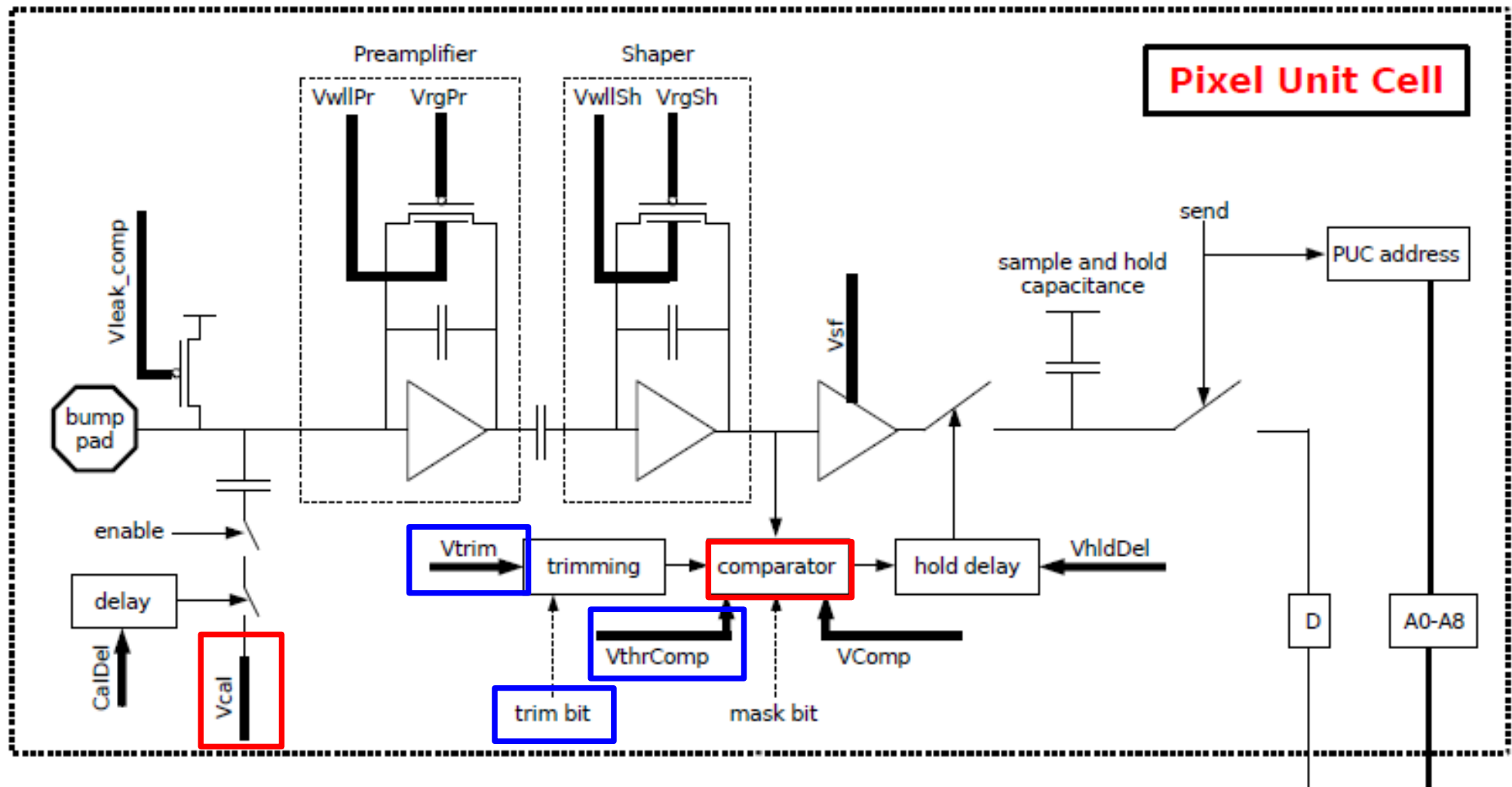


# **noise studies**

Ievgen Korol, G. Dolinska, Daniel Pitzl, DESY  
Hamburg CMS Pixel Upgrade meeting, 16.11.2012

- S-curve
- noise
- ROCs without and with sensor

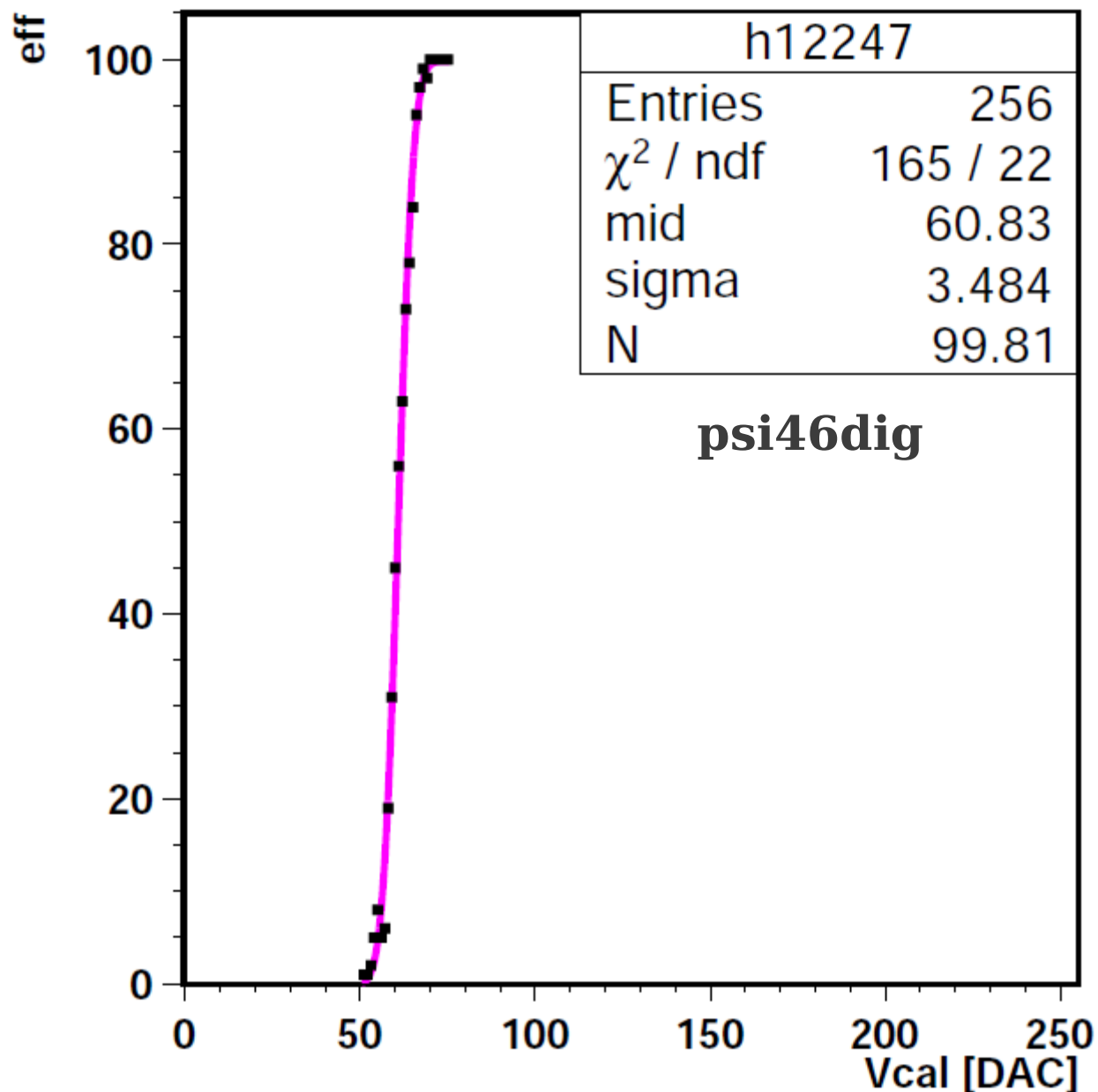
# Threshold



$$\text{Threshold} = V_{thrComp} - V_{trim} \cdot (15 - \text{trimbits})$$

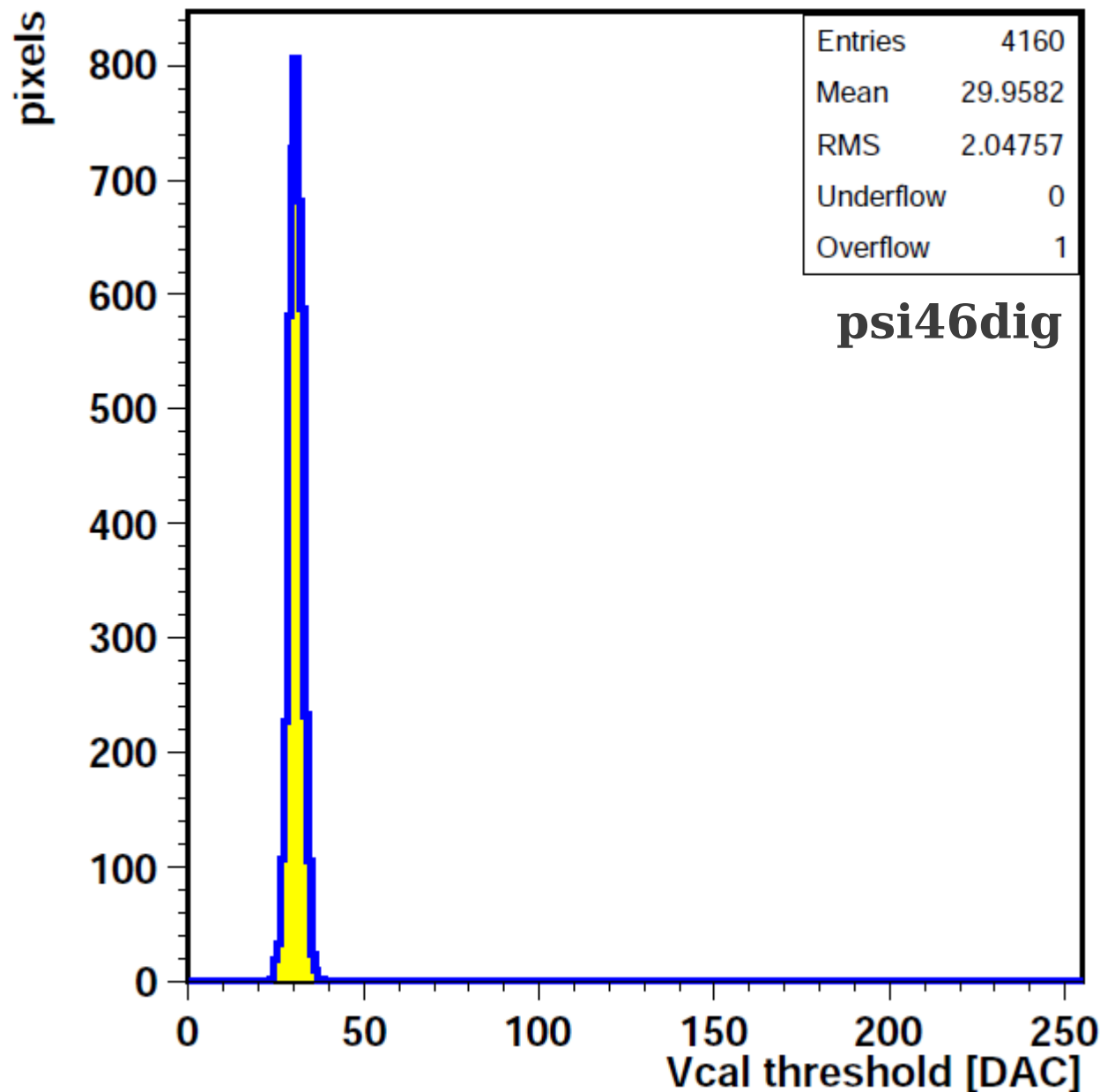
**measure threshold from efficiency vs Vcal test pulse**

# Threshold curve



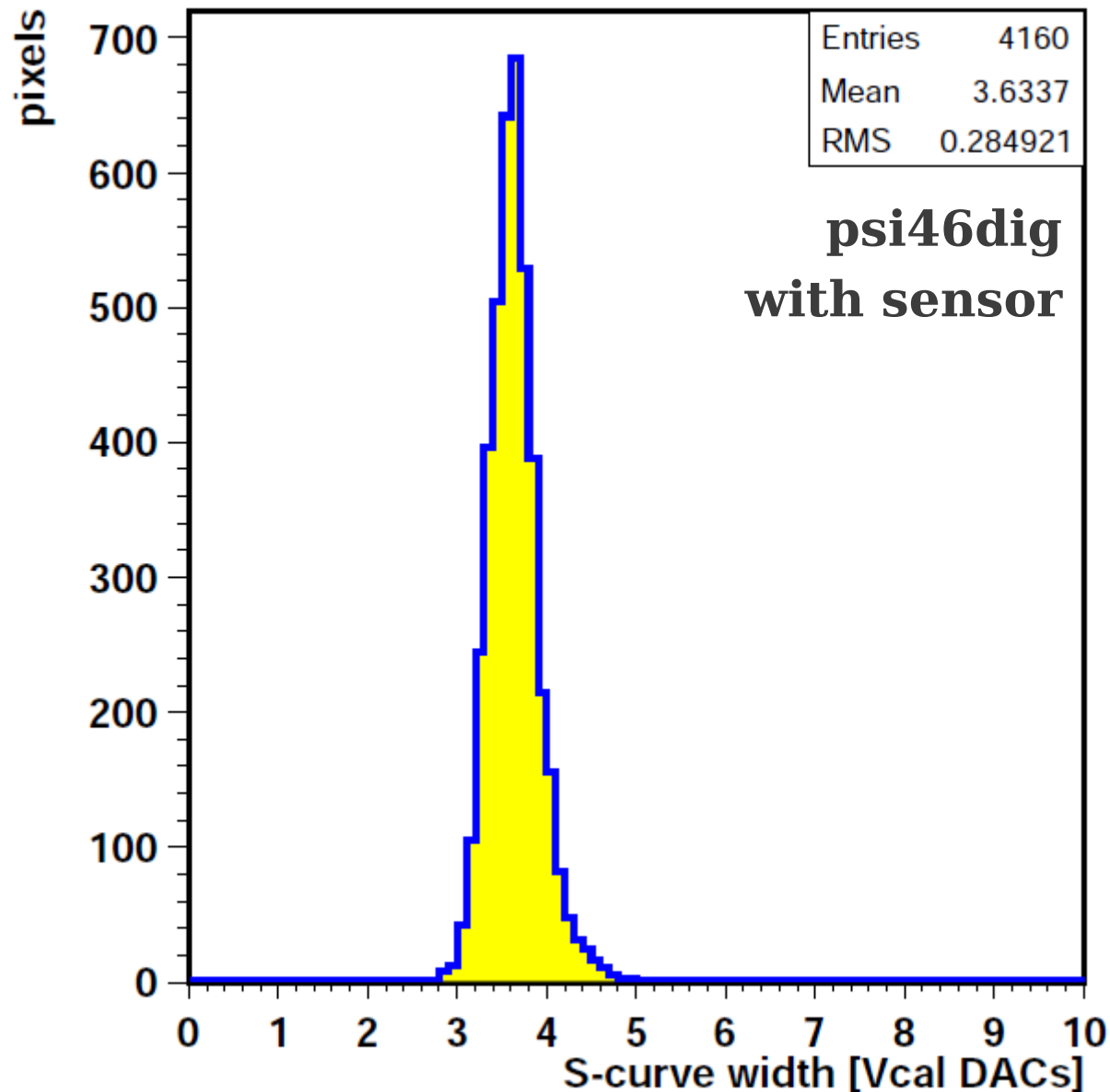
- Digital Chip 202
  - Ia 30 mA
  - trim 60
  - pixel (28, 7)
- Standard S-curve:
  - pixel efficiency vs small Vcal
- Fit by error function:
  - mid = threshold
  - sigma = noise

# Threshold distribution



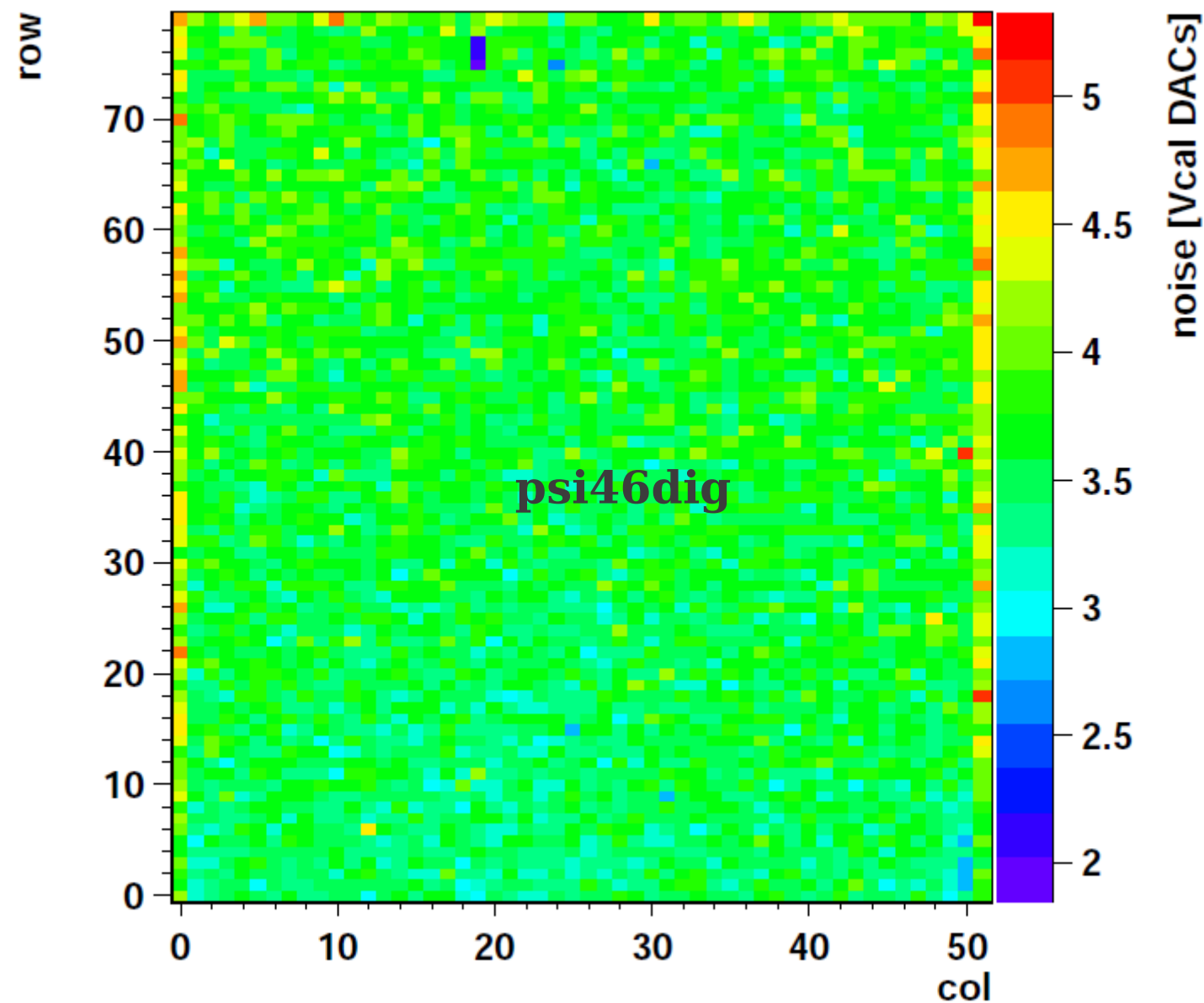
- Digital Chip 202
  - Ia 30 mA
  - trim 30
  - with sensor, -150 V
- nice narrow threshold distribution.

# Noise distribution digital ROC with sensor



- Digital Chip 202
  - with sensor
  - Ia 30 mA
- Width of S-curve = noise
  - 3.63 DAC = **180 e**

# Noise map with digital ROC



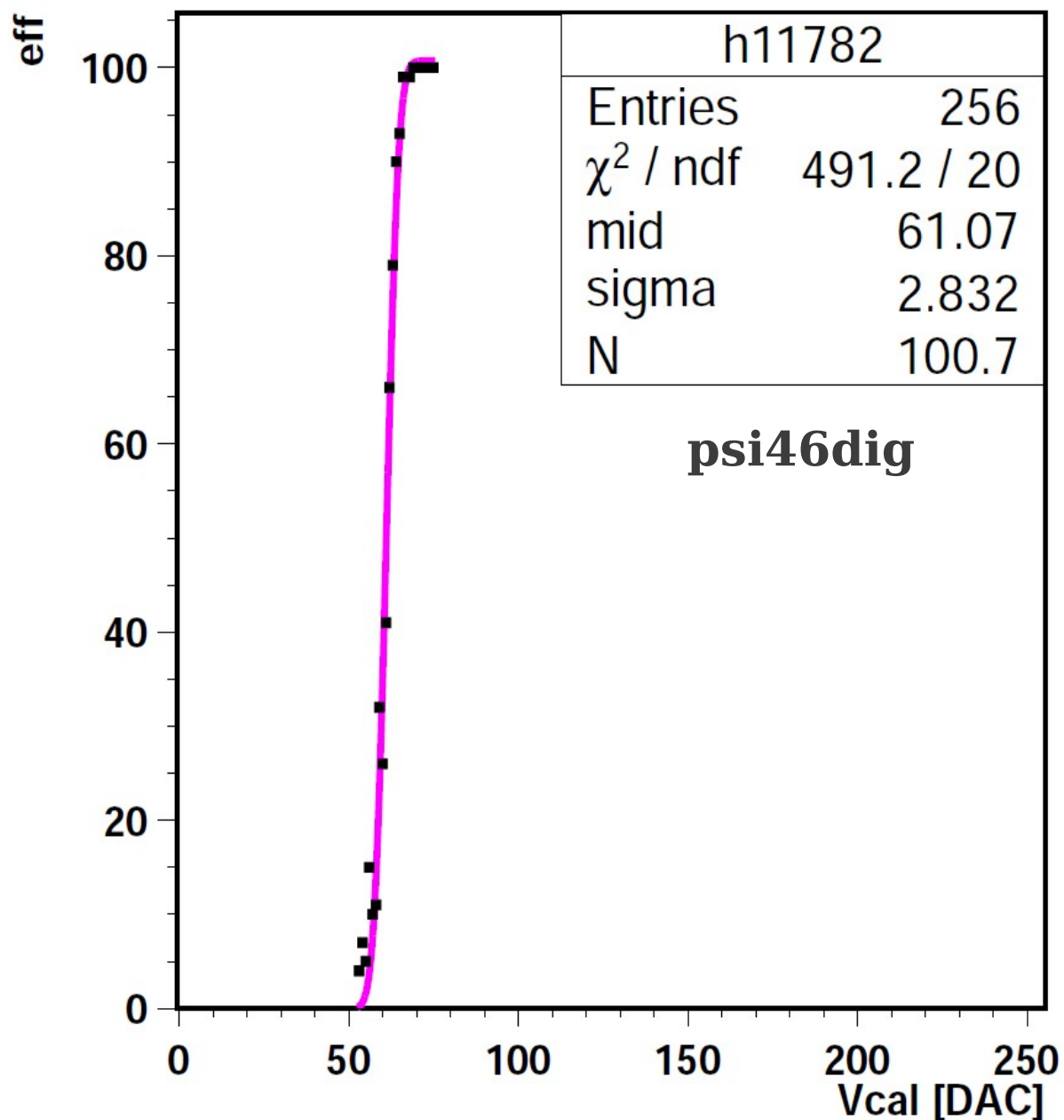
- Digital Chip 202
  - with sensor
  - Ia 30 mA
- Noise from width of S-curves
- Big pixels at the borders have larger noise (more sensor capacitance)
- 4 pixels with missing bump bonds appear with lower noise
- trend along row?

# **chip39**

**Psi46dig with sensor**

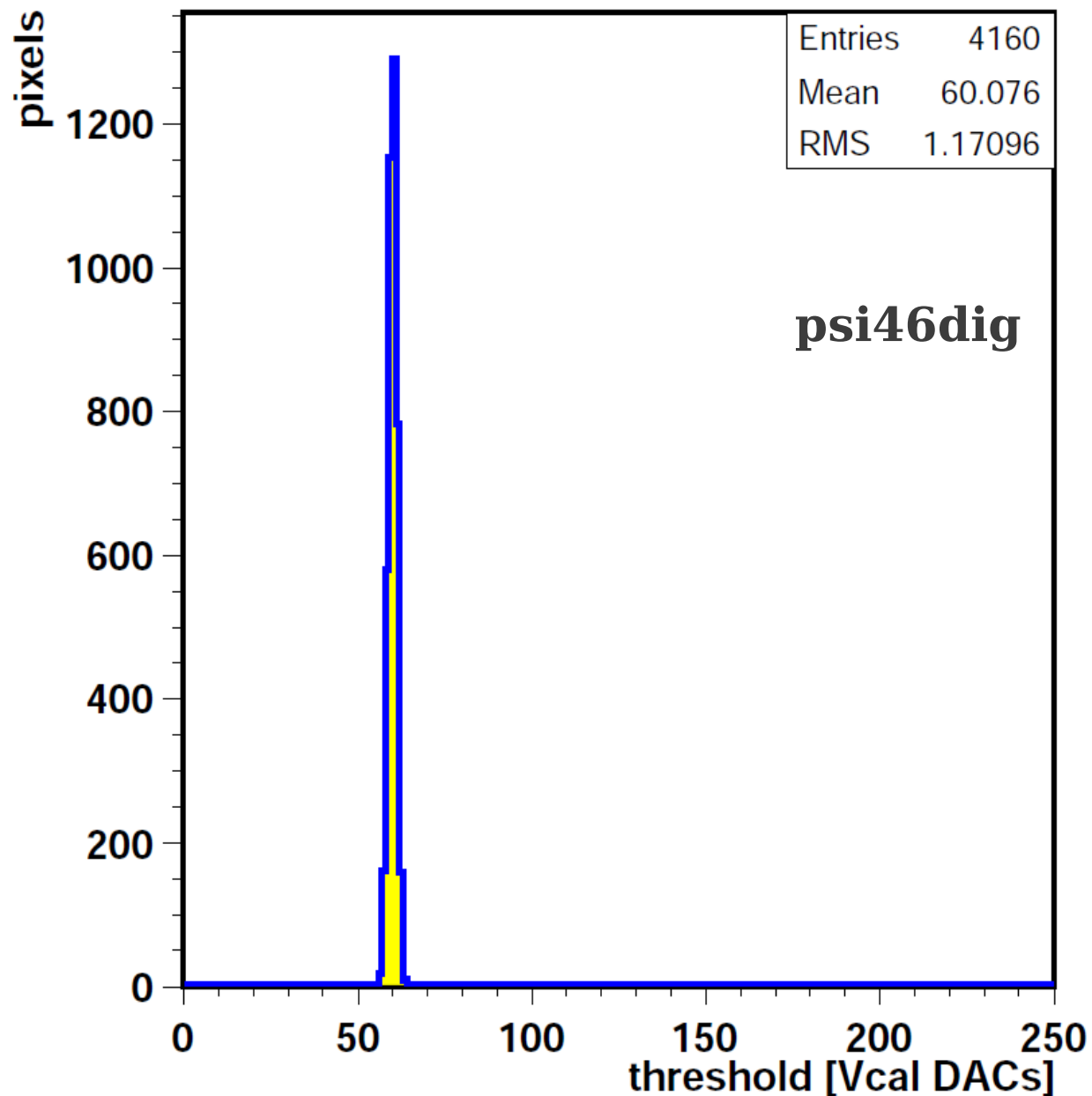
**On loan from Uni Hamburg**

# Threshold curve



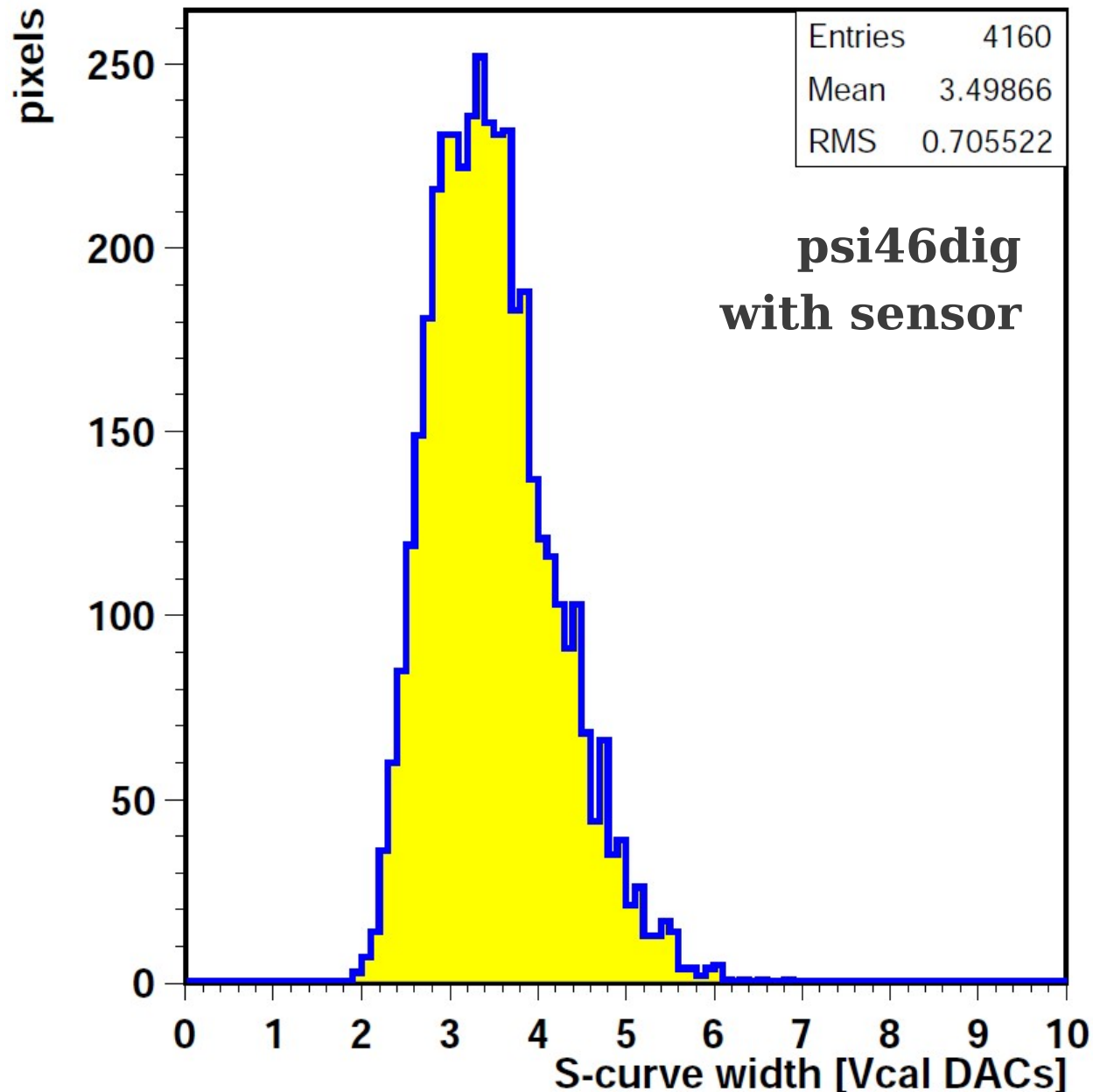
- Digital Chip 39
  - with sensor
  - Ia 35 mA
  - trim 60
  - pixel (22, 22)
- Standard S-curve:
  - pixel efficiency vs small Vcal
- Fit by error function:
  - mid = threshold
  - sigma = noise

# Threshold distribution



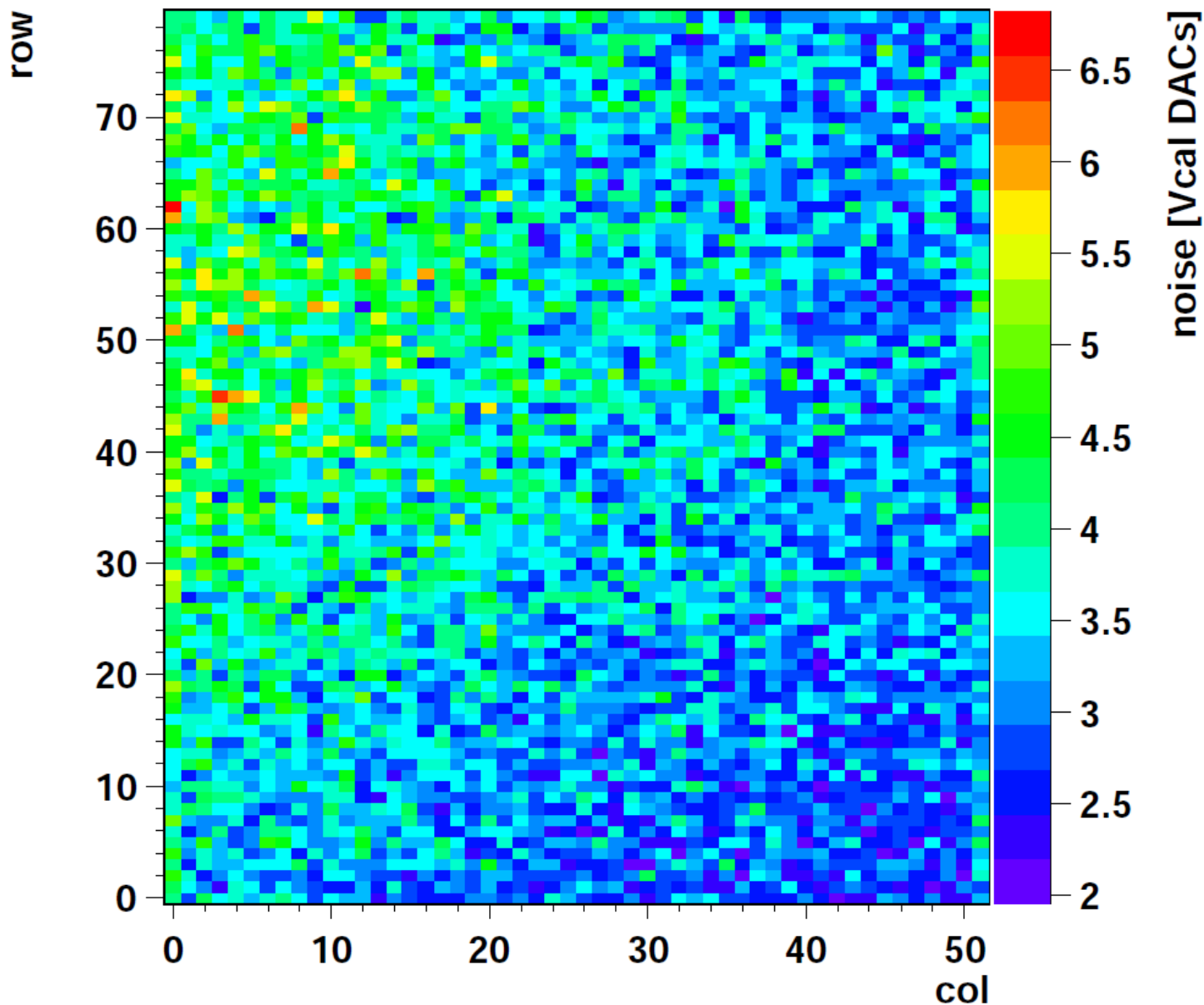
- Digital Chip 39
  - Ia 35 mA
  - trim 60
  - with sensor, -90 V
- nice narrow threshold distribution.

# Noise distribution with digital ROC sensor



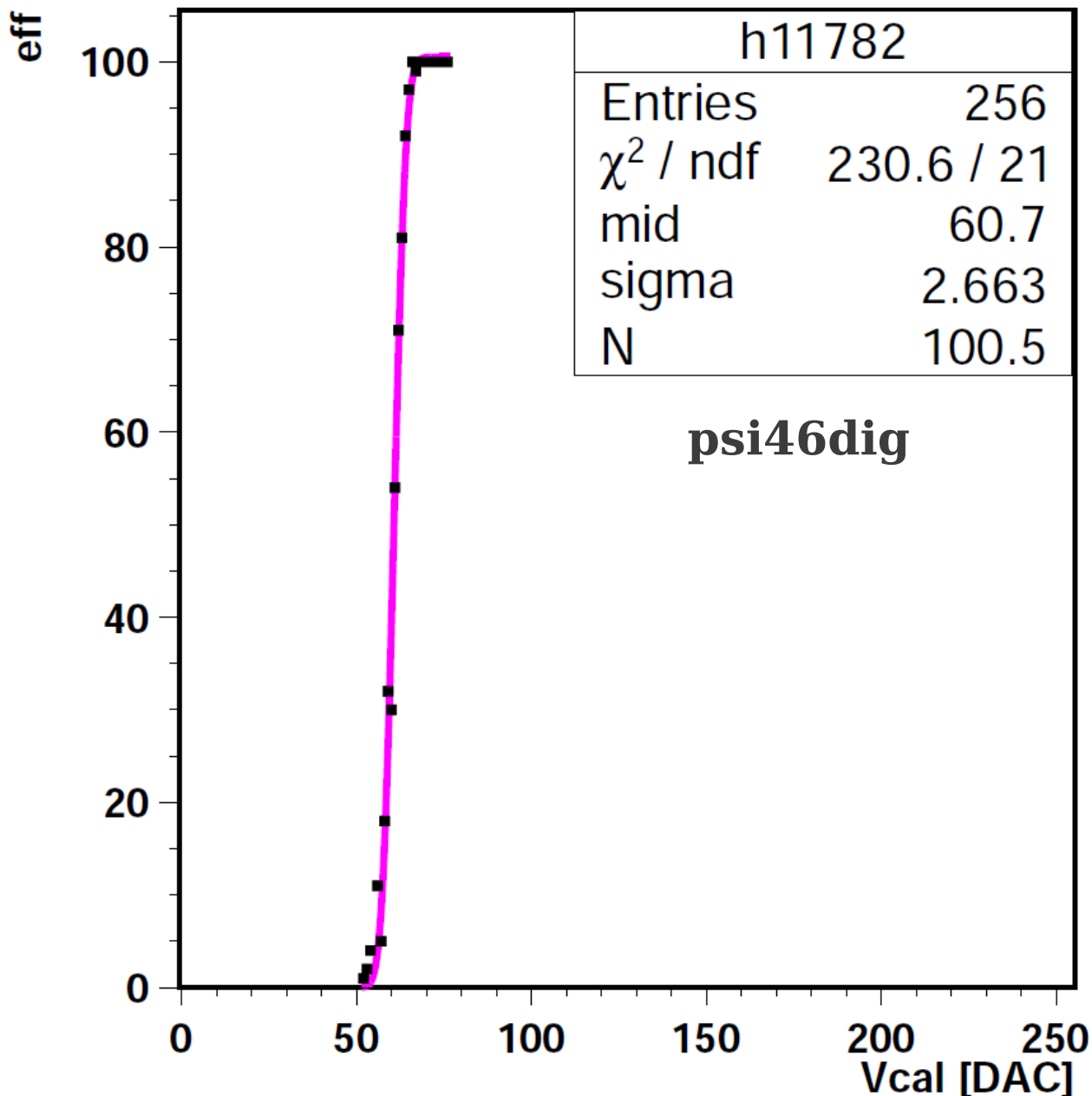
- Digital Chip 39
  - with sensor
  - **Ia 35 mA**
- Width of S-curve = noise
  - 3.5 DAC = **175 e**

# Noise map with digital ROC



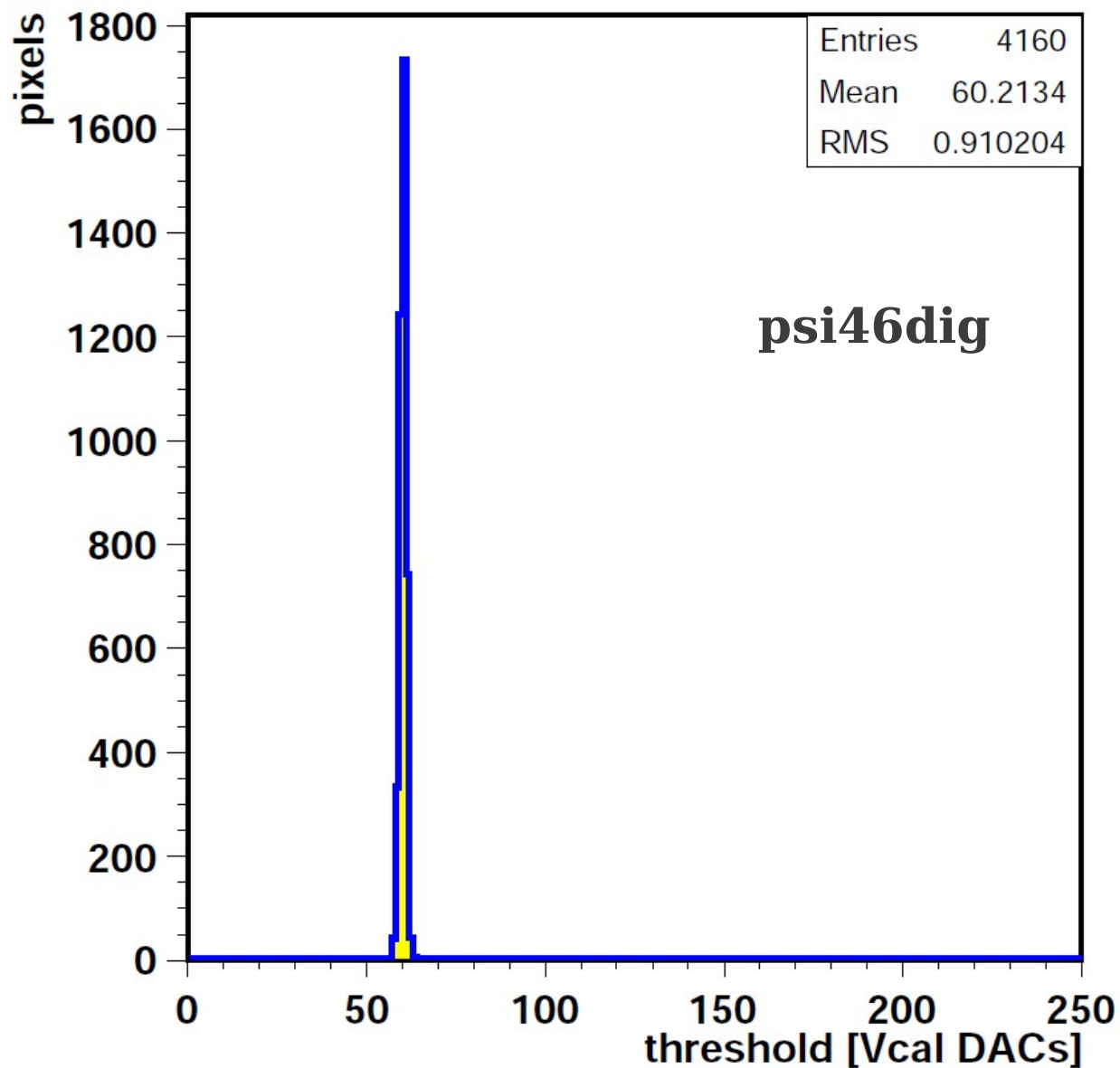
- Digital Chip 39
  - with sensor
  - **Ia 35 mA**
- Noise from width of S-curves
  - trend towards upper left?
  - Big pixels at the borders have larger noise (more sensor capacitance)

# Threshold curve at 40 mA analog current



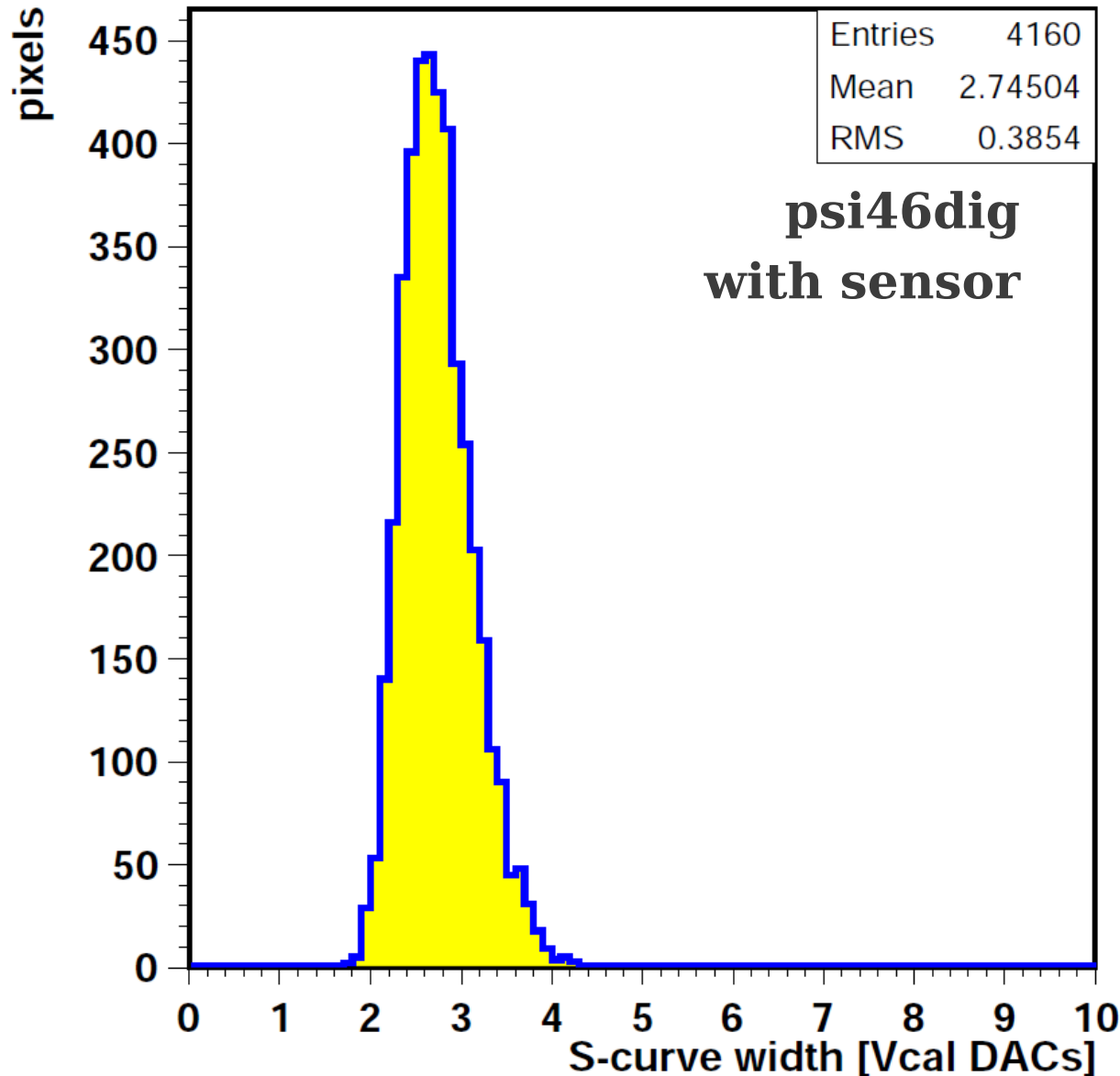
- Digital Chip 39
  - with sensor
  - **Ia 40 mA**
  - trim 60
  - pixel (22, 22)
- Standard S-curve:
  - pixel efficiency vs small Vcal
- Fit by error function:
  - mid = threshold
  - sigma = noise

# Threshold distribution



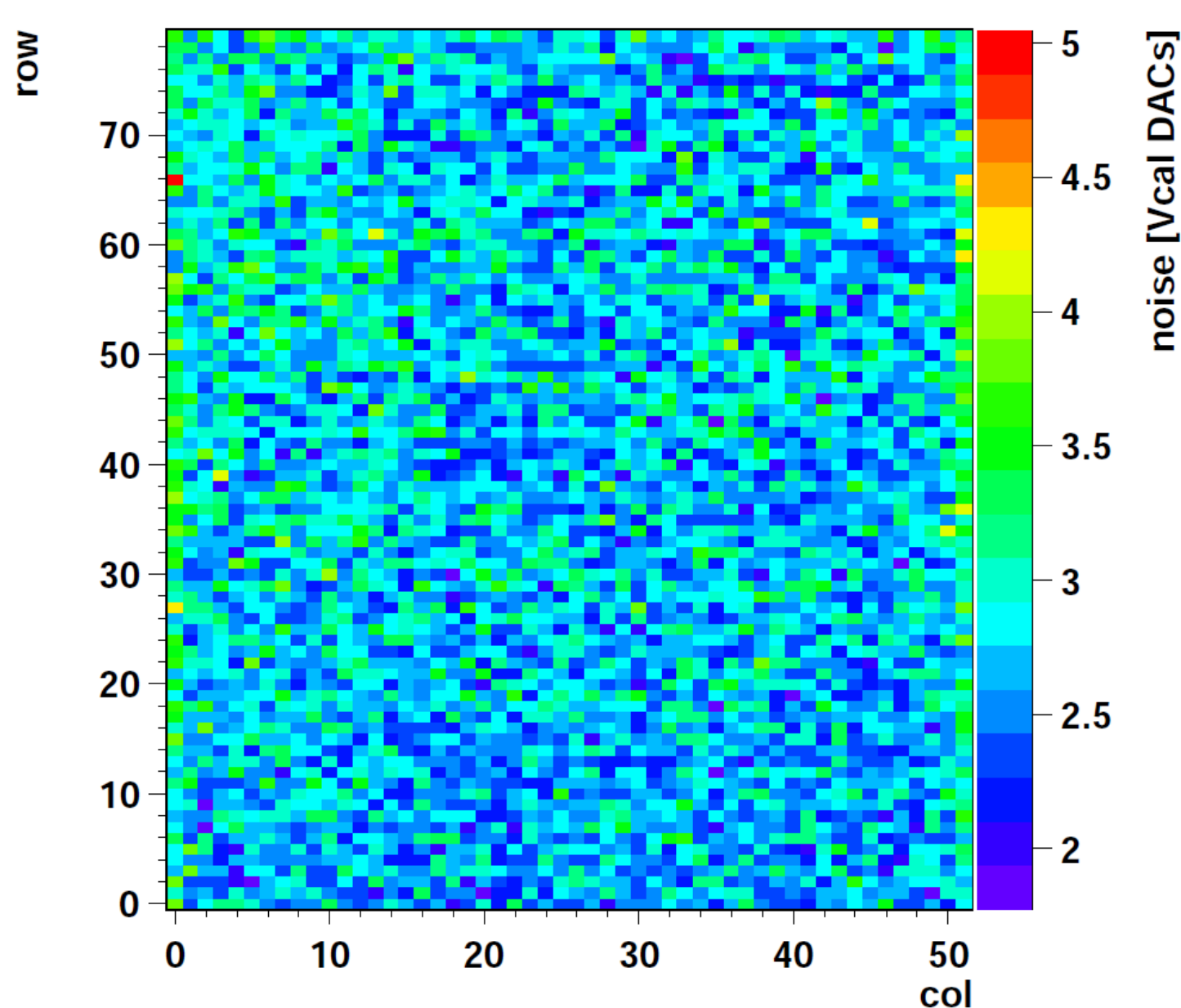
- Digital Chip 39
  - Ia 40 mA
  - trim 60
  - with sensor, -90 V
- nice narrow threshold distribution.

# Noise distribution with digital ROC sensor



- Digital Chip 39
  - with sensor
  - **Ia 40 mA**
- Width of S-curve = noise
  - 2.75 DAC = **140 e**
  - **More power = less noise!**

# Noise map with digital ROC

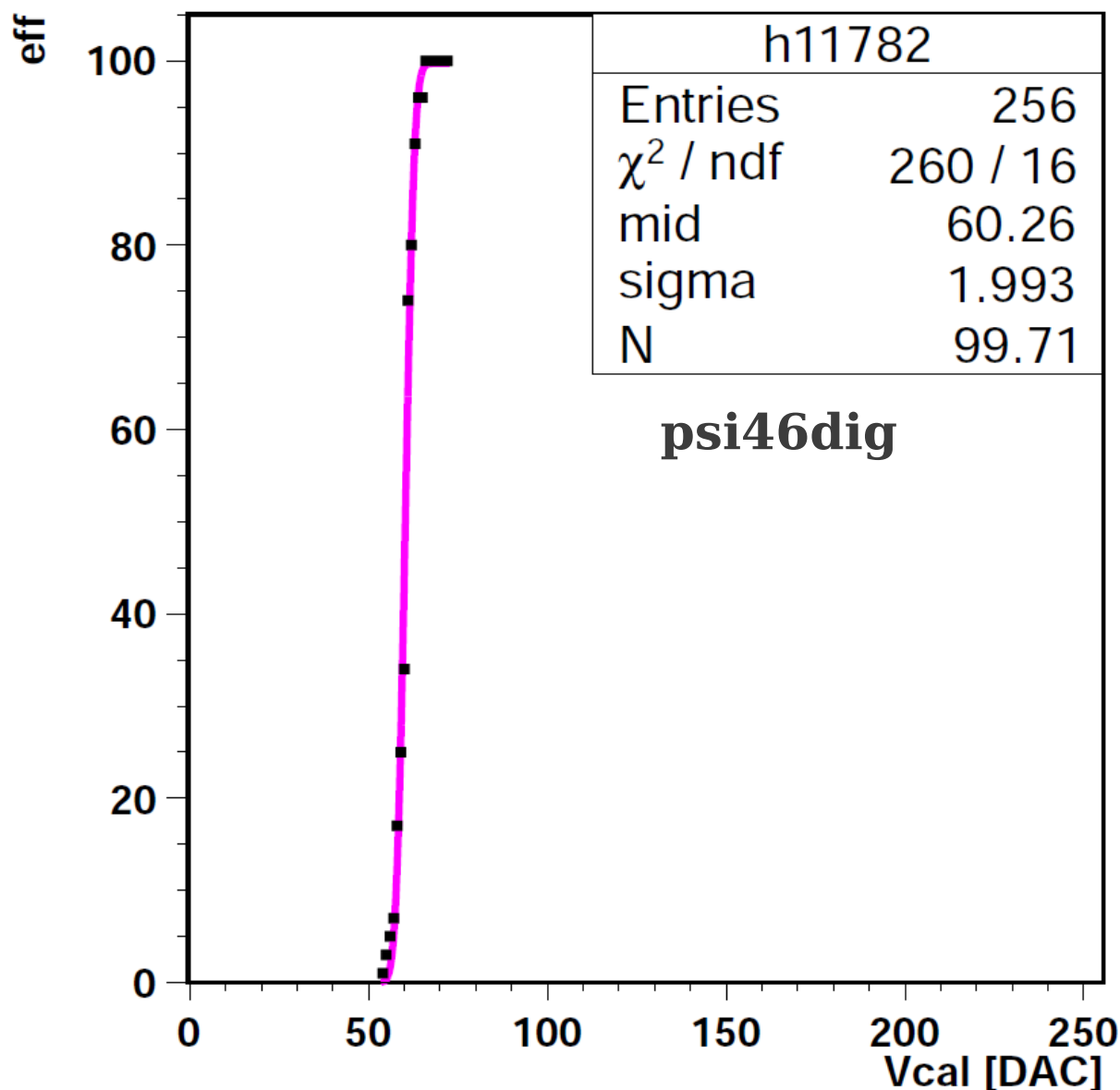


- Digital Chip 39
  - with sensor
  - **Ia 40 mA**
- Noise from width of S-curves
- Big pixels at the borders have larger noise (more sensor capacitance)
- No trend

# **chip214**

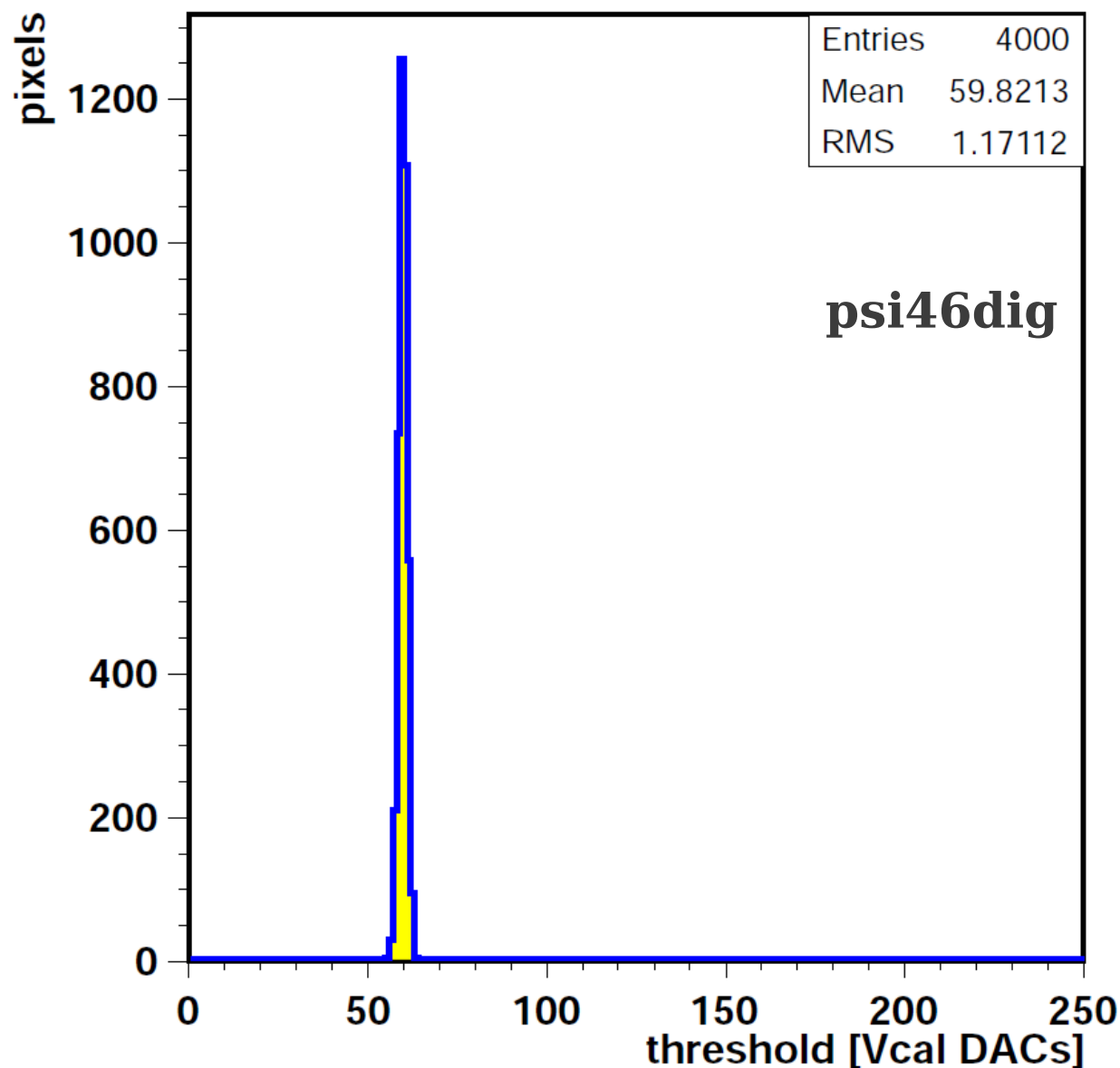
**Psi46dig\_trig without sensor**  
**Old comparator design**

# Threshold curve



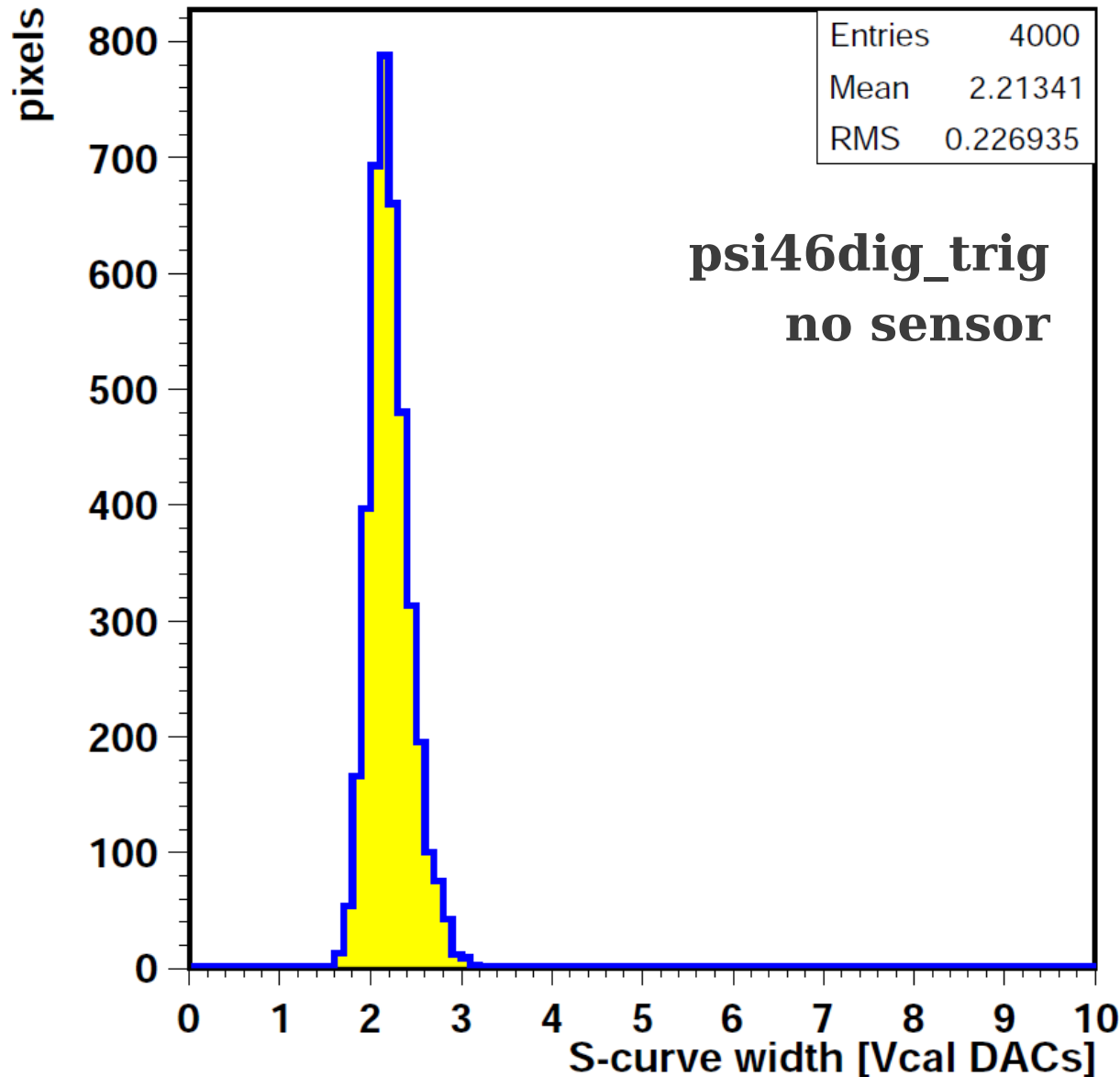
- Digital Chip 214
  - no sensor
  - Ia 40 mA
  - trim 60
  - pixel (22, 22)
- Standard S-curve:
  - pixel efficiency vs small Vcal
- Fit by error function:
  - mid = threshold
  - sigma = noise

# Threshold distribution



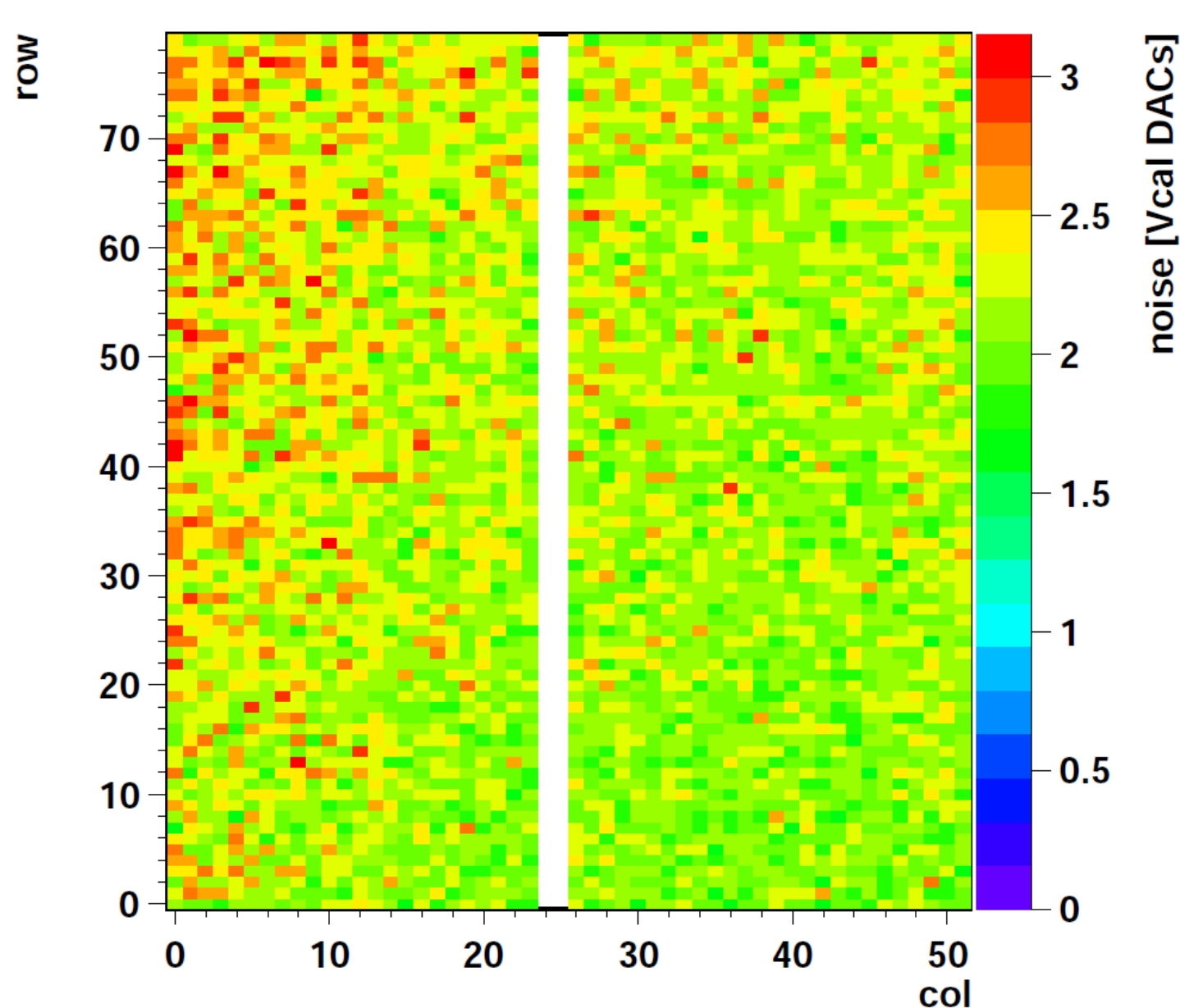
- Digital Chip 214
  - Ia 40 mA
  - trim 60
- nice narrow threshold distribution.

# Noise distribution with digital ROC sensor



- Digital Chip 214
  - **no sensor**
  - Ia 40 mA
- Width of S-curve = noise
  - 2.2 DAC = **110 e**
  - **Less noise without sensor**
  - **Comparator design does not influence noise**

# Noise map with digital ROC

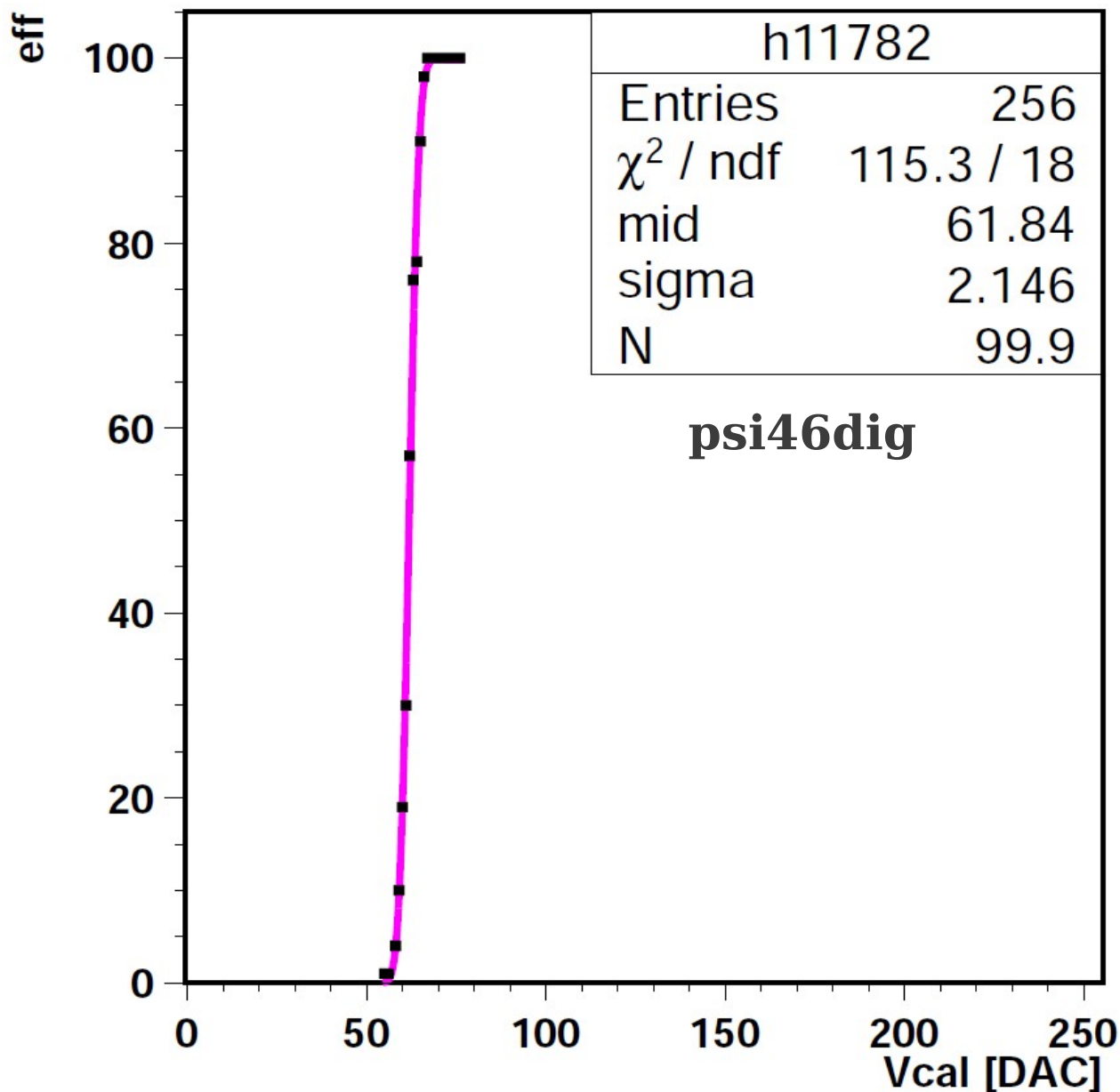


- Digital Chip 214
  - no sensor
  - Ia 40 mA
- Noise from width of S-curves
- trend towards left edge.

# **chip204**

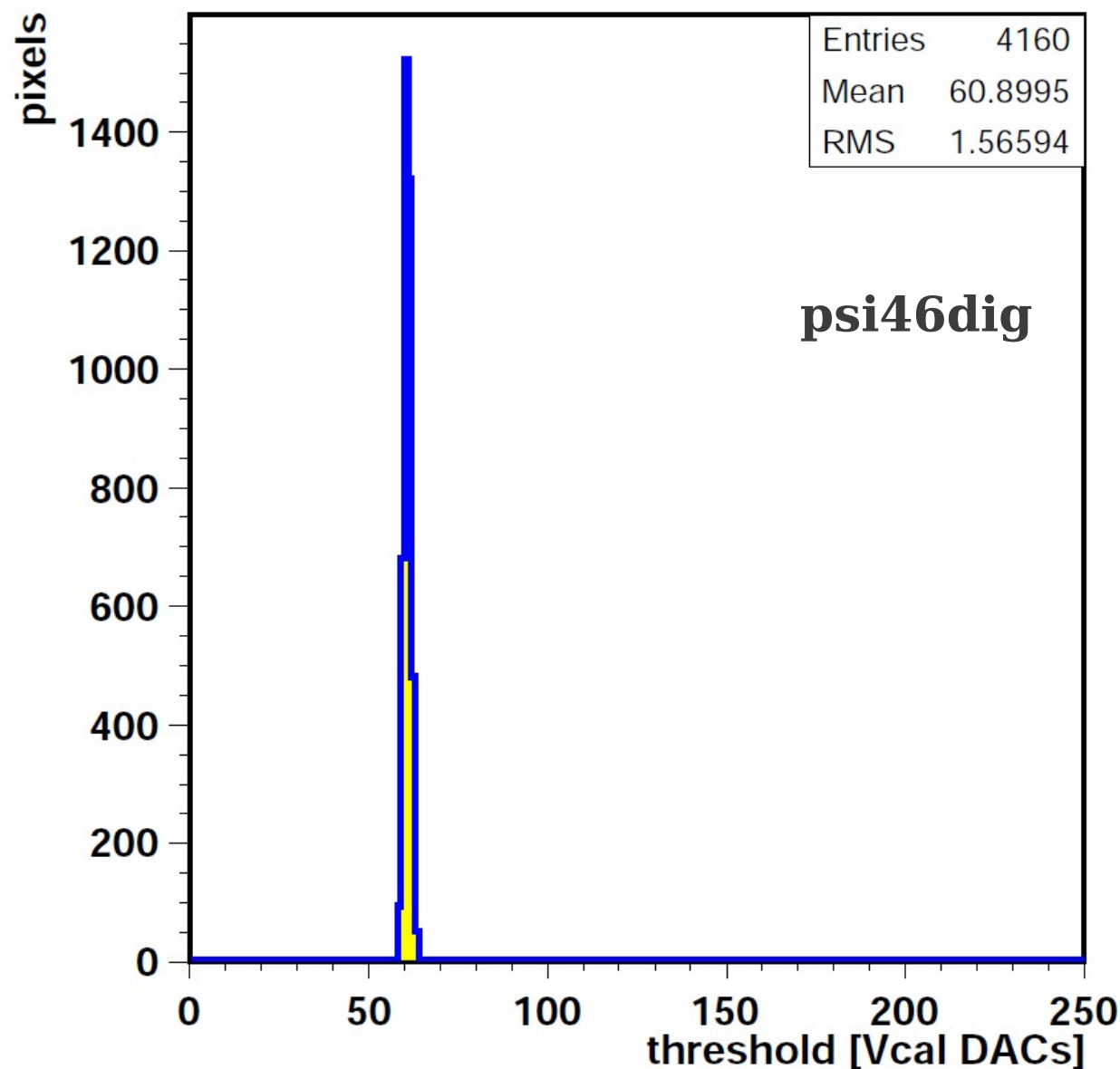
**Psi46dig without sensor**  
**New comparator design**

# Threshold curve



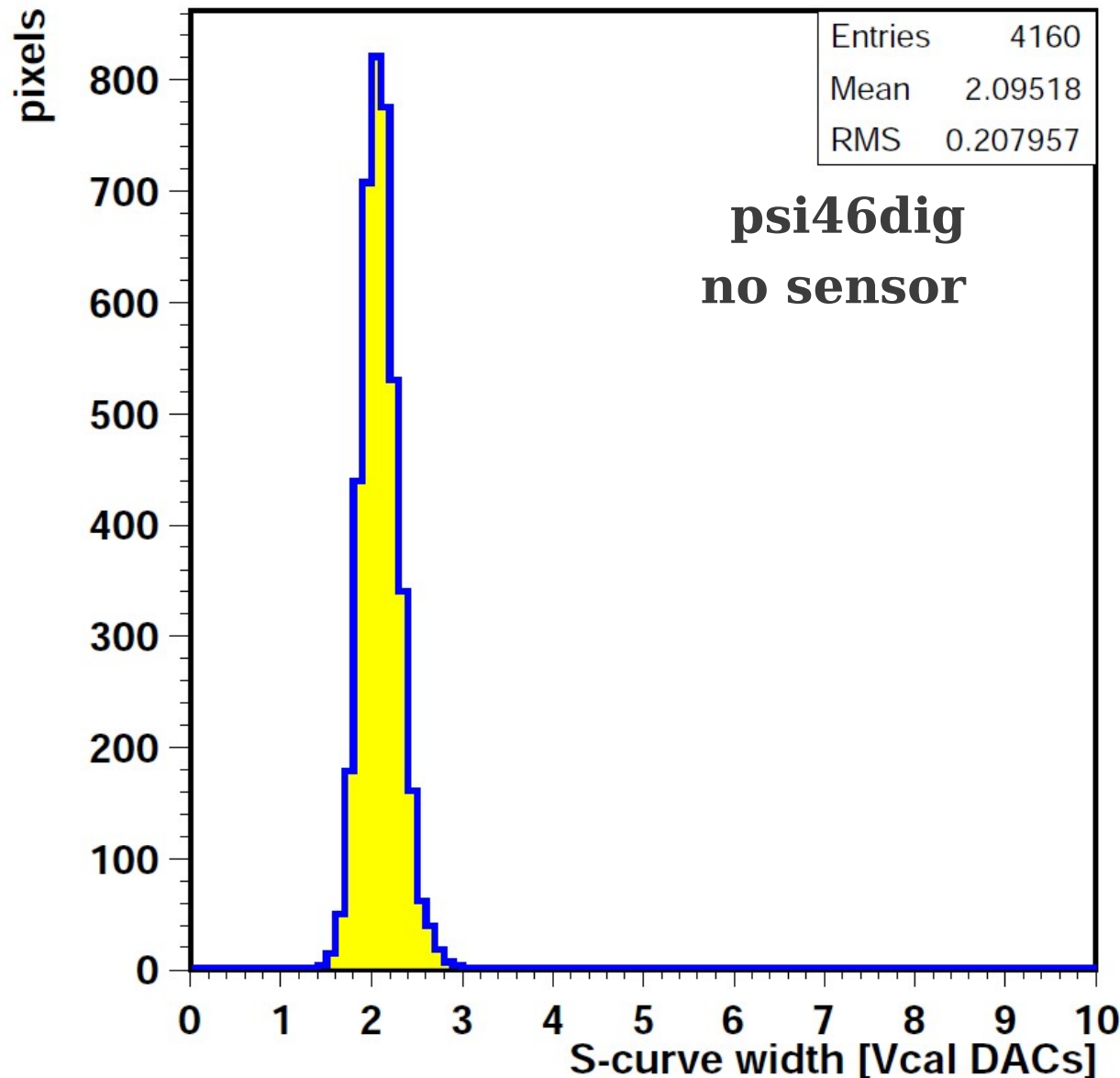
- Digital Chip 204
  - no sensor
  - Ia 35 mA
  - trim 60
  - pixel (22, 22)
- Standard S-curve:
  - pixel efficiency vs small Vcal
- Fit by error function:
  - mid = threshold
  - sigma = noise

# Threshold distribution



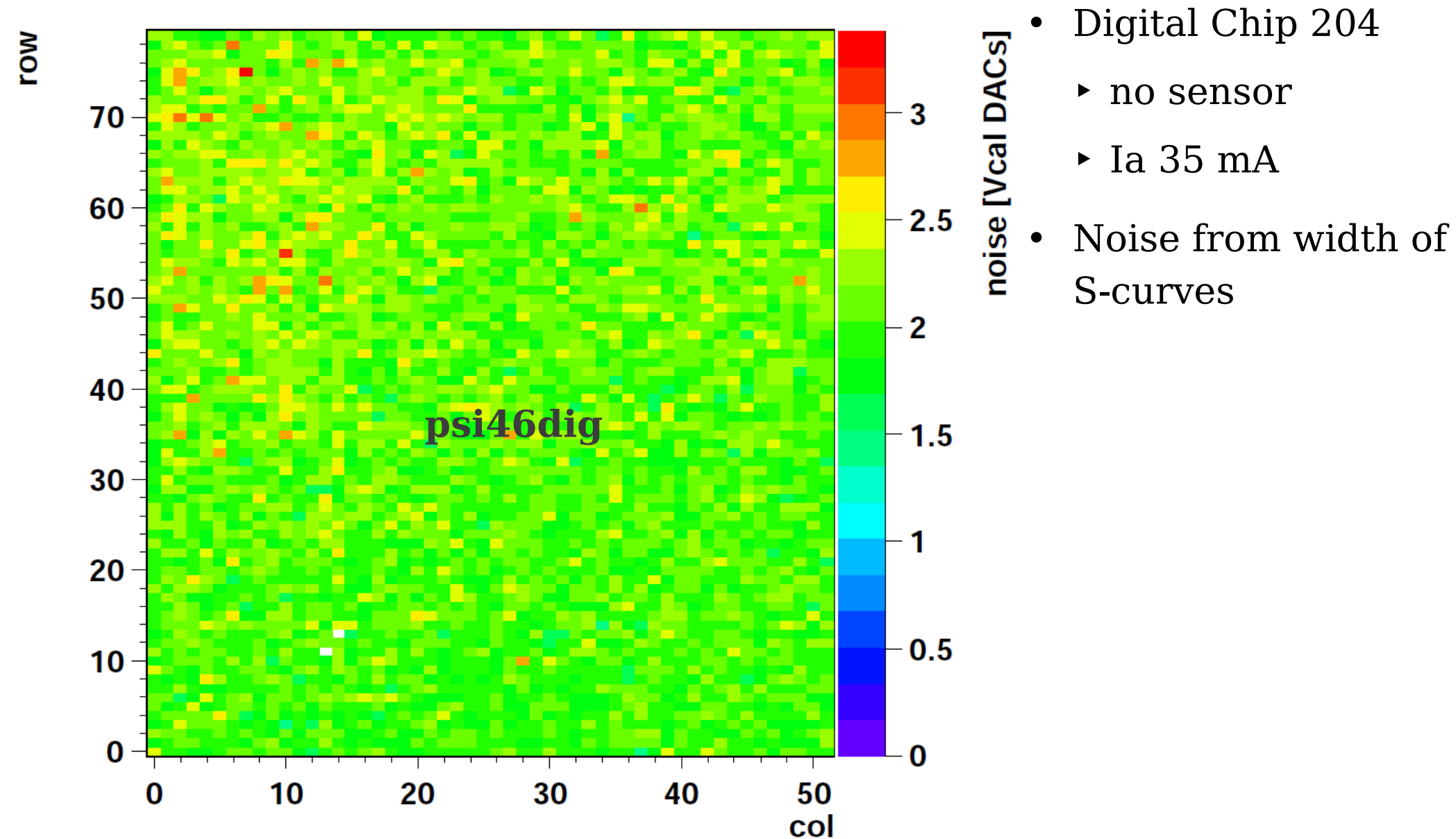
- Digital Chip 204
  - Ia 35 mA
  - trim 60
- nice narrow threshold distribution.

# Noise distribution with digital ROC sensor



- Digital Chip 204
  - no sensor
  - Ia 35 mA
- Width of S-curve = noise
  - 2.1 DAC = **105 e**

# Noise map with digital ROC

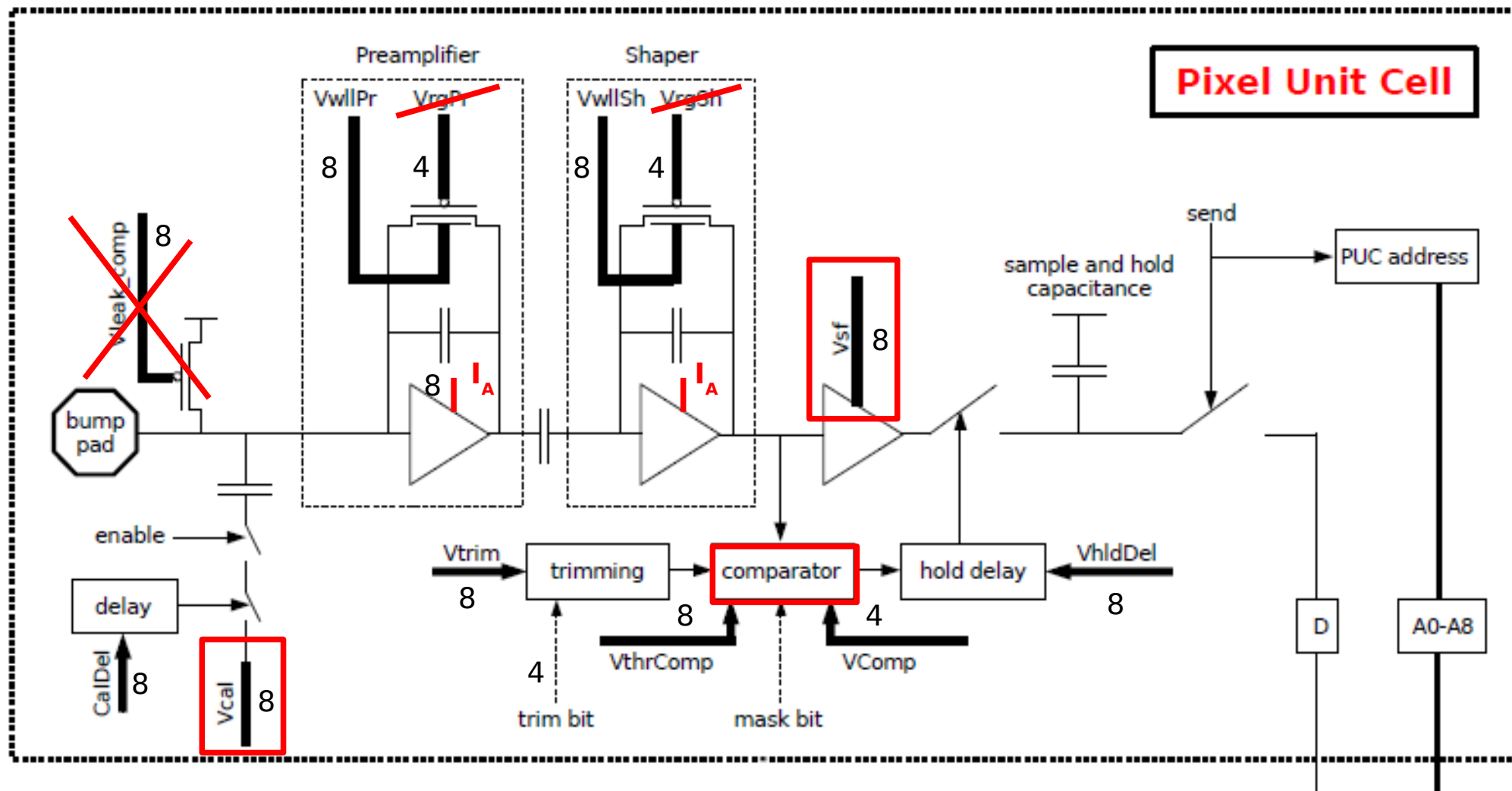


# Summary

- Pre-amplifier noise measured from width of comparator S-curves:
  - bare psi46dig: 105-110 electrons noise (better than psi46v2)
  - Comparator design does not influence noise
  - psi46dig with sensor: 180 electrons noise (like psi46v2) at 35 mA
  - Psi46dig with sensor: 140 electrons noise at 40 mA.
- Plan:
  - re-measure after irradiation (soon)
  - measure with DESY bump bonding (next year)

**Back up**

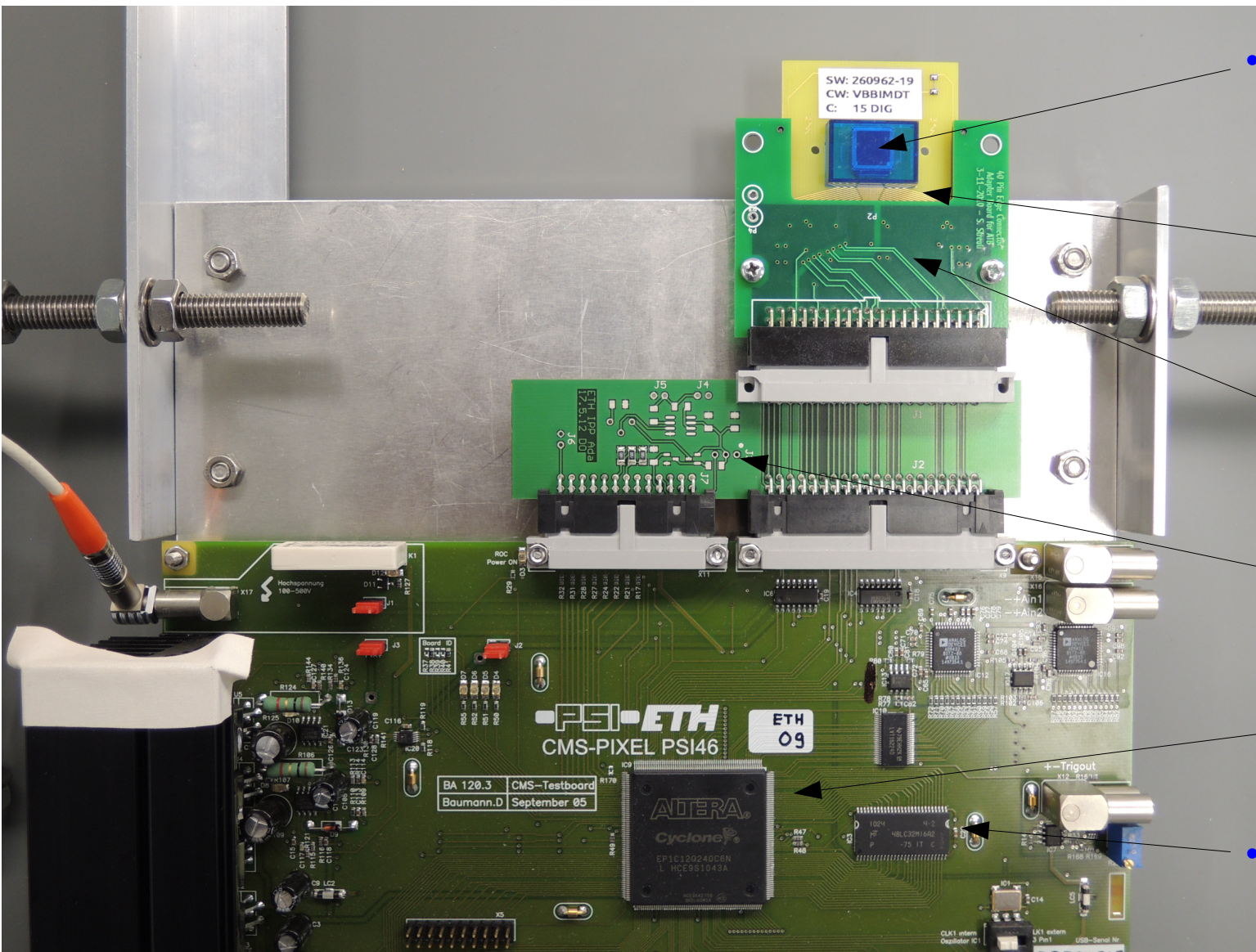
# psi46dig pixel unit cell



**adjustable by programmable DAC**

**modified in psi46dig**

# psi46 test board



- Single chip module:
  - Indium bump bonded at PSI
  - Glued and wire bonded to carrier printed circuit board
  - Interface card to psi46 TB with edge connector
  - ETH adapter card for digital 160 MHz differential signal directly into FPGA (LCDS into LVDS)
- 64 MB memory