Update on Small-Pad Micromegas

rate capability as a function of irradiated area

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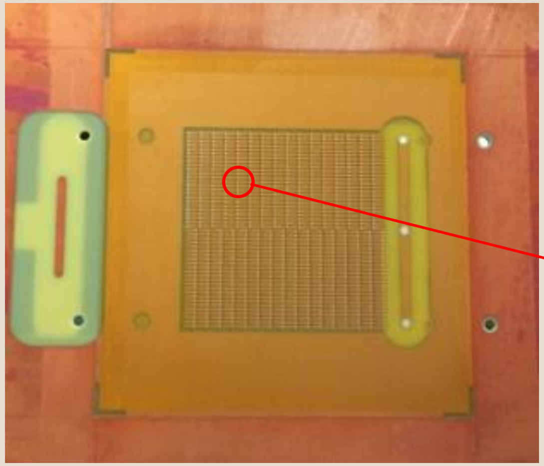
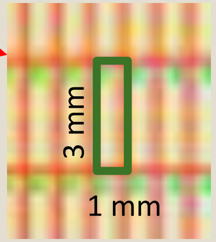
Small PAD resistive MICROMEGAS prototypes

Two classes of prototypes: Pad-Patterned (**PAD-P**) and uniform layer **DLC** (two techniques: **standard** and **S**equential **B**uild **U**p produced with copper clad DLC)

Pad readout electrodes

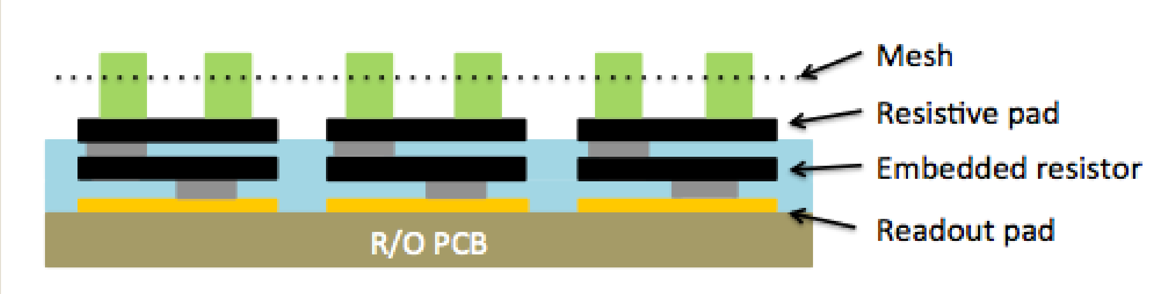


768 readout Pad matrix on 4.8x4.8 cm^2 active area.



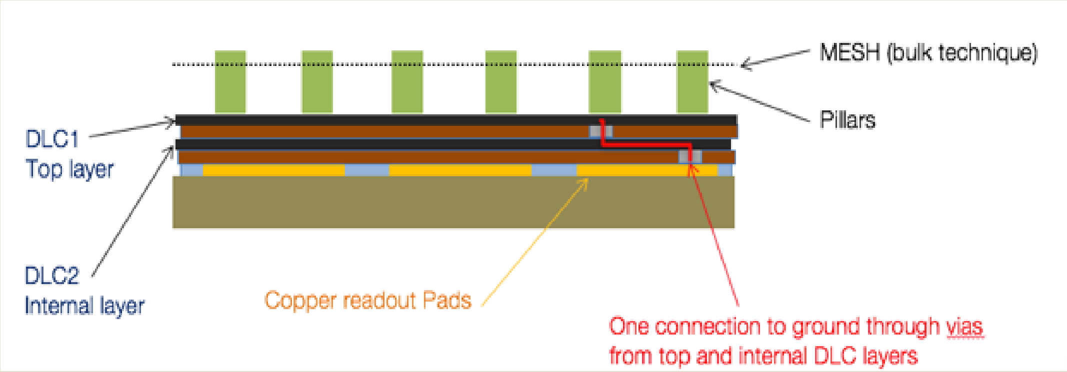
Customized **sparks suppression resistive** layout

PAD-Patterned Embedded resistor type (SCHEME 1);



Ref. [1] M. Alviggi, et al / JINST 13 (2018) no.11, P11019

DLC type and its latter version SBU (SCHEME 2)



Ref. [2] Alviggi et al. / NIM Research Sec. A, Vol. 936, 21 Aug 2019, pp 408-411

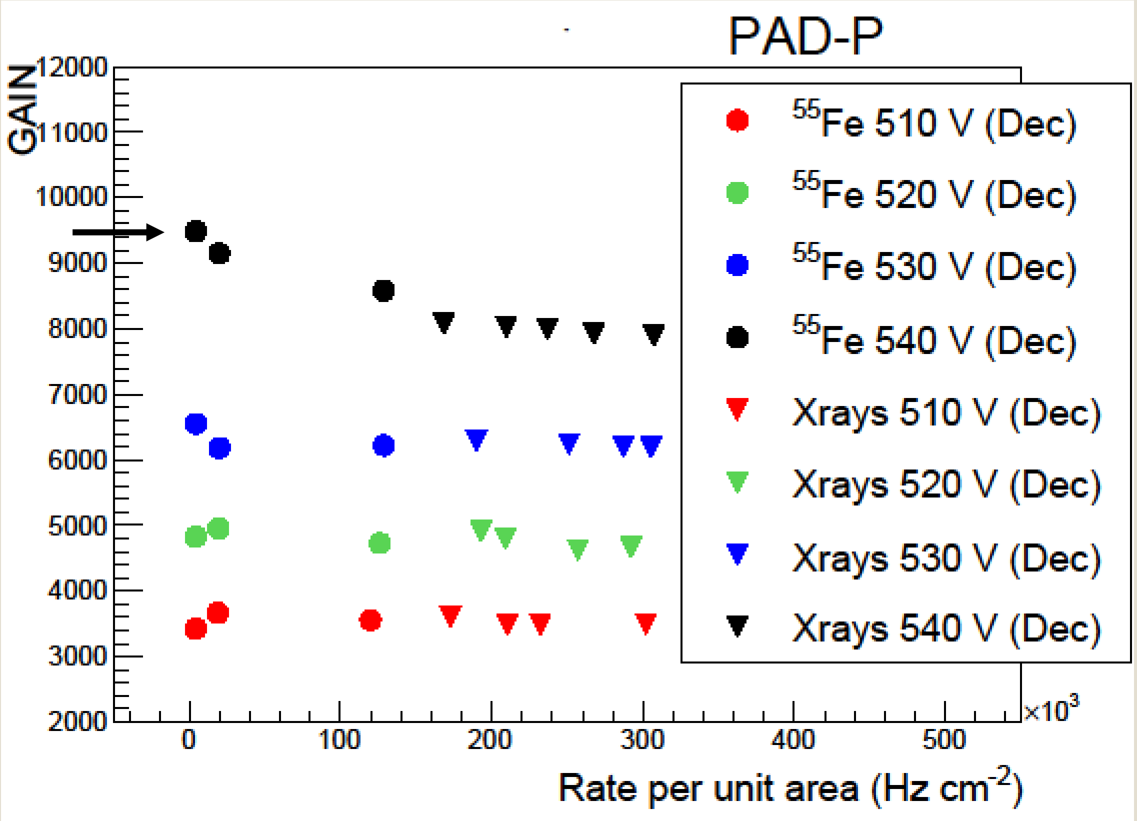
Brief recap:

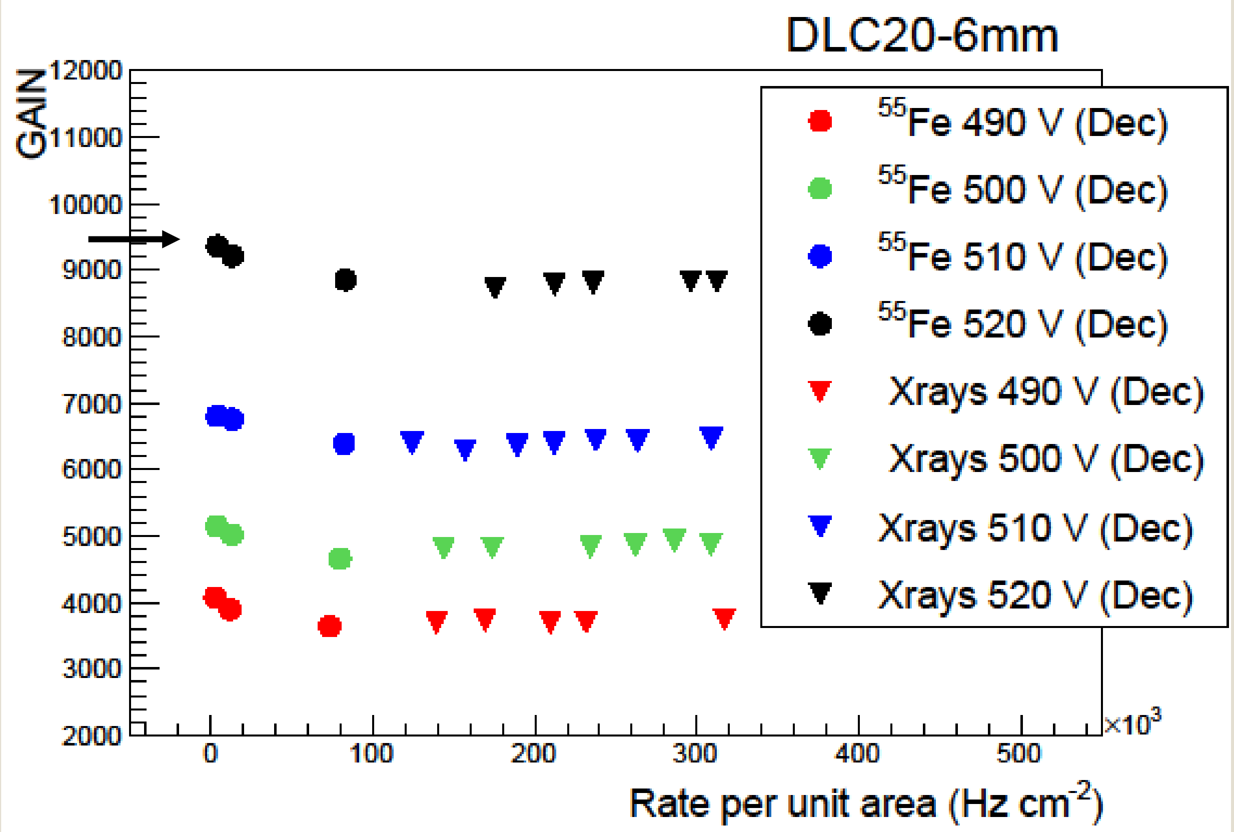
- https://indico.cern.ch/event/843711/contributions/3591285/attachments/1930604/3197497/Camerlingo_22_10_2019_RD51.pdf
  - Compared results between the small-PAD resistive Micromegas prototypes with PAD-P spark suppression layer and DLC spark suppression layer in term of rate capability up to 120 MHz/cm^2;
  - Preliminary results on the Exposure area dependence (Areas < 4 cm^2);
  - Summary of advantages of each spark suppression layer (Back-up);
- **Today**
  - Scan in amplification voltage (different gain factors)
  - Continuation of studies on exposure area dependence (Areas > 4 cm^2 and lower rate range < 30 MHz/cm^2);
  - Updates on the test campaign of the detectors @PSI (Full areas and < 200 kHz/cm^2) ;

SCAN in Amplification voltage (< 0.5 MHz/cm2 rate range)

Gain measurement in RD51 LAB: with ^{55}Fe and Xray(Cu target) sources and 0.79 cm^2 exposed area, (93:7)%Ar:CO_2;

- To set the working amplification voltages for which the detectors have the same gain at low rates;



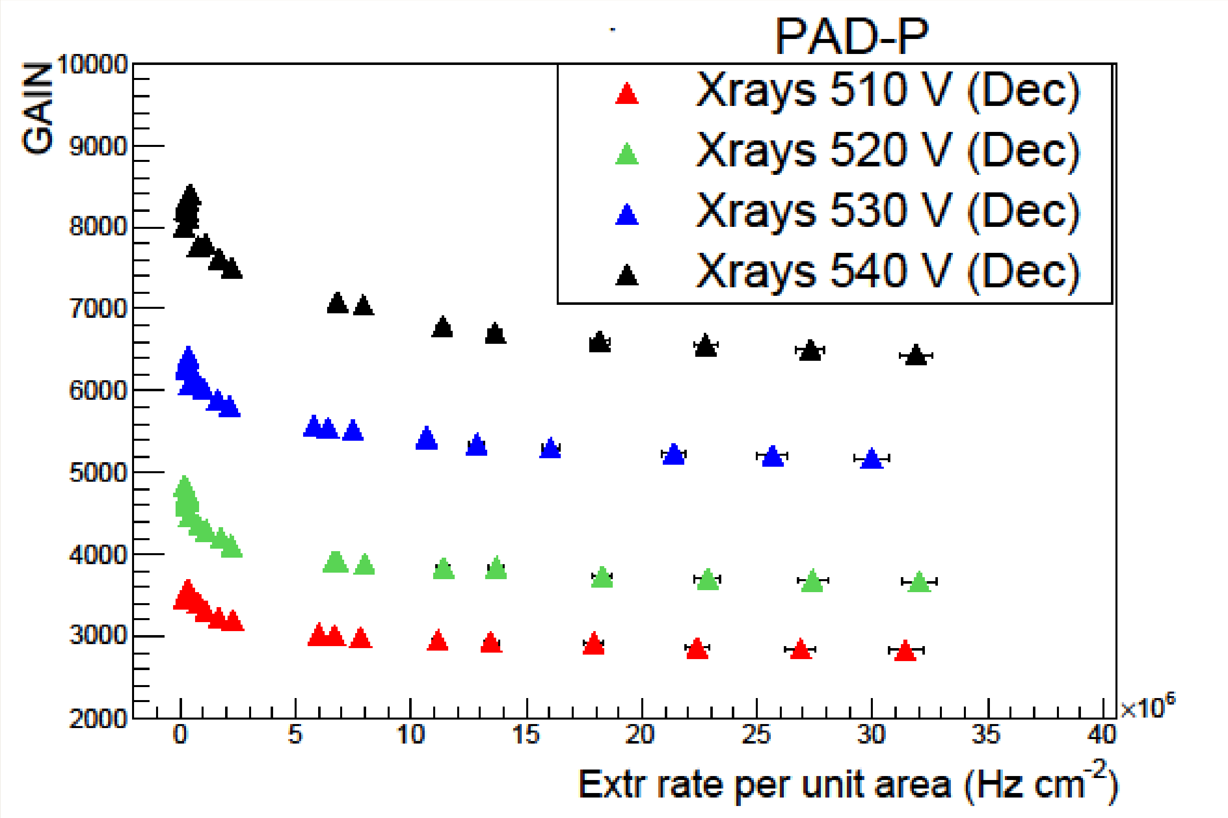


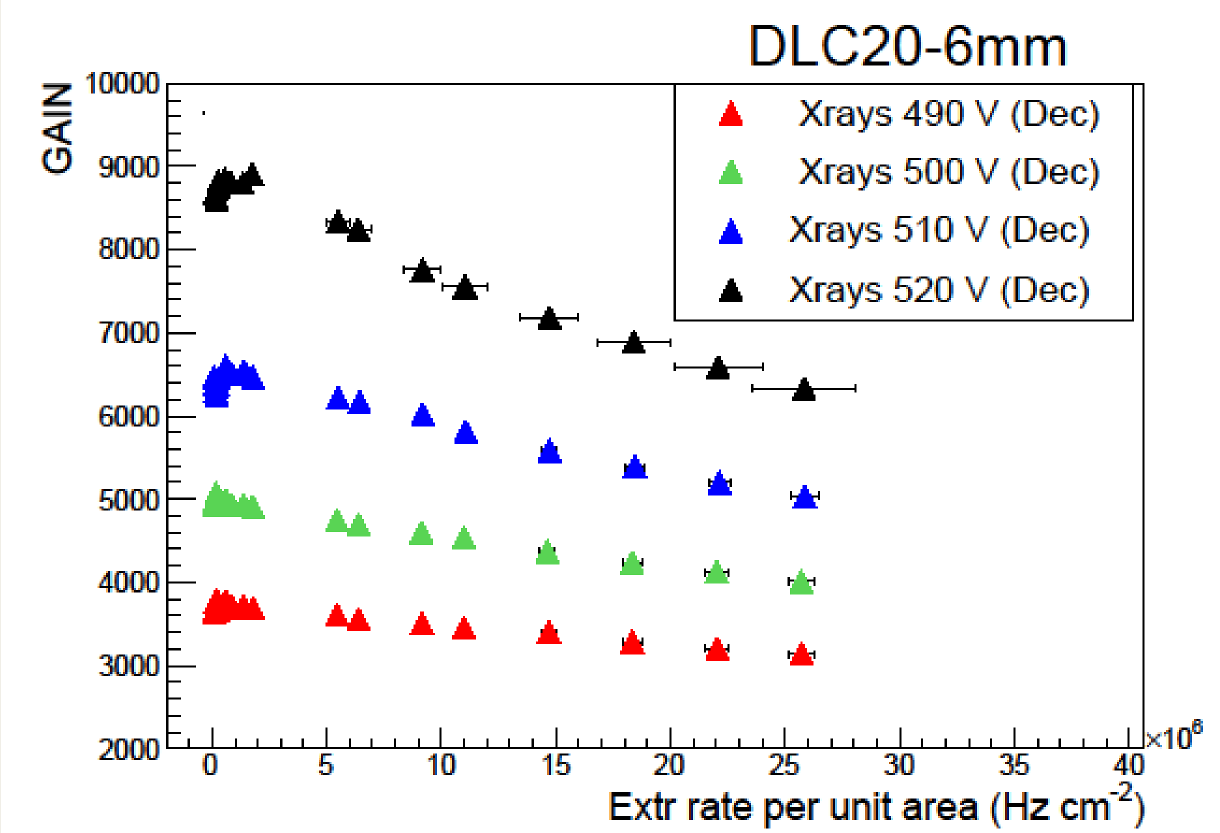
The ohmic voltage drops on the resistive layers are negligible in this range while the charging-up effects are already visible in PAD-P prototype.

PAD-P require an ampl. voltage + (20-30) V respect to DLC20 (effect of several contributions not completely quantified)

SCAN in Amplification voltage (rate range of interest)

Gain measurement in RD51 LAB: Xray(Cu target) sources and 0.79 cm^2 exposed area, (93:7)%Ar:CO_2;





PAD-P: Charging-up effect is more severe for increasing rate/cm2 (rel drop~16% from 1 MHz/cm^2 to 10 MHz/cm^2 at 530 V). The ohmic voltage drop for the individual pads still negligible in this range, too.

DLC-20: The ohmic voltage drop on the resistive DLC plane is significant in this range (rel drop ~12% from 1 MHz/cm^2 to 10 MHz/cm^2 at 510 V).

Dependence on the exposed area: PAD-P (updated)

Previous investigated areas

2r = 3 mm
Area 0.071 cm^2

10 mm
Area 0.79 cm^2

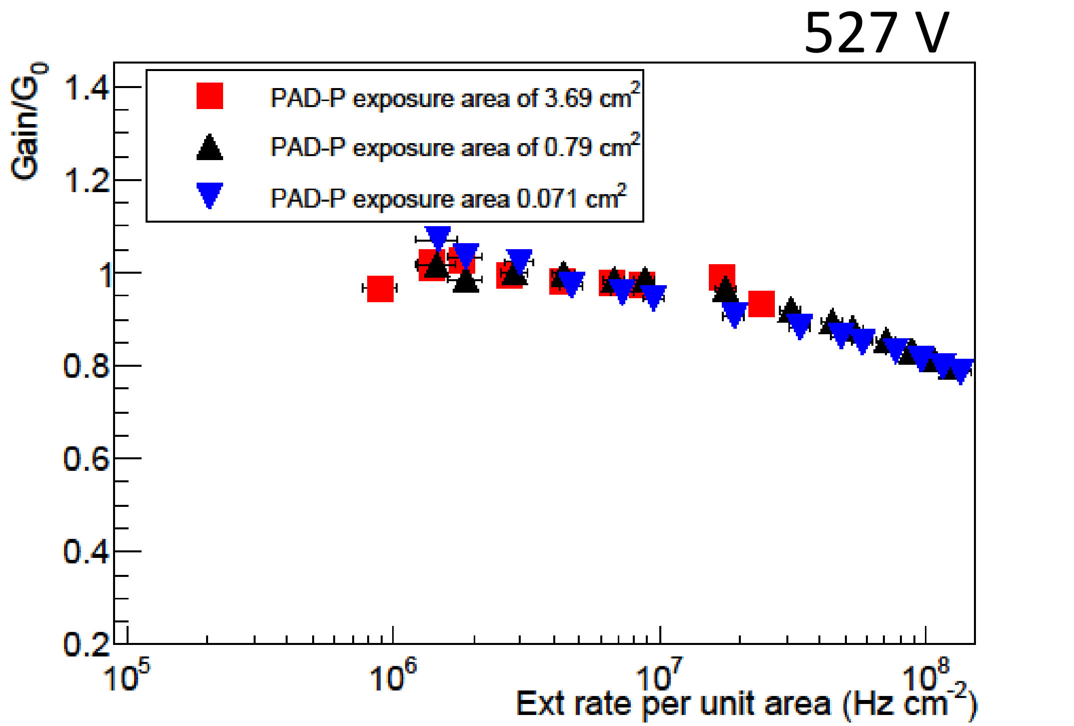
19 mm
Area 3.69 cm^2

New studies

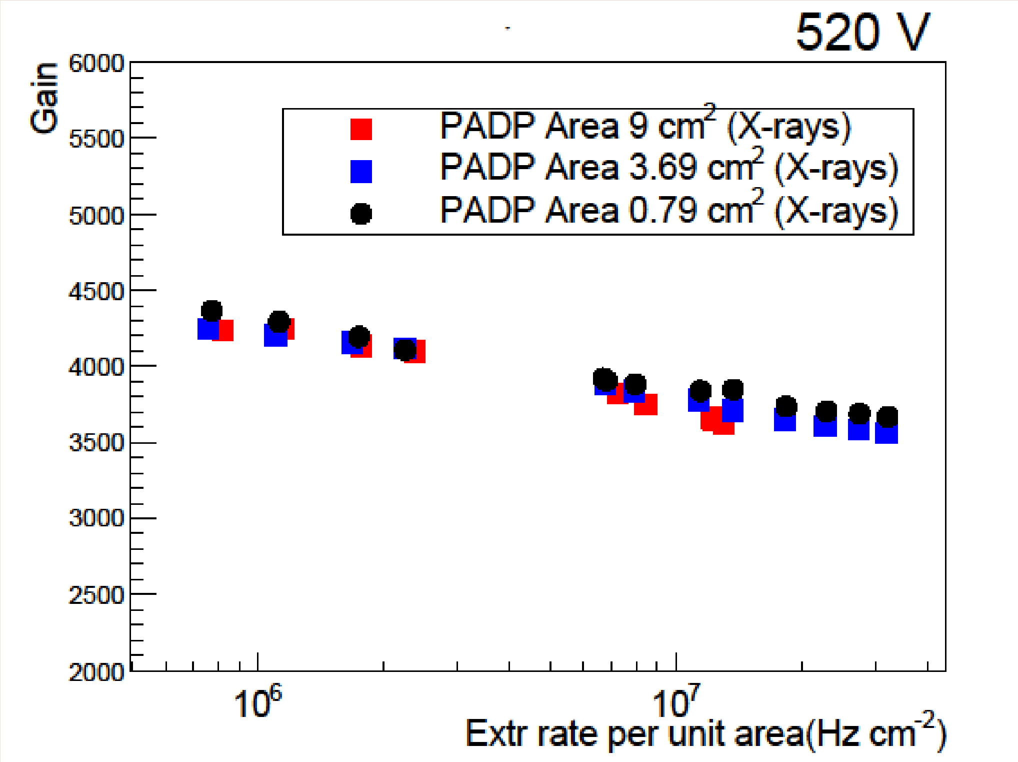
10 mm
Area 0.79 cm^2

19 mm
Area 3.69 cm^2

33,9 mm
Area 9 cm^2



Plot from 2019 IPRD, Siena

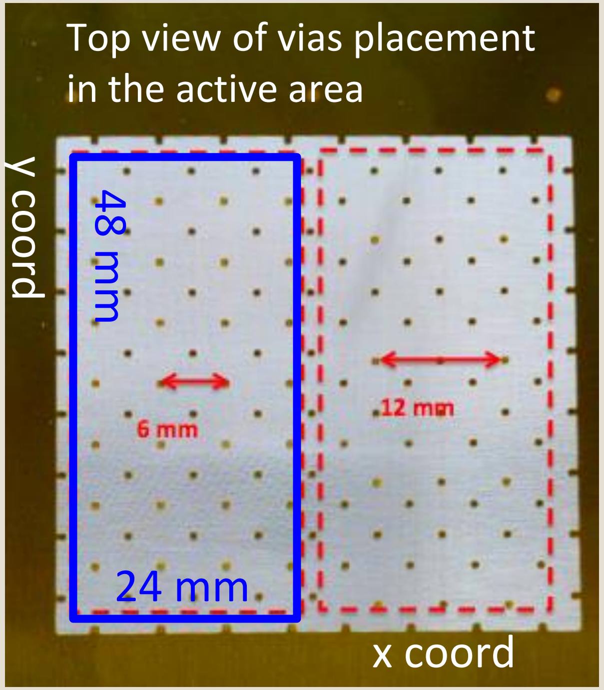


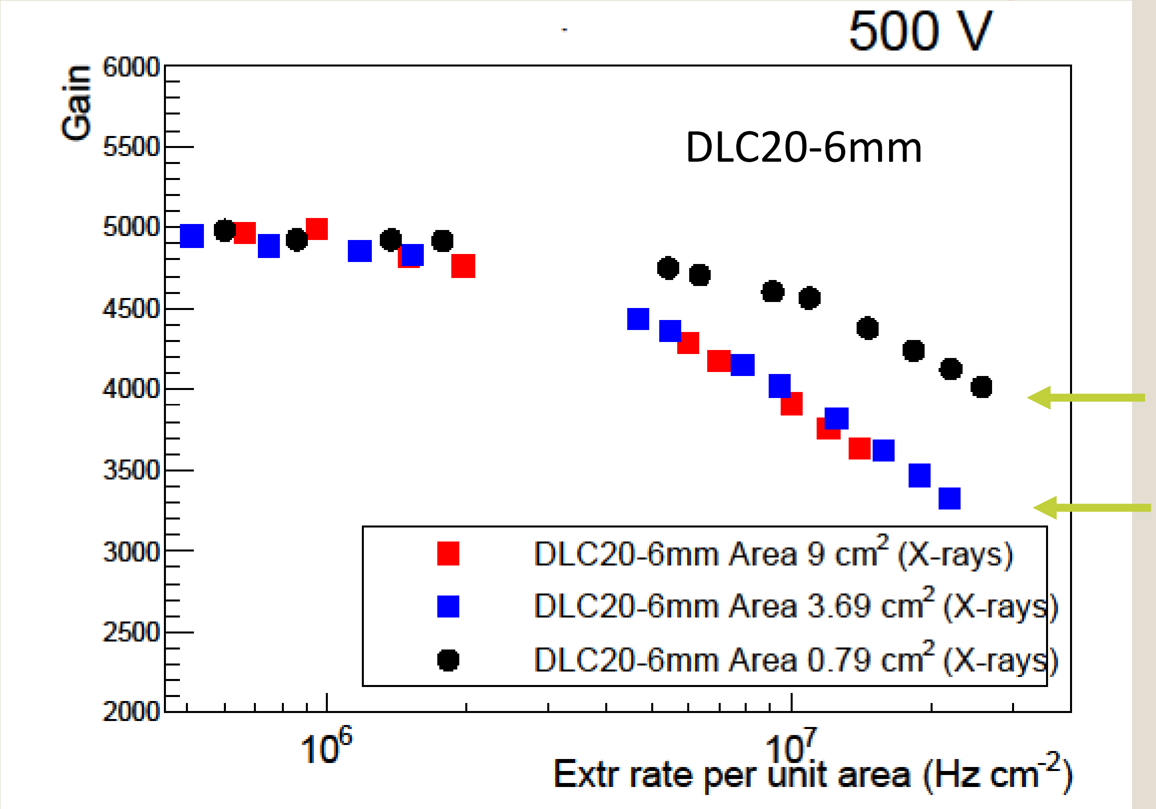
New studies confirm that PAD-P gain is **independent** on the exposed area.

Exposure area dependence:DLC20-6mm (updated)

10 mm | 19 mm | 33,9 mm

DLC series: DLC50 and DLC20 have two different vias pitches in the active area

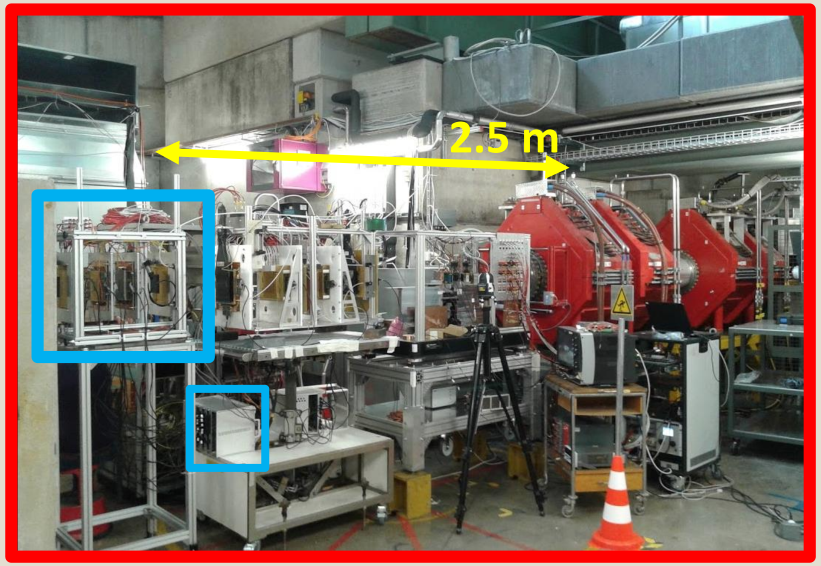




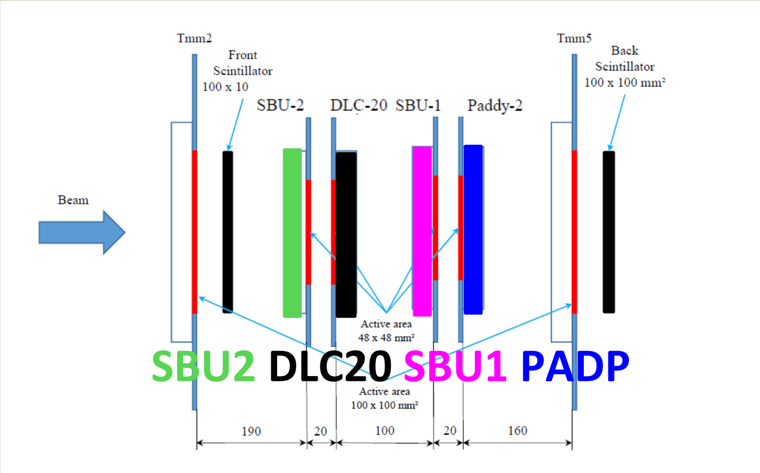
As already observed in DLC50 for {0.071, 0.79, 3.61} cm^2 areas and also in DLC20, the voltage drop depends on the exposed area for area < 3.6 cm^2 (10 times the area defined by the grounding vias pitches);

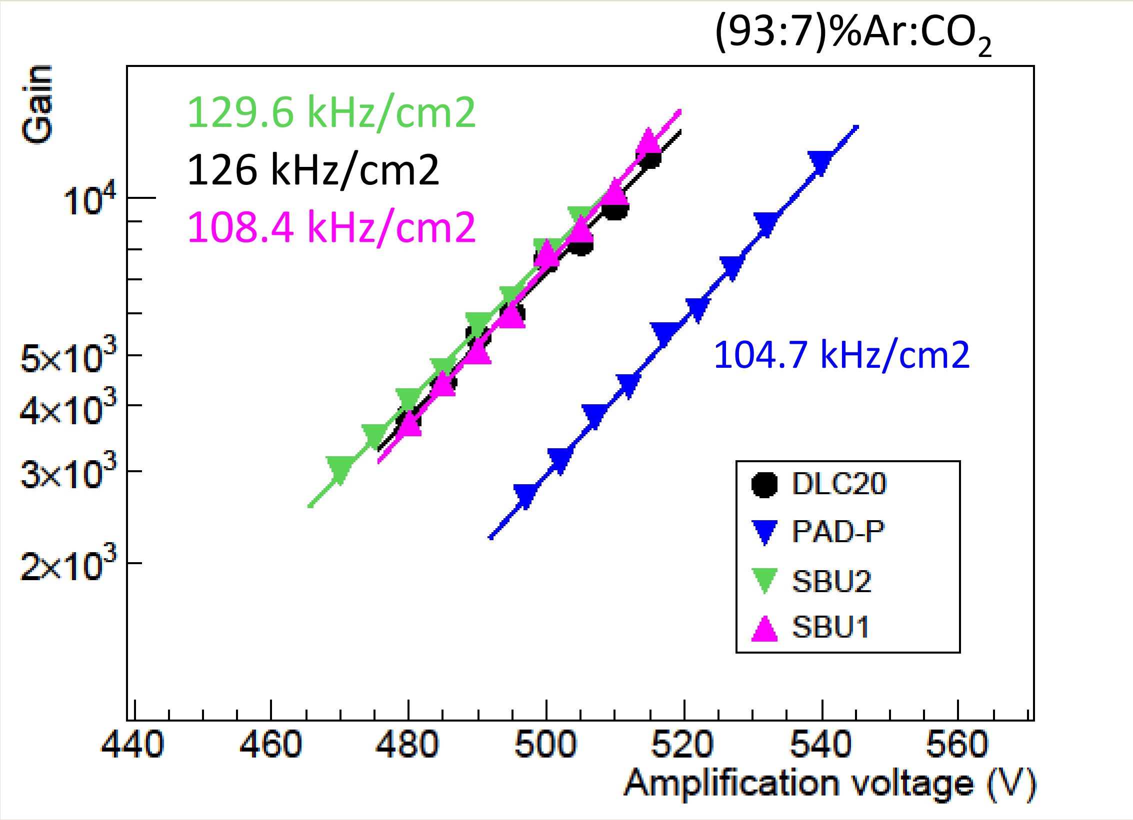
New studies: the gain drops in DLC20-6mm do not scale for areas > 3.6 cm^2 square. It is comparable for 3.69 cm^2 and 9 cm^2 areas.

2019 Test beam setup at PSI



300 MeV/c positive pion beam in continuum





Estimated from the current acquired from the mesh

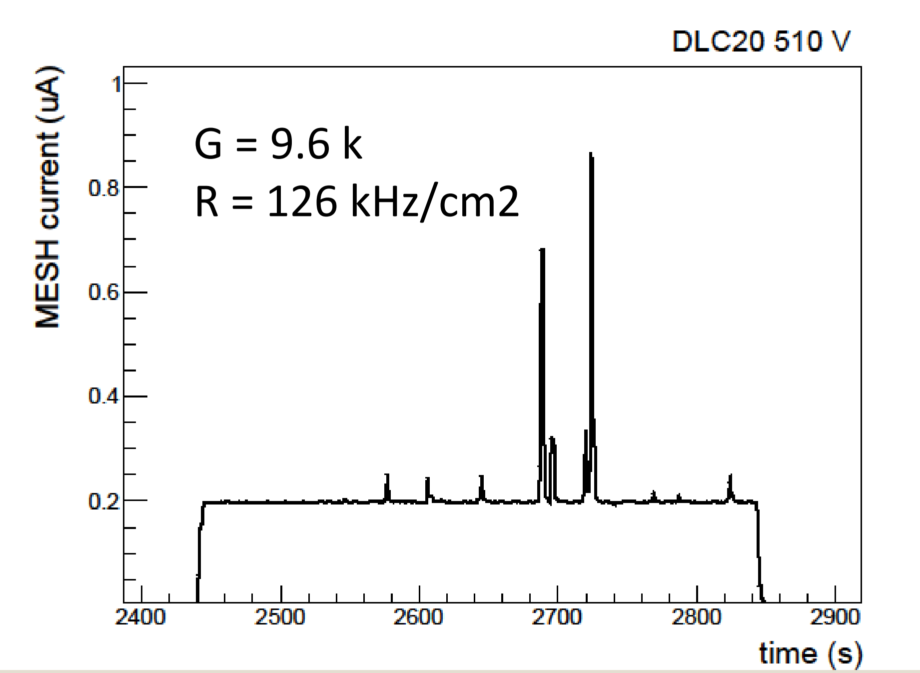
SBU2 and **DLC20** were almost at same distance from the beam focus and irradiated with comparable incident rate

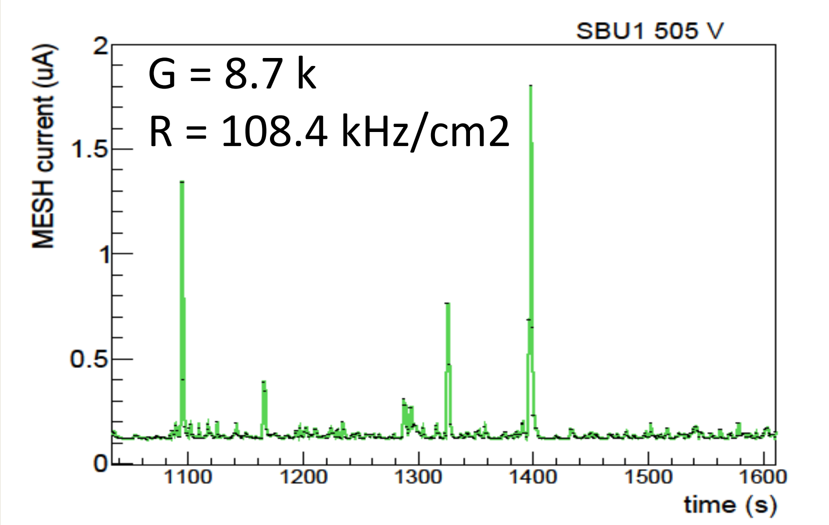
Also the gain measurements with pions confirmed the previous results with 55Fe/X-rays.

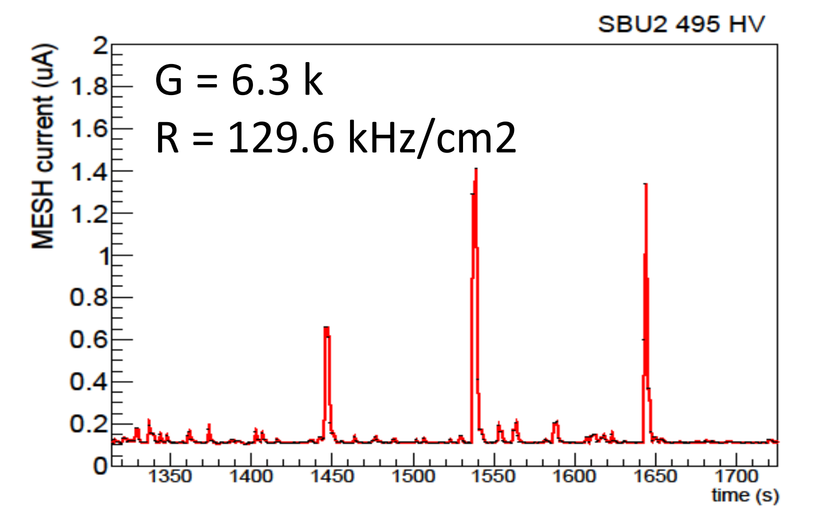
DLC-series: Spark events

A second DLC series (SBU) was realized to improve the robustness of DLC to suppress sparks. Therefore, a part of the test beam was dedicated to DLC spark studies

Three examples (acquired setting the max investigated gain for each detector)







DLC20 is more stable than SBU (contrary to our SBU construction goals)

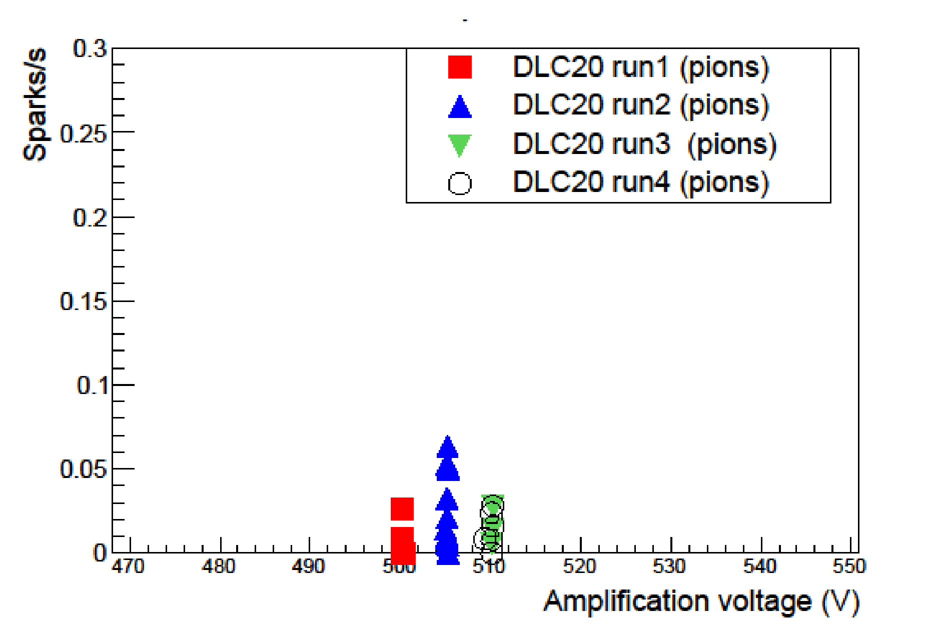
REMINDER:

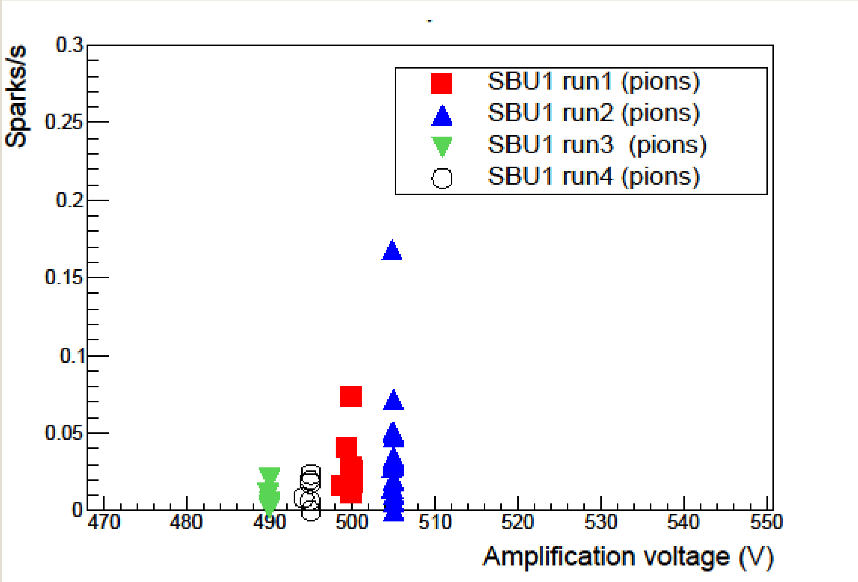
- DLC20 has both DLC foils with ~20 MOhm/sq;
- SBU internal DLC: 30 MOhm/sq ;
- SBU External DLC is only 5 MOhm/sq (possible cause of instabilities);

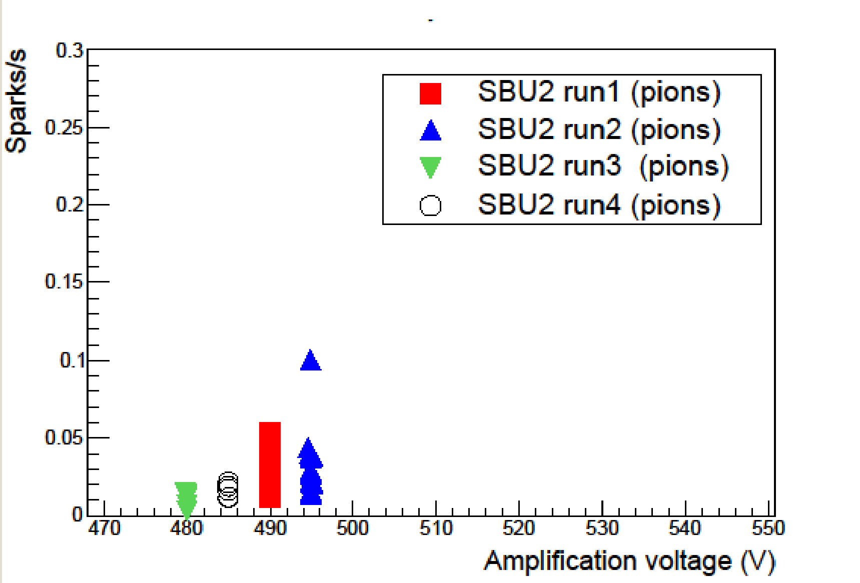
DLC: discharge counting (preliminary)

Sparks rate was evaluated for each voltage change and in different time intervals.

Spark criterium (preliminary) : >30% increase of instantaneous current;



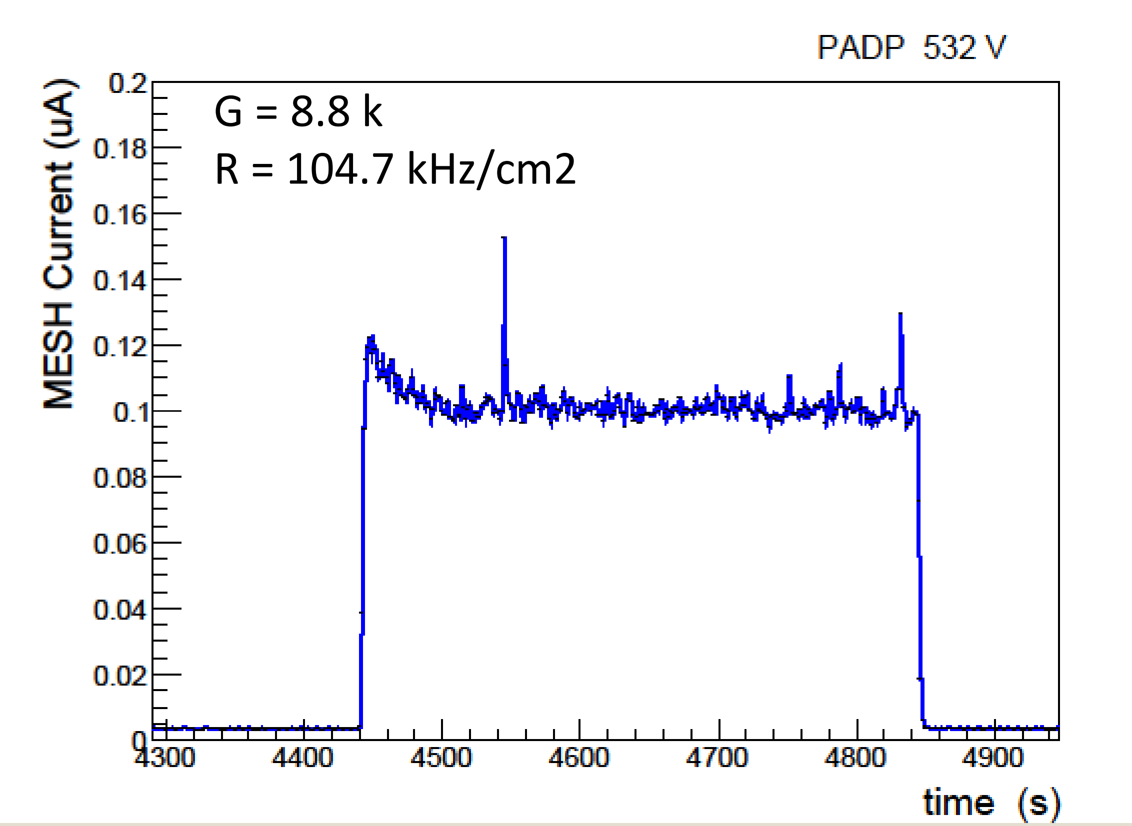




500 V (G~ 7.5k)	Inc rate (kHz/cm²)	sparks/s
DLC20	126	< 0.05
SBU1	108.4	~ 0.07
SBU2 (495 V)	129.6	> 0.1

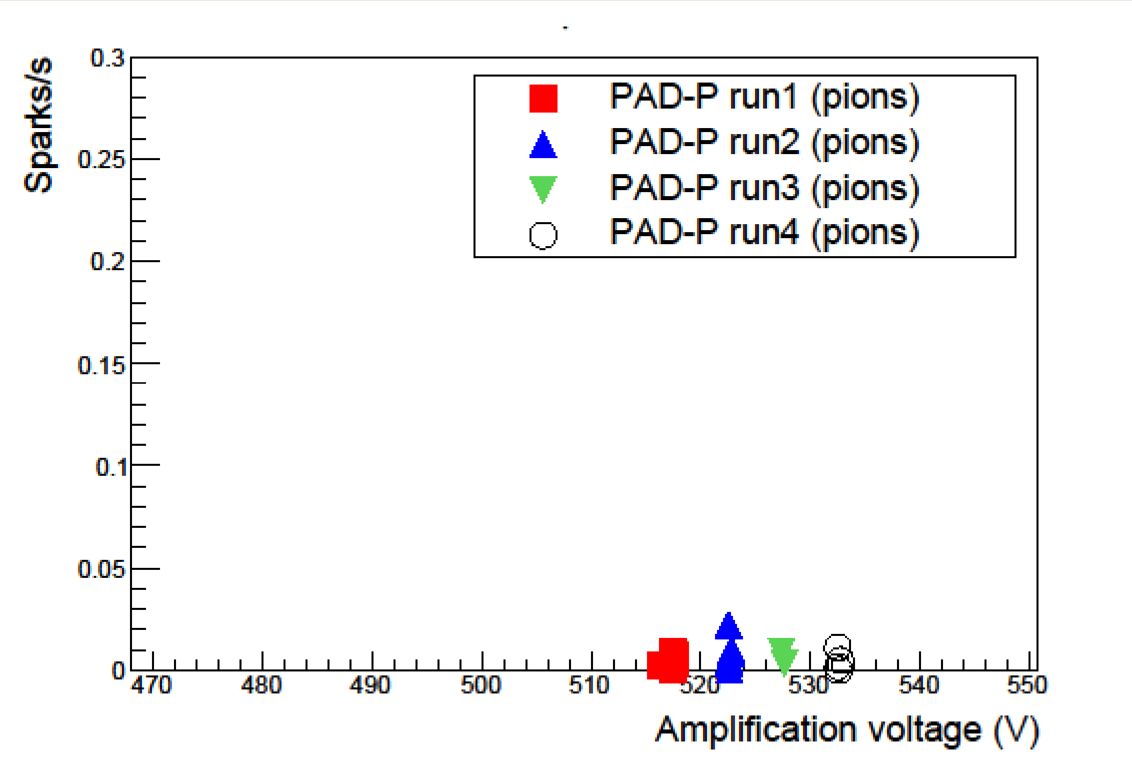
DLC20 is the most robust among the DLC series, despite to the constructive improvement of SBUs.

PADP: discharge counting (preliminary)



PAD-P confirmed to be the most robust prototype

Same criterium of the spark counting



527 V (G~ 7.5k)	Inc rate (kHz/cm²)	sparks/s
PAD-P	104.7	< 0.02

Conclusions

All the prototypes (PADP and DLC series) show a < 10% gain drop:

→ **PAD-P**: in the interest range (1 MHz/cm^2; 10 MHz/cm^2) for all the investigated cases;

→ **DLC**20: in the interest range (1 MHz/cm2; 10 MHz/cm^2) for the area 0.79 cm^2 and ampl. voltage < 520 V. Other cases the range stops at 7-8 MHz/cm^2 (STILL ACCEPTABLE);

- We investigated the dependence on the exposed area up to 50 MHz/cm^2:

→ **PAD-P**: PAD-P gain is not affected by the dimension of the exposed area thanks to its segmented layout;

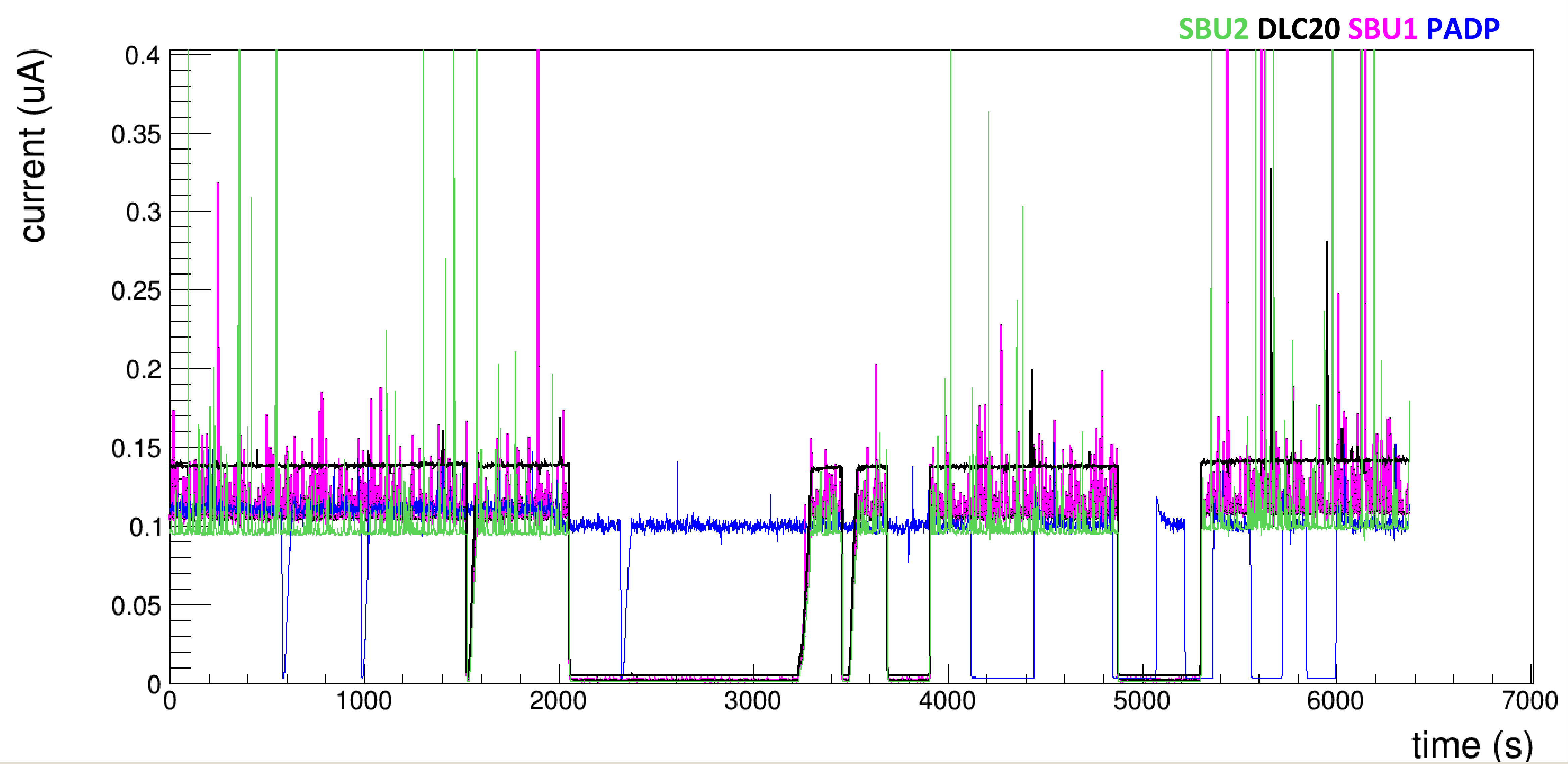
→ **DLC**20-6mm: the voltage drops do not increase when the exposed area is larger than a threshold area;

- Current-time trends and discharge studies (confirming the observations in lab):
  - **DLC** and DLC-**SBU** prototypes show some instabilities with moderate discharges up to a gain of about 6000.
  - **PAD-P** is VERY STABLE and show no-sparks up to a gain above 10000.

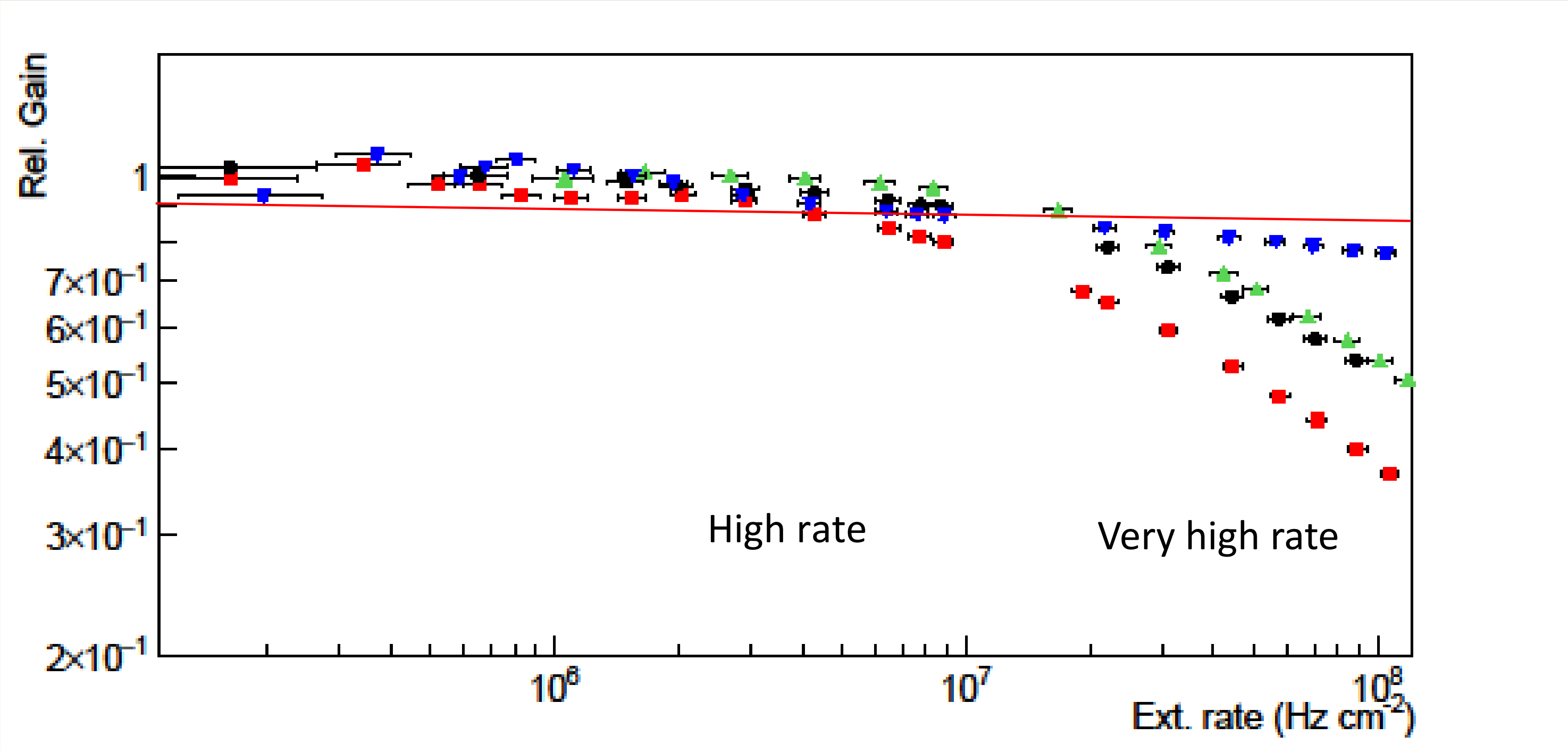
Thank you for the attention

Back-up

Current trend in full time window



Relative Gain



Direct info on voltage drop and rate capability;
(threshold value on deviation from the low rate value: 10%)

DLC50 G0 = (6.07 ± 0.10)x10^3

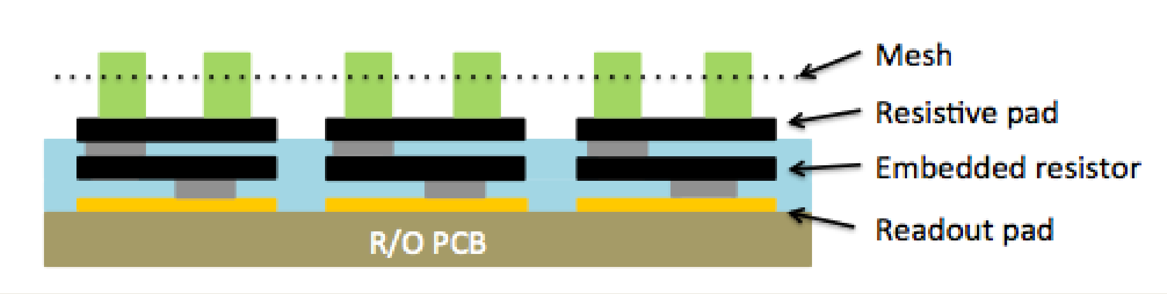
DLC20 G0 = (6.95 ± 0.08) x10^3

SBU2 G0 = (6.12 ± 0.04) x10^3

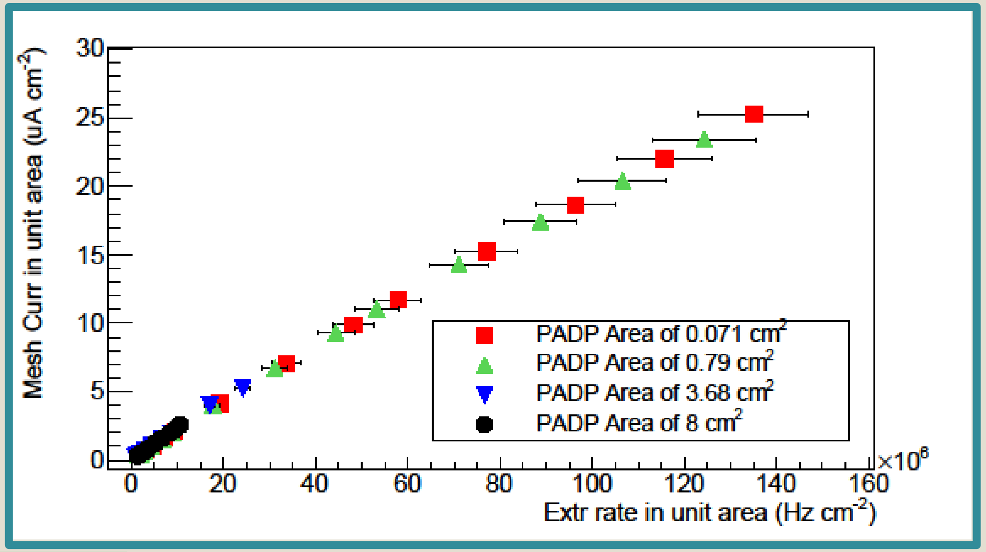
PADP G0 = (5.05 ± 0.16) x10^3

Area: 0.79 cm^2

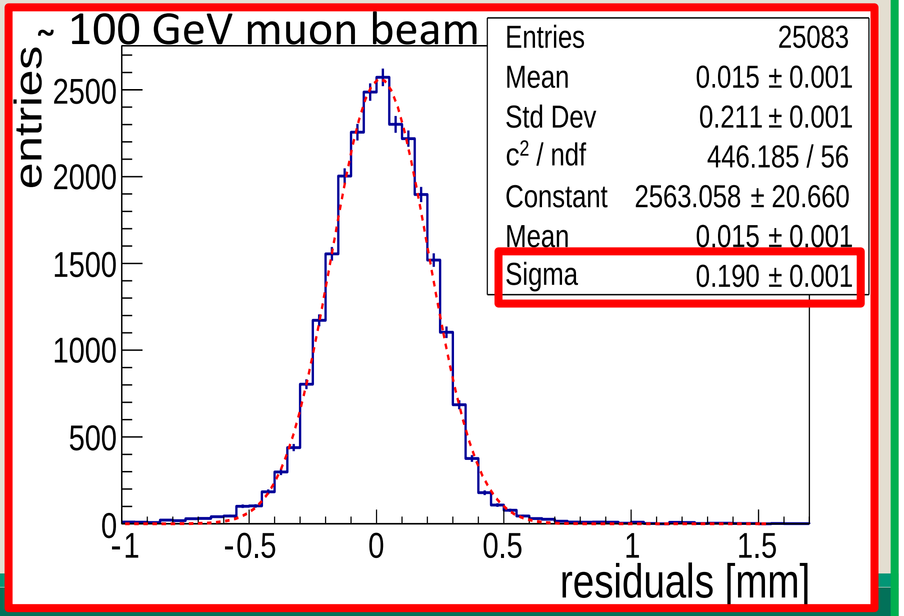
Summary on **PAD-P** scheme (1):

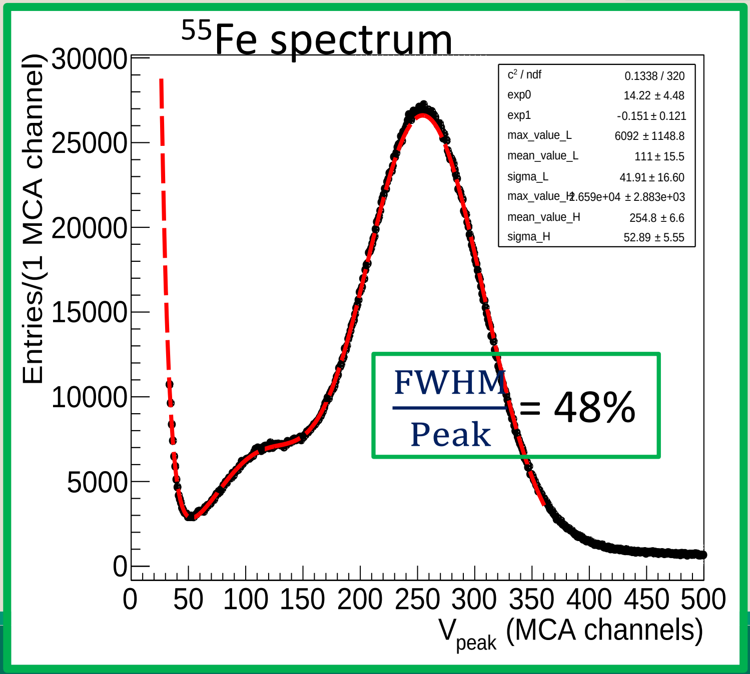


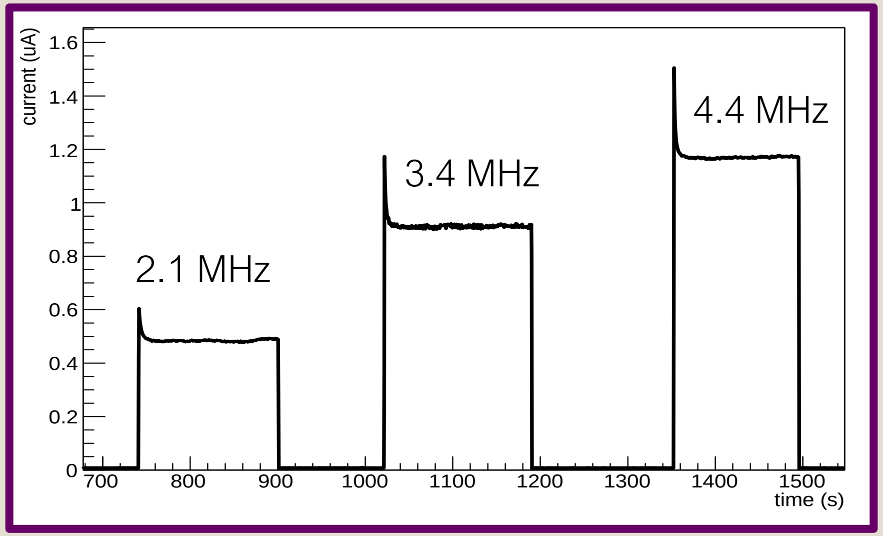
8 keV (Cu target) Xrays



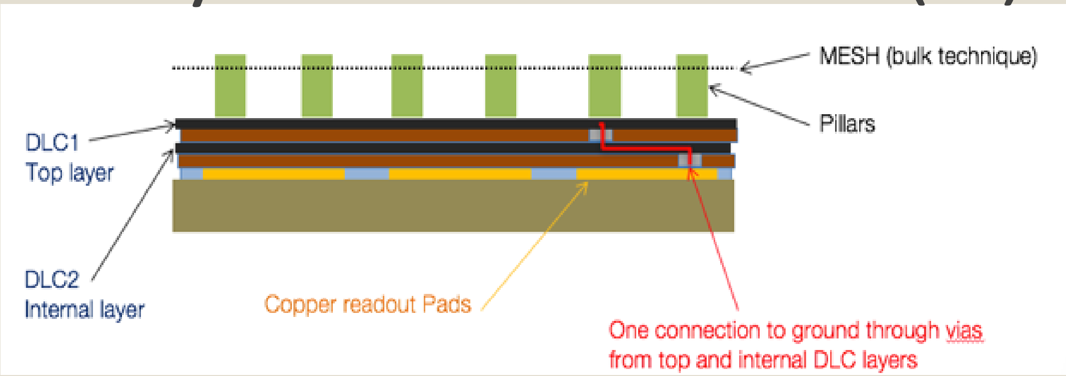
Good <u>rate capability</u> at rate higher than 10 MHz cm^{-2} , <u>current/cm^2 vs rate</u> independent from area, discrete <u>spatial resolution</u> on the precision coordinate, low <u>energy resolution</u> and <u>currents as function of time</u> affected by charging-up effects.



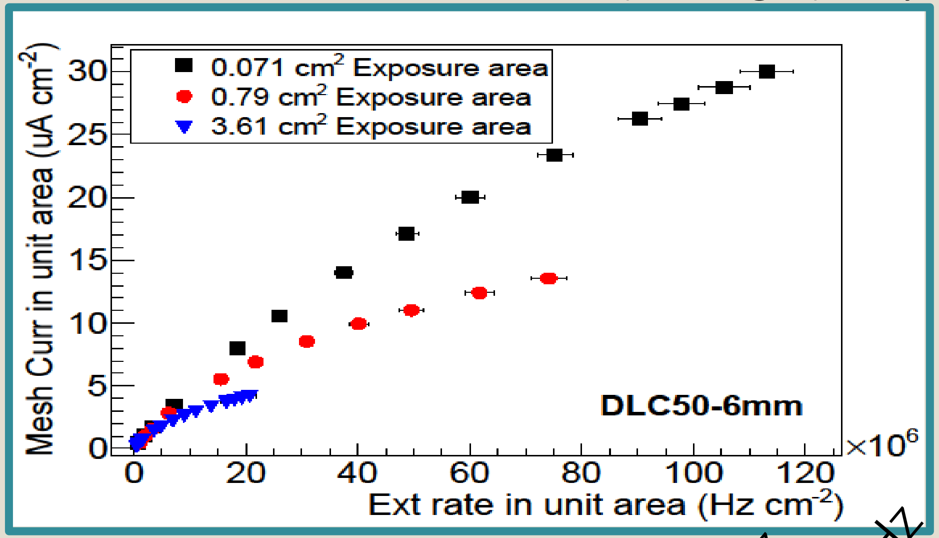




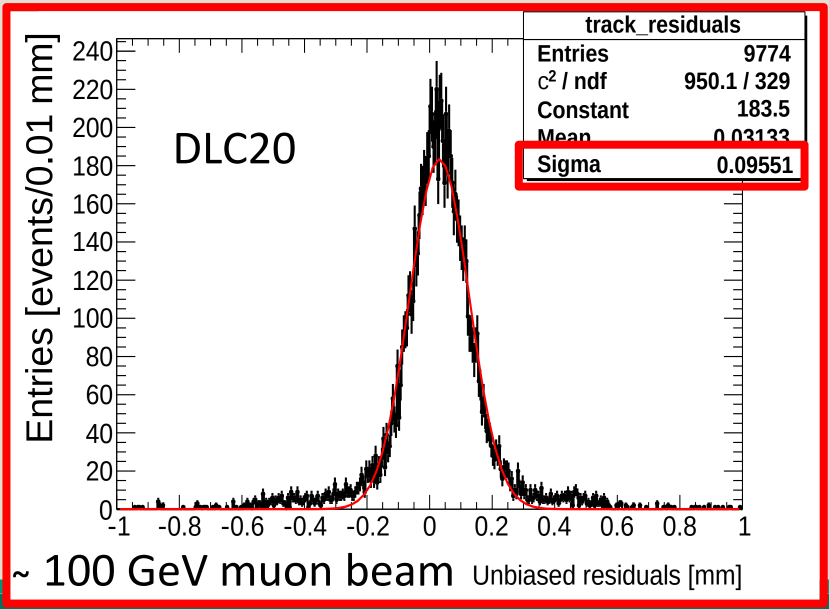
Summary **DLC** scheme (2):

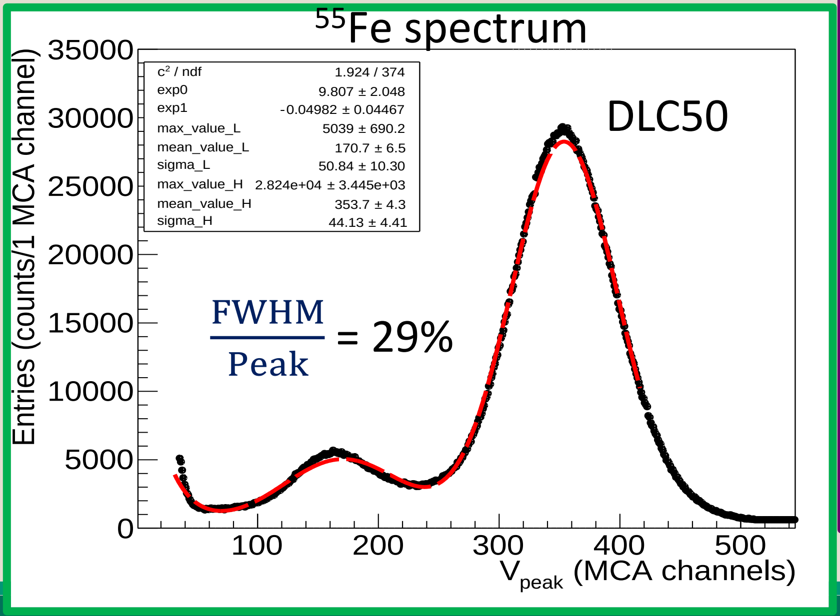


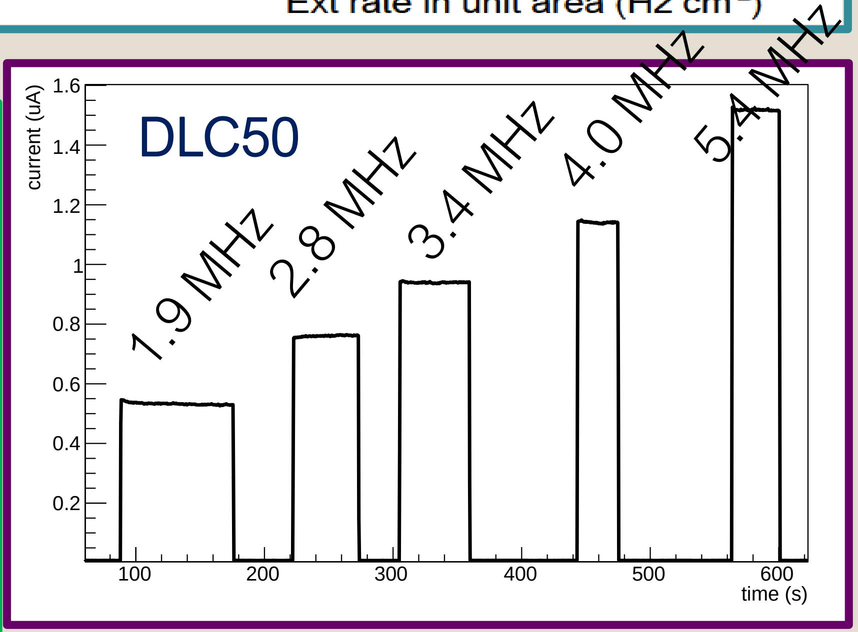
8 keV (Cu target) Xray



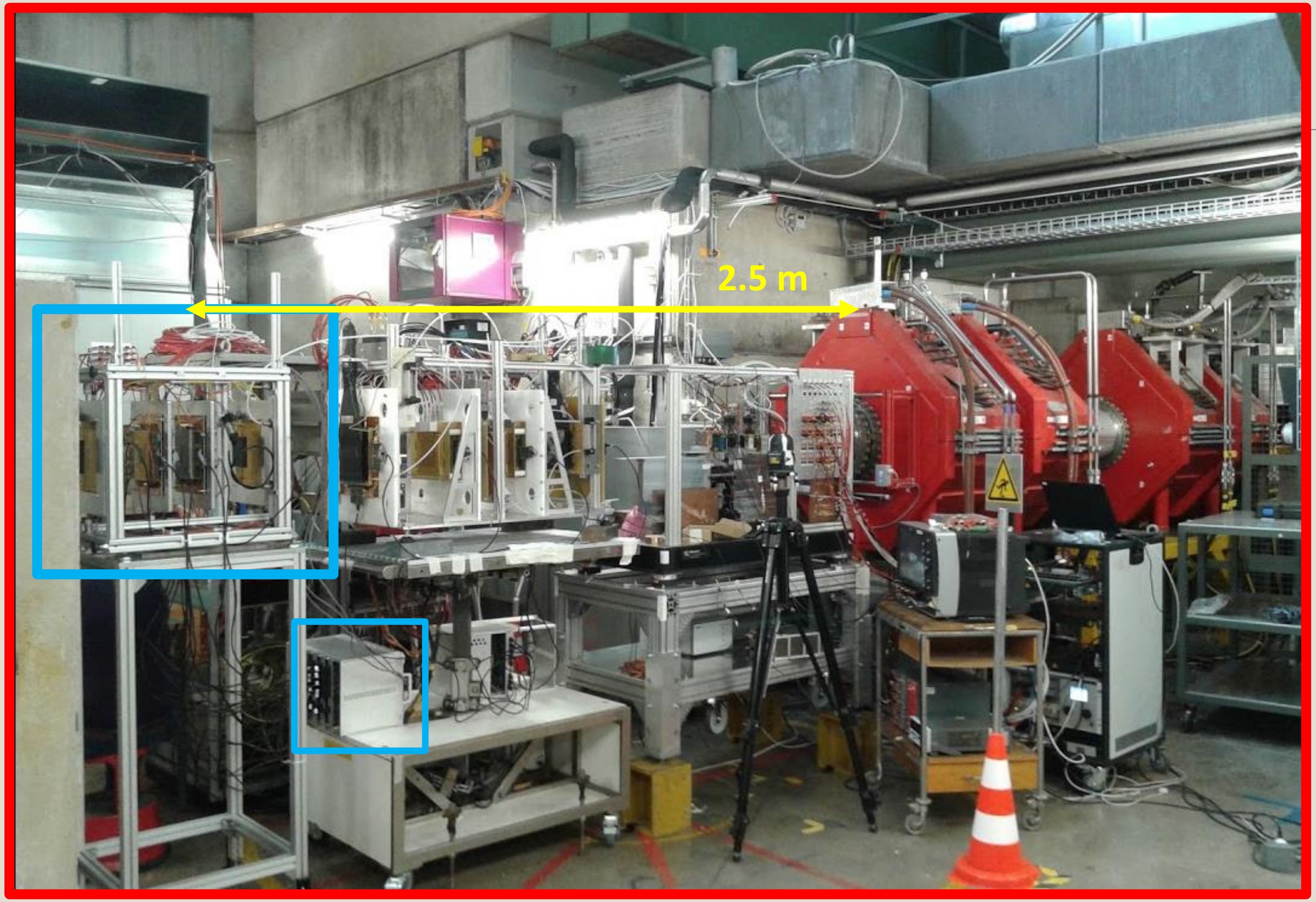
Good <u>rate capability</u> up to-10 MHz cm^{-2}, mesh current does not scale linearly with the spot size, better <u>spatial resolution</u> on precision coordinate, better <u>energy resolution</u> and no (or very little) charging up in <u>currents as function of time</u>.

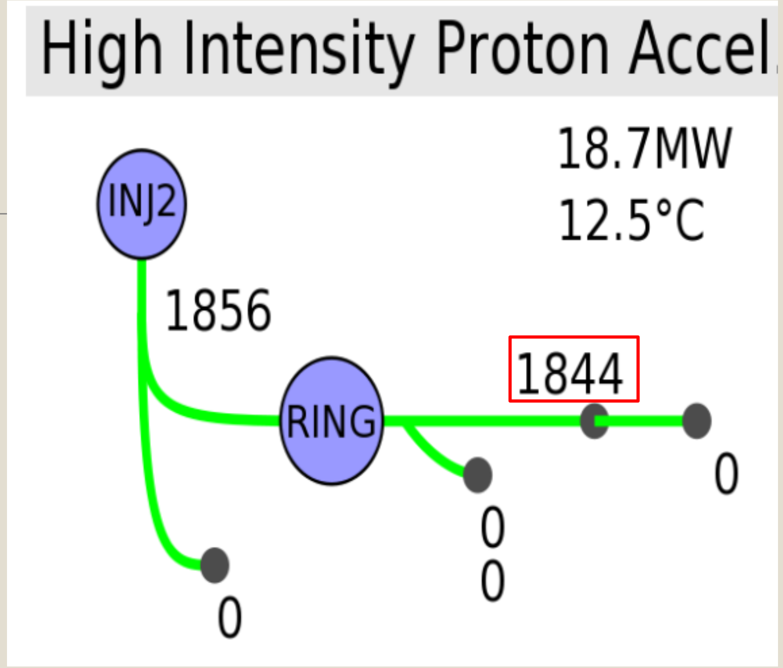






PSI πMU1 beam facility





Proton beam current on target

In exit of the target: positive pion with 300 MeV/c as max momentum (and 7% of proton contamination) in continuum https://www.psi.ch/sites/default/files/import/sbl/BLPiM1EN/fig3.gif

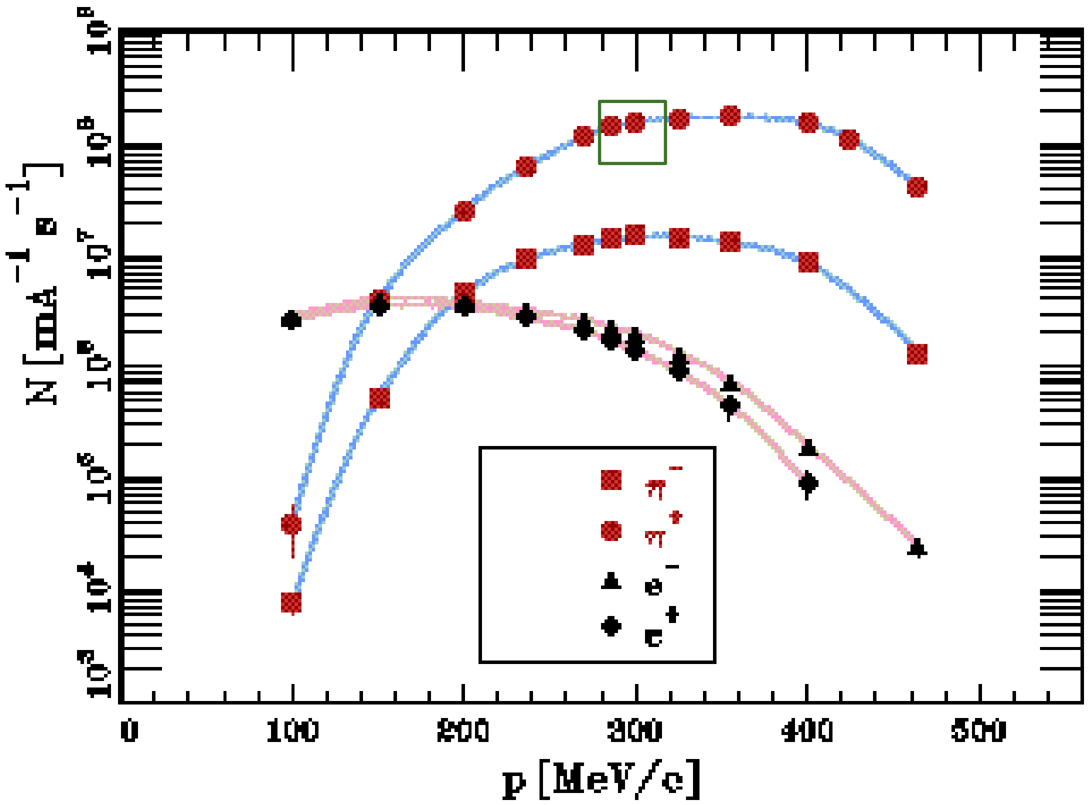


Table 1 : Characteristics of the piM1 beam line

Total path length	21 m
Momentum range	100-500 MeV/c
Solide angle	6 msr
Momentum acceptance (FWHM)	2.9 %
Momentum resolution	0.1 %
Dispersion at focal plane	7 cm/%
Spot size on target (FWHM)	15 mm horizontal
	10 mm vertical
Angular Divergence on target(FWHM)	35 mrad horizontal
	75 mrad vertical

Fig 3 gives the measured particle fluxes for the standard beam-line tune as a function of momentum with an uncertainty of 10% at the peak of the yield curves. The flux of muons is 100 times smaller than the corresponding pion flux at momenta around 300 MeV/c, and falls more slowly than for the pions toward low momenta. Since πM1 is the only beam line with a vacuum system separated from the proton-channel vacuum by a thin window, there are no "surface" muons available.