

LHCf: Results and plan for RUN II

Takashi SAKO

(STEL/KMI, Nagoya University)

for the LHCf Collaboration

Next meeting in Japan

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WORKSHOP ON FORWARD PHYSICS AND HIGH-ENERGY SCATTERING AT ZERO DEGREES

NAGOYA, JAPAN
September 9-12 2015

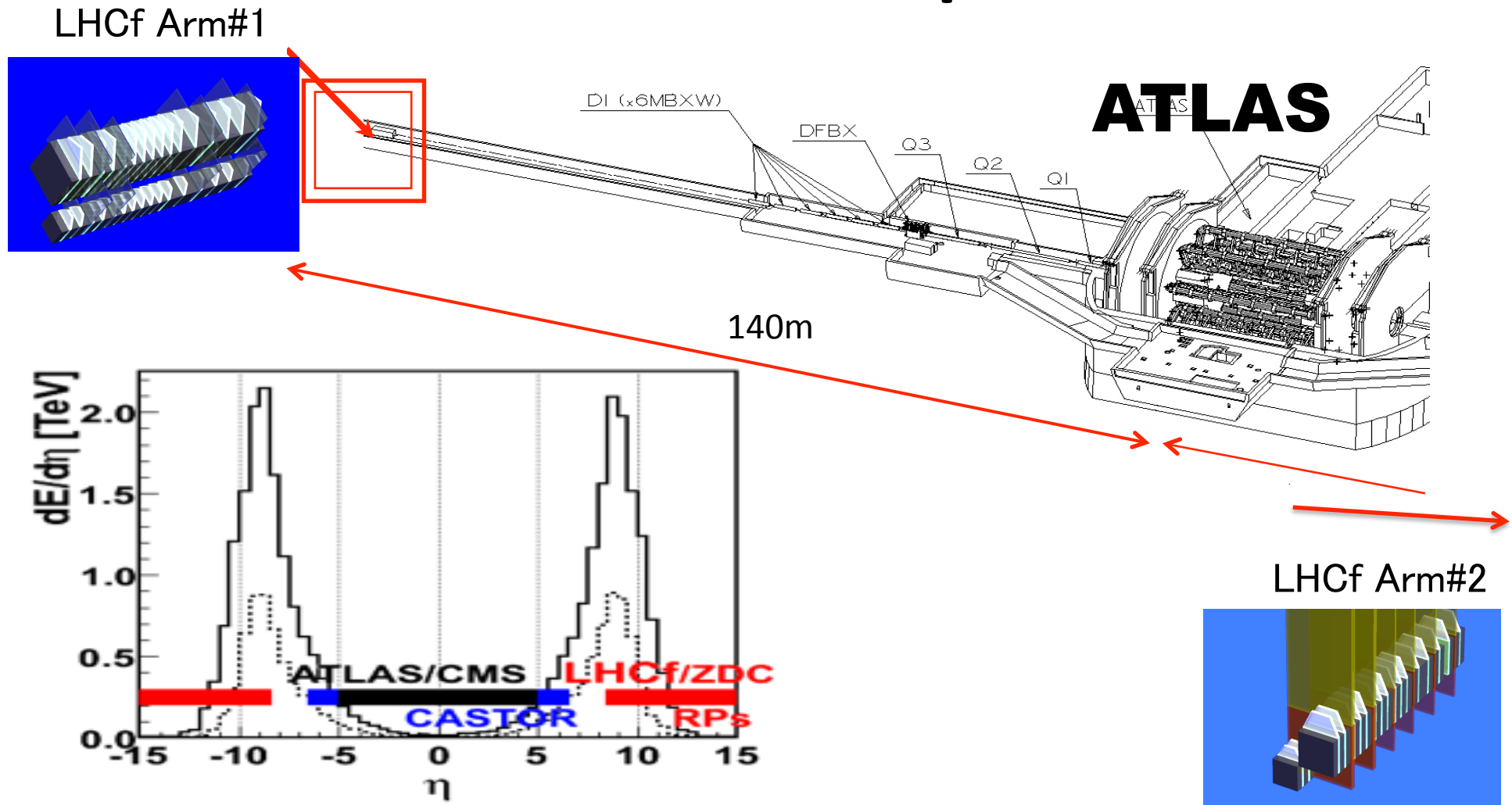


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Nicolo Cartiglia (CMS-Torino)
Simone Giani (TOTEM-CERN)
Yoshitaka Itow (LHCf-Nagoya)
Yuji Goto (PHENIX-Riken)
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Kiyoshi Tanida (PHENIX-Seoul)
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Yuji Yamazaki (ATLAS-Kobe)

- http://www-d0.fnal.gov/~royon/forward_nagoya/
- Hotel rooms are not held
- We are happy to help for booking your rooms
- Contact sako@stelab.nagoya-u.ac.jp

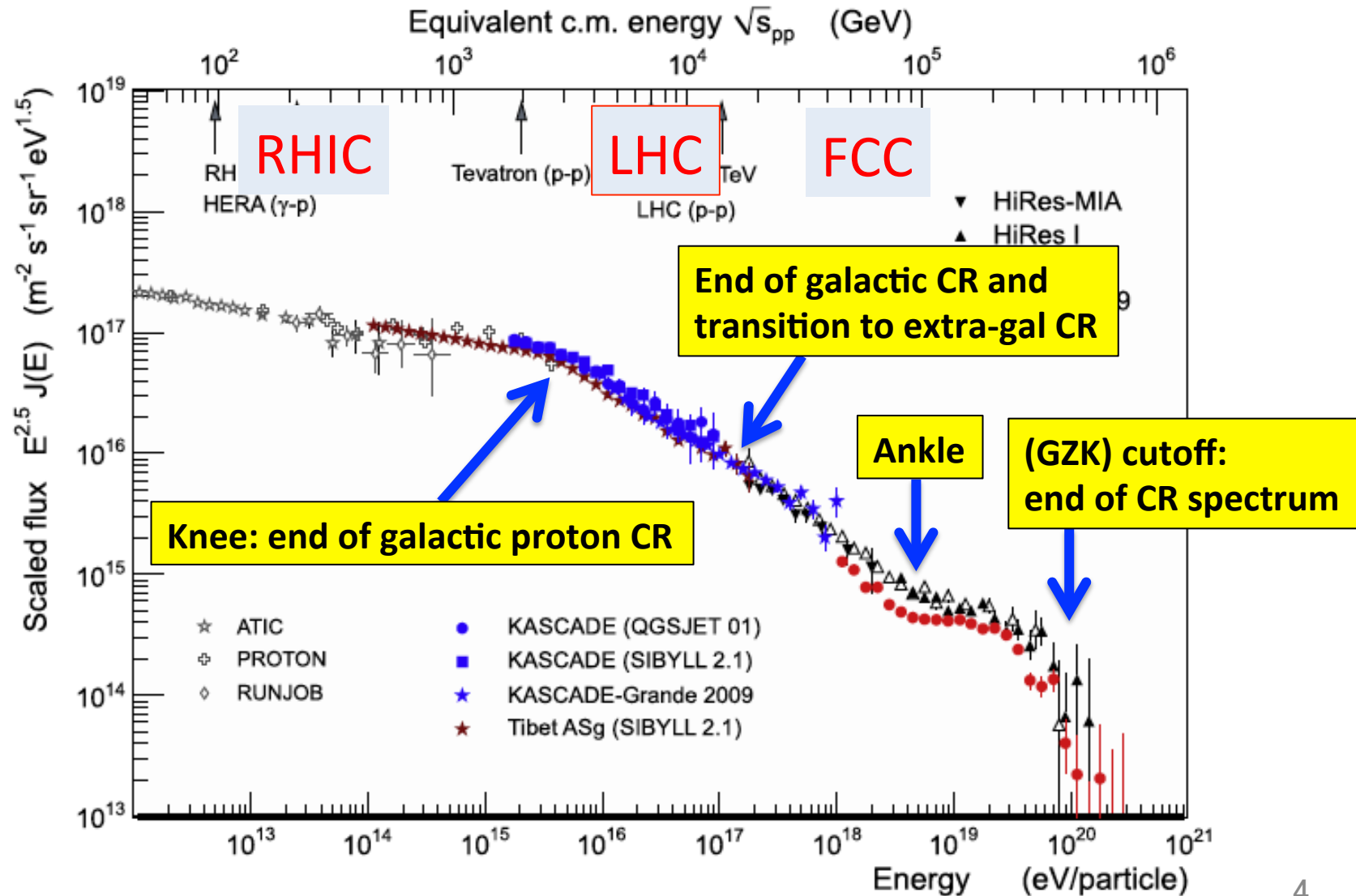
The LHC forward experiment



- Most of the collision energy flows into forward direction
- Neutral particles (photons and neutrons) emitted around 0 degree arrive at LHCf

Cosmic-ray spectrum and collider energy

(D'Enterria et al., APP, 35,98-113, 2011)



Brief history with LHC collisions

Year	Activity
2009	Operation with LHC $\sqrt{s}=0.9$ p-p collisions
2010	Operation with LHC $\sqrt{s}=0.9$ and 7TeV p-p collisions
2011	Upgrade to radiation-hard detectors (continued till 2014)
2012	
2013	Operation with LHC $\sqrt{s}=2.76$ TeV p-p collisions and 5.02TeV p-Pb collisions
2014	
2015	Operation with LHC $\sqrt{s}=13$ TeV p-p collisions (with ATLAS)
2016	Operation with RHIC $\sqrt{s}=0.51$ TeV p-p collisions (proposed)
2017-	p-N/N-N collisions at RHIC or p-O/O-O collisions at LHC (under discussions)

Publications

	Photon (EM shower)	Neutron (hadron shower)	π^0 (limited acceptance)	π^0 (full acceptance)	Performance
Beam test	NIM, A671 (2012) 129-136	JINST, 9 (2014) P03016			
0.9TeV p-p	PLB, 715 (2012) 298-303				IJMPA, 28 (2013) 1330036
7TeV p-p	PLB, 703 (2011) 128-134	submitted (hep-ex: 1503.03505)	PRD, 86, (2012) 092001	in preparation	
2.76TeV p-p			PRC, 89 (2014) 065209		
5.02TeV p-Pb					

physics results

performance results

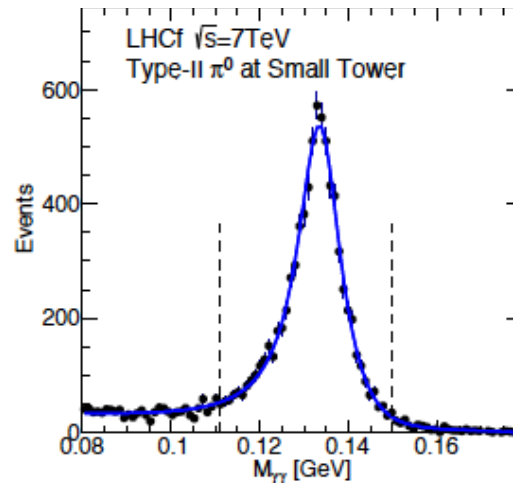
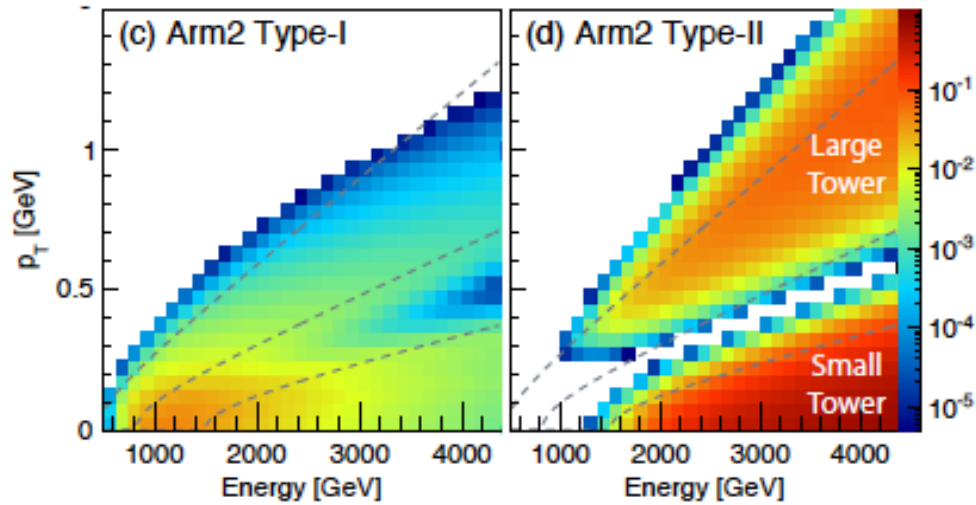
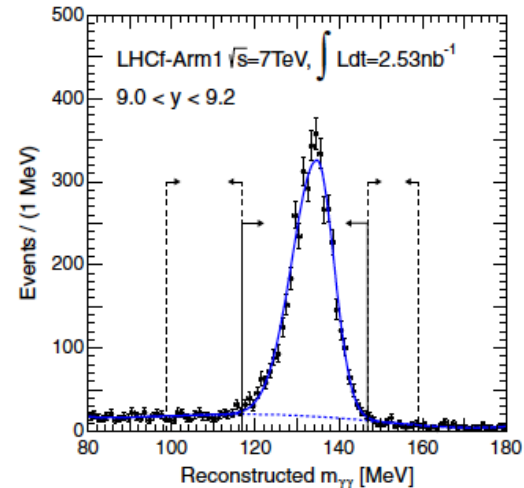
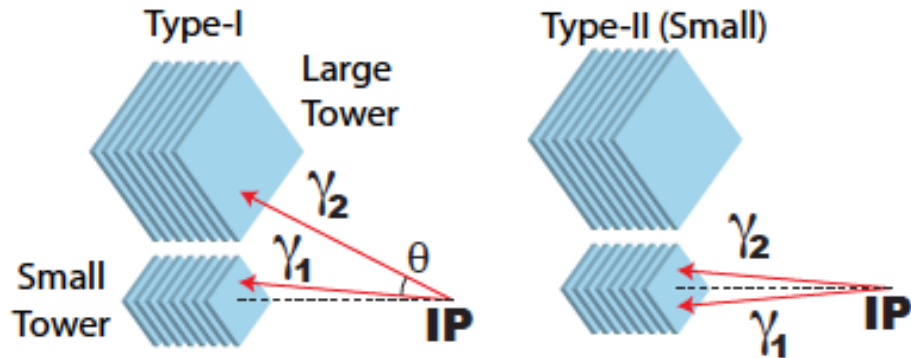
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physics results

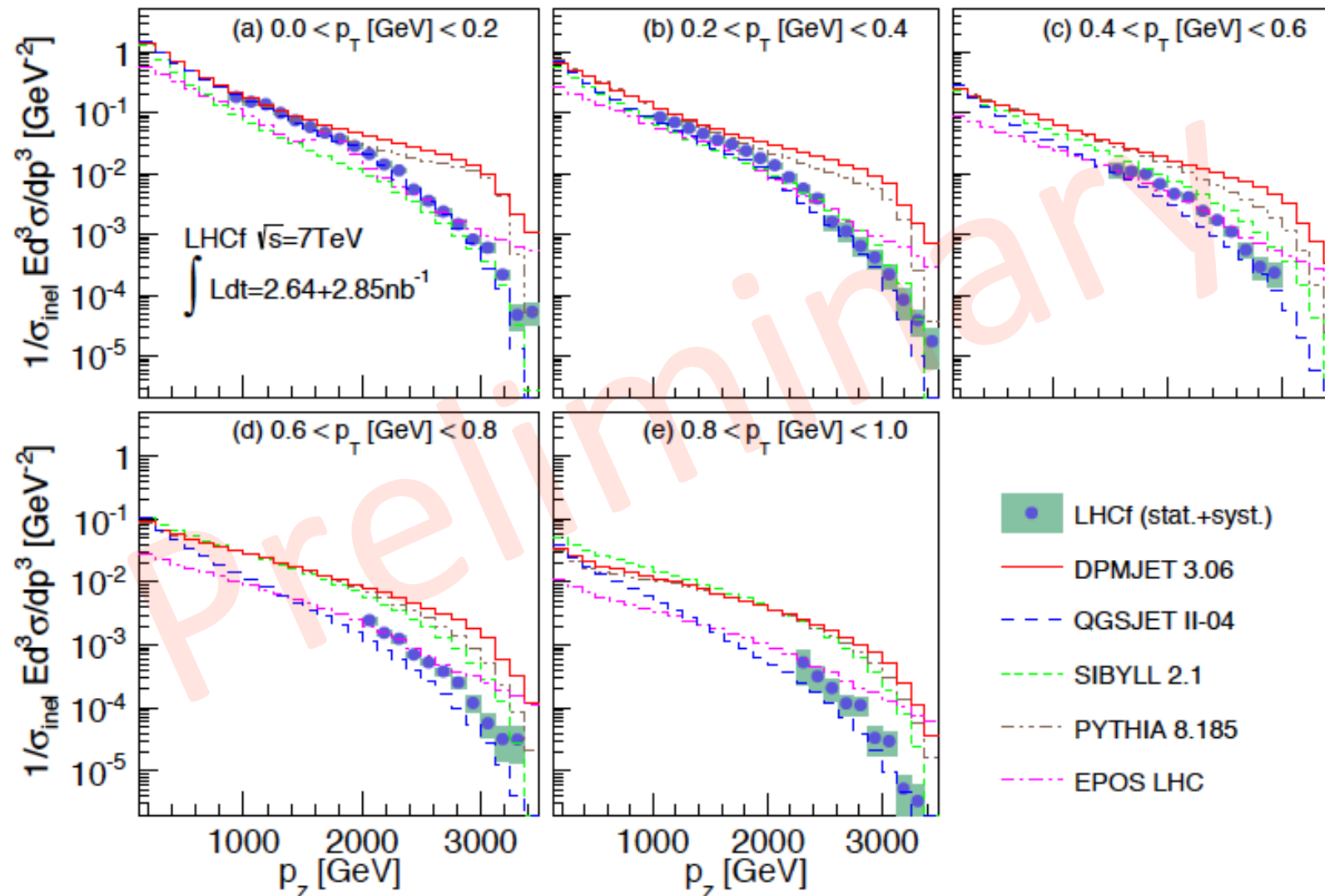
performance results

Update in π^0 Analysis

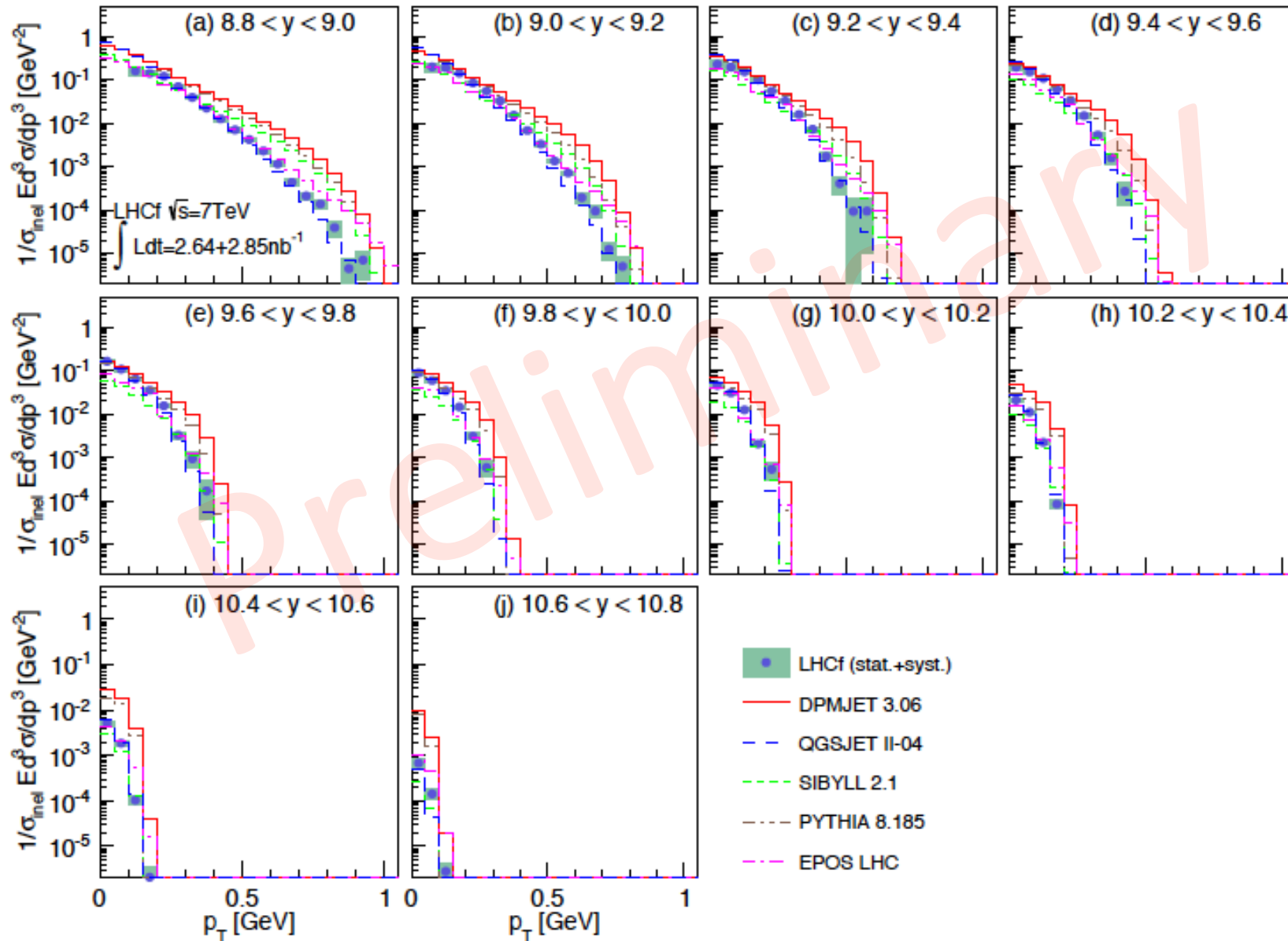


- Extension of π^0 phase space using Type-II events
 - Type-I Conventional analysis
 - Type-II New analysis

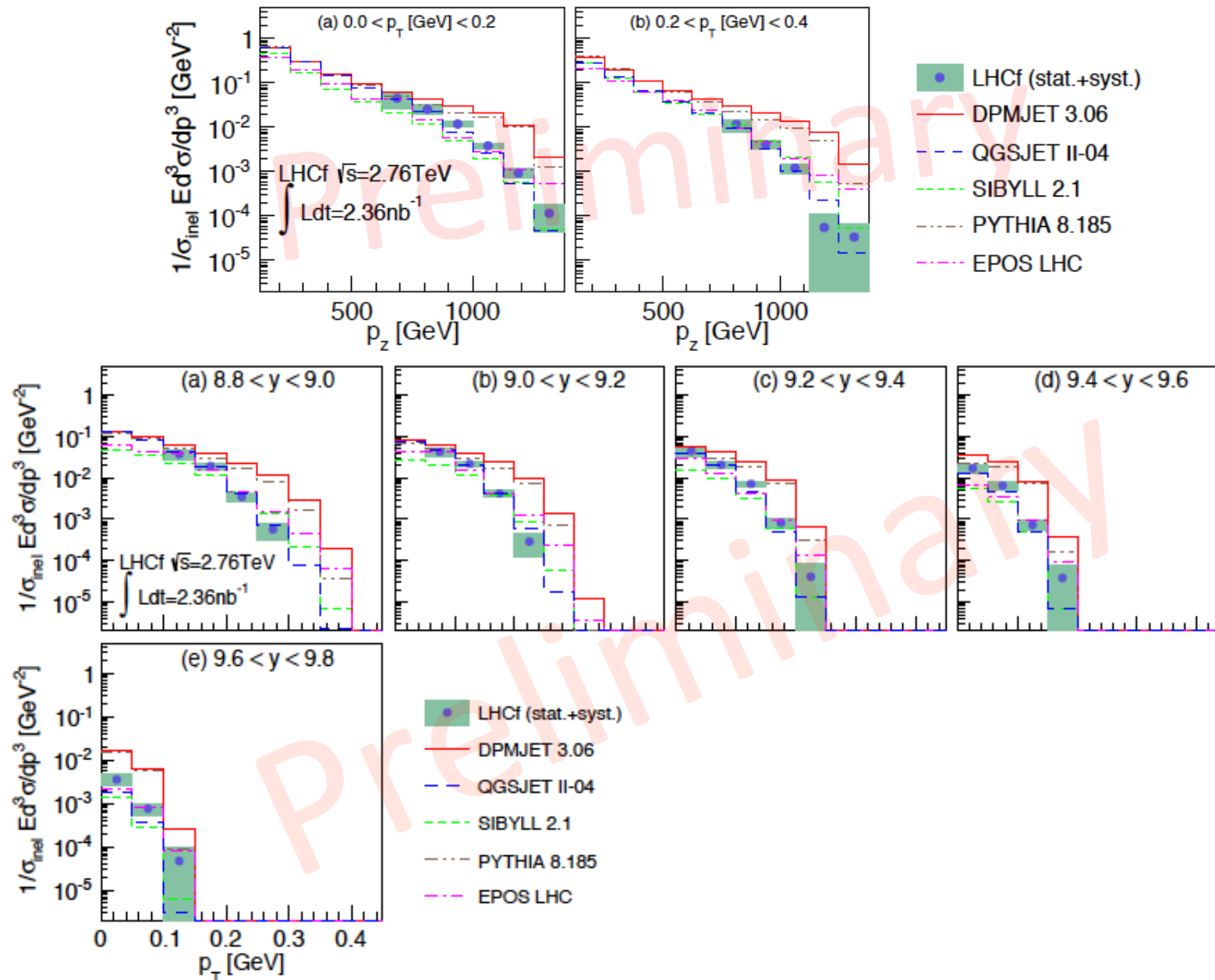
π^0 p_z spectra in 7TeV p-p collisions



π^0 p_t spectra in 7TeV p-p collisions

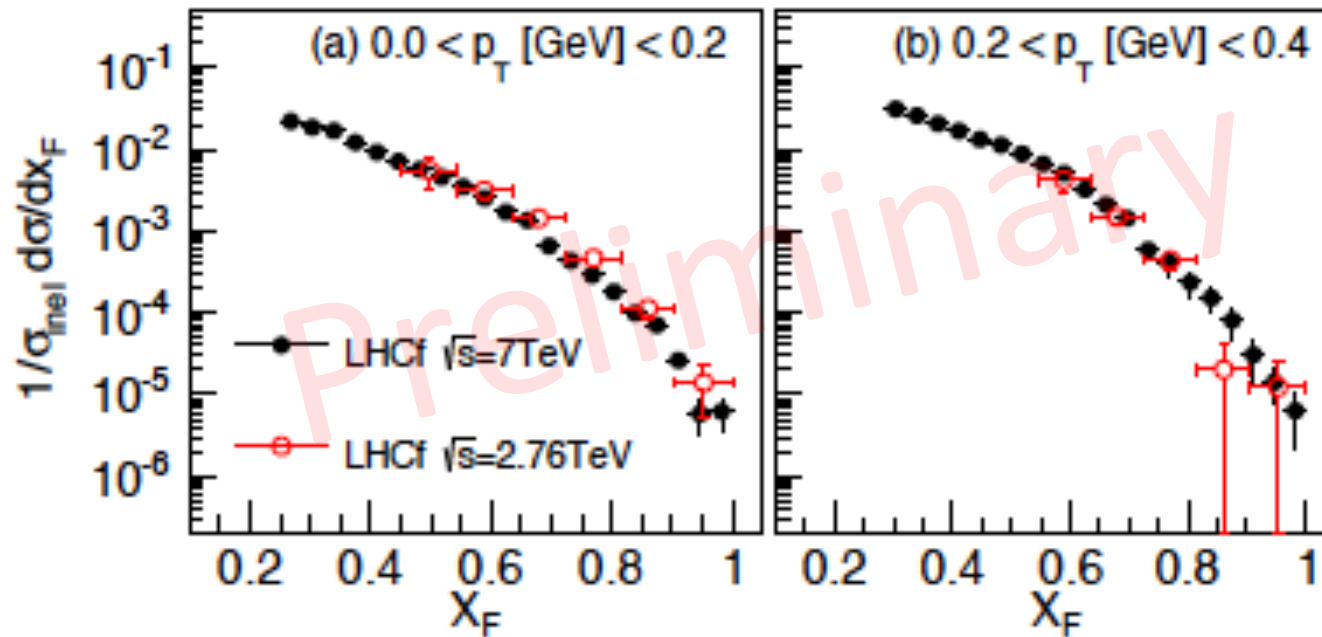
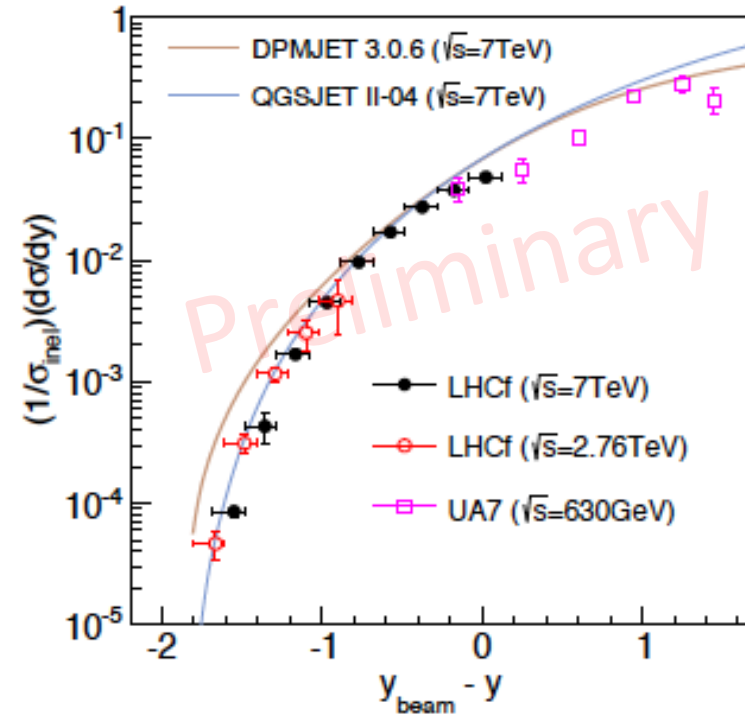


π^0 spectra in 2.76TeV p-p collisions



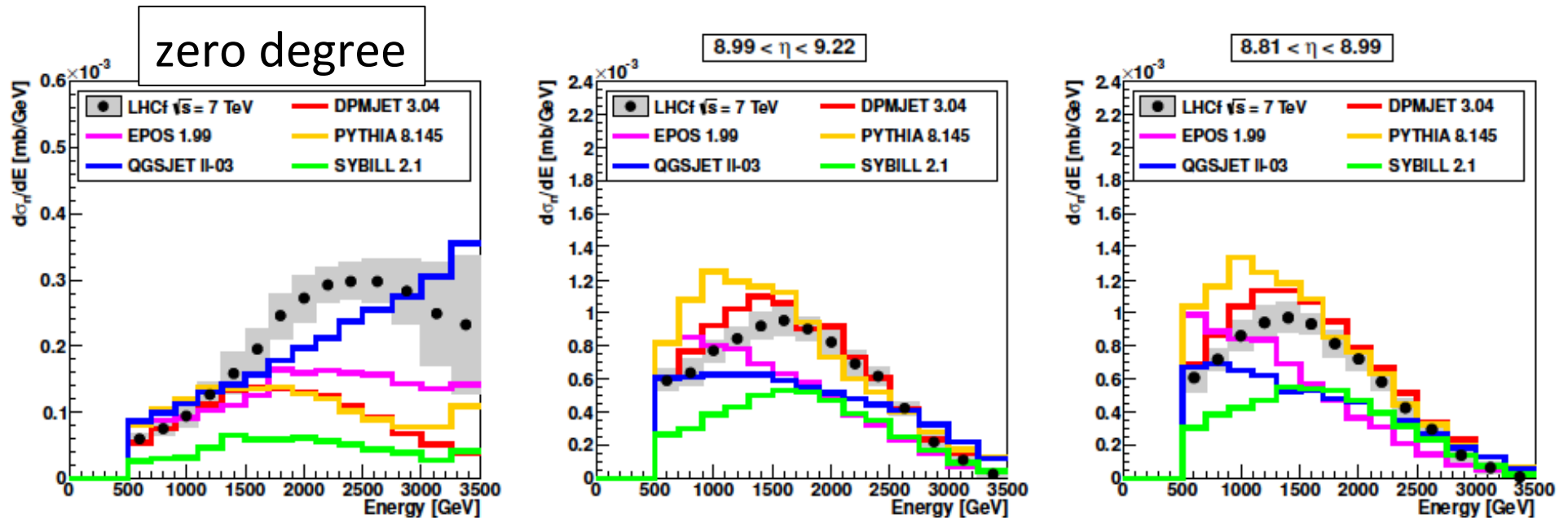
Scaling

(630GeV –) 2.76TeV – 7TeV



Forward neutron spectra

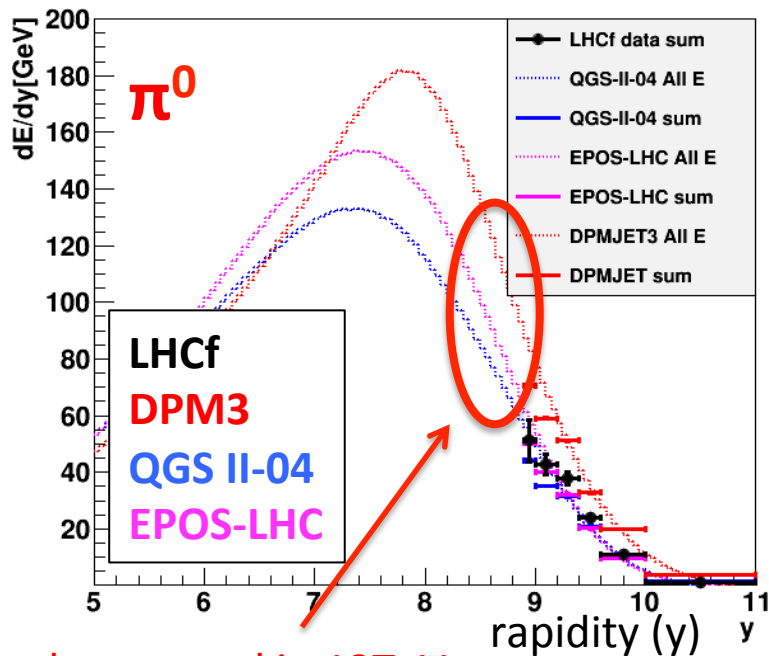
($\sqrt{s}=7\text{TeV}$ p-p; arXiv:1503.03505 [hep-ex])



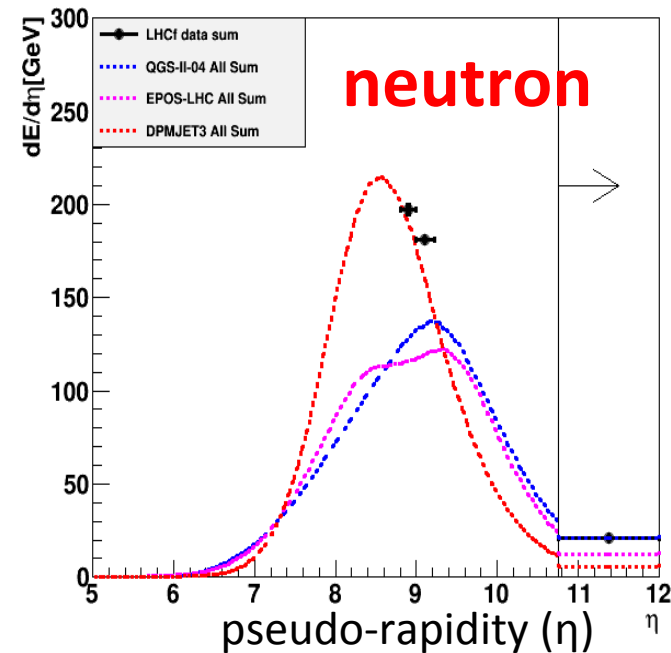
- Zero degree production is qualitatively explained by **QGSJET II**
- Non-zero-degree productions (larger cross section) are underestimated by popular **QGSJET II** and **EPOS** models

Energy flow

- Post-LHC models (**EPOS-LHC** and **QGSJET II-04**) well explain the π^0 results, but not for neutrons
- **DPMJET3** explains the neutron results, but it is not recently used for CR simulations



to be covered in 13TeV



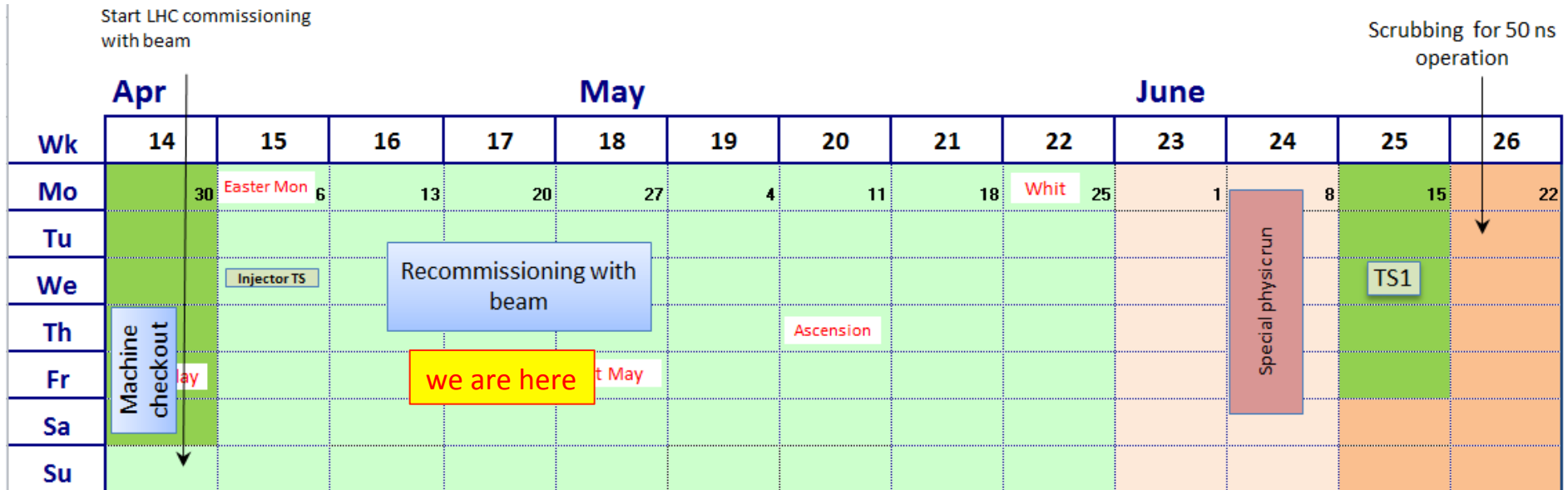
Black solid circle : LHCf data (π^0 , LHCf 2012)

Dotted lines : π^0 energy flow distribution of each model

Thick horizontal line : Energy flow calculation after p_T cut

RUN II

RUN II updated schedule



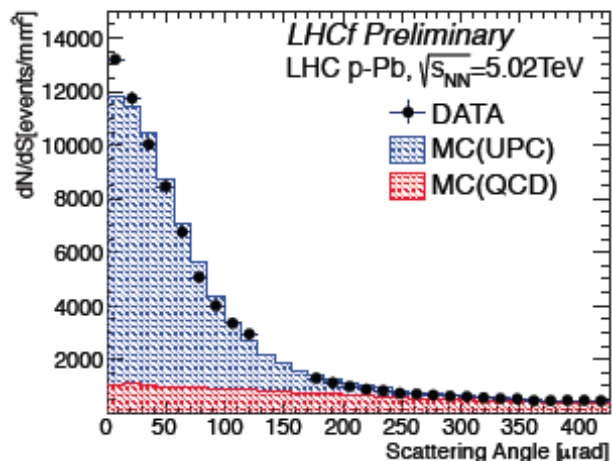
- 1-7 June: Physics (stable beams)
- 8-12 June: Special physics run
 - vdM scans
 - LHCf dedicated run
- 15-19 June: TS1

Beam conditions during LHCf run

- beta*; 19m
- pileup; 0.01-0.03 (in discussion)
- luminosity; $(0.6-1.8) \times 10^{29}$ (n_b ; 40 bunches)
- bunch spacing; >2usec
- a few non-crossing bunches
- crossing angle (@IP1); as much as possible up to 145urad downward
- integrated lumi; >10 /nb delivery (to be defined)
 - 3 (or 4) good fills

ATLAS-LHCf Joint operation

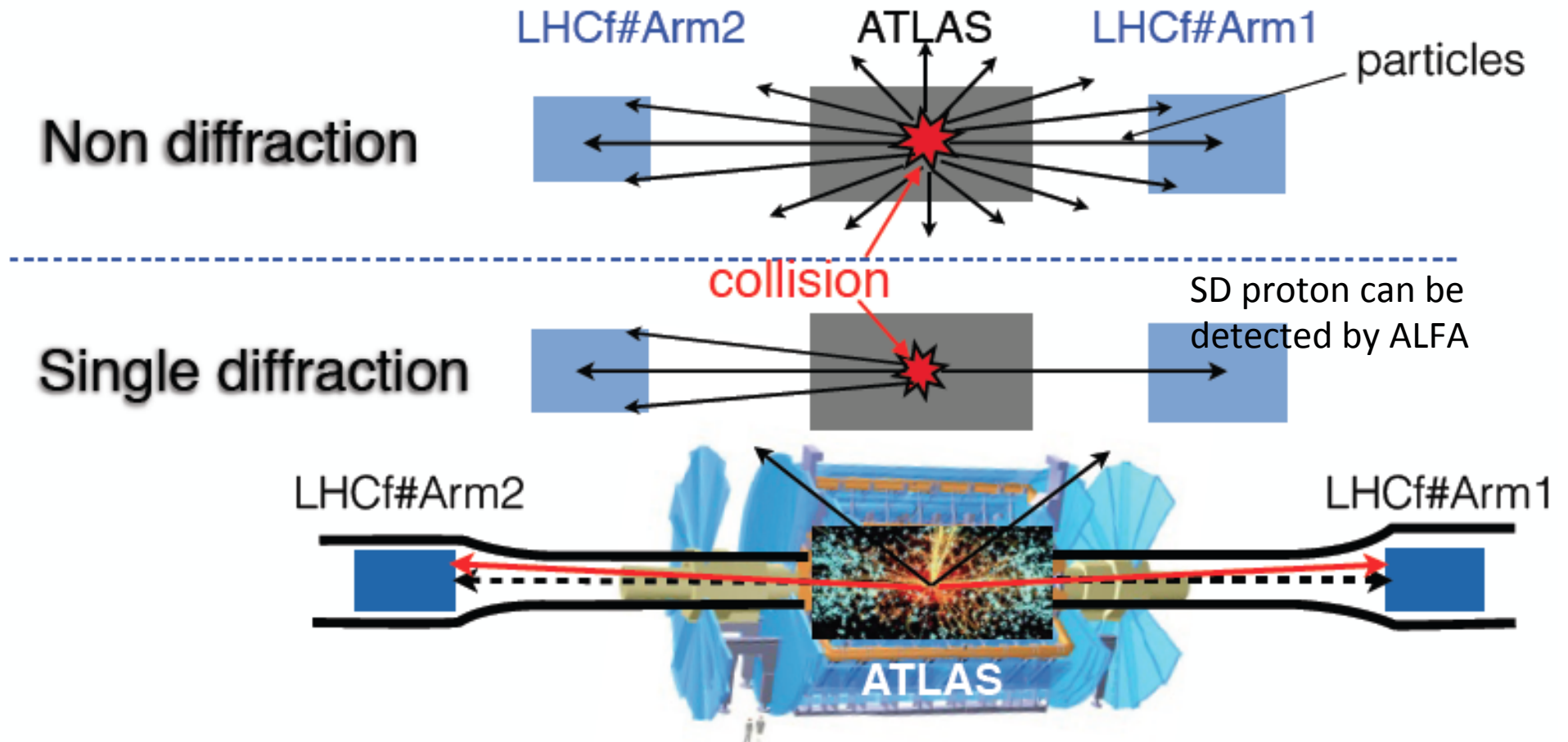
- LHCf sends trigger signal to ATLAS
- ATLAS records
 - full detector data up to 5M events
 - central track, MBTS, Lucid, ALFA up to 50M events
- Preliminary analysis was carried out using the 2013 p-Pb collision data and the results were presented in the last LHCC (closed session)
 - => we are going to make these results public



LHCf forward neutron in 5TeV p-Pb
Data vs MC (UPC+QCD)

UPC can be identified with no central activity

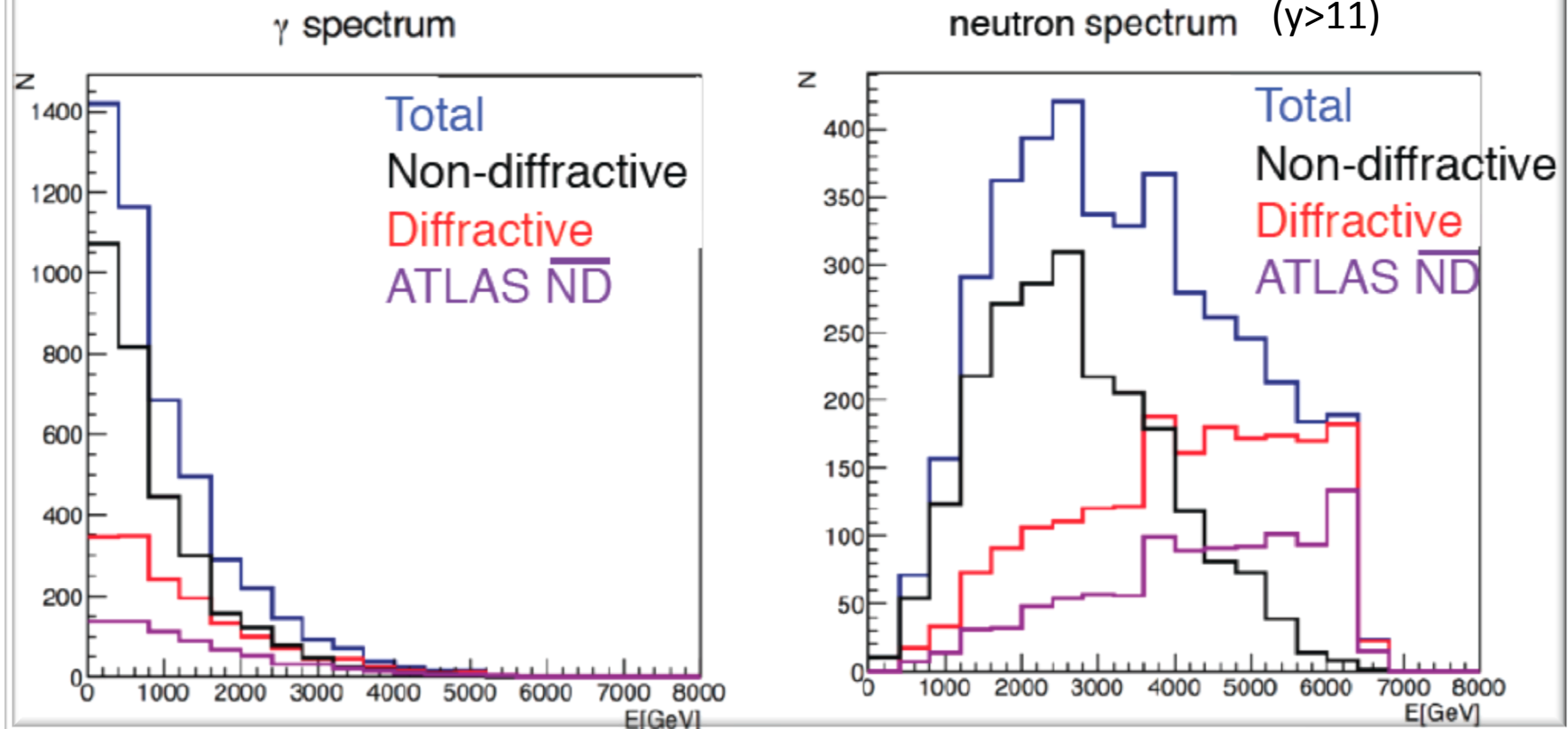
LHCf-ATLAS common operation



- Event classification using the central track information
- Event classification using the ALFA tagging (SD)

13TeV p-p LHCf-ATLAS (PYTHIA8)

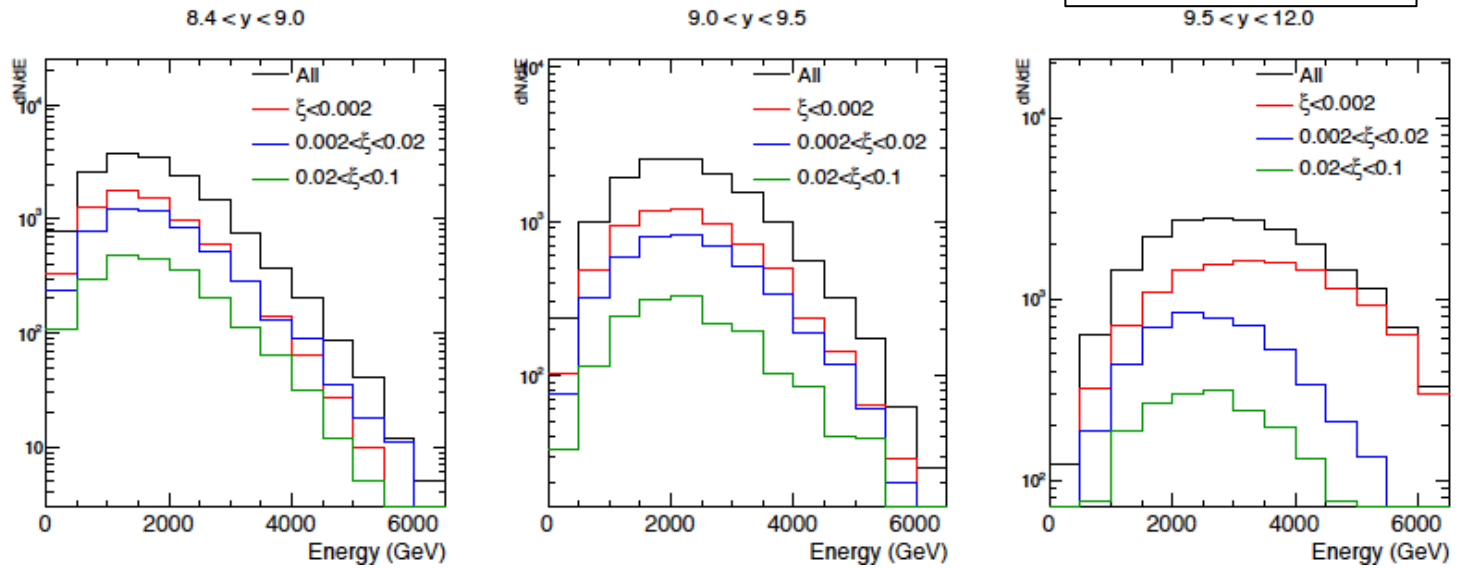
LHCf spectra (PYTHIA prediction)



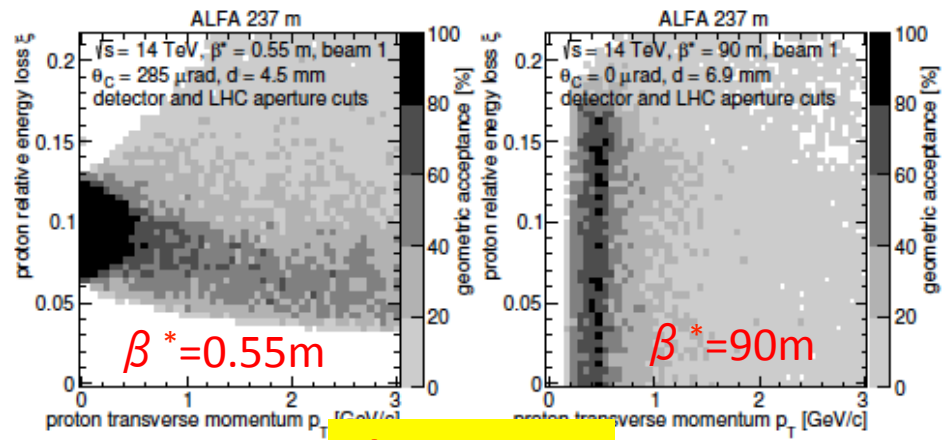
- ATLAS ND : $n_{ch} \geq 1$ with $|\eta| < 2.5$ and $p_T > 100 \text{ MeV}/c$
- ATLAS \overline{ND} : except ATLAS ND
- efficiency $\sim 40\%$, purity $> 99\%$ for diffraction selection

LHCf SD neutron spectra for different ξ

zero degree



- PYTHIA 8
- ALFA acceptance is not considered yet
- Good test for hadronization?



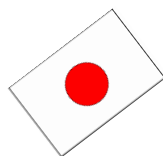
$\beta^* = 19 \text{ m}???$

Summary

- New analyses from the 2.76 and 7TeV data
 - neutron spectra at 7TeV
 - 30-40% higher energy flow than the latest models
 - π^0 in wide phase space and scaling
 - good scaling in $y_{\text{beam}} - y$ and x_F
- Ready for RUN II
 - schedule of ‘special physics run’ nearly fixed
 - collaboration with ATLAS
 - event classification in diffractive and ND
 - event classification in ξ

The LHCf experiment (Apr. 2015-)

****Y.Itow, *Y.Makino, *K.Masuda, *Y.Matsubara, *E.Matsubayashi,
***H.Menjo, *Y.Muraki, *Y.Okuno, **,T.Sako, *M.Ueno, *Q.D.Zhou**



**Solar-Terrestrial Environment Laboratory, Nagoya University, Japan*

***Kobayashi-Maskawa Institute, Nagoya University, Japan*

****Graduate School of Science, Nagoya University, Japan*

K.Yoshida

Shibaura Institute of Technology, Japan

T.Iwata, K.Kasahara, T.Suzuki, S.Torii

Waseda University, Japan

Y.Shimizu, T.Tamura *Kanagawa University, Japan*

N.Sakurai *Tokushima University, Japan*

M.Haguenaer *Ecole Polytechnique, France*

W.C.Turner *LBNL, Berkeley, USA*

O.Adriani, E.Berti, L.Bonechi, M.Bongi, G.Castellini, R.D'Alessandro,

M.Delprete, M.Grandi, G.Mitsuka, P.Papini, S.Ricciarini, A.Tiberio

INFN, Univ. di Firenze, Italy

A.Tricomi

INFN, Univ. di Catania, Italy

J.Velasco, A.Faus

IFIC, Centro Mixto CSIC-UVEG, Spain

A-L.Perrot

CERN, Switzerland

