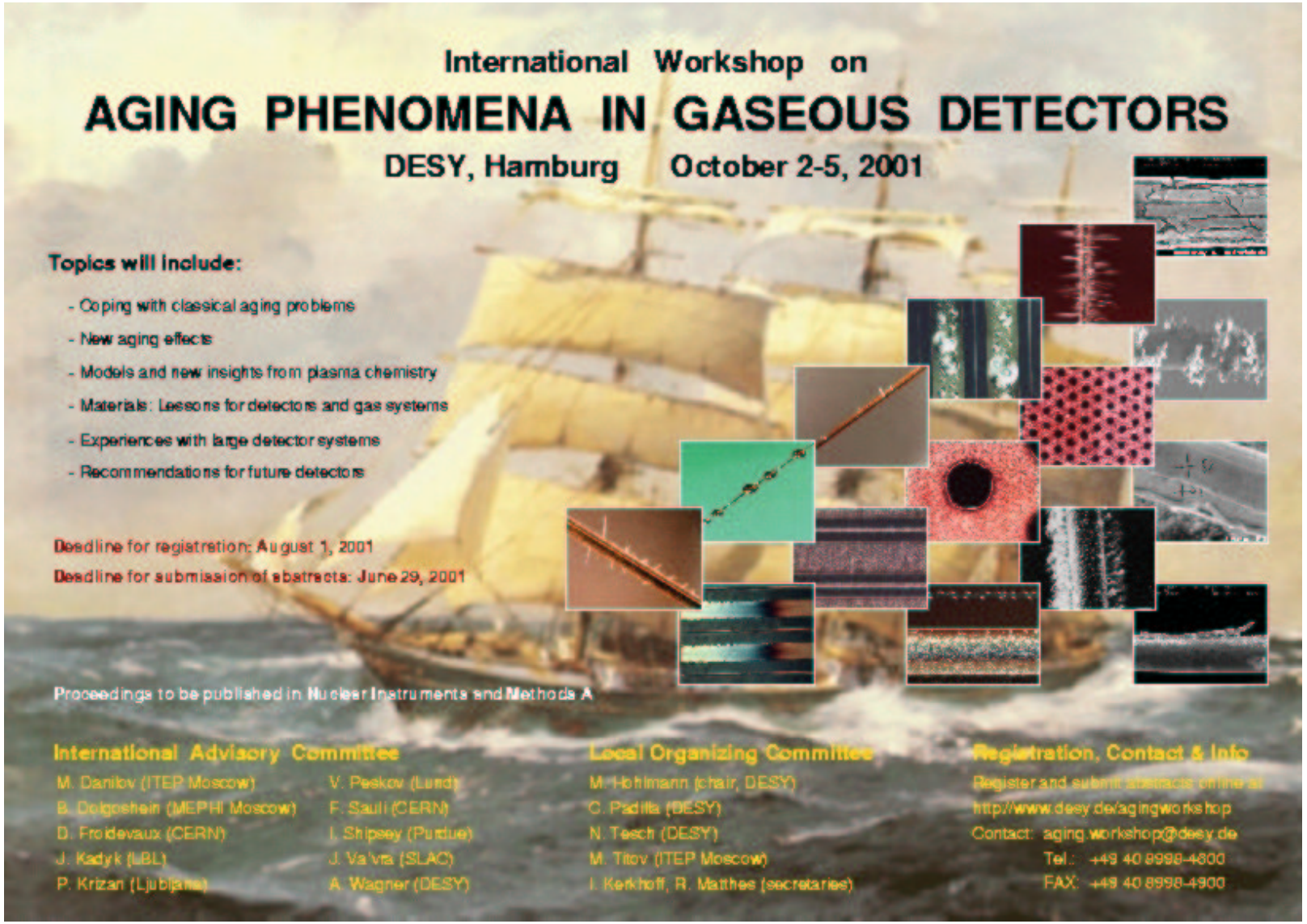
International Workshop on
AGING PHENOMENA IN GASEOUS DETECTORS
DESY, Hamburg October 2-5, 2001
Topics will include:
- Coping with classical aging problems
- New aging effects
- Models and new insights from plasma chemistry
- Materials: Lessons for detectors and gas systems
- Experiences with large detector systems
- Recommendations for future detectors
Deadline for registration: August 1, 2001
Deadline for submission of abstracts: June 29, 2001
Proceedings to be published in Nuclear Instruments and Methods A
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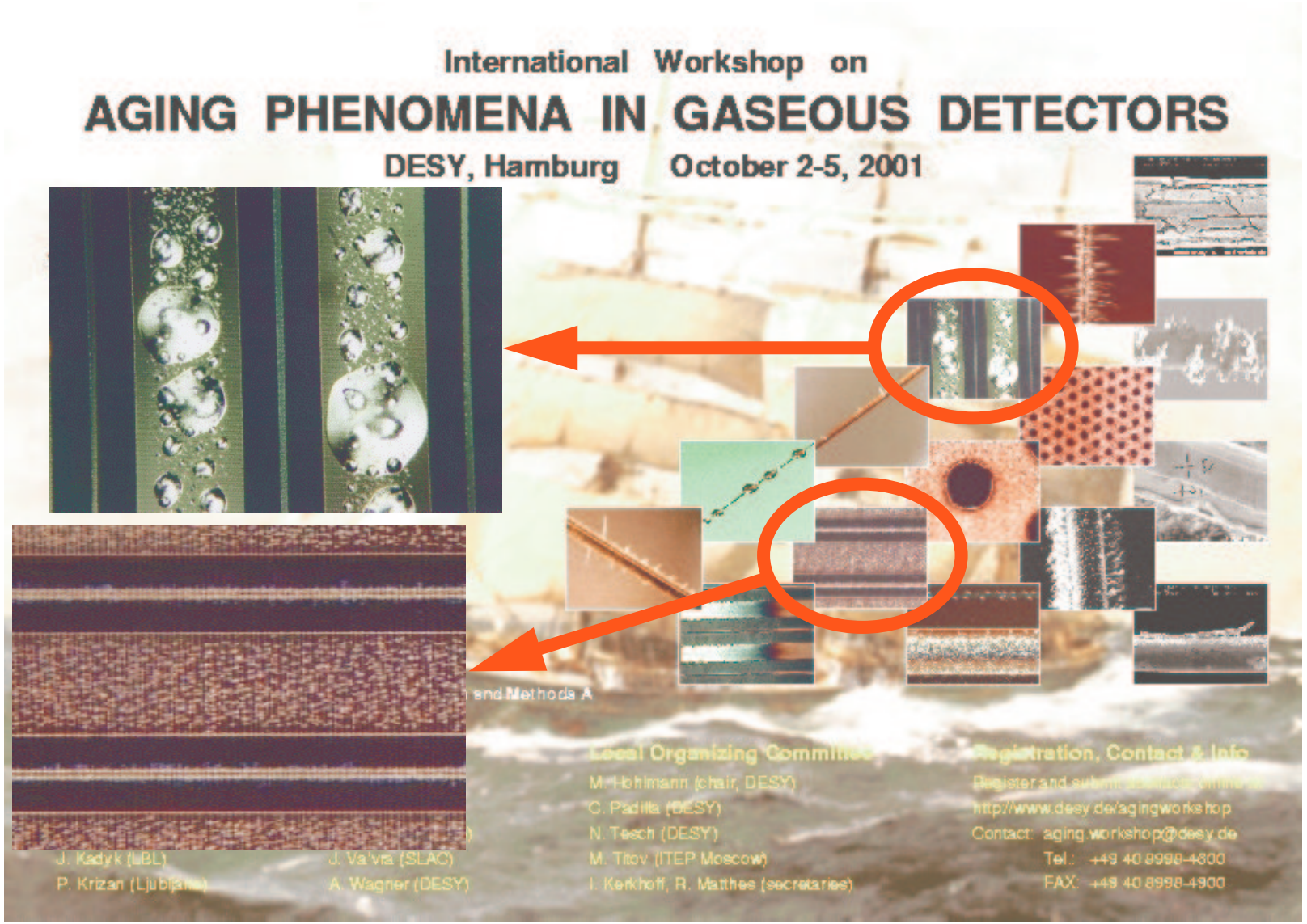
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Ageing Tests with GEM-MSGCs

- MSGC structure
- counting gas
- irradiation area

Malte Hildebrandt
University Zürich

Tests were performed in the scope of R&D of the
Inner Tracker of HERA-B (PhD thesis)

Ageing Measurements

Inner Tracker of HERA-B

- active area: 6 cm $\leq R_{\perp} \leq$ 30 cm
- particle flux up to $2 \cdot 10^4$ MIPs/ $mm^{-2}s$

  $\Rightarrow$ radiation dose up to 1 Mrad/a (10 kGy/a)

→ high rate & long term measurements essential !

Laboratory (GEM-MSGC)

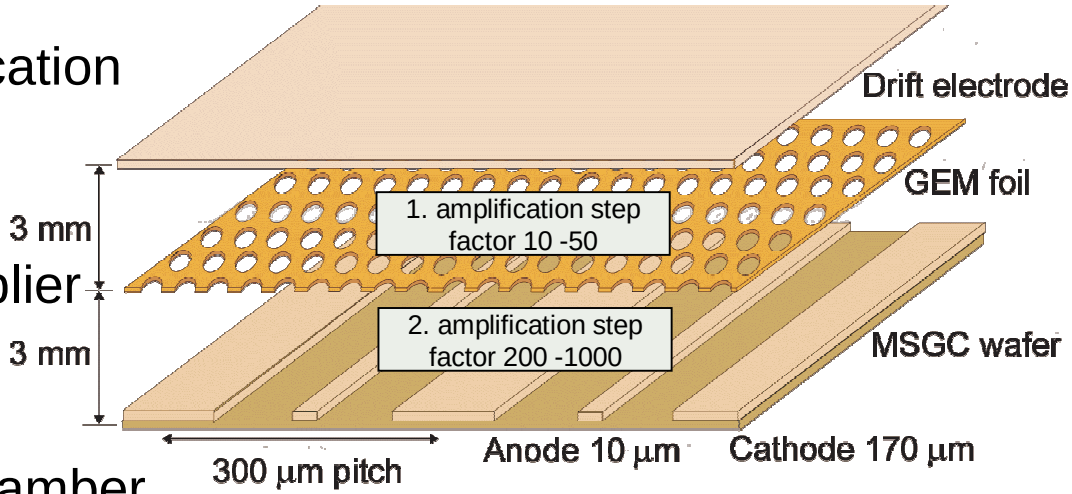
- accumulated charge "1 HERA-B year" — 5 mC/cm Anode
- copper K_{α}-photons (E_{γ} = 8 keV) $\Rightarrow$ ~10 × $N_{primary,MIP}$

GEM-MSGC

- two step gas amplification

→ **G**as **E**lectron **M**ultiplier

→ **M**icro **S**trip **G**as **C**hamber

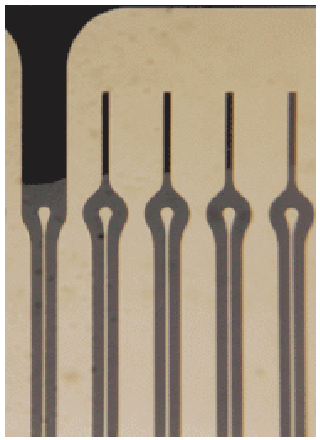


- 10 µm anode strips, 170 µm cathode strips, 300 µm pitch
- 6 mm total hight, 3 mm drift gap (primary ionisation)

MSGC Structure

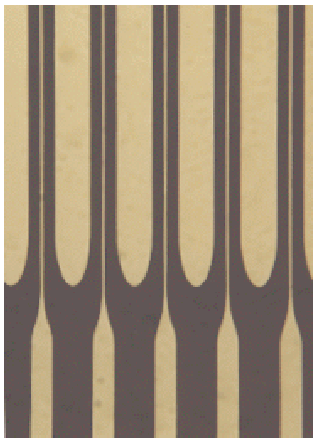
Substrate:

- 300 µm glass substrate AF45, DESAG (D)
- *diamond-like* coating, ~80 nm, $2 \cdot 10^{14}$ Ω/ □
  SURMET (USA)



Structure:

- 500 nm thickness, lift-off process, IMT (CH)
- aluminum
  - robust (cleaning)
  - ~10 kΩ/m ⇔ fast signals
- gold
  - sensitive
  - ~10 kΩ/m ⇔ fast signals



Test Detectors

GEM-MSGC

- size (10×10) cm^2
- frame material: G10, Peak
- GEM foil: different geometries
- drift electrode: 100 µm capton, 17 µm copper
- glue: EPO-TEK H72

High Voltage

- $U_{drift} \Rightarrow U_{GEM,up}, U_{GEM,down}$ with voltage divider
- $U_{cathode}$
- each voltage with current meter (nA)

Readout

- VV50 preamplifier

Counting Gas

Ar/DME (50/50):

- high primary ionisation
- good quencher
- CH_3-O-CH_3 $\leftrightarrow$ "hydrocarbon with oxygen"
- high drift velocity

Ar/CO_2 (70/30):

- inflammable
- no "C-chain" (no polymerisation effects)
- reduced HV stability

Water Admixture:

- operation more stable?

Distributor:

- Messer-Griesheim, DESY

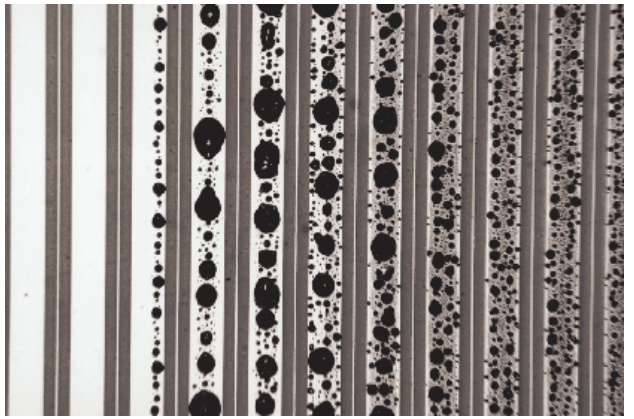
Gas System

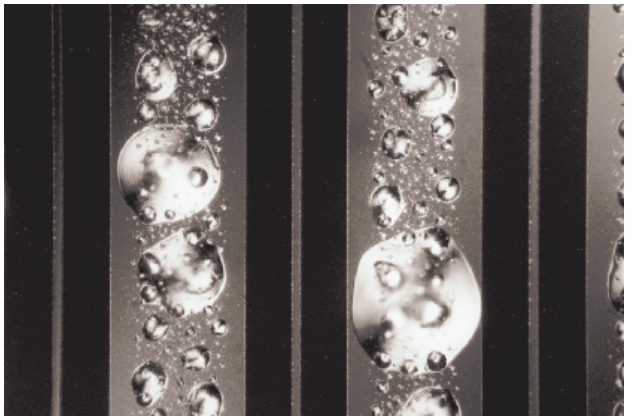
- stainless steel (tubes, valves, flow meter, tube fittings)
- sealing rings: Kalrez
- outlet: 10 m tube (no bubbler !)
- 2 bypass devices:
  - cooling trap (very clean H_2O @ T = -8° C)
  - α-particles source
  - (• samples of material or glue)
- gas flow 10 ml/min (= 10 detector volume / hour)

Aluminum, Ar/CO_2

MSGC structure:	aluminum
frame material:	G10
drift electrode:	capton, copper
filling gas:	Ar/CO_2 (70/30)
	pre-mixed DESY
particle flux:	$8 \cdot 10^3$ $\gamma/mm^2 s$
acc. charge:	2.7 mC/cm
total gain:	4000
GEM gain:	~11
MSGC gain:	~360
irradiated area:	350 mm^2

decrease of pulse hight ($0.3 \cdot A_0$)

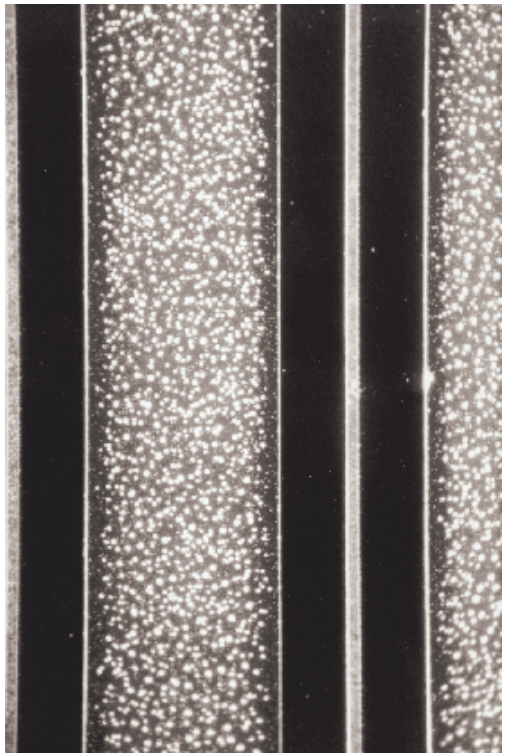




bubbles on cathodes

Aluminum, Ar/DME

MSGC structure:	aluminum
frame material:	Peak
drift electrode:	capton, copper
filling gas:	Ar/DME (50/50) + 0.3% H_2O
	Messer-Griesheim/DESY
particle flux:	$5 \cdot 10^3$ $\gamma/mm^2 s$
acc. charge:	0.8 mC/cm
total gain:	5000
GEM gain:	~10
MSGC gain:	~500
irradiated area:	100 cm^2



decrease of pulse hight

crates on cathodes

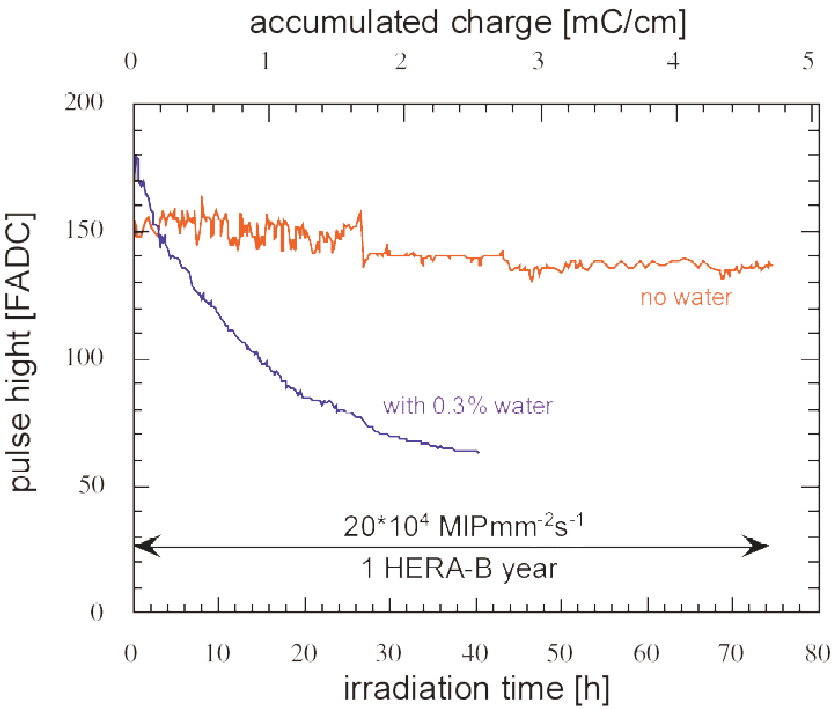
Water Admixture (0.3%)

"super clean" GEM-MSGC

MSGC structure: gold
frame material: glass
drift electrode: glass, gold

filling gas: Ar/DME (50/50)
pre-mixed DESY
± 0.3% H_2O

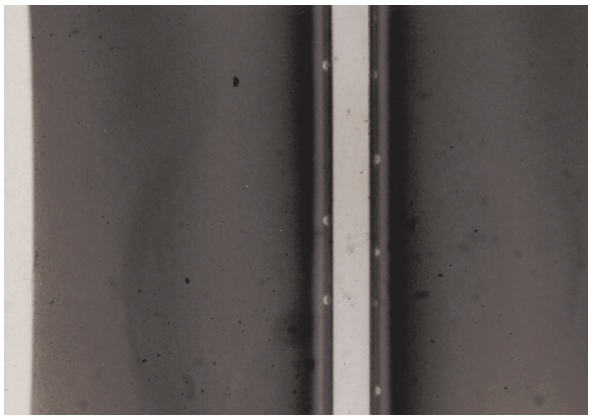
particle flux: 20•10³ γ/mm²s

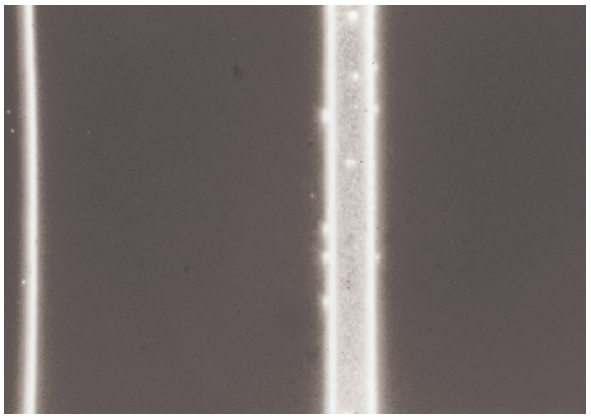


- experience in long term measurements:
  increased running stability, but massive anode ageing …

Gold, Ar/DME + H_2O

MSGC structure:	gold
frame material:	glass
drift electrode:	glass, gold
filling gas:	Ar/DME (50/50) + 0.3% H_2O
	pre-mixed DESY
particle flux:	$20 \cdot 10^3$ γ/mm^2s
acc. charge:	2.6 mC/cm
total gain:	5000
GEM gain:	~20
MSGC gain:	~250
irradiated area:	175 mm^2



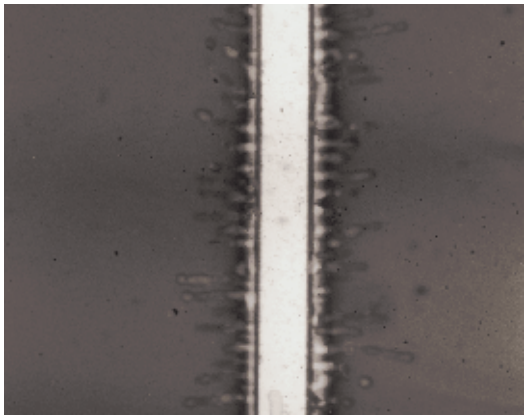


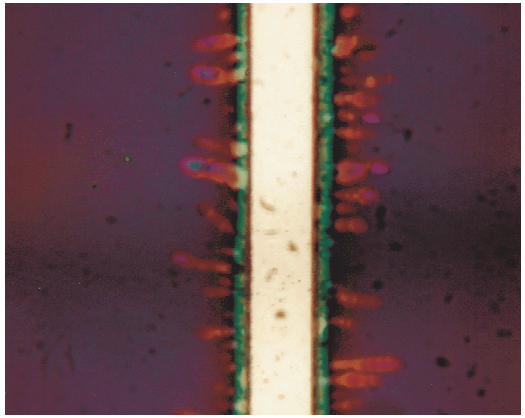
decrease of pulse hight ($0.3 \cdot A_0$)

coating on anodes

Gold, Ar/DME + H_2O

MSGC structure:	gold
frame material:	G10
drift electrode:	capton, copper
filling gas:	Ar/DME (50/50) + 0.3% H_2O
	pre-mixed DESY
particle flux:	up to $8 \cdot 10^3$ γ/mm^2s
acc. charge:	1.9 mC/cm
total gain:	4000
GEM gain:	~10
MSGC gain:	~400
irradiated area:	100 cm^2



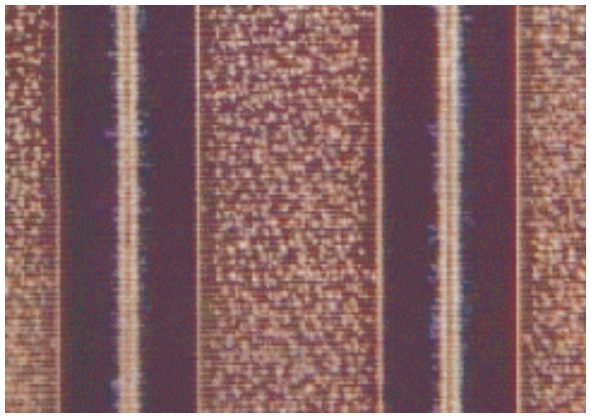


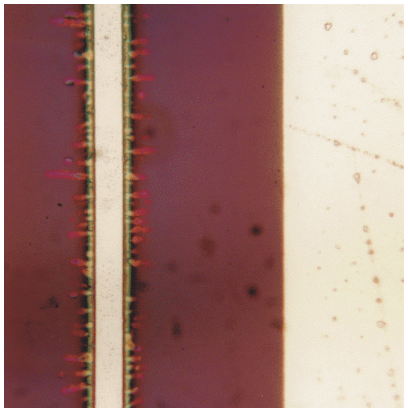
decrease of pulse hight

whiskers on anodes

Aluminum, Ar/DME + H_2O

MSGC structure:	aluminum
frame material:	Peak
drift electrode:	capton, copper
filling gas:	Ar/DME (50/50) + 0.3% H_2O
	Messer-Griesheim / DESY
particle flux:	up to $5 \cdot 10^3$ γ/mm^2s
acc. charge:	0.8 mC/cm
total gain:	4000
GEM gain:	~10
MSGC gain:	~400
irradiated area:	100 cm^2





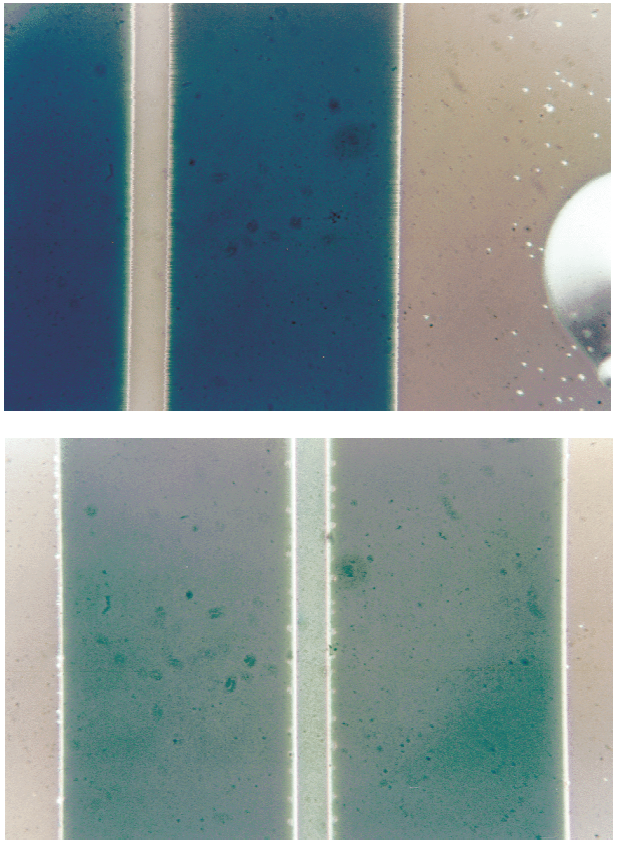
decrease of pulse hight

whiskers on anodes

Aluminum, Ar/CO2 + H_2O

MSGC structure:	aluminum
frame material:	G10
drift electrode:	capton, copper
filling gas:	Ar/CO_2 (70/30) + 0.3% H_2O
	pre-mixed DESY
particle flux:	up to $20 \cdot 10^3$ γ/mm^2s
acc. charge:	5.8 mC/cm
total gain:	4000
GEM gain:	~10
MSGC gain:	~400
irradiated area:	350 mm^2

drop of pulse hight ($0.5 \cdot A_0$)
decrease of energy resolution



whiskers on anodes

G10 / Eccobond 285

MSGC structure: gold
frame material: glass
drift electrode: glass, gold
filling gas: Ar/DME (50/50), pre-mixed DESY
particle flux: up to $20 \cdot 10^3$ γ/mm^2s

	G10	Eccobond 285
test samples:	120 cm^2	60 cm^2
acc. charge:	6.6 mC/cm	5.6 mC/cm
total gain:	4900	4200
GEM gain:	~22	~21
MSGC gain:	~220	~210

no ageing effects !

Glues - Summary

- EPO-TEK H72 ✔

Material	Type Curing	Use	Surface (cm2)	Outgassing in Argon	Outgassing in DME	Outgassing in Ar-DME	Effect in SWPC/ MSGC	Global result
EPOTEK H72	Epoxy 1.5 h @ 65 oC	MSGC assembly	150	Yes (in the 1st hour)	Yes (in the 1st hour)		No effect	OK

up to 48 mC/cm (Ref.: Hott)

- Stycast 1266 ✔

Material	Type Curing	Use	Surface (cm2)	Outgassing in Argon	Outgassing in DME	Outgassing in Ar-DME	Effect in SWPC/ MSGC	Global result
STYCAST	Epoxy Room Temp.	MSGC assembly	150	No	No		No effect	OK

- Eccobond 285 ✔

up to 5.6 mC/cm

Material	Type Curing	Use	Surface (cm2)	Outgassing in Argon	Outgassing in DME	Outgassing in Ar-DME	Effect in SWPC/ MSGC	Global result
DURALCO 4525	Epoxy Room Temp.	MSGC assembly	156			Yes @ Room T	Gain loss	Bad
STYCAST	Epoxy Room Temp.	MSGC assembly	150	No	No		No effect	OK
ARALDIT AW 106 HV (Hard. HV 953U)	Epoxy 2 d @ 70 oC	MSGC assembly	176			Yes @ Room T	Gain loss	Bad
ARALDIT 2014	Epoxy	MSGC assembly	150		Yes @ Room T			Bad
ARALDIT F (Hard. 905)	Epoxy	MSGC assembly	212	No	No			OK
EPOTECNY E 505 SIT	Epoxy i) 30 m @ 80 oC ii) 24h @ 50 oC	MSGC assembly				Yes @ Room T	No effect	OK
EPOTECNY 503	Epoxy 1 h @ 65 oC	MSGC assembly	185		Silicon at room T.			Bad
EPOTEK E905	Epoxy Room Temp.	MSGC assembly	150	Yes @ T> 45 oC	Yes @ T> 45 oC			Bad
EPOTEK H72	Epoxy 1.5 h @ 65 oC	MSGC assembly	150	Yes (in the 1st hour)	Yes (in the 1st hour)		No effect	OK
POLYIMIDE	Epoxy	MSGC	110	No	No			
Norland UVS 91	Epoxy UV light+50oC	MSGC assembly	150		Yes @ Room T			Bad
STESALIT 4411W	Fibreglass	MSGC frame	380			Yes @ T=75 oC	No effect	OK
VECTRA C150	Liquid crystal polymer	MSGC frame	142			Yes @ Room T	No effect	OK
RYTON R4	Polysulphur phenylene	MSGC Frame	306			Yes @ Room T	Gain loss	Bad
PEEK crystalline	Poly ether ether ketone	MSGC Frame	288	No	No		No	OK
PEEK amorphous	Poly ether ether ketone	pipe	2m long 3 mm ø					Bad

Ref.: GDD, CERN

Change of MSGC gain

MSGC structure: gold
frame material: G10
drift electrode: capton, copper
filling gas: Ar/DME (50/50), pre-mixed DESY
particle flux: up to $20 \cdot 10^3$ γ/mm^2s

coating:	SURMET	Fraunhofer	
acc. charge:	16.3 mC/cm	5 mC/cm	~25 mC/cm
total gain:	3000	~4000	
GEM gain:	~25		
MSGC gain:	~120		
irradiated area:	100 mm^2	10^4 mm^2	
MSGC gain:	+10 %	factor 2	factor 3-5

(Ref.: C. Richter)

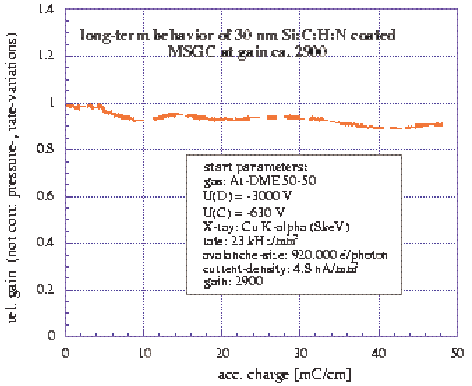
Change of GEM Gain

- Increase
  - turn-on effect (within first 20-60 s, only once): +20 %
  - charging up ("old" gain after interruption): +(30 – 60) %
    200/140/120 +30%; 140/120/70 +60%
- "Ageing"
  - decrease of GEM gain: up to (-50 %)
    200/140/80 –20%; 140/120/70 –50%
- Variations
  - ± 10 % (within 600 h)
    140/120/70
- Elongation
  - $\frac{\Delta h}{h_{trans}} = \frac{0.8mm}{3mm} \approx 30\% \Rightarrow$ gain variations up to factor 2
  - no elongation with Ar/CO_2 !

Irradiation area – Gas flow

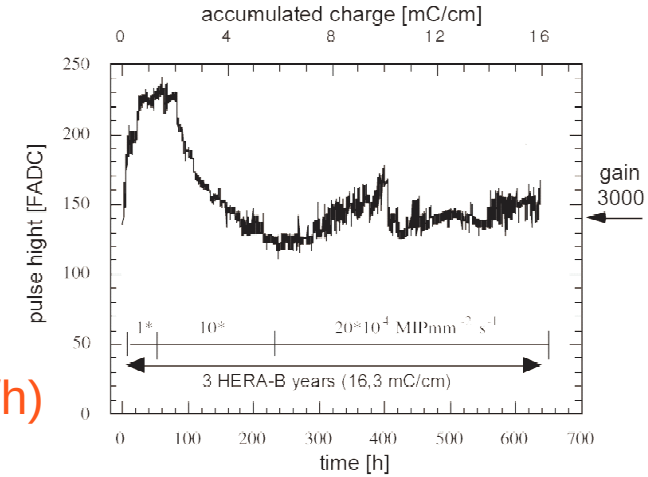
Tests of prototypes

MSGC:	(2×3×0.3) cm^3
irradiated area:	10^1 mm^2
filling gas:	Ar/DME (50/50)
acc. charge:	48 mC/cm
gas flow:	~1 ml/min (30 volumes/h)



Ref.: T.Hott

GEM-MSGC:	(10×10×0.6) cm^3
irradiated area:	10^2 mm^2
filling gas:	Ar/DME (50/50)
acc. charge:	16 mC/cm
gas flow:	10 ml/min (10 volumes/h)



How the story continued . . .

Tests of *full-size* detectors

GEM-MSGC:	(23×23×0.6) cm^3
irradiated area:	10^4 mm^2
filling gas:	Ar/DME (50/50)
acc. charge:	1 - 25 mC/cm
gas flow:	10 ml/min (2 volumes/h)

gas ageing

elongation of GEM foil

→ ~~Ar/DME~~ ⇒ Ar/CO_2 (70/30)

diamond ageing / etching → "coated" ⇒ "uncoated" MSGC

(Ref.: C. Richter)

Conclusion of Ageing Tests

- cathode material → no aluminum
- counting gas → no water admixture
- ageing tests → large irradiation area
- gas flow → comparable to final gas flow