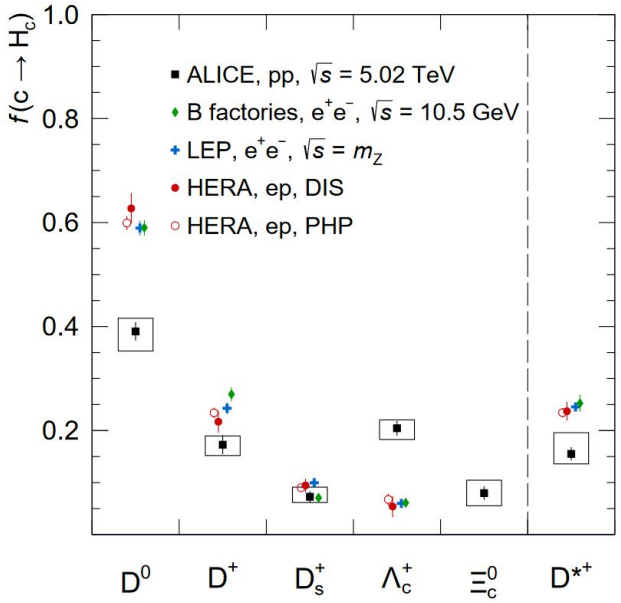
Open charm asymmetries in pNe with LHCb

Gabriel Ricart

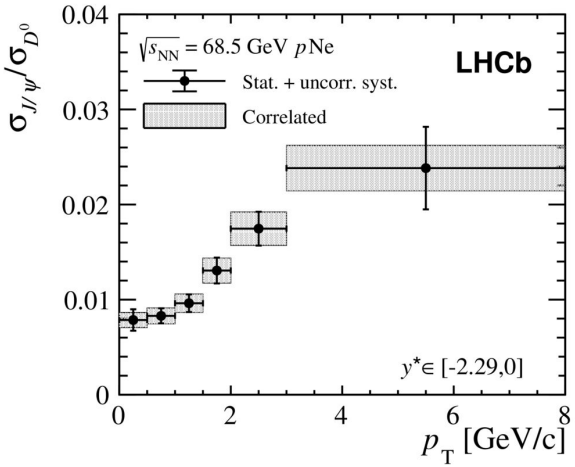
Why open charm in pNe ?

Test of charm fragmentation fractions universality



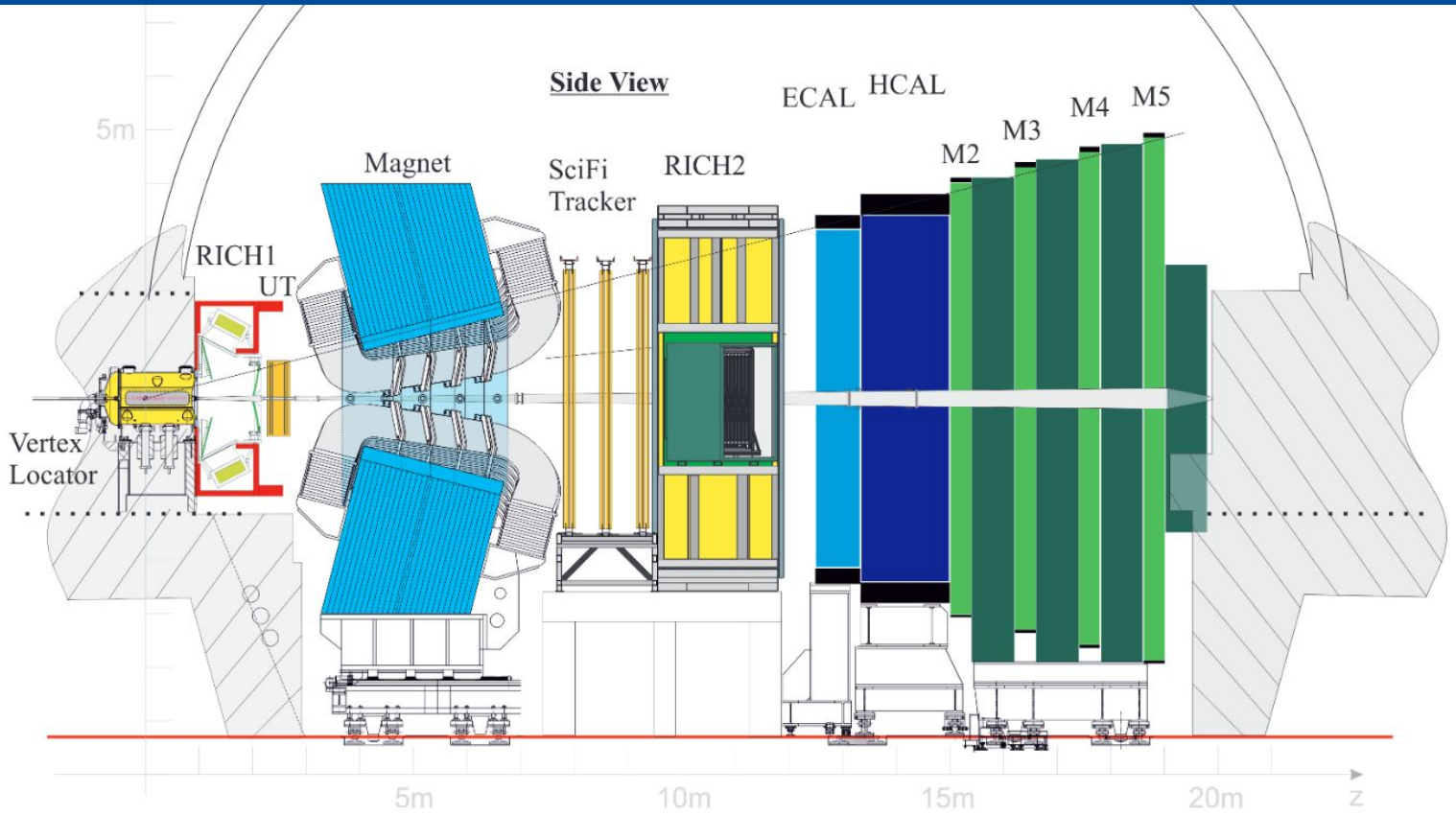
Charm-quark fragmentation fractions and production cross section at midrapidity in pp collisions at the LHC
ALICE collaboration
arXiv: 2105.06335

First measurement of J/Ψ over full open charm hadrons



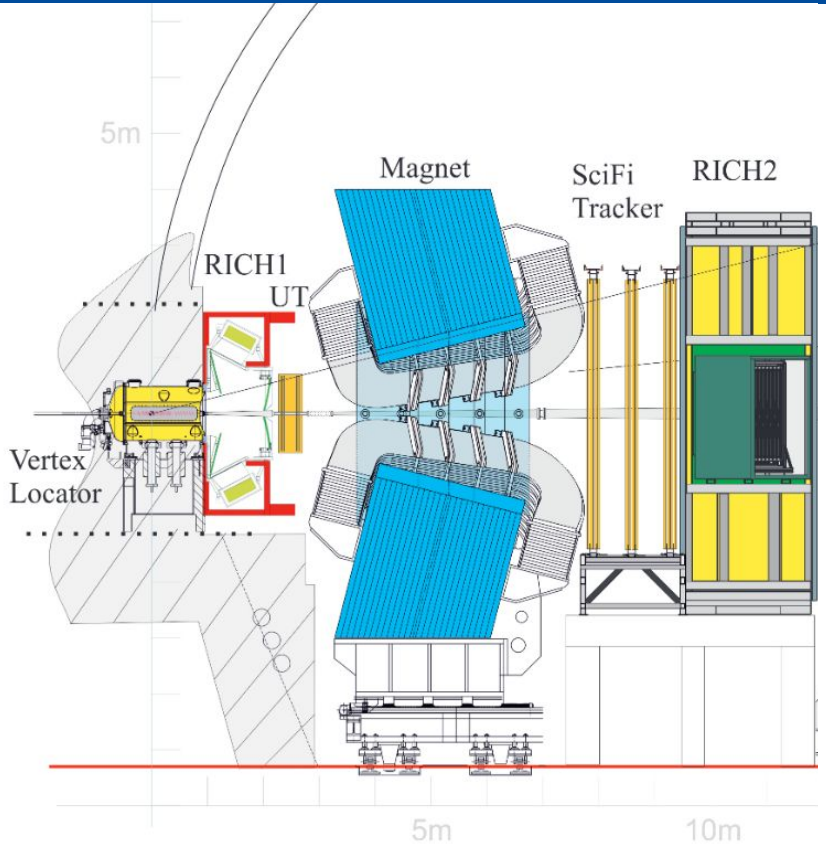
Charmonium production in pNe collisions at $\sqrt{s_{NN}}$ = 68.5 GeV
LHCb collaboration
arXiv:2211.11645 [hep-ex]

LHCb detector



LHCb Tracker Upgrade Technical Design Report
LHCb Collaboration
CERN-LHCC-2014-001

Fixed target LHCb



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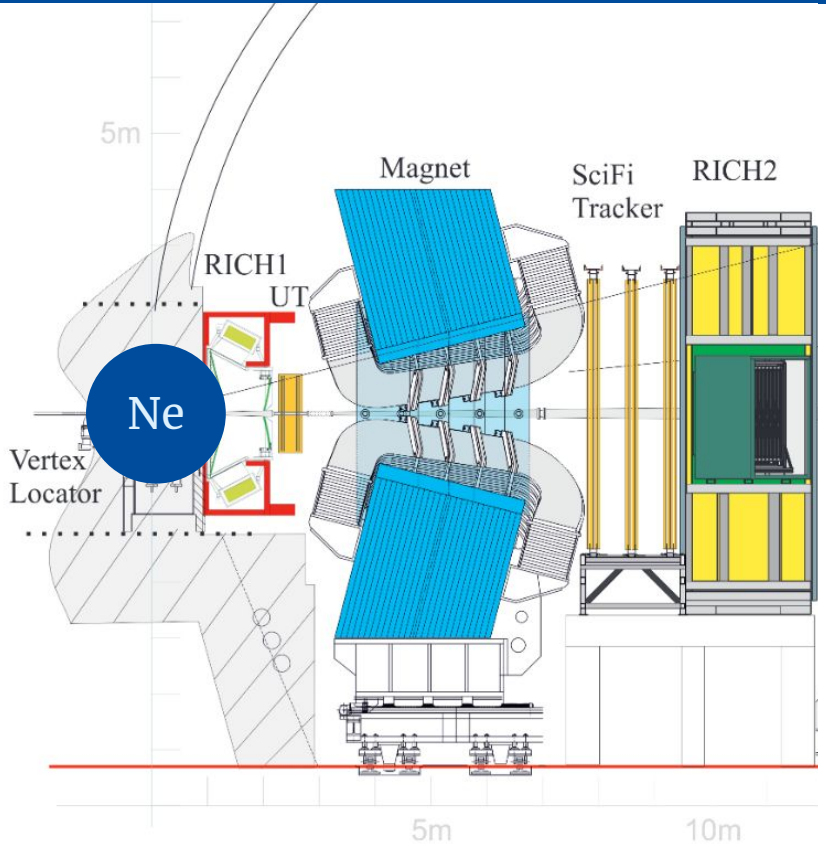
Fixed target LHCb



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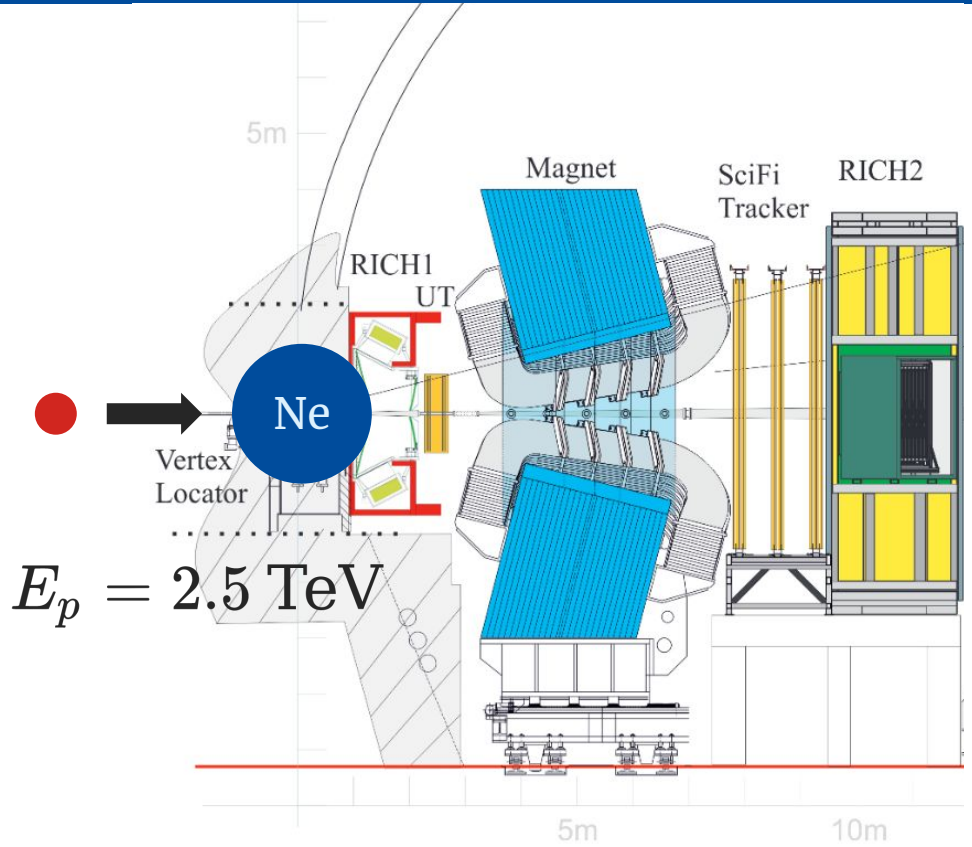
Fixed target LHCb



$E_p = 2.5\ \text{TeV}$

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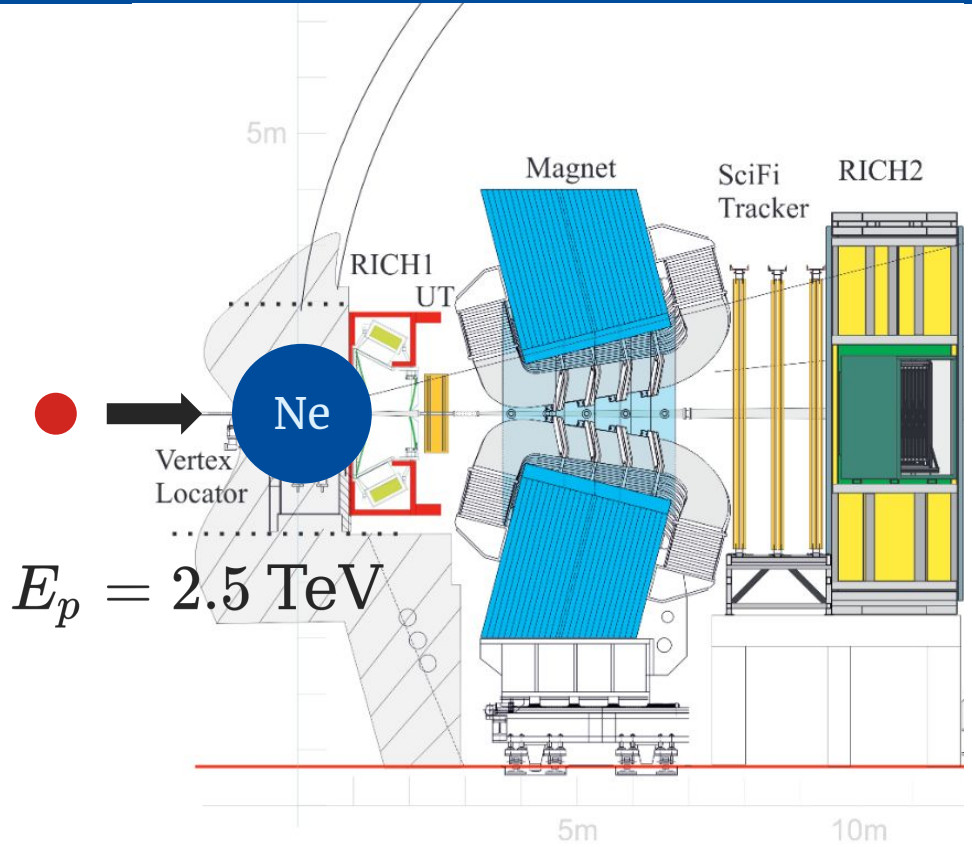
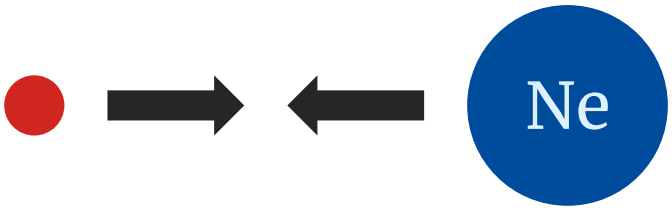
Fixed target LHCb



$E_p = 2.5$ TeV

$\sqrt{s_{NN}} = 69$ GeV

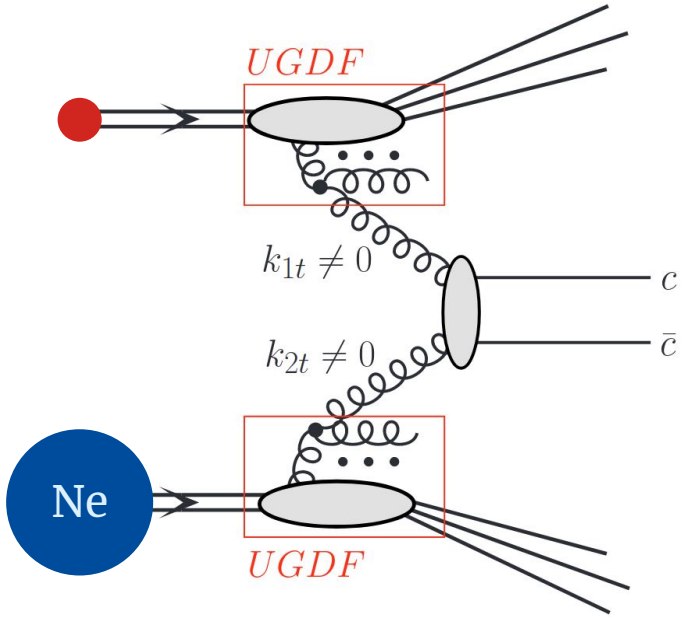


- LHCb forward acceptance becomes backward ($-2.3 < y^* < 0$) with fixed-target configuration.
- Allows to probe large Bjorken-x values of the target nucleon using charm.

LHCb Tracker Upgrade Technical Design Report
LHCb Collaboration
CERN-LHCC-2014-001

Charm production at fixed-target LHCb

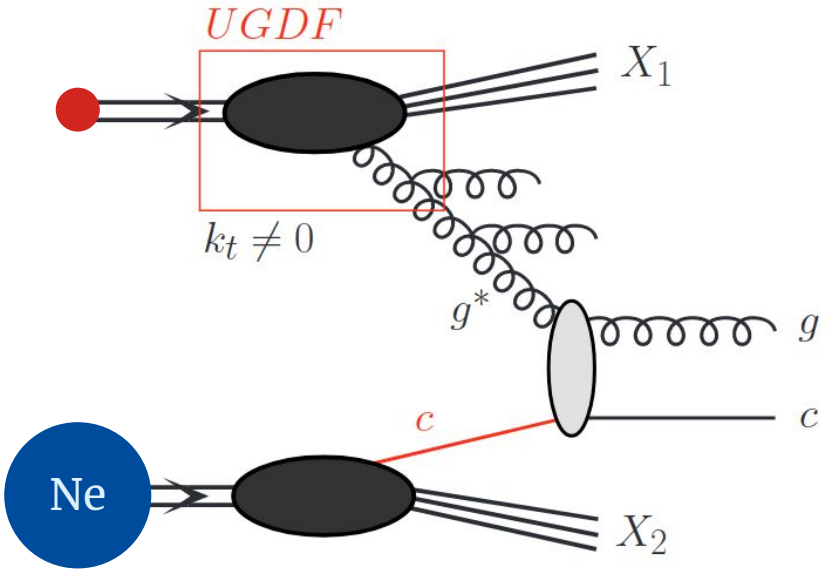
- Backward D-meson production models are still not completely understood.
- Fixed-target LHCb allows to directly probe this kinematic region.
- Leading contribution from "standard" QCD gluon-gluon fusion process.



Recombination mechanism for D0-meson production and D0-D0 production asymmetry in the LHCb p+^{20}Ne fixed-target experiment
Rafał Maciuła and Antoni Szczurek
arXiv:2206.02750 [hep-ph]

Charm production at fixed-target LHCb

- Knock-off of a charm quark from the target nucleon.
- Expected to enhance the D-meson cross-section at backward rapidity.
- However effect remains small, at the percent level.



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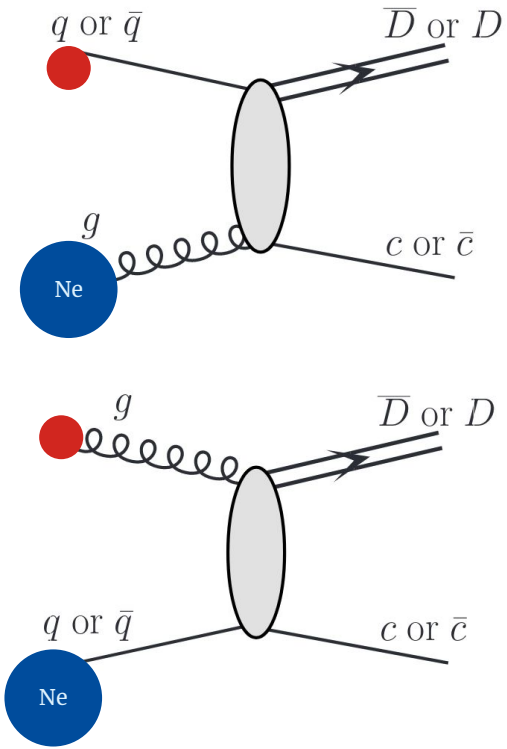

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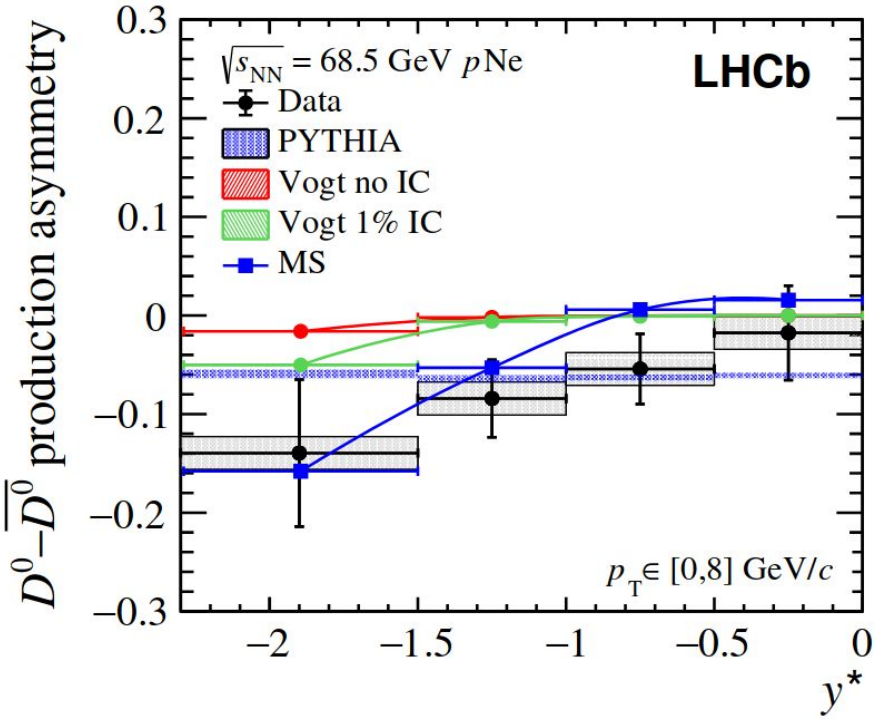
- Charge production asymmetry expected when a charm quark recombines with a light quark of the target nucleon.
- As valence region of the target nucleon is dominated by u and d quarks, expect a negative asymmetry increasing at backward rapidity.

$$A = \frac{N(c\bar{q}) - N(\bar{c}q)}{N(c\bar{q}) + N(\bar{c}q)}$$

D⁰ production asymmetry



- PYTHIA 8 predicts a flat negative asymmetry, but still compatible with data.
- Predictions including shadowing effects with (Vogt 1% IC) or without (Vogt no IC) intrinsic charm represents upper bands, with trends compatible with data.
- MS model including both 1% intrinsic charm and 10% recombination contributions best reproduce data points.

Open charm production and asymmetry in pNe collisions at $\sqrt{s_{NN}}$ = 68.5 GeV
LHCb collaboration
arXiv:2211.11633 [hep-ex]

Charged open charm analysis

Decay chains

$$D^+ \to K^- \pi^+ \pi^+$$

$$D_s^+ \to K^+ K^- \pi^+$$

$$D^{*+} \to \left(D^0 \to K^- \pi^+ \right) \pi^+$$

$$\Lambda_c^+ \to p K^- \pi^+$$

and charge conjugates

Signal extraction optimization cuts

- **Main philosophy** : As all the final state particles are the same, apply the same cuts to every decay.

Data quality cuts
PVz ∈ [-200; -100] ∪ [+100; +150] mm
nPV ≥ 1, PUHits < 5, BCType = 1

	Daughter cuts	
	Acceptance	PID
$K^{\pm}$	$2 < \eta < 4.5$ $p_T > 400$ MeV $p > 3$ GeV	$PID_K > 5$
$\pi^{\pm}$		$PID_K < 0$

	Mother cuts
$D^{\pm}$	$IP_{\chi^2}^{PV} < 15$ Vertex $\chi^2 < 22$ DIRA > 0.999
$D_s^{\pm}$	
$D^{*\pm}$	

$D^{\pm}$ signal yield

$$D^+ \rightarrow K^- \pi^+ \pi^+$$

- Signal : Double-sided Crystal-Ball
- Background : Constant
- Limited to $p_T > 1.5$ GeV due to harsh trigger line cuts.

$D^{*\pm}$ signal yield

$$D^{*+} \rightarrow \left(D^0 \rightarrow K^- \pi^+\right) \pi^+$$

- Signal : Double-sided Crystal-Ball
- Background : 3rd power polynomial
- Subtracting the reconstructed D^0 mass allows to minimize the resolution degradation due to the soft pion.
- Down to $p_T = 0$.

$D_s^{\pm}$ signal yield

$$D_s^+ \to K^+ K^- \pi^+$$

- Signal : Double-sided Crystal-Ball
- Background : 1st degree polynomial
- Limited to $p_T > 1.5$ GeV due to harsh trigger line cuts.

$D^{\pm}$ raw asymmetry

$$A = \frac{N(D^+) - N(D^-)}{N(D^+) + N(D^-)}$$

- Negative asymmetry increasing at backward rapidity.
- Compatible trend with D^0 asymmetry and recombination model predictions.
- However, more data is needed to confirm this trend.
- New SMOG2 cell for high luminosity.

$D^{*\pm}$ raw asymmetry

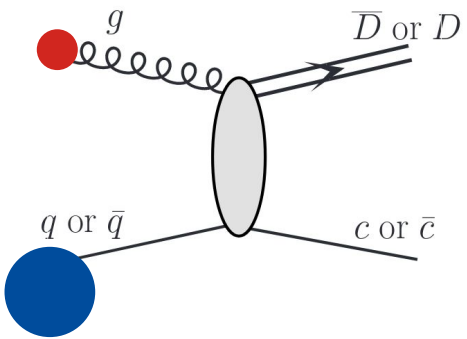
$$A = \frac{N(D^{*+}) - N(D^{*-})}{N(D^{*+}) + N(D^{*-})}$$

- Negative asymmetry mostly flat with rapidity.
- More statistics needed to observe any trend.
- New SMOG2 cell for high luminosity.

$D_s^{\pm}$ raw asymmetry

$$A = \frac{N(D_s^+) - N(D_s^-)}{N(D_s^+) + N(D_s^-)}$$

- No hint of asymmetry, as expected.
- Indeed, no strange quark expected in the target nucleon valence region.



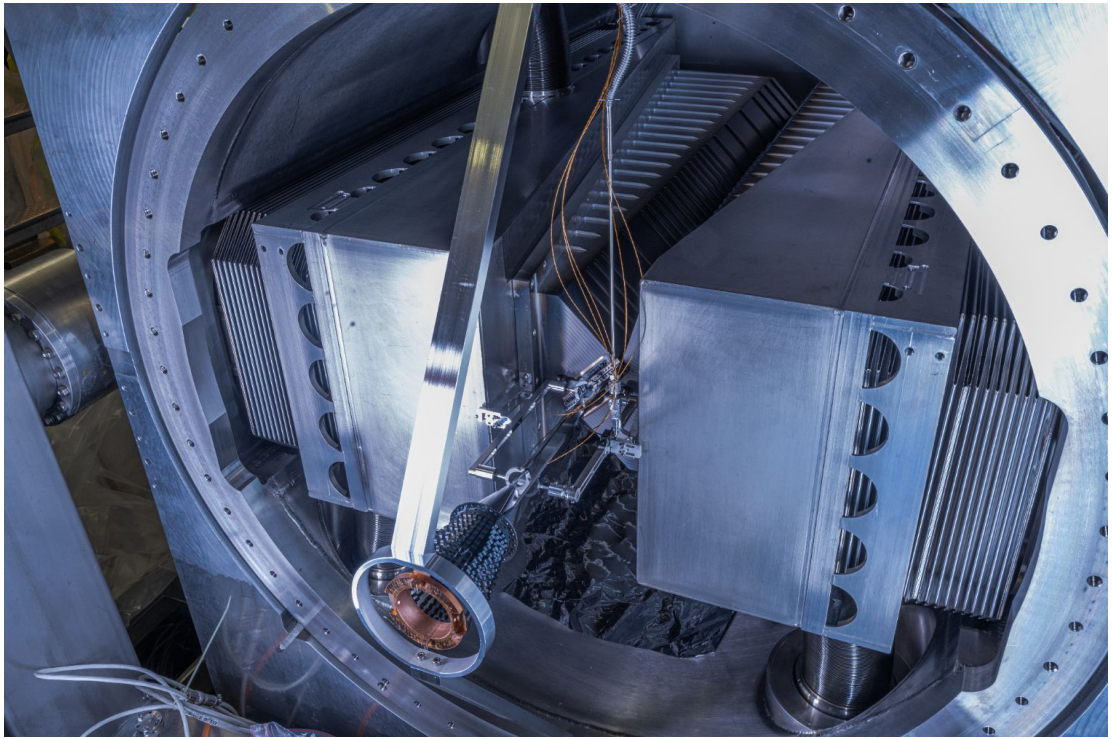
Summary

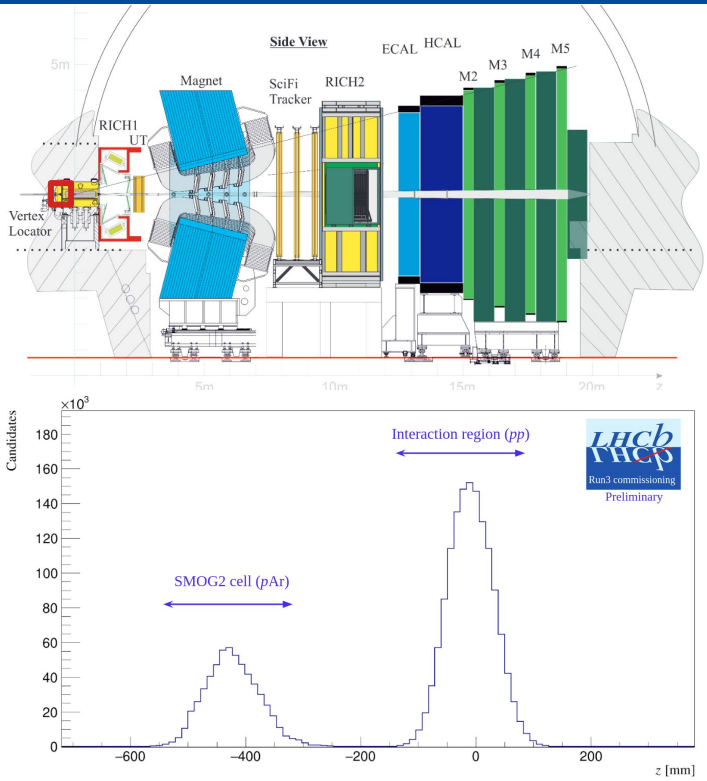
Thank you
for your attention

- Unique fixed-target LHCb program allows to probe backward rapidity, high-x charm production mechanisms.
- Hints of charge asymmetry are observed in D-meson production.
- Predictions including recombination best describe D^0 data, while other models seem to fail.
- Ongoing analysis to measure asymmetry in charged open-charm hadrons.
- More statistics is needed to confirm trends.
- Paving the way for SMOG2.

Backup

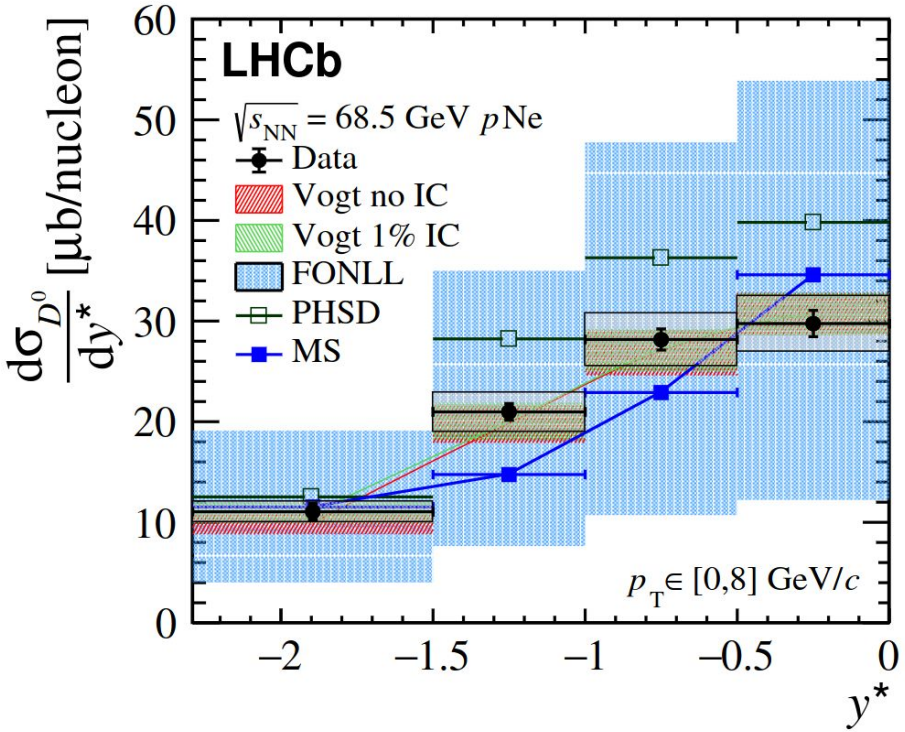
SMOG2

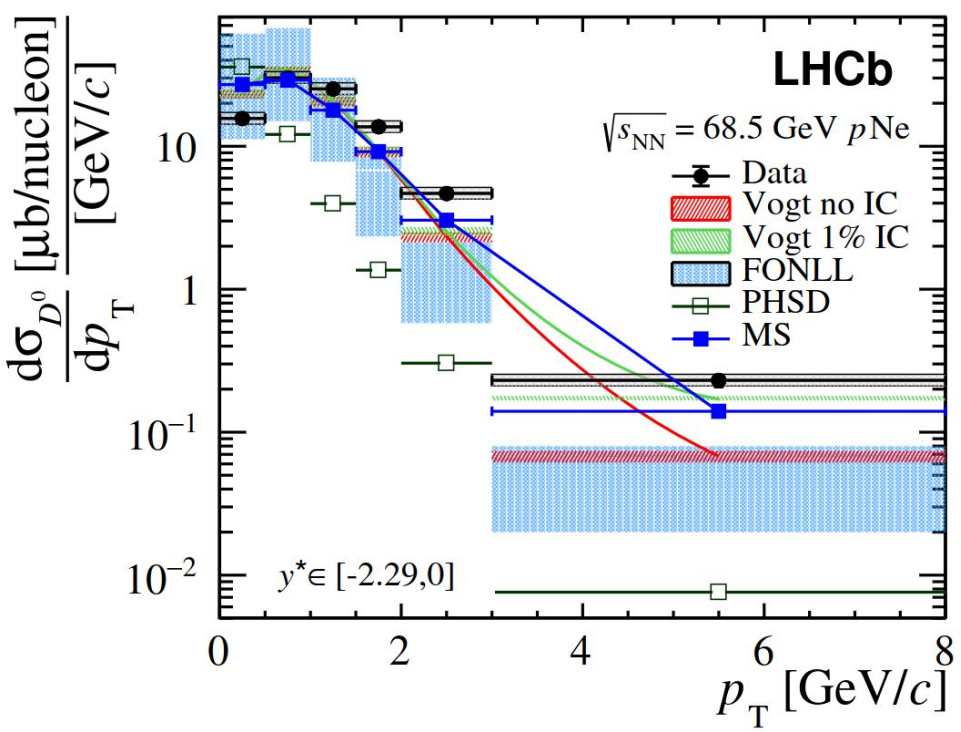




First LHCb upgrade reconstruction results on fixed-target data
LHCb Collaboration
LHCB-FIGURE-2023-001

D⁰ cross-section measurements





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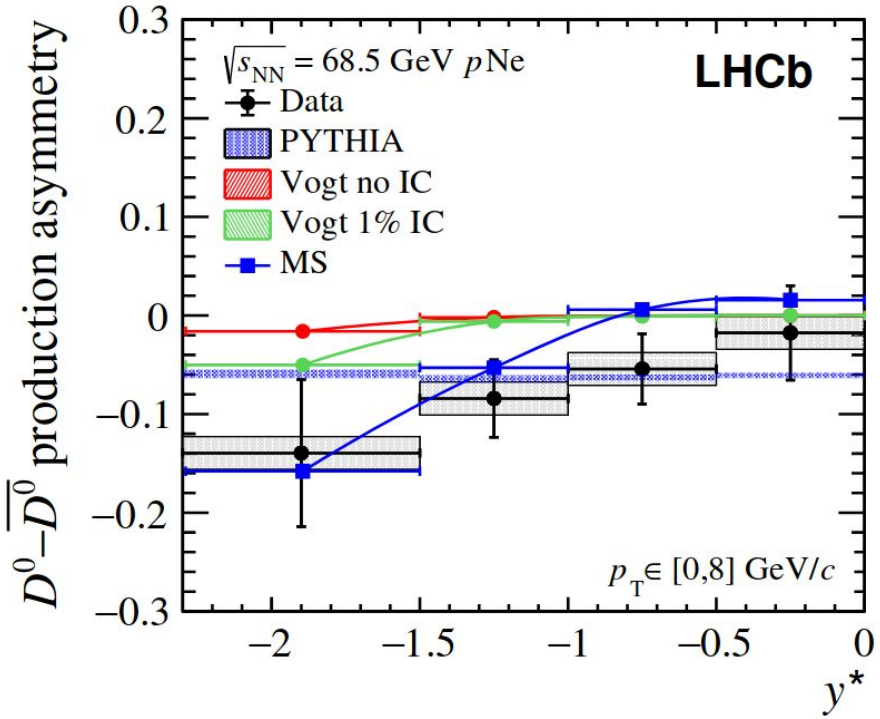

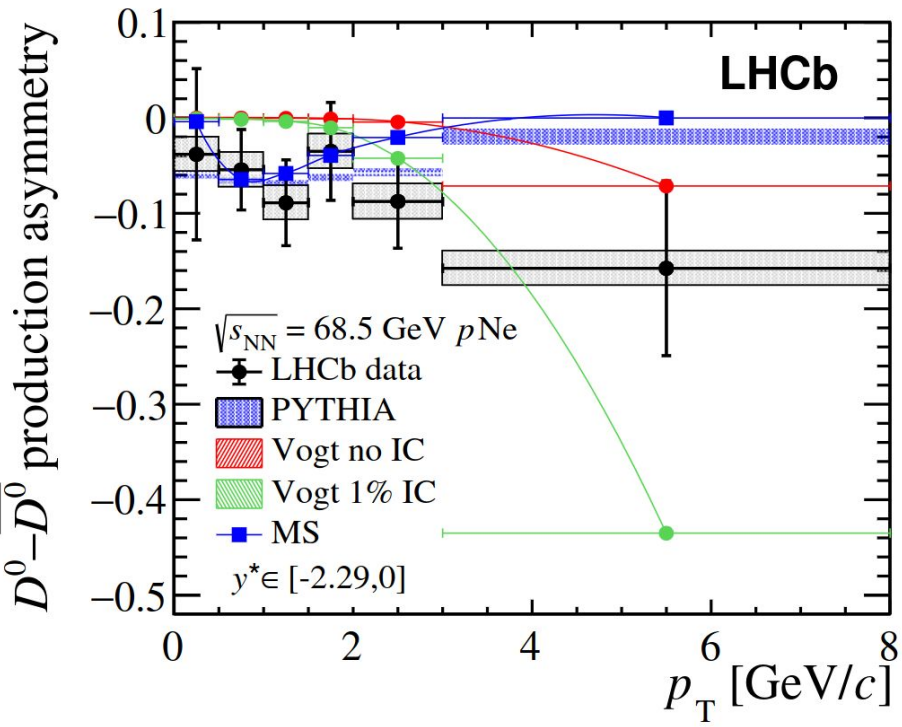

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