Air Light 03

International Workshop Bad Liebenzell, Germany, December 11 - 14, 2003

Design and tests of the AirFly spectrophotometer

Sergio Petrera, L'Aquila, for

the AIRFLY Collaboration

Summary

- Introduction
- The AirFly spectrophotometer
- What we expect to get from our instrument
- Preliminary background tests with a 'demo' spectrometer at the Frascati BTF
- Conclusions

Why measure the 'complete' spectrum of the air ?

The fluorescence light detected by telescope for cosmic ray measurements is modified by the Rayleigh scattering ($\propto 1/\lambda^4$)

Spectrum lines less intense but at lower wavelength could have relevant contribution to the total fluorescence signal

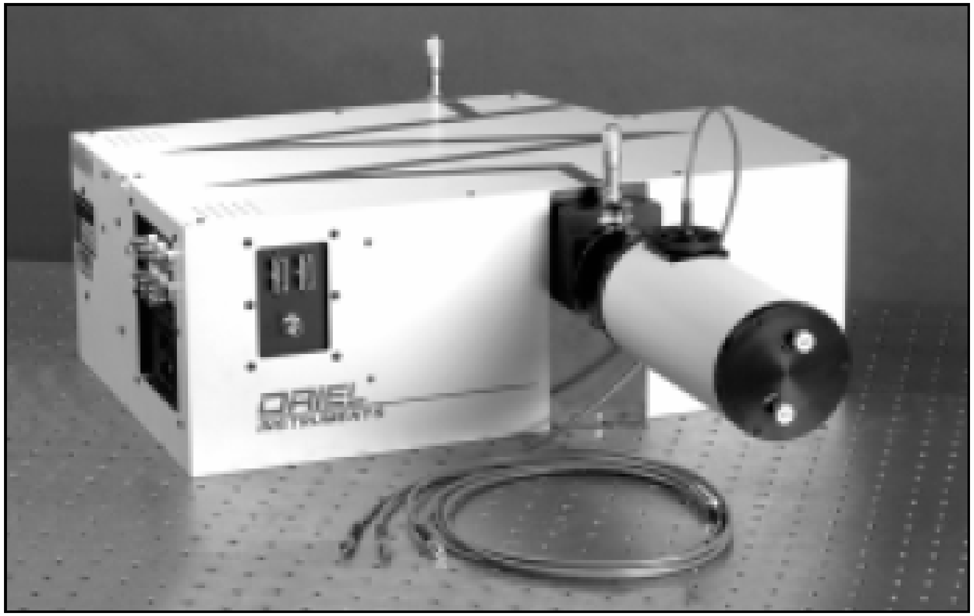
Why a spectrophotometer ?

Our choice: spectrometer + CCD

•Measuring the whole spectrum in the same time interval reduces systematics due to beam variability (⇒easier beam monitoring)

•Easier and more efficient calibration:
Xe NIST calibrated light source (Hamamatsu L7810) ≈ flat spectrum 300÷800 nm

AirFly spectrometer



L.O.T. Oriel Spectrometer MS257

Focal length: 25.7 cm
Nominal resolution: 0.1 nm
Multiple grating turret:
1200 L/mm Blaze 350nm
600 L/mm Blaze 400nm

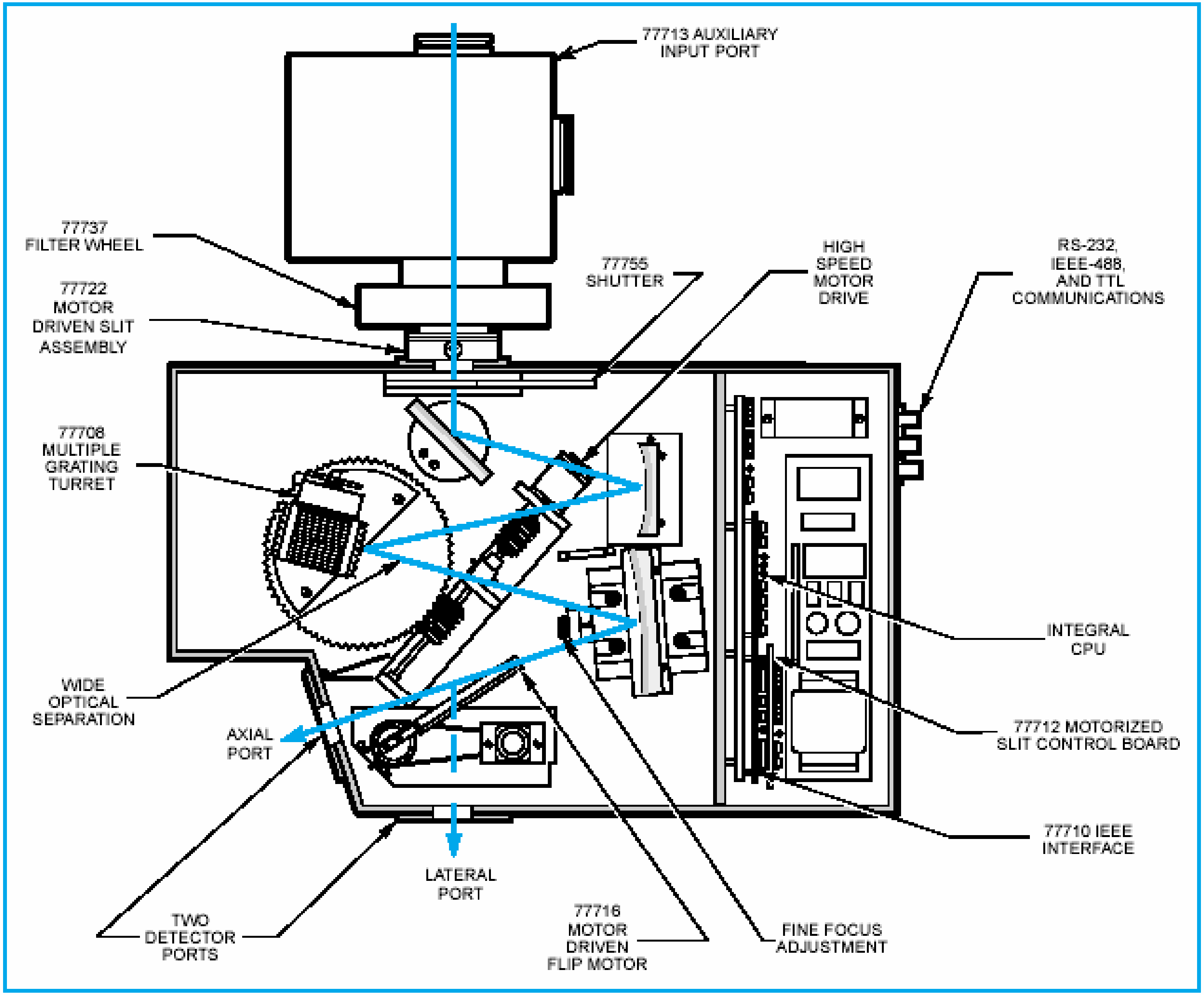
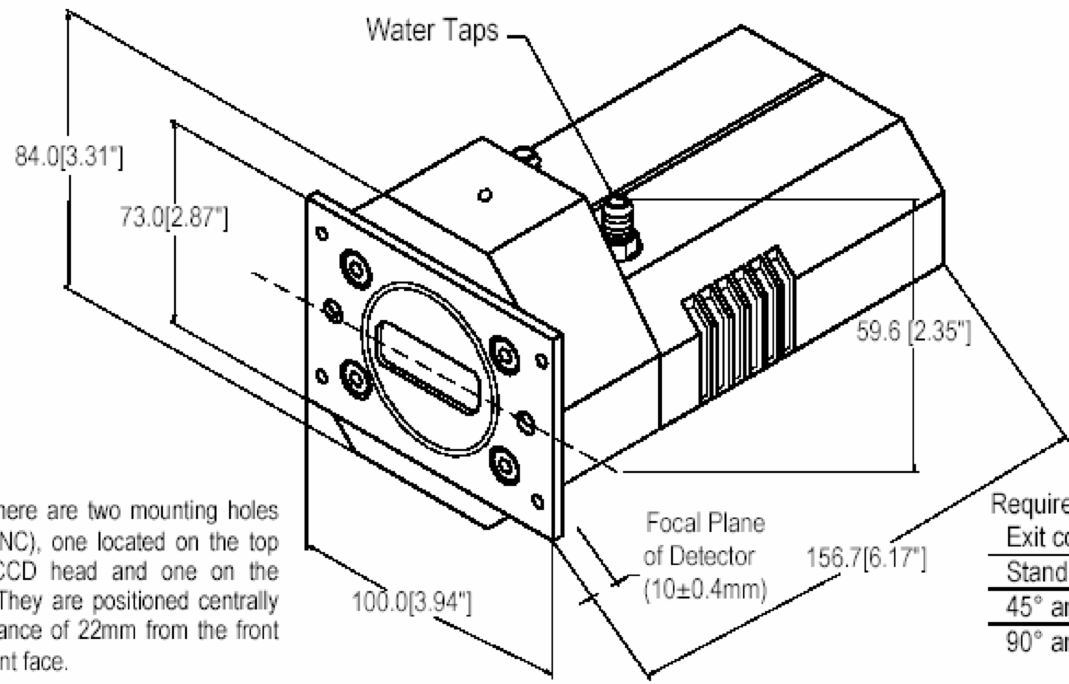


Fig. 1 MS257™ Monochromator and Spectrograph with selected optional accessories.

AirFly CCD

ANDOR TECHNOLOGY

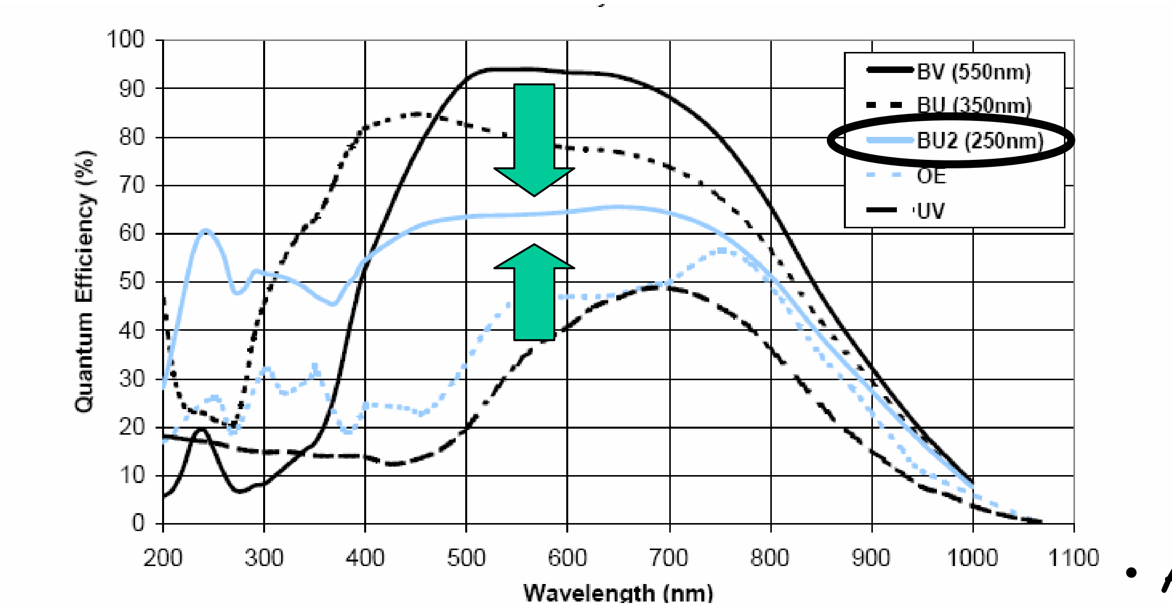
DV420



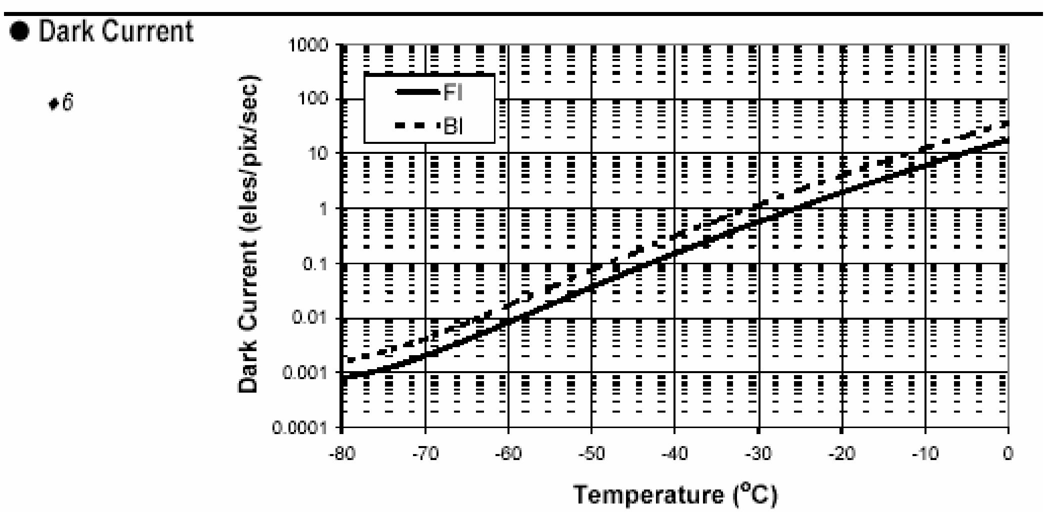
Note: There are two mounting holes (1/4-20UNC), one located on the top of the CCD head and one on the bottom. They are positioned centrally at a distance of 22mm from the front of the front face.

Required Cable Clearance at back:

Exit connector type	Clearance
Standard	140 mm
45° angle	50 mm
90° angle	40 mm

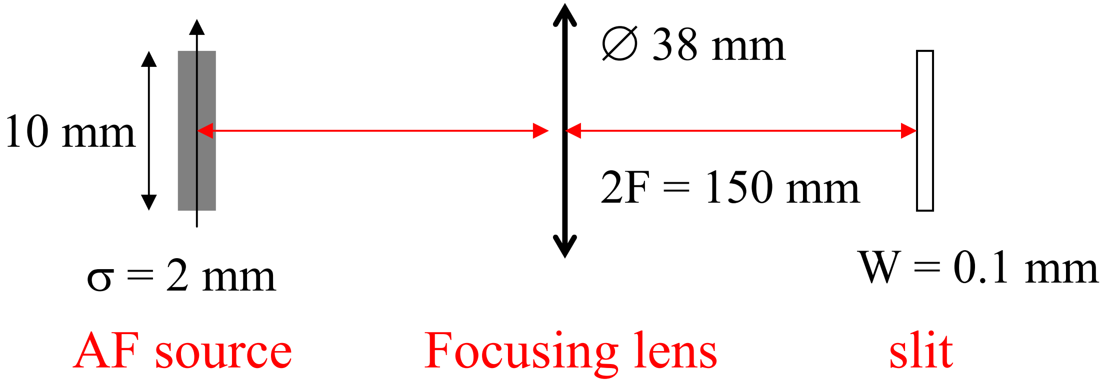


ANDOR CCD DV420



- Active pixels: 1024X256
- Dark current: 3.6 e/pixel/hr @ -80°C
- A/D converter: 32 bit
- Pixel grade: '1' (no spurious pixels)

What we expect to get from it?



$$\Delta\Omega/4\pi = 4 \times 10^{-3}$$

$$I_{in} = Y \times \Delta\Omega/4\pi \times L = 1.6 \times 10^{-4}\ \gamma / e$$

$$I_{det} = I_{in} \times F_{\gamma} \times \varepsilon_{blaze} \times \varepsilon_{mir} \approx 2 \times 10^{-6}\ \gamma / e \text{ @CCD}$$

0.025 0.6 0.8

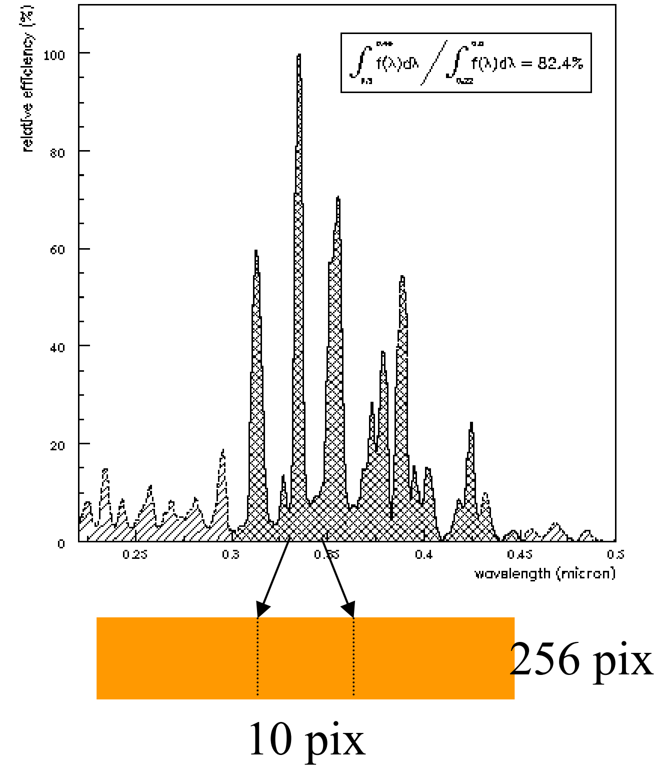
$$Signal = I_{det} \times R_{slit} \times \varepsilon_{CCD} \approx 6.5 \times 10^{-7}\ e_{CCD} / e$$

0.66 0.5

@ 10^8 e/bunch $\Rightarrow$ 65 e_{CCD} / bunch

337 nm line:

- ¼ Tot $\Rightarrow$ 16 e_{CCD} / bunch
- onto 10 × 256 pixels
- 24 Hz beam rep. Rate



Signal ~ 0.15 / pixel / s

Noise:

- Dark current ≈ 10^{-3} / pixel / s $\Rightarrow$ S/N ~ 150
- ReadOut noise ≈ 4 / pixel $\Rightarrow$ over 2560 pixels ≈ 200 e_{CCD}

Integrating signal over e.g. 60 s:

$IS_{337} = 0.15 \times 2560 \times 60 \approx 23000$ $\Rightarrow$ accuracy ~ %

Frascati tests

'Demo' spectrophotometer just to check the background behavior in the BTF room

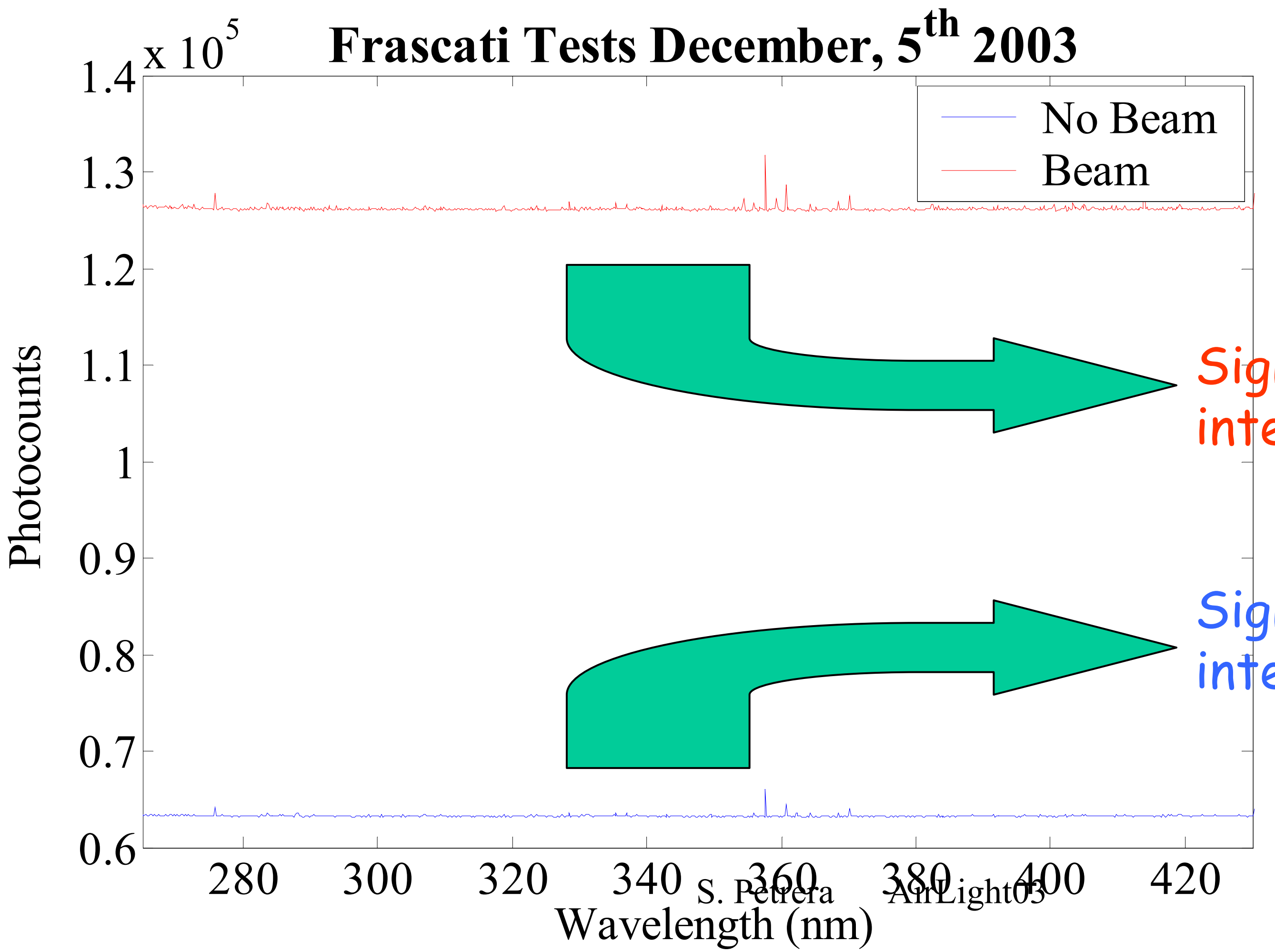
Less efficient of the instrument we got!:

Spectrometer MS125:
focal length 12 cm,
resolution 0.2 nm grating blaze @ 250nm
(efficiency @ 300nm 50% lower than ours).

CCD:
Front illuminated (1/5 less efficient than ours),
Active area: 1024x128 (half of ours)
Cooling @ - 40°C (100 times more noisy than ours)
Pixel grade: '3' (more than 12% of spurious pixels)

Frascati tests (Dec. 5, 2003)

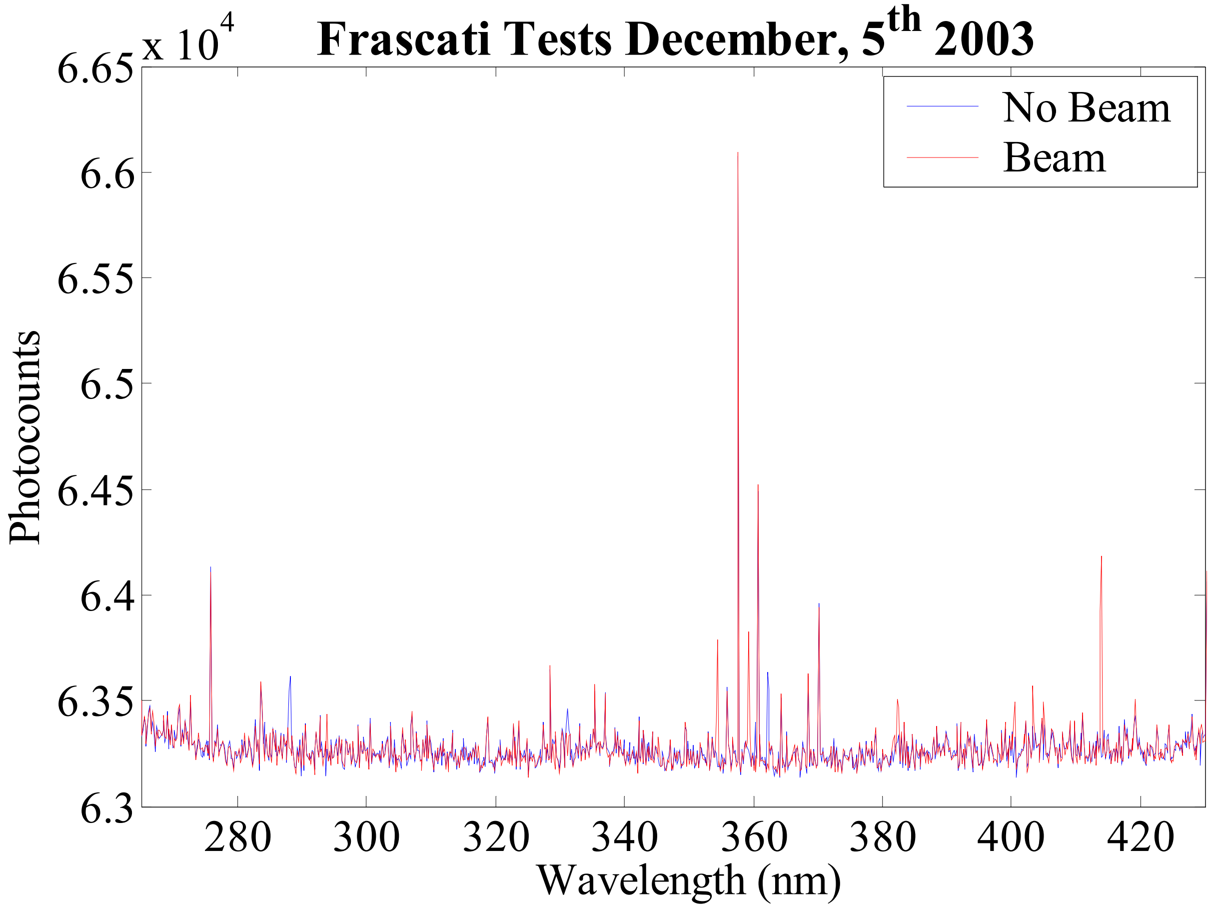
Beam: 442 MeV, ≈10^3 e^-/bunch



Signal with beam integration for 600 s

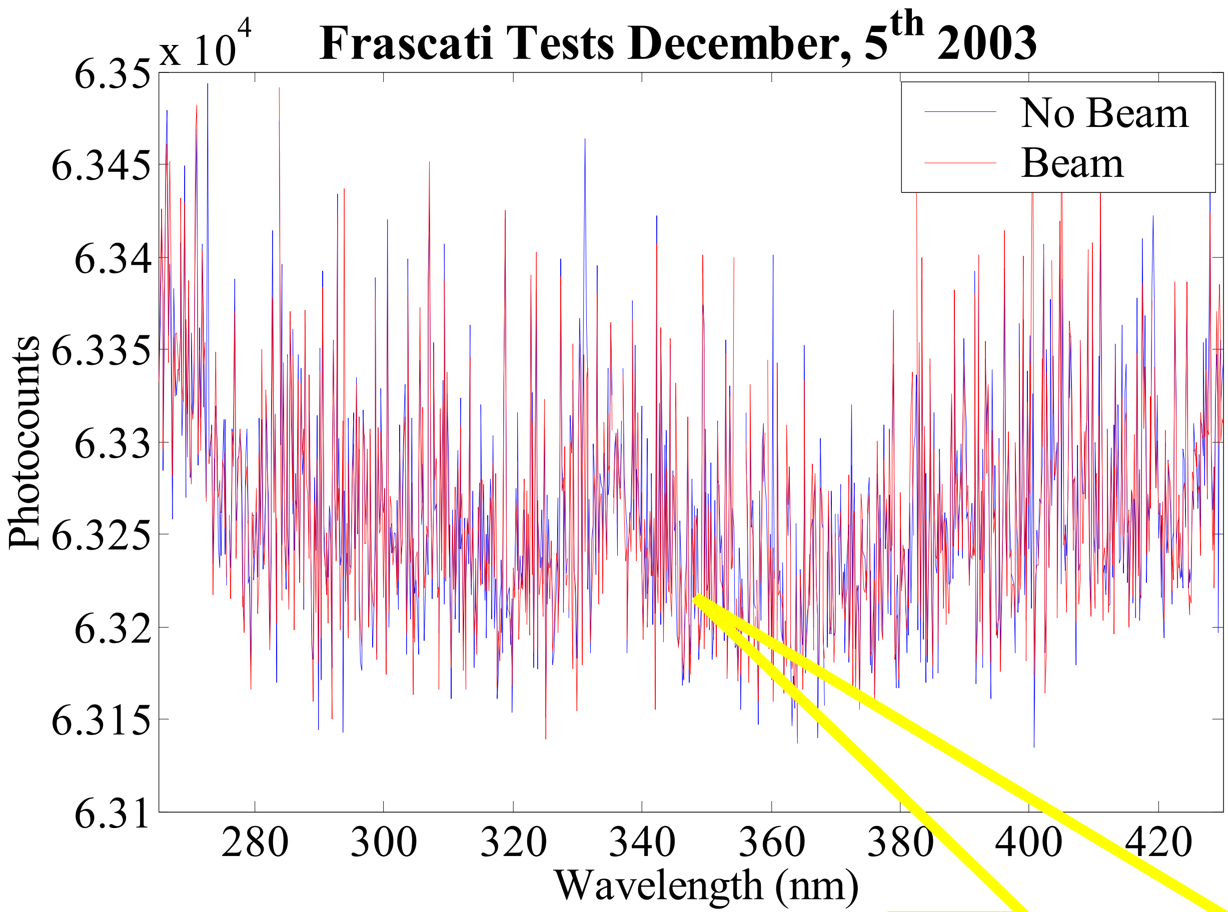
Signal No Beam integration for 300 s

Frascati tests



After normalization: spikes due to spurious pixels

Frascati tests



After removal of spurious spikes

No effects of the beam on the CCD background

⇒ 2 electron/pixel/s

Conclusions

- AirFly experiment going to measure the AF spectrum in 2004 H.I. runs
- Design spectrophotometer matches physics requirements
- Preliminary results from BTF confirm feasibility