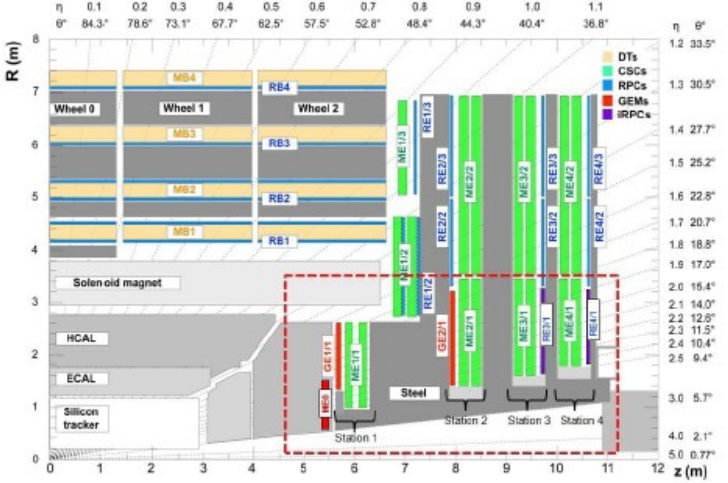
iRPC upgrade project for CMS during HL-LHC program

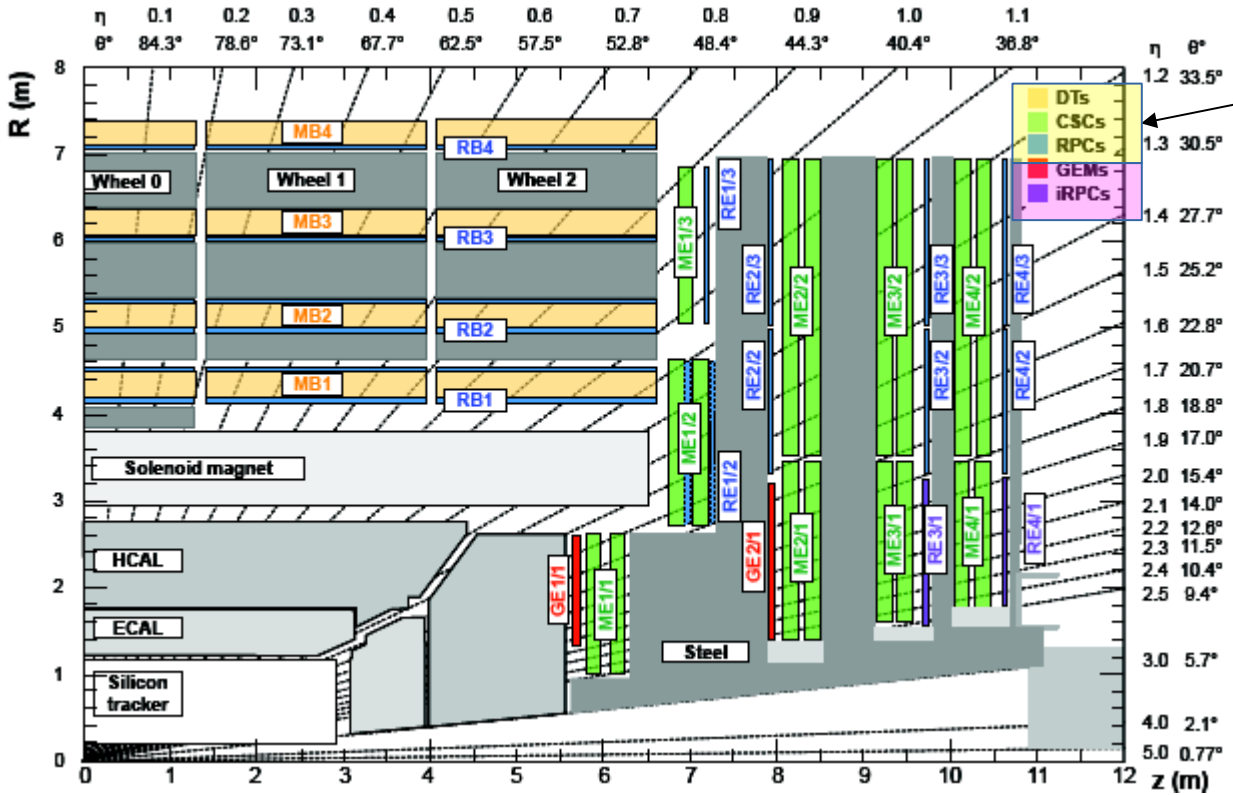


1) CMS muon spectrometer
2) iRPC project
3) Team, activities, timing

M. Gouzevitch (IPNL, France) and T.J Kim (Hanyang University, Korea)

FJPPL/FKPPL workshop in Strasbourg, May 2017

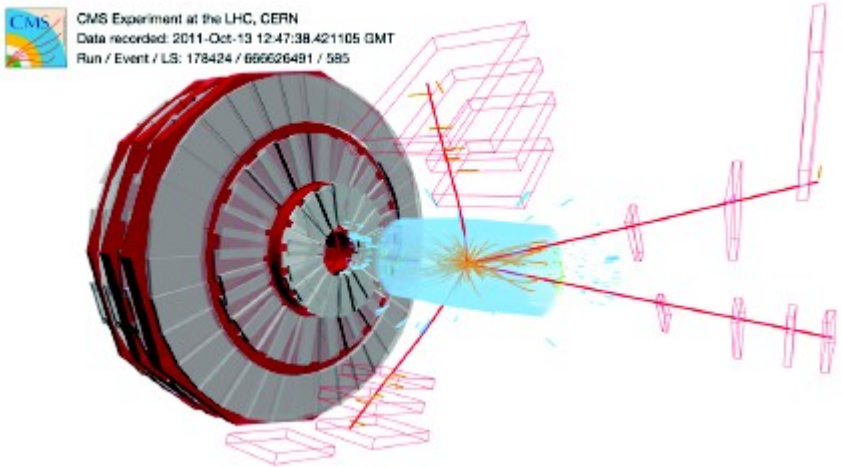
1.1) Actual CMS Muon spectrometer

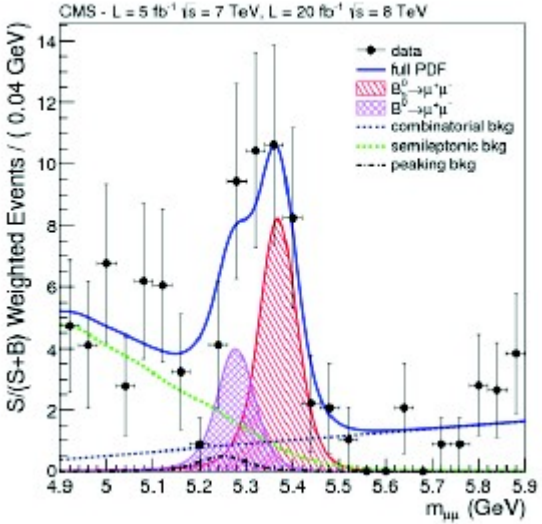


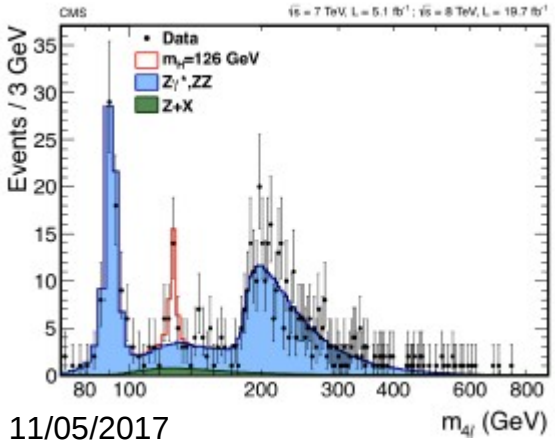
Existing systems

- M of CMS.
- Guarantee the SM “bosonic” part of CMS measurement and search program.
- Provides redundancy of 2 muon systems up to η= 1.6.
- Combines:
  - good space resolution (DT in Barrel, CSC in end caps) +
  - fast response (12.5 ns) RPC (L1 trigger).

1.2) Most famous results







H(125) → 4 μ / 2e2μ.

$B_s \rightarrow \mu\mu$

1.3) HL-LHC program

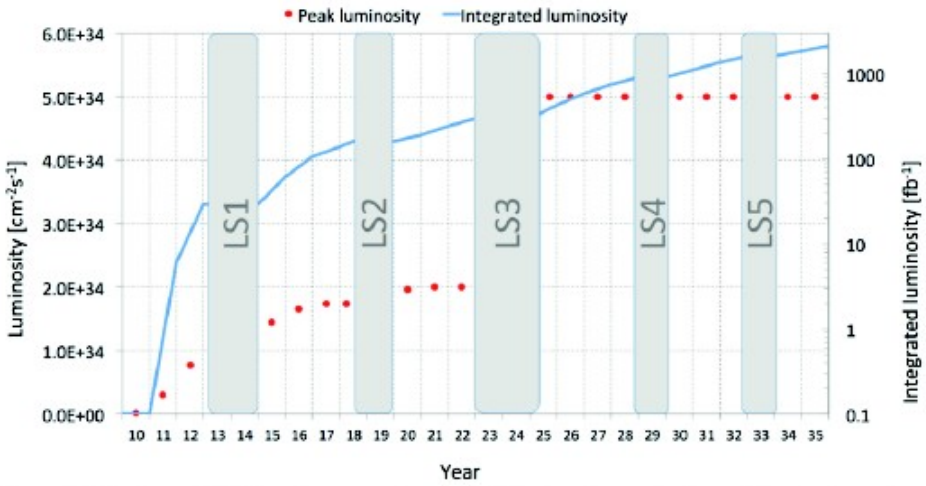
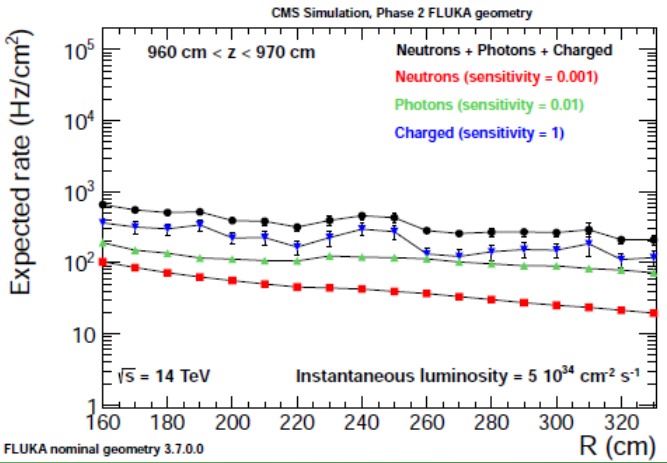


Figure 1.9: Projected LHC performance through 2035, showing preliminary dates for long shut-downs of LHC and projected luminosities.

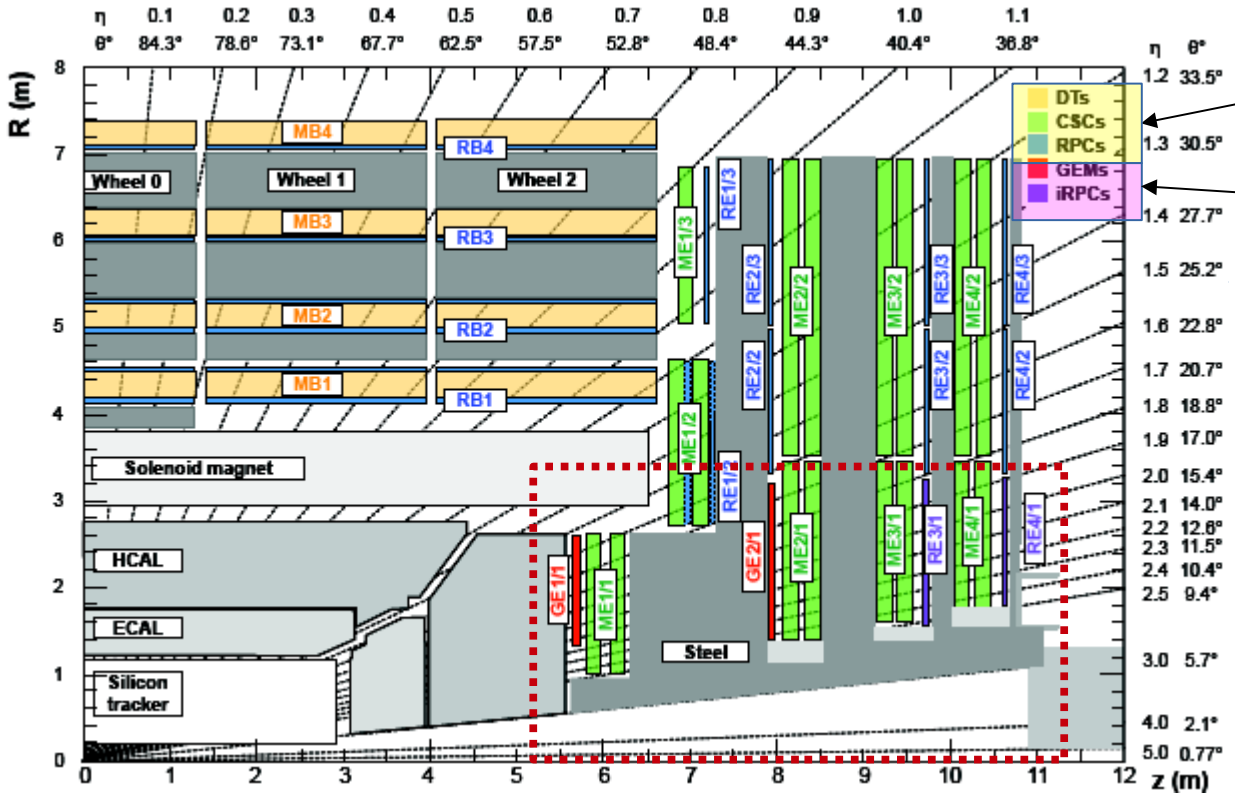
	LHC design	HL-LHC design	HL-LHC ultimate
peak luminosity /10^{34}/m^2/s	1.0	5.0	7.5
integrated luminosity /1/fb	300	3000	4000
average pileup	50	140	200

- We have collected ~ 1% of the expected luminosity.
- By the upgrade time (LS3) we would collect 10% of the expected luminosity.
- The main challenge for Run 4/5 Muon system would be the background rate.



CMS TP: https://cds.cern.ch/record/2020886?ln=fr

1.4) Upgrades CMS Muon spectrometer



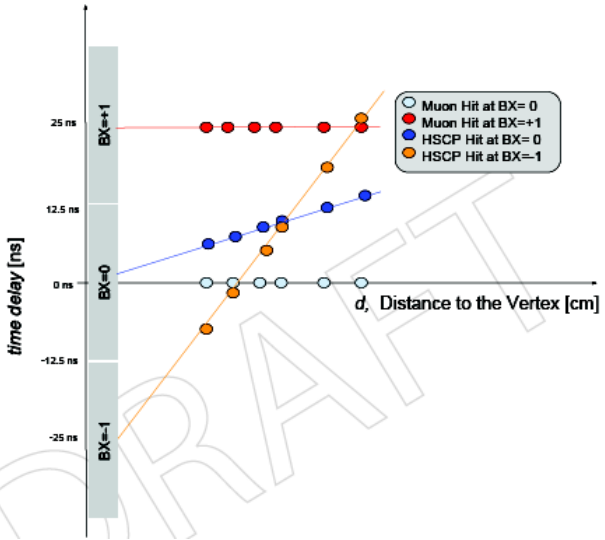
Existing systems

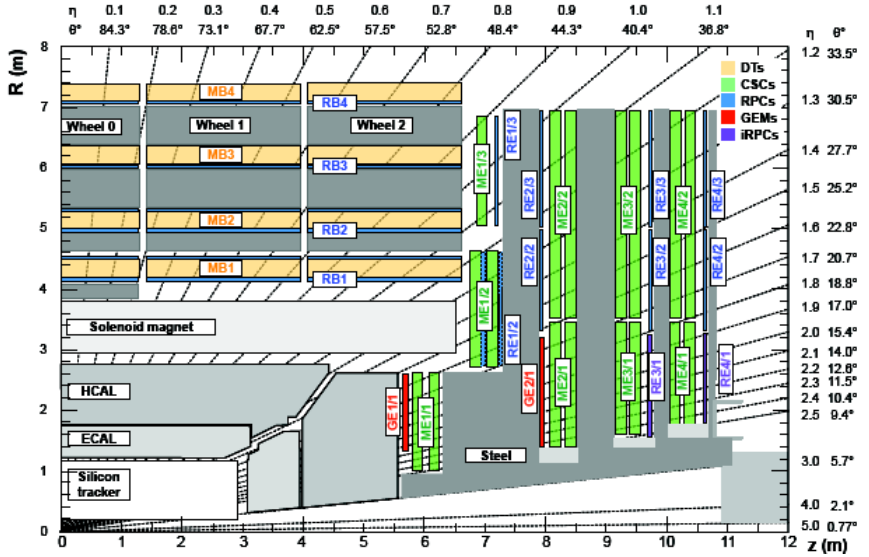
New systems

- The first ring was left free from RPC due to budget constraints and limited rate capabilities.
- Plan to occupy it:
  - RE1/2: with GEMs
    $\sigma_p \sim 0.1$ mm, $0.1 < \sigma_{t\sim} \sim 5$ ns.
  - RE3/4: with iRPC
    $\sigma_p \sim 1$ cm and $\sigma_t \sim 1$ ns.
- Upgrade of the electronic for the present system: aging and improved technology.

1.5) HSCP

- Heavy Stable Charged Particle predicted by a bunch of BSM theories.
- It is looked at through (see for example arXiv:1305.0491; arXiv:1411.6795):
- dE/dX; off time energy deposit in Calorimeter; TOF (Muon system).

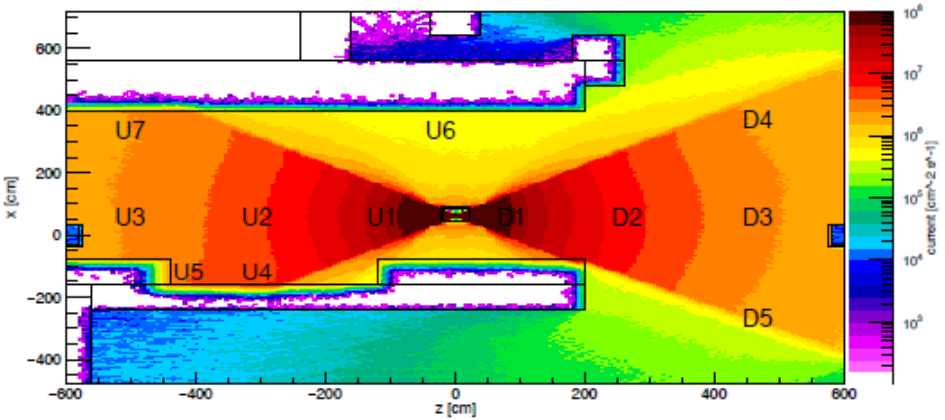




<u>TOF proposal with RPC</u>:
L1 trigger with timing for RPC with electronic upgrade: 4 layers with 1 ns resolution.
Apply the same to iRPC with resolution 0.1-1 ns.

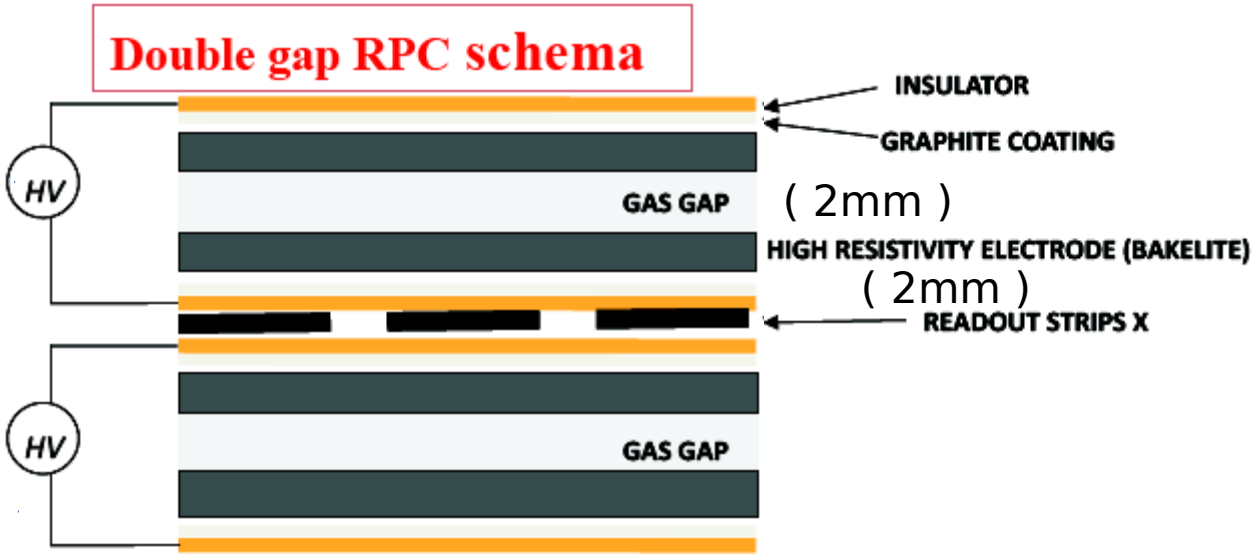
2.1) History of the iRPC project

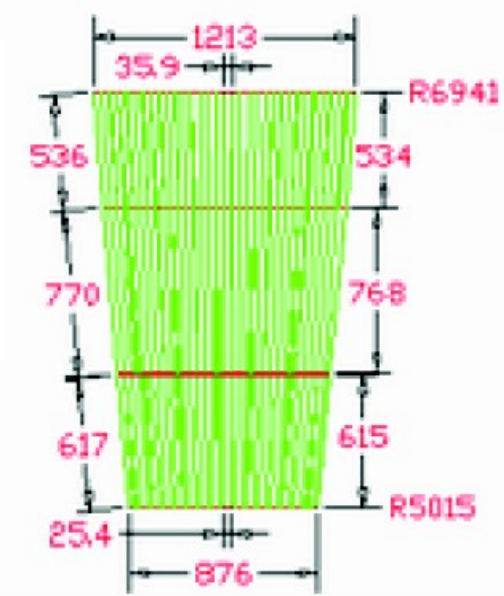
- 2013 – 2014 : first considerations and simulations.
- June 2015 : Technical Proposal.
- 2014-2015: preliminary tests in Korea, Italy, France, China, CERN.
- 2015 – now: installation and tests of prototypes in Gamma Irradiation Facility ++ (GIF++). This is a unique facility designed to emulate HL-LHC environment with infrastructure for gaseous detectors.
- October 2017: Technical Design Report
  - Single (+ spare) option on the large size chambers design.
  - Single option on the electronics design.



GIF++ photons flux

2.2) RPC design





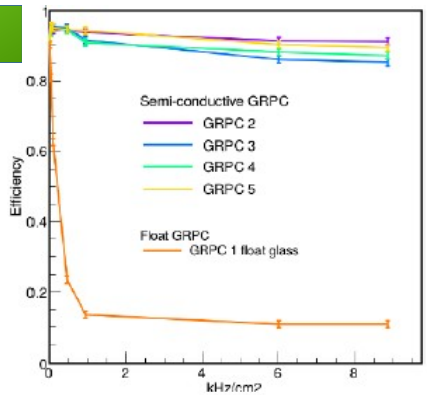
- The existing RPC chambers was validated up tp 300 Hz / cm2.
- The existing electronics uses only a resolution of 12.5 ns, while the potential is better than 1 ns.
- The existing design uses strips ~ 1 cm wide and ~ 70 cm long that limits the spatial resolution.

2.3) How to increase the rate capability

GLASS electrode

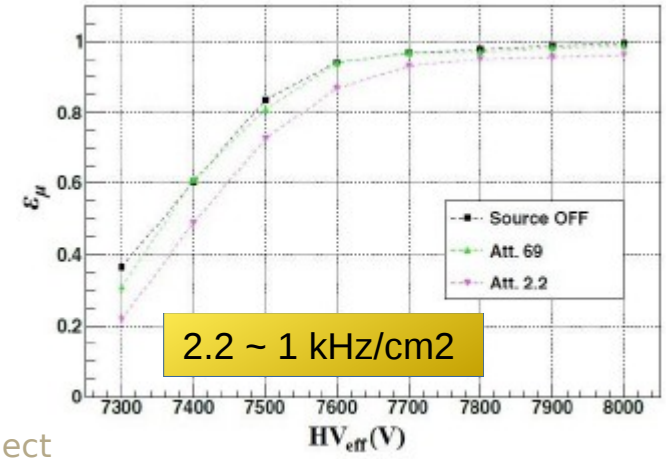
Reduce produced charge / improve speed of charge evacuation.

RPC2016 conference



- Reduce electrode resistivity:
  - Change properties of Bakelite electrodes (Italy / Korea).
  - Use low resistivity glass (China / France)
- Reduce electrode thickness (2 mm now) :
  - Glass: <= 1 mm
  - Bakelite: 1.2 – 1.6 mm
- Reduce gap thickness (2 mm now) :
  - Glass: 1.2 mm
  - Bakelite: 1.2-1.6 mm
- Improve electronics sensitivity (170 fC now) :
  - Use more sensitivity electronics based on ASICS technology (Omega collaboration - France)
- Gas:
  - Doped glass electrodes requires large fraction of electronegative gas (2-5%) different from default CMS composition. Expensive.

Bakelite electrode



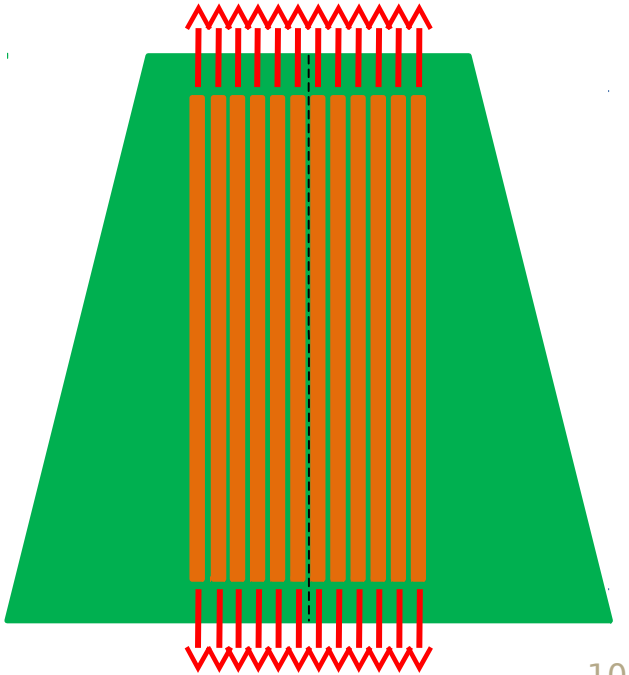
2.4) The actual situation

Good baseline candidate

- Italy / Korea: Bakelite electrodes with 1.4 / 1.4 mm (electrode / gap thickness).
- France / China: high rate / low threshold electronics on ASIC technology + TDC with strips read from both sides: σ_t = 1 ns and σ_d = 0.5 – 3 cm.

Alternative high timing solution (more expensive)

- China: Thin glass electrodes with 5 gaps (250 microns). R&D ongoing to fit CMS gas component.
- France / China: electronics (same than above).



3.1) Starting point of FKPPL project

- The RPC project at CMS: ~ 100 people, including IRPC: ~ 30 people. Initially “concurrents” Italy/Korea vs France/China. Now fused within a common project.

- Till now major efforts was dedicated to the hardware development of iRPC chambers.

- Very limited ressources/expertise allocated to the simulation of the iRPC in CMS (~5 people)!
  - Required to define the exact parameters of the RPC chambers described previously.
  - Required by steering committee to justify the upgrade project.

- CMSRPC for FKPPL: bring together simulation experts from Korea and France to strengthen the effort:
  - 1 well defined new physics channel: Heavy Stable Charged Particles (HSCP) search.
  - 2 area of application: iRPC in L1 trigger for HSCP and in physics analysis.
  - Design and test of chambers based on results from simulations.

3.2) Teams

- The direct contributors to FKPPL project are: all members are already active except K. Schablo who would start in September. Up to then we have a master student working on it (H. Khoudli)

ID: Title	CMSRPC					
List of participants	**French Group**			**Korean Group**		
	Name	**Title**	**Affiliation**	**Name**	**Title**	**Affiliation**
	Leader:			Leader:		
	Maxime Gouzevitch	CR1	IPNL, Villeurbanne	Tae Jeong Kim	Associate Professor	Hanyang University
	Konstantin Schablo	Student	IPNL, Villeurbanne	Sumin Jeong	Student	Hanyang University

3.3) Location and project flow

- 3 locations:
  - IPNL: local team.
  - Hanyang: local team.
  - CERN: support of ~5 people permanently in CERN. Place where the results have to be regularly presented.

- Steps:
  - Before TDR we have 1-2 month left. We plan to perform some simple studies emulating L1 trigger behavior of iRPC alone.
  - After TDR we plan to investigate in more details the combination of iRPC with the other upgraded Muons systems RPC, CSC in Trigger and offline analysis.

- Exchanges:
  - visit of Korean members to IPNL.
  - visit of IPNL members to Hanyang University.
  - 2 meetings at CERN in coincidence with test beams in GIF++.