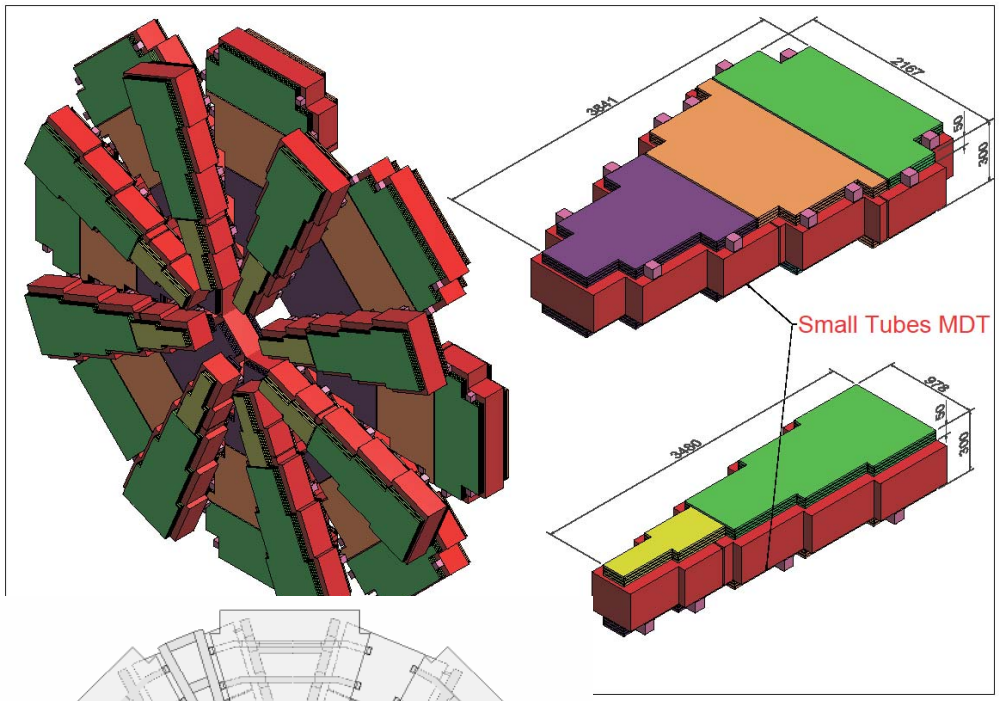
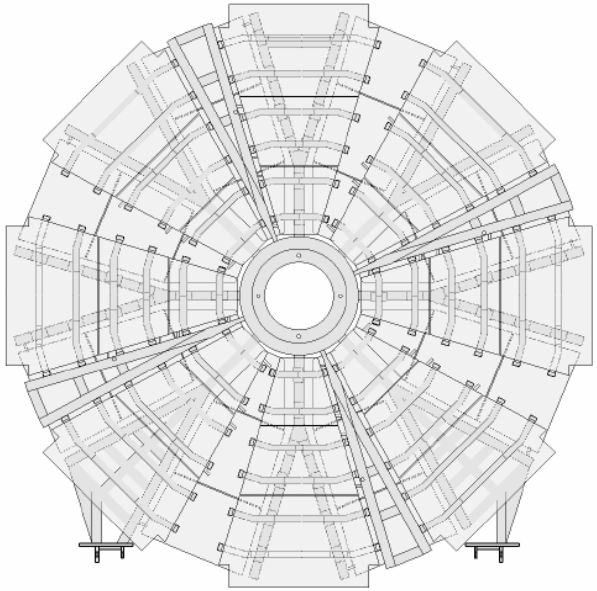
Drift-Tube Chambers for Phase I Small Wheel Upgrade

Hubert Kroha
MPI Munich

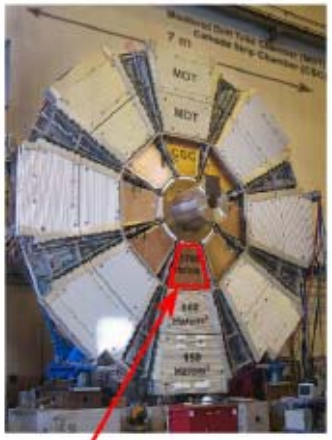
Chamber Design for Small Wheels

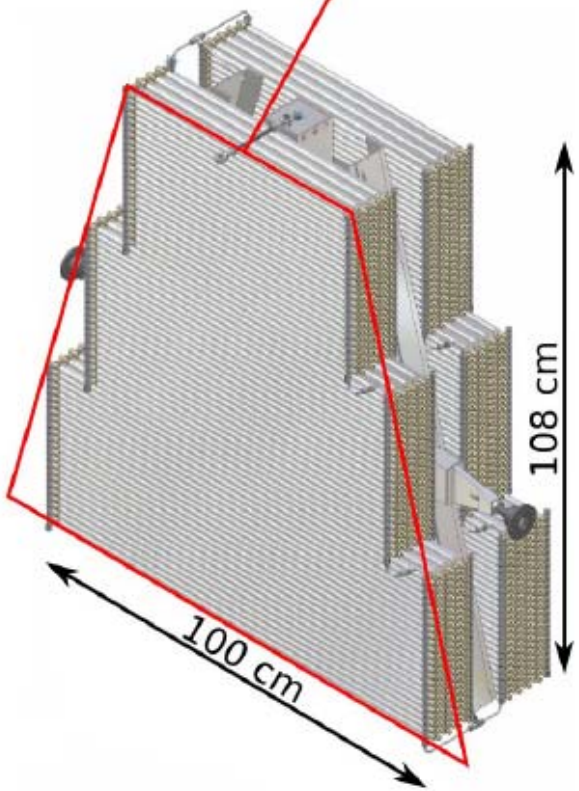




- Combination of Small-Drift Tube (sMDT) Chambers (15 mm tube ∅) with fast trigger chambers (TGCs, RPCs, Micromegas) providing second-coordinate information.
- Chamber design easily matched to the present endcap small-large chamber layout and to the ex. alignment lines.
- Precision mounting of the alignment sensors on the sMDT chambers during chamber construction part of the design from the beginning (realized already for the elevator chambers).
- Efficient, robust and well understood solution for SW tracking and trigger upgrade.

sMDT Chamber Design for Small Wheels





sMDT chambers with 15 mm ∅ drift tubes:

2 x 6 tube layers in CSC region (w. 140 mm spacer),

2 x 4 tube layers in rest of SW (w. 192 mm spacer)

< 50 μm spatial and 0.3 mrad angular resolution in bending direction,
> 99% tracking efficiency at < 15% occupancy

for maximum background rates at 5 x LHC design luminosity of 9 kHz/cm^2

96 chambers, 6 types EIL 0,1,2, EIS 0,1,2.

70000 tubes of 0.55 – 2.50 m length.

Electronics and services requirements well understood.

ASD, mezz. card, CSM upgrade development in progress.

Readout Channels and Power Consumption

Channel numbers for one Small Wheel

Chamber	# Tubes	# 32-ch. mezz. / # CSM	# 24 ch. mezz. / # CSM	Current / A (32-ch. / 24-ch mezz.)	Power / W (3.5 V / 5 V supply)
EIL0	72 × 6 × 2	28 / 2	36 / 2	16 / 16	56 / 80
EIL1	72 × 4 × 2	18 / 1	24 / 2	10 / 11	35 / 55
EIL2	96 × 4 × 2	24 / 2	32 / 2	14 / 14	49 / 70
EIS0	72 × 6 × 2	28 / 2	36 / 2	16 / 16	56 / 80
EIS1	88 × 4 × 2	22 / 2	30 / 2	14 / 14	49 / 70
EIS2	72 × 4 × 2	18 / 1	24 / 2	10 / 11	35 / 55
Total	**34816**	**1104 / 80**	**1456 / 96**	—	**2240 / 3280**

96 MRODs

- Same current / power consumption per channel as present mezzanines / CSM assumed
- Power consumption of possible phase-2 trigger logic on mezzanines not taken into account

Worst case: power consumption factor 3.5 higher than present SW

Power Supplies

Numbers for one Small Wheel

Power Supply Boards per Detector Side

LV boards

Chamber	PS Channel	Current / A
EIL0 + EIL1	2	14
EIL2	1	14
EIS0 + EIS2	2	13
EIS1	1	14
Total per side	**48**	max. **16** / channel

8 CAEN A3016 boards (6 ch. each)

HV boards

Chamber	PS Channel / ML	Exp. Current per ML / mA (at 5×10^{34} cm^{-2} s^{-1})
EIL0 / EIS0	4	3.4
EIL1 / EIS1	1	0.7
EIL2 / EIS2	1	0.6
Total per side	192	max. 1 / channel

16 CAEN A3540 boards (12 ch. each)

Services

Numbers for one Small Wheel

Cables and Gas Pipes per Detector Side

Routing via patch panel in sector 13 BI level

LV cable: min. 40 — max. 48

CAN bus cable: 8

Routing in flexible chains

TTC Fiber: min. 40 / 48 (on-chamber splitter) — max. 80 / 96

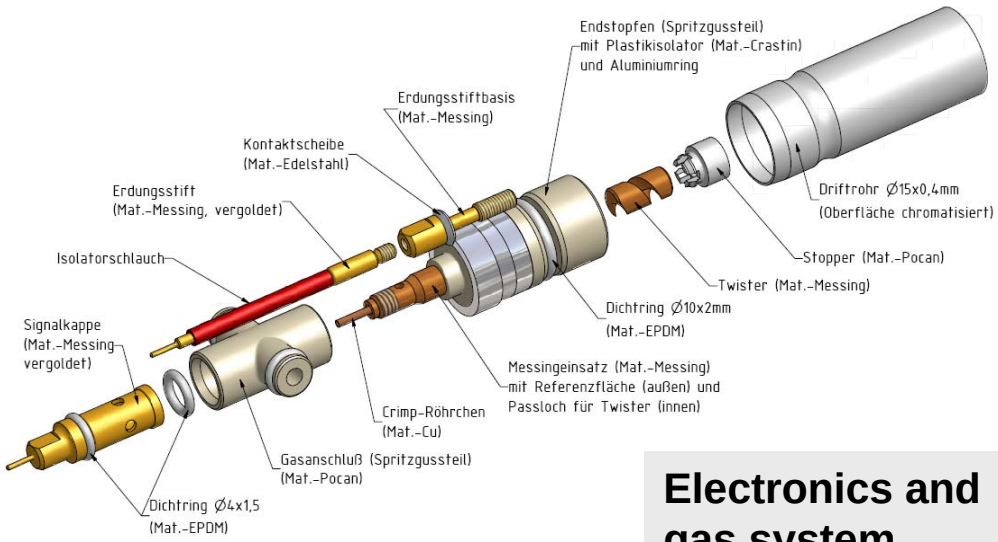
RO Fiber: min. 80 — max. 96

HV cable: 192

Alignment cable: ?

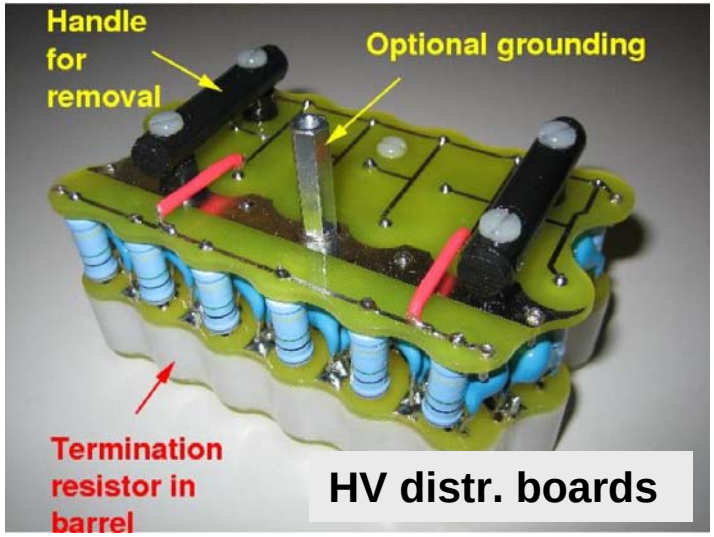
Gas pipes: 16 input and 16 output lines (1 channel per ML per 2 sectors, same as present SW)

Drift Tubes, Gas Distribution, Readout Board Design

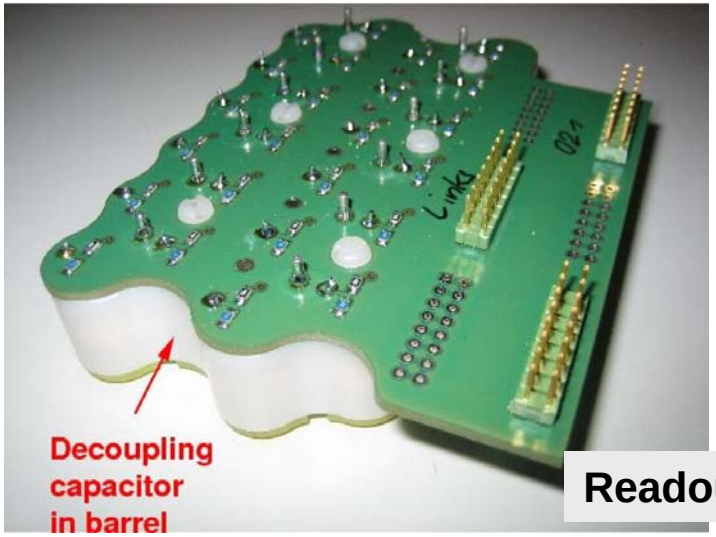


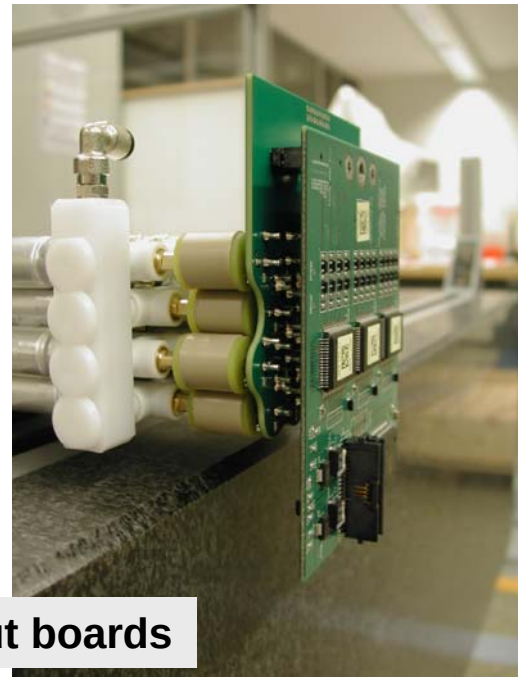
Electronics and gas system interfaces

Gas distribution system



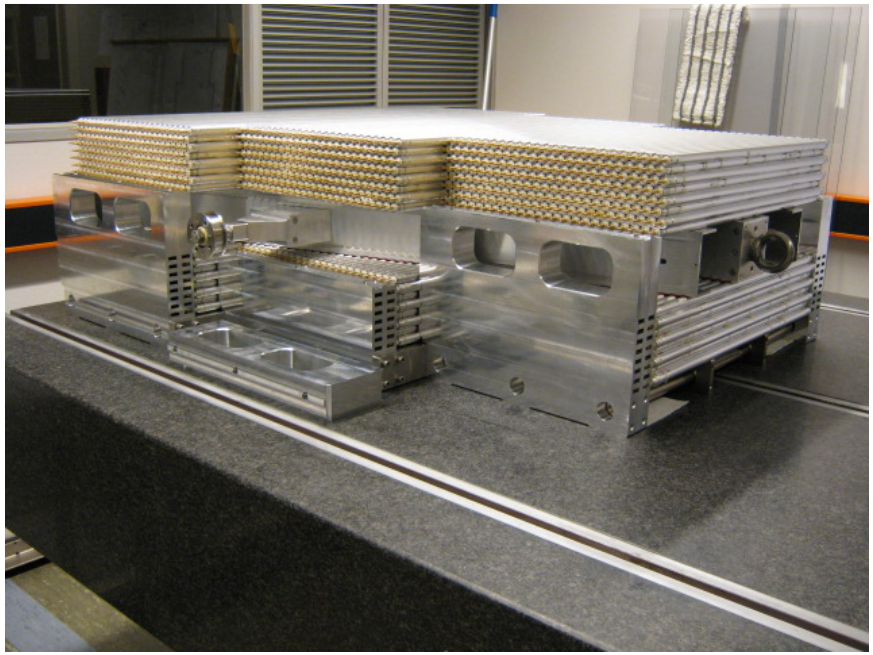
HV distr. boards





Readout boards

Chamber Design and Construction

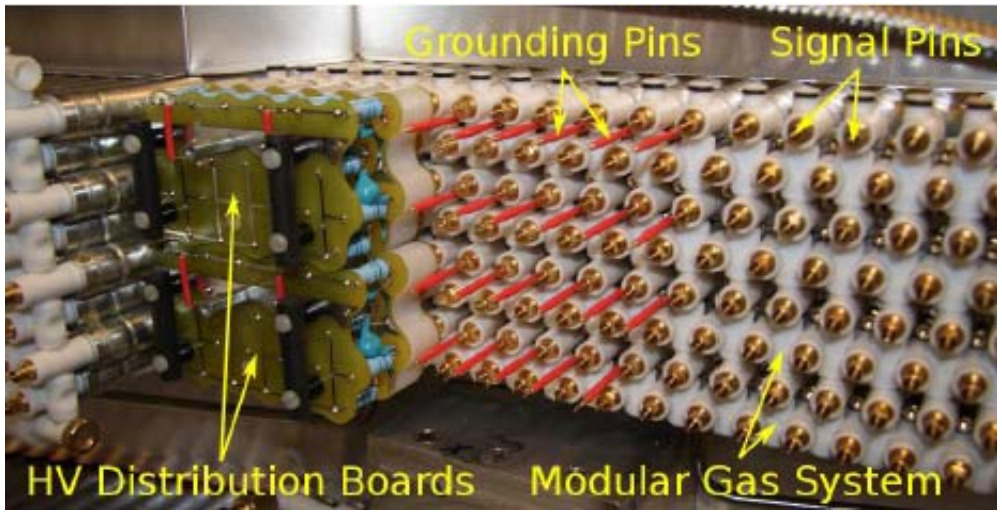


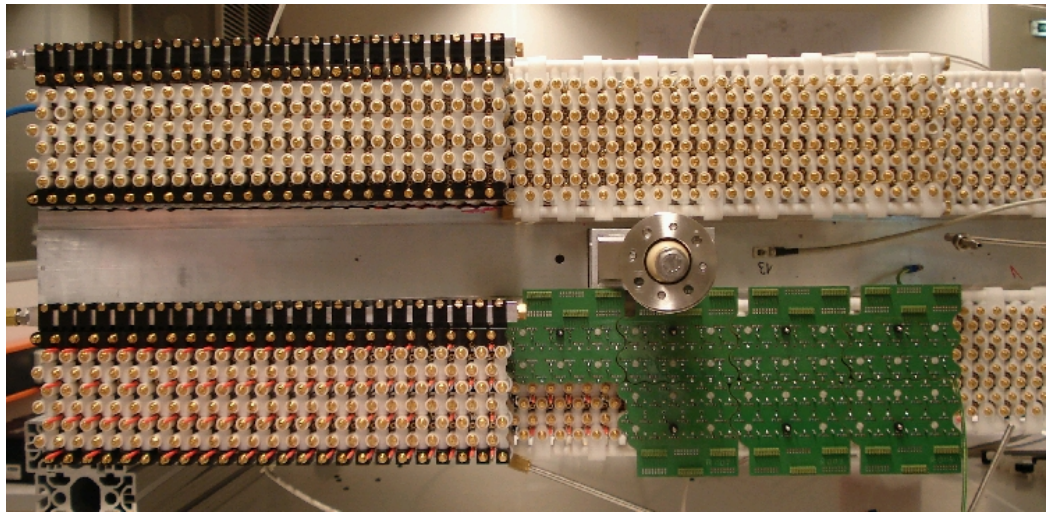
Basic sMDT chamber design ready.

Mechanical and electronics integration with trigger chambers in progress.

Full-scale prototype chamber constructed and tested in summer 2010.

Construction of sMDT chambers of same type for elevator regions.

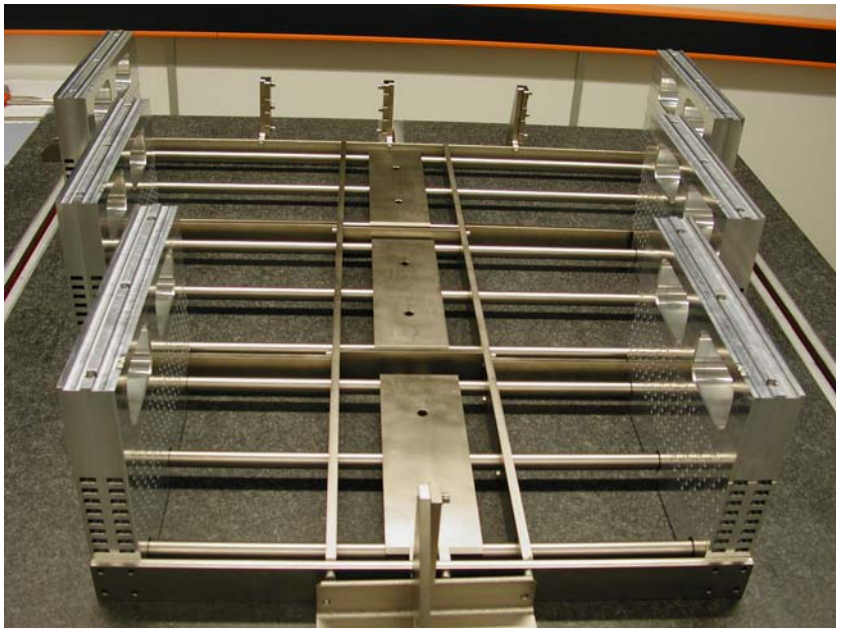




Chamber Assembly Facilities

Automated drift- tube assembly facility

Chamber assembly tooling

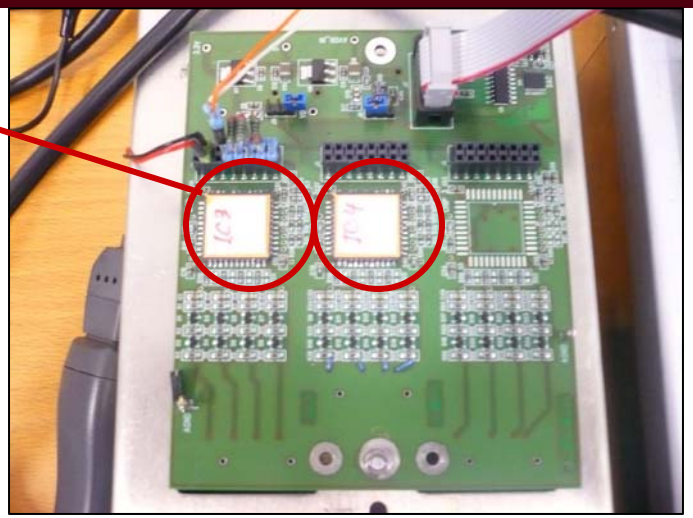


Assembly of a whole multilayer in one day

Assembly clean rooms

Development of new rad. hard MDT readout and trigger electronics

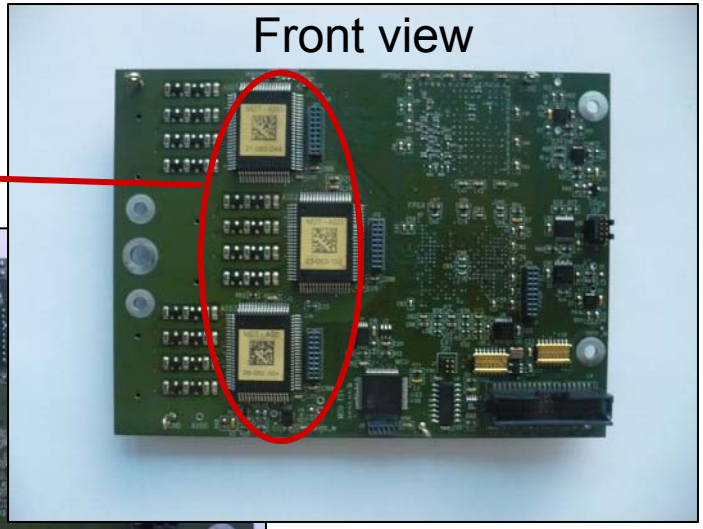
Prototypes of new radiation hard ASD chips in IBM 130 nm CMOS technology (for old and new MDT chambers) showed excellent performance before and after neutron irradiation.
Full prototype chip delivery in July.

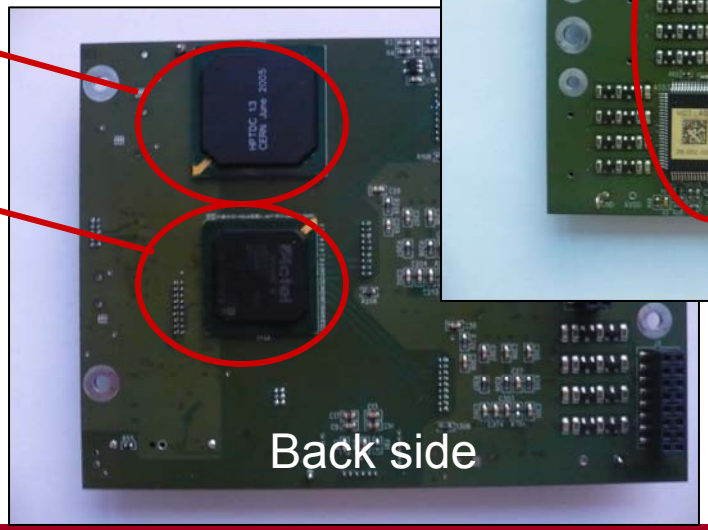


for 30 mm ∅ and
for 15 mm ∅
drift-tube chambers

Prototype of new mezzanine cards (24-channel) containing

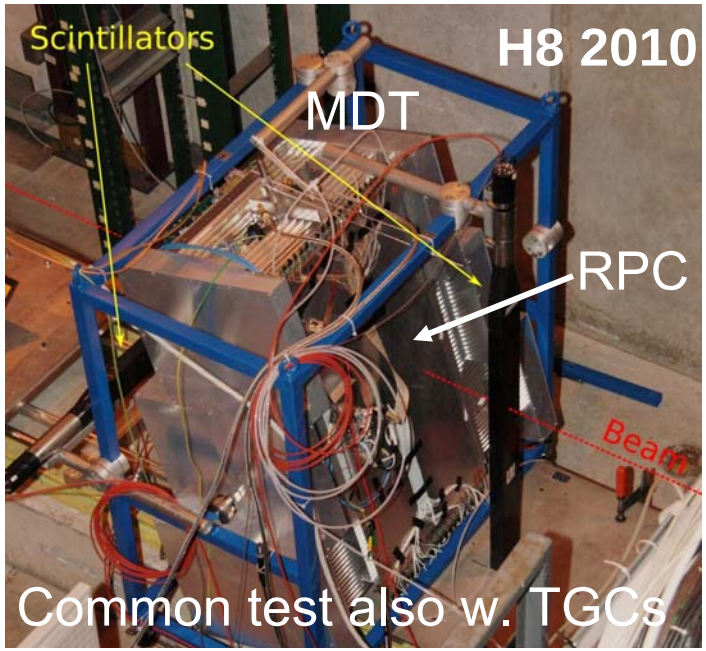
- new ASD chips
- new rad. hard TDC (CERN) with higher bandwidth
- rad. hard FPGA chip with L1 trigger functionality.

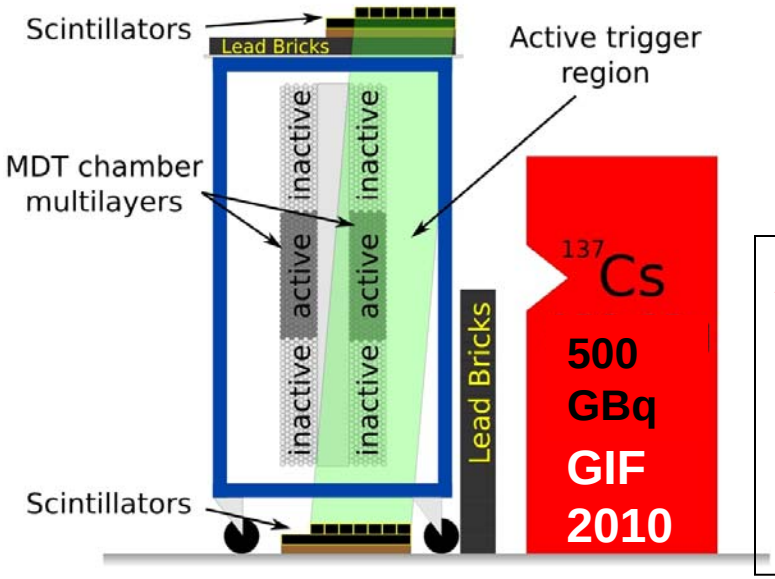




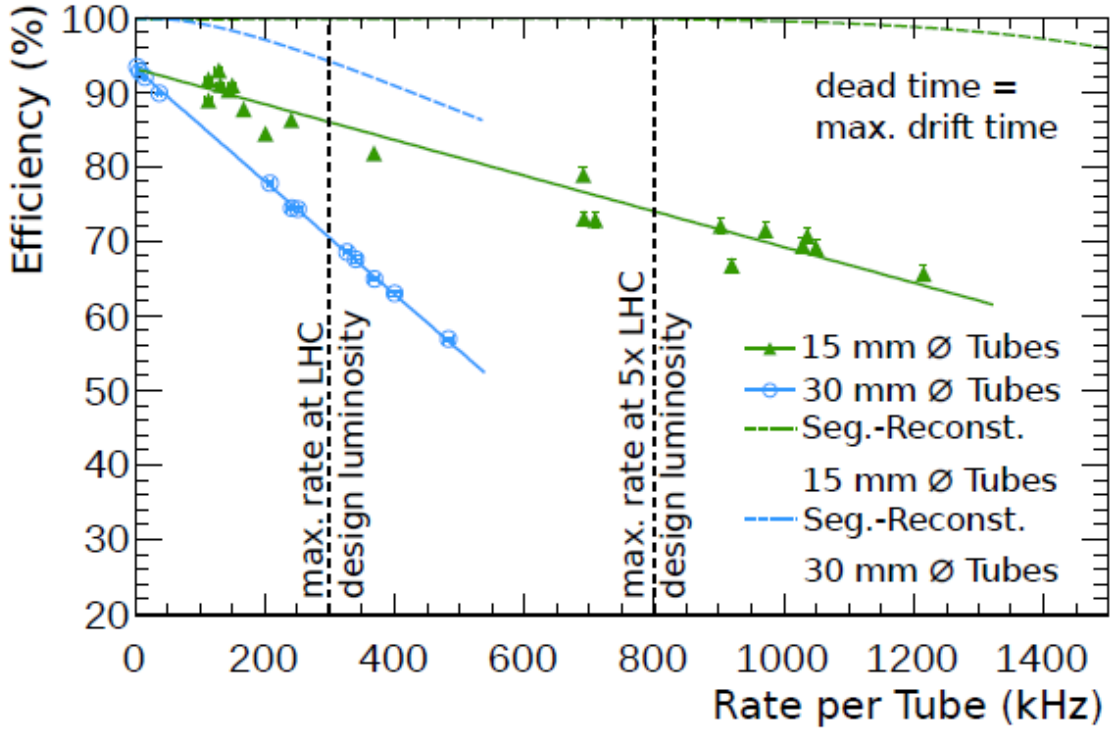
Under development:
radiation hard FPGA for new CSM with higher bandwidth and L1 trigger functionality.

Performance Prototype Chamber (GIF, H8)





Single-tube and segment efficiencies as expected, measured up to background rate of 1200 kHz/tube



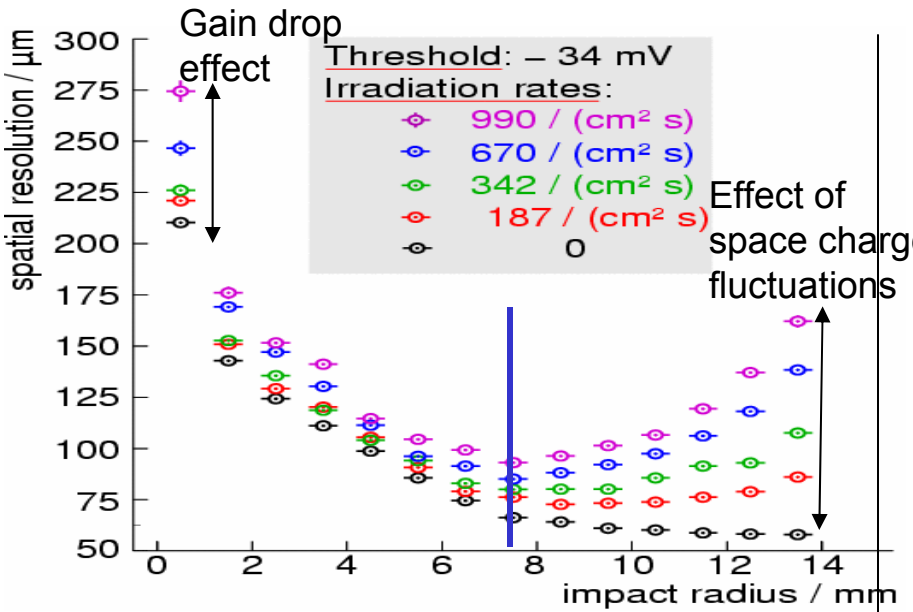
At 5 x design luminosity in SWs, worst case:

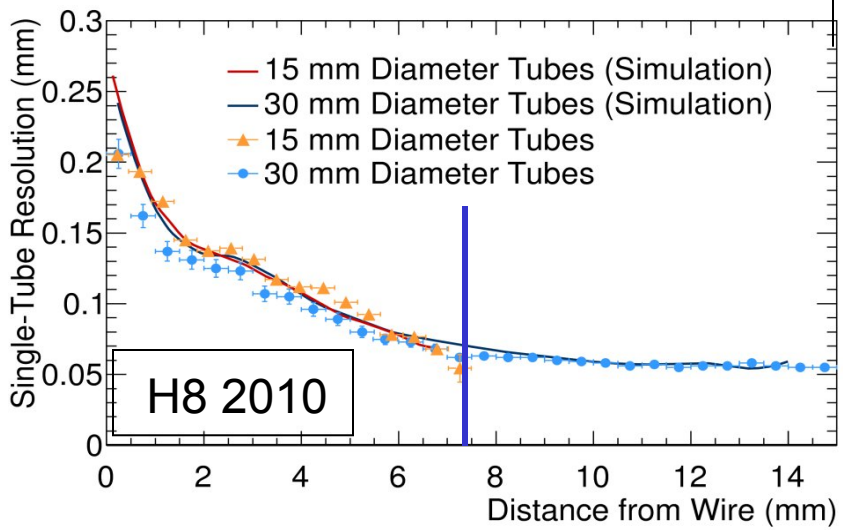
- Max. hit rate: 9 kHz/cm^2
- Max. counting rate: 750 kHz/tube
- Max. occupancy: 15 % (7 x less than f. 30 mm ∅)

Efficiency better than in ex. SW MDTs at design luminosity

Performance Prototype Chamber (GIF, H8)

S.Horvat et al., IEEE TNS Vol.53, No.2 (2006) 562

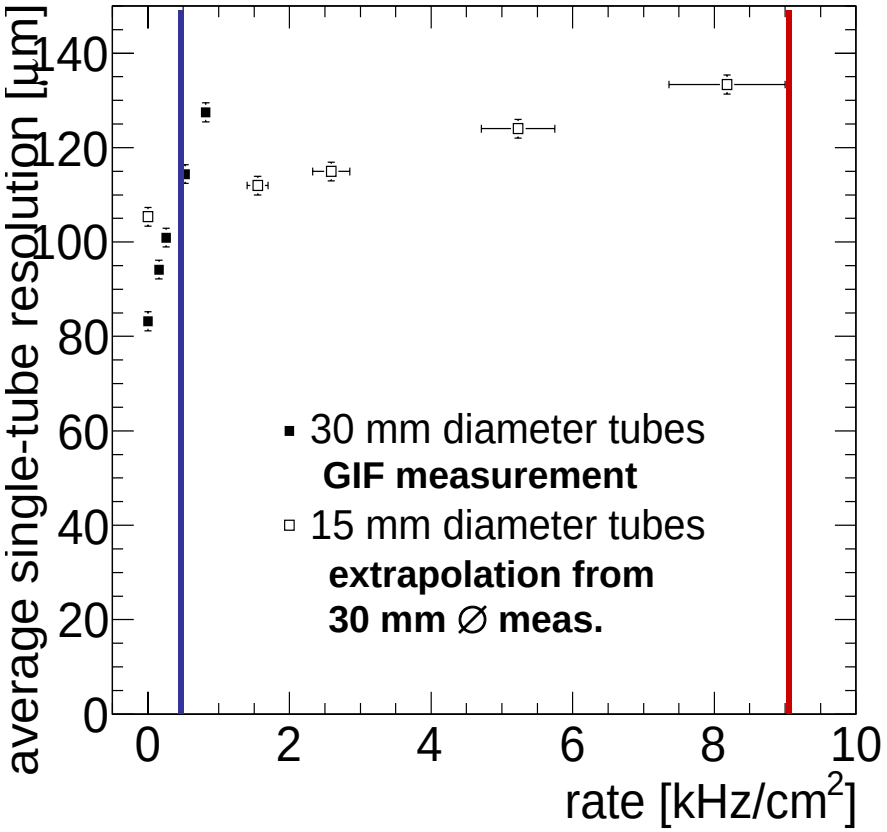




Almost no degradation of resolution with increasing background rate

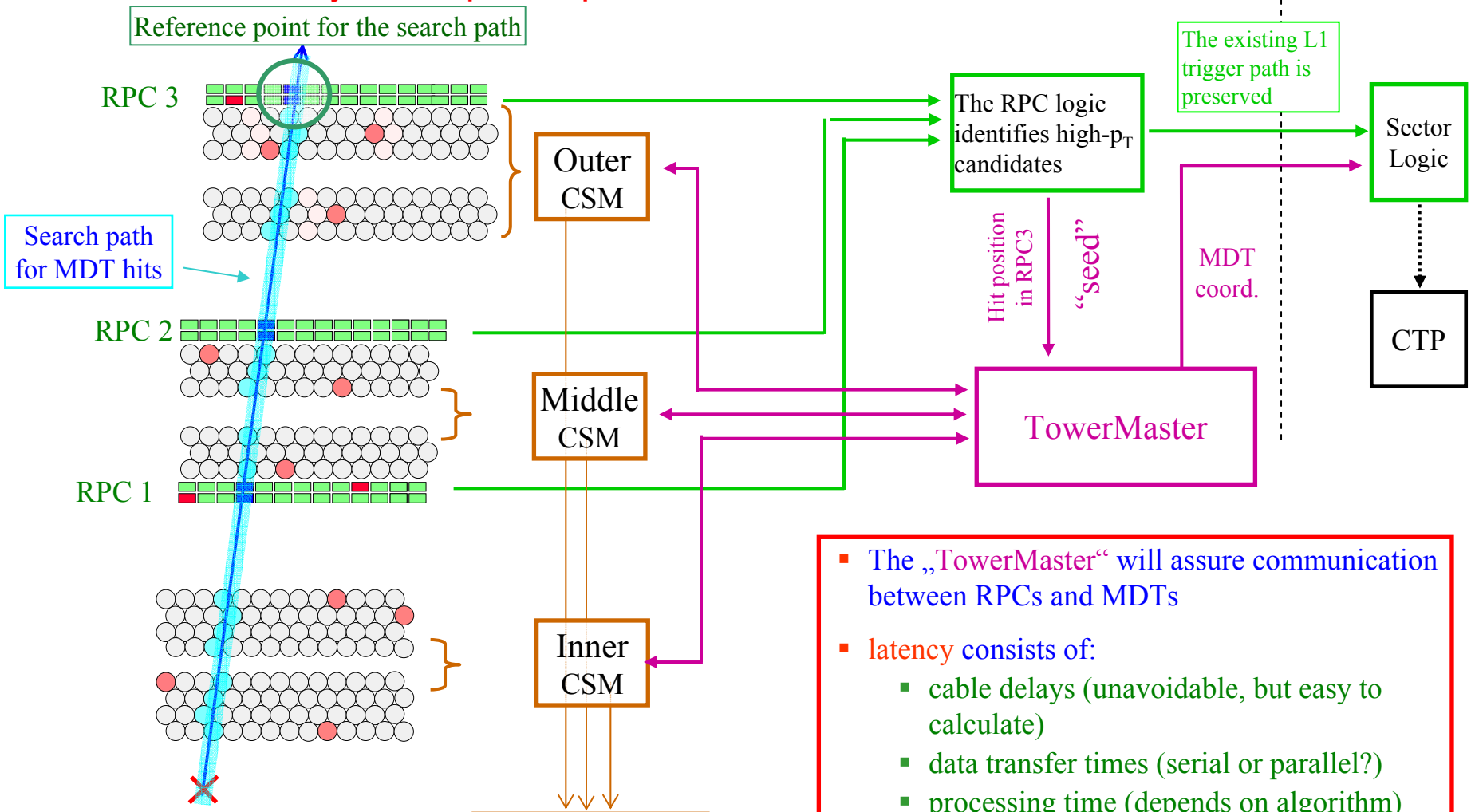
Max. rate in ex. MDT chambers at LHC design: 120 µm tube resolution

Max. rate in CSC region at 5 x LHC design: 130 µm tube resolution



MDT-Based L1 Muon Trigger: Barrel Phase II

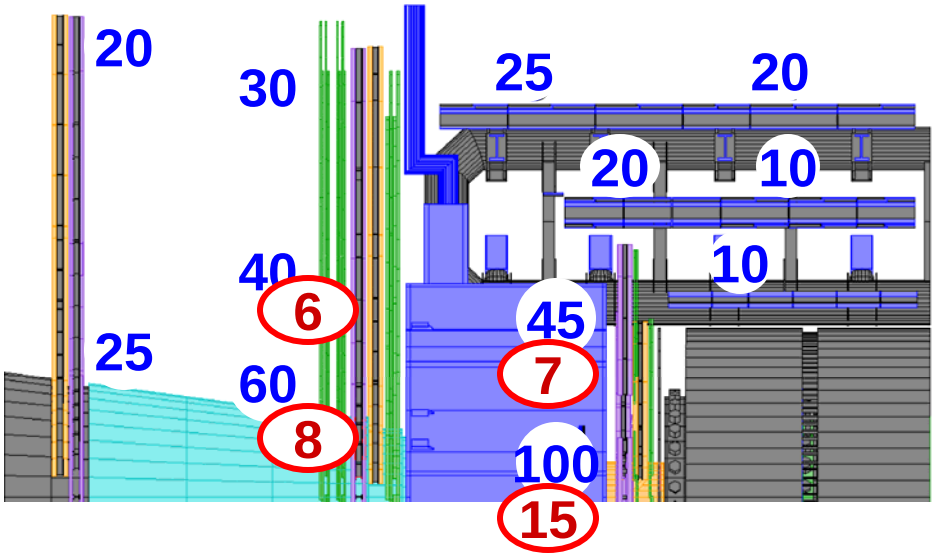
Communication added between trigger and MDT chambers within a trigger tower via the TowerMaster, latency > 2.5 μs, no problem for Phase II



- The „TowerMaster" will assure communication between RPCs and MDTs
- latency consists of:
  - cable delays (unavoidable, but easy to calculate)
  - data transfer times (serial or parallel?)
  - processing time (depends on algorithm)

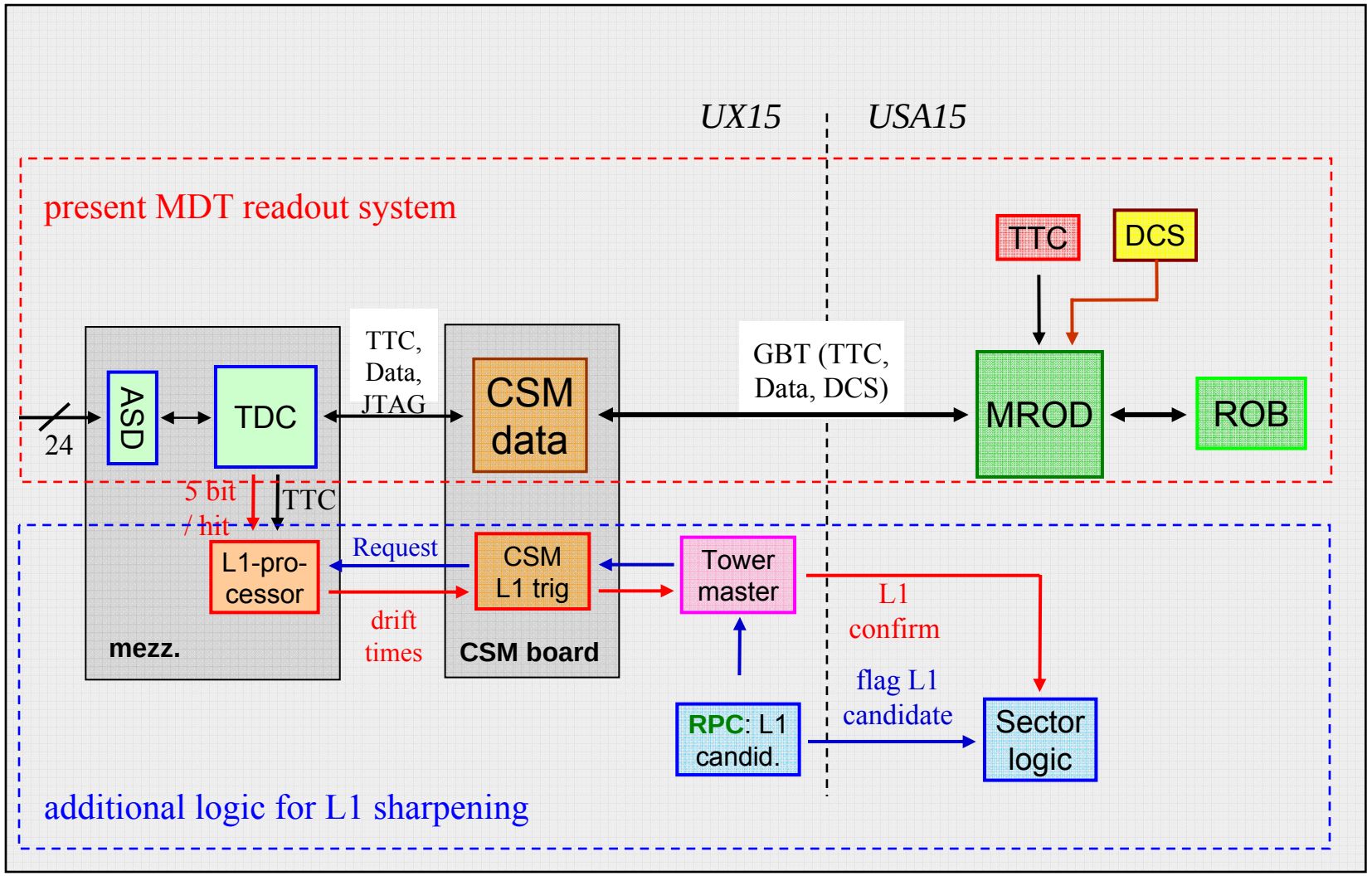
MDT-Based L1 Muon Trigger: Endcaps Phase II

Drift–tube occupancies at
5 x design luminosity (safety factor 5)



- If the MDT-based trigger concept works in the barrel (no alternative) it should also work in the endcaps (incl. alternative scheme by O.Sasaki).
- Additional redundancy and optimum angular and momentum resolution for muon trigger in Phase II.
- Have to prepare already in Phase I SW upgrade (MDT on-chamber electronics).
- Replace MDT electronics in BWs in Phase II upgrade as for barrel. Inner BW MDT chambers have to be replaced then anyway.

Architecture of new MDT readout electronics



Test Program 2011

- June: Wire position measurement of prototype chamber in cosmic ray stand.
- July: High-rate test of prototype ch. with RPC and integrated readout in GIF.
- August: Integration test with TGCs in H8 beam.
- August: Integration test with RPCs in H8 beam.
- Accelerated aging tests started.
- Installation of prototype chamber in ATLAS cavern in winter shutdown 2011/12.

Resources and Funding

- MDT chamber construction for new Small Wheels
  can be performed by Freiburg, LMU, MPI and Würzburg
  in 2013-2016.
- Common funding request planned for full new SW MDT system
  including electronics and services in German funding periods
  2012-2018.
  Submission deadline is in December 2011.
  Need decisions by Muon System and ATLAS.
- More collaborators are very welcome.

  Interest by NIKHEF/ Nijmwegen in new MROD development.

  Alignment system by Brandeis.