A proposal
for the MDT trigger scheme

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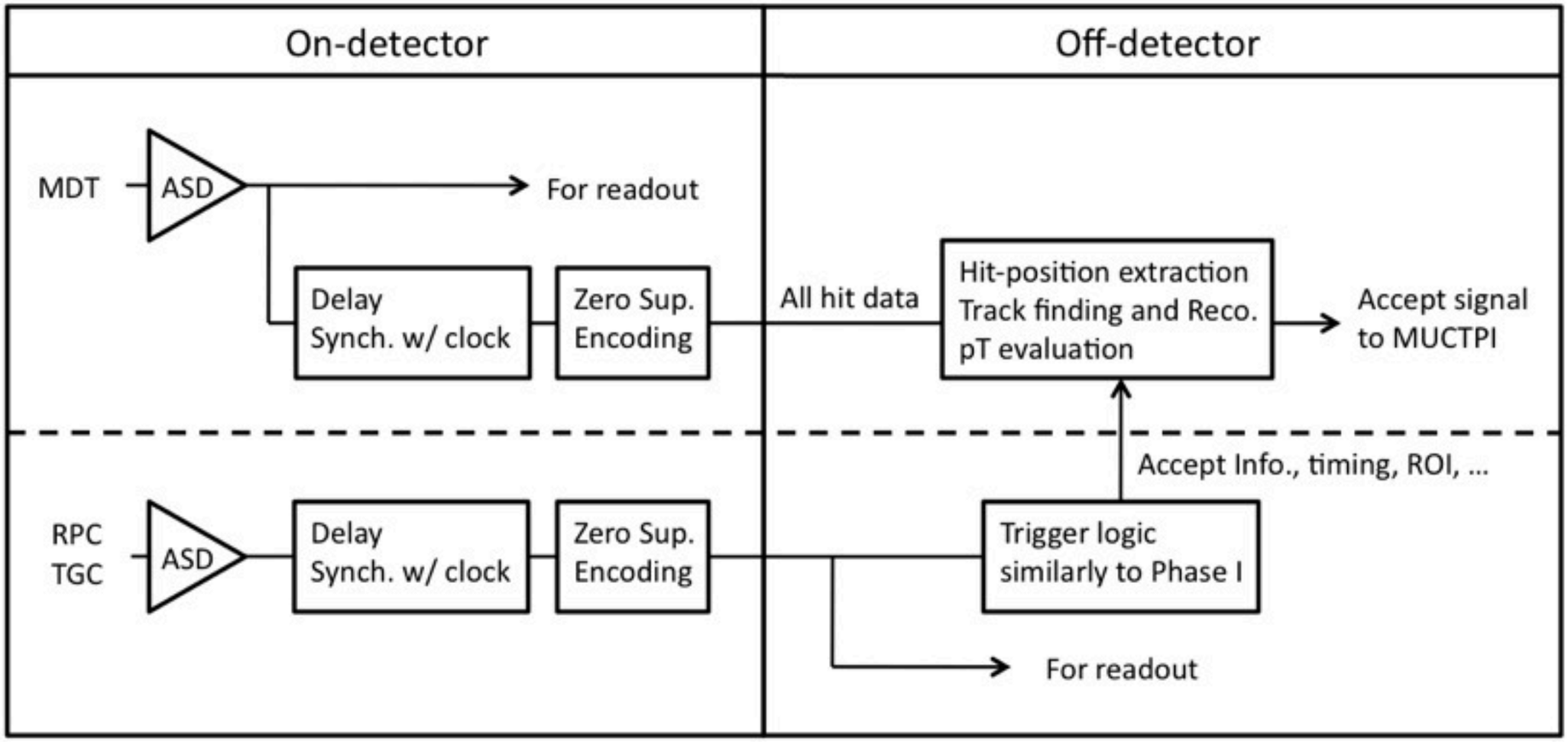
- We want to have a common “baseline” for the MDT trigger scheme.

- In the following, a proposal is described.

1. Introduction

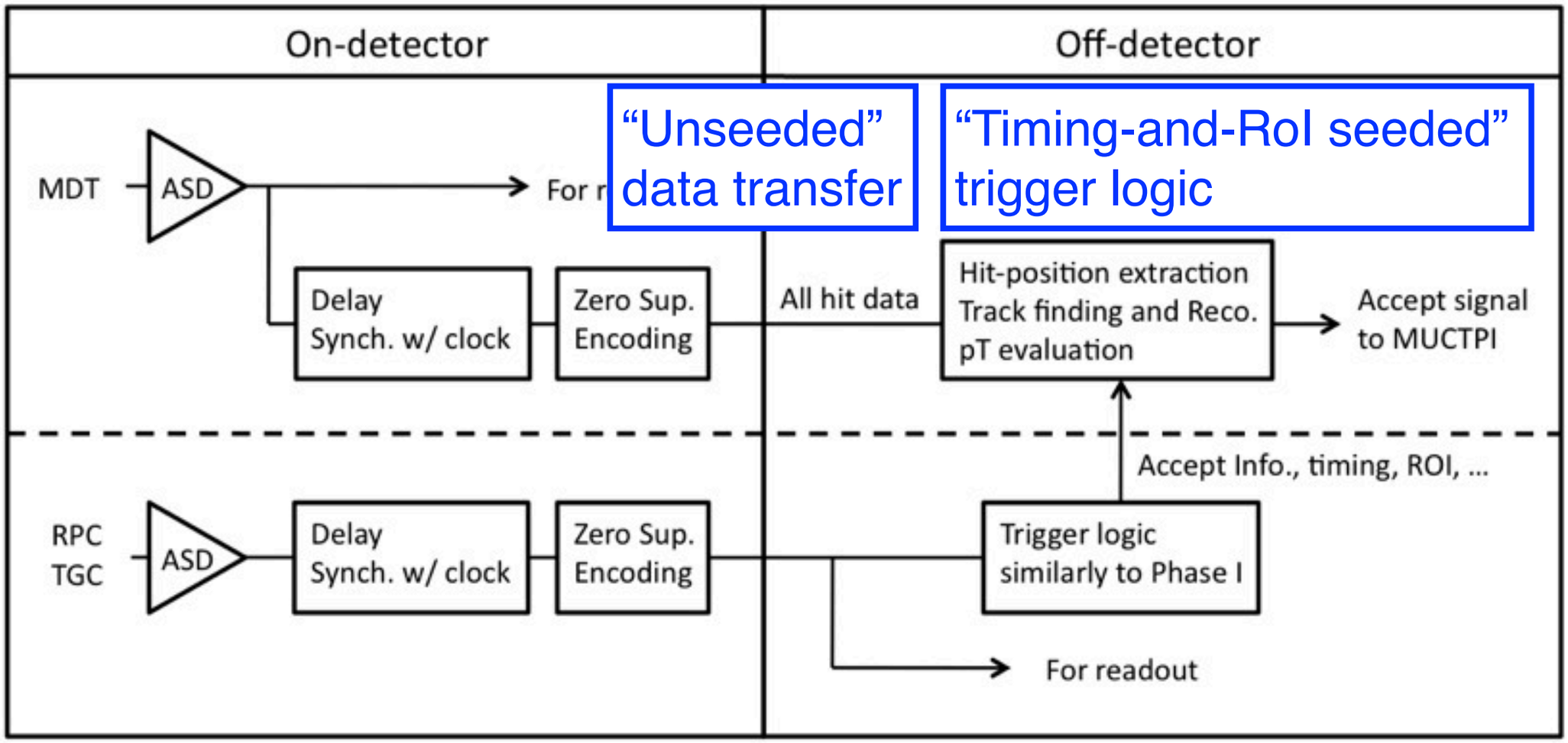
- The Level-1 muon trigger after the Phase-1 upgrade is based on
  - RPCs in the barrel,
  - NSW and BW-TGCs in the endcap.
    Tile calorimeter is also used in $1.05 < |\eta| < 1.30$.
- At the Phase-2 upgrade, it is proposed to include
  - MDTs in the middle and outer stations in the barrel,
  - MDTs in the middle station and MDTs in EIL4/EES in the endcap.

2. Overview of the proposed scheme



- All the MDT hit data are transferred to the off-detector room after synchronized with 40 MHz or further-divided clock.
- MDT hit positions are extracted with constraints on the timing and the ROI from RPCs and TGCs. Track finding and reconstruction follow.

2. Overview of the proposed scheme



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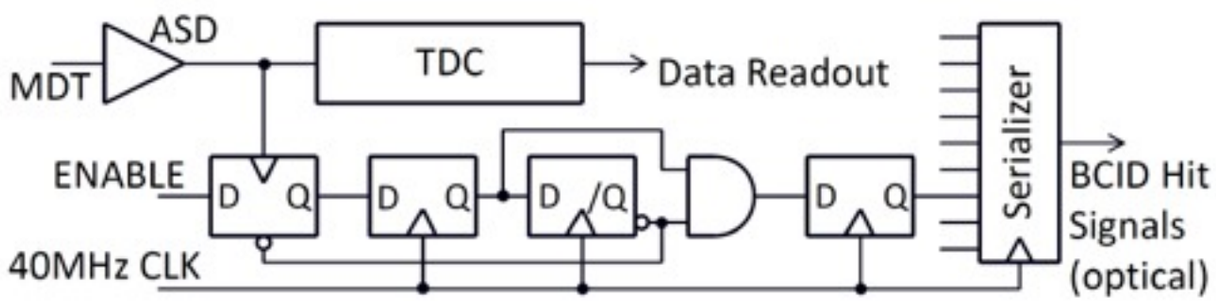
3. MDT data transfer

- MDT signal is divided after ASD.
  The signal for trigger is synchronized with 40 MHz or further-divided clock.



- All the MDT hit data are transferred to the off-detector room.
  - Advantages
    - Main: simplicity of the data flow or robustness against problems.
    - Additional: algorithm flexibility, lower radiation, and smaller latency.
  - Disadvantage
    - More optical links required. ~5k (~3k) links in the barrel (endcap) system assuming 1 link/mezzanine. It may be reduced by merging signals.

Number of mezzanine boards

Chamber type	Number of mezzanines
BMS/BMF	1024 (or less)
BML	1112
BOS/BOF	1484
BOL/BOG	1696
Barrel total	5316 (or less)

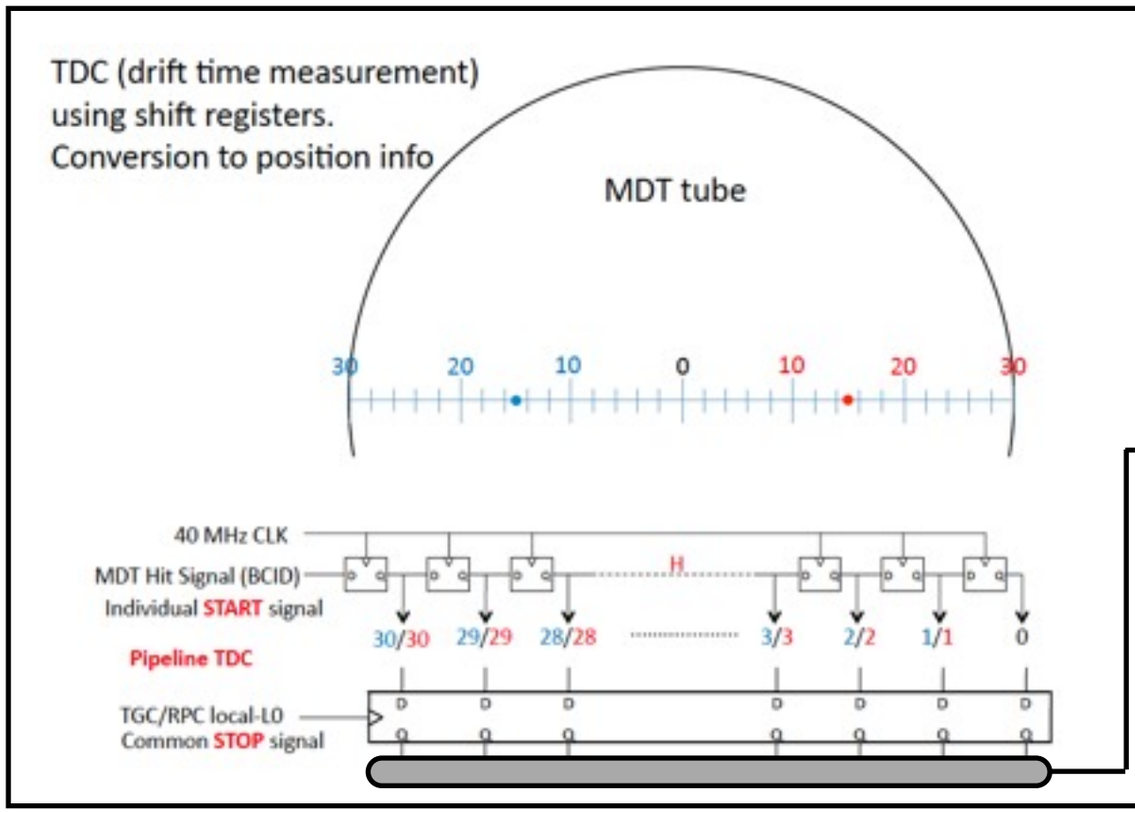
Chamber type	Number of mezzanines
EIL4	256
EES	352
BMS	1280
BML	1248
Endcap total	3136

The values are based on Joerg Wotschack, "MDT Parameter Book Draft 03" (2007).

- Assuming one optical link per mezzanine board (24 channels), a link needs a speed of 1.6 Gbps for 40 MHz with 8b/10b encoding.
- It is lower than the limit of current link technology.
- The signals from multiple mezzanine boards can be merged in terms of link speed.
  - No merging: 5.3k (3.1k) in barrel (endcap).
  - Merging by two: 2.7k (1.6k) in barrel (endcap).
  - Merging by three: 1.8k (1.1k) in barrel (endcap).

4. Trigger signal processing

- Transferred MDT hit signal is input into FPGA.
  - A shift register works as a pipeline TDC.
    The stop signal can be 40 MHz clock or timing from RPC/TGC.
  - Selection of hit positions done with (timing and) ROI from RPC/TGC.
  - Track finding and reconstruction follow. Method to be determined.



in FPGA of MDT sector logic

- MDT hit selection based on information from RPC/TGC.
- Track finding and reconstruction. (Method to be determined.)

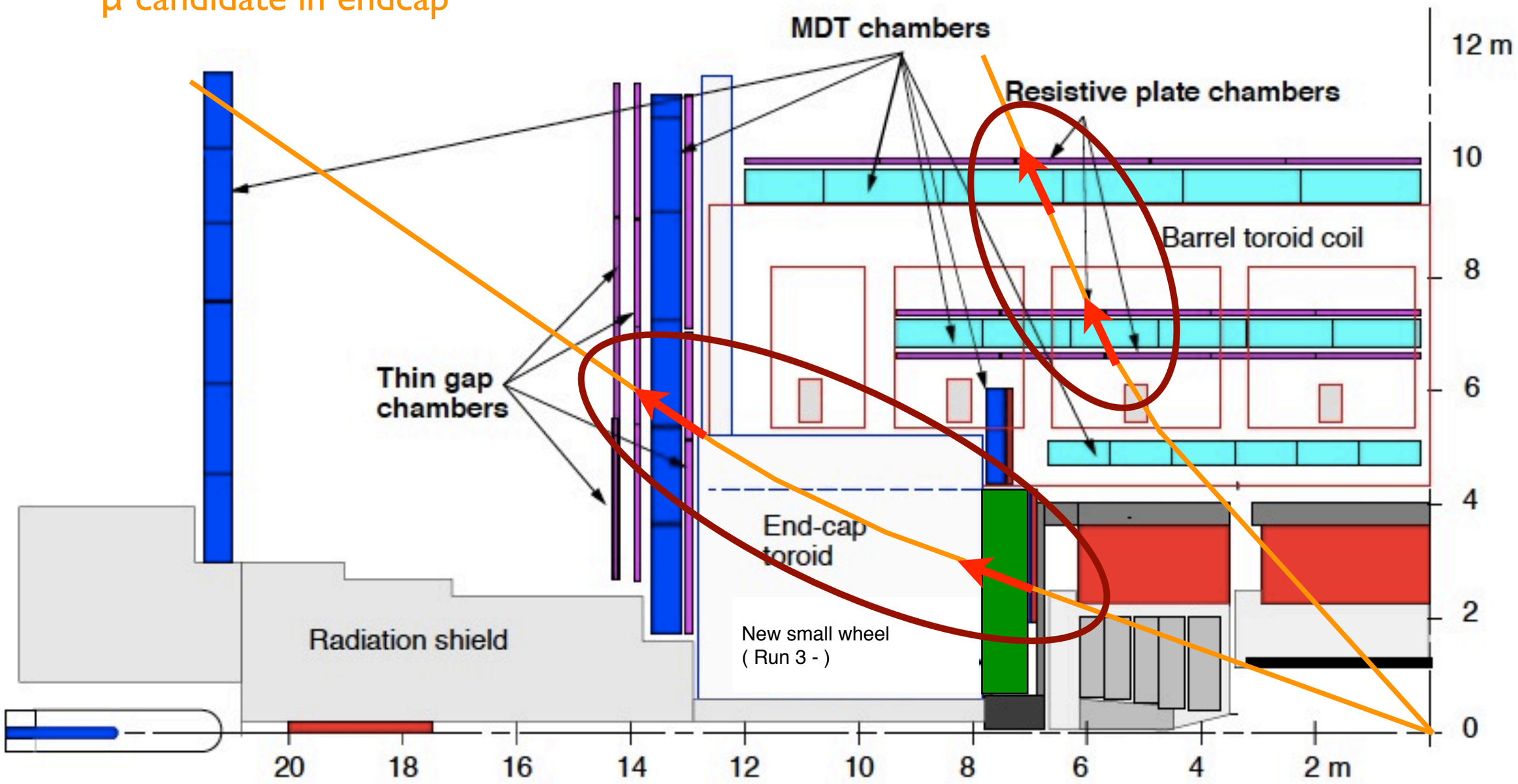
5. Conclusion

- A proposal for the MDT trigger scheme is shown.
- It includes
  - transfer of all MDT signal to the off-detector room
  - and a hit-position extraction using timing and RoI from trigger chambers in the logic off-detector.
- Algorithm for track finding and reconstruction is to be determined after further studies.

Backup Slides

μ candidate in endcap

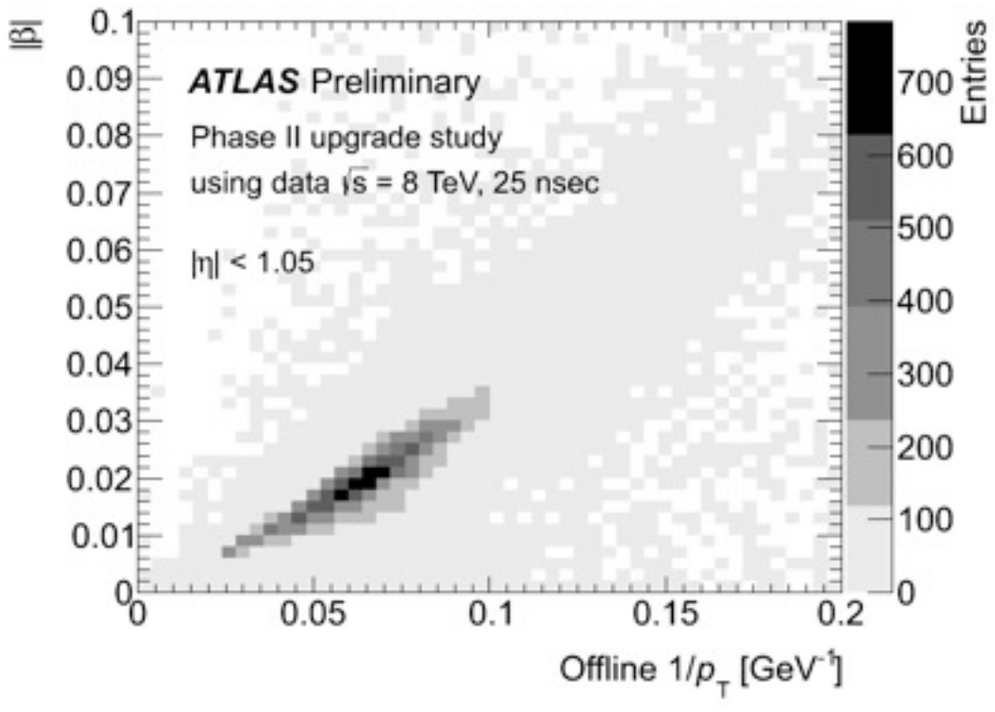
μ candidate in barrel



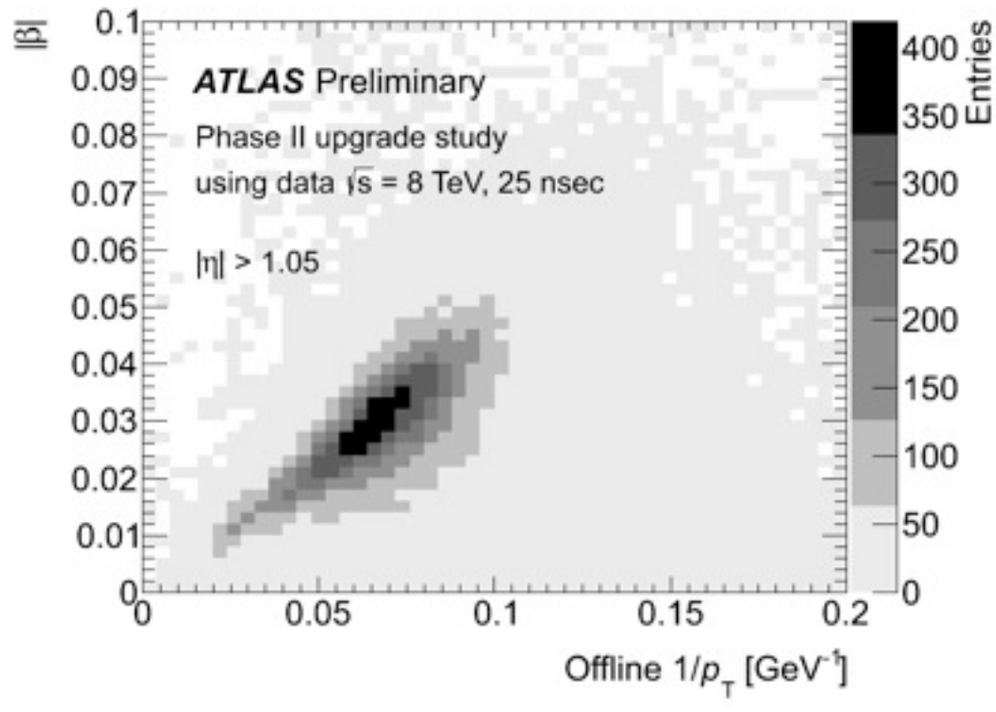
Employ the polar angle difference β between two segments.
Barrel: outer and middle stations.
Endcap: middle and inner stations and some extra chambers.

Relation between |β| and offline $1/p_T$

Barrel (|η|<1.05)

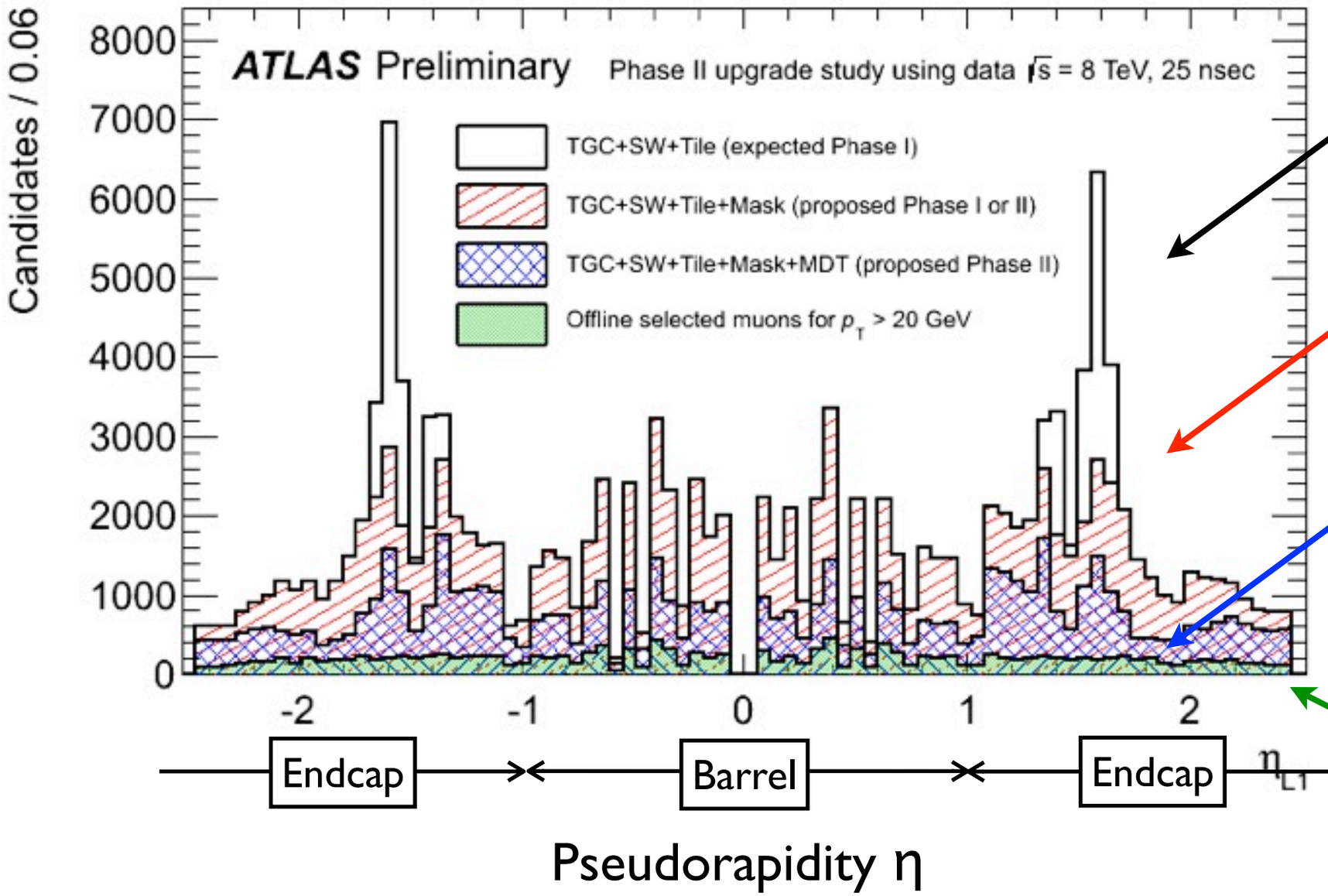


Endcap (|η|>1.05)



- The distributions are obtained for Level-1 muon candidates in 2012 data (8 TeV, 25 nsec) taken with neither high-level trigger nor event filter.
- A strong correlation between |β| and offline $1/p_T$ indicates a good discrimination of p_T using |β|.

η distributions for Level-1 muon candidates



After the requirements expected to be included before HL-LHC excluding ROI mask

After the requirements expected to be included before HL-LHC

After the MDT-based requirements (HL-LHC)

Offline p_T > 20 GeV

- By introducing an MDT-based requirement, the Level-1 muon candidates are reduced by a factor of about 50%.

Number of mezzanine boards; reason for “or less”

Table 7: Characteristics of BMS and BMF chambers. The numbers in brackets refer to the BMS4 and BMS6 chambers in which the last group of 3×8 tubes in multilayer 1 is missing.

Construction site	JINR Dubna (Russia)				
Type	BMS960	BMS/F1440	BMS1680	BMS/F1920	BMS/F2160
Number of chambers	12	52 (?)	12	4	4
Distance from beam axis (mm)	8095	8095	8095	8095	8095
Chamber length in z (mm)	976.1	1456.7	1696.9	1937.2	2177.5
Tube length (mm)	3071.5	3071.5	3071.5	3071.5	3071.5
Tube layers	2×3	2×3	2×3	2×3	2×3
Tubes/layer	32	48 (40)	56	64	72
Spacer height (mm)	170	170	170	170	170
Chamber height (mm)	364	364	364	364	364
Chamber weight (kg)	140	190	215	240	260
Gas volume/chamber (l)	395	592 (543)	691	790	889
Mezzanine boards/chamber	8	12 (11)	14	16	18
T-sensors/chamber	10	10	10	10	10
B-field sensors/chamber	2	2	2	2	2