QUARKONIUM PRODUCTION AS A PROBE OF THE GLUON CONTENT OF THE PROTON
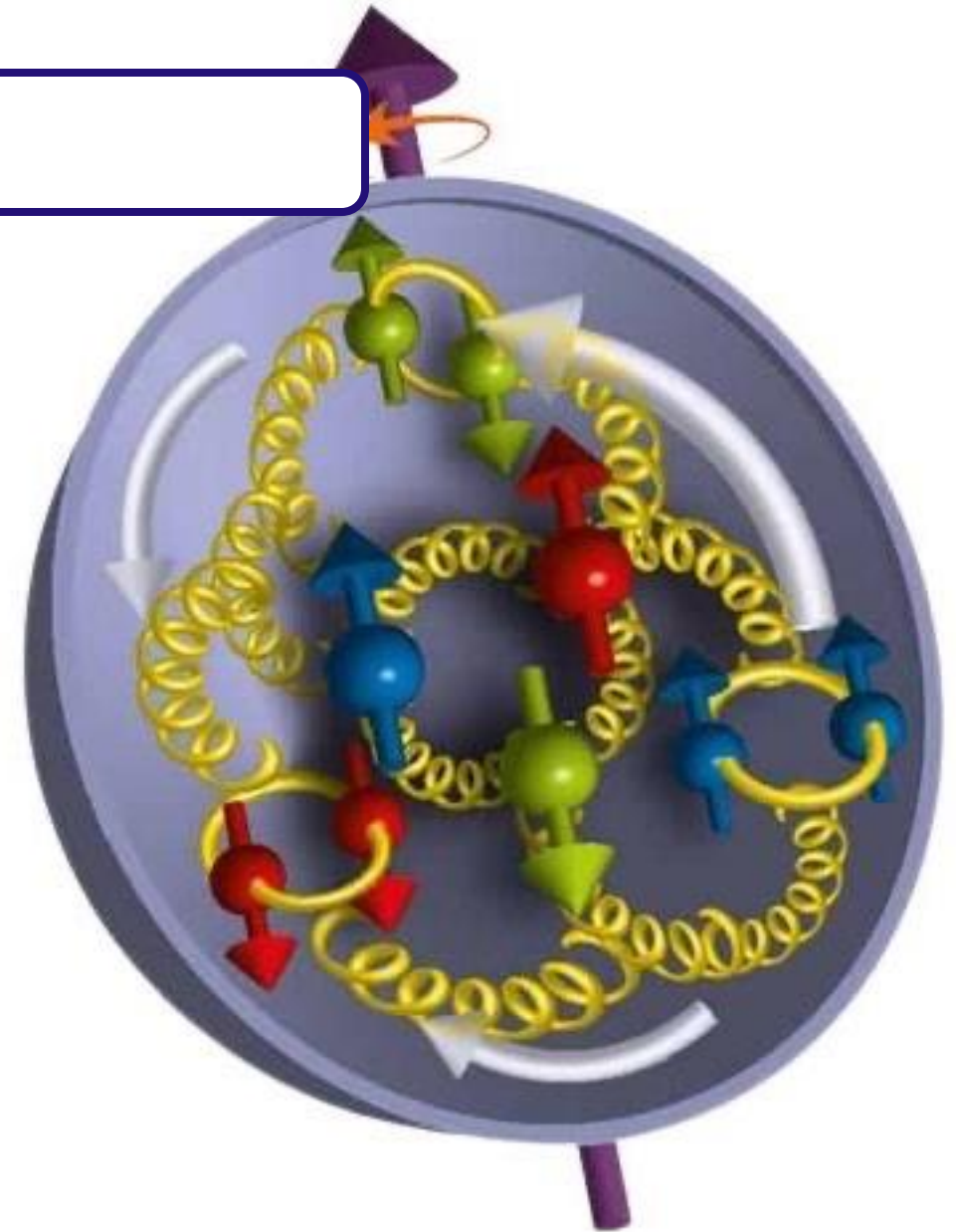
Nanako Kato, PhD student
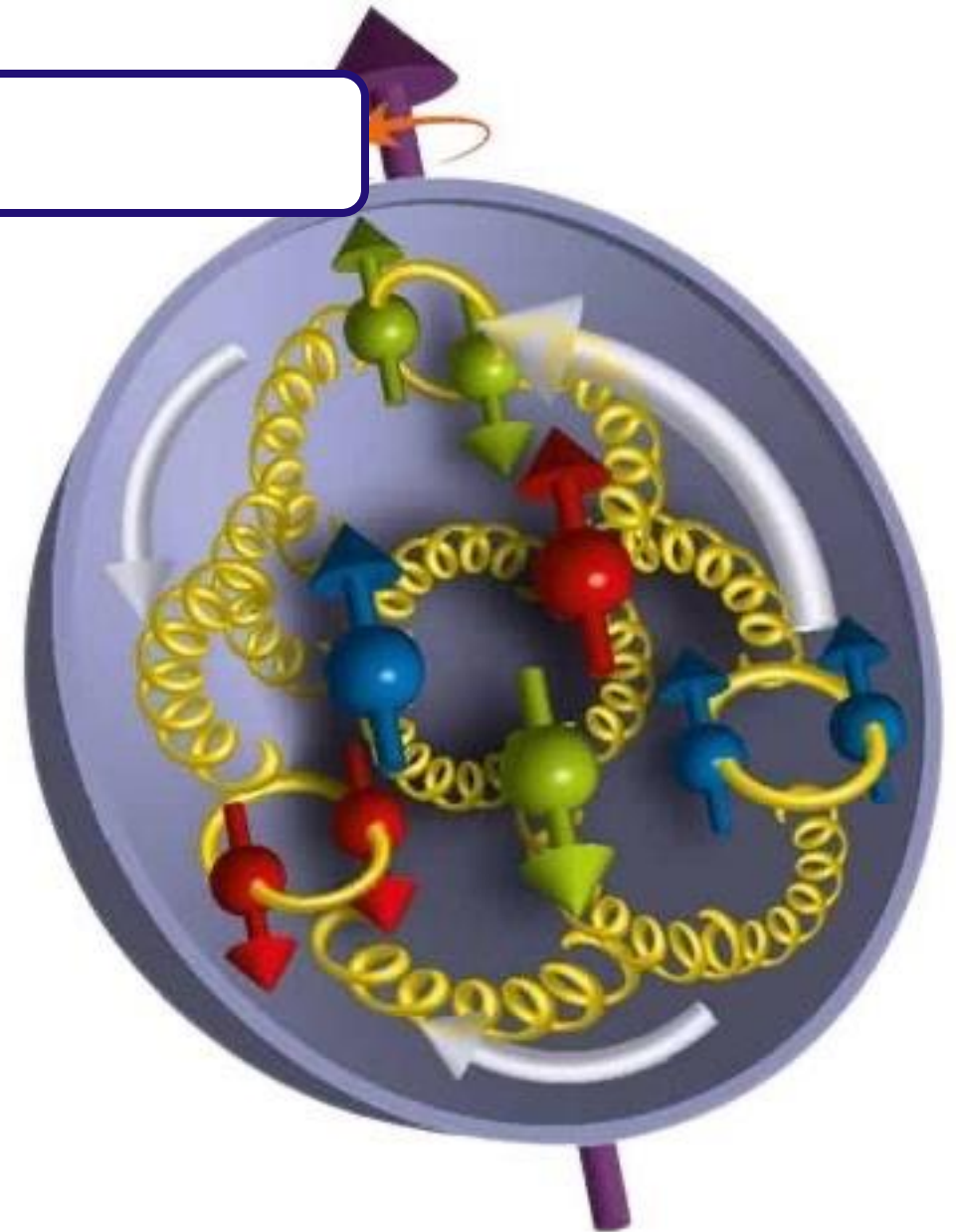University and INFN Cagliari

Motivation

Our purpose:
investigate the internal
structure of the proton

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structure of the proton

- How are quarks and gluons distributed?
- What's the contribution from quarks and gluons to the mass of the proton?
- Where does the proton's spin come from?

... and many more

Gluon TMDs

Transverse **M**omentum **D**ependent PDF:
Distributions of partons whose momentum have **longitudinal** and **transverse components** with respect to the parent proton's momentum

$$f(x, \vec{k}_T)$$

3D
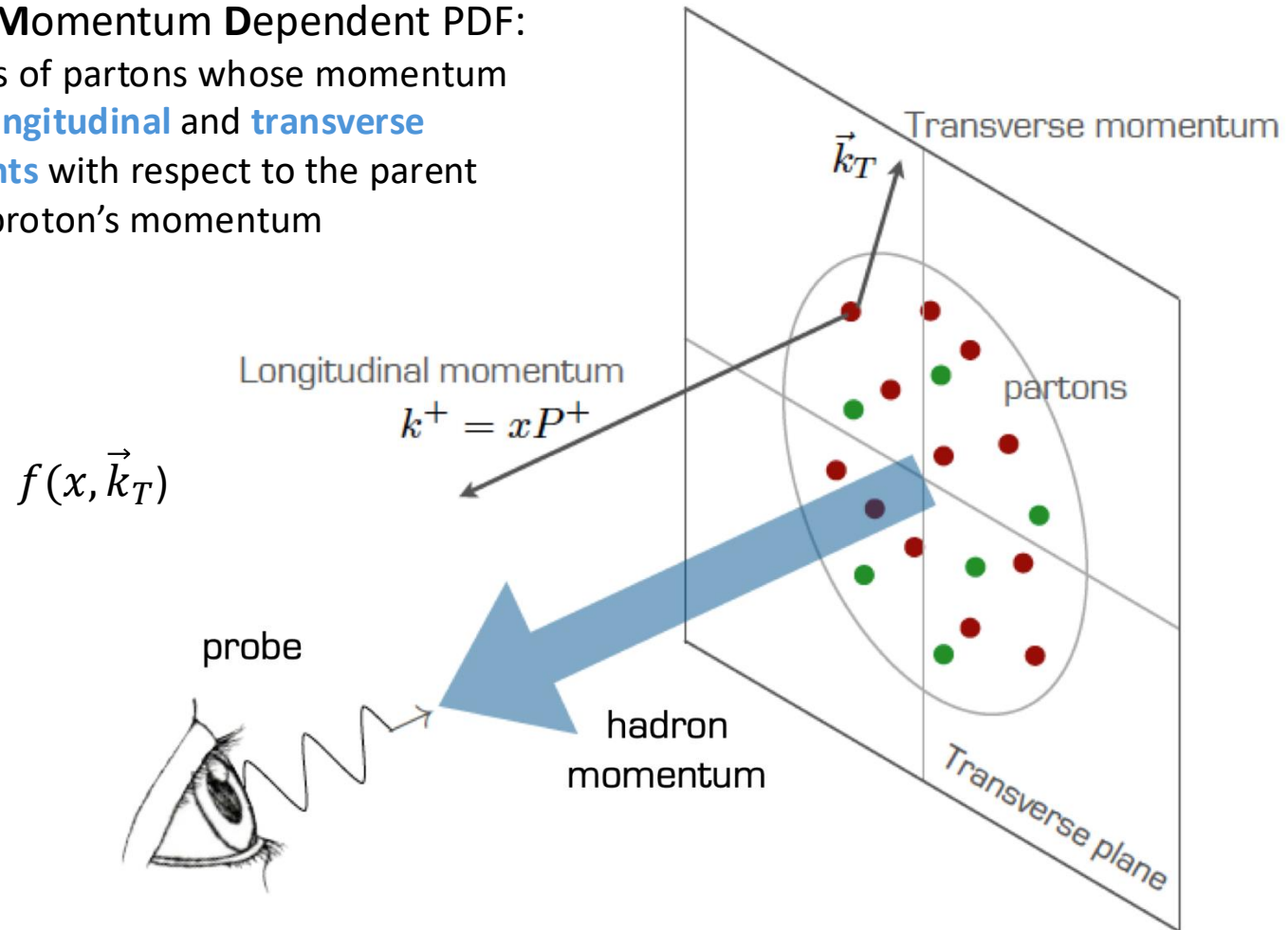
TMD PDFs:

- encode all the possible **spin-spin** and **spin-momentum** correlations between the proton and its constituents
- depend on x and $\vec{k}_T$

A. Bacchetta

Transverse Momentum Dependent Parton Distribution Functions (TMD PDFs)

GLUONS	unpolarized	circular	linear
U	f_1^g		$h_1^{\perp g}$
L		g_{1L}^g	$h_{1L}^{\perp g}$
T	$f_{1T}^{\perp g}$	g_{1T}^g	$h_{1T}^g, h_{1T}^{\perp g}$

← Gluon pol.

↑ Proton pol.

Angeles-Martinez et al., *Acta Phys., Pol B46 (2015)*

Nanako Kato - University & INFN Cagliari
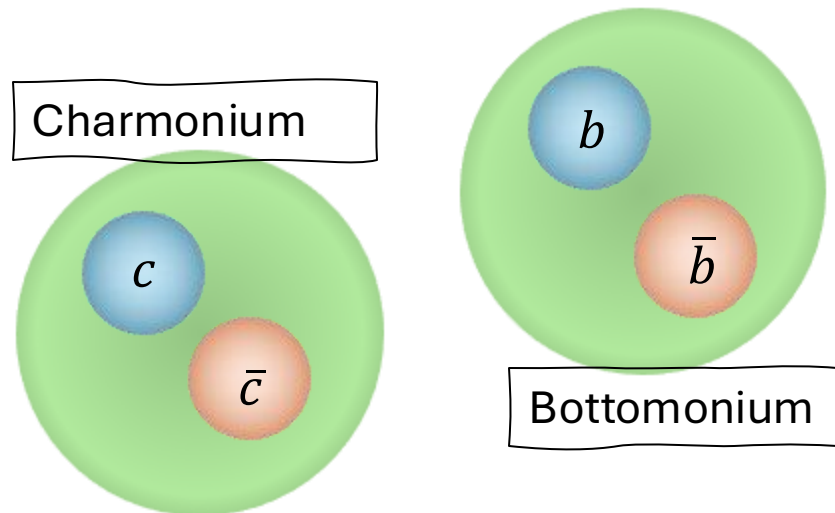
Quarkonium Production

$$p(P_A, S_A) + p(P_B, S_B) \rightarrow Q\overline{Q}[^{2S+1}L_J^{(1)}](q) + X$$
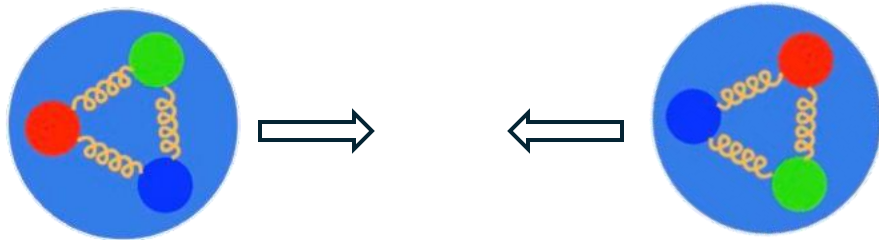
Quarkonium is a quark-antiquark bound state that can be produced in proton-proton collisions

Model: Non-Relativistic QCD (NRQCD)
- Double power series expansion in α_s and v
- Partonic subprocess $gg \rightarrow Q\overline{Q}$ calculated perturbatively
- Non-perturbative quarkonium formation from the $Q\overline{Q}$-pair encoded in the LDMEs

Charmonium

c

$\bar{c}$

b

$\bar{b}$

Bottomonium

Quarkonium Production

$$g(p_a) + g(p_b) \rightarrow Q\overline{Q}[^{2S+1}L_J^{(1)}](q)$$
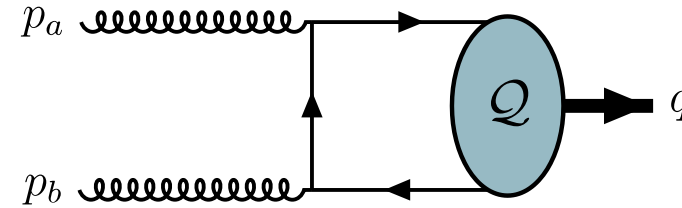
We calculated the single-polarized cross sections

UU, UL, UT

$$d\sigma^{pp \rightarrow Q\bar{Q}} = \sum_n d\hat{\sigma}[gg \rightarrow Q\bar{Q}] \langle 0| \mathcal{O}_n(^{2S+1}L_J^{(1)}) |0\rangle$$

Perturbative short-distance coefficients

Non-perturbative LDME

Current work

Currently doing my PhD at the University of Cagliari under the supervision of Prof. Cristian Pisano and Dr. Simone Rodini

- We also studied the double-polarized cross sections (LL, LT, TT)
  and *single spin asymmetries* for the process $pp \to \eta_c\, X$ in Phys. Rev. D **110**, 034038

- More study on gluon TMDs through *matching relations* with collinear PDFs

- Predictions for LHCSpin and EIC

THANKS FOR YOUR ATTENTION!