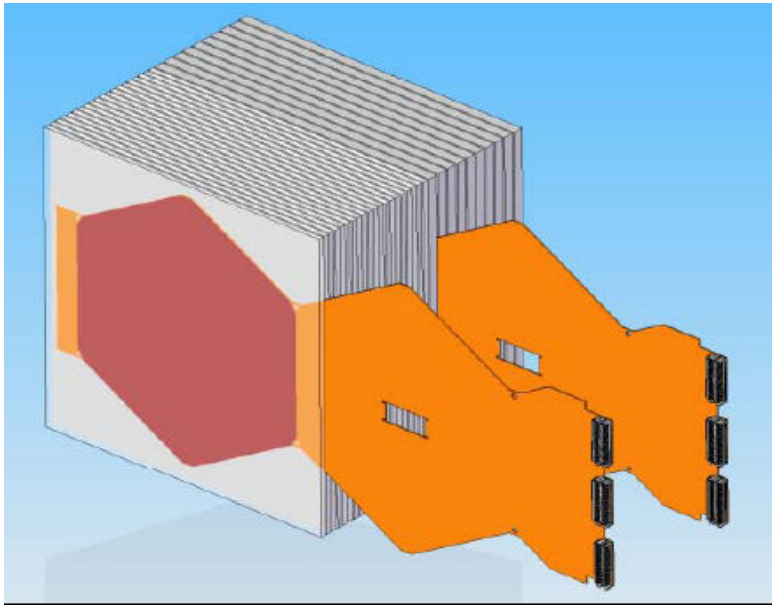
R&D Advances: SiW Calorimeter



LCWS 2010 Beijing
SiD Concept Meeting
March 28, 2010
John Jaros for SiD SiW Group
(thanks to Ray, Ryan, Mani, and Marco for slides)

SiD SiW Group

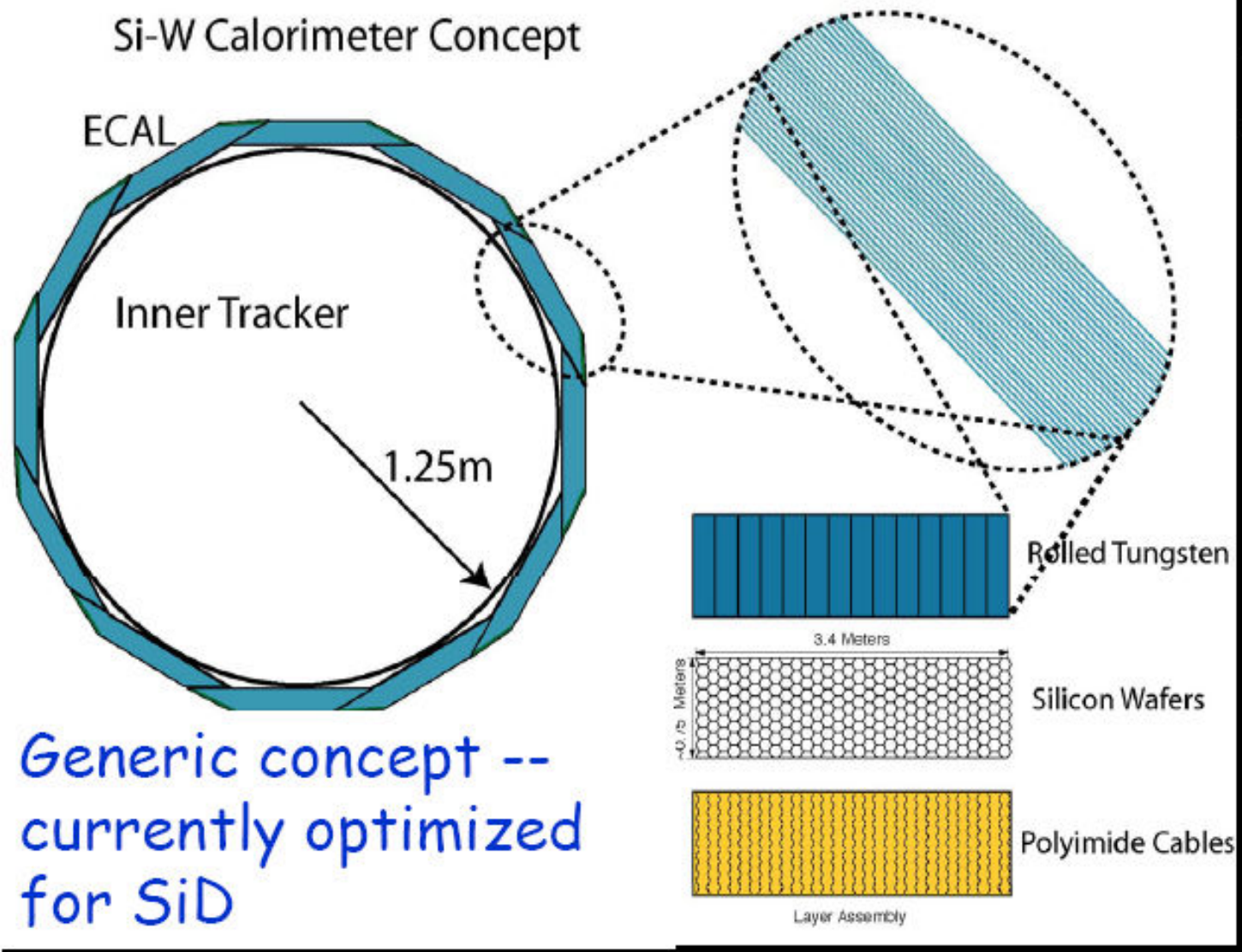
- **Pixel Detector Development and Readout**
  U Oregon (Brau, Frey, Strom)
- **KPiX Readout Chip and Mechanical Prototype**
  SLAC (Breidenbach, Freytag, Graf, Haller, Herbst, Jaros, Nelson)
  BNL (Radeka)
  LAPP, Annecy (Karyotakis)
- **Bump Bonding and Flex Cables**
  UC Davis (Lander, Tripathi, Holbrook)
- **MAPS Alternate (not covered in this talk)**
  RAL (Stanitzki, Strube, Tyndal)

GOALs:

Develop a Silicon-tungsten Electromagnetic Calorimeter for SiD

Produce a Test Module (employing "real" detector technologies) for Beam Test 2010-2011

Si-W Calorimeter Concept



Generic concept -- currently optimized for SiD

Baseline configuration:

- transverse seg.: 13 mm^2 pixels
- longitudinal seg:

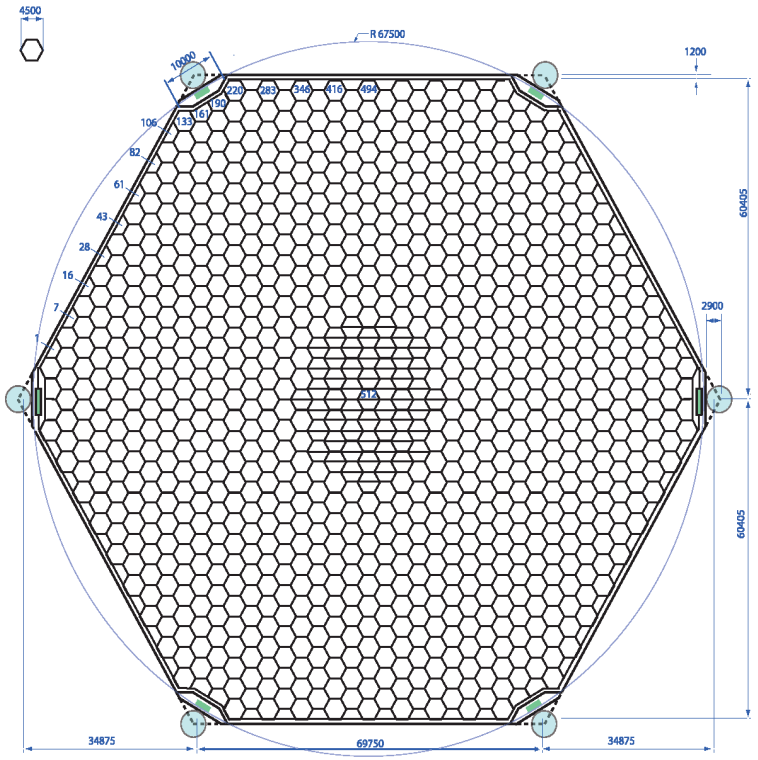
  (20 x 5/7 X_0) + (10 x 10/7 X_0)

⇒ **17%/sqrt(E)**

- 1 mm readout gaps ⇒ 13 mm effective Moliere radius

Sensor Status

V2 Sensor

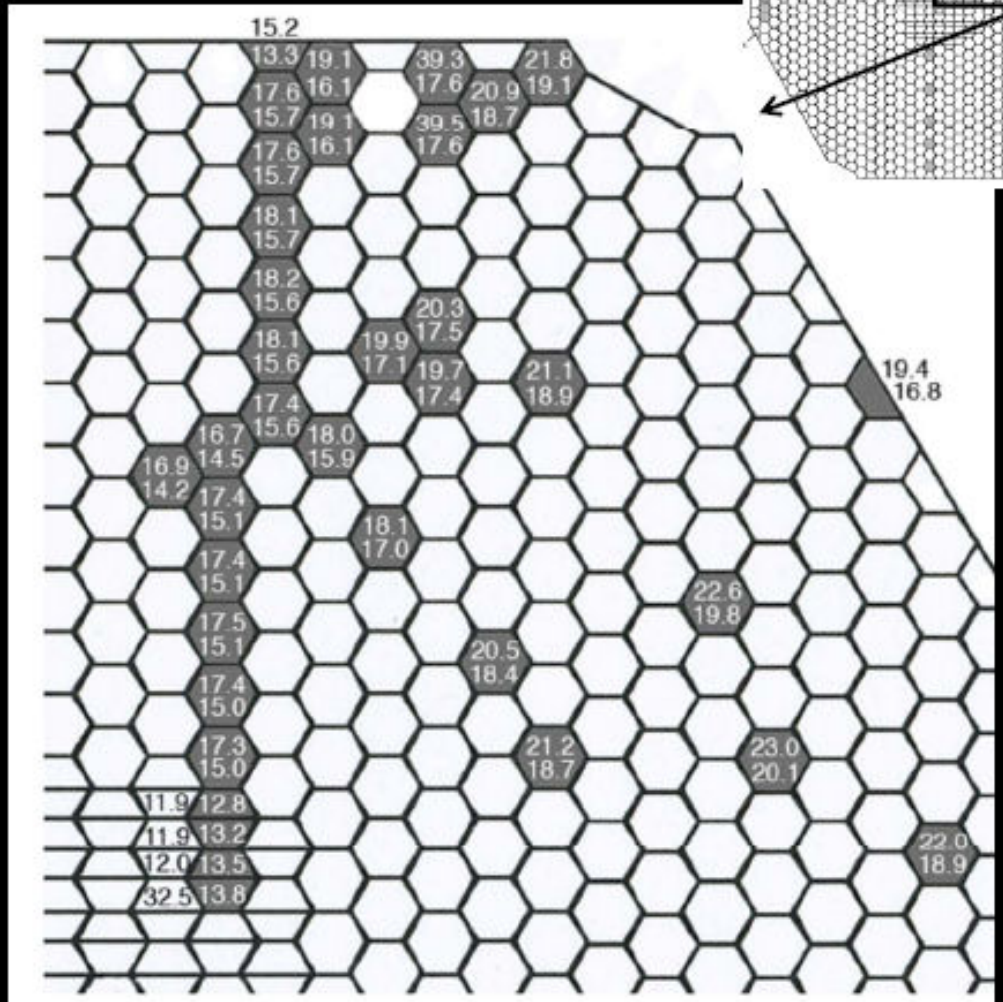


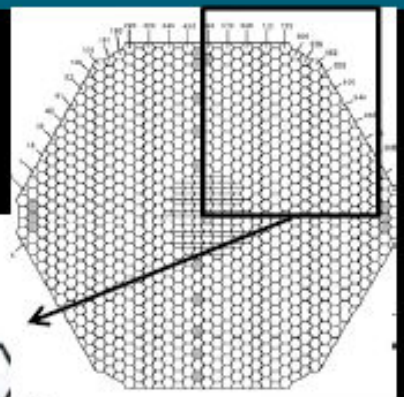
- **Have Hamamatsu sensors in hand**
  10- V1 used for interconnect studies
  40- V2 under test and for prototype

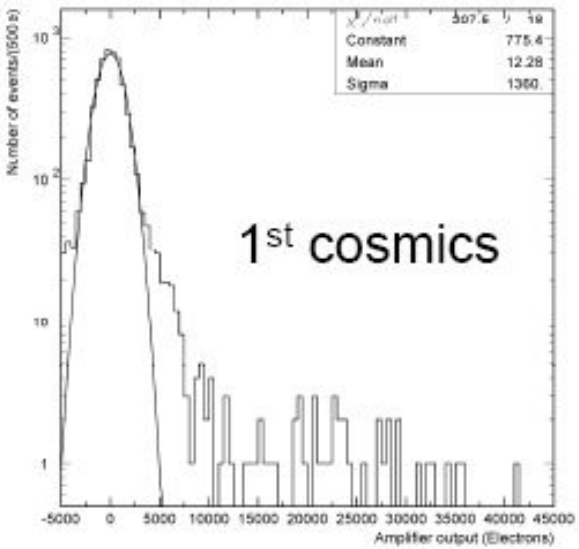
- **Plan for this Spring.**
  With a 512-channel KPiX-9 bump-bonded to a sensor, get noise measurements for the full range of input capacitances and resistances.

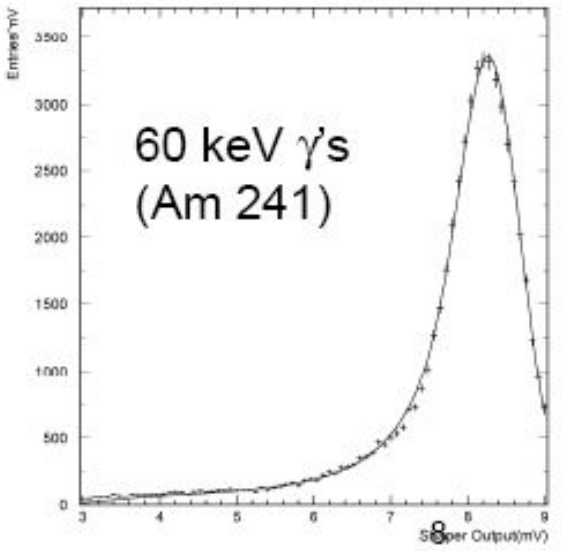
Initial studies of version 2 sensors

Capacitance:
expected/measured



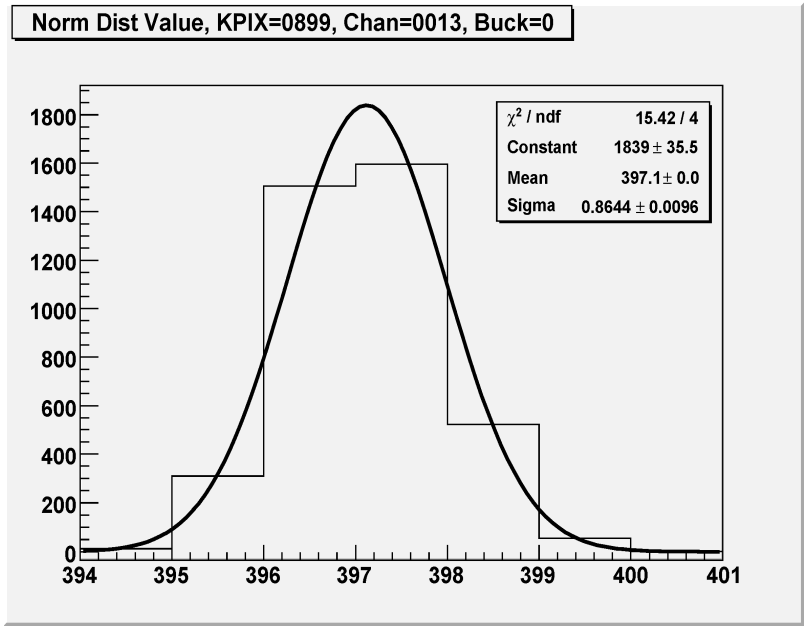




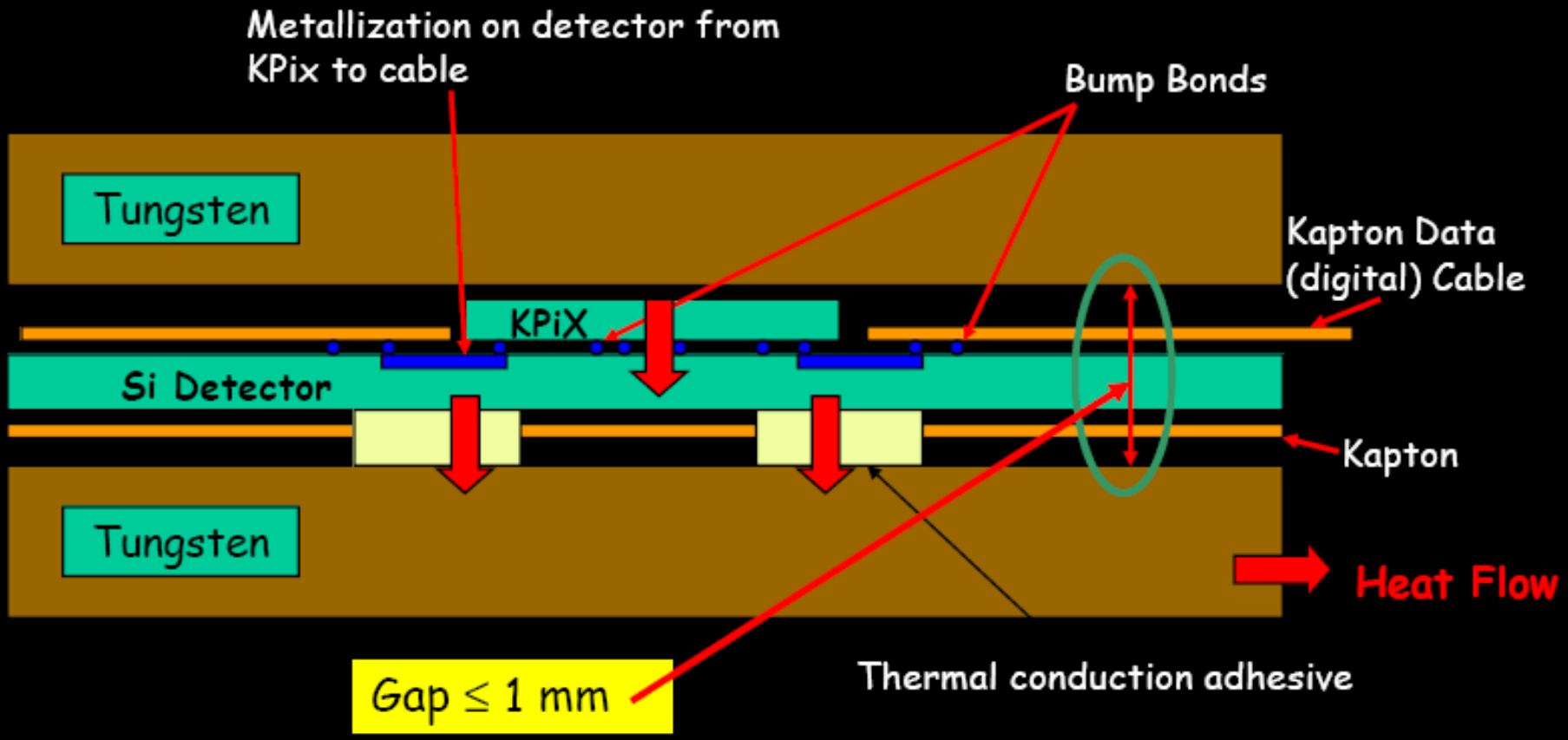


KPiX Status

- KPiX-8 (256 channel) under test.
  - * Noise measurements
    rms = 1300 e- (5% mip)
    OK for Ecal
  - * 40-50 mW/1000 channel
- KPiX-9 (512) just arrived SLAC.
  Design includes
  - * Further noise reduction
  - * Power reduction (->20 mW)
  - * More input protection for GEMs
- KPiX-10 (1024) order Summer '10

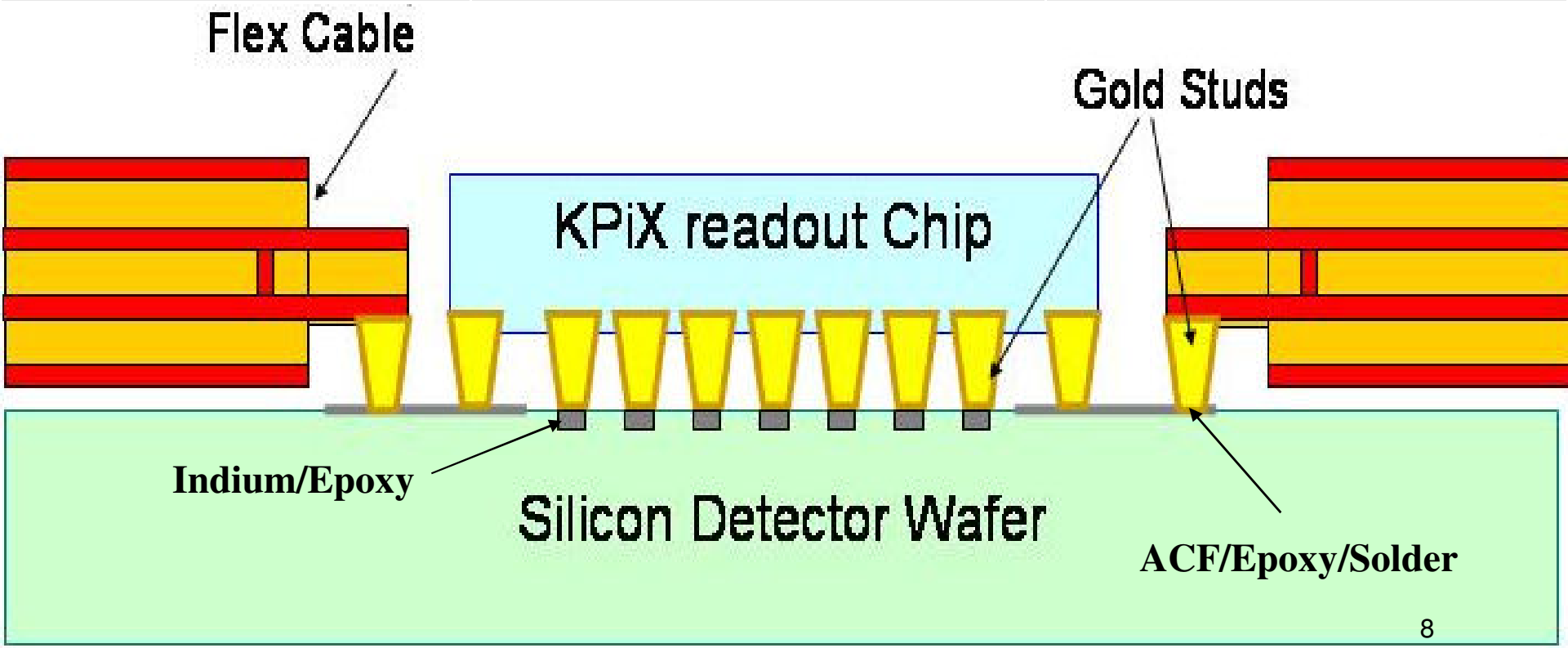


Readout gap cross section (schematic)

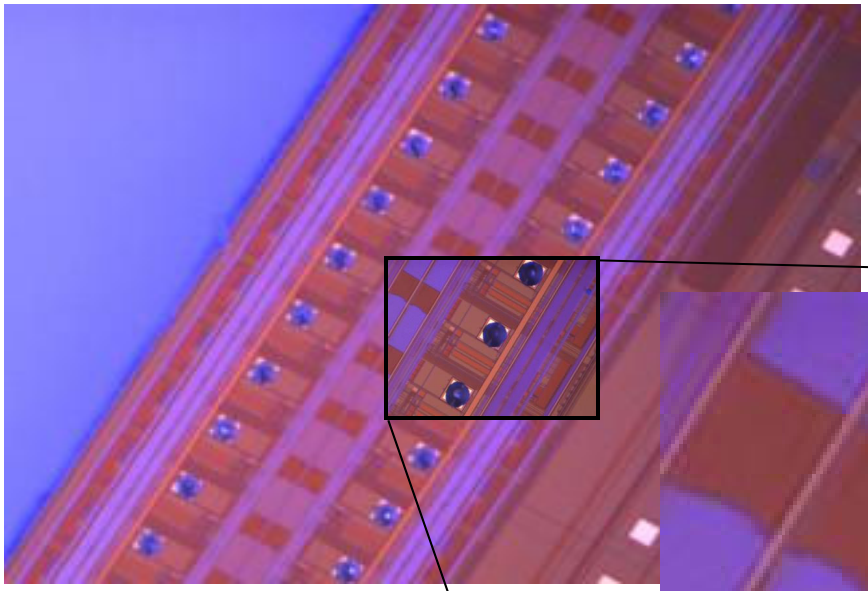


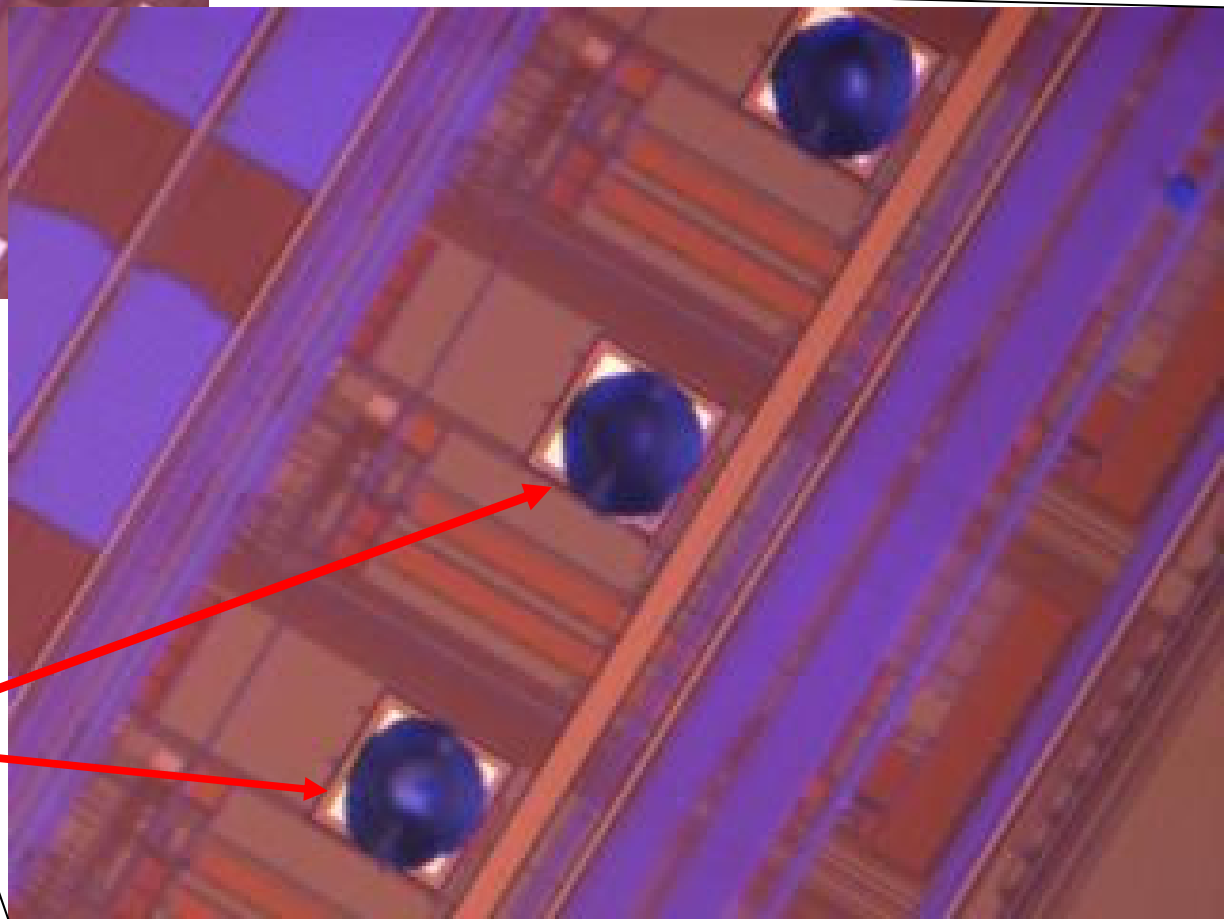
Interconnect issues: Technologies being considered

	Prototyping	Production
KPiX to Sensor	Gold Stud Bonding (Epoxy/Thermo-compression)	Indium/Solder Bump Bonding
Flex Cable to Sensor	Solder Balls Conducting Epoxy Anisotropic Conducting Film (ACF)	ACF?



KPiX with Gold Studs





Studs are well-formed and centered on the 70x70 μm pads.

Gold Stud Attachment

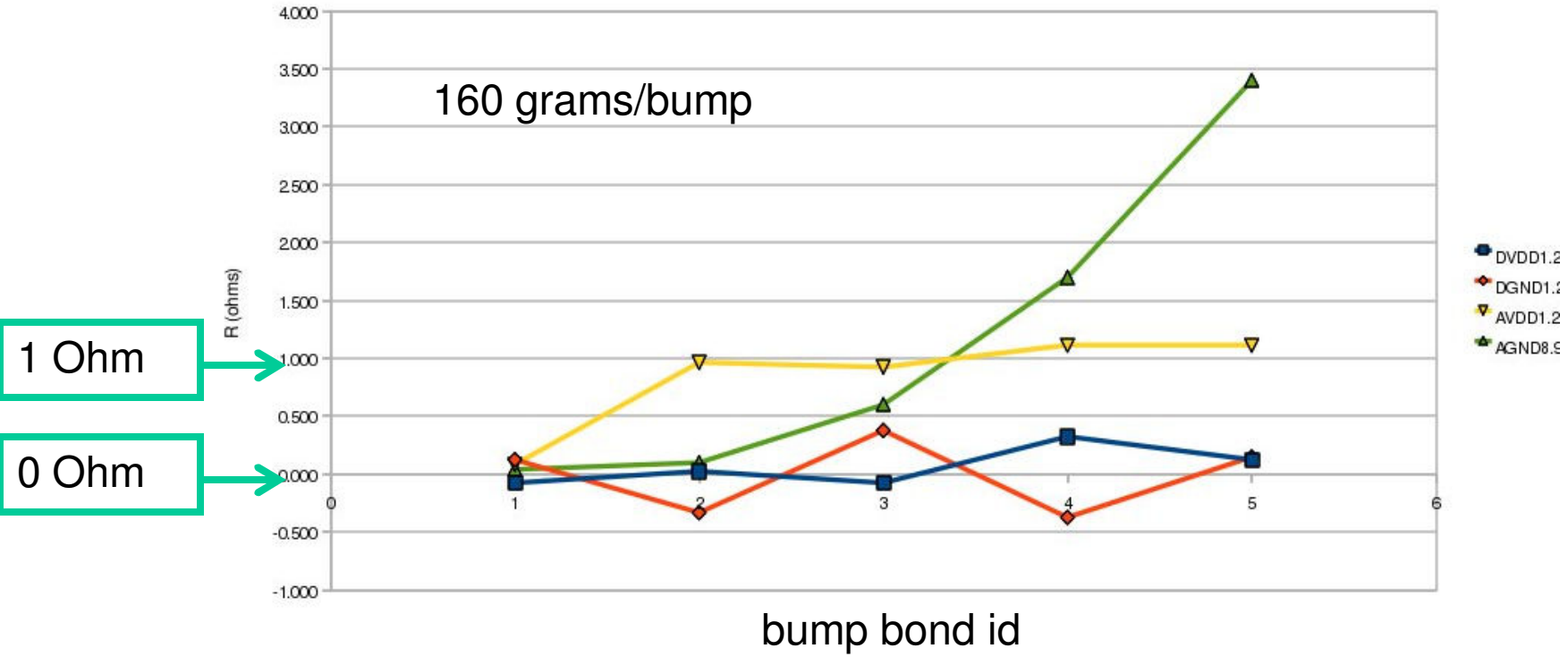
Three possibilities:

1. Conducting Silver Epoxy. High degree of bump height uniformity required. No limit on number of bumps. Low temp and pressure. Good success for large pads (>100 um). Work in progress for 50 um pads.

2. Thermo-compression. Typically, high temp and pressure: 300-350C and 150-200g/bump. Machine limit ~100-200 kg => Limits total number of bumps.

3. Thermosonic. Lower temp and pressure: 150C and 75g/bump. Limit on total number of bumps because of the limit on total deliverable ultrasonic power without breaking the chip.

gold-stud attachment via thermo-compression – preliminary results



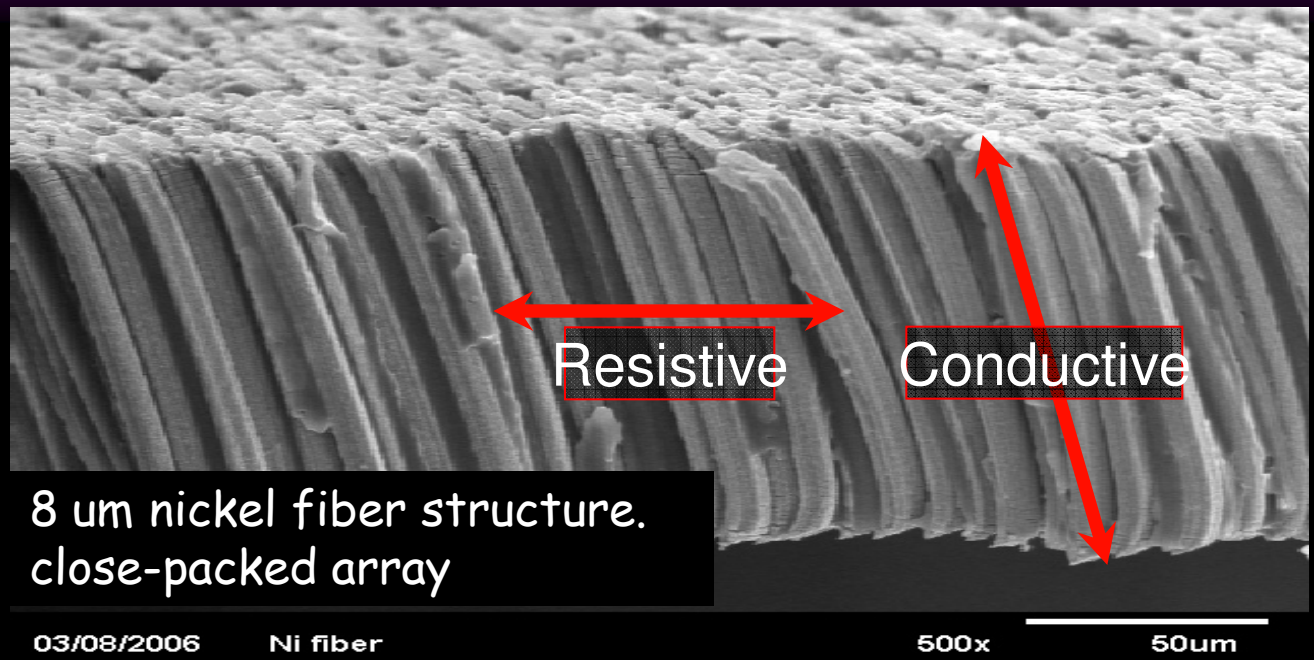
- 160 g/bump provides acceptable resistances for all bumps
- 100 g/bump was insufficient: 4 of 20 bumps were ~open
- Further study required:
  - Explore pressures greater than 160 g/bump
  - Pressure > 1 GPa gives some punchthrough of SiO2 between sensor metal layers – need to optimize temperature (gold softness) and Press

Thermoplastic Conducting Adhesive (ACF)

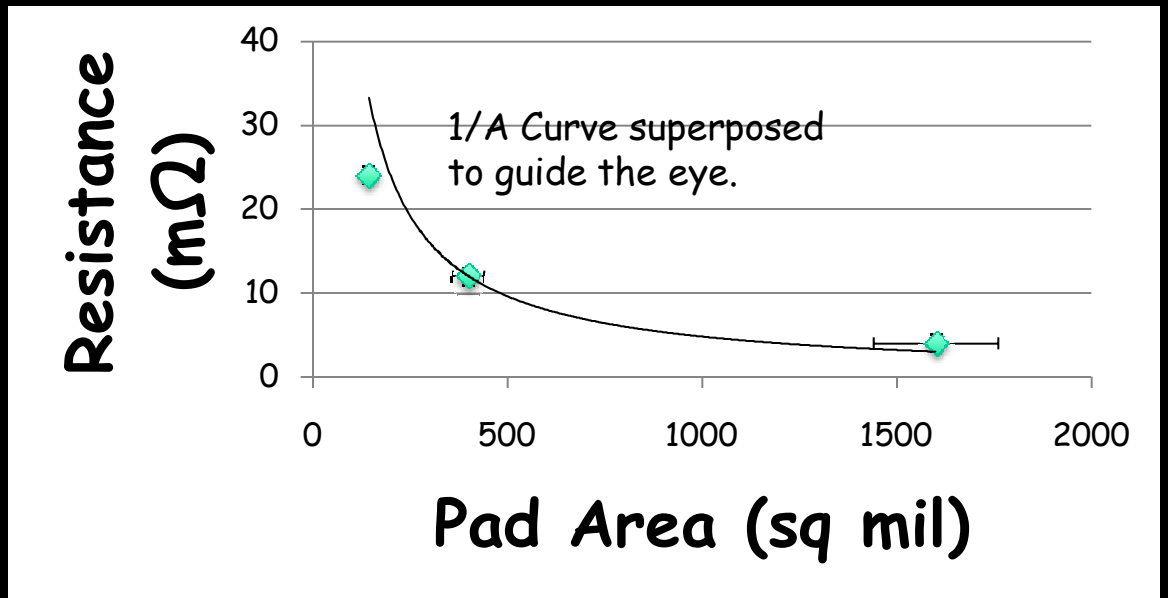
Btechcorp:

Metal fibers in a matrix ~2 x 10^7 fibers/in^2

Low Cure pressure: 50 psi



8 um nickel fiber structure. close-packed array



← Initial results are promising. Goal for Flex Cable pads (100 sq mil) is ~100 mΩ, which is achievable.

ECAL Mechanical prototype

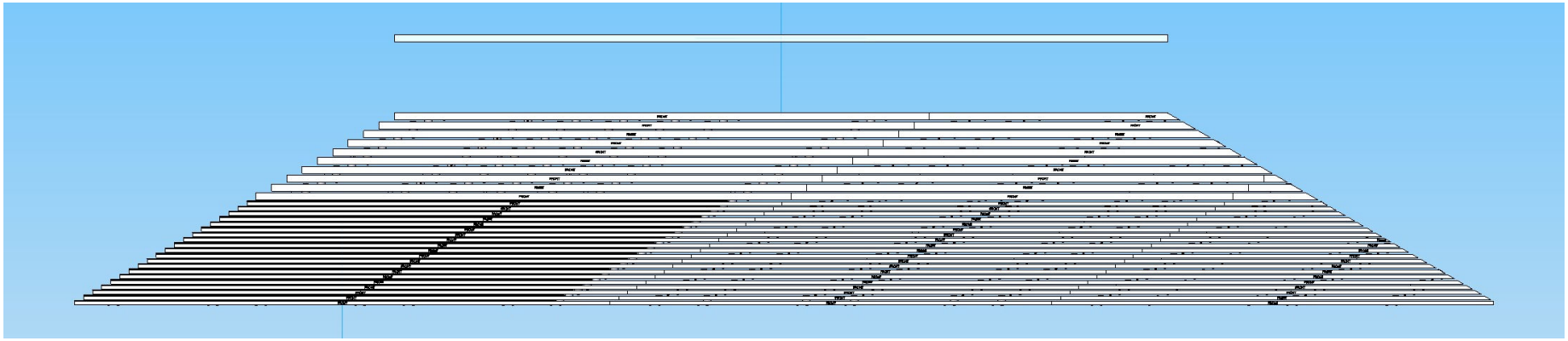
Plan to make a full scale prototype, full width, full thickness, short zee length

Stainless steel in place of Tungsten

We have 30 plates SS304L, 36”x48”

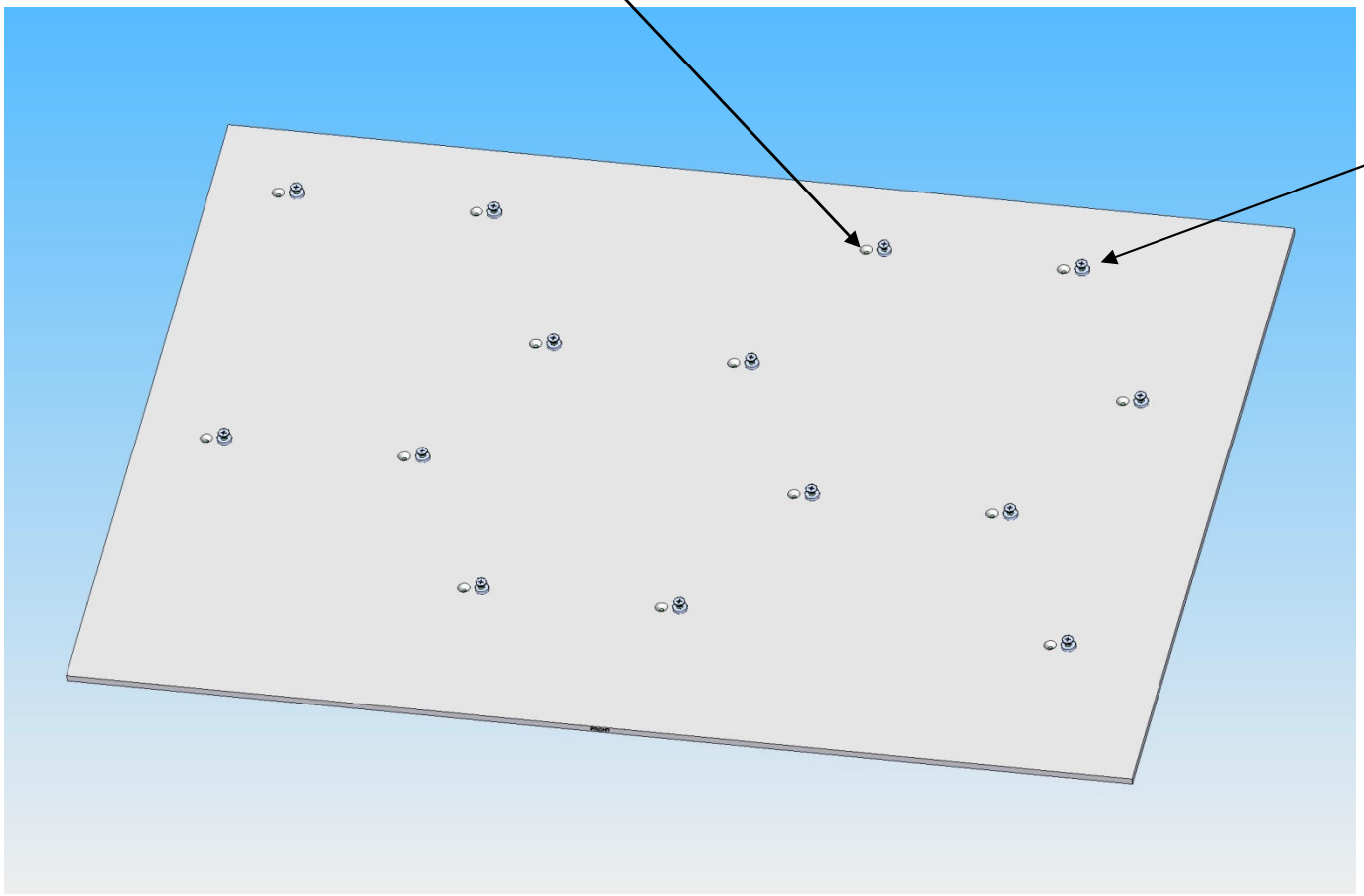
Perfect Test bed for

- the small screws design
- The integration of the electrical interconnections
- the cooling cold plates

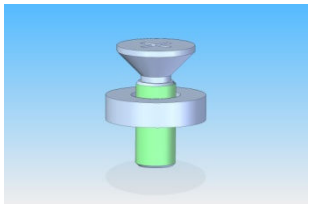


ECAL Mechanical prototype

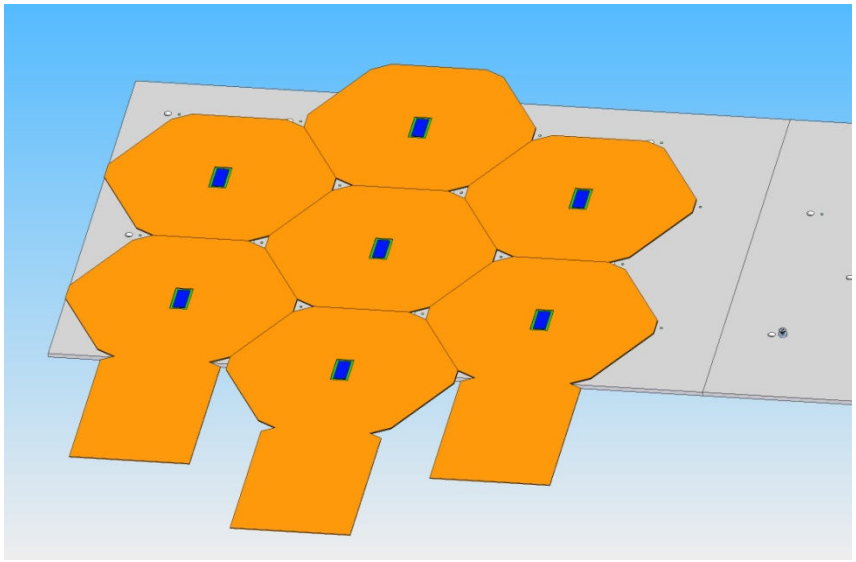
M2 tapped hole

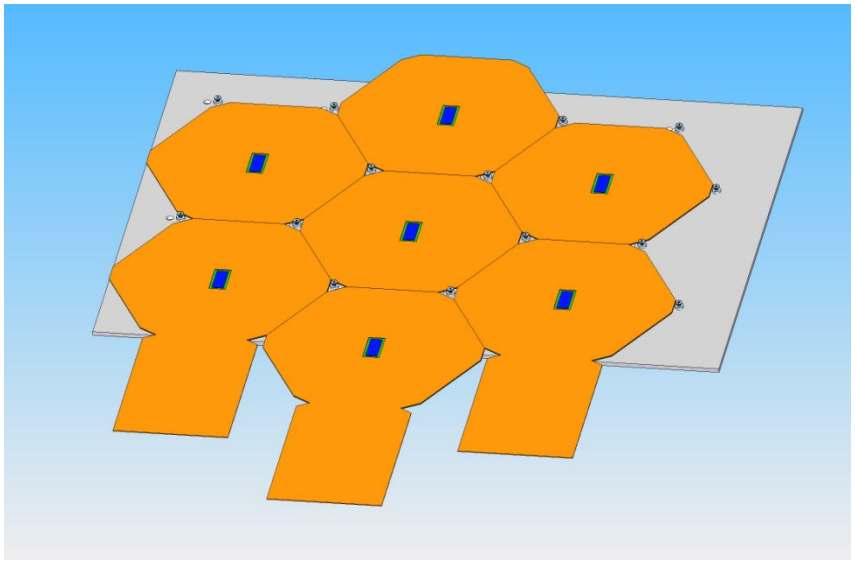


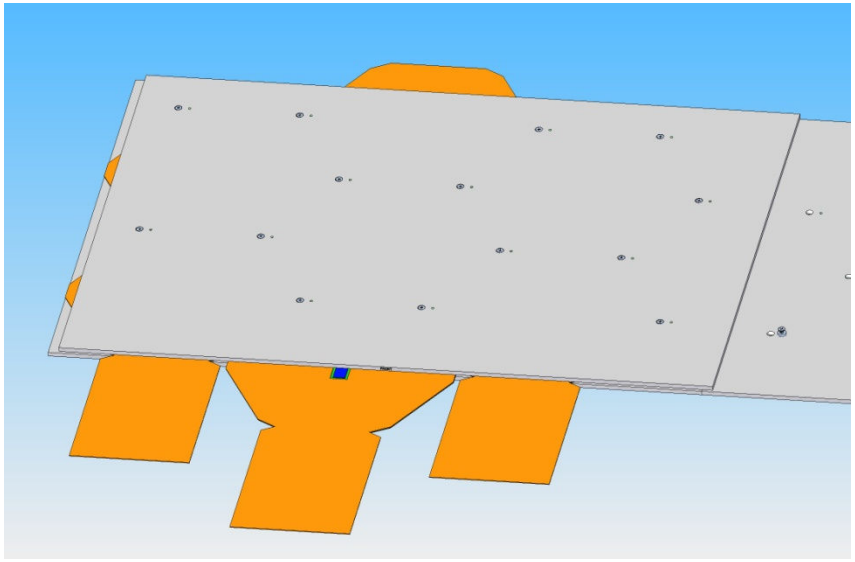
M2x6 screw + spacer

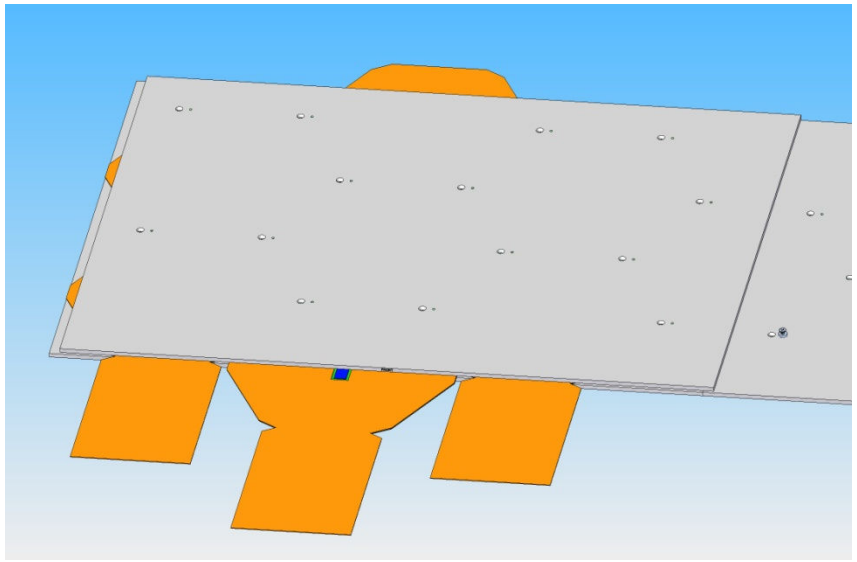


ECAL Mechanical prototype









Summary goals, progress, plans

	Year 1 (7/2009–7/2010)	Year 2 (7/10-7/11)	Year 3 (7/11-7/12)
Goal	Complete R&D on component technologies	Assemble test module, start beam test	Beam test, data analysis
Status	• Sensors – OK •Tungsten – OK • KPiX – 512 channel chip to be evaluated. If ok, order 1024 KPiX. • KPiX-Si bumps: need to converge on technology – gold stud thermo-compress? • Flex cable – ok • Cable-Si connect: needs R&D – ACF?	Need the integrated tests first. Flex cable can be done separately; same for DAQ	tbd
Plan	• Have 1024 KPiX and bumping technology by summer for combined testing in lab. (512 KPiX would be ok for initial combined tests.) • indium/solder bb as fallback for gold studs • Need to finalize cable-Si technology	If integrated tests look OK, begin planning for beam test. Assume SLAC beam for now.	tbd