(S)DHCAL
Status & plans

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Outline

✓ Gaseous HCAL

Status and pans :

✓ DHCAL

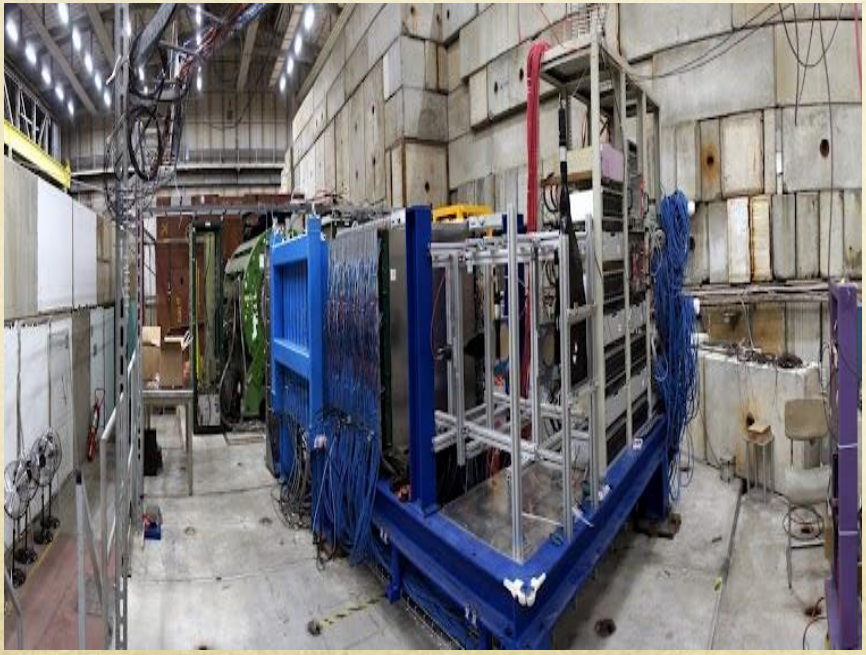
✓ SDHCAL-RPC

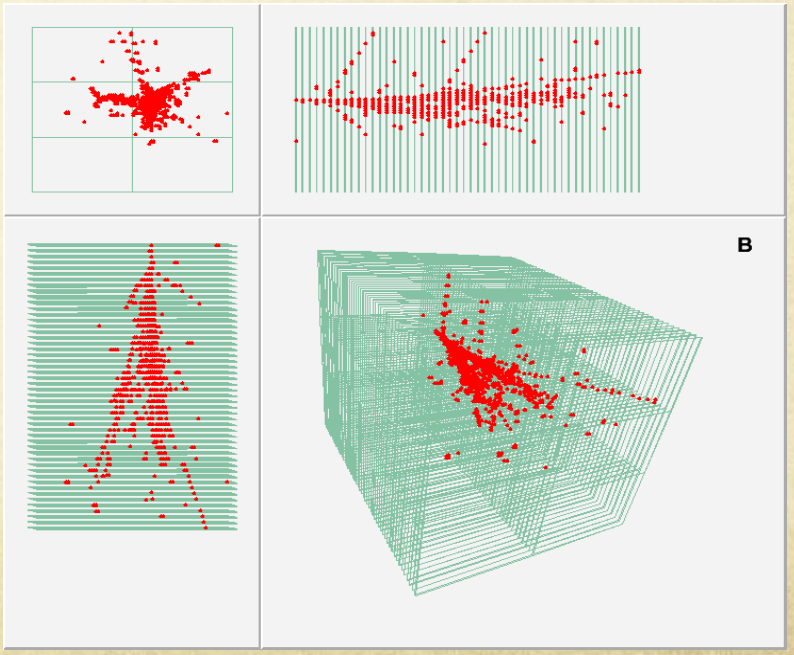
✓SDHCAL-Micromegas

✓Conclusion

DHCAL-RPC (54 units) :

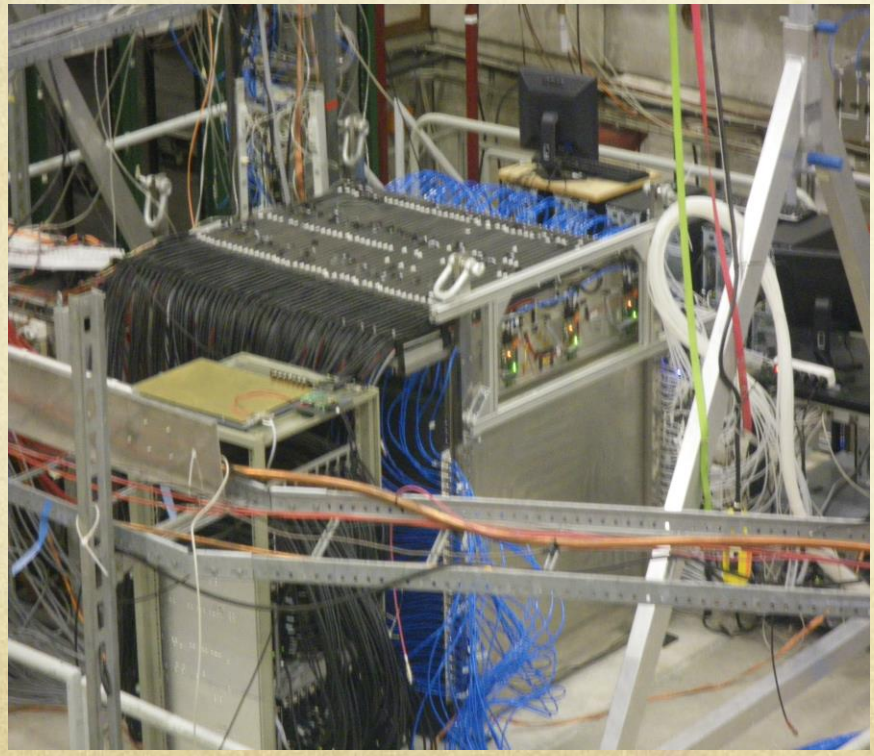
→Large detectors : 33X100 cm2 RPC → assembled to have $1m^2$
→Electronics : DCAL, embedded
→Readout : both sides of the $1m^2$
→ Cassette design : ok, copper plate to diffuse ASIC heating
→DAQ : ok

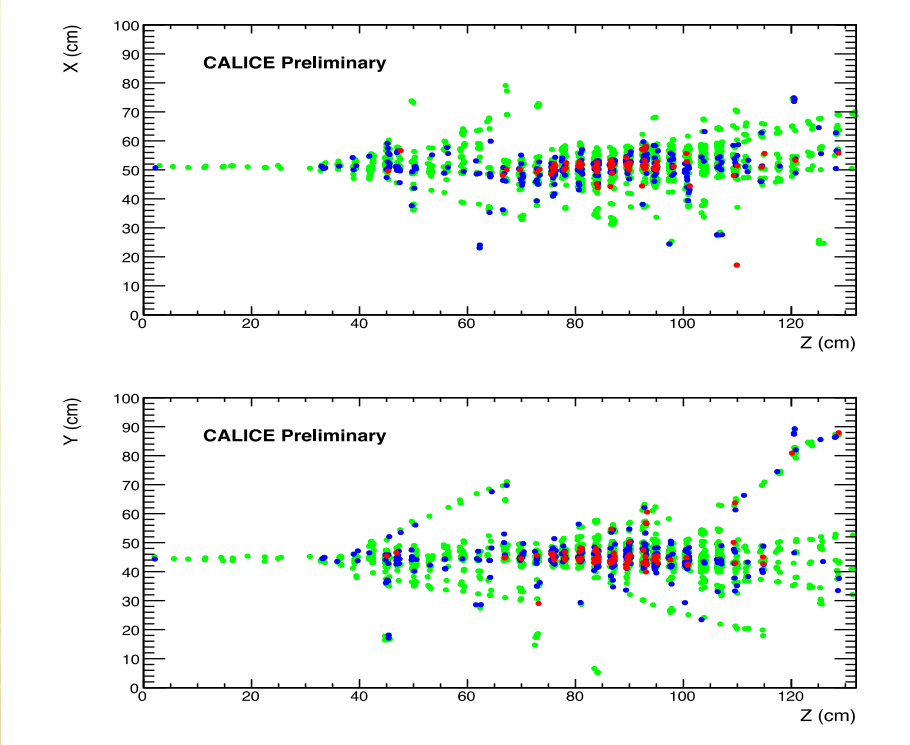




SDHCAL RPC (50 units)

→Large detectors : 100X100 cm2 RPC
→Electronics : HARDROC, embedded
→Readout : one side of the 1m2
→ Cassette design : ok, part of the absorber
→ DAQ : ok, not the final





Micromegas (4 units)

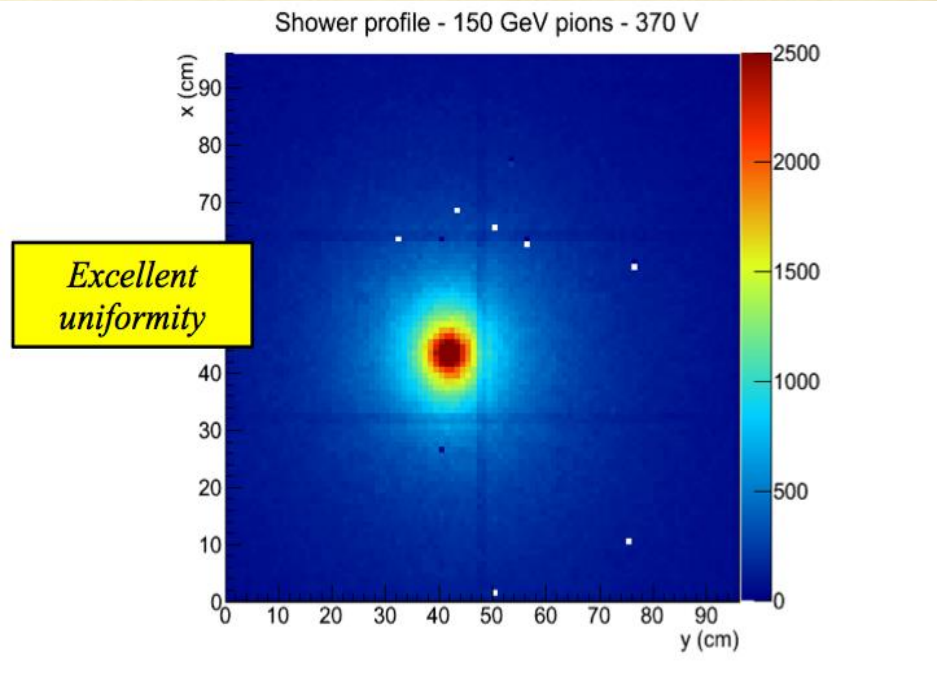
→Large detectors : 33X50 cm2 MM→ assembled by set of 6 to have 1 m2

→Electronics : Microroc, embedded

→Readout : one side of the 1m2

→Cassette design : ok, part of the absorber

→DAQ : ok, not the final one (same as for the SDHCAL-RPC)

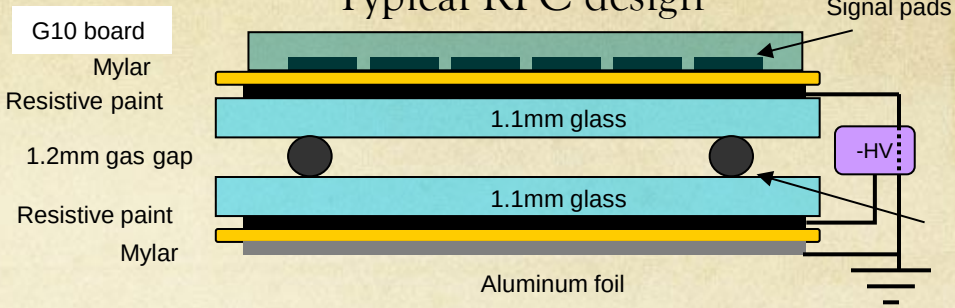


DHCAL-GRPC
plans

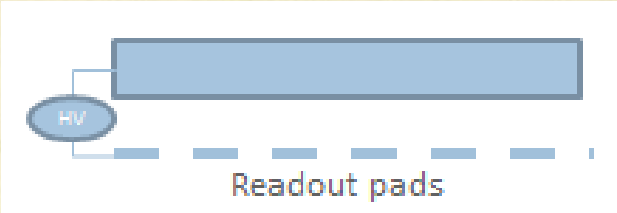
2-glass RPCs

1-glass RPCs

Typical RPC design



1-glass RPC design



Offers many advantages

Pad multiplicity close to unity
→ easier to calibrate

Better position resolution
→ if smaller pads are desired

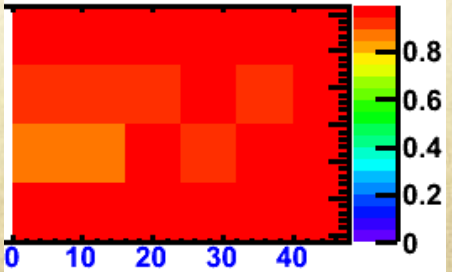
Thinner
→ $t = t_{chamber} + t_{readout} = 2.4 + \sim 1.5$ mm
→ saves on cost (coil)

Higher rate capability
→ roughly a factor of 2

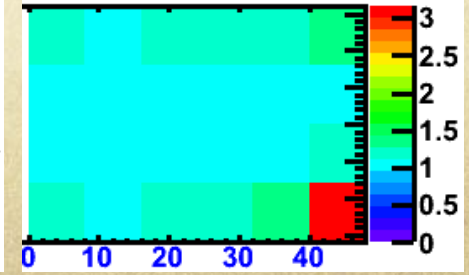
Status

Built several large chambers
Tests with cosmic rays very successful
→ chambers ran for months without problems
Both efficiency and pad multiplicity look good

Efficiency



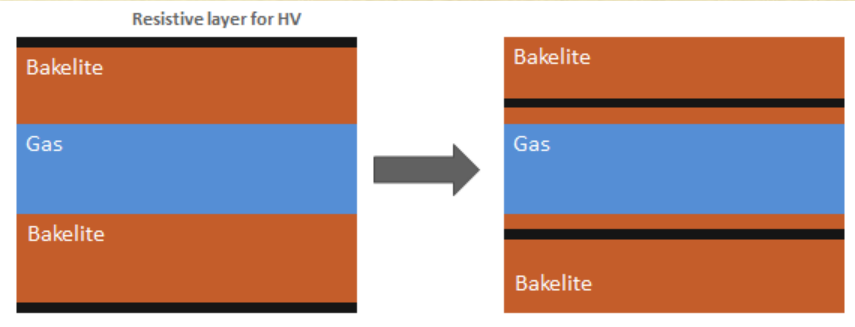
Pad multiplicity



High-rate Bakelite RPCs

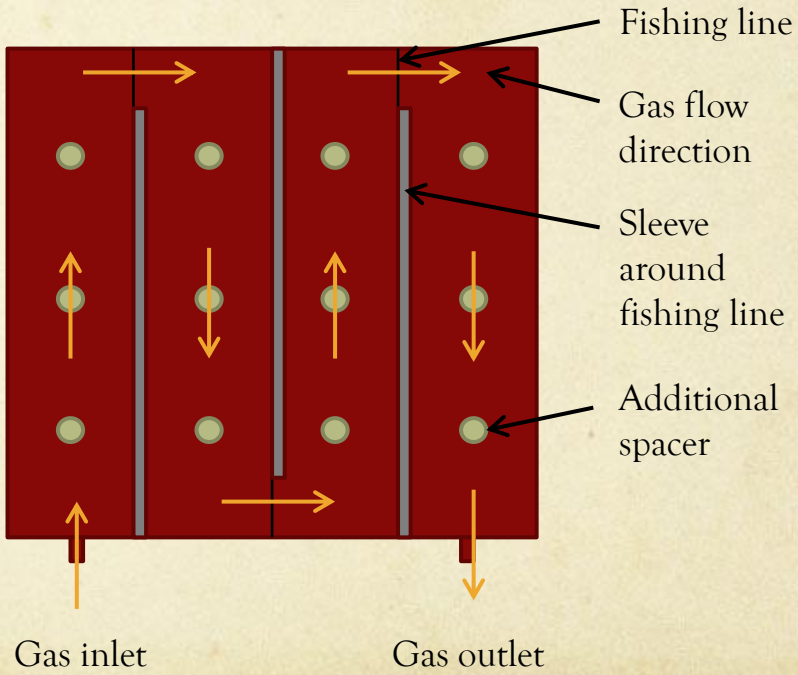
Bakelite

Is laminated and does not break like glass
but changes R_{bulk} depending on humidity
but needs to be coated with linseed oil



High-rate RPCs

Use of Bakelite with low $R_{bulk} \sim 10^8 - 10^{10}\ \Omega$cm
and/or Bakelite with resistive layer close to gas gap



Status

Several chambers built at ANL
First rate tests at GIF being evaluated

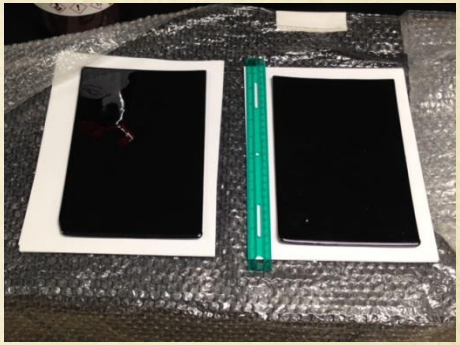
Development of semi-conductive glass

Co-operation with **COE college** (Iowa) and University of Iowa

World leaders in glass studies and development

Vanadium based glass

Bulk resistivity tunable
Procedure aimed at industrial manufacture (not expensive)



First samples

Very low resistivity $R_{bulk} \sim 10^8\ \Omega cm$

New glass plates

$R_{bulk} \sim 10^{10}\ \Omega cm$ produced
Plates still need to be polished
Production procedure being optimized

High Voltage Distribution System

Generally

Any large scale imaging calorimeter will need to distribute power in a safe and cost-effective way

HV needs

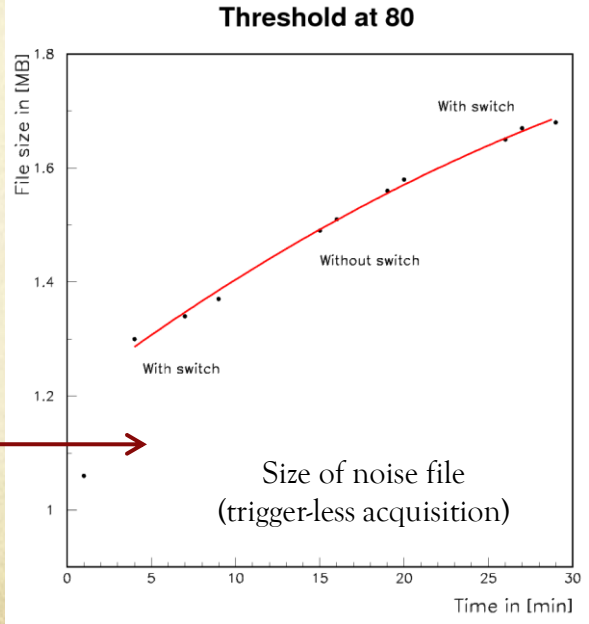
RPCs need of the order of 6 – 7 kV

Specification of distribution system

Turn on/off individual channels
Tune HV value within restricted range (few 100 V)
Monitor voltage and current of each channel

Status

Iowa started development
First test with RPCs encouraging
Work stopped due to lack of funding



Gas Recycling System

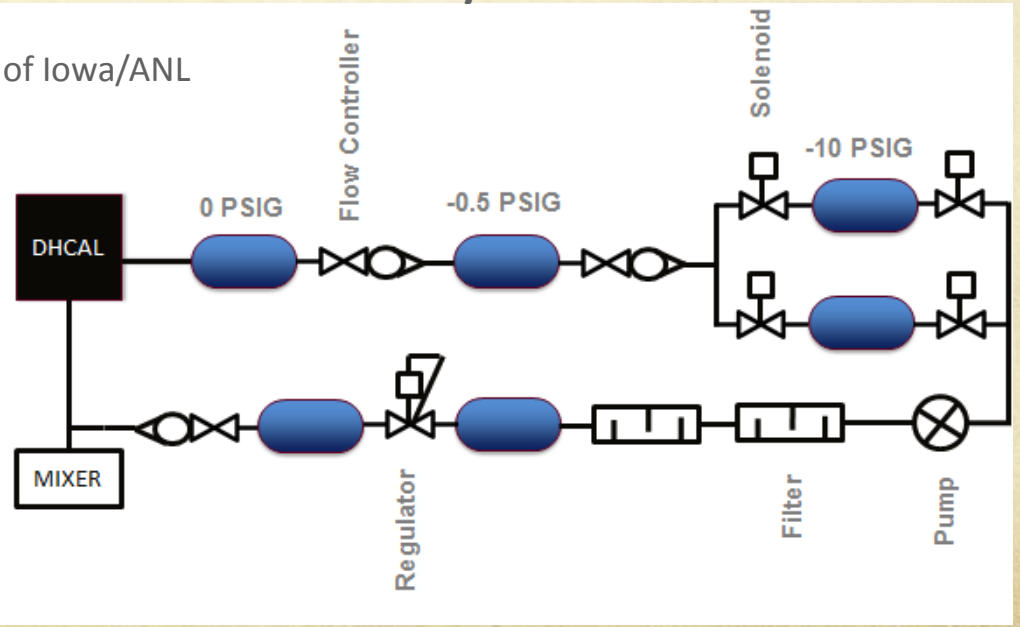
DHCAL's preferred gas

Gas	Fraction [%]	Global warming potential (100 years, CO_2 = 1)	Fraction * GWP
Freon R134a	94.5	**1430**	1351
Isobutan	5.0	3	0.15
SF_6	0.5	**22,800**	114

Recycling mandatory for larger RPC systems

Development of 'Zero Pressure Containment' System

Work done by University of Iowa/ANL



Status

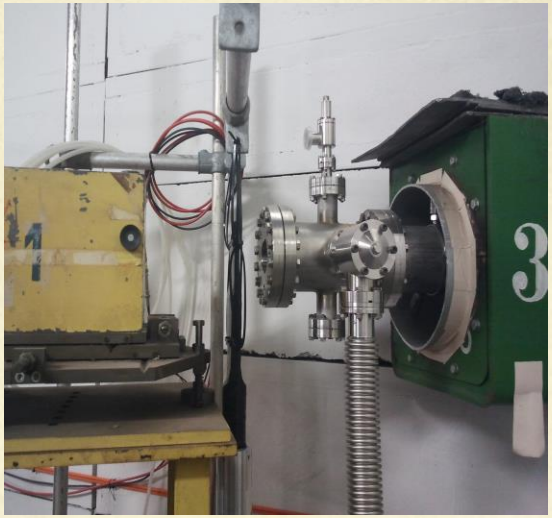
First parts assembled…

SDHCAL-GRPC
plans

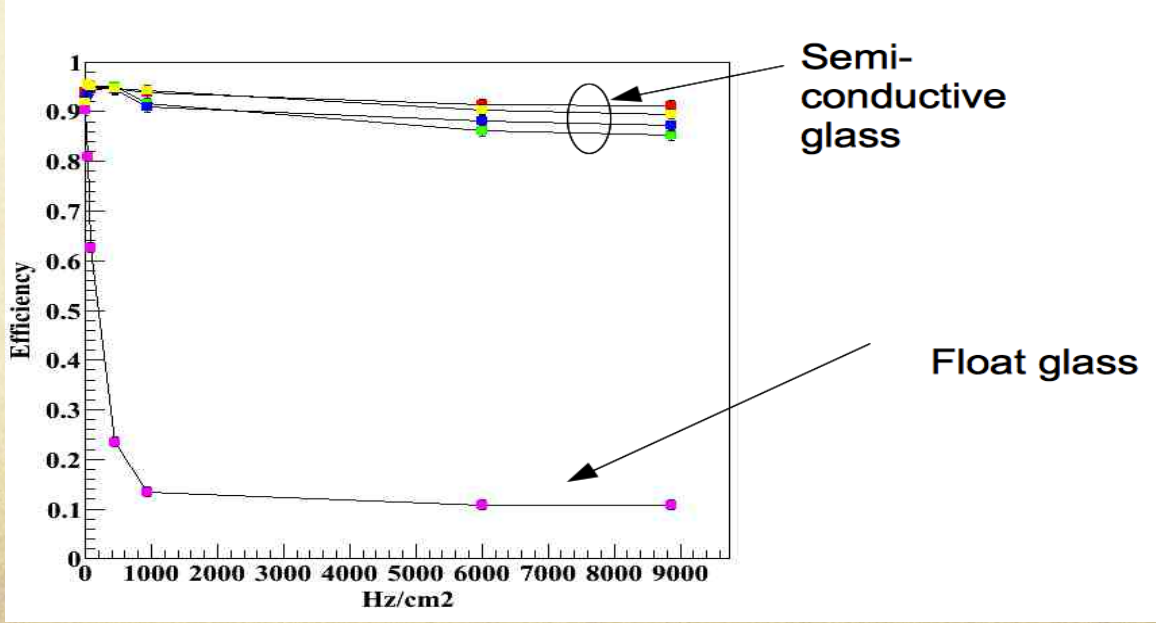
High-Rate GRPC

High-Rate GRPC may be needed in the very forward region

✓Semi-conductive glass (10^{10} Ω.cm) produced by our collaborators from Tsinghua University was used to build few chambers.
✓4 chambers were tested at DESY as well as standard GRPC (float glass)



Performance is found to be excellent at high rate for GRPCs with the semi-conductive glass and can be used in the very forward of ILD region if the rate exceeds 100 Hz/cm^2 in future ILD upgrades as well as for CLIC



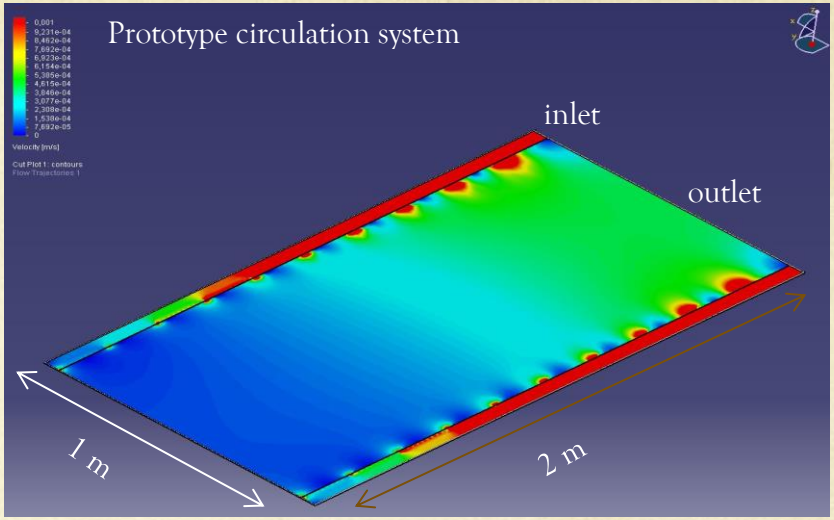
Large GRPC for ILD model:

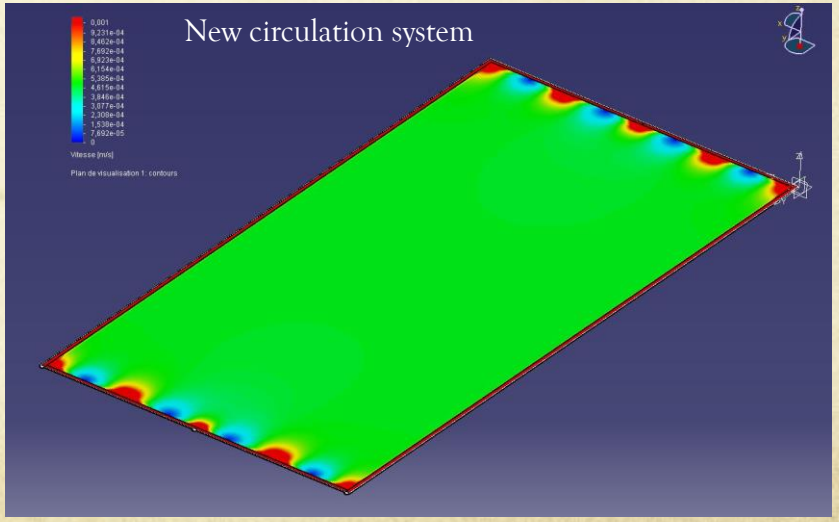
GRPC with a surface
$\leq$ 3 m^2 are needed.

We intend to build
a 2m^2 GRPC.

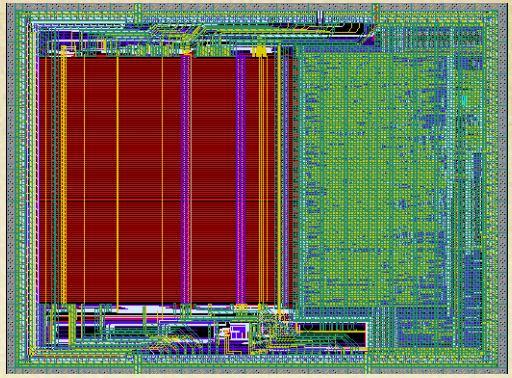
We are currently studying
the gas distribution system
to ensure a good gas
renewal.

Once the first large detector is built
the gas circulation of the new scheme
will be controlled using radioactive
^{183m}Kr





HARDROC3



This a new version of the HARDROC ASIC has:

-64 independent channels, zero suppression

-I2C link

-PLL: Input frequency 2.5 MHz =>output frequency: 10, 20, 40, and 80 MHz

Bandgap: new one with a better temperature sensitivity

Triple voting

Roll mode

Temperature sensor: tested in a building block, slope – 6mV/°C

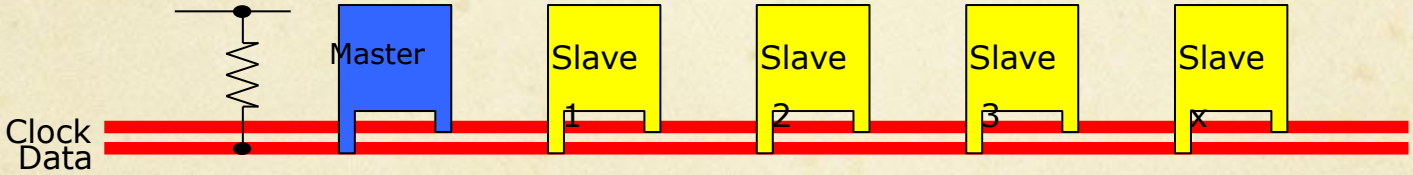
Die size ~30 mm2 (6.3 x 4.7 mm2)

Packaged in a TQFP208

The ASIC was produced and tested. All functionalities were successfully tested.

A minor problem was found with the I2C scheme (buffer stuck to zero)

This I2C was however successfully tested after a BIF.

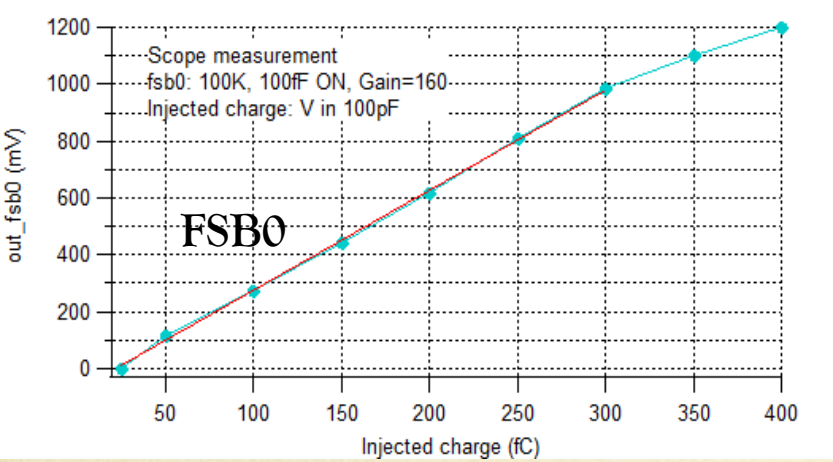


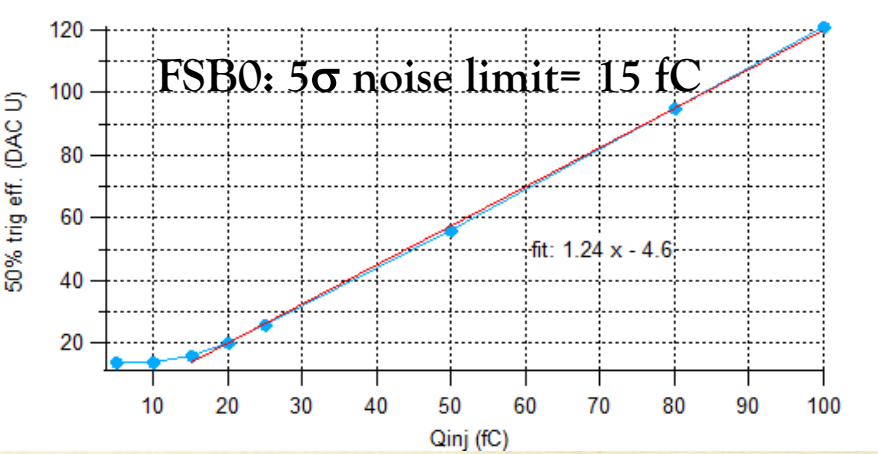
S	Slave address	$\overline{W}$	A	Reg address	A	data	A	P

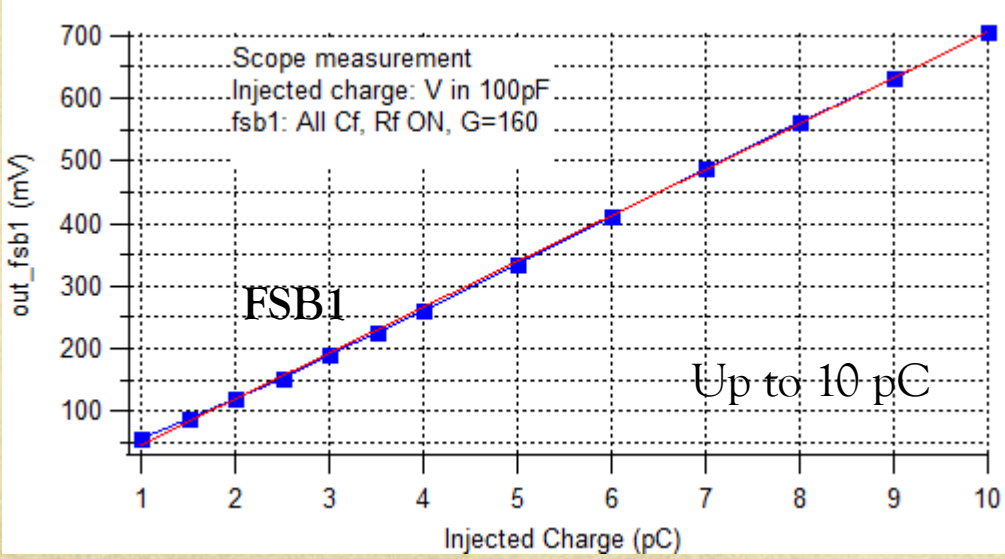
S	Slave address	$\overline{W}$	A	Reg address	A	P

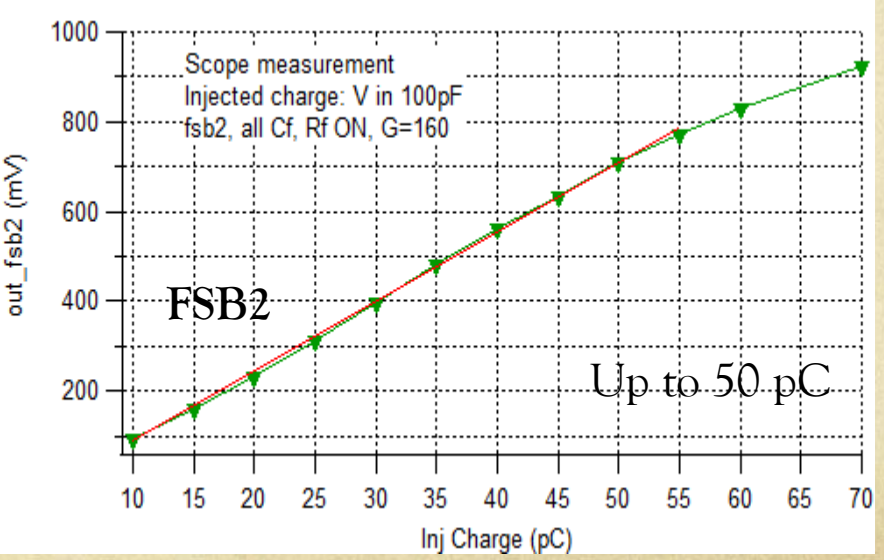
S	Slave address	R	A	data	$\overline{A}$	P

ANALOG PART: FSB LINEARITY



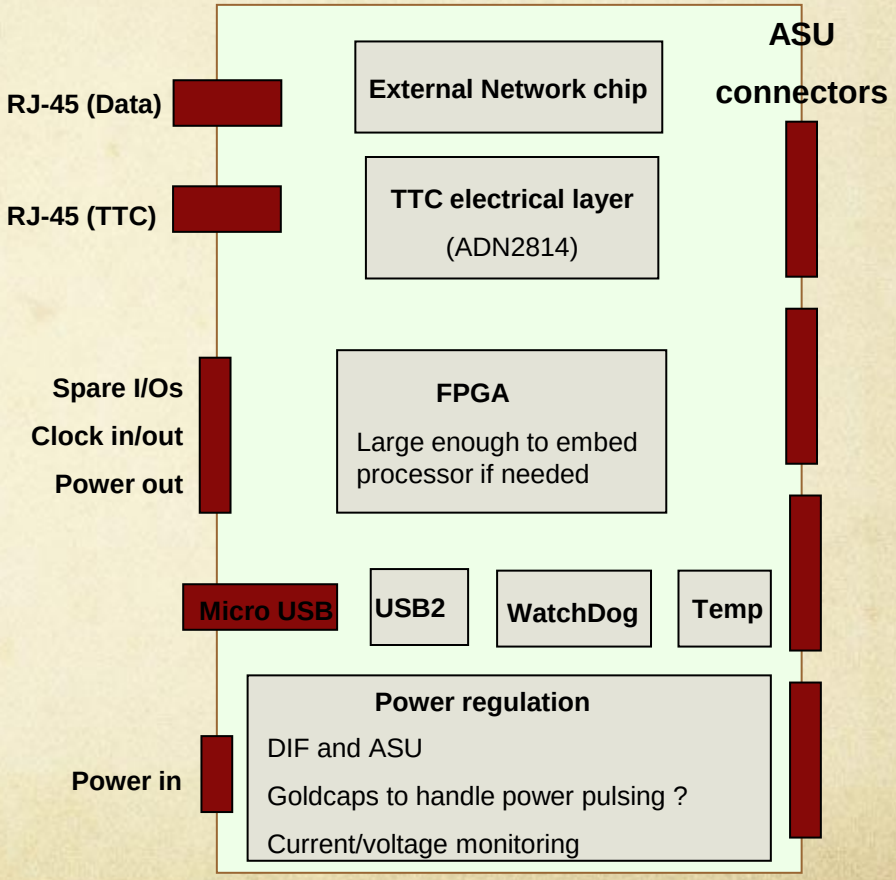






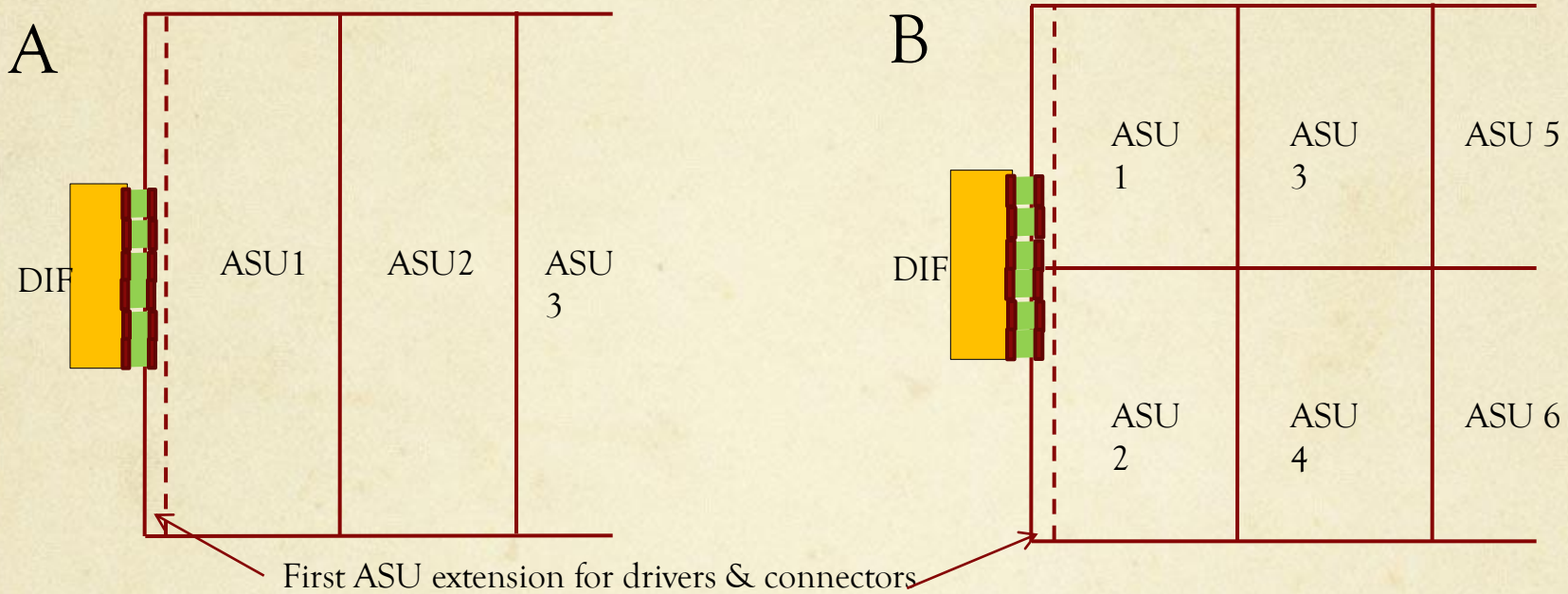
New SDHCAL DIF main features

- Only one DIF per plane. For the maximum length plane (1x3m) the DIF will handle 432 HR3 chips
- Slow control through the new HR3 I2C bus
- Data transmission to DAQ by Ethernet using commercial switches for concentration
- Clock and synchronization by TTC
- USB 2.0 for debugging
- Synergy with R&D on fast links R&D of LHC(GBT)



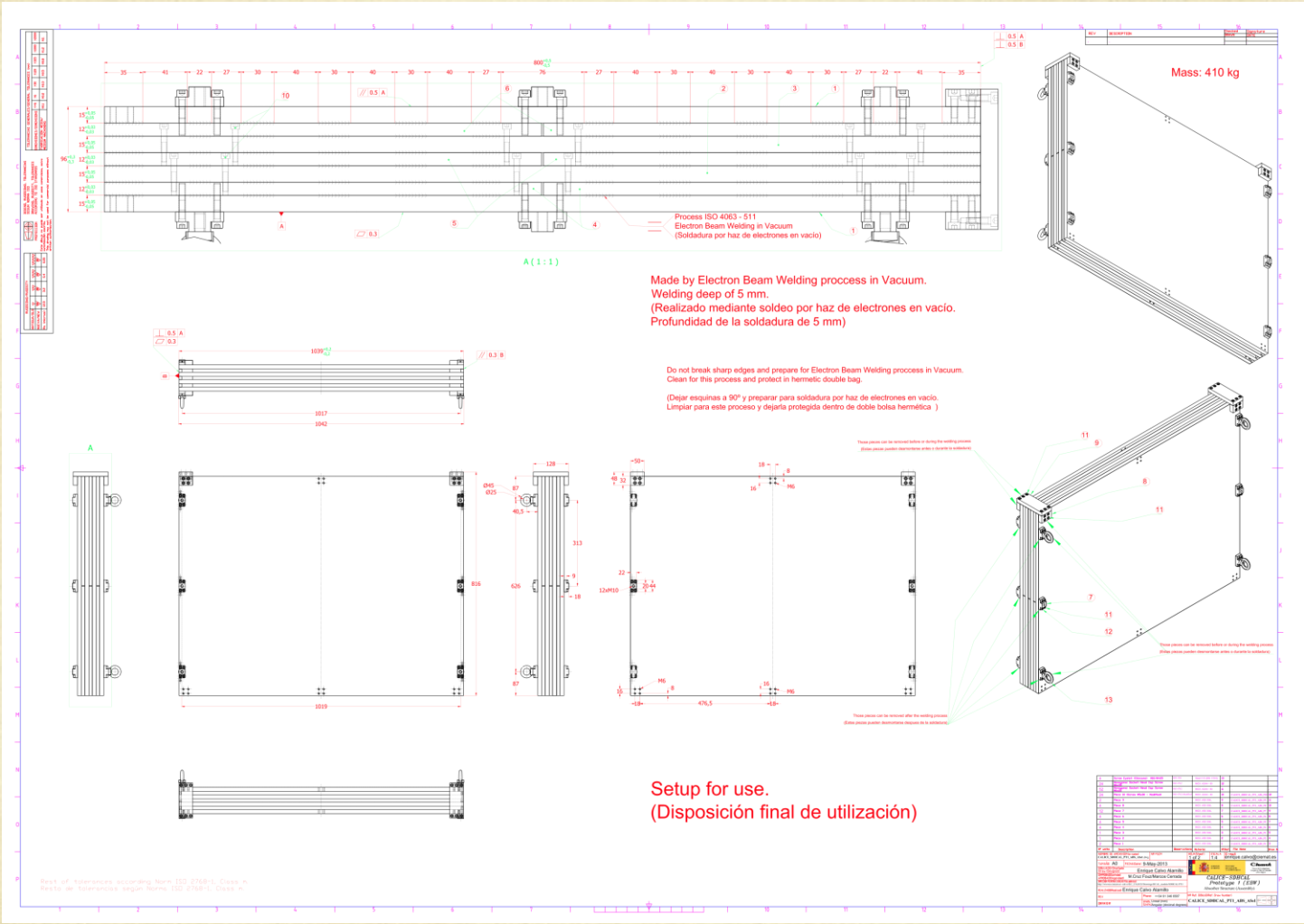
New ASU layout options

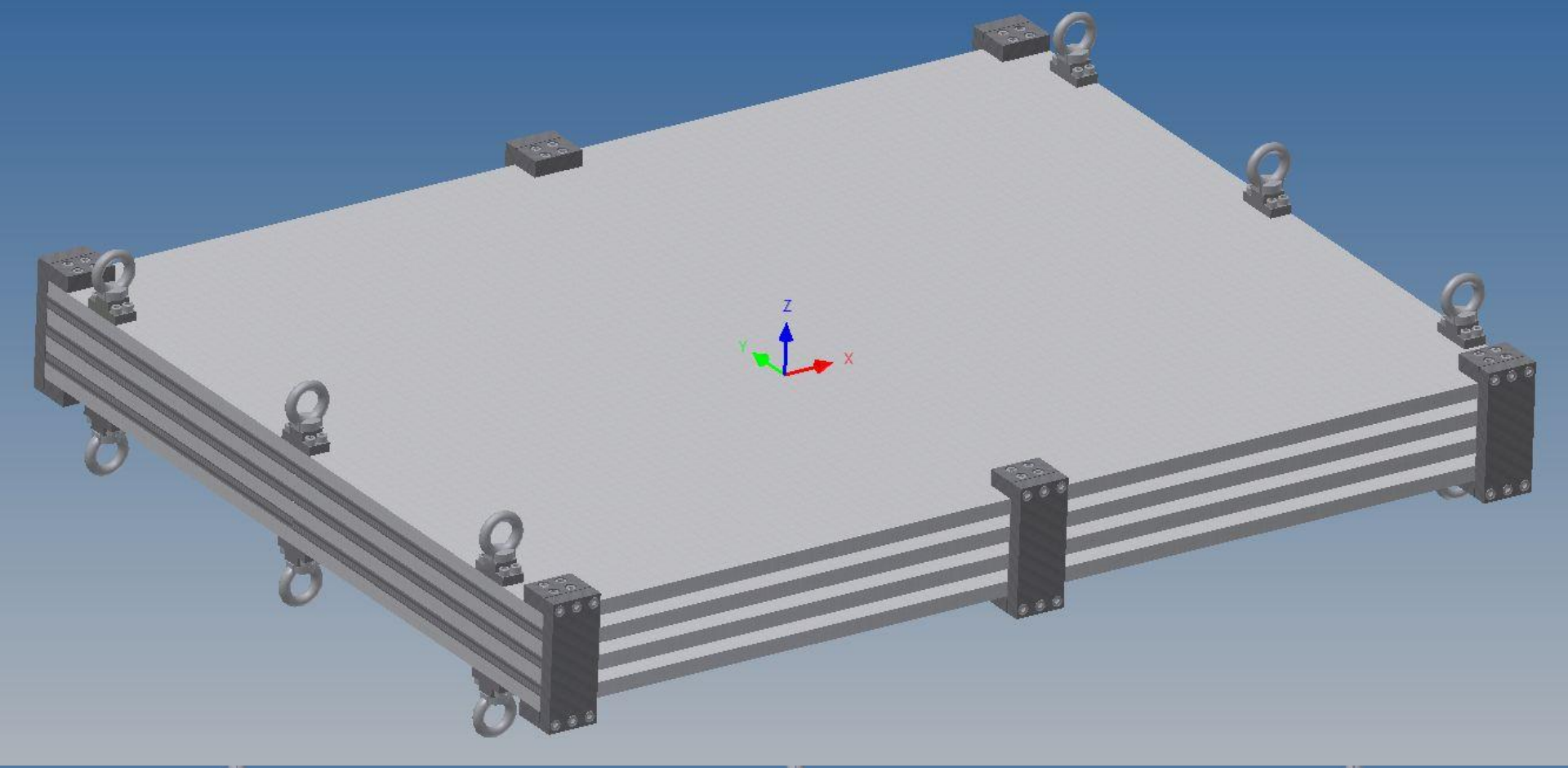
As there will be only one DIF per plane, the distribution of the ASU boards in the plane will be rearranged to reduce the number of conections between the DIF and the plane

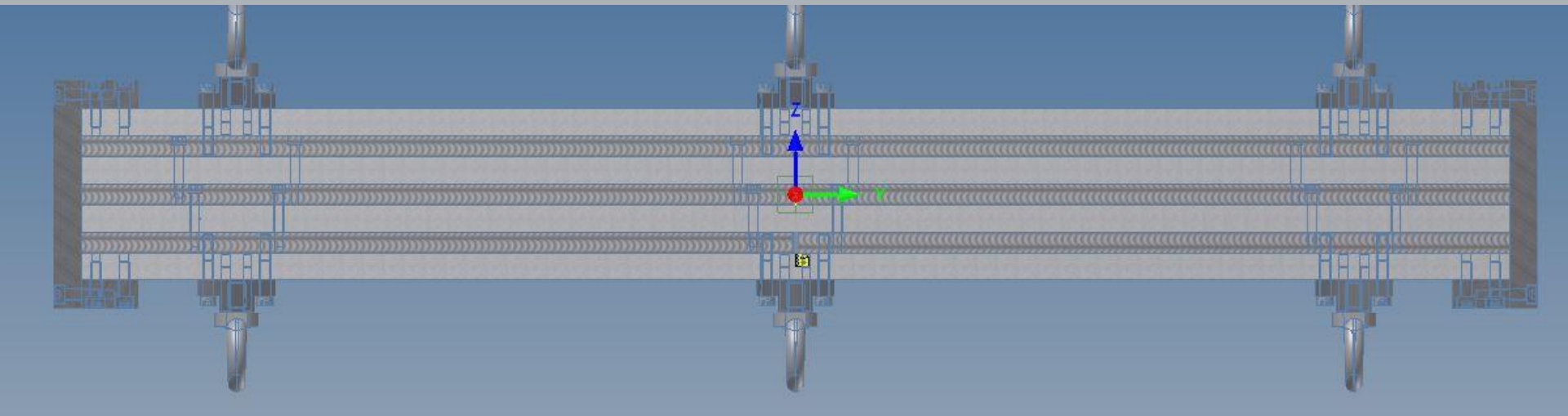


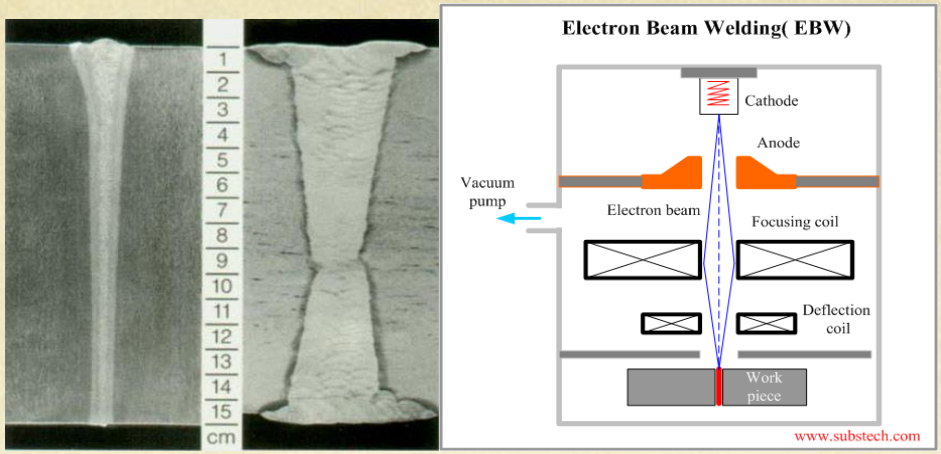
- In option B the common signals for the plane have to be sent twice (one per slab) while in option B they can be sent only once
- But, option A looks more risky from the point of view of the feasibility of the 1m long ASU boards.

- In both options the ASUs connected to the DIF will be a bit longer to host the connectors and the buffers for driving the long lines. This extension provides more freedom for the connectors selection and moves the drivers heat disipation to the ventilation area

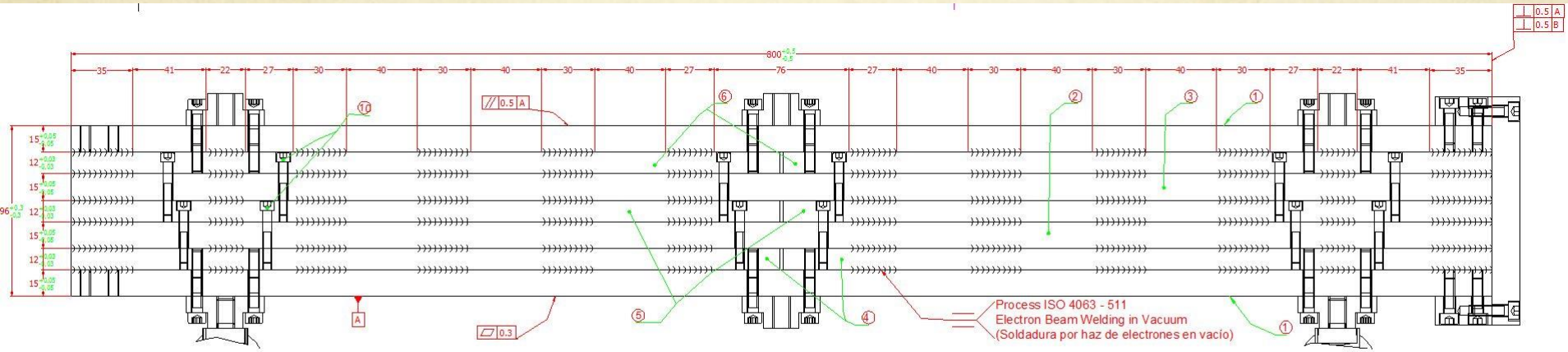

Mass: 410 kg
Process ISO 4063 - 511
Electron Beam Welding in Vacuum
(Soldadura por haz de electrones en vacío)
A (1 : 1)
Made by Electron Beam Welding proccess in Vacuum.
Welding deep of 5 mm.
(Realizado mediante soldeo por haz de electrones en vacío.
Profundidad de la soldadura de 5 mm)
Do not break sharp edges and prepare for Electron Beam Welding proccess in Vacuum.
Clean for this process and protect in hermetic double bag.
(Dejar esquinas a 90º y preparar para soldadura por haz de electrones en vacío.
Limpiar para este proceso y dejarla protegida dentro de doble bolsa hermética)
Setup for use.
(Disposición final de utilización)
Rest of tolerances according Norm ISO 2768-1, Class m.
Resto de tolerancias según Norma ISO 2768-1, Clase m.


Z
Y
X


Z
Y

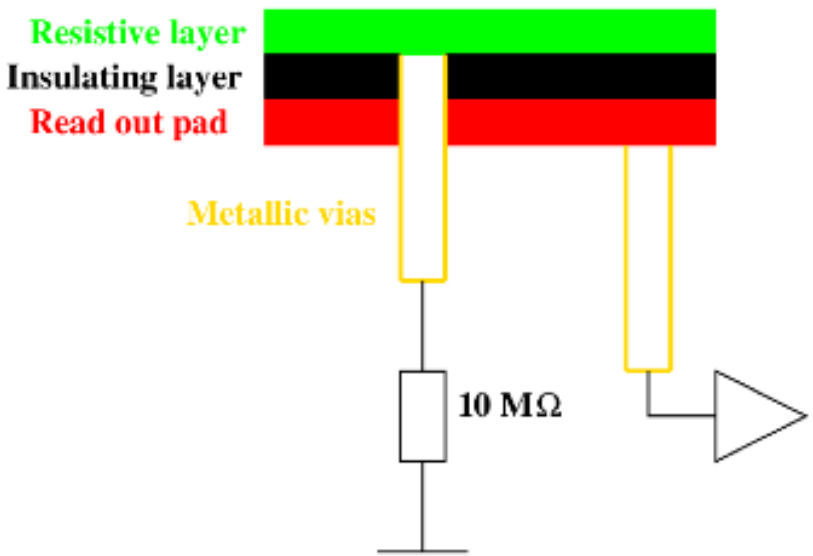


Welding techniques



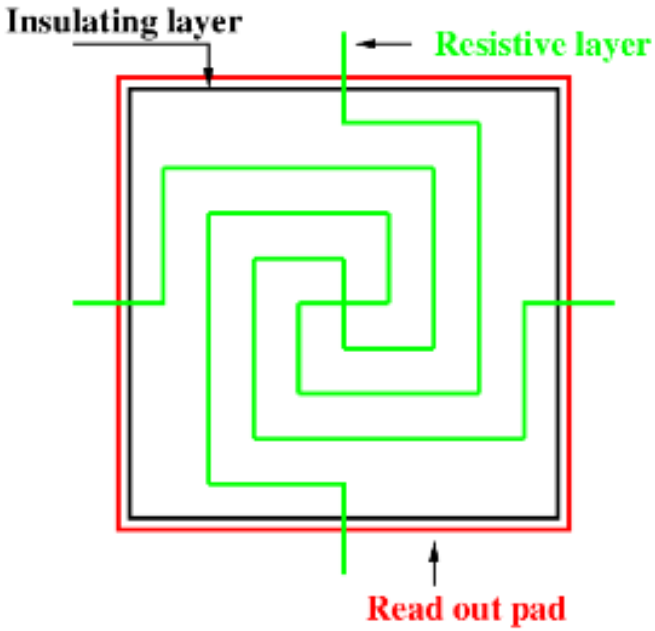
Made by Electron Beam Welding proccess in Vacuum.
Welding deep of 5 mm.

SDHCAL-MICROMEGA
plans



Design 1

Resistive vias configuration (independent pad)



Design 2

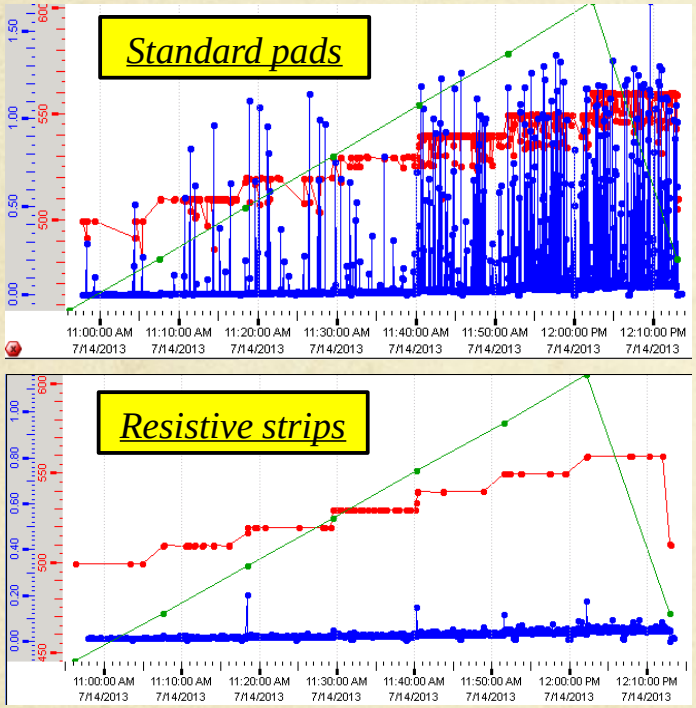
Resistive lines configuration (connected pads)

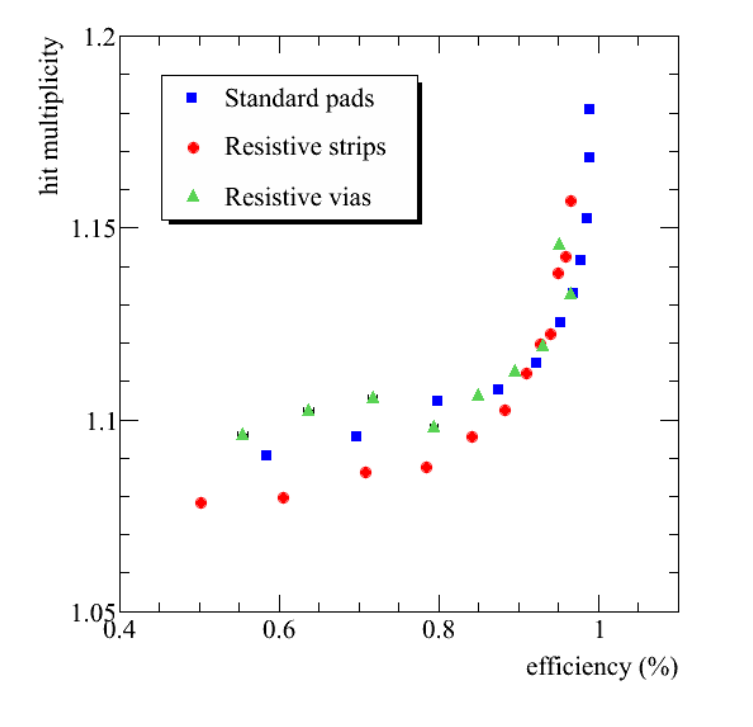
Resistive Micromegas (1/2)

Improvements of existing large prototypes

Avoid discharges (measured probability = 10^{-6} / showering pion / m^2) with resistive layers

Simplify PCB by removing current-limiting diodes

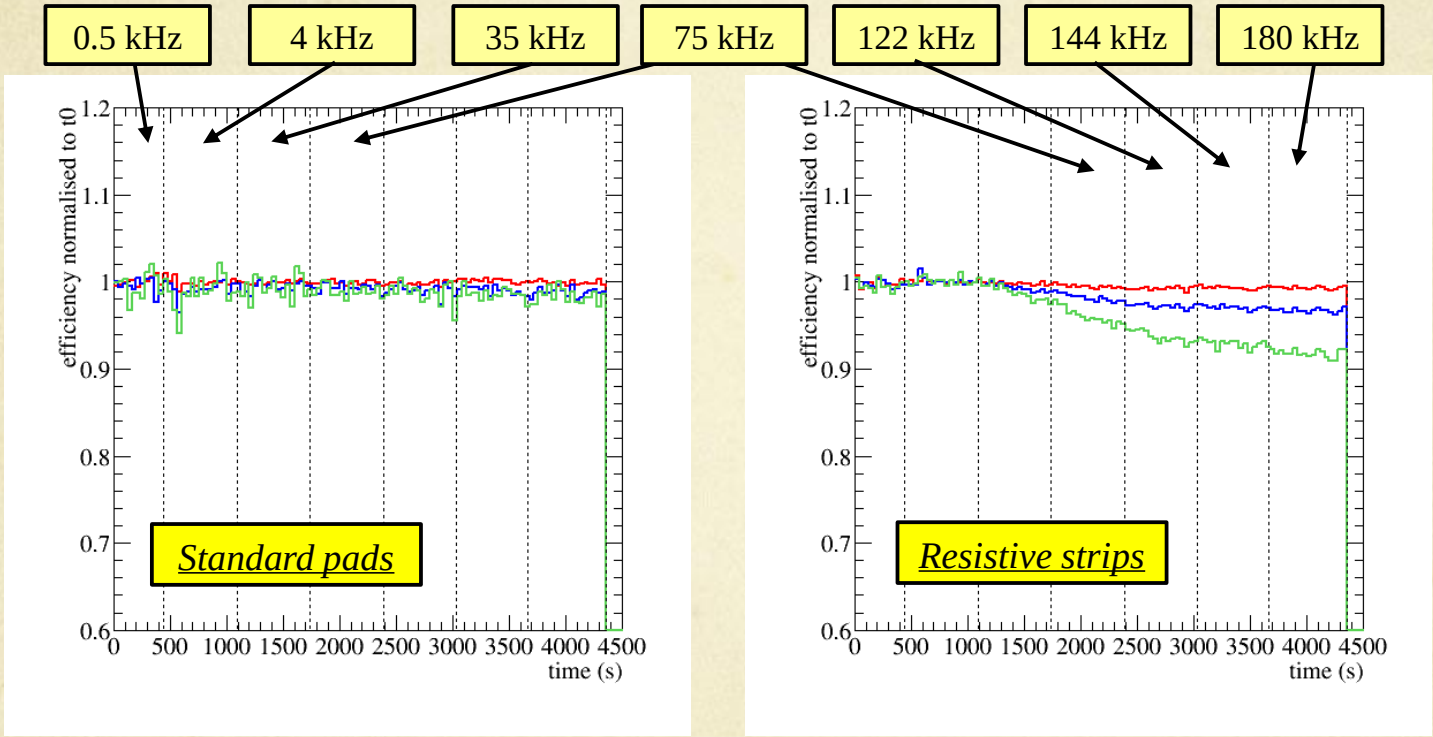




Challenge 1: do not change efficiency/multiplicity → specific R-strip patterns

Resistive Micromegas (2/2)

Challenge 2: Maintain rate capability as high as possible



Rate scan

5 GeV e^- beam

Collim. 2x2 cm^2

Thr0 = 0.5 MIP
Thr1 = 5 MIP
Thr2 = 15 MIP

Rate effects in resistive prototypes seen but remain small

Analysis on-going to understand & model the underlying mechanisms

Conclusion

Gaseous hadronic calorimeters have started last round

Rate capability of RPC are addressed (DHCAL, SDHCAL)

Very large detectors are being conceived and will be shortly build (SDHCAL-RPC)

Third generation electronics and new electronics readout are being developed.