MuPix9 - a HV-MAPS prototype with serial powering

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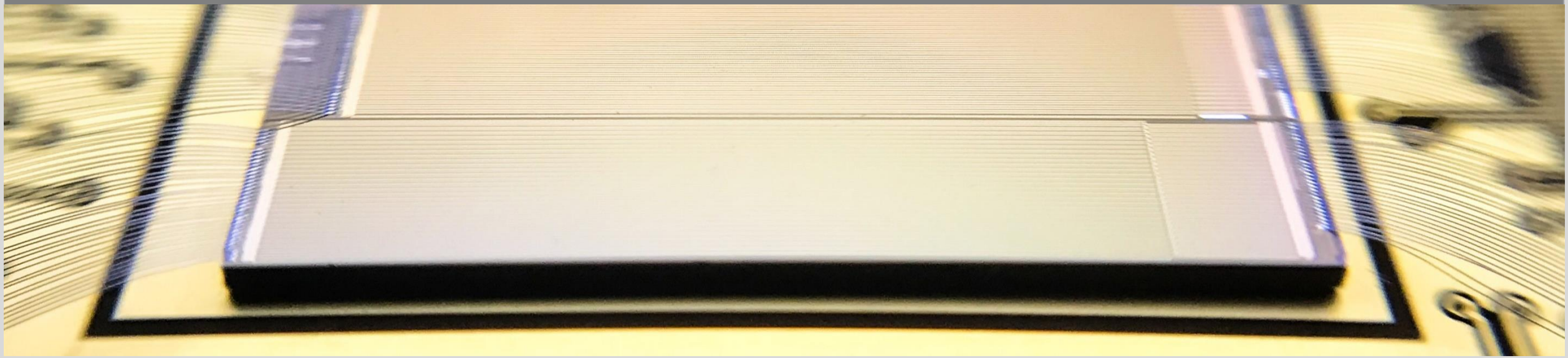
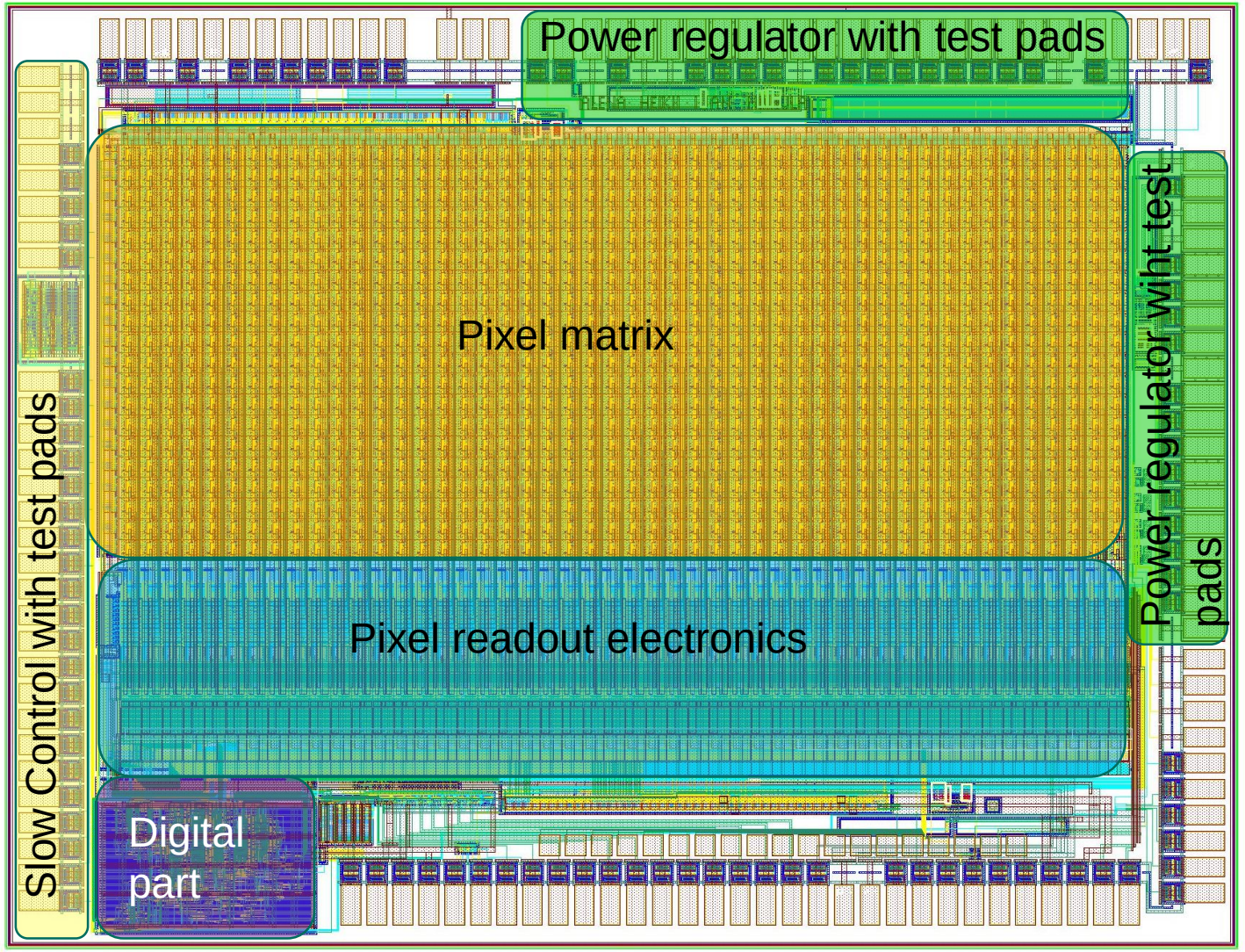


Outline

- Overview of the MuPix9
- Regulator element
- Serial powering – Introduction to standard concepts
- Serial powering – Introduction to HVCMOS concepts
- Chip interconnection concepts for serial powering
  - Concept 1: vdda and vssa separated
  - Concept 2: vdda = vssa
  - Concept 3: shared voltage
  - Concept 4: analog part serial and digital part parallel
- Version implemented on MuPix9
- Vision for next generation MuPix
- Outlook

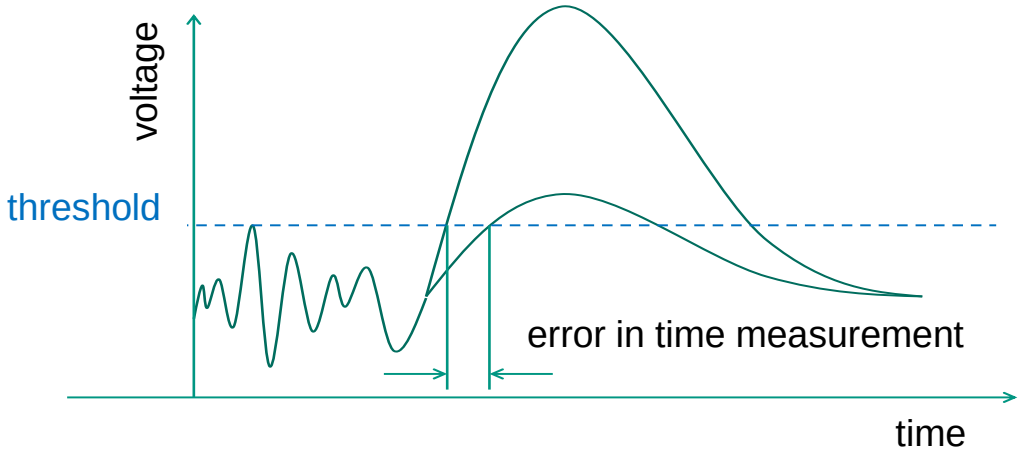
Overview of the MuPix9

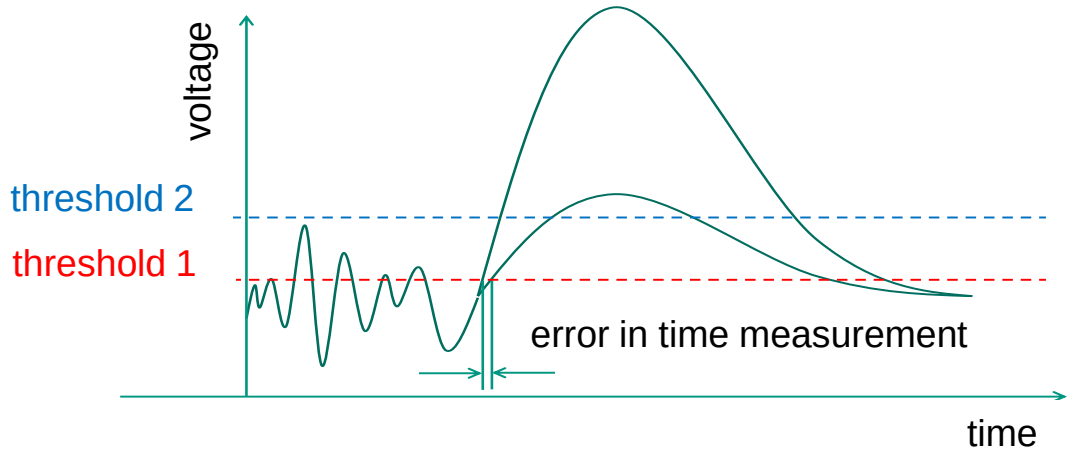
- Small sensor prototype (4700 um x 3600 um)
- AMS aH18 HV-CMOS
  - Minimal gate length of 180nm
  - Substrate with 20 Ωcm
  - 48 columns each with 20 pixels
- Main parts:
  - Pixel matrix
  - Pixel readout electronics
  - Digital part with slow control
  - Slow control as stand-alone part
  - Two power regulators



Overview of the MuPix9

- Changes in comparison to MuPix8
  - one pixel matrix
  - Pixels in NMOS instead of PMOS
  - Readout cells are modified: now with capacitor for capacitive coupling for serial powering. Three modes concept from MuPix8 is kept.

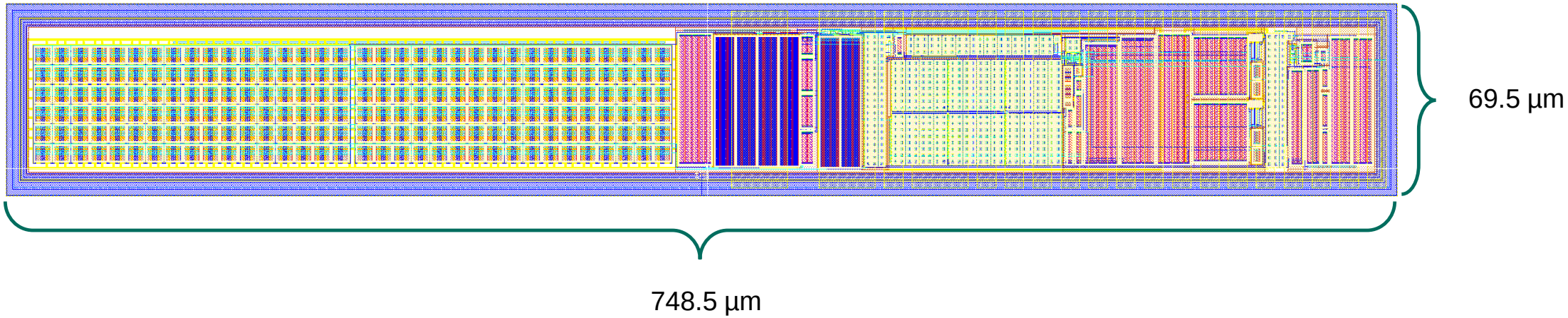




  - Digital part with modified state machine and new slow control
  - slow control as stand-alone part

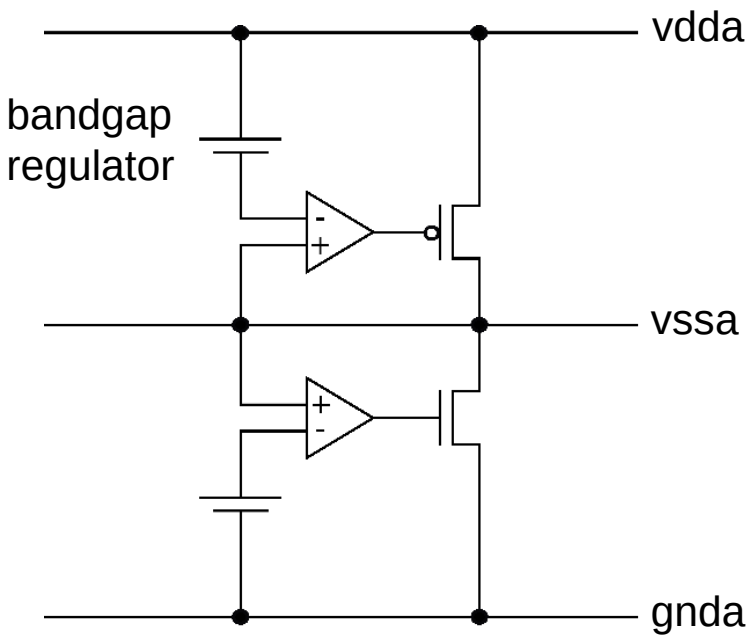
Regulator Element

- Same element with very small modifications for every solution
- Very small temperature dependency
- 8 tune bits
- Actual design as simple as possible, without linear regulator and as less space consuming as possible



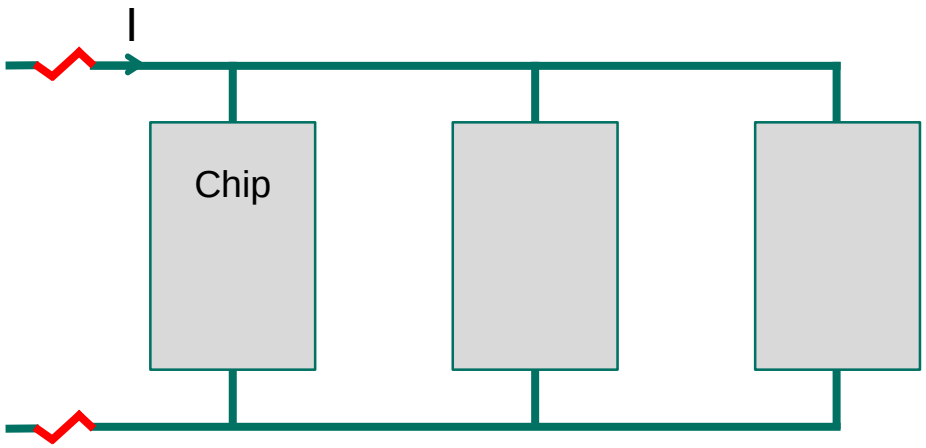
Regulator Element

- Same element with very small modifications for every solution
- Very small temperature dependency
- 8 tune bits
- Actual design as simple as possible, without linear regulator and very compact
- Functional concept is shown here:
  - bandgap regulator works like a battery, which supply a fixed current
  - in real circuit only one bandgap, current is mirrored
  - two differential amplifiers



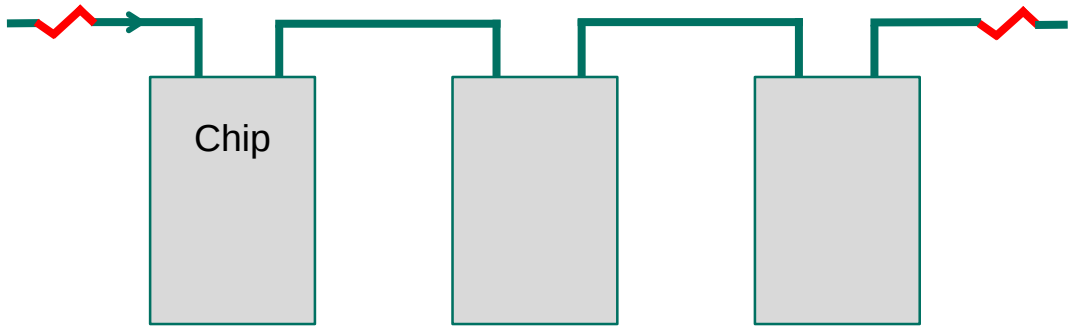
Serial powering – Introduction to standard concepts

- Parallel Powering



  - chip connection parallel, all outputs on same voltage level

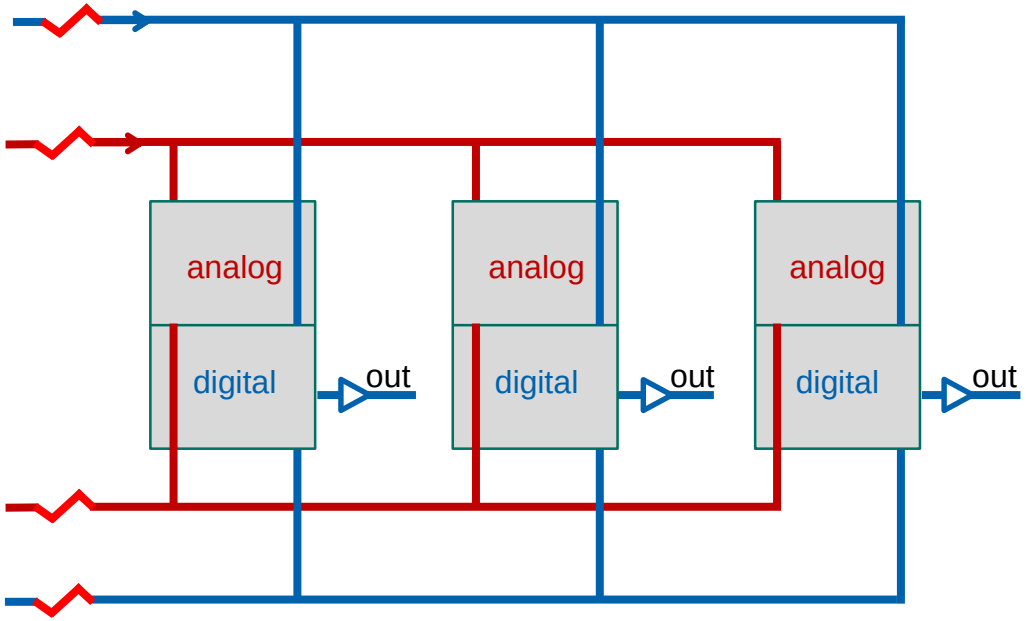
- Serial Powering



  - chip connection serial, all outputs on a different voltage level

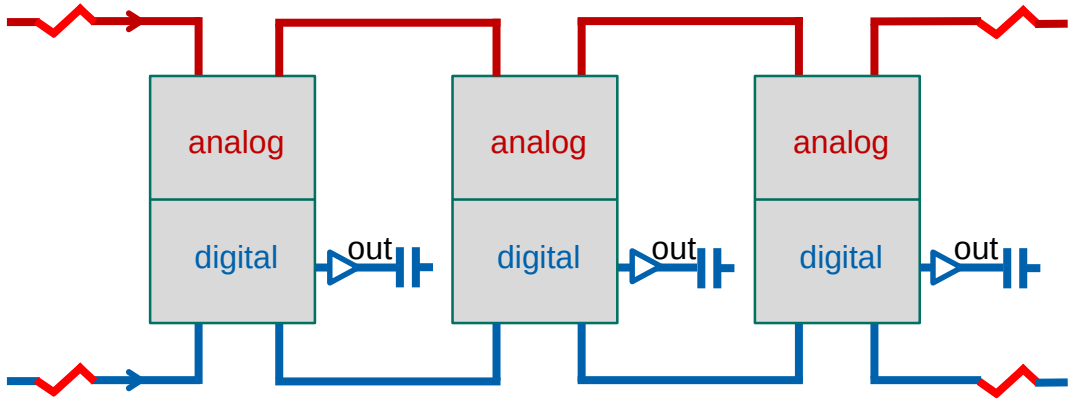
Serial powering – Introduction to HVCMOS concepts

- Parallel Powering



  - Analog and digital powering separated in two circuits
  - All digital levels are the same

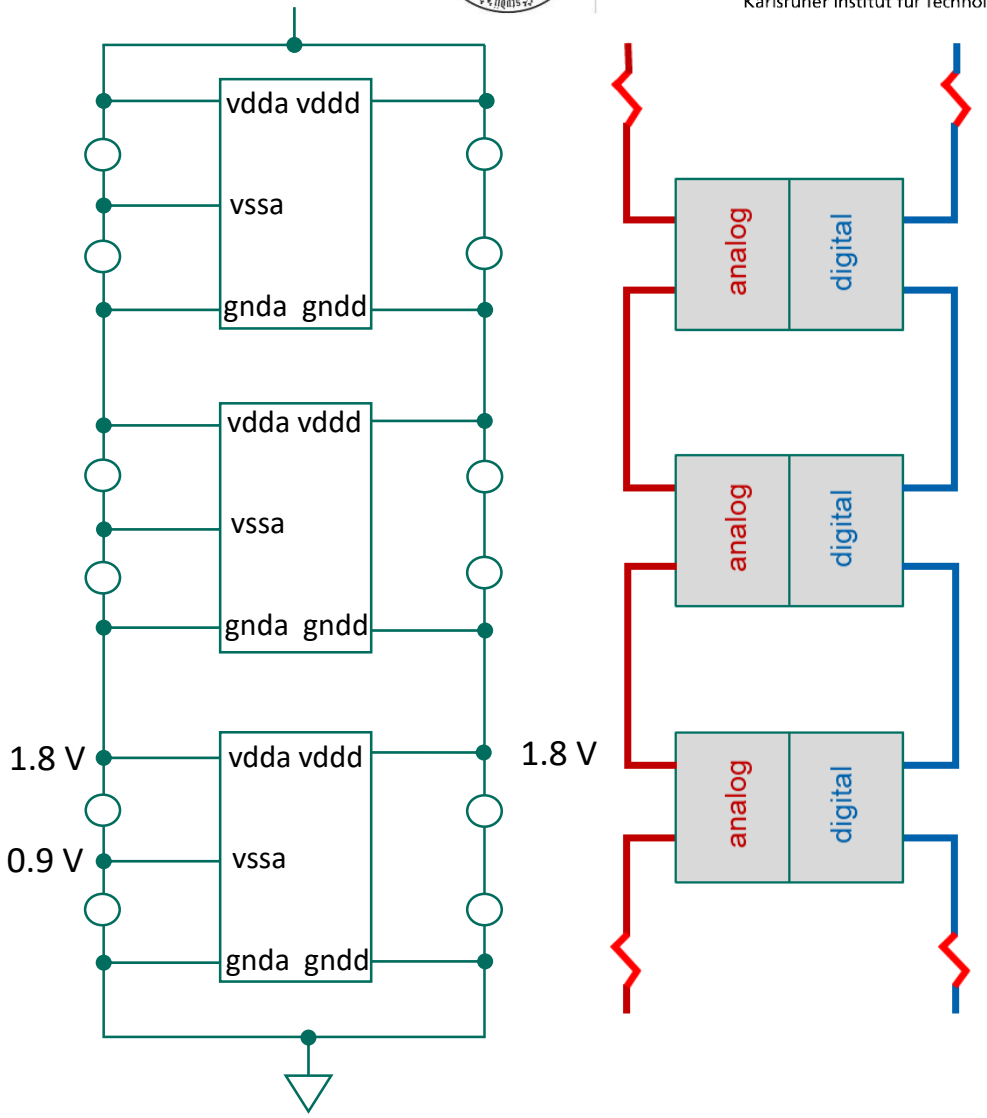
- Serial Powering



  - chip connection serial, all outputs on a different voltage level
  - Solution: conductive coupling

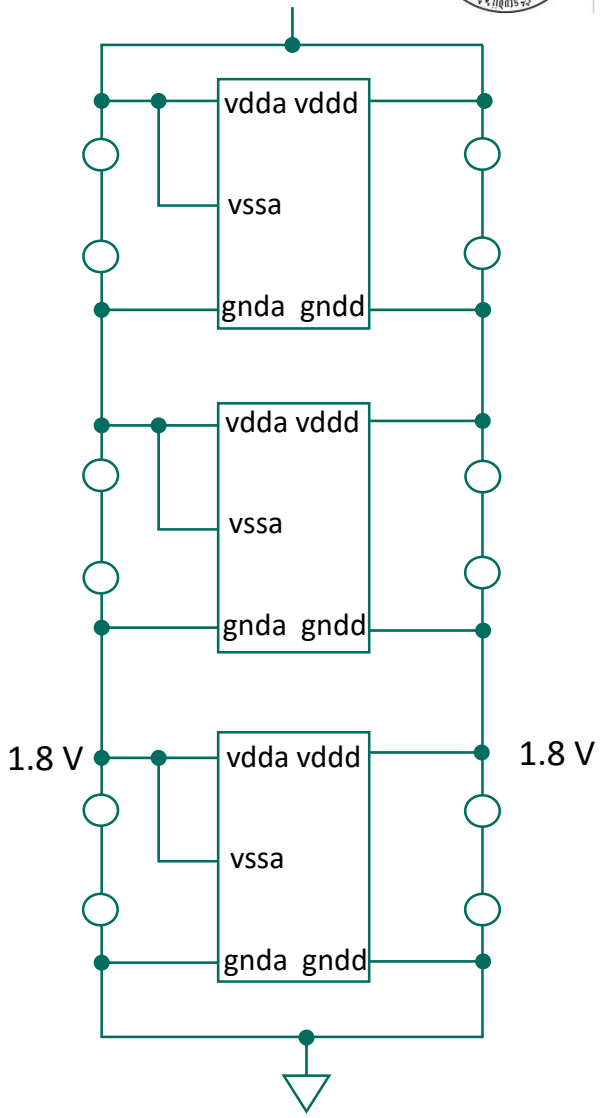
Chip interconnection concepts for serial powering
Concept 1: vdda and vssa separated

- Analog and digital voltage separated for lower noise
- Analog part with vdda (1.8 V) and vssa (0.9 V)
- Regulator element represented with two circles



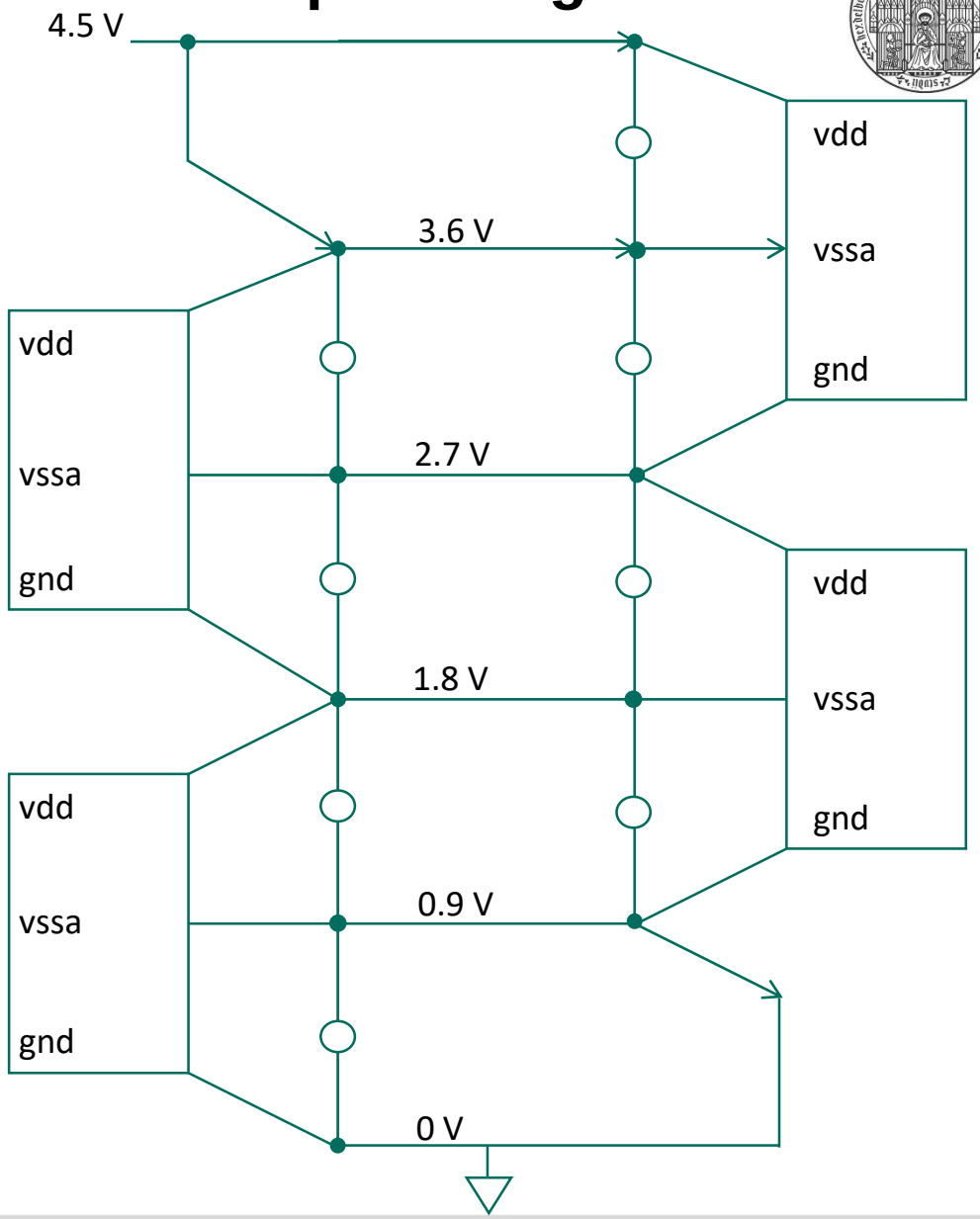
Chip interconnection concepts for serial powering
Concept 2: vdda = vssa

- Similar to concept 2, but:
- vssa = vdda = 1.8 V
- Redesign of pixel amplifier necessary



Chip interconnection concepts for serial powering
Concept 3: shared voltage

- Lower input current
- Less power consumption
- “Shared voltage”



Chip interconnection concepts for serial powering
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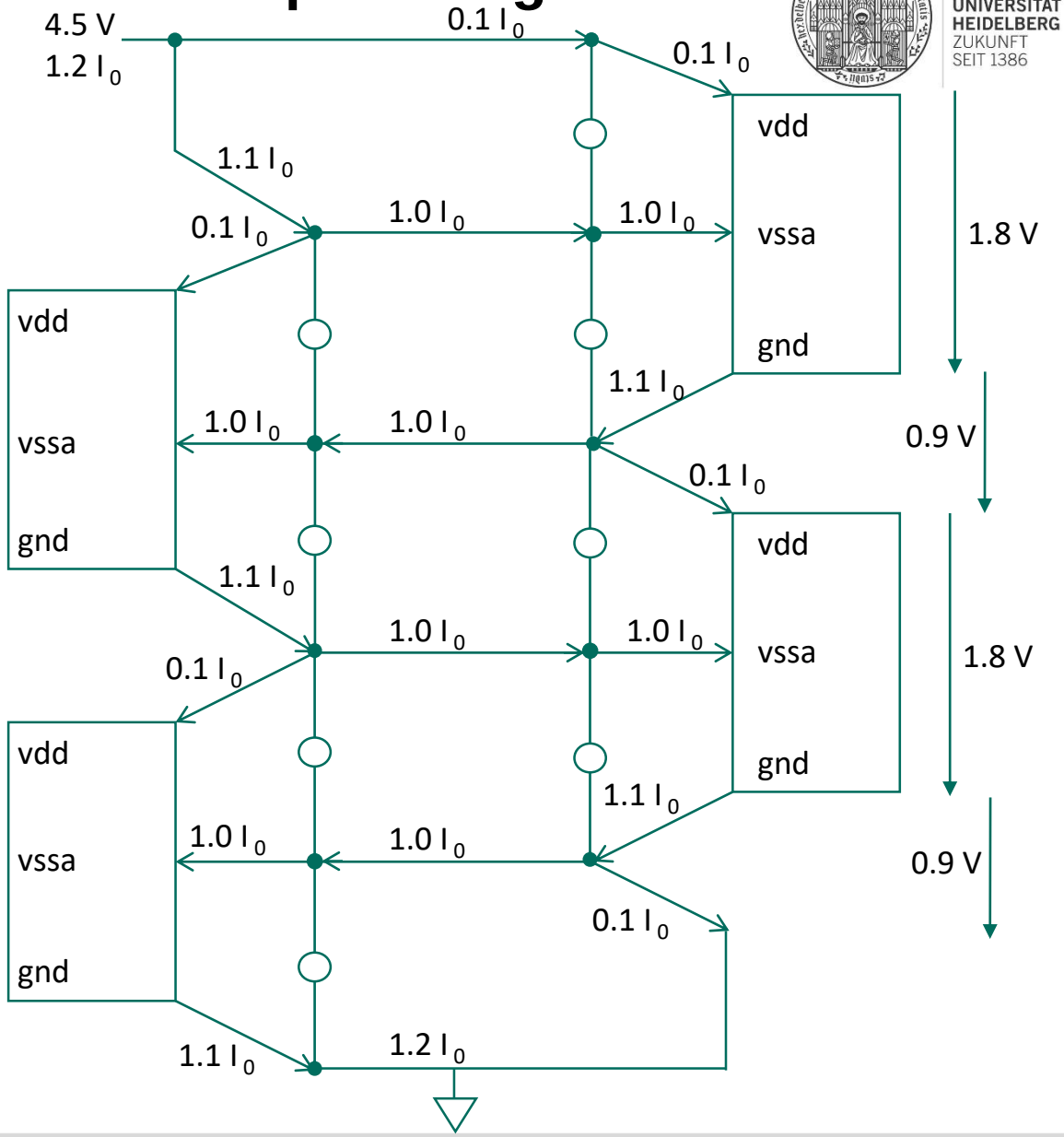
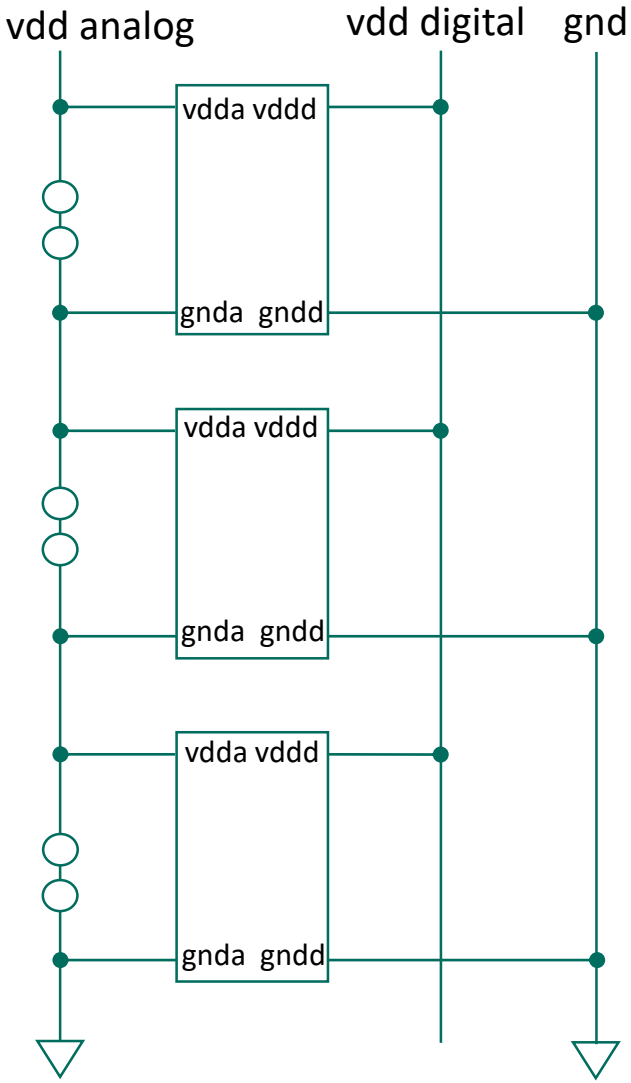


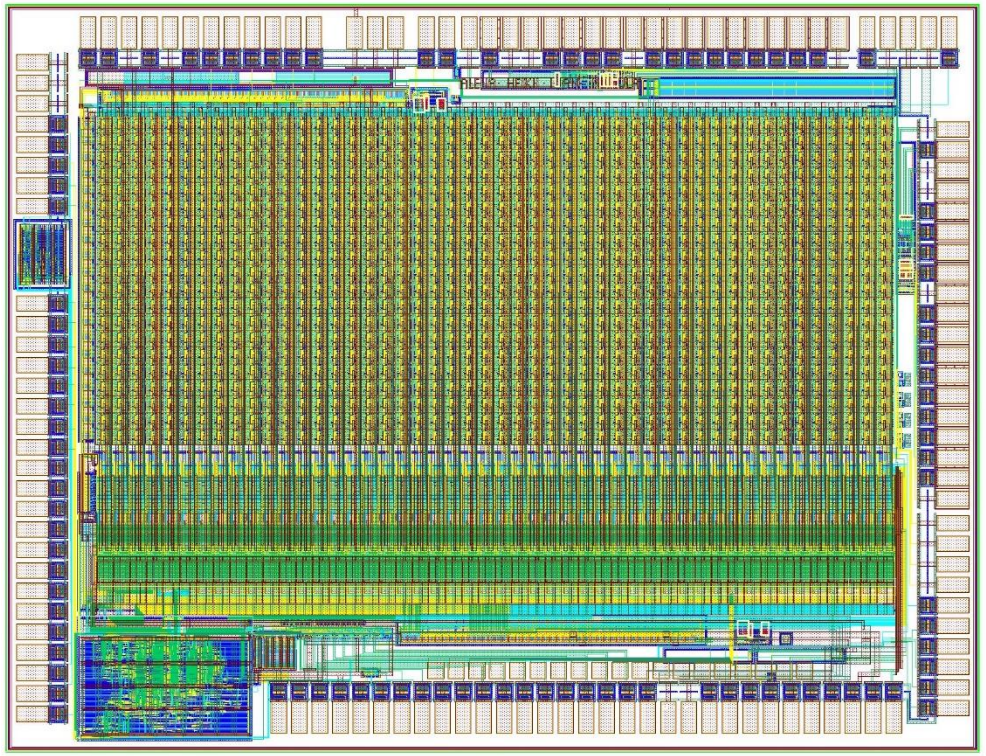
Chip interconnection concepts for serial powering
Concept 4: analog part serial, digital part parallel

- Analog and digital voltage separated
- Analog part serial, digital part parallel
- For analog part all concepts that were presented can be used



Version implemented on MuPix9

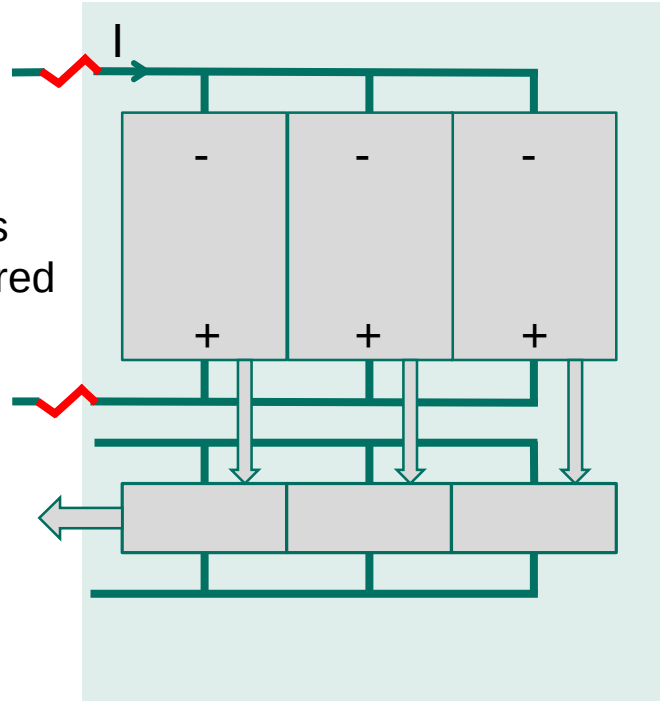
- Analog and digital power separated and capacitive coupled
- Two power regulators, one for the analogue part and one for the digital part
- Each power regulator can be testes as stand alone without out the matrix but also can be connected to the pixel matrix

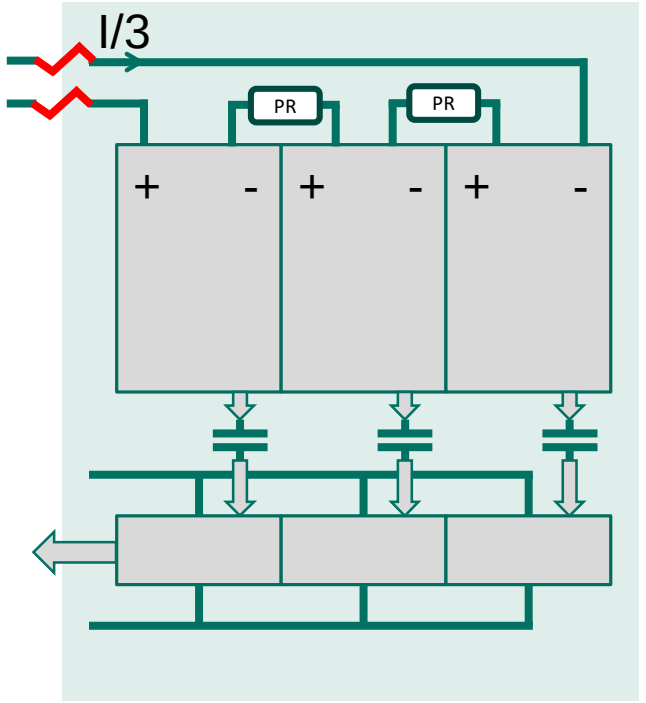


Vision for next generation MuPix

- On a full-size MuPix: three submatrices similar to MuPix8, but every submatrix identical
  - submatrices powered in serial
  - digital and analog power disconnected and captive coupled
  - chips powered in parallel
  - leads to a current reduction of 2/3

3 submatrices
parallel powered





3 submatrices
serial powered

Outlook

- In summer 2018 start testing of MuPix9
- Based on the test results of MuPix9 further improvement of the design of the power regulatc
- With results review of the serial power concepts and decision for one solution
- Next submission maybe end of 2018
- Final MuPix release in 2019
  - Minimal number of pads at the bottom side
  - Divided pixel matrix
  - Small pixel readout electronics
  - State machine with slow control
  - Two power regulators