Cosmic Visions Report: Future Projects & Instrumentation

Aaron Roodman

CPAD Instrumentation Frontier Meeting 2016

KIPAC

SLAC
NATIONAL ACCELERATOR LABORATORY

Cosmic Visions Dark Energy

Charge: collect & coordinate ideas from HEP community on:

- Enhancements to current program in Dark Energy, eg. DESI & LSST
- Motivation & Science reach of Future projects, beyond LSST
- Explore technology & instrumentation R&D relevant to such projects

Committee:

Scott Dodelson (Chair), Katrin Heitmann, Chris Hirata, Klaus Honscheid, Aaron Roodman, Uros Seljak, Anze Slosar, Mark Trodden

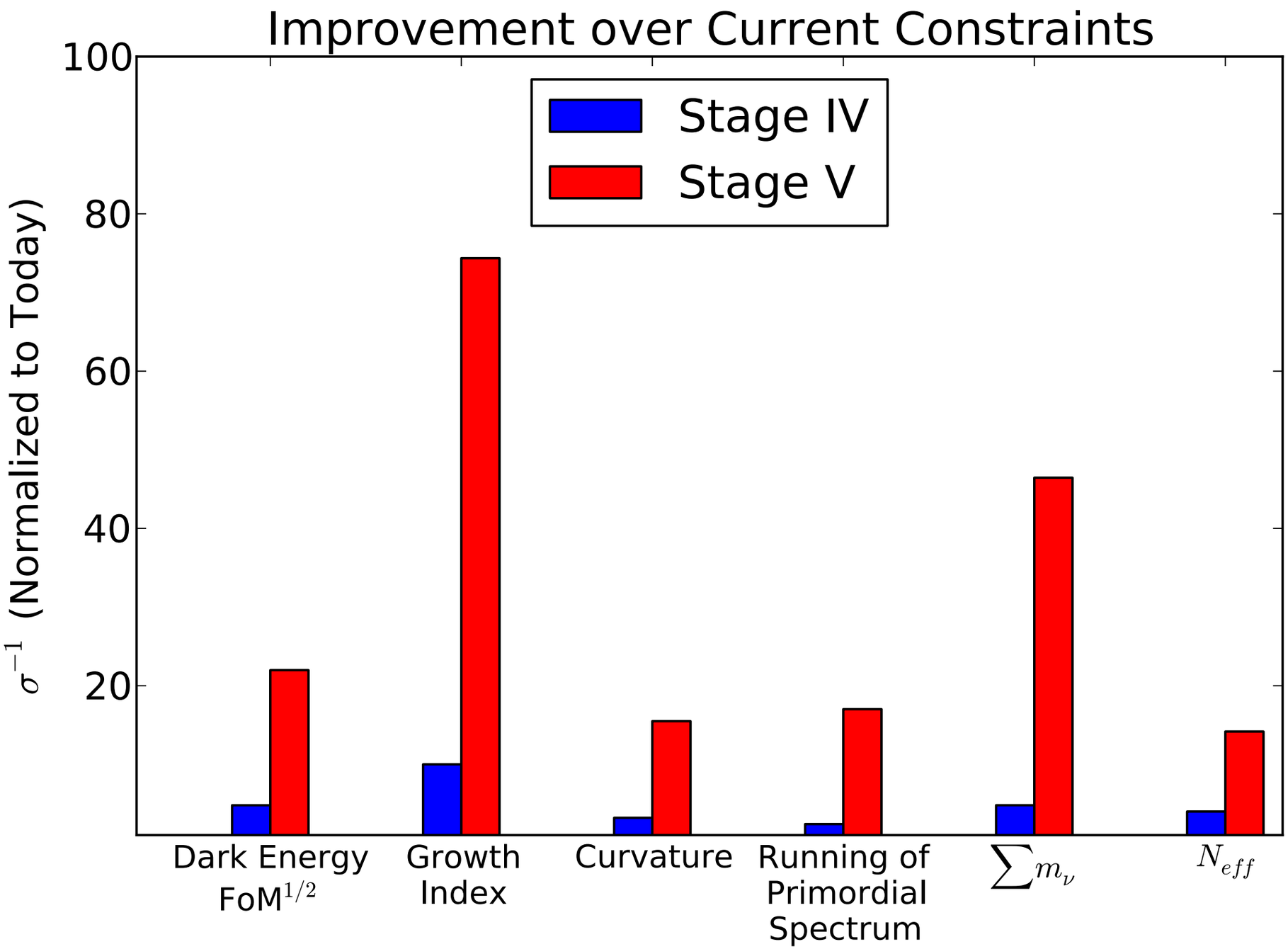
Workshops:

- BNL October 2015
- FNAL November 2015
- SLAC November 2015
- Future Surveys - Chicago September 2016

White Papers:

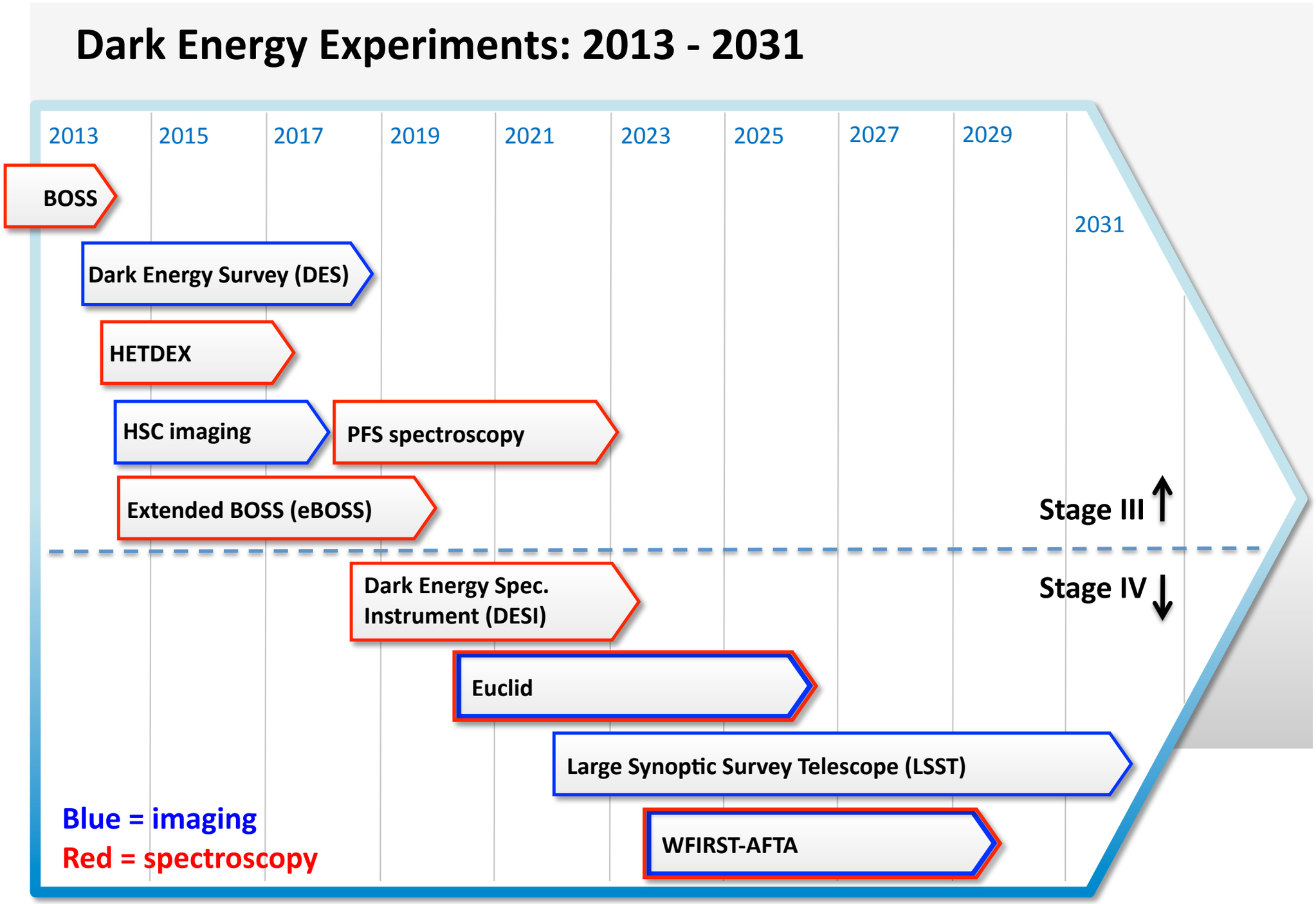
- Programmatics
- Science reach: Dark Energy, neutrino mass, gravity arXiv:1604.07626
- Technology & instrumentation R&D arXiv:1604.07821

Dark Energy beyond LSST & DESI

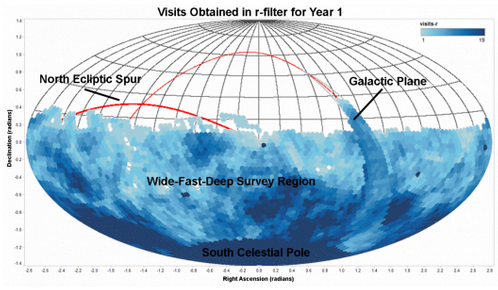


Much more information is contained in the observable Universe

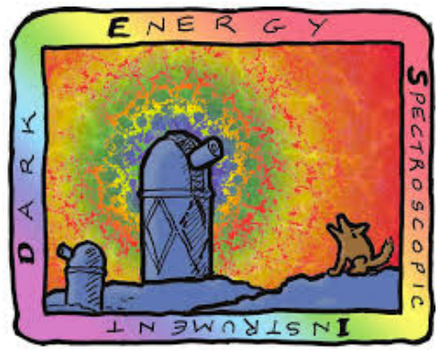
Current Roadmap for Cosmic Surveys



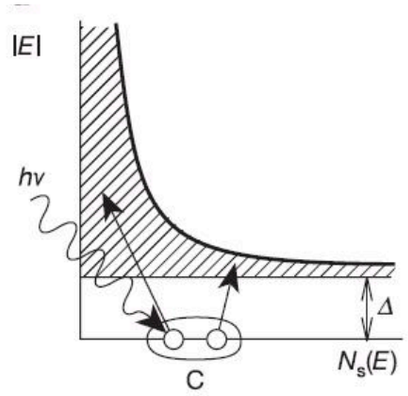
Possible Future Survey Projects



SSSI

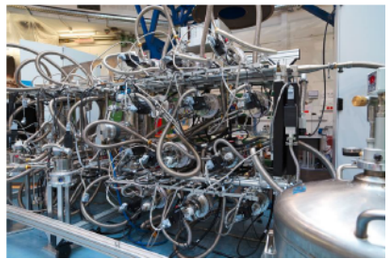


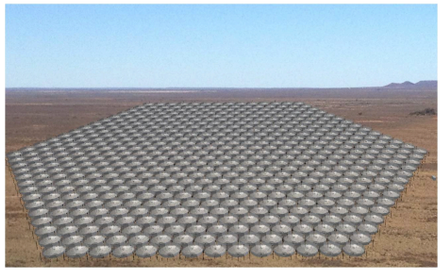
DESI-2



Low Resolution Spectroscopy

Billion Object Apparatus





21 cm

K. Honscheid summary slide

Technology R&D: Grand Challenges?

State of the art Optical/NIR sensors

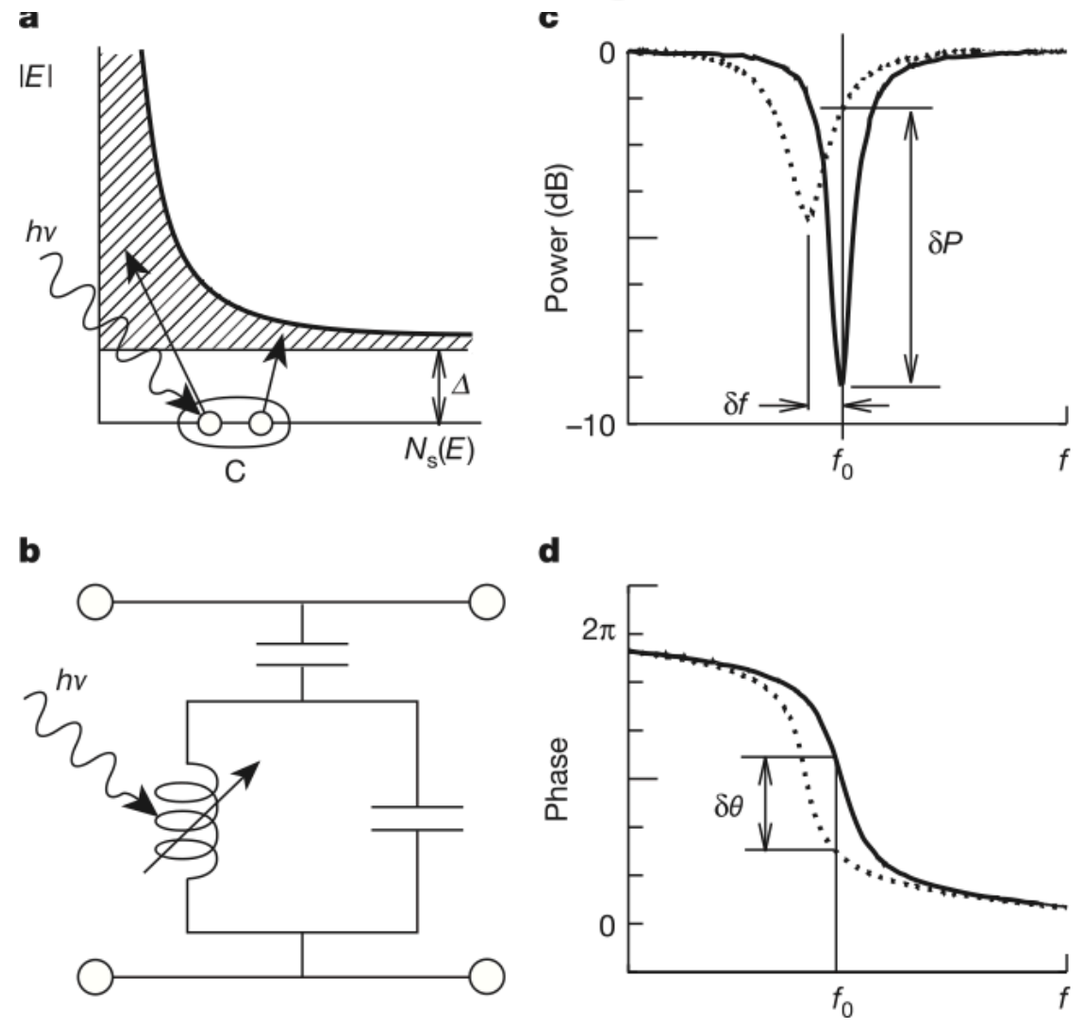
- Photon counting, with few electron level noise
- Pixel size matched to PSF
- Very Large F.O.V. possible
- High Q.E.
- Wide wavelength band
- Excellent cosmetics

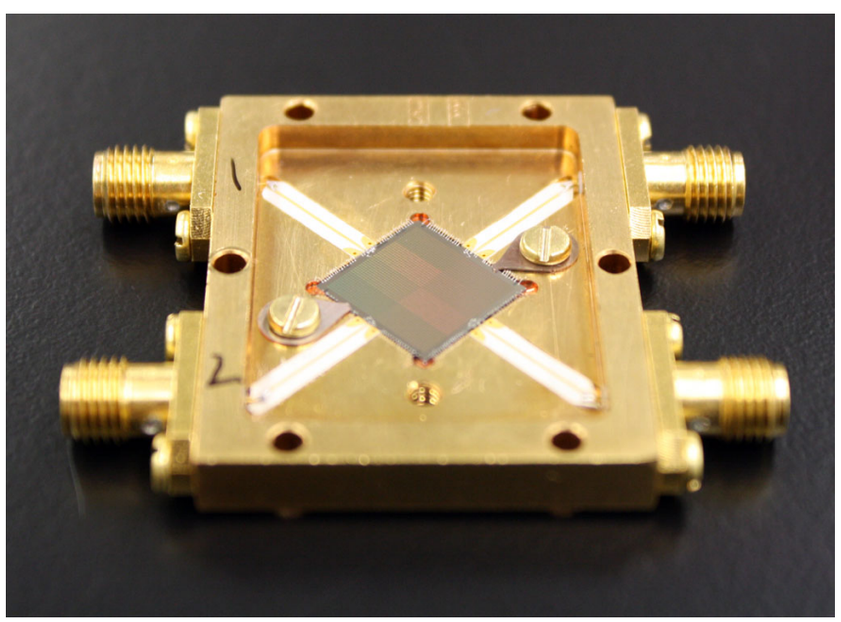
Ideal optical/NIR photon sensors?

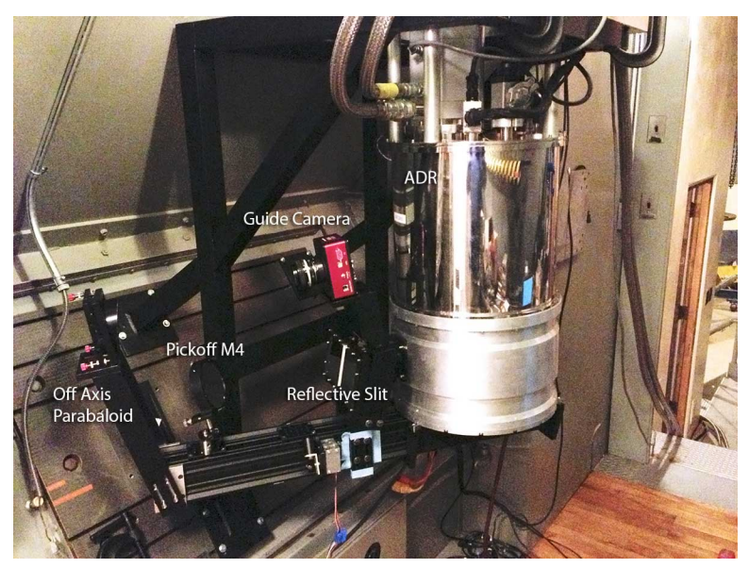
- Wavelength (Resolution?: 6-100)
- Time (msec or better resolution)
- Single Photon detection

Technology R&D: Sensors with Wavelength Sensitivity

MKIDs





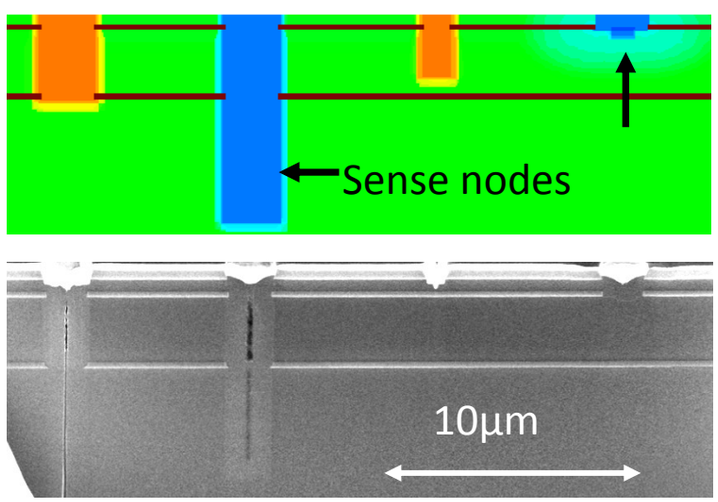


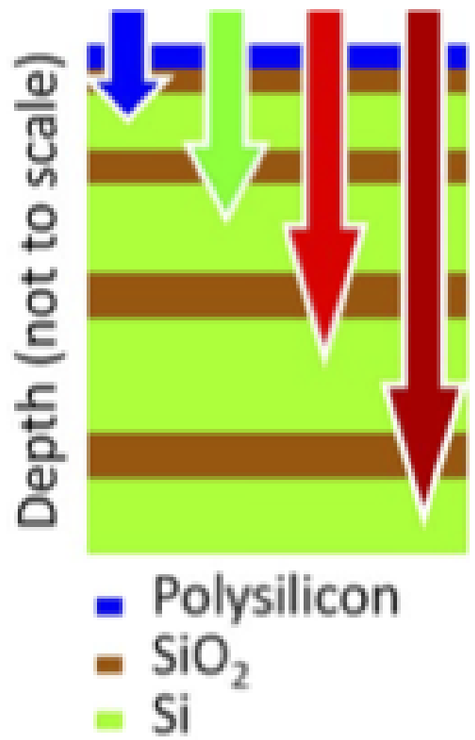
ARCONS
R ~ 8

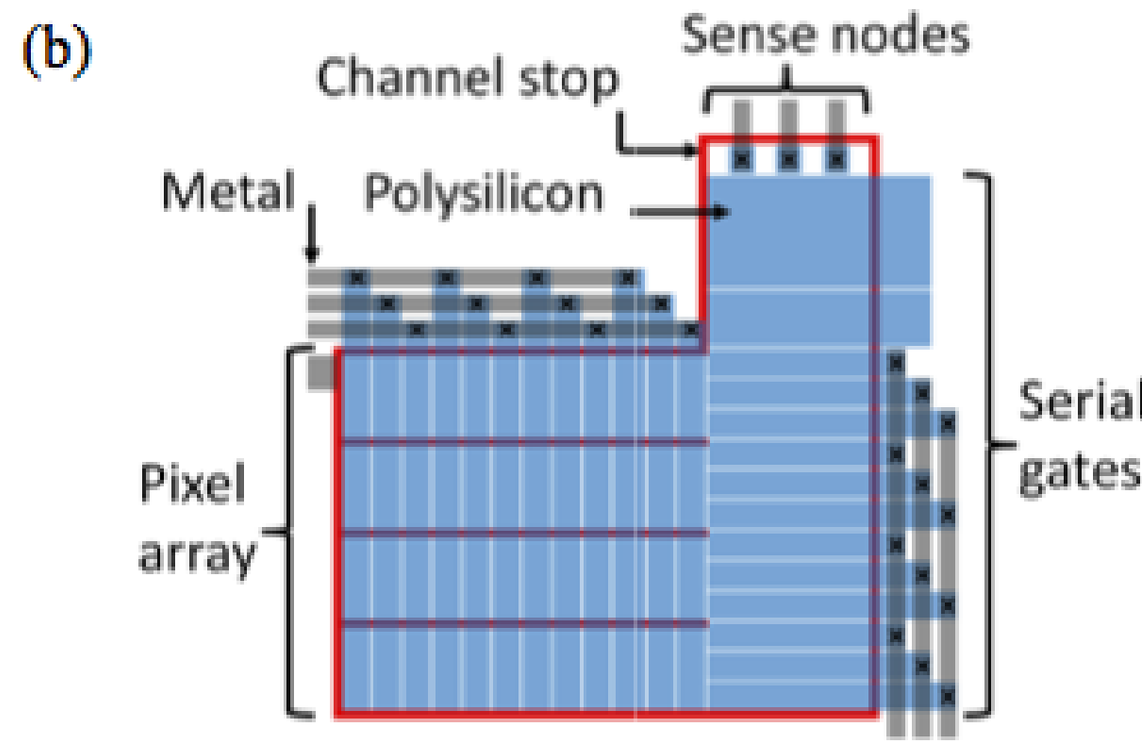
B Mazin

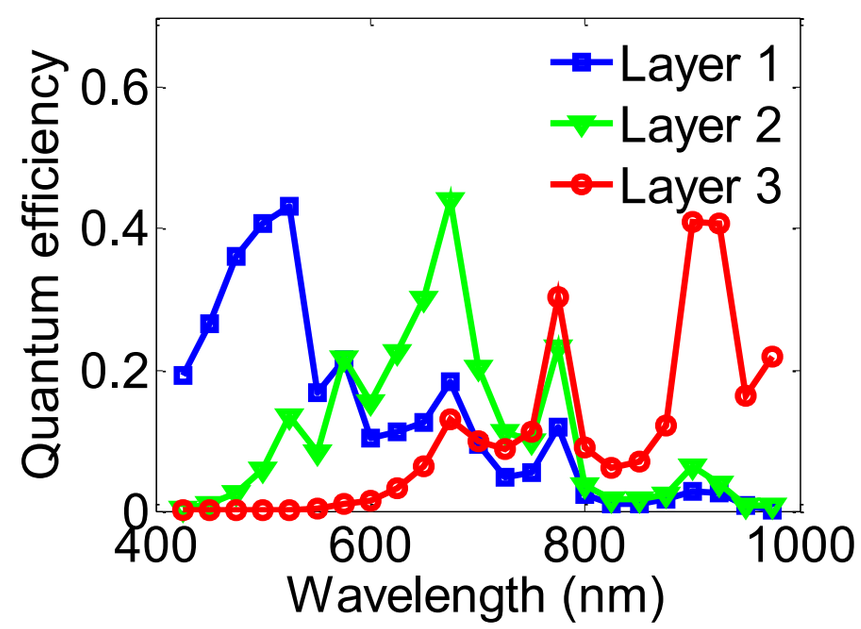
Technology R&D: Sensors with Wavelength

Multi-Band CCDs





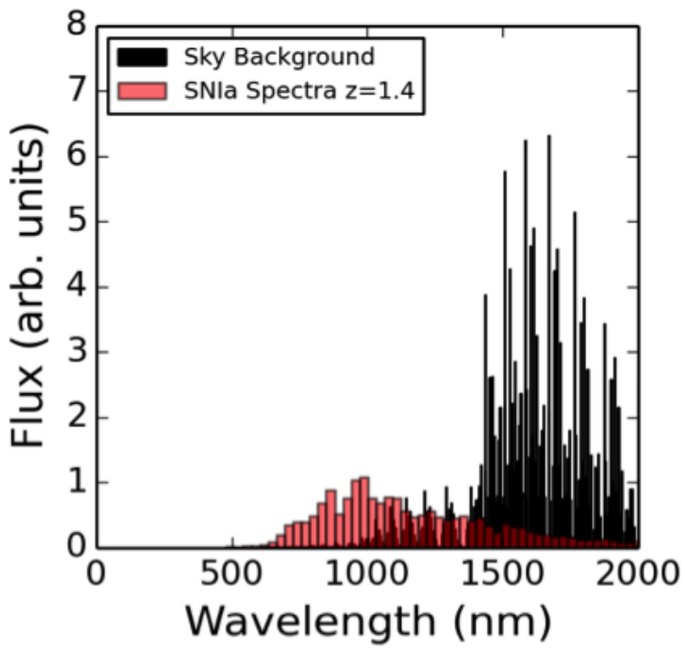


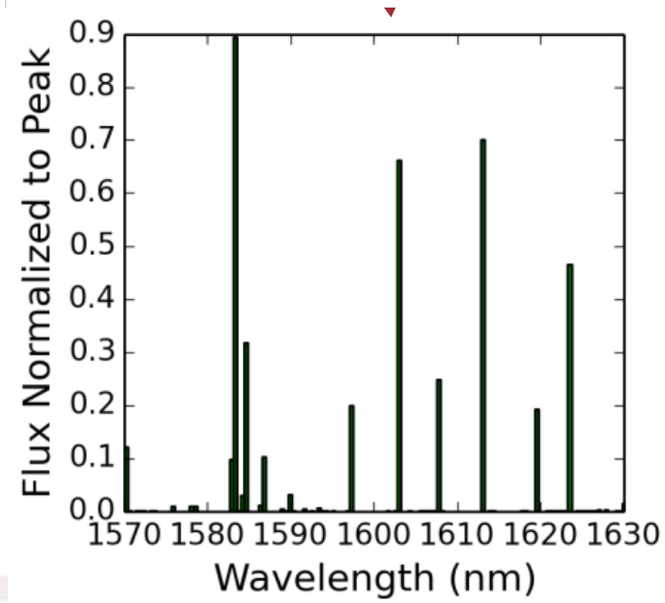


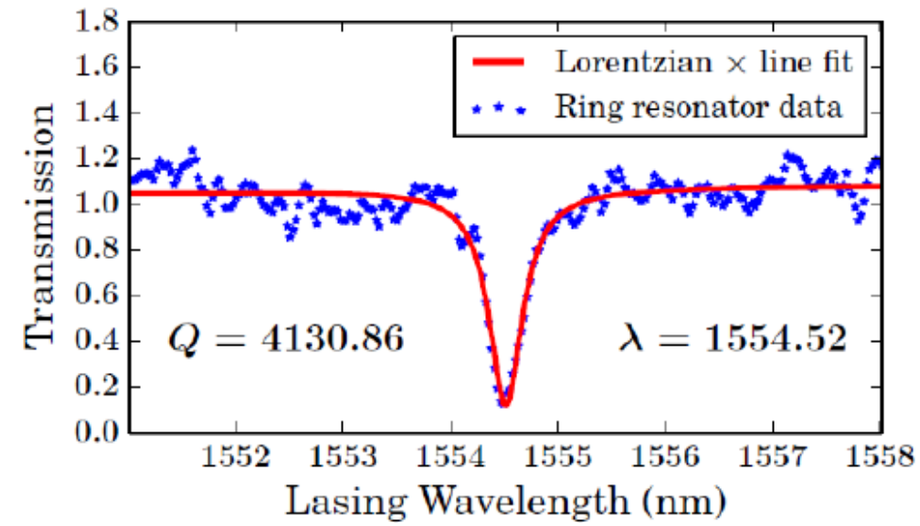
C. E. Chang

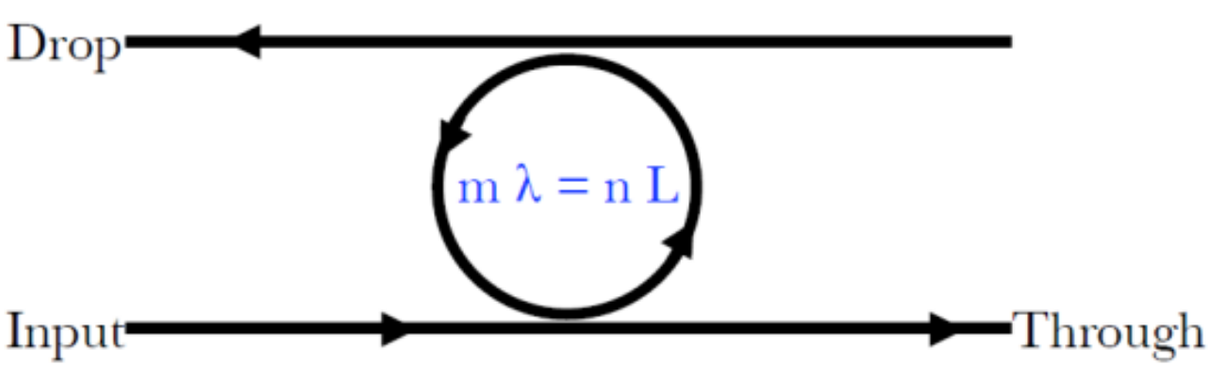
Technology R&D: IR Spectroscopy

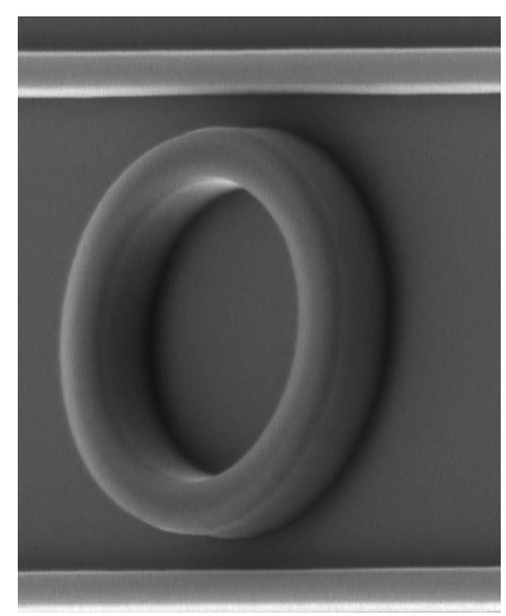
Optical Ring Resonators: Notch Filters









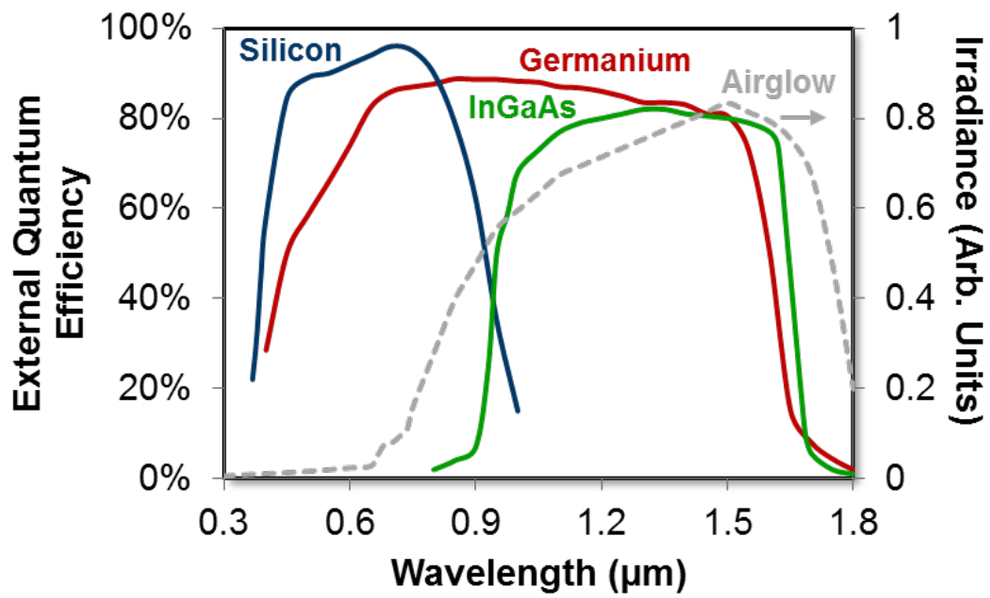


SEM pic: 3um scale

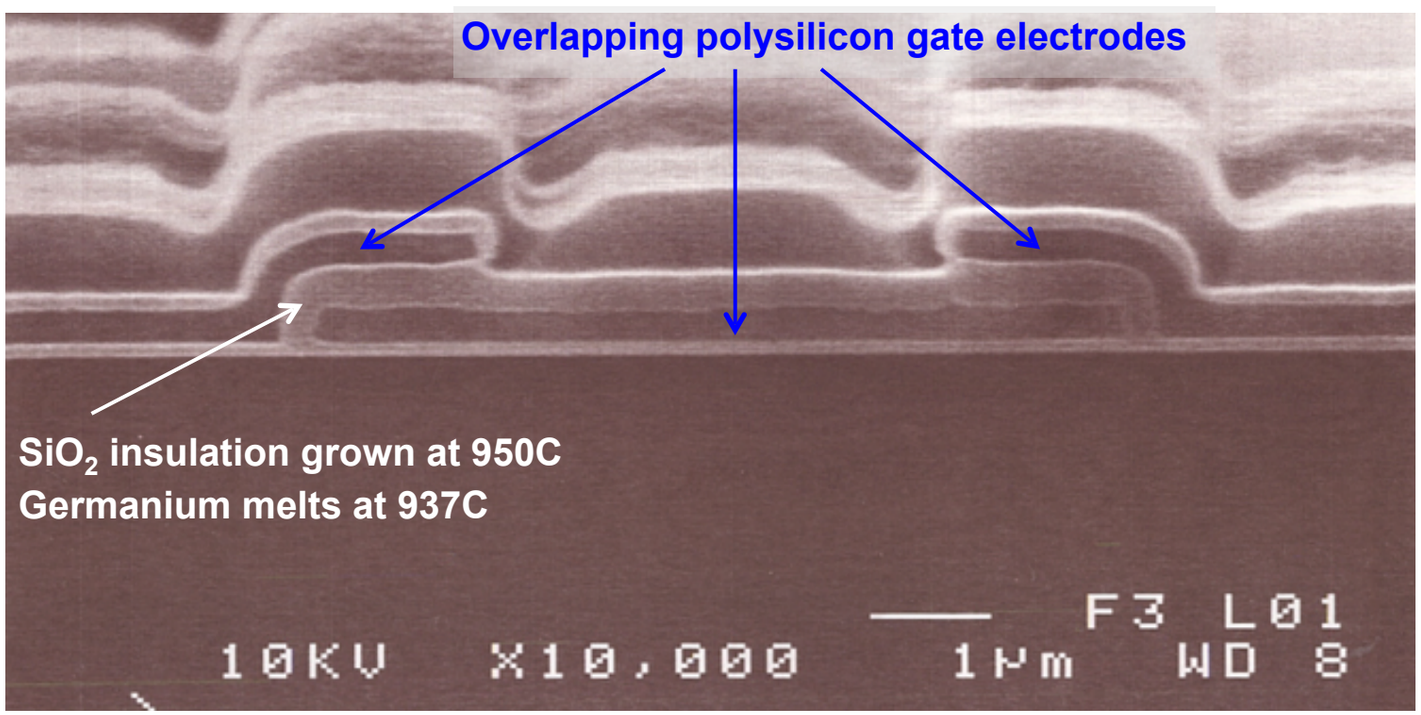
S. Kuhlmann

Technology R&D: IR Spectroscopy

Germanium CCDs

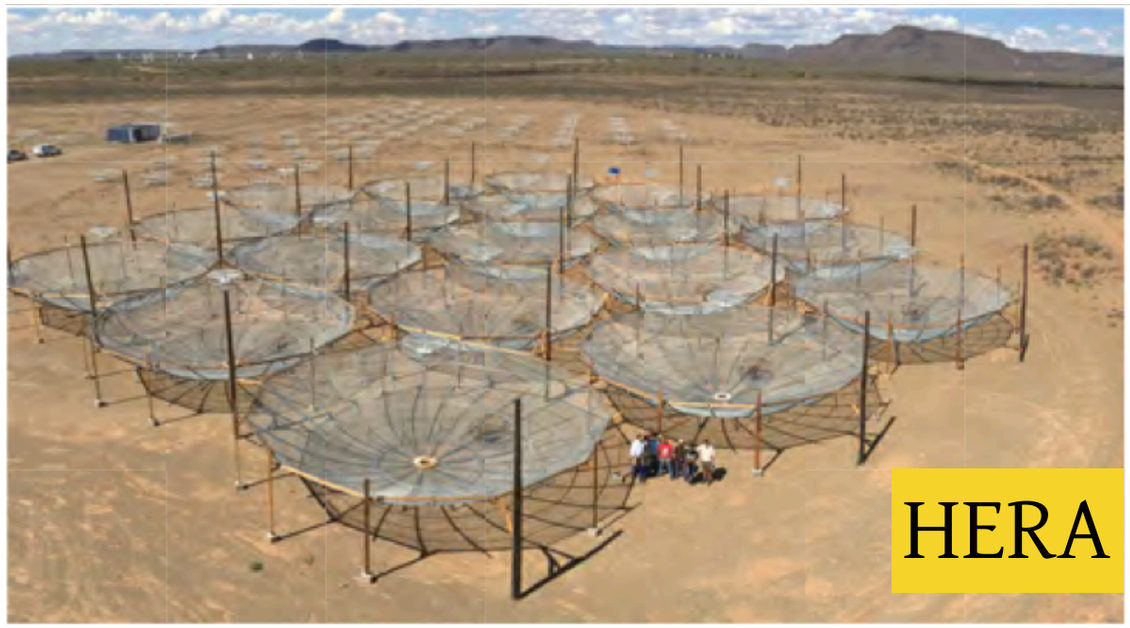


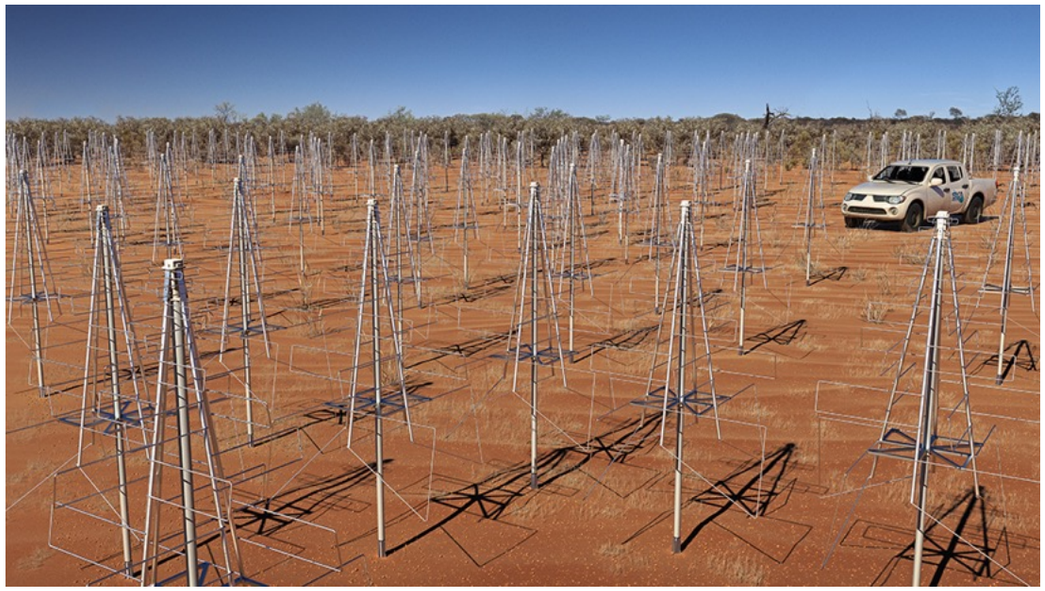
Metric	2016 Goal
Frame Rate	4 fps
Read Noise	10 e^-
QE	> 60% (400-1600 nm)
Well capacity	> 100 ke^-
Features	• TDI / Pushbroom easily implemented • On-chip binning w/o read noise penalty



K Honscheid
D Schlegel

Technology R&D: 21cm





SKA-Low

SKA-Mid

Technology R&D: 21cm

Challenges of Low-Frequency Radio Astronomy

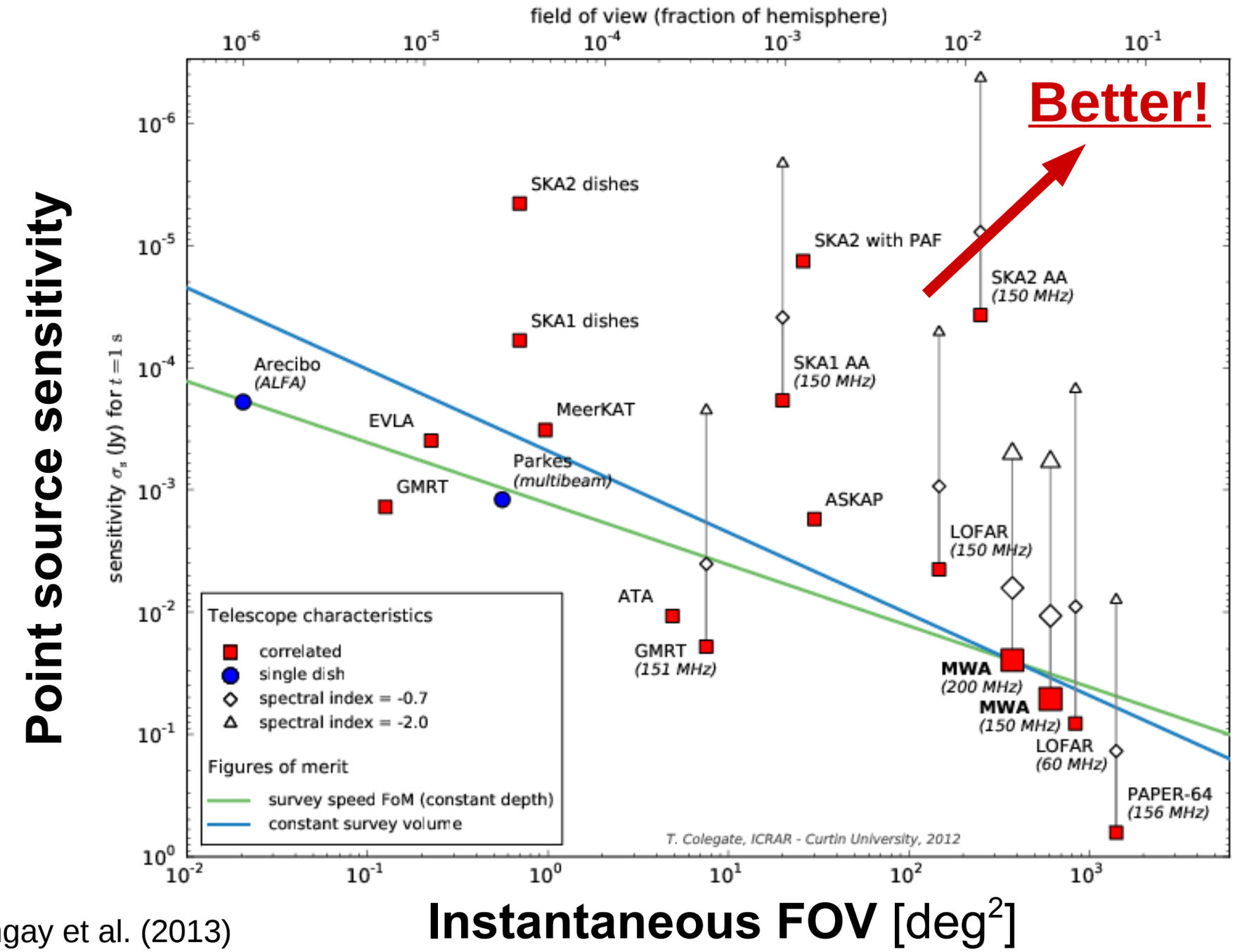
- Sky noise
- Foregrounds
- RFI
- Ionospheric fluctuations
- Calibration difficult

Require high speed computation to address – starting to be affordable only now
Instrument design must incorporate calibration requirements

J Hewitt

Technology R&D: 21cm

Survey telescopes



Tingay et al. (2013)

Technology R&D Comments

My own comments and opinions:

- MKIDs are an exciting possibility, but will the pixel count and spectral resolution needed for a Stage V project be reached?
- Novel technology like Ring resonators could be very valuable in more targeted instruments
- Ambitious, highly multiplexed spectroscopic project may require some new technologies: eg. micro-shutters, Germanium CCDs, etc.
- 21cm?
  - SKA Phase II - $$$
  - can advances in electronics/computer reduce cost?