Muon Phase I Upgrades - Summary

- **Summary of planned upgrades**

- **Schedule of talks**

- **For each muon detector:**

    - **A few details**
    - **Selected issues**

Muon Phase I Upgrades - Summary

- ## CSC Upgrades
  - ### ME4/2 build 72 new CSC chambers
  - ### ME1/1 build 7x72 Digital CFEBs
    - and 72 each associated trigger (TMB), readout (DMB) boards

- ## RPC Upgrades
  - ### Build another endcap station out to rapidity 1.6

- ## DT Upgrades
  - ### (BTI replacement – really a maintenance issue)

Muon Phase 1 Talks

- **Jay Hauser – Phase 1 Muon Upgrades Introduction**
- **Oleg Prokofiev - Update on ME4/2 Chambers and Tooling**
- **Ben Bylsma - Update on Digital CFEB**
- **Vadim Khotilovich – CSC efficiency studies**
- **Jason Gilmore - TMB Design Issues for ME1/1**
- **Piet Verwilligen - RPC Upgrade for Phase 1**
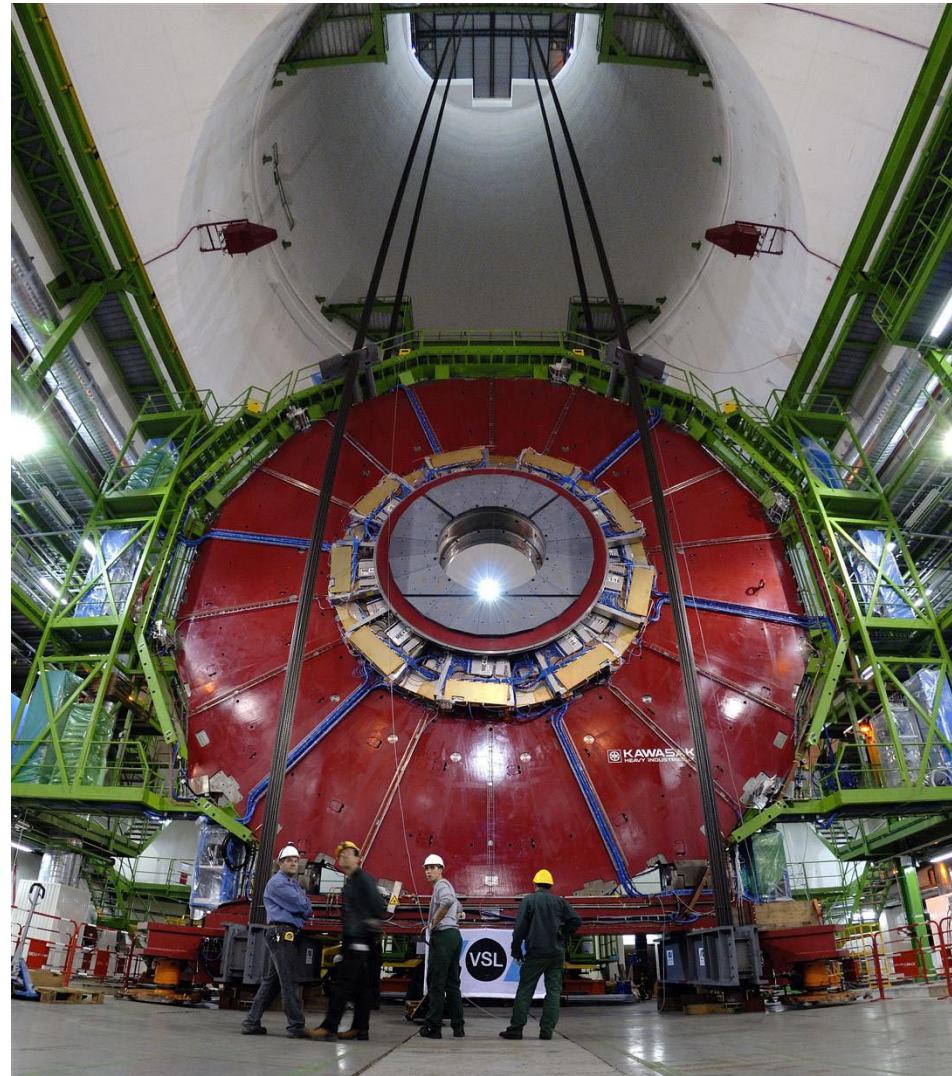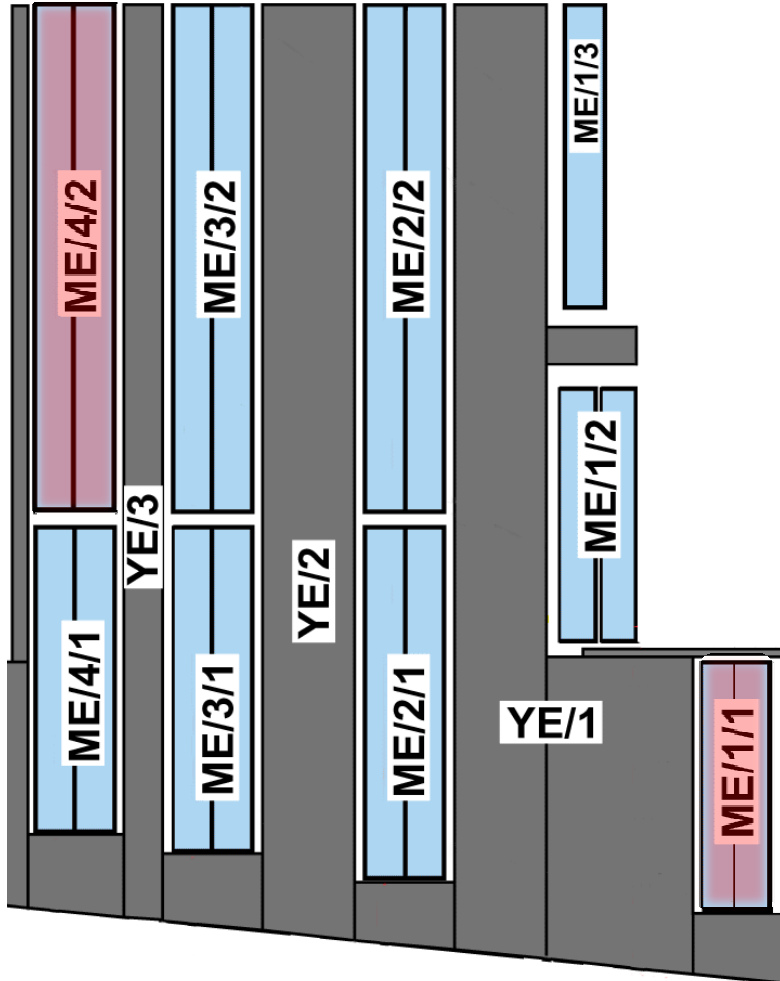- **Pierluigi Zotto – Barrel DT Phase 1 Upgrades**

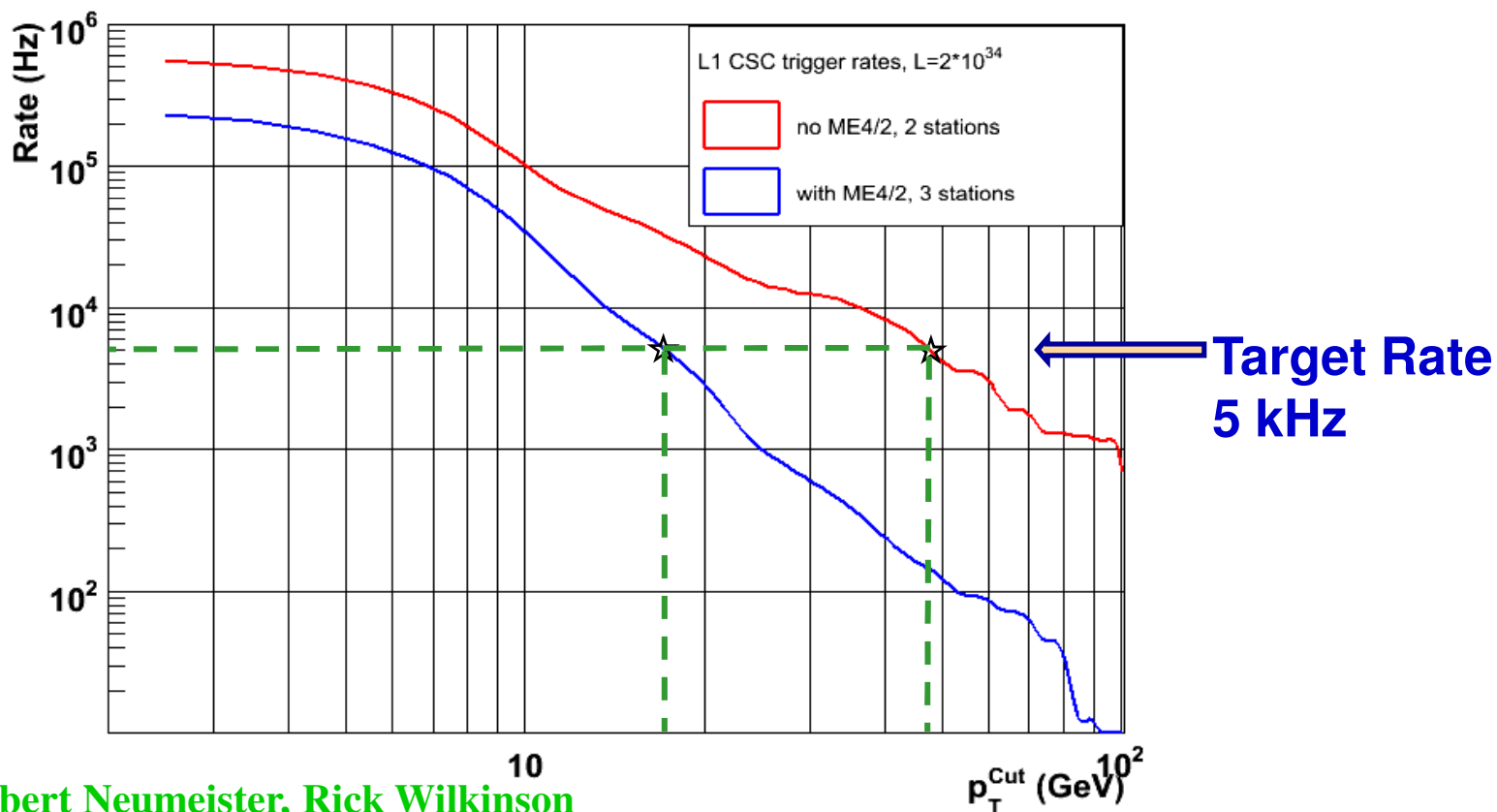# Muon Phase 1: CSC

ME4/2 and ME1/1 upgrades

R-Z cross-section

"Empty" YE3 disk ready for ME4/2

- **Triggering with & without the ME4/2 upgrade:**
  - **The high-luminosity Level 1 trigger threshold is reduced from 48 → 18 GeV/c**

Target Rate 5 kHz

Ingo Bloch, Norbert Neumeister, Rick Wilkinson

DCFEB Prototype

Build prototype with four options for preamp/ADC interface
Options include:
- Direct Coupling with scaling
- AC Coupling with scaling
- Single to Differential with Analog Devices ADA4950
- Single to Differential with TI THS4524

DAQ path:
- Virtex 5 or 6
- Data sent in MAC level ethernet packets

Trigger path:
- Three options (see slide 4) fiber or copper?
- Major concern is additional latency (seems unavoidable)
- Other concerns: additional components/power consumption
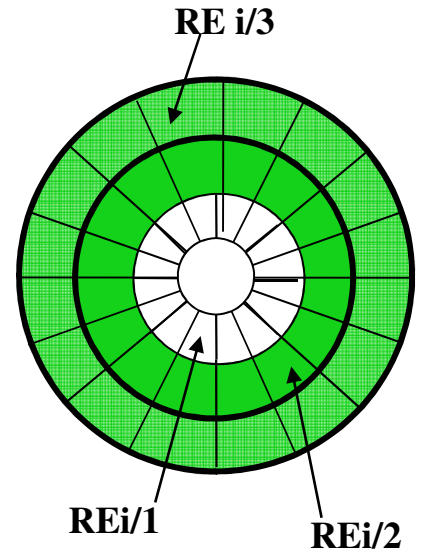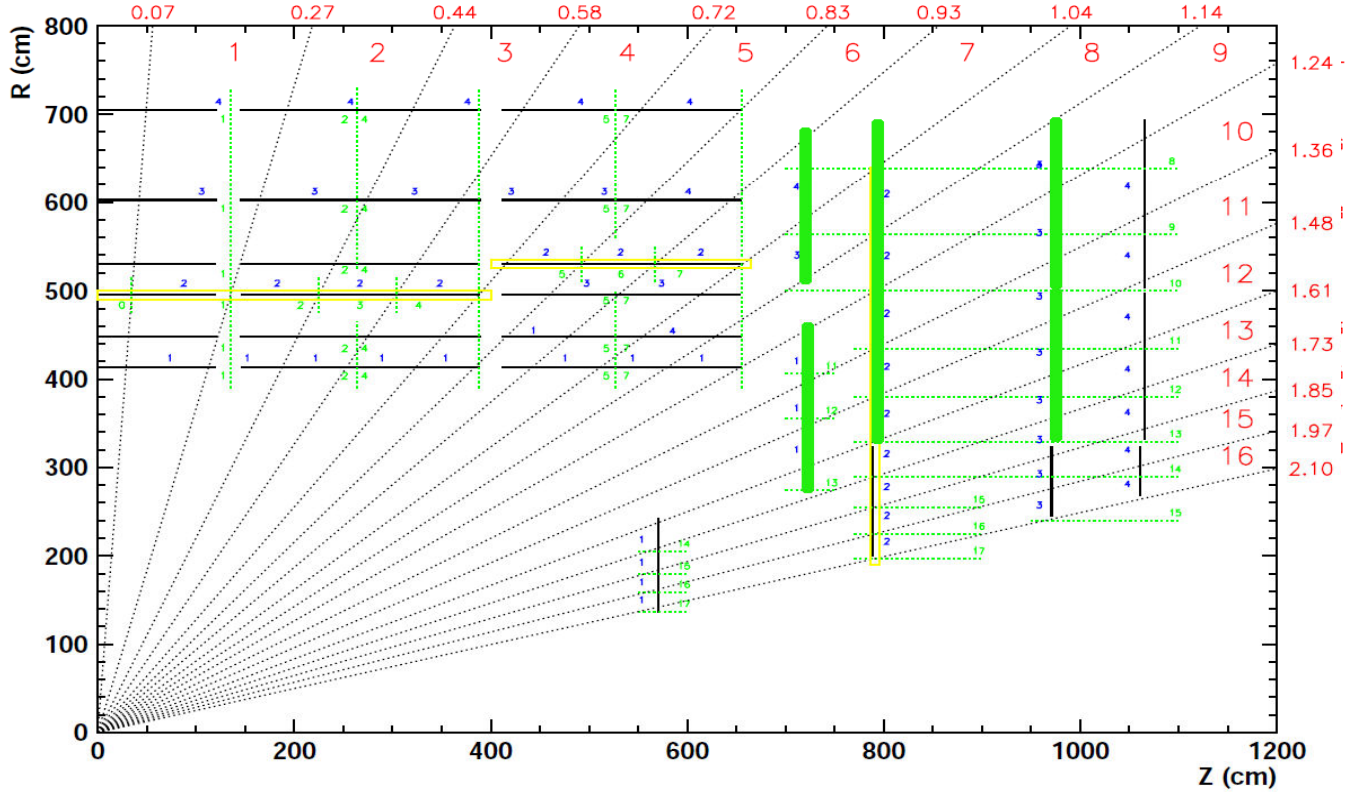- On TMB end: compatibility with mezzanine board

Muon Phase I: RPC

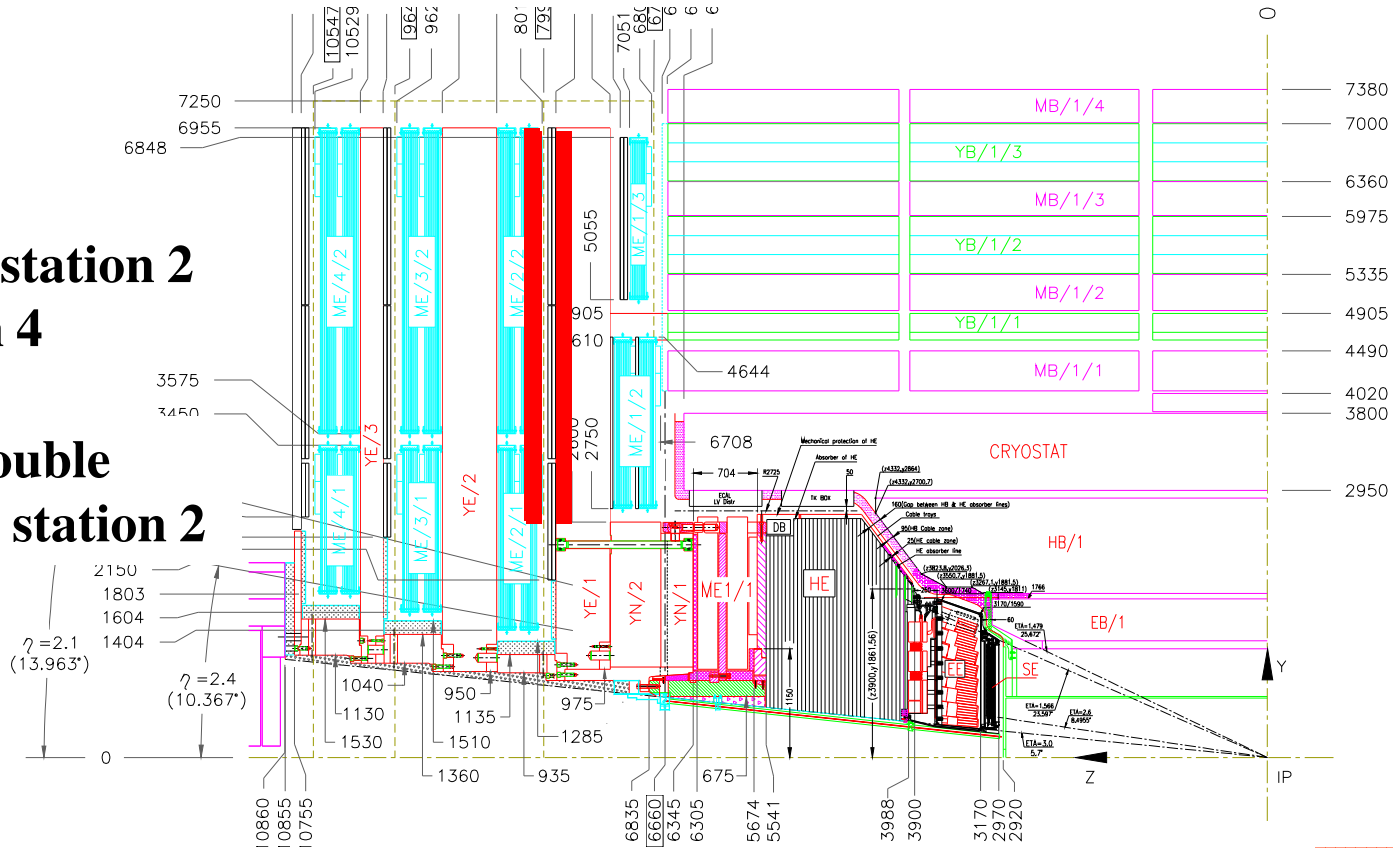|	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2	RE 2/3	RE 3/1	RE 3/2	RE 3/3	RE 4/1	RE 4/2	RE 4/3
No. of chambers	36*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2

The Double Chamber Approach

Move act. station 2 to station 4

Build a double station for station 2

	RE 1/1	RE 1/2	RE 1/3	RE 2/1	RE 2/2	RE 2/3	RE 3/1	RE 3/2	RE 3/3	RE 4/1	RE 4/2	RE 4/3
No. of chambers	36*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2	18*2	36*2	36*2

4th station

Validation

- **RE2bis was implemented as a logical "AND" of 2 RPCs**
  - $\epsilon = \epsilon^2$ 90% → 81 %
  - Rate?   Turned out to be negligible:
    2 x 100 Hz cm^{-2} → 0.05 Hz cm^{-2}

- **This plot was made in TDR geometry with:**
  - Rate: Neutron hits: Poisson Distribution for random noise
  - Efficiency: Single Muons, 10 - 200 GeV/c , 1.04 < η < 2.1
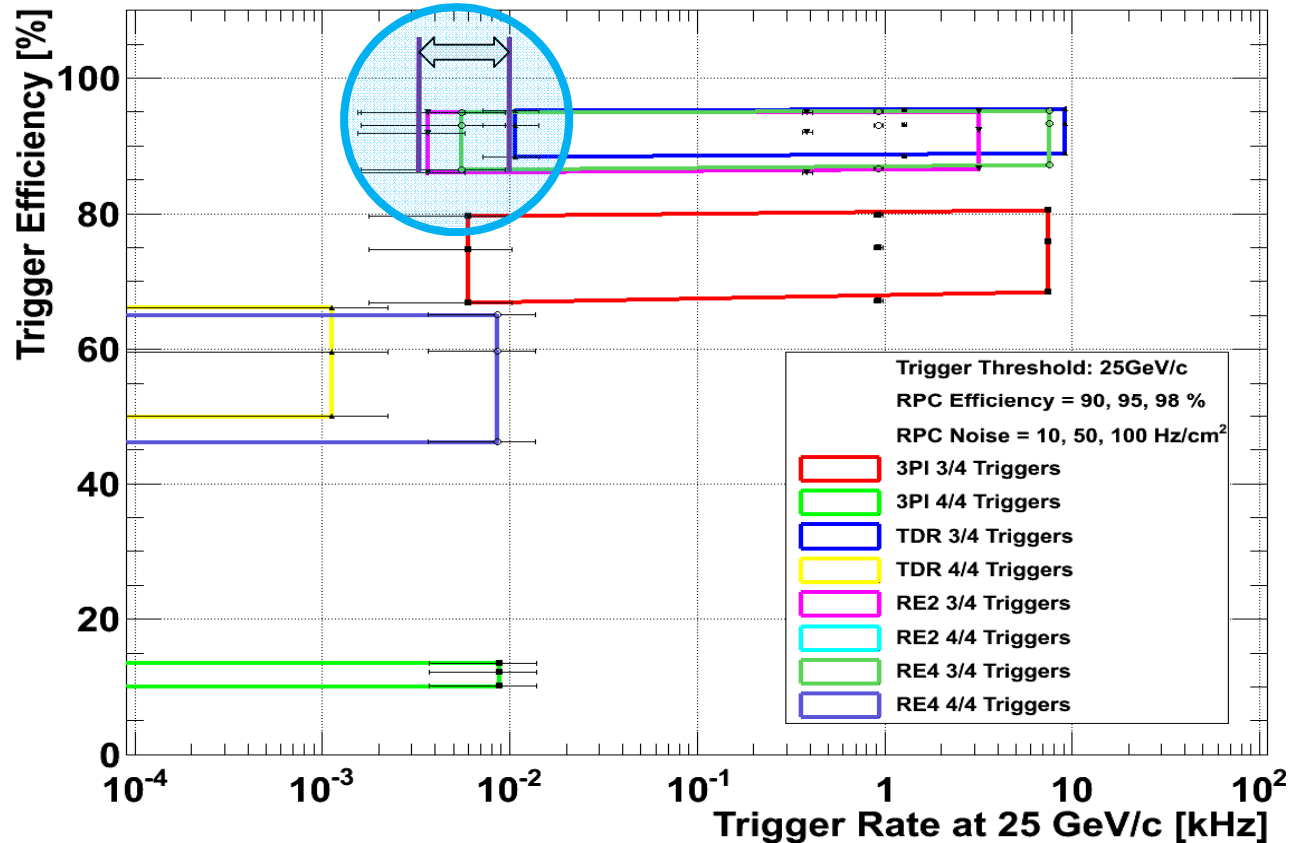 - → Pure Fake Rate,   no rate due to MinBias and Signal
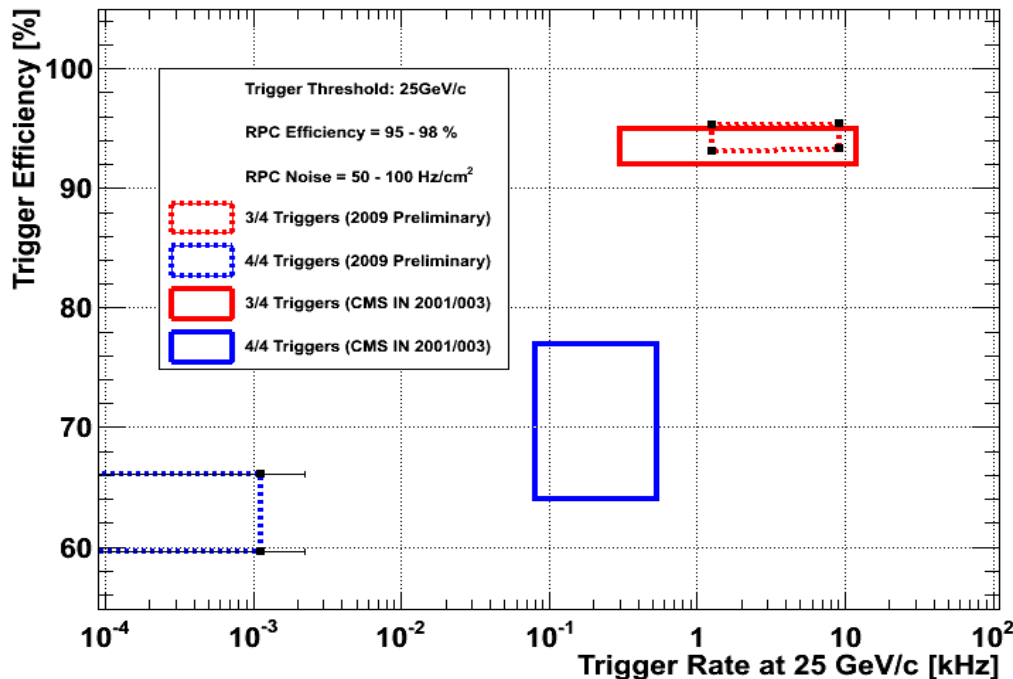
- **Unable to reproduce exactly the same result as 8 years ago**
- **Major Changes in Software:**
  - Patterns
    - Broad Patterns → Narrow Patterns
  - Algorithm: 3/4 → 4/6
  - Quality:
    - no preferred Layer
    - Q = # Planes hit - 3

Preliminary Results

Full Endcap (Towers 8 – 16 == 1.04 < η <2.10)

Slightly better (lower) Trigger Rate for RE2bis, but not as high as expected w.r.t. the simulation of a fully independent 5th plane.

Is this worth the effort?

(RPC) Conclusions

- **Simulation is ongoing:**
    - First results indicate that TDR approach will be adequate
    - Hopefully decision by beginning of next year

- **Funding & Responsabilities:**
    - Division of responsibilities between Europe and Asia is currently under discussion
    - Total cost of the project is in range 4 – 5 MCHF
    - Large part of the funds already ensured: Belgium, India, Pakistan, China, Korea
    - Involvement of CMS and Italy highly welcome

- **Ready to start:**
    - CMS RPC Collaboration is ready to start production in 2010
    - Milestone for completion could be 2013 - 2014

- **Infrastructure and integration issues to be discussed:**
    - Cooling in RE4
    - Integration with CSC

Muon Phase I Upgrades – CSC Issues

- **"Shovel-ready" ME4/2 (5 prototypes)→**

- **Arranging for chamber factory at CERN**
  - **Tooling to be shipped to CERN in few months**

- **Can Digital CFEBs be ready for installation in ME1/1 during the 2011 shutdown?**
  - **Results of prototype tests available ~Mar. 2010**
  - **Numerous technical details – can DCFEB be backward compatible?**

Muon Phase I Upgrades – RPC Issues

- **Detailed plans (e.g. double station in RE2) depend highly on simulation**
  - **First CMSSW simulation results now available**
  - **Only noise+neutron hits, other sources significant?**
    - Low-Pt muons + neutrons?

- **(Work plan: who builds what, schedule and financing)**

Muon Phase I Upgrades – Simulation Issues

- **Crucial but <u>severely limited by manpower</u>**

- **E.g. neutron hits**
  - **Tricky to add in**

- **Significant tuning will be needed after we take first LHC data**

Backup slides

# CSC Simulation result (May '09)

(Vadim Khotilovich, Alexei Safonov)

- Efficiency gaps for good quality TF tracks disappear with addition of ME4/2

- ME4/2 will be included by default in 31X

- Back-porting to 22X took a considerable amount of effort

 – Thanks to the experts: Rick Wilkinson, Tim Cox, Oana Boeriu and Slava Valuev!
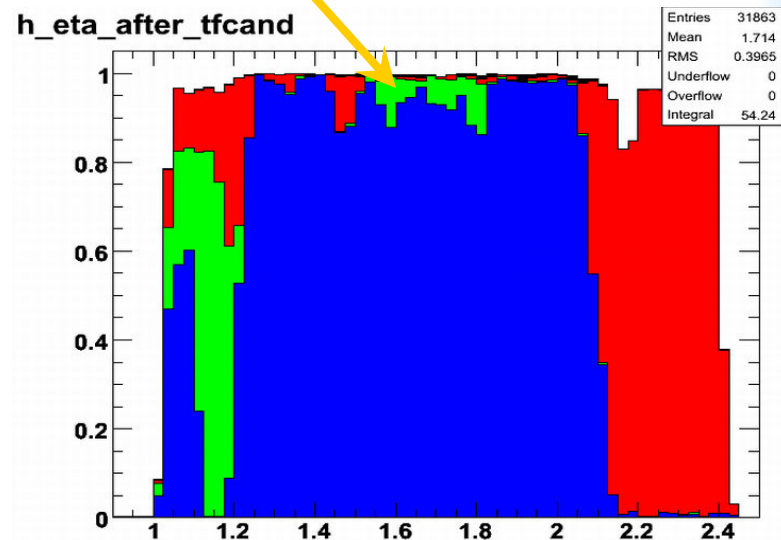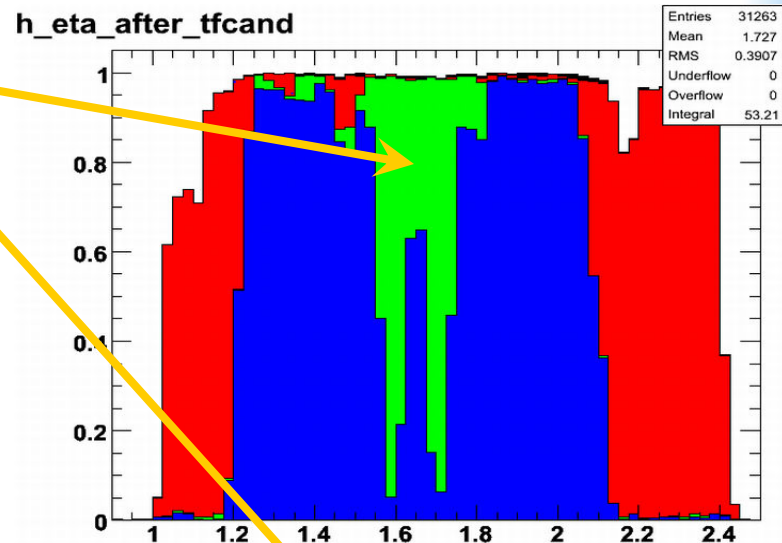
"Digital CFEB" cathode board

- **CSC principle: digitize cathode charges to ~1%, interpolate for fine position**

- **Current CFEB: the ADC is multiplexed 16:1**
  - **Requires analog charge storage ASIC (SCA)**
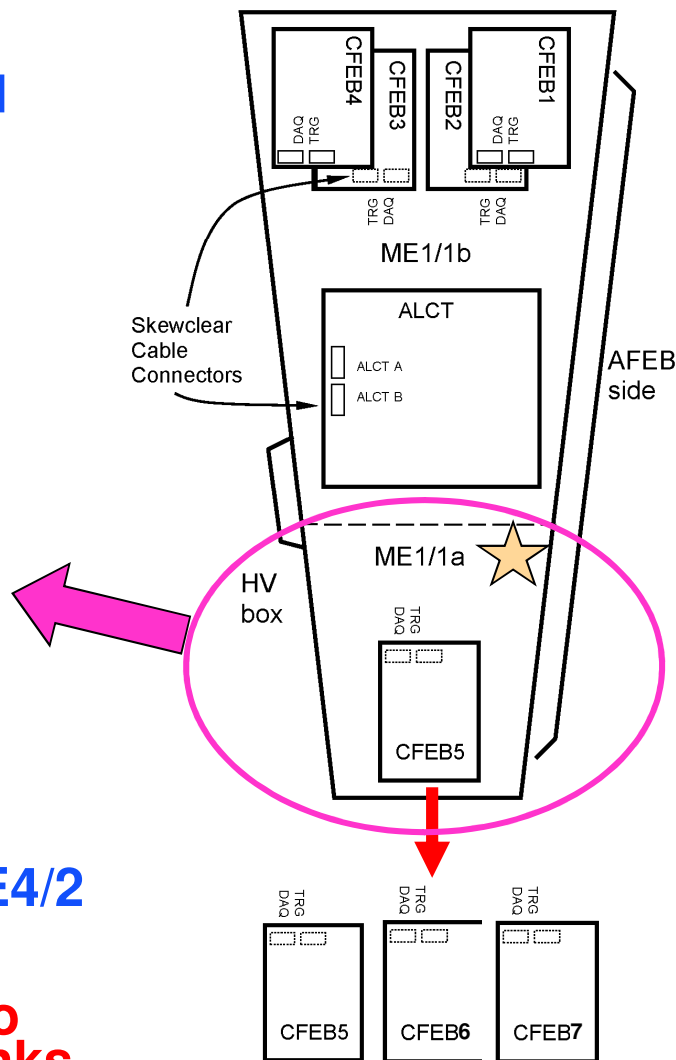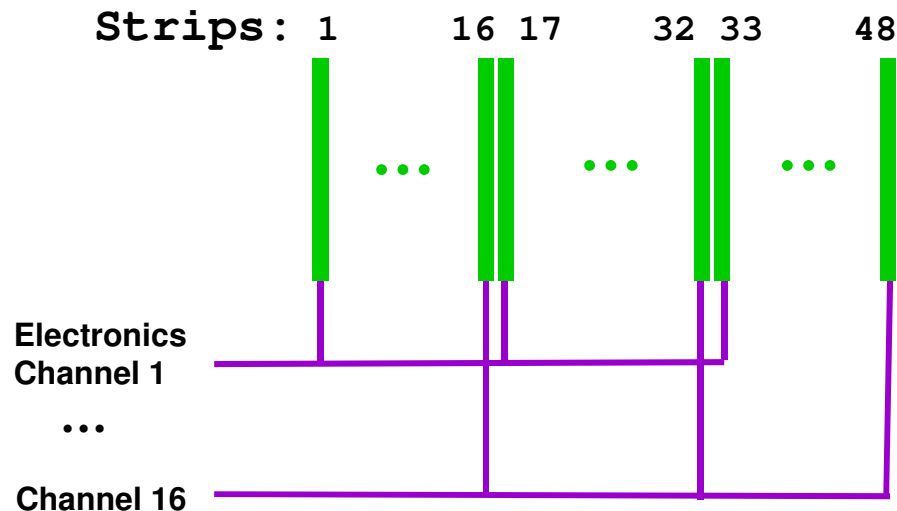 - **Serial digitization after L1A**
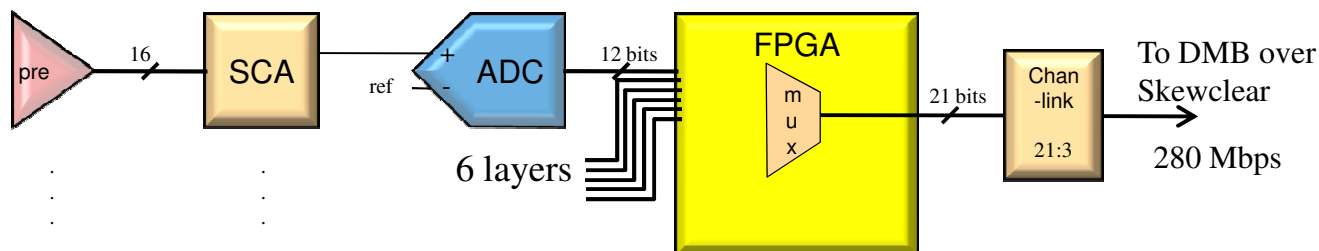
- **Digital CFEB uses Flash ADCs:**
  - **Continuous and deadtimeless digitization**
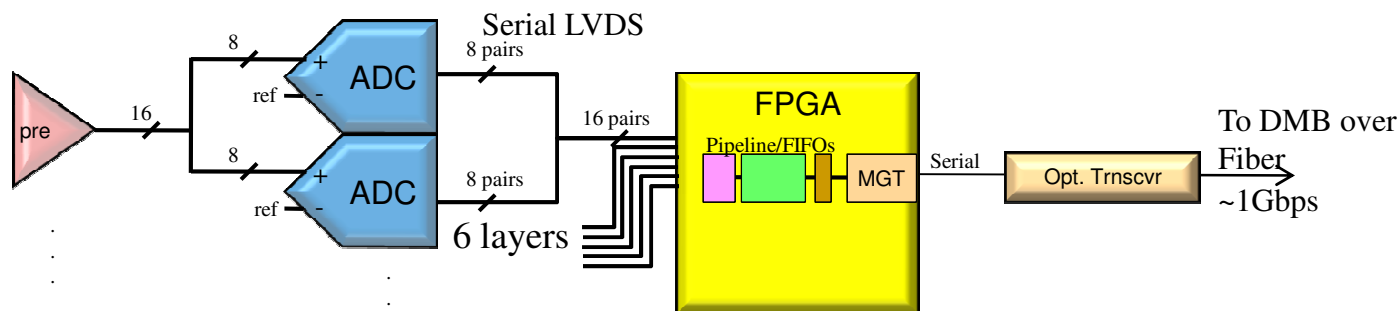
ME1/1 Restoration of η 2.1-2.4

- ## High-η section of ME1/1
  - ### Cathode strips are currently ganged 3:1

- ## Plan:
  - ### Install DCFEB boards on ME1/1
  - ### Move existing CFEBs from ME1/1 to ME4/2
  - ### Takes ~2.5 months per endcap
  - ### 72 new TMB and DMB boards needed to accommodate additional inputs, optolinks

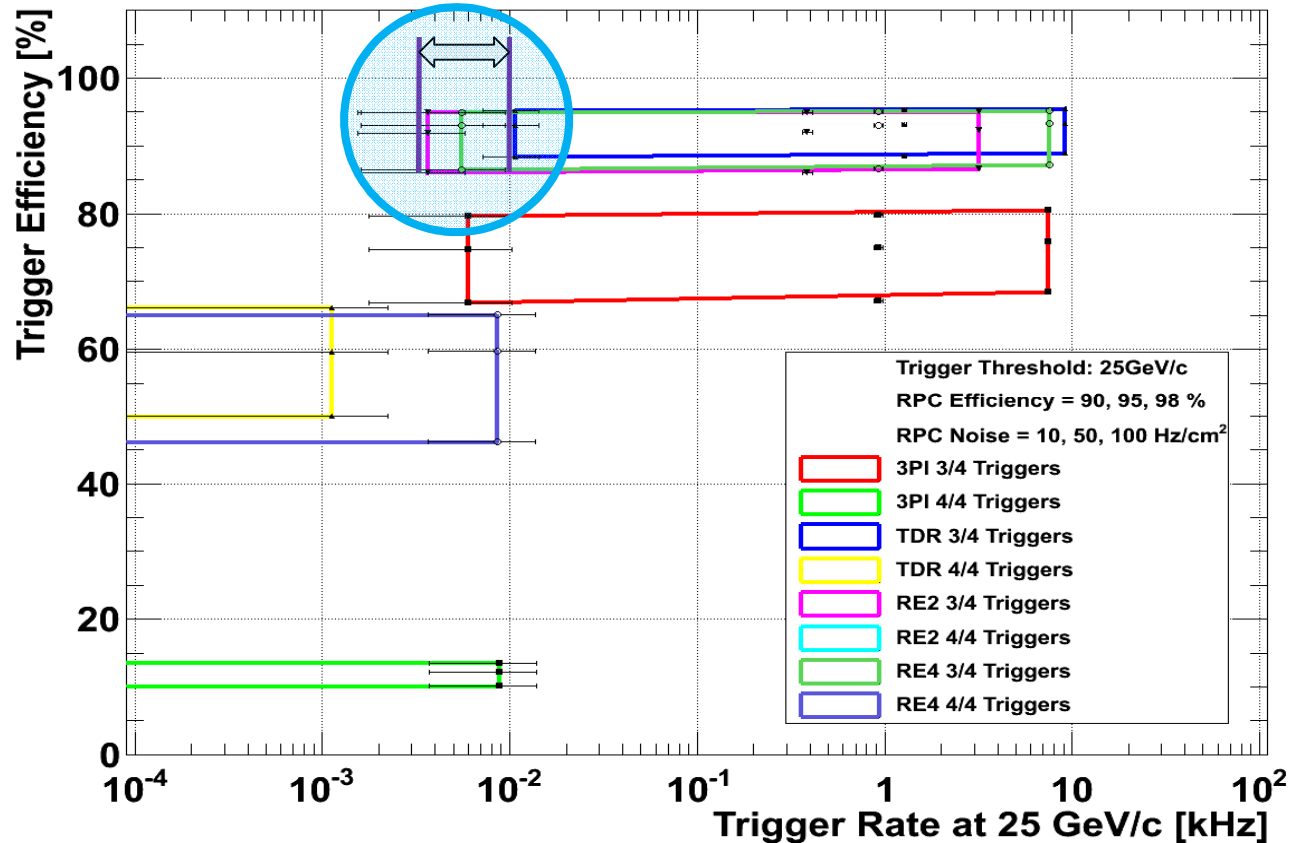| WBS	Task Name	Duration	2011	2012	2013	2014
1	**Emu ME4/2 upgrade**	**796 days**				
1.1	ME4/2 Procure mechanical parts and panels	260 days				
1.2	ME4/2 Panel production	390 days				
1.3	ME4/2 Chamber assembly and shipping	455 days				
1.4	ME4/2 Procure electronics parts (non-CFEB)	325 days				
1.5	ME4/2 Produce electronics boards (non-CFEB)	325 days				
1.6	Pre-production DCFEB	260 days				
1.7	ME4/2 Final assembly and test (FAST) at CERN	390 days				
1.8	Procure DCFEB parts	260 days				
1.9	Produce DCFEB boards	325 days				
1.10	Ready for start of ME4/2 chamber installation	0 days			3/29	
1.11	Installation of ME4/2 chambers (earliest date)	15 days				
1.12	Cabling and services for ME4/2 (earliest date)	65 days				
1.13	(Upgrade of ME1/1 with DCFEB, earliest date)	130 days				
1.14	Install CFEBs on ME4/2 chambers (earliest date)	15 days				

ME4/2 Upgrade Schedule

t_0 + 0 months	CD2 approval, money flows, begin work on Bldg 904
t_0 + 3 months	orders sent out for all parts
t_0 + 6 months	production tooling shipped to CERN and assembled in Bldg 904
t_0 + 9 months	chamber parts delivered, shipped to CERN
t_0 + 12 months	production begins at Bldg 904 at 2 CSCs/month
t_0 + 15 months	production ramps to 4 CSCs/month
t_0 + 18 months	FAST site begins assembly & testing at CERN (Bldg 904?), spare CFEB boards installed on ME4/2s
t_0 + 24 months	42 CSCs finished and tested -- ready for installation of 1st endcap, recover 200 CFEB boards from ME1/1s
t_0 + 33 months	all 76 CSCs finished
t_0 + 36 months	final 36 chambers ready for installation on 2nd endcap

Full Endcap (Towers 8 – 16 == 1.04 < η <2.10)

Slightly better (lower) Trigger Rate for RE2bis, but not as high as expected w.r.t. the simulation of a fully independent 5th plane.

Is this worth the effort?