

The $L\updownarrow C$ project

Pasquale Di Nezza

Kick-off meeting



is an innovative and unique project conceived to bring polarized physics at the LHC



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The LHC beams cannot be polarized



The only possibility to have polarized collisions is through a polarized fixed-target



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Collisions generated by a TeV-scale beam with a fixed target will explore a unique kinematic region that has been poorly probed before.

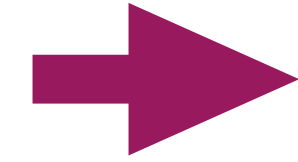
Advanced detectors make available probes never accessed before

International framework and feedback

International framework and feedback

Several experiments dedicated to spin physics, but with many limitations:

very low energy, no rare probes, no ion beam, ...

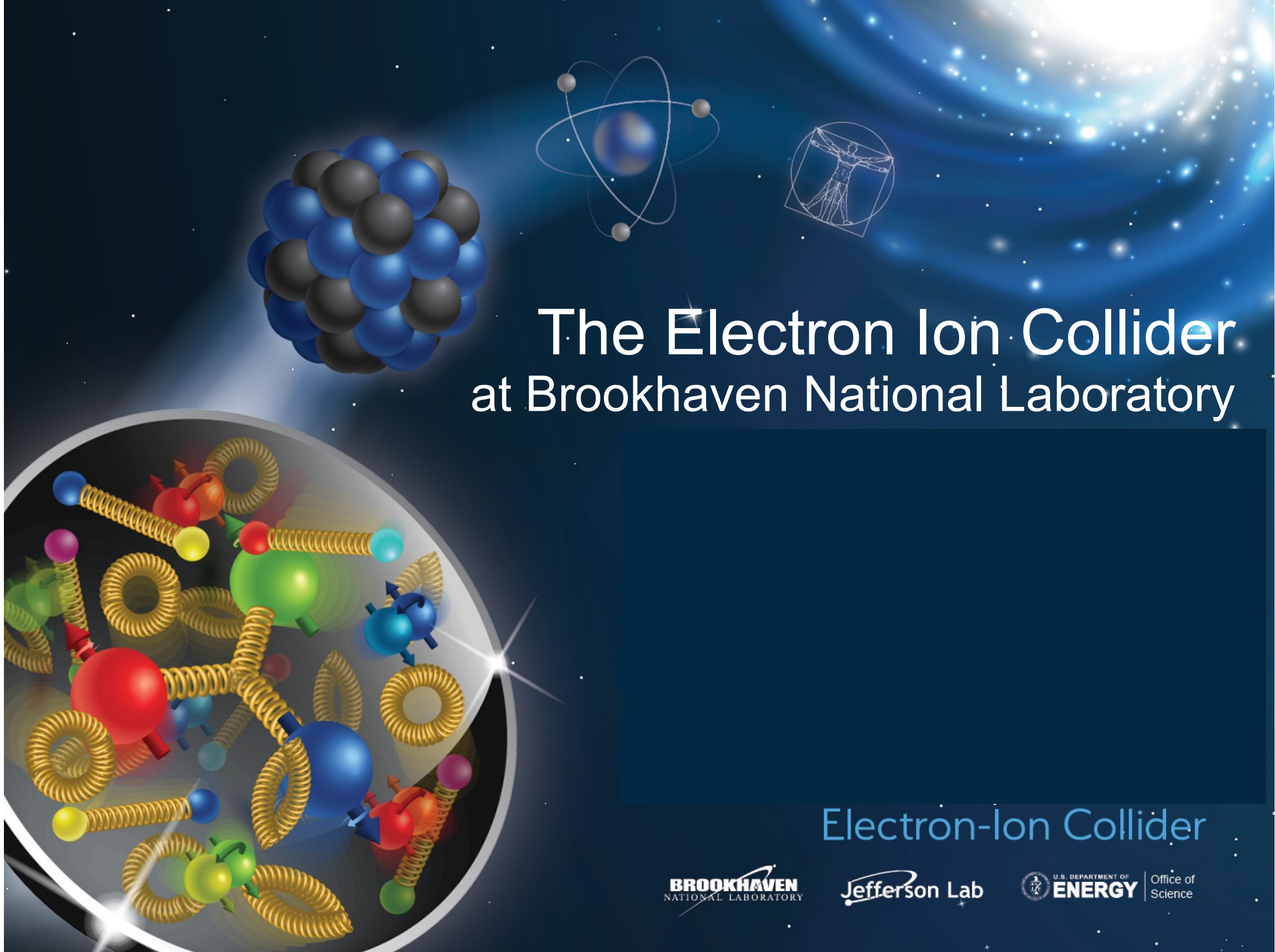


LHCspin is unique in this respect

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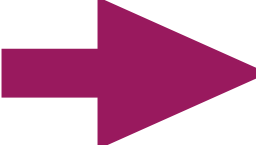


LHCspin is not better nor worse
it is complementary to EIC
it costs orders of magnitude less
it could take data a decade earlier

International framework and feedback

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LHCspin is unique in this respect

LHCspin is complementary to EIC

[D. Boer: [arXiv:1611.06089](https://arxiv.org/abs/1611.06089)]

unpolarized gluon TMD

| | DIS | DY | SIDIS | $pA \rightarrow \gamma \text{ jet } X$ | $ep \rightarrow e' Q \bar{Q} X$ $ep \rightarrow e' j_1 j_2 X$ | $pp \rightarrow \eta_{c,b} X$ $pp \rightarrow H X$ | $pp \rightarrow J/\psi \gamma X$ $pp \rightarrow \Upsilon \gamma X$ |
|----------------------|-----|----|-------|--|--|---|--|
| $f_1^g^{[+,+]}$ (WW) | × | × | × | × | ✓ | ✓ | ✓ |
| $f_1^g^{[+,-]}$ (DP) | ✓ | ✓ | ✓ | ✓ | × | × | × |

linearly polarized gluon TMD

| | $pp \rightarrow \gamma \gamma X$ | $pA \rightarrow \gamma^* \text{ jet } X$ | $ep \rightarrow e' Q \bar{Q} X$ $ep \rightarrow e' j_1 j_2 X$ | $pp \rightarrow \eta_{c,b} X$ $pp \rightarrow H X$ | $pp \rightarrow J/\psi \gamma X$ $pp \rightarrow \Upsilon \gamma X$ |
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TMDs (Sivers)

[D. Boer: [arXiv:1611.06089](https://arxiv.org/abs/1611.06089), D. Boer et al. HEPJ 08 2016 001]

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|--------------------------------|----|-------|-------------------------------|---|---|--|
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| $f_{1T}^{\perp g [+, -]}$ (DP) | ✓ | ✓ | ✓ | ✓ | × | × |

$f_{1T}^{\perp g [+,+]}$ (Weizsacker-Williams type or "f-type") → antisymmetric colour structures

$f_{1T}^{\perp g [+, -]}$ (Dipole s type or "d-type") → symmetric colour structures

- Can be measured at the Electron Ion-Collider (EIC)
- Can be measured at LHCspin

"Ambitious and long term LHC-Fixed Target research program. The efforts of the existing LHC experiments to implement such a programme, including specific R&D actions on the collider, **deserve support**" (European Strategy for Particle Physics)

"This would be **unique and highly complementary** to existing and future measurements in lepton-proton collisions, because the asymmetries in question have a process dependence between pp and lp that is predicted by theory" (CERN Physics Beyond Collider)

Recognised relevance

International framework and feedback

Several experiments dedicated to spin physics, but with many limitations:

very low energy, no rare probes, no ion beam, ...

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"Ambitious and long term LHC-Fixed Target research program. The efforts of the existing LHC experiments to implement such a programme, including specific R&D actions on the collider, deserve support" (European Strategy for Particle Physics)

"This would be unique and highly complex because the asymmetries in question have not been observed in lepton-proton collisions, but are predicted by theory" (CERN Physics Beyond Collider)

more in Marco Santimaria's talk

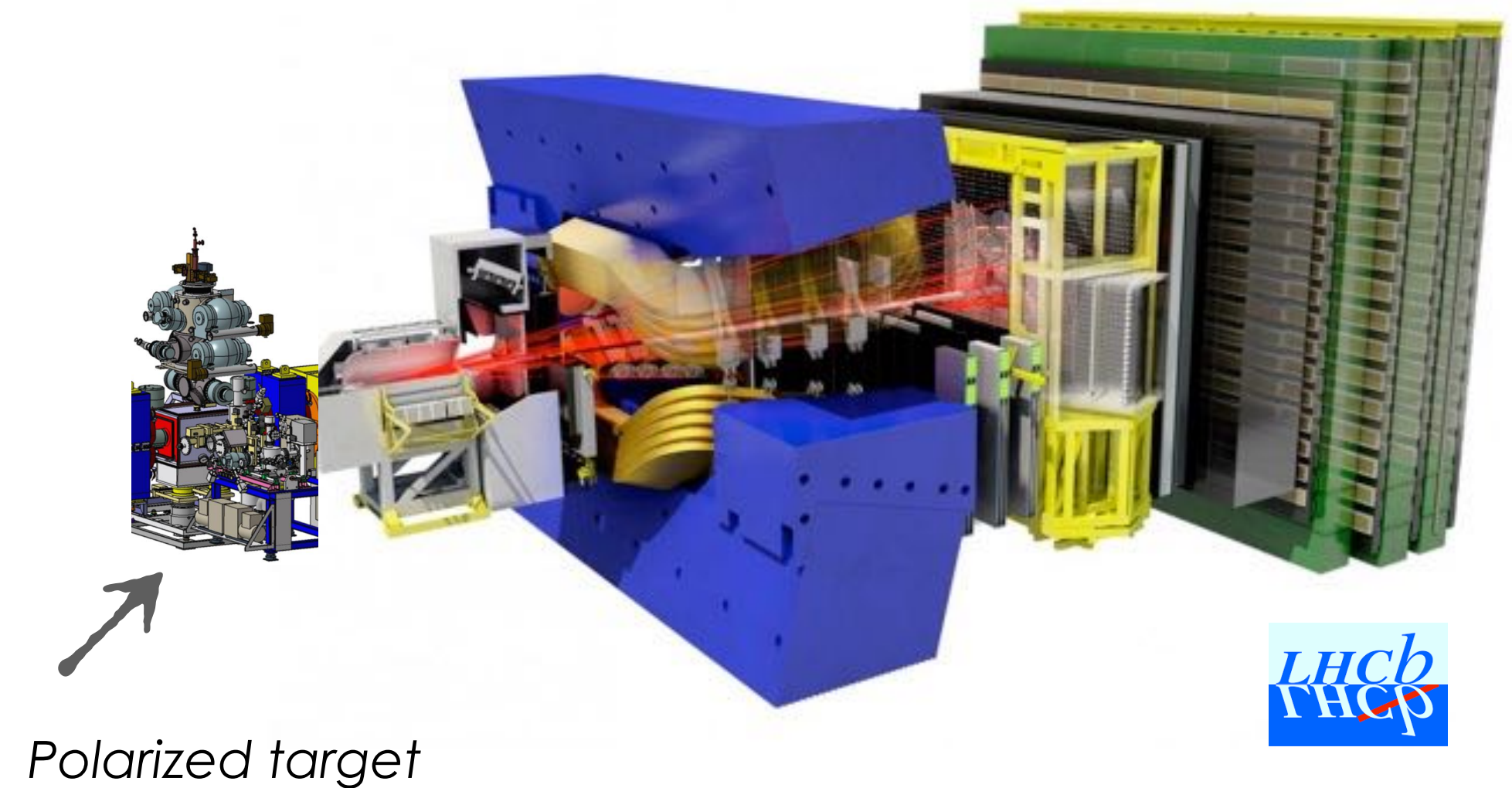
Recognised relevance

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Install the PGT in LHCb for the Run5 (~2033) and exploit all the enormous potentialities due to the LHCb (upgrade II) spectrometer: c-, b-quark reconstruction, rare probes, RTA, ...

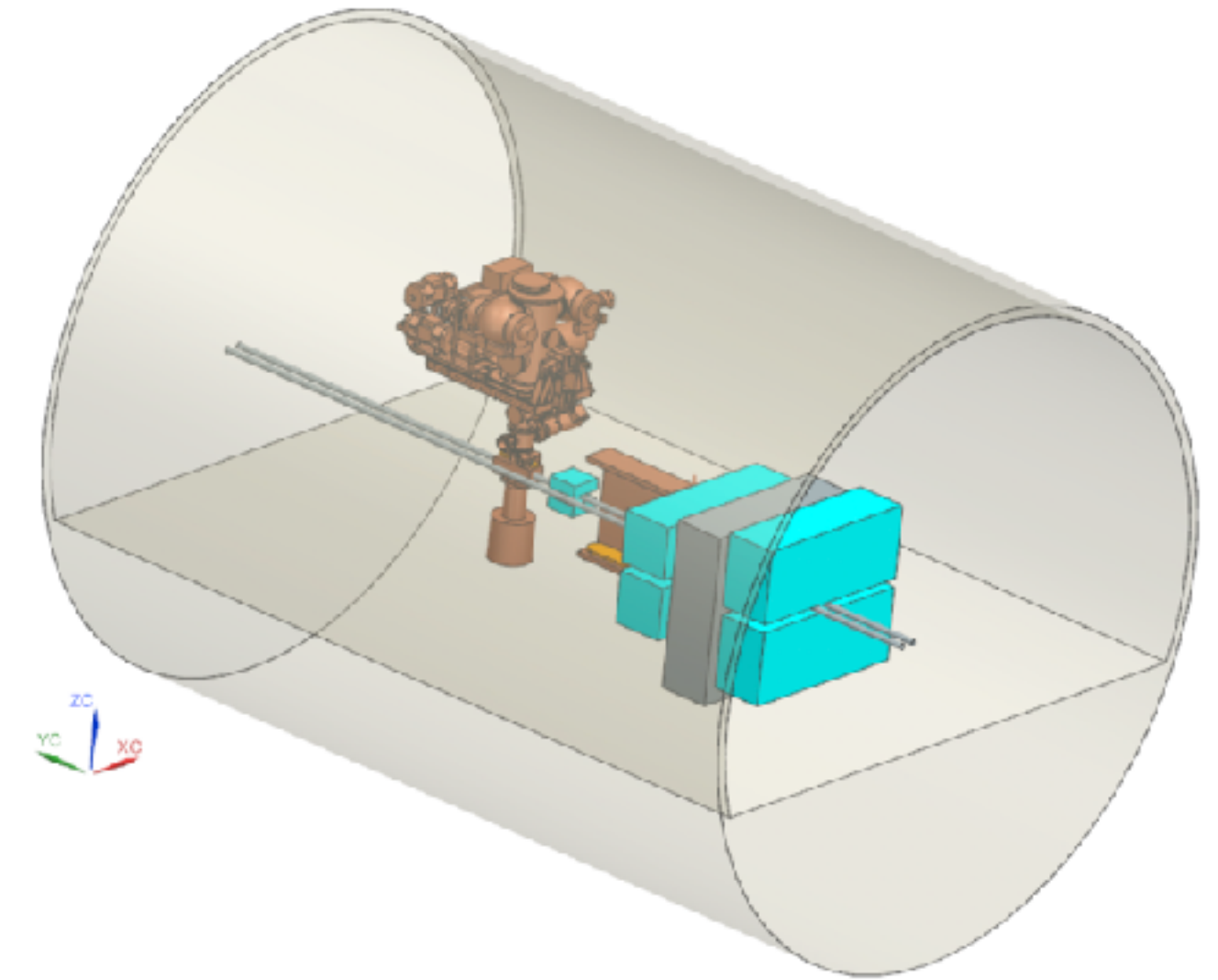


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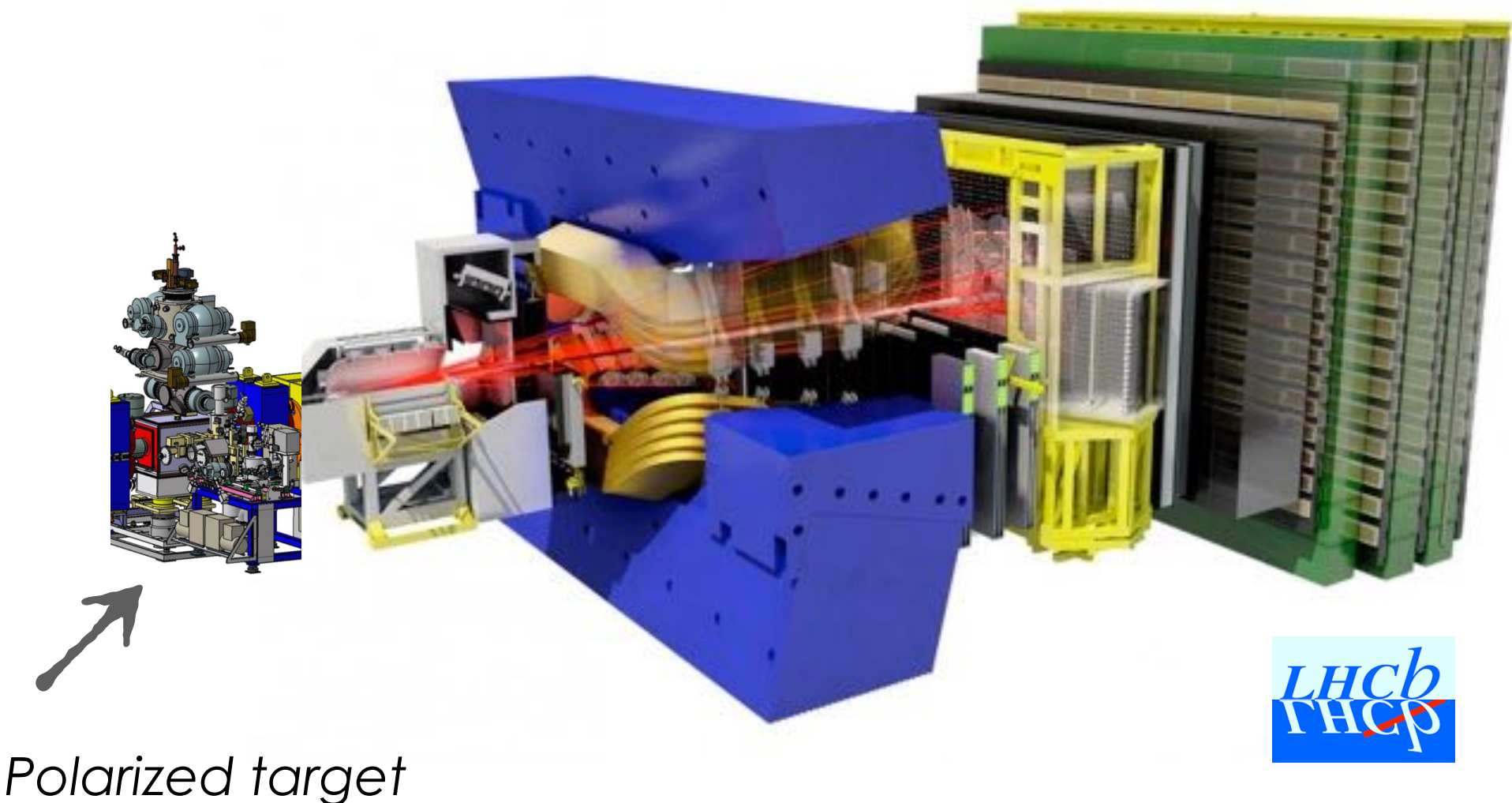
Develop a compact, LHCb independent, apparatus capable of:

- conducting R&D for a new generation PGT
- perform physics measurements never accessed before
- perform measurements connected to LHC
- etc...



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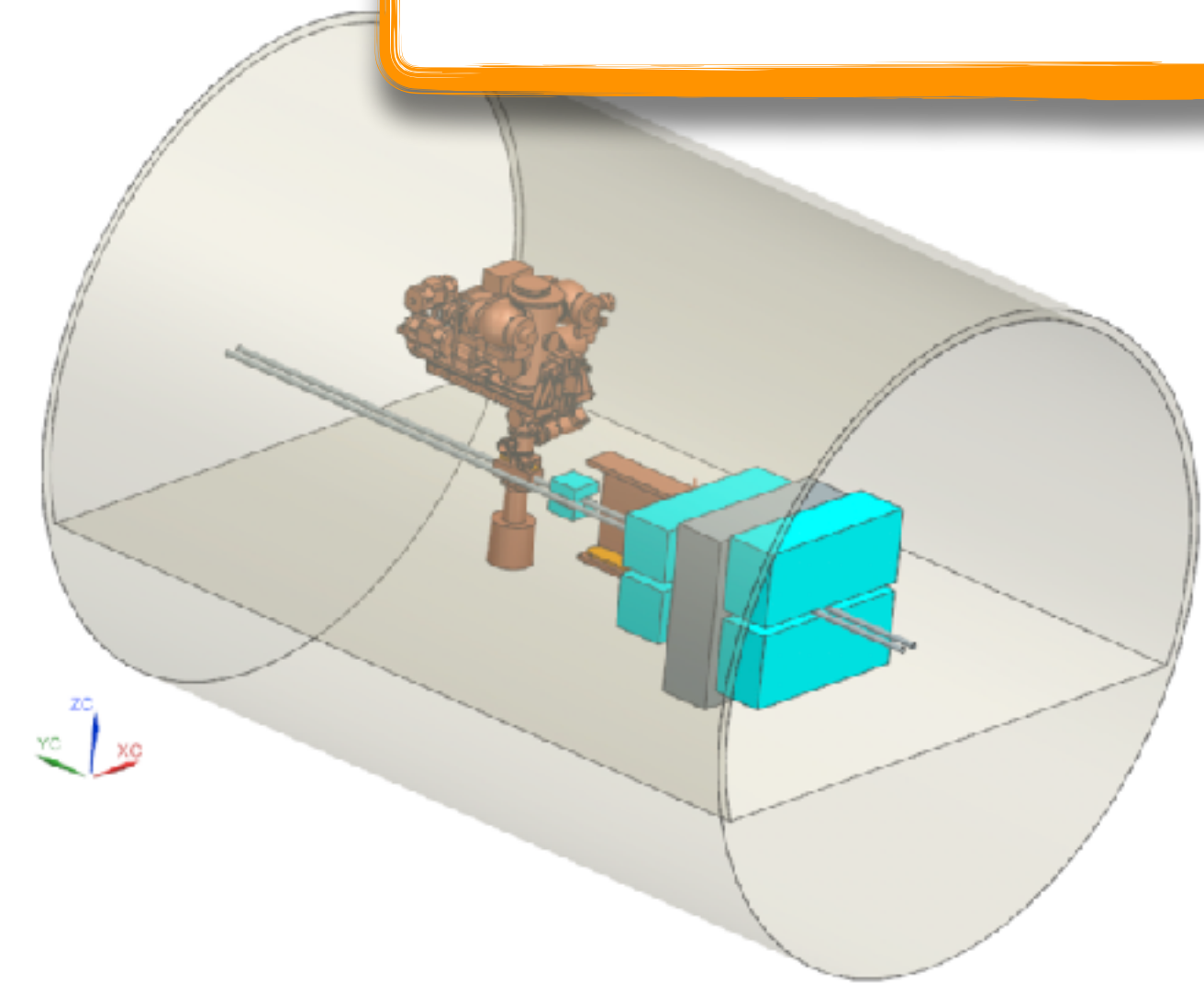
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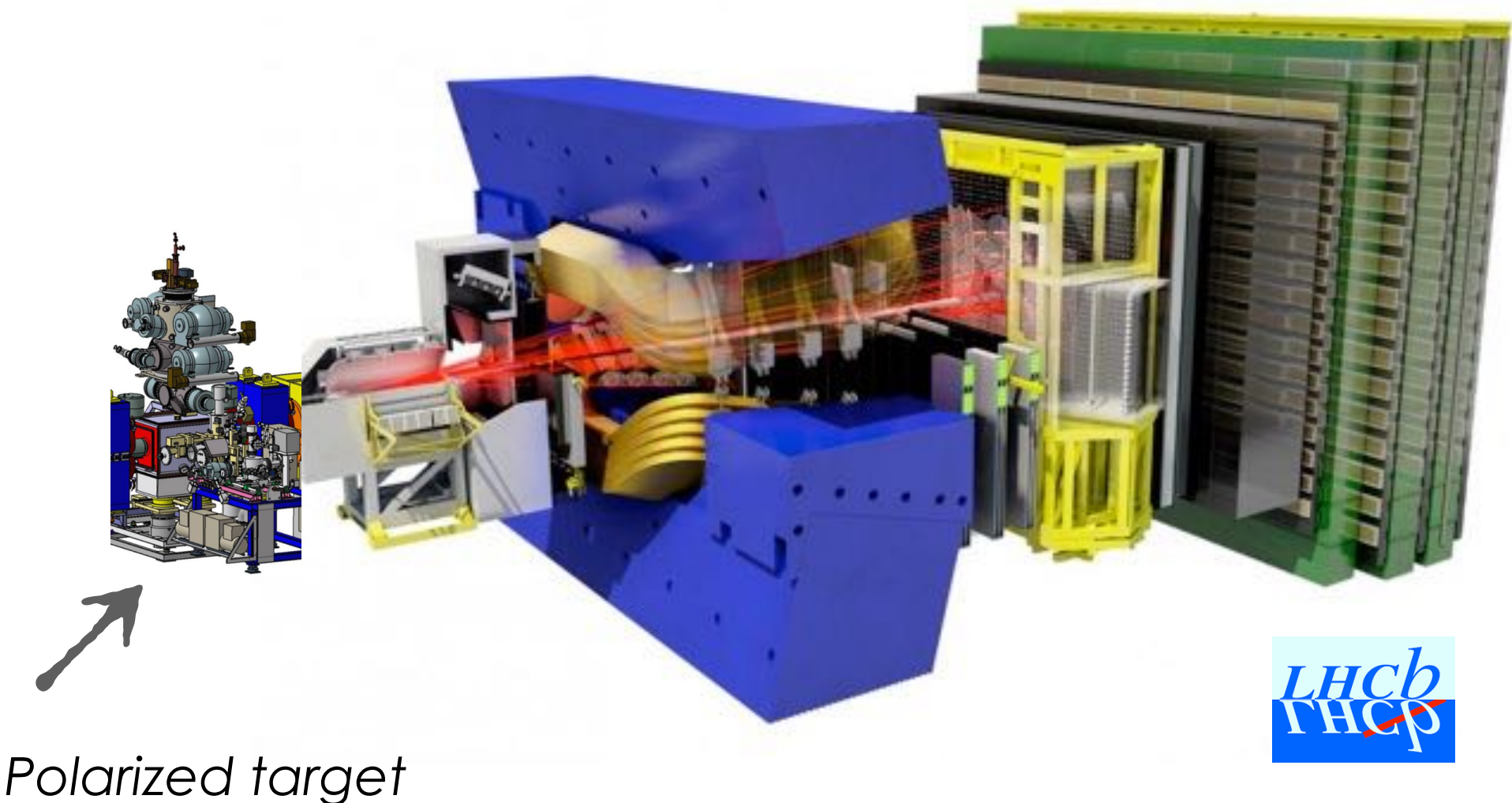
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more in Luciano Pappalardo's talk



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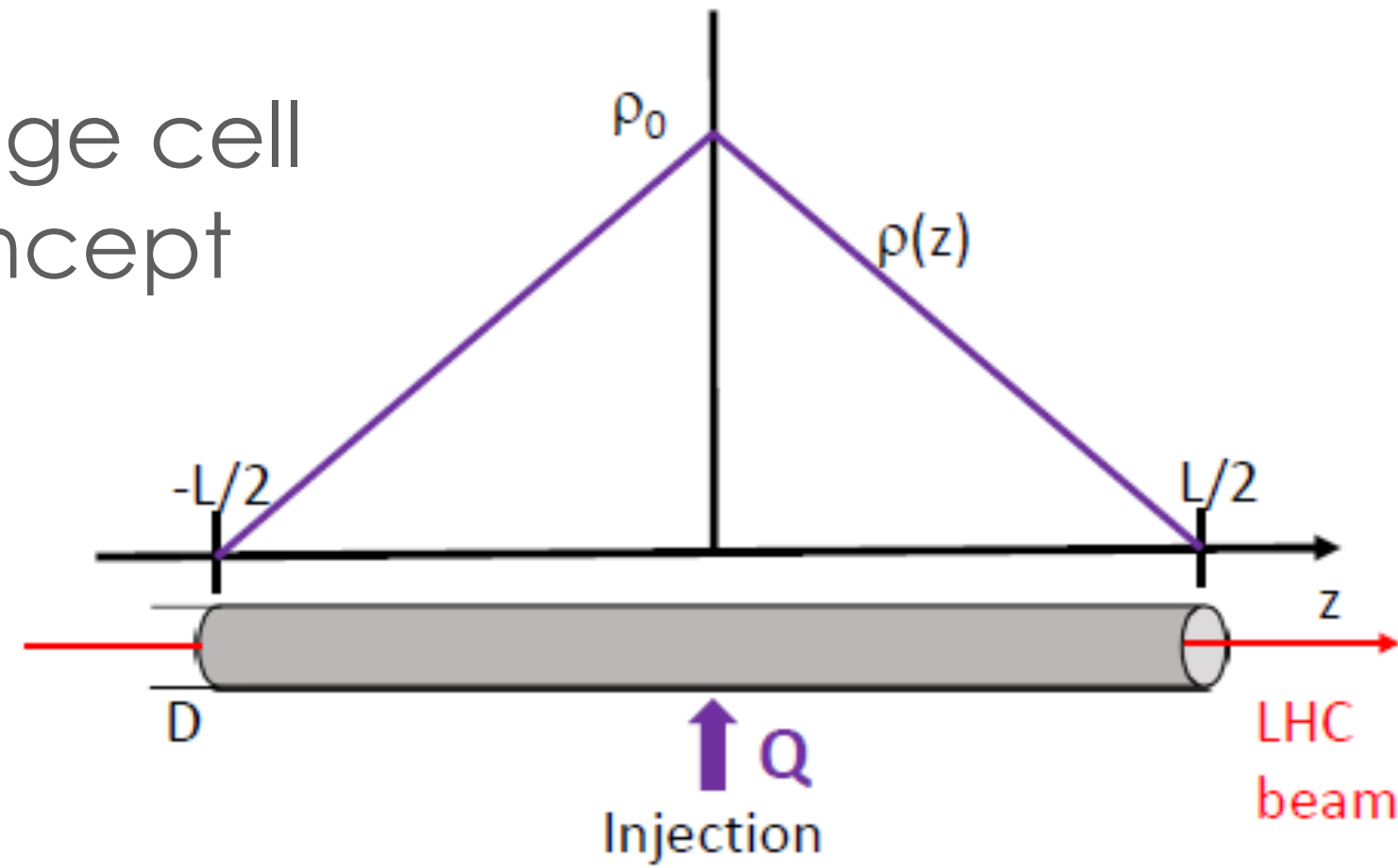
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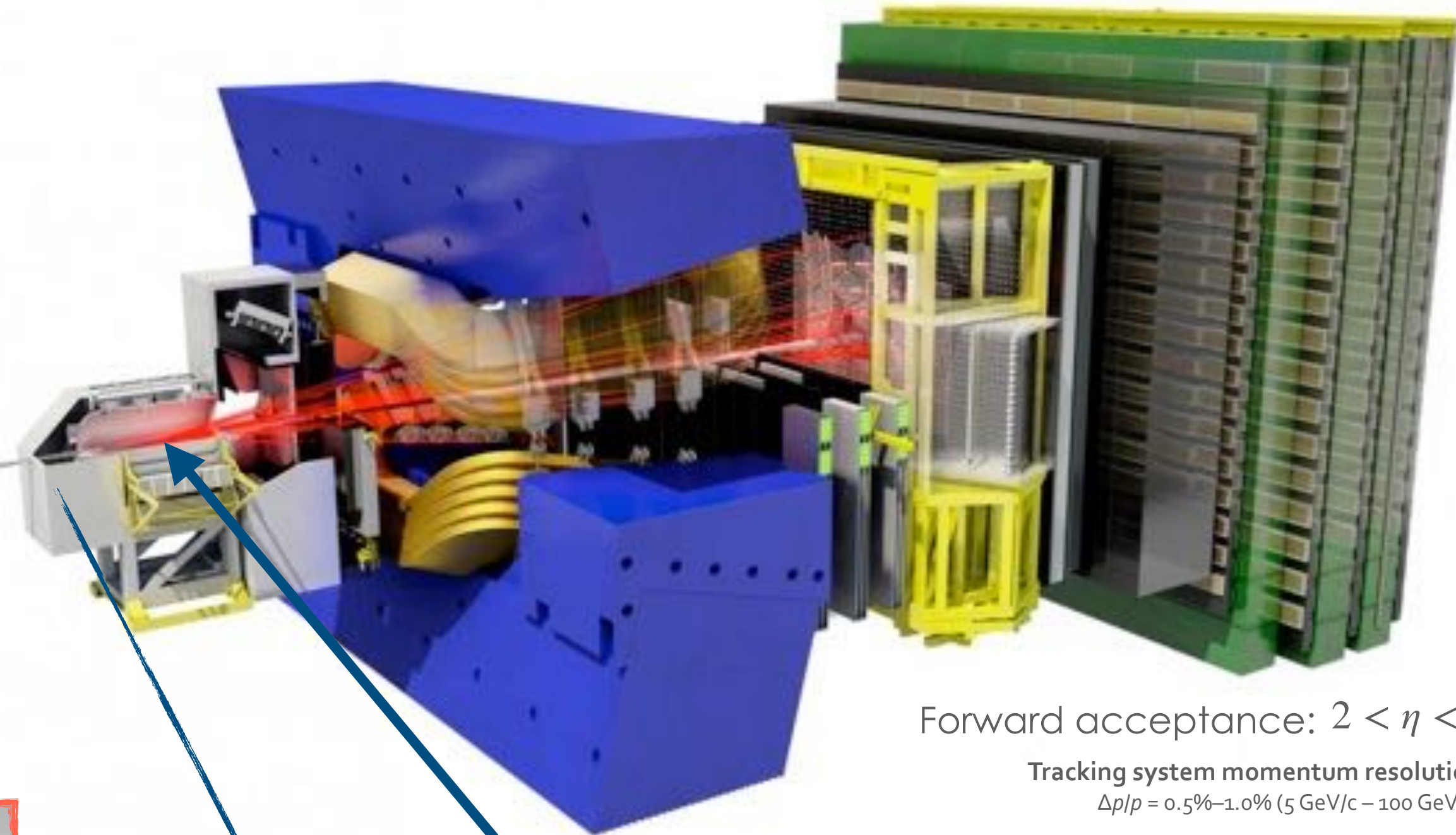
Starting from a solid base: SMOG2

JINST 3 (2008) S08005
IJMPA 30 (2015) 1530022

Storage cell concept



LHC beam

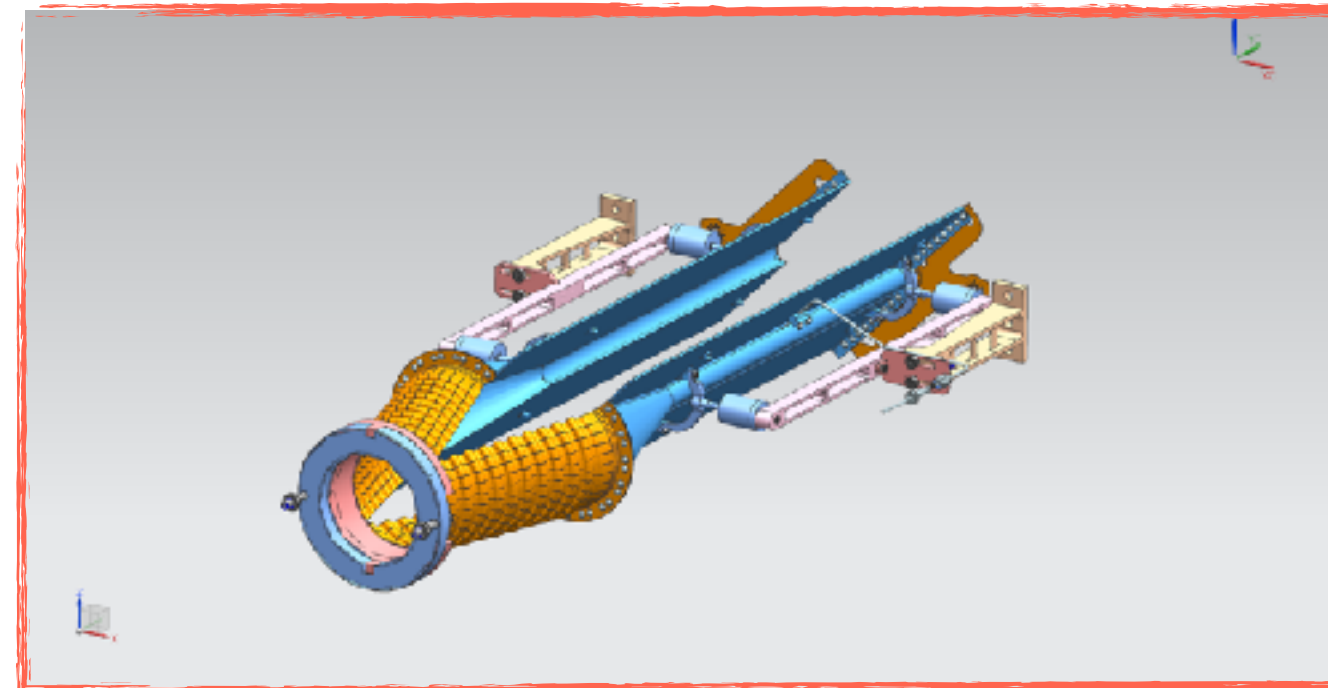
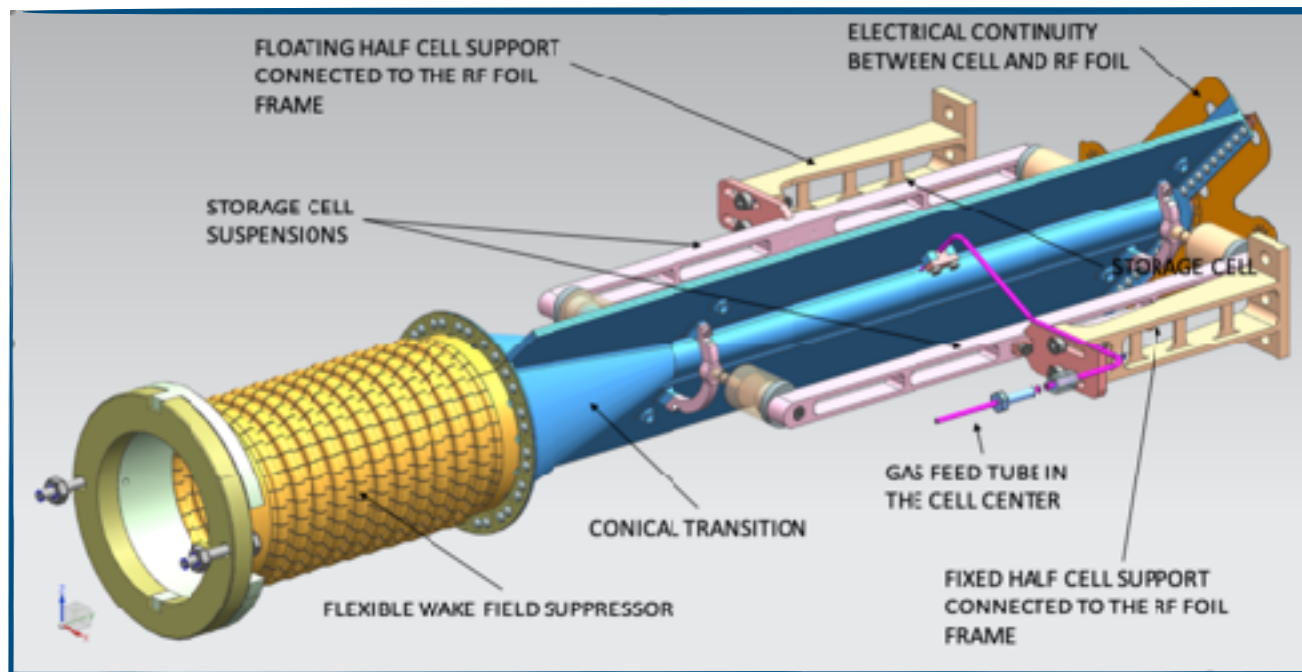


Forward acceptance: $2 < \eta < 5$

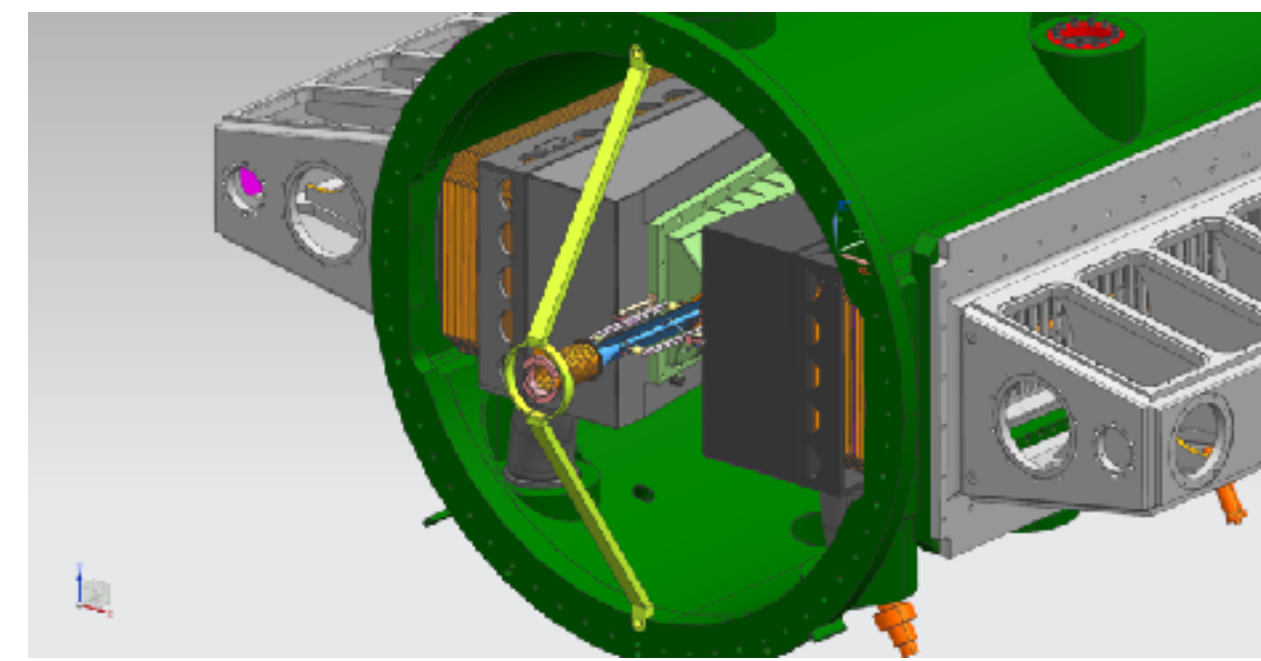
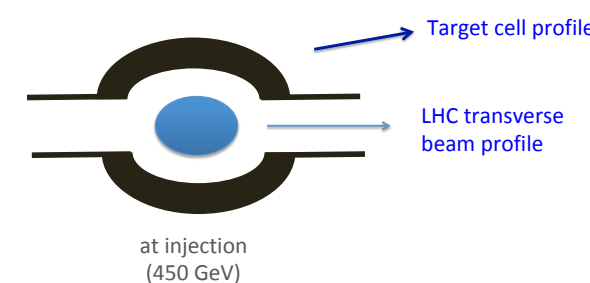
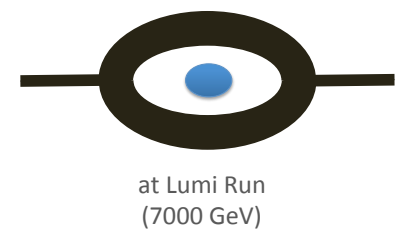
Tracking system momentum resolution
 $\Delta p/p = 0.5\% - 1.0\%$ (5 GeV/c - 100 GeV/c)

beam-beam collisions

Openable cell

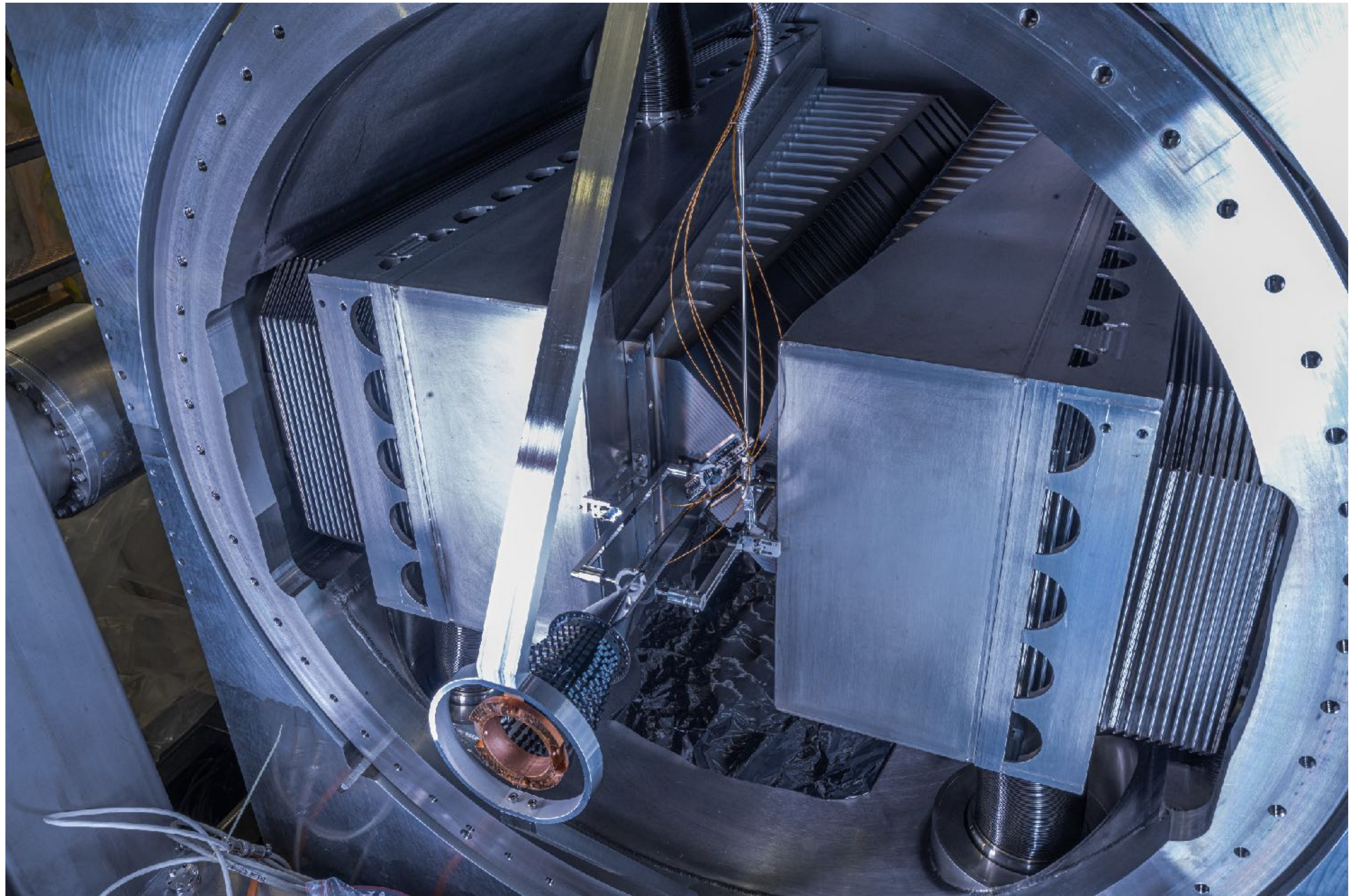


5 mm radius x 200 mm length



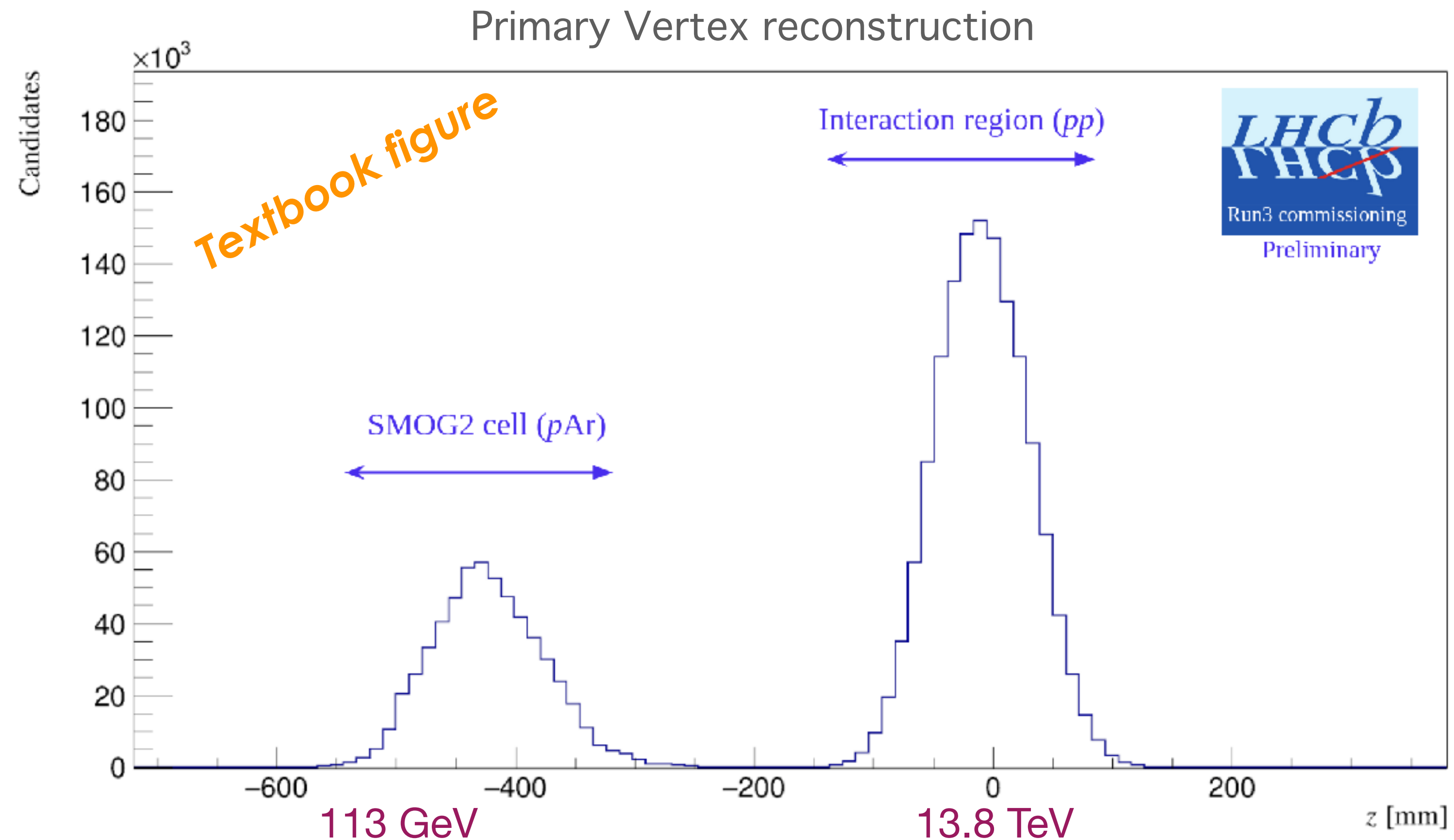
UNpolarized target
(beam-gas)

SMDQ2



It is the only system present in the LHC primary vacuum

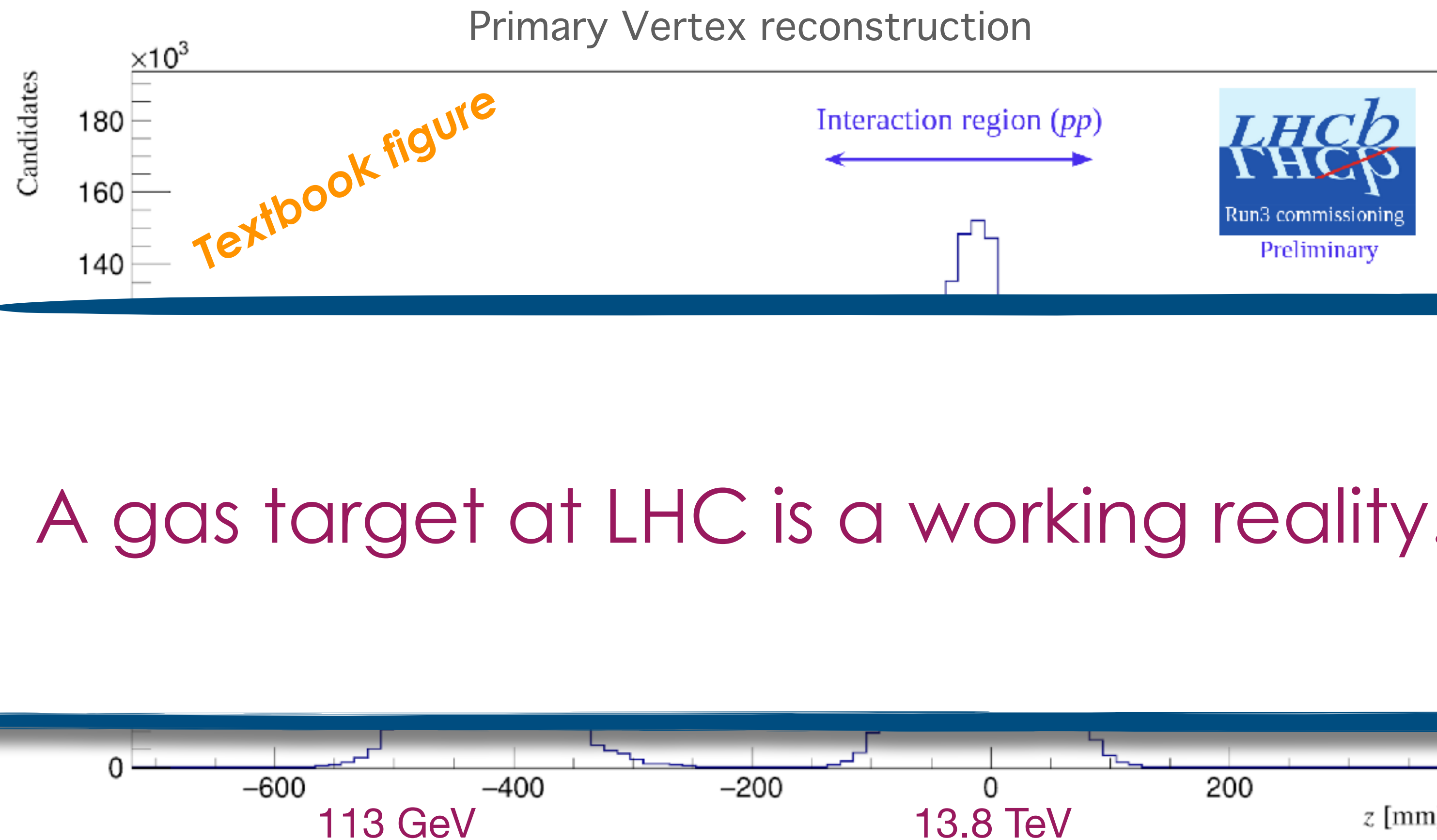
SMOG2 ... wow-factor!



Two well separated and independent Interaction Points working simultaneously

Negligible impact on the beam lifetime ($\tau_{beam-gas}^{p-H_2} \sim 2000$ days, $\tau_{beam-gas}^{Pb-Ar} \sim 500$ h)

SMDQ2 ... wow-factor!



A gas target at LHC is a working reality!

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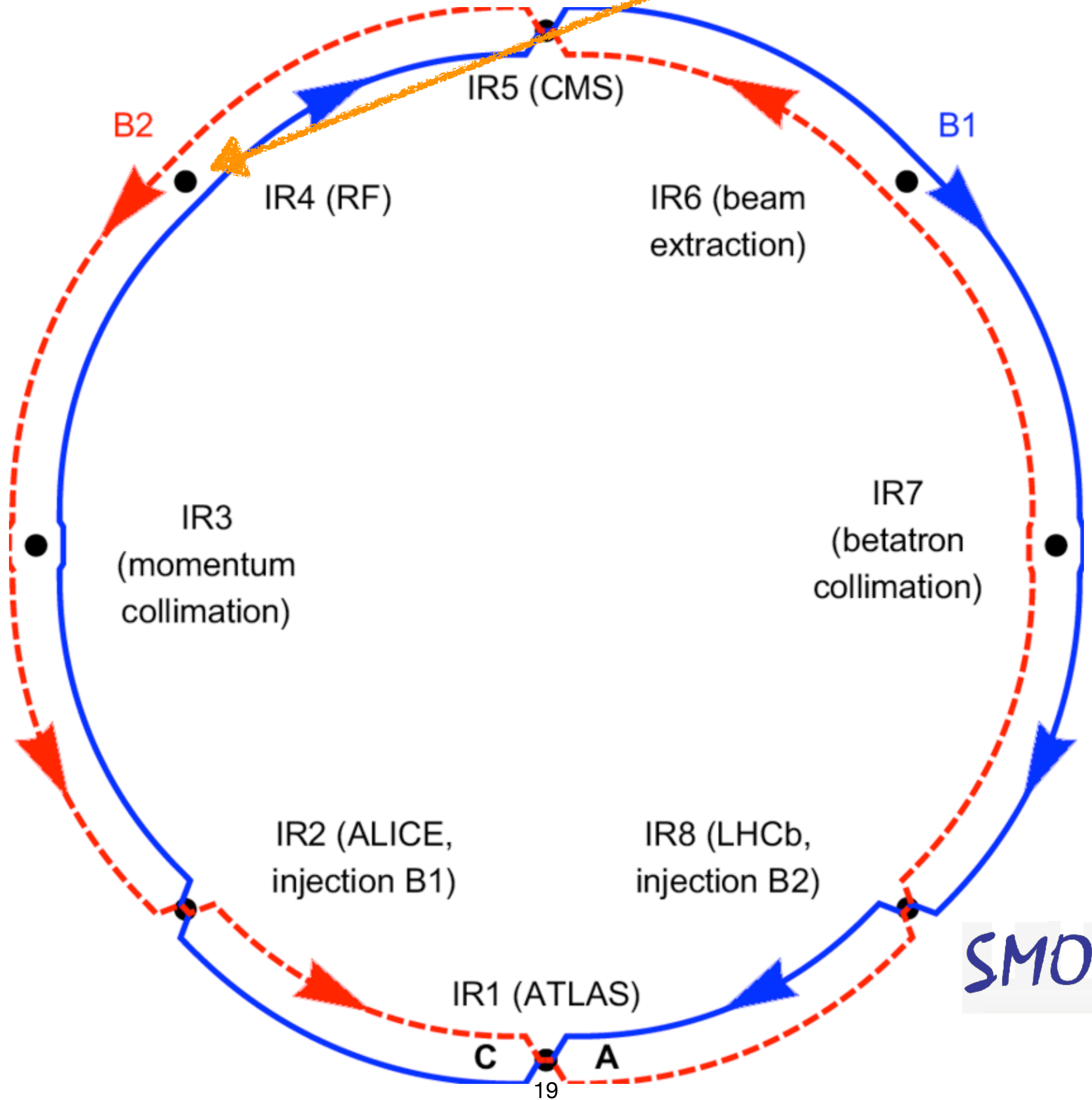
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Where can we built $L \updownarrow C$ phase 1

The LHC Interaction Regions



more in Luciano Pappalardo's talk



SMDQ2

Other possibilities:
-IR3
-IR8 just before or after LHCb (beyond the wall)

The LHC
Interaction
Region 3



The LHC
Interaction
Region 4
(larger tunnel)



BGV



https://indico.cern.ch/event/817655/contributions/3442649/attachments/1861615/3059737/2019_06_BGV_GasJetTarget.pdf

PHYSICAL REVIEW ACCELERATORS AND BEAMS 22, 042801 (2019)

Editors' Suggestion

Noninvasive LHC transverse beam size measurement using inelastic beam-gas interactions

A. Alexopoulos,^{*} C. Barschel, E. Bravin, G. Bregliozzi, N. Chritin, B. Dehning,[†] M. Ferro-Luzzi, M. Giovannozzi, R. Jacobsson, L. Jensen, R. Jones, V. Kain, R. Kieffer,[‡] R. Matev, M. Rihl, V. Salustino Guimaraes, R. Veness, S. Vlachos,[§] and B. Würkner^{||}
CERN, CH-1211 Geneva 23, Switzerland

A. Bay, F. Blanc, S. Giani, O. Girard, G. Haefeli, P. Hopchev, A. Kuonen, T. Nakada, O. Schneider, M. Tobin, and Z. Xu
EPFL Swiss Federal Institute of Technology, CH-1015 Lausanne, Switzerland

R. Greim, T. Kim, S. Schael, and M. Wlochal
RWTH Aachen University, I. Physikalisches Institut, Sommerfeldstrasse 14 D-52074 Aachen, Germany



This apparatus is not used and could be replaced by LHCspin

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2019)

astic



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-to develop a new generation target system

-to study the beam-polarized target mutual interactions (Beam Induced Depolarisation, Impedance, Coating, Recombination, SEY, ...)

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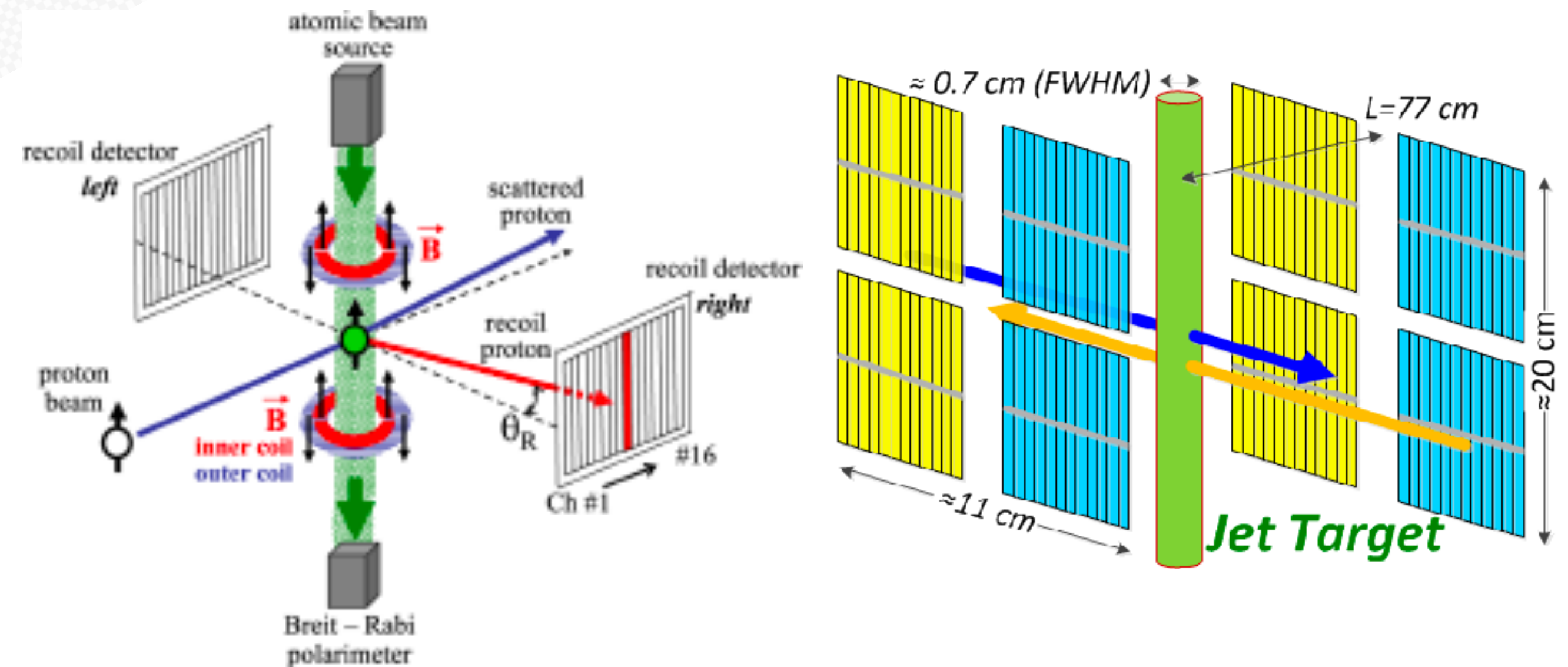
-to study the beam-polarized target mutual interactions (Beam Induced Depolarisation, Impedance, Coating, Recombination, SEY, ...)

-to develop a new polarimeter



e.g. similar to the RHIC/EIC hadronic polarimeter

more in Paolo Lenisa's talk



requires also R&D for silicon detectors in the LHC vacuum, interesting for many other projects

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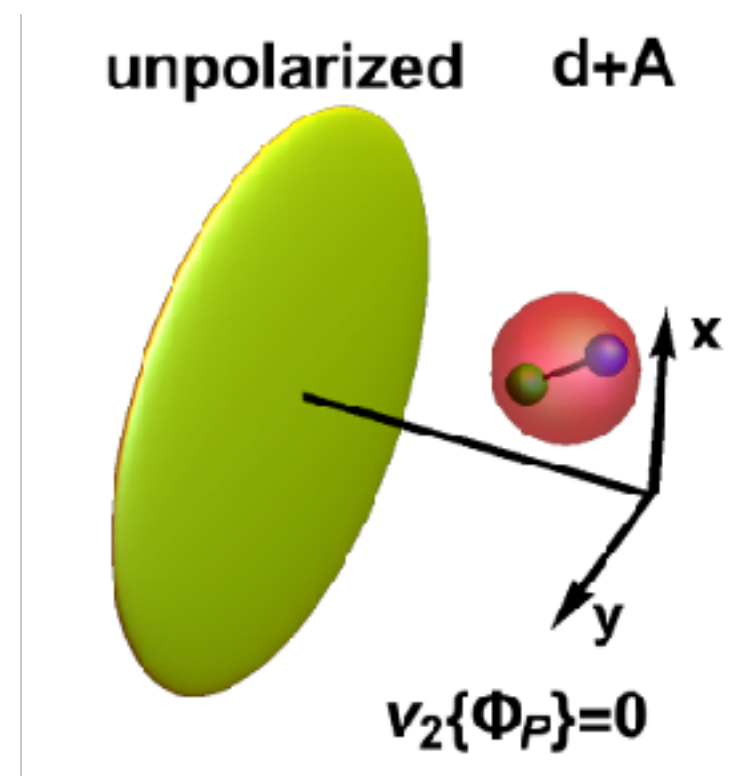
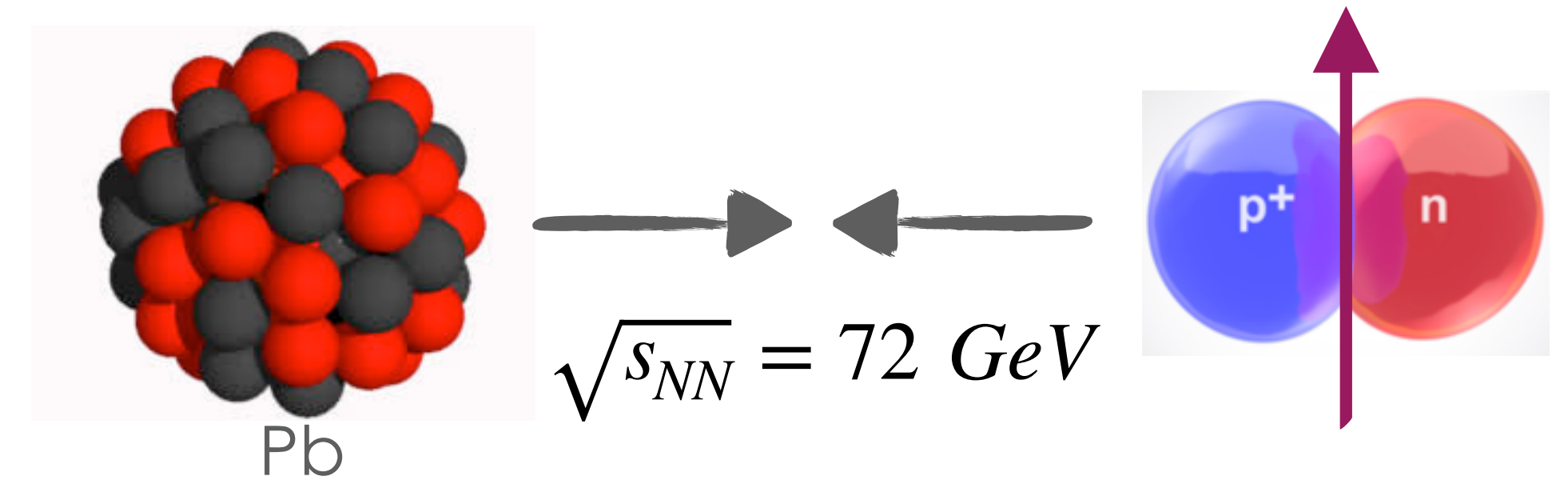
-to develop a new polarimeter

-to conduct interesting physics measurements, such as inclusive hadron production in pH^\uparrow , pD^\uparrow , PbH^\uparrow , PbD^\uparrow collisions

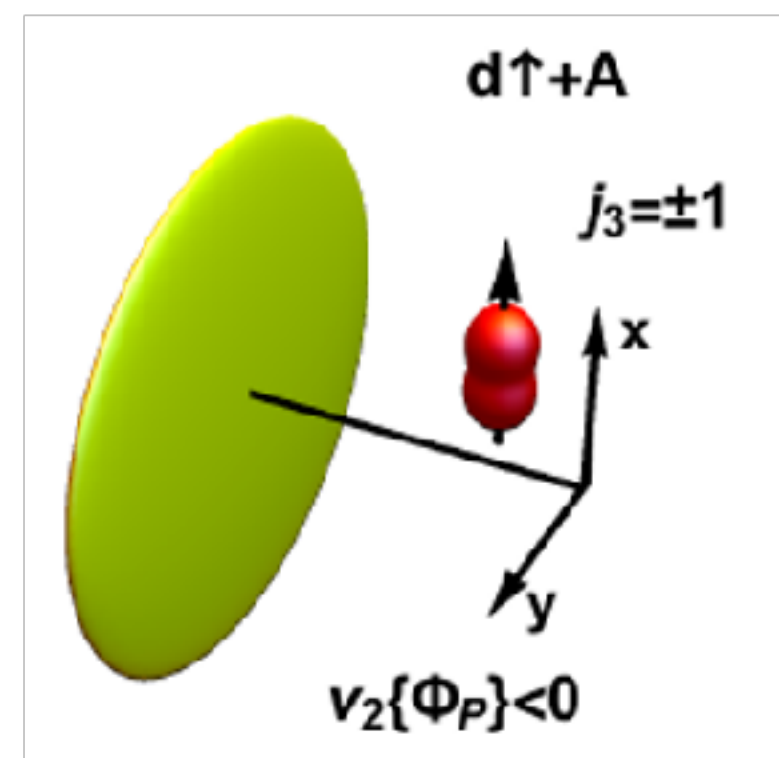
Spin physics in heavy-ion collisions

- probe collective phenomena in heavy-light systems through **ultra-relativistic collisions of heavy nuclei with trasv. pol. deuterons**

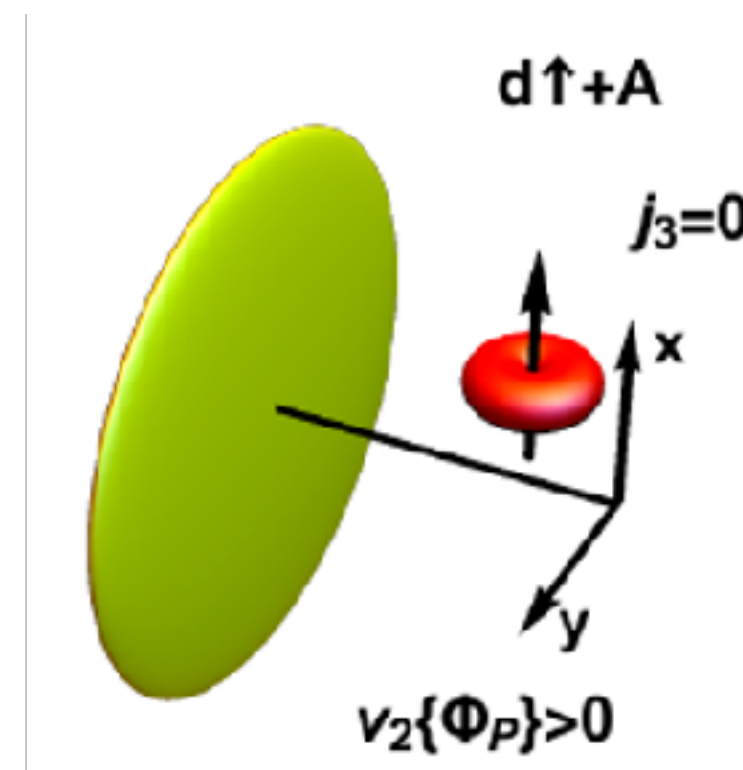
- polarized light target nuclei offer a unique opportunity to control the orientation of the formed fireball by measuring the **elliptic flow** relative to the polarization axis (**ellipticity**).



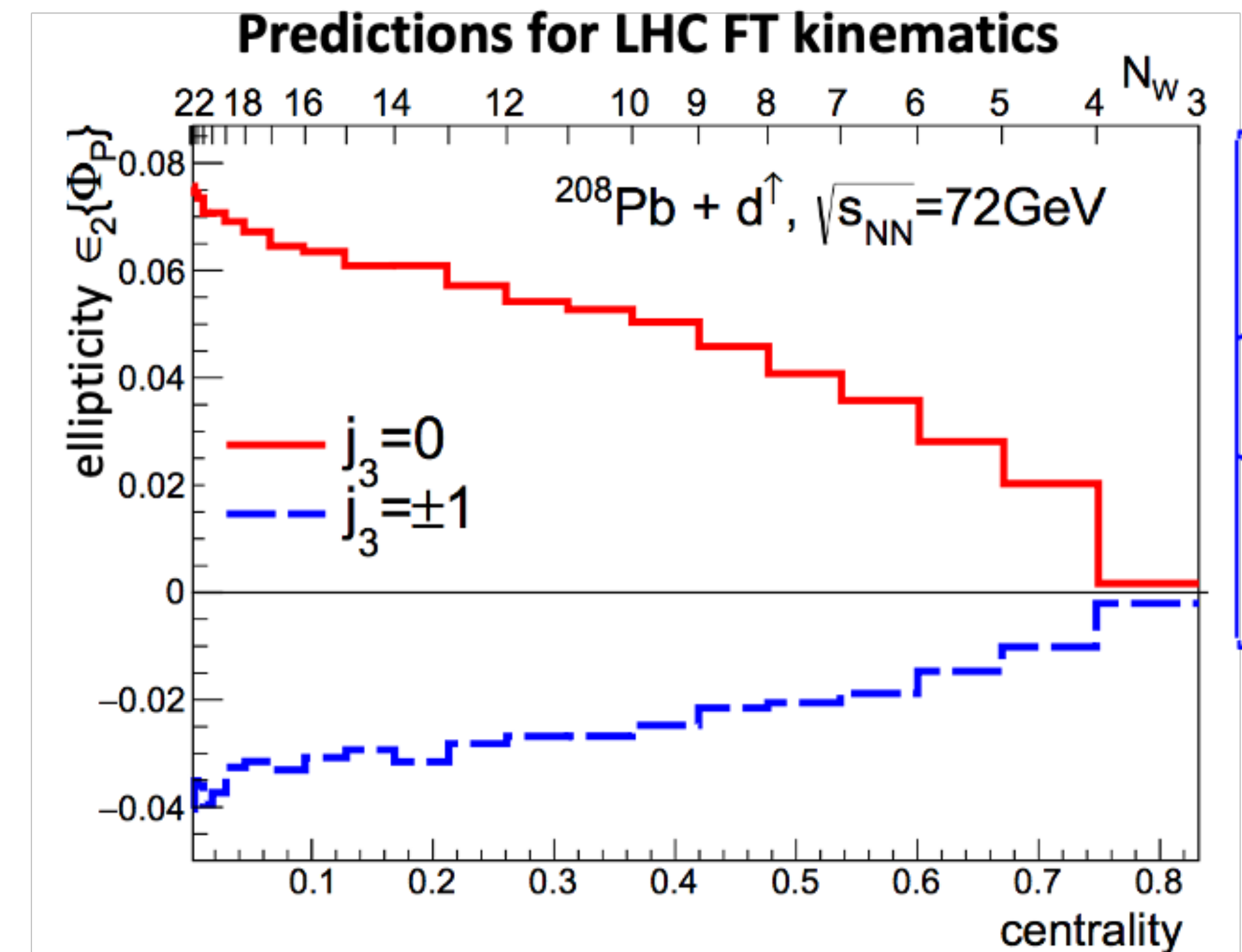
Unpol. deuterons: the fireball is azimuthally symmetric and $v_2 \approx 0$.



$j_3 = \pm 1 \rightarrow$ prolate fireball stretched along the pol. axis, corresponds to $v_2 < 0$



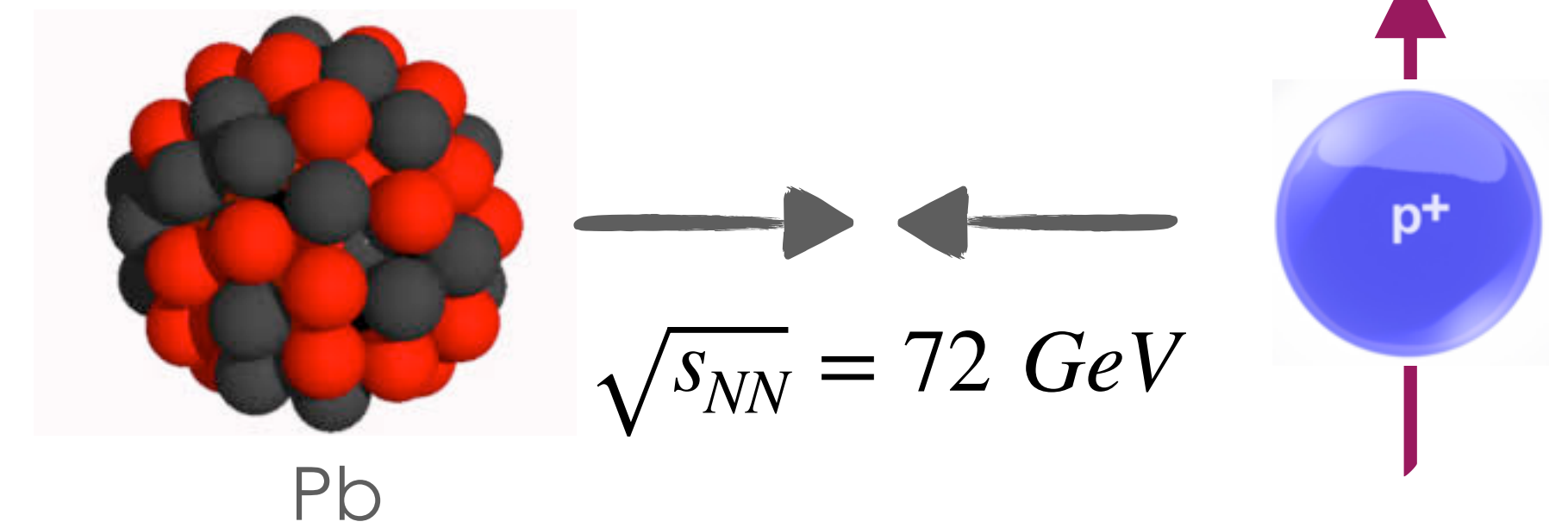
$j_3 = 0 \rightarrow$ oblate fireball corresponds to $v_2 > 0$



[PRC 101 (2020) 024901]

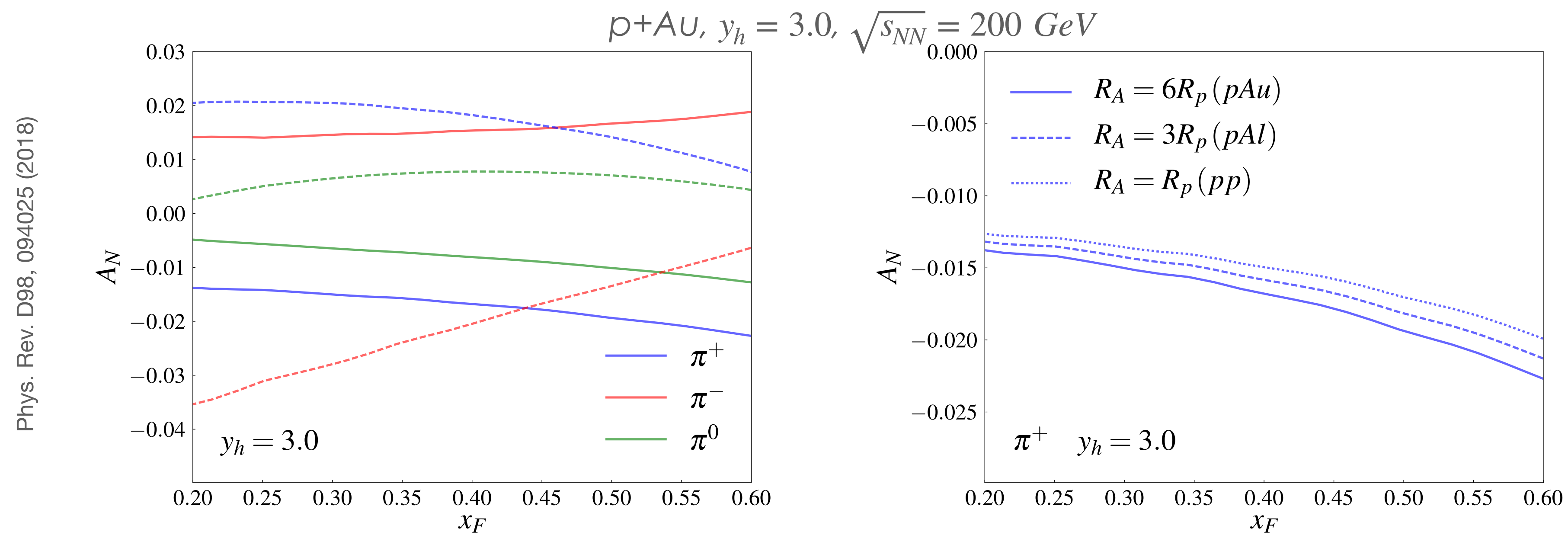
Wojciech Broniowski, Piotr Bozek

Spin physics in heavy-ion collisions



Single spin asymmetries in ultra-peripheral $p^\uparrow A \rightarrow hAX$ collisions

to test the assumed dominance of the contribution from twist-three fragmentation functions



kinematic region and required precision well fit the LHCspin potentialities

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-to develop a new polarimeter

-to conduct interesting physics measurements, such as inclusive hadron production in pH^\uparrow , pD^\uparrow , PbH^\uparrow , PbD^\uparrow collisions

-to develop a system, similar to the BGV, to measure the beam emittance

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All this developed at CERN, along LHC, in an international contest, by a small group of colleagues

What we ask you ... if you are interested





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to be included in the general mailing list

lhspin@lists.lnf.infn.it

sending the request to dinezza@INFN.IT



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to be part of one or more WGs

Polarized Gas Target

Implementation into LHC

Spectrometer

Simulations

DAQ & Slow Controls

names

names

names

names

names

WG1

WG2

WG3

WG4

WG5

Conclusions



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It is based on the feasibility of employing a gas target, as demonstrated by the SMOG2 project, and could use a location (IR4) along LHC that has already been tested by an apparatus

At the same time, LHCspin calls for a challenging R&D effort