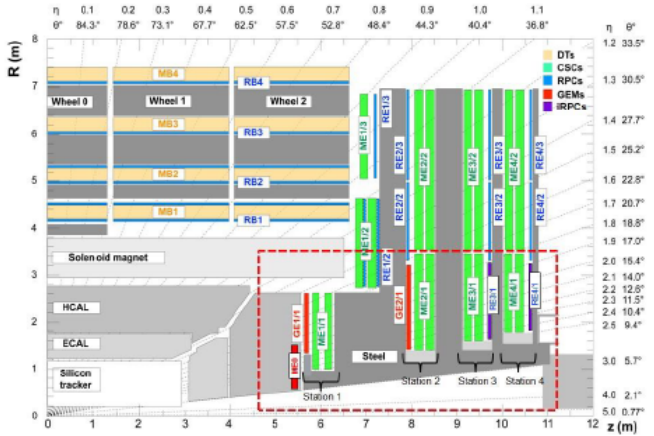
iRPC upgrade project for CMS during HL-LHC program

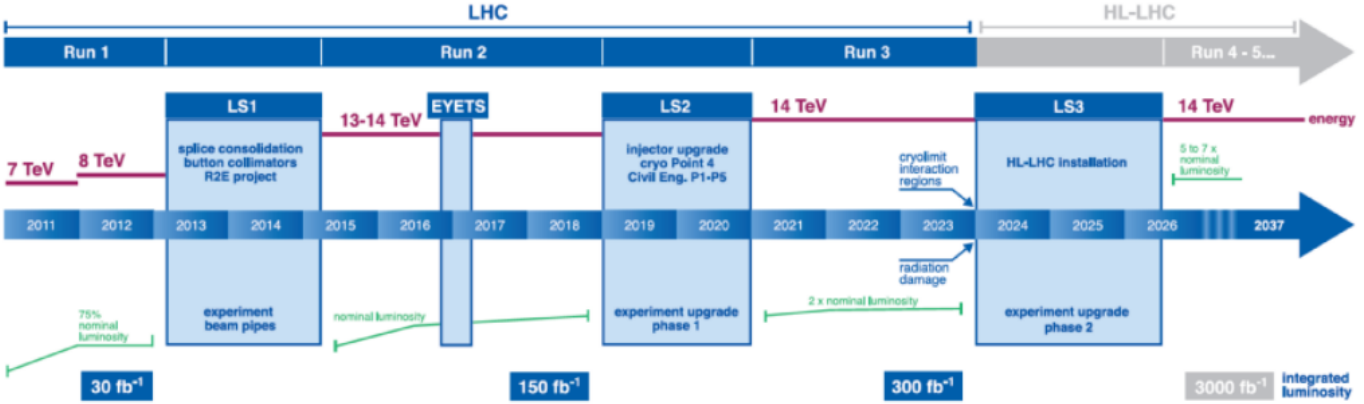
1) Reminder of iRPC project
2) Report on 2018 results: Hardware
3) Report on 2018 results: Analysis
4) Request for 2019 and first results



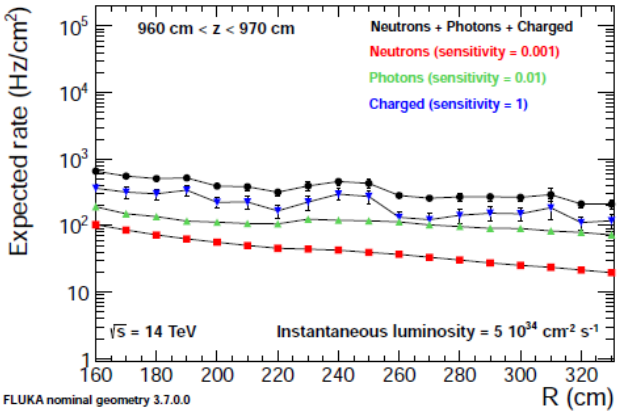
M. Gouzevitch (IPNL, France) and T.J Kim (Hanyang University, Korea) and FKPPL CMSRPC team

1.1) HL-LHC program

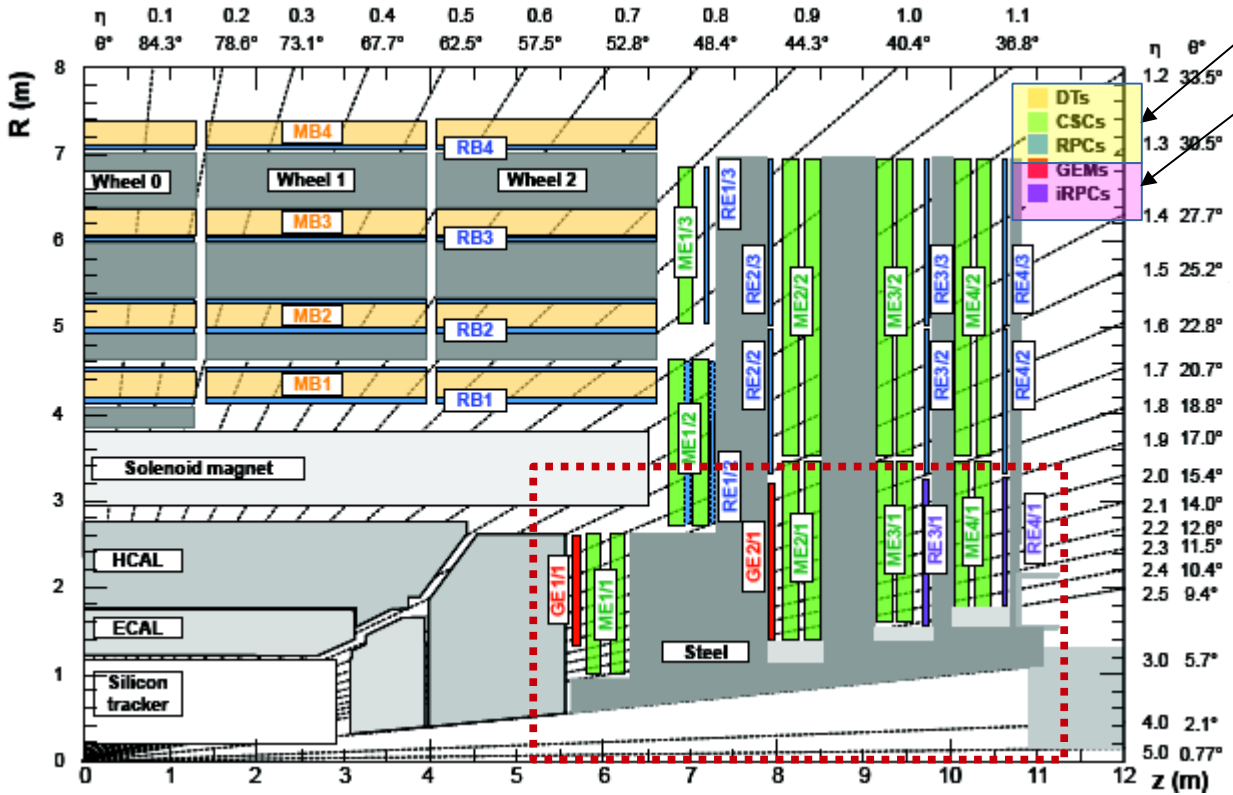
	LHC design	HL-LHC design	HL-LHC ultimate
peak luminosity /10^{34}/m^2/s	1.0	5.0	7.5
integrated luminosity /1/fb	300	3000	4000
average pileup	50	140	200



- 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.



1.2) 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, $0.1 < \sigma_t \sim 5$ ns.
  - RE3/4: with RPC
    $\sigma_p \sim 1$ cm and $0.1 < \sigma_t < 1$ ns.
- Upgrade of the electronic for the present system: aging and improved technology.

1.3) iRPC schedule

Choice of technologies

Engineering design

Mass production

Installation

2017-2018

Services installation

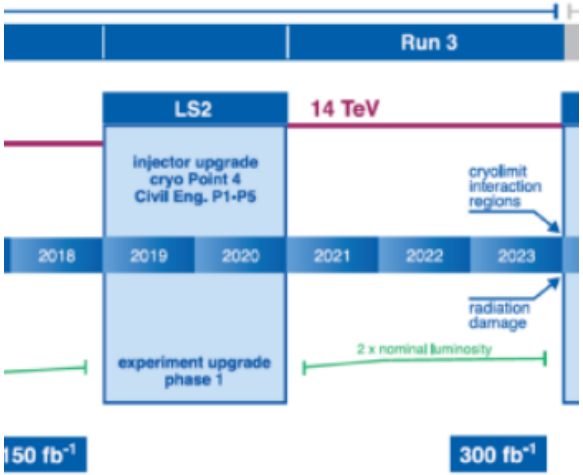
2019

2020-2021

2021-2023

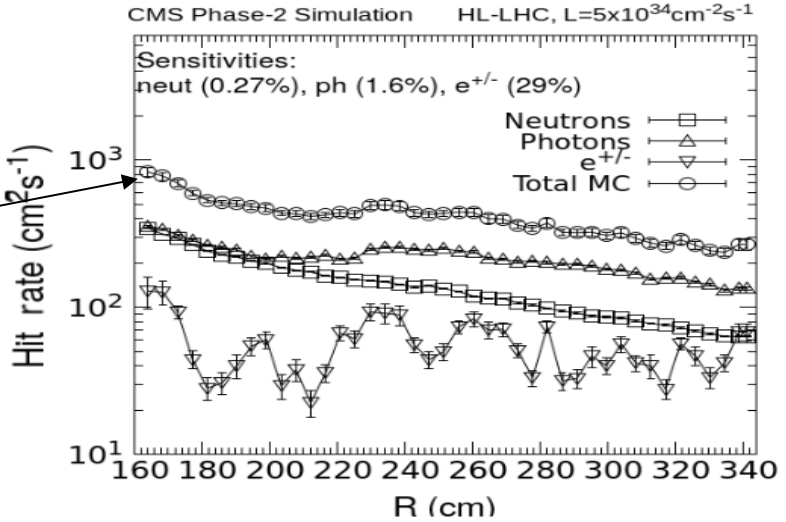
FKPPL

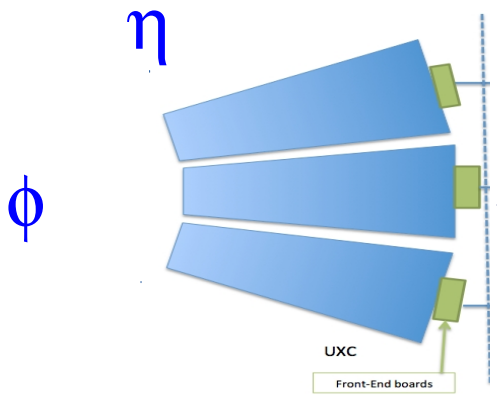
CMSRPC



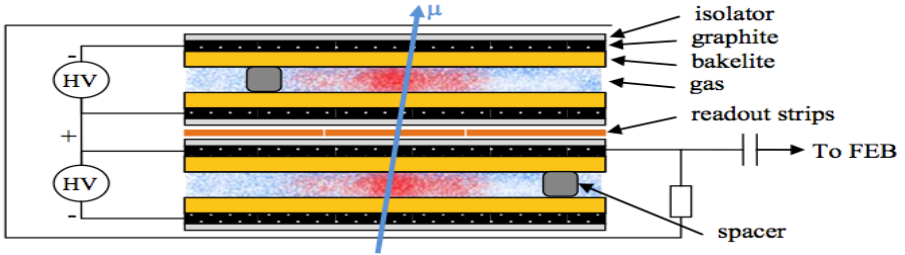
1.4) Requirements for the iRPC chambers

	Present system	iRPC
|η| coverage	0 – 1.9	1.8 – 2.4
Max expected rate (Safety factor SF = 3 included)	600 Hz/cm^2	2 kHz/cm^2
Max integrated charge at 3 ab^{-1} (SF = 3 included)	~ 0.8 C/cm^2	~ 1.0 C / cm^2
ϕ granularity	~ 0.3 °	~ 0.2°
η resolution	~ 20 cm	~ 2 cm
T resolution	1.5 ns	< 1 ns





1.5) iRPC chambers design

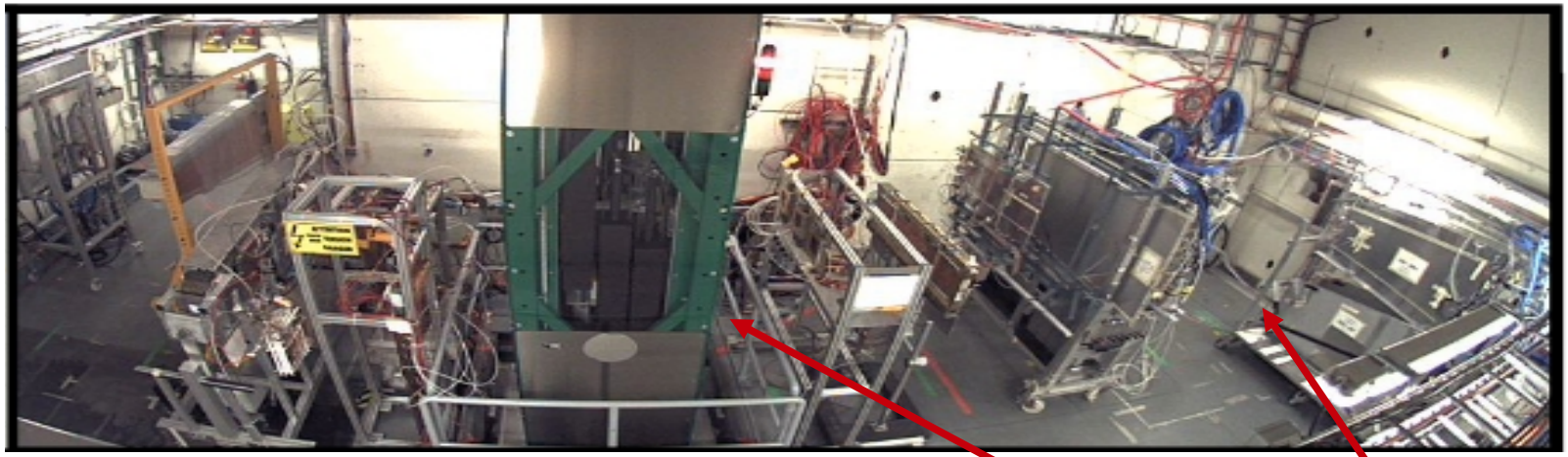


2.1) CMS MU FKPPL project in 2018: teams

Acronym:	Full title: CMSRPC Start year: 2017					
	French Group			Korean Group		
	Name	Title	Lab./Institute	Name	Title	Lab./Institute
List of participants	Leader: Maxime Gouzevitch	Scientist	IPNL, Villeurbanne	Leader: Tae Jeong Kim	Associate Professor	Hanyang University
	Konstantin Shchablo	PhD Student	"	Brieuc Francois	Post Doc	"
	Imad Laktineh	Professor	"	Sumin Jeong	Student	"
				Junghwan Goh	Postdoc	"

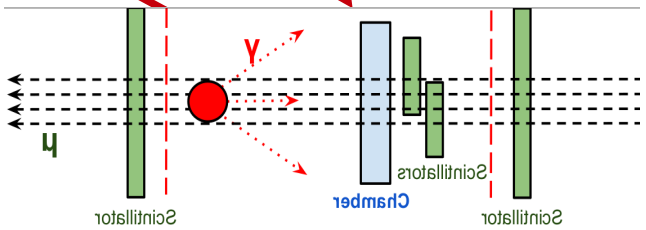
Visit of M. Gouzevitch to Hanyang in July 2018 and visit of B. Francois to IPNL in Nov. 2018.

2.2) Hardware : GIF++ Aug. 2018



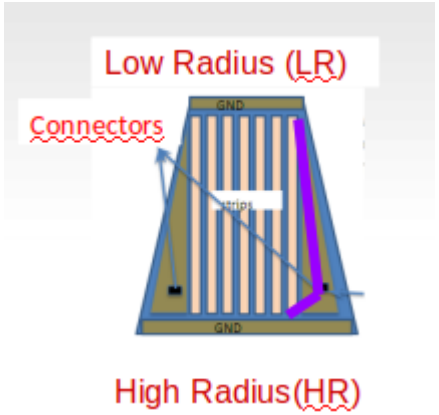
- Located at the end of CERN SPS H4 line that provide 150 GeV Muon beam.
- Irradiation with a 13 Tbq 137Cs source.
- We use 4 scintillators for tracking.
- Proceeding for ICHEP 2018 in Seoul:

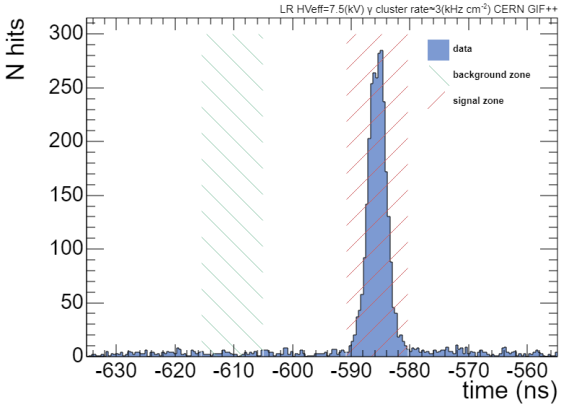
"Fast timing measurement for CMS RPC Phase II upgrade".
Submitted for review to PoS (Proceeding of science).

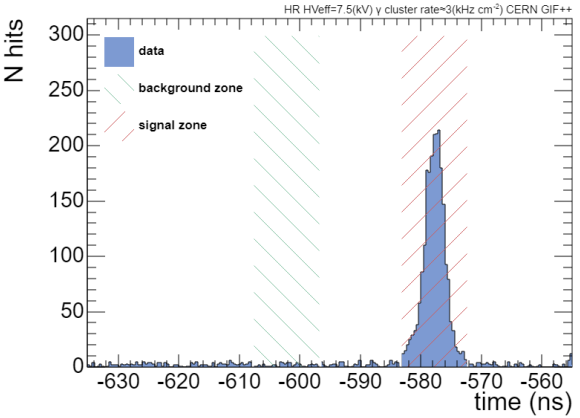


2.2) Analysis

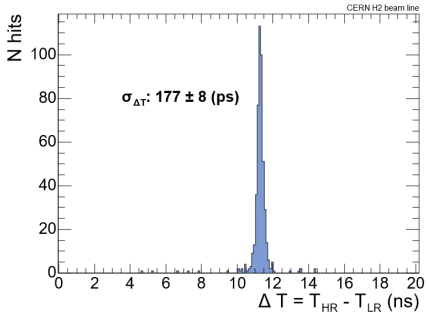
- Analysis code written by PhD student K. Shchablo member of FKPPL





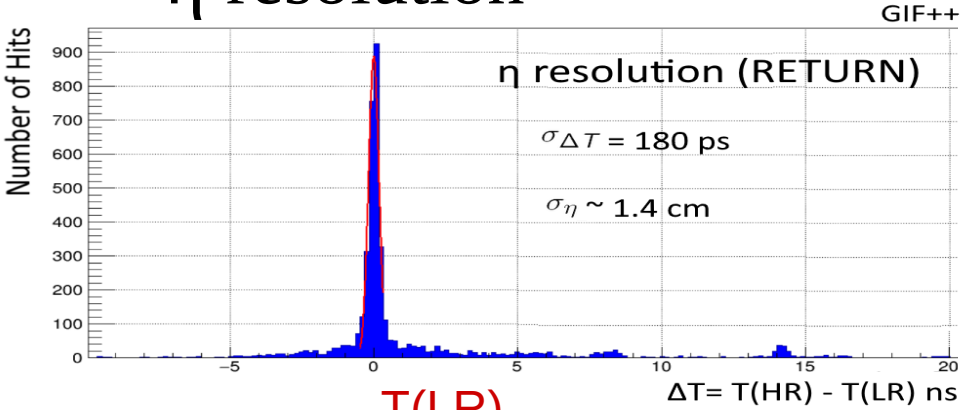


$\Delta T = T2 - T1$



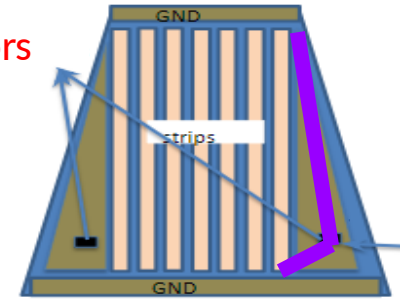
2.3) Time and space resolution

η resolution $\sigma_\eta = V * \sigma_{\Delta T}/2$



T(LR)

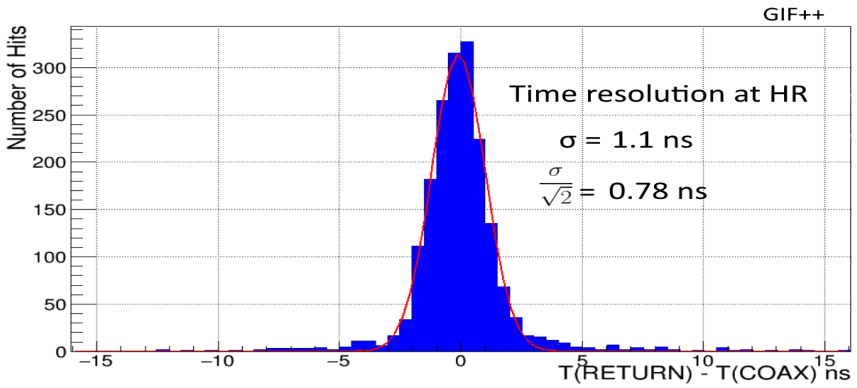
Connectors



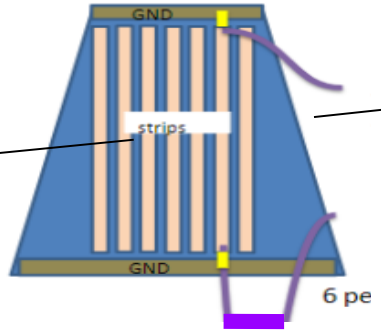
T(HR)

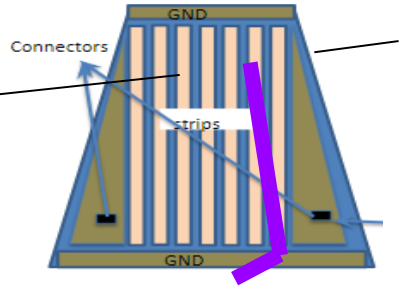
η

Intrinsic time resolution



μ

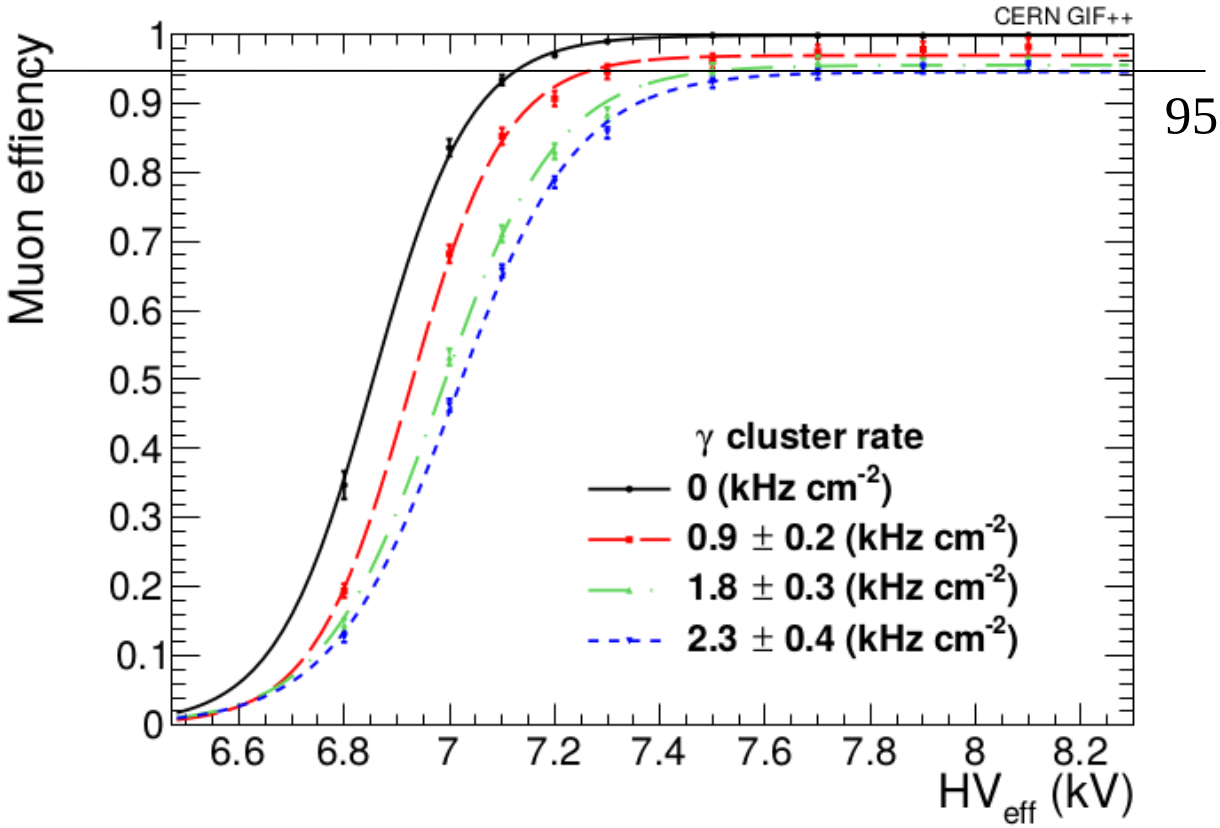




T(COAX) at HR

T(RETURN) at HR

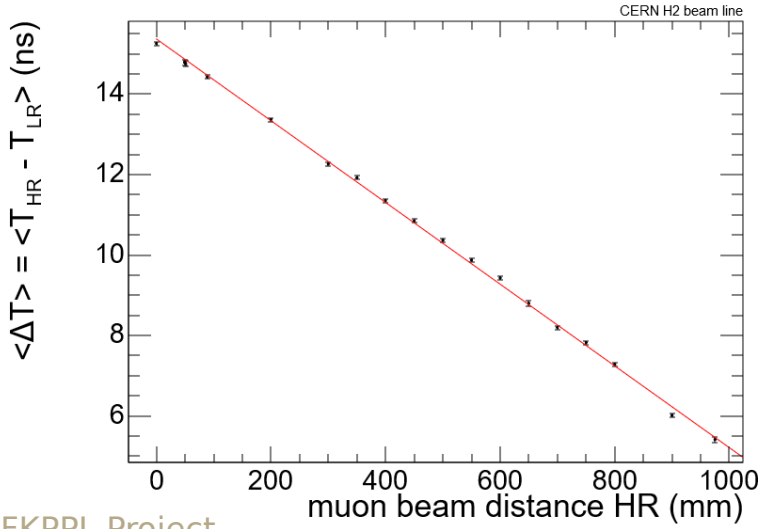
2.4) Absolute efficiency



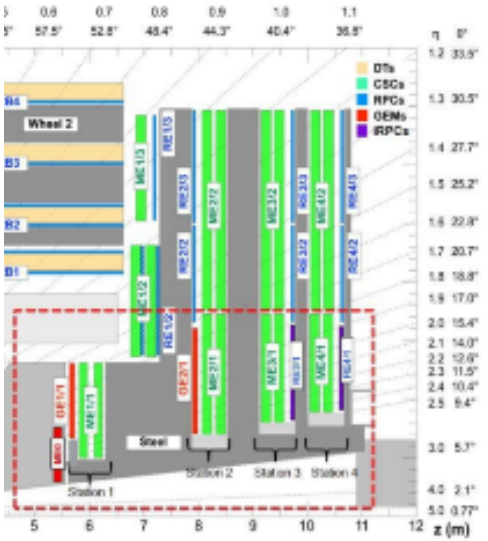
95 % declared to TDR

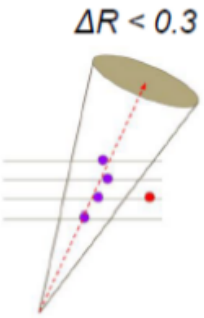
2.5) Uniformity

- A prototype with ¼ size of the 2-sided readout was tested in Muon beam in SPS at CERN.
- Installed on moving table with a position precision < 1 mm.

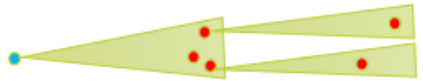


3.1) Analysis from 2018: Heavy Stable Charged Particles



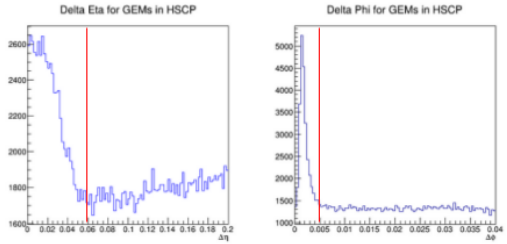


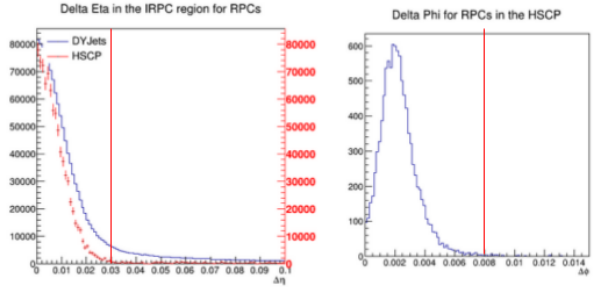
2017 simple cone matching



Successive cone matching using optimized radius

Δη and Δϕ distributions





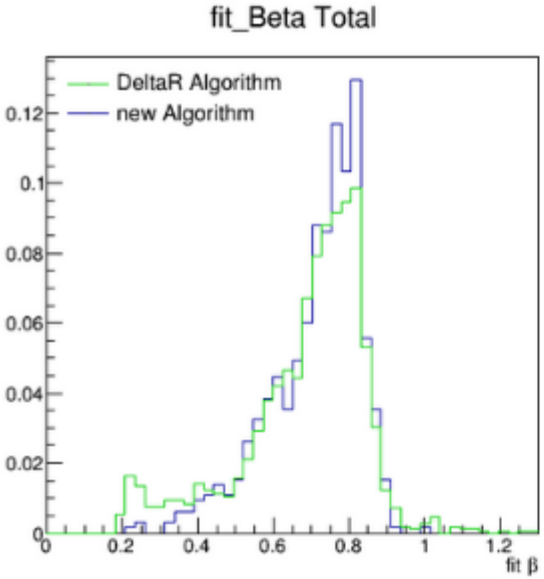
Cuts for the algorithm:

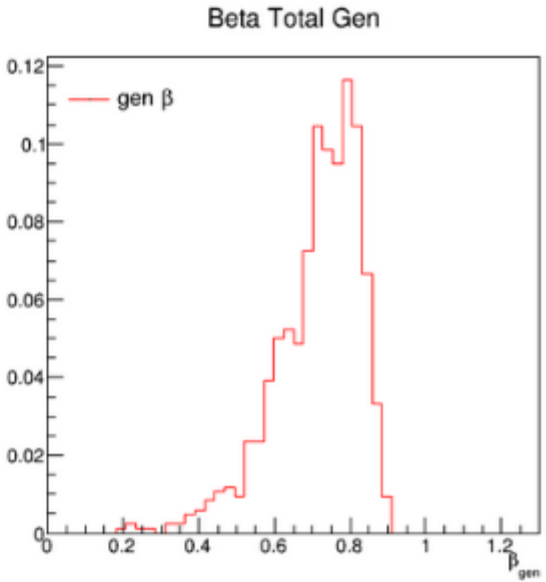
```
deltaEta_gem=0.06
deltaPhi_gem=0.005

deltaEta_rpc_IRPC=0.03
deltaPhi_rpc_IRPC=0.008
```

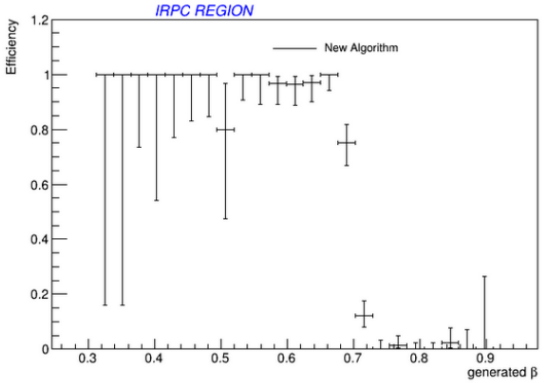
HL-LHC yellow report. “Beyond the Standard Model Physics at the HL-LHC and HE-LHC”, CERN-LPCC-2018-05. http://cds.cern.ch/record/2650173
+ J. Calderon summer student report

3.2) Analysis from 2018





HSCP Trigger efficiency



SLOW

Time Of Flight

$1/\beta = 1 + \frac{c\delta_t}{L}$ with δ_t = delay

- Much improved beta resolution with better matching algo.
- Improves by a lot the filtering of hits from 200 PU using excellent time and space resolution.

4.1) Request for 2019

FKPPL Project Proposal (2019)

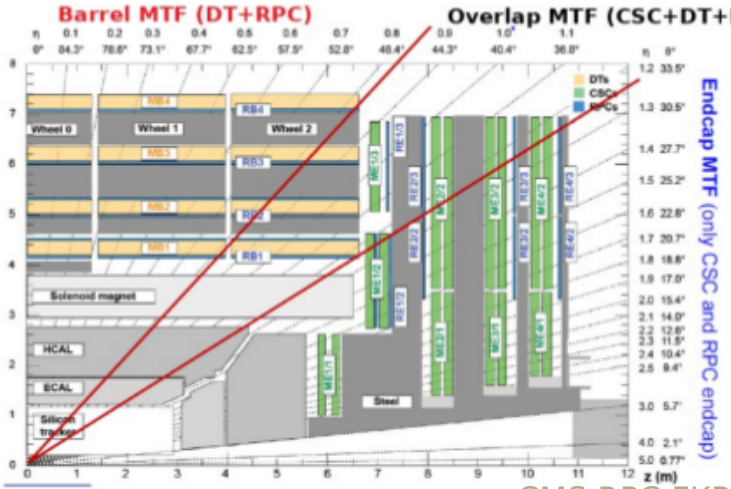
Acronym:	Full title:	Main French and Korean institute: IPN Lyon and Hanyang University
Domain:	Experimental HEP	

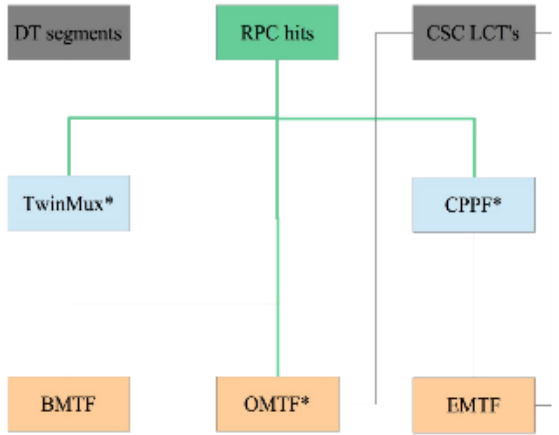
List of participants	French Group			Korean Group		
	Name	Title	Lab./Institute	Name	Title	Lab./Institute
	Leader: Maxime Gouzevitch	Scientist	IPNL, Villeurbanne	Leader: Tae Jeong Kim	Associate Professor	Hanyang University
	Konstantin Shchablo	PhD Student	“”	Brieuc Francois	Postdoc	“ “
	Imad Laktineh	Professor	“”	Ji Eun Choi	Student	“ “

- It is our 3rd year of request. We would like to ask for a small increase of funding to pay a visit 2 people to Korea (till now 1 person was traveling) : M. Gouzevitch and PhD student K. Shchablo
- Project :
  - Hardware : finalisation of iRPC prototype ready for mass production.
  - Software : we finished the HSCP trigger feasability study. Move to inclusion of iRPC to Phase II Muon trigger.

4.2) Project in 2019: CMS Muon trigger

- CMS Level-1 Trigger (L1T) has three different Muon Track Finders (MTF) separated in eta, with access to different detector Trigger Primitives (TP)
- The RPC system contributes to the three L1T MTF's differently
  - BMTF ($|\eta| < 0.83$ with DT+RPC): assign bunch crossing of low quality DT segments + build RPC only segments in MB1 and MB2 in case of DT segment absence
  - OMTF ($0.83 < |\eta| < 1.24$ with DT+RPC+CSC): the 8 RPC chambers (5 in barrel, 3 in end-cap) are used for position information
  - EMTF ($|\eta| > 1.24$ with RPC+CSC): RPC hits are used in case of CSC segment absence



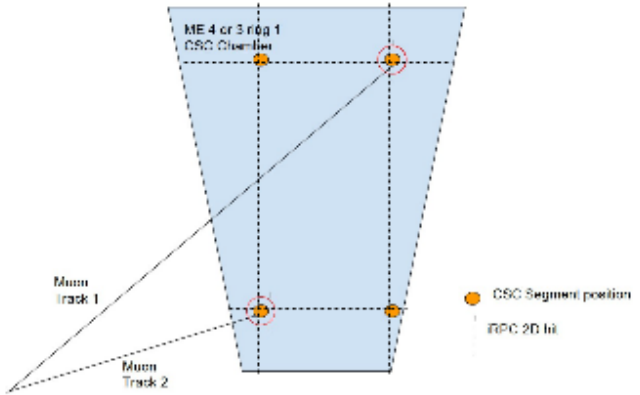


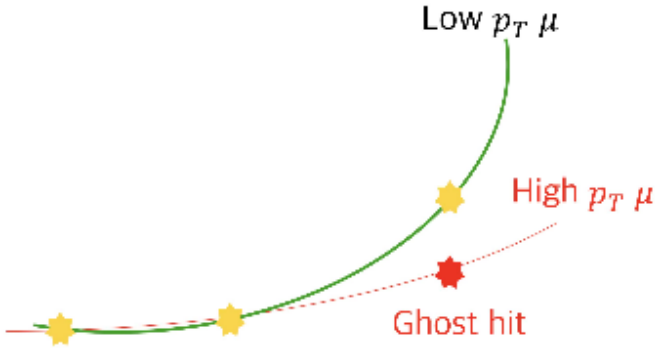
* Module with RPC hit clustering and cluster selection

4.3) First results for iRPC trigger

Poster in KPS by J.E . Choi

- CSC detector has two 1D readout which leads to ghost signal if two hits occur in the same chamber
  - Can promote low P_T muon to high P_T ones → trigger rate increase
  - iRPC 2D readout can be used to remove the CSC ghost Local Charged Track (LCT)
    - Try to match CSC segment to iRPC hits
    - If no match is found, consider segment as a ghost signal
    - Ghost signals are 3 times larger in case 4 LCT's are present in a chamber





Unmatched ratio	ME3/1	ME4/1
1 LCT per chamber	10.07 %	10.73 %
4 LCT per chamber	30.46 %	32.55 %

CONCLUSION

- The project enters into the 3rd year phase.
- In 2 years we:
  - Finalized the HSCP triggering feasibility study.
  - Significantly contributed to the iRPC prototype validation.
- Visits:
  - 5 Korean colleagues visited IPNL.
  - 1 IPNL colleague visited 2 times Hanyang University, in addition visit of KODEL Laboratory and Seoul University.
- We plan for next year:
  - Include the iRPC into the HL-LHC Muon trigger.
  - Contribute to the final detector prototype.
  - We would like to have 2 people coming this year to Hanyang: M. Gouzevitch and PhD student K. Shchablo.