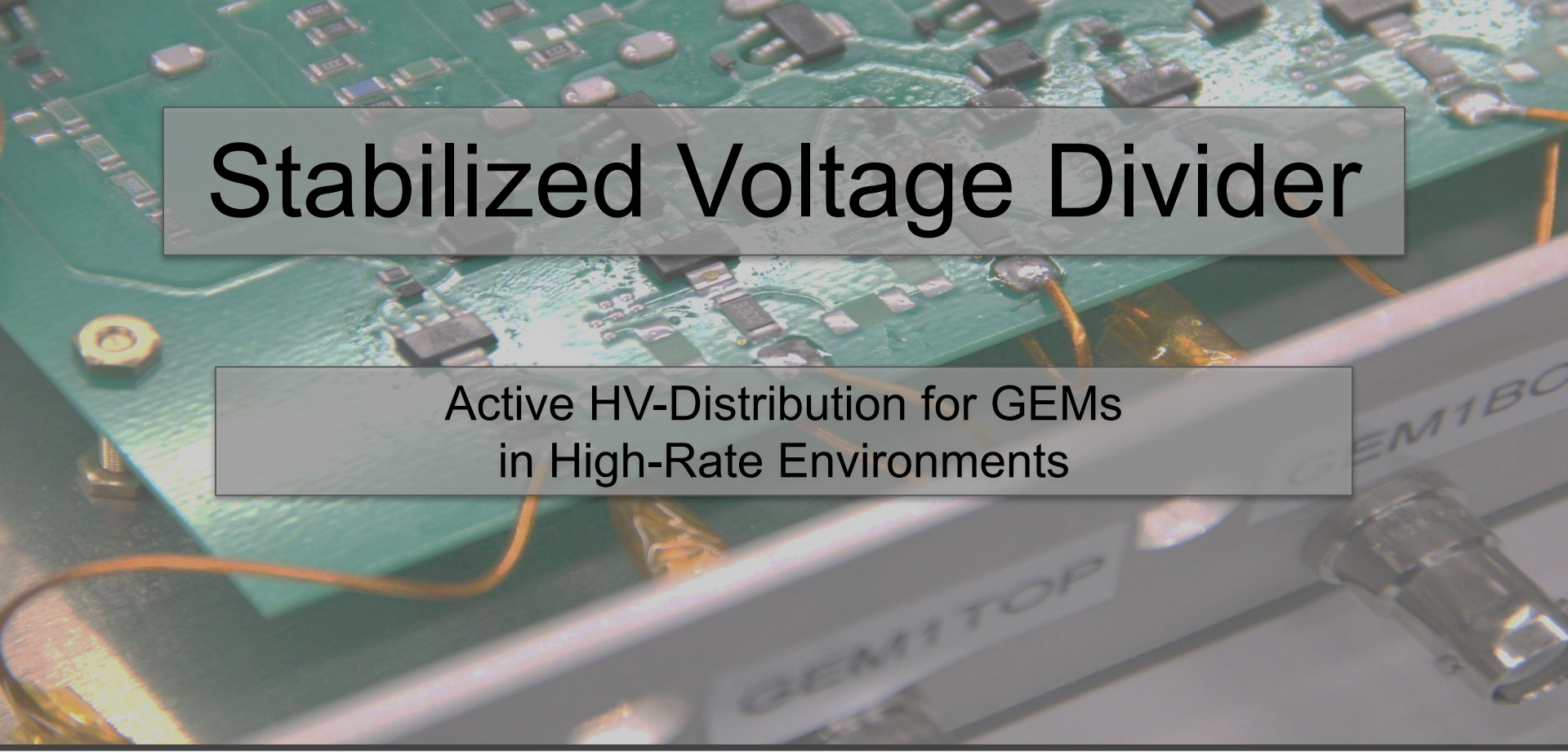



# Stabilized Voltage Divider

## Active HV-Distribution for GEMs in High-Rate Environments

Jakob Krauss
krauss@uni-bonn.de

1st DRD1 Collaboration Meeting
31st January 2024

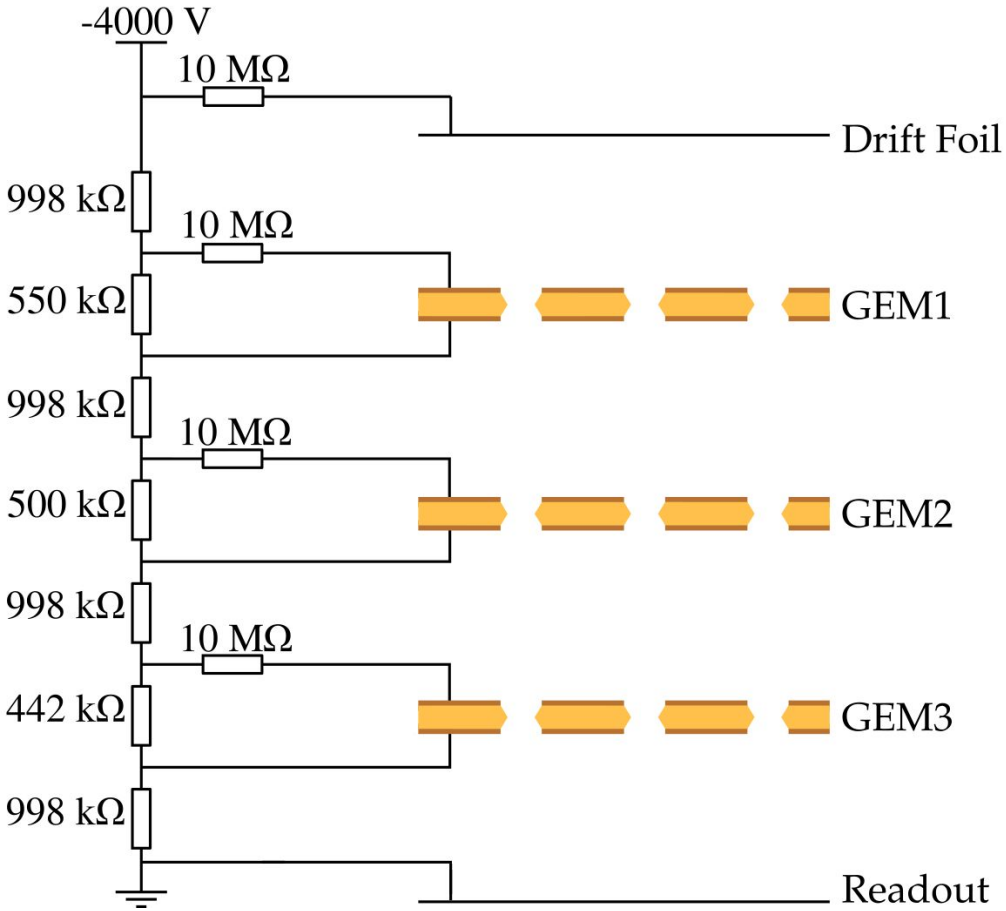
UNIVERSITÄT BONN
AG Ketzer

# **P**assive **V**oltage **D**ivider:

- Benchmark system
- 1 µA at GEM → 10 V drop
- Current between GEMs parallel to resistor chain

⇒ Potentials change under high rate

⇒ Effect on gain, efficiency, etc.

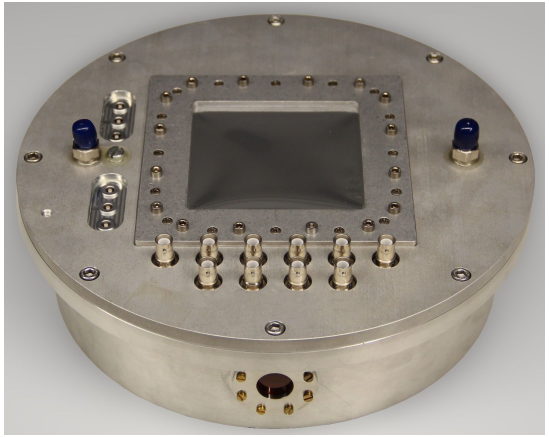


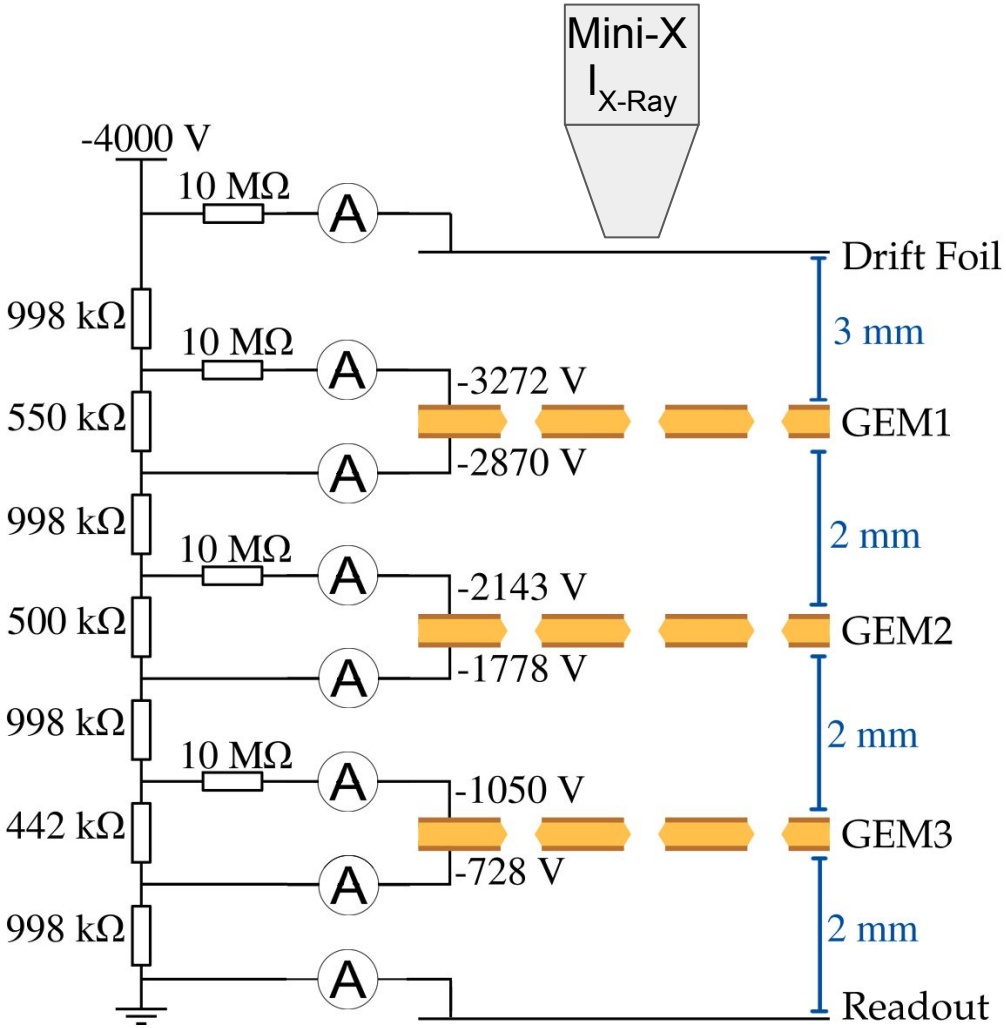
# **P**assive **V**oltage **D**ivider:

- Compass-like

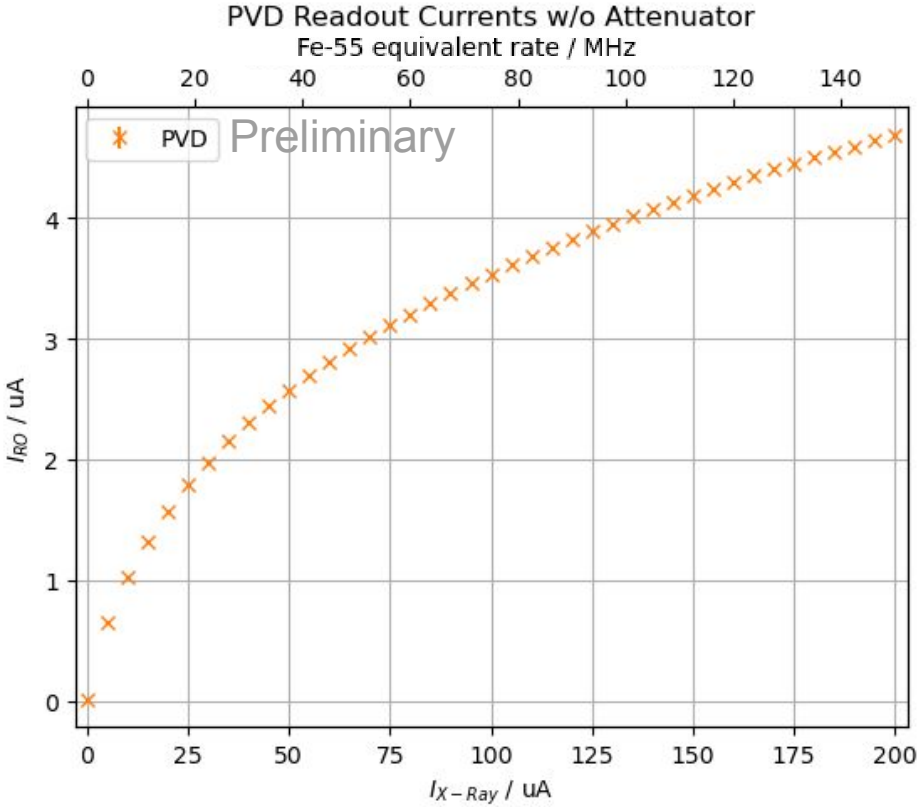
[C. Altunbas et al., “Construction, test and commissioning of the triple-gem tracking detector for compass”]

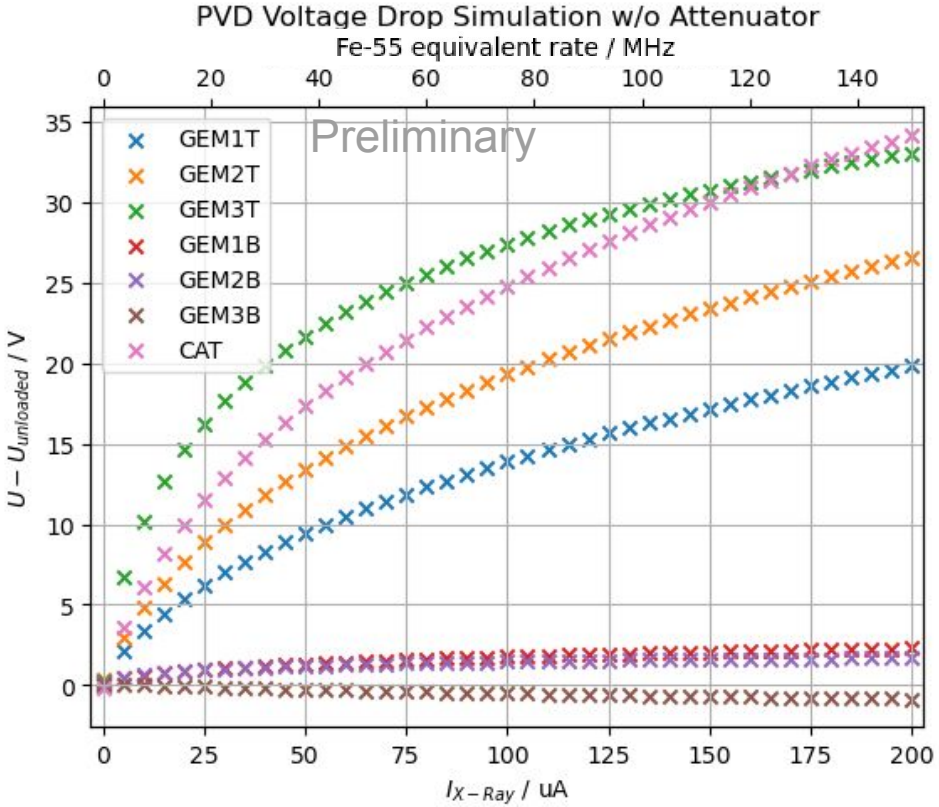
- 10x10 cm² GEMs
- Ar/$CO_2$ 70/30
- Mini-X + optional copper attenuator
- Picoamperemeters





# PVD – Drop in Voltage & Gain:

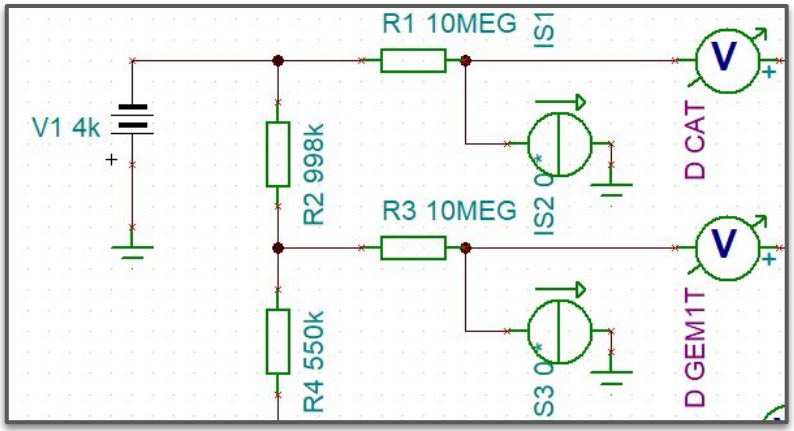


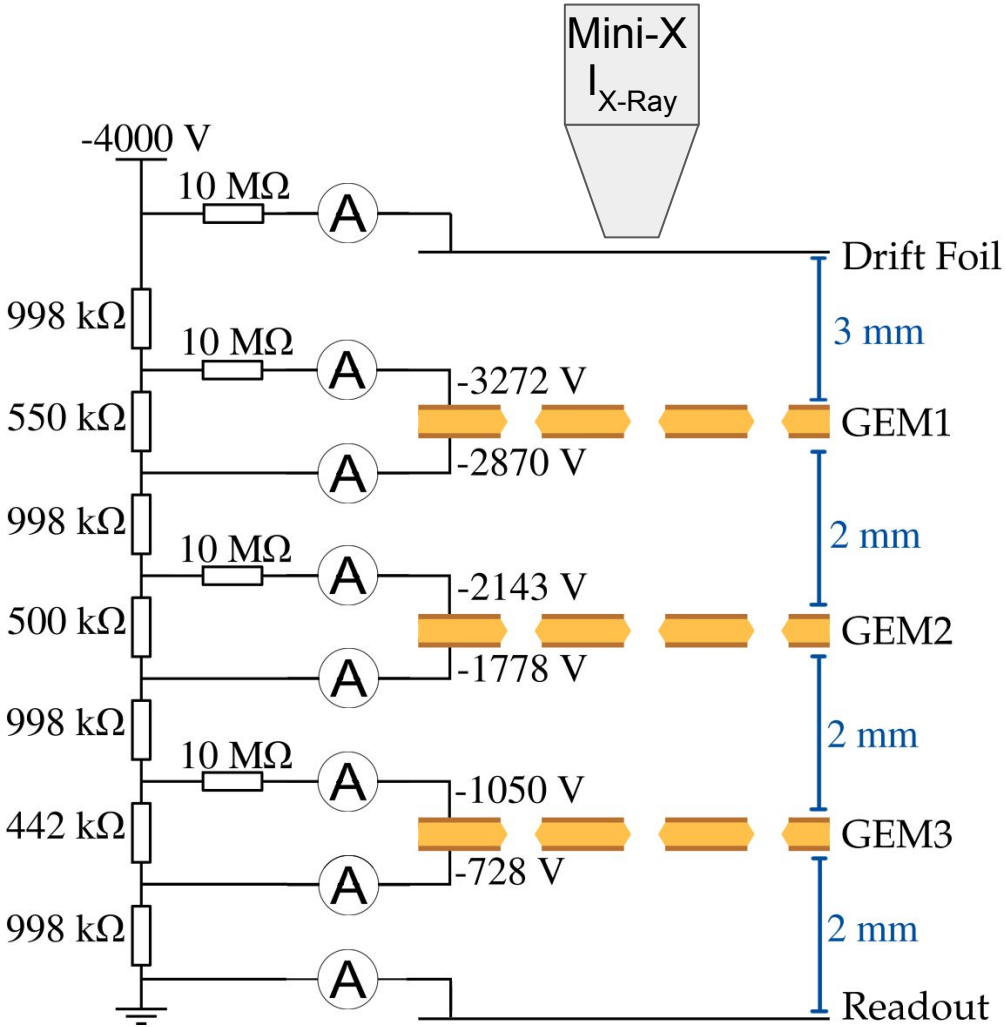



# PVD – Voltage Simulation

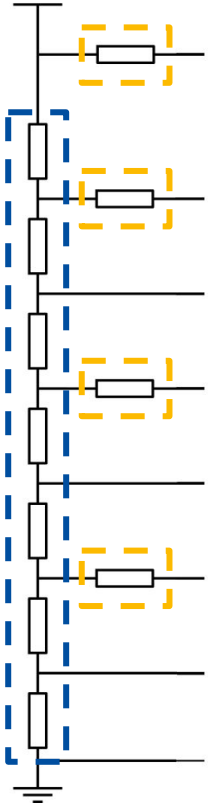
Direct voltage measurement loads circuit

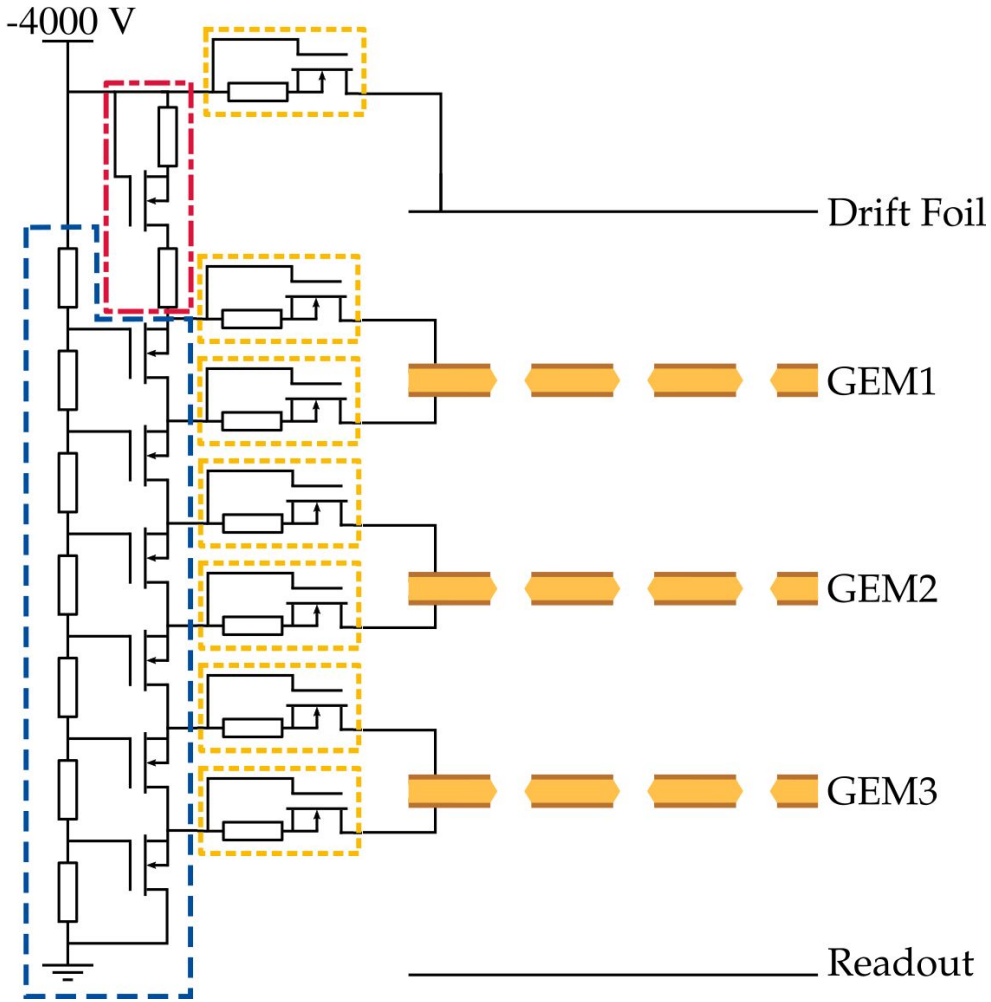
Measure currents and simulate voltages in TINA-TI



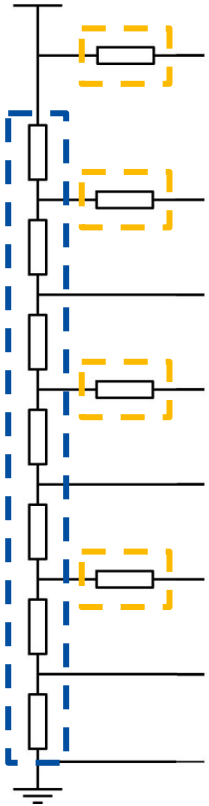



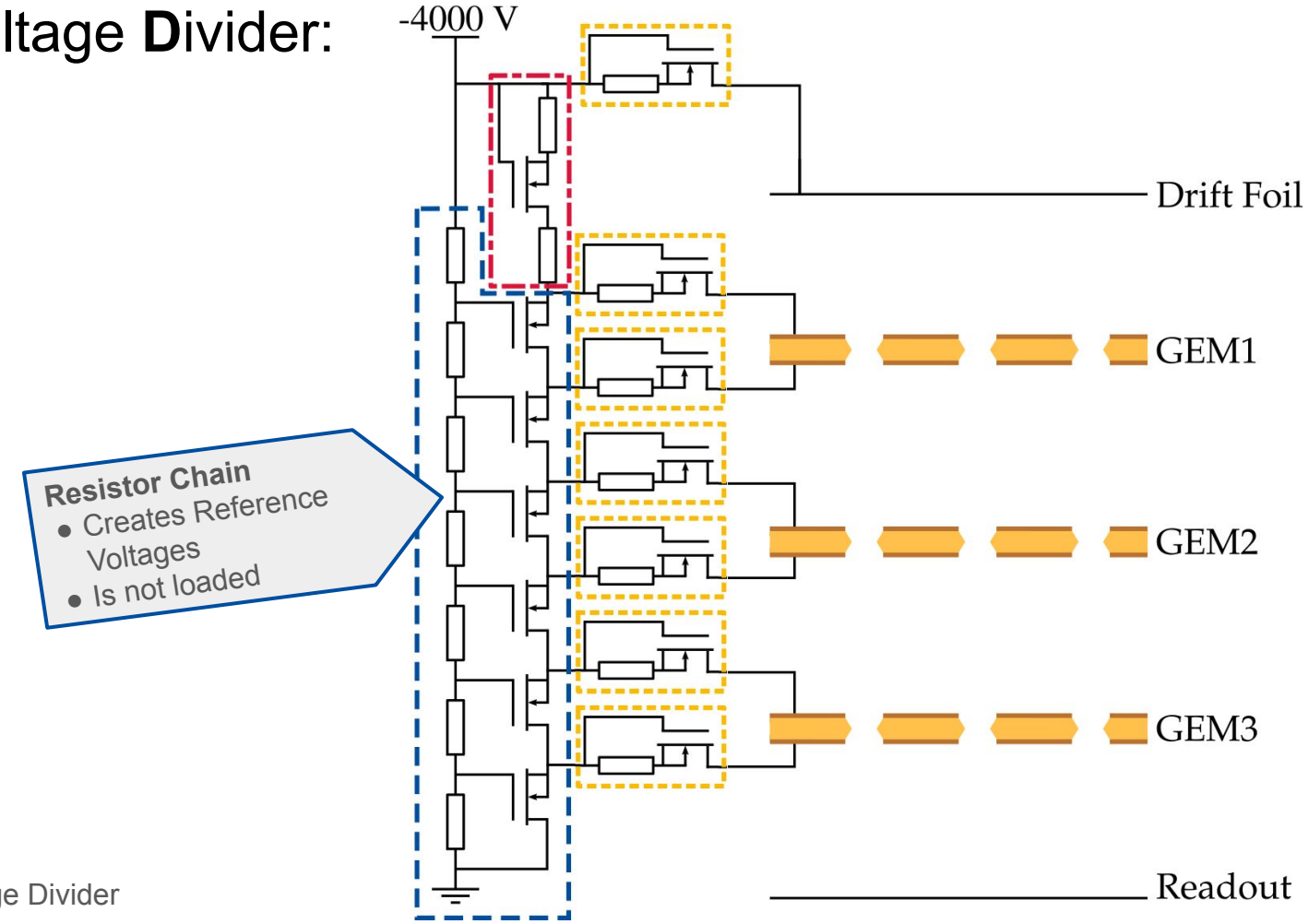
# **S**tabilized **V**oltage **D**ivider:



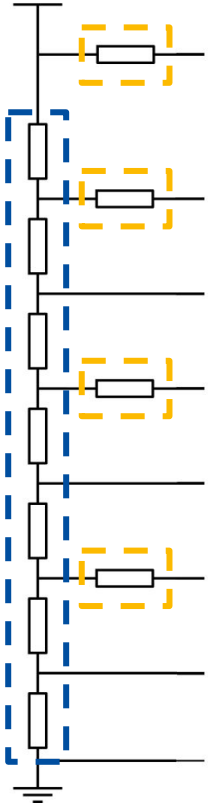


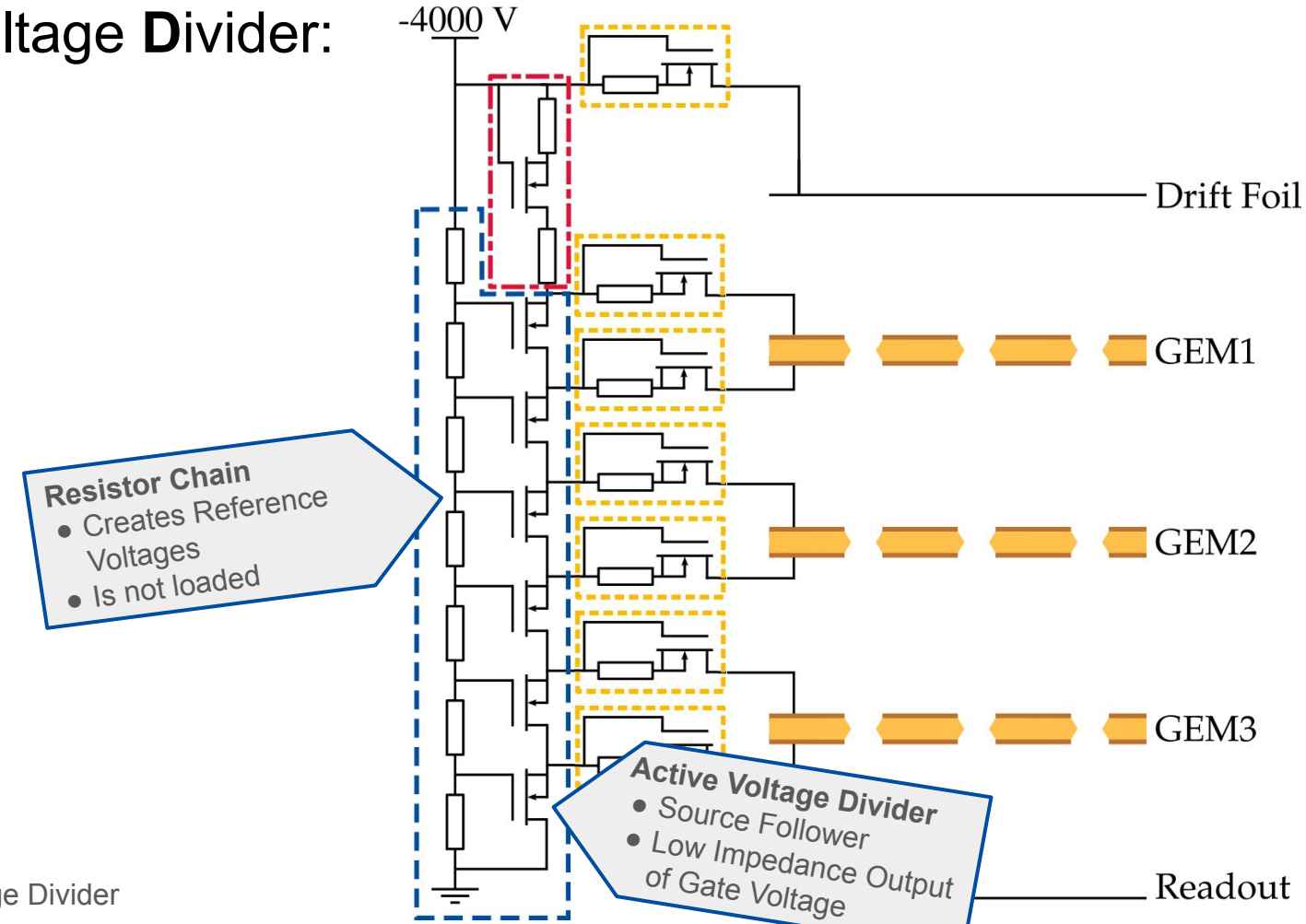
# **S**tabilized **V**oltage **D**ivider:



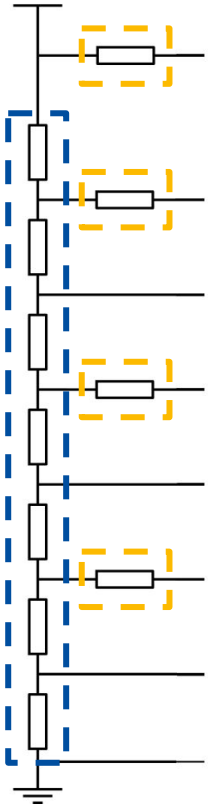


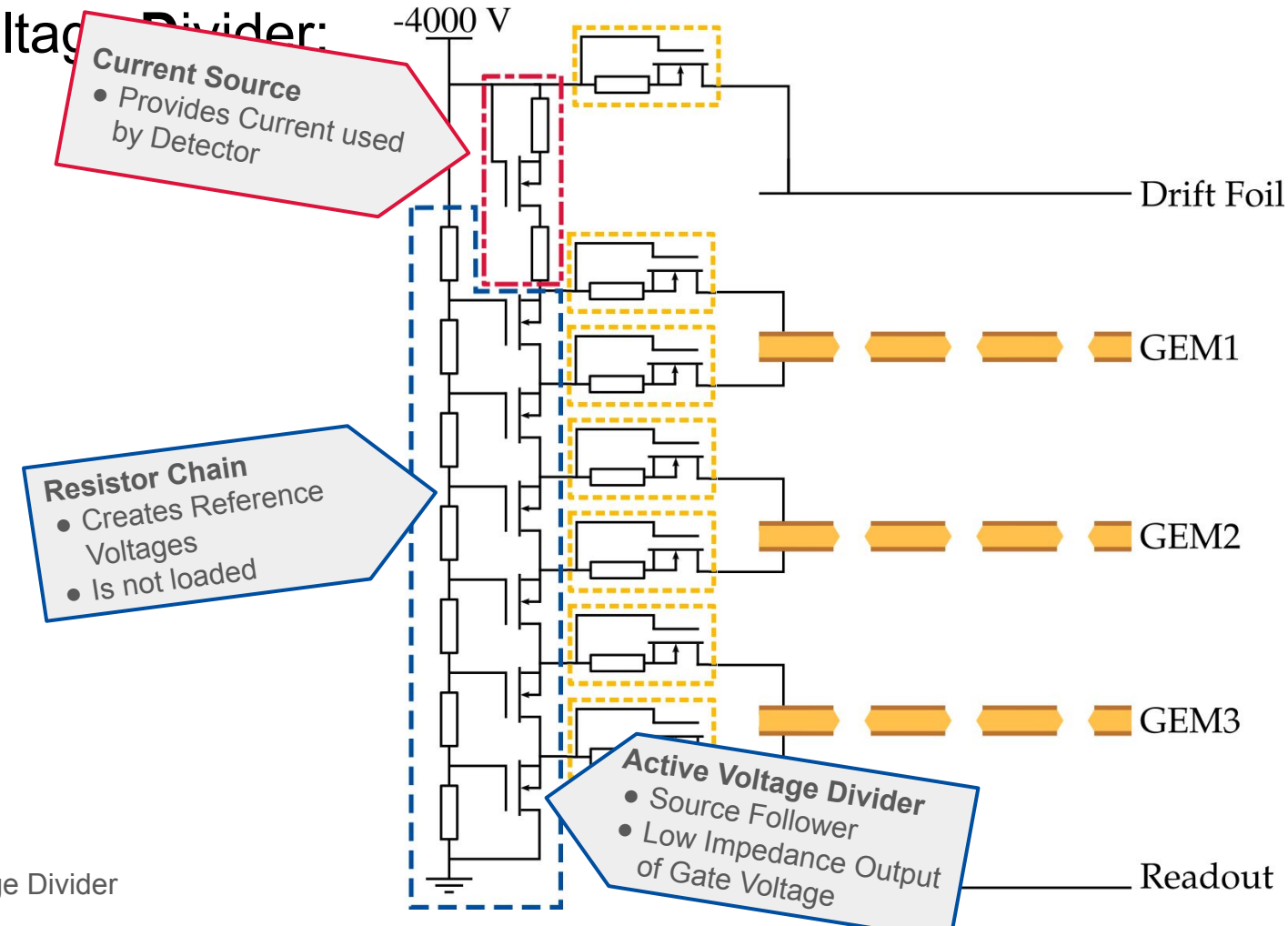
# **S**tabilized **V**oltage **D**ivider:



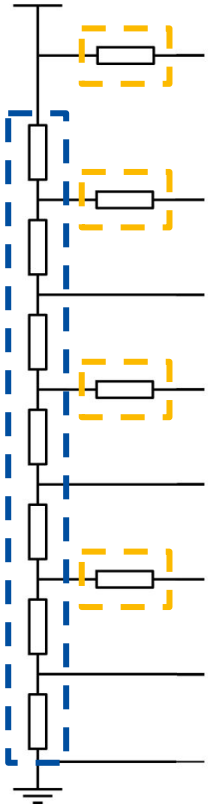


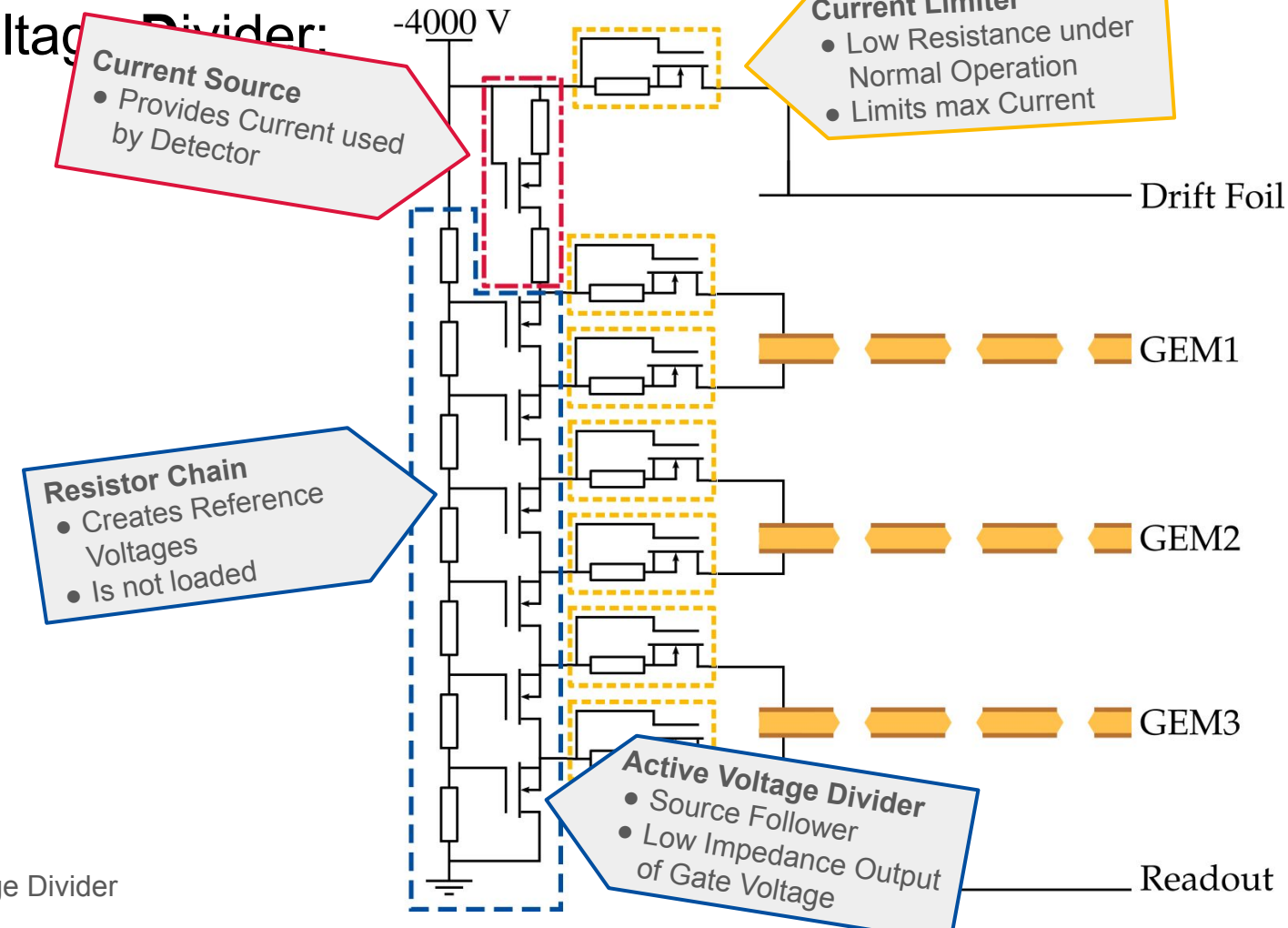
# Stabilized Voltage Divider:





# Stabilized Voltage Divider:

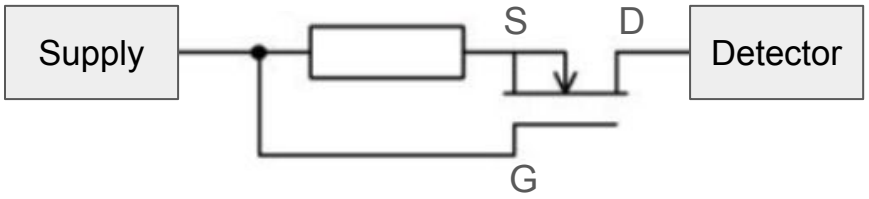




# Current limiter:

N-channel depletion mode as a switch

| | |
|---|---|
| $U_G + 1.5V > U_S$ |   |
| $U_G + 1.5V < U_S$ |   |




No Charges landing on Detector:
$U_G = U_S \Rightarrow$ conducting

# Current limiter:

N-channel depletion mode as a switch

| | |
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| $U_G + 1.5V > U_S$ |   |
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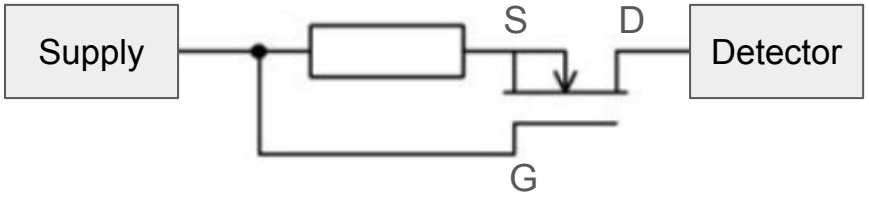
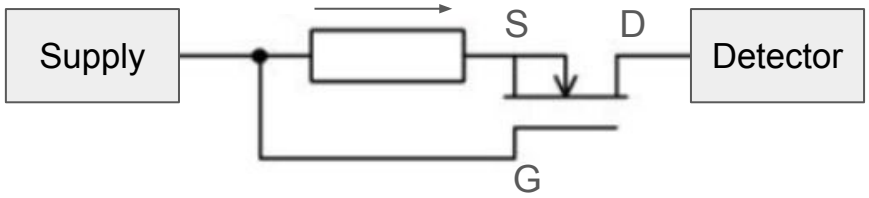



No Charges landing on Detector:
$U_G = U_S \Rightarrow$ conducting

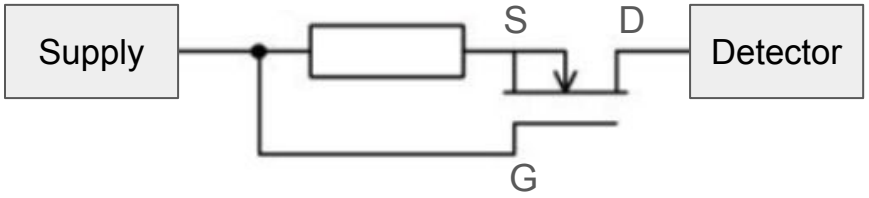



Negative Charges landing on Detector:
$U_G > U_S \Rightarrow$ conducting

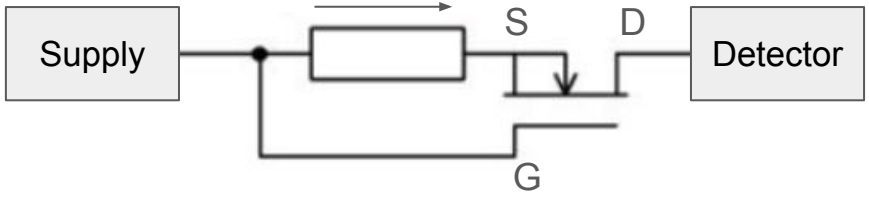
# Current limiter:

N-channel depletion mode as a switch

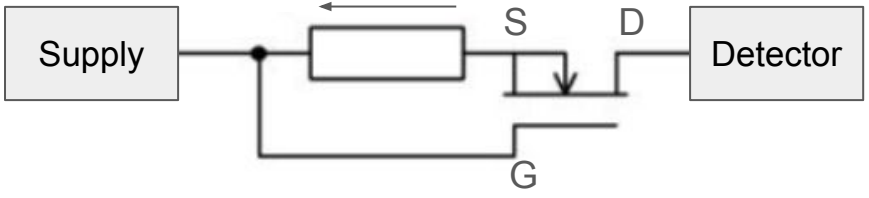
| | |
|---|---|
| $U_G + 1.5V > U_S$ |   |
| $U_G + 1.5V < U_S$ |   |




No Charges landing on Detector:
$U_G = U_S \Rightarrow$ conducting



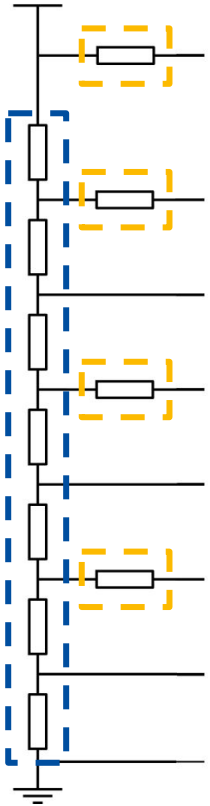

Negative Charges landing on Detector:
$U_G > U_S \Rightarrow$ conducting




Positive Charges landing on Detector:
$U_G < U_S \Rightarrow$ not conducting

$R = 100\ k\Omega \rightarrow I_{Max} = 15\ \mu A$

# Current limiter:

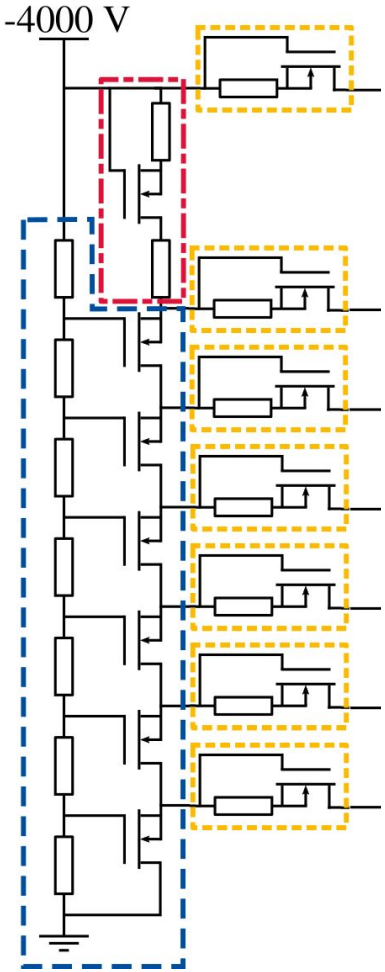


Positive charges interrupt supply

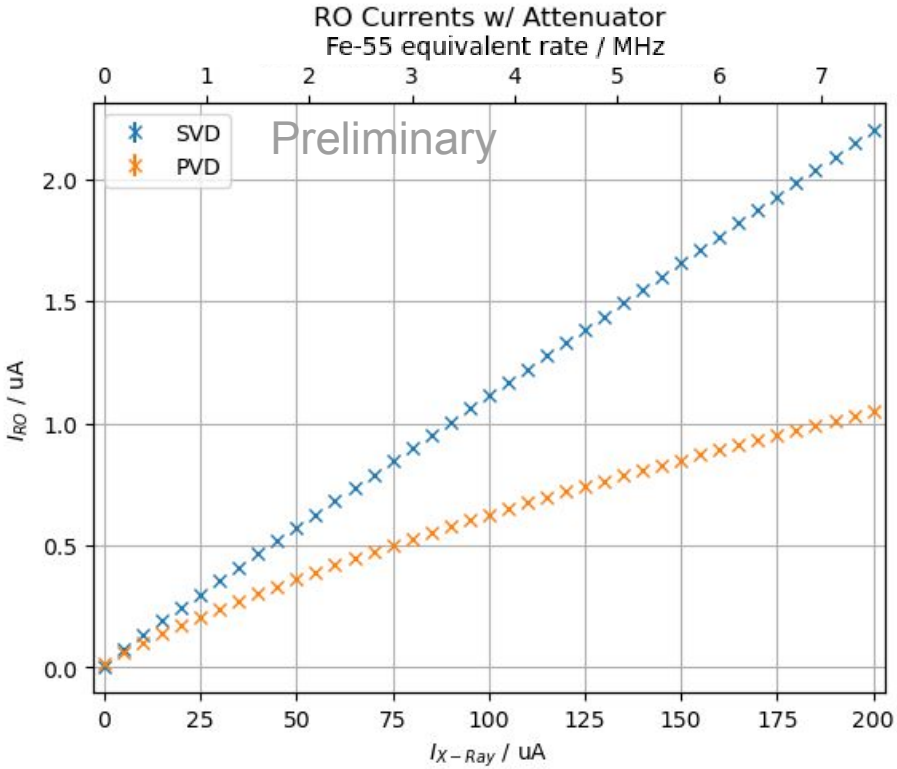
Discharge in a GEM:

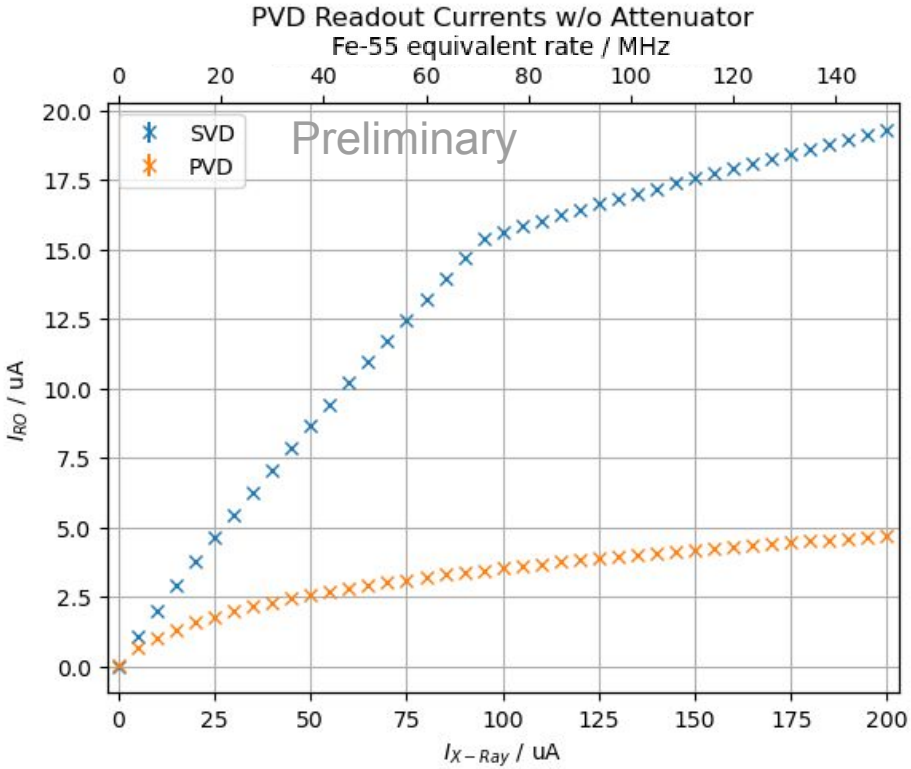
- Same behavior as resistors
- $U_{Top}$ is pulled to $U_{Bot}$
- $U_{Bot}$ stays the same

  ⇒ no change in the field below

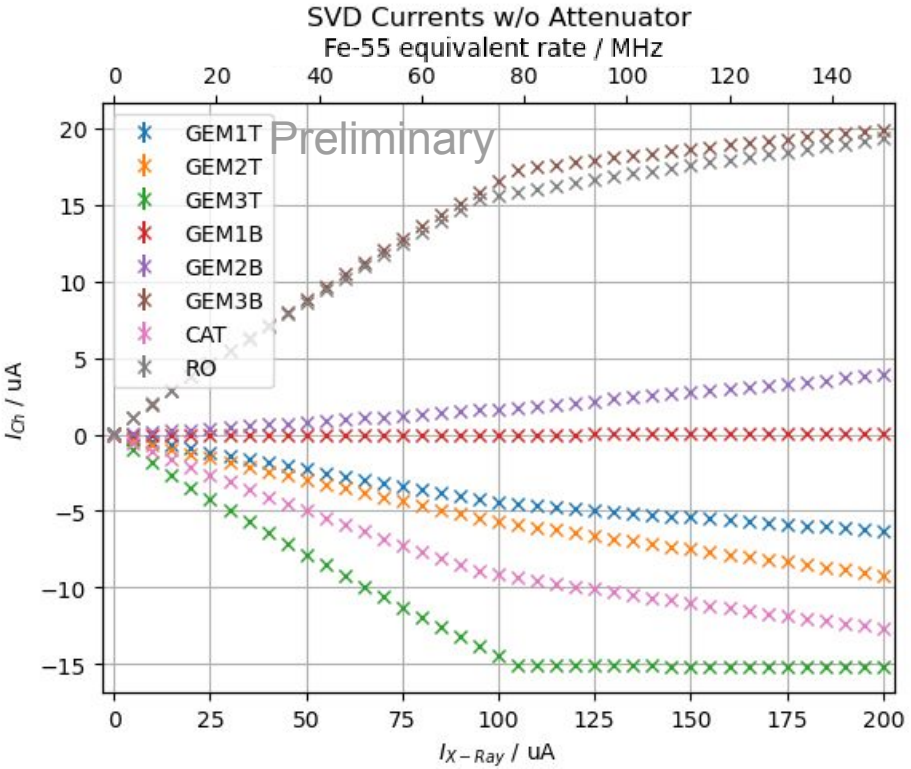


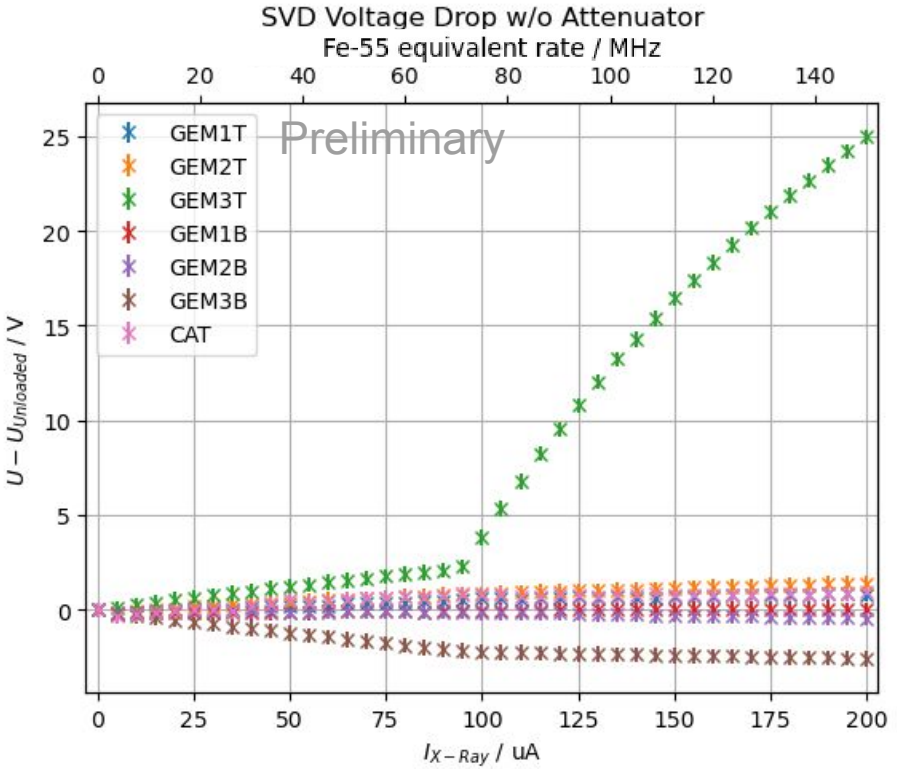
# PVD vs. SVD – RO Currents



# SVD – Current Limiter in Action



# What happens after a discharge?

- Does the transistor switch fast enough to avoid pulling $U_{Bot}$ to $U_{Top}$?
- What is the effect on secondary discharge rate?
- Are all potentials after a discharge safe?
  - Use TVS-Diodes to fix maximum potential differences

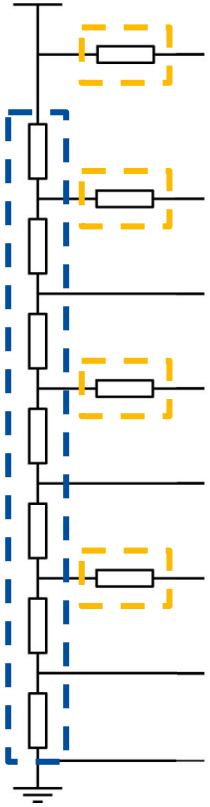
# Next up:

- Single GEM setup
  - Alpha induced discharges
  - Live monitoring of potentials

# Outlook:

- Beam tests
- AMBER

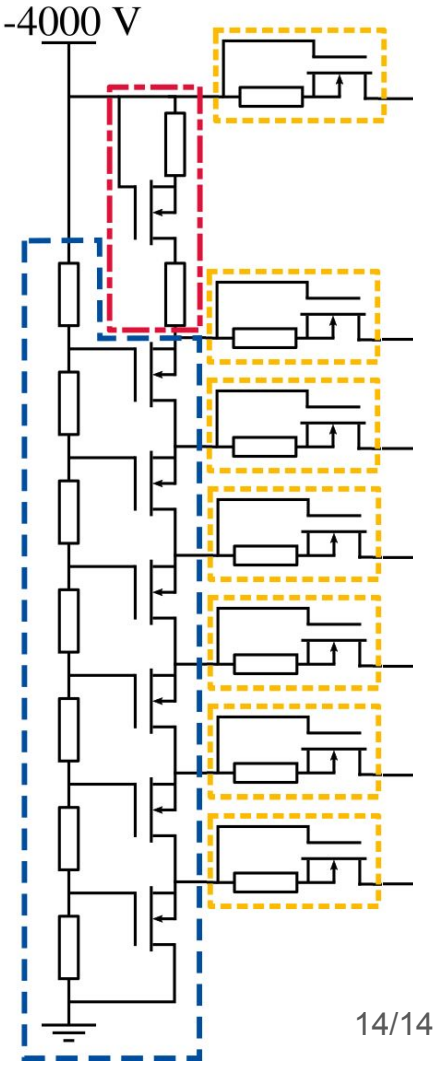
# Conclusion



The Stabilized Voltage divider has two components:

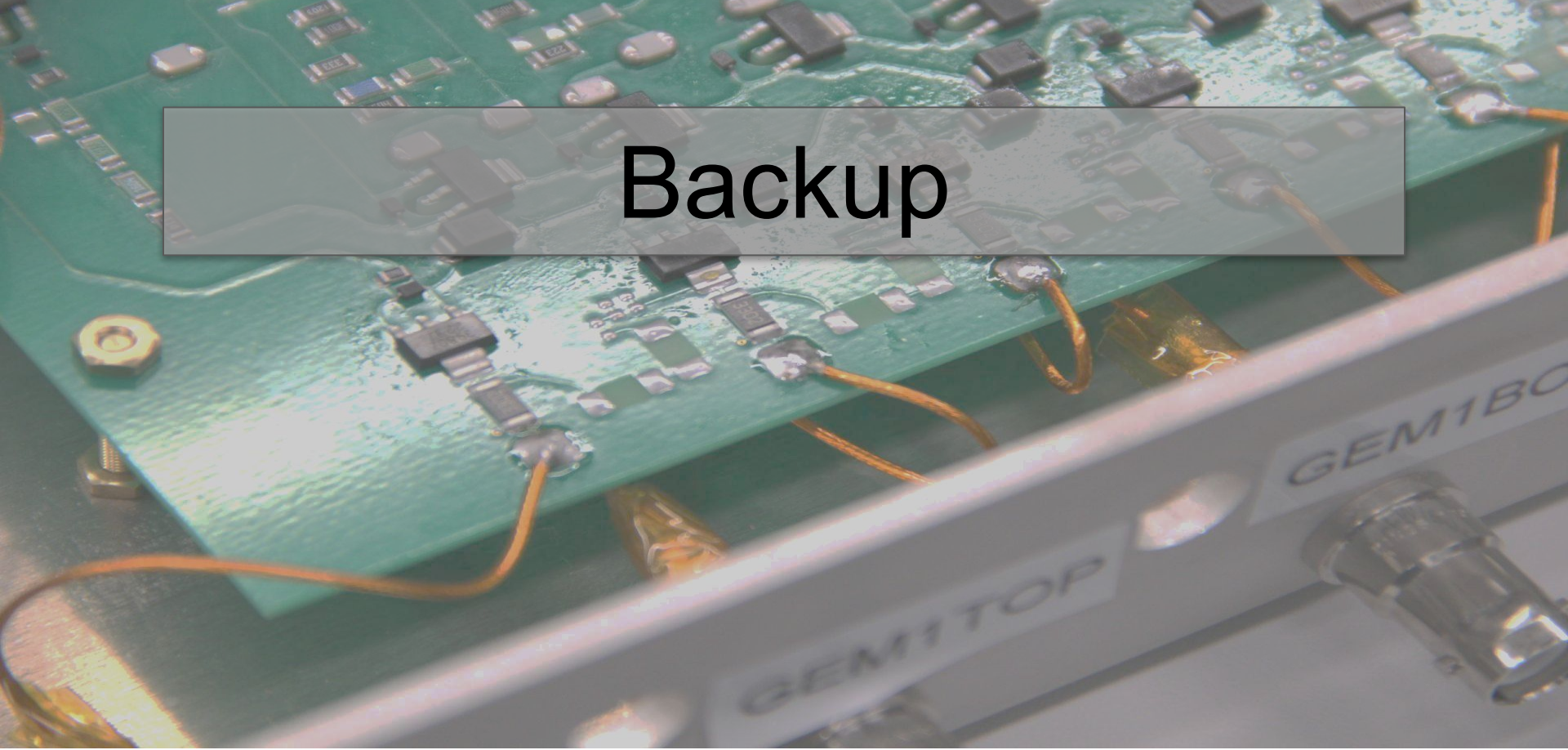
- Active Voltage Divider replace resistor chain
  - Not effected by parallel currents through detector
- Current limiter replaces 10 MΩ-Resistor
  - Minimal voltage drop (100 mV vs. 10V @ 1µA)

- High rate stability was proven
- Discharge behavior is under investigation



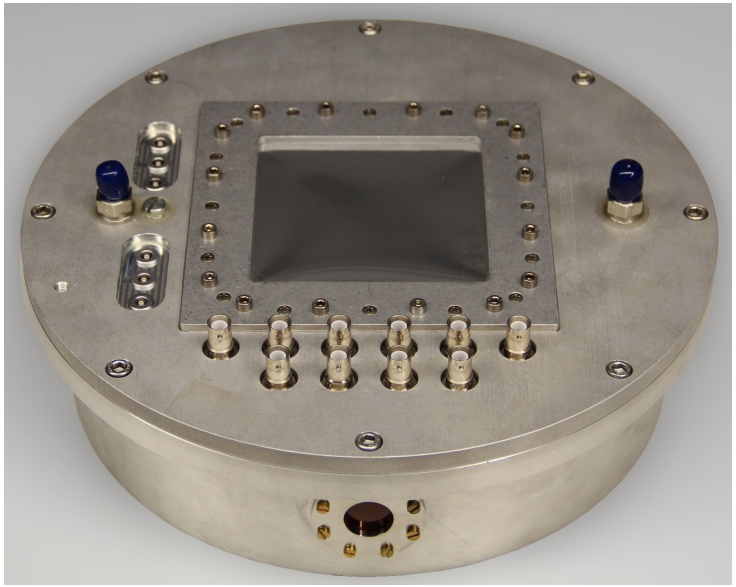

# Thank you for your attention!

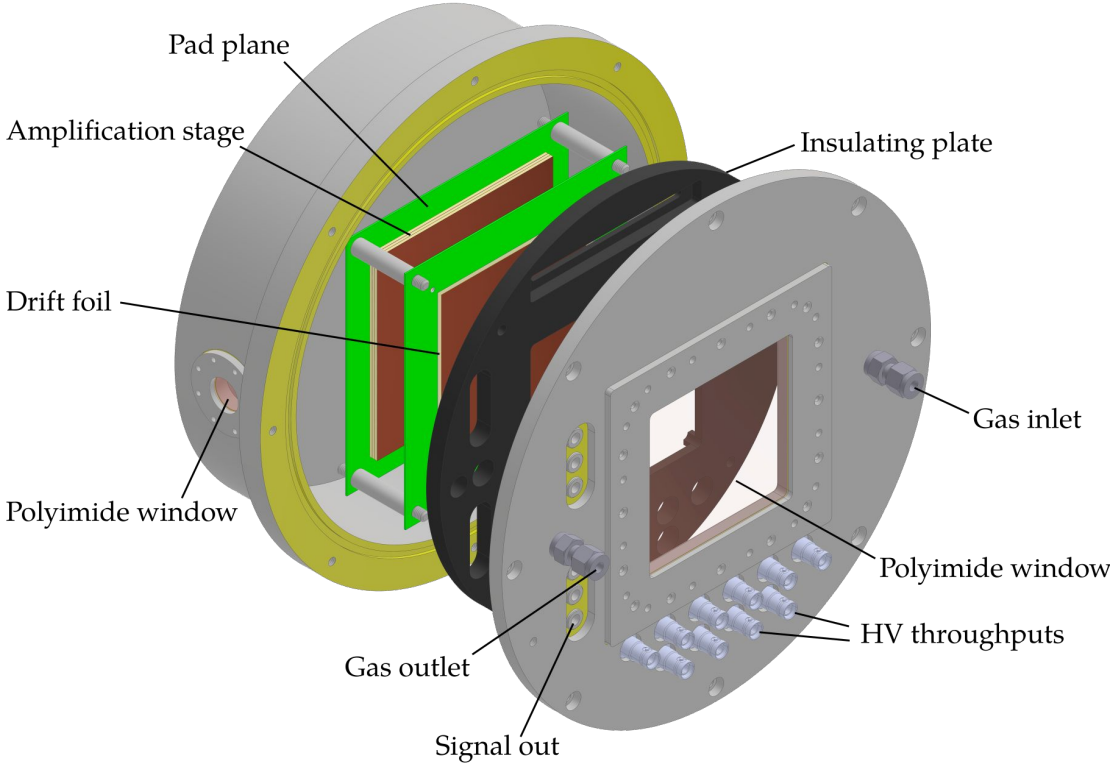
Jakob Krauß, Philip Hauer, Christian Honisch,
Karl Flöthner, Matiss Wolter, Bernhard Ketzer



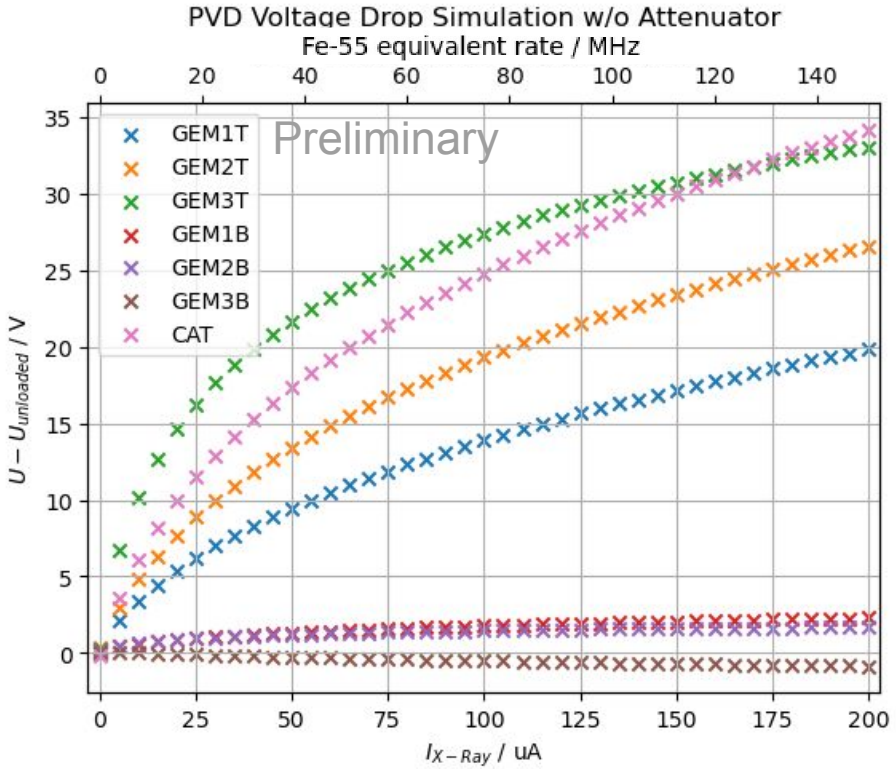

# Backup

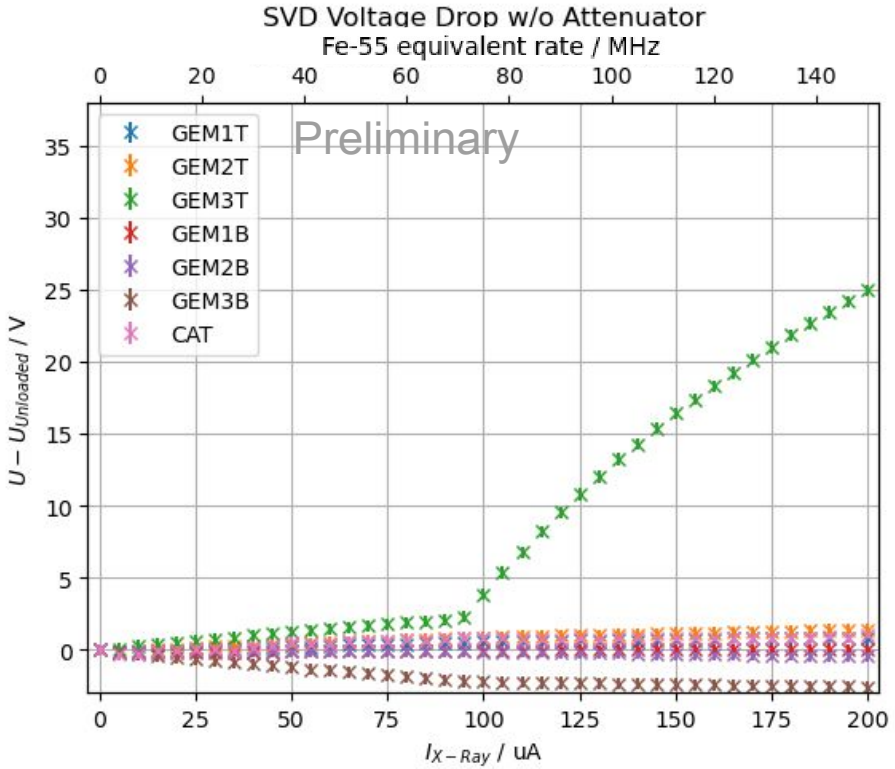
# Detector Setup:



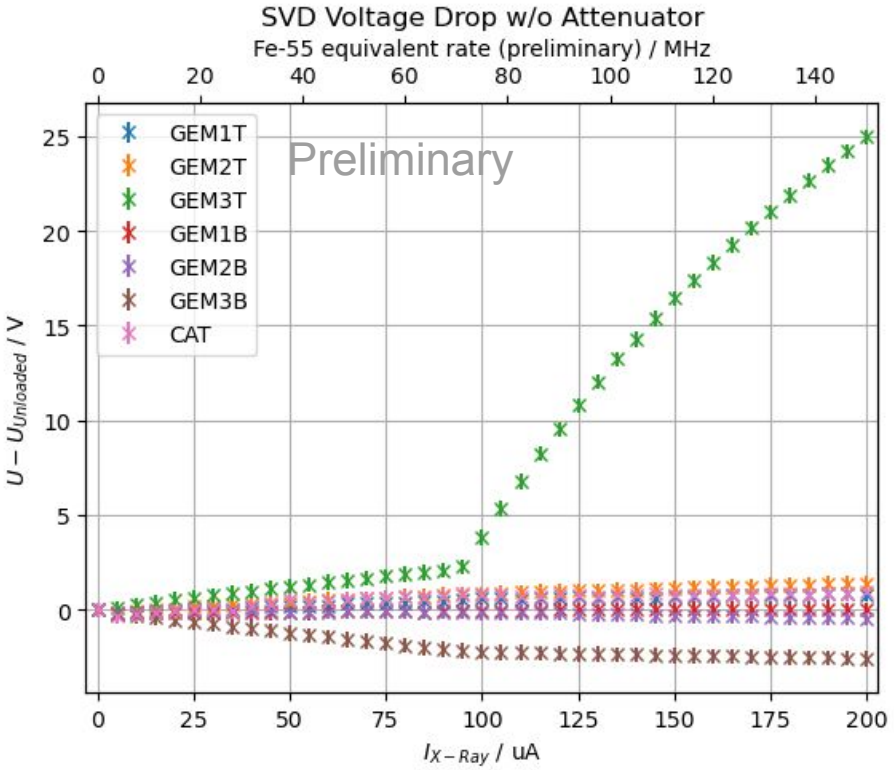


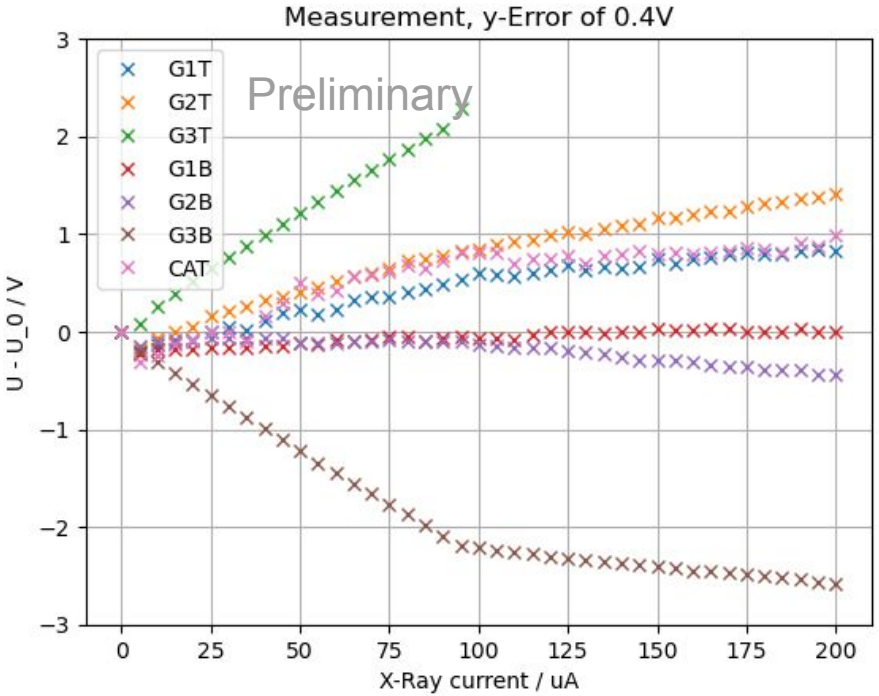
# SVD vs. PVD – Voltage Drop



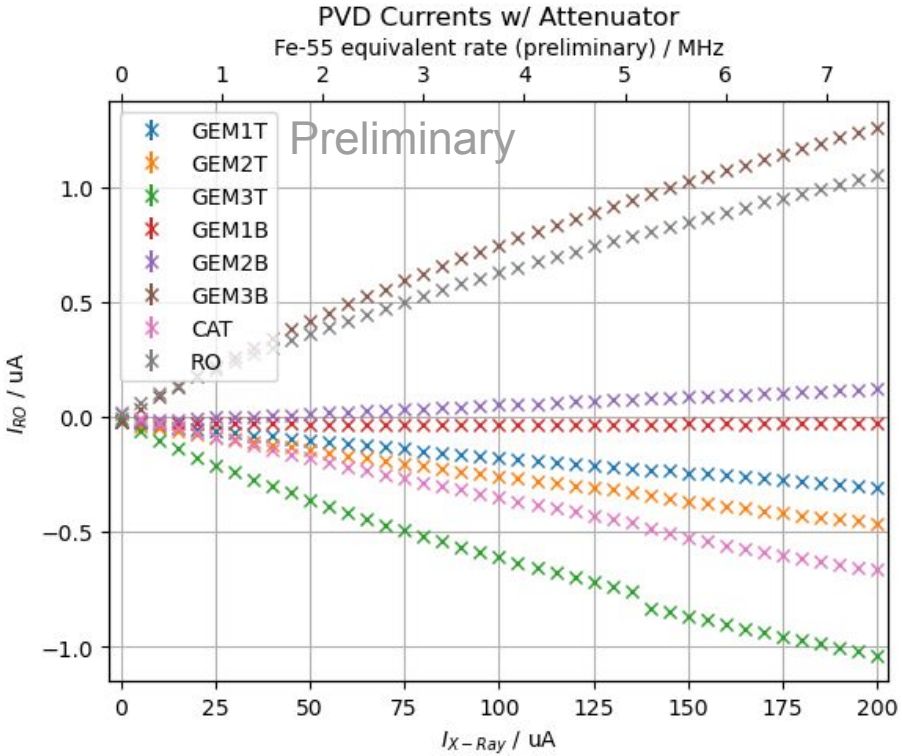



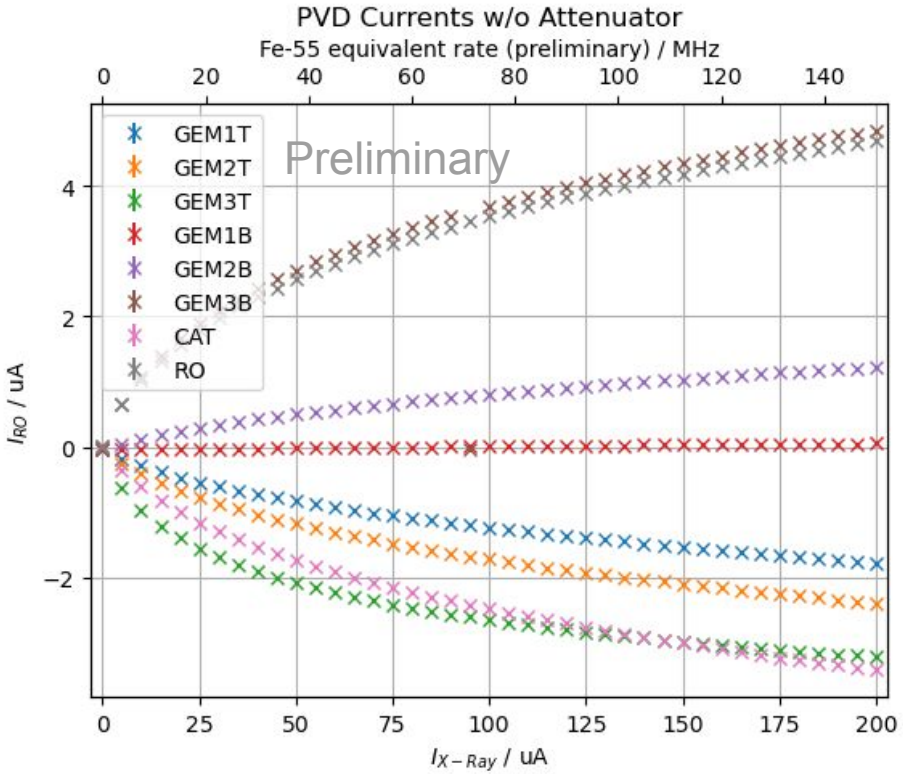
# SVD - Voltage drop w/o attenuator



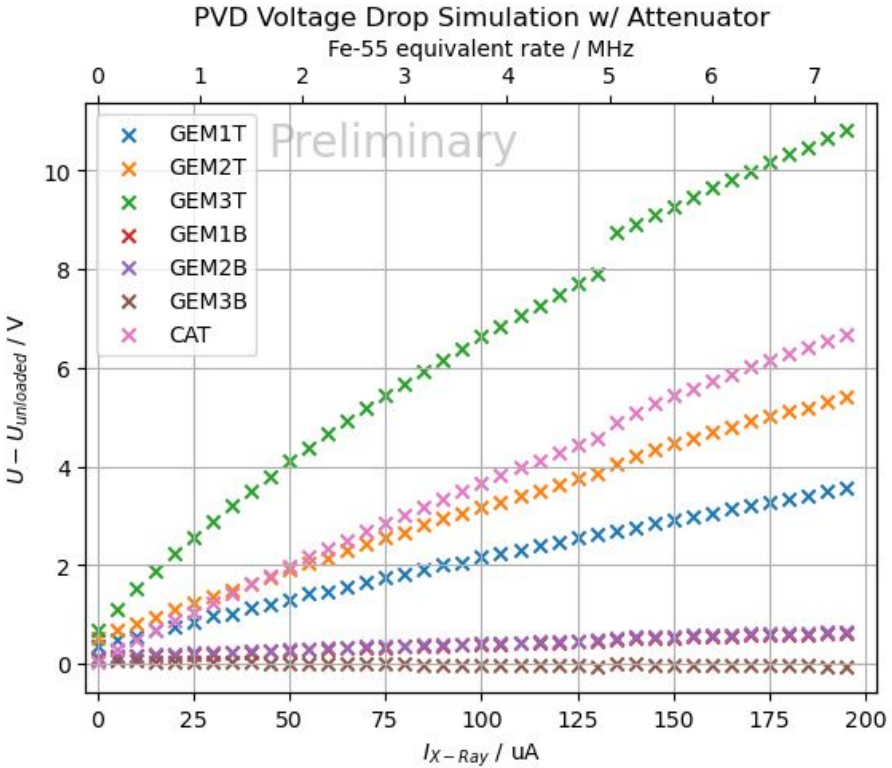



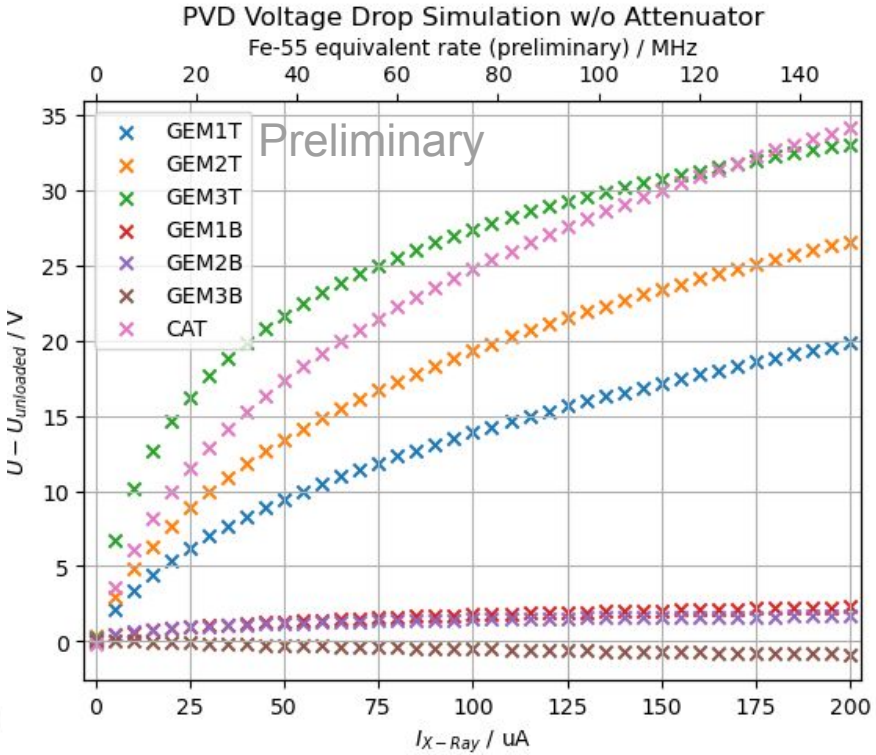
# PVD - Currents



# PVD - Voltage Drop



# Rough estimate of Currents in AMBER

Currents matter, not rates!

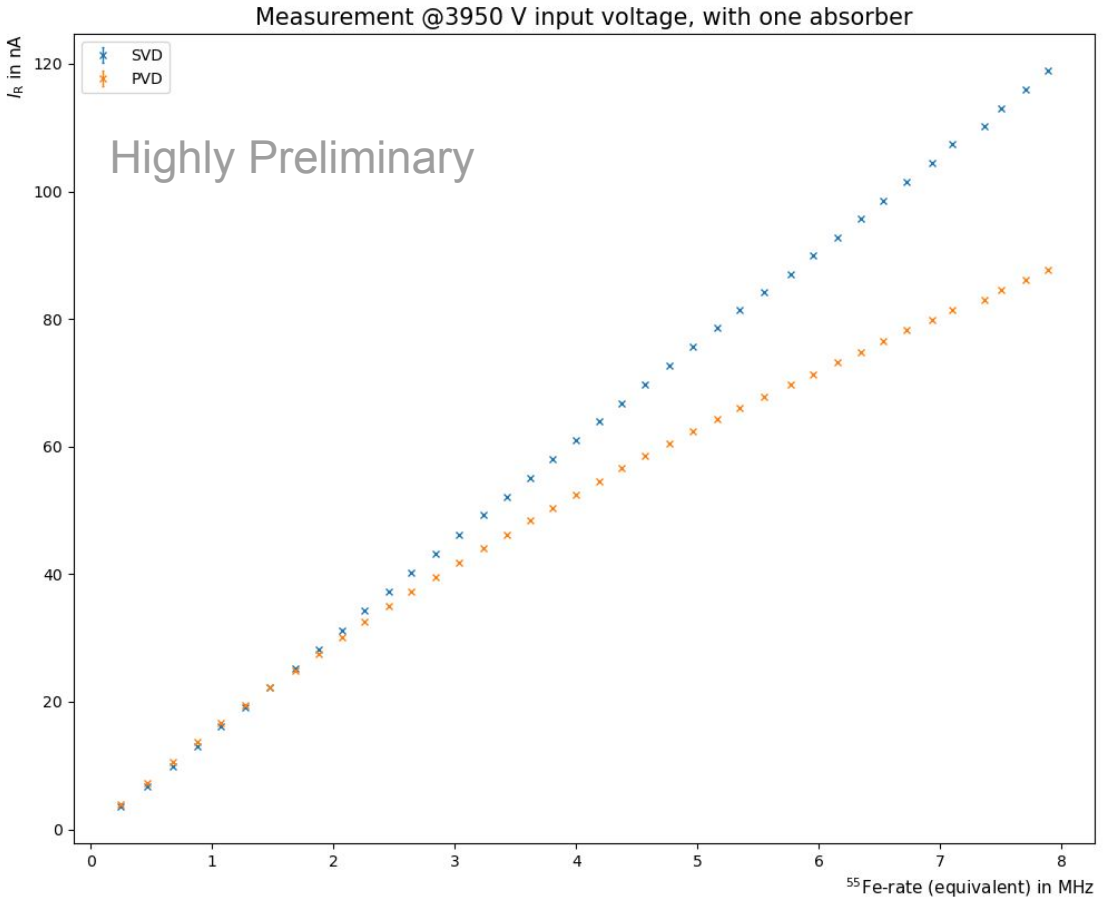
~1.7 MHz Muon Rate on inner 5x5 cm²

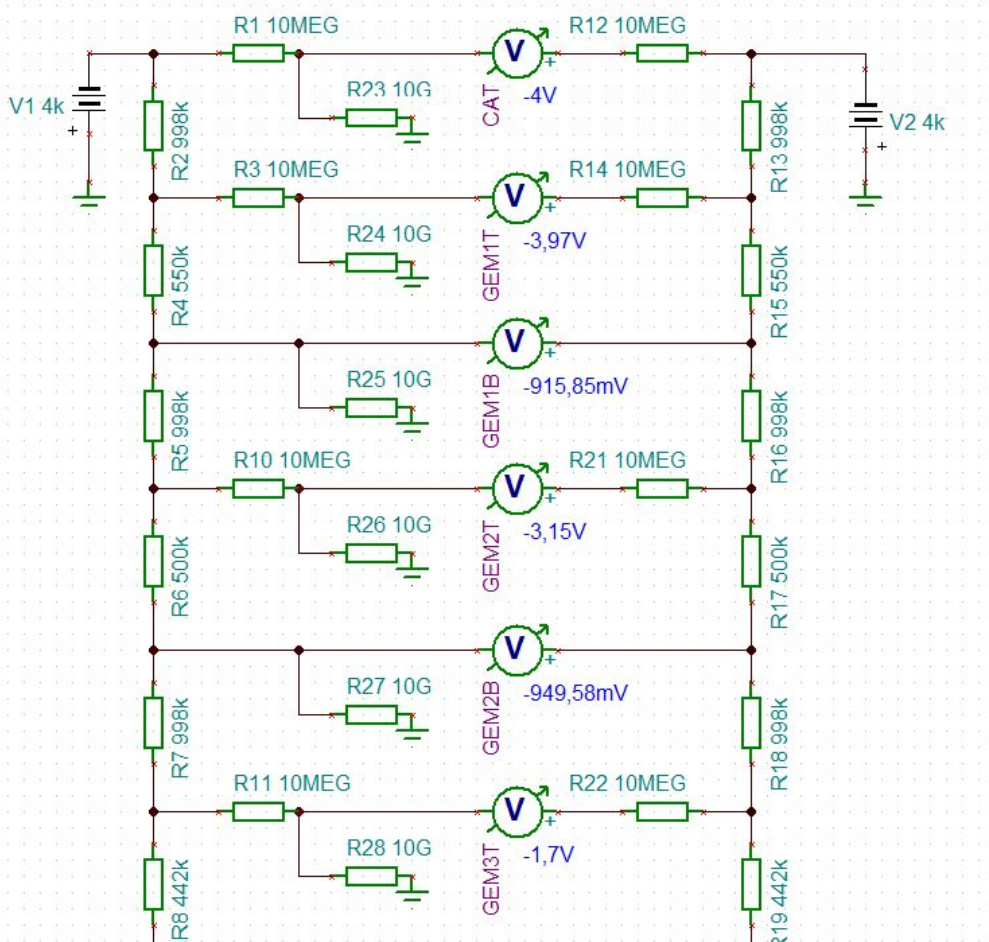
~as one Segments

~10 primary electrons in 3mm

~Gain $10^4$

$I_{RO} \approx 30$ nA




V1 4k
R1 10MEG
R23 10G
R2 998k
CAT
-4V
R12 10MEG
R13 998k
V2 4k
R3 10MEG
R24 10G
R4 550k
GEM1T
-3,97V
R14 10MEG
R15 550k
R25 10G
R5 998k
GEM1B
-915,85mV
R16 998k
R10 10MEG
R26 10G
R6 500k
GEM2T
-3,15V
R21 10MEG
R17 500k
R27 10G
R7 998k
GEM2B
-949,58mV
R18 998k
R11 10MEG
R28 10G
R8 442k
GEM3T
-1,7V
R22 10MEG
R19 442k