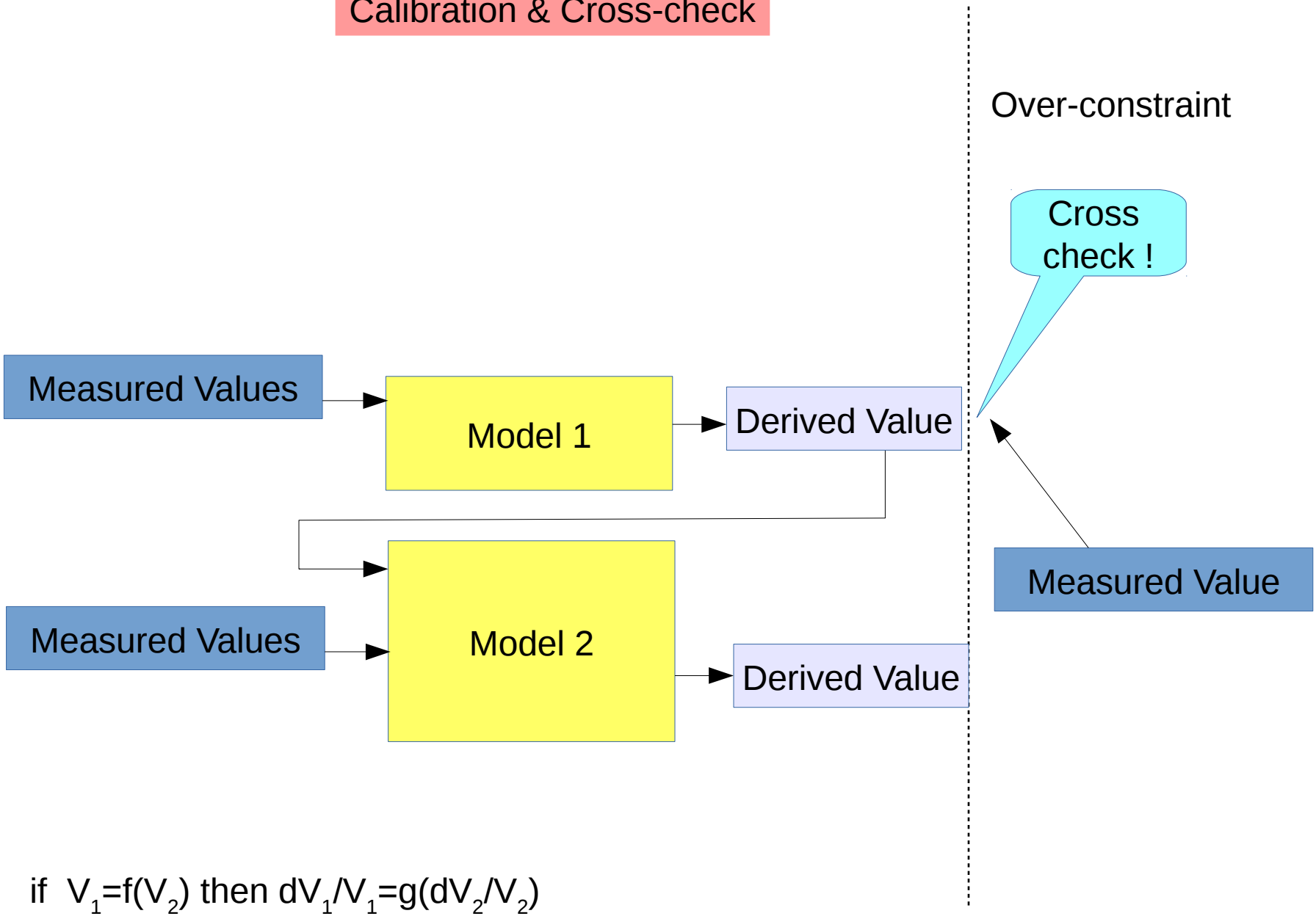
Energy calibration strategy with planned tools for protoDUNE

I. Kreslo on behalf of DUNE Calibration Group

ProtoDUNEs science workshop, CERN, 28-30 June 2016

Calibration & Cross-check



if $V_1=f(V_2)$ then $dV_1/V_1=g(dV_2/V_2)$

What if cross-check is failed ?

1. Go backward calibration chain

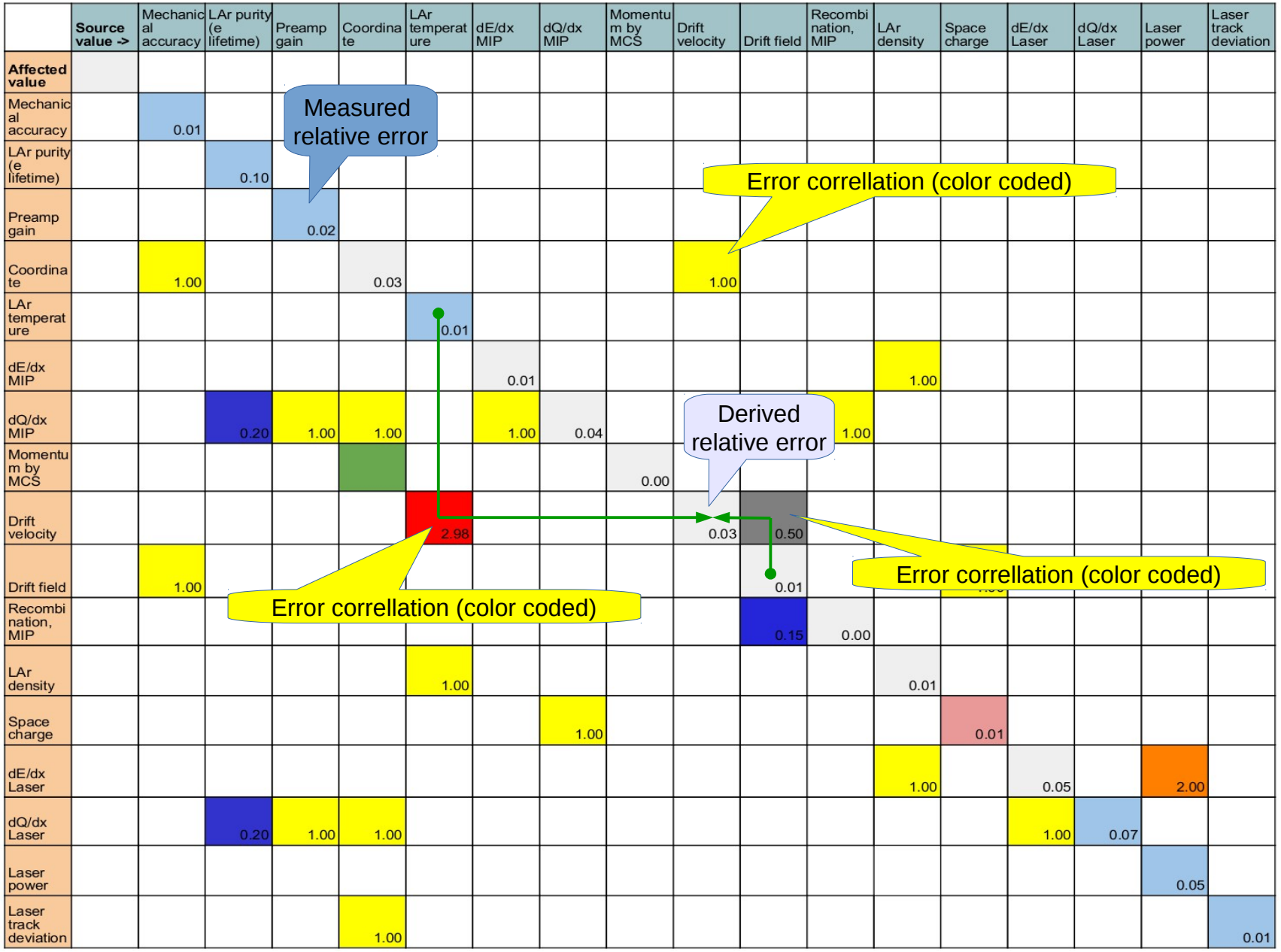
2. Identify sensitive step

3. Understand it better (missing factors?)

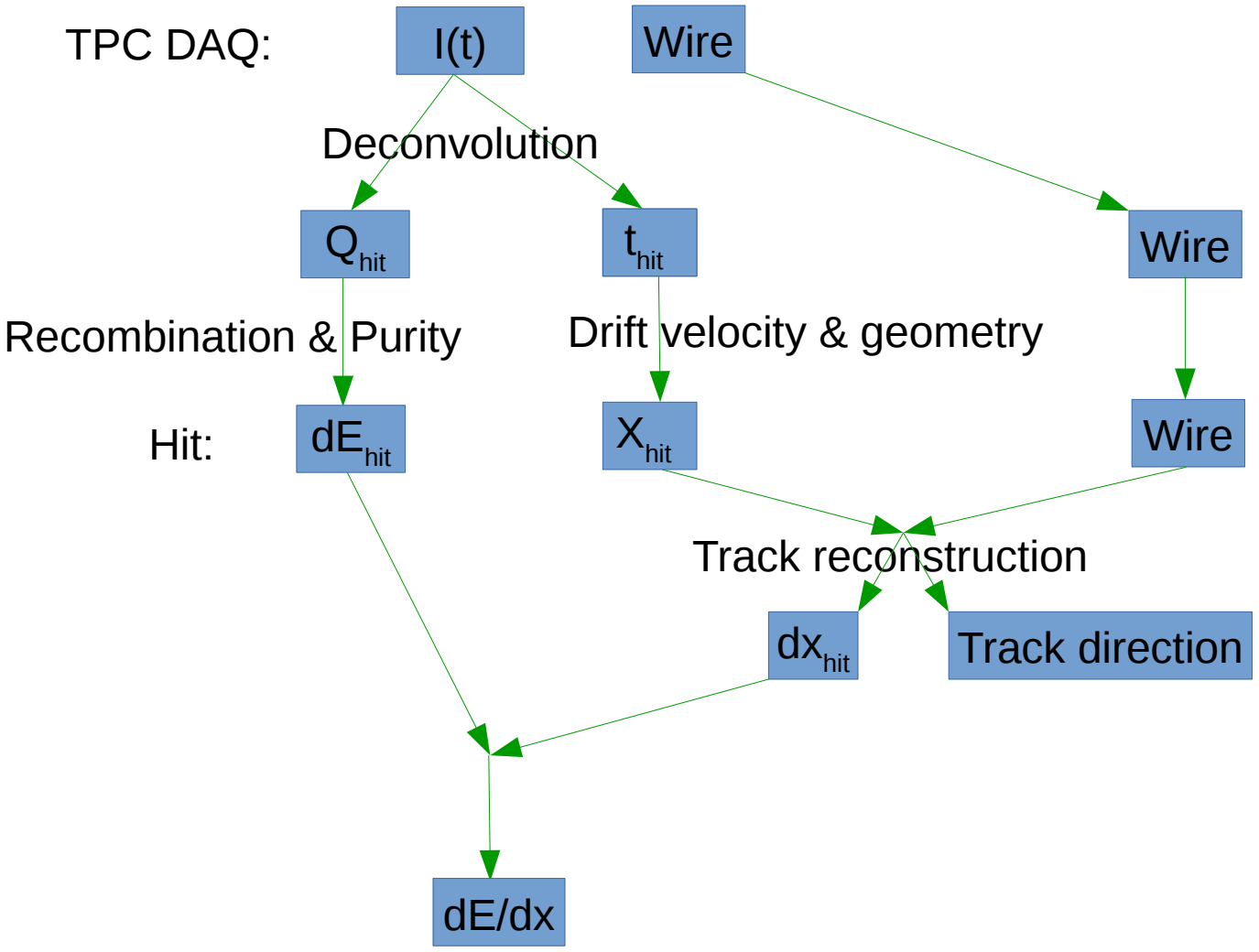
succeded -> correct -> recalibrate

not succeded -> declare discrepancy as systematic error

Parameter correllation matrix (example)



Pion track geometry and dE/dx (example)

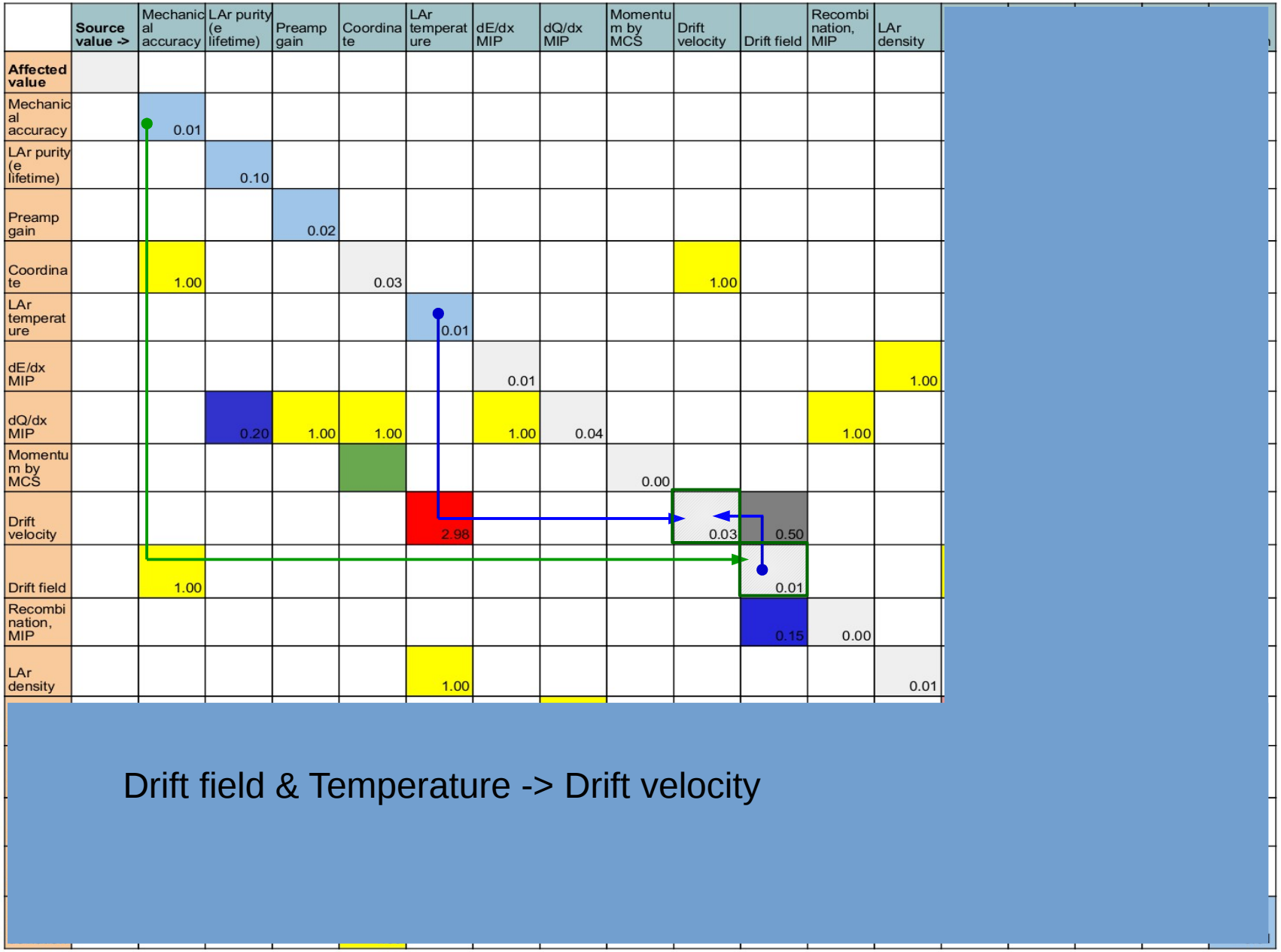


Proto-DUNE (no space charge)

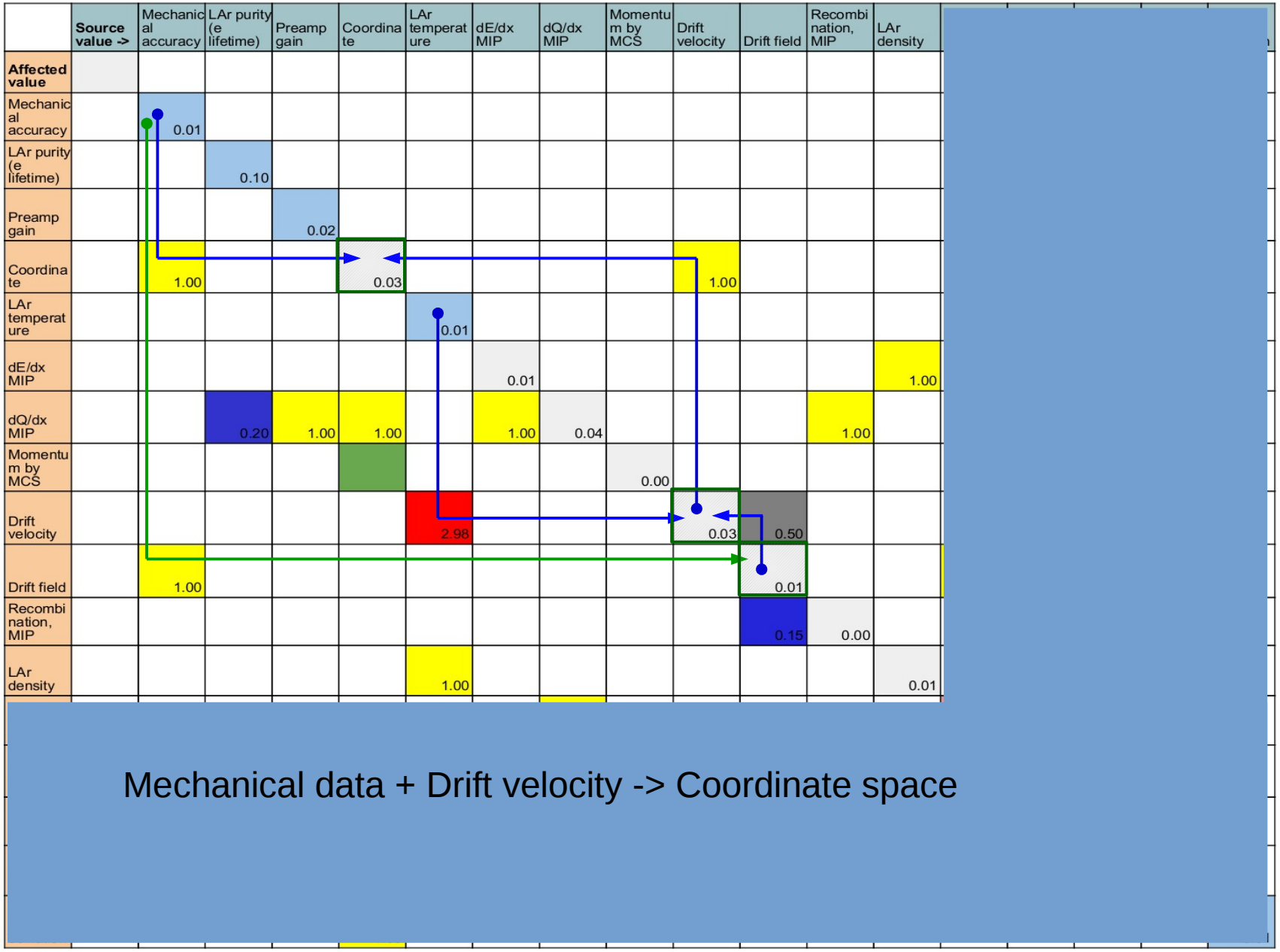
Affected value	Source value ->	Mechanical accuracy	LAr purity (e lifetime)	Preamp gain	Coordinate	LAr temperature	dE/dx MIP	dQ/dx MIP	Momentum by MCS	Drift velocity	Drift field	Recombination, MIP	LAr density
Mechanical accuracy		0.01											
LAr purity (e lifetime)			0.10										
Preamp gain				0.02									
Coordinate		1.00			0.03					1.00			
LAr temperature						0.01							
dE/dx MIP							0.01						1.00
dQ/dx MIP			0.20	1.00	1.00		1.00	0.04				1.00	
Momentum by MCS									0.00				
Drift velocity						2.98				0.03	0.50		
Drift field		1.00									0.01		
Recombination, MIP											0.15	0.00	
LAr density						1.00							0.01

Dimensions (& HV) -> Drift field

Proto-DUNE (no space charge)

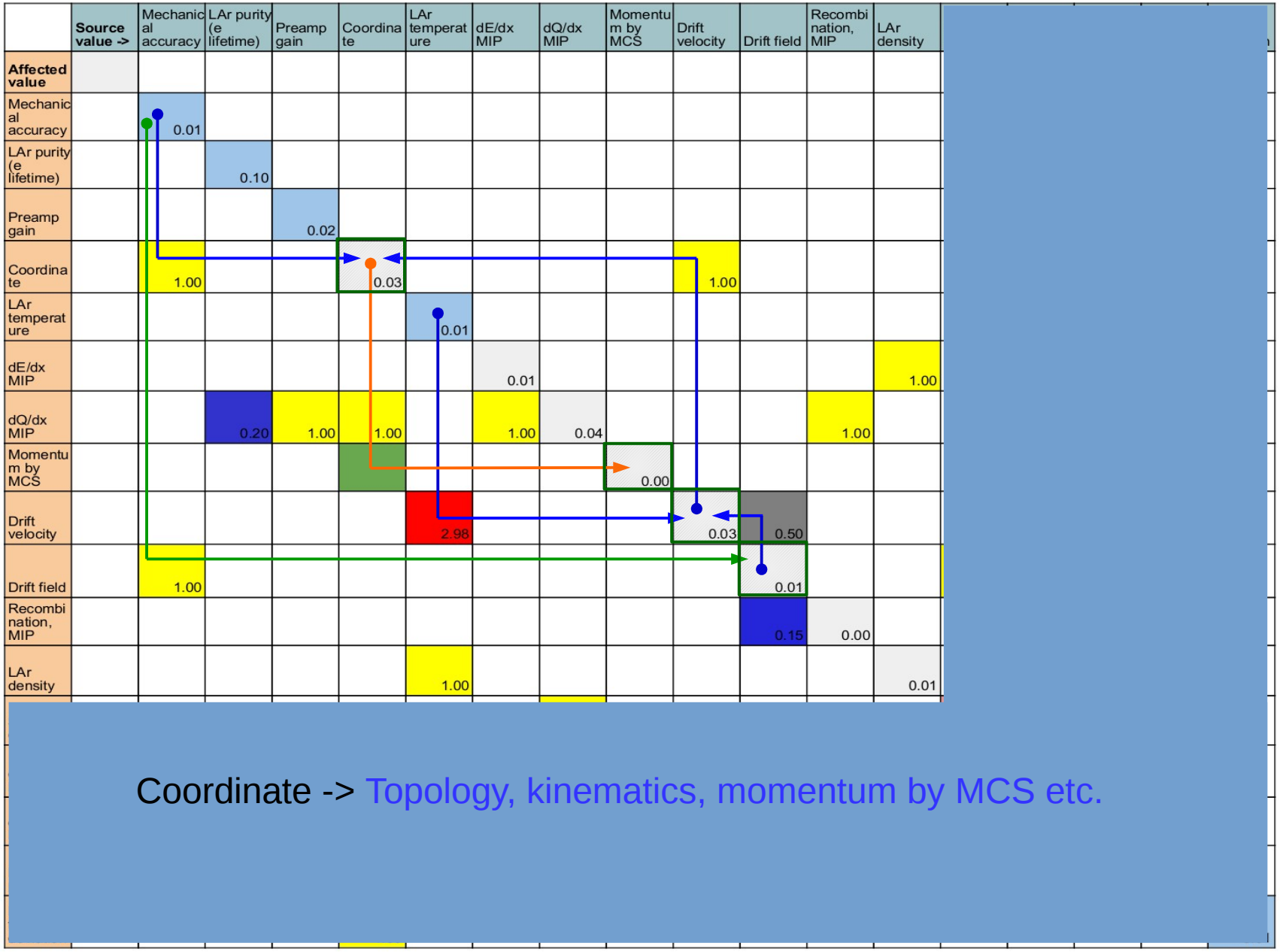


Proto-DUNE (no space charge)



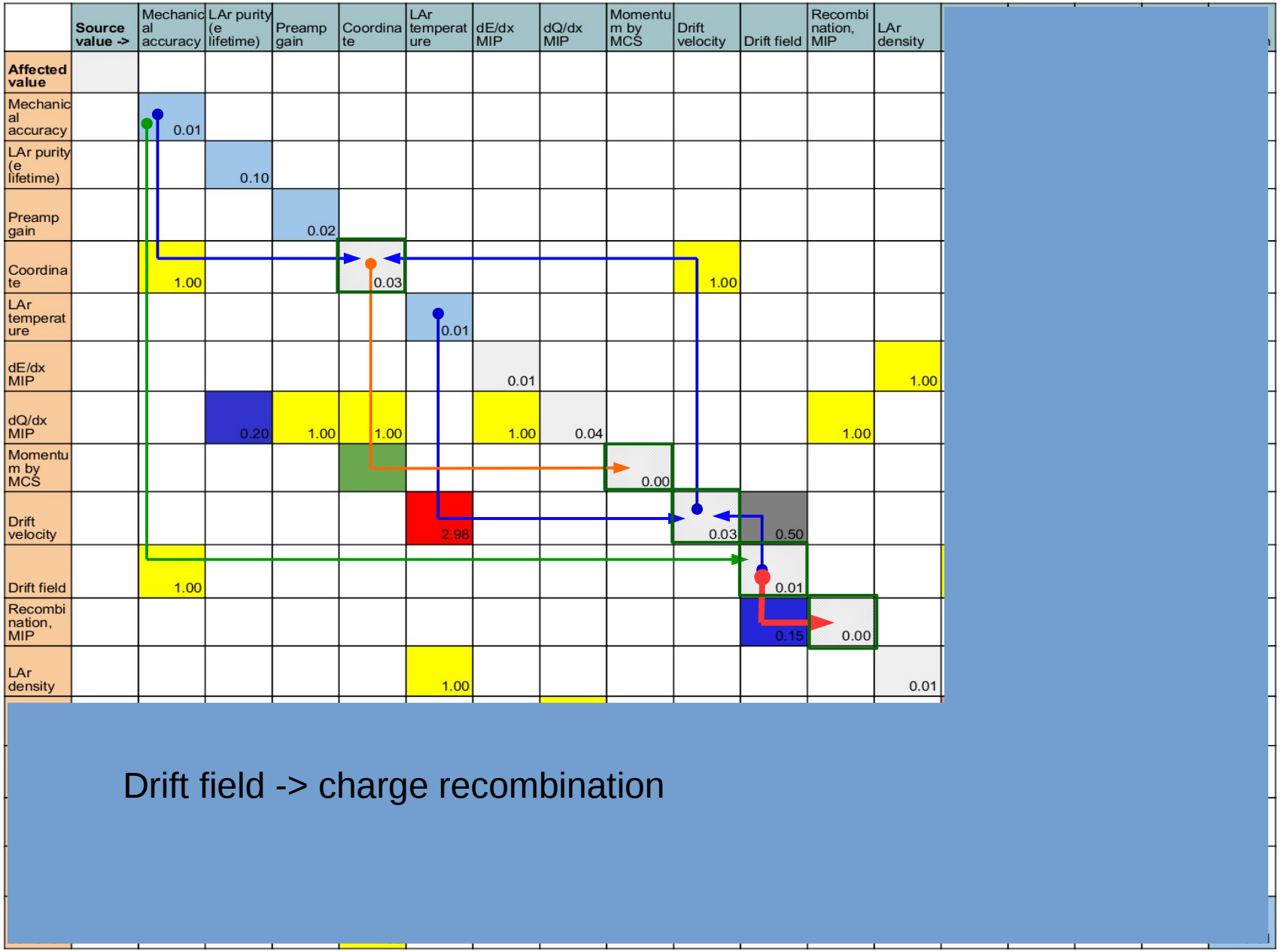
Mechanical data + Drift velocity -> Coordinate space

Proto-DUNE (no space charge)



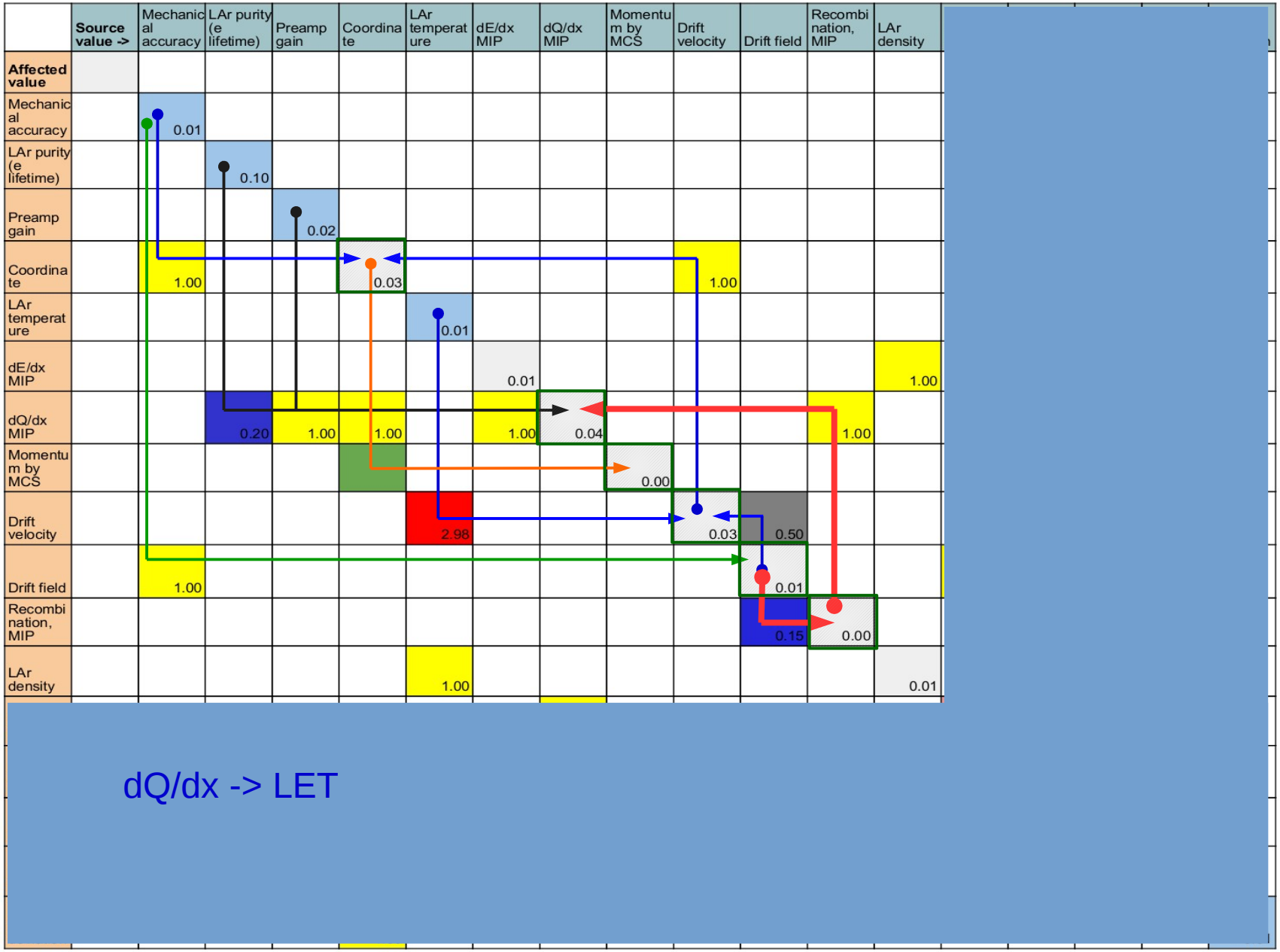
Coordinate -> Topology, kinematics, momentum by MCS etc.

Proto-DUNE (no space charge)

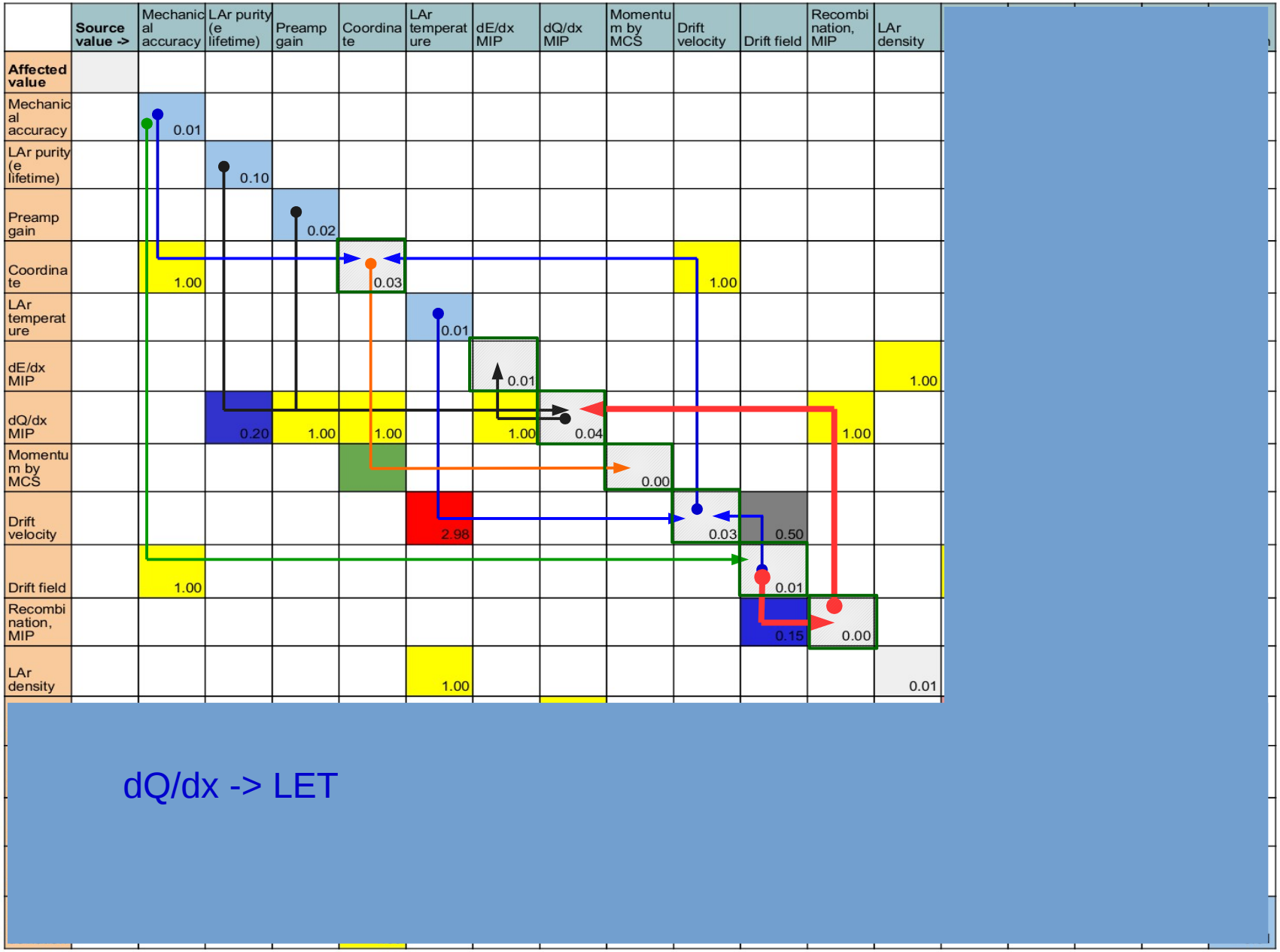


Drift field -> charge recombination

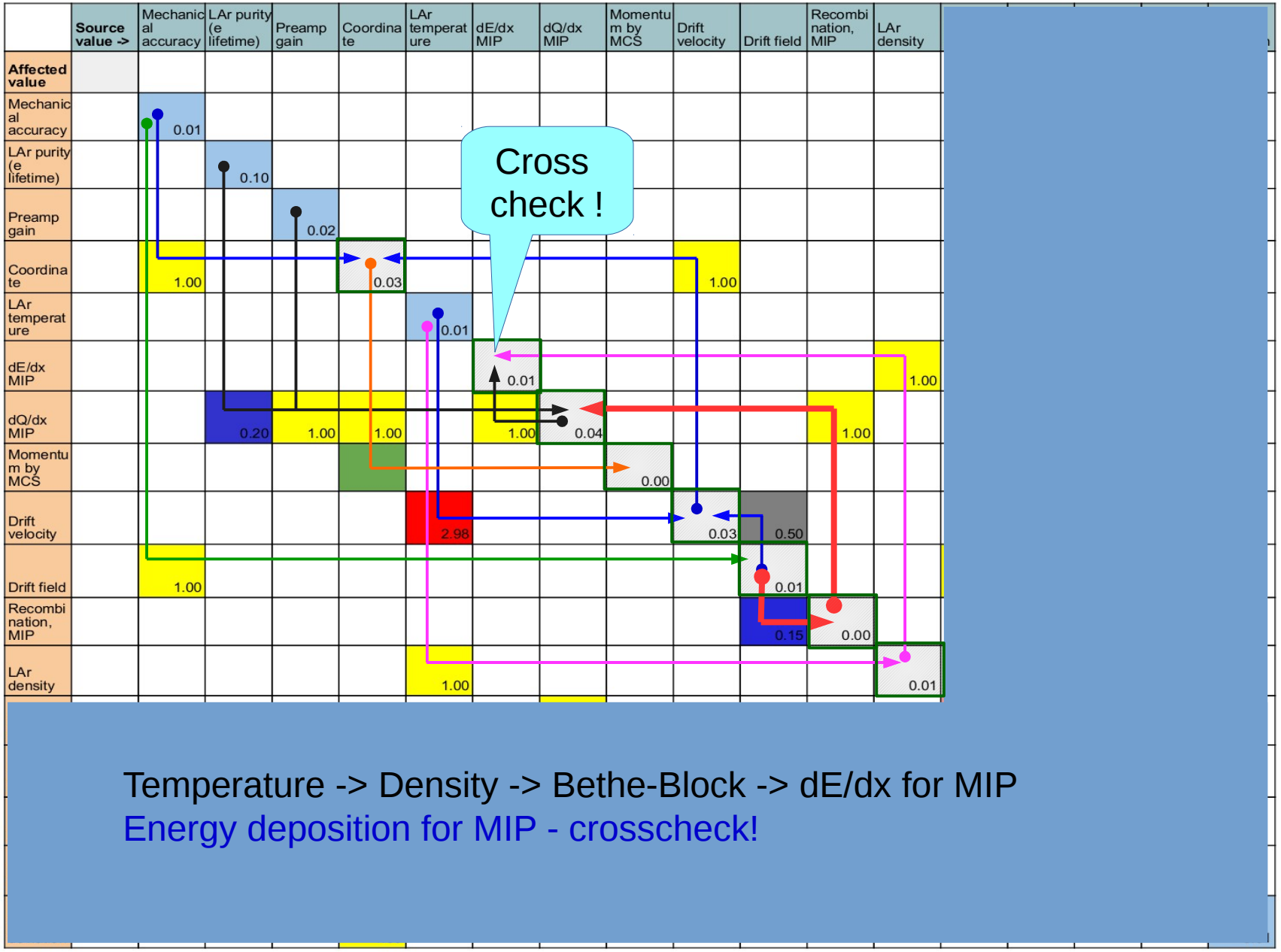
Proto-DUNE (no space charge)



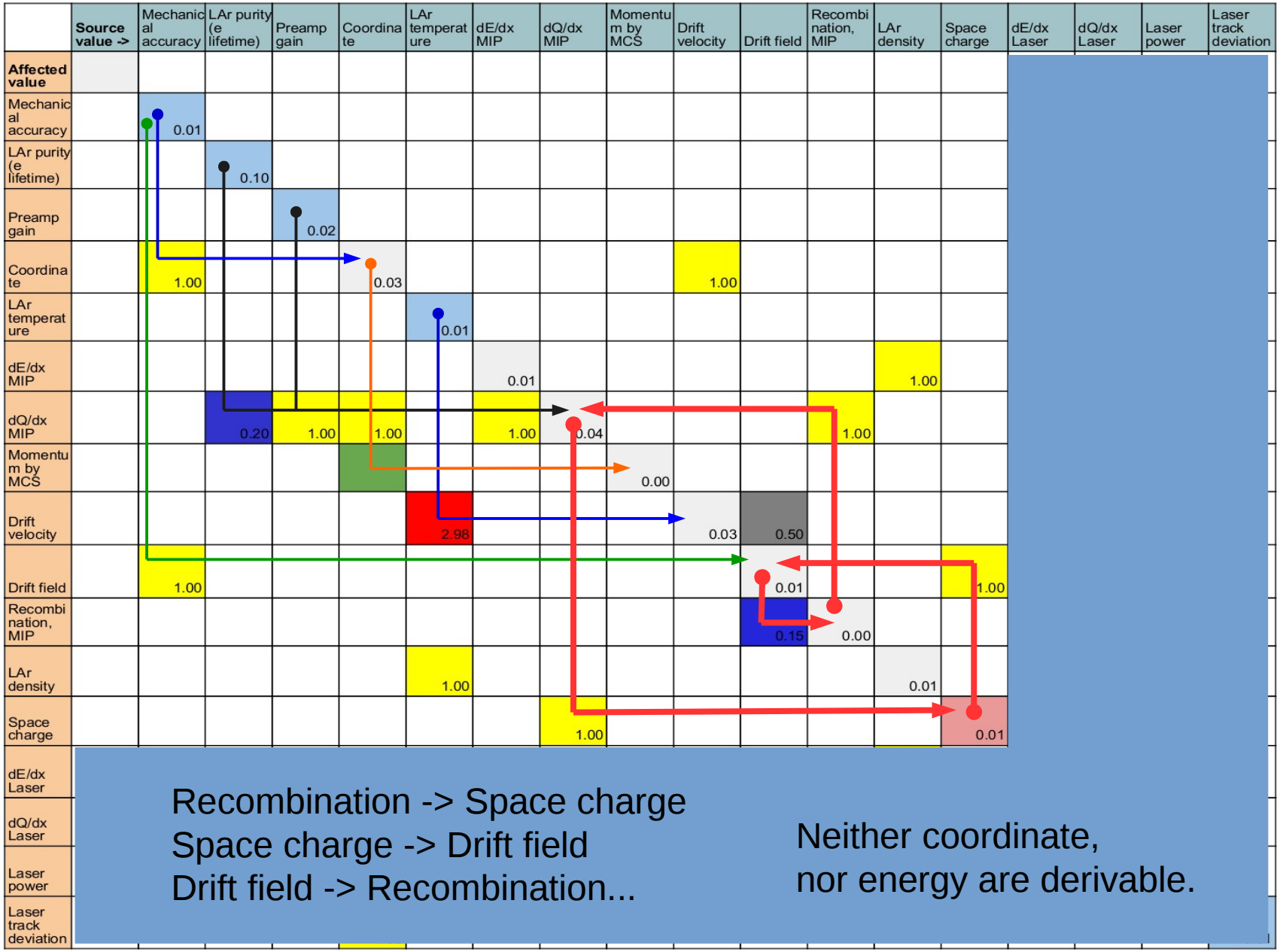
Proto-DUNE (no space charge)



Proto-DUNE (no space charge)



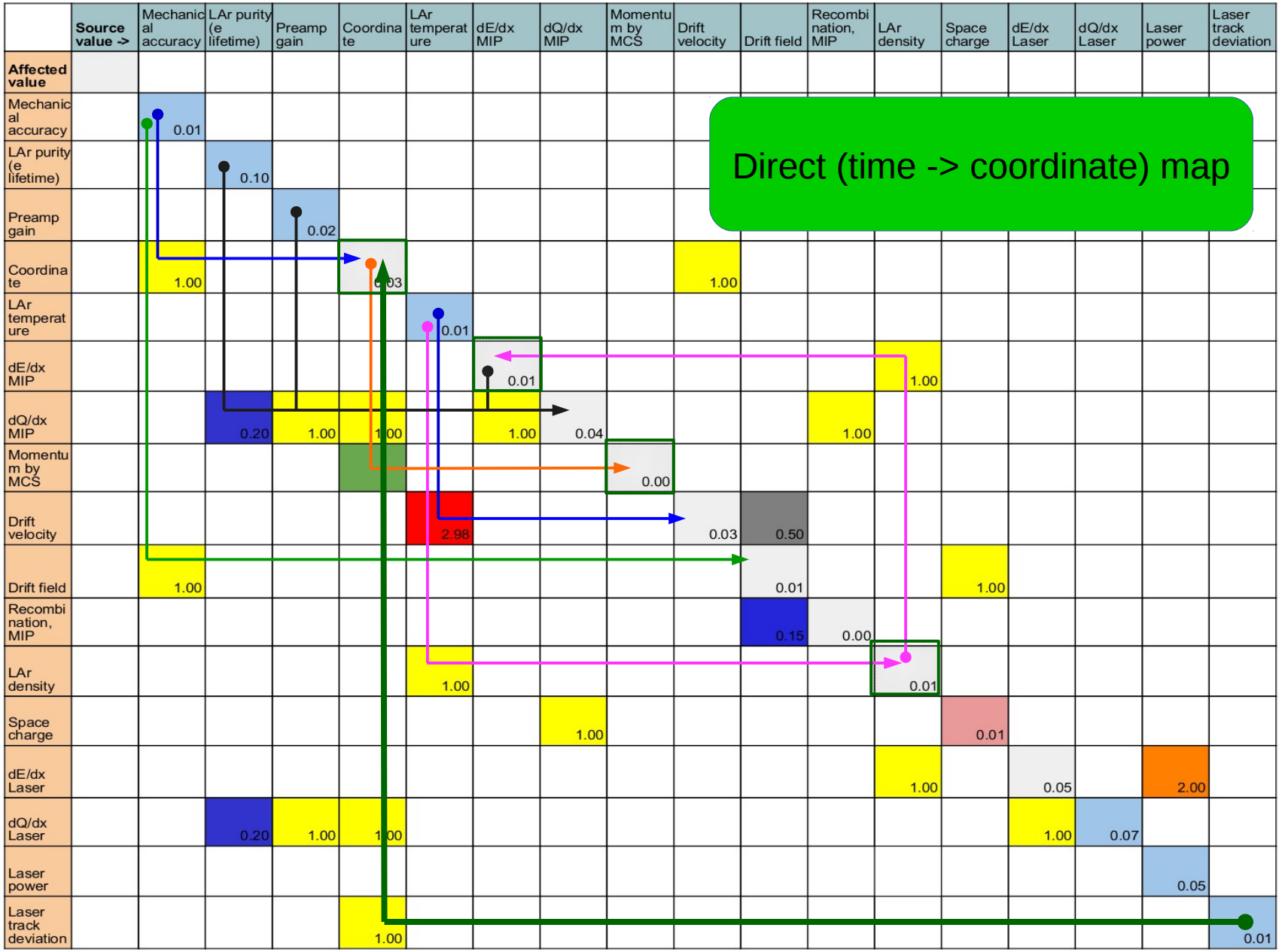
Proto-DUNE (with space charge)



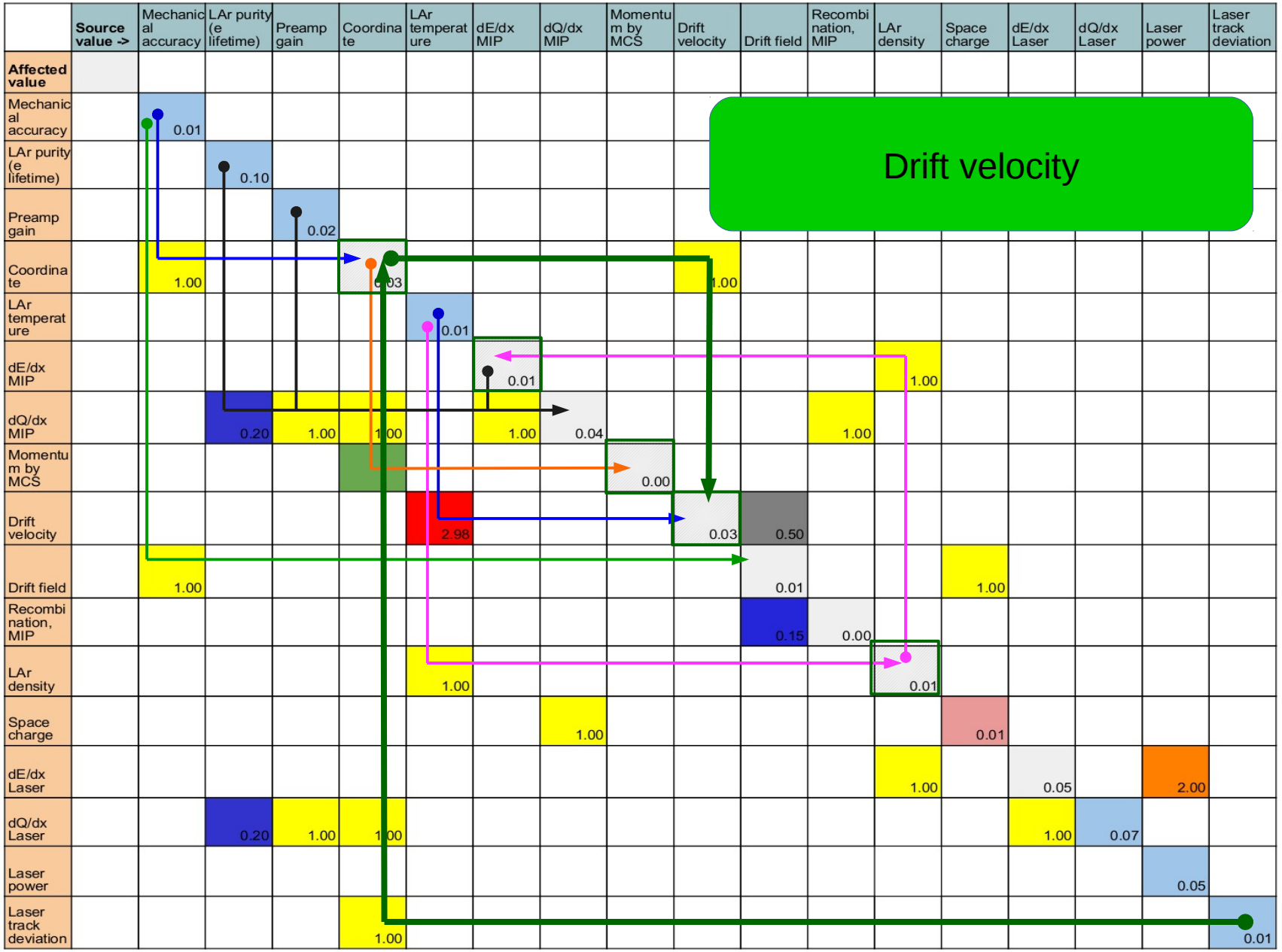
Recombination -> Space charge
Space charge -> Drift field
Drift field -> Recombination...

Neither coordinate,
nor energy are derivable.

Proto-DUNE


Source value ->
Mechanical accuracy
LAr purity (e lifetime)
Preamp gain
Coordinate
LAr temperature
dE/dx MIP
dQ/dx MIP
Momentum by MCS
Drift velocity
Drift field
Recombination, MIP
LAr density
Space charge
dE/dx Laser
dQ/dx Laser
Laser power
Laser track deviation
Affected value
Direct (time -> coordinate) map

Proto-DUNE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dE/dx Laser
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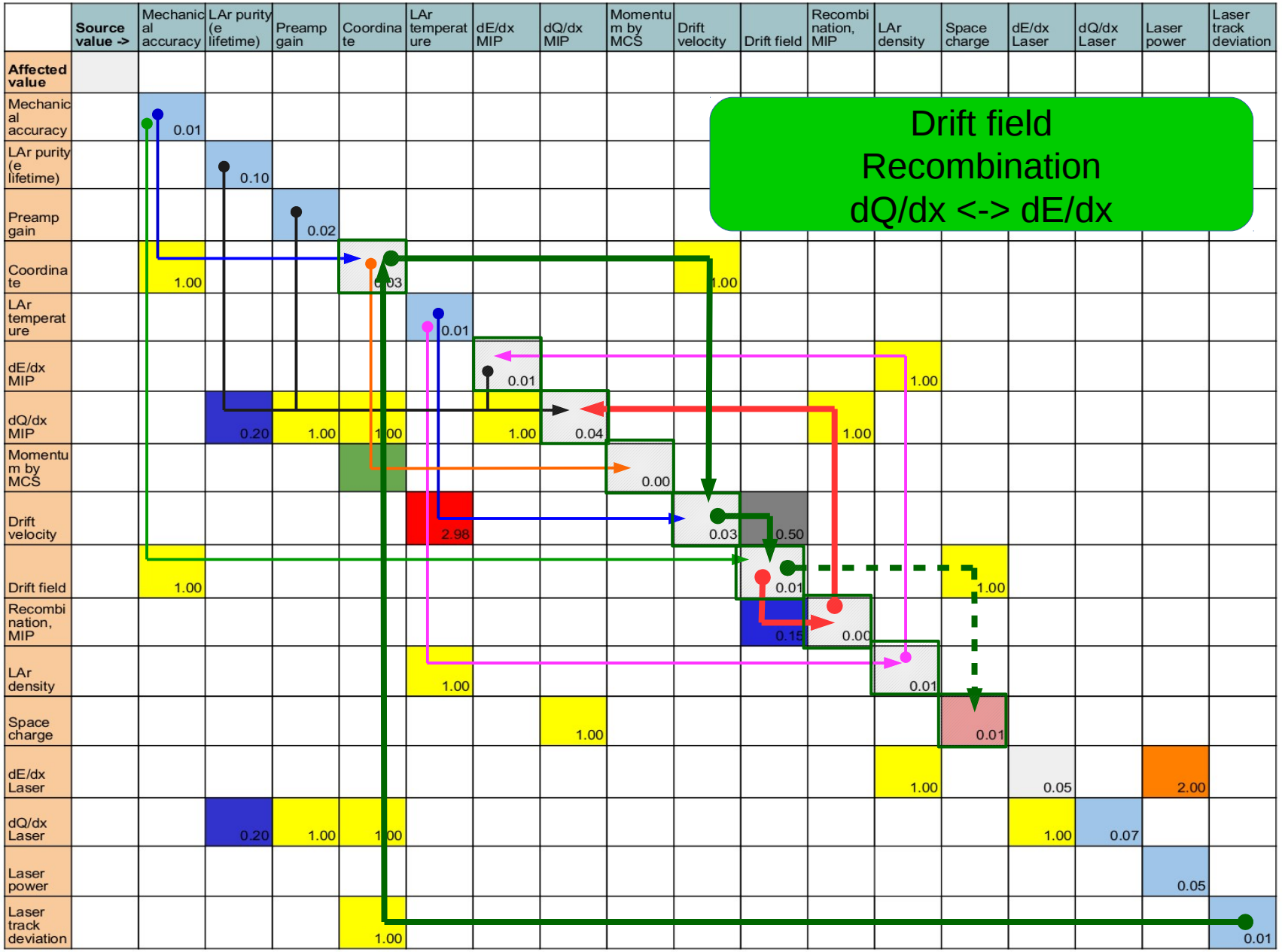
Drift velocity

Proto-DUNE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Drift field
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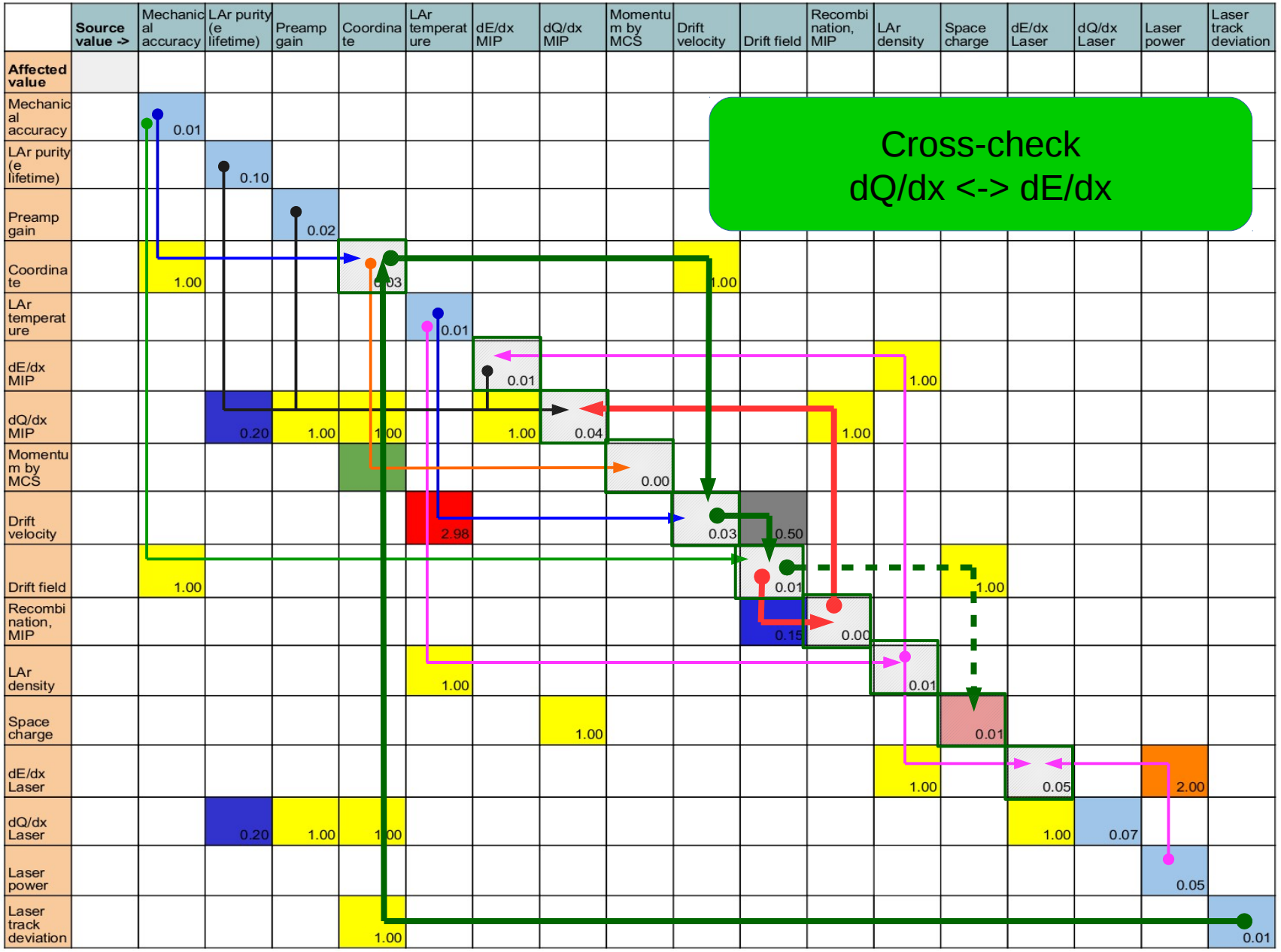
LAr density
Space charge
dE/dx Laser
dQ/dx Laser
Laser power
Laser track deviation
Drift field
Recombination
dQ/dx <-> dE/dx

Proto-DUNE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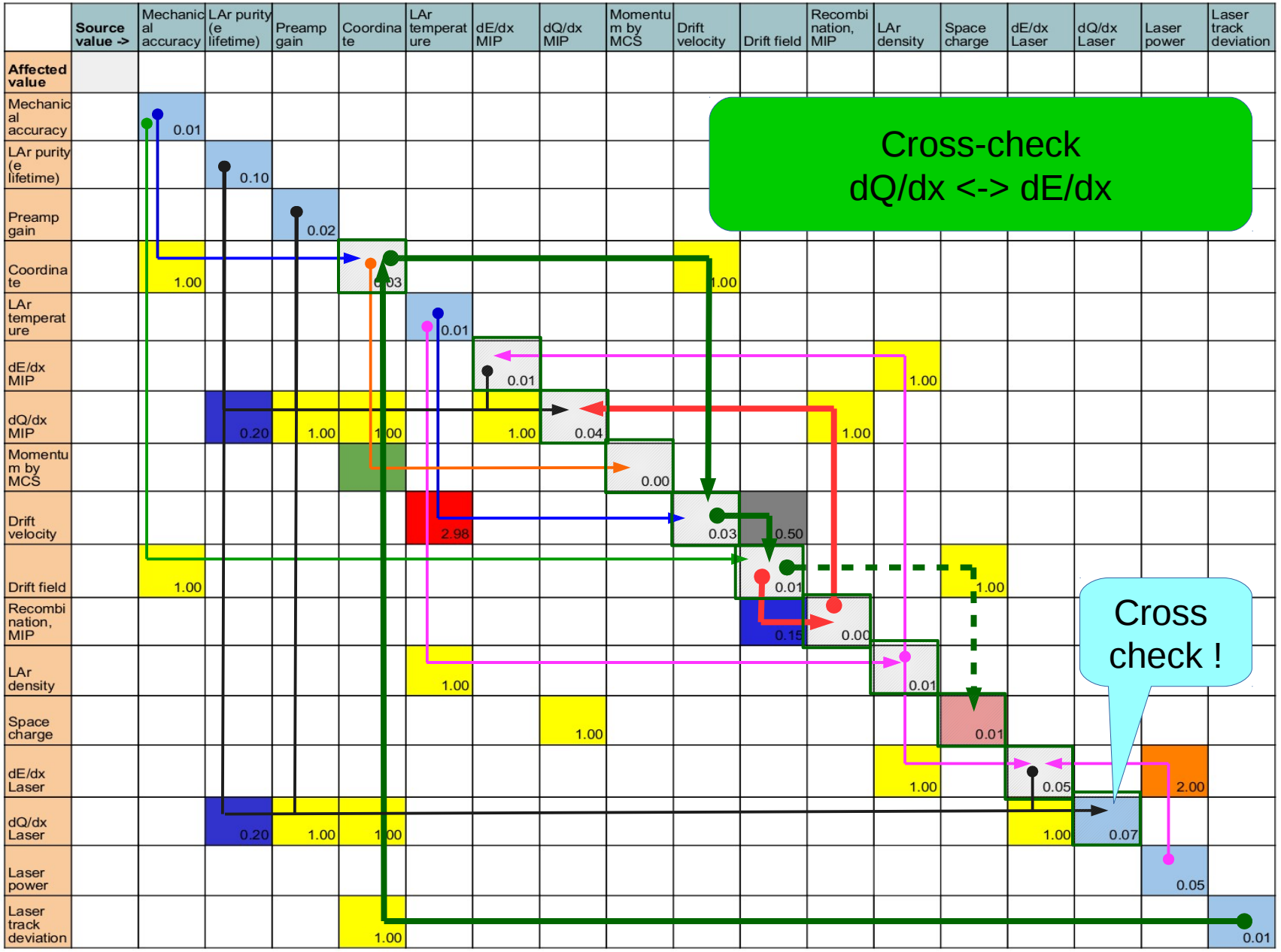
Drift velocity
Drift field
Recombination, MIP
LAr density
Space charge
dE/dx Laser
dQ/dx Laser
Laser power
Laser track deviation
Cross-check
dQ/dx <-> dE/dx

Proto-DUNE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Affected value
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LAr purity (e lifetime)
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Drift field
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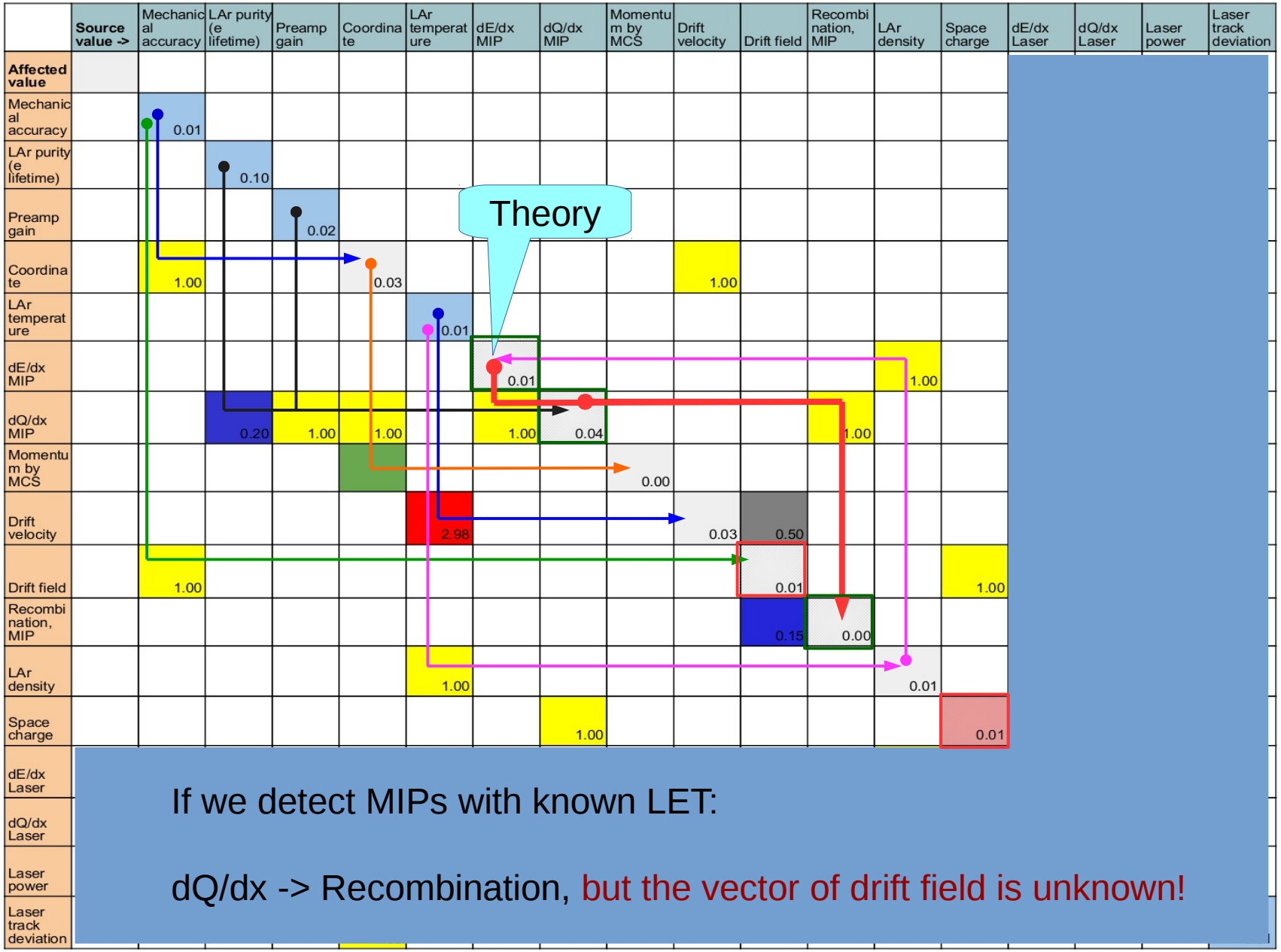
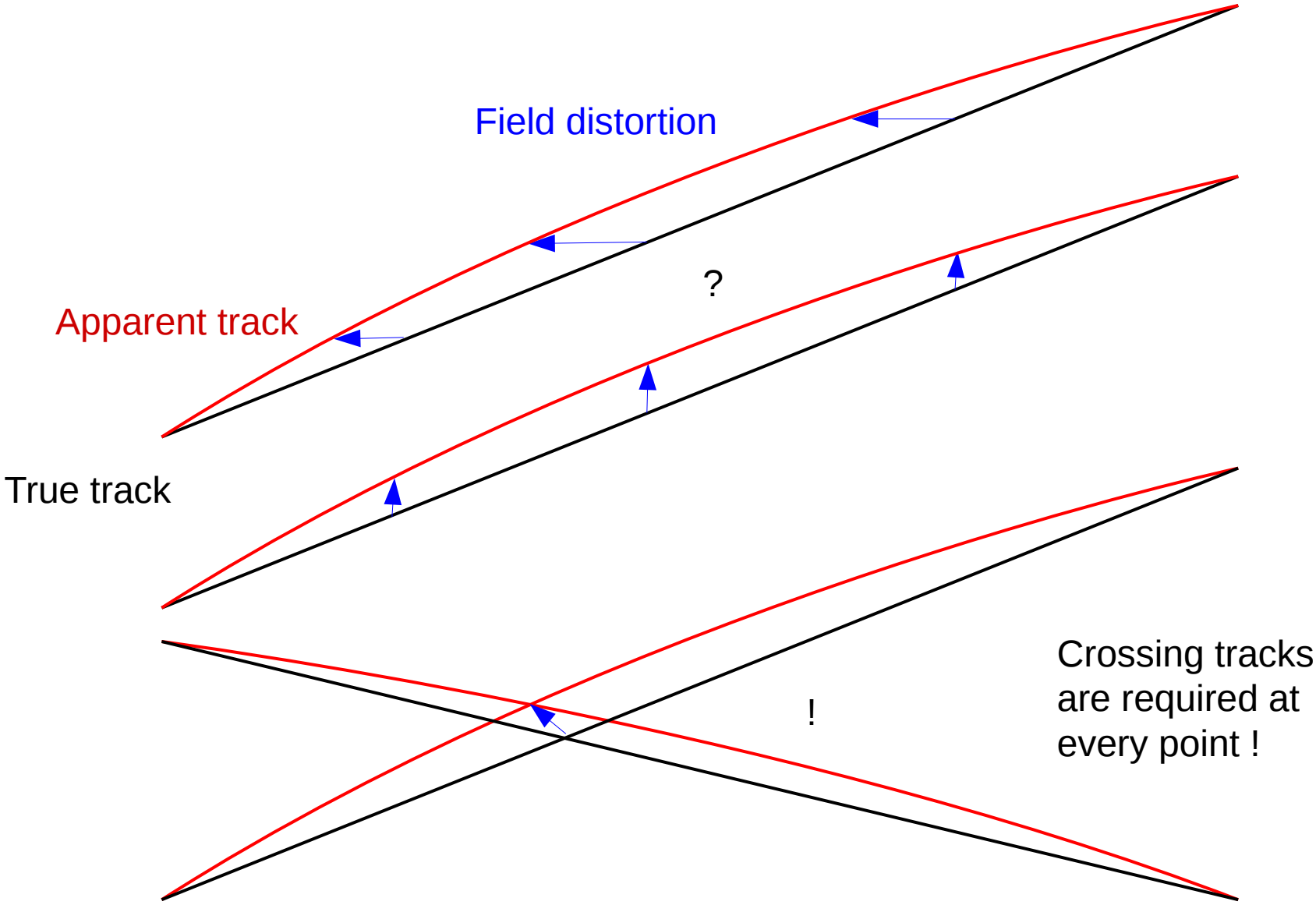
LAr density
Space charge
dE/dx Laser
dQ/dx Laser
Laser power
Laser track deviation
Cross-check
dQ/dx <-> dE/dx
Cross check !

Proto-DUNE : can we do this with tracks?



How do we reconstruct drift field from straight tracks?



What tools do we need?

Basic TPC calibration

1. Beam particles with known LET and coordinate (dE/dx only)

2. Cosmic tracks with known coordinates and directions (need a lot!)

3. Radioactive source (?) (only dE/dx and only limited volume is within reach)

4. Laser Calibration System (allows full calibration + crosschecks)

Physics & algorithms cross-checks

1. Stopping muons
2. Beam muons (halo)
3. Michel electrons
4. Pi-zeros
5. e-showers with known energy and coordinates

What analyses do we need?

1. Analyses of laser data---extraction of field, drift v, etc.

2. Analyses of muon tracks tagged by the veto---what should we be measuring?

3. How much calibration data do we need, from either the laser or the veto?

4. Stopped muons and their use for dE/dx, Delta-ray, MCS analyses

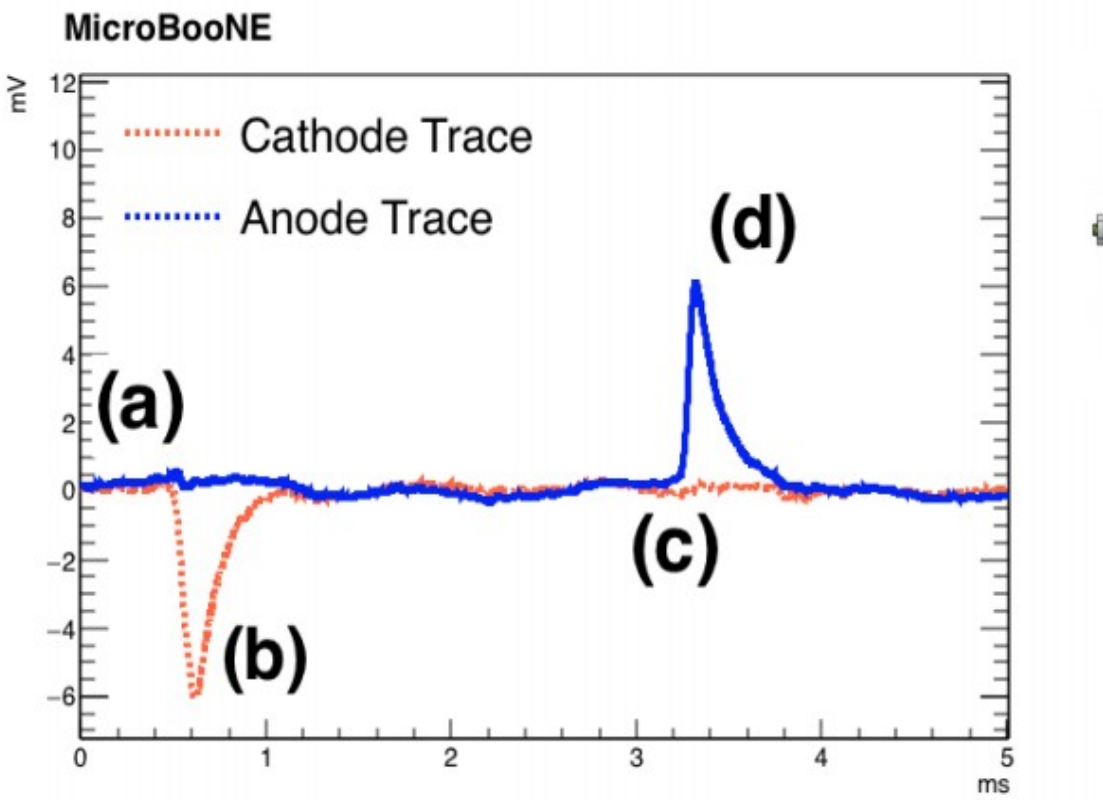
5. Michel electrons spectrum and sensitivity to detector calibration

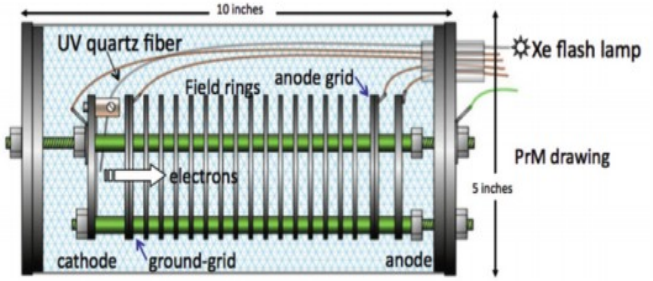
6. em-shower reconstruction and sensitivity to detector calibration

7. pi0 mass peak and sensitivity to detector calibration

MicroBooNE experience

Purity measurements (Public Note 1003)



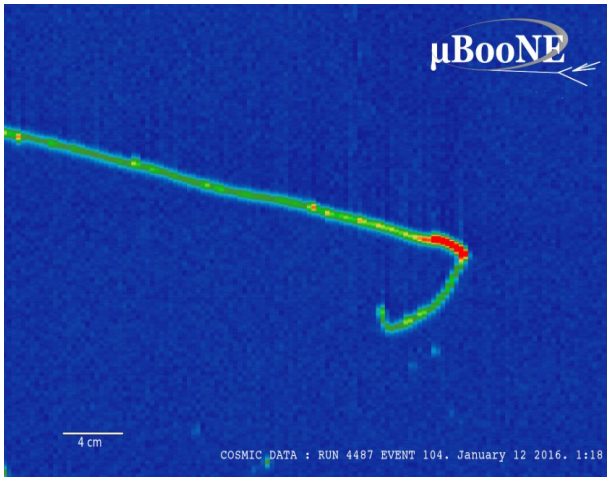


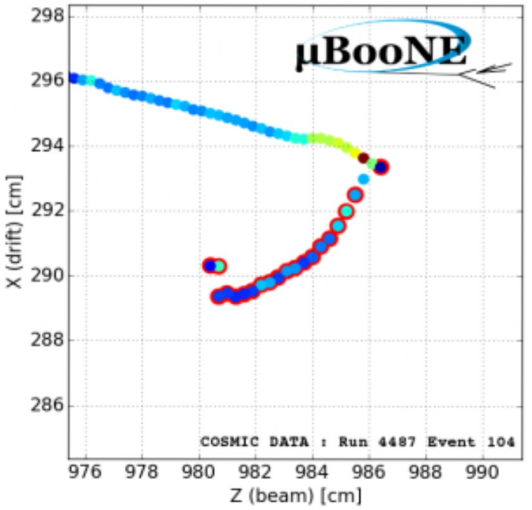
Typical value for free electron life time ~8 ms

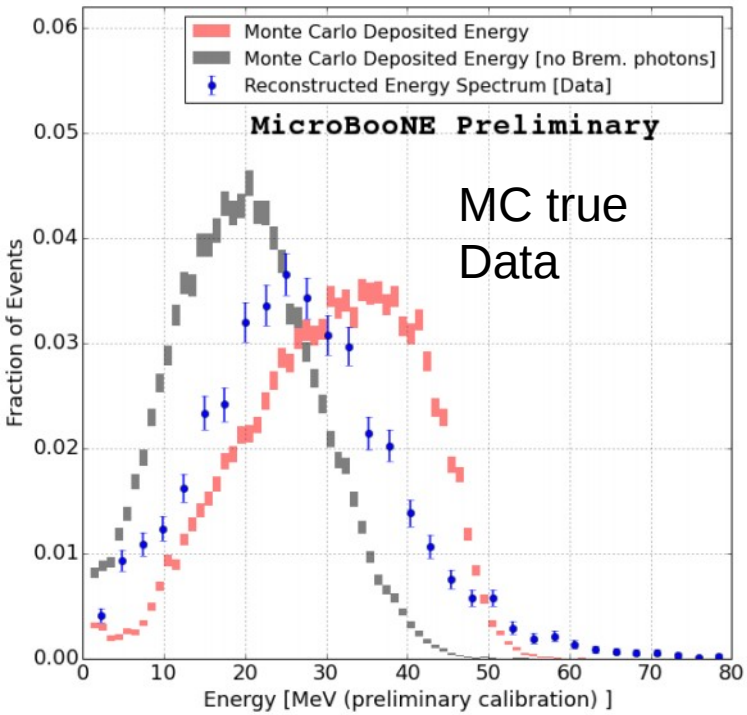
Figure 4: A plot of the oscilloscope traces from data taken with the long purity monitor on the afternoon of September 17. Both the traces before and after noise subtraction appear. The data produced a lifetime measurement of 8.4 ms. The cathode pulse maximum (b) and the point (a) where its baseline is determined are labeled. For the anode, the pulse maximum (d) and the baseline sample point (c) are also labeled. The waviness seen in the traces is suspected to arise from HV power supply ripple. The fall time of the pulses indicates the discharge time of the integrating circuit as mentioned in the text.

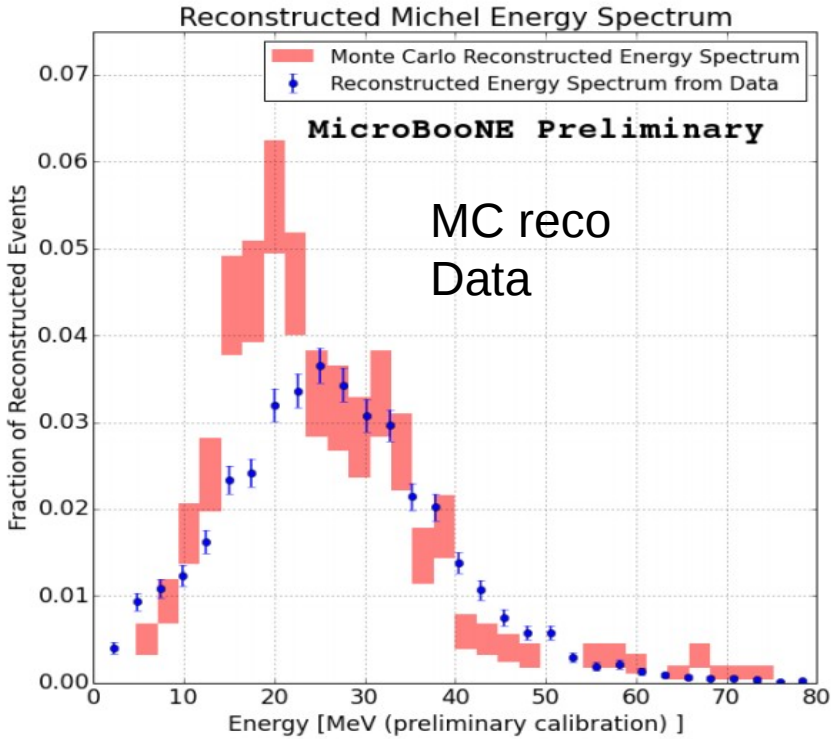
MicroBooNE experience

Michel electrons spectrum (Public Note 1008)









MicroBooNE experience

- Some work on space charge derivation is done (talk of Mike Mooney, pub. Note)

- Some more work on detailed space charge reco and direct time-coordinate mapping is in progress (laser system)

- Muon Tagger with X-Y resolution of 1.2-1.8 cm is being installed
  -> space charge & dE/dx calibration

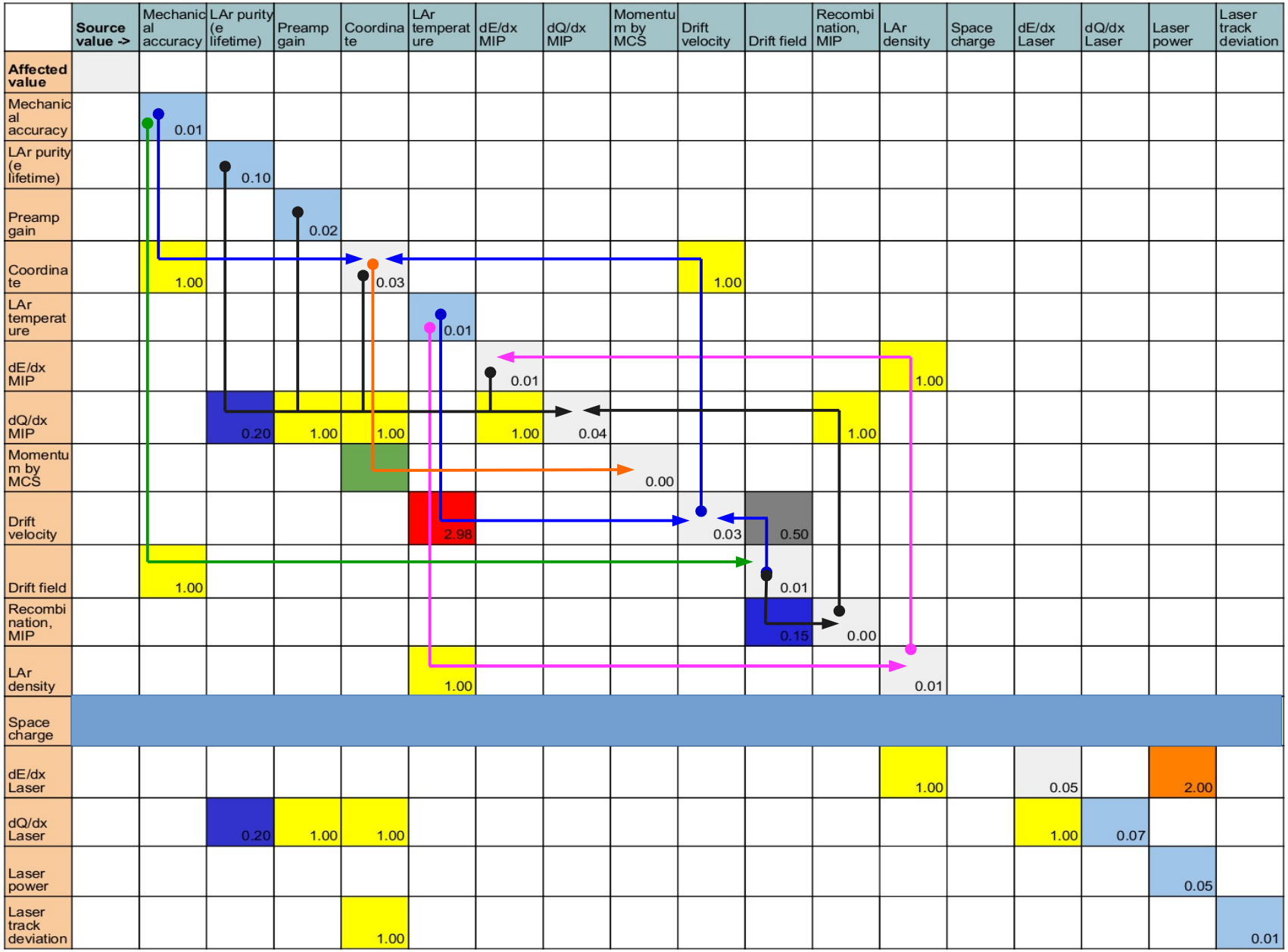
- Extended effort on Charge-to-Voltage calibration is in progress (pub. Note soon!)

- Data-MC comparison at the level of tracks basic geometry and dE/dx
  (pub Note soon!)

Thanks!

Backup Slides

DUNE FD (ND)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Preamp gain
Coordinate
LAr temperature
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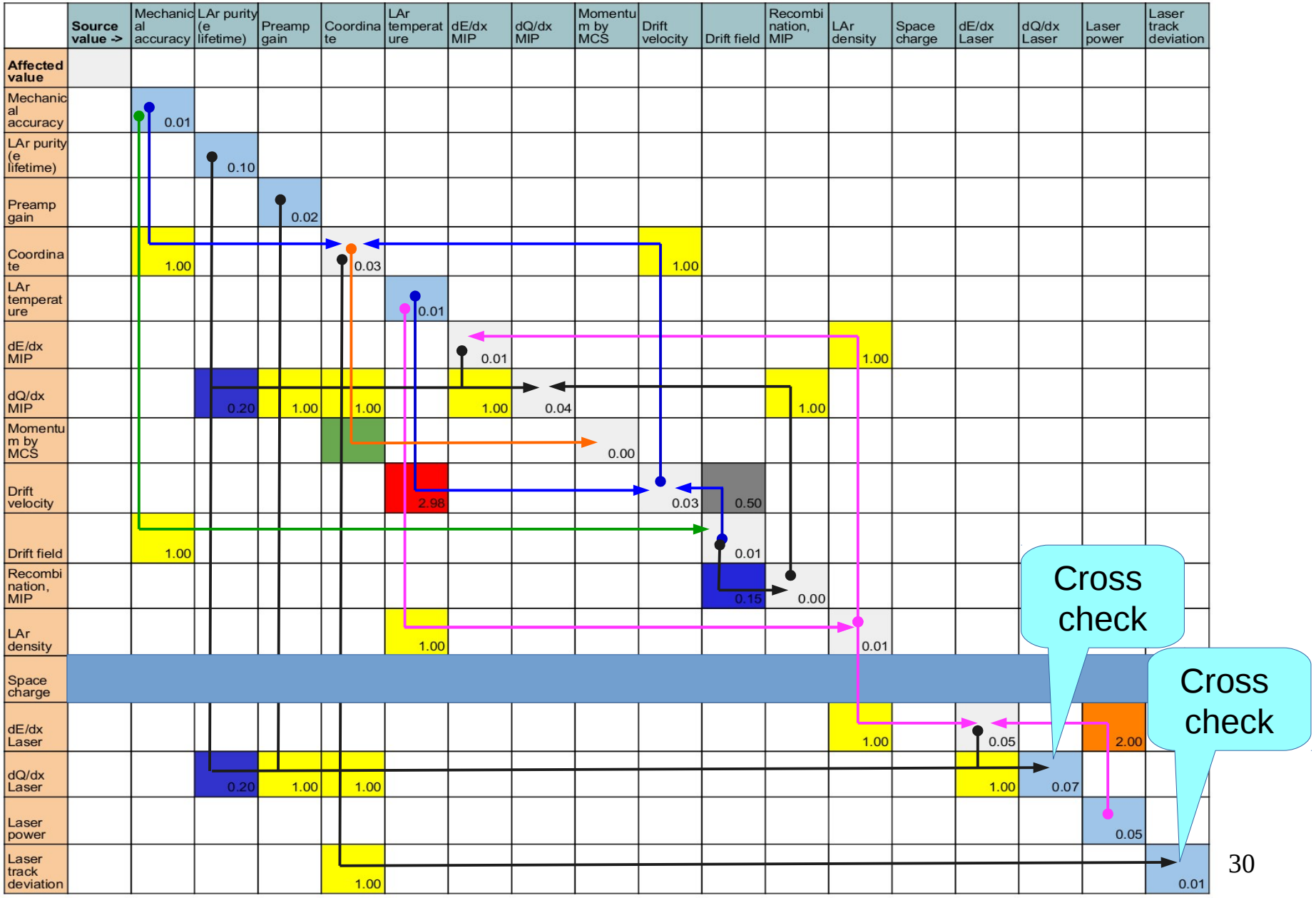
dQ/dx MIP
Momentum by MCS
Drift velocity
Drift field
Recombination, MIP
LAr density
Space charge
dE/dx Laser
dQ/dx Laser
Laser power
Laser track deviation
Affected value
0.01
0.10
0.02
1.00
0.03
1.00
0.01
0.01
1.00
0.20
1.00
1.00
1.00
0.04
1.00
0.00
2.98
0.03
0.50
1.00
0.01
0.15
0.00
1.00
0.01
1.00
0.05
2.00
0.20
1.00
1.00
1.00
0.07
0.05
1.00
0.01

DUNE FD (ND)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Affected value
Cross check
Cross check