The Photocathode Program of the Large Area Picosecond Photo Detector (LAPPD) Project

The PC-group

(Klaus Attenkofer)

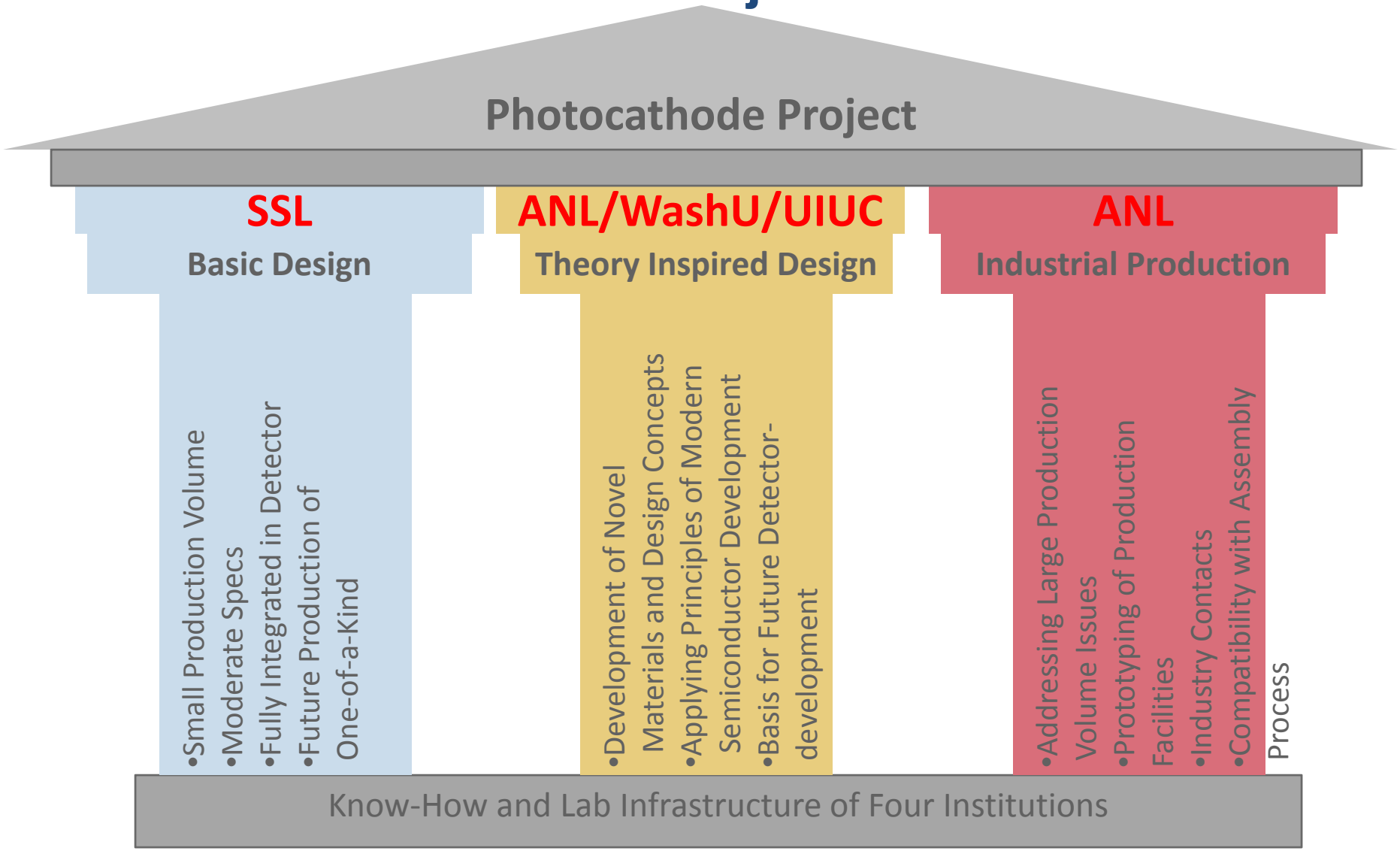
What are the Goals & Milestones:

- Goals: Bridging applied and basic sciences
  - Modern materials sciences approaches to tailor various properties of photocathodes
    - Wavelength response
    - Dark current
    - Timing response
  - Creating (using existing industrial capabilities if possible) appropriate production facilities
    - Proof of principle
    - Evaluating various recipes and approaches and selecting most cost-efficient processes
    - Creating prototype facilities which allows an industrial production (appropriate to the market conditions (~ 40,000 detector units of 8”x8” per year)
    - Understanding cost-quality relation ship (unit price versus QE, dark current……)
  - Creating new programs which build on expertise and know-how of the collaboration

What are the Goals & Milestones:

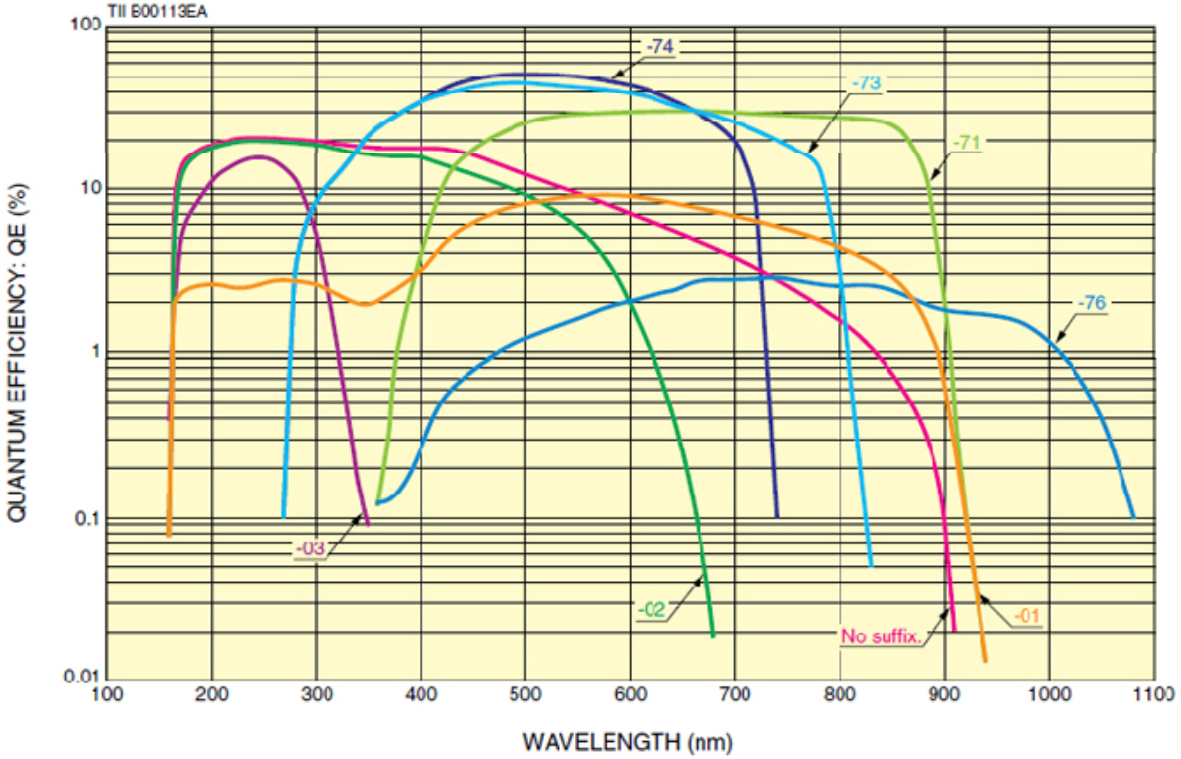
- 2010 (end of June)
  - Identify and characterize photo-emission properties of materials for photocathode development.
  - Upgrade existing vacuum transfer facility to match the 8”x8” square module assembly.
  - A design, including costing and interfacing with vendors of production sealed glass tubes, for a vacuum transfer/assembly facility for the 8” square module assembly.
  - Demonstration of an 8”square operational PC.
- 2011 (end of June)
  - Design and costing of a photocathode characterization facility.
  - Design and costing of an 8” glass tile assembly facility.

The Three Pillars of the Project



The Photocathode Families

Hamamatsu: http://jp.hamamatsu.com/products/sensor-etd/pd014/index_en.html



Suffix	Photocathode	Input Window
-71	GaAs	Borosilicate Glass
-73	Enhanced Red GaAsP	Borosilicate Glass
-74	GaAsP	Borosilicate Glass
-76	InGaAs	Borosilicate Glass
Non	Multialkali	Synthetic Silica
-01	Enhanced Red Multialkali	Synthetic Silica
-02	Bialkali	Synthetic Silica
-03	Cs-Te	Synthetic Silica

- Required spectral response still not clear (main application)
- Future applications (combination with scintillators) will require response optimization

Why we had Planed a Large Cathode Effort?

- **Multi-Alkali seems to have perfect cathode properties**
- But
  - Little understanding
  - Small community
  - No developed Industry
  - **Problems with mass-production**

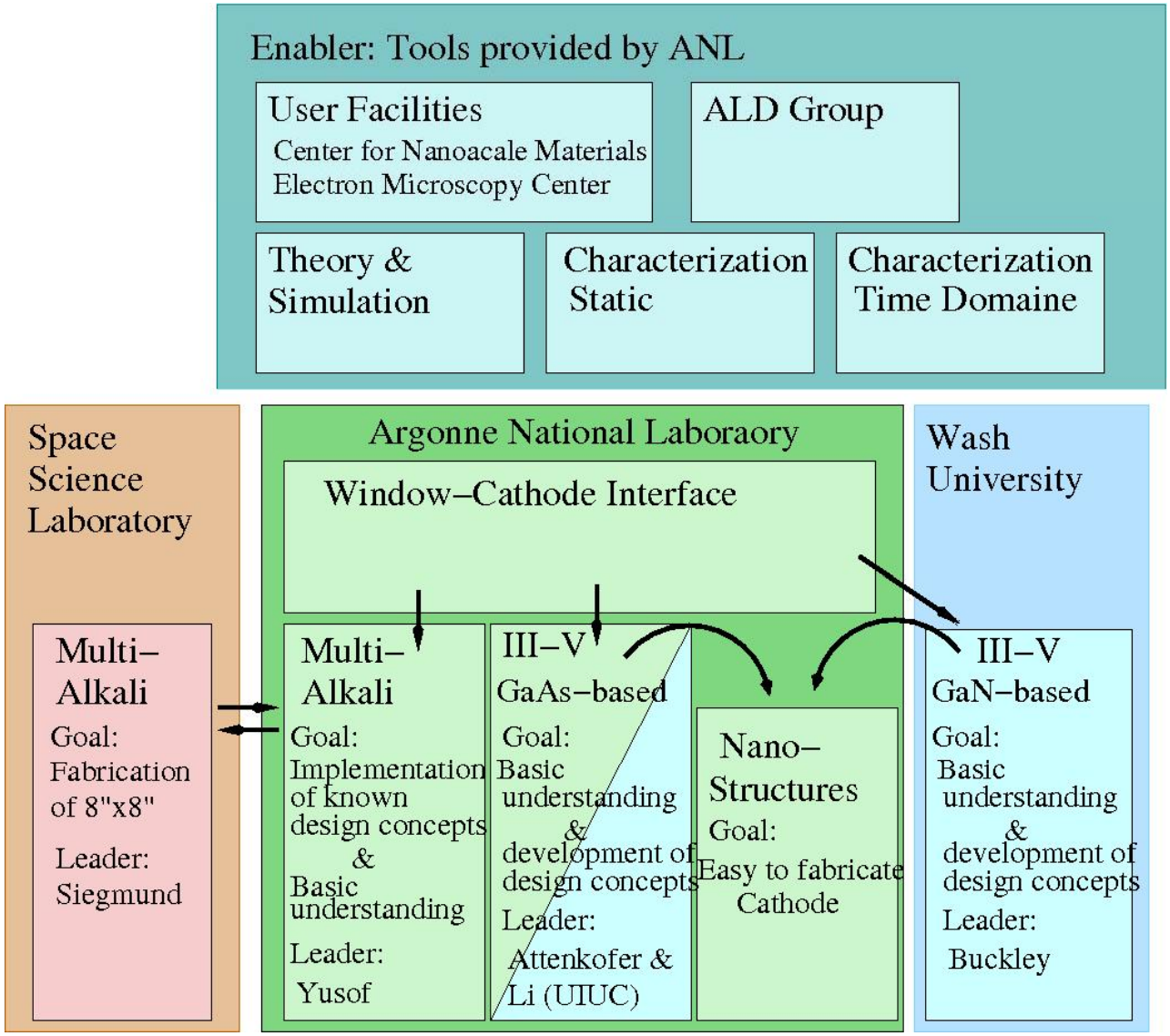
- **Existing III-V cathode have not the right properties**
- But
  - Excellent understanding
  - Large community
  - Excellent developed Industry
  - Easy mass-production

	Property	Multi-Alkali	GaAs-based	GaN-based
Photocathode Properties	Wavelength response (typical)	150nm-500nm	450nm-850nm	100nm-350nm
	Typical efficiency	20%	20%	30-40%
	Maximum efficiency	50%	60%	80%
	Wavelength tunability	low	large	Very high
	Dark current	~100cps/cm2	~10000cps/cm2	~100cps/cm2
Growth properties	Single crystal substrate	no	yes	yes
	Easy scalable	No	yes	yes
	Large production volume possible	No	Yes	Yes
	Prefabrication possible	No	Yes	Yes
	Temperature sensitive	High	Medium	Medium
	Existing Industry	No (besides night vision / small area)	Yes (foundries available)	Yes (foundries available)
Basic Physics	Good understanding	No	Yes	Yes
	Microscopic understanding of growth	No	Yes	Yes
	2-D Fabrication tools	No	Yes	Yes
	3-D Fabrication tools	No	Yes	Some
	Theoretical description	No	Yes	Yes
	Band-structure engineering	No	Yes	Yes

Not Clear which will be the best for the project

The People and Places (details will be presented in the following talks)

- Integration of 4 partners
- Collaboration partners bring:
  - Growth expertise (III-V and multi-alkali)
  - World class growth facilities
  - Standard and unique characterization tools
  - Connection to industry
  - Connection to science community (future funding)
- Unique effort for cathodes
  - Size
  - Completeness (growth, macroscopic and microscopic characterization, theory/simulation)



Summary

- Project is based on three pillars:
  - proof of principle & small production volume (SSL)
  - Basic sciences approach to address important issues of PC-production and increase QE, production yield, tune wavelength response, and reduce production costs (mainly ANL)
  - Design and commissioning of large scale production facility (ANL/Fermi)
- Potential PC-materials:
  - M_3Sb (M: K, Na, Cs and mixtures): mainly at SSL (polycrystalline) and ANL (amorphous)
  - Ga(In)N: amorphous growth on glass substrates at WashU
  - GaAs: crystalline growth with transfer and bonding technology at UIUC & ANL
- How does the group work?
  - Weekly teleconferencing meetings (Friday 3:30-chacago time)
  - Strong interaction during collaboration meetings and Godparent reviews (about every 3-4 months)
  - First successful test: investigations of interface effects of MgO (film growth at ANL, functionality test at SSL, optical tests and theory at ANL)
- Who works on this project:
  - SSL: ~3-4 staff
  - ANL: 2 staff (50% +30%); ~4 postdocs; additional 3 staff and 2 postdocs for characterization and theory, 1 student (UIUC)
  - WashU: 2staff