# Introduction

- **Acknowledgments**
  - ▷ Giovanni dal Maso, Peter-Raymond Kettle, Andreas Knecht!
  - ▷ Zachary Hodge

- **Setup**
  - ▷ G4BL version 3.06
  - ▷ GEANT4 version 10.05.p01
    both patched to include HIMB pion production model
  - ▷ PIONEER G4BL respositories of Zachary Hodge (https://gitlab.com/zhodge)

- **based on/incorporating material from**
  - ▷ HIMB pion production model (QGSP_BIC_HIMB_HYBRID_HP_BIAS_EMY)
    F. Berg, et al., Phys. Rev. Acc. and Beams 19, 024701 (2016)
  - ▷ 'CMBL - A High-intensity Muon Beam Line . . . ', Ph.D thesis, Felix Berg
  - ▷ 'Production, . . . of surface muon beams . . . ', Ph.D thesis, Zachary Hodge

- **Goals**
  - ▷ validate pioneer G4BL with Giovanni's surface muon G4BL
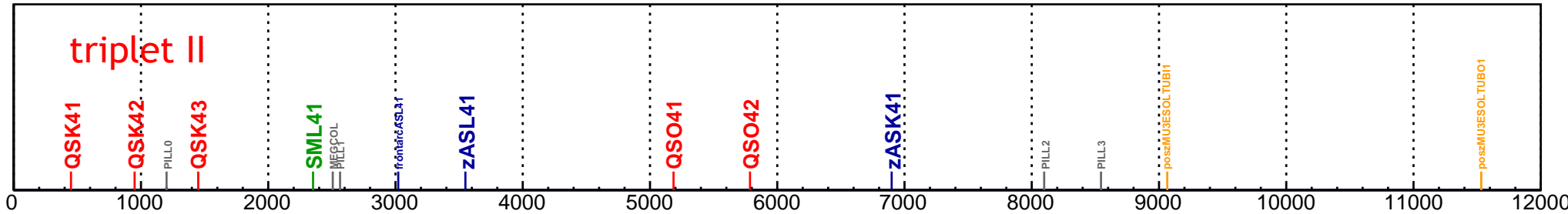 - ▷ pioneer G4BL for pions, phase space measurement, . . .

Beamline positions

$s = 12977.6\,\mathrm{mm}$ ↓

(from center TgE)

- **Zach's Positions.txt start at** $\mathrm{posAHSW41} = 0$
  - ▷ 'long version' starting from TgE
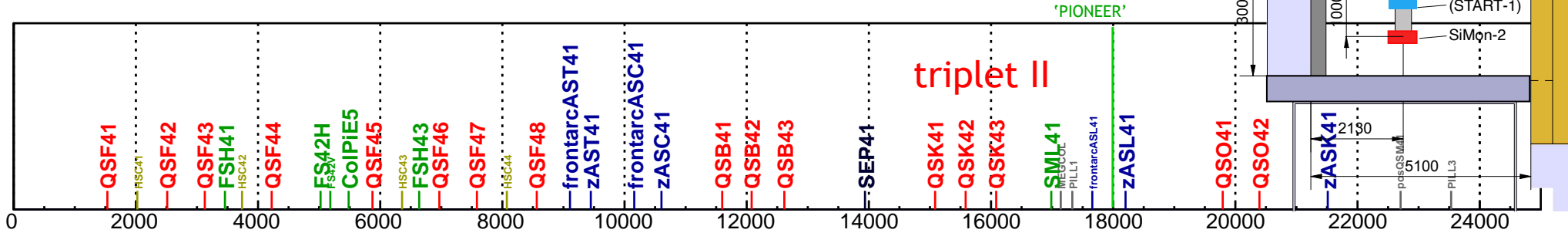
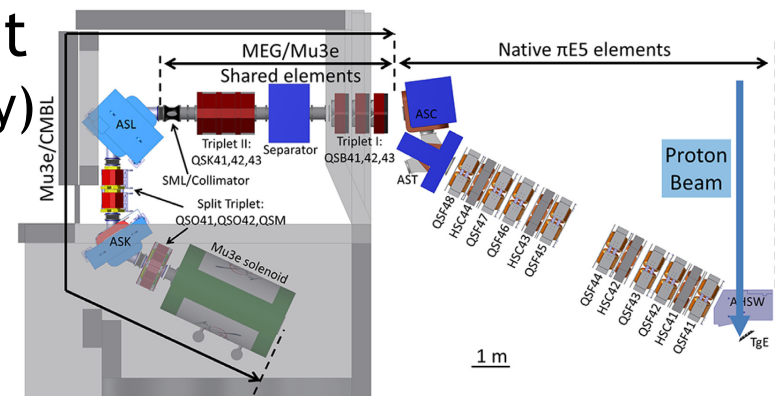- **Giovanni's Positions.txt start after SEP41 ('G4BL Short CMBL2018')**

- **Spacing differences not always constant**
  - ▷ Zach's settings based on 'design' ($\neq$ reality)
  - ▷ SML41: asymmetric $\rightarrow \pm 200$ kV

Element	Zach	Giovanni	Difference
QSK41	15084.5	450	14634.5
SML41	16986.5	2352.2	14634.3

  - ▷ offset ≈ 14634 mm (varying 'downstream')

Particle production

- **Particle production**
  - ▷ **HIMB model** (also tests without HIMB)

    physics QGSP_BIC_HIMB_HYBRID_HP_BIAS_EMY splittingFactor=100
  - ▷ **target**

    polycone TargetCone innerRadius=203.13912,200.89821,243.67818,246.86088

    outerRadius=203.13912,206.32182,249.10179,246.86088

    z=-20.618932,-17.948325,17.948325,20.618932

    initialPhi=0 finalPhi=360 maxStep=100

    material=TargetEGraphite color=1,1,1 kill=0

    place TargetCone copies=1 x=-194.9 y=0.0 z=112.5 rotation='Y(180+30)'
  - ▷ **beam<u>line</u> zero defined by initial dipole selecting** p

    posAHSW41=0
  - ▷ **write pions/muon**

    place DetEMuPiFromTarget copies=1 x=0.0 y=0.0 z=150.0
  - → (propagation of) beam starts at $z = 150$ cm

- **Samples, using param scaleMom (= p/28 MeV)**
  - ▷ surface muons with $p = 28$ MeV (comparison with Giovanni's results)
  - ▷ pions/muons with $p = 75.9$ MeV (from Zach)

Particle transport

- **beam 'sampling' (so far)**
  - ▷ virtualdetectors

    virtualdetector CALOENTR radius=200 length=1 material=Vacuum

    virtualdetector ATAR width=20 height=20 length=1 material=Vacuum
  - ▷ profile.txt

    profile zloop=$posQSF41,$posATAR,10 particle=mu+

    (also for pi+)
  - ▷ positions

    place CALOENTR z=$posCALOENTR

    place CALOCNTR z=$posATAR

    param posQSF41 1533.05
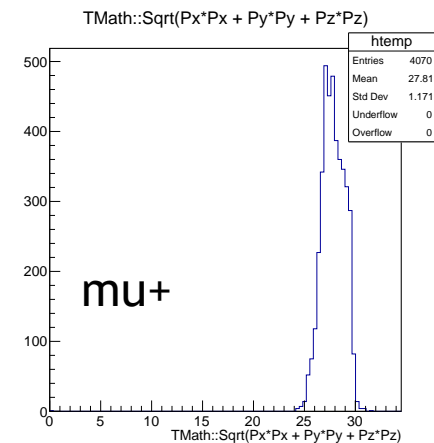
    param posCALOENTR 17199.
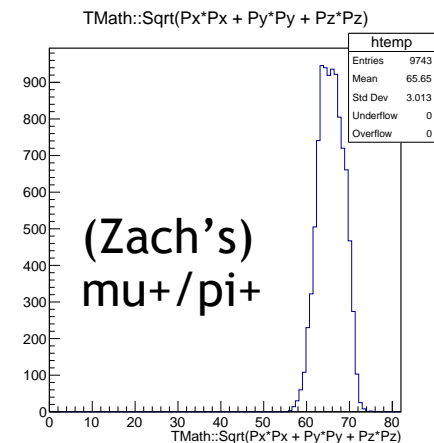
    param posATAR 18000.

    param posCALO 18000.

- **scaleMom**
  - ▷ Zach's default setting scaleMom = 2.3491 ($\rightarrow$p = 65 MeV)?
  - ▷ surface muons with scaleMom = 1

- **so far no 'air' in Zach's beamline**

CALOCNTR

TMath::Sqrt(Px*Px + Py*Py + Pz*Pz)

(Zach's) mu+/pi+

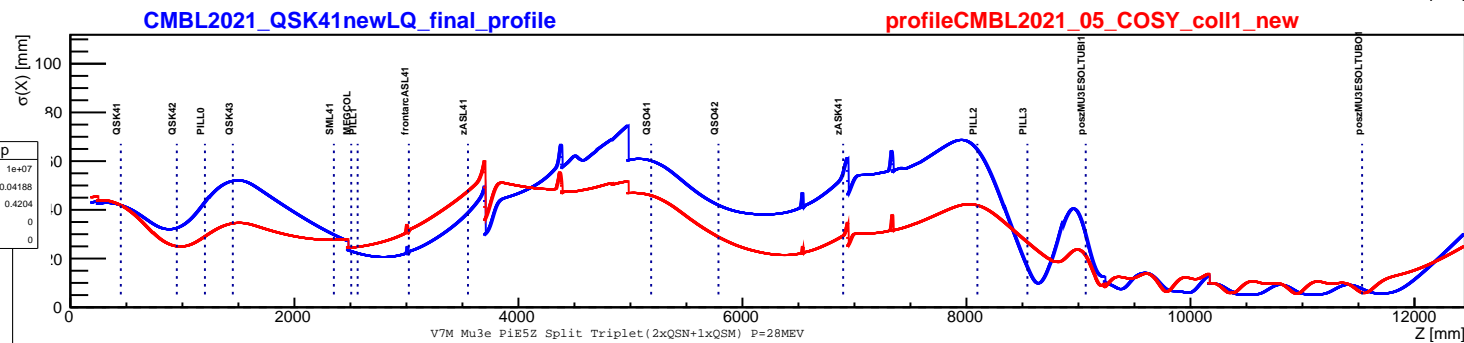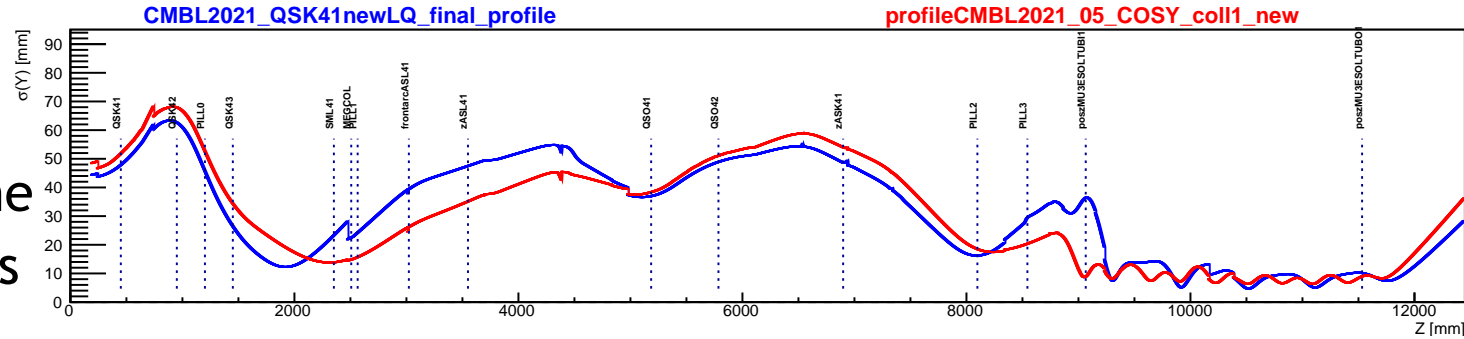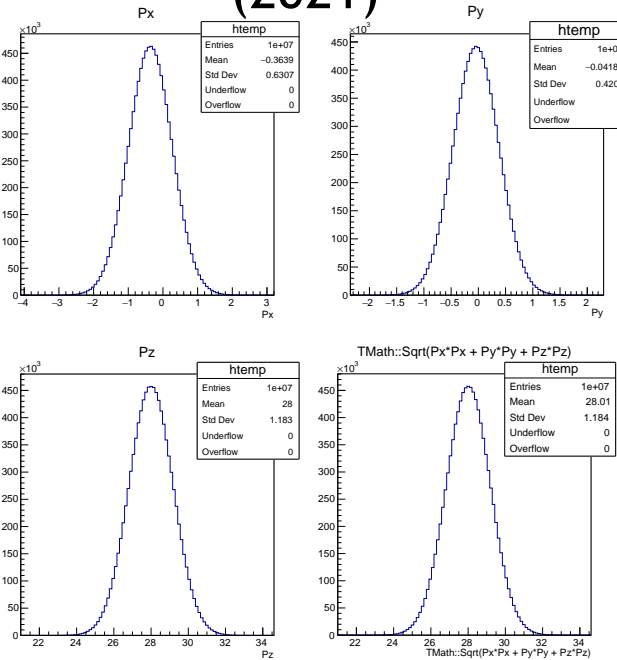TMath::Sqrt(Px*Px + Py*Py + Pz*Pz)
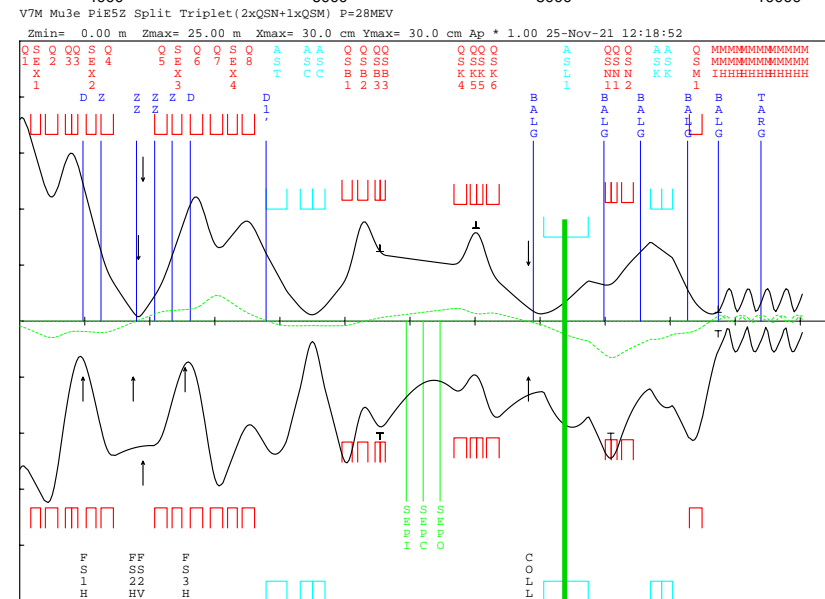

mu+

Giovanni's two profiles

many thanks to Giovanni!

- **beam**
  - ▷ latest profile
  - ▷ 'short' beamline
  - ▷ center positions
  - ▷ with measured beam profile (2021)

$z_{initial} = 450\,mm$
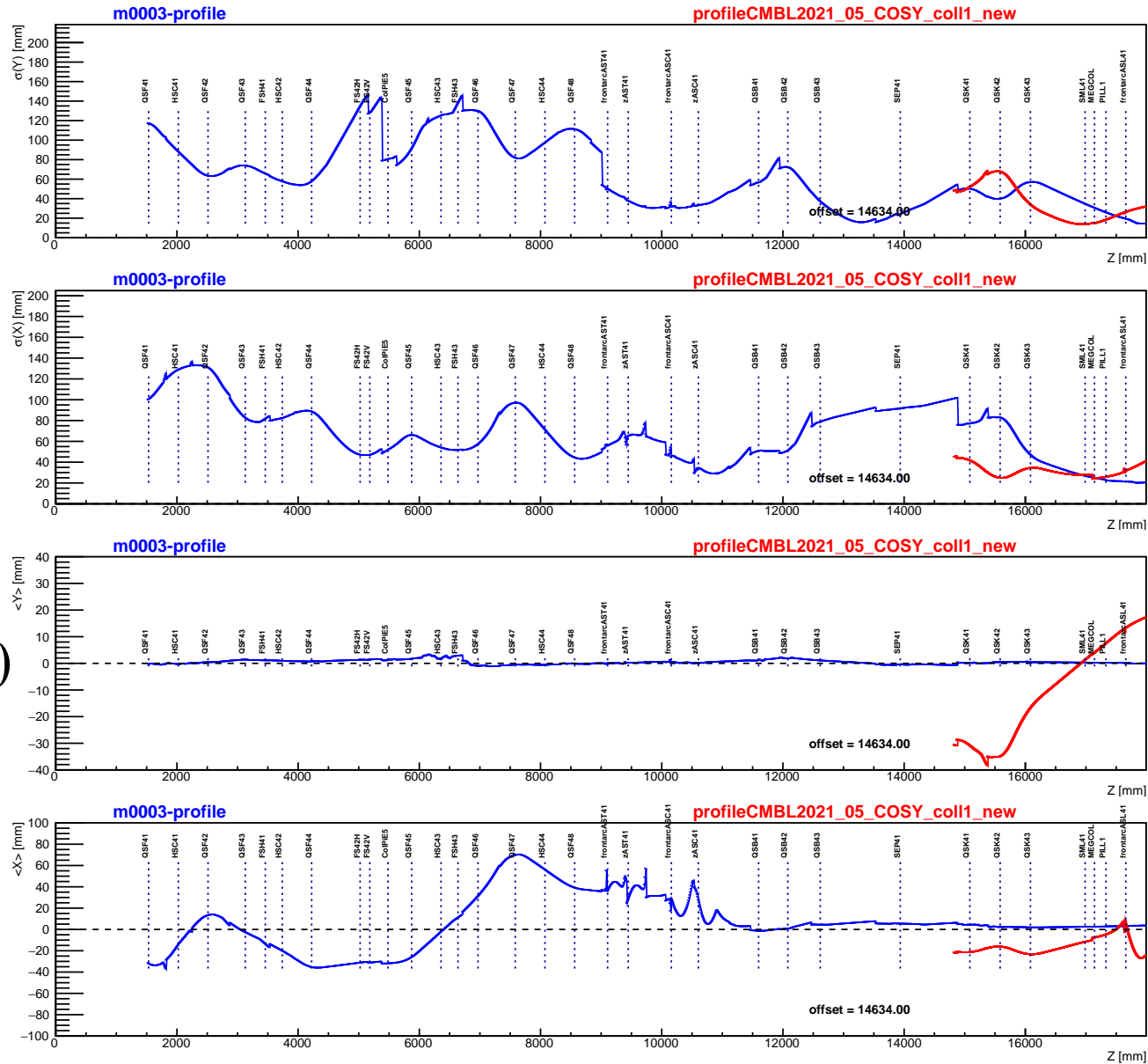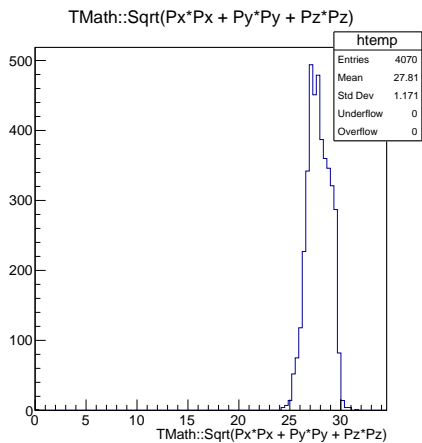before QSK41
(center)

- **TRANSPORT beam envelope**
  - ▷ covers entire beamline

Overlays beam positions/envelopes

- **Surface muons**
  - ▷ scaleMom = 1
    for production
    and transport
  - ▷ QSK focus
    horiz. - vert. - horiz.

- **Issues(?)**
  - ▷ sign error (triplet II)?
    - ▷ QSK ~ QSB
      (in principle)
  - ▷ beam offset? (target?)

Parameter comparison (I)

- **BeamTeam (google) [notebook](#) mirrors Giovanni's parameters in**
  - ▷ Settings/CMBL2021_05
  - ▷ TBC?! (different in Settings/CMBL2021_05_optimized)

- **currents and settings**

Name	Giovanni	Zach (m0003)
QSK41current	24.074974186601978	18.91
QSK41set	-0.60187435	0.598725
QSK42current	-41.088738057802146	-41.79
QSK42set	1.0272185	-0.931514
QSK43current	26.709925230374527	38.33
QSK43set	-0.66774813	0.613911
SML41cur	-12.412704330959823	-19
SML41set	0.0017422204	-0.0026667991
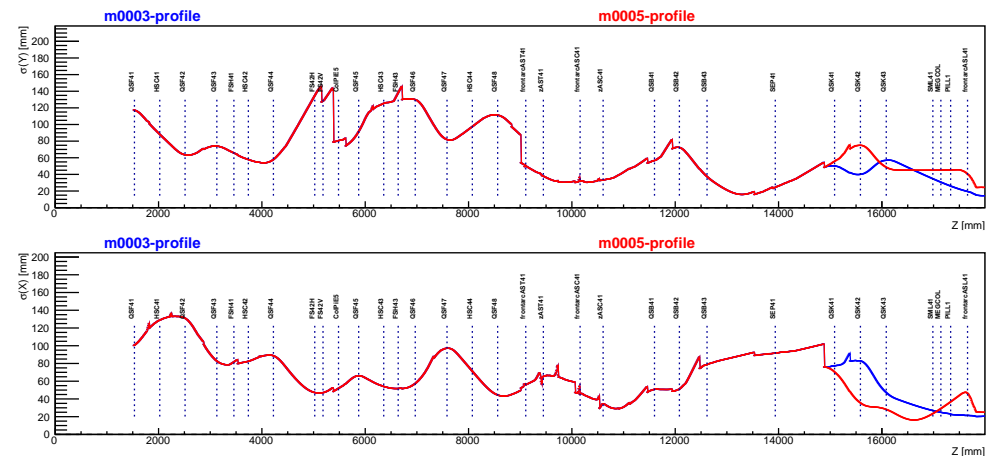
place QSK rename=QSK41 current=$scaleMom*$QSK41set z=$posQSK41

  - ▷ QSK4?current is not used

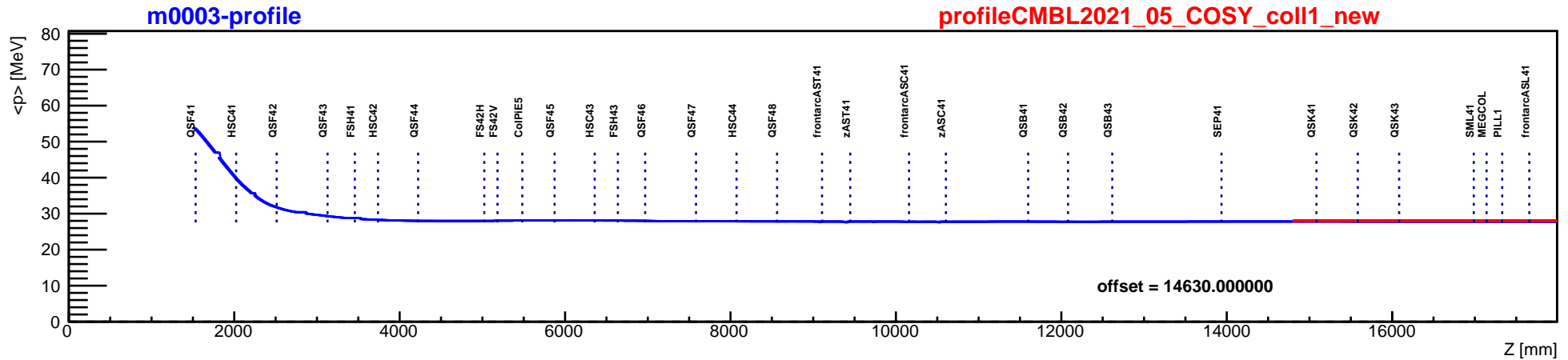- **Indeed, looks like a sign flip**
  - ▷ reason unclear (to me)

Giovanni/PIONEER (2nd try)
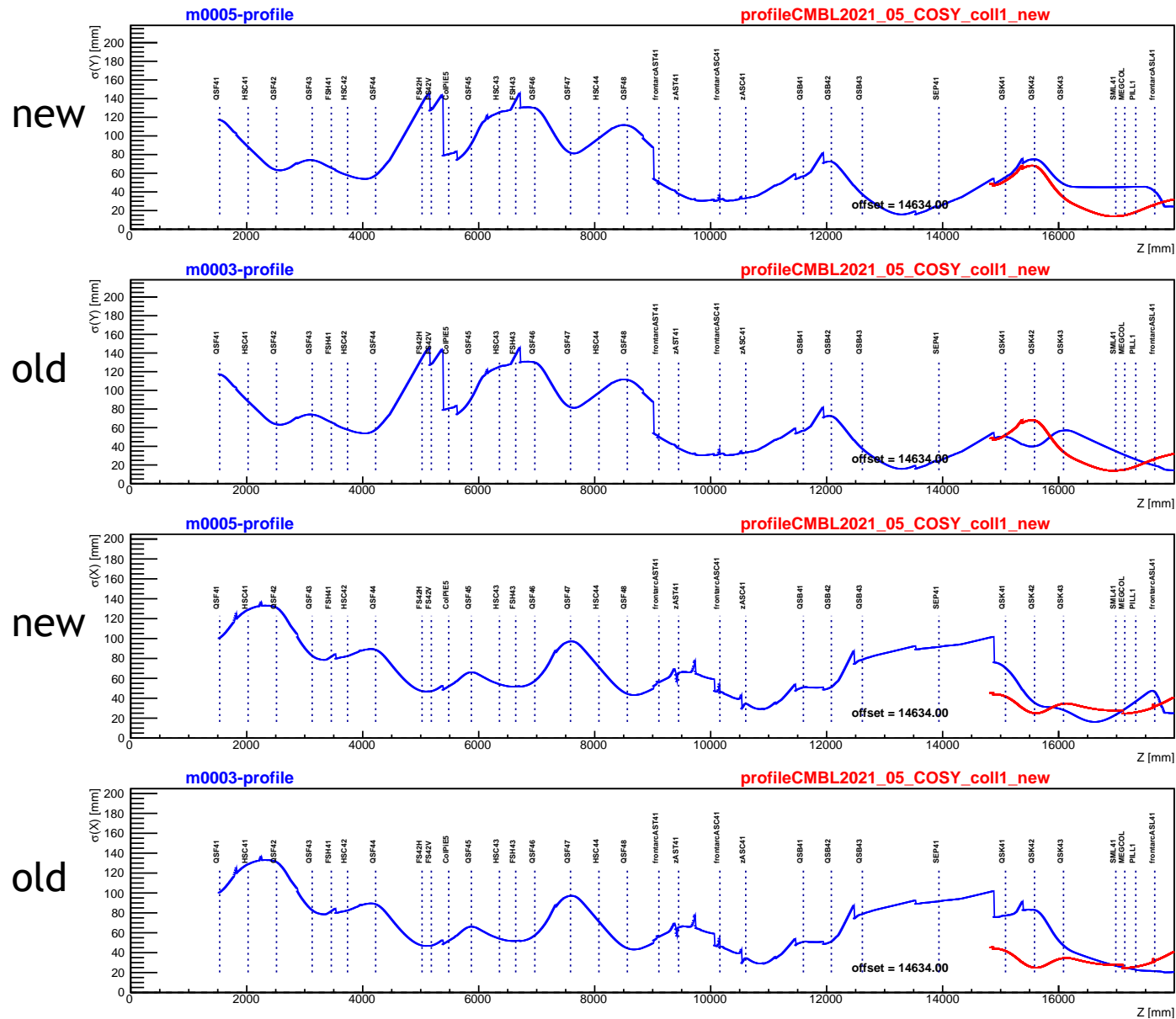
Momentum

- **Issue (?)**
  - ▷ AHSW selects momentum
  - ▷ driven by outliers? (profile.txt analysis)

Miscellaneous

- **Discussions with**
  - ▷ Giovanni dal Maso on 2022/05/04, plus emails/code exchange
  - ▷ Peter-Raymond Kettle on 2022/05/05

- **PRK past reference measurements**

p [MeV]	Rate f [π^+/sec @2.2mA]	$\sigma(X)$ [mm]	$\sigma(Y)$ [mm]	$f(\pi^+)/f(\mu^+)/f(e^+)$
107.8	6.8×10^8	11	9	75/20/5
84	4.7×10^8	13	13	71/19/9

- **Background (PRK)**
  - ▷ SEP41 (+/-200kV) may run into limitations at 'high' end of momentum
  - ▷ had had issues with protons ($\rightarrow$ teflon, tape)
  - ▷ maximize particle separation by optimizing TOF separation (position)

- **'Inversion' of (x, y, f) measurement to phasespace**
  - ▷ Peter-Raymond uses transport
  - ▷ Giovanni uses another setup
  - ▷ . . .