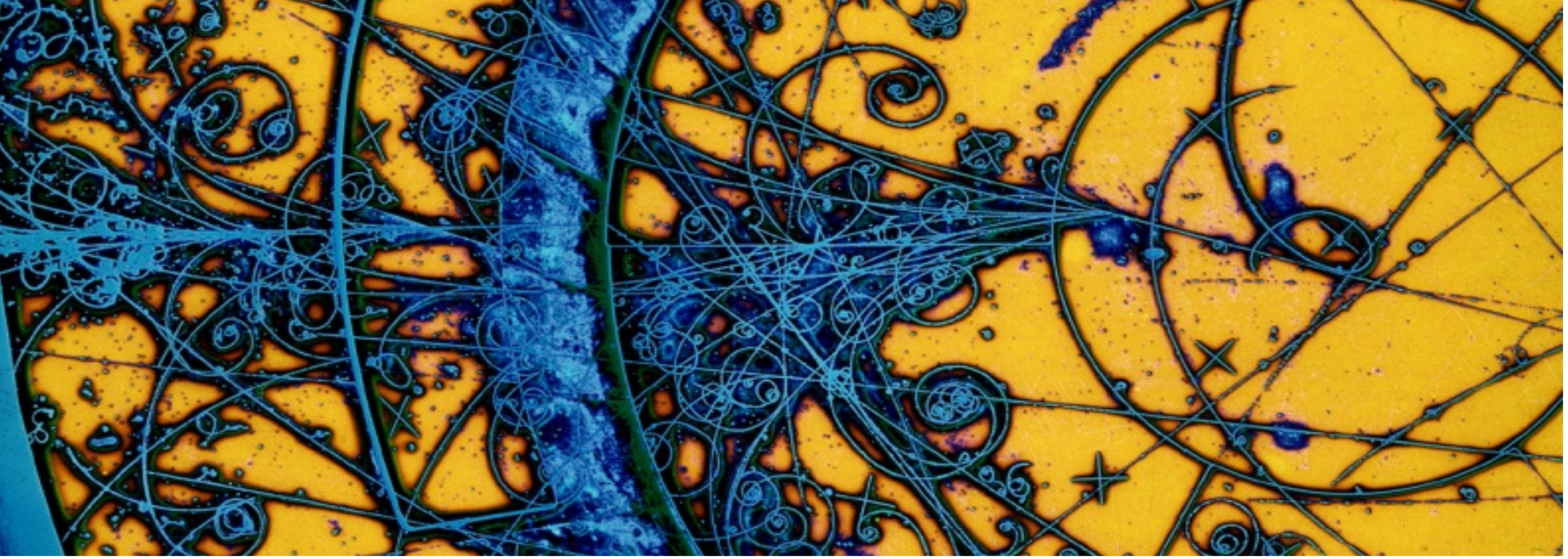


Fixed target at LHCb

Marco Santimaria (INFN-LNF)
in collaboration with V.Carassiti, G.Ciullo, P. Di Nezza, P.Lenisa, S.Mariani, L.Pappalardo, E.Steffens

CFNS Workshop / High Luminosity EIC
Stony Brook University, 22/06/2022

marco.santimaria@lnf.infn.it

The LHCb detector

- LHCb is a general-purpose forward spectrometer, fully instrumented in $2 < \eta < 5$, and optimised for c and b hadron detection
- Excellent momentum resolution with VELO + tracking stations:

$$\sigma_p/p = 0.5 - 1.0\,\% \;\; (p \in [2{,}200]\ \text{GeV})$$

- Particle identification with RICH+CALO+MUON

$\epsilon_\mu \sim 98\,\%$ with $\epsilon_{\pi\to\mu} \lesssim 1\,\%$

- Low momentum muon trigger:

$$p_{T_\mu} > 1.75\ \text{GeV}\ (2018)$$

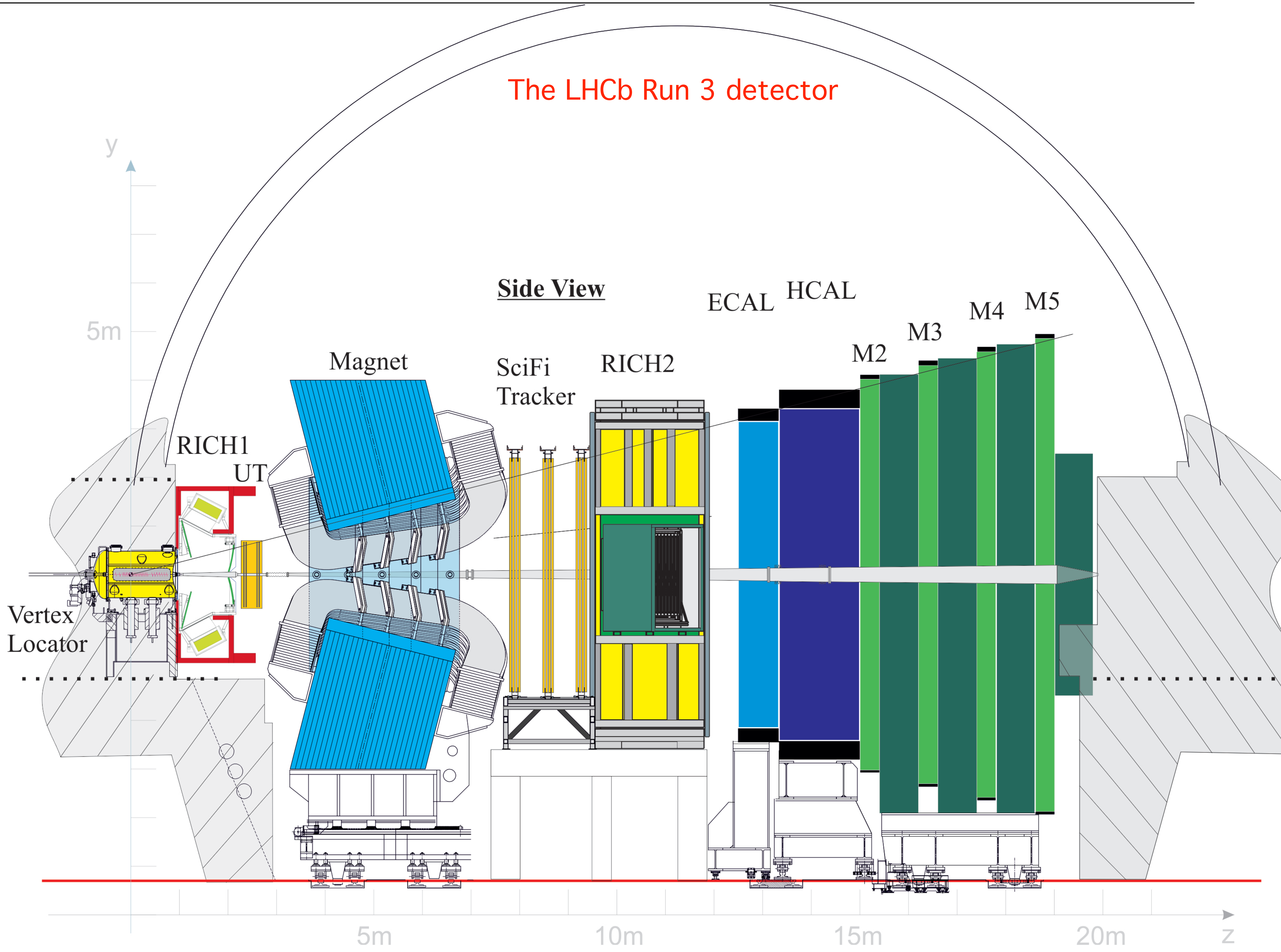
will be reduced thanks to the new fully-software trigger

- Major detector upgrades performed during LS2 for the Run 3 (5x luminosity)

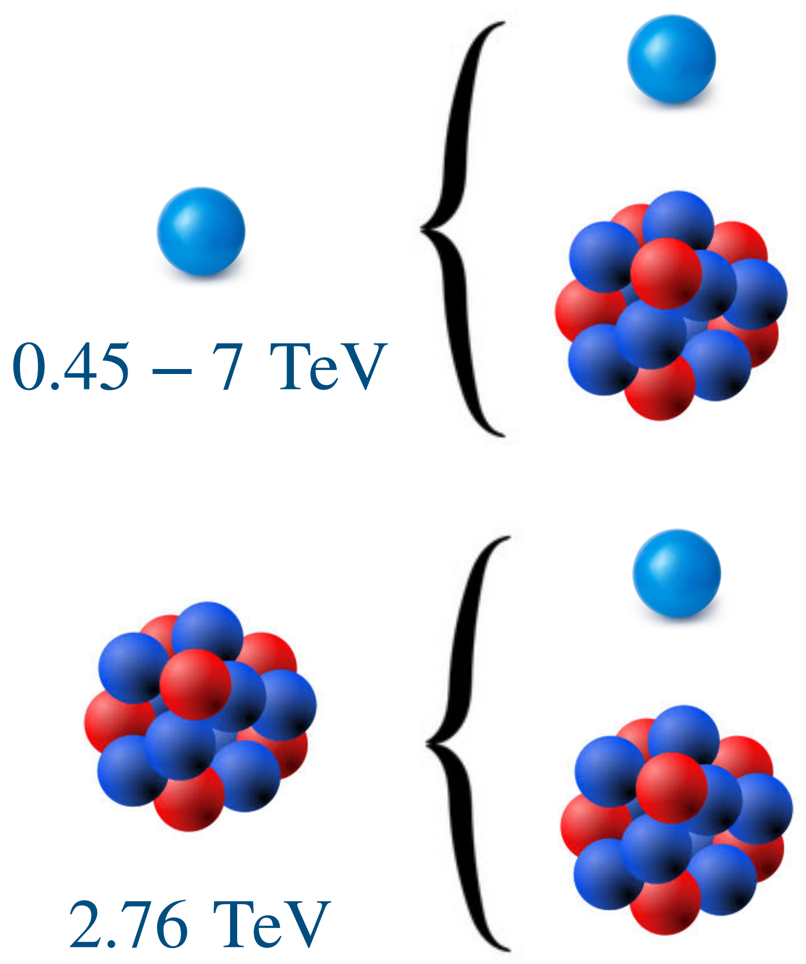
[JINST 3 (2008) S08005]

[IJMP A 30, 1530022 (2015)]

[Comput Softw Big Sci 6, 1 (2022)]



Fixed-target physics at LHCb



pp/pA collisions, 7 TeV beam:

$\sqrt{s} = \sqrt{2m_N E_p} = 115$ GeV

$2 \leq y_{lab} \leq 5 \ \rightarrow -3.0 \leq y_{CMS} \leq 0$

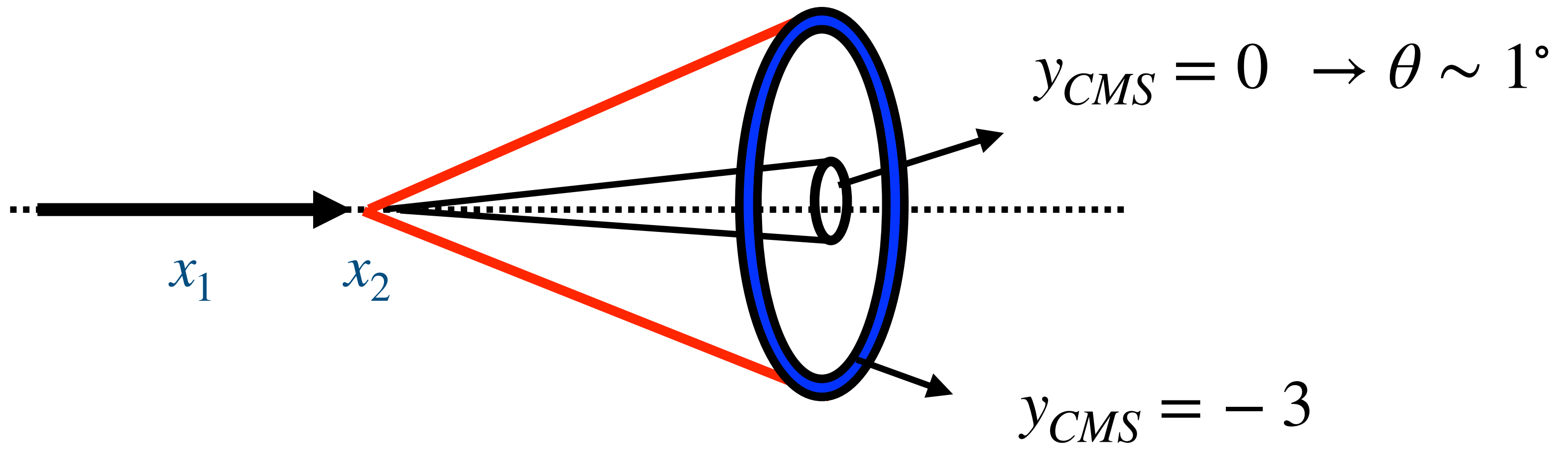
AA collisions, 2.76 TeV beam:

$\sqrt{s_{NN}} \simeq 72$ GeV

$y_{lab} = 4.3 \ \rightarrow \ y_{CMS} = 0$

1: beam, 2: target

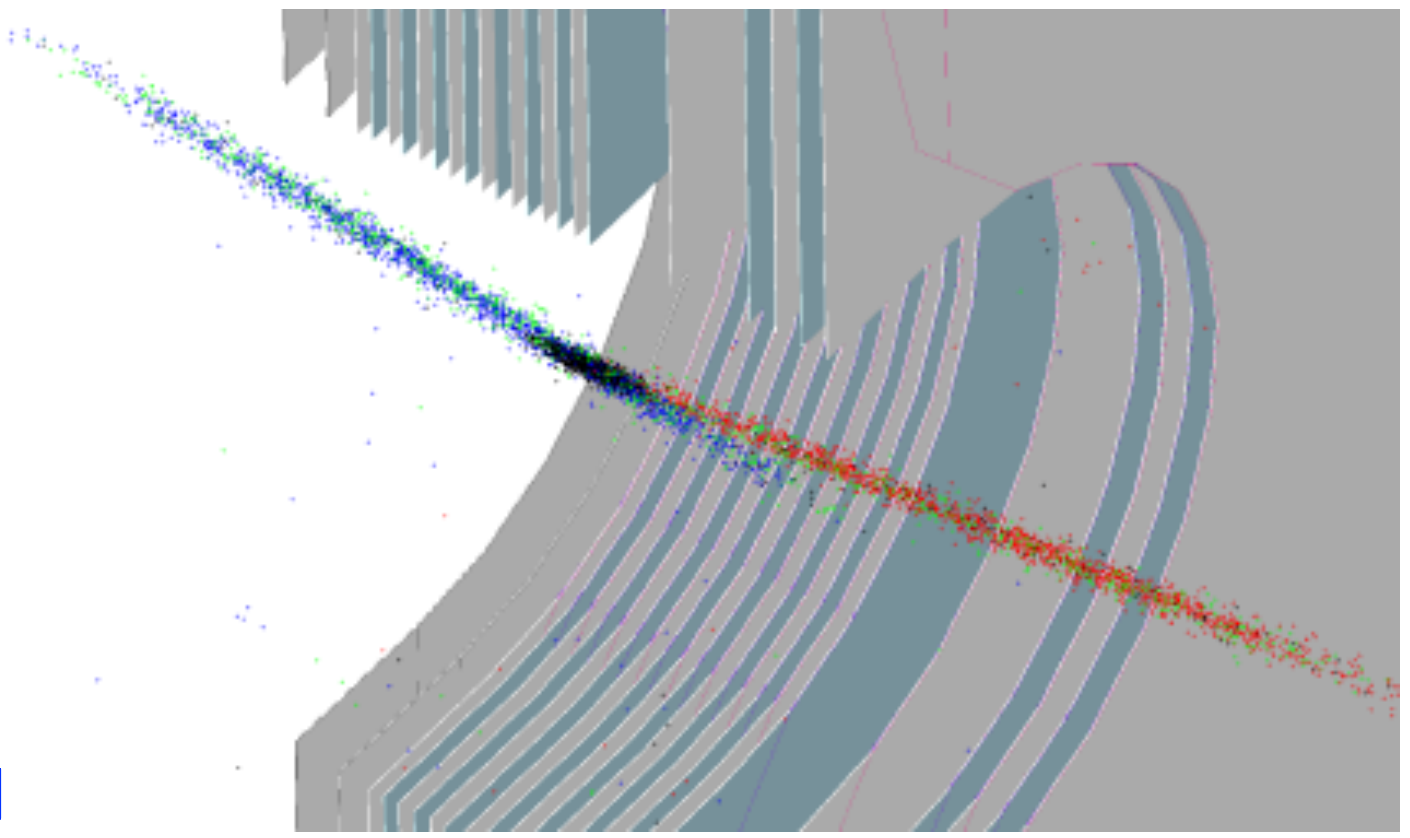
Large CM boost : large x_2 values ($x_F < 0$) and small x_1



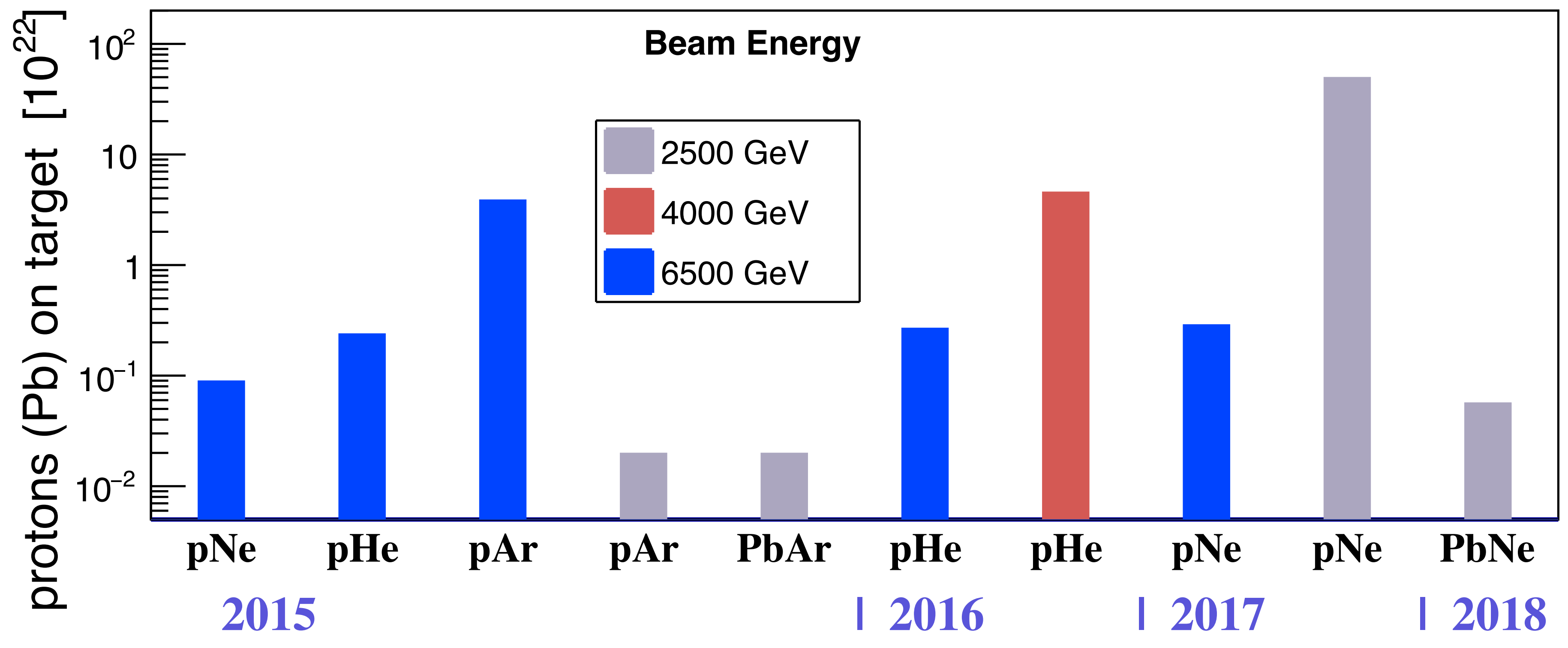
$\gamma = \dfrac{\sqrt{s}}{2m_p} \sim 60$

[JINST 9 (2014) P12005]

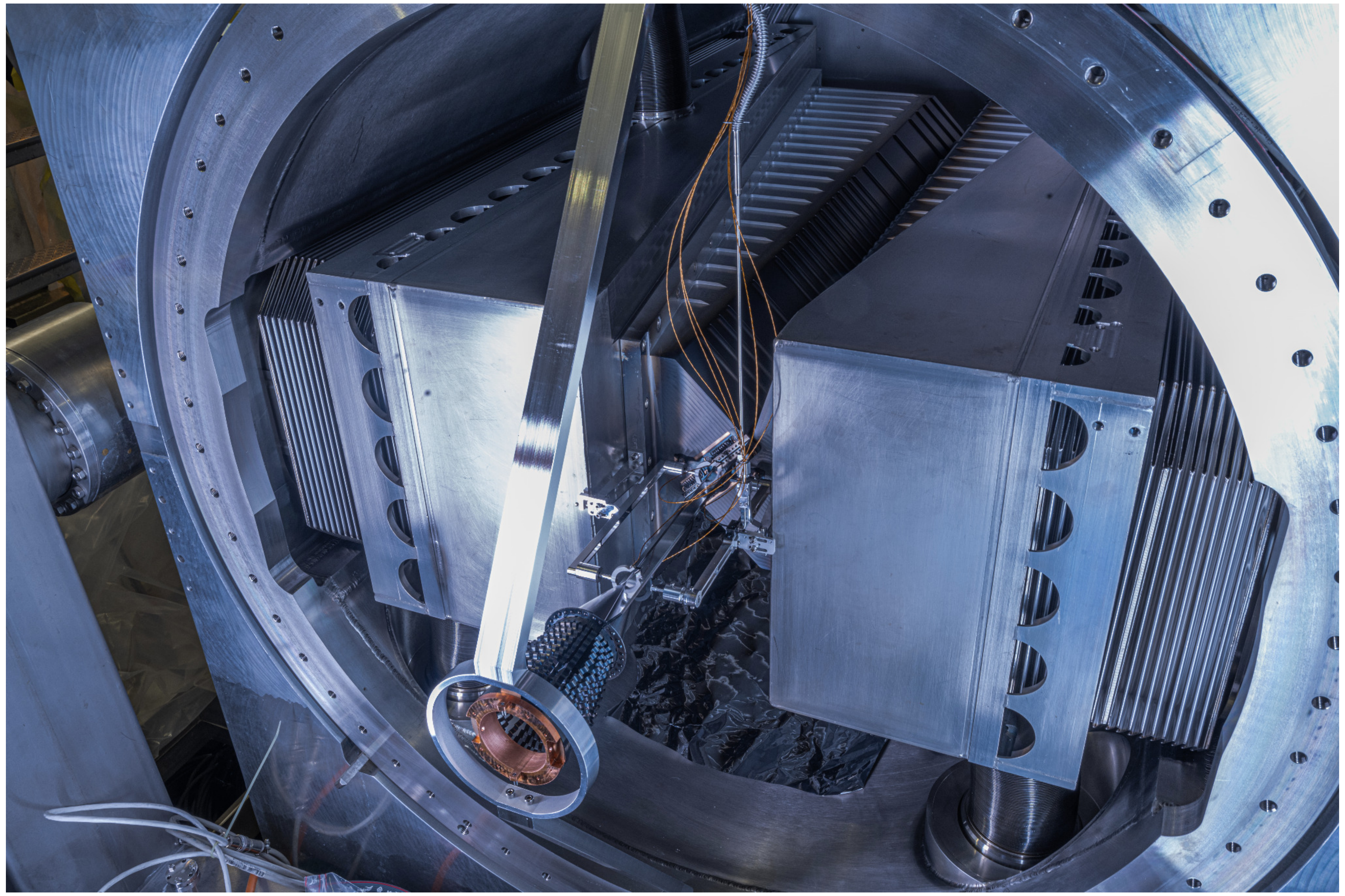
- The LHCb fixed-target physics program started with SMOG (System for Measuring the Overlap with Gas) in 2015
- Inject nobles gases into the VELO (± 20 m in the beam pipe)
- Trigger on beam-empty collisions: turns LHCb into an FT experiment!
- Two new results shown at SQM22 → [here]

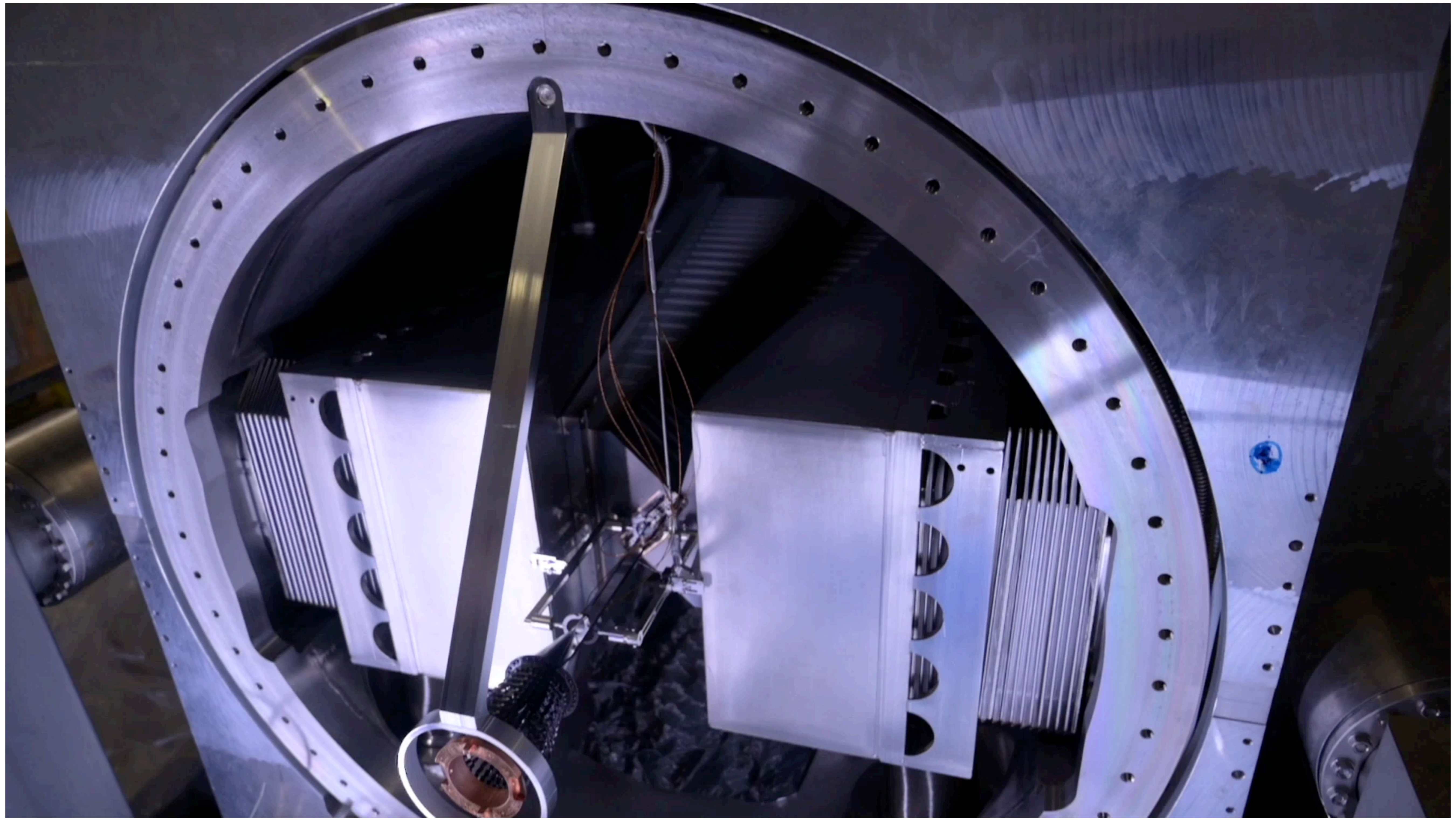


- SMOG data samples:



The SMOG2 gas storage cell





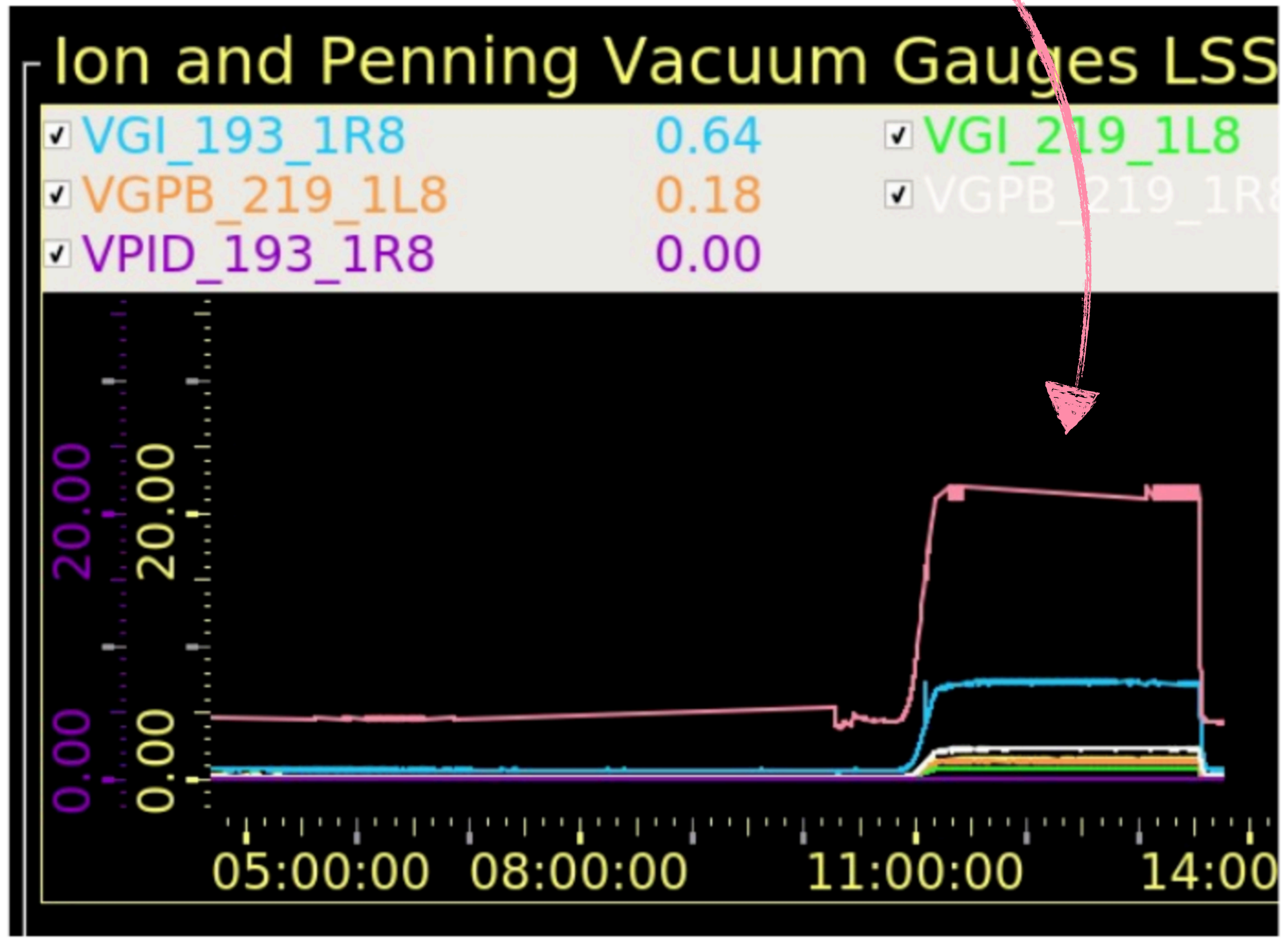
x10 faster

- SMOG2 storage cell installed in 2020
- Openable cell which follows the movement of the VELO (closed when the beam is stable)
- Boosts the gas density by $8-35$ X wrt SMOG
- Negligible impact on the beam lifetime: $\tau^{\mathrm{p-H_2}}_{beam-gas} \sim 2000$ days , $\tau^{\mathrm{Pb-Ar}}_{beam-gas} \sim 500$ h
- Equipped with temperature probes: luminosity measurement at $\sim 1\,\%$

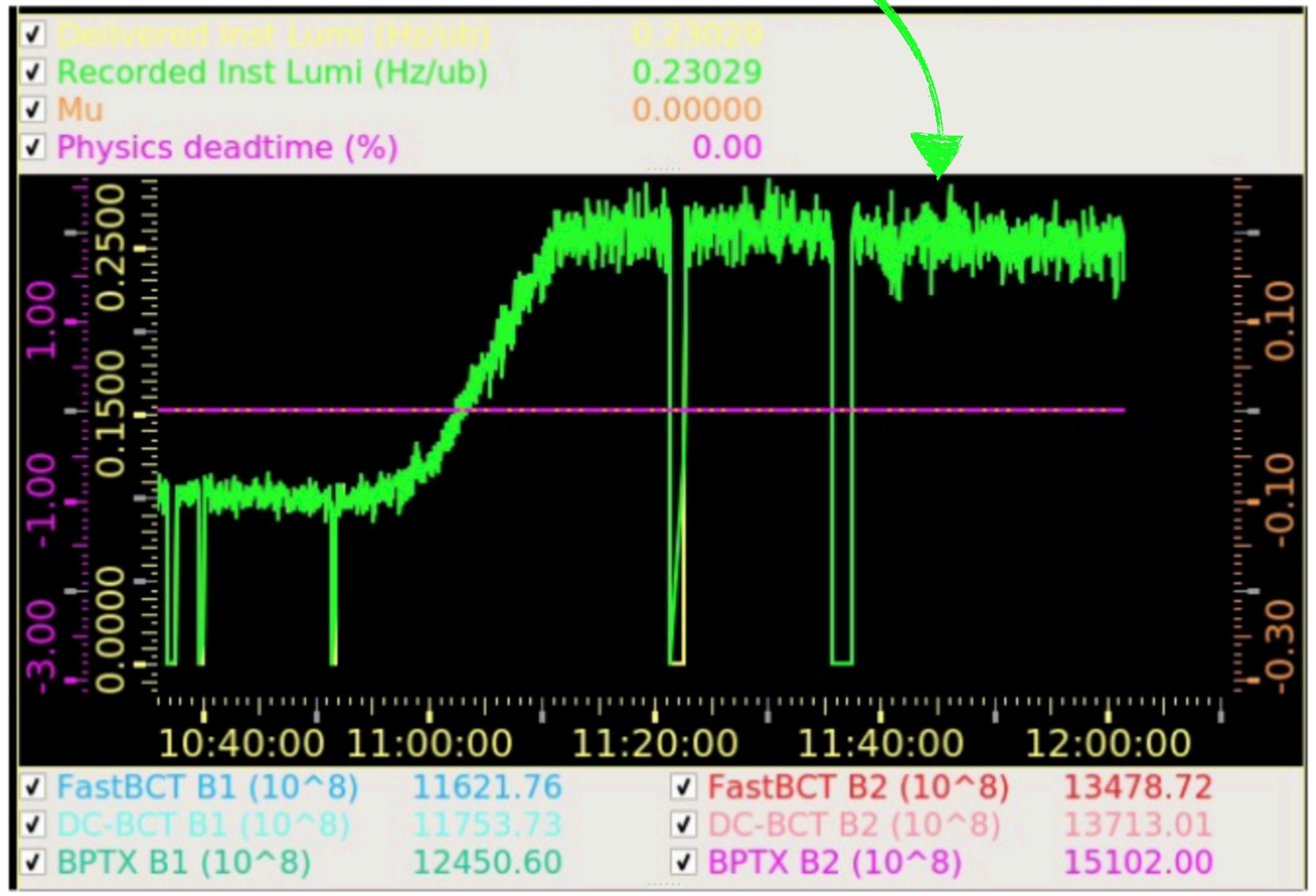
First SMOG2 operations

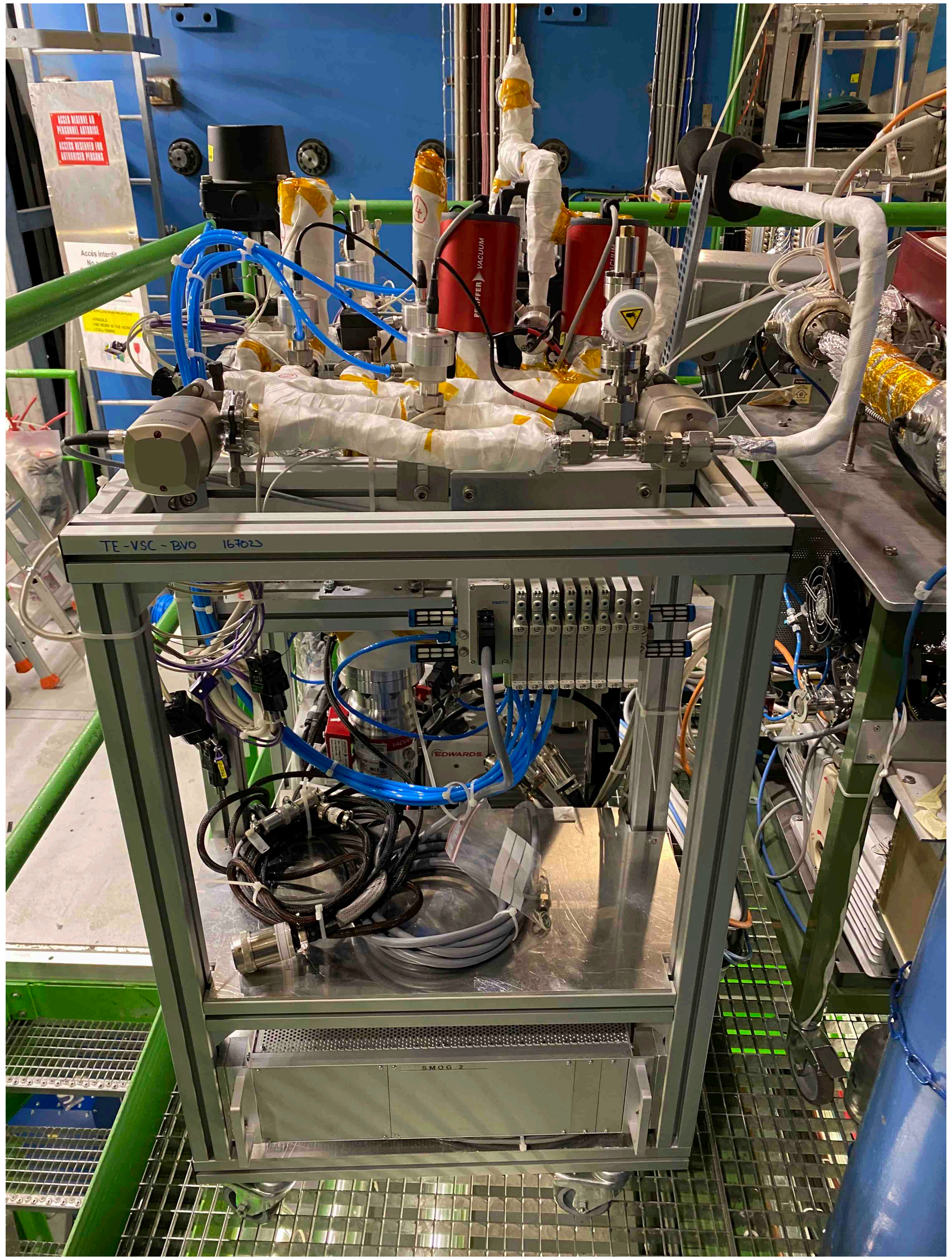
- Gas Feed System installed on 03/2022
- The cell can be filled with: He, Ne, Ar
- Under evaluation: H_2, D_2, N_2, O_2, Kr, Xe
- First Neon injections tested successfully with beam!

- Pressure increase observed in the beam-pipe is fast & stable



- Increased activity observed with the new luminometer (Plume)

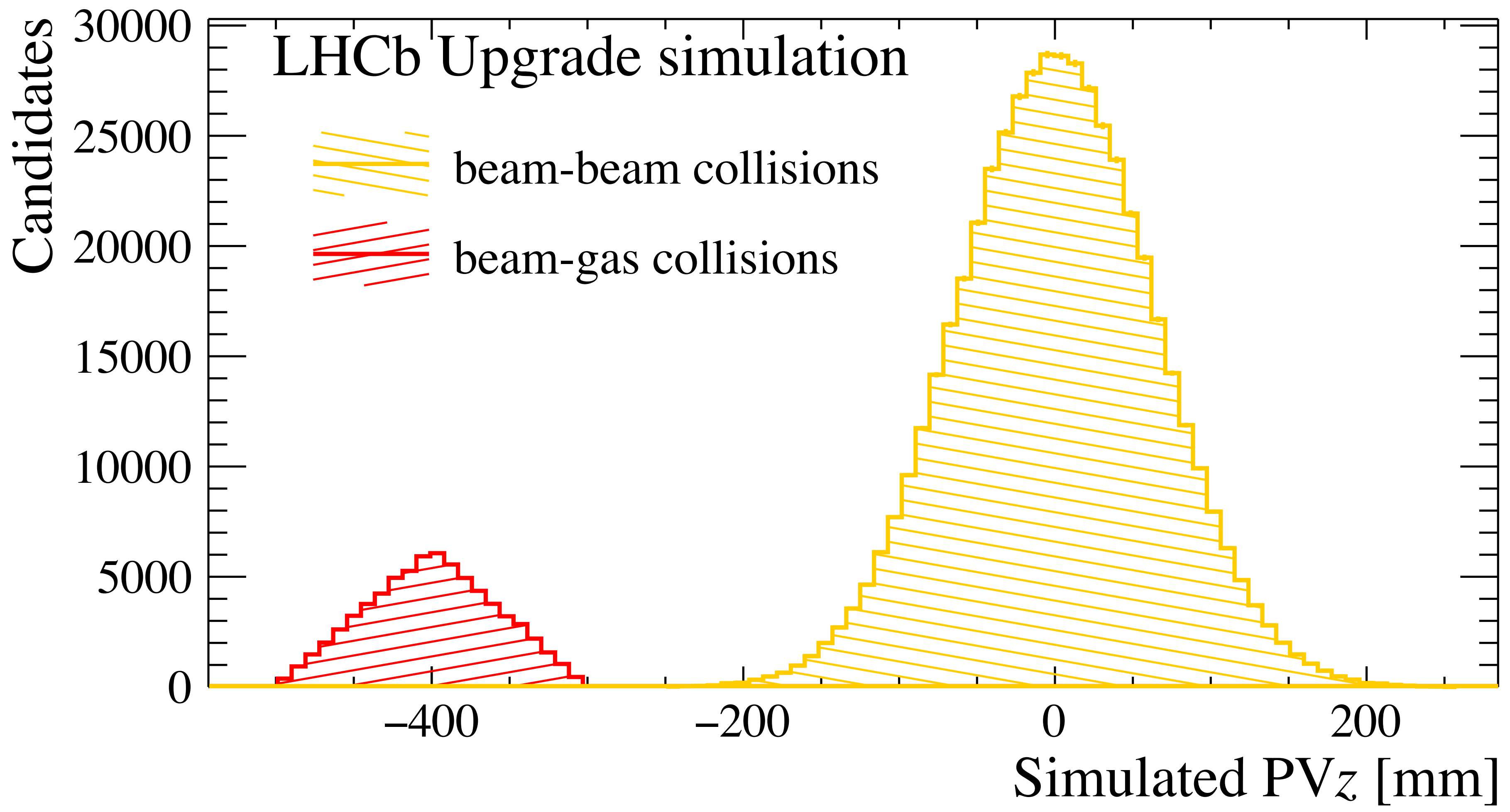


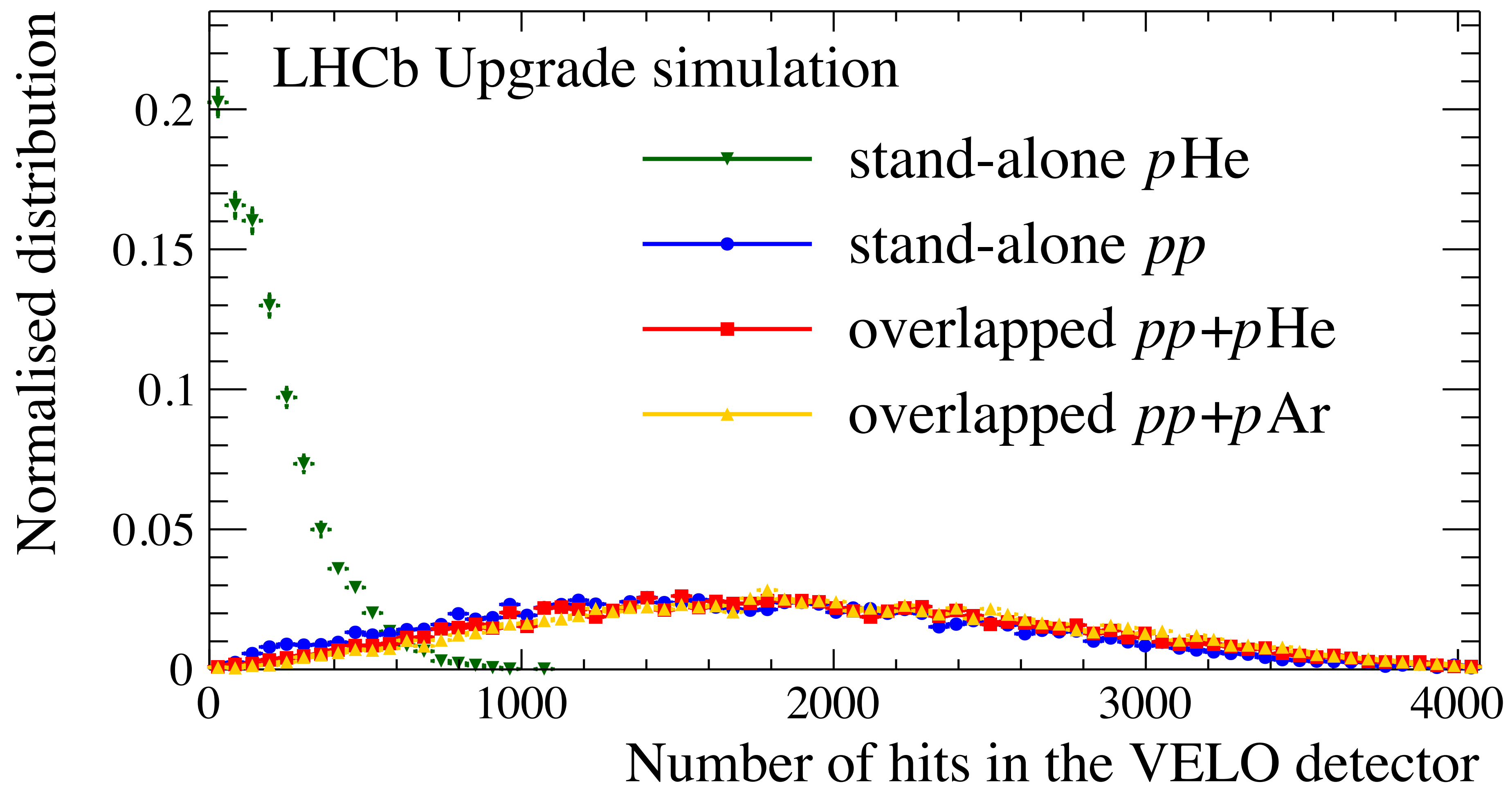


SMOG2 performance

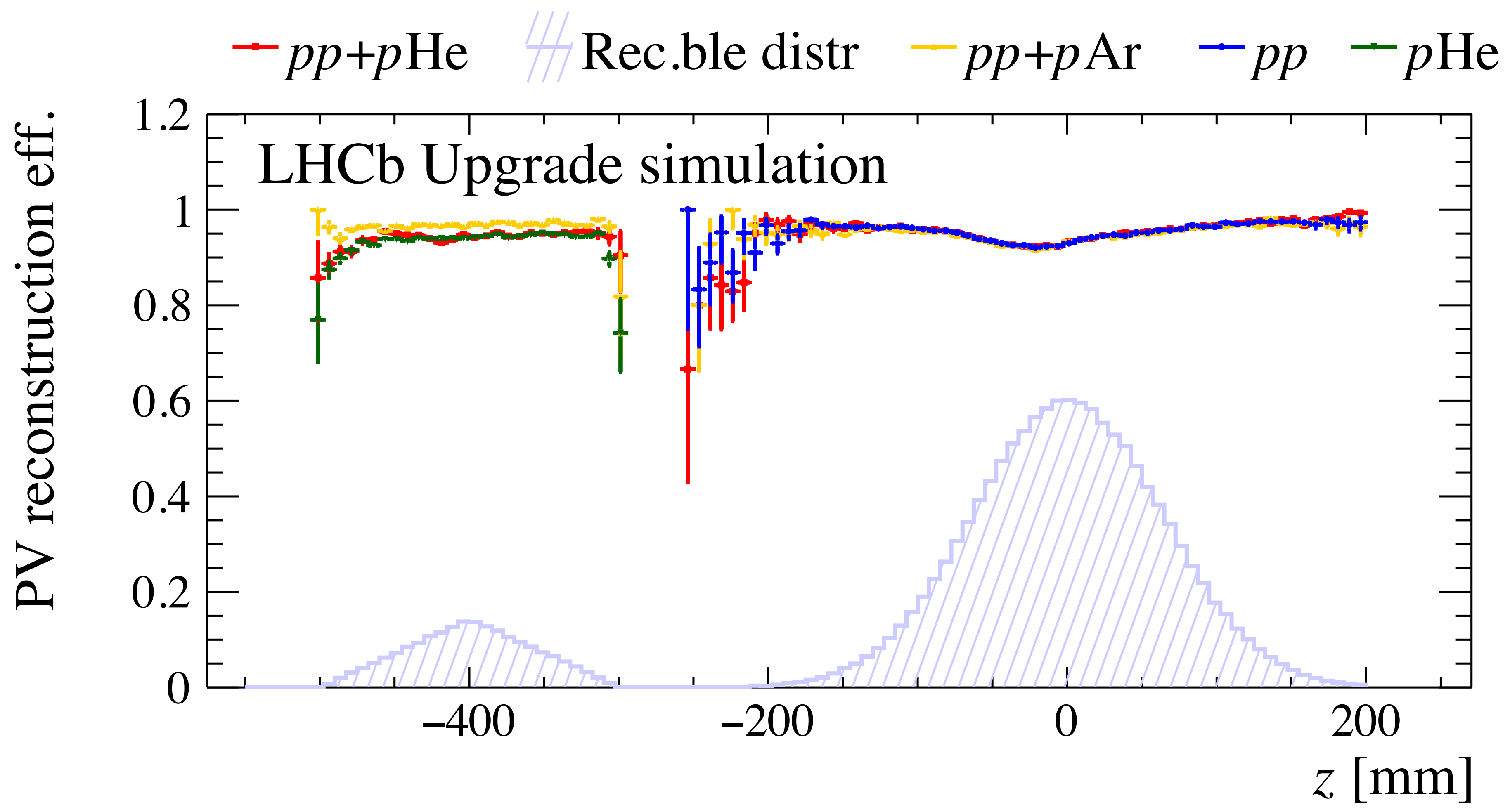
[LHCB-FIGURE-2022-002]

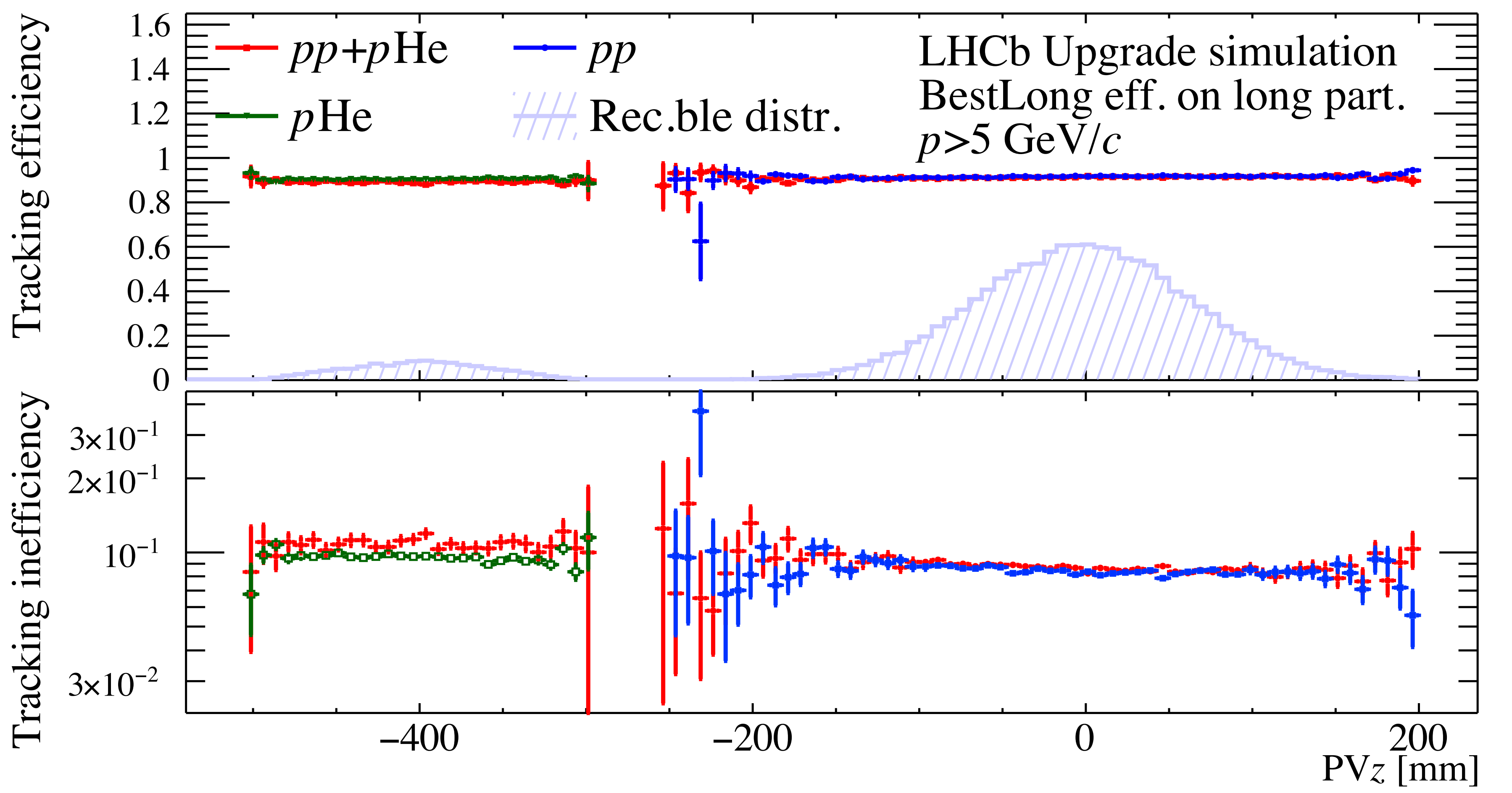
1. Beam-beam and beam-gas interaction regions are well detached
2. Negligible increase of multiplicity: small impact in the LHCb reconstruction sequence





3. Full reconstruction efficiency (vertex & tracking) retained in the beam-gas region





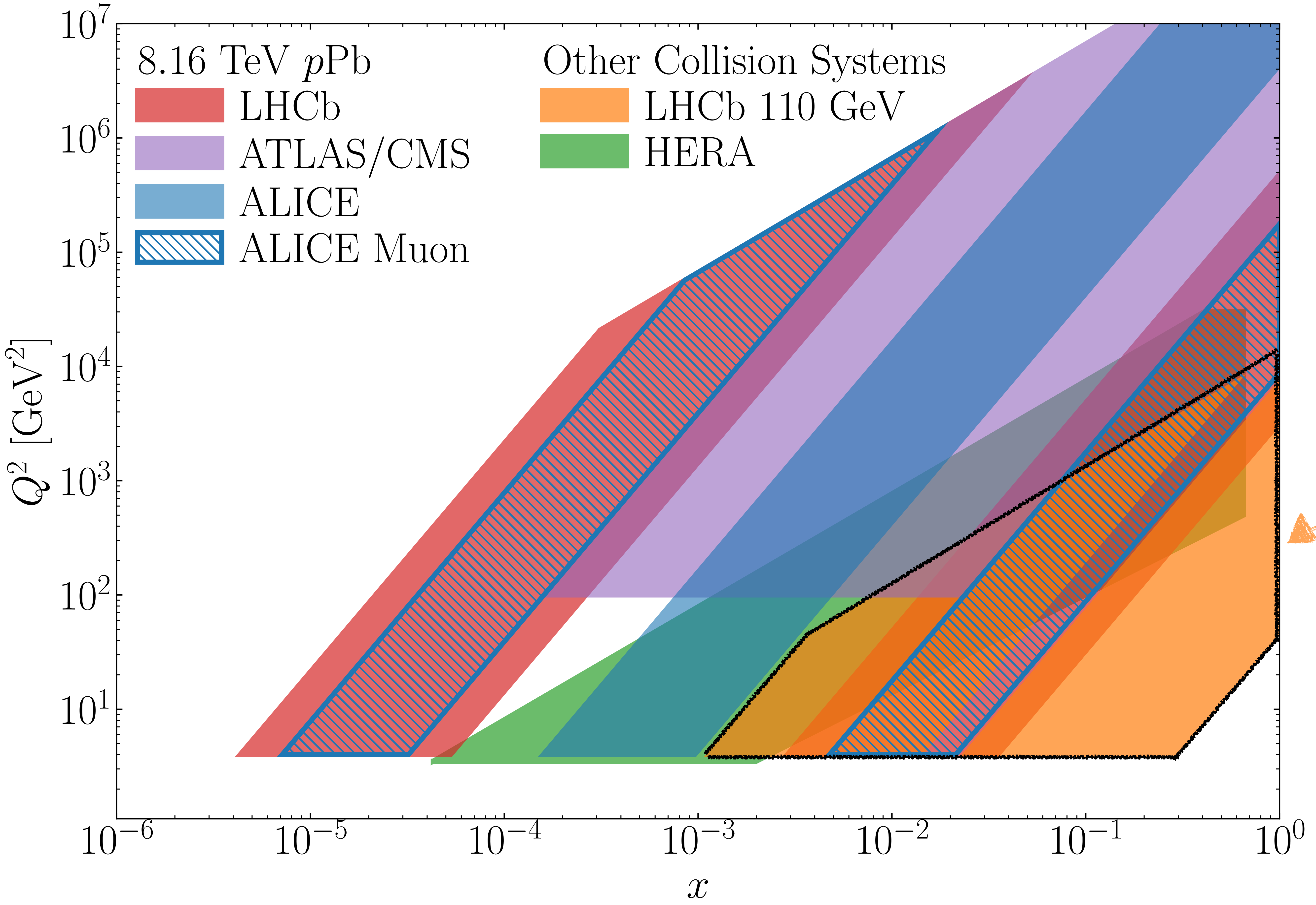
- LHCb will be the only experiment able to run in collider and fixed-target mode <u>simultaneously!</u>

The LHCspin project

- The SMOG2 program sets the basis for the development of a polarised gas target (PGT), that we aim to install during LS3

Two main goals of the LHCspin project:

1. Extend the broad physics program with unpolarised gases to Run 4 (2029) and Run 5 (2035, HL-LHC)
2. Bring spin physics at the LHC for the first time

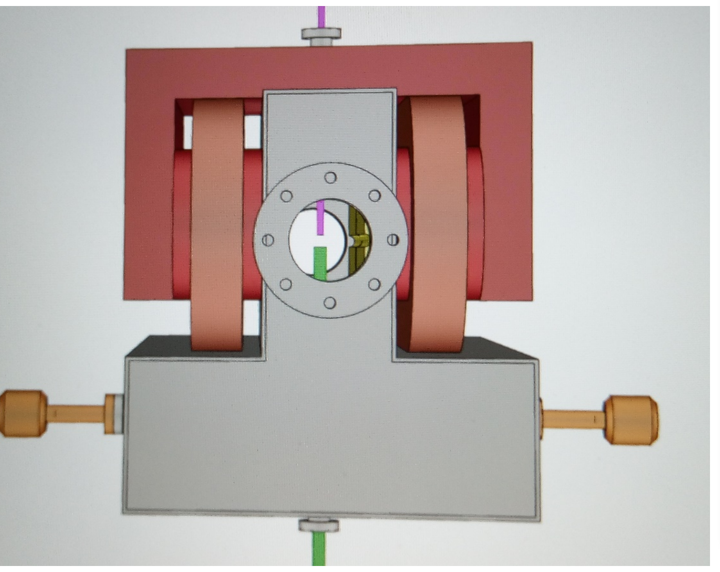


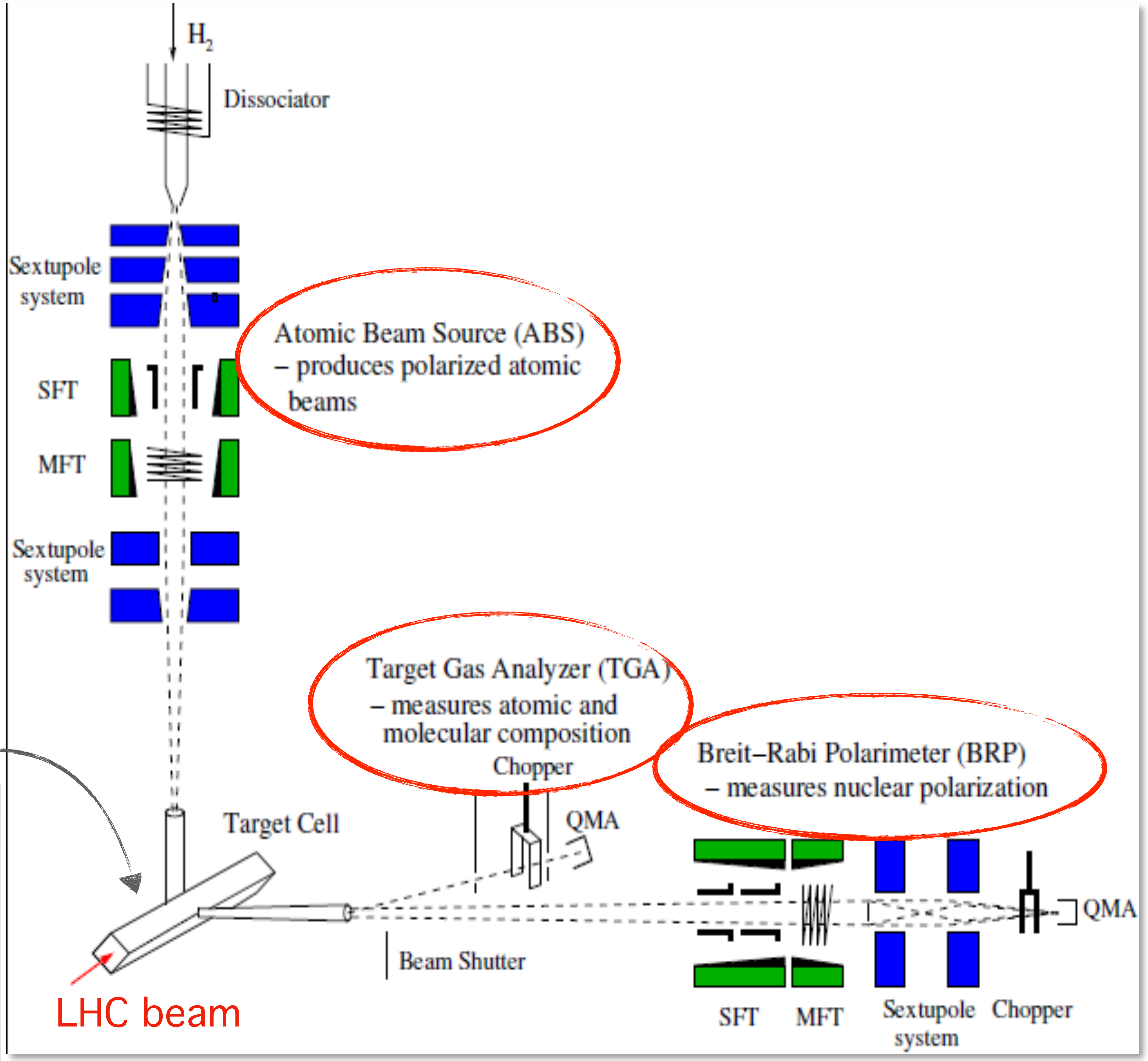
Unique QCD laboratory at LHC:

- Large-x content of g, $\bar{q}$ and heavy quarks in nucleons and nuclei
- Spin distributions of gluons inside unpolarised and polarised nucleons
- Heavy Ion FT collisions at an energy in between SPS and RHIC
- Broad and poorly explored kinematic range
- High luminosity, high resolution detectors: access to a large variety of probes incl. exotic
- Several unpolarised gas targets
- Polarised gas targets: $H^{\uparrow}, D^{\uparrow}$

Experimental setup

dipole



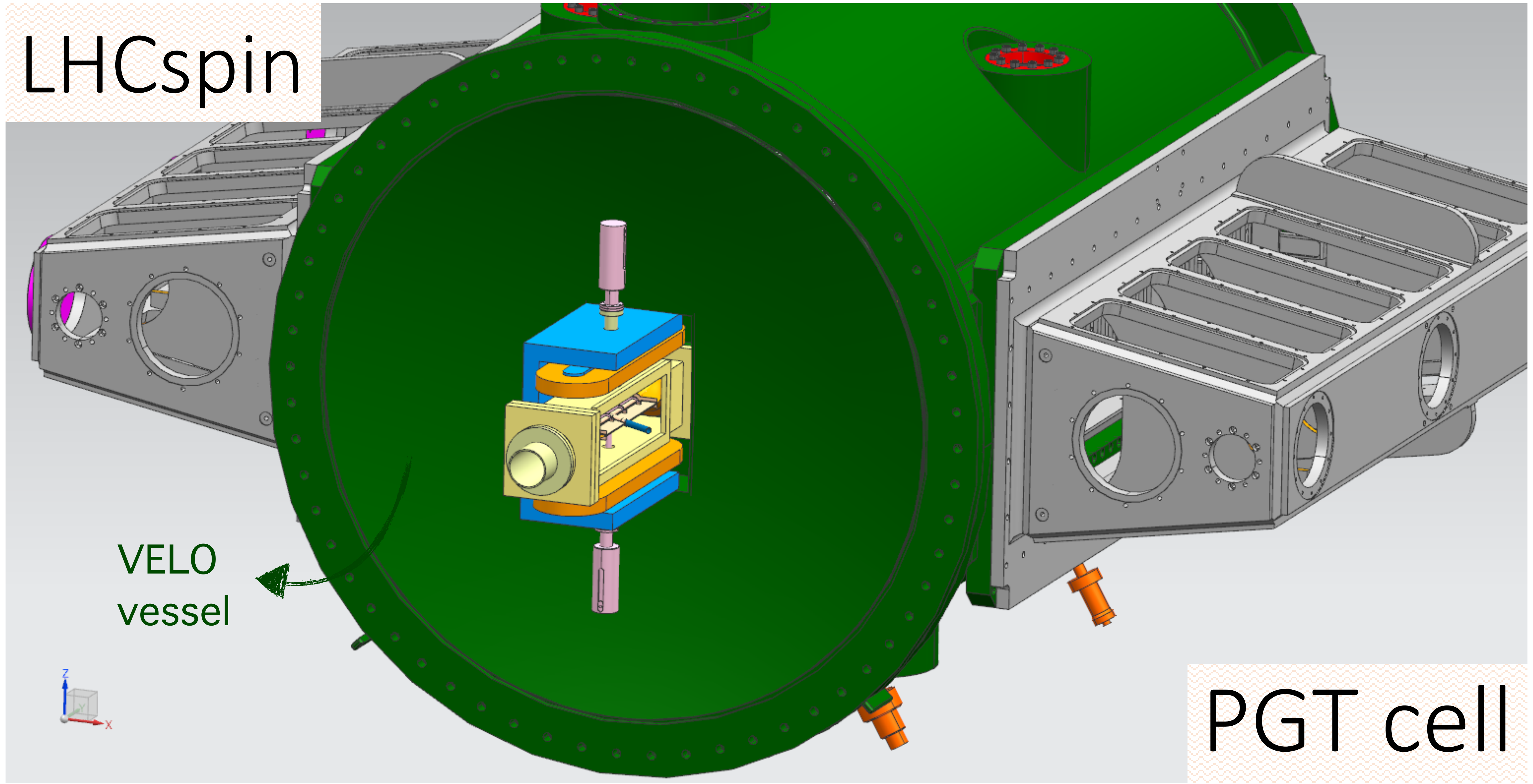


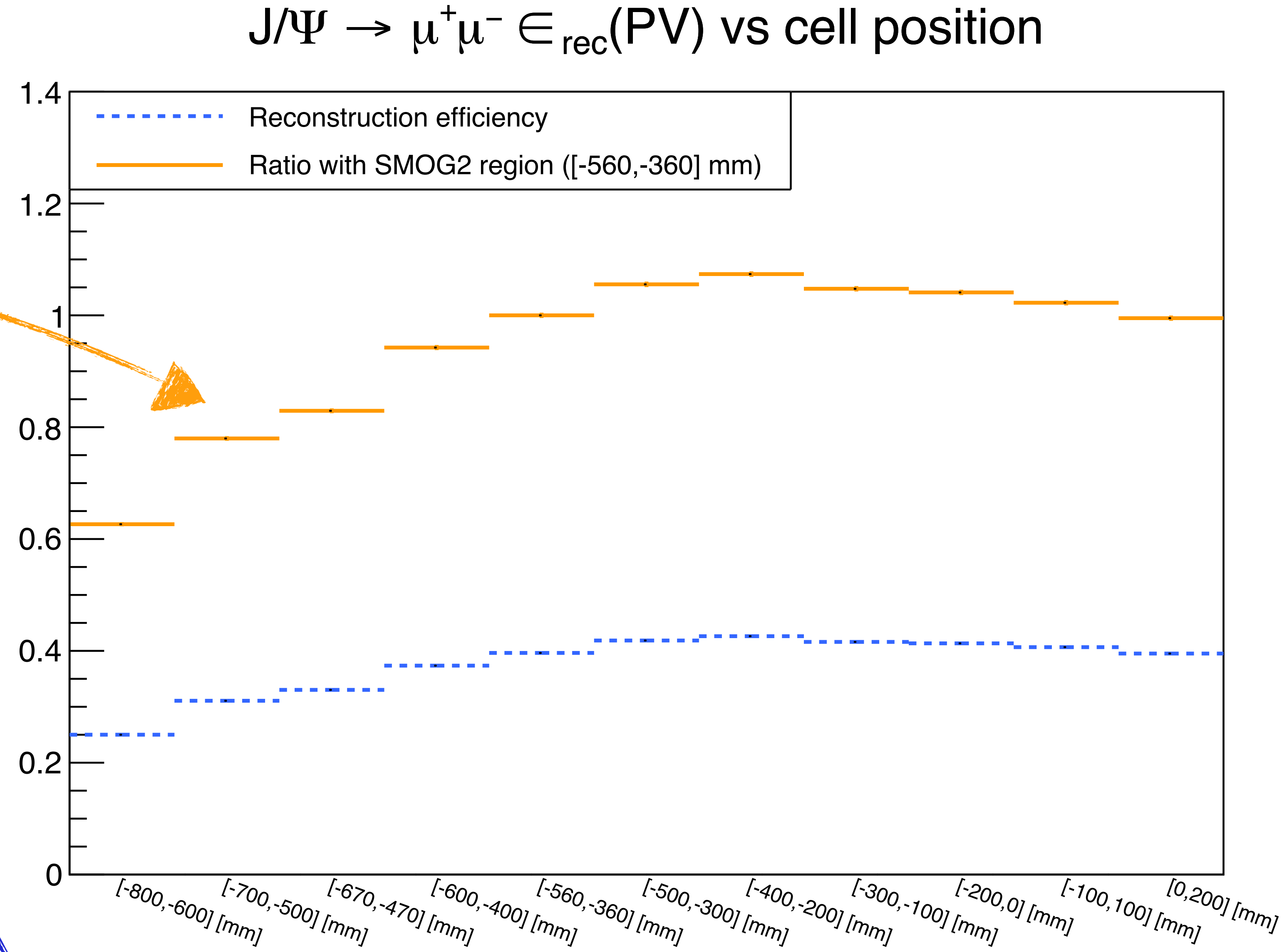
- Start from the well established HERMES setup @ DESY…
- … to create the next generation of fixed target polarisation techniques!

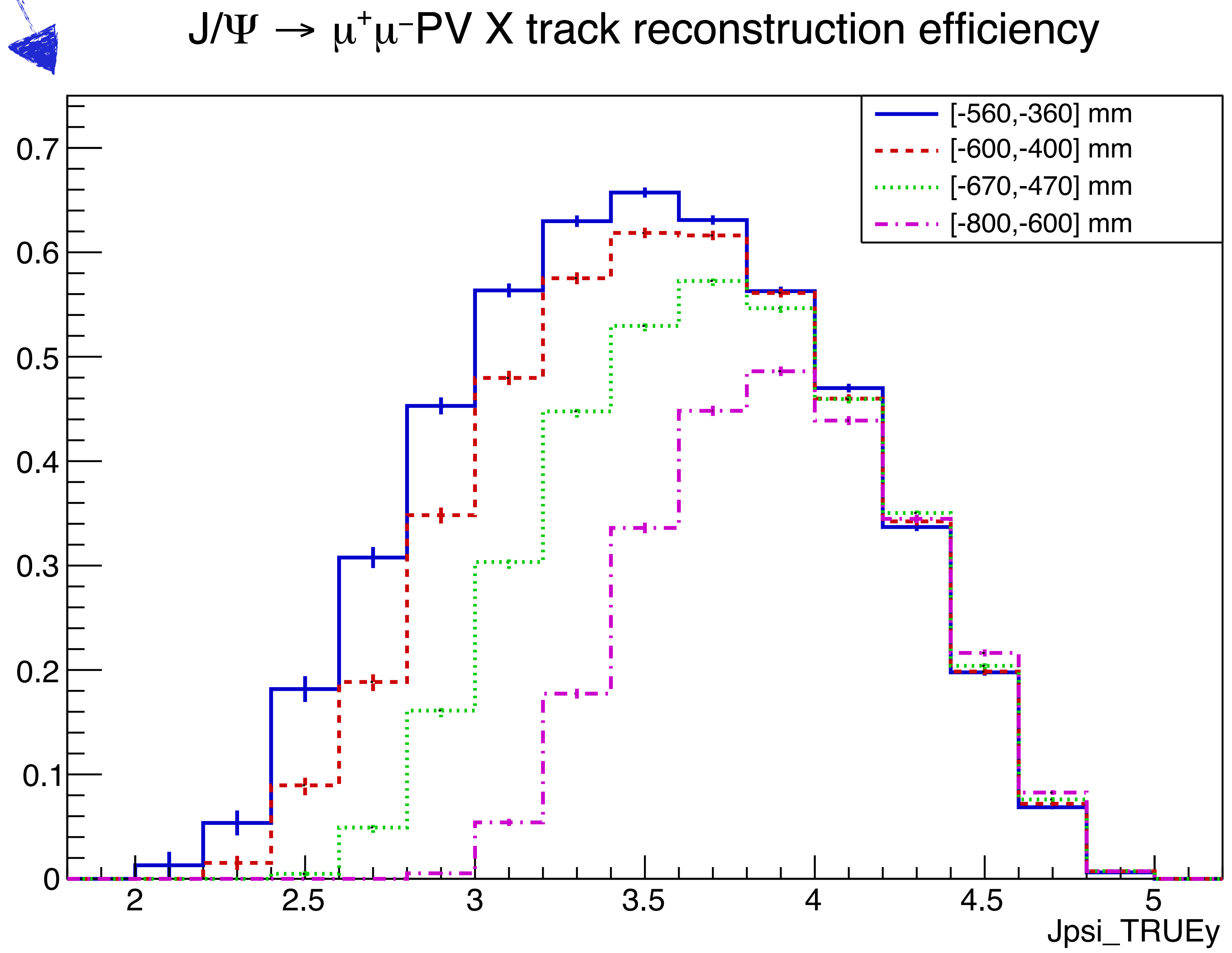
[NIMA 540 (2005) 68–101]

The Polarised Gas Target

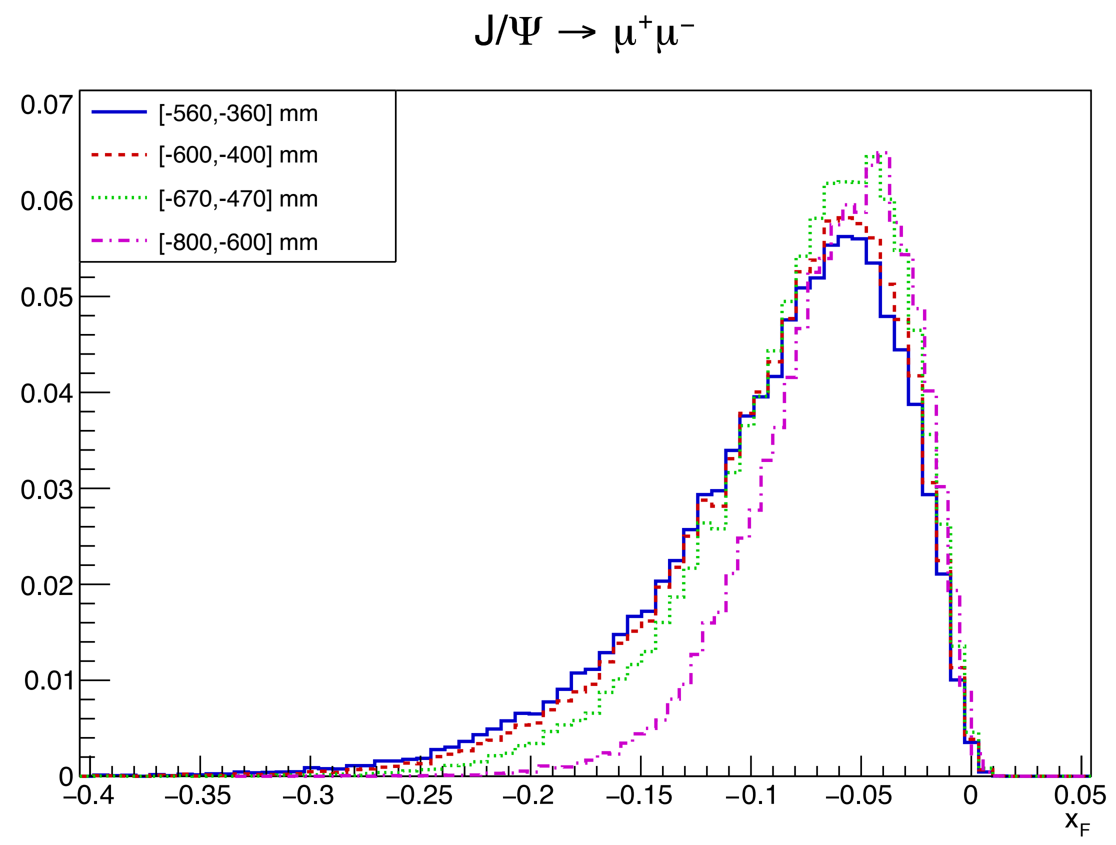
- Cylindrical target cell with $L = 20$ cm and $D = 1$ cm
- LHCb simulations show broader kinematic acceptance & higher efficiency at the same position of the SMOG2 cell
- Work ongoing to develop dedicated trigger lines and to improve reconstruction algorithms for the Run 3

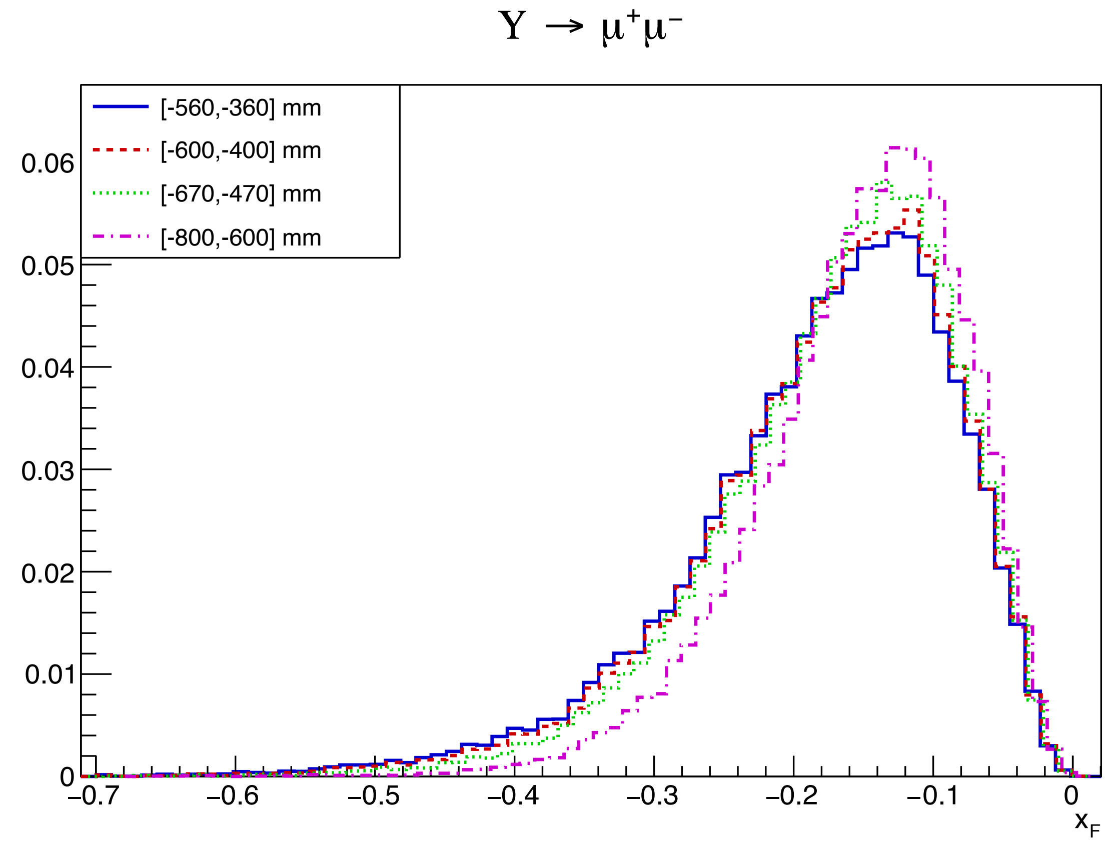


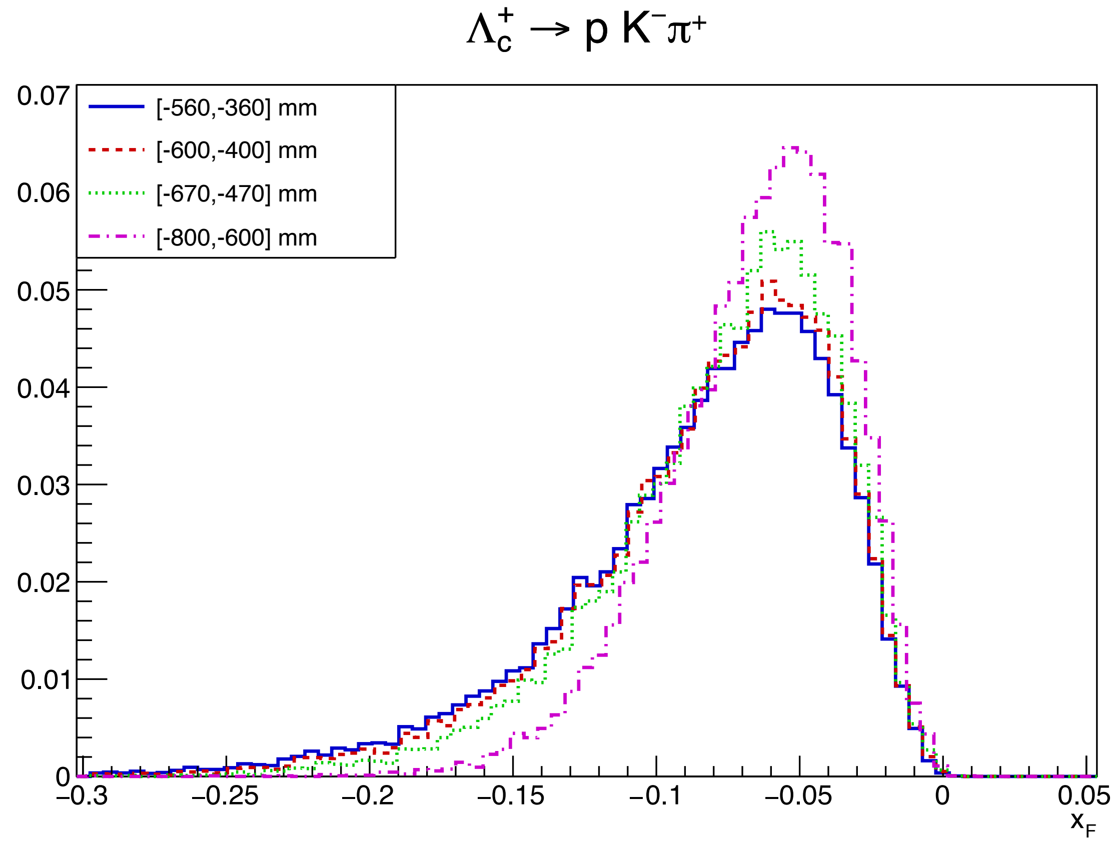


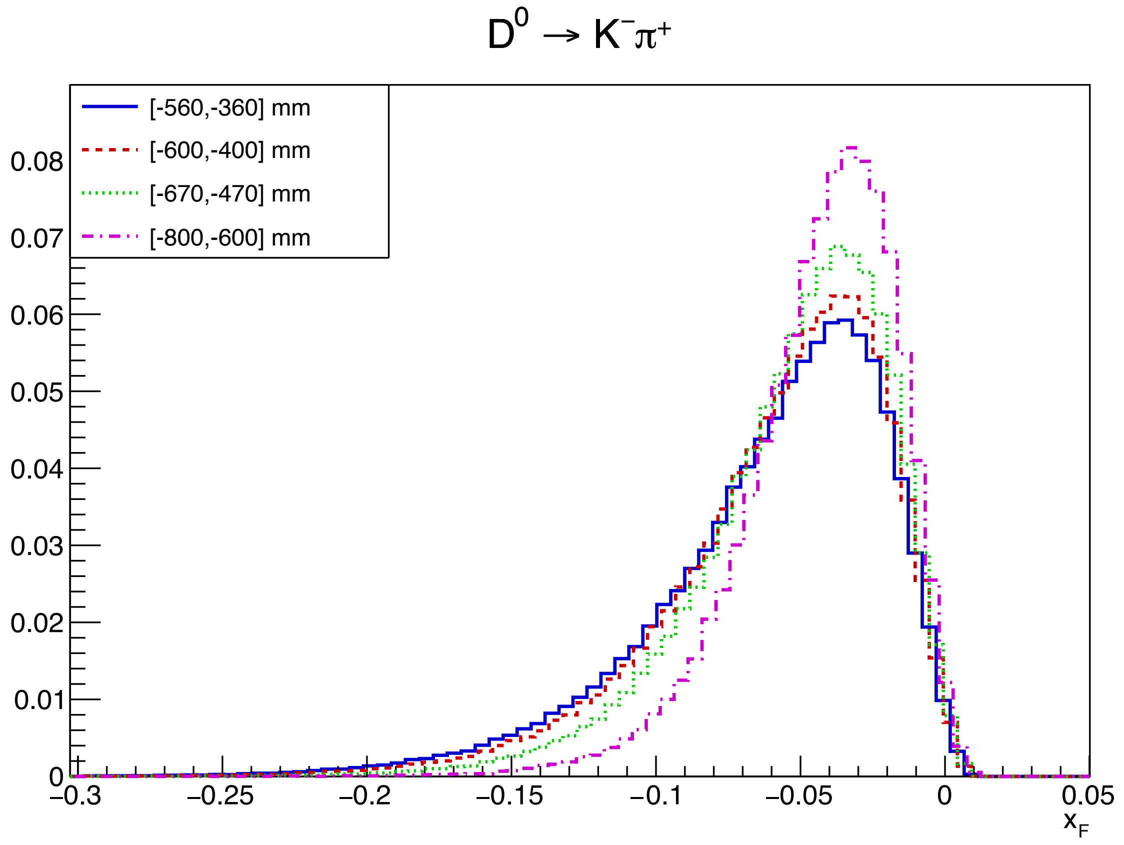


Kinematic coverage overview



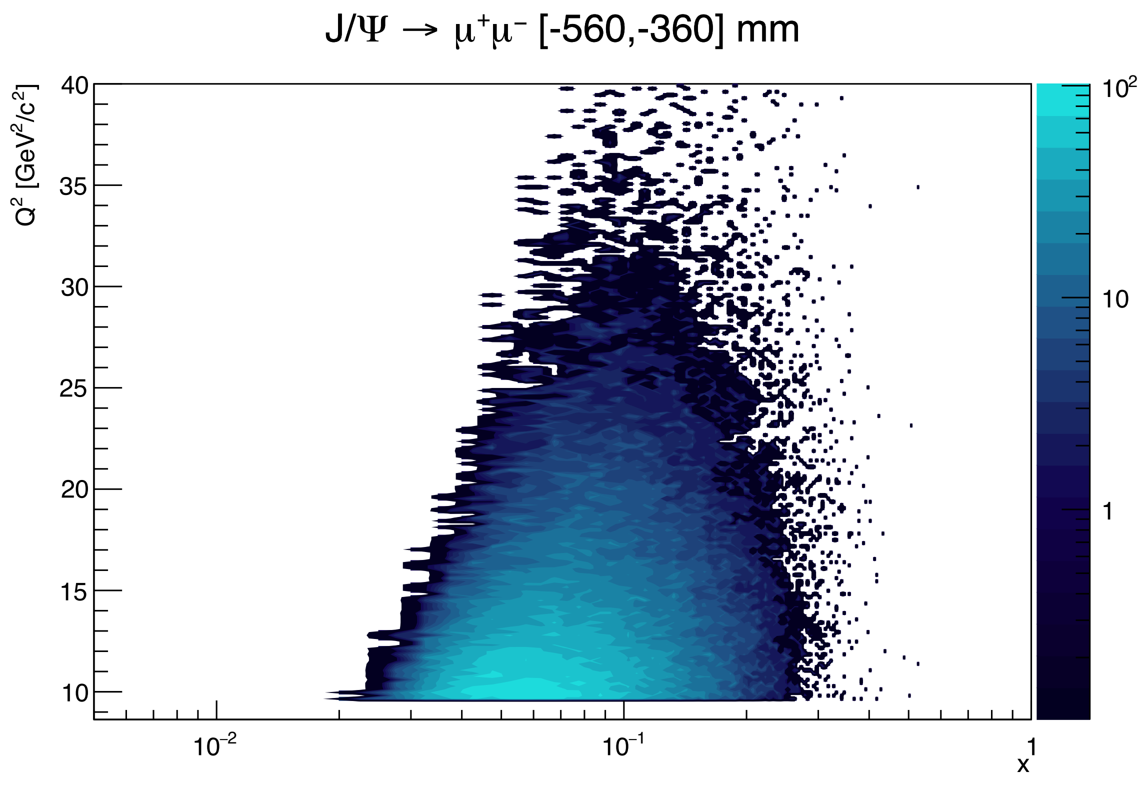


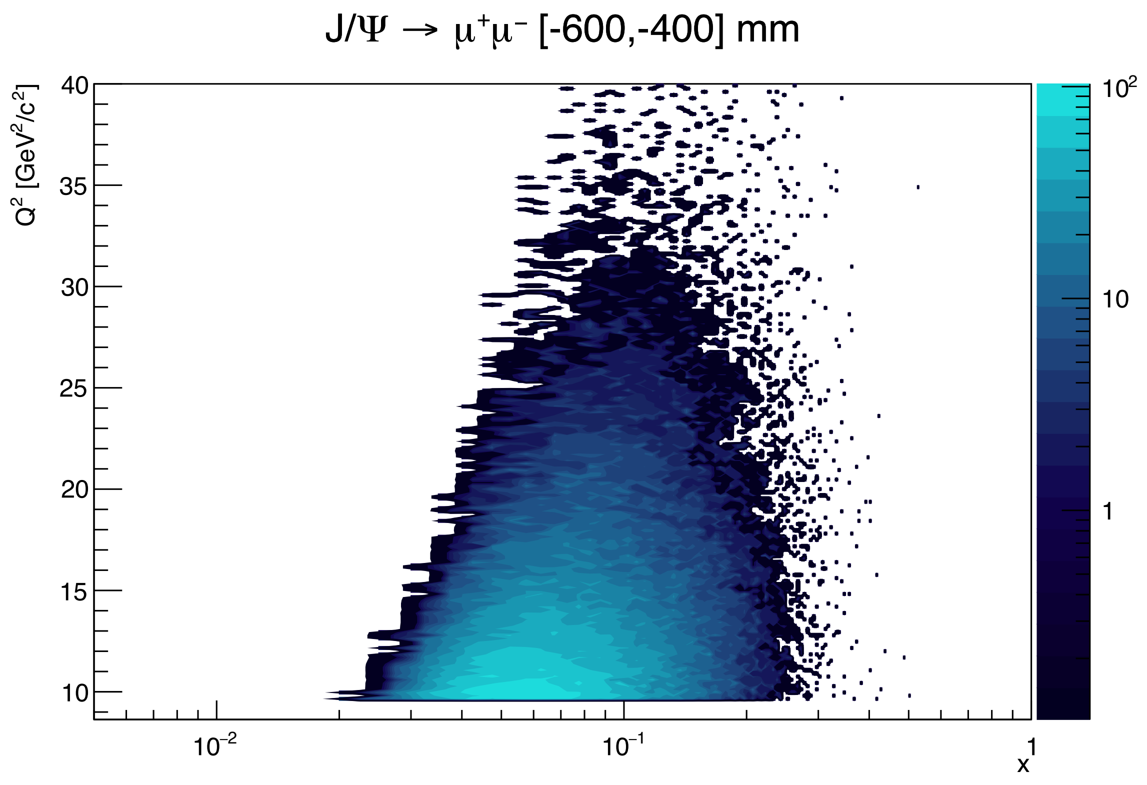


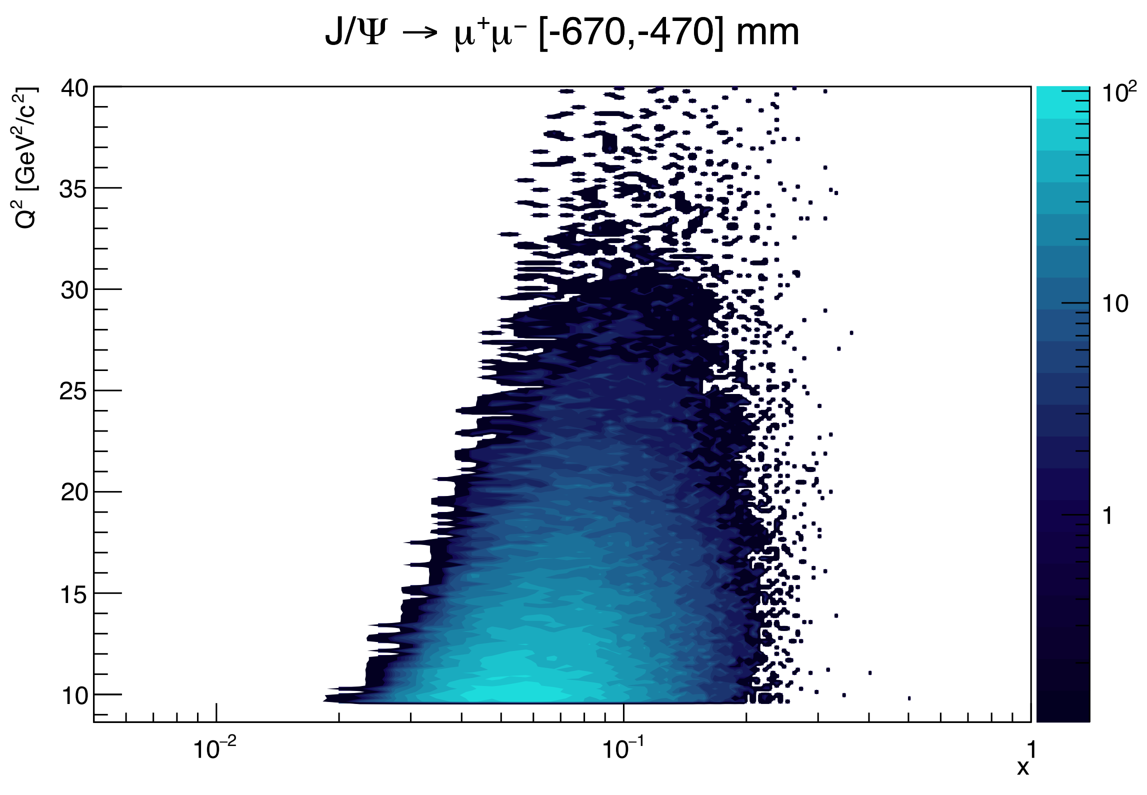


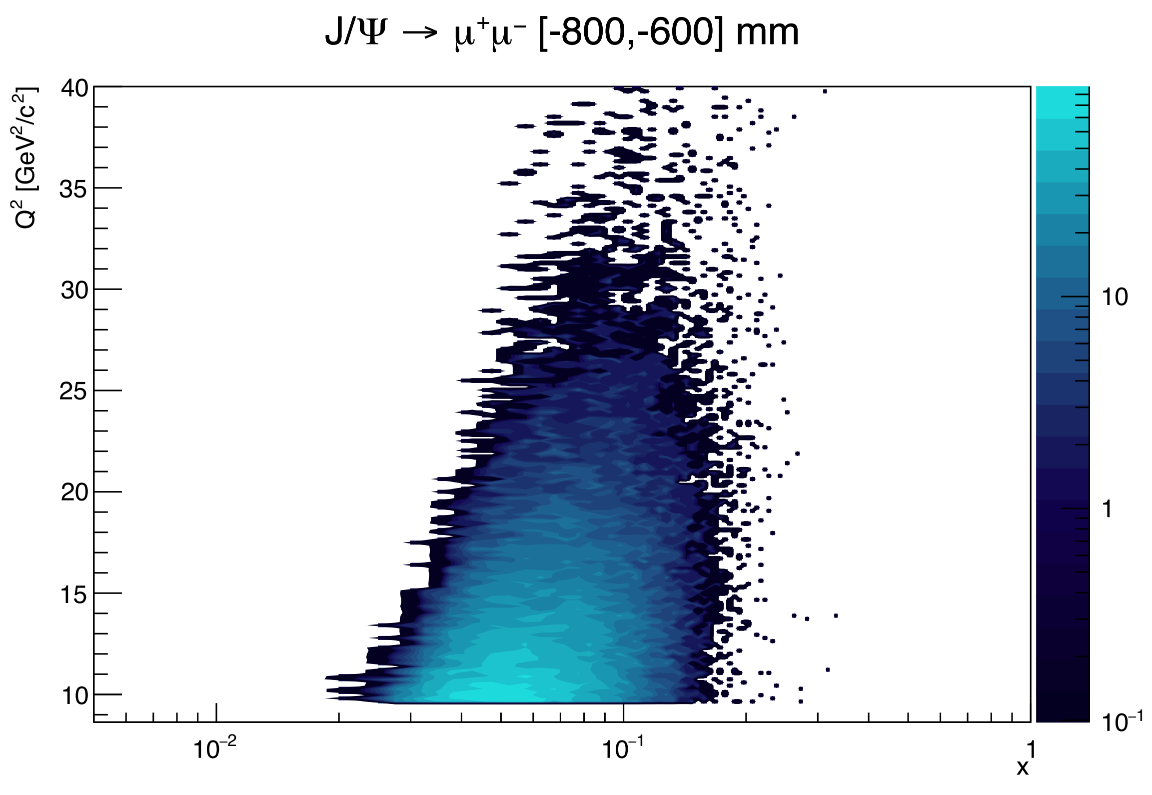
- LHCb p-H FT simulations at $\sqrt{s} = 115$ GeV
- Actual SMOG2 region $[-560, -360]$ mm as a reference, $[-670, -470]$ mm a possible solution to fit the LHCspin setup
- The kinematic coverage depends on the cell position: p_T slightly affected, x range shrinks when moving away from the VELO

- $J/\psi \to \mu^+\mu^-$ $x - Q^2$ vs cell position



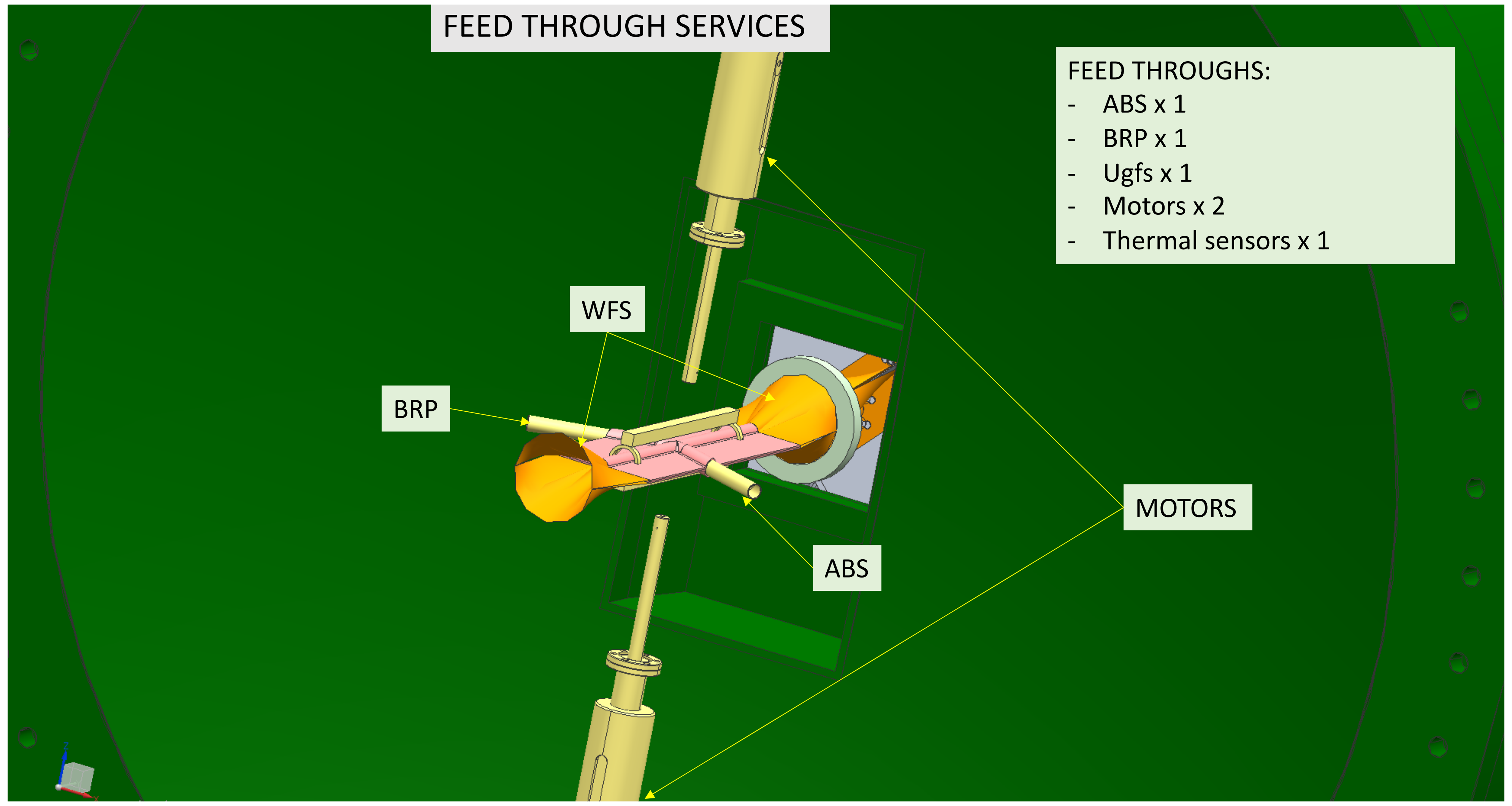


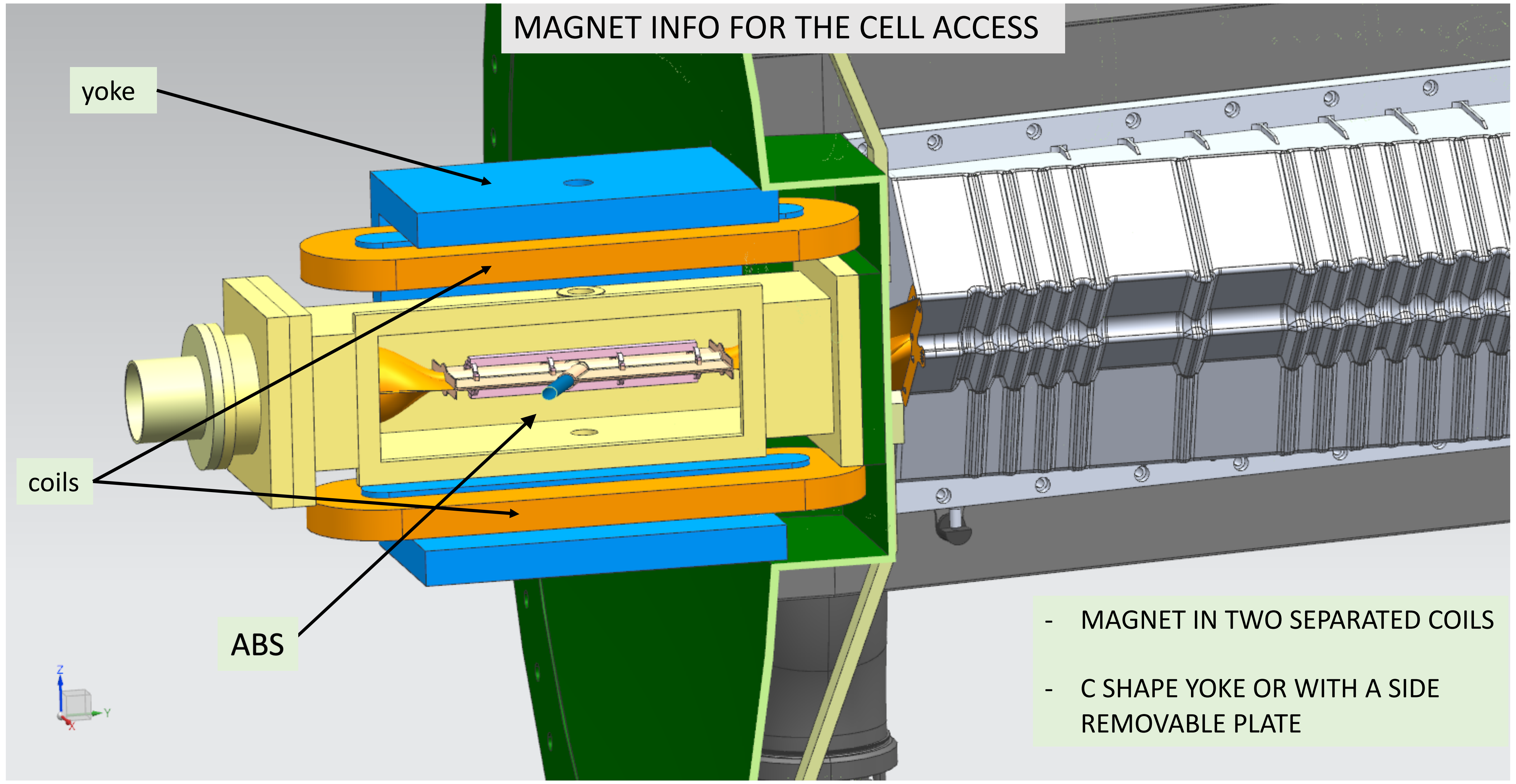




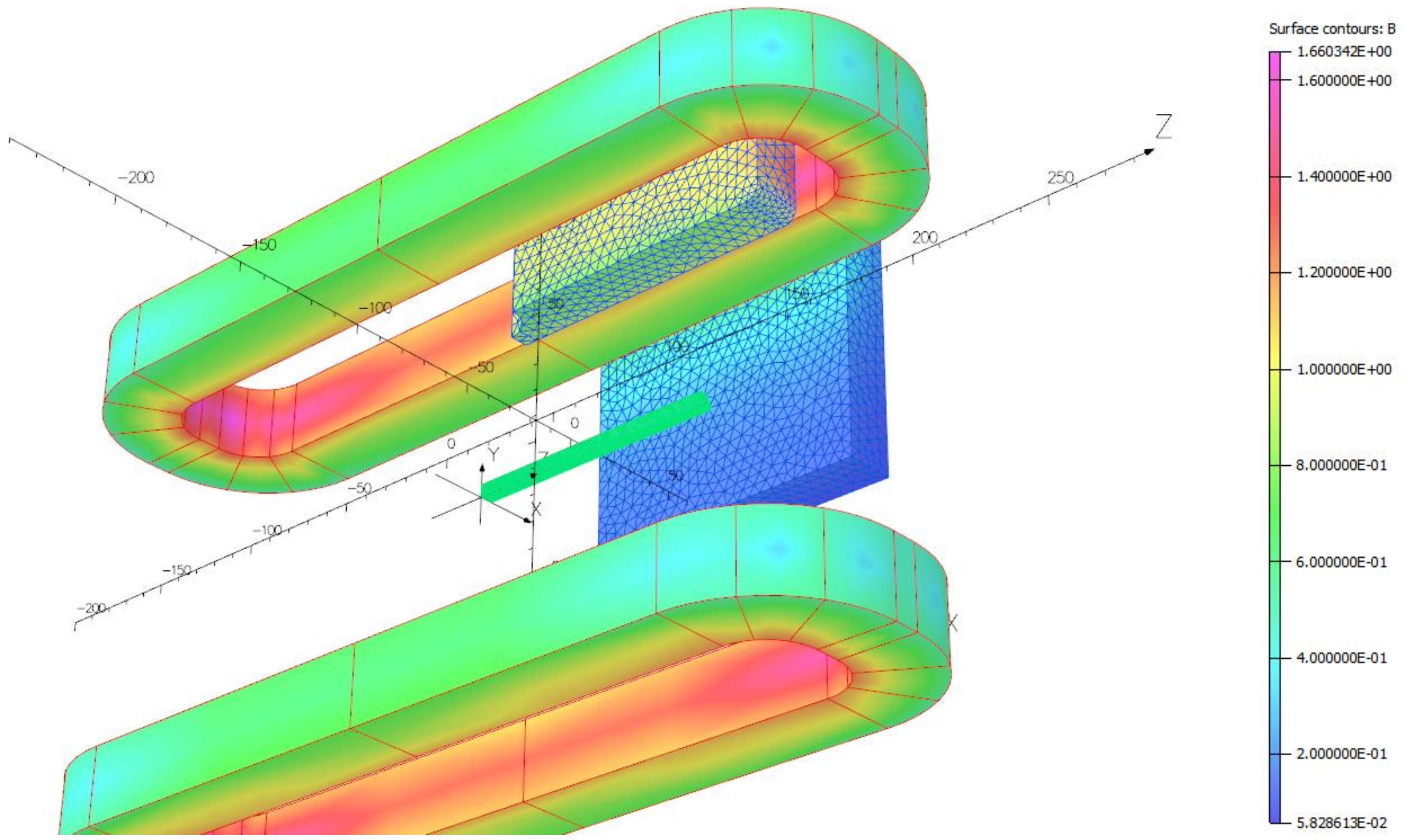
The Polarised Gas Target

- Inject both polarised and unpolarised gases via ABS and UGFS

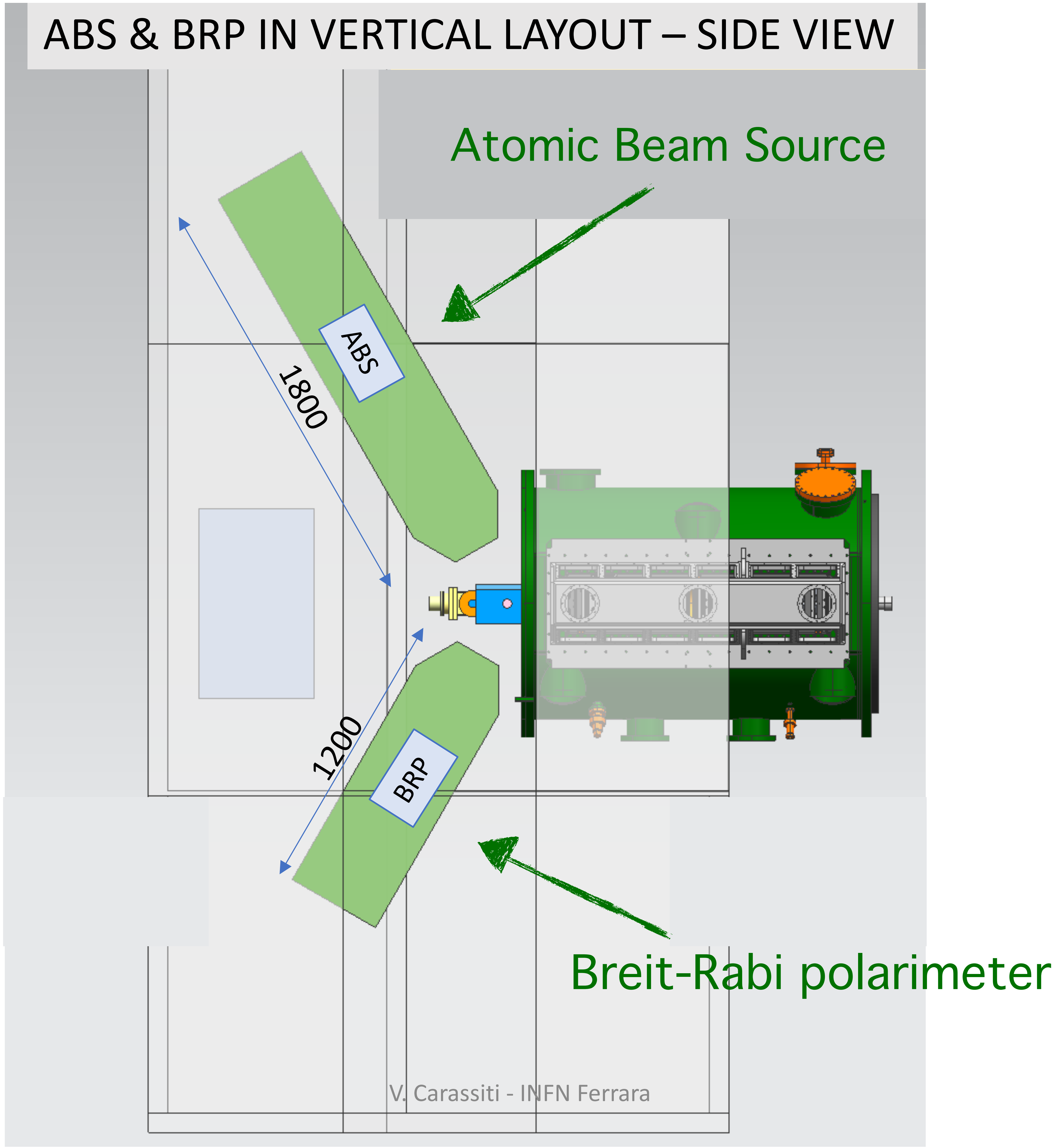




- Compact dipole magnet → static transverse field
- Superconductive coils + iron yoke configuration fits the space constraints
- $B = 300$ mT with polarity inversion
- $\Delta B/B \simeq 10\,\%$, suitable to avoid beam-induced depolarisation [PoS (SPIN2018)]
- Possibility to switch to a solenoid and provide longitudinal polarisation (e.g. in Run 5)



ABS and BRP R&D



- Reduce the size of both ABS and BRP to fit into the available space in the LHCb cavern: a challenging R&D!
- No need for additional detectors to LHCb: only a modification of the VELO flange is required
- Aiming at: [NIMA 540 (2005) 68-101]

Polarisation degree:
$\approx 85\,\%$

Intensity of injected H-atoms:
$6.5 \times 10^{16}\ \mathrm{s}^{-1}$

Luminosity (HL-LHC):
$\sim 8 \times 10^{32}\ \mathrm{cm}^{-2}\ \mathrm{s}^{-1}$

- Alternative solution is being investigated: a jet target provides lower density but higher polarisation degree

Cell coating R&D at LNF

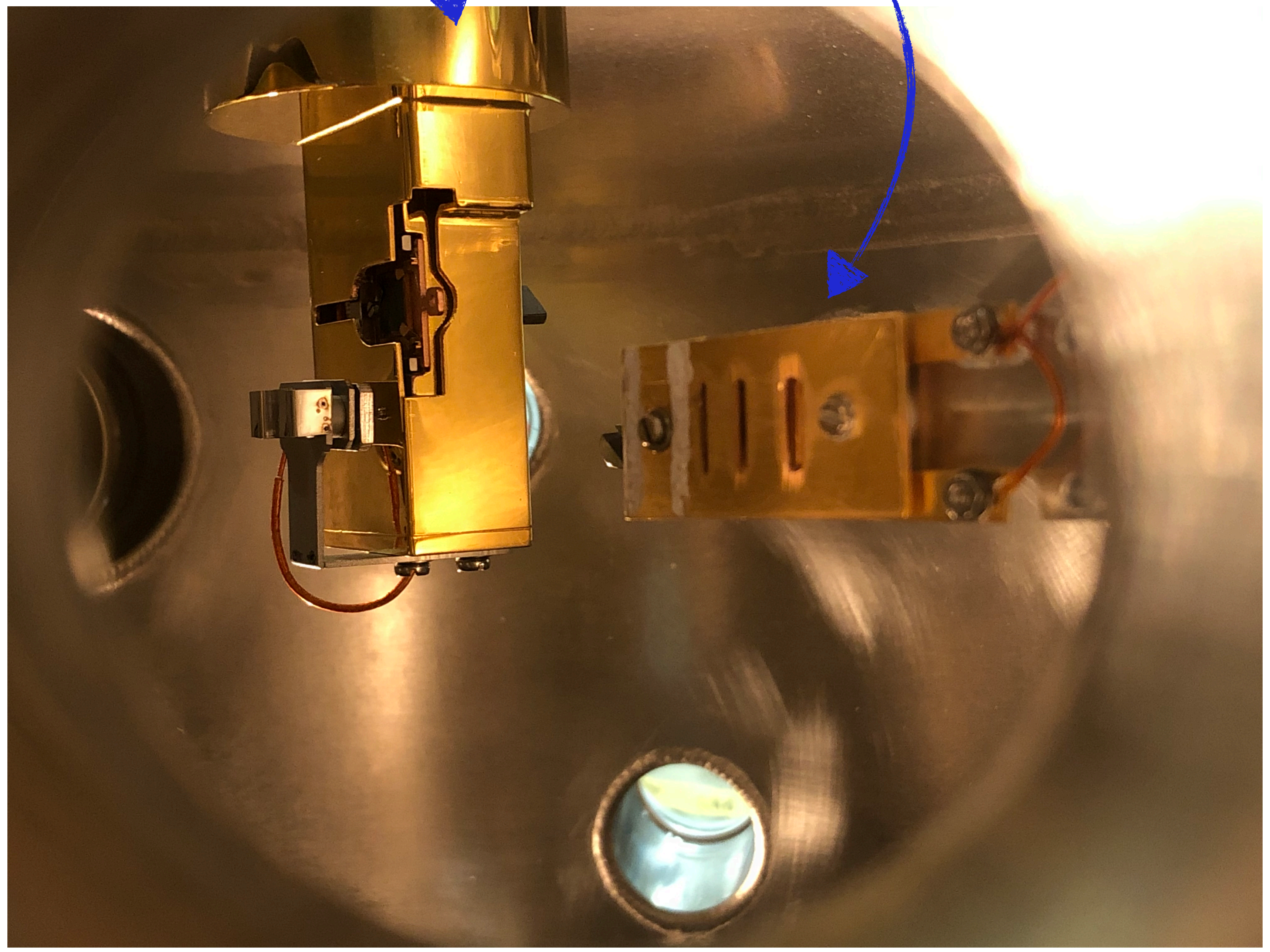
- The inner coating is a crucial aspect of the R&D and should:
  A. Minimise e-cloud related instabilities → measurements of Secondary Electron Yield (SEY)
  B. Minimise H depolarisation due to interactions with the walls → measurements of H recombination

Goal of the ARYA project at LNF:

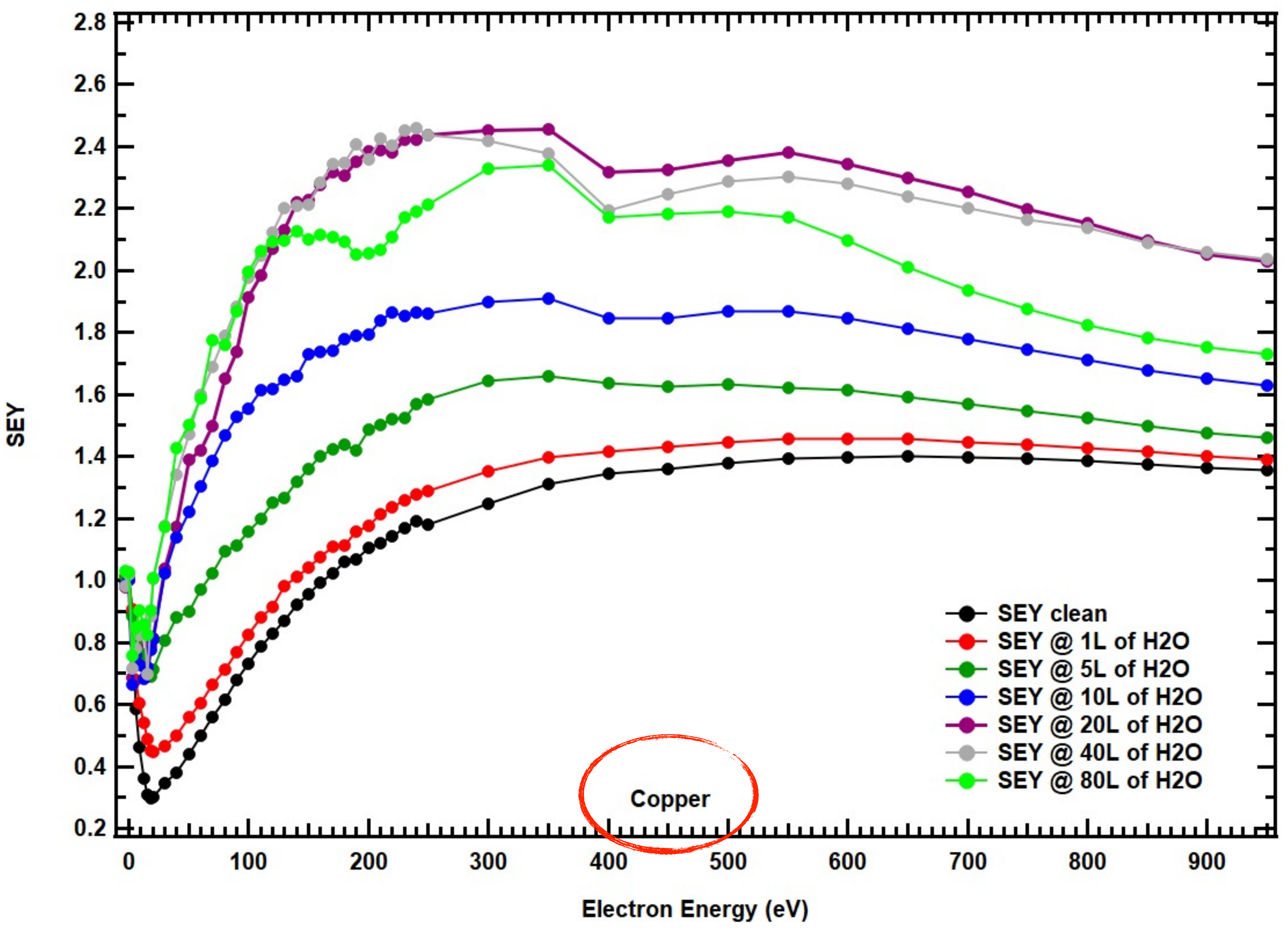
- Teflon and Drifilm are not compatible with LHC, while amorphous carbon (a-C) may induce depolarisation: a possible solution to the above issues foresees a thin H_2O layer on carbon-coated walls
- Renewable surface but requires cooling (~100K): higher SEY but less recombination is expected
- Installed a UHV-compatible ultrapure H_2O dosing system
- Measuring SEY as $\delta = I_{out}/I_{in}$ with an electron gun on the target vs H_2O dose

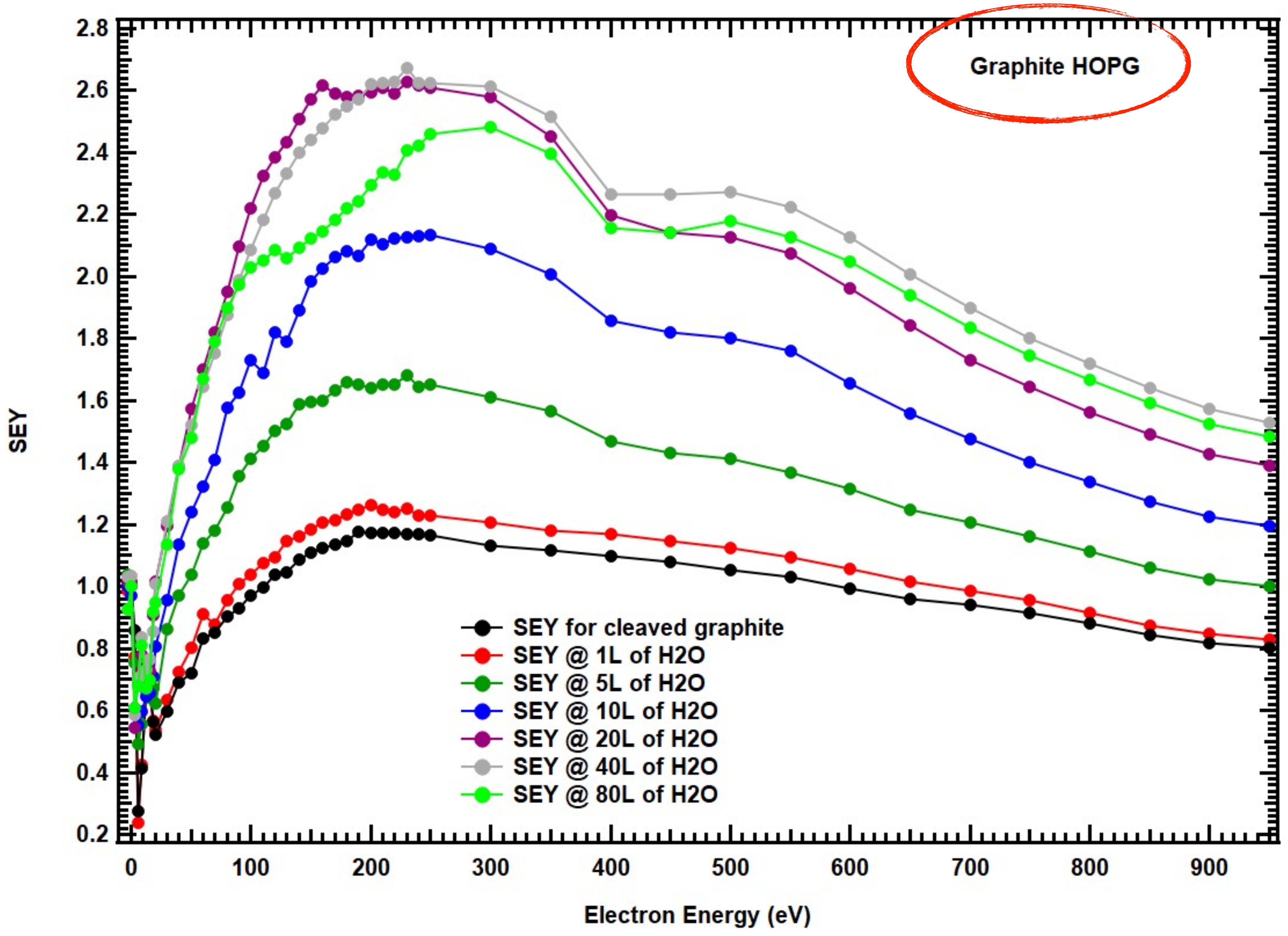
sample

Faraday gate



SEY curves

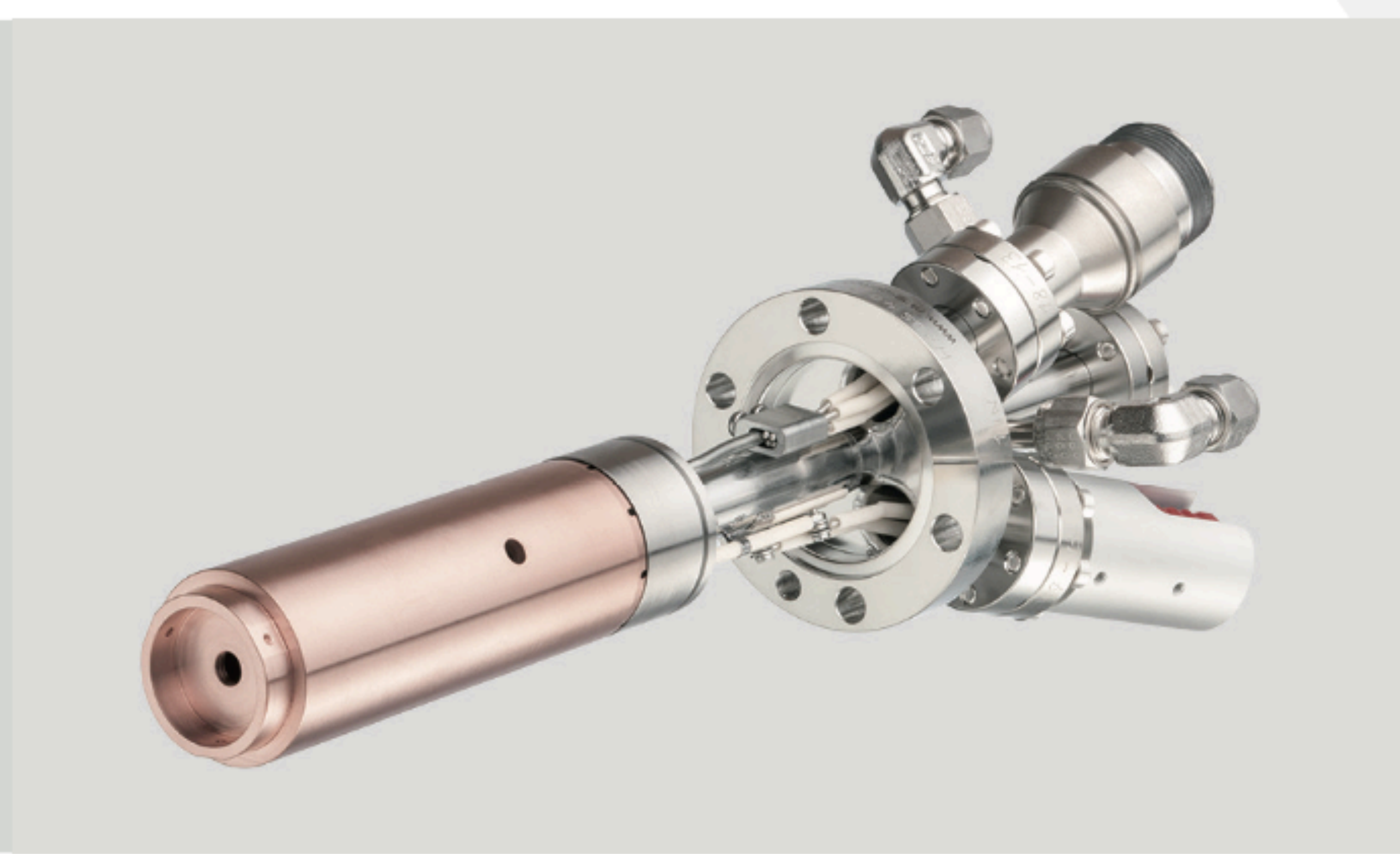




- Measuring SEY vs incident electron energy for copper (reference) and HOPG + 1,4,10,20,40,80 monolayers of H_2O at 90K
- SEY max 2.6: impact on LHC is under evaluation
- Next: measurements on the actual CERN a-C sample, measurement of H recombination

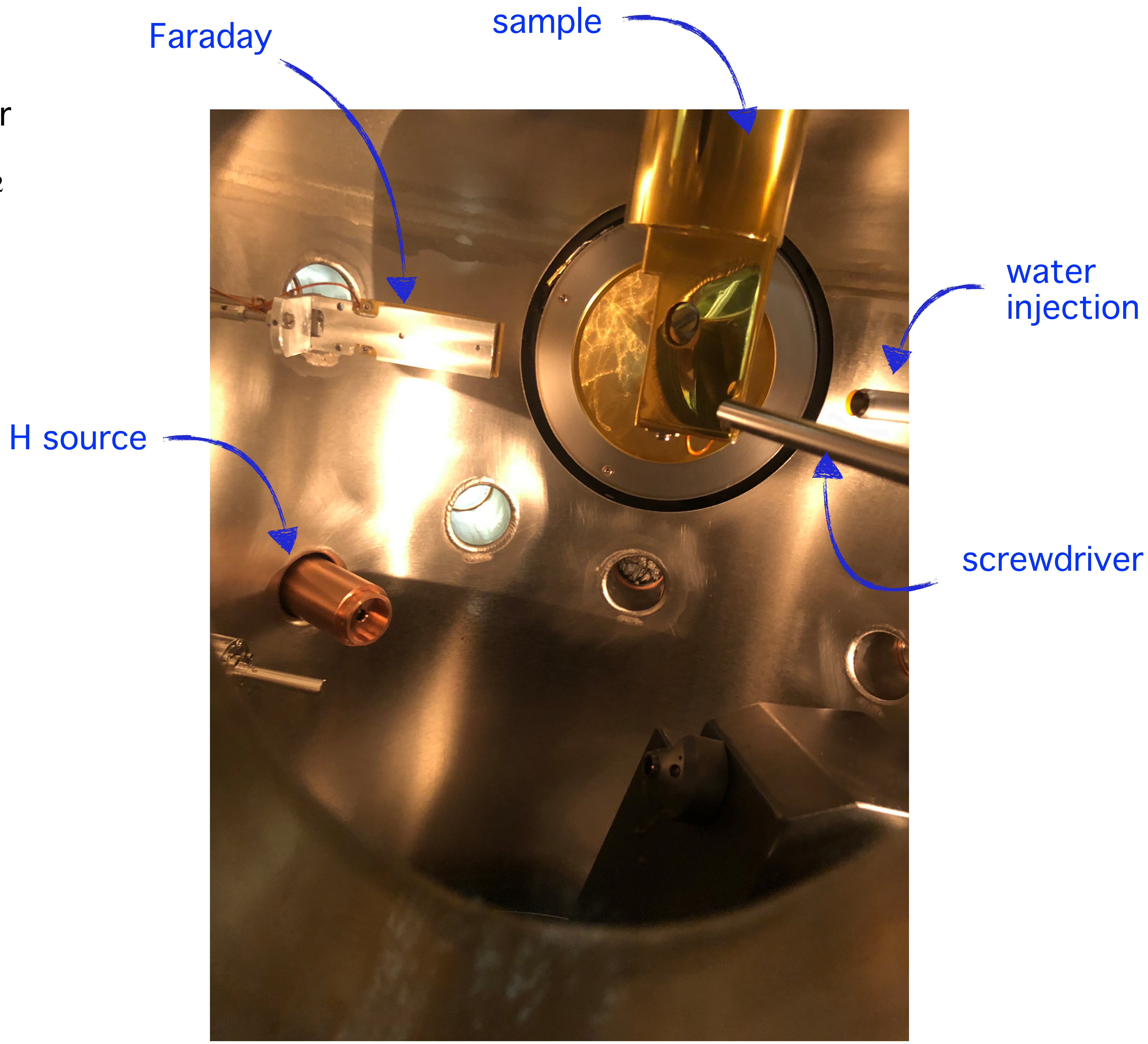
H recombination

- With the same setup, inject H by means of an atomic source
- Measure the H/H_2 fraction vs H_2O dose with a mass spectrometer
- Assuming depolarisation occurs when H atoms recombine into H_2
  → useful input for the depolarisation property of the surface



HABS 40 on DN40CF (O.D. 2.75") flange

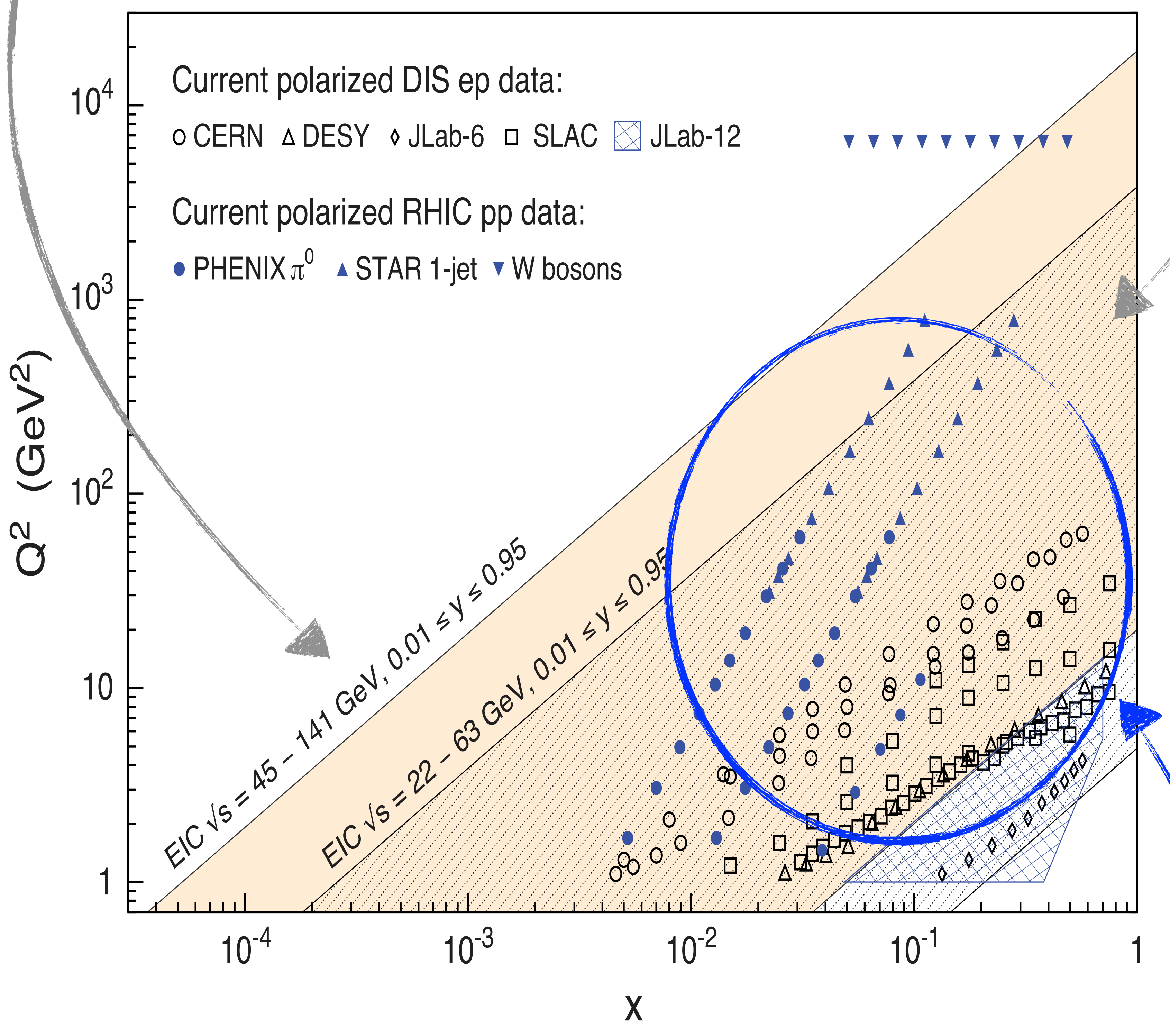
- H_2 dissociation typically 80 to 98%, depending on operation conditions
- Atomic H-flux density up to $10^{16}/cm^2s$
- No high-energy particles and ions
- Low power consumption (P < 200 W)
- Integrated water cooling, low thermal load on other experimental equipment



- More informations in: [these slides by R. Cimino]

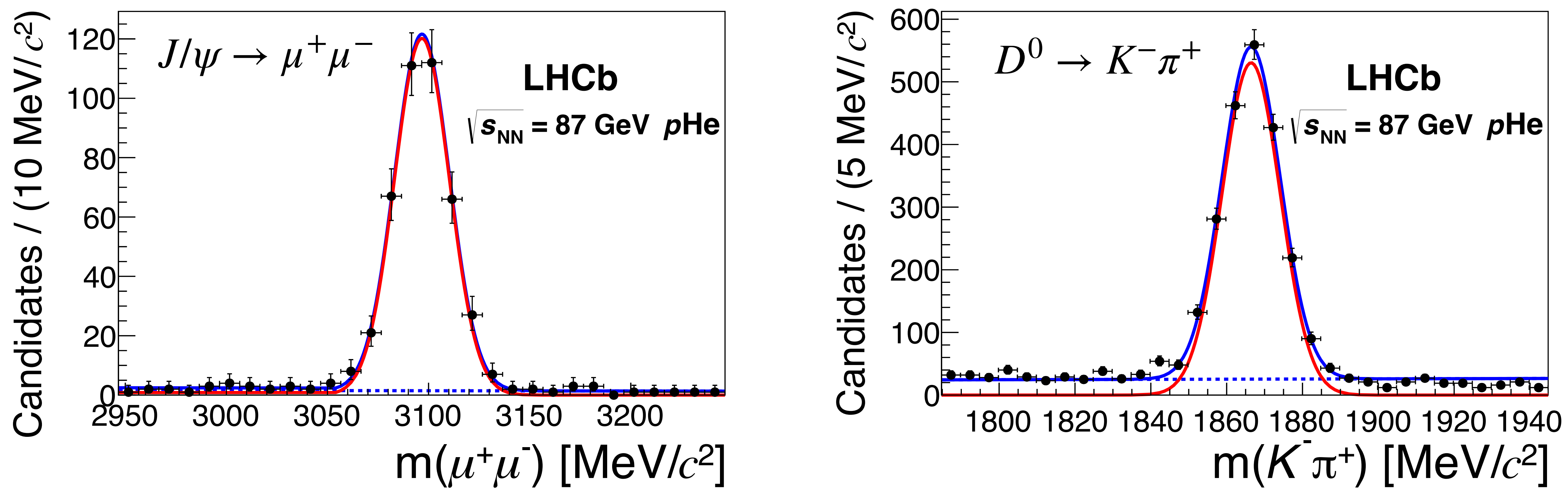
LHCspin physics: overview & expected rates

- Complementarity is the key:
- 12 GeV JLab probing high-x, low Q^2
- EIC measurements to focus on low-x
- higher Q^2 reach with future EIC upgrade



- LHCspin to best cover mid to high x at intermediate Q^2 with unique probes

- An example of SMOG data from 2016: $7.6\ \mathrm{nb}^{-1}$ in just 87 h
- Very clean samples of $\sim 400\ J/\psi \to \mu^+\mu^-$ and $\sim 2000\ D^0 \to K^-\pi^+$



[PRL 122 (2019) 132002]

- Expected signal statistics at LHCspin at the end of Run 4 (Run 4 + Run 5) with pH collisions:

Channel	Events / week	Total events
$J/\psi \to \mu^+\mu^-$	194k (434k)	23M (75M)
$\psi(2S) \to \mu^+\mu^-$	3.5k (7.7k)	414k (1.3M)
$D^0 \to K^-\pi^+$	976k (2.2M)	117M (380M)
$J/\psi J/\psi \to \mu^+\mu^-\mu^+\mu^-$	8 (17)	930 (3000)
Drell Yan ($5 < M_{\mu\mu} < 9$ GeV)	110 (250)	13k (43k)
$\Upsilon \to \mu^+\mu^-$	80 (190)	10k (32k)
$\Lambda_c^+ \to pK^-\pi^+$	19k (43k)	2.3M (7.5M)

- Huge statistics: precise spin asymmetries in a few weeks!

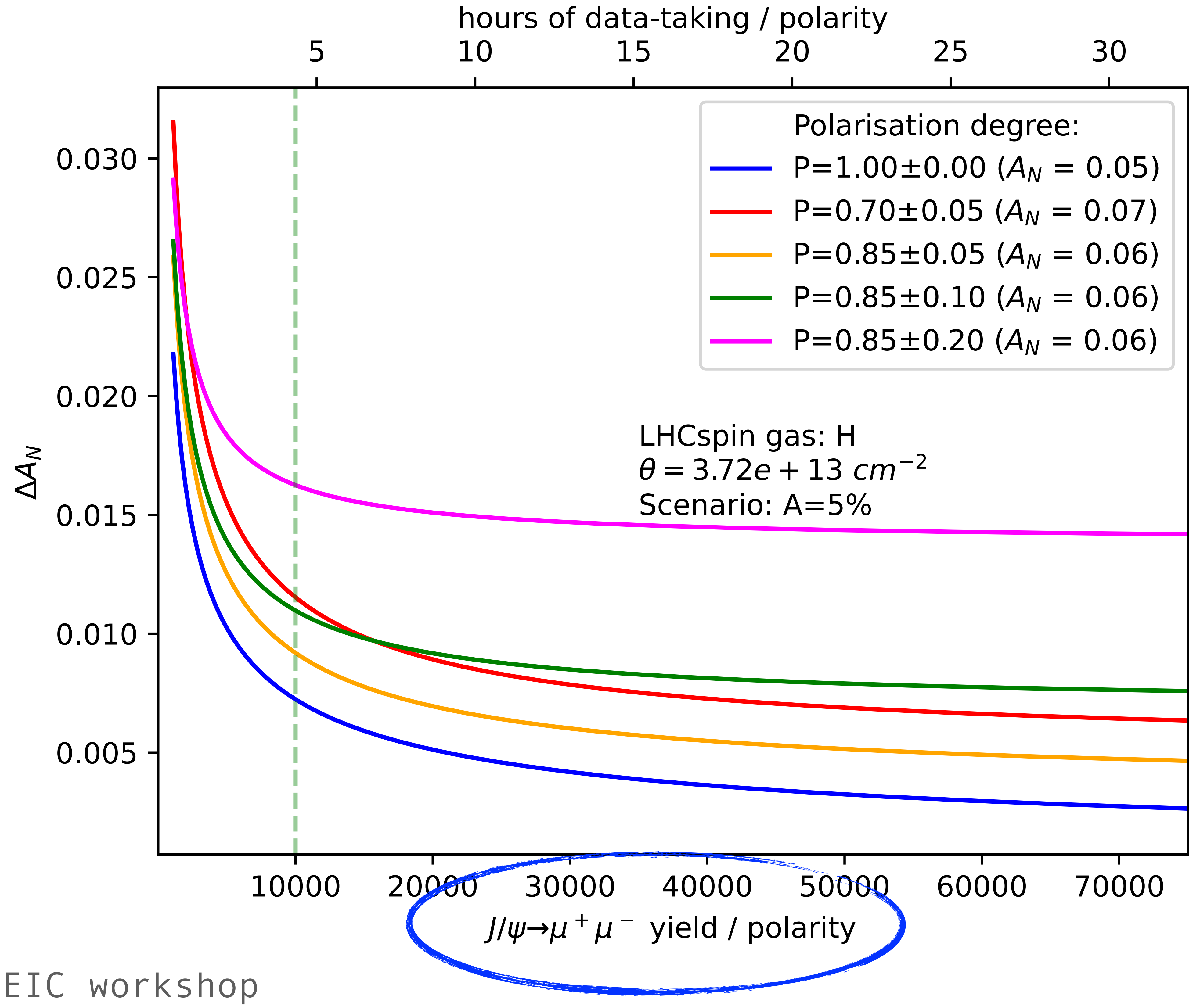
LHCspin: expected precision on A_N

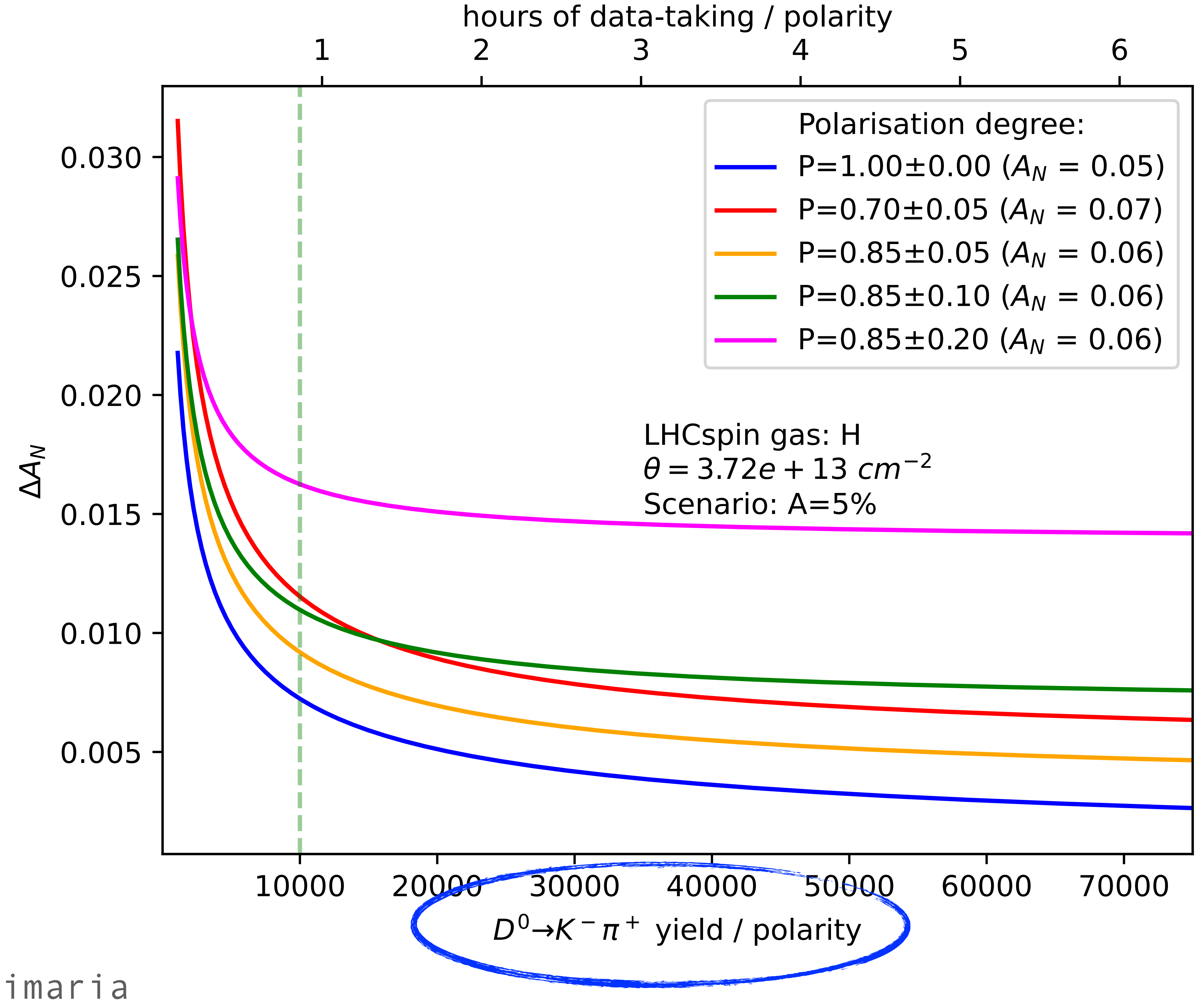
- Quick look at expected statistics in terms of a spin asymmetry:

$$A_N = \frac{1}{P}\frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

- Projected uncertainty on TSSA with different polarisation degrees

- Run4: precise spin asymmetry on $J/\psi \to \mu^+\mu^-$ for $pH^{\uparrow}$ collisions in just a few hours!
- Statistics further enhanced by a factor $\sim 3-5$ in Upgrade II
- More detailed TSSA analysis in the following slides

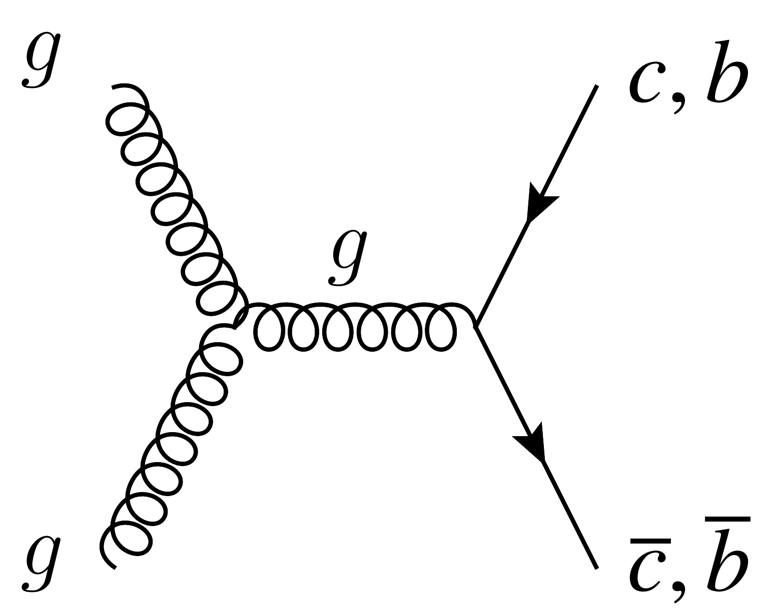


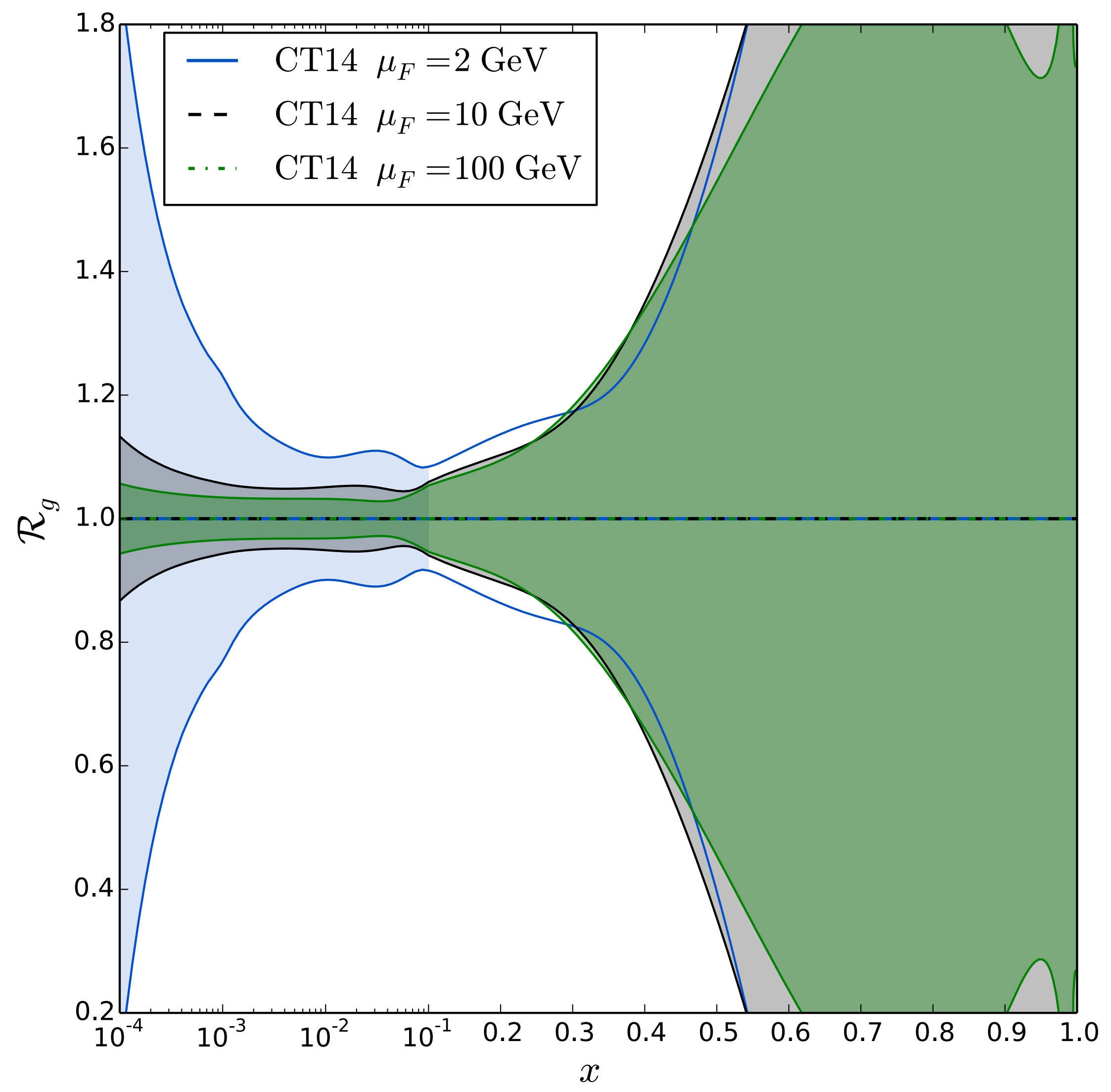


Unpolarised gases: PDFs

- high-x nucleon and nuclei structure is poorly known at all scales

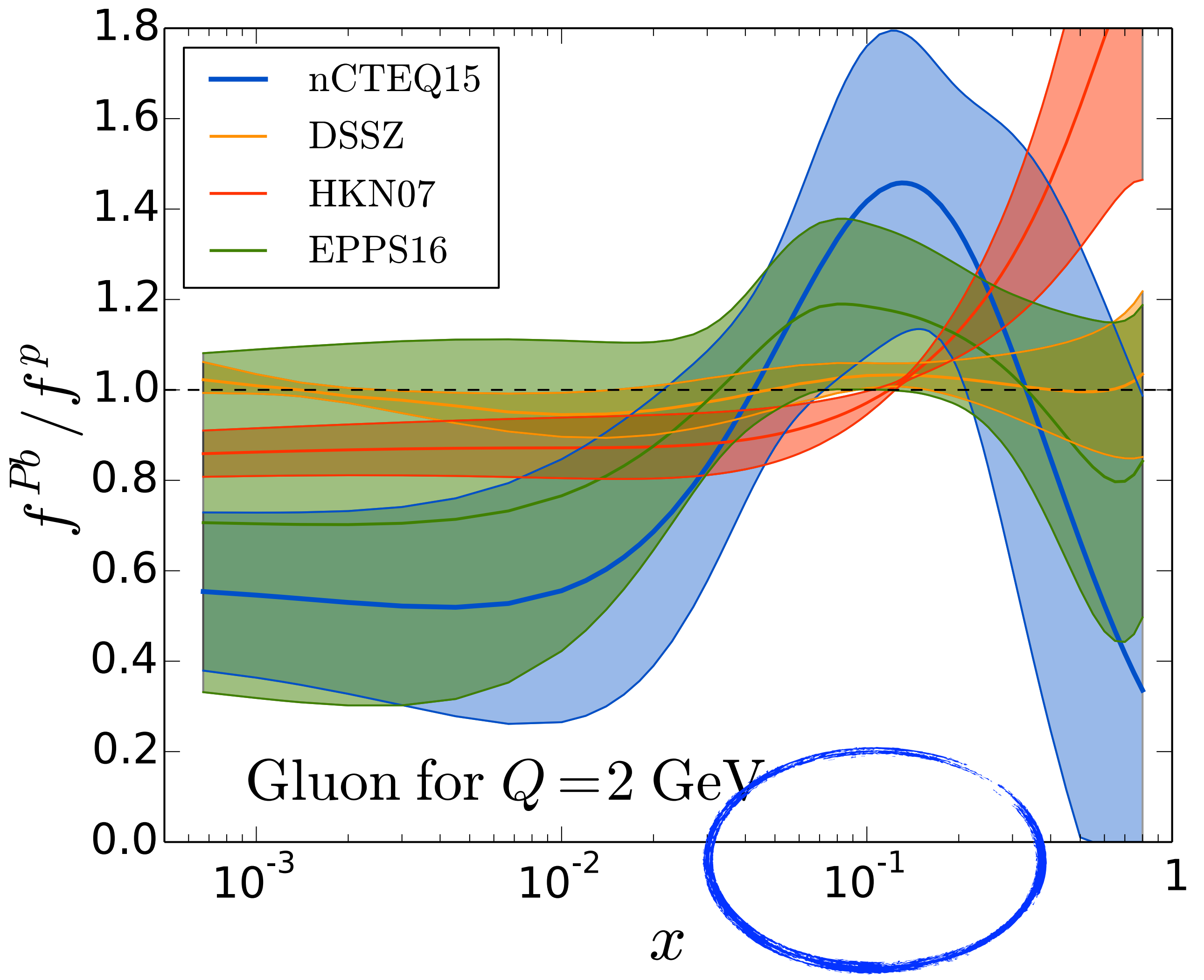
- Gluon PDFs are least known, accessed with heavy flavours: a strength point of LHCb!
- Probe quark PDFs via W production (~300/y)





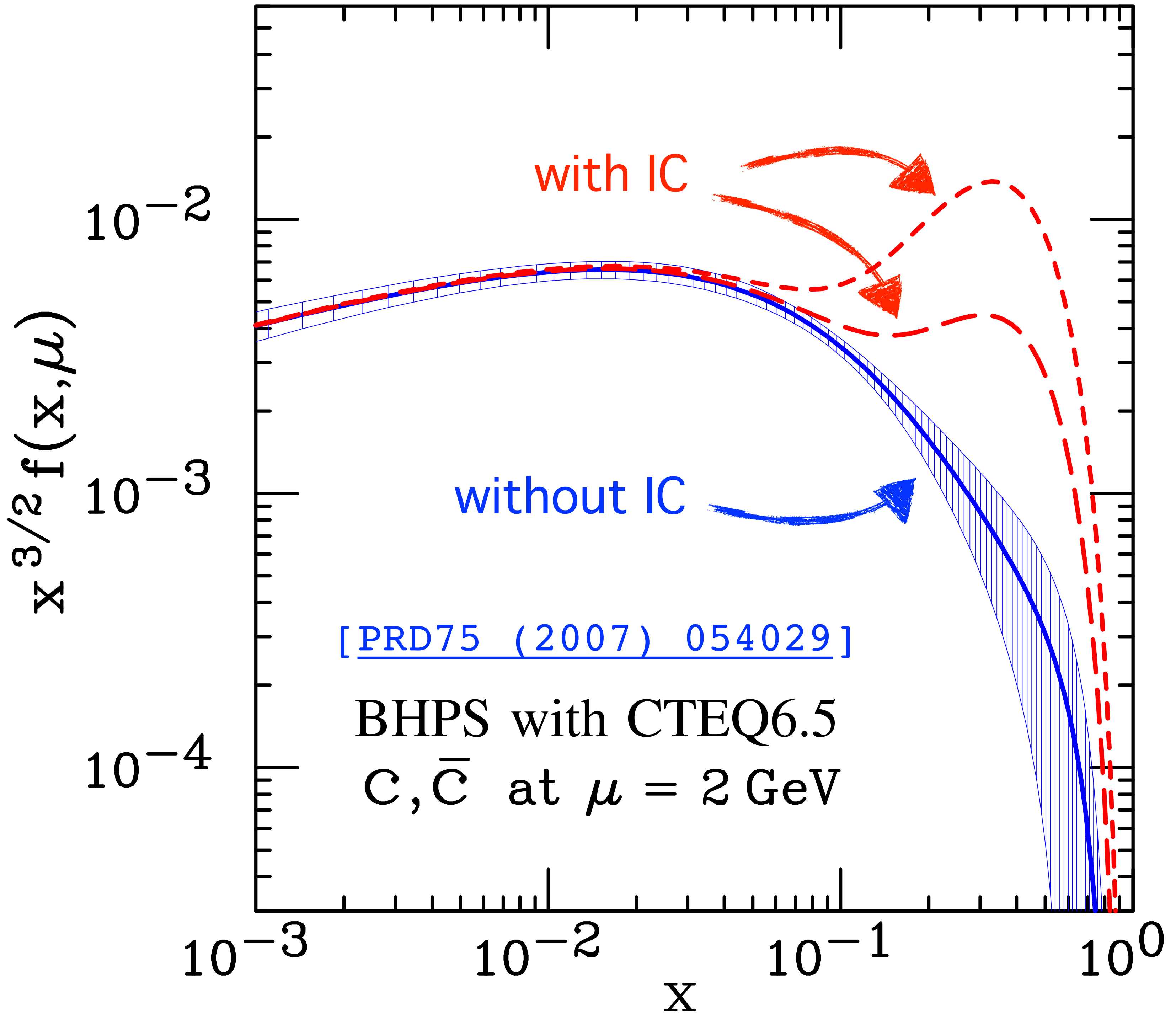
[PRD 93 (2016) 033006]

- Investigate the EMC effect → get more insight into the anti-shadowing region ($x \sim 0.1$)



[ArXiv:1807.00603]

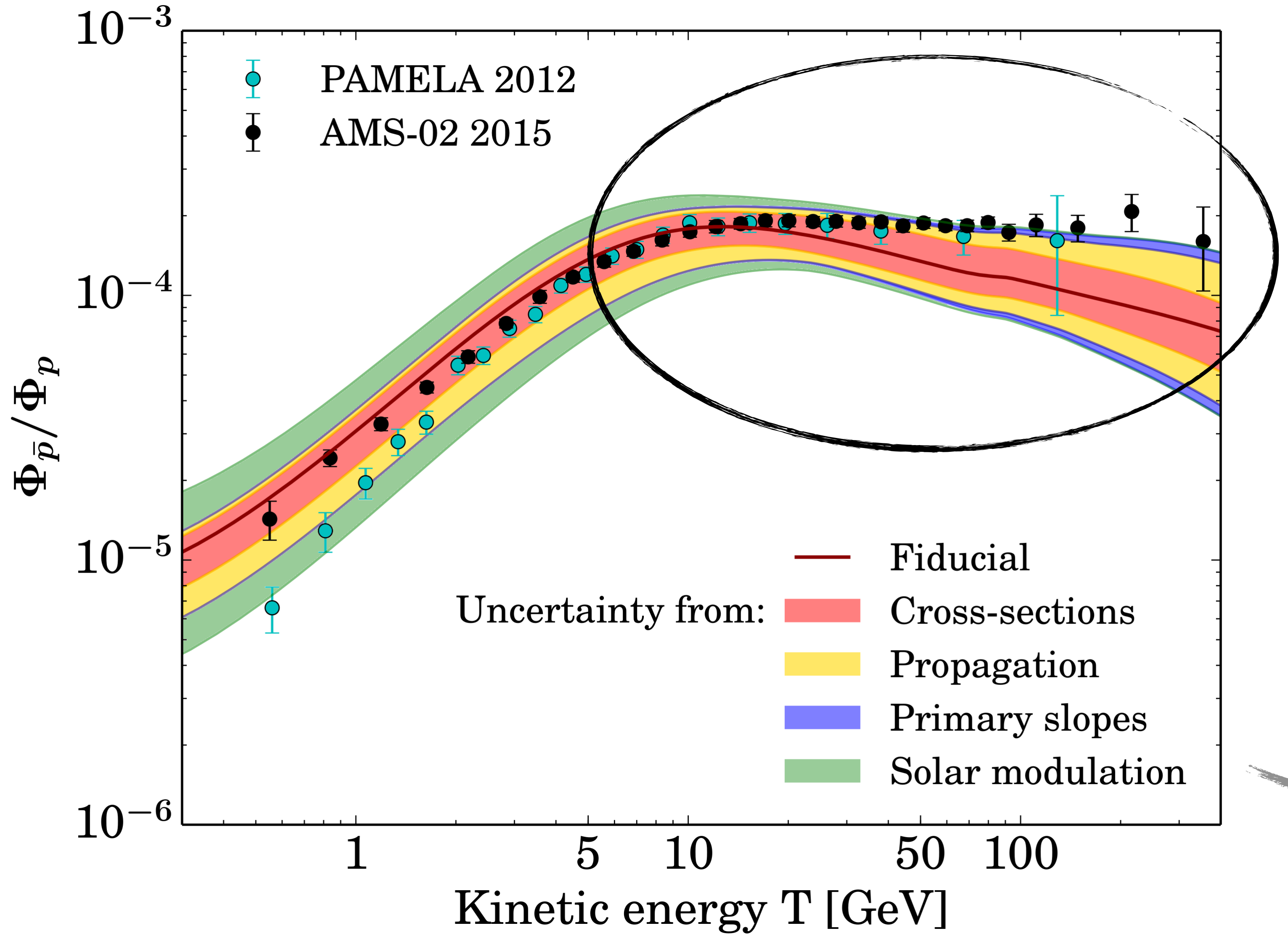
- Intrinsic Charm (IC) component in the proton can be large at $x > 0.1$
- First search performed with SMOG: [PRL 122 (2019) 132002]



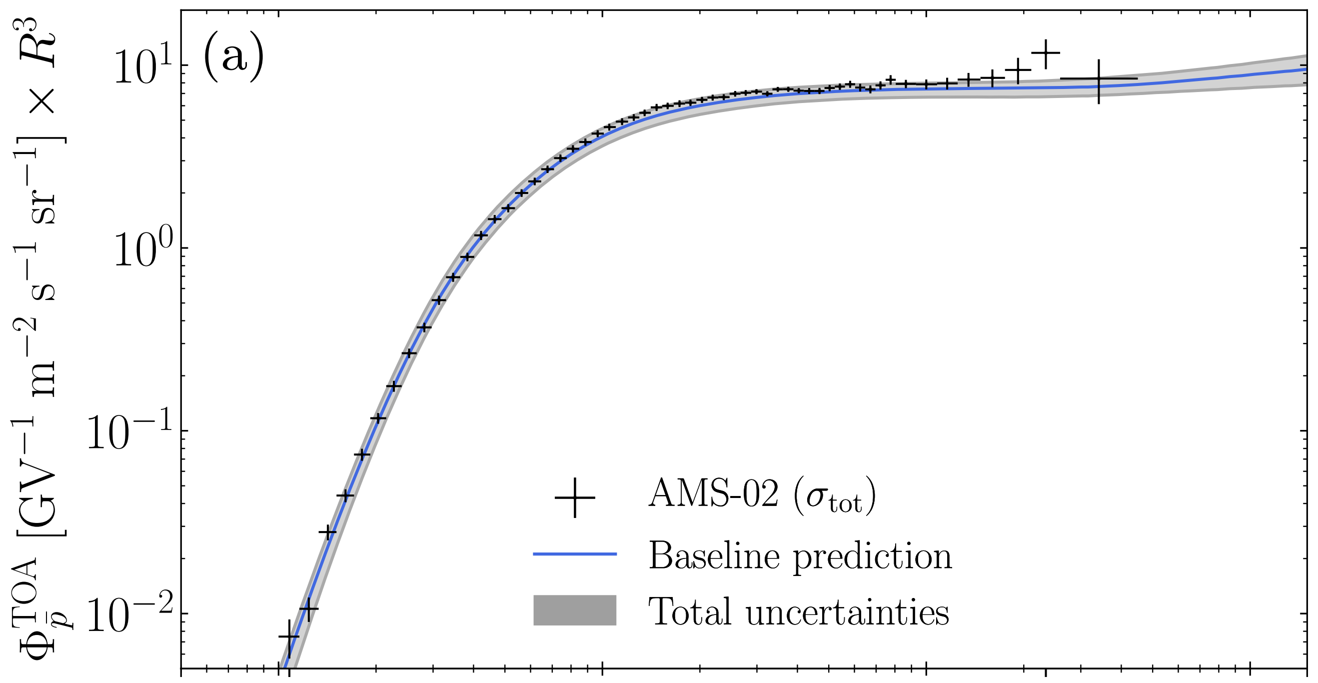
Unpolarised gases: impact on astrophysics

- $\bar{p}$ production on pHe collisions, first measurement from SMOG helped the interpretation of DM annihilation [PRL 121 (2018) 222001]
- New result on anti-hyperons suggest underestimate of generators [J. Sun @ QM2022]

[JCAP09 (2015) 023]

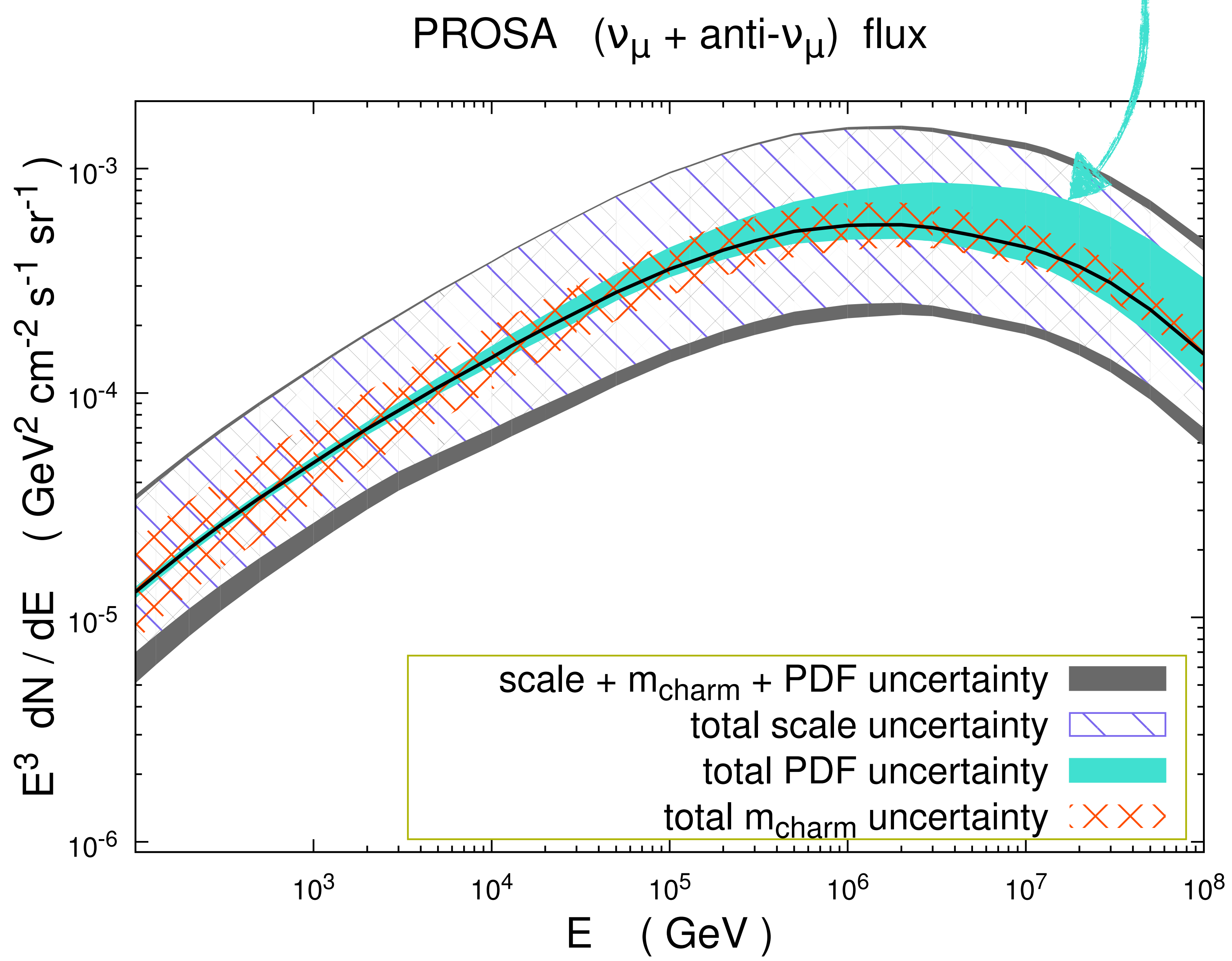


[ArXiv:1906.07119]



- Main uncertainty still due to cross sections!

- heavy-flavour hadroproduction measurements needed to improve the prompt ν_μ flux prediction at high energy



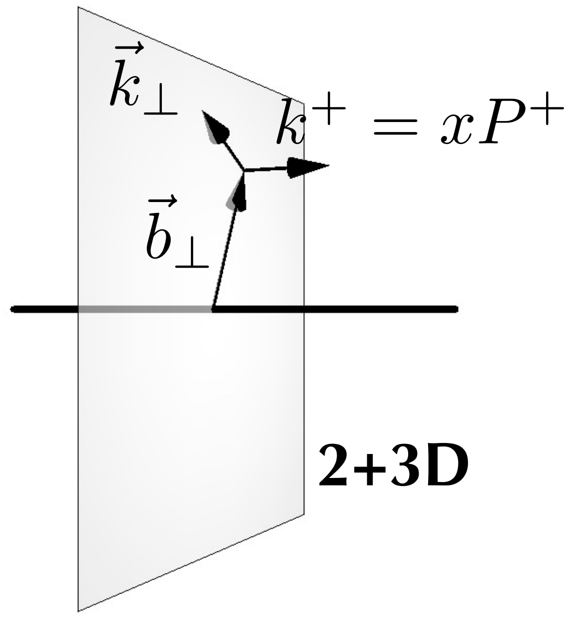
[JHEP 05 (2017) 004]

- Inputs for UHECR flux composition with pHe, pO, pN data
- ^{16}O beam foreseen for Run 3, would reproduce the actual processes:
- $^{16}\mathrm{O} + \mathrm{p} \rightarrow \bar{\mathrm{p}} + \mathrm{X}$ and $^{16}\mathrm{O} + {}^4\mathrm{He} \rightarrow \bar{\mathrm{p}} + \mathrm{X}$ [CERN-LPCC-2018-07]

- More in this → [Talk by G. Graziani]

Polarised gases: multi-dimensional nucleon mapping

- Overcome the 1D view of the nucleon and investigate its spin structure: GPDs and TMDs



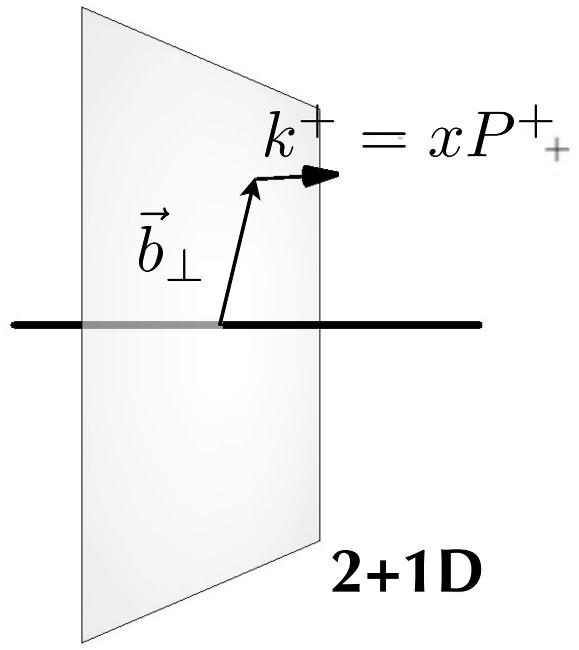
quark polarization

nucleon polarization

$\mathcal{W}_X$	U	L	T_x	T_y
U	$\langle 1 \rangle$	$\langle S_L^q \ell_L^q \rangle$	$\langle S_x^q \ell_x^q \rangle$	$\langle S_y^q \ell_y^q \rangle$
L	$\langle S_L \ell_L^q \rangle$	$\langle S_L S_L^q \rangle$	$\langle S_L \ell_L^q S_x^q \ell_x^q \rangle$	$\langle S_L \ell_L^q S_y^q \ell_y^q \rangle$
T_x	$\langle S_x \ell_x^q \rangle$	$\langle S_x \ell_x^q S_L^q \ell_L^q \rangle$	$\langle S_x S_x^q \rangle$	$\langle S_x \ell_x^q S_y^q \ell_y^q \rangle$
T_y	$\langle S_y \ell_y^q \rangle$	$\langle S_y \ell_y^q S_L^q \ell_L^q \rangle$	$\langle S_y \ell_y^q S_x^q \ell_x^q \rangle$	$\langle S_y S_y^q \rangle$

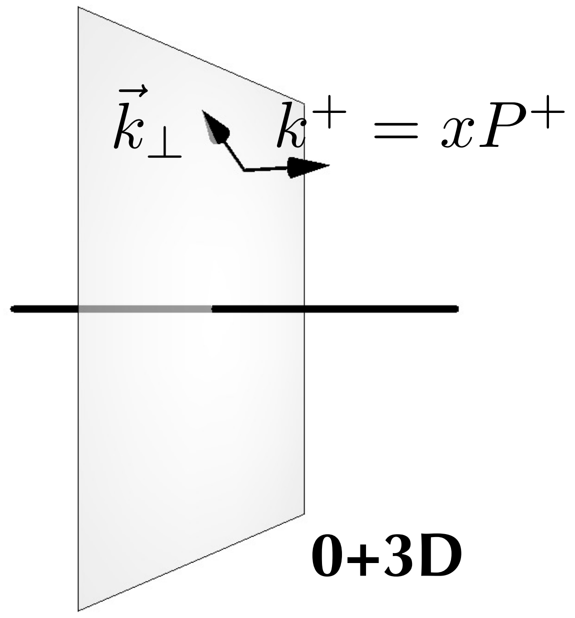
$\boxed{\xi = 0}$

$\int d^2\vec{k}_\perp$ $\int d^2\vec{b}_\perp$



GPD	U	L	T
U	H		$\mathcal{E}_T$
L		$\tilde{H}$	$\tilde{E}_T$
T	E	$\tilde{E}$	$H_T,\ \tilde{H}_T$

TMD	U	L	T
U	f_1		$h_1^\perp$
L		g_{1L}	$h_{1L}^\perp$
T	$f_{1T}^\perp$	g_{1T}	$h_1,\ h_{1T}^\perp$



[from B. Pasquini @ DIS2021]

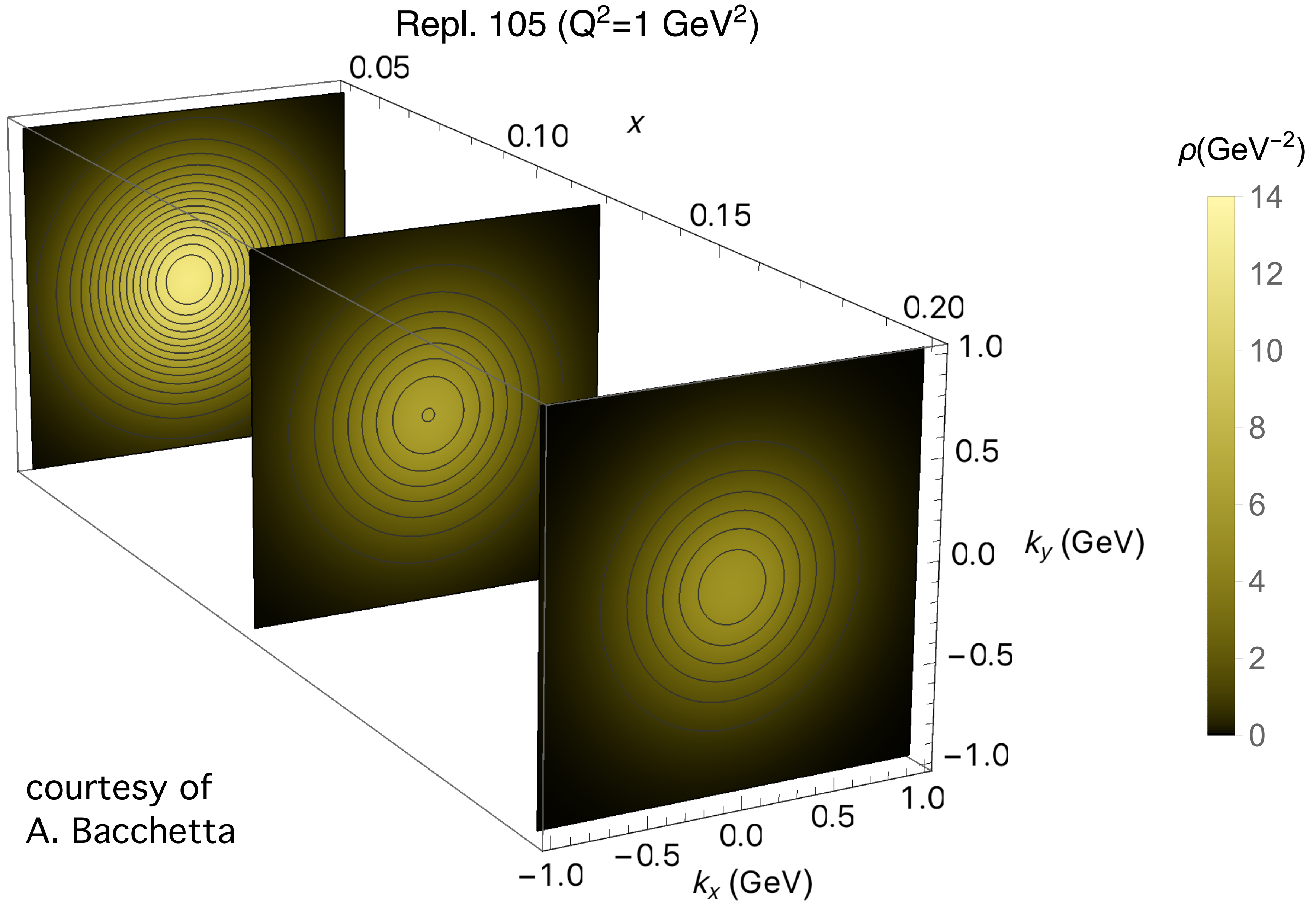
- red: vanish if no OAM

: accessible at LHCspin (dipole)

: accessible at LHCspin (solenoid)

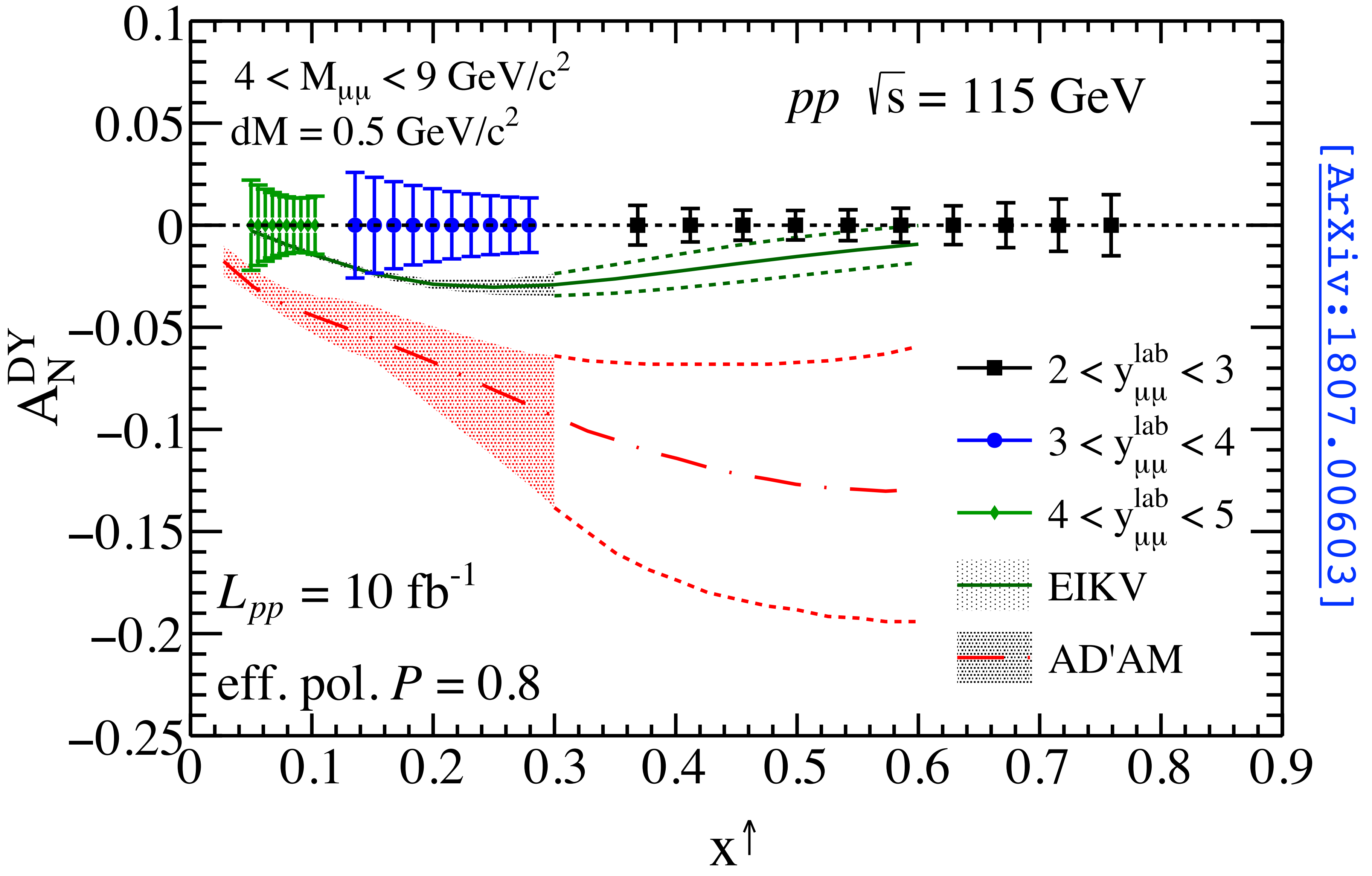
TMDs

- 3D momentum "tomography" of hadrons:



courtesy of
A. Bacchetta

- Projections of polarised Drell-Yan data with $10\ \mathrm{fb}^{-1}$



- Verify the sign change of the Sivers TMD in DY wrt SIDIS:

$$f_{1T}^{\perp q}(x, k_T^2)_{\mathrm{DY}} = -f_{1T}^{\perp q}(x, k_T^2)_{\mathrm{SIDIS}}$$

- + isospin effect with polarised deuterium
- Sea-quark component accessed via $W^\pm$ boson production, with $\Delta A_N \sim 0.1 - 0.2$ complementing RHIC [PRL 116 (2016) 132301]

- To access the transverse motion of partons inside a polarised nucleon: measure TMDs via TSSAs at high $x_2^\uparrow$ (and low x_1)

$$A_N = \frac{1}{P}\frac{\sigma^\uparrow - \sigma^\downarrow}{\sigma^\uparrow + \sigma^\downarrow} \longrightarrow A_N \sim \frac{f_1^q(x_1, k_{T1}^2) \otimes f_{1T}^{\perp\bar{q}}(x_2, k_{T2}^2)}{f_1^q(x_1, k_{T1}^2) \otimes f_1^q(x_2, k_{T2}^2)}$$

More TMDs

- Plenty of observables with polarised DY: azimuthal asymmetries of the dilepton pair to probe TMDs
- h_q^1 : transversity → difference in densities of quarks having T pol. ↑↑ or ↑↓ in T pol. nucleon
- $f_{1T}^{\perp q}$: Sivers → dependence on p_T orientation wrt T pol. nucleon
- $h_1^{\perp q}$: Boer-Mulders → dependence on p_T orientation wrt T pol. quark in unp. nucleon
- $h_{1T}^{\perp q}$: pretzelosity → dependence on p_T and T. pol of both T pol. quark and nucleon
- f_1^q : unpolarised TMD, always present at the denominator

$$A_{UU}^{cos2\phi} \sim \frac{h_1^{\perp q}(x_1, k_{1T}^2) \otimes h_1^{\perp \bar{q}}(x_2, k_{2T}^2)}{f_1^q(x_1, k_{1T}^2) \otimes f_1^{\bar{q}}(x_2, k_{2T}^2)}$$

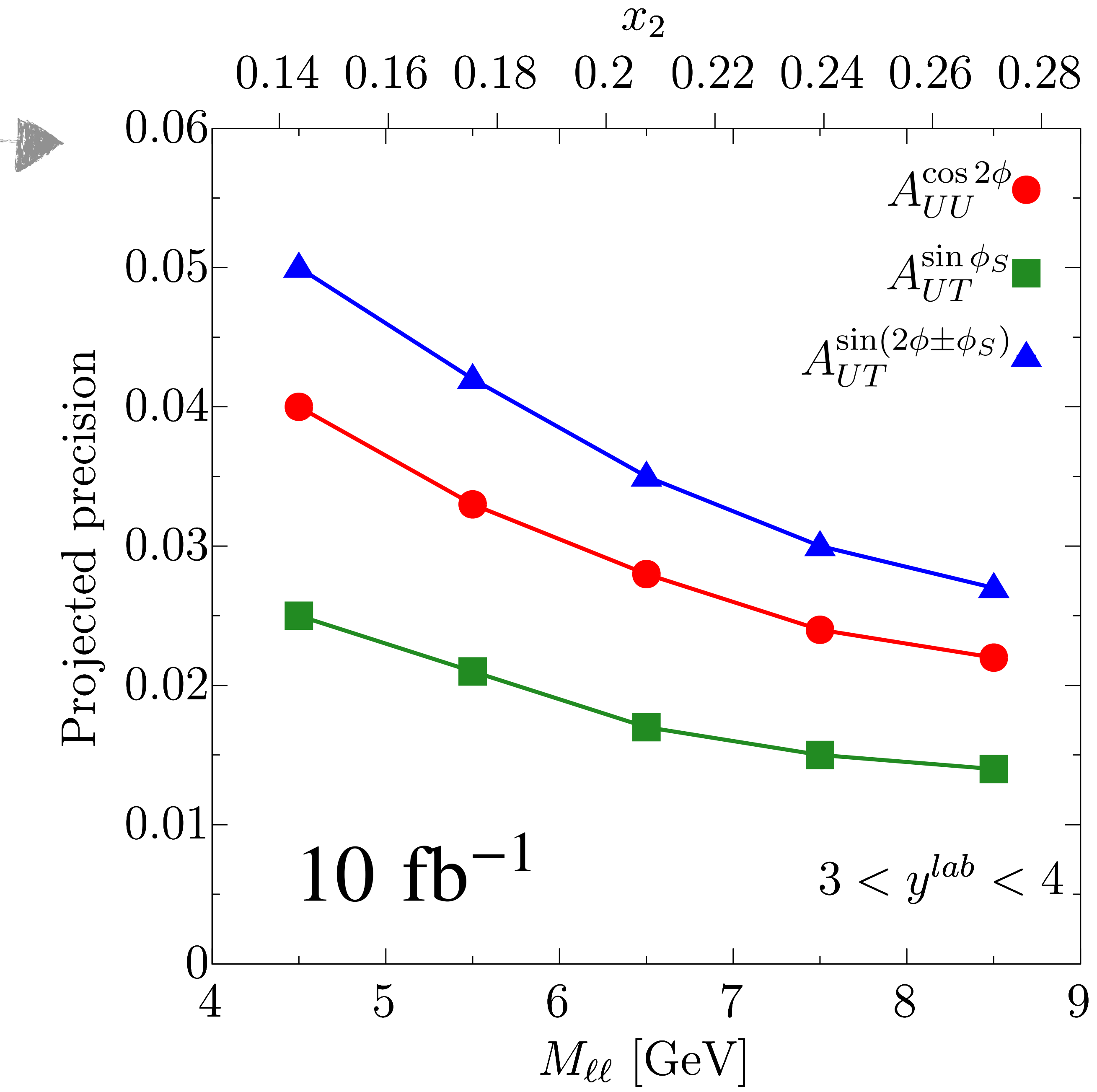
$$A_{UT}^{sin\phi_S} \sim \frac{f_1^q(x_1, k_{1T}^2) \otimes f_{1T}^{\perp \bar{q}}(x_2, k_{2T}^2)}{f_1^q(x_1, k_{1T}^2) \otimes f_1^{\bar{q}}(x_2, k_{2T}^2)}$$

$$A_{UT}^{sin(2\phi+\phi_S)} \sim \frac{h_1^{\perp q}(x_1, k_{1T}^2) \otimes h_{1T}^{\perp \bar{q}}(x_2, k_{2T}^2)}{f_1^q(x_1, k_{1T}^2) \otimes f_1^{\bar{q}}(x_2, k_{2T}^2)}$$

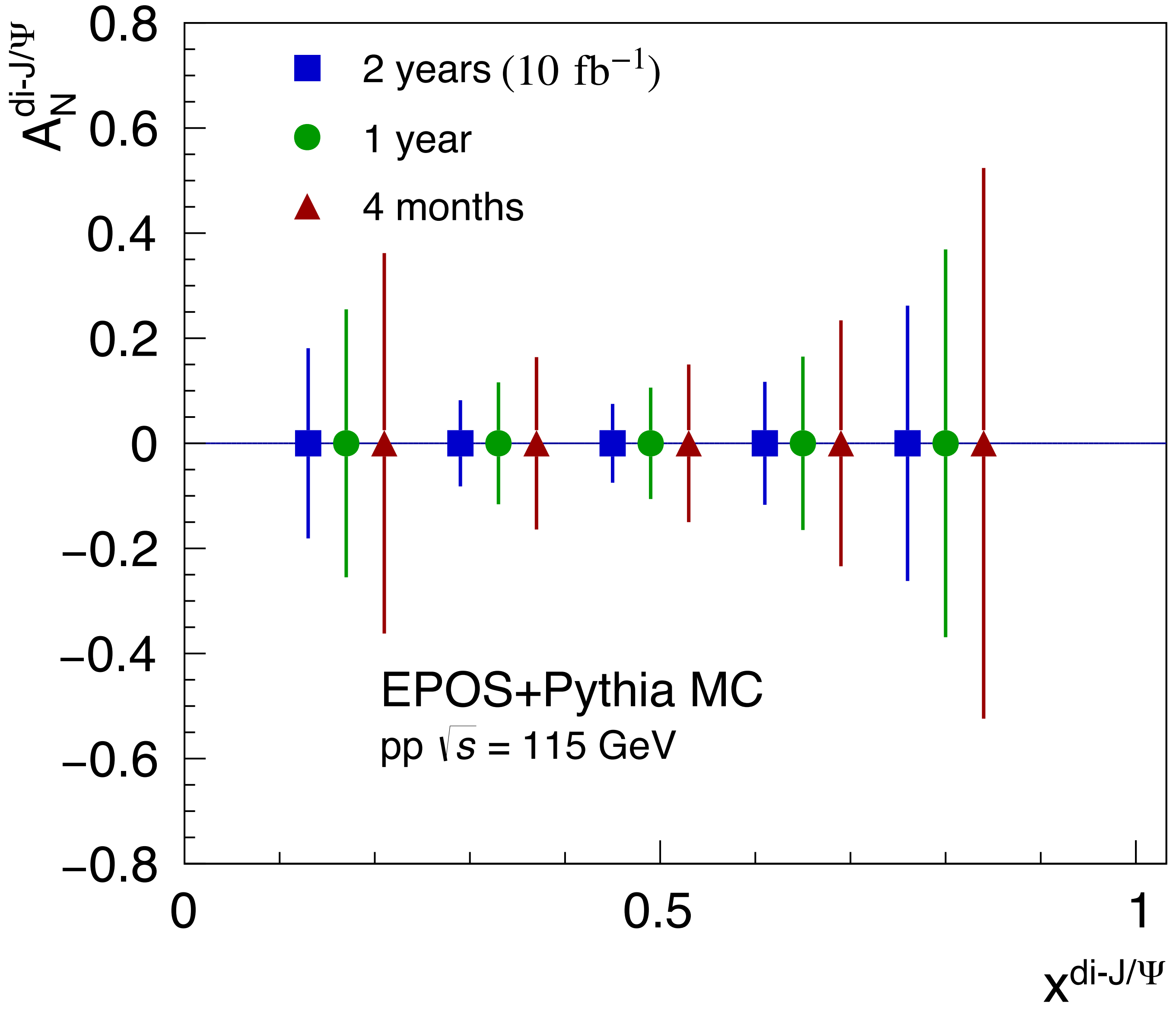
$$A_{UT}^{sin(2\phi-\phi_S)} \sim \frac{h_1^{\perp q}(x_1, k_{1T}^2) \otimes h_1^{\bar{q}}(x_2, k_{2T}^2)}{f_1^q(x_1, k_{1T}^2) \otimes f_1^{\bar{q}}(x_2, k_{2T}^2)}$$

- polarised Drell-Yan to access unpolarised TMDs of sea quarks and polarised TMDs in the valence region
- gluon-induced asymmetries: $h_1^{\perp g}$ never measured, can be accessed together with the f_1^g TMD (also unconstrained) in di-J/ψ and Υ production

[ArXiv:1807.00603] [PLB 784 (2018) 217-222]

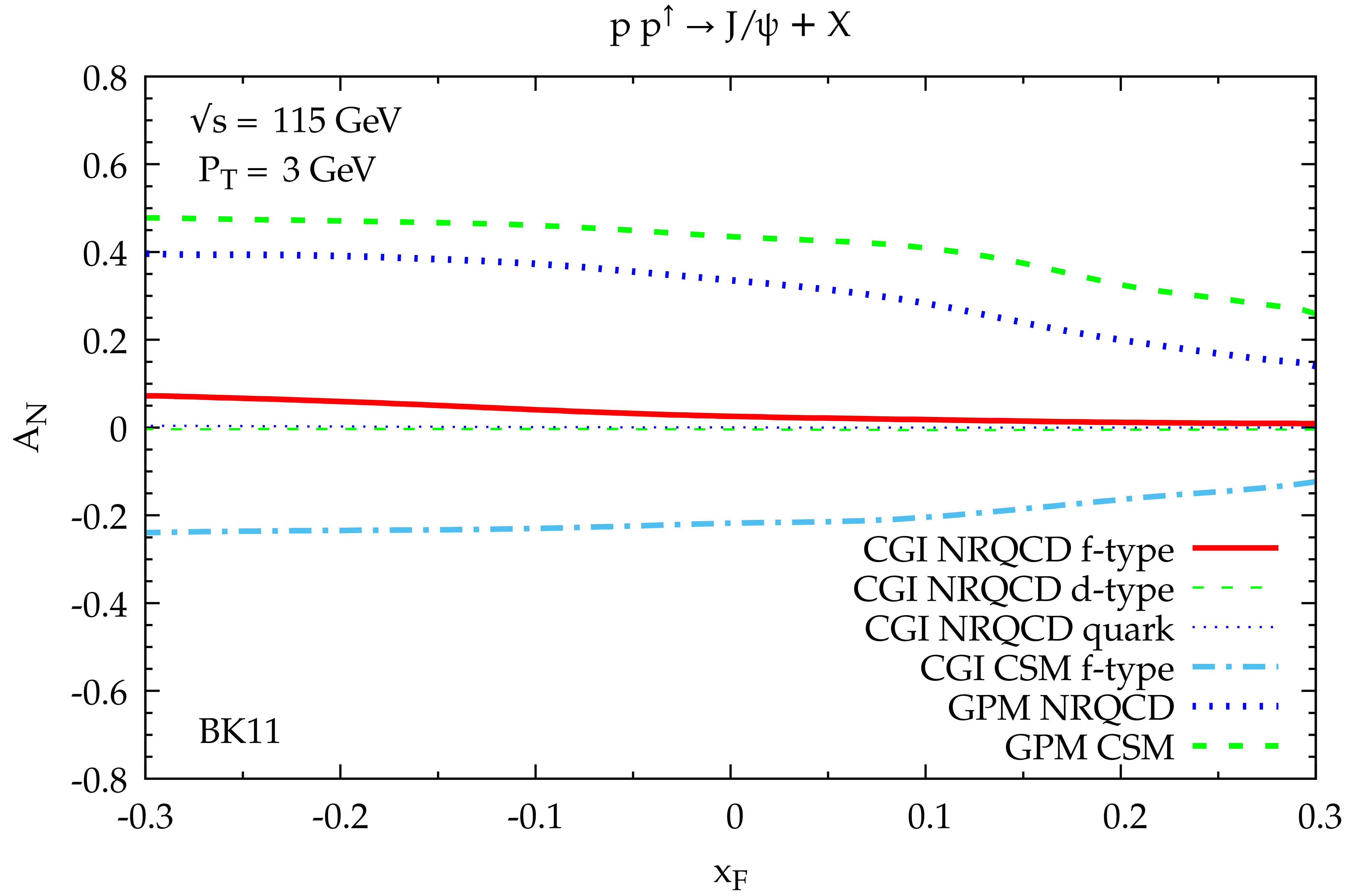


- $J/\Psi\ J/\Psi$ channel

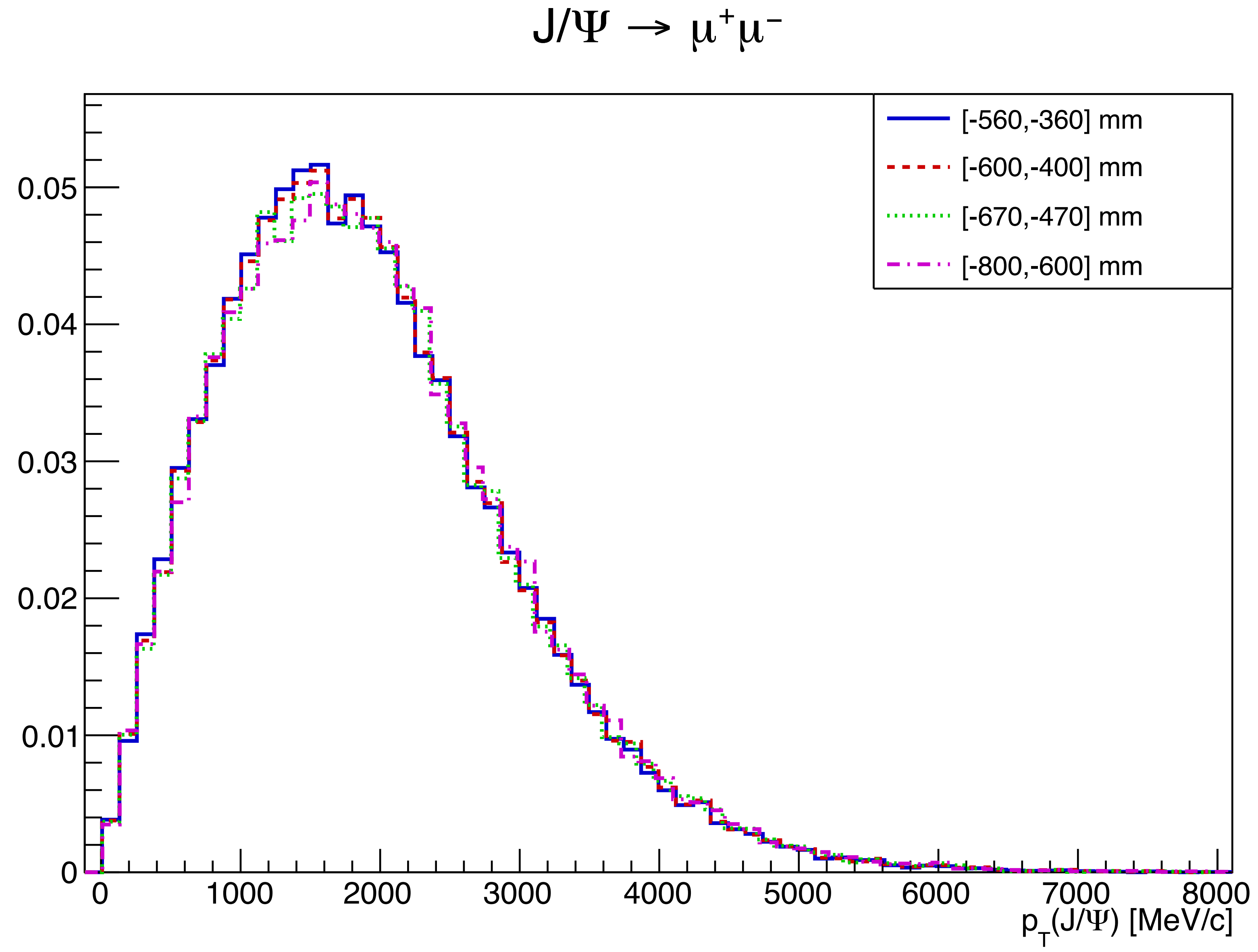


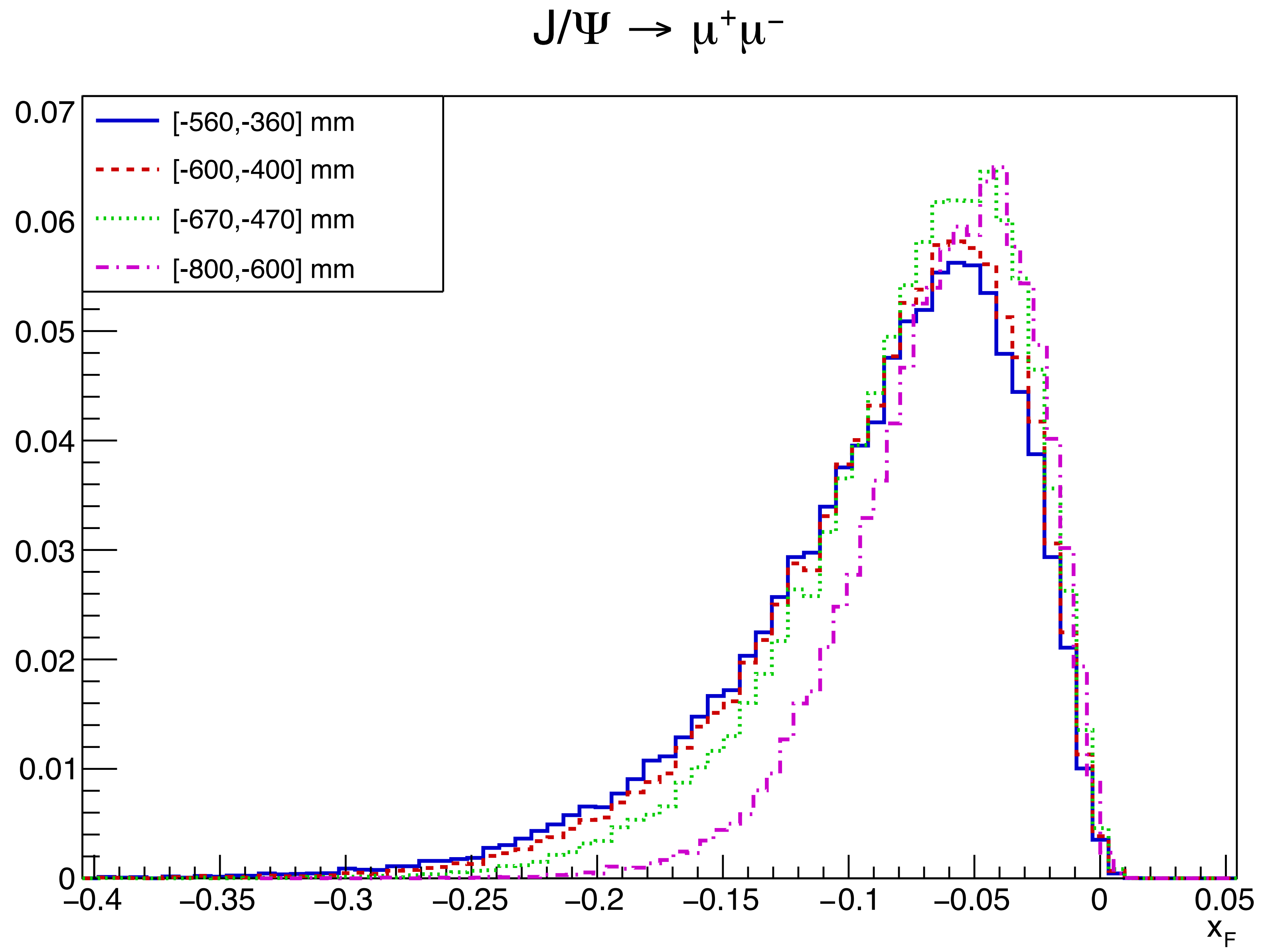
The gluon Sivers function

- Gluon Sivers function can be probed with quarkonia and open heavy-flavour production
- broad x range at a scale $M_T = \sqrt{M^2 + P_T^2}$ with lot of unique probes: η_c, χ_c, χ_b, $J/\psi J/\psi$ ...
  - A_N predictions on $J/\Psi \to \mu^+\mu^-$ with LHCspin kinematics

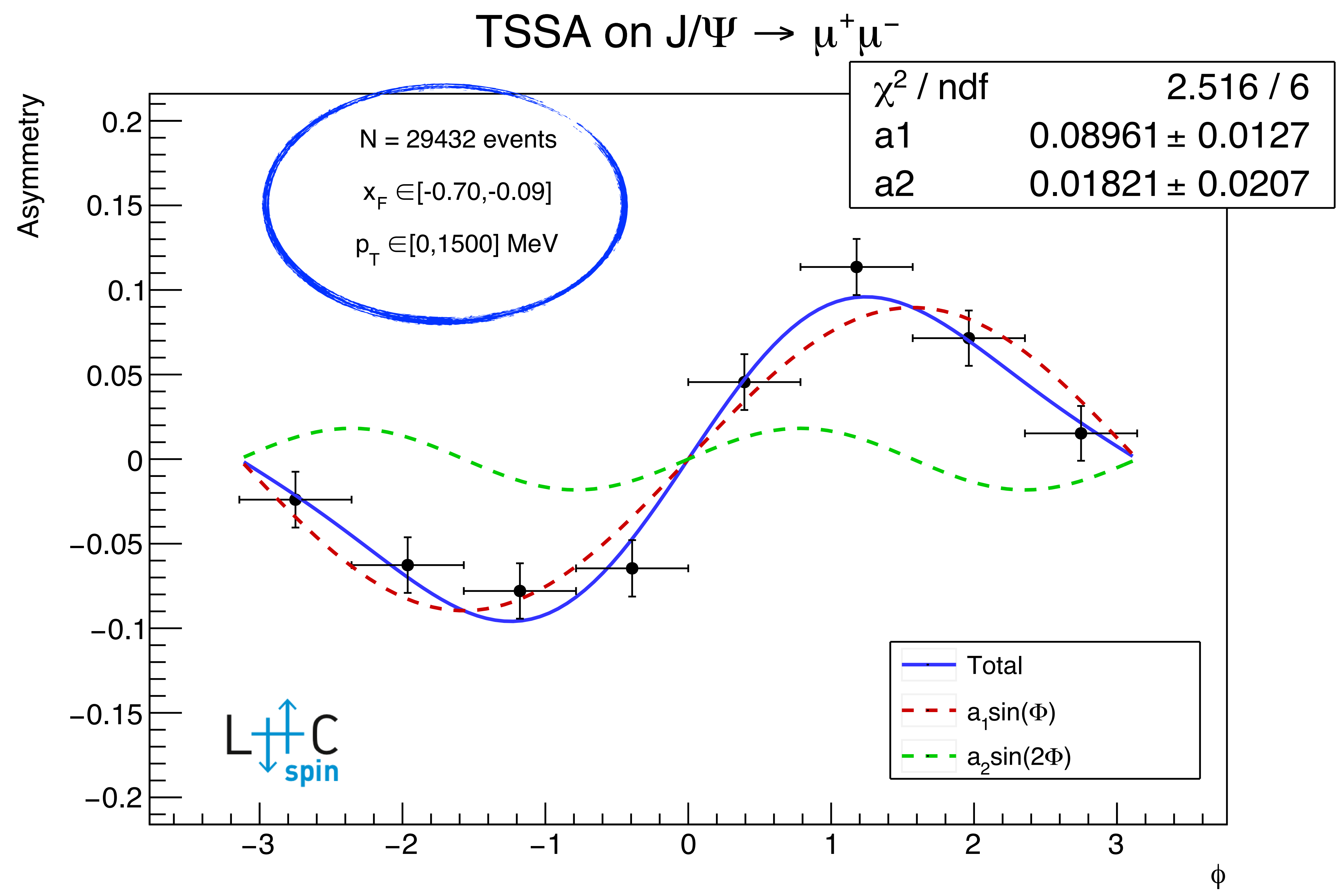


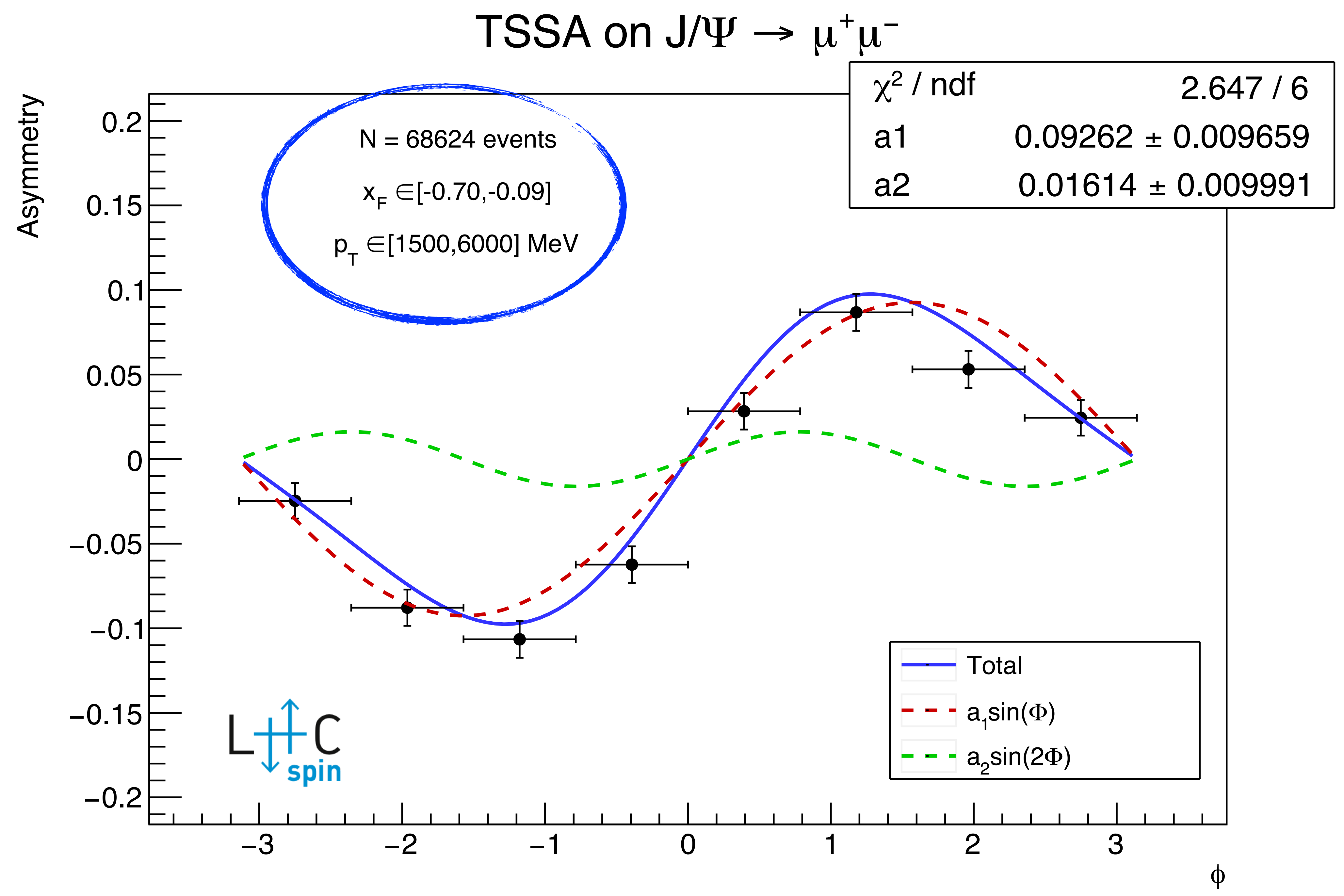
[PRD 102 (2020) 094011]



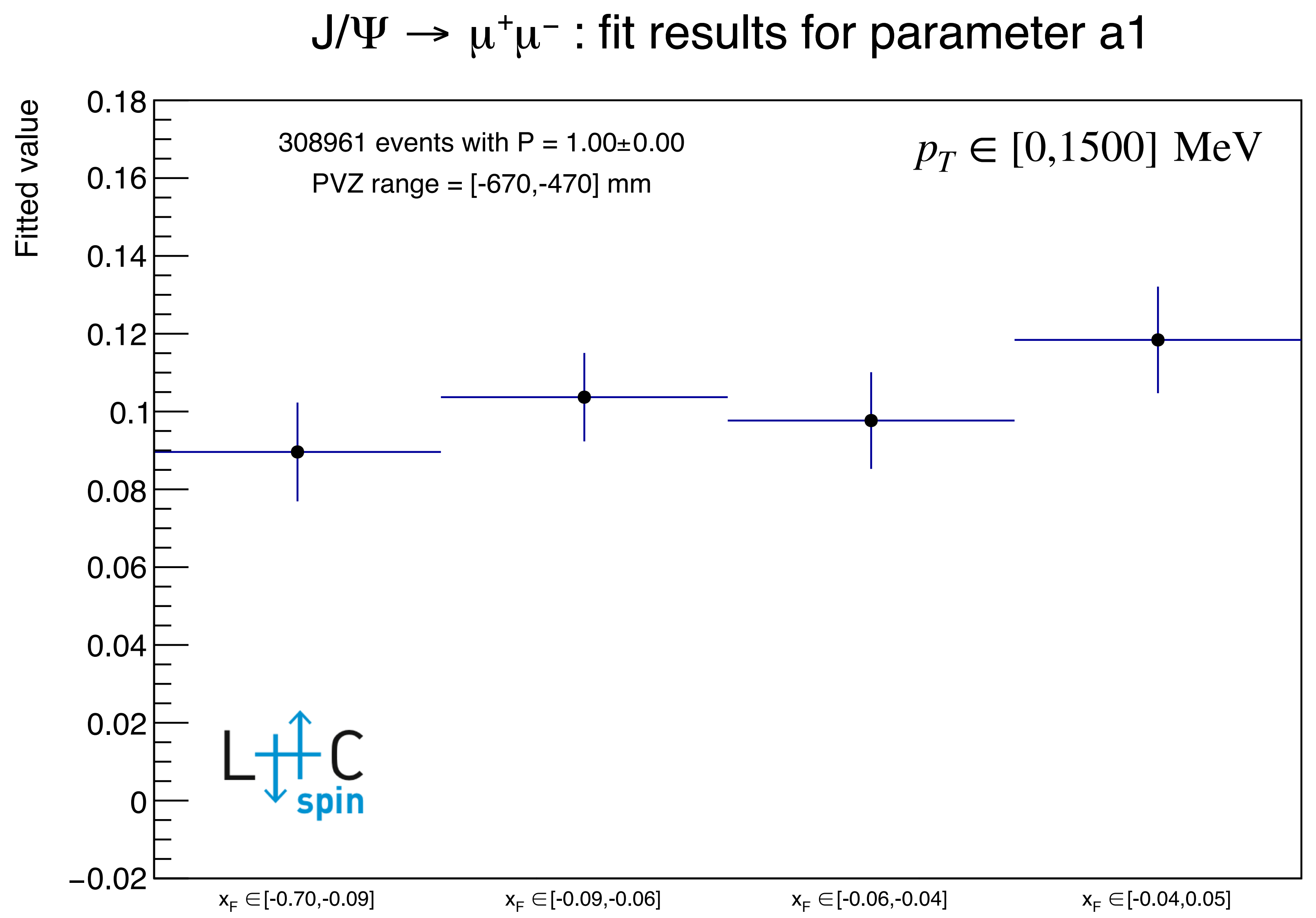


A TSSA analysis at LHCspin





- Full LHCb simulations → emulate the target polarisation by assigning a ↑↓ tag according to a model. In this example: 10% asymmetry $\sin\phi$, 2% on $\sin 2\phi$ with mild x_F, p_T dependence [JHEP 12 (2020) 010]
- Fit the polarised data with the sum of two Fourier amplitudes
- Within this statistics (~ 1 month of data-taking!): $A_N \sim 0.1 \pm 0.01$ with $4\ x_F \times 2\ p_T \times 8\ \phi$ bins on $J/\Psi \to \mu^+\mu^-$
- Work ongoing on other channels



Knowledge of the polarisation degree

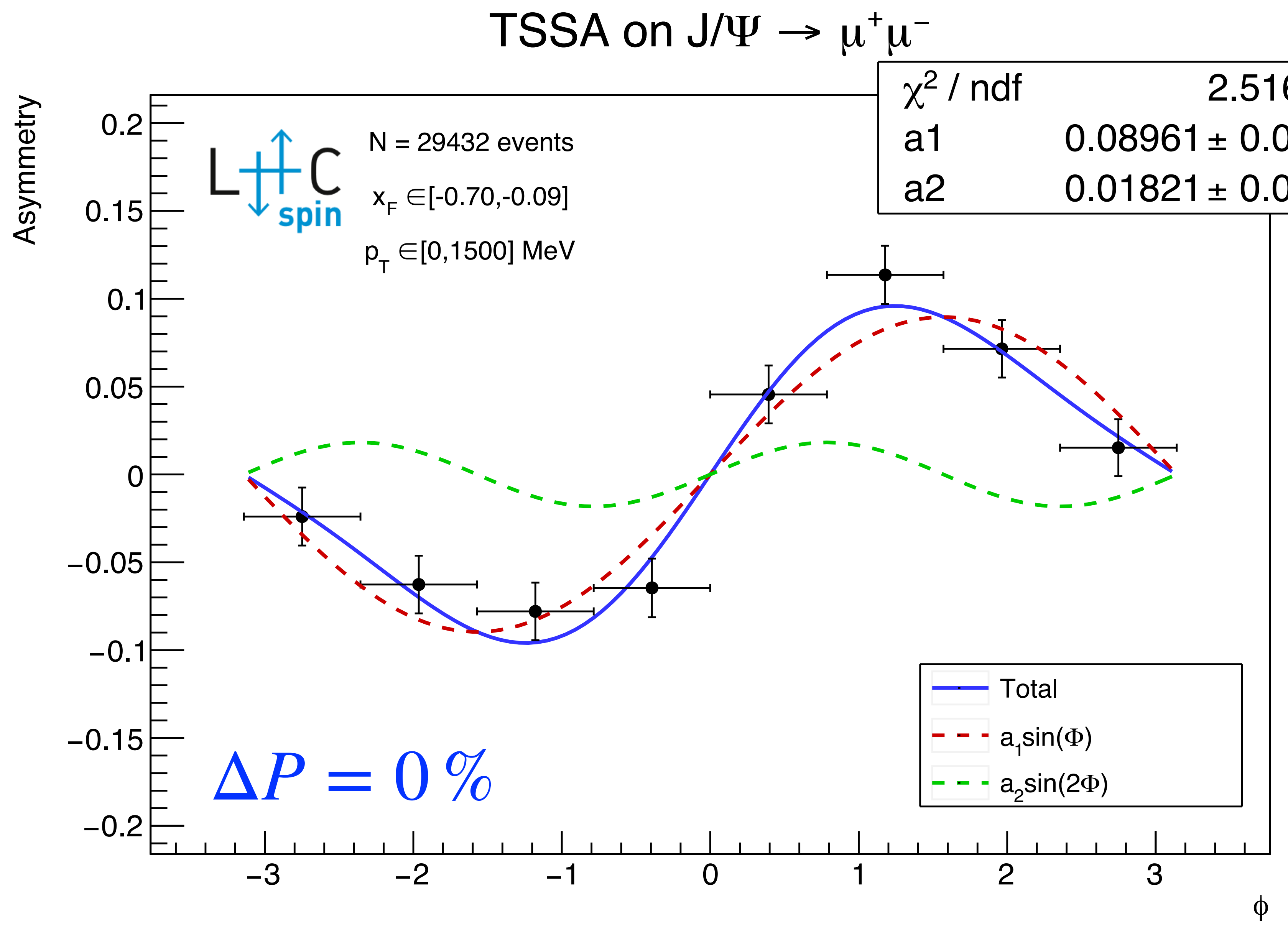
- Comparing statistical and systematic error on a_1 is very relevant for the R&D (e.g. gas vs jet target)
- With the shown analysis* :
- 5% error (realistic value): negligible effect
- 20% error: 30-40% of the stat. error
- 50% error: syst. dominated

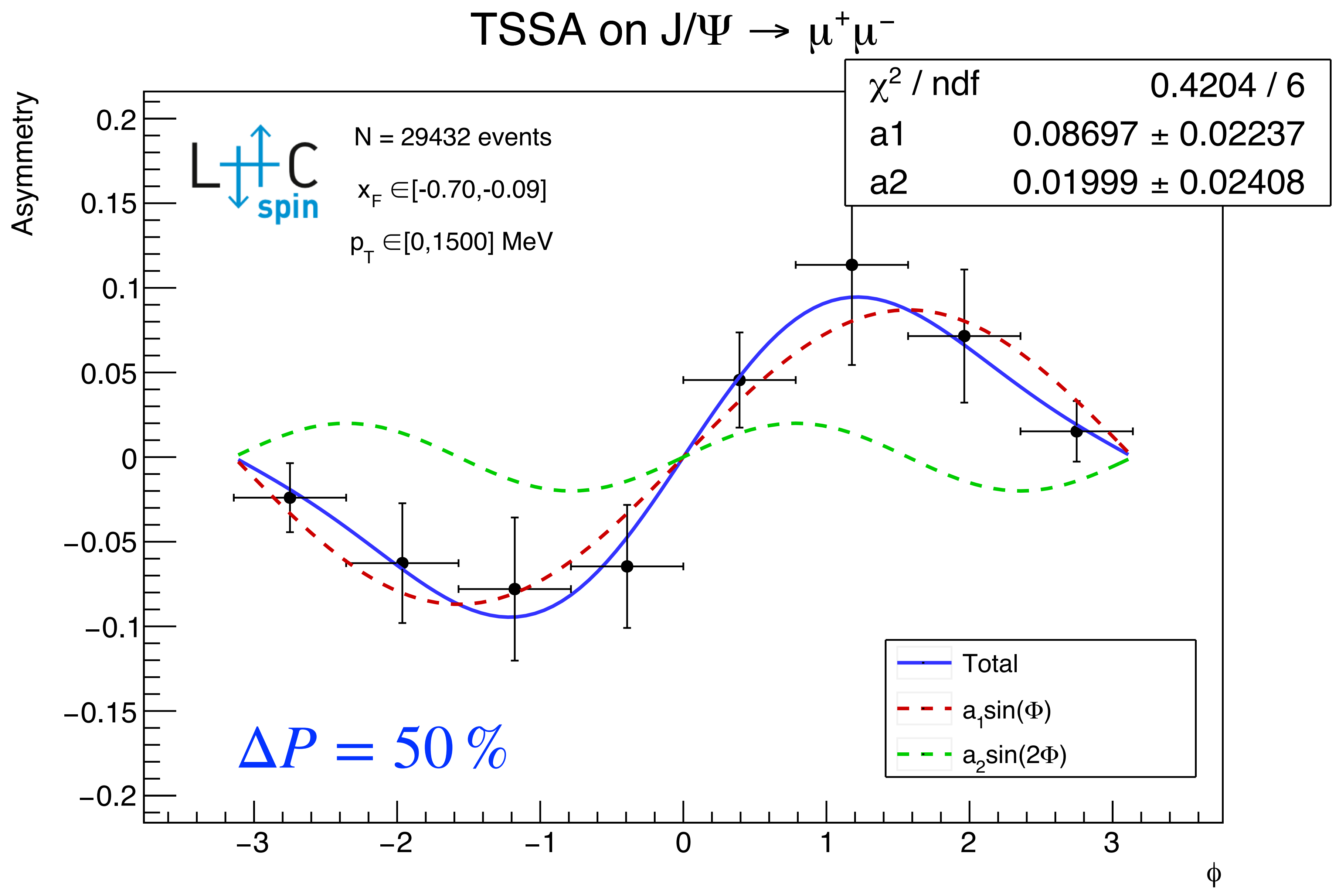
$\Delta P = 5\,\%$

p_T (MeV)	x_F	a_1
[0,1500]	[-0.70,-0.09]	0.089 ± 0.013
[0,1500]	[-0.09,-0.06]	0.104 ± 0.012
[0,1500]	[-0.06,-0.04]	0.098 ± 0.013
[0,1500]	[-0.04,0.05]	0.117 ± 0.014
[1500,6000]	[-0.70,-0.09]	0.092 ± 0.010
[1500,6000]	[-0.09,-0.06]	0.108 ± 0.011
[1500,6000]	[-0.06,-0.04]	0.105 ± 0.012
[1500,6000]	[-0.04,0.05]	0.105 ± 0.012

$\Delta P = 20\,\%$

p_T (MeV)	x_F	a_1
[0,1500]	[-0.70,-0.09]	0.087 ± 0.014
[0,1500]	[-0.09,-0.06]	0.103 ± 0.016
[0,1500]	[-0.06,-0.04]	0.097 ± 0.016
[0,1500]	[-0.04,0.05]	0.114 ± 0.017
[1500,6000]	[-0.70,-0.09]	0.090 ± 0.013
[1500,6000]	[-0.09,-0.06]	0.108 ± 0.015
[1500,6000]	[-0.06,-0.04]	0.104 ± 0.015
[1500,6000]	[-0.04,0.05]	0.102 ± 0.015

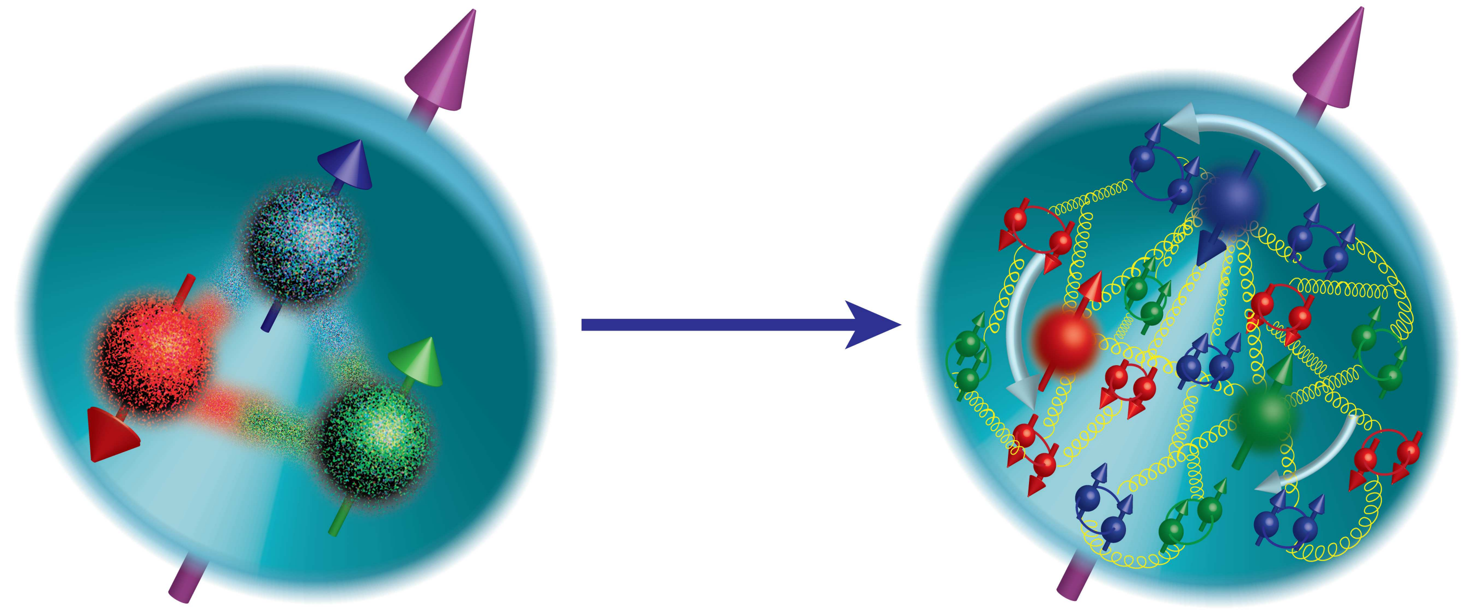




* of course the result depends on the statistics, model, channel, kinematic binning...

The spin puzzle & GPDs

- TMDs → nucleon spin



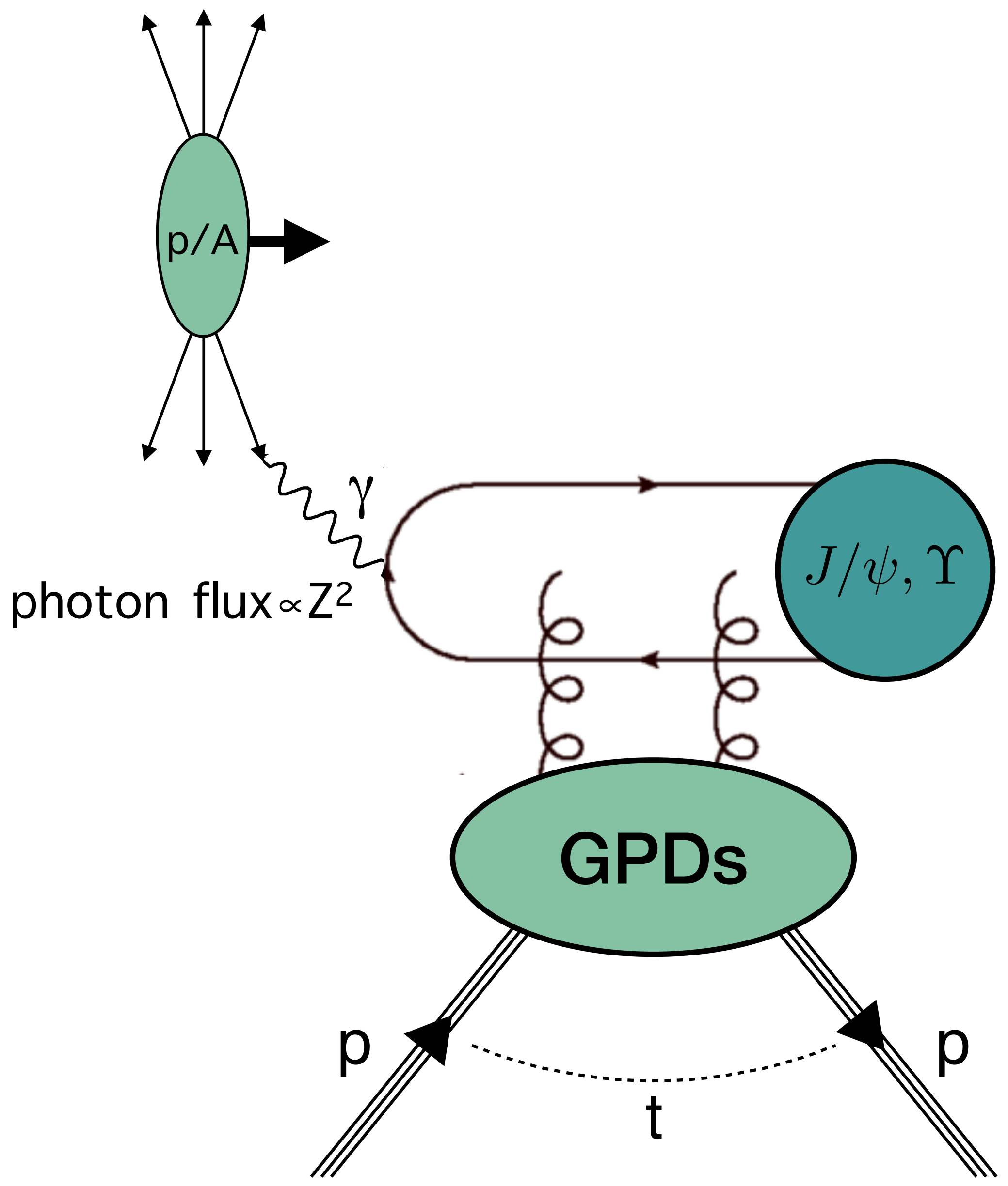
- Orbital Angular Momentum (OAM) information via TMDs is only indirect: position and momentum correlations are needed
- Quark OAM from GPD moments via Ji Sum Rule:

$$\frac{1}{2} = J^q(\mu) + J^g(\mu) = \frac{1}{2}\Delta\Sigma(\mu) + L_z^q(\mu) + J^g(\mu)$$

[PRL 78 (1997) 610–613]

- Experimental hints of large OAM contribution
- GPDs can be probed via UltraPeripheral Collisions (UPCs), dominated by EM interaction

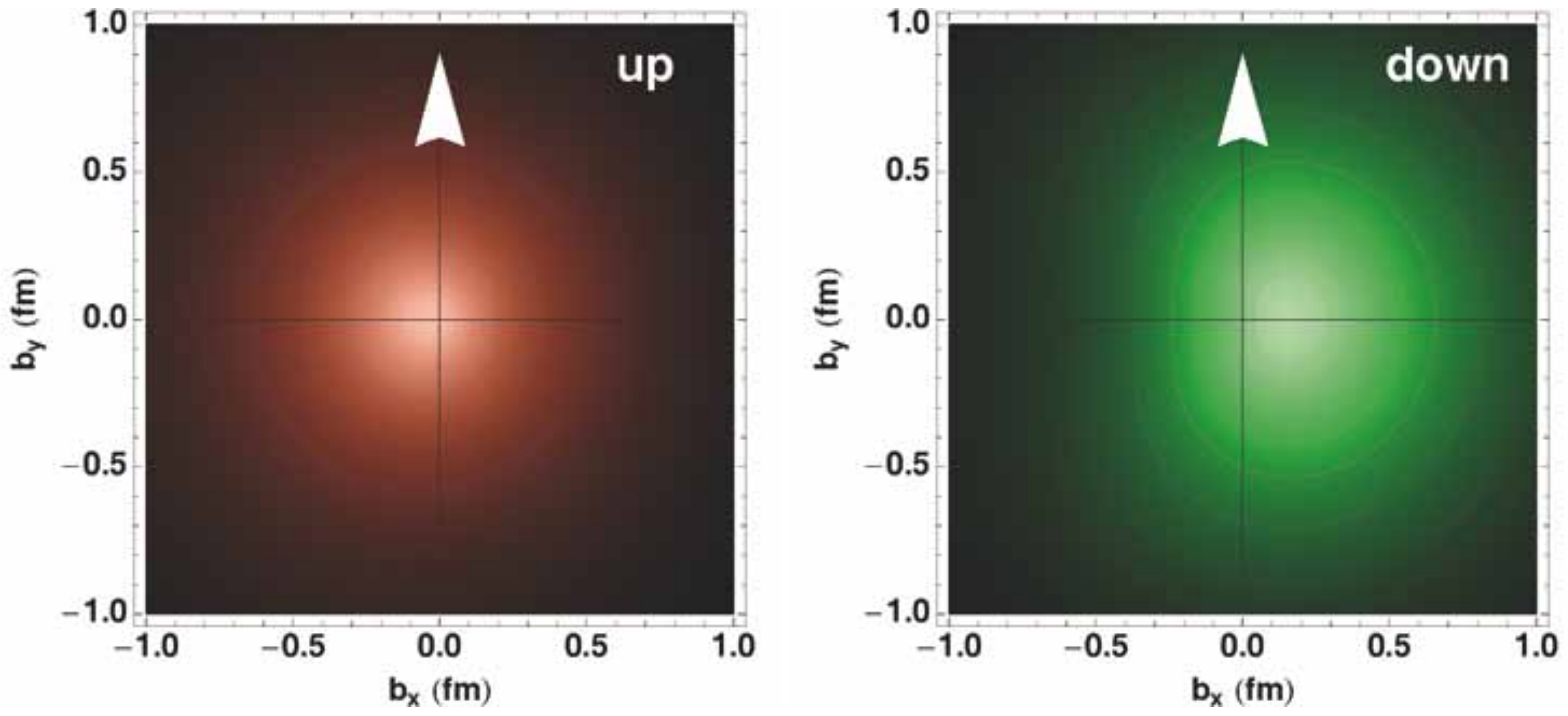
- Exclusive dilepton / exclusive quarkonia production, the latter being sensitive to gluon GPDs [PRD 85 (2012) 051502]



- UPCs already studied at LHC in collider mode
- LHCspin to access the unknown E_g via TSSAs : a key element of the sum rule

- GPDs to make a 3D "picture" of the proton

[PRL 99 (2017) 112001]

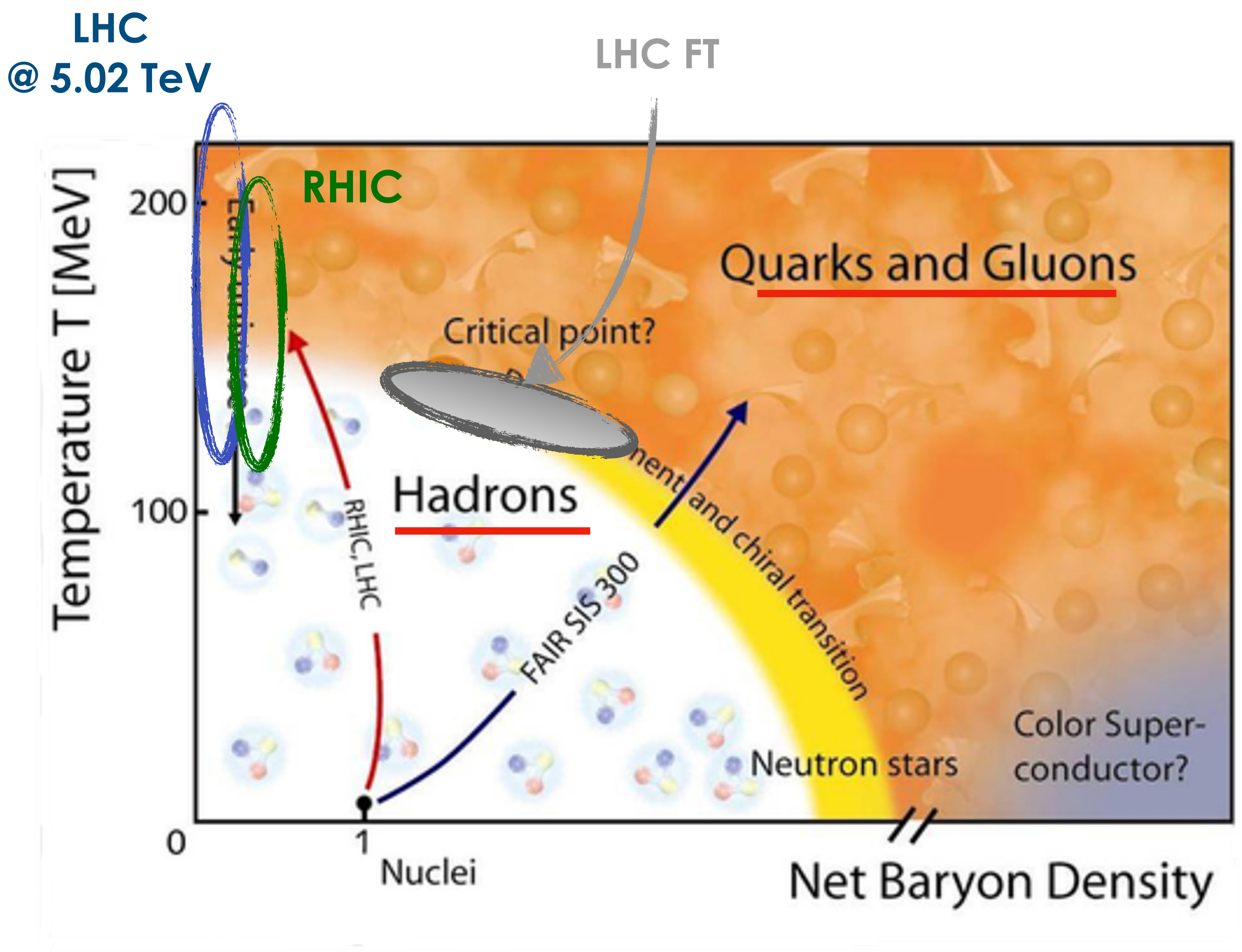


[NS 28 (2012) 1–2]

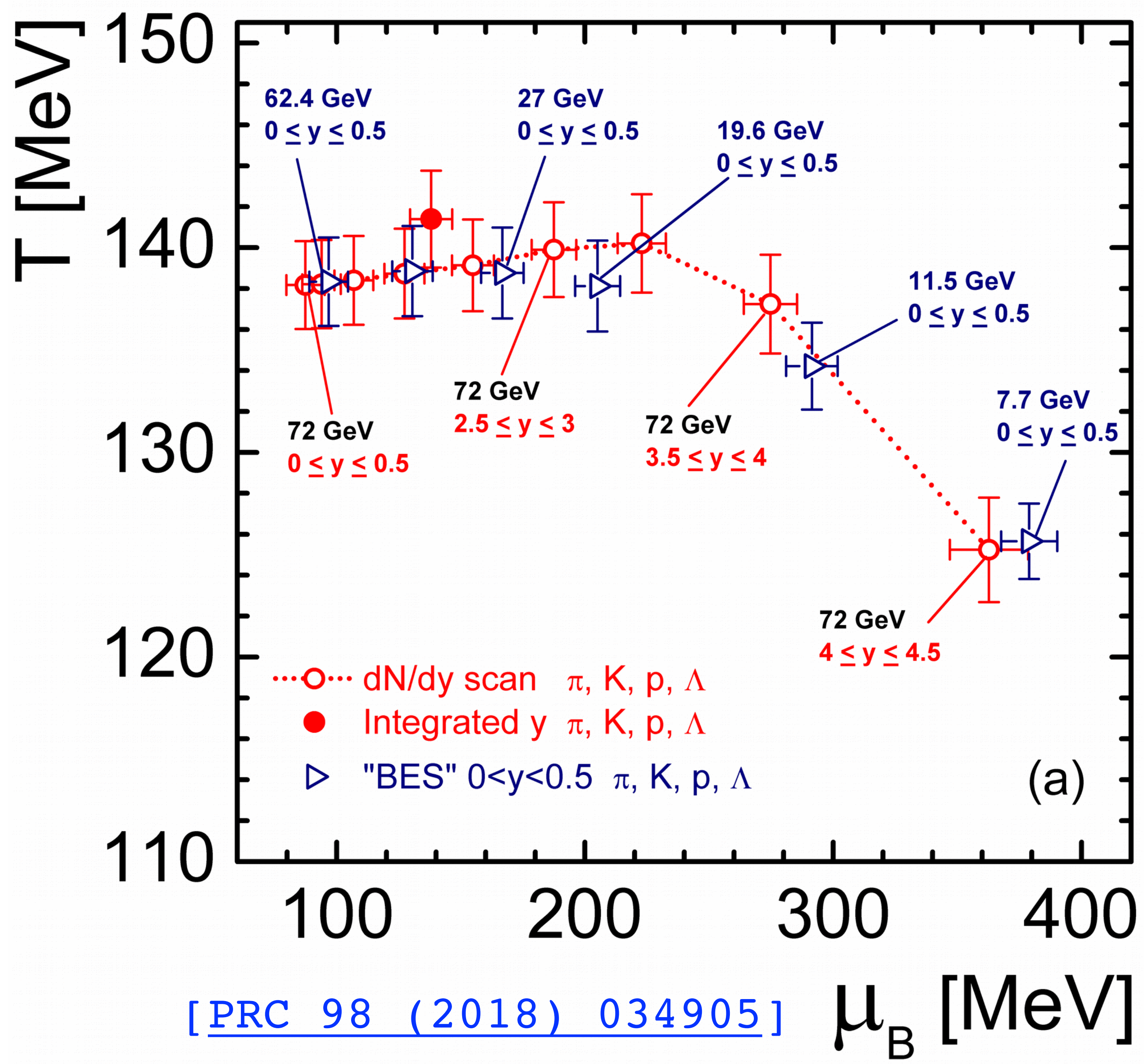
Heavy ion fixed-target collisions

- LHC delivers proton beam at $7\ \mathrm{TeV}$ and lead beam at $2.76\ \mathrm{TeV}$, while the storage cells technology allows for an easy target change
- Great opportunities to probe nuclear matter over a new rapidity domain at $\sqrt{s} = 72\ \mathrm{GeV}$

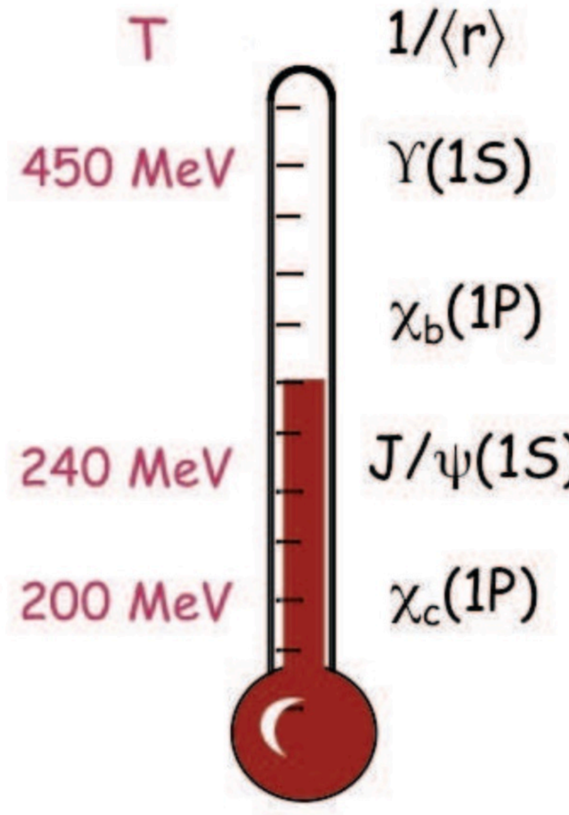
- Hints for deconfinement at this energy: FT collisions to explore the transition region



- Complement the RHIC Beam Energy Scan (BES) with a y scan



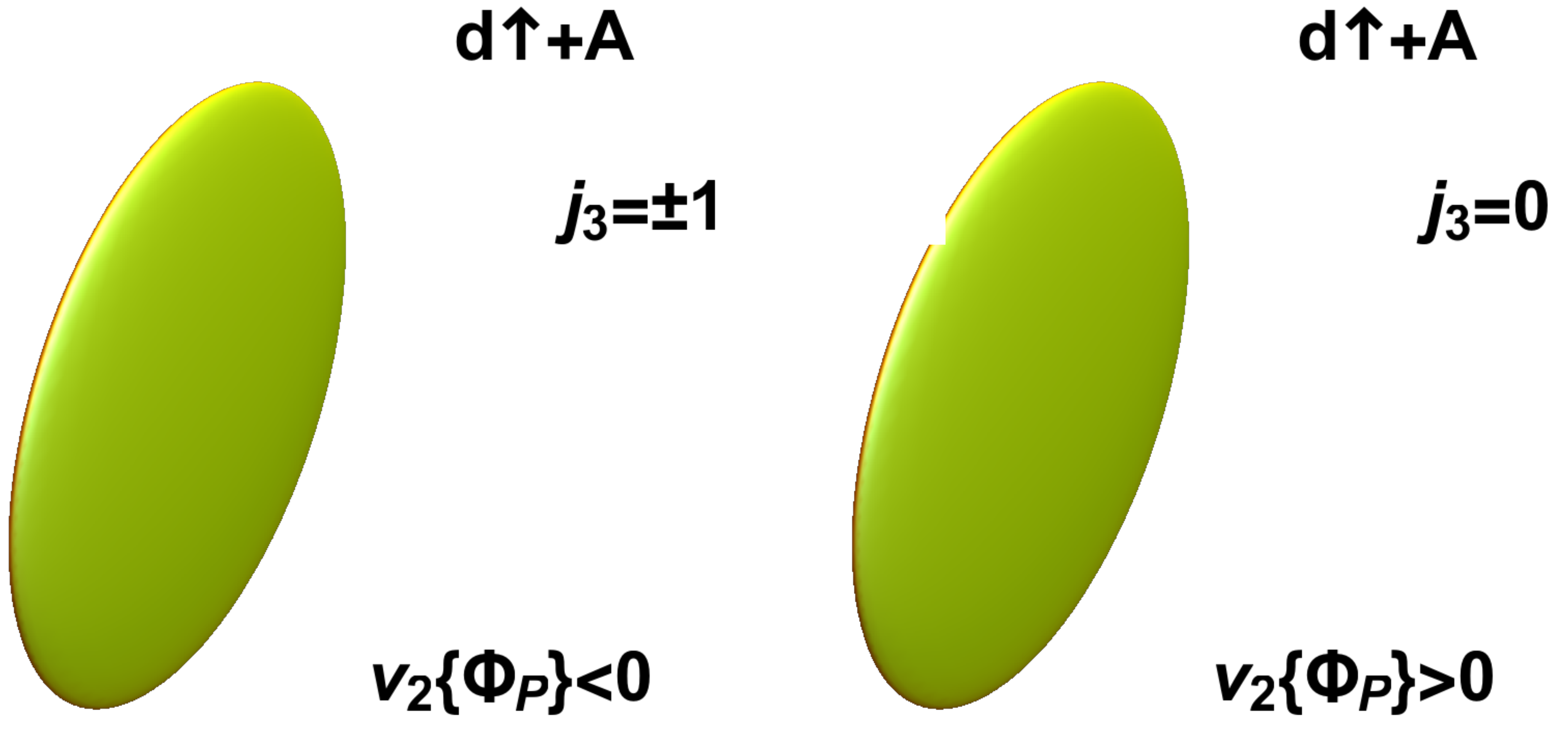
[PRC 98 (2018) 034905]



- Suppression of $c\bar{c}$ bound states as QGP thermometer
- States with different binding energy → different dissociation temperature
- LHCspin to access unique/heavy probes [IJMPA 28 (2013) 1340012]

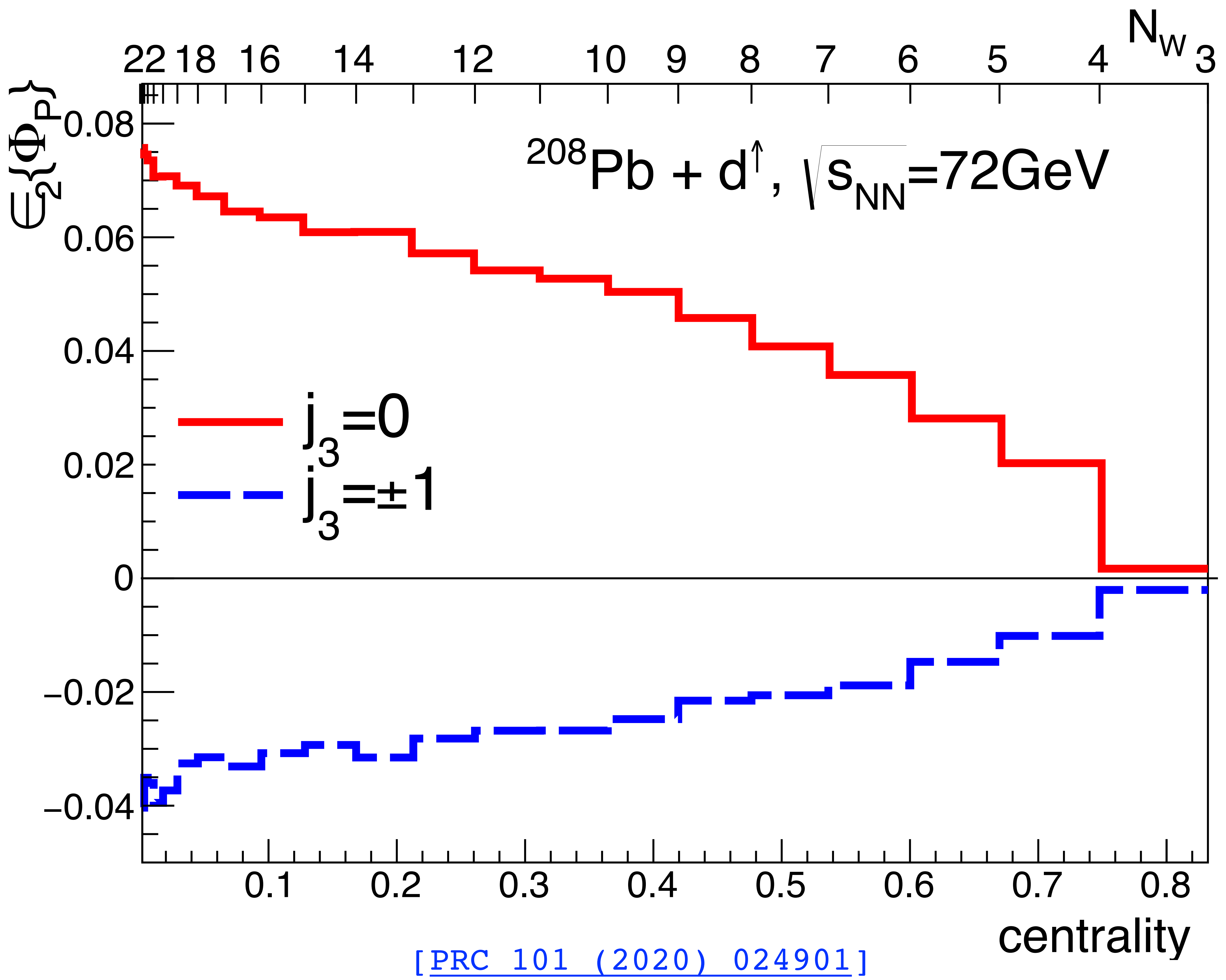
Heavy ion fixed-target collisions

- Interesting topic joining heavy ions and polarisation: probing the dynamics of small systems
- Ultra-relativistic collisions of heavy nuclei (Pb) on transversely polarised deuterons ($D^{\uparrow}$)
- Deformation of $D^{\uparrow}$ is reflected in the orientation of the generated fireball in the transverse plane



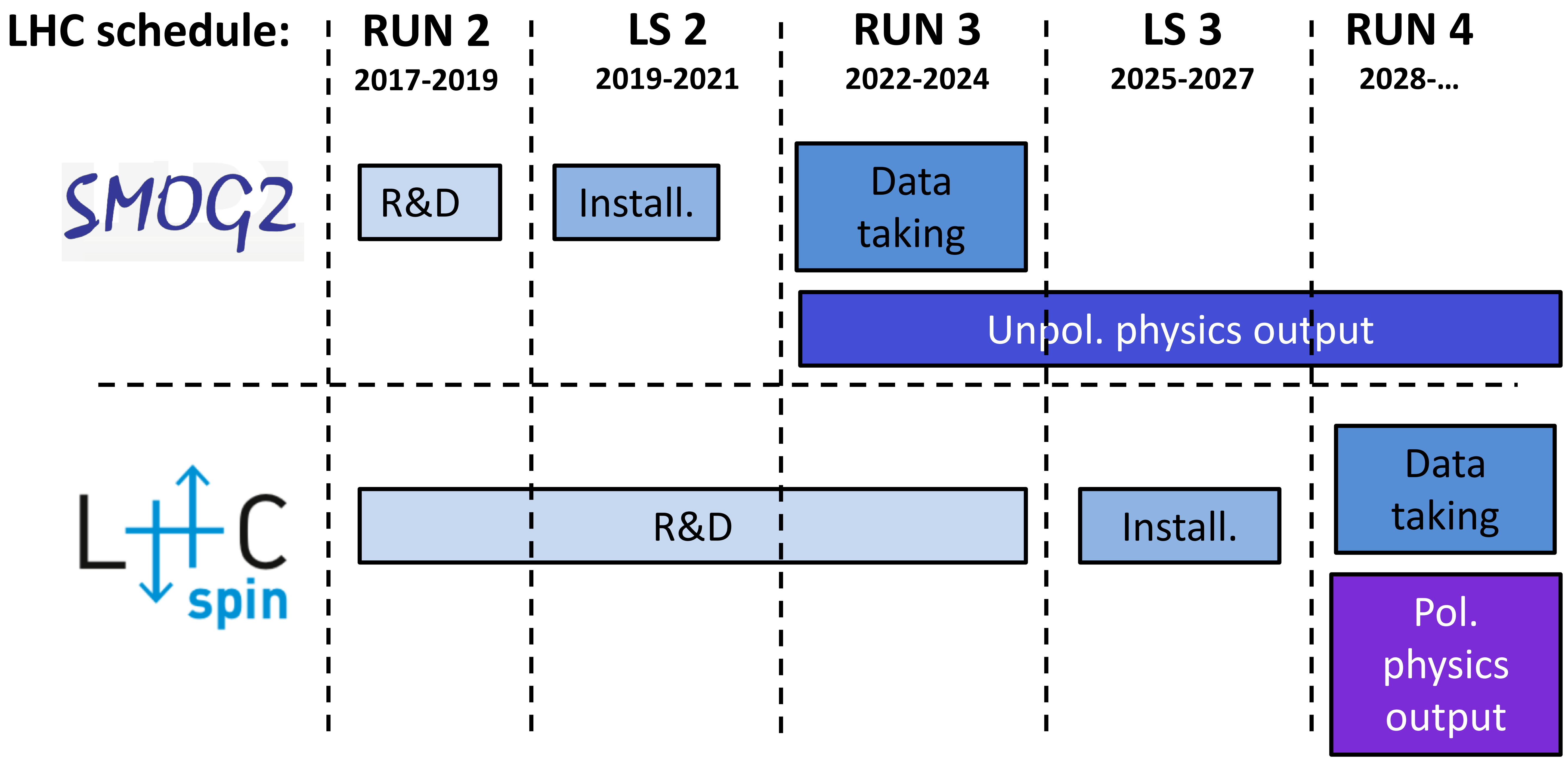
D polarised along Φ_p , perpendicular to the beam

- Quantified by the ellipticity, ϵ_2 wrt Φ_p
- Can be easily performed on minimum bias data



[PRC 101 (2020) 024901]

Conclusions



- The FT program at LHCb is active since Run 2, now greatly enriched with the SMOG2 cell for Run 3
- LHCspin is the natural evolution to extend this program and to bring spin-physics for the first time at LHC
- Vast physics program with both unpolarised and polarised gases for Run 4 and Run 5, with plenty of observables & final states
- The R&D calls for a new generation of polarised gas targets: challenging task but worth the effort!
- Complementary to both existing facilities and EIC