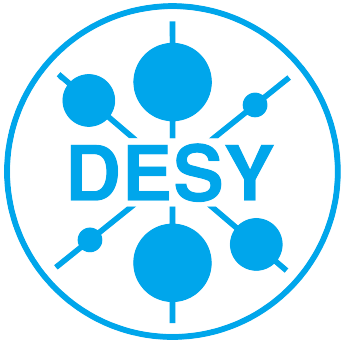





# Status of the Tungsten-Iron Comparison

Clemens Günter

CALICE AHCAL meeting, 11.12.2012

# Motivation

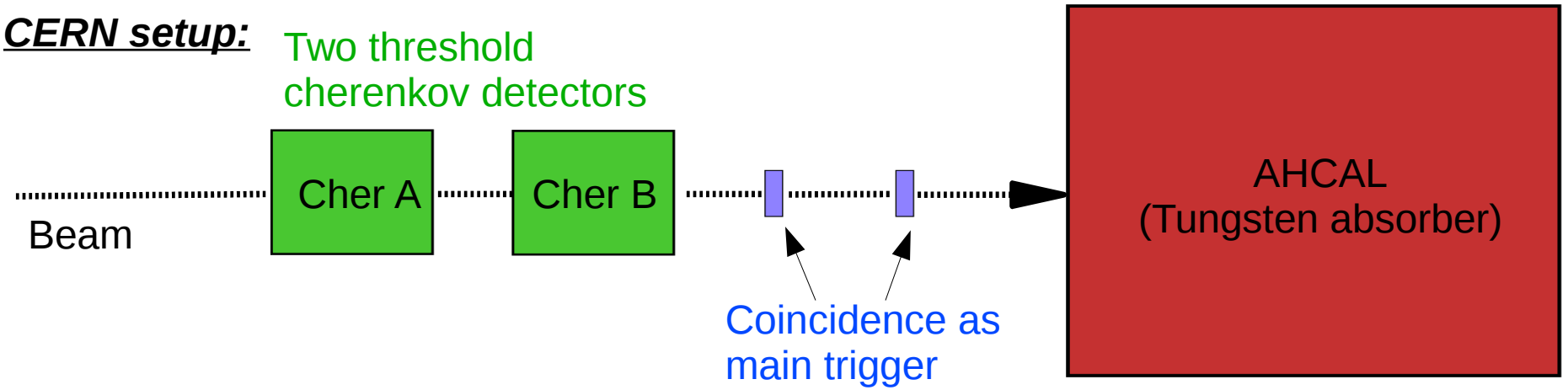
***Motivation:***

- Investigate and understand the differences between iron and tungsten absorber
  (tungsten absorber proposed for CLIC)

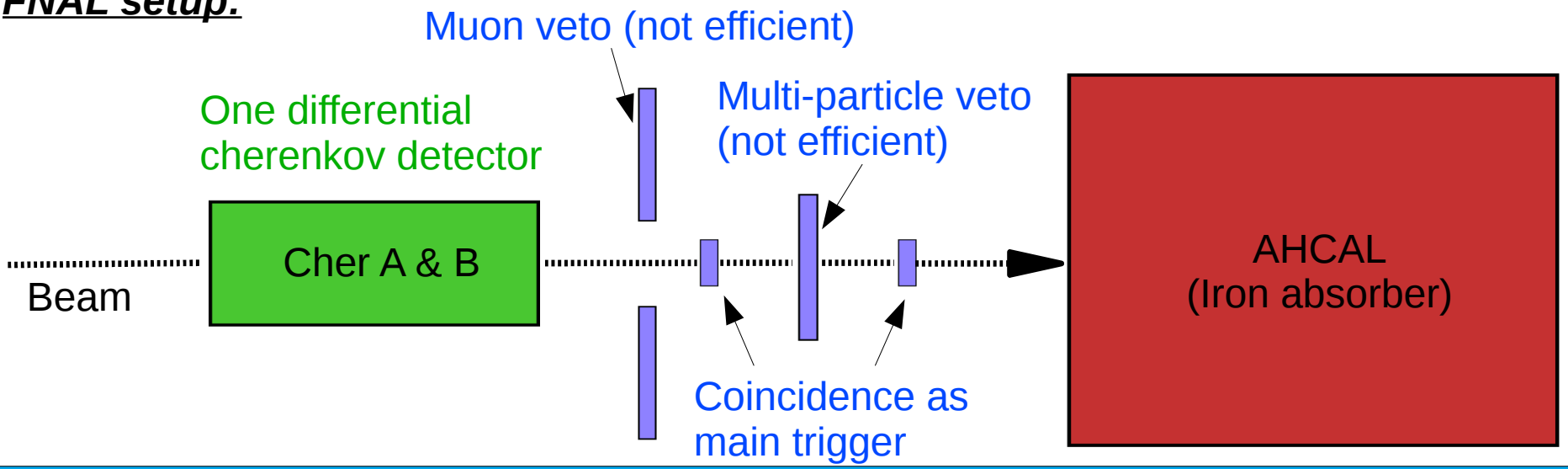
- Compare pion showers for iron (FNAL 2008 & 2009) and tungsten (CERN 2010) data for energies from 2-10 GeV (overlap of both testbeams)

# Schematic testbeam setups

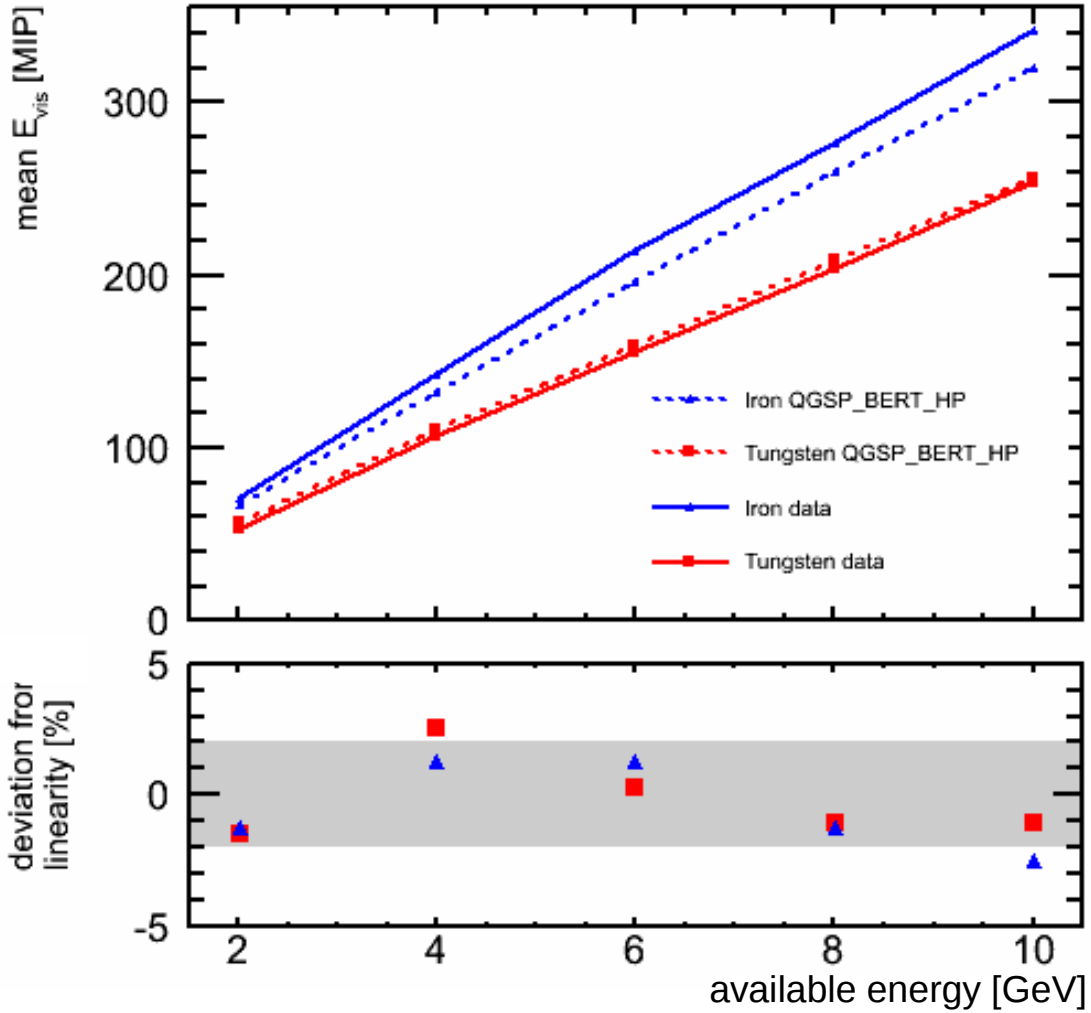
***CERN setup:***




***FNAL setup:***



# Linearity and comparison to simulation



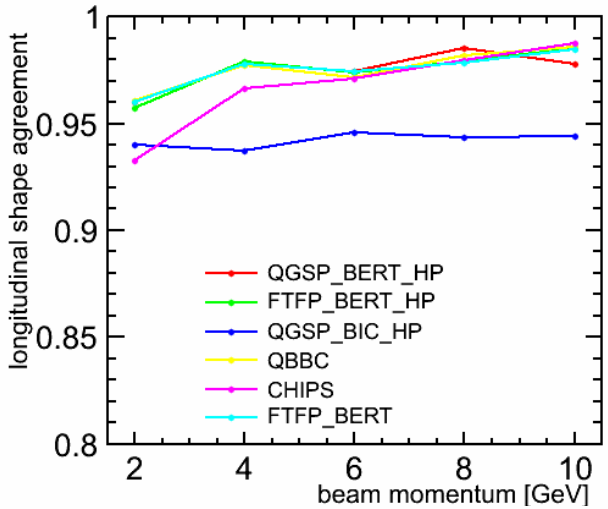

- Mean energy deposit for tungsten well described by simulation
- Less agreement between data and simulation for iron
- Higher energy deposit in data points to remaining contamination of sample
- Deviation from linearity for all data points less than 3 %

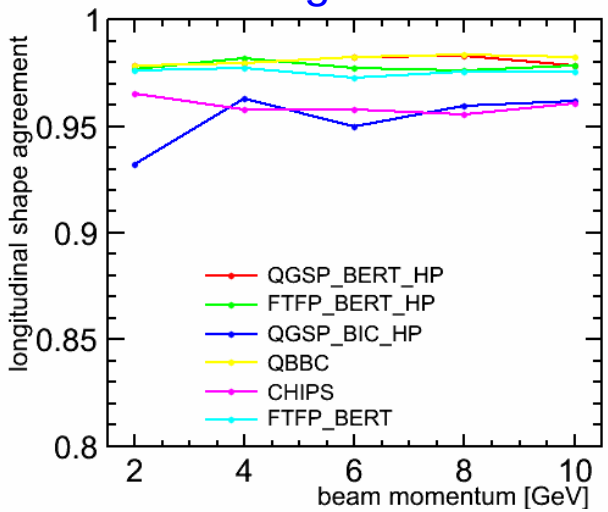
# Profile shape agreement

Iron

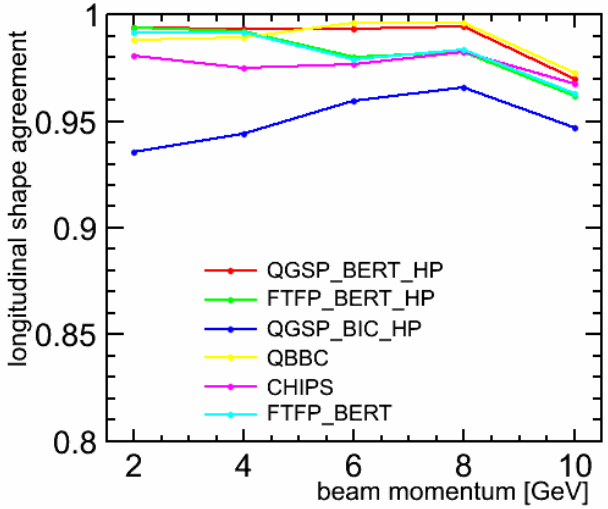
Tungsten

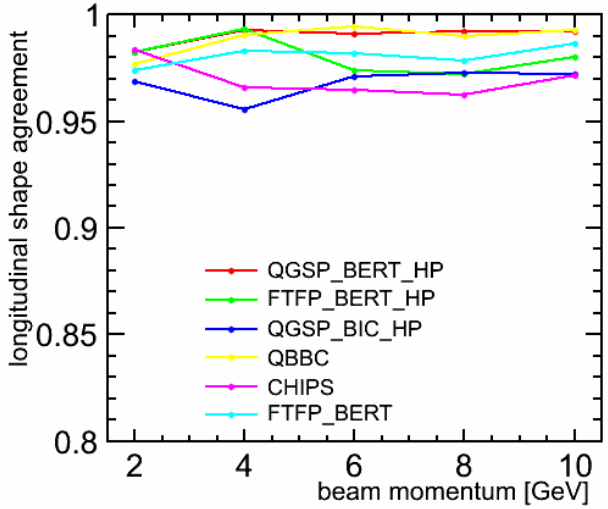
Longitudinal profile




Radial profile




- Shape agreement $\xi$: (describes overlap)

$$\xi = \sum_i min\left(\frac{E_i^{MC}}{E^{MC}}, \frac{E_i^{data}}{E^{data}}\right)$$

$E_i$ : energy deposit in i-th layer

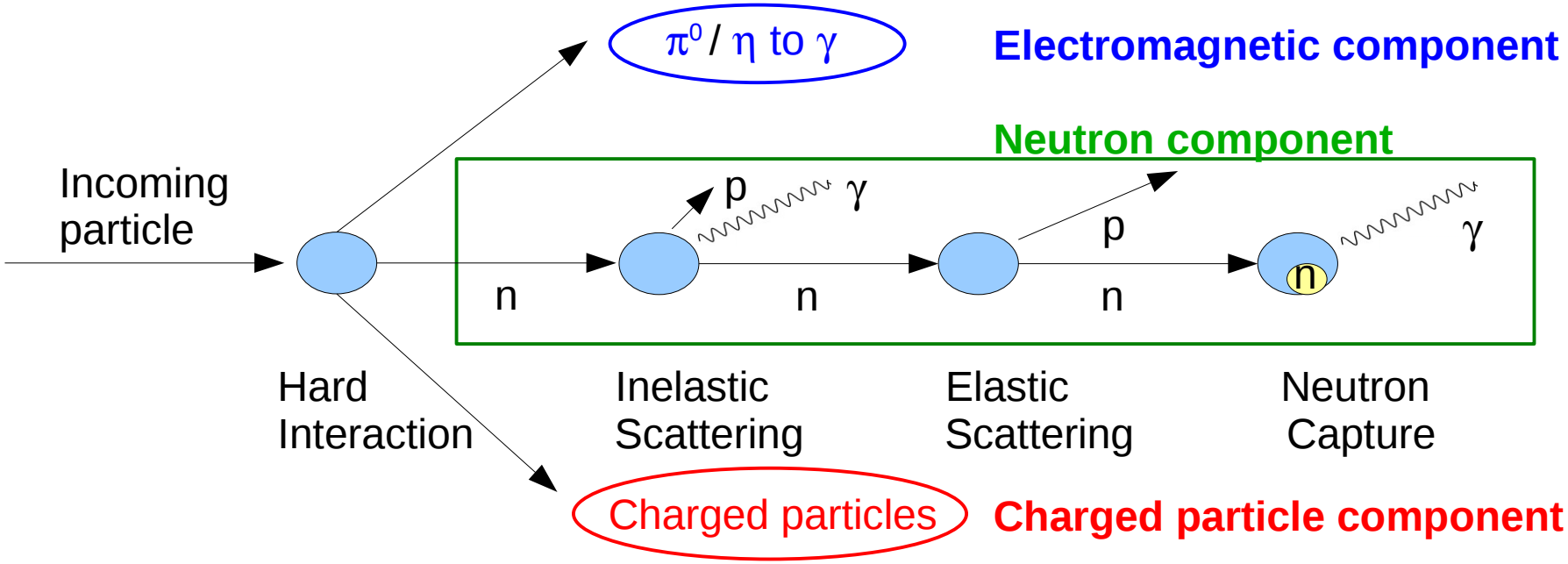
$E$ : total energy deposit

- On average QGSP_BERT_HP gives best description of shower profiles

# Shower decomposition

Shower decomposition plugin for Mokka developed together with M. Ramilli, S. Morozov and S. Lu

- Calculation of fractions of energy deposit for particles from certain physics processes implemented



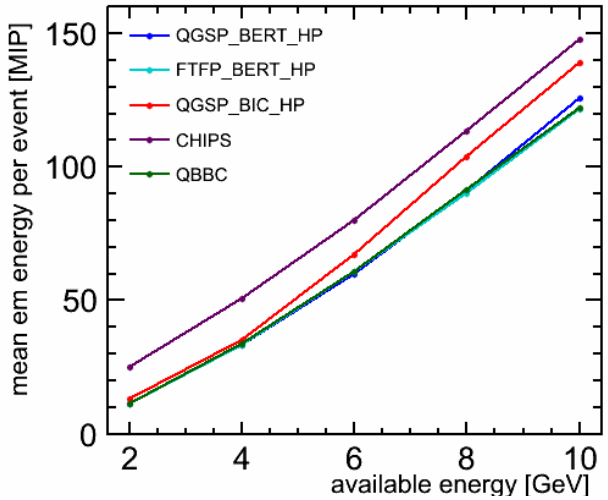
# Results for shower decomposition

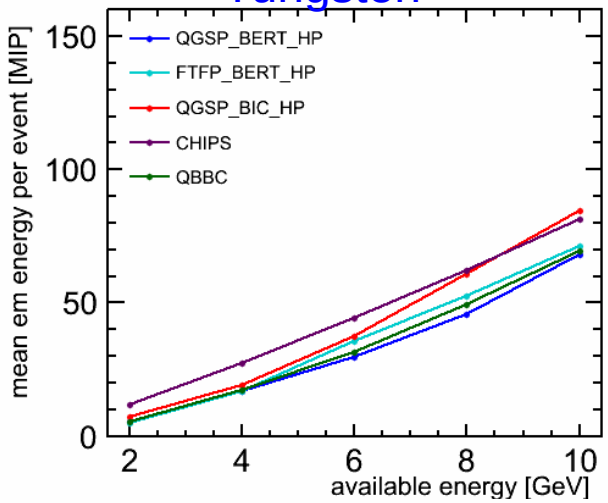
Only two components of the shower show a major difference between iron and tungsten

Iron

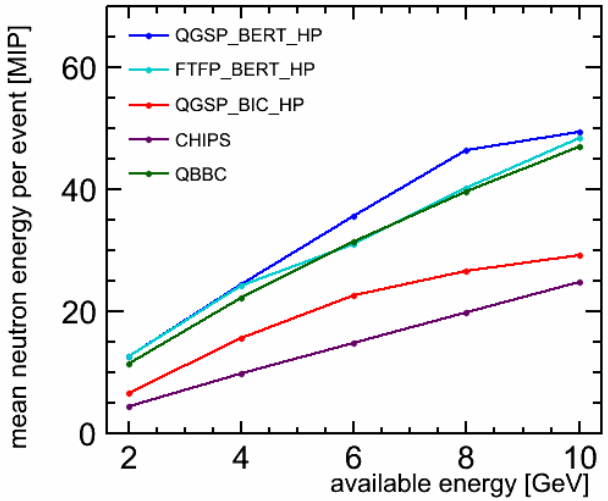
Tungsten

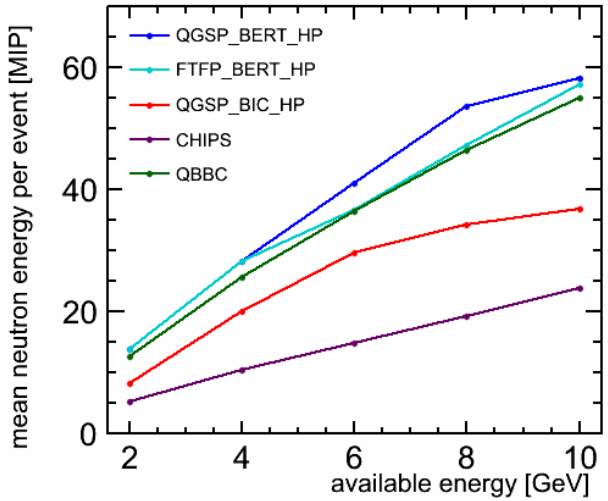
Em component




Neutron component

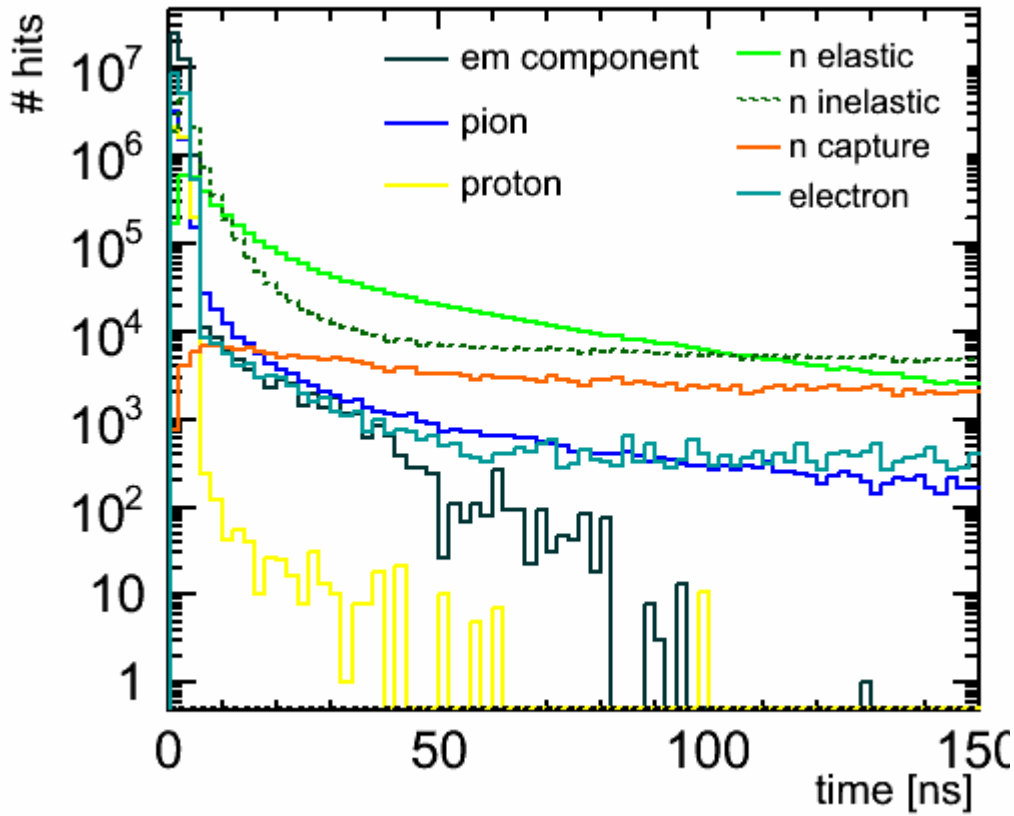


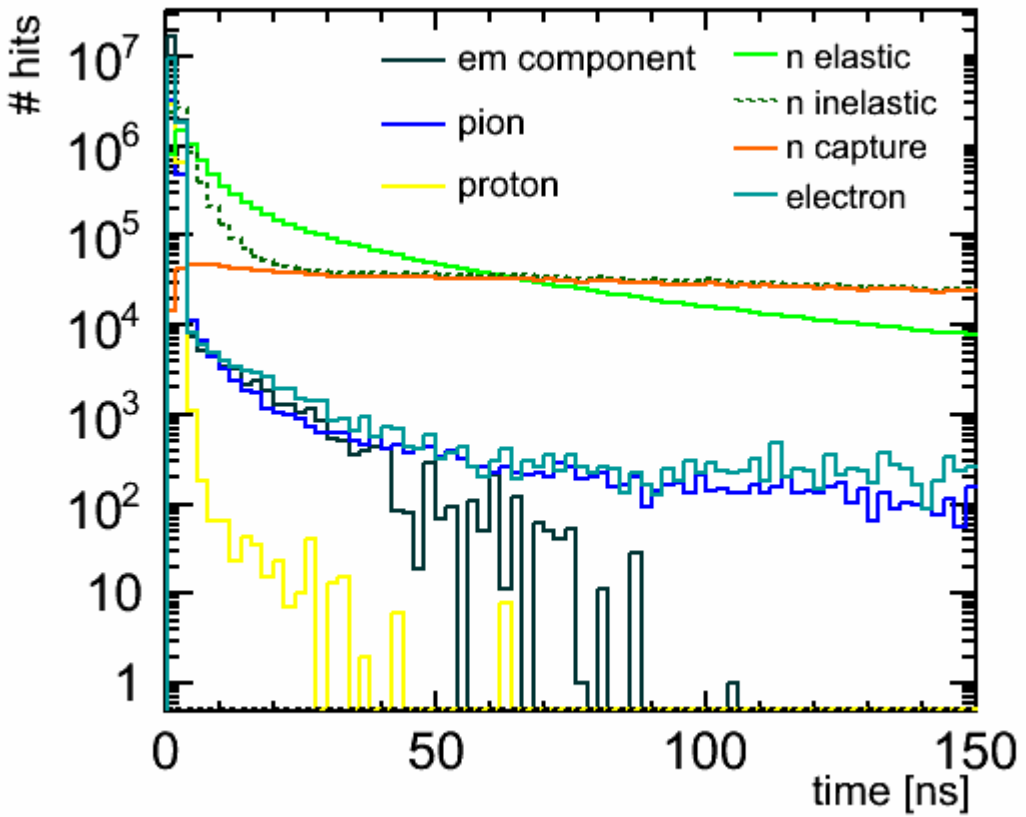

- Predictions by simulation vary strongly between physics lists
- Visible em compnent smaller in tungsten (partially absorbed in non-active material)
- Neutron component only slightly higher than in iron (also suppressed because of absorption in non-active layers)

# Decomposition timing

***8 GeV pion Iron:***




***8 GeV pion tungsten:***




- Hits from em component dominates first ns
- Neutron component dominates afterwards
- Tungsten has ~10 more neutron hits

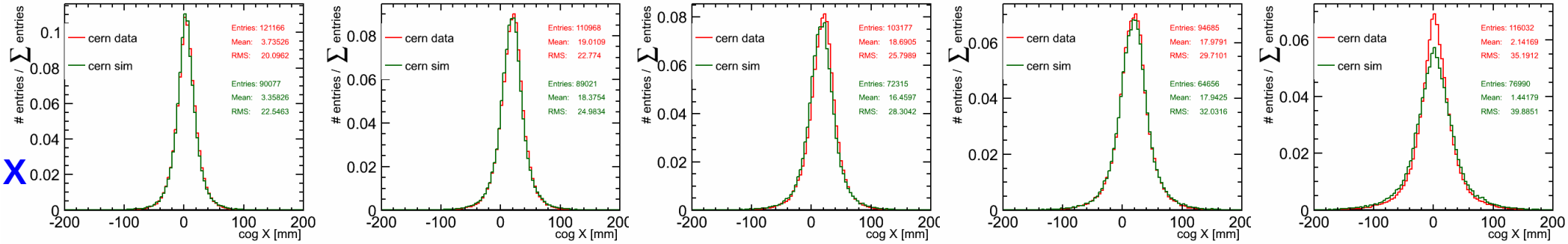
- Crosschecked with results from M.Ramilli

# Tuned beam profiles

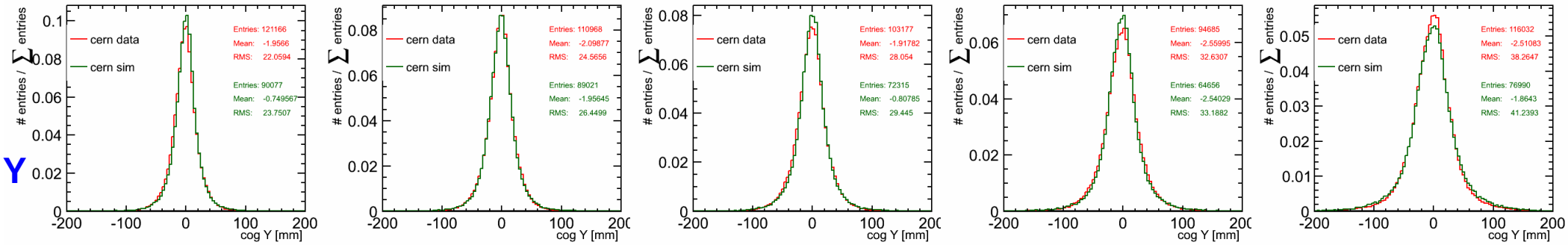
- Position of particle gun for simulation changed to have better agreement of beam profile in data and simulation (ongoing for FNAL iron data)

**10 GeV** **8 GeV** **6 GeV** **4 GeV** **2 GeV**

**X**

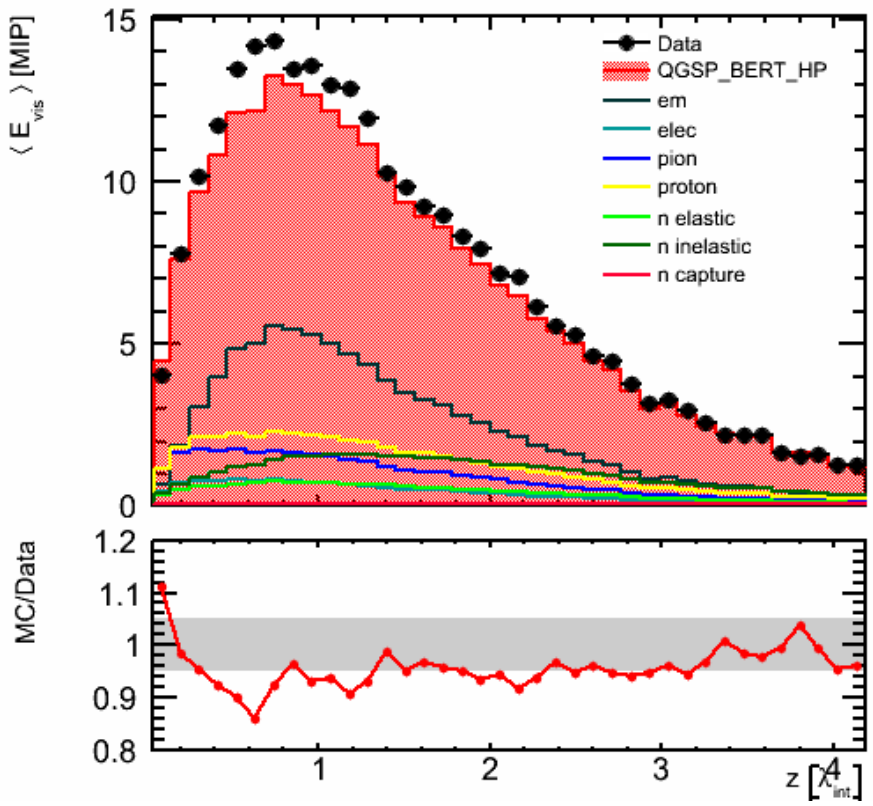



**Y**

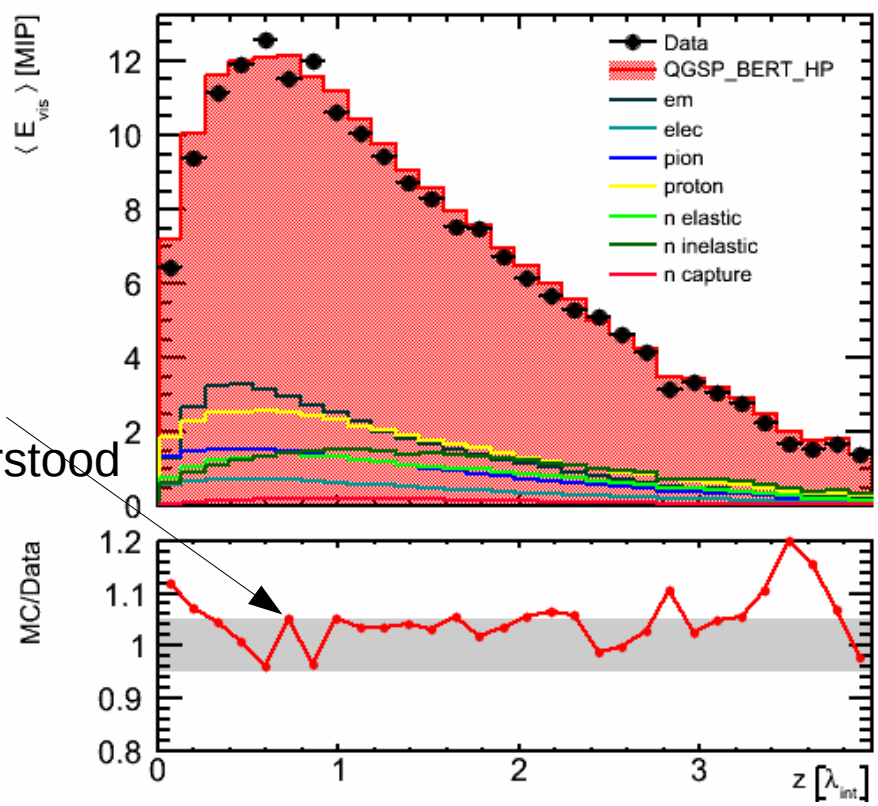


# Longitudinal profiles 8 GeV

***8 GeV pion iron:***




***8 GeV pion tungsten:***




Bug, understood

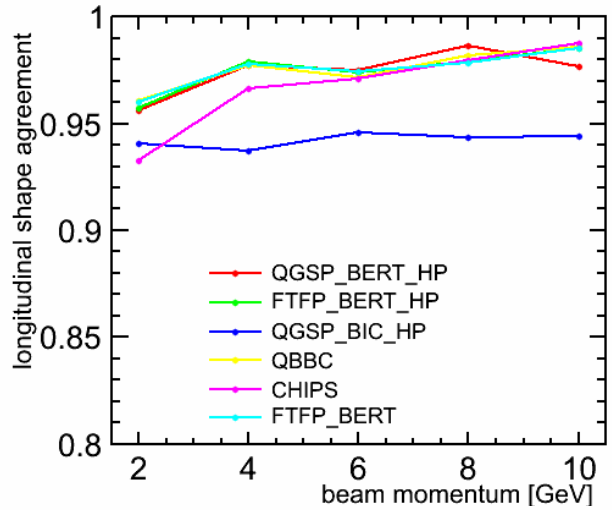
- MIP calibration from CAN-036 solved some problems for tungsten (e.g. bad MIP calibration for noisy cells found found for standard calibration)
- Iron profiles still have less agreement (multi-particle contamination estimation ongoing)

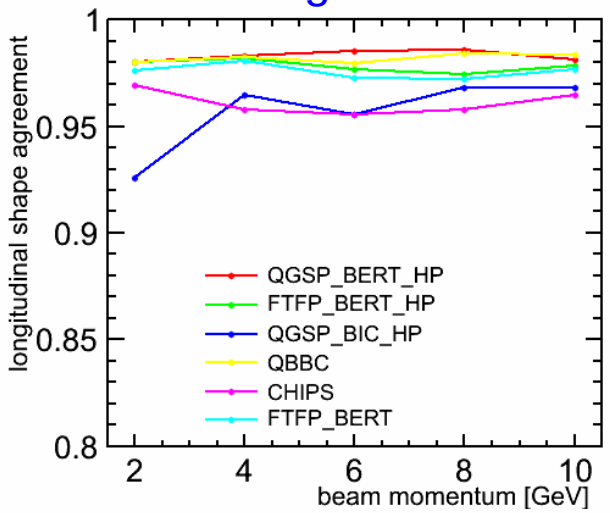
# Profile shape agreement

Iron

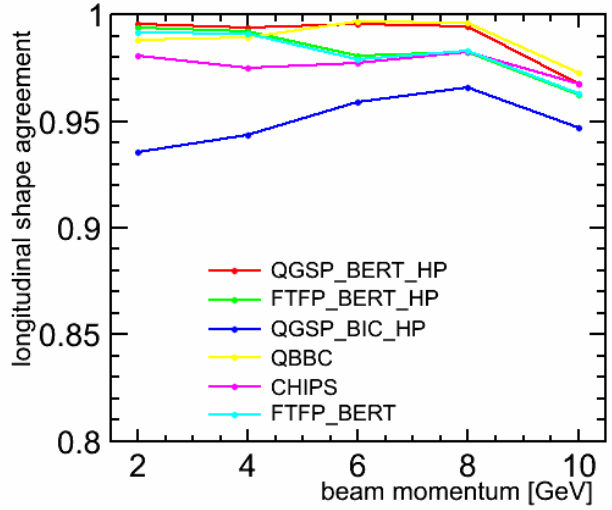
Tungsten

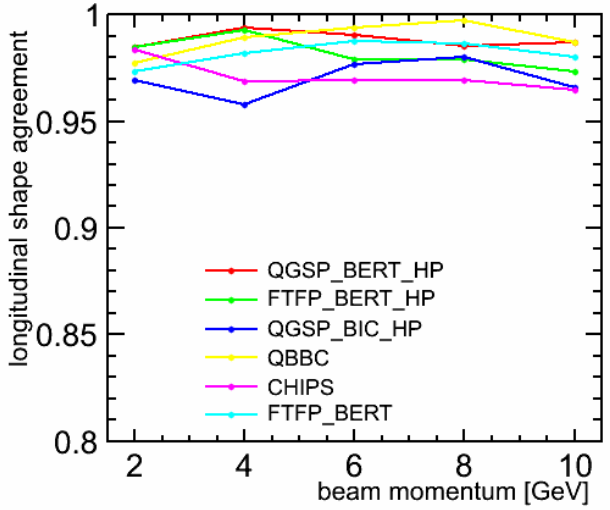
Longitudinal profile




Radial profile




- Shape agreement ξ: (describes overlap)

$$\xi = \sum_i min\left(\frac{E_i^{MC}}{E^{MC}}, \frac{E_i^{data}}{E^{data}}\right)$$

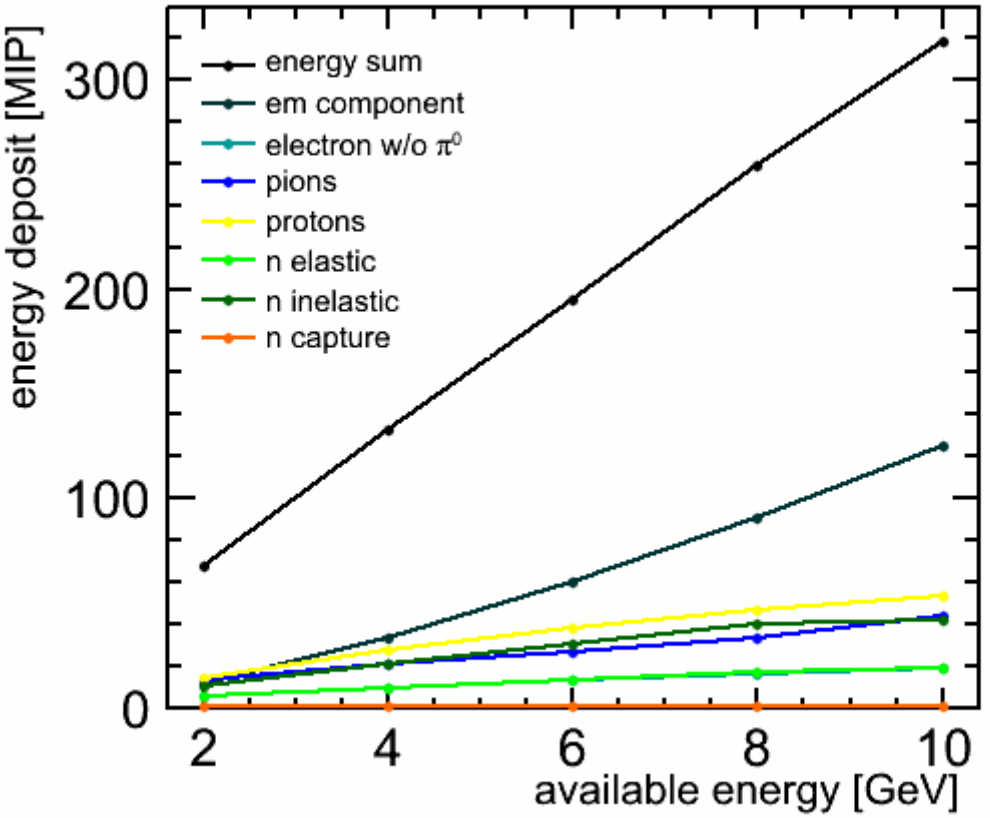
$E_i$ : energy deposit in i-th layer

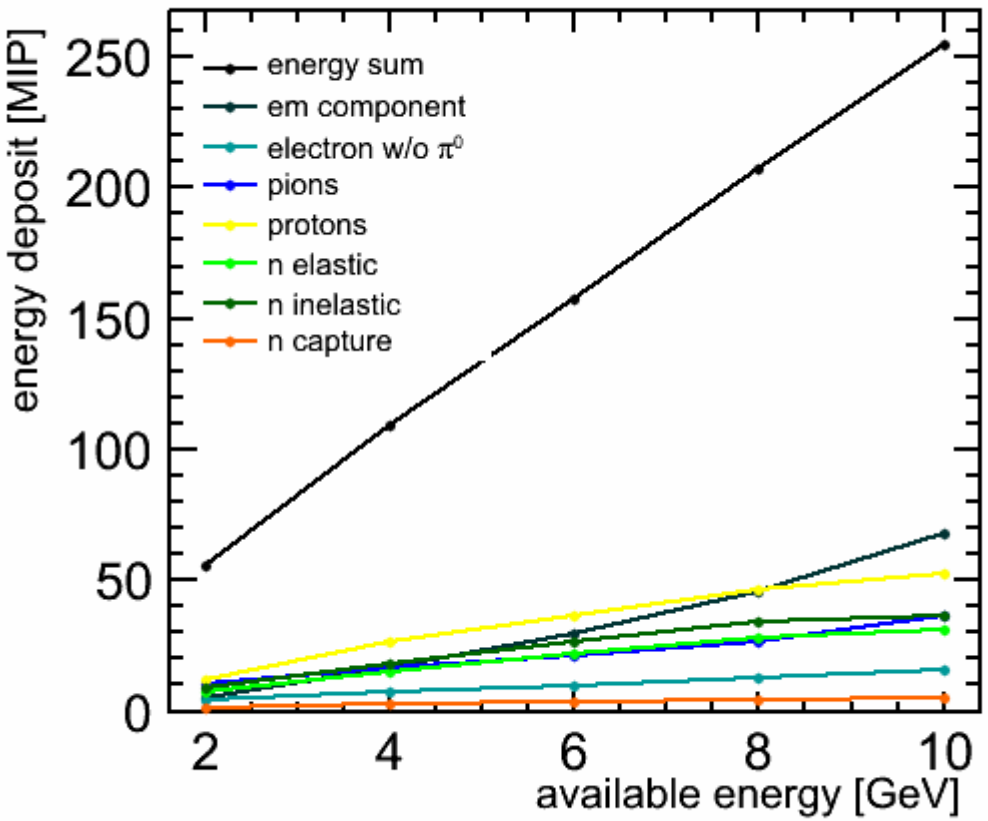
$E$ : total energy deposit

- On average QGSP_BERT_HP gives best description of shower profiles

# Decomposition vs beam momentum

***Iron:*** **QGSP_BERT_HP** ***Tungsten:***



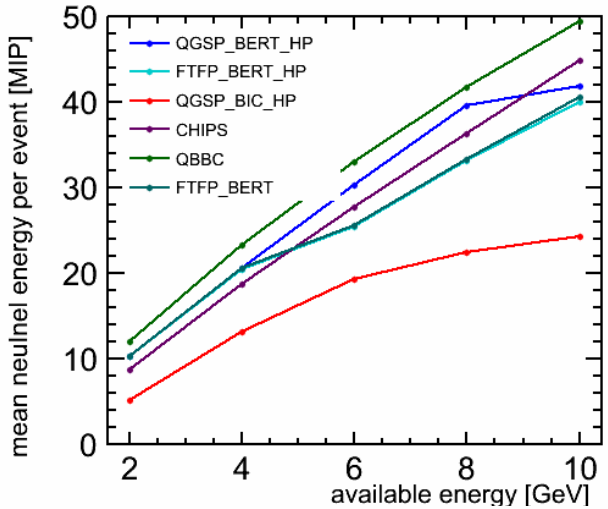

- Em component bigger for iron absorber
- Neutron components bigger for tungsten absorber
- Other components very similar for both absorber configurations

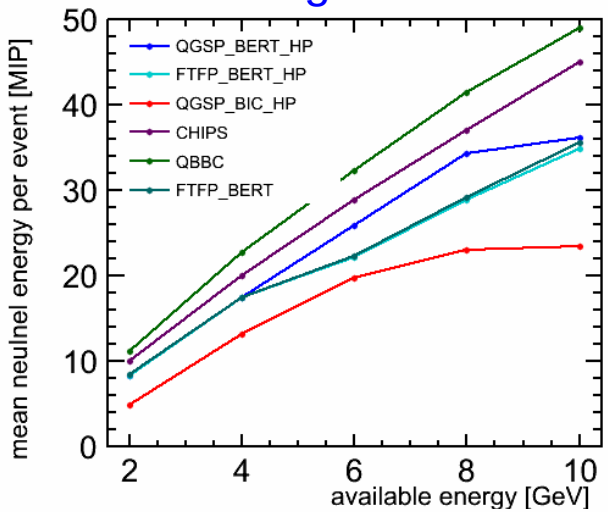
# The neutron component in detail I

Iron

Tungsten

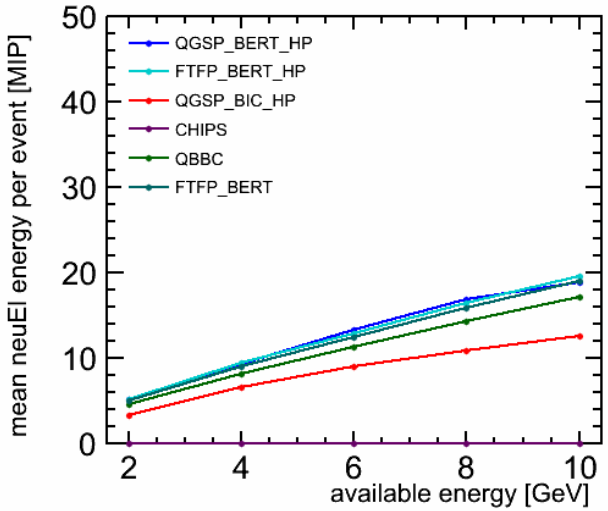
Neutron Inelastic

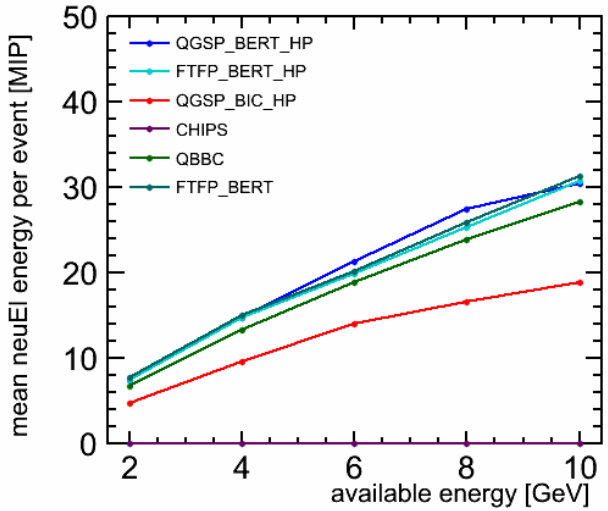



- Energy deposit via neutron inelastic scattering similar for both absorber configurations

Neutron elastic



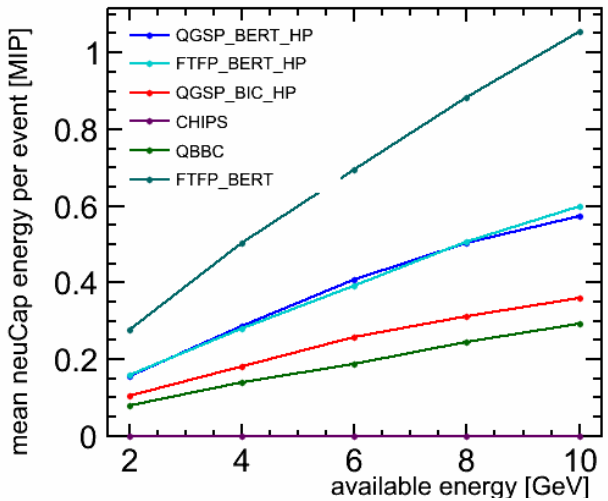

- Energy deposit via neutron elastic scattering higher in tungsten

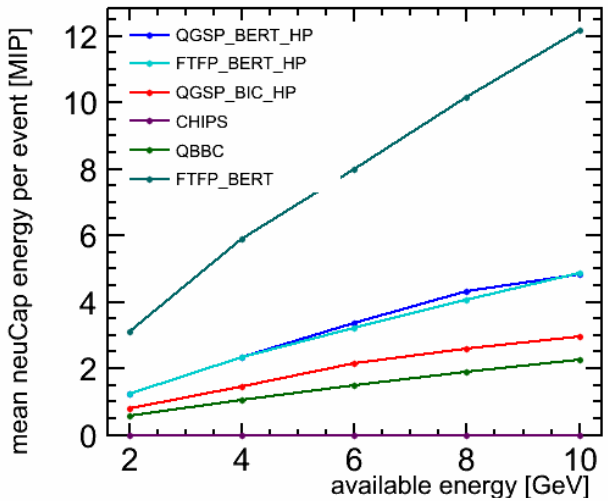
# The neutron component in detail II

Iron

Tungsten

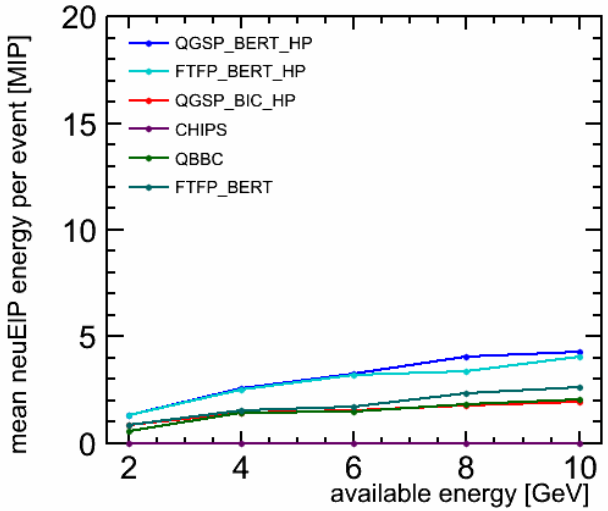
Neutron Capture

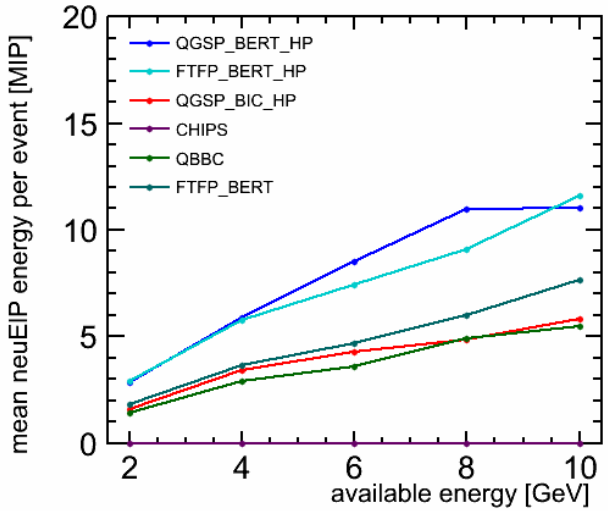



- Energy deposit via neutron capture much higher in tungsten (but in total small compared to other shower components)

Neutron elastic Proton




- Energy deposit via elastic scattering on protons (scintillator) higher in tungsten

# Summary

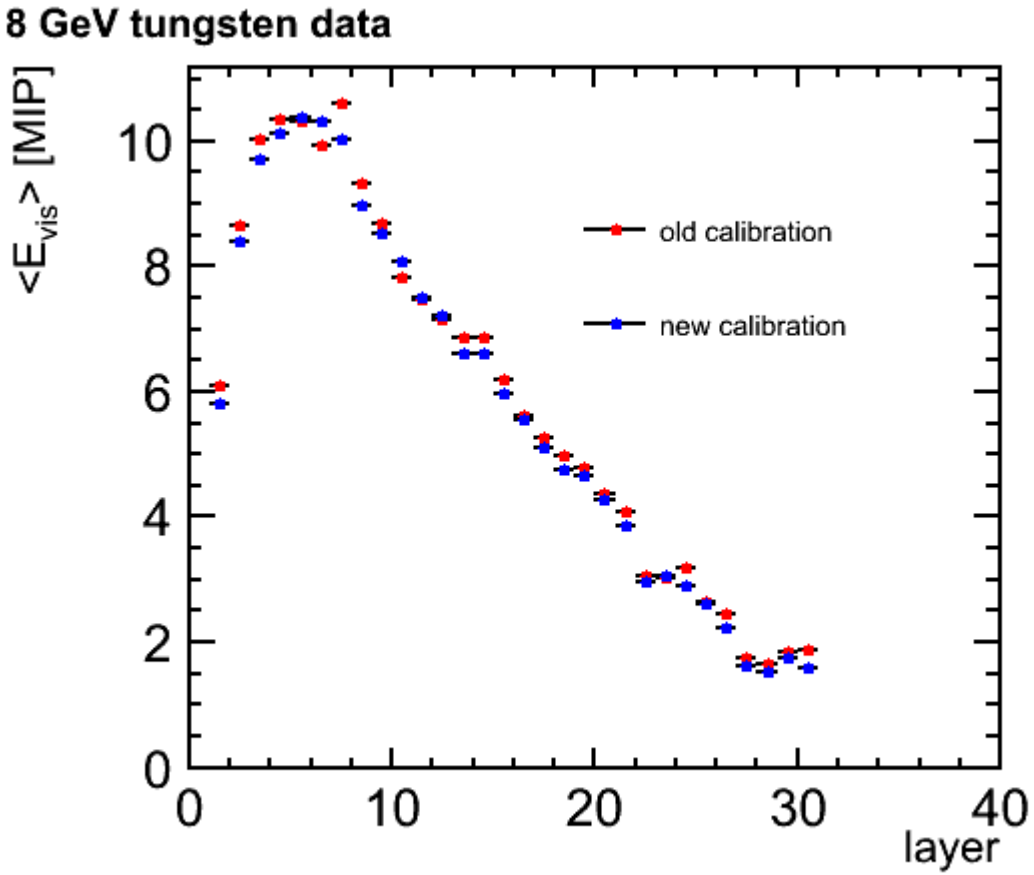
- Beam profiles have been tuned (ongoing for fnal)
- MIP calibration has been changed, which removed the “dips” in the longitudinal shower profile for layer 6 & 7 for tungsten
- Time distribution of hits in a shower has been shown as a crosscheck for the shower decomposition
- The neutron component of the shower has been studied in detail

***Plans:***

- Estimate systematic errors (esp. fnal multi-particle), ongoing
- Investigate impact of measured inter-tile crosstalk on radial profiles, ongoing

# BACKUP

# New MIP calibration cern




Just mip calibration changed

No event selection

# Event selection CERN

- Event selection from CAN-036 could not be taken over
  (because difficult to do comparable shower start selection for iron data)

=> Own event selection established for CERN testbeam data

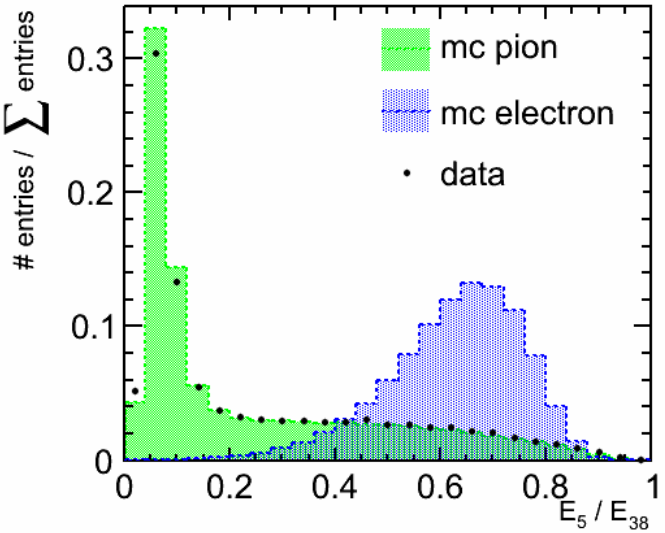
  - Selection based on cherenkov detector information
  - Pre-shower event rejection
  - Muon rejection extended for energies 2 GeV
  - Additional cuts for data quality
    ( rejection of bad event due to randomly fired led light ,
      empty event rejection cut )

=> Quality comparable to CAN-036 pion event selection
   (similar linearity, longitudinal profiles and resolution)

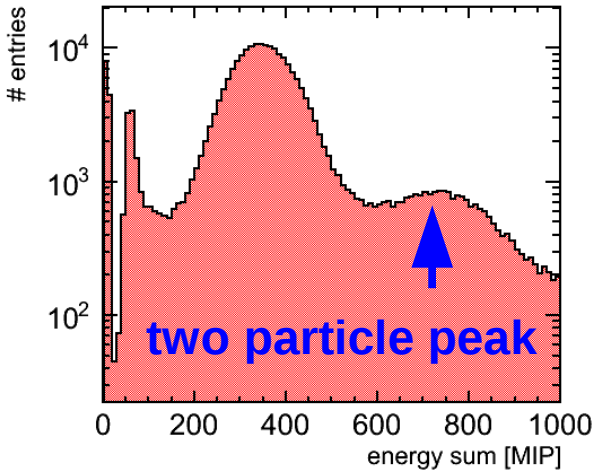
# Event selection FNAL

- Event selection for FNAL testbeam could not be taken over

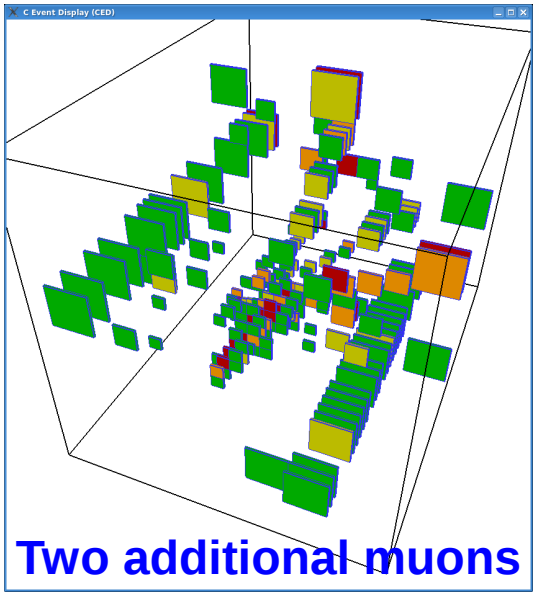
  => no evidence for contamination with electron events at 4 GeV and above




  => instead multi-particle contamination was found (2 types)




  => no better data available



# FNAL multi-particle rejection

- Rejection of events with additional muons developed
  (based on existing tracking algorithms)

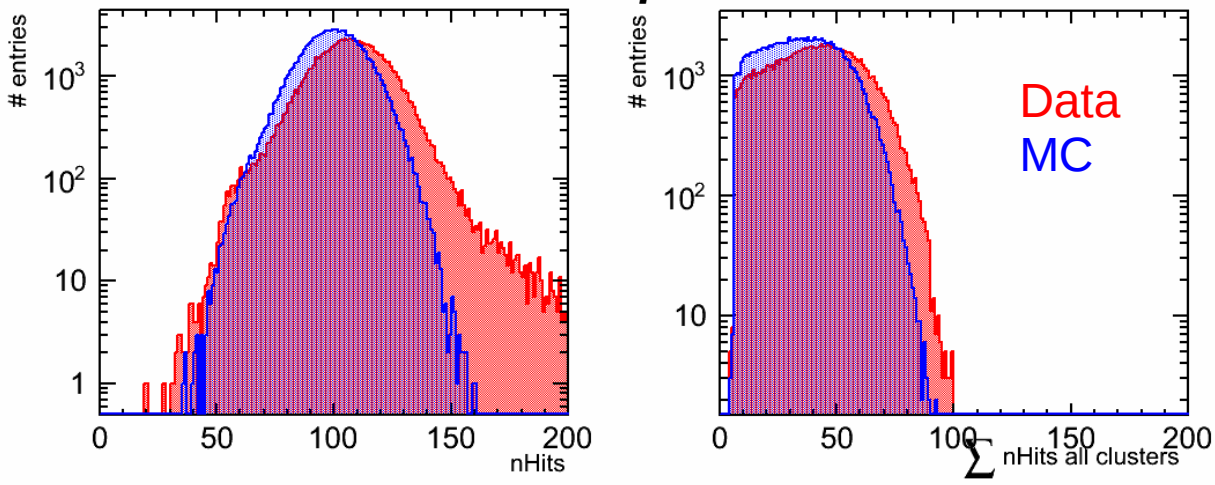
  => Inspection with event display shows almost no remaining events with additional muons leftover

- Rejection of event with more than one hadron developed
  (based on existing cluster algorithms, many other cuts tried)

  => Contamination could not be fully removed, but estimation of remaining contamination ongoing

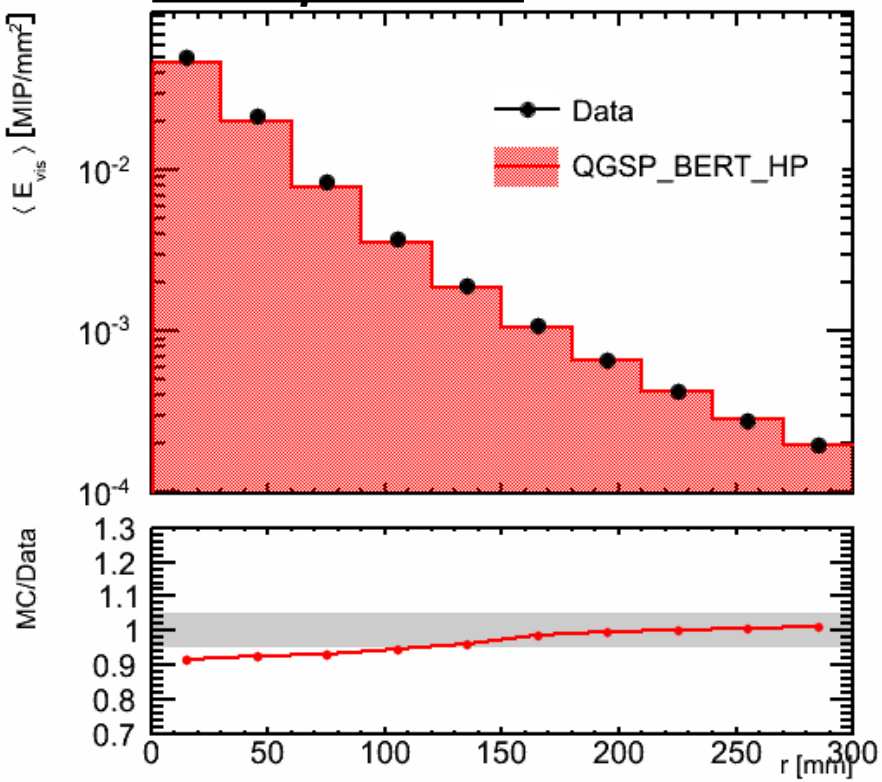
  => Production of multi-particle Event sample ongoing

***8 GeV pion:***



# Radial profiles 8 GeV

***8 GeV pion iron:***




***8 GeV pion tungsten:***