

Recherche de nouvelle physique dite « exotique » à Grenoble

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Journées scientifiques du GDRI P2IM, Rabat, décembre 2015

Un peu de contexte local

Groupe ATLAS au LPSC Grenoble depuis 1991.

Longue tradition de contributions au calorimètre LAr.

Cette tradition est encore clairement visible dans les contributions du groupe ...

Deux exemples récents :

- LAr data quality
- *software* des jets

... même si le futur du groupe se trouve dans le *tracking* (cf. présentation de Johann).

Ces centres d'intérêt en ce qui concerne les détecteurs sont fortement liés aux activités d'analyse de données..

ATLAS pp run: June-August 2015										
Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
98.5	99.7	100	99.1	100	100	99.3	100	100	100	99.6

Luminosity weighted relative detector uptime (in percent) and good quality data delivery during the stable beams in pp collisions at 13 TeV between June-August 2015, corresponding to 173 pb⁻¹ recorded luminosity.



ATLAS
Outstanding Achievement Award

Presented to

Pierre-Antoine Delsart

For leading and implementing crucial changes to jet and Emiss software and development of xAOD dual use tools during LS1.

ATLAS Collaboration Week, CERN, June 18, 2015



Les « exotiques » dans ATLAS

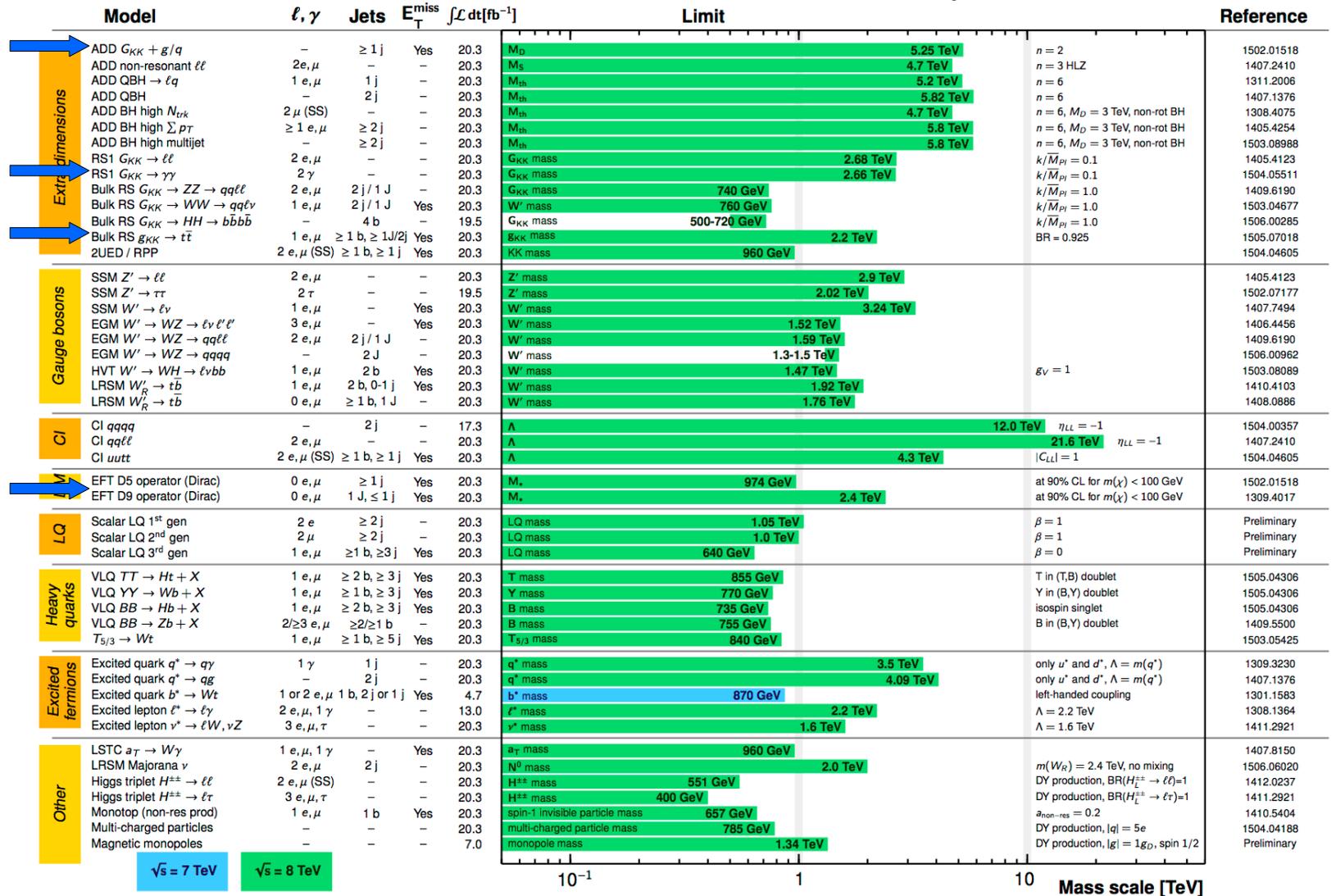
ATLAS Exotics Searches* - 95% CL Exclusion
 Status: July 2015

ATLAS Preliminary
 $\sqrt{s} = 7, 8 \text{ TeV}$

$\int \mathcal{L} dt = (4.7 - 20.3) \text{ fb}^{-1}$

contributions
grenobloises

Depuis peu :
paires top
se même signe

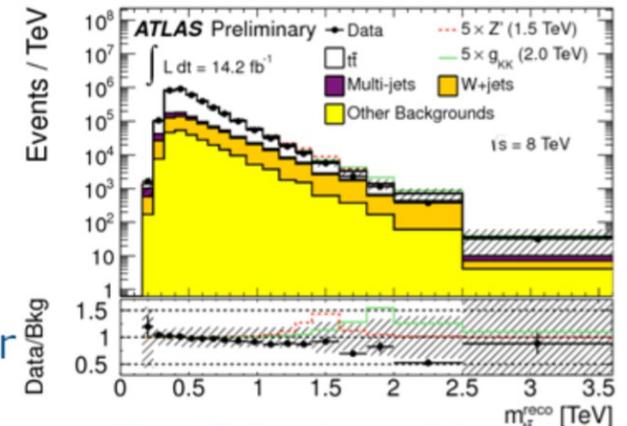


*Only a selection of the available mass limits on new states or phenomena is shown.

Résonances $t\bar{t}$ (lepton + jets)

Run 1 results

- Conference note published with 14 fb^{-1} :
 - model independent limits
 - **$0.5 \text{ TeV} < m(\text{narrow topcolor } Z') < 1.8 \text{ TeV}$**
 - **$0.5 \text{ TeV} < m(\text{broad KK gluon}) < 2.0 \text{ TeV}$**
- Paper with full lumi at 8 TeV (20 fb^{-1}) near completion



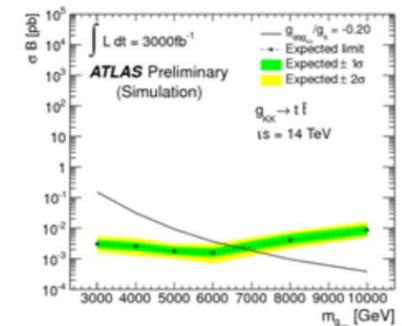
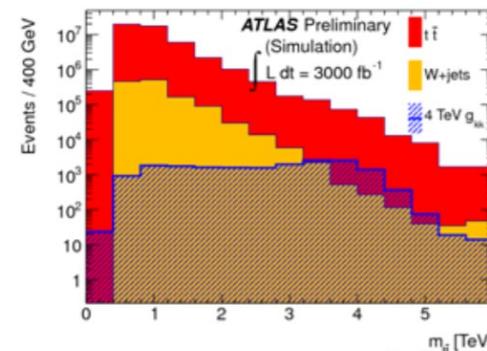
<https://cdsweb.cern.ch/record/1547568>

Run 2 prospect

- $\sim 5 \text{ fb}^{-1}$ needed at 13 TeV to reach run 1 sensitivity
- => high priority analysis in 2015
- Analysis team in place and analysis preparation started
- Challenges : boosted topology, b-tagging

HL-LHC prospect

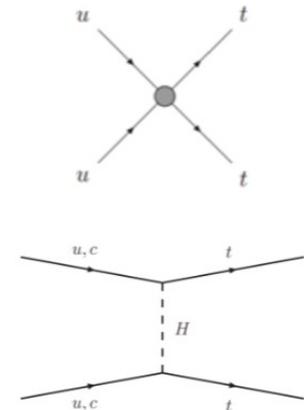
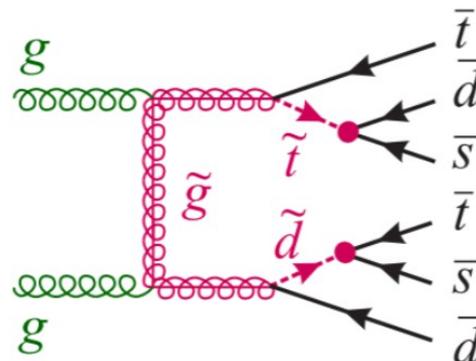
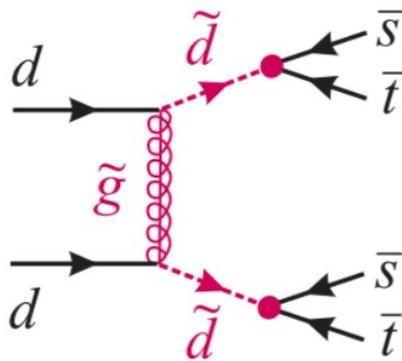
model	300 fb^{-1}	1000 fb^{-1}	3000 fb^{-1}
g_{KK}	4.3 (4.0)	5.6 (4.9)	6.7 (5.6)
Z'_{topcolor}	3.3 (1.8)	4.5 (2.6)	5.5 (3.2)



(<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2013-003/ttbarresprospect>)

Paires de tops du même signe (tt)

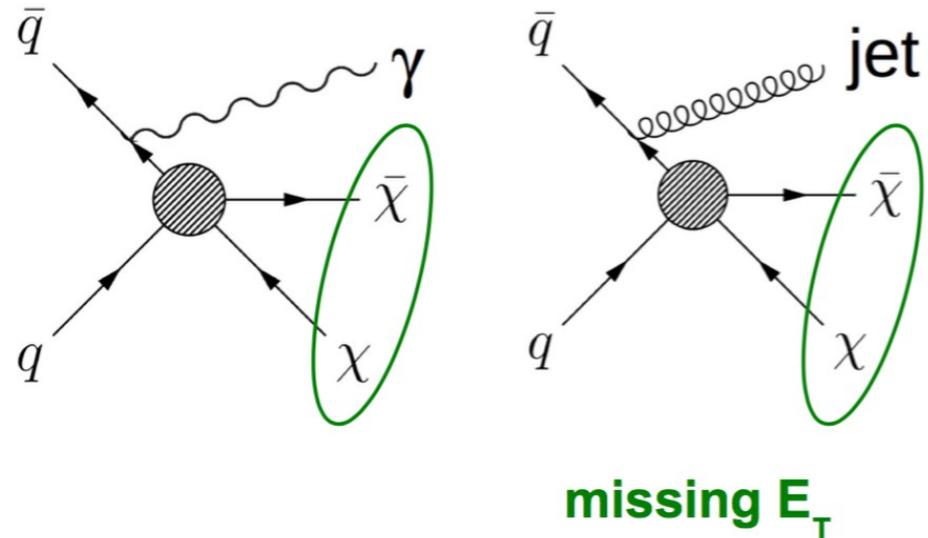
- Recherche d'événements avec deux quarks top de même signe:
 - Signature supprimée dans le cadre du Modèle Standard mais présente dans plusieurs scénarios de physique au-delà du MS
 - Etudes phénoménologiques dans le cadre de modèles de supersymétrie: modèle RPV avec scénarios « holomorphic/full minimal flavor violation » - Travail en liaison avec le groupe de physique théorique



- Recherche de signature tt au run-II à 13 TeV: limites et tests de modèles SUSY, d'interaction de contact (échange particule lourde), de couplage FCNC (échange particule réelle plus légère, Z' ou Higgs standard/exotique)
- S.Berlendis (doctorant 1^{ère} année), A.Lleres (directrice de thèse) et C. Smith (groupe théorie - co-encadrant)

Recherche de matière sombre au LHC

WIMP pair production on pp collisions in association with a jet or a photon.



The WIMPs escape detection.

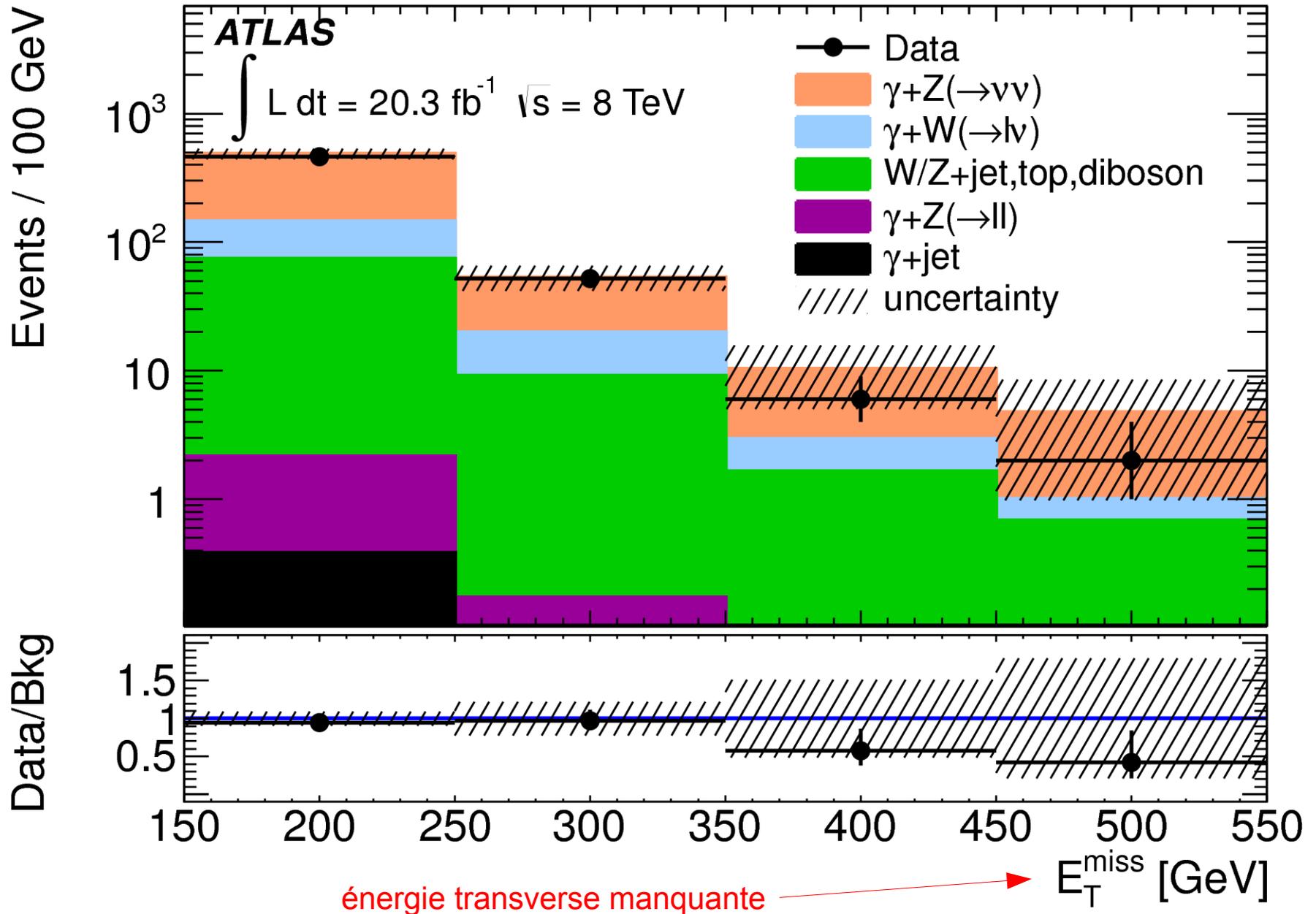
“Need something else in the event to observe.”
We get it (the γ or the jet) from QED or QCD radiation.

γ + missing E_T and jet + missing E_T are **clean final states with well-understood backgrounds**.
They are therefore promising channels in the search for new physics.

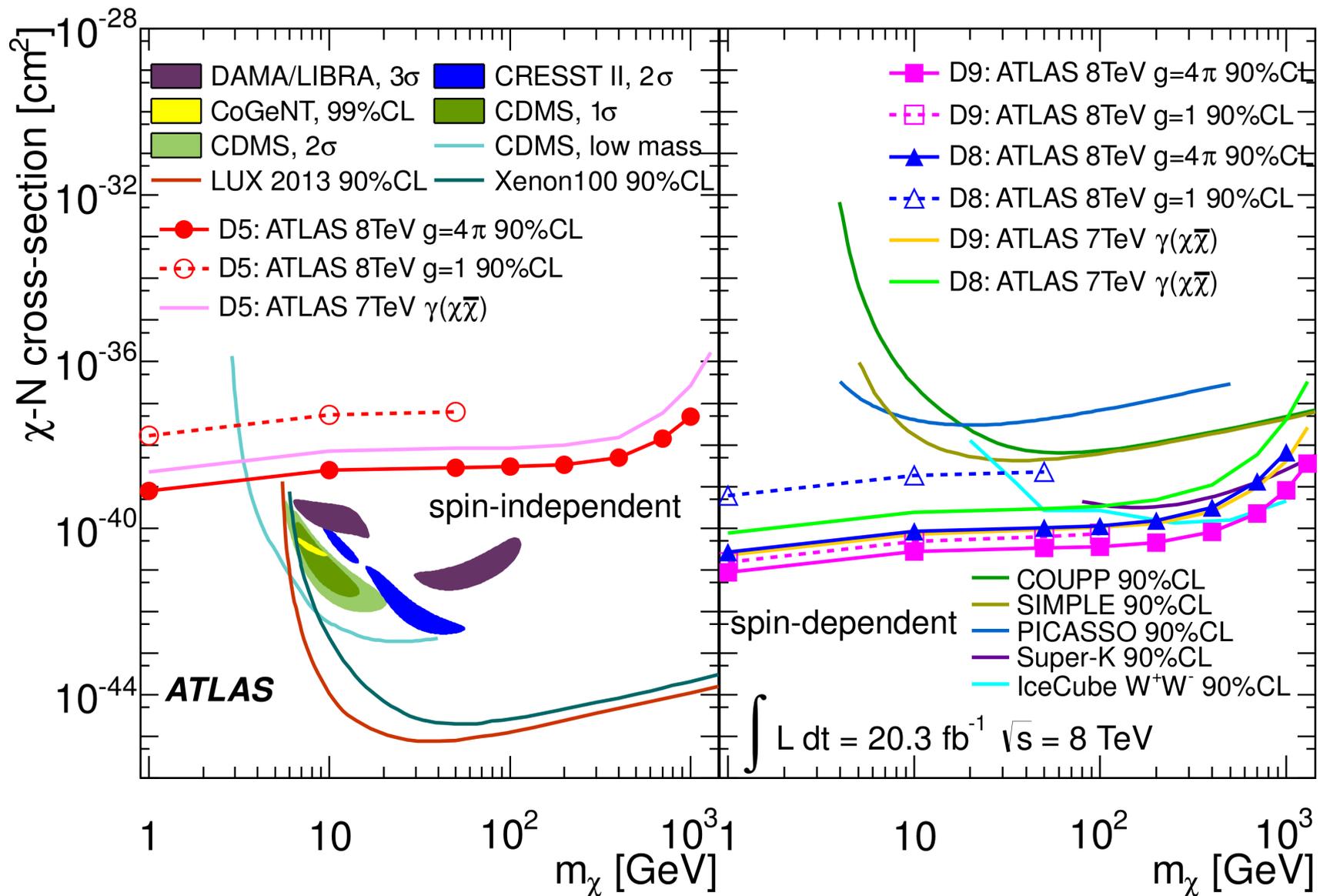
Independent verification of results from “direct searches”, sensitive to low masses (where direct searches are blind).

Limits on $\sigma(pp \rightarrow \chi\chi)$ are converted into elastic scattering cross section $\sigma(\chi p \rightarrow \chi p)$ for comparison with direct searches (nuclear recoil).

Recherche de matière sombre au LHC



Recherche de matière sombre au LHC



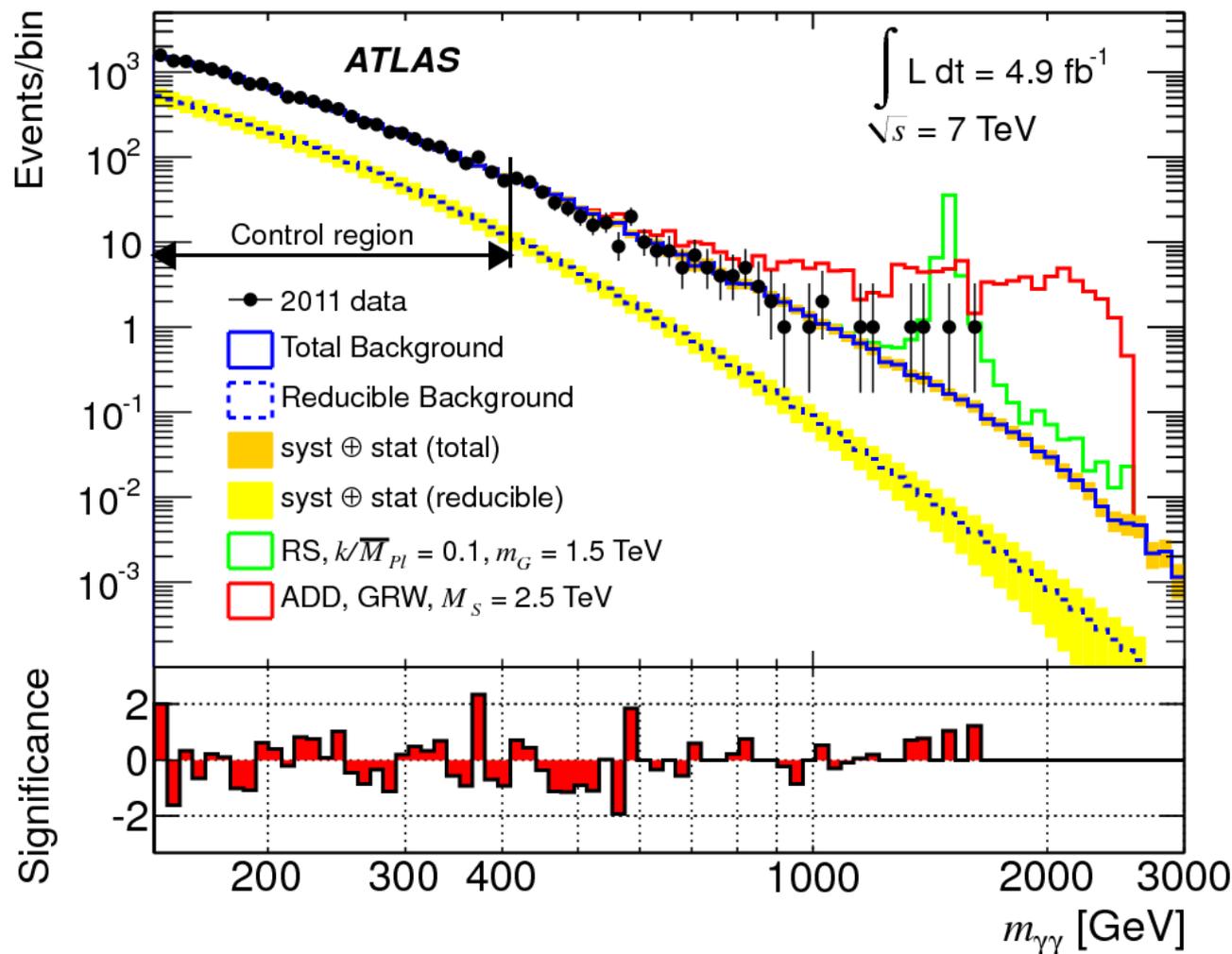
Recherche de nouvelle physique dans le canal diphoton

NJP 15, 043007 (2013)

This is one of the analyses which could show hints of new physics very early in Run 2.

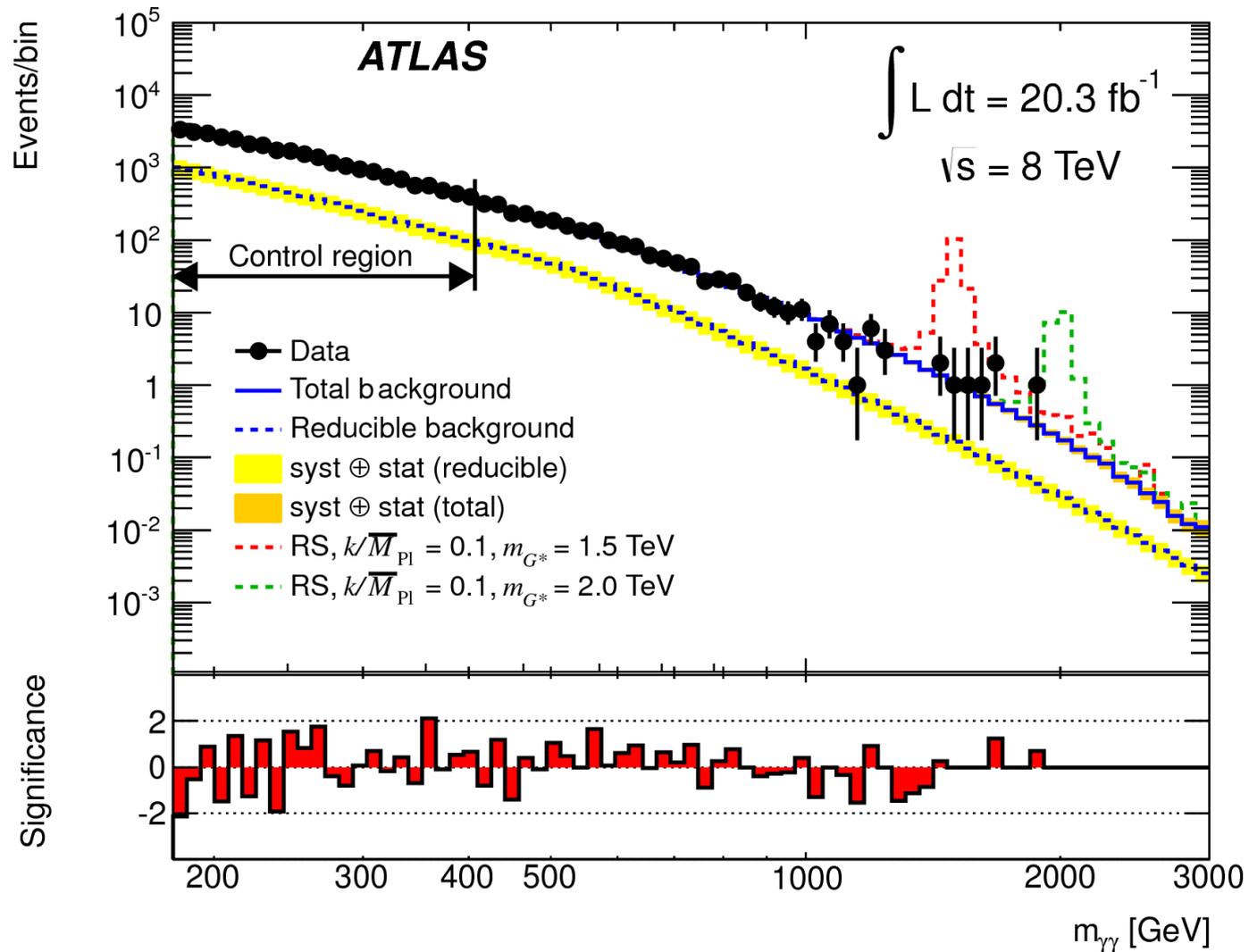
Basic strategy:

- Select diphoton events and check if the spectrum of the invariant mass of the diphoton system is consistent with the SM expectation or not.
- Two key features of the event selection:
 - **tight** photon identification
 - require photons to be **isolated**



Publication : données à 8 TeV

PRD 92, 032004 (2015)

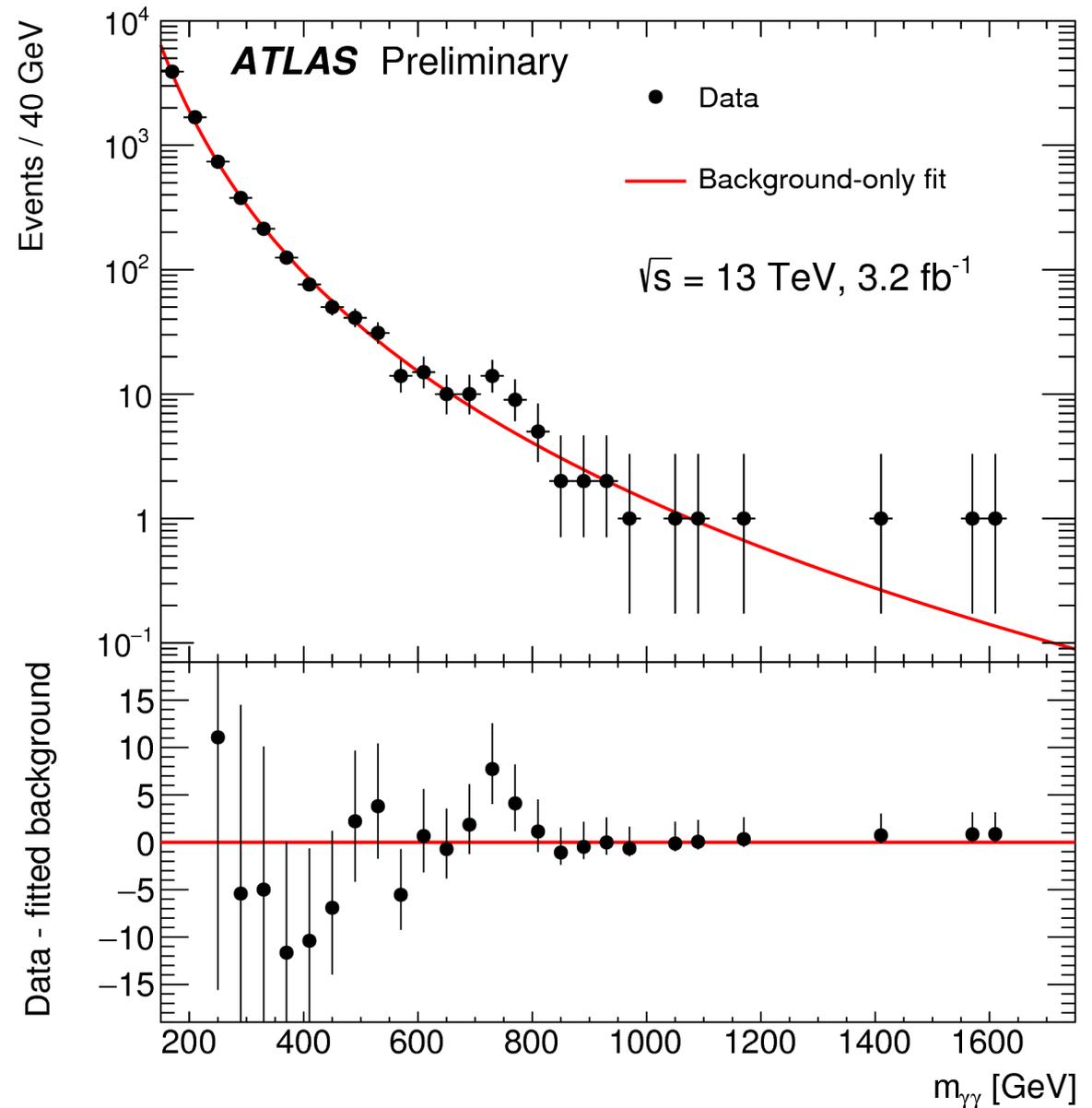


Préliminaire : données à 13 TeV

ATLAS-CONF-2015-081 :

<http://cds.cern.ch/record/2114853>

(15 décembre 2015)



Bob Dylan et autres

Ce résultat préliminaire a suscité pas mal d'intérêt dans la communauté de la physique des hautes énergies, cf. un exemple à droite.

Blagues à part, je vous demande de garder en tête ce paragraphe de la CONF note d'ATLAS :

The events in this region are scrutinized. No detector or reconstruction effect that could explain the larger rate is found, nor any indication of anomalous background contamination. The kinematic properties of these events are studied with respect to those of events populating the invariant mass regions above and below the excess, and no significant difference is observed.

En tout cas, il y aura un travail colossal et excitant pour arriver à une publication basée sur les données 2015 et pour une analyse rapide des données de 2016.

**Knocking on New Physics' door
with a Scalar Resonance**

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Abstract

We speculate about the origin of the recent excess at ~ 750 GeV in diphoton resonance searches observed by the ATLAS and CMS experiments using 13 TeV data. Its interpretation as a new scalar resonance produced in gluon fusion and decaying to photons is consistent with all relevant exclusion bounds from the 8 TeV LHC run. We provide a simple phenomenological framework to parametrize the properties of the new resonance and some interpretations in various concrete setups, such as a singlet (pseudo)scalar, composite Higgs, and the MSSM.

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arXiv:1512.04929v1 [hep-ph] 15 Dec 2015

Conclusions

C'est le Run-2 : quel saut en énergie ($\sqrt{s} = 8 \text{ TeV} \rightarrow \sqrt{s} = 13 \text{ TeV}$) !

Le moment privilégié pour la nouvelle physique de se montrer si jamais il y en a.

Les activités du groupe de Grenoble sont concentrés sur la nouvelle physique dite « exotique » (c-à-d : non-SUSY).

Longue tradition de travail sur la calorimétrie dans à Grenoble.

(→ plus récemment : transition vers le *tracking*, cf. présentation de Johann)

Recherches de nouvelle physique dans des états finals avec objets calorimétriques.

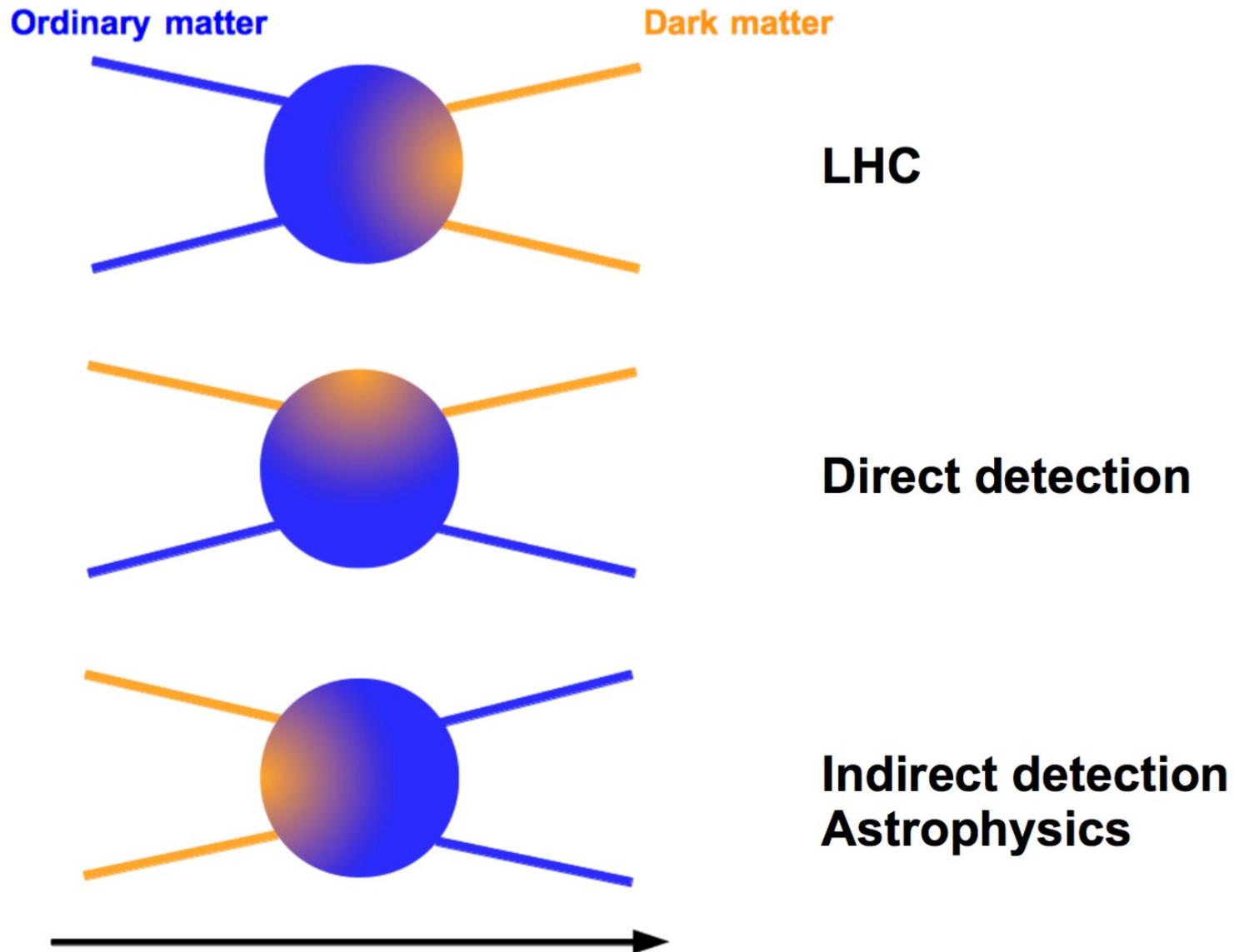
Deux exemples avec implication grenobloise de longue date :

- photon + énergie transverse manquante (→ matière sombre)
- **diphotons** (dimensions supplémentaires, ...)

Début de collaboration dans le cadre du GDRI.

Transparents supplémentaires

Different approaches to DM search



Direct / indirect searches for WIMPs

WIMPs trapped inside galaxies/massive objects

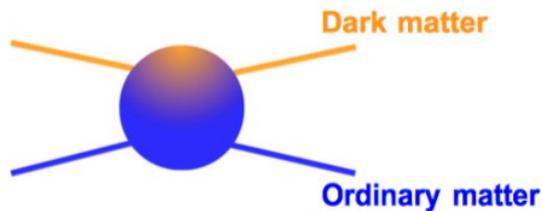
- local density of DM near solar system:

$$\sim 0.2 - 0.8 \text{ GeV/cm}^3$$

- average velocity w.r.t. Earth:

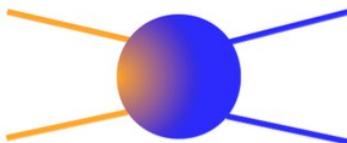
$$\sim 270 \text{ km/s}$$

Direct search:



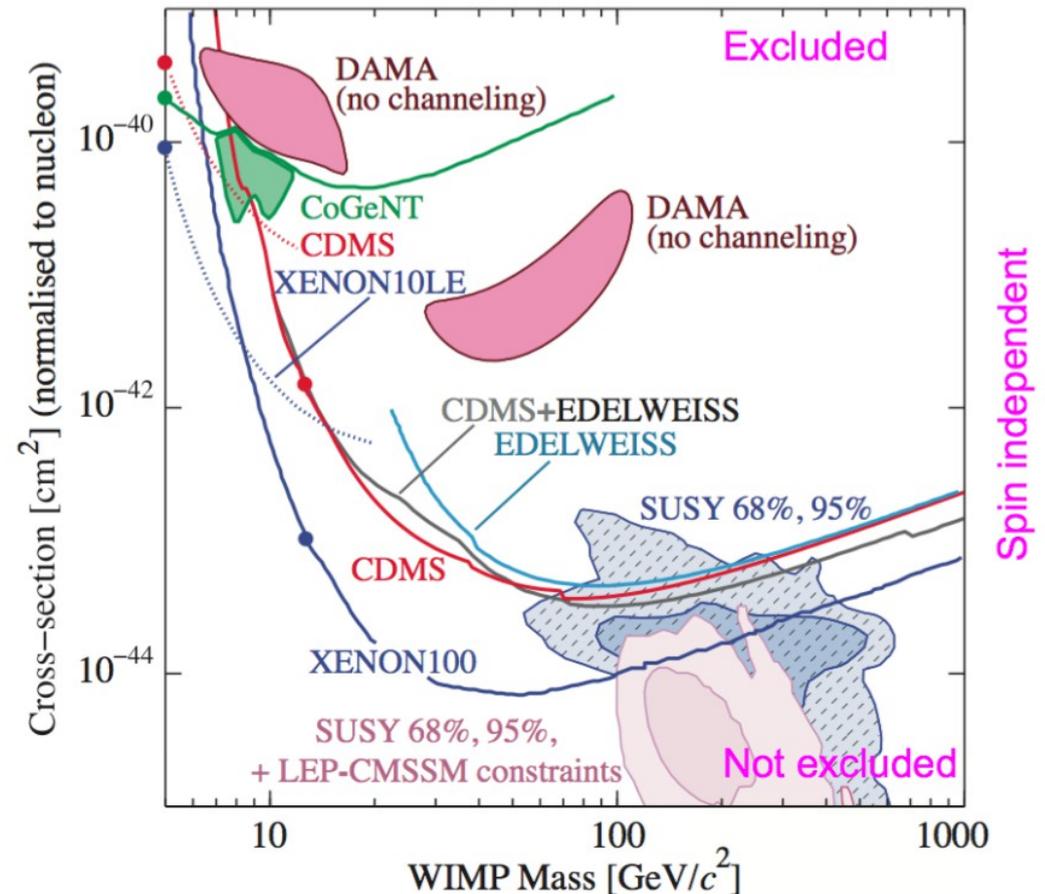
Elastic scattering WIMP-nucleon
in Earth-based detectors
(measurement of nuclear recoil)

Indirect search:



WIMP annihilation products (e.g. photons)
coming to us from celestial objects or from
the galactic halo

Experimental constraints on WIMP-nucleon scattering cross-section as a function of WIMP mass (summary plot from PDG):

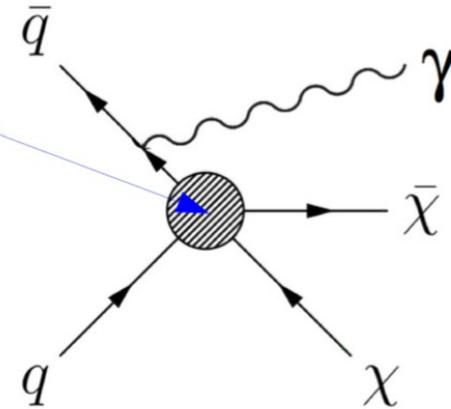


Effective operators

Parameterise interactions of WIMPs and quarks/gluons using effective operators:

- WIMPs assumed to be Dirac fermions.
- Interaction treated as point interaction with interaction strength M_*

i.e. all new particles mediating the interaction are too heavy to be produced directly.



Follow the naming scheme of Goodman *et al.*, Phys. Rev. **D82**, 116010 (2010).

Implemented in the MADGRAPH5 event generator.

spin independent interaction

spin dependent interaction

Name	Initial state	Type	Operator
D1	qq	scalar	$\frac{m_q}{M_*^3} \bar{\chi} \chi \bar{q} q$
D5	qq	vector	$\frac{1}{M_*^2} \bar{\chi} \gamma^\mu \chi \bar{q} \gamma_\mu q$
D8	qq	axial-vector	$\frac{1}{M_*^2} \bar{\chi} \gamma^\mu \gamma^5 \chi \bar{q} \gamma_\mu \gamma^5 q$
D9	qq	tensor	$\frac{1}{M_*^2} \bar{\chi} \sigma^{\mu\nu} \chi \bar{q} \sigma_{\mu\nu} q$
D11	gg	scalar	$\frac{1}{4M_*^3} \bar{\chi} \chi \alpha_s (G_{\mu\nu}^a)^2$