Forward Photon Measurements at the LHC
The FoCal Proposal in ALICE

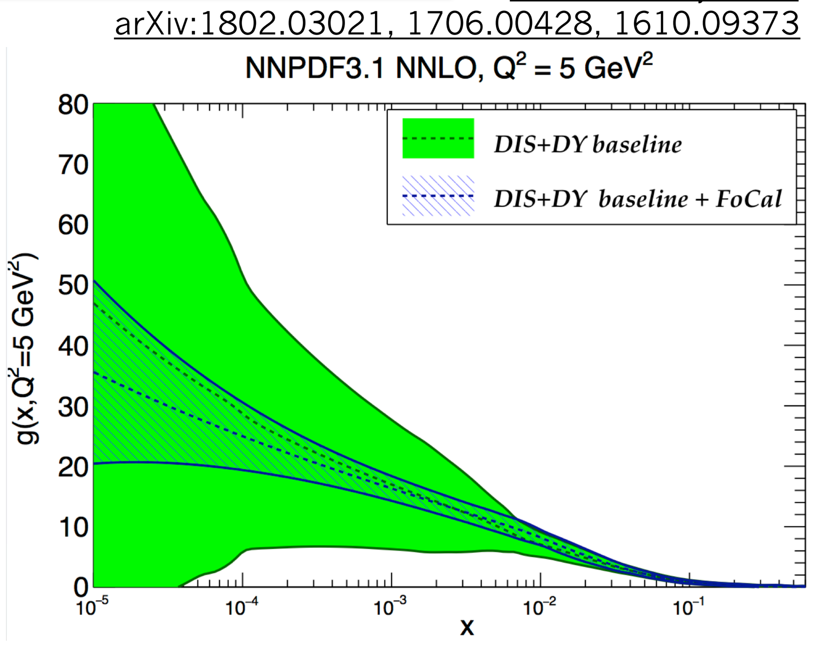
Norbert Novitzky for the ALICE-FoCal collaboration
Tsukuba University and Utrecht University

Motivation

The main goal of the FoCal proposal is to measure forward (3.2 < y < 5.3) **direct photons** in p+p and p+Pb collisions at LHC.

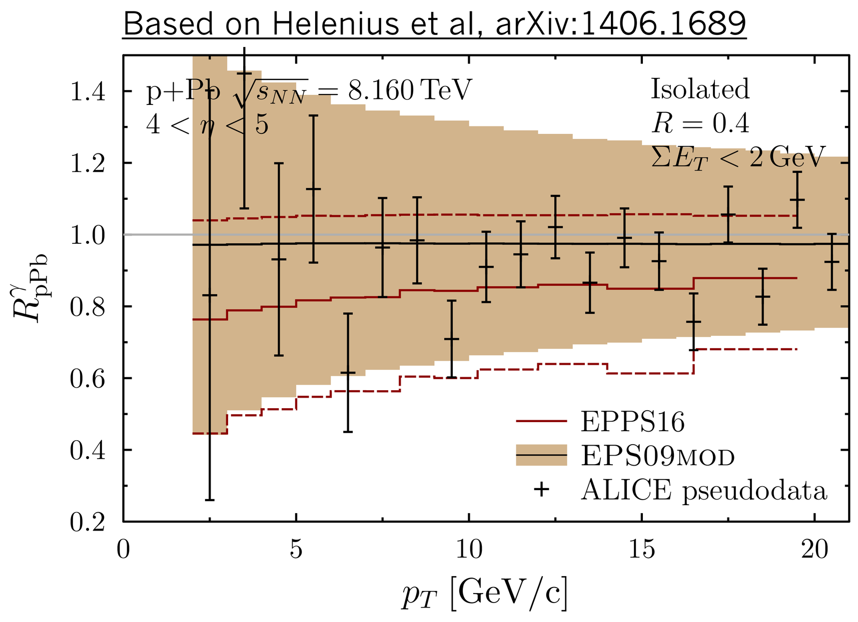
- The data will **provide unique experimental constraints** on the proton and nuclear parton distribution function (PDF) in the very low-x region (10^{-5}-10^{-6}).

Based on Rojo et al
arXiv:1802.03021, 1706.00428, 1610.09373



Estimated uncertainties of the gluon PDF from additional FoCal measurements

Based on Helenius et al, arXiv:1406.1689



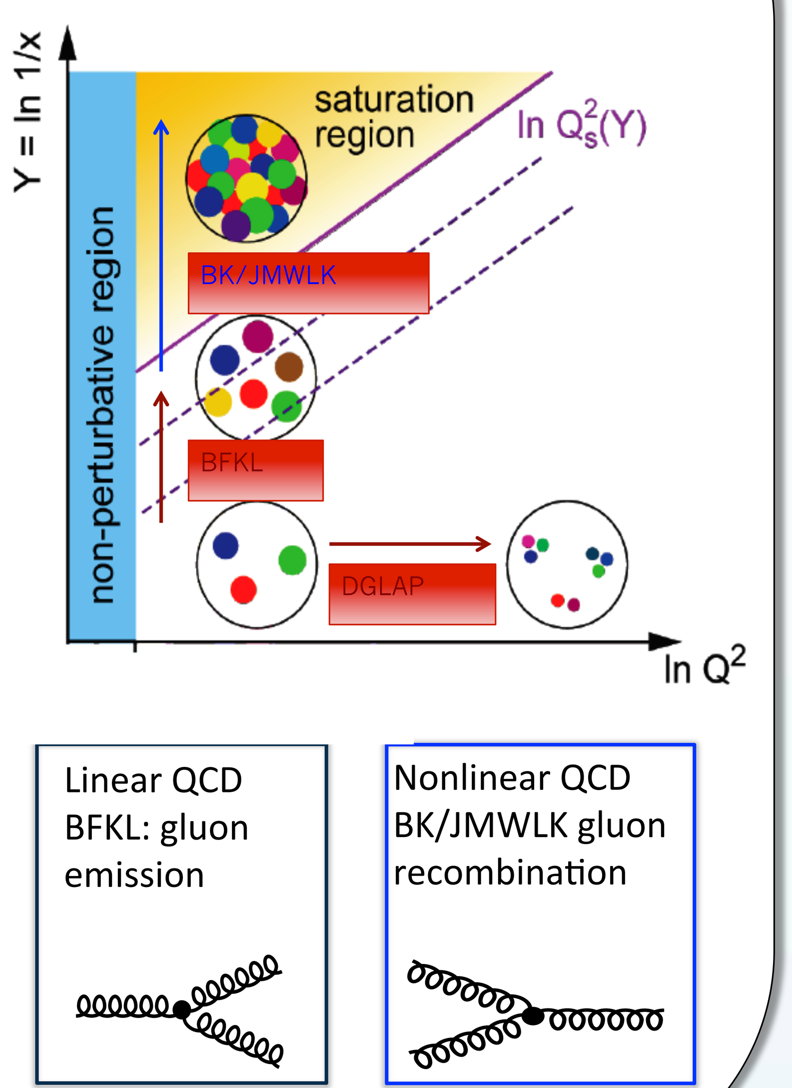
FoCal pseudodata for the forward direct photon nuclear modification factor compared to current NLO pQCD calculations.

- Simultaneous direct photon and neutral pion (or jet) measurement will provide a very important probe to **measure the gluon distribution at low-x** to study cold Nuclear Matter (CNM) effects. The behavior of the PDF in a heavy nucleus is of interest because it is not simply the superposition of the nucleon parton distribution, but displays effects related to the nuclear environment.

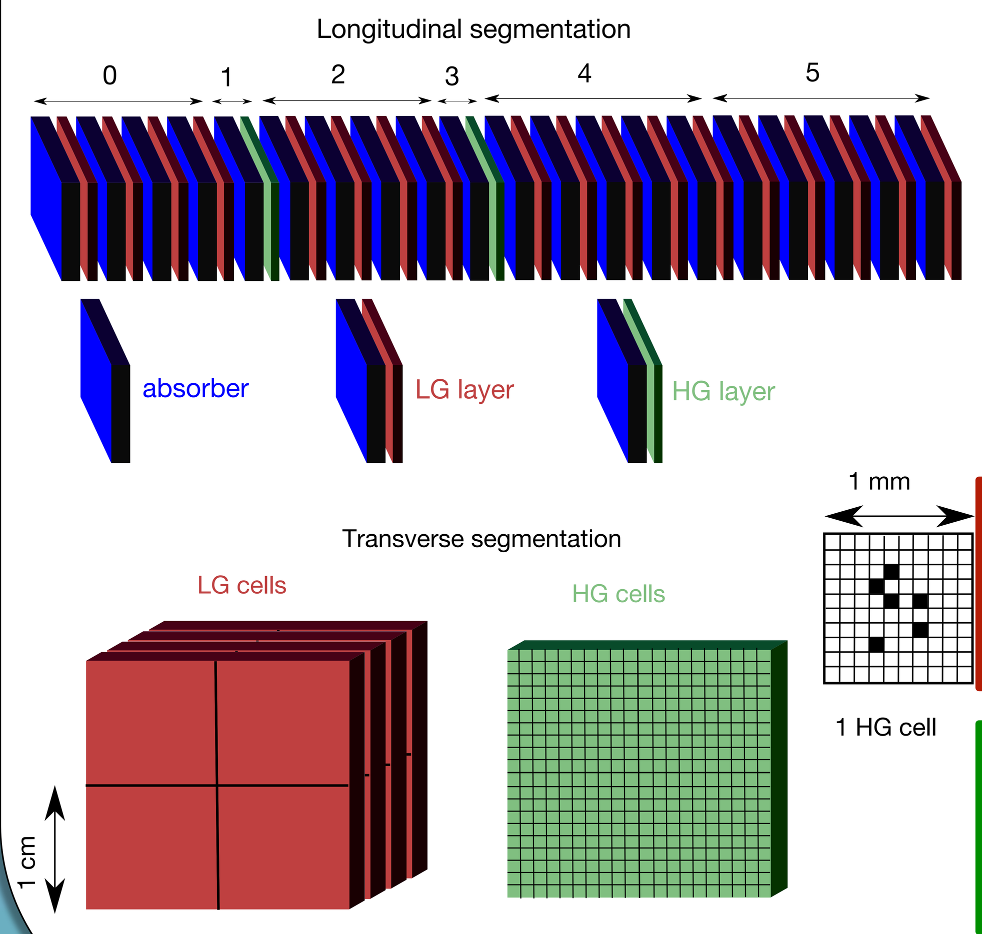
The detector will also allow a number of interesting measurements in Pb-Pb collisions.

Gluon Saturation

At low Q^2 and $Y = \ln(1/x)$ the proton is represented by the three valence quarks. The increase of the probe energy implies that more and more partons (fluctuations) are seen, which is described by the DGLAP (Q^2) and BFKL ($1/x$) evolution equations. The rapid rise of the low-x gluon PDF will result in nonlinear effects, which would eventually lead to gluon saturation. Effects are expected below a certain scale in momentum, the *saturation scale* Q_s. If the saturation scale is large compared to the perturbative scale, weak coupling techniques can be employed. This led to the development of the Color Glass Condensate (CGC) as a model for this state of matter.



Design



The detector is a **sampling detector** using alternating W and Si layers. To meet the required **two shower separation** a novel design is explored, using two different technologies of the Si layers:

- The Low Granularity (LG) layer
  Advantage of very good **energy** measurement

- High Granularity (HG) layers
  Advantage very good **position** measurement

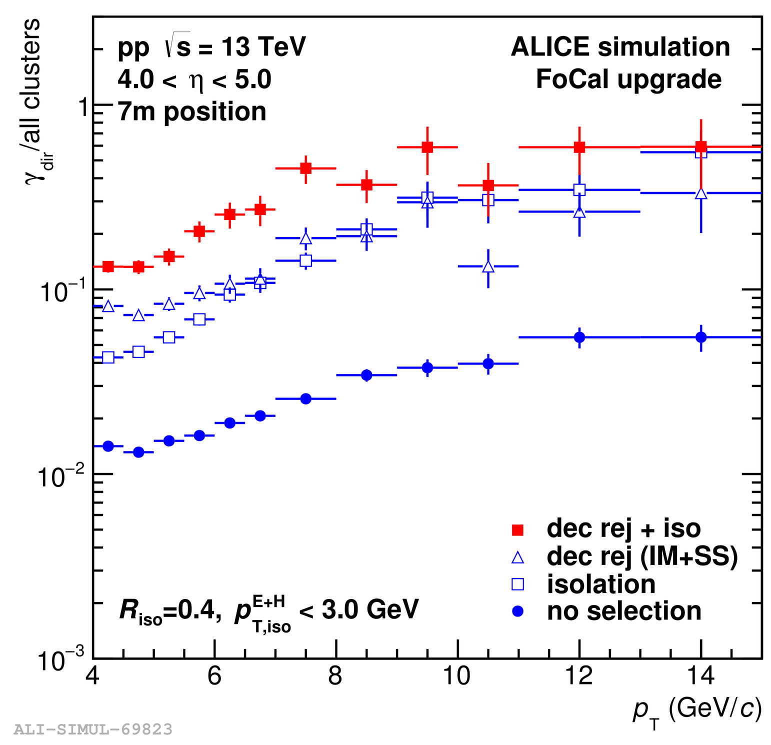
Performance

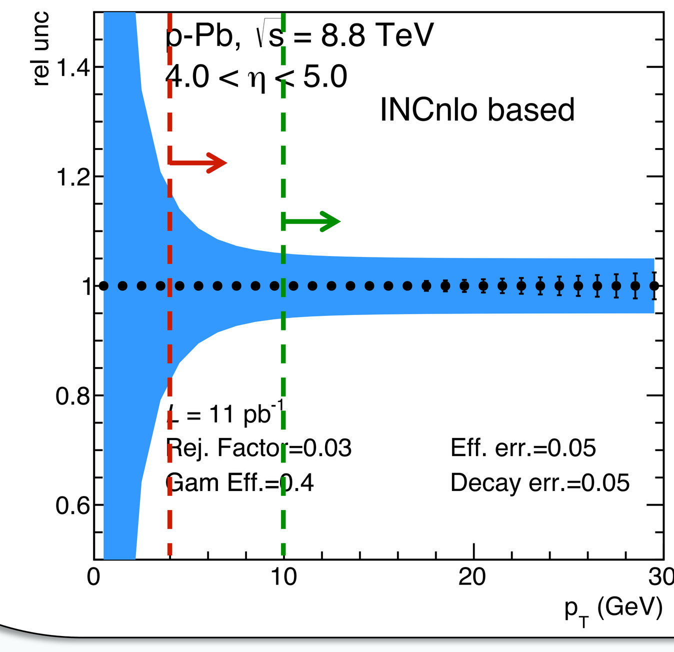
Very small signal requires high performance rejection of decay photons:

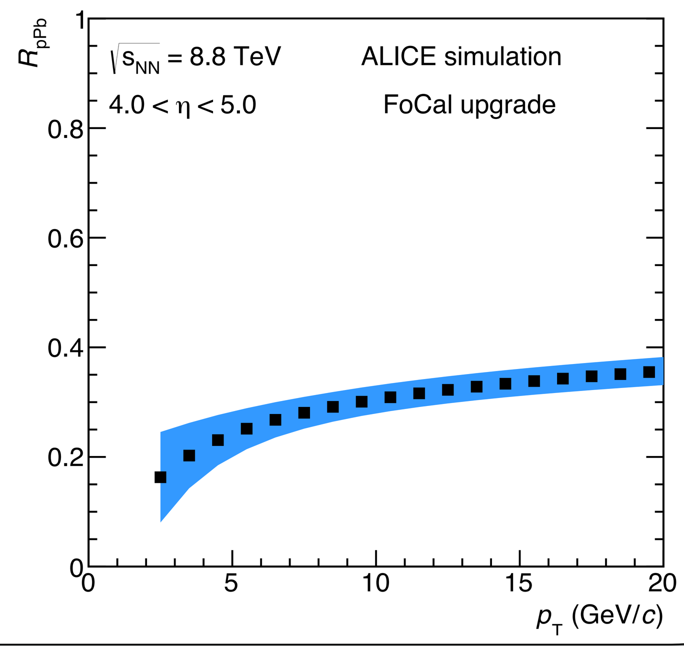
- **Direct rejection** by the pair mass cut and shower shape cut
- **Isolation cut** rejects also fragmentation photons

The estimated precision of the direct photon measurement is about

- < 20% for p_T > 4 GeV/c
- < 10% for p_T >10 GeV/c





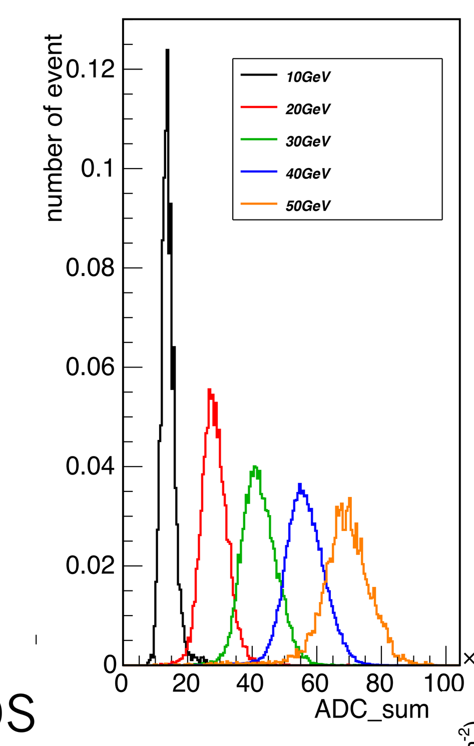


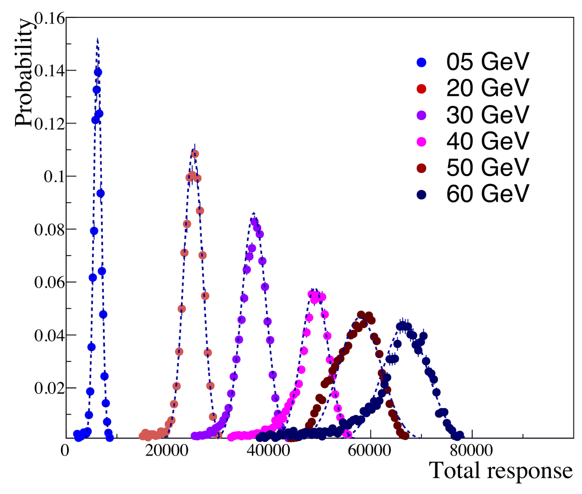
Test beam results

There is significant progress in the R&D in both of the LG and the HG layers.

Prototypes of the LG detectors:

- Beam tests: **good performance for energy measurement**
- Improvement of readout electronics foreseen: **larger dynamic ranges**

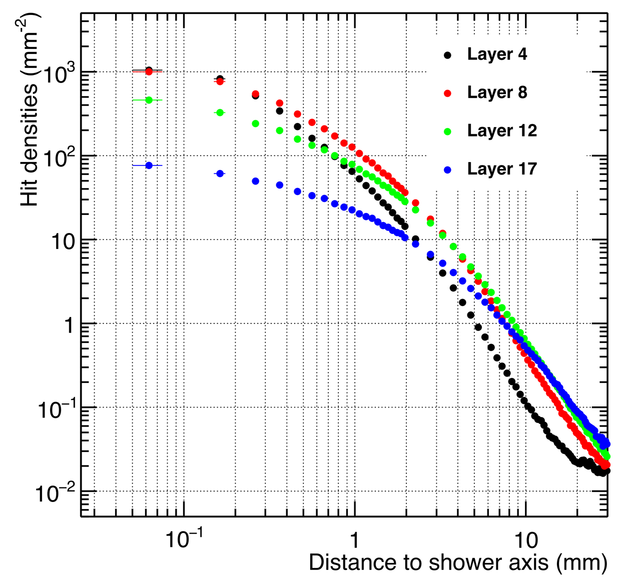




Response of the calorimeter for electrons incident at different energies.

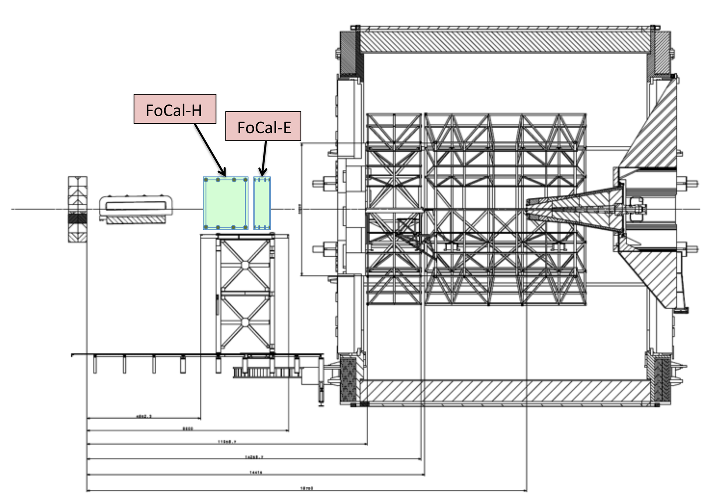
A HG prototype using CMOS also tested in beam.
(first results published in A.P. de Haas et al, JINST 13 (2018) P01014)

- **very good position resolution** and two-shower separation related to detailed measurement of the shower profile
- need development of **faster sensor** (synergy with ALICE ITS upgrade → ALPIDE)



The combination of the two types of layers, will provide very good separation for the $\pi^0 \rightarrow \gamma + \gamma$ separation (HG layers) and very good energy resolution (LG)

Future



The proposed location of the new FoCal detector in the ALICE cavern is 7m from the interaction point. The location provides an unobstructed view of the interaction point, which is crucial for a precision measurement.

Institutions involved: Utrecht U., Nikhef, Tsukuba U., Tsukuba Tech., Hiroshima U., Nara Woman U., Tokyo CNS, Nagasaki U., VECC, BARC, Bose Institute, Jammu, IIT-Bombay, IIT-Indore, IOP, ORNL, Tennessee, Wayne State U. Sao Paulo U., Bergen, Jyvaskyla U., CVUT Prague