Development of R&D platform for astronomical instrumentation in visible and near-IR

Thematic Areas:

■ (CF4) Dark Energy and Cosmic Acceleration: The Modern Universe
■ (CF6) Dark Energy and Cosmic Acceleration: Complementarity of Probes and New Facilities
■ (IF2) Instrumentation Frontier: Photon Detectors

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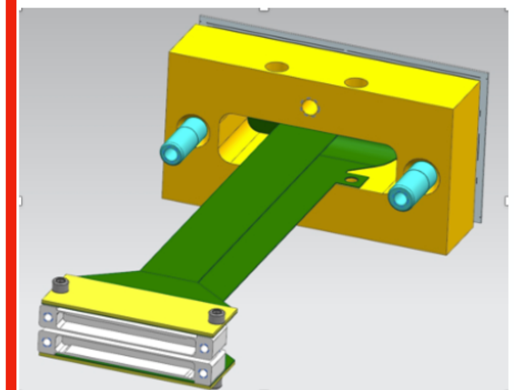
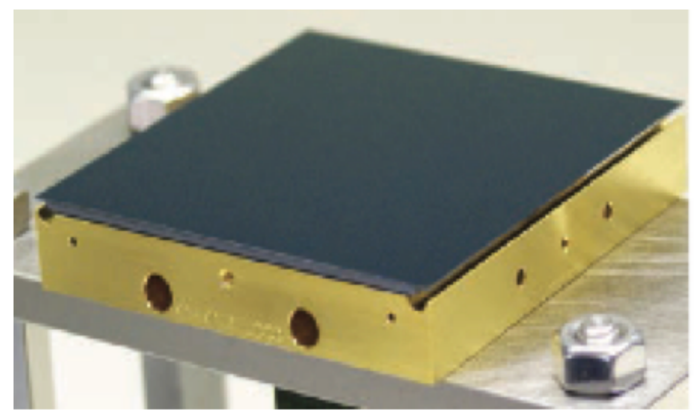
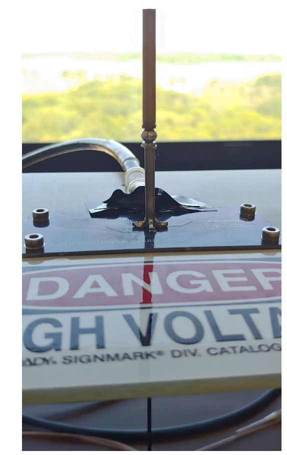
Abstract: The next generation of astronomical instruments for cosmic surveys will require the development of new technology. Examples of such developments include novel sensors, mechanisms for multi-fiber positioning systems, and electronic readout systems. These efforts are often started at instrumentation development facilities that do not have a direct access to telescopes for on-sky testing. Recently, NOIRLab was formed by amalgamation of Gemini Observatory, NOAO, and Rubin Observatory, and part of its strategic vision is enabling breakthrough discoveries via collaborations with other institutions. The current letter describes the interest in establishing a partnership between National Physical Laboratories, Universities, and NOIRLab to accelerate on-sky testing of new technologies.

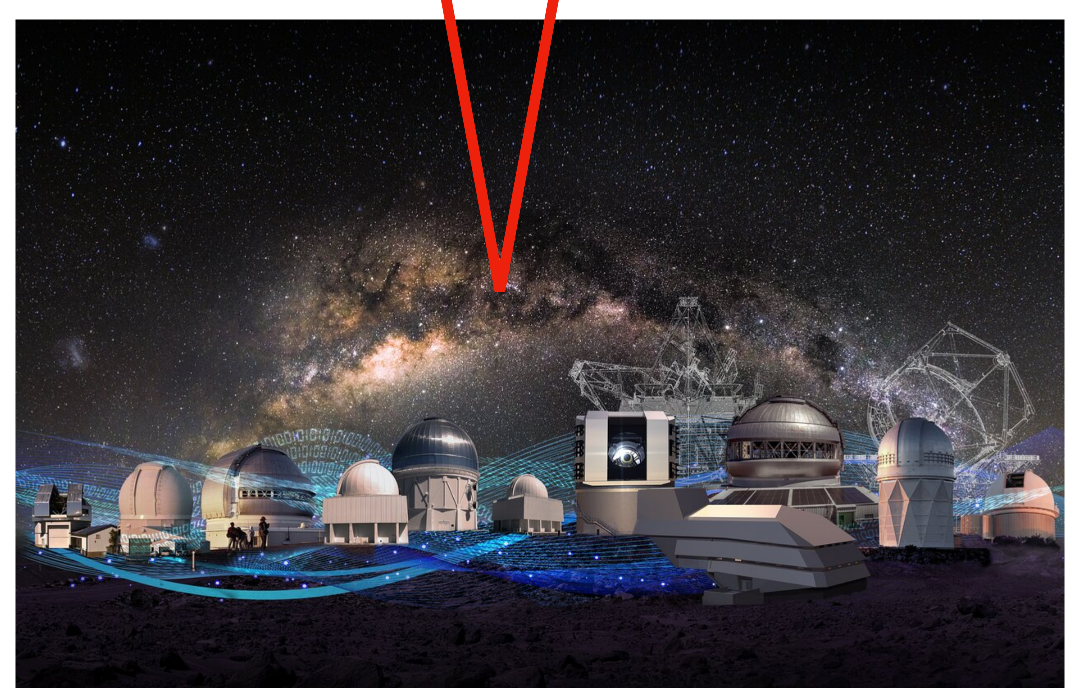
Universities and National Labs are developing enabling technology for the next generation of instruments in cosmology (sensors, multi fiber positioners , electronics, filters)







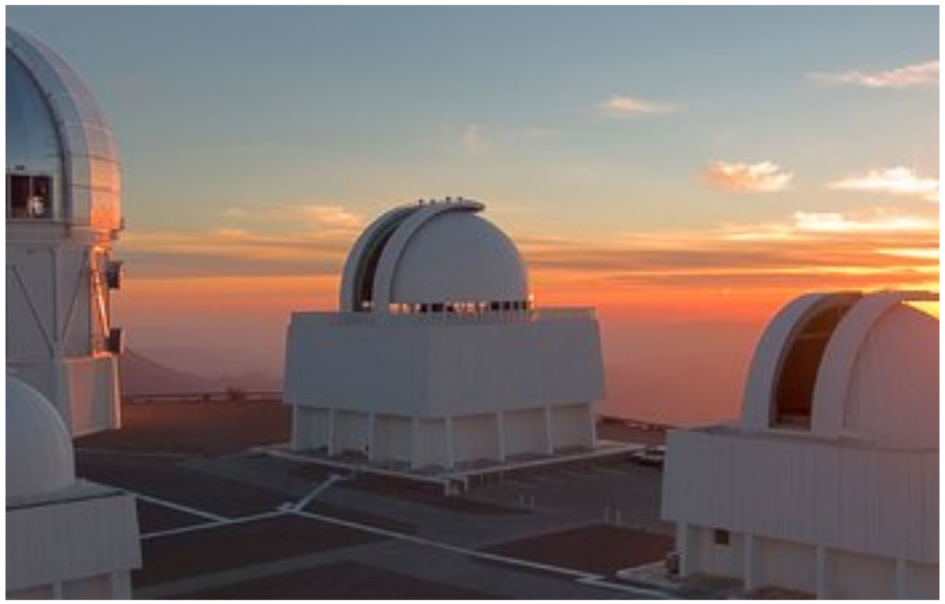
We want to establish a standard way of testing those at telescopes. NOIRlab can help with this.



it is the best way to debug… it is also the most fun

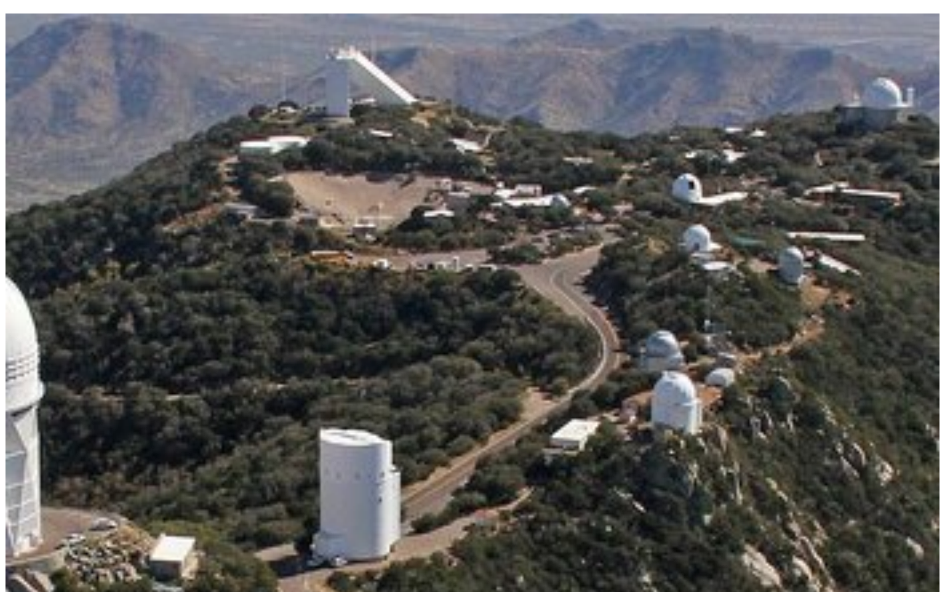
NSF NOIRLab

Cerro Tololo

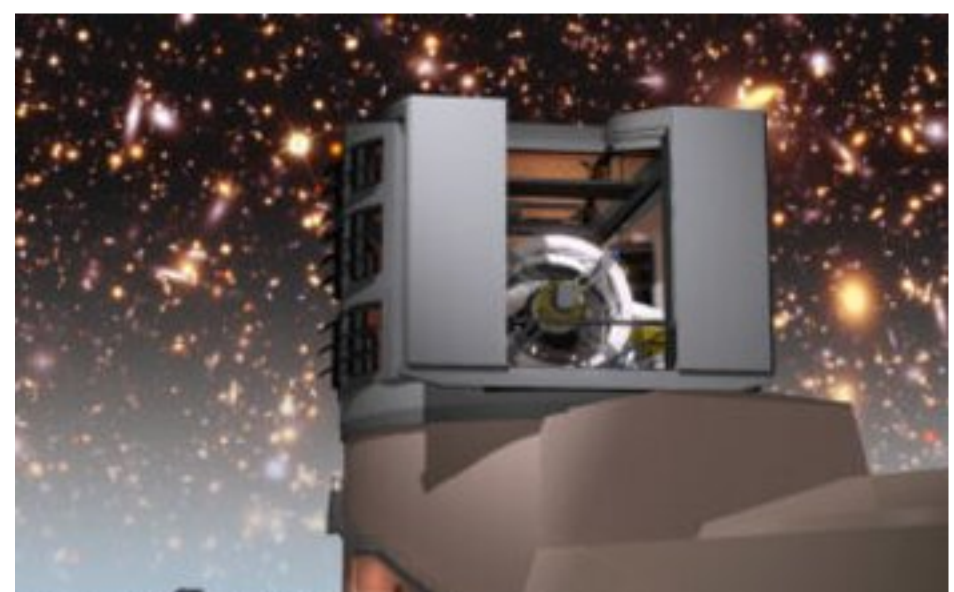


Gemini

Kitt Peak National Observatory



Vera C. Rubin Observatory

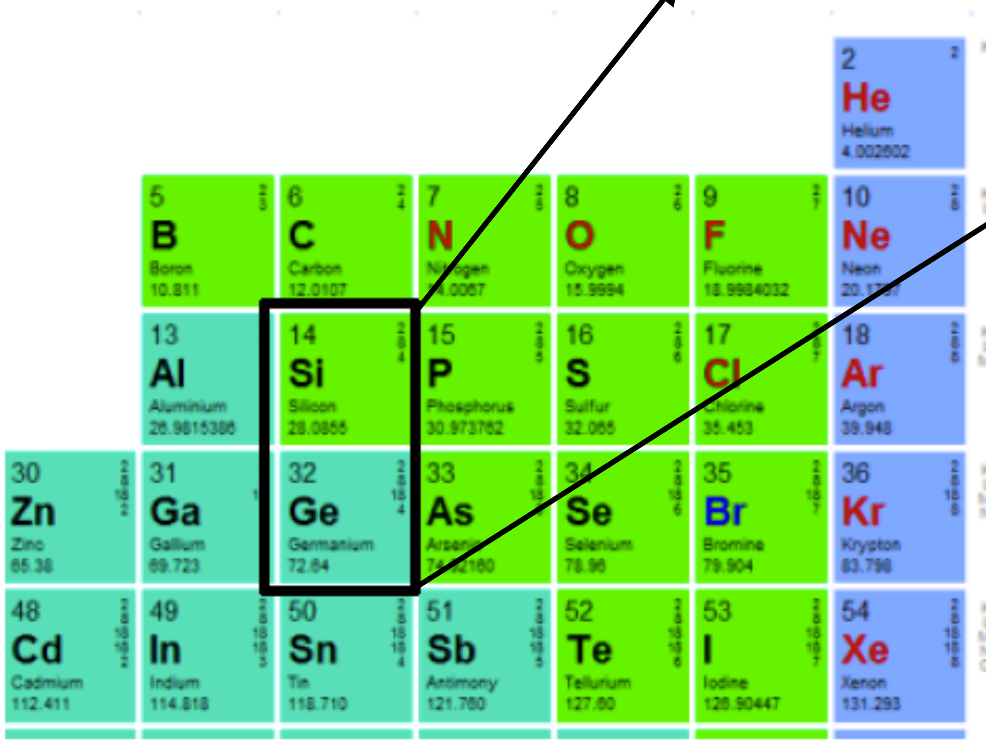


some example of technologies

Sensors : Ge CCDs

Egap = 1.12 eV

Egap = 0.67 eV



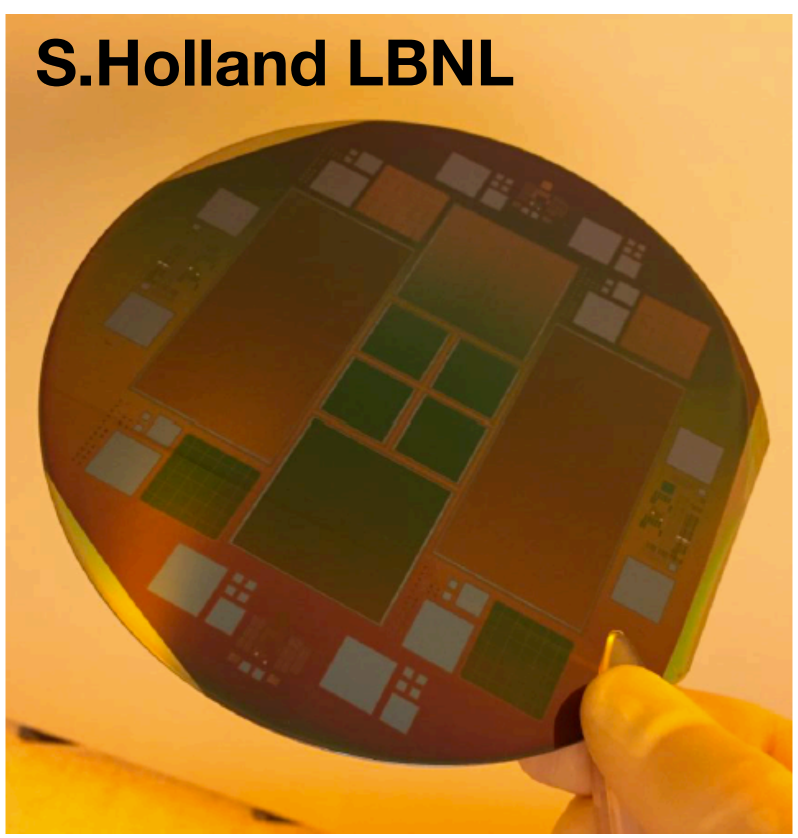
Ge extends the reach into IR

$$\lambda_{co} = \frac{1.24}{E_g}$$

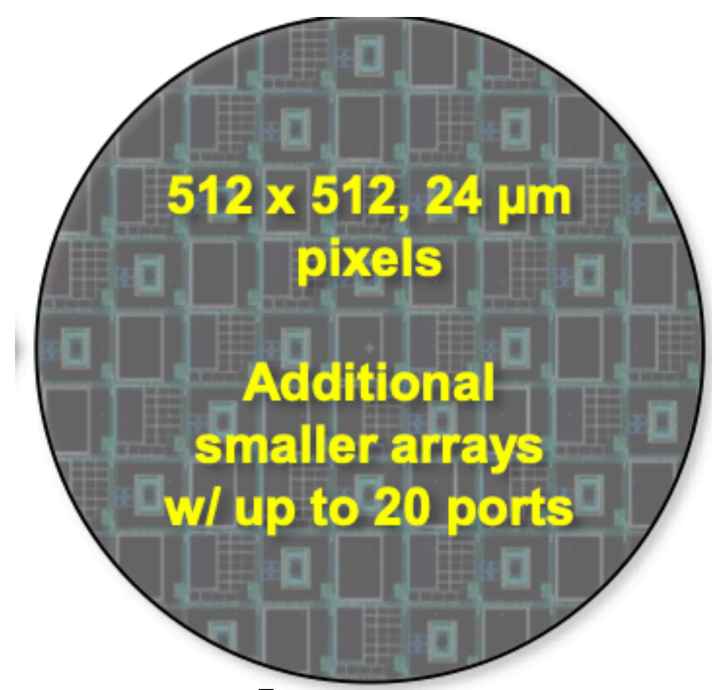
<u>This extends the redshift range of the instruments z~2.6.</u>

Ge has the additional challenge of higher dark current. New fabrication processes.

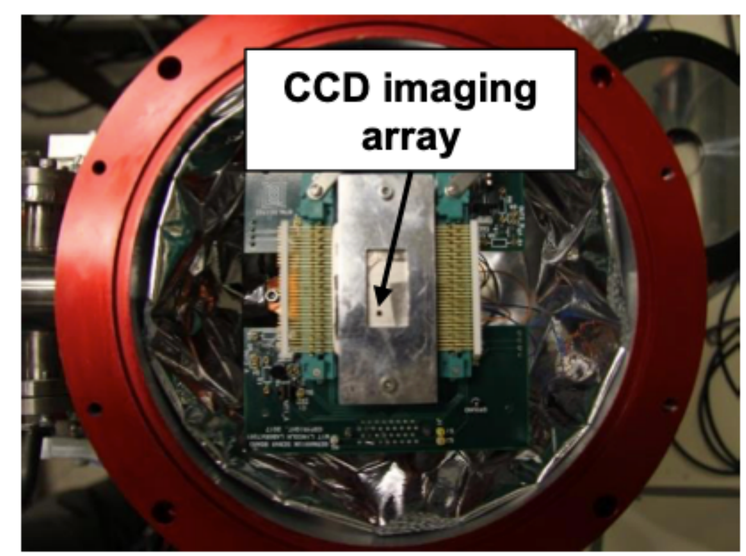
Active R&D, CCDs coming soon



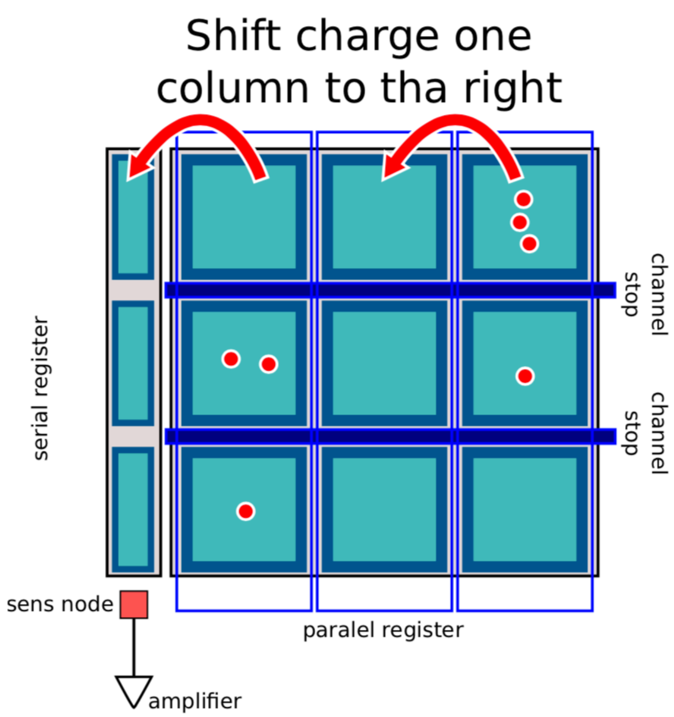
S.Leitz MIT-LL

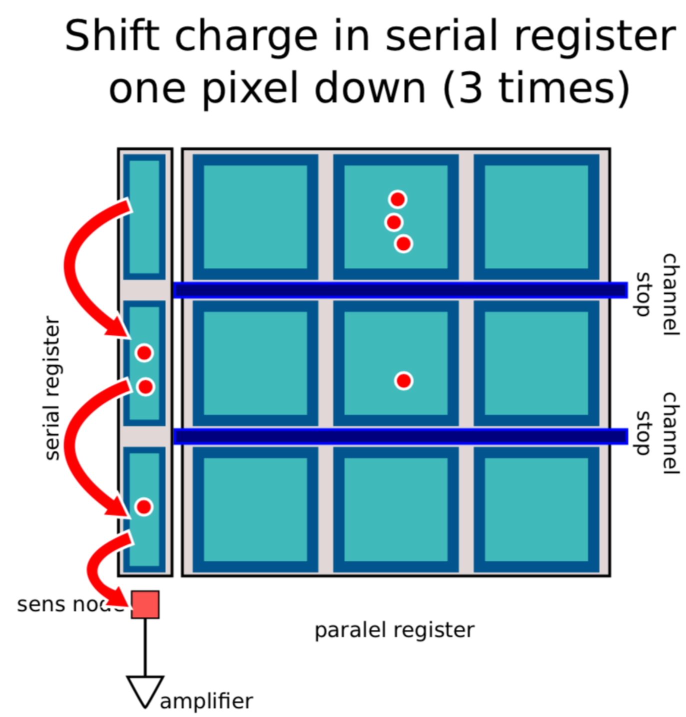


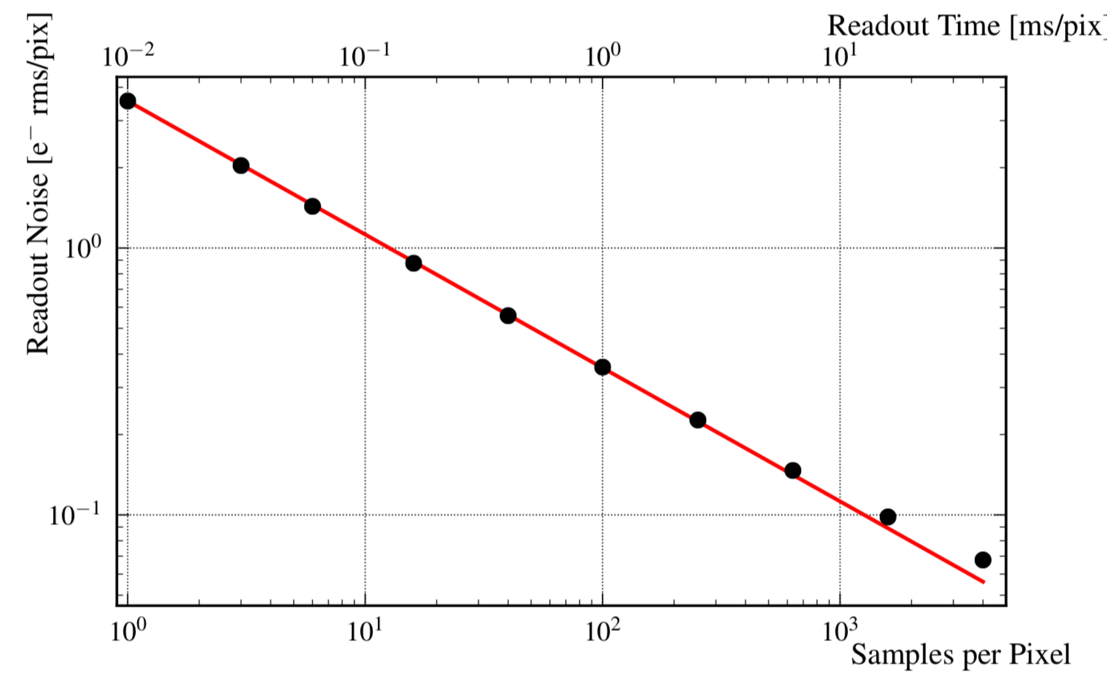
Tests MIT-LL

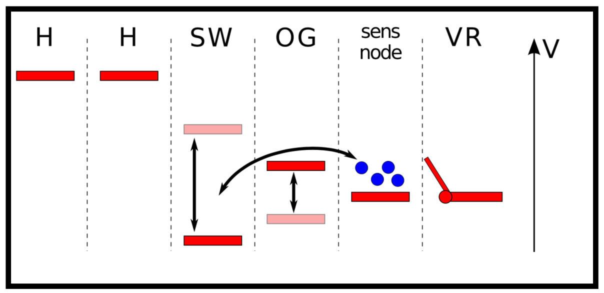


Sensors : skipper-CCD



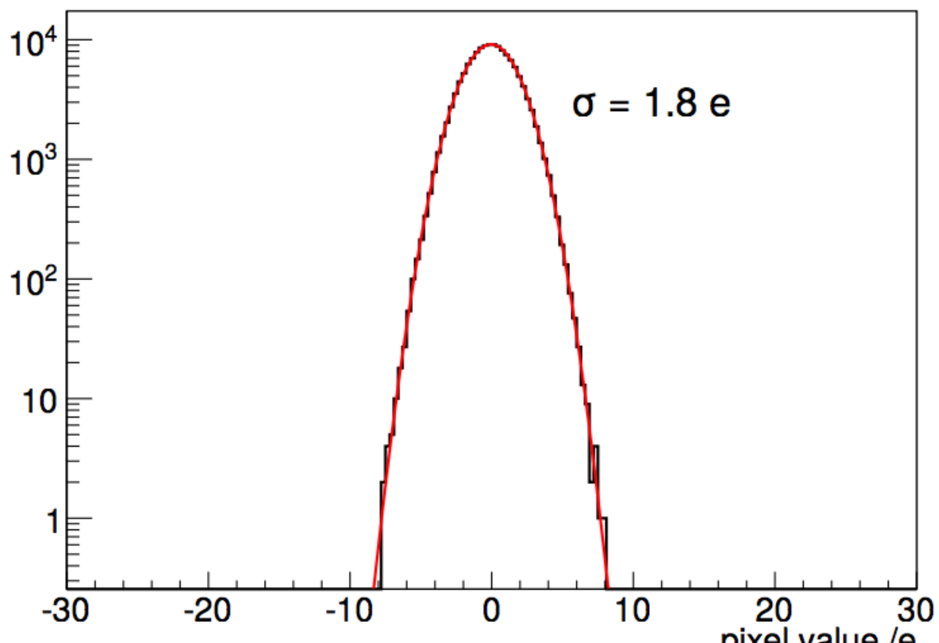


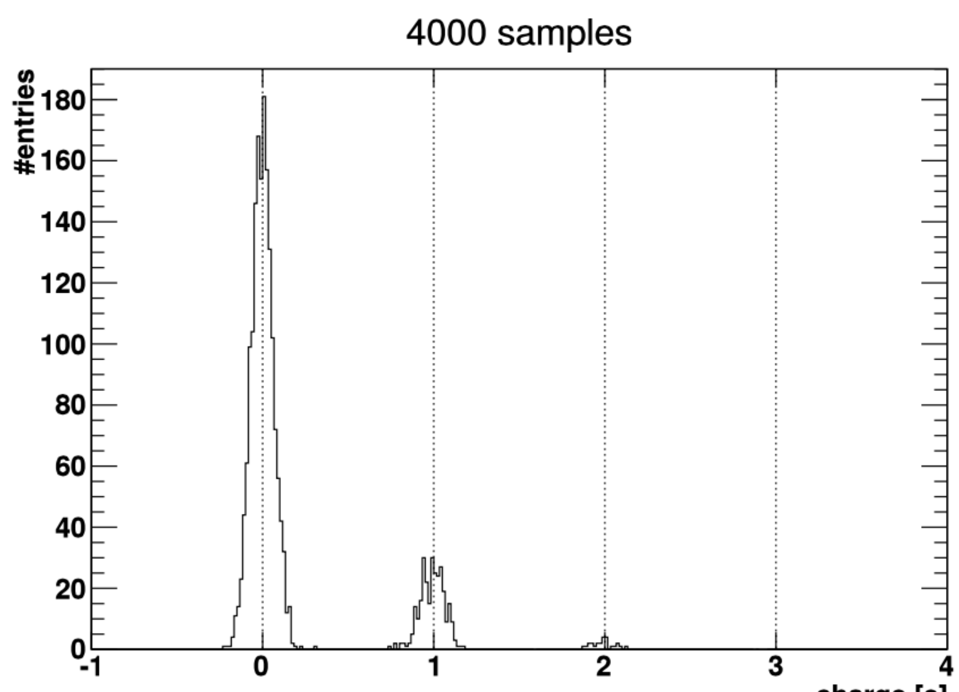




Multiple sampling reduces the noise to 0. Designed at LBNL (S.Holland) and demonstrated at Fermilab (J.Tiffenberg et al)

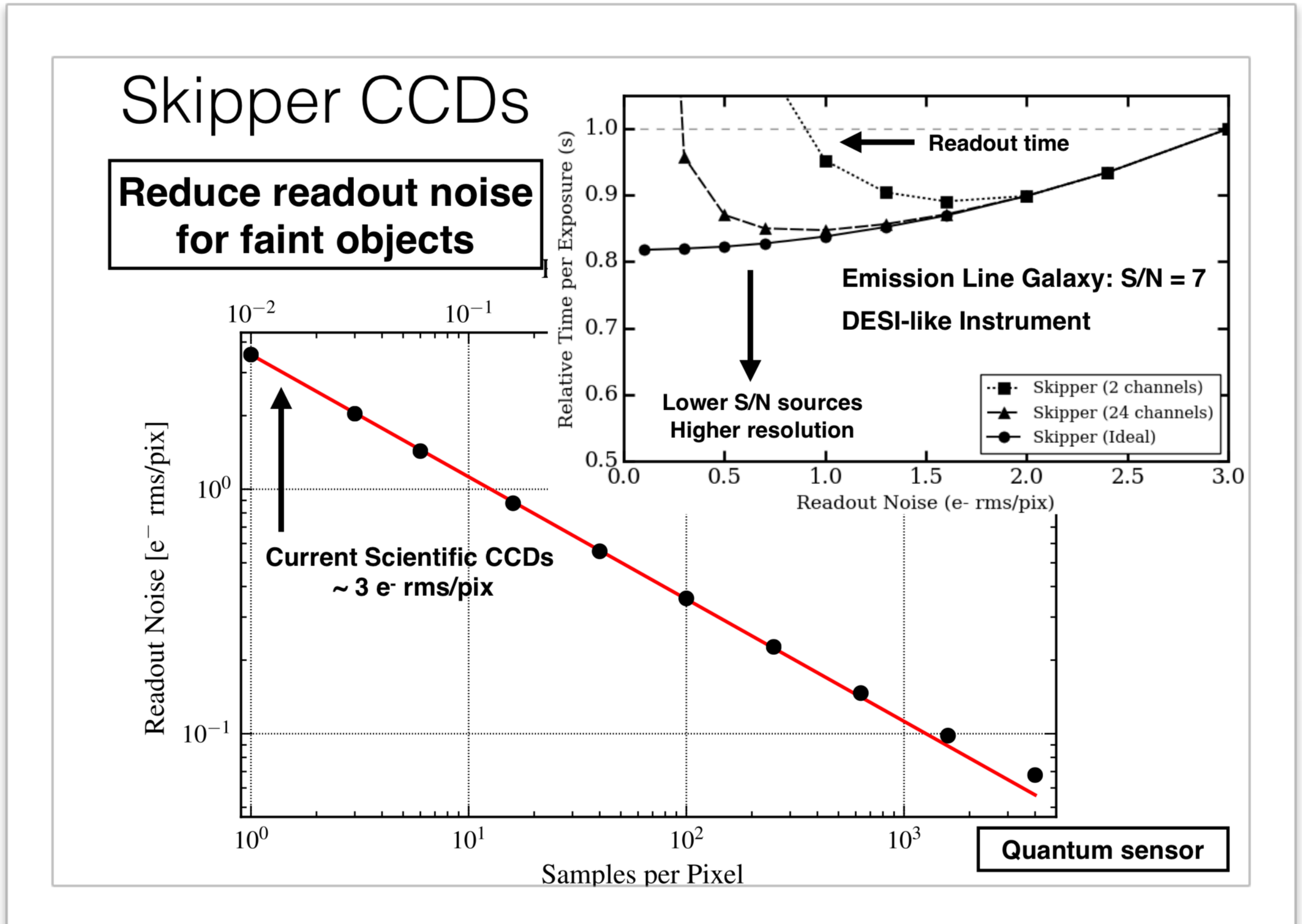
Leading light dark matter searches, test on sky coming soon.

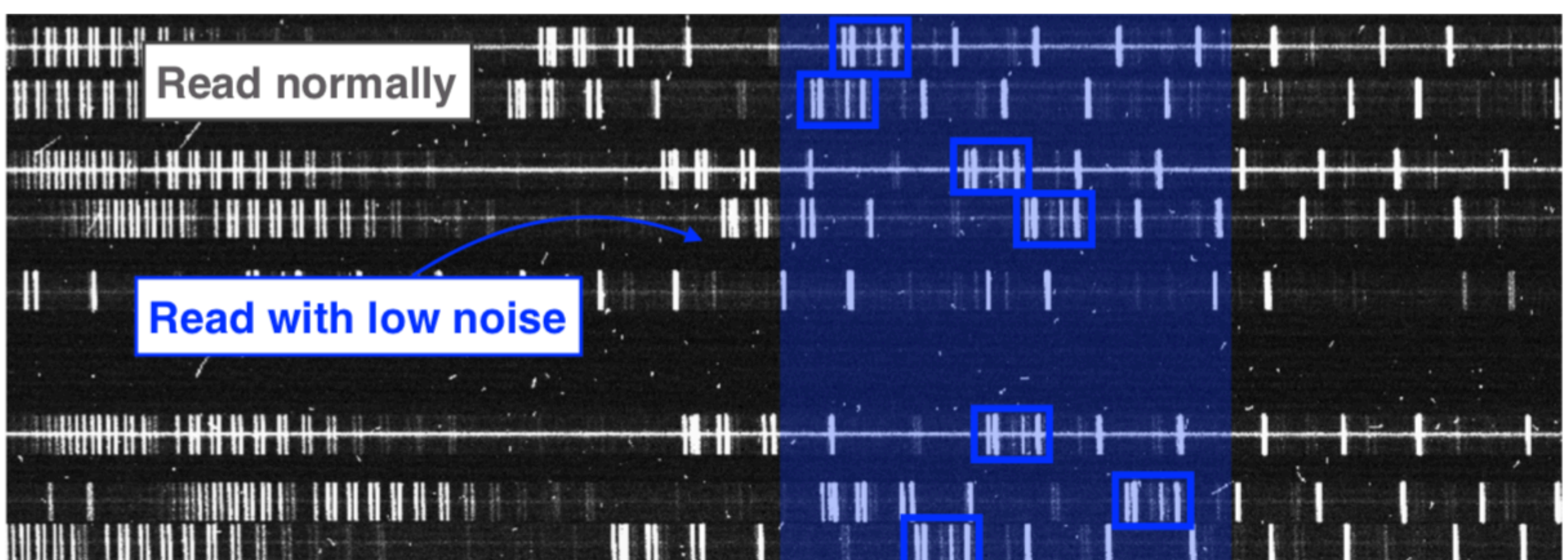




A.Drilica-Wagner is leading this effort, specially important for high resolution spectroscopy.

skipper for cosmic surveys





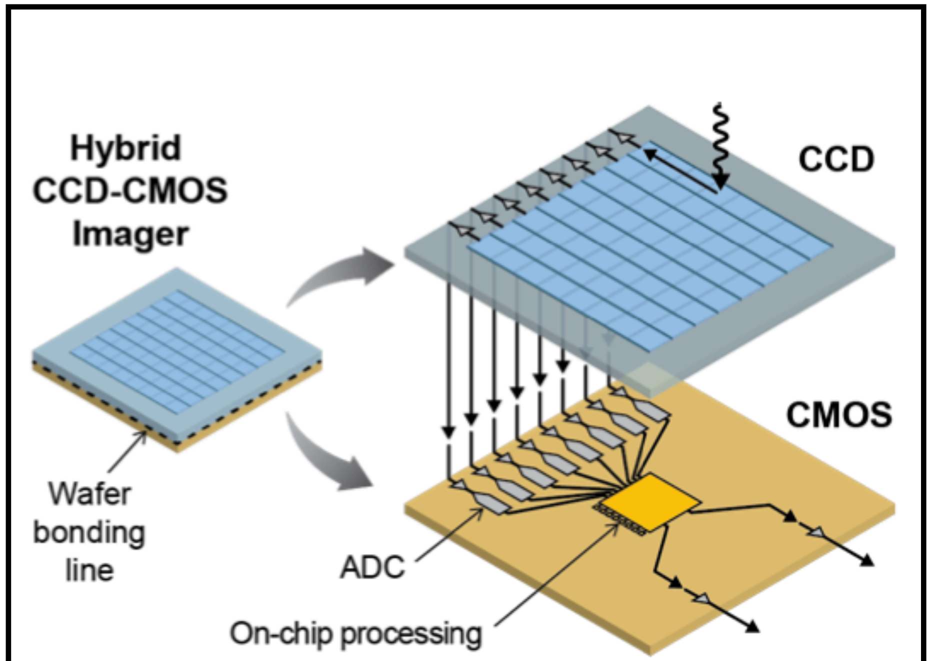
new skipper-CCD technology could improve the efficiency of a survey spectrograph reducing readout time.

Signal to noise could be tuned to optimizing readout time (target specific pixels for low noise).

(A.Drilica-Wagner)

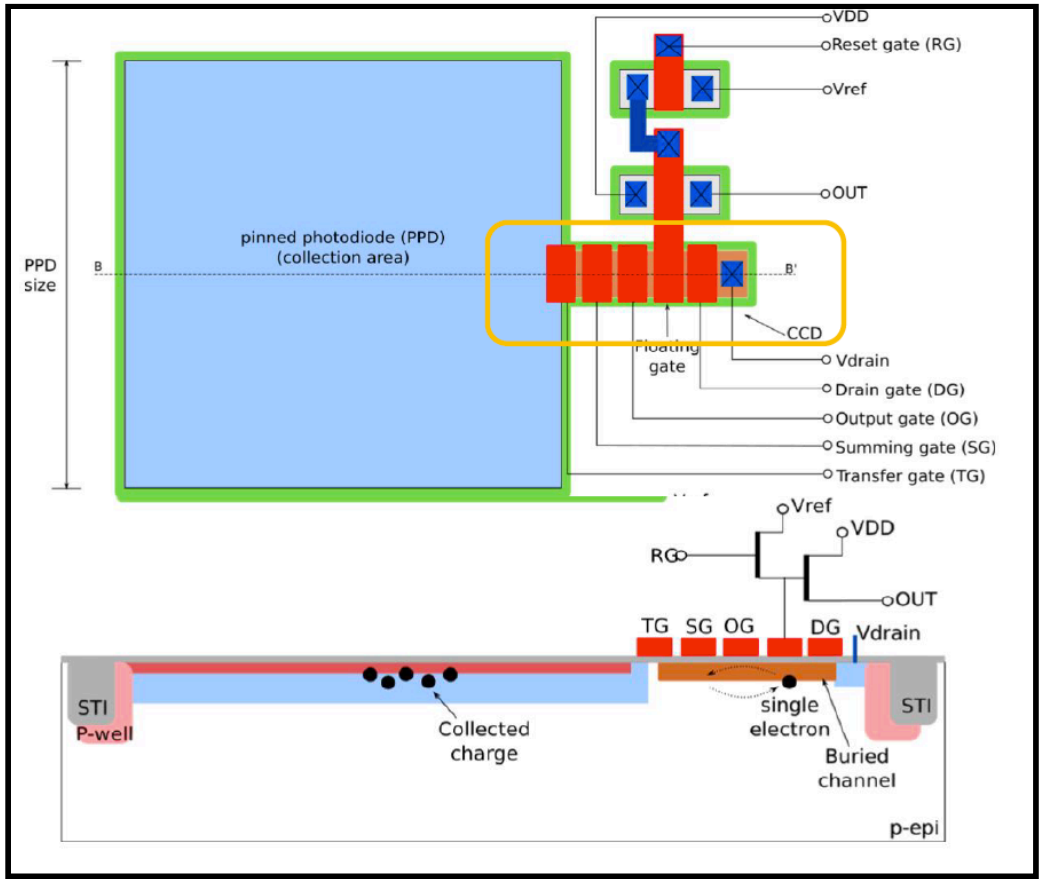
Sensors : CCD CMOS

Faster readout with single photon resolution

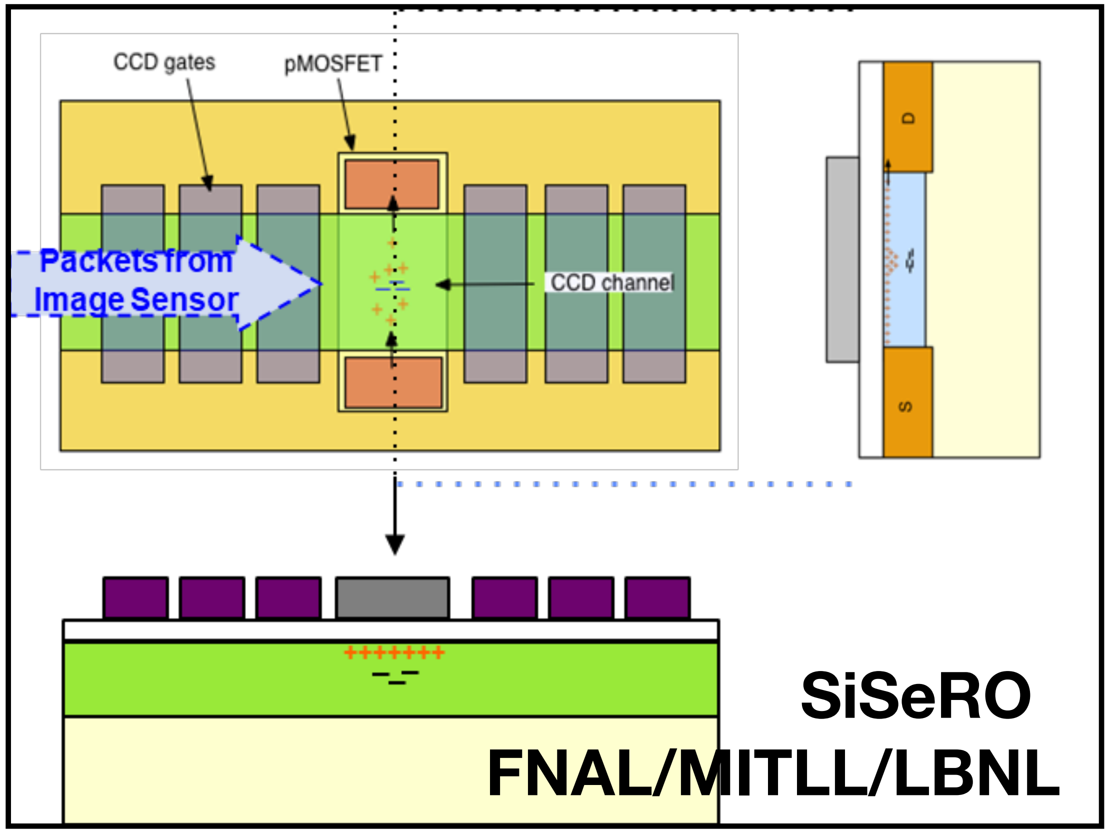


C.Leitz MIT-LL

M.Sofo-Haro et al



FNAL/SLAC

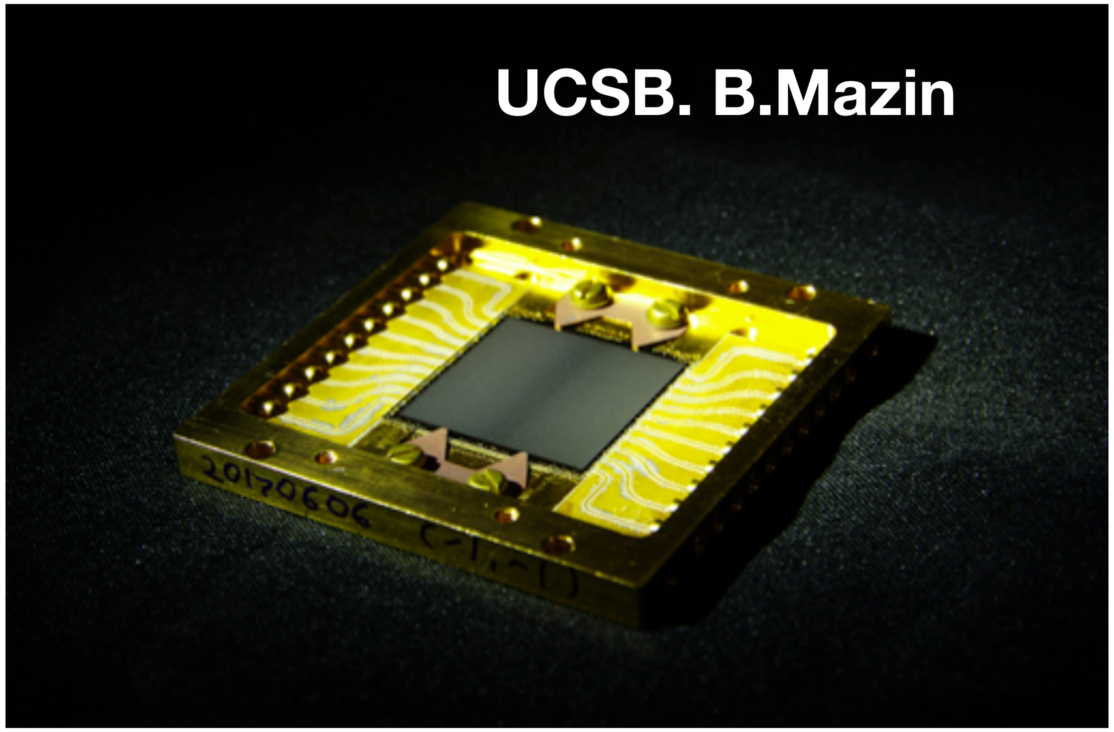


SiSeRO

FNAL/MITLL/LBNL

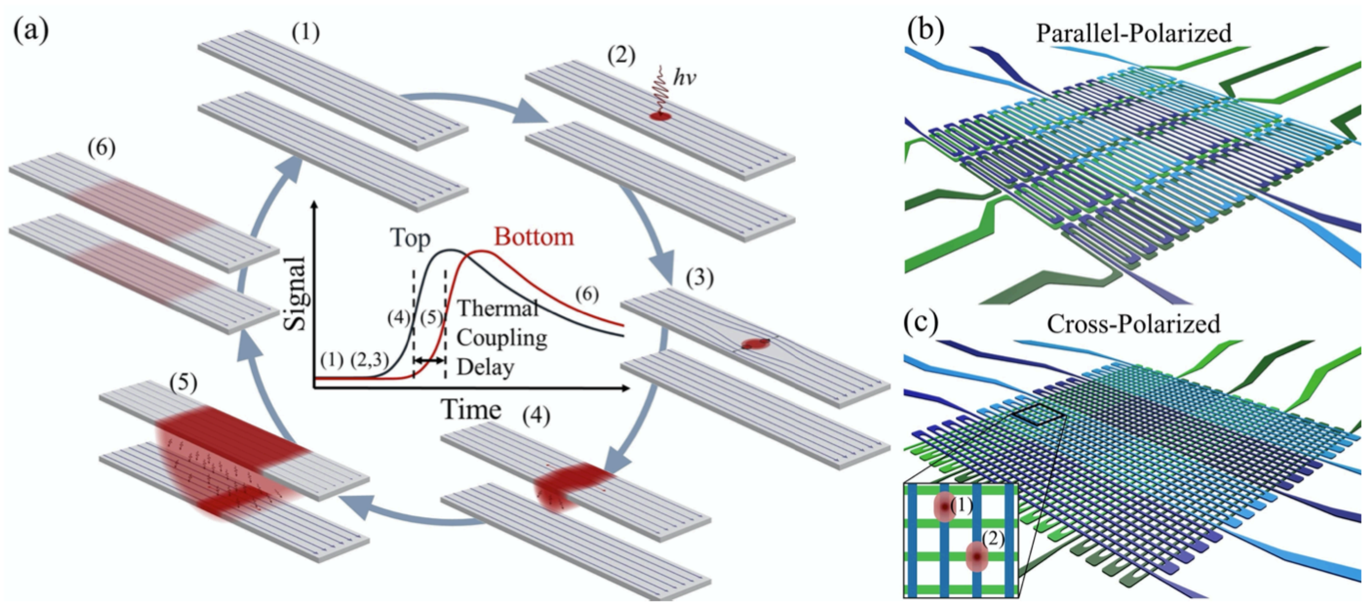
Non destructive readout in CMOS… several efforts in this direction.

Superconducting sensors and associated readout electronics



MKIDs in optical and near IR.
Fast, single photon energy resolution. Highly multiplexed.

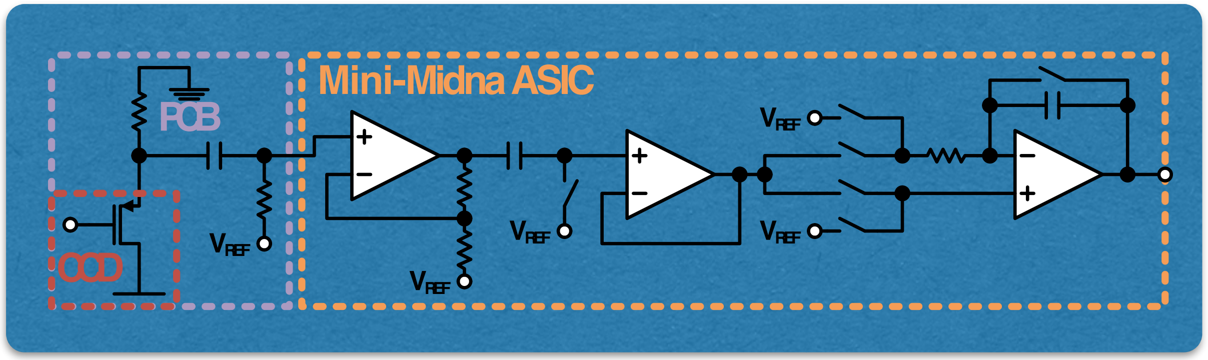
Caltech/JPL M.Shaw et al



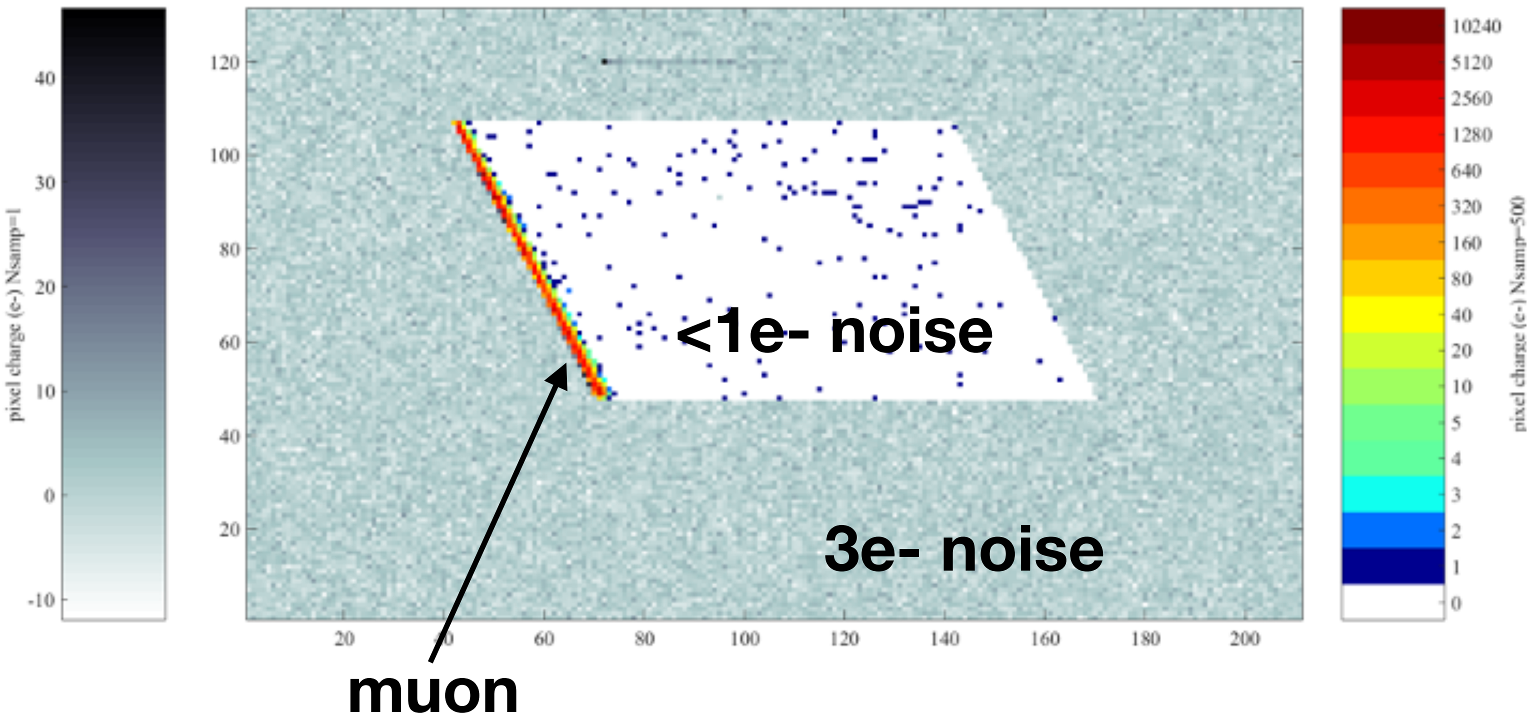
SNSPDs optical and IR.
Fast!!!!
Highly multiplexable

https://arxiv.org/pdf/2002.10613.pdf

Sensors : readout electronics

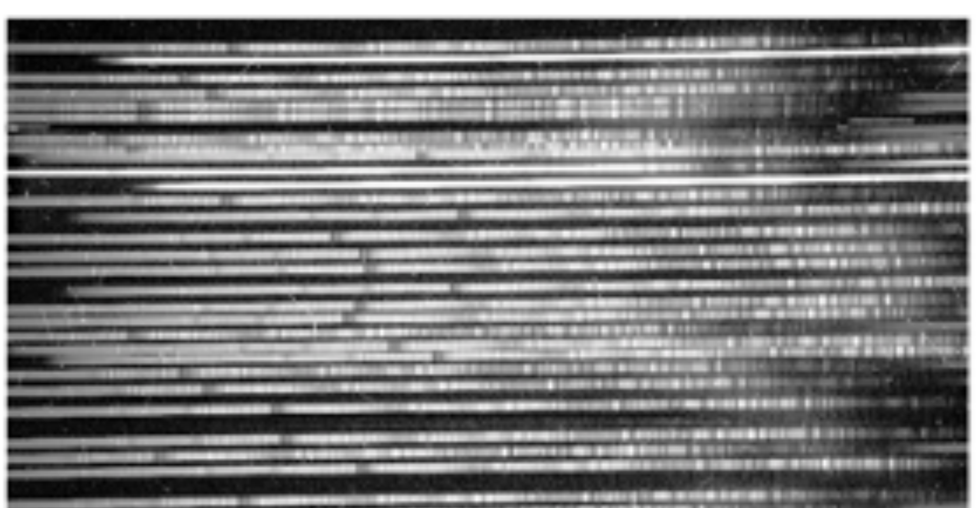


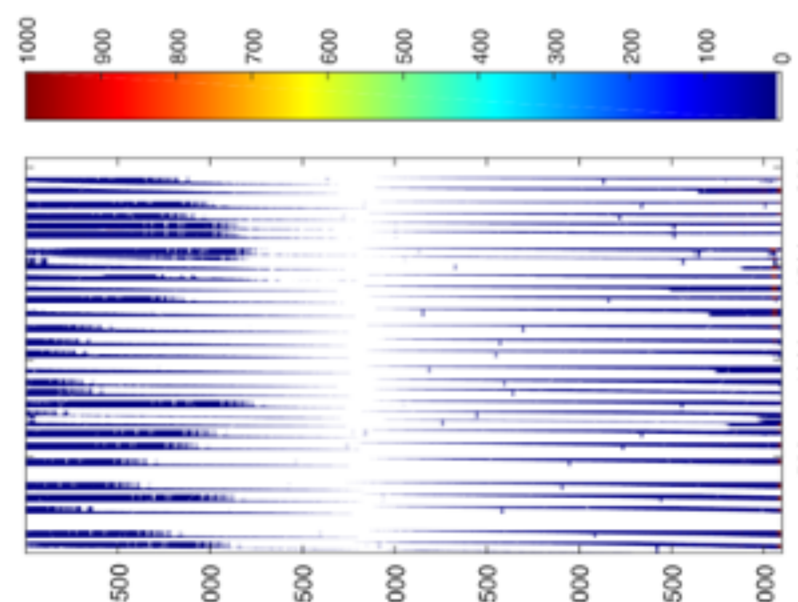
cold, low noise electronics for large sensor arrays (ASIC and discrete). Troy England's (FNAL) talk yesterday.



Smart readout for imagers with non-destructive readout. Peak at a pixel, and decide on the fly the desired noise on each case. Guillermo Fernandez Moroni (FNAL).

real spectrograph image

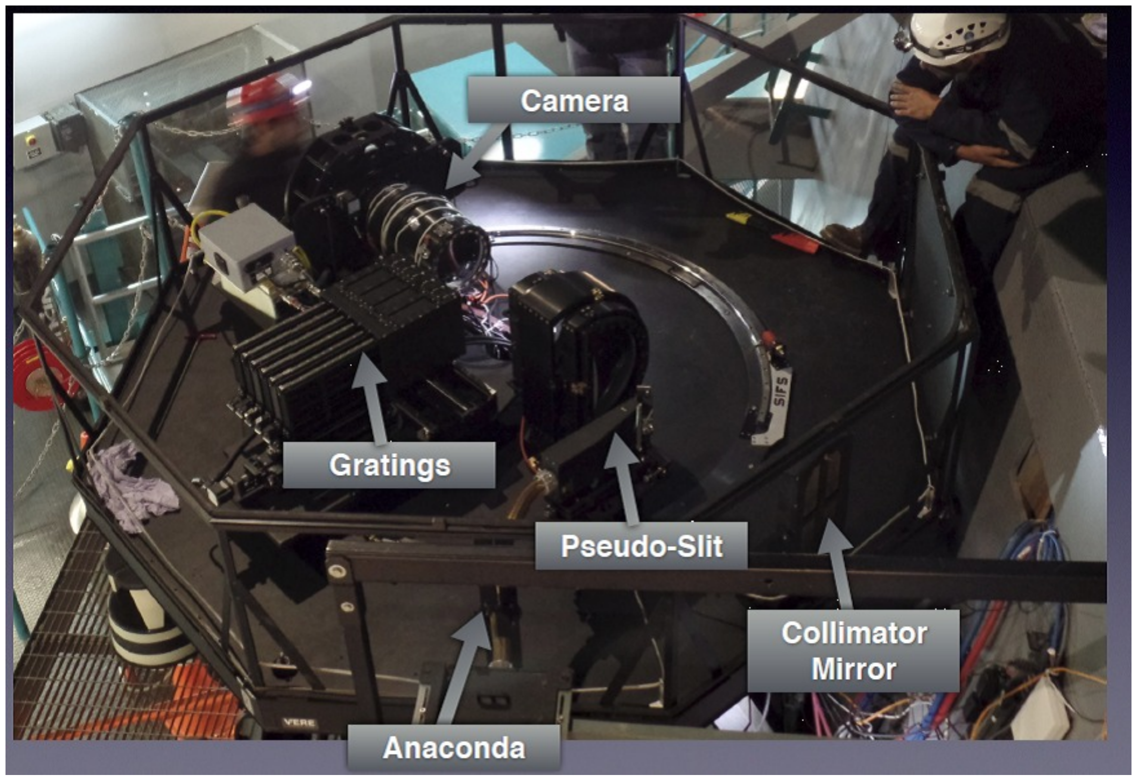


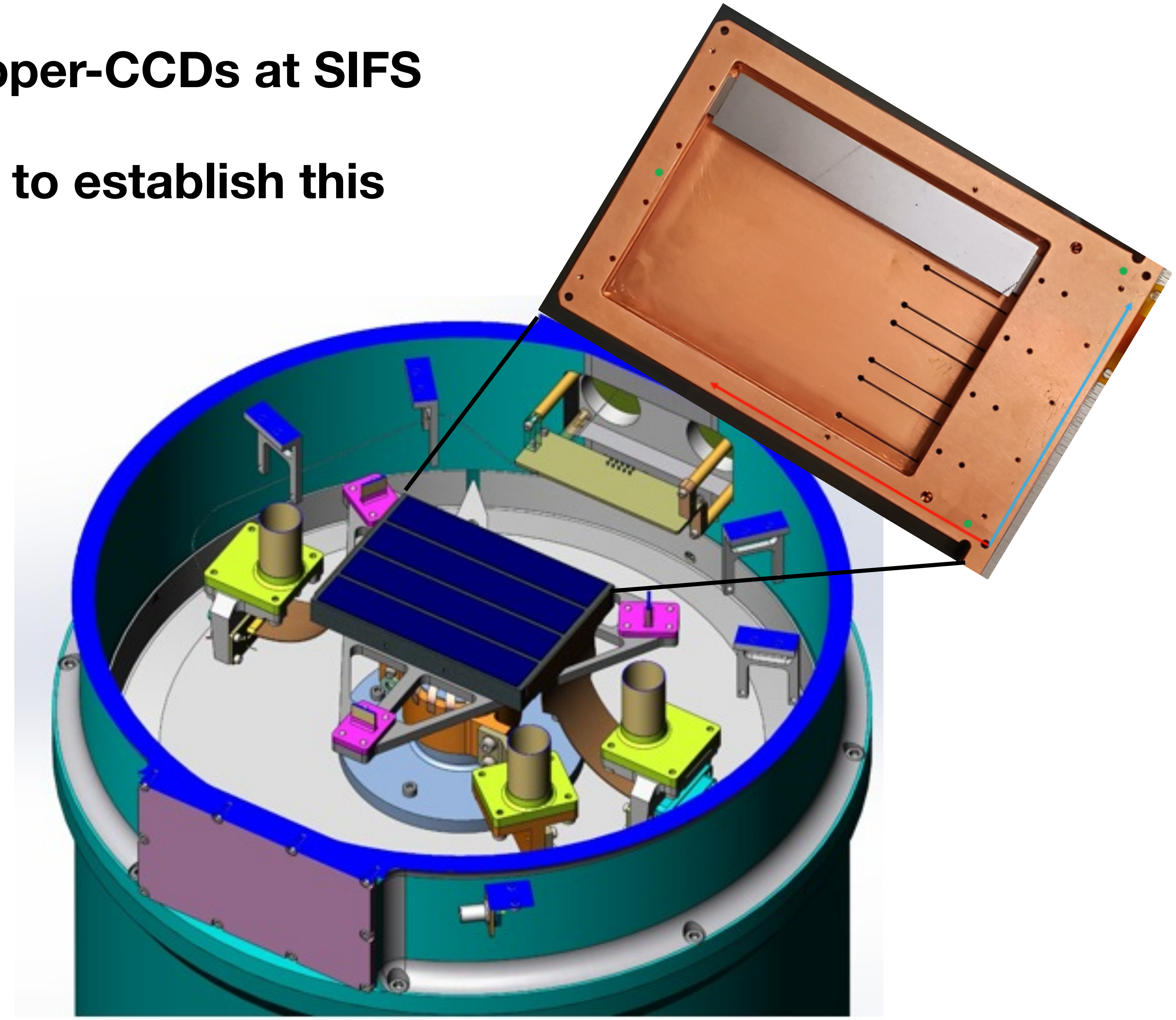


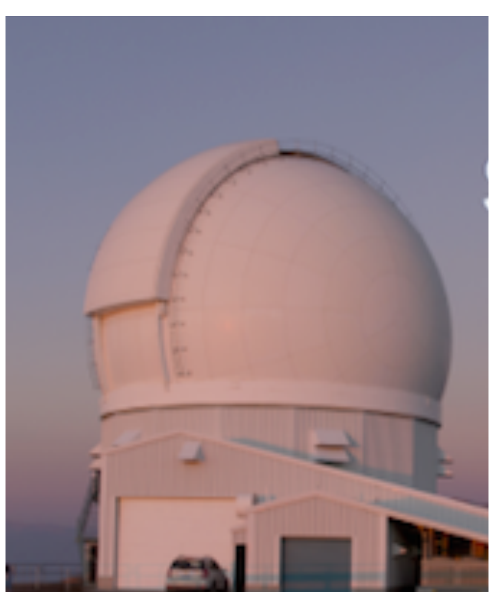
samples/pixel can be optimize to read x100 faster

Starting point for R&D platform : skipper-CCDs at SIFS

Found a lot of interest from NOIRlab to establish this collaboration







University of Chicago, Fermilab and NOIRlab are working together on the deployment of the first skipper-CCD sensors on a telescope. Soar 4M telescope.

Mechanics+Optics : NOIRLab
Readout electronics : NOIRLab-FNAL
Sensors : FNAL-UChicago
(sensor development in collaboration with QIS effort)

summary

- sensors, readout, filters, fiber positioners for astronomical instruments are being actively developed as part of HEP R&D.
- We need access to telescopes for testing these developments in realistic conditions.
- NOIRlab partnership with HEP labs and University groups will make this access more direct. Contact at NOIRLab (Marco Bonati mbonati@ctio.noao.edu)
- Small example underway, but the idea to to grow this as a testing platform for new technologies in astronomical instrumentation supported from both sides.