Experience with resistive coatings on GRPCs for the ILD SDHCAL technological prototype

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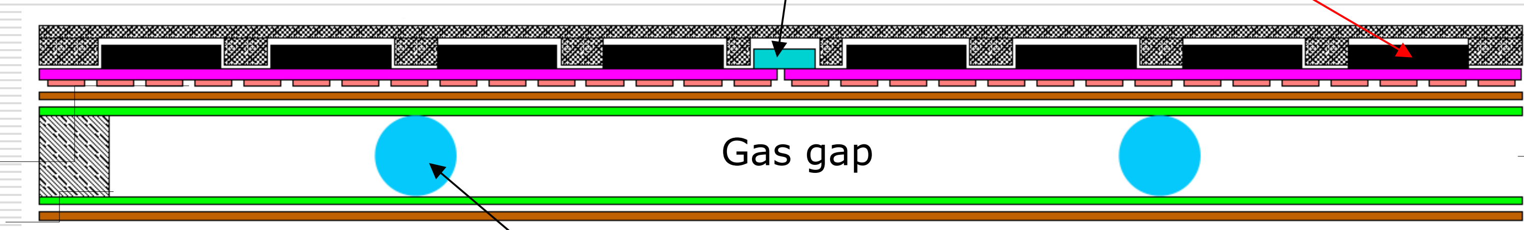
Considerations for a technological prototype

- Build 1 m3 module with ILC requirements for testing in beams at CERN and / or Fermilab :
- Challenges:
  - Large area (1m x 1m) GRPCs
  - Large number (48+) of detectors
  - Detector + electronics thickness < 6mm
  - Minimize dead zones
  - *Homogeneous gain*
  - *Efficiency >90% + minimize multiplicity*
  - Full integrated electronics with power pulsing
  - Realistic support structure for absorbers + RPCs

Chamber performance: key design parameters

- Homogeneity of gain / efficiency
  - Constant gas gap over large areas
  - Efficient gas distribution within chamber
  - No air gaps between readout pads and anode glass
- Optimization of multiplicity
  - Absolute value of coating resistivity
    - Higher values give lower multiplicity
    - Compromise: 0.5-10 MΩ/□
  - Uniformity of resistivity over surface

Cross-section of 1m² glass RPCs

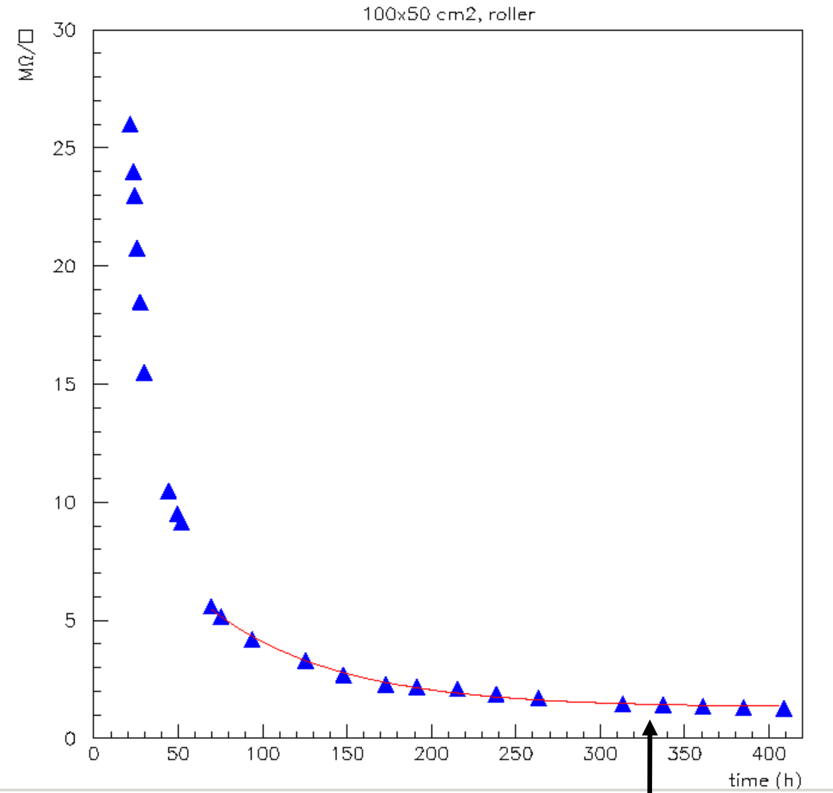


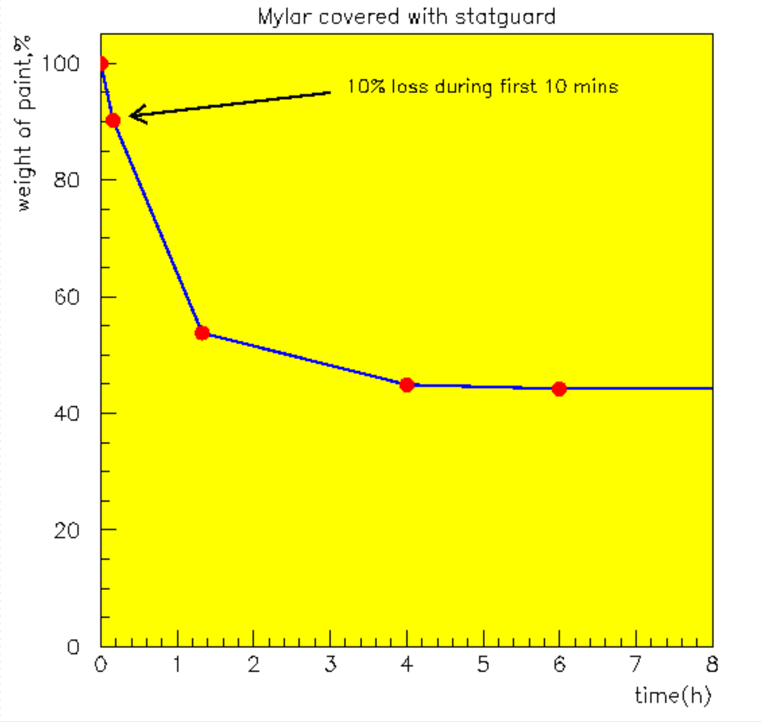
Total thickness: 6.025mm

Resistive coating - Statguard

- Contains oxides of Fe, Ti
- Floor coating for ESD applications
- Easily obtainable, e.g. Farnell
- Supplied as liquid in 1 gallon pots → wide choice of application methods: brush, roller, spray,…
- Cheap: ~EUR 40 / liter
- Disadvantage: long time constant for final surface resistivity
- Final ρ in range 1 – 10 MΩ/□ depending on layer thickness
- Electrostatic charging problems if ρ too high

Statguard – time stability

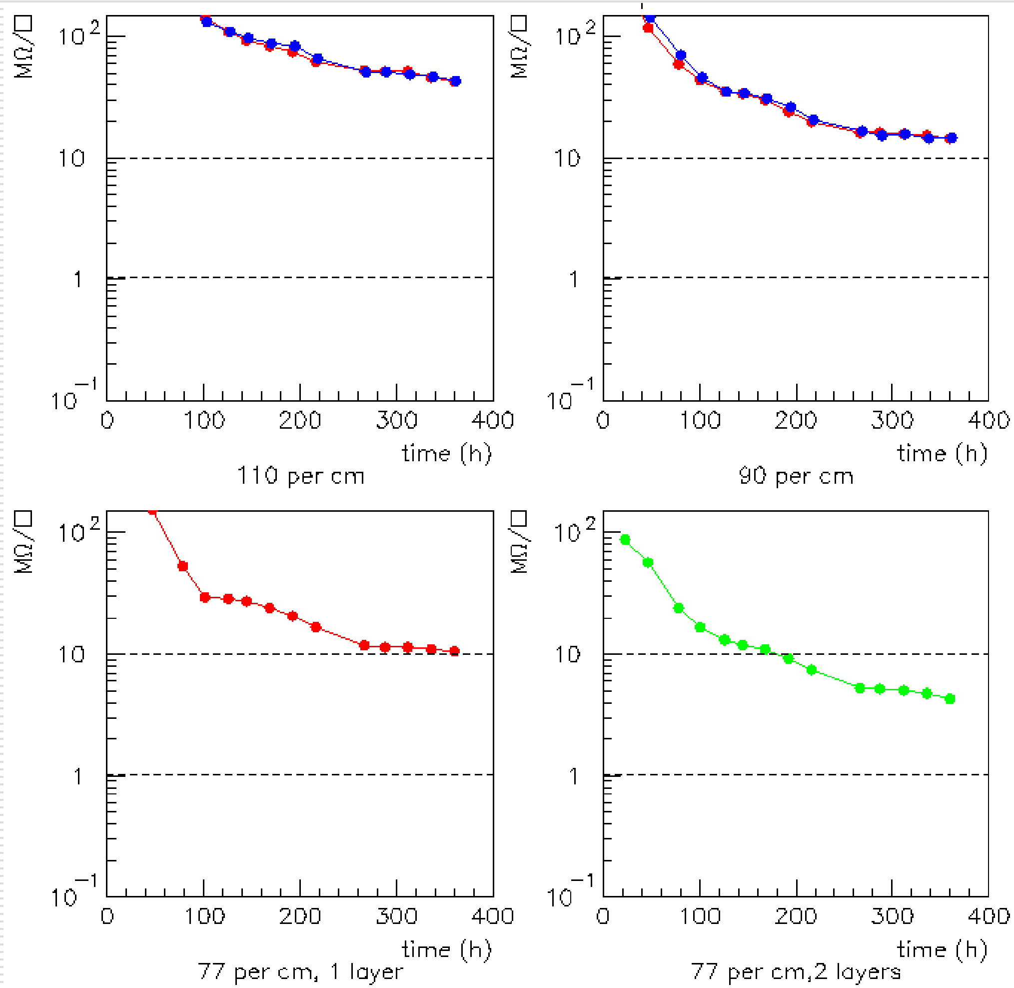




V.Gapienko

2 weeks!

Statguard – time stability (2)



V.Gapienko

Resistive coating - Licron

- Polymer layer (exact composition unknown)
- Surface resistivity ~20 MΩ/□
- Only available in spray cans in Europe – limits options for depositing
- Surface quality of latest product version inferior to old product (but still ‘OK’)
- Problems with HV connection:
  - Characteristic ‘thinning’ of coating around HV contact with eventual loss of contact
  - Seems to be linked to glue used to secure contact
  - Best results obtained using Epotek EE129 conductive epoxy but still unreliable

Resistive coating – summary of products tested

	Licron	**Statguard**	**Colloidal Graphite type I**	**Colloidal Graphite type II**
Surface resistivity (MΩ/□)	~20	1-10	~0.5	Depends on mix ratio; choose ~0.7
Best application method	Spray	Brush	Silk screen printing	Silk screen printing
Cost, EUR / kg	130	40	670*	240*
Delivery time (weeks)	3	<1	6	6

*Estimate 20m^2 (10 chambers) / kg using silk screen printing technique

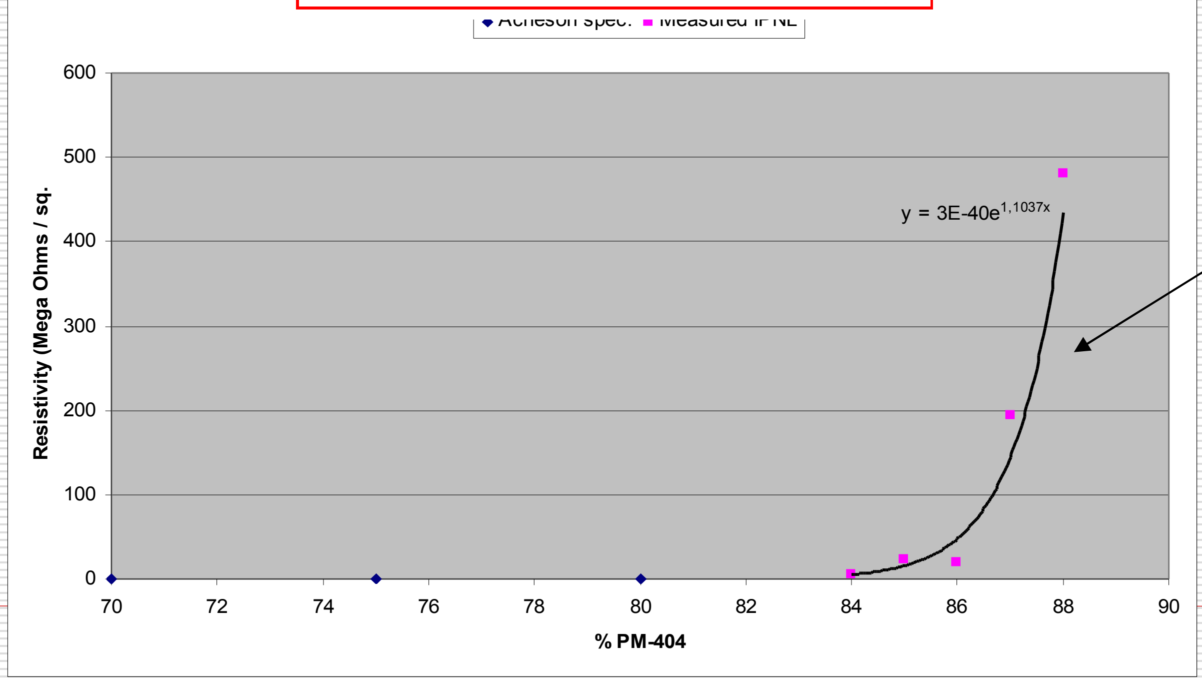
Licron: fragile coating, problems with HV connections over time
Statguard: long time constant for stable resistivity (~2 weeks), poor homogeneity

Baseline for technological prototype is colloidal graphite type II

Resistivity as a function of mix ratio

Company spec. →

Electrodag_1	Electrodag_2	Approx. sheet resistance (Ohm/sq. at 25 µm dry coating thickness
100	0	35
90	10	50
80	20	70
70	30	105
60	40	170
50	50	290
40	60	675
30	70	2160
25	75	4500
20	80	35000
10	90	$> 10^9$

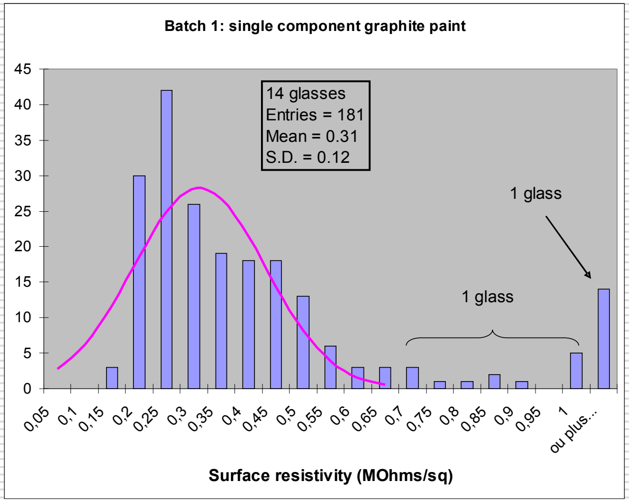


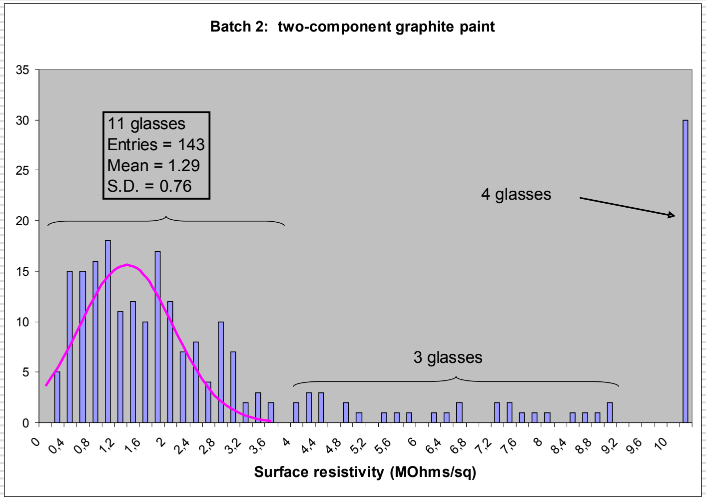
Extend with measured data

Silk screen printing at local company

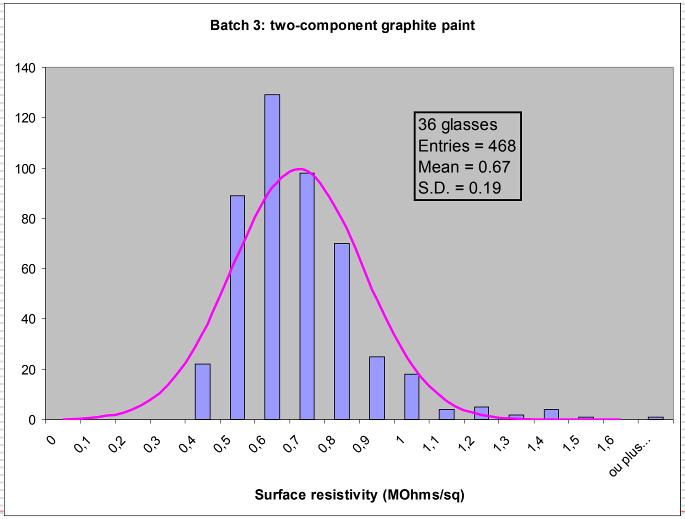
- Product requires curing at 170°C – company has suitable drying tunnel
- Tin-coated side of glass identified prior to silk-screen printing (paint always on this side)

Surface resistivity: first 70 glasses (35 RPCs)

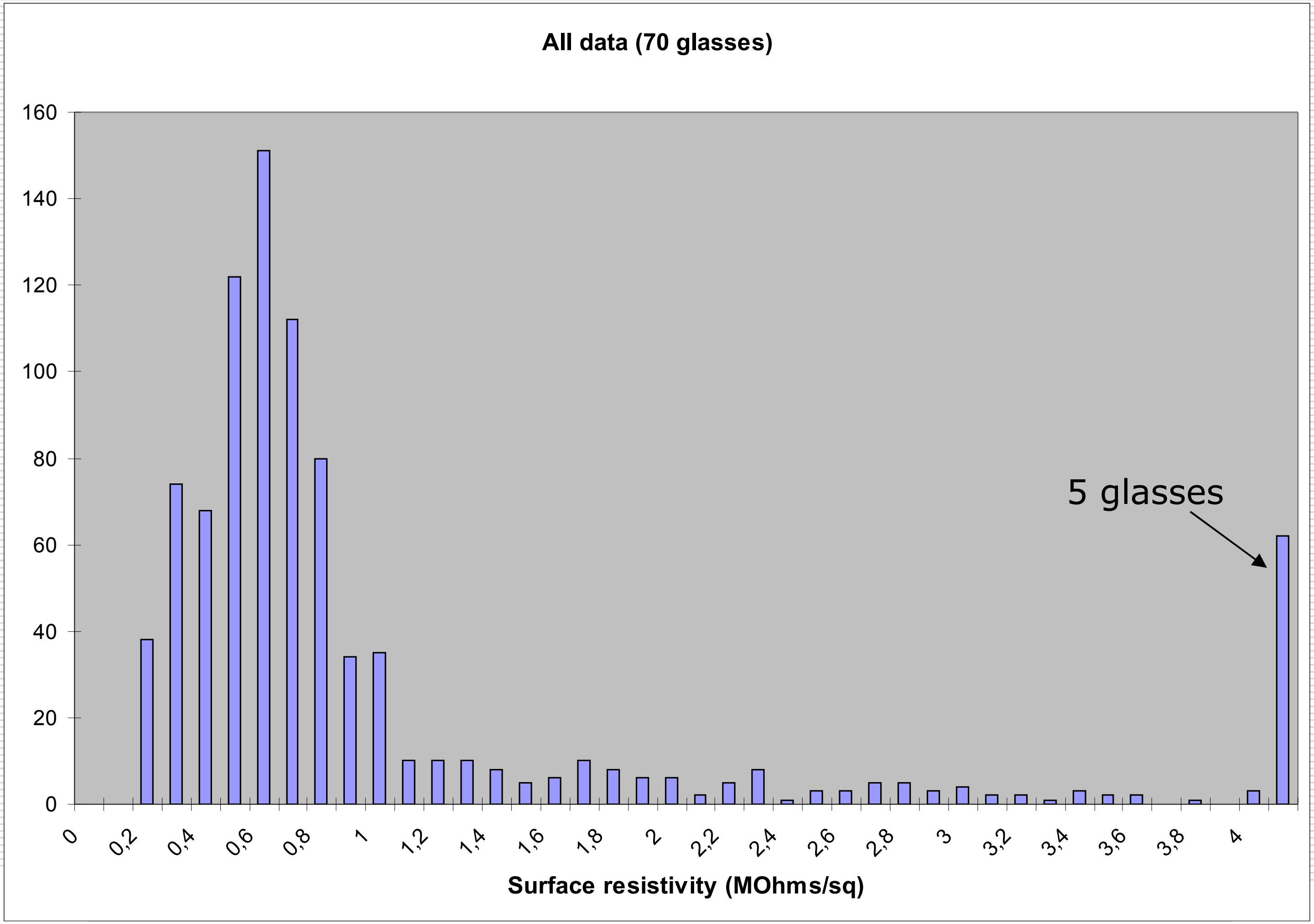




13 test points / glass



Data for all 35 chambers built so far



Checking the paint mixture

- Obtain desired mix ratio by weighing the two components (in principle very accurate)
- Resistivity checked in lab using small silk-screen set-up with similar mesh size
- Baked in oven as at company
- Result: 4.3 ±1.5 MΩ/□ (paint for Batch 3)

Measured value at IPNL factor 6 higher than result obtained at company!

Conclusions + Outlook

- A resistive coating suitable for the SDHCAL prototype has been identified
- Many promising products were found to be *not* suitable! (Finding the right one took a long time)
- Advantages:
  - Can be applied using silk-screen printing
  - Coating uniform across whole $1m^2$ surface
  - Very consistent surface resistivities for a given paint batch
  - Resistivity stable in time
  - Coating is mechanically robust
  - Reliable connection to HV contacts
- Disadvantages:
  - Requires high temperature curing (large oven)
  - Obtaining a specific surface resistivity is tricky (but for our purposes we have quite a lot of latitude)