Effect of the mesh geometry on Micromegas discharges

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Thanks to R. De Oliveira, R. Hertenberger for useful discussions

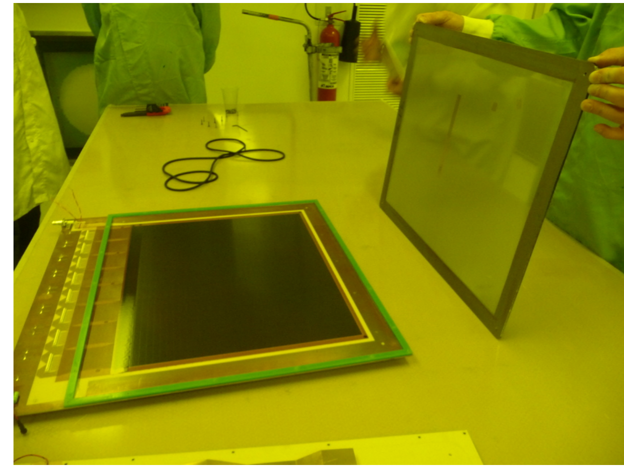
- RD51 week, CERN -

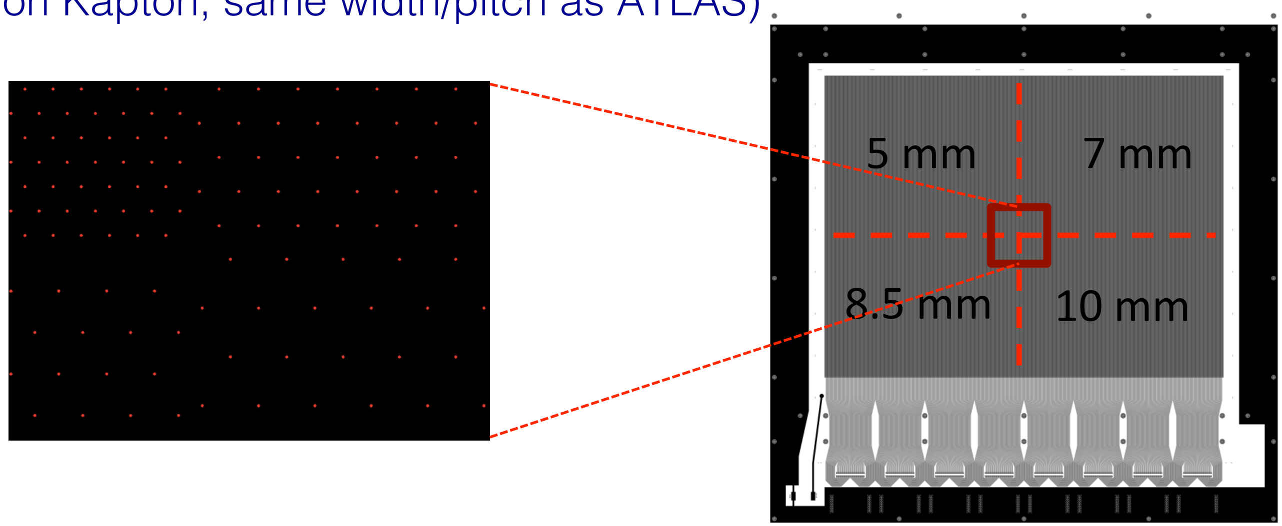
Outline

- Detector description
- Tested meshes and expected results
- Challenges and procedures
- Results
  - Current and ‘discharge spike rate’ vs HV
  - Gain and rate from signal vs HV
  - Current and ‘discharge spike rate’ vs Gain
  - Rate from signal vs Gain
- Conclusions

Exchangeable Mesh detector (ExMe)

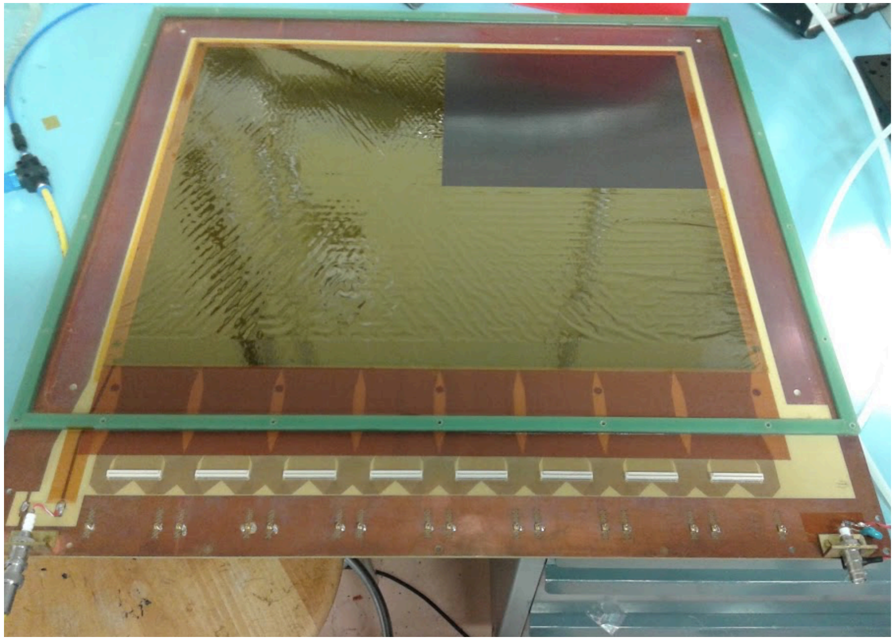
- ExMe (exchangeable mesh) detector
  - Designed and built at CERN in 2014 (J. Wotschack, P. Iengo, R. De Oliveira, G. Sekhniaidze) to help selection of mesh type and pillar spacing for the ATLAS NSW project
  - Mesh stretched on iron frame → easy to replace
  - 4 sectors with different pillar spacing: 5/7/8.5/10 mm
  - Circular pillars (300 um diameter)
  - Otherwise similar to ATLAS MM (screen-printed resistive lines on Kapton, same width/pitch as ATLAS)

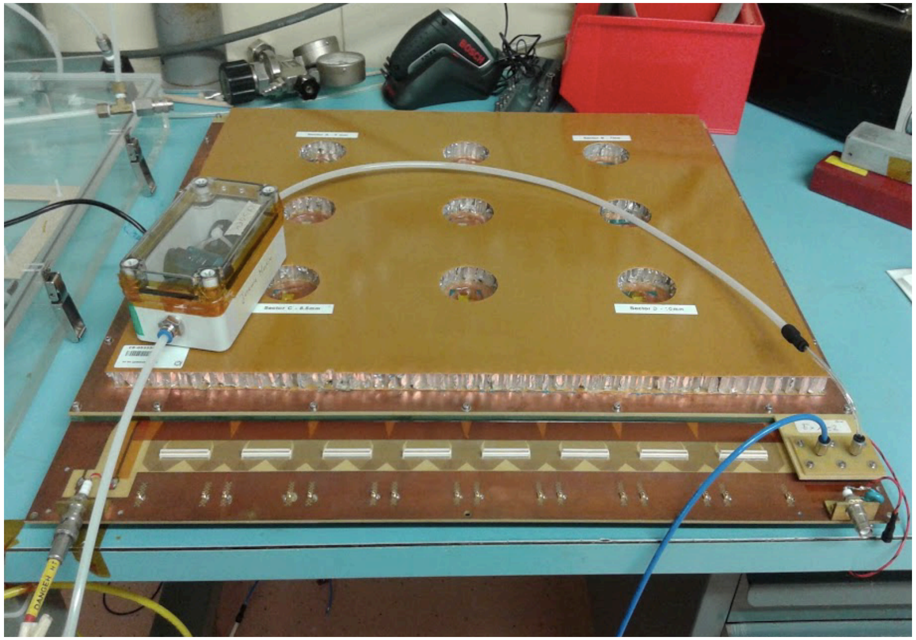




Exchangeable Mesh detector (ExMe)

- Only sector with 7mm pillar spacing active
- Other sectors passivated with12.5 um kapton film on top of the pillars
- RH, P, T measured at the gas output of the detector



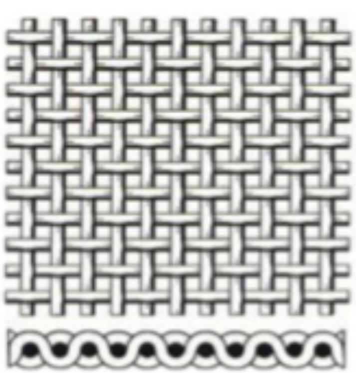


Tested meshes

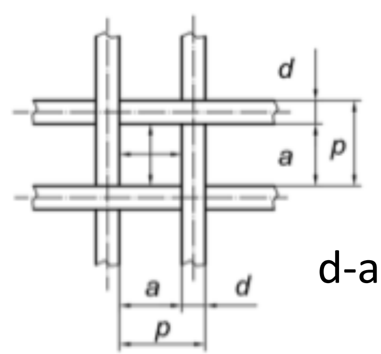
Old: purchased in 2014
New: newly purchased in 2018

Type (d-a um)	Comment
30-71 C	Calendered - new
18-45 C	Calendered - old
18-45 N	Non calendered - new
30-71 P	Non calendered, Hand polished - old
28-50 N	Non calendered - old
30-80 C	Calendered - old

Test sequence ↓



Plain weave



d-a

Calendered mesh

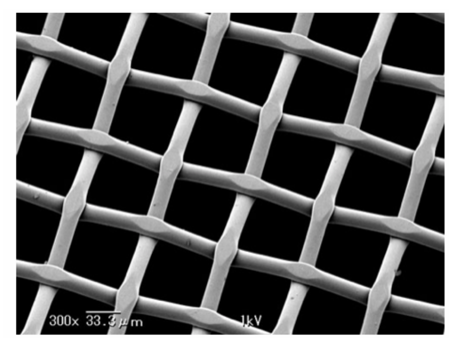
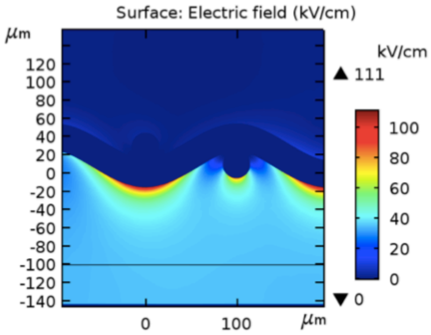
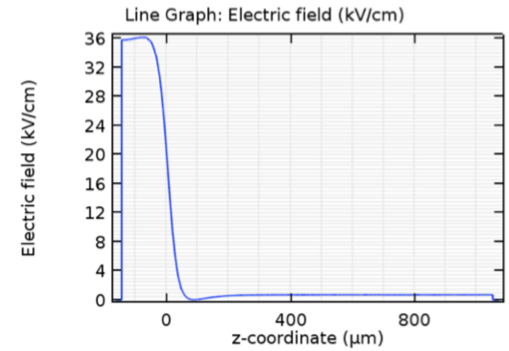


PHOTO A: M30 360-16μm calendered mesh

Predictions from simulations

- Max achievable voltage → breakdown
- Average voltage → gain/working point
- See presentation by D. Bhattacharya from yesterday



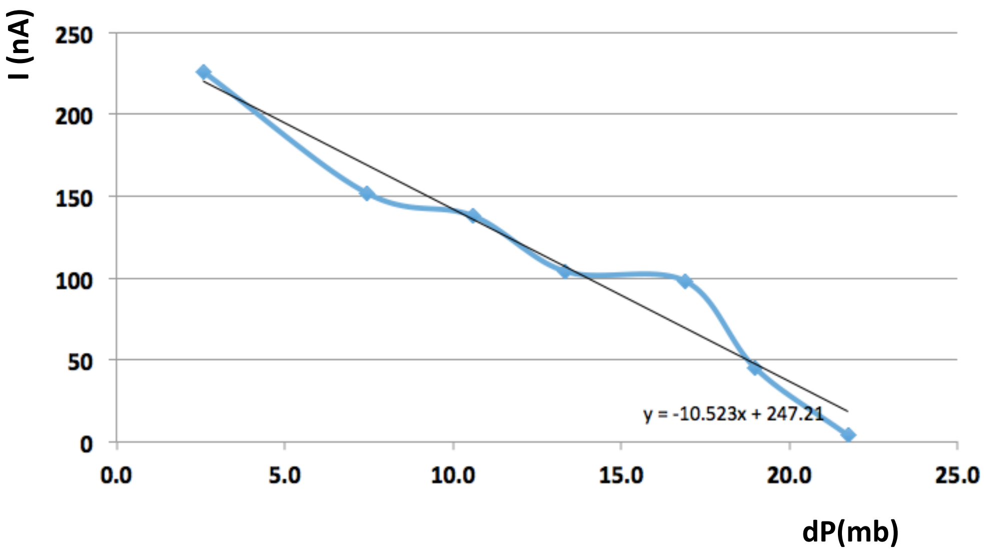


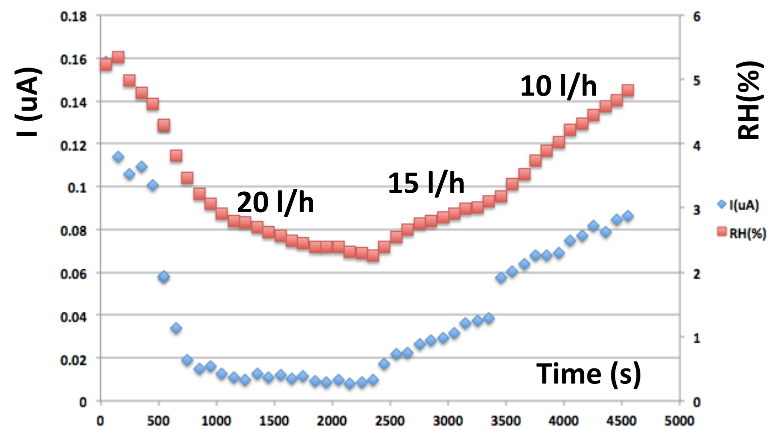
Type	Max (kV/cm)	Average (kV/cm)	Ave/max (%)
18-45 C*	89.2	40.5	45.4
30-85 C*	88	39.5	44.88
18-45 N	112	38.75	34.59
28-50 N	104	38.25	36.77
30-71 C*	84	40	47.5
30-71 N	104	37.25	35.81

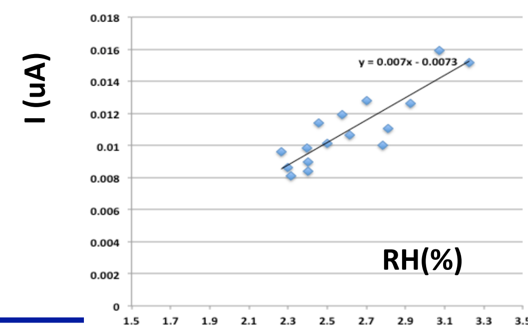
* Ideal calendering

Experimental issues

- Discharges at breakdown triggered by defects/geometry or external dust → crucial to ensure the same level of cleanliness as the detector is opened/closed to replace the mesh
- Current values affected by T/P and RH → measurements done trying to keep constant overpressure (few mb) and RH (~3%)

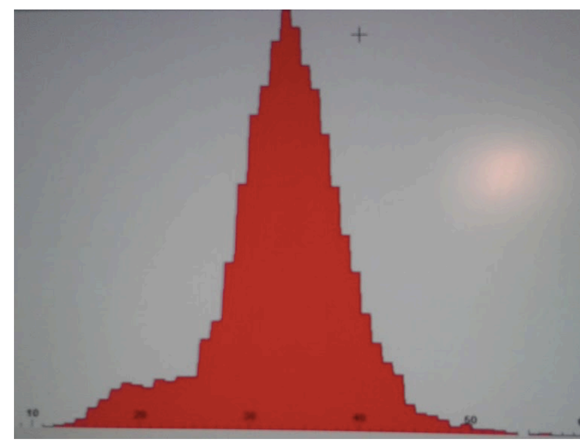






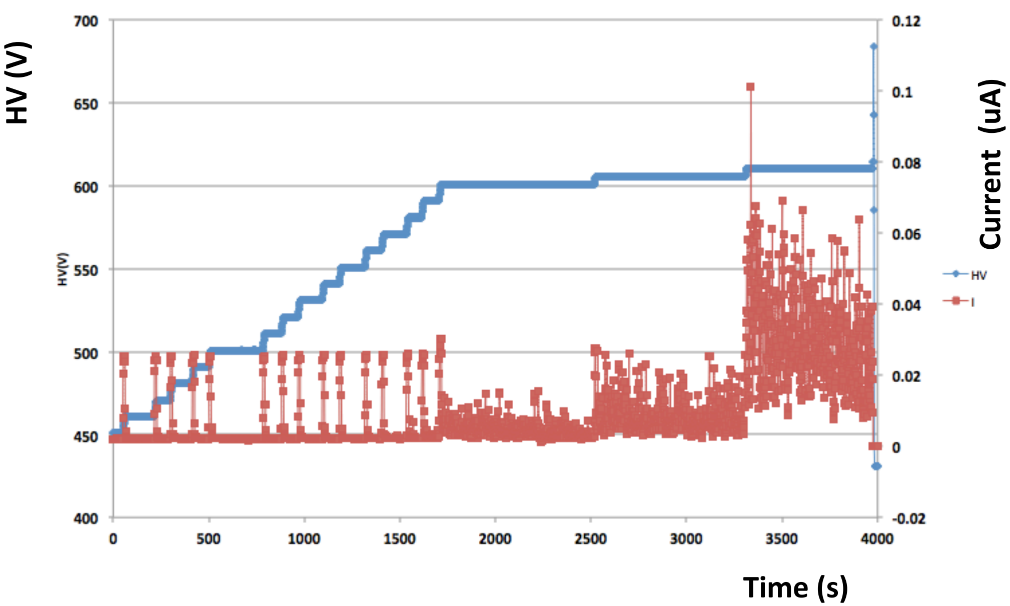
Test procedure

- HV scan in dry air
- HV scan in Ar:CO2 (93:7) w/ and w/o ^{55}Fe source
- Gain measurement (^{55}Fe peak position with Ampteck MCA)
- Rate measurements
  - Measured by taking signals from 1 Panasonic connector (128 channels → 51.2 mm)
  - DAQ: Pre-ampl → amplifier (Ortec) → discriminator → scaler
  - Irradiated region ~ 2 mm diameter → rate ~ 3 kHz/cm^2
- V_{drift} = 300V



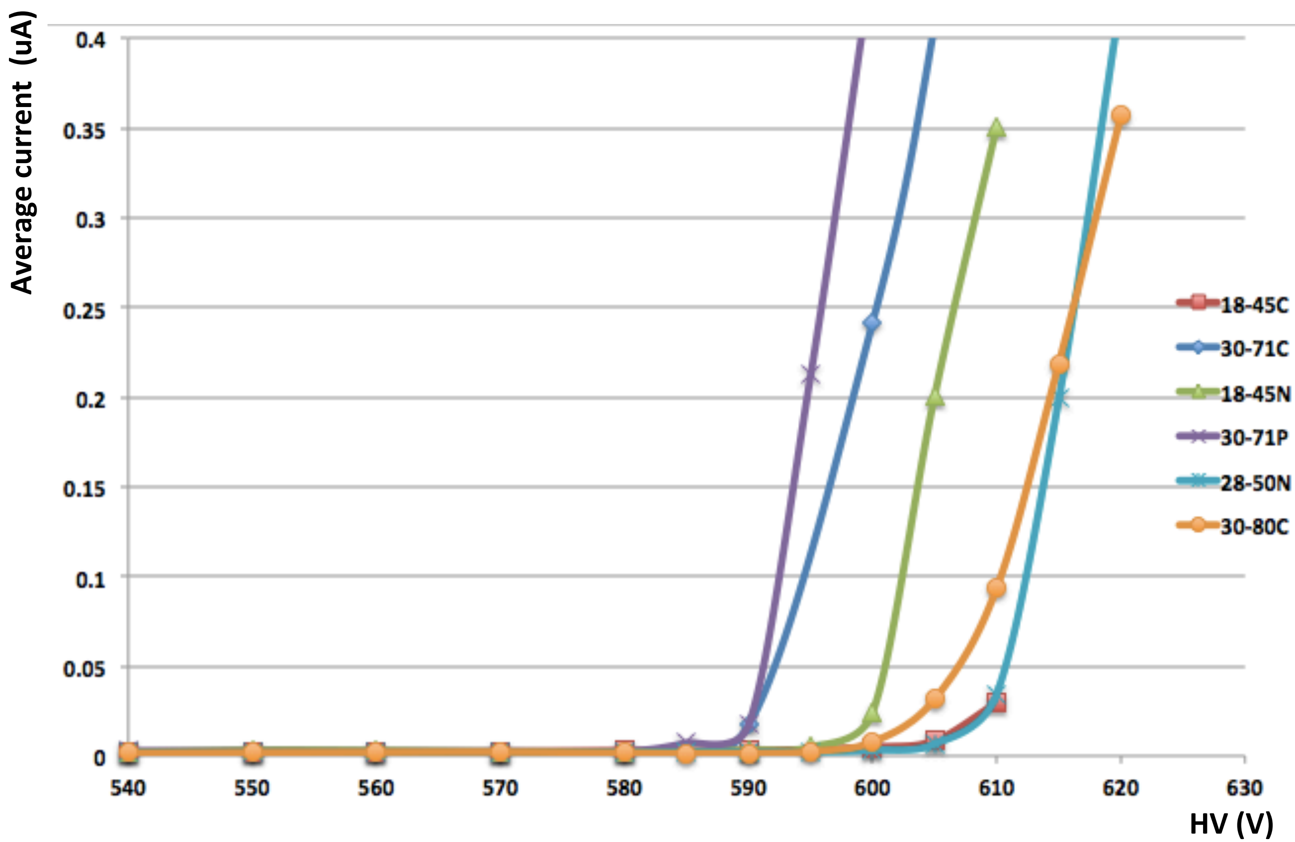
HV scan

- HV scan performed w/ and w/o Fe source
  - From 450 V up to the max achievable (600 to 620 V with 5-10 V steps)
  - No significant difference in currents measured w/ and w/o source → currents mostly from discharges, not from 'signals'
  - Current value measured every sec



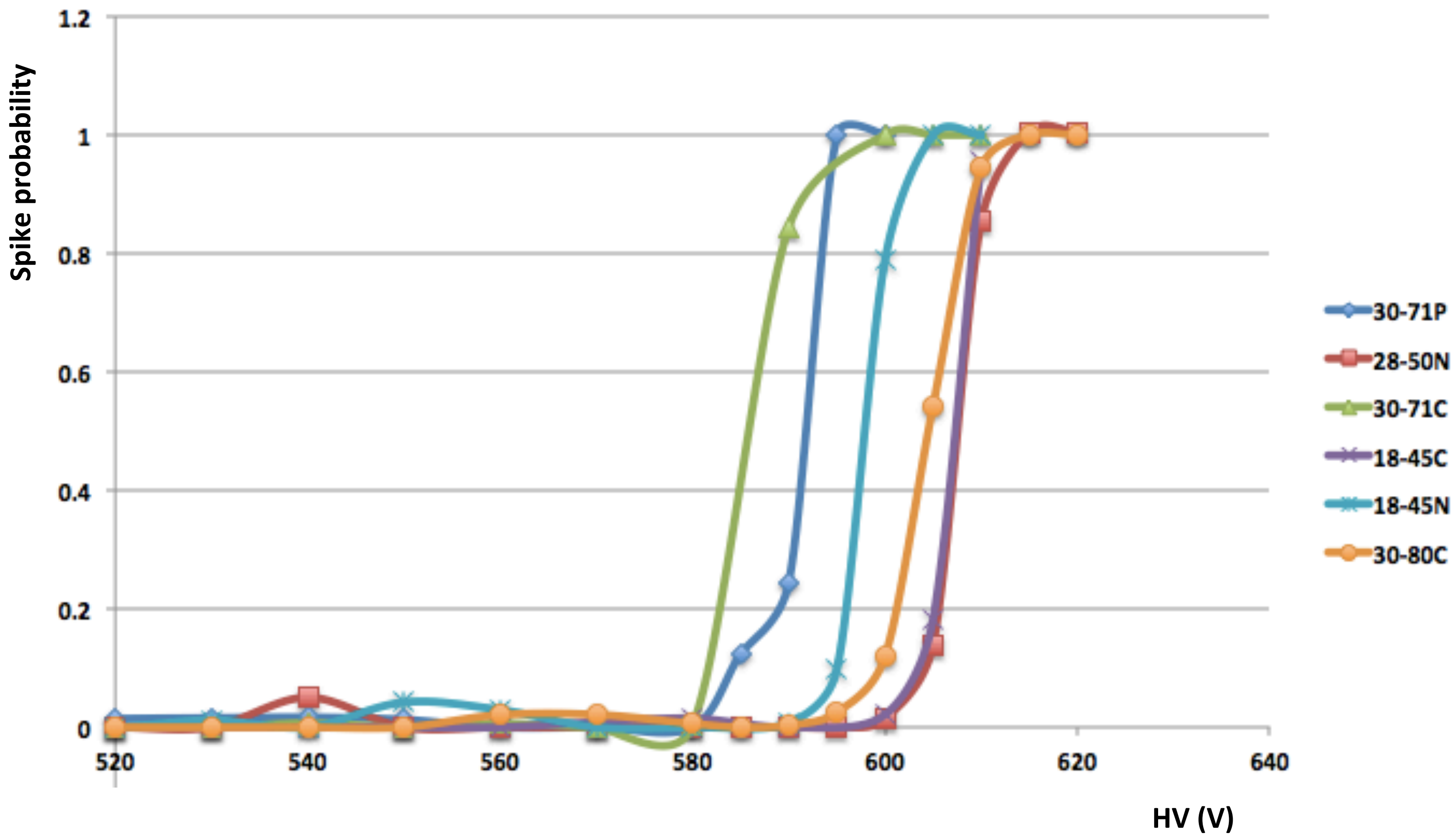
Current vs HV

- ^{55}Fe source on (as in all following slides)
- Current is averaged over the period at constant voltage (removing points during transient)



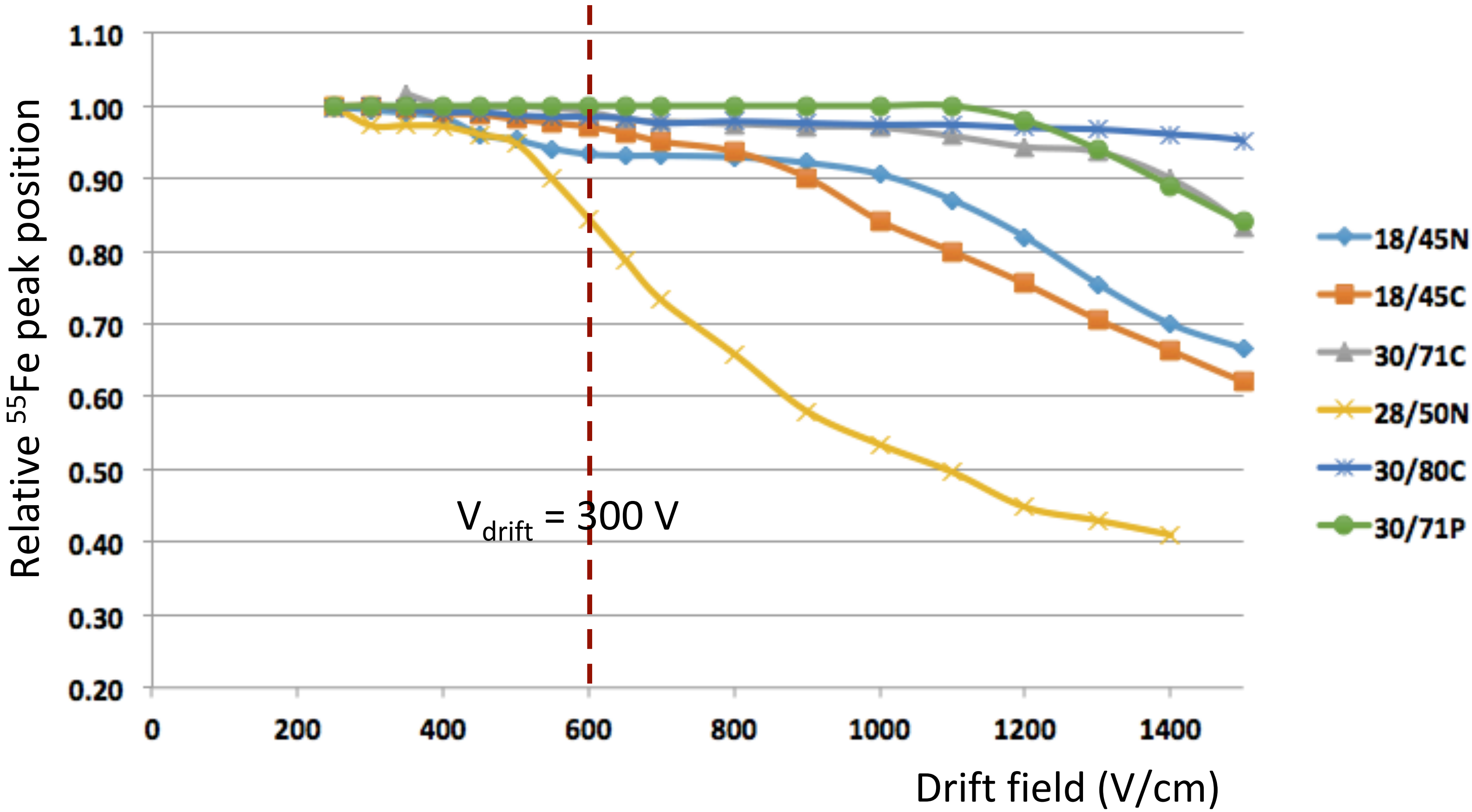
Spike probability vs HV

- A spike is (arbitrarily) defined as a current value > 10 na



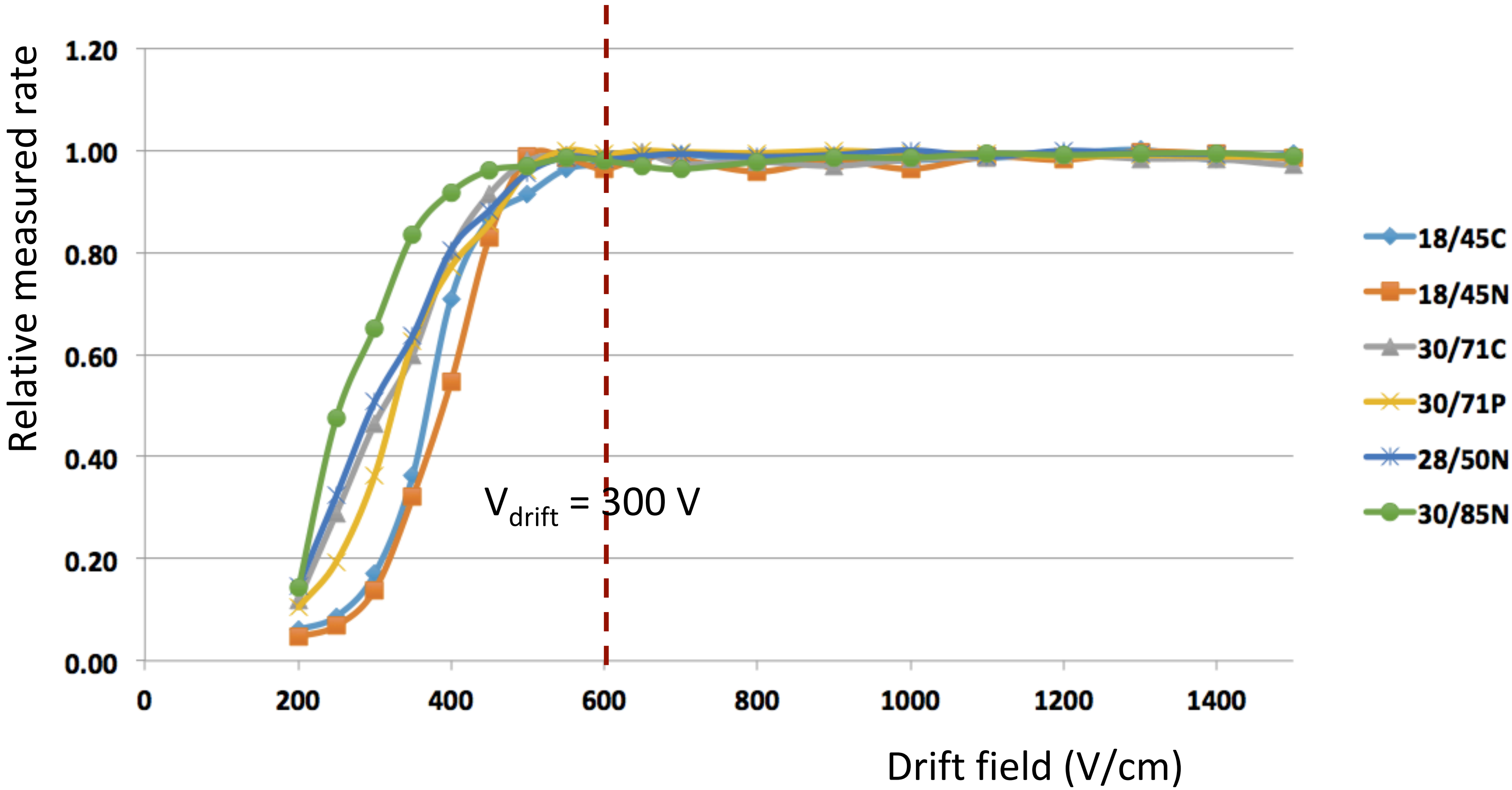
Transparency

- Drift scan: at V_{drift}=300V all mesh except 28-50N have a relative transparency >90%



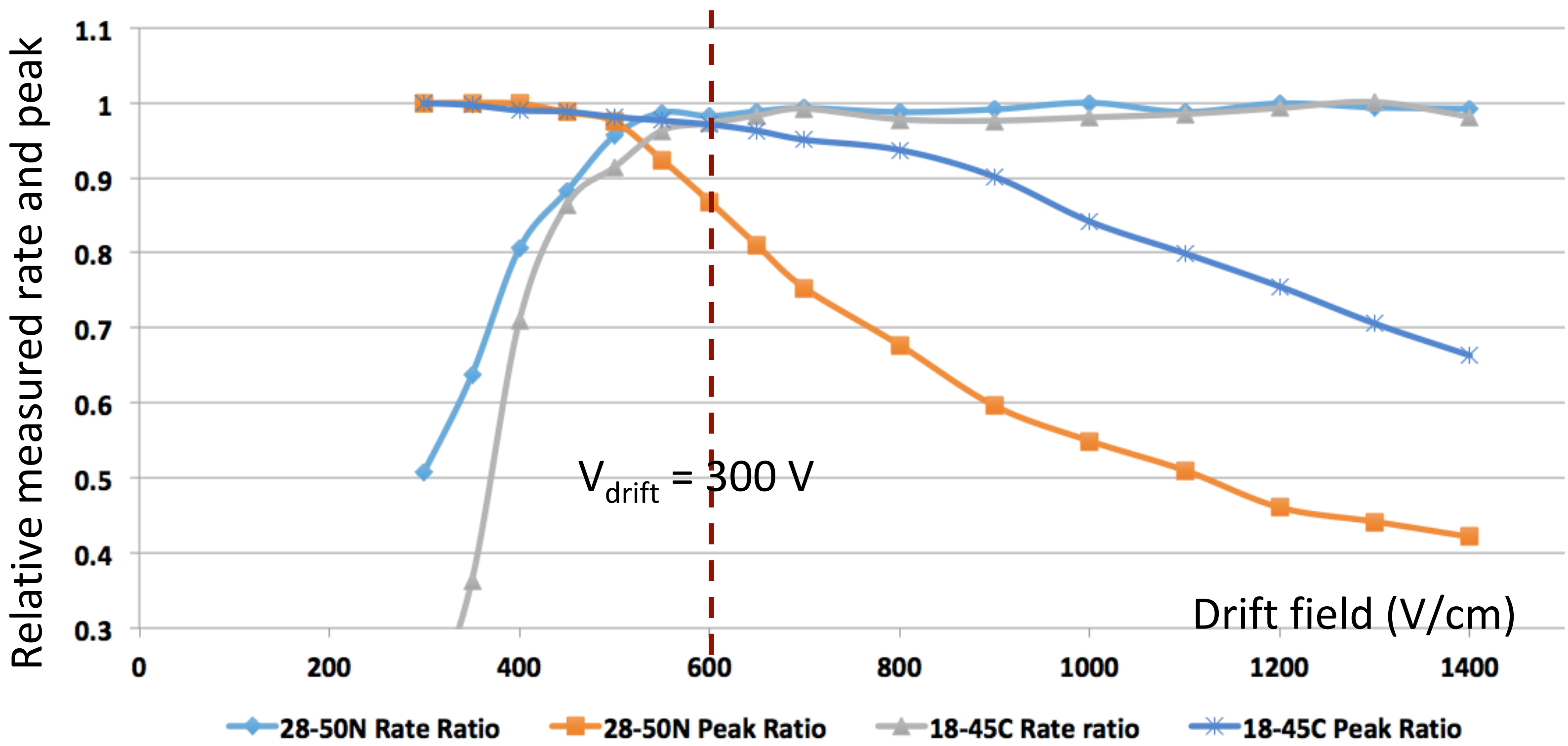
Rate vs V_{drift}

- Drift scan: at V_{drift}=300V all meshes are inside the plateau of the rate measurement



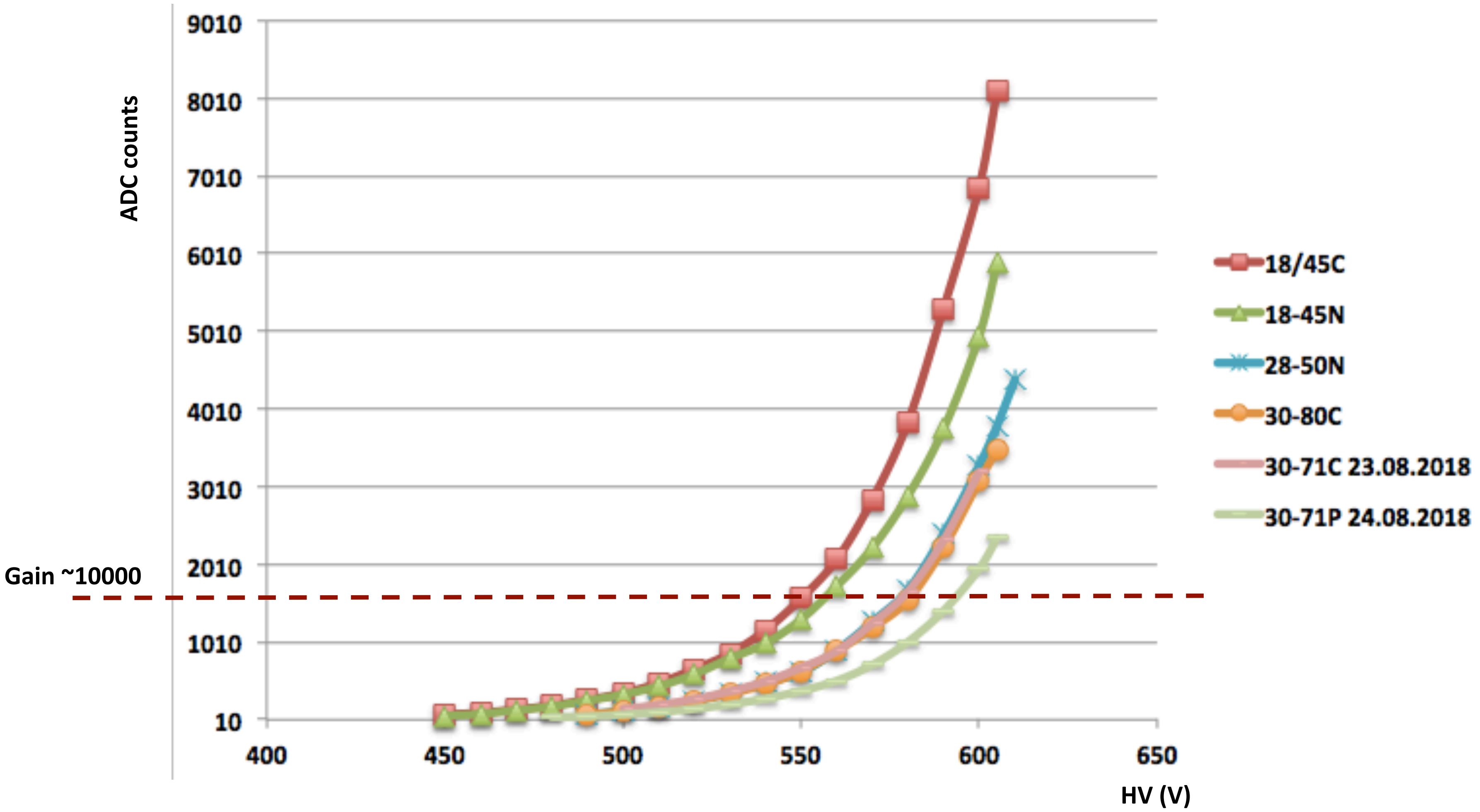
V_{drift} scan for 28-50

- Not possible to maximize both rate and transparency for 28-50



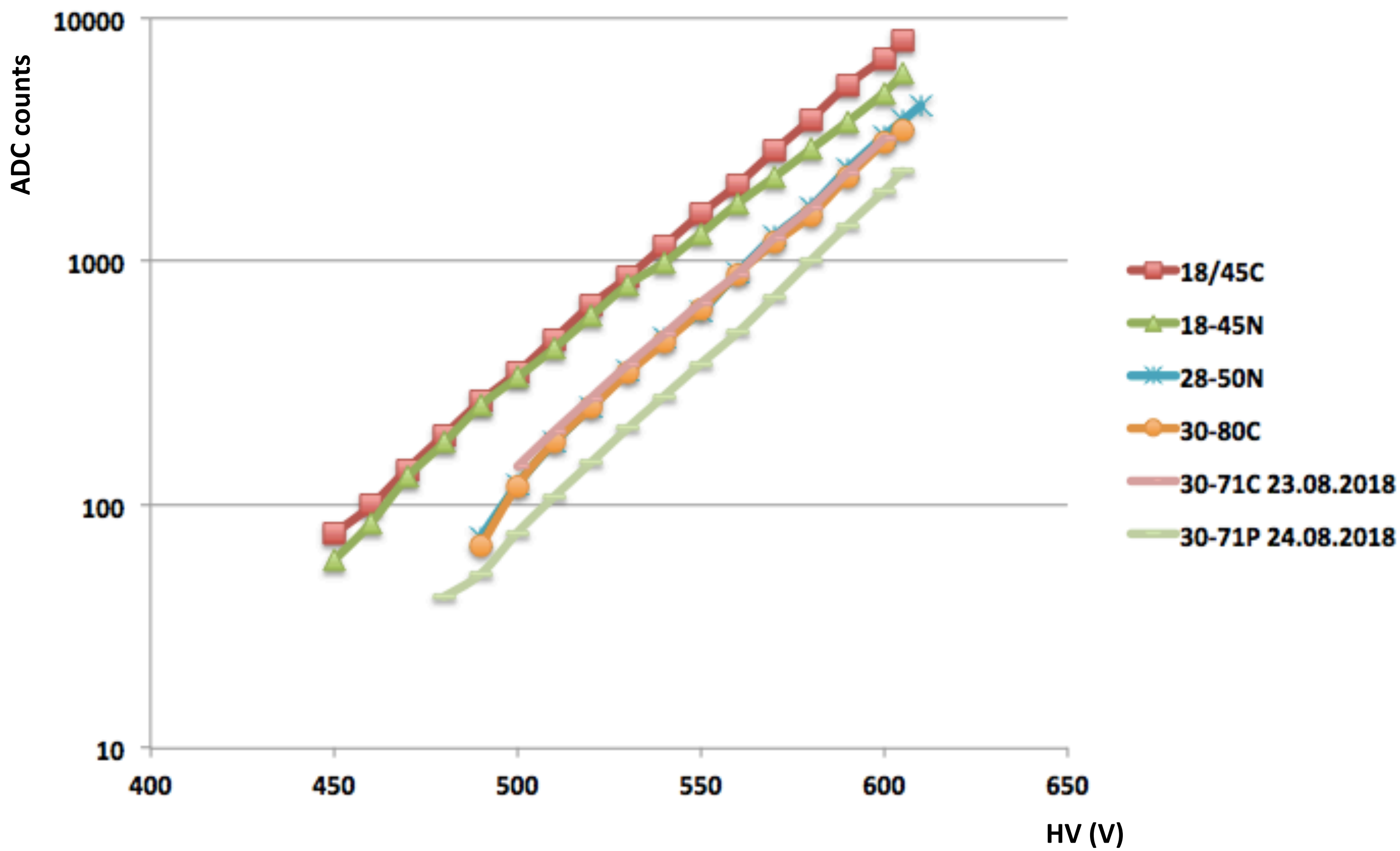
^{55}Fe peak position vs HV

- Gain



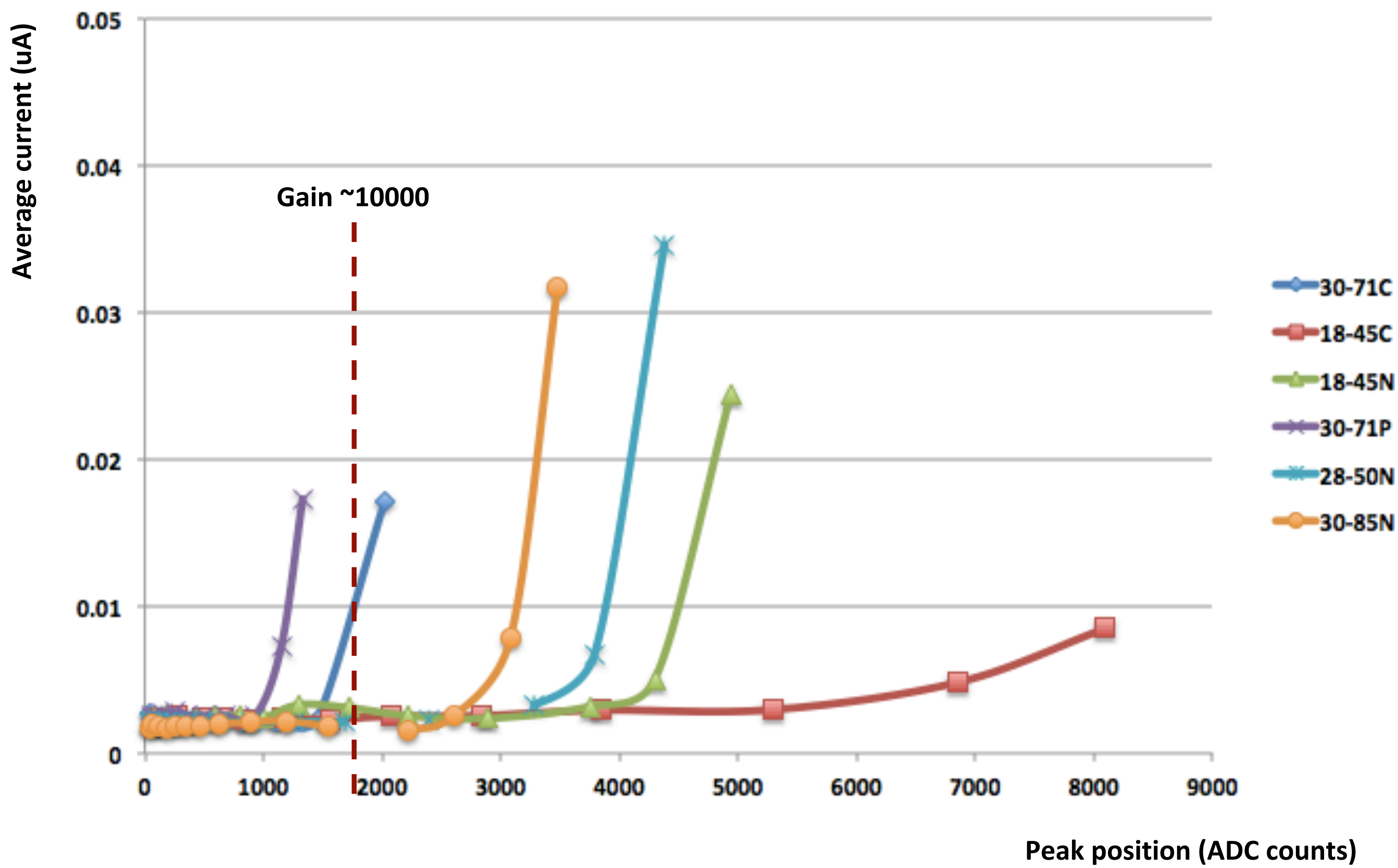
^{55}Fe peak position vs HV

- Log scale



Current vs peak position

- Current is averaged over the period at constant voltage (removing points during transient)



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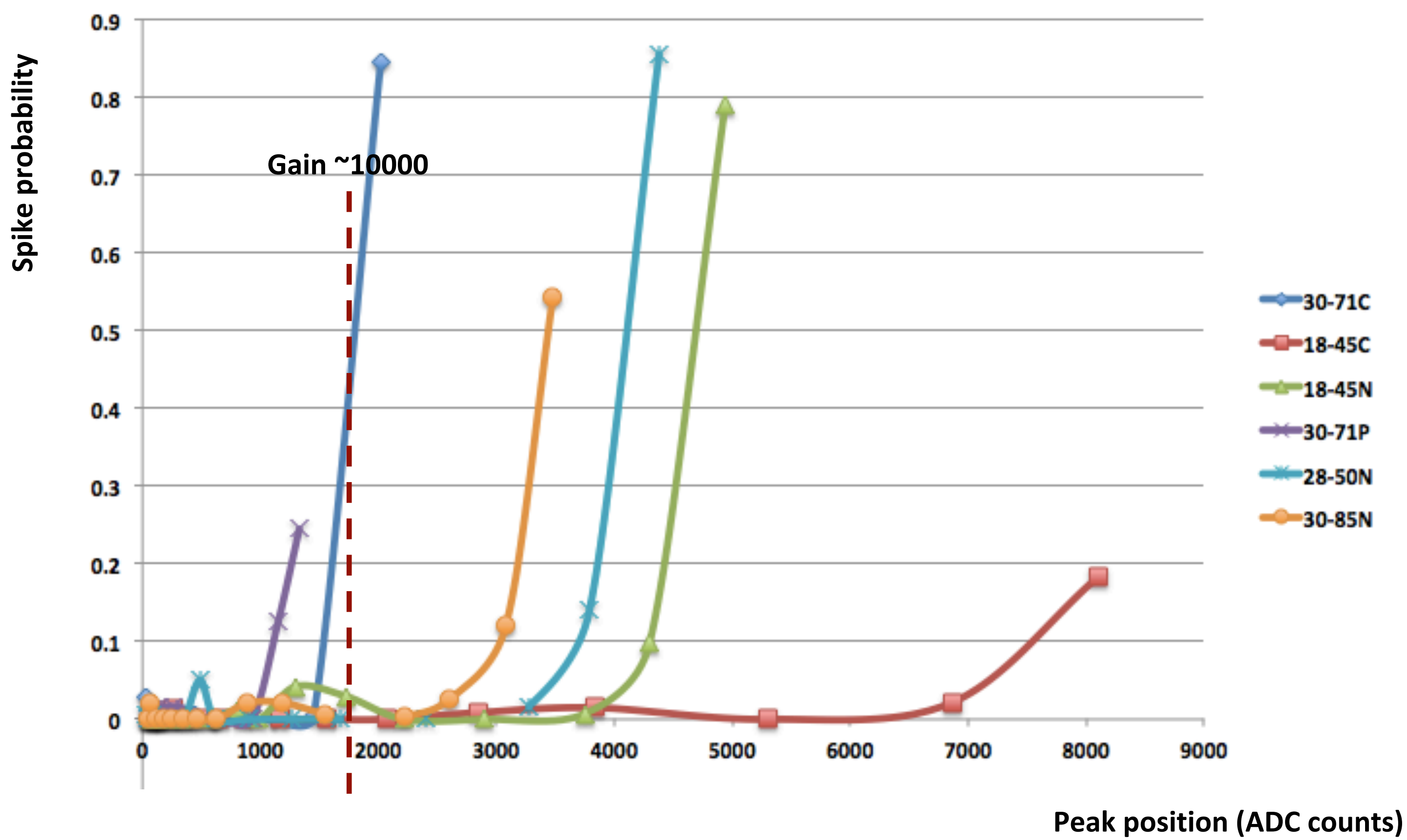

Rate vs HV

- Rate measurements
  - Measured by taking signals from 1 Panasonic connector (128 channels → 51.2 mm)
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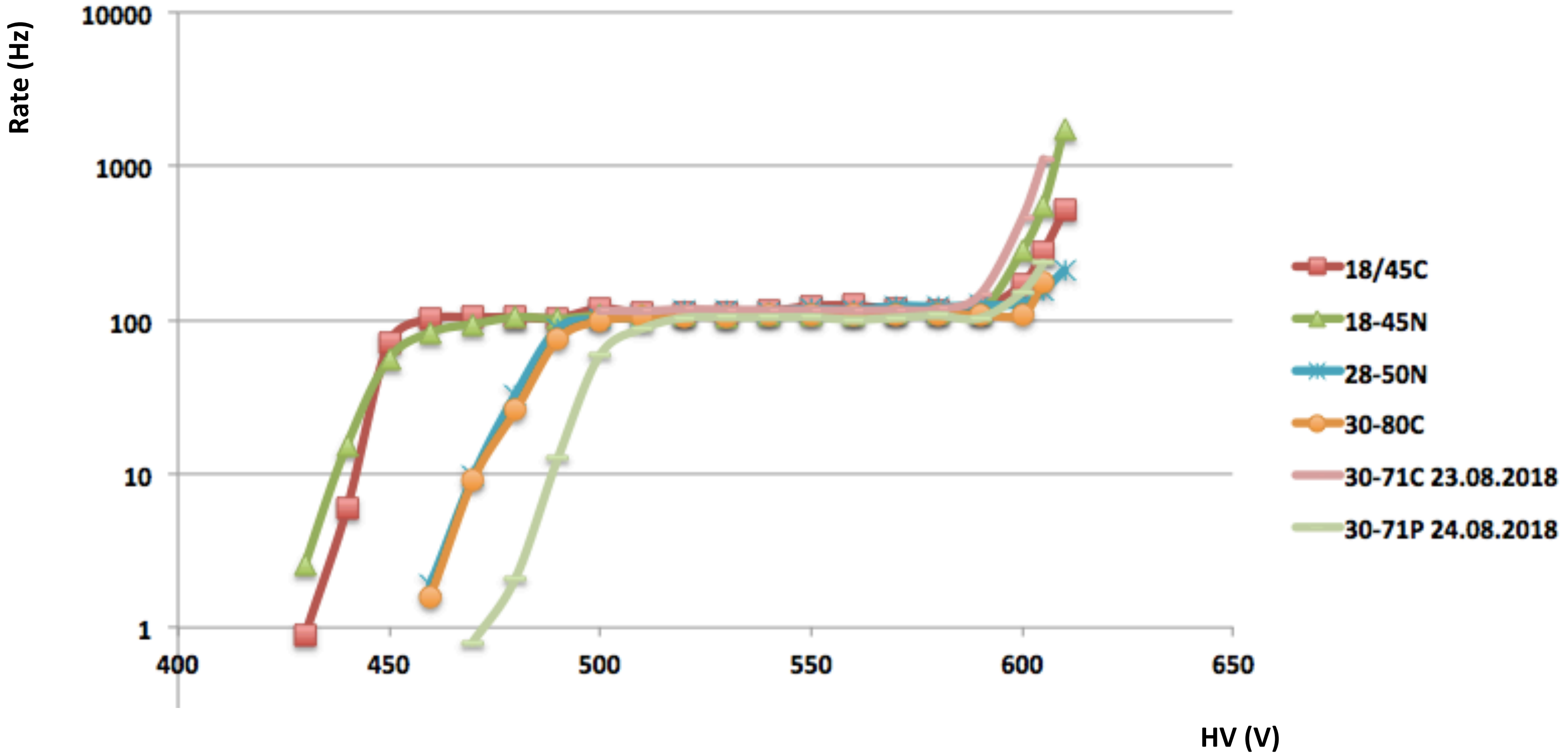
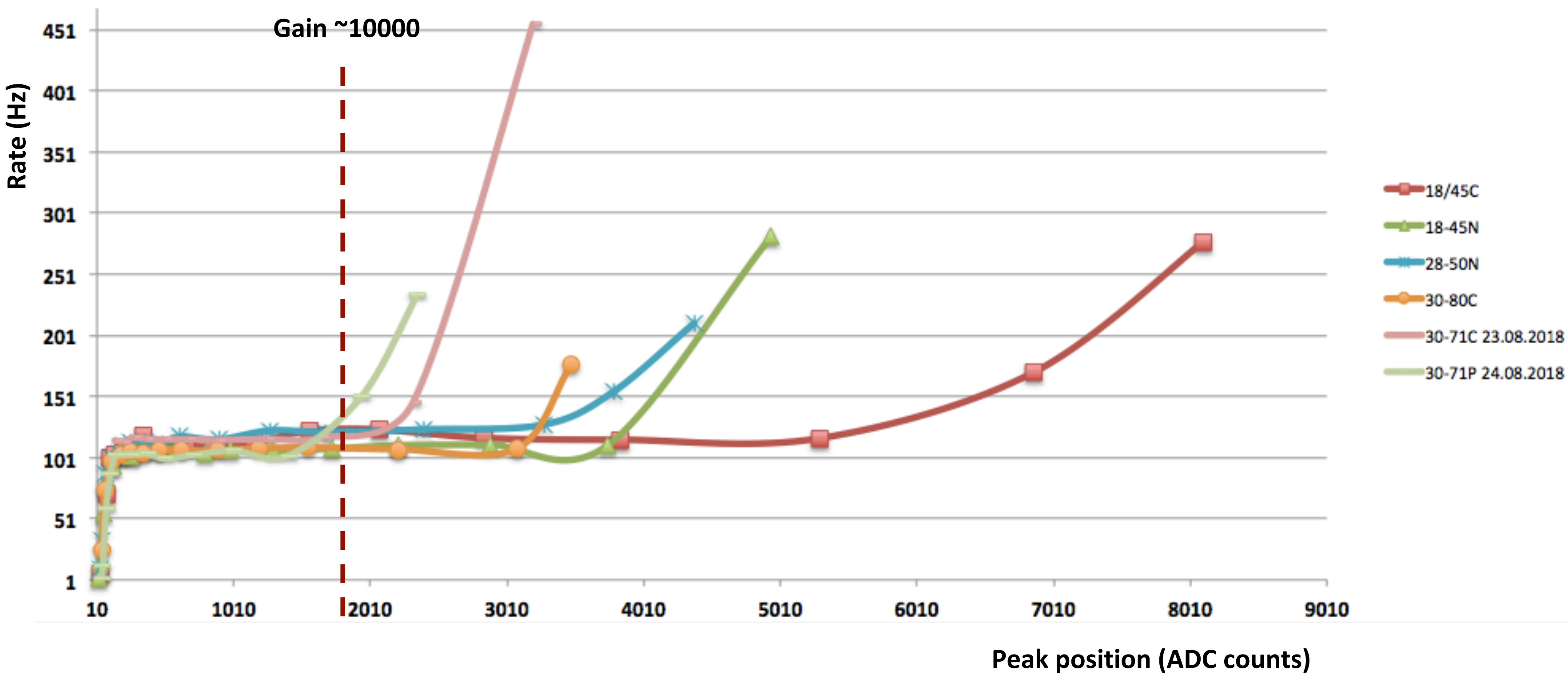


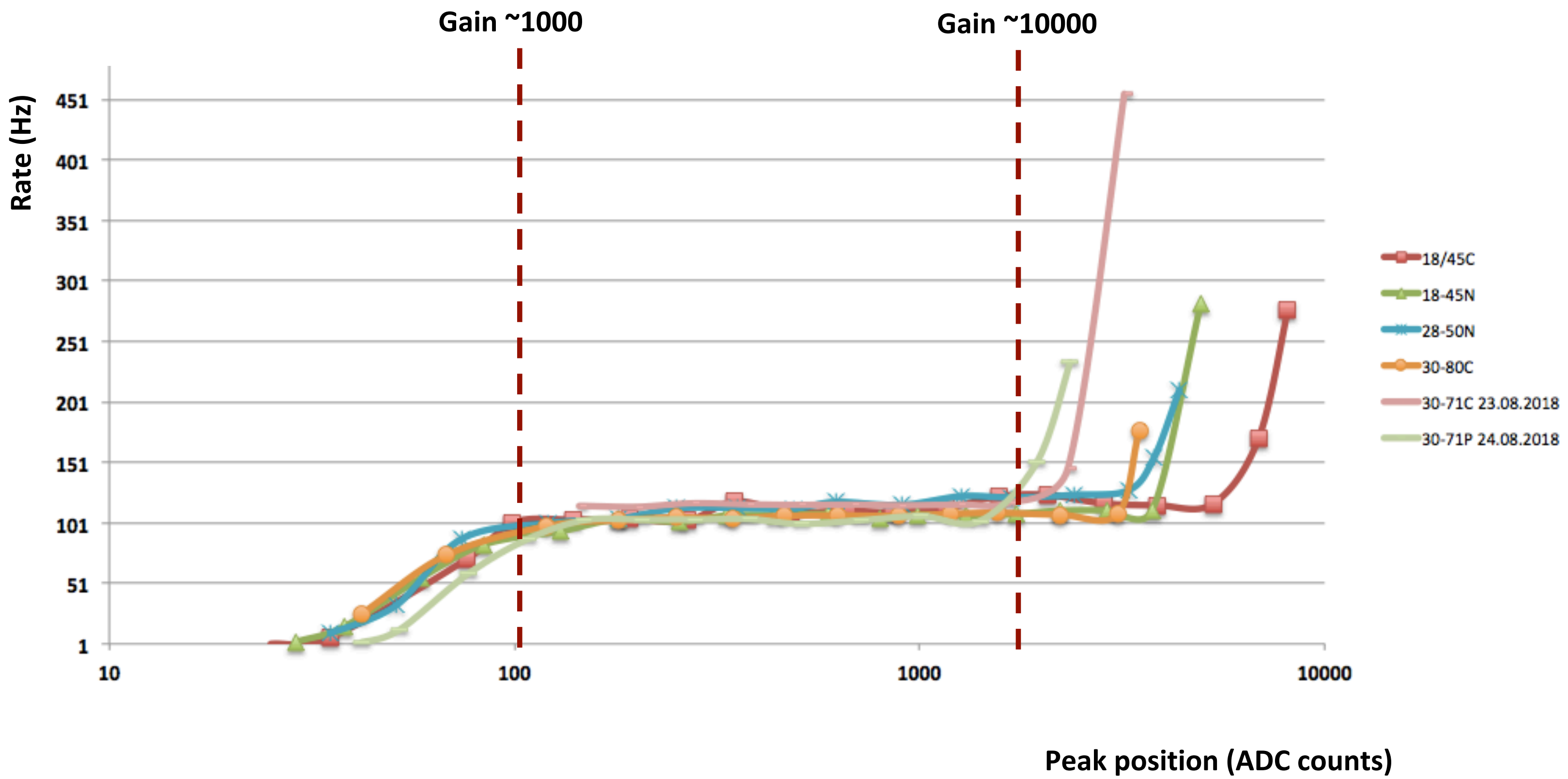
Rate vs peak position

- Linear scale



Rate vs peak position

- Log scale



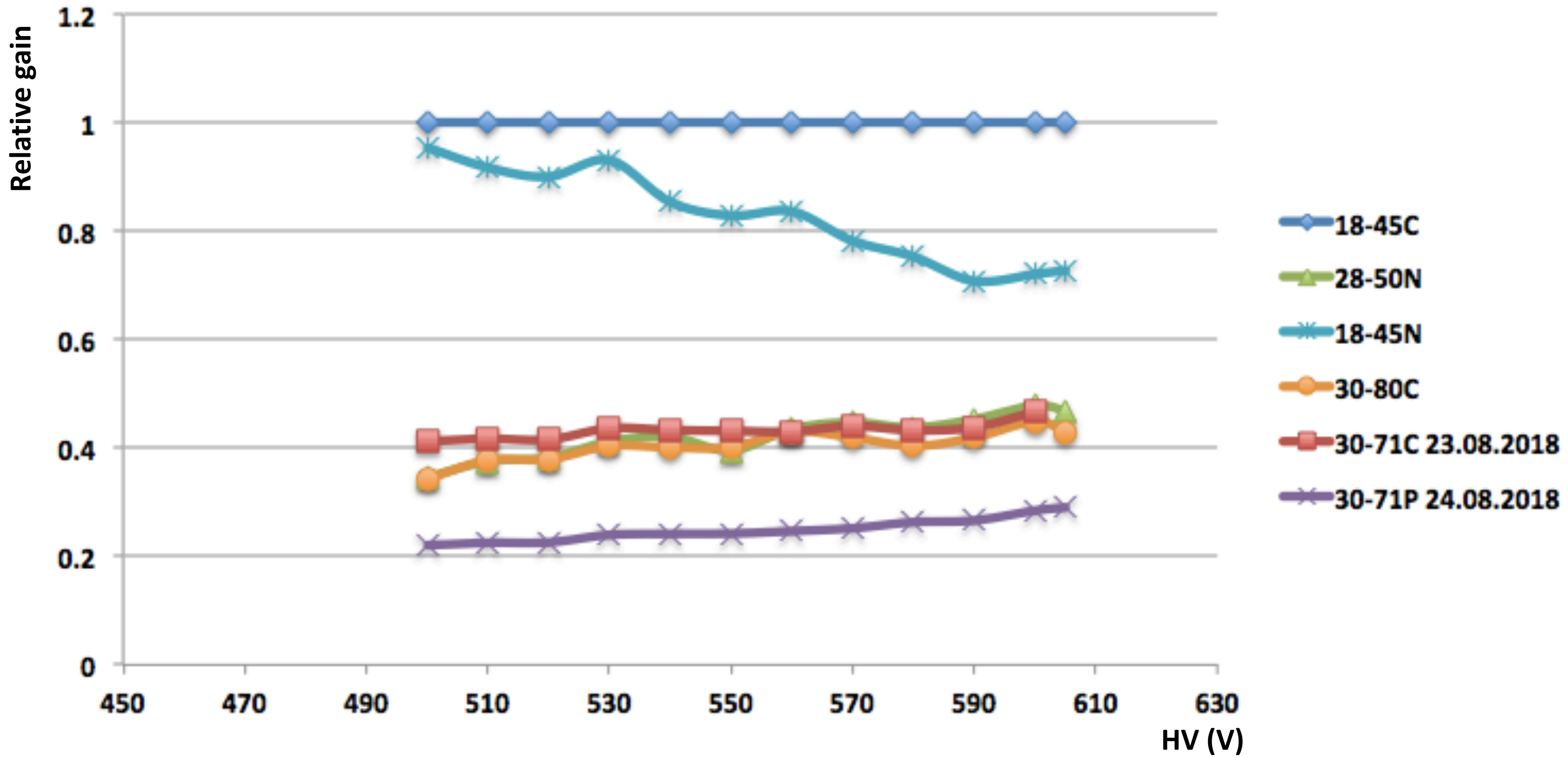
Conclusions

- We have studied the impact of mesh geometries on the HV stability of MM detectors
- Clear dependence of stability on geometry
  - Smaller openings give larger stability region (field uniformity)
  - Calendered meshes perform better
- Experimental results in (qualitative) agreement with prediction
  - 18-45 C found to be the best tested mesh
  - 30-71 C worst than 30-80 C (might be because of local defects)
- Selection of the right mesh should not only look to gain and transparence. The full picture is relevant, including breakdown

Additional Material

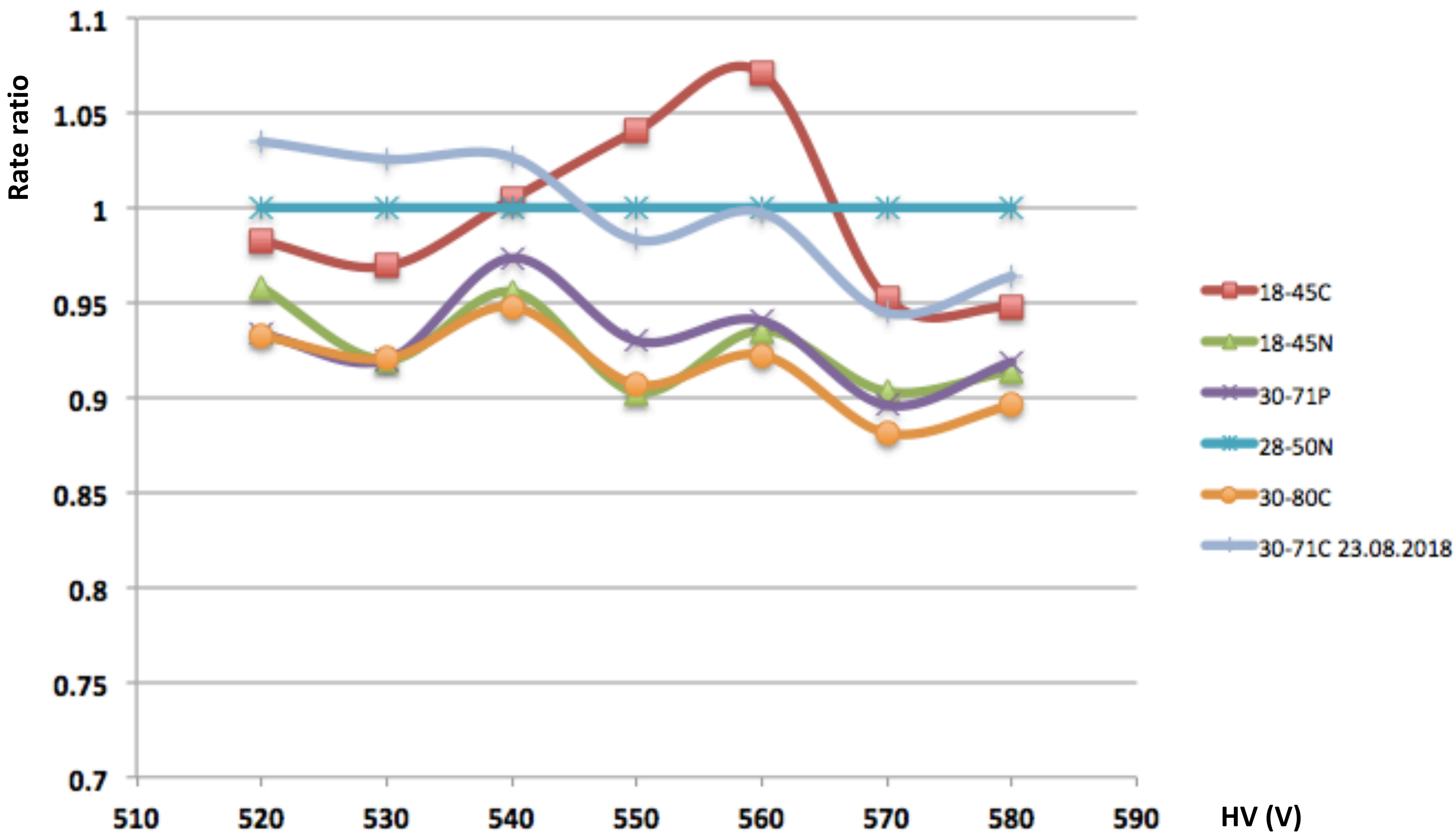
Gain comparison

- 18-45 C (highest gain) taken as reference



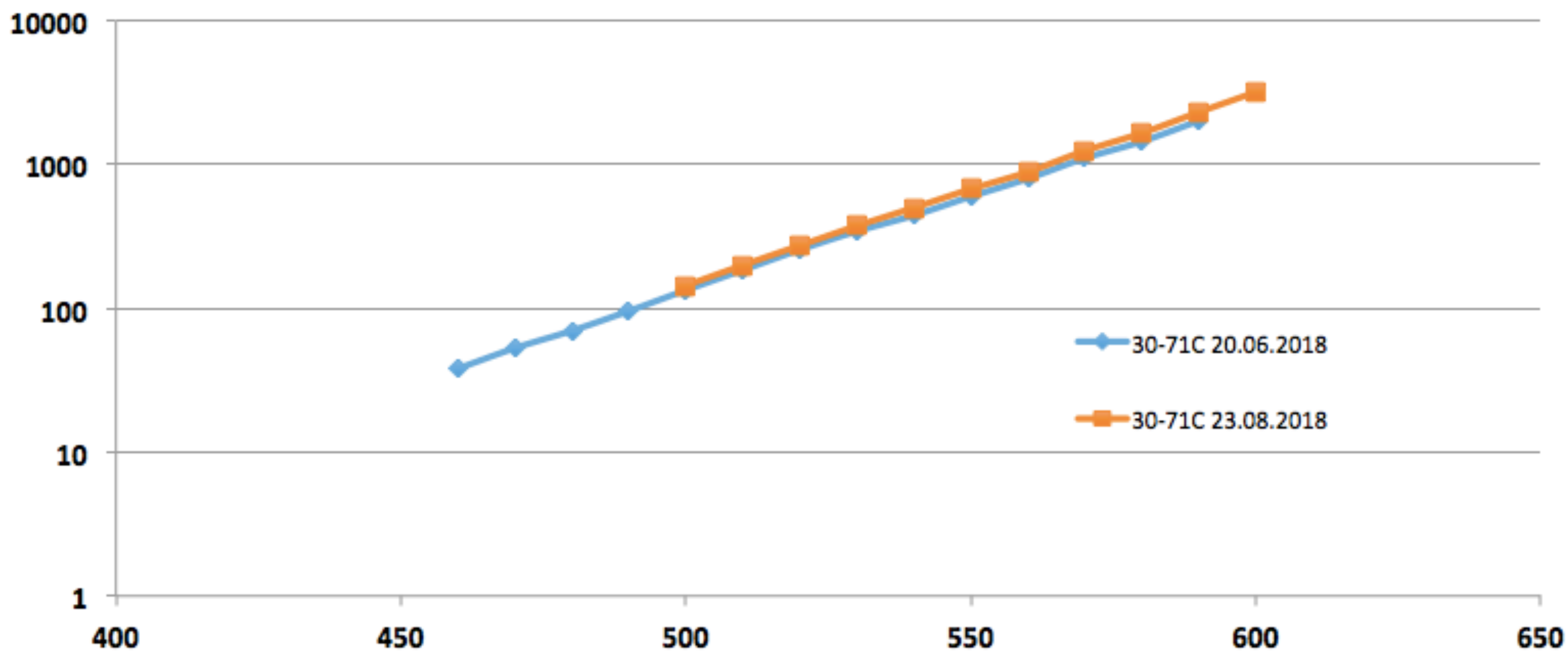
Rate comparison

- 28-50N taken as reference



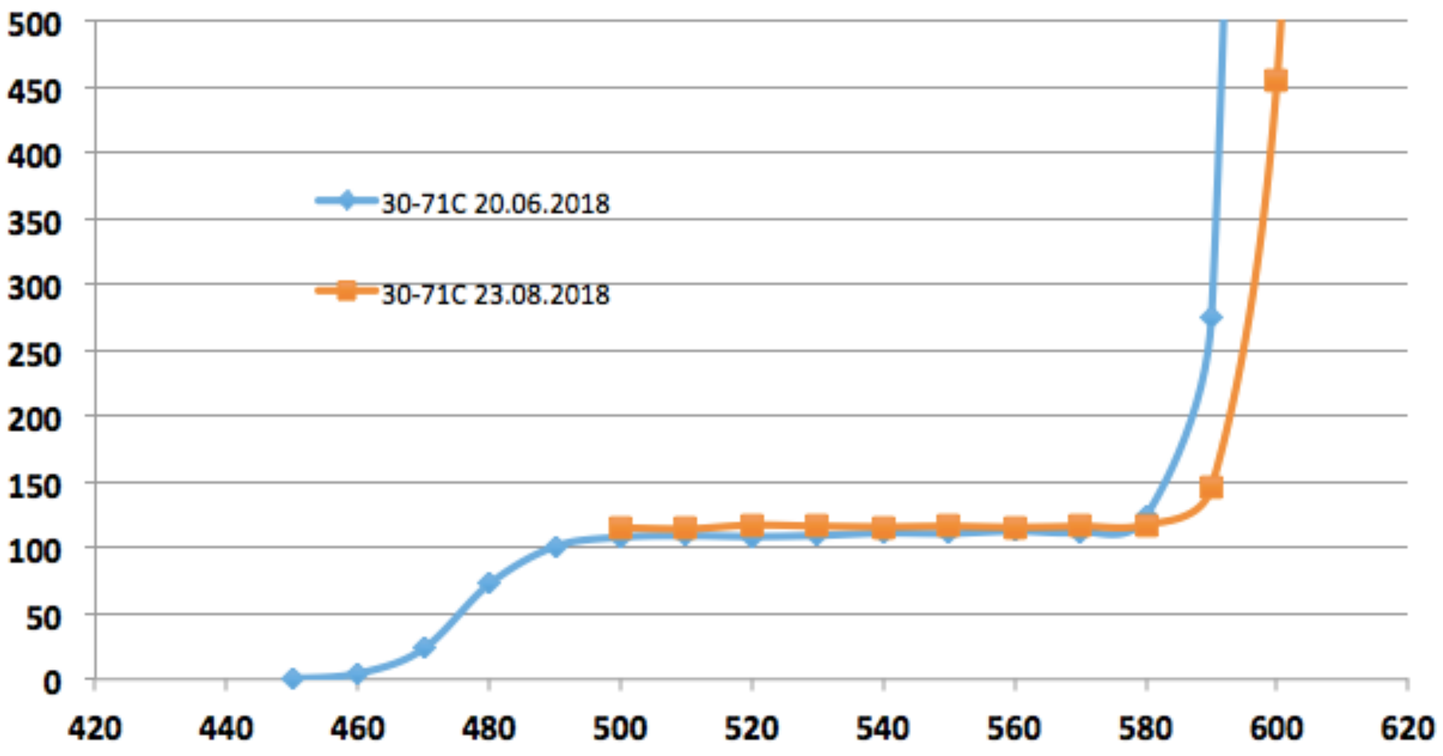
Reproducibility

- Repeated measurements with the same mesh: peak position vs HV



Reproducibility

- Repeated measurements with the same mesh: rate vs HV



Reproducibility

- Repeated measurements with the same mesh: rate vs peak position