

# TNG Focal Plane Instruments: Development and Improvement

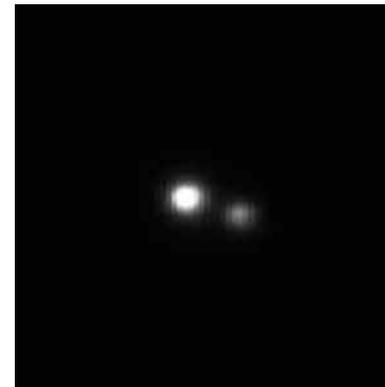
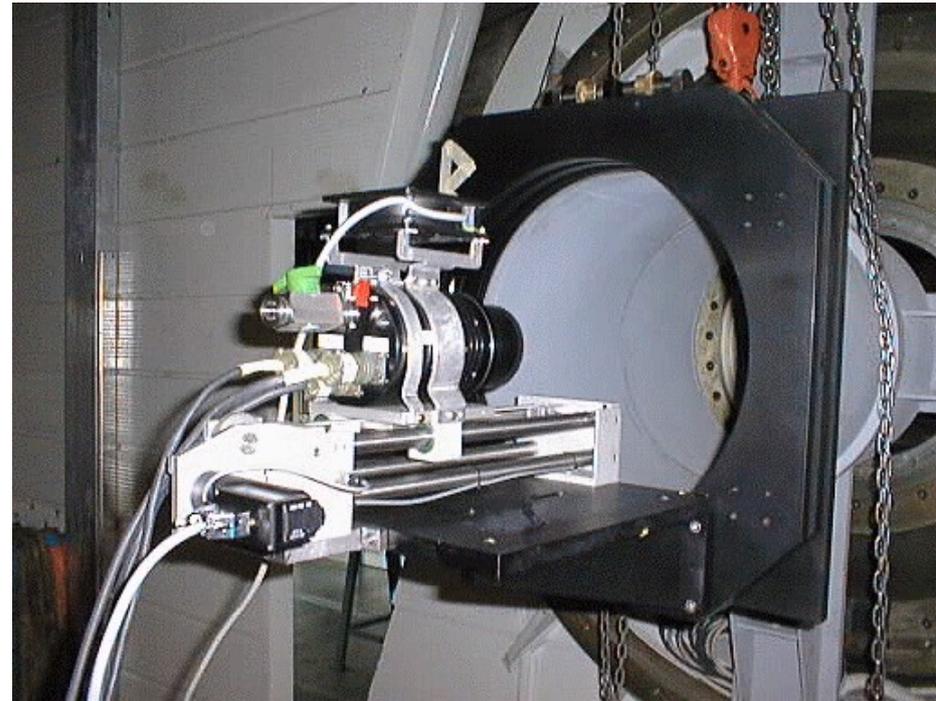
*Adriano Ghedina*



Focal plane inst: development and  
Improvement by A.Ghedina

La Palma 19/10/2021

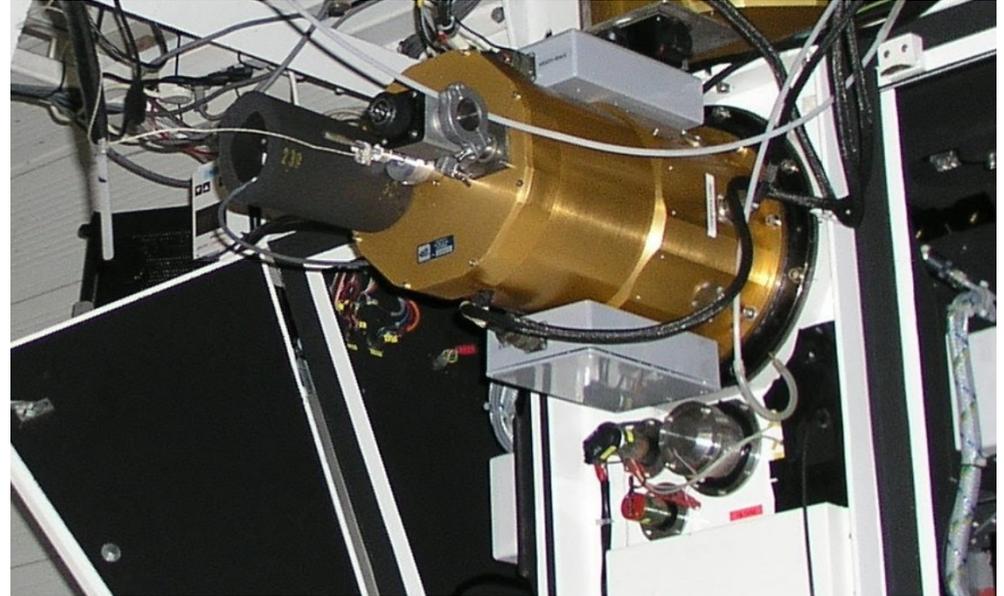
Instrument	Date
TNG	June, 9 <sup>th</sup> 1998
OIG	Dec, 10 <sup>th</sup> 1998
ARNICA	Dec, 18 <sup>th</sup> 1998
AdOpt	Dec, 18 <sup>th</sup> 1998
DOLORES	May, 20 <sup>th</sup> 2000
SARG	June, 9 <sup>th</sup> 2000
NICS	September, 17 <sup>th</sup> 2000
HARPS-N	March, 21 <sup>st</sup> 2012
GIANO	July, 27 <sup>th</sup> 2012
GIANO-B	Oct, 27 <sup>th</sup> 2016
GIARPS	March, 14 <sup>th</sup> 2017



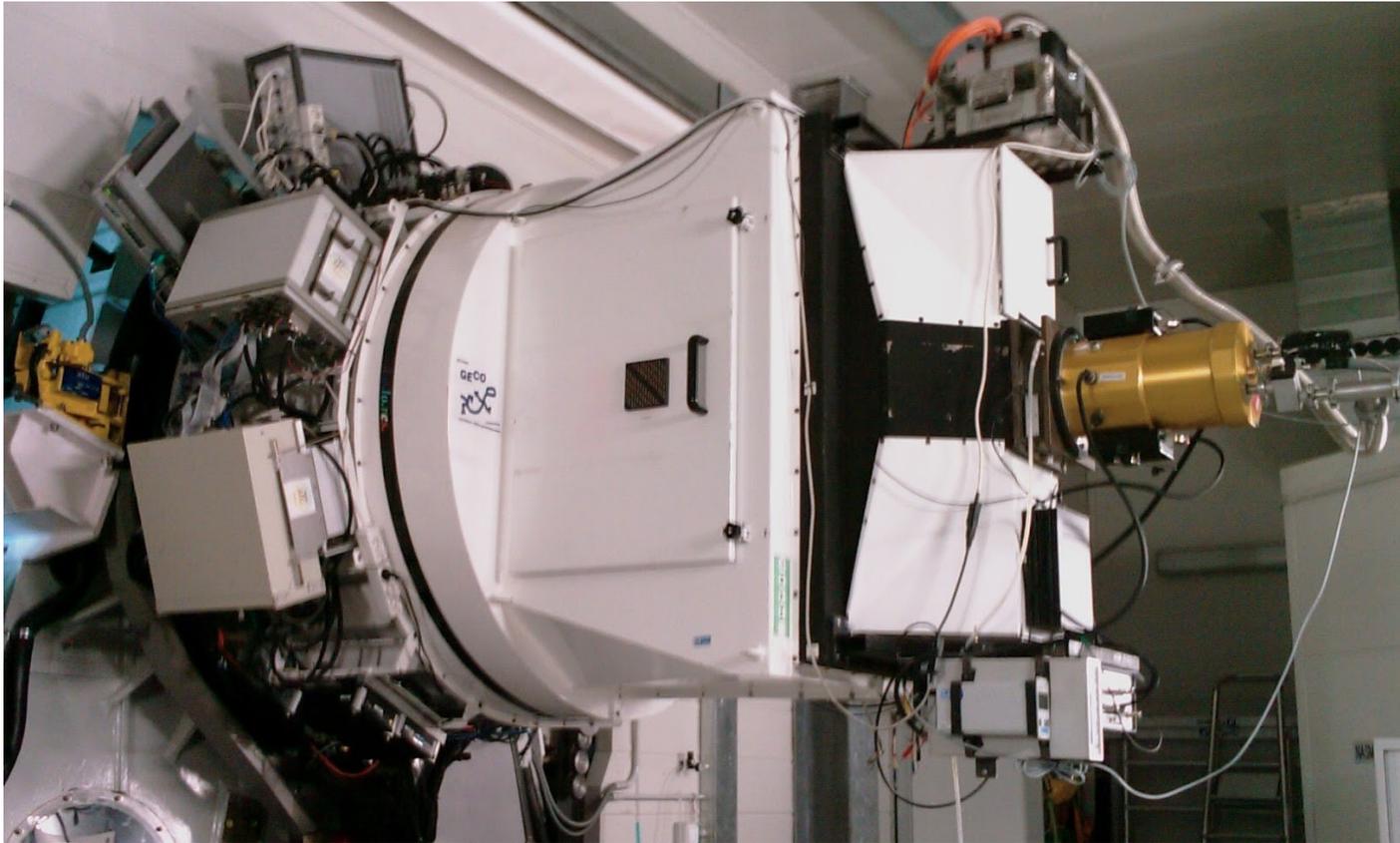
# Ar.NI.Ca.(1998-2000)



# O.I.G.(1998-2008)



# LRS(05/2000- )



# DOLORES improvements

- 2002 SLOAN set for Dolores and OIG
- Andover Narrow Band Filters ( $H_{\alpha}$  and redshifted,  $H_{\beta}$ , S[II], N[II], O[II], O[III]), TiO, CN
- Geco and then Geco2 to remove flexures [OABrera]
- PMAC → ArDolor [FGG]
- Loral → **05/2007 E2V CCD42-40 Astro Broadband, Deep Depleted** (QE peaks at 95.8% around 600 nm and is 52.7% at 900 nm) [OABrera, OAPD, OACT, FGG]
- PAOLO- Double Wollaston for simult 4 states polarimetry and retarders [FGG, OACT, Merate]
- Pyramid for focusing [FGG]
- VPHG [OABrera]
- ARC controller [FGG-2022]

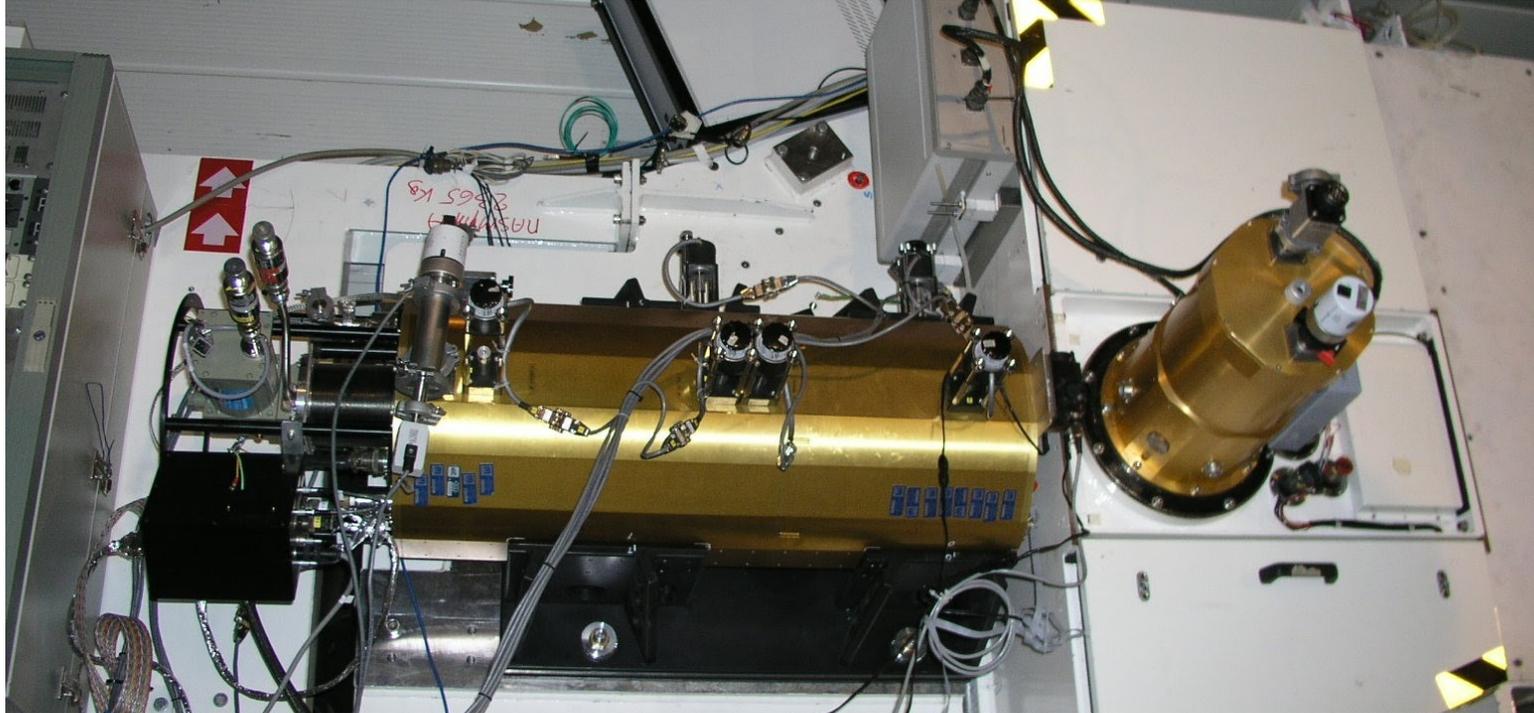


# SARG

(2000/2012)

- R~144000
- 30" slit FoV
- 380-900nm
- RV < 2m/s
- Polarimeter

# NICS (09/2000)



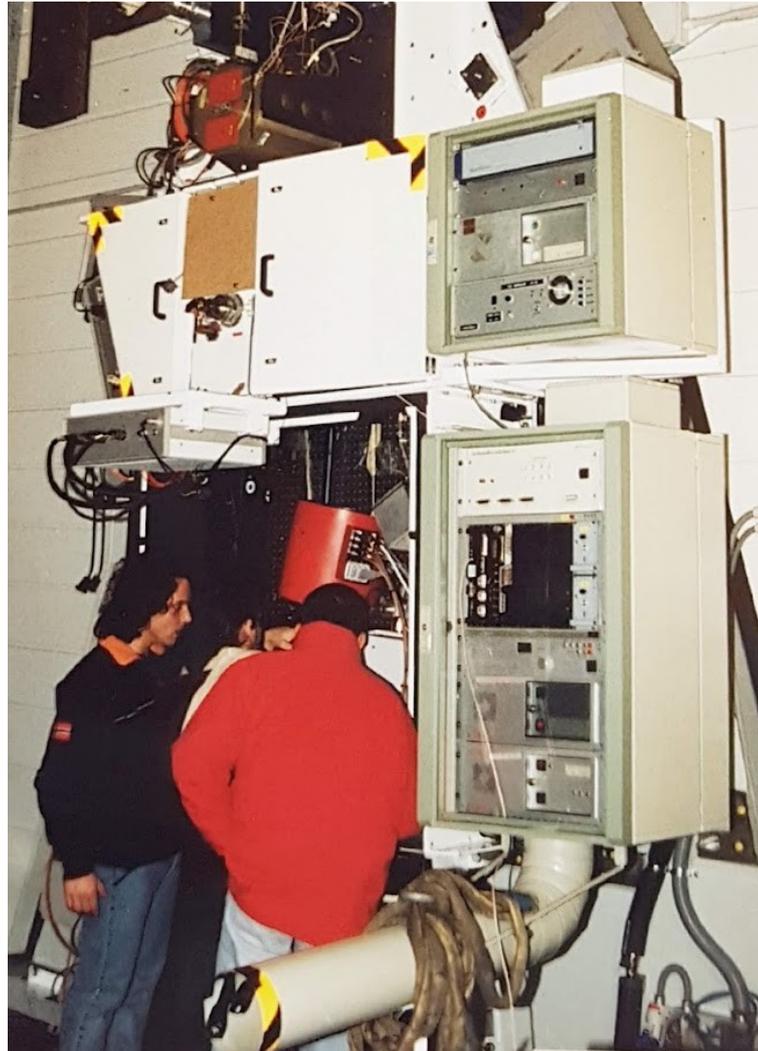
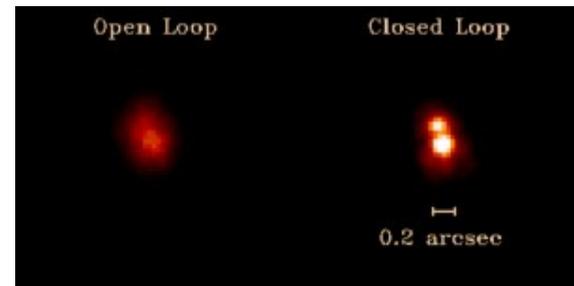
# NICS

- 1st light 09/2000
- 02/2003 Refurbished electro/mech (OAArcetri)
- Amici prism → hi efficiency
- 2006 new RO electronics: FASTI
- 2009 furthest GRB observation  $z \sim 8.1$

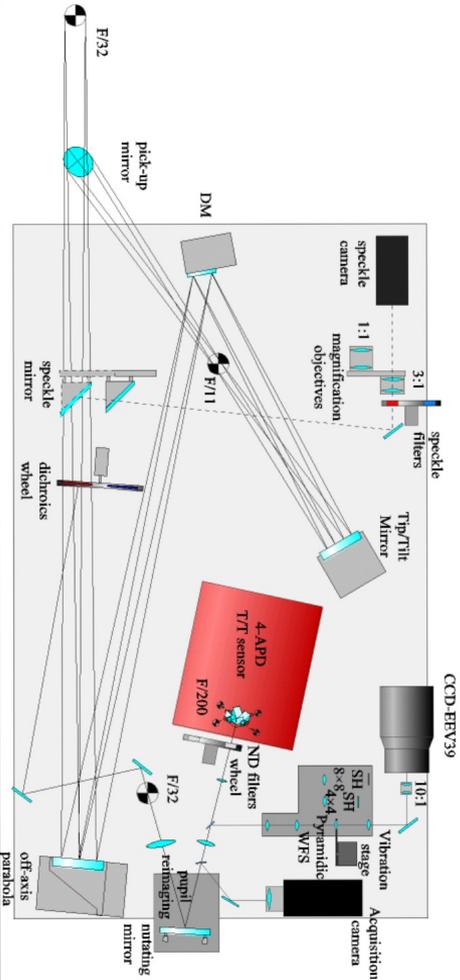
# AdOpt@TNG

(1998-2009)

- +Speckle camera
- First time ever use of Pyramid WFS on sky
- Loop closed 2001
- 2003 RT linux

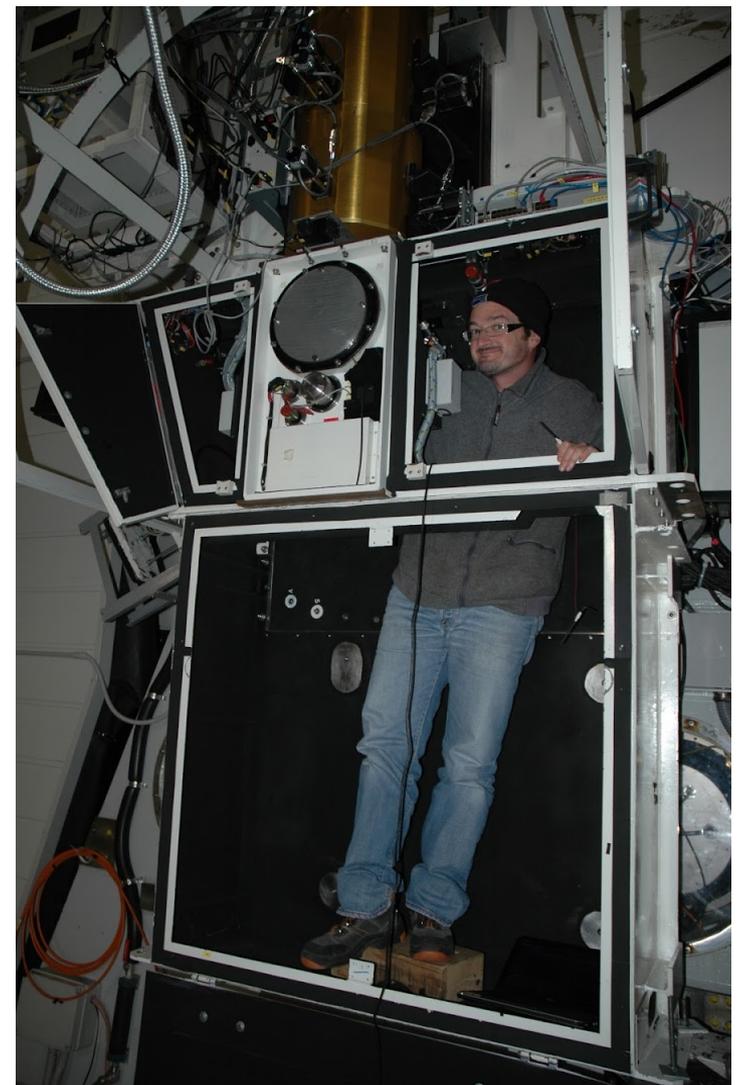


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## 2008-2009

- OIG no more offered;
- FGG to become INAF structure;
- Sell TNG to IRAN;
- Adaptive M2 from ISRAEL;
- Leave space for new instruments;
- Decommissioning AdOpt;
- Delay of GIANO;
- Visiting Instruments Document;



**"[...] mentre rischiamo di richiamare entro l'anno in Italia i trenta dipendenti e ricercatori che da anni tenevano in attività il telescopio Galileo alle Canarie [...] - continua il presidente dell'Inaf - È il nostro fiore all'occhiello, ma nel 2009 per la manutenzione e la gestione sono stati necessari 2,5 milioni di euro che non potremo permetterci quest'anno".**

**(Repubblica, 02/2010)**



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# BATMAN (2010-?)

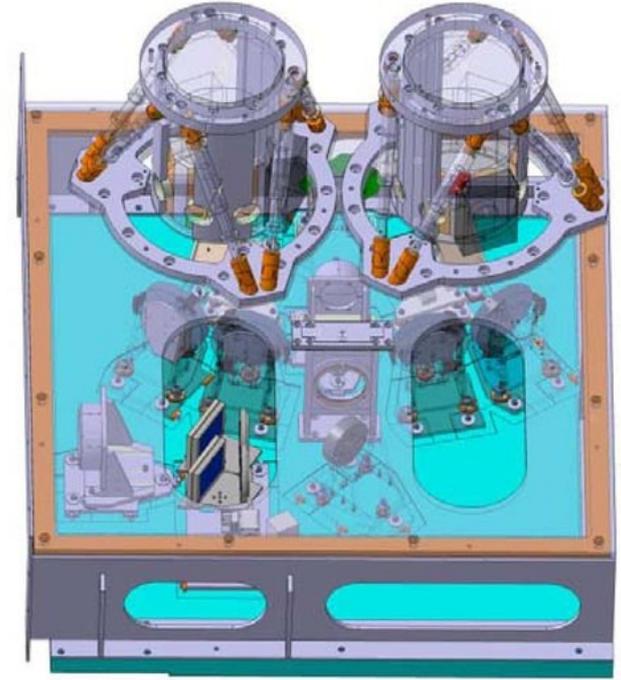
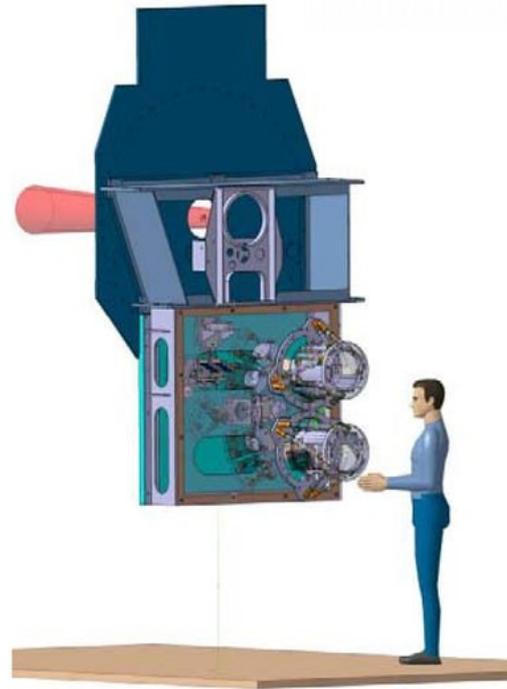
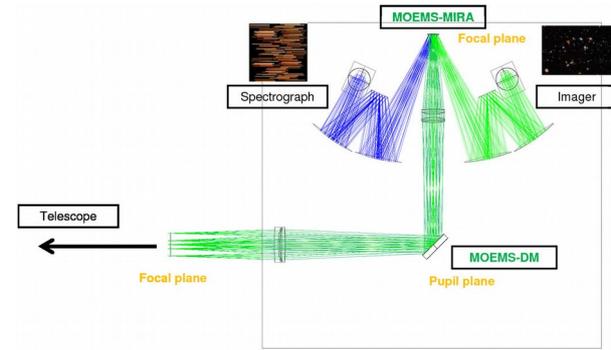
[Marseille LAM, FGG, OAPa, OATS]

PI instrument DMD based:

Simultaneous Imager ( $7 \times 4 \text{ arcmin}^2$ )  
and  
Spectrograph ( $R \sim 560$ )

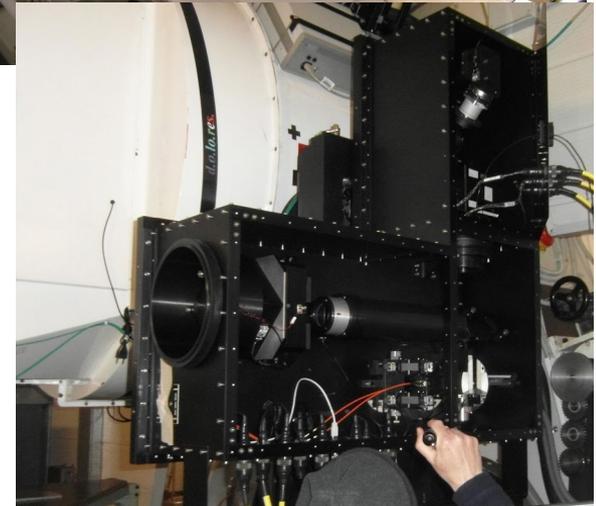
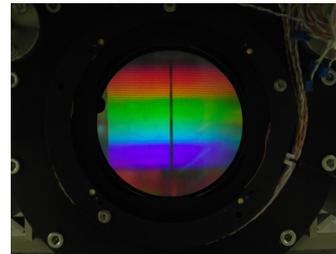
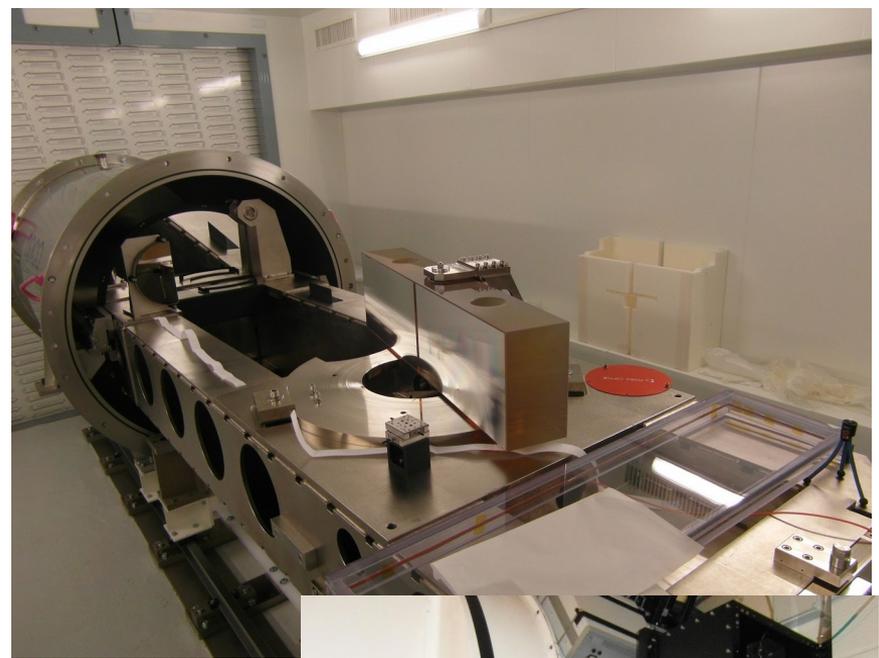
2EEV  $2k \times 4k$

Unfortunately never converged.



# HARPS-N

- 2010 F.Pepe w/o telescope → CFHT INAF
- 2011 Nasm B, FEU on SARG, Vessel room in the Basement, fiber routing
- $R \sim 115000$ , range=380-690 nm, RV  $\sim 0.1$  m/s
- 03/2012 First light
- Ultra stable spectrograph

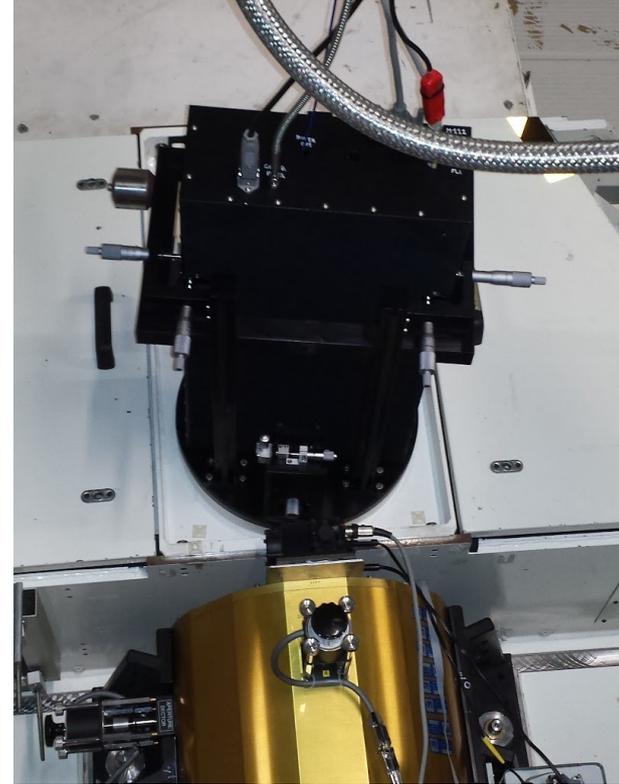
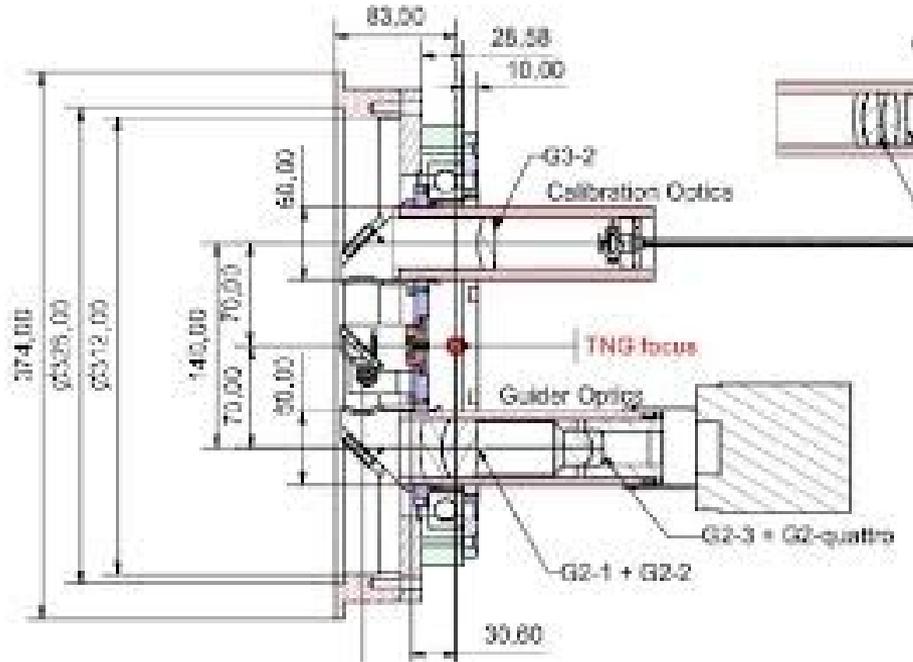


# GIANO 2012



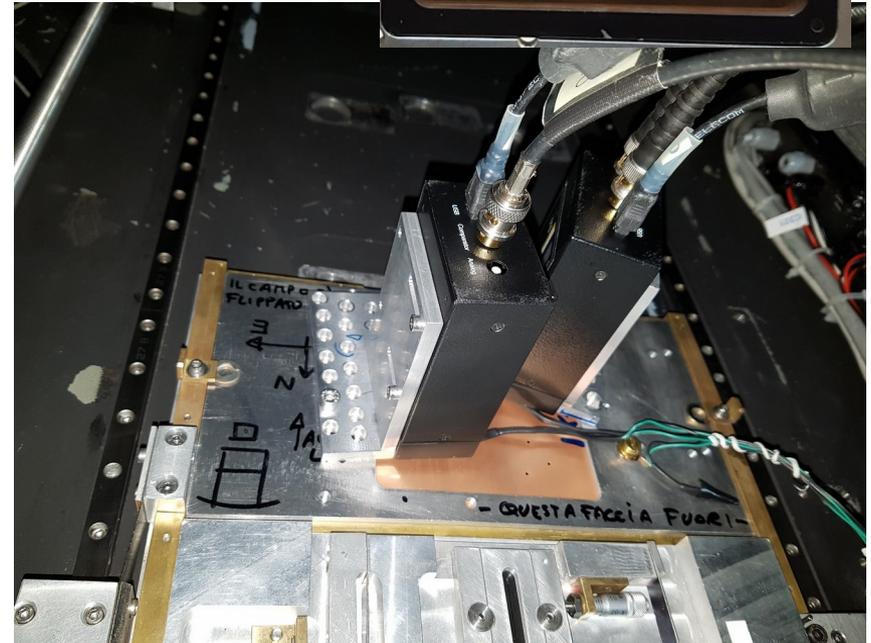
- Fiber fed + image slicer
- $R \sim 50000$
- $RV \sim 7 \text{ m/s}$
- 900-2500 nm

# GIANO A1 → GIANO A2 (2014)



# SiFAP (2014)

- [La Sapienza+FGG]
- MPPC based
- 8ns time tag
- MOS FoV
- Transitional ms PSR



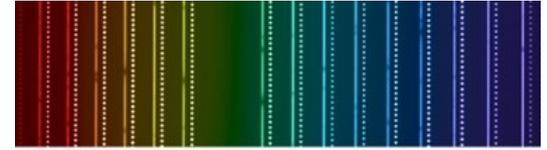
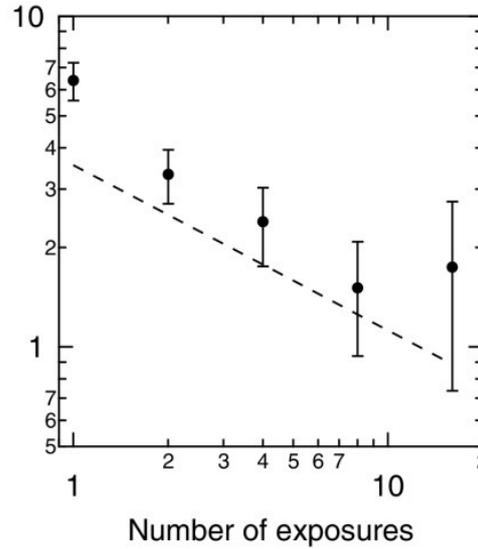
# Green AstroComb

(Stanford CfA) [2013-2017]

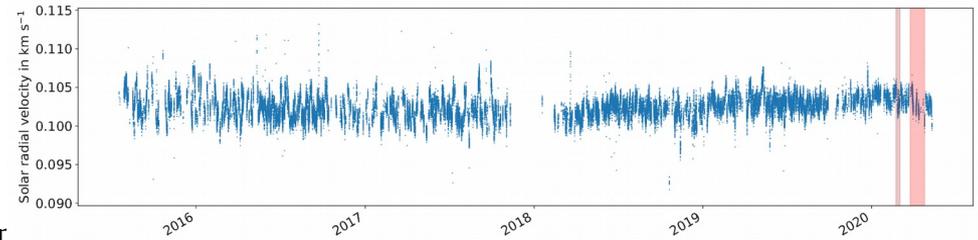
500-620nm



Two sample deviation of differential RV shift (cm/s)

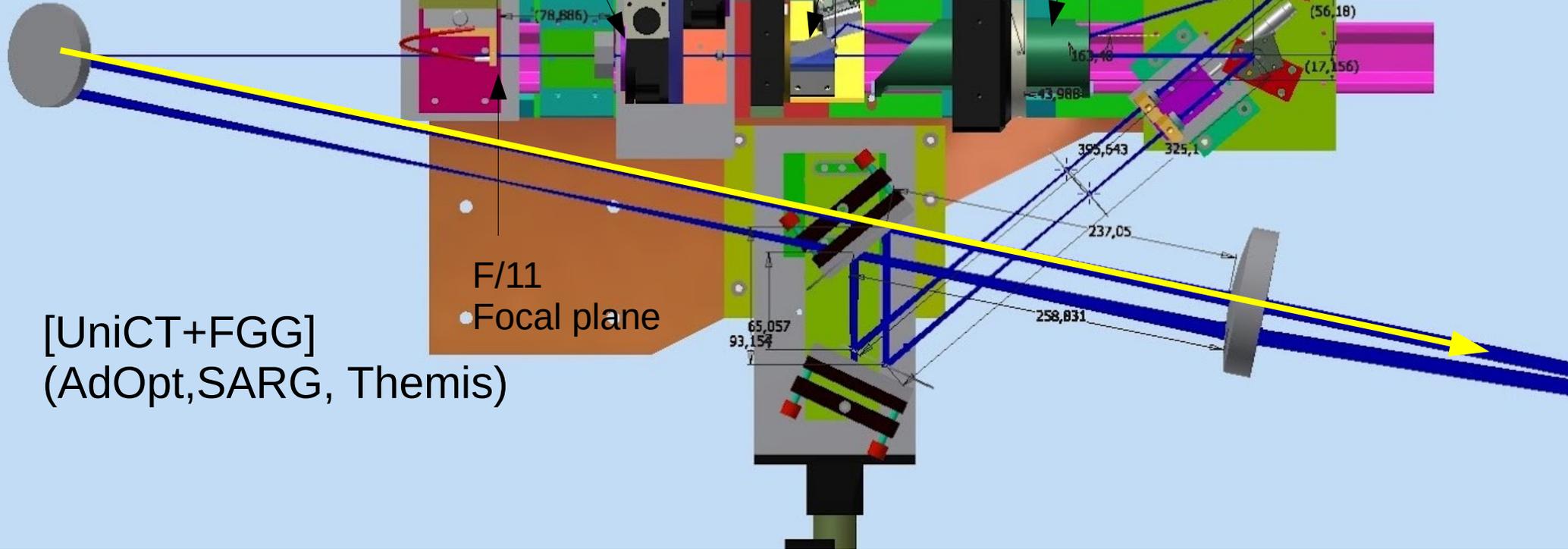


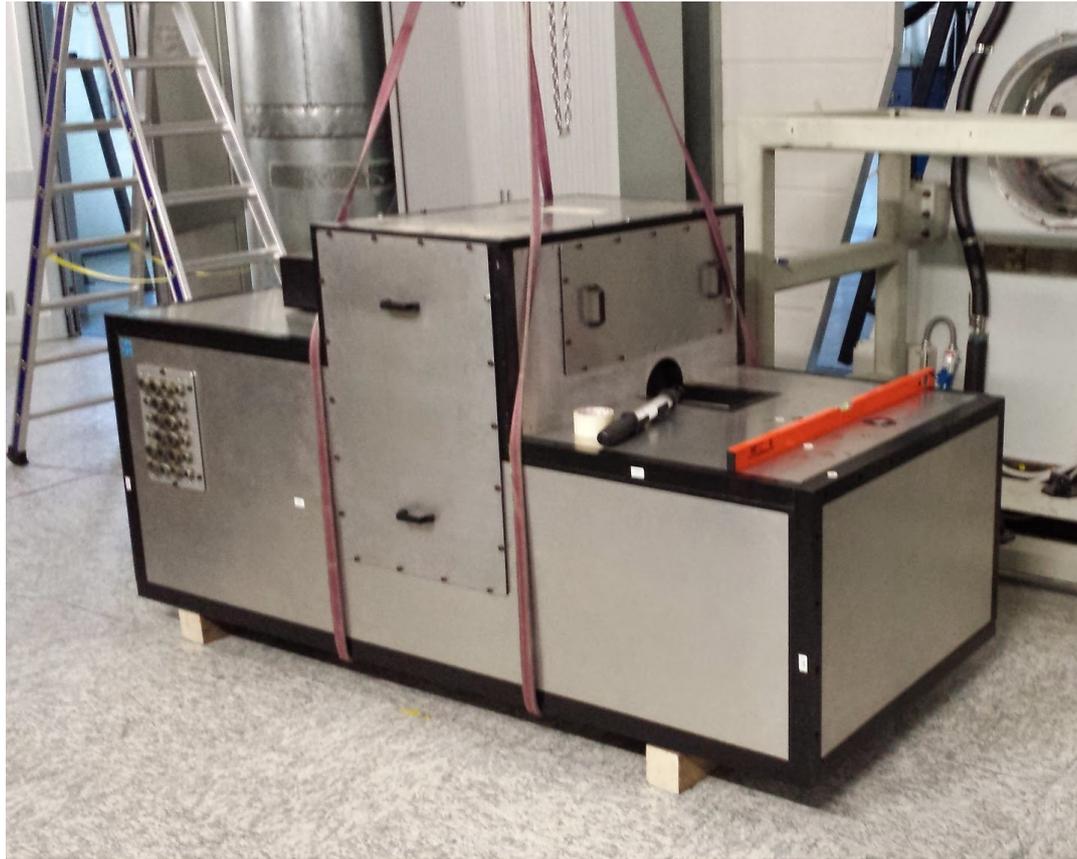
LCST (2015-)



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# HANPO 2014





## 2015 SARG DOWN

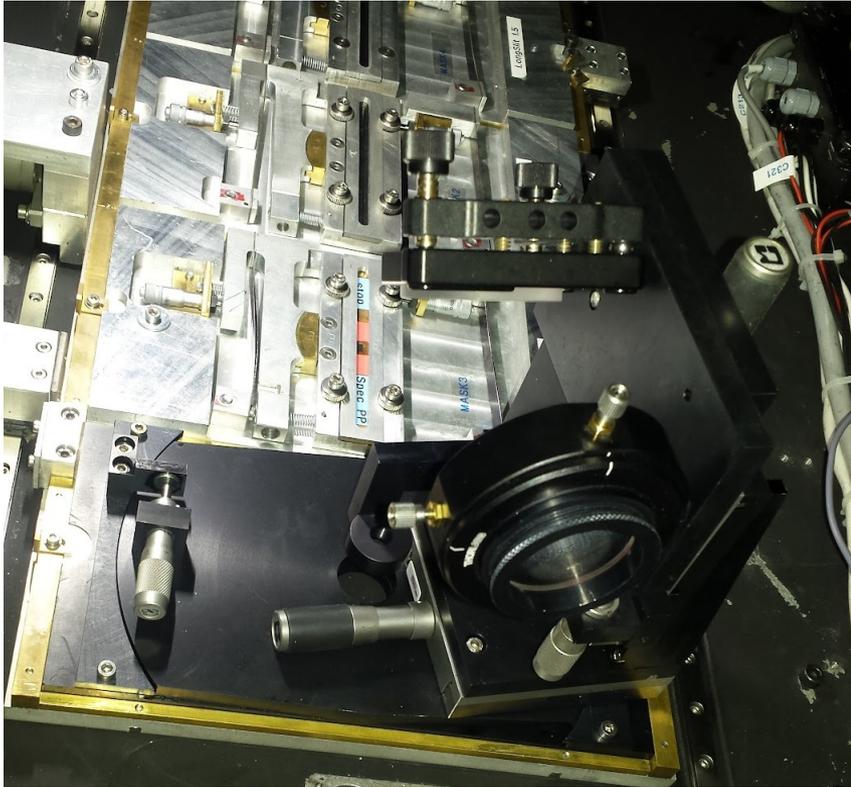
- Last AOT 2012
- Removed 2015
- Sent to INFN LabSud 2018

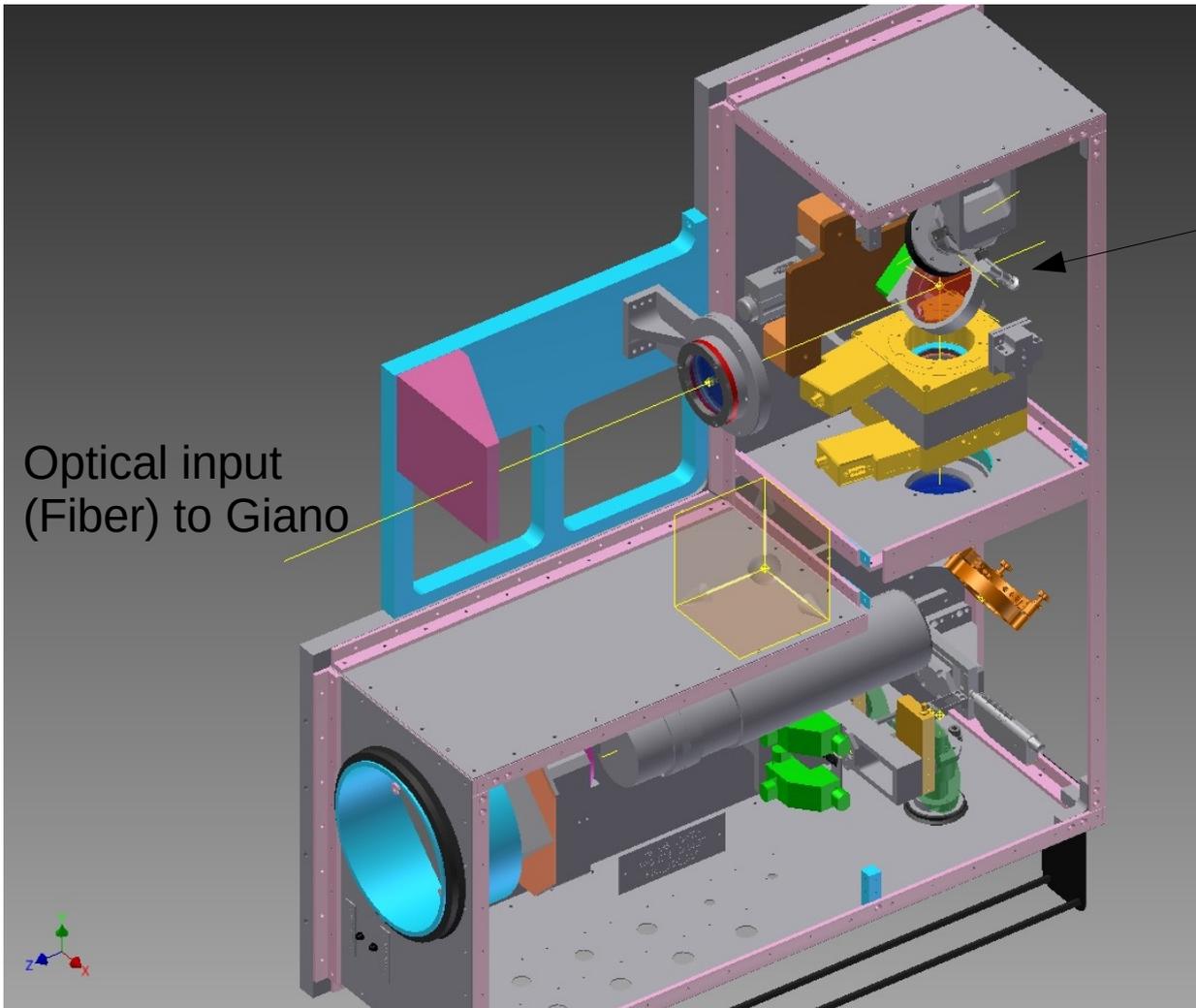
# 2016 GIANO B



- Premiale WOW = \$\$\$
- (FGG, OAPD, OAPA, OAMI, OAA, OABO, OATO, OACT, OAGE)
- GIANO A → B
- Preslit (OAA + FGG)
- GIARPS (DICH FGG)
- LOCNES (+OPC, OAR)
- CELLE (+IAPS OAR)

# Pick-UP and Preslit





Optical input  
(Fiber) to Giano

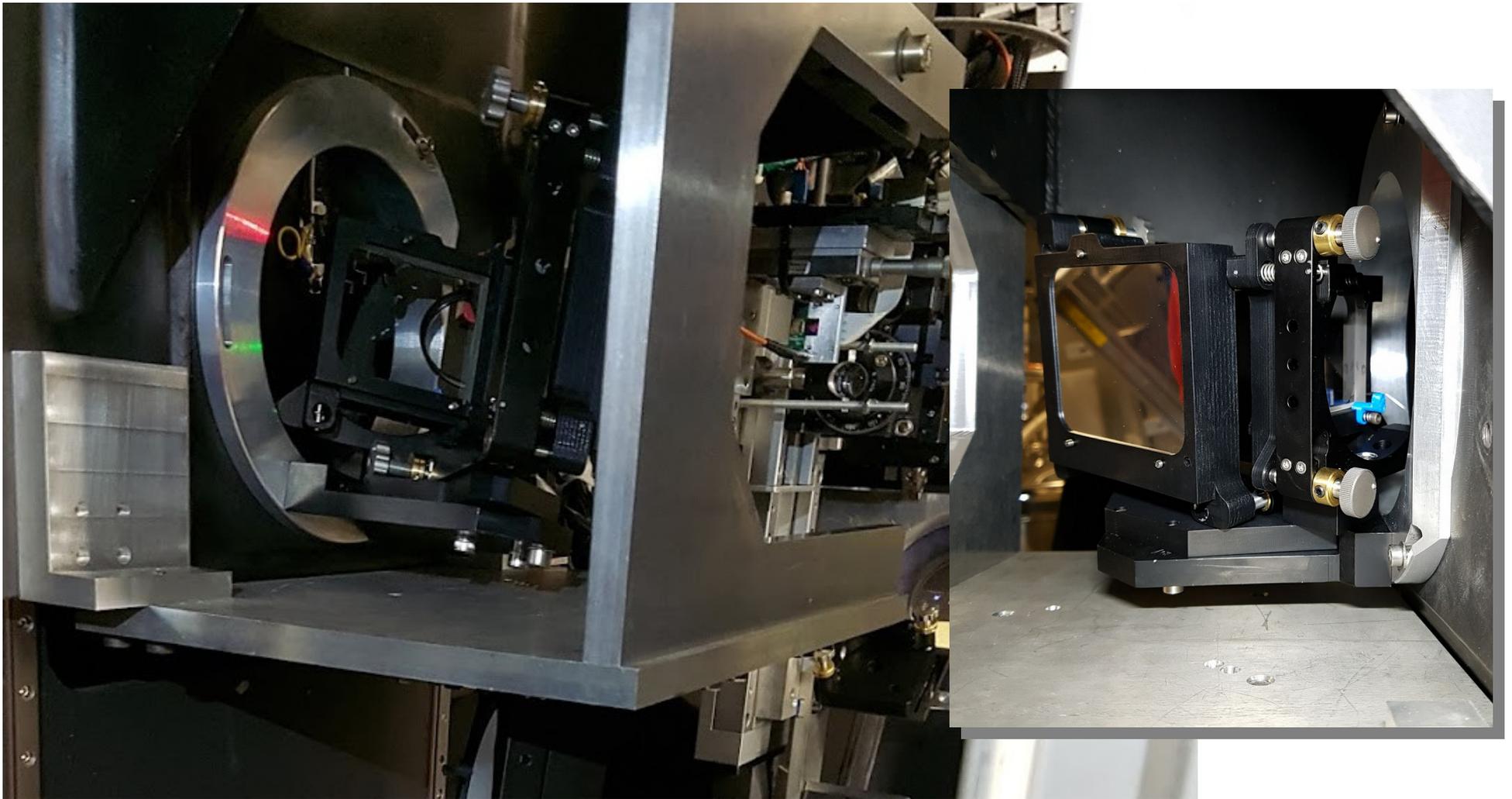
January 2013

EM: Dich M3

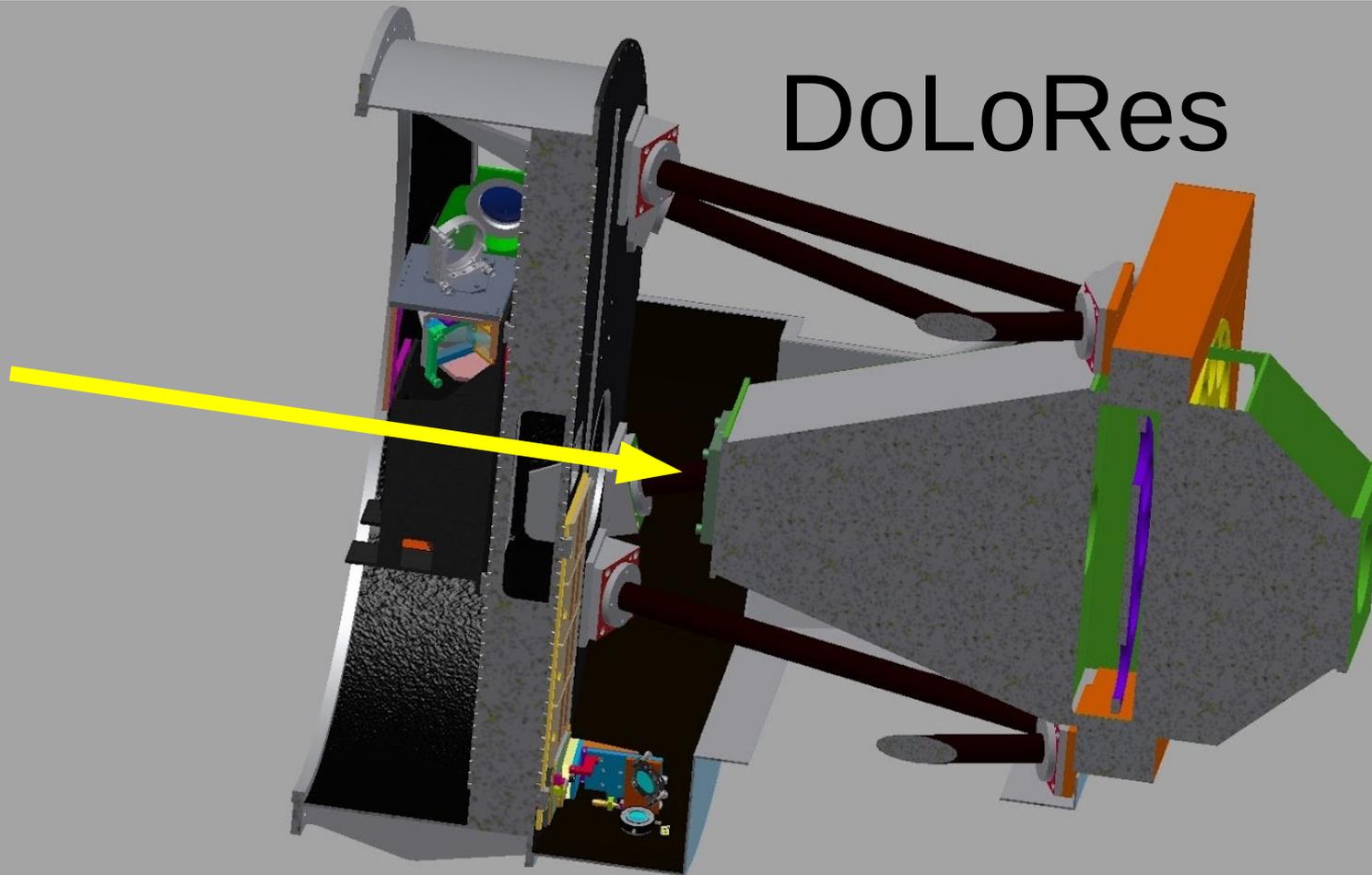
1st IDEA of M6 Dich  
And fiber feed Giano

2nd IDEA of M4 Dich  
And fiber feed on LRS  
Masks

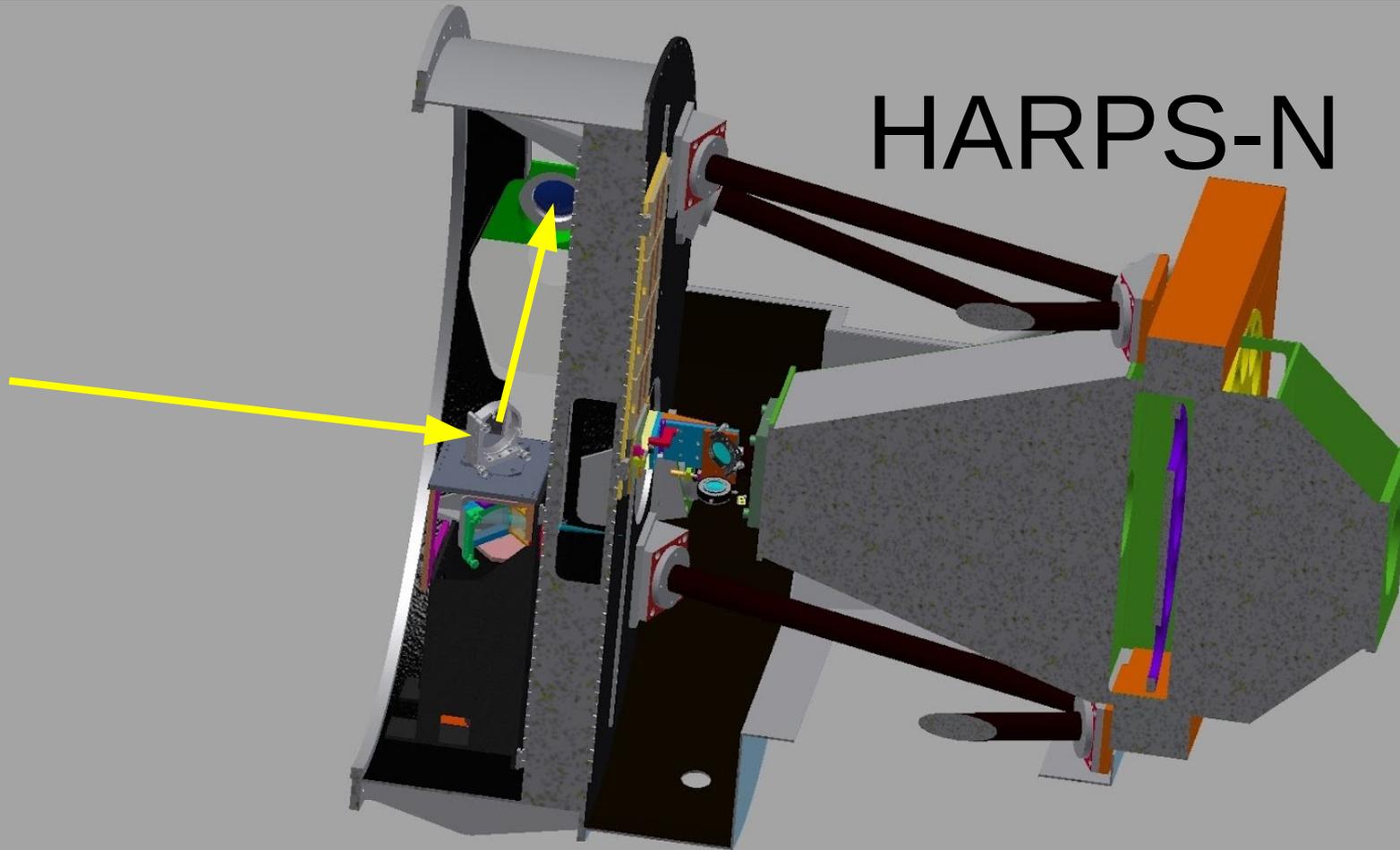
3rd Final IDEA of M4 Dich  
And pick-up



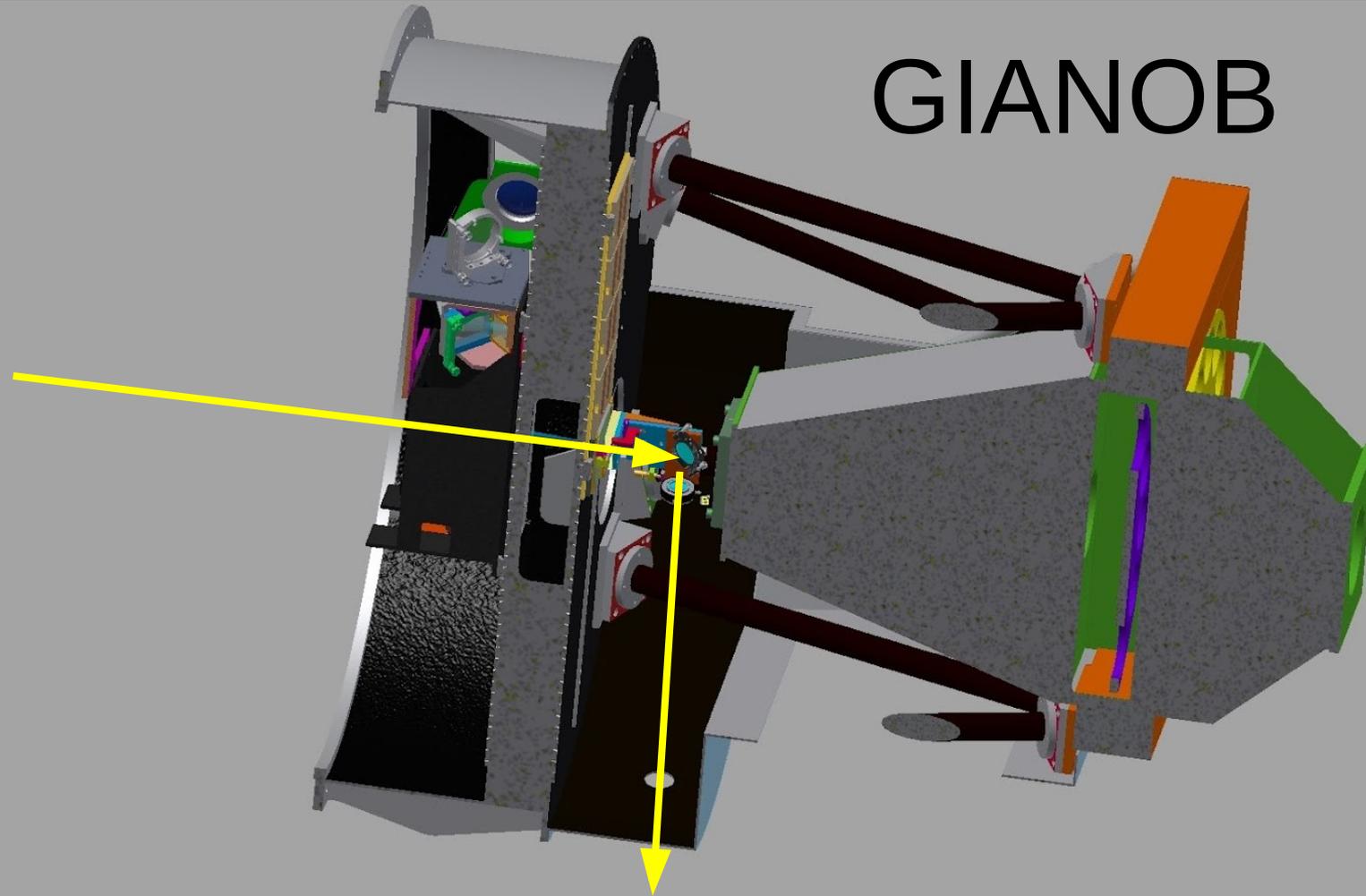
# DoLoRes



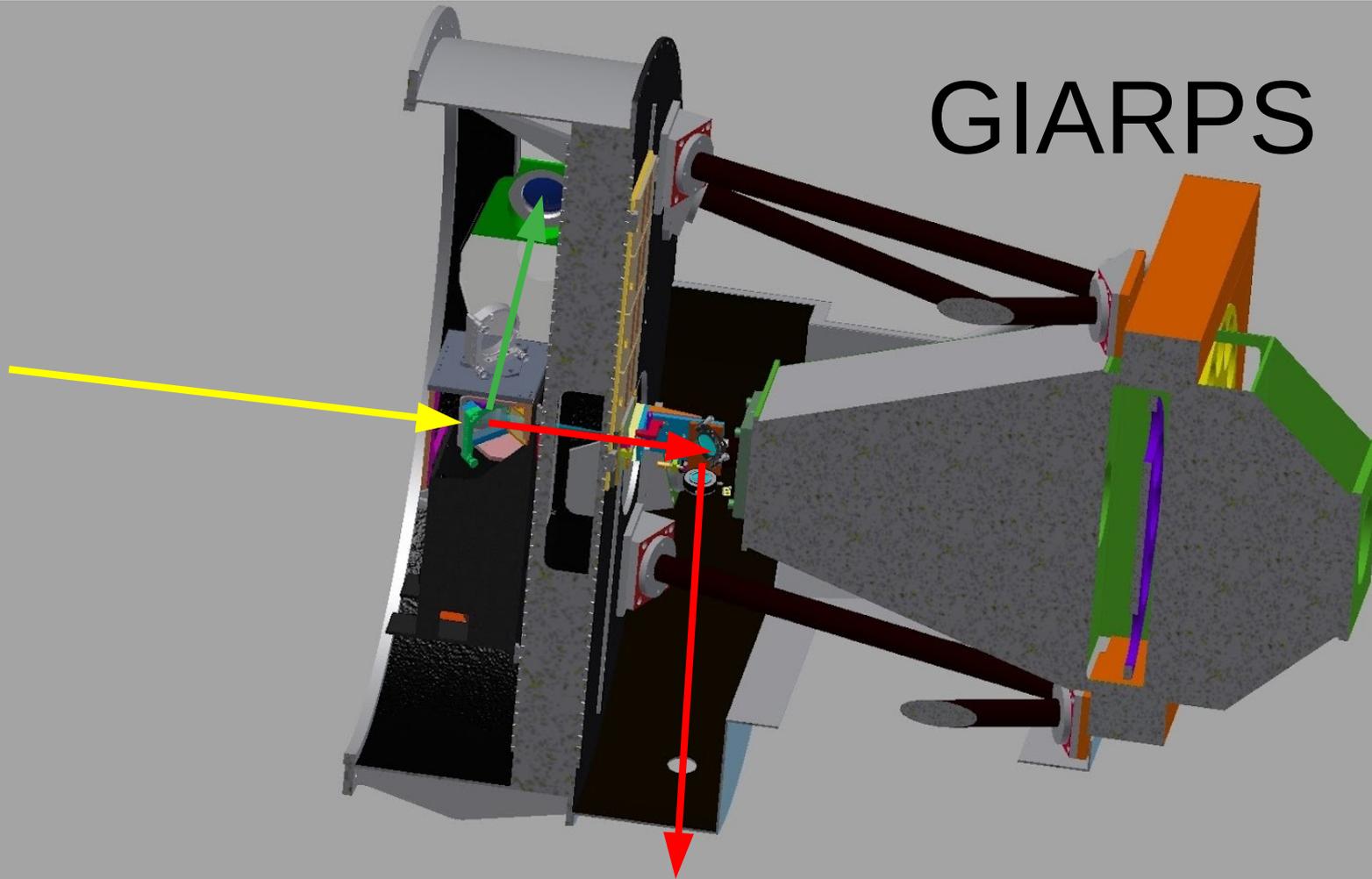
# HARPS-N



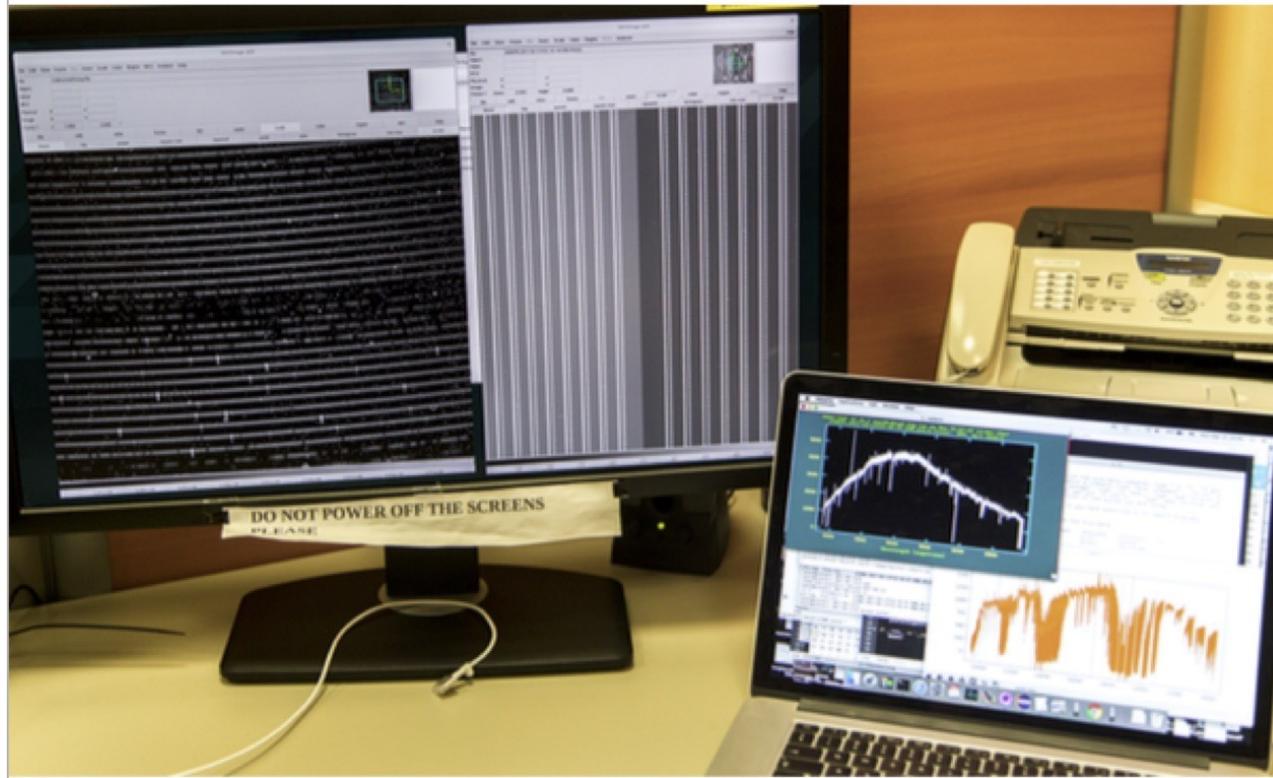
# GIANOB

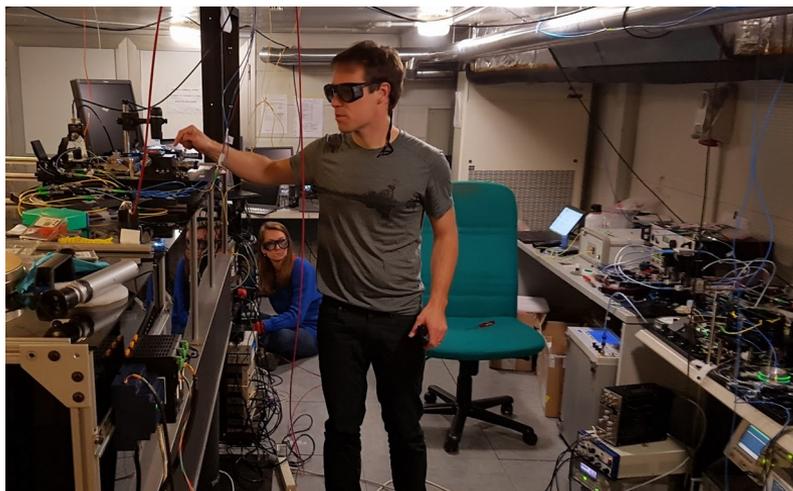


# GIARPS



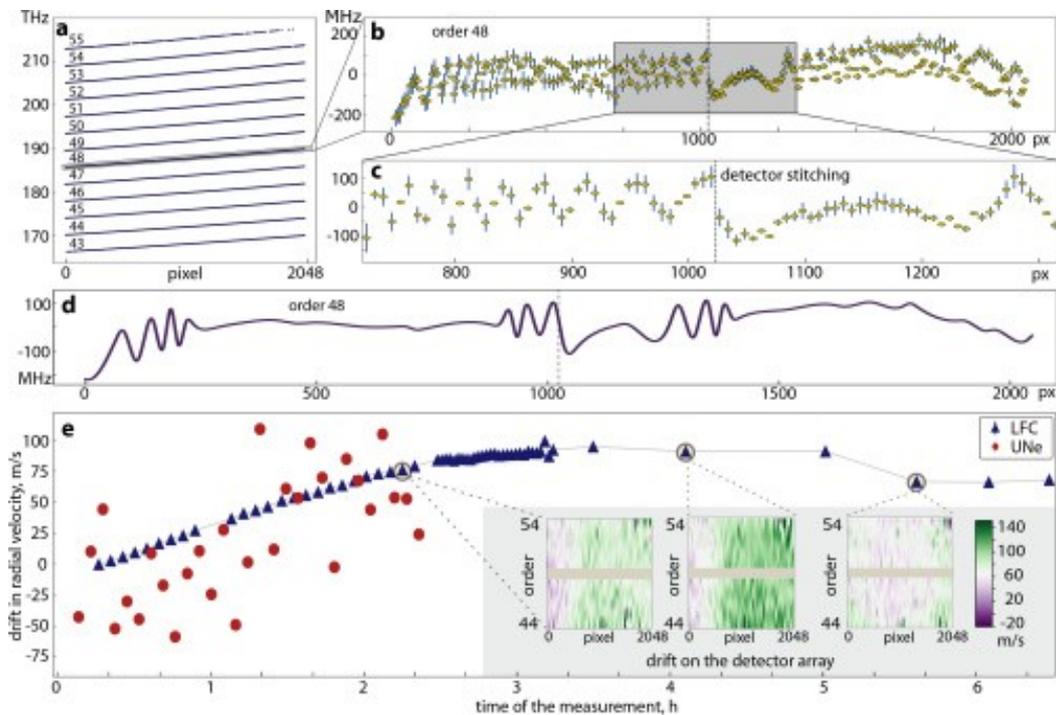
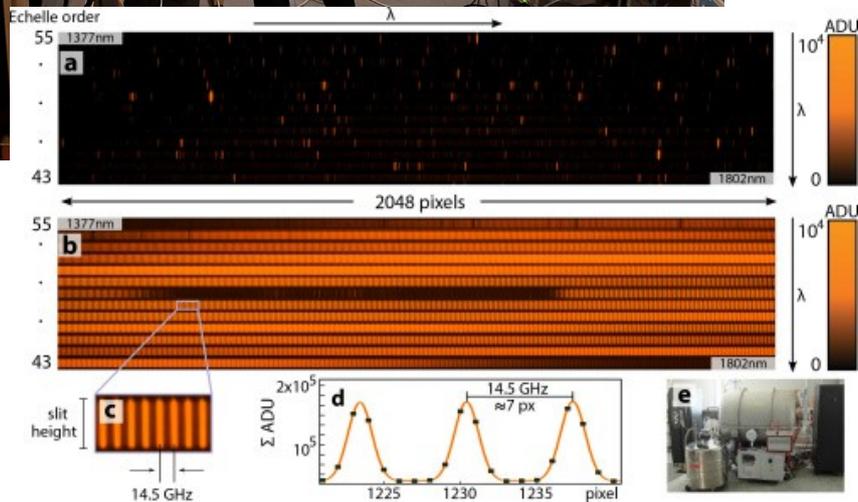
# GIARPS at TNG is the only facility that allows for simultaneous VIS-NIR Hi-Res spectra.



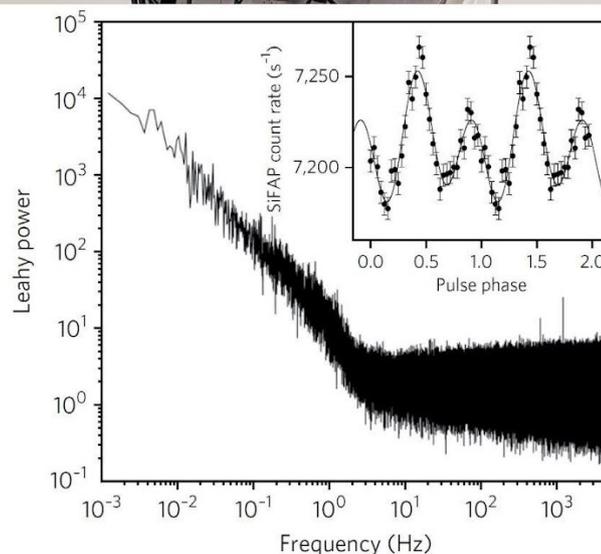
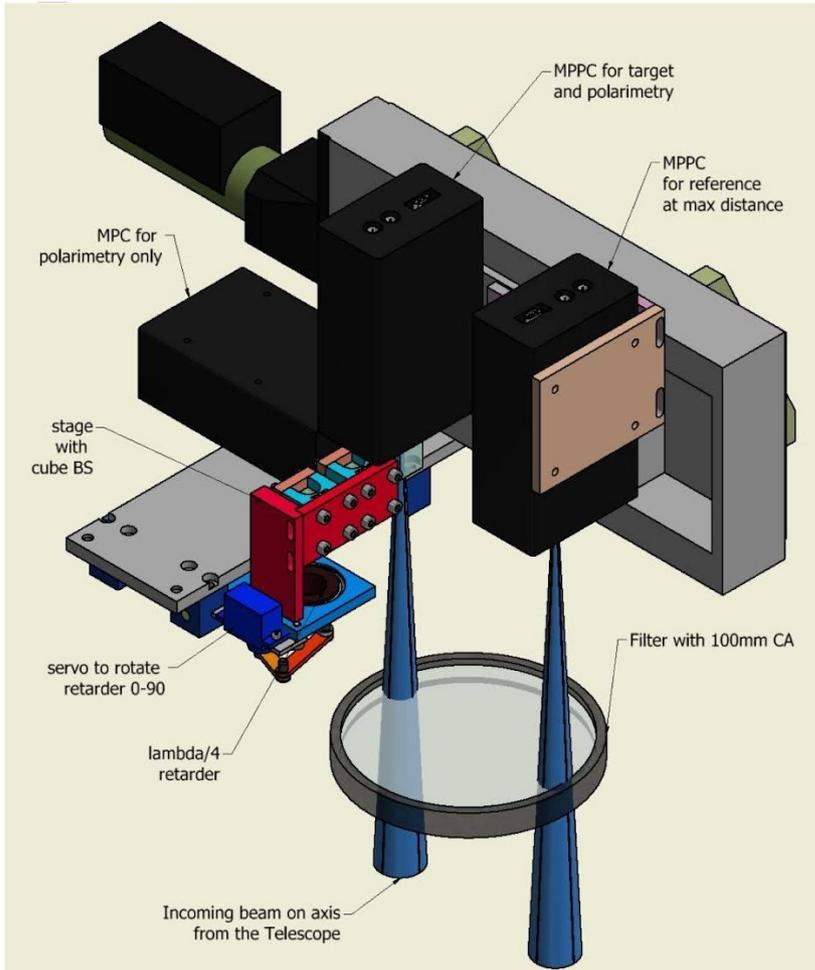


# NIR Electro Optics LFC

[CSEM Neuchatel, ObsGeneva, OABrera, OACA, FGG] (2017)



# SiFAP2 (2018) (OAR, LaSapienza, OACT, FGg)



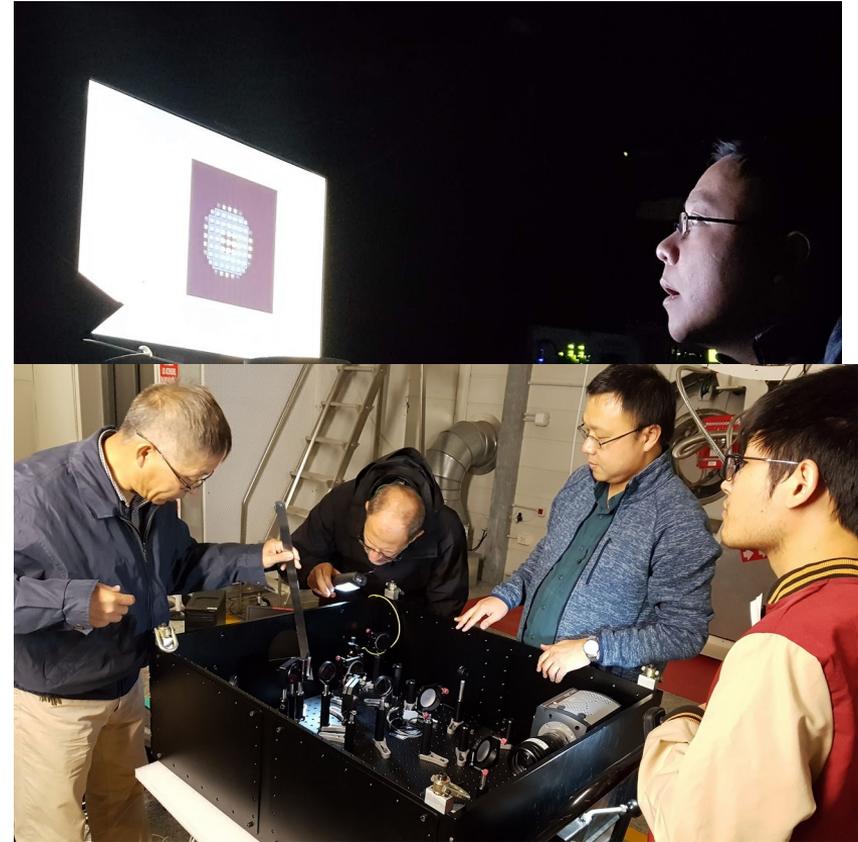
- 1) L/C polarimetry
- 2) ref  $r=[3.5-8]'$
- 3) OIG filter set
- 4) GPS clocks
- 5) offered as PI inst
- 6) niche instrument

ms PSR, Compact objects,  
lunar/ asteroid occultations, FRB,  
simult Radio/X/Magic

IQuEye (2014)  
(Uni PD, DEI PD)

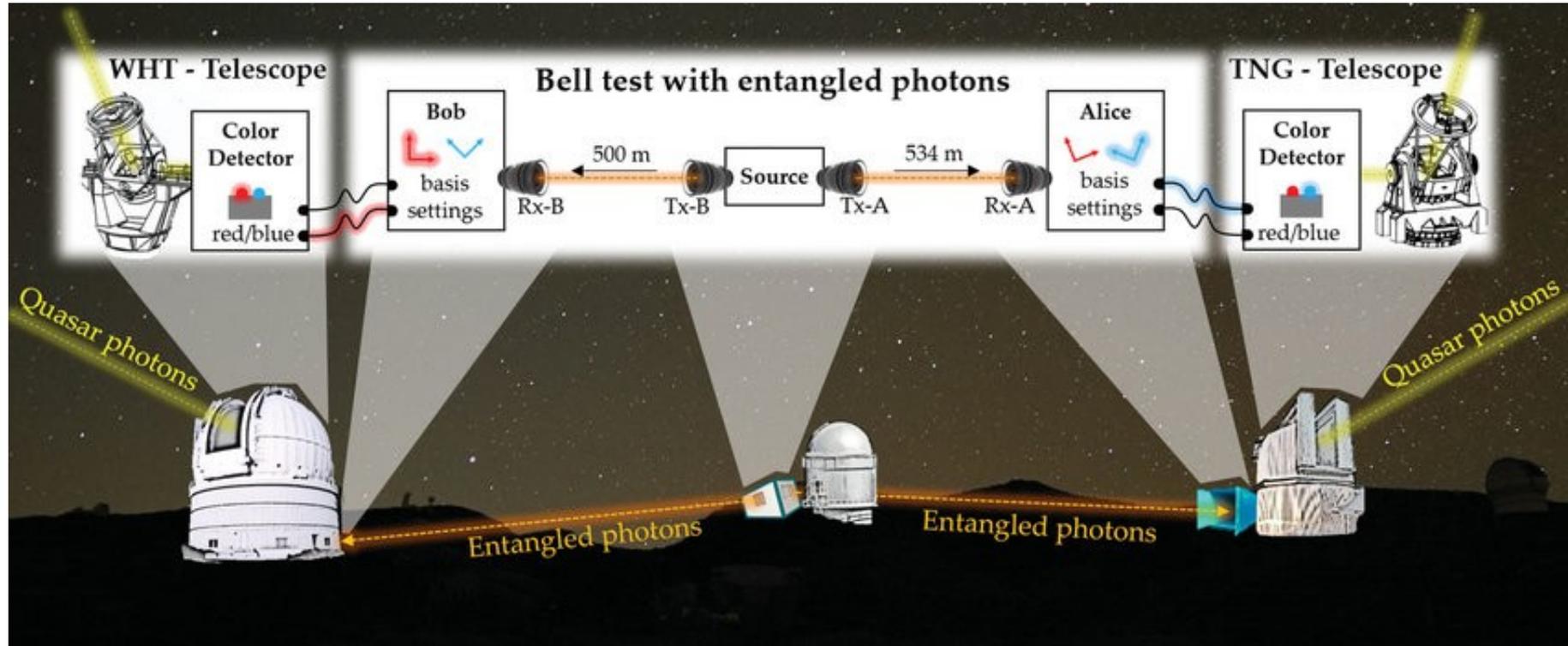


PAO (2019)  
(CSUN, Chinese academy of science)

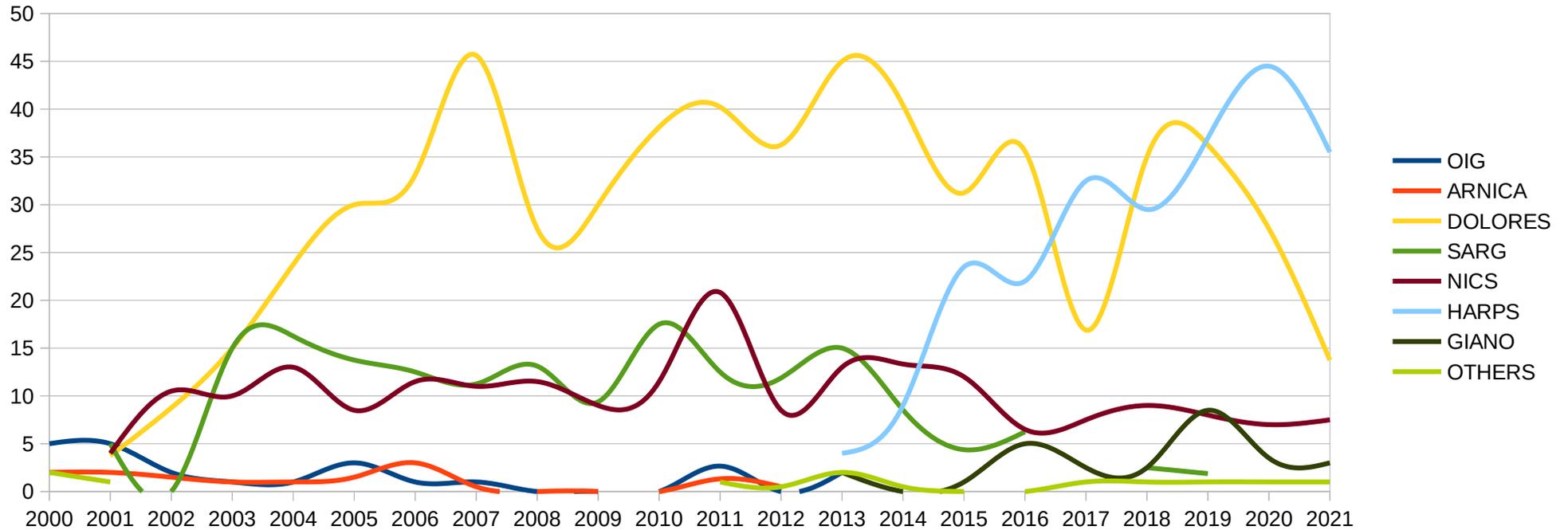


# Cosmic Bell Experiment (2018):

Demonstration of quantum entanglement at cosmic scale  
[Wien Univ. (Prof. Zeilinger), WHT, NOT, TNG]



# Scientific Publications



OIG	ARNICA	DOLORES	SARG	NICS	HARPS	GIANO	OTHERS
26	14	491	141	214	237	28	12

# Which future for the TNG?

- 2 Instruments (Dolores and NICS) more than 20 years old; still competitive but not reliable. What if they break down?
- R.Gratton 2017 in PD → missing 3<sup>rd</sup> gen plans for the TNG inst (call 4 ideas + develop + AIV = 5-10 years);
- INAF has no instrument plan;
- Wait for PI instruments only?
- What does the astronomical community need?

# Not only a technical issue

- The staff needs **new challenges** otherwise there is loss of interest, loss of enthusiasm, of energy, of ideas;
- We need money and FTE not only to repair and upgrade the systems, but to develop new ideas, we need plans;
- **We are efficient, we have the ideas, we want to be competitive;**

BUT

- We cannot participate in Premiali/Prin (FGG not a INAF structure);
- We cannot host PhD students (FGG not recognized as research institute);
- Researcher don't want to work here because you are cut out, away from the institutes, forgotten;
- The staff is getting older; no plan for turnover; we cannot increase the staff.

## What Can we Do?



Focal plane inst: development and  
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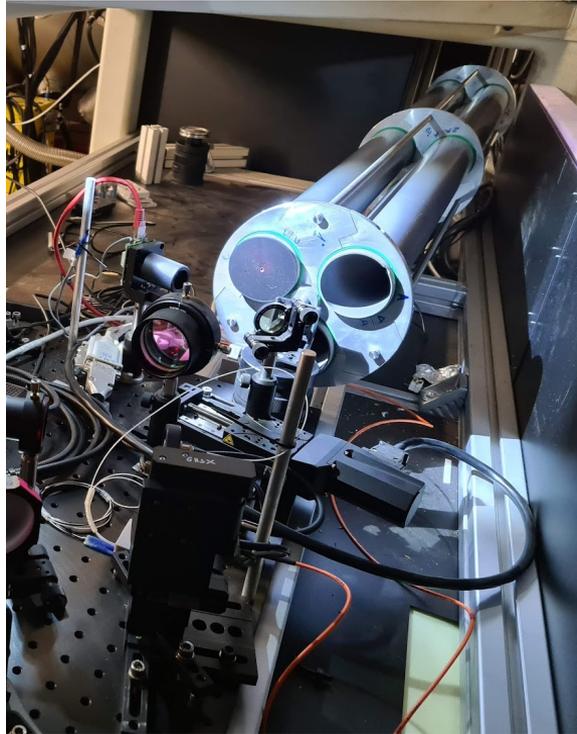
# We dream of new instruments



- ~~PRIN 2019 with e-SiFAP2; fiber fed and NIR extended;~~
- ~~Premiale: LFC VIS – NIR (Polit.MI, OACT)~~
- ~~BATMAN? NTE? LOL~~
- Fiber IFU (Granada) for LRS.
- UV spectrograph?

# Absorbing CELLS [2022]

(OAPD, OAA, OABr, OACT, IAPS)

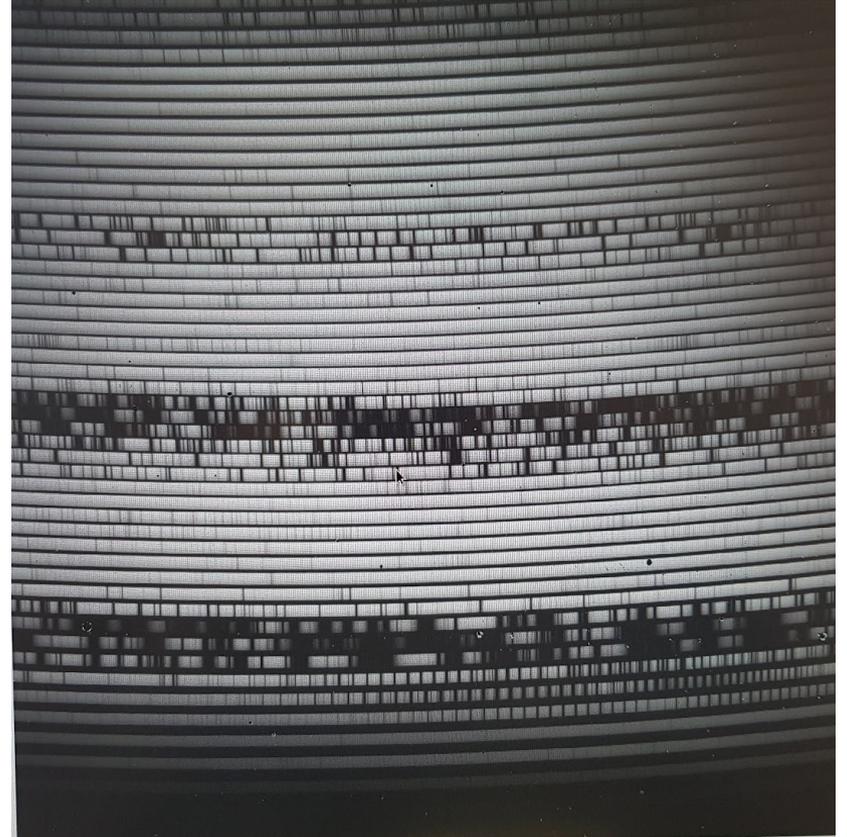


*GIANO RV ~3m/s*



# LOCNES (2022)

(OAPD, OAA, OABr, OACT, IAPS, OAR)



# SIFAP2 Tuning to support IXPE mission with simultaneous observations

*Near Future(December 2021)*

FGG, OAR, OACT, IAPS (Costa, Soffitta)



**IXPE**  
Imaging X-Ray Polarimetry Explorer

Home About For Scientists MSFC X-ray Astronomy Links Contact Partners

**Polarization**  
The Physics of Polarization  
Polarization - Creation  
Polarization - Detection

**Useful Resources**  
In the News  
Chandra X-ray Observatory  
Multimedia

**IXPE Home: Expanding the X-ray View of the Universe**

The Imaging X-ray Polarimetry Explorer (IXPE) exploits the polarization state of light from astrophysical sources to provide insight into our understanding of X-ray production in objects such as neutron stars and pulsar wind nebulae, as well as stellar and supermassive black holes. Launch has been set for December 9, 2021. Technical and science objectives include:

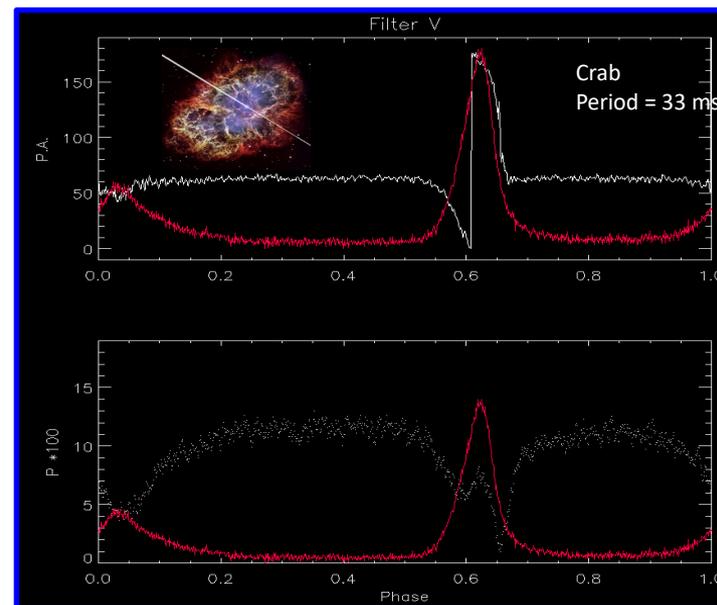
- improving polarization sensitivity by two orders of magnitude over the X-ray polarimeter aboard the Orbiting Solar Observatory OSO-8 (scientists see HEASARC: Observatories),
- providing simultaneous spectral, spatial, and temporal measurements,
- determining the geometry and the emission mechanism of Active Galactic Nuclei and microquasars,
- finding the magnetic field configuration in magnetars and determining the magnitude of the field,
- finding the mechanism for X ray production in pulsars (both isolated and accreting) and the geometry,
- determining how particles are accelerated in Pulsar Wind Nebulae.



L'Imaging X-ray Polarimetry Explorer (IXPE) è una missione in sviluppo che fa parte del programma spaziale SMEX (Small Explorer) della NASA, il cui Principal Investigator è il Dr. Martin Weisskopf del NASA/Marshall Space Flight Center (MSFC) ad Huntsville in Alabama. IXPE porterà a bordo 3 telescopi con rivelatori in grado di misurare la polarizzazione nei raggi X emessi da sorgenti astronomiche, con una sensibilità di due ordini di grandezza migliori del polarimetro nei raggi X a bordo di Orbiting Solar Observatory (OSO-8), una missione operativa tra fine anni '60 e inizio anni '70. I rivelatori sono sviluppati da un team di scienziati dell'INFN e dell'INAF, con il finanziamento dell'Agenzia Spaziale Italiana. Il team italiano ha una lunga esperienza in rivelatori per misure di polarizzazione nei raggi X, dato che ci ha lavorato fin dagli anni '70.

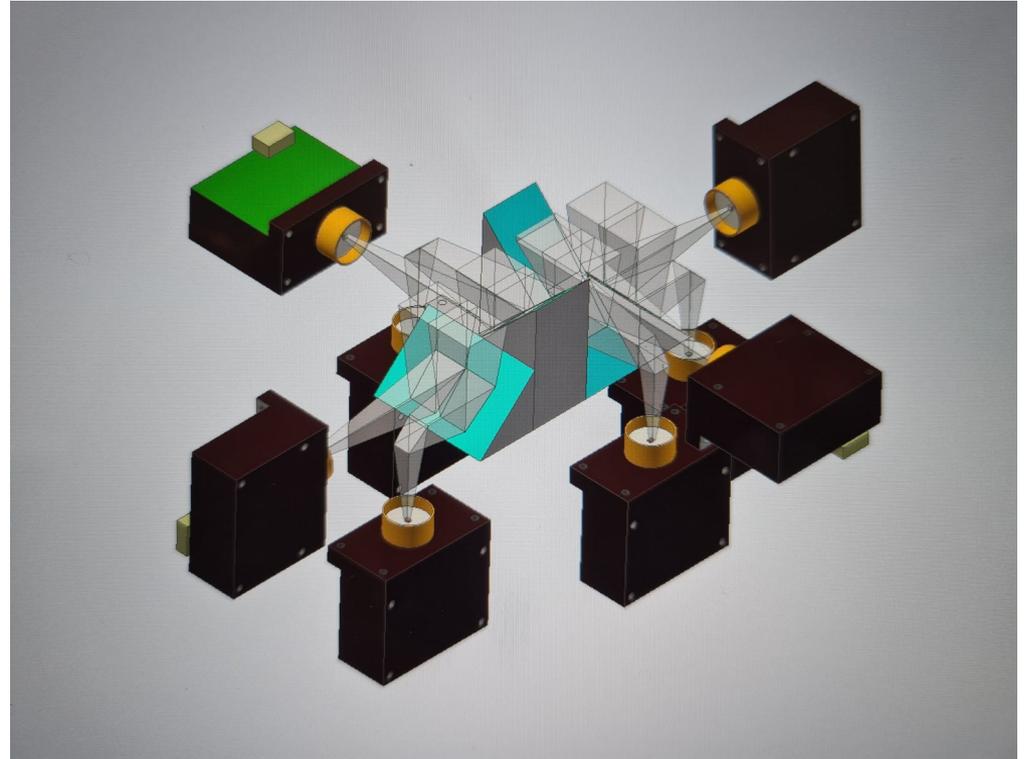
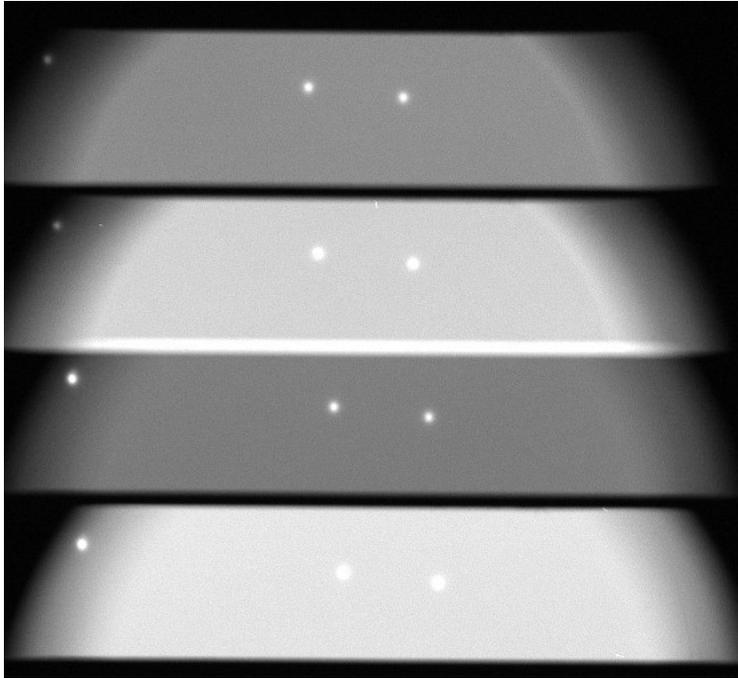


- Calibrations
- High-Time Multiwavelength polarisation

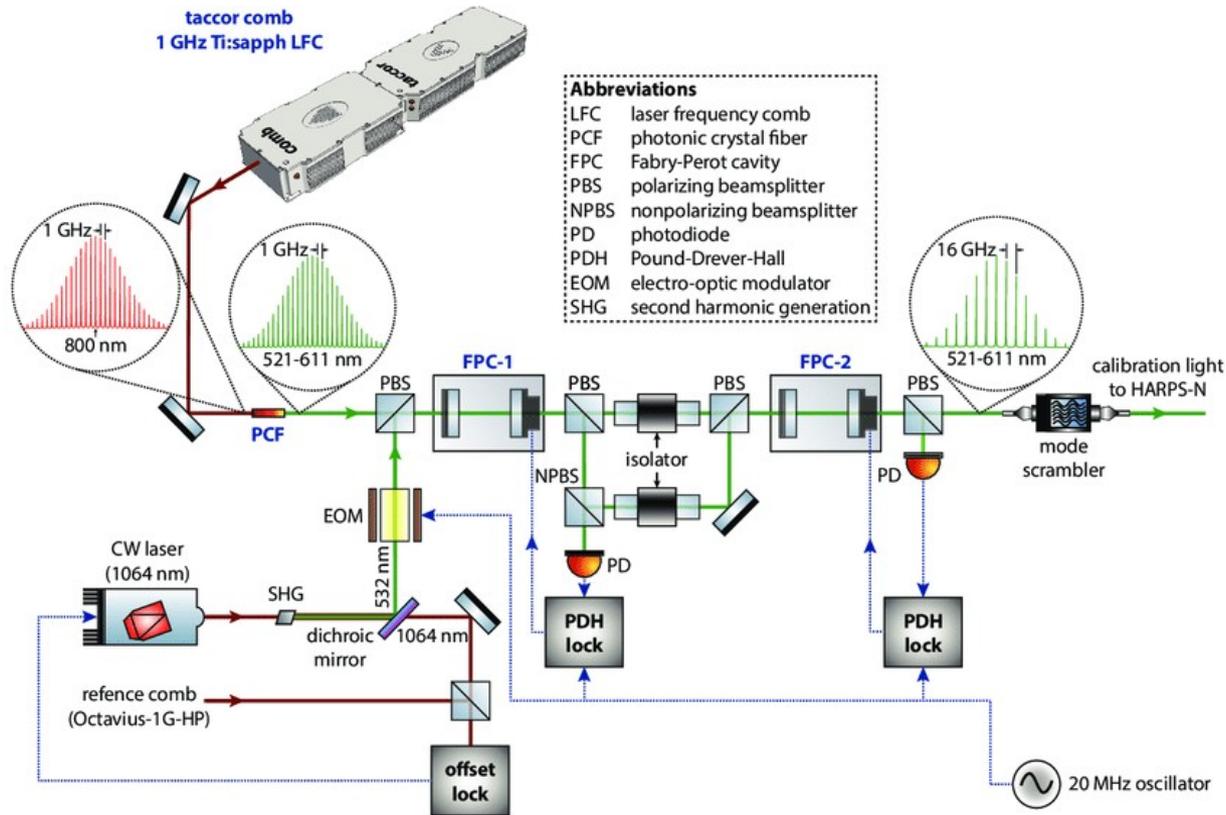


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# PAOLO output with MPPC

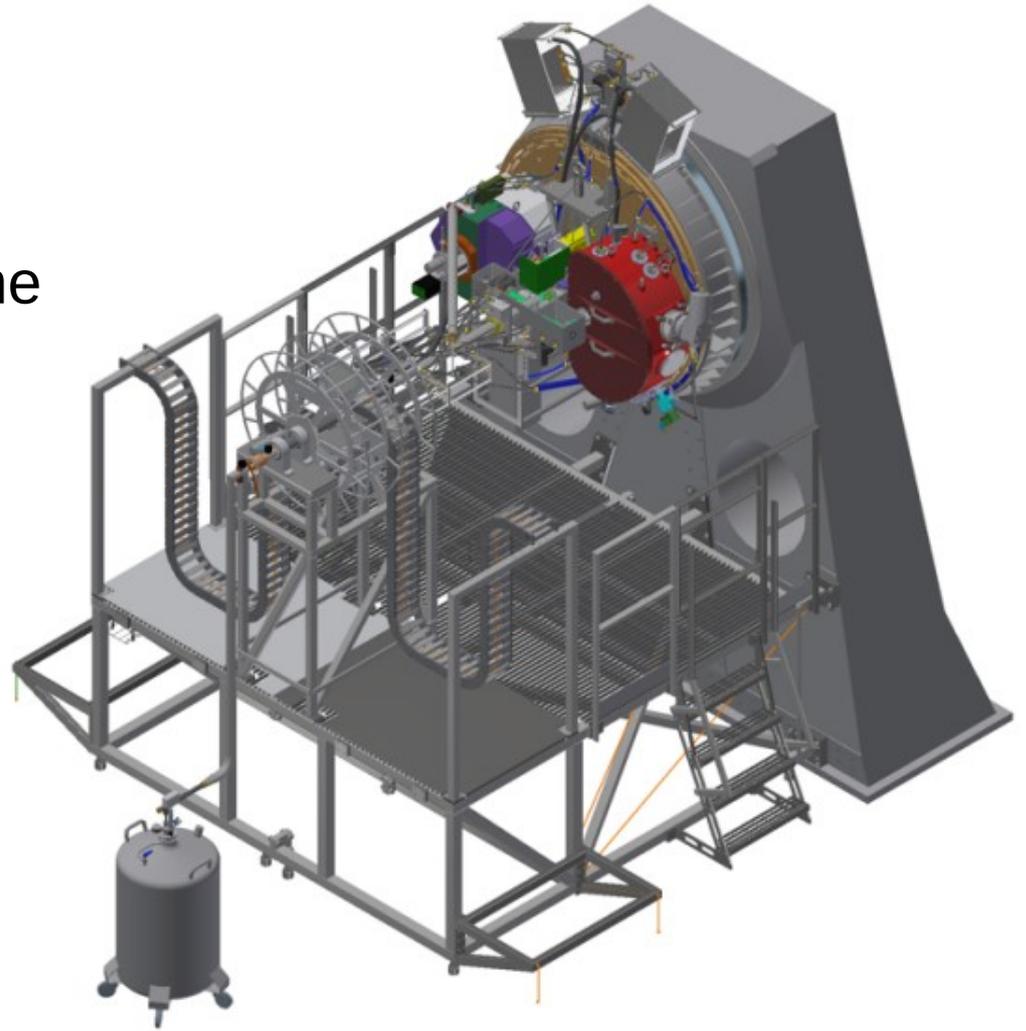


# Turn key LFC [2022?]



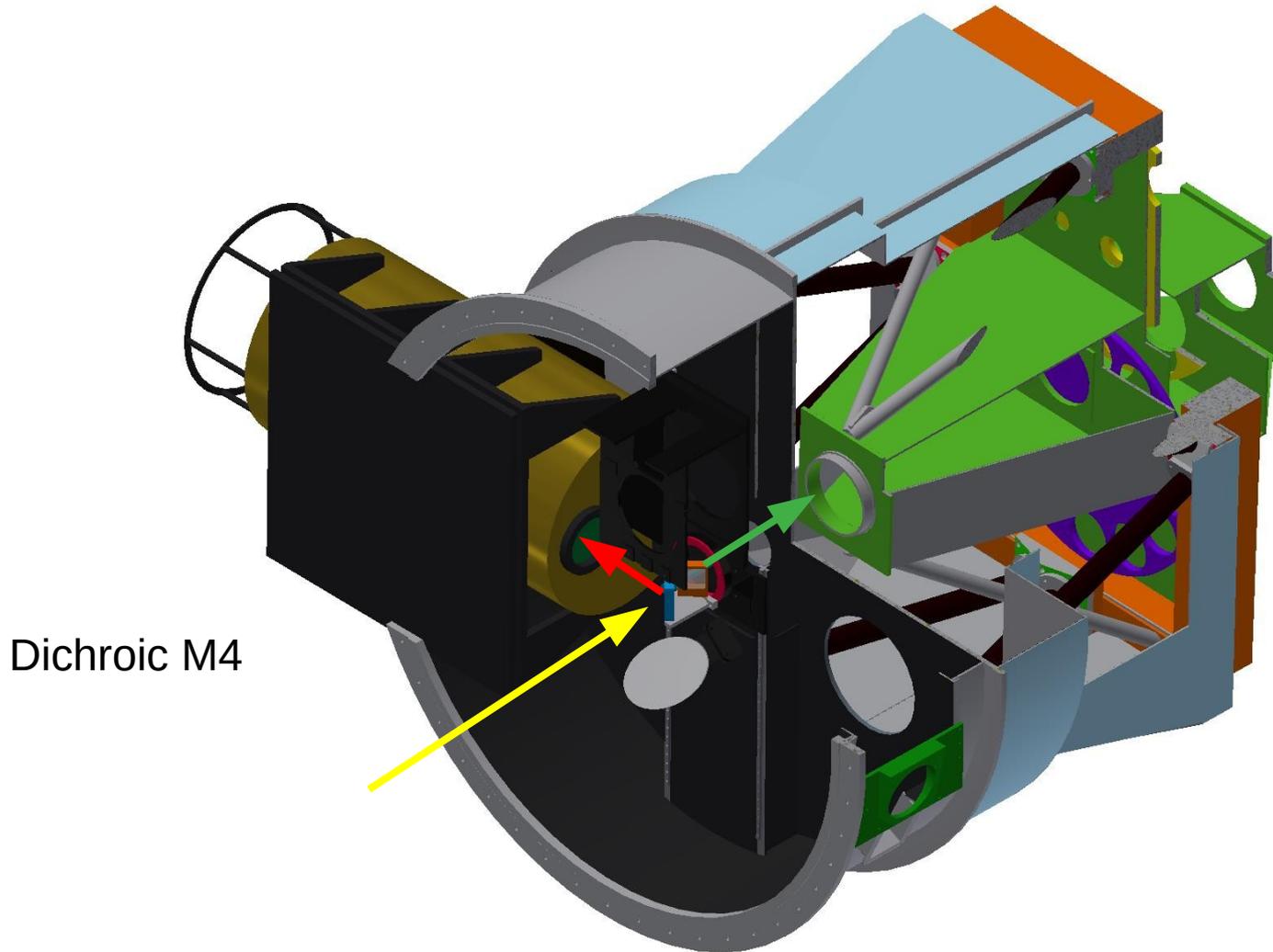
# DOXS at TNG?

- Complementary to SOXS in the North
- INAF has the know-how;
- NTE terrible delay;
- Do it now before we forget;
- Use TNG fast response capabilities for transients



	<b>SOXS</b>	<b>DOLORES/NICS</b>	<b>NTE</b>
VIS detector	E2V CCD44-82 2kx4k	E2V CCD 42-40 4kx4k	EEV 2k x2k
NIR detector	HgCdTe 2kx2k	HgCdTe 1kx1k	HgCdTe 2kx2k
Ima FoV [arcmin <sup>2</sup> ]	3.5x3.5(Slit viewer)	8.6x8.6/4x4	6x6
Scale [mas/pix]	280	252	180
Filters VIS	-	BB/NB	BB/NB
Filters NIR	-	1uJHKK' & 10NB	JHKK' & NB
Sp.Range [nm]	350-850 / 850-2000	350-900 / 900-2500	335-2200
Resolution	~4000 / 5000	600-6000 / 50-500-1250	5000
Slit length	12"	long/MOS/slitless	20"

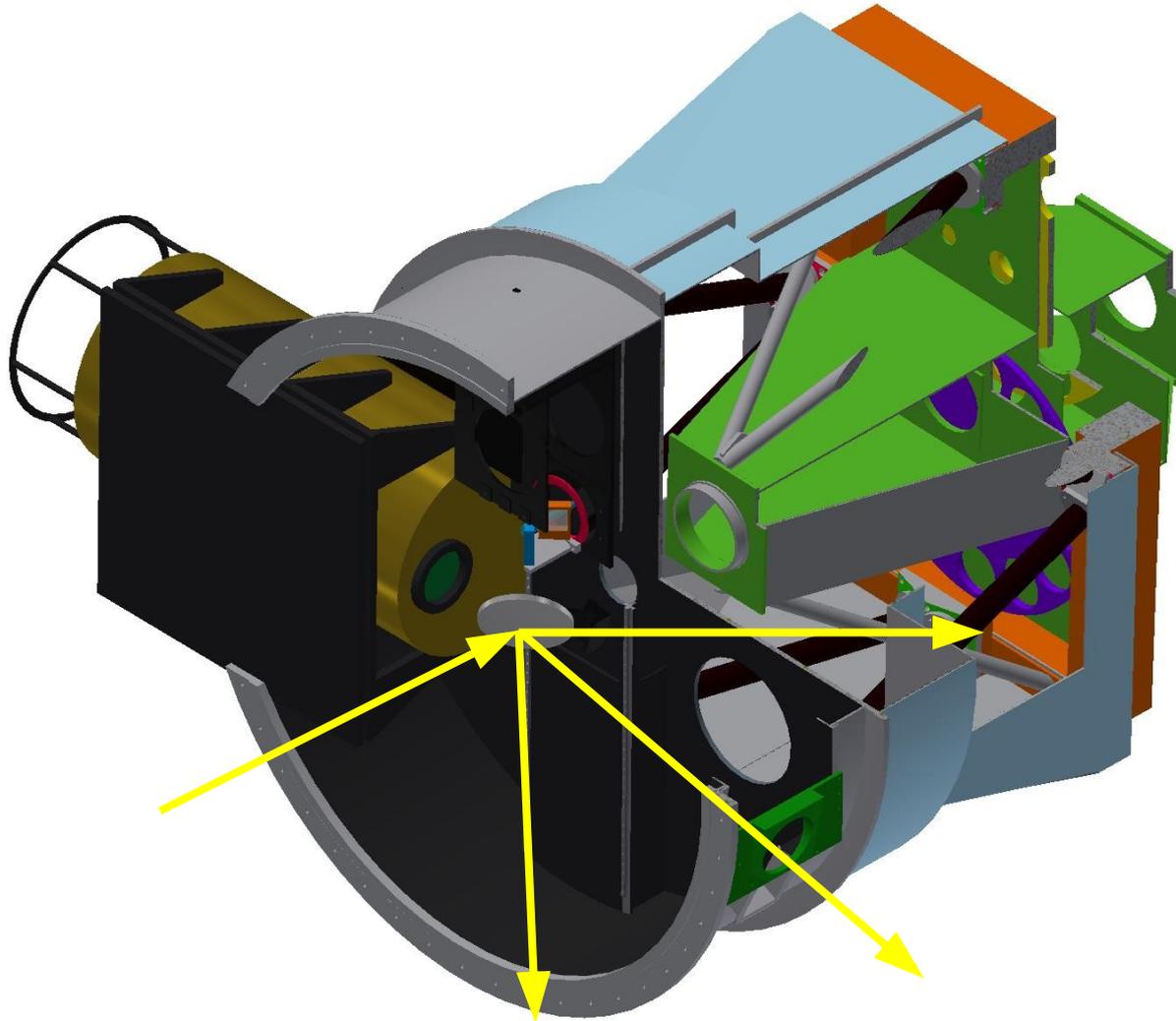
# So.Ni.Do.



Dichroic M4

- Copy LRS Interface
- Dichroic M4
- New electronics
- Obs mode:
  - DICH(VIS/NIR)
  - Hole (VIS)
  - M4 (NIR)
- ...

# So.Ni.Do.



Rotating M4:

- NICS
- IFU
- PAO
- PI inst

+ MegaSifap  
in Nasmb

# Conclusions

- In 25 years many things have changed but not the dedication of the TNG staff and the feel of belonging and contribute to something unique.
- TNG is **still efficient, reliable and competitive** with the installed instruments and their versatility, mixed together with **fast response capabilities** and **enthusiasm of the staff**
- New projects and long-term planning are needed to maintain the interest and motivation for 25 years further.

If INAF wants the TNG to remain competitive we need Long Term Plans for the Telescope and for the people

**ES47 2100 9169 0122 0017 9456**

**BIC / SWIFT Code: CAIXESBBXXX.  
Addressee: Cabildo Insular de La Palma  
Indicate in the subject 'Volcano Donation'**