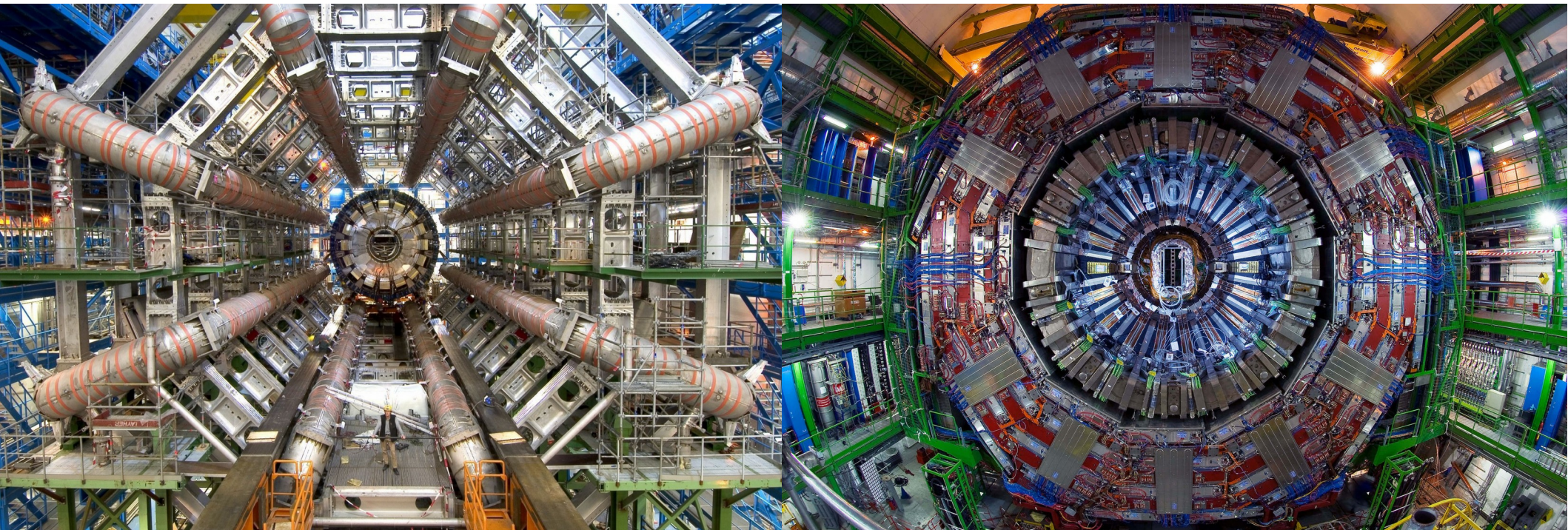


DM AL LARGE HADRON COLLIDER



Jacopo Pazzini

Università & INFN Padova, CERN

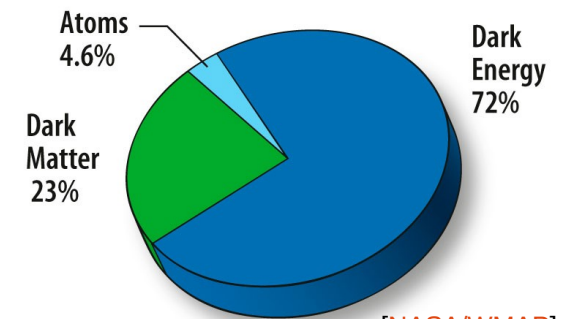
per le collaborazioni **ATLAS** e **CMS**

Dark Matter

- FORTE EVIDENZA DI FISICA NON STANDARD MODEL
- DETTATA DA OSSERVAZIONI ASTROFISICHE E COSMOLOGICHE
 - BULLET CLUSTER , LENSING GRAVITAZIONALE, CMBR, VELOCITÀ DI ROTAZIONE DI GALASSIE, ...
- CONTRIBUTO SIGNIFICATIVO AL BILANCIO ENERGIA-MATERIA DELL'UNIVERSO
 - ~25 % (5X IL QUANTITATIVO DI MATERIA “ORDINARIA”)
- MA NE SAPPIAMO VERAMENTE POCO:
 - A PARTE CHE INTERAGISCE GRAVITAZIONALMENTE
 - E CHE NON INTERAGISCE ELETTROMAGNETICAMENTE
- AND... THAT'S PRETTY MUCH IT*



[chandra.harvard.edu]



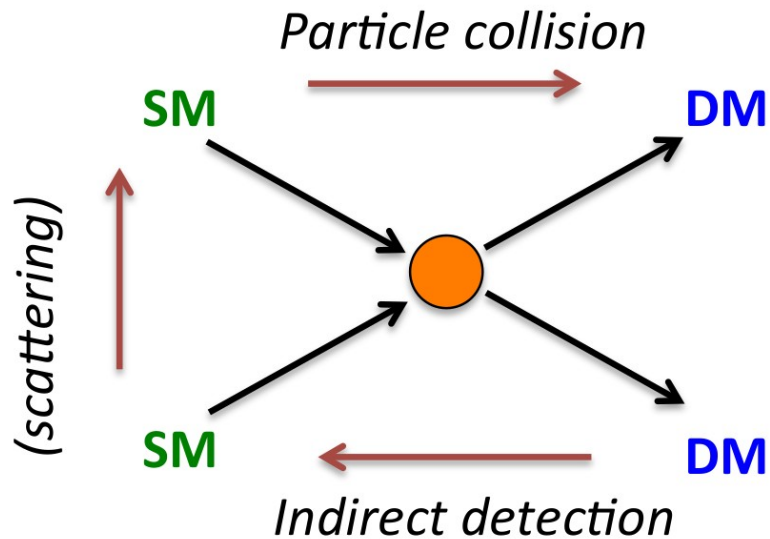
[NASA/WMAP]



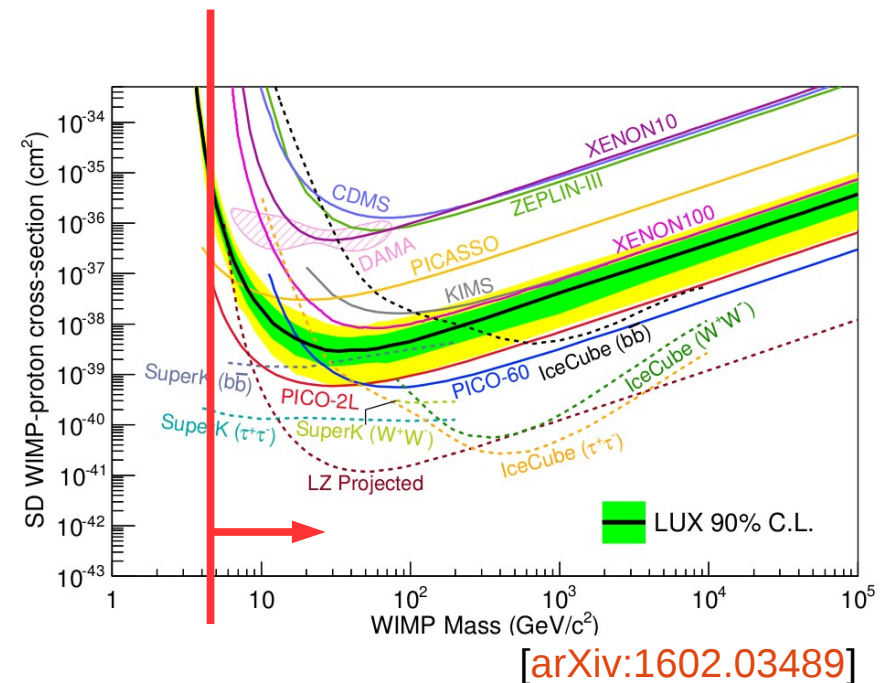
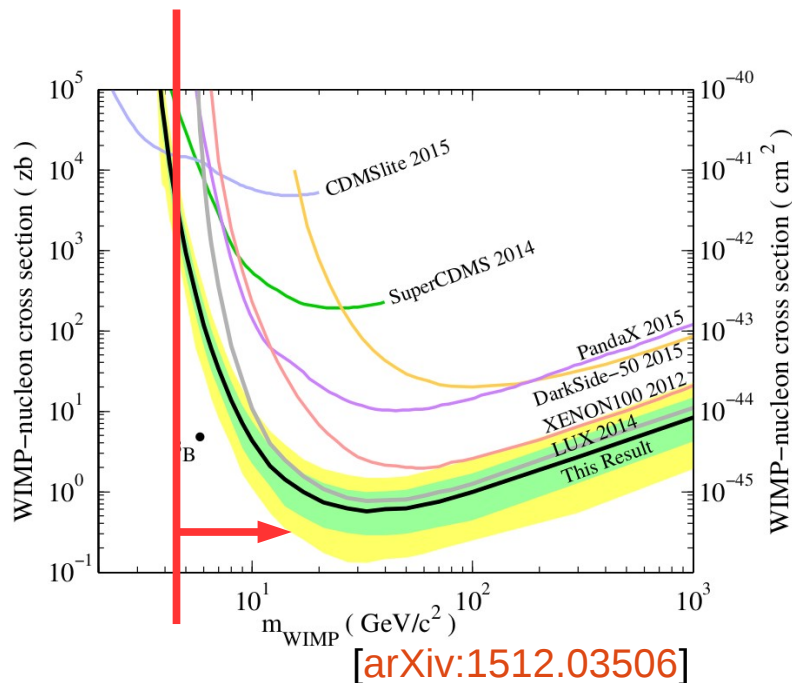
[PhDcomics]

* AN OVERSIMPLIFICATION, OF COURSE

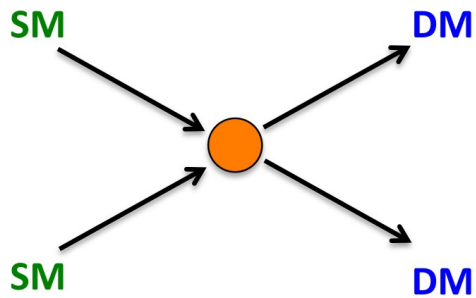
Ricerca di DM: 3 strategie complementari



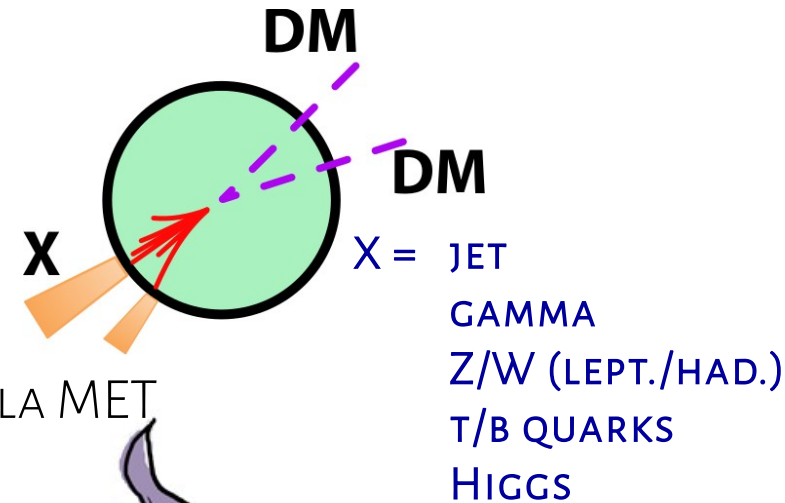
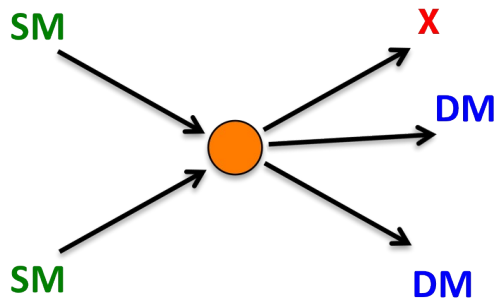
- **AI COLLIDER** → PRODUZIONE COPPIE DI PARTICELLE DI DM DA SCATTERING P-P
- **INDIRETTA** → ANNICHILAZIONE DI DM (AMS, FERMI/LAT, PAMELA, MAGIC, HESS, ...)
- **DIRETTA** → SCATTERING DI DM SU NUCLEI (LUX, XENON, CDMS, CRESST, PICO, ...)



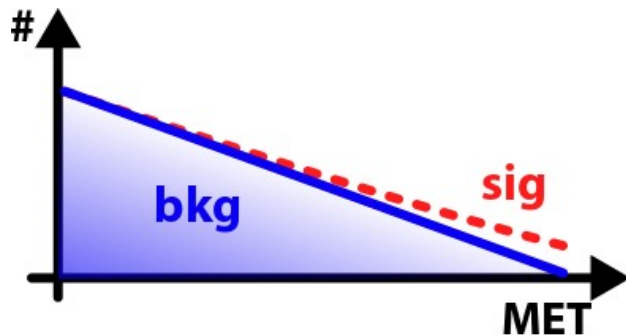
Ricerca ai collider: segnale



- RICERCHE IN EVENTI IN CUI OGGETTI SM SONO PRODOTTI DI RINCULO ALLA DM
 - ALTO IMPULSO TRASVERSO MANCANTE (MET) NEL DETECTOR

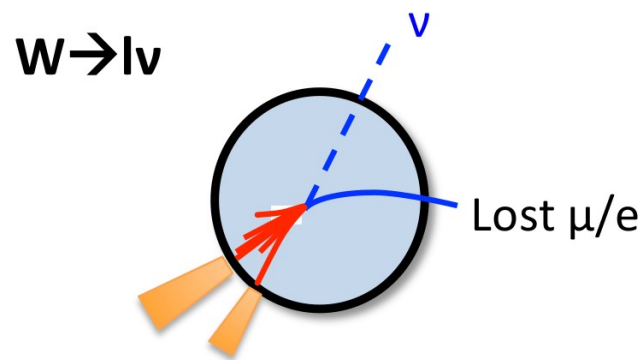
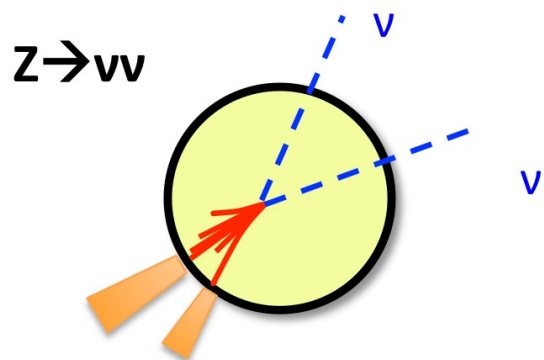


- SEGNALE → ECCESSO NELLE CODE DELLO SPETTRO DELLA MET

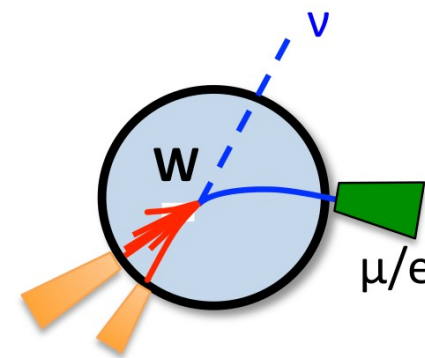
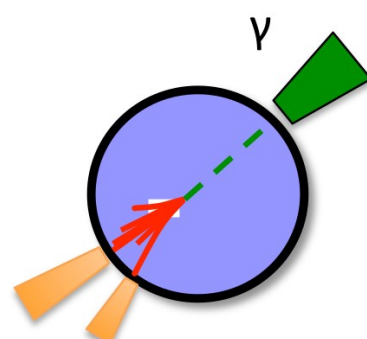
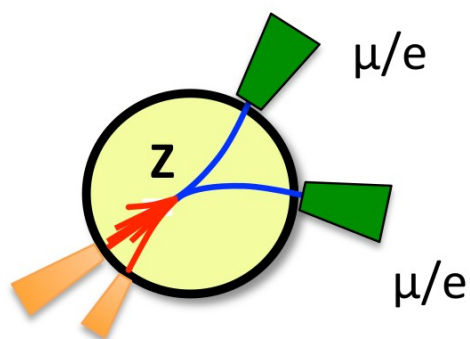


Ricerca ai collider: fondi

- FONDI SM COMUNI ALLA MAGGIOR PARTE DEI CANALI (ALTA MET)



- ESTRAPOLAZIONE DI NORMALIZZAZIONE (E SHAPE) DA CANALI DI CONTROLLO

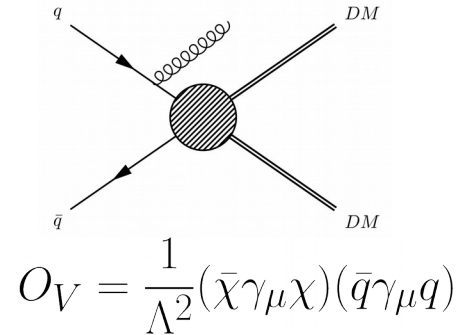


- RINCULO RIDEFINITO RIMUOVENDO LEPTONI/FOTONI/... (PSEUDO-MET)
- ESTRAPOLAZIONE REGIONI DI CONTROLLO \rightarrow REGIONE DI SEGNALE
ATTRAVERSO FUNZIONI DI TRASFERIMENTO DA SIMULAZIONI/TEORIA

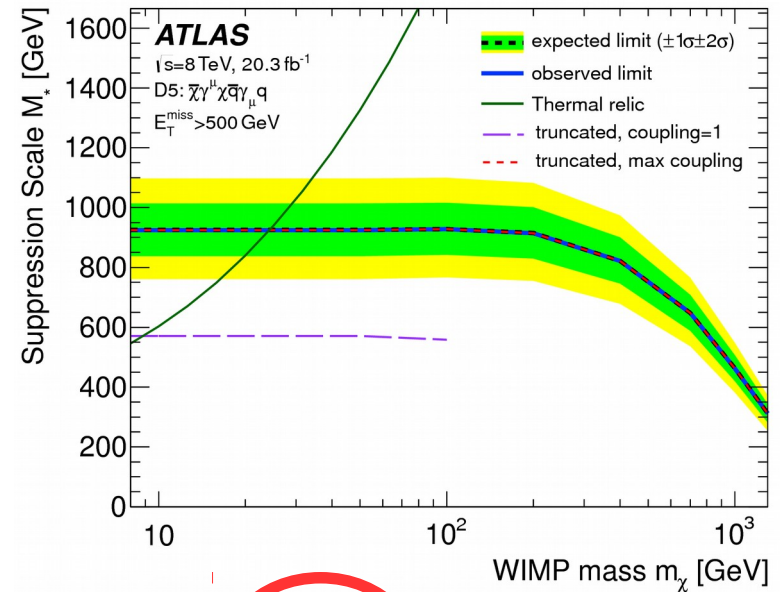
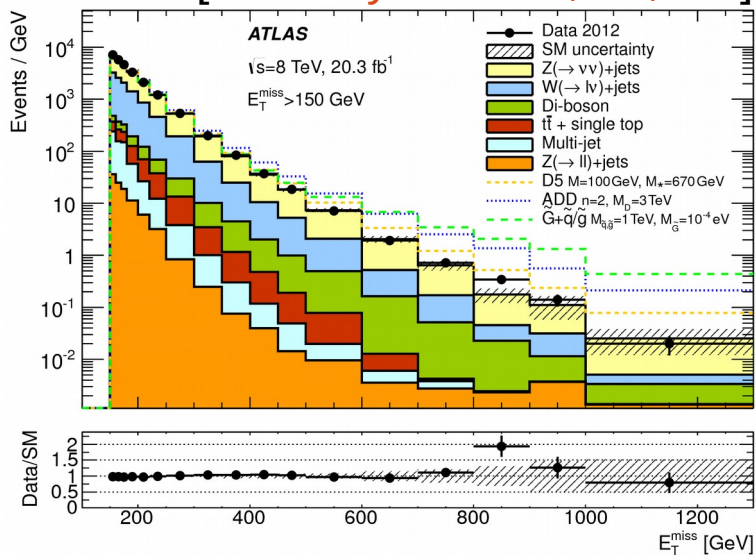
Run-1 - Dove eravamo?

* POSTER → **GIORGIA MINIELLO**

- ~20/FB @ 8 TeV → NUMEROSE ANALISI PRESENTATE DALLE DUE COLLABORAZIONI IN MOLTEPLICI STATI FINALI (JET, FOTONE, Z/W, HF, HIGGS*, ...)
- INTERPRETAZIONE CON EFFECTIVE FIELD THEORIES (EFT)
 - APPROCCIO VALIDO NELL'IPOTESI $M^2 \gg \langle Q^2 \rangle$
 - APPROSSIMAZIONE NON SEMPRE VALIDA A LHC



[Eur. Phys. J.C75,n.9,408]



EFT models

Simplified models

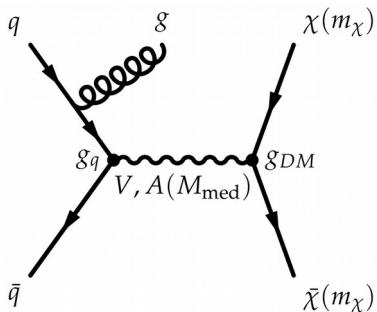
UV complete models

Un po' di ordine...

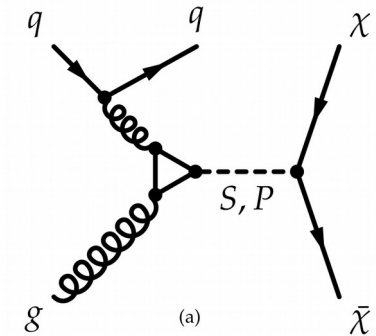
- DARK MATTER FORUM [[ARXIV:1507.00966](#), [TWIKIPAGE](#)]

→ SFORZO CONGIUNTO DI TEORICI E SPERIMENTALI PER DEFINIRE UNO SCENARIO DI MODELLI DI BENCHMARK COERENTE ED EFFICACE PER RICERCHE DI DM A LHC

- “PULIZIA” DEL PANORAMA EFT A FAVORE DI MODELLI SEMPLIFICATI



$g_{DM} Z'_{\mu} \bar{\chi} \gamma^{\mu} \chi$	$g_{DM} S \bar{\chi} \chi$
$g_{DM} Z''_{\mu} \bar{\chi} \gamma^{\mu} \gamma^5 \chi$	$g_{DM} P \bar{\chi} \gamma^5 \chi$



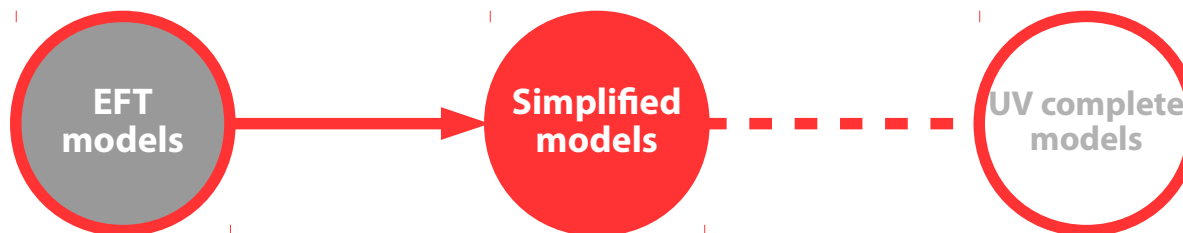
- ACCESSO DIRETTO AL MEDIATORE → SOLUZIONE AL PROBLEMA DI VALIDITÀ DEI MODELLI EFT

– 5 PARAMETRI (M_{DM} , M_{MED} , g_{SM} , g_{DM} , $GAMMA$)

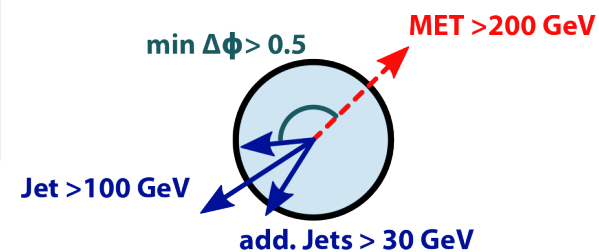
m_{χ} / GeV	M_{med} / GeV									
1	10	20	50	100	200	300	500	1000	2000	10000
10	10	15	50	100						10000
50	10		50	95	200	300				10000
150	10				200	295	500	1000		10000
500	10						500	995	2000	10000
1000	10							1000	1995	10000

$GAMMA \rightarrow$ “MINIMAL WIDTH”
(SOLO DA COUPLINGS)

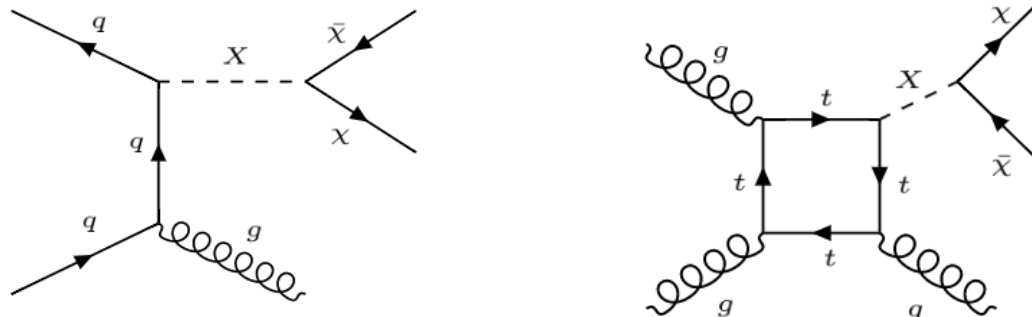
- POSSIBILITÀ DI CONFRONTO DIRETTO / COMBINAZIONE ATLAS+CMS



Run-2 → MonoJet



PARTICOLARMENTE ADATTO A TESTARE MODELLI VETTORIALI;
SOPPRESSIONE PER MEDIATORI SCALARI;



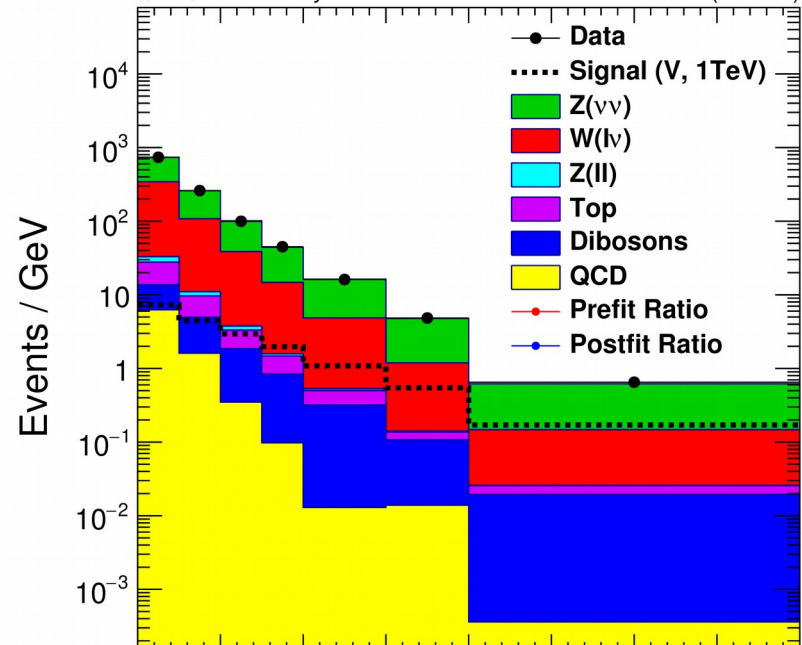
SELEZIONE:

- ALTA MET (>200 GeV)
 - 1 JET CON ALTO PT (>100 GeV)
- FONDI ELETTODEBOLI → VETO SU LEPTONI ISOLATI
FONDO TOP → VETO B-JET
FONDO MULTI-JET → ALTO DELTAPHI TRA JET E MET

[CMS-EXO-15-003]

CMS Preliminary

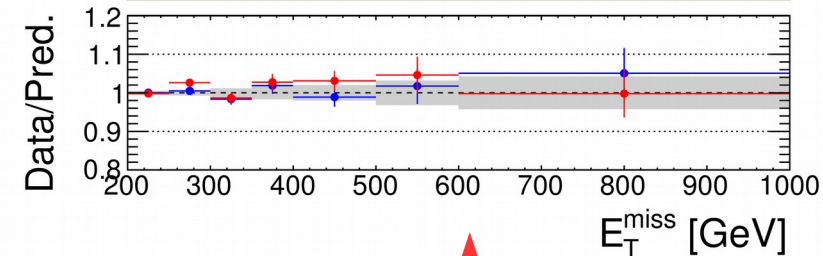
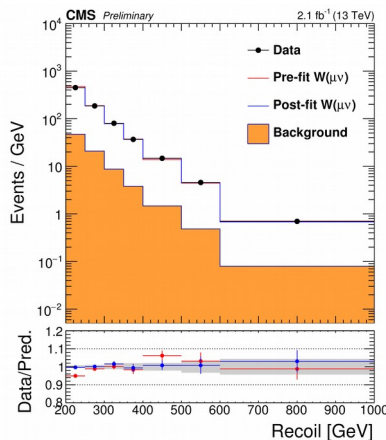
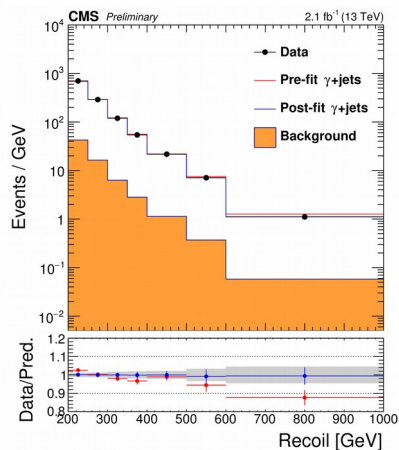
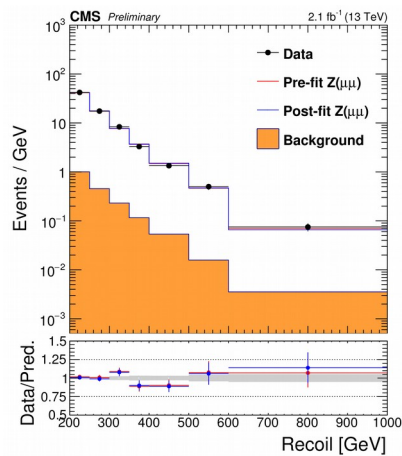
2.1 fb⁻¹ (13 TeV)



Z → ll + JET

GAMMA + JET

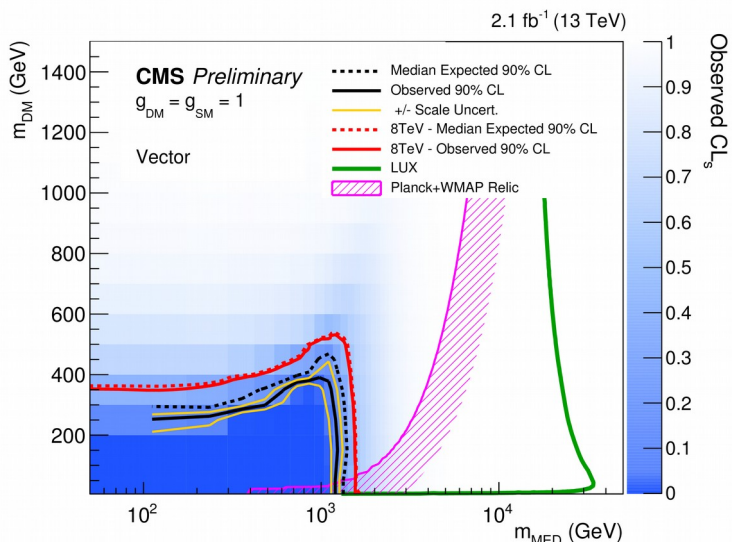
W → lv + JET



$$N_i^W(SR) \rightarrow N_i^W(CR) \cdot R_i$$

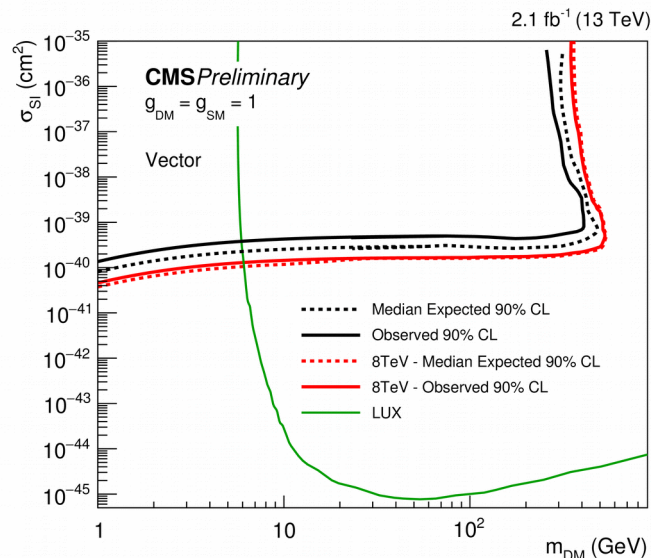
MonoJet

CMS: LIMITI MENO STRINGENTI RISPETTO A RUN-1 → STESSA SENSITIVITÀ ATTESA PER 5/FB

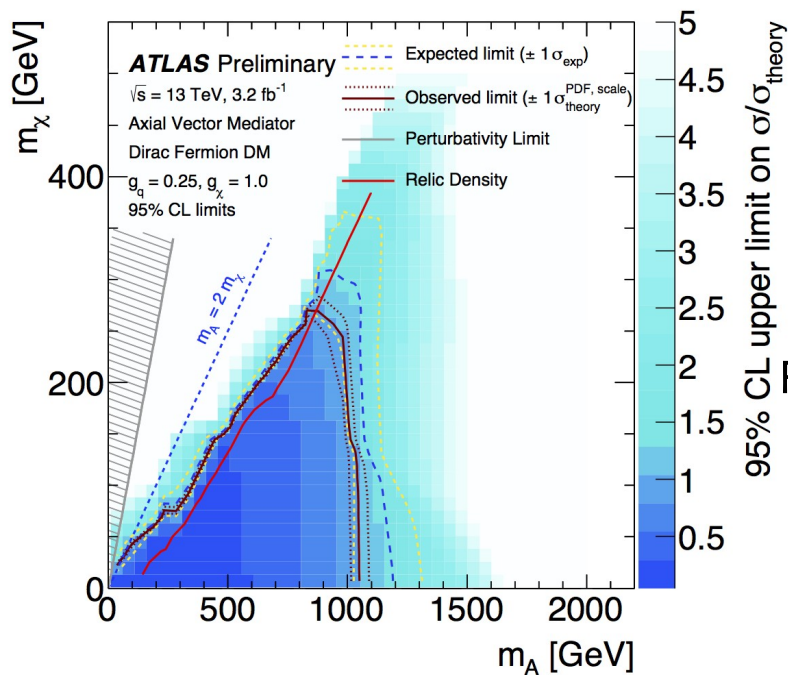


[CMS-EXO-12-055]

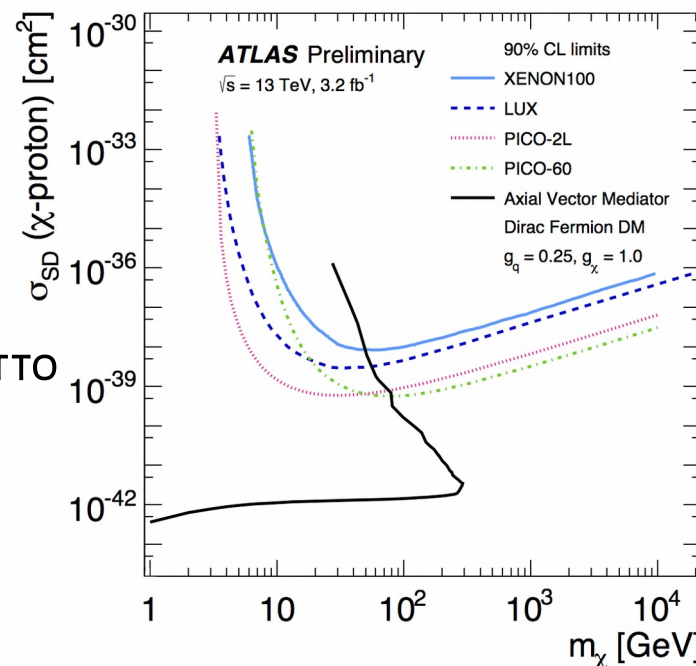
*POSTER
 MARCO CIPRIANO



ATLAS: [ATLAS-EXOT-2015-03]

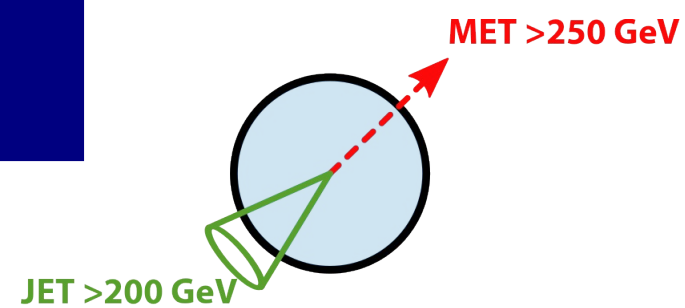


*POSTER
 FRANCESCO CIROTTO

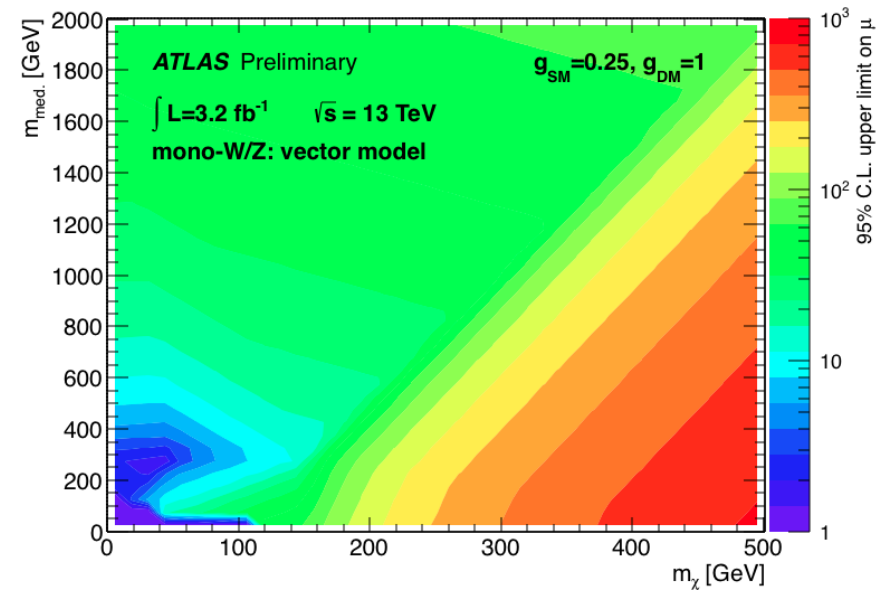
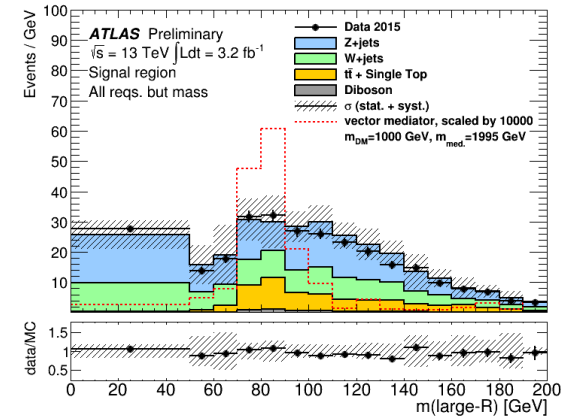
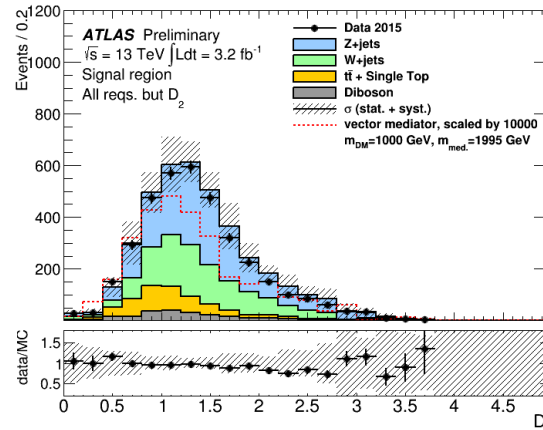
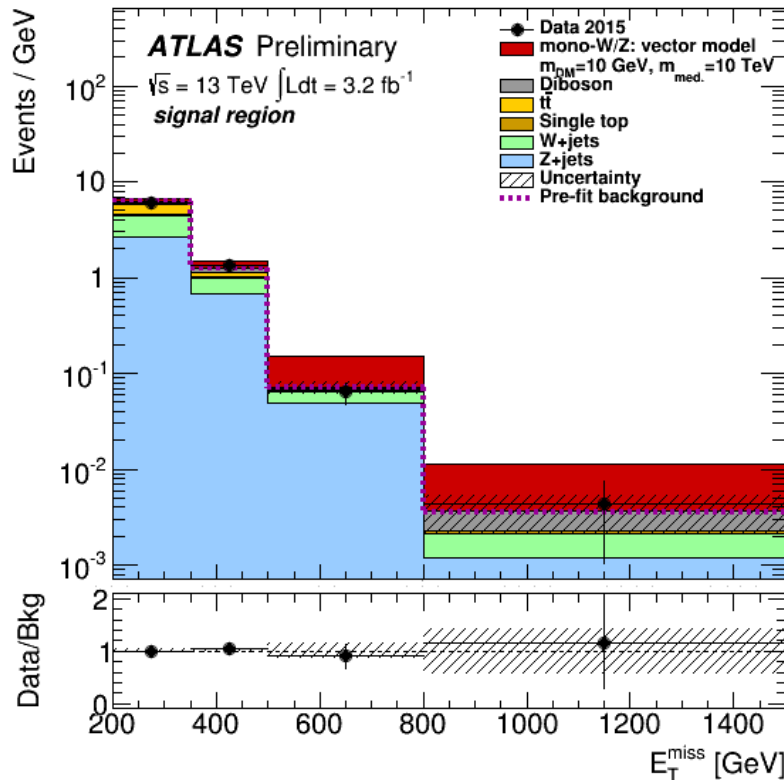


MonoW/Z (adronico)

- BOSONE VETTORE CON ALTO BOOST \rightarrow 2 JET RICOSTRUITI COME UN SINGOLO "FAT"-JET
- USO DI TECNICHE DI JET-SUBSTRUCTURE



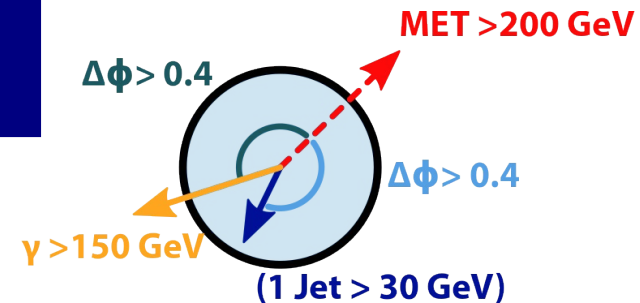
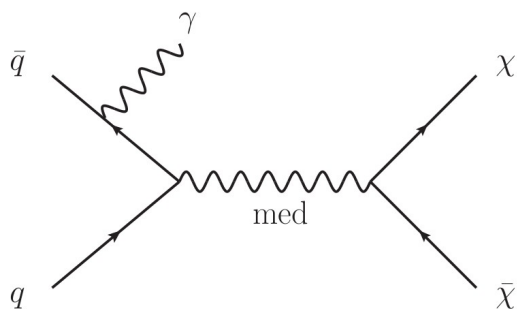
[ATLAS-CONF-2015-080]



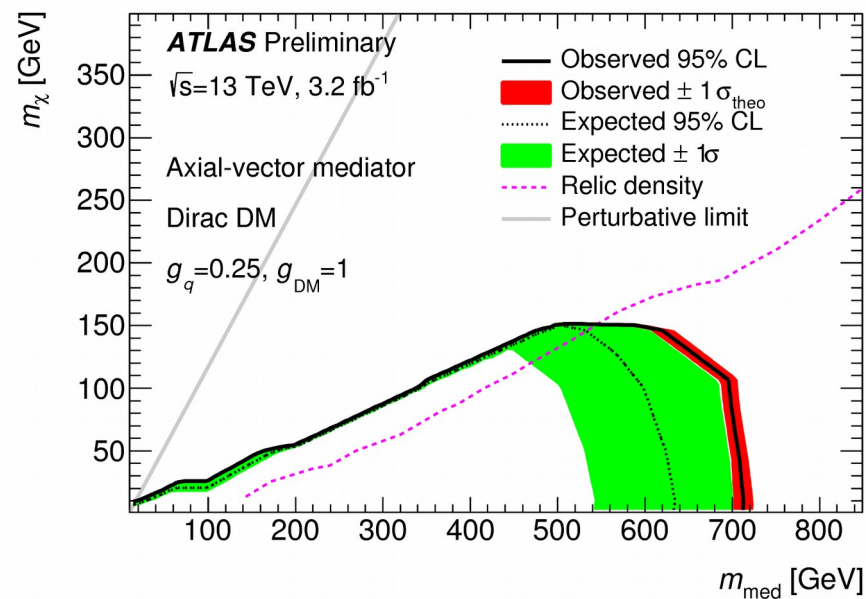
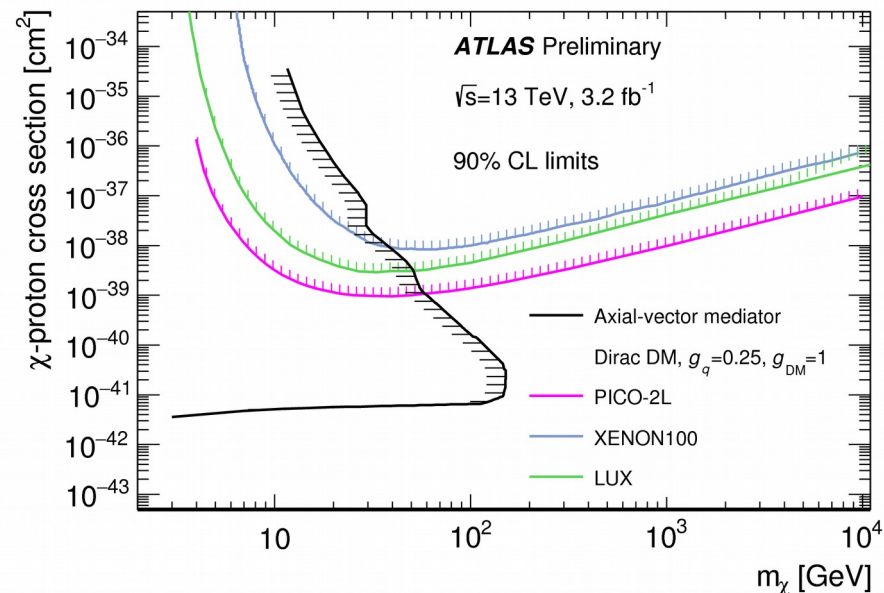
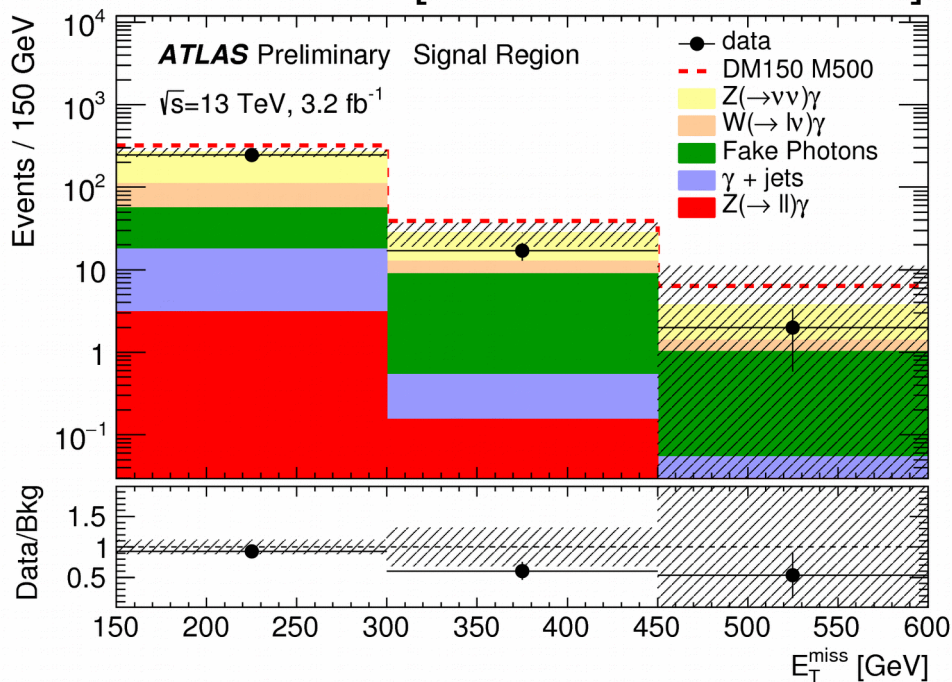
MonoFotone

- PROCESSO SIMILE AL MONOJET

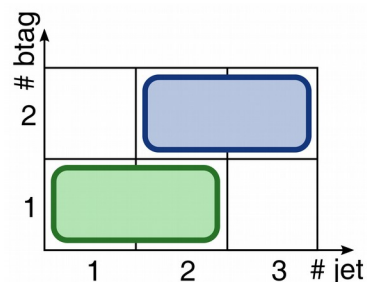
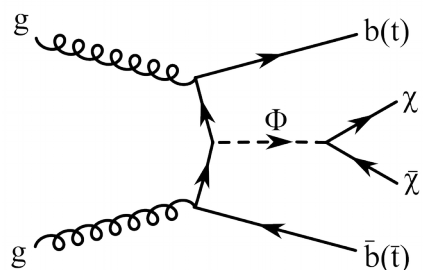
– SEZIONE D'URTO PIÙ BASSA, MA MENO FONDI



[ATLAS-EXOT-2015-05]



DM+quark pesanti

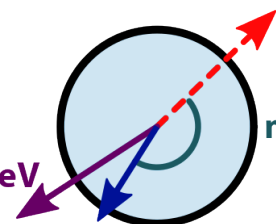


$b\text{-Jet} > 50 \text{ GeV}$

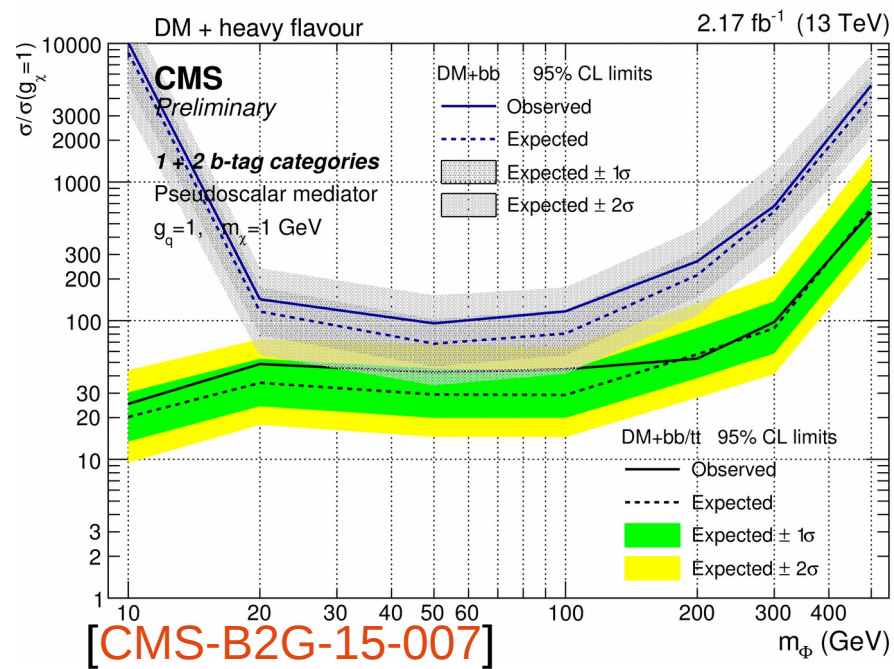
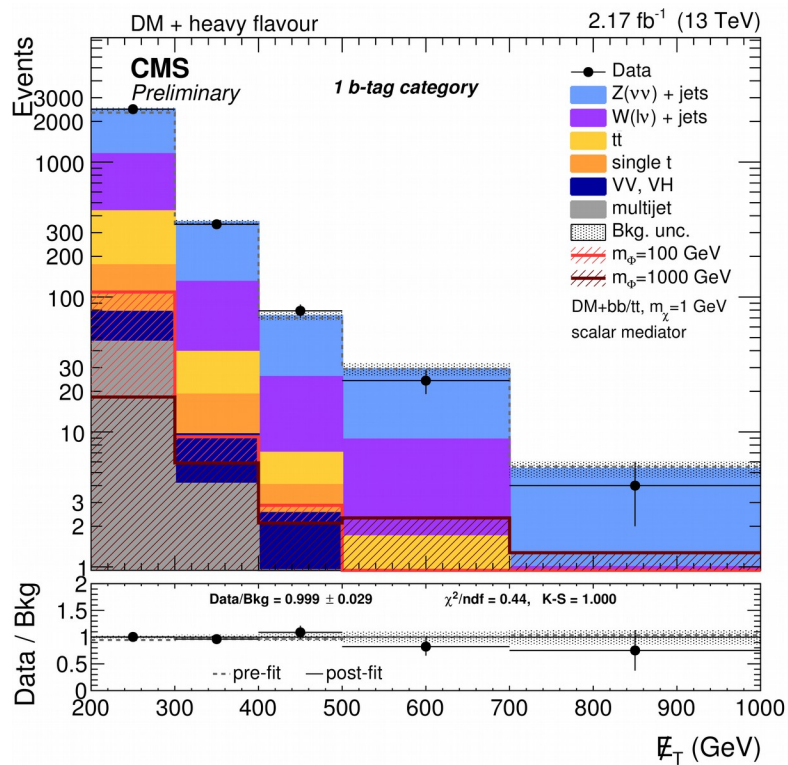
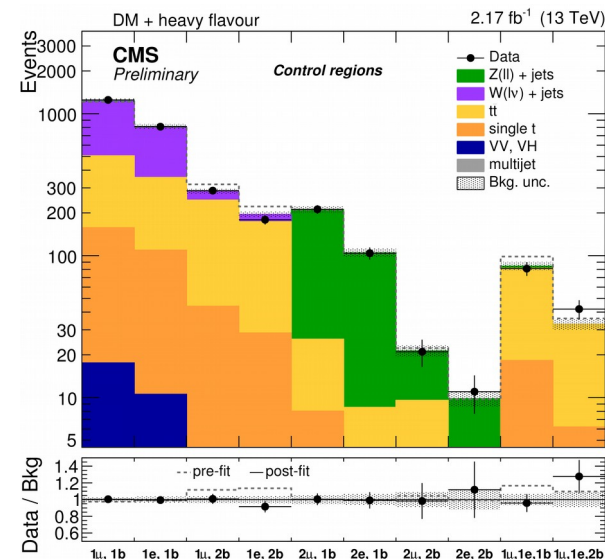
add. Jets $> 30 \text{ GeV}$

$\min \Delta\phi > 0.5$

$\text{MET} > 200 \text{ GeV}$



- COMPLEMENTARE AL MONOJET
 - SENSIBILE AL COUPLING (PSEUDO)SCALARE
- CONTRIBUTO SIGNIFICATIVO DA TOP
 - 10 REGIONI DI CONTROLLO (Z/W/TOP)



[CMS-B2G-15-007]

Conclusioni

- RICERCA DI DARK MATTER AGLI ACCELERATORI → COMPLEMENTARE ALLE MISURE DIRETTE E INDIRETTE
 - ESPLOREAZIONE DI UN SETTORE IN CUI NON VI È SENSIBILITÀ DA R.D. (<10 GeV) E POSSIBILITÀ DI TESTARE MODELLI SPIN-DEPENDENT (PSEUDOSCALARE)
 - FORTE COLLABORAZIONE TRA COMUNITÀ TEORICA ED ESPERIMENTI (DMF) HA PORTATO ALLA DEFINIZIONE DI NUOVI SCENARI DI BENCHMARK
-
- DM@LHC → FERVIDA ATTIVITÀ NEL RUN-1
 - RUN-2 → GIÀ VICINI ALLA SENSIBILITÀ @8TeV CON I DATI RACCOLTI NEL 2015
 - NESSUN SEGNO DI DM@LHC FINORA...
... MA LA NUOVA PRESA DATI È ALLE PORTE!

STAY TUNED !

