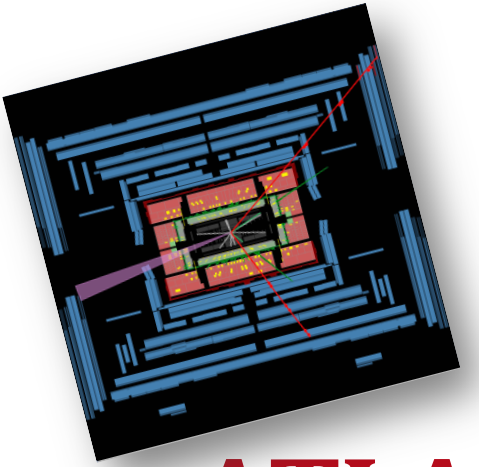
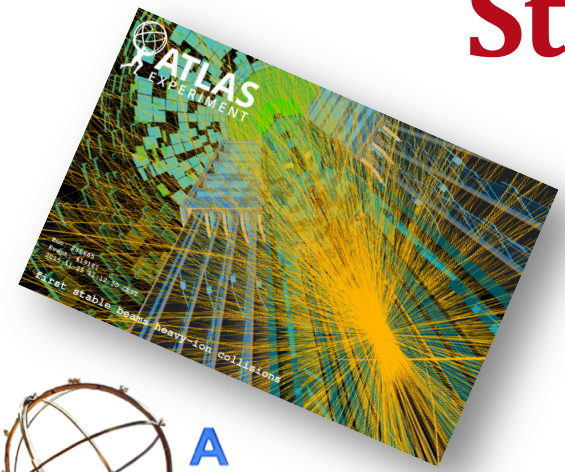
Riunione di Gruppo 1 - Napoli

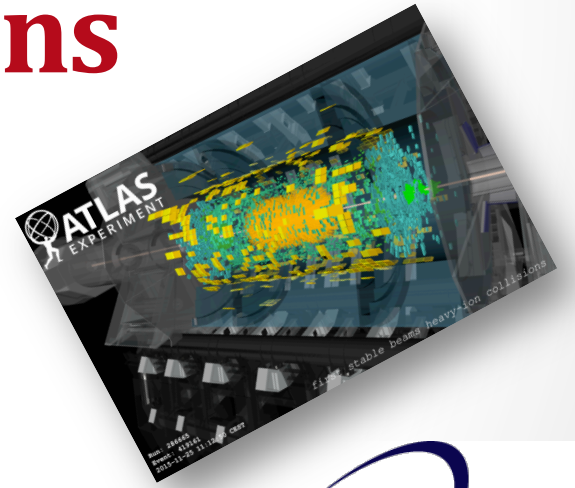
8 Gennaio 2016



ATLAS Experiment Updates: Status and Plans

Elvira Rossi





ATLAS

INFN

Istituto Nazionale di Fisica Nucleare

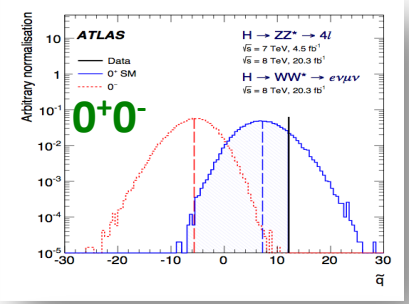
ATLAS Updates

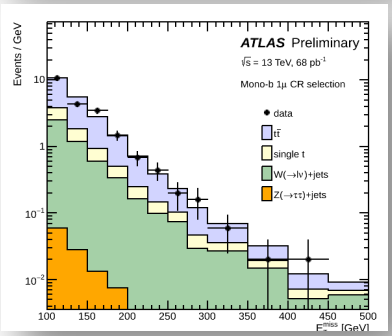
- ATLAS Napoli team
- Preliminary LHC and ATLAS schedule
- Datasets @ 13 TeV
- Main Improvements in Run-II and Detector Performances
- First results with Run-II data
- ATLAS detector and Trigger Upgrades for Phase I
- ATLAS detector and Trigger Upgrades for Phase II
- Napoli Tier2: status and activities

ATLAS Napoli

Anagrafica 2016 (ATLAS + R&D Fase2) = 14.65 FTE

- ***Università 'Federico II':*** **A. Aloisio (60%), M. Alviggi (80%), F. Ambrosino (20%), V. Canale (80%), G. Chiefari (0%), M.Della Pietra (80%), P. Massarotti (20%), L. Merola (70%), G.Russo (35%), G. Saracino (20%)**
- ***INFN:*** **G. Carlino (80%), R. de Asmundis (70%), A. Doria (70%), V. Izzo (70%), G. Sekhniaidze (80%)**
- ***Università Parthenope:*** **F.Conventi, E.Rossi**
- ***Dottorandi e assegnisti:*** **F. Cirotto, R. Giordano (30%), S. Perrella, A.Sanchez, G.Zurzolo**
- ***Laureandi 2016-2017:*** **M. Lavorgna, (A. Giannini, M. D'Errico, C. Calamita)**





Attività del gruppo:

Sistema di trigger di muoni di I livello:

- **RPC detectors**
- **Trigger e DAQ**

New Small Wheel:

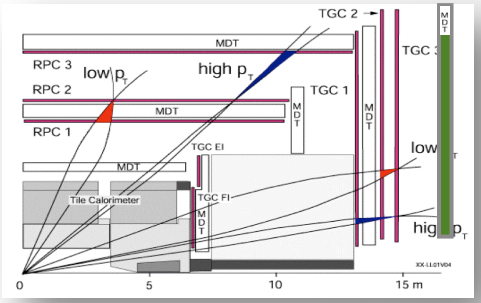
- **Micromegas detectors**

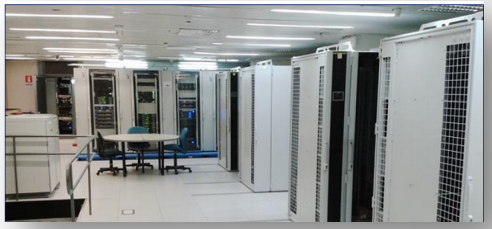
Fisica:

- **Higgs: misura parametri risonanza, ricerca di risonanze BSM H-like**
- **BSM e Esotica: ricerche BSM con bjet(s) e Missing E_T**

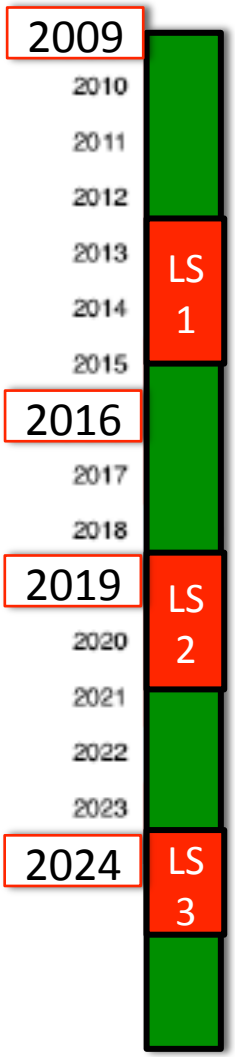
Computing

- **Tier2**





Preliminary LHC schedule & ATLAS Runs



LHC startup $\sqrt{s}$=900 GeV, Phase-0

Run-I (2011-2012): $\sqrt{s}$= 7 and 8 TeV, L=6x10^{33} cm^{-2}s^{-1}, bunch spacing 50ns, 75% of nominal luminosity → ~25fb^{-1}

Long Shutdown 1 (LS1) → Go to design energy and nominal luminosity

Run-II (2015-2018): $\sqrt{s}$= 13 and 14 TeV, L=10^{34} cm^{-2}s^{-1}, bunch spacing 25ns → ~75fb^{-1}

LS2 → Injector + Upgrade to LHC Phase-1 to ultimate design luminosity

Run-III (2020-2022): $\sqrt{s}$=14 TeV, L=2x10^{34} cm^{-2}s^{-1}, bunch spacing 25ns → ~300fb^{-1}

LS3 → Upgrade to HL-LHC Phase-2 (ATLAS scoping document → CERN-LHCC-2015-020)

Run-IV: $\sqrt{s}$=14 TeV, L=5x10^{34} cm^{-2}s^{-1} → ~3000fb^{-1}

Phase-0

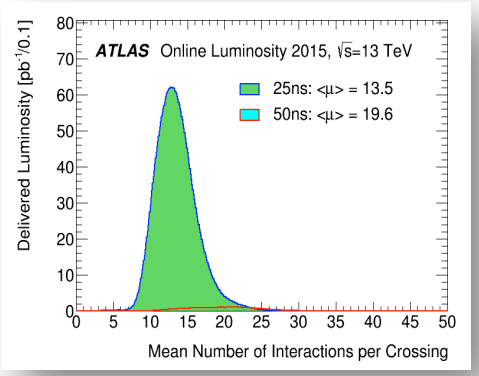
Phase-1

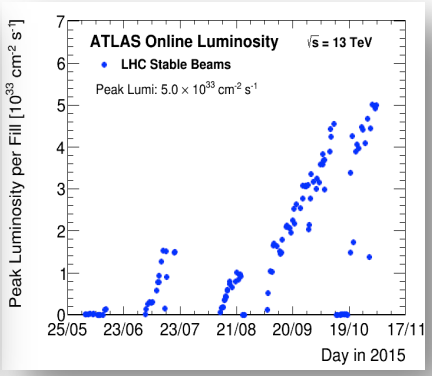
Phase-2

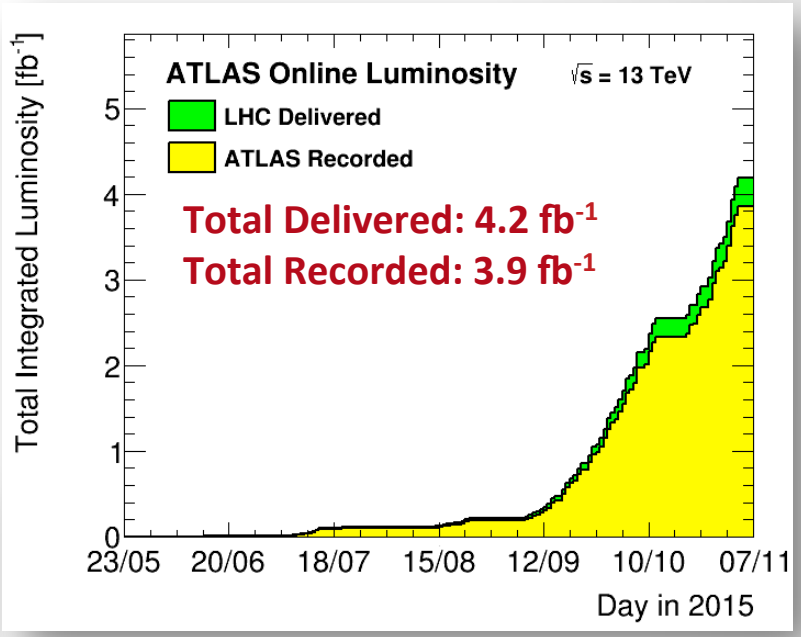
13 TeV 2015 Dataset

- **Data taking efficiency of 92%**
  - **50 ns data:** 100 pb^{-1} good for physics (μ~ 20)
  - **25 ns data:** 4fb^{-1} recorded (μ~13)
  - **Run-1**: 8 TeV (μ~21) and 7 TeV (μ~9)

- **Highest instantaneous Luminosity reached $5x10^{33}cm^2s^{-1}$ (Run-1: 7-8$x10^{33}cm^2s^{-1}$)**

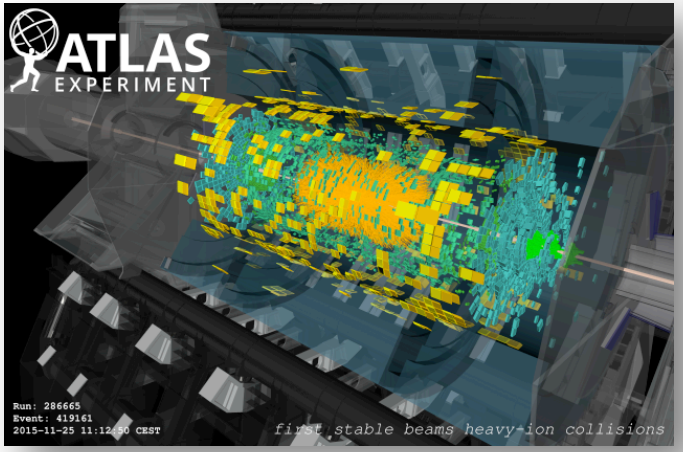






- **Special runs:**
  - 90 m elastic run with 10 μb^{-1} collected
  - 170 μb^{-1} of "low μ" data (special runs with LHCf)
  - **Heavy Ion** running with 680 μb^{-1} collected and corresponding pp reference at 5TeV with 27 pb^{-1}(μ~1.5)

PbPb Collision at 1.1 PeV



ATLAS Improvements for Run-II

Phase-0

Main Improvements for the Run-II

Important changes in all areas of the experiment:

Detector

- 4th innermost layer of pixels (3.3 cm, 2nd layer at 5.05 cm) →Pixel Insertable B-Layer (IBL)
- Consolidation: Complete muon coverage (feet), Luminosity detectors, Repairs (Lar and Tile), Beam Condition, Monitors

Infrastructure

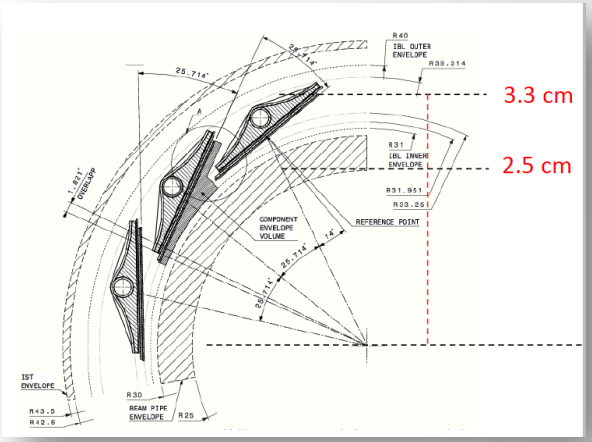
- New Beam Pipe, Magnets and Cryogenic system, Muon Chamber shielding, New pixel services

Trigger/DAQ

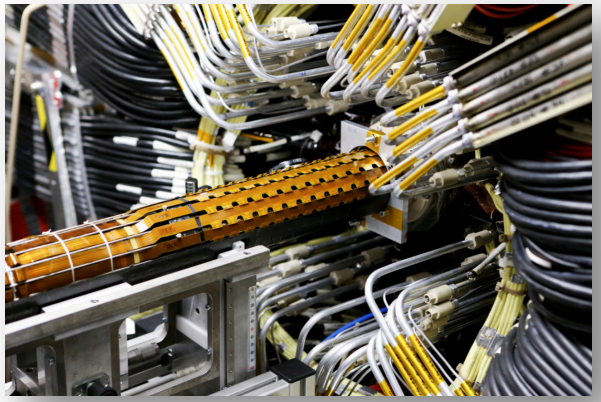
- Increase max Level 1 (LVL1) rate from 75kHz to 100kHz
- New Central Trigger Processor
- Merge Level 2 (LVL2) and High Level Trigger (HLT) farms, Additional SFOs allowing for higher output rate (limited by storage capacity to 1.1-1.5 kHz)

Software and Computing

- Improved reconstruction software, New analisys framework with new data format



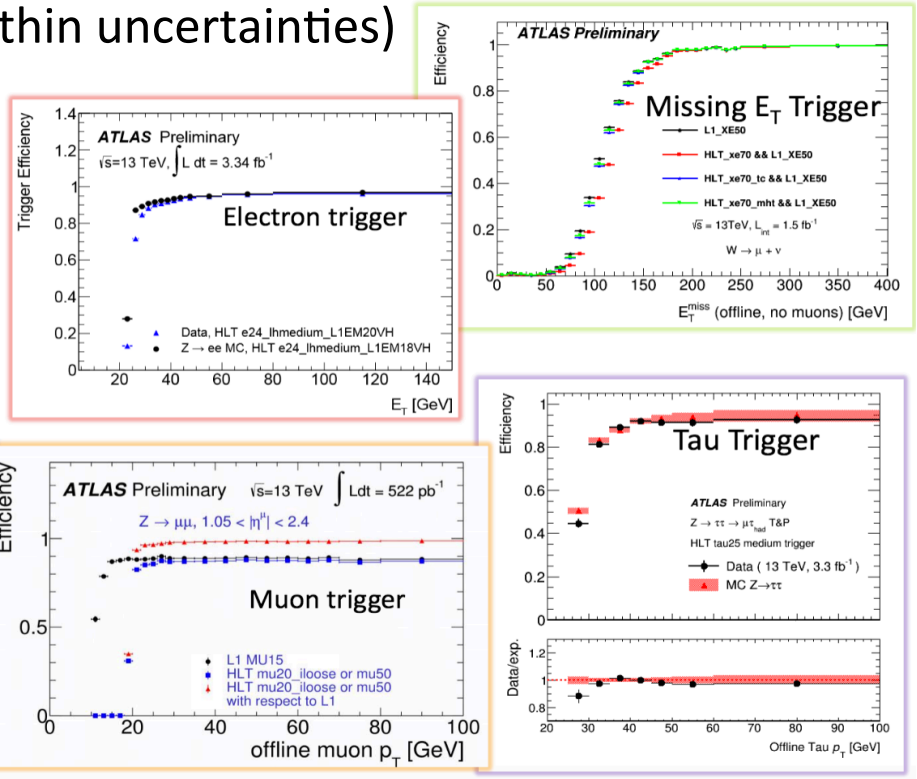
IBL TDR:
http://cds.cern.ch/record/1291633



For a complete ATLAS Status: see A. Polini talk at LHCC Open Session (Dec 2, 2015)
http://indico.cern.ch/event/460278

Performance

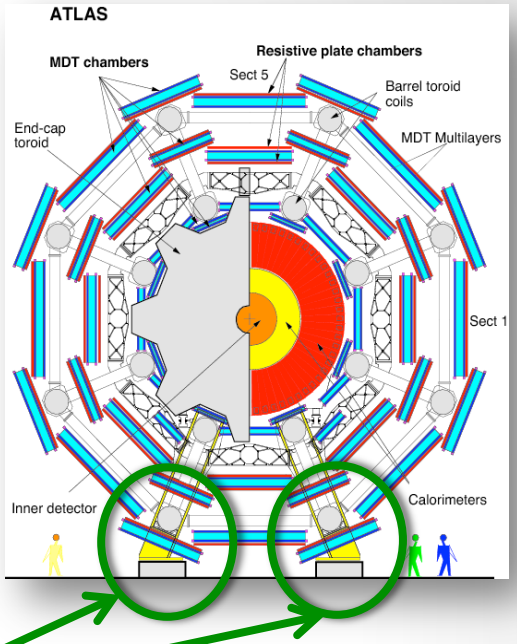
- **Data Quality efficiency: Average 93% (Run-I Average 94%)**
- **Luminosity Measurement**: preliminary uncertainty 5%: **3.2 ± 0.2 fb^{-1}** (with IBL off 3.5 ± 0.2 fb^{-1})
- **Continued excellent performance and stability of trigger throughout the run**
- **Tracking:** Pixel Insertable B-Layer (IBL) leads Improved Tracking performance
- **Flavor Tagging:** Improvement from IBL and new algorithms, Improved light jet rejection of a factor of 4 (precise data driven light jet rejection is becoming challenging), MC calibration checked with top events in data (fully consistent with current MC within uncertainties)



Muon Barrel Level 1 trigger

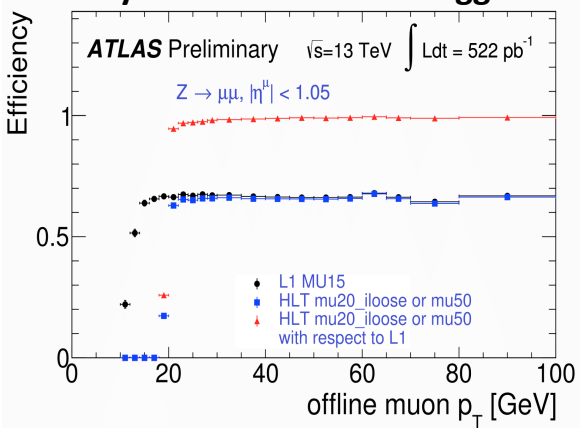
Activities in Napoli (A. Aloisio, F. Conventi, M. Della Pietra, V. Izzo, S. Perrella, E. Rossi, V. Bruscino (graduate student from Informatica)):

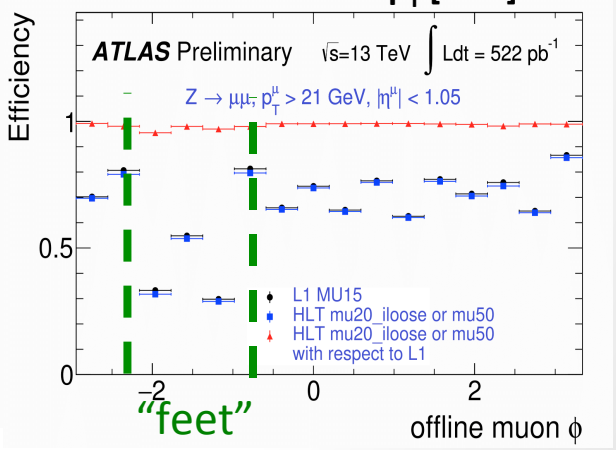
- Maintenance of the ReadOut Driver (ROD) boards and of the Optical Links to read Trigger data Level 1 Muon Trigger Operation
- Trigger and DAQ RPC Maintenance: DAQ software updates for the Level 1 muon trigger to manage RODs and the Sector Logic (SL)
- Monitoring Online for the Data Quality
- Inclusion in the TDAQ system of the RPC in the "feet" and "elevator" region → 3% coverage recovered.



Muons: Close to nominal performance of O(10%) relative resolution in $(1/p_T)$ for TeV muons

Efficiency for Level 1 Muon Trigger Threshold 15 GeV vs. Muon p_T [GeV] and Φ





ATLAS Status and First results with Run-II data

ATLAS submitted **501 papers** → 251 of these papers were searches, 219 measurements and 31 performance papers (https://twiki.cern.ch/twiki/bin/view/AtlasPublic/):

- **496** papers with the **Run-I** dataset (not covered in this talk)
- The ATLAS Collaboration has released a host of new results with the **full 2015 13 TeV dataset, in 24 Conference Notes and 5 Journal Papers**

(Available at the following location: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/December2015-13TeV)

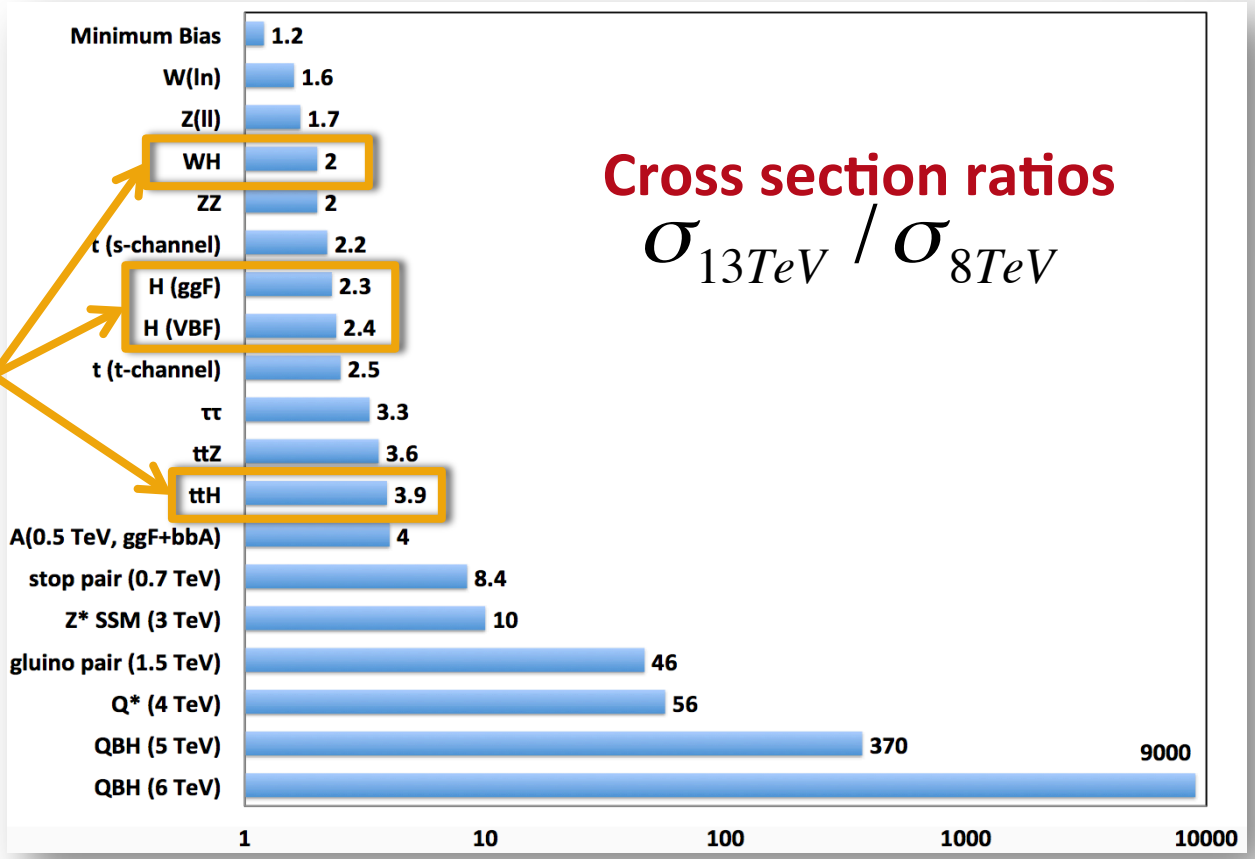
- New measurements of single top and diboson cross sections
- First look at H(125 GeV) production
- Many searches for new physics with sensitivity exceeding the Run 1 reach, investigating a vast number of topologies and event characteristics
- Modest excesses begging for more data

CERN End Of Year Event (EOYE): https://indico.cern.ch/event/442432/

All the public ATLAS results with the first Run-II data are summarized in Marumi Kado's talk: https://indico.cern.ch/event/442432/contribution/1/attachments/1205572/1756971/CERN-EOY-Seminar-2015.pdf

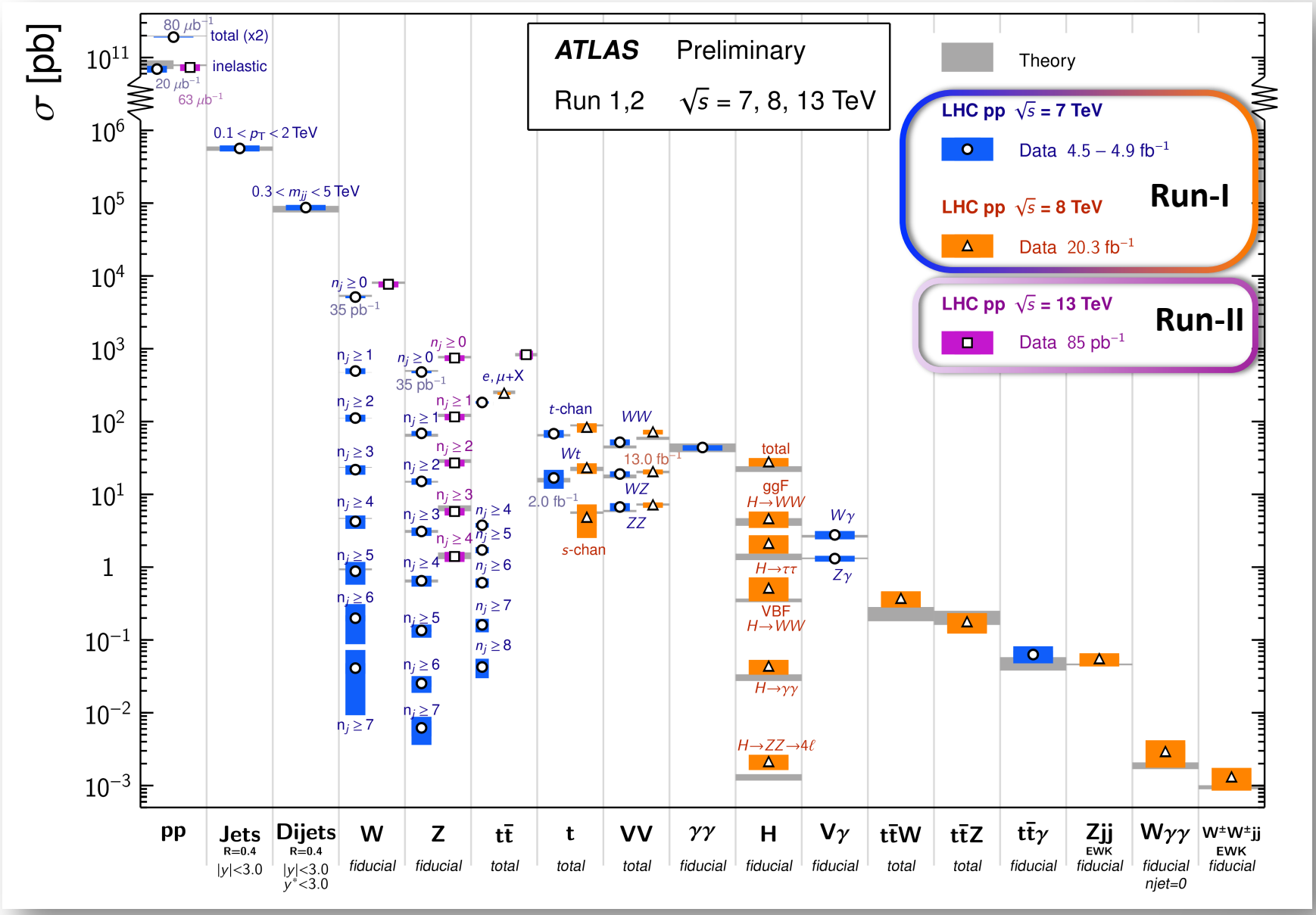
Moving from 8 → 13 TeV

SM signal increases by a factor 2 – 4

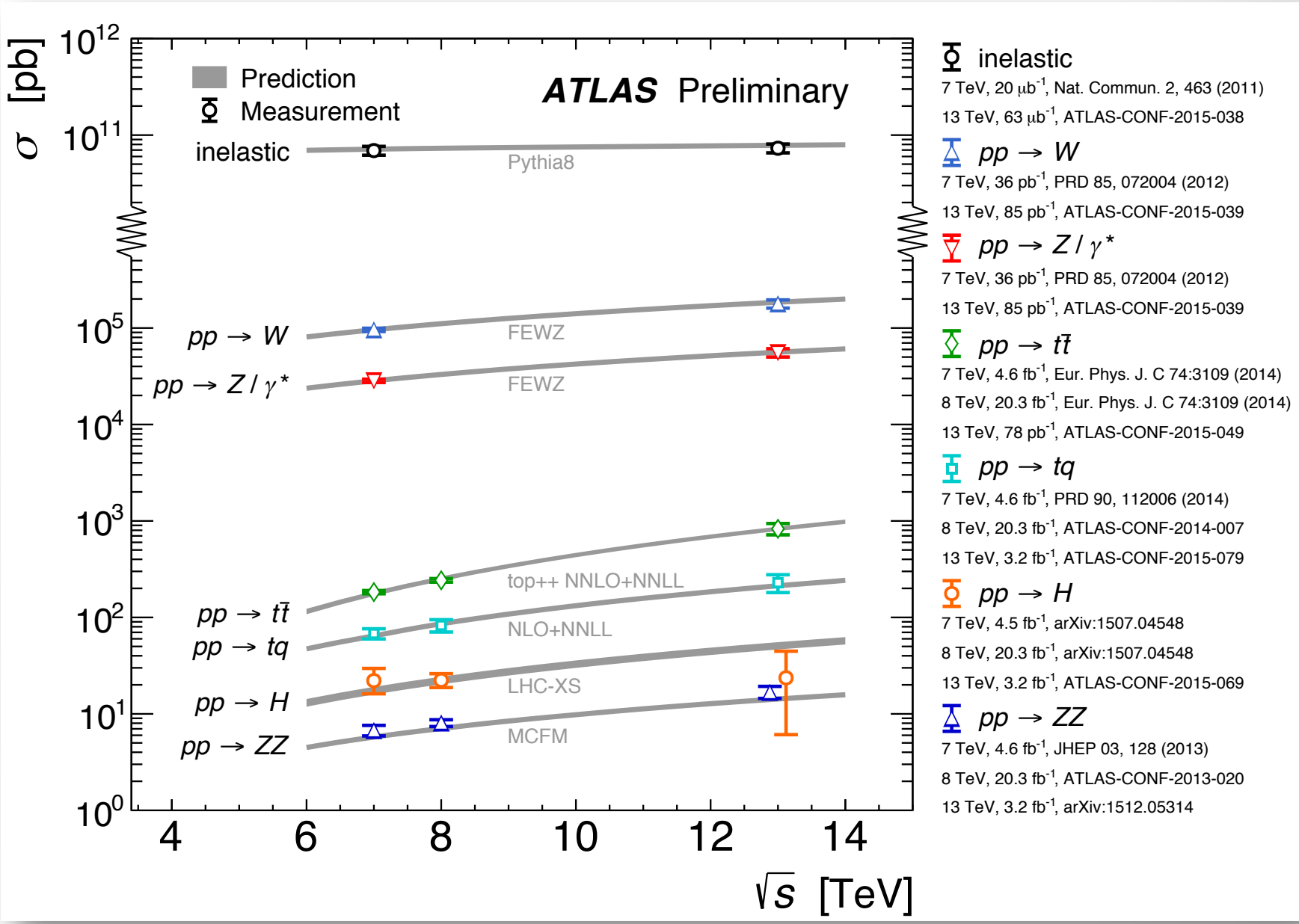


- Higgs signal increases by factor 2.3
- Background typically increases by factor 1.9 (3.3 for tt)
- Significance scales as S/√B → Sensitivity gain: 1.6
- Sensitivity scales with √L → √(25 fb^{-1}/ 10 fb^{-1}) = 1.6
- Sensitivity for 10 fb^{-1} @ 13 TeV corresponds to full Run-I dataset (25 fb^{-1} @ 7/8 TeV) → Expected for summer conferences
- Combination of full Run 1 + 10 fb^{-1} of Run-II will increase the sensitivity by 40 % w.r.t Run-II data alone

Standard Model Production Cross Section Measurements



Summary of Run-2 Total Cross Section Measurements



inelastic
7 TeV, 20 μb^{-1}, Nat. Commun. 2, 463 (2011)
13 TeV, 63 μb^{-1}, ATLAS-CONF-2015-038

$pp \to W$
7 TeV, 36 pb^{-1}, PRD 85, 072004 (2012)
13 TeV, 85 pb^{-1}, ATLAS-CONF-2015-039

$pp \to Z / \gamma^*$
7 TeV, 36 pb^{-1}, PRD 85, 072004 (2012)
13 TeV, 85 pb^{-1}, ATLAS-CONF-2015-039

$pp \to t\bar{t}$
7 TeV, 4.6 fb^{-1}, Eur. Phys. J. C 74:3109 (2014)
8 TeV, 20.3 fb^{-1}, Eur. Phys. J. C 74:3109 (2014)
13 TeV, 78 pb^{-1}, ATLAS-CONF-2015-049

$pp \to tq$
7 TeV, 4.6 fb^{-1}, PRD 90, 112006 (2014)
8 TeV, 20.3 fb^{-1}, ATLAS-CONF-2014-007
13 TeV, 3.2 fb^{-1}, ATLAS-CONF-2015-079

$pp \to H$
7 TeV, 4.5 fb^{-1}, arXiv:1507.04548
8 TeV, 20.3 fb^{-1}, arXiv:1507.04548
13 TeV, 3.2 fb^{-1}, ATLAS-CONF-2015-069

$pp \to ZZ$
7 TeV, 4.6 fb^{-1}, JHEP 03, 128 (2013)
8 TeV, 20.3 fb^{-1}, ATLAS-CONF-2013-020
13 TeV, 3.2 fb^{-1}, arXiv:1512.05314

Search for resonances decaying to photon pairs

Inclusive search for two photon resonance
(optimized for a scalar resonance)

- Selection of two photons with pT/m thresholds of 0.3 and 0.4 and pT dependent calorimeter and track isolation criteria
- Typical prompt photon purity 90%

Background from a functional

Similar to the dijet search but chosen using the Fisher F-test and the spurious signal method measured in events from Sherpa, Diphox and Jetphox:

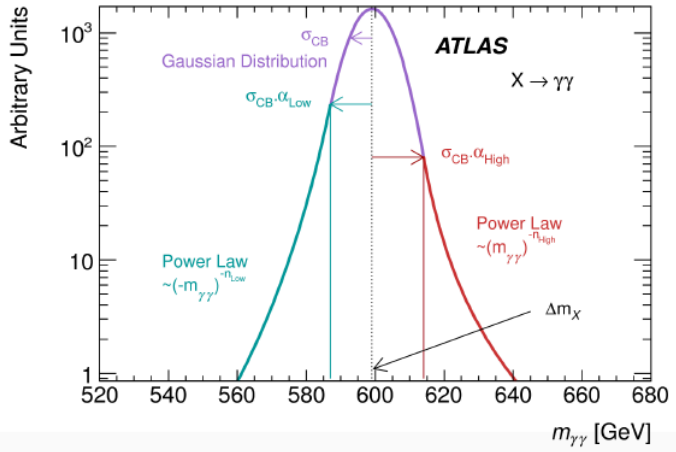
$$f_{bkg}(x;b,\{a_k\}) = (1-x^{1/3})^b\, x^{\sum_{j=0}^{k} a_j \log(x)^j}$$

$$x \equiv \frac{m_{\gamma\gamma}}{\sqrt{s}}$$

Here a simple form with k=0 is used

Signal Model

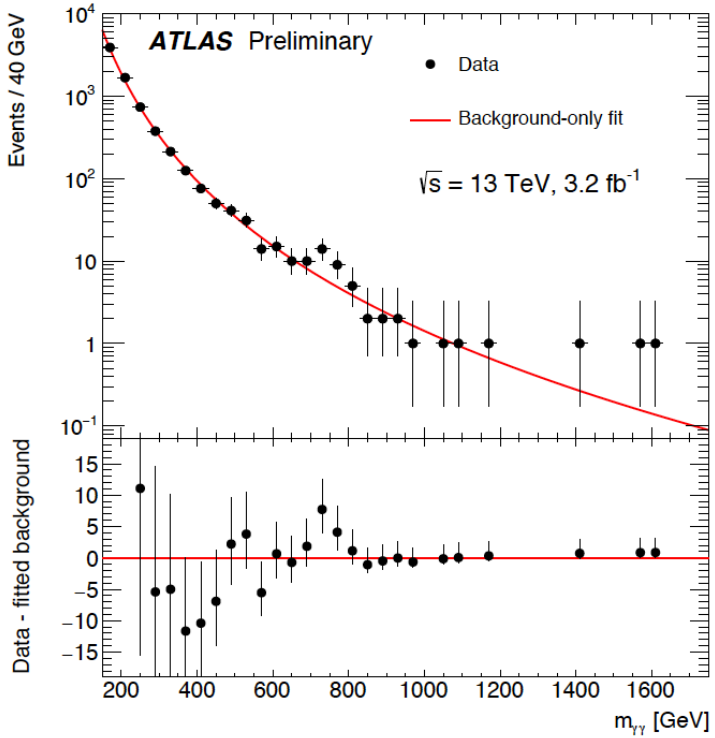
- **NWA**: Use Double Sided Crystal Ball function
- **LW**: Use DSCB fitted from simulated samples with different widths with up to 25% of the resonance mass

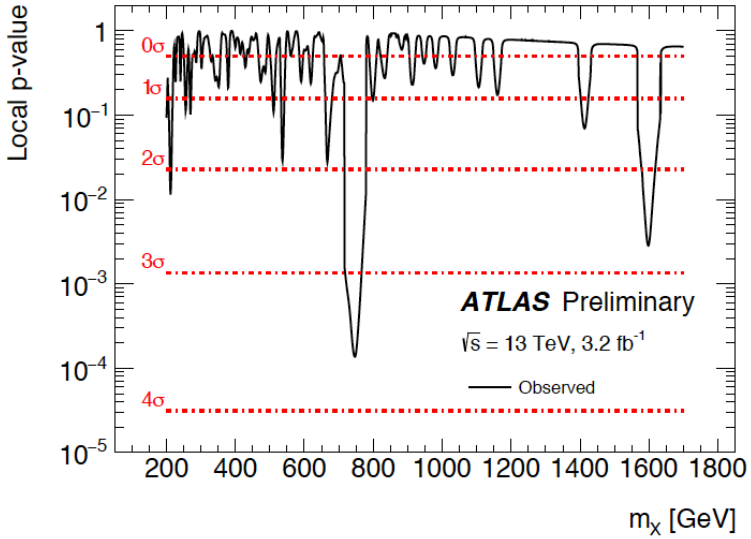


ATL-CONF-2015-081: https://cds.cern.ch/record/2114853/files/ATLAS-CONF-2015-081.pdf

Search for resonances decaying to photon pairs

Results: Events with mass in excess of 200 GeV are included in **unbinned fit**





- **In the NWA search**, an excess of **3.6σ** (local) is observed at a mass hypothesis of minimal p_0 of 750 GeV

- Taking a LEE in a mass range (fixed before unblinding) **of 200 GeV to 2.0 TeV** the global significance of the excess is **2.0σ**

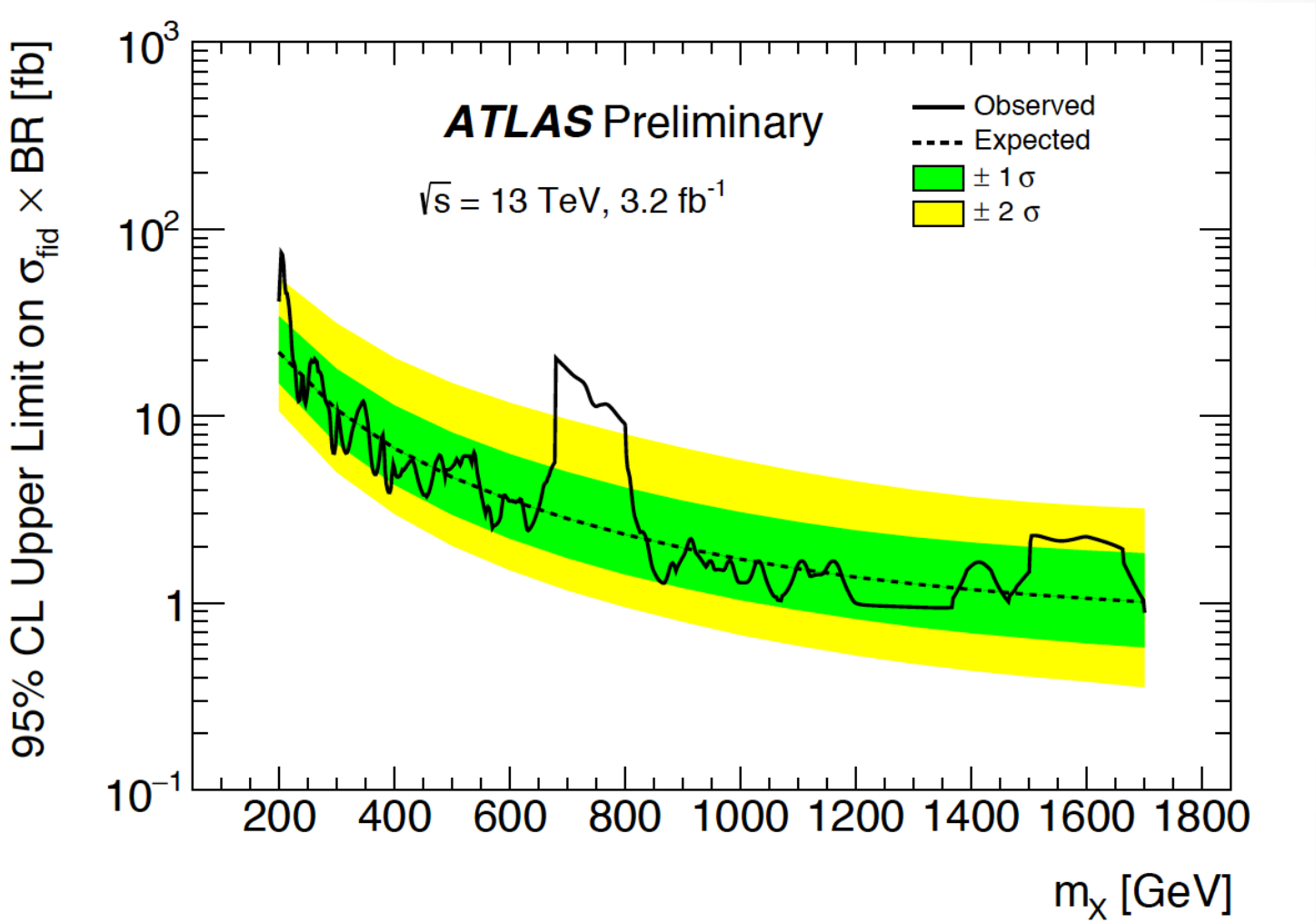
In the NWA fit the resolution uncertainty is profiled in the NWA fit and is pulled by 1.5σ

The data was then fit under a **LW hypothesis** yielding a width of approximately 45 GeV
(Approx. 6% of the best fit mass of approximately 750 GeV)

- As expected the local significance increases to **3.9σ**

- Taking into account a LEE in mass and width of up to **10%** of the mass hypothesis of **2.3σ** (Note: upper range in resolution fixed after unblinding)

Search for resonances decaying to photon pairs



Expected and observed upper limits on fiducial σ_{fid} x BR(X→ γγ) expressed at 95% CL, as a function of the assumed value of the narrow-width scalar resonance mass.

New CERN Director-General

"We have a great legacy to build on, and a very bright future ahead."

How excited should we be about the latest LHC results, which already hint at signals that could turn out to be due to new physics phenomena?

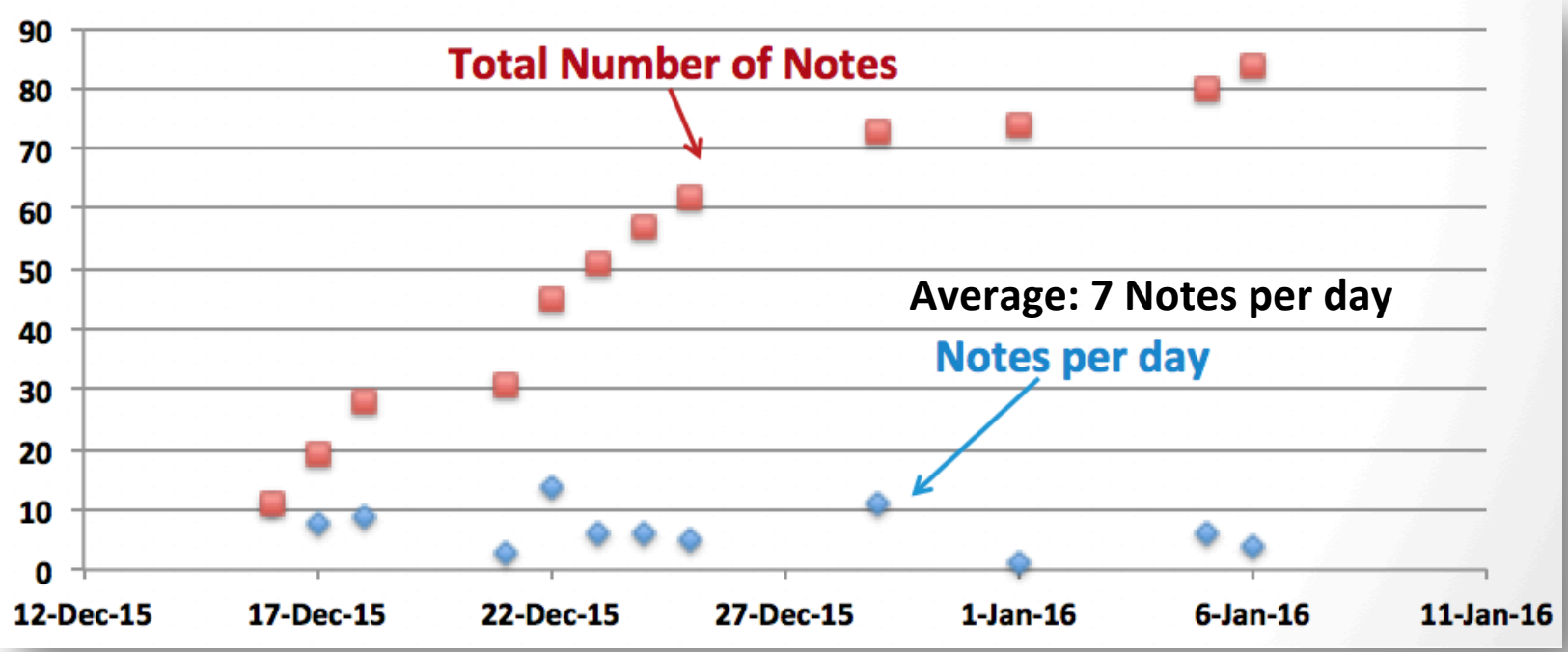
At the moment, experiments are seeing some fluctuations and hints, which, if they are due to signals from new physics, will next year consolidate with the huge amount of data the LHC will deliver. On the other hand, if they are just fluctuations, they will disappear. We have to be patient. In addition to looking for new physics, we are going to study the Higgs boson with very high precision.

Will any of the hints that we've already seen be directing the physicists' searches?

I don't think that the direction of exploration is being guided by the hints people see here and there. The correct approach is to be totally open and not be driven by our prejudices, because we don't know where new physics is, or how it will look.

Theoretical Notes from arXiv

Days from EOYE	date	Number of notes	composite models	DM	2HDM	vector-like	SUSY	axion	UED	Hidden Sector	GUT
1	16/12/15	11	2	3	2	1	2	1			
2	17/12/15	8		1	1	2	2	2	1		
3	18/12/15	9	2	2	1	3	1		2		
6	21/12/15	3				1	2		1		
7	22/12/15	14	1	6	1	2	4		3	1	
8	23/12/15	6	1	2		3					1
9	24/12/15	6			4	1	1		1		1
10	25/12/15	5				2	3		1	1	
14	29/12/15	11		2	2	4	2	1	2		
17	01/01/16	1					1				
21	05/01/16	6		1	1		1				3
22	06/01/16	4		2	1						1
Total		84	6	19	13	19	19	4	11	2	6



Theoretical Notes from arXiv

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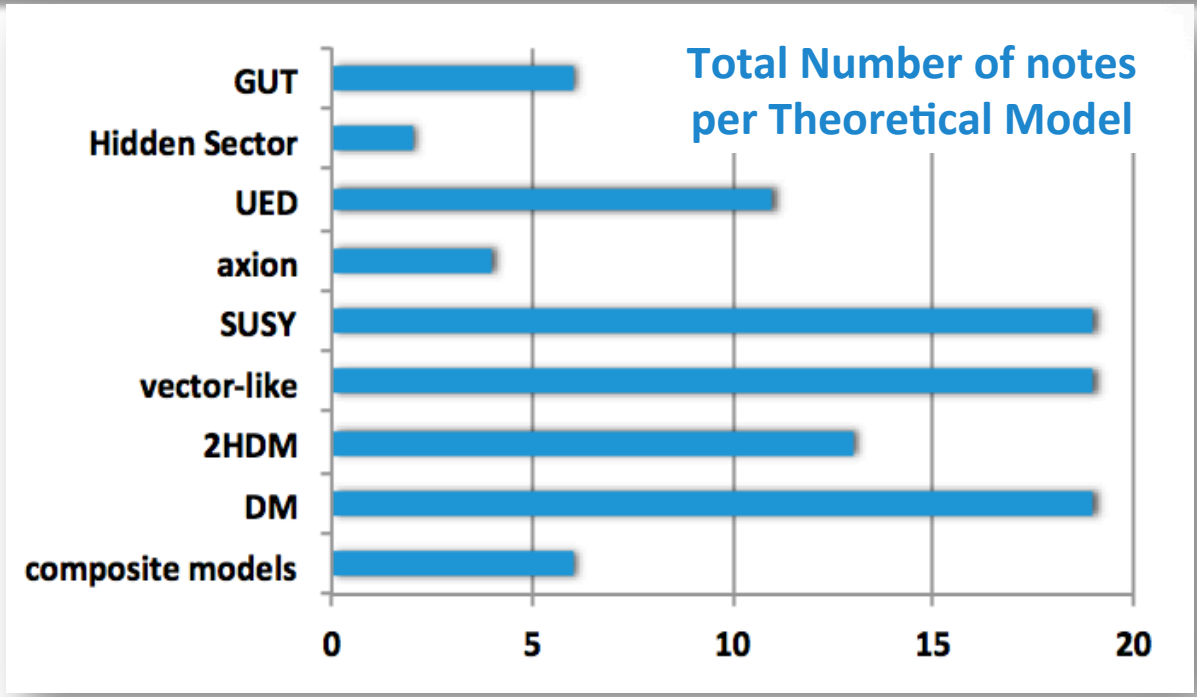
2	17/12/15	8		1	1	2	2	2	1		
3	18/12/15	9	2	2	1	3	1		2		
6	21/12/15	3				1	2		1		
7	22/12/15	14	1	6	1	2	4		3	1	
8	23/12/15	6	1	2		3					1
9	24/12/15	6			4	1	1		1		1
10	25/12/15	5				2	3		1	1	
14	29/12/15	11		2	2	4	2	1	2		
17	01/01/16	1					1				
21	05/01/16	6		1	1		1				3
22	06/01/16	4		2	1						1
Total		84	6	19	13	19	19	4	11	2	6



Ultimi arrivi: 08/01/2016

- arXiv:1601.01355 Date: Thu, 7 Jan 2016 00:07:56
  Title: **The 750GeV diphoton excess: who introduces it?**

- arXiv:1601.01381 Date: Thu, 7 Jan 2016 03:06:05
  Title: **The Diphoton and Diboson Excesses in a Left-Right Symmetric Theory of Dark Matter**

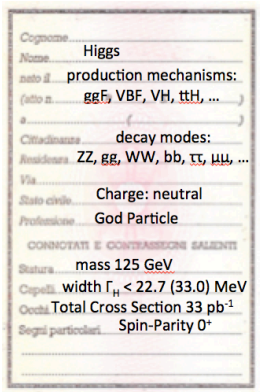
- arXiv:1601.01569 Date: Thu, 7 Jan 2016 15:38:41
  Title: **750 GeV Di-photon excess at CERN LHC from a dark sector assisted scalar decay**

- arXiv:1601.01571 Date: Thu, 7 Jan 2016 15:41:02
  Title: **A 750 GeV Portal: LHC Phenomenology and Dark Matter Candidates**

Analysis Activities in Napoli

(F. Conventi, F. Cirotto, M. Lavorgna, E. Rossi, A. Sanchez)

- **Higgs:** Searches and Higgs Properties Measurements in the Golden Channel **H→ZZ→4leptons**: Discovery and Re-Discovery, Mass, Spin-Parity, Set limit on Beyond Standard Model (BSM) coupling and mixing angle in CP even (or odd) mixing scenarios
- **Beyond Standard Model H-like Resonances:** Searches for a Resonance in llqq Final States (ZZ→ℓℓjj)
- **Beyond Standard Model and Exotics:** BSM searches with bjet(s) and Missing E_T: Mono-Higgs and Mono-bjet searches

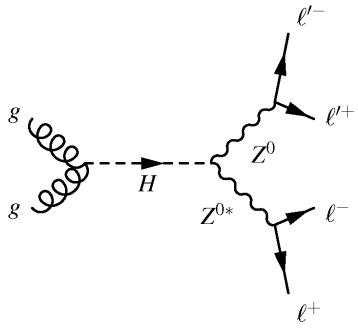


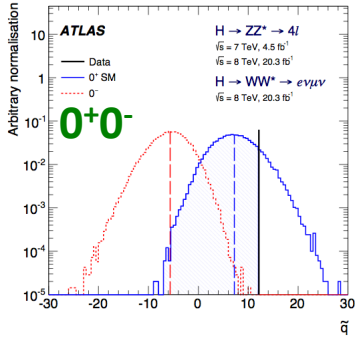
Spin and CP mixing Measurements in H→ZZ→4leptons channel

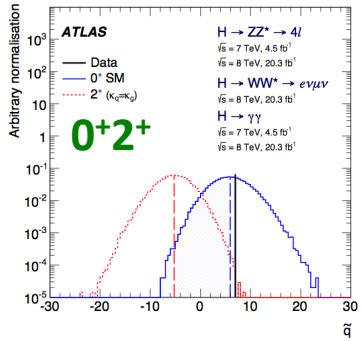
Eur. Phys. J. C75 (2015) 476

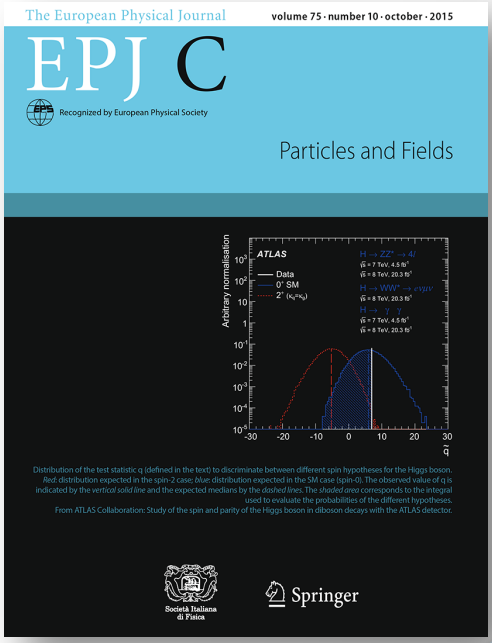
SM Higgs boson hypothesis favored, alternative models excluded > 95% CL.

No CP violation in Higgs sector is observed.









Searches for a Resonance in Diboson VV Final States

Analysis Overview

- Search for high mass resonance in boosted region
- ***Combined effort between Higgs and Exotics group***
- Interpretation on W'→WZ, G*→ZZ, H→ZZ (narrow width and large width)

For the EOYE we have been focused on:

- Resonance mass > 1 TeV (boosted/merged regime)
- Merged jets ⇒ jet substructure studies
- Nearby leptons (ℓℓ from Z candidate) ⇒ lepton isolation and trigger studies
- **ATLAS-CONF-2015-071: https://cds.cern.ch/record/2114843**

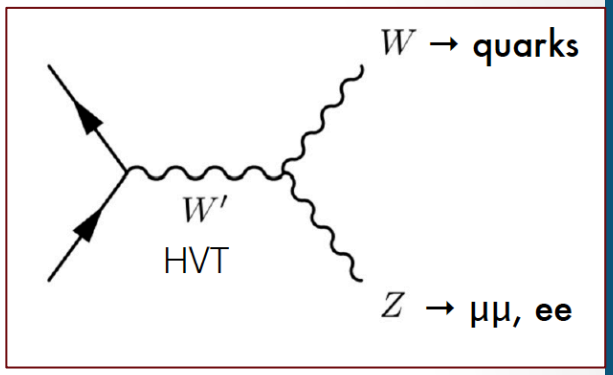
For Moriond:

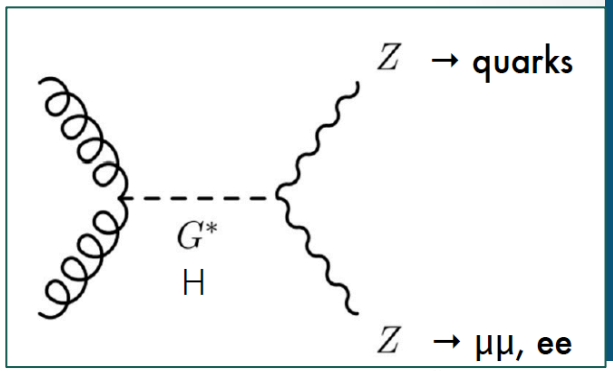
- Both merged and resolved regime (Resonance mass <1 TeV)

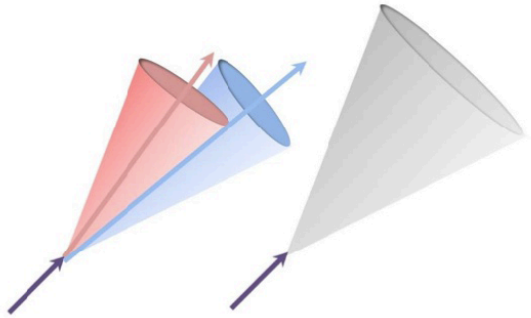
Activities in Napoli (F. Conventi, E. Rossi A. Sanchez):

- Analysis of the ZZ→ℓℓjj both for merged and resolved regime

ZV→ℓℓJ





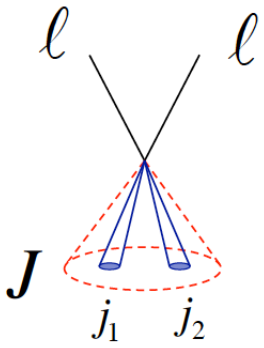


Boosted di-jet merging into mono-fat-jet (J) topology

Searches for a Resonance in Diboson VV Final States

ATLAS-CONF-2015-068, ATLAS-CONF-2015-071, ATLAS-CONF-2015-075

ZV (with Z to dilepton)

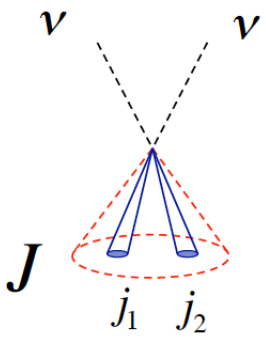


Backgrounds

Z-jets is the main background, estimated using MC and normalised to mJ sidebands

Diboson and top from MC

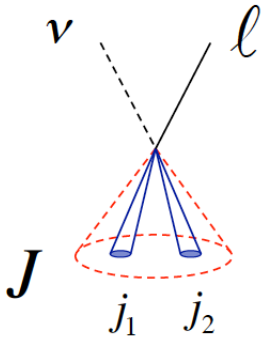
ZV (with Z to νν)



Backgrounds

Z-jets, W-jets and top are main backgrounds, these are estimated using CRs with 1 or 2 muons and one b-tag for the Top CR.

WV (with W to lν)



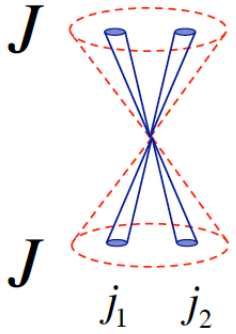
Backgrounds

Z, W and top shapes from MC

Diboson fully from MC

Multijet shape from loose lepton ID

VV to JJ

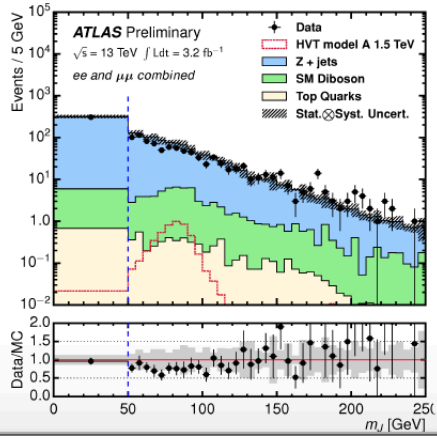


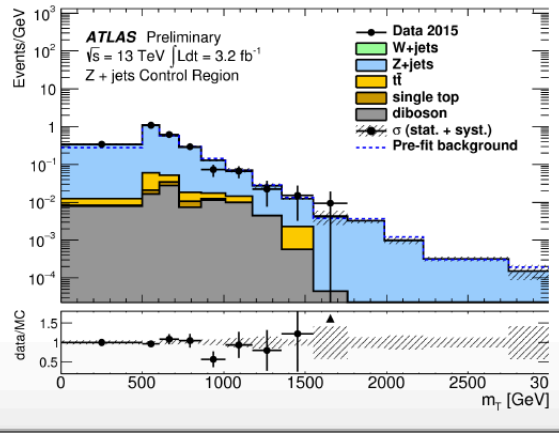
Modest excess Run-1

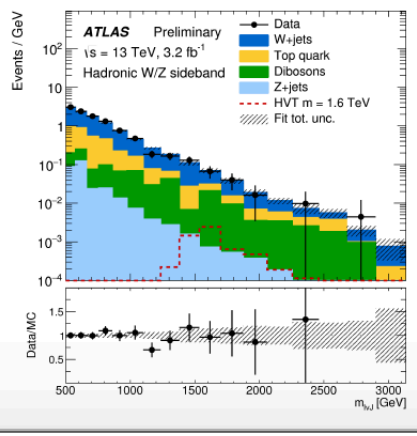
observed at Run 1 to be checked

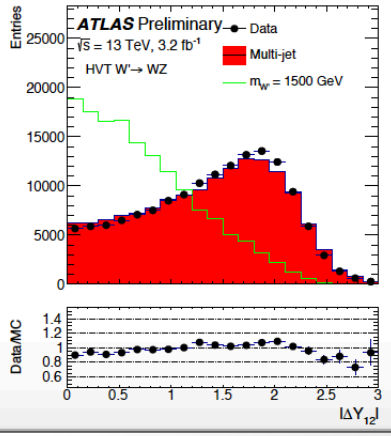
Background

Estimated using a functional form







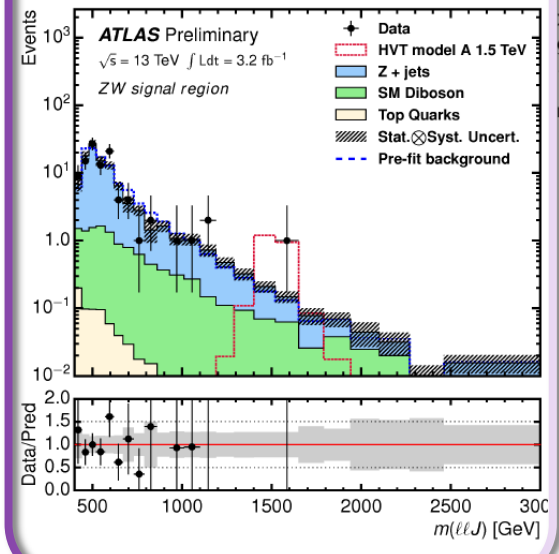


Searches for a Resonance in Diboson VV Final States

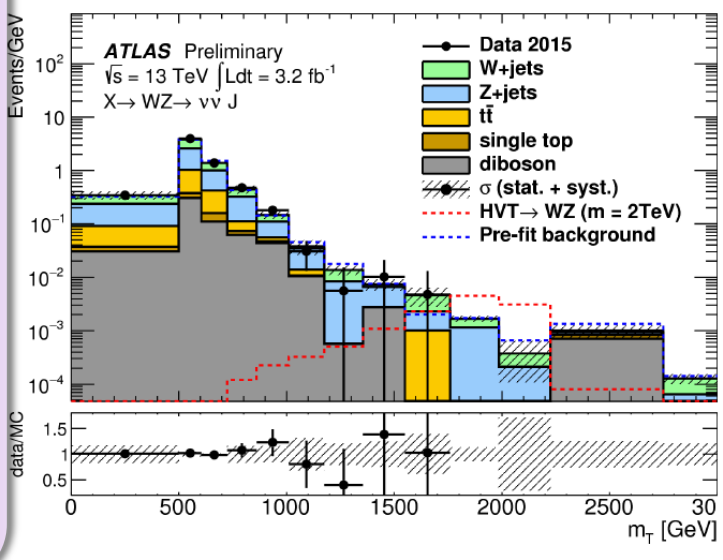
ATLAS-CONF-2015-068, ATLAS-CONF-2015-071, ATLAS-CONF-2015-075

Signal Regions (WZ) distributions in m_{VV}

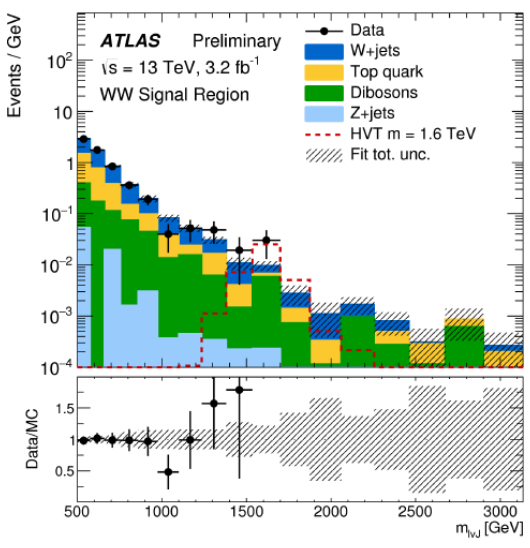
ZV (with Z to **dilepton**)



ZV (with Z to **νν**)



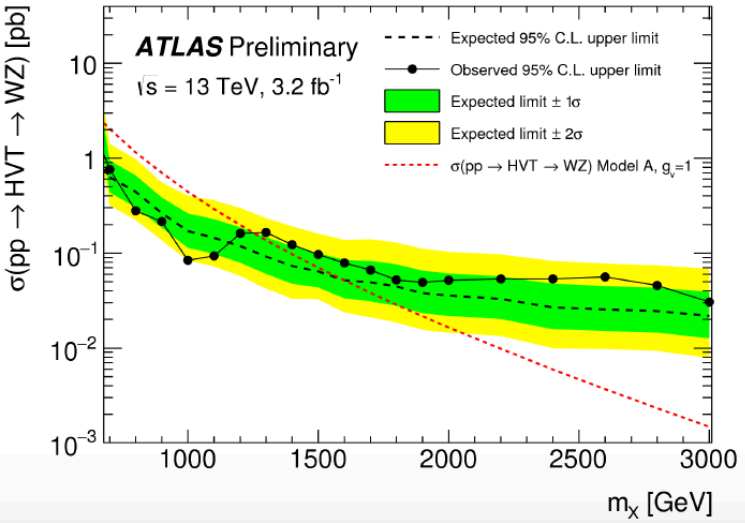
WV (with W to **lν**)



Results:

All analyses have similar sensitivities ranging between 1.4 TeV and 1.6 TeV :

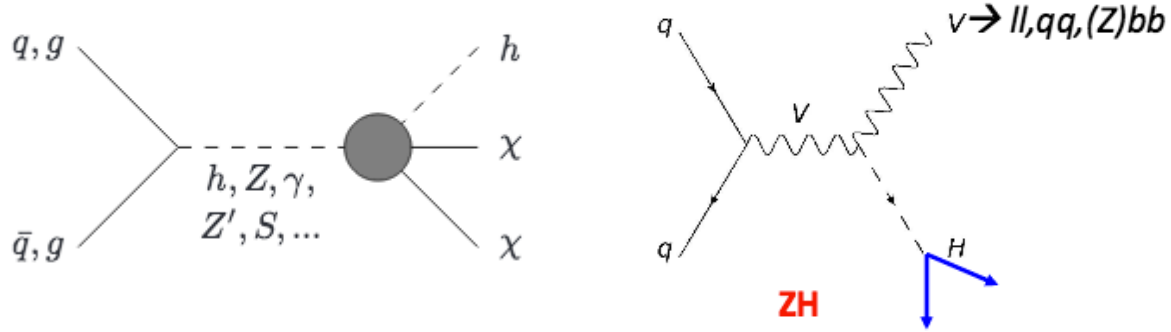
- **No significant excess observed, limits are set in these scenarios (heavy vector triplet, Randall-Sundrum graviton and additional heavy Higgs boson models)**



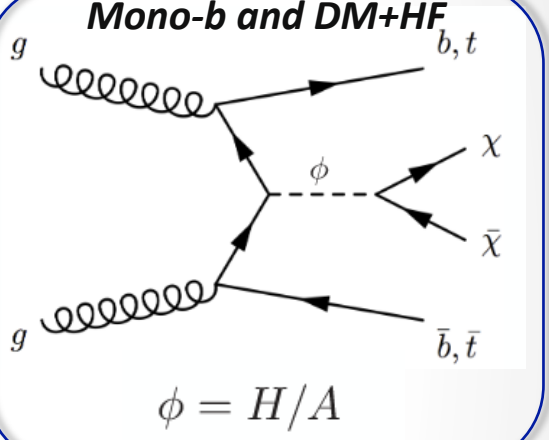
BSM searches with bjet(s) and Missing E_T

- Inclusive search for BSM models: **Invisible Higgs, DarkMatter, LargeExtraDimension**
- Basic selection: require at least 1 bjet + Missing Transverse Energy (MET) + veto leptons
- Backgrounds: Z(νν) + jets, tt, W(lν)+jets

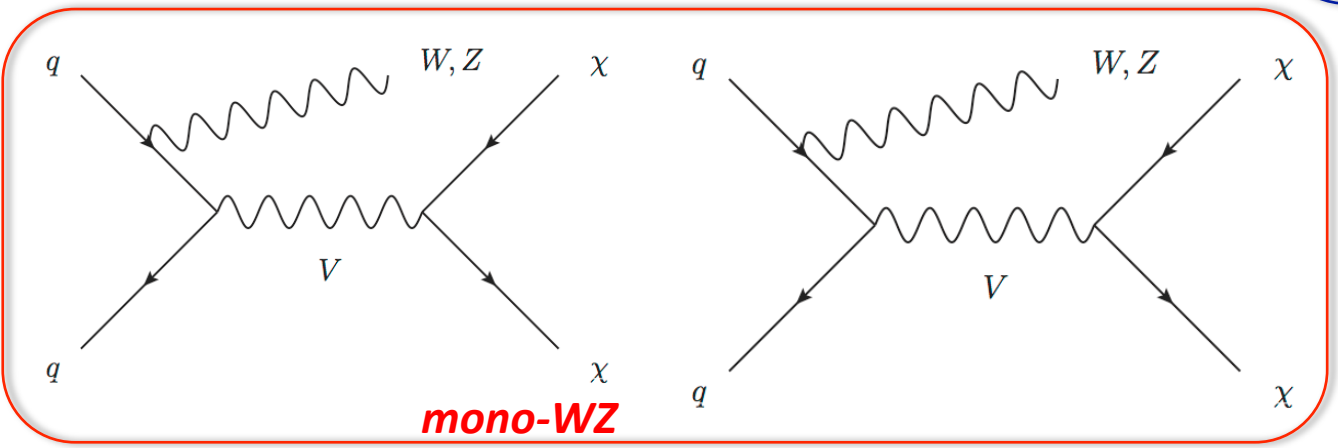
mono-Higgs and Invisible Higgs

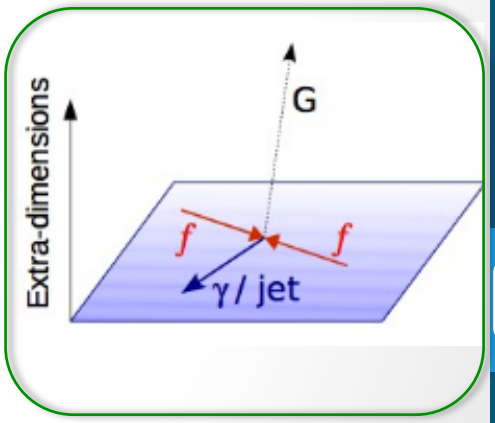


Mono-b and DM+HF



mono-WZ





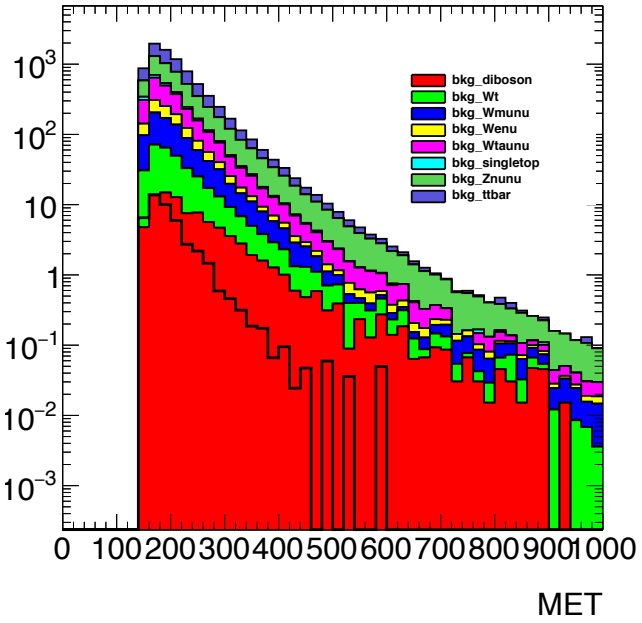
Mono-bjet and DM+HF

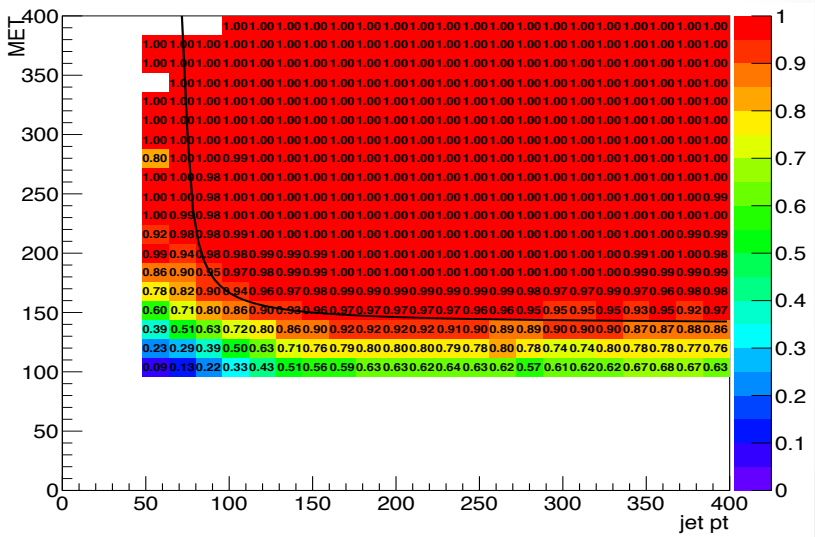
- Inclusive search for BMS models: **Invisible Higgs, DarkMatter, ADD**
- **Napoli: F. Conventi, F. Cirotto, M. Lavorgna, E. Rossi, A. Sanchez**
- Roma I: *Marco Resigno* + monojet team Harvard: *Valerio Ippolito* Stoccolma: *Priscilla Pani and* MPI*: Claudia Giuliani*
- Basic selection: require at least 1 bjet + Missing Transverse Energy (MET) + veto leptons
- Backgrounds: Z(vv) + jets, tt, W(lv)+jets

HLT Trigger:

Many BSM models with soft MET distribution:

- **2015** data taking: Lowest unprescaled MET trigger item (XE70) with reduced acceptance
- **2016** data taking: MET+bJET triggers NEW





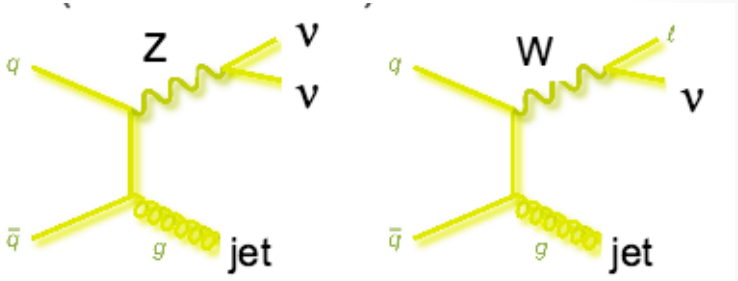
Preliminary 2D plateau region (+30-50% signal yields)

Mono-bjet analysis in Napoli

- Inclusive search for BMS models: **Invisible Higgs, DarkMatter**
- **Napoli: F. Conventi, F. Cirotto, M. Lavorgna, E. Rossi, A. Sanchez**
- Basic selection: require at least 1 bjet + Missing Transverse Energy (MET) + veto leptons
- Backgrounds: Z(vv) + jets, tt, W(lv)+jets

Responsabilita' del gruppo di Napoli:

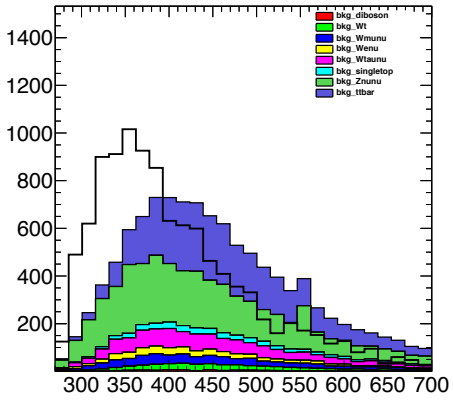
- **Ottimizzazione della selezione**
- **Stima del fondo Wjets and tt**
- **Interpretazione statistica**

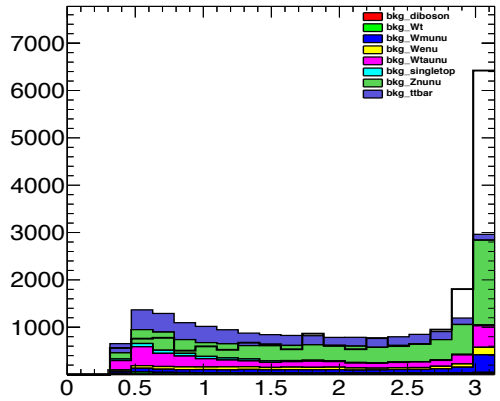


yields @3fb^{-1}

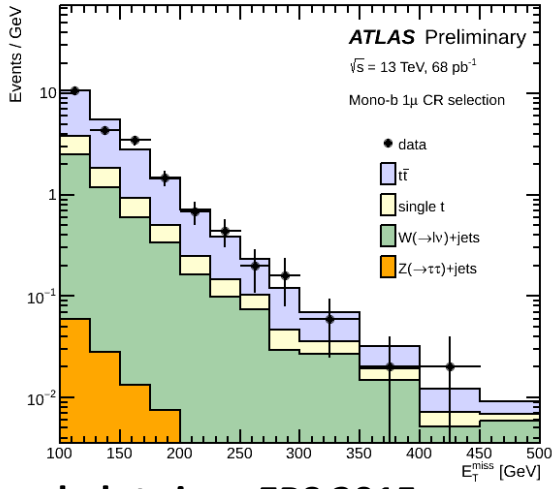
Trigger	signal	bkg	s/b
xe70	120	11000	0.01

Example of discriminating variables





Control regions definition for top background and W+jets are almost ready

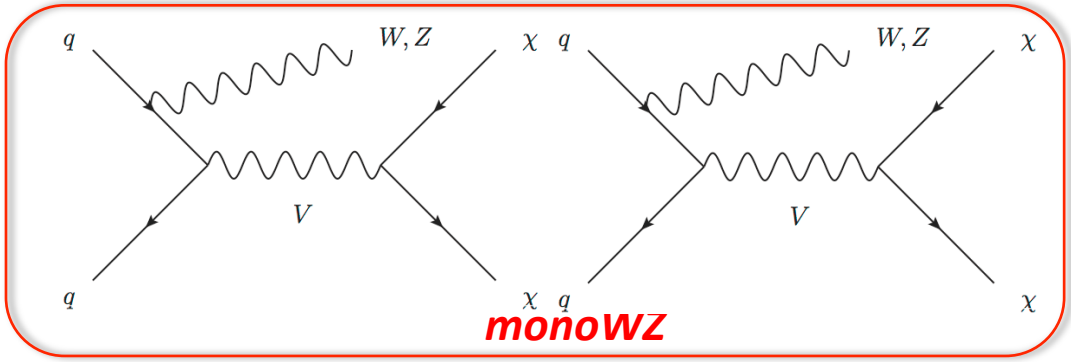


Approved plot since EPS 2015

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/EXOT-2015-007/

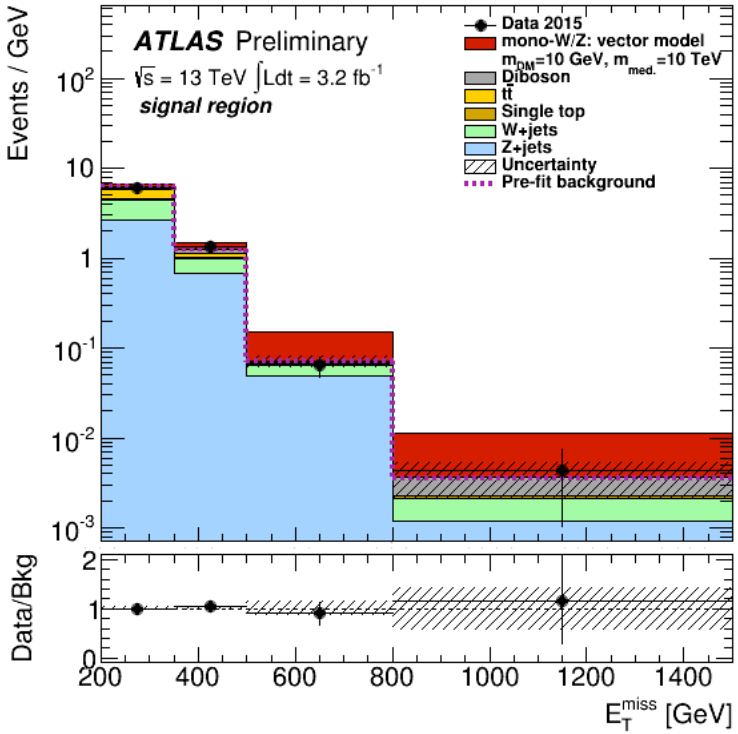
Mono-V analyses

ATLAS-CONF-2015-080

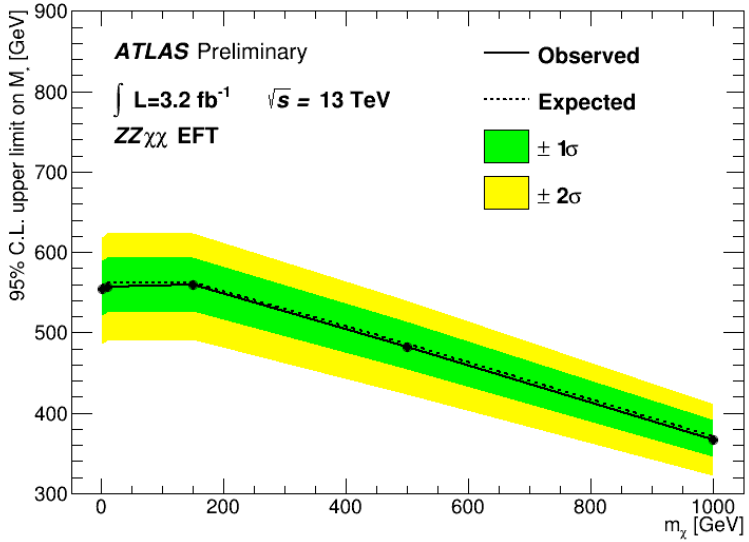


A. Sanchez:

- **sviluppo del framework di analisi (CxAOD)**
- **responsabile della produzione samples data/MC**



Same selection as for the VZ-Jvv selection with the use of the MET shape in the final fit



Preliminary LHC schedule & ATLAS Runs

2009 LHC startup √s=900 GeV, Phase-0

2010

2011

2012

Run-I (2011-2012): √s= 7 and 8 TeV, L=6x10^{33} cm^{-2}s^{-1}, bunch spacing 50ns, 75% of nominal luminosity → ~25fb^{-1}

2013 LS 1

2014

2015

Long Shutdown 1 (LS1) → Go to design energy and nominal luminosity

Run-II (2015-2018): √s= 13 and 14 TeV, L=10^{34} cm^{-2}s^{-1}, bunch spacing 25ns → ~75fb^{-1}

2016

2017

2018

2019 LS 2

LS2 → Injector + Upgrade to LHC Phase-1 to ultimate design luminosity

2020

2021

2022

Run-III (2020-2022): √s=14 TeV, L=2x10^{34} cm^{-2}s^{-1}, bunch spacing 25ns → ~300fb^{-1}

2023

2024 LS 3

LS3 → Upgrade to HL-LHC Phase-2 (ATLAS scoping document → CERN-LHCC-2015-020)

Run-IV: √s=14 TeV, L=5x10^{34} cm^{-2}s^{-1} → ~3000fb^{-1}

Phase-0

Phase-1

Phase-2

Preliminary schedule for Phase-1 and Phase-2 strongly → depends also on the results from Run-II

- **Phase-1: Fast Trigger tracker (FTK), New Small Wheel (NSW), Calorimeter ReadOut**
- **Phase-2: Re-design of the trigger system, new tracking, updates on the Muon system, Calorimeter electronics and forward region upgrades**

ATLAS detector and Trigger Upgrades for Phase-1

Upgrade Phase-1

Lar calorimeter electronics:
Increase of the granularity of a factor 10 → better resolution, longitudinal informations on the shower (Increase of the efficiency and a better identification of backgrounds and fakes).

Fast Track Trigger (FTK):
Track finding and fitting online (just after the second level of trigger (LVL2) processing) with resolutions very close the one from the offline.

New Small Wheel (NSW): replacement of the existing Small Wheel→ more details in the following slides.

New Readout Electronics: compatibility with Phase 2 upgrades, increase of the informations to the trigger processors.

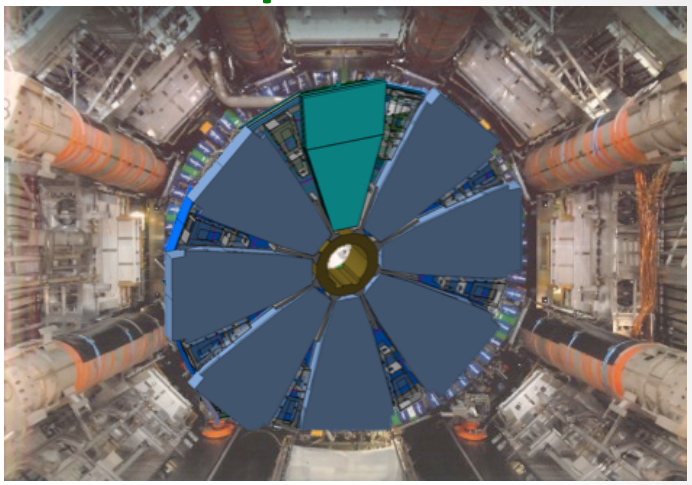
TDAQ:
- **Interface board to MUCTPI @Napoli:** development, production and test of the Interfaces boards to MuCTPI send data trough optical links from the Sector Logic (SL) in USA15 to Central Trigger Processor (CTP) → more details in the following slides.

Phase-1 Upgrade: New Small Wheel (NSW)

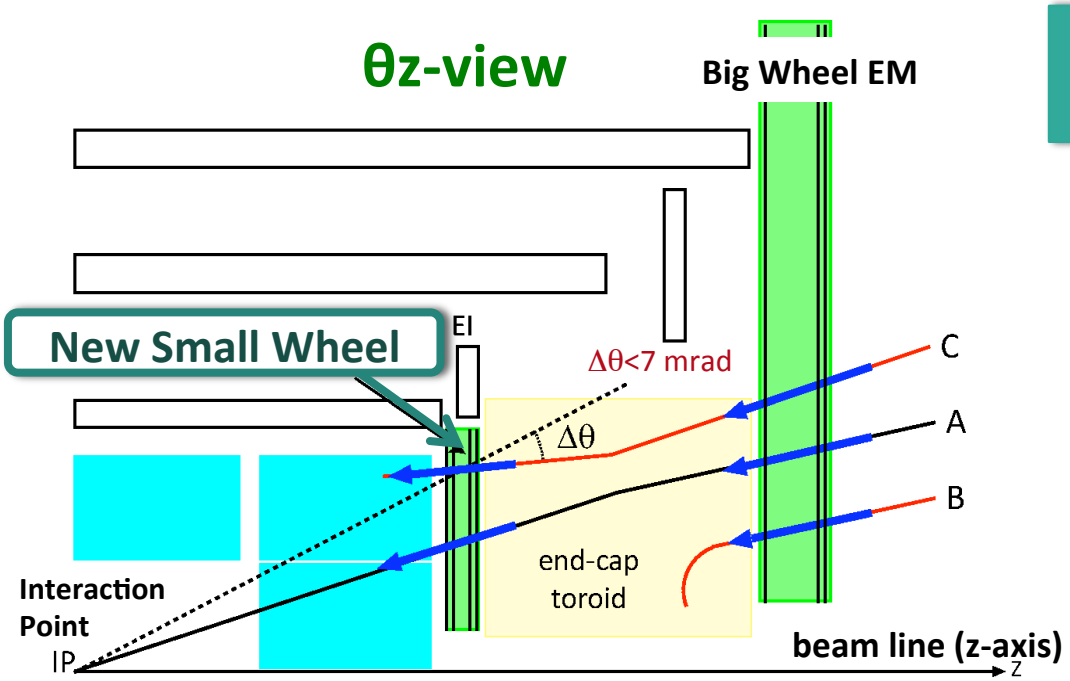
The New Small Wheel Upgrade with the replacement of the existing Small Wheels has the goal to address:

- The high fake track rate with the current setup
- Prohibitively high trigger Level 1 Muon rates if current p_T thresholds would be kept at luminosities as expected after LS2 and during the Phase-2 HL-LHC

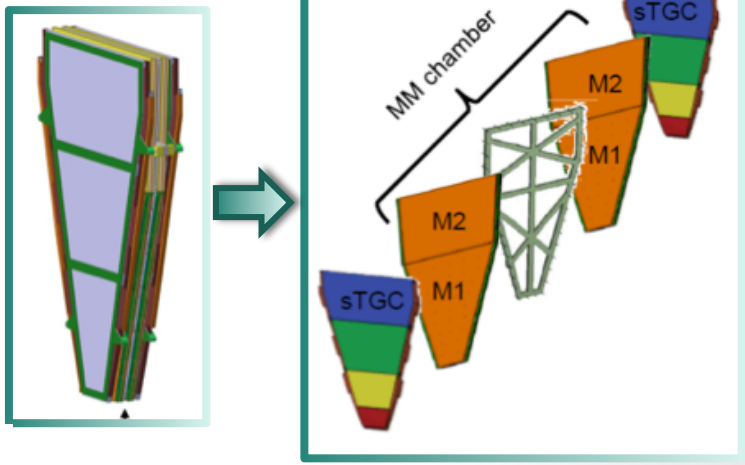
ϕ-view



θz-view



NSW Sector: Package of sTGC and MicroMegas + central spacer frame

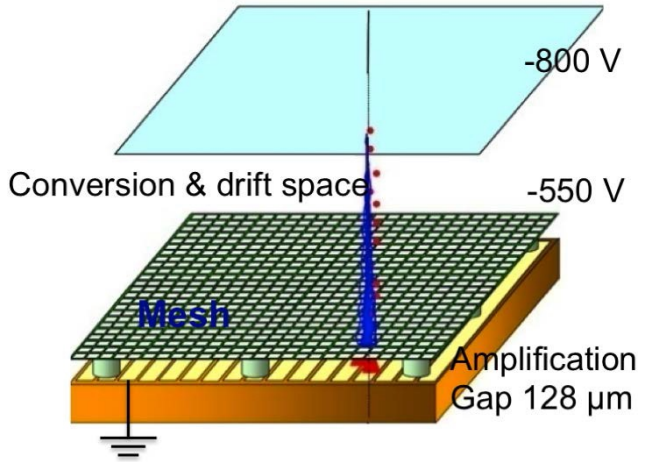


New Small Wheel Detectors

Two detector technologies, High redundancy, 16 active detection plane in total, technologies complement each other, both with trigger and tracking capabilities!

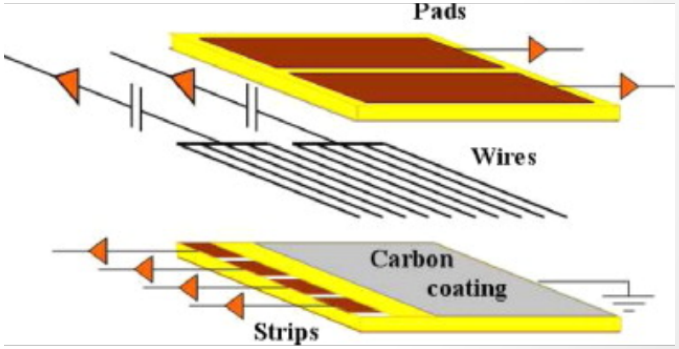
Micro-Mesh Gaseous detectors (MicroMegas) → primary precision tracker

- Space resolution < 100 μm independent of track incidence angle
- Good track separation due to small 0.5 mm readout granularity (strips)
- Excellent high rate capability due to small gas amplification region and small space charge effects



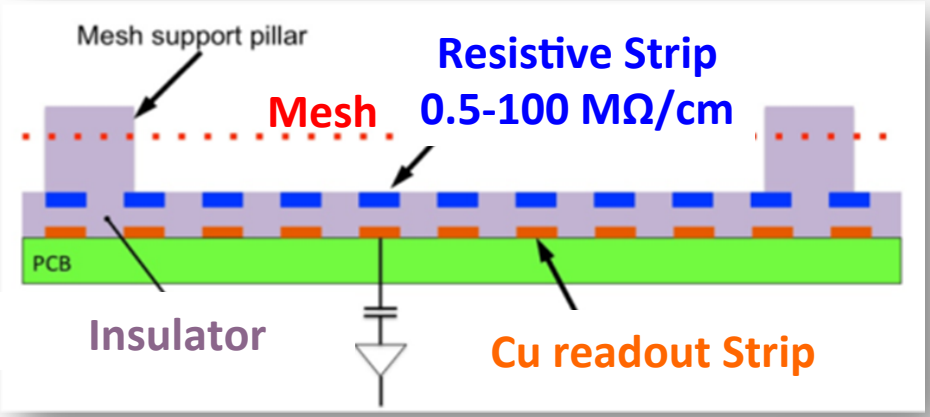
small Thin Gap Chambers (sTGCs) → primary trigger detector

- Bunch ID with good timing resolution – additional suppression of fakes
- Good space resolution providing track vectors with < 1 mrad angular resolution
- Based on proven TGC technology, PAD electrodes instead of only strips as in current detector



(a) a

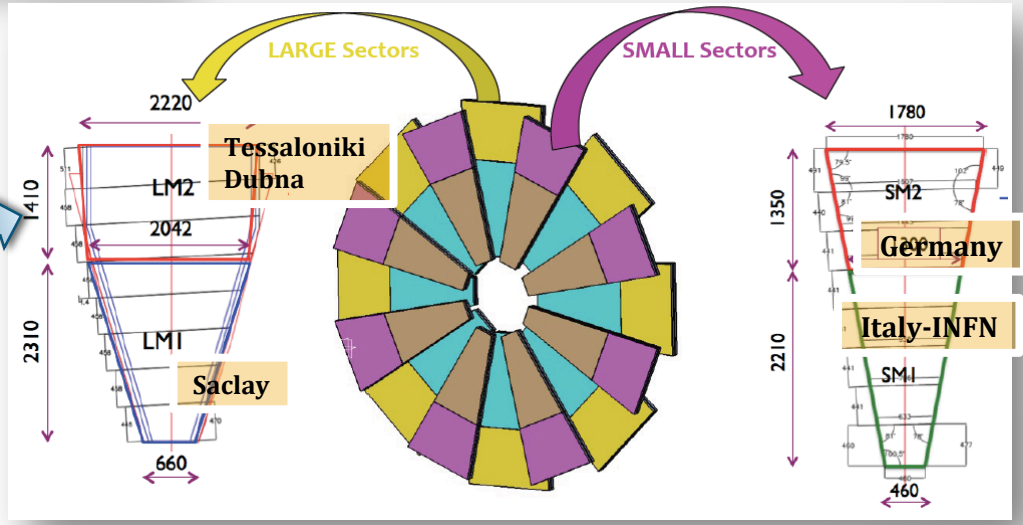
Micro-Mesh Gaseous (MicroMegas) Chambers Construction



Micro-Mesh Gaseous (MicroMegas):

- M. Iodice coordinator
- 8 active layer with dimension up to 3 m^2
- Resistive Strips (to reduce sparks effect) +"floating mesh"

Large Sector MicroMegas 2 (LM2) Module-0 will be assambled at CERN with great effort from G. Sekhniaidze



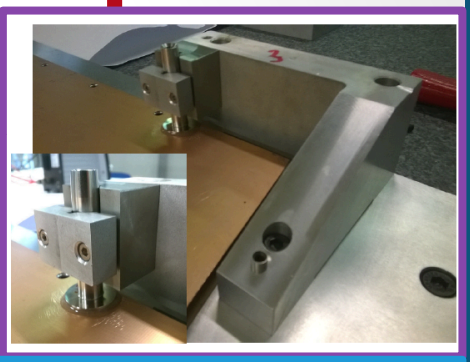
MicroMegas quadruplet construction type SM1 → Italy-INFN: Cosenza, Frascati, Lecce, Napoli, Pavia, Roma 1, Roma 3

Napoli: Fabrication of tooling, Component Maching

MicroMegas Activities in Napoli

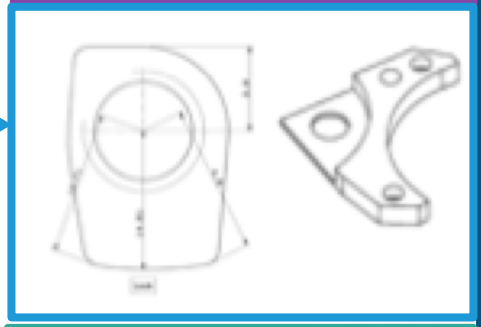
Module-0 components construction:

- "Angolari" di precisione portati a Pavia
- tecnici a LNF e Pavia per produzione pannelli drift
- camme (180) e molle (200) per le 'compression bar Zebra connectors'



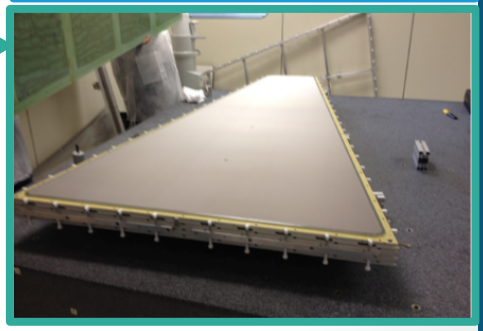
I pannelli di drift e read-out per il Module-0 sono in fase di costruzione in collaborazione con altri siti INFN (Pavia, Roma1, Roma3, LNF, Cosenza, Lecce)

→ completamento Modulo-0 italiano entro fine febbraio



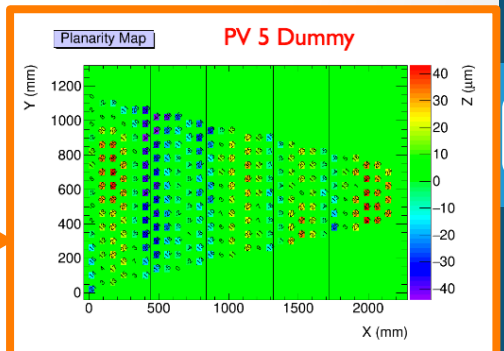
For MicroMegas production:

- Napoli → meccanica per angolari drift gaps (500) e barre laterali
- Napoli → meccanici @ LNF



Other activities (M. Alviggi, V. Canale, G. Sekhniaidze, C. Didonato, F. Cirotto):

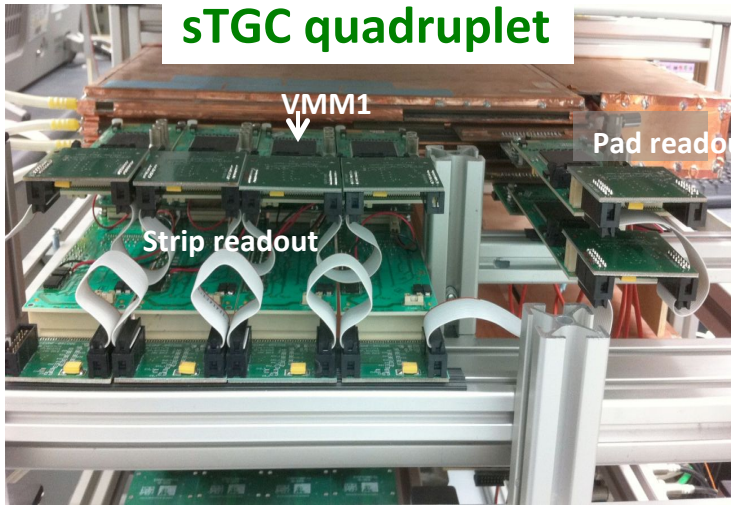
- Disegni dei layout dei diversi PCB per tutte le MicroMegas di Atlas
- Acquisto e Test per la comunità italiana di due schede per la lettura delle MicroMegas tramite VMM2, in programma l'utilizzo di almeno una di queste a Napoli team di test PCB alla Eltos (se produrrà parte delle PCB)
- Limbo test per la verifica della planarità dei pannelli di drift
- Decodifica dati di APV25 → VMM2



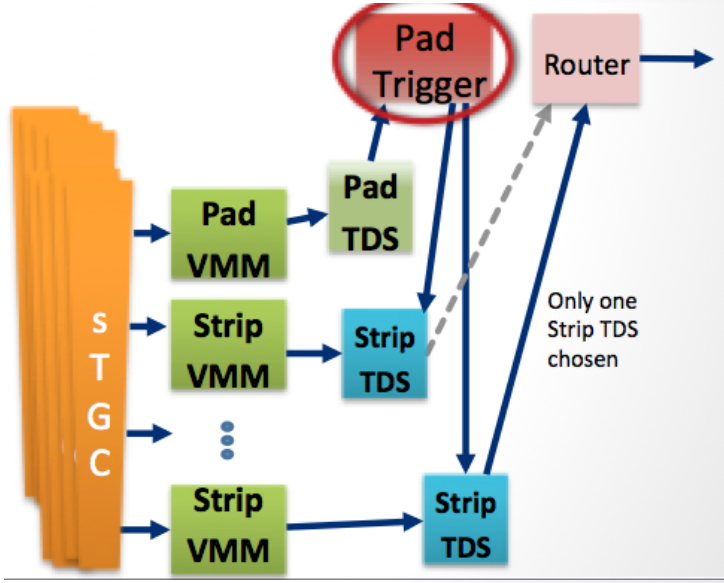
New Small Wheel: Electronics

NSW project does not involve only detector construction, but substantial electronics development as well:

- New Frontend boards and VMM frontend chip, common to sTGC and MM
- Micromegas and sTGC trigger-on-detector electronics. Sector logic, and off-detector processors ...
- **Napoli in collaboration with Roma1 is involved in the development of the sTGC PAD Trigger Board**



- **The PAD Trigger board is used to select the NSW regions having a hit, thus reducing the amount of data to be transferred Off-detector**
- **3/4 majority logic is required on both sTGC quadruplet.**
- **Strip-TDS sends only selected strip data to the routers.**

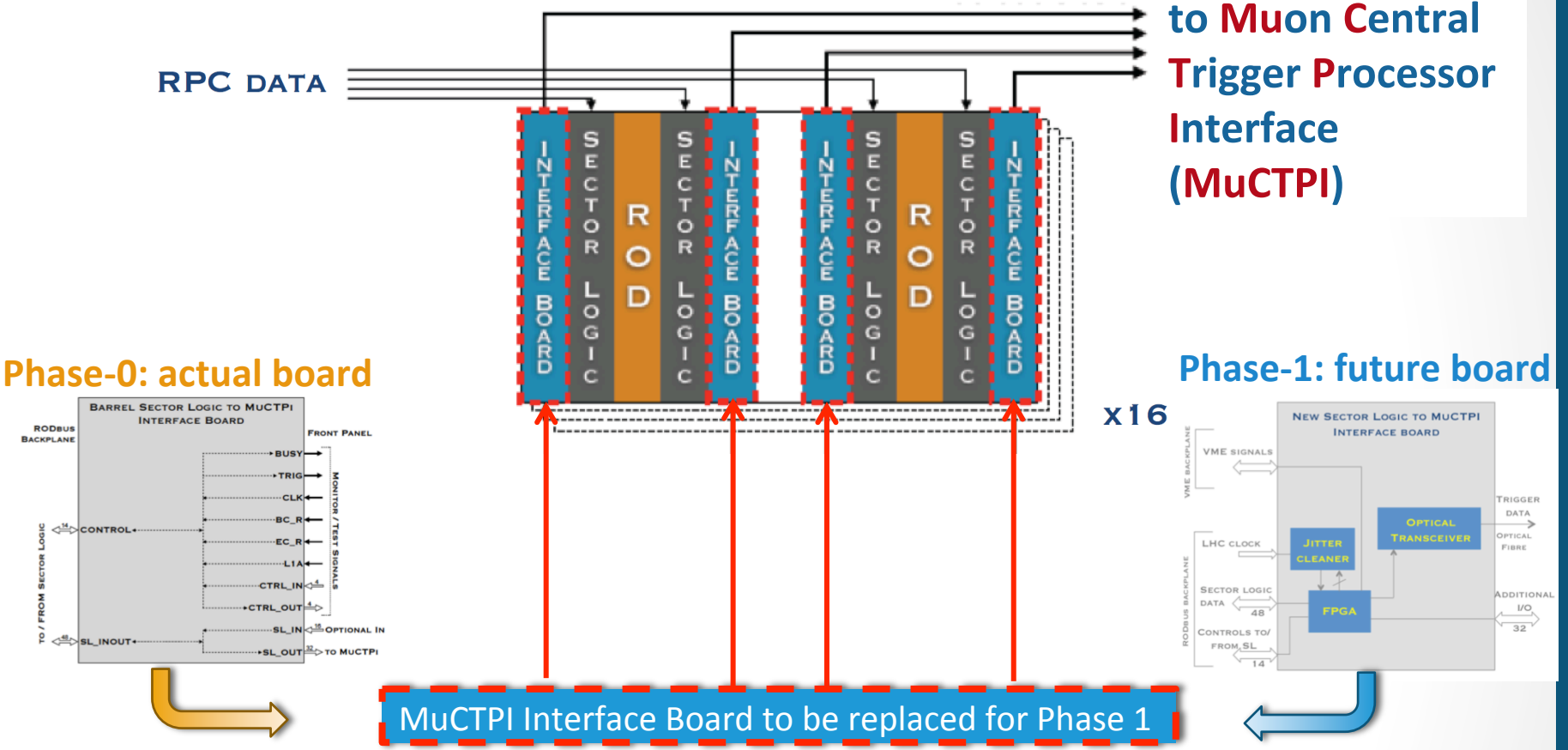


Activities in Napoli (V. Izzo, S. Perrella, R. Giordano):

- **Hardware and firmware development for the sTGC PAD Trigger Board**
- **Development of a fast serial link on FPGA for the DAQ MicroMegas and for the NSW Trigger**

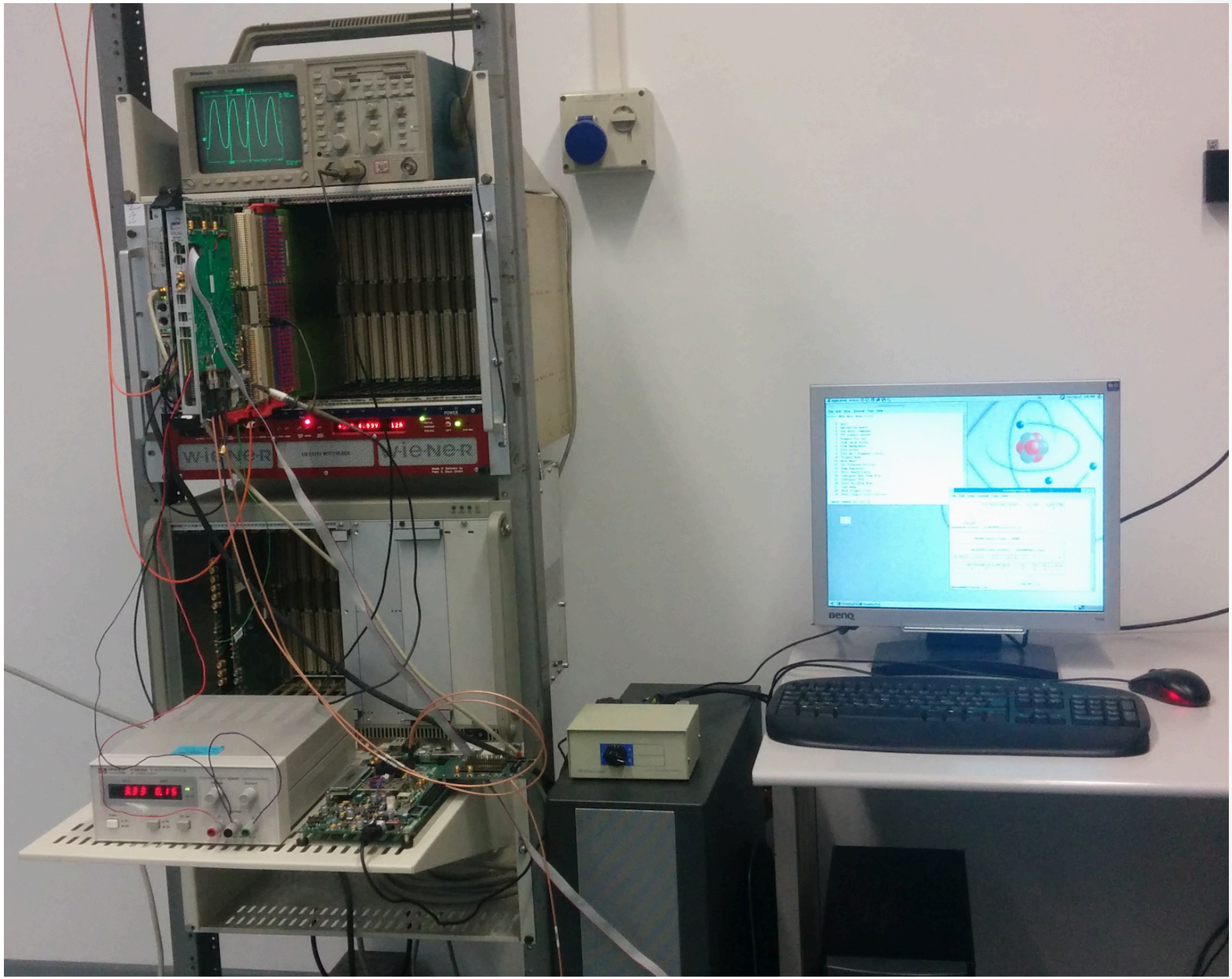
New MuCTPI Interface Board

*INFN Napoli, Roma1, Roma2



- New Interface board equipped with a last-generation FPGA, allowing VME communication and serialization to MuCTPI via optical fibre
- Optical SFP+ transceiver, Data Rate: 6.4 Gb/s: 128 bit @ 40 MHz or 64bit @ 80MHz (Phase-0: 32 bit @ 40 MHz on copper cables)
- Serialization logic synchronous with 40 MHz LHC clock

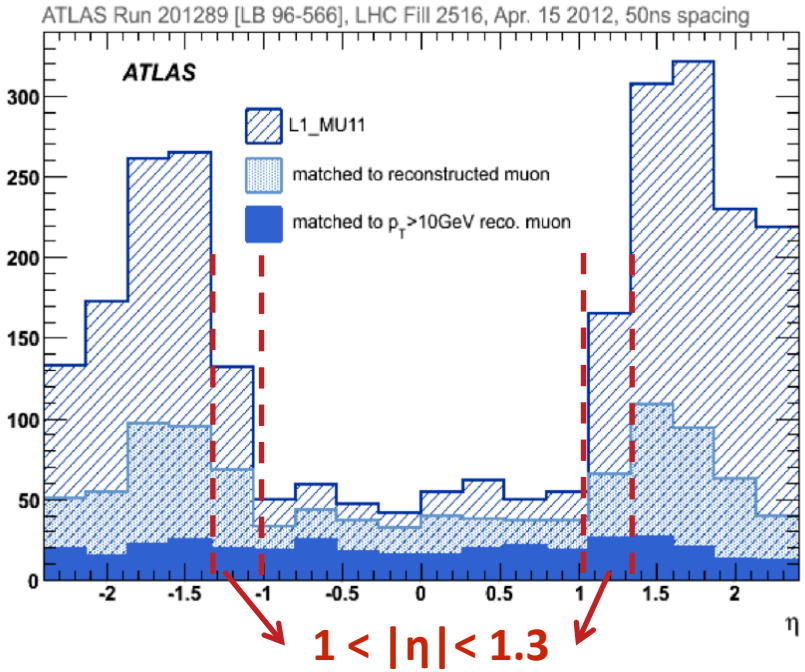
Preliminary Tests in Napoli

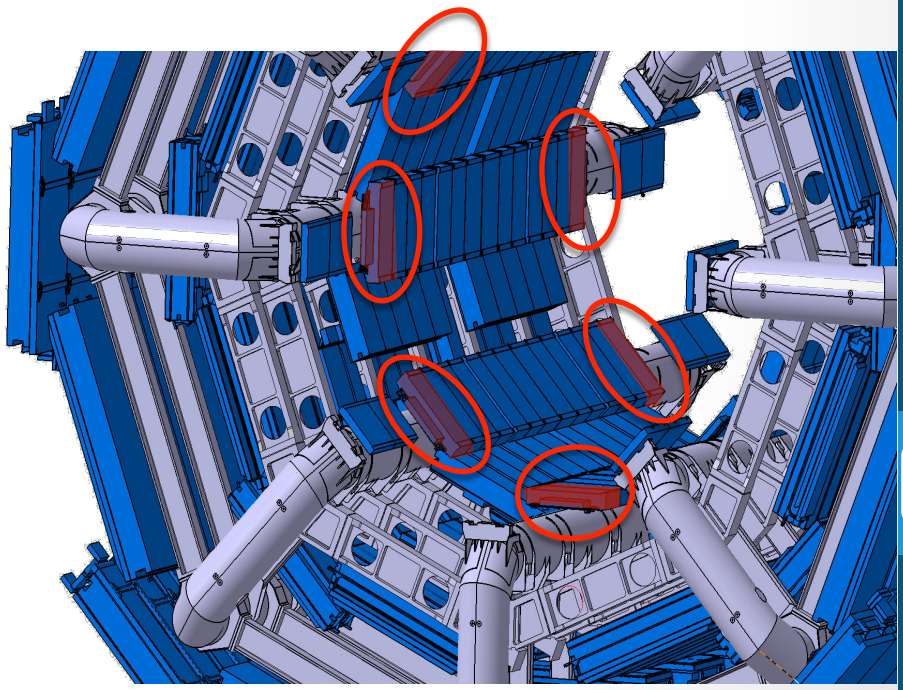


The BIS78 project

*INFN Napoli, Roma1

- The Barrel/EndCap transition region (1<|η|<1.3), not covered by the New Small Wheel, will suffer from high trigger fake rate with increasing luminosity.
- The additional RPC chambers in the Barrel Inner Small region (16 new stations) can significantly reduce the foreseen fake rate.
- 16 Pads will receive RPC time hit data and produce the muon trigger candidate to be sent to the End-Cap Sector Logic boards in USA15.
- Performs a 2/3 majority logic and sends the trigger candidate to the End-Cap Sector Logic through an optical fibre.
- System is compatible with Phase-2.





ATLAS detector and Trigger Upgrades for Phase-2

ATLAS Upgrade for Phase-2

For Phase-2 to cope with ATLAS scopes and the very high luminosity many upgrade have been conceived. The project's development phase is very active and the changes will affect both the Detector and the Trigger system:

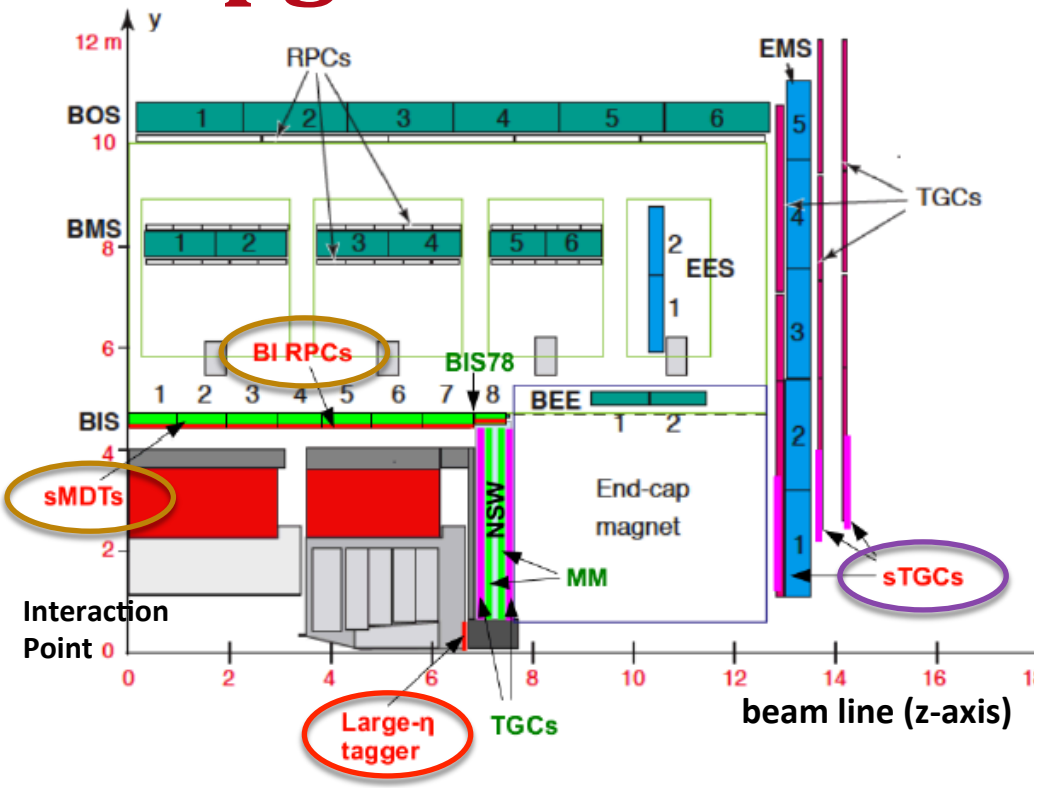
Trigger

- New Trigger architecture: split the actual Level-1 in two sub trigger level → Level-0 and Level-1
- New detector readout
- Re-design of the Trigger Software
- **Great interest from INFN in many tasks and in particular in Level 1 Muon Barrel trigger (Roma1, Roma2, Napoli, Bologna) to higher the rate capability (from 100kHz to 500kHz) → electronic and trigger algorithms re-design**

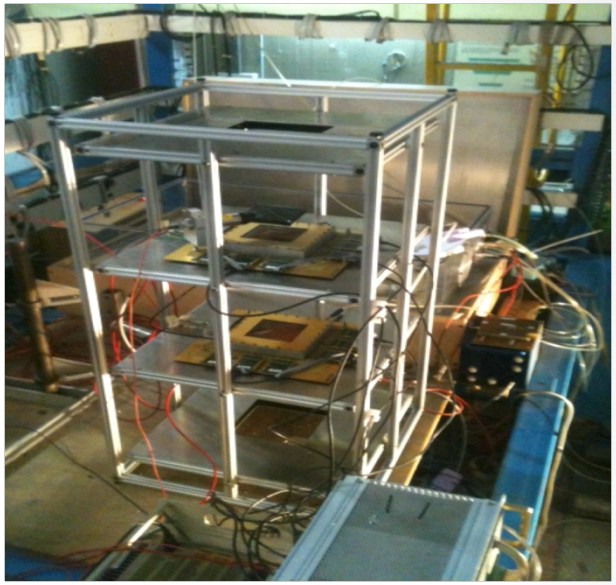
Detector

- **Muon Detector → great interest from INFN-Napoli** more details in the next slide
- **Calorimeters:**
  - **Lar:** new Front-end electronics (radiation damage and compatibility with the new trigger architecture) **→great interest from INFN (Milano)**
  - **TileCal:** New Read Out Electronics (radiation damage and compatibility with the new trigger architecture, increase of the Trigger informations) **→great interest from INFN (Pisa)**
- **Tracker:** the project is to replace the Inner Detector to cope with the high radiation damage and also to the very high occupancy, several possible scenario proposed (new detector with only pixel and silicon microstrip) **→great interest from INFN**

Upgrade Phase II: Muon Detector



MicroMegas tower test in the "hangar" in Napoli



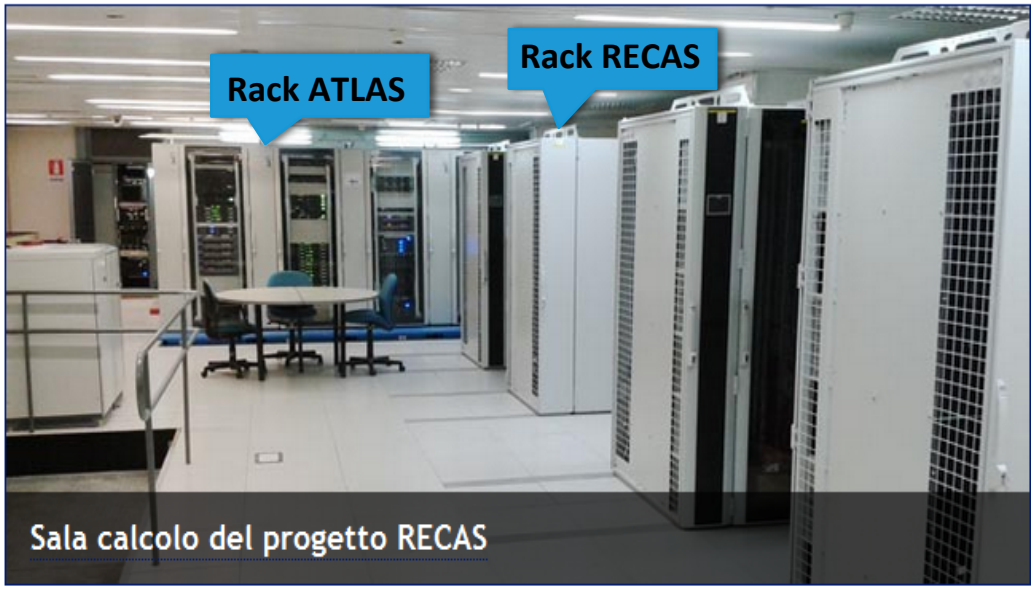
- **New RPCs in the Inner Layers** (BI) and substitution of the MDT with **sMDT** to free space for RPCs to maximize the acceptance of the barrel muon trigger and to recuperate inefficiencies of Middle (BM) and Outer (BO) RPC layers in regions of high background
- **New sTGSs** in the Endcap Middle Layers with an higher rate capability
- **Large η Muon tagger to identify muons in the region with 2.7 <|η|<4.0 → possible candidate detector MicroMegas with little resistive pads (~1 MHz/cm^2), I^o prototype build by INFN Napoli and Roma3, MicroMegas tower test in the "hangar" in Napoli**
- New electronics to cope with the ATLAS Trigger scheme for Phase-2

Il Tier2 di Napoli

- stato e attività -

Tier 2 @ Napoli

L'infrastruttura (sistema di raffreddamento, gruppi di continuità, gruppo elettrogeno) utilizzata dal Tier2 di ATLAS a Napoli è integrata con quella realizzata per il progetto RECAS . E' utilizzata anche una parte dell'infrastruttura del precedente PON SCOPE.



Sala calcolo del progetto RECAS

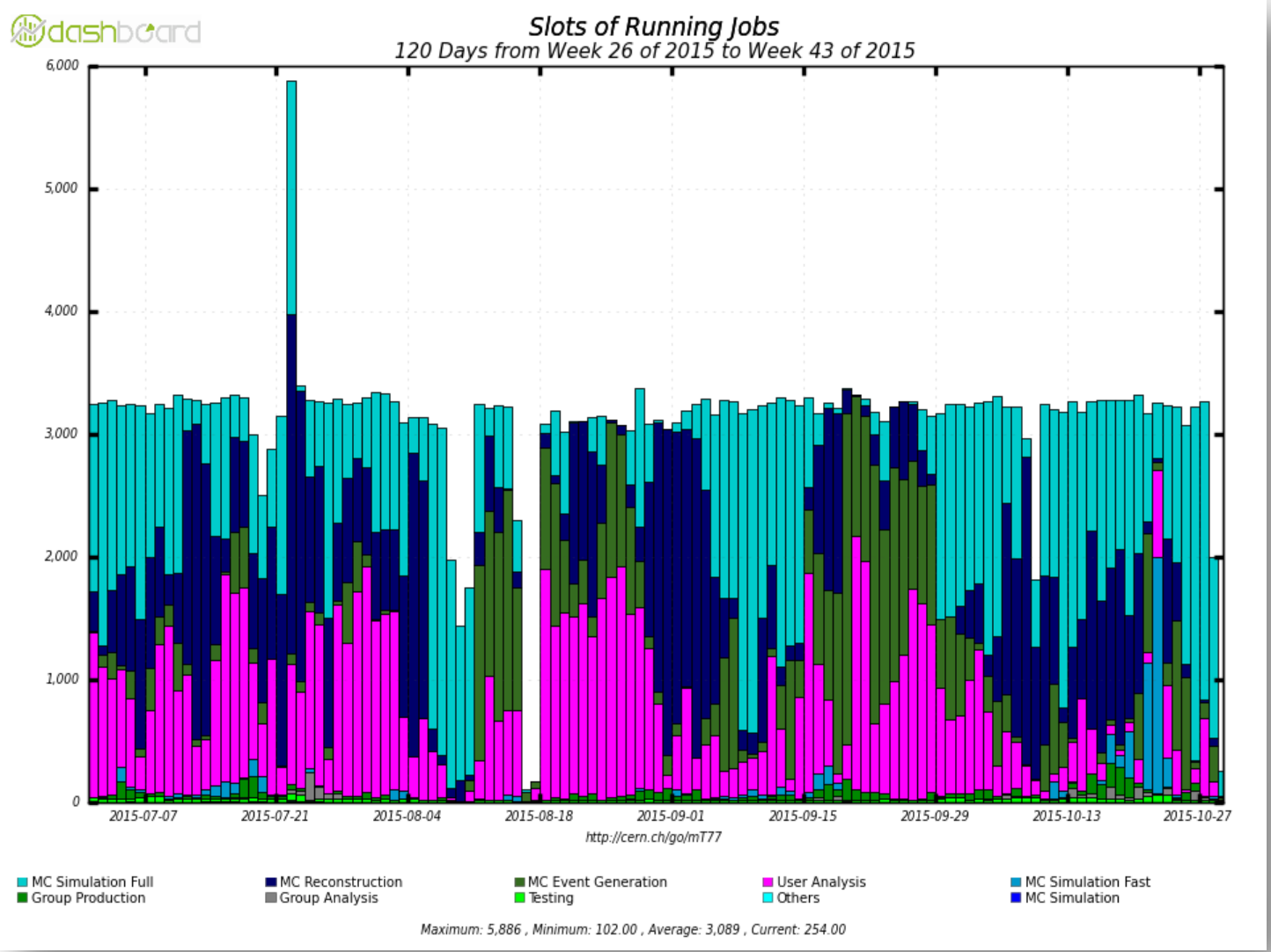
In totale il Tier2 ha a disposizione 15 rack raffreddati , che contengono un totale di:

- **130 nodi di calcolo, 2700 core, 3400 job running slot**
- **~ 30 macchine di servizio**
- **~ 1.4 PB di spazio disco**

Attività specifiche a Napoli (G. Carlino, A. Doria, L. Merola, G. Russo):

- RPC e LVL1 Muon Trigger calibrazione e performance
- Il Tier2 è uno dei siti di calibrazione di ATLAS, connesso direttamente al Tier0 con un canale FTS dedicato. Riceve la muon calibration stream e le NTUP e D3PD del muon trigger
- Aree di storage dedicate per i dati di PHYS-HIGGS e TRIG-DAQ → in base alle principali attività dei gruppi afferenti e gestiti dai working group di ATLAS

Job slot utilizzate per attività



La maggior parte della produzione di ATLAS attualmente avviene in modo multi-core:

Simulazione (Geant4) e digitizzazione, Ricostruzione di dati reali e simulati

Restano in single-core: Event generation, Analisi

Conclusions and Plans

- **Phase-0:**
  - The ATLAS collaboration submitted **496** papers with the **Run-I** dataset (not covered in this talk)
  - The **ATLAS** Collaboration has released first **results with the full 2015 dataset @ 13 TeV** in **24 Conference Notes** and **5 Journal Papers**
  - **All ATLAS public results are** available at the following location: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/)
- **Phase-1 Upgrades:** ATLAS detector and Trigger Upgrades ongoing
  - great effort from our team in particular for the New Small Wheel and MuCTPI interface board construction and design
  - Participation in BIS78 project
- **Phase-2 Upgrades:** The project's development phase is very active and the changes will affect both the Detector and the Trigger system
  - Great involvment of our team for the Large η Muon tagger design and construction
- **Tier-2:** 3400 job running slot and ~ 1.4 PB disk capacity

Eagerly awaiting a much larger haul of data in 2016!

Backup

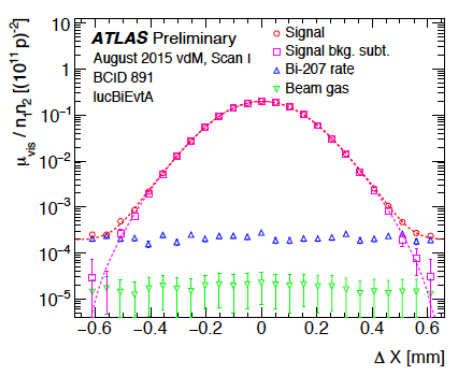
Data Quality Efficiencies, Luminosity and Trigger

Data Quality efficiency

- Average 93% (Run 1 Average 94%)
- Requiring IBL as well 87%

Luminosity Measurement

- Preliminary uncertainty from complete scan (Valid for entire 2015 dataset) **5%**



"All Good" dataset :

$3.2 \pm 0.2 \quad fb^{-1}$

With IBL Off runs

$3.5 \pm 0.2 \quad fb^{-1}$

Trigger

- **Run-2 Menu**: Approximately 1500 HLT selections seeded by about 400 L1 items
  - Primary triggers, typically unprescaled;
  - Numerous other triggers for Support, Background, Alternative algorithms, Backup and Calibration
- **Continued excellent performance** and stability of trigger throughout the run
- Rates for typical lowest unprescaled single object triggers:

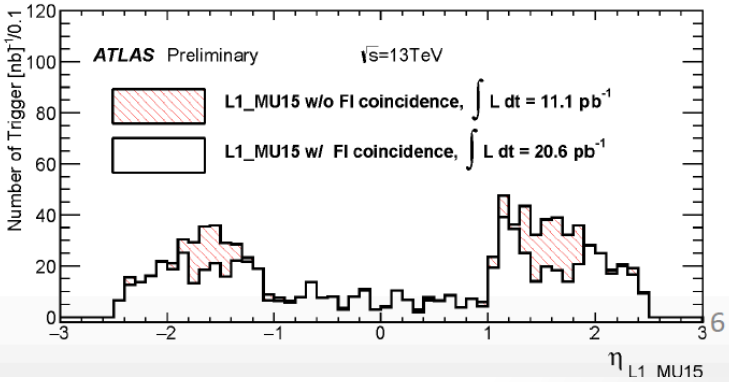
Trigger	p_T Threshold (GeV)		Rate (Hz) *	
	Run 1	Run 2	Run 1	Run 2
Inclusive e	24	24	70	97
Inclusive μ	24	20	45	130
E_T^{mis}	80	70	18	55

Improvements at Run-2

L1 Calo Per bunch baseline subtraction large reduction in MET trigger rates

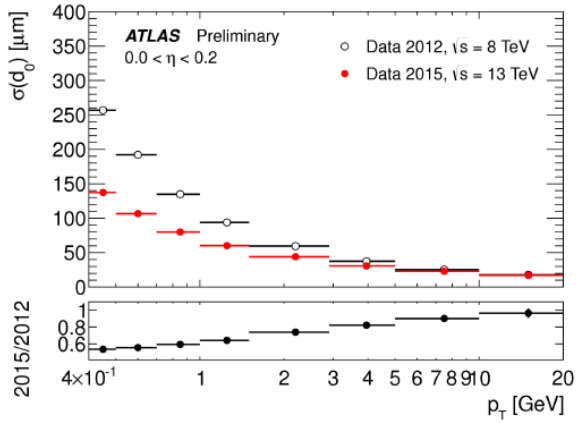
L1 Muon triggering Use of FI coincidences **50%**

Rate reduction (in $1.0 < \eta < 1.9$ at p_T 20 GeV)

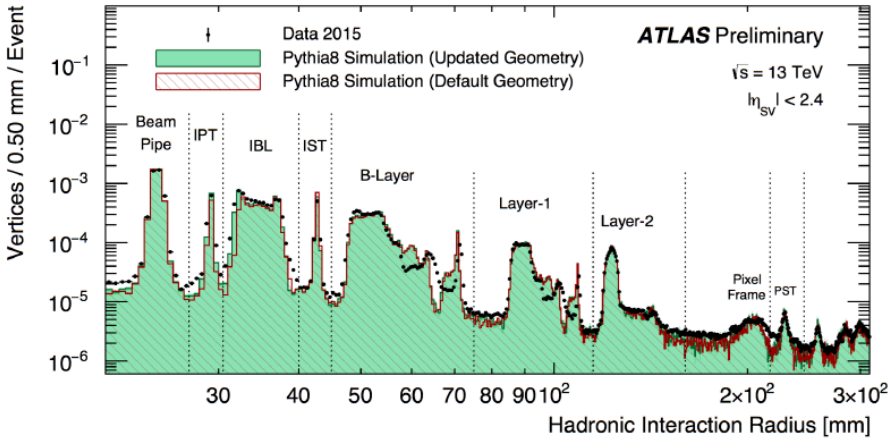


Combined Performance - **Tracking**

IBL: Improved Tracking performance



IBL, new Beam Pipe and Services: Additional material (and main systematic uncertainty for tracking)



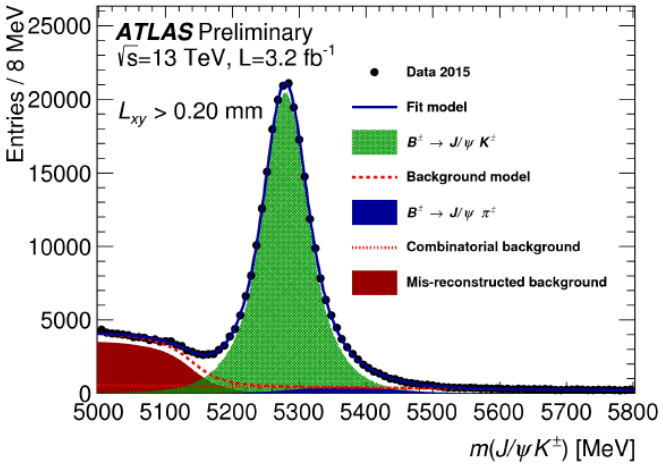
Material studies using hadronic interactions and conversions have led to a new geometry for simulations

Alignment and Tracking Performance check with $B^{\pm}$ mass

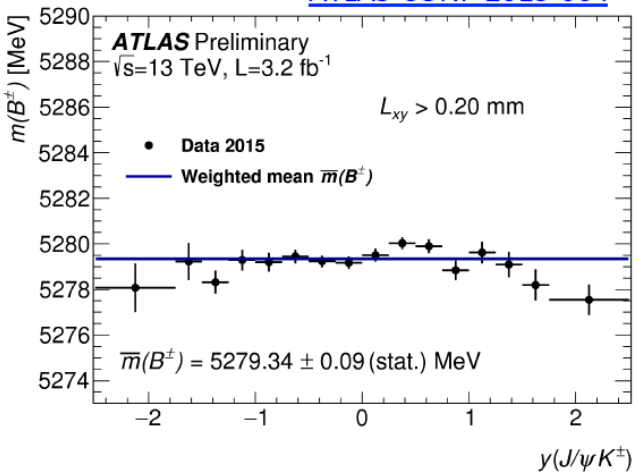
$$B^{\pm} \rightarrow J/\psi K^{\pm}$$

No specific trigger selection

Selection of J/Psi(μμ) and a track (assume Kaon), J/Psi π background from MC



ATLAS-CONF-2015-064



$$m(B^{\pm}) = 5279.32 \pm 0.10(stat) \pm 0.22(fit\ syst)\ MeV$$

$$m(B^{\pm}) = 5279.29 \pm 0.15\ \text{MeV}\ (World\ Average)$$

Cross check: Systematics on peaking background and fit, but not on momentum scale and vertexing

Combined Performance (III)

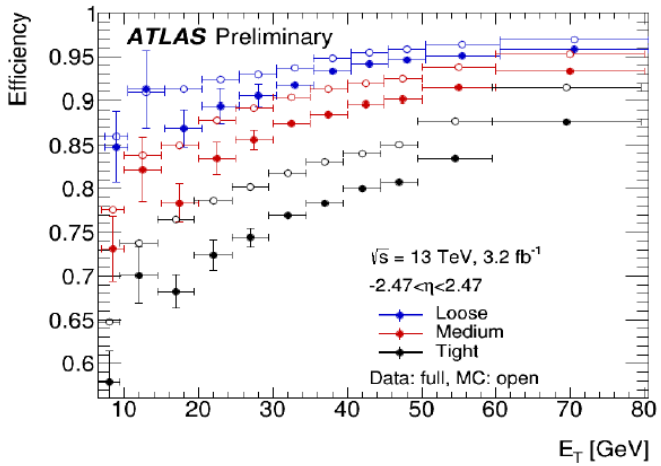
Electrons and Photons

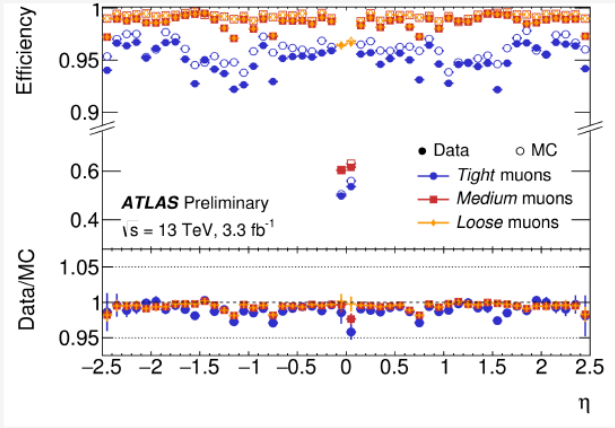
Electron Efficiency: Full 2015 data driven measurements

Long-standing lateral shower shape difference in G4 simulation present at Run 1 – Taken into account in ID optimization

Photon Efficiency: From Run-1 and MC extrapolation

Calibration: based on Run-1 with MC extrapolation
Checked with Run-2 data to be well within uncertainties





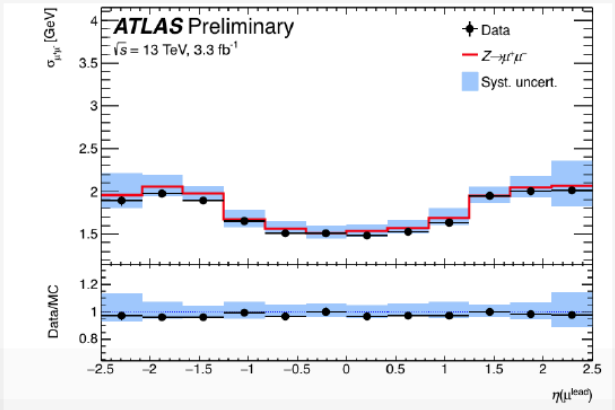
Muons

Efficiency: Full 2015 data driven trigger and reco efficiencies using Tag and Probe (with Z and J/Psi)

Energy scale and resolution: calibration on full 2015 dataset (using Z and J/Psi)

Using preliminary Toroid Off Alignment

(Alignment close to final O(50μm) in the barrel and O(100μm) in the Endcap)



Close to nominal performance of O(10%) relative resolution in (1/pT) for TeV muons

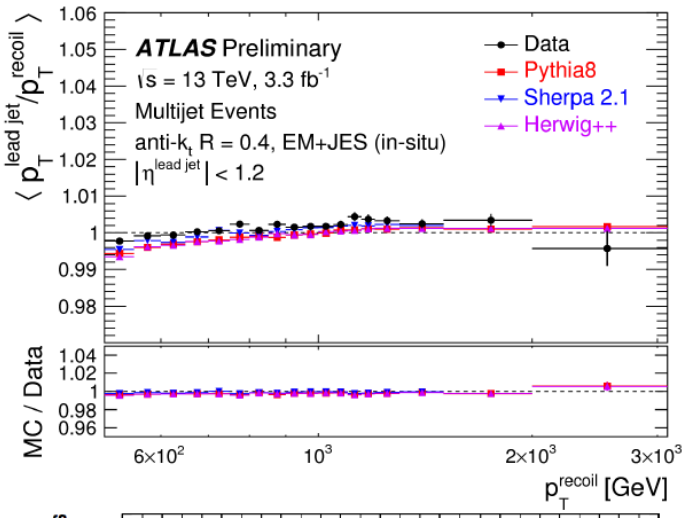
Combined Performance (IV)

Jets

MC extrapolated Run 1 Performance and Jet η-inter-calibration with balanced di-jet events.

Many checks with Run-2 data in particular

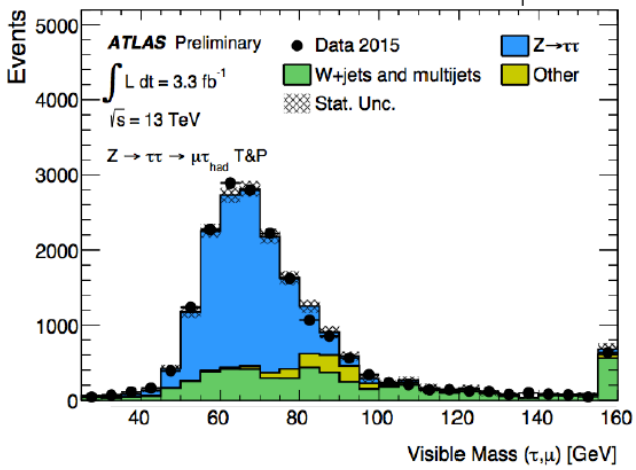
- JES balance in photon-Jet events
- ***JES balance with Multi Jet*** (Highest pT reach)



MET

Based on Tracking Soft Term, Performance and uncertainties extrapolated with MC from Run-1

Multiple checks in data



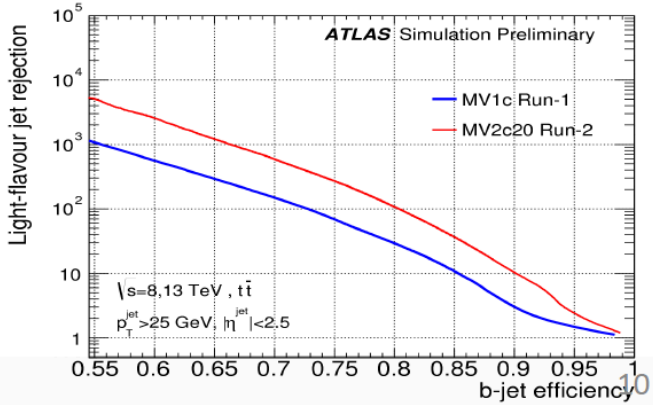
Taus

extrapolated with MC from Run-1

Many checks with full dataset for fakes and efficiency (using Tag and probe with Z events)

Flavor Tagging [ATL-PHYS-PUB-2015-022]

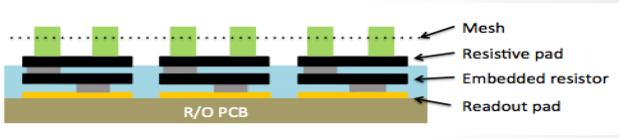
- Improvement from IBL and new algorithms
- Improved light jet rejection of a factor of 4 (precise data driven light jet rejection is becoming challenging)
- MC calibration checked with top events in data (fully consistent with current MC within uncertainties)

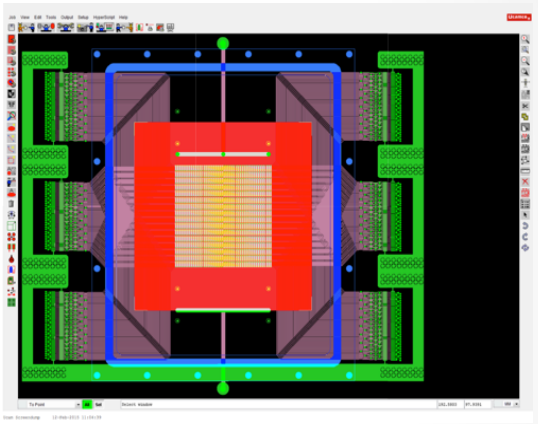


Upgrade Phase II: 3.Large η Muon Tagger

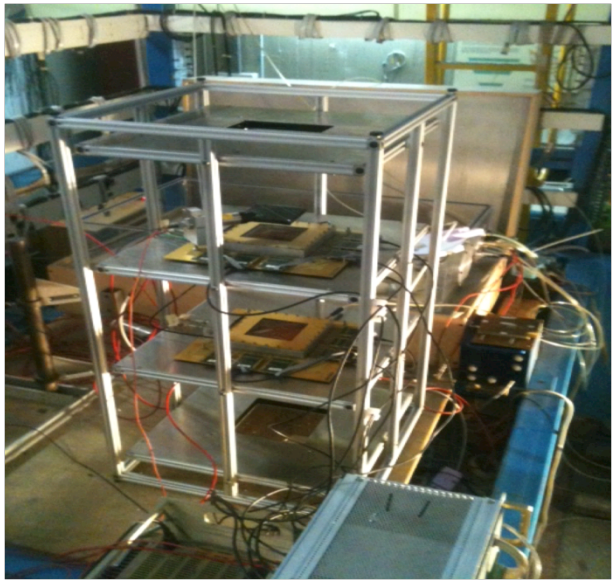
Large η Muon tagger to identify muons in the region with 2.7 <|η|<4.0 → possible candidate detector MicroMegas with little resistive pads (~1 MHz/cm²), Iº prototype build by INFN Napoli and Roma3

- First design of a small size prototype:
  - *Matrix of 48x16 pads*
  - *Each 0.8mm x 2.8mm (pitch of 1 and 3 mm in the two coordinates)*
  - *A total of 768 channels*





MicroMegas tower test in the "hangar" in Napoli



NEW CONSTRUCTION TECHNIQUE (Rui De Oliveira) with a stack of all layers all deposited by screen-printing

Applications:

- Large area fine tracking and trigger with high rate capability (one possible application: ATLAS very forward extension of muon tracking
- Sampling Hadron Calorimetry

Upgrade Phase II: Trigger DAQ

- New Trigger architecture: split the actual Level-1 in two sub trigger level → Level-0 and Level-1
- New detector readout
- Re-design of the Trigger Software

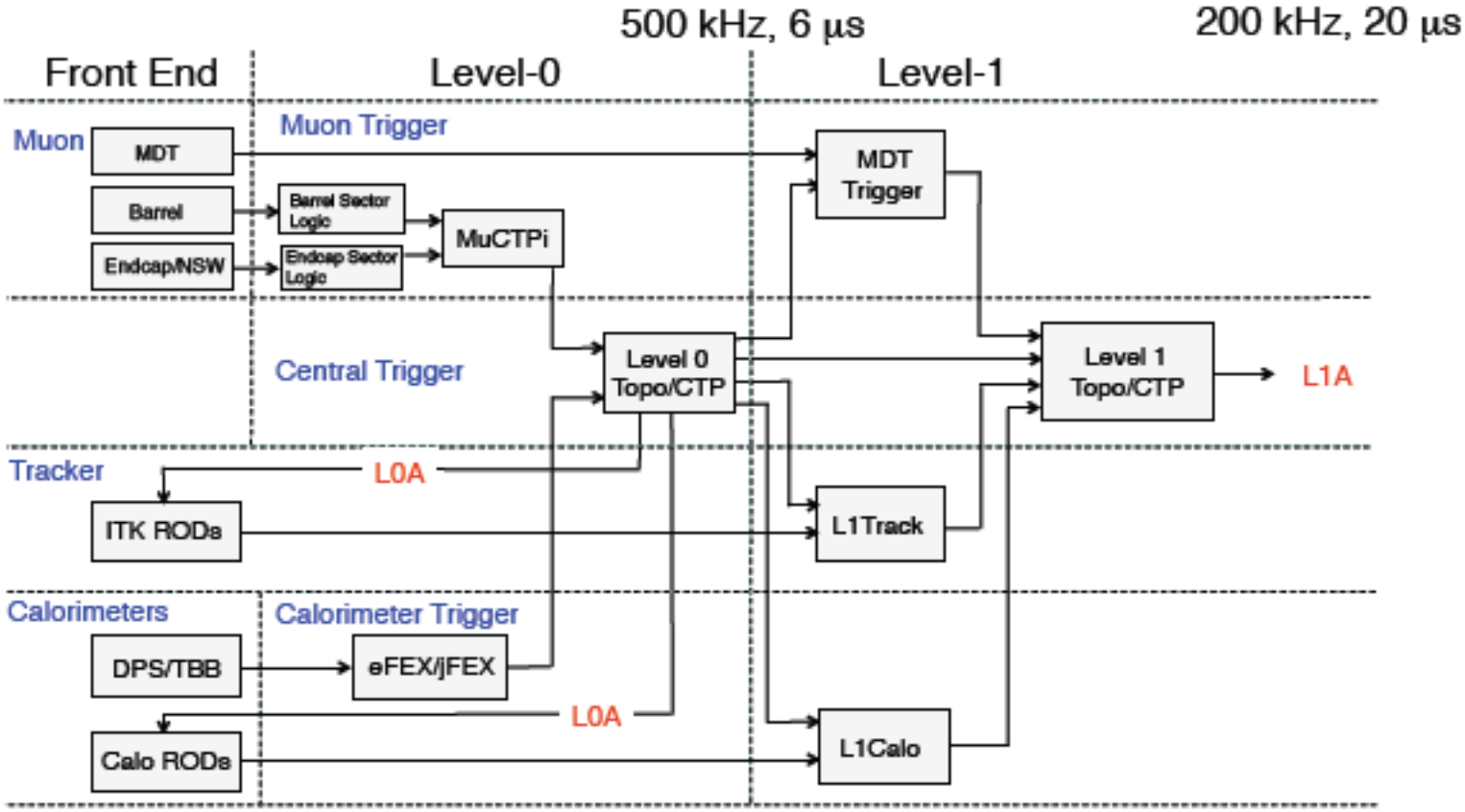
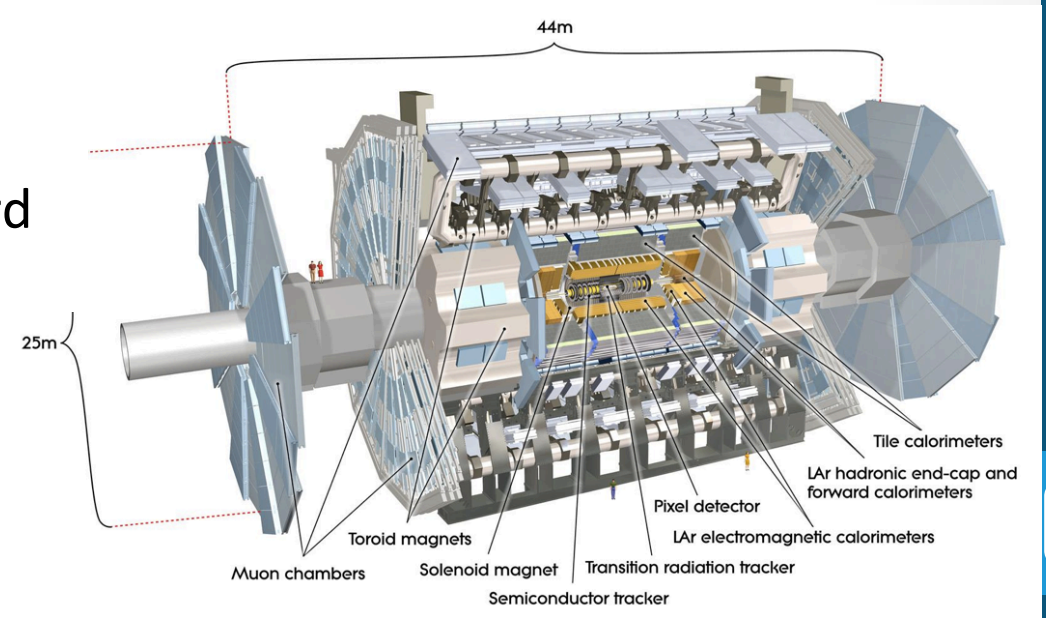


Figure 2.2: A block diagram of the architecture of the split Level-0/Level-1 hardware trigger proposed for the Phase-II upgrade. (The MDT trigger is shown as part of the Level-1 but may be used at Level-0).

Upgrade Phase II: 2. Muon, Big Wheel

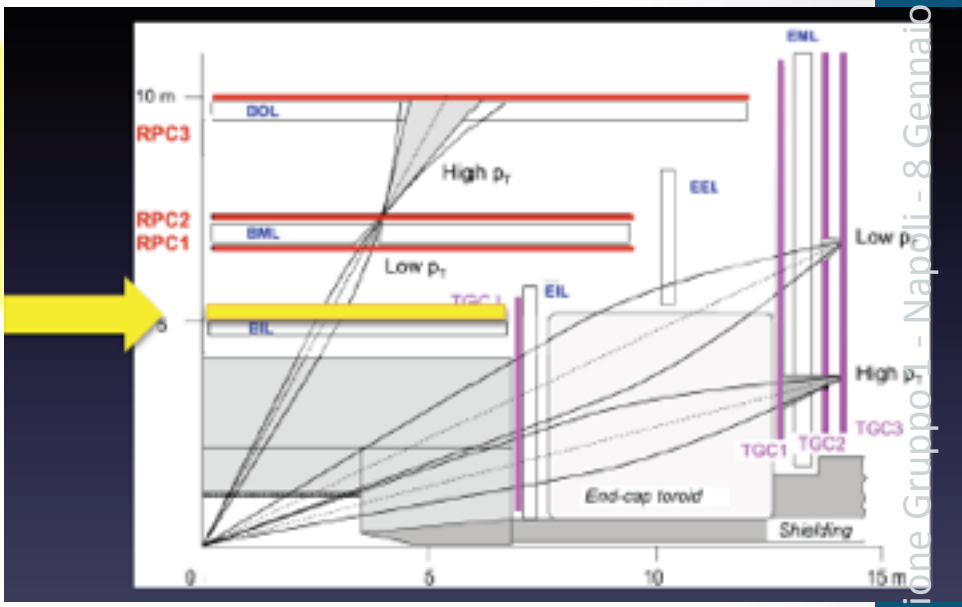
- Muon LVL1 trigger in the endcap is generated from three TGC layers in the Big Wheel
- Possible solution to sharpen the high-p_T threshold in this region:

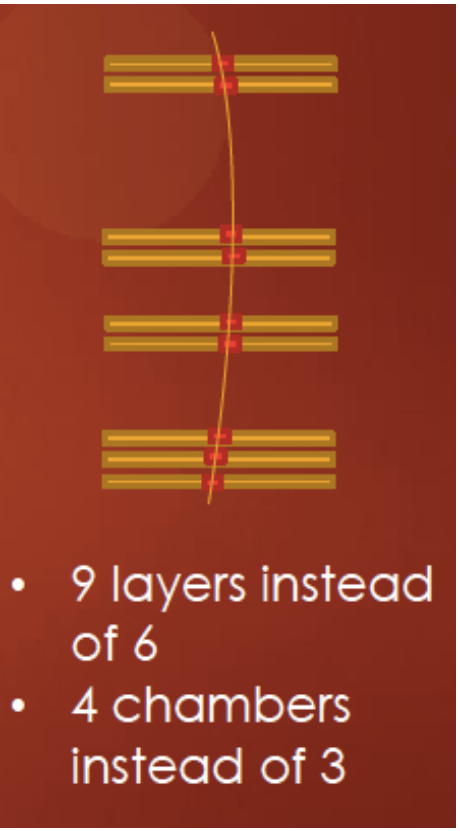
– replace the TGC in the Big Wheel inner ring with the sTGC (same as in the NSW) with higher resolution
– use the MDT precision coord



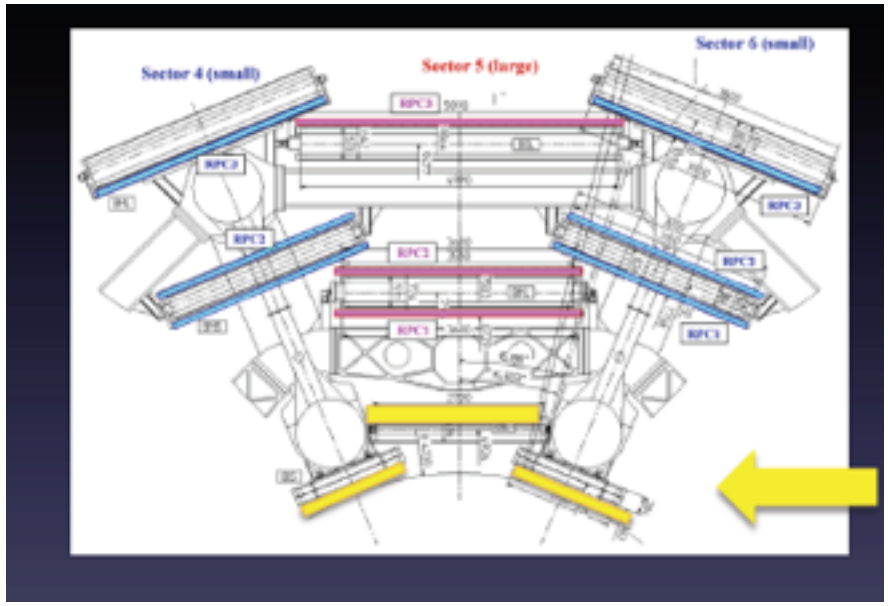
Upgrade Phase II: 1. Muon Barrel

RPC (Bo, RM1, RM2):
vari piccoli upgrades
- principale: 1 layer (3 gap) nello strato interno di MDT





- 9 layers instead of 6
- 4 chambers instead of 3

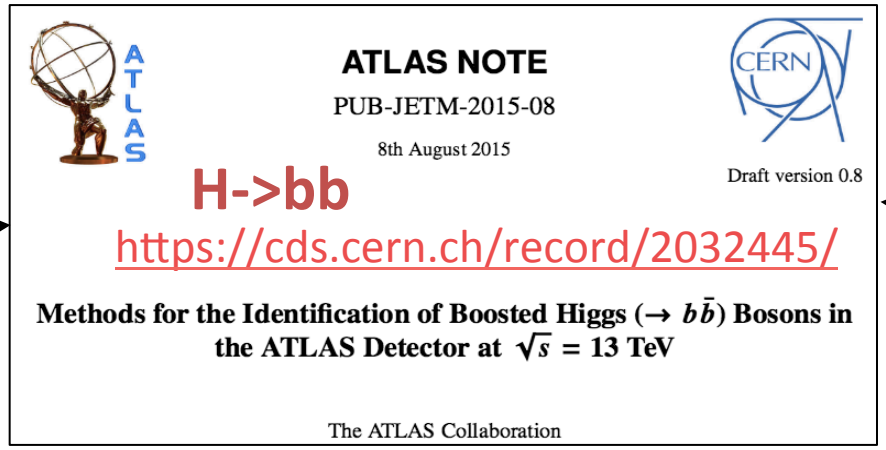


RPC+sMDT oppure Micromegas?

circa 500 m^2

Mono-V analyses

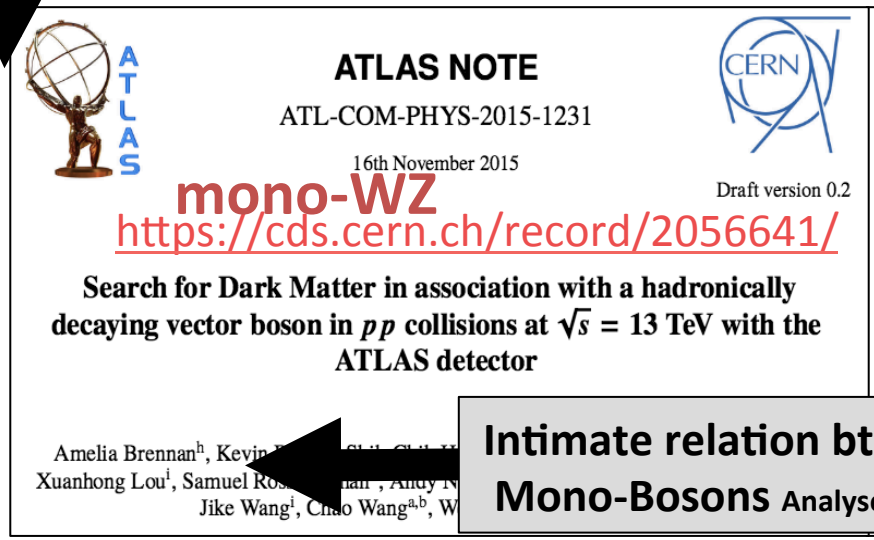
A. Sanchez

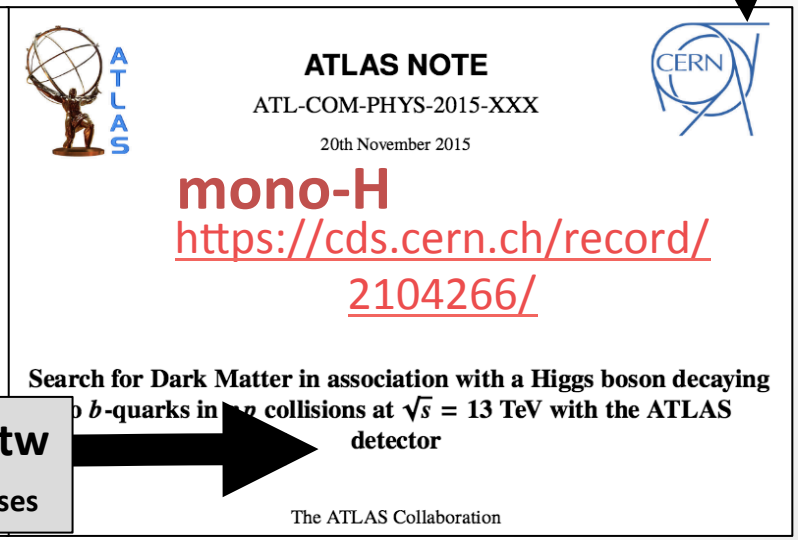


Mono-WZ
To **V->qq tagger**

H->bb tagger
To **Mono-H**

Interconnected works relative to the identification *-and physics analysis-* of boosted bosons: Mono-H and Mono-W/Z





Intimate relation btw Mono-Bosons Analyses