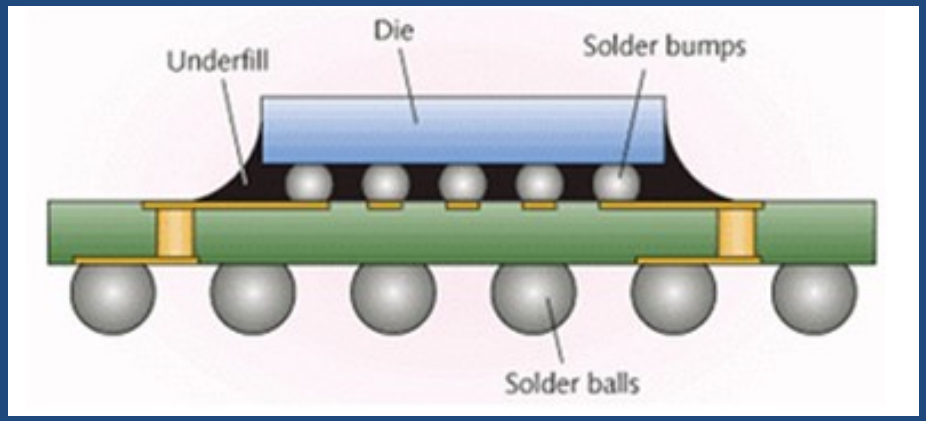
Experience with C4 flip-chip

.....from the point of view of chip design & testing and on behalf of the GBT project

- **Motivation**
- **Implications for design & testing**

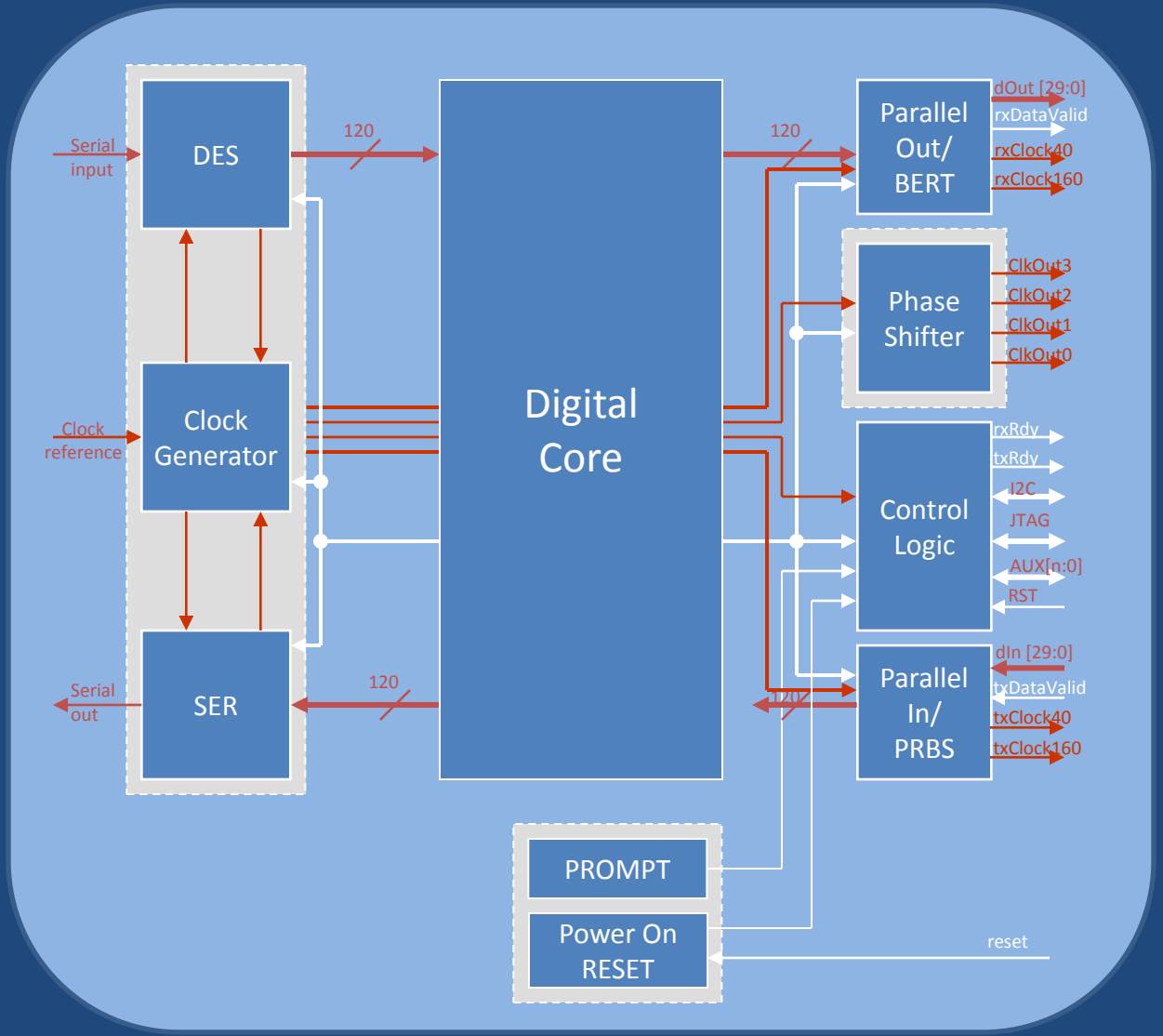
Controlled Collapse Chip Connection



Motivation: GBT-SERDES (prototype GBTX)

4.8 Gbit/s serial data

More details from Paulo Moreira today



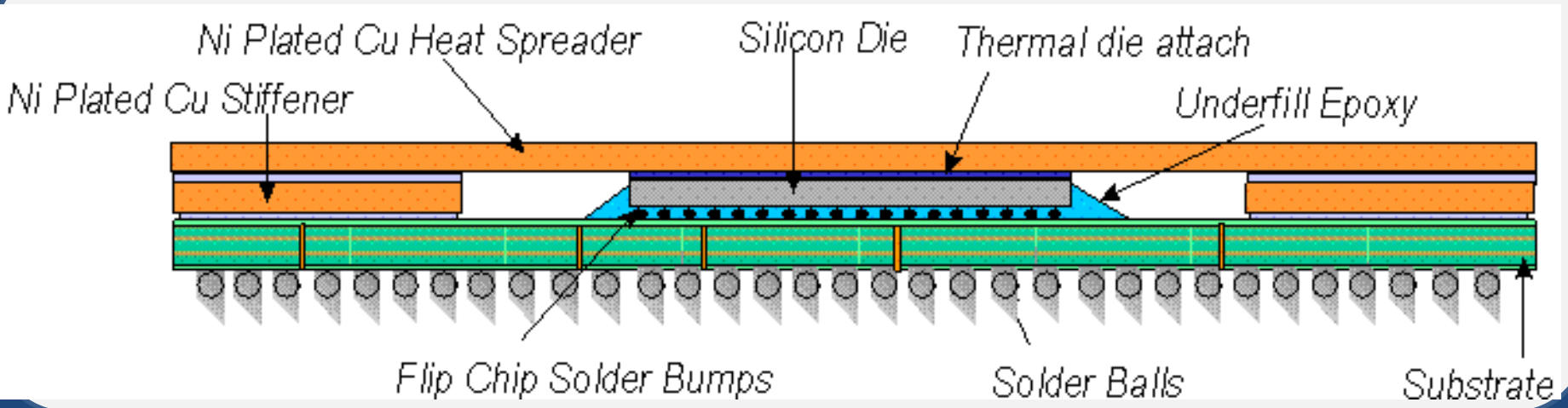
60-bit I/O bus at 160 MHz

.....

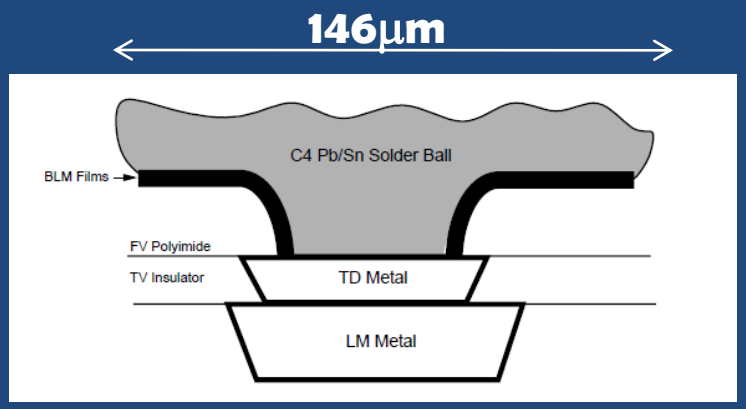
169 pads (but many more for GBTX)

Motivation: GBT-SERDES (prototype GBTX)

- High speed lines: minimise inductance
- Direct powering to blocks
- Direct cooling on back-side (although coverplate is material eg Cu)
- Die size is pad-limited; extra silicon (400 I/Os in GBTX)
- Mount on BGA package



Technical Information



IBM 130nm library
- C4 pad only in LM metal stack
- pad & drivers separate blocks

IBM deposit bumps on wafers;
- more masks => extra cost
- MPWs: split between C4 & wirebond

Size/pitch = "5 on 10" IBM standard (recommended for yield)
= 125/250µm

Package vendor recommended High-Temperature Solder (97Pb3Sn) for reliability

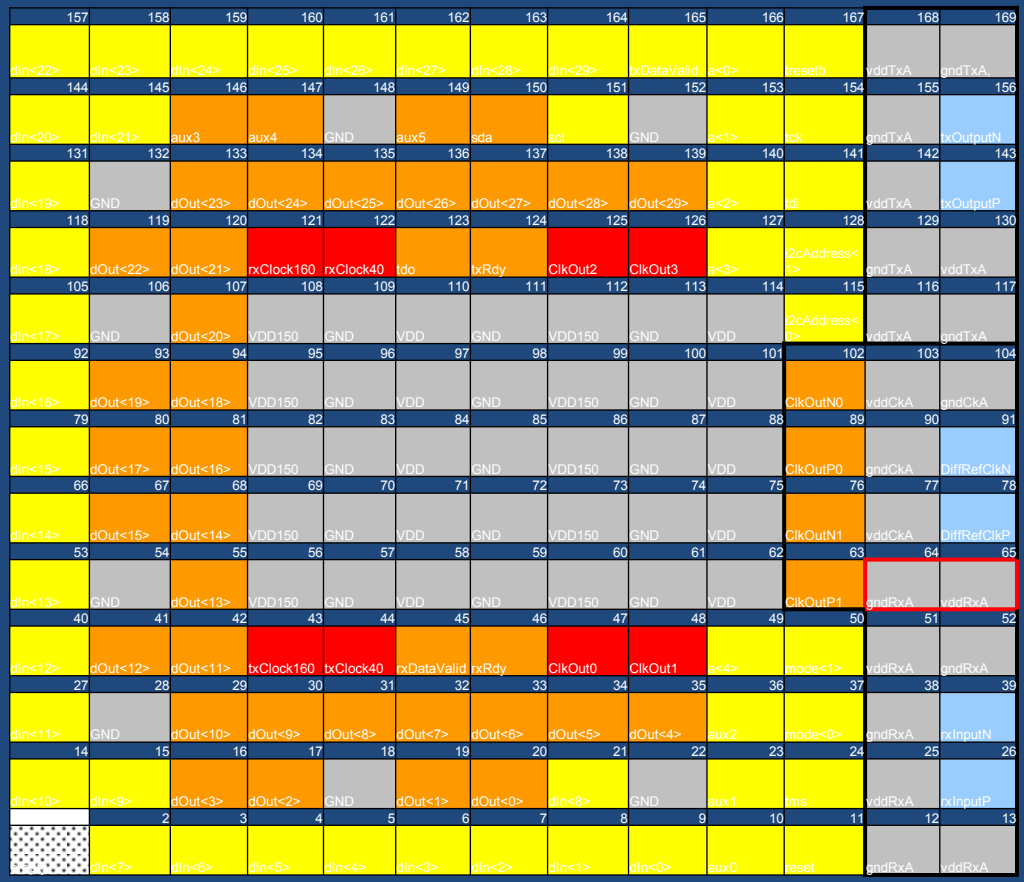
Design Implications

Floorplan at start of design

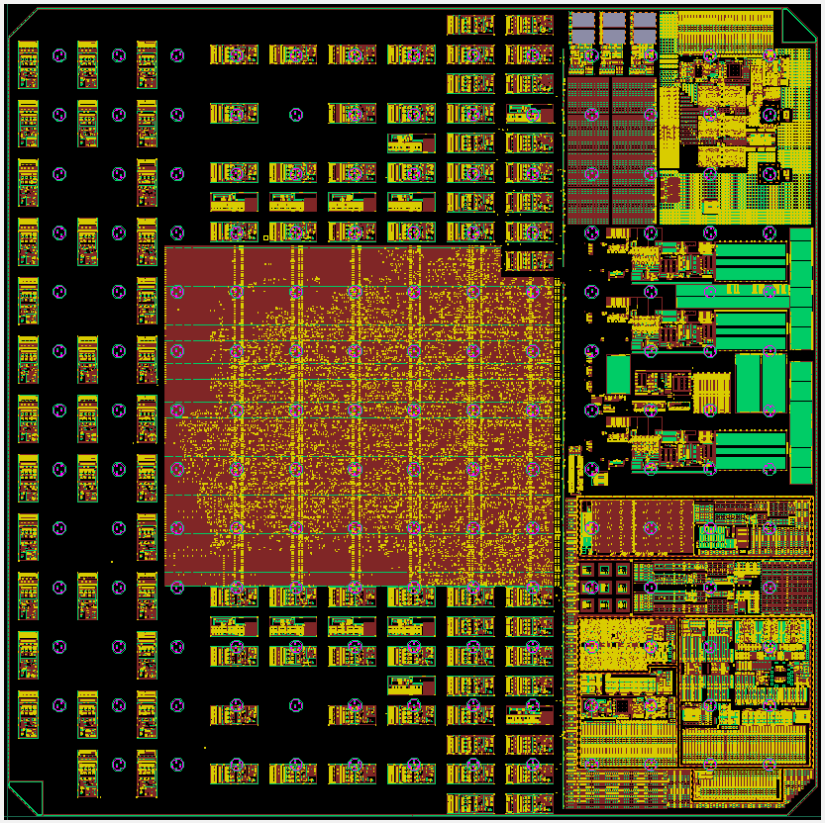
Communicate early with package/hybrid designers
-> we iterated a few times
-> placement of signal/power pads

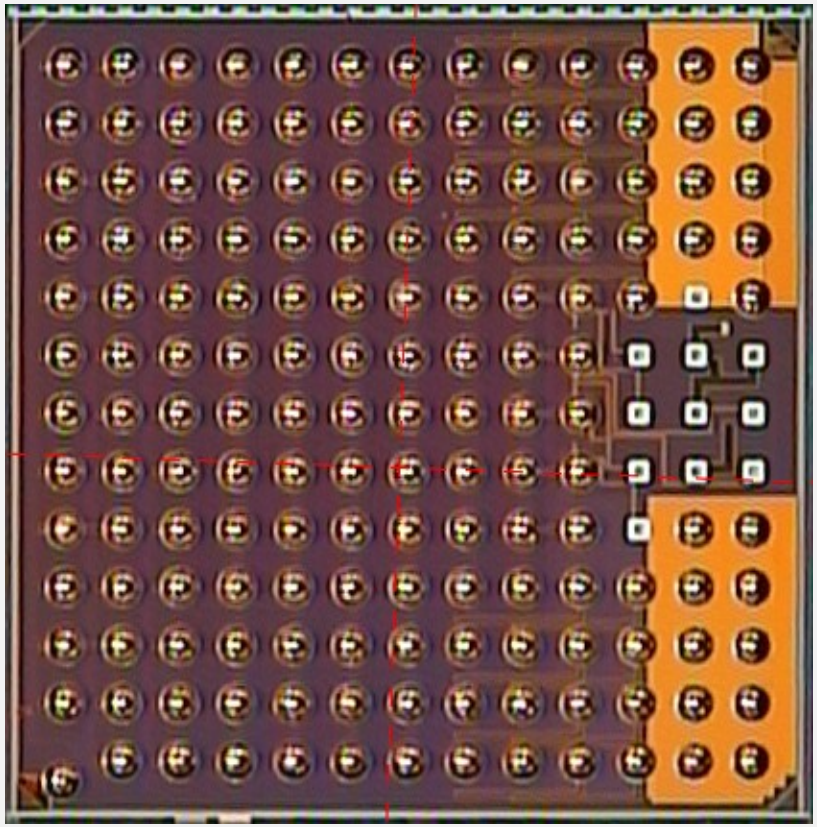
Routing by hand is difficult
-> we used the CERN-VCAD 'digital design flow'
(analog blocks incorporated as black-box abstracts)

Solve ALL DRCs (even if not physical!)



Layout & Bumped Die



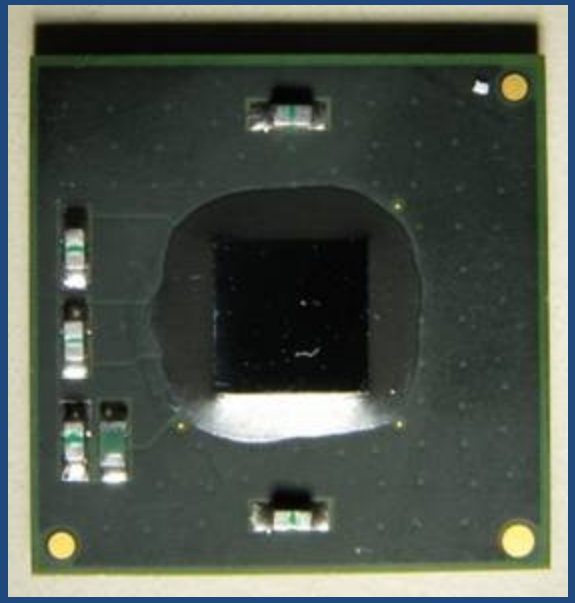


Testing Results

Package designed by Endicott Interconnect

Assembly by Endicott

No cover-plate mounted



No C4 problems found on chips tested so far

Chip testing issues:

Need complex package/hybrid immediately

Package design was significant part of project cost

Chip orientation is bad for radiation testing

attenuation of 10keV X-rays in CERN facility
back-grinding needed for heavy ion tests

Summary

C4 has many performance advantages

Standard industrial process

Requires careful planning: floorplan, package/hybrid

Implies extra financial cost upfront

Extra cost may be offset by savings elsewhere