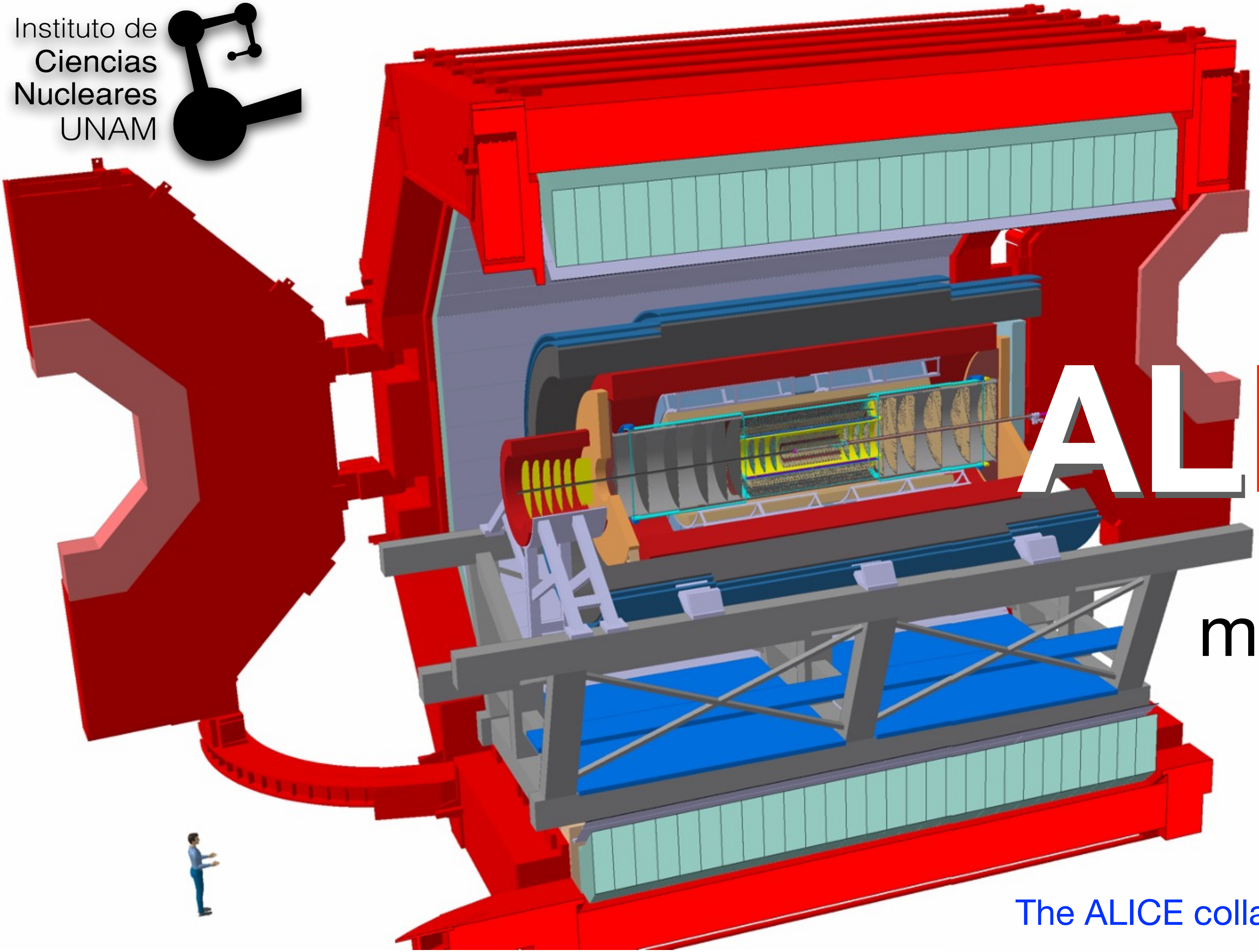
Instituto de Ciencias Nucleares UNAM

FirstMuonID Mexico Meeting
DECEMBER 15-16, 2022



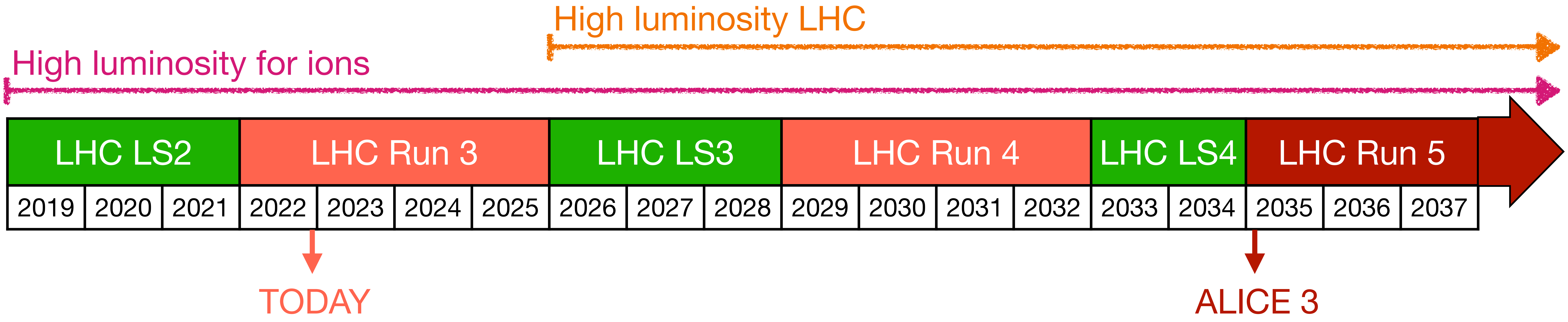
ALICE 3 and the muonID project

Antonio Ortiz
(CERN, ICN-UNAM)

The ALICE collaboration, arXiv:2211.02491

Outline

- High-luminosity era of the LHC
  - LHC programme
- Heavy-ion collisions physics at the LHC
  - Program for Runs 3 and 4
  - Remaining questions beyond Run 4
- Next-generation heavy-ion collisions experiment at CERN: ALICE 3
  - Detector concept
  - The muonID detector



The LHC program and the ALICE upgrade

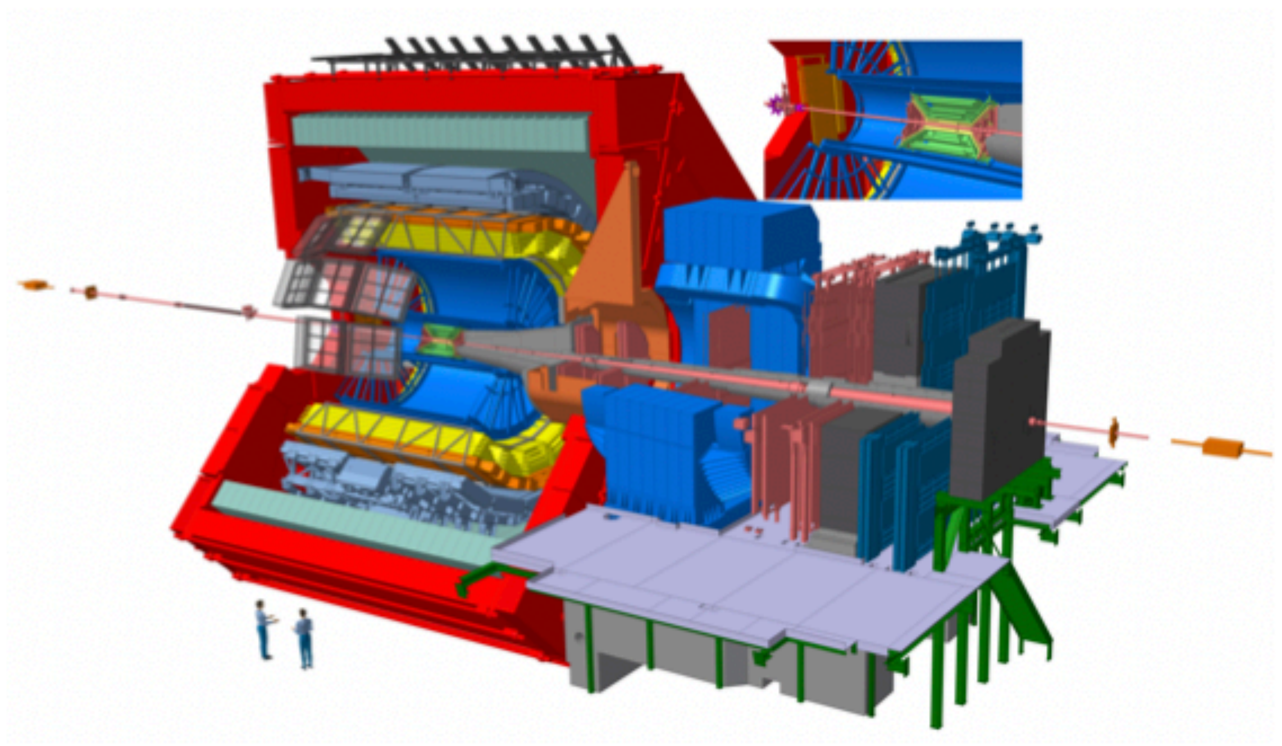
Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
pp, p-Pb, Pb-Pb	pp, p-Pb, Xe-Xe, Pb-Pb	pp, p-O, O-O, p-Pb, Pb-Pb	pp, p-Pb, Pb-Pb	pp, p-A?, A-A	pp, p-A?, A-A
2009-2013	2015-2018	2022-2025	2029-2032		

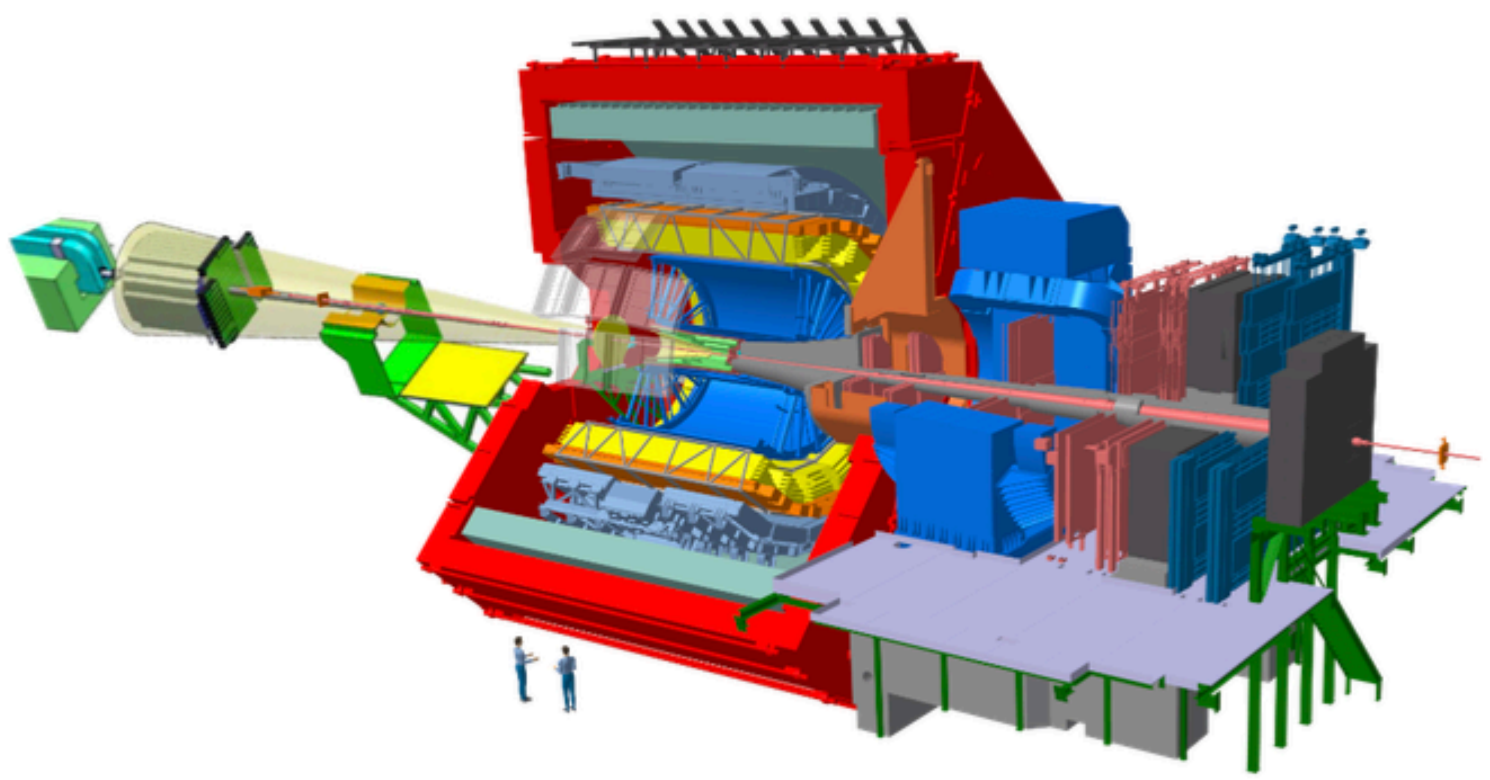
High luminosity for ions

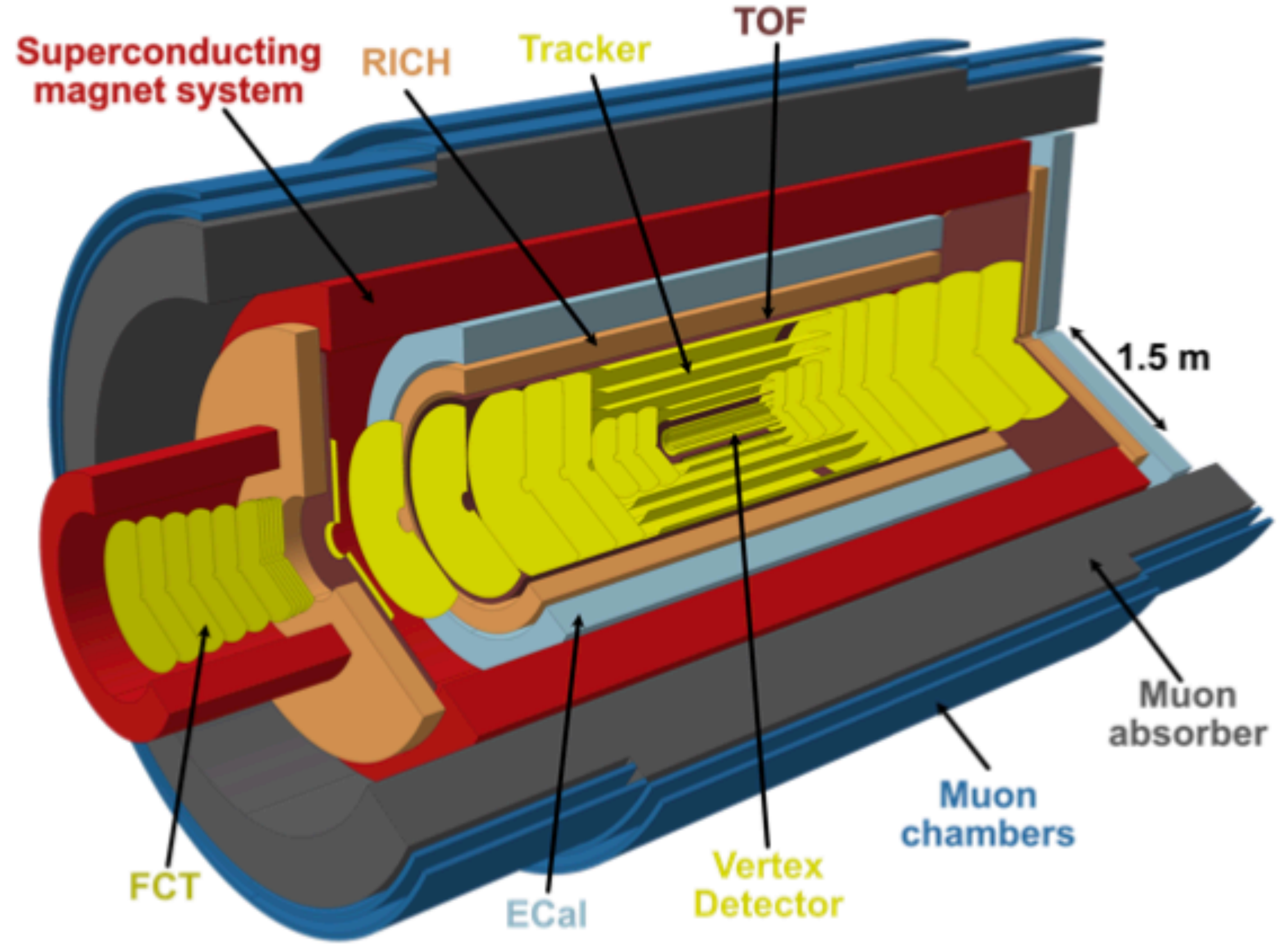
High luminosity LHC

Higher luminosity for ions

ALICE 1 | ALICE 2 | ALICE 2.1 | ALICE 3





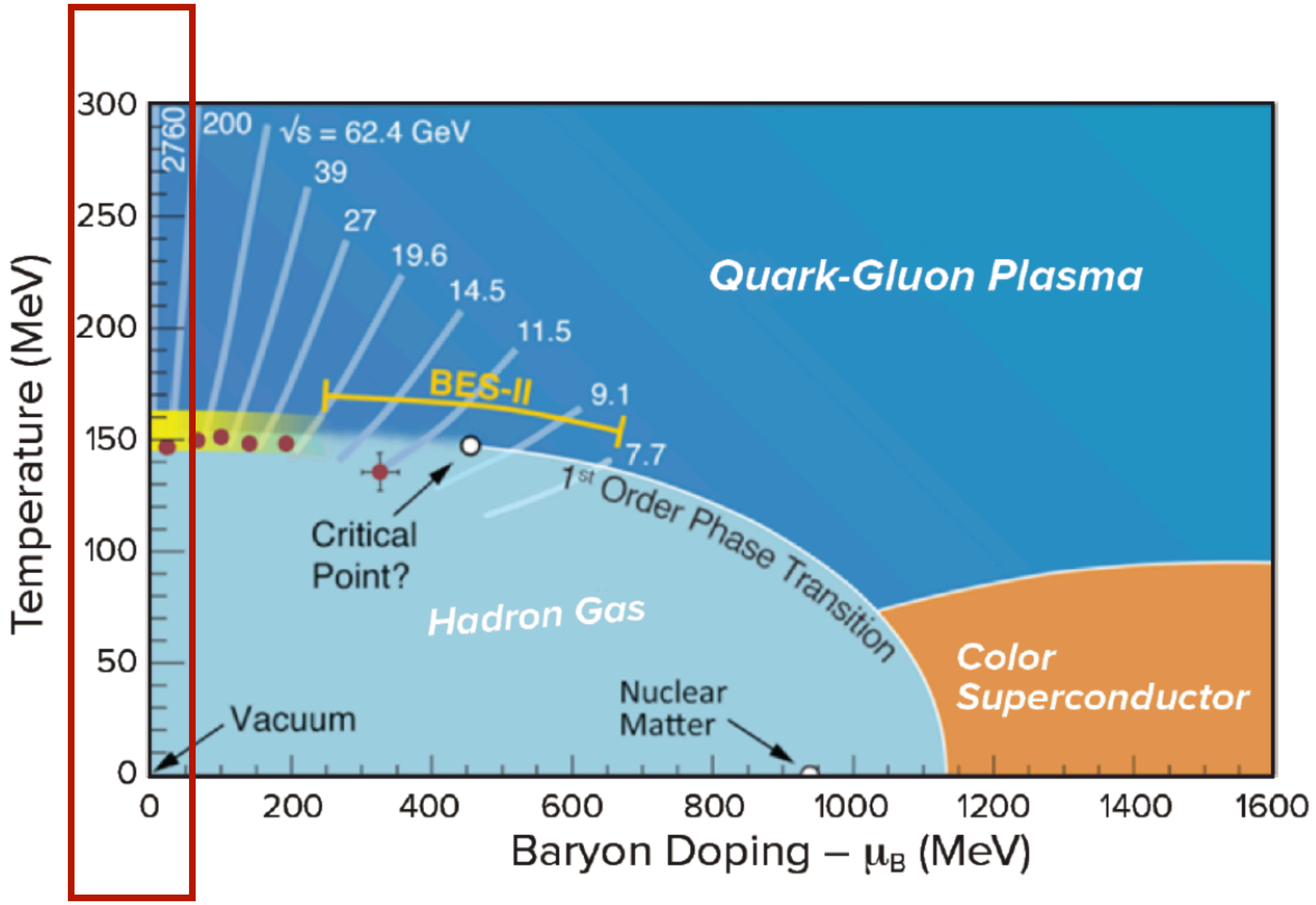


Major upgrade | Intermediate upgrade

Heavy-ion physics at the LHC

Unique potential of HIC at the LHC:

- high T, low μ_B, large heavy-flavour yields



Ann. Rev. Nucl. Part. Sci. 68 (2018) 339-376

QGP evolution from early phase onwards: temperature, chiral symmetry restoration, …

- Precision measurements of dilepton spectra

Transport properties and thermalisation in the QGP

- Precision measurements of heavy-flavour probes

Transition of partons from the QGP to hadrons

- Charmed baryons, exotic states

Quenching and connection to collectivity in small systems

- Systematic measurements of different collision systems

Onset of collective behaviour

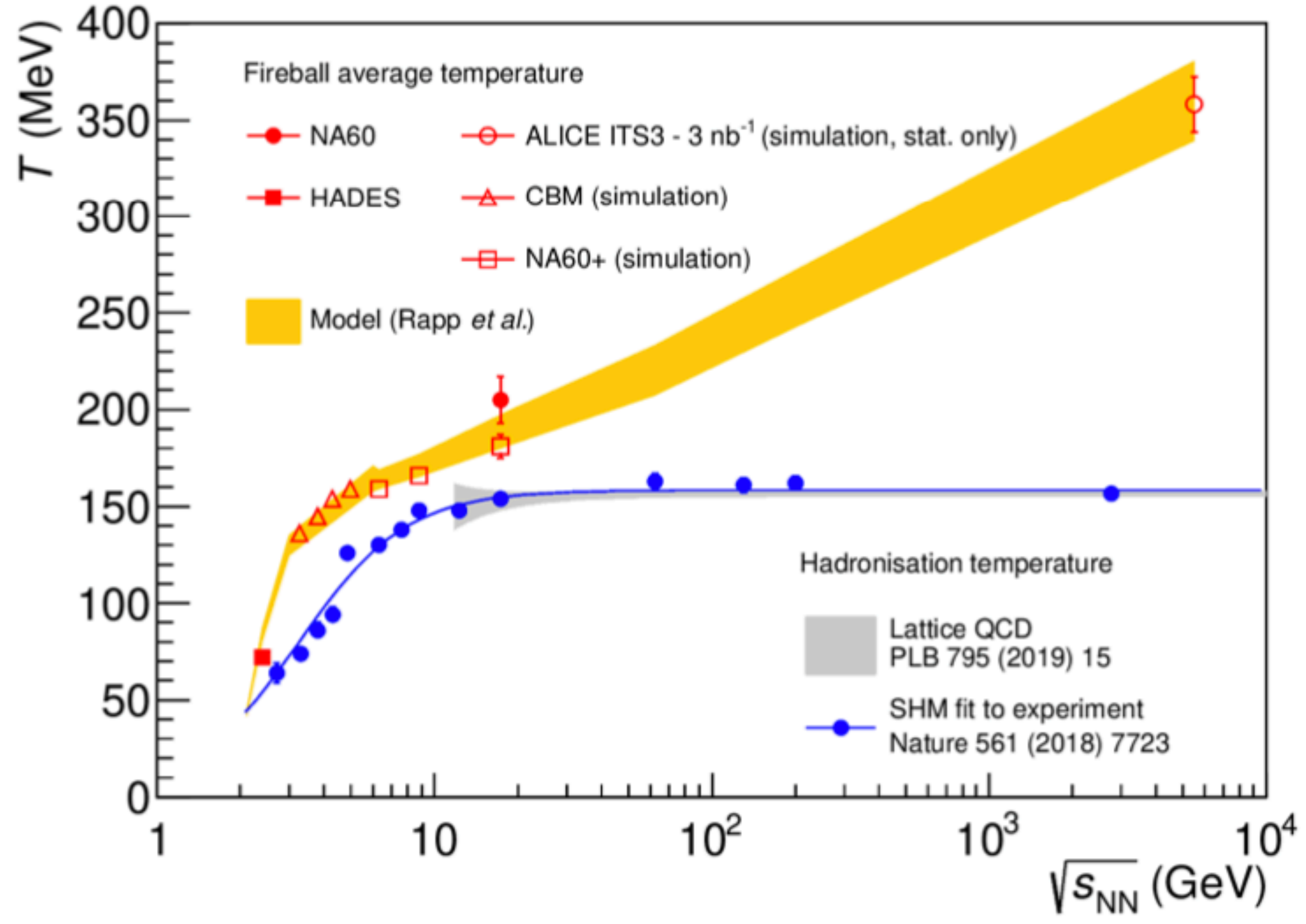
- High-multiplicity pp collisions, intermediate systems (OO)

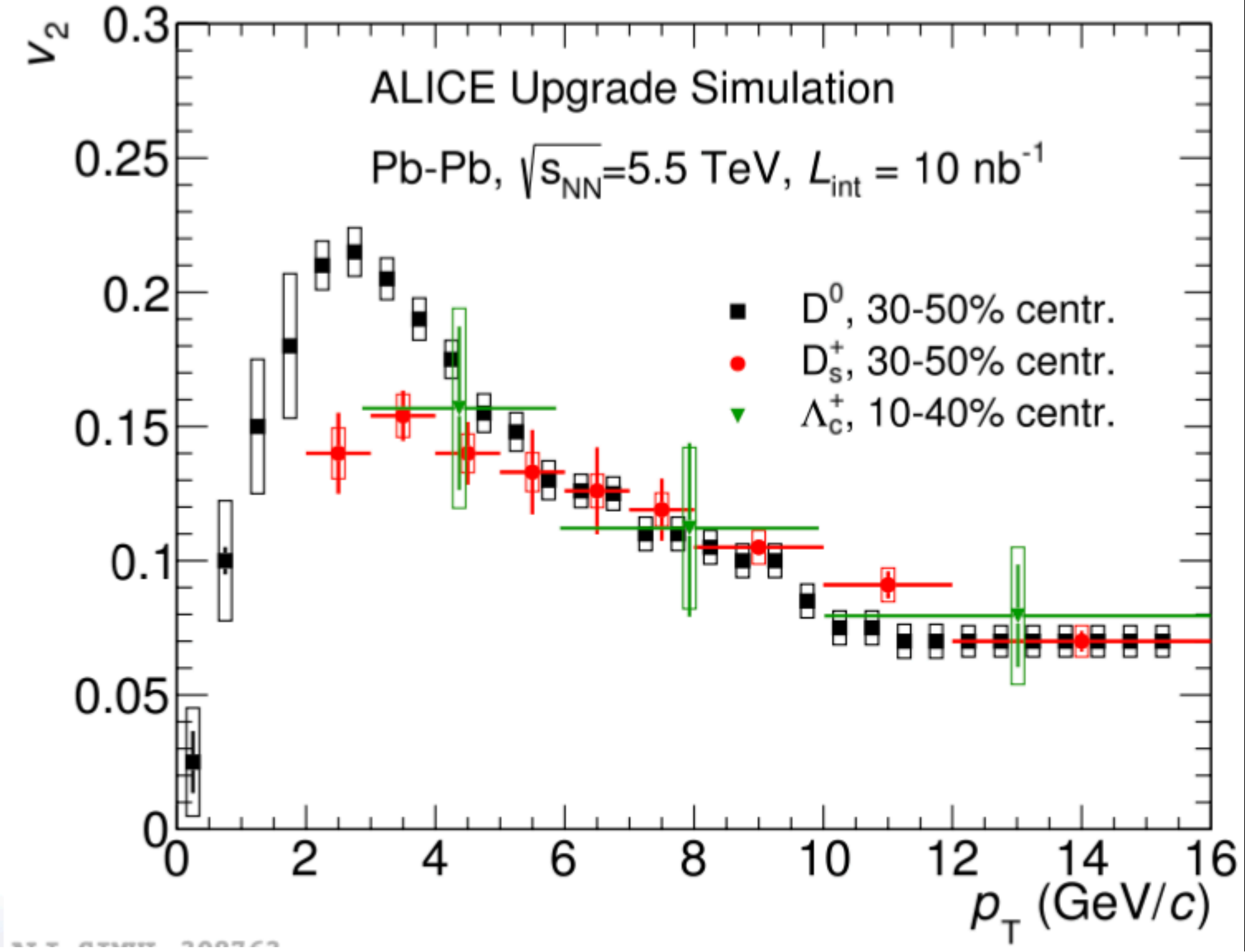
Nuclear PDFs

- Ultra-peripheral collisions, p-A

Questions beyond Run 4

Runs 3 and 4





Time-averaged thermal radiation from QGP

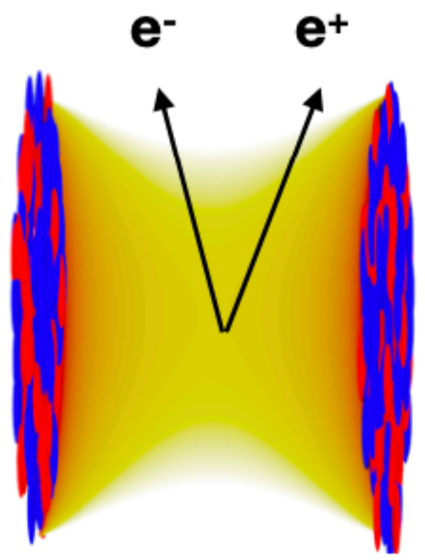
Medium effects and hadrochemistry of single charm

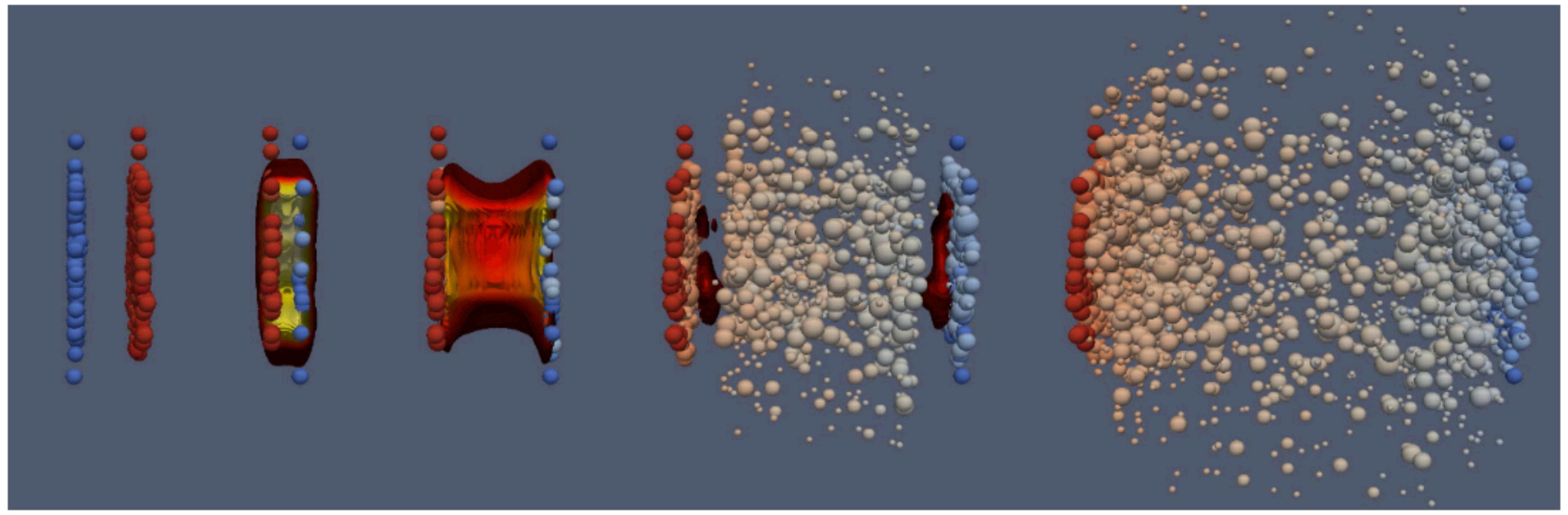
- What is the nature of interactions between highly energetic quarks and gluons and the quark-gluon plasma?
- To what extent do quarks of different mass reach thermal equilibrium?
- How do quarks and gluons transition to hadrons as the quark-gluon plasma cools down?
- What are the mechanisms for the restoration of chiral symmetry in the quark-gluon plasma?

Measurements beyond Run 4

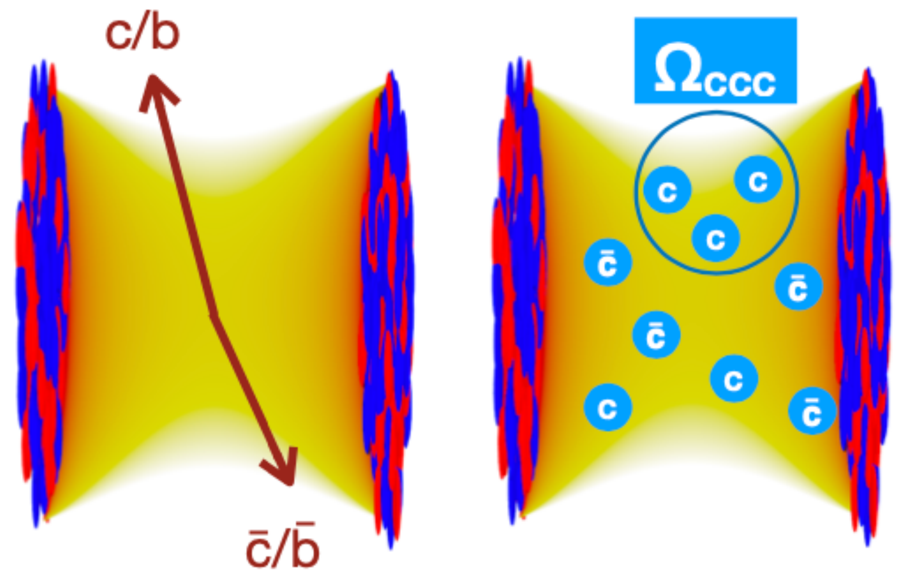
Further progress relies on

- Precision measurements of dileptons
  - evolution of the QGP / mechanisms of chiral symmetry restoration in the QGP

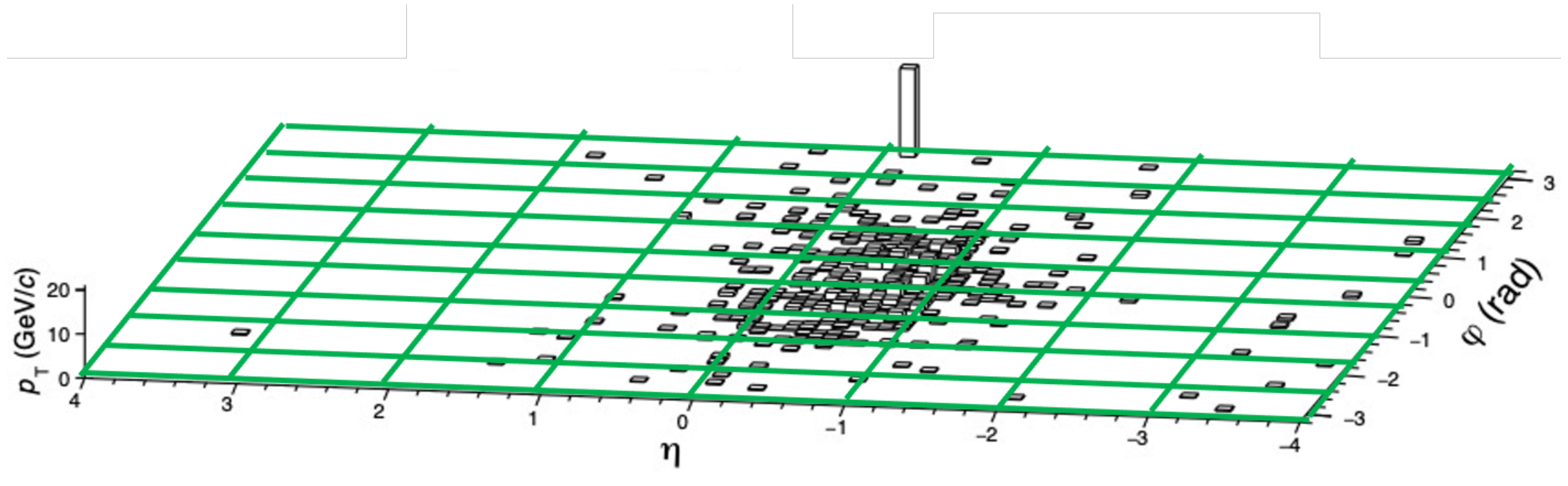




- Systematic measurements of (multi-)heavy-flavoured hadrons
  - transport properties in the QGP / mechanisms of hadronisation from the QGP



- Collectivity in small systems
  - ALICE 3 would open an unique opportunity to fully understand the origin of collectivity in small systems



Probes

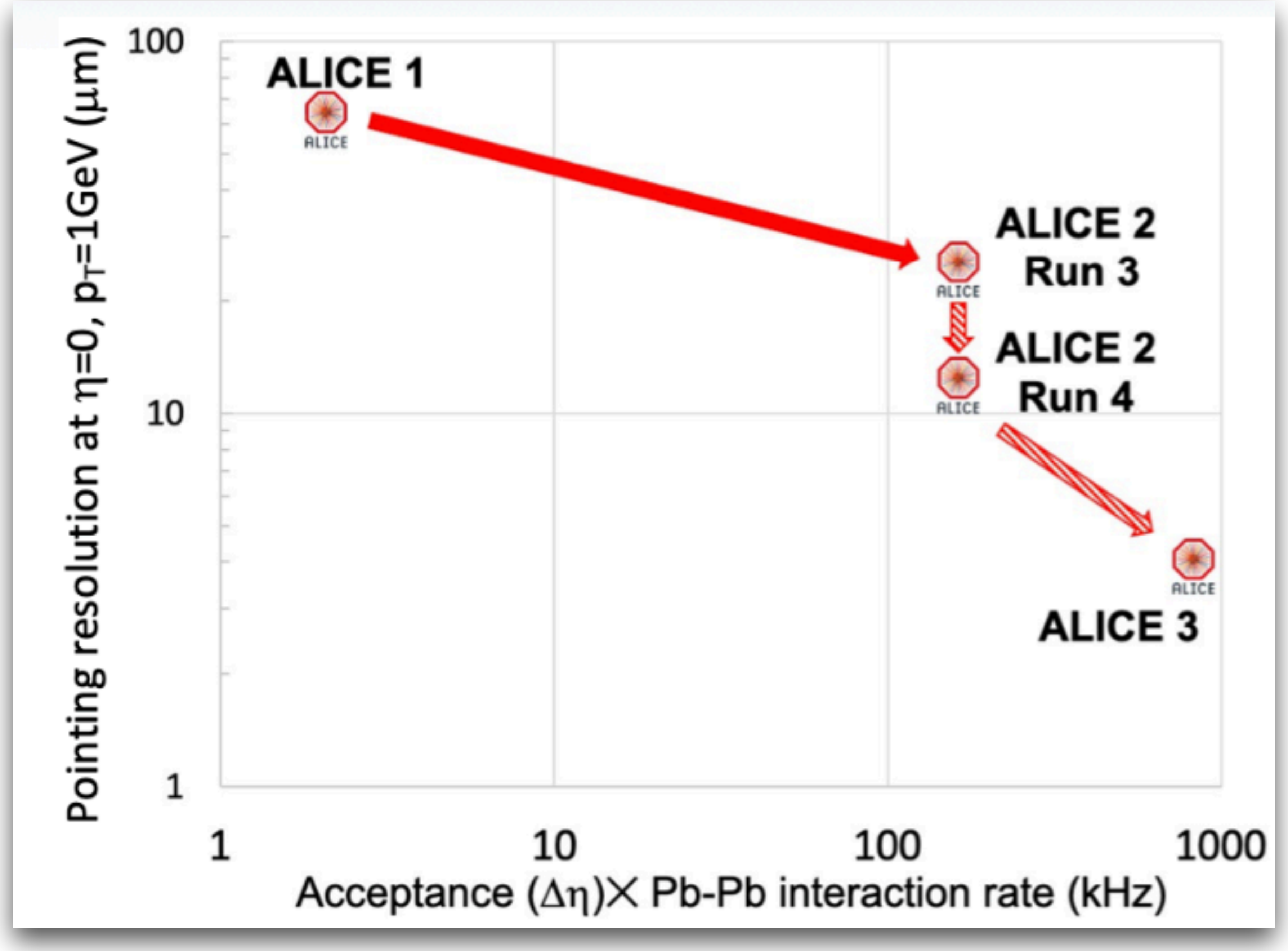
- Heavy-flavour hadrons ($p_{\mathrm{T}} \rightarrow 0$, wide η range)
  - vertexing, tracking, hadron ID
- Dileptons ($p_{\mathrm{T}} \approx 0.1-3$ GeV/c, $M_{ee} \approx 0.1-4$ GeV/c^2)
  - vertexing, tracking, lepton ID
- Photons ($0.1-50$ GeV/c, wide η range)
  - electromagnetic calorimetry
- Quarkonia and Exotica ($p_{\mathrm{T}} \rightarrow 0$)
  - muon ID
- Jets
  - tracking and calorimetry, hadron ID

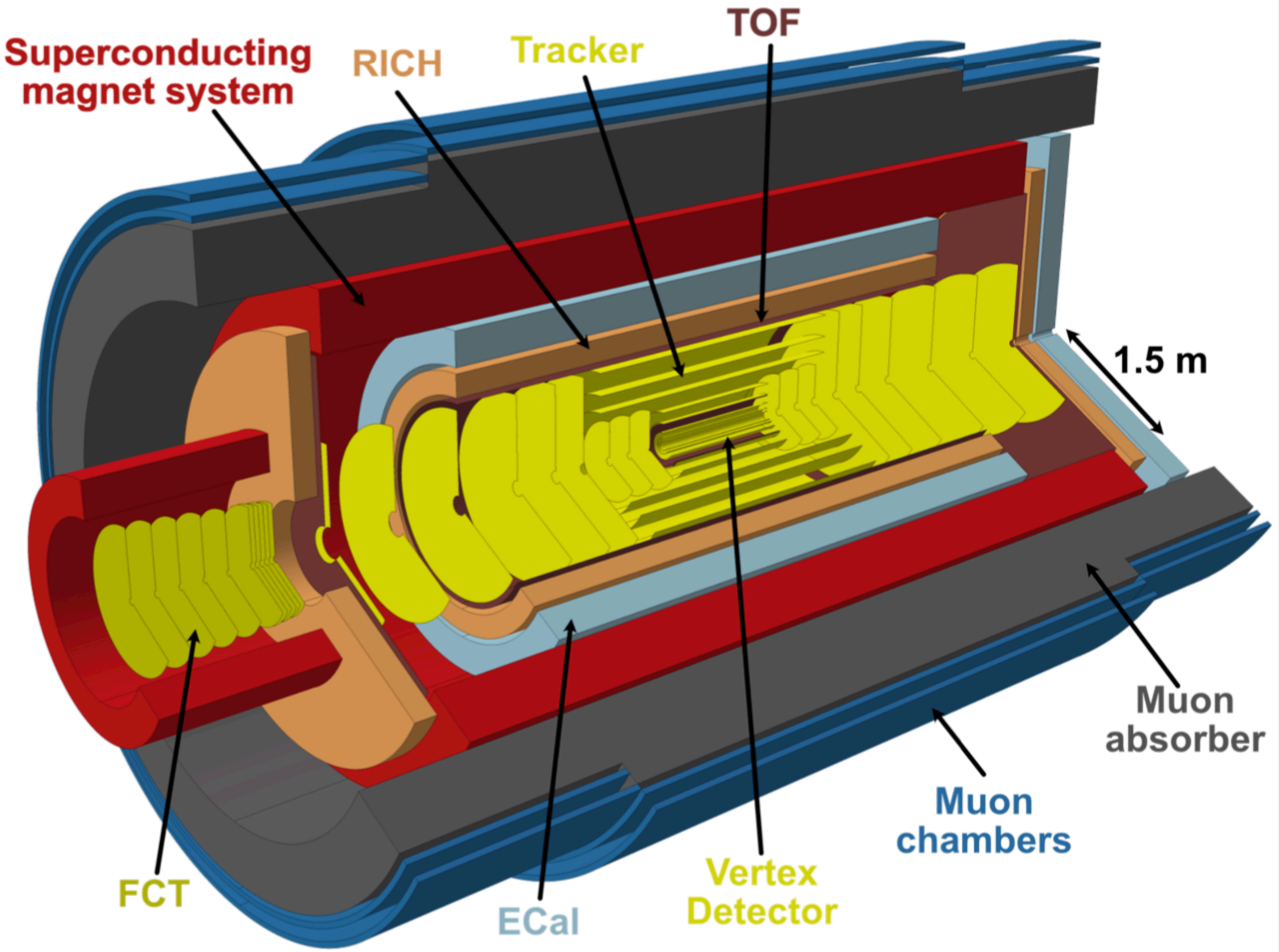
Qualitative steps needed in detector performance and statistics
→
next-generation heavy-ion experiment

ALICE 3

Novel and innovative detector concept

- Compact and lightweight all-silicon tracker
- Retractable vertex detector
- Particle identification systems
- Large acceptance





- Superconducting magnet system / Continuous read-out and online processing

Detector requirements

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Component	Observables	Barrel ($\|\eta\| < 1.75$)	Forward ($1.75 < \|\eta\| < 4$)	Detectors
Vertexing	(Multi-) charm baryons, dielectrons	Best possible DCA resolution, $\sigma_{\rm DCA} \approx 1\,\mu$m at $p_{\rm T} = 200$ MeV/c, $\eta = 0$	Best possible DCA resolution, $\sigma_{\rm DCA} \approx 30\,\mu$m at $p_{\rm T} = 200$ MeV/c, $\eta = 3$	Retractable Si-pixel tracker: $\sigma_{\rm pos} \approx 2.5\,\mu$m, $R_{\rm in} \approx 5$ mm, $X/X_0 \approx 0.1\,\%$ for the first layer
Tracking	(Multi-) charm baryons, dielectrons, photons …	$\sigma_{p_{\rm T}}/p_{\rm T} \approx 1-2\,\%$		Silicon pixel tracker: $\sigma_{\rm pos} \approx 10\,\mu$m, $R_{\rm out} \approx 80$ cm, $L \approx \pm 4$ m, $X/X_0 \approx 1\,\%$ per layer
Hadron ID	(Multi-) charm baryons	$\pi/{\rm K}/{\rm p}$ separation up to a few GeV/c		Time of flight: $\sigma_{\rm tof} \approx 20$ ps RICH: $n \approx 1.006 - 1.030$, $\sigma_\theta \approx 1.5$ rad
Electron ID	Dielectrons, quarkonia, $\chi_{\rm c1}(3872)$	Pion rejection by 1000x top to 2-3 GeV/c		Time of flight: $\sigma_{\rm tof} \approx 20$ ps RICH: $n \approx 1.006 - 1.030$, $\sigma_\theta \approx 1.5$ rad
Muon ID	Quarkonia, $\chi_{\rm c1}(3872)$	Reconstruction of J/ψ at rest, i.e. muons from $p_{\rm T} \approx 1.5$ GeV/c at $\eta = 0$		Steel absorber: $L \approx 70$ cm muon chambers (scintillators, RPCs or MWPC)

Some key measurements

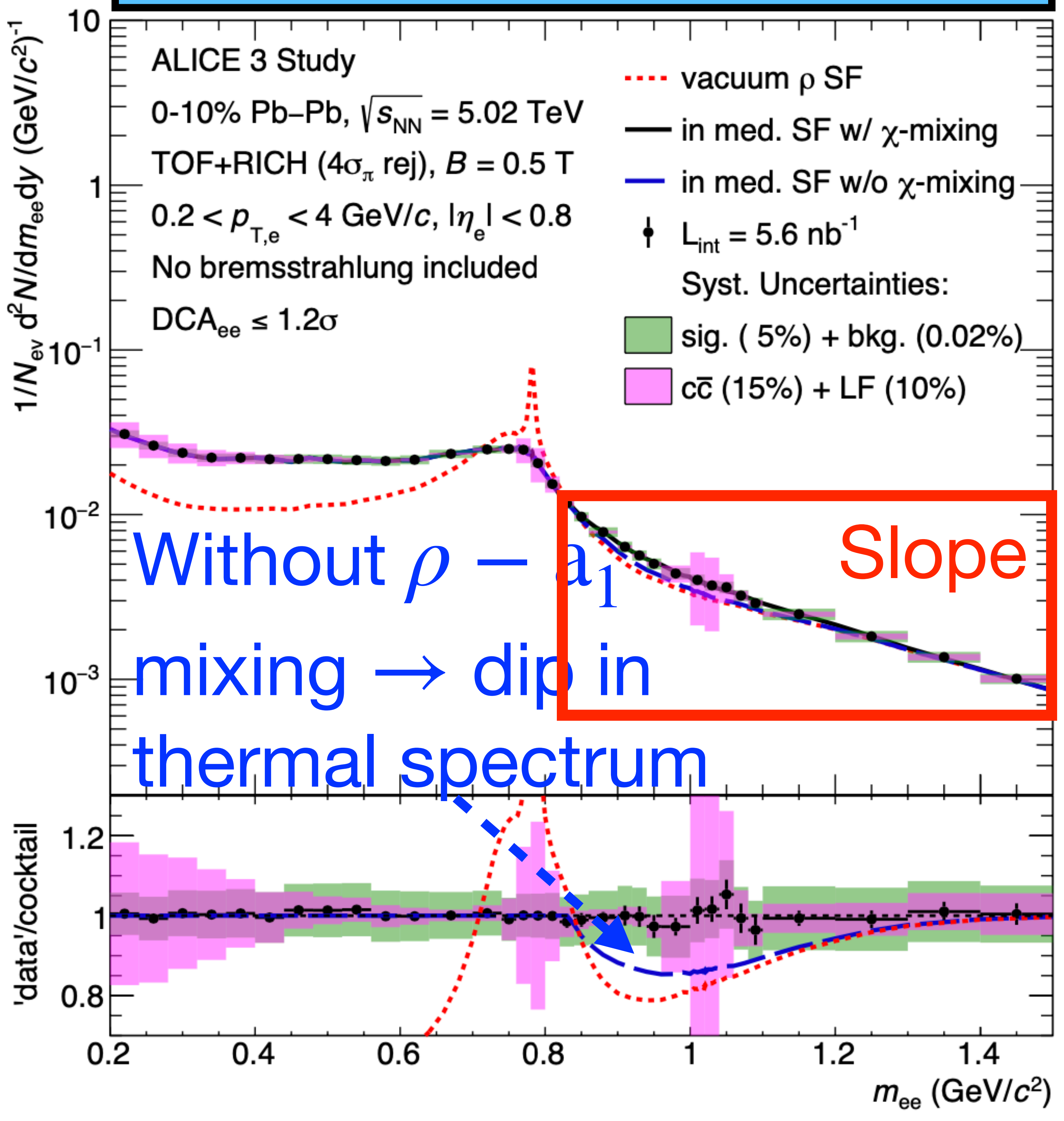
- Accurate measurements of charm and beauty hadrons and their correlation over a wide rapidity range: interactions of heavy quarks of different mass in sQGP down to the thermal scale
- Multi heavy-flavoured hadrons (e.g. as the yet undiscovered Ω_{ccc}) for which the production from sQGP is expected to be enhanced by orders of magnitude: sensitivity to how quarks combine into hadrons depending on their degree of thermalisation
- Production and behaviour of the charmed exotic states in the sQGP and their structure, e.g. strong interaction potential between hadrons from measurements of their momentum correlations $X(3872) \rightarrow J/\psi + \pi^{+}\pi^{-}$ muonID!
- High-precision, multi differential measurements of electromagnetic radiation from the sQGP to probe its early evolution and the restoration of chiral symmetry through the coupling of vector and axial-vector mesons
- Onset of collective behaviour: HM pp collisions

Time evolution & chiral symmetry

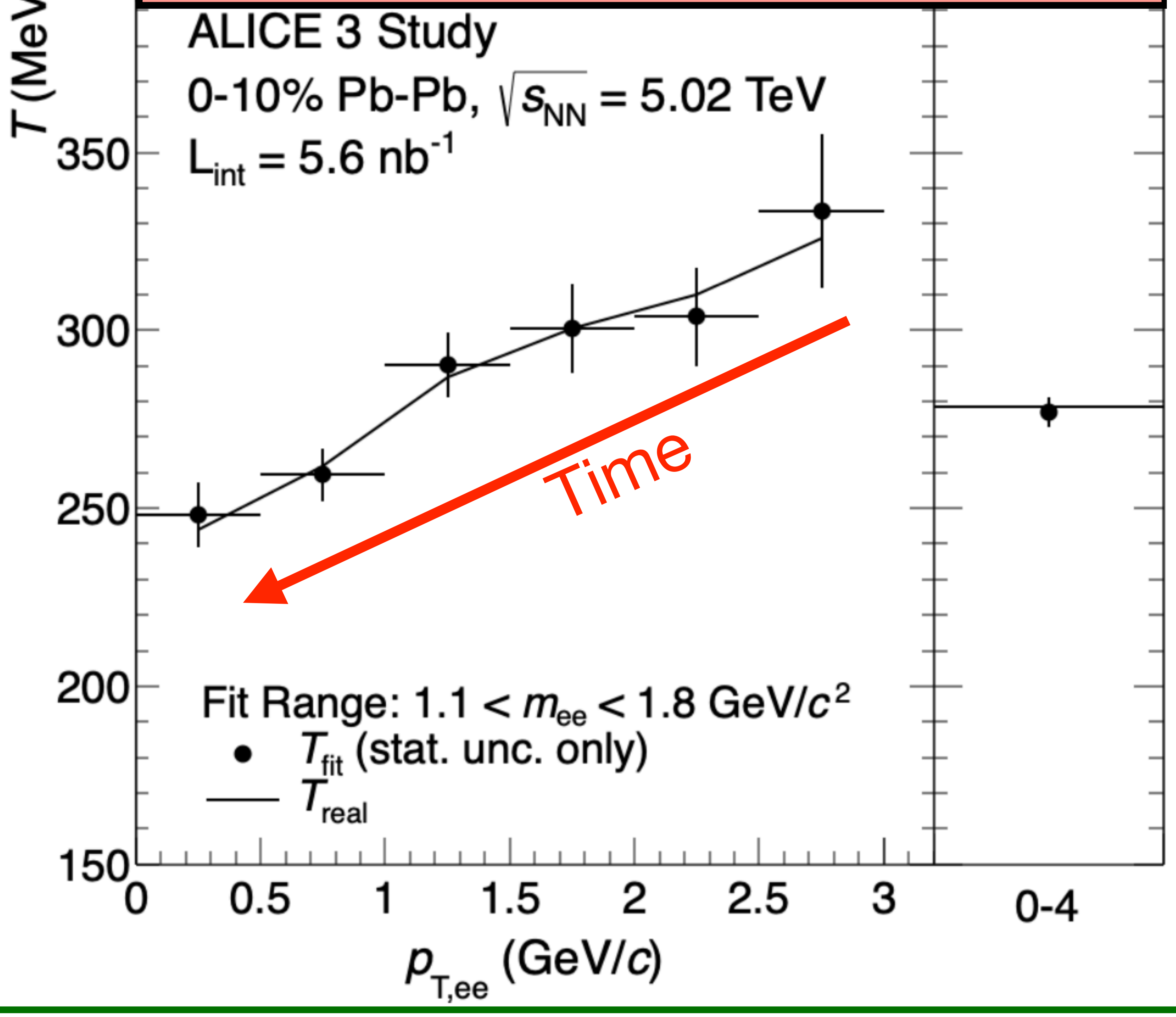
Understand time evolution and mechanisms of chiral symmetry restoration

- High-precision measurements of dileptons, also multi-differentially
- Further reduced material; excellent heavy-flavour rejection

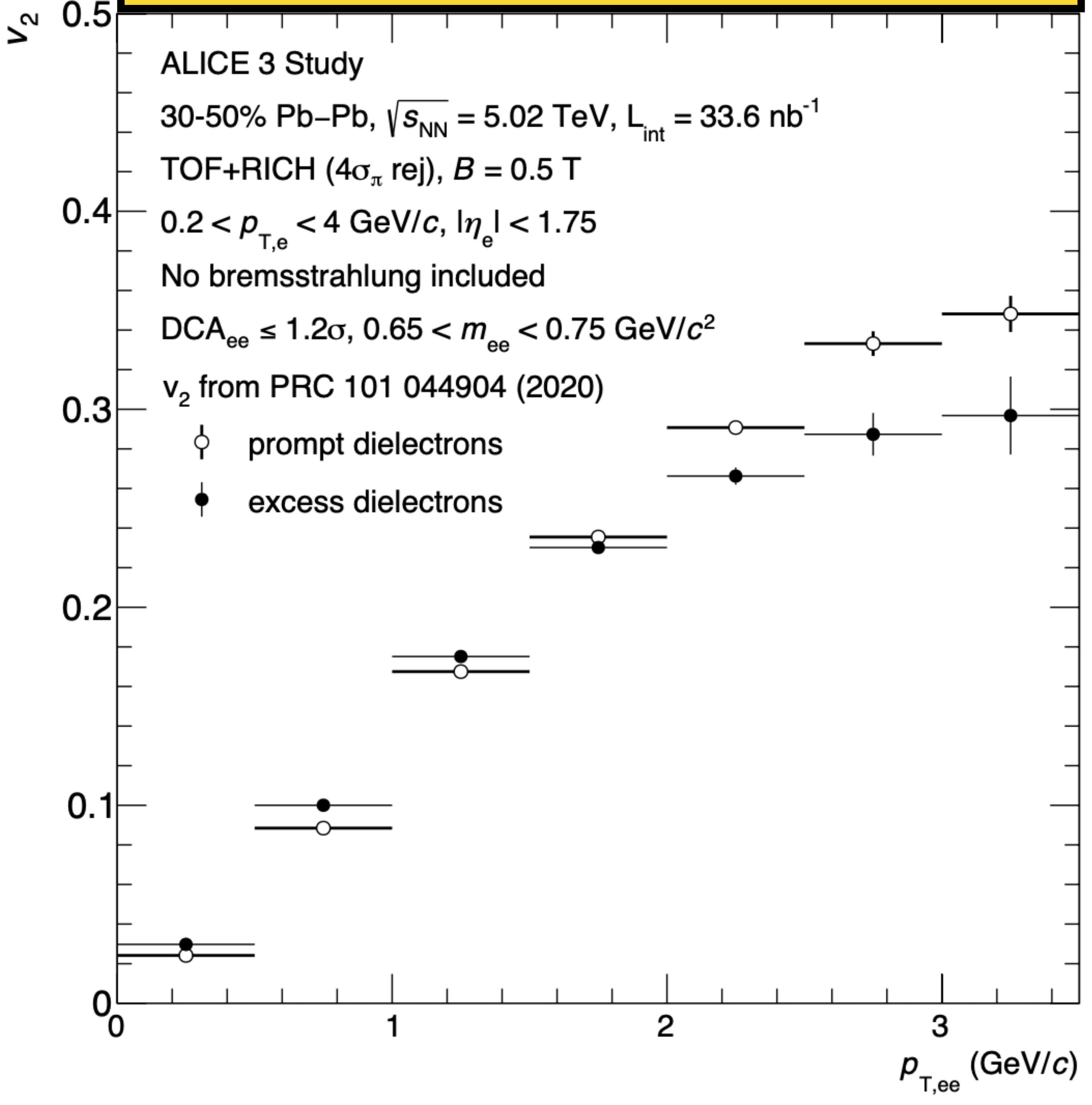
Invariant mass spectrum of dielectrons



$T(p_{T,ee})$
→ control on emission time

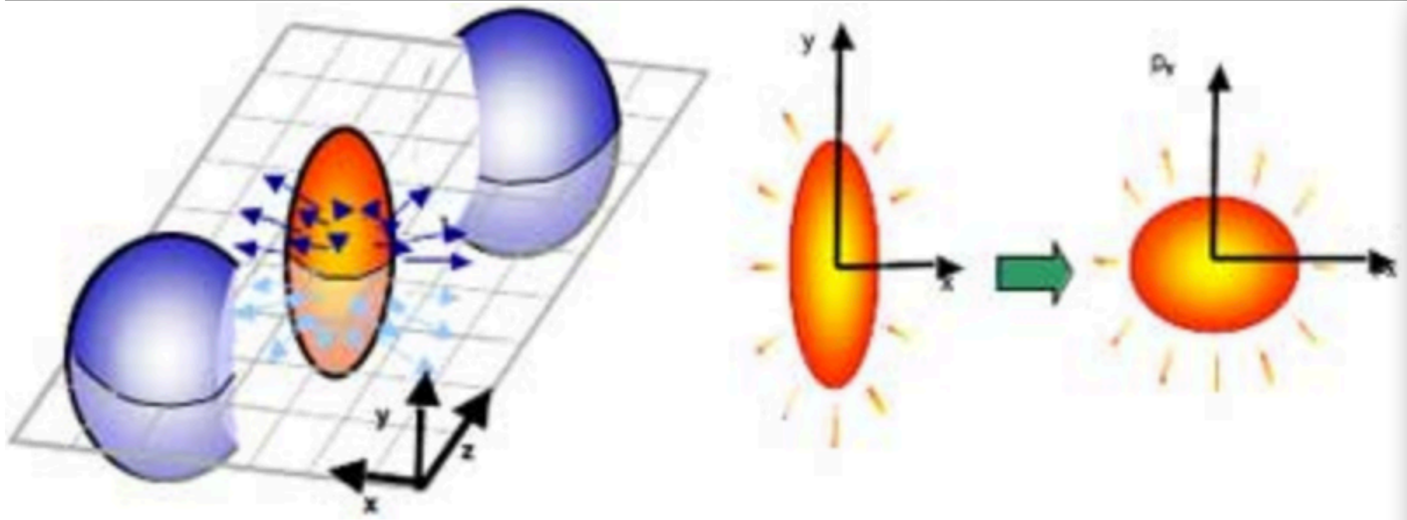


Dilepton v_2 temporal
→ emission profile



Heavy-flavour transport

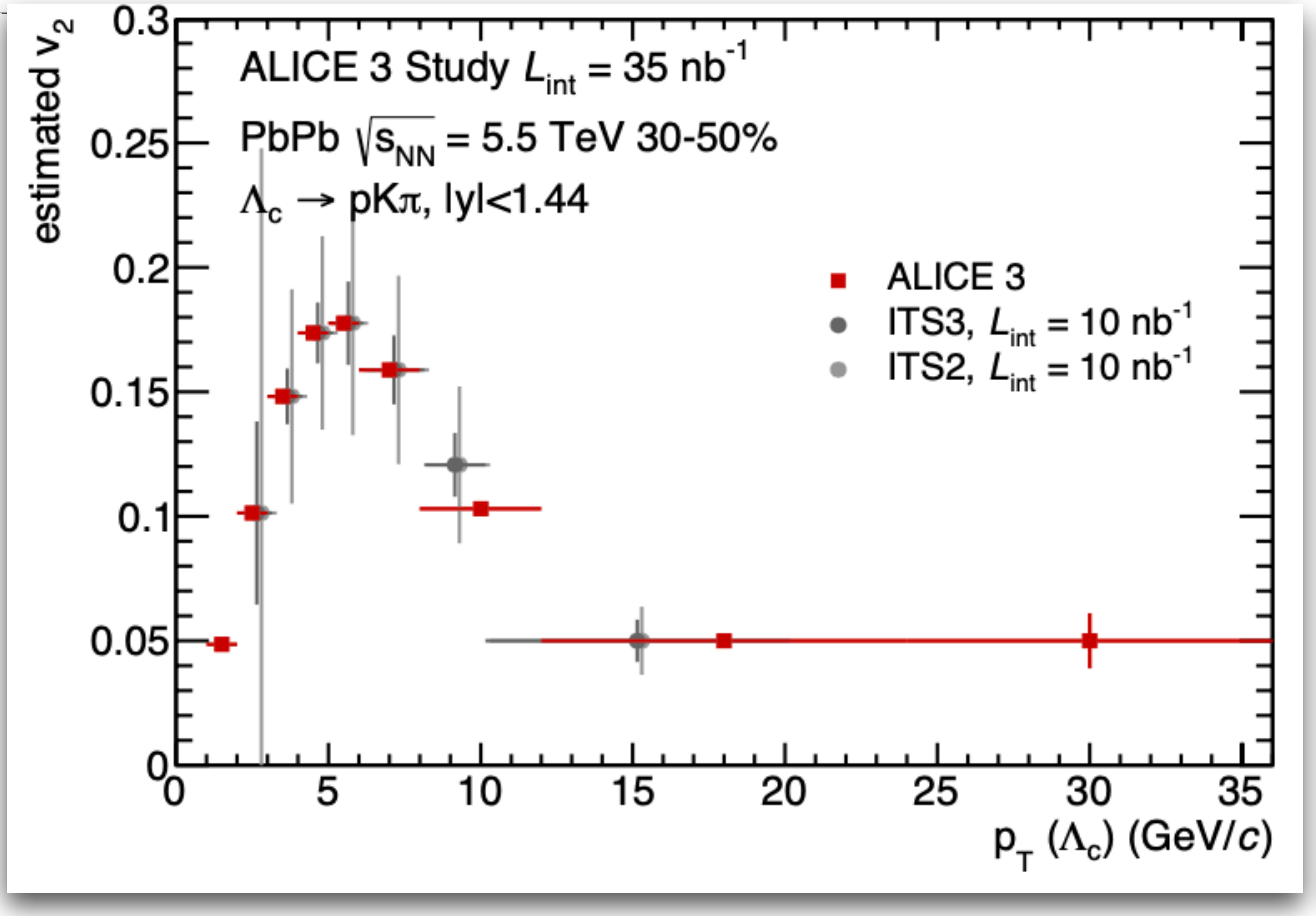
Non central collisions



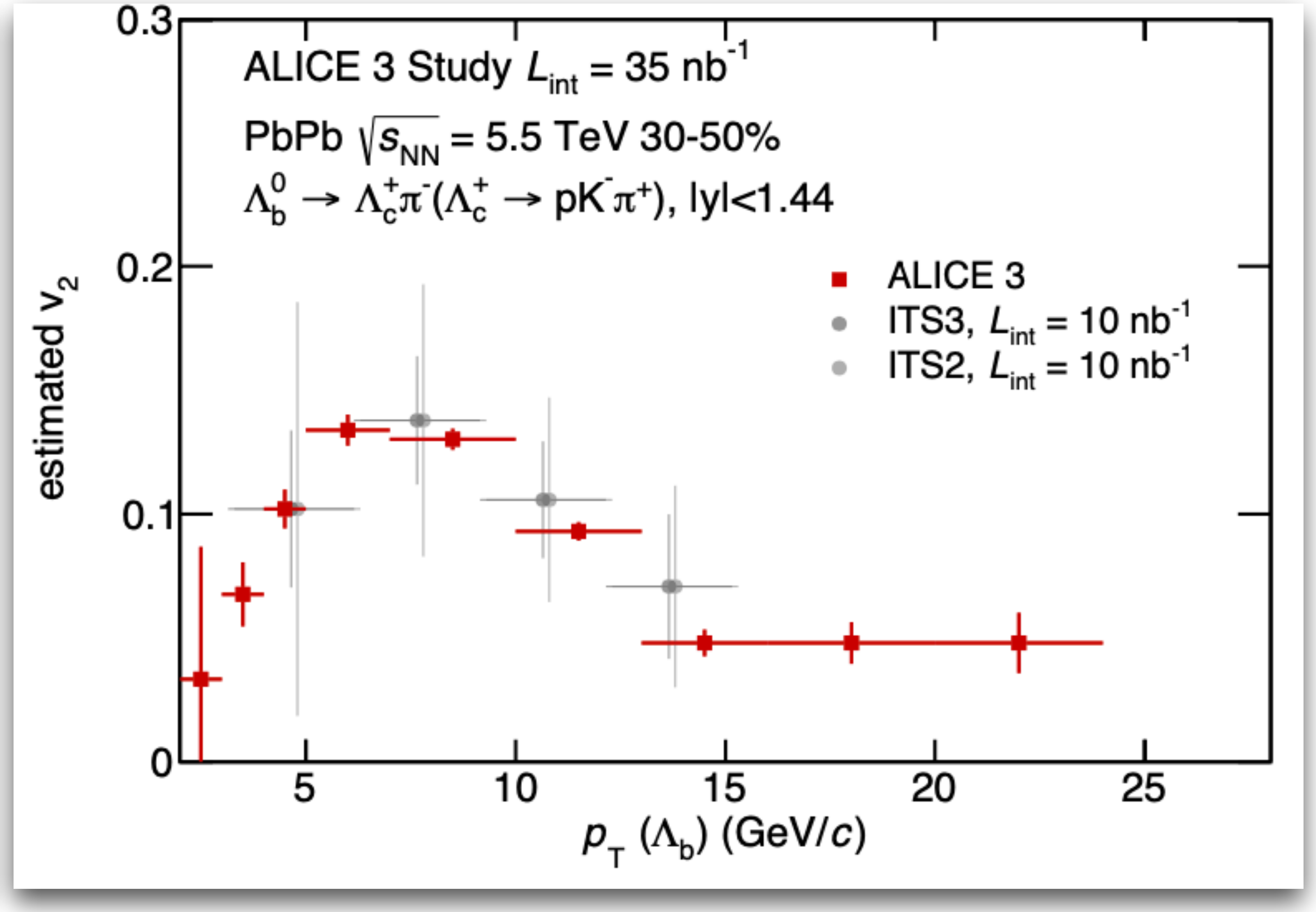
Interactions with the plasma generate azimuthal anisotropy v_2:

$$\frac{dN}{d\phi} \propto 1 + 2v_2 \cos 2(\phi - \psi)$$

Λ_c v_2 performance



Λ_b v_2 performance



Heavy quarks: access to quark transport at hadron level

- Expect beauty thermalisation slower than charm - smaller v_2

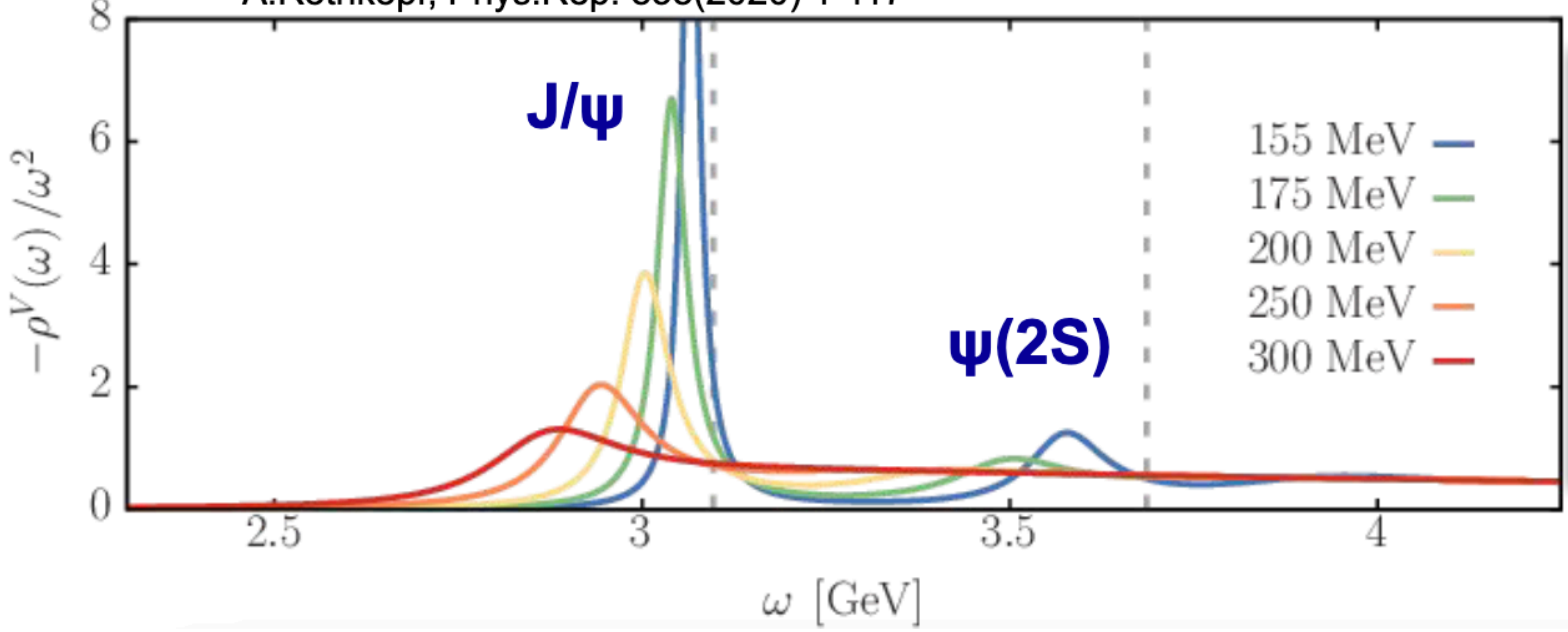
Need ALICE 3 performance (pointing resolution, acceptance) for precision measurement of e.g. Λ_c and Λ_b v_2

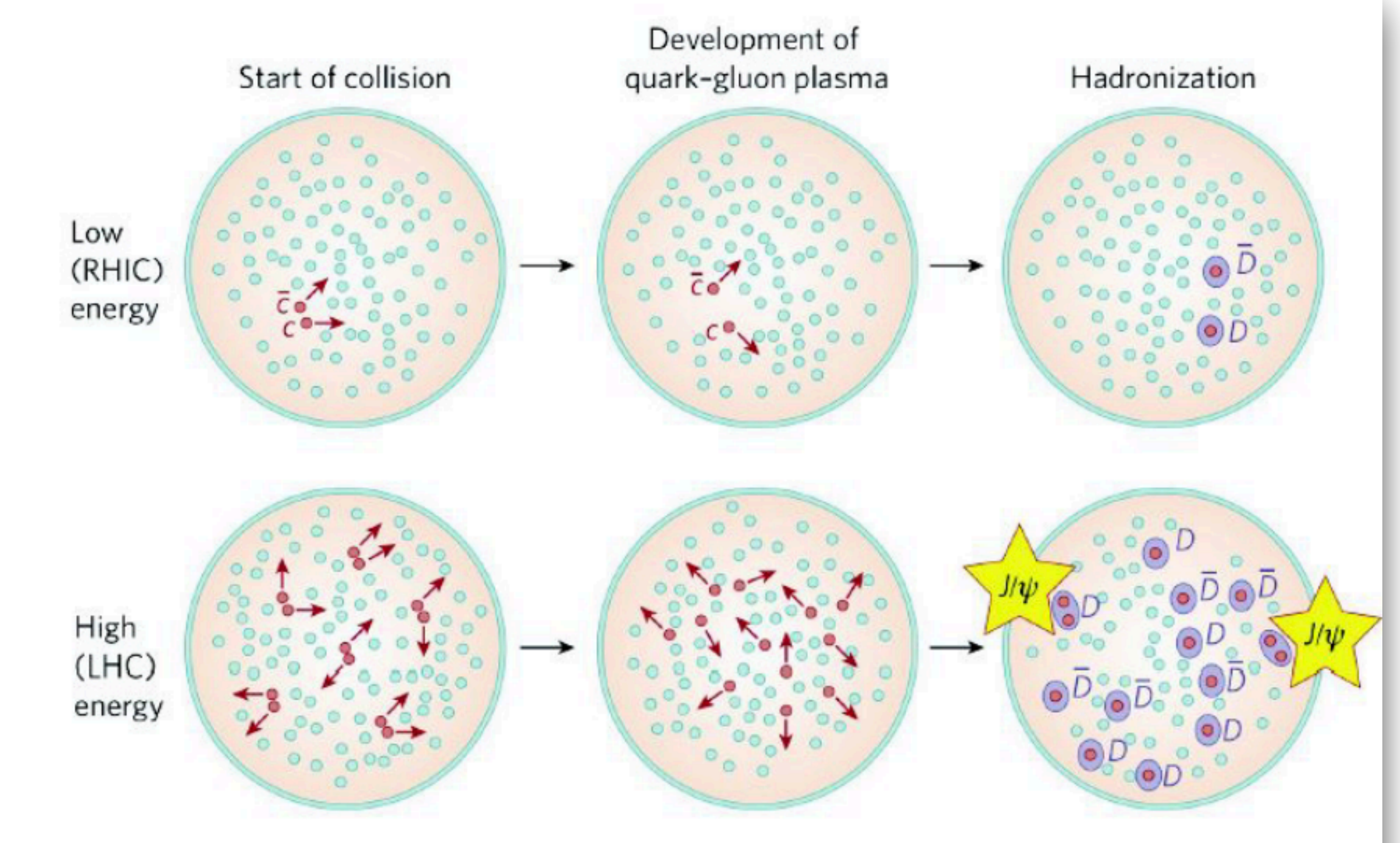
Charmonium states (muonID)

Charmonium production as probe of QGP in heavy-ion collisions

Dedicated talk: Lizardo Valencia

A.Rothkopf, Phys.Rep. 858(2020) 1-117

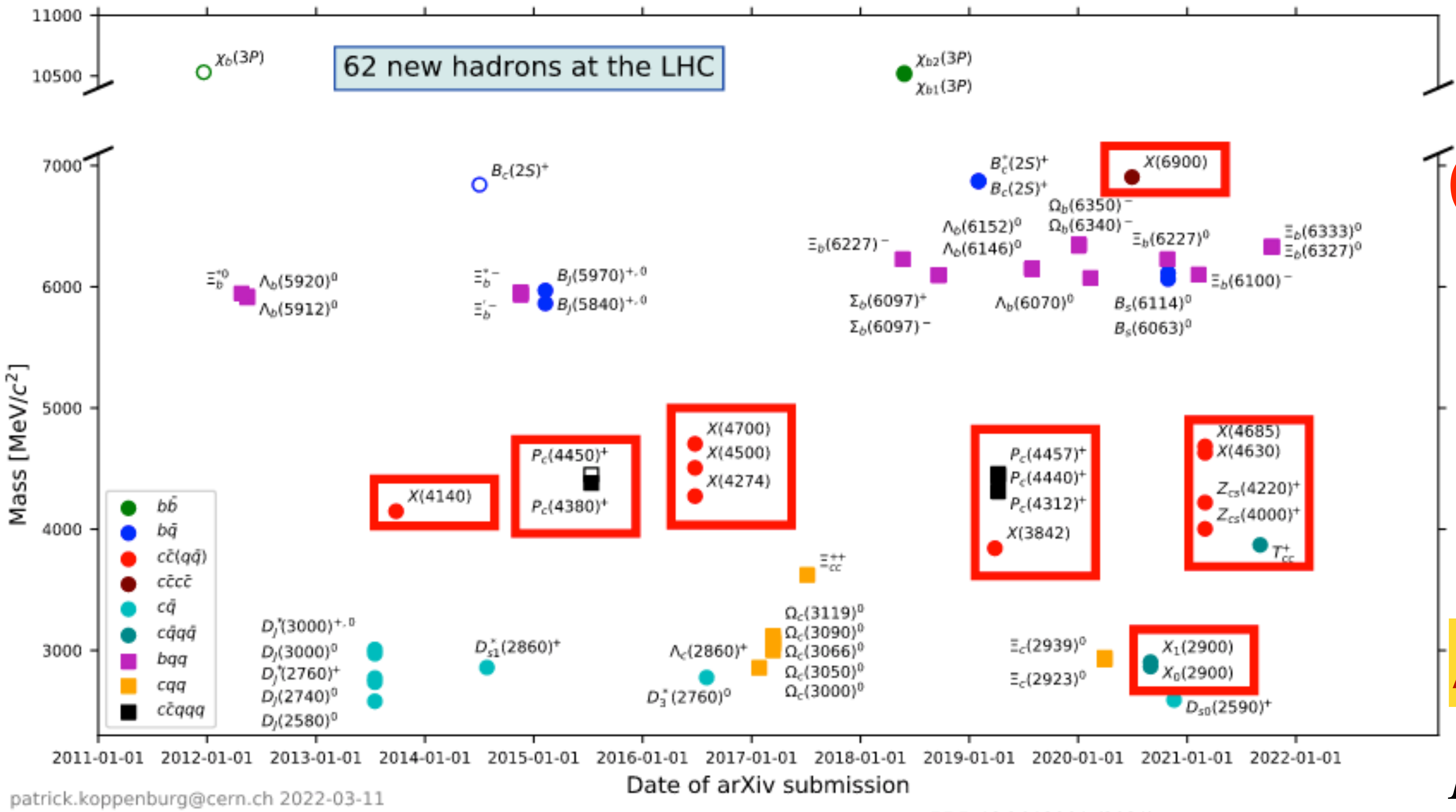




Braun-Munzinger, P., Stachel, J. The quest for the quark–gluon plasma. *Nature* 448, 302–309 (2007)

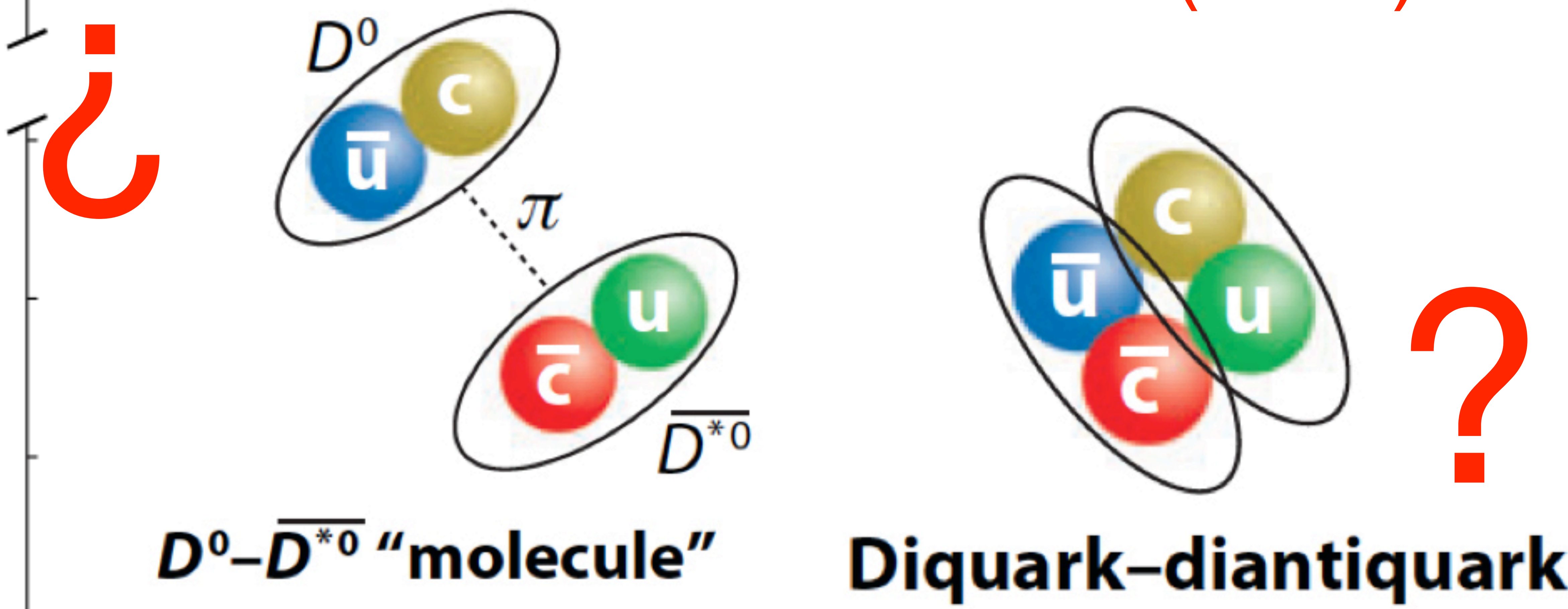
Sequential dissociation → expectation of stronger suppression for ψ(2S) w.r.t J/ψ

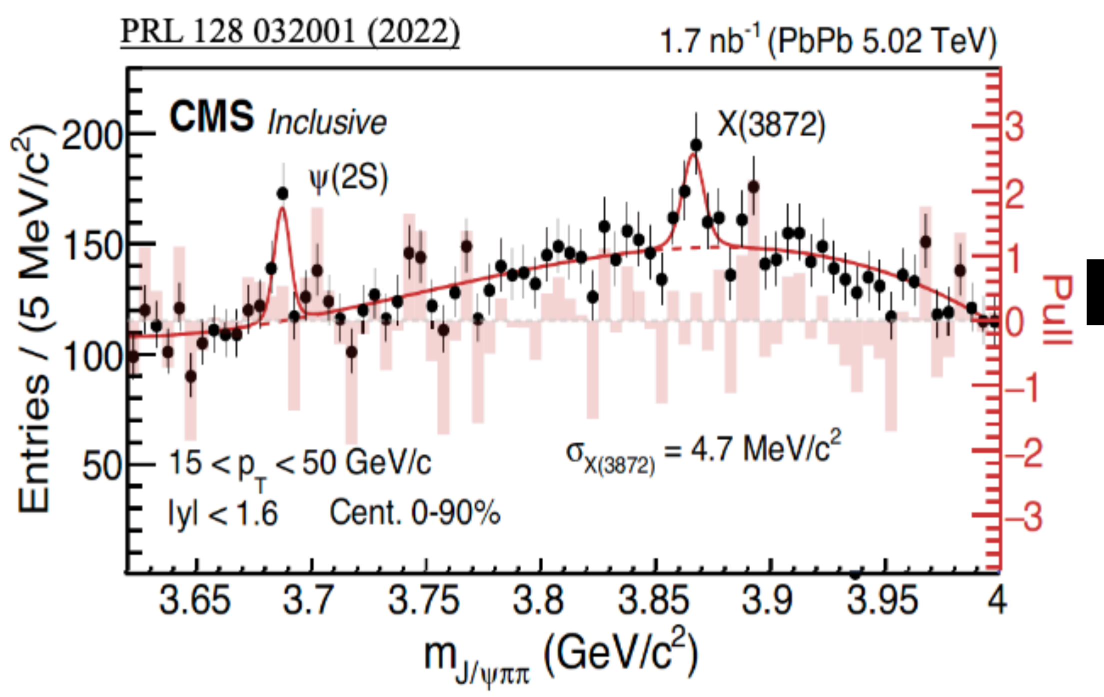
Exotica (muonID)



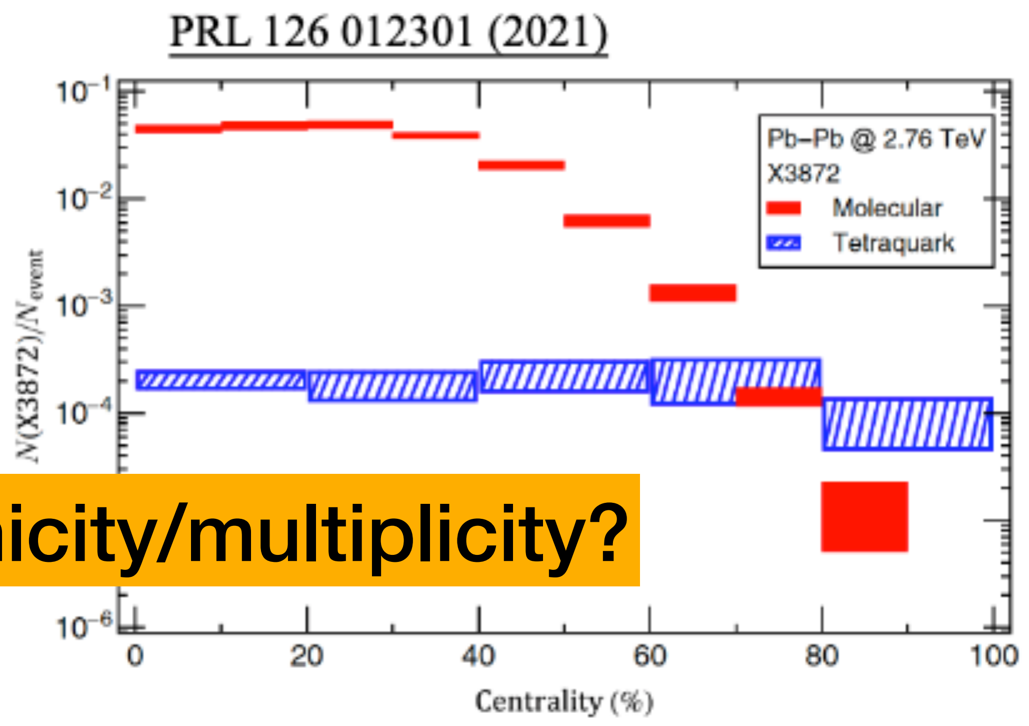
Dedicated talk: César Fernández

X(3872)





pp vs flatenicity/multiplicity?



ALICE 3 muonID: muons down to low p_{T} (~1.5 GeV/c at $\eta = 0$) ->unique p_{T} reach to study the formation and dissociation of e.g. X(3872) in HIC at thermal momentum scales.

CMS: $p_{\mathrm{T}} > 10$ GeV/c.

Multiparton interactions (muonID)

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Studies of multiple production of hard/heavy particles:

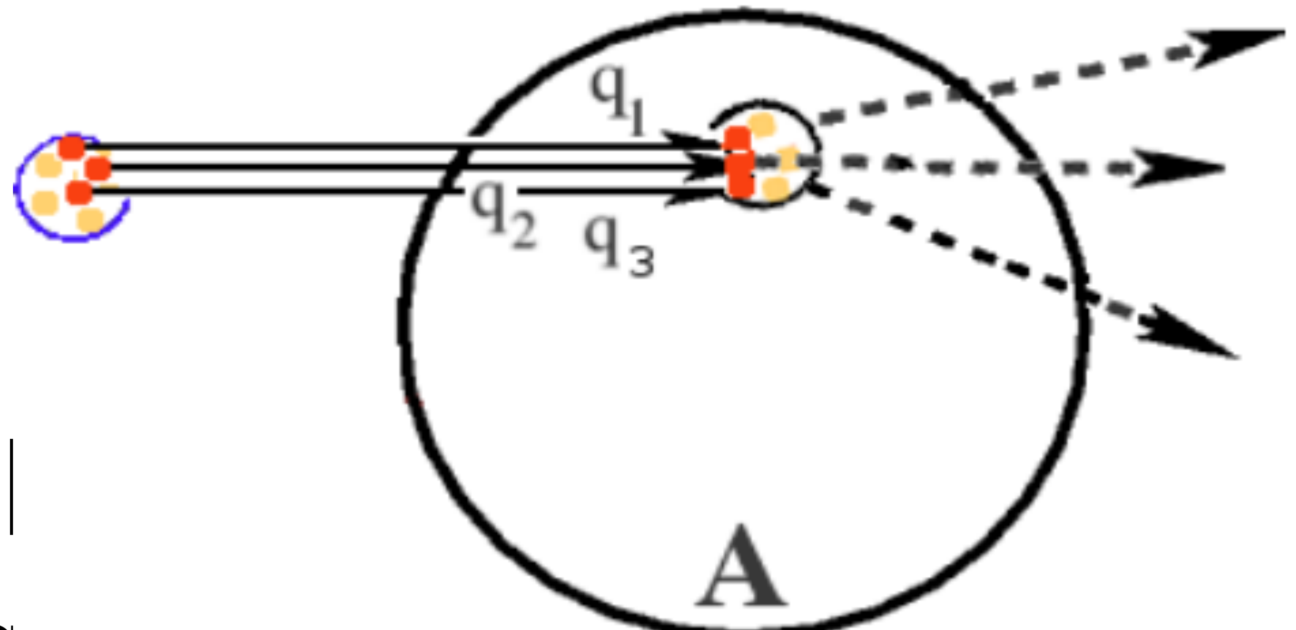
- Generalized PDFs (x,Q2 ,b) of the proton, in particular the unknown energy evolution of transverse proton profile
- Role ... ;
  colo...

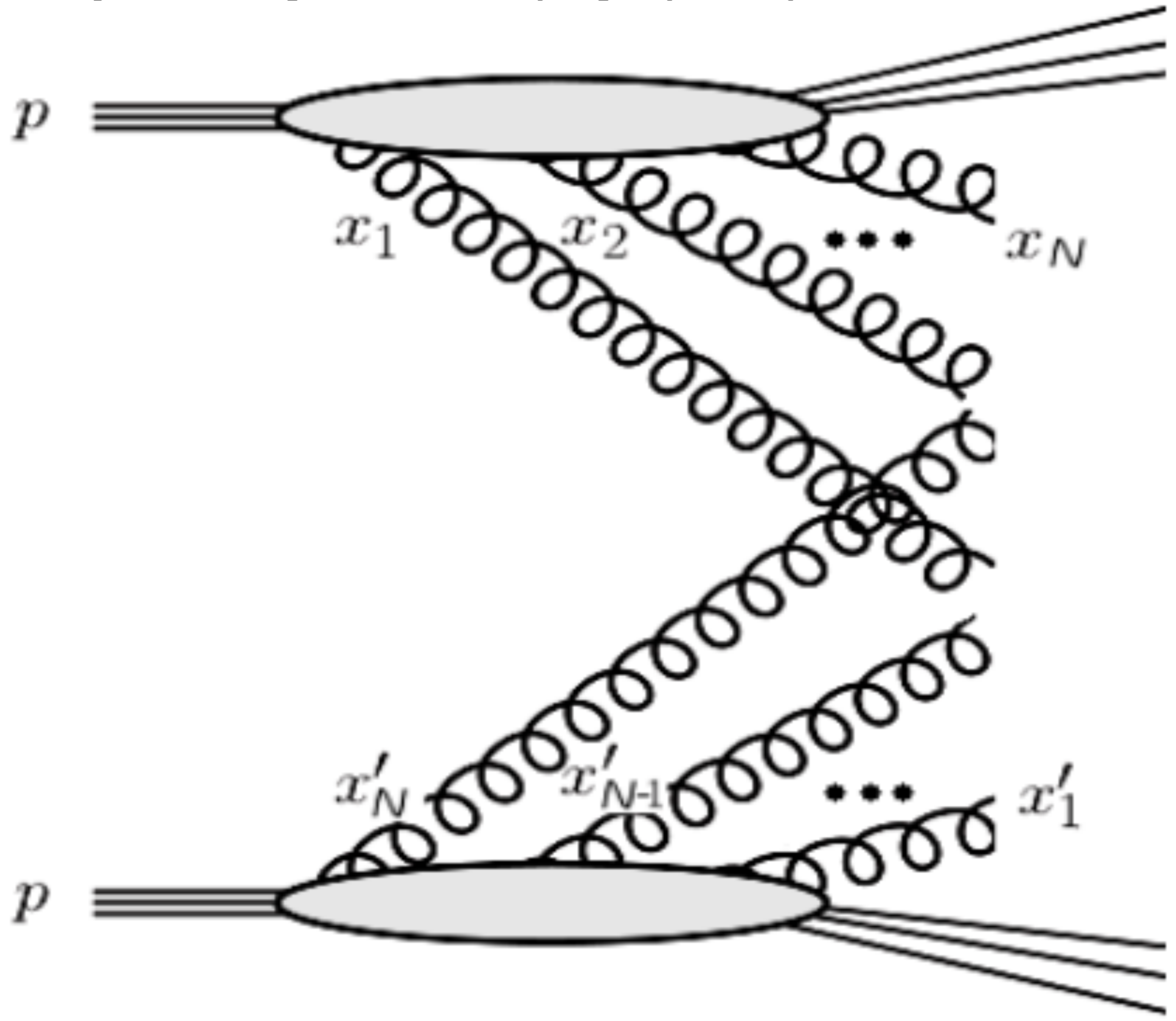
...) 359

normal ... (~
averag... al
combinatorial factor (m/3!) to avoid triple-counting in case of same particles produced

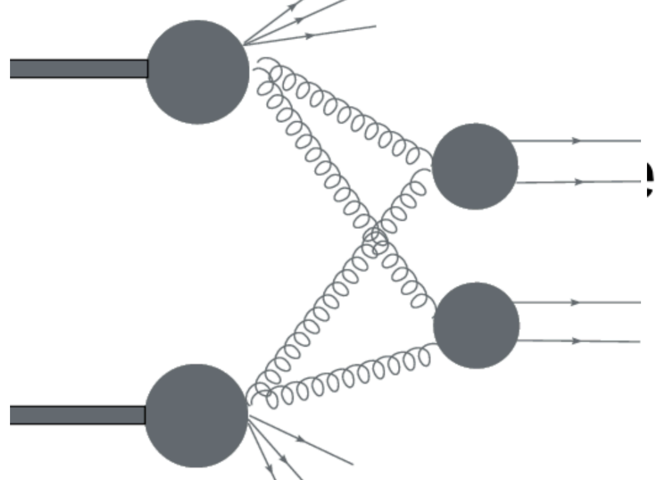
Generic N-parton scattering x-sections (pp)

ALICE 3: multi-J/ψ production in pp and even in p-A collisions

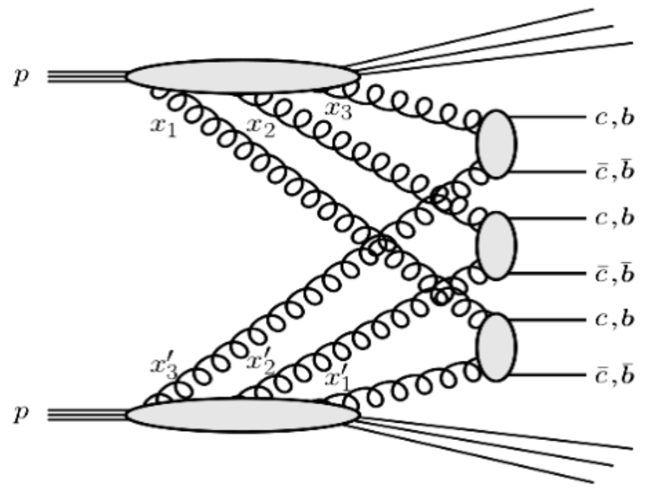




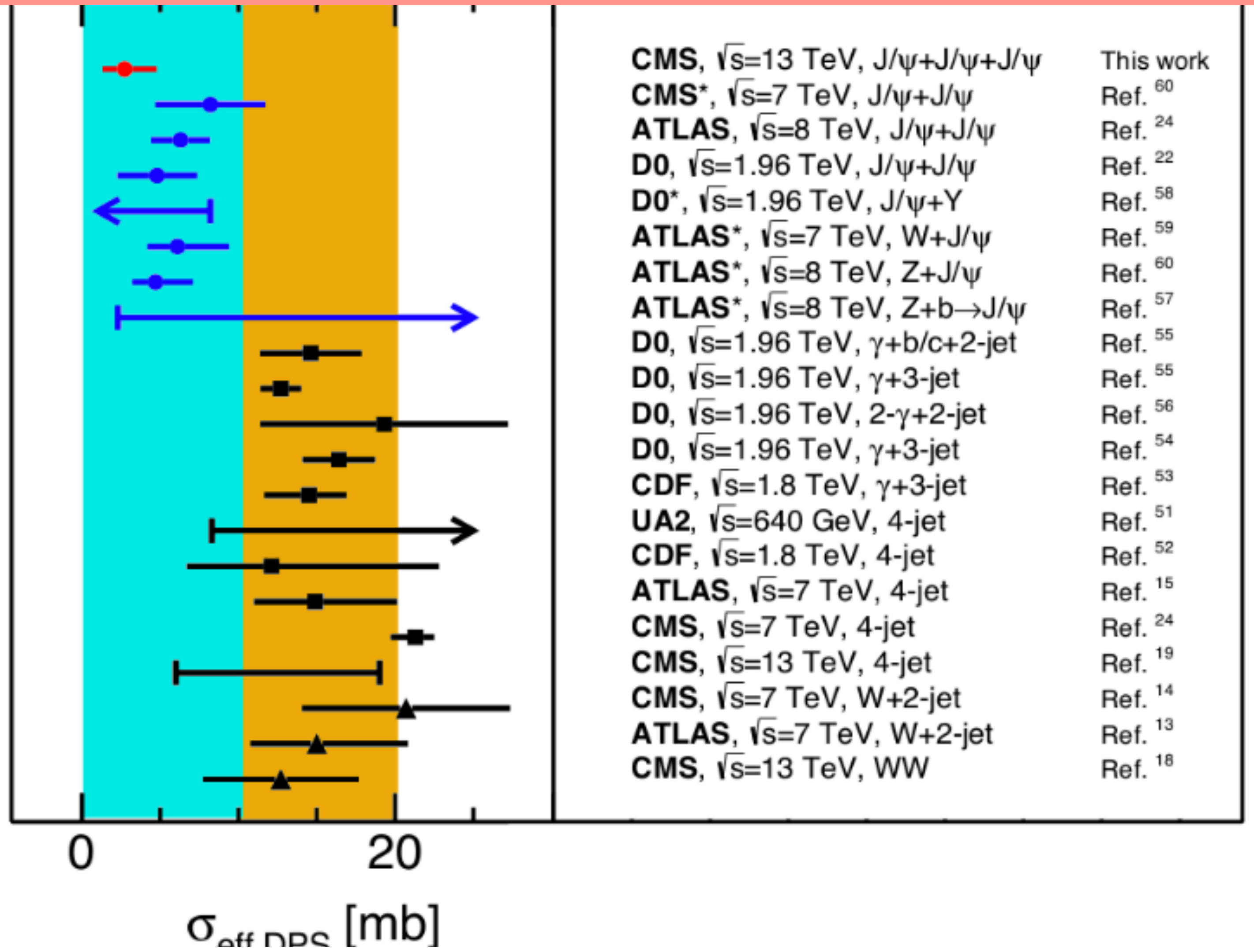
DPS

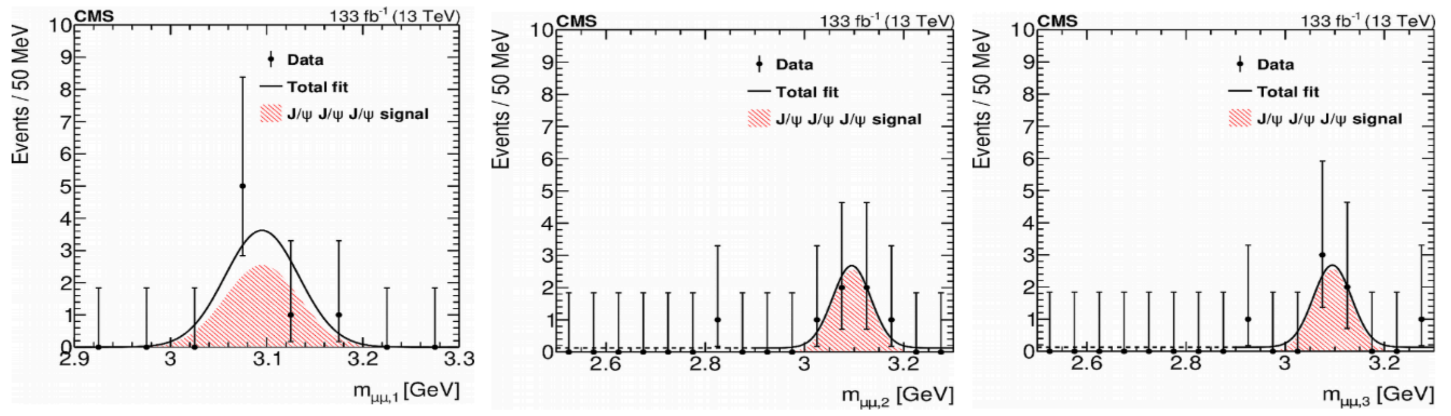


NEW: TPS



First observation of triple-J/ψ production (CMS) (Nat. Phys. to appear)





MuonID (3 options)

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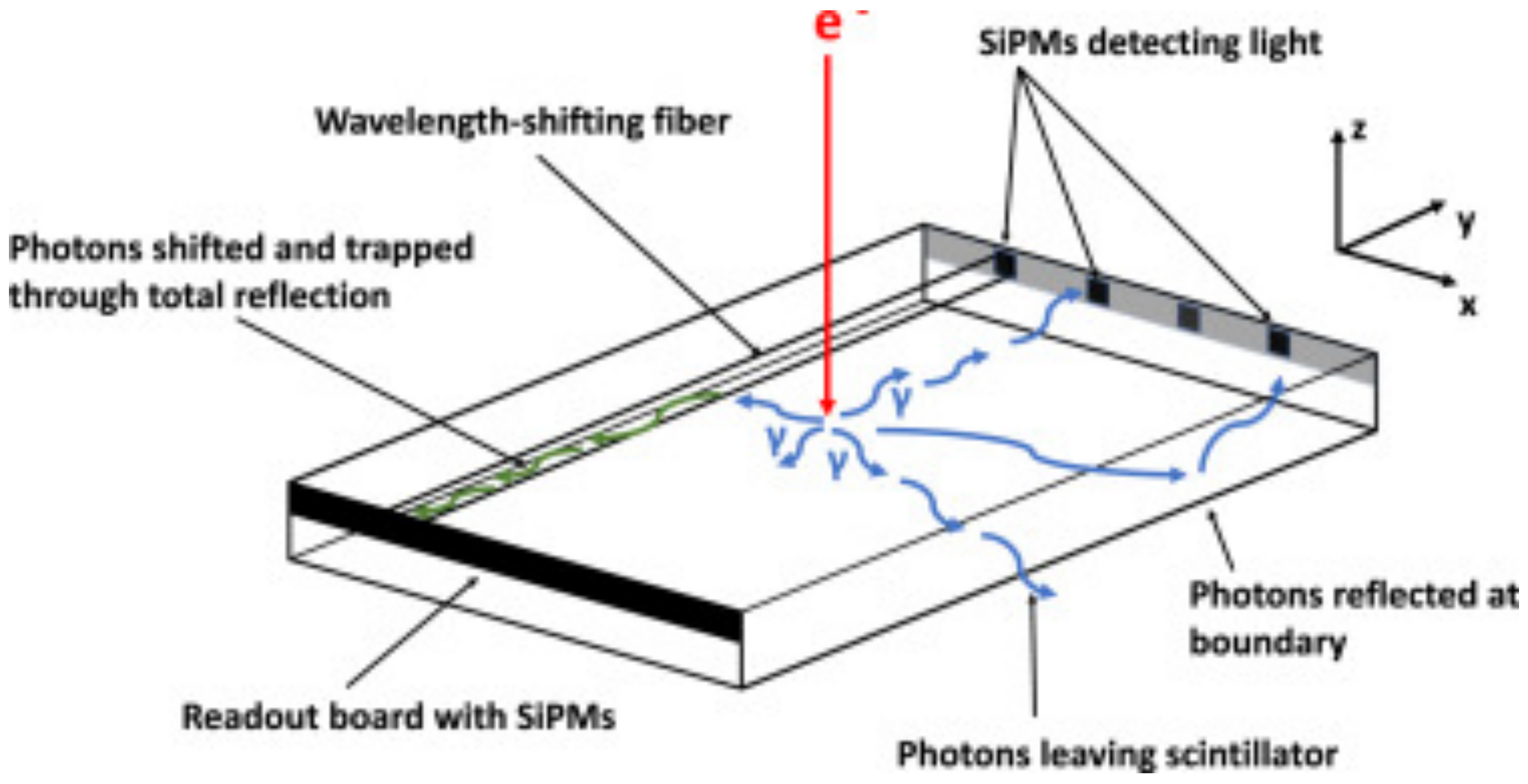
S13360 series



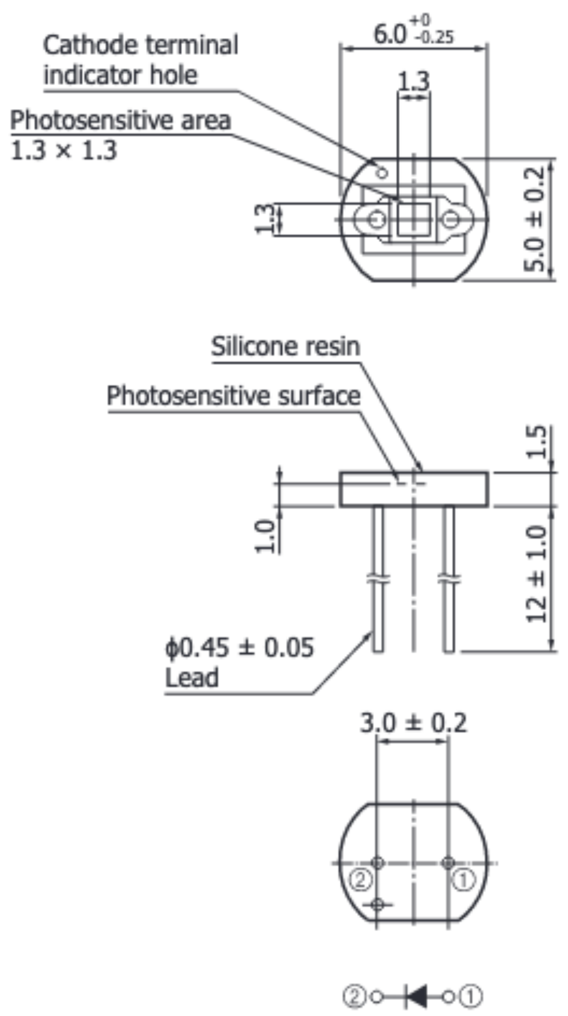
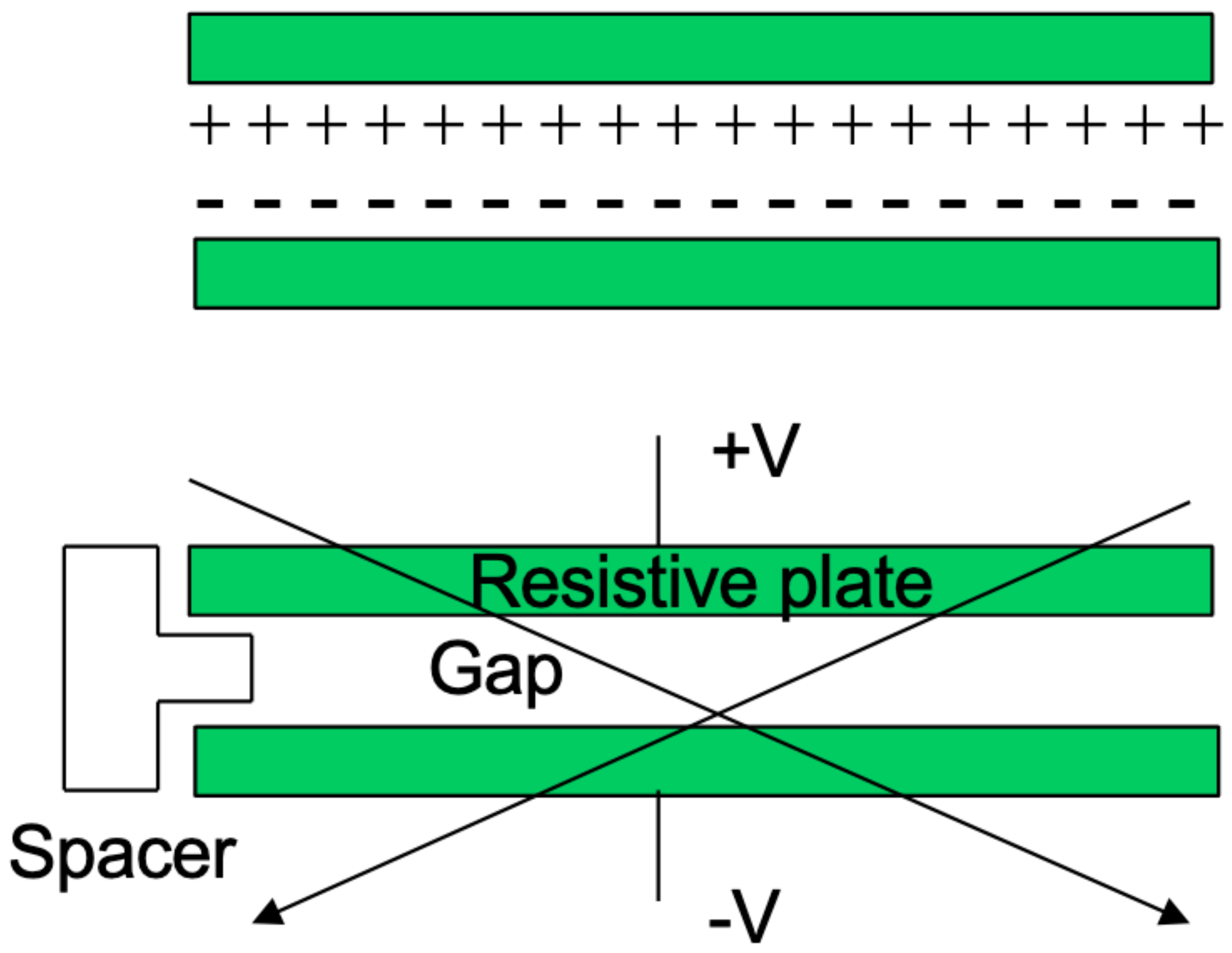
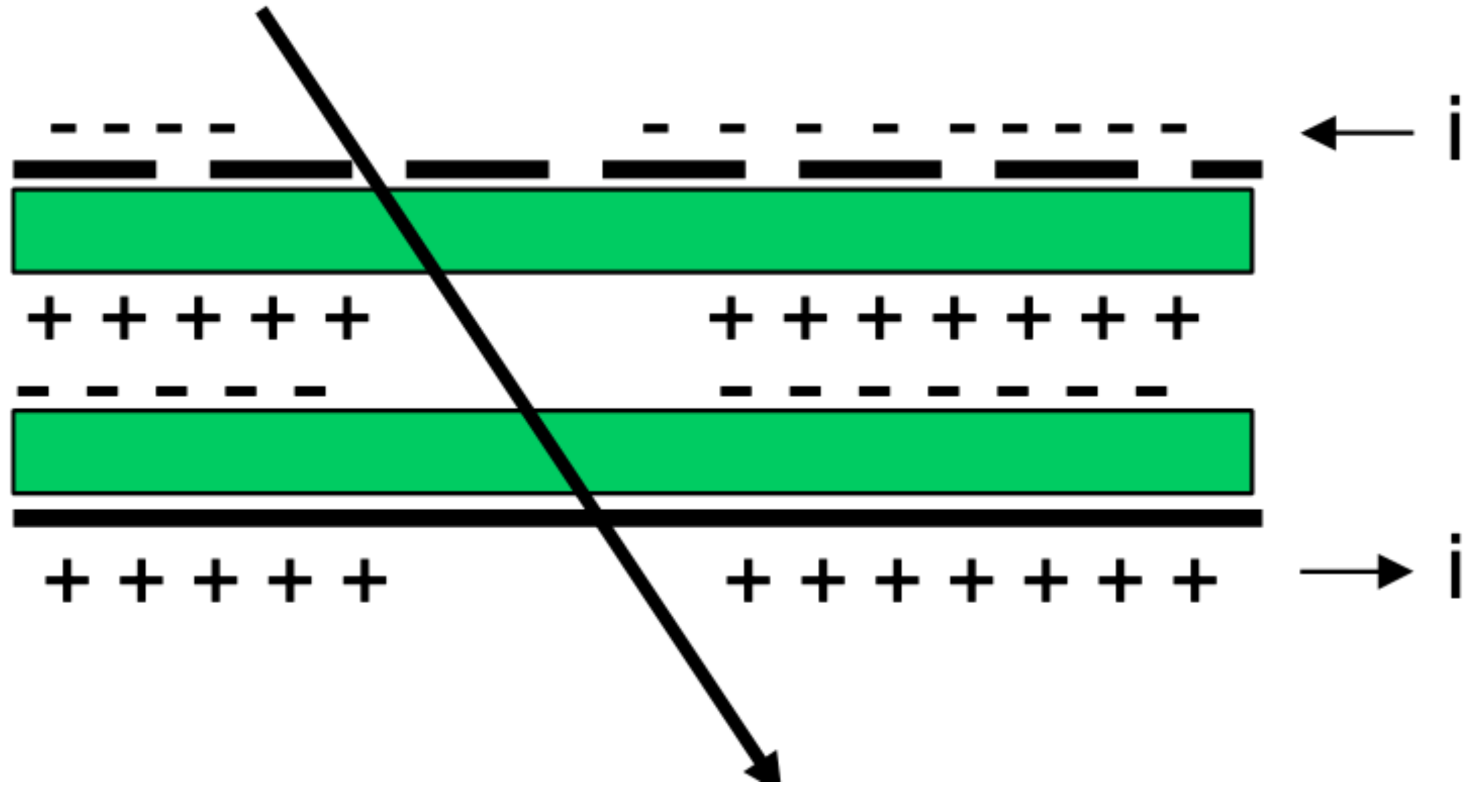
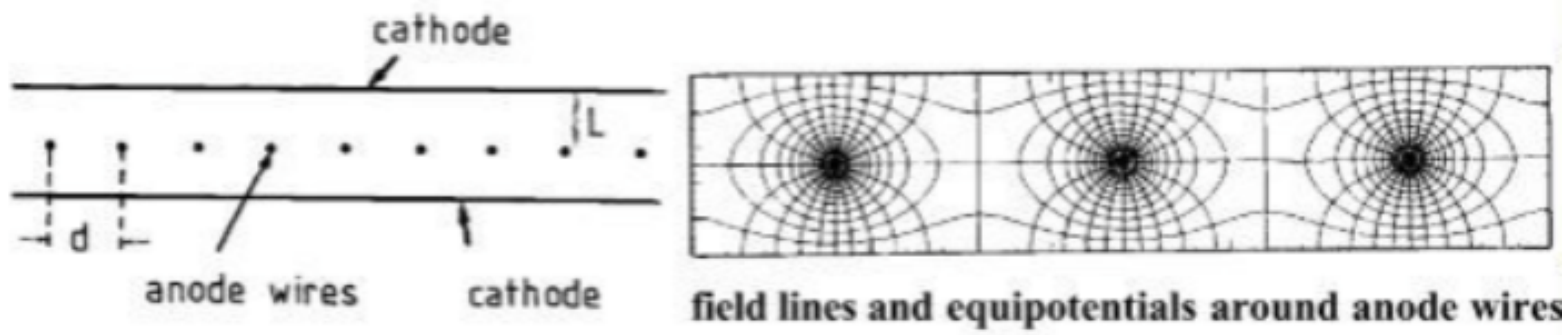


Figure taken from: NIM A 1012 (2021) 165617



Plastic scintillator + SiPM for readout
(talks by Ildefonso León, Mario Rodríguez, Varlen Grabski)





MWPC (talk by Dezso Varga)

RPC (talks by Varchaswi Kashyap, Zubayer Ahammed, Saikat Biswas)

Geometry of the detector, example with plastic scintillator

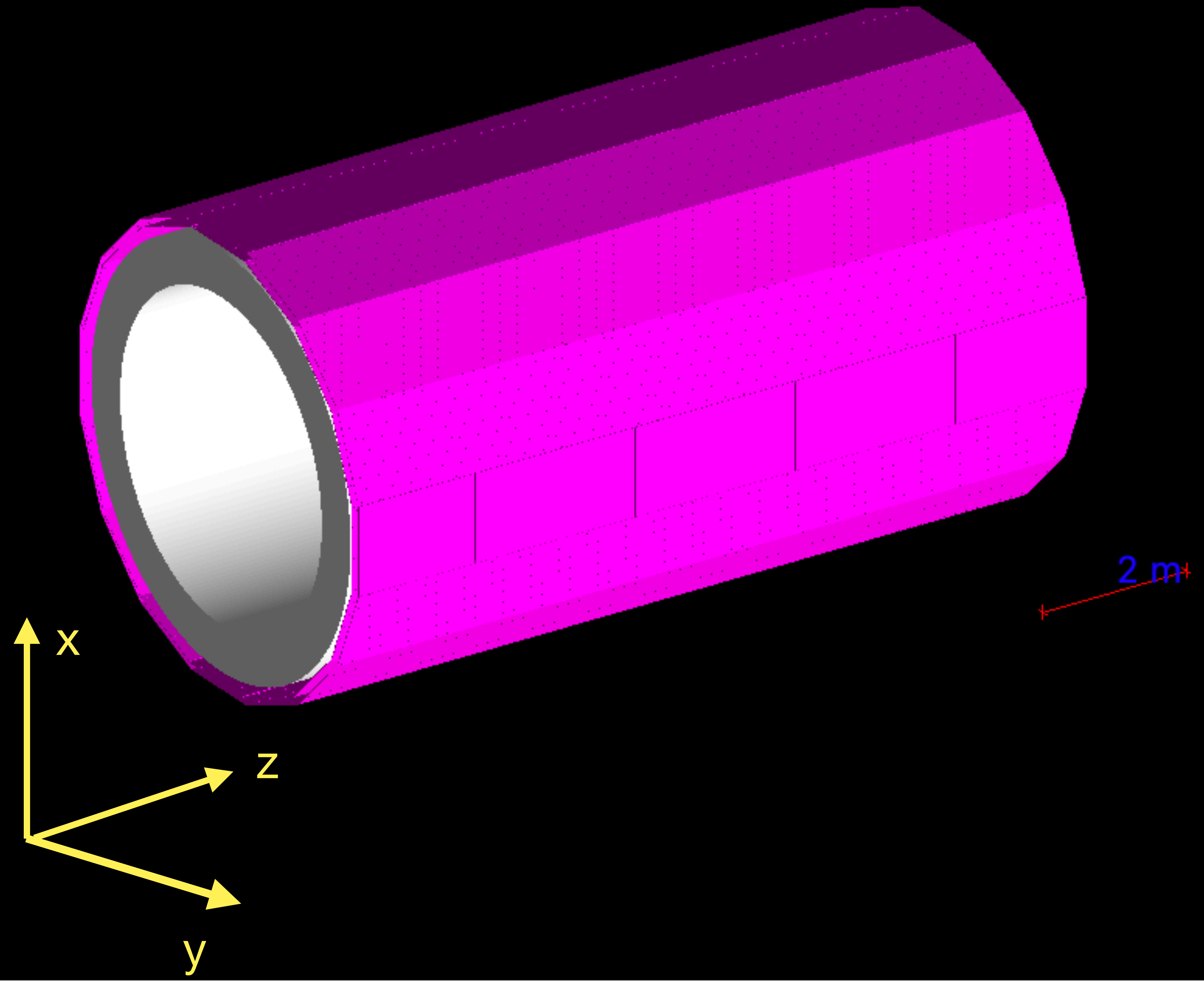
MuonID (absorber)

Absorber: $R_{\text{in}} = 2.05\,\text{m},\ R_{\text{out}} = 2.75\,\text{m},$
length: 10 m, weight: ~1kt

MuonID (chambers, example with scintillator)

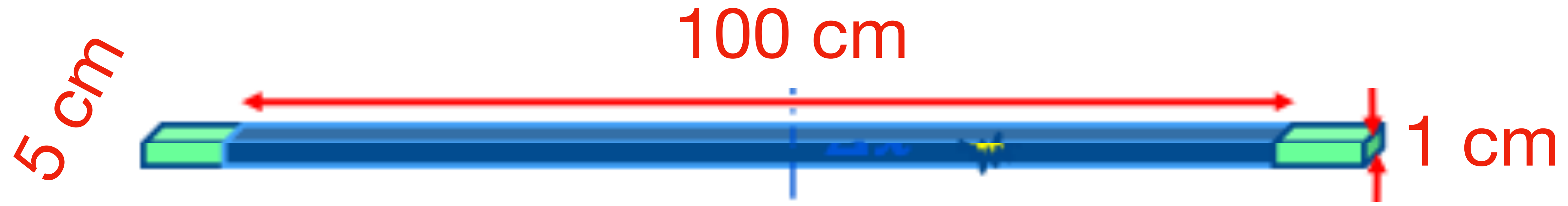
Absorber: $R_{\text{in}} = 2.05\,\text{m},\ R_{\text{out}} = 2.75\,\text{m},$
length: 10 m, weight: ~1kt

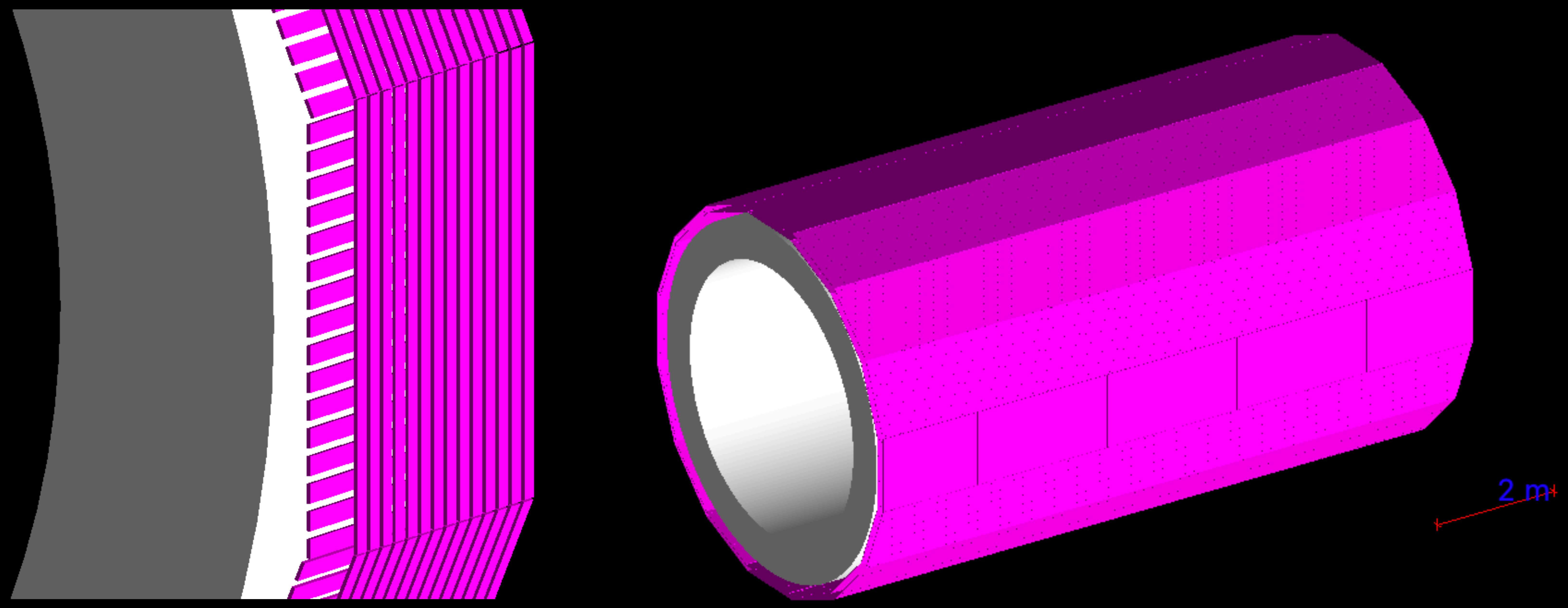
2 layers of muon chambers
Scintillator bars equipped with wave-length shifting fibres (width 5 cm, gap between layers 10 cm)



Absorber (iron)

MuonID (chambers)



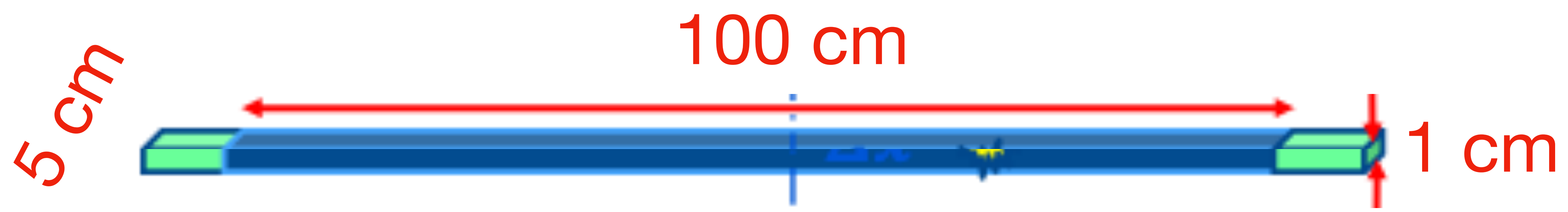


Muon chambers:

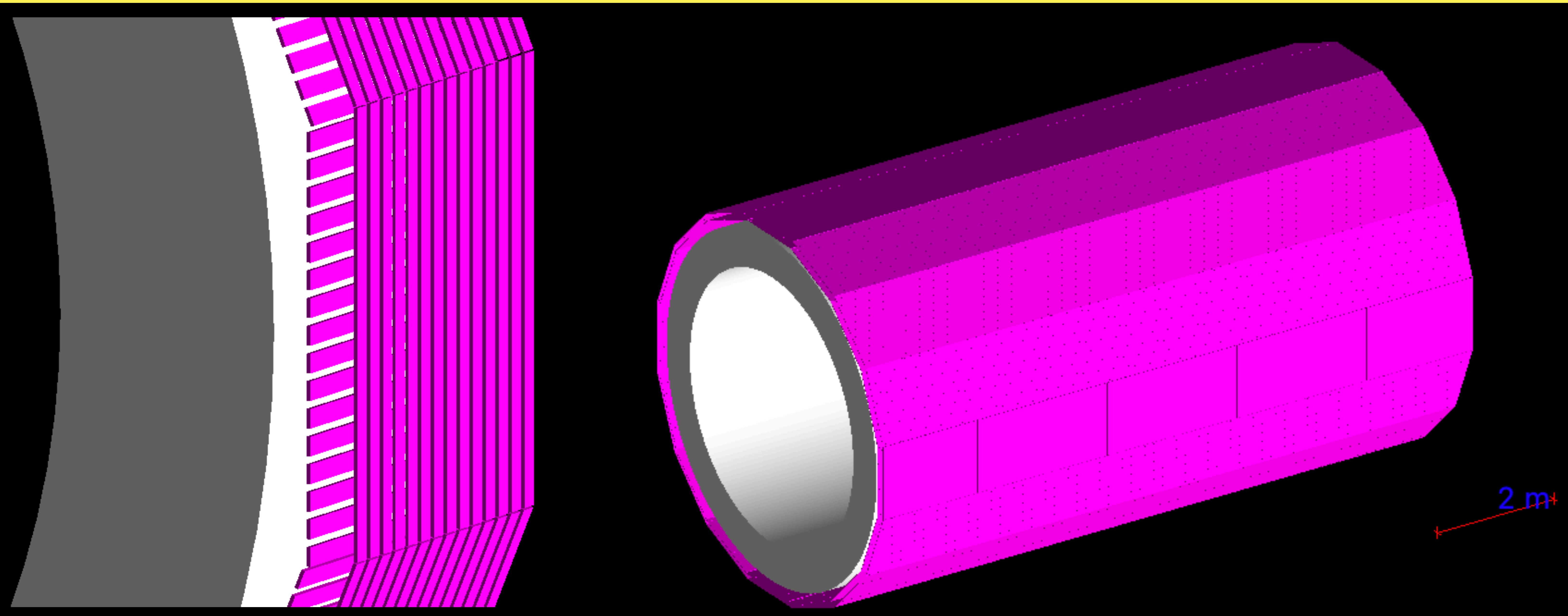
- inner layer (size of chambers 1.1x1.0m^2)
  3520 bars: w=5 cm, t: 1cm, length: 100 cm
- second layer (size of chambers: 1.15x1.0 m^2)
  3200 bars: w=5 cm, t: 1cm, length: 115 cm

We should to cover ~360m^2 of area
Readout in both sides of bars: 13440 channels

MuonID (chambers)



We still need to consider the mechanical supports and PCBs which may slightly reduce the size of the active area



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We should to cover ~360m² of area
Readout in both sides of bars: 13440 channels

Timing requirements (preliminary ideas)

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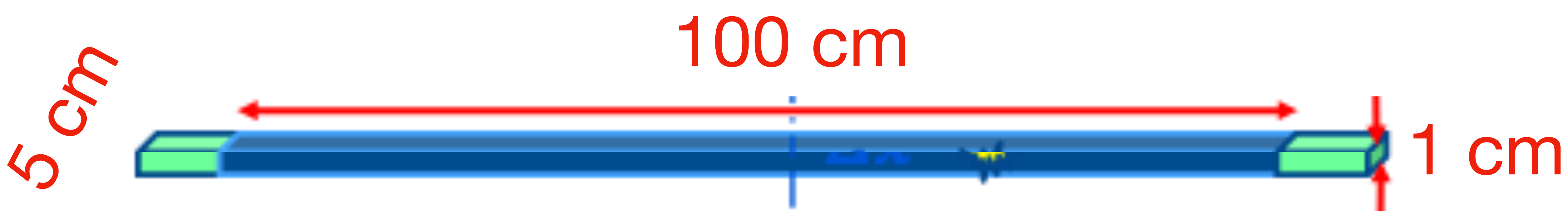
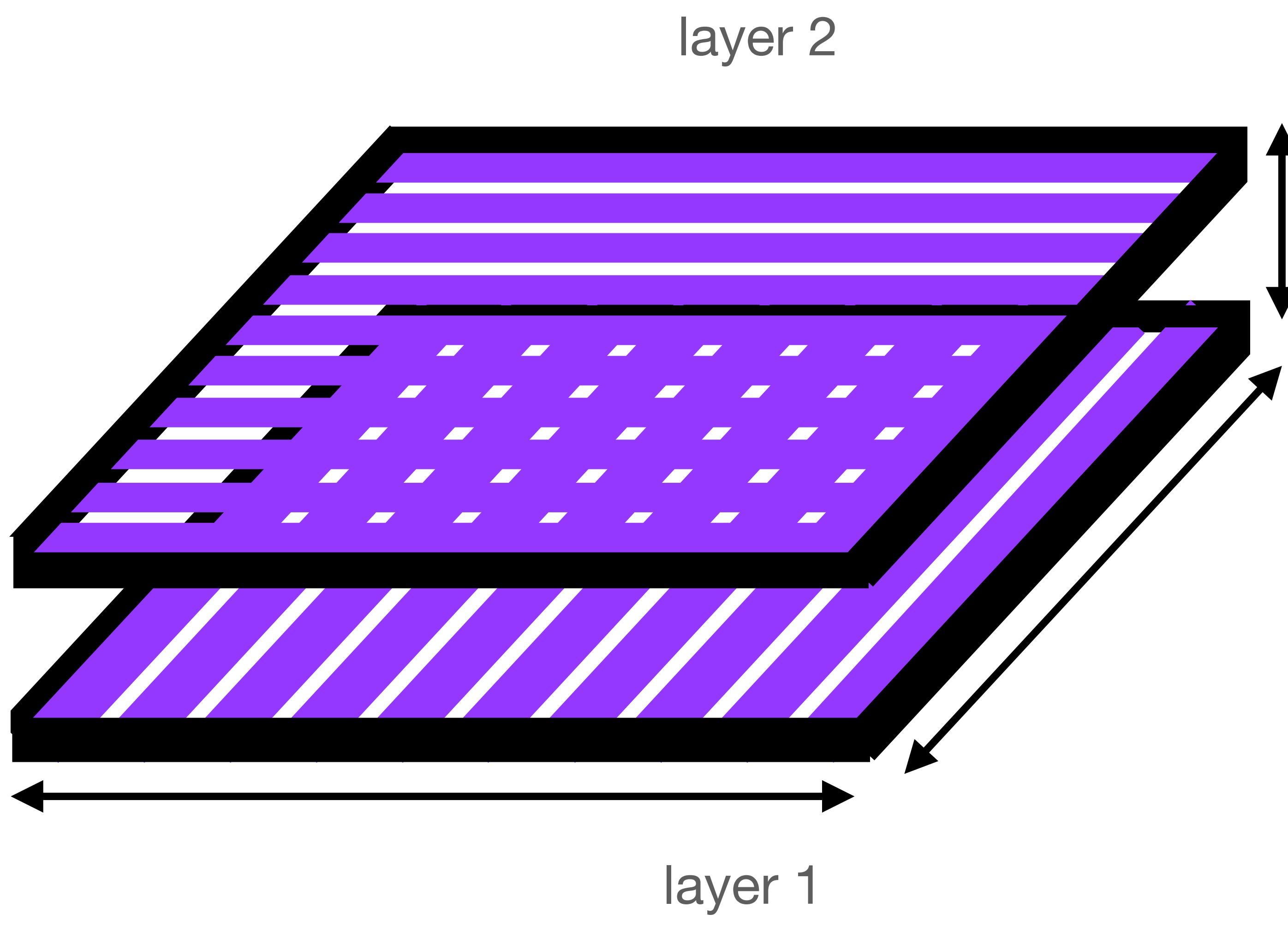
Typical time resolution of the detector (scintillator+WLS+SiPM) is of a few ns

Time information can be provided by the average of the times measured at both ends of the bars



We are interested in events in which at least one bar (two channels) is activated in each layer of the muonID (keep in mind that we would have ~13500 channels). Using the centers of the fired bars a tracklet can be reconstructed

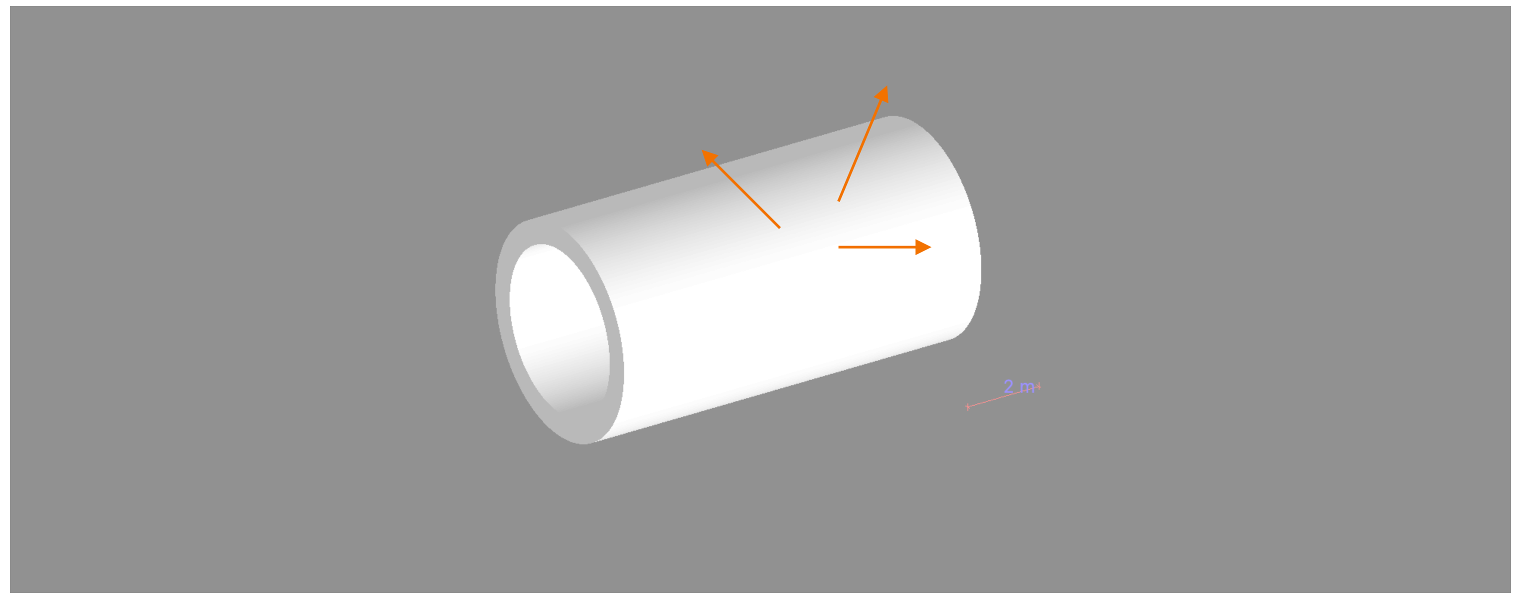


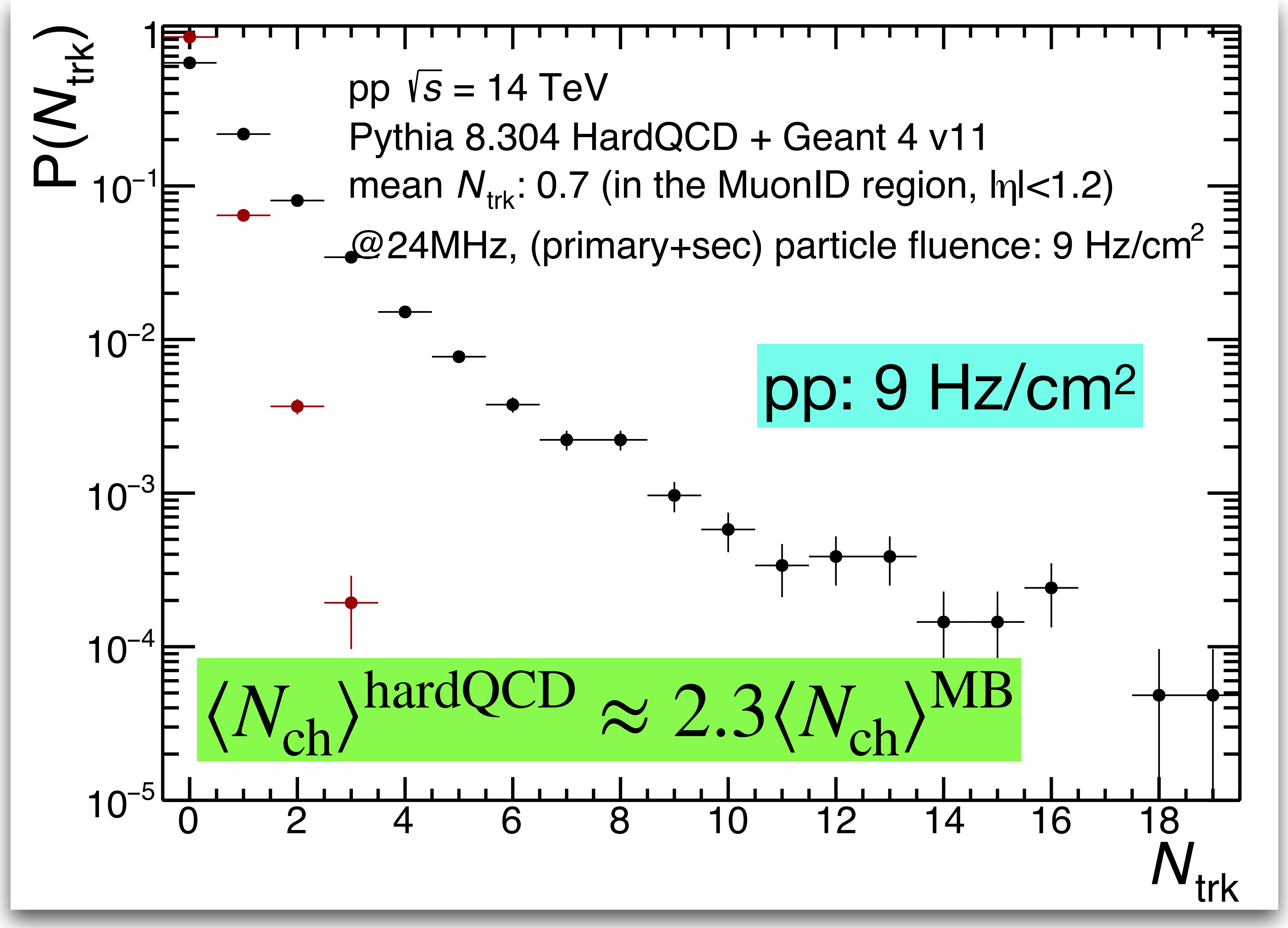
Since we will match muonID tracklets with tracks, maybe we can aim at a detector readout time of ~100 ns

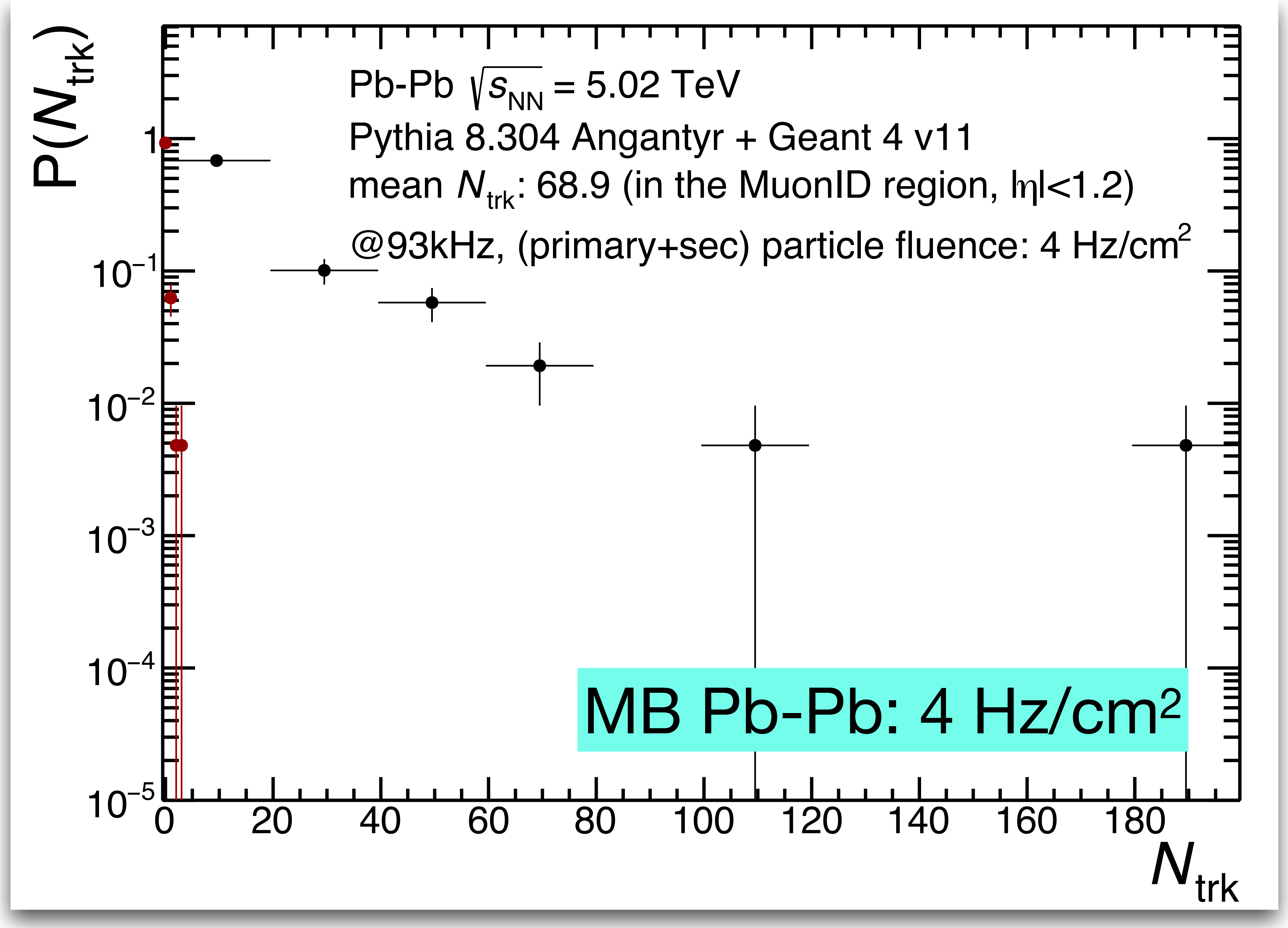
Particle fluence in the muonID region

Primary particles which were not filtered by the absorber

Secondary particles can be produced in the absorber

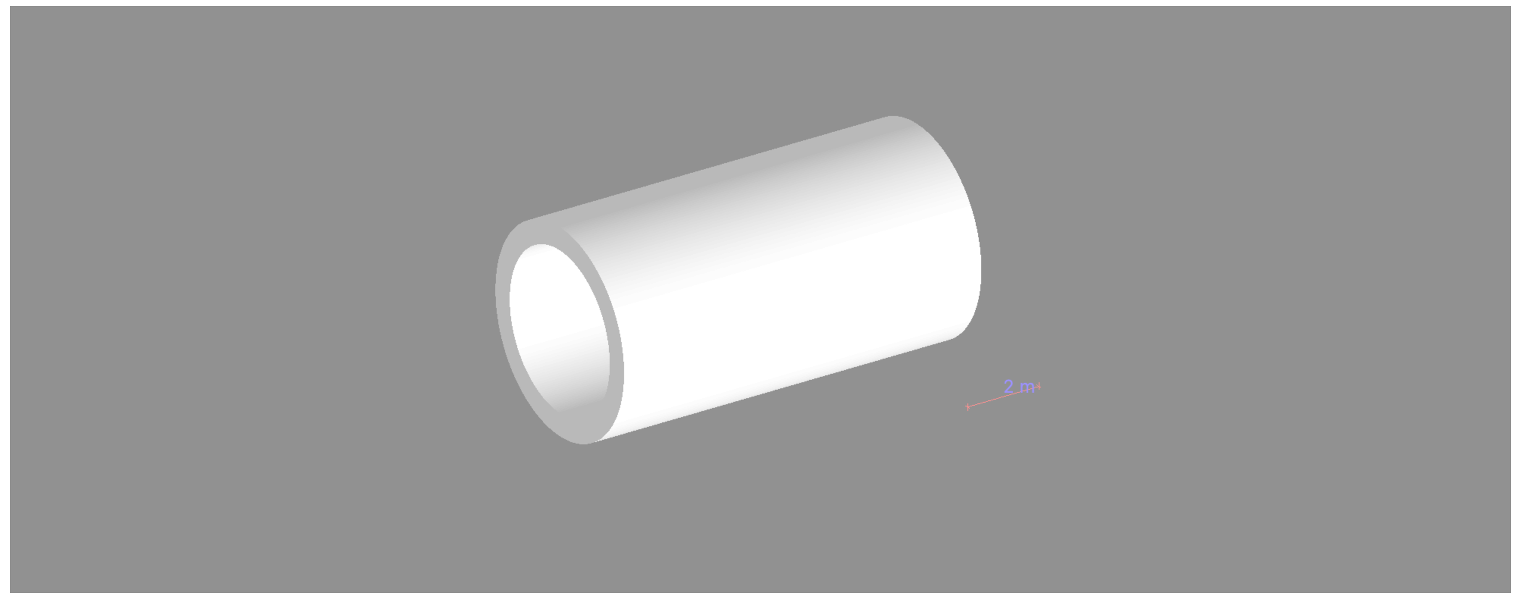


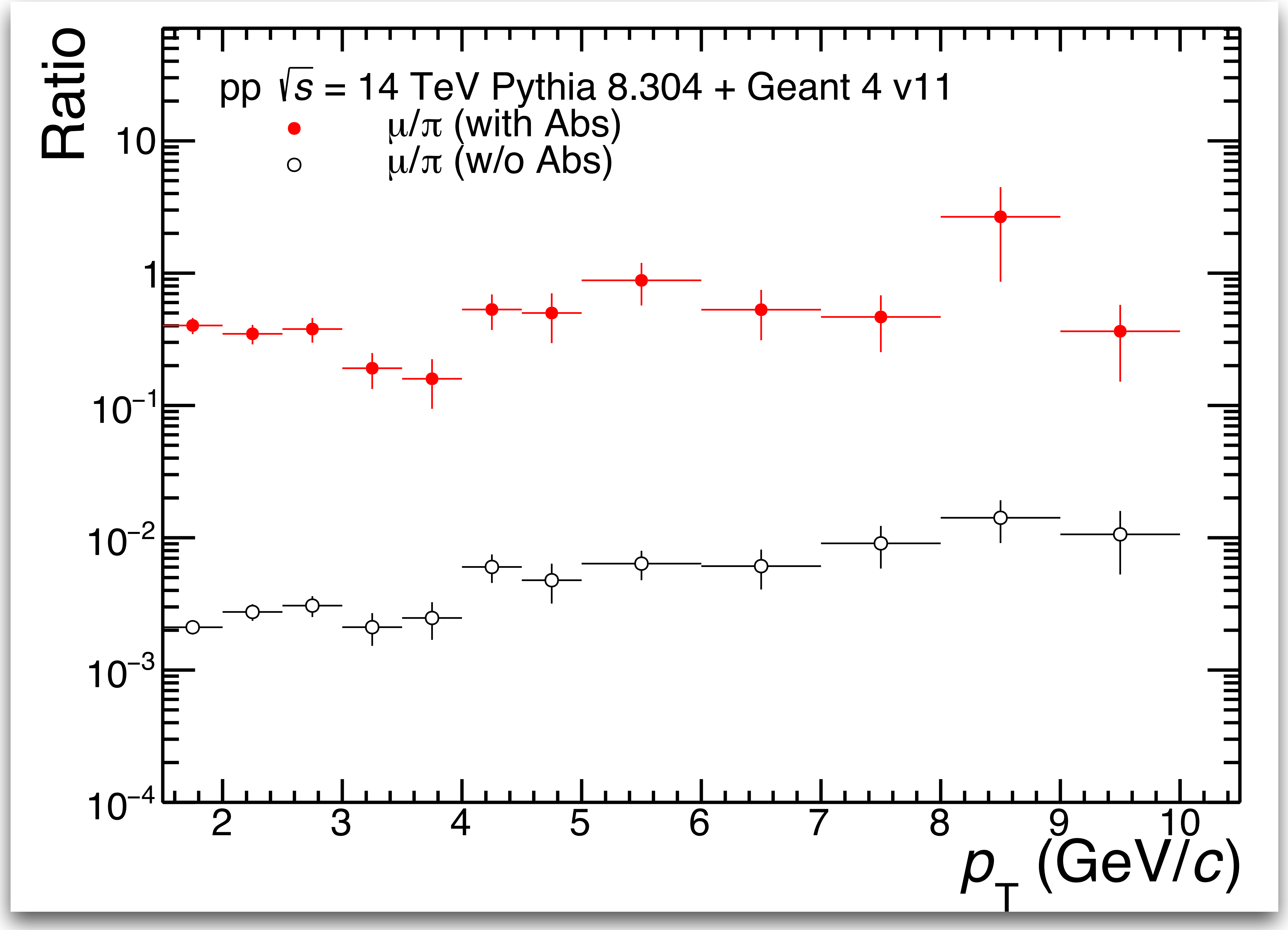


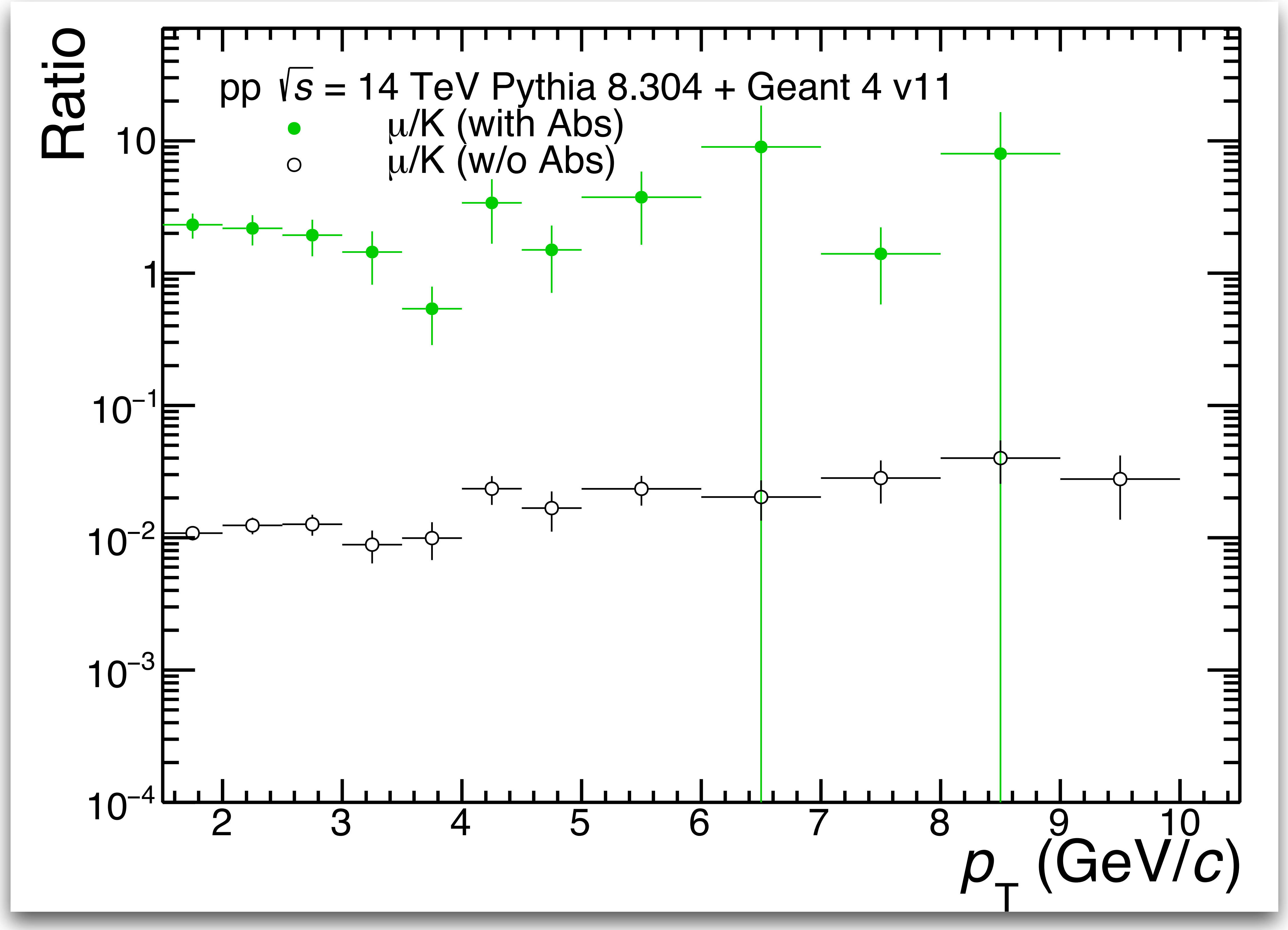


Rejection factors (just due to absorber)

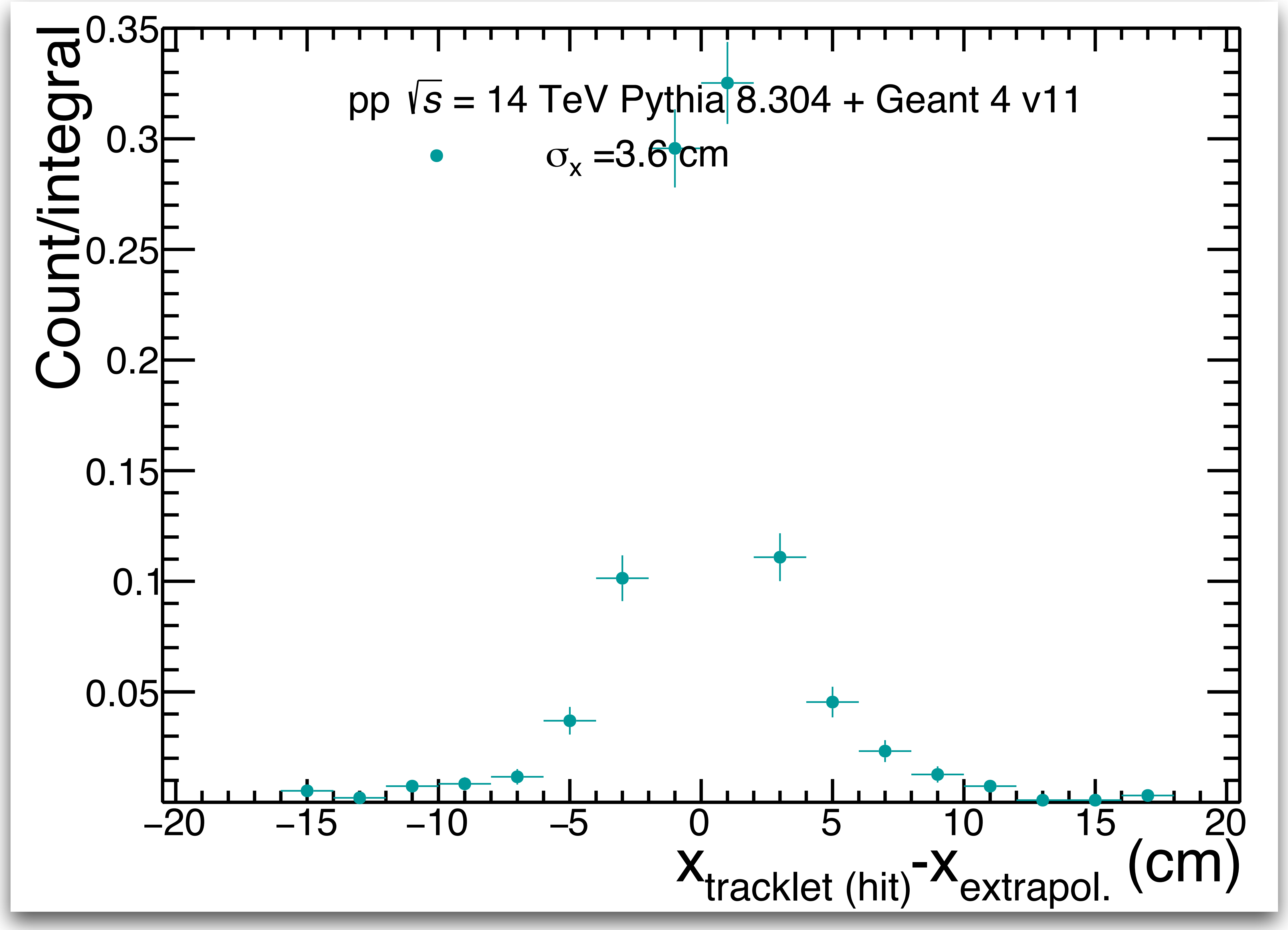
Only primary particles which reach the muonID region are considered, rejection factors between 50-100% are seen

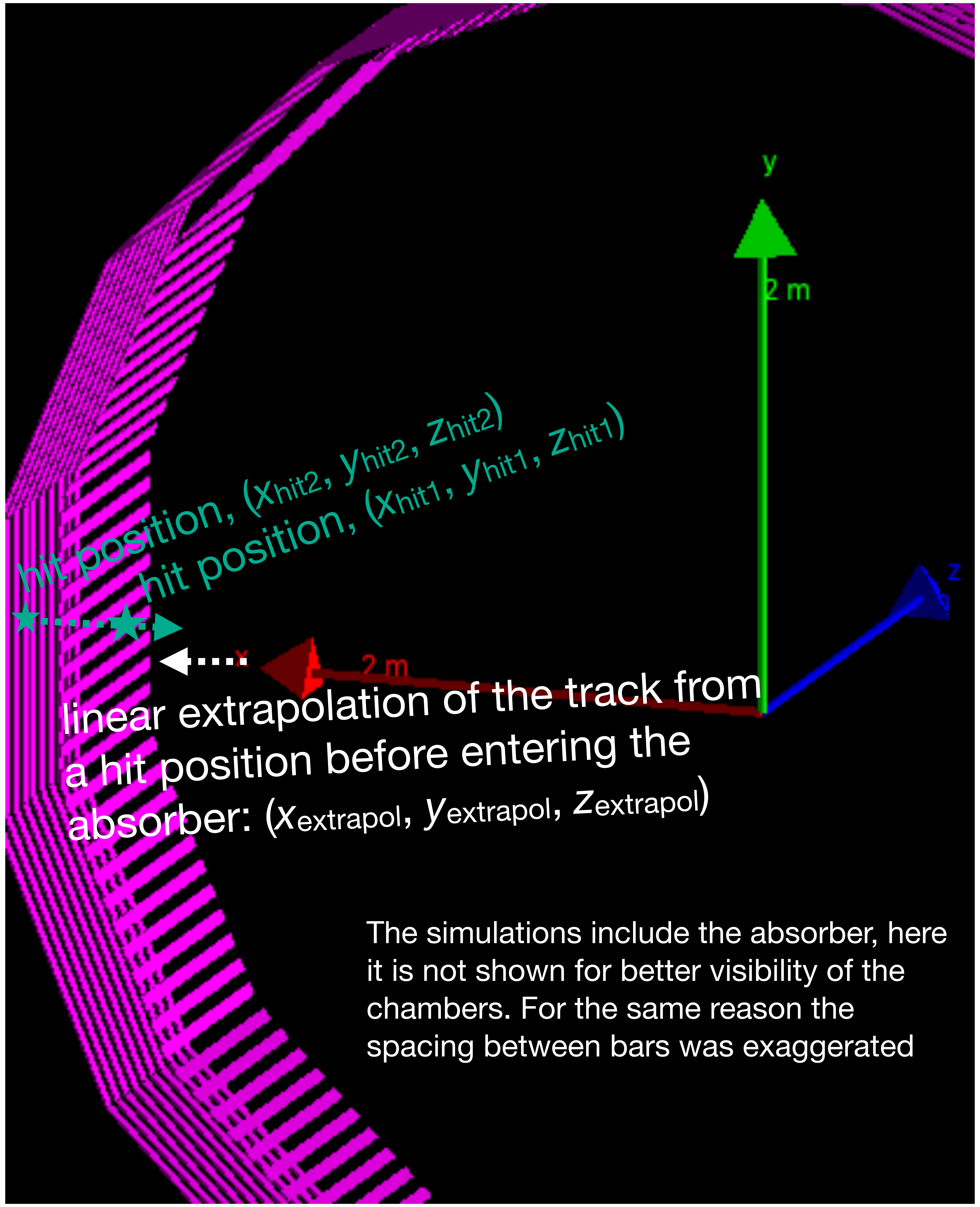






Tracklets from hits (ideal case)





Tracklets from hits (ideal case)

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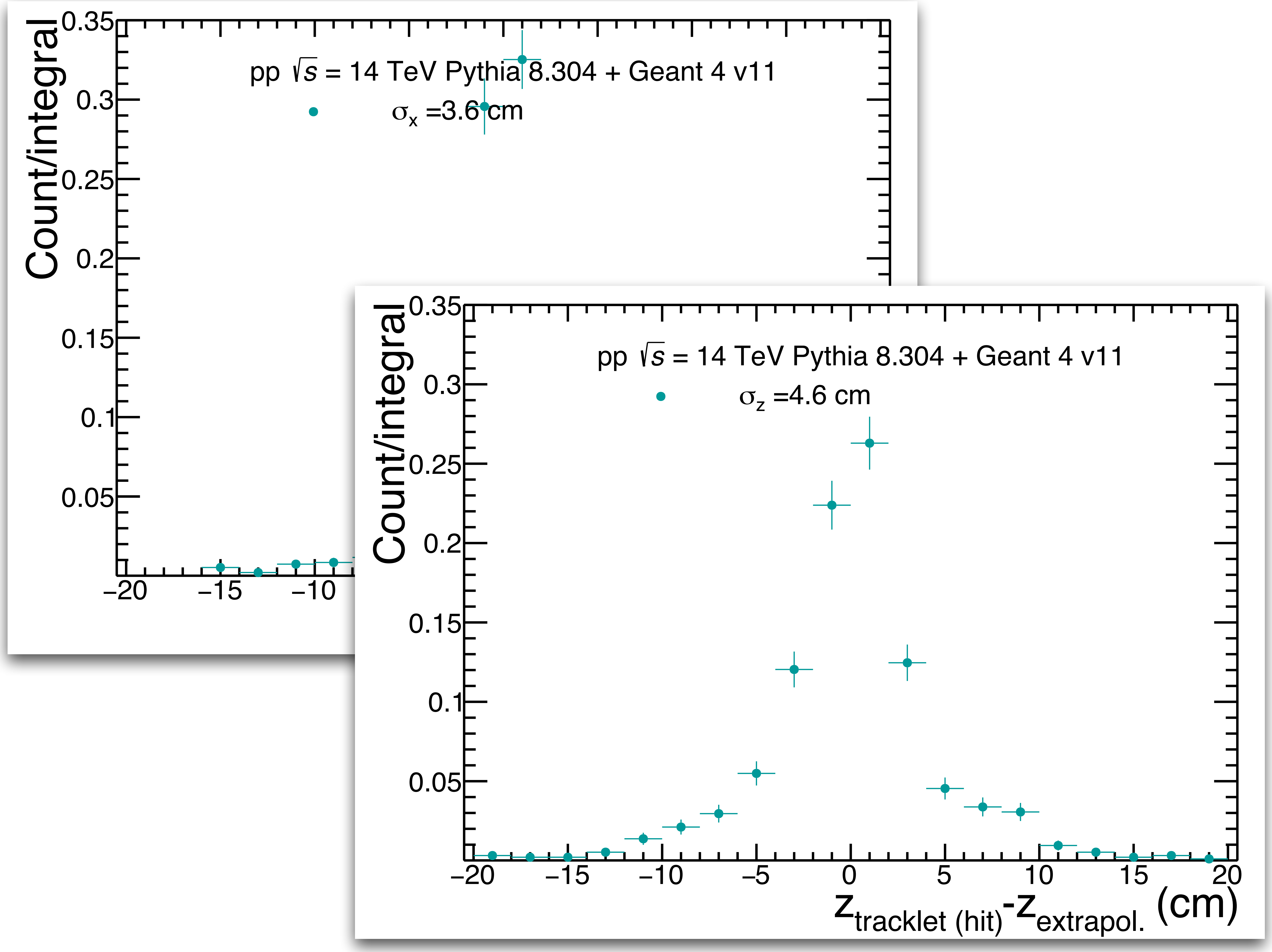
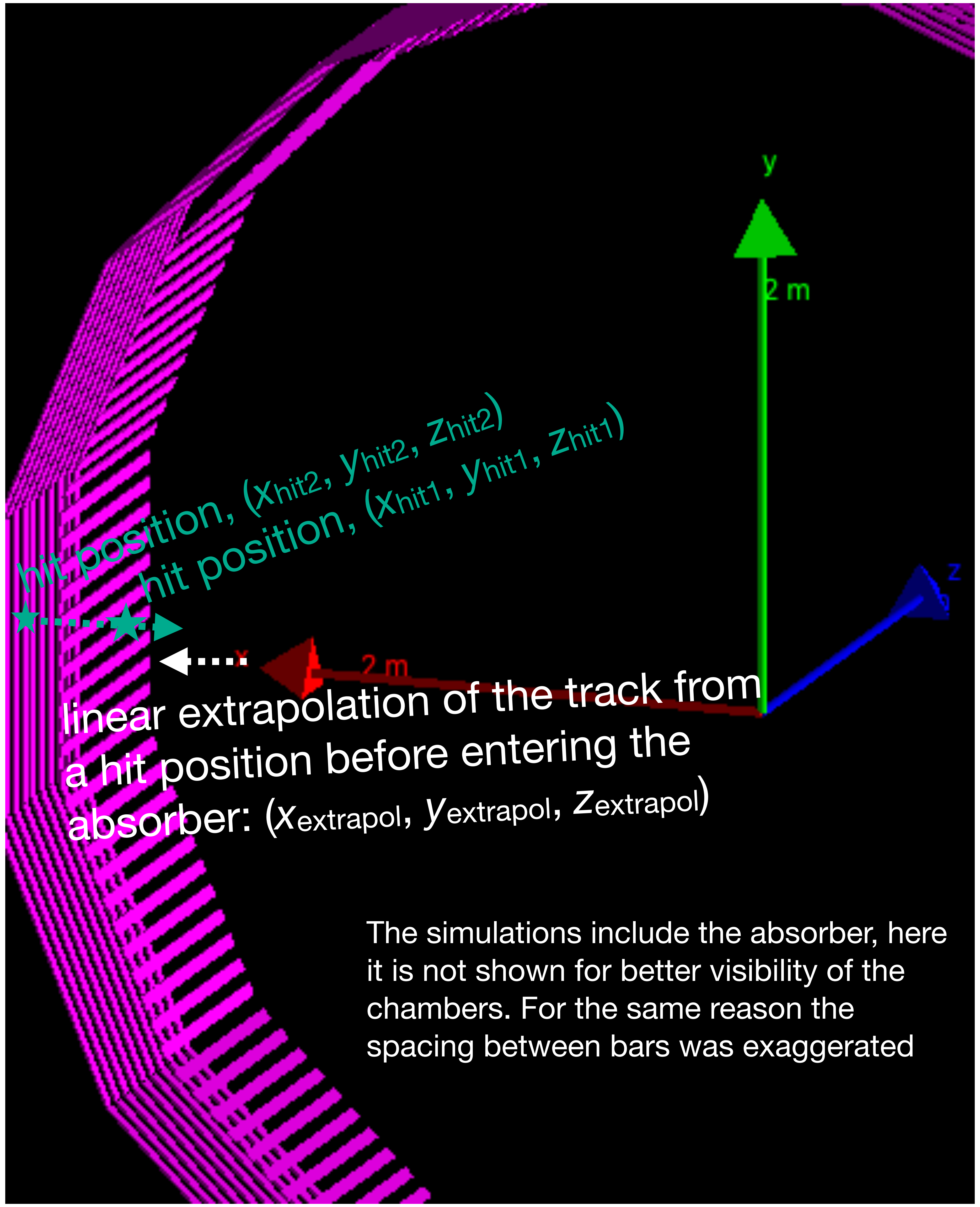




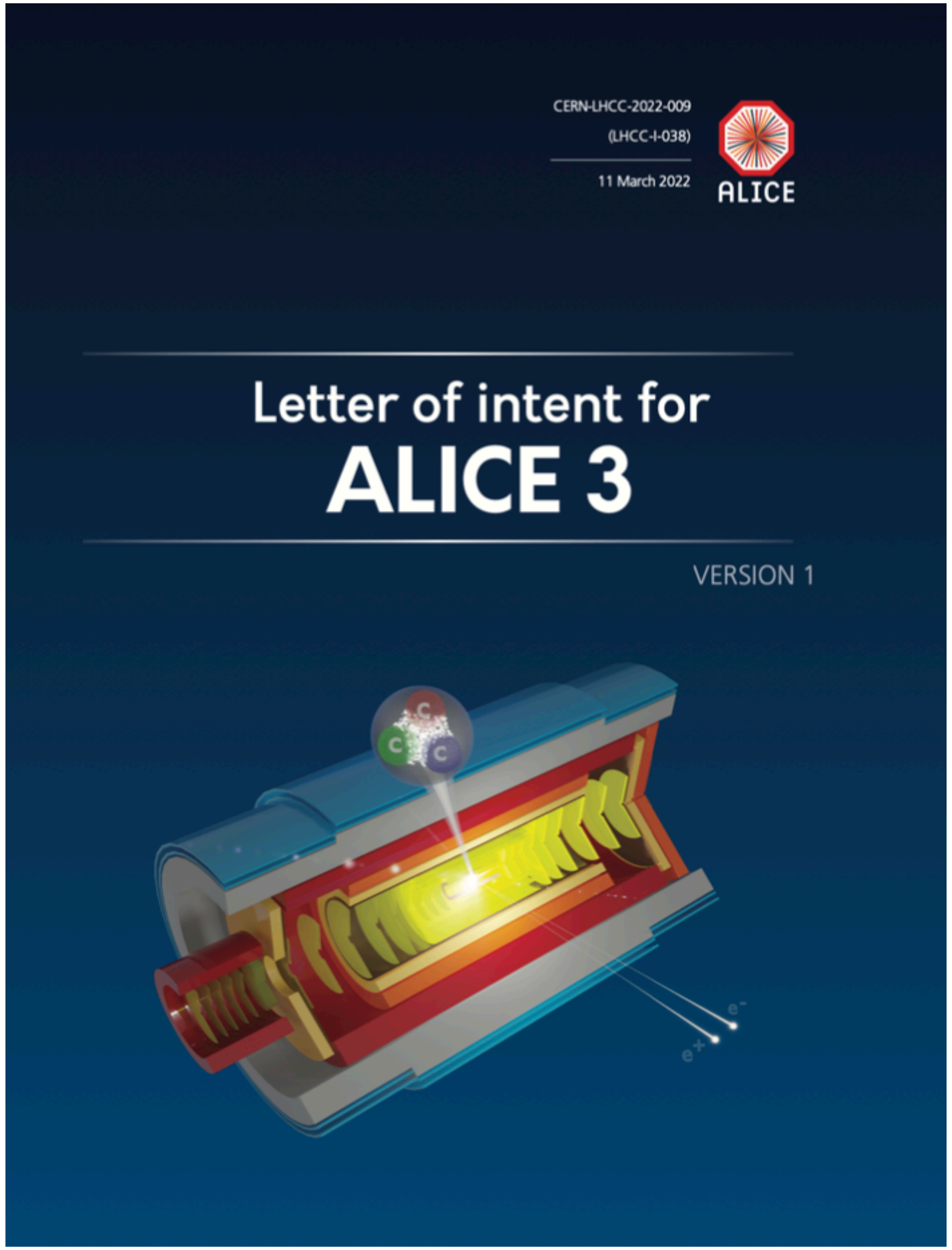
Status and planning ALICE 3

Physics case and detector concept developed in the course of 2020-2021 → Letter of Intent

- endorsed by Collaboration Board in January 2022
- LHCC review concluded in March 2022

  → very positive evaluation [LHCC-149]
  - Exciting physics program
  - Detector well matched with physics program and strategically interesting R&D opportunities
- R&D activities have started

Timeline
2023-25: selection of technologies, small-scale proof of concept prototypes
2026-27: large-scale engineered prototypes
Technical Design Reports
2028-31: construction and testing
2032: contingency
2033-34: Preparation of cavern and installation of ALICE 3



Organisation (muonID)

Physics performance

Somebody from ICN or BUAP?

- MC simulations (detector + physics performance)

Plastic scintillator and WLS fibres

Somebody from UAS or IFUNAM?

- characterisation of photosensors, machine the bars, chemical reflectors, adhesive, …

RPCs (eco gases), MWPC

Somebody from India or Hungary?

Mechanical structure

Electronics

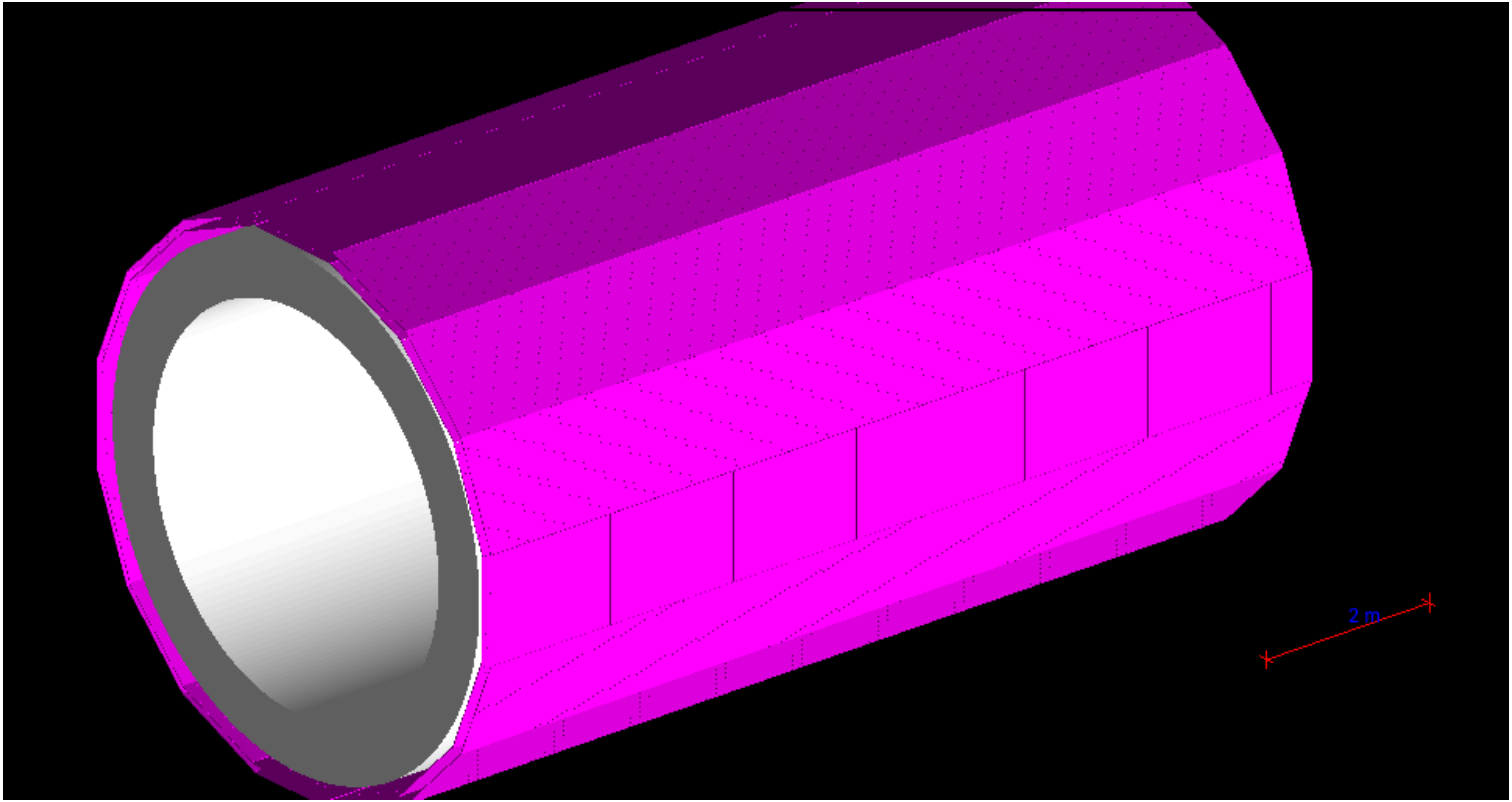
Somebody from INAOE or BUAP?

- FEE **and** DAQ

In this workshop we will define responsibilities for the different tasks

Backup

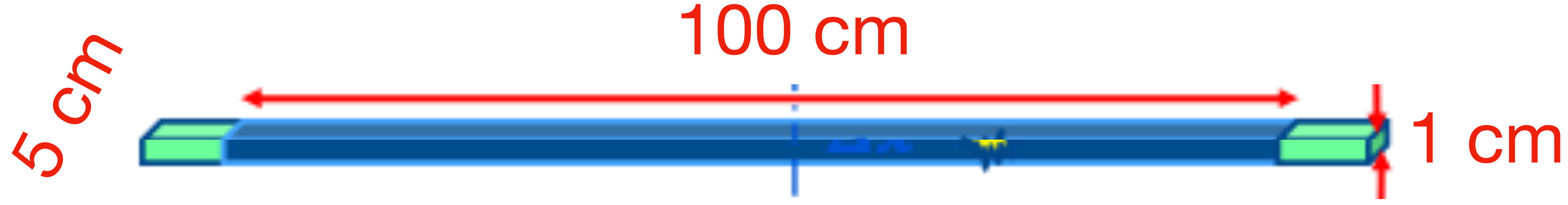
Muon chamber (baseline option)

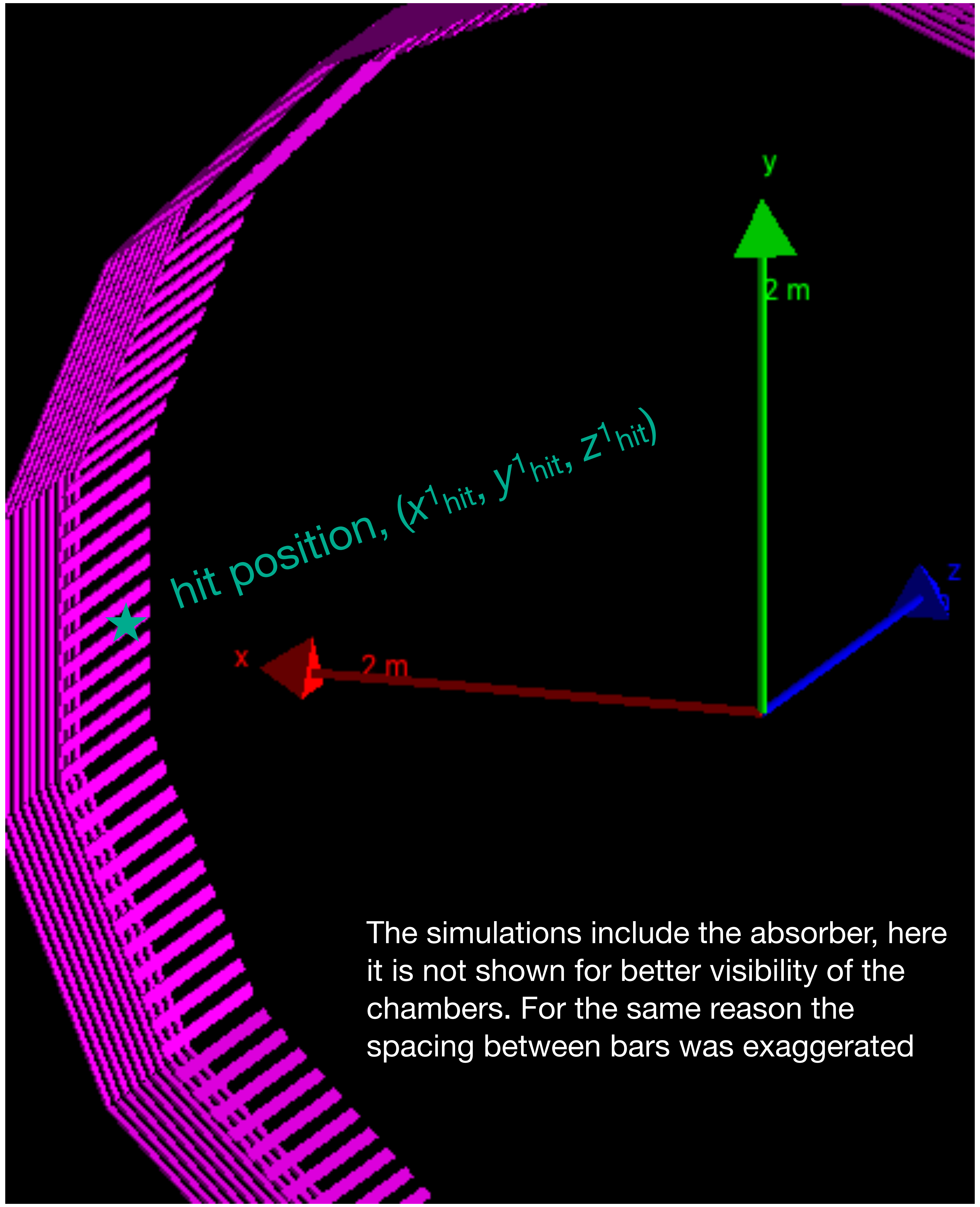


Spatial resolution

Bar width: 5 cm,

expected resolution ~ $5\,\mathrm{cm}/\sqrt{12} \approx 1.4\,\mathrm{cm}$

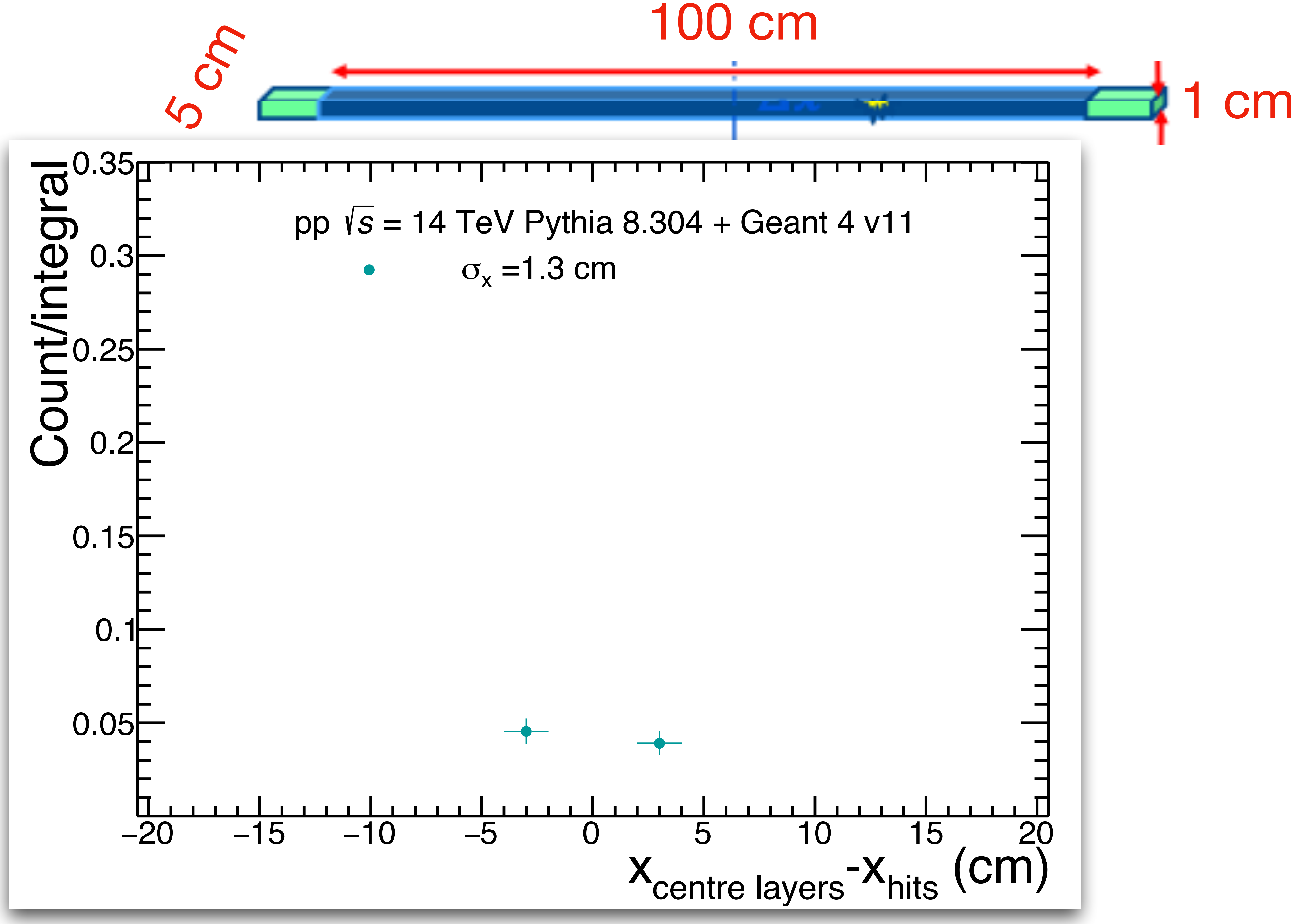


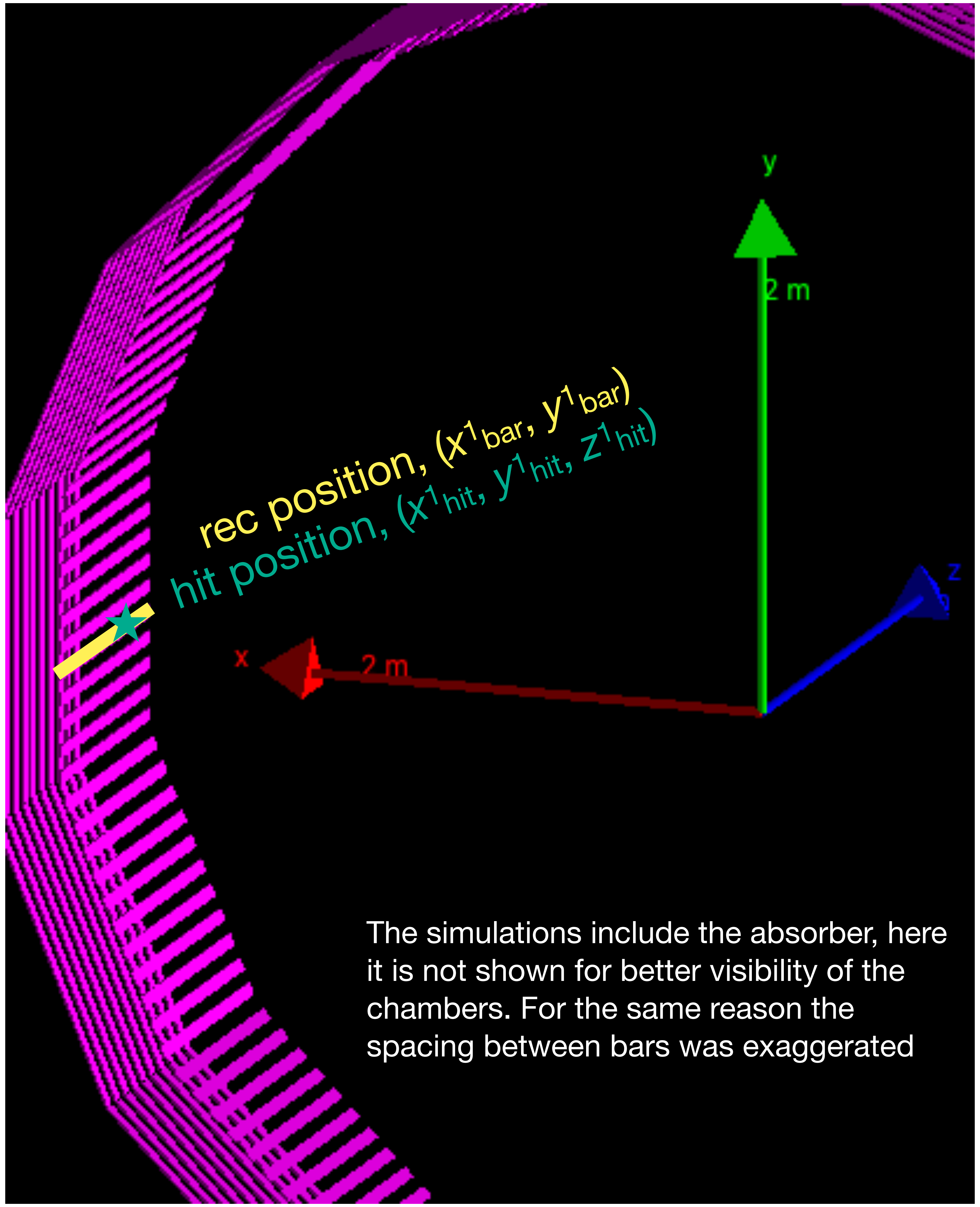


Spatial resolution

Bar width: 5 cm,

expected resolution ~ $5\,\text{cm}/\sqrt{12} \approx 1.4\,\text{cm}$

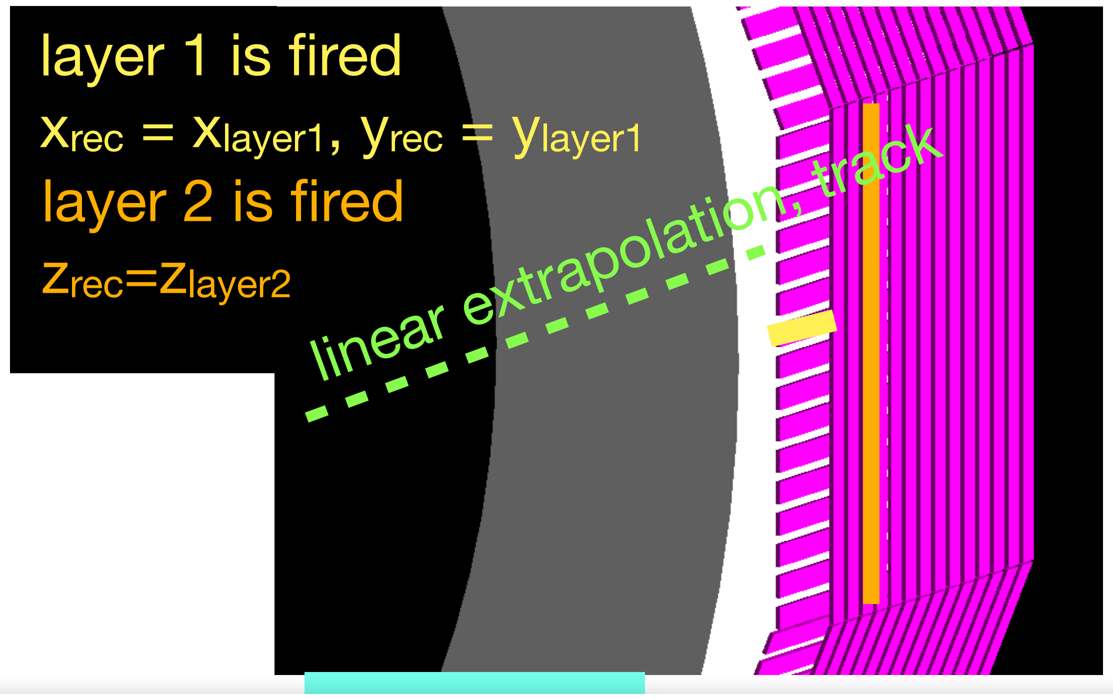


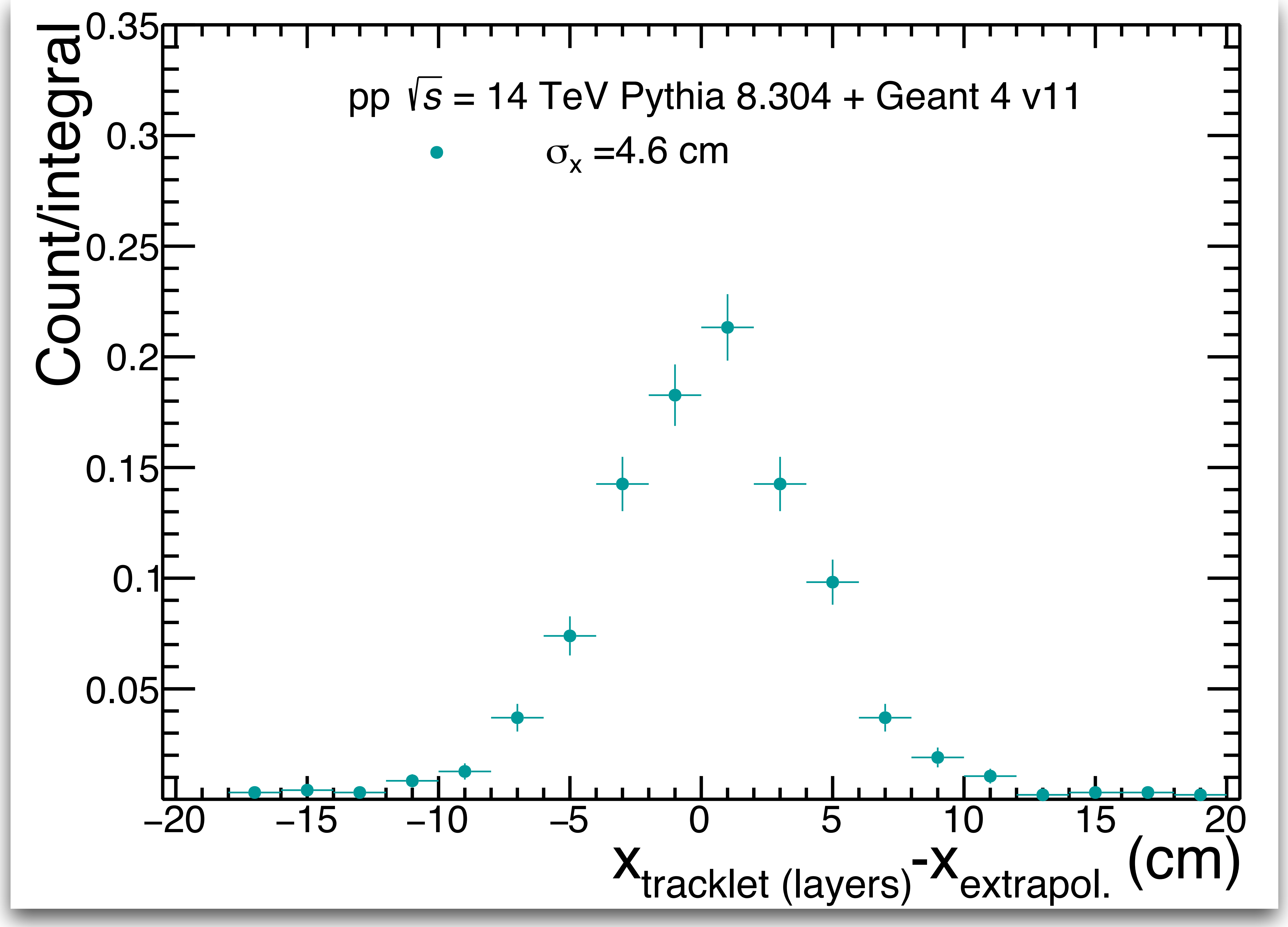


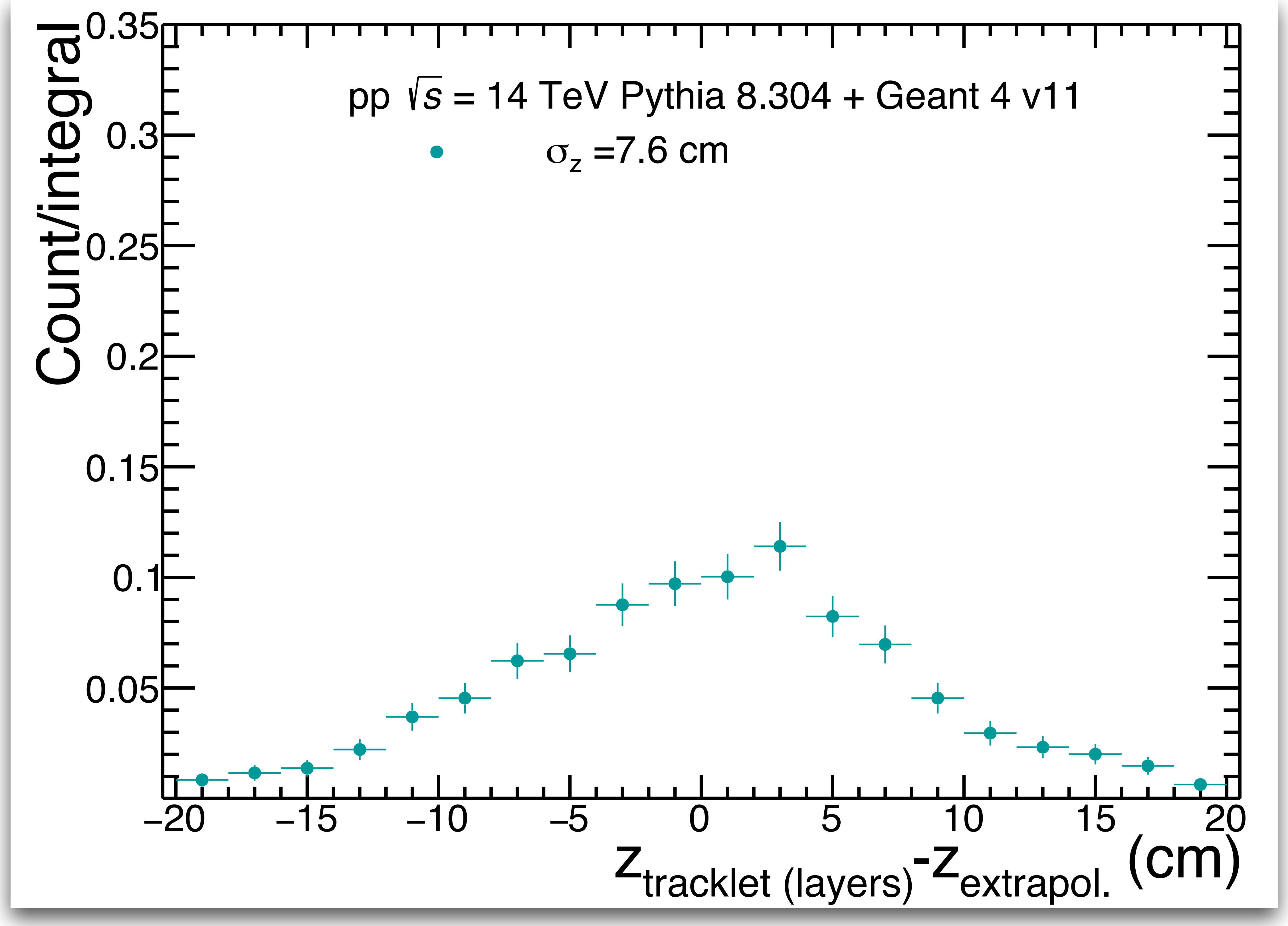
The simulations include the absorber, here it is not shown for better visibility of the chambers. For the same reason the spacing between bars was exaggerated

Tracklets reconstructed in muonID

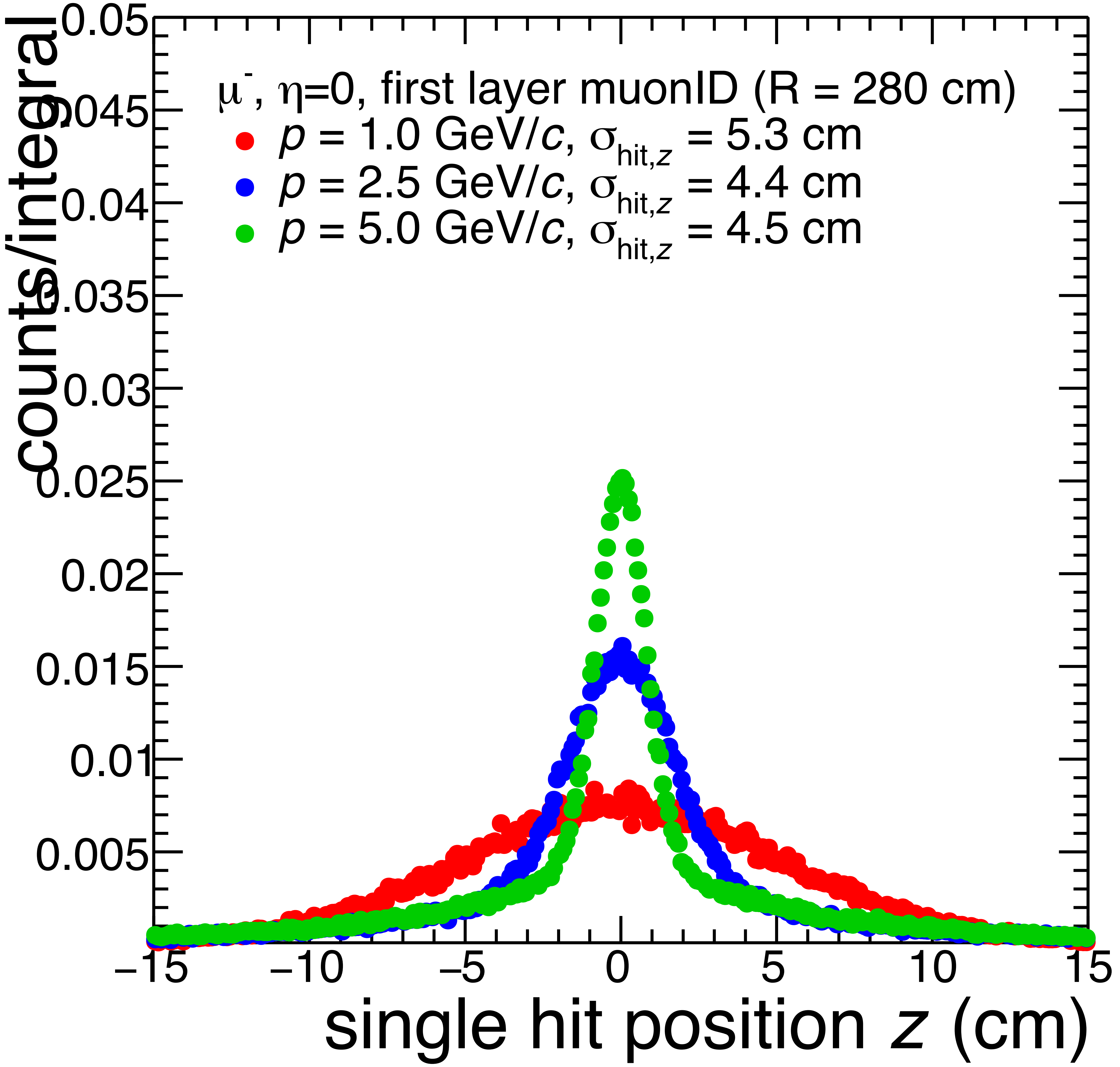
We only need to know which bars were fired

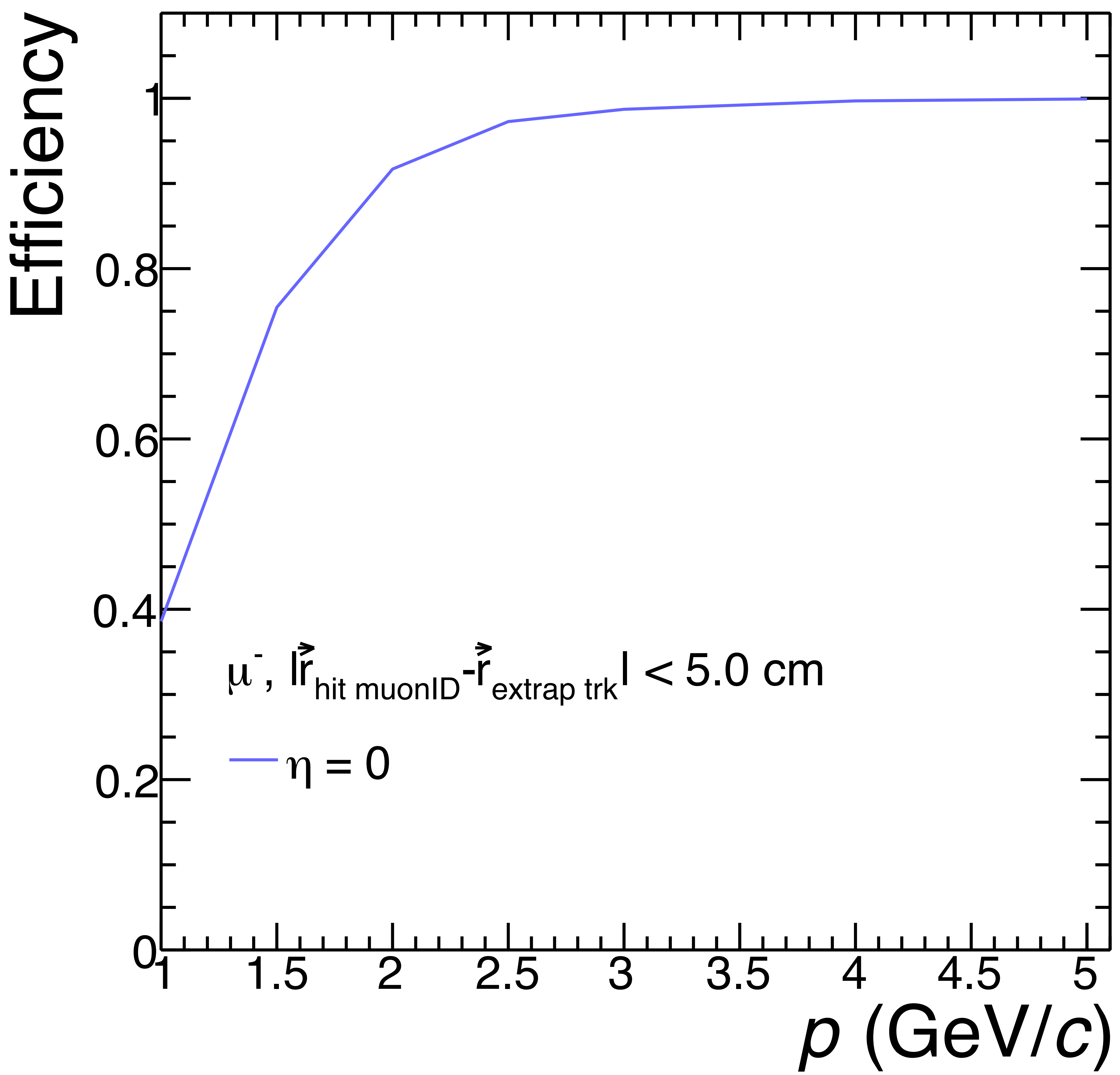






Geant4 simulations





Scintillator: vinyltoluene, gap between scintillator bars: 2mm

Charmonius states

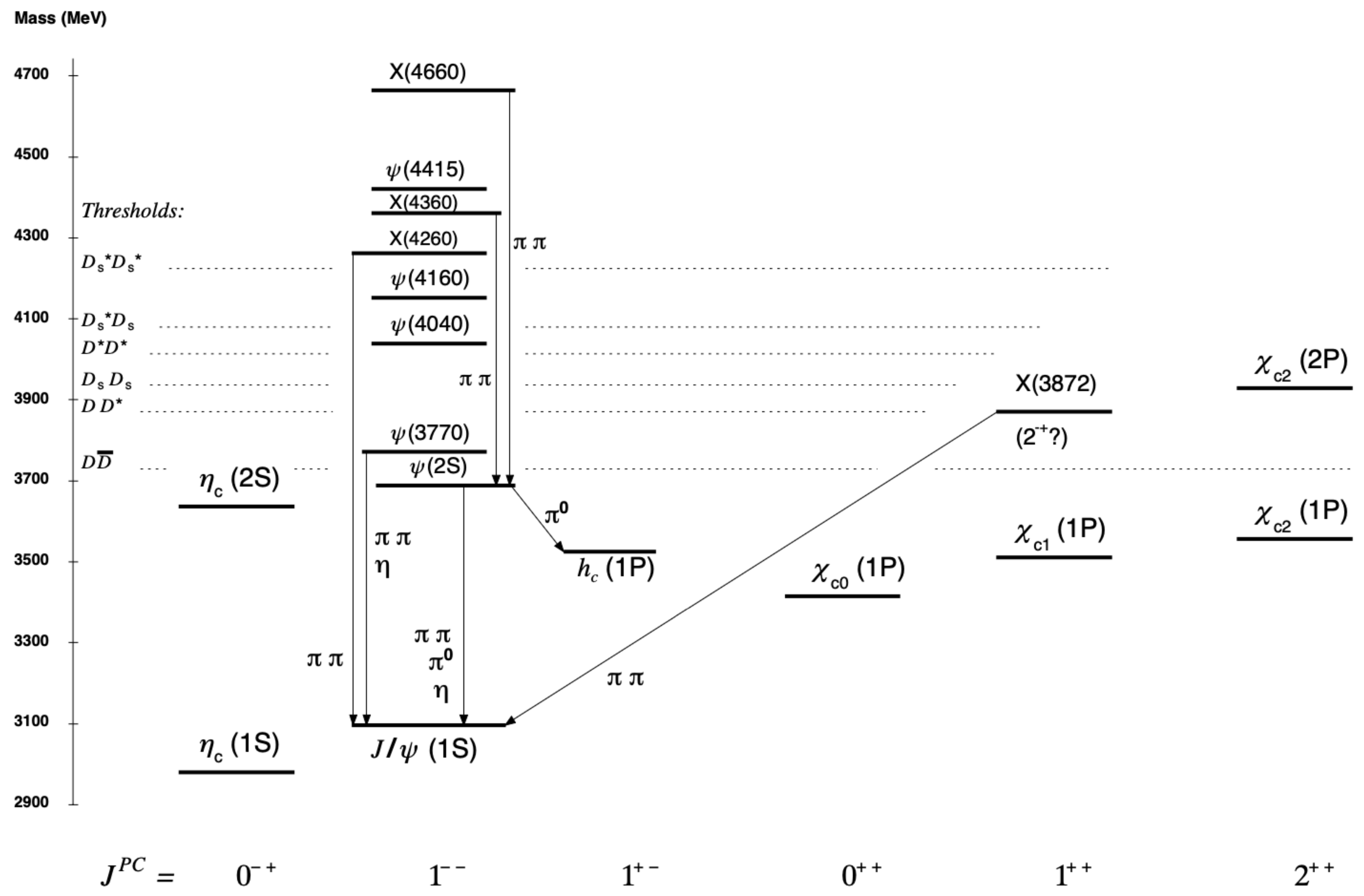


Figure 3.1: The experimentally observed charmonium states. The states labelled X, the nature of which is unknown, are not thought to be conventional charmonium states. Figure from Ref. [3].

Example: SiPM

MPPC (Multi-Pixel Photon Counter) | S13360 series

Selection guide

Type no.	Pixel pitch (μm)	Effective photosensitive area (mm)	Number of pixels	Package	Fill factor (%)
S13360-1325CS	25	1.3 × 1.3	2668	Ceramic	47
S13360-1325PE				Surface mount type	
S13360-3025CS		3.0 × 3.0	14400	Ceramic	
S13360-3025PE				Surface mount type	
S13360-6025CS		6.0 × 6.0	57600	Ceramic	
S13360-6025PE				Surface mount type	
S13360-1350CS	50	1.3 × 1.3	667	Ceramic	74
S13360-1350PE				Surface mount type	
S13360-3050CS		3.0 × 3.0	3600	Ceramic	
S13360-3050PE				Surface mount type	
S13360-6050CS		6.0 × 6.0	14400	Ceramic	
S13360-6050PE				Surface mount type	
S13360-1375CS	75	1.3 × 1.3	285	Ceramic	82
S13360-1375PE				Surface mount type	
S13360-3075CS		3.0 × 3.0	1600	Ceramic	
S13360-3075PE				Surface mount type	
S13360-6075CS		6.0 × 6.0	6400	Ceramic	
S13360-6075PE				Surface mount type	

Example: scintillator plastic, optical fibre

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Material	Light output w.r.t. anthracene (%)	λ at max. emission (nm)	Decay constant (ns)	Rise time (ns)	Bulk light attenuation length (cm)	Refractive index	H/C ratio	Density (g/cm^3)
BC-404	68	408	1.8	0.7	160	1.58	1.107	1.023
BC-420	64	391	1.5	0.5	110	1.58	1.102	1.023

	λ at max abs. (nm)	Abs. Coeff. x10^4 (cm^2/g)	λ at max emiss. (nm)	Quantum Efficiency (%)	Index of refraction	Decay time (ns)
NOL 38	382	11.6	431, 458	88		0.95
EJ 280	427		490	86	1.58	8.5
EJ 282	390		481	93	1.58	1.9
EJ 286	355		425	92	1.58	1.2

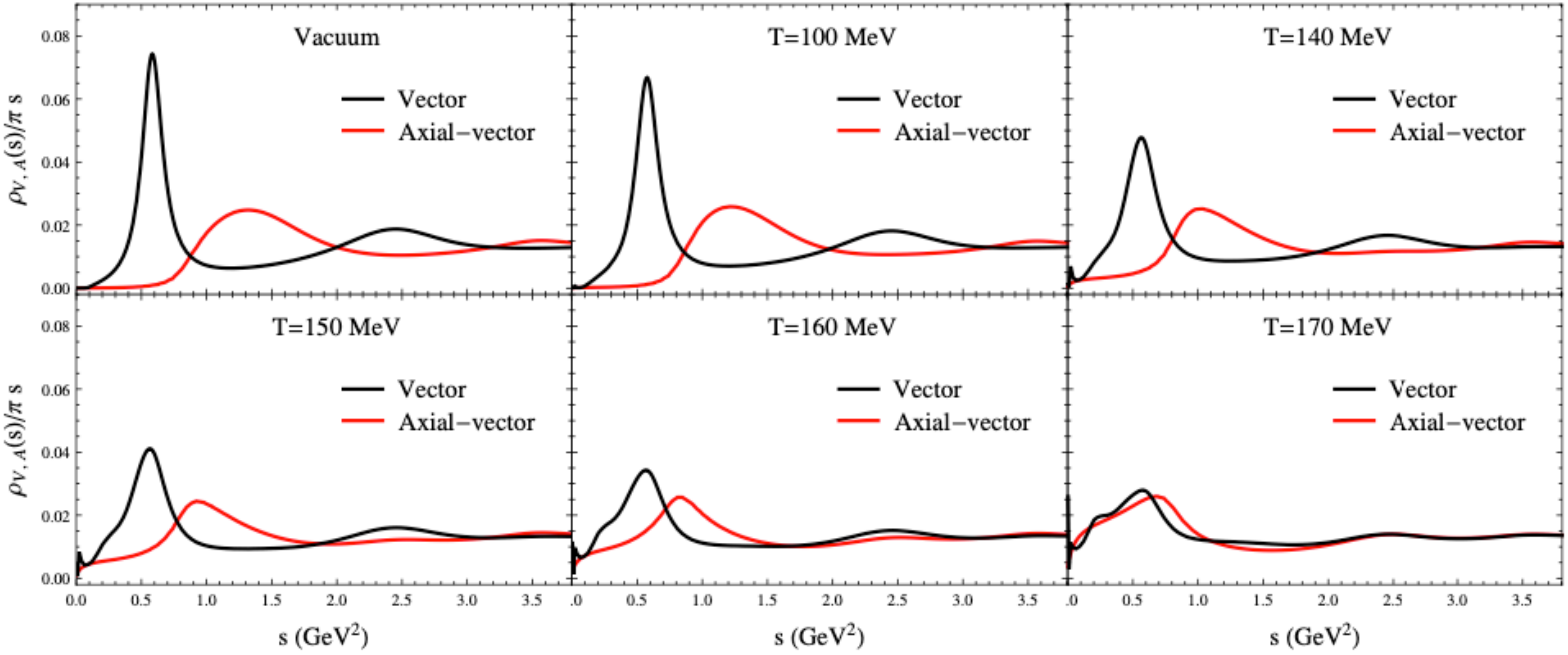
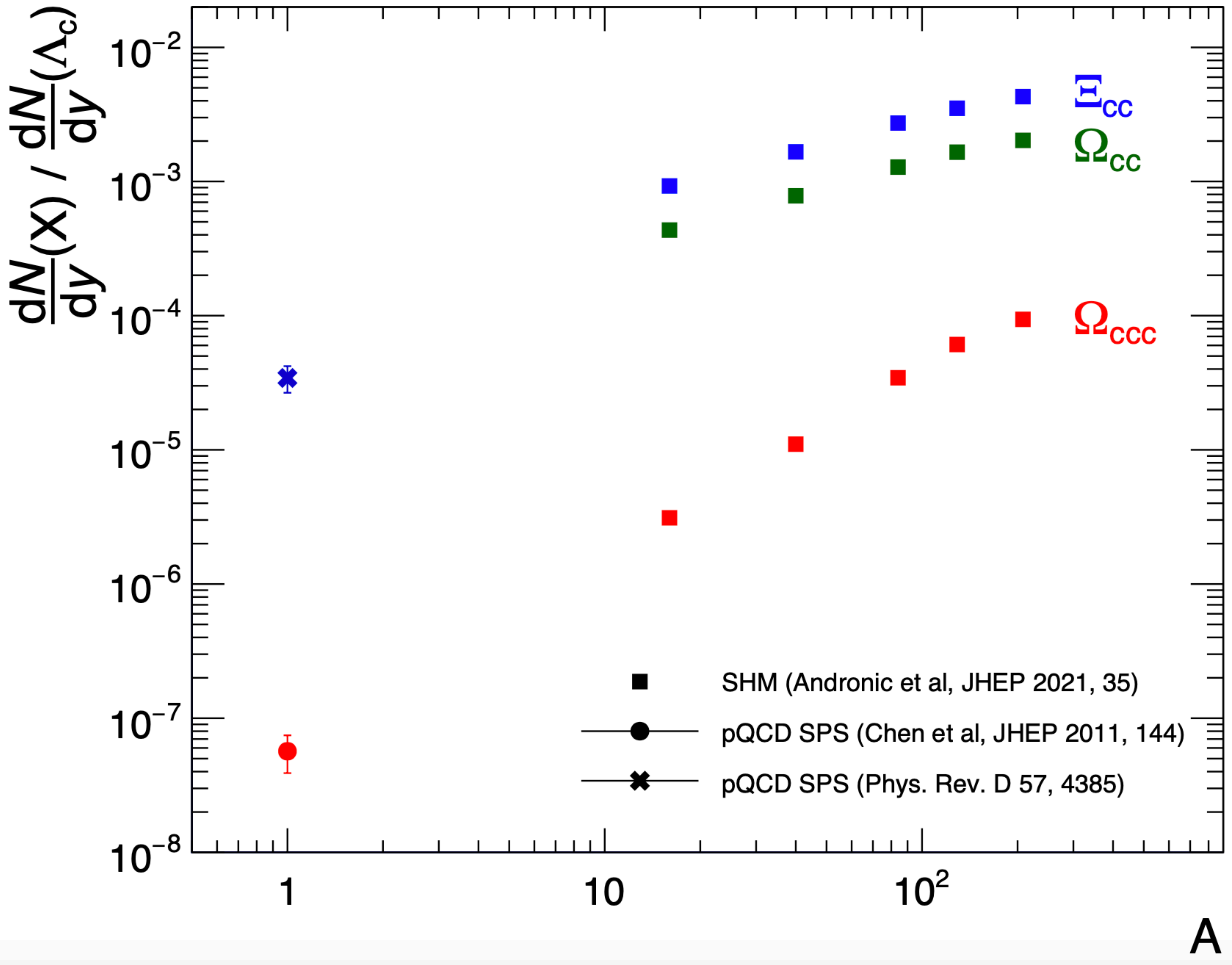


Figure 5: Temperature evolution of vector and axial-vector spectral functions (non-linear realization) [132].

$\Xi_{cc}^{+} \rightarrow \Xi_{c}^{+} + \pi^{+}$

$\Xi_{c}^{+} \rightarrow \Xi^{-} + 2\pi^{+}$



Selected physics cases: exotic hadrons

SCHEMATIC MODEL OF BARYONS AND MESONS *

M. GELL-MANN
California Institute of Technology, Pasadena, California

Received 4 January 1964

anti-triplet as anti-quarks $\bar{q}$. Baryons can now be constructed from quarks by using the combinations (qqq), $(qqqq\bar{q})$, etc., while mesons are made out of $(q\bar{q})$, $(qq\bar{q}\bar{q})$, etc. It is assuming that the lowes

AN SU_3 MODEL FOR STRONG INTERACTION SYMMETRY AND ITS BREAKING

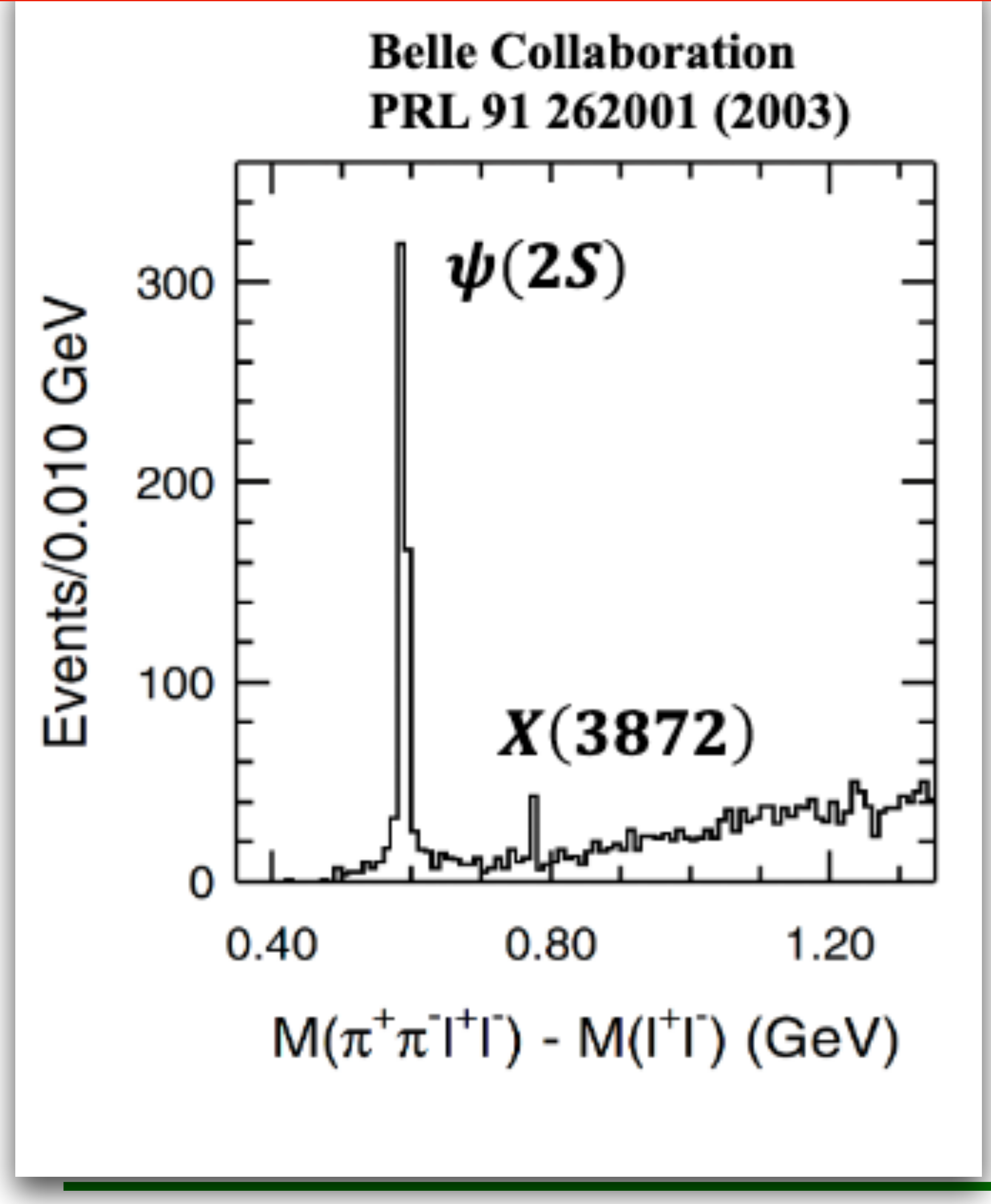
G. Zweig *)
CERN – Geneva

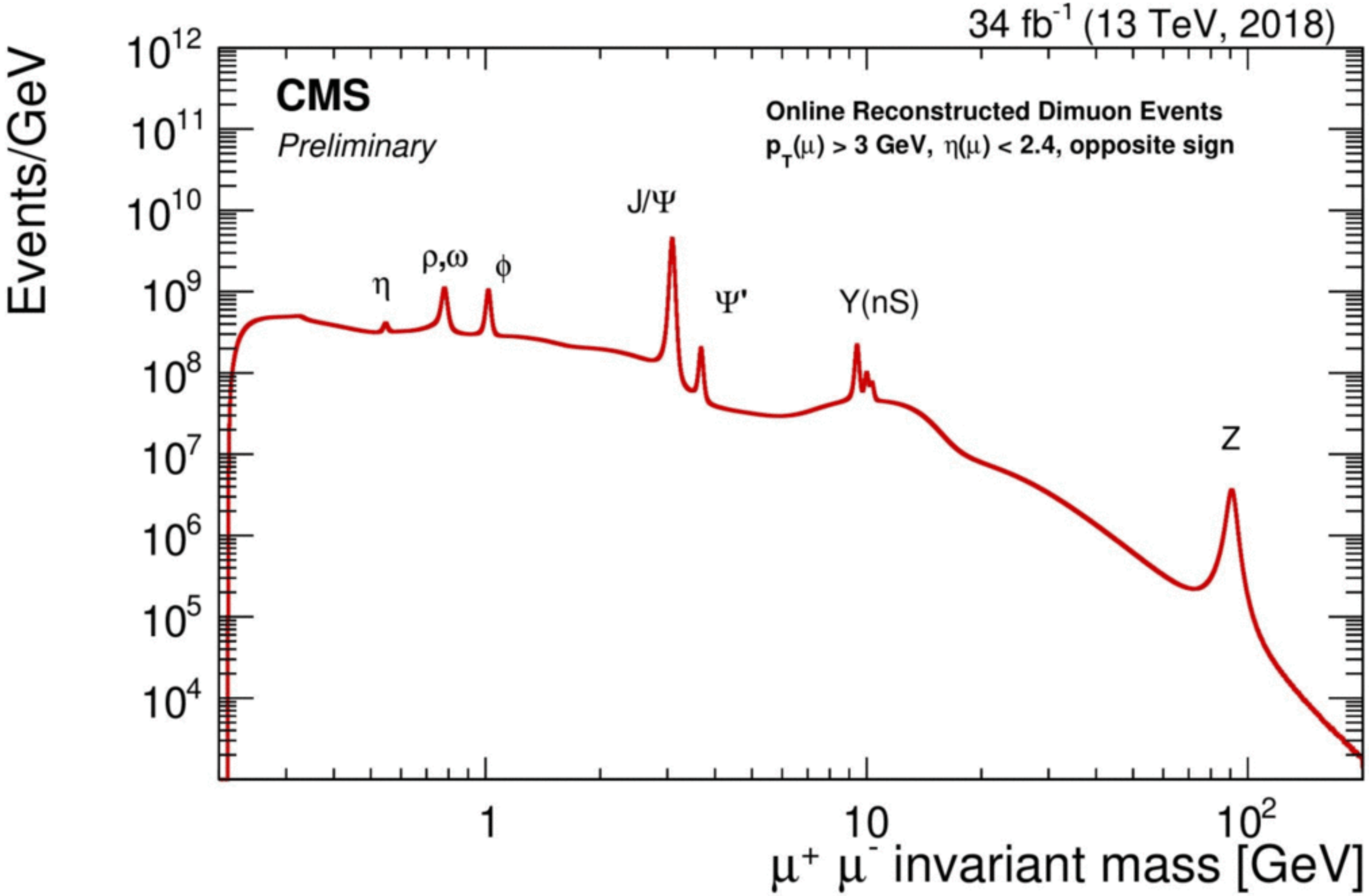
In general, we would expect that baryons are built not only from the product of three aces, AAA, but also from $\bar{A}AAAA$, $\bar{A}\bar{A}AAAAA$, etc., where $\bar{A}$ denotes an anti-ace. Similarly, mesons could be formed from $\bar{A}A$, $\bar{A}\bar{A}AA$ etc. For the low mass mesons and baryons we will assume the simplest possibilities, $\bar{A}A$ and AAA, that is, "deuces and treys".

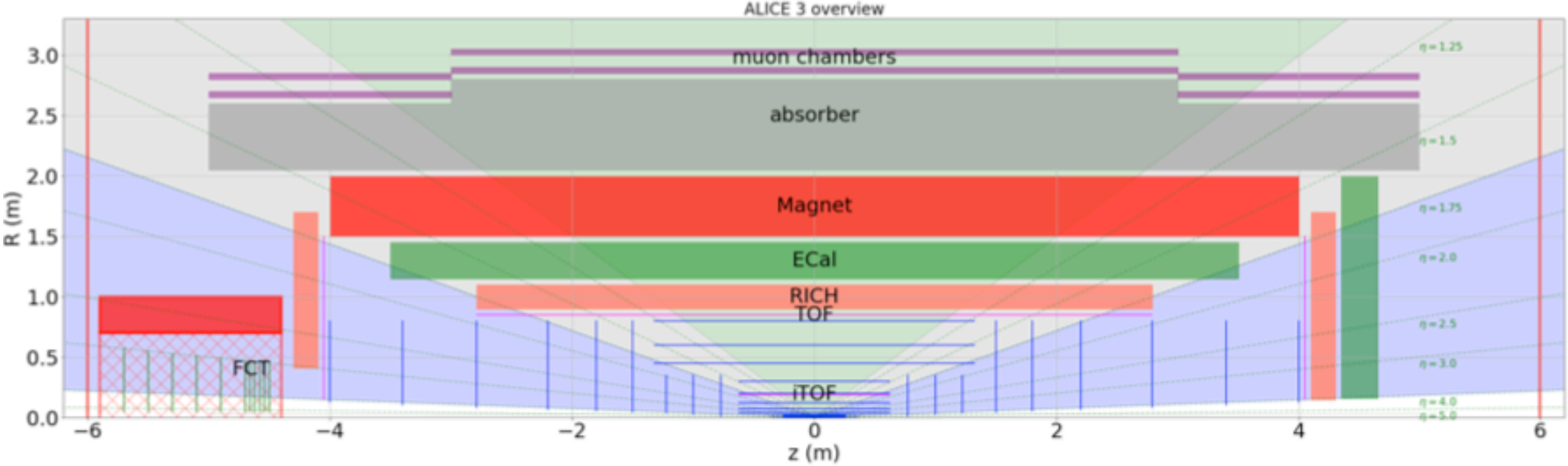
Multiquark hadrons are called exotics:

- "tetraquarks": qqqq
- "pentaquarks": qqqqq

The first heavy quark exotic: X(3872)




34 fb^{-1} (13 TeV, 2018)
CMS
Preliminary
Online Reconstructed Dimuon Events
$p_T(\mu)$ > 3 GeV, $\eta(\mu)$ < 2.4, opposite sign
Events/GeV
η
ρ,ω
φ
J/Ψ
Ψ'
Υ(nS)
Z
$\mu^+ \mu^-$ invariant mass [GeV]



ALICE 3 overview
muon chambers
absorber
Magnet
ECal
RICH
TOF
iTOF
FCT
R (m)
z (m)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−6
−4
−2
0
2
4
6

Contributions to ALICE

- Run 1 and 2: ACORDE and V0 (scintillation detectors)
- Run 3: new FV0 and FDD detectors (scintillator detectors), TPC upgrade
- Data analysis / MC simulations

Example for FDD

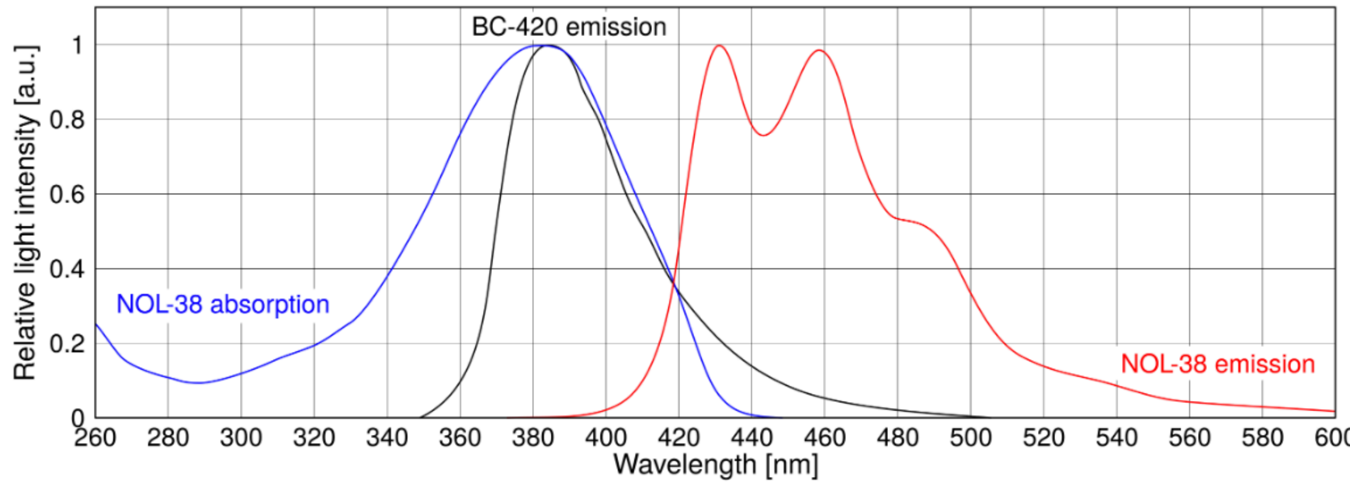
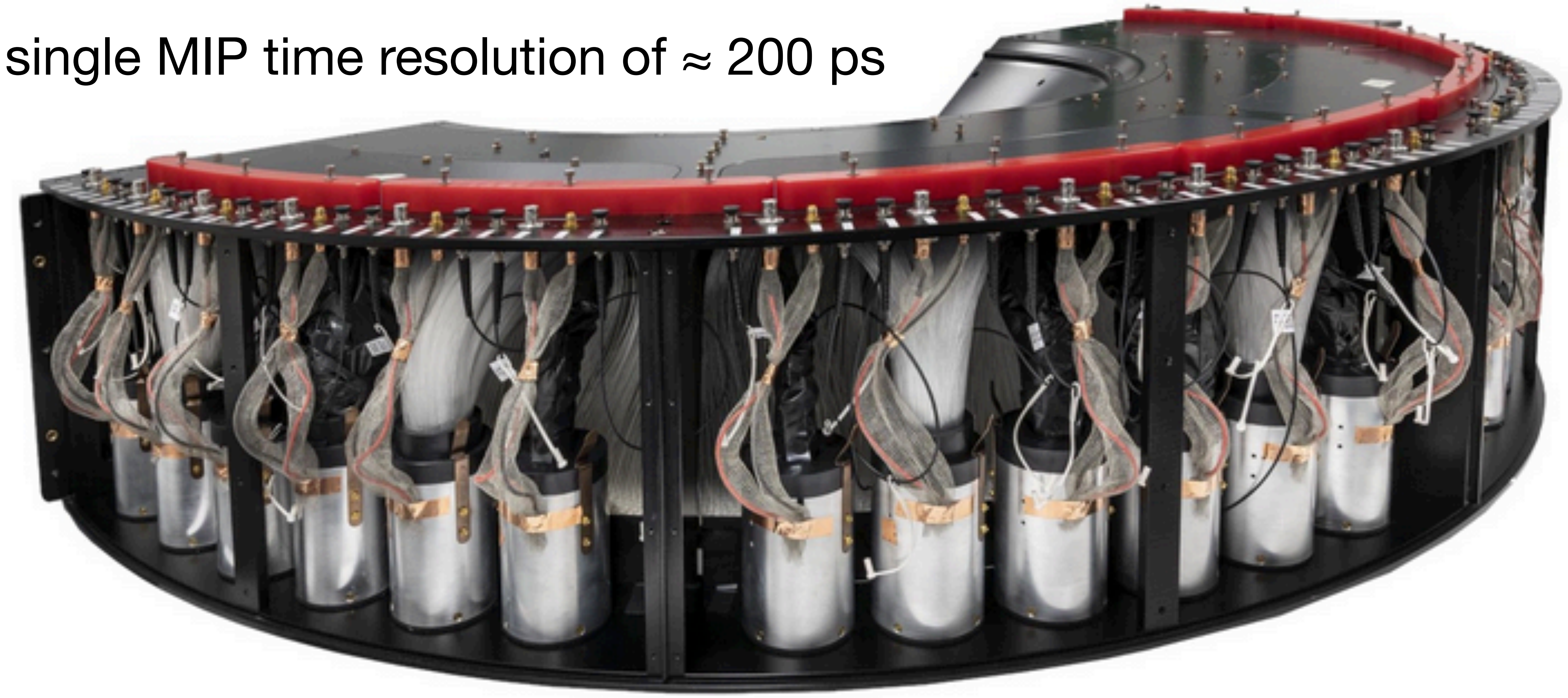
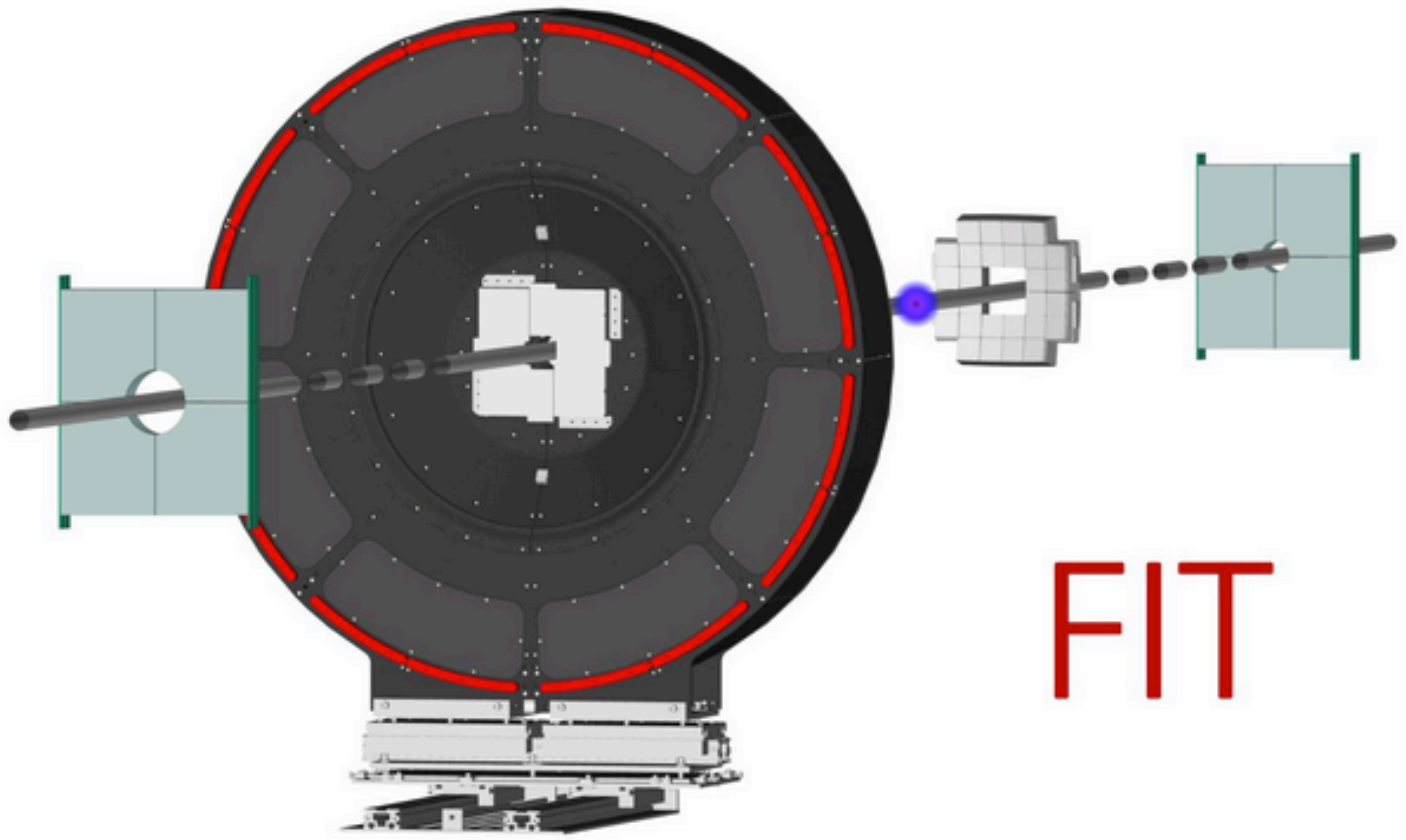


Figure 3.66.: Emission spectrum of the BC-420 scintillator (*black line*), based on figure published by the manufacturer [179]. Emission (*red*) and absorption (*blue*) spectrum of NOL-38 wavelength shifter are also shown

single MIP time resolution of ≈ 200 ps





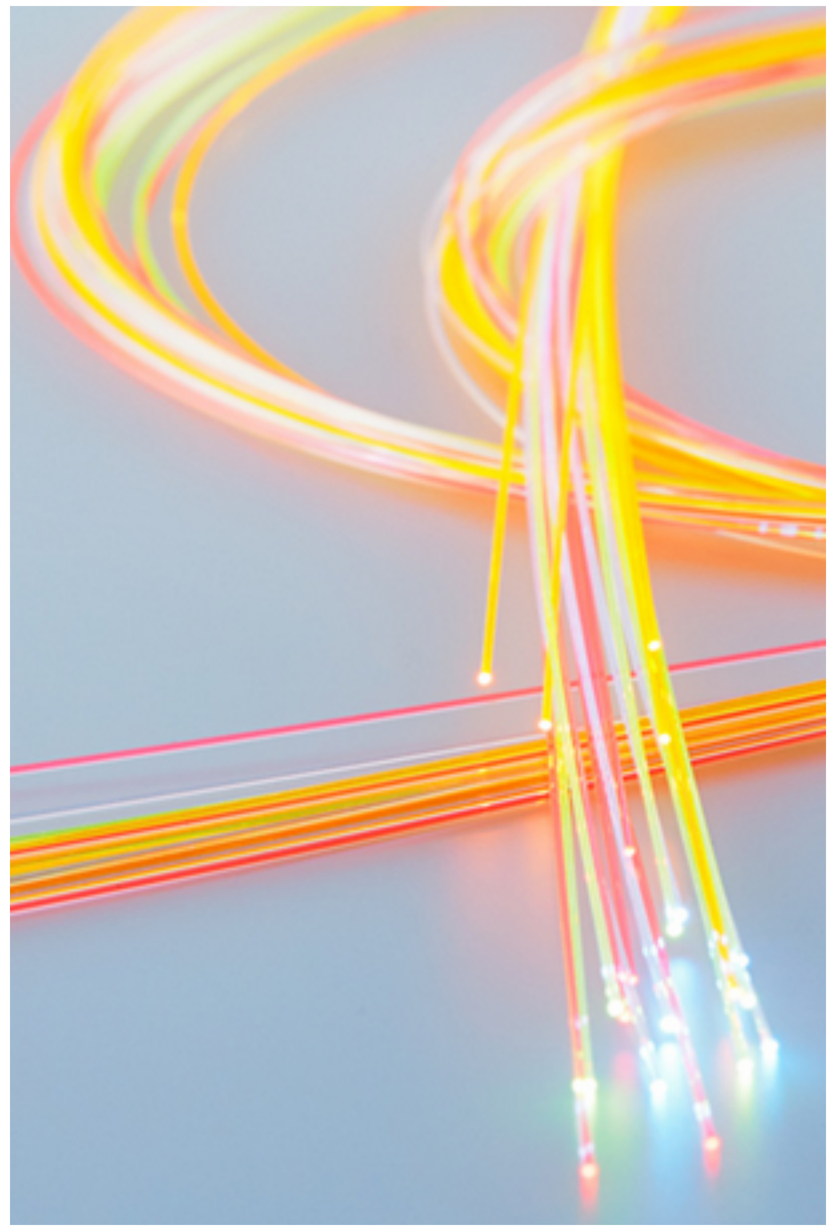
Fibres

The light produced by the particle interaction has to be collected, re-emmited, and transported to the photodetectors efficiently by WLS fibres

Companies: Saint-Gobain and Kuraray factories

- Multiclad fibres with long attenuation length (~2-3 m). Tests with other fibres smaller attenuation lengths

Type	Luminescence			Absorption Peak (nm)	Attenuation length² (m)	Characteristics
	Color	Spectra	Peaks (nm)			
Y-7 (100)	Green	Refer to	490	439	>2.8	Blue to green shifter
Y-8 (100)	Green		511	455	>3.0	Blue to green shifter
Y-11 (200)	Green		476	430	>3.5	Blue to green shifter (u K-27 formulation) High luminescence High attenuation length



Existing studies (FNAL-NICADD)

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ALICE

- Typical time resolution, ~1 ns

Table 1. Prototypes of extruded scintillator bars from NICADD manufacturer. All the bars were instrumented with fibres Kuraray WLS Y11(200) S-type except the S2 bar that has been instrumented with fibres from the Saint Gobain company (BCF92). The fibres in the L1, L2 and L4 bars were read out at both ends. The fibres in the S1, S2, S5 and S8 bars were read out only at one end. The main parameters of the photosensors are shown in Table 3.

	Bar dimensions (h × w × l) mm^3	number of fibres/bar	fibre diameter [mm]	SiPM model (AdvanSiD company)
L1	(10 × 45 × 3000) mm^3	1 fibre in 1 groove	2	ASD-NUV3S-P
L2	(20 × 40 × 3000) mm^3	1 fibre in 1 groove	2	ASD-NUV3S-P
L4	(20 × 40 × 3000) mm^3	1 fibre in 1 groove	1.2	ASD-NUV1S-P
S1	(10 × 45 × 250) mm^3	2 fibres in 1 groove	1.2	ASD-NUV3S-P
S2	(10 × 45 × 250) mm^3	2 fibres in 1 groove	1.2	ASD-NUV3S-P
S5	(20 × 40 × 250) mm^3	2 fibres in 1 groove	1.2	ASD-NUV3S-P
S8	(20 × 40 × 250) mm^3	1 fibre in 1 hole	2	ASD-NUV3S-P

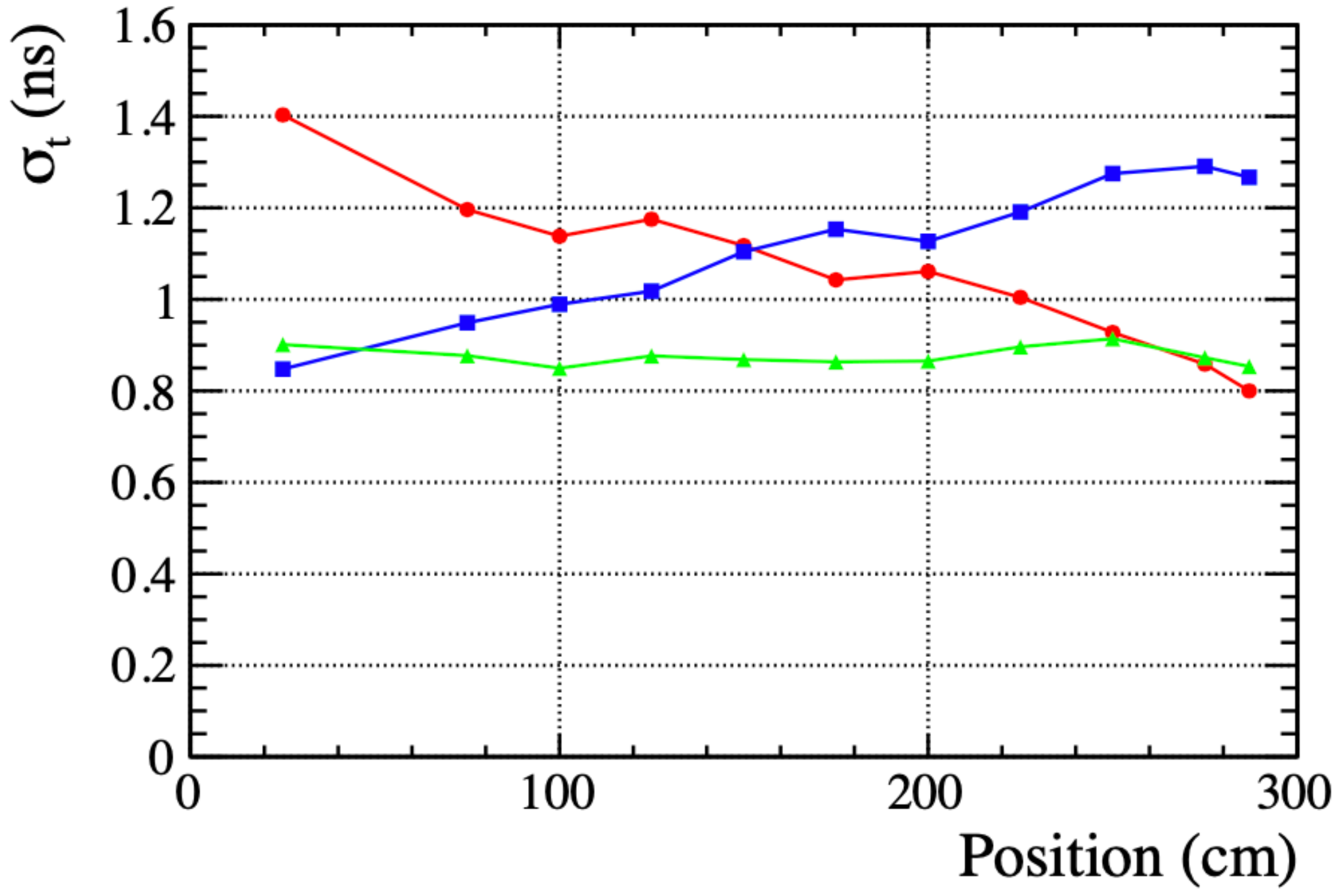

Figure 14. L1 bar time resolution using only SiPM $L(R)$, red circles(blue squares) and both SiPMs (green triangles).

W. Baldini, *JINST* 12 (2017) 03, P03005

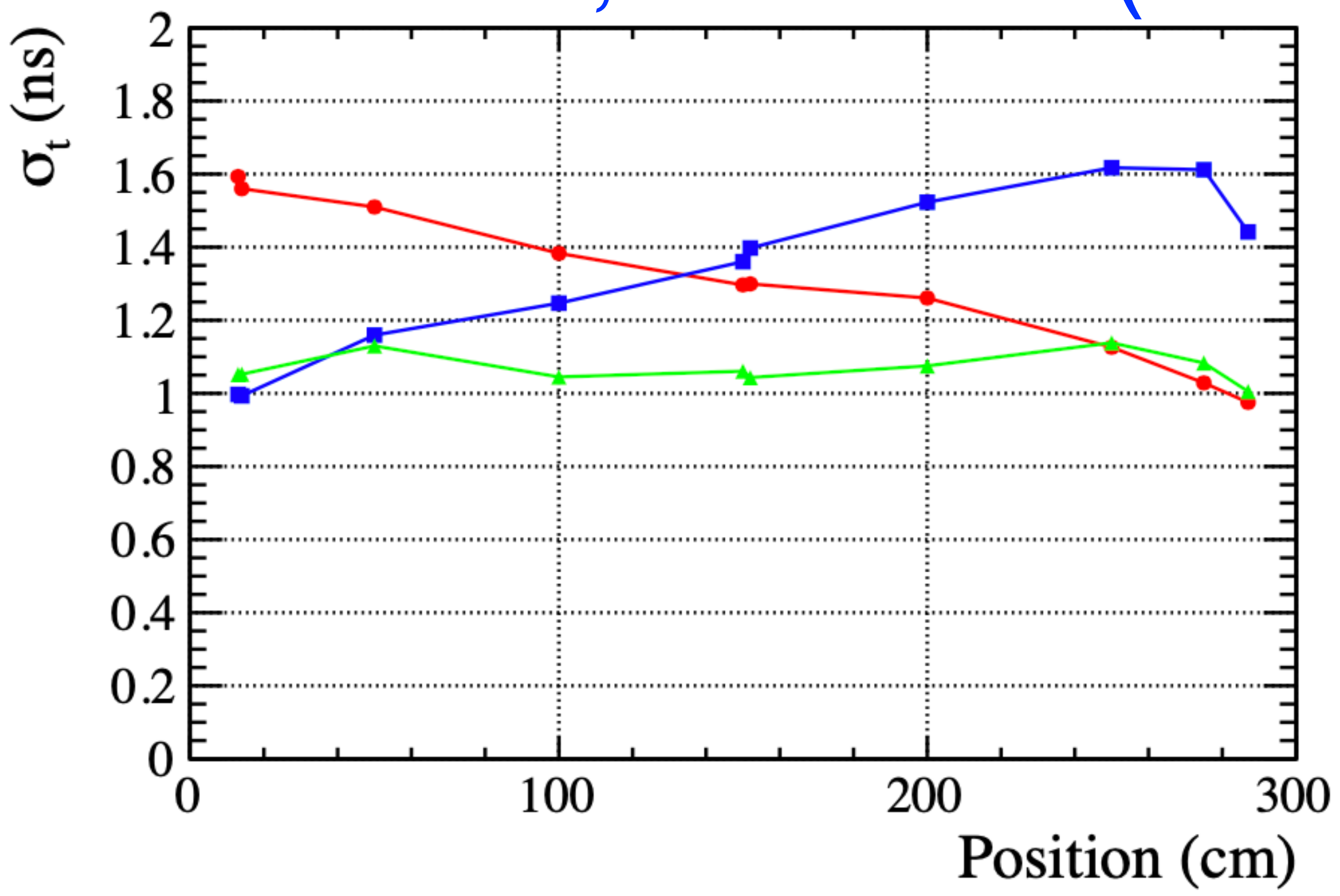

Figure 16. L4 bar time resolution using only SiPM $L(R)$, red circles(blue squares) and both SiPMs (green triangles).

Existing studies (FNAL-NICADD)

- Typical time resolution, ~1 ns

Table 1. Prototypes of extruded scintillator bars from NICADD manufacturer. All the bars were instrumented with fibres Kuraray WLS Y11(200) S-type except the S2 bar that has been instrumented with fibres from the Saint Gobain company (BCF92). The fibres in the L1, L2 and L4 bars were read out at both ends. The fibres in the S1, S2, S5 and S8 bars were read out only at one end. The main parameters of the photosensors are shown in Table 3.

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L2	(20 × 40 × 3000) mm^3	1 fibre in 1 groove	2	ASD-NUV3S-P
L4	(20 × 40 × 3000) mm^3	1 fibre in 1 groove	1.2	ASD-NUV1S-P
S1	(10 × 45 × 250) mm^3	2 fibres in 1 groove	1.2	ASD-NUV3S-P
S2	(10 × 45 × 250) mm^3	2 fibres in 1 groove	1.2	ASD-NUV3S-P
S5	(20 × 40 × 250) mm^3	2 fibres in 1 groove	1.2	ASD-NUV3S-P
S8	(20 × 40 × 250) mm^3	1 fibre in 1 hole	2	ASD-NUV3S-P

With this option, the estimated cost can be reduced to 0.2 MCHF. But different scintillator plastics will be tested (BC-408,)

Component	Comment	Cost (MCHF)
Absorber	non-magnetic steel (3CHF / kg * 1100 t), support	5.0
Scintillators	2 * 175 m^2 extruded scintillators with WLS	0.6
Readout	SiPMs + FEE (10 k channels)	0.2
Power	LV PSUs	0.2
Mechanics	4 * 18 modules * 5000 / module	0.5
Services		0.5
Total		**7.0**

Table 7: Estimated core cost of the muon identifier

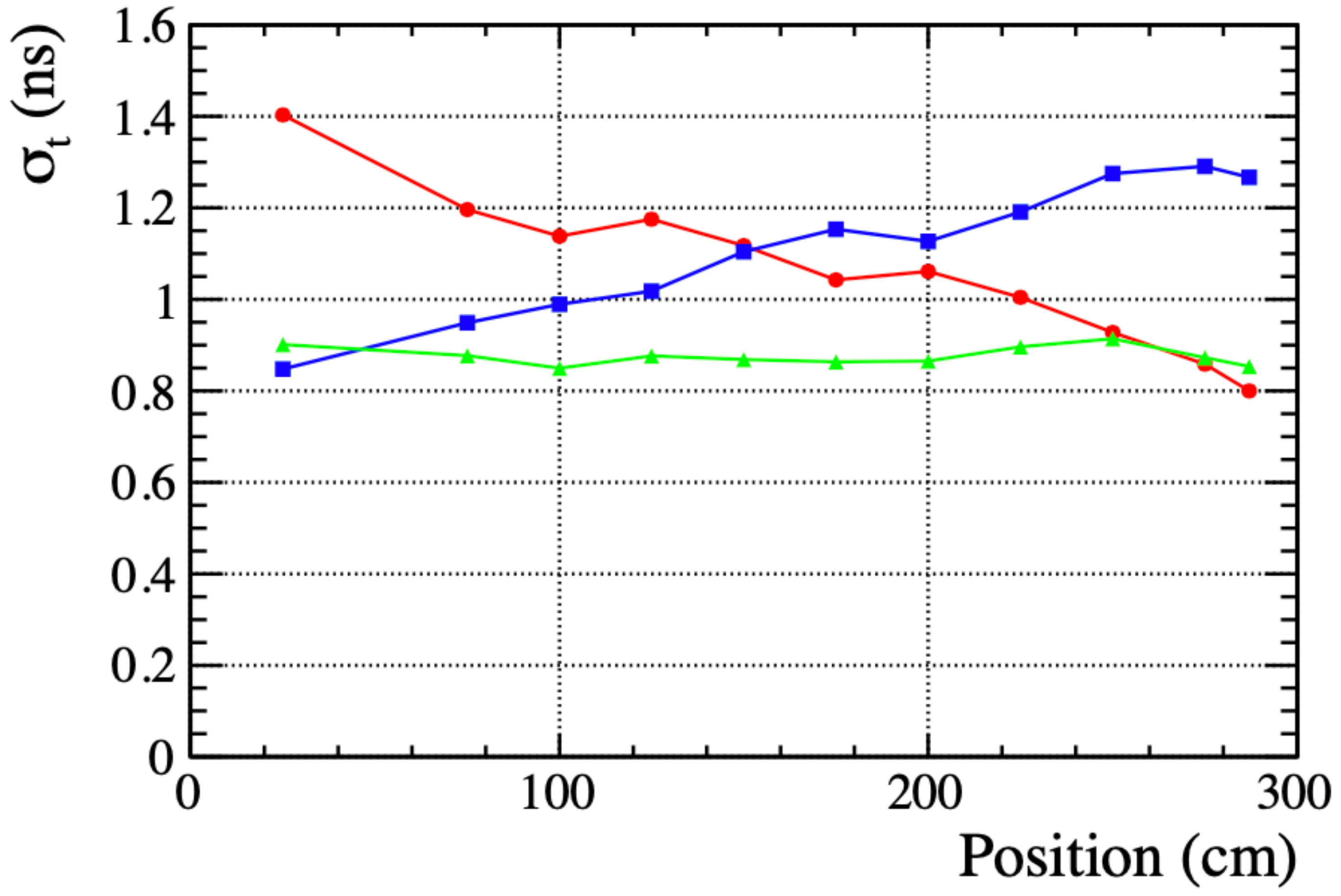

Figure 14. L1 bar time resolution using only SiPM $L(R)$, red circles(blue squares) and both SiPMs (green triangles).

W. Baldini, *JINST* 12 (2017) 03, P03005

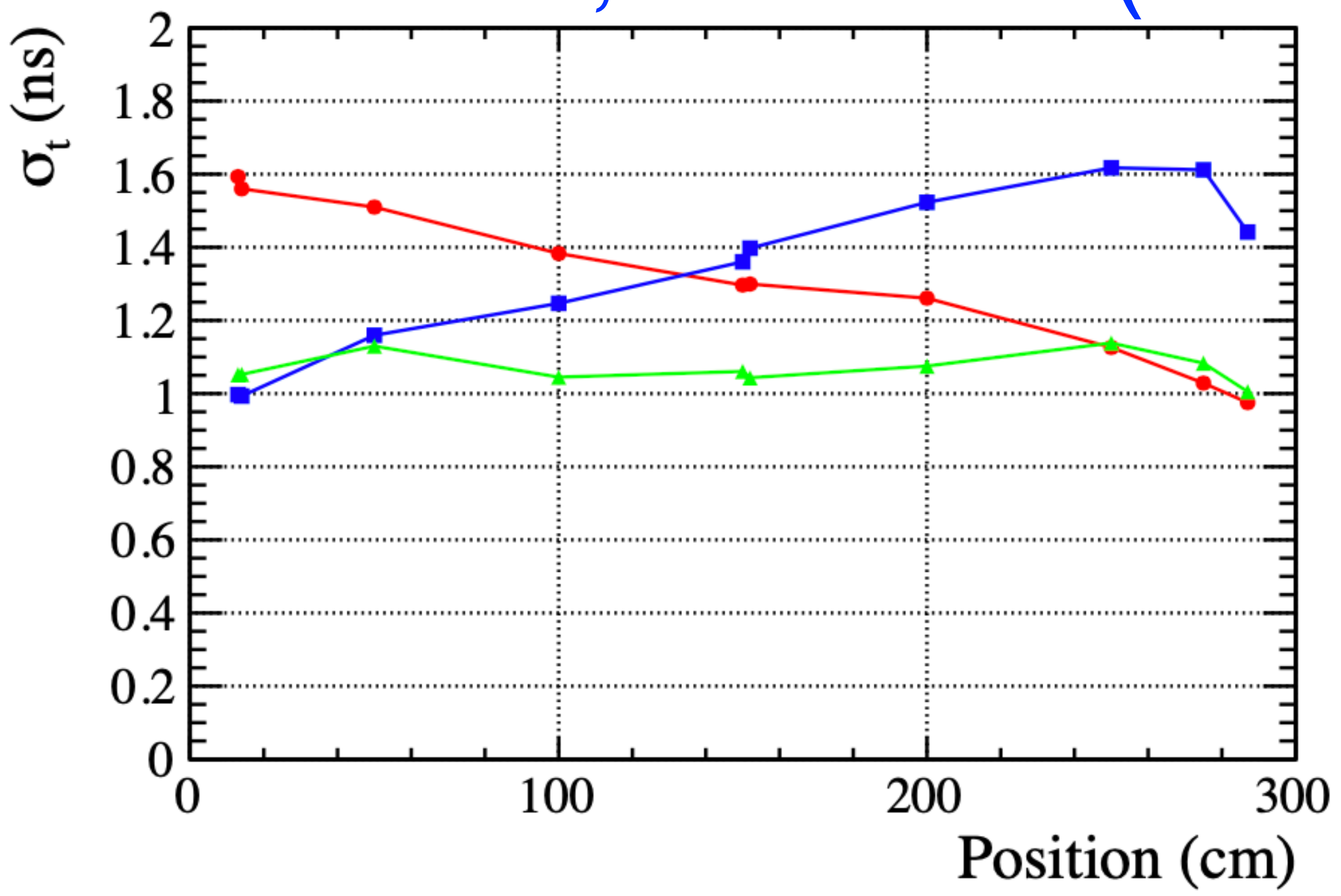

Figure 16. L4 bar time resolution using only SiPM $L(R)$, red circles(blue squares) and both SiPMs (green triangles).

ALICE 3

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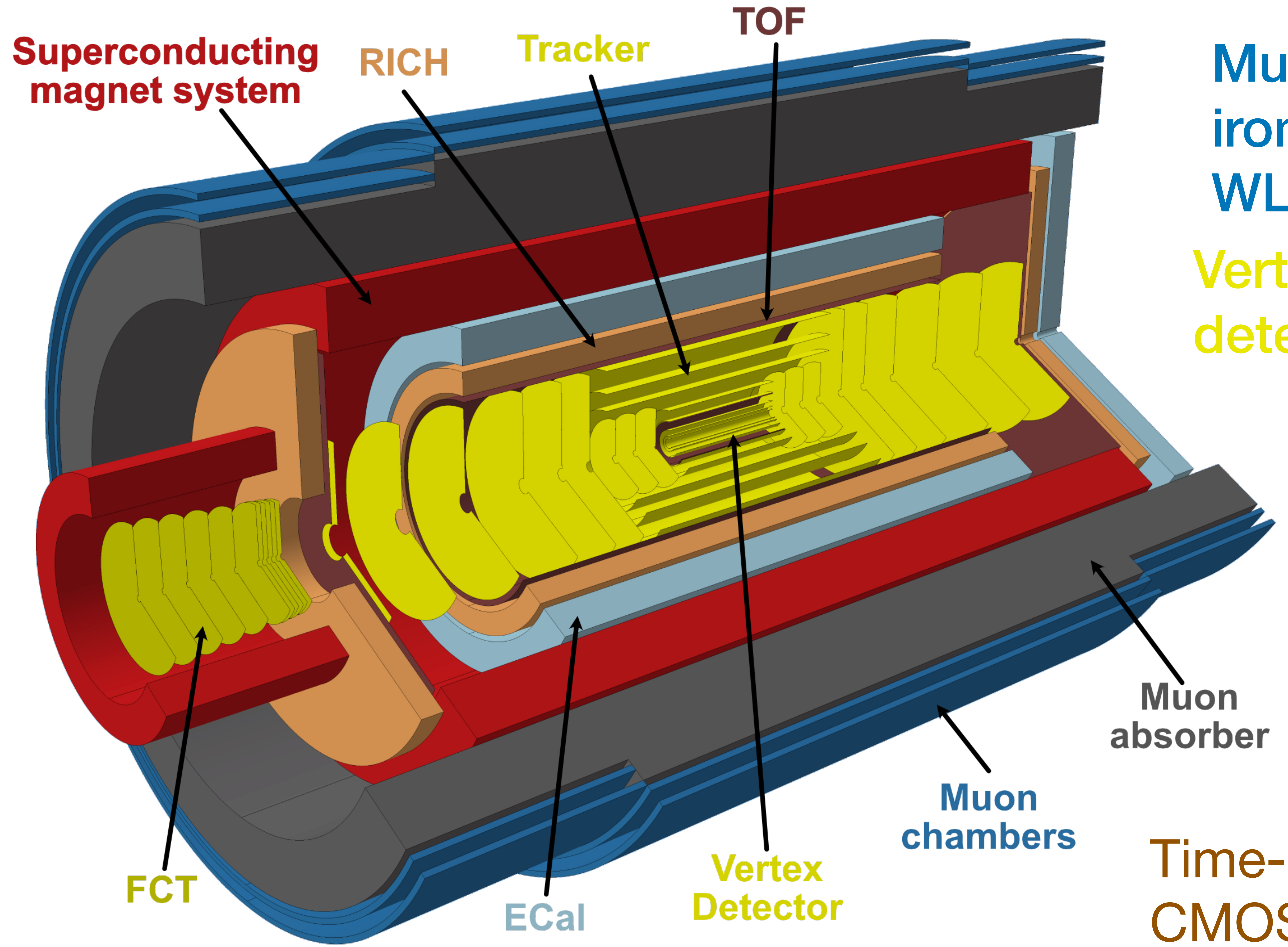

MuonID:
iron absorber, scintillating bars, WLS, SiPM

Vertexer detector: retractable detector, R_{in}~5mm

RICH: aerogel radiator, SiPM readout

Tracker: monolithic CMOS sensors

Tracker: monolithic CMOS sensors

Time-of-flight detector monolithic CMOS sensors with gain layer

Charmonium states

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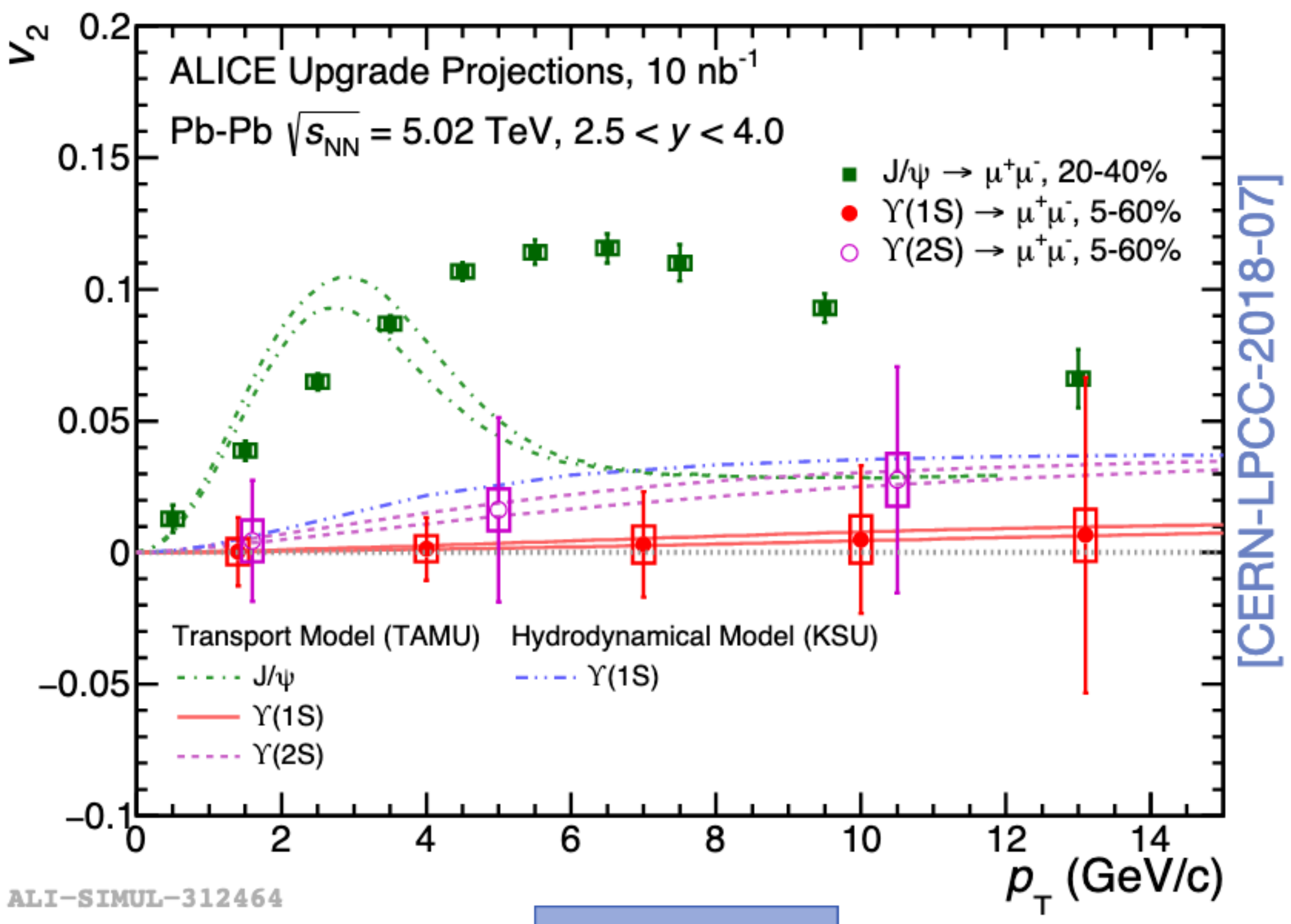
Charmonium production as probe of Q…

Measuring quarkonia down to zero p_T

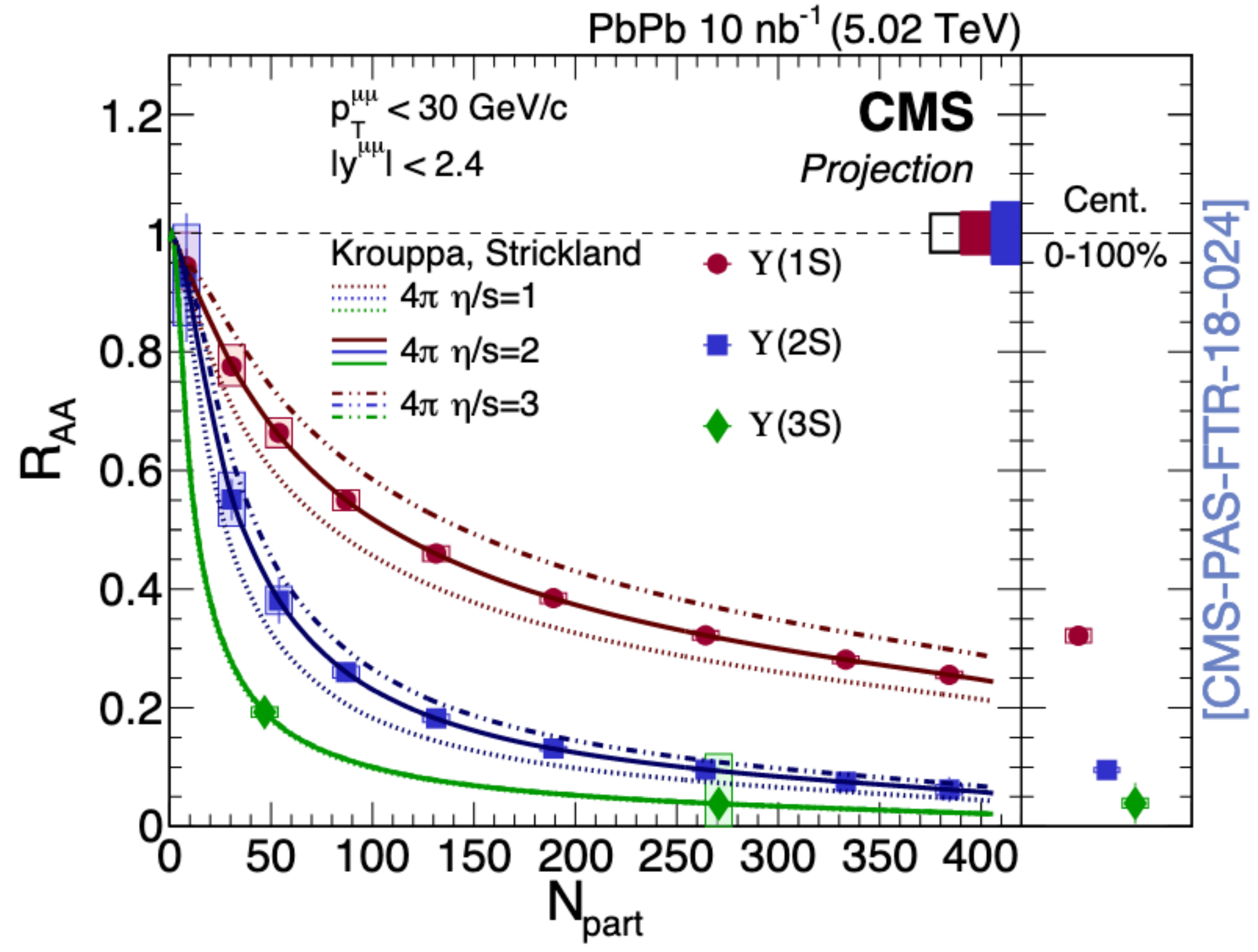
- "Signature" ALICE feature from the beginning
- Also in the future a distinctive factor wrt ATLAS/CMS
- Extend this capability in ALICE3 for the muon decay channel at midrapidity

v_2 for J/ψ, Υ



Run 3 & 4

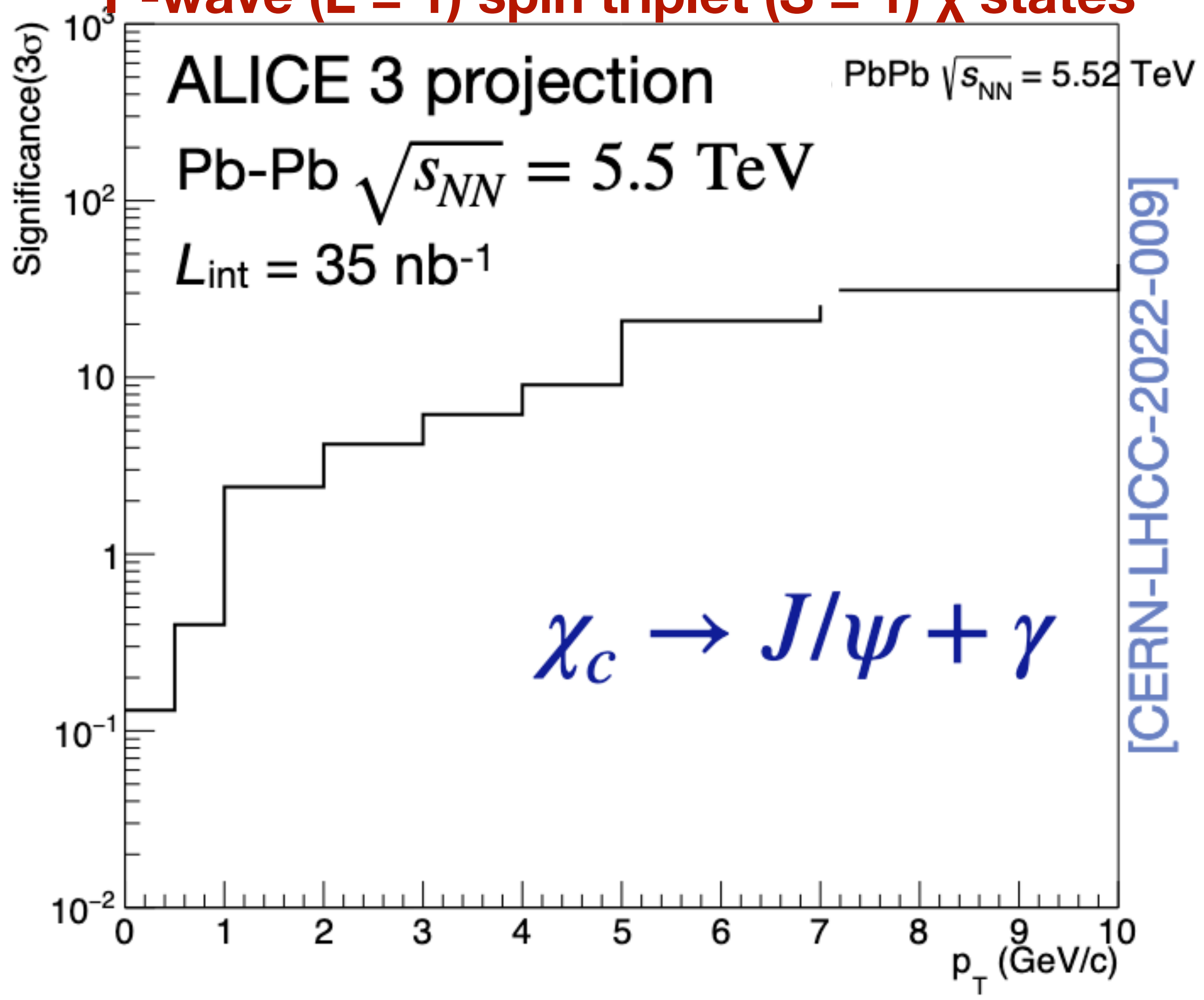
R_{AA} for Υ states



Run 3 & 4

χ_c in Pb-Pb collisions

P-wave (L = 1) spin triplet (S = 1) χ states



Run 5 & 6

Multi-charm baryons

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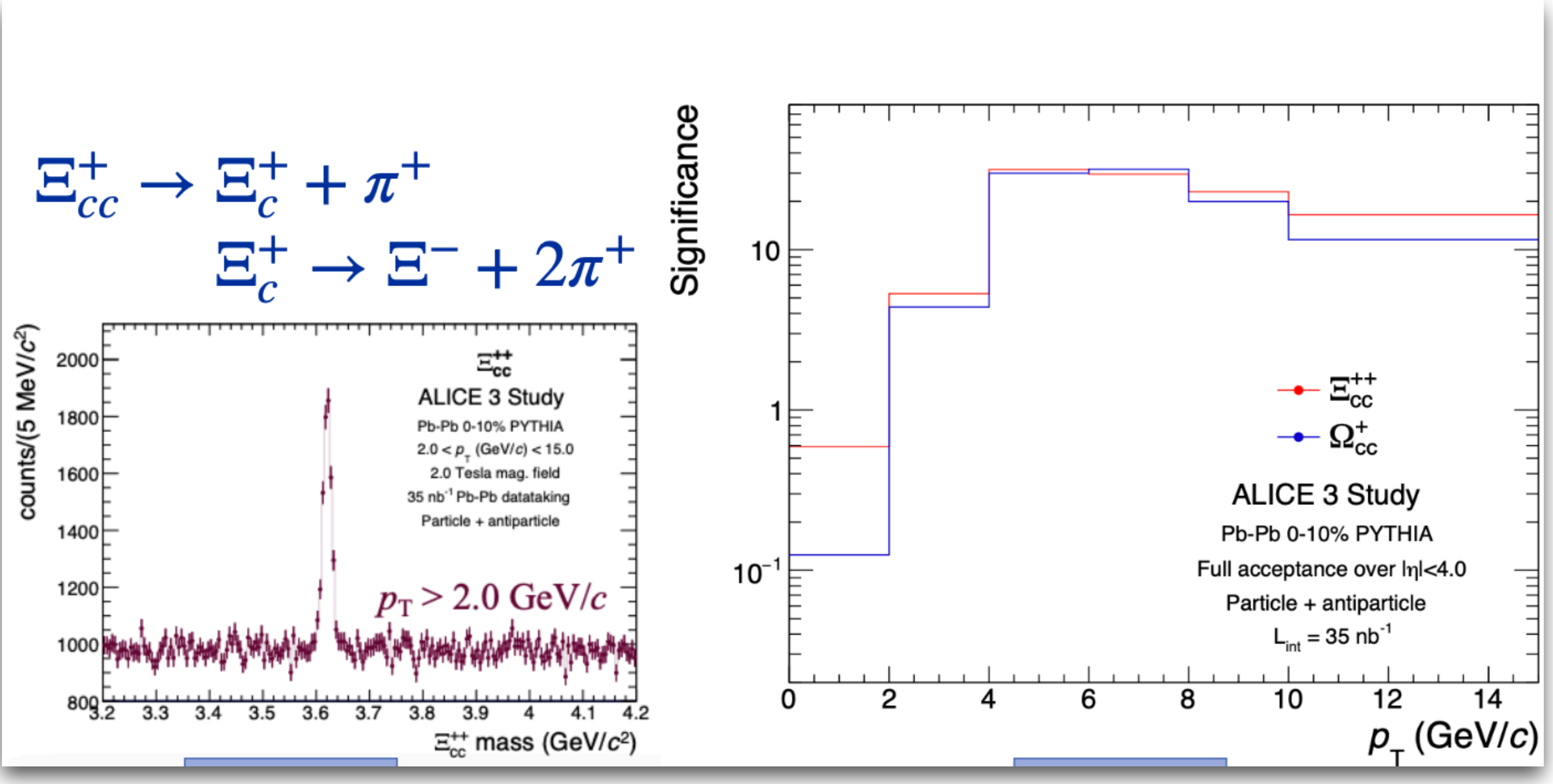
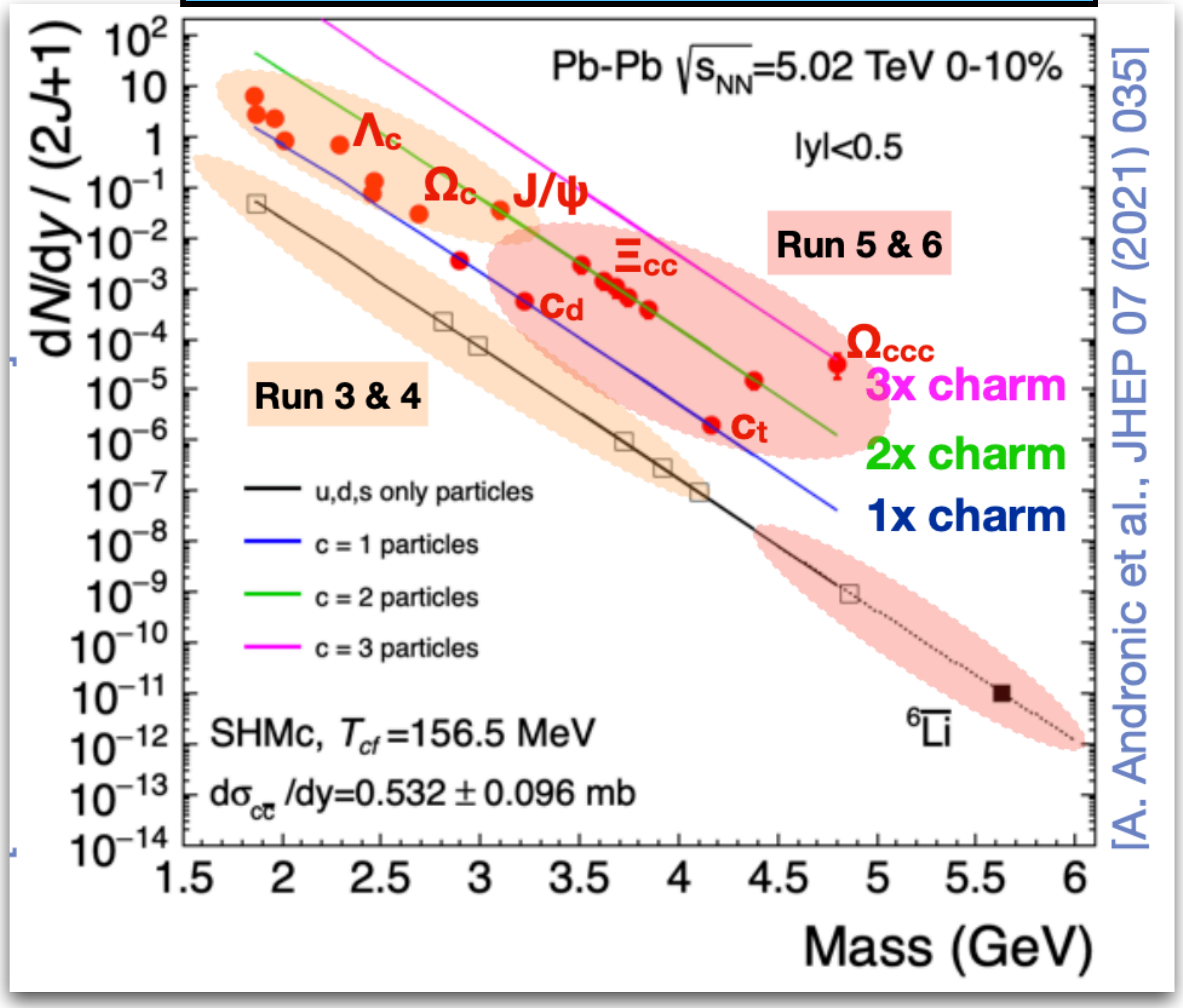
Expected enhancement of multi-charm states provides high sensitivity to equilibration

- Systematic measurement of hadron yields
- Luminosity, acceptance, vertexing, PID, strangeness tracking



Hadron yields in statistical hadronisation model



Low cost extruded scintillator

Low cost (~45 USD/kg), if equipped with WLS fibre ->good optical response

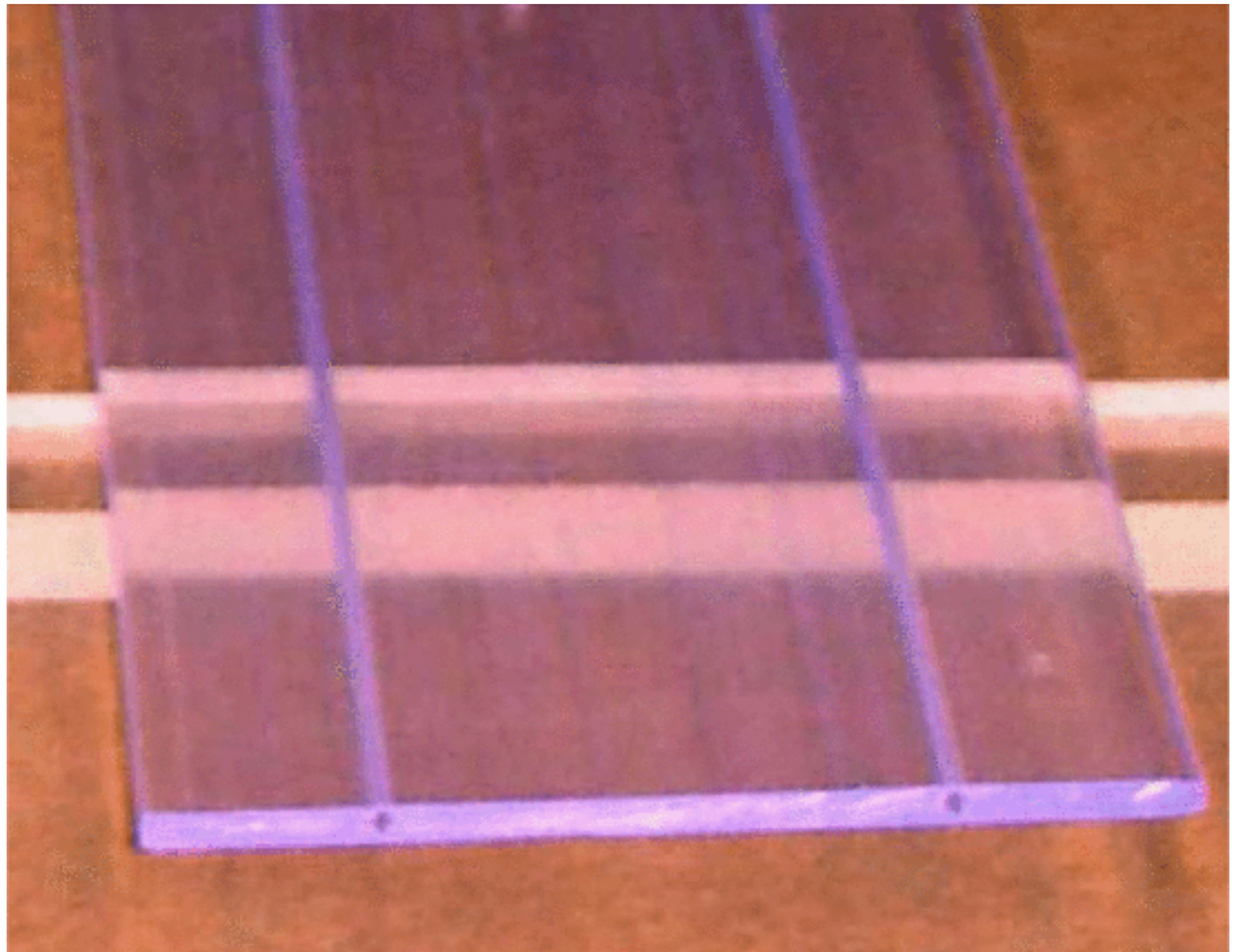
Fermilab extrusion facility (FNAL-NICADD)

- Produced scintillators for MINOS/SciBar/INGRID/P0D/ECAL/WAGASCI

May need to produce/test new die

We need ~ 4 t of scintillator (0.17 MCHF)

	Bar dimensions (h x w x l)
L1	(1.0X4.5X300) cm^3
L2	(2.0X4.0X300) cm^3



Polystyrene, dopants (PPO and POPOP)

https://ieeexplore.ieee.org/abstract/document/1462328