Implementing CSpad in HORUS
CSPAD basic info

- 194x185 (110 \( \mu \text{m} \))^2 pixels per ASIC
- High/Low gain selectable per pixel
- On chip ADC using external ramp signal
- ADC counter (14-bit) counts clock cycles until ramp is lower than signal
- 500 \( \mu \text{m} \) silicon sensor
Saturation behavior
Available data sets of silverstearate:

<table>
<thead>
<tr>
<th>Acquisition time [µs]</th>
<th>files</th>
<th>frames</th>
<th>useful</th>
<th>Avg number of photons in useful frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>10’000</td>
<td>90</td>
<td>6’464</td>
<td>100%</td>
<td>40</td>
</tr>
<tr>
<td>100’000</td>
<td>140</td>
<td>9’112</td>
<td>33.2% (3027)</td>
<td>300</td>
</tr>
<tr>
<td>1’000’000</td>
<td>2’194</td>
<td>157’776</td>
<td>0.8% (1302)</td>
<td>2’500</td>
</tr>
<tr>
<td>5’000’000</td>
<td>69</td>
<td>4’904</td>
<td>4.8% (237)</td>
<td>17’000</td>
</tr>
<tr>
<td>10’000’000</td>
<td>115</td>
<td>8’216</td>
<td>0.6% (54)</td>
<td>26’000</td>
</tr>
</tbody>
</table>

Total matrix size is 35890 pixels
Chip has 367 bad or unread pixels (~1%)
Problems with common mode

As there is a low photon count the average frames gives a reasonable estimate of the common mode.
Pedestal distribution

After common mode correction

Spans 800 ADU from red to violet

1 ADU $\sim 0.42$ keV
Noise distribution

Spans 2.6-3.6 ADU

~ 300 electrons (violet)

~ 412 electrons (red)
Input data
Summed over the image

General behavior modeled, fine tuning needed for gain (variations) and photon probability
Non-continuous source

Will limit data to useful frames (3027)
Sum histogram much better
Deviation

Let's have a look in detail

absolute

Relative to measurement error
Relative deviation

Additional fluorescence at 3.1 keV: Ag L\(_{\beta}\) line?

Mismatch of simulated and real gain
\(~0.1\) ADU/8.05 keV

Non-Gaussian noise tail

Probability of multiple hits to low -> avg. photon prob. To low
Spatial pix by pix difference

Span +- 0.1 sigma

Systematic effect of hot and cold regions

⇒ non-constant source
⇒ source movement?
Individual pixels (empty)
Individual pixels (2\textsuperscript{nd} ring)

Relative shift of 1 ADU
Individual pixels (1st ring, lo)

Too few photons
Individual pixels

Too many photons
Source movement

First 300 images – last 300 images

Red = more photons in the beginning

Violet = more photons in the end

Displacement of ring center
Current modules can be used

New module needed, but very similar to adaptive gain switching

New ADC routine needed?
Analog

Digital

MMPAD

Simulation

preamp voltage [mV]

number of 20 keV photons

0
1000
2000
3000
1500
1000
500
0

digital counts

number of 20 keV photons

0
1000
2000
3000
0
10
20
30
40
50
Non-Gaussian noise

Noise seems like gain variations
Image autocorrelations

Bad side

Good side

Different scale on both images
Temporal autocorrelation

Crosstalk stays in the system for 
~ 100-200 frames of image series
Gain variations?

High intensity data reconstructed with constant gain

Gain change at column 104?
Summary

- CSpad implementation working
  - Limited by knowledge of data set
- MMpad working in principle, fine tuning needed
  - Major issues with chip
  - Dataset mostly unknown

![Images of wildlife](image1.jpg) ![Images of wildlife](image2.jpg) ![Images of wildlife](image3.jpg) ![Images of wildlife](image4.jpg)