ALICE 3 detector scope and physics performance

5th ALICE Upgrade Week,
Kraków, 8 October 2024

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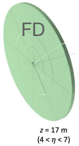
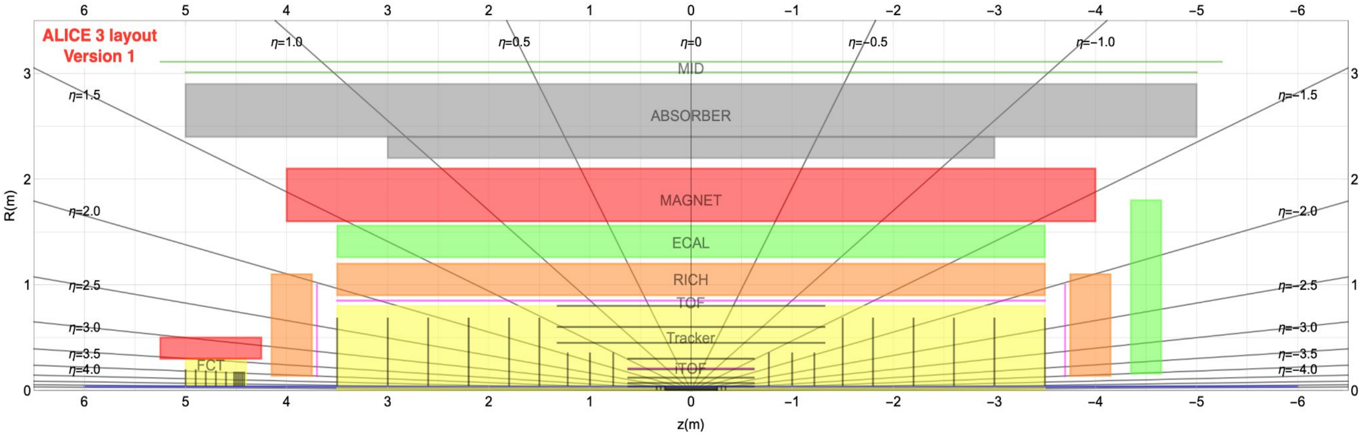
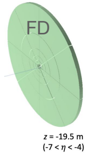
Scoping Document: Status and Review

- Scoping Document ("public part") submitted to LHCC (accessible here)
  - Thanks to Editorial Group, in particular the WG coordinators, and IRC!
- Now working on the "confidential part":
  - Money matrix (FAs vs subsystems)
  - Personnel matrix (institute FTEs vs subsystems)
- Review by LHCC during the next two meetings, aim to conclude by March
- Summary of scoping scenarios:
  - **v1** reference detector, very similar to LoI
  - **v2-2T**: -12% cost; clear impact without ECal on specific parts of the programme
  - **v2-1T**: -20% cost; degradation of most HF measurements, especially at forward rapidity (*y*)
  - **v3 (reduced acc.)**: -32% cost; unique programme remains, but loss of *y*-dependent studies
- No option with L3 magnet: large degradation even for v3
  - This question likely to come back due to large SC magnet cost → is a version with TPC conceivable?

Reference detector: “Layout version 1”

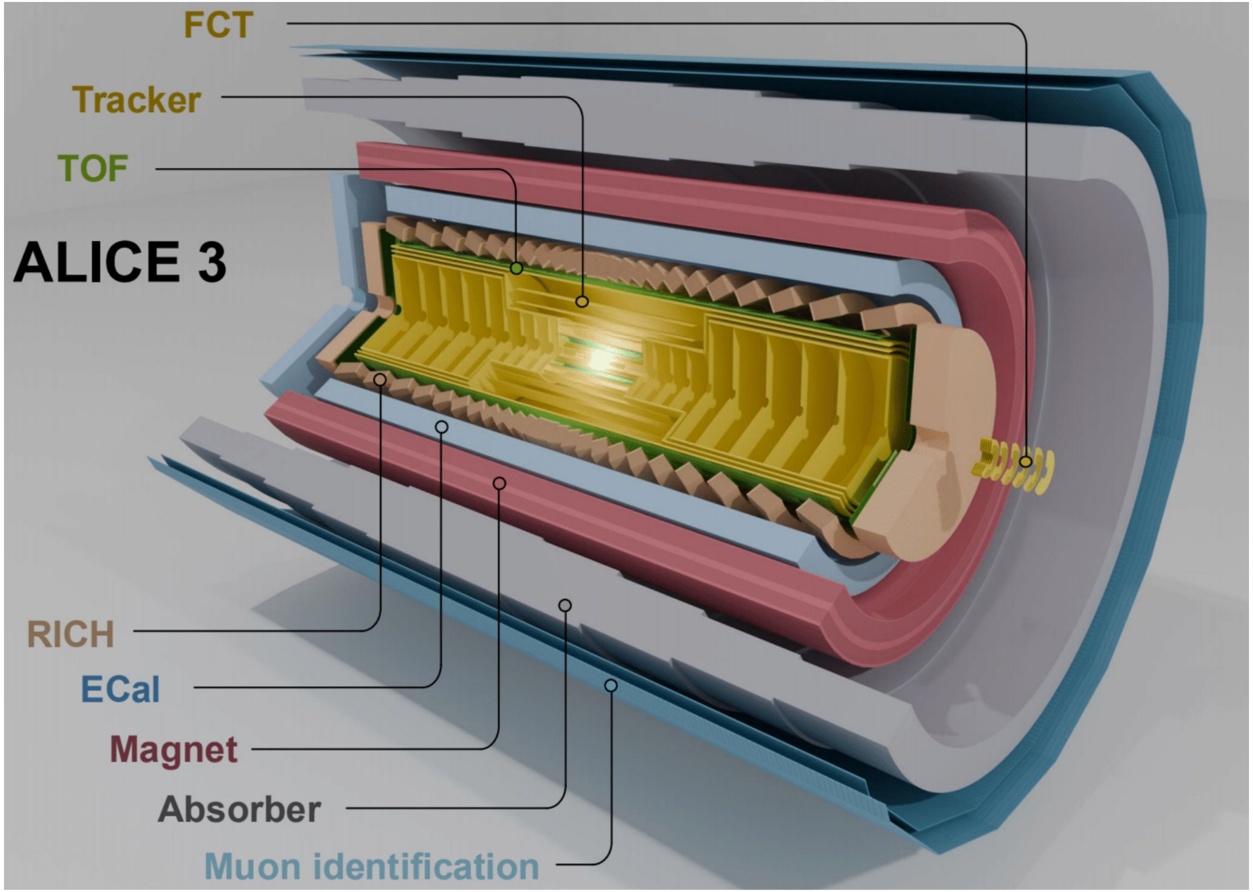






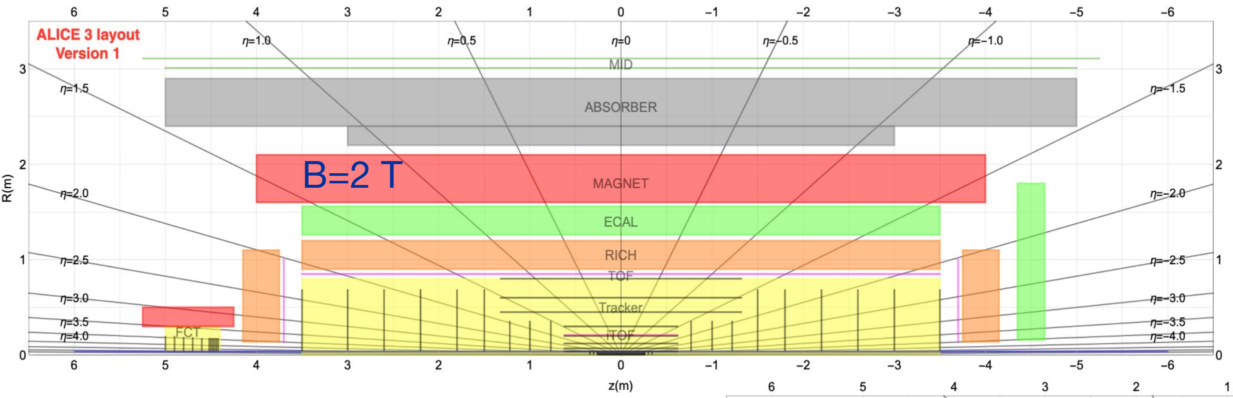
- Changes compared to LoI version:
  - Changes in barrel/disks transitions in view of integration and installation
  - Two Forward Detectors based on scintillator disks added on each side at $4<|\eta|<7$: luminometers, event-activity measurement and veto
  - Reduced FCT acceptance: $3<\eta<5 \rightarrow 4<\eta<5$; more studies in progress (detector not fully part of baseline)

Reference detector: "Layout version 1"



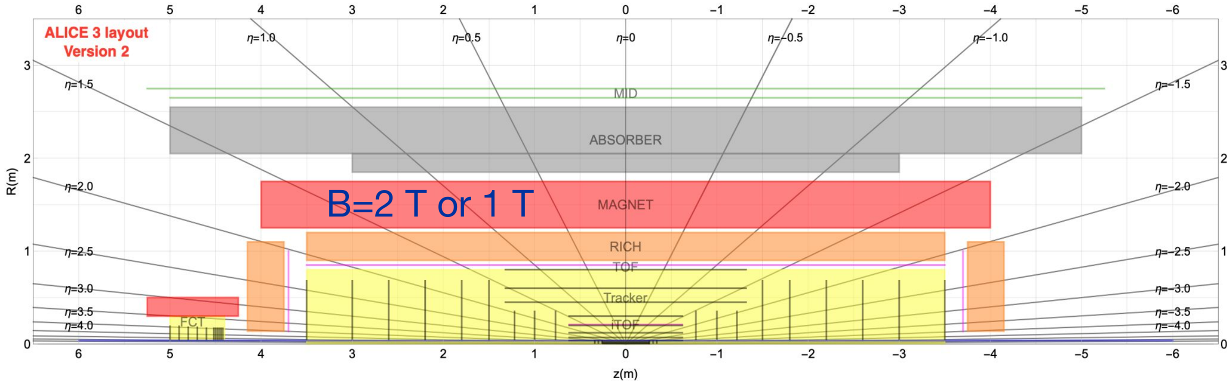
D.Chinellato, M. Concas

Detector scoping options: version 2

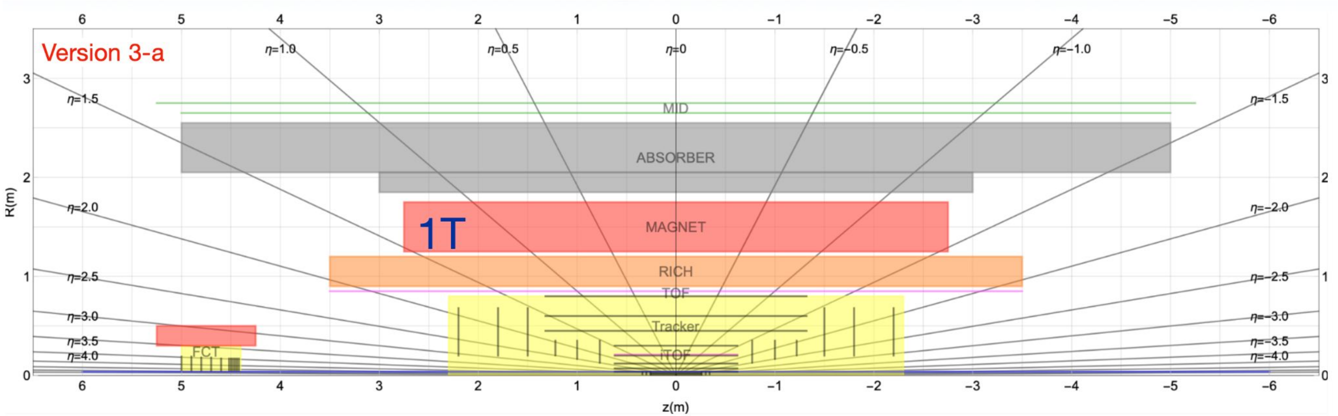


Reference Detector Configuration

- Version without ECal and smaller magnet radius → **v2-2T**
- Possibility to reduce B field value to 1 T → **v2-1T**



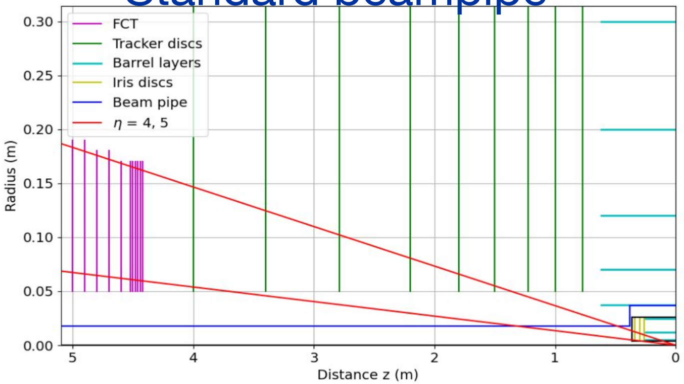
Detector scoping options: version 3



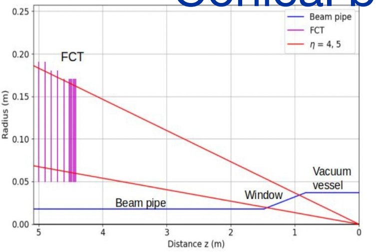
- SC magnet B=1T, length=5.5m
- **|η|<2.5 tracker, |η|<2 with PID**
- No fTOF, fRICH disks
- OT |z|<2.3m
- Only 3 OT disks and with R_{in}~20cm, defined by |η|=2.5
- 3 ML disks with R_{in}~10cm, defined by |η|=2.5
- No VD disks
- Shorter VD and ML layers
- OT, iTOF, oTOF, bRICH, MID unchanged
- Further descoping (v3-b): bRICH |η|<0.8

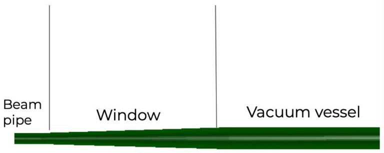
FCT studies

Standard beampipe

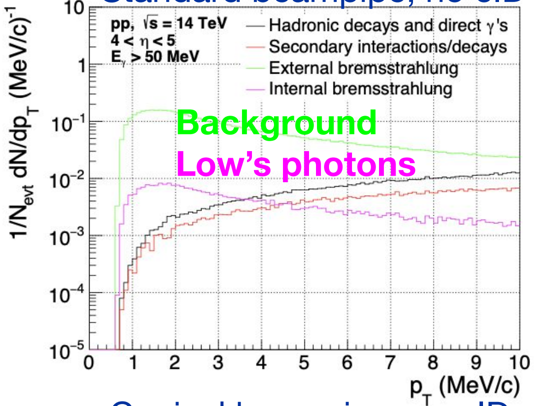


Conical beampipe

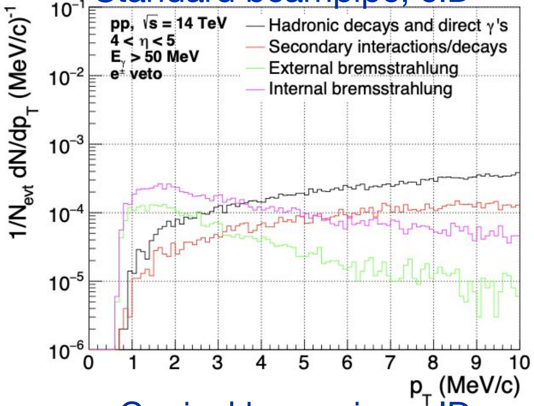




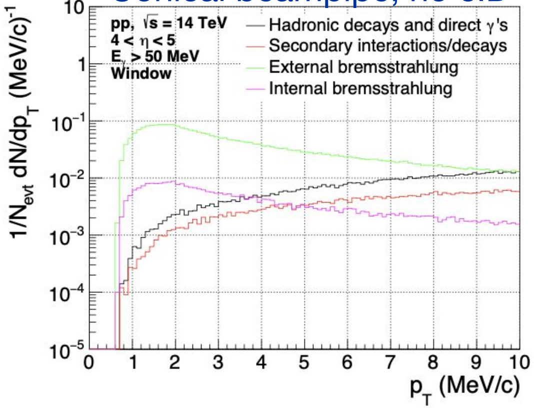
Standard beampipe, no eID



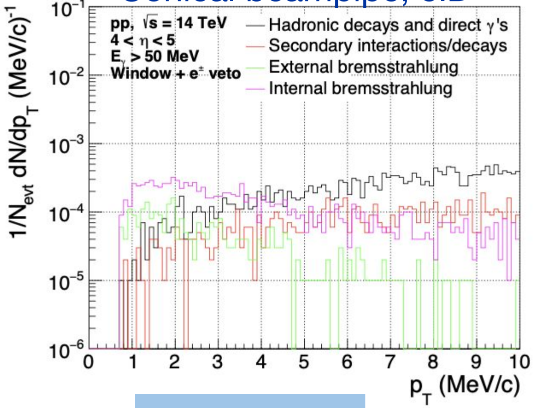
Standard beampipe, eID



Conical beampipe, no eID



Conical beampipe, eID

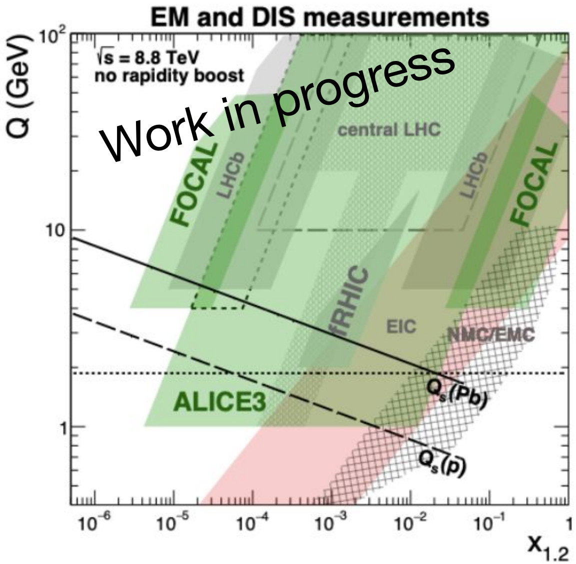


→ eID is necessary: a RICH behind FCT under study

C.van Veen

FoCal in ALICE 3?

- Combined acceptances of ALICE 3 and FoCal → 10 units in η
- Forward di-jets and γ_{dir}+jet would allow probing a wide range of x values
- FoCal on the A side of ALICE setup, at 7 < *z* < 8.5 m
  - compatible with ALICE 3 setup, including the FCT, which would be on the same side at 4.6 < *z* < 5.5 m
- Aspects to be investigated:
  - Integration
  - Radiation damage on Si-detectors of FoCal-E and on SiPMs of FoCal-H

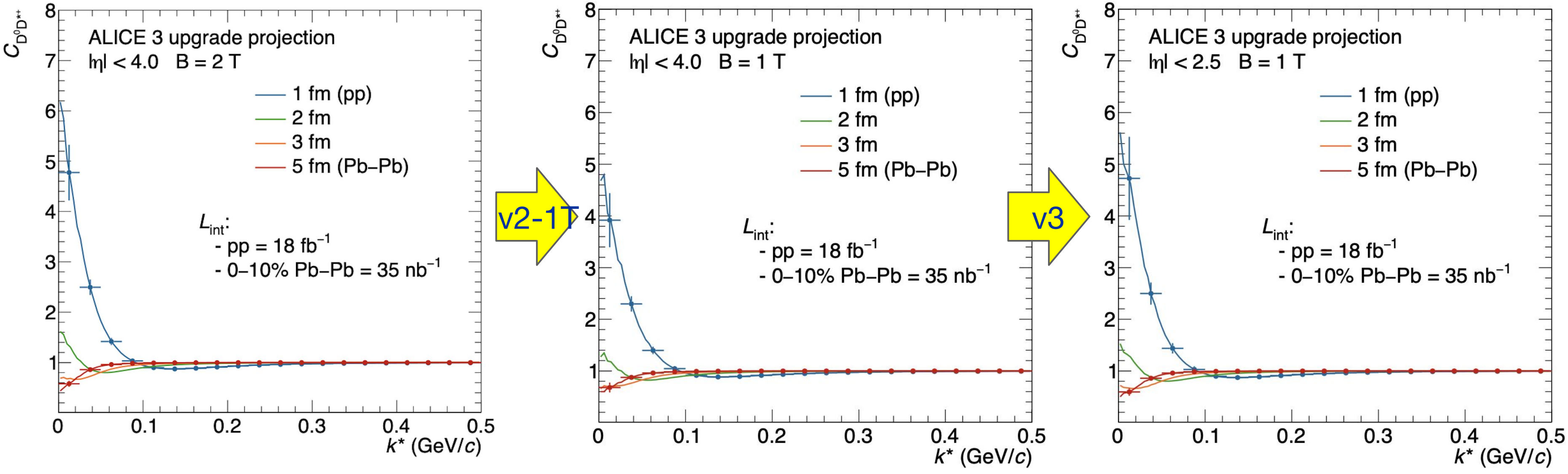


F.Jonas, P.Jacobs

Costs of scoping options

Version	Cost (MCHF)	Difference to v1
Reference detector layout v1	148.2	
Without ECal	−18.1	−12%
Smaller radius of magnet	−6.3	
Smaller radius of absorber and MID	−0.4	
Detector layout v2-2T	123.4	−17%
Magnetic field of 1 T	−5.1	
Detector layout v2-1T	118.3	−20%
Without TOF and RICH disks	−3.0 −4.3	
OT disk surface reduction	−5.0	
IT disk surface reduction	−2.0	
Shorter magnet (1 T)	−3.0	
Detector layout v3-a	101.0	−32%
Smaller RICH acceptance	−6.5	
Detector layout v3-b	94.5	−36%
Common items	+22.0	
Additional cost with FCT	+3.45	

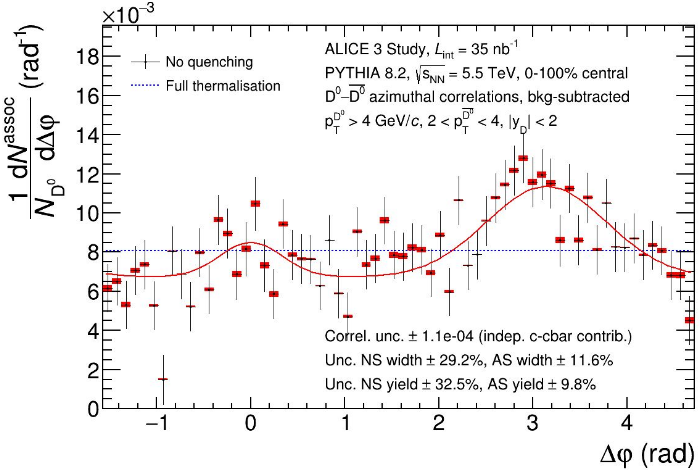
Layout v3: D-D* femtoscopy

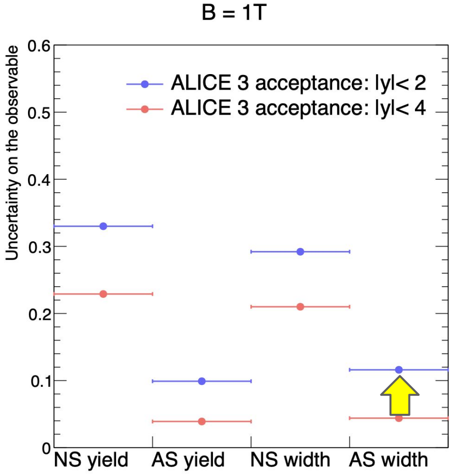


- **D-D* femtoscopy**: larger uncertainty, especially in pp collisions (blue points)
- Reduced sensitivity to source size dependence of correlation function, which is crucial to test D-D* hypothesis for exotic cc states like T_{cc}

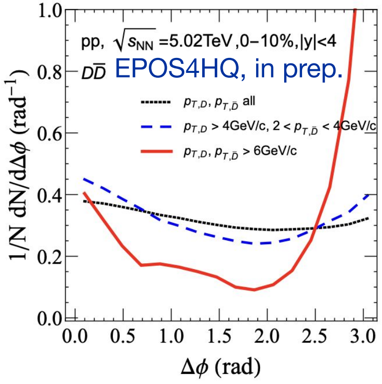
D.Battistini

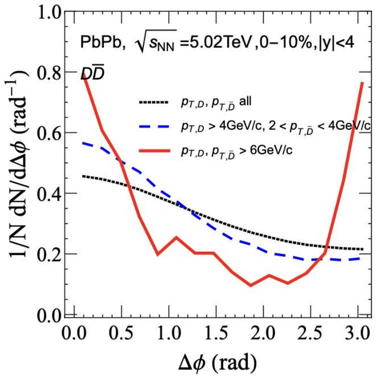
Layout v3: D-Dbar azimuthal correlations

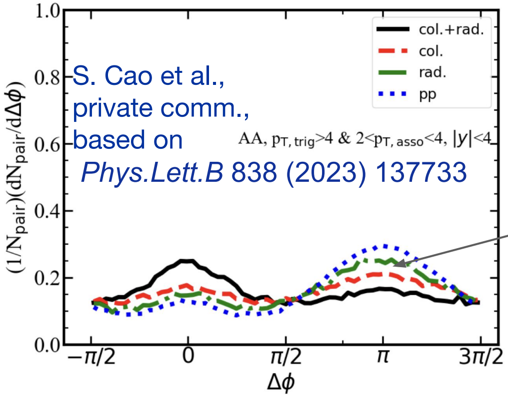




- **D-Dbar away-side** width precision 4.5% (v2-1T) → 11.5% (v3)
  - with 2T: 3.5% → 10%







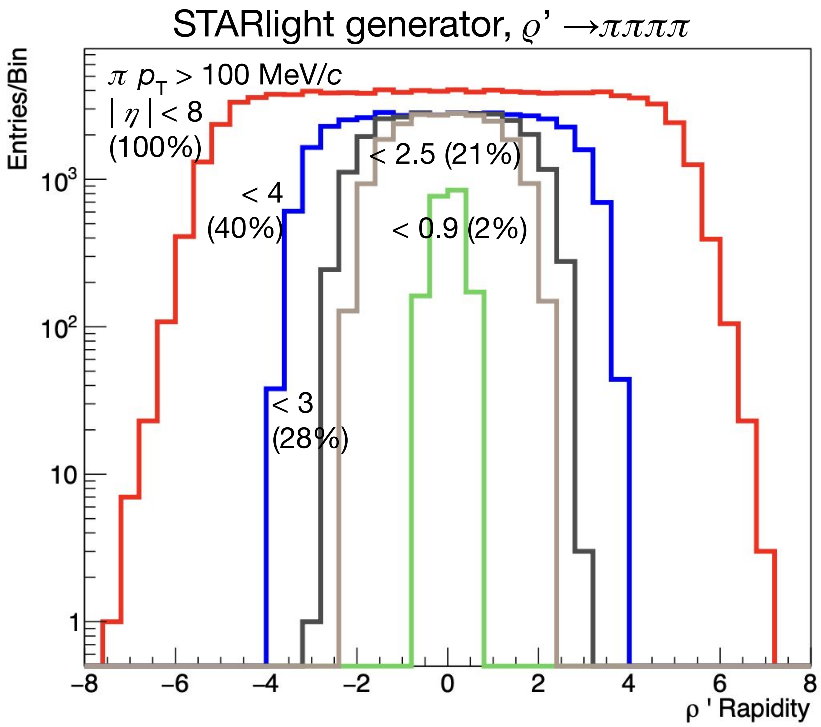
S. Cao et al., private comm., based on *Phys.Lett.B* 838 (2023) 137733

- 11.5% statistical precision is quite small, compared to modification predicted by models
- But difference between effects of collisional and radiative energy loss also quite small

M.Mazzilli

Layout v3: vector mesons in UPCs

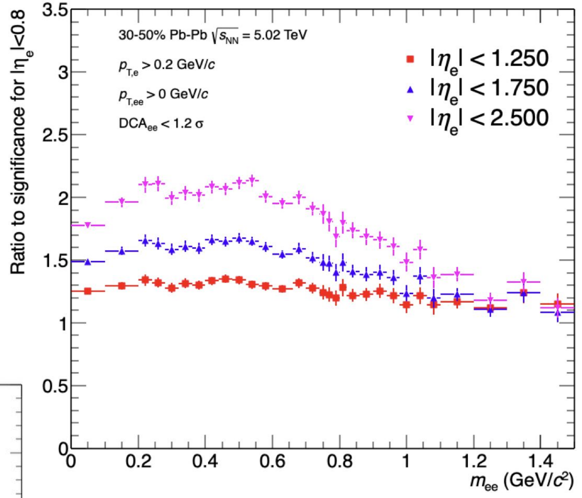
- **UPCs (rho' → 4pi as example)**: reduction of acceptance and photon energy range
  - **Acceptance |eta|<4: 40%**
  - **Acceptance |eta|<3: 28%**
  - **Acceptance |eta|<2.5: 21%**
  - **Acceptance |eta|<0.9: 2%**
- → v3 still x10 increases wrt current acceptance; could be x15 with |eta|<3
- 2<|eta|<2.5 (or 3?) with tracking and no PID: should not be a big limitation in UPCs, because combinatorial background is low

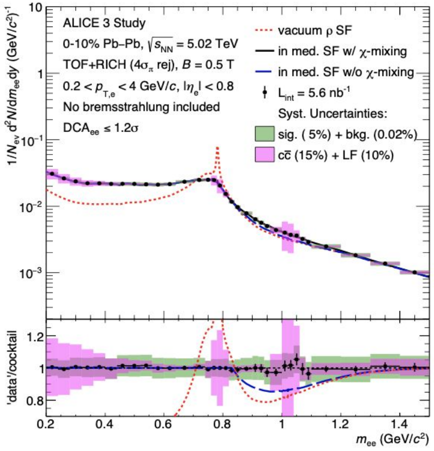


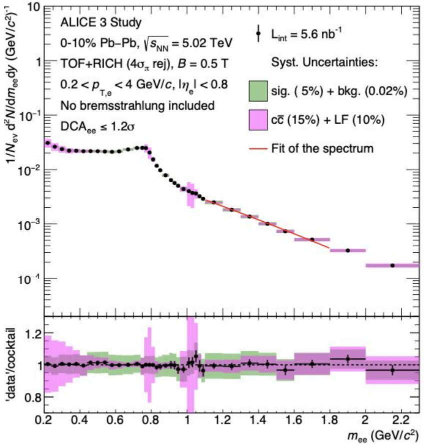
S.Klein

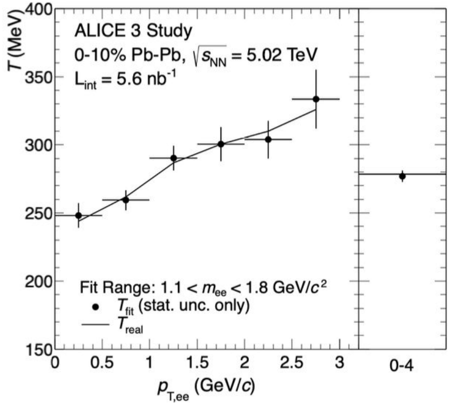
Layout v3-b: impact on dielectrons

- bRICH acceptance reduced to |eta|<0.8
- **Dielectrons**:
  → Significance scales with sqrt(delta-eta) for M<0.8 GeV
  → and ~independent of delta-eta for 1.2<M<1.5 GeV
  → in addition, measurements are mostly systematics-limited









R.Bailhache

Summary of impact of scoping options: v2

Measurement	Layout v2-2T	Layout v2-1T
ALPs searches in $\gamma\gamma \to \gamma\gamma$	strongly limited ($m_a < 2$ GeV/c^2, $1/\Lambda_a > 0.2$ TeV^{-1})	
$\chi_{c1,2} \to J\psi\gamma$	measurement limited to $p_T > 4$ GeV/c	
		minor additional impact
γ–jet correlations	limited improvement w.r.t. ALICE 2	
$\chi_{c1}(3872) \to J\psi\pi\pi$	not affected	minor impact
Ξ_{cc} yield	not affected	minor impact
Ξ_{cc} rapidity dependence	not affected	large impact
B^+ yield and flow	not affected	moderate impact at low and high p_T
Λ_c and Λ_b flow	not affected	large impact at $2 < \lvert y \rvert < 4$
D^0–$\overline{D^0}$ vs. $\Delta\varphi$	not affected	minor impact
D–D* vs. k^*	not affected	significant impact
Dielectrons	not affected	can exploit full integrated luminosity

→ **B = 2 T is the preferred field strength**

→ **B = 1 T not the ideal option, but still enables a strong programme**

→ an intermediate value of magnetic field (e.g. 1.5T), can be considered as well

Summary of impact of scoping options: v3

Measurement	Layout v2-2T	Layout v2-1T	Layout v3-a	Layout v3-b
ALPs searches in $\gamma\gamma \to \gamma\gamma$	strongly limited ($m_a < 2$ GeV/c^2, $1/\Lambda_a > 0.2$ TeV^{-1})			
$\chi_{c1,2} \to J\psi\gamma$	measurement limited to $p_T > 4$ GeV/c	minor additional impact		
γ–jet correlations	large degradation without ECal		reduction of jet acceptance from 7 to 4 η units	
$\chi_{c1}(3872) \to J\psi\pi\pi$	not affected	minor impact		
Ξ_{cc} yield	not affected	minor impact		
Ξ_{cc} rapidity dependence	not affected	large impact	prevented	
B^+ yield and flow	not affected	moderate impact at low and high p_T		
Λ_c flow	not affected	large impact at $3 < \|y\| < 4$	prevented at $\|y\| > 2$	moderate additional impact at high p_T and $\|y\| > 0.8$
Λ_b flow	not affected	large impact at low and high p_T		moderate additional impact at high p_T and $\|y\| > 0.8$
D^0–$\overline{D^0}$ vs. $\Delta\varphi$	not affected	minor impact	significant additional impact	
D–D* vs. k^*	not affected	significant impact	minor additional impact	
Dielectrons	not affected	can exploit full integrated luminosity	prevented at $\|y\| > 2$	prevented at intermediate masses at $\|y\| > 0.8$
Net-charge fluctuations	not affected		significant reduction of pseudorapidity separation from $\Delta\eta = 8$ to $\Delta\eta = 4$	
Photoproduction, diffraction	not affected		significant reduction of acceptance from 8 to 5 η units	
π^0 and η background for real γ	not affected		large reduction of acceptance at low p_T	

→ **Clear limitation of physics reach**

→ **But unique and strong programme remains**

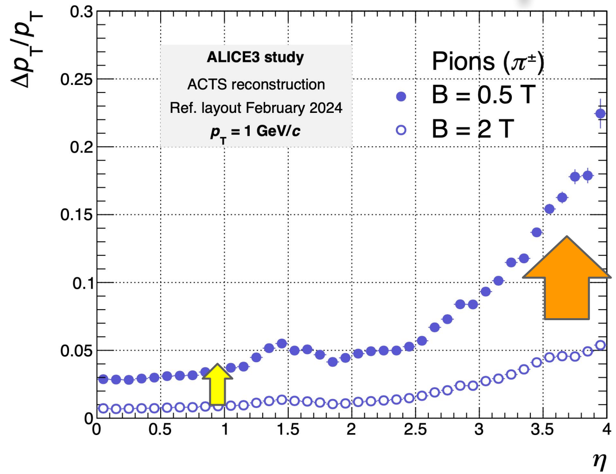
Impact of using present ALICE (“L3”) magnet (B=0.5T)

- Studied to address question by LHCC (November)

- **Large detector performance degradation** (details in the next slides)
    - p_T resolution reaches 15-20% at forward rapidity and low p_T
    - Some charm-hadron mass peaks overlap at forward rapidity
    - PID separation becomes poor at forward rapidity and low p_T
    - Impact on physics benchmarks estimated (multi-charm, D-Dbar, D-D femto, HF baryon flow)
    - **Impact less severe for layout v3, but still large degradation**

- Electricity saving with SC magnet: -94%, i.e. ~0.22 TWh (~20 MCHF), with respect to current ALICE electricity consumption
    - About 10 MCHF with L3 solenoid only

Impact of magnetic field on p_T and mass resolution

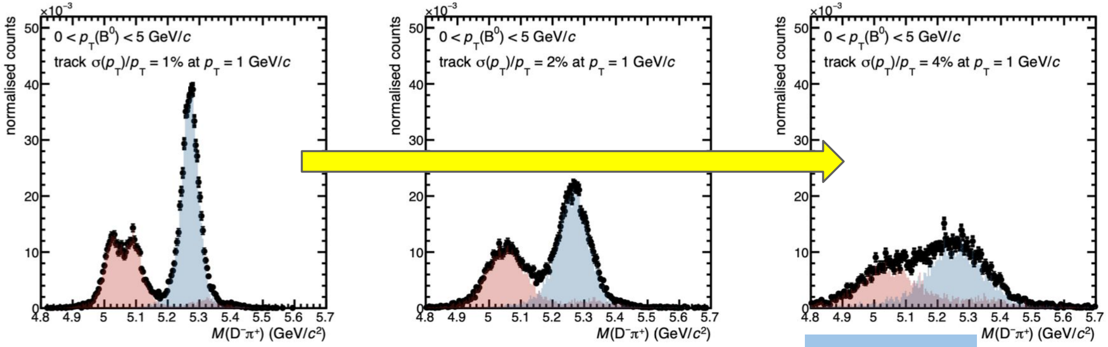


Resolution worse by x4 compared to 2T baseline and present ALICE detector

- Very poor resolution (10-20%) for $|\eta|>2.5$ (all particles all p_T's)

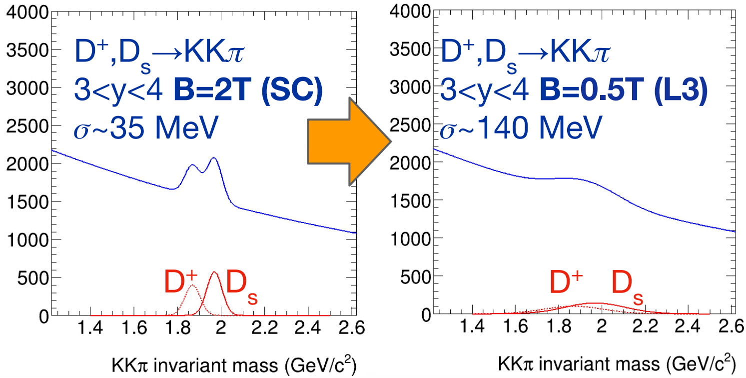
P.Larionov

Overlap of signal and correlated bkgs in B decays



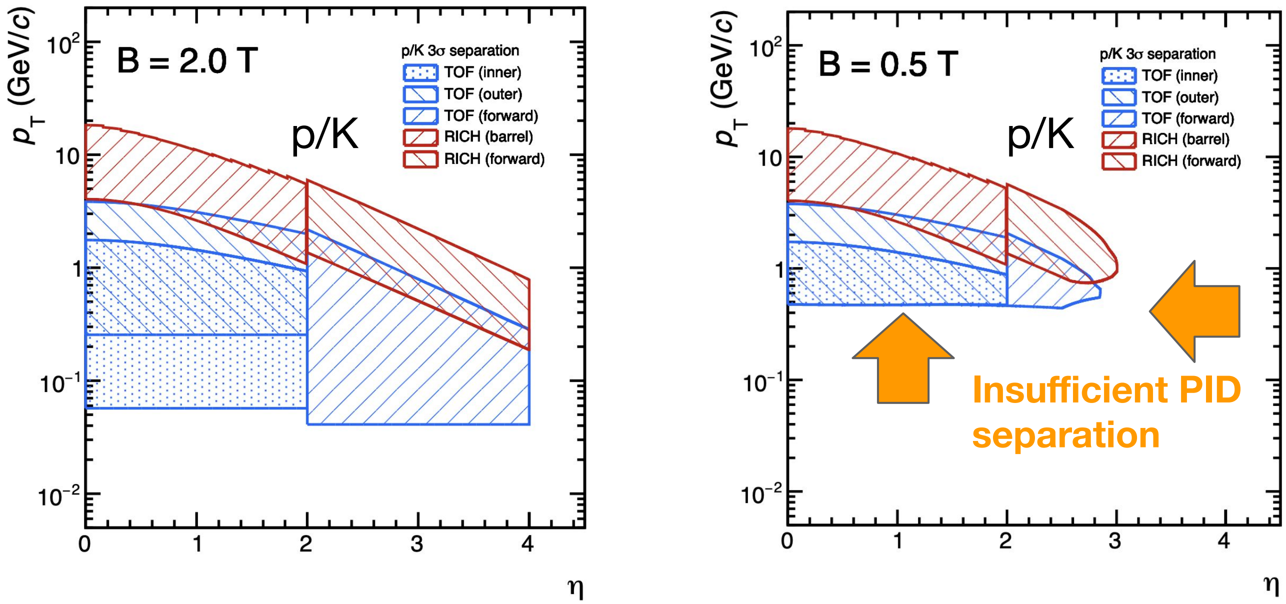
F.Grosa

Overlap of mass distributions, e.g. D^+ and D_s



Impact of magnetic field on TOF & RICH PID

Separation of hadron species (3 sigma)
Coverage in p_T vs η



- **Poor p_T resolution at low p_T and at high rapidity causes loss of particle species separation, with degradation of many aspects of the programme**

N.Nicassio

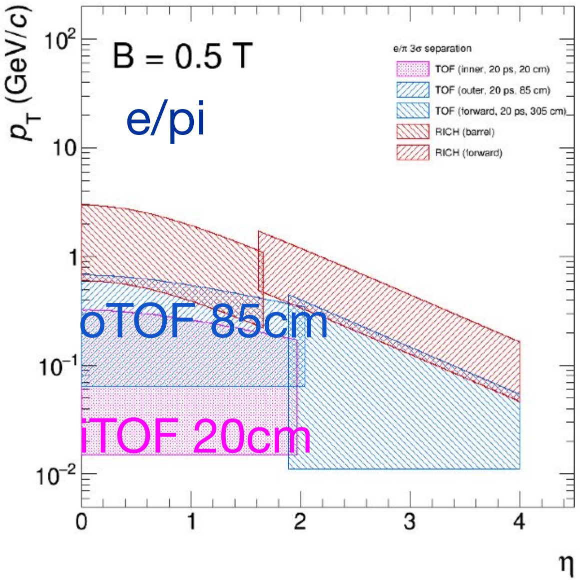
Version with 0.5 T and TPC?

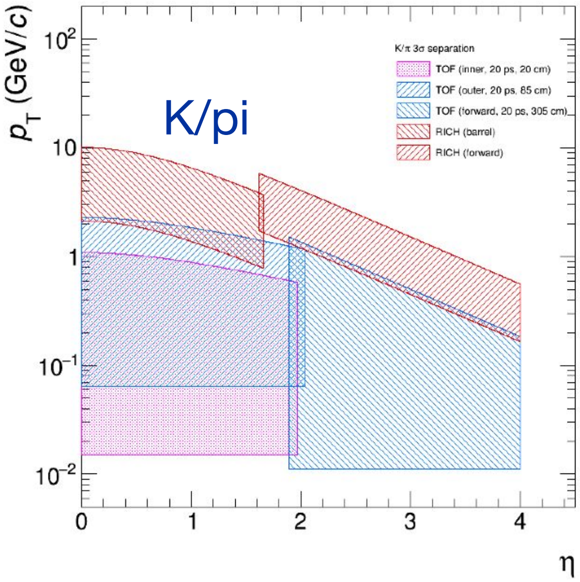
- B = 0.5T field is not completely excluded for v3, but implies a strong further degradation, due to the poor p_T resolution
- It is quite natural to ask what could be the physics reach of a version with L3 and the TPC (to keep good p_T resolution and eID up to high p_T)
- To prepare for this question, we started to study what a "version 4", with TPC, could look like and perform
- Only for internal discussion for now

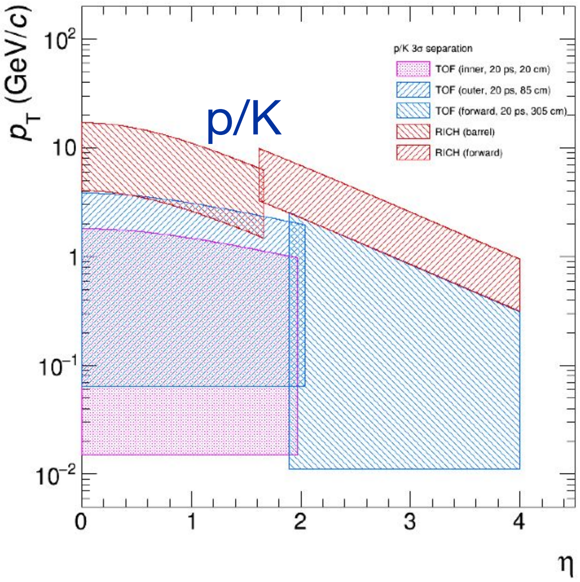
Layout version 4 *draft*

- MAPS-tracker: |eta|<1.5 (or 2)
  - Vertex Detector (Iris), shorter barrel |eta|<1.5-2, no disks
  - Middle Layers 7<R<20 cm (optionally ultralight)
  - Outer Tracker barrel (3 layers - e.g. 25, 40, 45 cm) – the TPC "vessel" starts at R~50 cm
  - All with 100 ns resolution → can potentially run w/o TPC at 24 MHz pp
  - OT with 5 μm precision to improve standalone pT resolution?
- Inner Si-TOF at R~45 cm (with 20 ps resolution)
- TPC: Pb-Pb more than 50 kHz? pp more than 4 MHz?
  - Very large data throughput for pp 4 MHz → strong impact on EPN processing
- TRD needed for TPC calibration?
- Current TOF would be important for PID up to few GeV
  - However, in case of hardware failures (FEE), supermodule extraction very difficult
- New and larger FIT for event characterisation and vetoing
- Can include FCT, FoCal
- To be considered: RICH for PID at 0.9<|eta|<1.5? MID around L3 magnet?

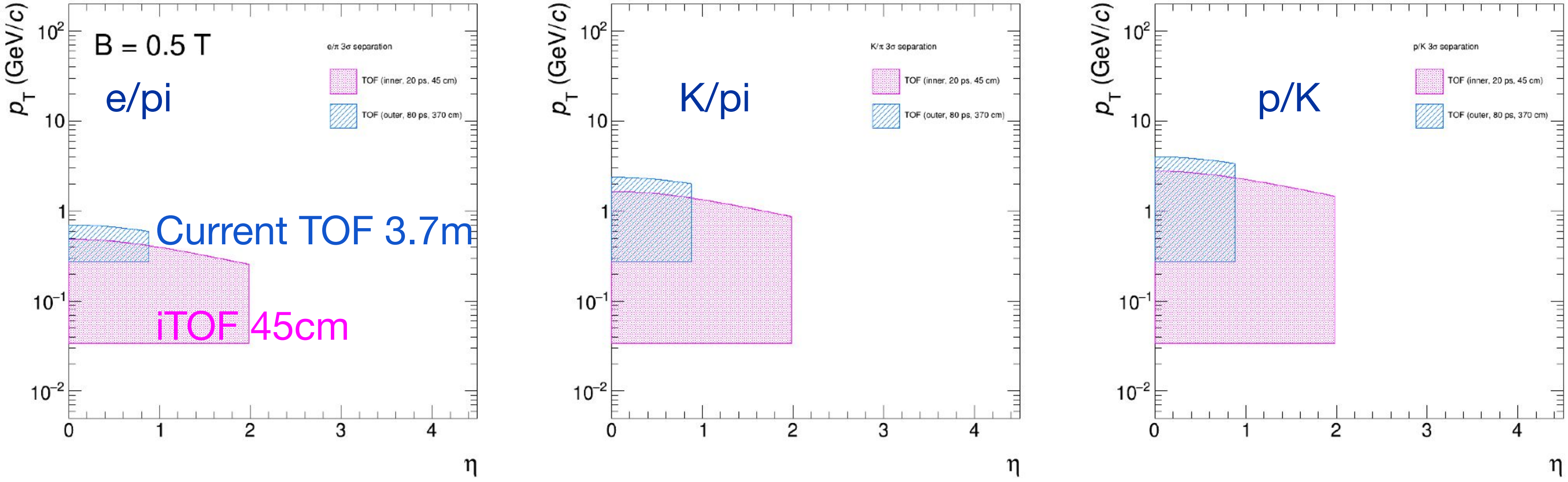
ALICE 3 PID


B = 0.5 T
e/pi
e/π 3σ separation
TOF (inner, 20 ps, 20 cm)
TOF (outer, 20 ps, 85 cm)
TOF (forward, 20 ps, 305 cm)
RICH (barrel)
RICH (forward)
oTOF 85cm
iTOF 20cm
p_T (GeV/c)
10^2
10
1
10^{-1}
10^{-2}
0
1
2
3
4
η


K/pi
K/π 3σ separation
TOF (inner, 20 ps, 20 cm)
TOF (outer, 20 ps, 85 cm)
TOF (forward, 20 ps, 305 cm)
RICH (barrel)
RICH (forward)
p_T (GeV/c)
10^2
10
1
10^{-1}
10^{-2}
0
1
2
3
4
η


p/K
p/K 3σ separation
TOF (inner, 20 ps, 20 cm)
TOF (outer, 20 ps, 85 cm)
TOF (forward, 20 ps, 305 cm)
RICH (barrel)
RICH (forward)
p_T (GeV/c)
10^2
10
1
10^{-1}
10^{-2}
0
1
2
3
4
η

ALICE 3 v4:
iTOF at R=45cm and keep current TOF?



e/pi 35-500 MeV

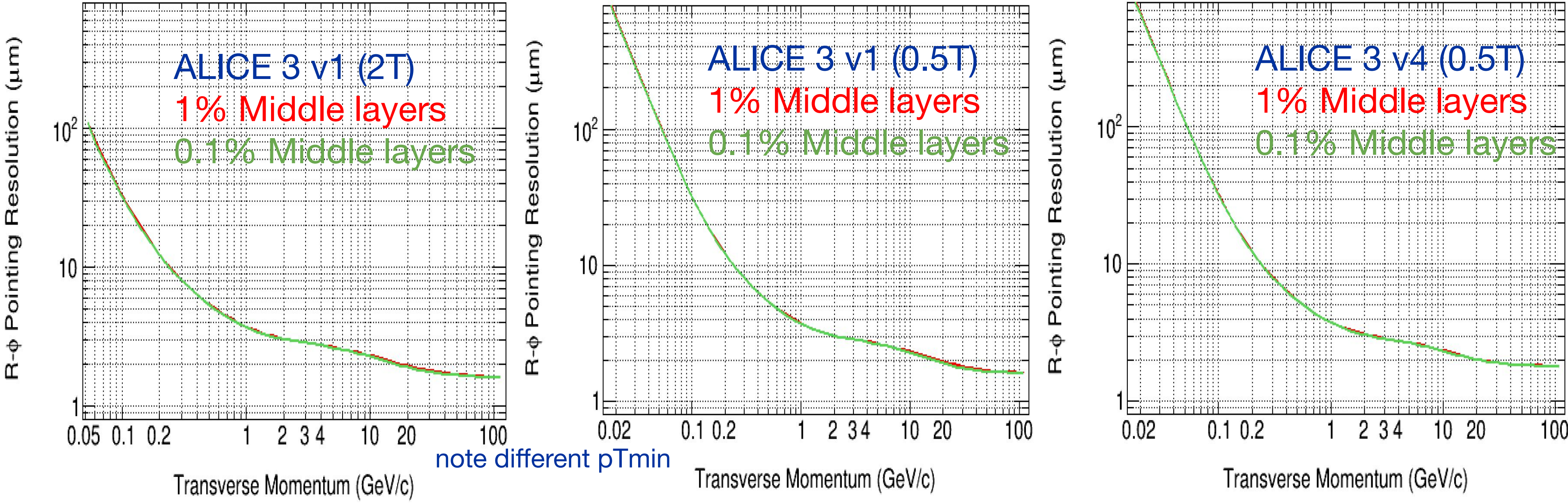
K/pi <1.7 GeV eta=0
<1.2 GeV eta=1.5
Current TOF: < 2.5 GeV

p/K < 2.5 GeV eta = 0
< 2 GeV eta = 1.5
Current TOF: < 4 GeV

ALICE 3 v4: d_0 resolutions

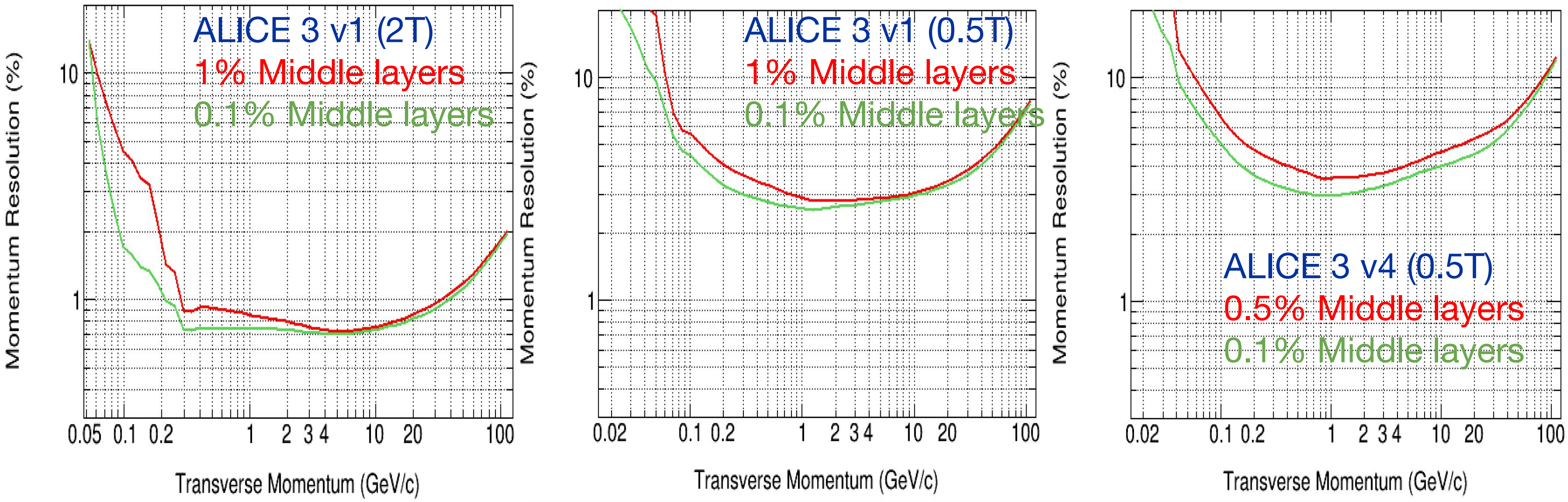
- Test with IT as in ALICE 3 (0.5, 1.2, 2.5, 7, 10, 13, 16) + iTOF 20 cm + OT 25, 40, 45 cm
  - With x/X_0 = 0.1% for VD and 1% for ML/OT, and res 2.5 and 10 um, respectively
  - With B=0.5T, without TPC

→ ~same pointing resolution for v1-3 2T, v1-3 0.5T, and v4 0.5T



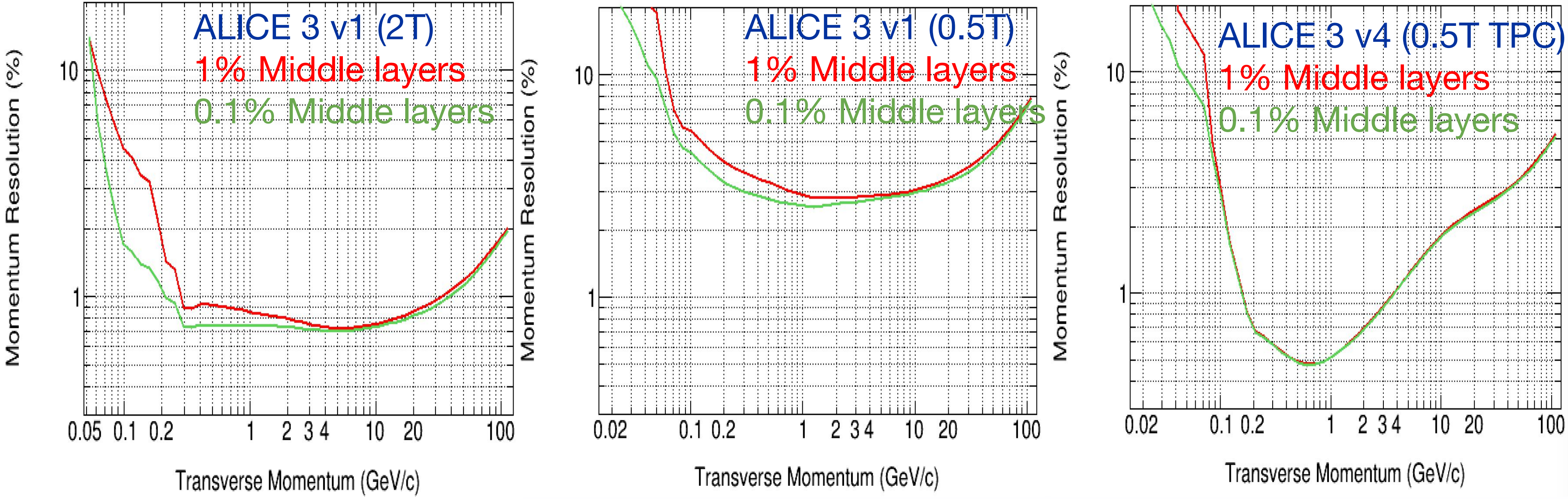
ALICE 3 v4: p_T resolutions

- Test with IT as in ALICE 3 (0.5, 1.2, 2.5, 7, 10, 13, 16) + iTOF 20 cm + OT 25, 40, 45 cm
  - With x/X_0 = 0.1% for VD and **0.5% for ML/OT**, and res 2.5 and **5 um**, respectively
  - With B=0.5T, without TPC



ALICE 3 v4: p_T resolutions

- Test with IT as in ALICE 3 (0.5, 1.2, 2.5, 7, 10, 13, 16) + iTOF 20 cm + OT 25, 40, 45 cm
  - With x/X_0 = 0.1% for VD and 1% for ML/OT, and res 2.5 and **5 um**, respectively
  - With B=0.5T, **with TPC**



ALICE 3 v4: *provisional performance summary*

- Eta coverage severely reduced wrt to v1-3
  - Push to extend to |eta| < 1.5 with extended Si and partial TPC tracks?
- PID:
  - Inner TOF at R=45 cm with 20 ps resolution
    - eID to lower pT than TPC, may enable using 0.5T for ee programme
    - p/K separation up to 2.5 GeV, compared with 4 GeV for current TOF
  - Extension beyond |eta|>0.9 with long iTOF at R=45 cm or with RICH on TPC sides?
- Pointing resolution: same as ALICE 3 baseline
- p_T resolution:
  - Si + TPC has same resolution as current ALICE
  - Si-only could be similar to v3 with 0.5T (acceptable for eta extension and in pp?)
- Interaction rate:
  - Pb-Pb: >50 kHz possible? but IROC occupancy ~30% at 50 kHz
    - Pb-Pb optimistic scenarios → 200-300 kHz (see talk by LHC HI team)
  - pp: TPC may reach ~4-6 MHz, but very heavy processing for async+skimming; alternative: Si-only for pp? But iTOF-only PID and poor p_T resolution

Provisional - work in progress

Observable	Uniqueness	ALICE 3 v3-1T	ALICE 3 v4-TPC
Physics goals			
Multi-charm baryons	Observation of multi-charm baryons in AA collisions	ok, mid-y	better than v3, but not in pp?
D-Dbar correlations	Angular de-correlation of soft charm	Stat. err. ~12%	quite close to v3-0.5T (but expect AS width unc >20%); pp should be ok
Beauty mesons and baryons	Precision of 0.01 on elliptic flow	ok, mid-y	mid-y ~similar to v3 with 1T
Quarkonia, $\chi_{c1}(3872)$	Measurement at low p_T and central rap.	ok	low-p_T reach compromised by limited rate in pp and TPC acc
$\chi_{c1,2}$	Excited charmonia in AA collisions	ok	no gain wrt Run 4 (only lumi)
Di-leptons (T, flow, χ-symm)	Time-evolution of thermal radiation; chiral symm. at μ_B=0	ok	~ same as LoI, but smaller eta range at low masses; access to higher M (eID to higher pT)
Net-baryon fluctuations	6th order net-proton cumulants	1.8→4 eta units	1.8 → 3 eta units with Si-tracker + iTOF
Photon-jet, full jets	High-precision low-p_T, large-R jet modification	Acceptance incr. & HF jets	HF-jets
Hadronic physics (femtoscopy, nuclei)	Charm-charm hadronic inter.; (hyper)nuclei with A = 5 and 6	~ ok with 1-2T	D-D* femto: Pb-Pb should be ok; but pp quite poor Light and hyper nuclei: no gain wrt Run 4 (only lumi)? c-deuteron search: ~same as LoI (used |y|<1.44)
Searches in $\gamma\gamma$ in UPCs	ALPs m>0.1GeV and low coupling	limited	no gain wrt Run 4 (only lumi)
Ultrasoft photons	Validity and limits of Low theorem	Ok, with FCT	Ok, with FCT & no FIT-A

Summary

- **ALICE 3 scoping scenarios documented in SD**
  → v2 being considered as goal for financial/personnel discussions
  → v3 compromises on acceptance, but still strong programme

- **Review by LHCC in next 3-4 months**
  - **Expect focus on schedule-risk mitigation**
  - **Request for option with L3 magnet may be reiterated**

- **Important to continue internal assessment of version with L3 and TPC**
  - **Clear limitations from acceptance and rate capabilities**
  - **Cost estimate to be also worked out**

Thanks for your attention!

LS4 schedule

Dismantling of ALICE 2, installation of magnet and services, and of ALICE 3 fit in LS4

Begin date	End date	Dura...
12/6/32	6/22/33	143
7/1/33	4/6/34	200
7/1/33	8/18/33	35
8/19/33	10/6/33	35
10/7/33	2/9/34	90
10/7/33	10/20/33	10
10/21/33	12/8/33	35
10/21/33	11/24/33	25
12/9/33	1/5/34	20
1/6/34	1/19/34	10
1/20/34	2/9/34	15
2/10/34	3/2/34	15
3/3/34	5/11/34	50
3/3/34	4/27/34	40
5/12/34	6/29/34	35
6/30/34	8/24/34	40
8/25/34	10/12/34	35
10/13/34	11/30/34	35
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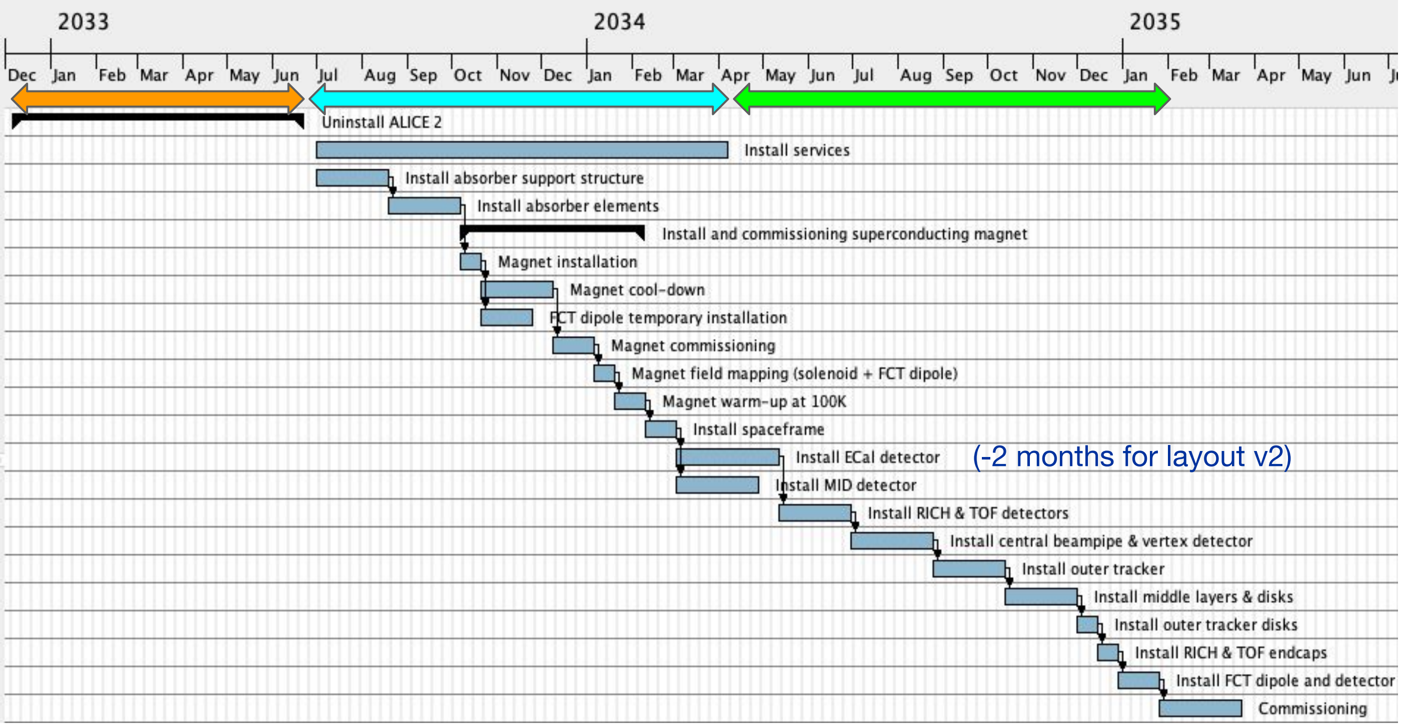
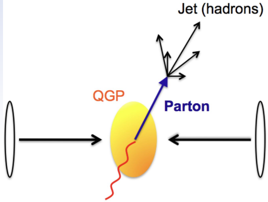
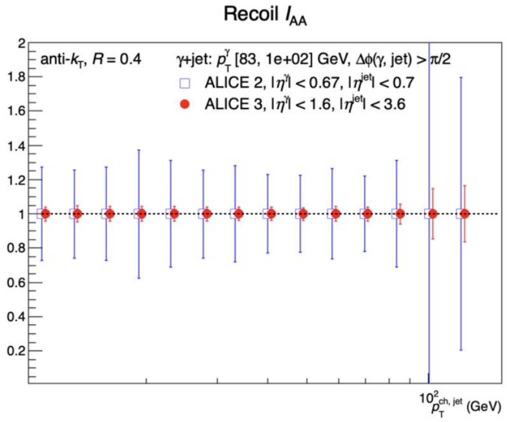
12/15/34	12/28/34	10
12/29/34	1/25/35	20
1/26/35	3/22/35	40

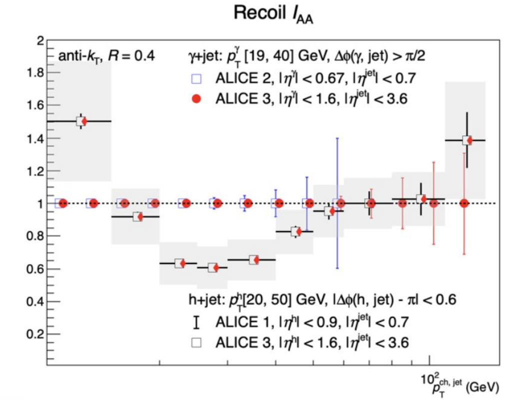


ECal: gamma-jet



- ECal can measure photons with x10 larger acceptance than ALICE 2 (EMCal)
- Photon can be correlated with charged-jets in |eta|<4 (exploiting ALICE 3 tracker acceptance)
- Uniqueness:
  - wrt ATLAS/CMS: low p_T
    - p_{Tjet}>10 GeV in ALICE 3 (same ALICE), vs 50 in ATLAS/CMS
    - p_{Tgamma}>10-20 GeV in ALICE 3, vs 50 in ATLAS/CMS
  - wrt ALICE 2: x10 larger acceptance for the photon (EMCal vs ECal), x2 larger L_{int}, ch. jets in |eta|<3.6 vs |eta|<0.5
- Projections for recoil jet R_{AA} and I_{AA}





Layout v2-2T: ECal descoping

Physics loss without ECal:

- Strong limitation in performance for BSM searches in $\gamma\gamma \to \gamma\gamma$
- $\chi_{c1,2}$ measurement starts at p_T 4-5 GeV/c instead of 1-2 GeV/c
- No possibility of full-jet and gamma-jet measurements

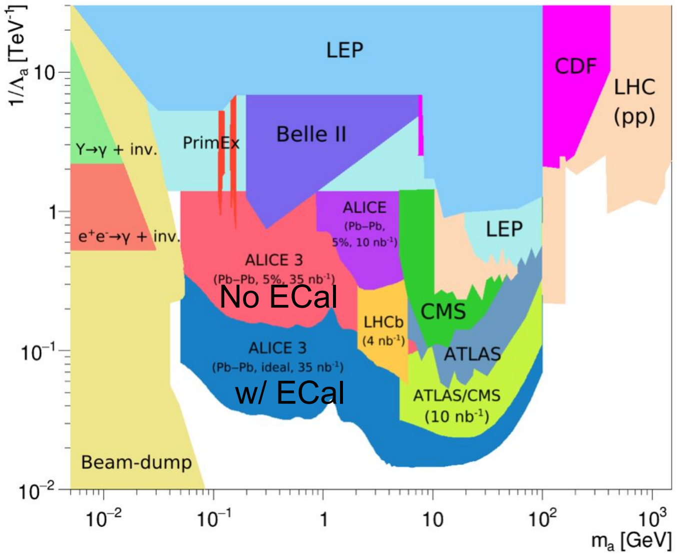
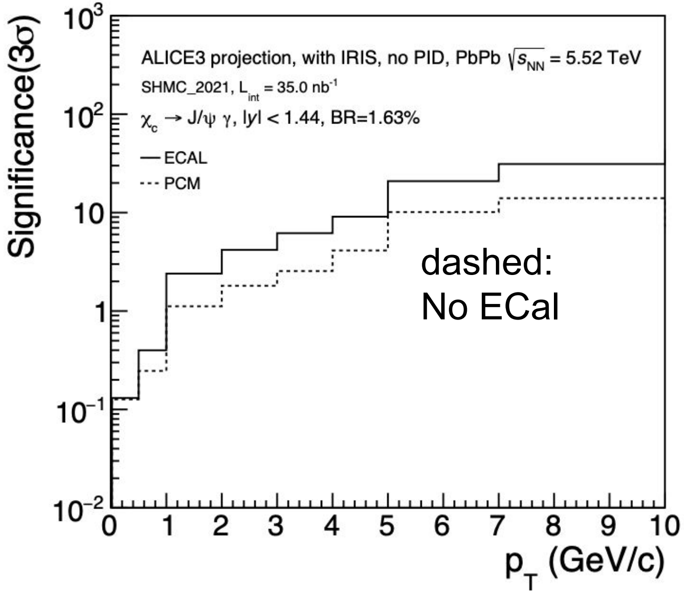


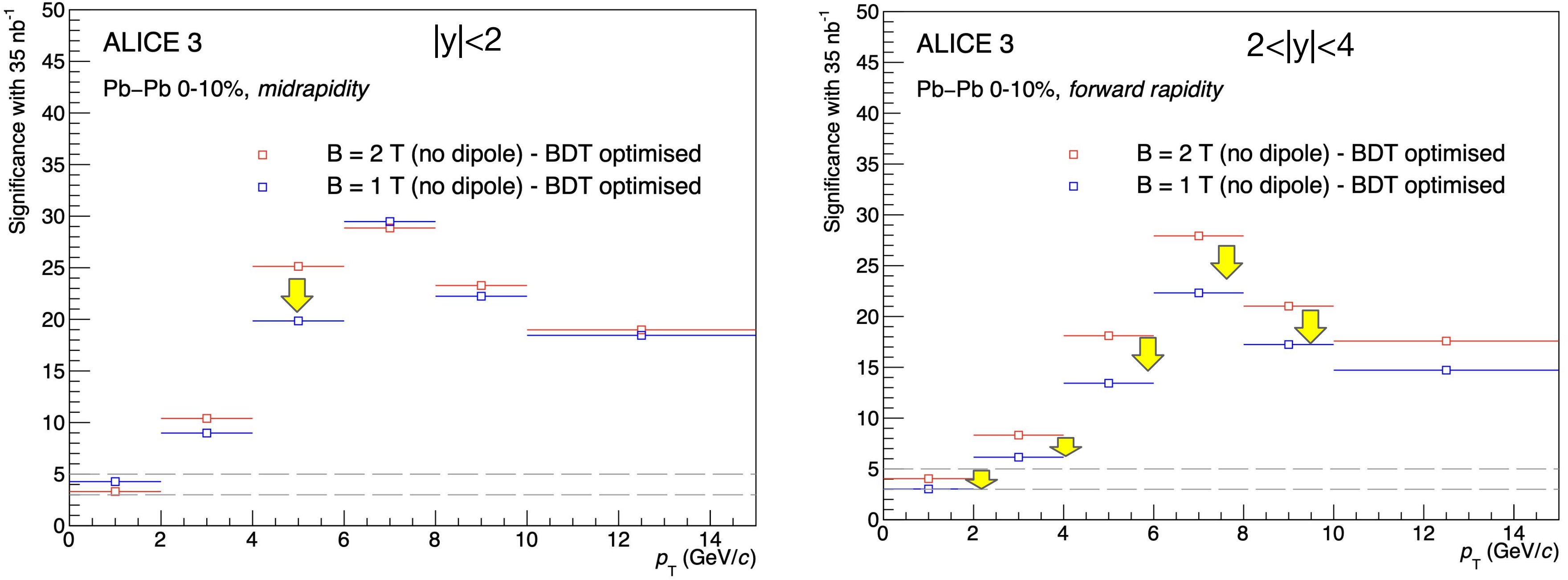
Figure 76: Bounds in the $(m_a, 1/\Lambda_a)$ plane from existing and future ALP searches.



Layout v2-1T: multicharm baryon Ξ_{cc}

$$\Xi_{cc}^{++} \rightarrow \pi^+ \Xi_c^+ (\rightarrow \pi^+ \pi^+ \Xi^-)$$

- **Significance at forward rapidity is reduced by ~25% with 1 T compared with 2 T**



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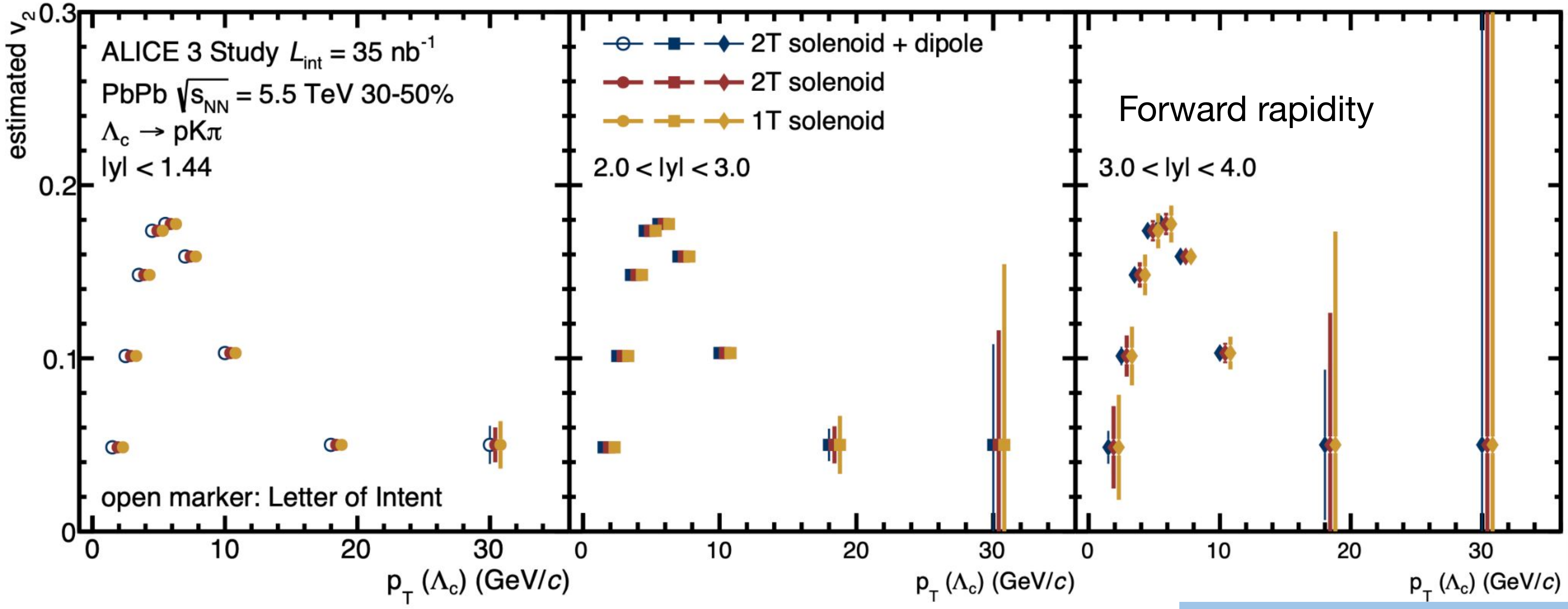
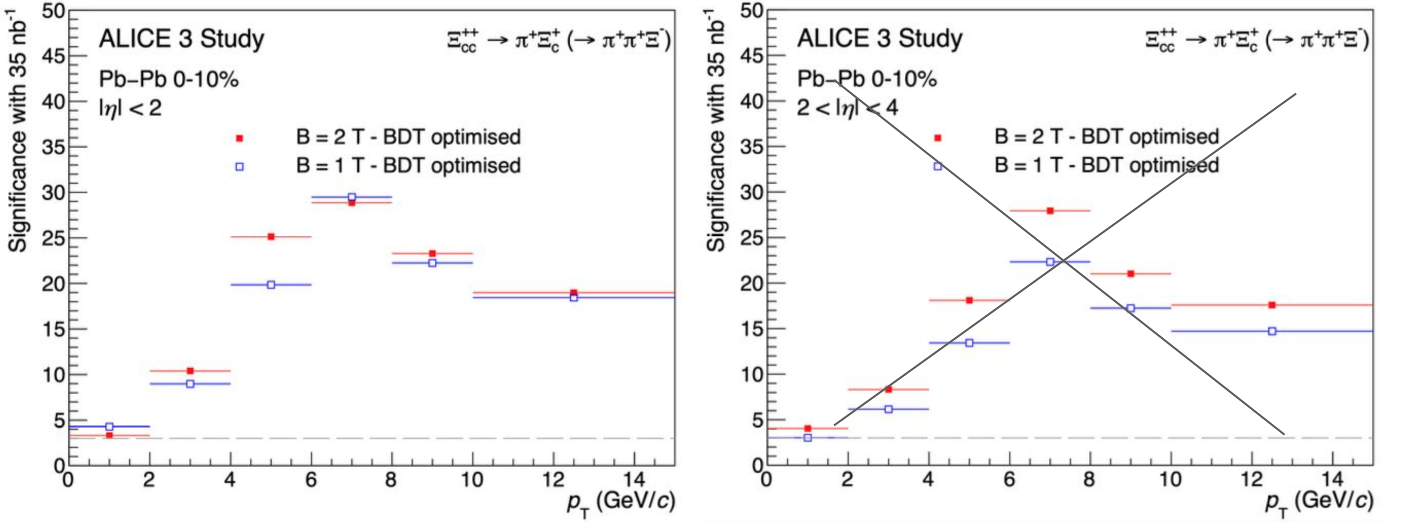
Layout v2-1T: Λ_c elliptic flow

- **Measurement at central rapidity |*y*|<3 remains precise** also with solenoid 1 T
- **Measurement at forward rapidity 3<|*y*|<4 is degraded**, especially with 1T



K.Kryzkova Gajdosova

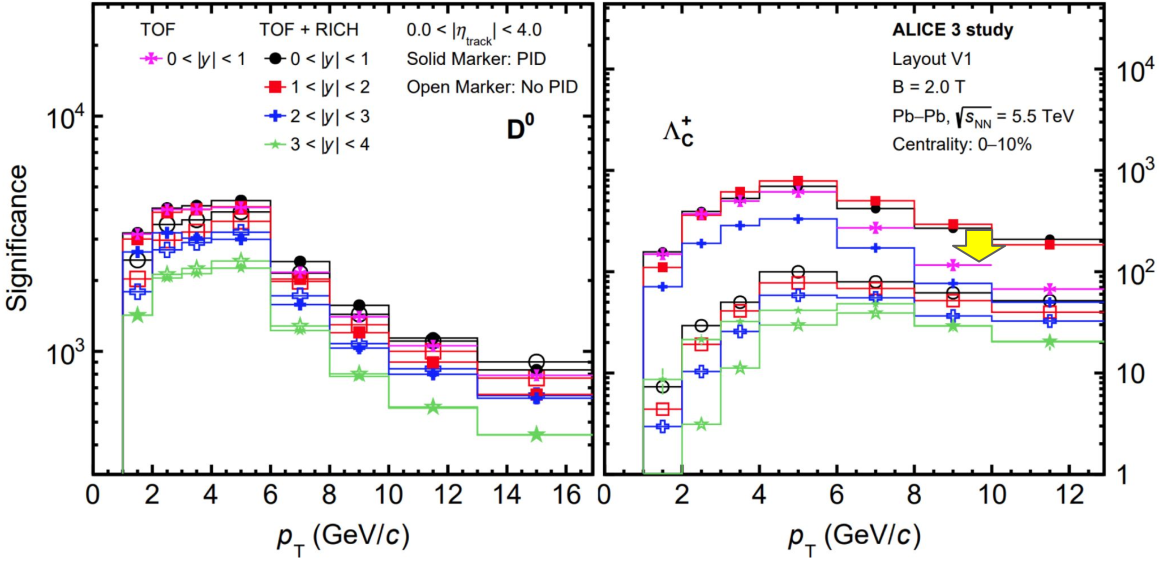
Layout v3: multicharm baryon Ξ_{cc}



- ***Ξ*$_{cc}$ yield measurement** at fwd-y prevented
- Comparison with hadronisation model predictions has to rely only on mid-rapidity yield
  - Centrality dependence; possibly system-size dependence

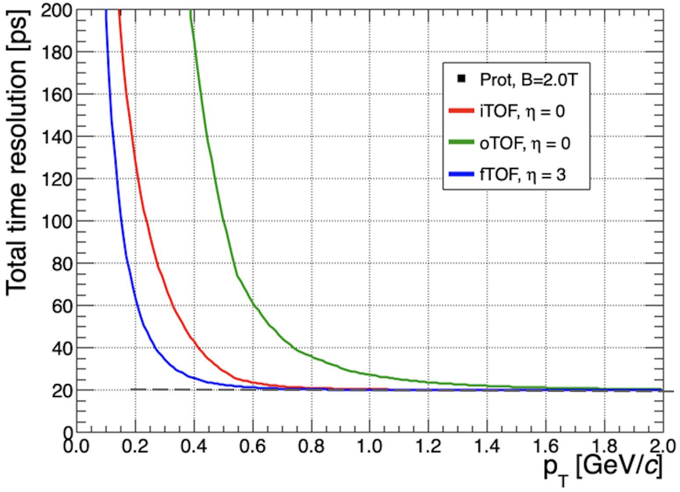
Layout v3-b: heavy flavour

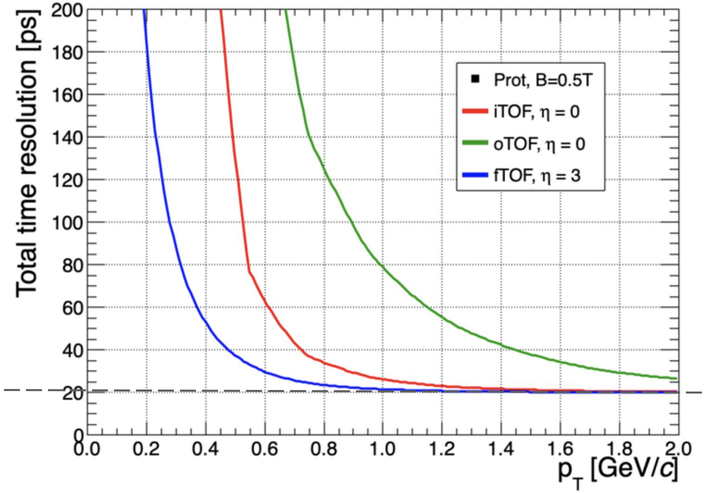
- Without hadron PID RICH in 0.8<|eta|<2:
  - Low-p_T HF: no degradation; covered by TOF PID
  - High p_T Λ_c and Λ_b : reduction of significance without proton ID from RICH



0.5T: impact of p_T resolution on TOF & RICH PID

- PID via TOF uses comparison of calculated track arrival time for different mass hypotheses with measured time-of-flight $t_{TOF,hypothesis} = \frac{L_{track}}{\beta c}$ with $\beta = \frac{p}{\sqrt{m^2+p^2}}$ and $p = p_T \cosh(\eta)$
- PID via RICH uses comparison of calculated photon emission angle (ring radius) for different mass hypotheses with measured angle $\theta_{RICH,hypothesis} = \arccos\left(\frac{\sqrt{m^2+p_T^2\cosh^2(\eta)}}{n \cdot p_T \cdot \cosh\eta}\right)$ with n = aerogel refractive index
- p_T resolution contributes to uncertainty on calculated arrival time and emission angle





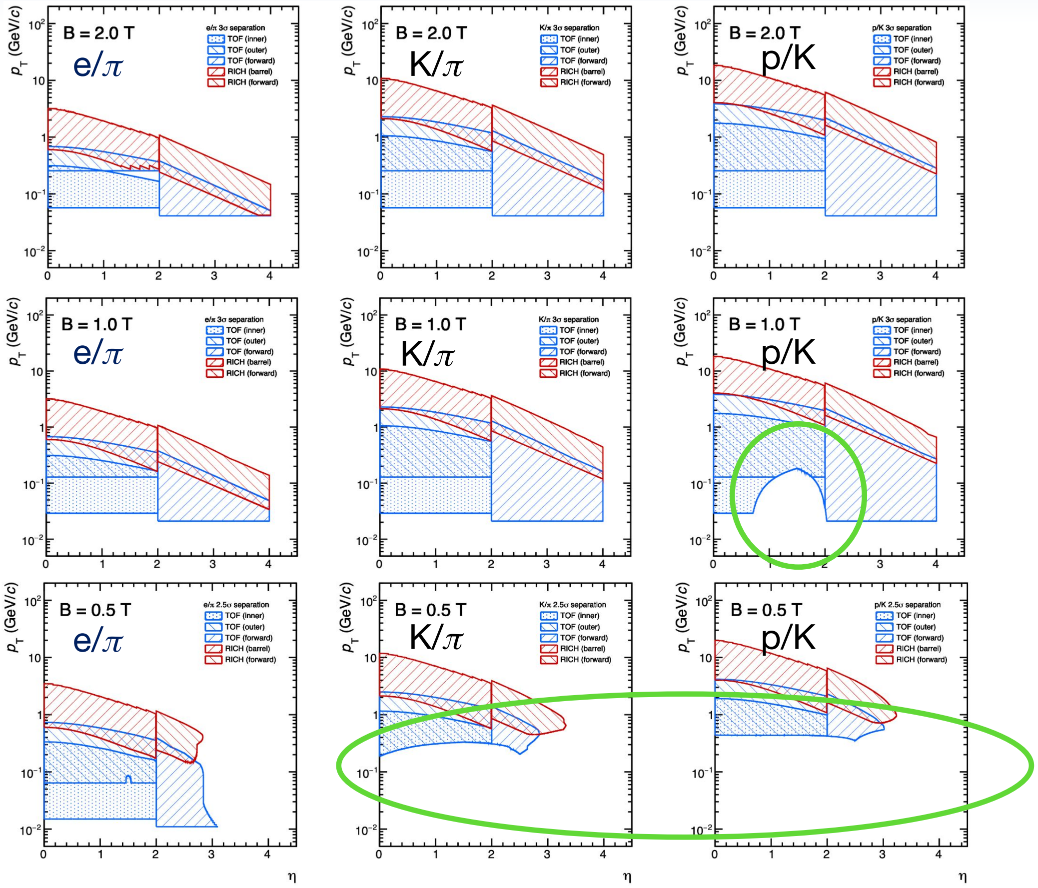
20 ps res. on measured TOF

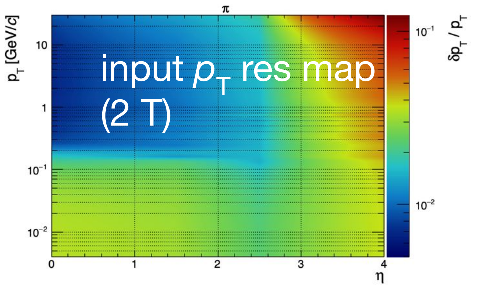
0.5T: impact of p_T resolution on TOF & RICH PID

B=2T
3 sigma separation
coverage: p_T vs η

B=1T
3 sigma separation
coverage: p_T vs η

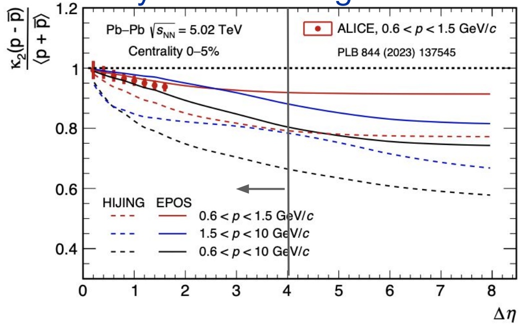
B=0.5T
2.5 sigma separation
coverage: p_T vs η

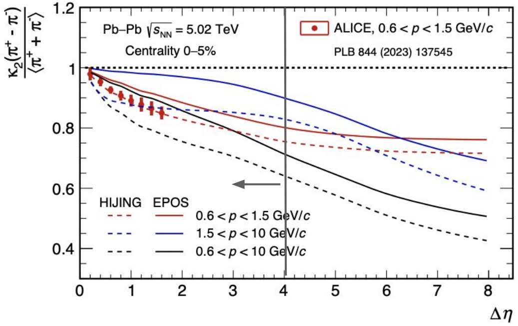




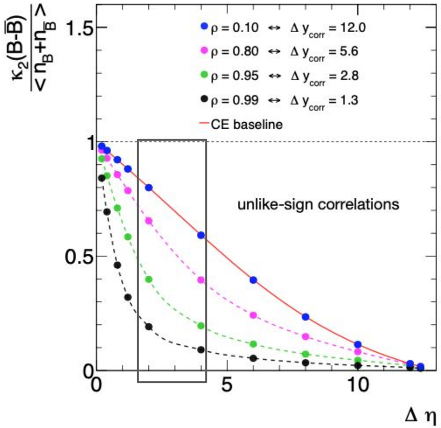
v3-a performance degradation (examples)

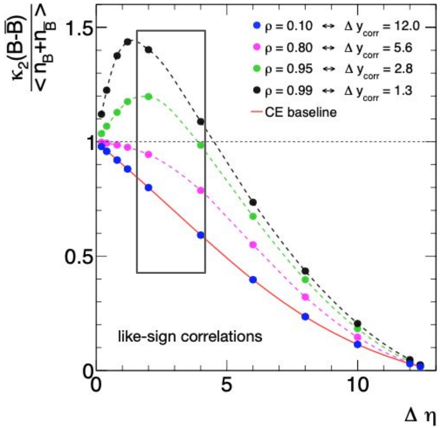
- **Net-proton fluctuations**: reduced lever arm for possible dynamics at large Delta-eta





- Second-order cumulants of net-baryons expected to have maximum deviation from Canonical Ensemble baseline at $\Delta\eta$ = 3-4
  - Braun-Munzinger et al., arXiv:2312.15534.

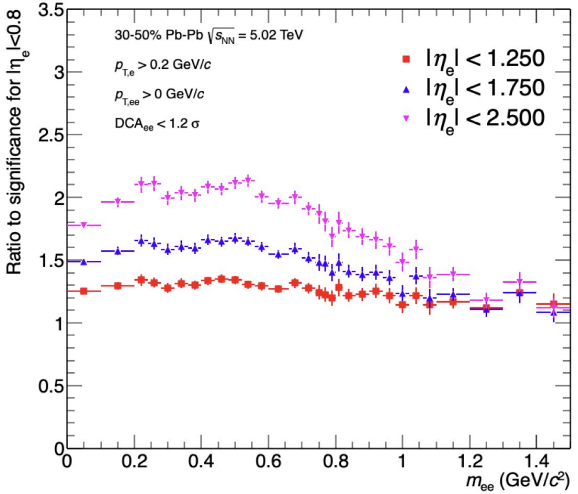




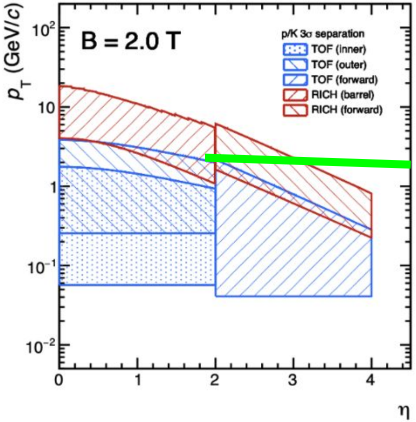
v3-b performance degradation

- bRICH acceptance reduced to |eta|<0.8
- **Dielectrons** (studied during LoI preparation):
  → Significance scales with sqrt(delta-eta) for M<0.8 GeV
  → and ~independent of delta-eta for 1.2<M<1.5 GeV
  - However, studied only for low $p_{T,ee}$ ($p_{T,ee}$>0) → to be checked at higher $p_{T,ee}$

  → in addition, measurements are mostly systematics limited

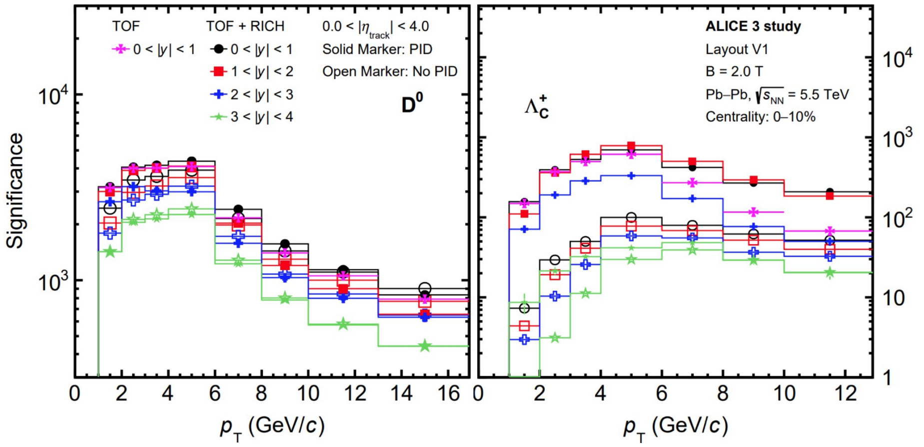


- **Net-protons:**
  - TOF coverage up to p_T=2 GeV at eta=2 sufficient for net-p analysis

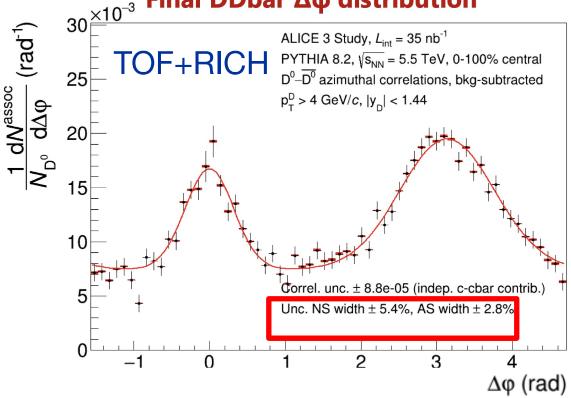


v3-b performance degradation

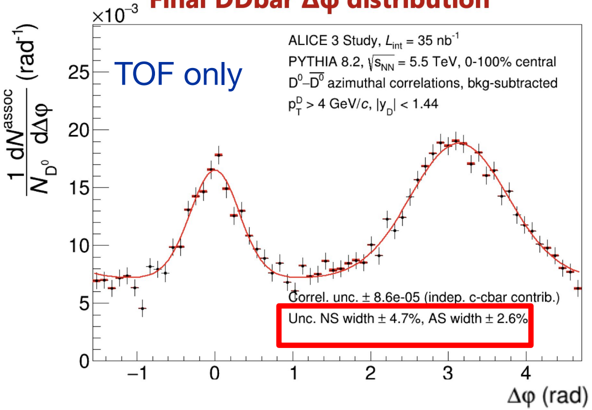
- **Heavy flavour :**
  - hadron PID from TOF is enough for low-p_T HF region (the most critical)
  - possible effect on high p_T Λ_c and Λ_b (to be assessed)



Final DDbar Δφ distribution



Final DDbar Δφ distribution



v3: ALICE 3 uniqueness remains

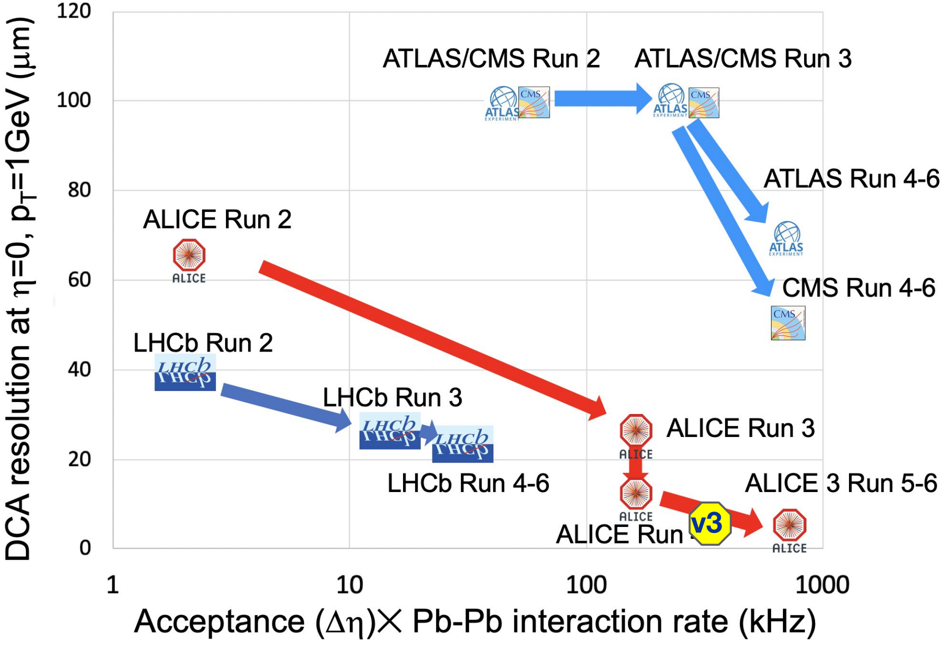
Lowest material

Closest layer (5mm)

Fast readout (100kHz Pb-Pb, 24 MHz pp, no limitations for possible lighter nuclei runs)

Electrons, muons, hadrons, nuclei over largest p_T range at mid-y

>2x current η acceptance



Dielectrons: "T vs time", ϱ-a_1, flow

Multi-charm hadrons with strangeness tracking

Beauty baryon flow

D-Dbar azimuthal correlations

D-D femtoscopy

R=0.5 low-p_T jets $|\eta|<2$

Excited charmonia, exotica

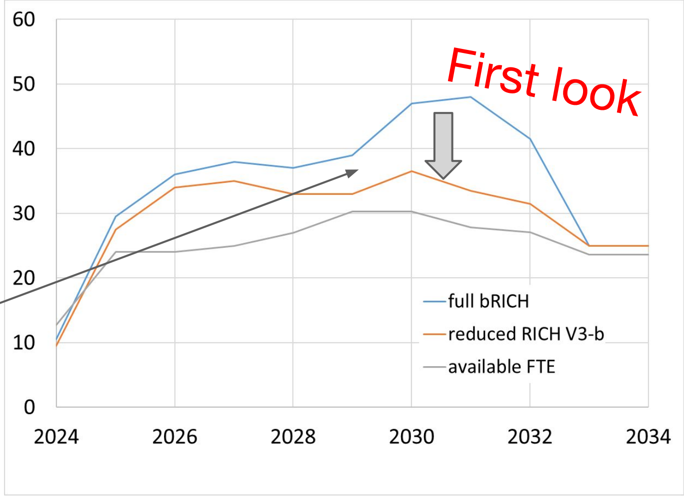
Hyper-nuclei and search for charm-nuclei

ALPs search at low masses

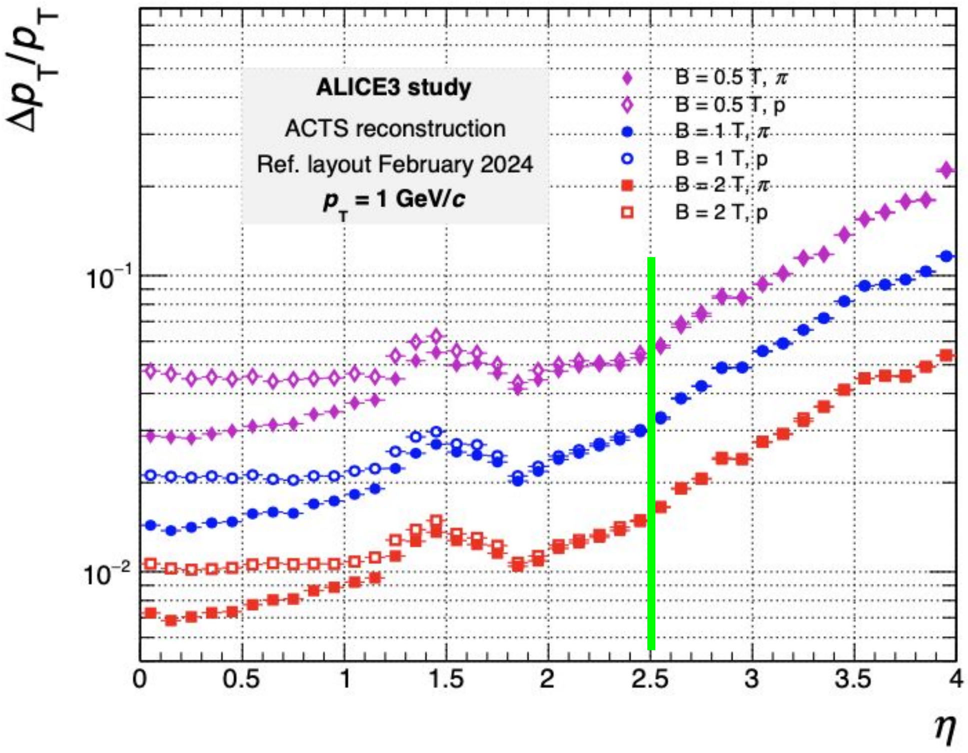
Large acceptance increase for UPCs

Possible impact of v3 on resources

- Removes the regions with maximum radiation load and occupancy (except for VD), relaxing the constraints for the OT/ML/TOF sensors and making less severe the challenge for RICH sensors
- Reduces by ~20% (tbc) the required resources for TOF and RICH, and reduces the mechanical design complexity (no disks, projective RICH geometry not needed in v3-b)
  - Further reduction can be achieved if the option of oTOF combined with bRICH is technically feasible (already in SD draft and under R&D)
- v3-b reduces by ~25% the RICH production FTEs
- Reduces the FTEs for OT disks, but 6 (or 8) disks remain a large project



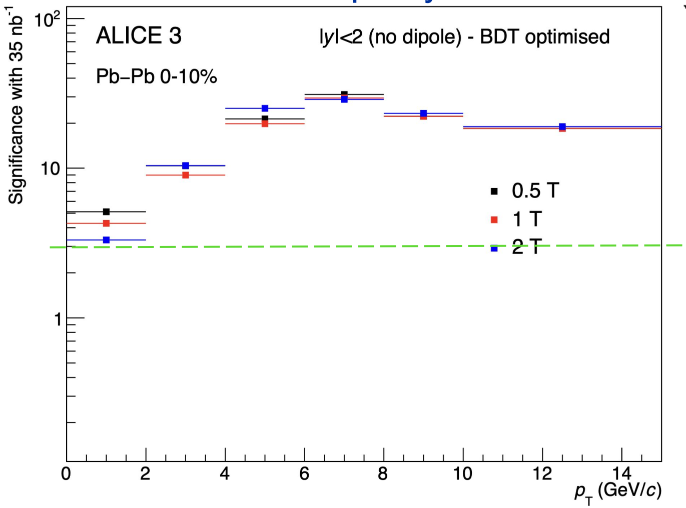
Why |η|<2.5?



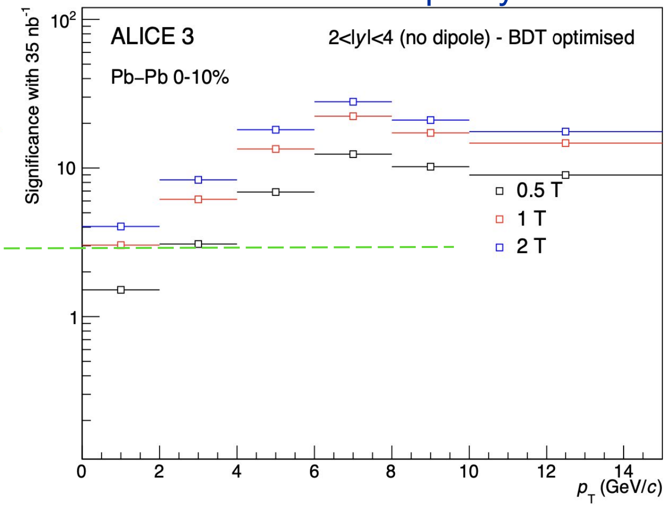
- p_T resolution quite constant in 1.3<η<2.5, then it starts to worsen
- <3% with B=1T
- <5% with L3 magnet
- However, 2.5 could be changed to 3, if physics gain is significant
  - would require an additional OT disk

0.5 T: Ξ_{cc} performance

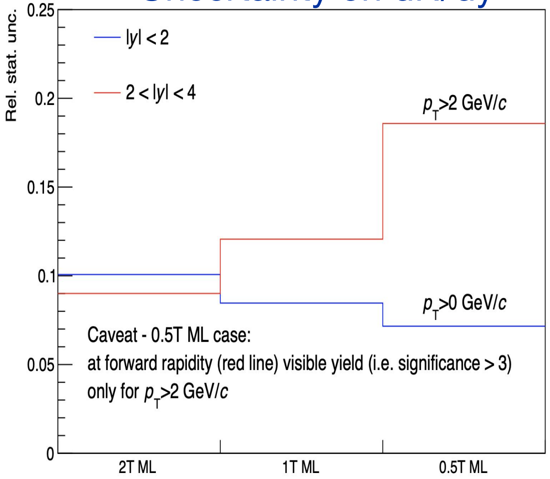
Central rapidity



Forward rapidity



Uncertainty on dN/dy



- Central rapidity precision slightly better with 0.5T wrt 2T: 7% vs 10%
- Forward-y precision much worse (19% vs 9%) and measurement limited to p_T>2 GeV/c (~30% of the yield to be extrapolated)

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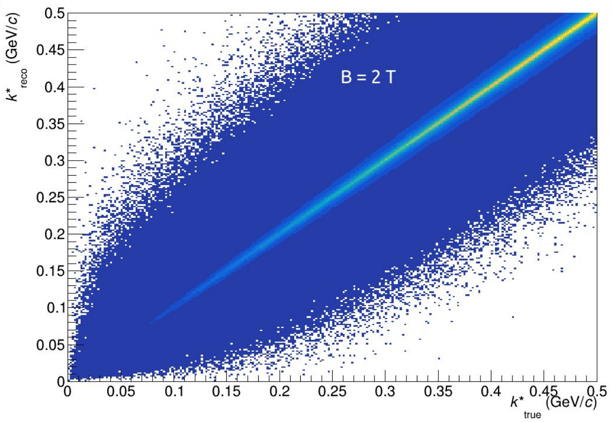
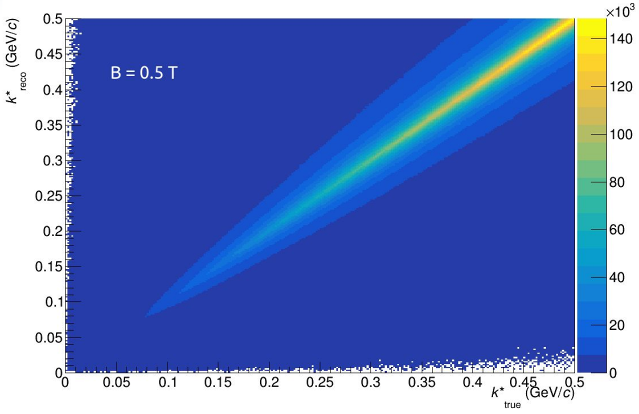
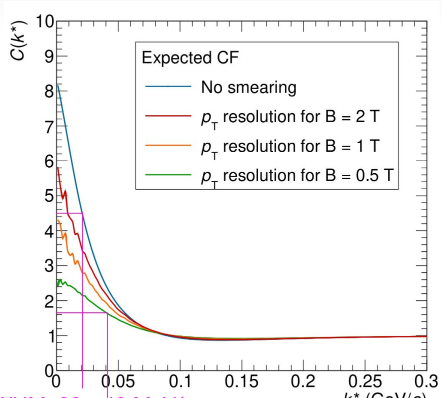
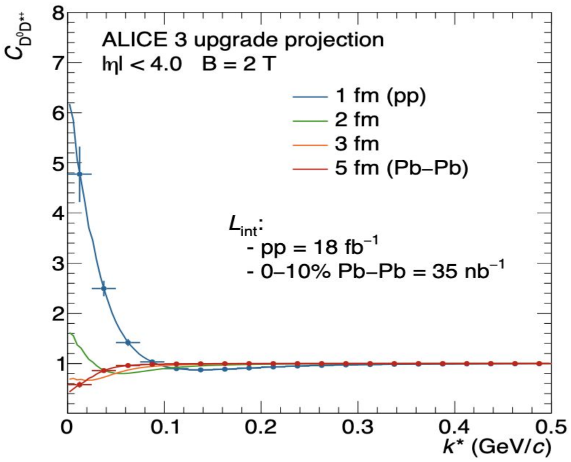
0.5 T: D^0-D^* femtoscopy

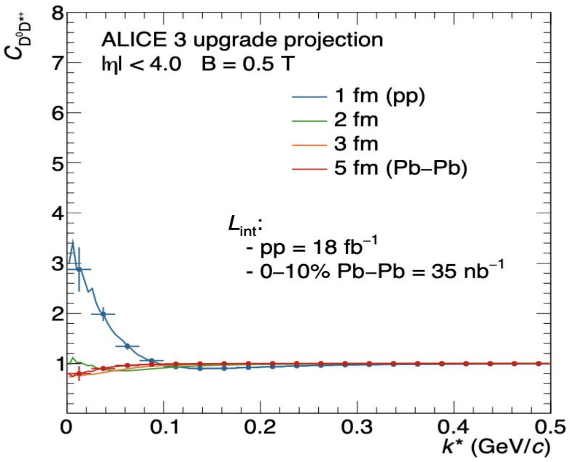






FWHM: 20→40 MeV/c



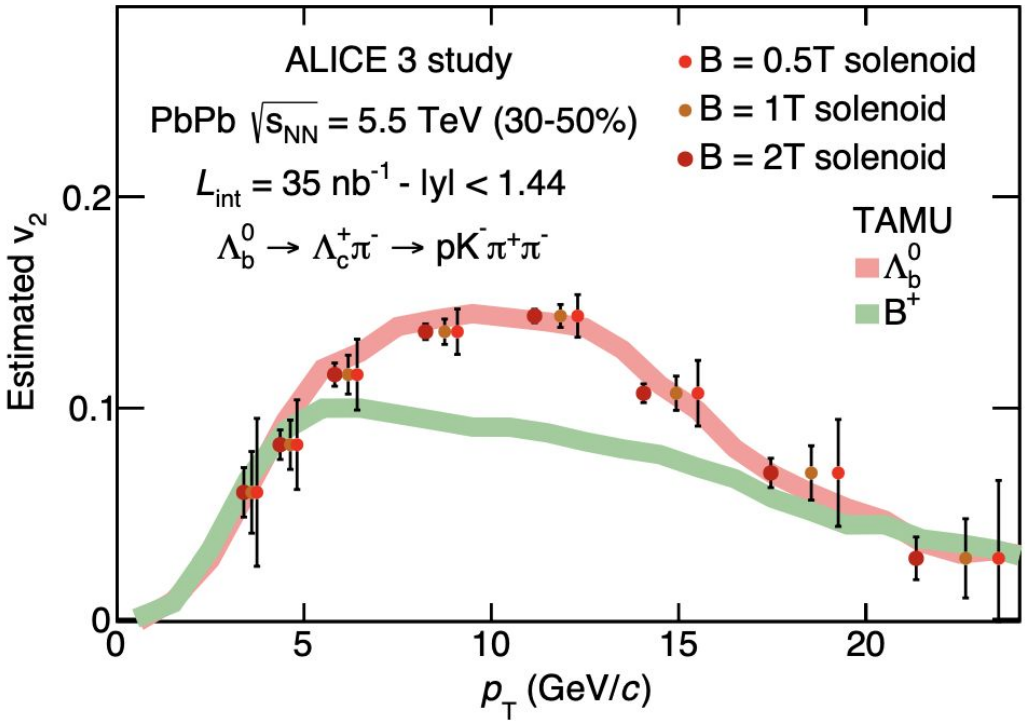


Very diluted *C(k*)* with 0.5T:

- pp *C(k*)* > 1 by only 3σ
- Pb-Pb *C(k*)* not significantly different from 1 → inflection due to possible bound states cannot be resolved

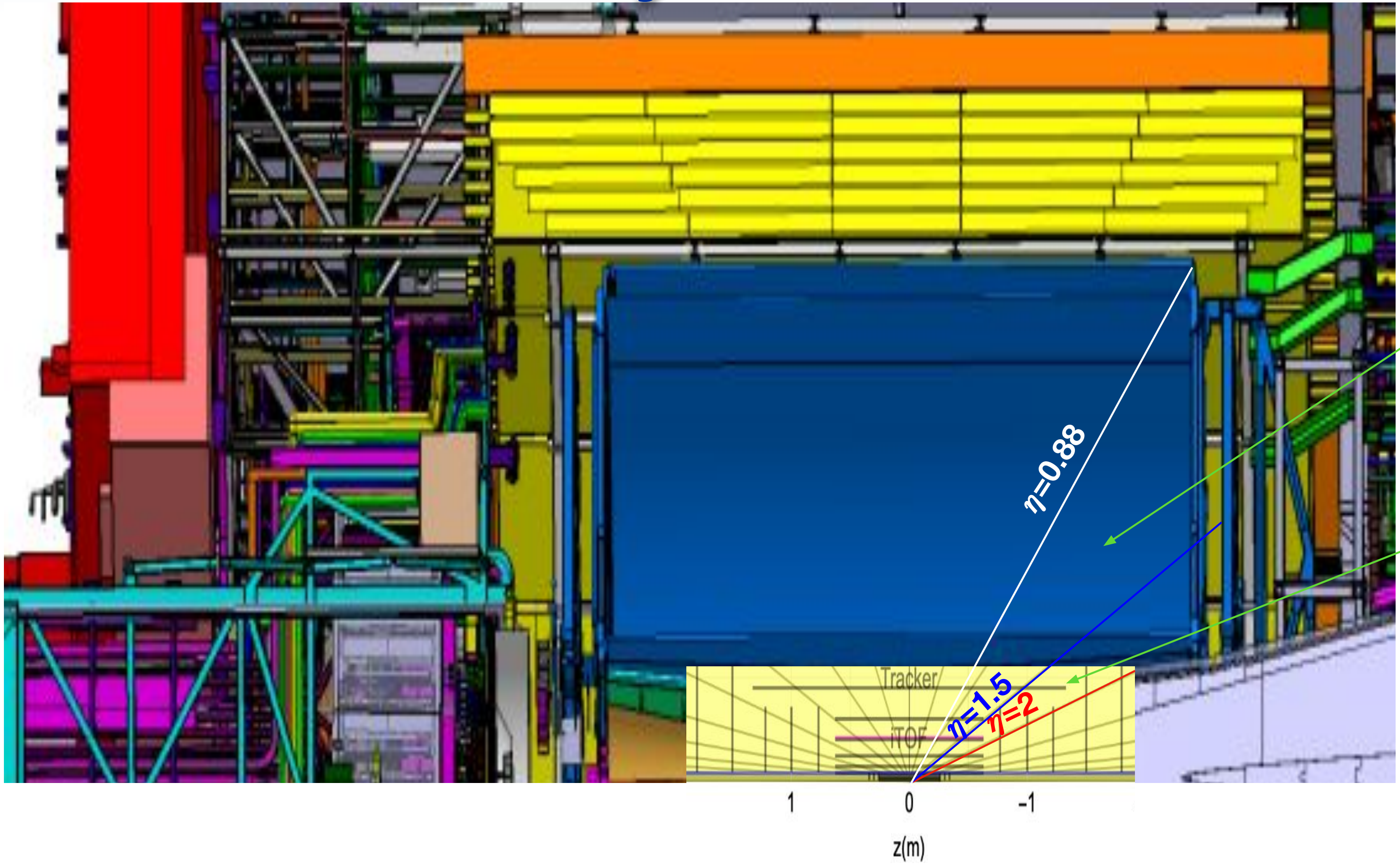
D.Battistini

0.5 T: beauty baryon flow



P.Christakoglou

Layout version 4



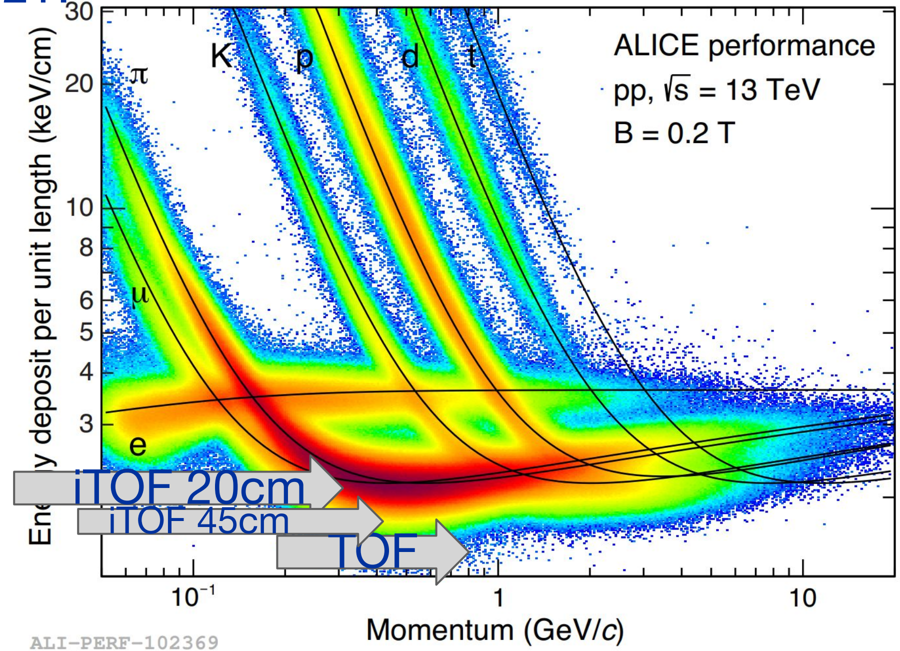
Use this region 0.9<|eta|<1.5 with TPC short tracks+dE/dx?

OT L8 z+-1.3 m covers to |eta|=1.5

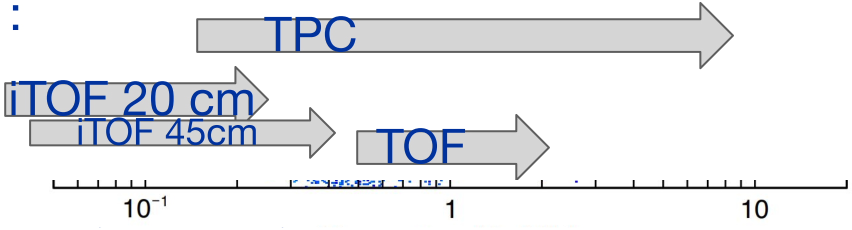
Reaching |eta|=2 requires outer layer z +-1.8 m (difficult?) and no absorber

ALICE 3 v4: Dielectrons and iTOF

0.2T:



0.5T:



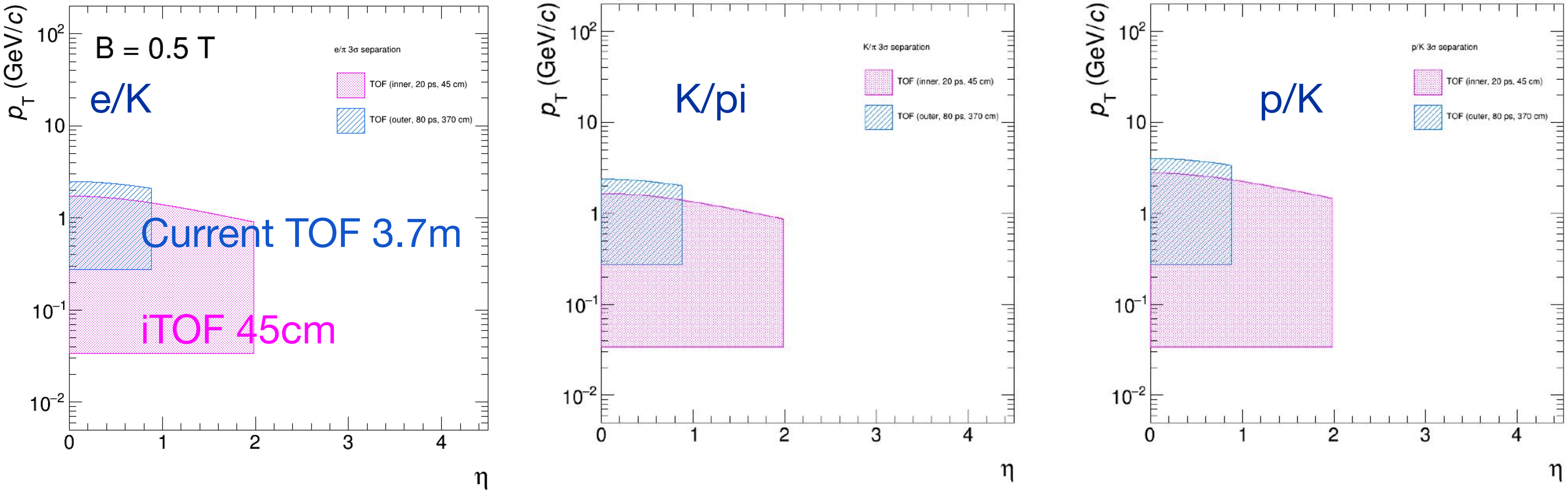
0.2T:

- iTOF extends eID from 60 down to ~10 (?) MeV
- iTOF removes pi band crossing dEdx

0.5T:

- iTOF extends eID from 150 down to ~20 MeV
- iTOF removes pi and K band crossing dEdx
- Dielectron programme at 0.5T? TBC
  - Also with iTOF at R=45cm?

ALICE 3 v4:
iTOF at R=45cm and keep current TOF?



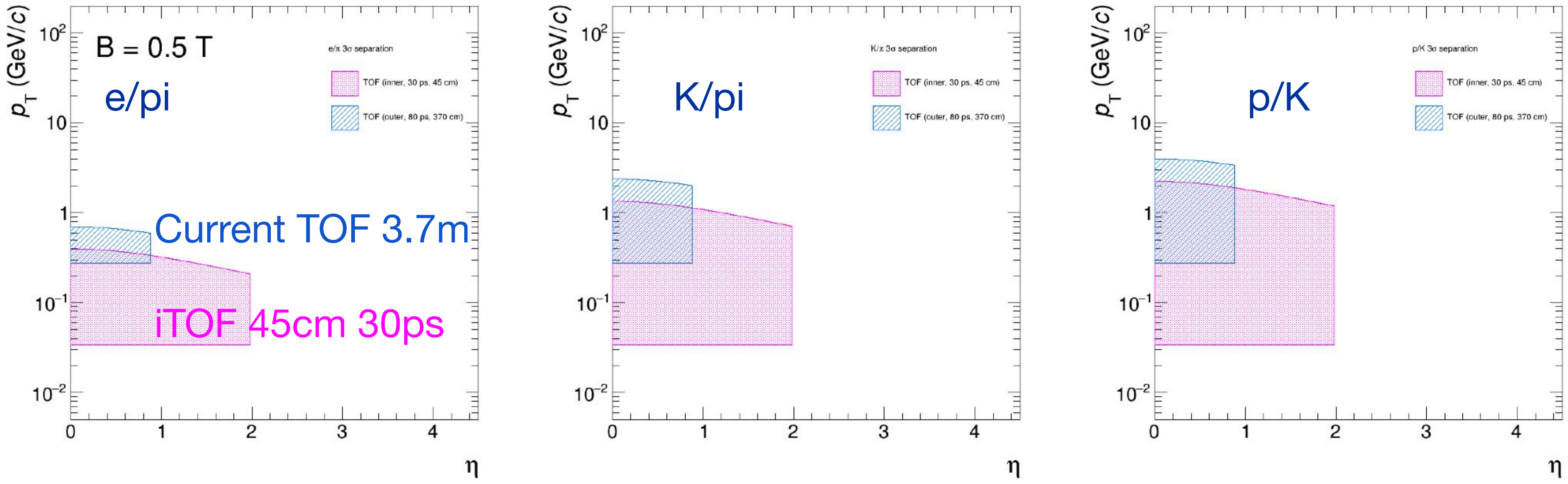
e/pi 35-500 MeV

e/K 35-1.7 GeV

K/pi <1.7 GeV eta=0
<1.2 GeV eta=1.5
Current TOF: < 2.5 GeV

p/K < 2.5 GeV eta = 0
< 2 GeV eta = 1.5
Current TOF: < 4 GeV

ALICE 3 v4:
iTOF at R=45cm and keep current TOF?

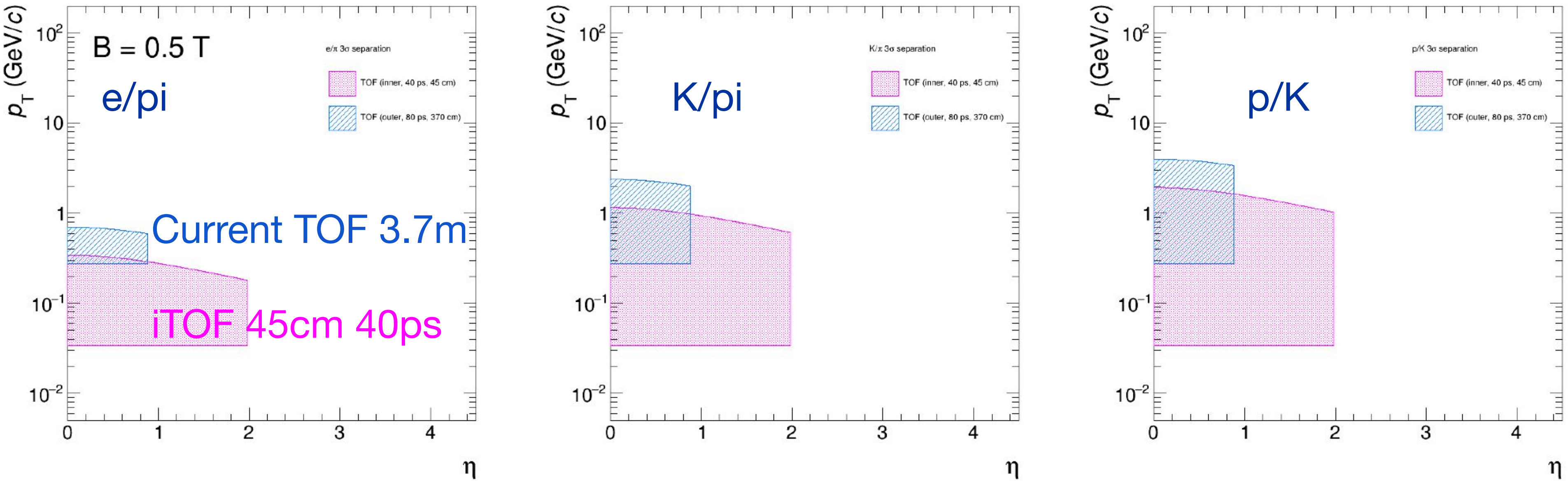


e/pi 35-400 MeV

K/pi <1.3 GeV eta=0
<0.9 GeV eta=1.5
Current TOF: < 2.5 GeV

p/K < 2.2 GeV eta = 0
< 1.5 GeV eta=1.5
Current TOF: < 4 GeV

ALICE 3 v4:
iTOF at R=45cm and keep current TOF?



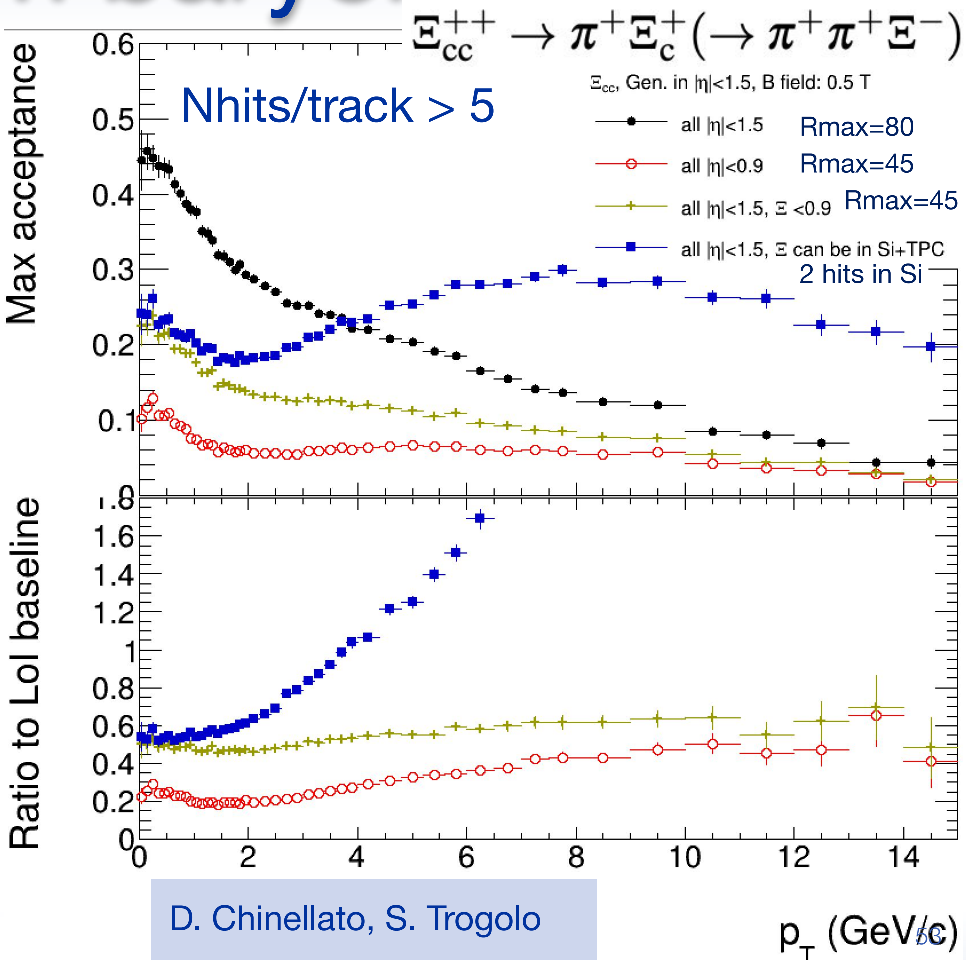
e/pi 35-350 MeV

K/pi <1.1 GeV eta=0
<0.8 GeV eta=1.5
Current TOF: < 2.5 GeV

p/K < 1.9 GeV eta = 0
< 1.3 GeV eta=1.5
Current TOF: < 4 GeV

Multicharm baryons

- Acceptance:
  - reduction by a factor ~5 with |eta|<0.9 and R_{max}=45cm wrt |eta|<1.5 R_{max}=80
  - by a factor ~2 with |eta|<0.9 only for Xi daughters → reduction of significance by ~1.4? (sqrt(2))
  - Increase by a factor up to 3-4 at high p_T when not requiring 6 Si hits for Xi daughters, but only 2 (+TPC)
- p_T res: gain ~ x2 significance from p_T resolution with TPC 4x better than v3 with 0.5T
  - gain: sqrt(2)^(N_masscuts)=sqrt(2)^2=2
- PID ok: with iTOF, TOF and TPC



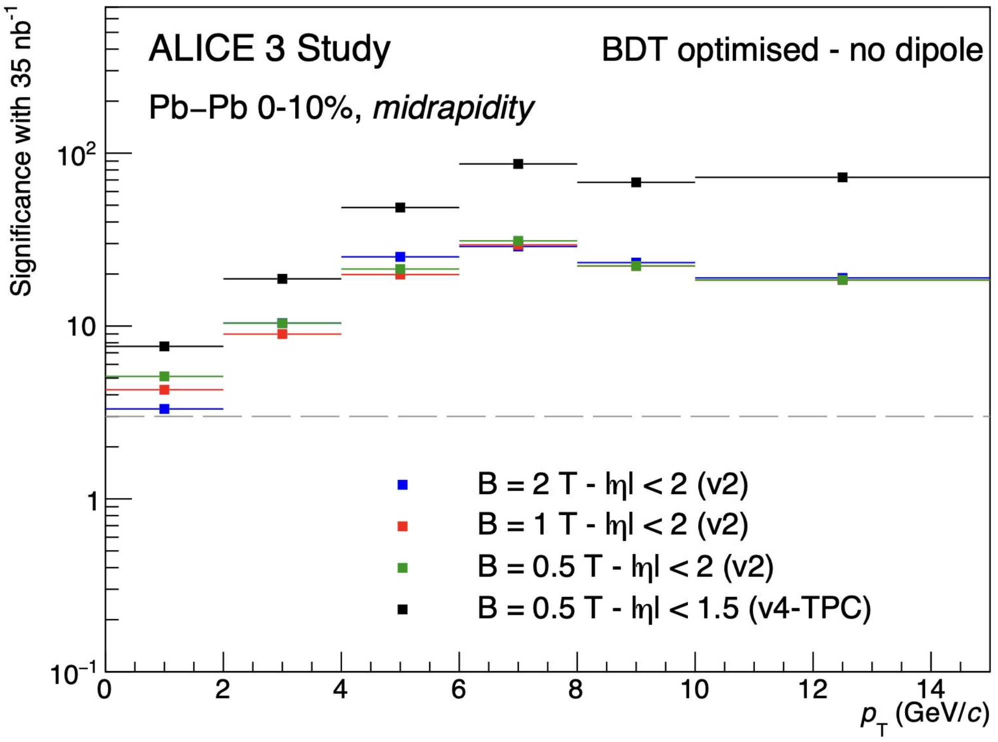
D. Chinellato, S. Trogolo

Multicharm baryons

$$\Xi_{cc}^{++} \rightarrow \pi^+ \Xi_c^+ (\rightarrow \pi^+ \pi^+ \Xi^-)$$

- Acceptance:
  - reduction by a factor ~5 with |eta|<0.9 and R_{max}=45cm wrt |eta|<1.5 R_{max}=80
  - by a factor ~2 with |eta|<0.9 only for Xi daughters → reduction of significance by ~1.4? (sqrt(2))
  - Increase by a factor up to 3-4 at high p_T when not requiring 6 Si hits for Xi daughters, but only 2 (+TPC)
- p_T res: gain ~ x2 significance from p_T resolution with TPC 4x better than v3 with 0.5T
  - gain: sqrt(2)^(N_masscuts)=sqrt(2)^2=2
- PID ok: with iTOF, TOF and TPC
- **Overall increase ~ x2 of significance at low pT < 5 GeV and ~x3 at high p_T**

- pp reference difficult with lower int. rate; also, software triggering may be difficult

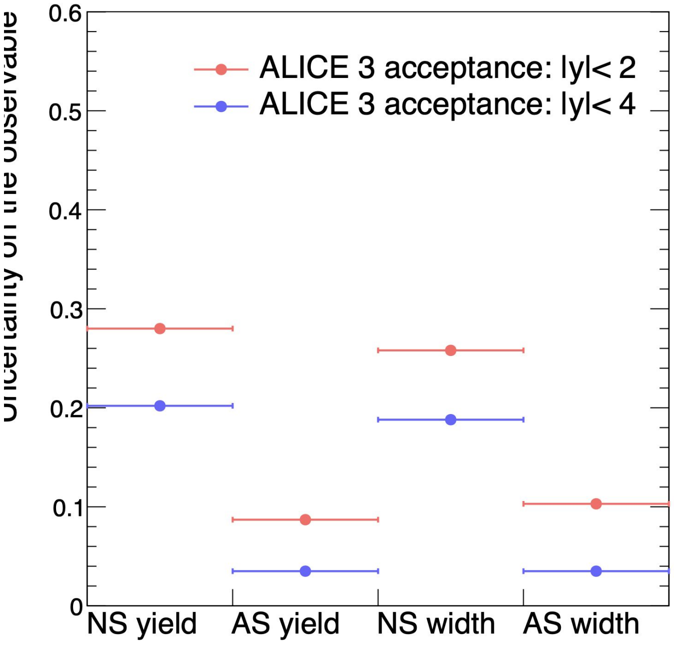


D. Chinellato, S. Trogolo

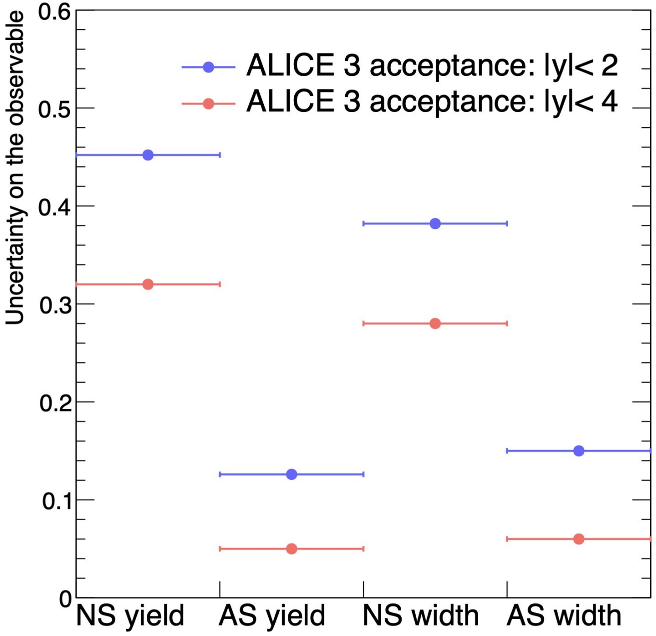
D-Dbar azimuthal correlations

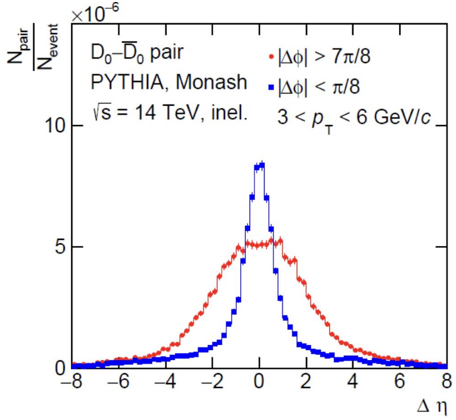
- B=2T: decrease of precision on AS width from 3.5% (|eta|<4) to 10% (|eta|<2)
- B=0.5T: decrease of precision on AS width from 6% (|eta|<4) to 15% (|eta|<2)

B = 2T solenoid



B = 0.5 T





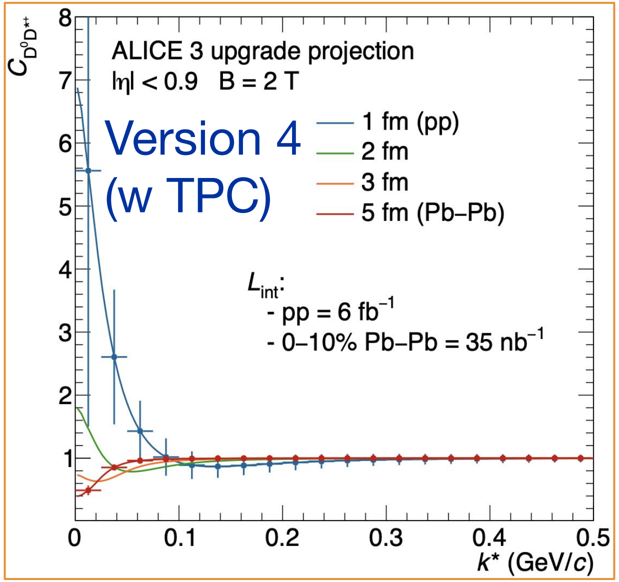
M. Mazzilli

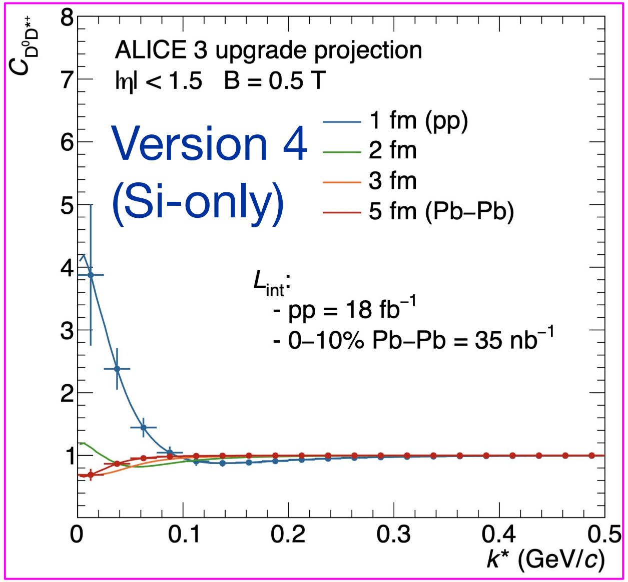
→ Will be repeated for |eta|<0.9 (2T) as proxy for v4: **expect unc >20%**

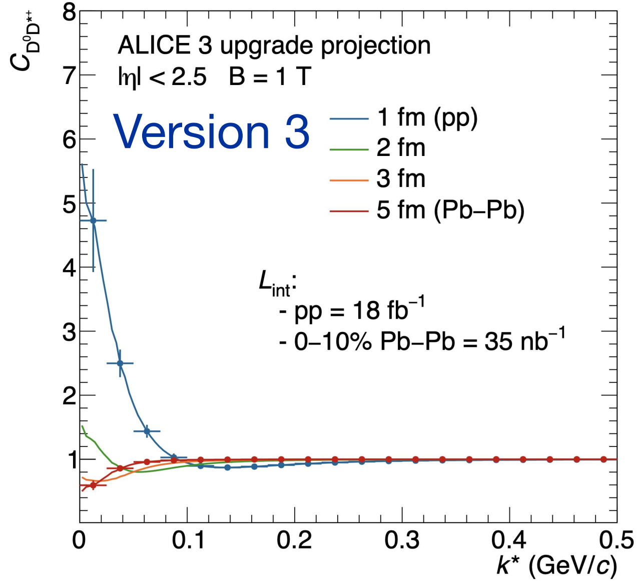
D-D* femtoscopy

- Pb-Pb measurement should be accessible with good precision
- pp measurement is necessary to get small-source baseline
  - |eta|<0.9 with good p_T resolution (used 2T as proxy), but limited to 8 MHz (TBC)
  - OR |eta|<1.5 with poorer p_T resolution (used 0.5T as proxy), and 24 MHz

→ Both much worse than version 3 (even Si-only case has separation from C=1 barely ~3-4 sigma)

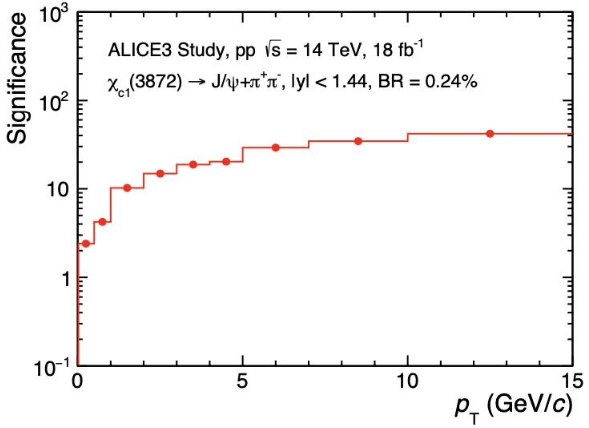


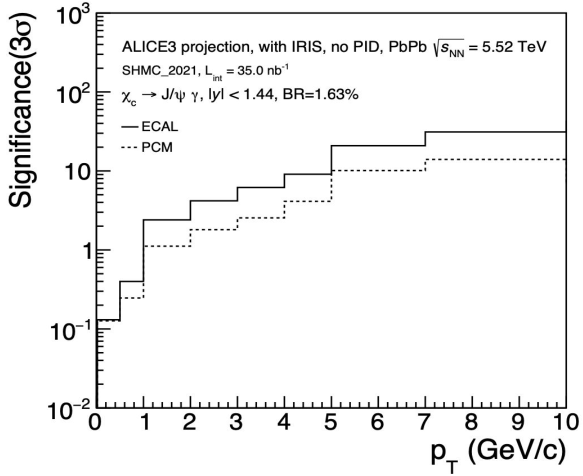




D. Battistini

Charmonia: X(3872) and chi_c1,2





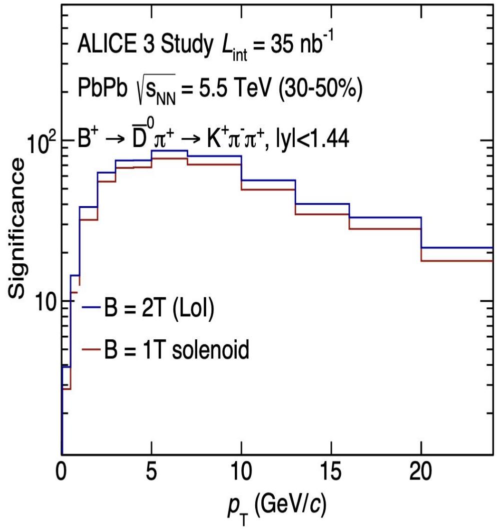
- Jpsi→ee in v4 has similar S/B to Jpsi→mumu in v1, but **lower acceptance |eta|<0.9**

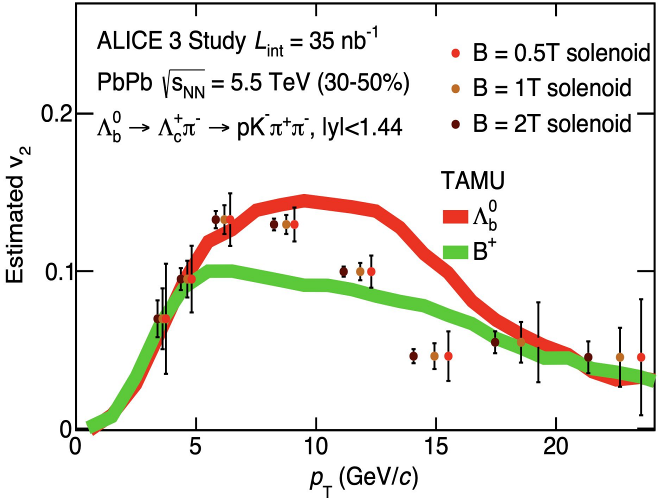
- X(3872) → J/psi + 2pi:
  - Acceptance for the two pions can be similar to this plot (|eta|<1.5), but their pT res. is poorer
  - 18/fb (24 MHz) needed for measurement down to 1 GeV/c
  - **Measurement limited to higher pT with 8 MHz** (or less)

- Chi_c1,2 → J/psi + gamma: probably no gain compared to Run 4 (only L_{int})

Beauty meson and baryon flow

- Performance in |eta|<0.9 could be similar to ALICE 3 v_2 (|y|<1.44) with 1T
  - Better p_T resolution than v2 2T, but smaller acceptance





Version 4 cost (first guess)

- ALICE 3 version 4: total ~50M (+-30% unc)
  - Replace ITS2 with small OT barrel and full IT barrel (~25M)
  - Inner TOF R=45cm? (~10M)
  - L3 consolidation (2M)
  - EPN and disk to run TPC at MHz in pp (10-20M)
  - Common items (15% ~ 8M)
  - Add FCT (~5M)

Operation cost (L3) ~11M