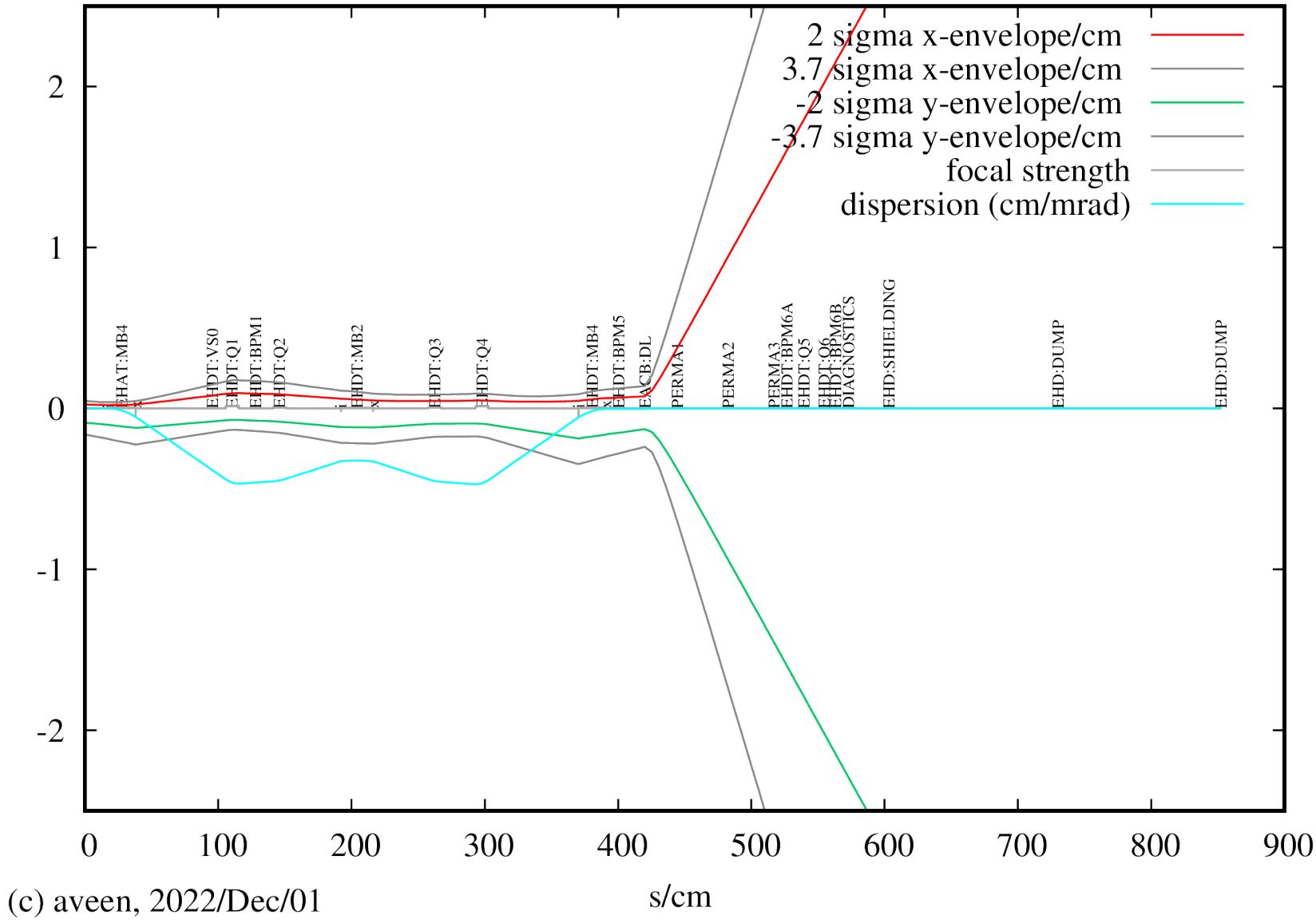
TRIUMF

# Status of DarkLight Beam Optics

Aveen Mahon
Beam Physics Group

June 1, 2023

# Target Scattering



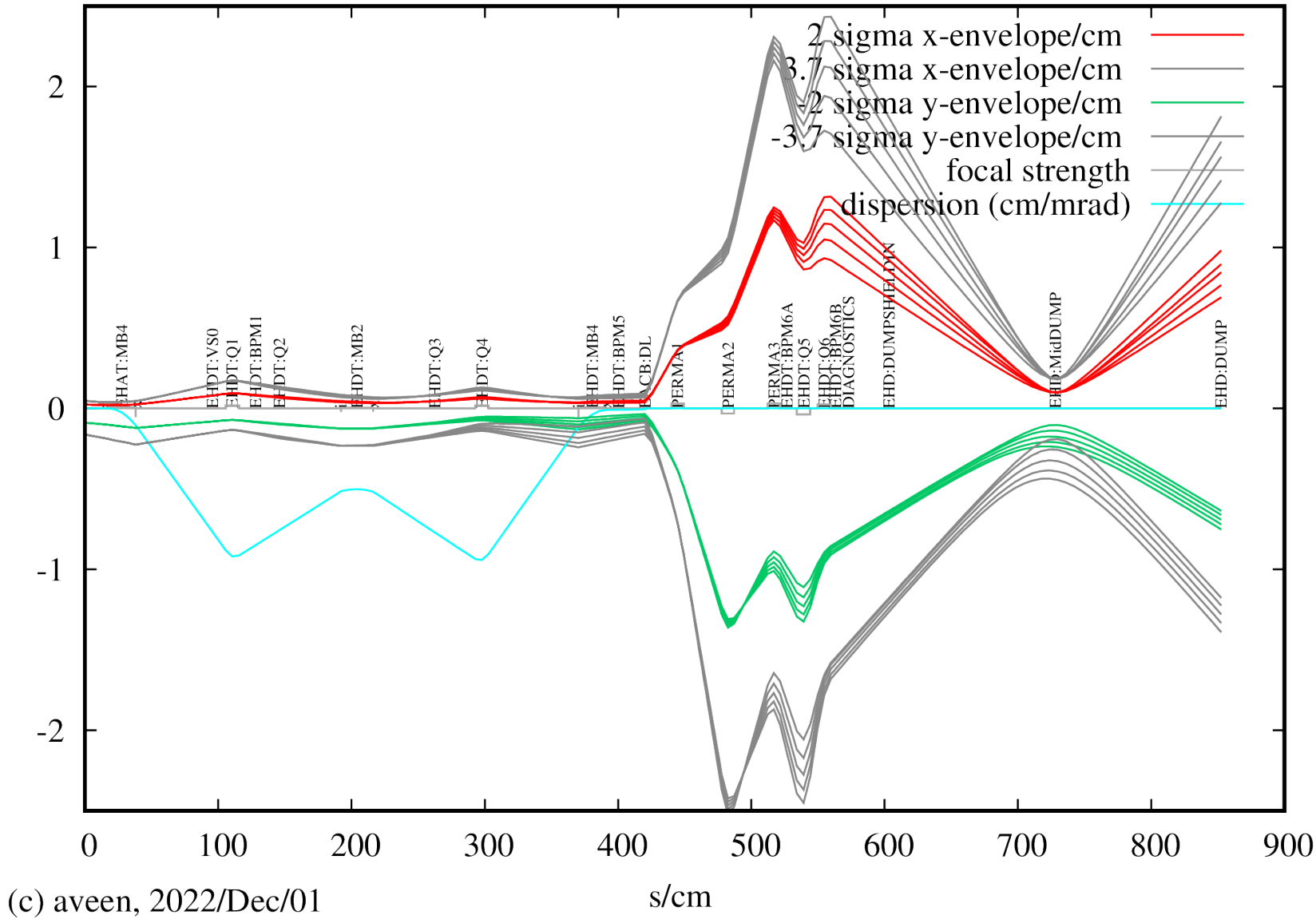

(c) aveen, 2022/Dec/01

# Beam Optics Model

Requirements:

- 3.7 sigma envelope fully contained withing 1” radius of beampipe
- Minimize beam size through the dump
- Valid for energy range of 27-31 MeV
- Compatible with regular operation (no target)
- Include sufficient diagnostics elements for operation

# Beam Optics Model - Latest

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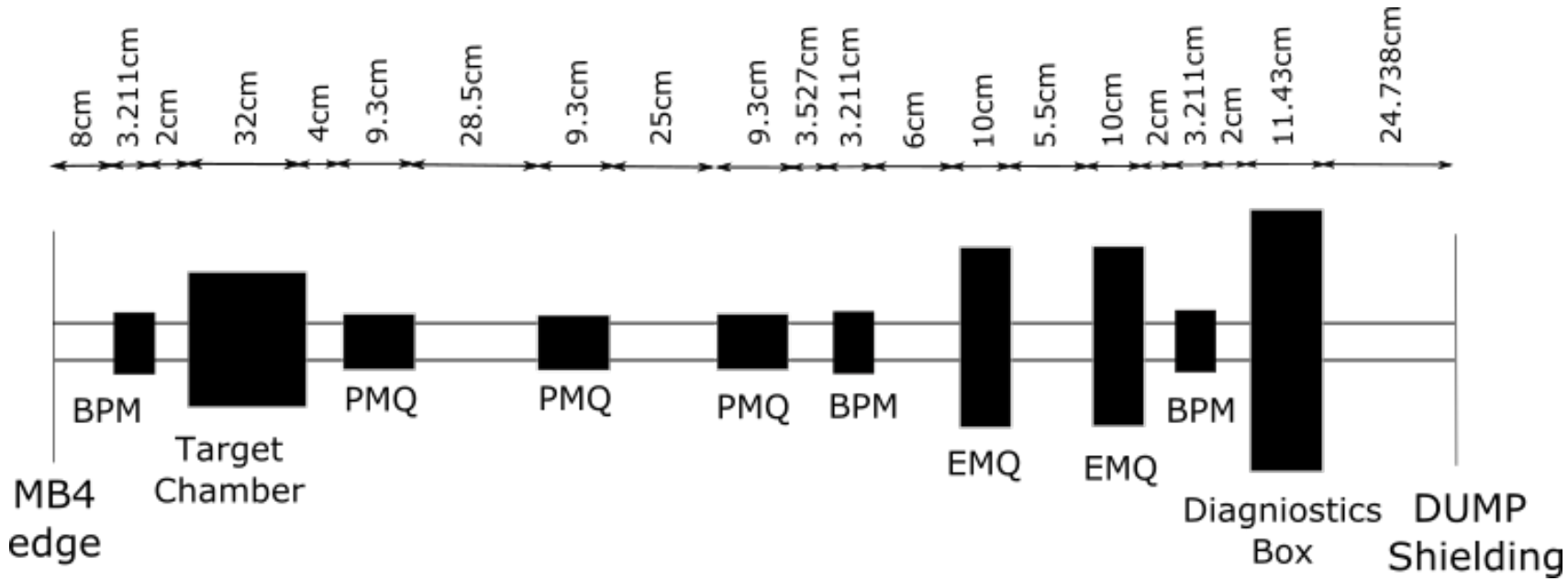
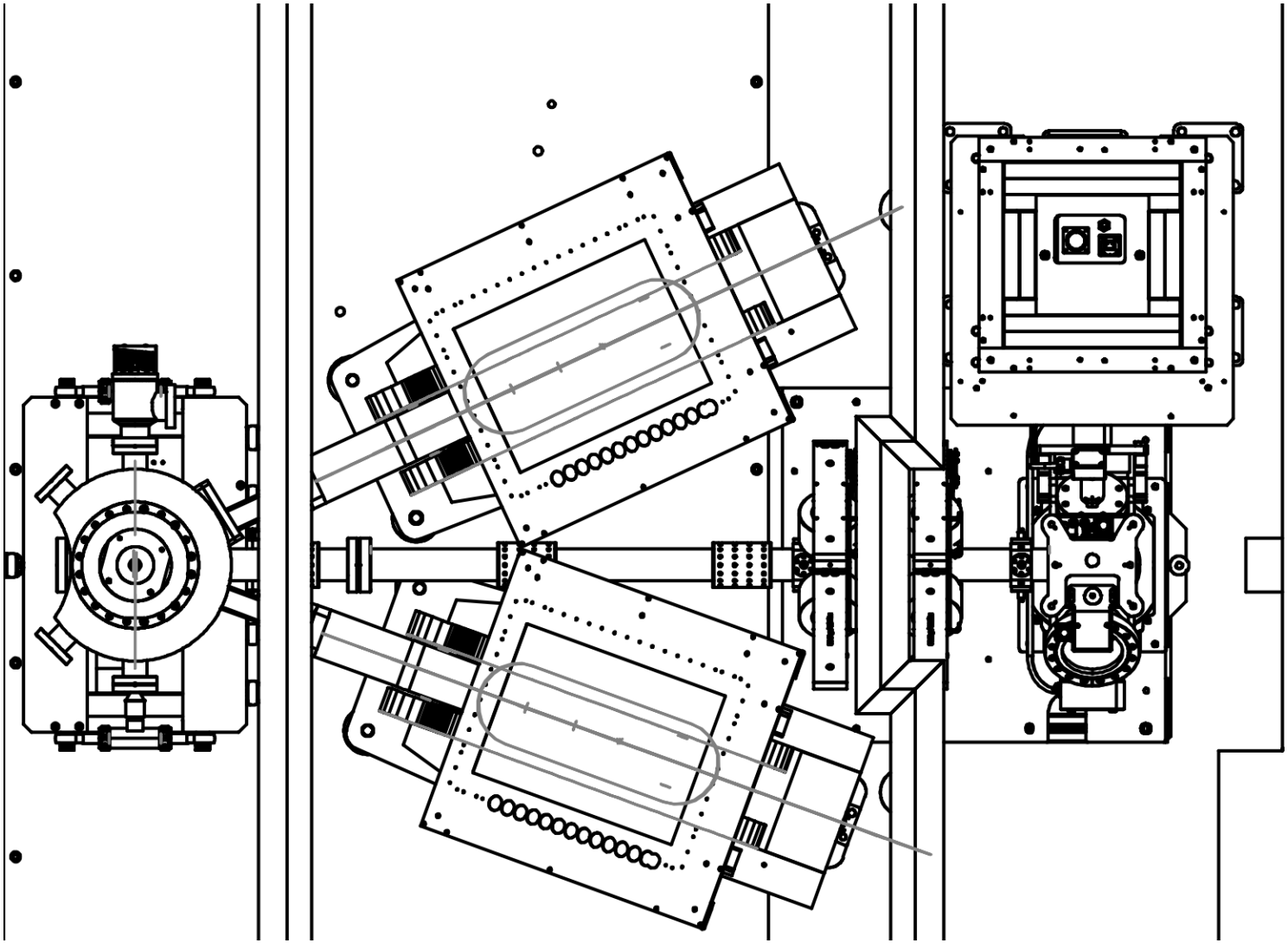
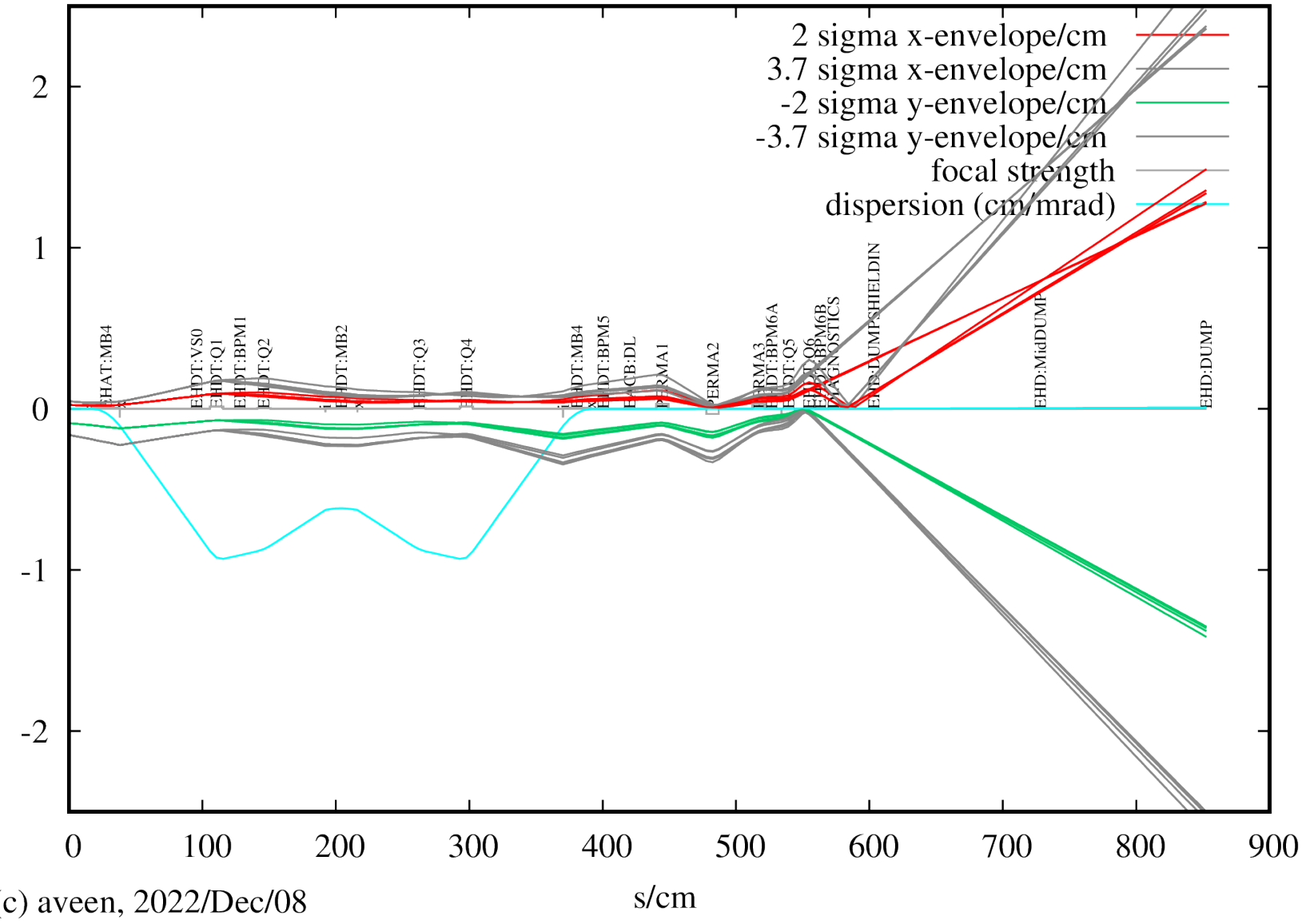
# Visual layout



# Visual layout



# Without Target

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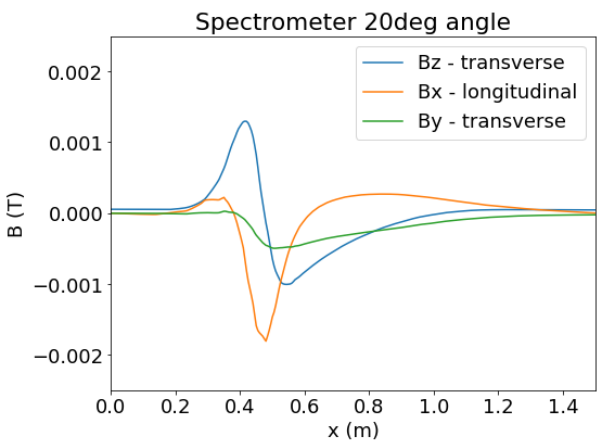
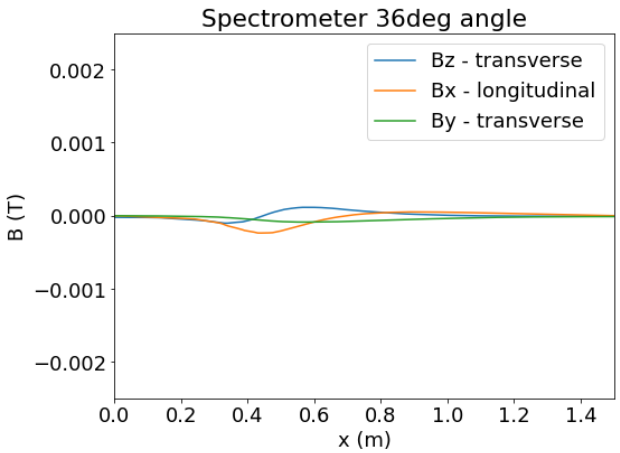
# Stray Field from Spectrometers

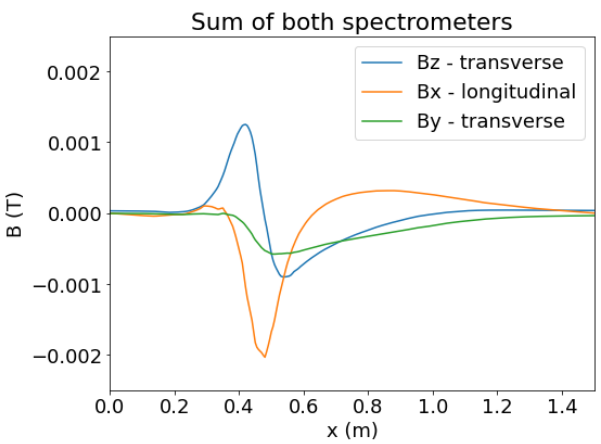
- Typical e-Linac steerer strenght 500 Gcm = 5 Gm




Integrated transverse components:
z: -0.522 Gm
y: -2.12 Gm
Deflection angle:
z: -5.13$\times 10^{-4}$ rad
y: -2.08$\times 10^{-3}$ rad




Integrated transverse components:
z: 0.0804 Gm
y: -0.511 Gm
Deflection angle:
z: 7.90$\times 10^{-5}$ rad
y: -5.41$\times 10^{-4}$ rad




Integrated transverse components:
z: -0.441 Gm
y: -2.67 Gm
Deflection angle:
z: -4.34$\times 10^{-4}$ rad
y: -2.63$\times 10^{-3}$ rad

# Parameterization of Magnetic fields

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **15**, 074002 (2012)

**Quadrupole shapes**

R. Baartman*
*TRIUMF, 4004 Wesbrook Mall, Vancouver, BC, Canada V6T 2A3*
(Received 17 January 2012; published 30 July 2012)

The usual practice of constructing quadrupoles from truncated cylindrical hyperbolae is put into question. A new shape is proposed. This shape has an analytic potential function. The exact shape of the analytic quadrupole may be impractical, but in the short case where aspect ratio length/aperture ≈ 1, pole shapes can be spherical. The optimal spherical radius is found to be 1.65 times the aperture radius. An example is also given demonstrating that for aspect ratio >1, the aberrations of order 5 and higher are lower for the optimized shape.

- Magnetic field components:

$$F_x = \frac{K}{2}\frac{\sin 2x}{\cos 2x + \cosh 2z} = \frac{K}{2}\frac{\sin x \cos x}{\cos^2 x + \sinh^2 z} \quad (10)$$

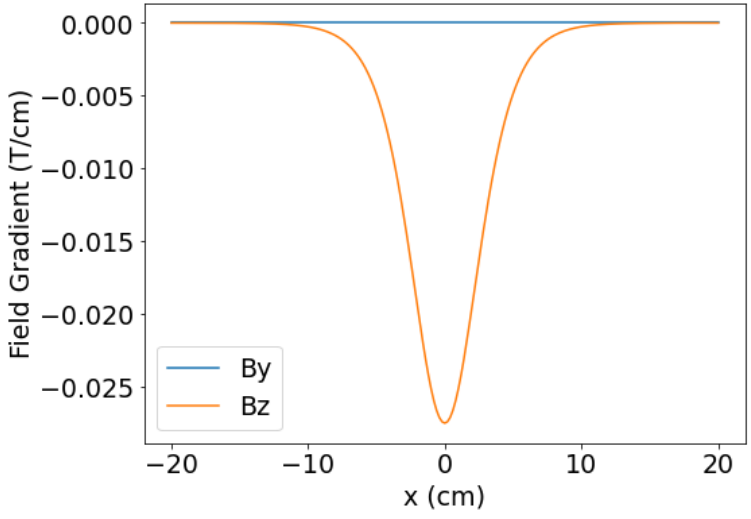
$$F_y = -\frac{K}{2}\frac{\sin 2y}{\cos 2y + \cosh 2z} = -\frac{K}{2}\frac{\sin y \cos y}{\cos^2 y + \sinh^2 z} \quad (11)$$

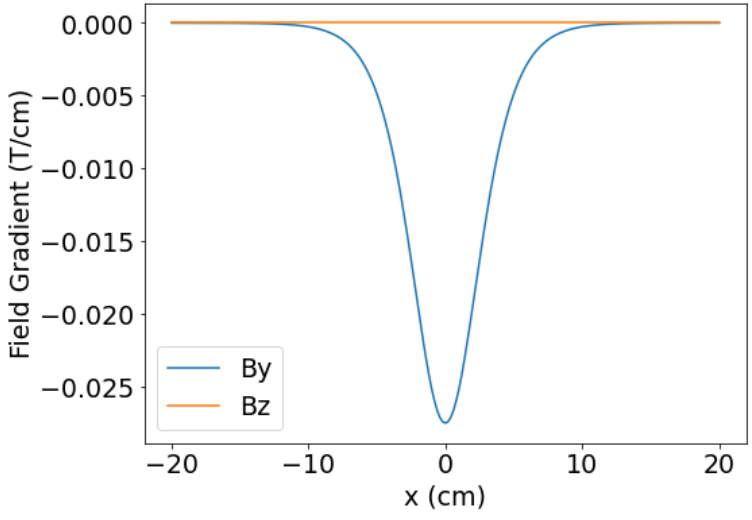
$$F_z = \frac{K}{2}\left(-\frac{\sinh 2z}{\cos 2x + \cosh 2z} + \frac{\sinh 2z}{\cos 2y + \cosh 2z}\right). \quad (12)$$

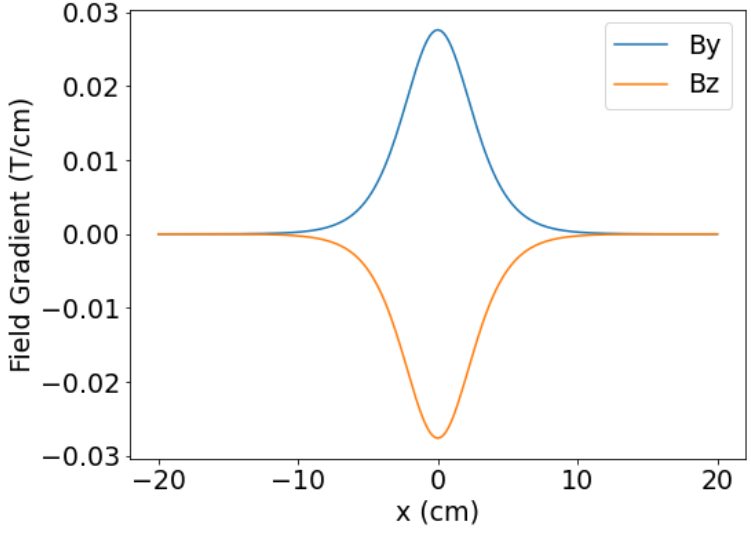
# Standard EM quadrupole

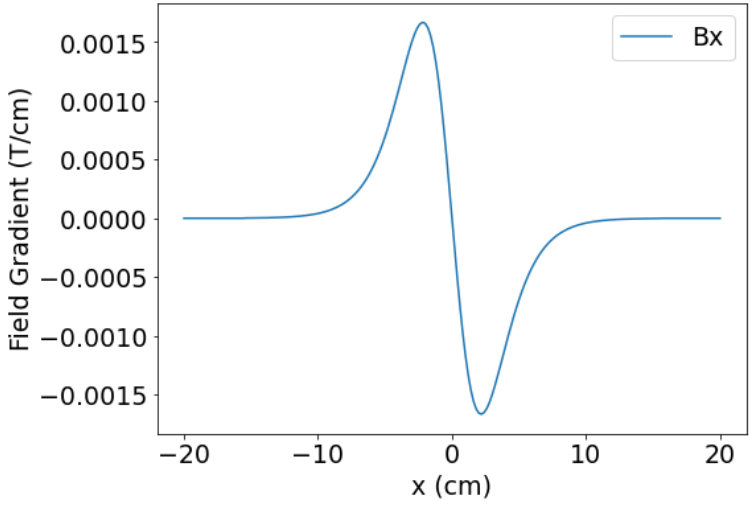
# Standard EM quadrupole

- Parameterized fields when displacing in the y and z directions:



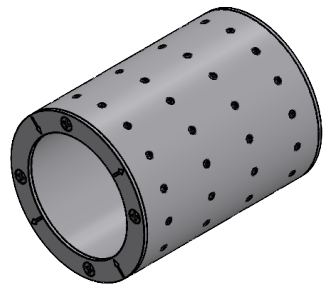



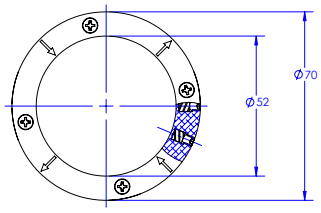



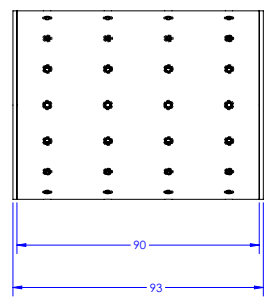
# Permanent magnet quadrupoles

Notes:
1. Integrated Field Strength: 0.30T -0%/+5%
2. Nominal Gradient: 3.33T/m
3. Harmonic Content: Bn/B2 @ r=20mm, n=3, 4, 5, 6 <= 1% each term
4. Magnet Material: SmCo2:17
5. Housing Material: Aluminum alloy 6061-T6, no finish
6. Hardware: 18-8 Stainless Steel

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | REV. | DESCRIPTION | DATE | APPROVED |



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| | FINISH - | ENG APPR. - - | SIZE C / CAGE CODE - / DWG. NO. 105500 / REV - |
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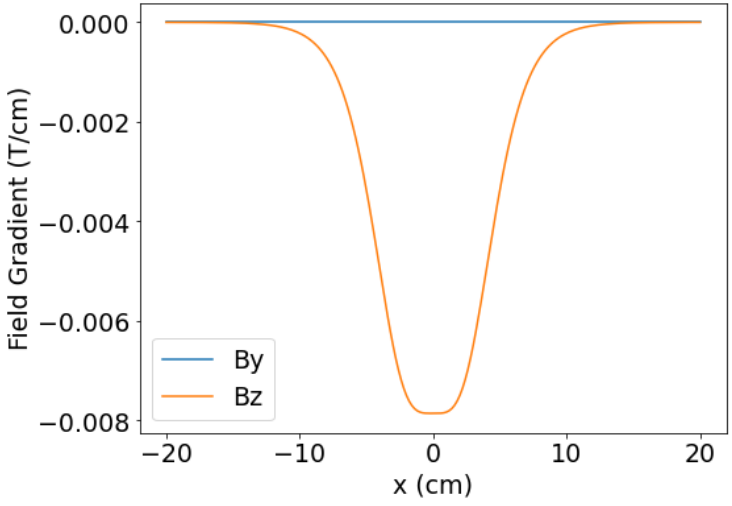
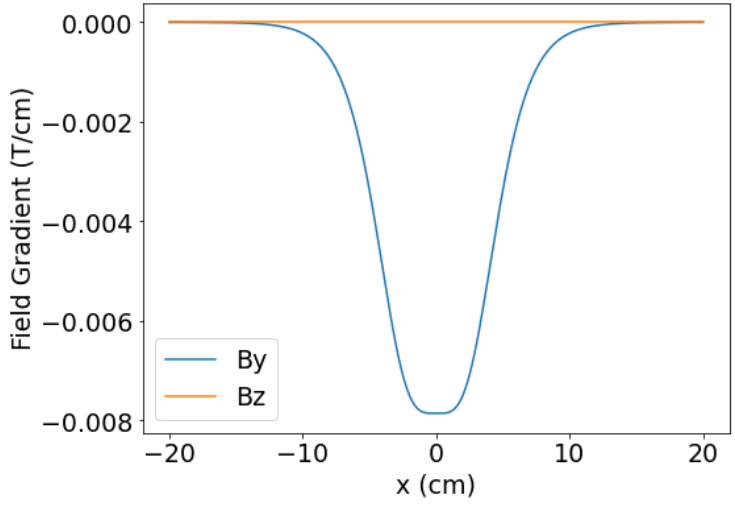
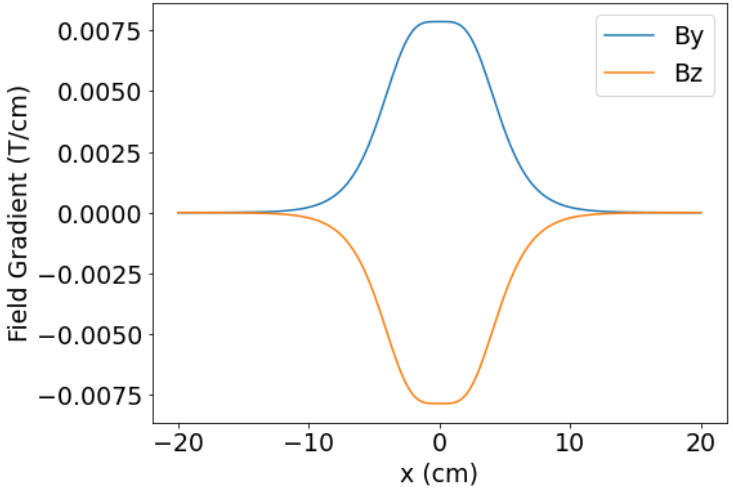
| | | FILENAME: | |

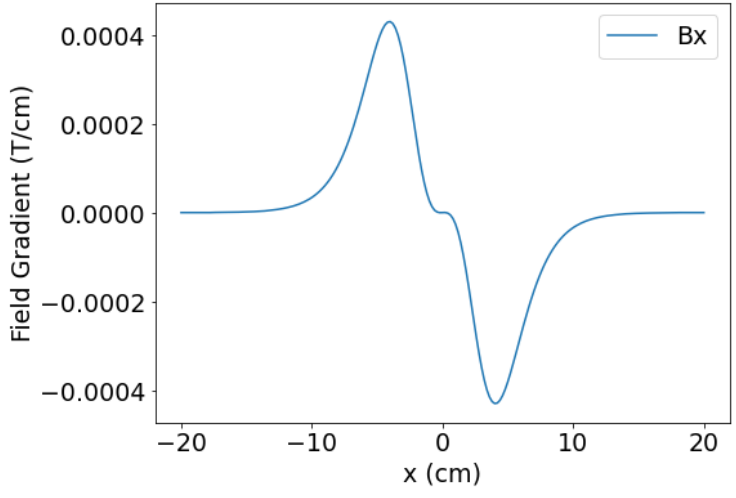
# Permanent magnet quadrupoles

- Parameterized fields when displacing in the y and z directions:



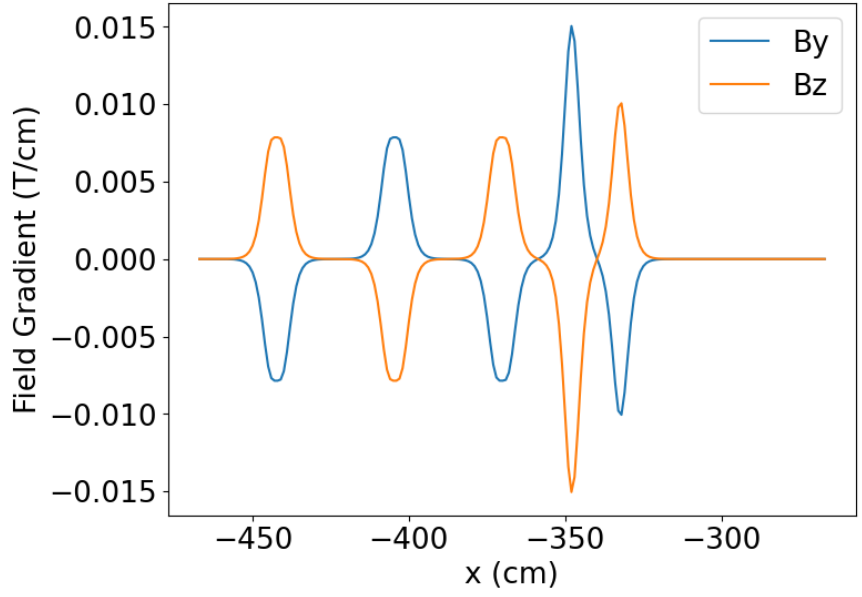



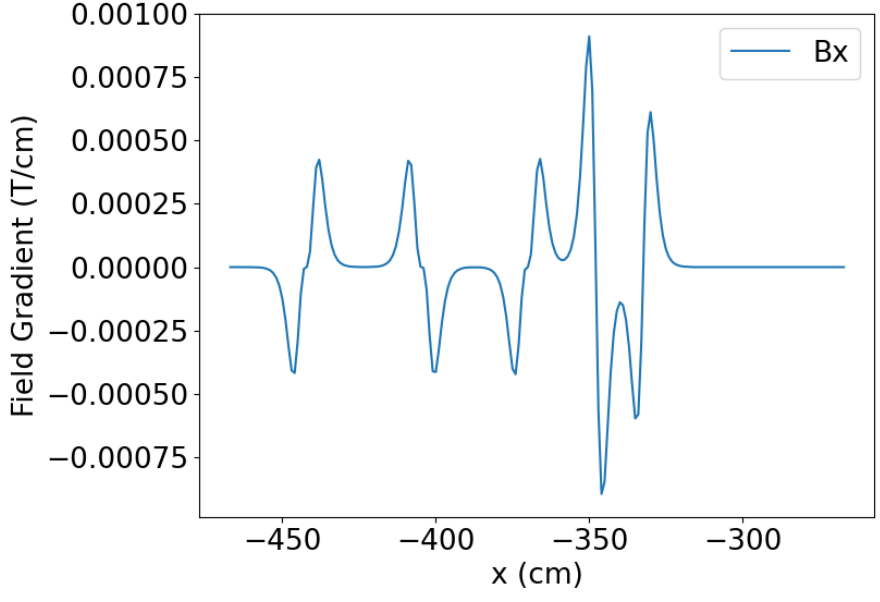



# Full DL Beamline

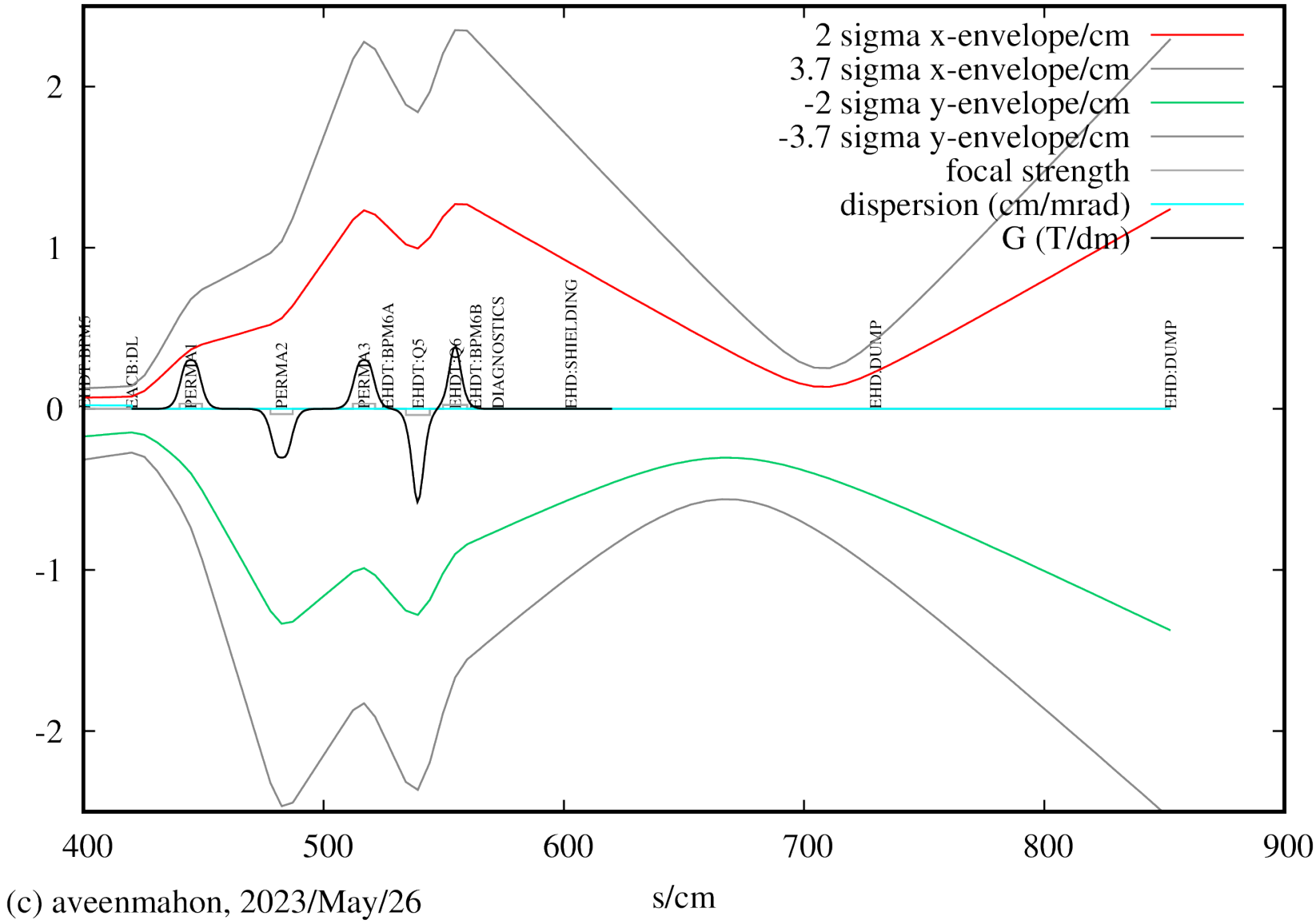
Transverse Fields:



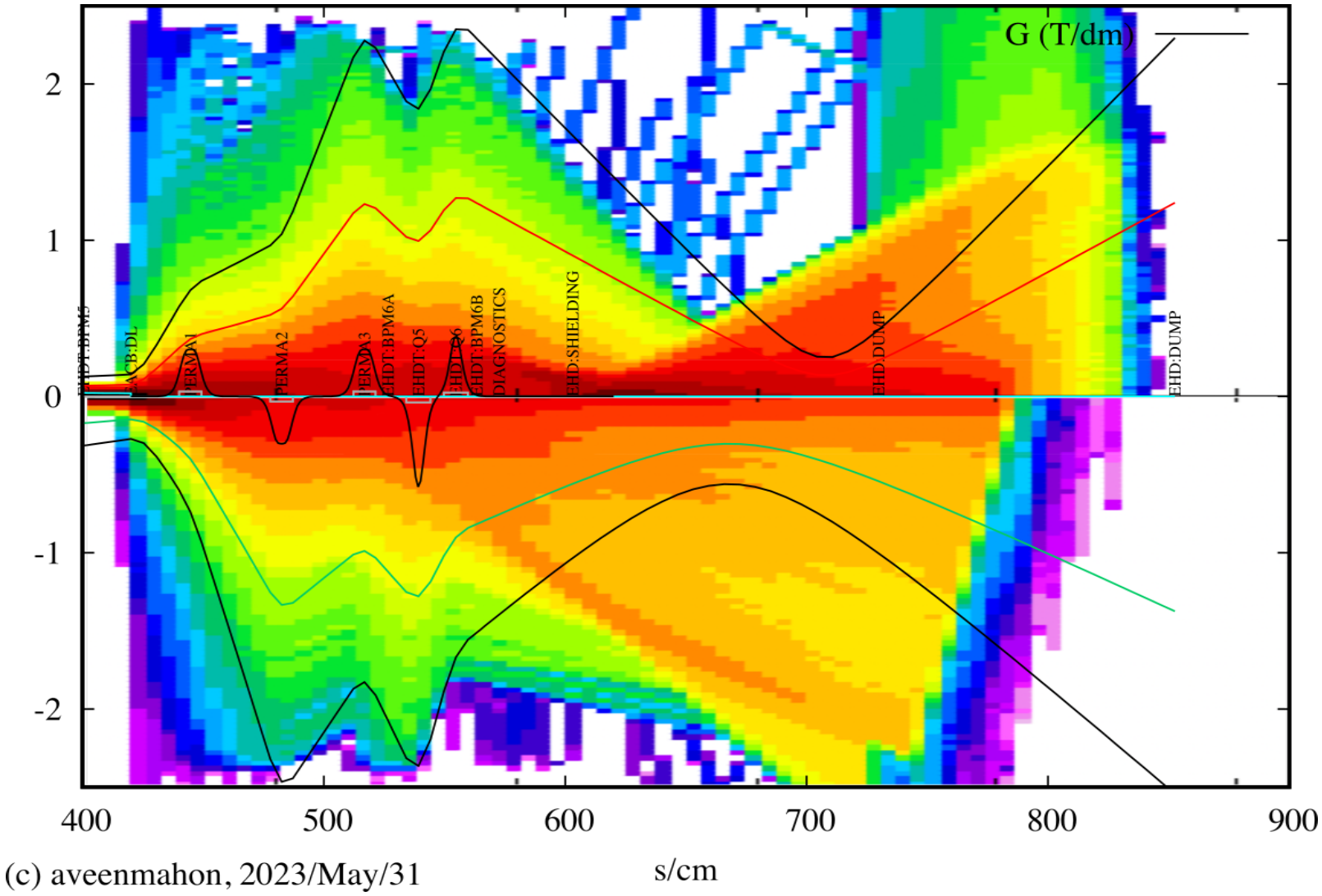

Longitudinal Field:



# Comparison to TRANSOPTR



# Comparison to FLUKA



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# Thank you
# Merci