

ATLAS upgrade (part 1)

calorimétrie et spectromètre à muons

calorimetry and muon spectrometer



ID: see Giovanni talk

- Introduction
- Calorimetry upgrades (EM + Had)
- Muon spectrometer upgrades
- TGIR
- Conclusion

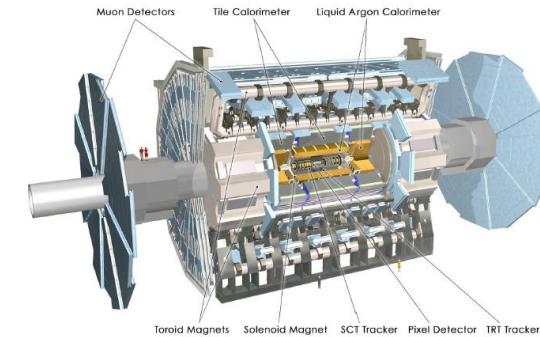
Philippe Schune
(IRFU, CEA-Saclay)

- “HL-LHC”: see Laurette Ponce talk
- “Physics”: see talks from A.Nisati, Juan Alcazar, Ch.Grojean

More information:

- B.Trocme (CS IN2P3, juin 2012)
- I.Wingerter-Seez (Atlas w., 02/2013)
- LoI Atlas Phase-II upgrade (12/2012)





ATLAS

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(also ID upgrade)

Engagez-vous !!
Rengagez-vous !

LPNHE
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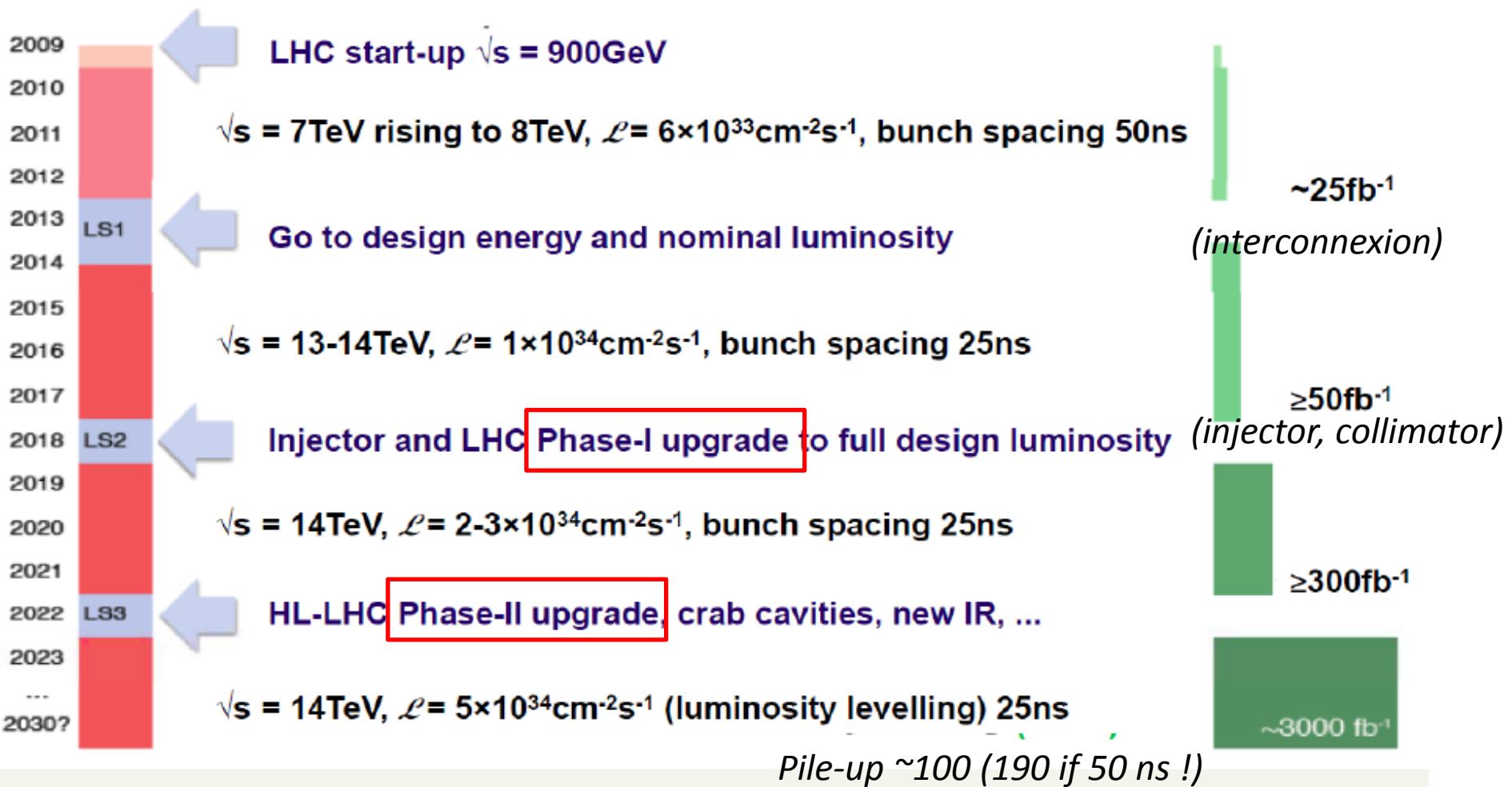
lapp

IPNL

LPSC
Grenoble

Irfu
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Introduction: (HL-)LHC planning



Introduction: ATLAS upgrade planning

Phase-0 (2013+2014, LS1):

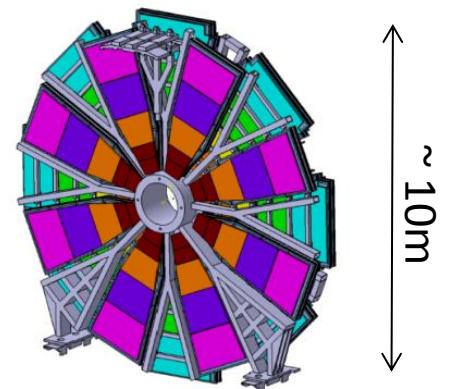
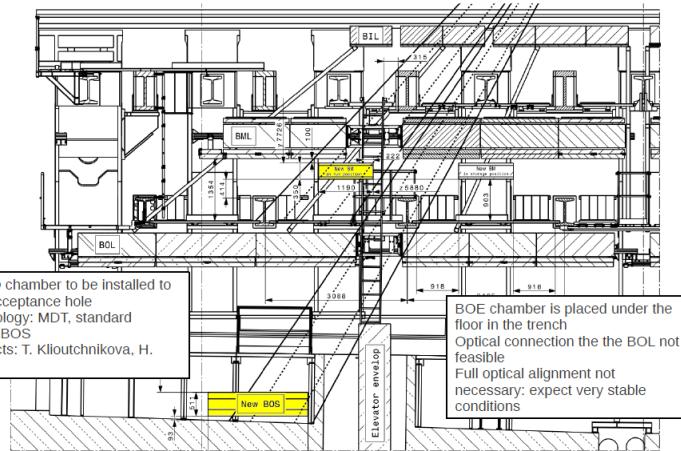
- IBL
- Detector completion (eg muon elevator region, etc.)
- LAr trigger demonstrator in view of phase-I (~2% of total)



LAr

Phase-1 (2018 +2019?, LS2):

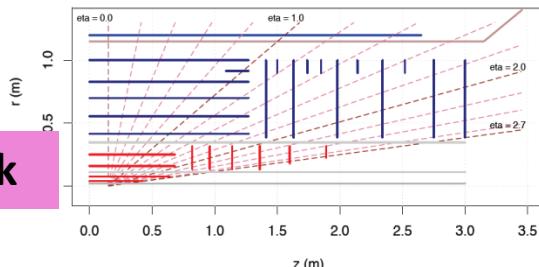
- LAr new trigger (full)
- Muon **New Small Wheel** (MicroMegas+TGC technology)
- New very forward detector (~210m from IP)



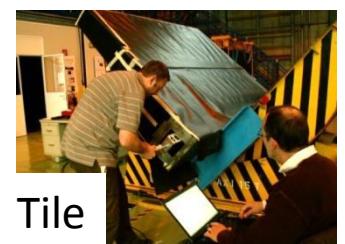
Muon New Small Wheel

Phase-2 (2022 +...?, LS3):

- New ID (full Si) detector
- New front end elx (LAr - 700fb^{-1} max- and had. tile)
- New front end elx of muon system

 300 fb^{-1} 

ID: see Giovanni talk



Introduction: why do we need to upgrade detectors?

***Still working with low threshold (~20GeV) -like for Atlas
design- and continue to trigger even with high (~100) pileup***

=> 3 upgrade families:

- Coming from trigger (saturation)
- Coming from ageing (to high radiation ~10 kHz/cm²)
- Coming from combinatorial (inner gaseous tracker TRT)

All combination are possible, e.g. muon NSW : trigger + ageing.

Global cost of ATLAS upgrade I + II :

230 up to 280 M-CHF (~190 up to 230 M-euros)

Trigger rate:

Today	/ Phase-I	/ Phase-II (more information)
(for an equal split between different trigger families)		
L1 : ~75 kHz	/ ~100 kHz (latency 2,5 µsec)	/ ~200 kHz (two stage trigger 6 µsec + 20 µsec latency)
L2 : ~3.5 kHz max	/	
EF : ~200 Hz max	/	HLT ~ 5kHz

Introduction: why do we need to upgrade detectors?

**Still working with low threshold ($\sim 20\text{GeV}$) -like for Atlas
design- and continue to trigger even with high (~ 100) pileup**

=> 3 upgrade families:

- Coming from trigger (saturation)
- Coming from ageing (to high radiation $\sim 10 \text{ kHz/cm}^2$)
- Coming from combinatorial (inner gaseous tracker TRT)

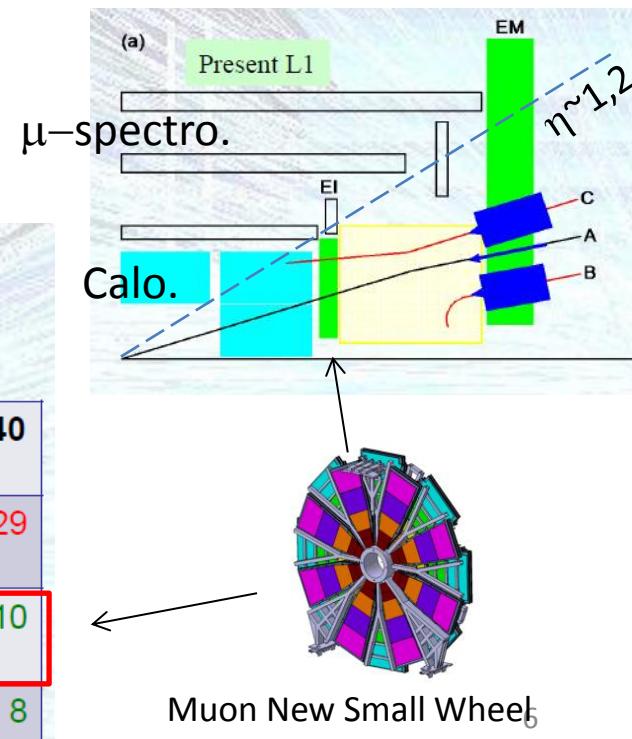
Present muon (EC) L1 trigger saturated by fake muon (only $\sim 5\%$ are real $>20\text{GeV}$ muon)

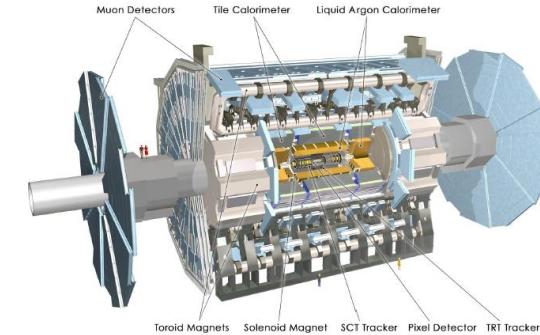
All combination are possible, e.g. muon NSW : trigger + ageing.

L1 : $\sim 75 \text{ kHz}$ max
L2 : $\sim 3.5 \text{ kHz}$ max
EF : $\sim 200 \text{ Hz}$ max

	Mu20	Mu40
Without NSW	60	29
With NSW	22	10
NSW + phase-0	17	8

06/04/2013





ATLAS upgrade (part 1)

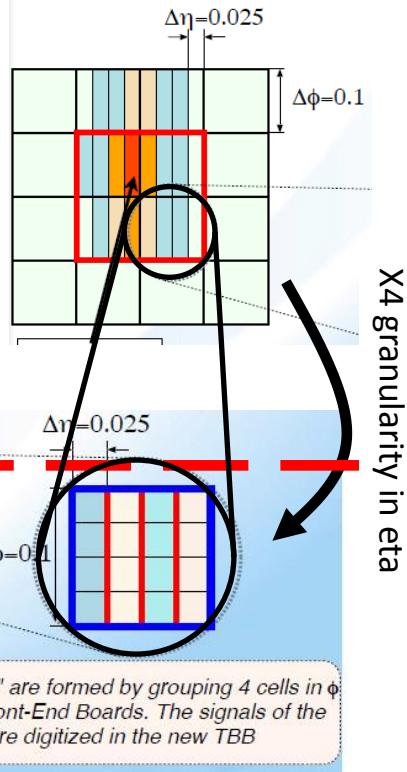
calorimétrie et spectromètre à muons

calorimetry and muon spectrometer

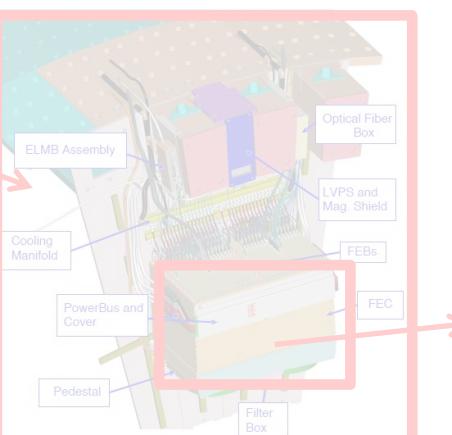
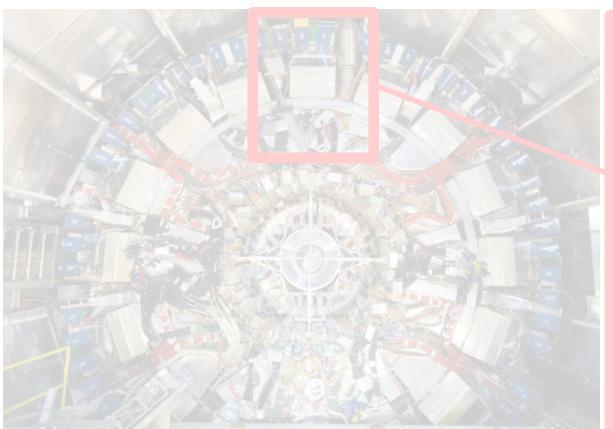
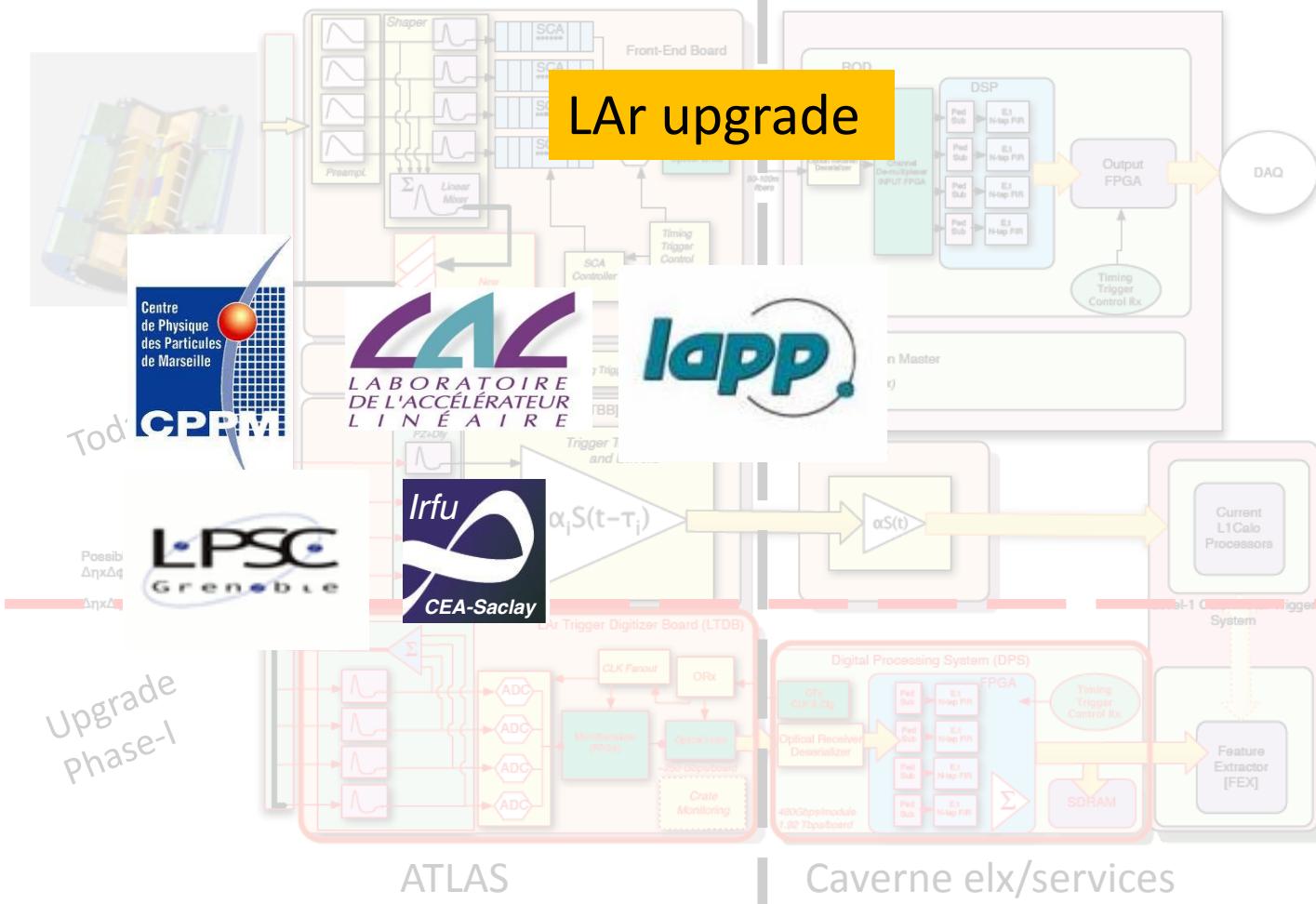


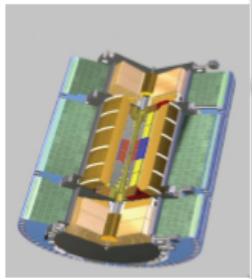
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- Conclusion

Phase-I goal: have full cell granularity (η , ϕ) at trigger level:



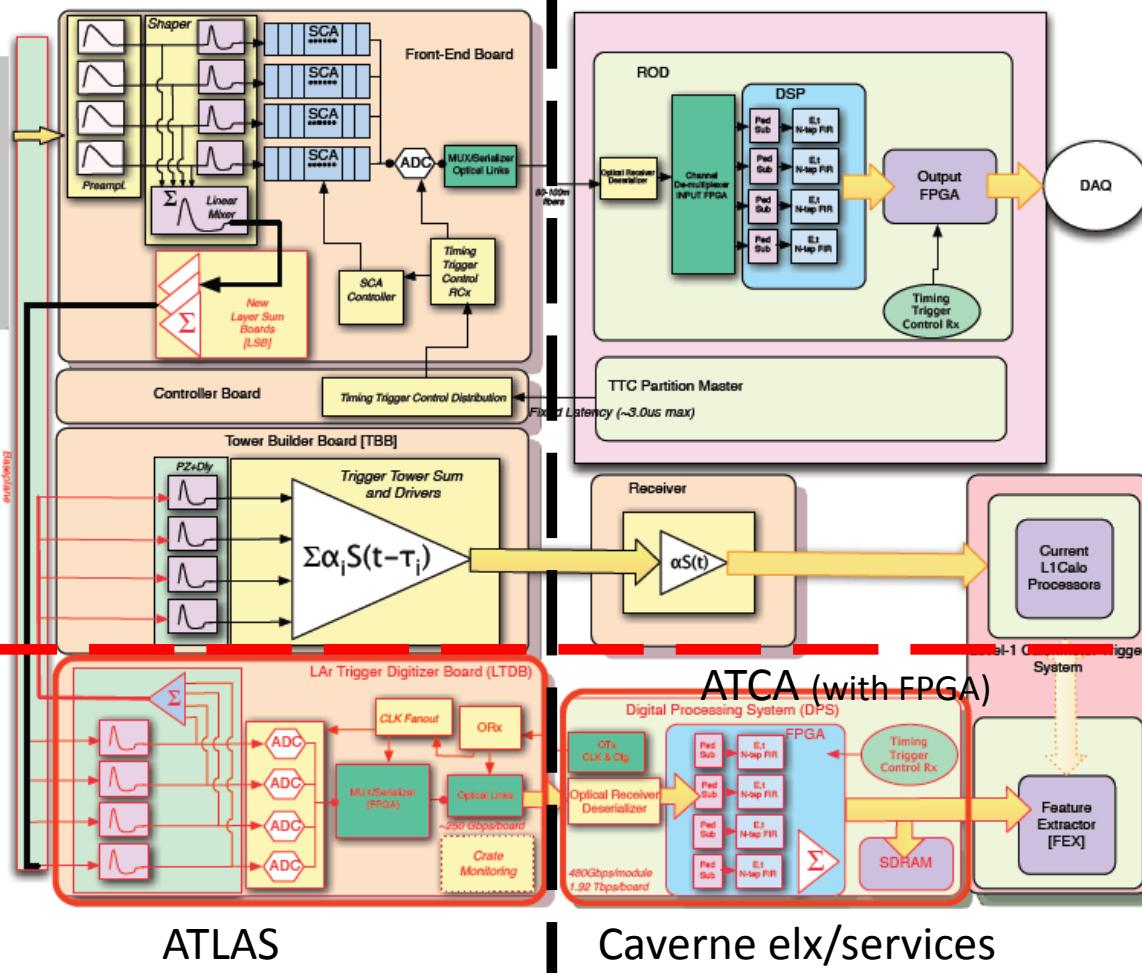
LAr upgrade



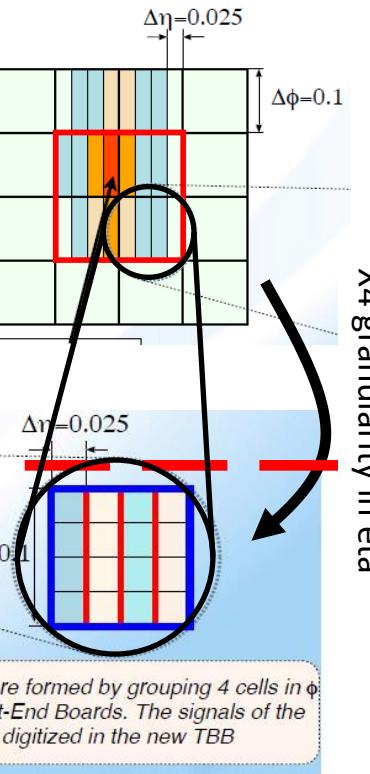


Today

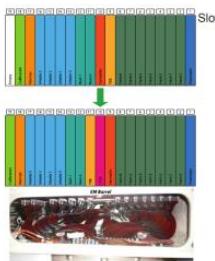
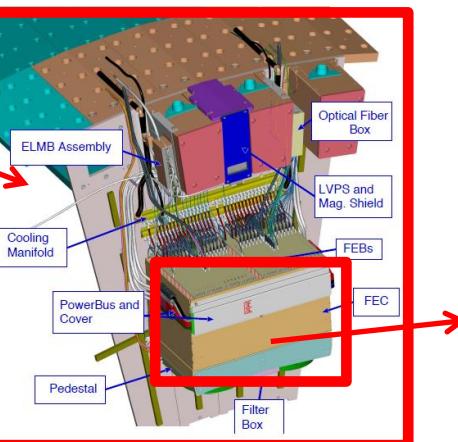
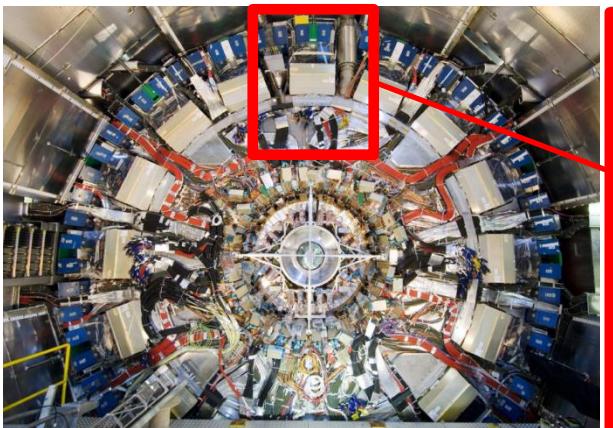
Upgrade
Phase-I

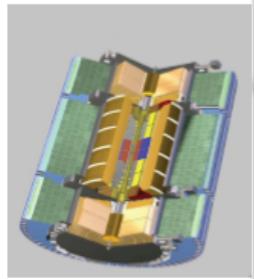


Phase-I goal: have full cell granularity (η , ϕ) at trigger level:



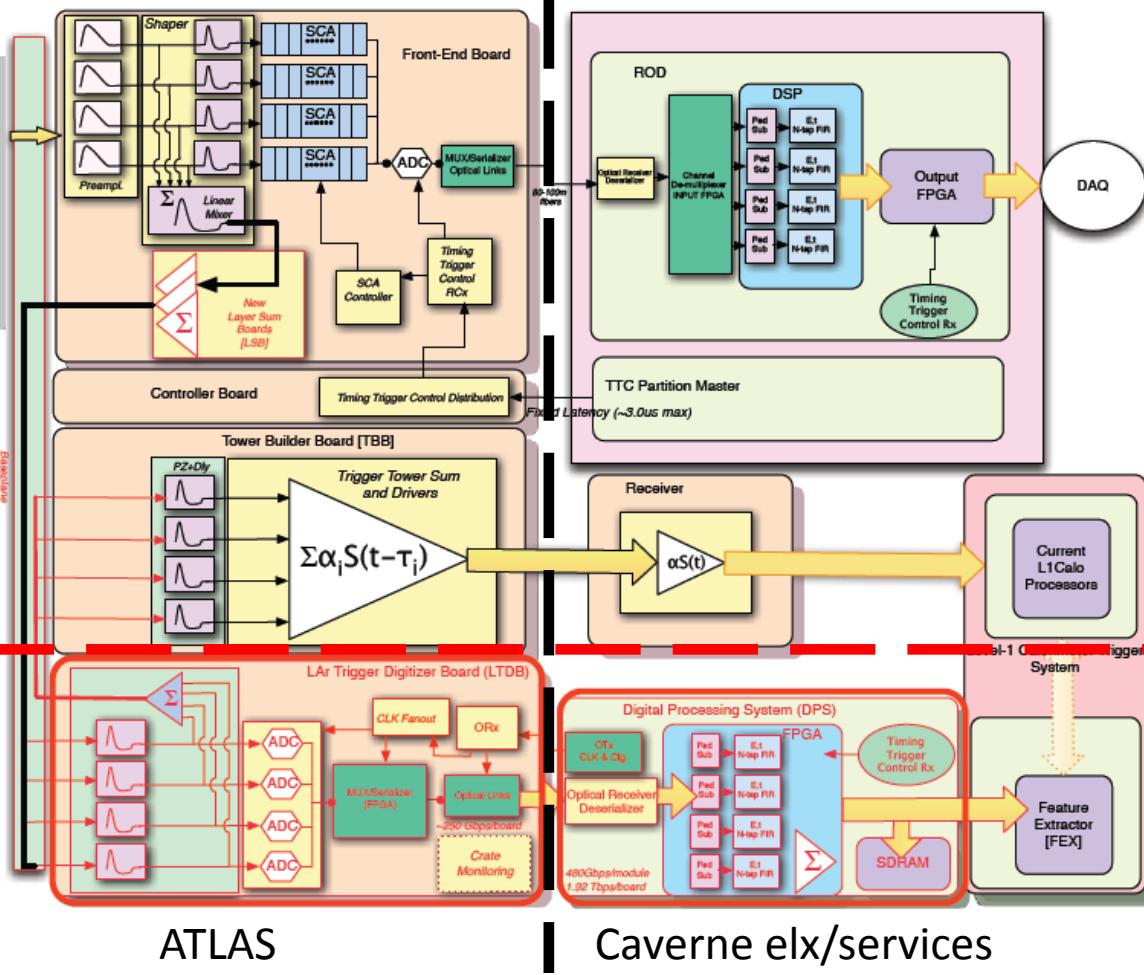
Gain rate L1 : ~1/3



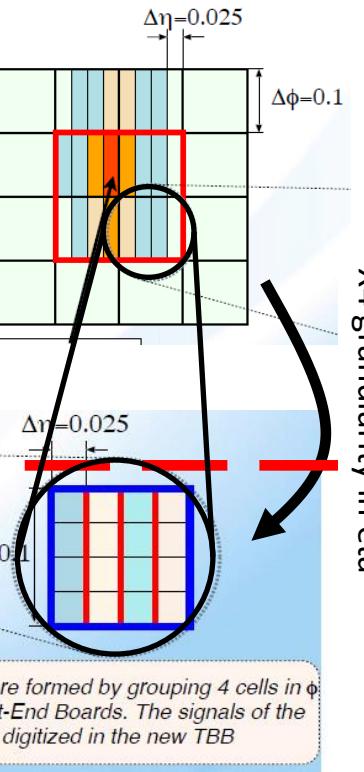


Today

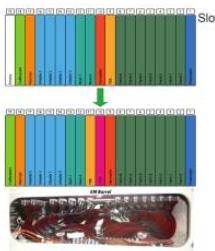
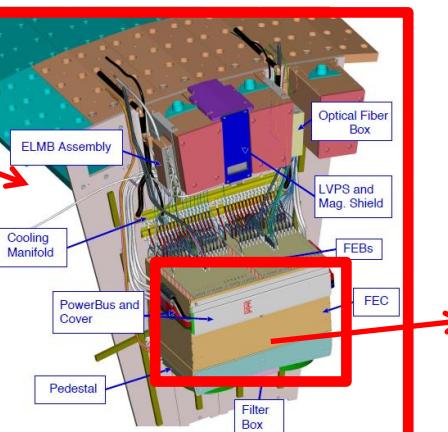
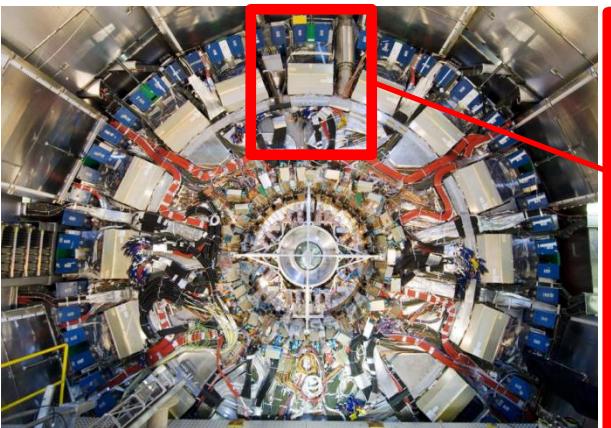
Upgrade
Phase-I



Phase-I goal: have full cell granularity (η , ϕ) at trigger level:



Gain rate L1 : ~1/3

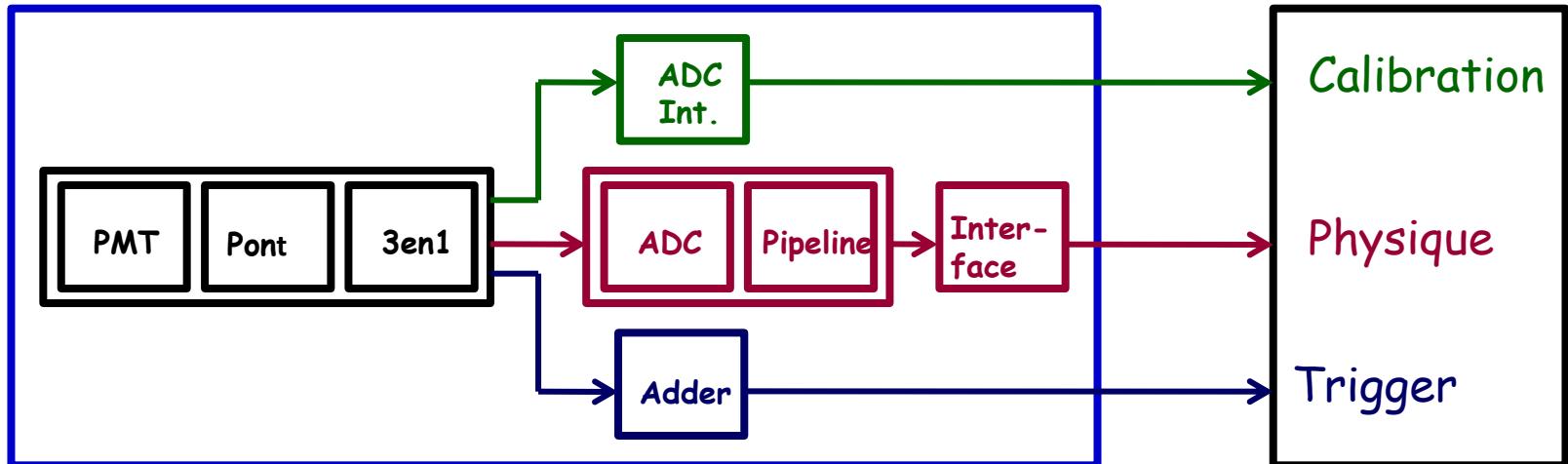


Phase-II: change all front elx (ageing -design for 700fb^{-1} -, full (continues) digital readout (no more pipeline))

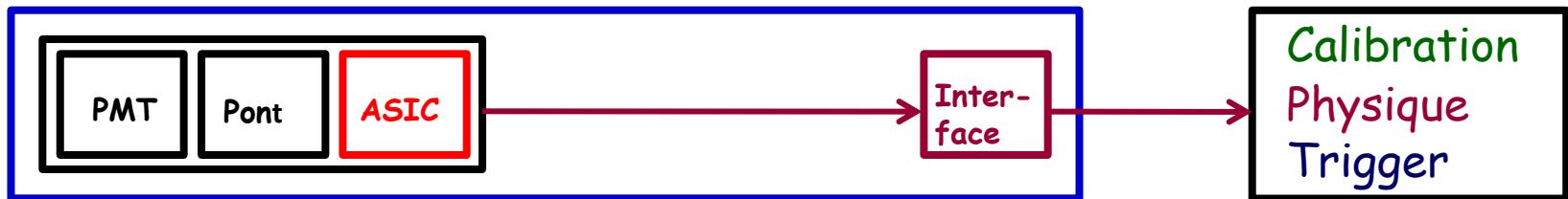


Phase-II upgrade: Had Cal (Tile)

Today



Ideal new scheme

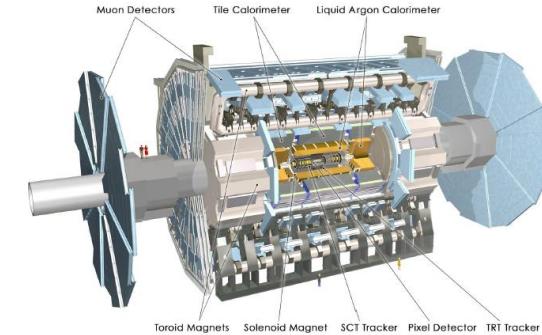


- TileCal phase-II like LAr, goal is to have a higher trigger granularity
- Also full replacement of front end elx
- All functionalities within one component (**LPC proposition**):
 - Calibration signal
 - Continues readout (40 MHz)
 - High-Lumi increases inter-dynode current => new divider design
(to maintain non-linearity at 0.1% level, otherwise more than 4%)

New mechanical “drawers” (*super-tiroir*)

Demonstrator in 2014





ATLAS upgrade (part 1)

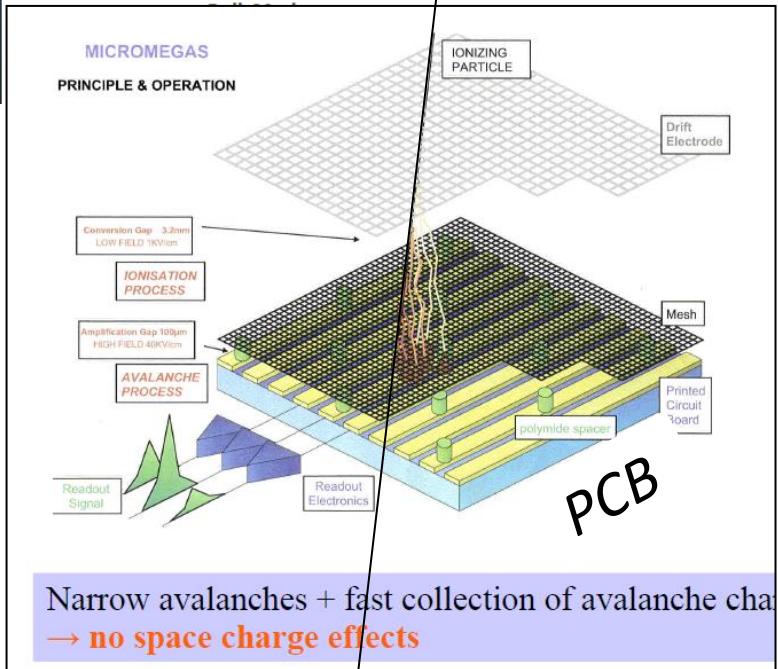
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μ

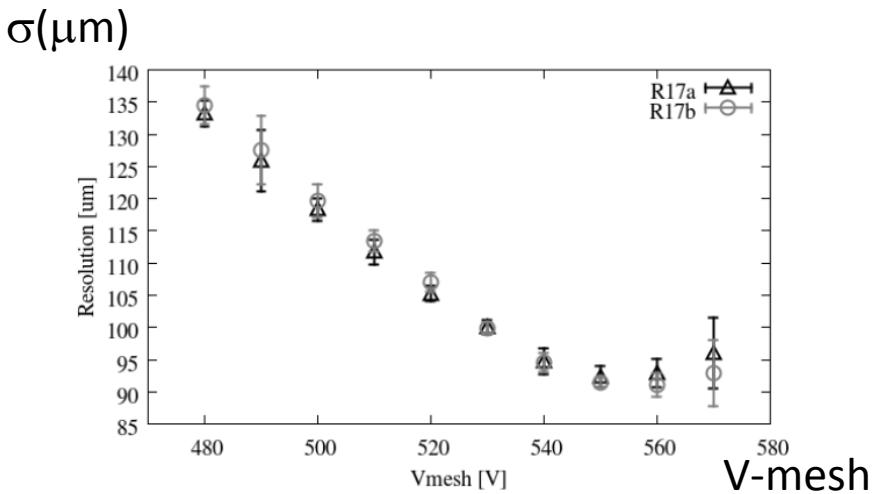
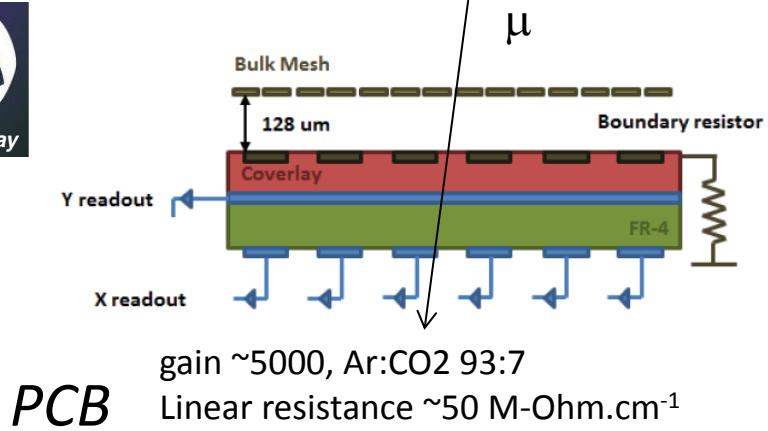
Muon New Small Wheel



Requirements:

- ~1200 m² of sTGC + MM (10x10cm² in 2011)
- Multilayer detector (2x4)
- Resolution : <100 microns
- **Mechanical precision: 40 μm (plan) ~100 μm (⊥)**
- Trigger L1
- Ageing (n, X-ray, gamma, alpha...)





Plan resolution after ageing
(n-th, X, gamma, alpha: >10 ans HL-LHC)

Muon New Small Wheel

Requirements:

- ~1200 m² of sTGC + MM (10x10cm² in 2011)
- Multilayer detector (2x4)
- Resolution : <100 microns
- **Mechanical precision: 40 μm (plan) ~100 μm (⊥)**
- Trigger L1
- Ageing (n, X-ray, gamma, alpha...)



Muon spectrometer upgrade phase-II

No French Lab in these developments.

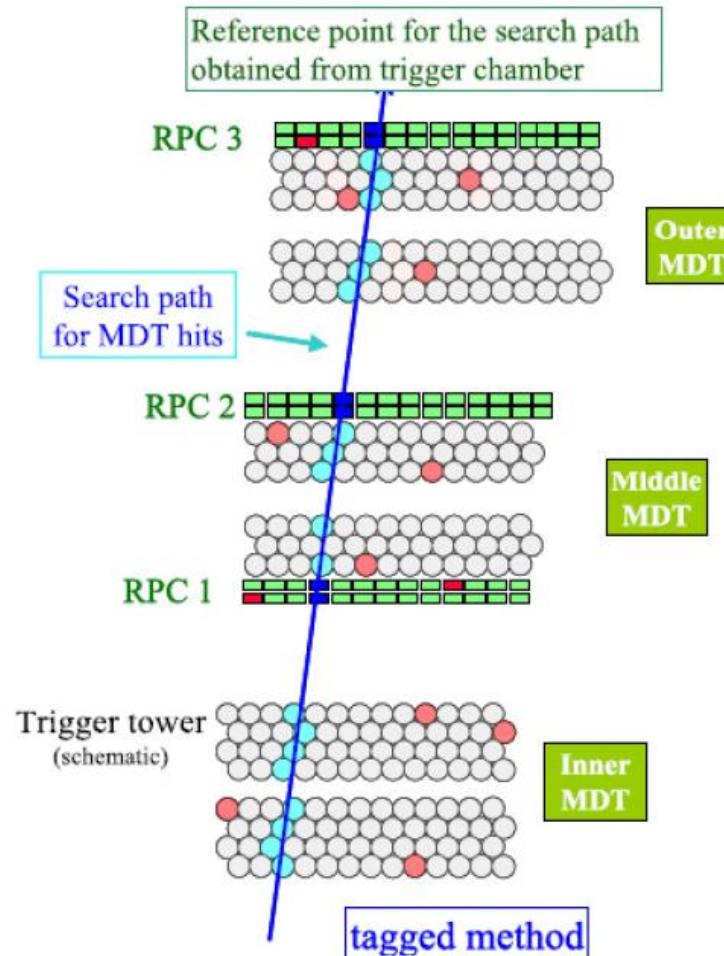
Goal is to have Phase-II L1 as precise as present L2.

RPC strip pitch is 3 cm (in Barrel)
MDT diameter is 3 cm

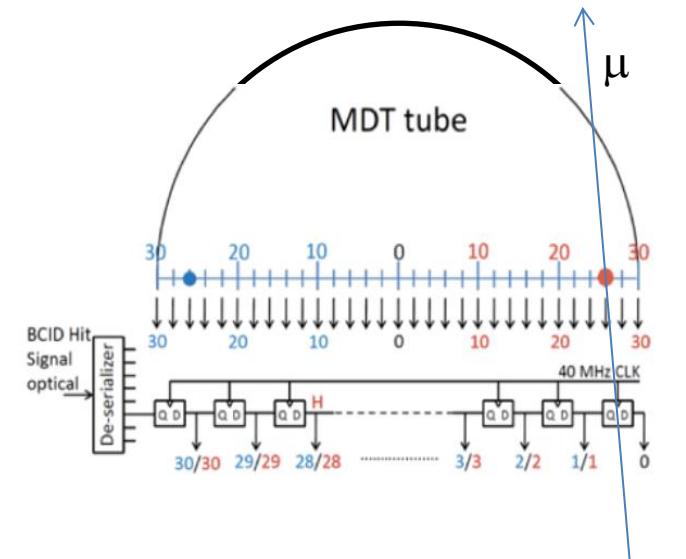
RPC:

New elx to cope to higher latency and rates.

Also possibly have RPC trigger in USA15 using dedicated FPGA (rather than specific ASIC).

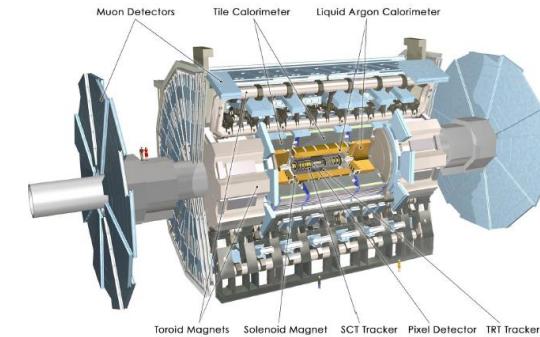


MDT:



~0,5mm resolution
possible in (new) L0 6 μ s latency

Also Track Trigger to
improve EM trigger



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Cost / TGIR

<i>Item</i>	CORE cost (MCHF)	Possible additions	2015	2016
New Inner detector	131.500	26.000	2.400	5.60
LAr Calorimeter upgrades	32.124	15.096	0.547	3.17
Tile Calorimeter upgrades	7.483	2.517	0.000	0.00
Muon spectrometer upgrades	19.632	0.500	0.100	0.27
Trigger and DAQ upgrades	23.315	0.900	0.000	0.07
Common Fund	16.280	0.000	0.000	0.10
Total (MCHF)	230.334	45.013	3.047	9.22

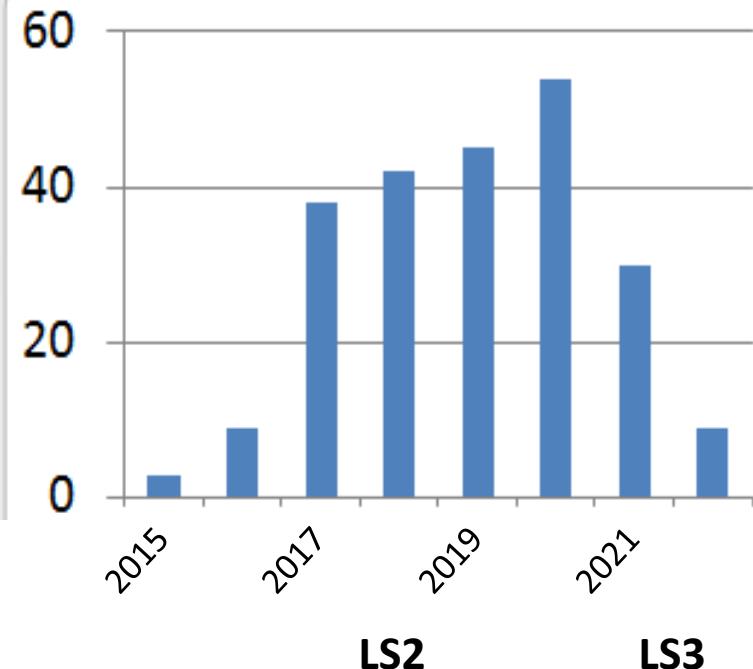


Table 10.18: CORE Cost table

Upgrade: Phase-1 projects

#	Project	<i>Letter of Intent presented and approved by LHCC</i>	<i>Initial Design Review</i>	<i>Kick-off meeting</i>	<i>CB approval</i>	<i>TDR due</i>	<i>LHCC Session</i>	<i>I-MOU needed</i>	<i>MOU-due for signature (RRB)</i>
1	FTK	21-Mar-12	2-Dec-10	3-Dec-10	24-Jun-11	30-Apr-13	11-Jun-13	yes	15-Oct-13
2	nSW	21-Mar-12	29-Aug-12	31-Aug-12	5-Oct-12	31-May-13	11-Jun-13	not clear	15-Oct-13
3	LAr	21-Mar-12	9-Jan-13	11-Jan-13	8-Feb-13	15-Sep-13	24-Sep-13	not clear	15-Oct-13
4	TDAQ	21-Mar-12	21-Jan-13	23-Jan-13	8-Feb-13	15-Sep-13	24-Sep-13	not clear	15-Oct-13
5	AFP	21-Mar-12	17-Sep-12	19-Sep-12	2014	2014	2014	yes	14-Oct-14

+ detailed cost estimation

French TGIR (prospect activities 10-20 years)

Main goals of Large French Research Infrastructures (TGIR) in our field:

- Provide a First level position for French activities (*position d'excellence*)
- Help developing new technology realisation
- Push for science and scientific career interest

For our field:

- HL-HLC and detectors (HE-LHC mentioned), followed by ILC or CLIC (TLEP not mentioned)
- massive computing (CC-IN2P3 centre)

Both French and European reports mention that first large project was developed for high energy physics community.

[...] ***It was at CERN that the idea of Research Infrastructures first dawned on the research community. [...] birth of the internet [...]***

Could we conclude that we may get automatically our TGIR ticket ? NO !

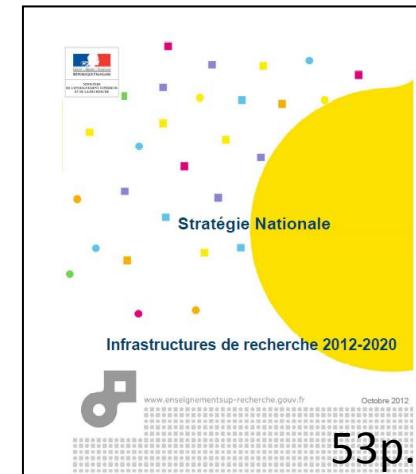
Present “request:available” ratio is ~1.7:1 (?)

We should produce our file/dossier :

- TDR (one per system, most in May 2013)
- Development plan (+ organisation)
- **Industrial partner** (e.g. muon NSW: R&D with industrial partners: ELVIA (France) and ELTOS (Italy), PCB companies). Already some resources through ANR. *Try join labs + regional grants ?*
- Clear physics case (see next morning session)

OBJECTIF DES T.G.I.R.

Susciter d'importantes avancées technologiques en favorisant la créativité des scientifiques et en proposant un environnement propice aux recherches les plus ambitieuses. La France est un des pays les plus avancés dans ce domaine.

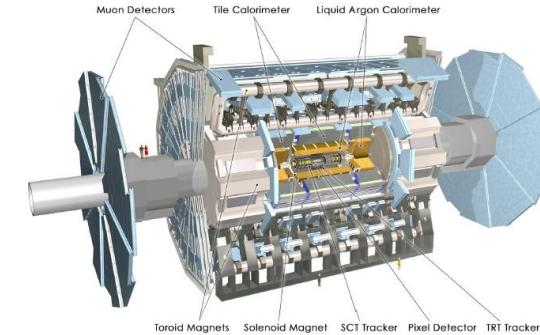


53p.

ESFRI (Eur. Strategy Forum on Research Infrastructures) end 2010 ; updated in 2015.



84p.
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Calo Had. (HCal)

Conclusions



Calo EM (LAr)



These upgrade programs are *mandatory* for working in good conditions with high radiations and pile-up at HL-LHC (with pt trigger as before).

Upgrade needed already for Phase-I: trigger LAr, muon-NSW (new detector technology: Micromegas)

Upgrade Phase-II: calorimeters (EM+Had) readout

Even if French community is already deeply involved in ATLAS upgrades, you are welcome to join the projects! (*qualification task for students*)

Today, Saclay-IRFU is more involved in Phase-I and IN2P3-labs more in Phase-II.

Requested Core investments are: IN2P3: ~14,5 M-euros (+/-) and IRFU-Saclay: ~# to 6 M-euros (+/-).

End of this year, our file/dossier in good shape for a TGIR request:

physics case / TDR / cost evaluation / development plan / **industrial partners...**

(presentation foreseen in May in Brussels during European Ministers “competitiveness” meeting)

Not mentioned: muon spectrometer completion (=> alignment!)

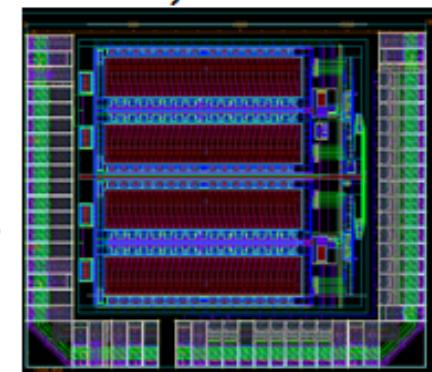
- last chambers installation (MDT)
- elevator regions (sMDT+(m)RPC)
- Barrel/end-cap transition trigger coverage (?) (mRPC)
- Toroid Feet region (?) (sMDT)

Rab / spare...

I

Calorimétrie LAr : numériseur pour carte LTDB

- Spécifications drastiques:
 - Haute fréquence (40MS/s) et faible latence (<70ns).
 - Grande gamme dynamique (12 bits).
 - Résistance aux radiations et faible consommation (<70mw/canal).
- Développement par LPSC d'un composant dédié à ce contexte:
 - Architecture SAR (successive approximation register) : faible latence (25ns) par design.
 - Nécessité de générer une horloge de $12 \times 40 = 480$ MHz localement. Rendu possible par technologie IBM 130nm (conseillée par CERN - tenue aux radiations éprouvée).
 - Premières simulations : consommation très modérée (30mW / canal).
- A venir:
 - Production d'un premier prototype prévue en aout 2012
 - Test à l'automne avant 2^{nde} production éventuelle à l'hiver.
 - Décision de la collaboration au printemps 2013.

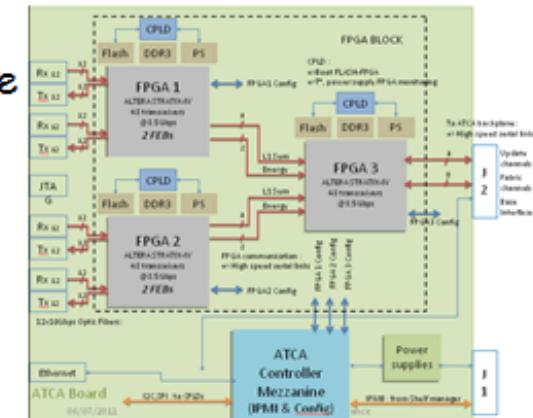


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I

Calorimétrie LAr : traitement du signal dans l'électronique déportée

- Implications de longue date du LAPP dans l'électronique déportée principale (ROD) et son futur remplacement de phase II:
 - Choix du standard ATCA (Advanced Telecom Computing Architecture) répondant à nos contraintes et pressenti pour devenir un standard CERN.
 - Carte dédiée ATCA pour tester fonctionnalités.
 - Carte mezzanine de contrôle IPMI (aussi adoptée par LHCb).
 - Carte « ROD evaluator » en cours de production pour tester les transferts rapides en entrée et sur la carte.
- Conception d'une carte DPS de conception proche pour traiter signaux issus de LTDB:
 - Carte mezzanine (FPGA DSP) pour traitement du signal (extraction énergie des super cellules).
 - Souhait d'avoir la carte utilisée dans le démonstrateur prévu durant la phase 0.

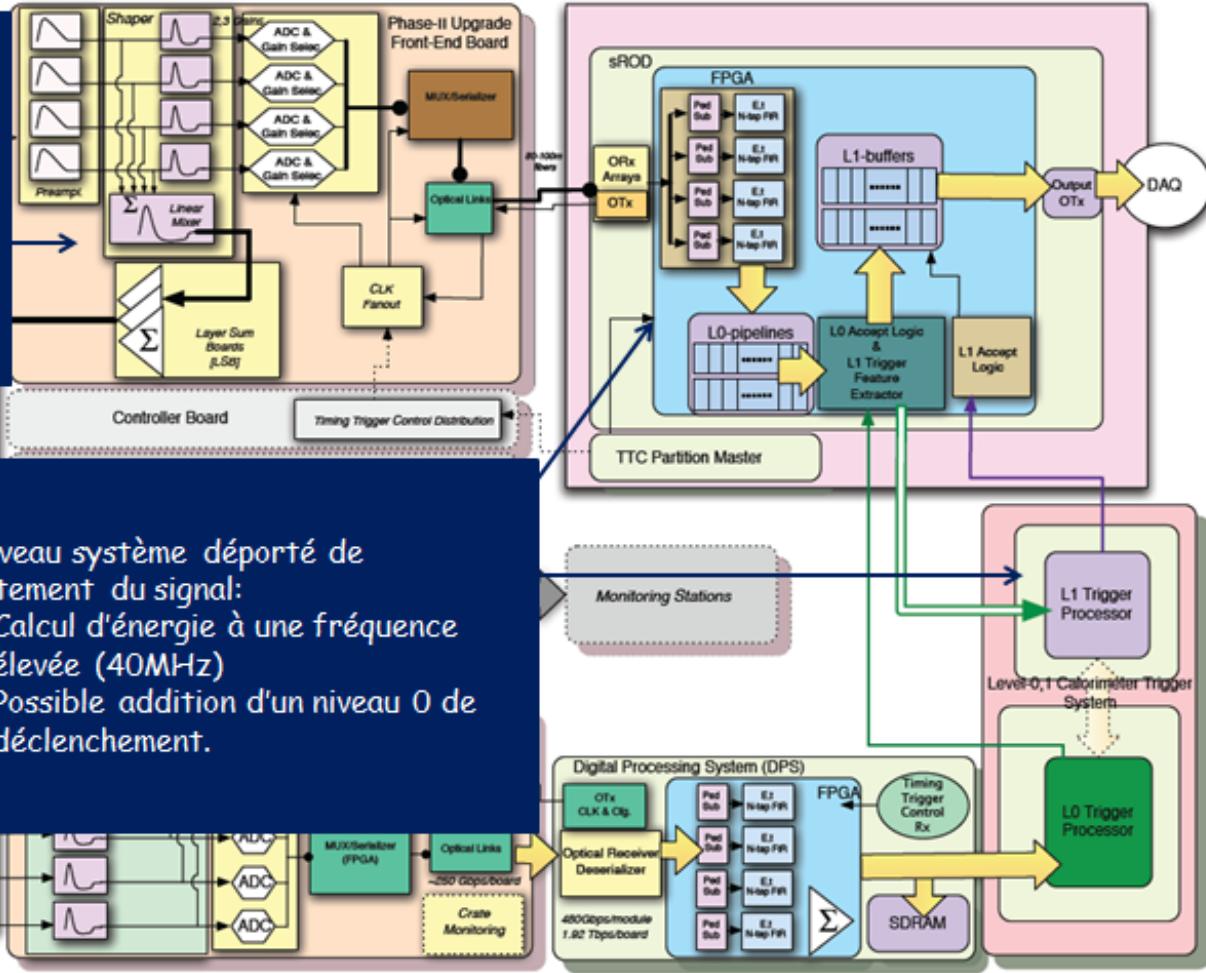


II

Calorimètre LAr : schéma de lecture envisagée pour la phase II

Nouvelle carte frontale de lecture:

- Gamme dynamique 16 bits (inchangée)
- Lecture continue (40MHz) des données.
- Plus de pipeline!



Nouveau système déporté de traitement du signal:

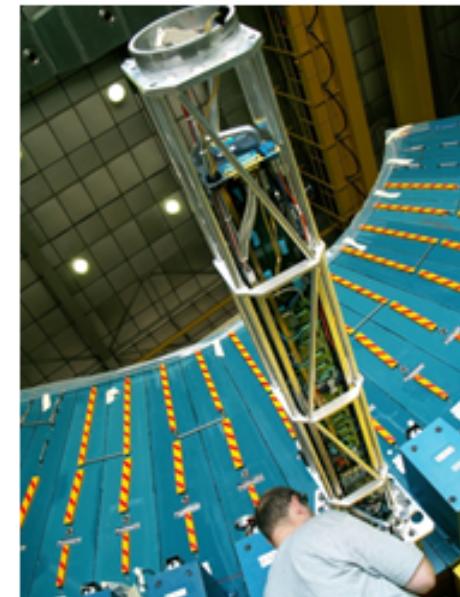
- Calcul d'énergie à une fréquence élevée (40MHz)
- Possible addition d'un niveau 0 de déclenchement.

II Calorimètre LAr : une continuation de la phase I

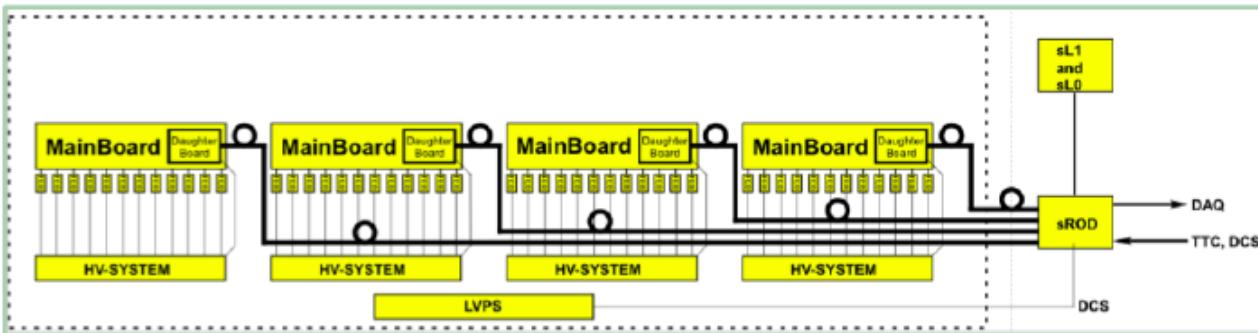
- Beaucoup de concepts/technologies explorés lors de la phase I:
 - Numériseur haute fréquence, grande gamme dynamique, faible consommation (LPSC).
 - Traitement déporté du signal à haute fréquence pour extraction de l'énergie (LAPP, CPPM).
- Autres expressions d'intérêt dans la continuité de l'expertise de construction originelle:
 - Conception de la nouvelle carte de lecture frontale (LAL).
 - Conception de la nouvelle carte de calibration (LAL, LAPP, LPSC).

Calorimètre à tuiles : mini tiroirs et alimentation haute tension

- Inconvénients des "super tiroirs" utilisés actuellement:
 - Dimensions importantes compliquant les manipulations.
 - Nécessité d'une certification globale de la structure.
- Proposition par LPC d'un remplacement par des mini tiroirs:
 - Premiers prototypes prometteurs sans problème apparent.
 - Validation finale en cours.
 - Impact sur le système d'alimentation haute tension, qui devra être remplacée de toutes façons.
- Validation de toutes les R&D dans le cadre des démonstrateurs:
 - 2012-2013 : module test en surface.
 - 2014-2017 : 1-4 modules de l'expérience équipés.



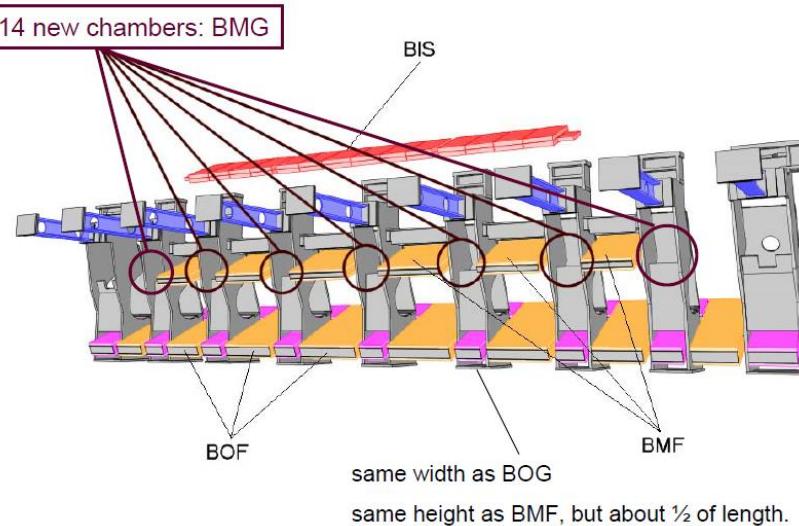
Tile Calorimeter



- Replace and upgrade readout system to meet new TDAQ architecture with full digital readout
- Front-End boards – three alternative designs under development
 - Final FE choice based on testbeam tests ~ 2014-2016
 - Improved robustness: cells are readout independently by 2 PMTs
- Power supplies
 - Voltage dividers capable of compensating for non-linear response due to high current flow
 - Upgrade LV supplies using low noise DC-DC convertors with radiation hard point-of-load regulation being developed by CERN
- Install first demonstrator in the pit in Spring 2014

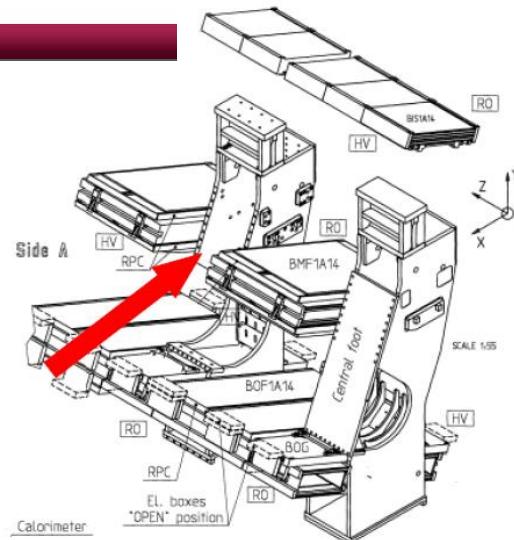
Upgrade of Sectors 12 and 14, BMF Layer

Extension of the coverage for 3-point track measurement
in the gaps between BMF chambers:



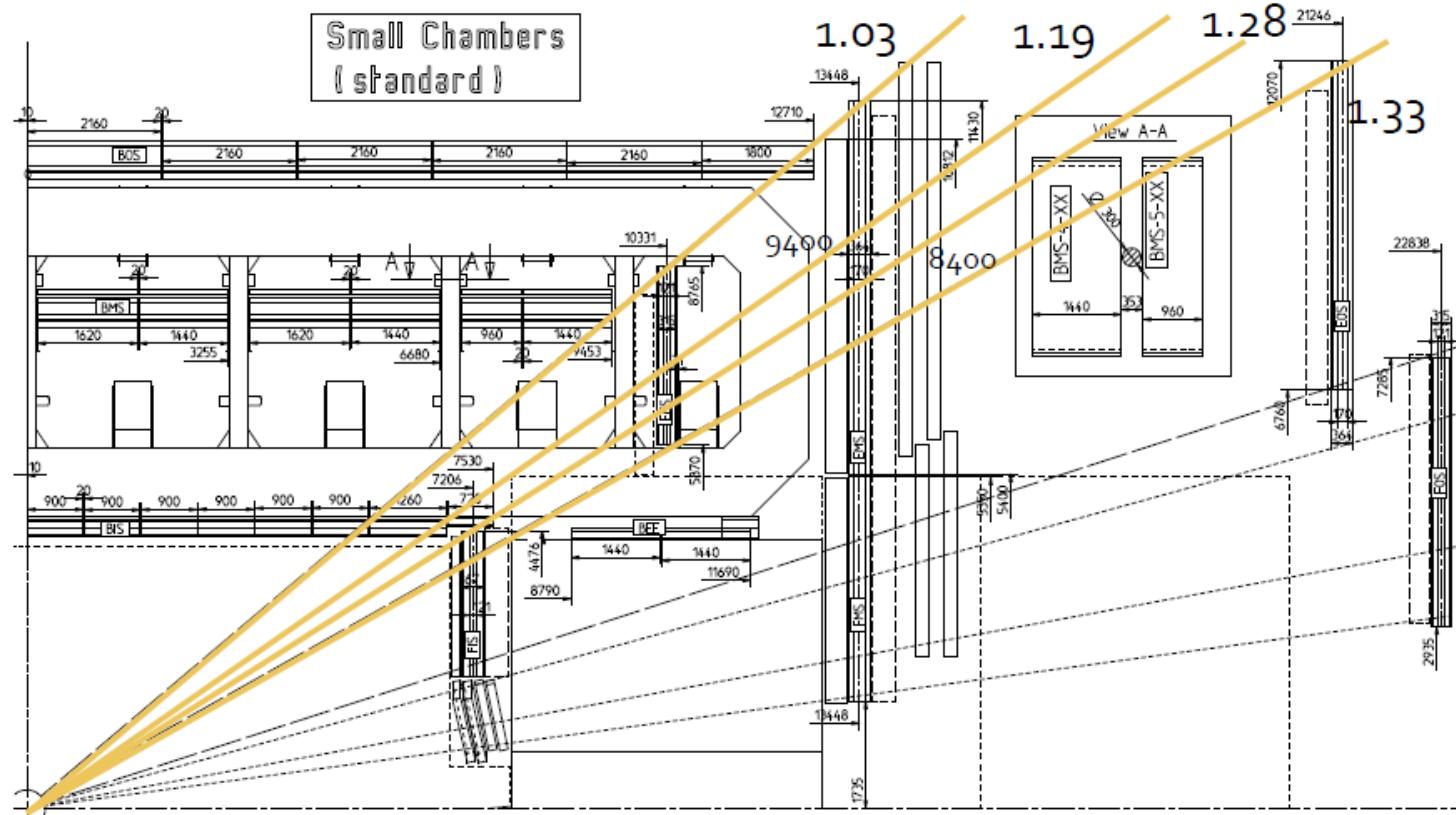
Installation

Inspection in the cavern indicates
ion should be feasible.



H.Kroha (MPI) March muon week

Photo by Ludovico P.



RPC trigger community proposition (march 2013) of BIS7-BIS8 coverage using mRPC chambers
 (should use thin chambers since space available is particularly reduced in these areas...)

Upgrade: Phase-1 projects

#	Project	Letter of Intent presented and approved by LHCC	Initial Design Review	Kick-off meeting	CB approval	TDR due	LHCC Session	I-MOU needed	MOU-due for signature (RRB)
1	FTK	21-Mar-12	2-Dec-10			2013	11-Jun-13	yes	15-Oct-13
2	nSW	21-Mar-12	29-Aug-12			2013	11-Jun-13	not clear	15-Oct-13
3	LAr	21-Mar-12	9-Jan-13			2013	24-Sep-13	not clear	15-Oct-13
4	TDAQ	21-Mar-12	21-Jan-13			2013	24-Sep-13	not clear	15-Oct-13
5	AFP	21-Mar-12	17-Sep-12	19-Sep-12	2014	2014	2014	yes	14-Oct-14

Crucial milestones:
 Jun/Sept LHCC
 ↓
 October RRB

FTK: approved at March 2012 CB; vertical slice tested parasitically in 2012-2013 run; simulation for TDR (physics case) on critical path

Muon New Small Wheels: approved at Oct 2012 CB; now following up on milestones, e.g. full size Micromegas ($2 \times 1 \text{ m}^2$), sTGC trigger demonstrator, etc. → TDR in May

LAr (higher-granularity readout for trigger): IDR and kick-off in January; approved by EB → for endorsement at Friday CB

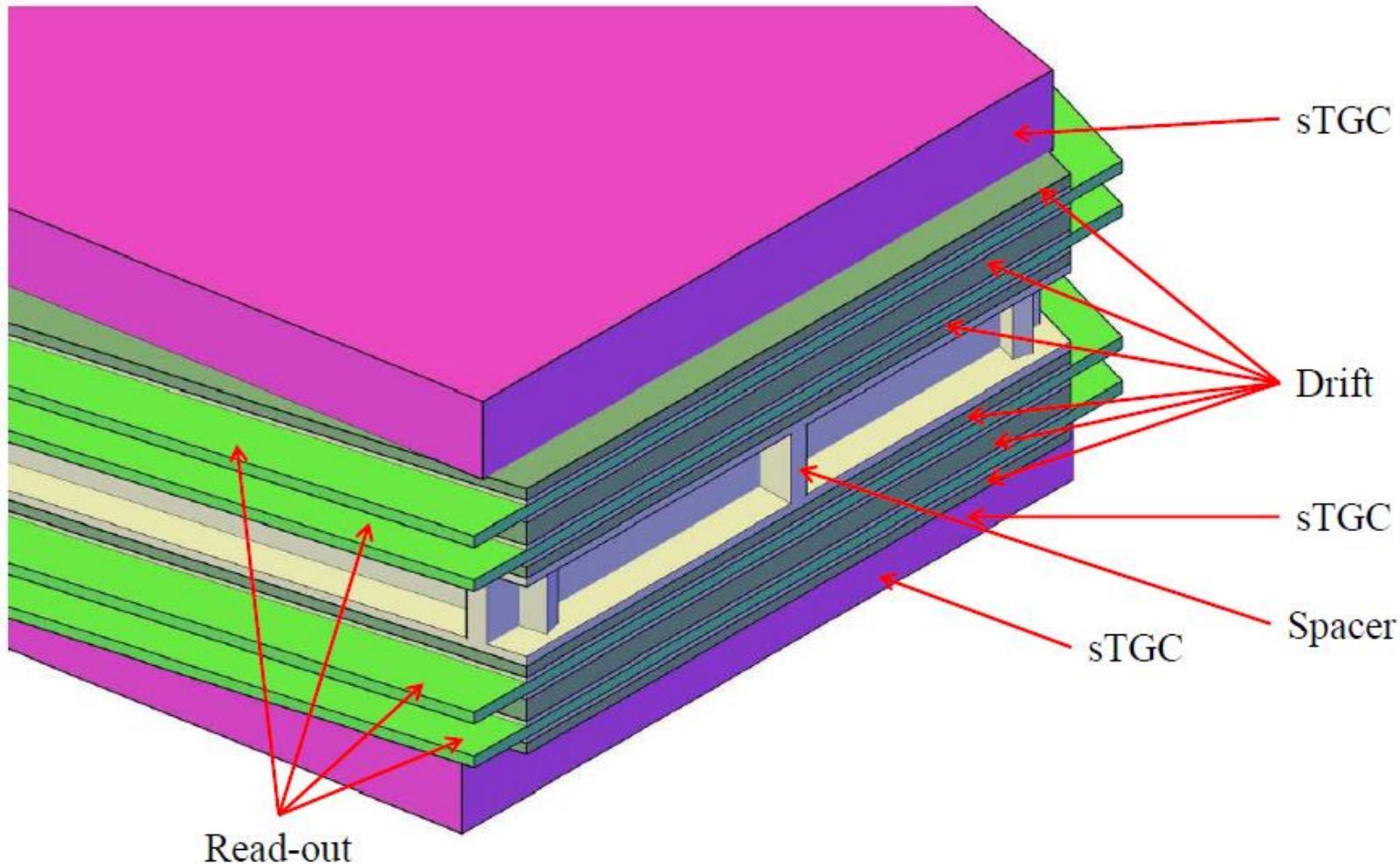
TDAQ (LVL1, HLT/DAQ, trigger/online software, etc.): IDR and kick-off in January; approved by EB → for endorsement at Friday CB

AFP: IDR and kick-off in Sept 2012 → following up on milestones (e.g. project organization, consolidation of physics case) → CB approval in 2014

Consolidating a (coherent) physics case for above projects is one of most crucial/urgent aspects in view of TDRs; presently hampered by severe lack of effort, in all of software developments, validation, performance/physics studies, as well as by computing resources → more involvement also from the upgrade community is needed
 → efforts being organized to increase synergies with Physics/CP groups

Muon NSW detectors structure

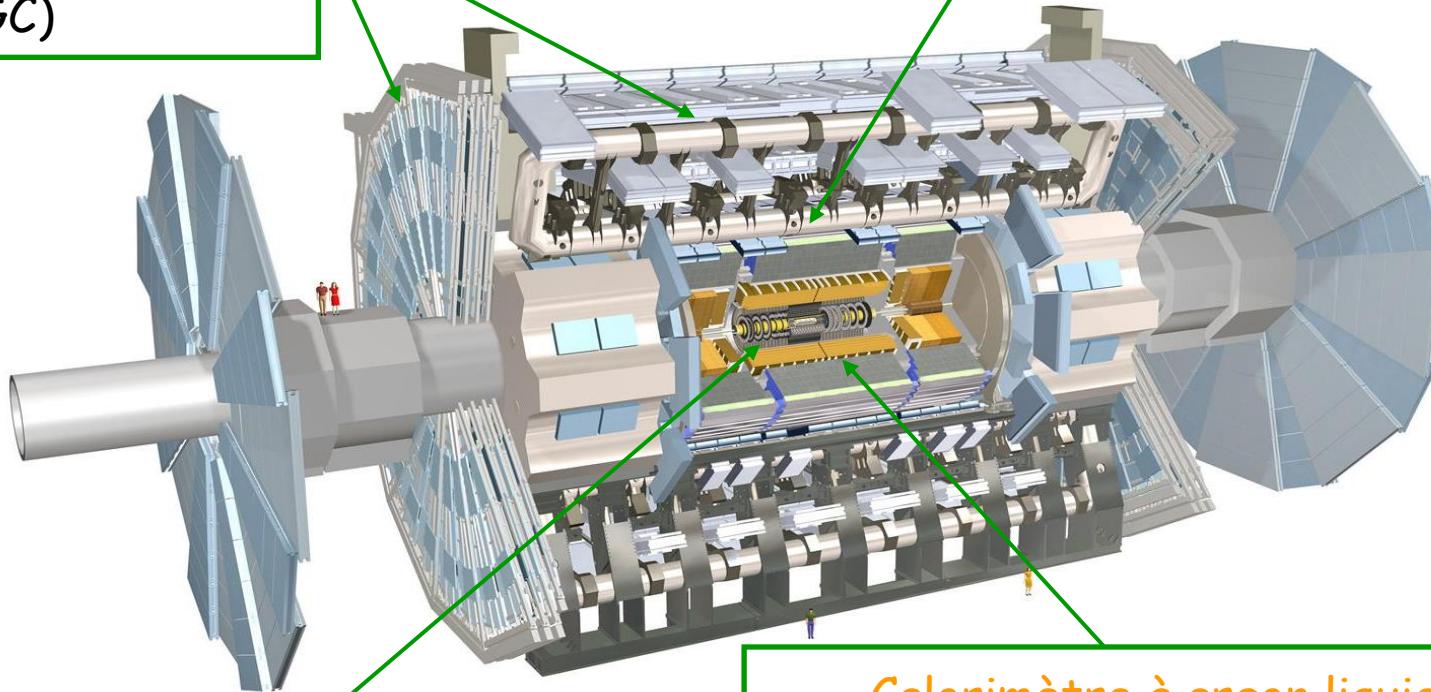
Large sector



Le détecteur ATLAS

Spectromètre à muons
1 + 2 aimants toroïdaux
Chambre (CSC-MDT-RPC-TGC)

Calorimètre hadronique à tuiles
Fer - scintillateurs



Détecteur de traces
Pixels silicium + micropistes silicium
Détecteur à pailles avec mélange Xe/CO₂
Aimant solénoïdal 2T

Calorimètre à argon liquide (LAr)
EM (accordéon) : Plomb / Argon
Hadronique : Cuivre / Argon
Calo. avant : Cuivre - Tungstène/Argon