

# Story Outline



**Historic work and timeframe**

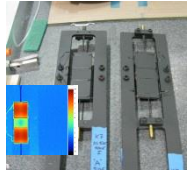
**Interaction between R&D and Projects**

**Challenges current and future**

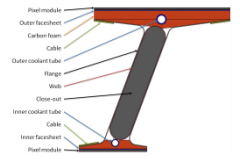
**Phased R&D planning**

# Timeline Past Prototype Development

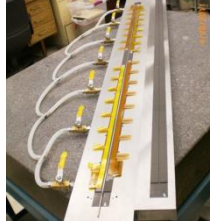
Stavelet Test



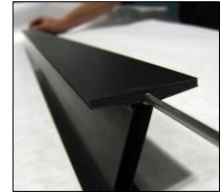
I-Beam Thermal Test



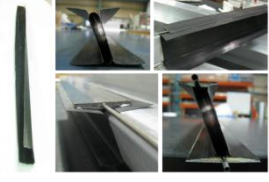
1.4m Stave Buried Cable



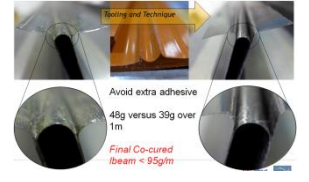
1st 1m I-Beam



Co Cure Studies

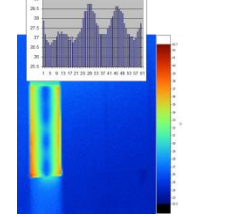


100g I-beam

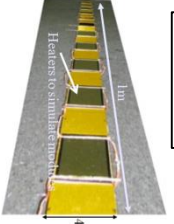


Defect Studies

Thermal Cycling



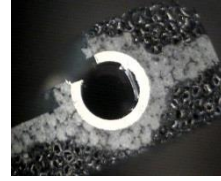
1m Stave Test w/C02



Foam Co-Cure

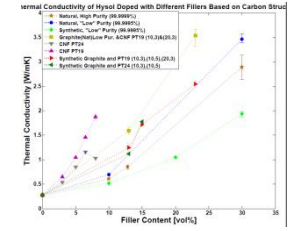


Glue Mass Studies

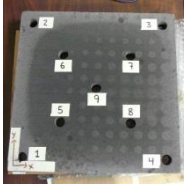


Film Adhesive On Tube/Foam

Adhesive Modification



Allcomp K7



Allcomp K7-130

Allcomp K9



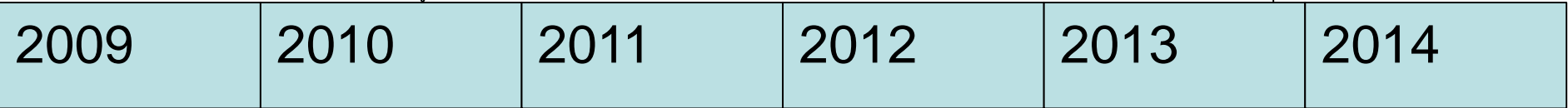
30gsm M46J

LOI

45gsm K13C2U

45gsm K13D2U

30gsm M55J



$\Delta T \sim 12C$     $\Delta T \sim 10C$     $\Delta T \sim 9C$     $\Delta T \sim 8C$   
 (Peak  $\Delta T$  for 4cm module 0.5W/cm<sup>2</sup> 2.2mm OD tube)

$\Delta T > 7C?$

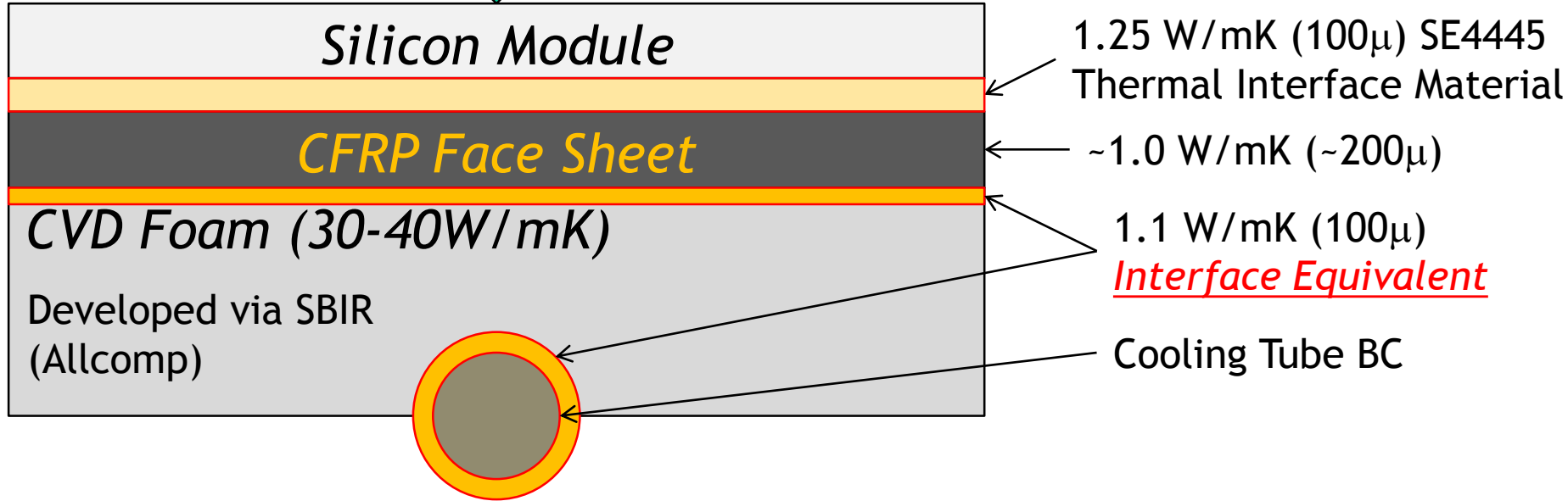
Understand/Improve Thermal Performance

Decrease Mass



# Thermal Interfaces need improvement

$\sim 0.5-1 \text{ W/m}^2$



- All 'Interface Materials'  $\sim 1 \text{ W/mK}$ ; foam and Si  $\gg 10 \text{ W/mK}$
- Improving quality of any one of these can reduce  $\Delta T$
- Current R&D efforts all directed at improving thermal conductivity of Adhesives/matrix resins in Composites—also new phase 1 SBIR topic 29D

# New Challenges



- **Discussions at Pixel 2016/18 indicate large push for CMOS detector tech**
  - Heavy Ion Experiments (Low data rate, Low Radiation) → LOW Power
  - HEP Detectors e.g LHC Upgrades FCC? (High data rate, and thermal runaway) → still High-ish Power
- **Reduction in mass will always be interesting**
  - State of art 0.35% X0 both air and water cooled (HI)
  - Serial Powering and DC/DC reduces mass of power services (done in ASIC's)
  - Increased Data rates make Data services as massive as former power services currently...
    - Optical readout at low radius not viable presently
    - CMOS does not solve this problem...

# R&D Targets



- **Reduction in structural Mass**
  - Minor gains—already near minimum and structural mass a small fraction of total mass
- **Thermal performance for conductive cooling**
  - Need to enhance thermal performance of structural materials, continuation of current R&D
  - Still required for HEP and High Data rates
- **Reduction of mass of Data Services**
  - Data services now represent the largest fraction of mass in current and future detectors
  - Wireless is not really an option in the next decade
  - Optical readout is a packaging and ASIC problem
  - CNT (Carbon Nano-Tube) data transmission has some R&D examples in industry

# Parallel efforts



- R&D in mechanics is often limited by funding for FTE
- Use of current project efforts and upcoming proposals focuses our effort in engineering
  - sPHENIX and EIC have upcoming new needs, both Heavy Ion experiments, likely CMOS low power
    - Reduced mass, perhaps Air Cooling 2020-2025 (current)
  - ATLAS/CMS replacement L0/L1 Pixel systems
    - Concentrate on Data Service Reduction 2027+ (future)
- SBIR, LDRD, and direct R&D
  - SBIR works directly with business, awarded yearly with 2-5 years to 'commercialization'—existing or proposed projects
  - LDRD internal 2-3yr funding opportunity for 'future projects' to get to 'early stage'
  - Direct R&D supports existing 'early stage' projects