sPHENIX TPC electronics ~Rough first idea~

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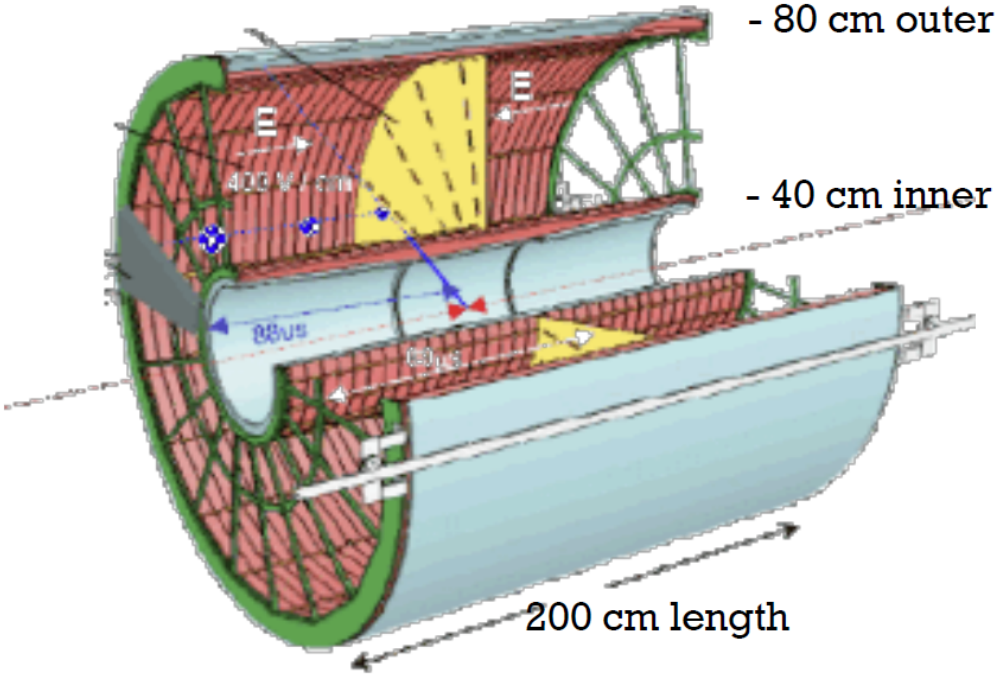
References:

- STAR CDR of TPC (published in 1992 and 1993)
- STAT NIM paper, NIM A499 (2003) 659
- ALICE CDR of TPC upgrade (published in 2014)
- ALICE NIM paper, NIM A622 (2010) 316

Starting out from this design

Nominal sPHENIX TPC Design

- R_{outer}, B_{field}, length, fixed by BaBar Magnet

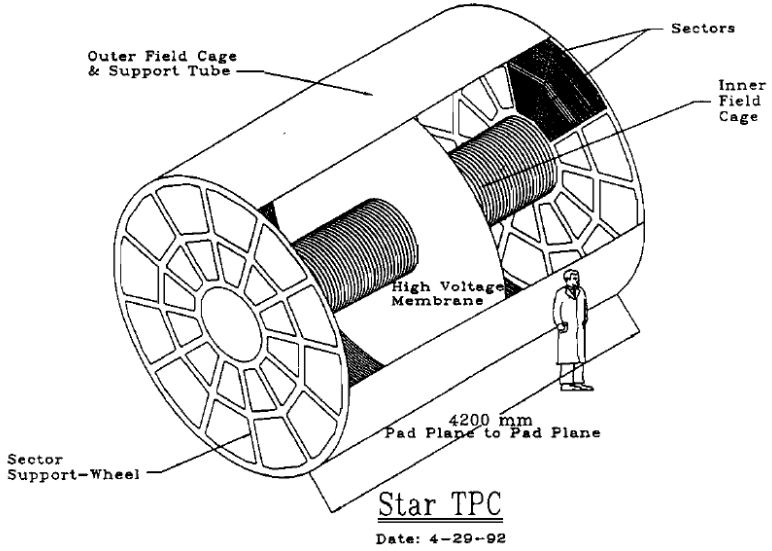


B = 1.45 Tesla
E = 200 V/cm
T2K gas (95-3-2)
3-Gem/MicroMega
SAMPA Chip Readout
r-pitch = 8 mm
ϕ-pitch = 1.2 mm
t-bucket = 40 ns

- Subject to physics/engineering optimization

How sPHENIX TPC is compared with others?

- STAR
  - Radial position: 60cm-1.9m
  - Longitudinal volume: 2*2.1m
  - Drift voltage: 28kV (135V/cm)
  - Electronics: 140K channels
  - dN/dy: 3000
- ALICE
  - Radial position: 85cm-2.5m
  - Longitudinal volume: 2*2.5m
  - Drift voltage: 100KV (400V/cm)
  - Electronics: 560K channels
  - dN/dy: 8000 (40% occupancy at the inner radius)



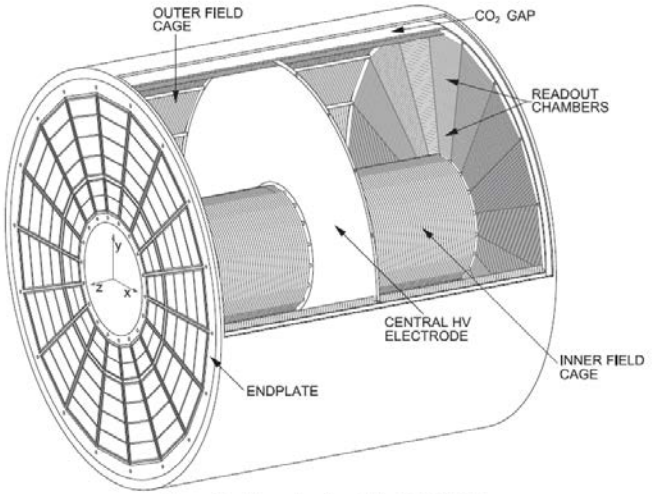


Figure 2.1: Schematic view of the ALICE TPC.

sPHENIX TPC is around half scale downsize of these TPCs!

Designing of sPHENIX TPC Readout

- Number of channels: ~200K channels
  - dN/dy should be no larger than current.
  - Production effort should be 1/3 of ALICE case.
  - I'm supposing ALICE GEM-TPC upgrade case
- HV holding structure should be no different from ALICE or STAR's
  - Drift HV to be applied: ~ 15KV?
  - Field between the TPC cage and beam pipe wouldn't be different
- Use SAMPA Chips used for ALICE

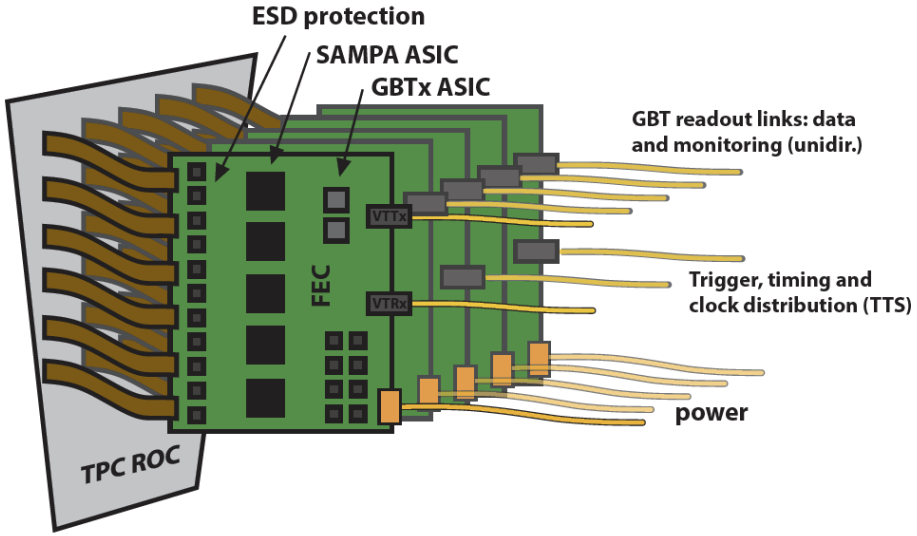


Figure 6.1: Schematic of the readout system of the GEM TPC. The two main building blocks of the FEE are shown: The front-end ASIC SAMPA on the front-end cards (FECs). The FECs connect to a Common Readout Unit (CRU), located off-detector in the control room, through radiation hard GBT links.

Readout scheme for ALICE upgraded TPC

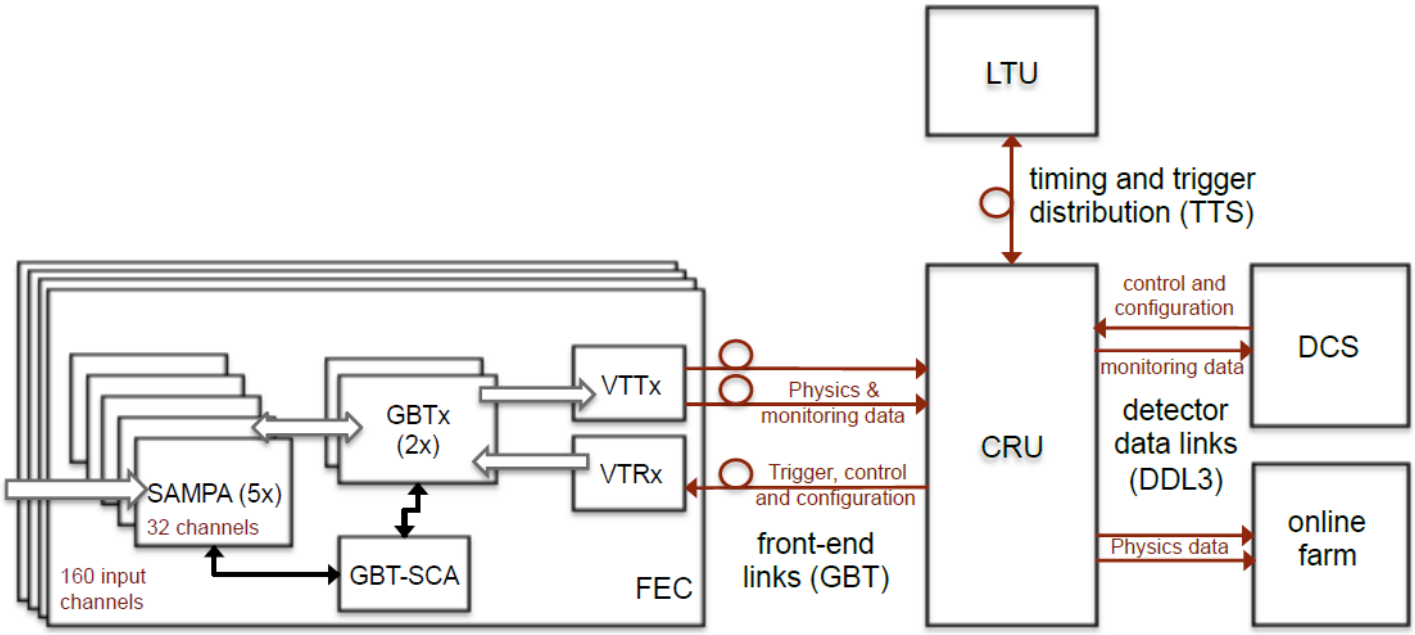


Figure 6.9: Schematic of the TPC readout system with the CRU as central part interfacing the front-end electronics to the trigger system, the DCS and the online farm.

Costs (from ALICE TPC upgrade CDR)

- With 560K channels: 6.6M CHF
  - 1CHF~1.03USD (as of today)
  - 6.8M USD
  - Not sure how the labor is included in this cost.

- May be downscaled the number by the channels for sPHENIX TPC case?
  - 200K channels = 2.5M USD?

Readout chambers	Quantity (incl. spares)	Cost (MCHF)
GEM foils[1]	480	0.5
Frames and components	960	0.1
Pad planes	160	0.4
Chamber bodies	80	0.3
HV divider	80	0.1
Assembly and installation tooling		0.4
Total Readout Chambers		**1.8**
Services		Cost (MCHF)
GEM HV system		0.2
Fast current monitoring		0.2
HV supply for last FC resistor		0.1
Other services		0.2
Total Services		**0.7**
FEE and Readout	Quantity (incl. spares)	Cost (MCHF)
SAMPA ASIC	19,500	0.78
Front-end card	3900	0.35
GBTx ASIC	7000	0.38
Optical transmitters/receivers	5500	0.79
CRU (control room, AMC40)		2.00
Optical fibers	9000	1.32
TPC Event Processing Nodes (TPC-EPN)		1.00
Other		0.02
Total Electronics		**6.64**
Total IROC	40	3.3
Total OROC	40	5.84
Total		**9.14**

Table 12.3: CORE cost estimate for the TPC upgrade.

Schedule (from ALICE TPC upgrade CDR)

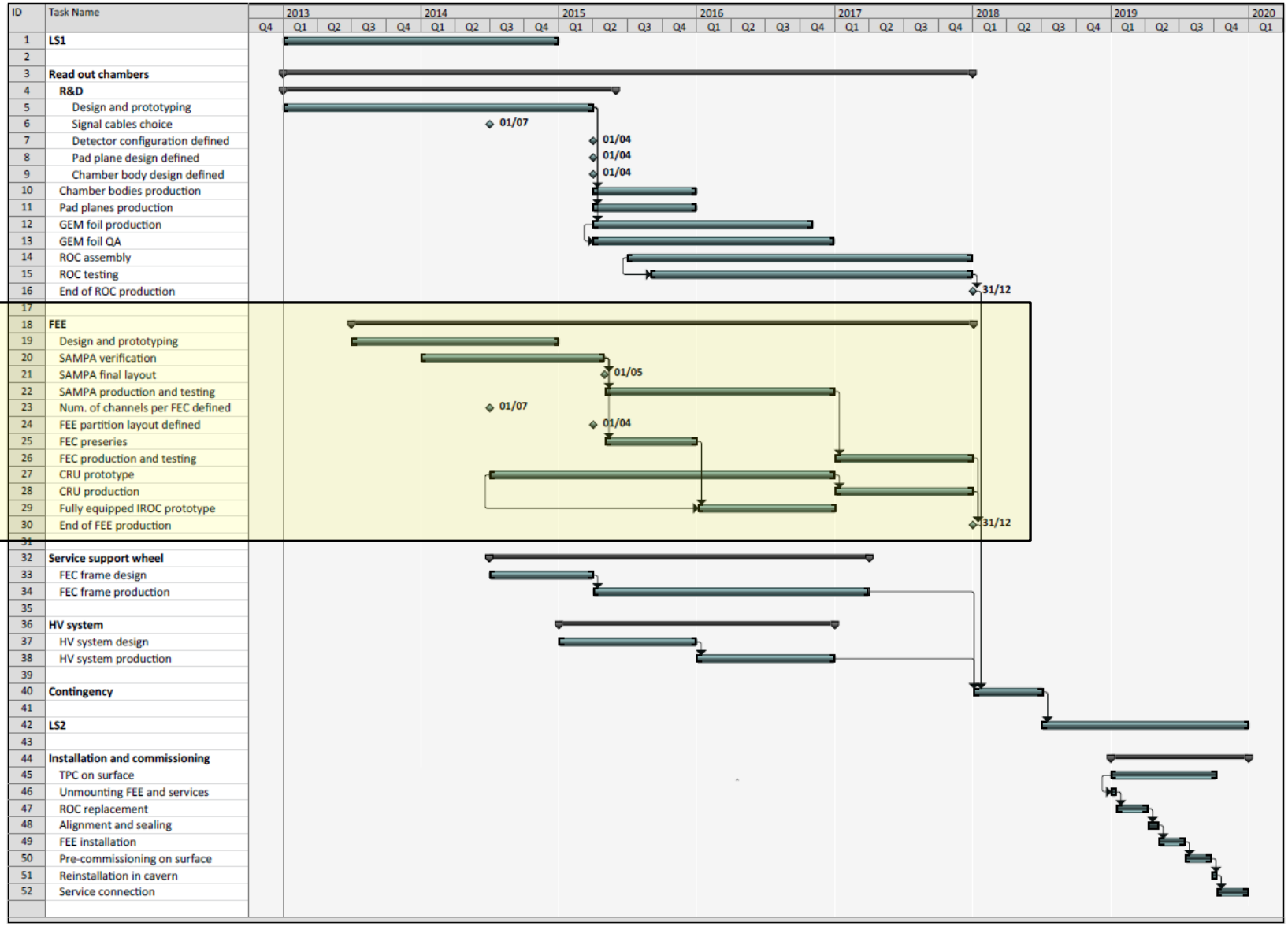
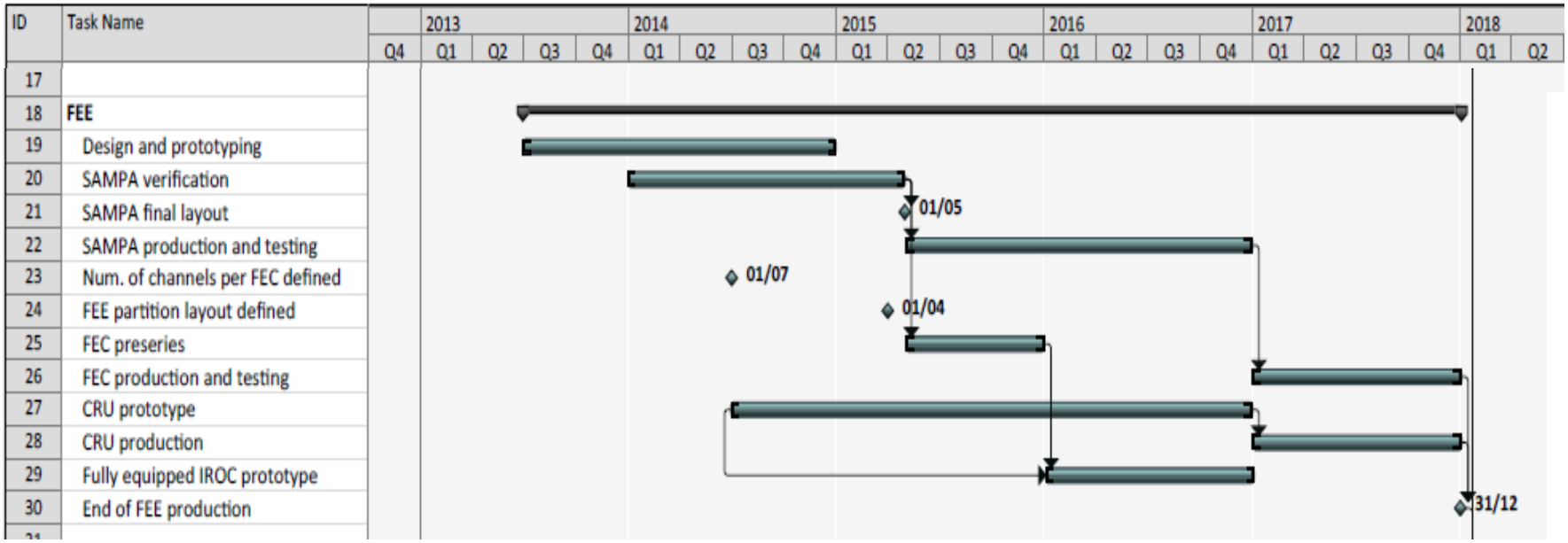


Figure 12.2: Time line for the TPC upgrade.

Time saving our case?

- Time for developing SAMPA chips and CRU can be reduced to ~half?
  - Conservative estimate
- Production and testing time can be reduced by the difference of number of channels → half year?
- In the ALICE case, it takes around 4.5 year.
  - The sPHENIX case could be shorter: ~ 3 years? (conservative estimate)



TODO

- We shoudl start talking to ORNL people if we decide on SAMPA option
  - We could get whole WBS from them
- We could downscale the cost and labor by the number of channels for some portion

SAMPA chip in detail

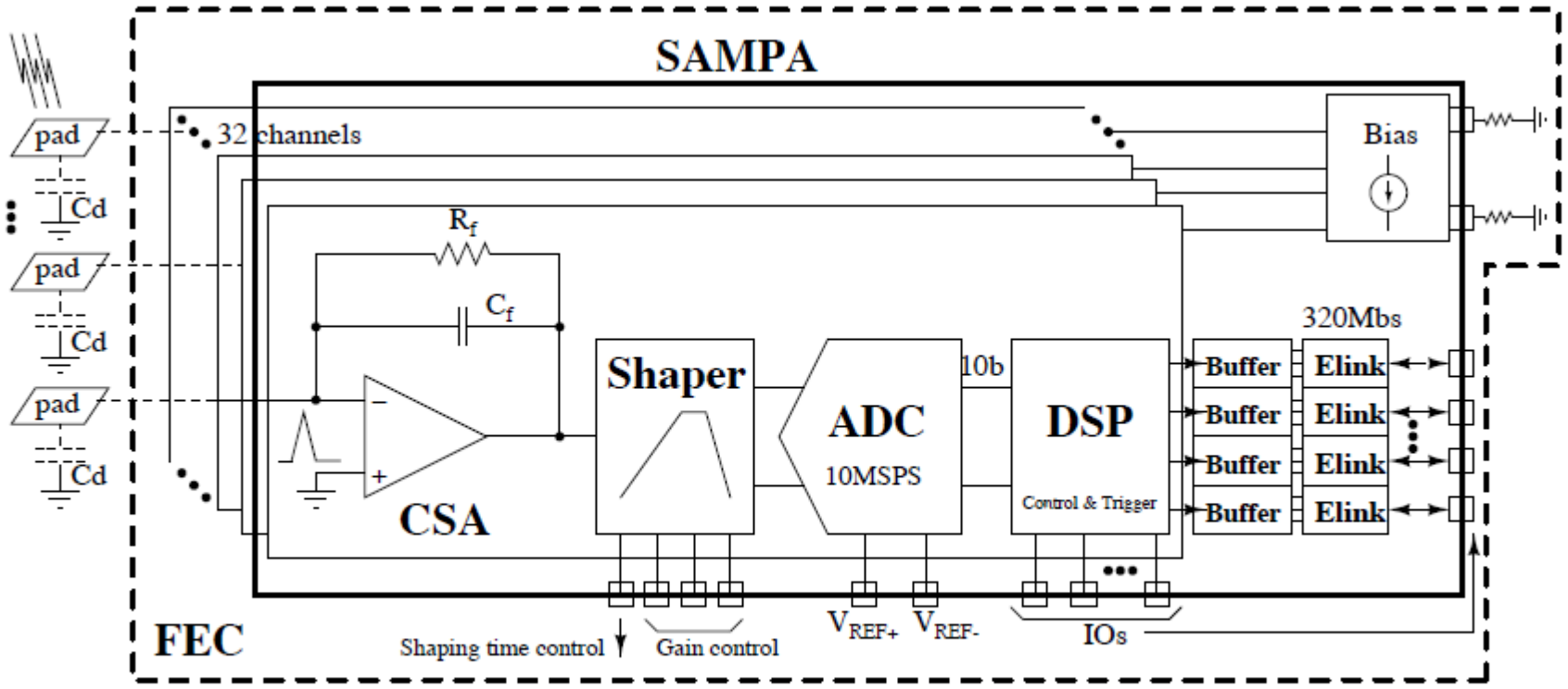


Figure 6.4: Schematic of the SAMPA ASIC for the GEM TPC readout, showing the main building blocks.

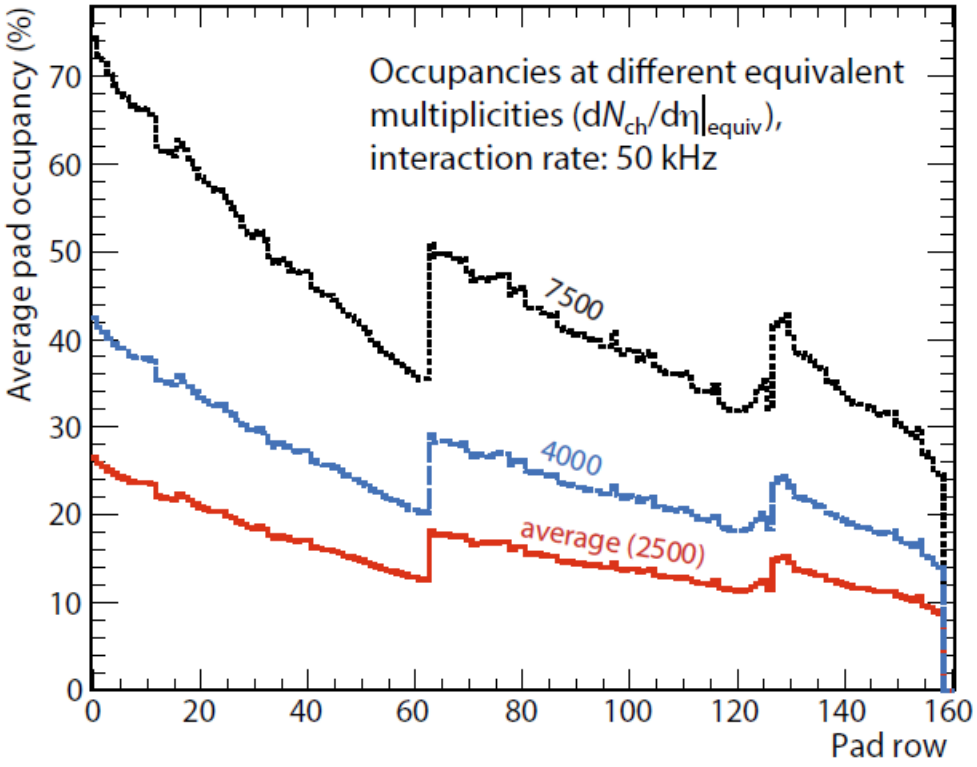


Figure 6.3: Expected average occupancies within a given time window for equivalent multiplicities of $dN_{ch}/d\eta|_{equiv} = 2500$, 4000 and 7500. The data is extrapolated using measured occupancies in isolated (no pileup) events recorded in 2010.