

L'esperimento LHCf

Misura delle distribuzioni di energia e impulso trasverso delle particelle prodotte in avanti a LHC

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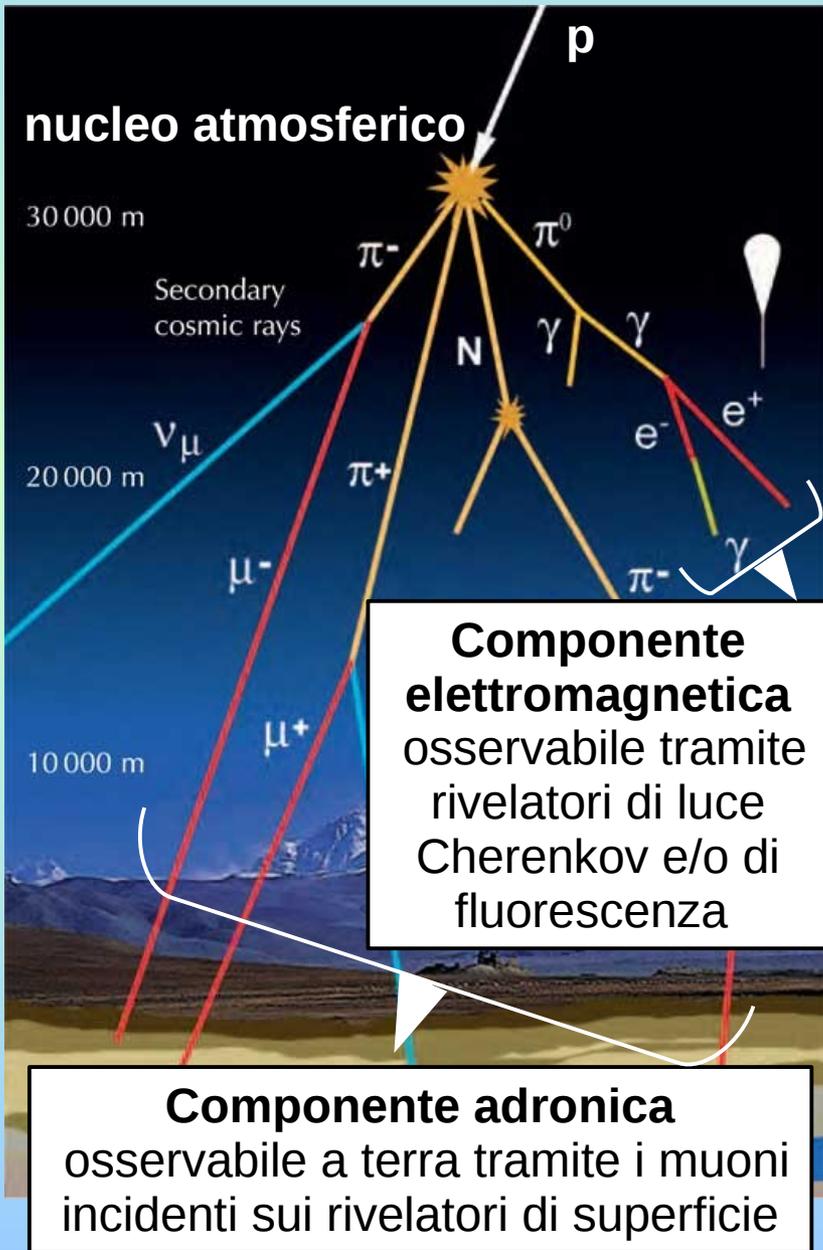
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Ultra High Energy Cosmic Rays (UHECR)



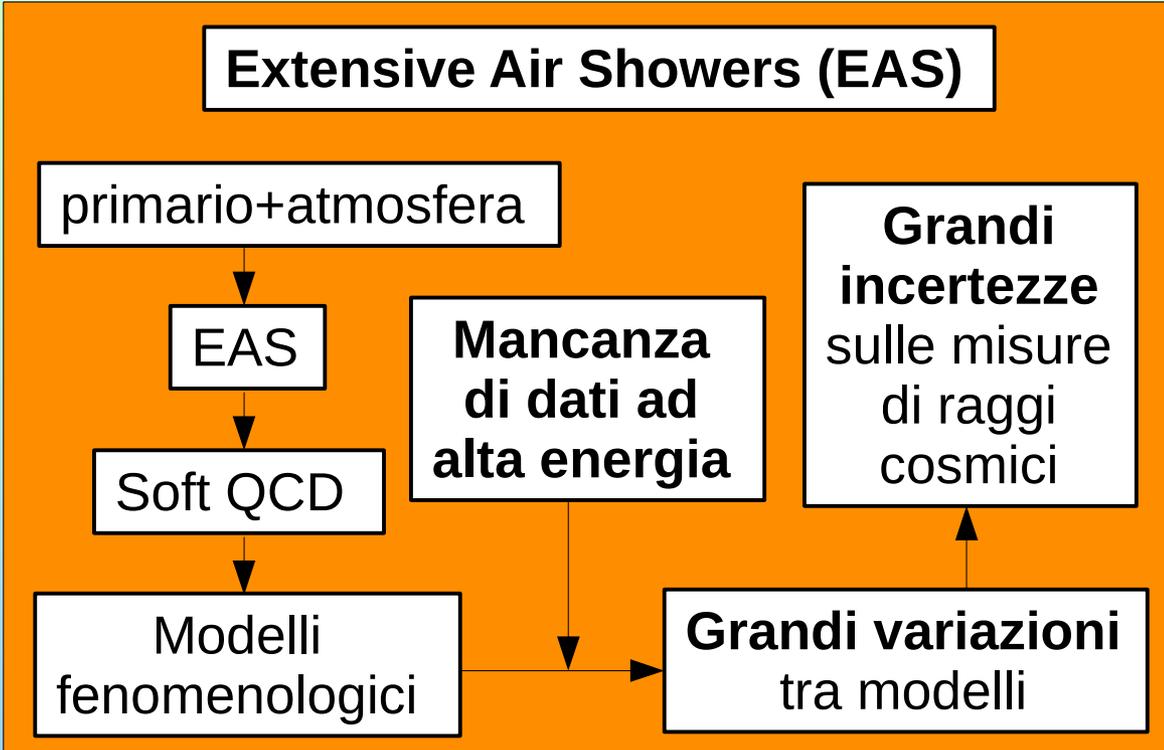
Componente elettromagnetica
osservabile tramite rivelatori di luce Cherenkov e/o di fluorescenza

Componente adronica
osservabile a terra tramite i muoni incidenti sui rivelatori di superficie

Gli **UHECR** sono i raggi cosmici di energia superiore a 10^{18} eV

Flusso inferiore a 1 particella per km^2 all'anno

Misure indirette tramite grandi apparati di rivelatori disposti a terra



Calibrazione dei modelli

Cosa misurare?

- **sezione d'urto** (TOTEM, ATLAS, CMS, ALICE)
- **molteplicità** (ATLAS, CMS)
- **distribuzioni di E e p_t nella forward region** e **inelasticità $k = 1 - p_{\text{lead}}/p_{\text{beam}}$** (LHCf)

Perché LHC?

- misurare le **caratteristiche delle EAS** ad un'energia vicina a quella degli UHECR

Run p-p $\sqrt{s}=14$ TeV \longrightarrow 10^{17} eV p su p a riposo

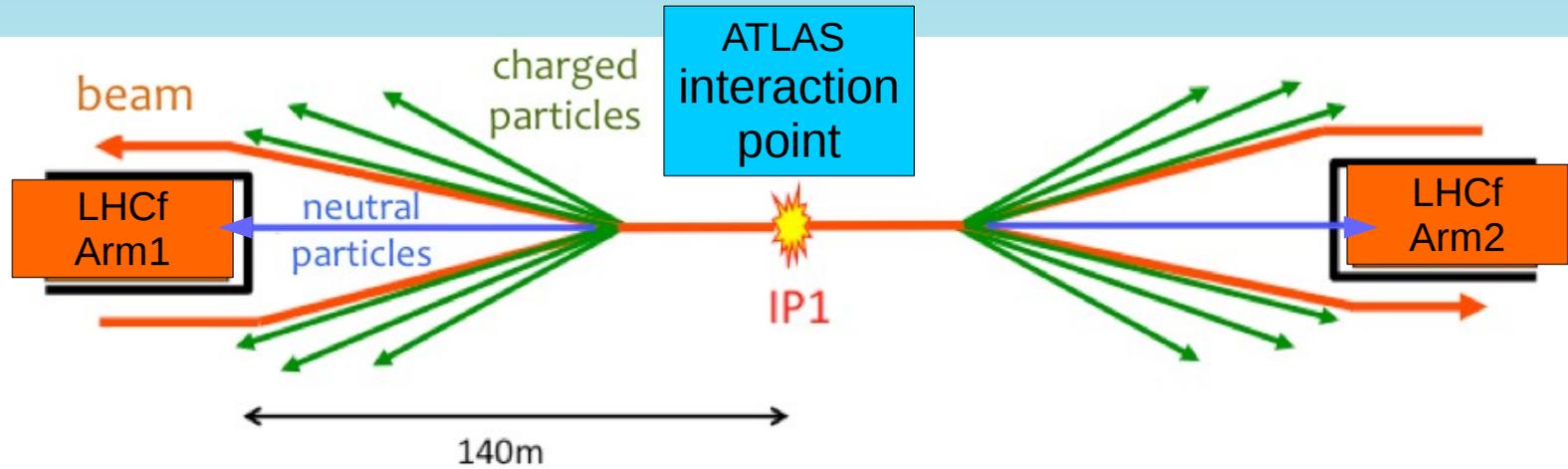
- verificare la validità di **leggi di scala** (Feynman scaling, $\langle p_T \rangle$ scaling, limiting fragmentation) utili per estrapolare i parametri ad energie superiori a 10^{17} eV

Run p-p $\sqrt{s}=0.9, 2.76, 7, 13$ TeV

- studiare la dipendenza del rate di produzione delle particelle secondarie al variare del **numero di nucleoni del bersaglio**

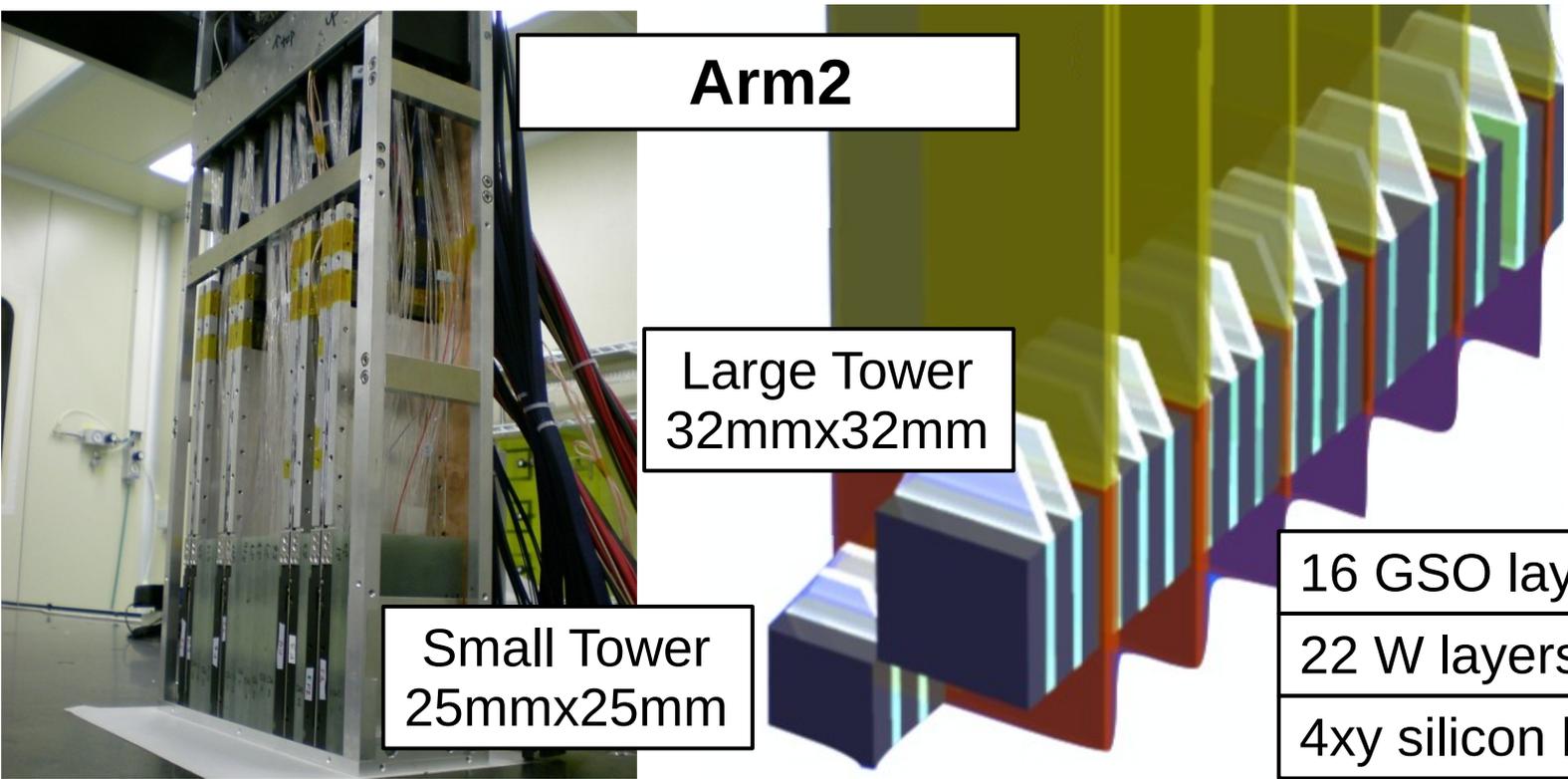
Run p-p, p-Pb

L'esperimento LHCf



Rivelazione delle particelle neutre prodotte in avanti ($\eta > 8.4$)

- fotoni
- π^0 ($\pi^0 \rightarrow 2\gamma$)
- neutroni



$\sigma_{\text{pos}} : \sim 40 \text{ mm}$

σ_E/E :

- <5% per γ
- $\sim 40\%$ per h

Distribuzione di energia dei neutroni

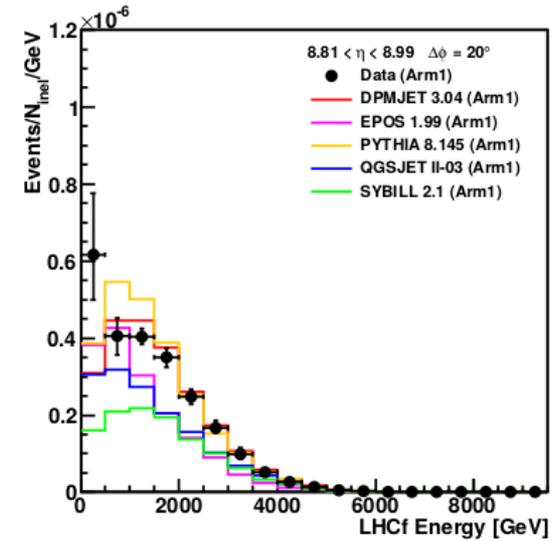
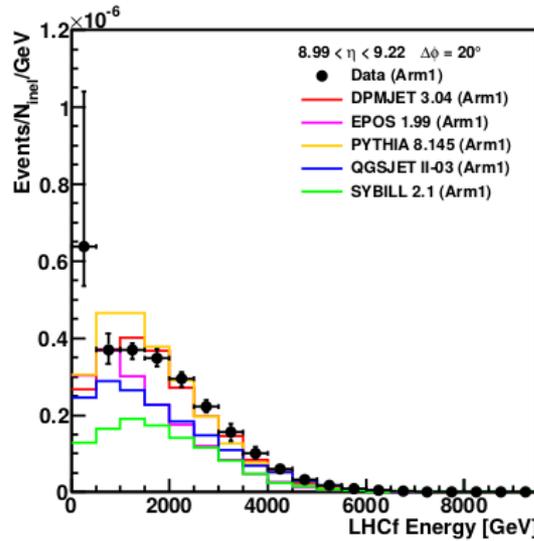
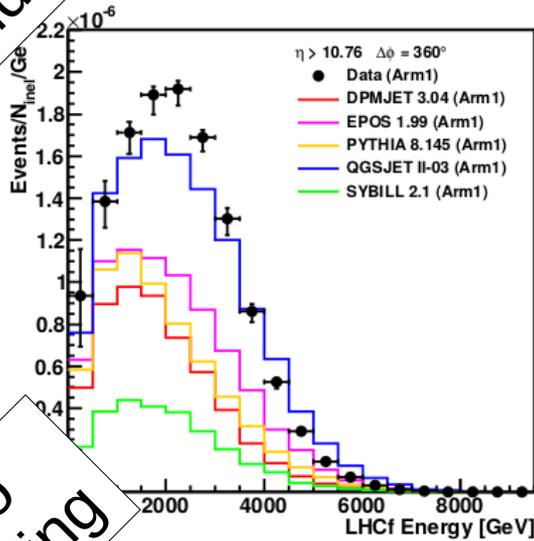
p-p $\sqrt{s} = 7$ TeV

Prima di unfolding

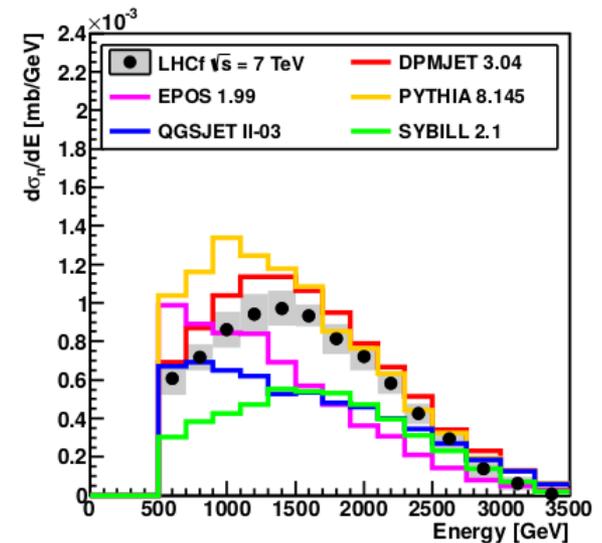
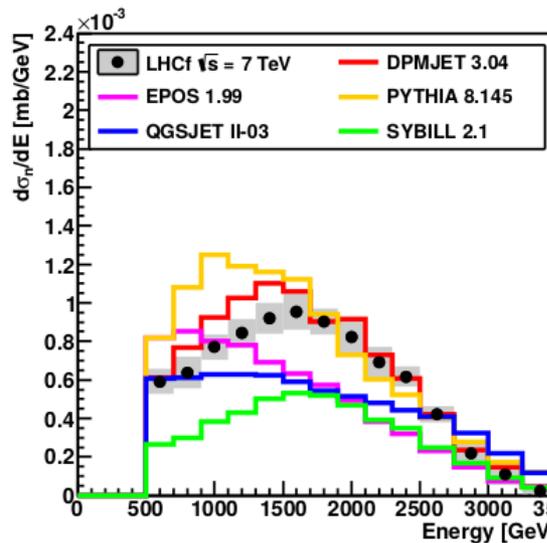
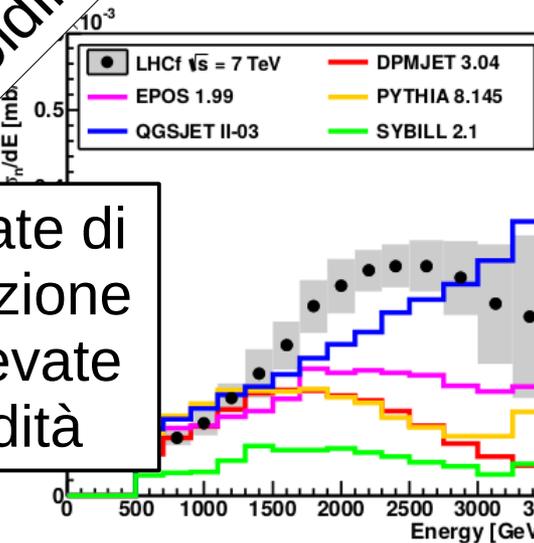
$\eta > 10.76$

$8.99 < \eta < 9.22$

$8.81 < \eta < 8.99$



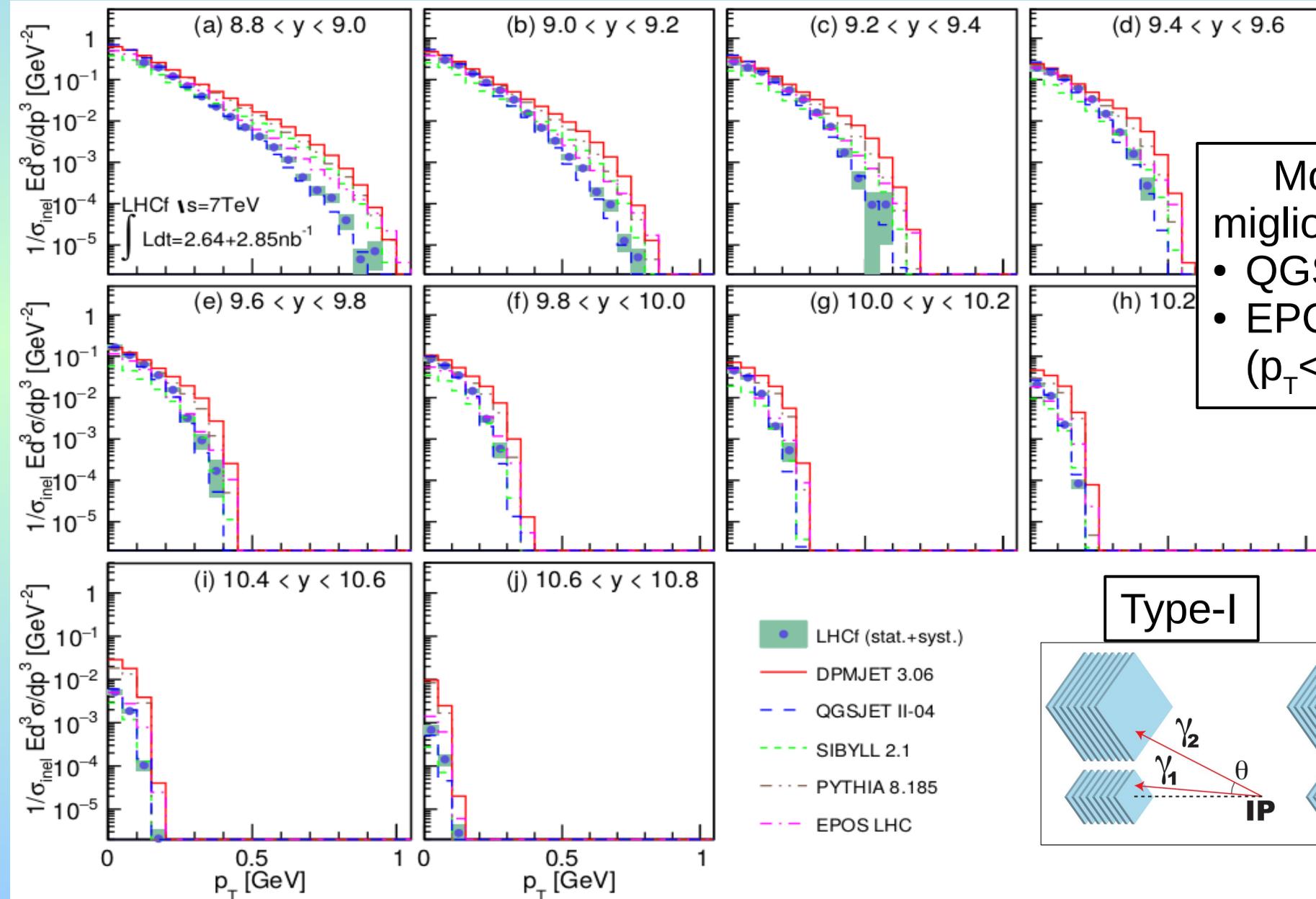
Dopo unfolding



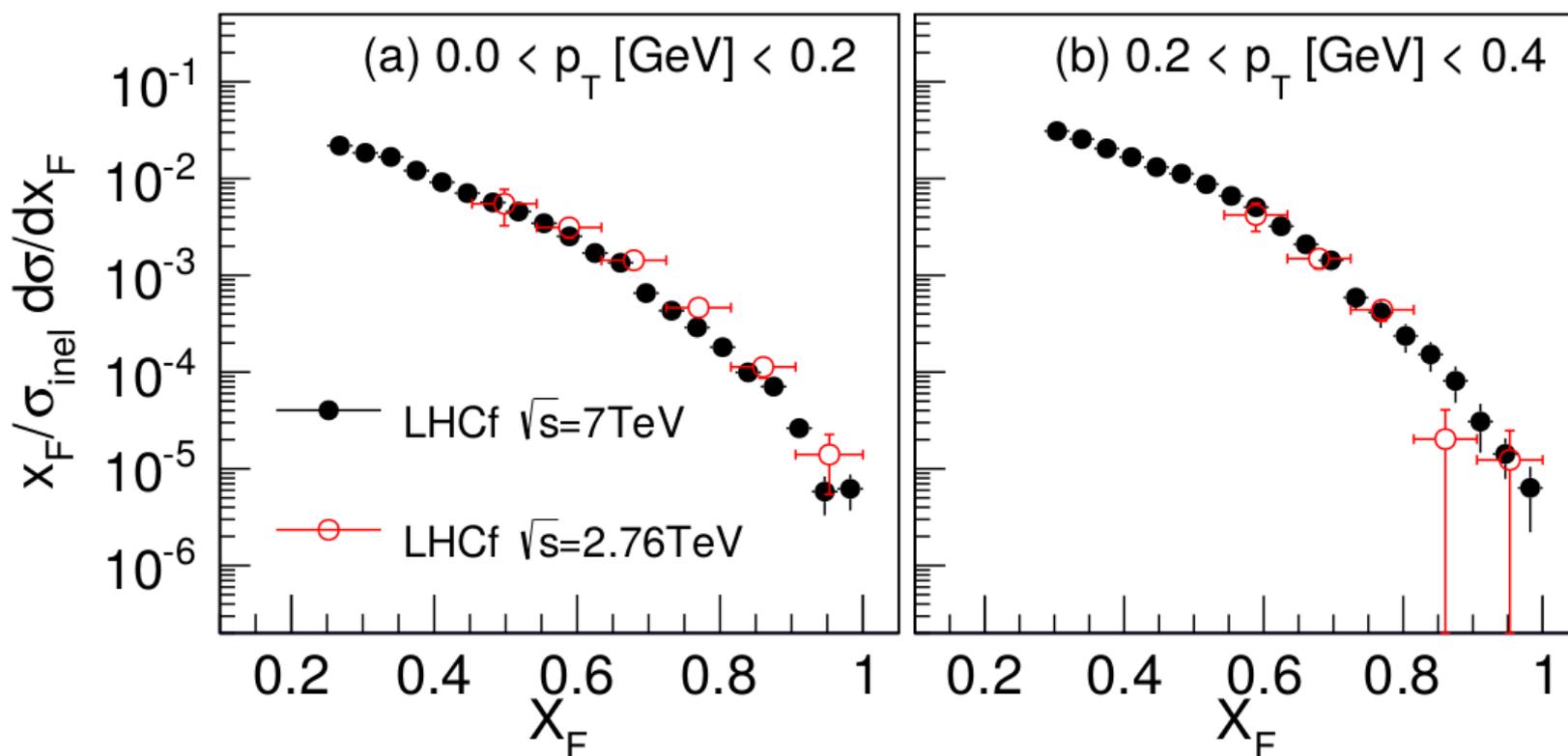
Alto rate di produzione ad elevate rapidità

Distribuzione di p_T dei π^0

p-p $\sqrt{s} = 7$ TeV



Feynman scaling ed altre leggi di scala



Feynman scaling
la sezione d'urto di produzione espressa in funzione della variabile x_F è indipendente da \sqrt{s}

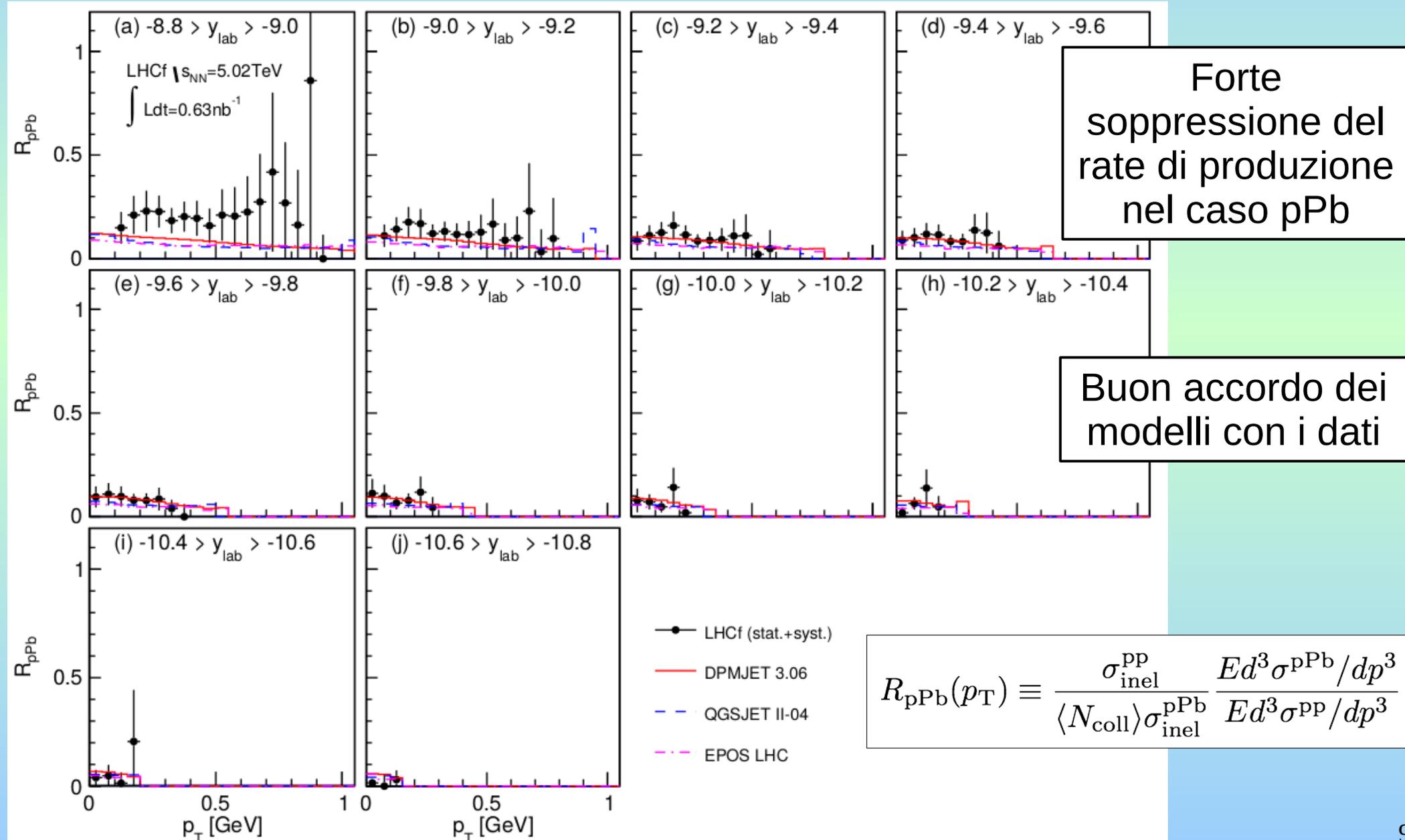
$$x_F = 2p_z / \sqrt{s}$$

Validità delle leggi di scala verificate da LHCf

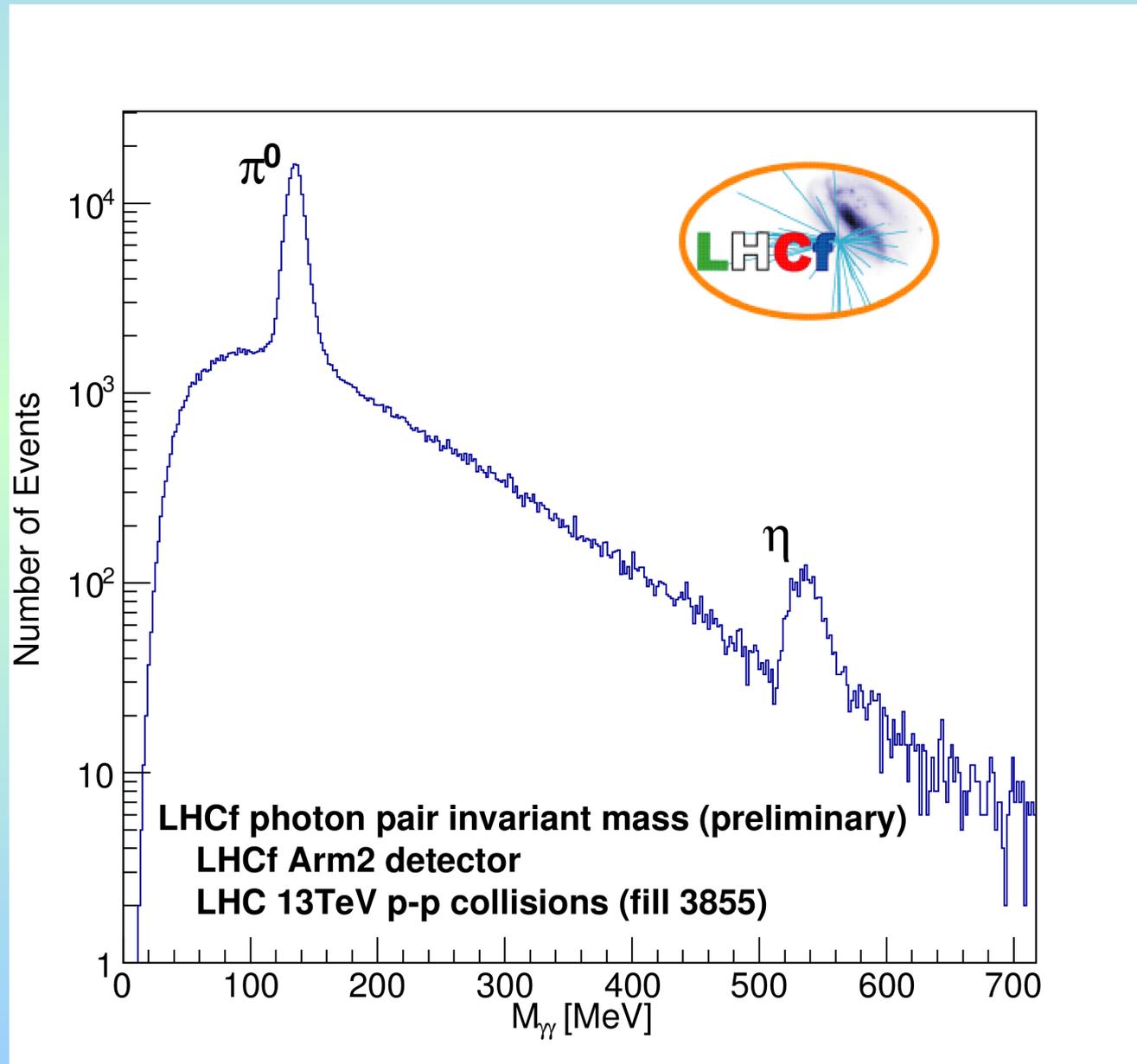
- **$\langle p_T \rangle$ scaling** $\pm 10\%$
- **limiting fragmentation** $\pm 15\%$
- **Feynman scaling** $\pm 20\%$

Buona validità
delle leggi di scala

Nuclear modification factor

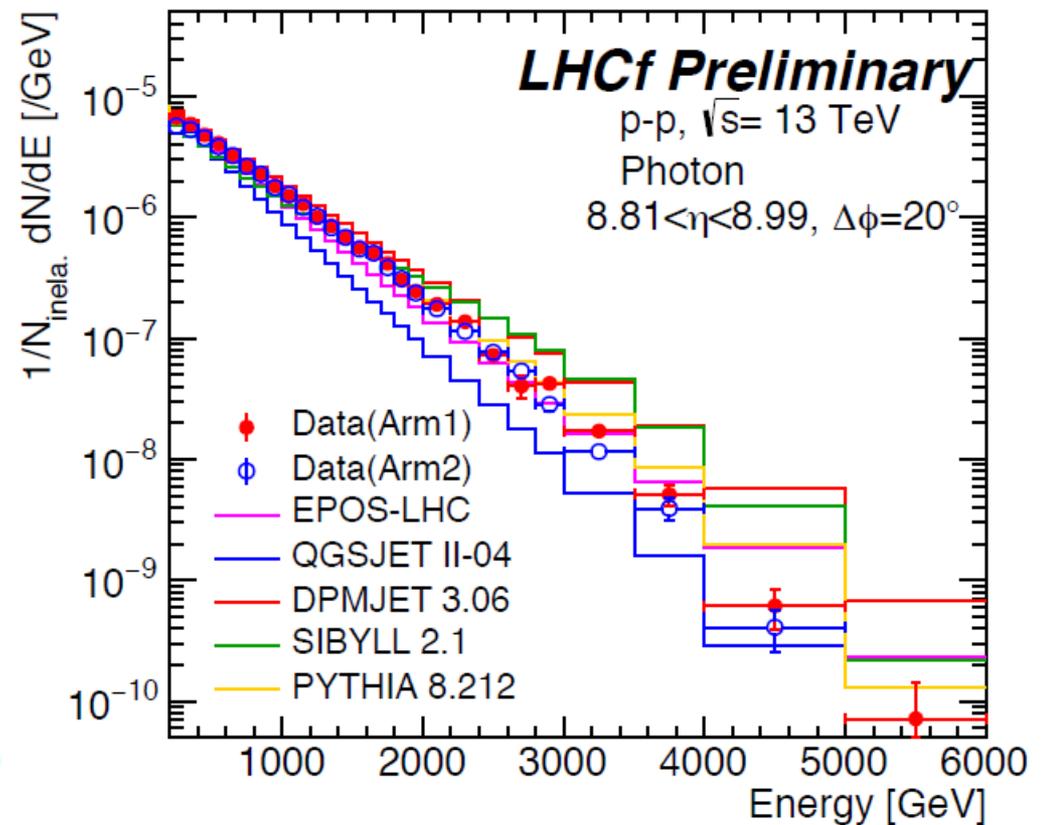
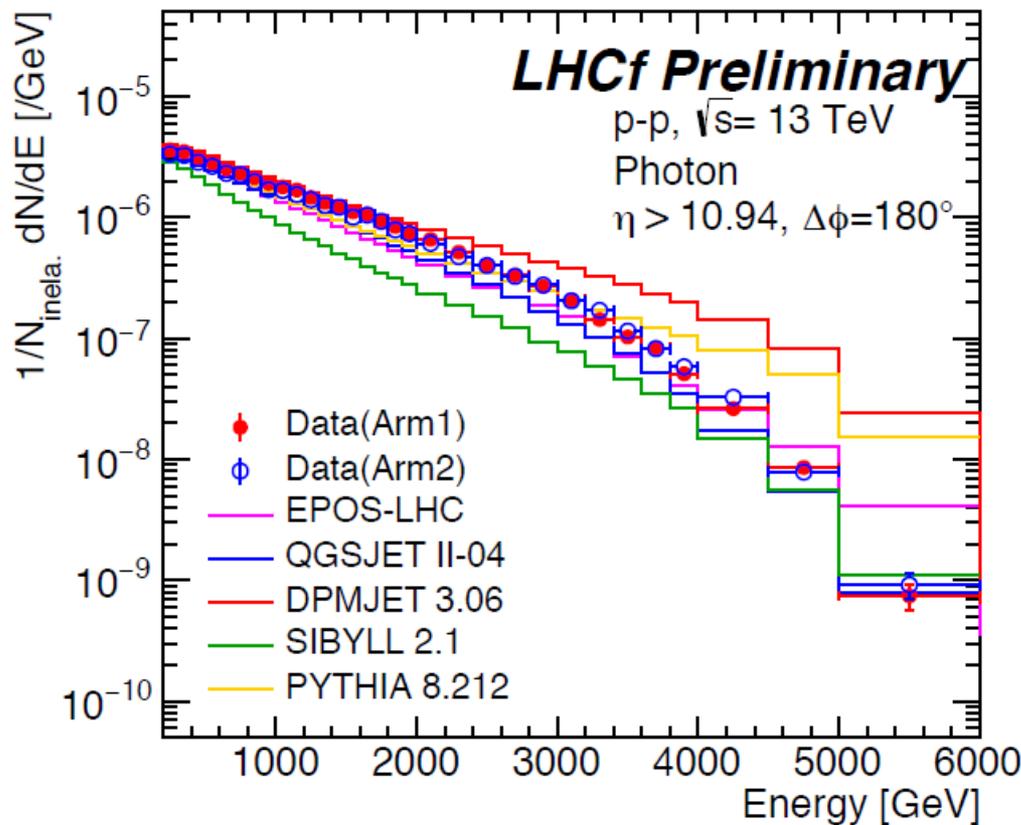


Plot preliminari p-p $\sqrt{s} = 13$ TeV massa invariante $M_{\gamma\gamma}$



Plot preliminari p-p $\sqrt{s} = 13$ TeV

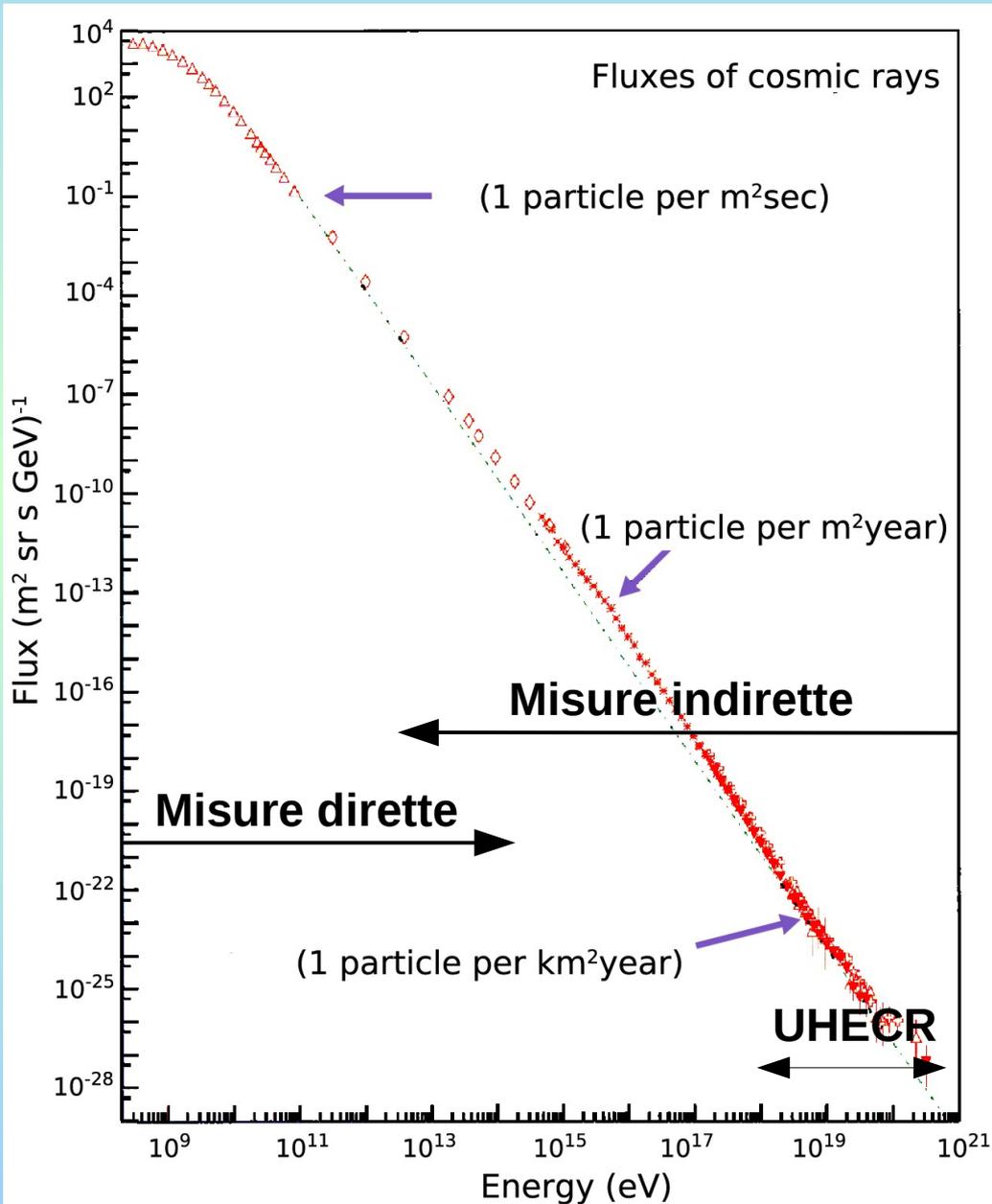
Distribuzioni di energia dei fotoni



Error bars show only the statistical errors.

Back Up

La fisica dei raggi cosmici



Obiettivo

Verifica dei modelli di accelerazione e propagazione dei raggi cosmici

Misure accurate di flusso e composizione in funzione dell'energia

Misure dirette
(palloni stratosferici e satelliti)

Misure indirette
(grandi apparati sulla superficie terrestre)

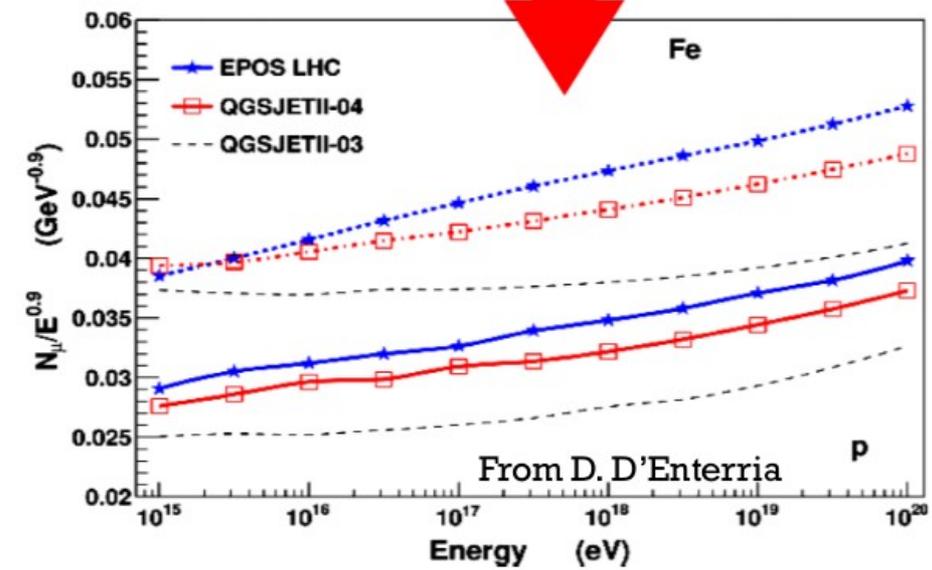
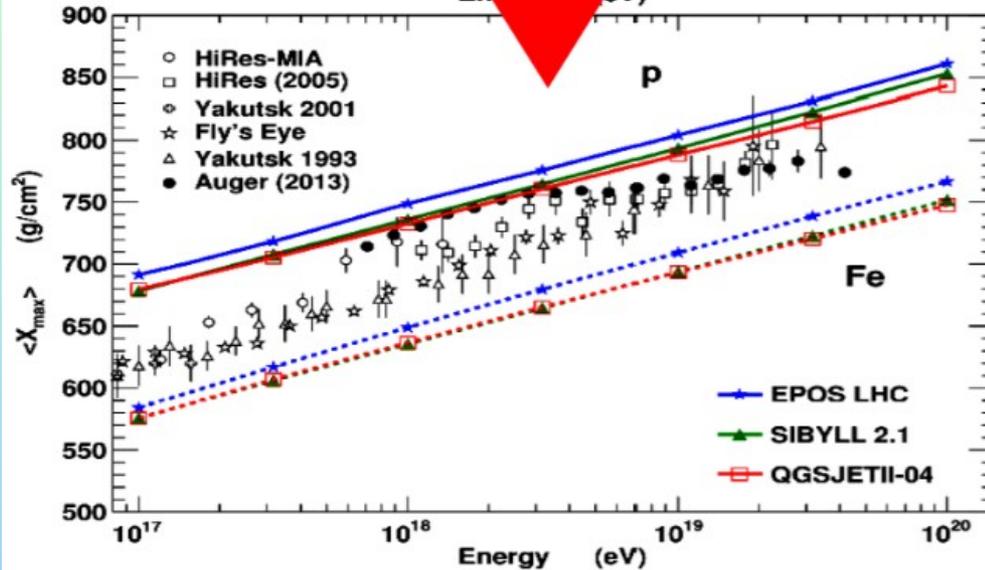
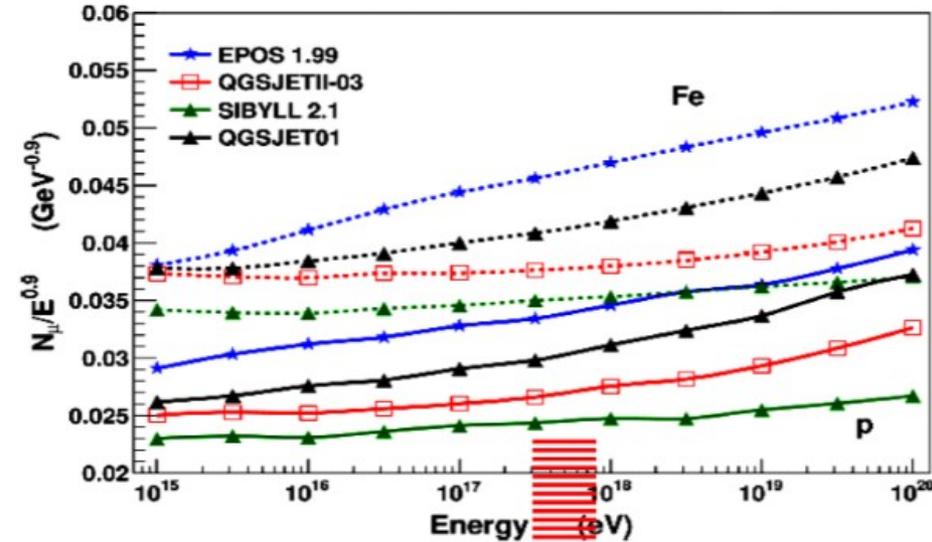
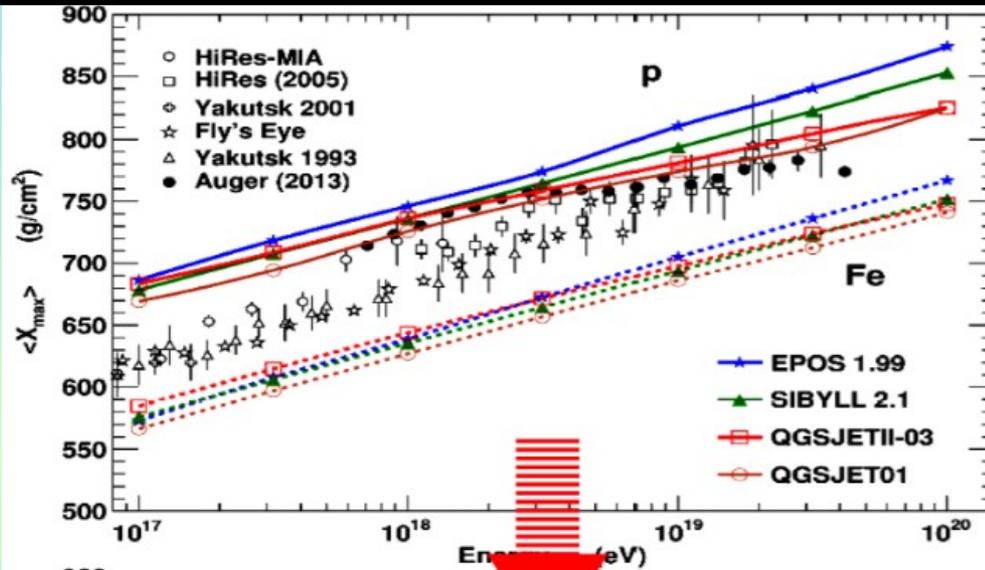
Componente elettromagnetica

Profondità media attraversata dallo sciame a cui il numero di particelle è massimo

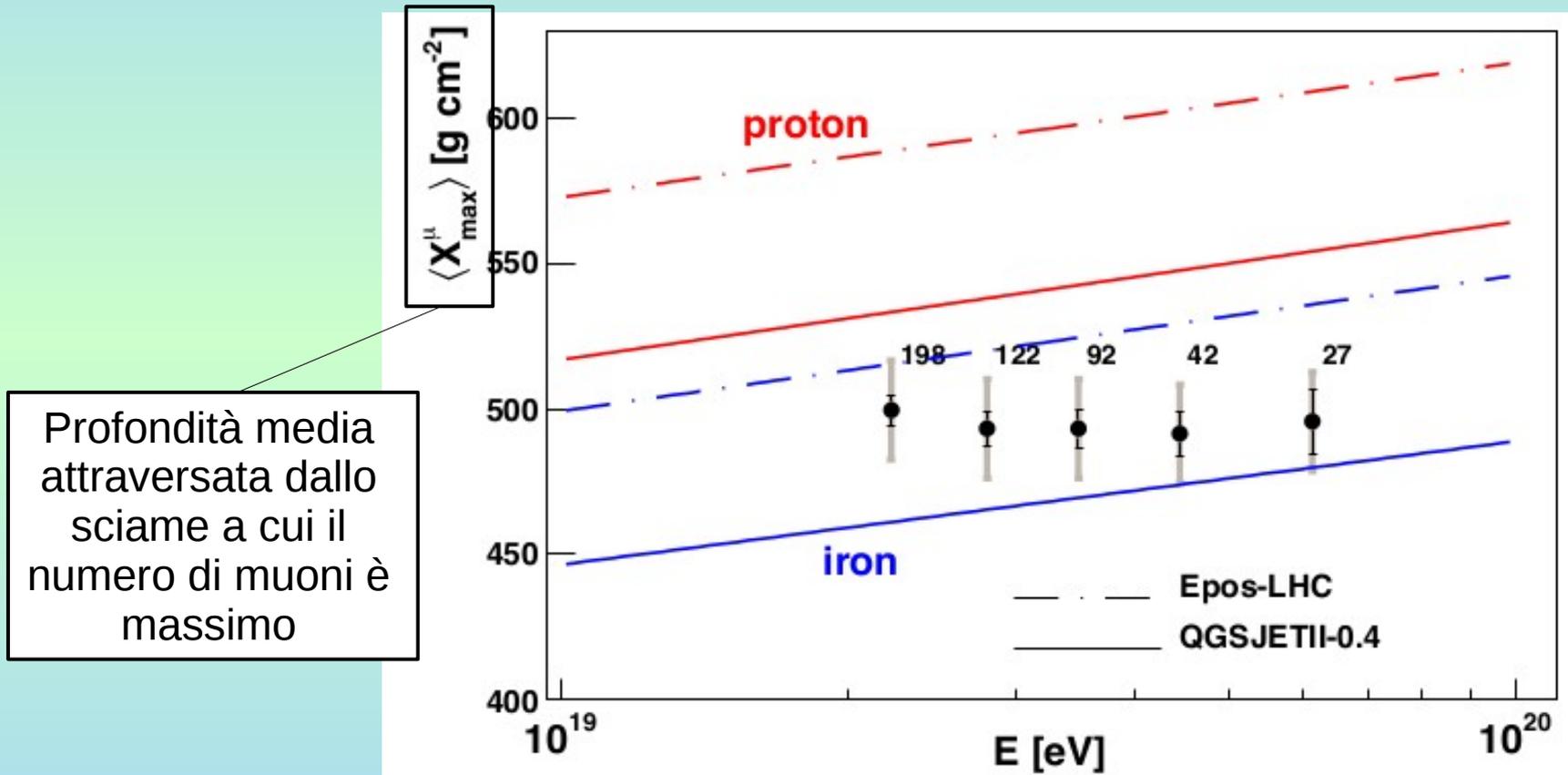
Numero di muoni a terra

Pre-LHC

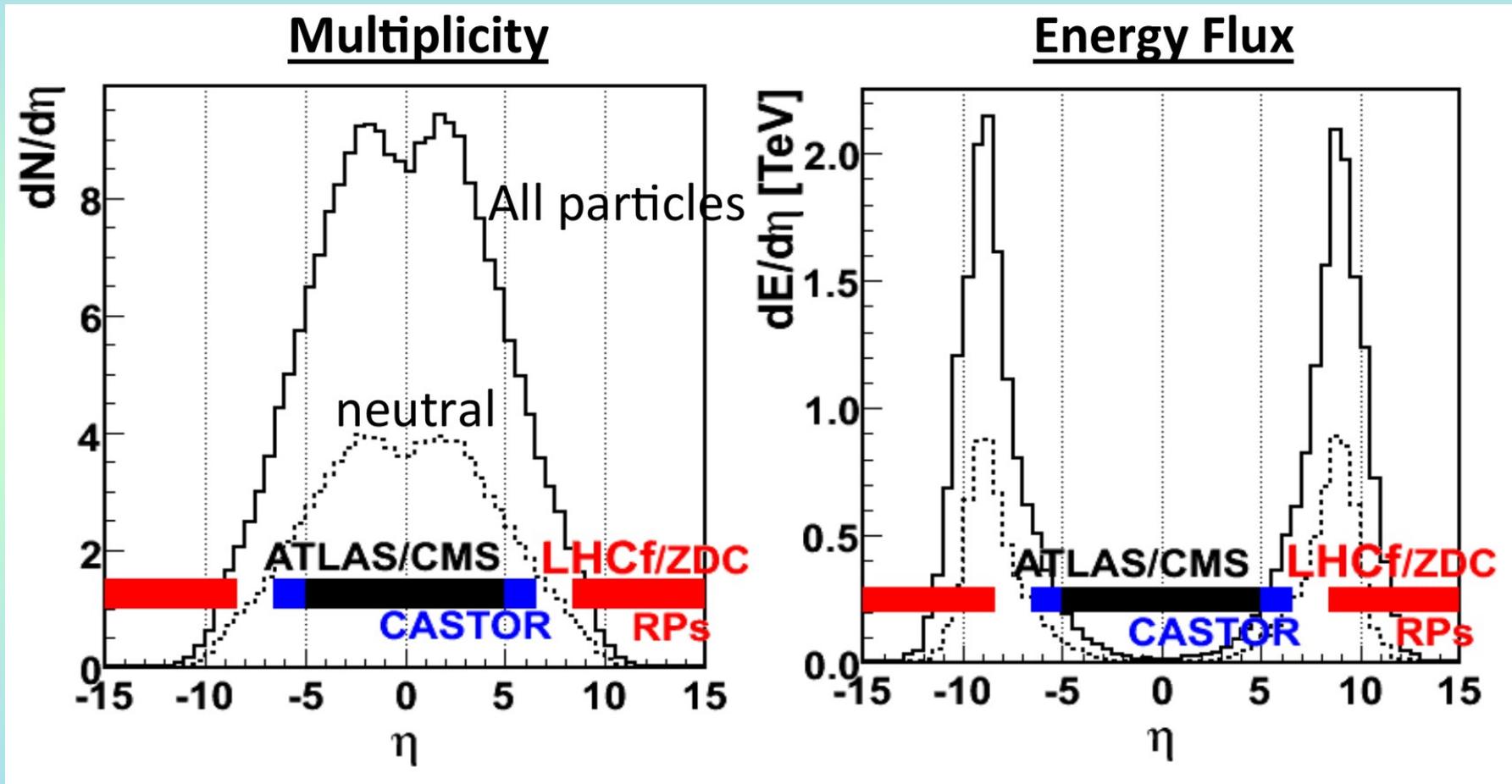
Post-LHC



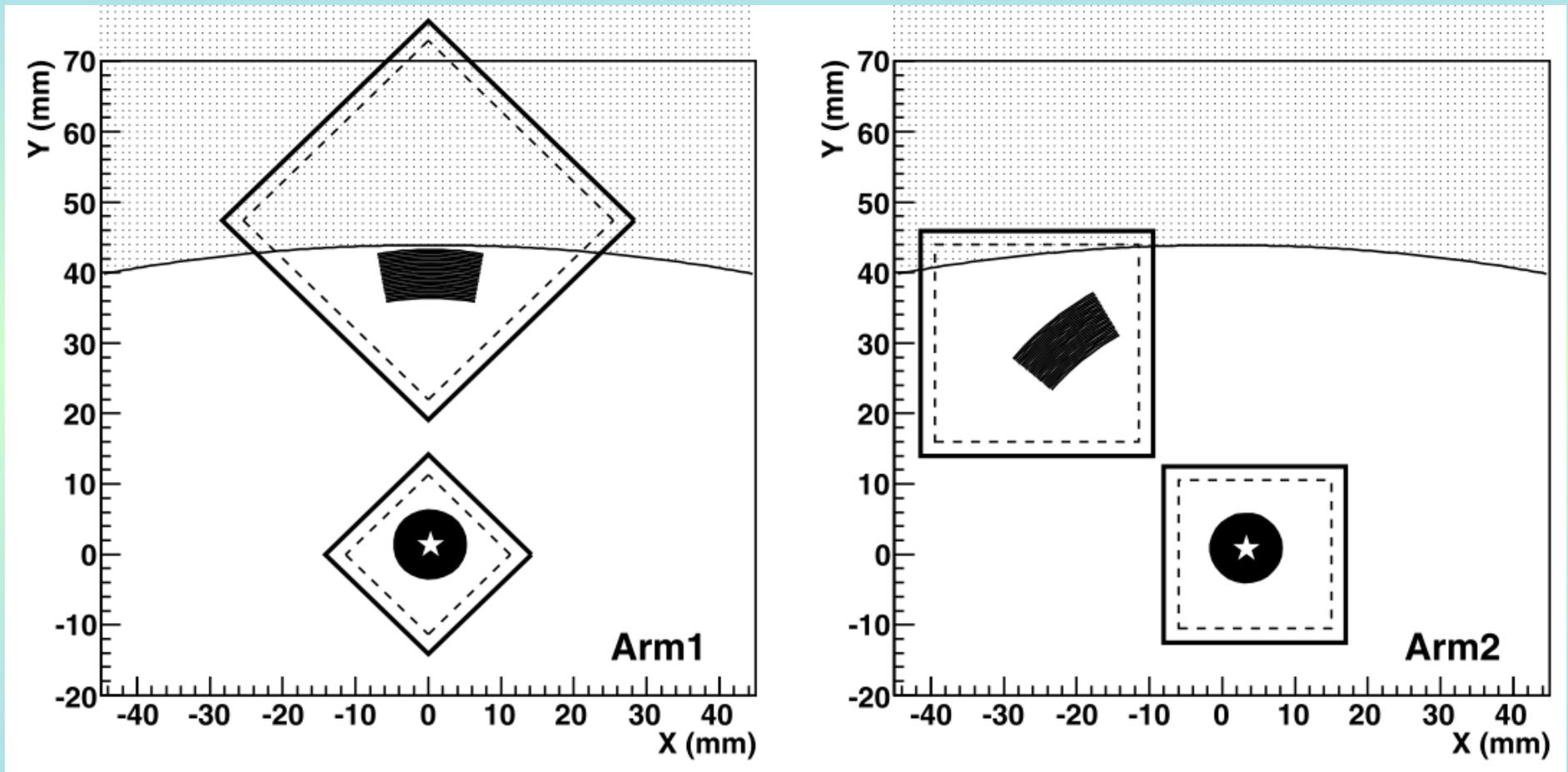
Componente muonica



Flusso di energia a LHC



Disposizione dei rivelatori di LHCf

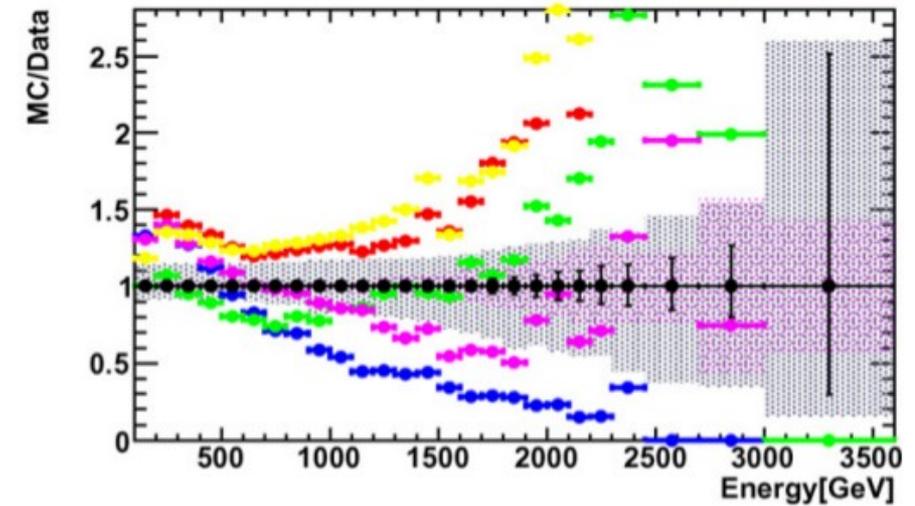
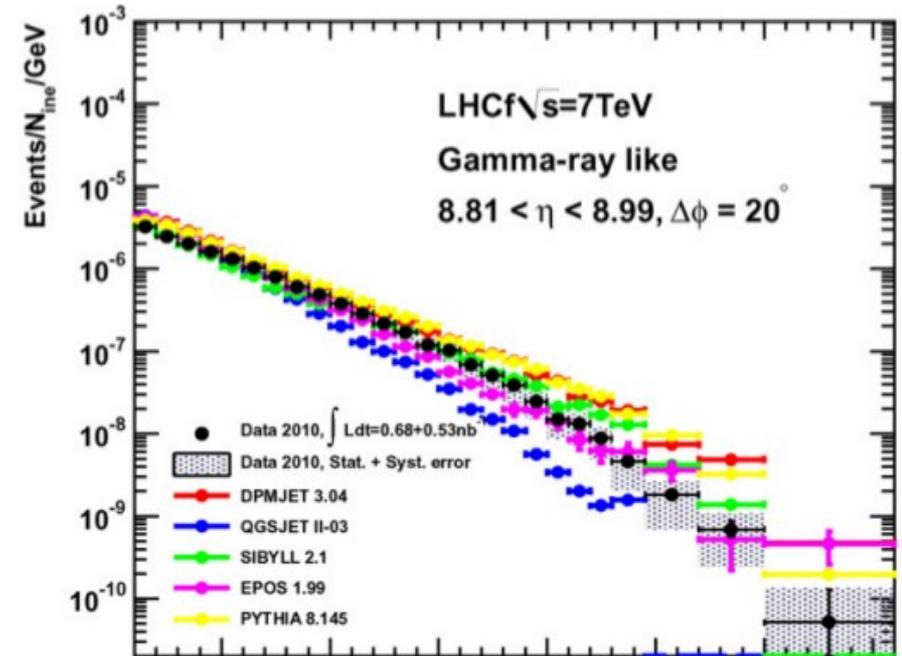
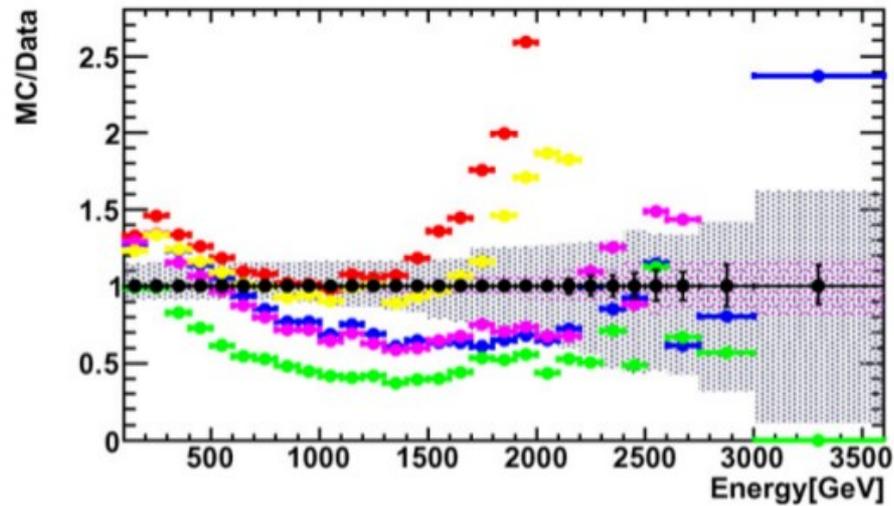
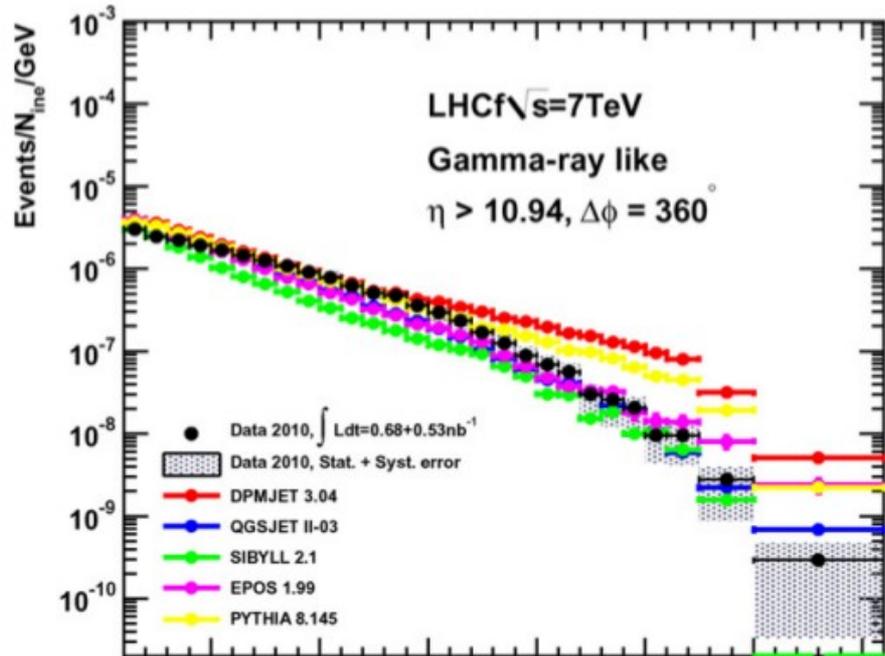


Risultati pubblicati

	Proton equivalent energy in LAB (eV)	γ	n	π^0
SPS test beam		NIM A, 671, 129 (2012)	JINST 9 P03016 (2014)	
p+p 900 GeV	4.3×10^{14}	Phys. Lett. B 715, 298 (2012)		
p+p 7 TeV	2.6×10^{16}	Phys. Lett. B 703, 128 (2011)	Phys. Lett. B 750 (2015) 360-366	Phys. Rev. D 86, 092001 (2012) + Submitted to Phys. Rev. D (Type-II)
p+p 2.76 TeV	4.1×10^{15}			Phys. Rev. C 89, 065209 (2014) + Submitted to Phys. Rev. D (Type-II)
p+Pb 5.02 TeV	1.4×10^{16}			Submitted to Phys. Rev. D (Type-II)
p+p 13 TeV	9.0×10^{16}	Data taken in June 2015 after the restart of LHC Analysis is on-going		
p+Pb 8.1 TeV	3.6×10^{16}	Letter of Intent just submitted to the LHC Committee...		

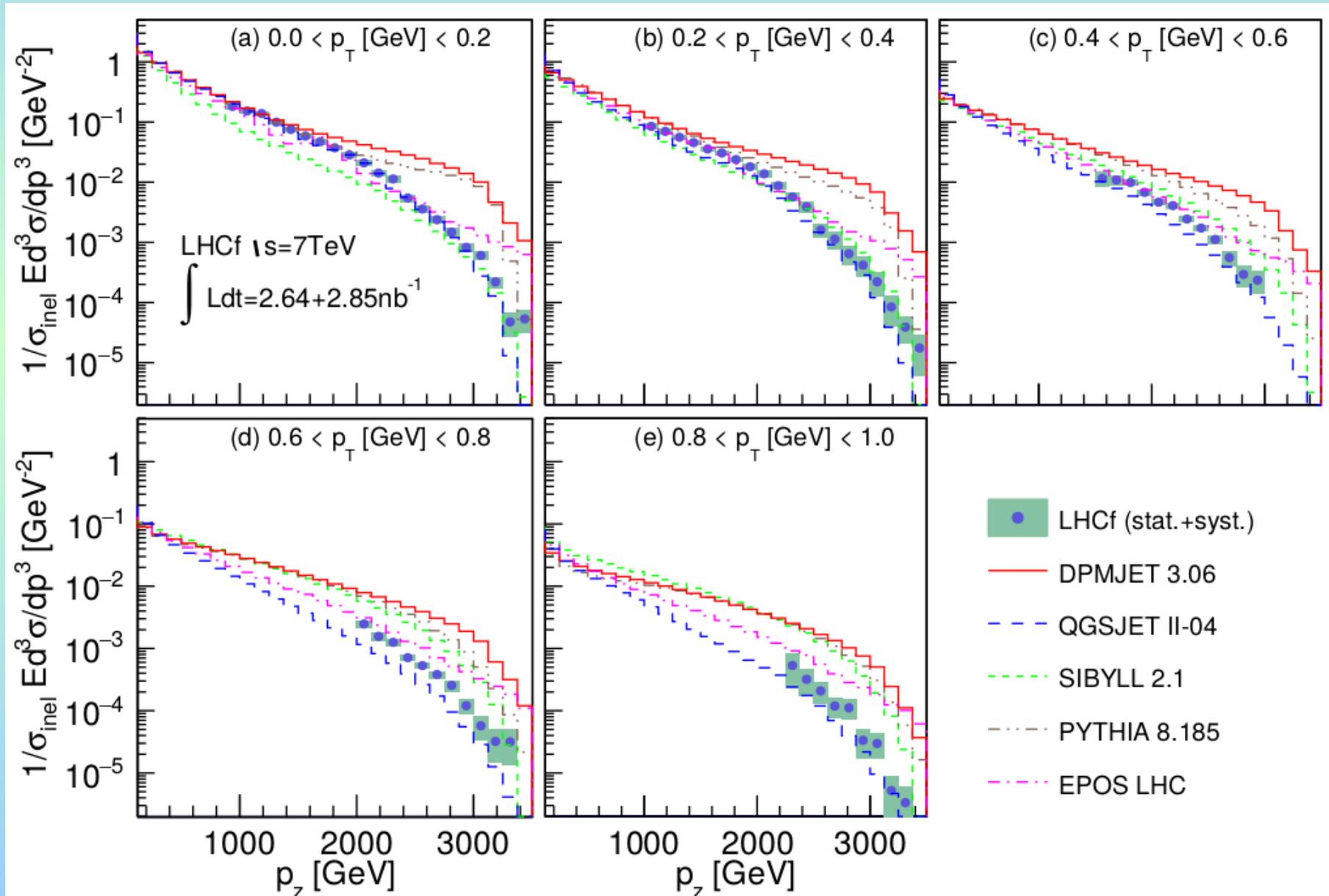
Presa dati comune LHCf + ATLAS

Distribuzione di energia dei fotoni p-p $\sqrt{s} = 7$ TeV



Distribuzione di p_z dei π^0

p-p $\sqrt{s} = 7$ TeV



Plot preliminari p-p $\sqrt{s} = 13$ TeV Type-I π^0 event



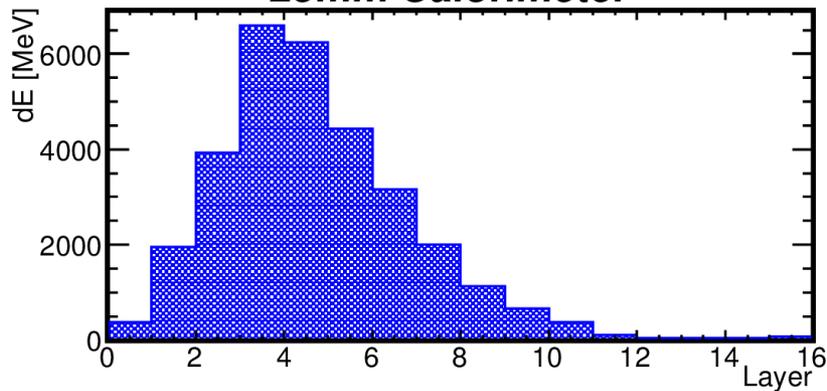
LHCf Arm2 Detector

π^0 Candidate Event

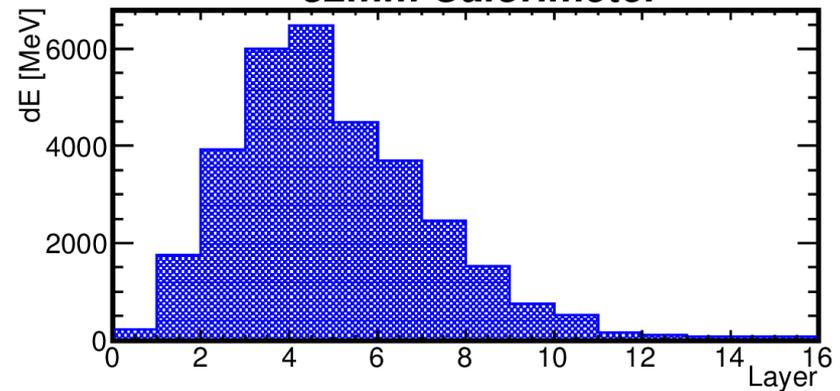
LHC p-p, $\sqrt{s} = 13$ TeV Collisions

RUN: 44484
NUMBER: 3010
TIME: 1434152507
FILL: 3855
 E_{25mm} : 1014 GeV
 E_{32mm} : 1021 GeV
 $M_{\gamma\gamma}$: 147 MeV

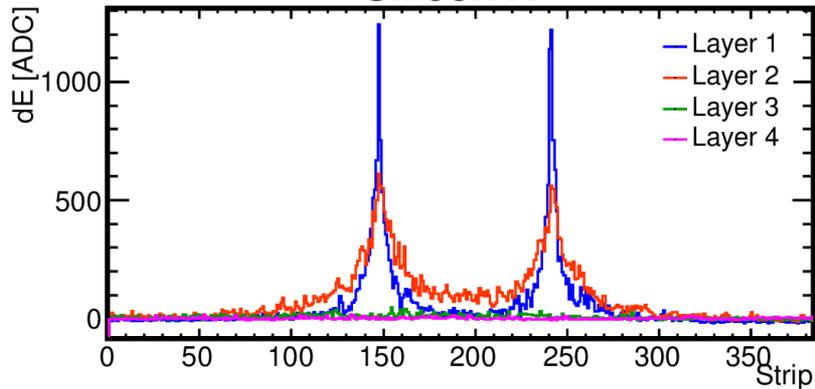
25mm Calorimeter



32mm Calorimeter



Silicon X



Silicon Y

