DRD1 Detectors electronics properties

DRAFT ... your input is needed

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GEM (Multi-GEMs based detectors)

Applications

High-rate tracking, X-ray imaging, TPC amplification

Parameter	Detector Performance	ASIC Requirement
Gain	10^4–10^5	0.5 – 16 mV/fC CSA
Signal type	High-Z current source	CSA charge amplifier
Signal rise t_r tail/fall time t_f	tr 20-30 ns, tf 5-10ns	Signal BP f_0 12- 1.5 MHz
Time resolution ($s_t = t_r/SN$)	3–5 ns	2nd O Peaking time tp ~25 - 250ns
Rate capability	>10^6 Hz/cm^2	4 MHz/channel
Signal charge	~1–10 pC neg	Dynamic range Vcc 1V Linear 2pC gain 0.5 mV/fC
Energy resolution	15–20% FWHM	~10-bit ADC
Noise sensitivity	Moderate	ENC ≤ 1 fC @ tp 250 ns
Spark probability	Low (but possible)	Neg. charge input protection required
Signal coupling	Minimize traces and connection for minimal Cd	AC: Cin ~ 1/(BW* GAIN). High amplifier BW reduces input impedance. For best charge sharing choose coupling capacitor such that Cd ≪ Cin
Trigger source	GEM bottom , pos	Dedicated amplifier, opt. local ASIC trigger input

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Micromegas

Carefully selected detector teams

Tracking, neutron imaging, radiography

Parameter	Detector Performance	ASIC Requirement
Gain	Up to few10^4	CSA 5. - 10 mV/fC
Signal type **Signal rise t_r , tail/fall time t_f**	High-Z current source tr 2-5ns, ion tail 40 ns	CSA charge amplifier Signal BP f_0 12- 1.5 MHz
Time resolution (s_t = t_r/SN)	2– 5 ns	2nd O Peaking time 25-250ns
Rate capability	>10^6 Hz/cm^2	4 MHz/channel
Signal charge	2 pC neg	Dynamic range Vcc 1V Linear 2pC gain 0.5 mV/fC
Energy resolution	~15–20% FWHM	~10-bit ADC
Noise sensitivity	Moderate	ENC ≤ 1 fC @ tp 250 ns
Spark probability	Reduced (resistive versions)	ESD protected input stage
Signal coupling	Minimize traces and connection for minimal Cd	AC: Cin ~ 1/(BW* GAIN). High amplifier BW reduces input impedance. For best charge sharing choose coupling capacitor such that Cd ≪ Cin
Trigger source	Mesh , several nF , positive	Dedicated amplifier, opt. local ASIC trigger input

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µRWELL

Applications

High-rate tracking, low-mass vertex detectors

Parameter	Detector Performance	ASIC Requirement
Gain	10^3–10^4 (multi-stack up to 10^6)	CSA 5. - 16 mV/fC
Signal type **Signal rise t_r , tail/fall time t_f**	High-Z current source tr 1-5ns, tf = 20 ns	CSA charge amplifier Signal BP f_0 16- 3 MHz
Time resolution (s_t = t_r/SN)	1 –5 ns	2nd O Peaking time ~ tp 20-100 ns
Rate capability	>10^5 Hz/cm^2	Rate ~10 MHz
Signal charge	2 pC	Dynamic range Vcc 1V Linear 2pC @ gain 0.5 mV/fC
Energy resolution	~20% FWHM	6–10 bit ADC
Signal coupling	Minimize traces and connection for minimal Cd	AC: Cin ~ 1/(BW* GAIN). High amplifier BW reduces input impedance. For best charge sharing choose coupling capacitor such that Cd ≪ Cin
Noise sensitivity	Moderate	ENC ≤ 1 fC @ tp = 100ns
Spark probability	Intrinsically protected	neg charge ESD protected input stage

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MWPC

Applications

TPC endcaps (legacy), muon chambers

Parameter	Detector Performance	ASIC Requirement
Gain	~10^4	CSA 1 – 10 mV/fC
Signal type **Signal rise t_r , tail/fall time t_f**	High-Z current source tr 10ns, tf 20-50 ns	CSA charge amplifier Signal BP f_0 3 - 1 MHz
Time resolution (s_t = t_r /SN)	8–10 ns	2^{nd} O Peaking time 50-250ns
Rate capability`	10^4–10^5 Hz/cm^2	Max 1 MHz
Signal charge	1 pC neg	Dynamic range Vcc 1V Linear 1pC @ gain 1 mV/fC 6–8 bit ADC
Energy resolution	~20% FWHM	Hit-mode acceptable
Signal coupling	Minimize traces and connection for minimal Cd	AC
Noise sensitivity	Moderate	ENC ~1–2 fC @ tp = 250ns
Spark probability	High	Ext neg overcharge protection mandatory
Trigger source	HV mesh capacitive pickup pos	Dedicated amplifier, opt. local ASIC trigger input

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Drift Chambers

Applications

Tracking, some TOF systems

Parameter	Detector Performance	ASIC Requirement
Gain	~10^4	CSA 1 – 10 mV/fC
Signal type	High-Z current source	CSA charge amplifier
Signal rise t_r tail/fall time t_f	tr 10ns, tf 20-50 ns	Signal BP f_0 12- 1.5 MHz
Time resolution (s_t = t_r/SN	5-10ns drift gas dependent	TDC or fast discriminator
Rate capability	~10^4 Hz/cm^2	100 kHz
Signal charge	~1–2 pC neg	6–8 bit ADC or TDC mode
Energy resolution	Not primary	Not critical
Signal coupling	Minimize traces and connection for minimal Cd	AC
Noise sensitivity	medium	ENC ~1–2 fC @ tp = 250ns
Drift velocity	2–5 cm/μs	Time measurement precision
Spark probability	Possible	neg charge ESD protected input stage

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Straw Tubes

Applications

Large-area, very high rate tracking, muon systems, beam diagnostics

Parameter	Detector Performance	ASIC Requirement
Gain	10^4–10^5	TIA: 5k – 20k CSA: 0.5 – 6 mV/fC
Signal type **Signal rise t_r , tail/fall time t_f**	High-Z, high energy current source 50-100W terminted tr 1-10ns, tf 100ns – 1us	TIA current amplifier, 50-100W terminated Signal BP f_0 100- 10 MHz
Time resolution **$s_t = t_r/SN$**	1–2 ns	2^{nd} O Peaking time 20 -100ns
Rate capability	10^5–10^6 Hz/cm^2	Local rate >10 MHz Requiring fast reset and tail cancellation
Signal charge	Up to ~10 pC	Dynamic range Vcc 1V CSA Linear 2pC @ gain 0.5 mV/fC TIA 5kW 10 mV over 50W input May need dyn range extension
Signal coupling	50 W coax	DC to 50W or Balun to CSA
Energy resolution	18–20% FWHM	8–10 bit ADC
Noise sensitivity	Moderate	ENC ≤ few fC
Spark probability	High	External input protection to amplifier inputs against > 15 mW per hit.

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RPC (Single-gap & Multi-gap)

Applications

Muon trigger, TOF, large-area timing

Parameter	Detector Performance	ASIC Requirement
Gain	~10^3 (avalanche), up to 10^6 (streamer)	TIA gain 5-20 kW CSA gain 0.5mV/fC – 6mV/fC
Signal type **Signal rise t_r , tail/fall time t_f**	High-Z current source over 50W tr 1-2ns, tf 400ns	TIA current amplifier, 50-100 OHM terminated Signal BP f_0 100- 10 MHz
Time resolution **$s_t = t_r/SN$**	0.8 ns (single), 100 ps (stack)	TDC ≤ 50–100 ps alt: 10 ns shaper peaktime sampling @ 400 MSPS for 15 samples over envelope 35 ns
Rate capability	10^4–10^5 Hz/cm^2	≥10 MHz local handling
	Fast (~sub-ns rise), 50 Ω pos or neg	50 Ω impedance matching at amplifier , TIA or Balun-coupled CSA
Signal coupling	50 W coax	DC to 50W TIA or Balun to CSA
Signal charge	Up to ~10 pC	Dynamic range Vcc 1V TIA 5kW max 10mV over 50W CSA Linear 2pC @ gain 0.5 mV/fC
Energy resolution	Not primary	Not required
Noise sensitivity	Moderate	Fast discriminator
Spark probability	Low in avalanche mode	50OHM termination or Balun sufficient

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PICOSEC (Fast Micromegas Timing)

Applications

Precision TOF, particle identification

Parameter	Detector Performance	ASIC Requirement
Gain	10^3–10^4	
Signal type **Signal rise t_r , tail/fall time t_f**	High-Z current source terminated 50W, mixed electron Peak and tion tail tr SAT O(800ps), tf (ion tail 40- 100 ns)	TIA or LNA amplifier, 50W E-peak signal BP f_0 350 -100 MHz Tail suppression via ext. Balun
Time resolution $s_t = \frac{1}{SN} \frac{1}{\sqrt{3fs*fbw}}$	20–70 ps RMS	s_t function of preamp f_{BW} and Nr SAT samples fs Alt: 10 ns p_T shaper envelope sampled at 400 MSPS over semigaussian envelope 30 ns
Rate capability	>10^6 Hz/cm^2	> 1 GHz TDC
Signal charge	Time-coherent electron avalanche = very high S/N	Dynamic range e-peak 1–10 pC
	Fast (~sub-ns rise), 50 Ω neg	50 Ω impedance matching at amplifier , LNA, TIA or Balun-coupled CSA-shaper
Signal coupling	50 W coax	DC to 50W or Balun
Energy resolution	Not primary	Not required
Noise sensitivity	High (timing-driven)	Very low jitter front-end

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TPC (GEM / Micromegas / MWPC-based)

Applications

Central tracking, dark matter, X-ray imaging

Parameter	Detector Performance	ASIC Requirement
Gain	10^3–10^4 (amplification stage)	CSA 0.5 – 16 mV/fC
Signal type	High-Z current source	CSA charge amplifier
Signal rise t_r tail/fall time t_f	tr 20-30 ns, tf up to 50 us	Signal BP f_0 12- 1.5 MHz
dE/dx resolution	5–7%	10–12 bit ADC
Rate capability	Up to 10^5 Hz/cm^2	4 MHz /ch
Signal duration	µs scale	Waveform sampling ADC with buffer
Signal coupling	Minimize traces and connection for minimal Cd	AC: Cin ~ 1/(BW* GAIN). High amplifier BW reduces input impedance. For best charge sharing choose coupling capacitor such that Cd ≪ Cin
Noise sensitivity	High (dE/dx critical)	ENC ≤ 1 fC
Backflow constraint	$<10^{-3}$	Baseline stabilizer , multi-hit detection

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SiPM Readout

Applications Photon detection, calorimetry, timing layers

Parameter	Detector Performance	ASIC Requirement
GAIN	Up 10^6	CSA GAIN: 0.5 - 10 mV/fC Dual gain for high N*Qs > 2pC TIA GAIN: 10 - 20k for5-2.5 mV input
Single p.e. charge	Qs ≥20 fC for N=1 above U_{br} Signal Amplitude N * Qs N= Nr of primary p.e.	Noise < 5 fC
Signal type	High-Z Anode current source Or terminated 50W Voltage source coupled via 50W Balun to CSA	TIA current Zin < 500W CSA lowest gain input < 80 W BP f_0 > 10-100 MHz
Signal rise t_r , tail/fall time t_f	tr Anode O(2ns) tf 40ns) tr Fast capacitive OR 200ps FWHM 600 ps	Tail suppression via Balun FOR: higher gain for lower amplitude
Time resolution **$s_t = t_r/SN$**	Single photon SPTR 200-300 ps SPAD 20-50 ps	Ultrafast , Nino like 10ps comparators Alt: 10 ns p_T shaper envelope sampling @ 400 MSPS over semigaussian envelope 30 ns
Recovery time	10 – 200ns as function of cell geometry and capacitance	Discharge required for DC coupled SiPMs, AC or Balun coupled preferred
Dynamic range	Limited by microcells	20–50 pC Dyn range extensions: • Split in high/low gain channels • Log preamplifier • Amplitude extrapolation via ToT
PDE	≥45% @ 400 nm	Not ASIC-limited
Rate capability	Up to ~10 MHz/ch for fast recovery devices	~4 MHz/ch
Noise sensitivity	10 fC below Qs	5 fC
Bias requirement	External bias control	Integrated DAC/monitoring

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Electromagnetic Calorimeter (Crystal or Sampling)

Applications

Add the gaseous detector case but keep all other technologies- to pool additional interetse outside DRD1

e/γ measurement, cosmic rays, fixed-target

Parameter	Detector Performance	ASIC Requirement
Gain (sensor dependent)	APD / SiPM / PMT	Compatible input stage
Time resolution	~100 ps (system dependent)	Sampling up to 200 MHz
Rate capability	~1 MHz/channel	1 MHz sustained
Signal charge	1–50 pC	Dual gain or auto-ranging
Energy resolution	~0.1/√E	12–14 bit equivalent
Noise sensitivity	Very high	≤1 fC ENC
Signal shape	100–200 ns shaping	Flexible shaping time

Please contact convenors for comments and additions