Image Sensor Testing and Characterization.

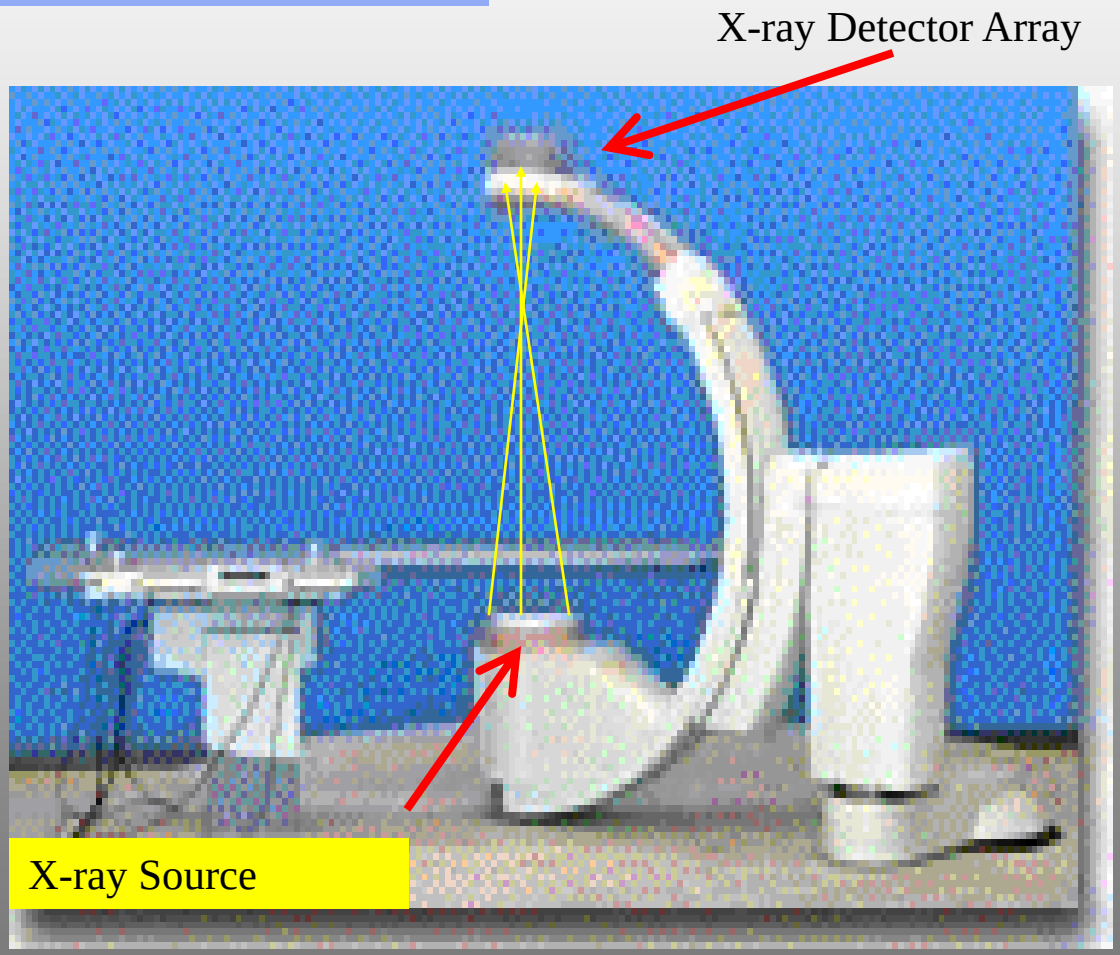
Presentation Prepared for the Staff of
Nelcor/Tyco Health Care

Presented By: Nick Nickols, Director of Engineering, DMR LLC

Overview

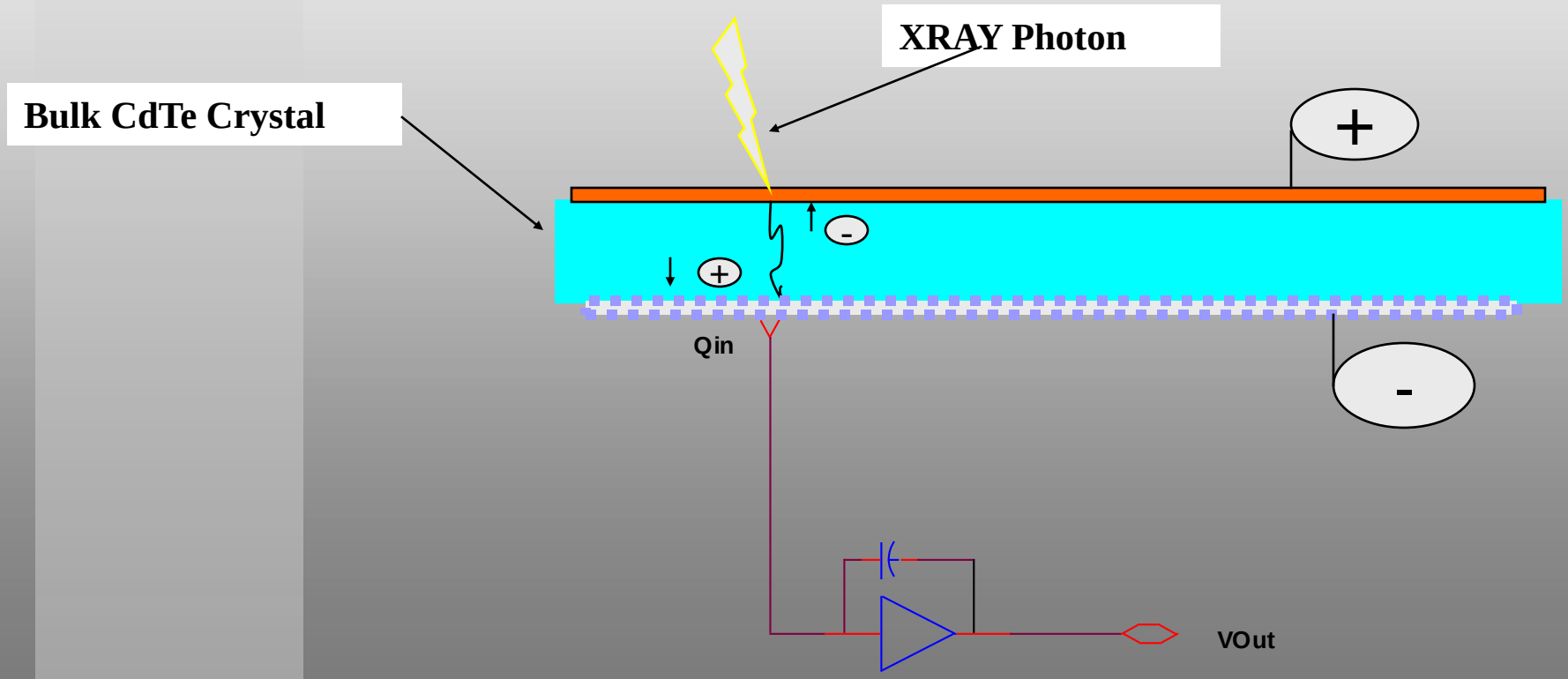
- I recently have been involved in CCD and X-ray image sensor development projects. My contributions have included:
- System level and FPGA design/modification.
- Characterization of Hybrid CdTe X-ray detectors.
- Design, integration, certification, and release to manufacturing of a CCD camera.
- Analyzing the clocking and timing of sensors as it impacts image quality in detector arrays.
- Bring up/debug next generation X-ray Detector Hybrids.
- Product support for manufacturing of CCD camera.

NexRay Medical

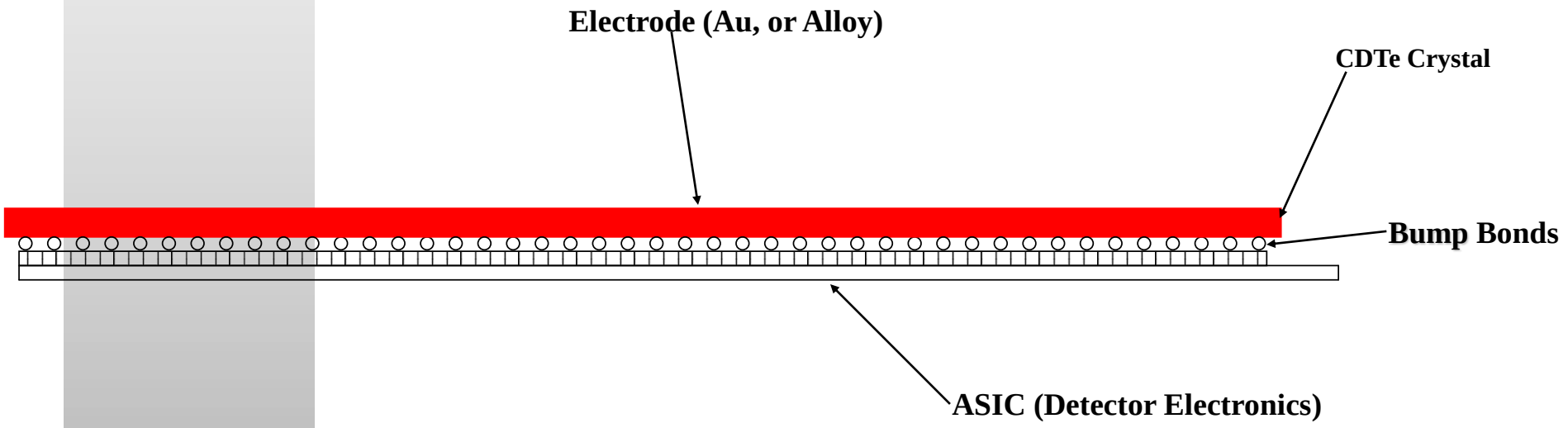


X-ray Detection with CdTe Crystals

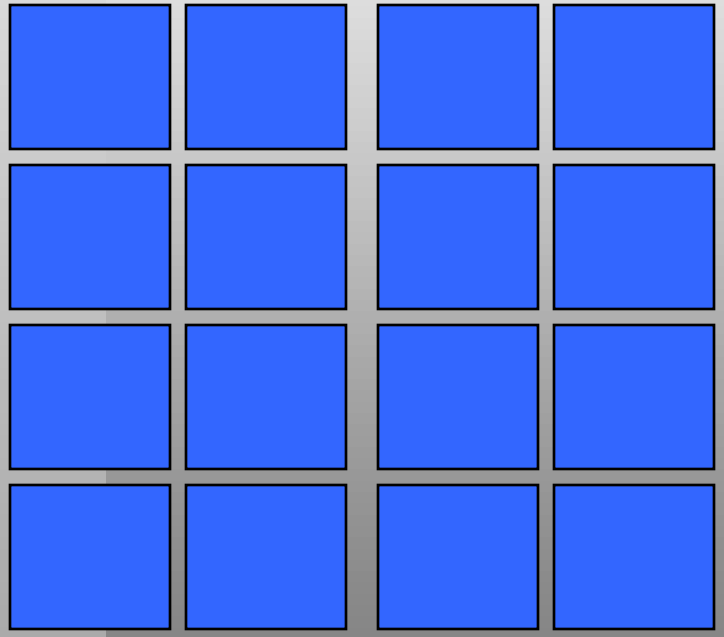
- **Cadmium Telluride is a semi conducting material used in focal plane arrays and X-ray detectors.**



X-ray Detector Array Construction



X-ray Detector Array

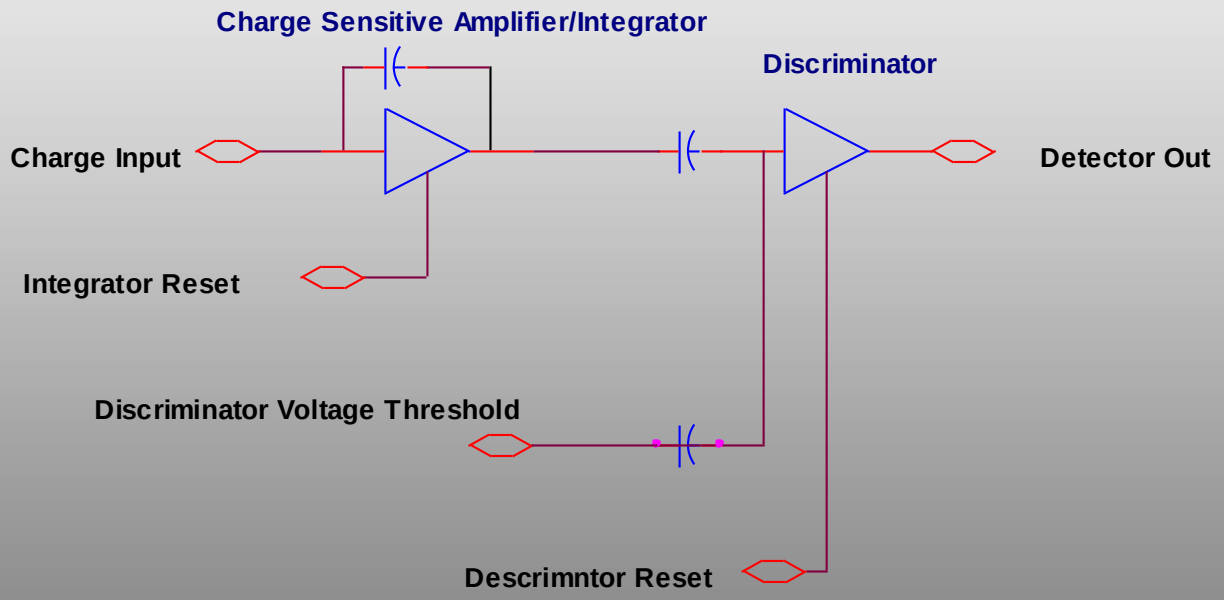


Detector is comprised of 16 Hybrid detectors.

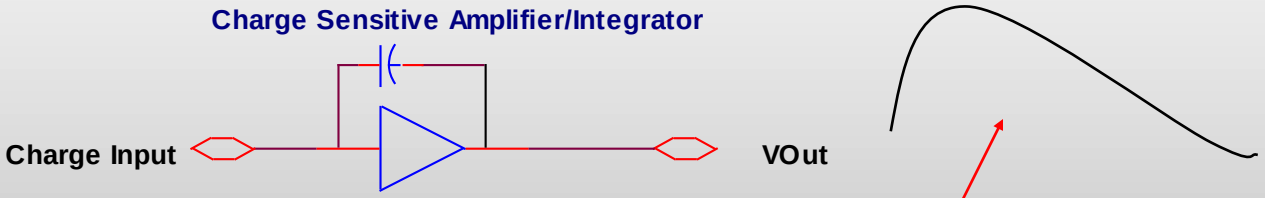
Each hybrid detector has an array of +/- 480 charge sensitive amplifiers (Sub pixels).

The combination is an array of 7680 pixels.

Charge Detection and Discrimination



Charge Sensitive Preamplifiers

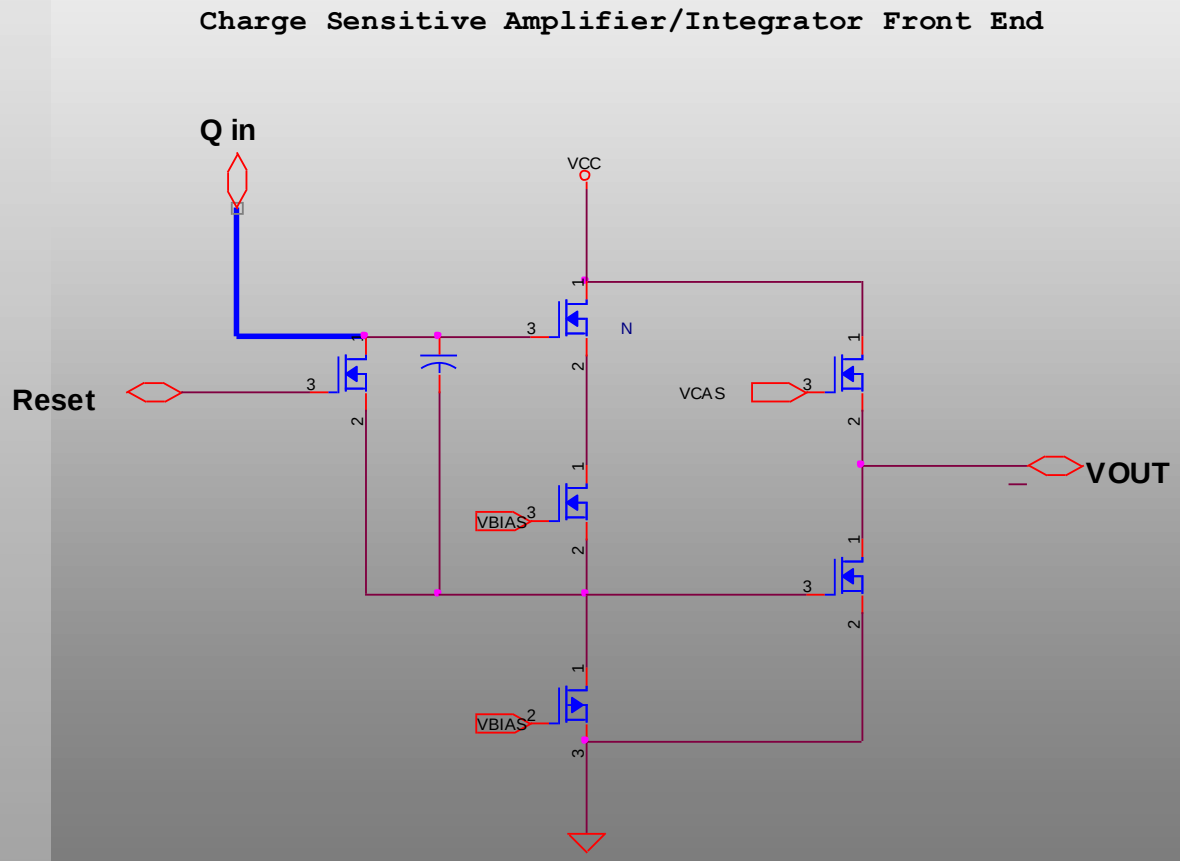


Qin

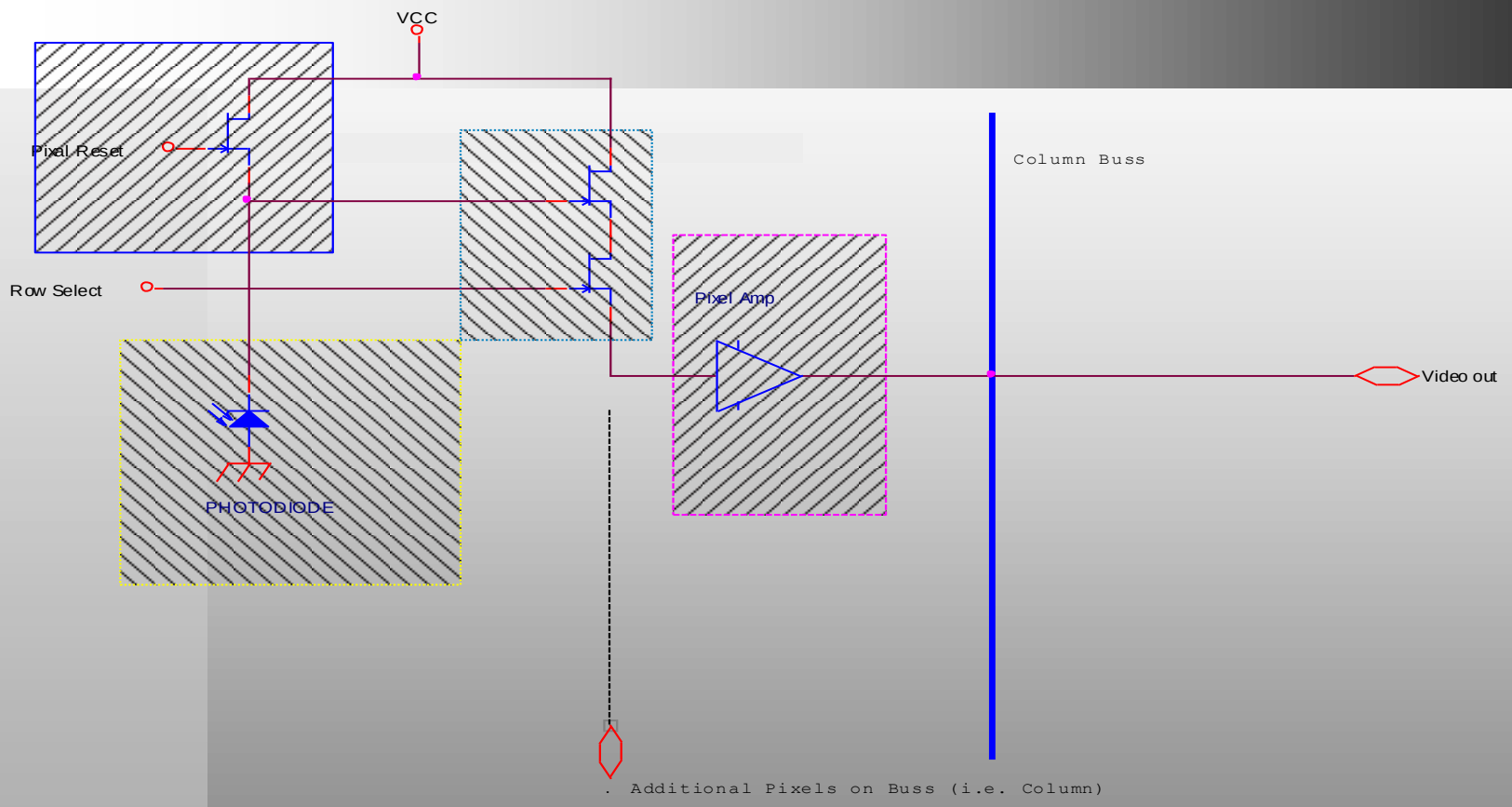
$$Qin = \int_0^t I(t)dt$$

VOut = Qin/Cf

Construction of Charge Sensitive Amplifiers

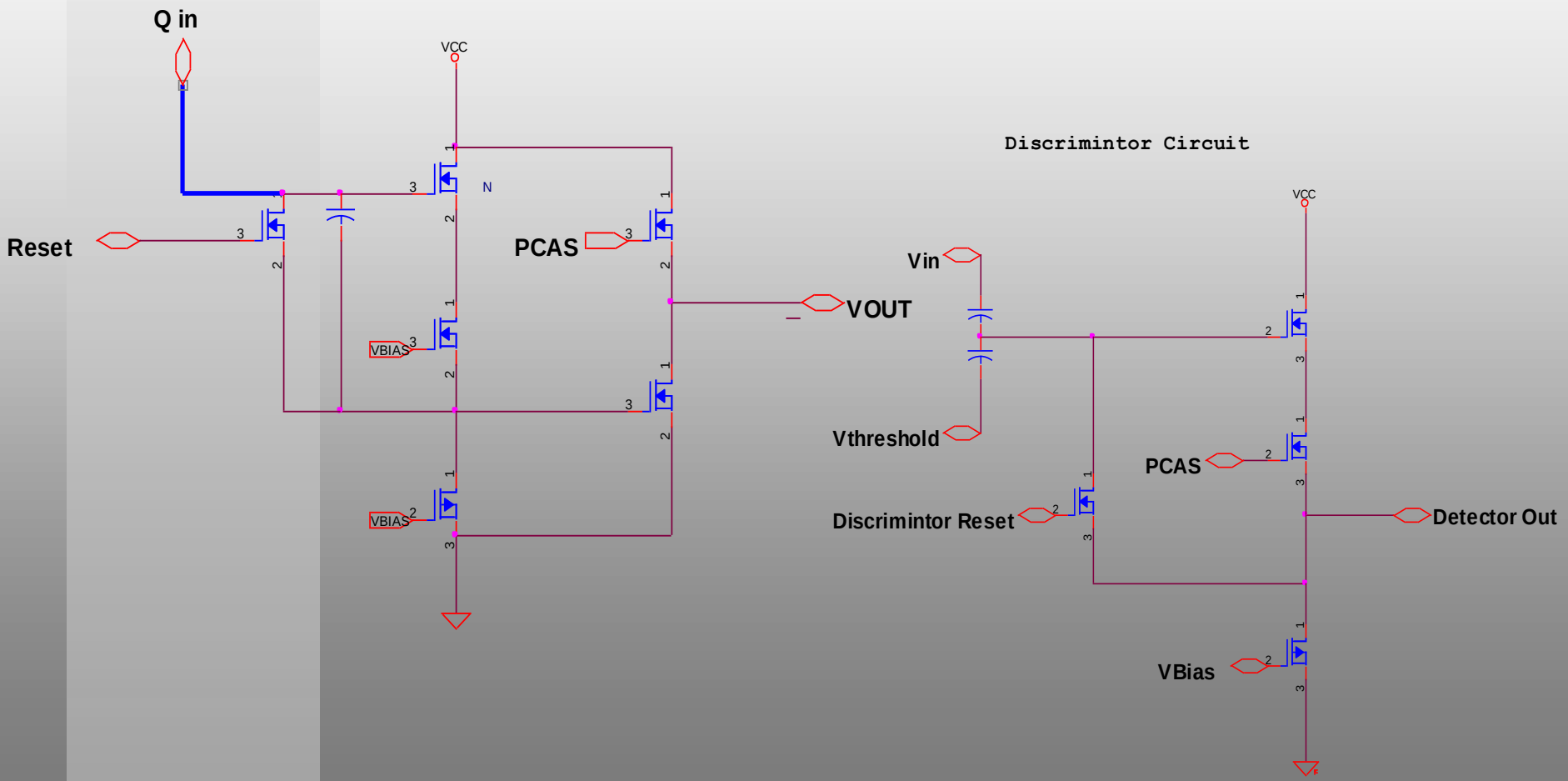


Active Pixel Sensor Front End



Transistor Implementation of X-Ray Detector Front End

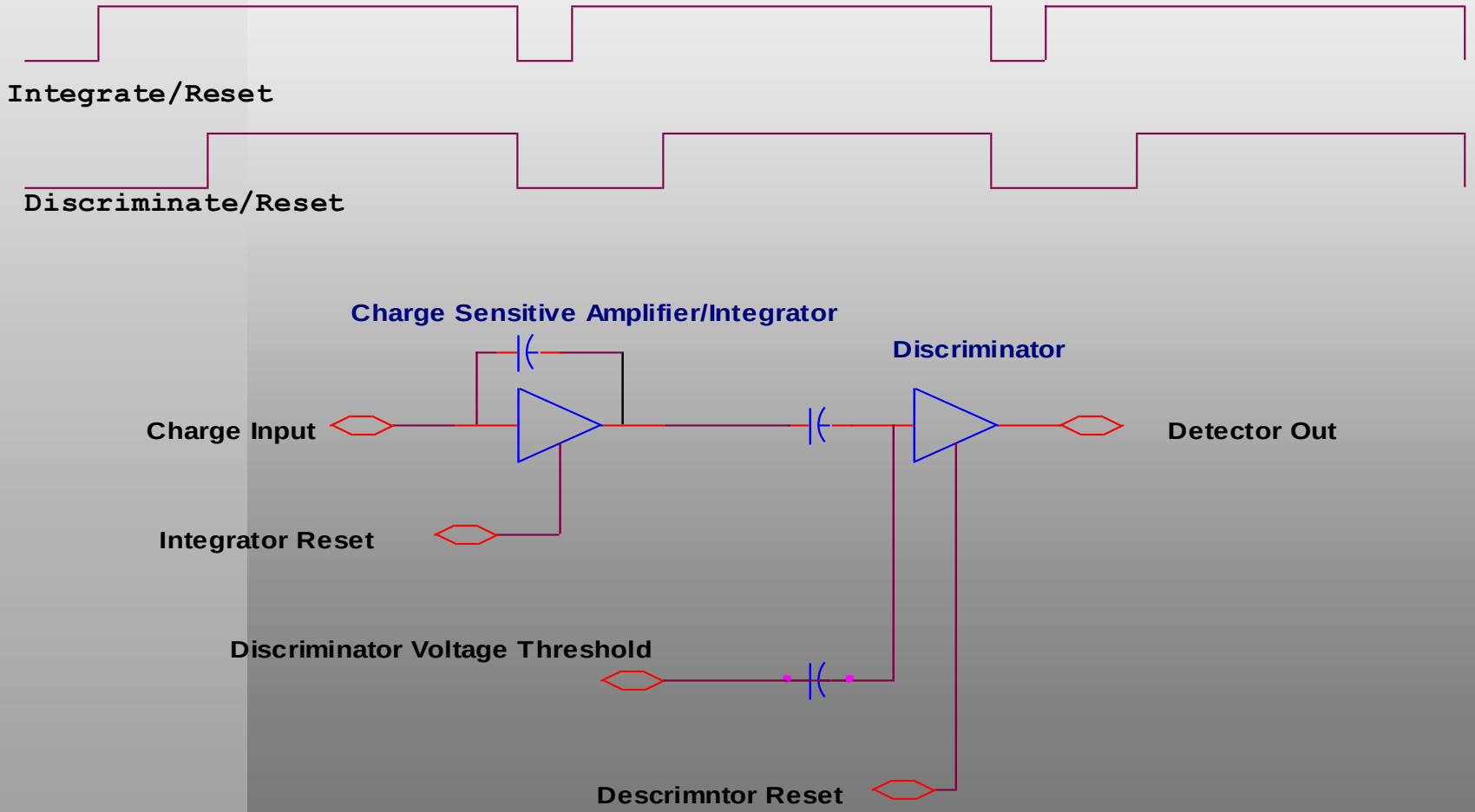
Charge Sensitive Amplifier/Integrator Front End



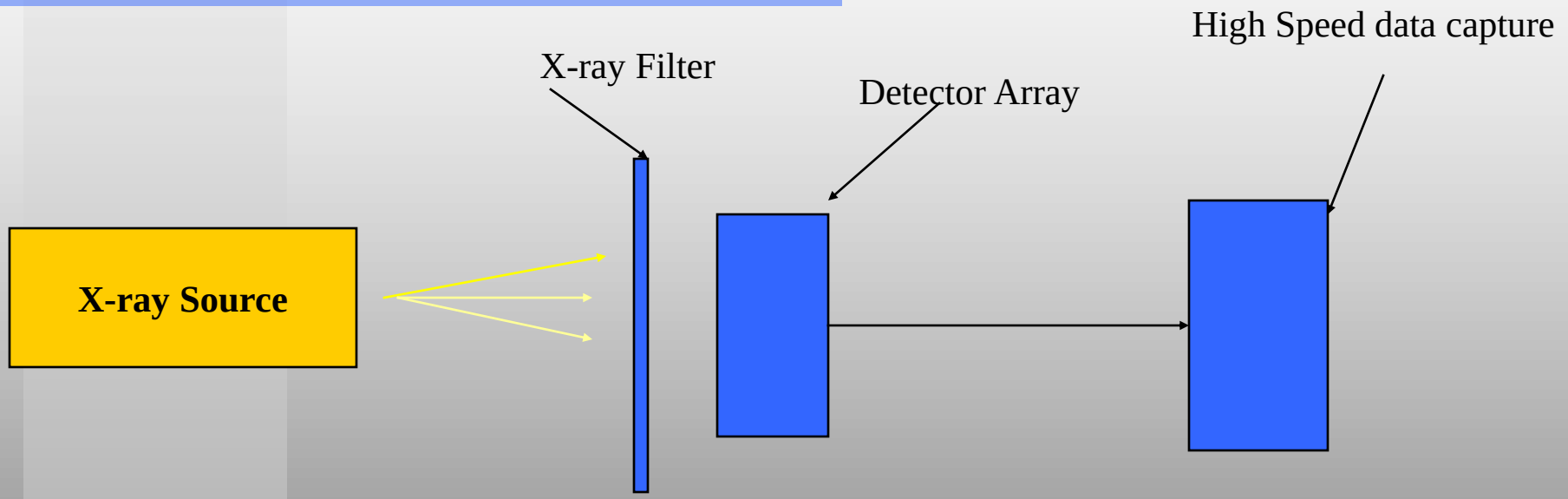
Integrating the Hybrid X-Ray detector with an FPGA

- Timing for each Hybrid X-ray detector controlled by a FPGA.
- One can optimize the integration and discrimination timing at the front end of the detector array.
- Bump bond height variations cause integrator/discriminator circuits to read slightly different charge variations under monochrome X-ray source conditions.
- Modifications in FPGA timing can be used to equalize out some of these variations.

FPGA Timing Model(simplified)



Detector Testing



Experiments for characterizing detector hybrids

- Compared pixels variations under:
- Varying X-ray Illumination levels. Quantified Poisson excess noise.
- Swept V threshold of Discriminator for each X-ray illumination level.
- Altered FPGA timing on each hybrid; attempting to equalize for variations in detection elements.
- Ran experiments to capture turn on time and impulse response to pixel (charge sensitive amplifier) without an X-ray source.
- This mapped variations in Bump Bond Heights.

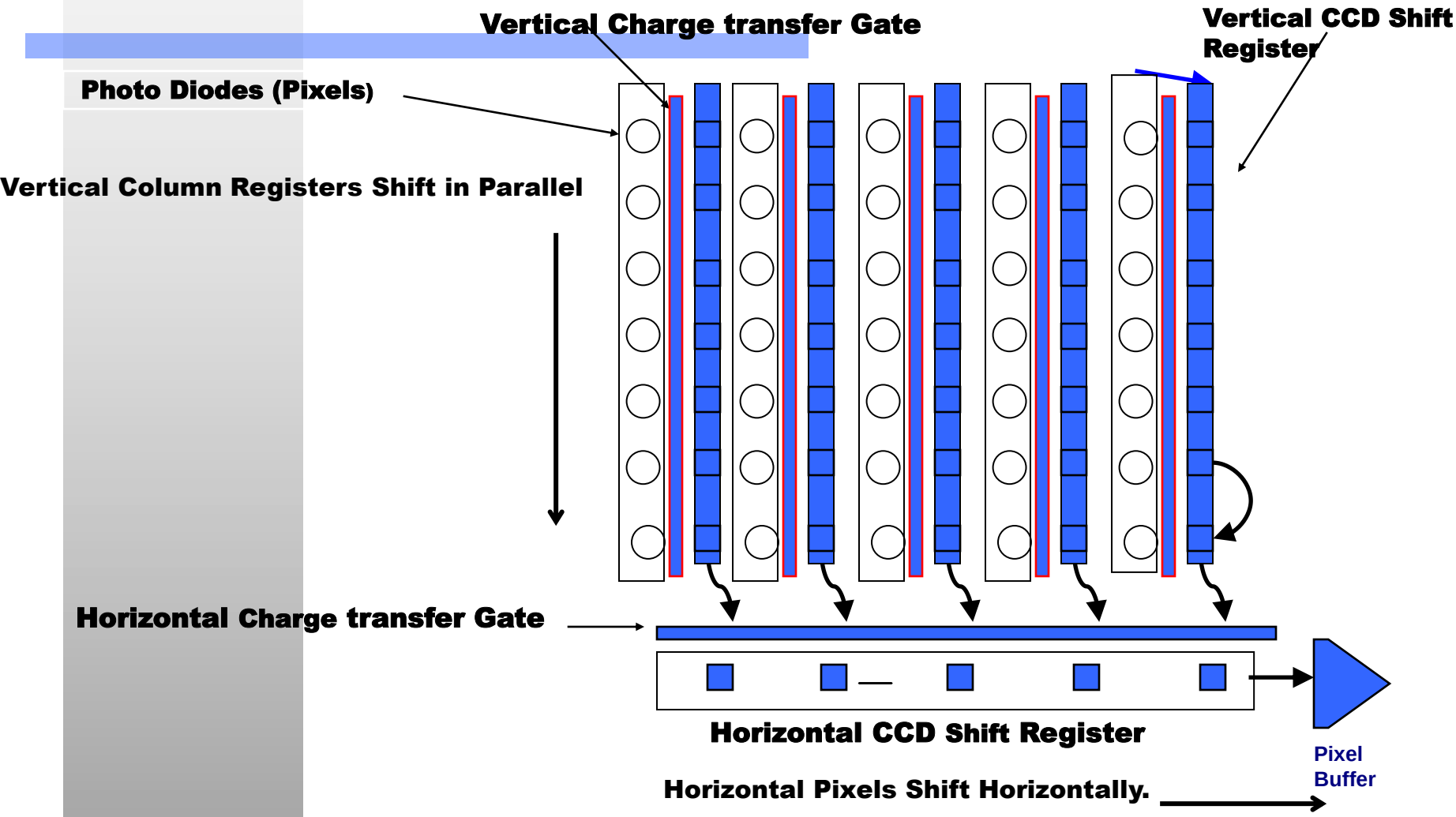
Results of Hybrid Characterization

- Determined Optimal FPGA timing for each hybrid.
- Determined Optimal Voltage threshold values for each hybrid.
- Characterized the X-ray sensitivity boundaries.
- Determined Poisson Excess noise sources and validated noise models.
- Characterized manufacturing and construction processes of several CdTe and Bump Bonding vendors.

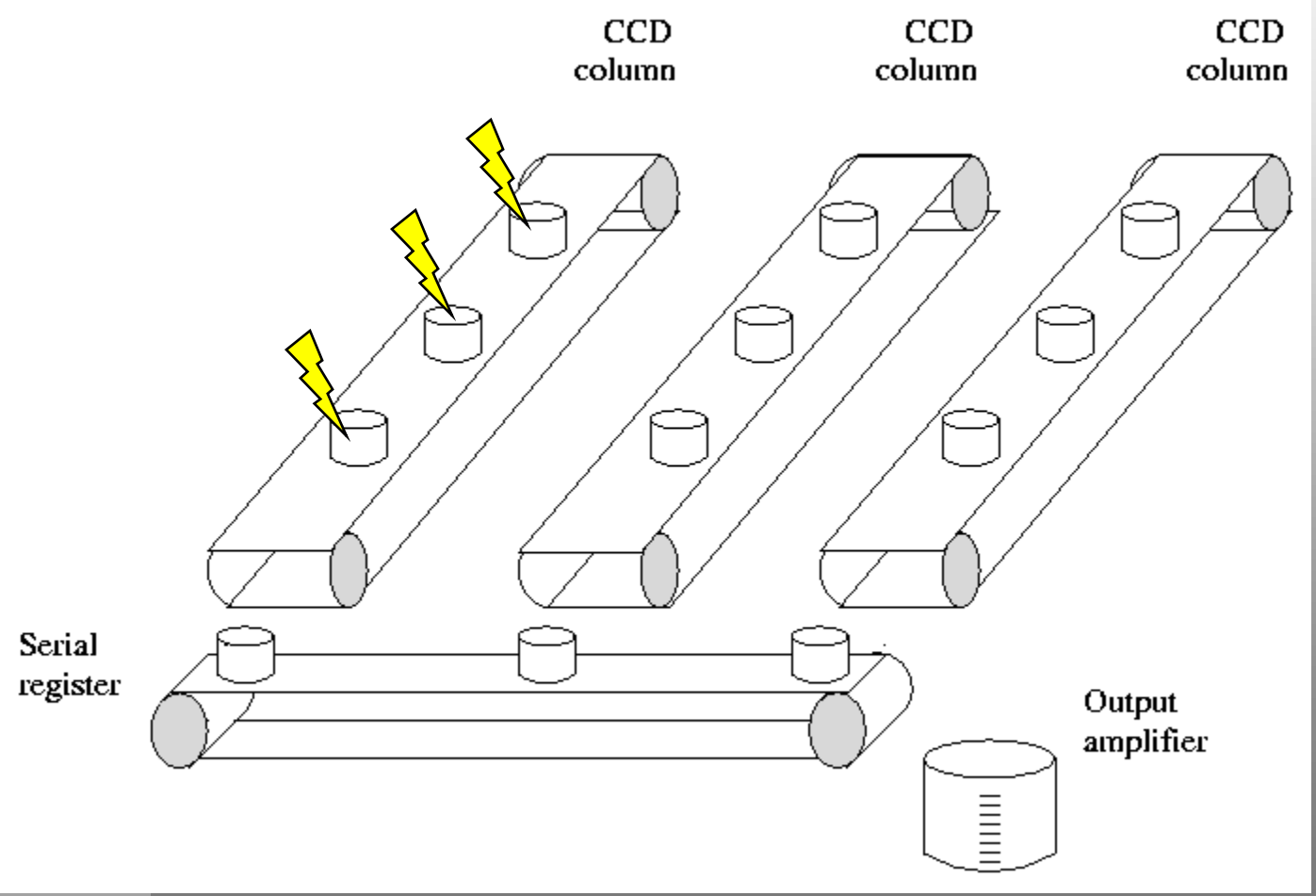
CCD Camera Design for Biometric Imaging

- Formally employed with Identix Inc.
- Designed the CCD camera electronics for the TP3800 Imaging system.
- Characterized camera and Optics for FBI appendix F certification.

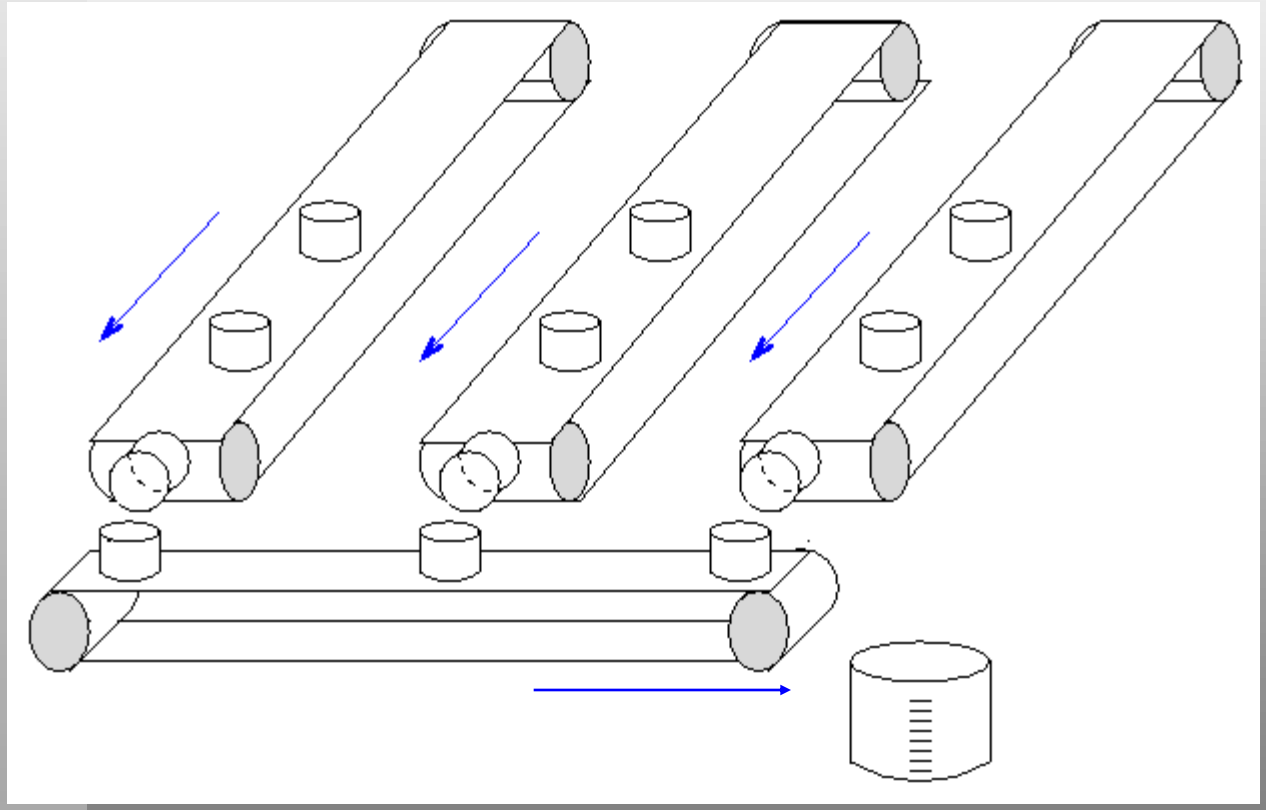
Interline CCD Technology Simplified



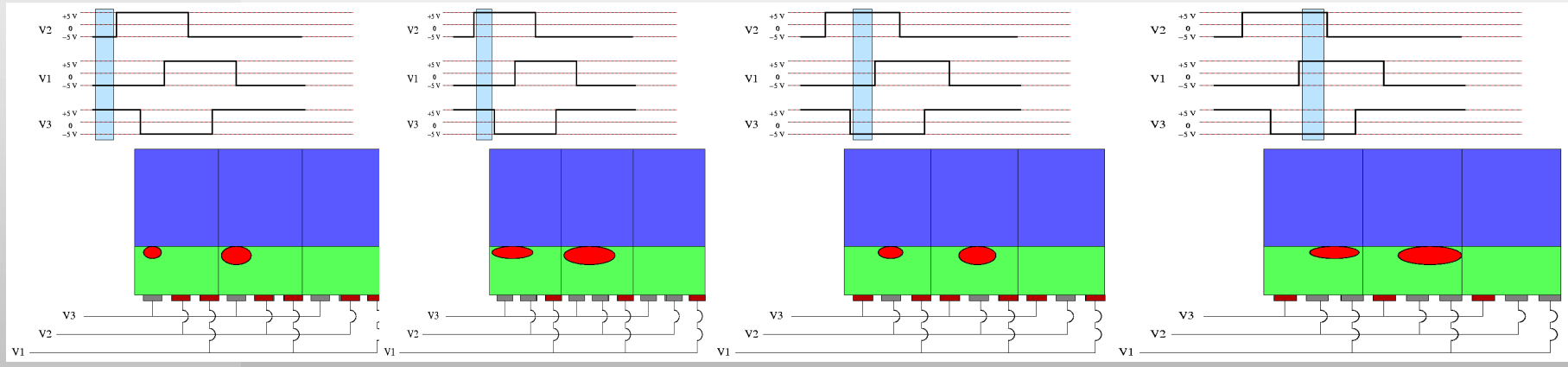
Charge Integration Analogy

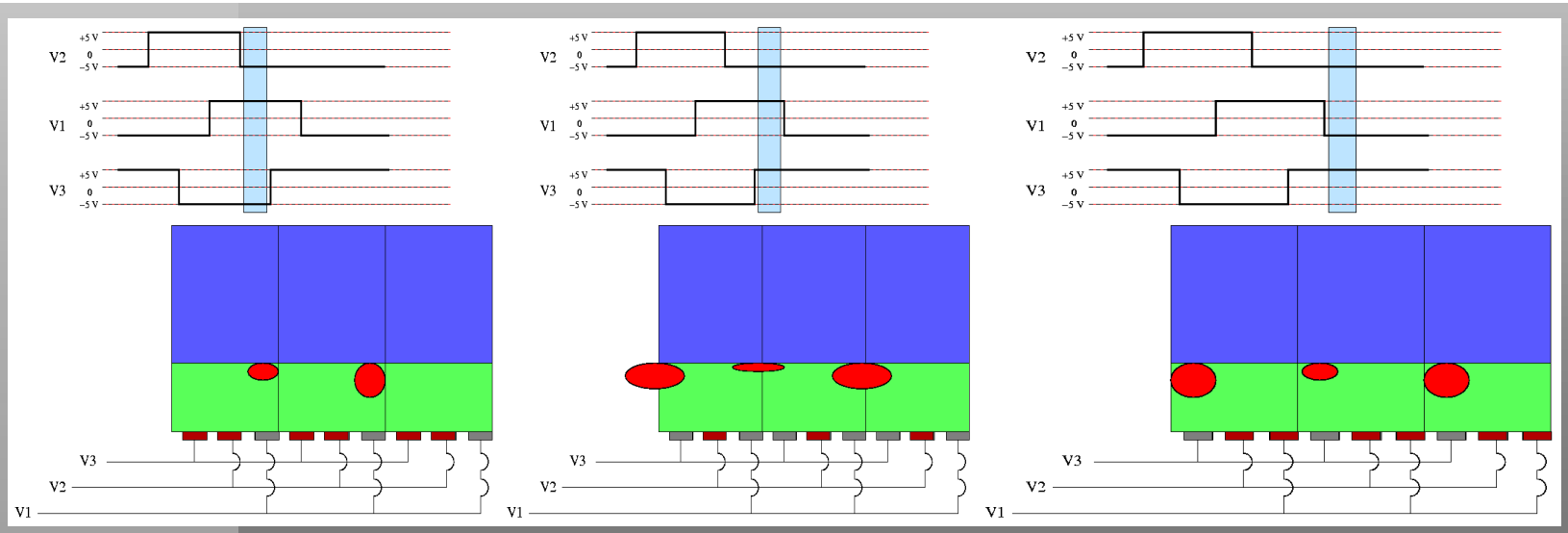


Charge Transfer Analogy

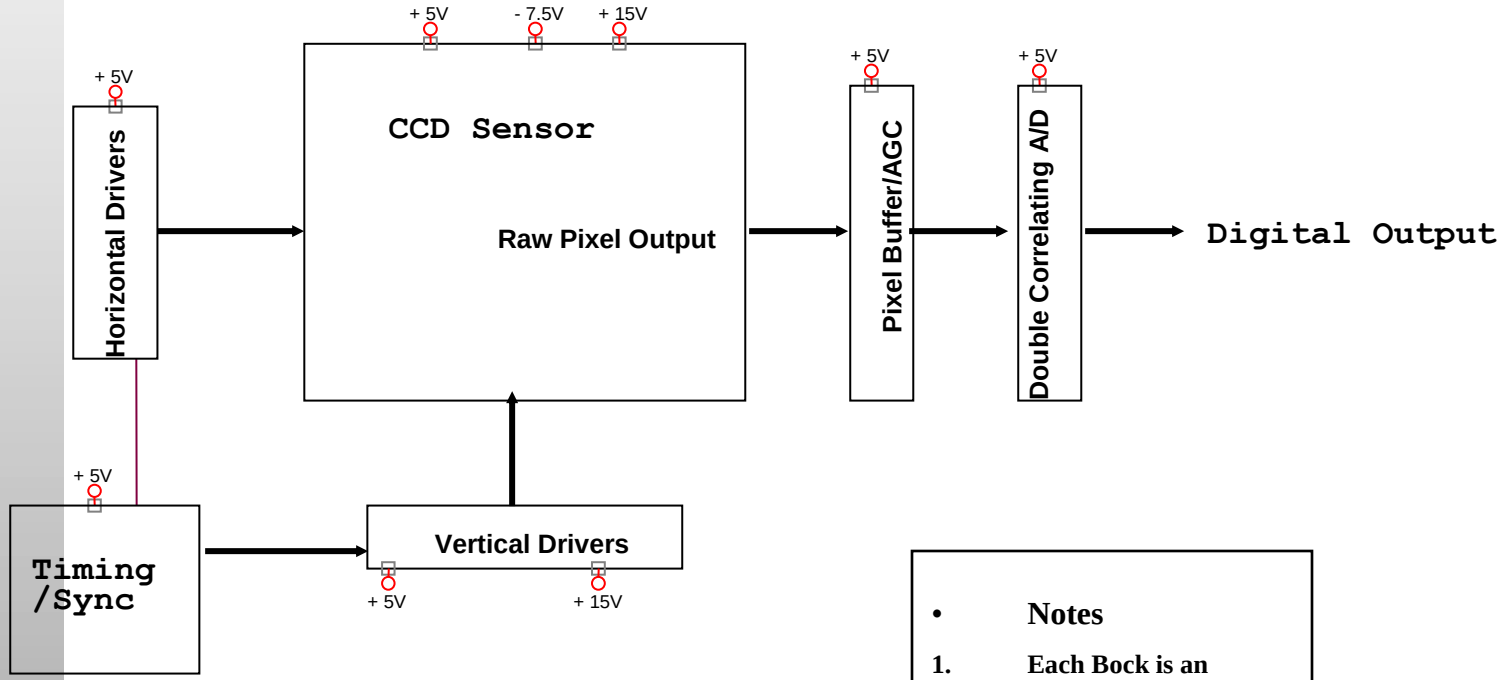


Three Phase Vertical Transfer Timing Model





Typical CCD Camera/System



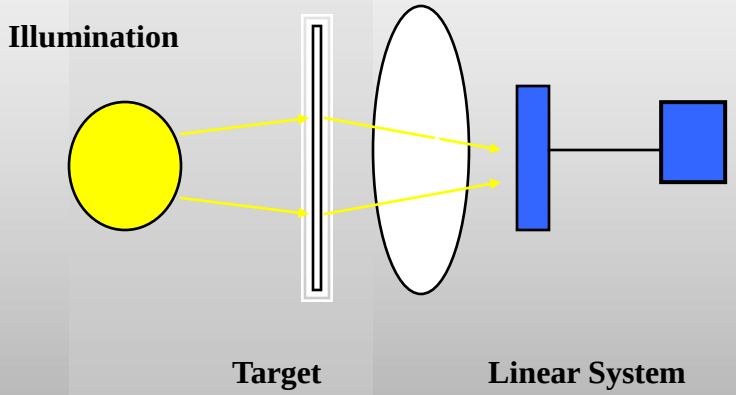
- **Notes**

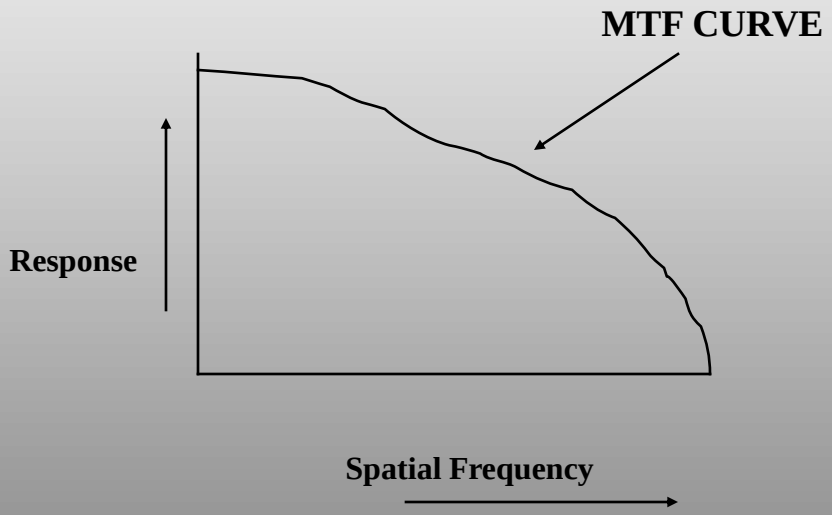
1. **Each Bock is an Individual Component/s.**
2. **Typically three Power Supply Voltages Required**

FBI Appendix F Specs For AFIS

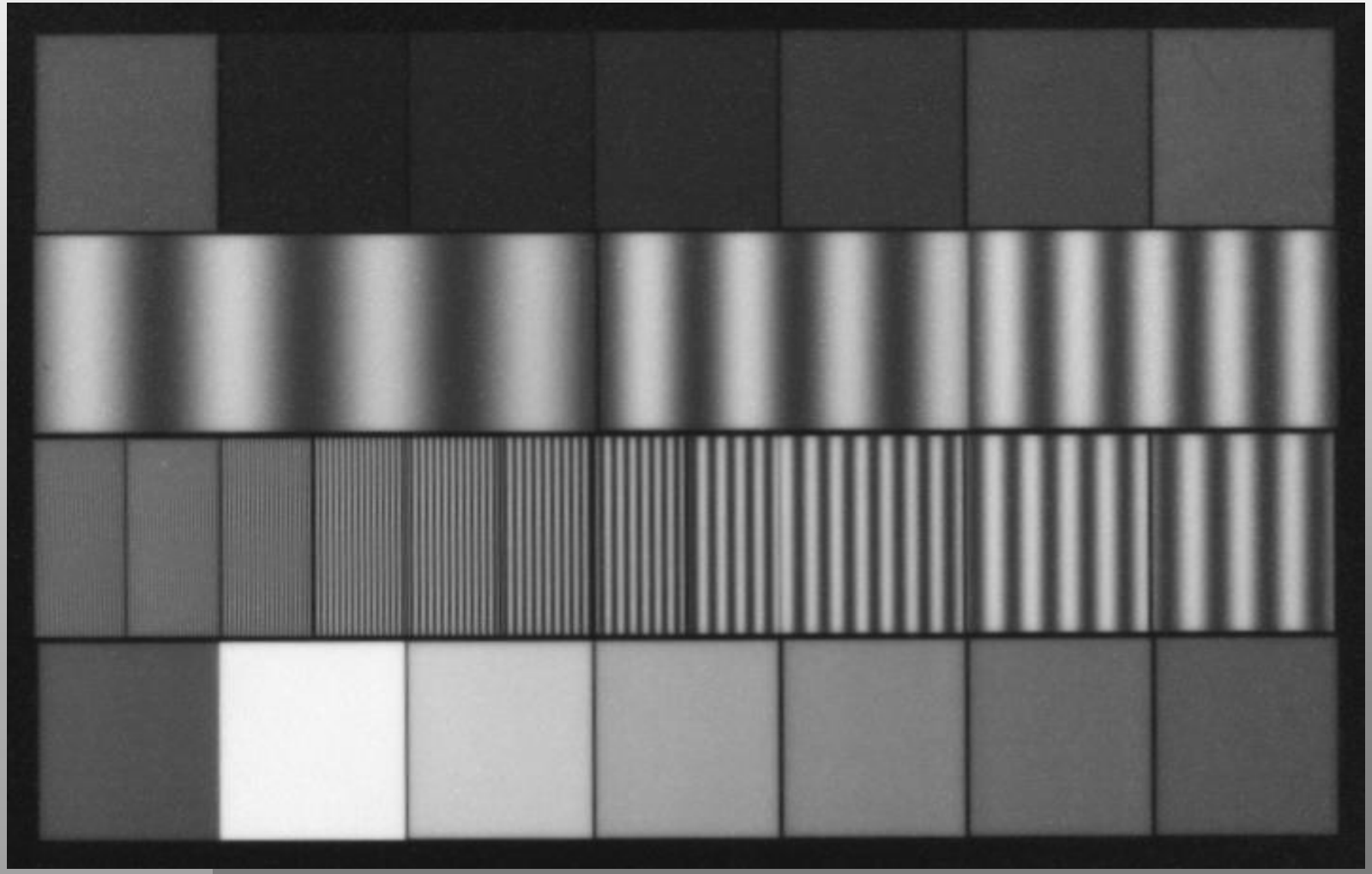
- 500 dots per inch
- Must resolve 20 line pairs per mm at 10% MTF.

MTF Test Procedure

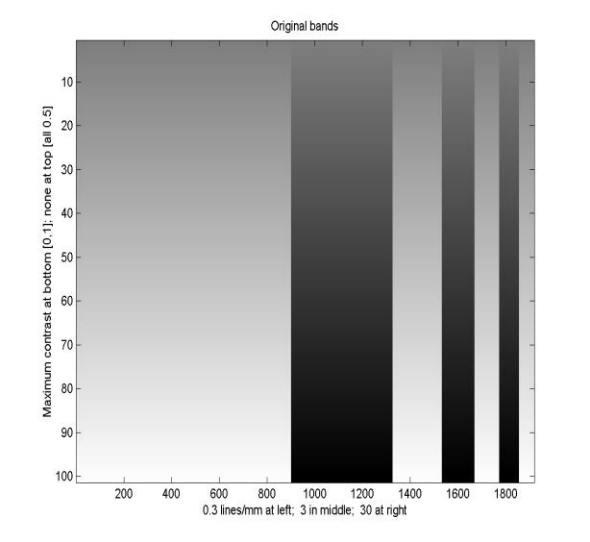


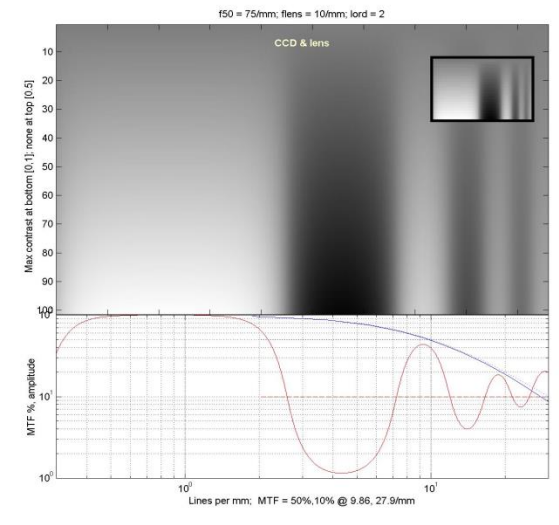


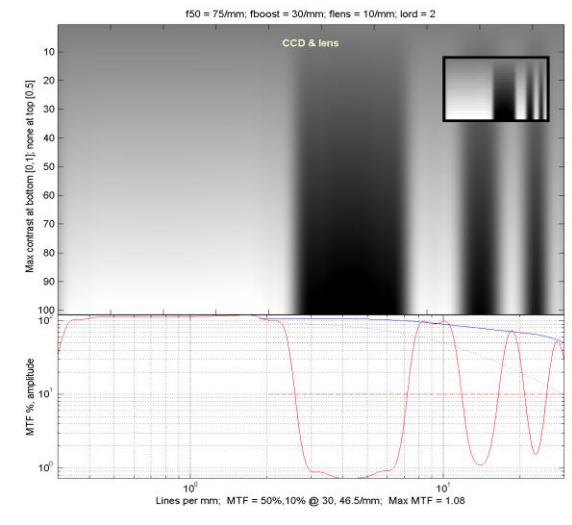
MTF Test Pattern



MTF Test Data







Results and Project Conclusions.

- Camera received FBI certification.
- Camera was integrated into TP 2000 later renamed to TP 3800.
- First systems shipped in January 2002.
- Identix shipped 20 systems per month in 2001-2002.
- Identix merged with Visionics in 2/2002.