SDHCAL and ILD/CEPC activities in Shanghai

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On behalf of RPCLab

INPAC, Shanghai Jiao Tong University

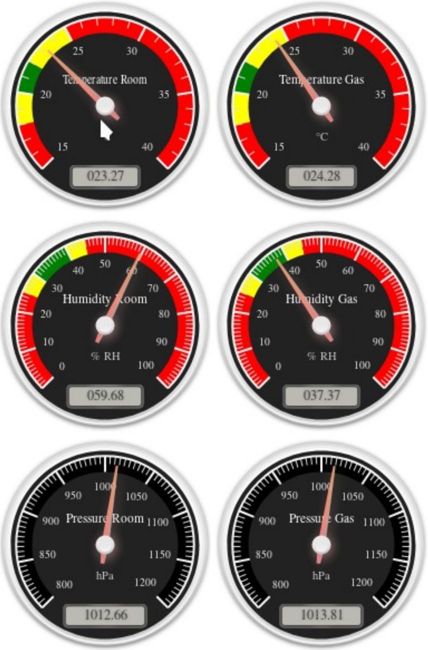
Outline

- New laboratory building
- Glass RPC construction
- CEPC HCalCooling SystemSimulation
- Gas Flow simulation
- SDHCAL TB analysis
- Hadron energy reconstruction using MLP and BDTG

SJTU RPClab

- We move some months ago to a new room.
- Temperature, humidity and presure are monitored and store in database (room and gas).

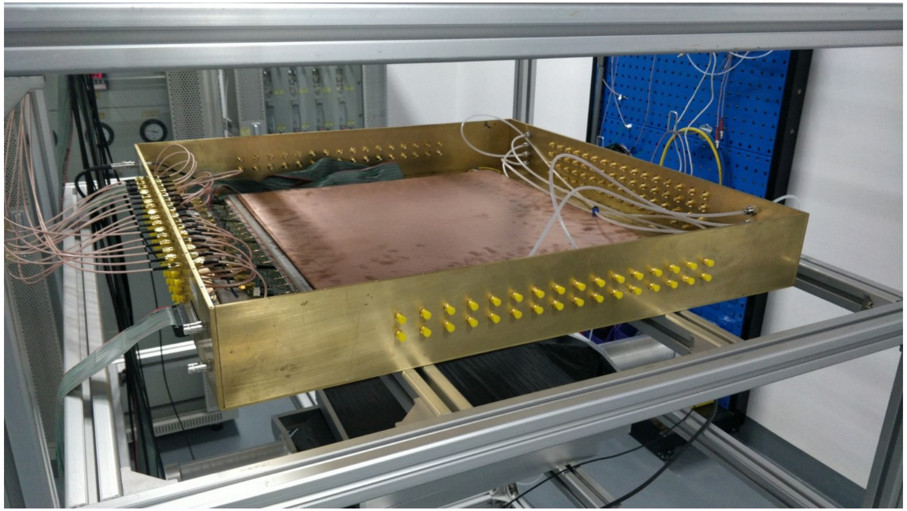


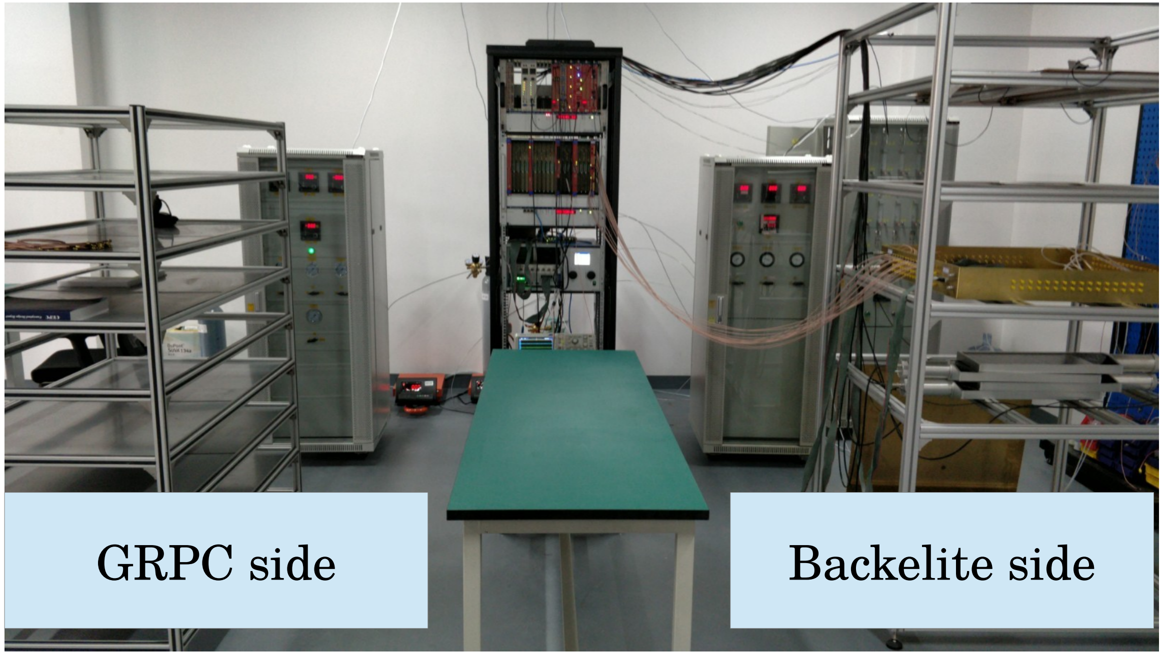


SJTU RPClab

Two different gas mixer :

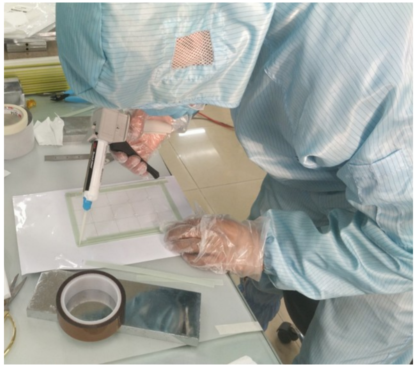
- Allow to test different ratio at the same time
- Glass RPC and Backelite in parallel (with humidity)





Glass RPC construction

- 2 months ago we went to USTC to learn how to build “ATLAS-like” (G)RPC chambers.



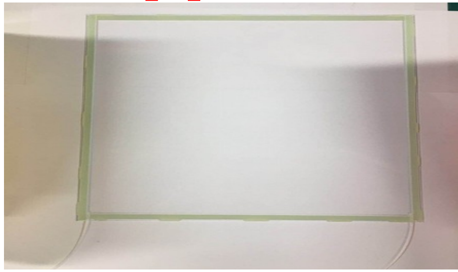
Glass RPC construction

For our first production we decide to build (20*20cm2) SDHCAL-like GRPC :

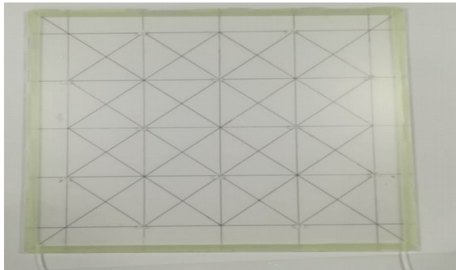
- We had the materials
- The design is simpler
- Test our skills
- Write a procedure student can follow
- Check the problems we have during the process and improve it.

1.Position the walls and pipes

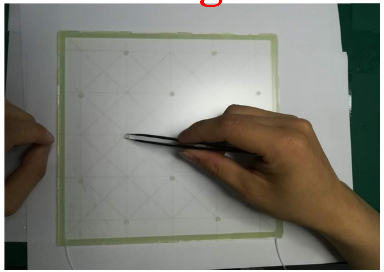
2.Glue walls and pipes.



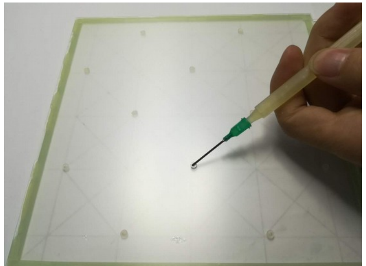
3.Draw the spacer position sketch



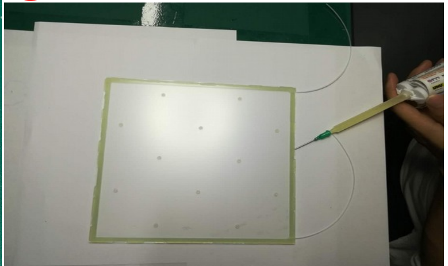
4.Put the spacers on the glass



5.Glue the spacers



6. Glue the second glass to the walls

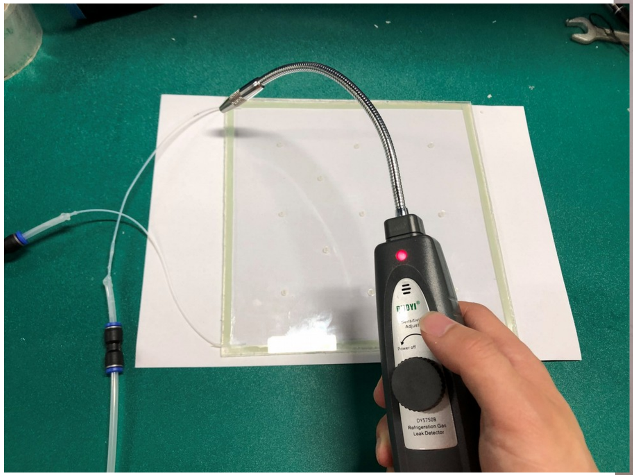


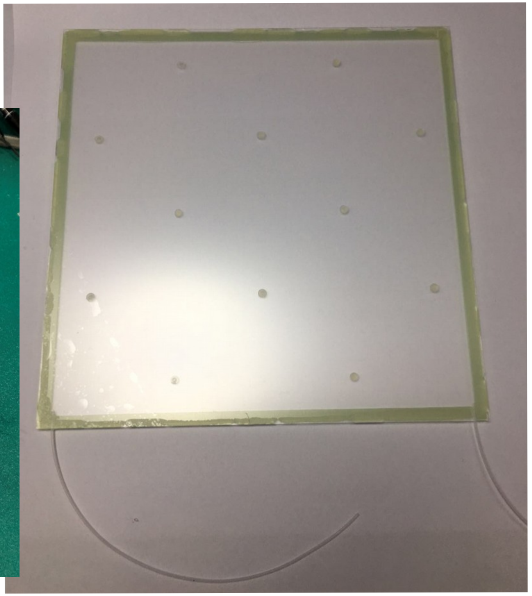
7. Gas tight with silicon and test leaks

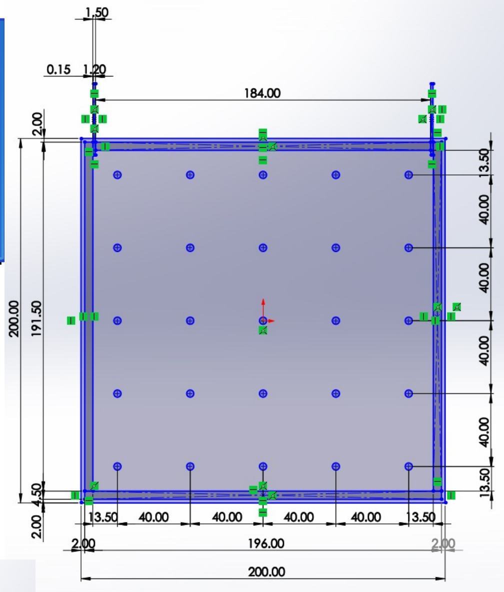
Glass RPC construction

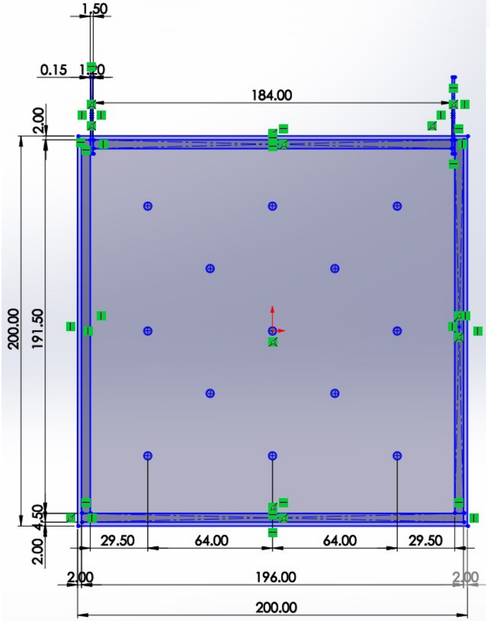
Up to now we made 5 20*20cm2 GRPC.

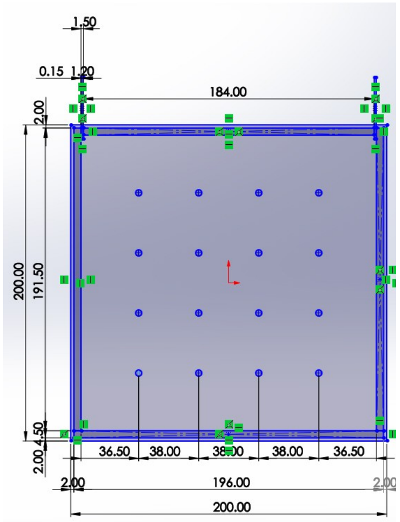
- Tested for gas leak with sniffer
- We don't have the tools and room for the graphite coating











Glass RPC construction

We would like to create a tool and procedure to test them :

- Volumic resistivity of electrodes
- Surface Resistivity of the coating

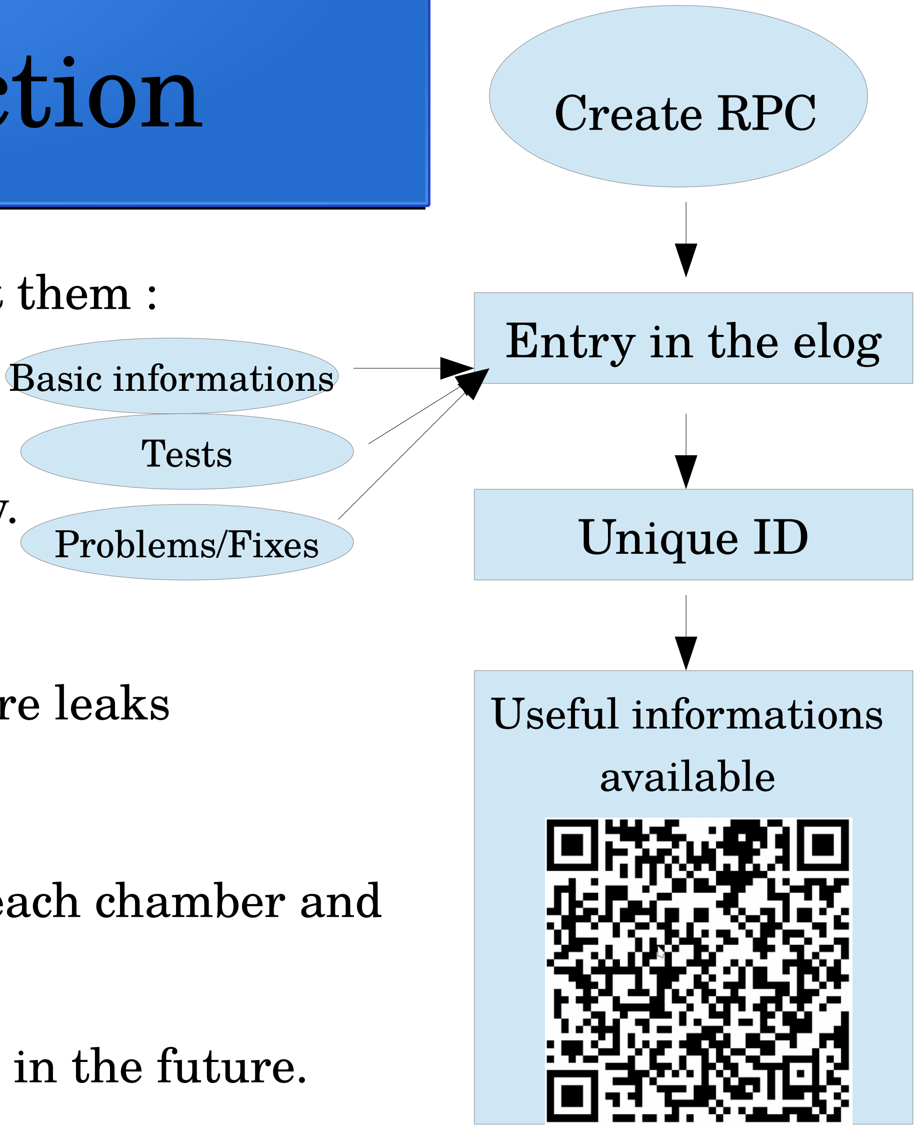
→ Electrometer, probes are bought or under review.

- Gas leak test

→ We are trying to design a leakage box to measure leaks

- I vs U test …
- We are developping logbook to conserve history of each chamber and tag them

→ Detect and point conception, material problems in the future.



Glass RPC construction

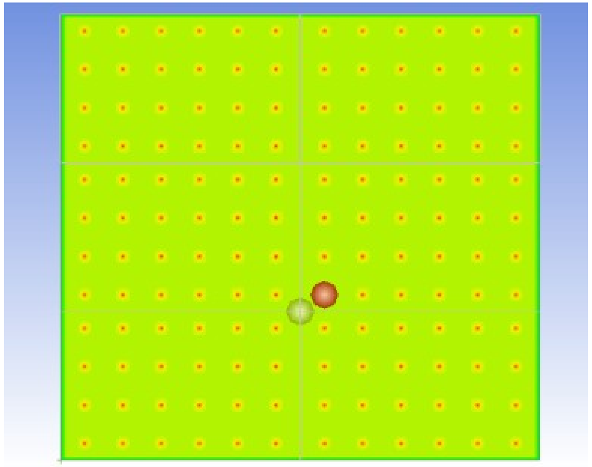
Future :

- Build ATLAS-like Chambers
- Build bigger chambers 35*50cm2 → CEPC cooling simulation
- Perform resistivity measurement maps.
- Improve the building process
- Try spacer configuration and modifications based on simulation results

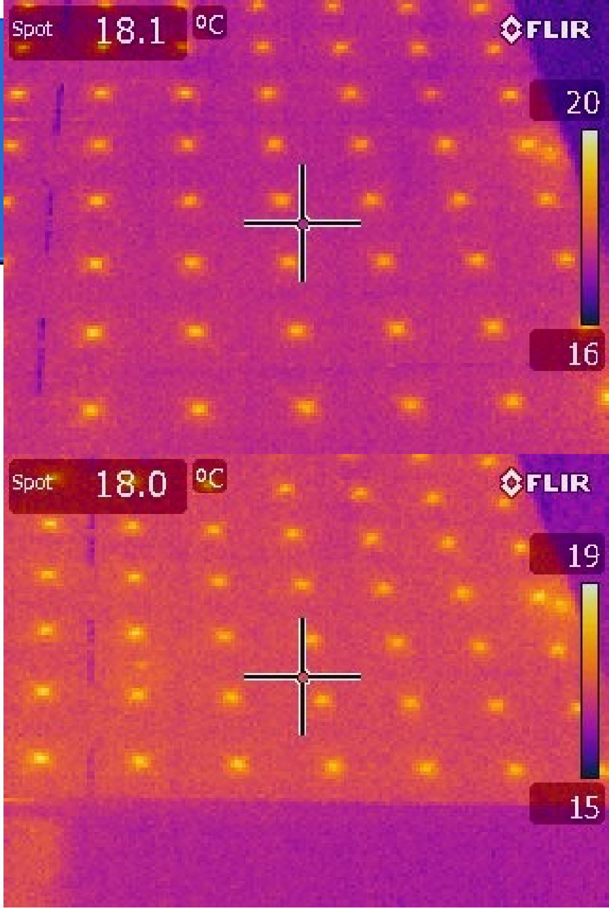
CEPC Hcal Cooling System Simulation

Simulation vs experiment

No. of PCBs	Highest T (°C)	T on monitored PCB point (°C)
1	18.2652	15.9839
2	18.6658	16.6922
3	19.1317	17.2382
4	19.7537	17.7879
5	20.1912	18.2427
6	20.6500	18.6863



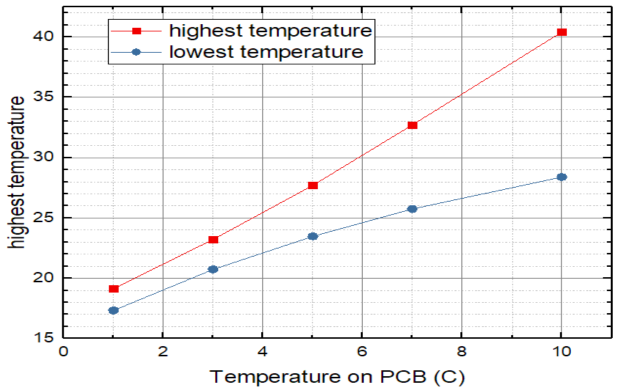
Results (ANSYS Icepak, T_ambient: 15°C)



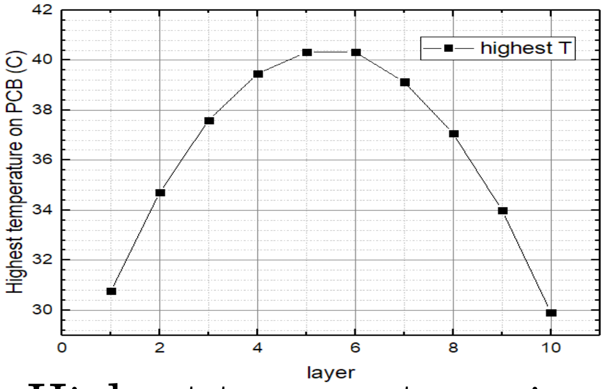
6 PCB results at IPNL

Little discrepency between simulation and real data.

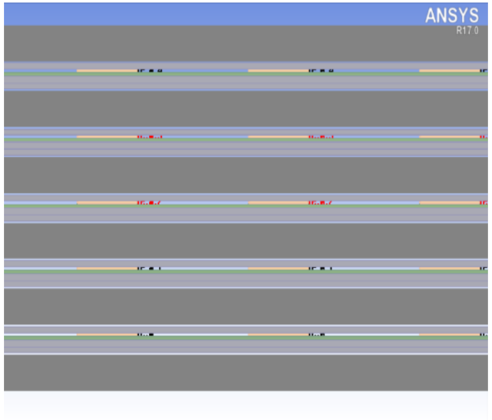
Results without cooling



Temperature vs multi-layer model,Tambient: 15℃

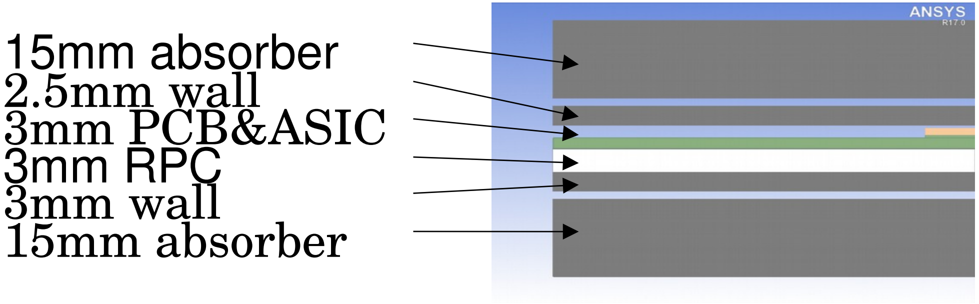


Highest temperatures in a 10-layer model, Tambient: 15℃



A 5-layer simulation model

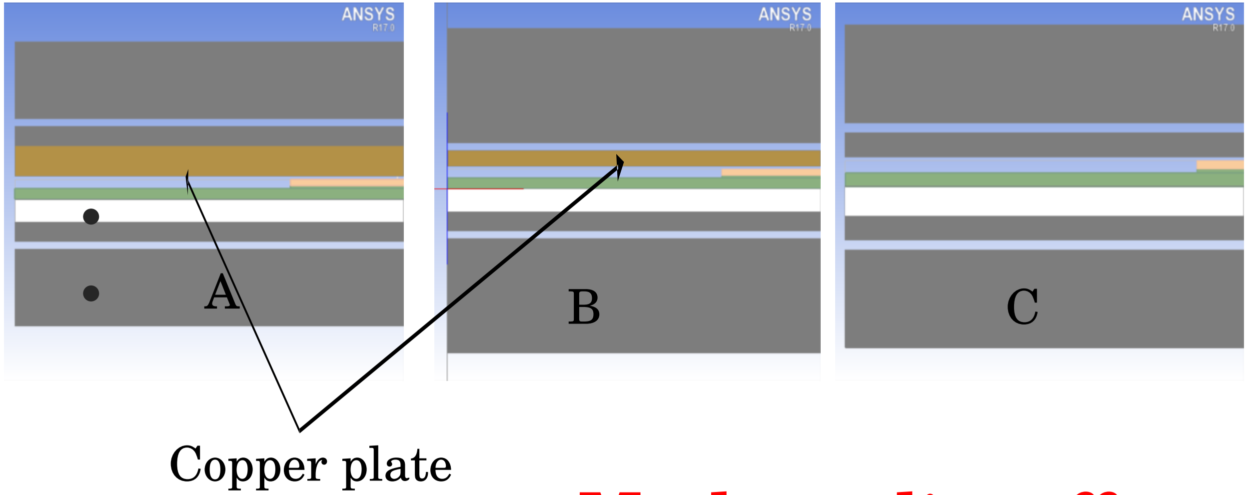
An active cooling system is needed



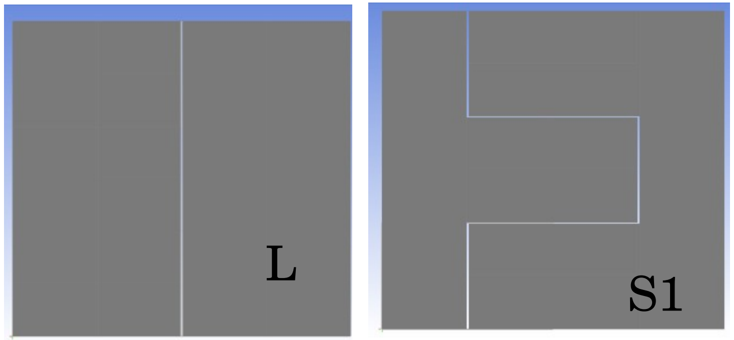
Designs study

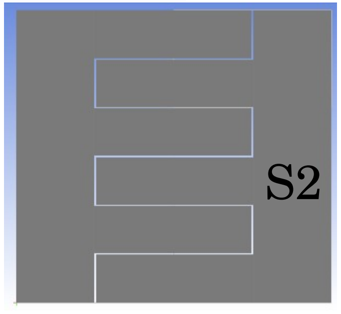
Three design of plates :

A : 4mm copper plate inserted into the cassette
B : The copper plate is used as cassette wall
C : Absorber as cooling plate



Three design of pipes :
L : Linear pipe
S1 : S shaped 1
S2 : S shaped 2

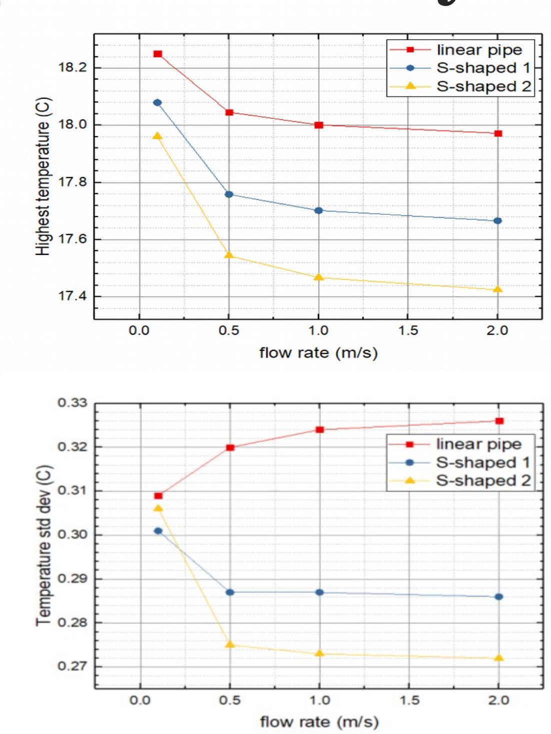




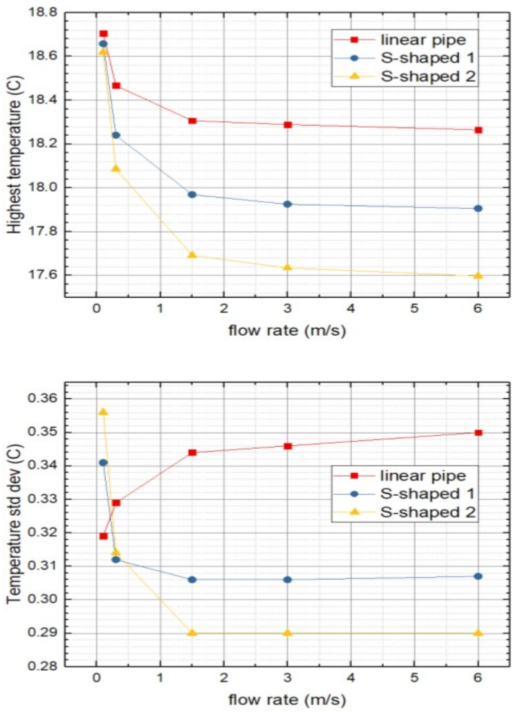
Mesh quality affects a lot

Results with cooling

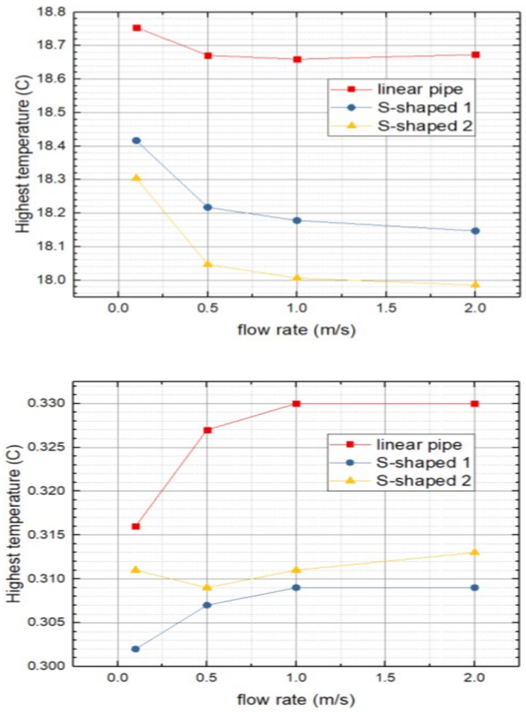
Efficiency: Plan A > B > C; S2 > S1 > linear



Plan A



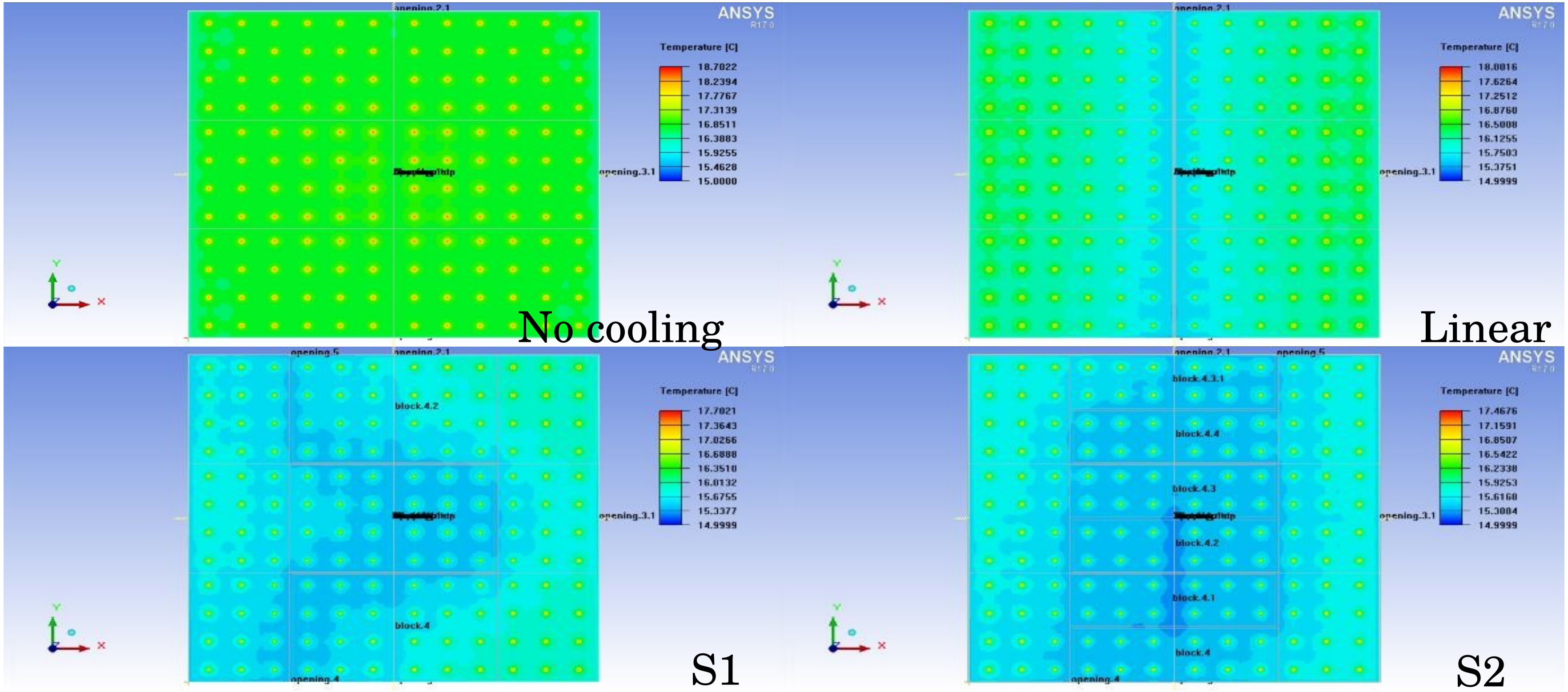
Plan B



Plan C

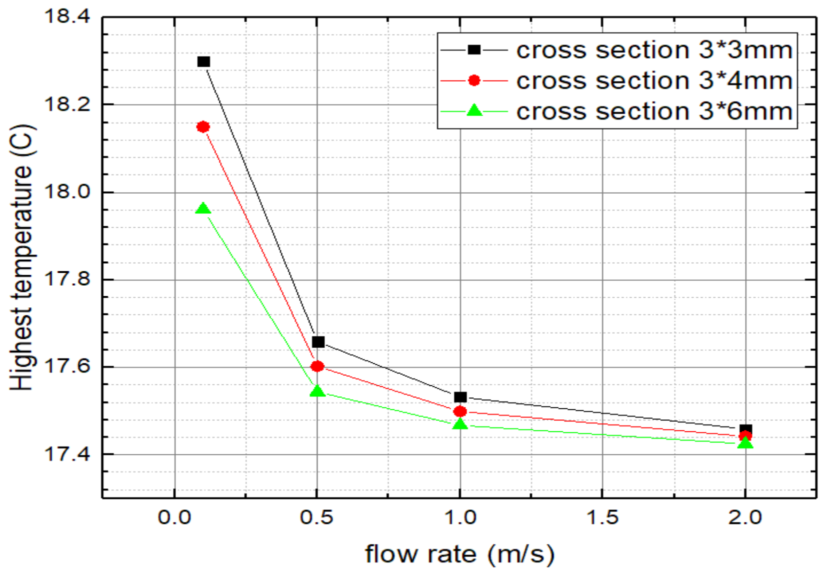
Results with cooling

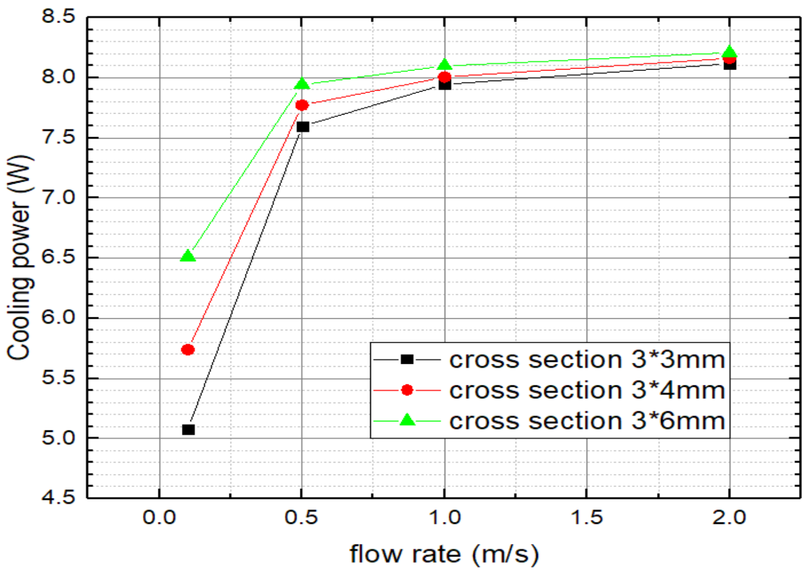
Results of Plan A, 2m/s



Pipe cross section

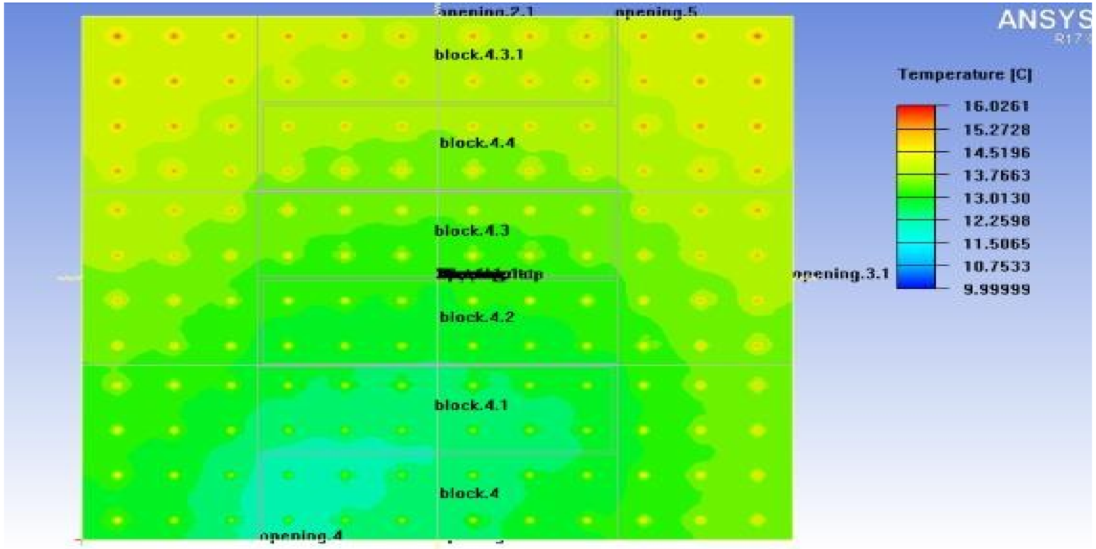
Cross section: 3*3, 3*4, 3*6mm ^{2}



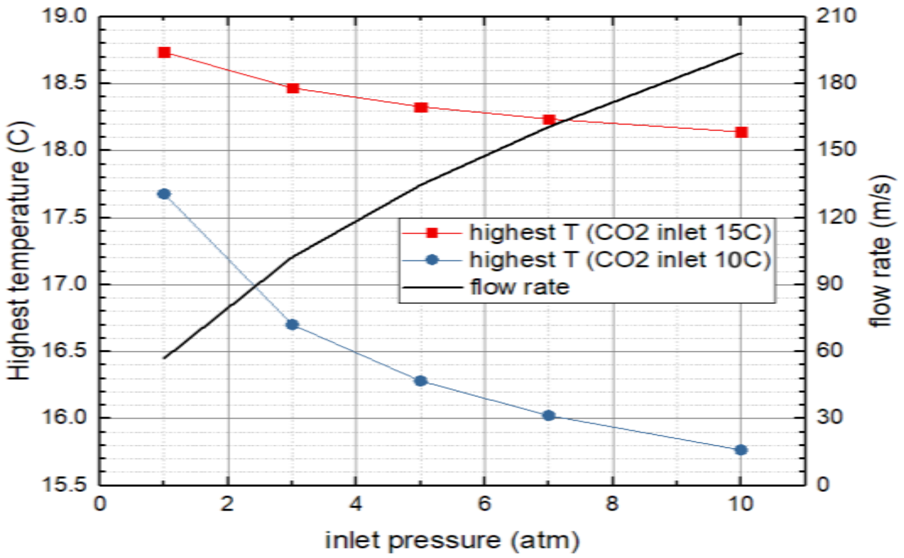


More pipes or bigger pipes ?

CO2 cooling



10 atm, 10℃ CO2, plate attached to the ASICs, S-shapped 4mm piper, Tambient : 15℃



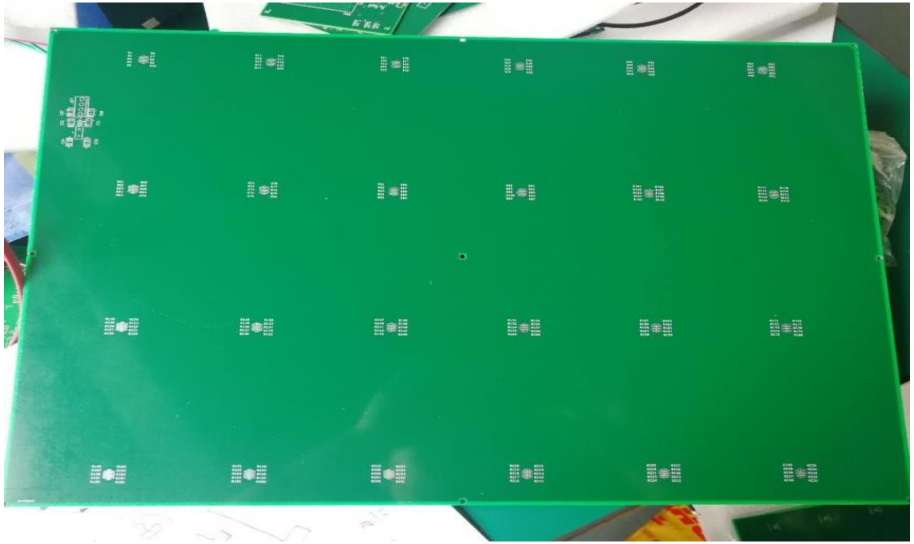
1 layer, CO2, Tambient 15℃

Gaseous: h~10W/(m2*K)
Supercritical: > 304.1K, 72.8atm, h~1000W/(m2/K)

Prototype

A test in lab is on-going

New computing resource is highly demanded



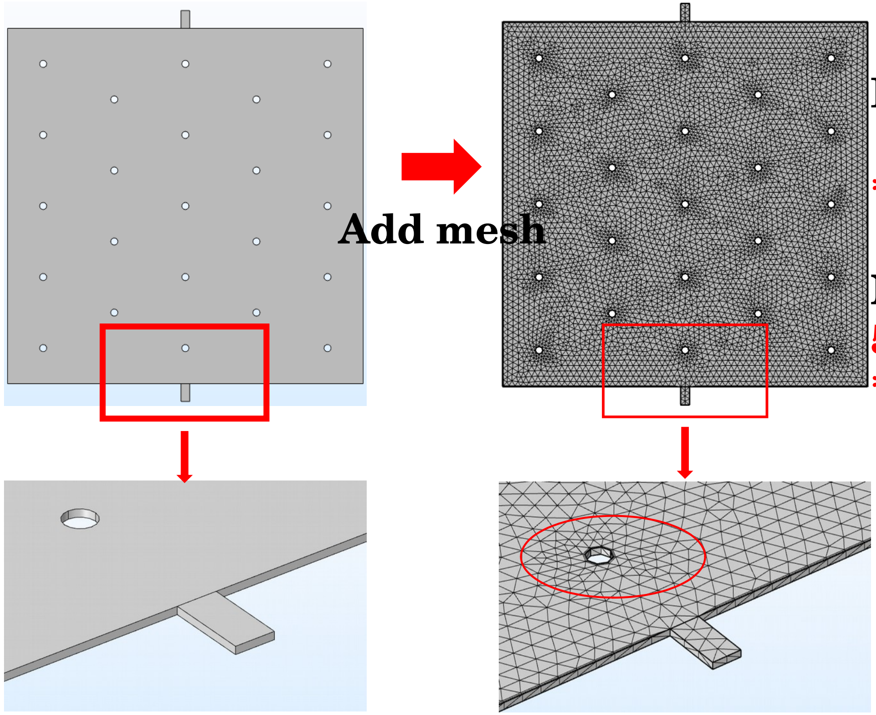
PCBs with resistances to mimic the ASICs

Cooling study Summary

- Temperature increase significantly with more layer.
- Water cooling is a option.
- Gaseous C02 is a other option especially at low temperature and high pressure.
- Complicated design has to been made in order to insert the cooling plate into each layer in a safe and effective way.
- Increase of the cost could be a problem.

Gas Flow Simulation

We would like to find the best position of the spacers and its configuration to optimize the gas flow and avoid to stress chambers.



RPC size:
200mm*200mm *1mm

Nozzles size:
5mm*10mm *1mm

For now we focus on two parameters :

- Variance of velocity:

$$\sigma_u^2 = \frac{\sum_{i=1}^{n} (u_i - \bar{u})^2 V_i}{\sum_{i=1}^{n} V_i}$$

V_i : the volume of the i^{th} grid element

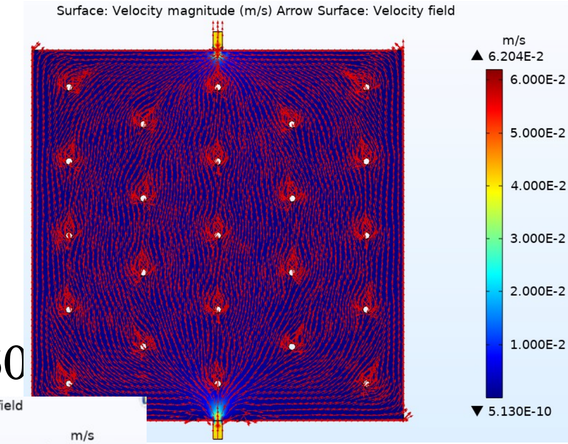
- Vorticity of velocity:

$$w = \nabla \times u \qquad \bar{w} = \frac{\sum_{i=1}^{n} w_i * V_i}{\sum_{i=1}^{n} V_i}$$

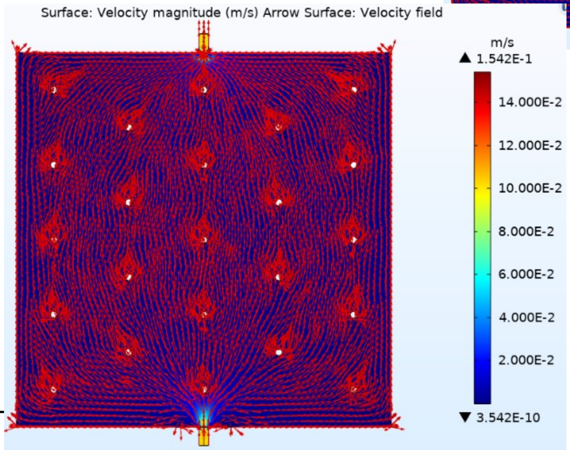
Gas Flow Simulation

		Velocity field	
Initial input Velocity[*m*/*s*]	**Gas flow rate[*sccm*]**	**Average velocity[*m*/*s*]**	**Variance velocity σ_u**
0.04	12	$1.31363*10^{-3}$	$3.20693*10^{-6}$
0.08	24	$2.65461*10^{-3}$	$1.34546*10^{-5}$
0.10	30	$3.33075*10^{-3}$	$2.13663*10^{-5}$
0.12	36	$4.00982*10^{-3}$	$3.11851*10^{-5}$
0.16	48	$5.37800*10^{-3}$	$5.69037*10^{-5}$

0.04m/s velocity(60X)



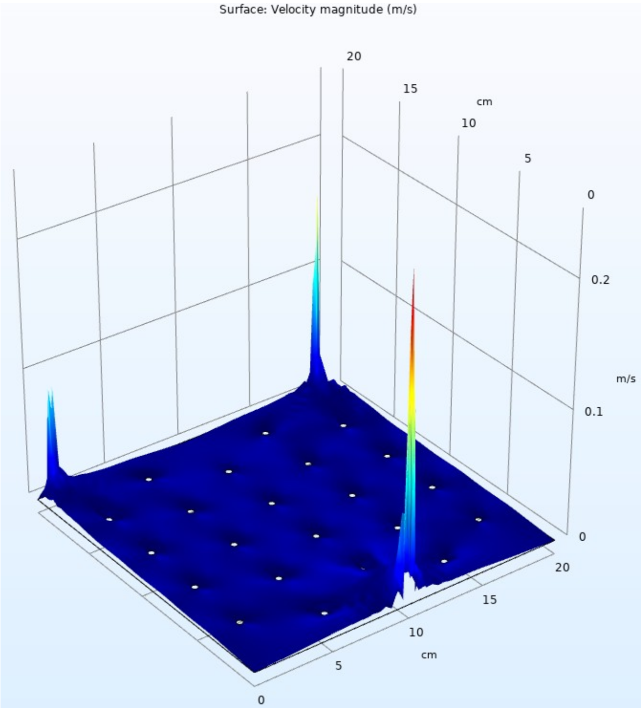
0.1m/s velocity (X60



Gas Flow Simulation

Vorticity magnitude

Initial input Velocity[m/s]	Gas flow rate[*sccm*]	Average vorticity[1/s]
0.04	12	0.094015
0.08	24	0.194042
0.10	30	0.245374
0.12	36	0.297475
0.16	48	0.404437



Distribution of vorticity for u=0.1mps
3D view

Simulation

We test different configurations :

- Find the best space configurations
- Test 50*50cm2

  Find the best number and configurations of spacers for the gas gap uniformity given the pressure and electric-field constraints.

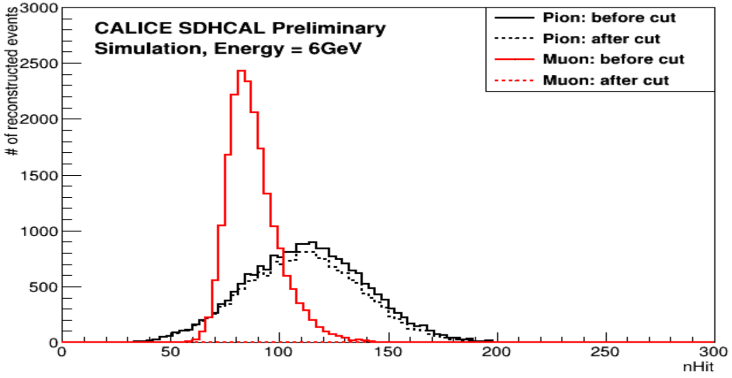
→ Find the best configuration for gas flow and gas gap uniformity .

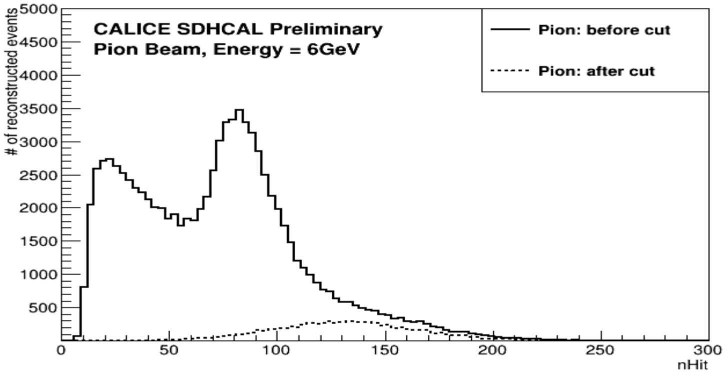
SDHCAL TB analysis

Low energy beam data analysis

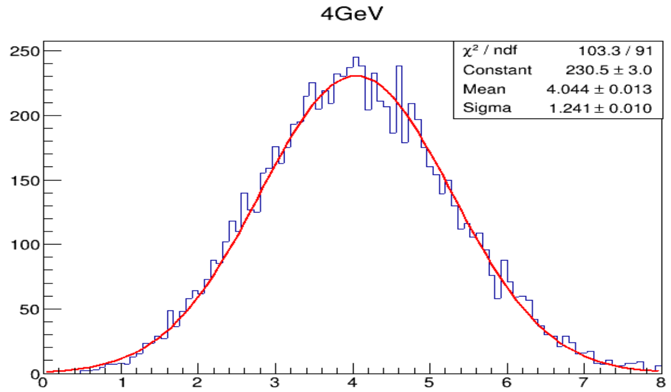
- Data samples were taken at PS, May 2015
- Energy(GeV) : 2,3, 4, 5, 6, 7, 8, 9, 10, 11
- Contamination : muons , (since using electron eliminator in test beam period, the electron contamination is negligible)
- Simulation: FTF_BIC , geant4.9.6

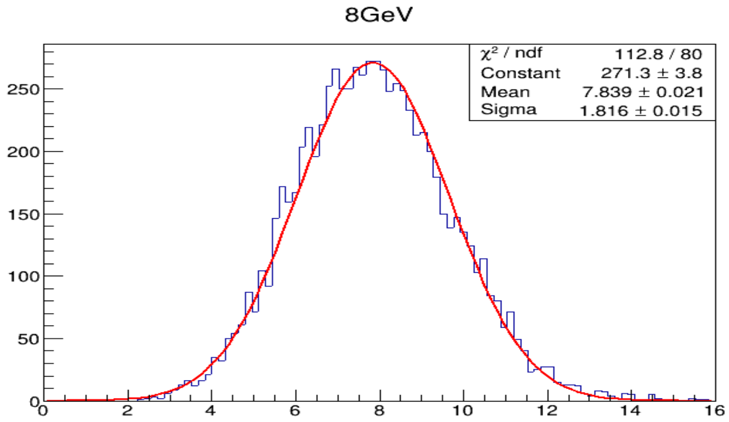
SDHCAL TB analysis





Event Selection

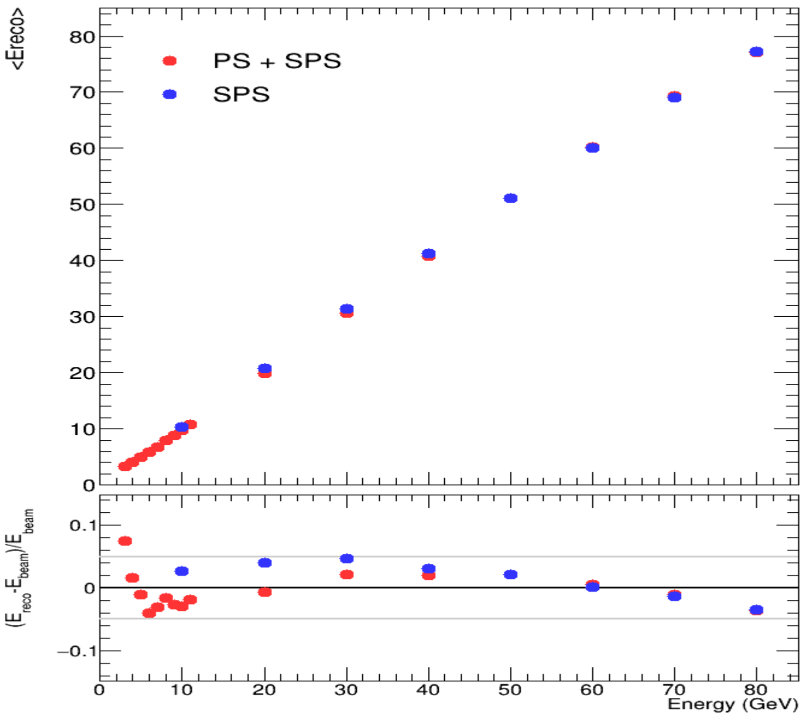


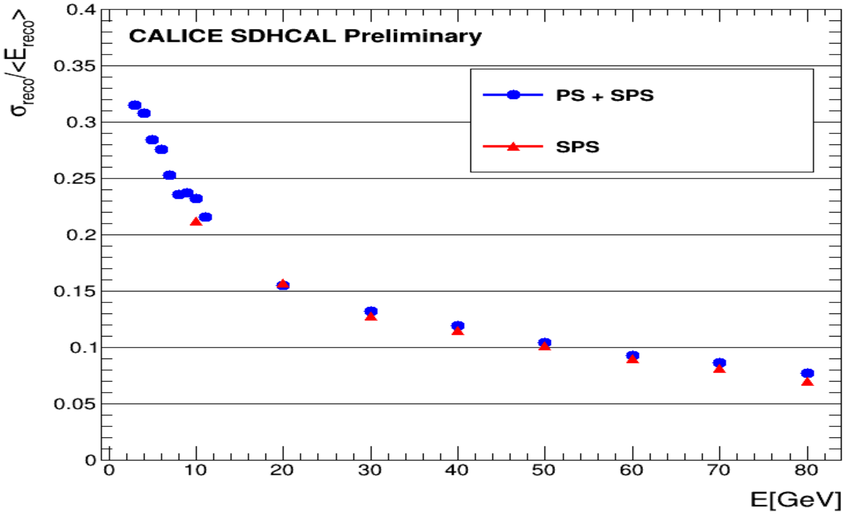


Energy reconstruction

SDHCAL TB analysis

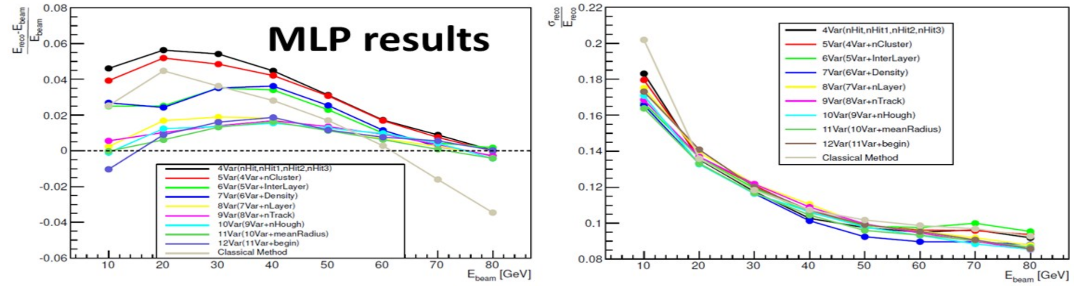
Linearity & resolution



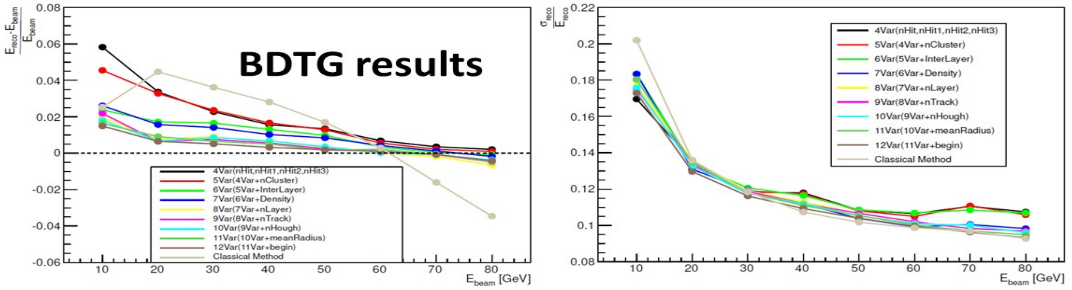


Good linearity and have nice agreement with beam data taken at SPS

Energy reconstruction with BDTG and MLP method with π-



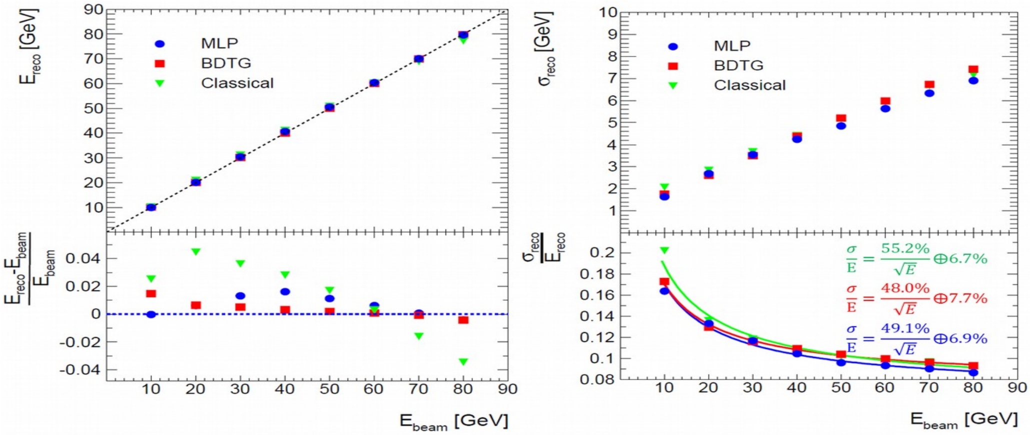
(a) Linearity (b) Resolution



(a) Linearity (b) Resolution

Both linearity ($\Delta E/E_{beam}$) and resolution are improved by machine learning methods.
In the future, we will apply these methods on data to study the energy reconstruction

This study based on CALICE SDHCAL protype
J INSTRUM, 2016, 11(04):P04001.
The input variables are shown in (CALICE-CAN-2019-001), among these variables, InterLayer, nLayer and nCluster make a significant contribution for the linearity performance.



Energy reconstruction with BDTG and MLP method with π-

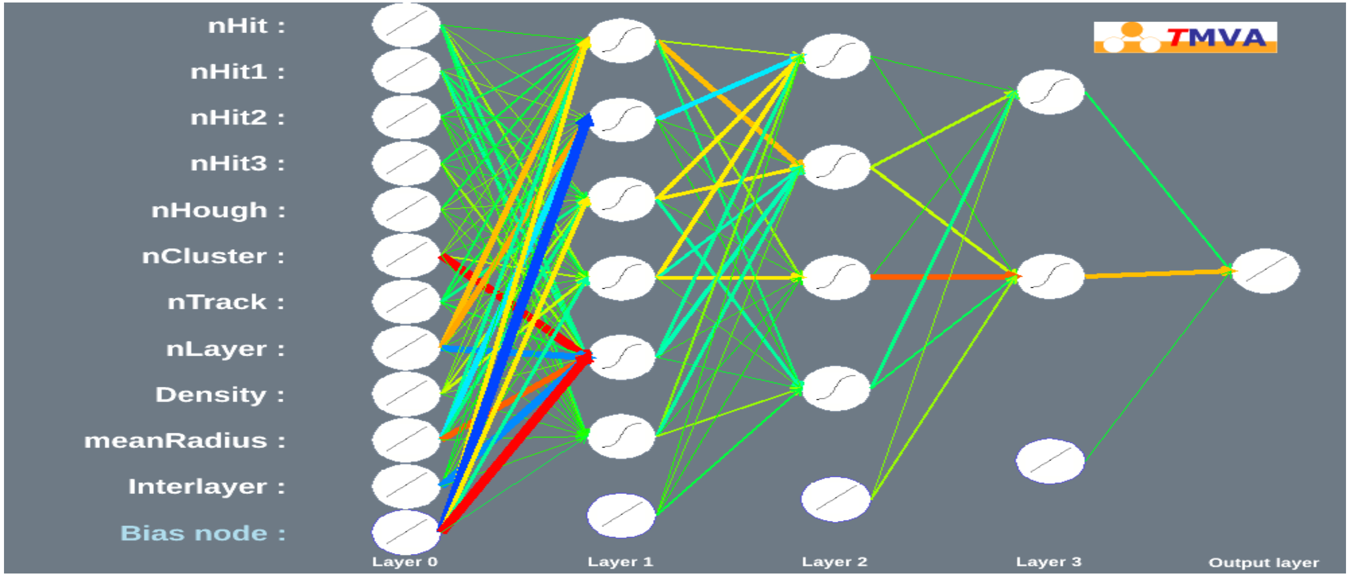
This work use below MC samples, based on CALICE SDHCAL protype.

The training samples have uniform distribution with energy range of 1-110GeV, with 457706 events.

The test samples have 8 energy points (10GeV, 20GeV … 80GeV), and each point has 20000 events.

BDTG: Ntrees: 2000, Learning rate: 0.1, MaxDepth: 11

MLP: 3 hidden layers, with 7, 5, 3 neurons for corresponding hidden layer



Classical method:

$$E_{reco} = \alpha N_1 + \beta N_2 + \gamma N_3$$

$$\alpha = \alpha_1 + \alpha_2 N_{total} + \alpha_3 N^2_{total}$$

$$\beta = \beta_1 + \beta_2 N_{total} + \beta_3 N^2_{total}$$

$$\gamma = \gamma_1 + \gamma_2 N_{total} + \gamma_3 N^2_{total}$$

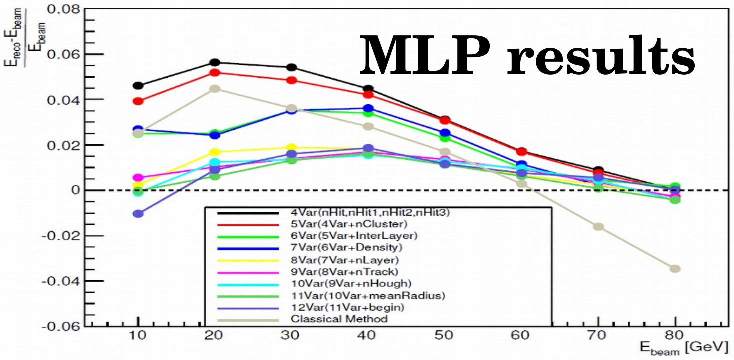
$$N_{total} = N_1 + N_2 + N_3$$

BuridonV, et al. J INSTRUM, 2016,11(04):P04001.

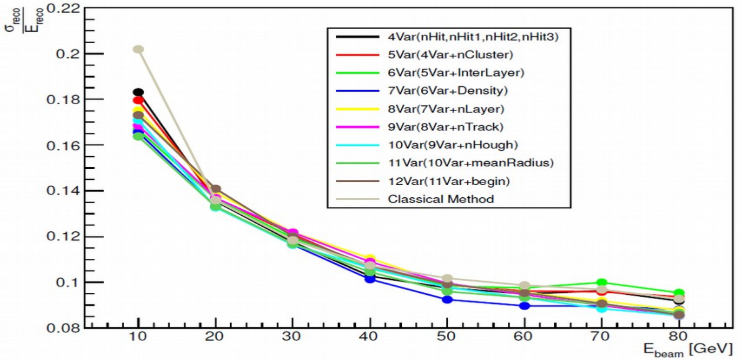
Input variables for BDTG and MLP

Input variables: $nHit_1$, $nHit_2$, $nHit_3$, nhit, nCluster, InteractingLayer, Density, nLayer, nTrack, nHough, meanRadius, begin. CALICE-CAN-2019-001.

InterLayer, nLayer and nCluster help to improve energy reconstruction in low energy region

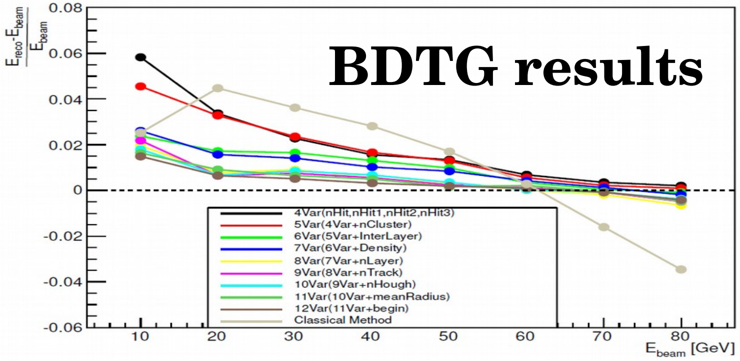


(a) Linearity

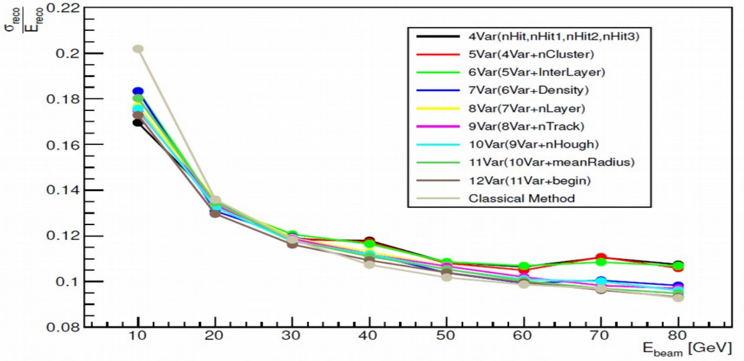


(b) Resolution

InterLayer, nLayer and nCluster make a significant contribution for the linearity performance



(a) Linearity



(b) Resolution

Classical method Vs machine learning methods

Both linearity ($\Delta E/E_{beam}$) and resolution are improved by machine learning methods.
In the future, we will apply these methods on data to study the energy reconstruction