

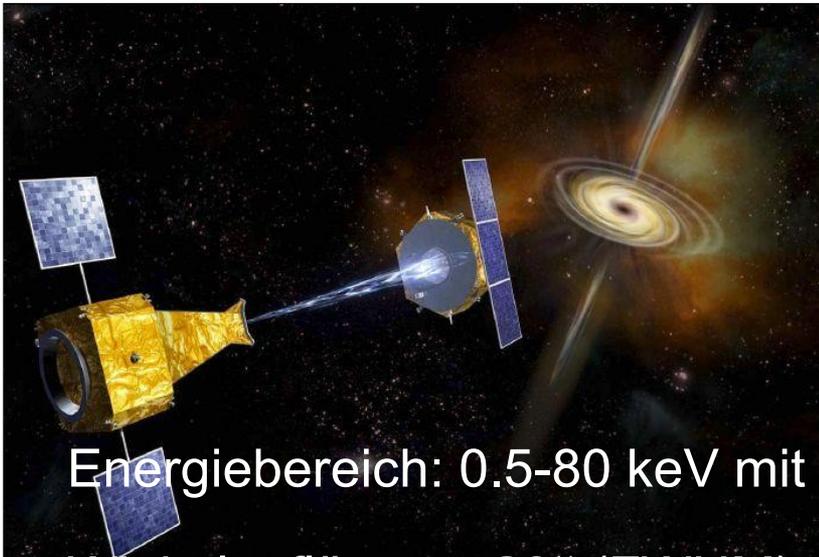
# Nachweis von Strahlung und Teilchen mittels DEPFET- Detektoren

Schule für Astroteilchenphysik 2009

# Inhalt:

- 1) Die Symbol-X Mission
- 2) Der CCD-Sensor
- 3) Niederenergieedetektor: ein DEPFET-Detektor für Makropixel
- 4) Elektronik um den DEPFET
- 5) Hochenergie-Detektor: CdTe-Detektor

# Die Symbol-X Mission



Franz. – Ital. Mission

Start: 2014

Erstmaliger **Formationsflug**

Energiebereich: 0.5-80 keV mit **fokussierender Optik**

Winkelauflösung: 20" (FWHM)

Gesichtsfeld: 12' @ 30 keV

Energieauflösung: 120 eV @ 6 keV

**Zeitaufklärung: 128  $\mu$ s**

?

Akkretionsphysik

Teilchenbeschleunigung

# Charakteristika von CCD's:

- Framezeit = Integrationszeit + Auslesezeit

Bsp. EPIC:  $t = 68.7 \text{ ms} + 4.6 \text{ ms}$

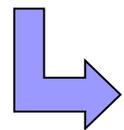
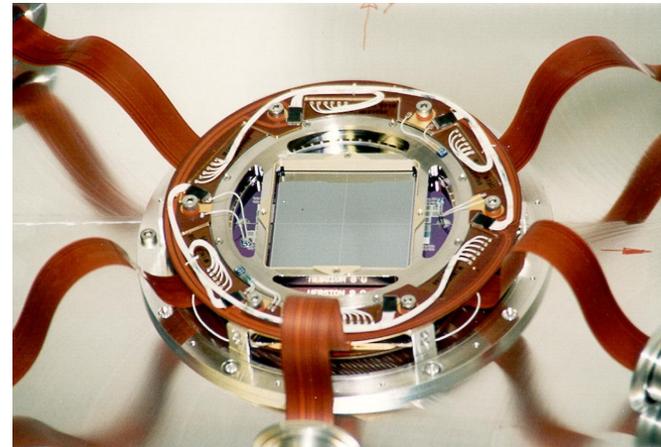
- Out-of-time Events

- Diverse Varianten:

- Frame Store CCDs

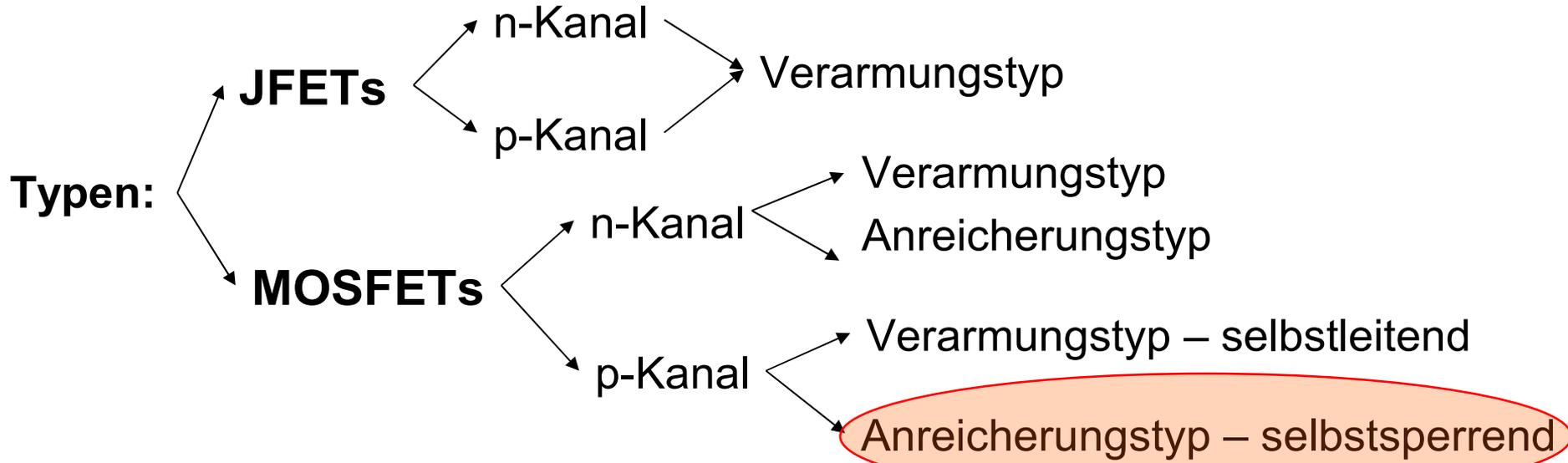
- Interline CCDs

- Window Modus:

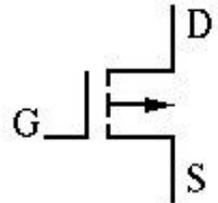
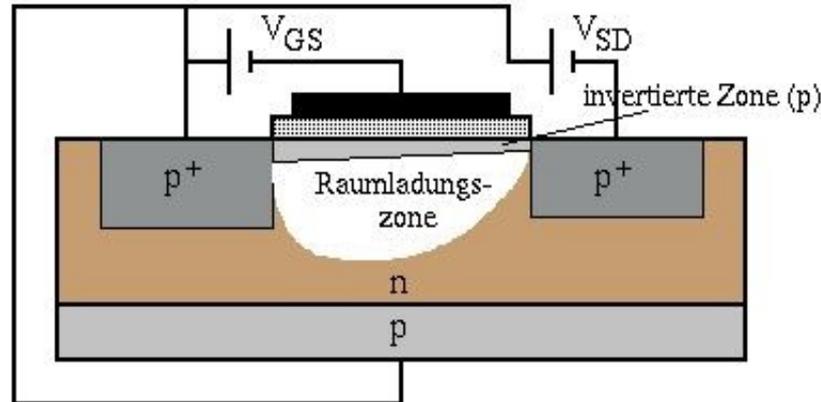
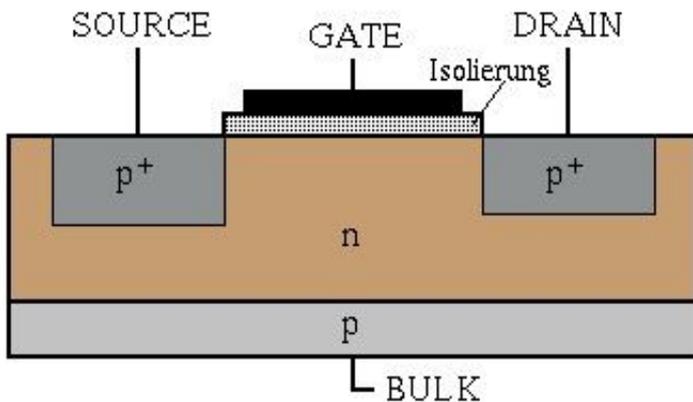


Auf Kosten von: Gesichtsfeld, räumliche Auflösung, eff. Beobachtungszeit

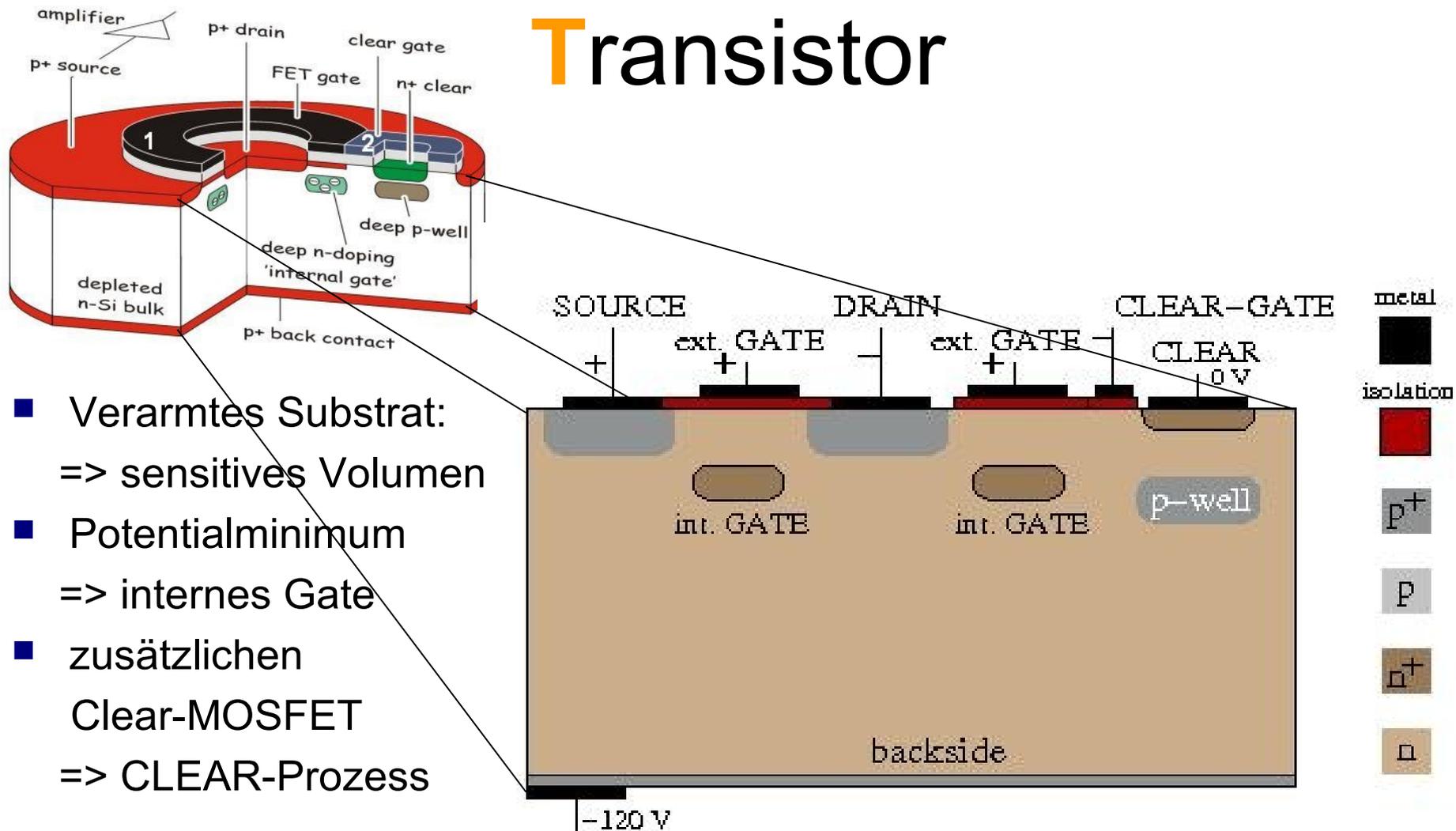
# Feldeffekttransistor: MOSFET



## Funktionsweise:



# Depleted P-canal Field Effect Transistor



- Verarmtes Substrat:  
=> sensitives Volumen
- Potentialminimum  
=> internes Gate
- zusätzlichen  
Clear-MOSFET  
=> CLEAR-Prozess

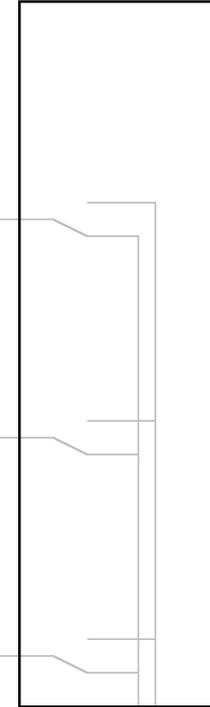
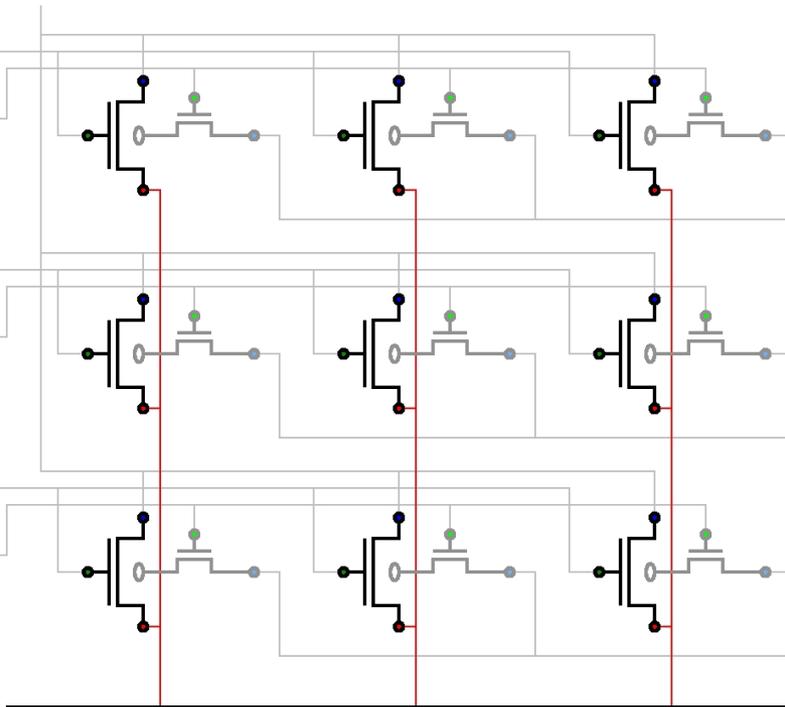
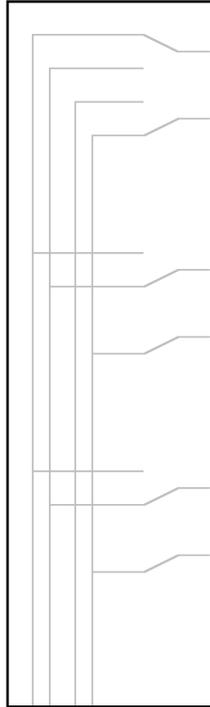




SWITCHER  
CHIP 1

common  
DRAIN

SWITCHER  
CHIP 2



SOURCE

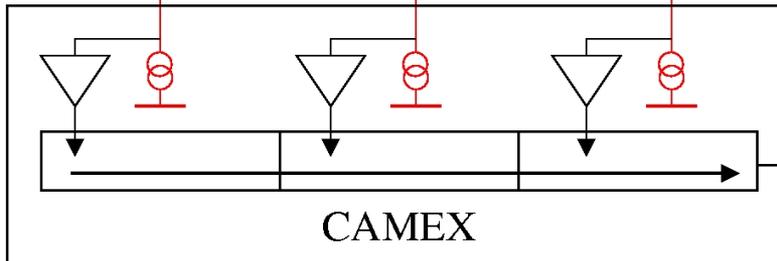
DRAIN

GATE

CLEAR-  
GATE

CLEAR

- CG off
- CG on
- GATE off
- GATE on

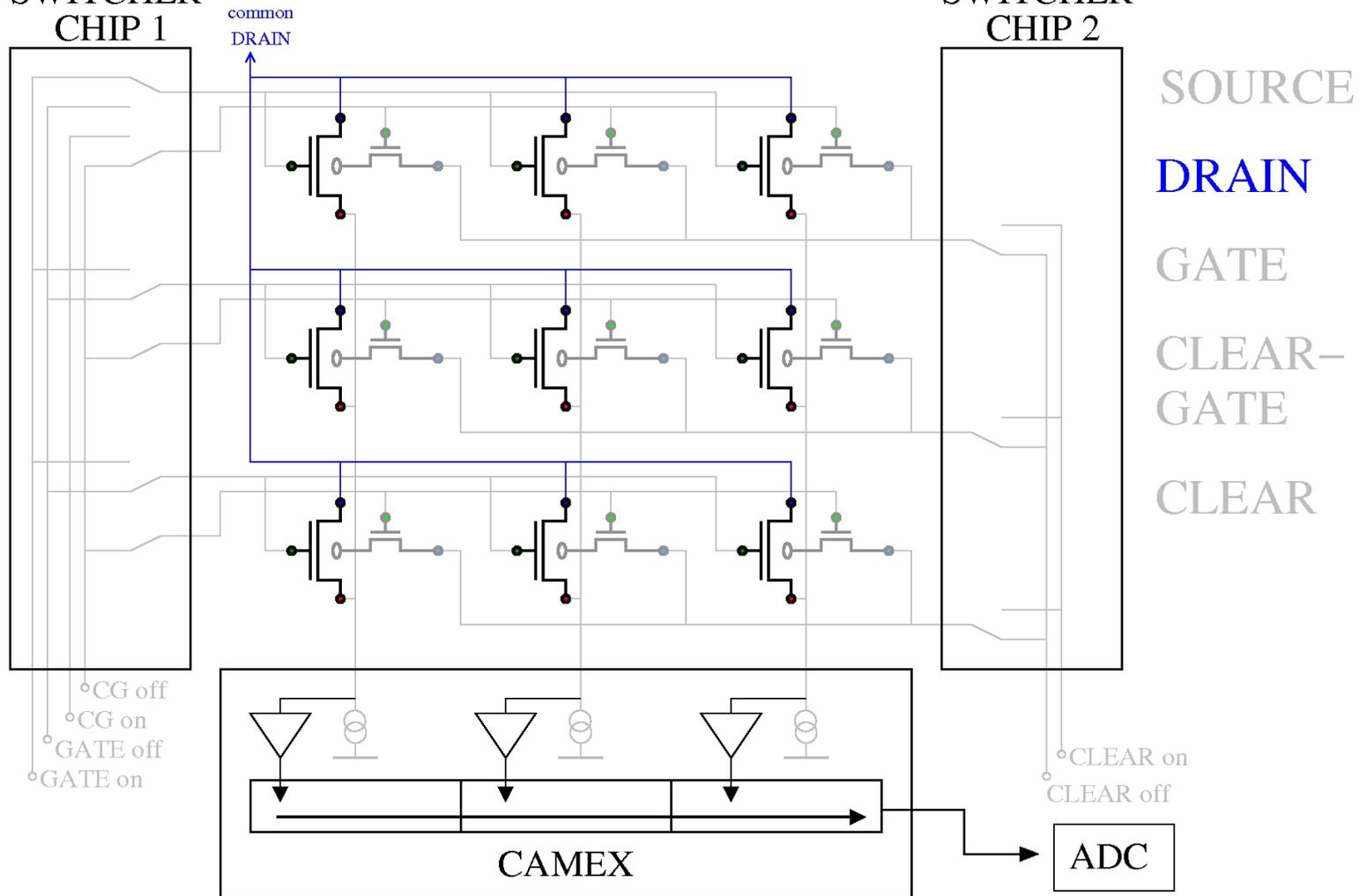


- CLEAR on
- CLEAR off



SWITCHER  
CHIP 1

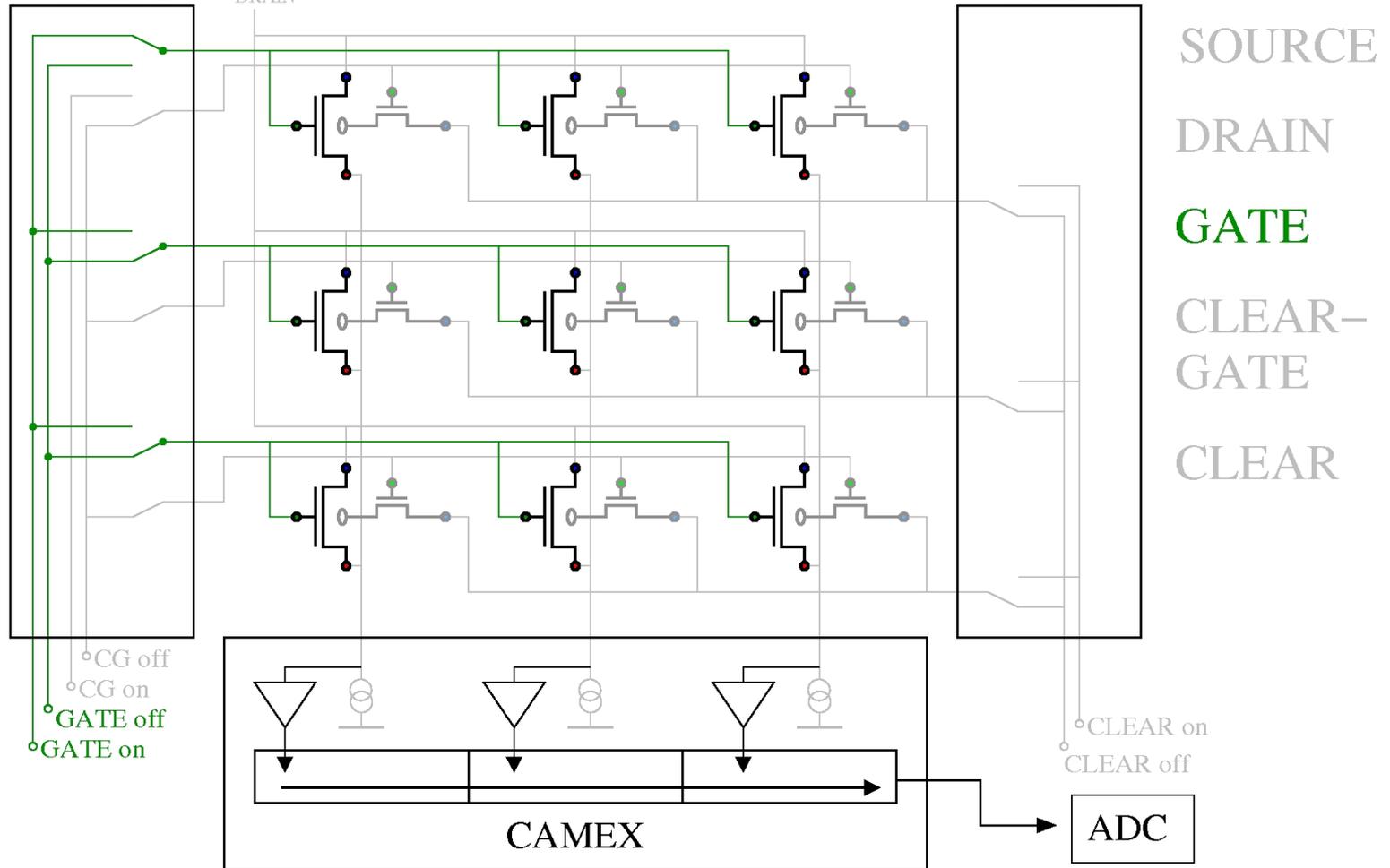
SWITCHER  
CHIP 2



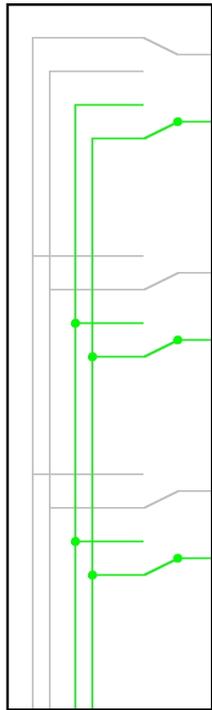
SWITCHER  
CHIP 1

common  
DRAIN

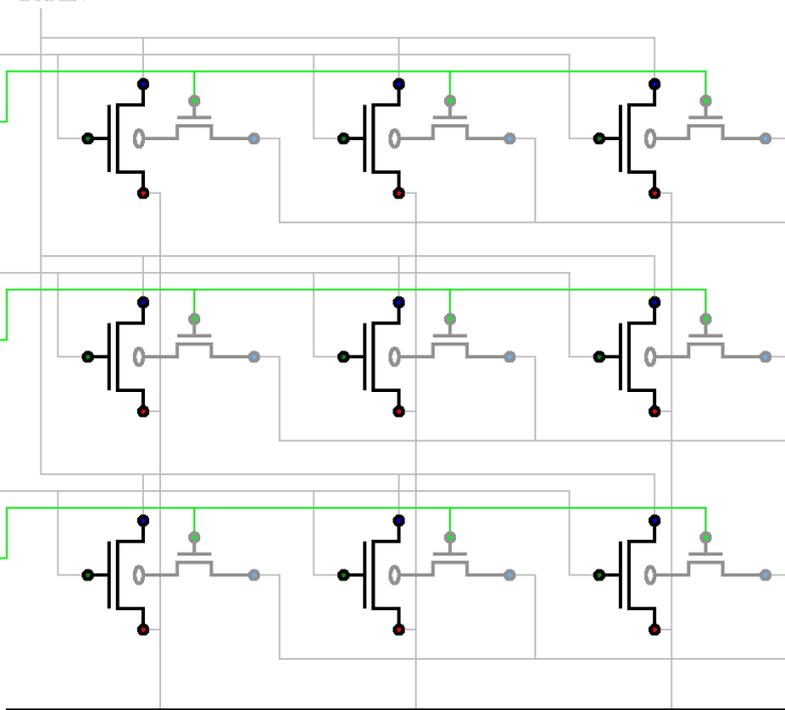
SWITCHER  
CHIP 2



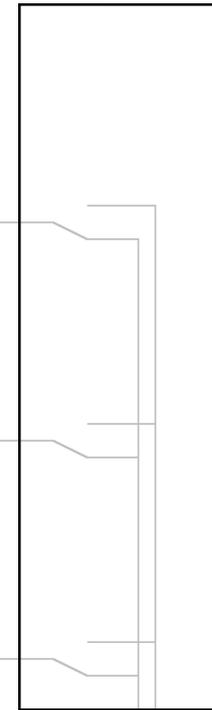
SWITCHER  
CHIP 1



common  
DRAIN

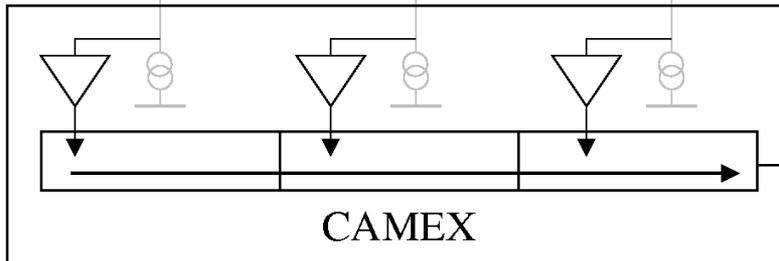


SWITCHER  
CHIP 2



SOURCE  
DRAIN  
GATE  
CLEAR-GATE  
CLEAR

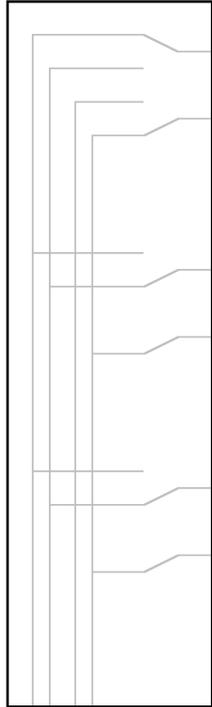
CG off  
CG on  
GATE off  
GATE on



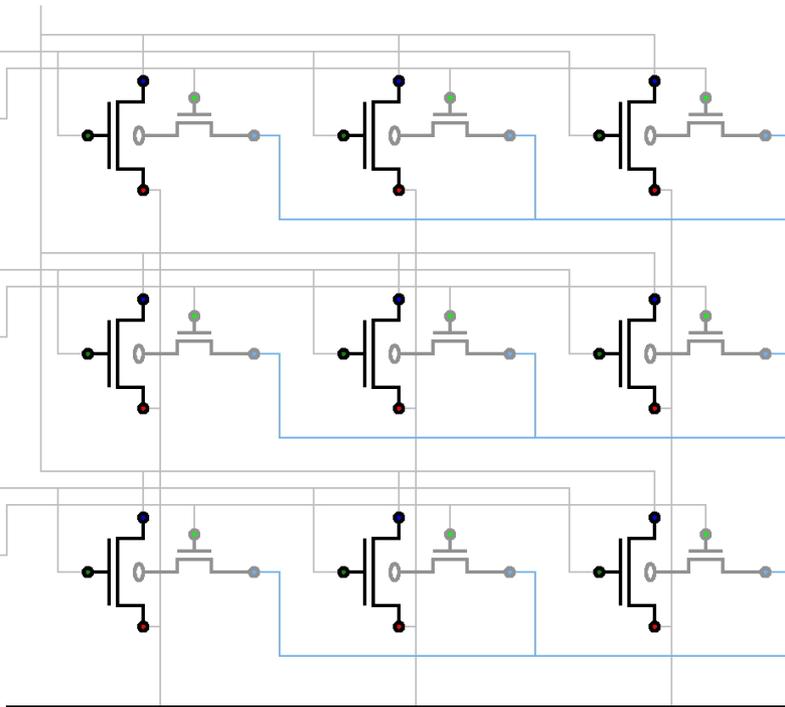
CLEAR on  
CLEAR off

ADC

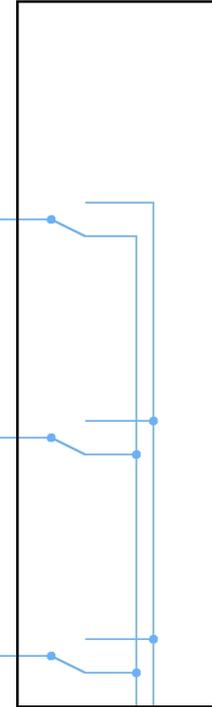
SWITCHER  
CHIP 1



common  
DRAIN

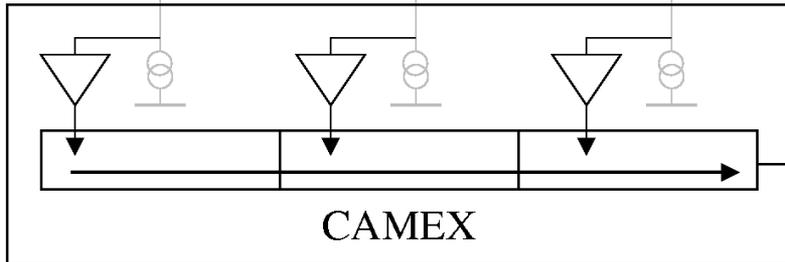


SWITCHER  
CHIP 2



SOURCE  
DRAIN  
GATE  
CLEAR-  
GATE  
CLEAR

CG off  
CG on  
GATE off  
GATE on



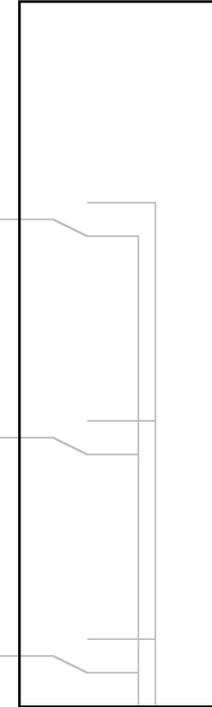
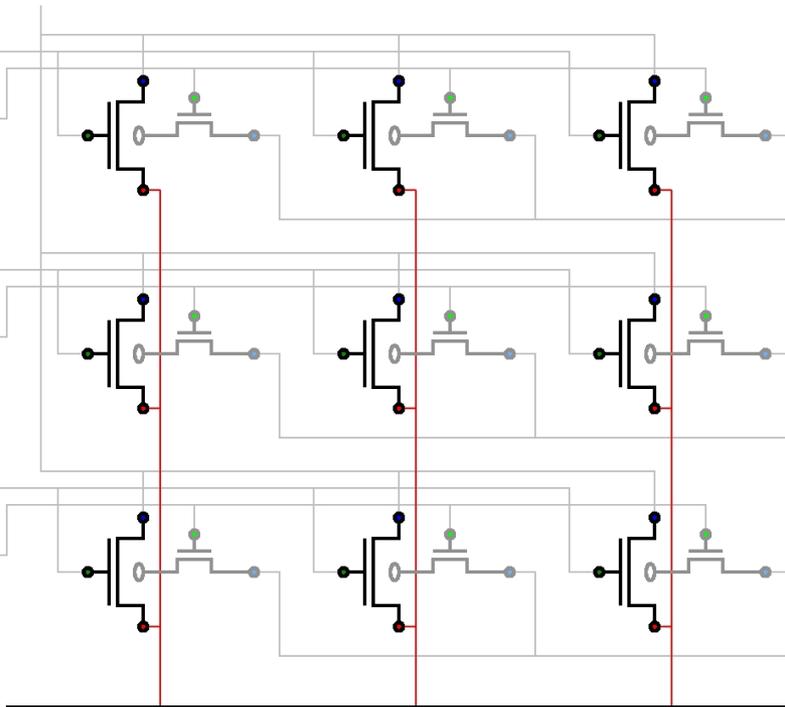
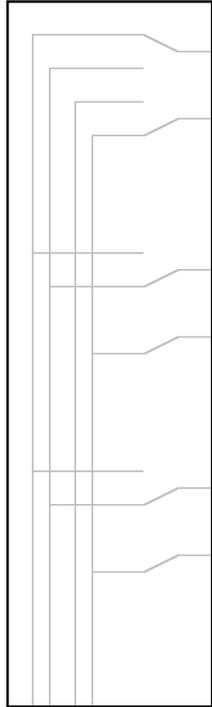
CLEAR on  
CLEAR off

ADC

SWITCHER  
CHIP 1

common  
DRAIN

SWITCHER  
CHIP 2



CG off  
CG on  
GATE off  
GATE on

SOURCE

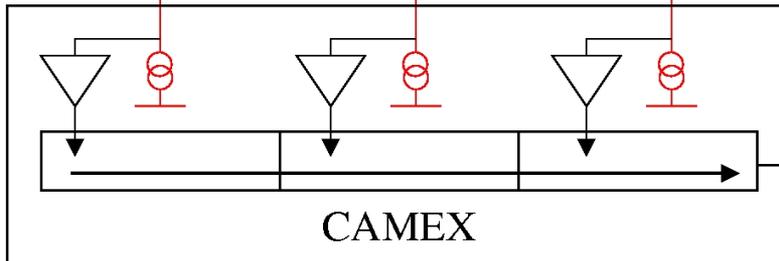
DRAIN

GATE

CLEAR-  
GATE

CLEAR

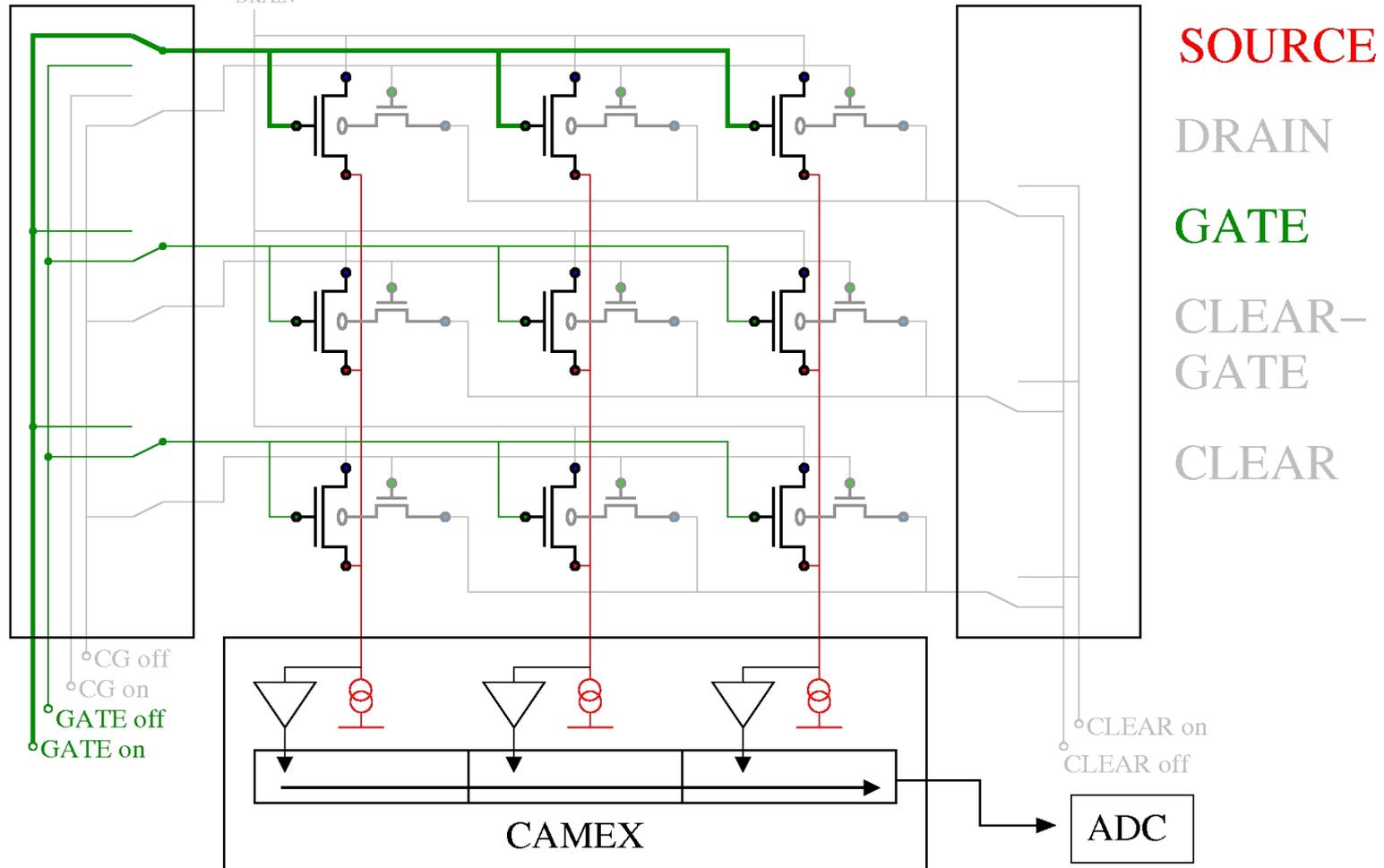
CLEAR on  
CLEAR off



SWITCHER  
CHIP 1

common  
DRAIN

SWITCHER  
CHIP 2



SOURCE

DRAIN

GATE

CLEAR-GATE

CLEAR

CG off  
CG on  
GATE off  
GATE on

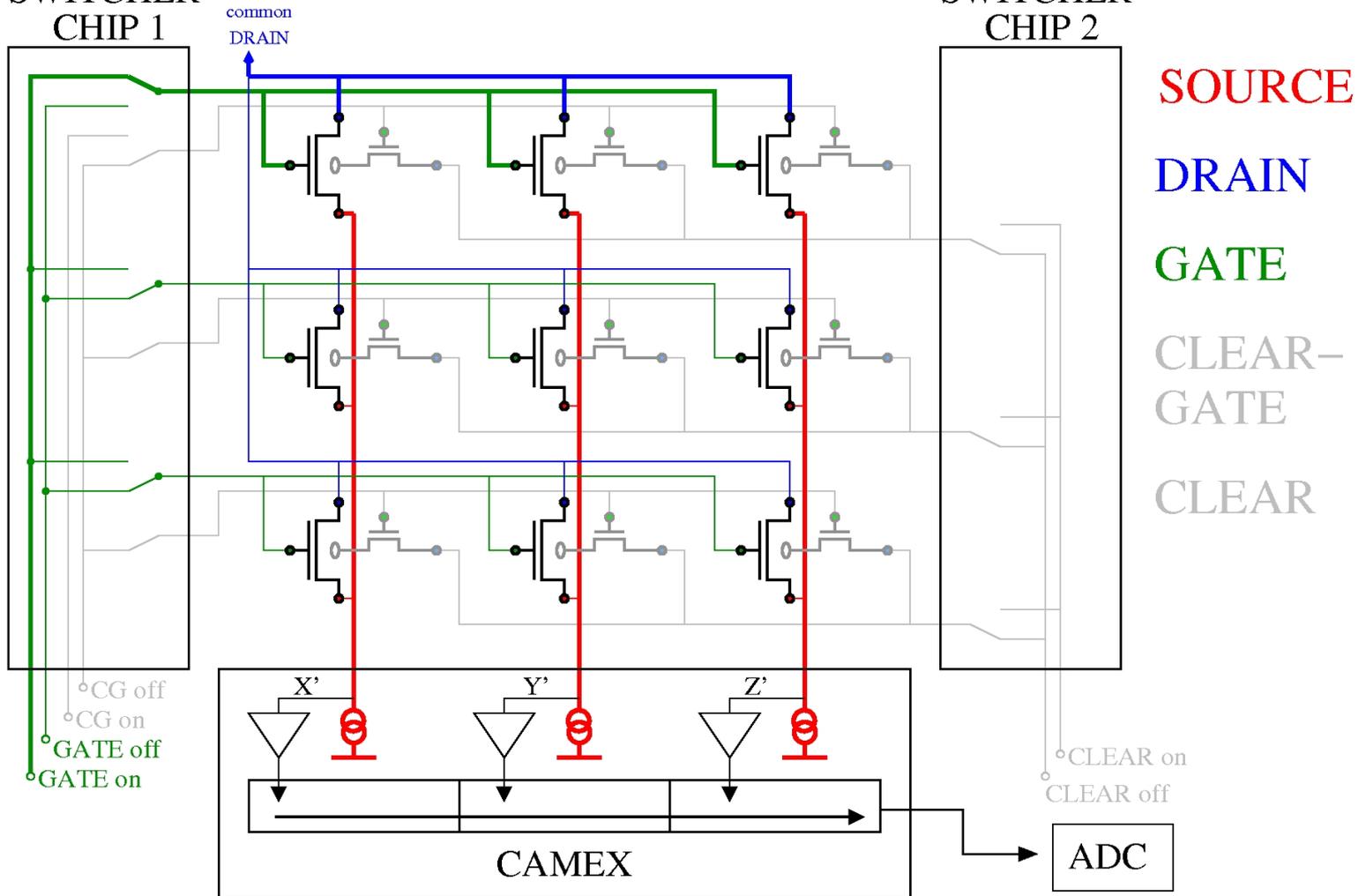
CLEAR on  
CLEAR off

CAMEX

ADC

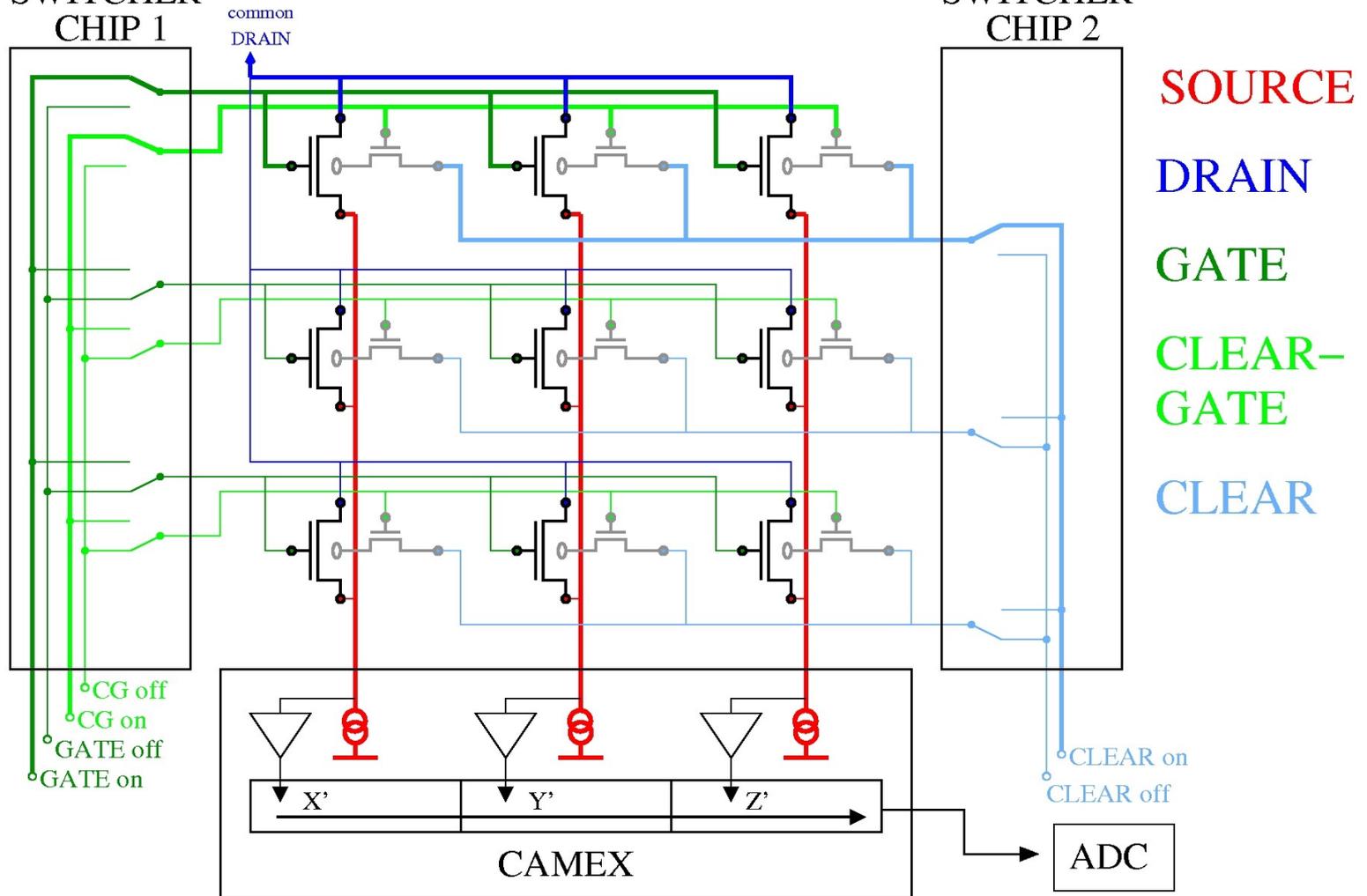
SWITCHER  
CHIP 1

SWITCHER  
CHIP 2



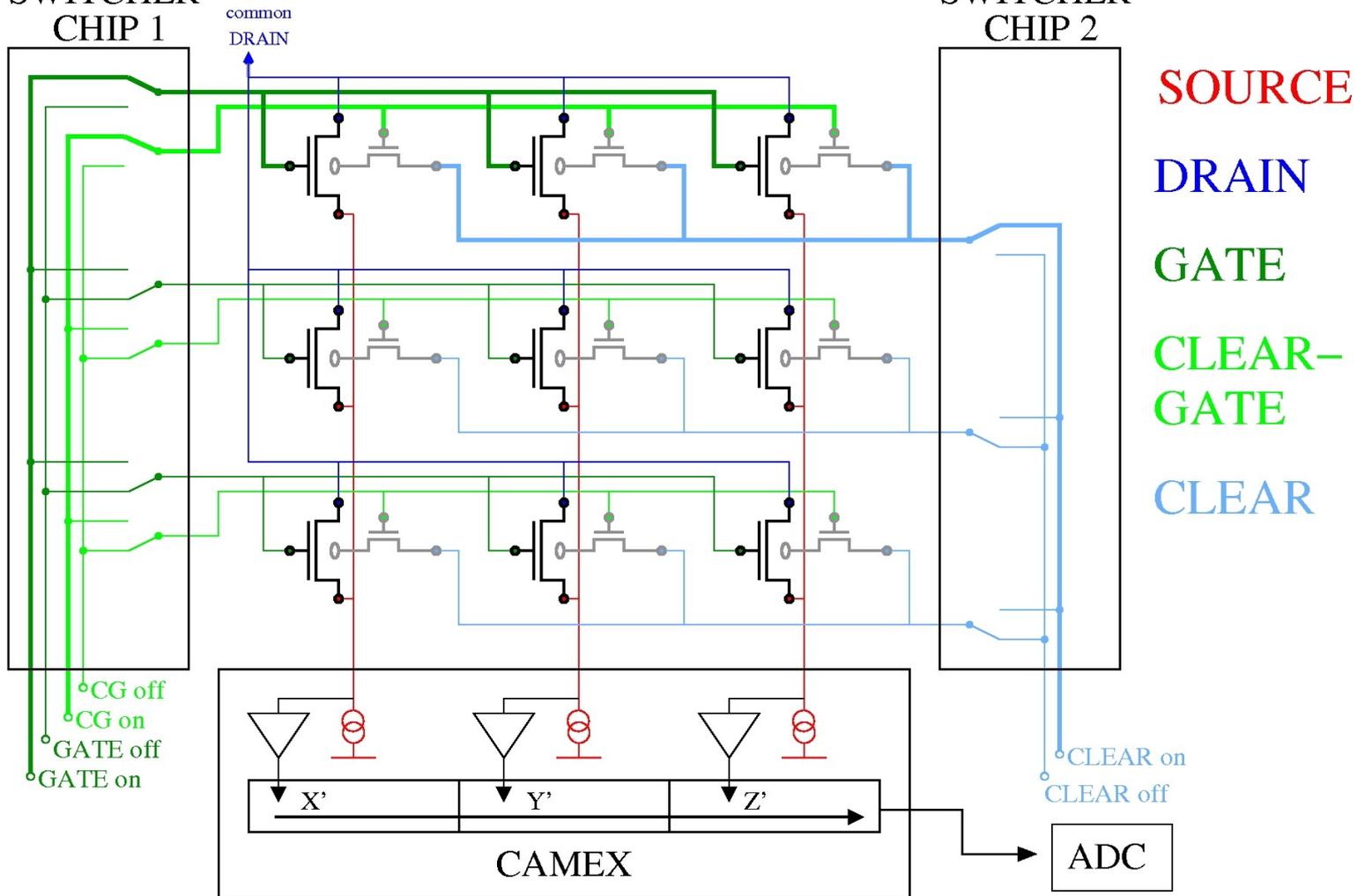
SWITCHER  
CHIP 1

SWITCHER  
CHIP 2



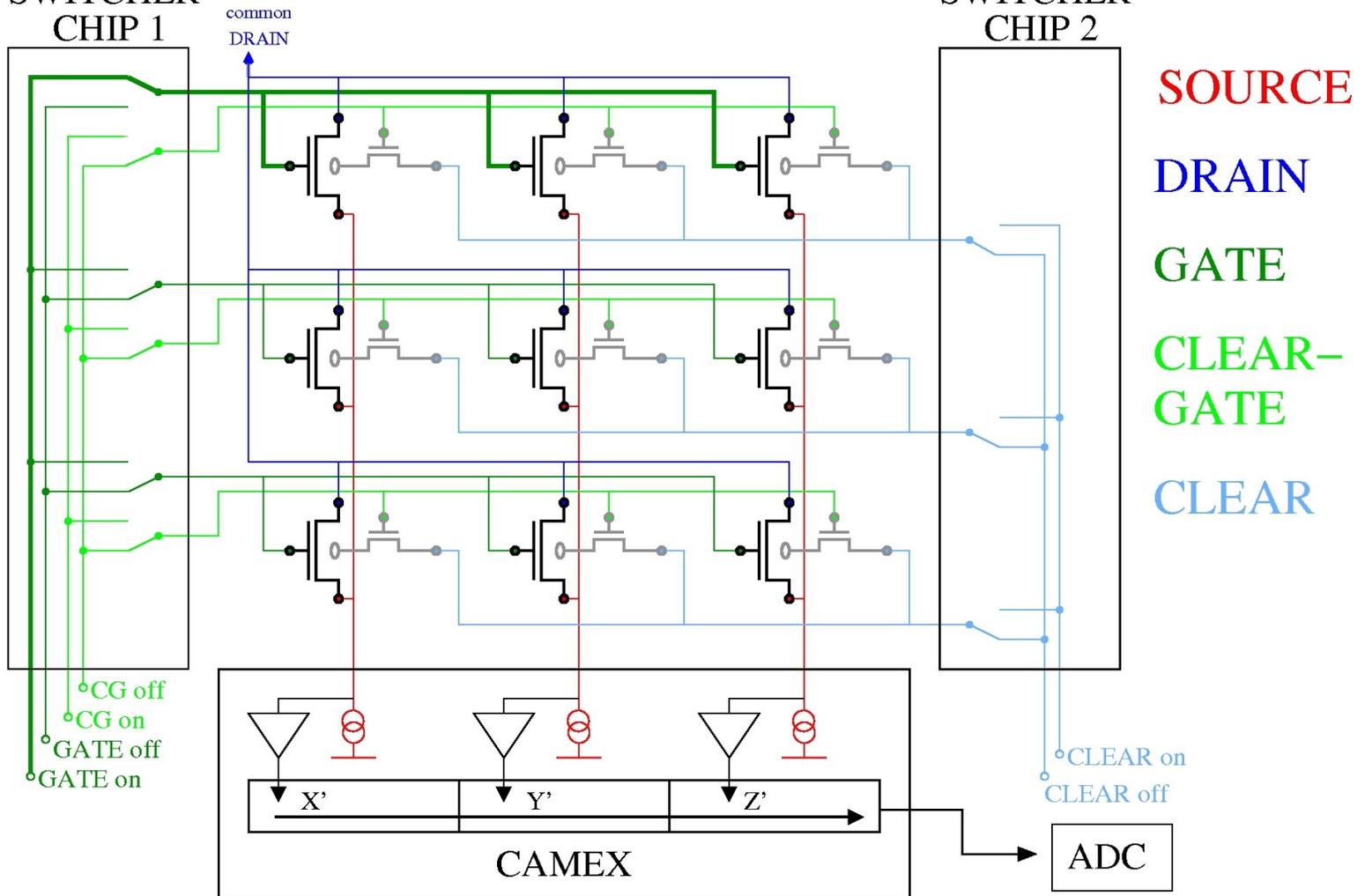
SWITCHER  
CHIP 1

SWITCHER  
CHIP 2



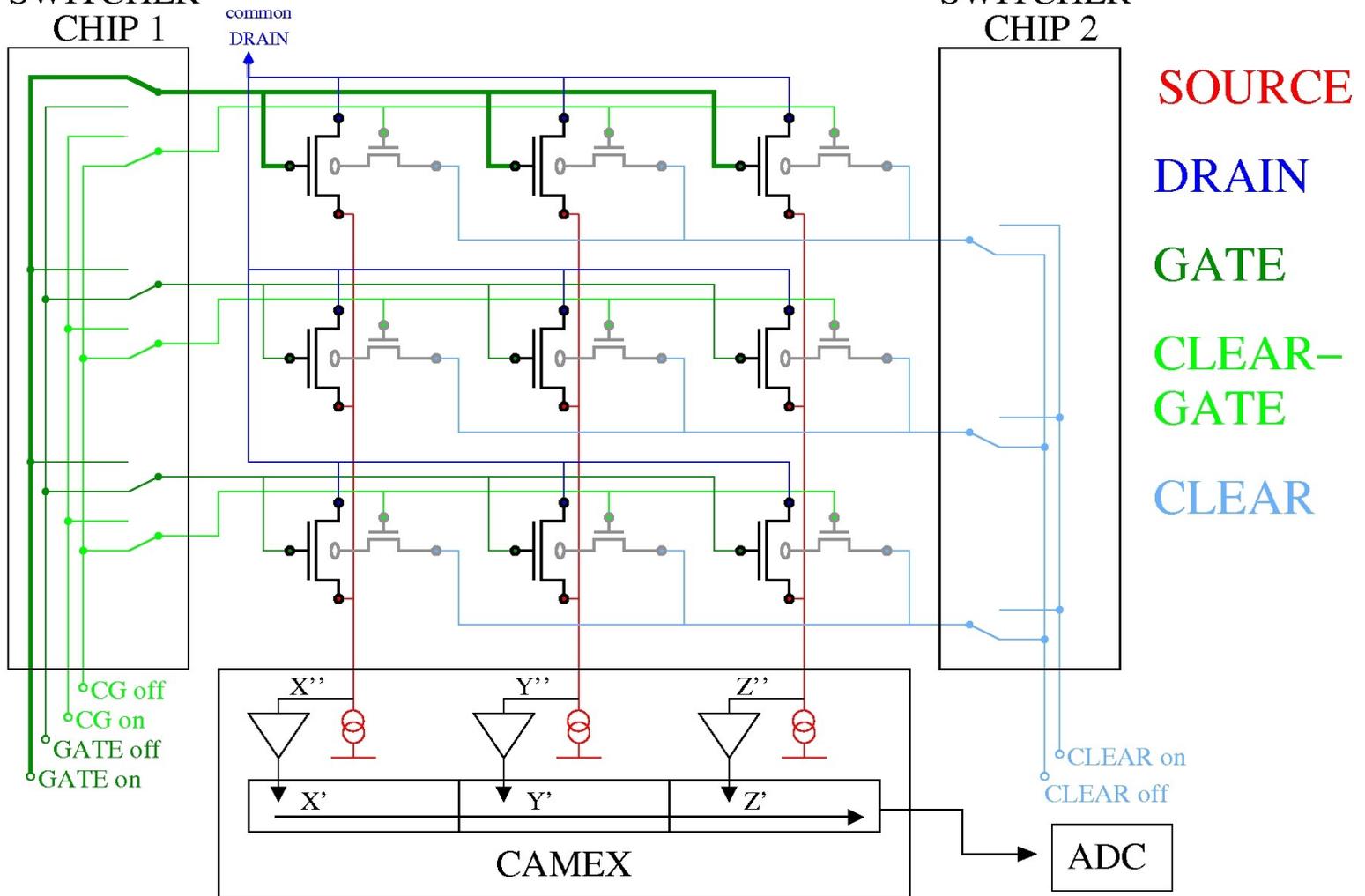
SWITCHER  
CHIP 1

SWITCHER  
CHIP 2



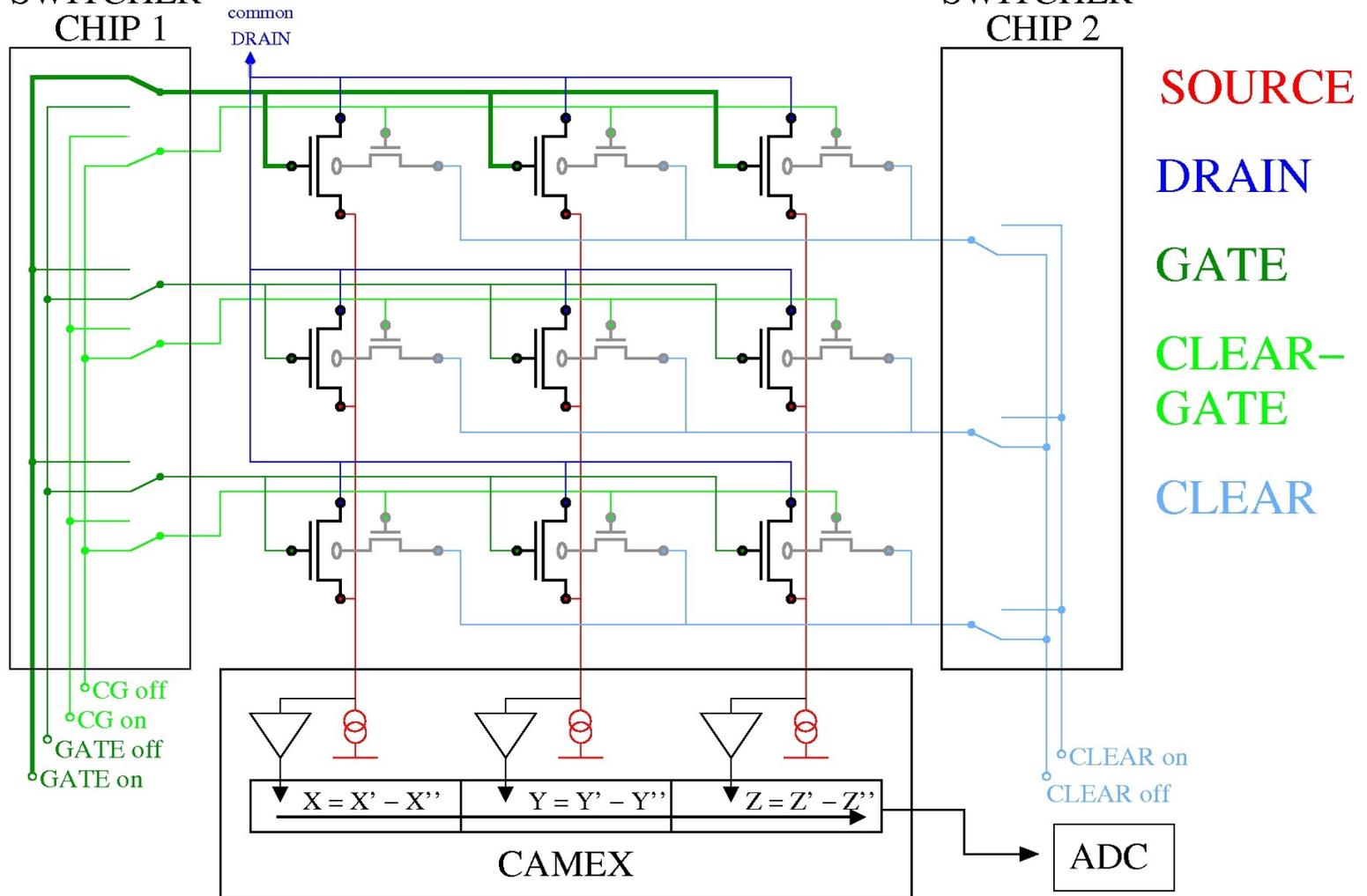
SWITCHER  
CHIP 1

SWITCHER  
CHIP 2



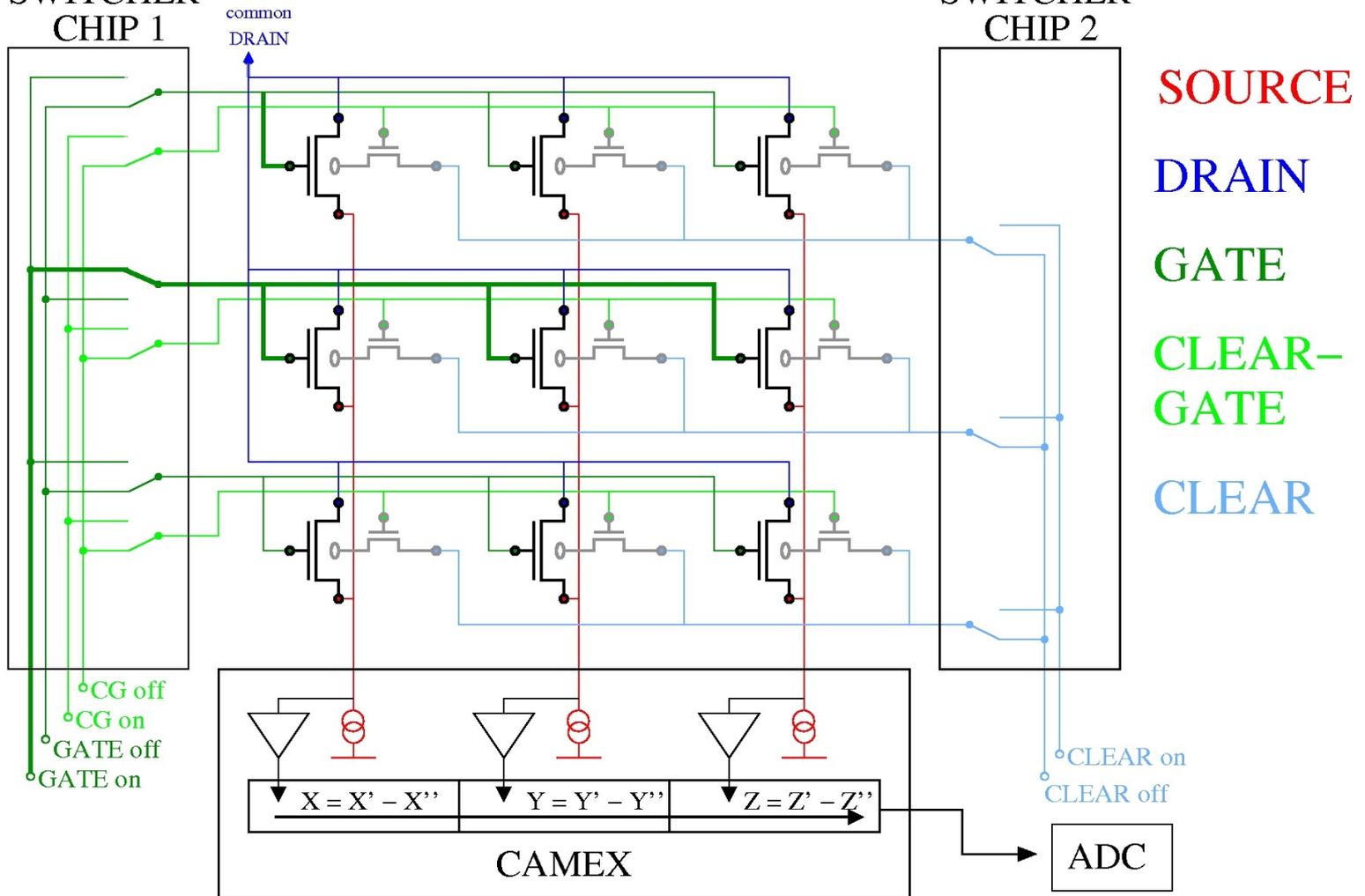
SWITCHER  
CHIP 1

SWITCHER  
CHIP 2



SWITCHER  
CHIP 1

SWITCHER  
CHIP 2



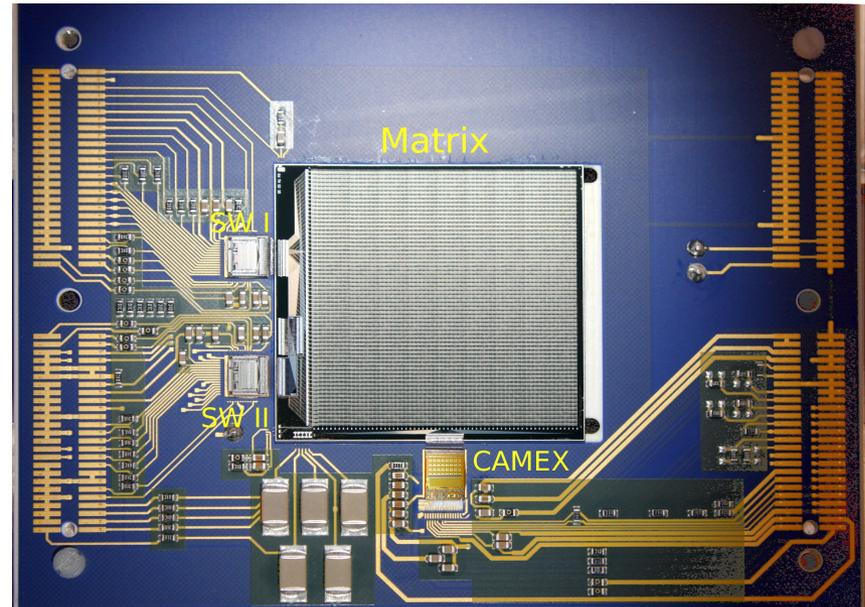


und so weiter...

mit 8000 Bildern pro Sekunde !

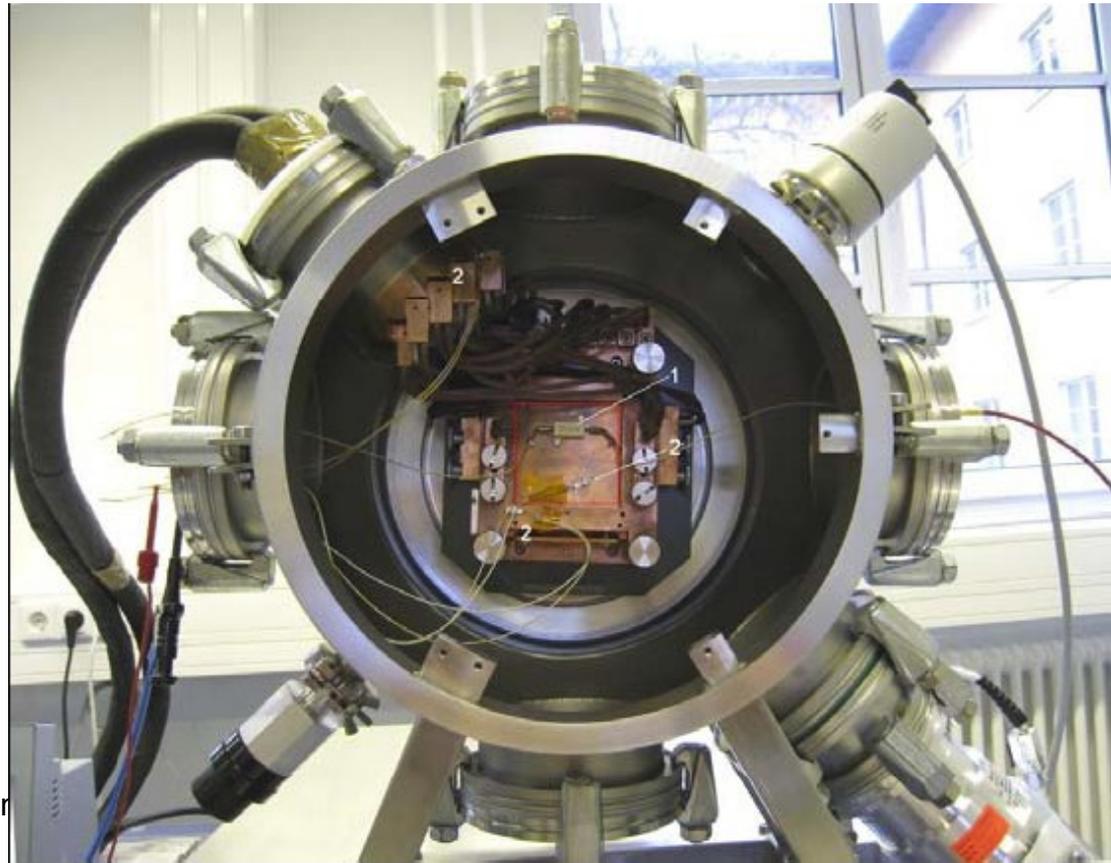
# Elektronik um den DEPFET

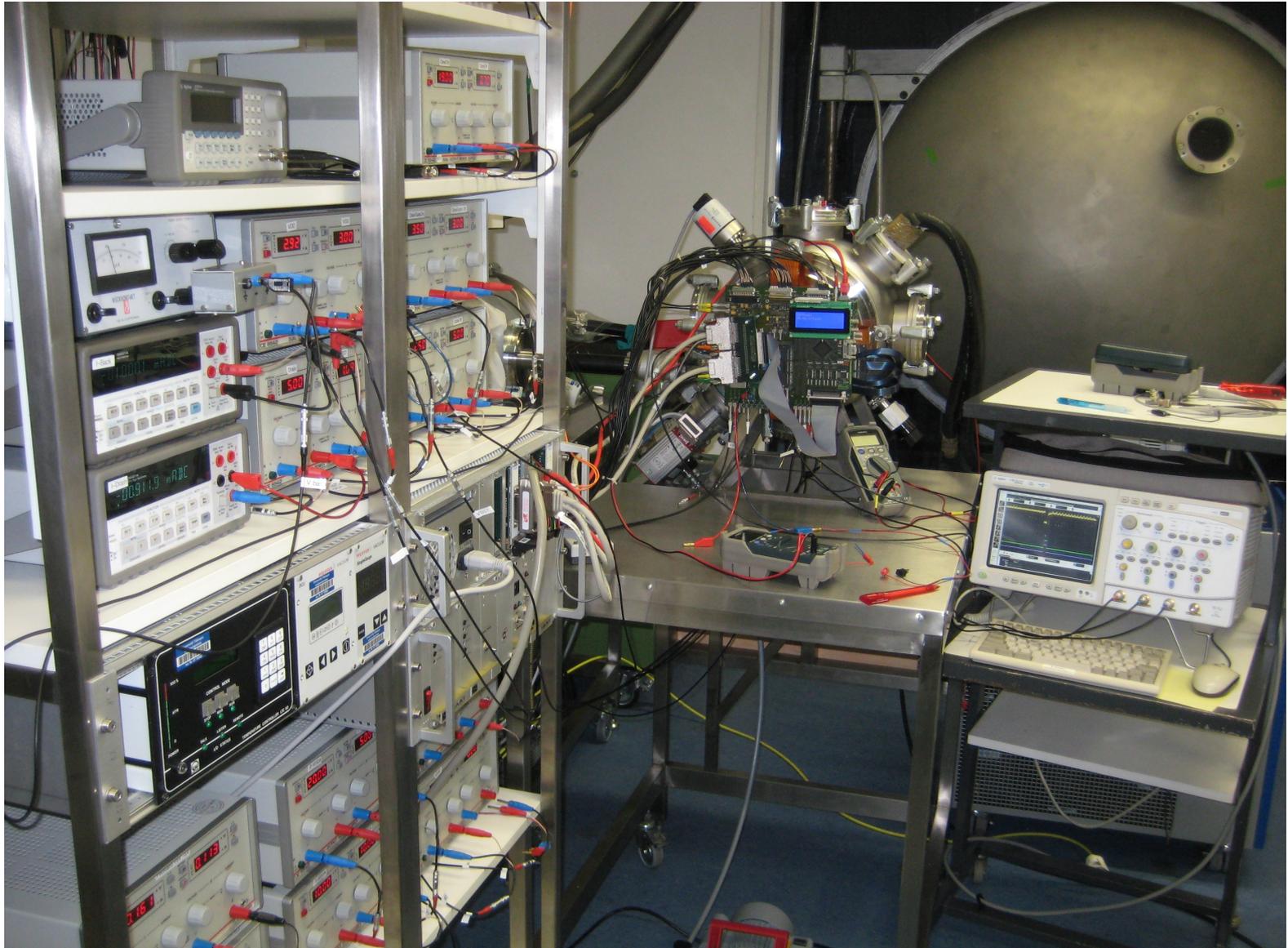
- Hybrid:
  - Matrix
  - SWITCHER
  - CAMEX
- Analog-digital-converter ADC
- Event Pre-Processor EPP
- Interface Controller IC
- Sequencer SEQ



# Anordnung des Teststands

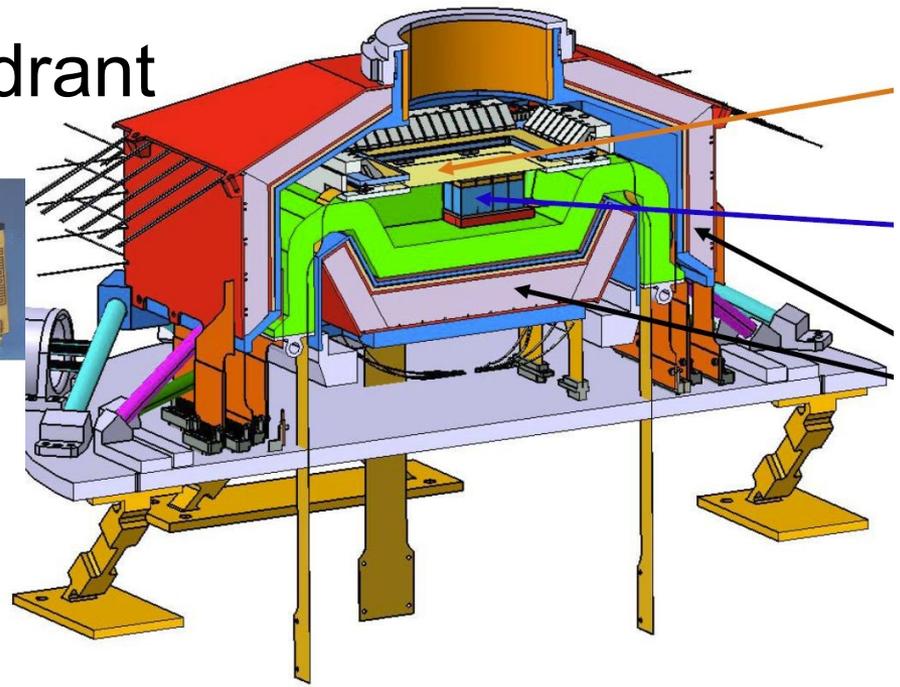
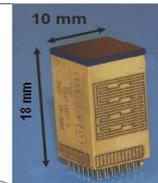
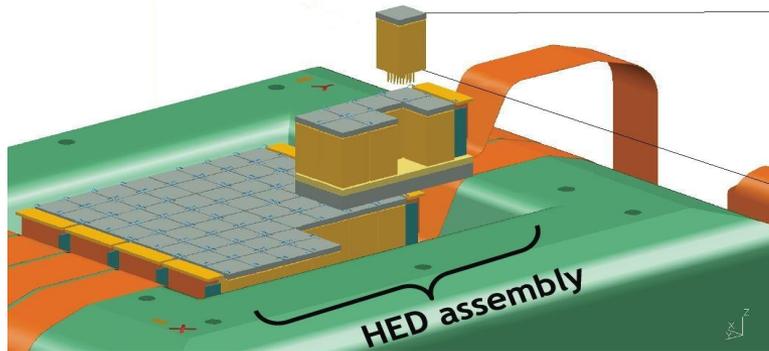
- radioaktive Quellen:
  - Fe-55:  $K_{\alpha}$  (5.9 keV)
  - Am-241: (13.9 keV)
- Betriebstemperatur:  
 $T = -45^{\circ}\text{C}$
- Vakuumkessel:  
 $P = 10^{-7}$  mbar

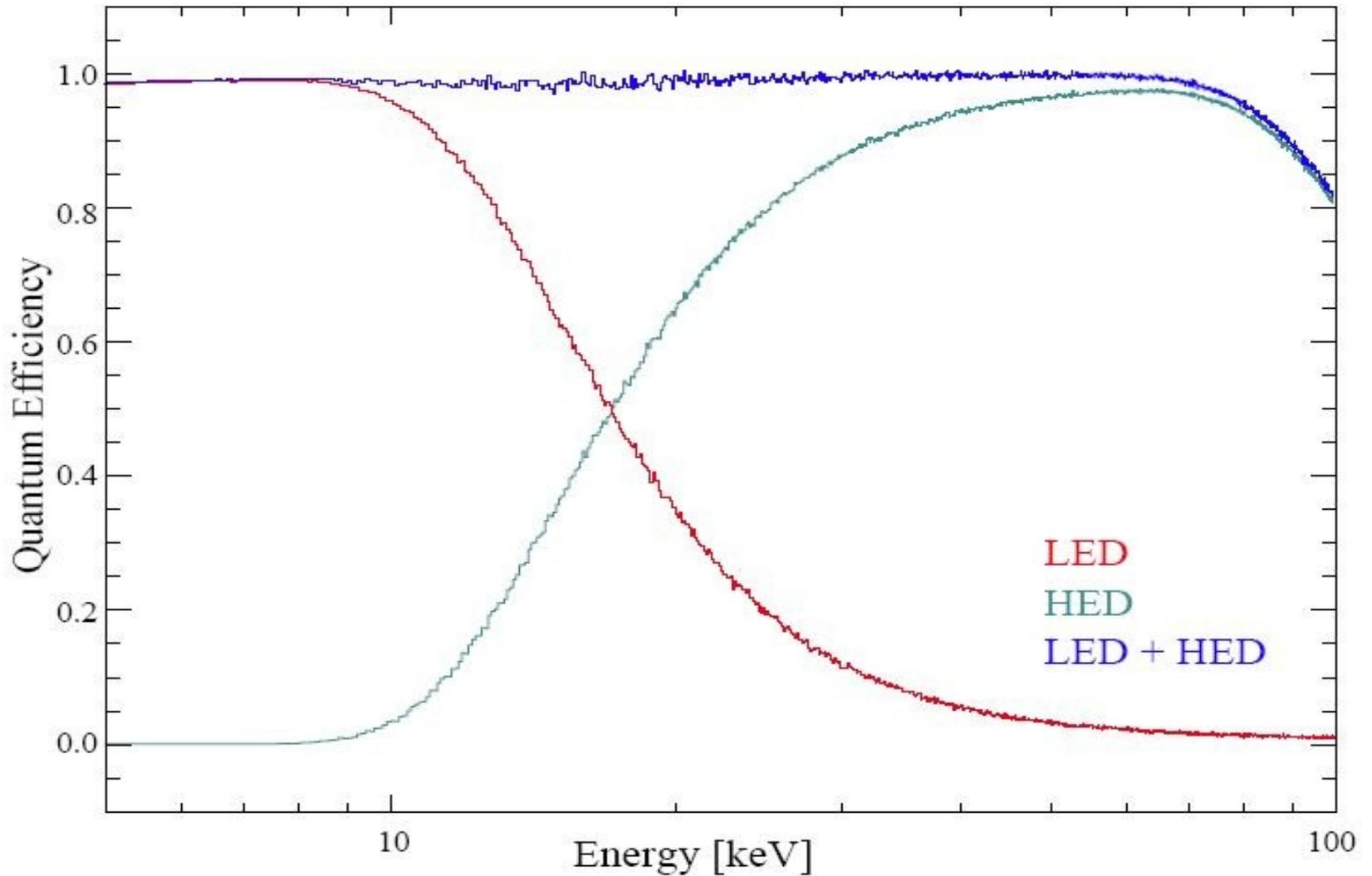




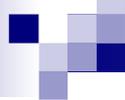
# Hochenergiedetektor:

- 1 or 2 mm dicker CdTe
- Detektor -> Effizienz: 97% @ 80 keV
- Energieauflösung 1.2 keV FWHM @ 60 keV
- Zeitauflösung: 50  $\mu$ s
- Wärmeabgabe: 4W/Quadrant





Quanteneffizienz von LED und HED (Simulation Chris Tenzer AIT)



Zusammenfassung:

2) Simbol-X Mission im Formationsflug

3) DEPFET-Sensor: die neue Technologie

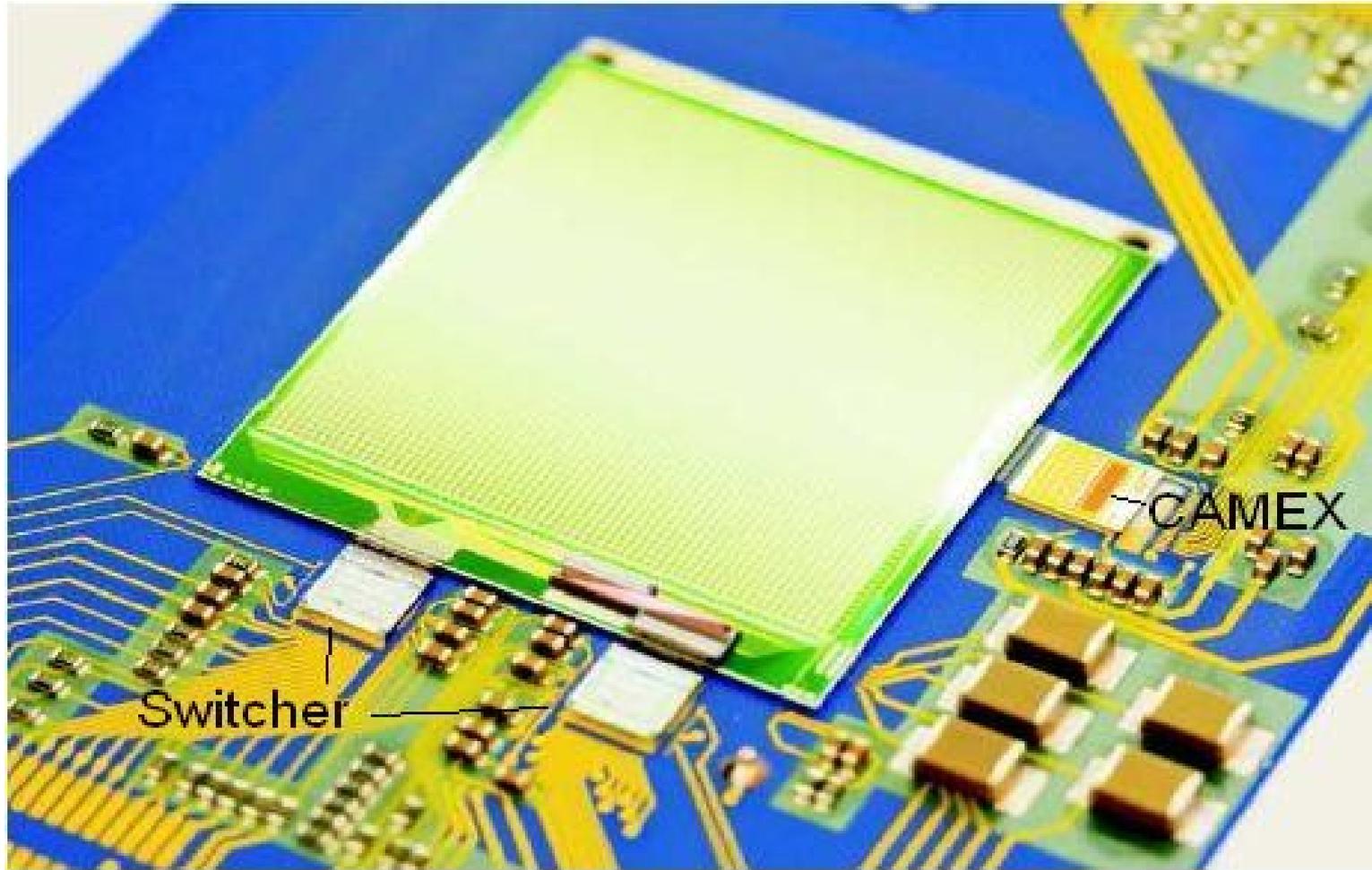
4) Notwendige Elektronik für den Betrieb eines Detektors

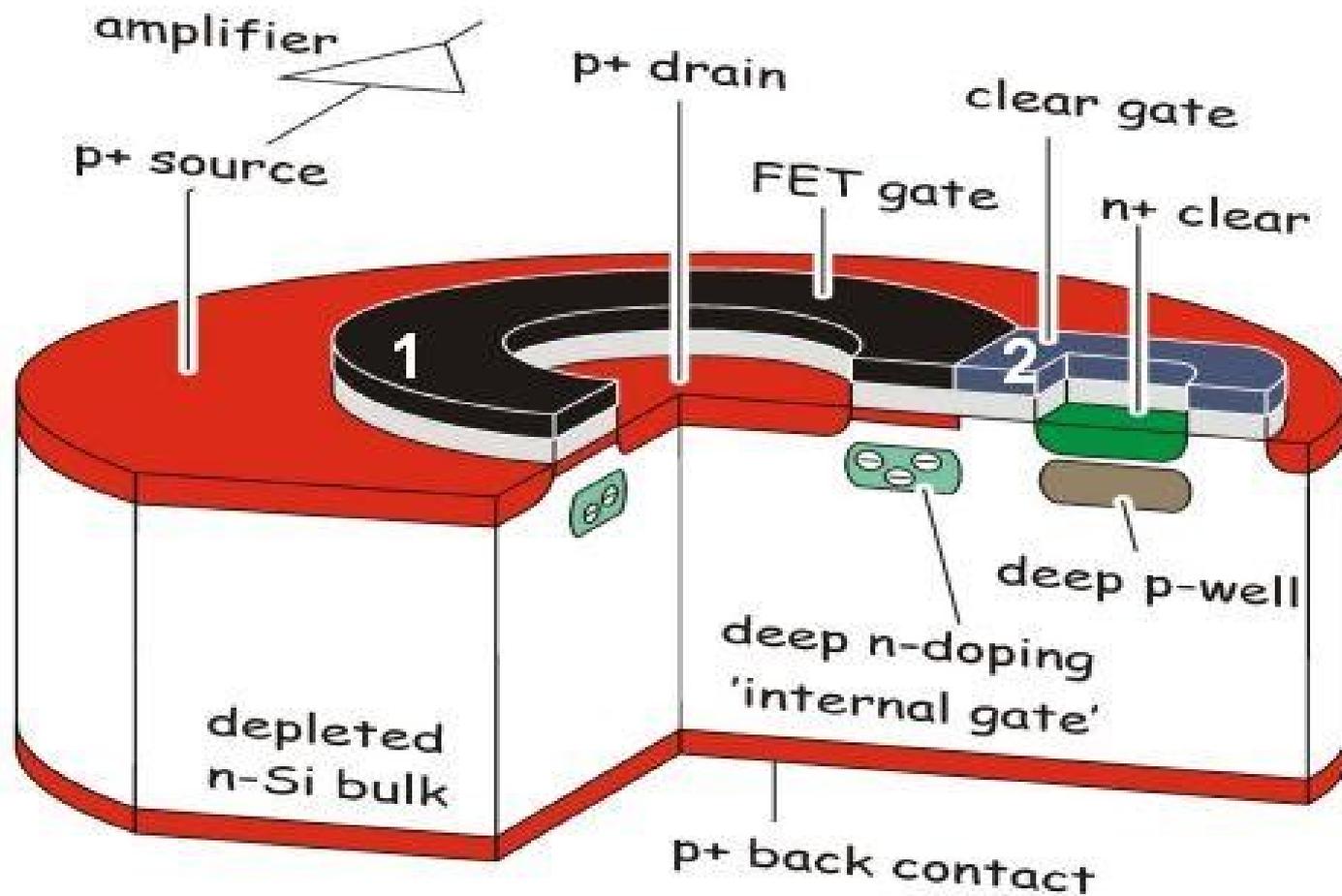
5) Sandwich-Konzept aus zwei Detektoren

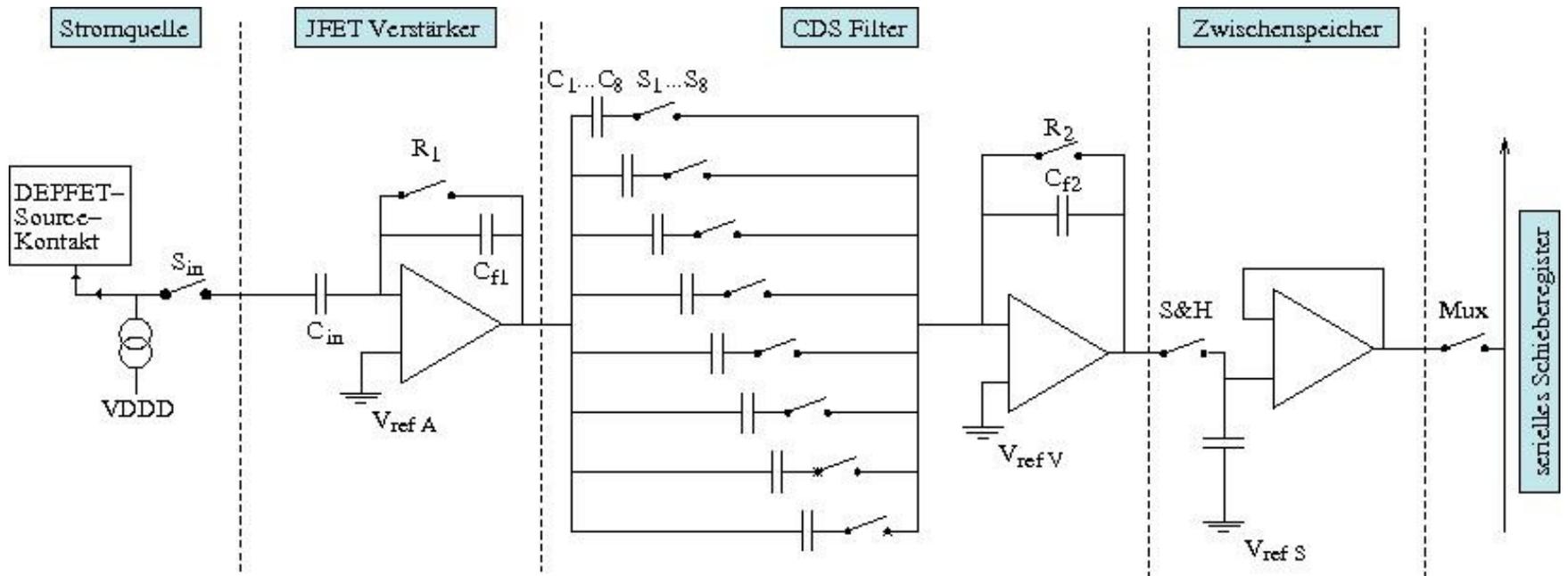
# Fine

	Simbol-X <sup>1</sup>	XMM-Newton <sup>2</sup>
Energiebereich	0.5-80 keV	0.1-15 keV
Energieauflösung (FWHM) @ 6 keV	120 eV	161 eV
Energieauflösung @ 60 keV	< 3%	—
Empfindlichkeit (1 Ms, 3 $\sigma$ )	1.4 $\mu$ Crab @30 keV	ca. 0.1 $\mu$ Crab
Winkelauflösung (FWHM)	20"	6"
effektive Fläche @ 2 keV	1000 cm <sup>2</sup>	4000 cm <sup>2</sup>
Gesichtsfeld	> 12' @ 30 keV	30' @ 6 keV
Zeitauflösung	128 $\mu$ s	73.3 ms <sup>3</sup>
Missionsdauer	3 + 2 Jahre	13 Jahre
beobachtete Quellen (erwartet)	(1000 + 500)	200 000

Energie [keV]	Intensität [%]	QE LED [%]	$(\text{Int} \cdot \text{QE})_{\text{absolut}}$ [‰]	$(\text{Int} \cdot \text{QE})_{\text{relativ}}$ [%]
<b>13.9</b>	37	22.6	<b>83.6</b>	<b>83.6</b>
<b>26.3</b>	2.3	17.7	<b>4.0</b>	<b>4.0</b>
33.2	0.13	10.0	0.13	0.13
42.7	0.0055	6.2	0.0034	0.0034
43.4	0.073	6.0	0.044	0.044
51.0	$2.6 \cdot 10^{-5}$	4.3	$1.1 \cdot 10^{-5}$	$1.1 \cdot 10^{-5}$
55.6	0.018	3.7	0.0067	0.0067
<b>59.5</b>	35.9	3.3	<b>11.85</b>	<b>11.85</b>
64.8	$1.5 \cdot 10^{-4}$	2.9	$4.2 \cdot 10^{-5}$	$4.2 \cdot 10^{-5}$
67.5	$4.2 \cdot 10^{-4}$	2.8	$1.2 \cdot 10^{-4}$	$1.2 \cdot 10^{-4}$
69.8	0.003	2.7	$7.8 \cdot 10^{-4}$	$7.8 \cdot 10^{-4}$
75.8	$5.9 \cdot 10^{-4}$	2.4	$1.4 \cdot 10^{-4}$	$1.4 \cdot 10^{-4}$
			Σ = 99.67	







# Rückblick: Charge-Coupled Device

