

Magnetic and electric dipole moments of short-lived particles and proposal for their measurements at LHC

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L. Massacrier (IPN), D.Mirarchi (CERN), A. Natochii (LAL, KNU), E. Niel (LAL), S. Redaelli (CERN), P. Robbe (LAL),
W. Scandale (LAL, CERN, INFN), N.F. Shul'ga (KIPT, KhNU)

- Overview

- Short living baryons (Σ , Λ_c , ...)

- ▶ PRINCIPLE OF MEASUREMENT

- ⌚ Spin precession in a bent crystal
 - ⌚ Initial polarisation in double crystal setup (1)
 - ⌚ Optimal crystal orientation for EDM (1)

- ▶ SENSITIVITY STUDIES

- ⌚ Impact on the machine (2)
 - ⌚ Precision on the MDM versus time (1)

- Tau lepton (3)

- ▶ PRINCIPLE OF MEASUREMENT

- ⌚ Initial polarisation
 - ⌚ The idea of the setup

- ▶ SENSITIVITY STUDIES

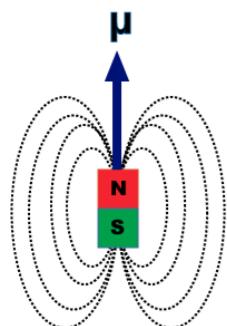
- ⌚ Optimal crystal orientation
 - ⌚ Background filtering
 - ⌚ Precision versus PoT

(1) A.S. Fomin et al., [arXiv:[1909.04654](https://arxiv.org/abs/1909.04654)], submitted to EPJ C [[inSPIRE](#)]

(2) D. Mirarchi et al., [arXiv:[1906.08551](https://arxiv.org/abs/1906.08551)], submitted to EPJ C [[inSPIRE](#)], (PBC FT 2019, [WS on EDM 2019](#))

(3) A.S. Fomin et al., [arXiv:[1810.06699](https://arxiv.org/abs/1810.06699)], JHEP 1903 (2019) 156 [[inSPIRE](#)], ([Channeling 2018](#), [WS on EDM 2019](#))

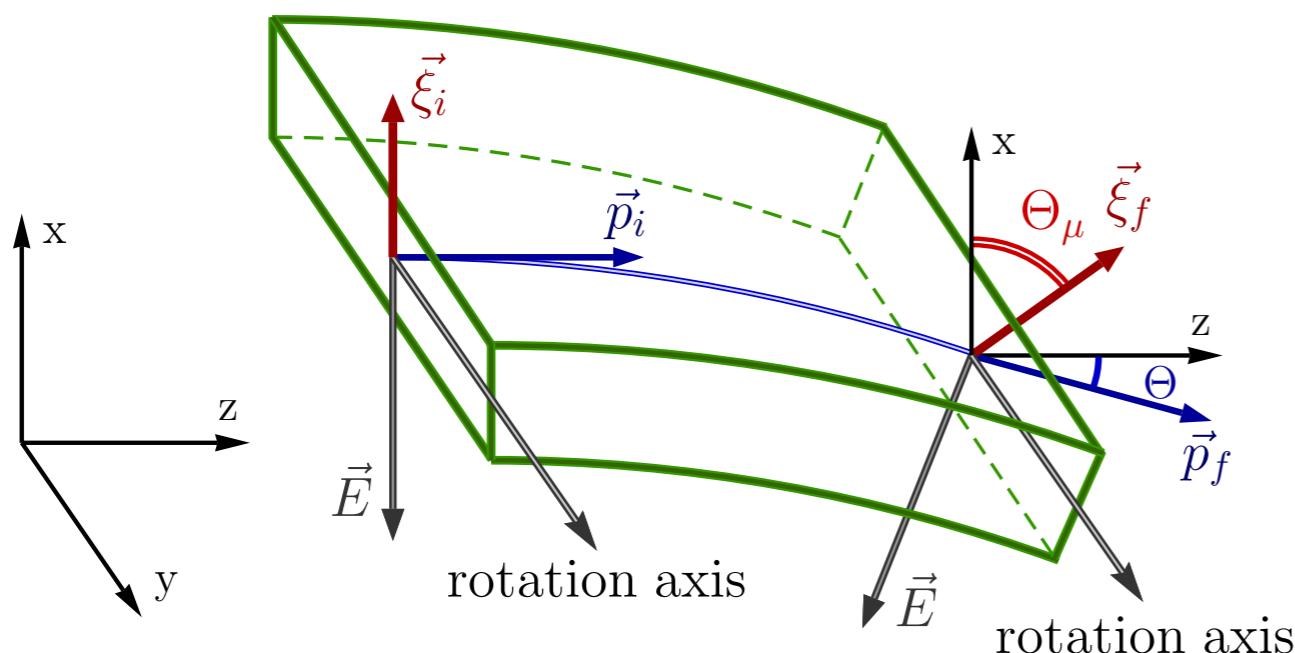
INTRODUCTION: Magnetic dipole moment (MDM) of short-living particles



$$\vec{\mu} = \frac{g}{2} \frac{e}{m} \vec{S}, \quad \vec{S} = \frac{\hbar}{2} \vec{\sigma}$$

$|g| = 2 \rightarrow$ a point-like Dirac particle
 $|g| \approx 2 \rightarrow$ a radiative corrections
 $|g| \neq 2 \rightarrow$ a composite structure or NP

Particle	cτ	g-factor	Comments	Experiment
e ⁻		- 2.002 319 304 361 82 (52)	exp. most accurate determinations of a	Harvard 2008
μ ⁻	659 m	- 2.002 331 8361 (10) - 2.002 331 8418 (13)	theor. SM prediction exp. 3.4 σ deviation	BNL: E821 2006
τ ⁻	87 μm	- 2.002 354 42 (10) - 2.036 (34) - 2.002 (6) no direct measurement	theor. SM prediction exp. σ (e ⁺ e ⁻ → e ⁺ e ⁻ τ ⁺ τ ⁻) exp. assuming EDM _τ = 0 exp. Proposed in arxiv:1810.06699	LEP2: DELPHI 2004 <i>from LEP and SLD 2000</i>
p n		+ 5.585 694 702 (17) - 3.826 085 45 (90)	exp. exp.	
Σ ⁺	2.4 cm	+ 6.233 (25) + 6.1 (12) _{stat} (10) _{syst}	exp. world-average value exp. using Bent Crystals	Fermilab 1990
Λ _c ⁺	60 μm	+ 1.90 (15) not measured	theor. assuming g _c ≈ 2 exp. Feasibility studies at LHC	



$$\Theta_\mu \equiv \angle(\vec{\xi}_i \vec{\xi}_f) = (1 + \gamma \alpha) \Theta$$

$$\alpha = \frac{g - 2}{2}, \quad \Theta = \frac{L}{R}$$

$\vec{\xi}_i, \vec{\xi}_f$ – initial and final polarisations of Λ_c (before and after the crystal)

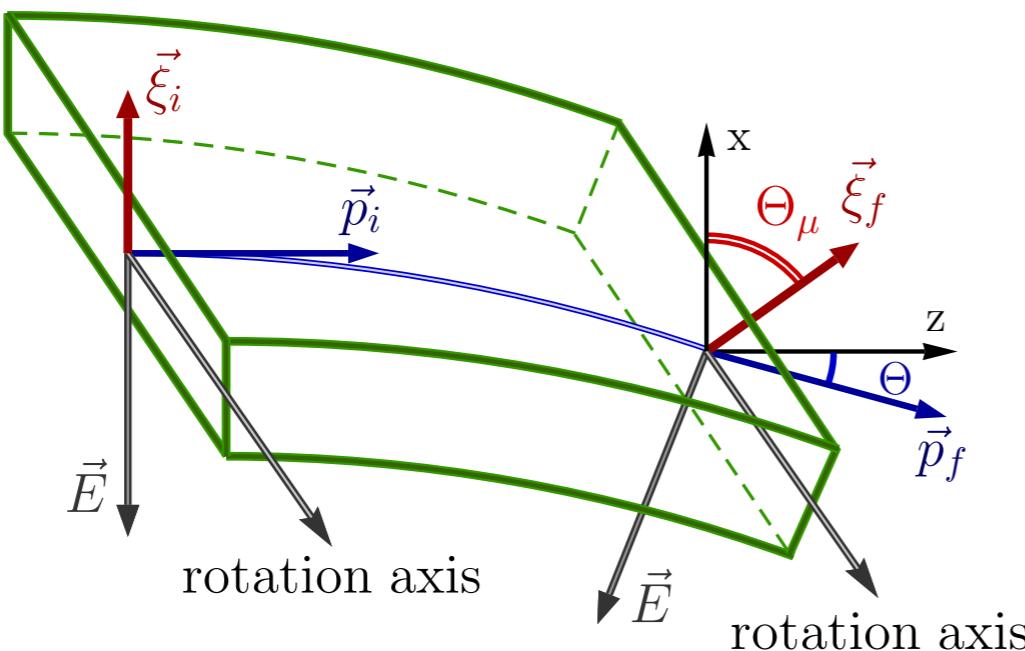
γ, g, α – Lorentz factor, g -factor, anomalous MDM of Λ_c

Θ, L, R – deflecting angle, length, curvature radius of the crystal

V.G. Baryshevsky, Sov. Tech. Phys. Lett. 5 (1979) 73.

V.L. Lyuboshits, Sov. J. Nucl. Phys. 31 (1980) 509 [[inSPIRE](#)].

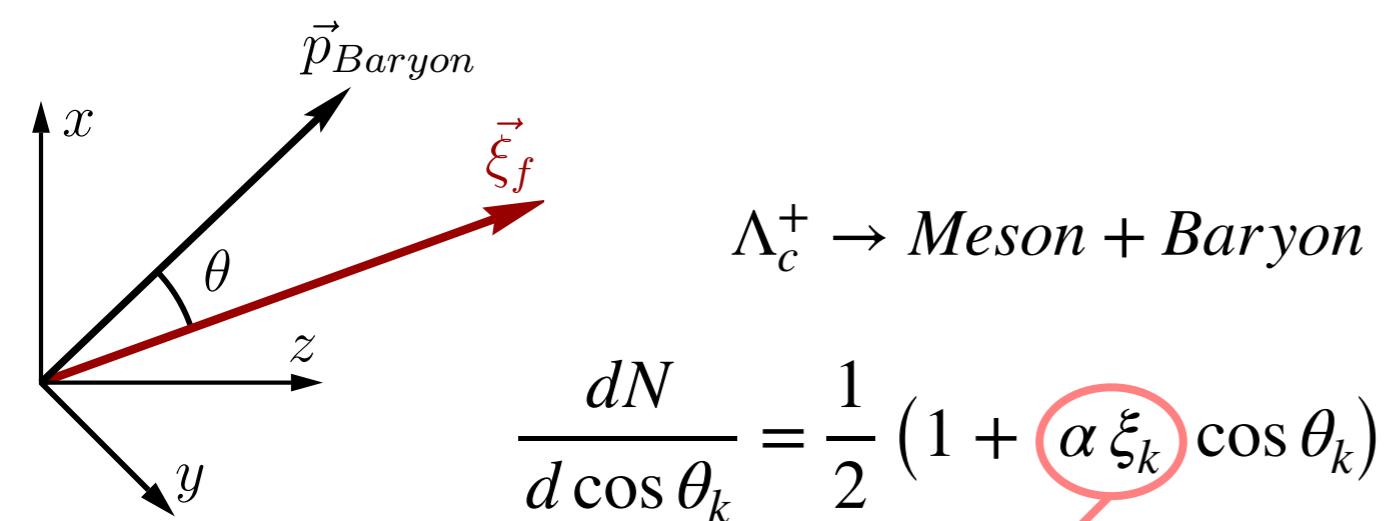
PRINCIPLE OF MEASUREMENT: Magnetic dipole moment (MDM) of short-living particles



$$\Theta_\mu \equiv \angle(\xi_i \xi_f) = (1 + \gamma a) \Theta$$

$$\vec{\xi}_i = \xi (1, 0, 0)$$

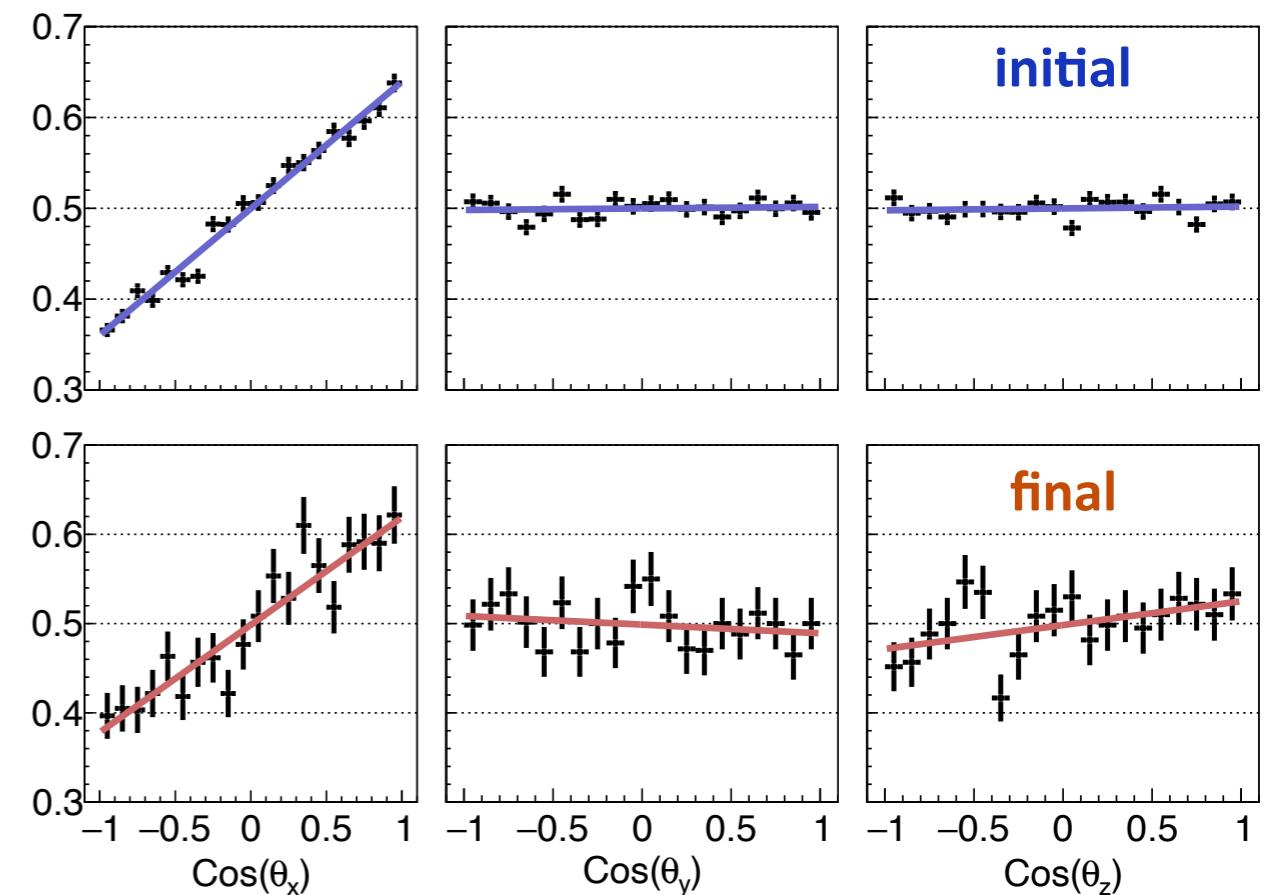
$$\vec{\xi}_f = \xi (\cos \Theta_\mu, 0, \sin \Theta_\mu)$$



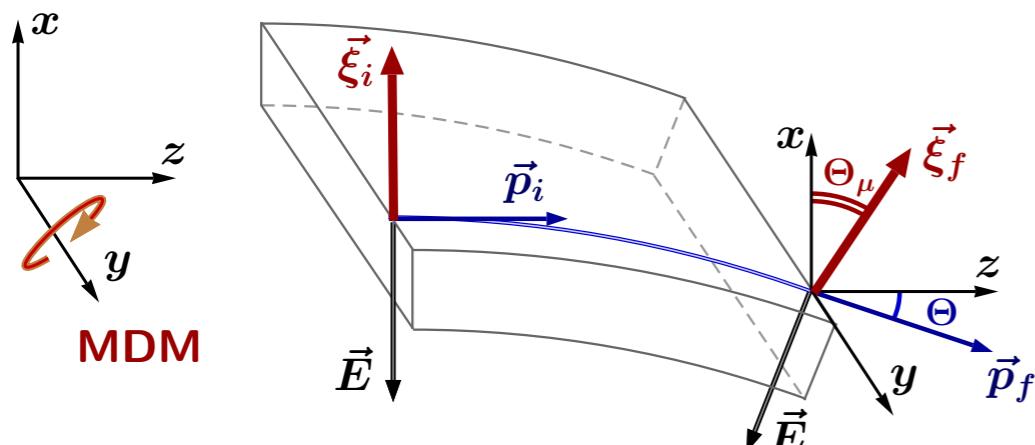
$$b \equiv \alpha \xi \Theta_\mu \quad \Delta b = \sqrt{\frac{3}{N}}$$

$\xi \neq 0$ – Λ_c polarisation at the production

$\alpha \neq 0$ – reveals polarisation at the decay



PRINCIPLE OF MEASUREMENT: Magnetic and electric dipole moments of short-living particles

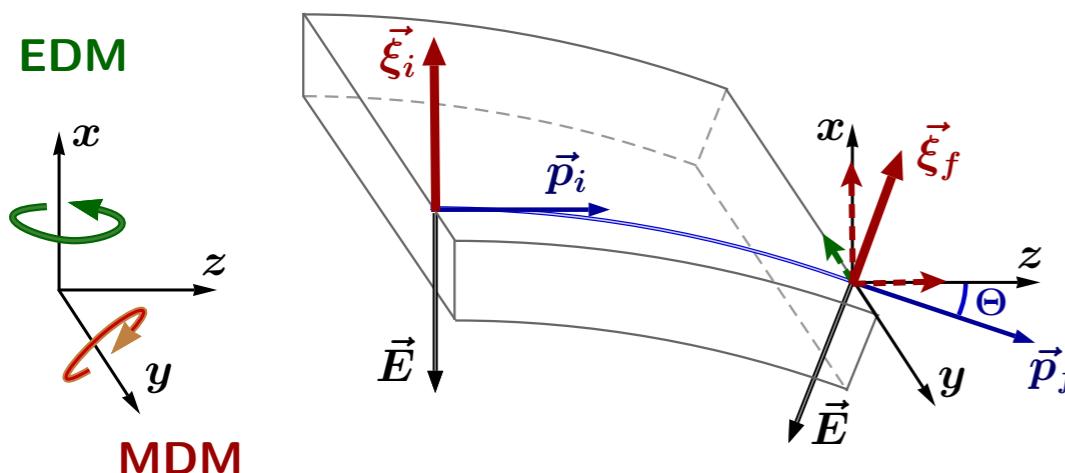


$$\Theta_\mu \equiv \angle(\vec{\xi}_i \vec{\xi}_f) = (1 + \gamma a) \Theta$$

V.G. Baryshevsky,
Sov. Tech. Phys. Lett. 5 (1979) 73.

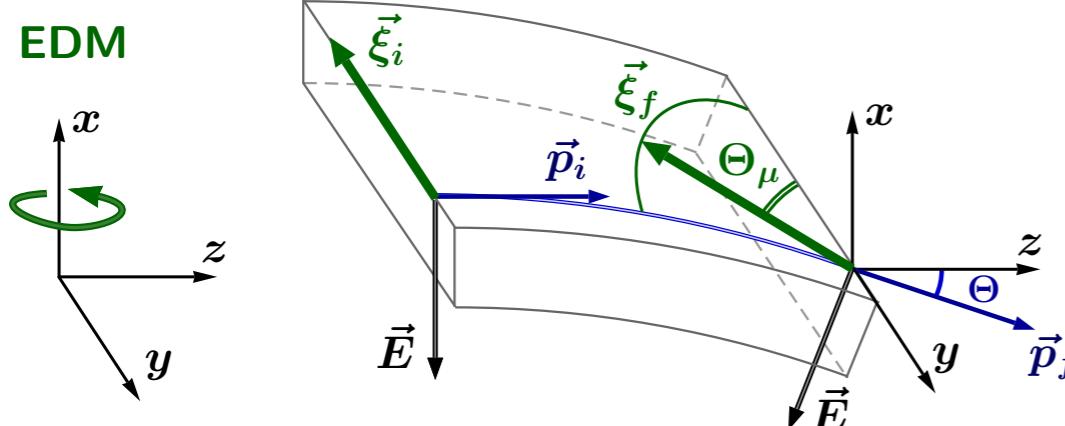
$$\Delta g = \frac{2}{\alpha \langle \xi_x \gamma \rangle \Theta} \sqrt{\frac{3}{N}}$$

V.L. Lyuboshits,
Sov. J. Nucl. Phys. 31 (1980) 509
[inSPIRE].



$$\frac{\Delta f}{\Delta g} = \frac{2 \gamma a}{\Theta (1 + \gamma a)^2}$$

F. J. Botella et al.,
EPJ C77 (2017) 181 [inSPIRE]



$$\Theta_d \equiv \angle(\vec{\xi}_i \vec{\xi}_f) = (1 + \gamma f) \Theta$$

V.G. Baryshevsky,
EPJ C79 (2019) 350 [inSPIRE]

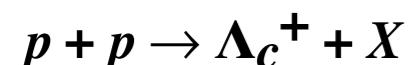
$$\Delta f = \frac{2}{\alpha \langle \xi_y \gamma \rangle \Theta} \sqrt{\frac{3}{N}}$$

A.S. Fomin et al.,
arXiv:1909.04654 [hep-ph]

PRINCIPLE OF MEASUREMENT: Initial polarisation of Λ_c baryon

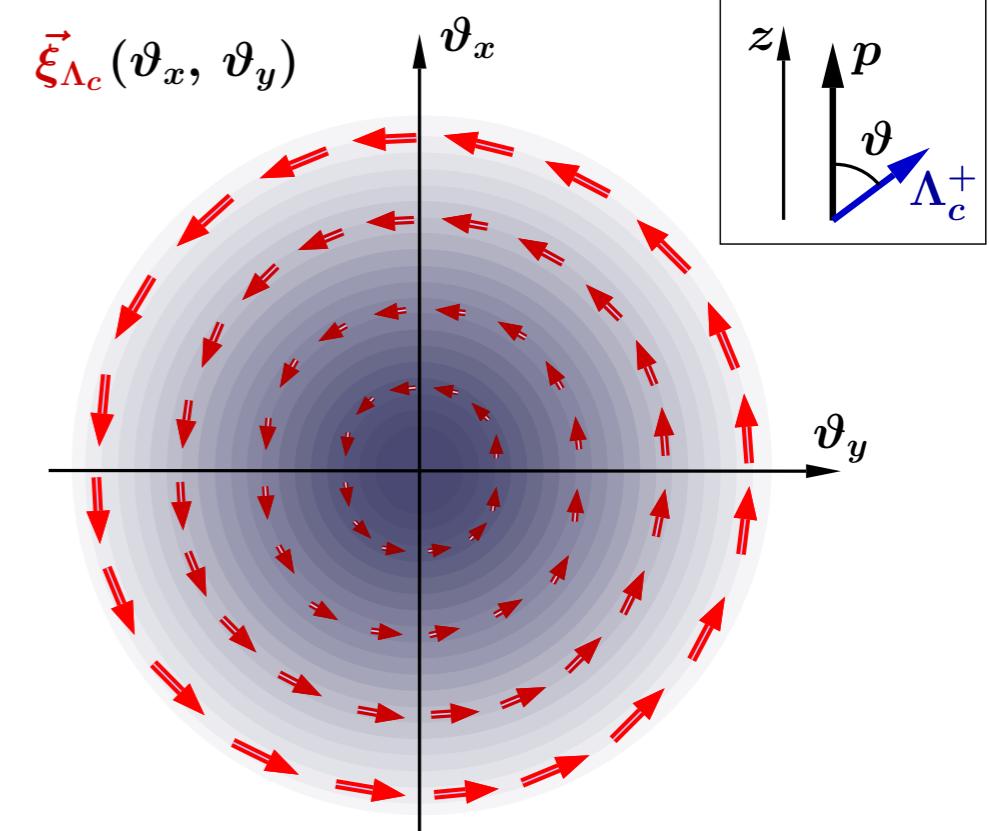


A.S. Fomin, S. Barsuk, A.Yu. Korchin, V.A. Kovalchuk, E. Kou, M. Liul, A. Natochii, E. Niel, P. Robbe, A. Stocchi,
[arXiv:1909.04654 \[hep-ph\]](https://arxiv.org/abs/1909.04654), (submitted to EPJ C)



due to the space-inversion symmetry of the strong interaction

polarisation vector $\vec{\xi}$ of Λ_c^+ is perpendicular to the reaction plane



Λ_c^+ distribution over transverse momentum (Pythia 8.243)

Λ_c^+ initial polarisation as a function of transverse momentum

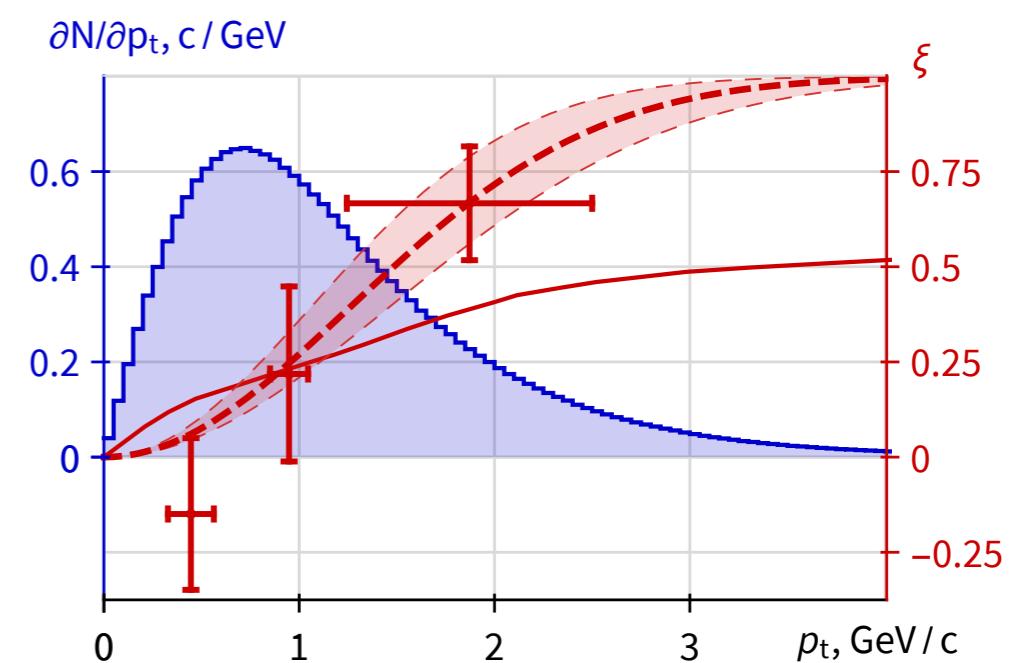
$$|\xi| = 1 - e^{-\frac{p_t^2}{2 \langle p_t^2 \rangle}}$$



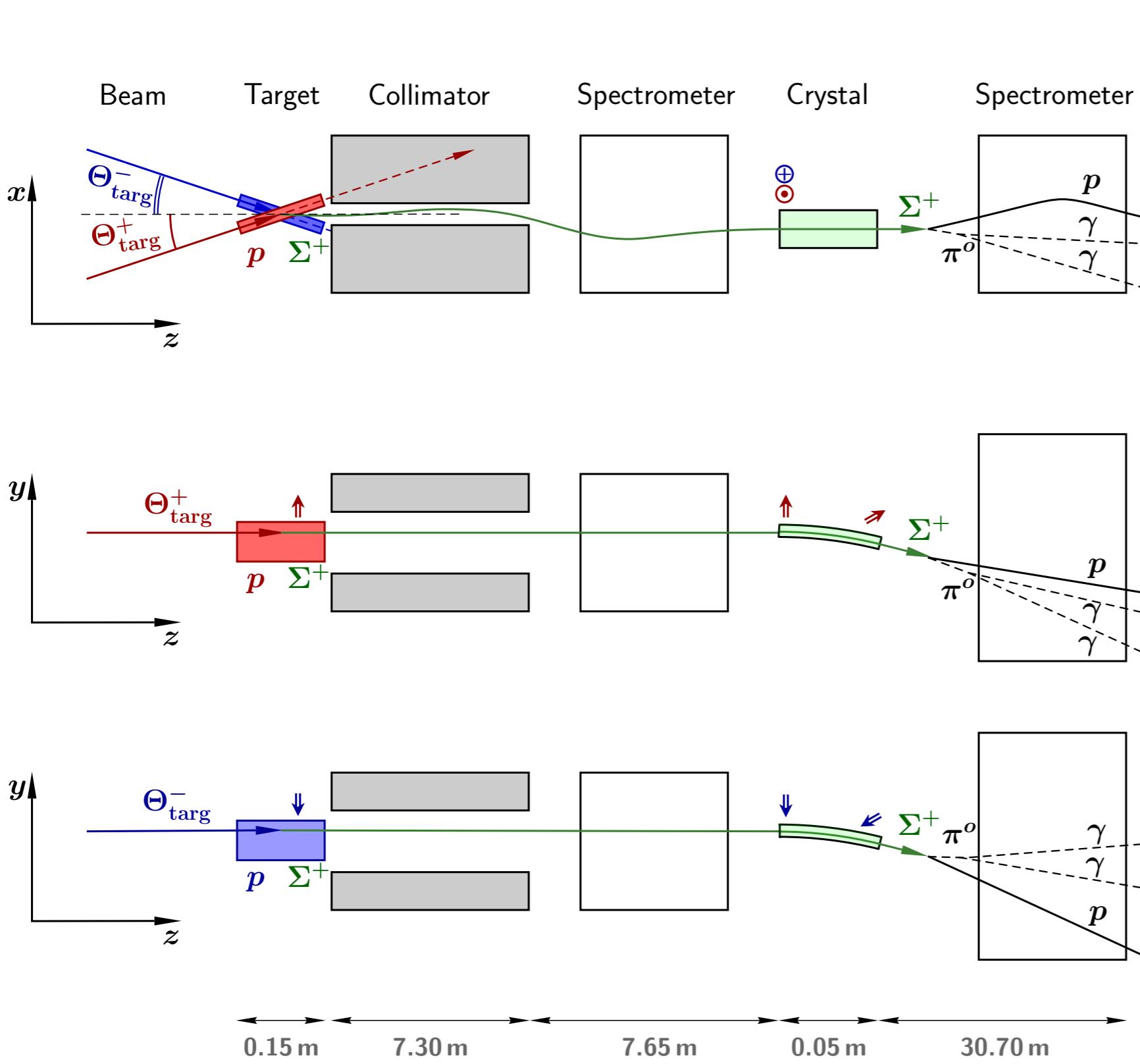
E791 collaboration, Phys. Lett. B 471 (2000) [[inSPIRE](https://inspirehep.net/search?p=find+EPRINT+hep-ph/0001187)]



G.R. Goldstein, hep-ph/0001187 (2000) [[inSPIRE](https://inspirehep.net/search?p=find+EPRINT+hep-ph/0001187)]



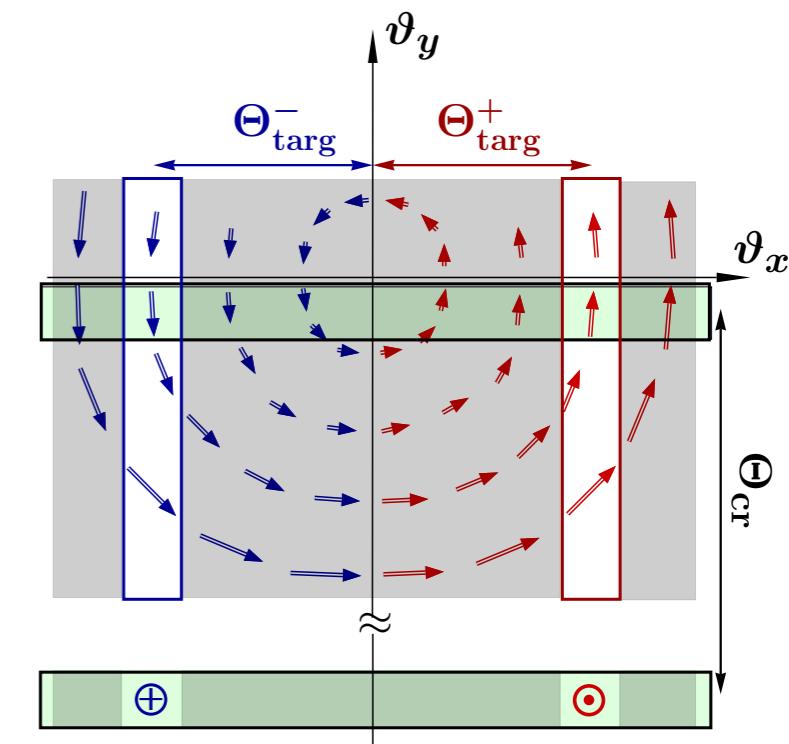
D. Chen, [The Measurement of the Magnetic Moment of \$\Sigma^+\$ Using Channeling in Bent Crystals, PhD thesis, SUNY, Albany, 1992.](#)



$$N_j^+ \equiv \frac{dN_j^+}{N_{0j}^+ d \cos \vartheta_j} = \frac{Aj(\vartheta_j, \dots)}{2} (1 - \alpha \xi_j^+ \cos \vartheta_j)$$

Cancelation of apparatus biases (Aj)

$$\frac{N_j^+ - N_j^-}{N_j^+ + N_j^-} = \alpha \xi_j^+ \cos \vartheta_j$$



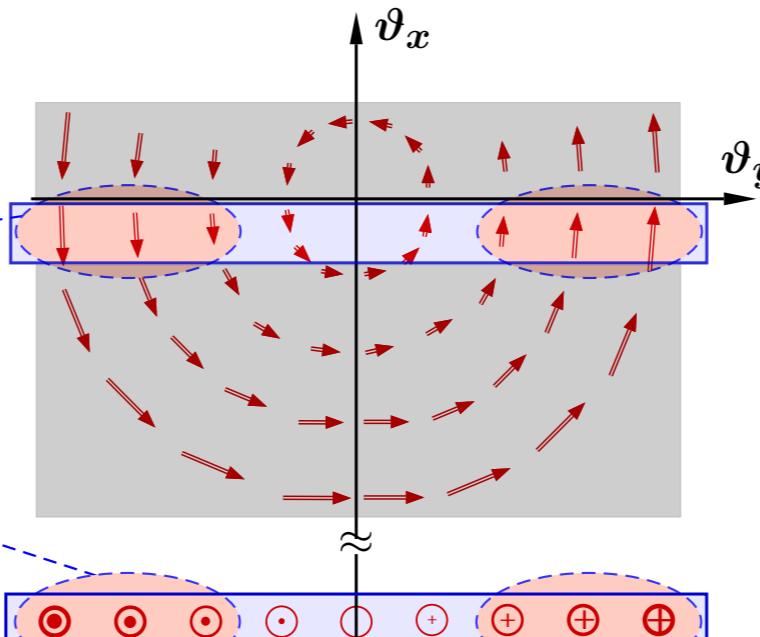
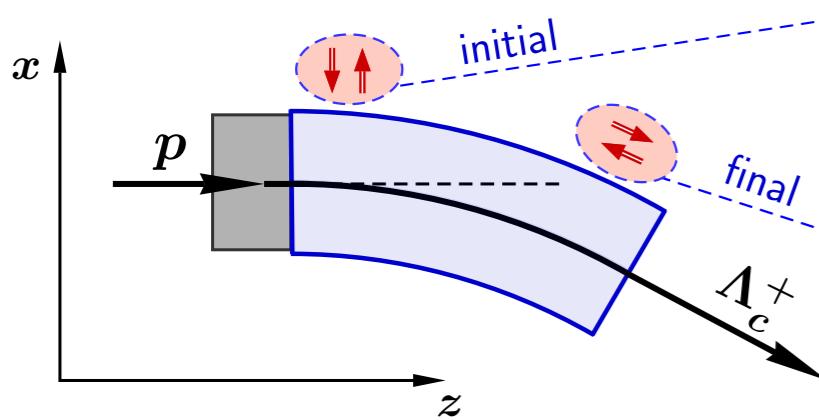
PRINCIPLE OF MEASUREMENT: Optimal crystal orientation for EDM measurement



A.S. Fomin, S. Barsuk, A.Yu. Korchin, V.A. Kovalchuk, E. Kou, M. Liul, A. Natochii, E. Niel, P. Robbe, A. Stocchi, et al.,
[arXiv:1909.04654 \[hep-ph\]](https://arxiv.org/abs/1909.04654), (submitted to EPJ C)

Optimal for MDM measurement

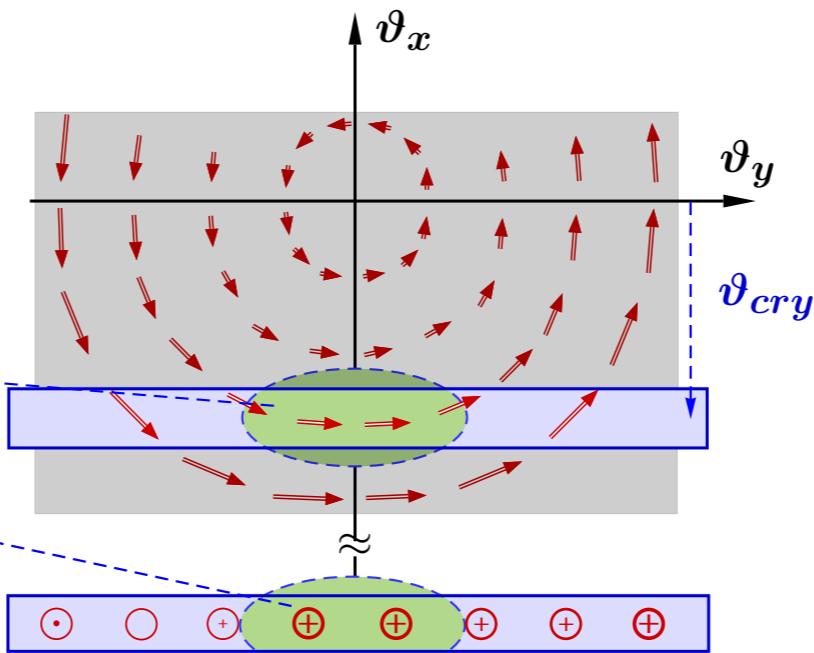
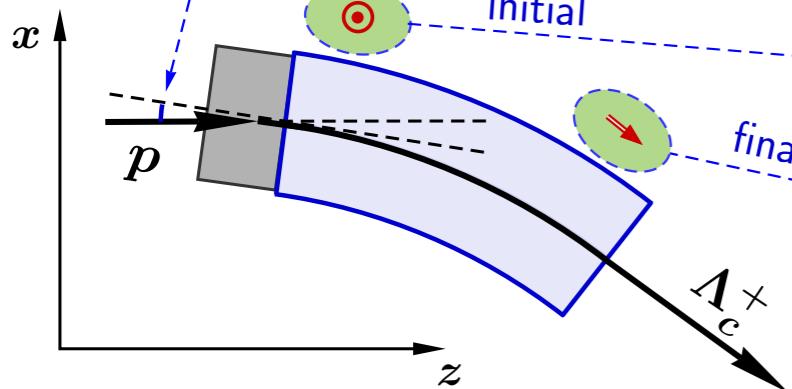
$$(\vartheta_{crys} \sim 0)$$



$$\Delta g = \frac{2}{\alpha \langle \xi_x \gamma \rangle \Theta} \sqrt{\frac{3}{N}}$$

Optimal for EDM measurement

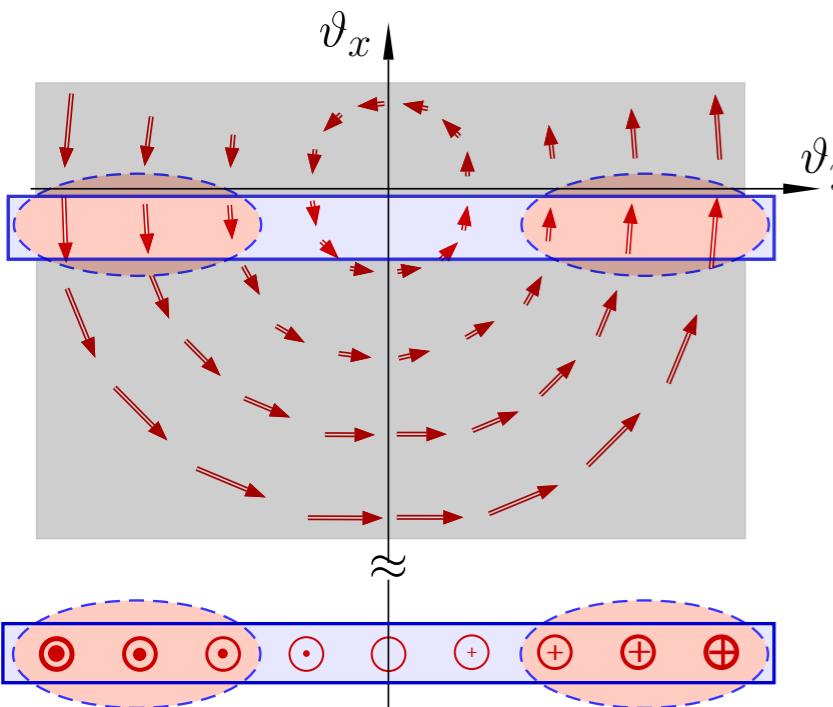
$$(\vartheta_{crys} \sim 0.4\text{--}0.9 \text{ mrad})$$



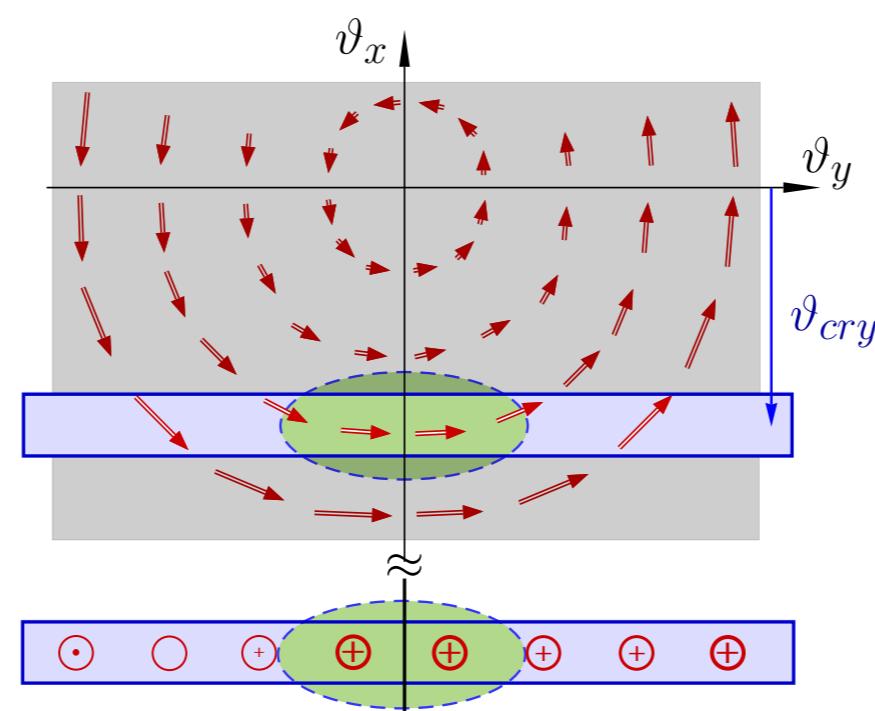
$$\Delta f = \frac{2}{\alpha \langle \xi_y \gamma \rangle \Theta} \sqrt{\frac{3}{N}}$$

PRINCIPLE OF MEASUREMENT: Optimal crystal orientation for EDM measurement

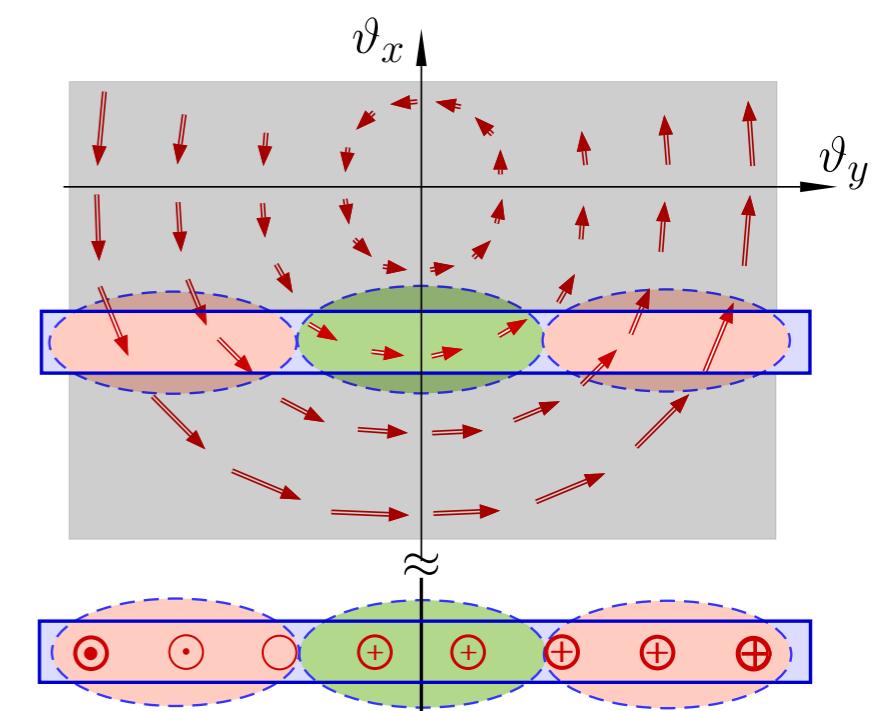
Optimal for MDM measurement



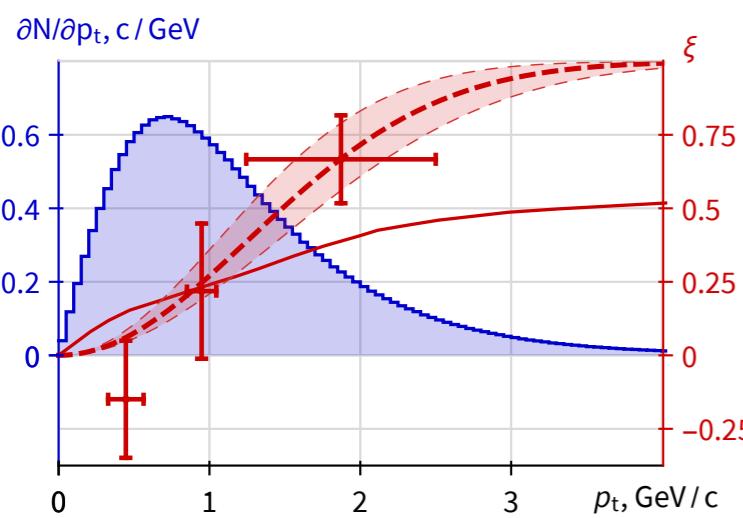
Optimal for EDM measurement



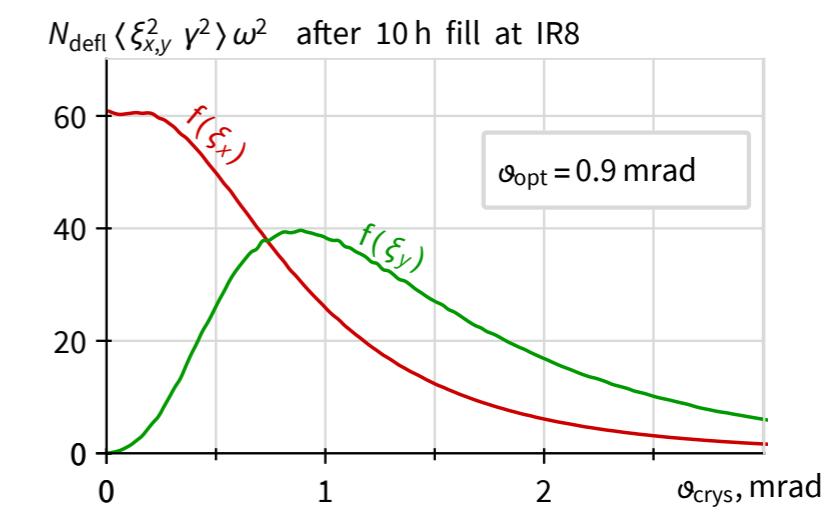
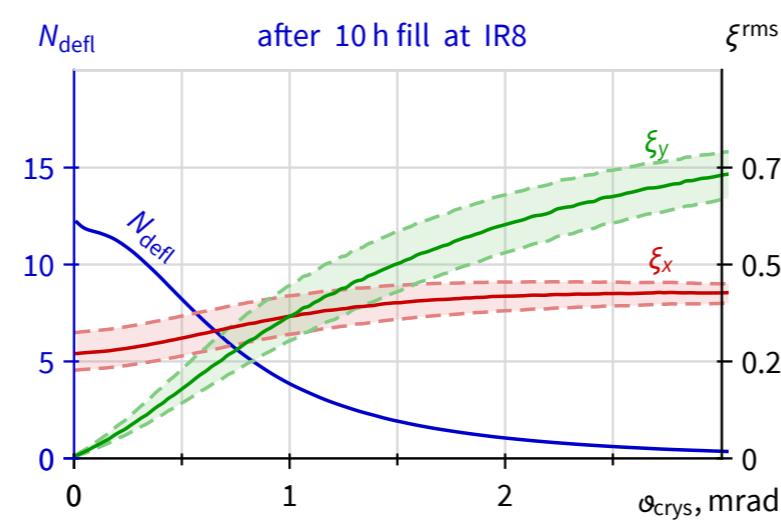
Simultaneous measurement



Quantitative analysis



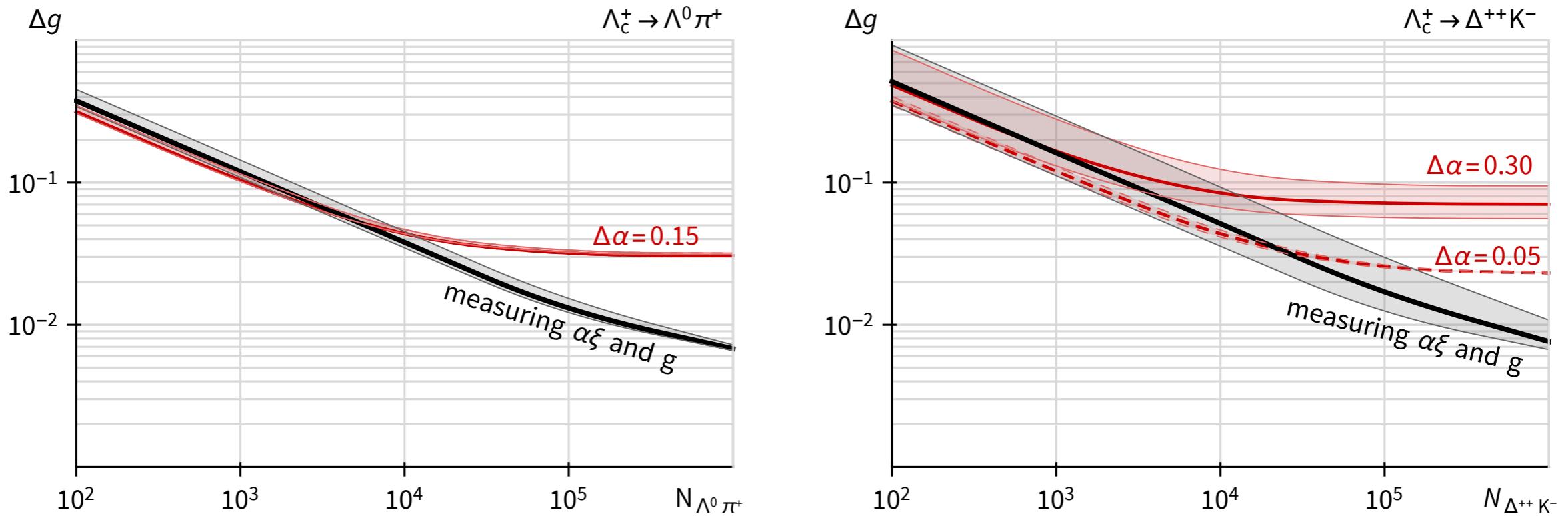
Initial polarisation
of deflected Λ_c^+



$$\Delta g = \frac{2}{\alpha \langle \xi \gamma \rangle \Theta} \sqrt{\frac{3}{N}}$$

SENSITIVITY STUDIES: Precision of MDM versus number of registered events.

A.S. Fomin, S. Barsuk, A.Yu. Korchin, V.A. Kovalchuk, E. Kou, M. Liul, A. Natochii, E. Niel, P. Robbe, A. Stocchi, et al.,
[arXiv:1909.04654 \[hep-ph\]](https://arxiv.org/abs/1909.04654), (submitted to EPJ C)



- 1) use pre-measured values of $\alpha \cdot \xi$ factor
- 2) measure $\alpha \cdot \xi$ and g -factor simultaneously

$$\frac{dN}{d \cos \theta_z} = \frac{1}{2} \left(1 + \alpha \xi_z \cos \Theta_\mu \cos \theta_z \right)$$

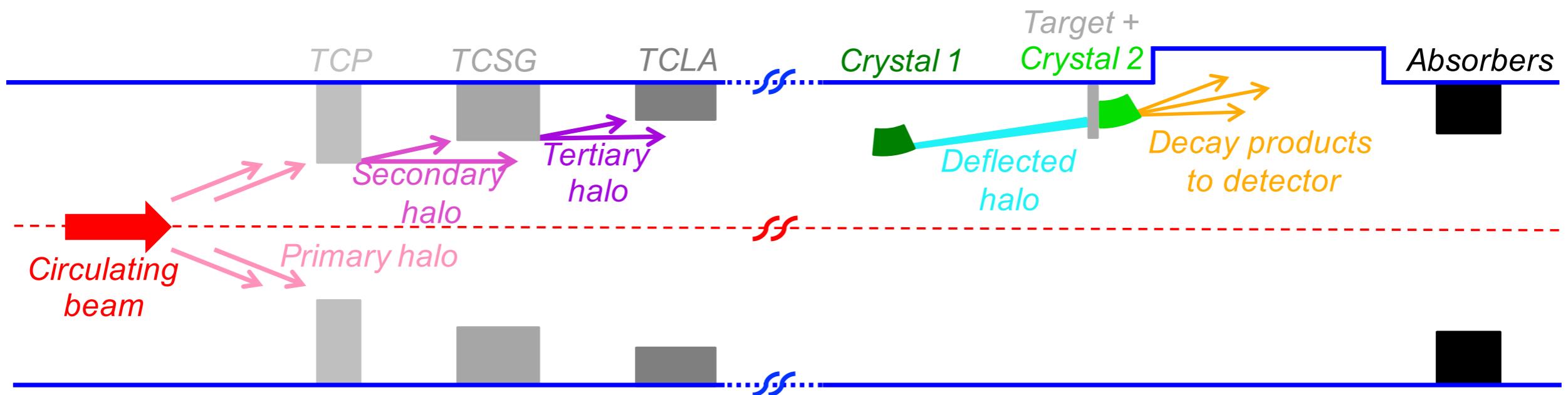
$$\frac{dN}{d \cos \theta_x} = \frac{1}{2} \left(1 + \alpha \xi_x \sin \Theta_\mu \cos \theta_x \right)$$

Decay channel	Branching ratio	Weak decay parameter α	Detector efficiency*		Weight $(\Delta g / \Delta g_j)^2$
			IR3	IR8	
$\Lambda_c^+ \rightarrow p K^*(892)$	1.96(27)	0.66(28)	0.2	0.2	~ 0.60
$\Lambda_c^+ \rightarrow \Delta^{++}(1232) K^-$	1.08(25)	-0.67(30)	0.2	0.2	~ 0.35
$\Lambda_c^+ \rightarrow \Lambda(p\pi^-) \pi^+$	0.83(5)	0.91(15)	0.02	0.004	0.01–0.05
$\Lambda_c^+ \rightarrow \Lambda(1520) \pi^+$	2.20(5)	-0.11(60)	0.2	0.2	0.02

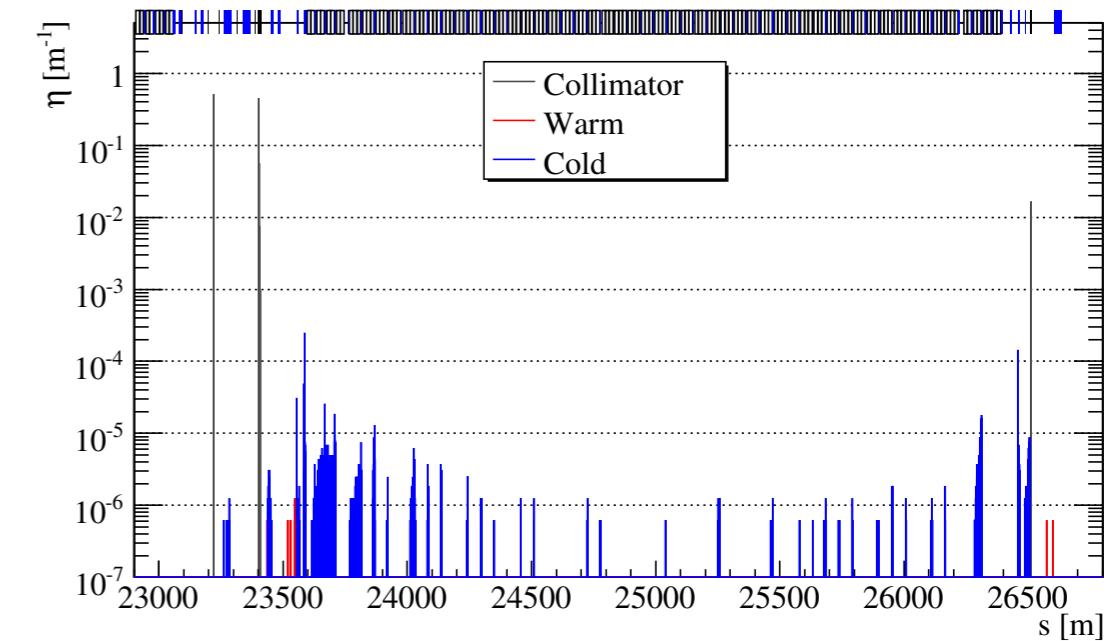
* E. Bagli et al., EPJ C77 (2017) no.12, 828 [[inSPIRE](#)]

SENSITIVITY STUDIES: Layouts for EMDM experiments at LHC

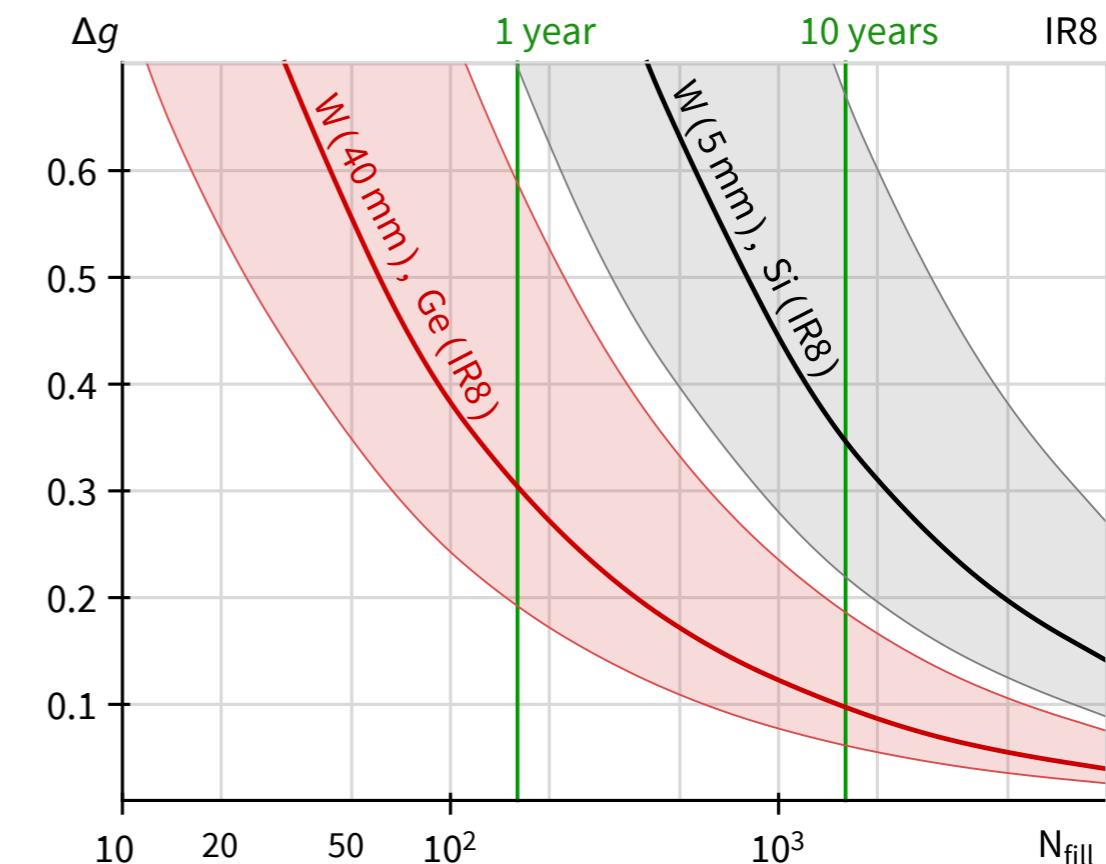
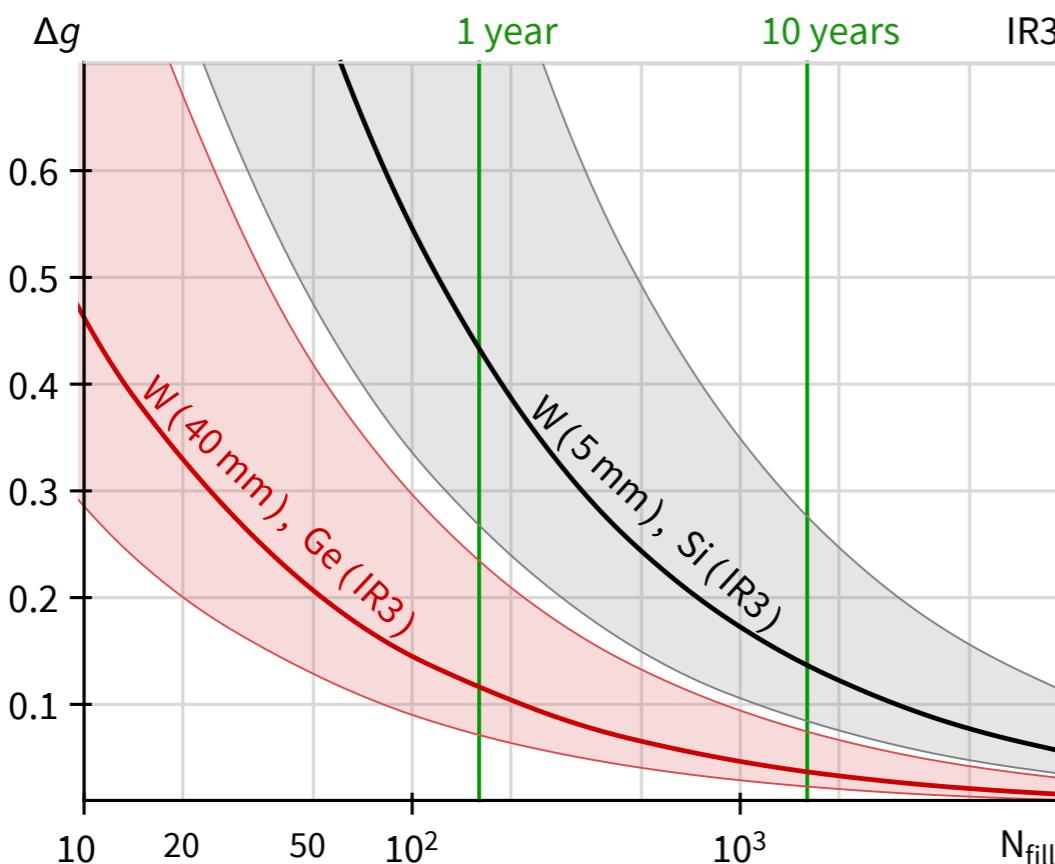
D. Mirarchi, A.S. Fomin, S. Redaelli, W. Scandale. Layouts for fixed-target experiments and dipole moment measurements of short-living baryons using bent crystals at the LHC. [arXiv:1906.08551](https://arxiv.org/abs/1906.08551) (submitted to EPJ)



- impact on the machine
- optimisation of Crystal 1 and Absorbers positions
- running experiment in a parasitic mode
- layout in front of LHCb (IR8) 4.3×10^{10} POT/fill
- alternative layout at IR3 3.0×10^{10} POT/fill
- restriction on Crystal 2 bending radius



SENSITIVITY STUDIES: Precision of MDM versus number of 10h LHC fills.



- running experiment in a parasitic mode
- 10 year at LHCb, 5mm, Si $\rightarrow \Delta g \sim 0.35$
- 1 year at IR3, 40mm, Ge $\rightarrow \Delta g \sim 0.12$
- big uncertainty ($\times 10$) due to α parameter
- 10 years at IR8, 40mm, Ge, $\Delta d \sim 2.6 \cdot 10^{-16} e\text{ cm}$

Possible improvements:

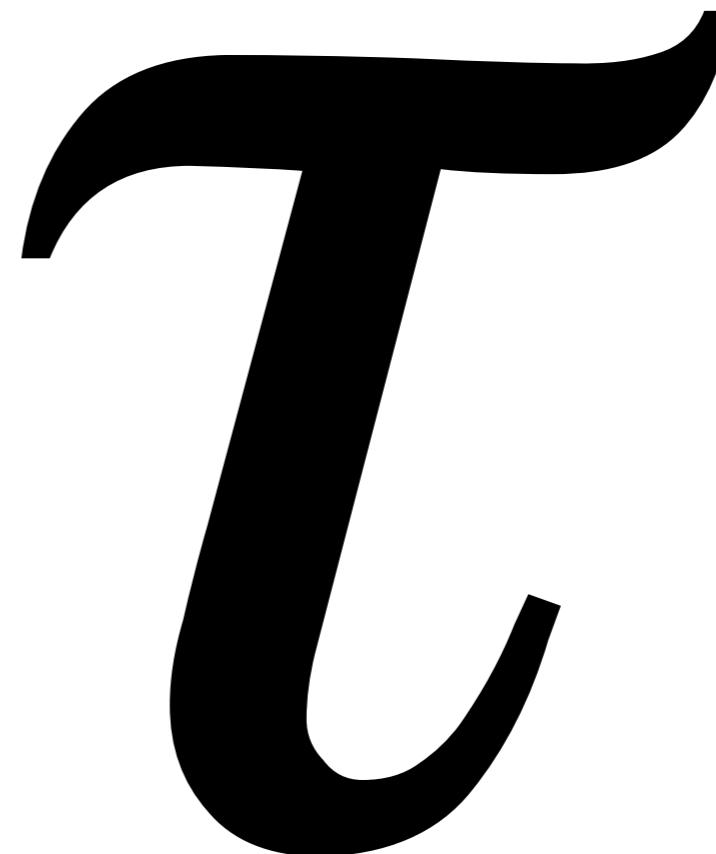
	$1 \rightarrow 2$	t_1/t_2
Target	$5\text{ mm} \rightarrow 40\text{ mm}$	6
Crystal	$\text{silicon} \rightarrow \text{germanium}$	2.4
Detector	$\text{LHCb (IR8)} \rightarrow \text{dedicated at IR3}$	7.5
Beam exitation	currently under studies	...

Electromagnetic dipole moments of τ -lepton

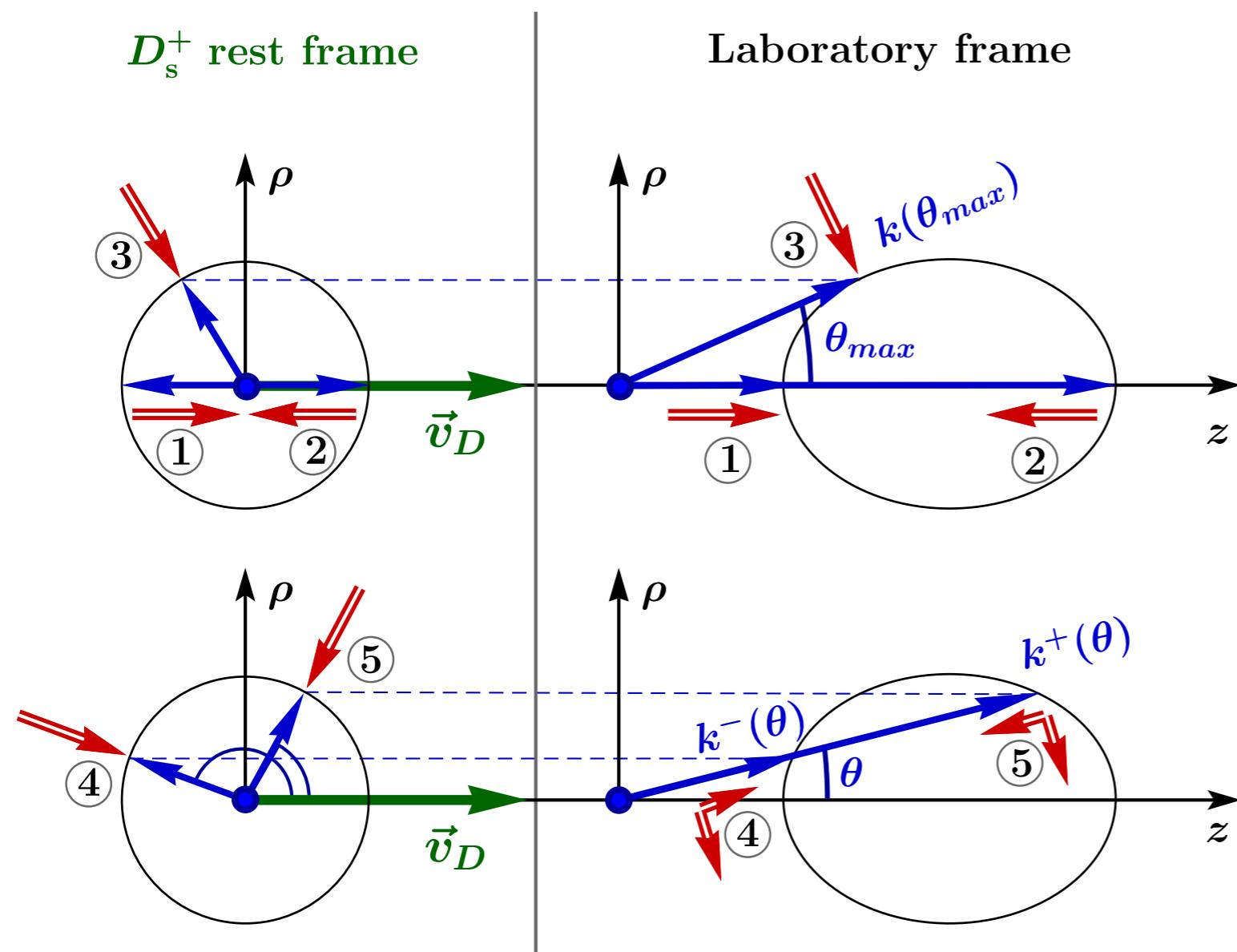
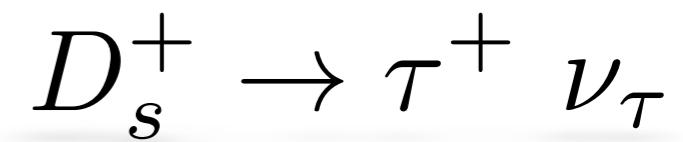
A.S. Fomin, A. Yu Korchin, A. Stocchi, S. Barsuk, P. Robbe, [arXiv:[1810.06699](https://arxiv.org/abs/1810.06699)] (2018), JHEP 1903 (2019) 156 [[inSPIRE](#)],
Feasibility of τ -lepton electromagnetic dipole moments measurement using bent crystal at the LHC

Do you possess any EDM
or aMDM ?

???



PRINCIPLE OF MEASUREMENT: Initial polarisation of τ lepton

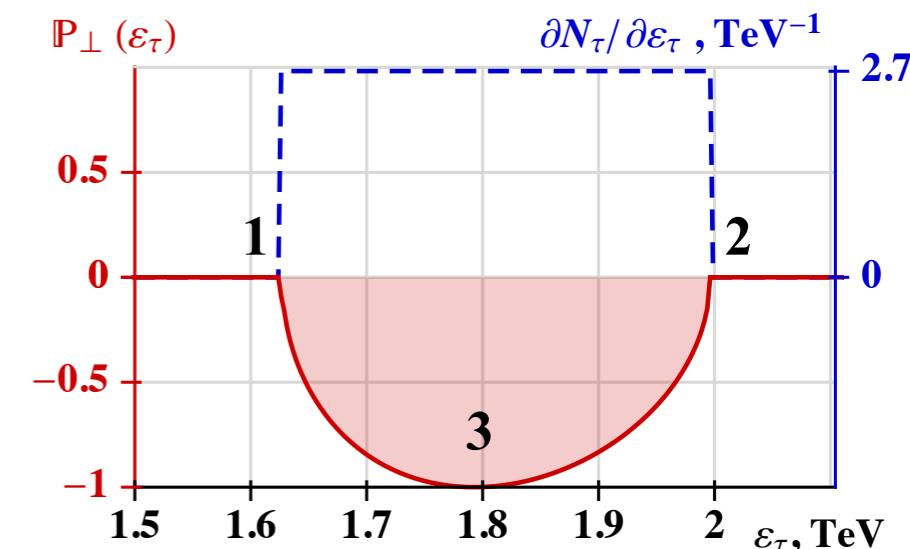
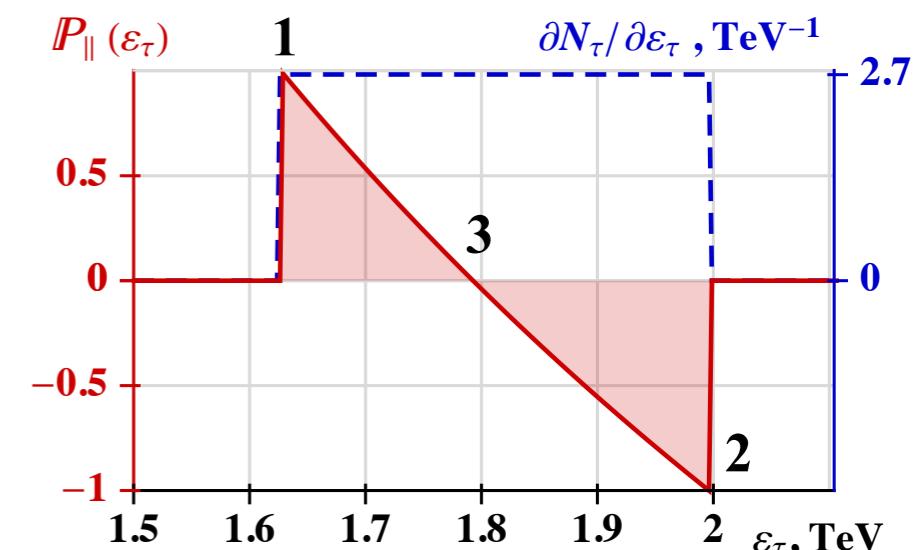


$$\theta_{max} \approx \frac{0.1025}{\gamma_D} \quad (\gamma_\tau \gg 1)$$

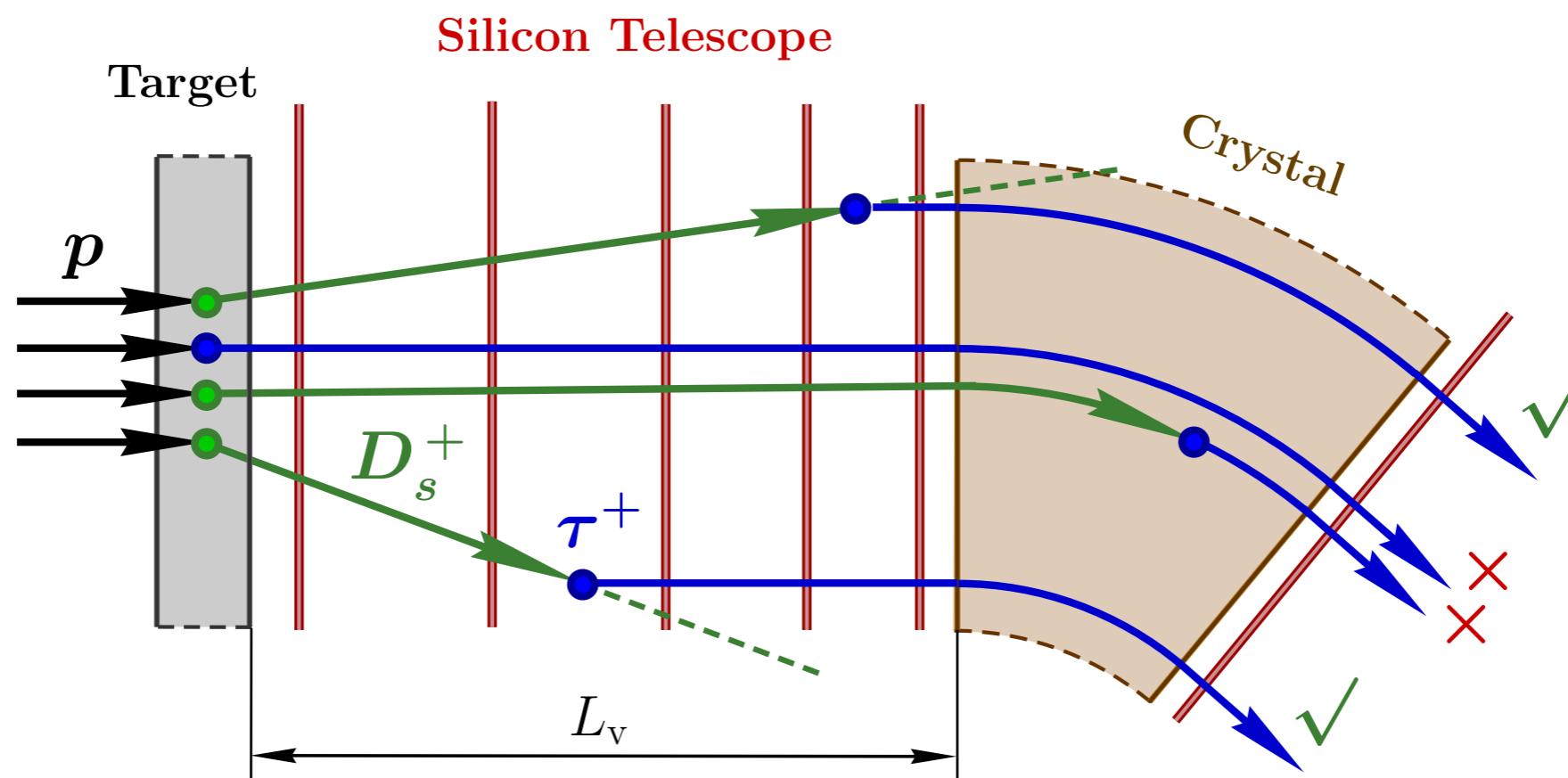
$$\theta_{max}(E_D = 2 \text{ TeV}) \approx 100 \mu\text{rad}$$

$$|\vec{P}_\perp| = \frac{m_\tau p_D}{M_D k_\tau^*} \sin \theta,$$

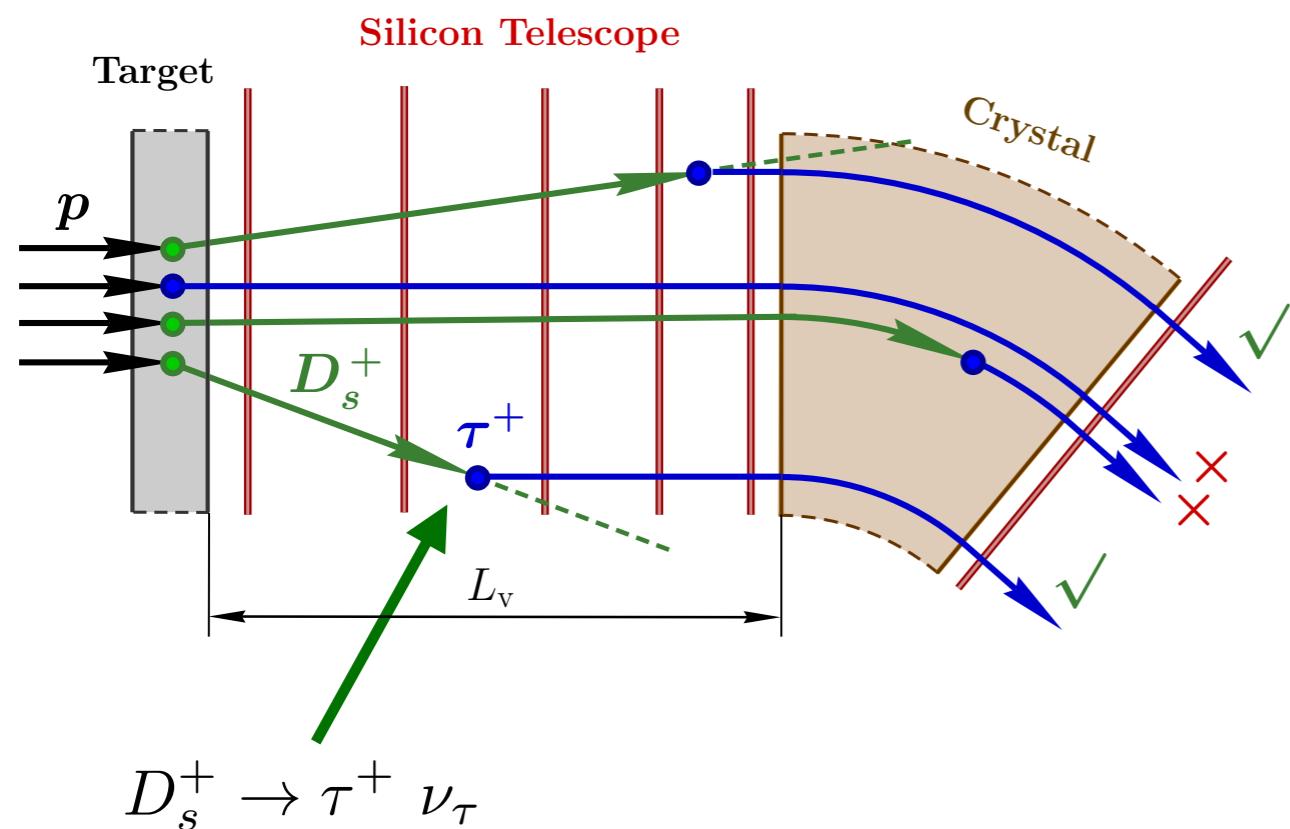
$$\vec{P}_\parallel^2 = 1 - \vec{P}_\perp^2$$



$$p p \rightarrow D_s^+ \dots \rightarrow \tau^+ \dots \rightarrow 2\pi^+ \pi^- \dots$$

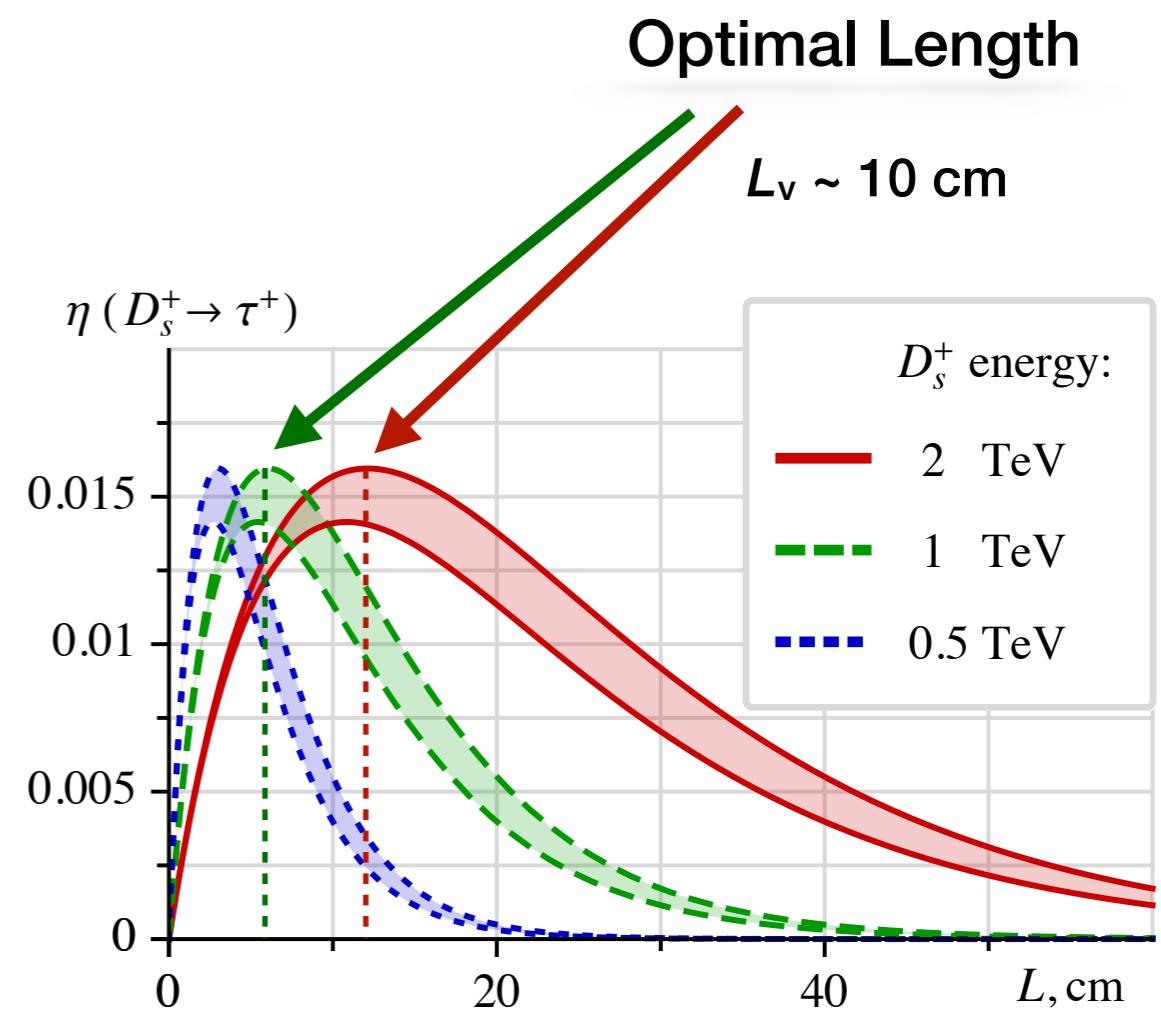


- we need to select events: $D_s^+ \rightarrow \tau^+ \rightarrow 2\pi^+ \pi^-$ out of the background: $X^+ \rightarrow 2\pi^+ \pi^-$
- directions of D_s^+ and τ^+ momenta should be measured very accurately $\Delta\theta < 100 \mu\text{rad}$



$$\eta^*(L_v, E_D, \varepsilon_\tau^*) = Br_i \frac{e^{-L_v / T_D} - e^{-L_v / T_\tau}}{T_D / T_\tau - 1}$$

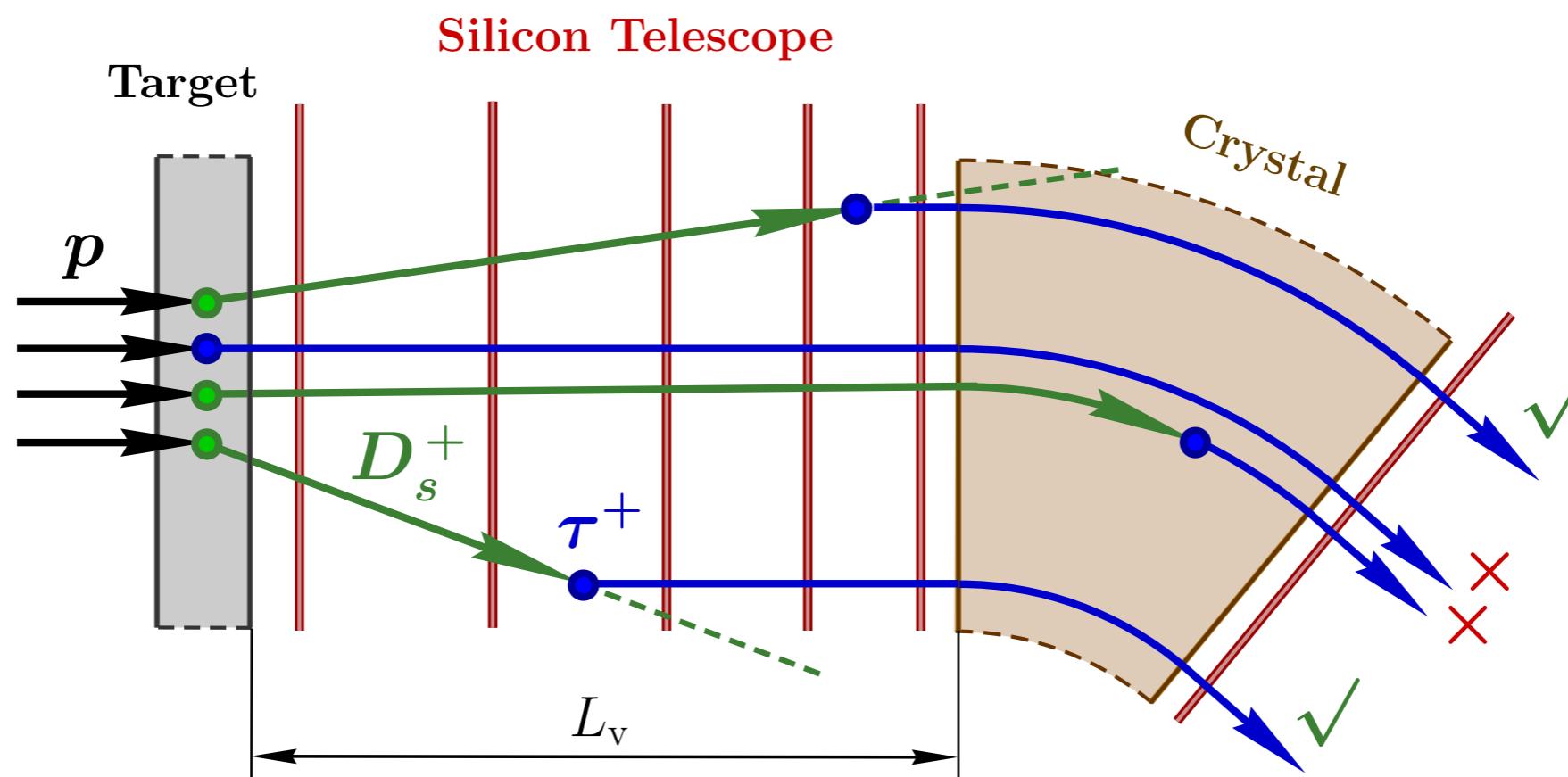
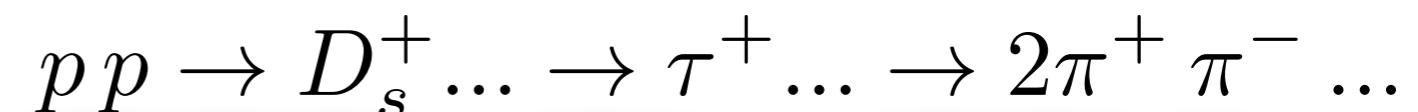
$$\eta(L_v, E_D) = \frac{\int_{\varepsilon_\tau^{min}}^{\varepsilon_\tau^{max}} d\varepsilon_\tau \frac{\partial N_\tau}{\partial \varepsilon_\tau} \int_0^{L_v} dx \frac{\partial N_{\text{prod}}}{\partial x} N_{\text{dec}}(L_v - x)}{\int_{\varepsilon_\tau^{min}}^{\varepsilon_\tau^{max}} d\varepsilon_\tau \frac{\partial N_\tau}{\partial \varepsilon_\tau}}$$



$$T_i = c \tau_i \gamma_i \quad c \tau_D \approx 150 \mu\text{m}$$

$$c \tau_\tau \approx 87 \mu\text{m}$$

$$Br_j \approx 0.055$$



- we need to select events: $D_s^+ \rightarrow \tau^+ \rightarrow 2\pi^+ \pi^-$ out of the background: $X^+ \rightarrow 2\pi^+ \pi^-$
- directions of D_s^+ and τ^+ momenta should be measured very accurately

Problems:

- the background overload,
- the telescope should have a very high angular resolution $\Delta\theta < 100 \mu\text{rad}$ on a rather short base $L_v \sim 10 \text{ cm.}$

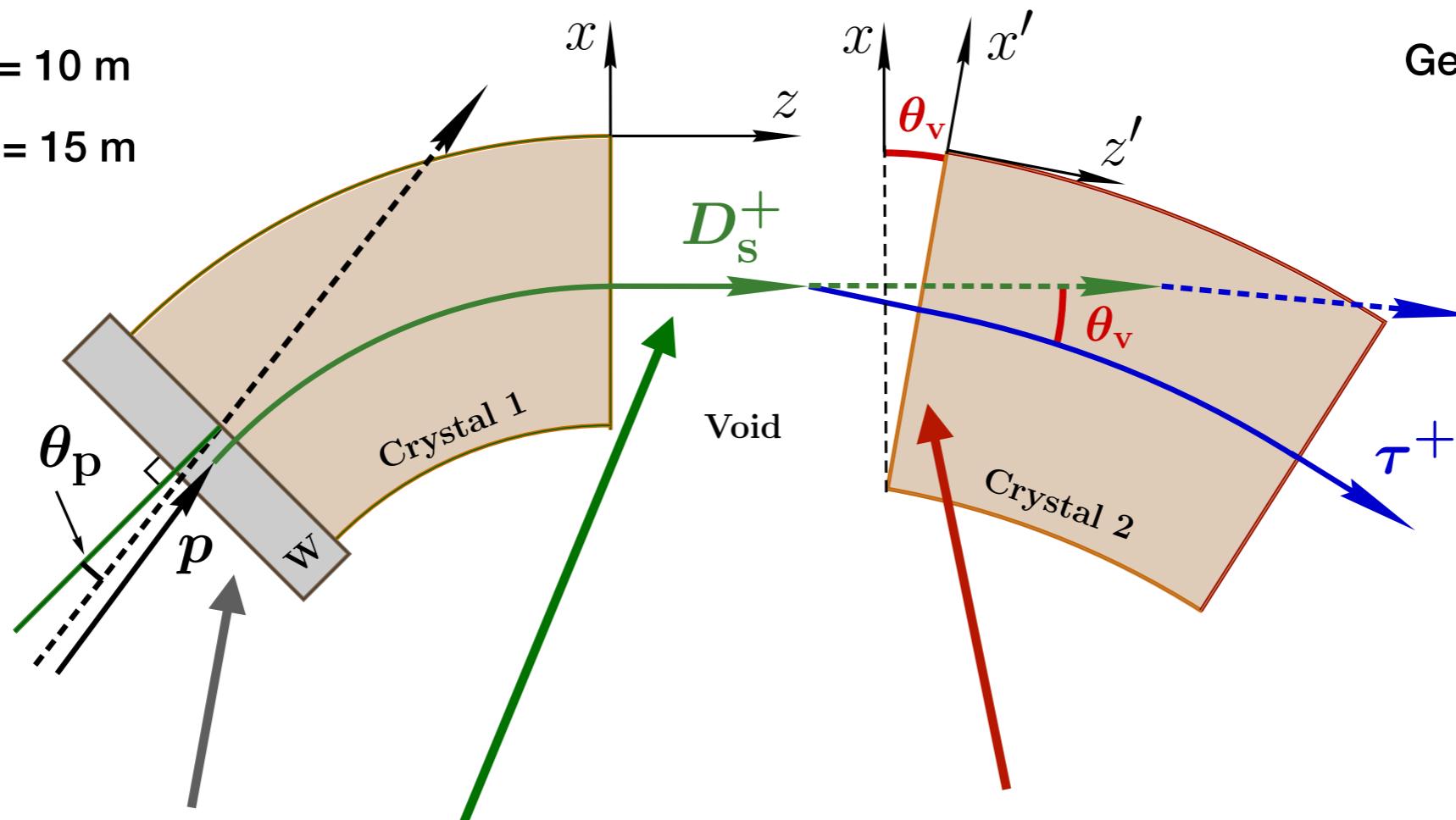
Crystal 1:

Ge: $L = 3$ cm $R = 10$ m

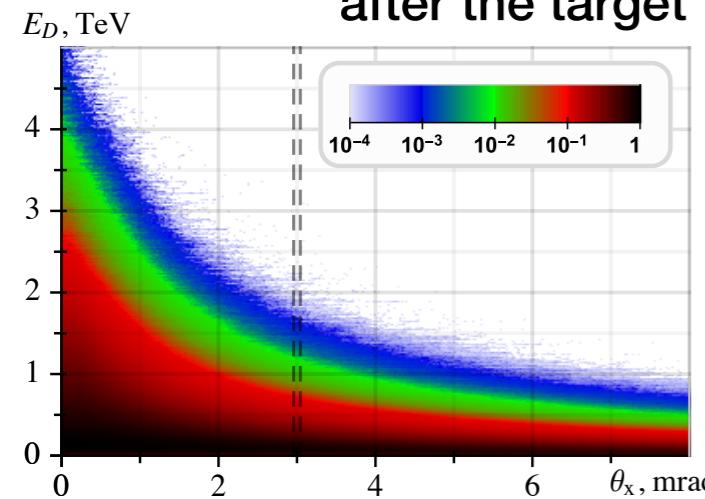
Si: $L = 4.5$ cm $R = 15$ m

$\Theta_D = 3$ mrad

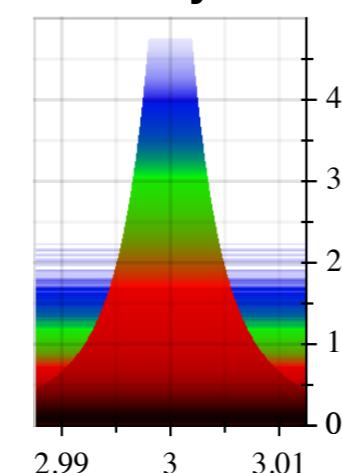
$\theta_p = 0.1$ mrad



Sp.-ang. distribution of Ds
after the target



after Crystal 1



Crystal 2:

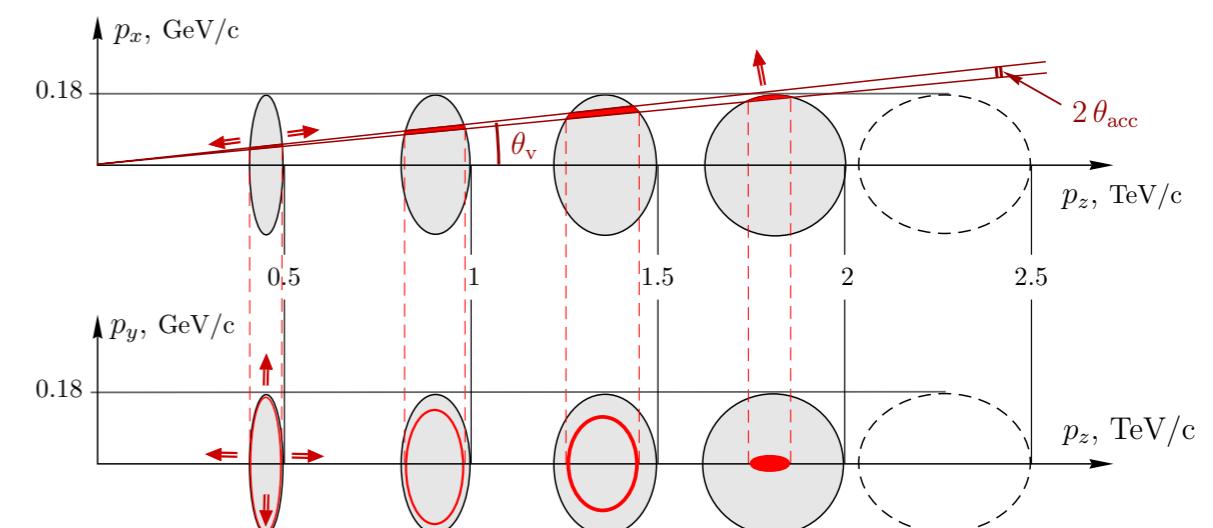
Ge: $L = 10$ cm $R = 7$ m

$\Theta_T = 14$ mrad

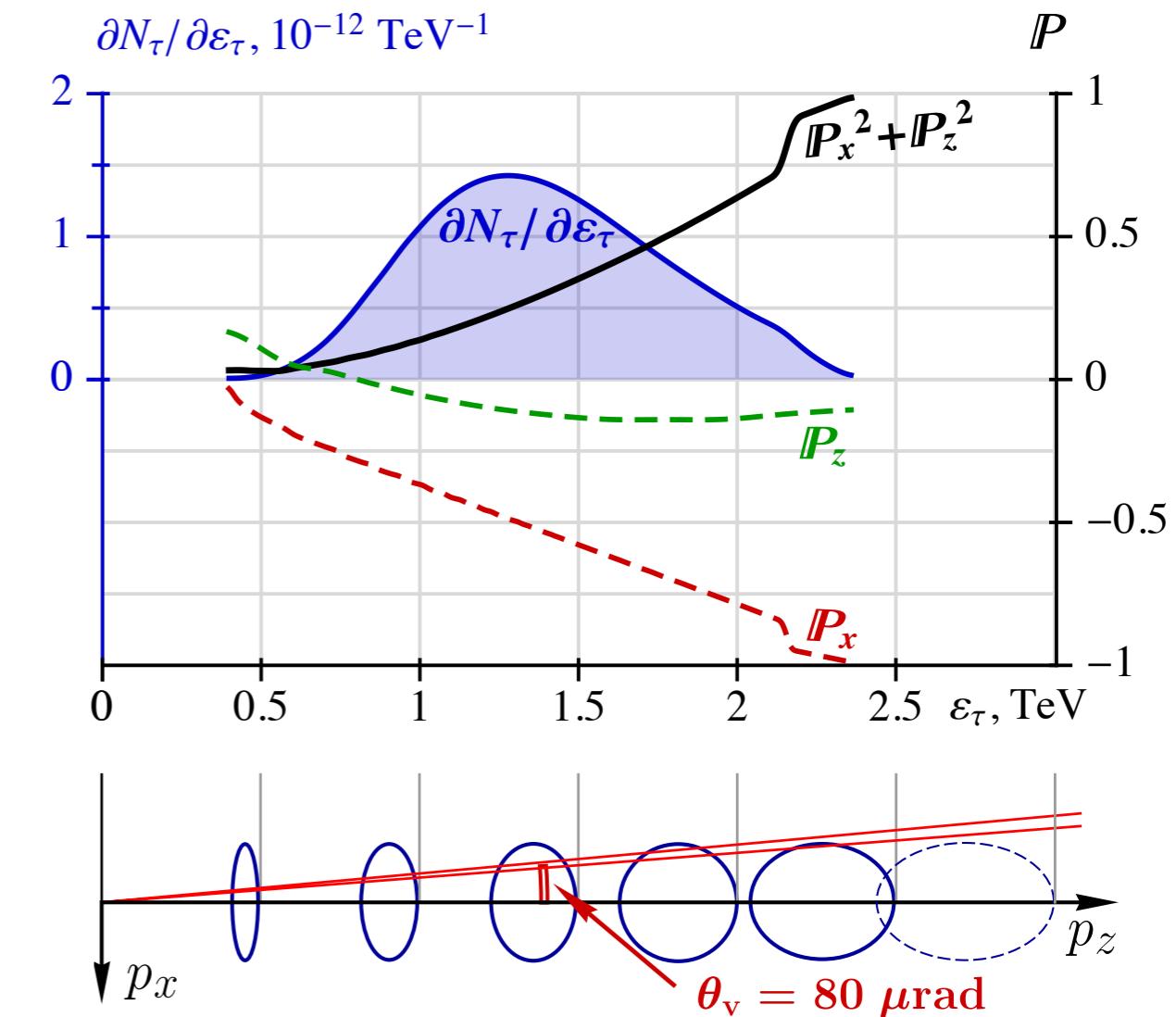
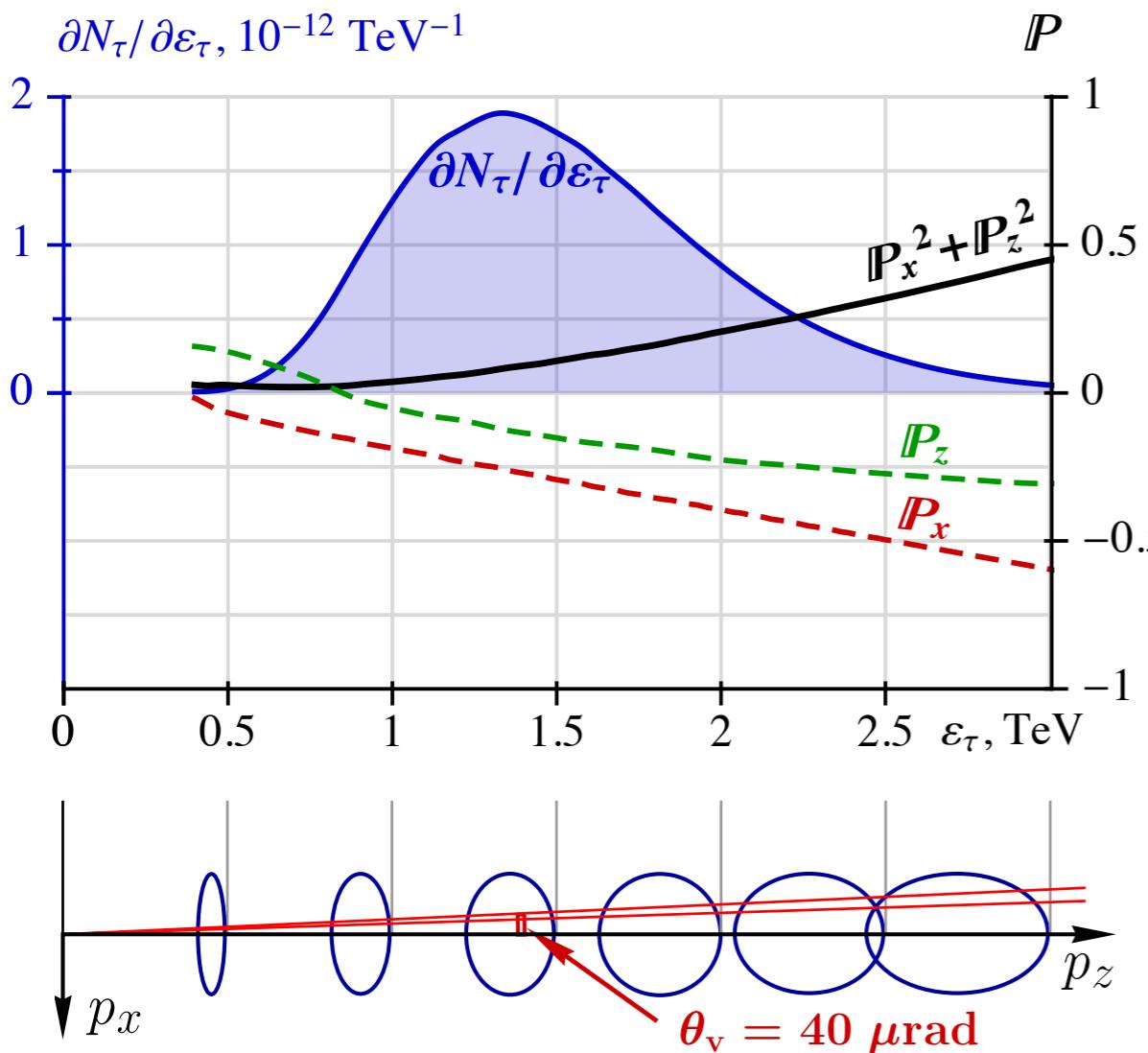
$\theta_v = 0.08$ mrad

$L_v = 10$ cm

Angular collimation of τ by Crystal 2



SENSITIVITY STUDIES: Spectrum and polarisation of deflected τ leptons



Spectra:

$$\frac{\partial N_\tau^{\text{def}}}{\partial \varepsilon_\tau} = \int_0^{\varepsilon_{\max}} dE_D \frac{\partial N_D}{\partial E_D} \eta(L_v, E_D) \frac{\partial N_\tau}{\partial \varepsilon_\tau}(E_D) \eta_{\text{coll}}(E_D, \varepsilon_\tau) \eta_{\text{chan}}(\varepsilon_\tau)$$

Polarisation:

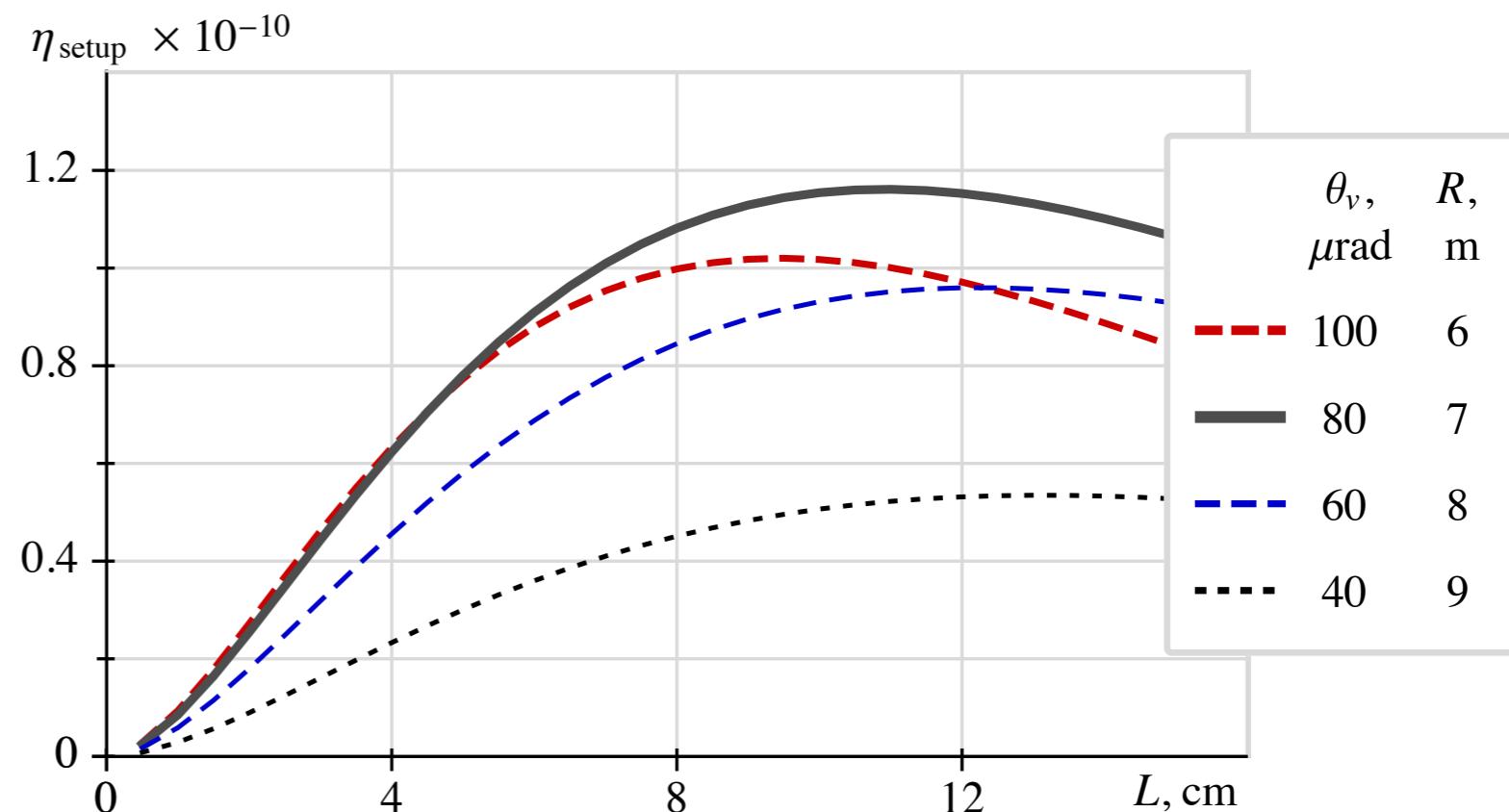
$$P_z(\varepsilon_\tau) = \frac{1}{\partial N_\tau^{\text{def}} / \partial \varepsilon_\tau} \int dE_D \frac{\partial N_D}{\partial E_D} \frac{\partial N_\tau^{\text{def}}}{\partial \varepsilon_\tau}(E_D) P_z(E_D, \varepsilon_t)$$

$$P_x(\varepsilon_\tau) = \frac{1}{\partial N_\tau^{\text{def}} / \partial \varepsilon_\tau} \int dE_D \frac{\partial N_D}{\partial E_D} \frac{\partial N_\tau}{\partial \varepsilon_\tau}(E_D) P_\perp(E_D, \varepsilon_\tau) \frac{1}{\pi} \int_{\phi_{\min}(\varepsilon_\tau)}^{\phi_{\max}(\varepsilon_\tau)} \sin \phi d\phi.$$

SENSITIVITY STUDIES: The setup efficiency (target + two crystals)

$$\Delta a_\tau = \sqrt{\frac{1}{N_p \eta_{\text{det}} S^2 \eta_{\text{setup}}}}$$

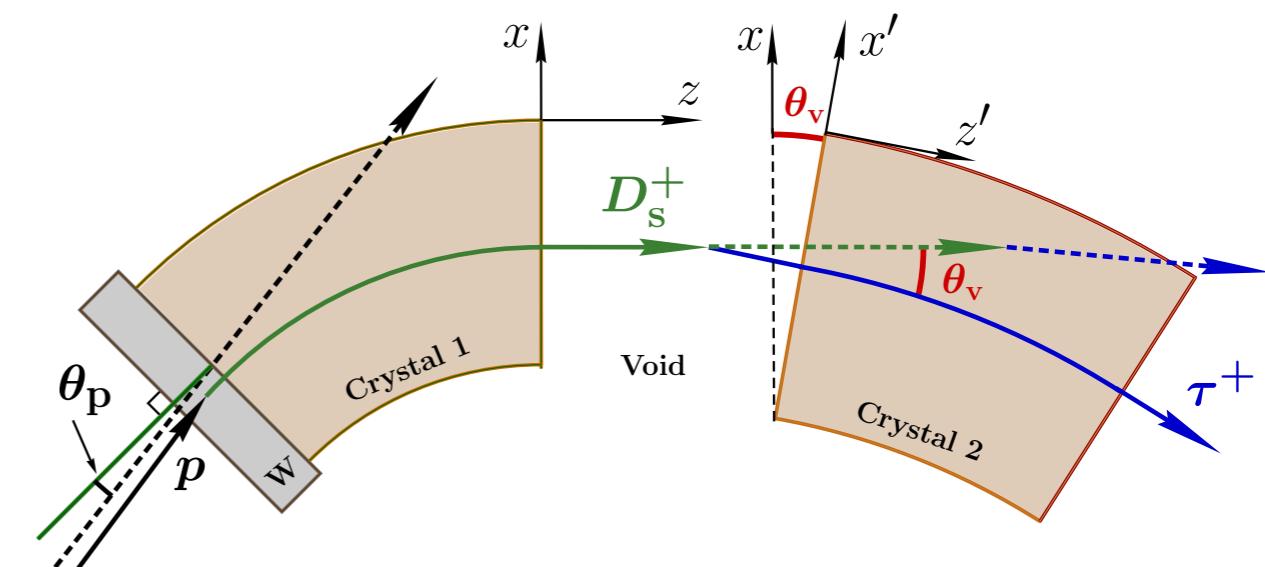
$$\eta_{\text{setup}} = \Theta^2 \int d\varepsilon \frac{\partial N_\tau^{\text{def}}}{\partial \varepsilon} \gamma_\tau^2 P^2$$



N_p is the integral number of protons,

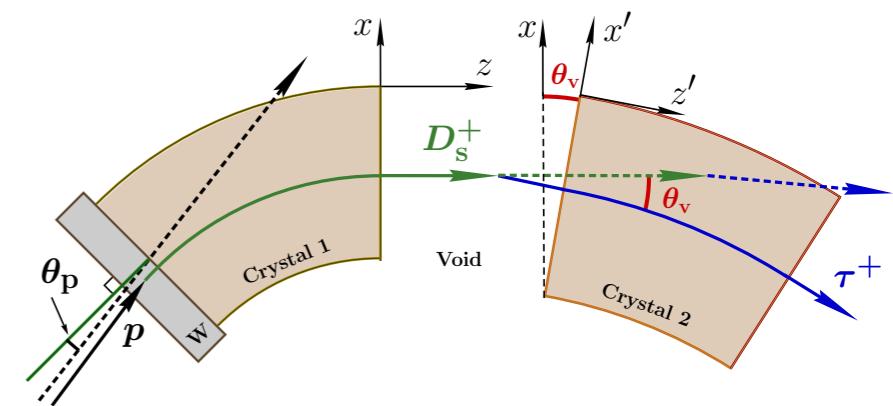
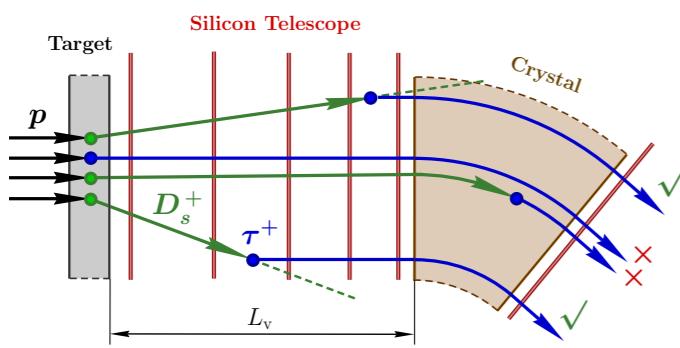
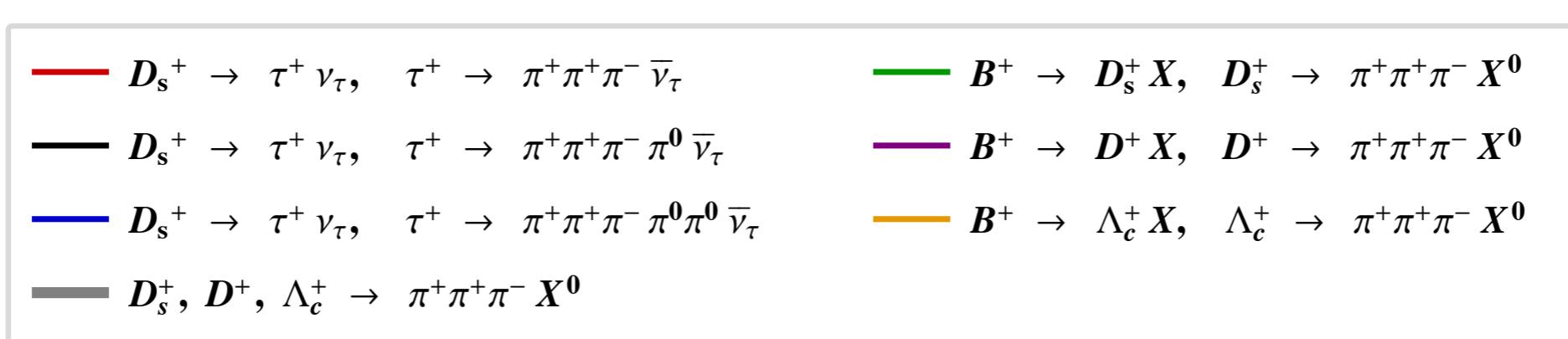
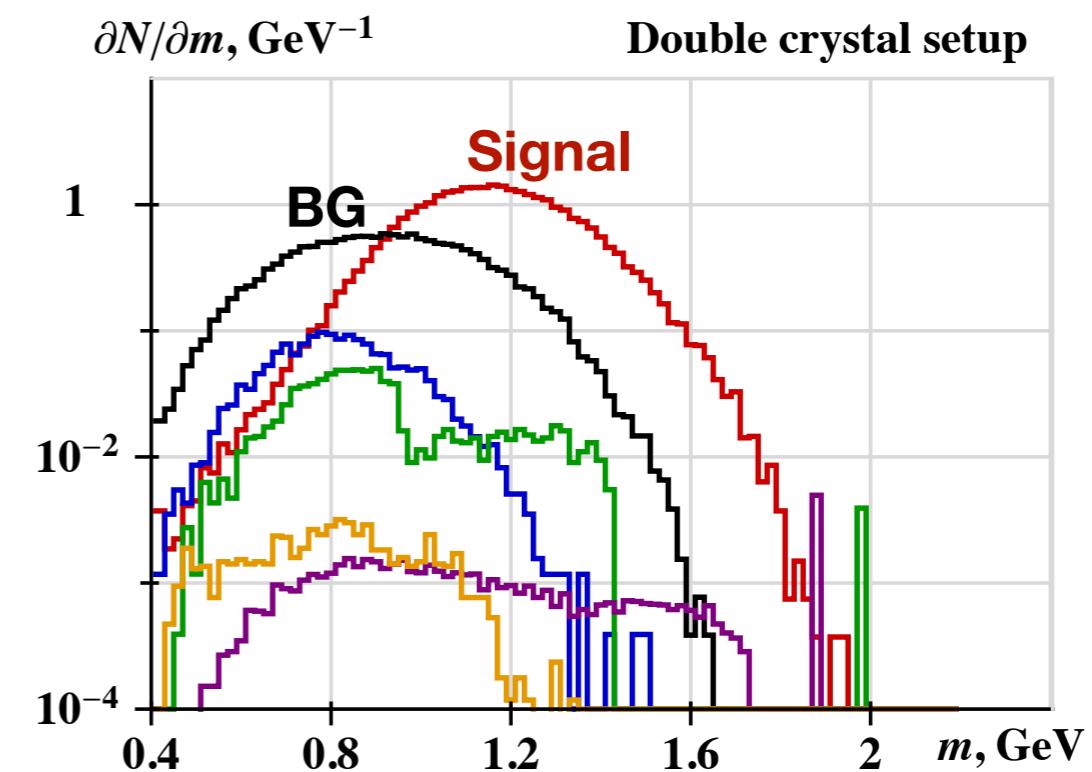
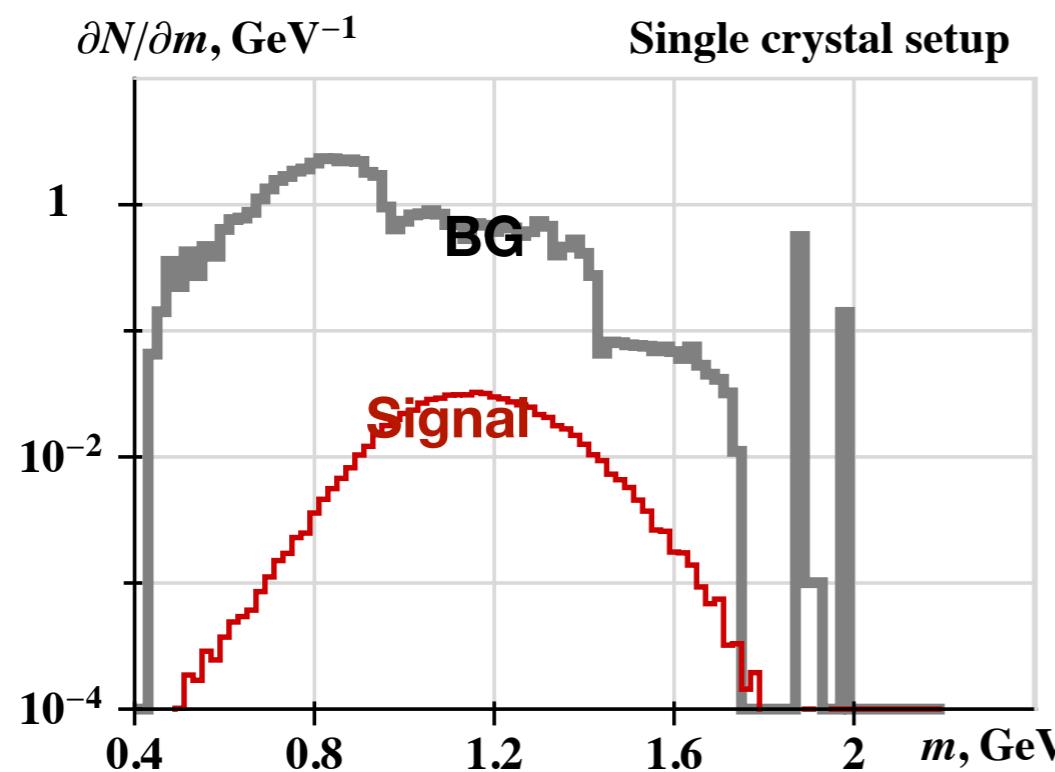
η_{det} is the detector efficiency

S is the sensitivity of polarisation reconstruction
by the analysis of τ decay⁽¹⁾



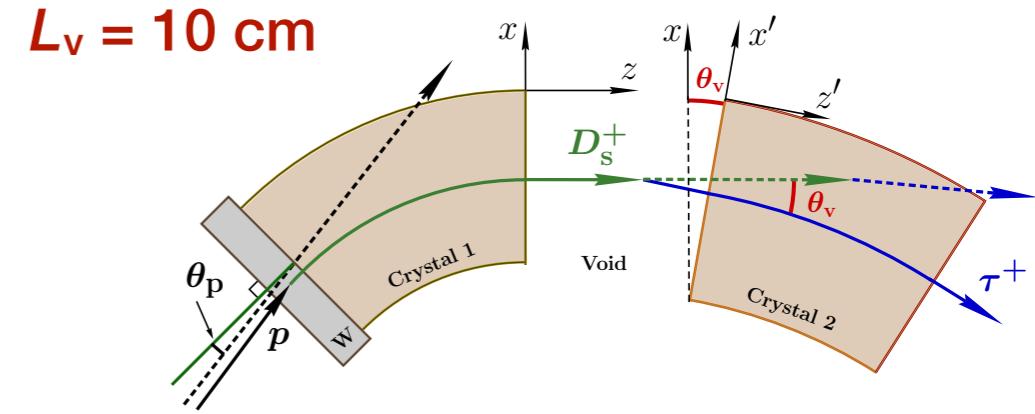
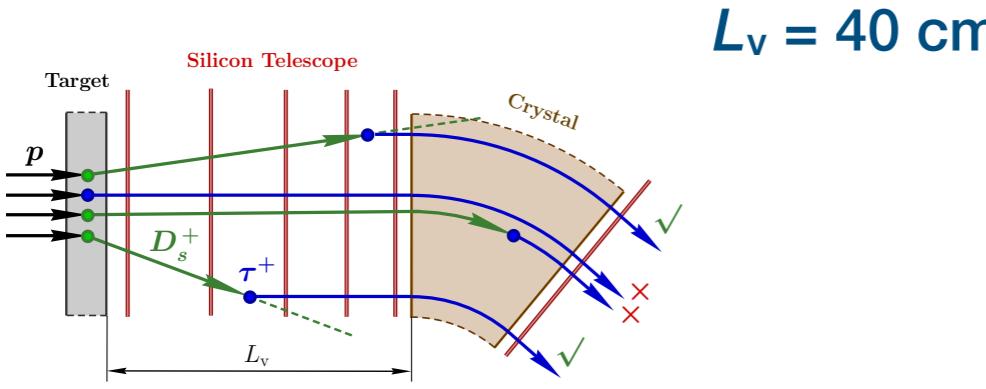
⁽¹⁾ J. Bernabeu et al., JHEP, 01:062, 2009

SENSITIVITY STUDIES: Background from other decay channels.



Efficiency of the measurement: current (by process) and total (per incident proton).

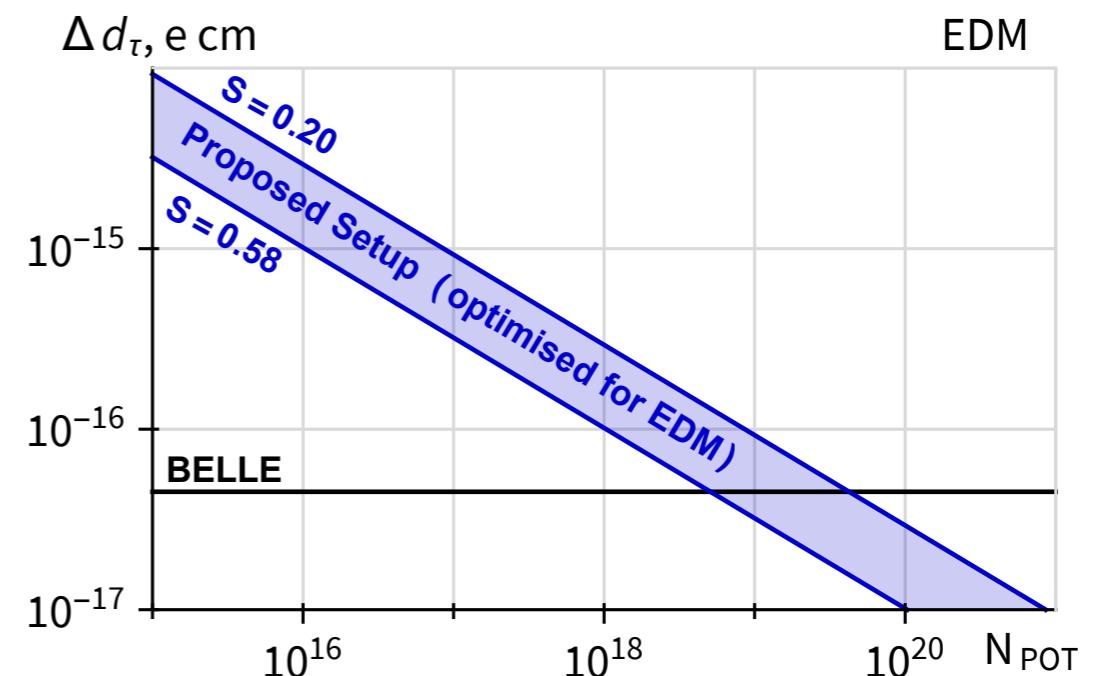
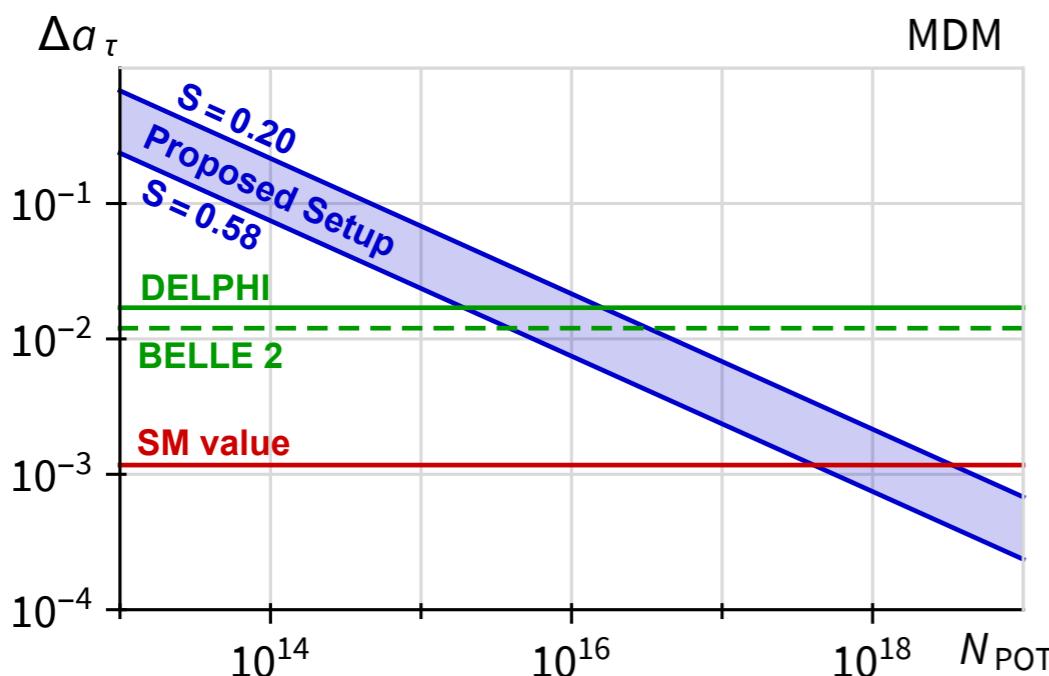
Place	process (factors)	single crystal setup		double crystal setup	
		current	total	current	total
target	$p \rightarrow D_s^+, D_s^+$	$1.1 \cdot 10^{-4}$	$1.1 \cdot 10^{-4}$	$1.1 \cdot 10^{-4}$	$1.1 \cdot 10^{-4}$
crystal 1	D_s^+ collimation	—	—	$0.8 \cdot 10^{-2}$	$0.9 \cdot 10^{-6}$
crystal 1	D_s^+ deflection	—	—	$1.3 \cdot 10^{-1}$	$1.1 \cdot 10^{-7}$
void	$D_s^+ \rightarrow \tau^+$	$0.5 \cdot 10^{-3}$	$0.5 \cdot 10^{-7}$	$1.2 \cdot 10^{-2}$	$1.4 \cdot 10^{-9}$
crystal 2	τ^+ collimation	$1.7 \cdot 10^{-2}$	$0.9 \cdot 10^{-9}$	$0.5 \cdot 10^{-1}$	$0.7 \cdot 10^{-10}$
crystal 2	τ^+ deflection	$0.3 \cdot 10^{-1}$	$0.3 \cdot 10^{-10}$	$0.3 \cdot 10^{-1}$	$2.2 \cdot 10^{-12}$
detector	$\eta_{\text{det}} \times Br$	$0.4 \cdot 10^{-1}$	$1.3 \cdot 10^{-12}$	$0.4 \cdot 10^{-1}$	$1.0 \cdot 10^{-13}$
reconstr.	$\eta_{\text{MDM}} \sim \langle P^2 \gamma^2 \rangle$	~ 0.5	$\sim 0.7 \cdot 10^{-12}$	~ 8	$\sim 0.7 \cdot 10^{-12}$
reconstr.	$\eta_{\text{EDM}} \sim \langle P^2 \gamma^2 \rangle$	$\sim 1.1 \cdot 10^{-4}$	$\sim 0.8 \cdot 10^{-16}$	$\sim 1.5 \cdot 10^{-3}$	$\sim 1.1 \cdot 10^{-16}$



$$\Delta a_\tau = \sqrt{\frac{1}{N_p \eta_{\text{det}} S^2 \eta_{\text{setup}}}}$$

$$\eta_{\text{setup}} = \Theta^2 \int d\varepsilon \frac{\partial N_\tau^{\text{def}}}{\partial \varepsilon} \gamma_\tau^2 P^2$$

$$\frac{\Delta f_\tau}{\Delta a_\tau} \approx \left| \frac{4 \gamma \bar{a}_\tau}{\Theta(1 + \gamma \bar{a}_\tau)^2} \right|$$



- Target (W) — Double Crystal Setup at LHC $Ds^+ \rightarrow \tau^+ \nu_\tau, \tau^+ \rightarrow \pi^+ \pi^+ \pi^- \bar{\nu}_\tau$
- $L_{\text{tar}} = 1 \text{ cm}$
- Crystal 1 (Ge) — DELPHI: limit on aMDM from LEP2 experiment $\gamma \gamma \rightarrow \tau^+ \tau^-$
J. Abdallah et al. Eur. Phys. J., C35:159–170, 2004
- $L_D = 3 \text{ cm},$
- $R_D = 10 \text{ m},$
- $\theta_p = 100 \mu\text{rad}$
- Crystal 2 (Ge) — BELLE 2: limit on aMDM expected for the BELLE 2 experiment
S. Eidelman, et al. JHEP, 03:140, 2016.
- $L = 10 \text{ cm},$
- $R = 7 \text{ m},$
- $\theta_\nu = 80 \mu\text{rad}$
- $\eta_{\text{det}} = 50 \%$ — SM value: aMDM value predicted by a Standard Model
S. Eidelman et al. Mod. Phys. Lett., A22:159–179, 2007.
- — Belle collaboration, Search for the EDM of the τ lepton,
Phys. Lett. B 551 (2003) 16 [hep-ex/0210066].

Express of interest:

- L. Burmistrov, G. Calderini, Yu. Ivanov, L. Massacrier, P. Robbe, **W. Scandale**, A. Stocchi,
Measurement of short living baryon magnetic moment using bent crystals at SPS and LHC,
CERN-SPSC-2016-030, CERN, Geneva Switzerland, **June 2016** [[SPSC-EOI-012](#)].
- L. Burmistrov, G. Calderini , M. Calviani, F. Cerutti, O. Fomin, M. Garattini, I. Kirillin, A. Korchin, Y. Ivanov, D. Mirarchi, L. Massacrier, S. Montesano, S. Redaelli, P. Robbe, W. Scandale, **A. Stocchi**,
Measuring magnetic moments with bended crystal, [talk at Physics Beyond Collider Workshop](#), CERN, Geneva Switzerland, **6–7 September 2016**.

Papers:

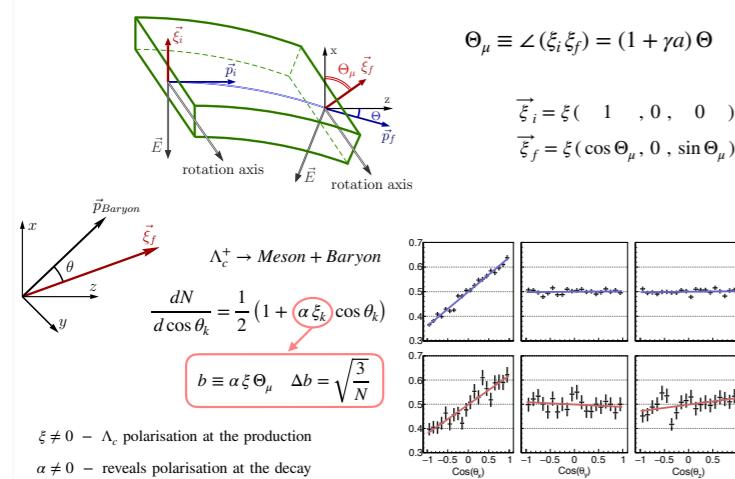
- A.S. Fomin, A.Yu. Korchin, A. Stocchi, O.A. Bezshyyko, L. Burmistrov, S.P. Fomin, I.V. Kirillin, L. Massacrier, A. Natochii, P. Robbe, W. Scandale, N.F. Shul'ga,
Feasibility of measuring the magnetic dipole moments of the charm baryons at the LHC using bent crystals,
[arXiv:[1705.03382](#)] JHEP 08 (2017) 120 [[inSPIRE](#)]
- A.S. Fomin, A. Yu. Korchin, A. Stocchi, S. Barsuk, P. Robbe,
Feasibility of τ -lepton electromagnetic dipole moments measurement using bent crystal at the LHC,
[arXiv:[1810.06699](#)] (2018), JHEP 1903 (2019) 156 [[inSPIRE](#)]
- D. Mirarchi, A.S. Fomin, S. Redaelli, W. Scandale,
Layouts for fixed-target experiments and dipole moment measurements of short-living baryons using bent crystals at the LHC.
[arXiv:[1906.08551](#)] (2019) (submitted to EPJ C) [[inSPIRE](#)]
- A.S. Fomin, S. Barsuk, A.Yu. Korchin, V.A. Kovalchuk, E. Kou, M. Liul, A. Natochii, E. Niel, P. Robbe, A. Stocchi,
The prospect of charm quark magnetic moment determination,
[arXiv:[1909.04654](#)] (2019), (submitted to EPJ C) [[inSPIRE](#)]

PhD theses:

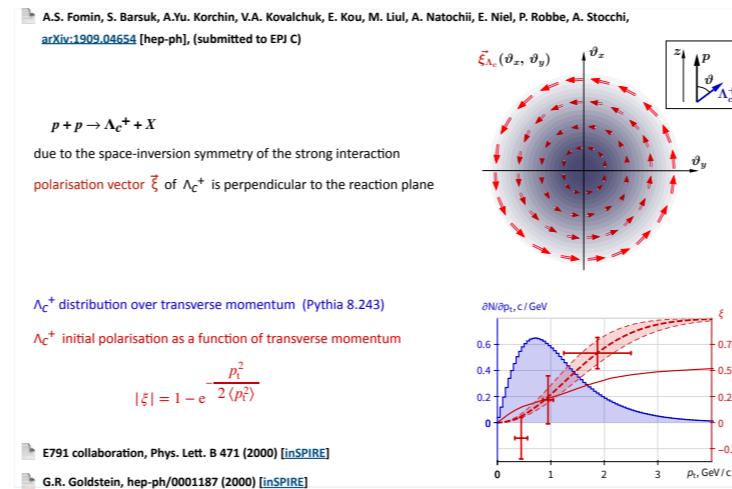
- A.S. Fomin, Ph.D. thesis, Paris-Sud University, Paris France, (2017) [[full text](#)],
Multiple scattering effects on the dynamics and radiation of fast charged particles in crystals. Transients in the nuclear burning wave reactor.
- A. Natochii, Ph.D. thesis, Paris-Sud University, Paris France, (2019), *Detectors developments for the UA9 experiment at the CERN SPS.*

THANK YOU! Questions ?

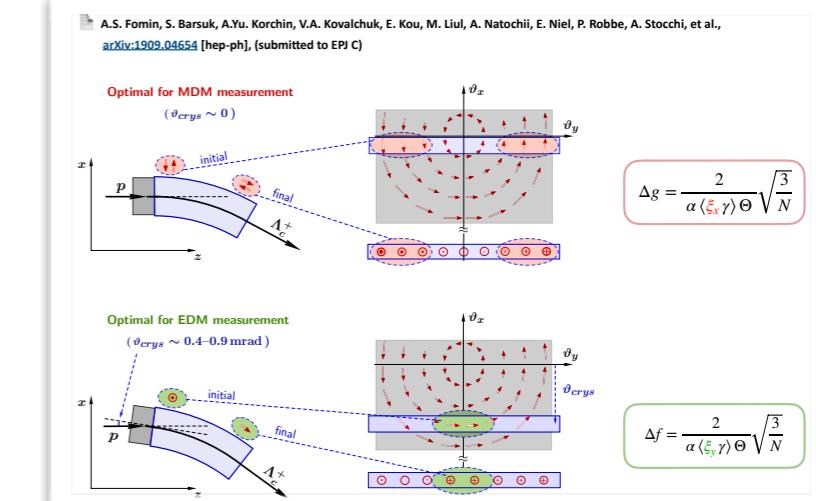
Principle of measurement pp 4–6



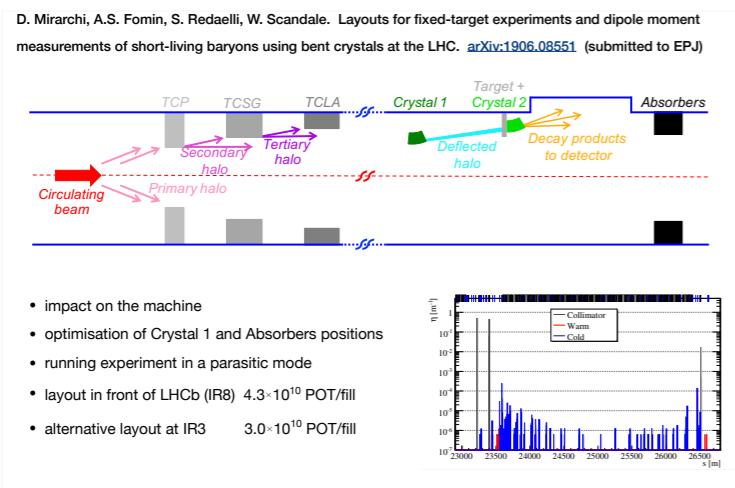
Initial polarisation of Λ_c pp 7–10



MDM / EDM setup pp 6, 9, 10



Layouts for experiments p 12



Sensitivity studies pp 11–13

