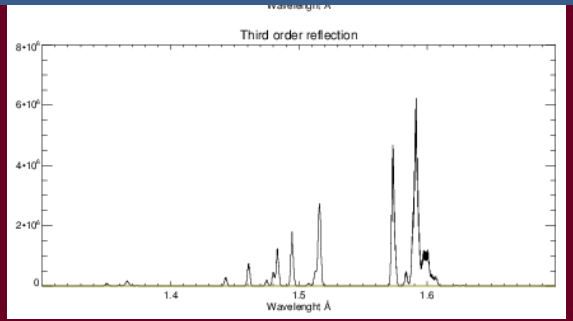




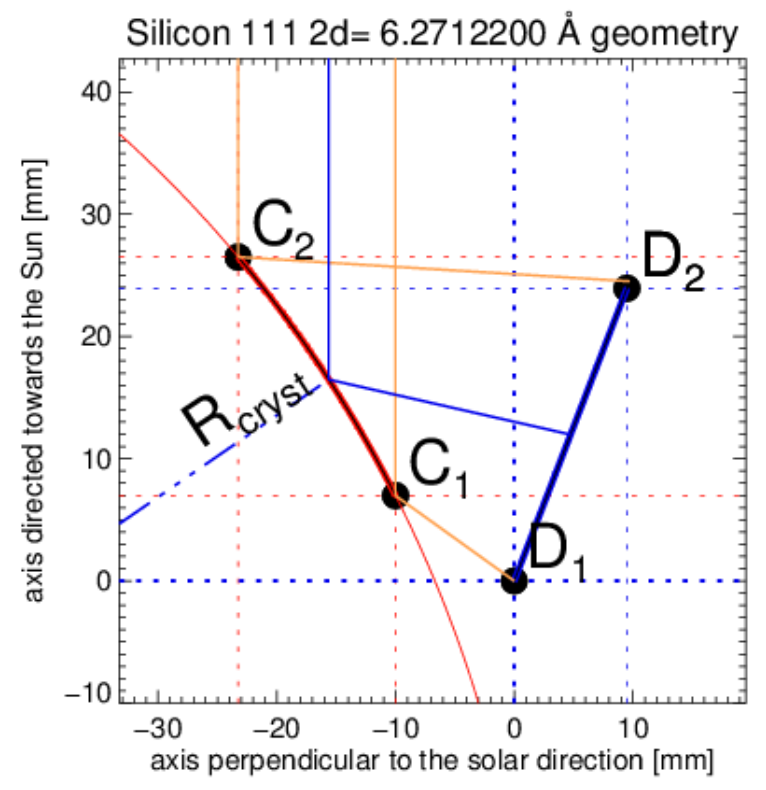


5 MK

10 MK

20 MK

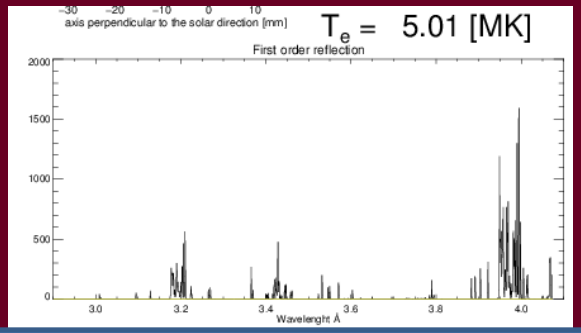
Spectral Coverage 3 - 4 Å

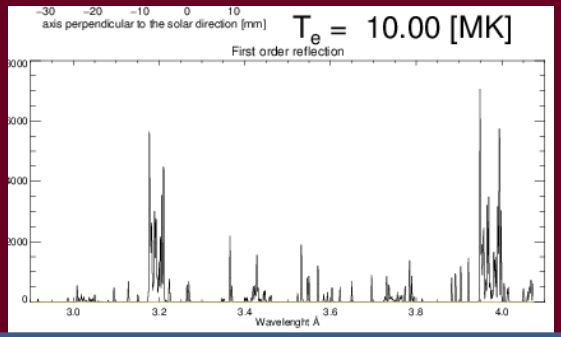


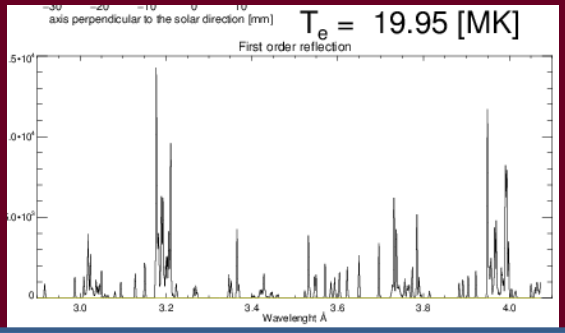
[2.900, 4.073] Å

$theta_{1(min)}$	:	27.544 [deg]
$theta_{2(max)}$	:	40.827 [deg]
det. angle	:	111.629 [deg]
R_{cryst}	:	102.000 [mm]
C_{length}	:	23.647 [mm]
$C_{1[x,y]}$	:	[−10.000, 6.979] [mm]
$C_{2[x,y]}$	:	[−23.257, 26.497] [mm]
$D_{1[x,y]}$	:	[0.000, 6.979] [mm]
$D_{2[x,y]}$	:	[9.492, 26.497] [mm]
D_{length}	:	25.753] [mm]
D_{angle}	:	111.629 [deg]
$D_{pixel\ No.}$	:	2048
$D_{pixel\ size}$	:	12.575 [microns]
$D_{av\_resolution}$	:	0.00057 [A/pixel]
$D_{av\_dlamb/dthet}$	:	0.09072 [A/degree]

Higher orders of reflections..Si 111







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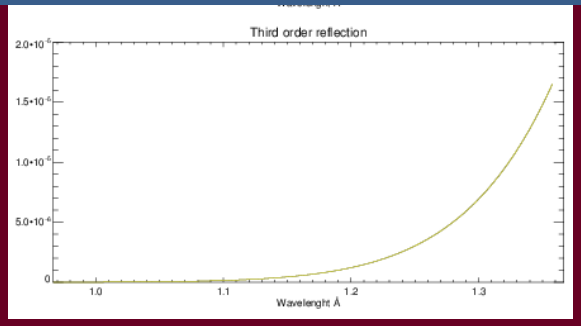
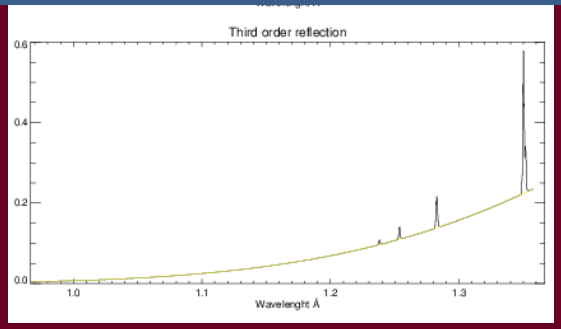
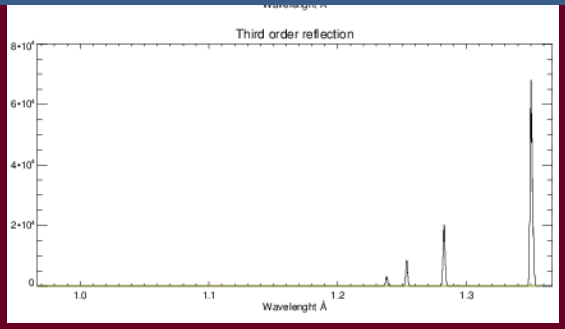




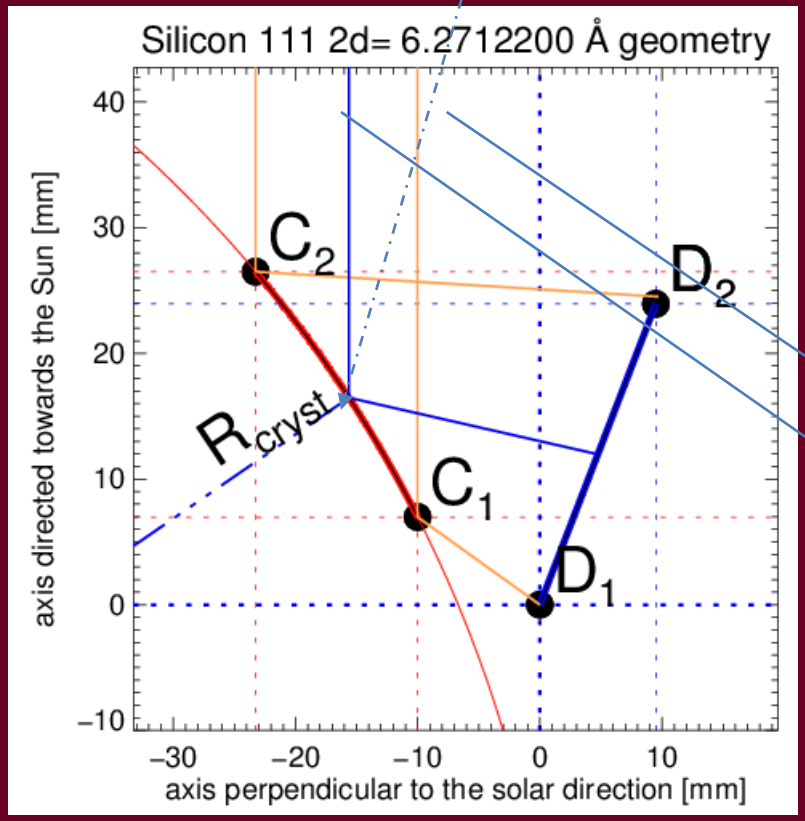


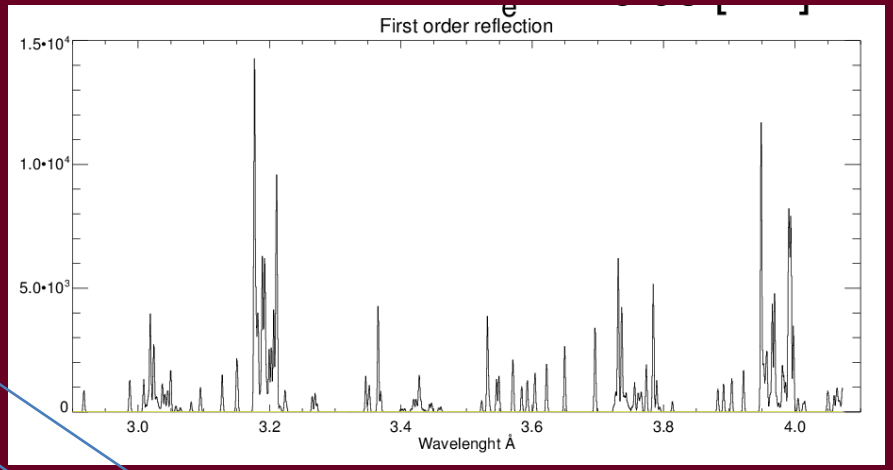
5 MK

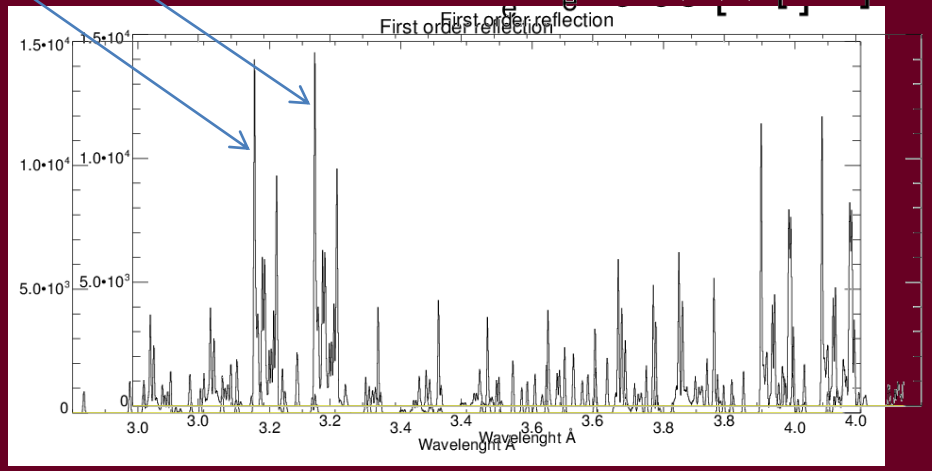
10 MK

20 MK

Why the collimator?

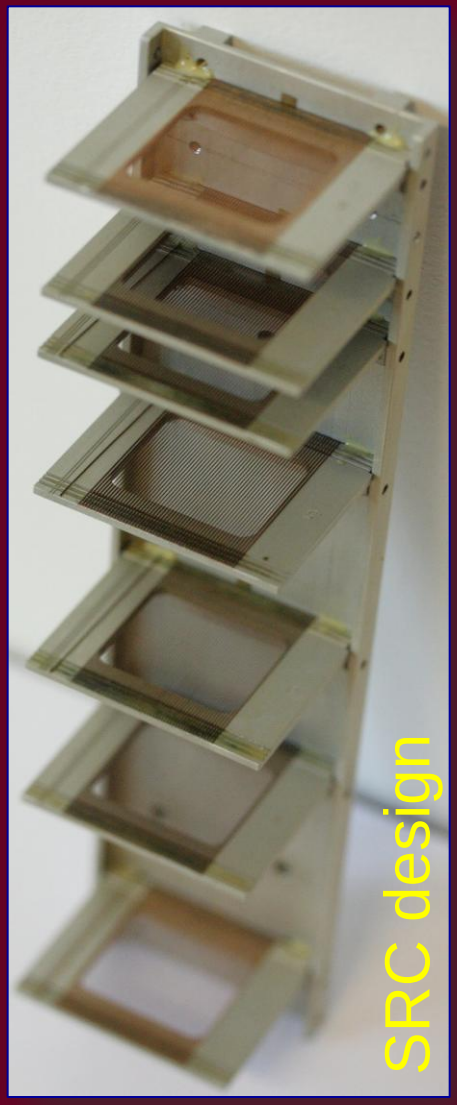






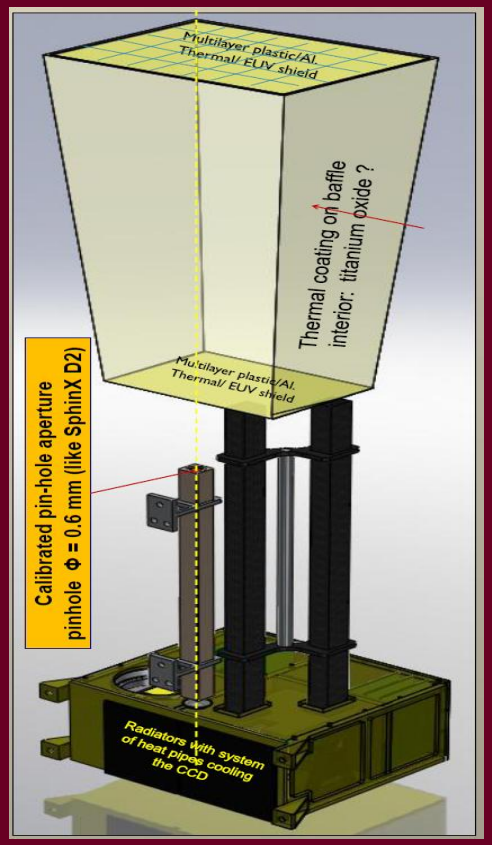
RESIK bad experience →

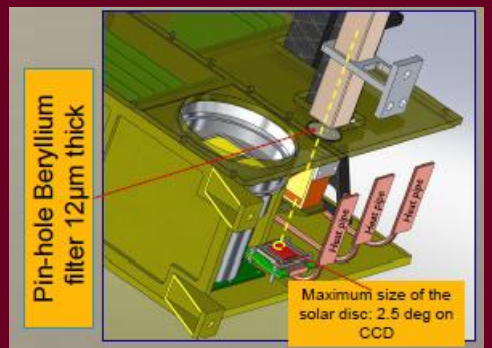
Why the collimatosr? → just a single AR



- Fixes beam FOV to desired angular range
  - 100 thousand km? on the Sun for AR at close distance
  - 30 thousand km? for flare kernels, good for AR at larger distances
- Prevents side illumination to within 2.5 deg
- Flight tested on Vertical-11 and Interball-tail
- GENETIC algorithms now in use
- Experience present in aligning and transmission measurements

Summary: the attributes of the instrument





- X-ray pin-hole camera (dedicated CCD)
  - 100 thousands km → allow to „isolate" indiviual AR
  - All the time determines the brightest area on the disk & the coordinates
  - Investigate the light-curves of individual AR
  - Provides info for the crystal collimator where to point…
- Flare- like flags issued for individual AR
- Fast re-pointing to the brighest area, but a dedicated sequence can override
- Nano-flare brightennings
- GOES+ measurements for individual AR X-ray activity

Possible science outcome again

- Line and continuum intensities → Absolute elemental abundances to within 0.01-0.02 in log scale, i.e. many times better than from optical range, meteorites etc, evenet to event variability. The best ever- superior to photosperic
- Non-thermal component of line excitation
  - Behaviour of tail electrons below 10 keV
  - Diagnostics of interaction regions plasm velocities & Doppler shifts & ion temps & el Temps & PDF's possibly
  - Detection of bumps on PDF for particles
- Turbulent properties (wave signatures?) of flaring plasmas
- Absolute line positions & detailed studies of Doppler line shifts during flares (obs vs, evaporation theory) comparison with results of hydrodynamic modelling (we have running codes of NRL & Palermo-Harvard)

Funding

- Inviting letter to kick-off → v. important
- Grant application for phase B of ChemiX for NCN (deadline early June)
- Seeking possible support from „other” institutions
- Some work already done (geometry simulations) - all ideas are wellcome from atomic physics specialists in Russia in the first instance – „free tokomak plasma spectra”

Great Thanks !!!

To:

all Friends

here in Russia, for „letting us in” aboard the InterHelioZond

☺

Wroclaw team