Data converters for high frame rate imaging detectors

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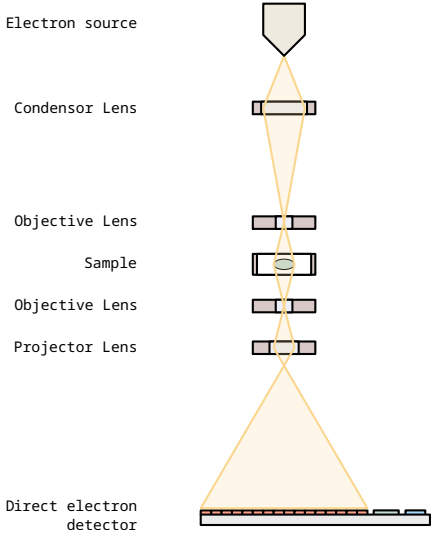
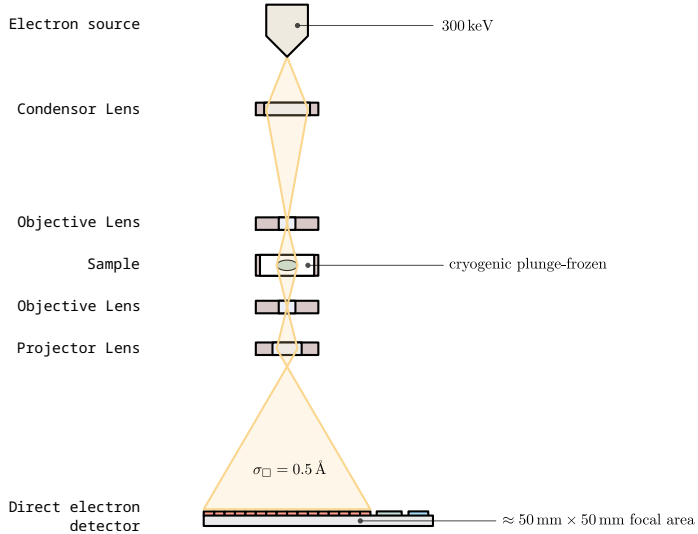
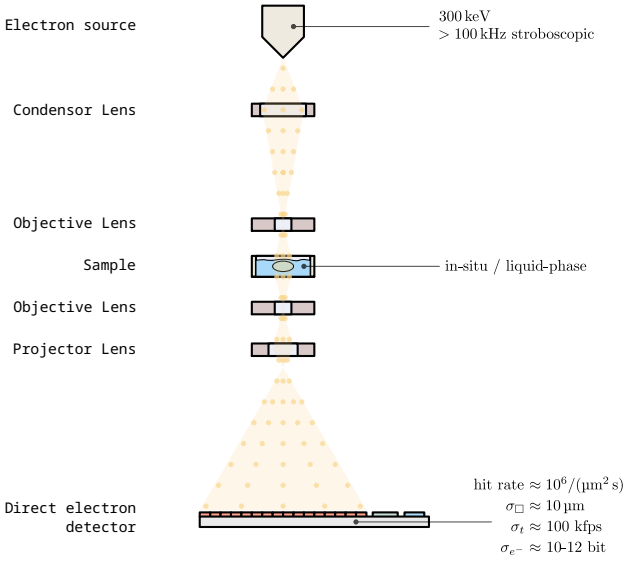
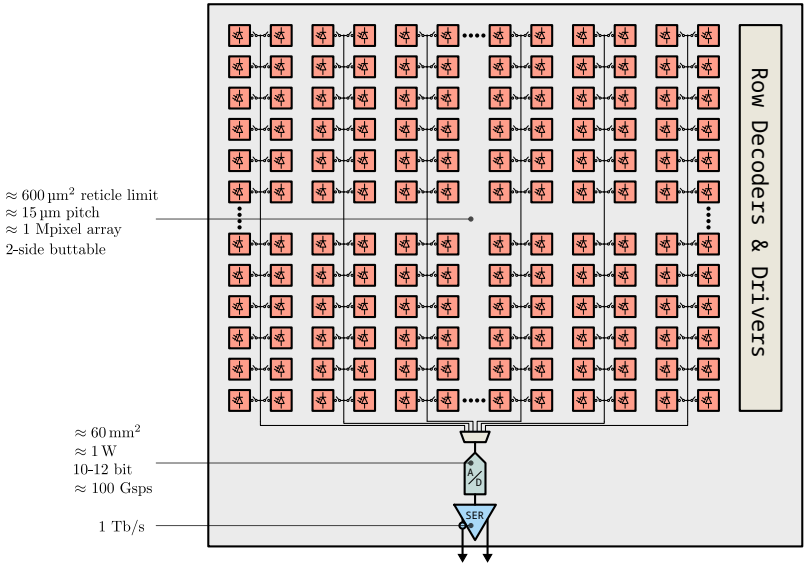
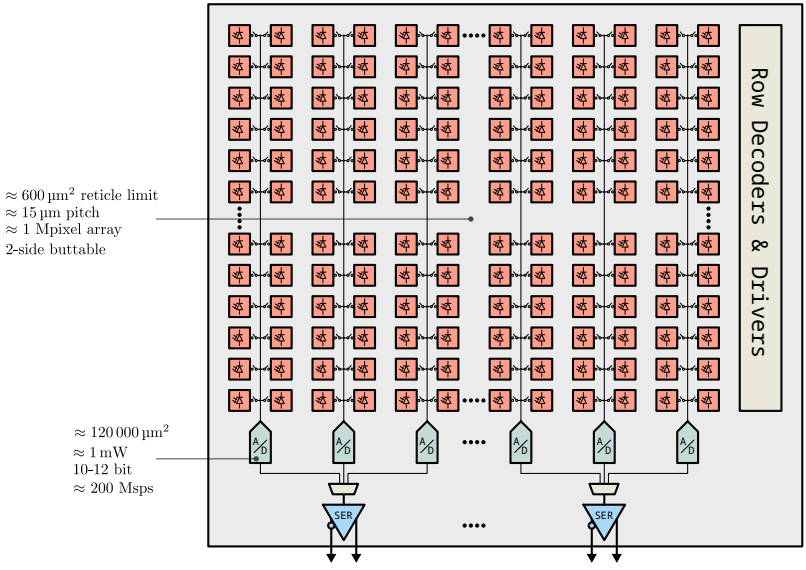

Electron source
Condensor Lens
Objective Lens
Sample
Objective Lens
Projector Lens
Direct electron
detector

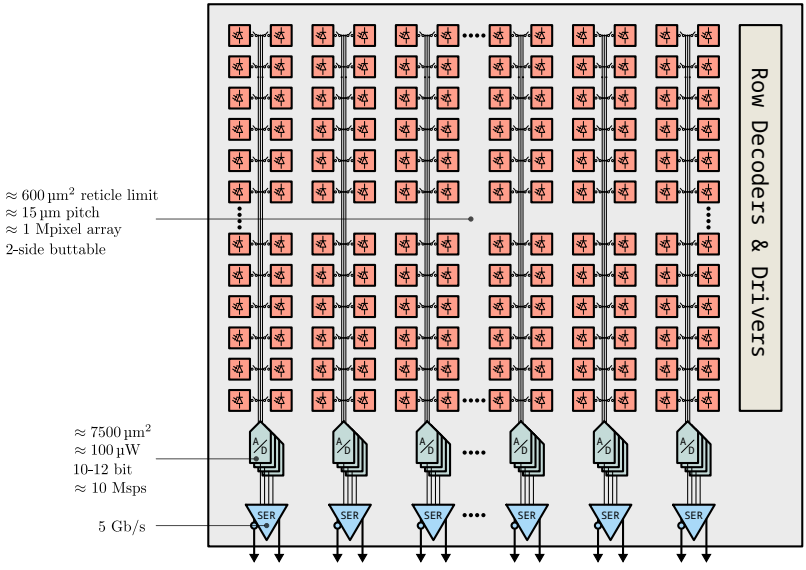

Electron source
300 keV
Condensor Lens
Objective Lens
Sample
cryogenic plunge-frozen
Objective Lens
Projector Lens
$\sigma_{\square} = 0.5\,\text{Å}$
Direct electron detector
$\approx 50\,\text{mm} \times 50\,\text{mm}$ focal area

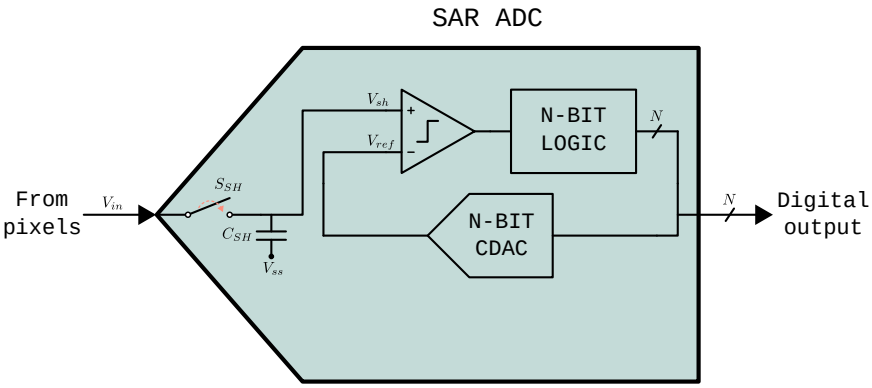

Electron source
300 keV
> 100 kHz stroboscopic
Condensor Lens
Objective Lens
Sample
in-situ / liquid-phase
Objective Lens
Projector Lens
Direct electron detector
hit rate ≈ 10^6/(µm^2 s)
σ□ ≈ 10 µm
σt ≈ 100 kfps
σe− ≈ 10-12 bit

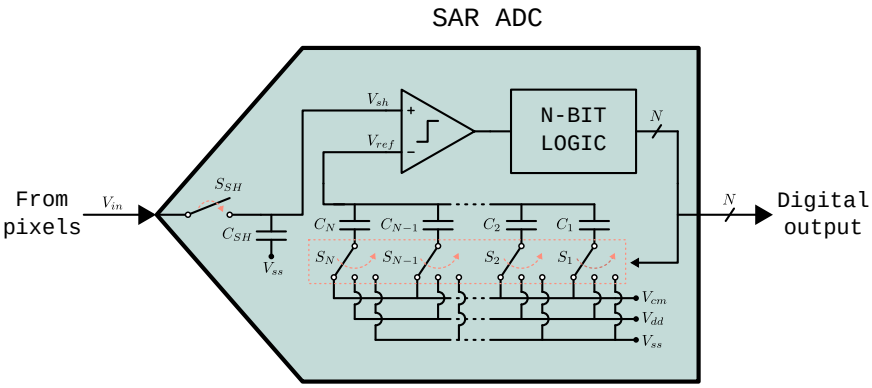
$\approx 600\,\mu m^2$ reticle limit
$\approx 15\,\mu m$ pitch
≈ 1 Mpixel array
2-side buttable


≈ 600 µm² reticle limit
≈ 15 µm pitch
≈ 1 Mpixel array
2-side buttable
≈ 60 mm²
≈ 1 W
10-12 bit
≈ 100 Gsps
1 Tb/s
Row Decoders & Drivers
A/D
SER

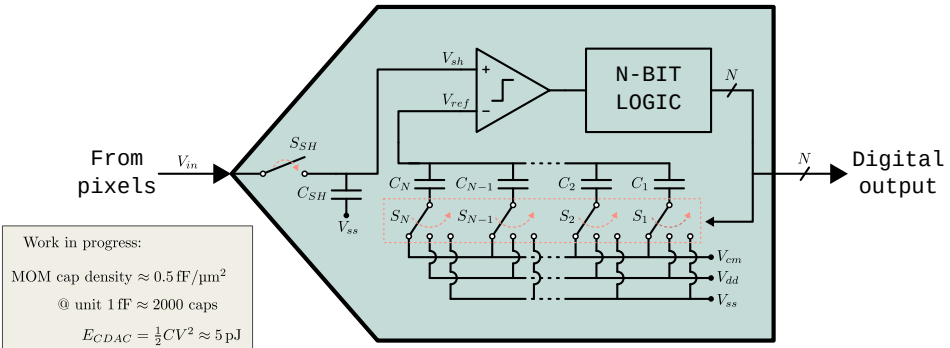

≈ 600 µm² reticle limit
≈ 15 µm pitch
≈ 1 Mpixel array
2-side buttable
≈ 120 000 µm²
≈ 1 mW
10-12 bit
≈ 200 Msps
Row Decoders & Drivers
A/D
SER
SER


≈ 600 µm² reticle limit
≈ 15 µm pitch
≈ 1 Mpixel array
2-side buttable
≈ 7500 µm²
≈ 100 µW
10-12 bit
≈ 10 Msps
5 Gb/s
Row Decoders & Drivers
A/D
SER


SAR ADC
From pixels
V_{in}
S_{SH}
C_{SH}
V_{ss}
V_{sh}
V_{ref}
+
−
N-BIT LOGIC
N-BIT CDAC
N
N
Digital output


SAR ADC
From pixels
V_{in}
S_{SH}
C_{SH}
V_{ss}
V_{sh}
V_{ref}
+
−
N-BIT LOGIC
N
N
Digital output
C_N
C_{N-1}
C_2
C_1
S_N
S_{N-1}
S_2
S_1
V_{cm}
V_{dd}
V_{ss}

SAR ADC



Work in progress:

MOM cap density $\approx 0.5\,\mathrm{fF}/\mu\mathrm{m}^2$

@ unit $1\,\mathrm{fF} \approx 2000$ caps

$E_{CDAC} = \frac{1}{2}CV^2 \approx 5\,\mathrm{pJ}$

Non binary-weighting