Status Update of NoMoS

(Neutron Decay Products Momentum Spectrometer)

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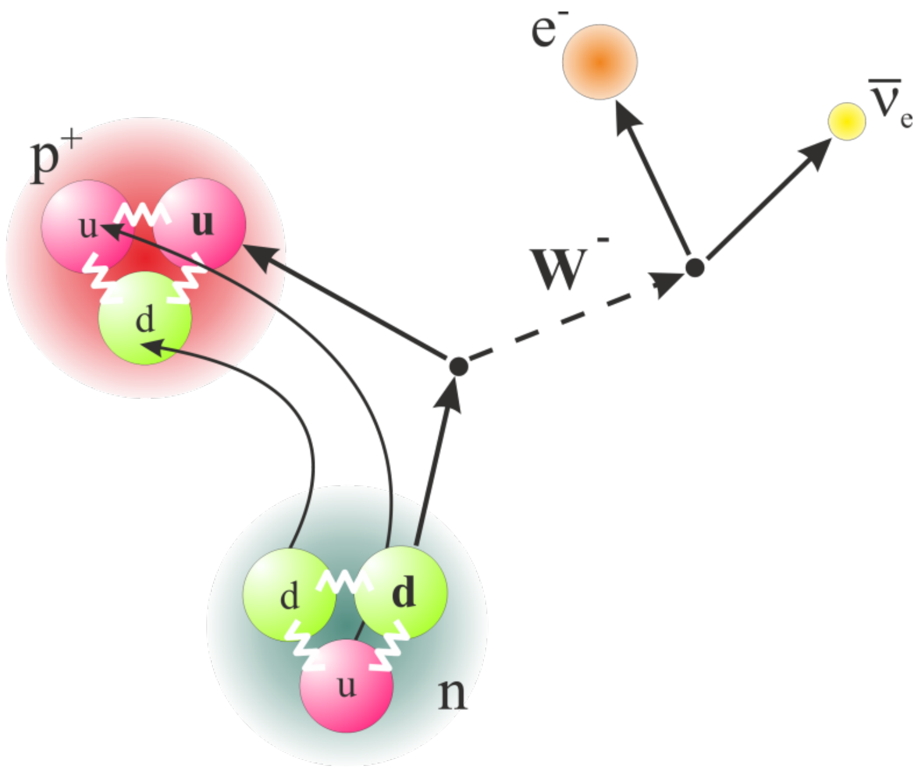
at the joint meeting of SPS and OEPG 2017

Neutron Decay in the Standard Model



Described within V – A theory

$$n \rightarrow p + e + \bar{\nu}_e + 782.334\, keV$$

$$\tau_n = \frac{1}{|V_{ud}|^2} \frac{(4908.7 \pm 1.9)\, s}{(1+3|\lambda|^2)} = 880.2(1.0)\, s$$

quark mixing

$\lambda = g_A / g_V$

Beyond Standard Model → e.g. Fierz interference term → scalar or tensor currents

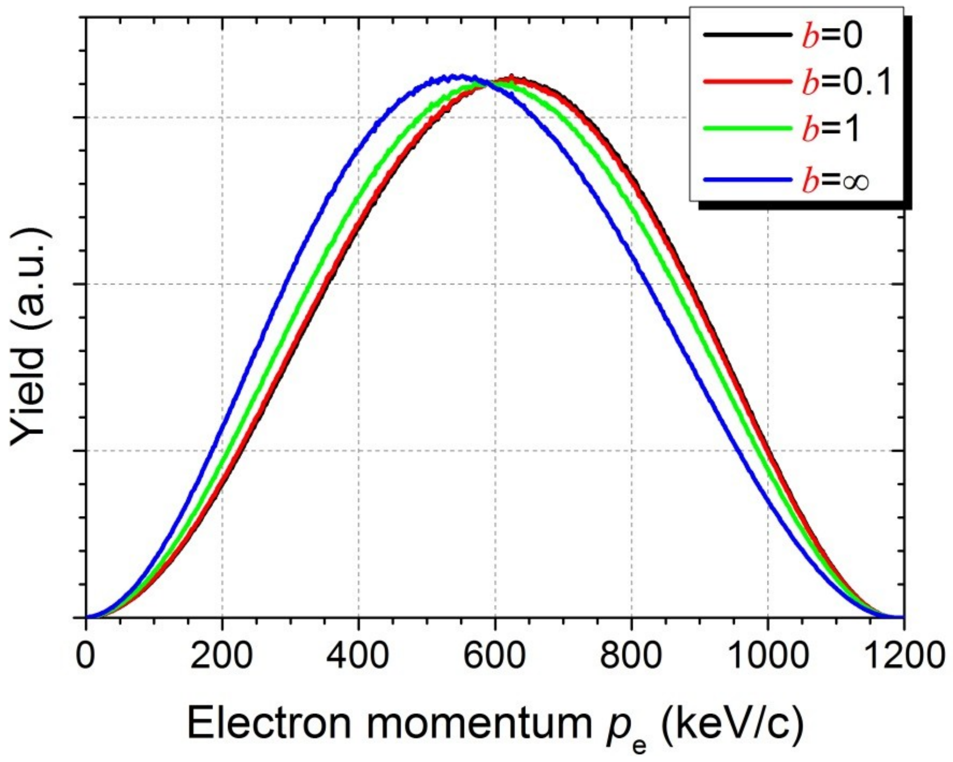
Why we investigate the neutron decay

- Momentum spectrum measurement → Fierz term b

first approach:

$$b = 0.067 \pm 0.005_{stat} \left({+0.090 \atop -0.061} \right)_{sys}$$

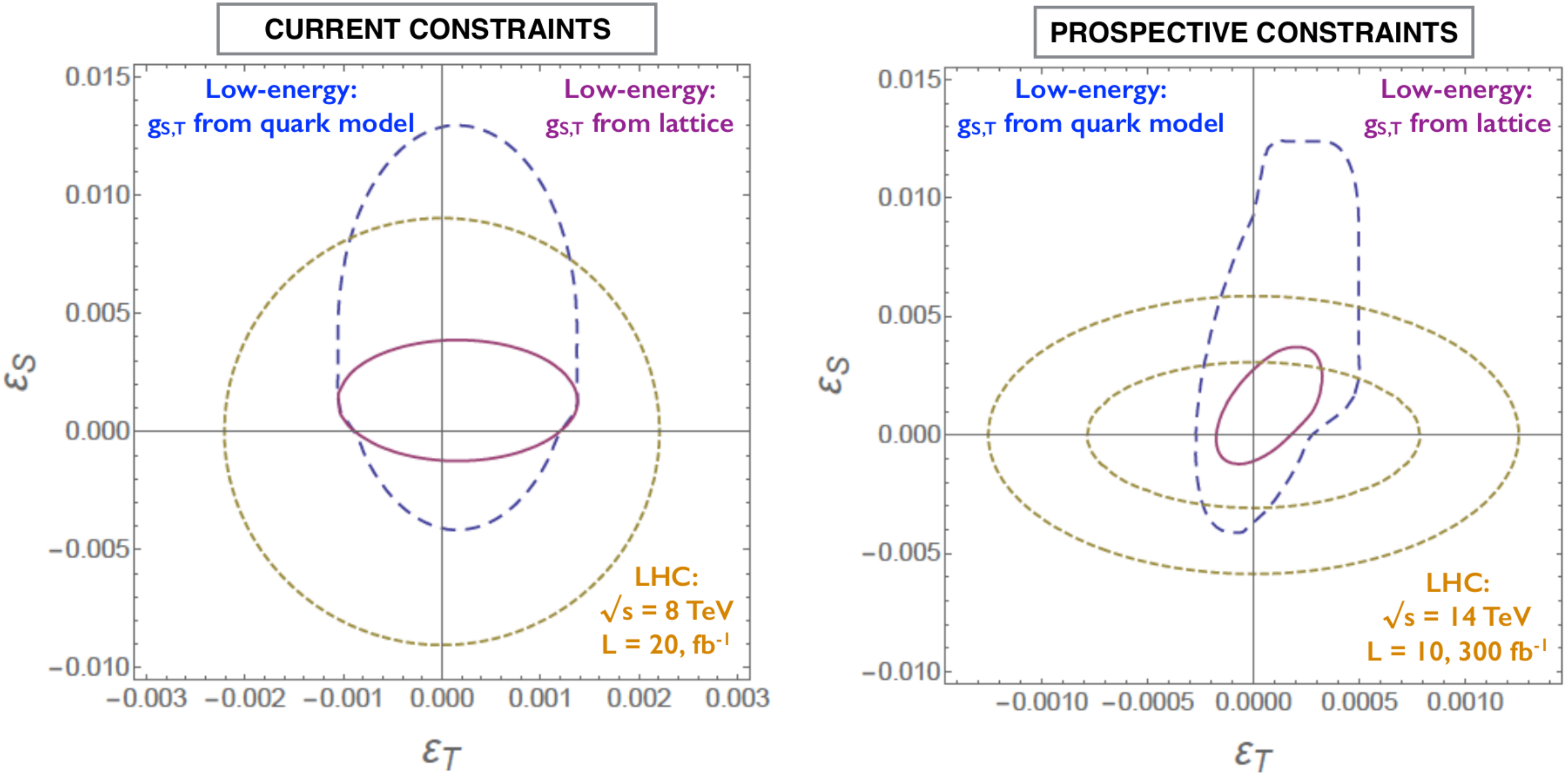
Hickerson et. al. 2017,
arXiv: 1707.00776



- Other correlation coefficients (a,A,B,C,…)

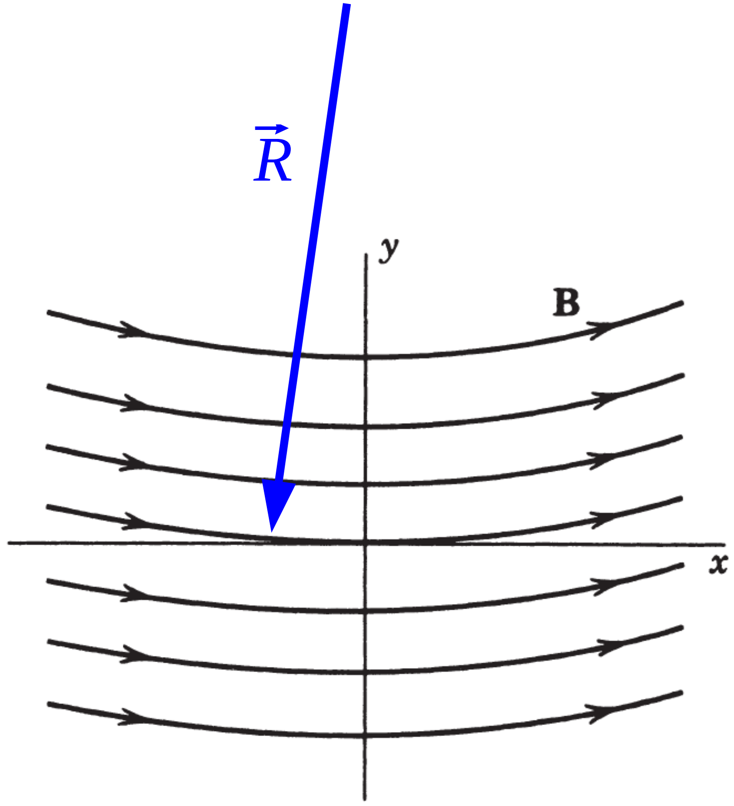
→ e.g. scalar and tensor current constraints (BSM)

Constraint Comparison



Bhattacharya et. al. 2016, Phys. Rev. D 94, 054508, arXiv: 1606.07049v3

The RxB Drift



Gradient drift

$$v_{\vec{\nabla} B} = \frac{\frac{1}{2} m v_\perp^2}{qB} \frac{\vec{B} \times \vec{\nabla} B}{B^2}$$

Curvature drift

$$\vec{v}_R = \frac{m v_\parallel^2}{qB} \frac{\vec{R} \times \vec{B}}{R^2 B}$$

2D gradient approx.

$$\frac{\nabla B}{B} = -\frac{\vec{R}}{R^2}$$

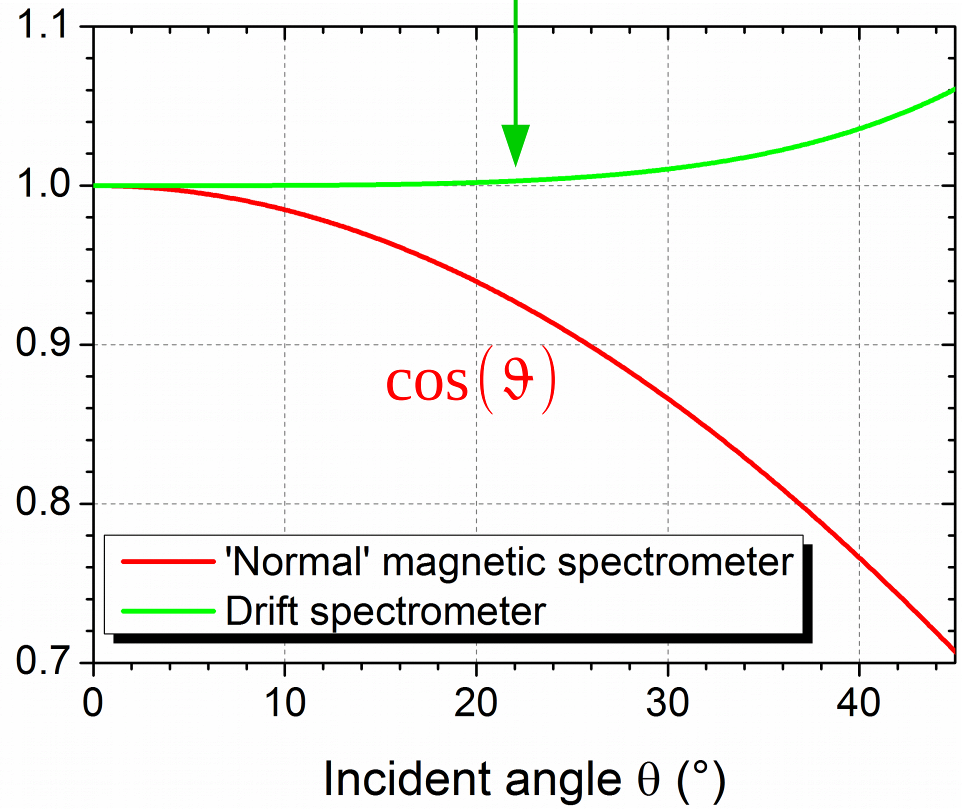
Inertia drift

$$\vec{v}_d = \frac{mv}{qRB} v_\parallel f(\vartheta) \frac{\vec{R} \times \vec{B}}{RB} + \frac{m}{q B^2} (\dot{\vec{v}}_d \times \vec{B})$$

The R x B Drift for our purposes

$$\vec{v}_d^{\,1st} = \frac{mv}{qRB} v_{\parallel} f(\vartheta) \frac{\vec{R}\times\vec{B}}{RB} \longrightarrow D_{1st}(p,\vartheta) \approx \frac{p}{qB} \alpha \frac{1}{2}\left(\cos\vartheta + \frac{1}{\cos\vartheta}\right)$$

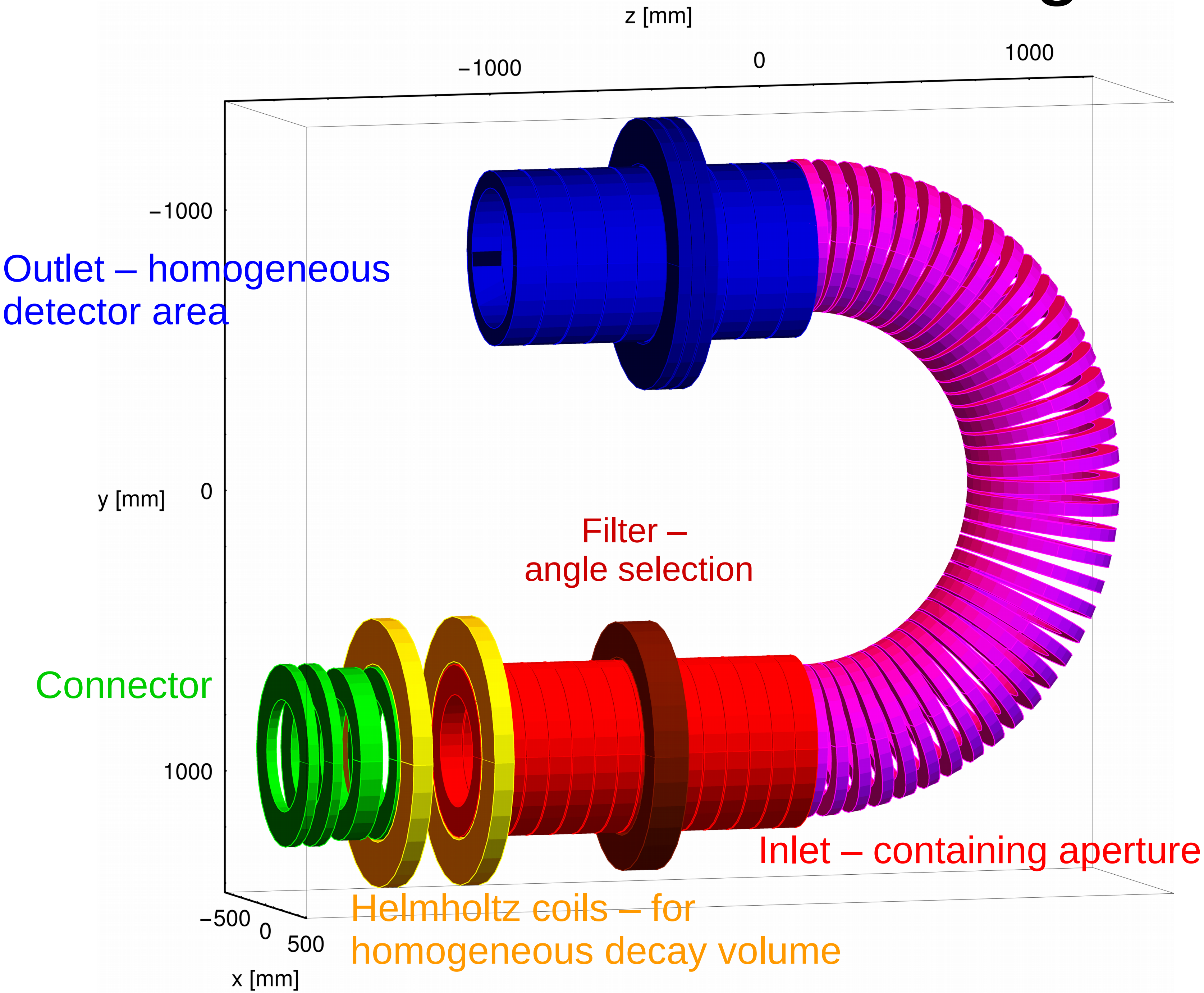
- small θ correction
- large θ acceptance
- high resolution



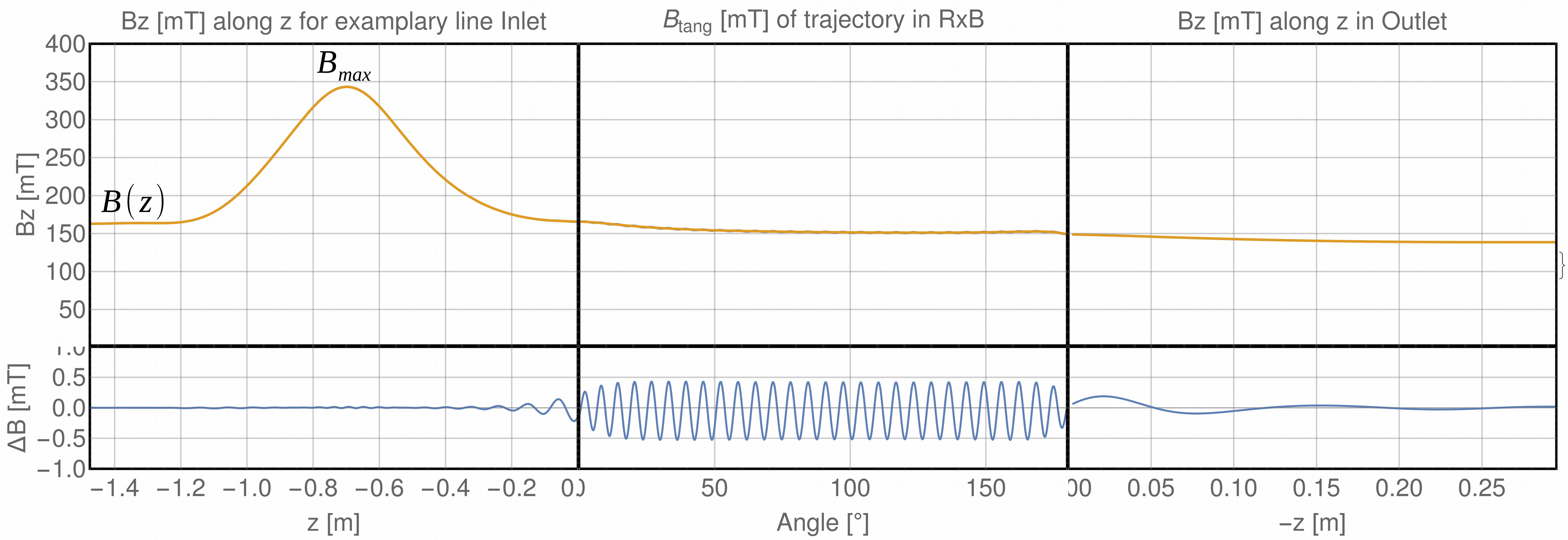
$$D_{max} = 83\,mm \quad for \quad p = p_{max} = 1187.29\,keV/c,\ \vartheta = 9°,\ B = 0.15\,T,\ \alpha = \pi$$

$$\Rightarrow p_{max}/D_{max} = 14.4\,keV/c/mm \ \Rightarrow\ 1.2\%/mm$$

NoMoS – current design

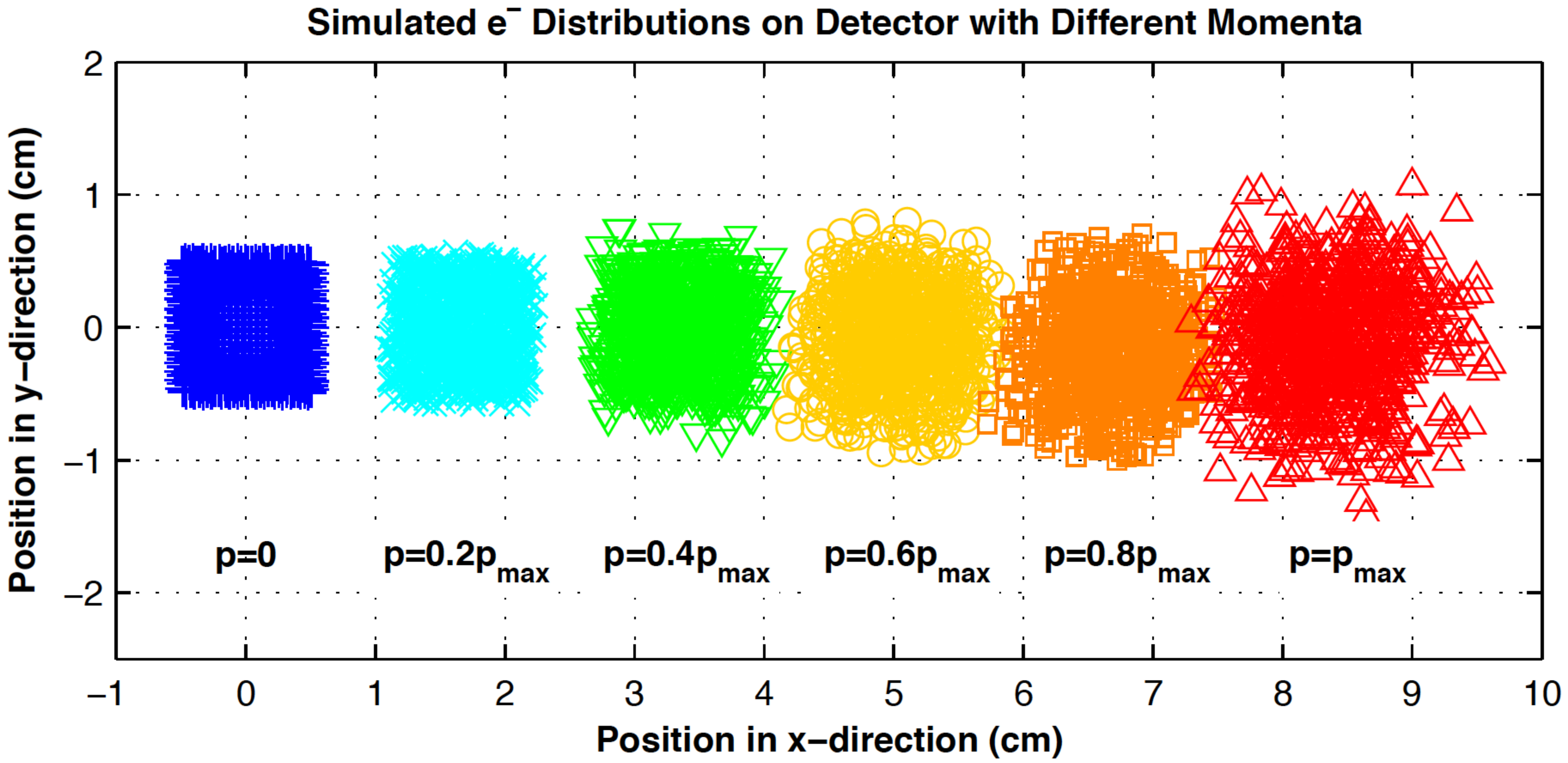


B-field of trajectory



$$\sin\vartheta_{crit} = \sqrt{B(z)/B_{max}} \longrightarrow \vartheta_{crit} \approx 45° \quad for \quad B(z) = 165\,mT, \quad B_{max} = 325\,mT$$

Examplatory Drift Simulation



Planned Set-Ups

- with calibration sources @ Atominstitut, TU Vienna (2019)

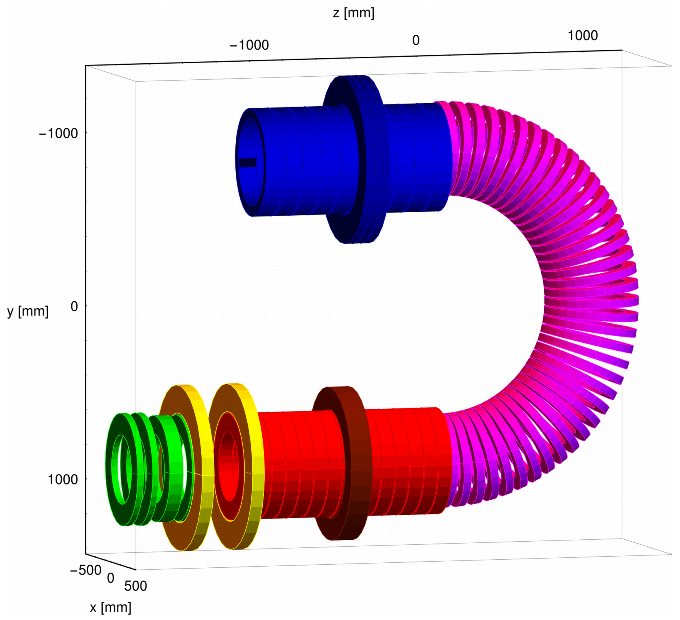
- Standalone @ ILL, Grenoble (2019/20)

- PERC @ FRM2, TU Munich (later)

- ANNI @ ESS, Lund (later)

Current Investigations

<u>Requirements</u> of the magnetic field:
- B-field homogeneity in all areas
- Defined properties of beam (e.g. angle, done by PERC or filter)
- Clearly defined RxB Drift → entrance, RxB, exit



Possible <u>adjustments</u>:
- Coil properties (current, position, dimensions,...)
- Number of coils
- Magnetic Shielding

<u>Goal</u>: be able to describe particle movement analytically

Summary

- BSM searches in neutron decay
- Momentum spectrum measurement via RxB drift
- Magnetic design in progress
- Currently call for feasibility study

Outlook

- Finalize design of magnetic set-up (including systematics)
- Construction
- Magnetic field measurement
- First measurement 2019