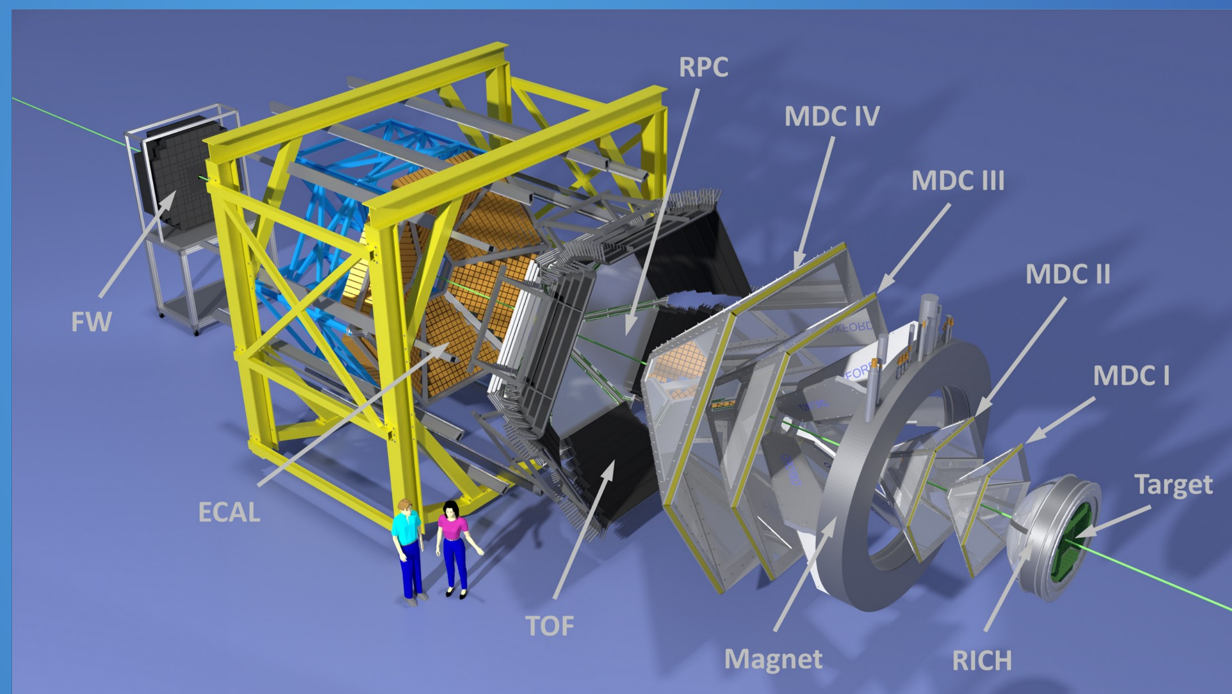
HADES MDC

HADES drift chambers past and future

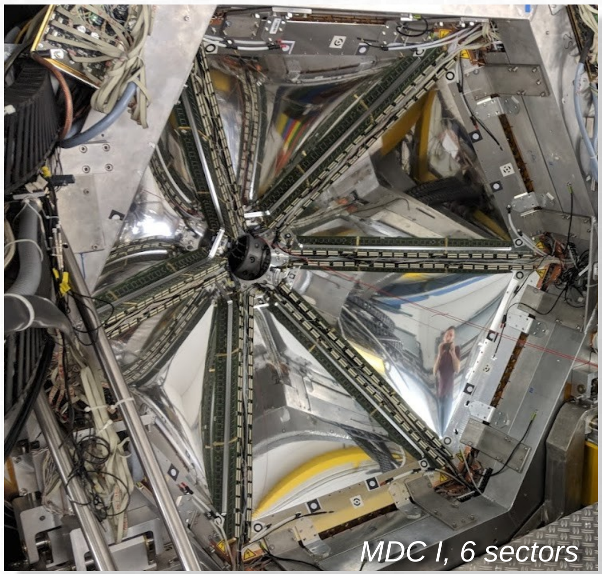


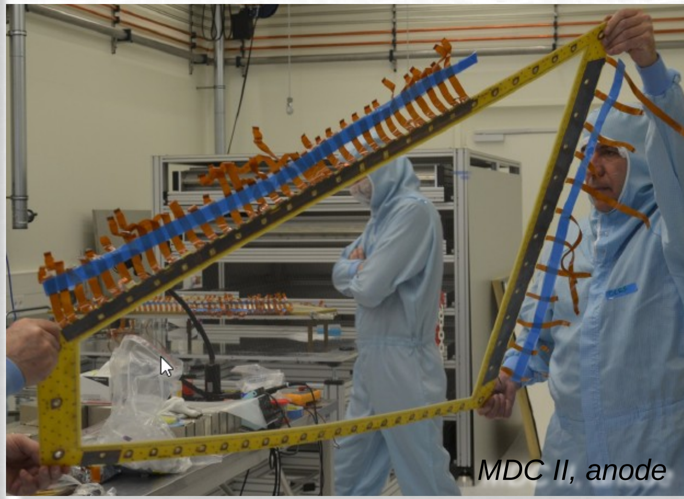
Christian Wendisch from the GSI Helmholtz Centre for Heavy Ion Research
for the HADES MDC detector team

HADES

GSI

HADES drift chambers


MDC I, 6 sectors


MDC II, anode


MDC III

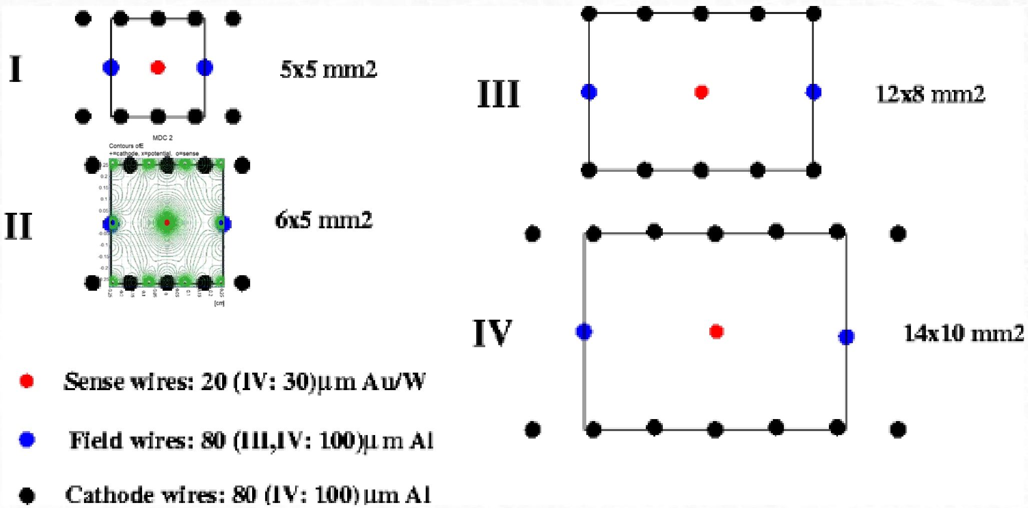

MDC III

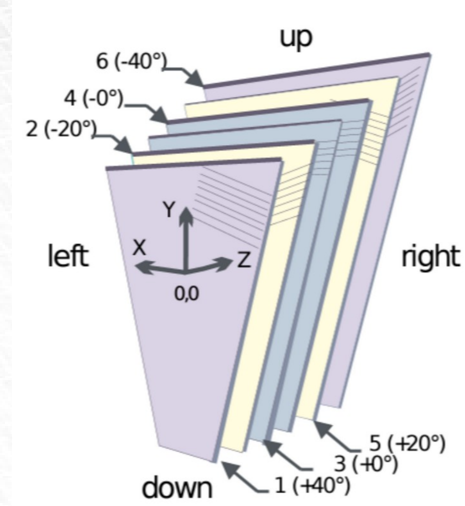
- 4 different sizes
- 24 chambers
- 26 256 channels
- closed gas system with O_2 purifiers
- constructed in
  I. GSI Darmstadt,
  II. JINR Dubna,
  III. FZ Rossendorf,
  IV. IPNO Orsay

Plane	sense wires	cell size (X x Z)	active area	inner size	volume	gas flow
	number	mm x mm	m²	mm x mm	liter	volume / h
MDC I	1006	5 x 5	0.35	760(120) x 790	18	0.8
MDC II	1104	6 x 5	0.53	860(200) x 1000	27	0.6
MDC III	1098	12 x 8	2.21	1850(300) x 2060	194	0.13
MDC IV	1168	14 x10	3.21	2200(320) x 2550	321	0,08
Total (6 sectors)	26256		37.8		3360	

HADES mini drift chambers - MDC

mini drift cells 5 mm x 5 mm

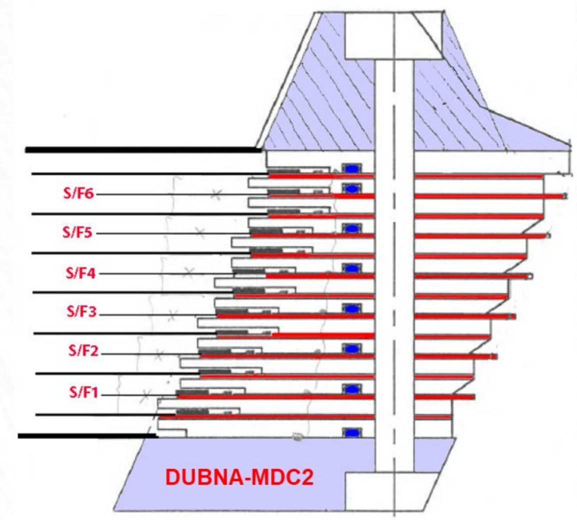




6 layers of stereo angles

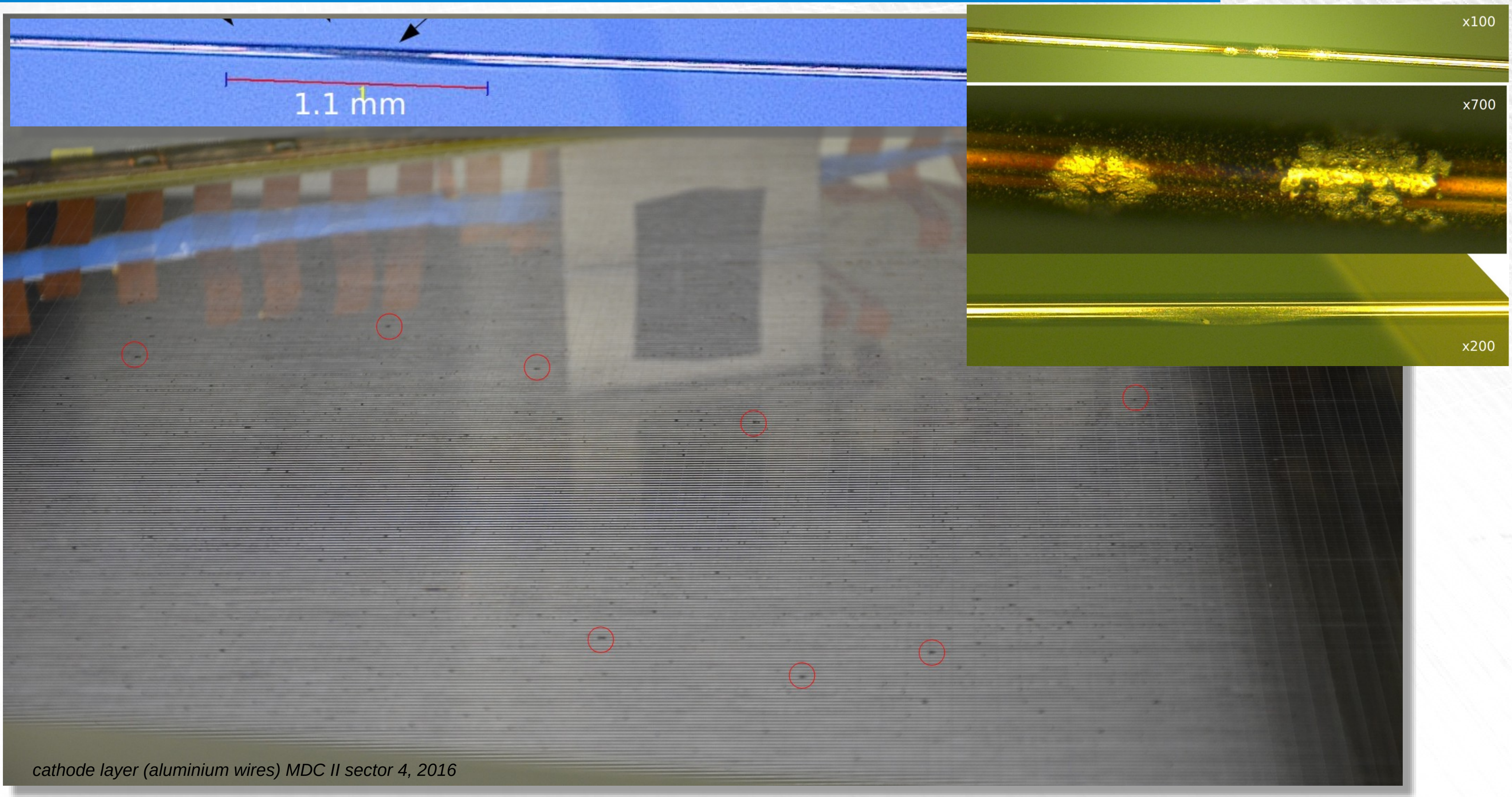
design optimized for:

- **low-mass**
  - → He / isobutane gas mixture
  - → cathode wires: aluminium (gold plated)
  - → material budget in radiation length x / X_0 = 0,06 %
- **high acceptance:**
  - → inactive structures inside shadow of magnet coils
  - → frames limited in width
- sandwich layer design allowing **re-workability**
  - → mech. challenge: guarantee wire tension



MDC II frame cross-section

Aging: deposits MDC II - 2016

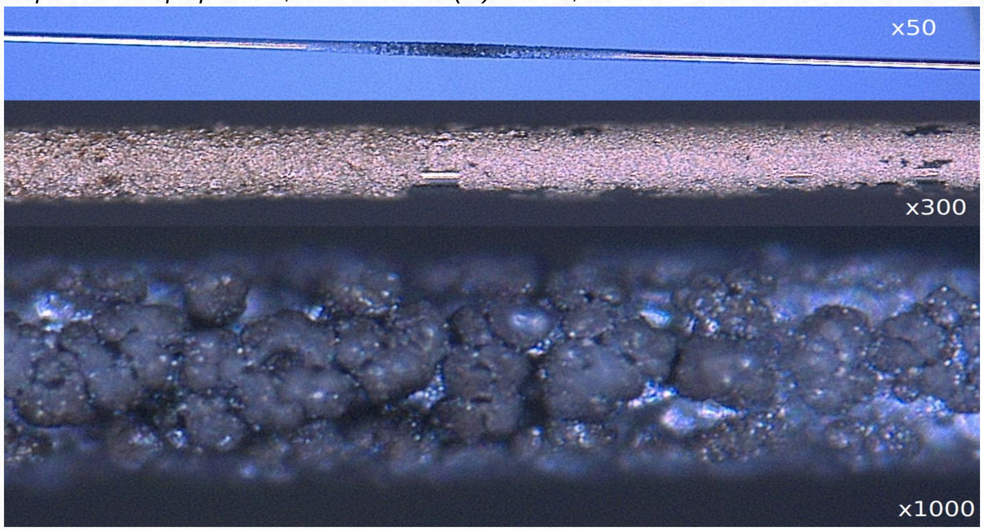


- deposits **homogenously distributed** over full chamber
- cleaning of deposits not feasabile (high risk) → **find operation mode recovering stability**

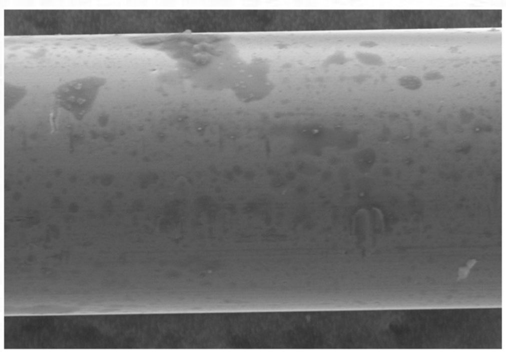
Case B: deposits MDC II - 2016

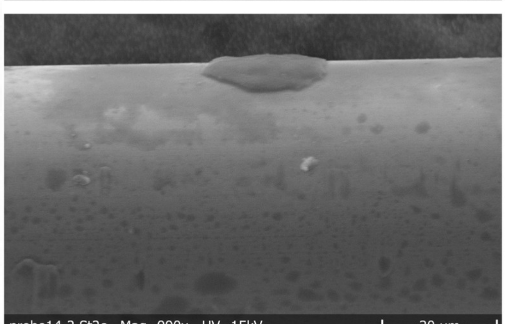
HADES MDC

opt. microscope pictures, cathode wires (Al) MDC II, 2016

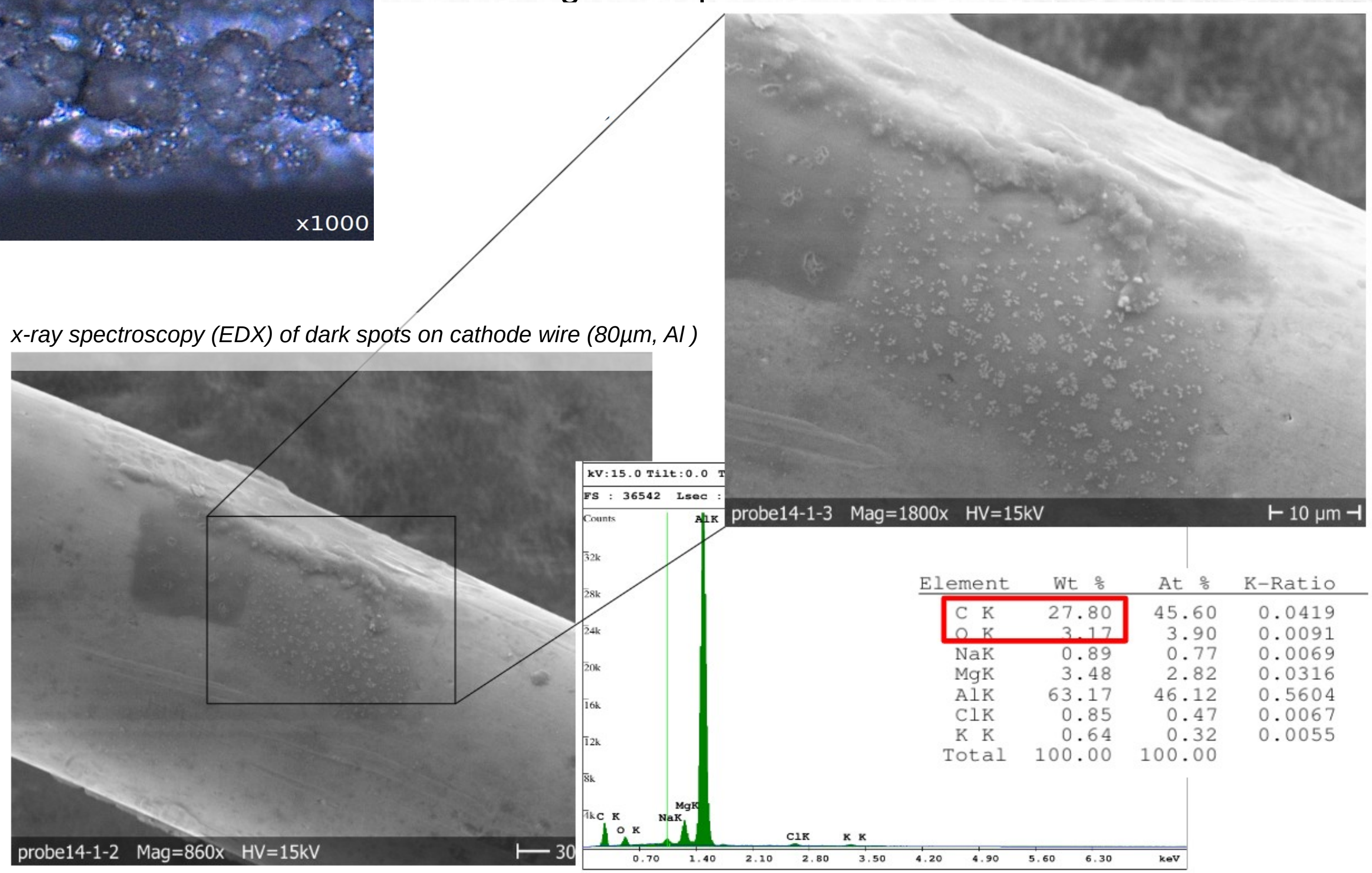


- fast *aging* during Au+Au beamtime
  - 84% Ar + 16% **i-C_4H_{10}**
  - load << 10 mC / cm (I$_{max}$ on wire 1 nA / cm)
- abundant dark spots on cathode & field wires found
- no silicone deposits, instead carbon
- anode wires clean
  - no gain drop observed



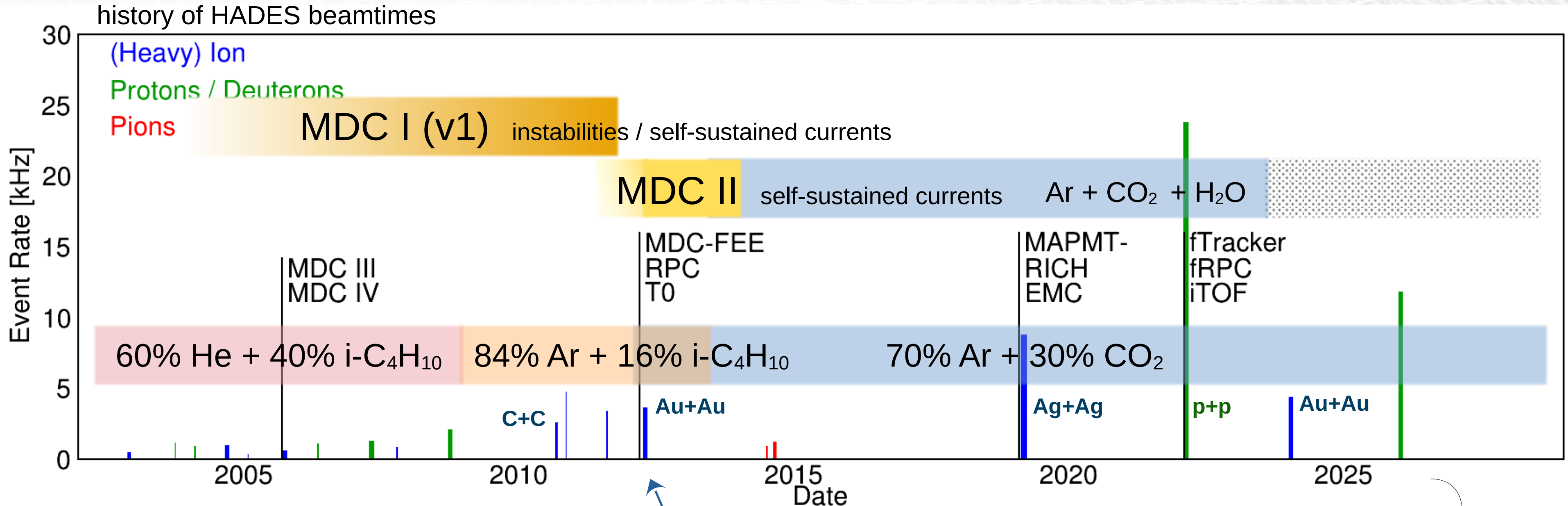


x-ray spectroscopy (EDX) of dark spots on cathode wire (80µm, Al)



Element	Wt %	At %	K-Ratio
C K	27.80	45.60	0.0419
O K	3.17	3.90	0.0091
NaK	0.89	0.77	0.0069
MgK	3.48	2.82	0.0316
AlK	63.17	46.12	0.5604
ClK	0.85	0.47	0.0067
K K	0.64	0.32	0.0055
Total	100.00	100.00	

HADES drift chamber history



accum. load
<< 10 mC / cm

design optimized for:

- low-mass
  - → He / isobutane gas mixture
  - → cathode wires: aluminium (gold plated)

gas changes:

1. He / isobutane, chosen because of low material budget, approved by accelerated aging
2. Ar / isobutane, for reducing HV, because high primary ionization allows lower gas gain
3. Ar / CO_2 , for preventing aging

➔ faste drift velocity (lower spatial resolution) & inhomogenius drift velocity, due to lower field in edges, depends on gas properties
 (CO_2 ratio kept high, since reduced quenching, compared to isobutane)

outlook

HADES will move to SIS100:

What is the stability at higher rates ?
→ open question to be resolved

→ tension of Aluminium wires close to critical limit

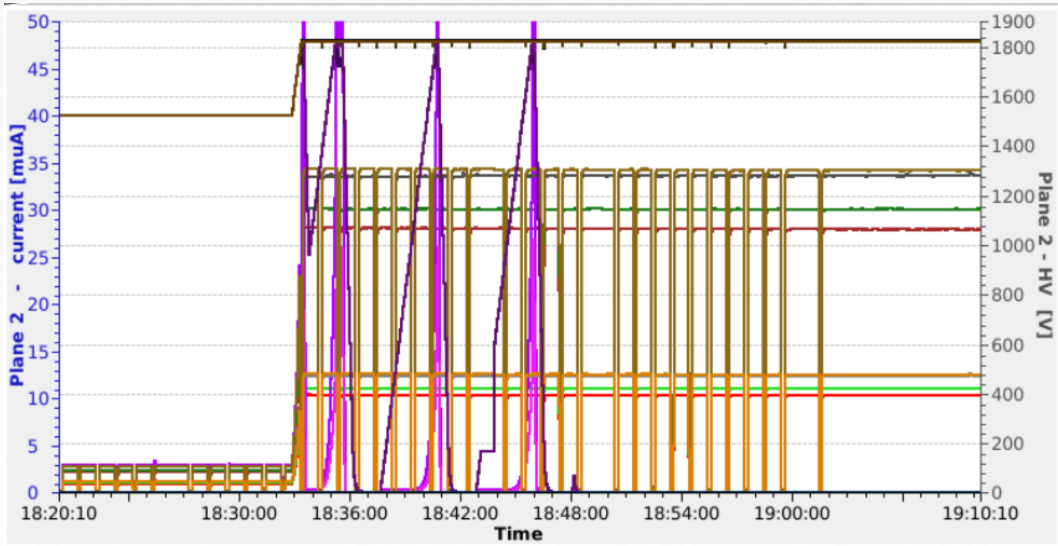
→ **rebuild of MDC II seems to be mandatory**

HADES MDC

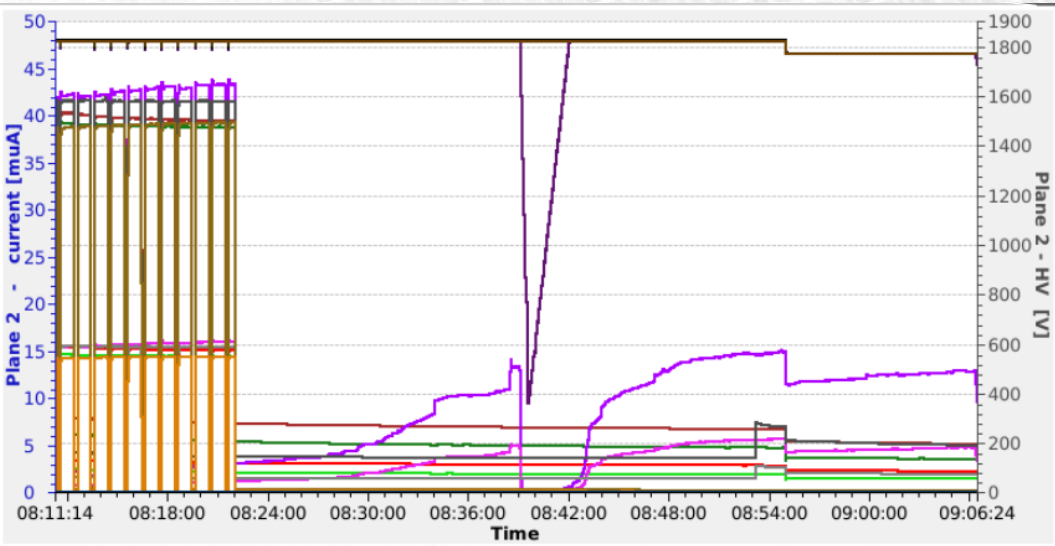
backup

Effect of water additive

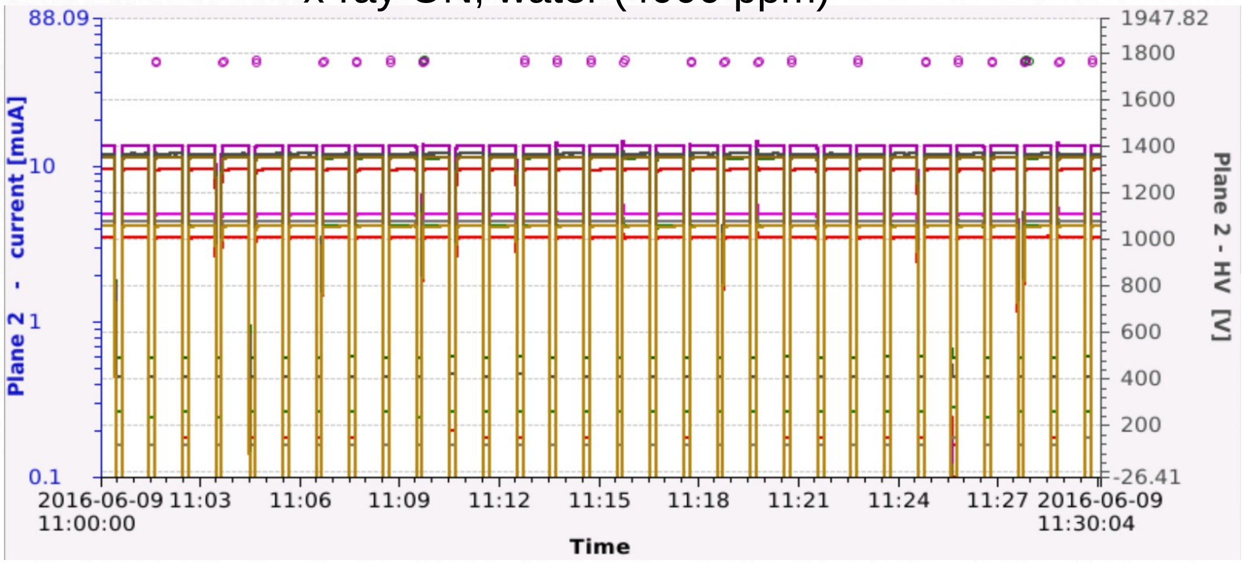
x-ray ON, no water (0 ppm)



x-ray OFF, no water (0 ppm)

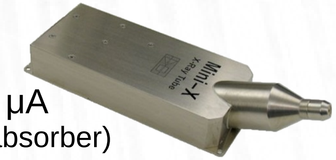


x-ray ON, water (4000 ppm)

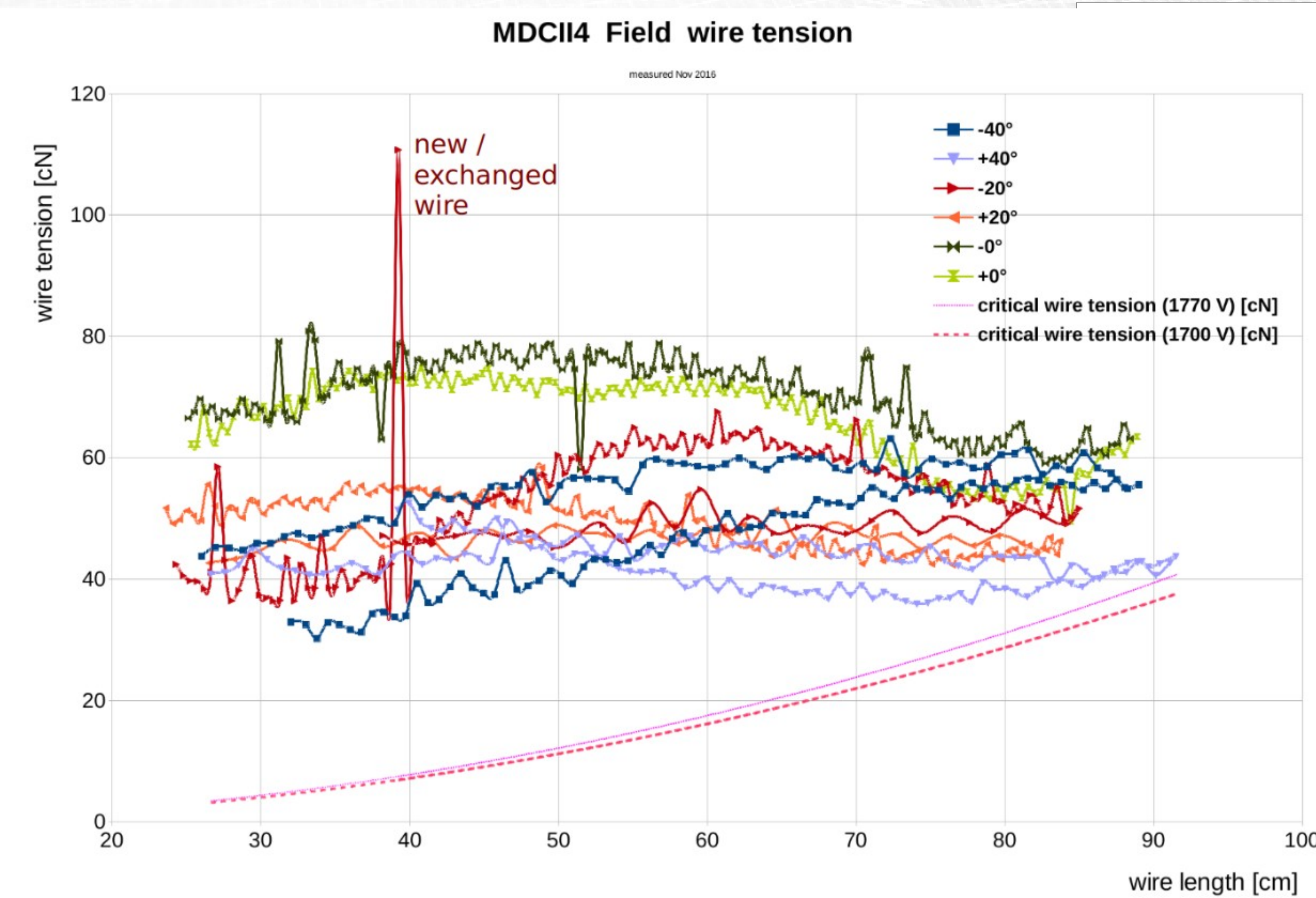


- self-sustained currents (without load)
- extinguished by adding water (4000 ppm)

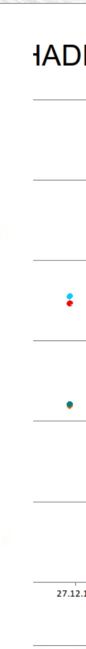
Amptek Mini-X:
HV = 25 kV, I ~7 µA
(+ 140 µm copper absorber)



wire tension - Aluminium

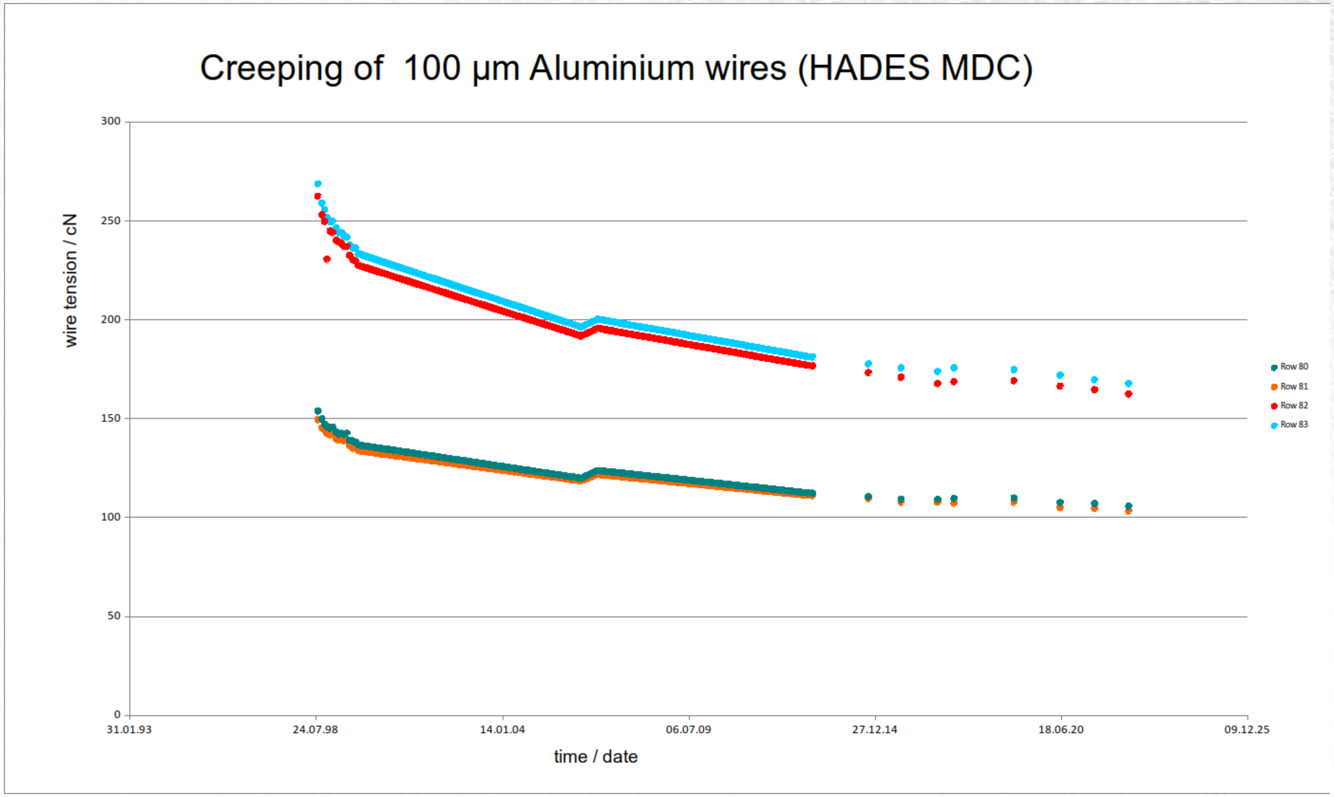


- Aluminium wires (80 µm diameter)
  - substential loss of tension initial ~100 gramms!
  - No evident tension dependence on length, rather on wire orientation / frame forces



wire tension - Aluminium

- Creeping of Al wires is well known, most pronounced during first months (years)
- It levels off after > 10-15 years, but seems not to stop
- During repairs in plane II creeping was confirmed, measured in average (still) above the critical tension (below this value: electrostatic instabilities expected, sagging, sticking wires ...)



➔ Conclusion: not considered being the primary show stopper, but will, especially in combination with discharges = oscillations, lead to repair work.

MDC II rebuild: cost estimation

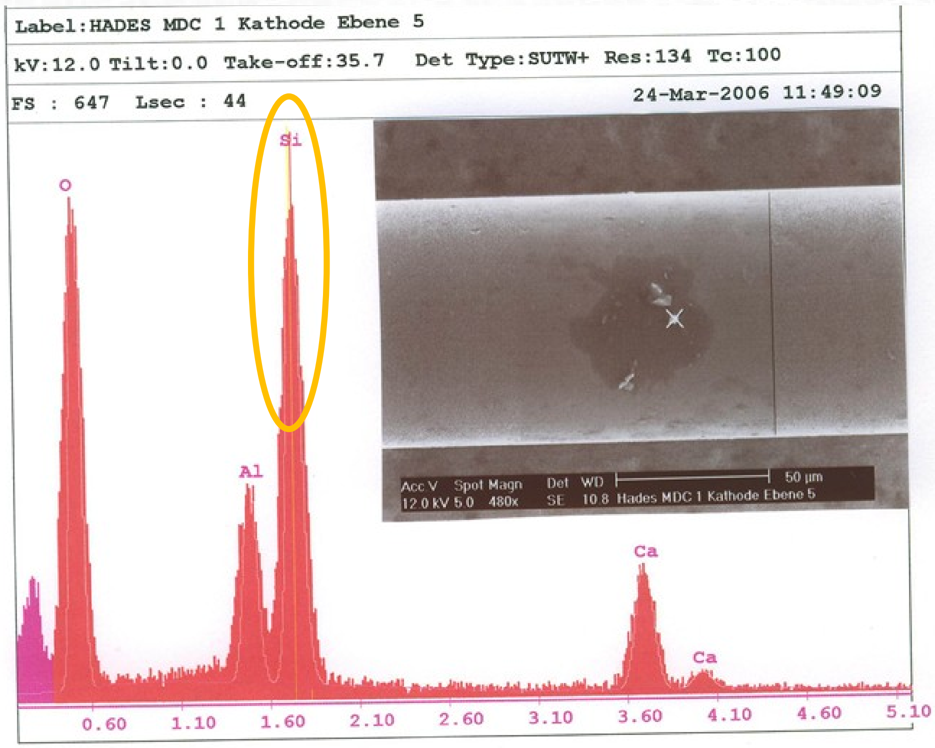
MDCII Rebuild Cost Estimate			
	"area factor" for scaling MDCI → MDCII:	1,44	
fill color: to be updated with new offers!	increase of market prices	1	
	inflation	1	
Hardware	**2010/11 prices (Rossendorf production)**		
Item	**Costs in k€ for MDC-1 (chamber 8)**	**Estimate for MDC-2 (+44%), k€**	
Wire frames (Vetronit)	2,25 k€	3,24 k€	
Window frames (Al)	0,50 k€	0,72 k€	
Utilities (grinder, polish paper, glue)	1,00 k€	1,44 k€	
Wire (Sense, Au/W, 8 km)	2,26 k€	3,25 k€	
Wire (C/F, Cu/Be, 60 km)	0,40 k€	0,58 k€	
PCB (HV distribution)	0,20 k€	0,29 k€	
PCB-frame (from MDC II): FR4 boards, 0.5mm, 10€/dm^2	2,20 k€	3,17 k€	
Flex (from MDC II, III, IV), ILFA-version per 4 wires ~ 10€/flex (incl. offsets + crimp)	3,00 k€	4,32 k€	
Price Tag per module (Hardware)	**11,81 k€**	**17,00 k€**	
Price Tag 7 modules (Hardware)	**82,66 k€**	**119,02 k€**	
Manpower			
1 module production: 2 months, 2 people: 4 PM/module	8,40 k€	8,40 k€	
Offset/preparations 2-3 months, 1-2 people: 4 PM	8,40 k€	8,40 k€	
Price Tag 7 modules (Manpower)	**67,20 €**	**67,20 €**	
Grand total 7 modules	**149,86 k€**	**186,22 k€**	
Vetronit EGS 103: 150€ per 4x1170x1070 mm3 Sheet			
# Sheets / module	15		
price per sheet	150 €		
Vetronit Costs / module	2.250 €		
Sense Wire: (at 24km order spool 6km)			
price per km	300 €		
offset	500 €		
total length 7 chambers (km)	51		
Sense wire costs per module (offset distr.)	2.257,14 €		
Field Wire: (at 130km=5kG order spool 12km)			
price per 5 kg = 130 km	$800	1 unit (km)	130
price per km	$6,15		
offset	$400		
total length 7 chambers (km)	420		
Field wire costs per module	401 €	1$ = (20/12/22)	0,94 €
Manpower:			
Manpower/PM (assume 30days * 70€ (accomondation+meals) 1800€/month = 1 PM)	2,10 k€		

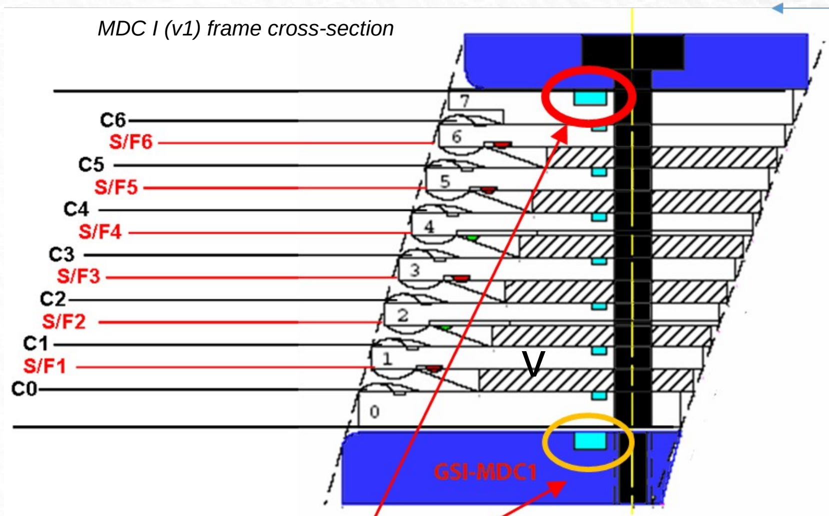
Case A: deposits in MDC I (v1)

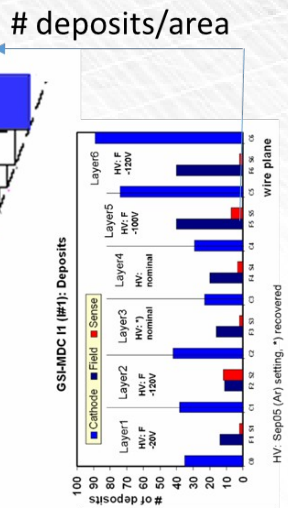
2000 – 2011: MDC I (v1) self-sustained currents & discharges could be traced back to silicon contamination (from vacuum grease)

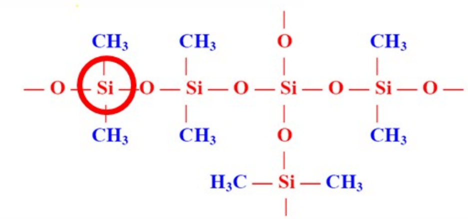
cathode wire (Al) with deposits

energy dispersive x-ray spectroscopy (EDX) of deposits on cathode wire (80µm, Al)









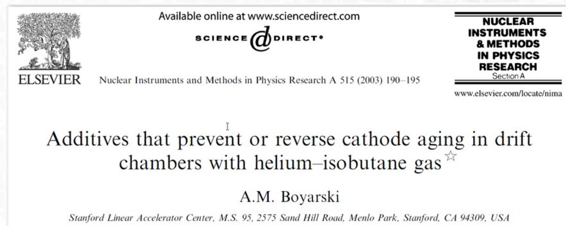
- lesson learned
- silicon deposits rel. inert chemically, removing deposits not possible
- water additive triggering discharges towards inside steel frames
- → rebuild 6 drift chambers

Effect of water additive

adjusting water amount for MDC II

self-sustained currents

- points to Malter-effect
- **water can recover operation**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ELSEVIER Nuclear Instruments and Methods in Physics Research A 515 (2003) 190–195
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

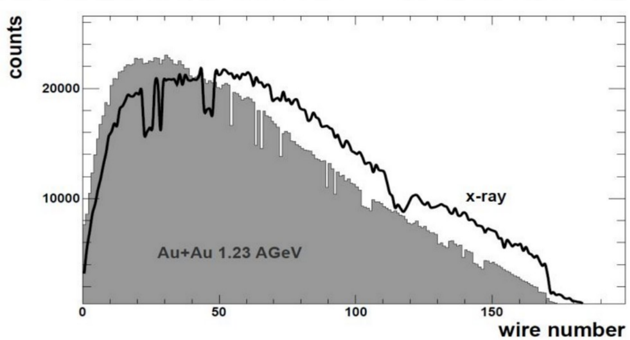
Additives that prevent or reverse cathode aging in drift chambers with helium–isobutane gas☆

A.M. Boyarski

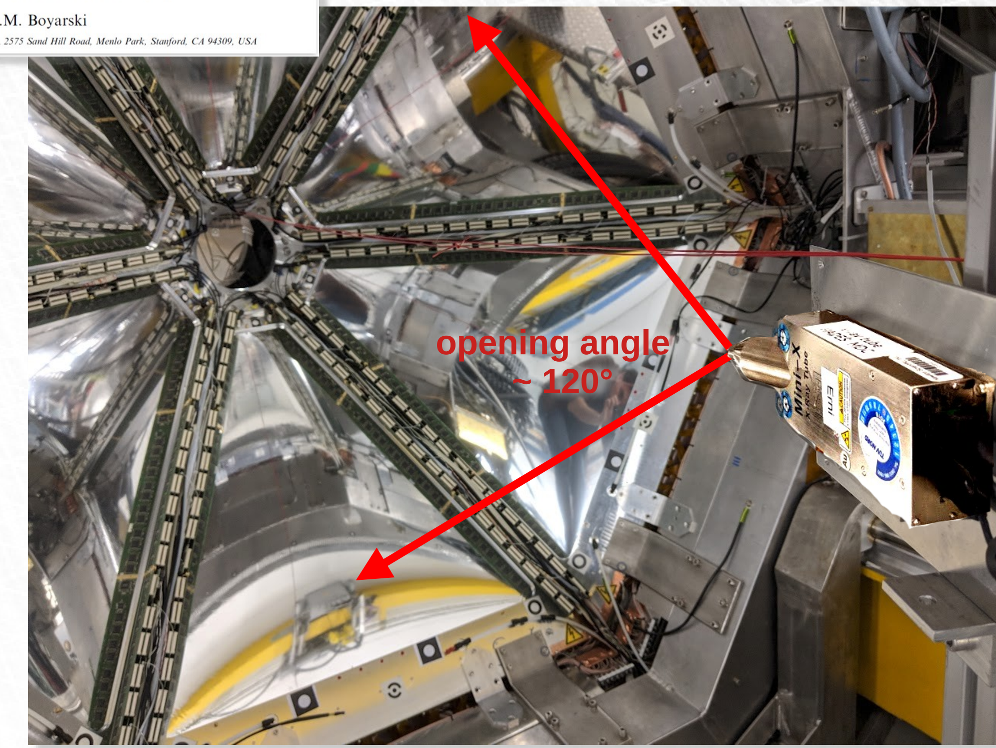
Stanford Linear Accelerator Center, M.S. 95, 2575 Sand Hill Road, Menlo Park, Stanford, CA 94309, USA

no beamtime in between production runs

- with x-ray tube try to reproduce:
  - beam load ~ 1 nA/cm
  - beam spill duty factor: 40s / 10s
  - hit occupancy distribution



- individual amount of deionized water adjusted for each of 6 drift chambers
  - fine tuning during beamtime needed, due to accumulation of water during weeks of running
- conditioning (HV & water) prior to beamtime beneficial

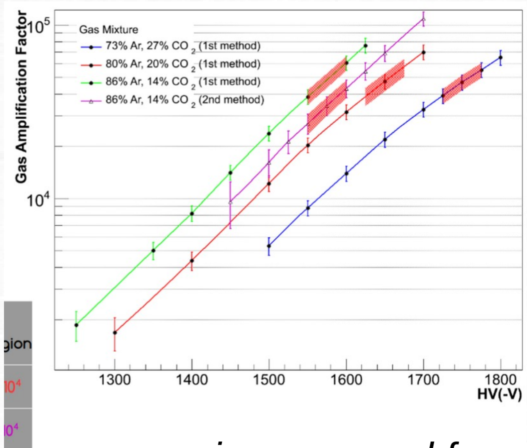


x-ray tube installed at HADES target point in front of MDC I

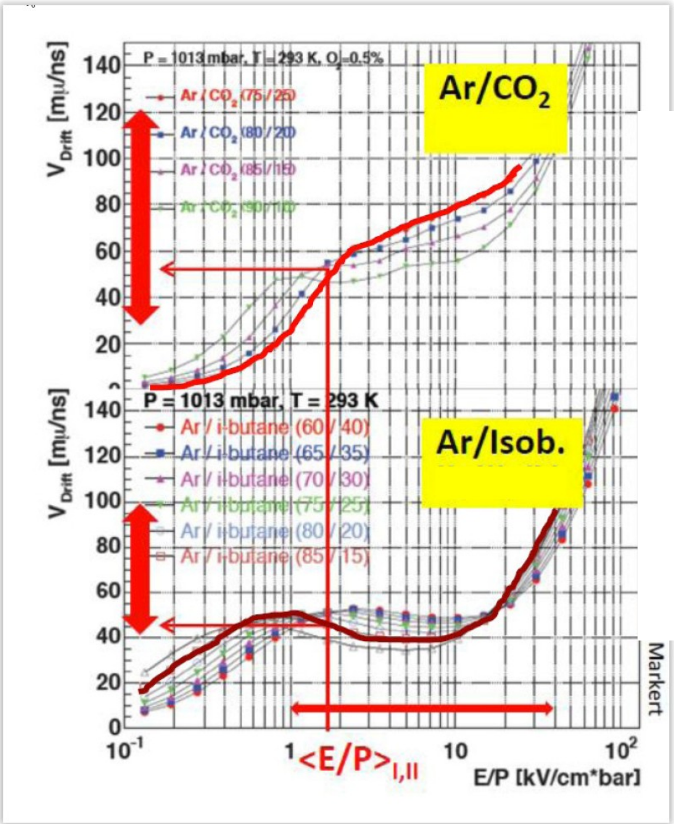
MDC II	sector 1	sector 2	sector 3	sector 4	sector 5	sector 6
H_2O fraction	1800-2100 ppm	1000-1800 ppm	2000-3000 ppm	3000-3500 ppm	1800-2000 ppm	2500-3000 ppm

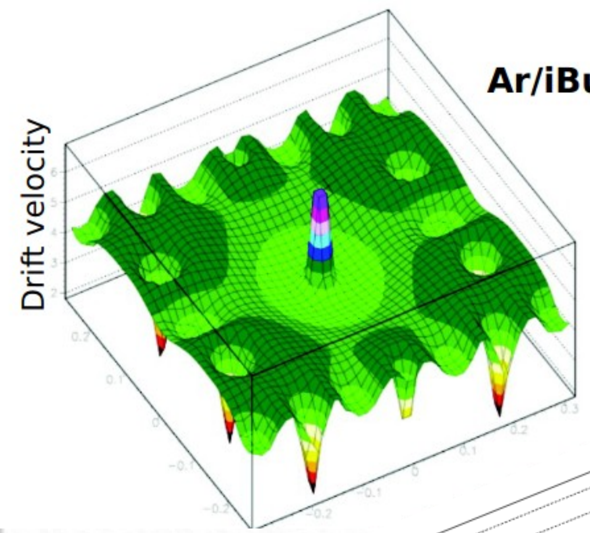
by Luis Lopes 2013 (x-ray) – 2022 (beam)

HADES mini drift chambers - MDC

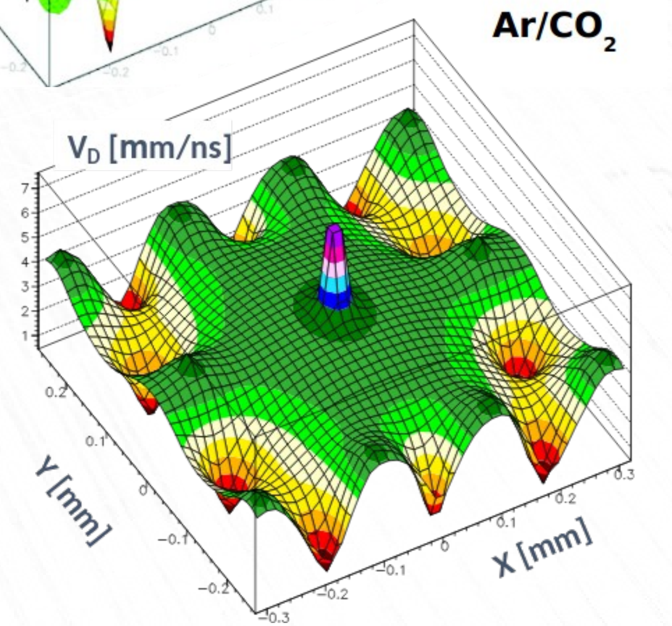


gas gain measured for several gas mixtures: 3-5 x 10^4





Drift velocity of Ar/CO2 higher compared to Ar/iButane



design optimized for:

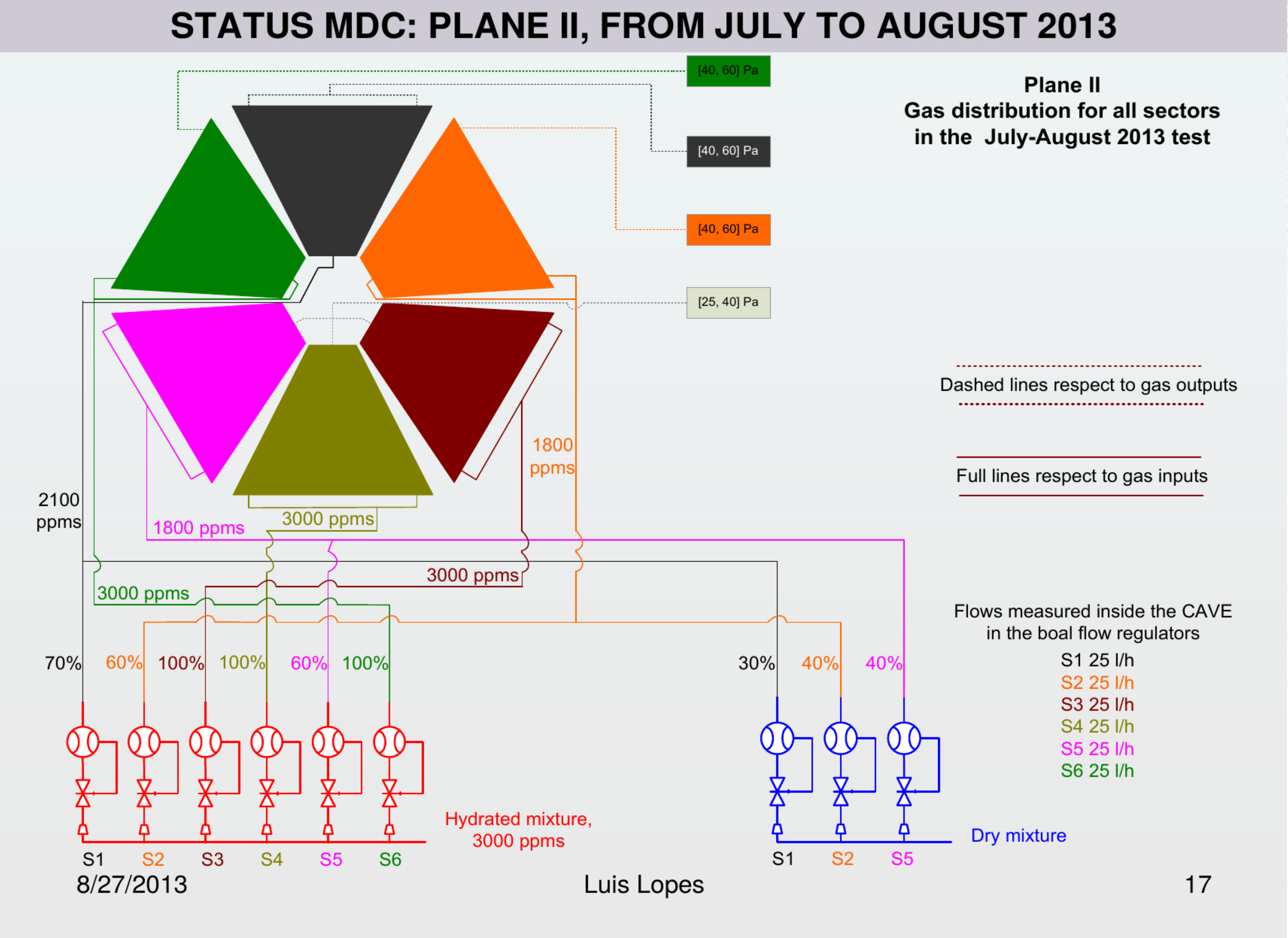
- low-mass
  - → He / isobutane gas mixture
  - → cathode wires: aluminium (gold plated)

gas changes:

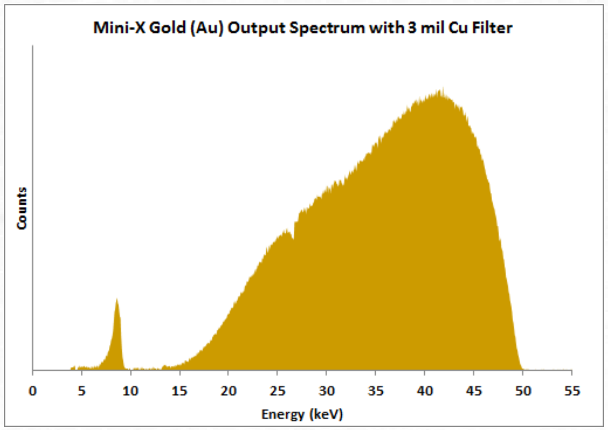
1. He / isobutane, chosen because of low material budget, approved by accelerated aging
2. Ar / isobutane, for reducing HV, because high primary ionization allows lower gas gain
3. Ar / CO_2 , for preventing aging

➔ faste drift velocity (lower spatial resolution) & inhomogenius drift velocity, due to lower field in edges, depends on gas properties
 (CO_2 ratio kept high, since reduced quenching, compared to isobutane)

water additive MDC II

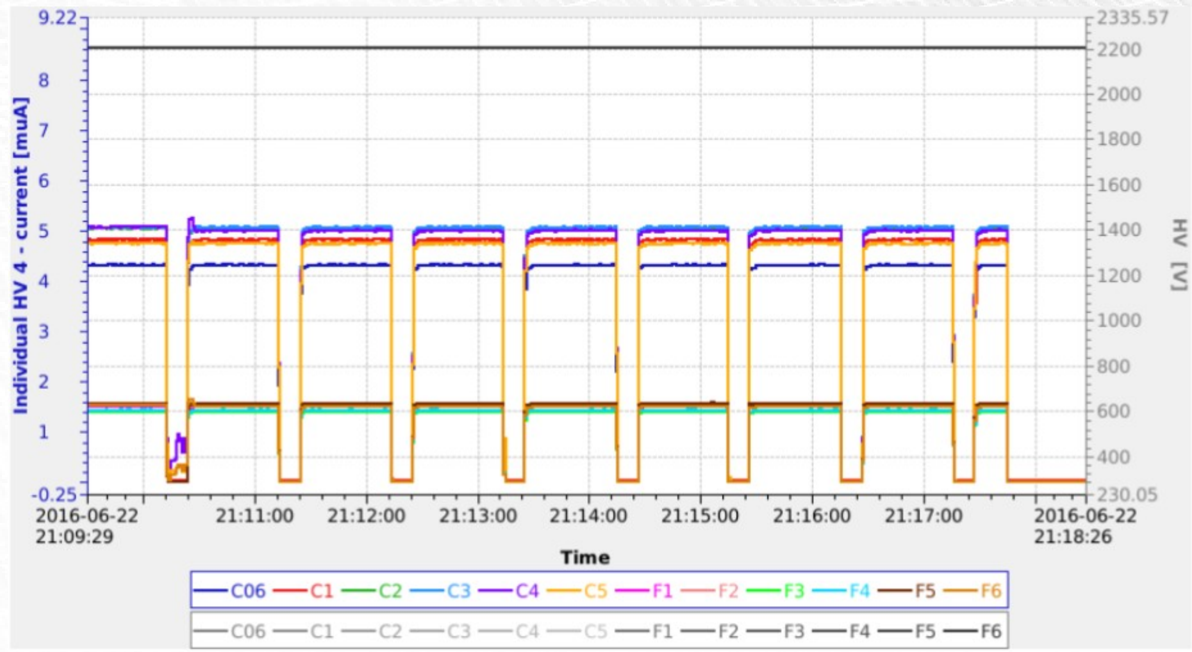


method of training by x-ray irradiation

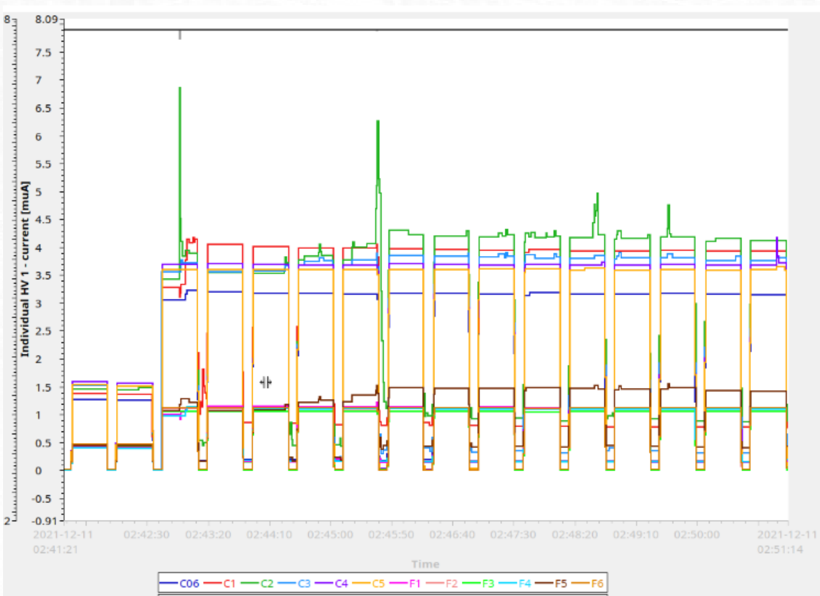


high energy x-rays, filtered by 140 µm Cu sheet, provide nearly equal load for all internal wire layers

MDC IV (sector 1) Individual layer HV,
x-ray On, NO sustained currents @ WP+50 V = 2200 V



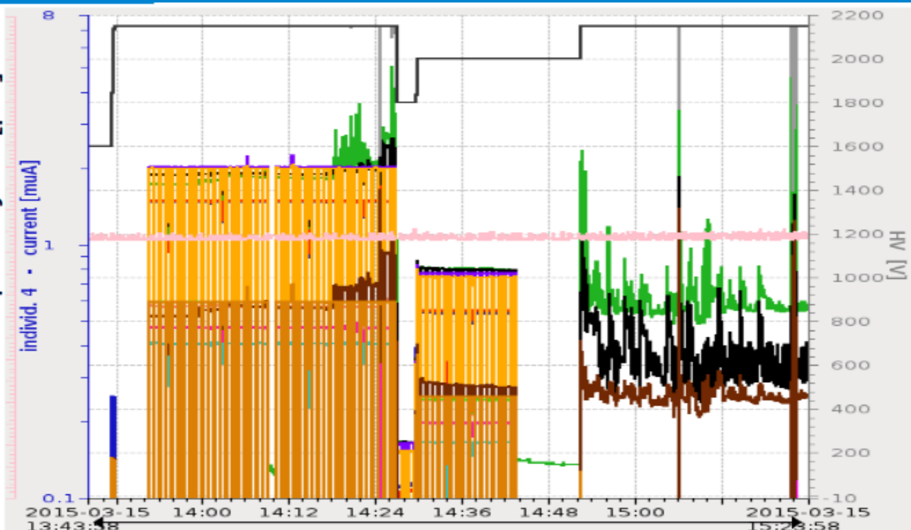
➔ MDC III & IV: stable at nominal beam intensity



➔ increase of x-ray intensity, triggers self-sustained currents

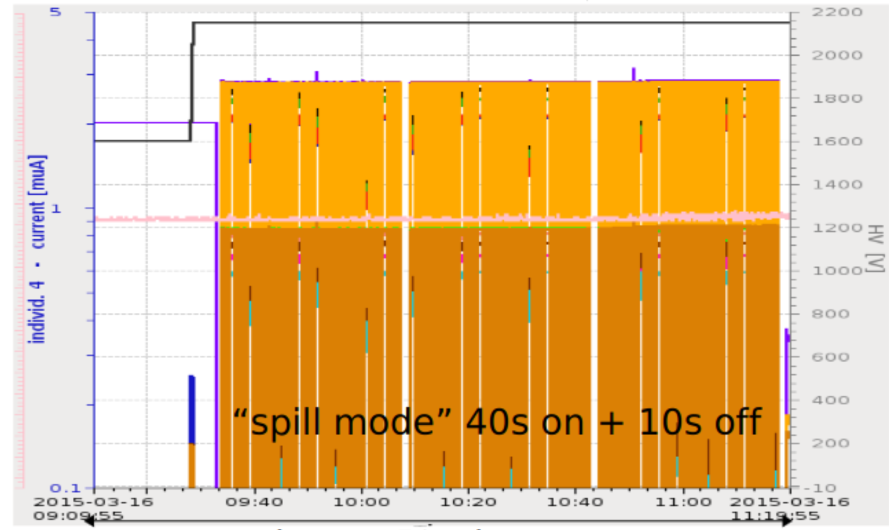
method of training by x-ray irradiation

current per layer [µA]



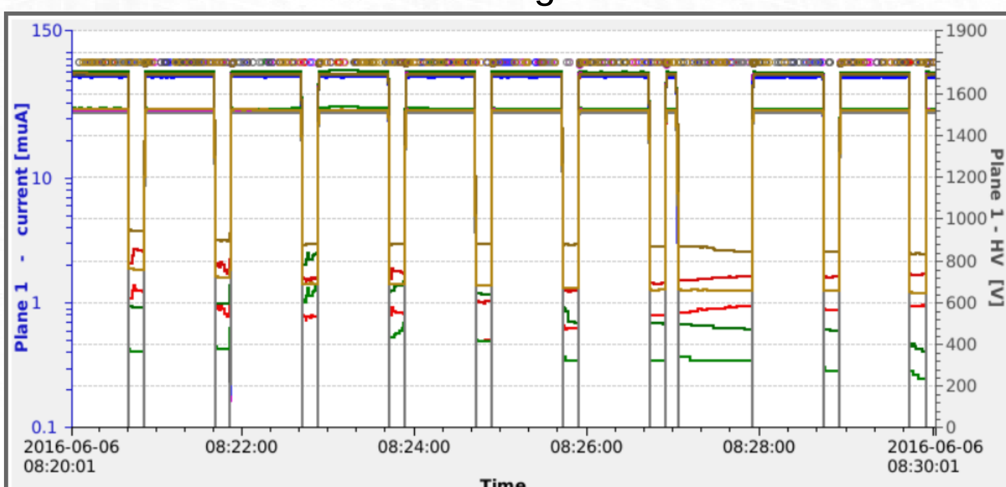
time ~ 90 minutes

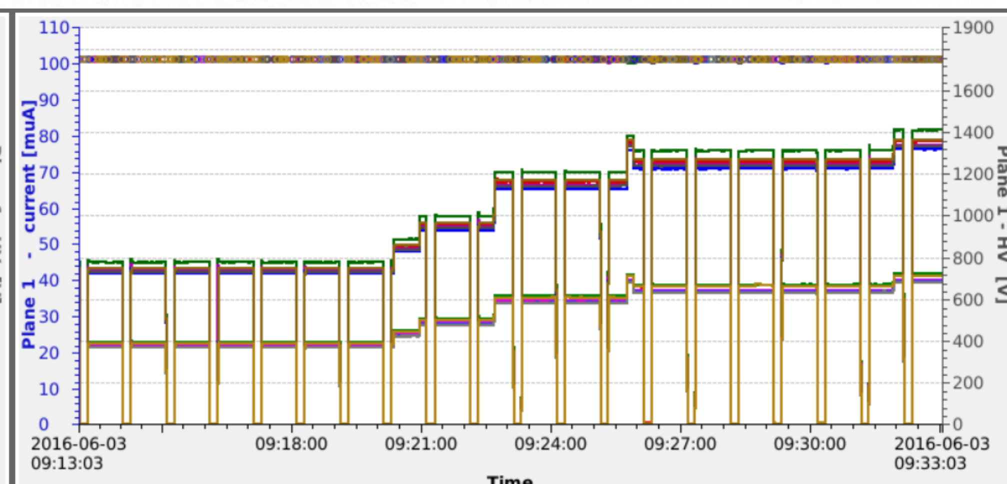
5h conditioning



time ~ 150 minutes

- MDC I v2 (Cu/Be cathodes) exhibit self-sustained currents correlated with high beam intensities
- immediately stable with water additive (1000 ppm)



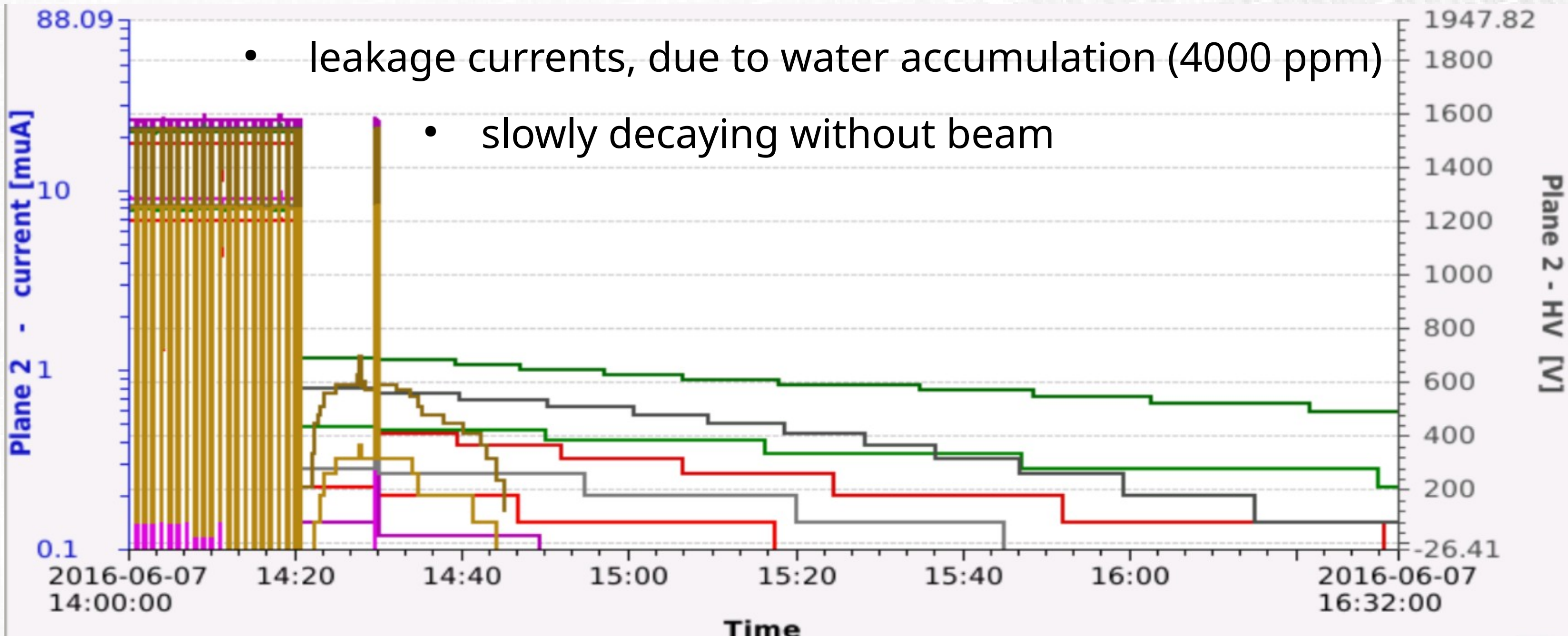


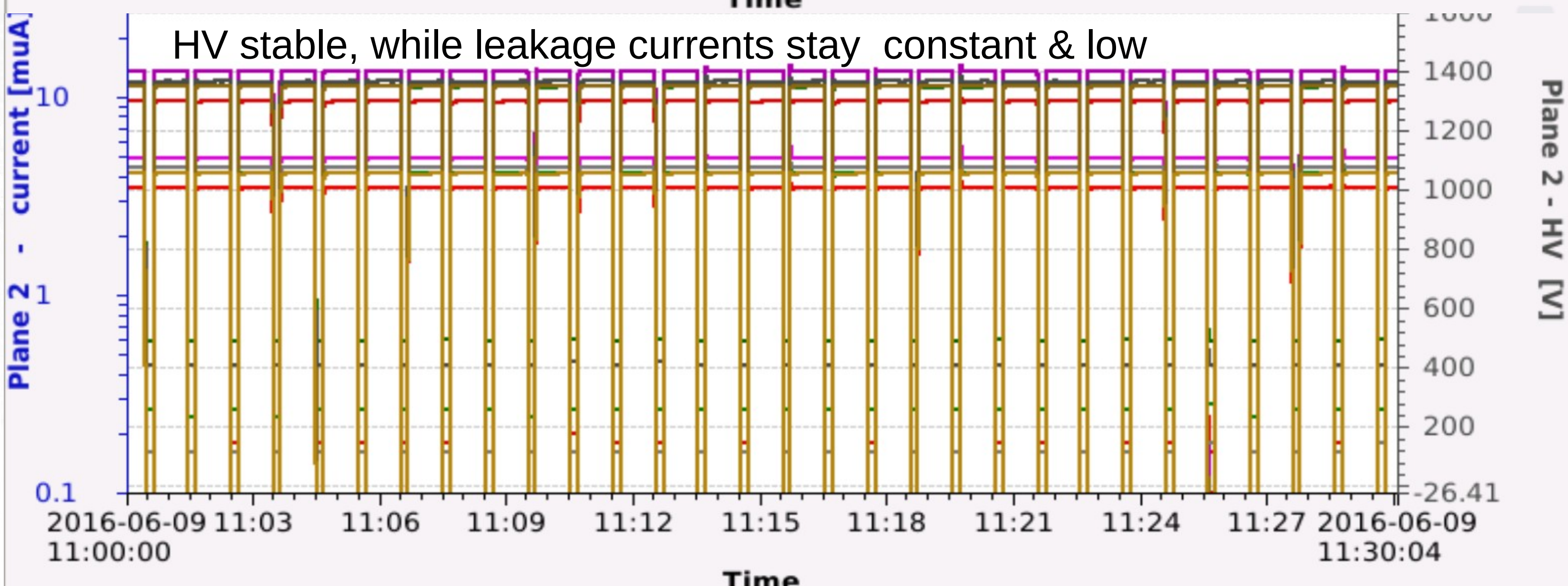
WP = 1750 V x-ray ON, dry

WP x-ray ON, 1000 ppm water

Effect of water additive

HADES MDC



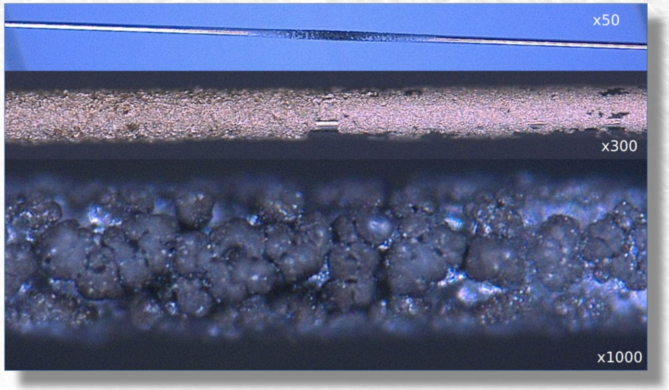


Summary & conclusion

- $\mathcal{O}$ (10 mC/cm) load on wires and accel. aging test do not suggest *"classical"* aging issues (even with isobutane) in a clean gas system
- MDC I: Si (EDX) induced issue = home made (rebuild of 6 drift chambers)
- MDC II:
  - self-sustained currents & discharges triggered by (hydro-) carbon deposits on cathodes (visual & EDX)
  - **water additive restores stable operation**
- isobutane banned in MDC (replaced by CO_2)

➔ **enabled 10 years of successful beamtimes** since then

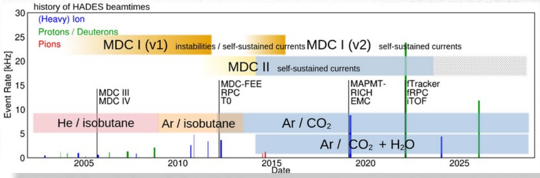
- not finally resolved: short time scale (week) of *aging* of MDC II during Au+Au beamtime



- not elaborated in this talk:
  - MDC I v2 (Cu/Be cathodes) exhibit self-sustained currents correlated with high beam intensities, stable with water additive (1000 ppm)
  - MDC III & IV: stable at nominal beam intensity

outlook

- **HADES will move to** SIS100:
  - What is the stability at higher rates ? → open questions to be resolved
  - rebuild of MDC II seems to be mandatory



Thanks to all contributors: Luis Lopes, Christian Müntz, Erwin Schwab, Christian Wendisch
& Oleg Fateev, Jörg Hehner, J. Pietraszko, L. Naumann, L. Heinrich, J. Hutsch

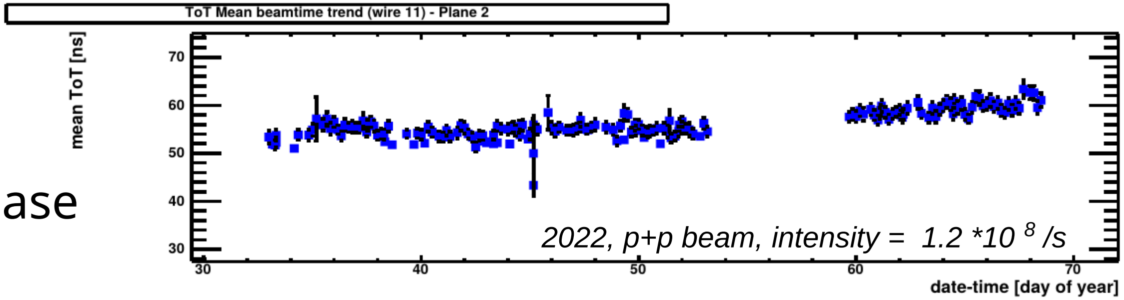
additionnal facts

- amount of water inside the gas needs to be defined individually for each single chamber, reasons could be:
  - position of the chamber and direction of gas flow inside relative to gravity, the gas flwo direction is adjusted therefore (sectore 1 has opposite direction to sector4)
  - different leakage rates (O2)

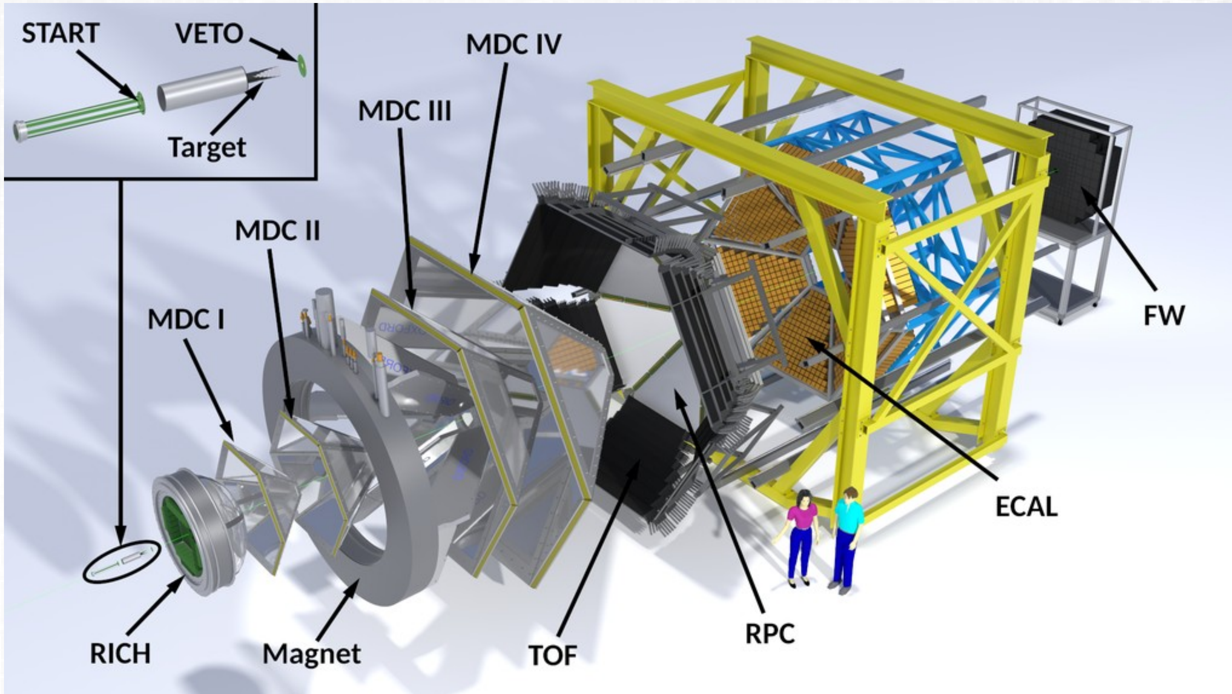
O_2 contamination	Plane1	Plane2	Plane3	Plane4
S0	800ppm			
S1		2500ppm	100ppm	100ppm
S2		1800ppm	200ppm	1500ppm
S3		<100ppm		3100ppm
S4		<100ppm	200ppm	100ppm
S5		<100ppm	200ppm	100ppm
S6		<100ppm	200ppm	100ppm

by Erwin Schwab 2012

- proof no anode aging is present, by efficiency, gain measured by ToT is still high & does not decrease

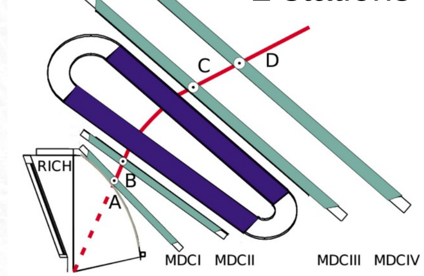


High Acceptance Di-Electron Spectrometer - HADES @ GSI

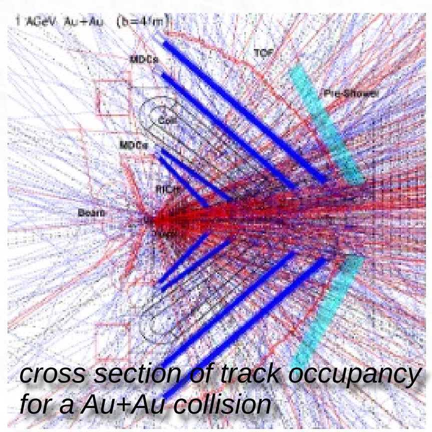


momentum measurement:

- superconducting toroidal magnet ~ 1 T
- tracking system:
  2 drift chamber planes in front +
  2 stations behind magnet



- SIS18 energy regime for heavy-ions: 1-2 AGeV
- fixed target experiment
- boost to forward direction
  - ➔ inhomogeneous irradiation of detectors
- polar angle coverage 18 – 85°
- beam intensity: 2x10^6 heavy-ions / s
- interaction probability 1-2%
  + delta electron production



cross section of track occupancy for a Au+Au collision