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AI-Assisted PQC Integration in Bouncy Castle

Roy Basmacier · Cryptographer, Bouncy Castle team at Keyfactor

15.10.2026

Nine schemes, one release

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40
Round 1 · 2023

→

14
Round 2 · Oct 2024 · NIST IR 8528

→

9
Round 3 · 14 May 2026

Family	Round 3 schemes	In Bouncy Castle
Multivariate	MAYO · UOV · QR-UOV · SNOVA	1.81 (MAYO, SNOVA) · 1.85 (UOV, QR-UOV)
MPC-in-the-head	MQOM · SDitH	1.85
Symmetric	FAEST	1.85
Isogeny	SQIsign	1.85
Lattice	HAWK (withdrawn from NIST)	1.85, then pqc.legacy in 1.86

Bouncy Castle 1.85, 12 July 2026: all nine.

What adding a scheme takes

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core	prov
Engine: KeyPairGenerator · Signer · Parameters · key parameters	<Alg>ParameterSpec · <Alg>Key interface
BCObjectIdentifiers: one OID per parameter set	BC<Alg>PublicKey · BC<Alg>PrivateKey (constant-time equals)
Utils: OID ↔️ parameters maps and lookups	KeyFactorySpi · KeyPairGeneratorSpi · SignatureSpi
PublicKeyFactory · PrivateKeyFactory	Mappings → BouncyCastlePQCProvider.ALGORITHMS
SubjectPublicKeyInfoFactory · PrivateKeyInfoFactory	module-info · tests · release notes

loadPQCKeys(): the BC ↔️ BCPQC bridge. Skip it and certificates decode via BCPQC but not via BC.

About 15 files, 16 steps. One of them is invisible from any single file.

The sprint: 15 May 2026

The day after NIST announced Round 3. Six branches in five minutes, one prompt each.

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Our goal is to implement SDitH (Syndrome-Decoding-in-the-Head). An implementation is provided in https://github.com/sdith/sdith. The specification is provided in https://sdith.org/docs/sdith-v2.0.pdf. Follow the policies in PQC_SIGNING_POLICIES.

The kick-off prompt, one per scheme

- read ML-DSA, write PQC_SIGNING_POLICIES (the template problem starts here)
- branches: sqisign · mqom · sdith · qr-uov · uov · faest
- **Inputs** reference C beside the tree, the spec PDF, the KAT .rsp files
- **By 18 May** checkstyle hook that auto-formats every edit; the porting skill applied to SQIsign

Fourteen days to merge, 58 to release

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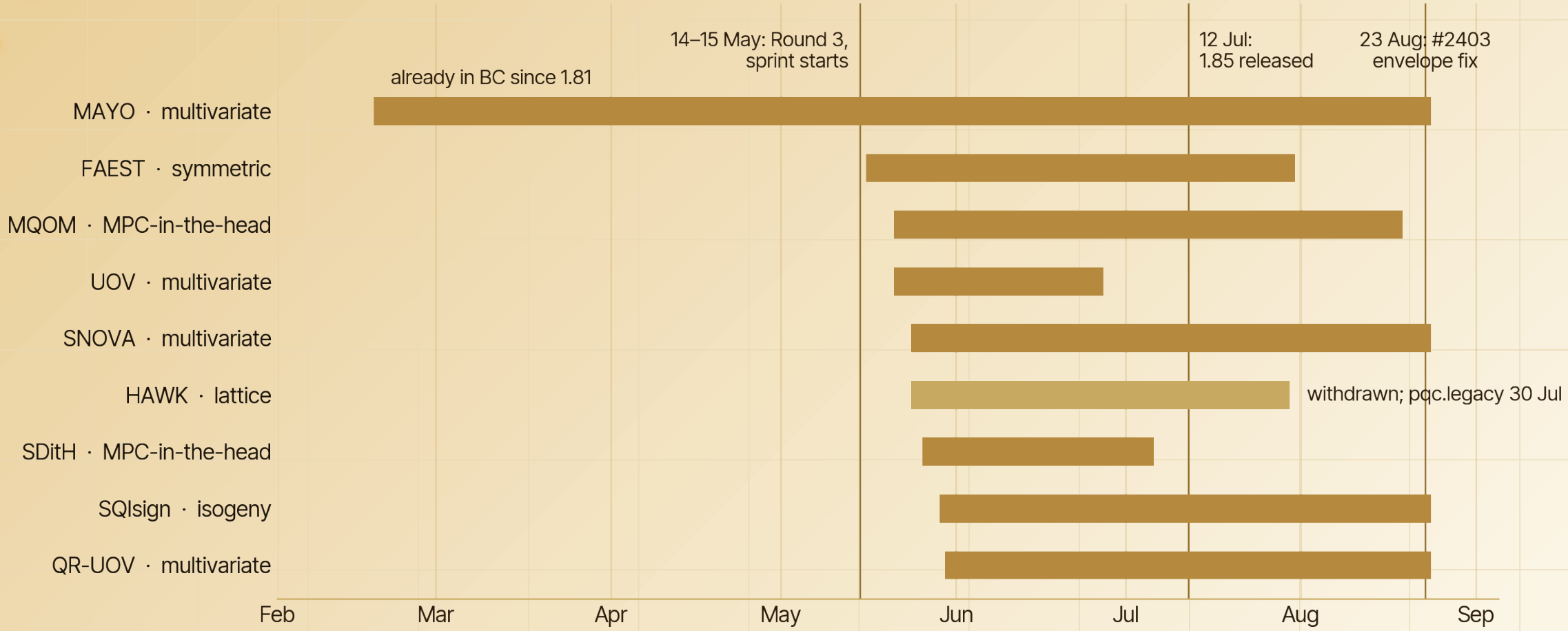

Accelerates: the plumbing

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- **Mechanical, cross-cutting, easy to half-finish** exactly what the model does fast and consistently
- **Template chain** SNOVA → FAEST → HAWK
- **Codified** bcpqc-add-signature-algorithm skill: 16 steps, ~15 files, invoked by name
- **One person, six ports in flight** because the model holds the per-scheme reference quirks

1 Utils OID maps	9 KeyPairGeneratorSpi
2 PublicKeyFactory	10 SignatureSpi
3 PrivateKeyFactory	11 Mappings
4 SPKI / PKI factories	12 BCPQC ALGORITHMS
5 ParameterSpec	**13 loadPQCKeys bridge**
6 Key interface	14 module-info
7 Key wrappers	15 Tests
8 KeyFactorySpi	16 Release notes

The skill's checklist

Accelerates: bottom-up, with an oracle

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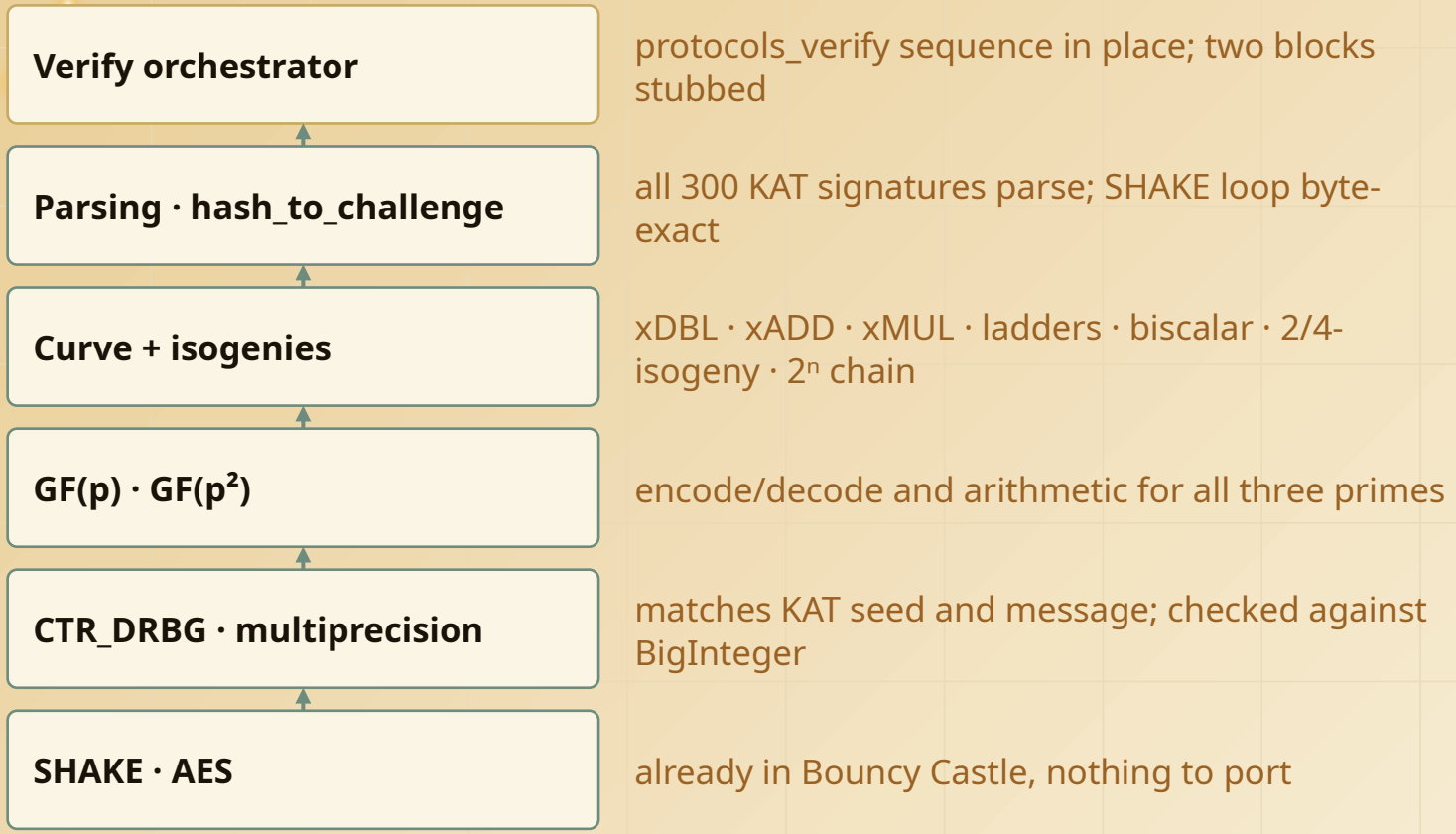

Every tier: capture vectors from the C harness, pin the Java byte-exact, then move up.

Thousands of lines of field and curve arithmetic landed correctly.

The workflow got codified: repeatable, not heroic

CLAUDE.md

First version, then split into docs/claude/*.md: build and test, architecture, conventions. Reference quirks go here.

Hooks

After every edit: run the IntelliJ checkstyle. On failure run the formatter.

Skills

Bcpqc-add-signature-algorithm, vulnerability-analysis · bc-crypto-review

Memory

SDitH quirks, the BCPQC-vs-mainline rule, the bare-signature contract: written once, applied to every later port.

Stalls: 21,000 lines of constants

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~29K
lines of algorithmic C · ported tier by tier

~21K
lines of Sage-generated constants per level · the stall

~1.5K
lines of theta-isogeny (2,2) chain · the other stall

- **The model ports algorithmic C.** It does not accelerate transcribing or regenerating tables that need the original Sage toolchain.
- **Left alone it computes the tables** rather than importing them.
- **Two verify blocks stayed stubbed:** basis-from-hint (needs precomp) and the theta chain.
- **Human time on SQIsign went here,** plus the quaternion-algebra and LLL routines in keygen.

Passes KAT, still wrong

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Reference quirk in the SDitH port	cat1_gf256	cat3 / cat5 (p251)
Raw Keccak vs SHAKE padding	passes	fails
Opposite sign convention in the SD equation	passes	fails
Different secret-key byte layout	passes	fails
Different XOF consumption order	passes	fails
NB_PARTIES = field size, not 2^k	passes	fails
Different signed-message framing	passes	fails

A green KAT on the default parameter set is not evidence of correctness.

The model will declare victory. Force it onto the hard parameter set.

Why cat1 hid it: with GF(256) the field is a byte, so layout and XOF-order errors line up by accident, and XOR steps cancel sign errors. p251 has none of those coincidences.

The envelope that survived five ports

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What the reference KAT harness writes (crypto_sign “sm”)

signature (fixed length)	message …

What the spec defines, and what a MessageSigner must return

signature (exact length)

verify(): exactly this length, else false

Round trips test that you match the harness, not the spec.

- **Five schemes shipped it:** MAYO · SNOVA · QR-UOV · SQIsign · AIMer
- **Why it survived:** sign-then-verify passes with the envelope on both ends
- **Consequence:** every cert, CRL, CMS SignedData and TLS CertificateVerify carried a copy of the signed data
- **Fixed 23–24 Aug 2026 for 1.86 (github #2403);** canonical-encoding bugs in QR-UOV and SNOVA found on the way
- **Now enforced:** exact length, and neither envelope order verifies

The invisible wire

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BC provider
BouncyCastleProvider · what most applications register

loadPQCKeys()

one key-info converter per OID
without it: independent service tables

BCPQC provider
BouncyCastlePQCProvider · where the new scheme is wired

Path	With the bridge	Without it
KeyPairGenerator / Signature via BCPQC	works	works
Unit tests in the BCPQC suite	pass	pass
CertificateFactory.getInstance("X.509", "BC")	decodes the key	public key is null
PKCS#8 / CMS / S/MIME through BC	works	silently fails

90% done is 0% shipped. Test BouncyCastleProvider.getPublicKey() for every parameter set.

Wrong template, and the guardrails

Generalising from the wrong example

- **Policies written from ML-DSA:** FIPS 204, standardised, mainline
- **So SQIsign went to mainline too.** Wrong: Round 2/3 schemes belong in BCPQC
- **Corrected** by a human
- **Pattern:** the most prominent example wins, not the correct one

Its own safety tooling got in the way

"Algebraic-property tests (not byte-level, because the auto-mode classifier blocked the C harness build at this stage)"

sqisign-reference/JAVA_PORT_STATUS.md

- **The verification bar dropped** from byte-exact to algebraic
- **Crypto work trips classifiers constantly** notice when it lowers your standard

What KATs never see

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Scheme	Secret-dependent behaviour found after landing	Fixed
FAEST	grind check and challenge decode returned early on secret-derived data	31 Jul
SNOVA	Gaussian elimination: pivot search, conditional row swap, zero-factor skip	31 Jul
UOV	zero-ness leak; guard added	16 Jun
SDitH	data-dependent zero-coefficient skips in secret loops	12 Jun
HAWK	data-dependent branch	28 May

“Performance is not as important as security!” · 21 May 2026, after the model proposed scratch-buffer promotions on secret data

All KAT-identical before and after. The countermeasure was manual audit passes, then the review arena.

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The verification discipline

Every failure on the last six slides was caught by one of these five habits.

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1 The C reference is the oracle

Capture intermediate vectors; pin each primitive byte-exact before moving up.

2 Stash the fix

The test must fail on the original symptom without the fix, and pass with it.

3 Hard parameter set first

cat3/cat5, p251, the awkward field. Not the one where XOR hides errors.

4 Encoding assertions

Exact length, no envelope, zero padding bits, elements in [0, q).

5 Memory across sessions

CLAUDE.md, docs/claude, the skill. Written once, used every port.

An adversarial reviewer, measured

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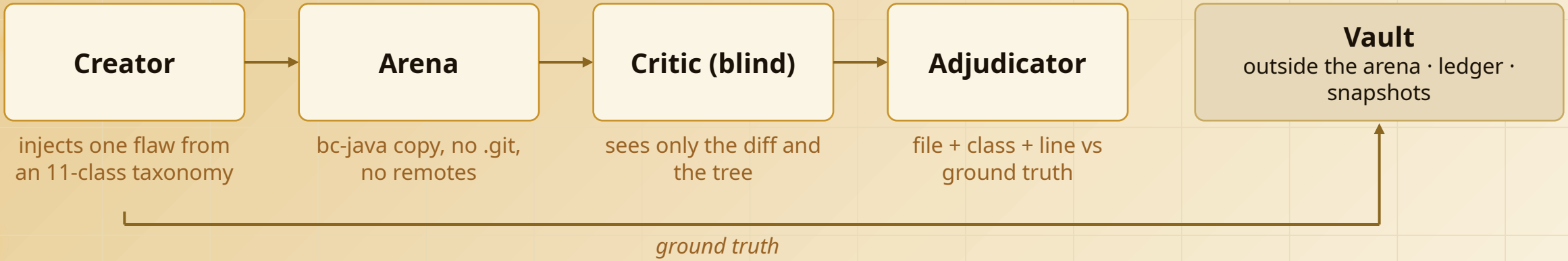

59 / 59
planted flaws caught

0 / 11
clean controls flagged

- **Subtle catches:** widened HAWK norm bound · dropped MPC soundness round · FAEST opening relaxed to zero-fill · QR-UOV rank-deficient solve
- **70 rounds, 13 batches, v1.0 on 20 July 2026.** Shipped as the bc-crypto-review skill.

Shipped, honestly

1.85 · 12 July 2026

- **New:** FAEST · HAWK · QR-UOV · MQOM · UOV · SQIsign · SDitH
- **Also new:** AIMer · HAETAE (KpqC)
- **MAYO** on the OQS interop OIDs; usable in CMS and X.509
- All parameter sets, all KATs green

1.86 · in progress

- **#2403:** bare signatures for MAYO, SNOVA, QR-UOV, SQIsign, AIMer
- **Canonical encodings** inside QR-UOV and SNOVA signatures
- **MAYO** clears the secret buffers the reference clears
- **HAWK** withdrawn from NIST → pqc.legacy
- **Constant time:** FAEST, SNOVA, UOV, SDitH

Takeaways

Same story in both columns: the acceleration was real, and so were the things it let through.

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1 The mechanical 90% takes days, not weeks.
Fifteen files, sixteen steps, six ports in parallel.

2 The remaining 10% is still human.
Precomputed tables, the hardest maths, the one wire no file shows.

3 Green KATs lie. Round trips lie.
Speed is real only with an oracle, the hard parameter set, and encoding checks.

4 Maturity is a checked-in recipe.
CLAUDE.md, hooks, skills, a measured reviewer.

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Thank you. Questions?

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