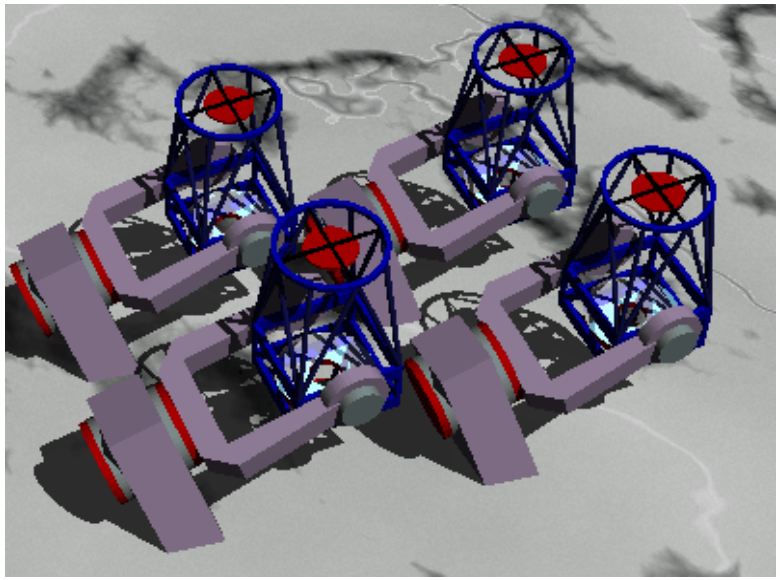
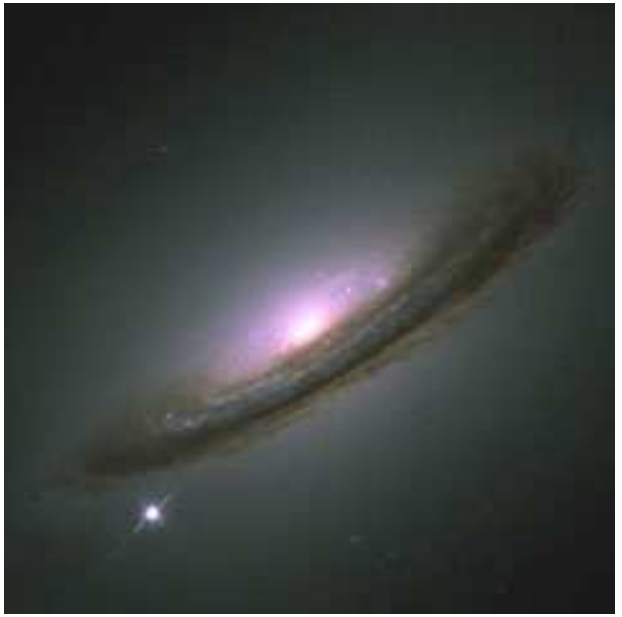
Pan-STARRS and SNe





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MAUI HIGH PERFORMANCE COMPUTING CENTER

SAIC Science Applications International Corporation

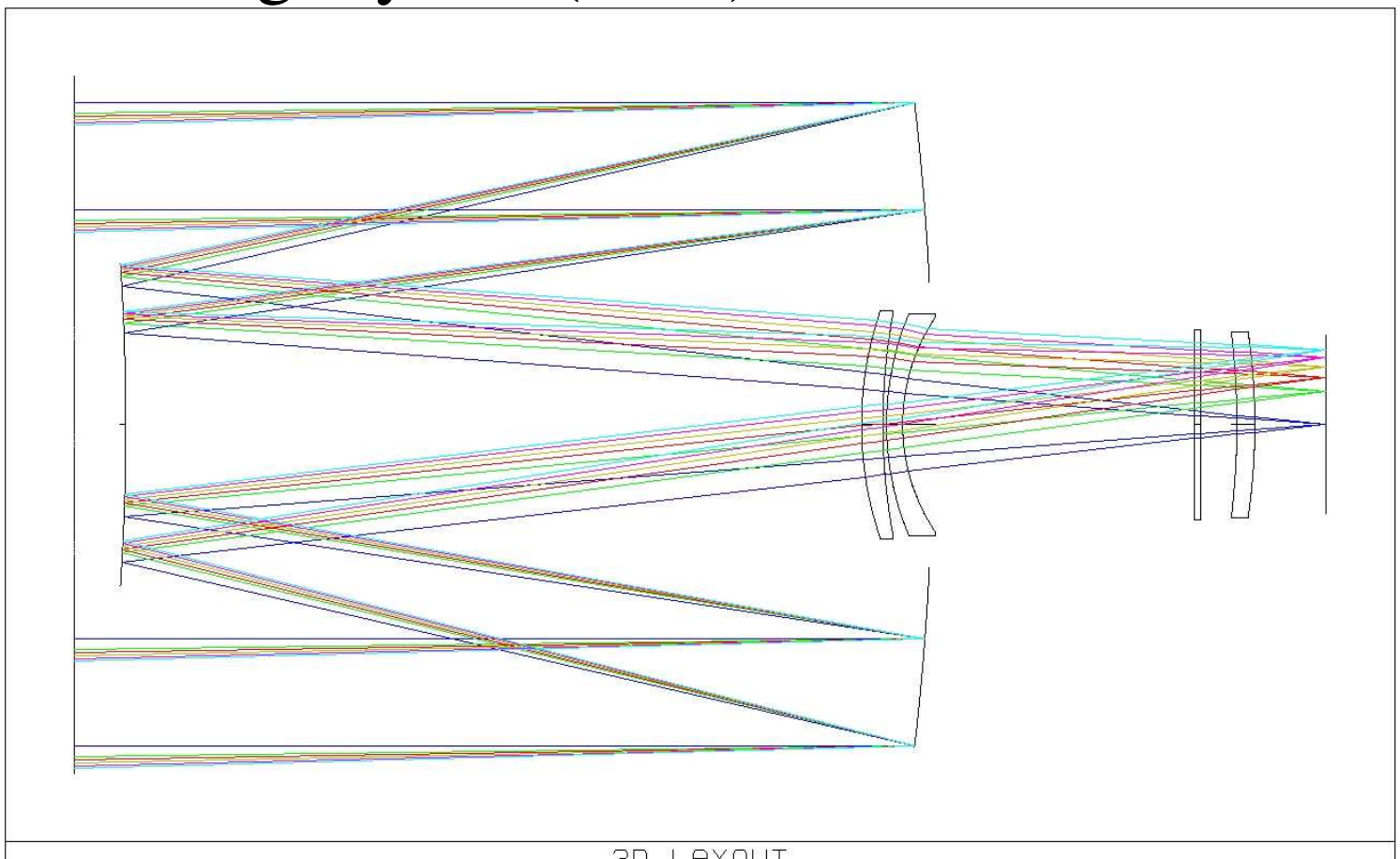
An Employee-Owned Company

Pan-STARRS

- Panoramic Survey Telescope And Rapid Response System
- A fore-runner to the LSST, funded by AFRL
- A dedicated optical survey instrument, 54 $m^2 deg^2$
- Collaboration between:
  - IfA
  - MHPCC: Data processing
  - SAIC: Databases
  - MITLL: Detectors
- To be operational in Autumn 2006

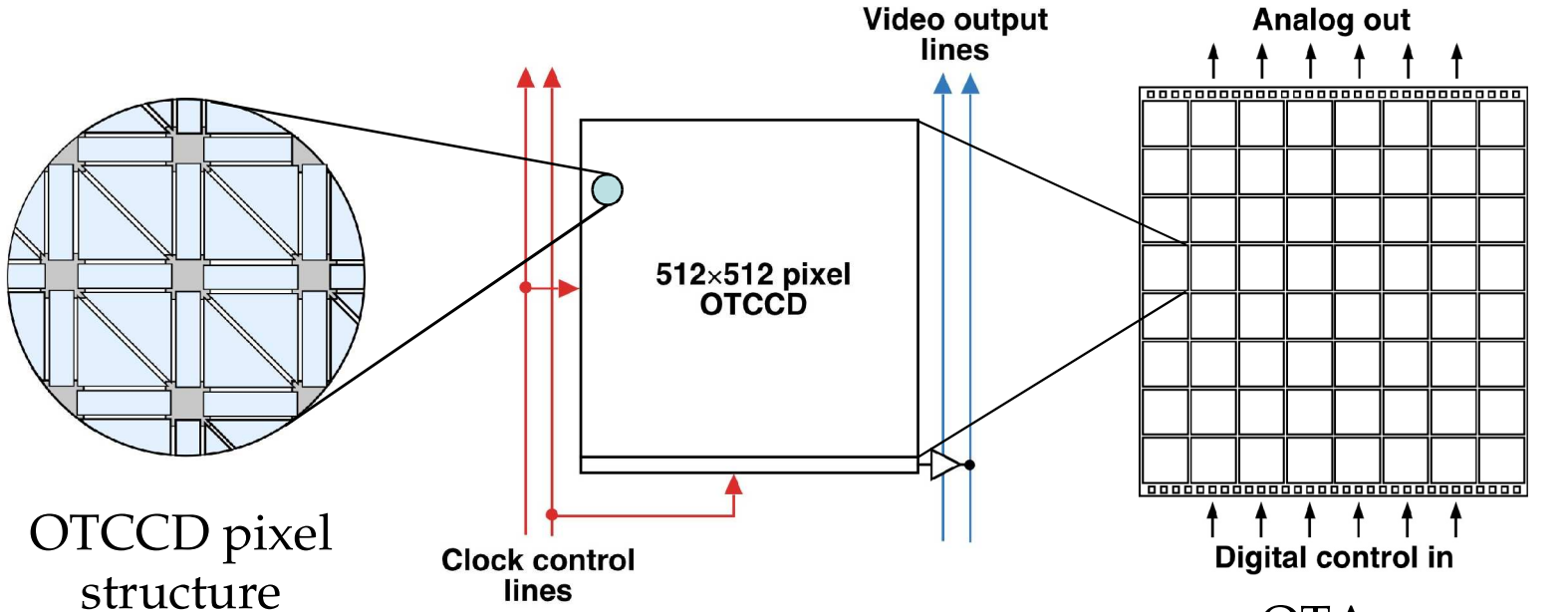
Optics

- 4 x 1.8m telescopes, f/4, 7 deg^2 FoV, ADC option
- $A\Omega = 4 \times 13.5\ m^2deg^2$
  - MEGACAM, SuPrimeCam ~ 8 m^2deg^2
- Filters: grizy, SS (V+R)



Detectors

- OT technology (demonstrated with OPTIC)
- 4 x (8x8) x (8x8) x (512x512) ~ 4 Gpix
- 0.3” pixels (12μ pitch)
- COTS approach, 2 sec readout, $3e^-$ RN



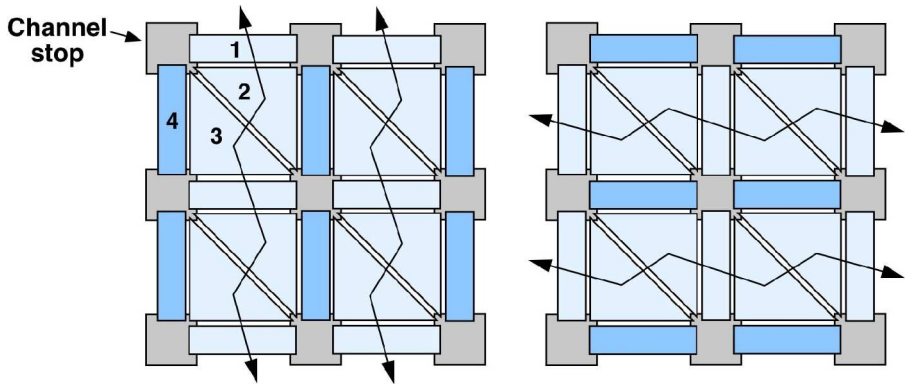
OTCCD pixel structure

Basic OTCCD cell

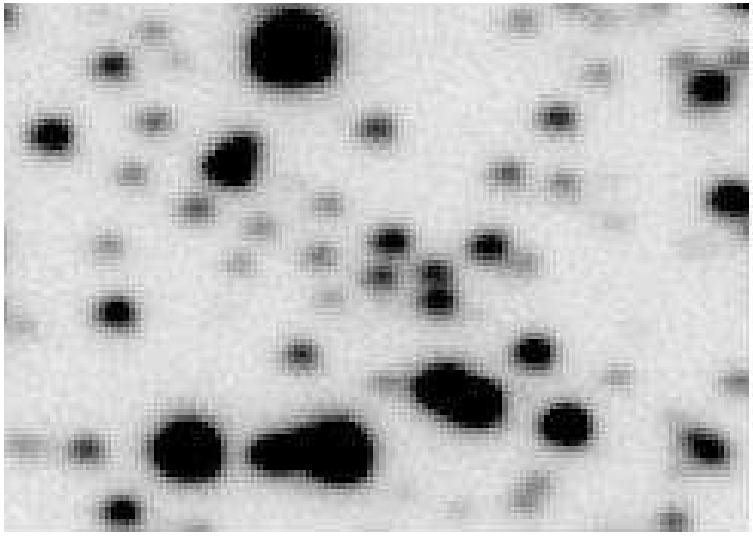
OTA:
8x8 array of OTCCDs

Orthogonal Transfer

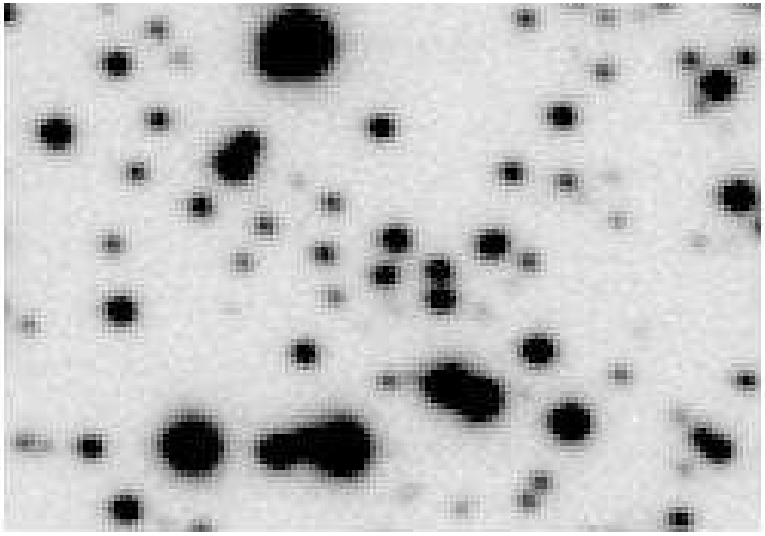
- Tip/tilt compensation
  - remove image motion
  - high speed (~ 100 Hz)



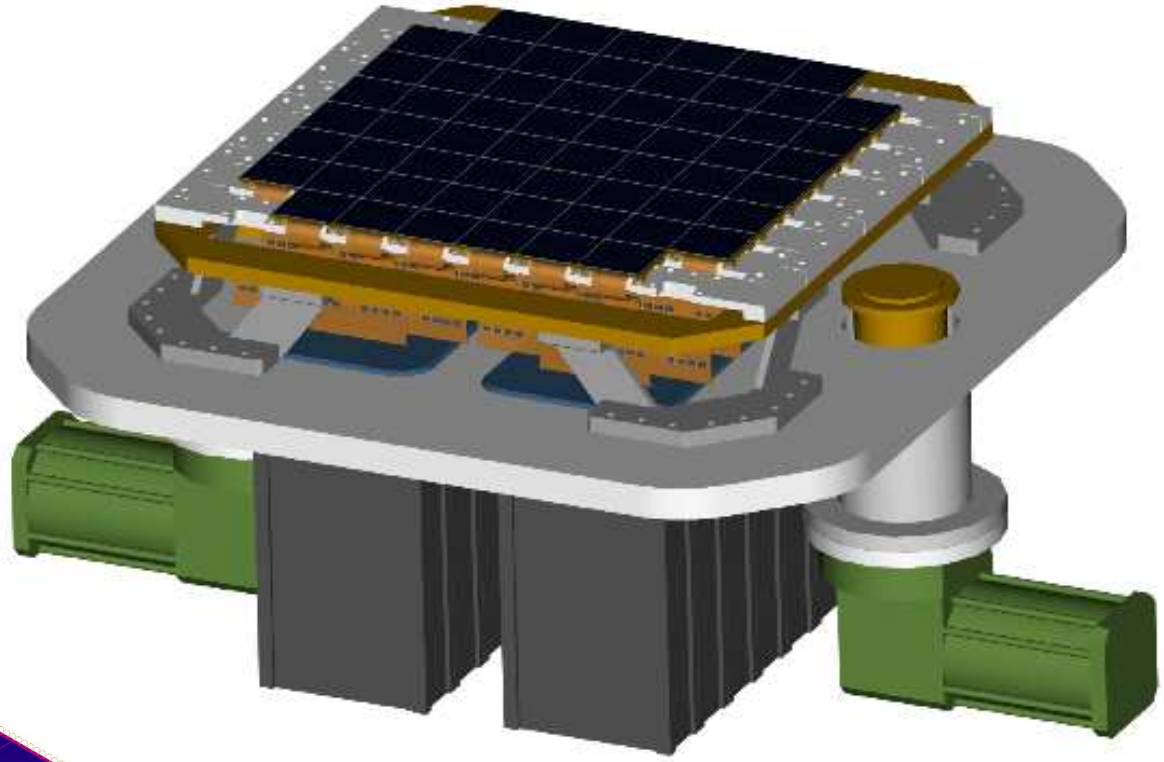
Normal guiding (0.73")

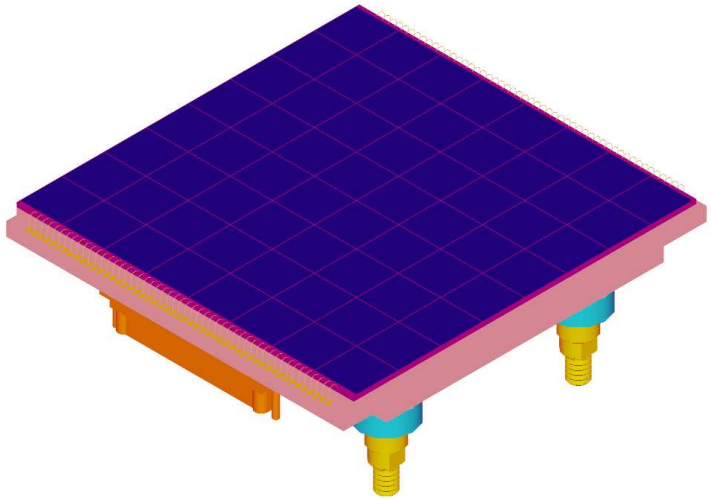


OT tracking (0.50")



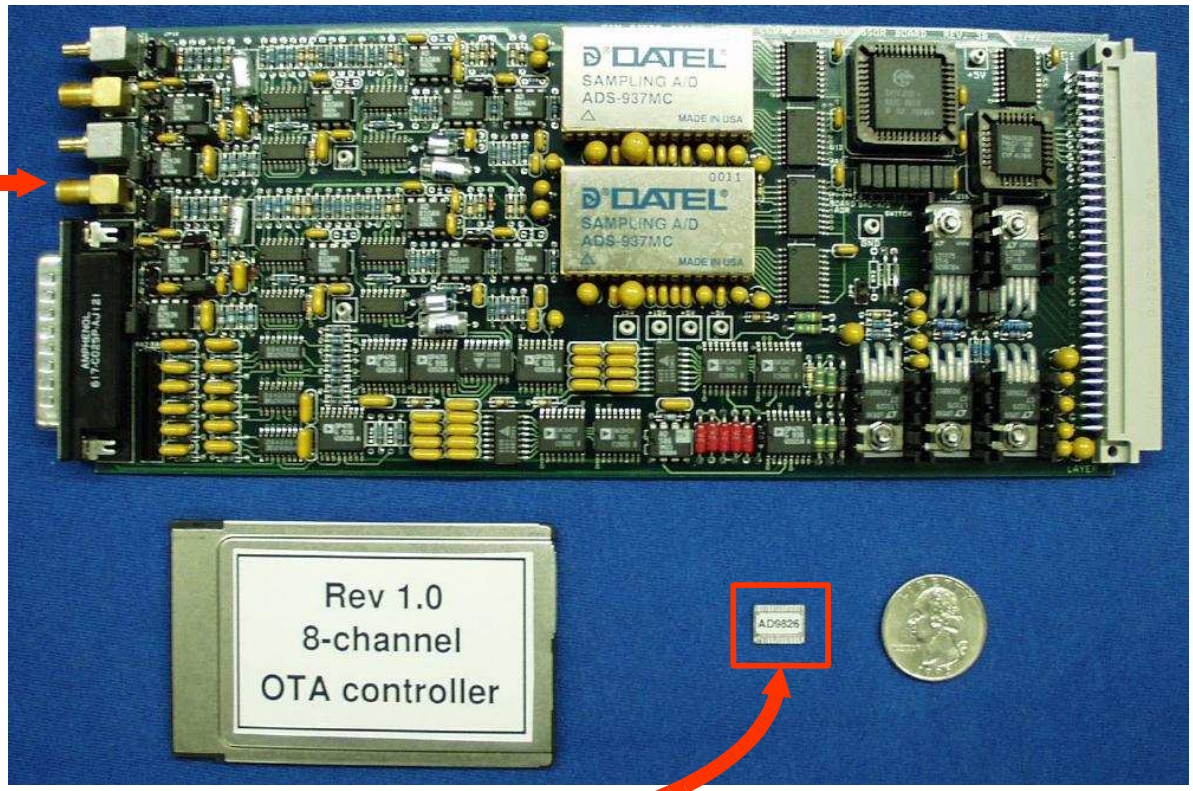
Internal View of Gigapixel Camera Cryostat





Readout Electronics

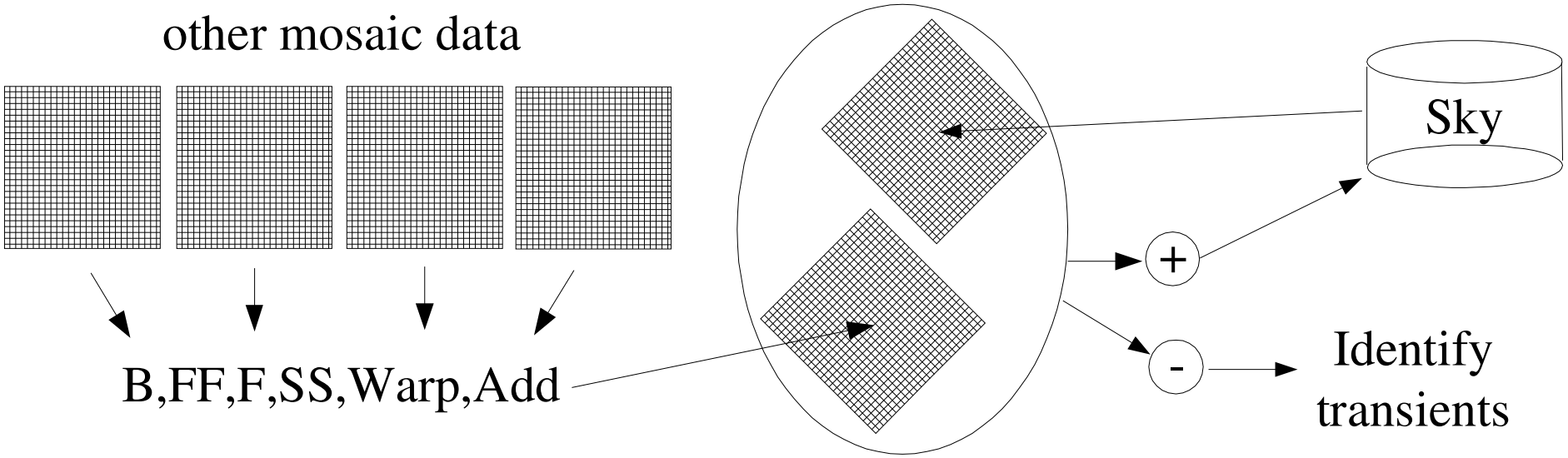
- SDSU dual channel video board
  - 2 channels
  - 150 kpixel/sec
  - CDS, 16 bit ADC
  - 15 W power



- Analog Devices 9826
  - 3 channels (RGB)
  - 15 Mpixel/sec
  - CDS, 16 bit ADC
  - 250 mW power

Image Reduction

- 4 Gpix / 32 sec --> 10 TB raw data per night, 3 PB per year
- Process data in near-real time (30-60 sec each):
  - Bias, flat-field, fringe, sky-subtraction
  - Map individual images to static sky representation
  - Combine individual images from each telescope
  - Subtract static sky and identify transients
  - Add to static sky
- Desire is to create a flexible system that can be used to reduce other mosaic data



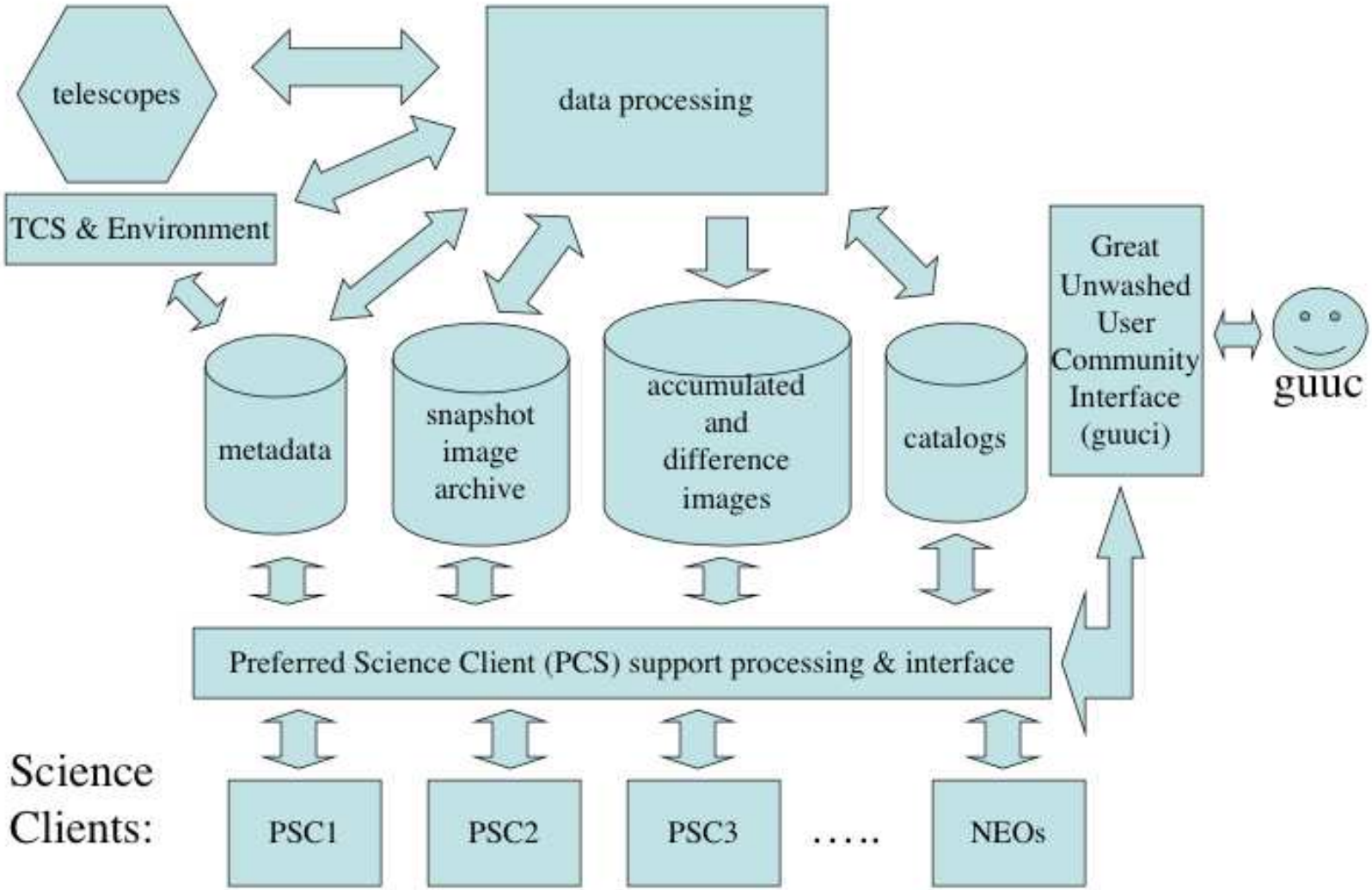
Data Products

- Subtracted images
- List of transients identified in subtracted images
  - Depending upon cadence, may be uncertainty in proper motion for up to several days
- Static sky images
- Source catalogues
- Client Science Programs will plug in to have access to the streams (e.g. planet occultations)
- Other access via Virtual Observatory

Final Data Products

- Sky, the wallpaper:
  - 10 Tpix x 6 colors x N versions
- Sky, the movie:
  - 10 Tpix x 6 colors x 50 epochs
- Sky, the database:
  - 2×10^{10} objects (x 6 colors x 20-60 epochs)
  - 10^9 proper motions (complete over 3π)
  - 10^8 variable stars and AGN
  - 10^7 asteroids (10^4 NEO/PHA)
  - 10^7 transients (SN, GRB, etc.)
  - 3×10^5 stars within 100 pc (with good parallax)

Pan-STARRS Overview



Survey Modes

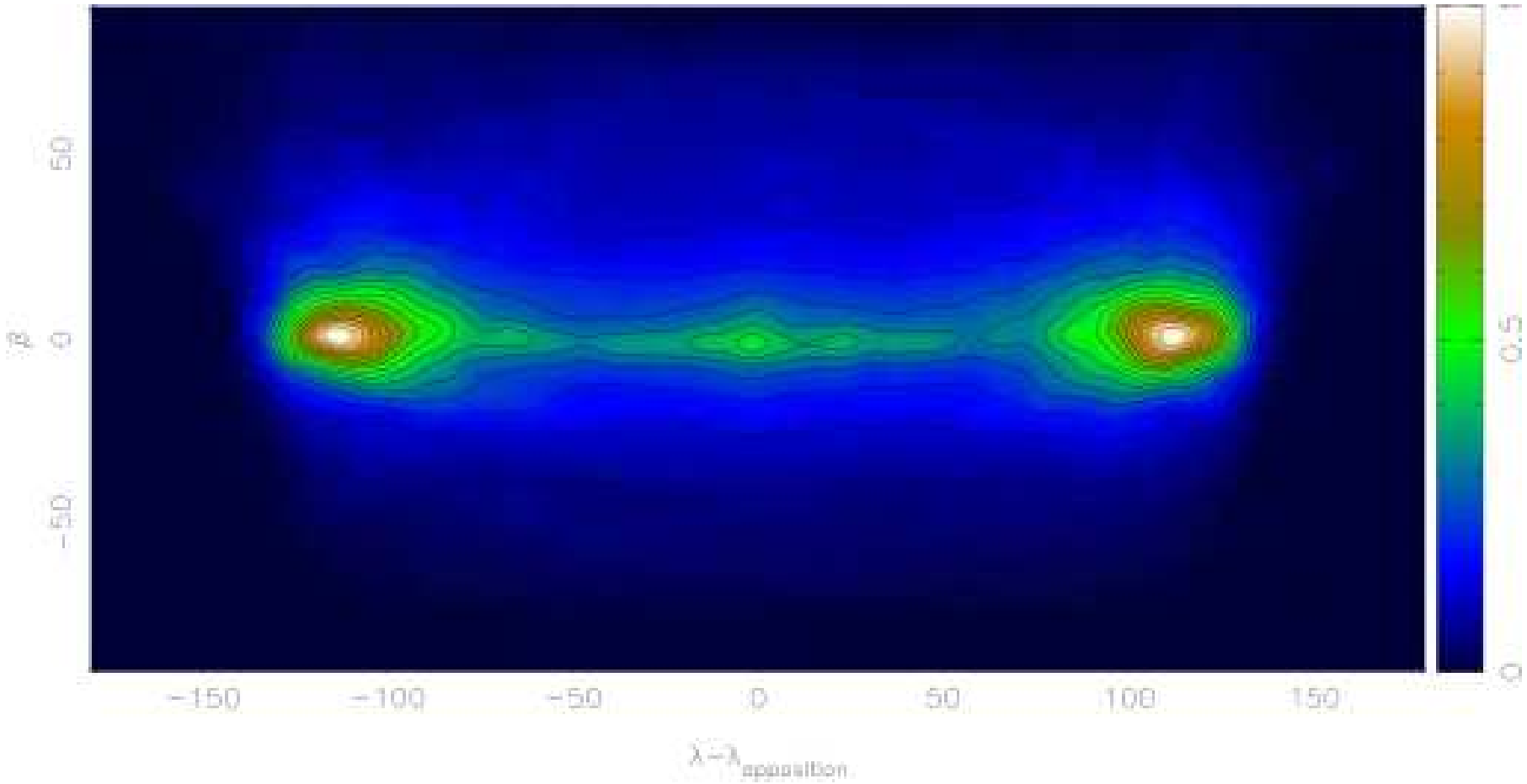
- 7 deg^2, 30 sec integrations --> 6000 deg^2/night, or visible sky thrice per lunation to R ~ 24 mag

Mode	*PSY*	*Area*	*Cad.*	SS	B/g	r	i	z	Y
SS NEO	1.1d 0.2b	7000	h/d/m	27.5 300					
SS KBO	1.0d 0.2b	3π	hdmy	26.5 60					
Var.	0.8d 0.8b	133	4 min	29.4 22000	28.8 7400		28.7 4400		25.1 4400
3π	1.3d 2.5b	3π	14d		26.1 30	25.8 30	25.6 60	24.1 20	22.5 30
Med. Deep	0.6d 0.9b	1200	4d		27.3 271	27.2 460	27.5 1200	25.2 1900	24.2 600
Ultra Deep	0.5d 0.7b	28	4d		29.3 10000	29.2 18000	28.2 6300	27.2 6700	26.2 26000

5-σ limit (AB)

Total int. (min)

Sweet Spots



Collision risk density on the sky for 1000MT colliders

Science with Pan-STARRS

- Moving Object Science
  - NEO – Near Earth Object threat
  - OSS/MBO – Main Belt and Other Solar System science
  - KBO – Kuiper Belt Objects
  - SOL – Solar Neighborhood (parallaxes and proper motions)
- Static and Invariable Object Science
  - WL – Weak Lensing
  - LSS – Large Scale Structure
  - LSB – Low Surface Brightness and dwarf galaxies
  - SPH – Spheroid formation
  - EGGS – Extragalactic and Galactic Stellar science
- Transient and Variable Object Science
  - AGN – Active Galactic Nuclei
  - SNE – Supernovae
  - GRB – Gamma Ray Bursts and afterglows
  - EXO – Exoplanets (occulation)
  - YSO – Young Stellar Objects
  - VAR – Variability Science (especially stars)
- TGBN (Things that Go Bump in the Night)

SNE Project (Tonry)

- Using Medium-Deep, Ultra-Deep surveys
- Goal is to measure w(z) to 10% over $0 < z < 1$
- 5,000 SNe Ia per year, $0 < z < 1$
  - Most found on the rise
  - 80 per month @ $I < 22$ mag
  - 350 per month @ $22 \text{ mag} < I < 24$ mag
- Spectrographic follow-up required
  - 365 nights/year on an 8m-class

Pan-STARRS: In General

- Estimate ~ 10^4--10^5 SNe of all types per year discovered by Pan-STARRS
- In general (i.e., apart from Tonry SN program):
  - Limited colour information (e.g. SS program)
  - Limited temporal information (e.g. 3π survey)
- Need follow-up resources to identify interesting variable sources (SN types, GRB, unknowns)
- SN studies limited by spectroscopic resources