Muon Upgrade 2

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For the Muon U2 Group

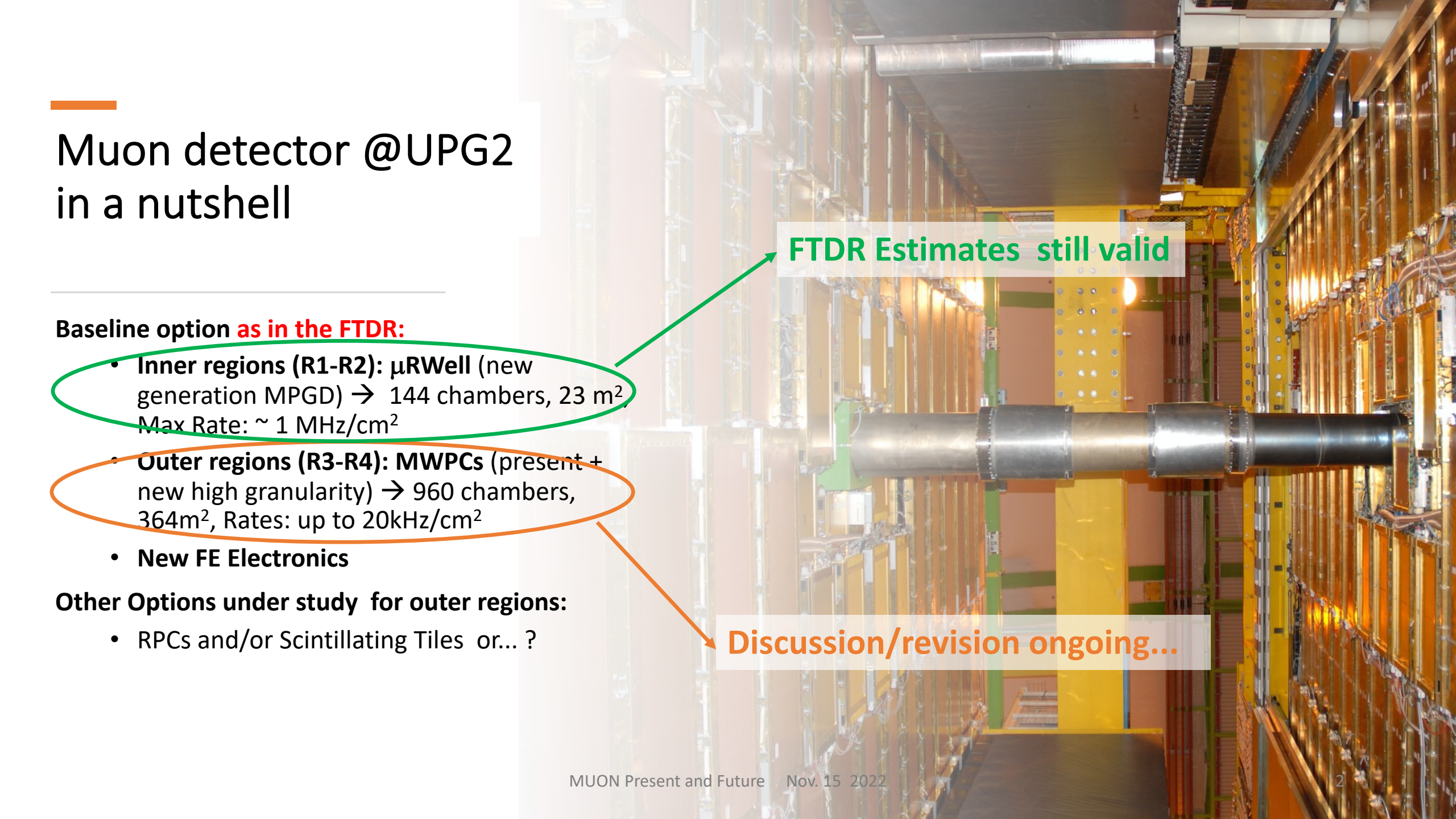
Muon detector @UPG2 in a nutshell

Baseline option as in the FTDR:

- **Inner regions (R1-R2): µRWell** (new generation MPGD) → 144 chambers, 23 m^2, Max Rate: ~ 1 MHz/cm^2
- **Outer regions (R3-R4): MWPCs** (present + new high granularity) → 960 chambers, 364m^2, Rates: up to 20kHz/cm^2
- **New FE Electronics**

Other Options under study for outer regions:

- RPCs and/or Scintillating Tiles or... ?

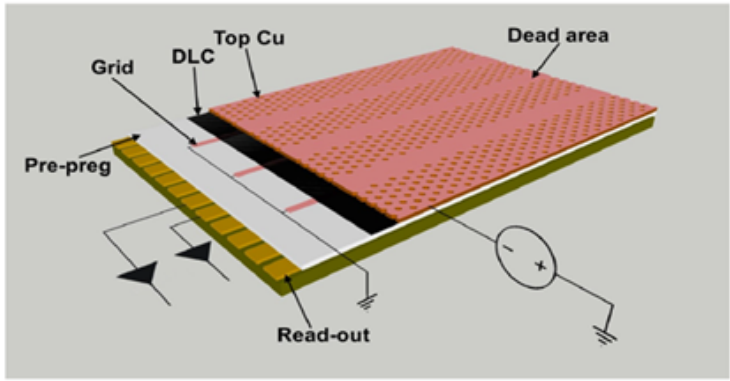


FTDR Estimates still valid

Discussion/revision ongoing...

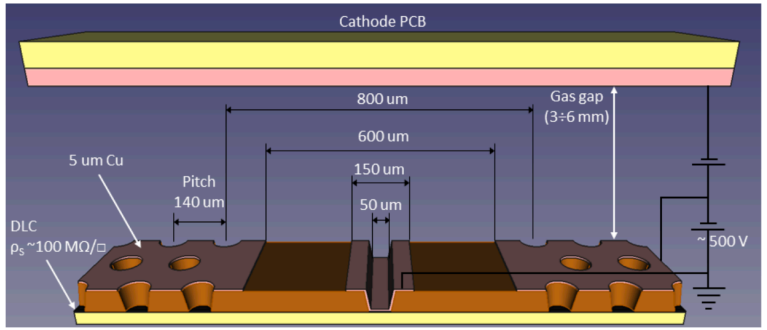
µRWell for the R1 and R2 Regions

- New generation MPGD detectors, optimized to cope with rates up to few MHz/cm^2 suitable for the Muon inner regions @ Upgrade 2 conditions (max expected rates ~1MHz/cm^2)



- Developed a new layout, easier to be produced: PEP HR
- Version PEP-v2.1 under test with FATIC
- Studies with ECO-friendly gas (no CF4): Ar:CO_2:iC_4H_{10} = 68:30:2 %
- Groups currently involved: LNF and Bari
- More details in the dedicated talk

The new PEP HR layout



MWPC For the R3 and R4 Regions

- M1R2 chambers in RUN1+RUN2 integrated **0.7 C/cm with no visible signs of ageing** → this charge will be integrated **at 350fb^{-1}** only in M2R3, with all other R3 and R4 regions well below

→ we do not expect significant ageing effects (to be checked with more tests and opening M1R2 chambers)

→ for the rate capability and inefficiencies see next slide...

- The initial plan (as in the framework TDR) was to fully equip R3 and R4 by keeping ~90% of R3 and R4 MWPCs and build ~ 100 new high granularity MWPCs (to be built in PNPI...)
- the present political situation and a more precise estimate of rates and expected inefficiencies is significantly affecting this plan

	R1	R2	R3	R4
M2	0.67	0.42	0.10	0.02
M3	0.17	0.08	0.02	0.01
M4	0.22	0.06	0.01	0.004
M5	0.15	0.03	0.01	0.003

Max integrated C/cm at 50 fb^{-1} → max 0.7 C/cm @ 350 fb^{-1}

MWPC For the R3 and R4 Regions

- At present we cannot count on russian institutions → **we cannot build new MWPCs**
- We are estimating the expected inefficiencies (possibly up to IsMuon) with the UPG2 extrapolated rates and with different FEBs dead times (at present is ~100ns)
- Depending on the results (in ~few months) we can envisage few scenarios:
  1. it's possible to design new FEBs with dead time such to have a"fully efficient" detector (total ineff <few%) we will replace all FEBs on the present MWPCs (anyway a lot of work!)
  2. It's not possible:
     1. Equip R3&R4 with a brand new technology → more groups needed!
     2. Keep the detector as it is now, accepting the inefficiency (to be seen also as a downscaled option)

Single GAP **Physical PAD** rate in Q3 M2C @ 1.5 x 10^34 + shielding + iron wall

D	C	B	A			
879286	1103944	442425	1309089	2621916		16
719601	950036	369271	955715	1425362	2510864	15
751914	864069	320513	634022	1473319		14
545615	674309	213039	403450	741793		13
550472	580860	167437	534988			12
403145	436048	115019	344341			11
406106	373774	91283	230748			10
300378	277553	59088	147131			9
297388	248735	547882	1131020			8
226216	182092	354010	759693			7
218607	164476	307603	567551			6
166905	119156	213986	377909			5
165665	112886	185122	300079			4
126350	93725	141490	219876			3
119315	107028	152398	206111			2
110229	116724	163530	205714			1

Expected M2 rates at 1.5 x 10^{32}cm^{-2}s^{-1} for Single (top) and bigap (bottom) readout

BI-GAP PAD Rate in Q2 M2C @ 1.5 x 10^34 + shielding + iron wall

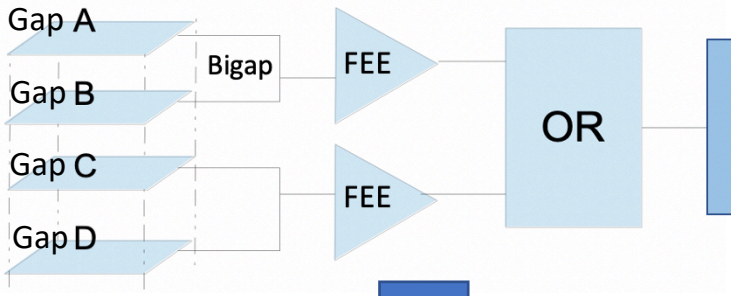
D	C	B	A			
1175326	1475623	693531	2231054	4601730		16
961879	1269898	578857	1628807	2501656	4406823	15
1005071	1154987	502426	1080551	2510948		14
729314	901337	333953	687592	1264223		13
735807	776426	262468	838630			12
538877	582858	180300	539778			11
542835	499617	143093	361713			10
401511	371001	92624	230638			9
397514	332479	732344	1511816			8
302379	243399	473199	1015470			7
292209	219852	411168	758637			6
223099	159274	286032	505145			5
221442	150893	247450	401111			4
168890	125281	189127	293904			3
159487	143063	203707	275506			2
147341	156022	218588	274975			1

New FE Electronics

- **The readout electronics is a crucial point of the project**

- Once we have the estimates of ineff. vs deadtime we'll see if it's possible to design a FEE that satisfies the requirements
- We can read single gaps everywhere but M2, M3, M4 - R4
- If "useful" we can also logically combine the 4 gaps, but inefficiency have to be careful evaluated
- The option of keeping the present electronics is discouraged (mainly due to ageing) but not discarded... (e.g. for a downscaled option).

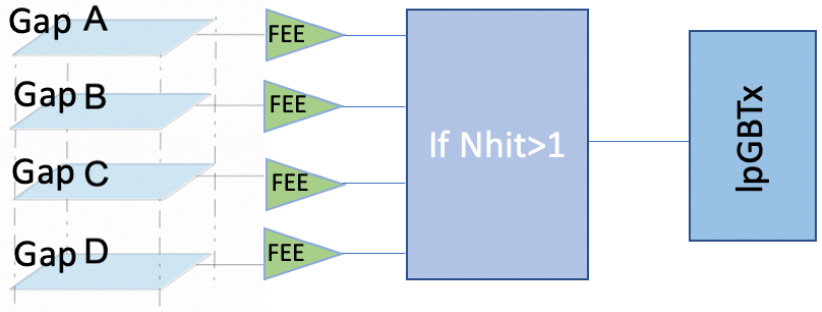
Present FEE



fraction of correlated hits (%)

	M2	M3	M4	M5
R1	7	5	10	8
R2	9	8	12	10
R3	15	22	30	20
R4	32	45	45	12

Proposed Upgrade 2 FEE



Other Options for External Regions

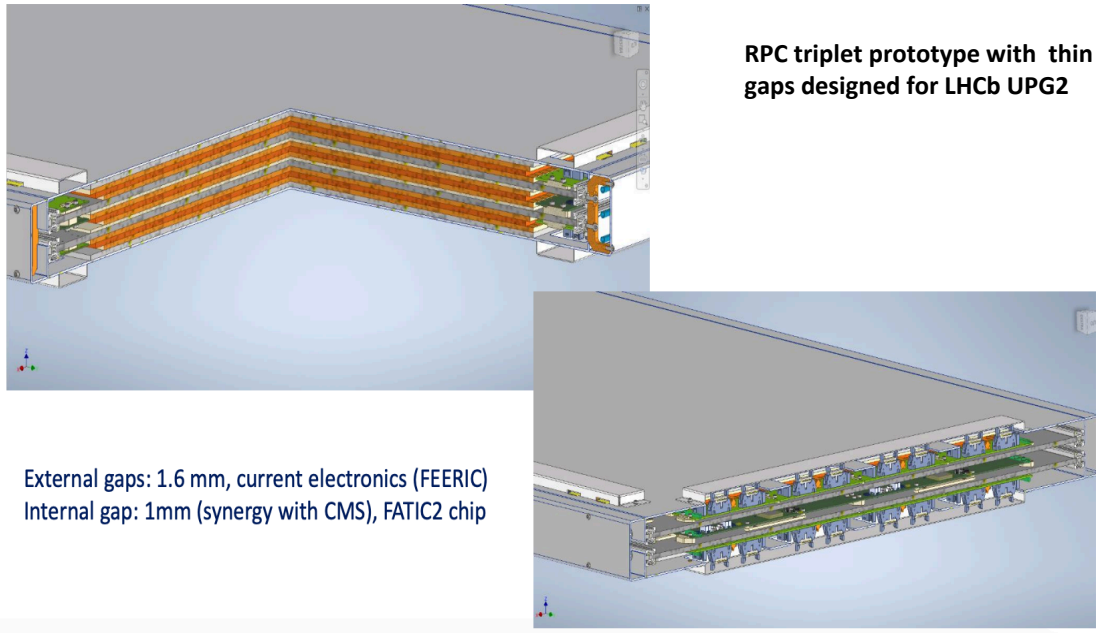
M.Deserio

RPCs for the R4 region

- Thin RPC (1.6mm) with ECO-friendly gas (CO_2/HFO mixture) seems promising
- Designed an RPC triplet with thin gaps
- Tests ongoing with cosmics and at GIF++

- Working on a FATIC version for both: RPCs and μRWELLs (FATIC3)

- Groups involved: Bari



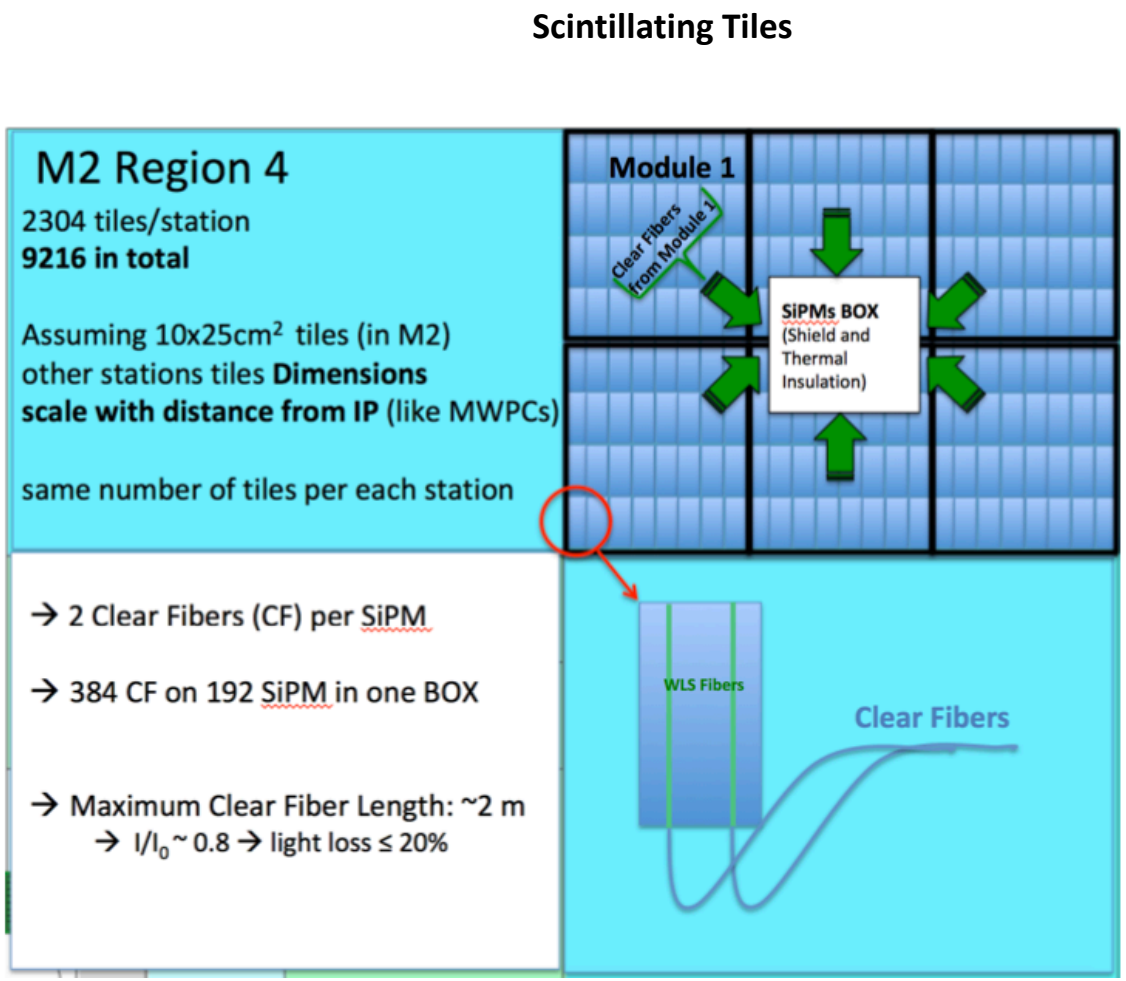
RPC triplet prototype with thin gaps designed for LHCb UPG2

External gaps: 1.6 mm, current electronics (FEERIC)
Internal gap: 1mm (synergy with CMS), FATIC2 chip

Other Options for External Regions

- **SCI-Tiles for the R4 region**
  - Simple to build and relatively inexpensive, main issue is the radiation damage of SiPMs, which should be put in a shielded-cooled volume and/or replaced periodically (~1-2 years).
  - Needs more studies and more groups

- Groups involved: Ferrara



Spare Slides