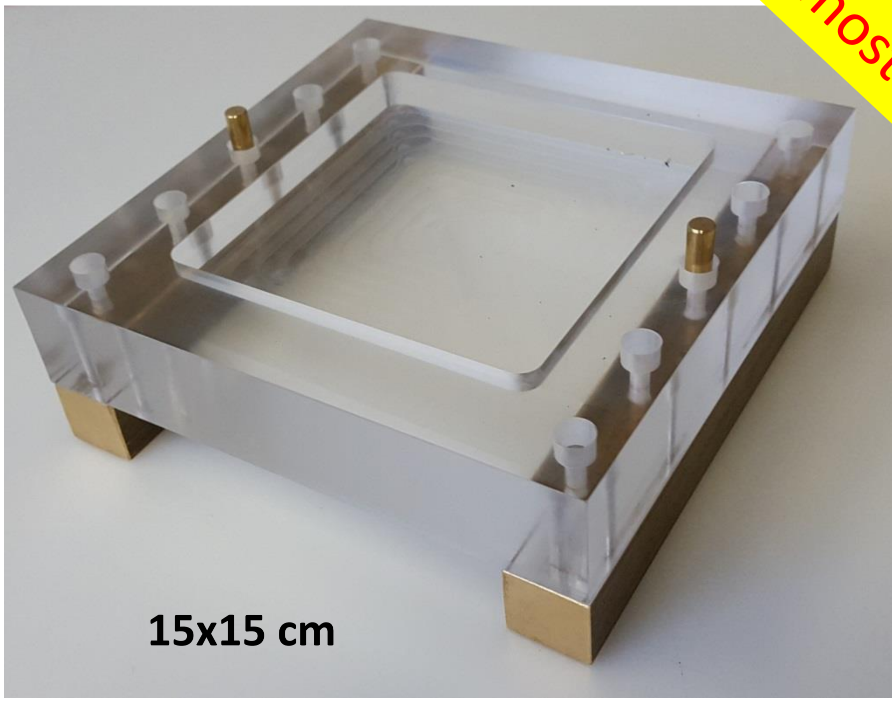
μ-RWELL DLC detectors under high rate at PSI

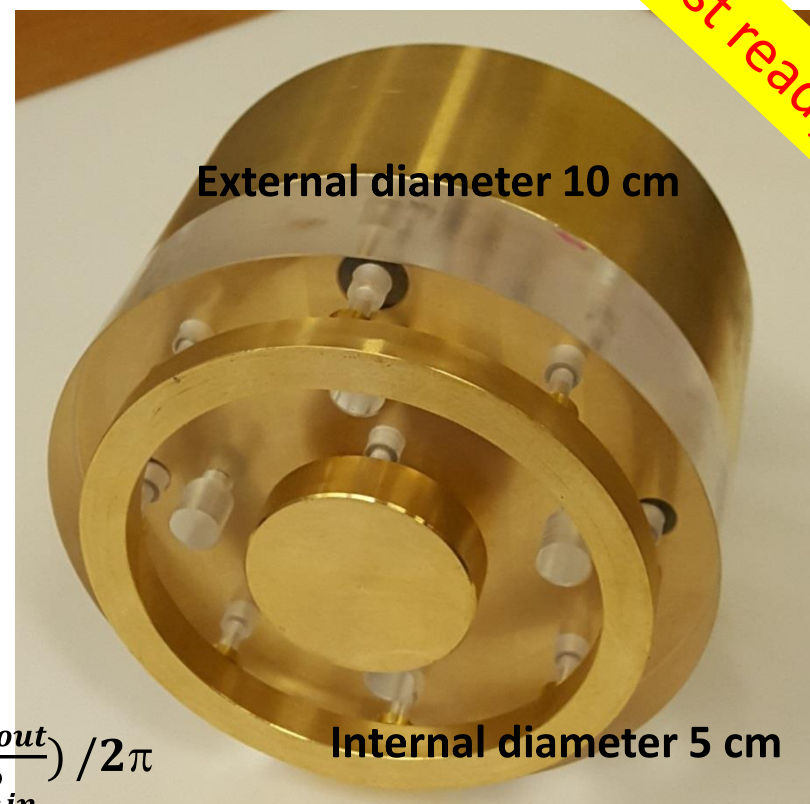
M. Poli Lener

on behalf of Resistive DLC collaboration

Tools for the measurement of DLC Surface Resistivity

Surface Resistivity tools (I)



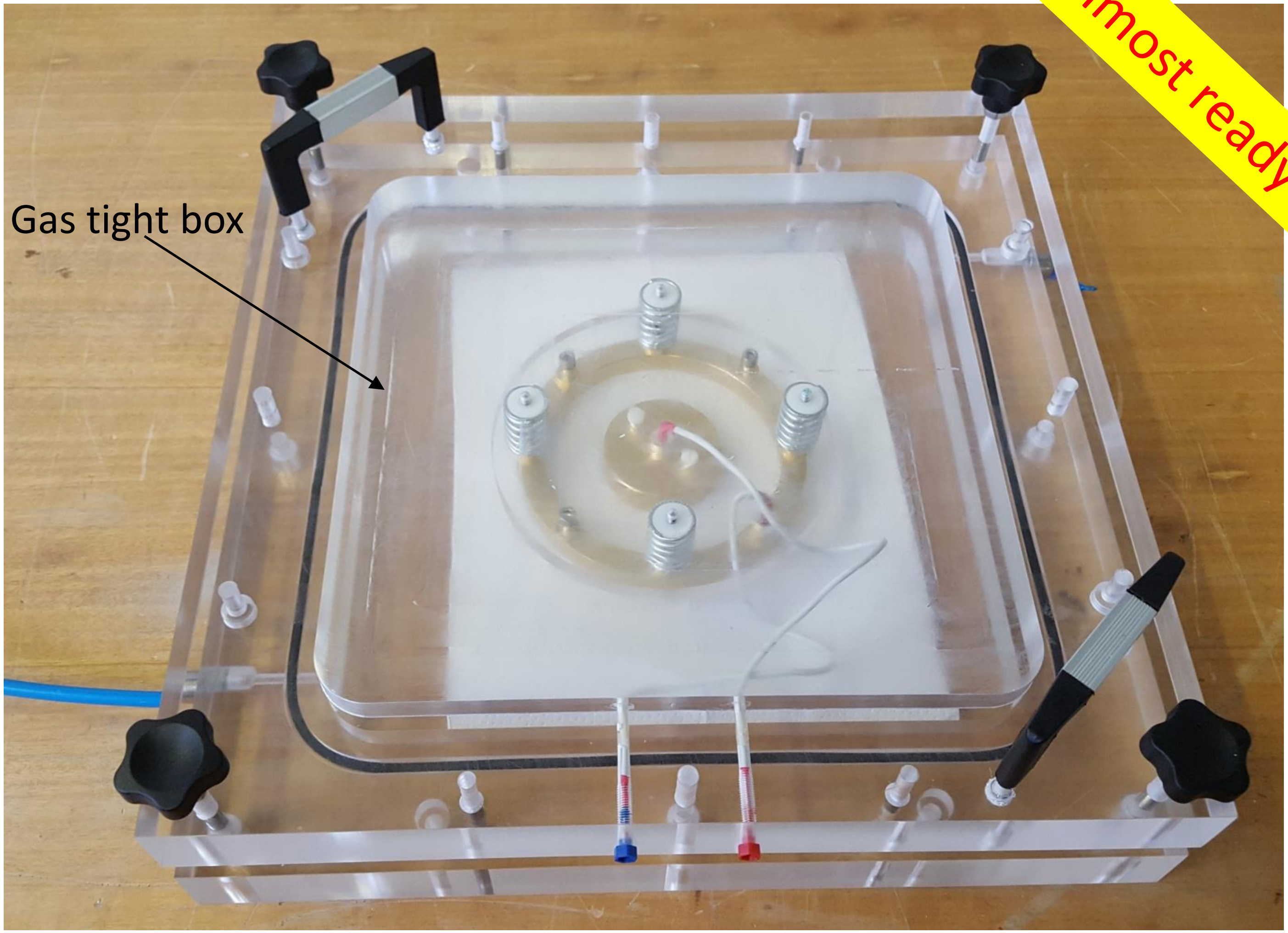


Electrodes will be covered with conductive sponge or rubber in order to avoid a dicrect conctact of metal with DLC

$$\Omega = \rho_s * \log(\frac{R_{out}}{R_{in}})/2\pi$$

Surface Resistivity tools (II)

Gas tight box for DLC resistivity measurement in controlled atmosphere

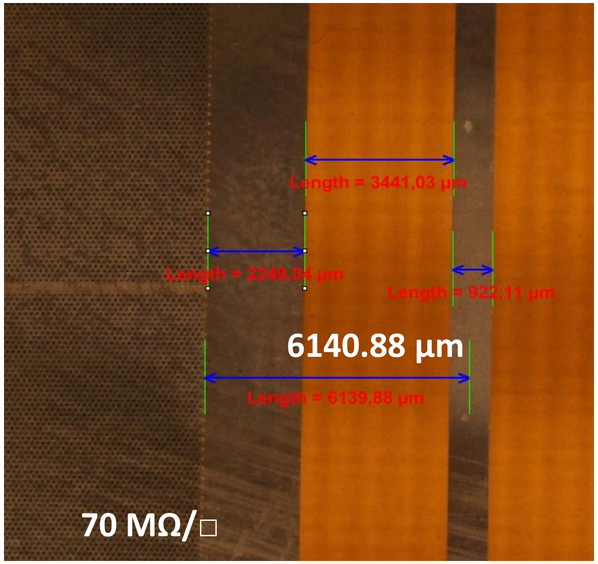


Thanks to E. Tskhadadze for drawing /assembly

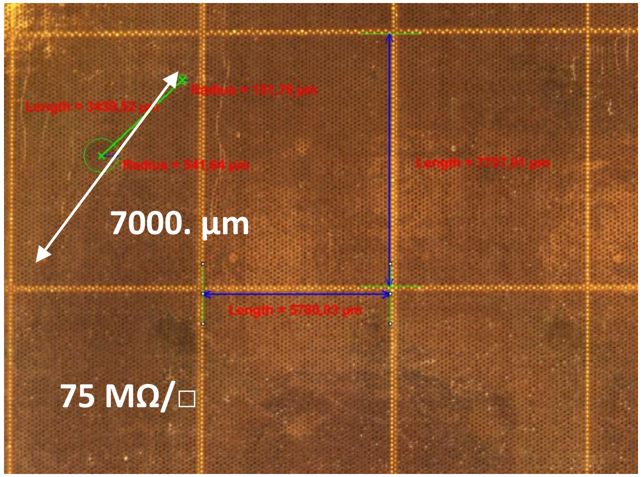
High Rate performance of μ-RWELLs with PADs readout

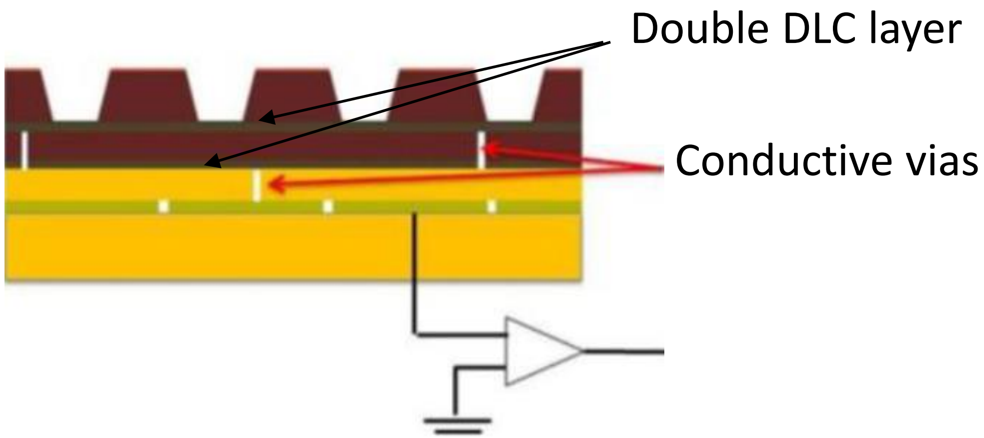
Detector geometrical parameters (I)

Baseline Geometry
Single DLC layer (LR)



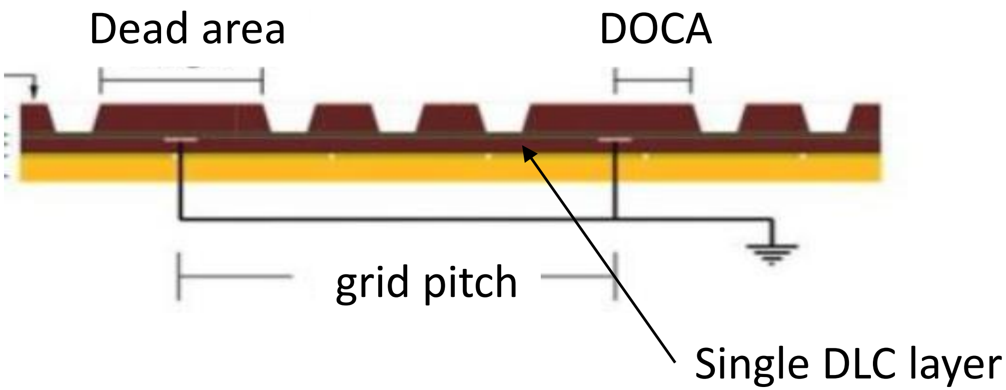
Double DLC Layer (DL)



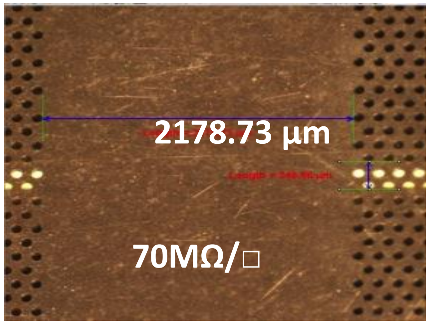


Detector geometrical parameters (II)

The aim is to maintain a very short path for current moving on the DLC layer to ground and simplifying the construction process

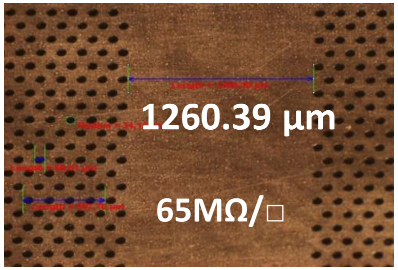


Silver Grid v1 (SG1)



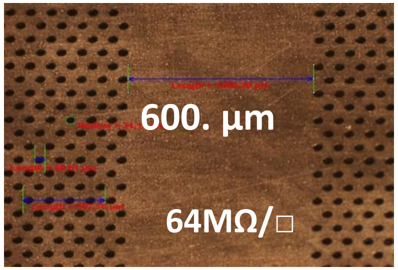
grid-pitch 6 mm
dead area 2 mm
conductive line 300 um
(screen printing)
→ Geometrical acceptance: 66%

Silver Grid v2 (SG2)



grid-pitch 12 mm
dead area 1 mm
conductive line 300 um
(screen printing)
→ Geometrical acceptance: 90%

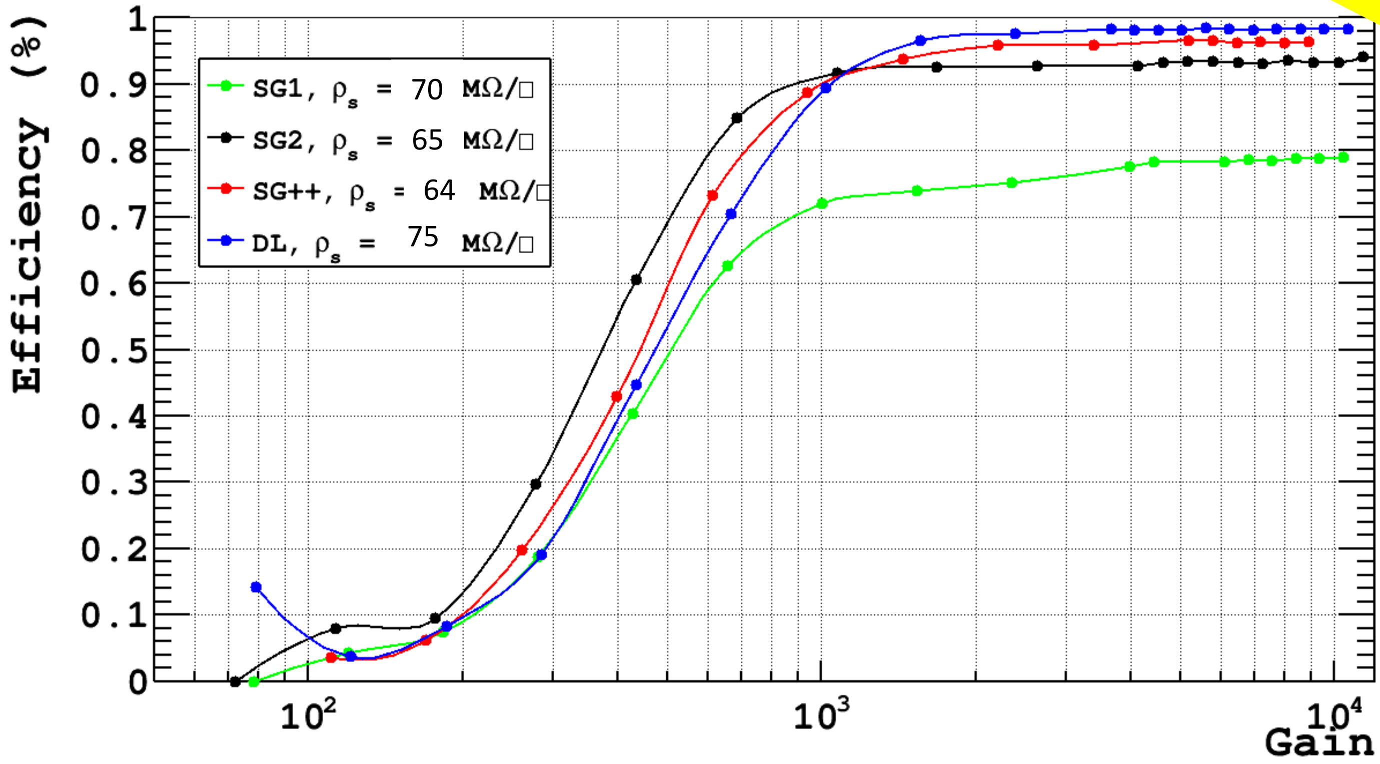
Silver Grid v2++ (SG2++)



grid-pitch 12 mm
dead area 0.6 mm
conductive line 100 um
(DLC+Cu polyimide foil has been produced by Zhou Yi – USTC, Hefei (PRC))
→Geometrical acc.: 95%

HR layouts performance: the efficiency

NEW



As expected the **DL prototype** reaches **full tracking efficiency** – **98%** (NO DEAD ZONE).
The **SG1, SG2 and SG2++** show lower efficiency **(76% -94% - 97%) BUT higher than their geometrical acceptance** (**66% - 90% - 95%** respectively), thanks to the **efficient electron collection mechanism** that **reduce the effective dead zone.**

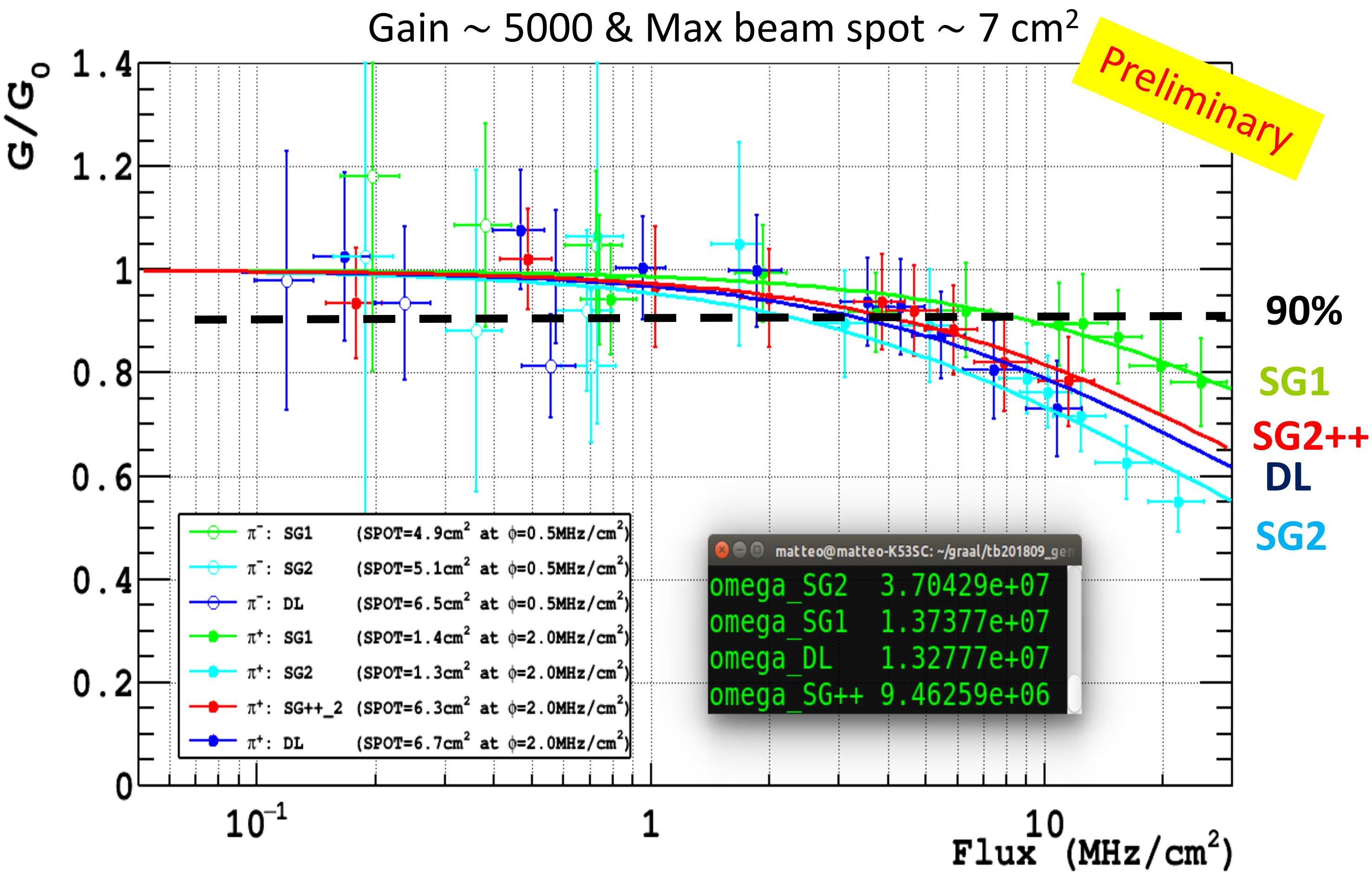
Detector parameters (III)

	SG1	SG2	SG2++	DL	LR
Grid-pitch	6 mm	12 mm	12 mm	6 mm	100 mm
Dead zone	2 mm	1.1	0.6	-	-
Conductive line width	300 um	300 um	100 um	-	-
Doca (distance of close approch) between edges active area & conductive line	**0.85 mm**	**0.45 mm**	**0.25 mm**	**7 mm (path between vias on the 2nd layer)**	**5.5 mm**
Effective average resistance to ground*	**134 MΩ**	**209 MΩ**	**200 MΩ**	**640 MΩ**	**1947 MΩ**
Nominal resistivity	70 MΩ/□	65 MΩ/□	64 MΩ/□	75 MΩ/□	70 MΩ/□

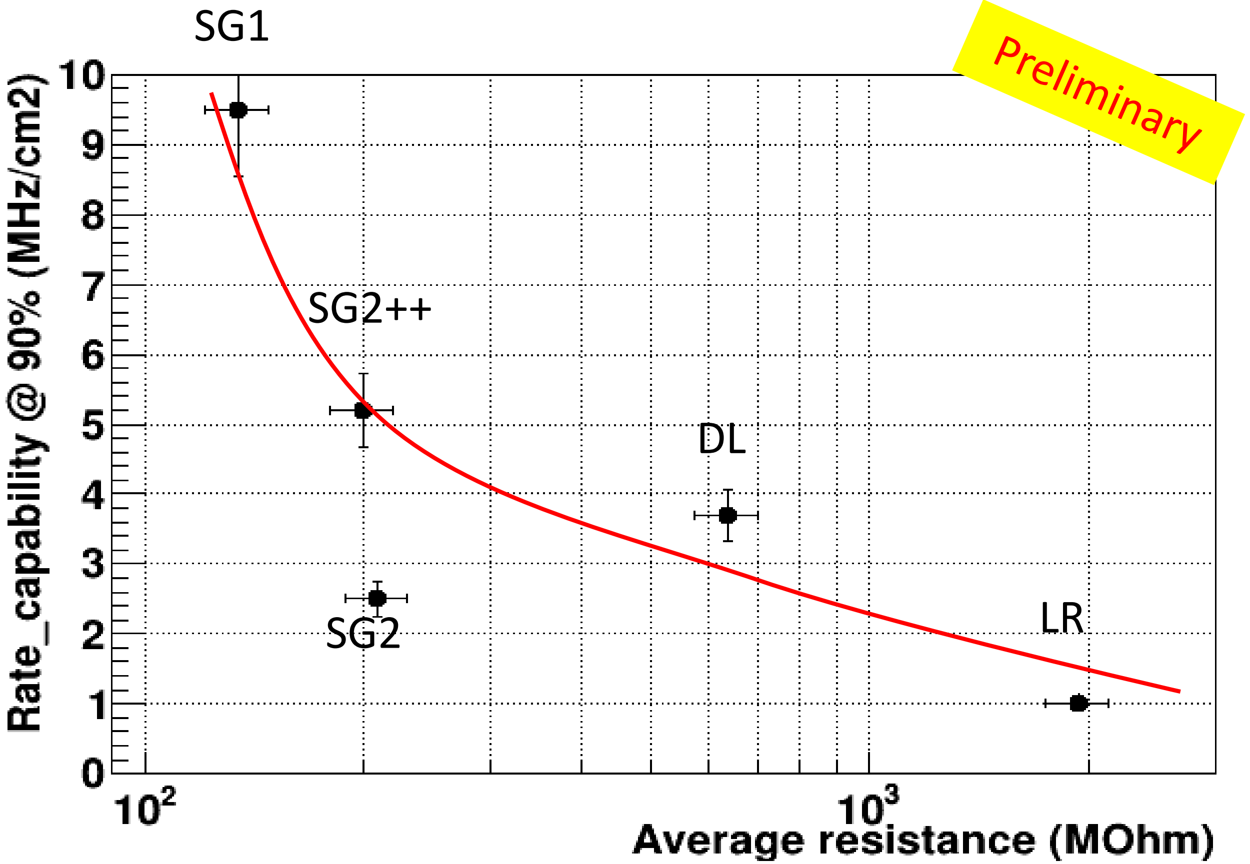
$$* \, \Omega \simeq \frac{\rho}{2} \times (pitch/2 + DOCA)$$

The average resistance to ground ,Ω, is a parameter summarizing the electrical (ρ) and geometrical (DOCA, pitch) features of the current evacuation scheme of each detector prototype

HR layouts performance: the rate capability

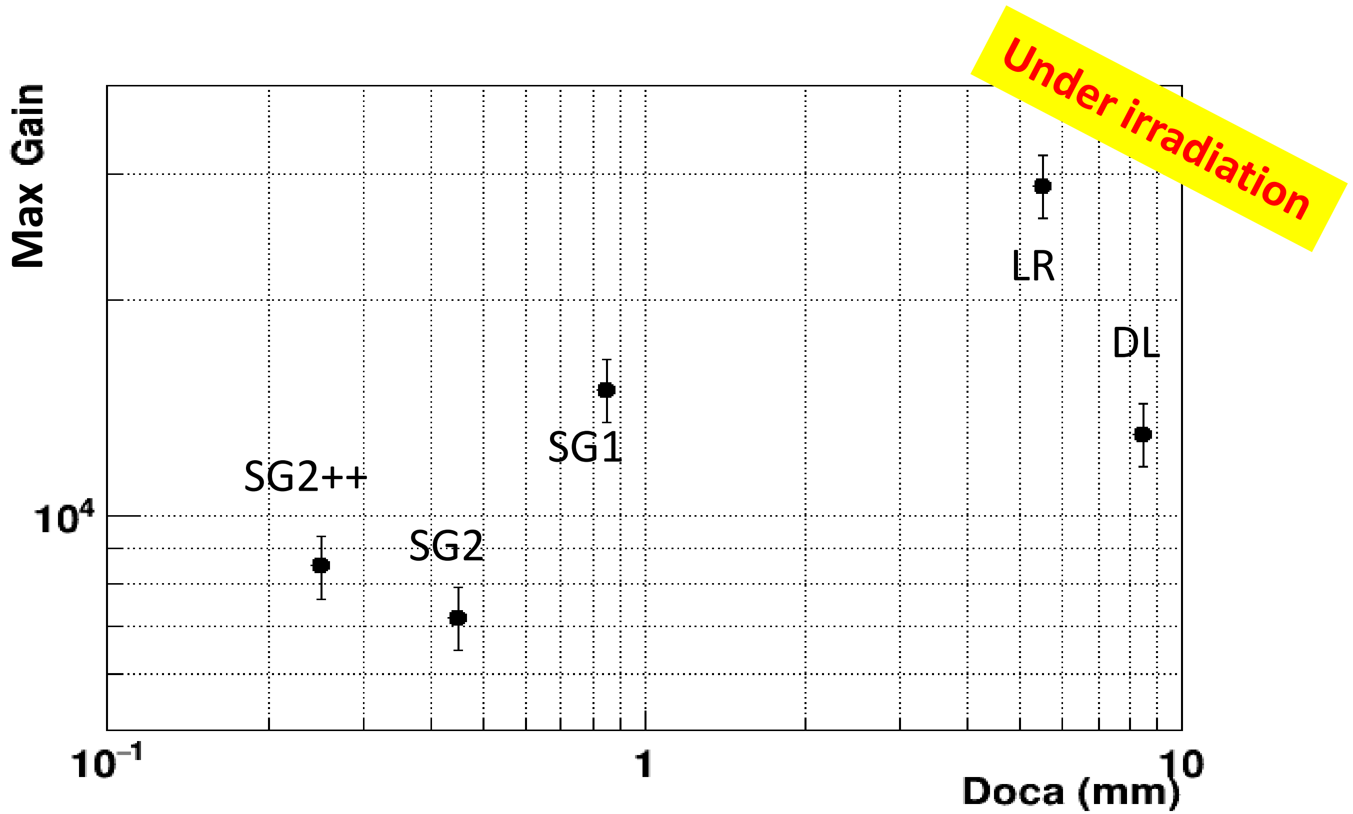


Rate capability vs effective average resistance



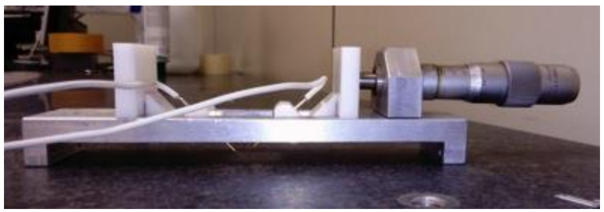
As expected, lower is the effective average resistance (Ω) higher is the rate capability

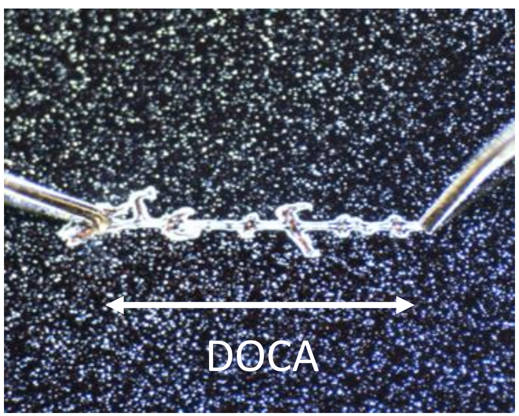
Detector stability vs DOCA

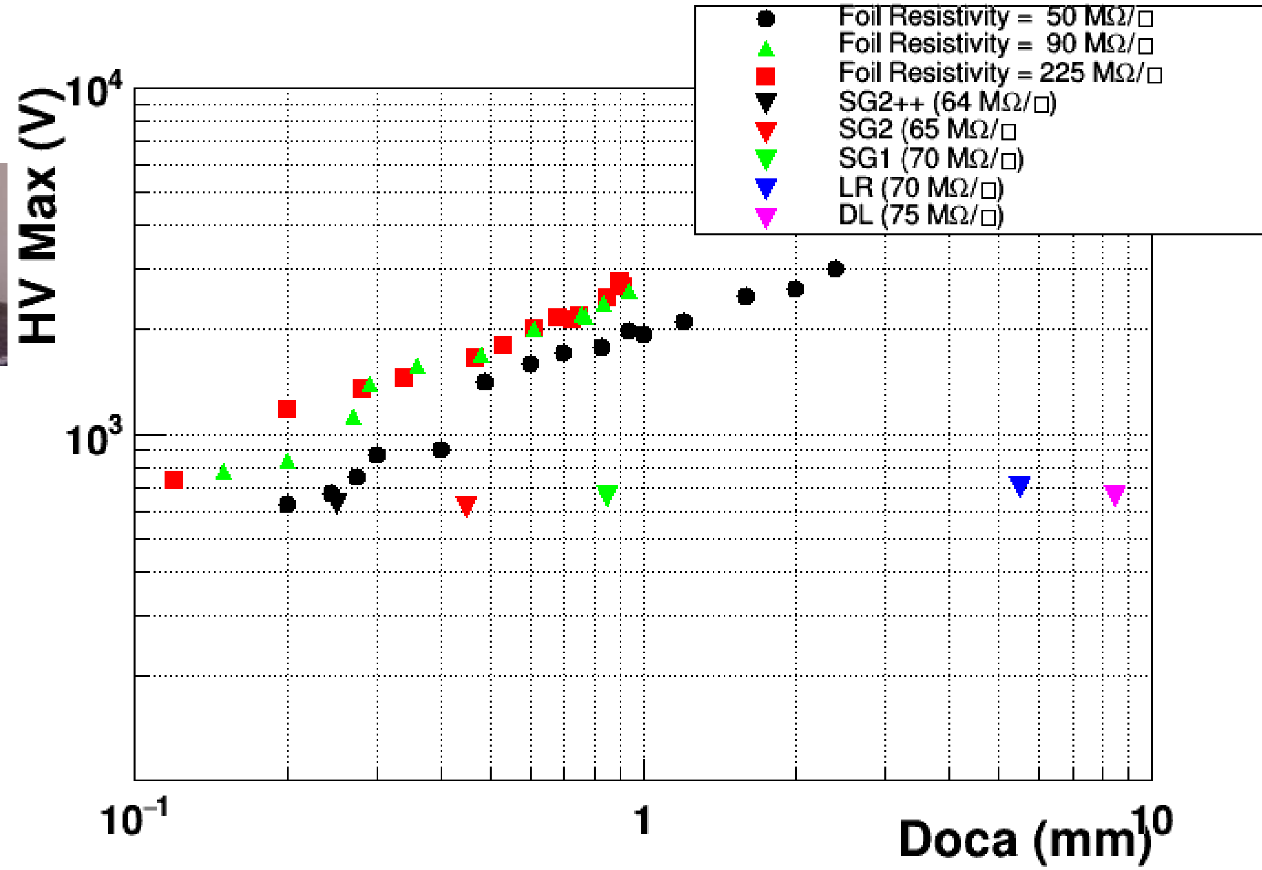


<u>Does the max gain</u> depend on DOCA?
More investigation/statistics is required

Limiting factor: Doca vs HV max



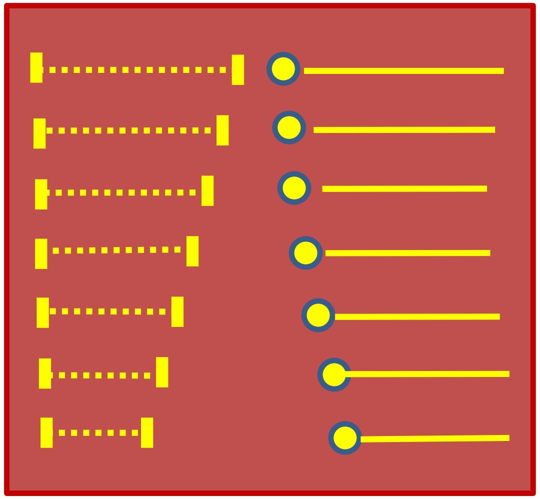


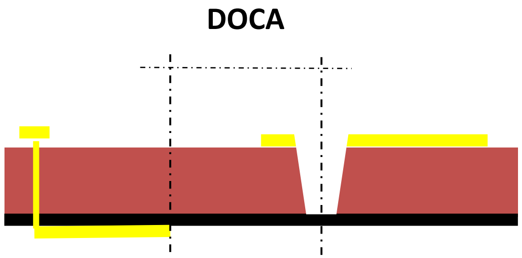


At higher resistivity and small DOCA other effect can dominate such as arc/corona discharge in air.
A solution is under study with Rui: a detector with different DOCA (single hole + conductive line at different distance)

Samples for DOCA test

- **Yi:**
  - produce foils with different DLC+Cu deposition (i.e. 25, 50, 75, 100, 200, 300 Mohm/sq)
- **Rui:**
  - produce a pattern of electrode contacts on the DLC side of the foils placed at a pre-determined DOCA distance (i.e. 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 2.0, … mm) from a single-HOLE pattern etched on the top side of the foil (copper side)
  - The contacts are brought on the top Cu side of the foils by vias.
  - The foils is glued with an FR4 foil





To do list: 1/12/18 – 31/3/19

- Deposition test of DLC/Cr/Cu on a 1um roughness surface to solve adhesion problem
- Comparison of thick – thin DLC:
  - Production of foil-samples for check of uniformity & long term stability
  - Production of two detector prototypes (standard single layer) with thick and thin DLC for test of robustness under discharge
- DOCA test for thick – thin DLC:
  - Preparation of special samples of DLC with electrode contacts at different DOCA & glued on thin FR4 (details in the drawings – next slide)

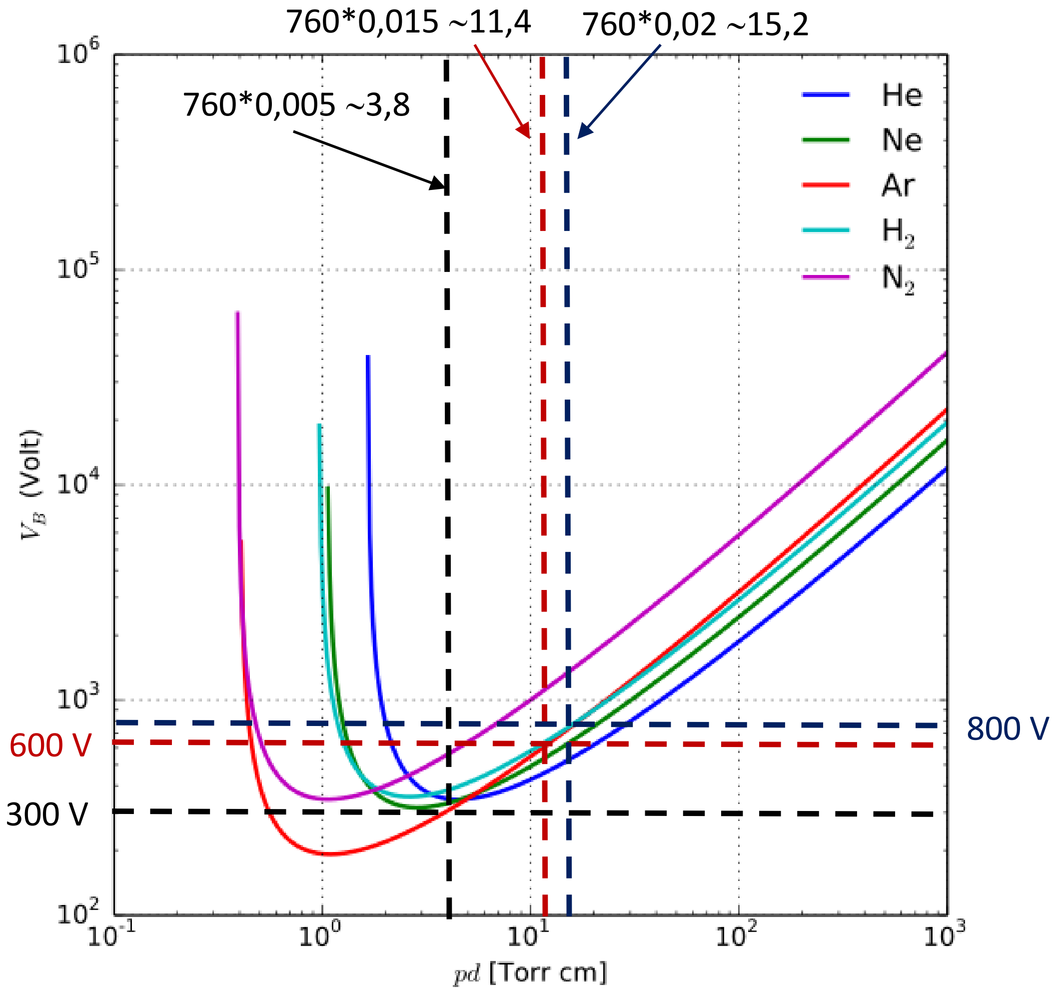
Conclusions

- **Resistivity tools almost ready.**

- **We are planning:**
    - **charaterization of thin and thick DLC layer: uniformity and long term stability**
    - **thin and thick DLC single layer detectors in discharge mode**

- **High rate measurements:**
    - **Efficiency higher than 97 %** with DOCA =0.25 mm & DEAD ZONE=0.6 mm (SG2++)
    - **Rate capability: 2-10 MHz/cm2** with grounding pitch between 6 & 12 mm
    - **GAIN & STABILITY under irradiation**: the average gain is about 10^4 & the maximum is between 2-3 10^4
    - A study of the **maximum gain for** thin & thick DLC protos with single amplification hole as function of DOCA is planned for the next months

Paschen



760*0,015 ~11,4
760*0,02 ~15,2
760*0,005 ~3,8
He
Ne
Ar
H_2
N_2
V_B (Volt)
10^6
10^5
10^4
10^3
10^2
600 V
300 V
800 V
10^{-1}
10^0
10^1
10^2
10^3
pd [Torr cm]

3 – HR layout: next prototypes

Following the **recipe adopted for Silver Grid (SG1 & SG2)** layouts (based on the definition of the **grid-pitch, grid-width)** we would like to **minimize as much as possible the dead zone** (for a given **DLC resistivity around 60-80 MΩ/□**)

HR Layout	Resistive layer	Grounding grid-pitch	Grounding	Dead-zone	Grid width	DOCA
SG2++	single	12 mm	Conductive grid + edge grounding	0,3 + 0,3 mm	100 um	250 um
Dashed Grid	single	Variable	Conductive dashed grid + DLC resistance + edge grounding	-	100 um	-

The very fine grid structure is made possible thanks to the <u>DLC+Cu technology</u> under study at USTC-Hefei (CP-RD51):

→ photolithography grid manufacturing down to 0.1 mm wide