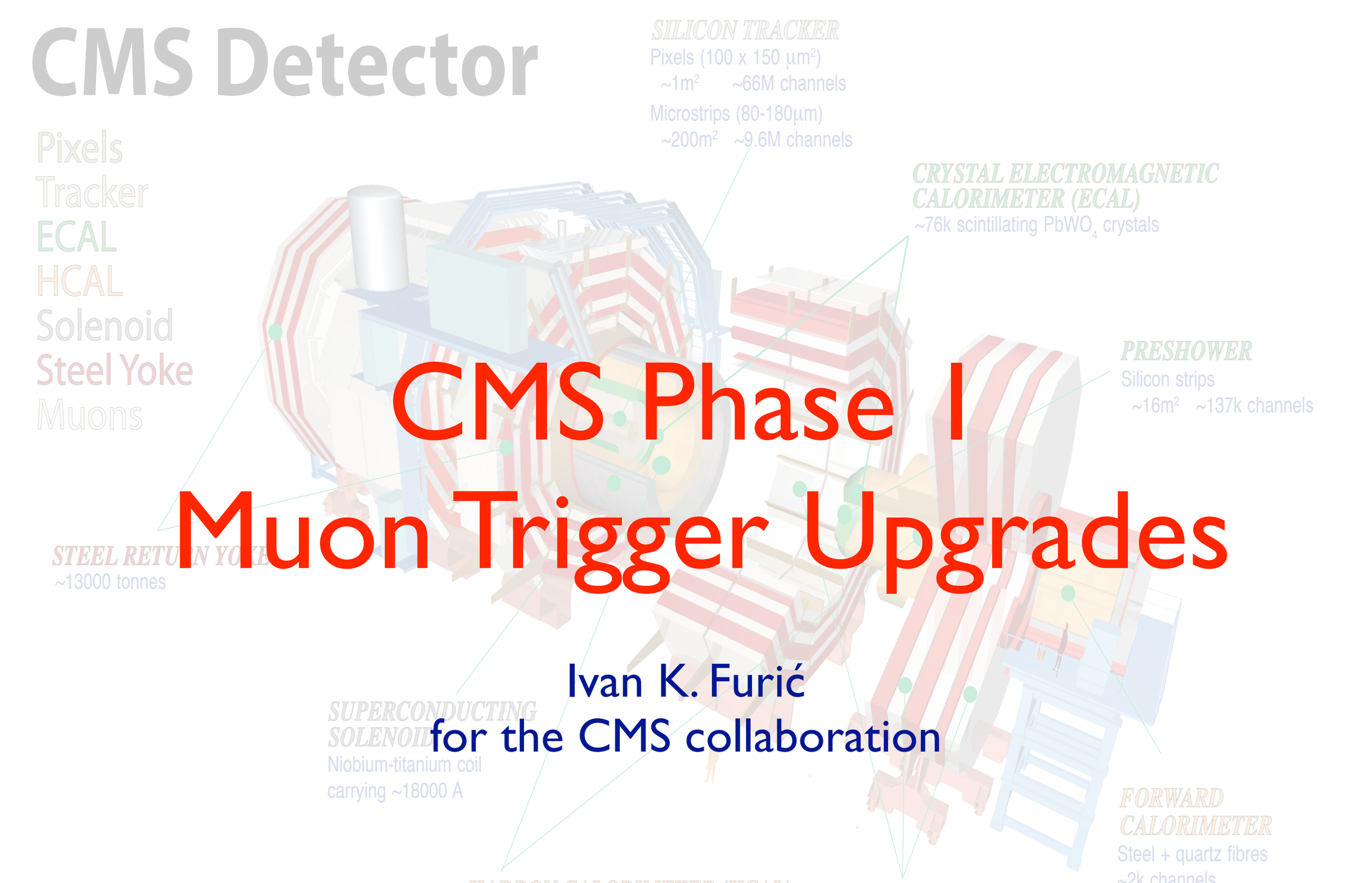
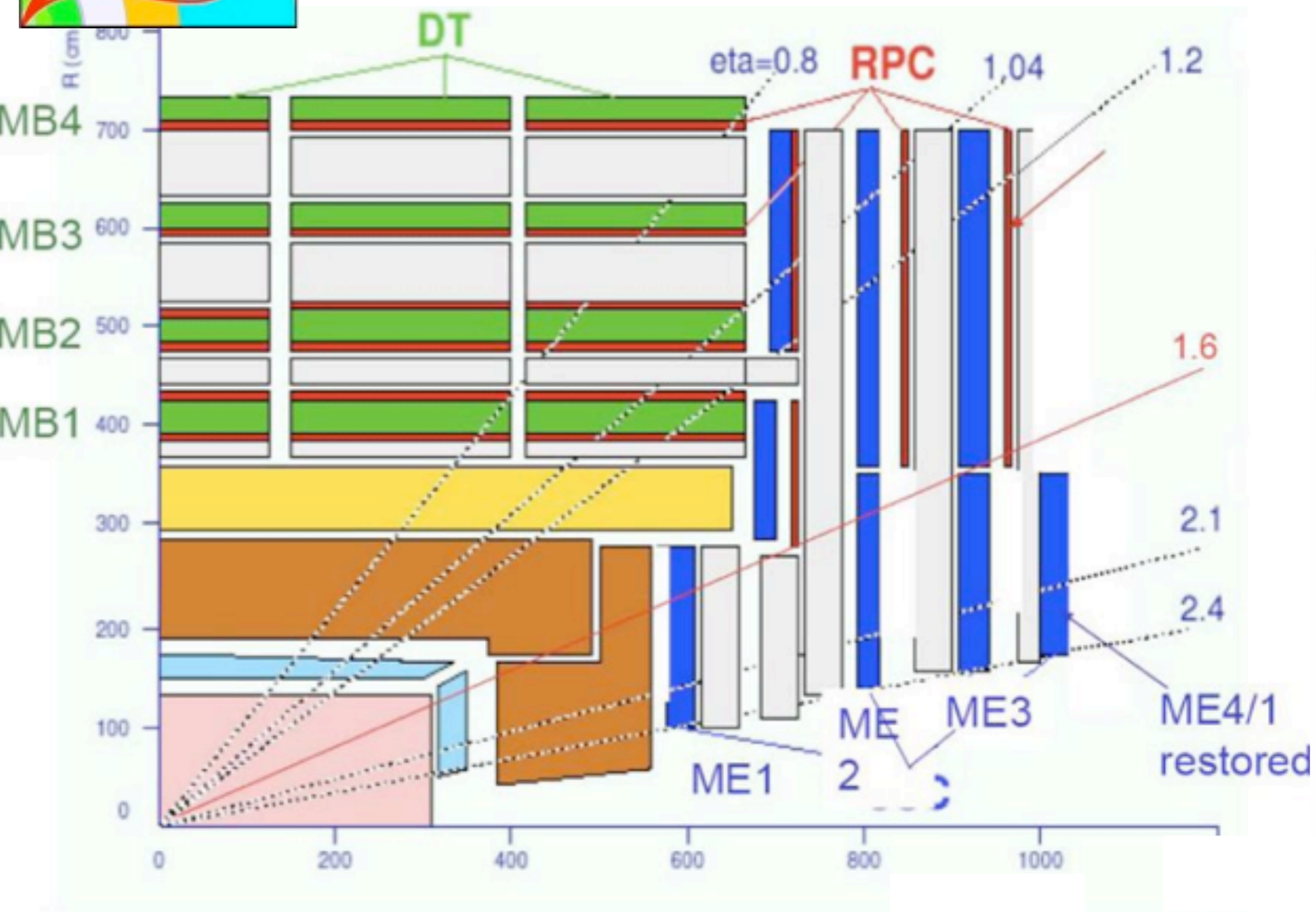
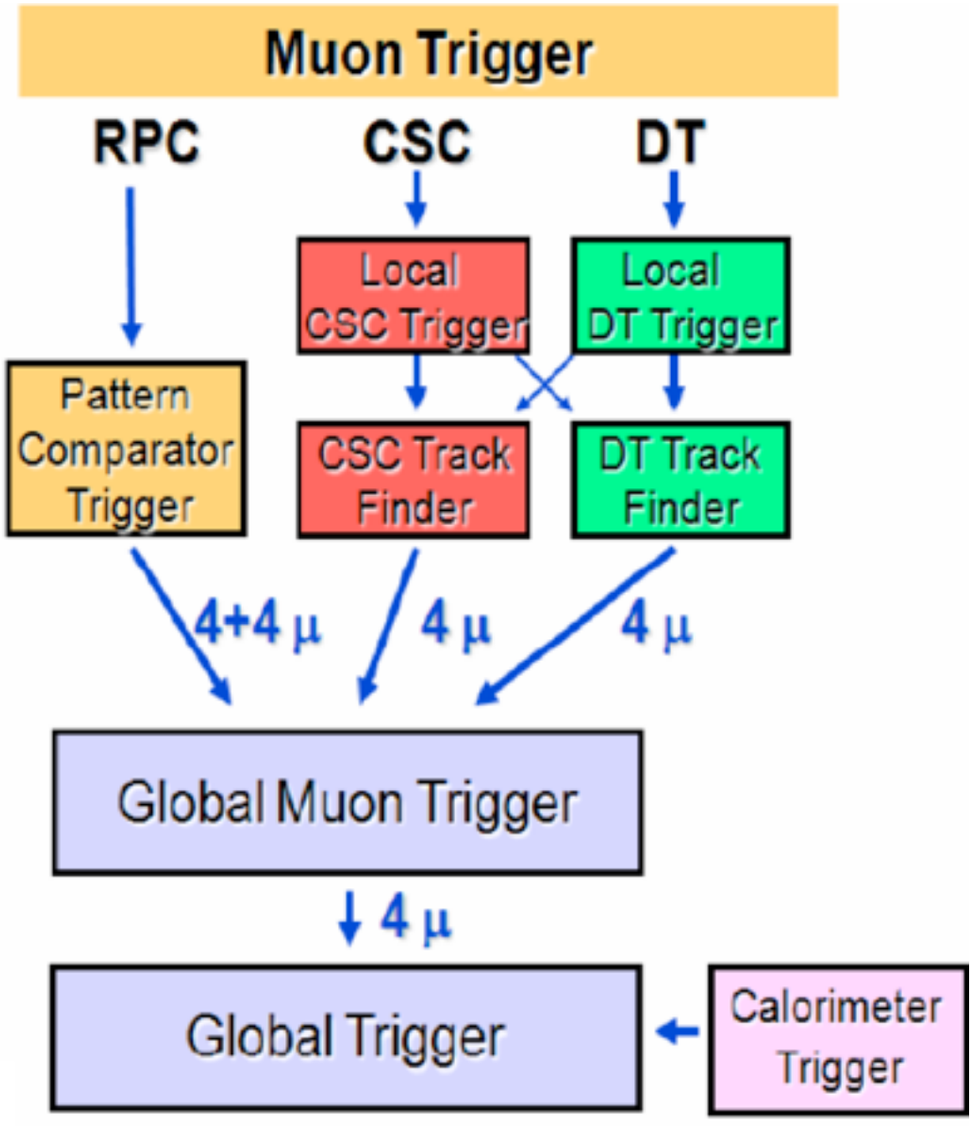


CMS Phase I Muon Trigger Upgrades

Ivan K. Furić
for the CMS collaboration

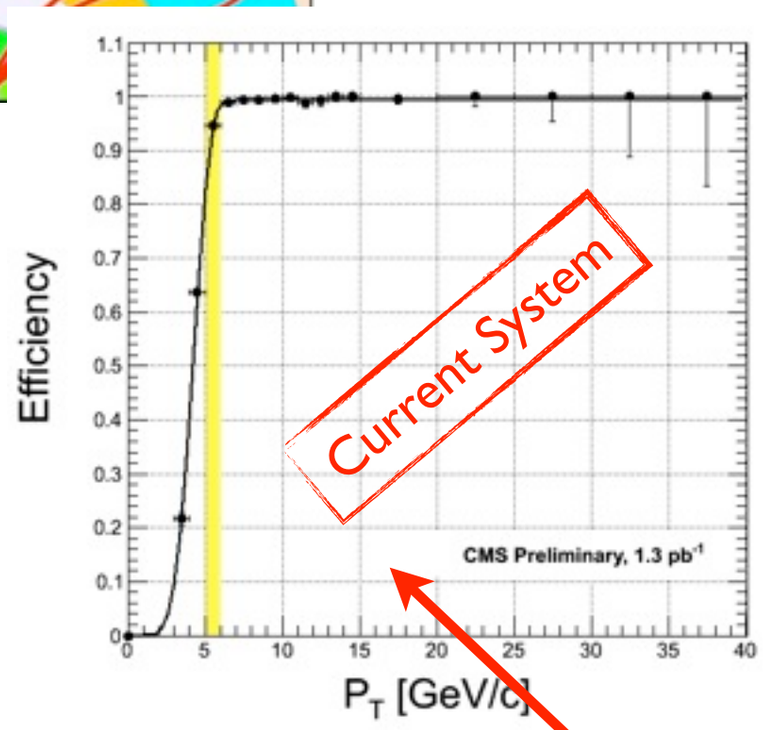
CMS Muon Trigger

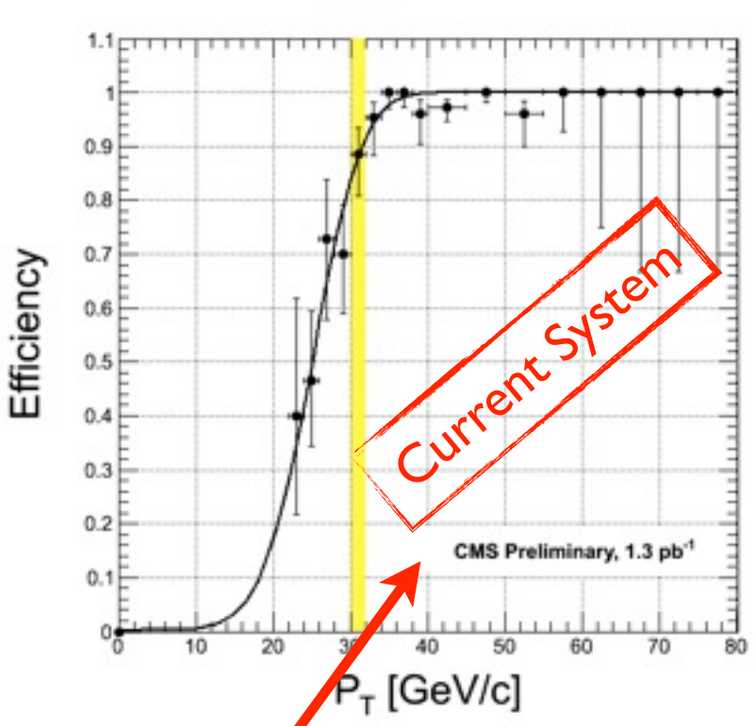


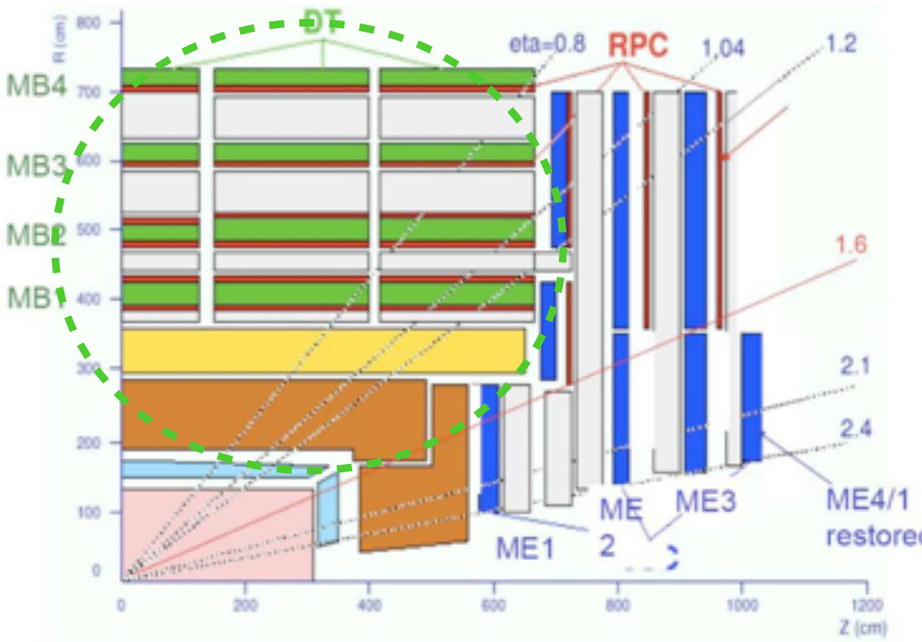


- in this talk: data flow, algorithms, architechture of trigger system (mostly off detector electronics)
- muon electronics upgrade - see talk by M. Matveev at 18:35

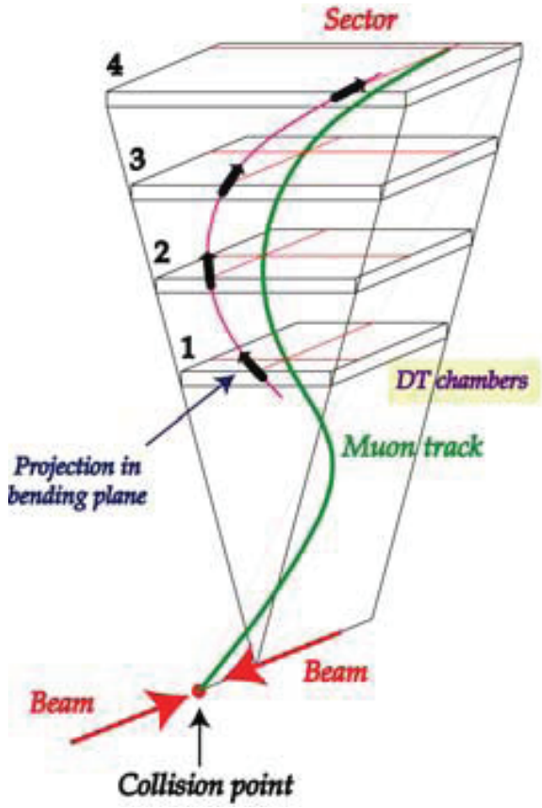
DTTF Upgrade Motivation

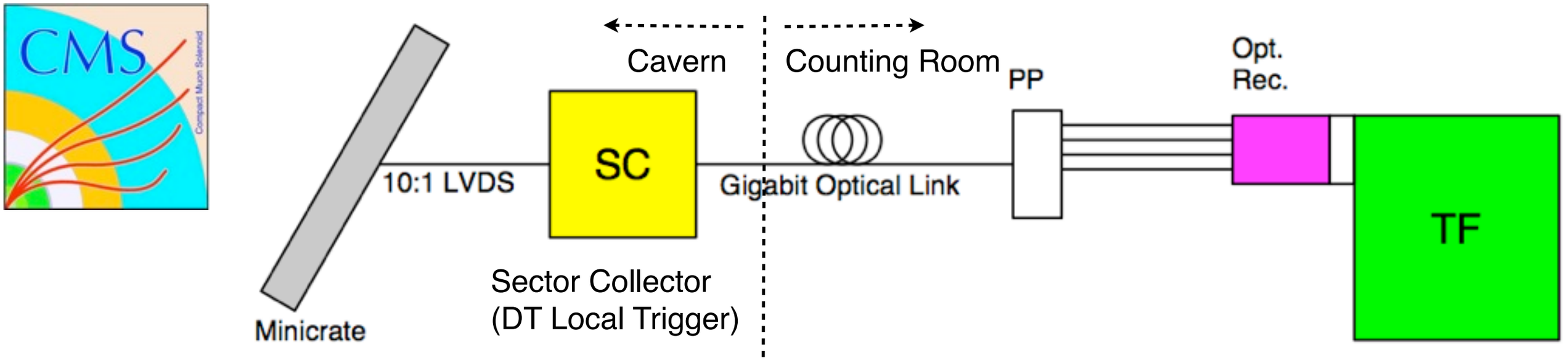






- p_T assignment very close to optimal
- present design based on requirement for low latency
- highly interconnected, high speed parallel links ~ 35k pins input + out
- take advantage of high speed serial links, new FPGAs → more flexibility

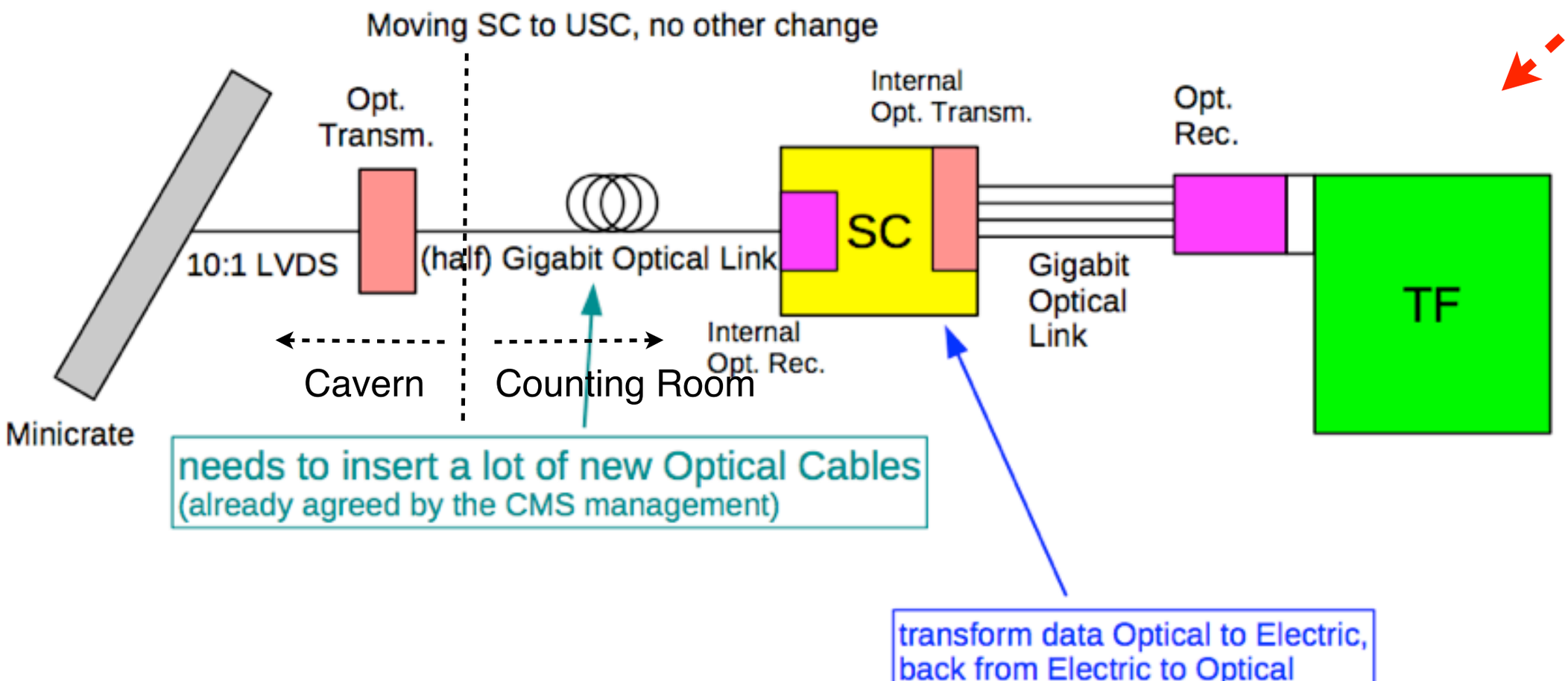




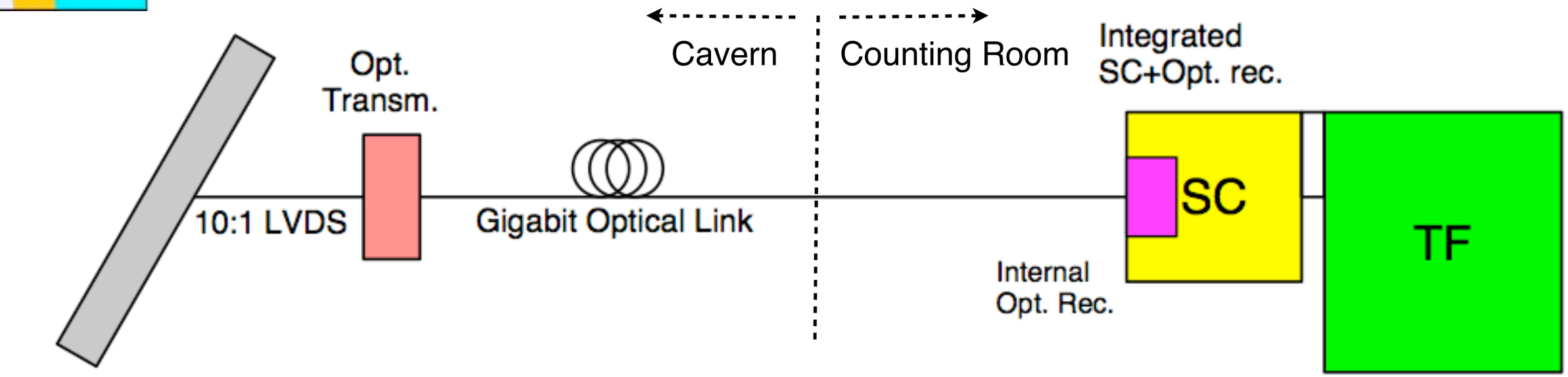
Present DT Trigger Chain

Track Finder Board
Pattern Recognition
p_T Assignment

Moving SC to counting room ...

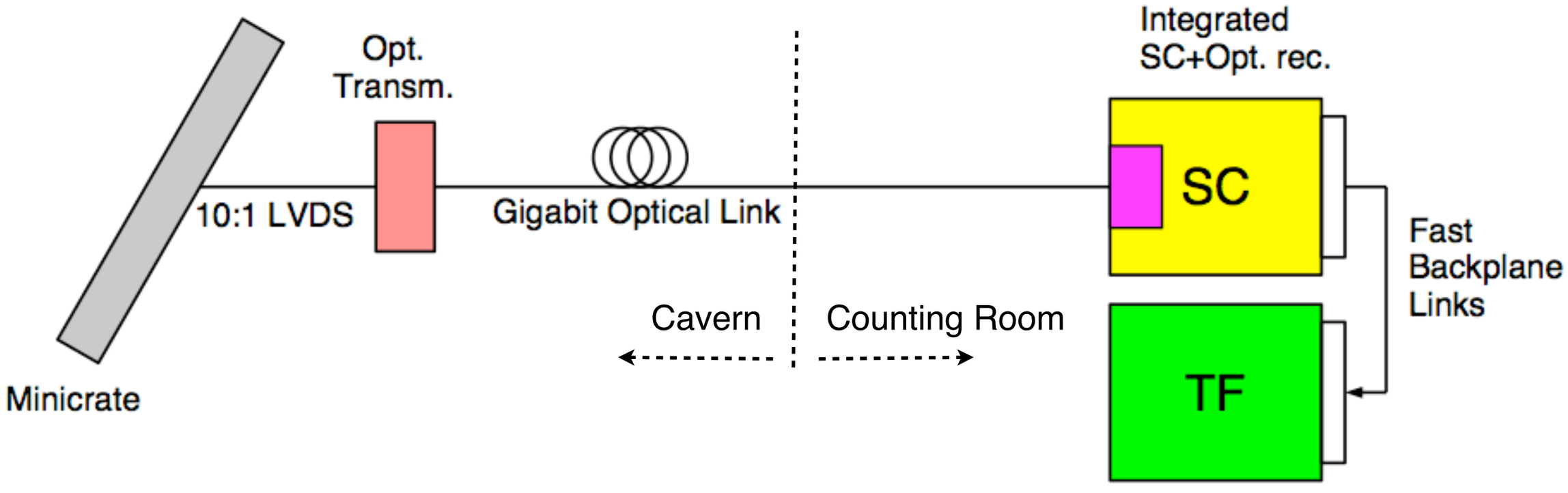


.. allows design flexibility



Minicrate

SC – Optical Receiver Integration



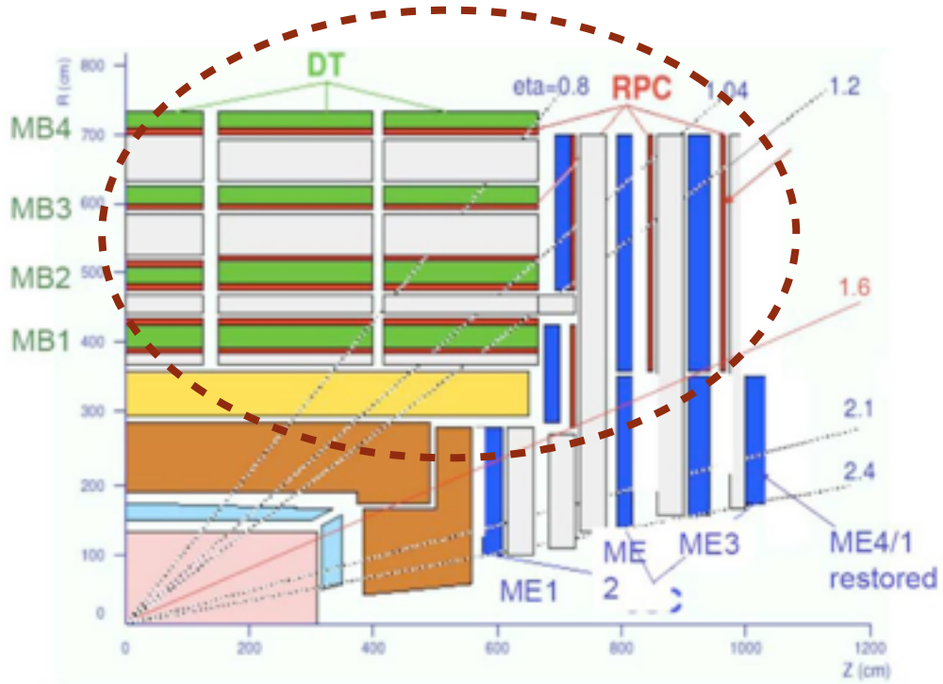
Trigger Object distribution through fast serial Links (μTCA)

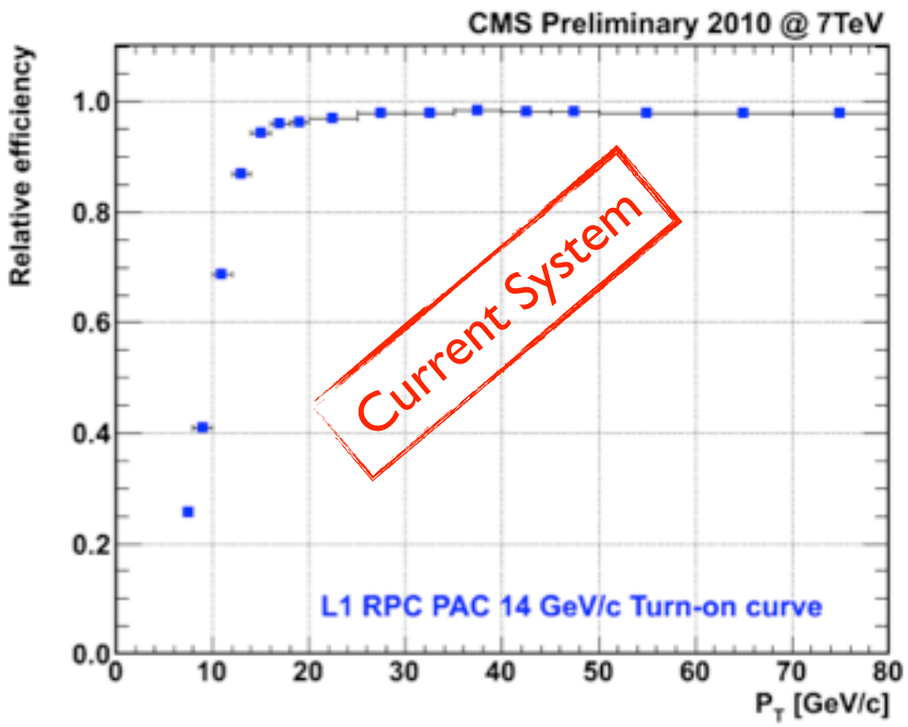
Drift Tube Track Finder Upgrade Considerations

- avoid crate to crate cabling as much as possible
- Currently considering platforms:
  - μTCA: card size might be too small to fit needed I/O
  - ATCA: more surface per card
    - enough rack space in USC?
- if possible avoid custom backplanes in design
- use common CERN design units as much as possible

RPC Trigger Upgrade

- current coverage $|\eta| \leq 1.6$
- p_T assignment performing well
- plan: complete coverage to $|\eta| \leq 2.1$
- current trigger electronics well suited
- working on pattern optimization for high occupancy environment
- high $|\eta|$ triggering difficult due to high occupancy
- $|\eta| \sim 1.6$ difficult for both CSC and RPC triggers in 2/3 configuration - can we add an extra hit in this region?

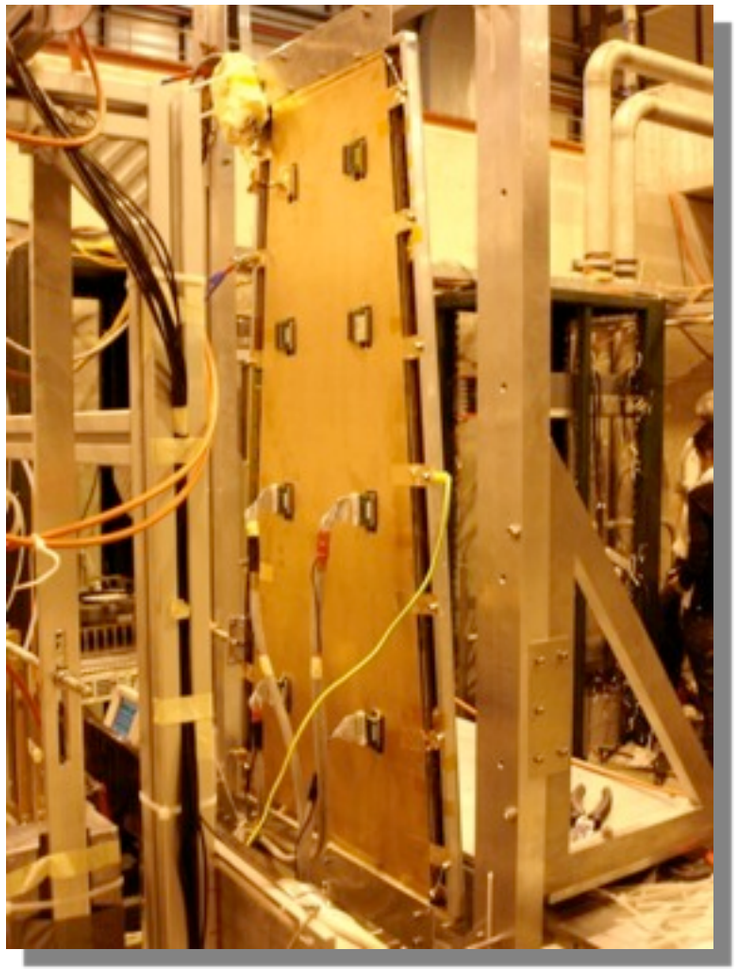




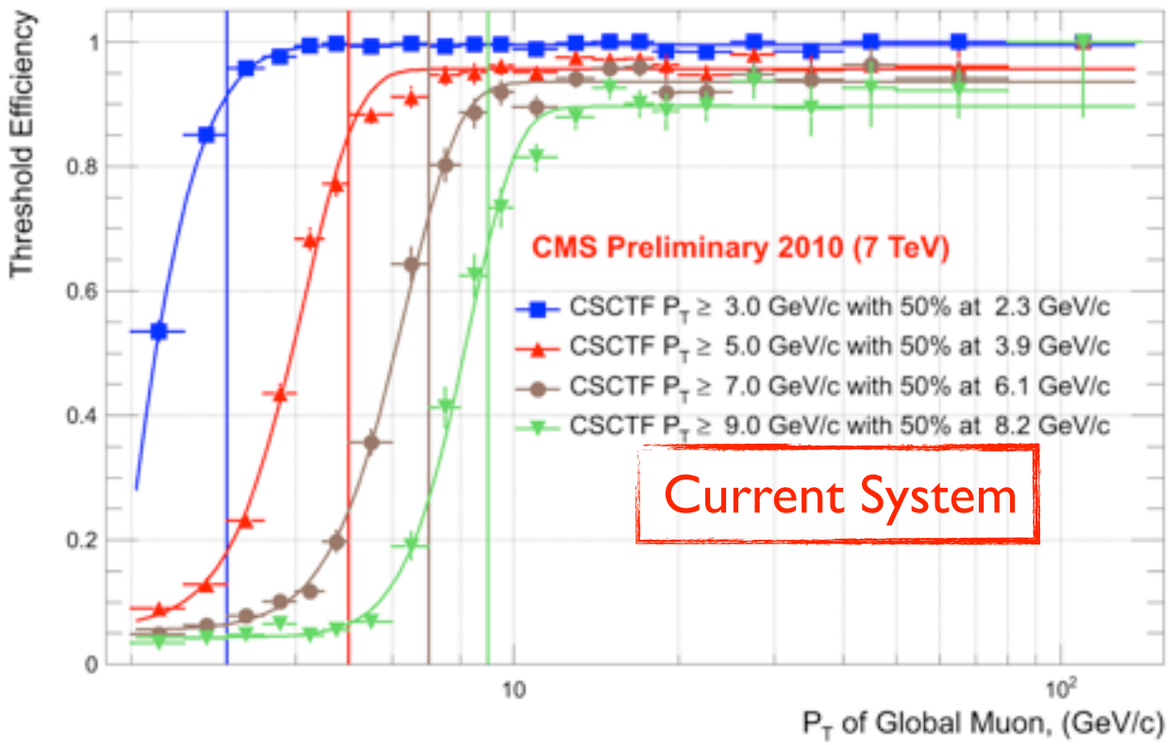
Possible new technology: MPGD Chambers

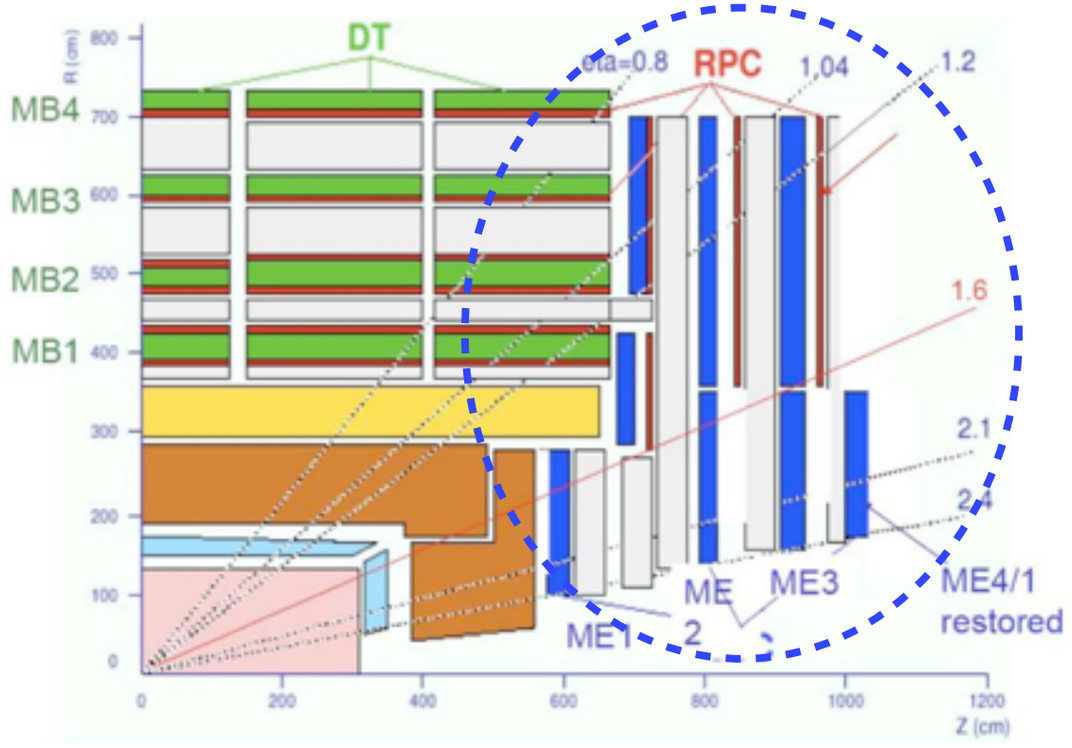
- rate capability : $10^4/mm^2$
- space/time resol: ~100 μm / ~ 4-5 ns
  - ideal for high |η| + high occupancy
- efficiency > 98% ;
  excellent long term operation
- gas mixture: Argon - CO2
  (non flammable mixture)
- large area: ~1m x 2m with industrial processes
- multiple scattering, geometry, offline momentum resolution studies underway
- trigger enhancement with MPGD chamber studies underway in parallel

Large Prototype: GE1/1
BeamTest @ RD51 setup
October 2010



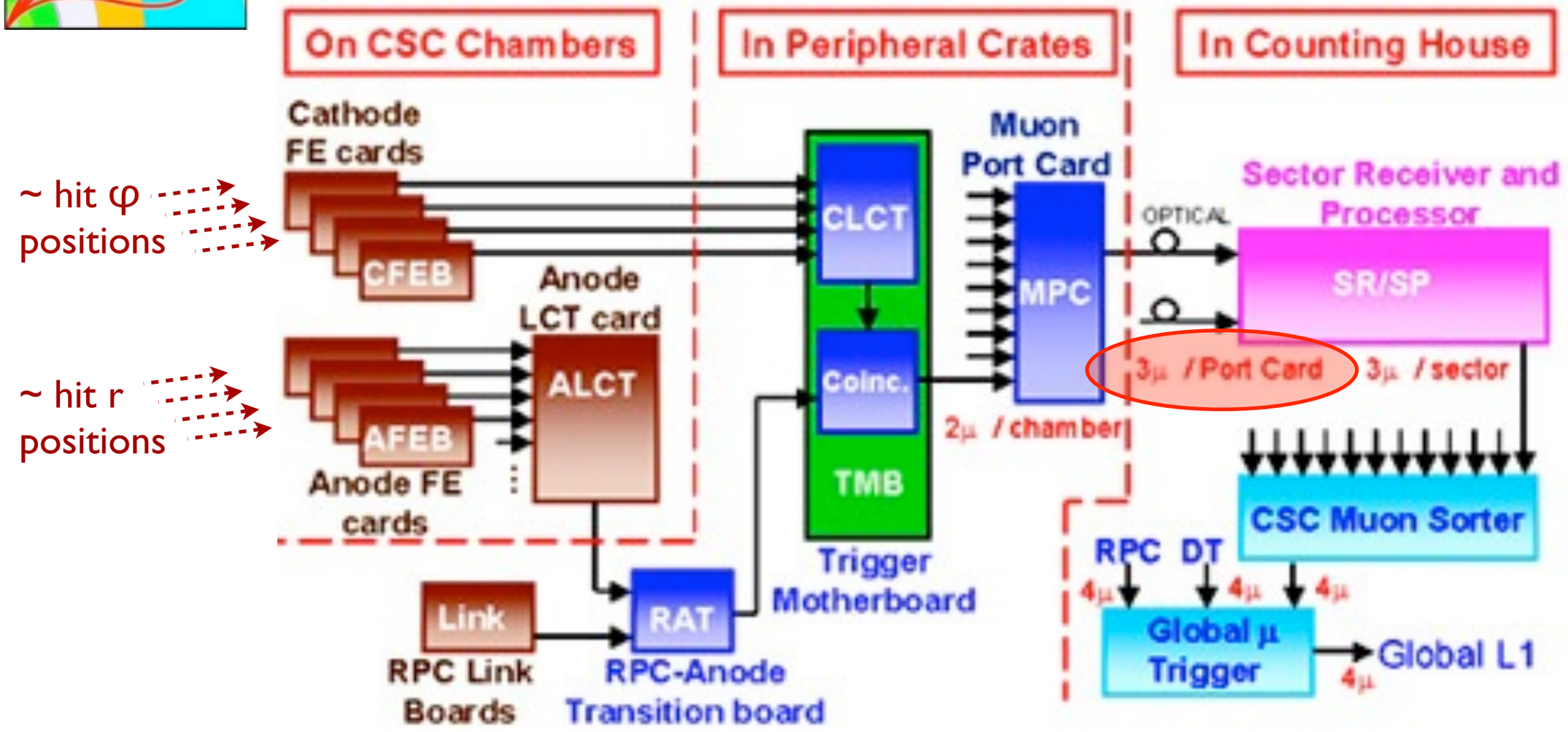
CSCTF Upgrade Motivation





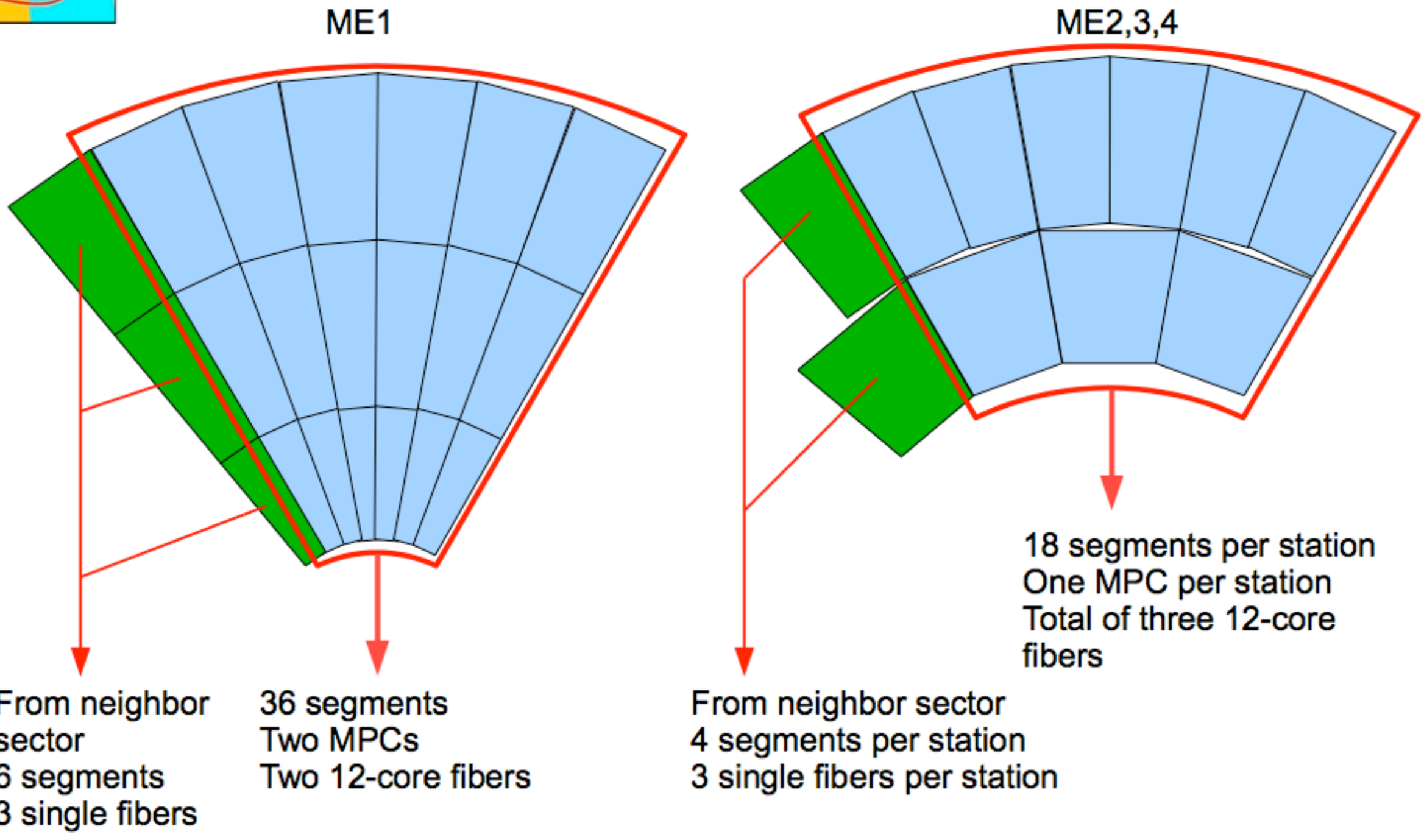
- momentum assignment pretty good, possibly limited by LUT address space
- concern - possible high occupancy in forward region
- improve p_T assignment if possible
- recover efficiency at 30° trigger sector borders

CSCTF Current Data Flow



- multi-step analysis and reduction designed for "low" occupancy
- in high occupancy environment, 3 primitives per station per 30° sector may become a bottleneck
- pull all stops - allow all L1 primitives into Sector Processor

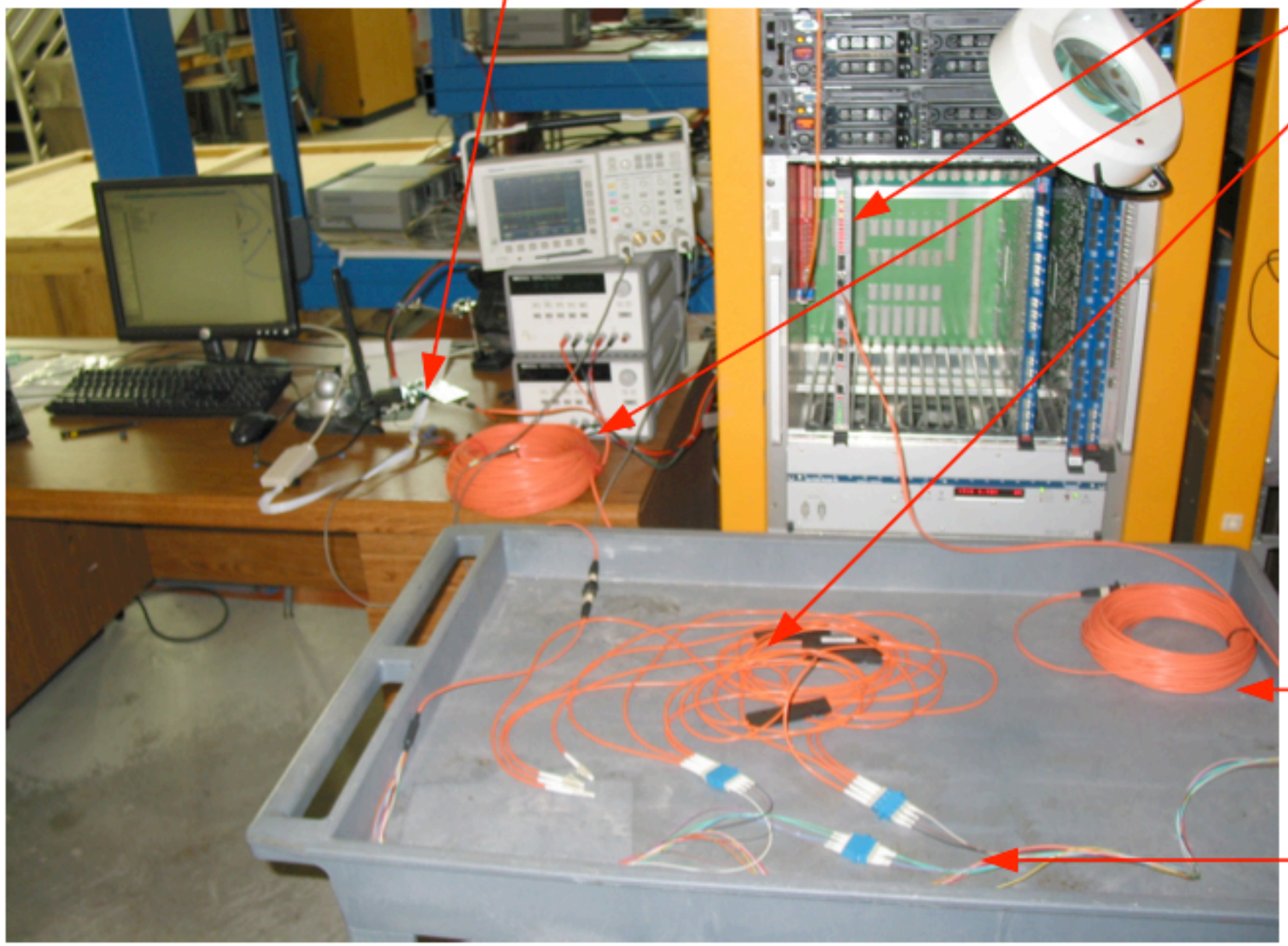
CSCTF Data Flow Upgrade



CSCTF Data Flow Demonstrators

Upgrade CSCTF
Sector Processor RX Prototype

Upgrade Muon Port Card
TX Prototype



100-meter 12-core fiber

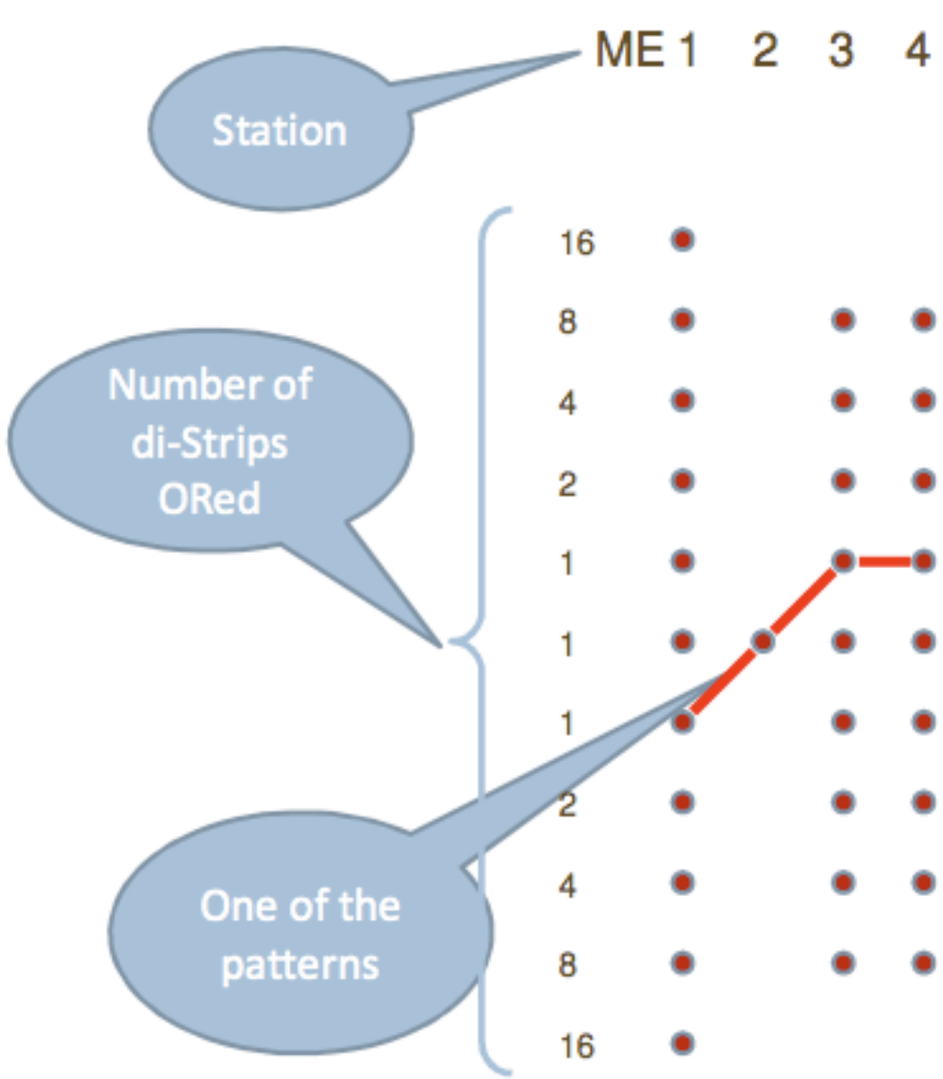
4 optical splitters
50/50 %

25-meter 12-core fiber

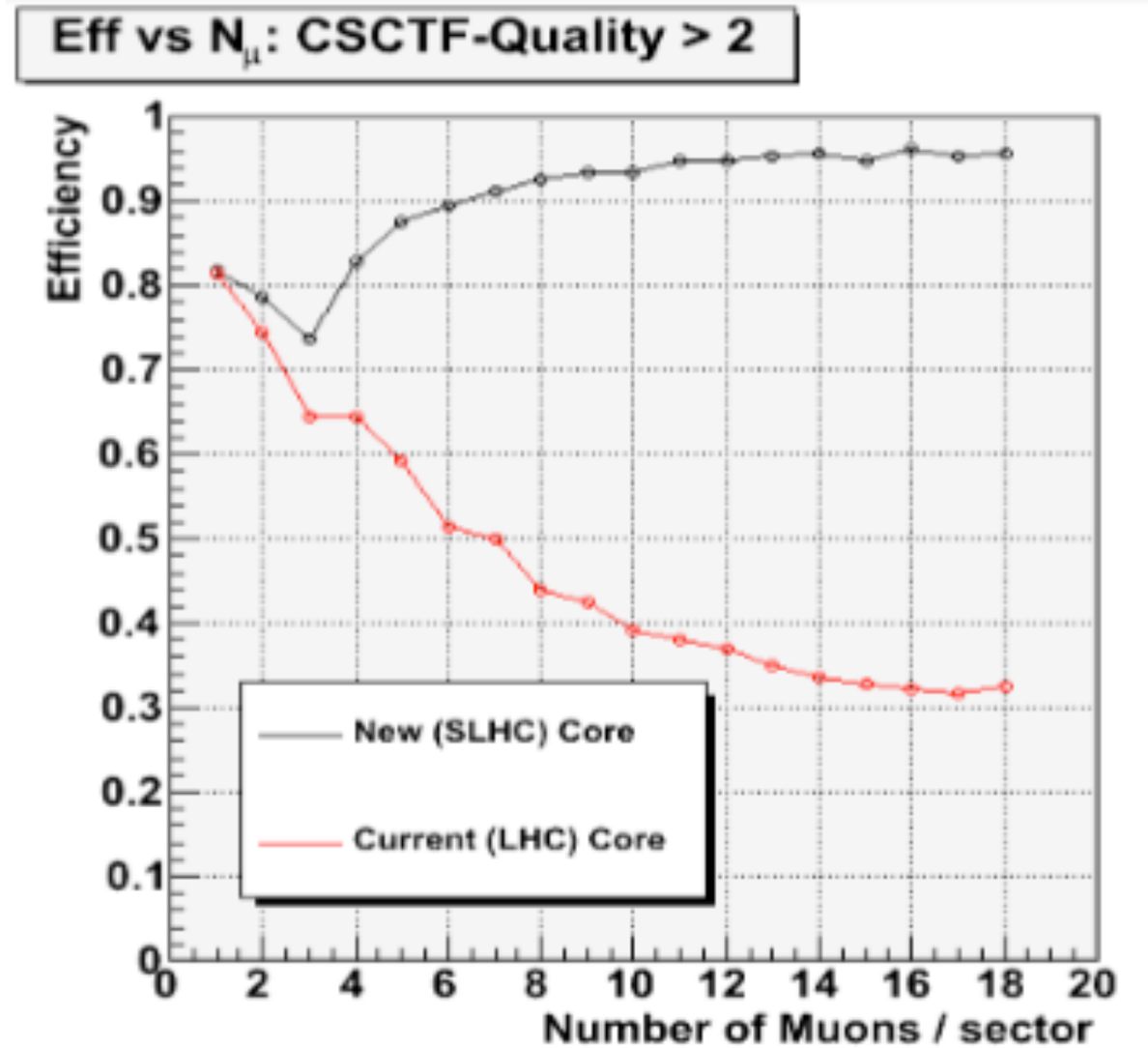
12-core fanout

Track finding algorithm

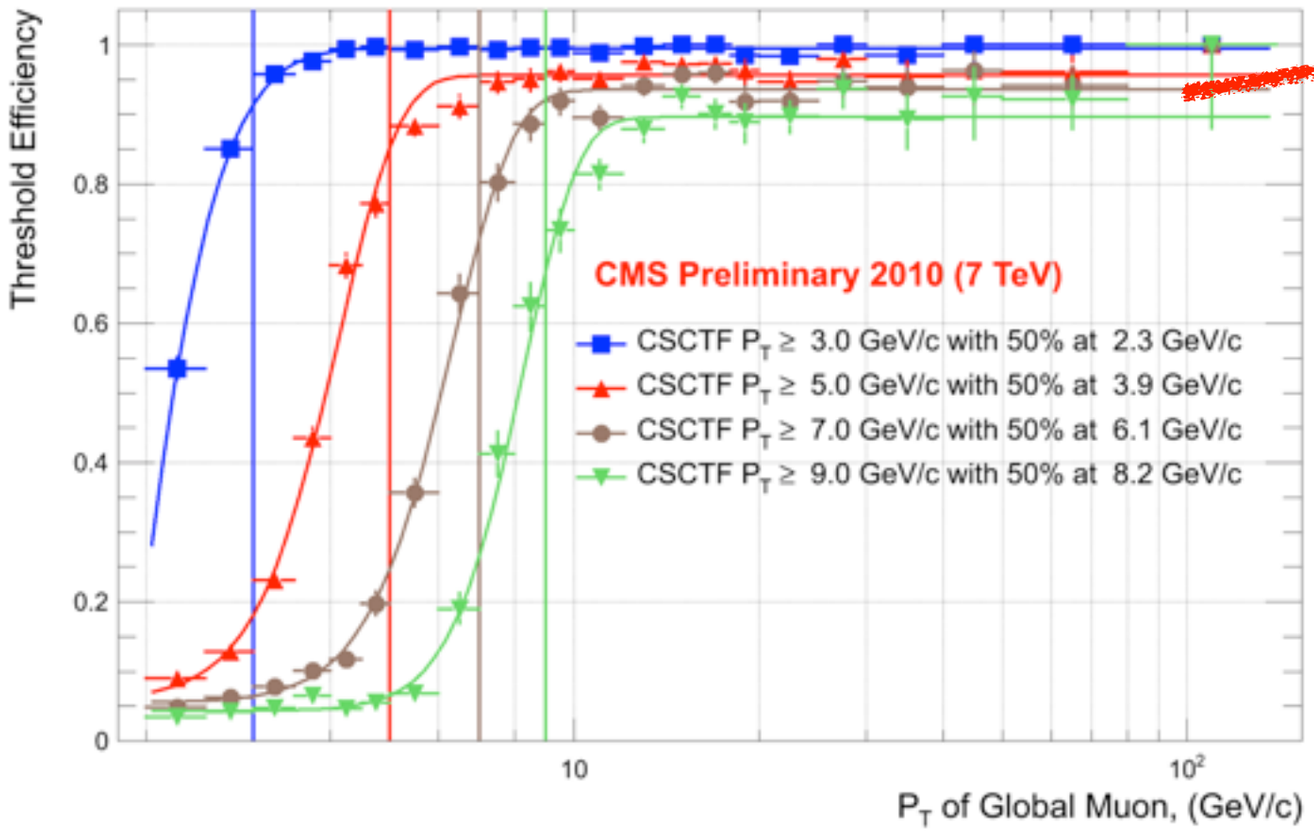
- current design - ϕ comparisons, does not scale well
- switch to pattern matching system for upgrade

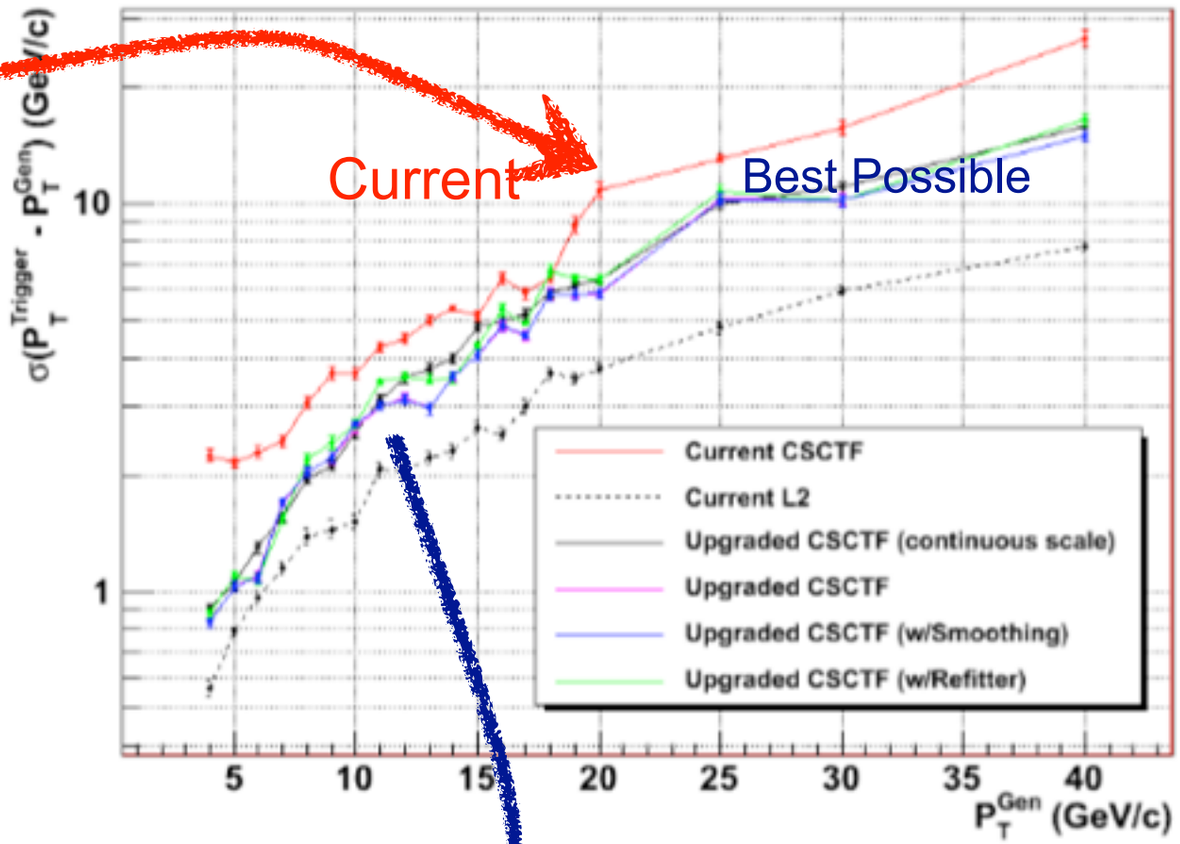


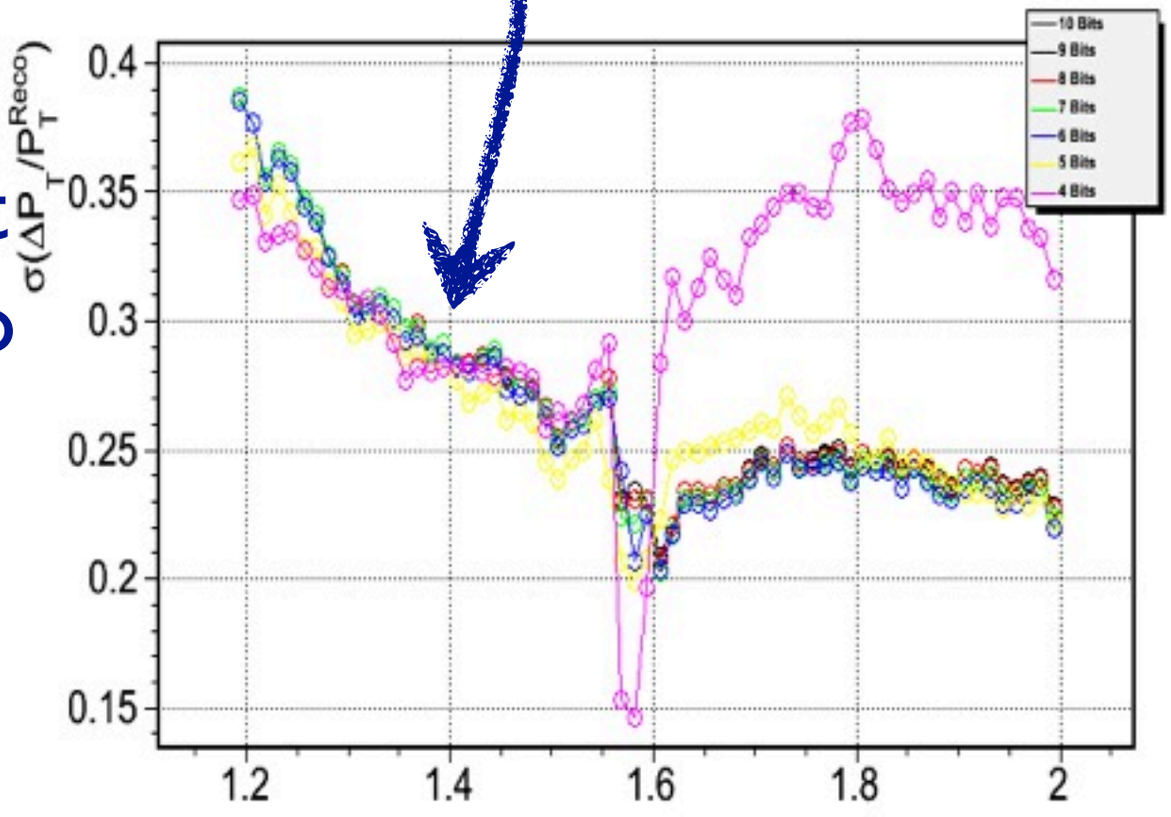
Possible φ pattern envelope structure



p_T Assignment







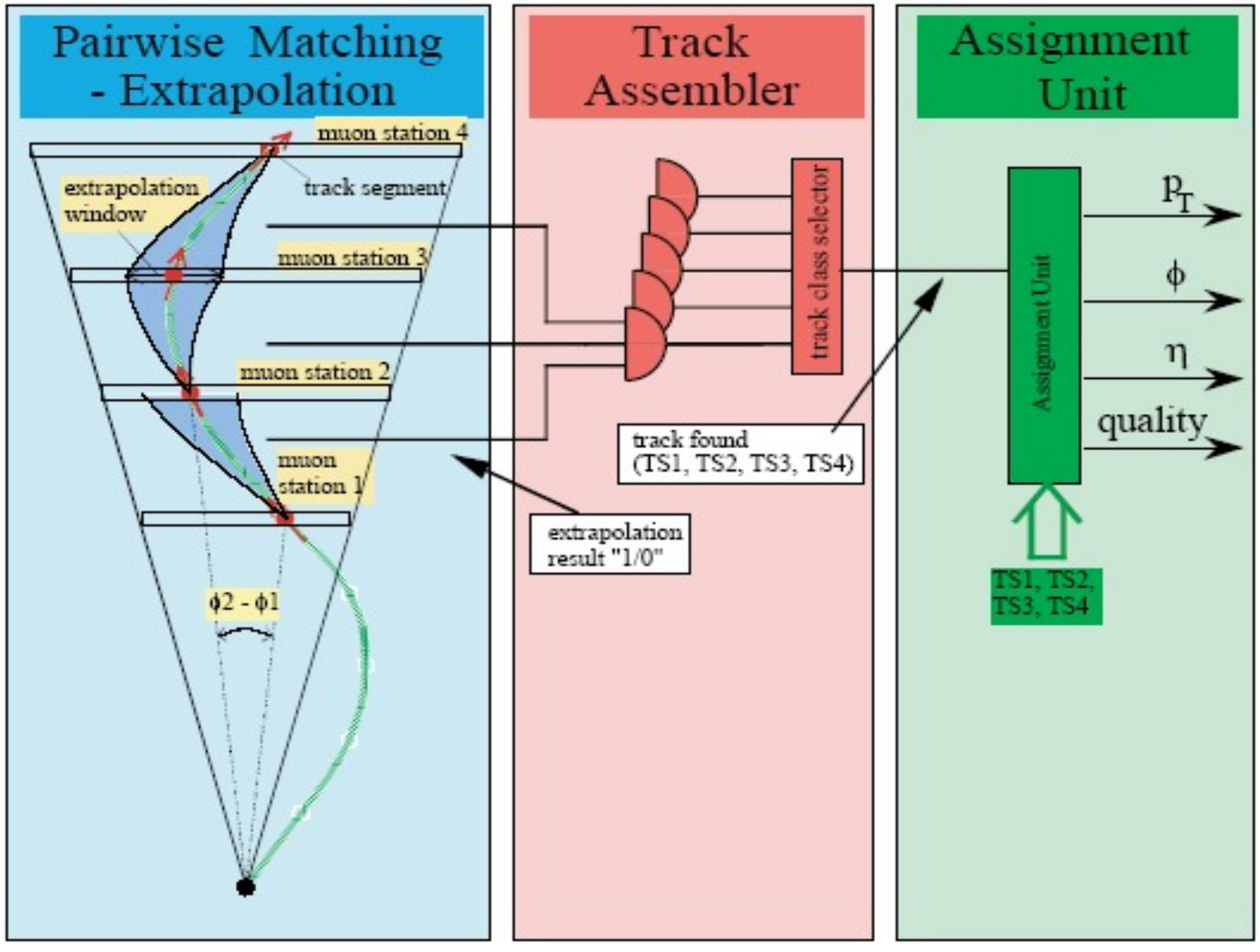
- best possible - load L1 trigger primitives into offline Kalman fit
- testing nonlinear $\Delta\phi$ binning to optimize information content
- determines LUT address space, further correction algorithms

Conclusions

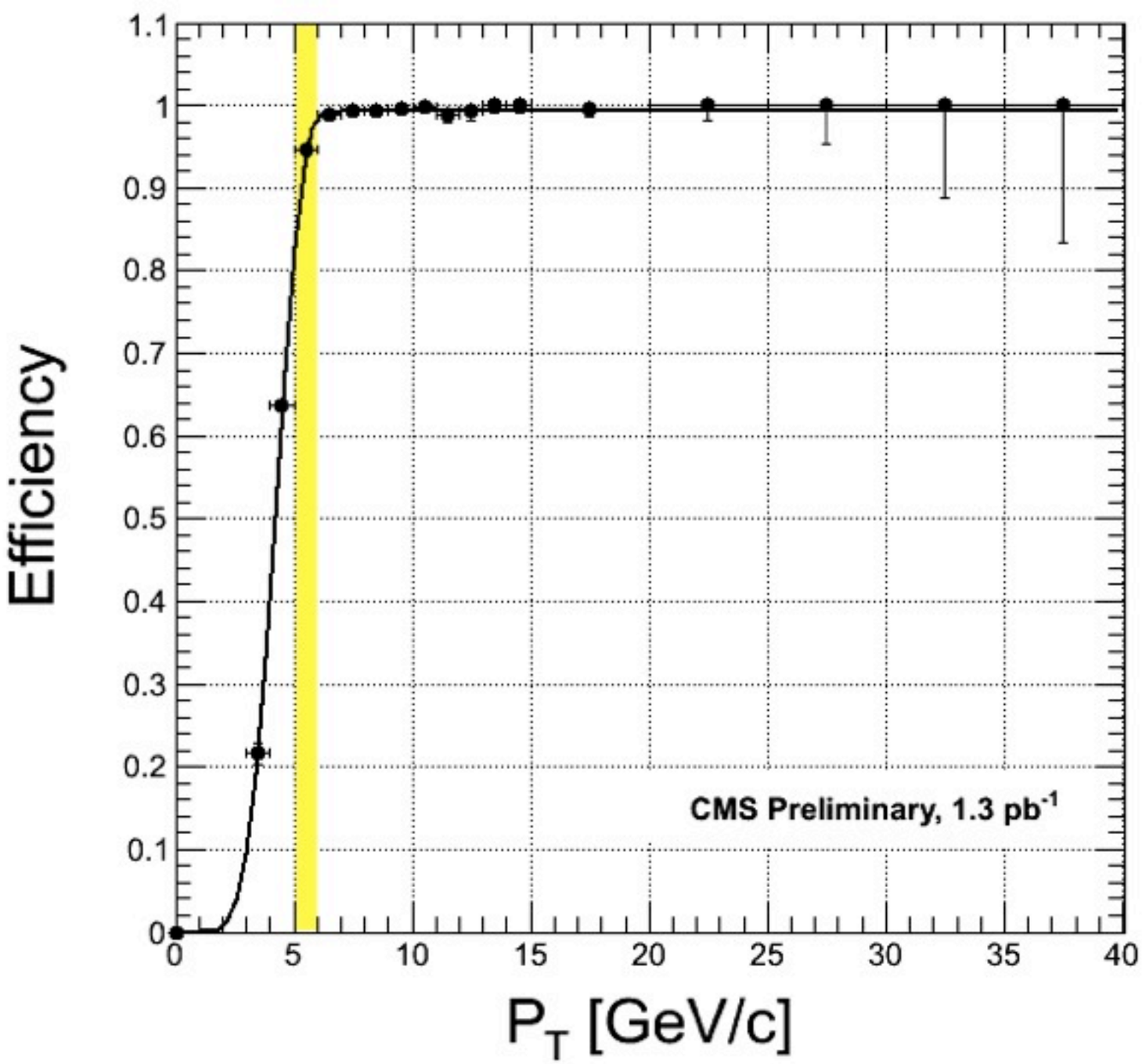
- DT
  - algorithms in great shape, upgrade architecture will take advantage of fast serial links and new FPGAs
  - new design will allow for more flexibility (for the future)
- RPC (+ MPGD)
  - increase coverage: $|\eta| > 1.6$ - possibly use MPGD
  - plan to build more copies of current boards to cover
  - optimizing patterns for high occupancy and high $|\eta|$
- CSC
  - robustness: fully open internal data throughput to SP
  - sector crosstalk - recover inefficiency at boundaries
  - improve p_T assignment: studies in progress
- Phase II: see talk by A. Montanari tomorrow at 9:30 am

Supporting Slides

DT Track Finder Algorithm



DTTF 5 GeV/c P_T Turn-on from J/ψ

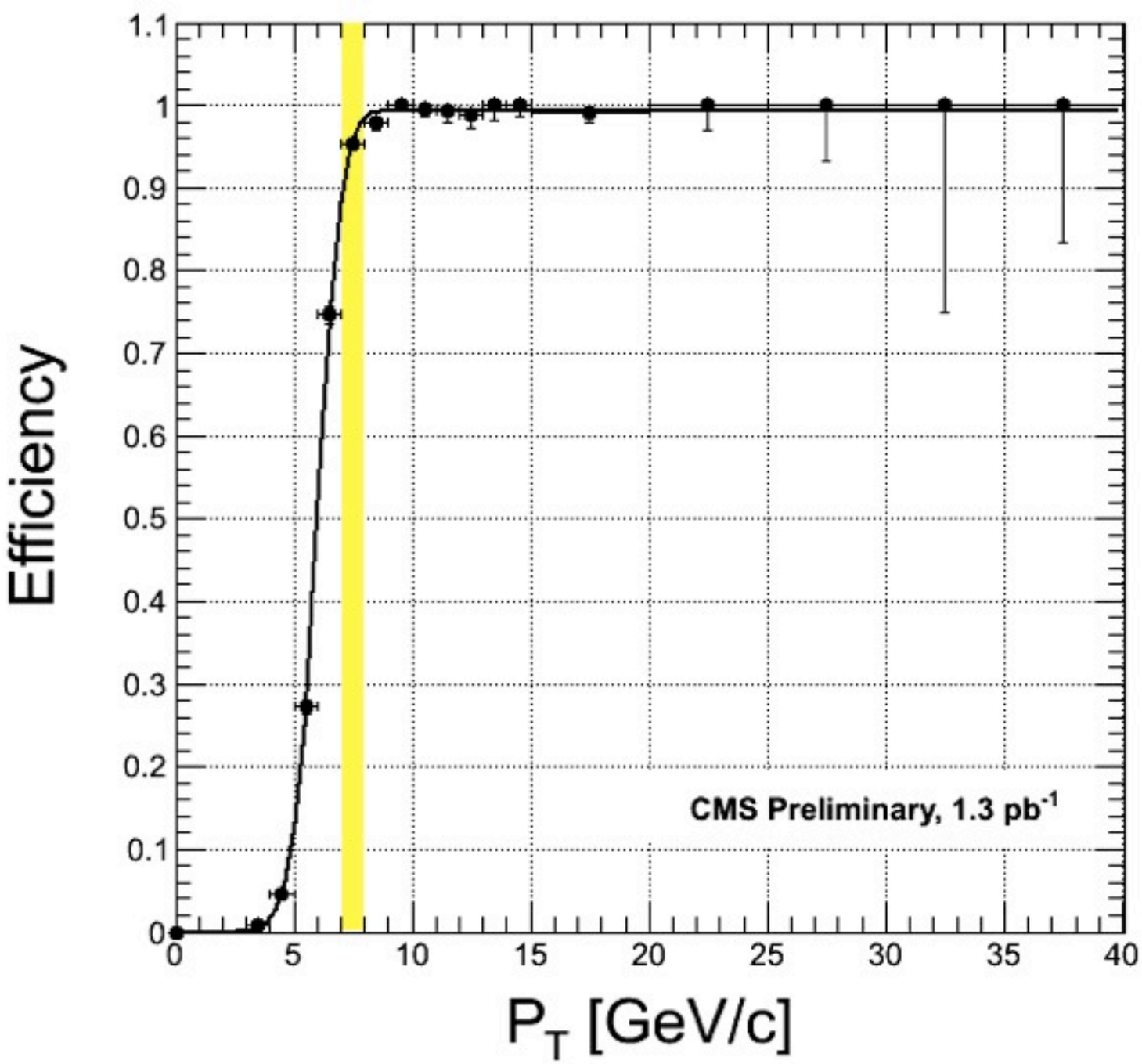


$|\eta| < 1.1$

N.B. In this plot, three known PHTFs, where DT trigger segments at MB2 have bad slope are not considered.

Turn-on expected to reach ≥ 90% efficiency at the nominal cut.

DTTF 7 GeV/c P_T Turn-on from J/ψ

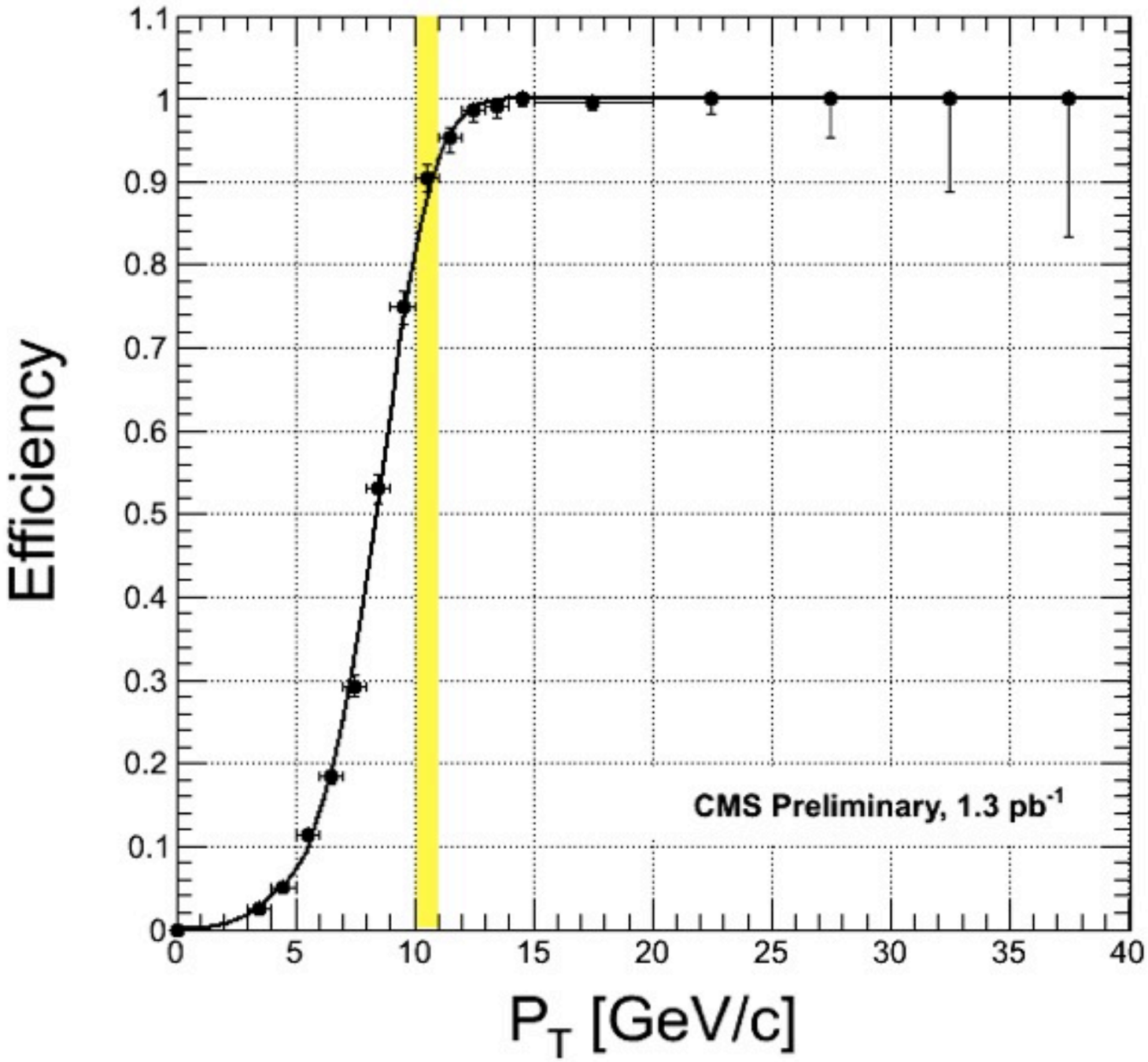


$|\eta| < 1.1$

N.B. In this plot, three known PHTFs, where DT trigger segments at MB2 have bad slope are not considered.

Turn-on expected to reach ≥ 90% efficiency at the nominal cut.

DTTF 10 GeV/c P_T Turn-on from J/ψ

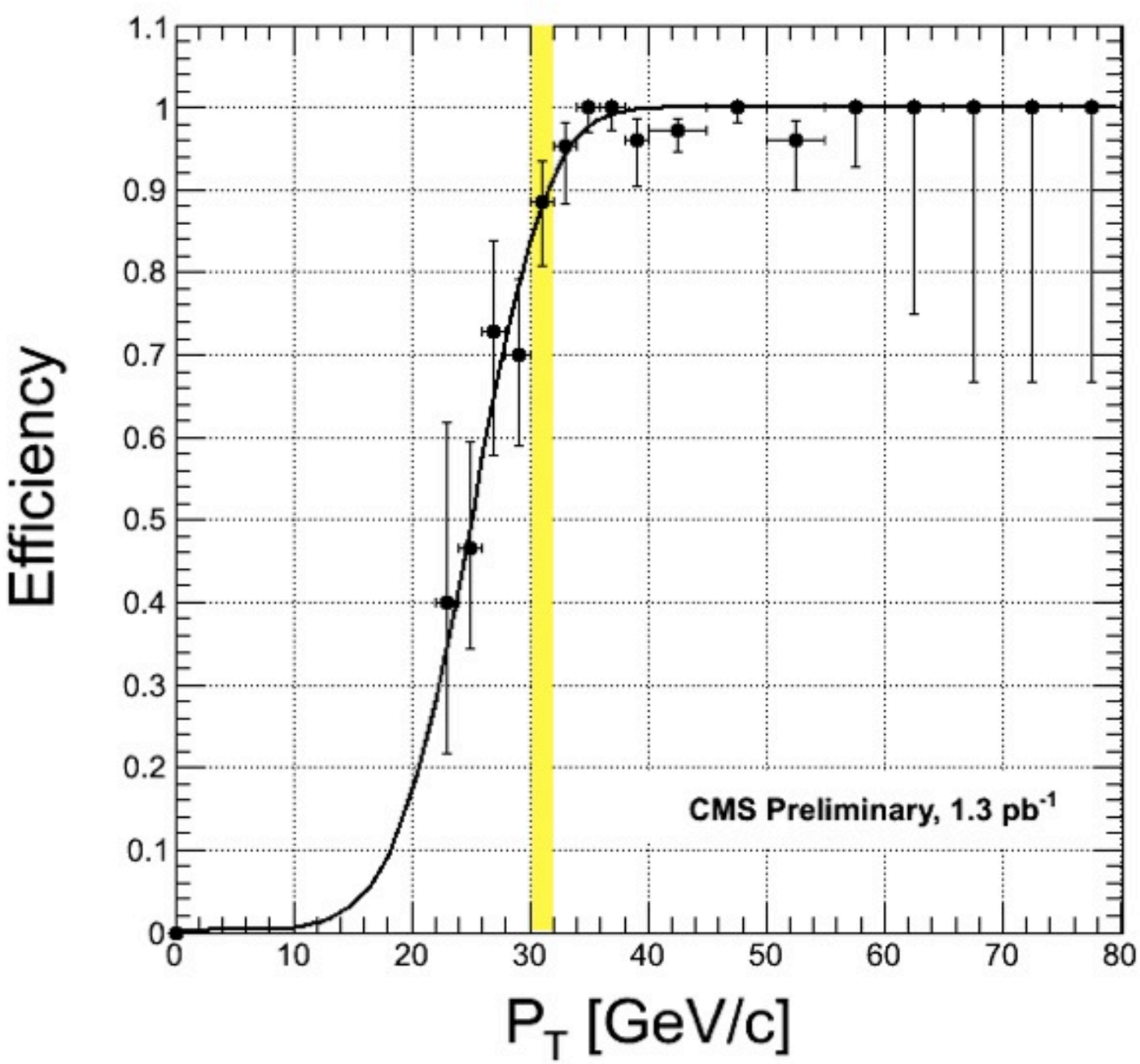


$|\eta| < 1.1$

N.B. In this plot, three known PHTFs, where DT trigger segments at MB2 have bad slope are not considered.

Turn-on expected to reach ≥ 90% efficiency at the nominal cut.

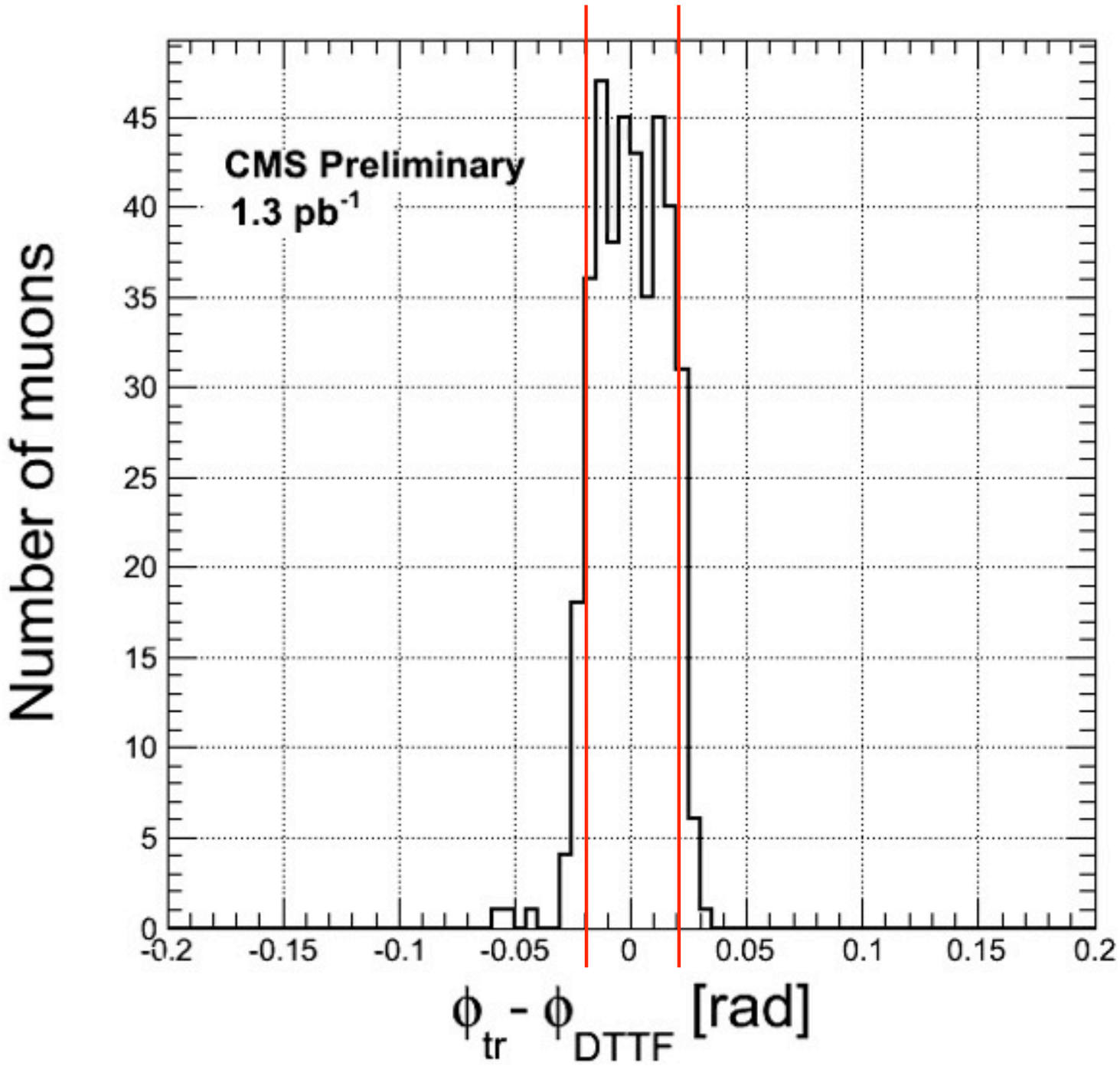
DTTF 30 GeV/c P_T Turn-on from Zs



$|\eta| < 1.1$

Turn-on expected to reach ≥ 90% efficiency at the nominal cut.

DTTF Phi Resolution from Zs

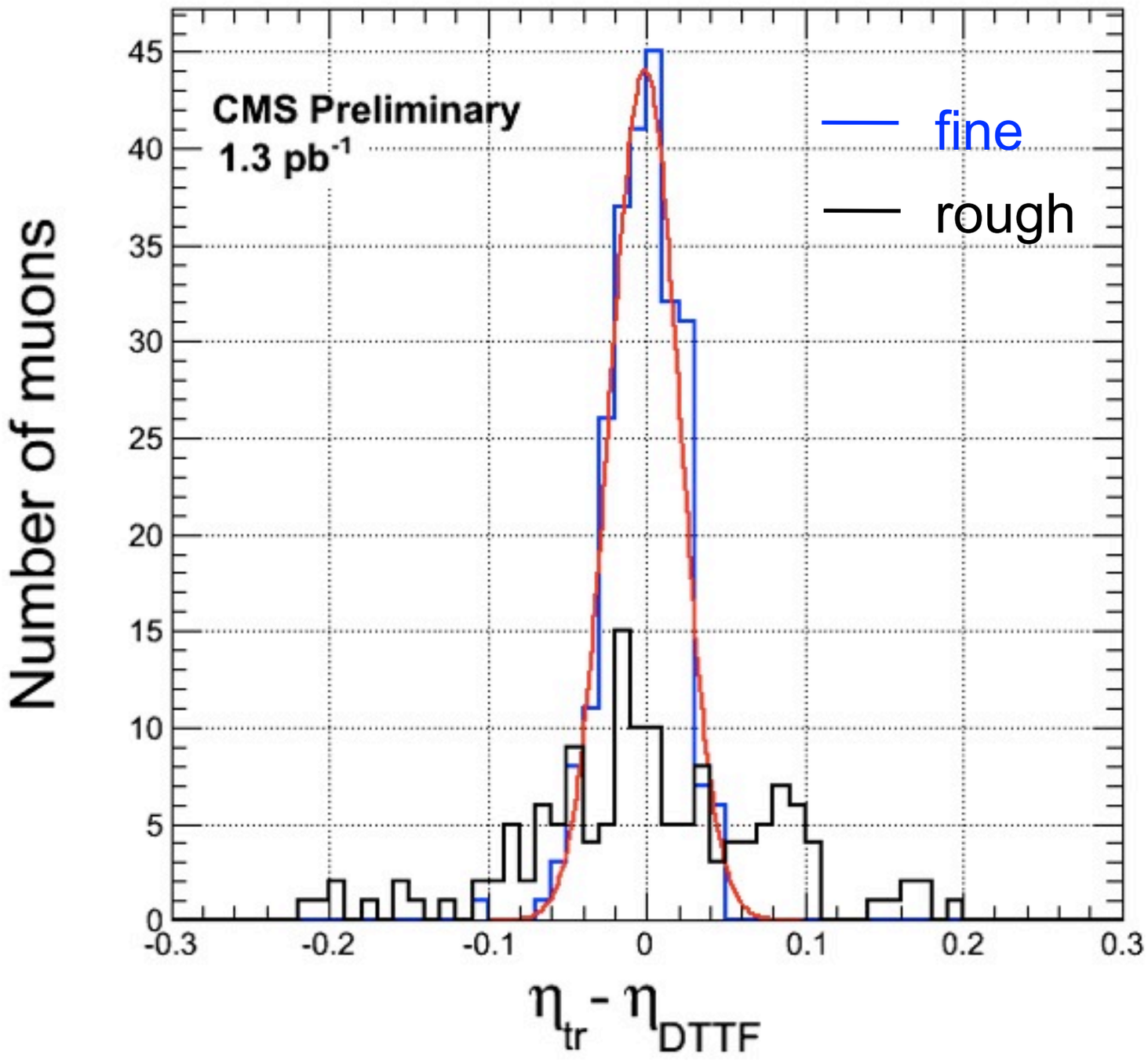


$|\eta| < 1.1$

DTTF ϕ bin size:

0.044 rad

DTTF Eta Resolution from Zs



$|\eta| < 1.1$

Fine η assignment resolution:

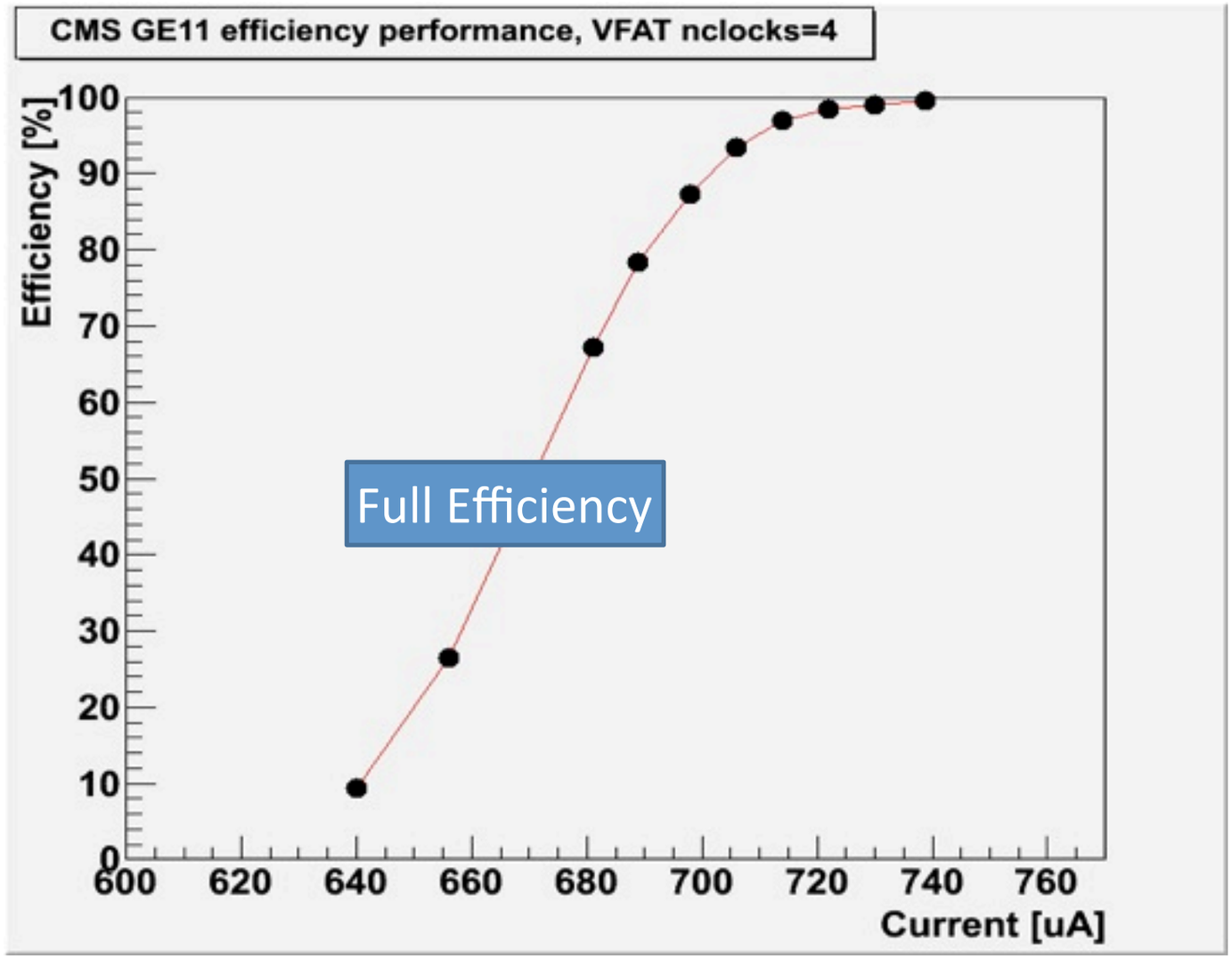
0.021 ± 0.001

Expected:

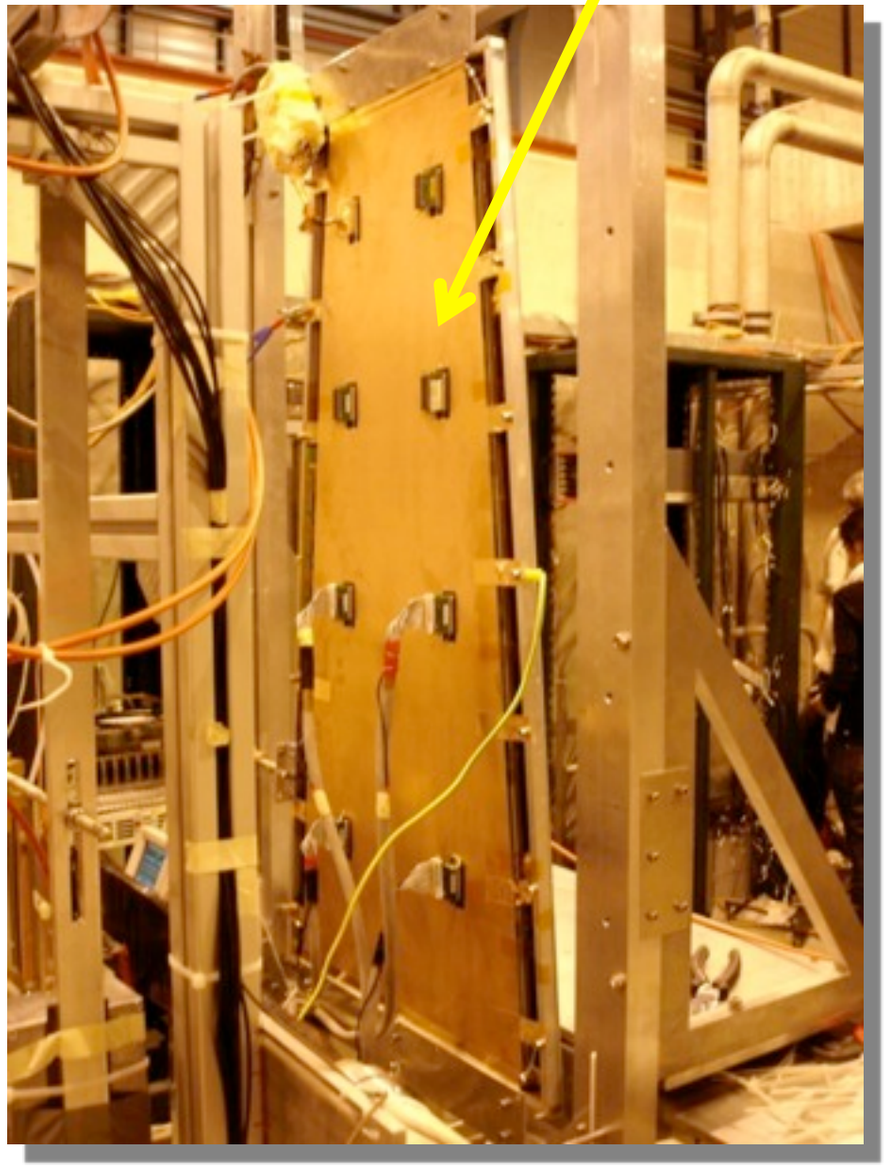
0.025

CMS TS-2008/008

CMS GE1/1 1.6>η>2.1
Investigating: Extension to 2.4
And adding detector in Barrel End-cap crack

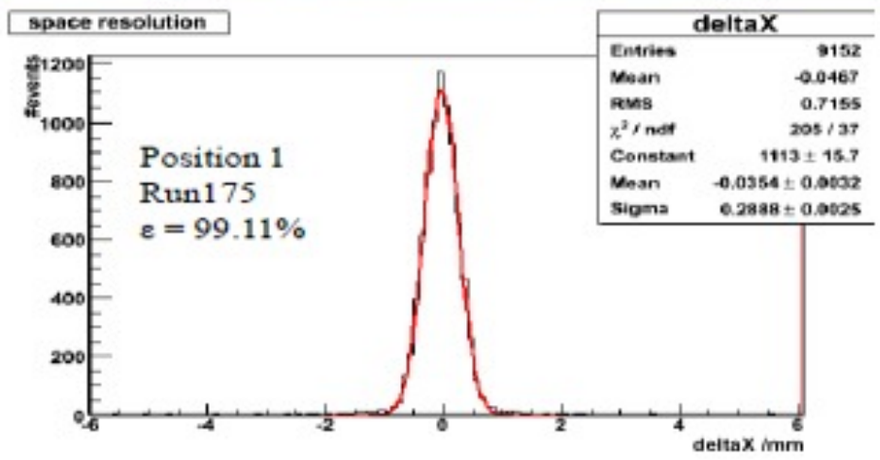


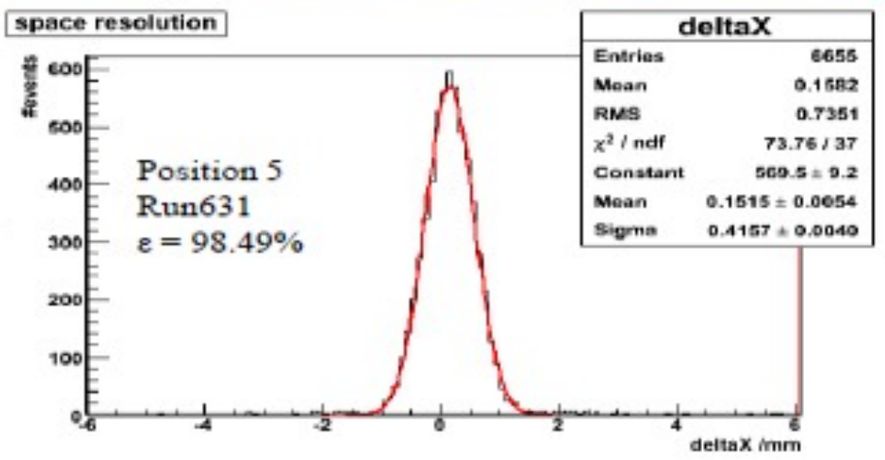
Large Prototype: GE1/1
BeamTest @ RD51 setup
October 2010



Rate capability : $10^4/mm^2$
Space/Time resolution: ~ 100 μm / ~ 4-5 ns
Efficiency > 98% ; Excellent Long Term Operation
Gas Mixture: Argon CO_2 (non flammable mixture)
Large areas ~ 1m x 2m with industrial processes

Excellent Space Resolution: Measured with Large Proto at Beam Oct 2010





Position	1	2	3	5
space resolution (mm)	0.289	0.288	0.316	0.416
average pitch (mm)	1.06	1.05	1.16	1.49
average pitch/sqrt(12)	0.305	0.304	0.335	0.430

$$resolution \approx \frac{pitch}{\sqrt{12}}$$

Simulation Studies Started:

PAC Trigger performance with MPGD – Karol Bunkowski and team

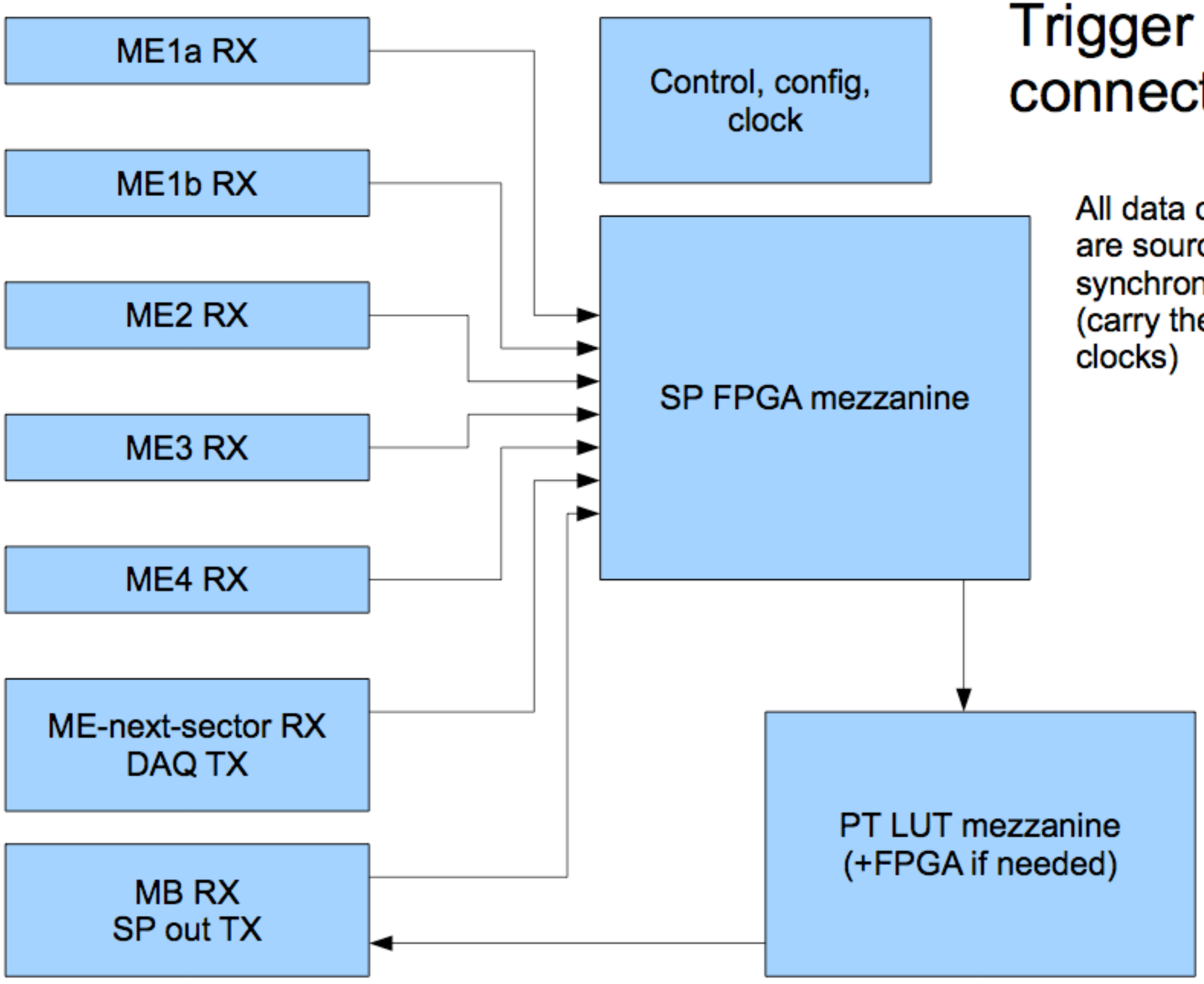
Muon Momentum resolution, geometry and multiple scattering effects at high pT: improvement with MPGD – Marcello Maggi and team

Tracking can be performed due to the excellent space resolution - in combination with CSC and inner detectors – no one is looking at this

CSCTF in VME

- modular construction
- all logic on mezzanines (modules)
- main board:
  - linked connections with plenty of spare connections
    - adjustable DC-DC converters for each module
- configurable DC power sequencers
- provides easy upgrade path - upgrade only the module that needs upgrades, not entire board
- use parallel low latency connections for trigger data
- DAQ and control via serial links between FPGAs

Trigger data connections



All data connections are source-synchronous parallel (carry their own data clocks)

DAQ connections

ME1a RX

ME1b RX

ME2 RX

ME3 RX

ME4 RX

ME-next-sector RX
DAQ TX

MB RX
SP out TX

Control, config, clock

SP FPGA mezzanine

All connections to SP mezzanine are serial 2.4 or 3.2 Gbps

DAQ output connections are 6.4 Gbps

PT LUT mezzanine
(+FPGA if needed)