

ESO Workshop, February 25<sup>th</sup> - March 1<sup>st</sup> 2013  
Shaping E-ELT Science and Instrumentation

High resolution IR spectroscopy over  
the full 0.95-2.45  $\mu\text{m}$  spectral range:

first results from *GIANO*

Livia Origlia - INAF - Bologna, Italy



# GIANO



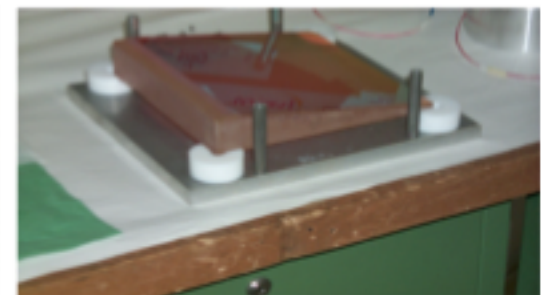
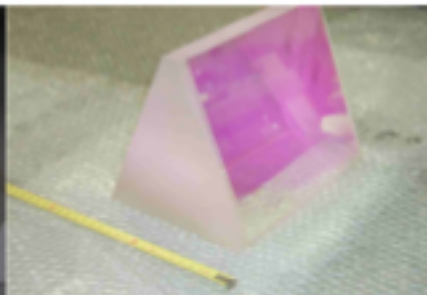
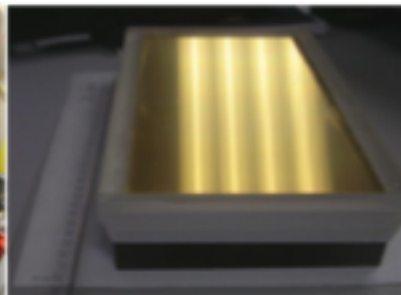
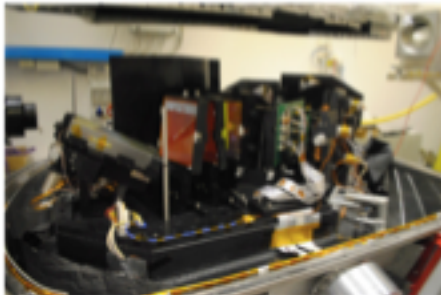
<http://www.bo.astro.it/giano>



GIANO is an optimized near infrared echelle spectrograph fiber-fed, which can yield, in a single exposure, 0.95-2.45 micron spectra at a resolution  $R \sim 50,000$ .

This project is part of the 2nd Gen Inst Plan of the TNG, and it has been entirely funded by INAF.

GIANO can provide high res spectra for accurate radial velocity measurements of exo-planets and for chemical & dynamical studies of stellar or extra-gal objects down to a magnitude limit comparable to that of 2MASS.





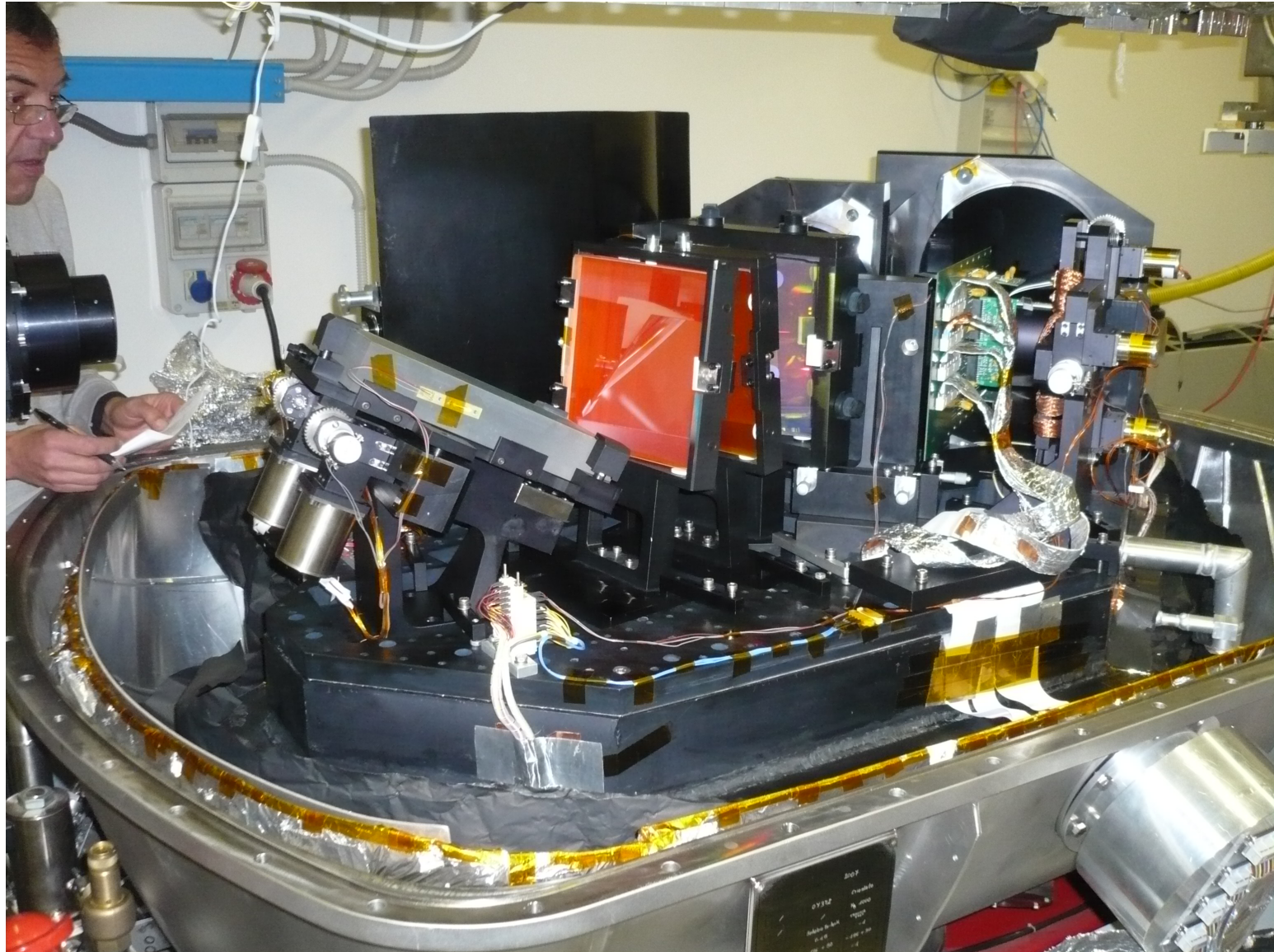
**GIANO**



TELESCOPIO  
NAZIONALE  
GALILEO

<http://www.bo.astro.it/giano>

in the Arcetri lab ...





# GIANO



<http://www.bo.astro.it/giano>

arrival at the TNG ... July 2012





# GIANO



TELESCOPIO  
NAZIONALE  
GALILEO

<http://www.bo.astro.it/giano>

... at the Nasmyth A ...



**TNG & GIANO teams**





# GIANO

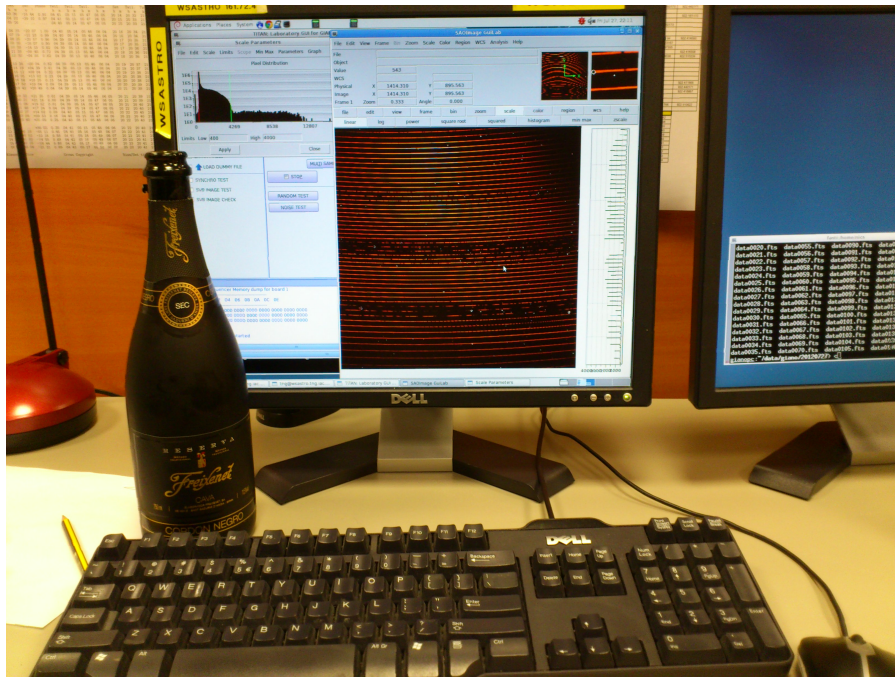


TELESCOPIO  
NAZIONALE  
GALILEO

<http://www.bo.astro.it/giano>

unpacked, mounted, ready in 9 days !

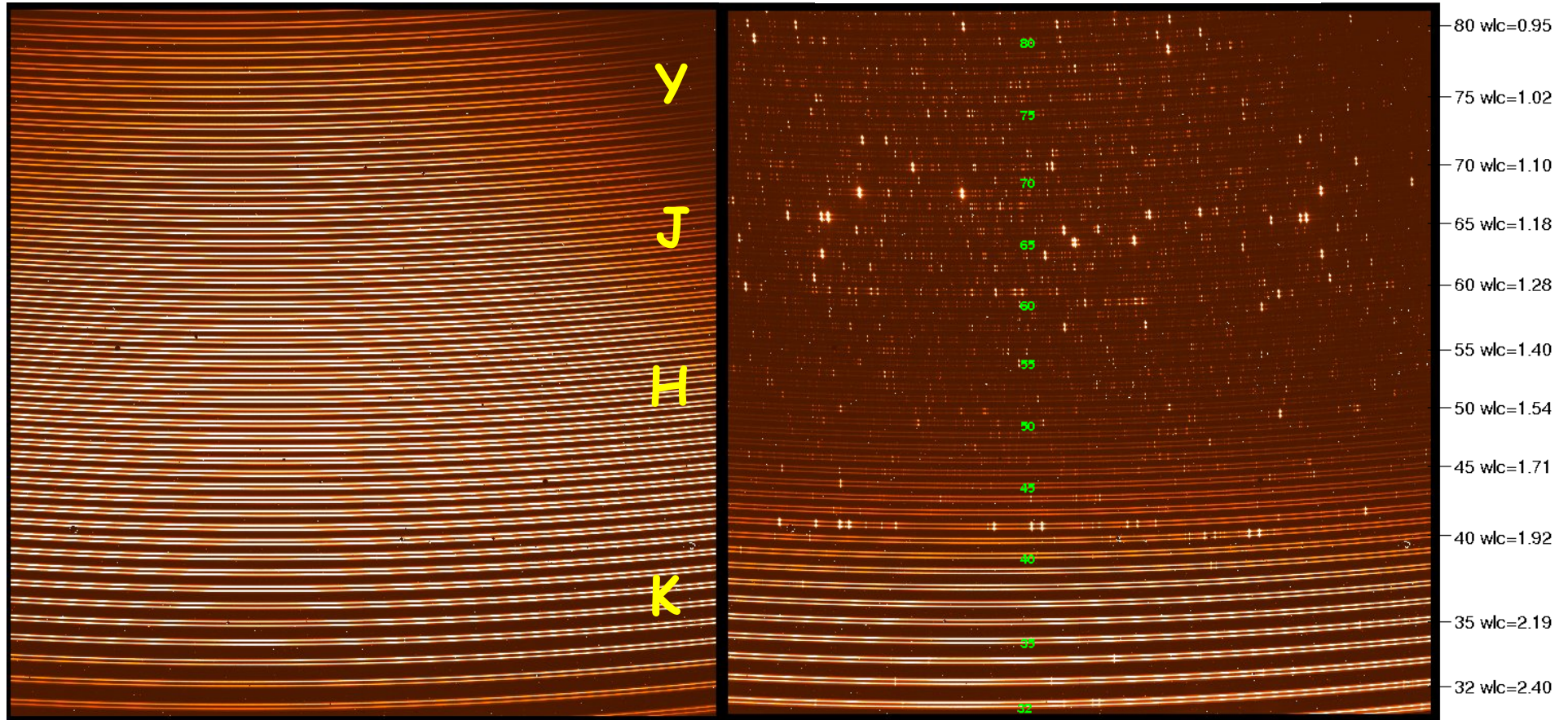
... first light on July 27, 2012



# GIANO: commissioning results

flat-field lamp

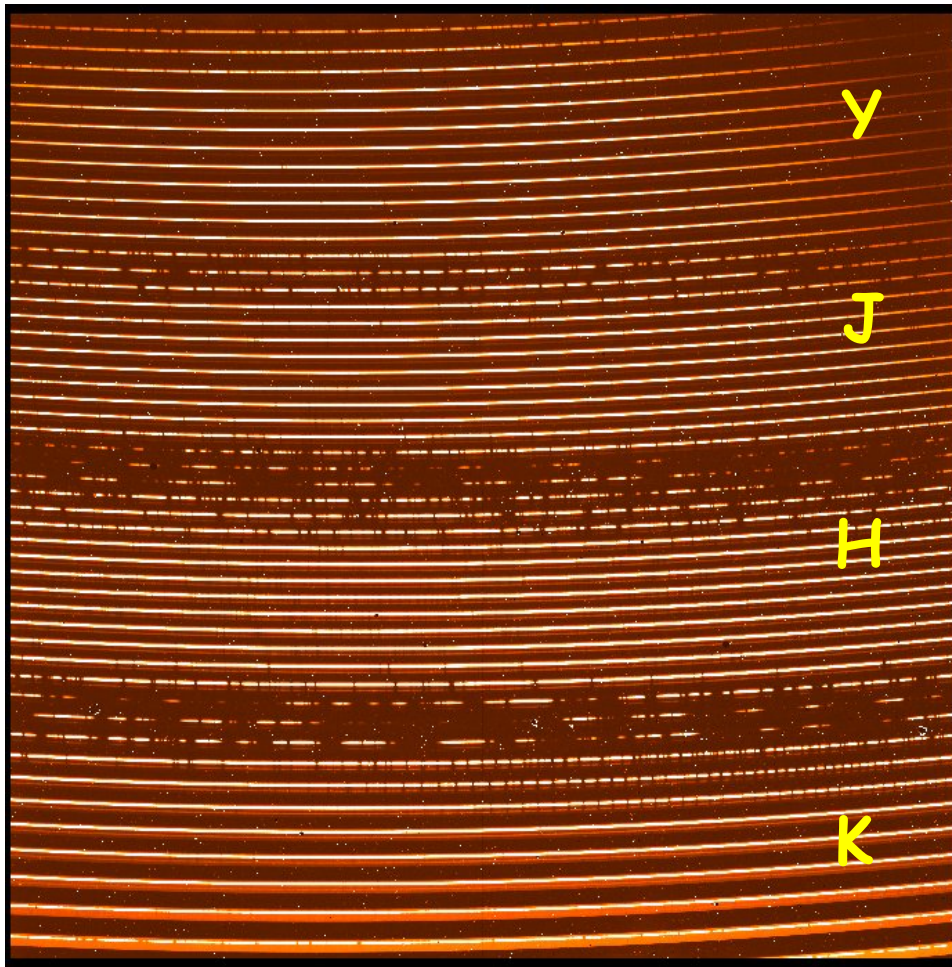
U-Ne lamp



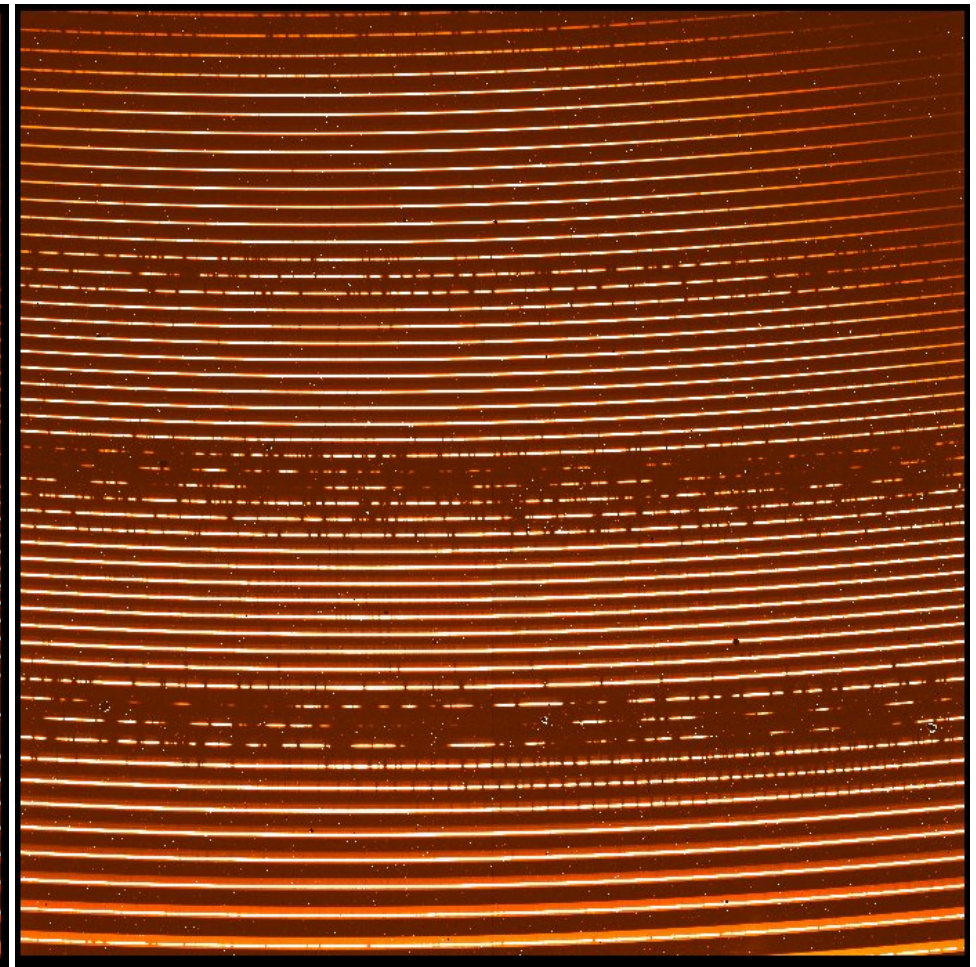
2 x 1" fibers 3" separation

# GIANO: commissioning results

nodding between fibers A & B



star in fiber A

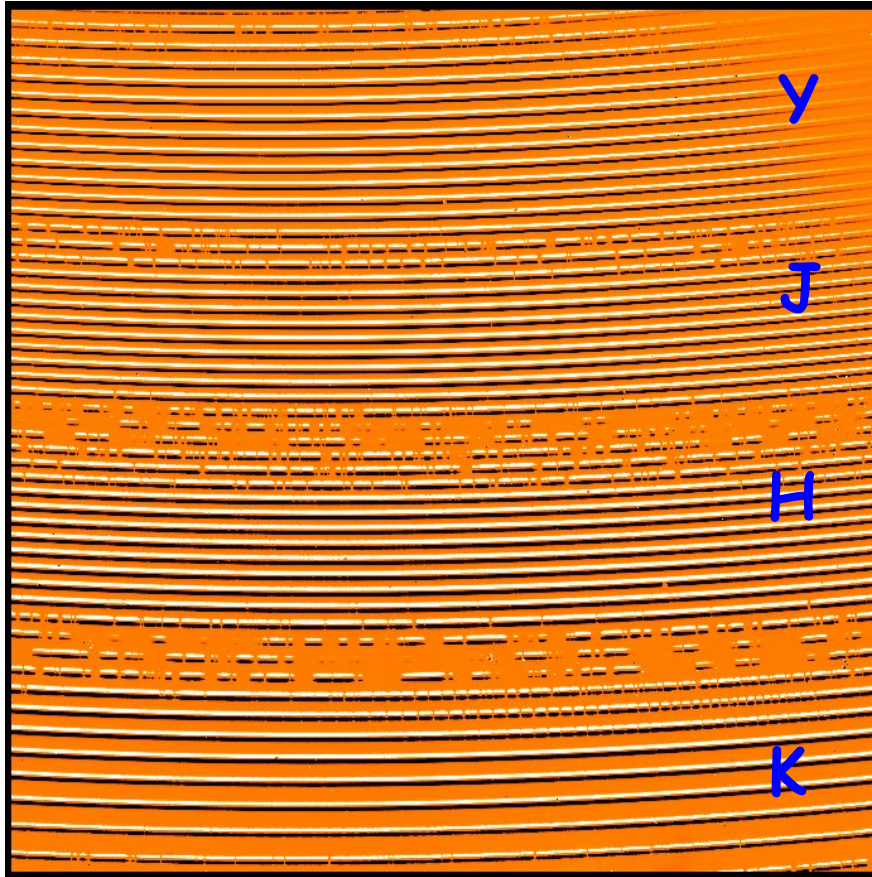


star in fiber B

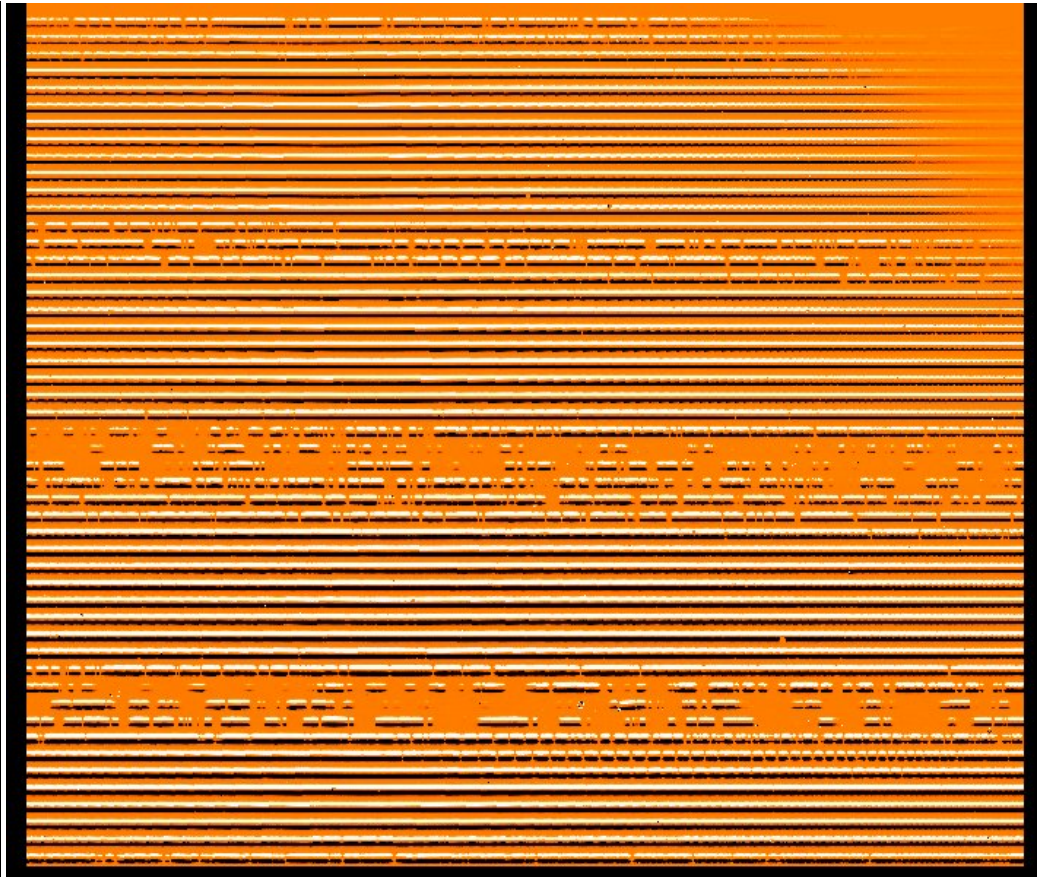


# GIANO: commissioning results

sky/detector subtraction with standard A-B

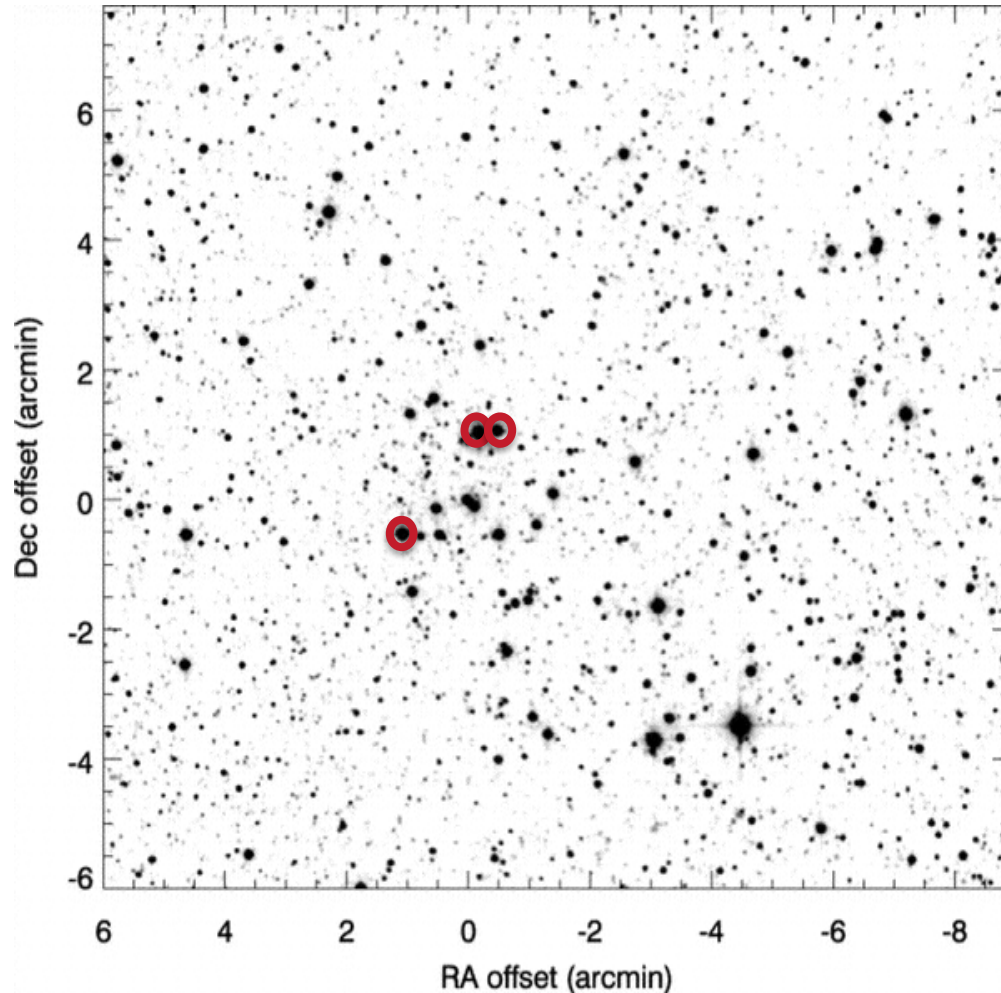


A-B frame



A-B frame rectified

# GIANO first science ...work in progress...



## RSGC2

young (10Myr), massive ( $4 \times 10^4 M_{\odot}$ )  
cluster at  $R_{GC} \sim 3.5$  kpc  $\rightarrow$

inner disk pop tracer

huge extinction ( $A_V \sim 15$  mag!)  $\rightarrow$   
genuine IR target

**3 M3-5 I stars observed**

J~7-8, H~5-6, K~4-5 mag

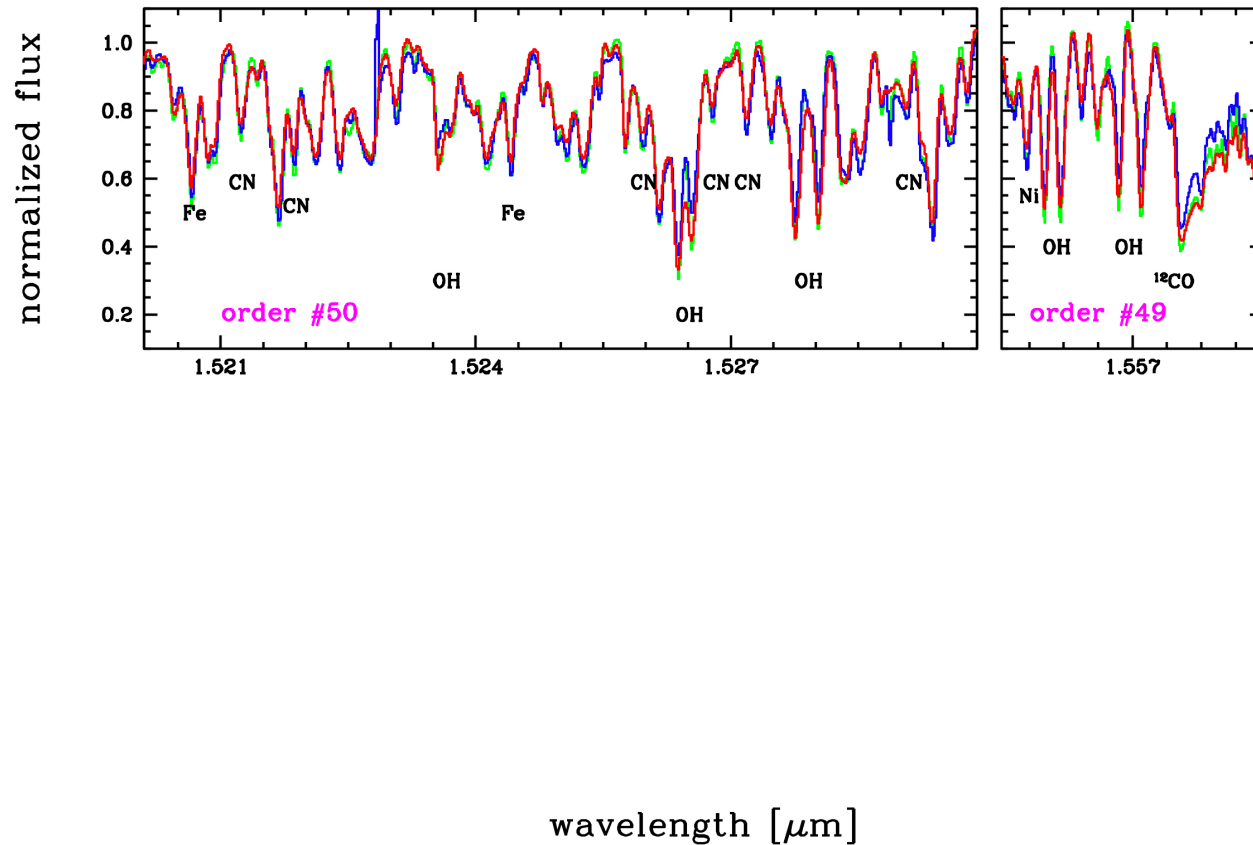
# GIANO first science ...work in progress...

M3I

M4I

M5I

also APOGEE science at R~20k...

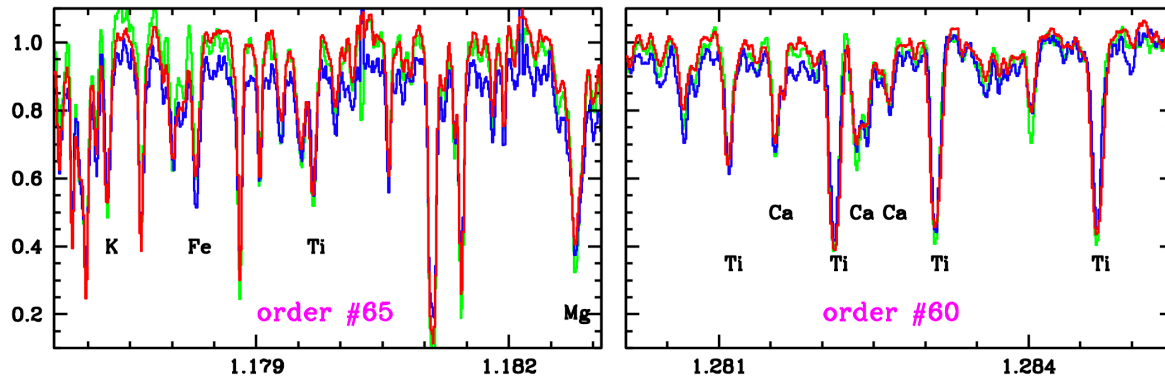


H crucial for OH, CN,  
 $^{12}\text{CO}$ , Ni, V, Co, Cu

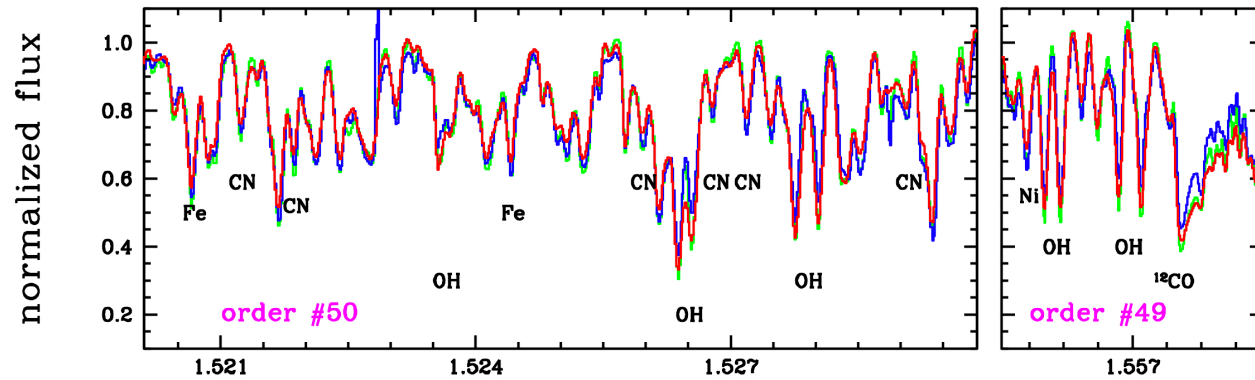
a few lines of Fe,  
Ti, Ca, Al, Si, Mg,  
K, Cr, Mn

# GIANO first science ...work in progress...

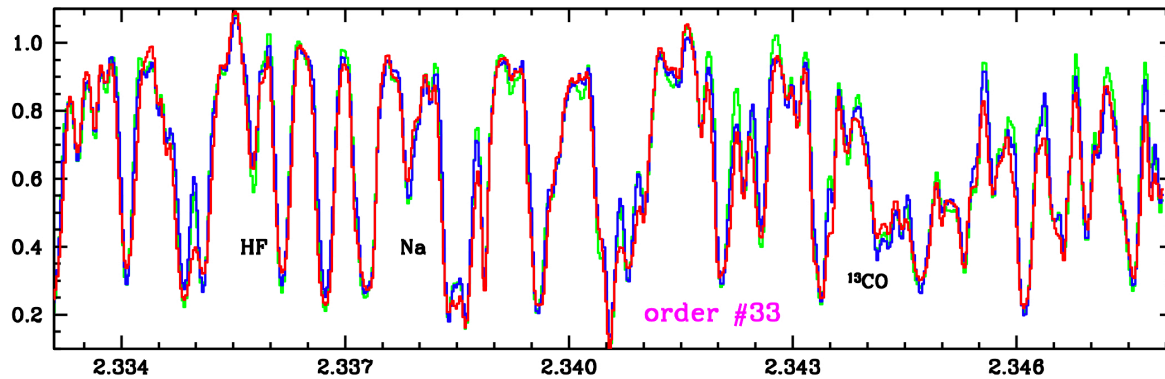
**M3I**  
**M4I**  
**M5I**



**YJ** crucial for  
**SrII**,  
**K, Mn, Cr** (cool)  
**S** (metal-poor)



**H** crucial for **OH, CN,**  
**12CO, Ni, V, Co, Cu**

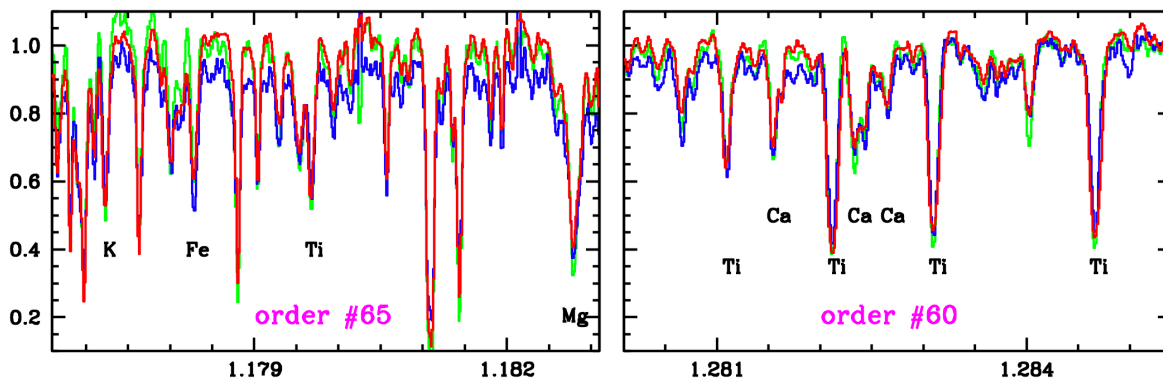


**K** crucial for **Na, HF,**  
**Sc, S** (metal-rich),  
**O isotopes** (R~100k)  
best for 13CO

wavelength [ $\mu\text{m}$ ]

# GIANO first science ...work in progress...

M3I  
M4I  
M5I



YJ crucial for  
SrII,  
K, Mn, Cr (cool)  
S (metal-poor)

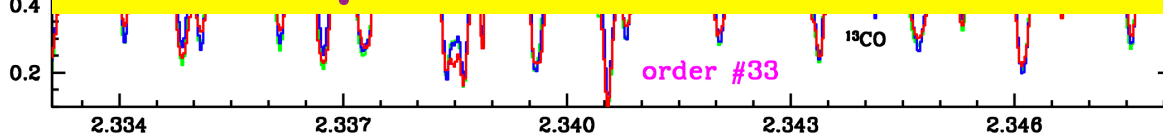
normalized flux

several to tens lines  
Fe, Ti, Ca, Al JHK  
Si, Mg JH

crucial for OH, CN,  
CO, Ni, V, Co, Cu

work ongoing to identify/check  
new lines/species for different  
stellar parameters ...

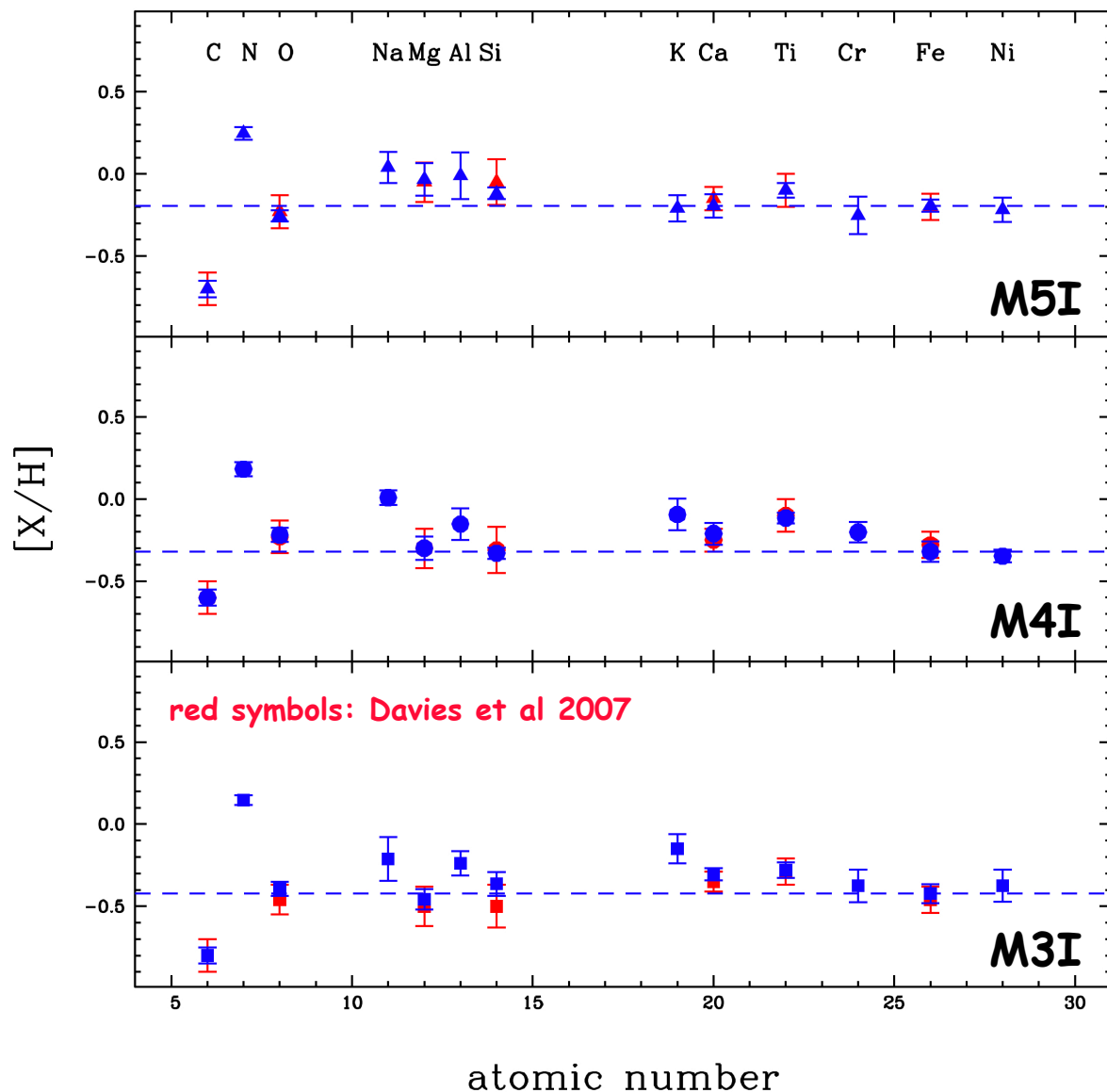
crucial for Na, HF,  
C, S (metal-rich),  
isotopes (R~100k)  
best for <sup>13</sup>CO



wavelength [ $\mu$ m]

# GIANO first science ...work in progress...

## chemical abundances



several  $\rightarrow$  few tens lines per specie!

limited by crowding & macroturbulence

- $\triangleright$   $[\text{Fe}/\text{H}] \sim \frac{1}{2}$  solar
- $\triangleright$  similar Fe-peak (Cr, Ni)
- $\triangleright$   $\sim$ solar scaled  $\alpha$ , K
- $\triangleright$  depleted (2-3x) C
- $\triangleright$  enhanced (2-3x) N, F
- $\triangleright$   $^{12}\text{C}/^{13}\text{C} \sim 10 \pm 1$

$$\Delta[X/H] = \sigma / (N_{\text{lines}})^{1/2} \sim 0.05 \text{ dex}$$

systematic error  $\rightarrow \sim 0.2 \text{ dex}$

$$\Delta T_{\text{eff}} = 100 \text{ K} \quad \Delta \log g = 0.5 \text{ dex}$$

$$\Delta \xi = 0.5 \text{ km/s} \quad \Delta v_{\text{macro}} = 1 \text{ km/s}$$



# GIANO



<http://www.bo.astro.it/giano>

## work in progress ...

- modification of the pre-slit to improve the fiber-telescope coupling and maximize the efficiency
- full characterization of the ZBLAN fibers transmitting out to the K band → (efficiency, modal noise, scrambling etc.)
- development & optimization of data reduction procedures & pipeline
- analysis and characterization of telluric & OH-sky spectra over the full 0.95-2.45 micron spectral range at  $R \sim 50k$

# R ~ 20k → 100k spectroscopy in the near IR

## existing facilities ...

CRIRES @VLT	→	$\lambda/100$	~2MASS	single obj	R<=100k
NIRSPEC @Keck	→	$\lambda/10$	~2MASS	single obj	R<=37k

## recent, new facilities

APOGEE @2.5m	→	H-band	H<11-12	300 fibers	R~20k
GIANO @TNG-3.5m	→	YJHK	~2MASS	single obj	R~50k

## near-future facilities

CRIRES+ @VLT	→	Y/J/H/K	>2MASS	single obj	R<=100k
CARMENES @CalarAlto	→	YJH	~2MASS	single obj	R<=82k
SPIRou(?)@CFHT	→	YJHK	~2MASS	single obj	R<=75k
ISHELL @IRTF	→	$\lambda/10$	<2MASS	single obj	R~80k
MOONS(?) @VLT	→	J&H	>2MASS	1000 fibers	R~20k

also in the near IR very promising (scientifically & technologically)  
test-benches towards E-ELT HIRES