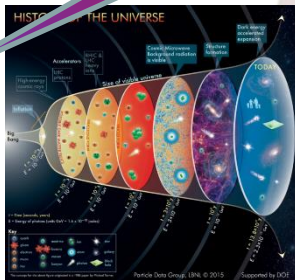
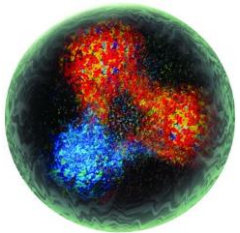
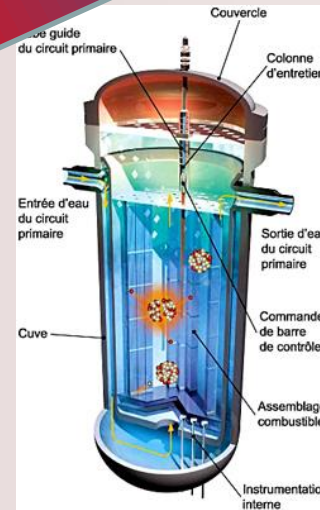
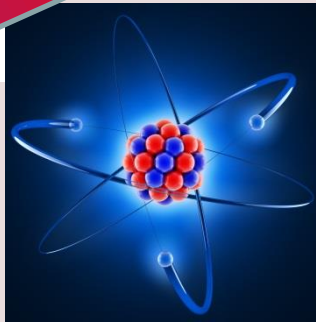
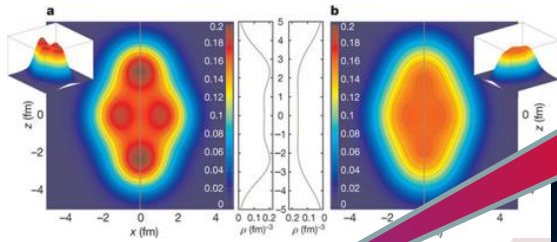
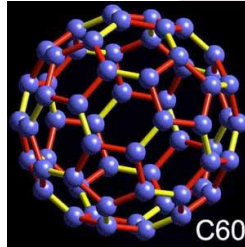


IPN Orsay : created in 1956 by I. & F. Joliot-Curie



Nobel prize in chemistry 1935

To infinitely big...

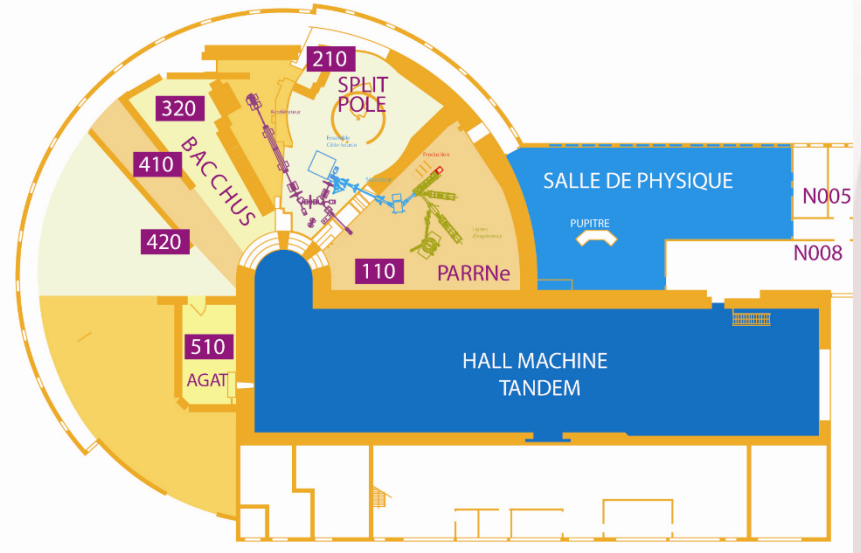


From infinitely small...

~300 personnel

ALTO

15 MV tandem, 50 MeV e⁻ linac, ISOL
facility γ -fission, Ucx targets



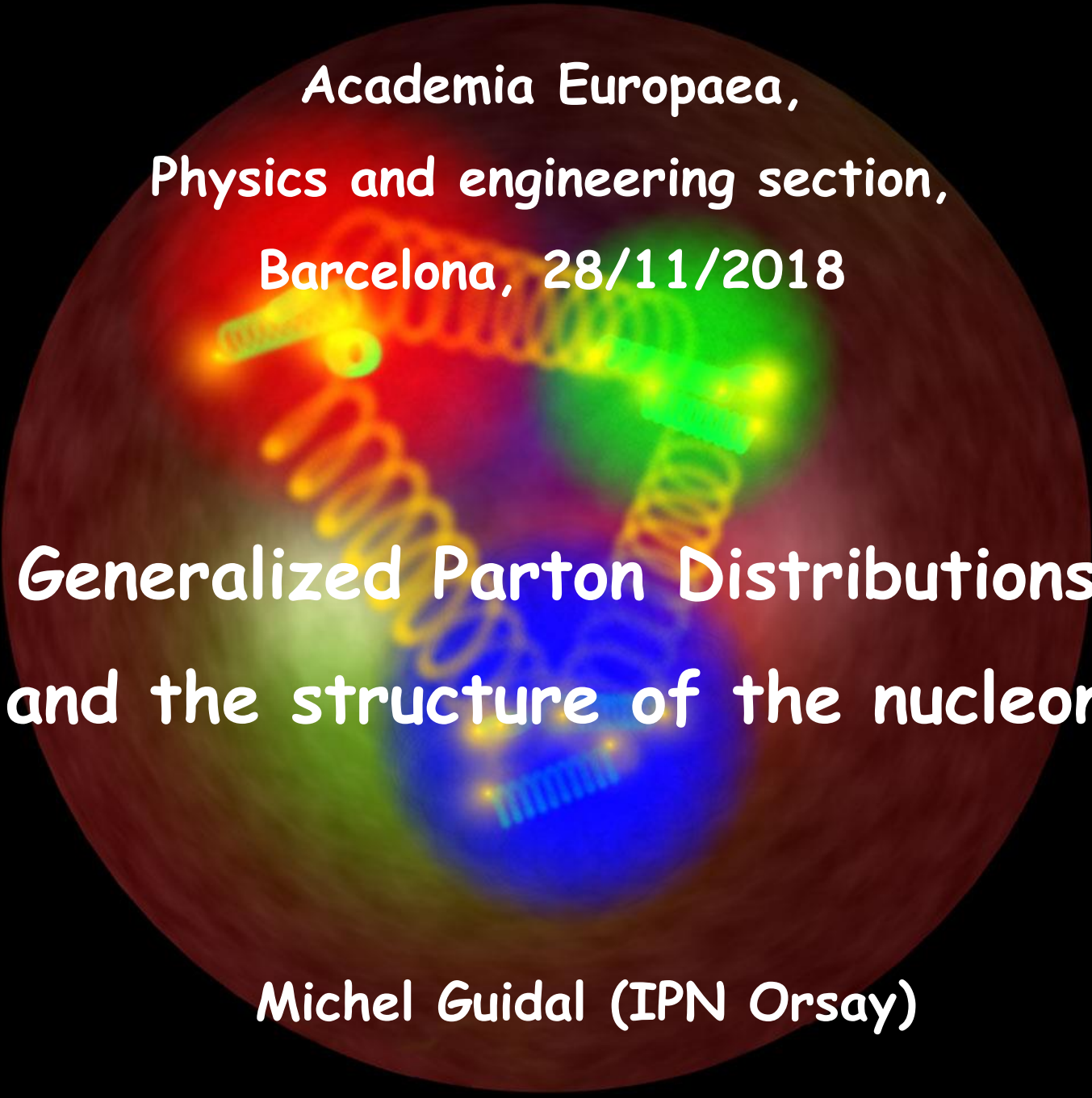
ANDROMEDE

4 MV Van de Graaf, nanoparticles and clusters



SUPRATECH

White room, design, cryomodules and
cavities tests, R&D,...



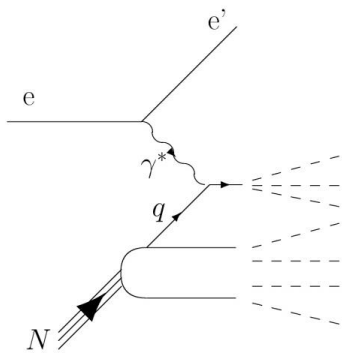
Academia Europaea,
Physics and engineering section,
Barcelona, 28/11/2018

Generalized Parton Distributions and the structure of the nucleon

Michel Guidal (IPN Orsay)

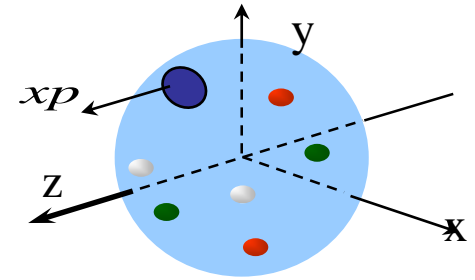
$ep \Rightarrow eX$

(DIS)



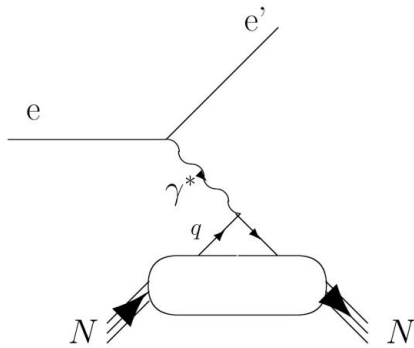
$$f_1(x), g_1(x)$$

(Parton Distribution Functions: PDF)



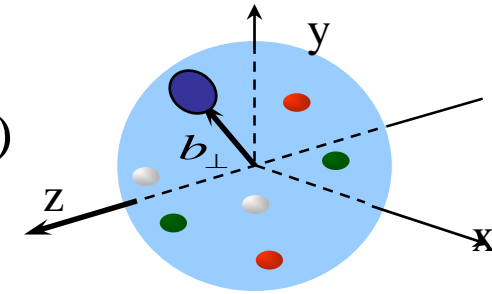
$ep \Rightarrow ep$

(elastic)



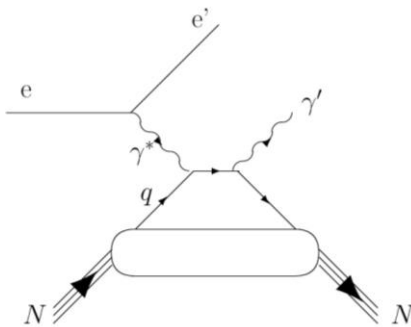
$$F_1(t), F_2(t), G_A(t), G_P(t)$$

(Form Factors: FFs)



$ep \Rightarrow epy$

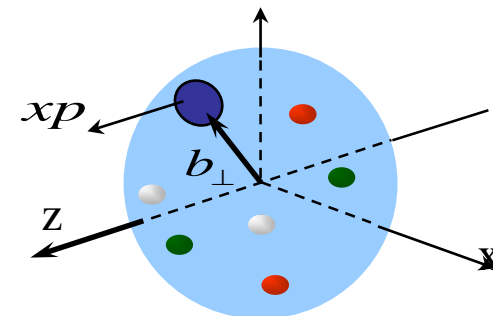
(DVCS)



$$H(x, \xi, t), E(x, \xi, t),$$

$$\tilde{H}(x, \xi, t), \tilde{E}(x, \xi, t)$$

(Generalized Parton Distributions: GPDs)



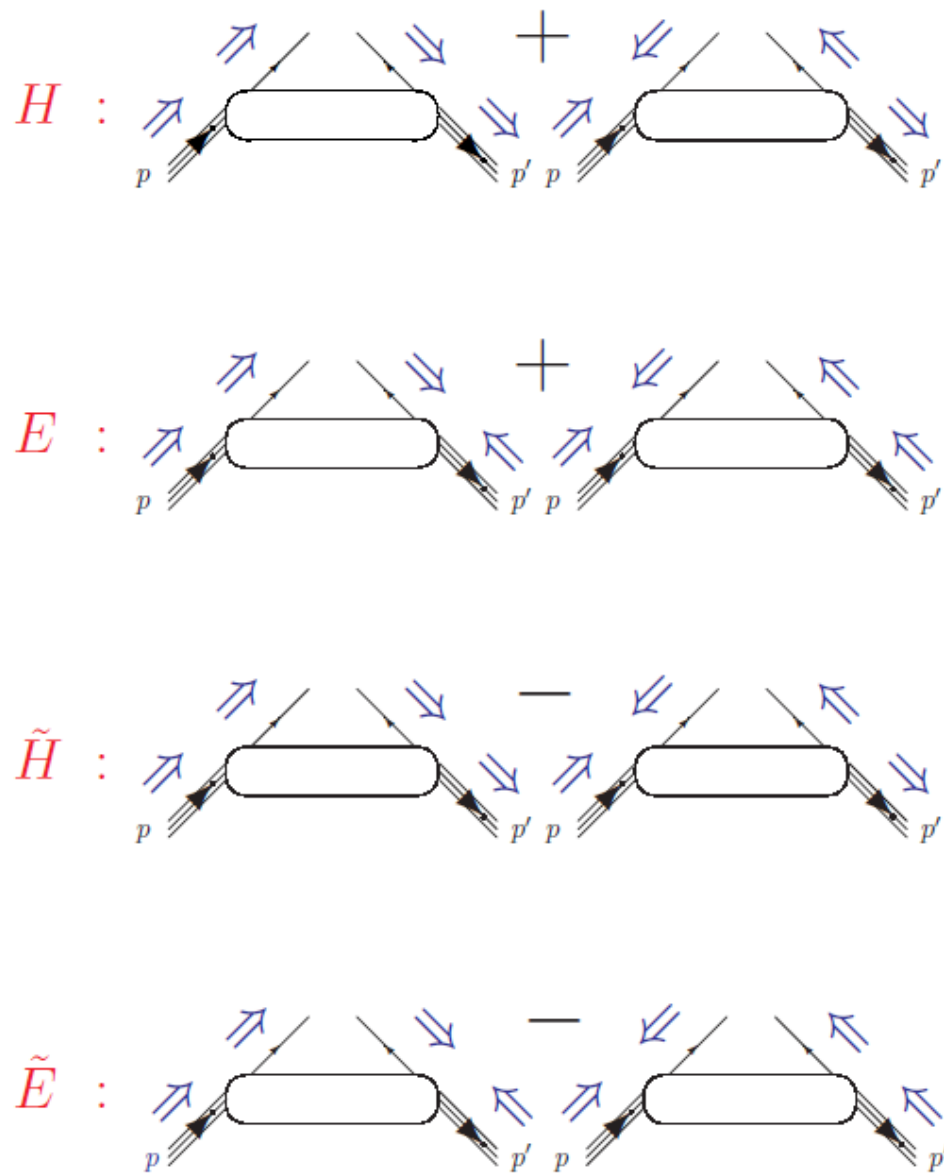
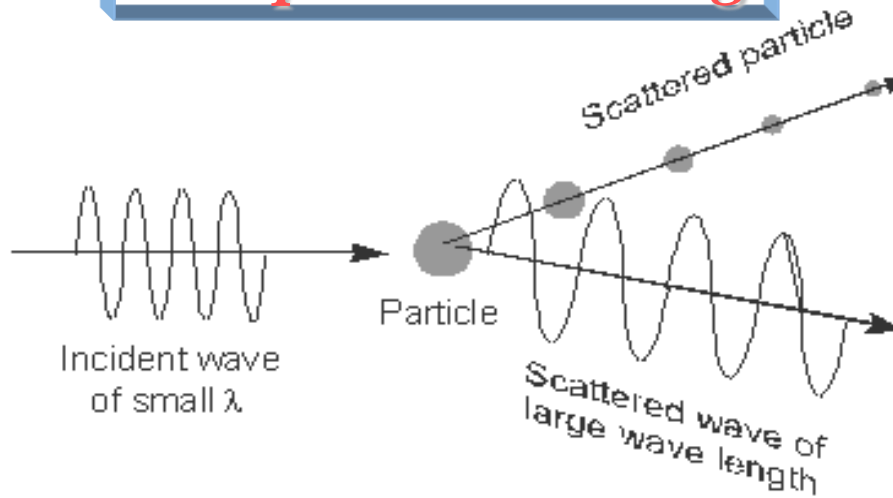
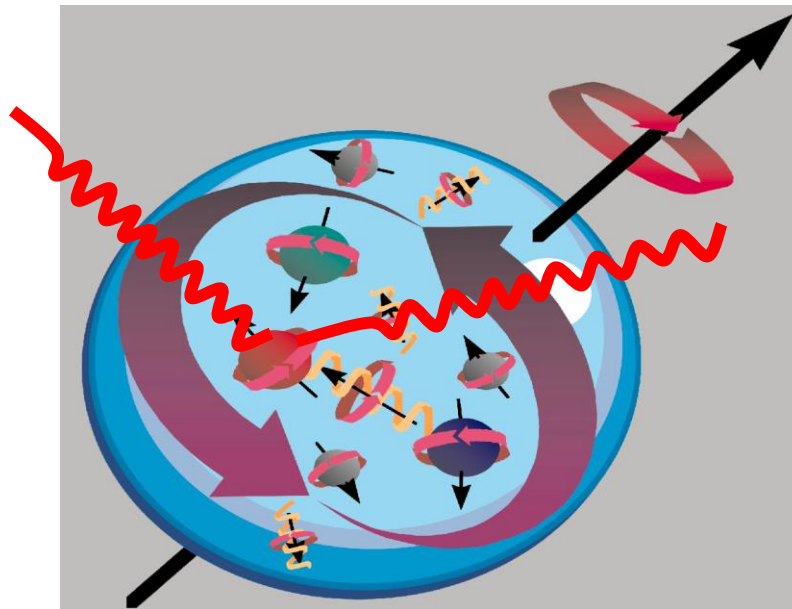


Figure 5. The four GPDs H , E , \tilde{H} and \tilde{E} correspond to the various quarks helicity and nucleon spin orientations.

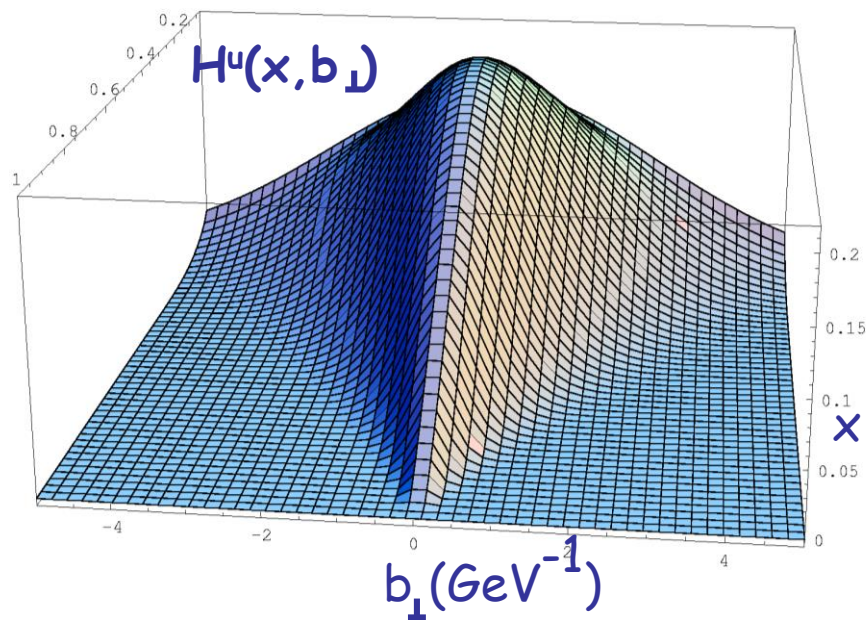
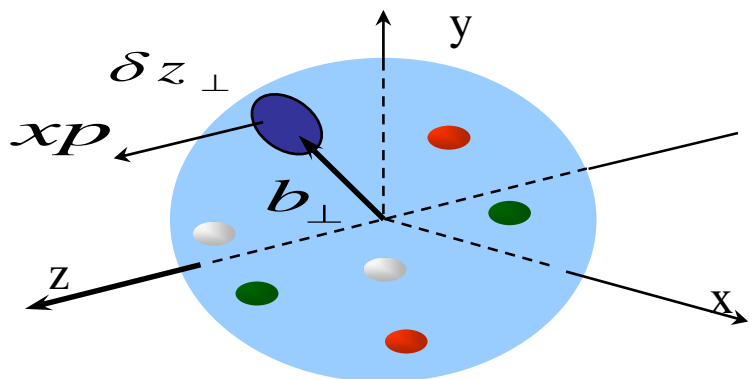
Compton Scattering



"DVCS" (Deep Virtual Compton Scattering)



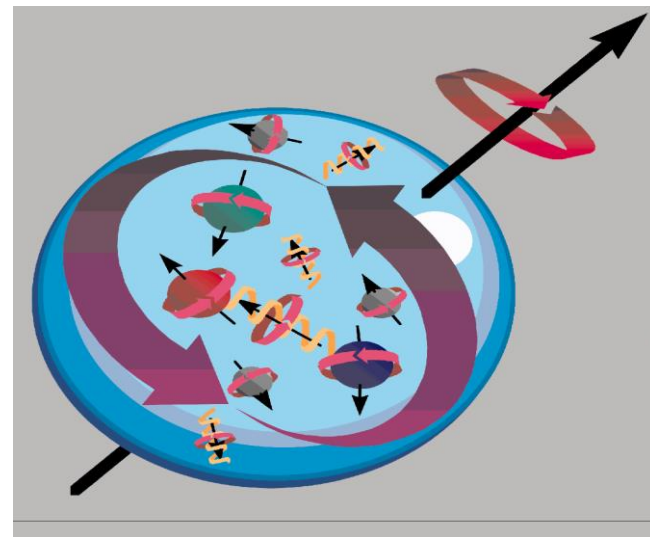
GPDs or the tomography of the nucleon



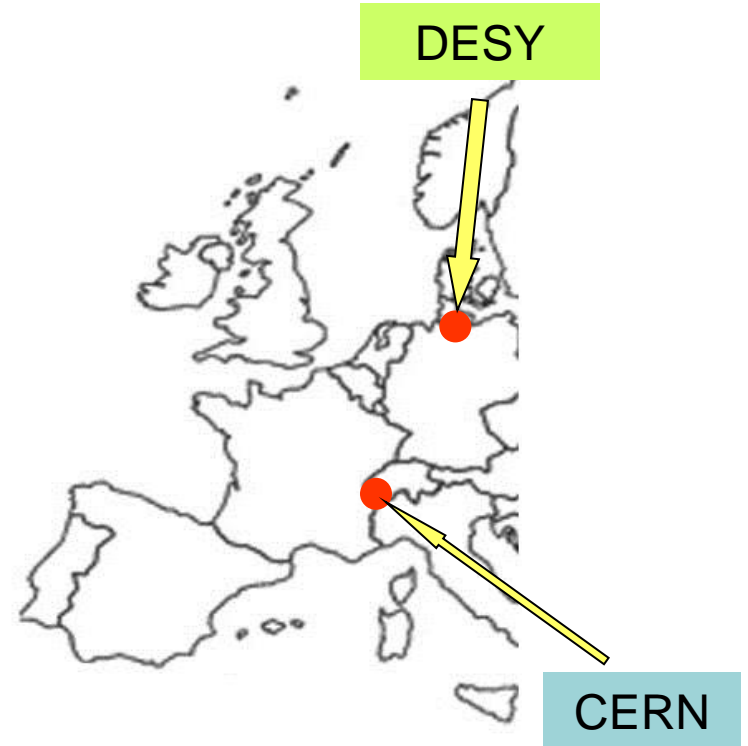
Ji's sum rule

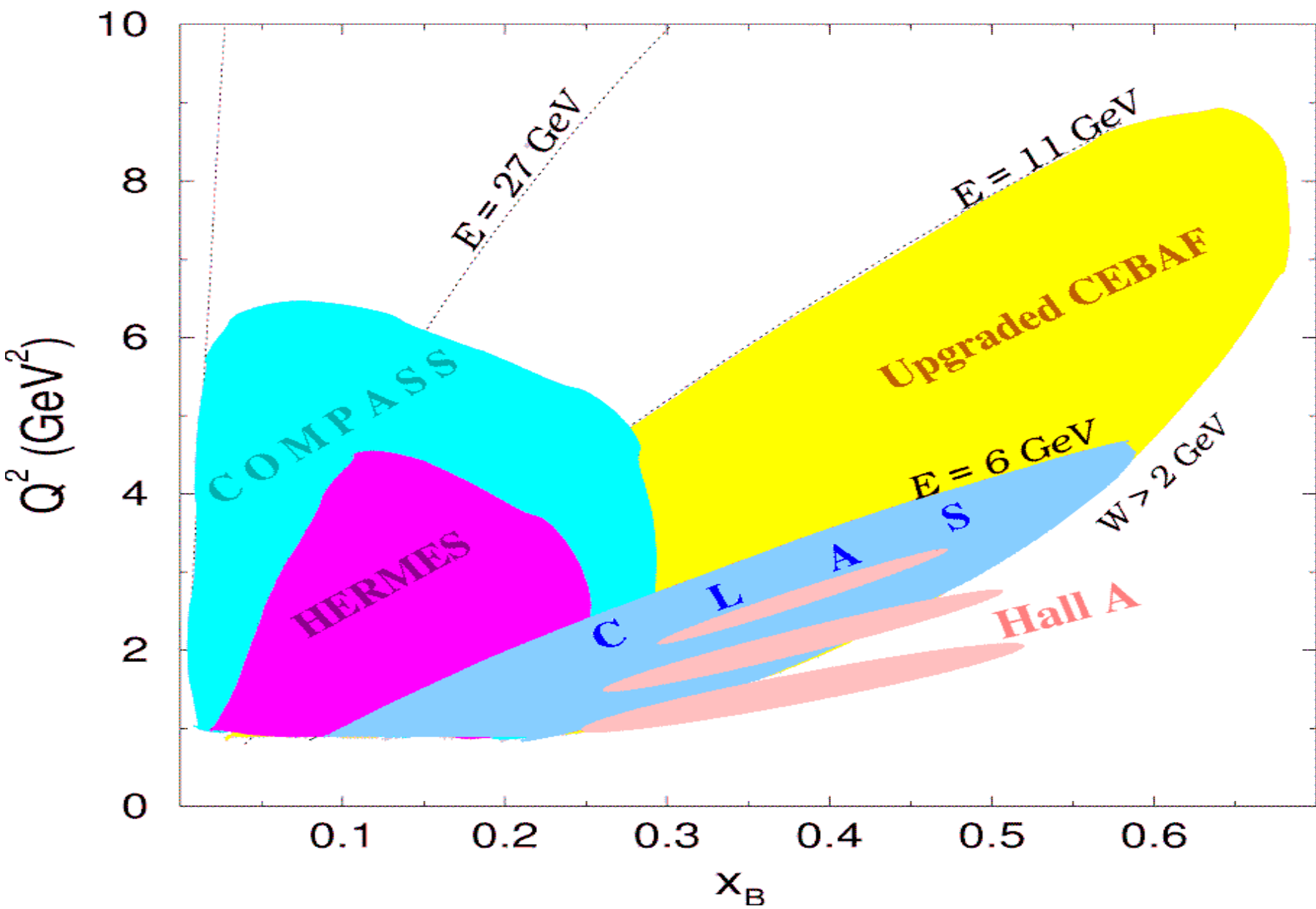
$$2J_q = \int x(H+E)(x, \xi, 0) dx$$

$$\frac{1}{2} = \left(\frac{1}{2} \Delta\Sigma + L_q \right) + (\Delta G + L_g)$$



The experimental actors

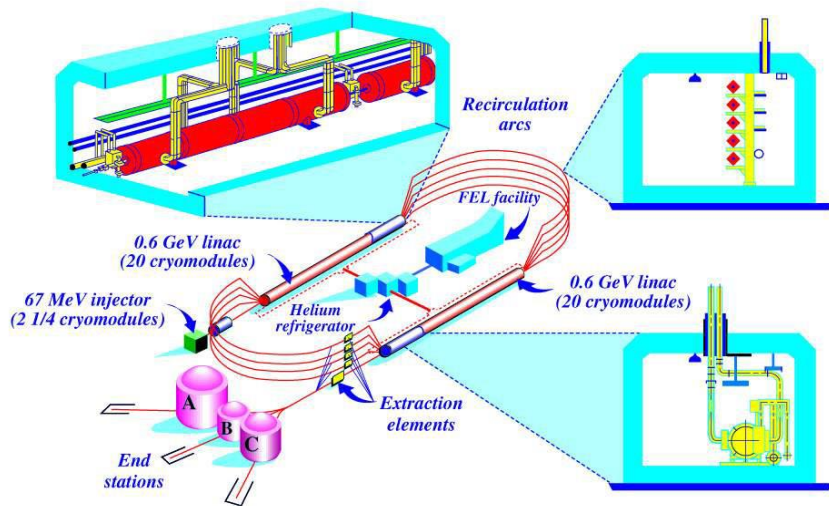




CEBAF (Continuous Electron Beam Accelerator Facility)

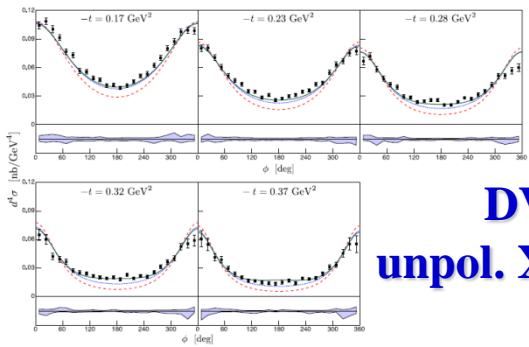
At JLab (Jefferson Laboratory) at Newport-News (VA, USA)

MACHINE CONFIGURATION

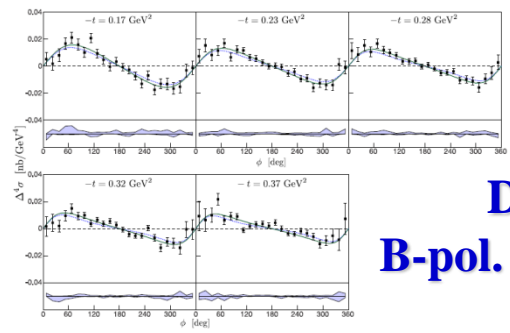


- ➔ *Supraconducting electron accelerator (338 cavities, Gain > 5 MeV/m),*
- ➔ *$I_{max} = 200 \mu A$, $E_{max} = 6 GeV$, 100% duty cycle, $\delta E/E = 10^{-4}$, $\sigma \sim 100 \mu m$,*
- ➔ *Polarized electron source (constrained GaAs), ~80% long. pol.,*
- ➔ *1500 physicists, ~30 countries, operational since end 97*

JLab Hall A



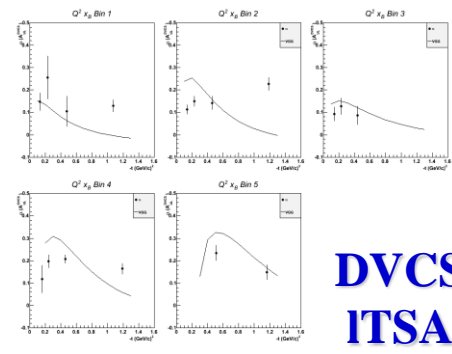
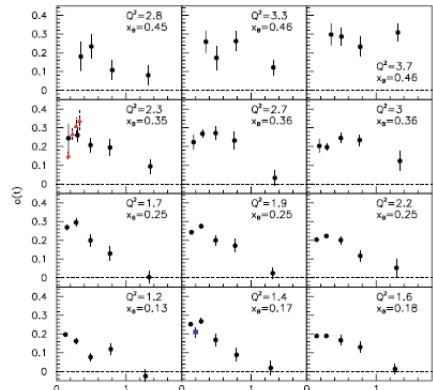
DVCS
unpol. X-section



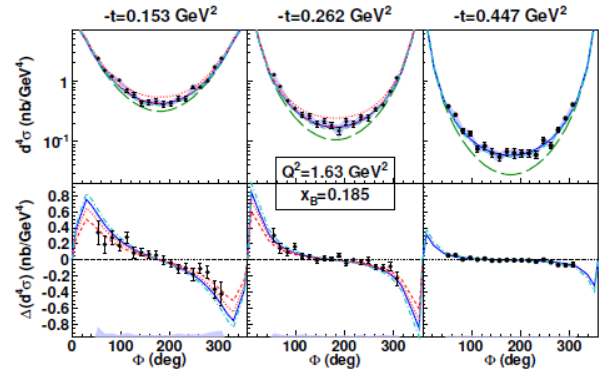
DVCS
B-pol. X-section

JLab CLAS

DVCS
BSA

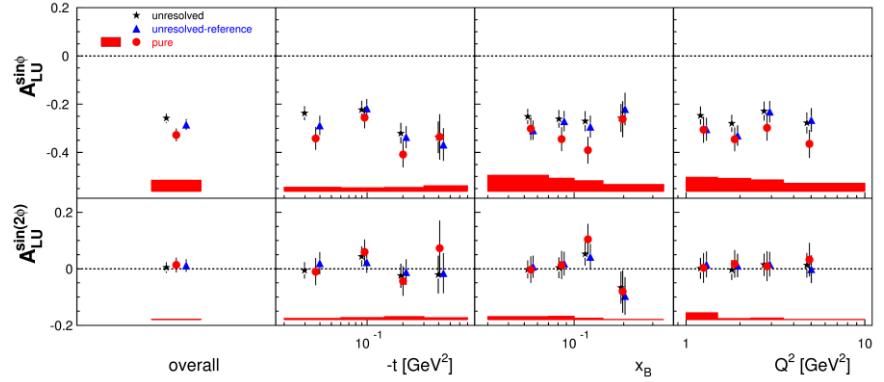
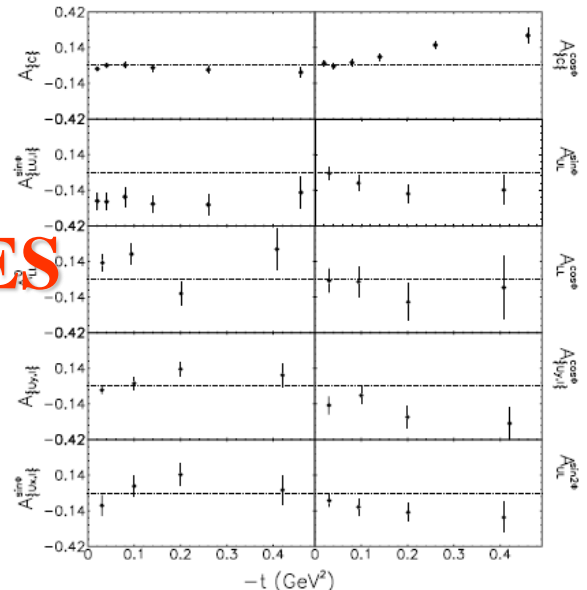


DVCS
ITSA

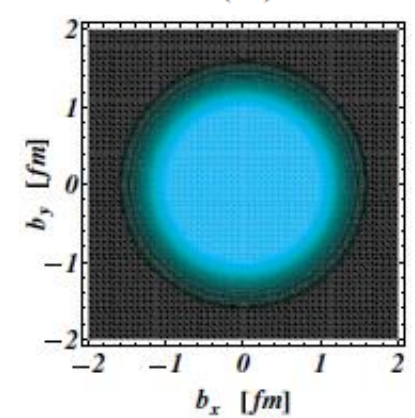
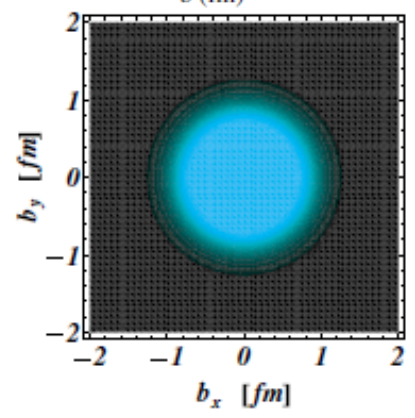
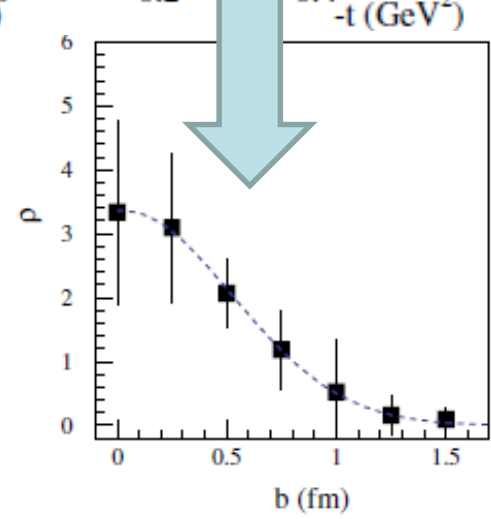
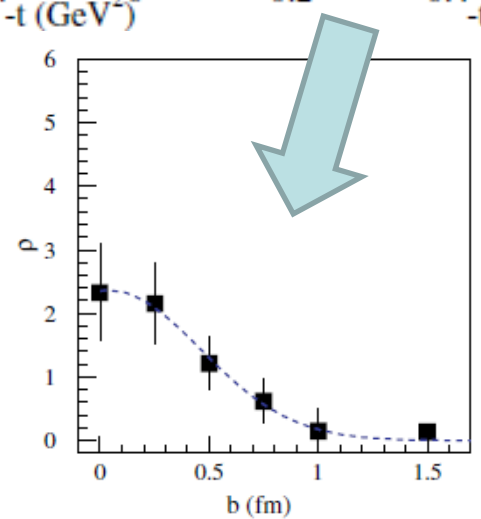
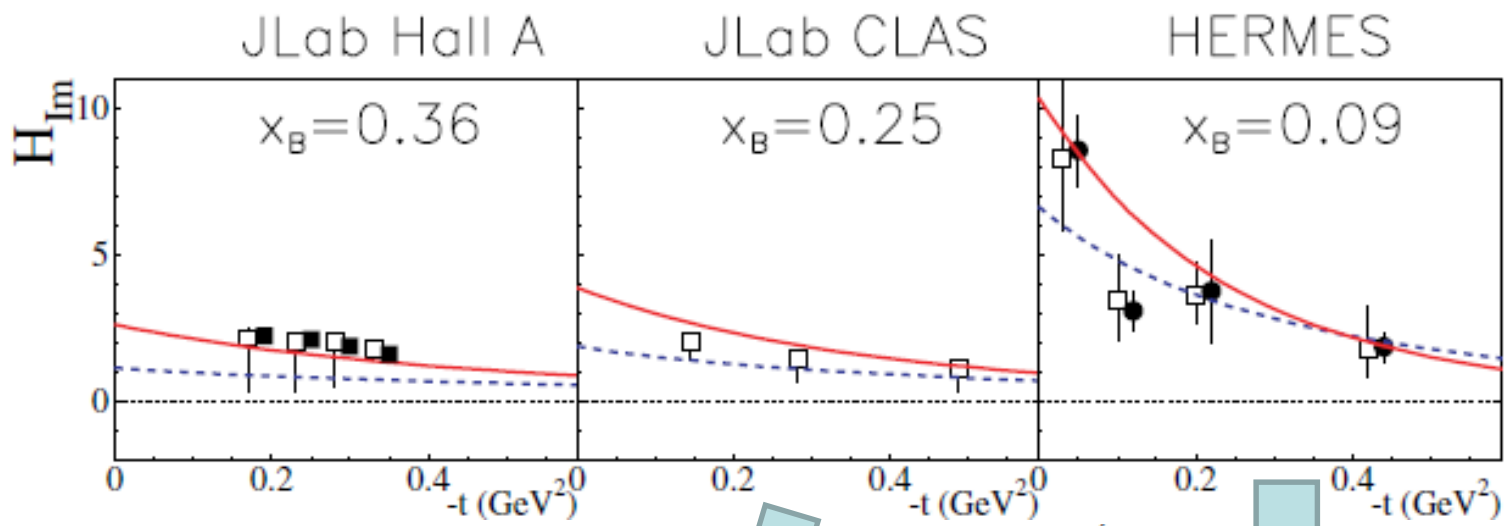


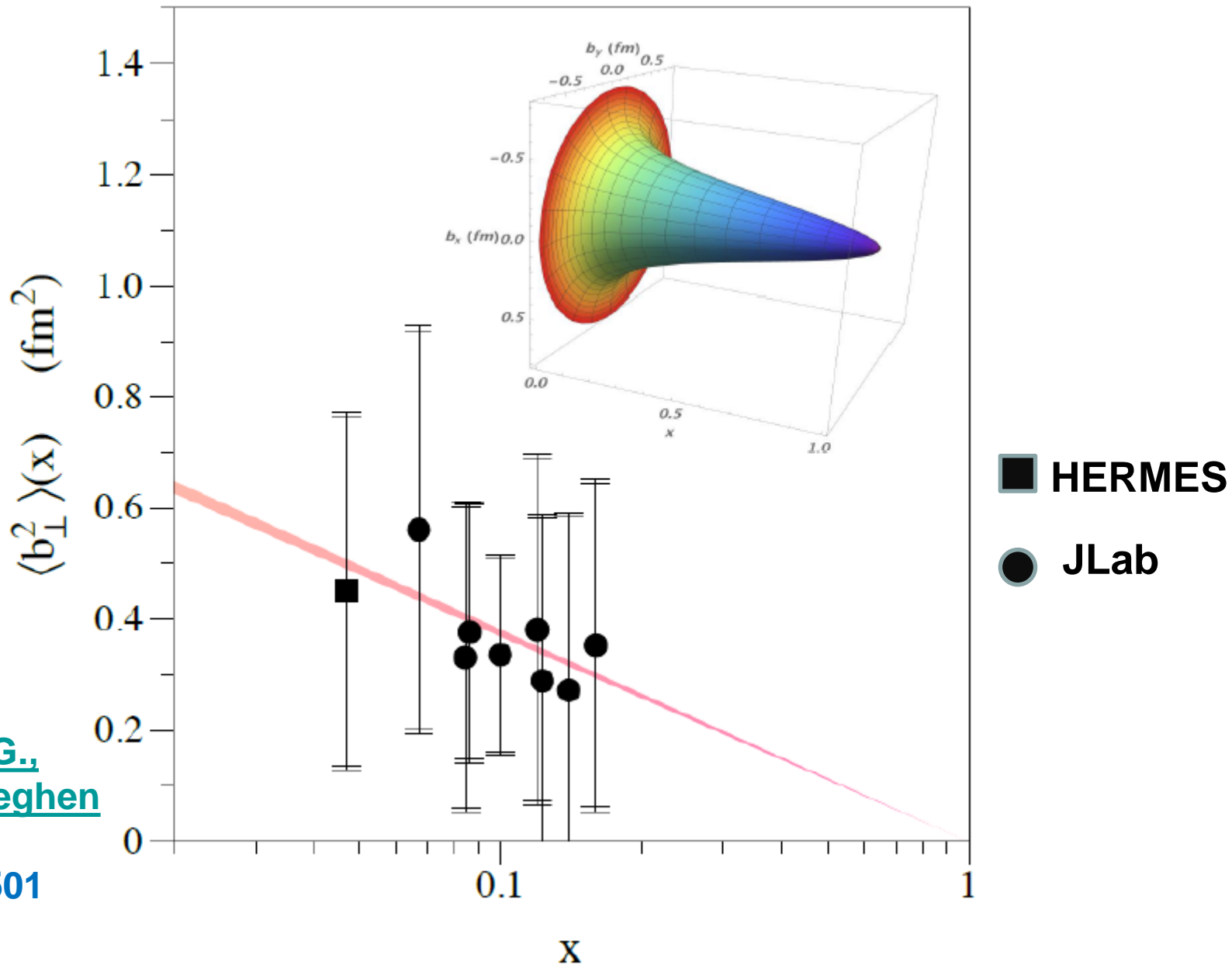
DVCS unpol. and
B-pol. X-sections

HERMES



DVCS
BSA, ITSA, tTSA, BCA

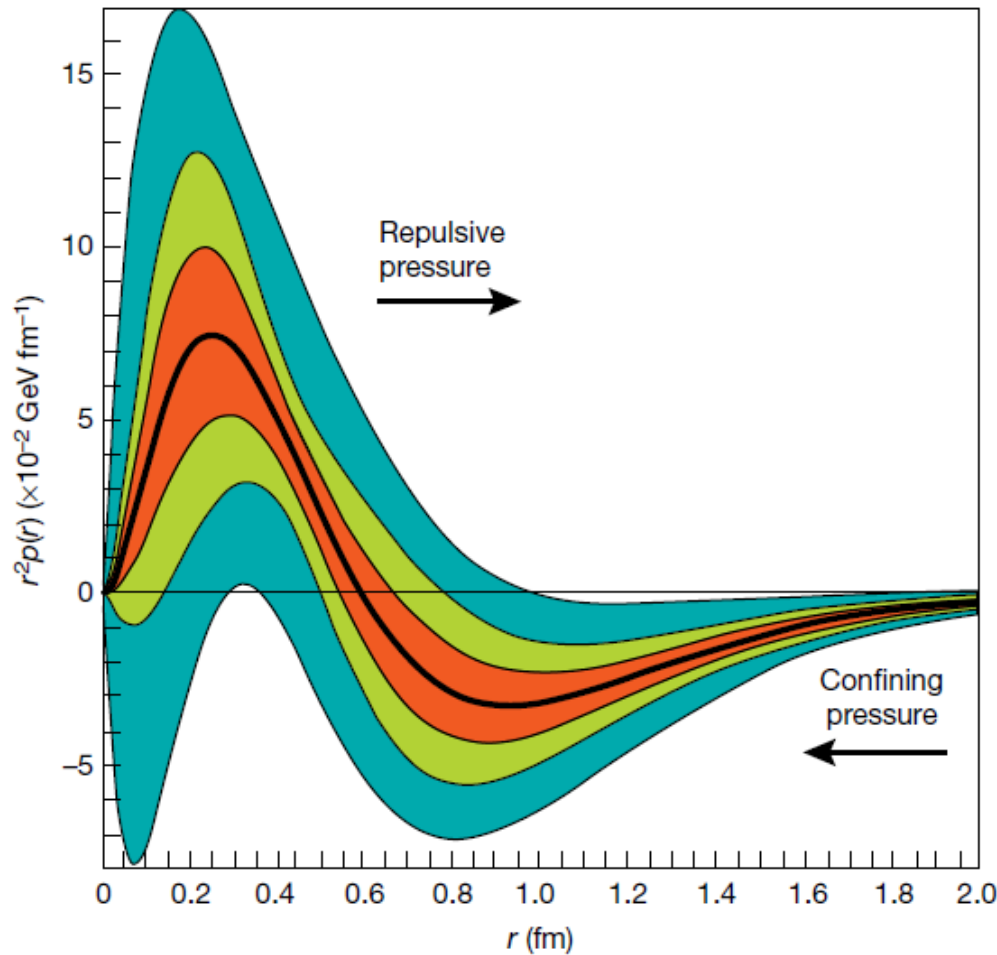




R. Dupré, M.G.,
M. Vanderhaeghen

PRD 95, 011501
(2017)

« Integrated » radius from elastic form factor F1: $\langle b_{\perp}^2 \rangle = 0.43 \pm 0.01 \text{ fm}^2$




V. Burkert, L. Elouadrhiri,
F.-X. Girod,
Nature 557 (2018), 396

« The average peak pressure near the center is 10^{35} Pascals which exceeds the pressure estimated for the most densely packed known objects in the Universe, neutron stars »

Fig. 1 | Radial pressure distribution in the proton. The graph shows the pressure distribution $r^2 p(r)$ that results from the interactions of the quarks in the proton versus the radial distance r from the centre of the proton. The thick black line corresponds to the pressure extracted from the D-term parameters fitted to published data²² measured at 6 GeV. The corresponding estimated uncertainties are displayed as the light-green shaded area shown. The blue area represents the uncertainties from all the data that were available before the 6-GeV experiment, and the red shaded area shows projected results from future experiments at 12 GeV that will be performed with the upgraded experimental apparatus³⁰. Uncertainties represent one standard deviation.

 **GPDs contain a wealth of information on nucleon structure and dynamics: space-momentum quark correlation, orbital momentum, pion cloud, pressure forces within the nucleon,...**

 **Large flow of new observables being released and new data expected soon (JLab6,JLab12,COMPASS)
(Other DVCS-related processes planned for JLab 12 GeV (TCS, DVMP, DDVCS,...))**

 **First new insights on nucleon structure already emerging from current data with new fitting algorithms**

 **Theory developments: higher twists, target mass corrections, NLO corrections, ...**