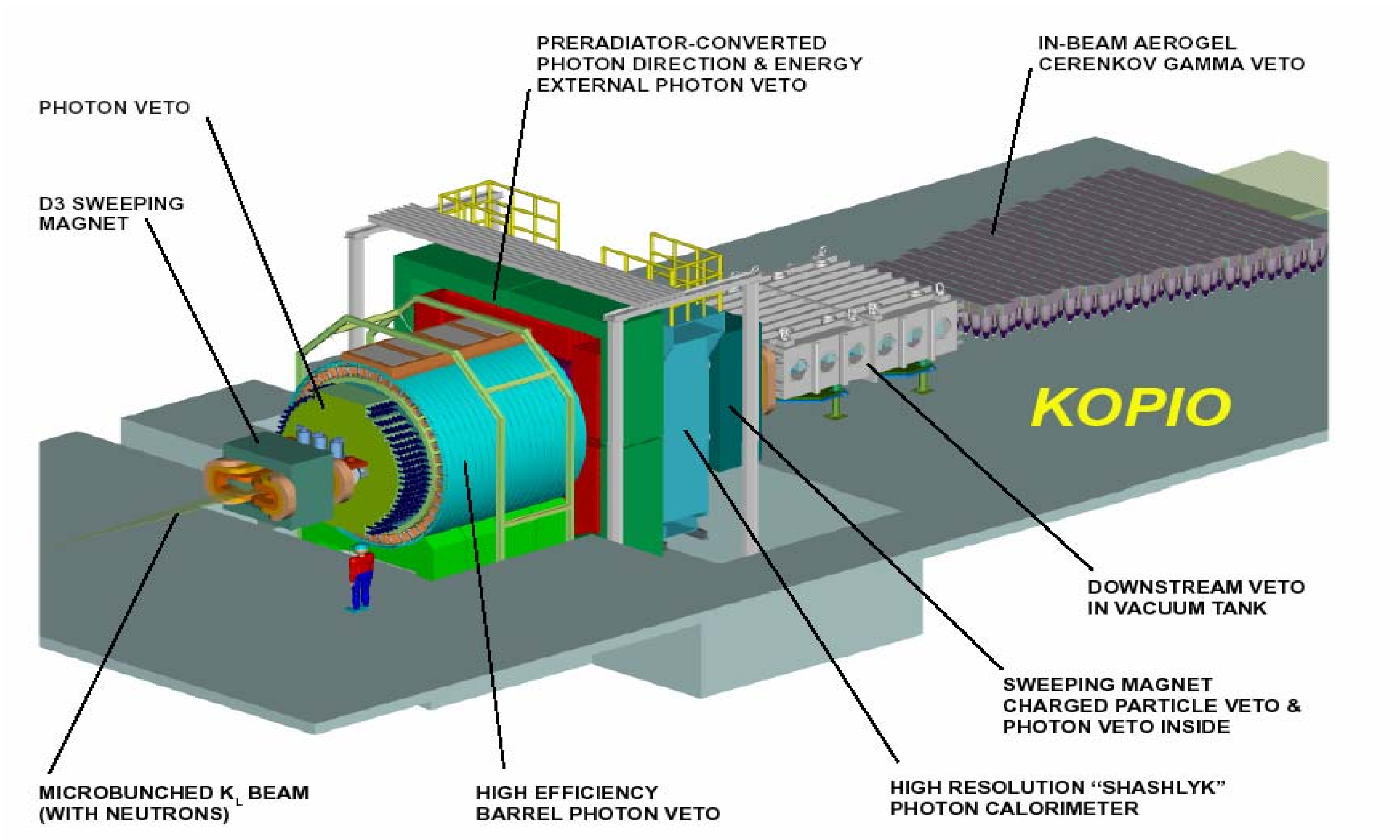
Status of KOPIO Subsystems

2005 RHIC & AGS Users' Meeting
Brookhaven National Laboratory
June 20, 2005

Steve Kettell


PRERADIATOR-CONVERTED
PHOTON DIRECTION & ENERGY
EXTERNAL PHOTON VETO
IN-BEAM AEROGEL
CERENKOV GAMMA VETO
PHOTON VETO
D3 SWEEPING
MAGNET
KOPIO
DOWNSTREAM VETO
IN VACUUM TANK
SWEEPING MAGNET
CHARGED PARTICLE VETO &
PHOTON VETO INSIDE
MICROBUNCHED K_L BEAM
(WITH NEUTRONS)
HIGH EFFICIENCY
BARREL PHOTON VETO
HIGH RESOLUTION "SHASHLYK"
PHOTON CALORIMETER

KOPIO Challenges

- Cracks/material
  - GEANT indicates 2mm inert or 4mm air gaps tolerable
  - E787/949 provides proof of principle
- Vacuum 10^{-7} in neutral beam regions
  - 10^{-6} achievable with detectors not isolated (*cf* CKM R&D, Hseuh)
  - Background < 0.1 events at 10^{-7} =>scales with vacuum
- Catcher veto blindness
  - Dominated by prompt (~ 10MeV!) gamma flash
  - Loss of events from high P_{KL} mitigated by kinematic fitting of $K_{\pi 2}$
- Uncertainty in K_L flux
  - Mitigated by optimizing spill (8% loss for 20% lower flux)
- Neutron-induced losses
  - KOPIO accidental veto losses not dominated by neutrons:

    K_L 37.6%; μ 11.5%; neutrons in catcher 4.5%; neutron halo 1.4%

KOPIO Project Organization

WBS	System	SSM	Institutions
1.2	KOPIO	M. Marx	
1.2.1	Vacuum System	Ralph Brown	BNL, Stony Brook
1.2.2	Preradiator	Toshio Numao	TRIUMF, Montreal, UBC
1.2.3	Calorimeter	Vladimir Issakov	Yale, IHEP
1.2.4	Charged Particle Veto	Andries van der Schaaf	Zurich,BNL,Kyoto,Yale
1.2.5	Photon Veto	Oleg Mineev	INR,IHEP,VaTech
1.2.6	Catcher	Noburo Sasao	KEK, Kyoto, Kyoto UE
1.2.7	Trigger	Nello Nappi	Perugia (informal)
1.2.8	DAQ	George Redlinger	BNL
1.2.9	Offline Computing	Renee Poutissou	TRIUMF, BNL, All
1.2.10	Systems Integration	Dana Beavis	BNL
1.2.11	Project Services	Jesse Becker	BNL, SBU
	FEE	Dean Schamberger	SBU
	AGS Mods	Michael Sivertz	BNL
	Beams	Dana Beavis	BNL
	Simulations	David Jaffe	BNL

3 KOPIO Spokesmen *ex officio* on KOPIO Technical Board

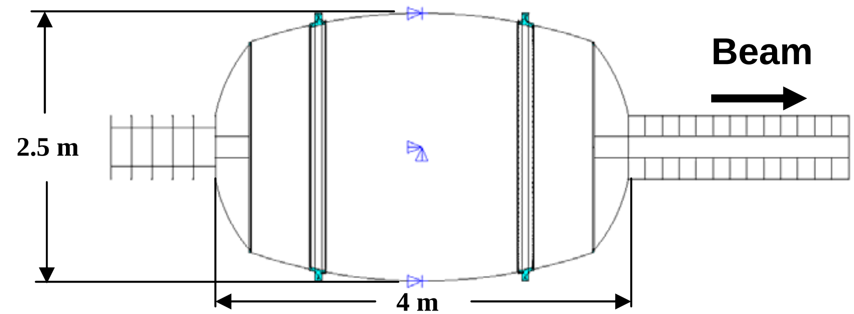
KOPIO Project/Collaboration

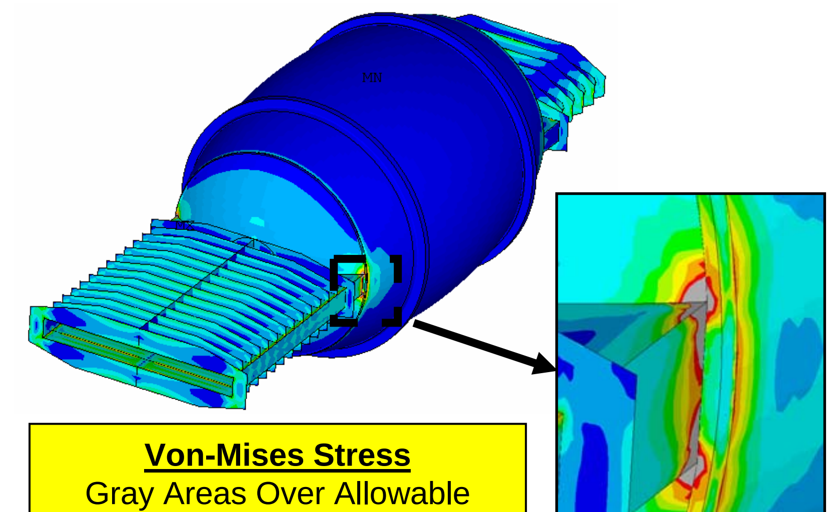
- 80 scientists 10 Grad students
- 6 countries 19 institutions
  - Expected to grow
    - Discussions with Italian, U.S scientists in progress
- 11 WBS Level 3 systems
  - 5 Detector Systems – all non-US SSM
  - 3 Trigger => Off-line – 2/3 non-US SSM
- Current KOPIO funding
  - Non-US provides 17% (20%) of KOPIO total (base), plus $5M to AGS
  - Canada, Japan, Russia, Swiss currently contributing $ and in-kind
  - Non-US collaborators contributing to 7 WBS Level 3 systems
- Majority of KOPIO R&D funds have been non-US
- Benefit to KOPIO/RSVP far exceeds $ value of contributions
  - Non-US support is unique to KOPIO in RSVP
  - Requires significant degree of diplomacy

1.2.1 Vacuum

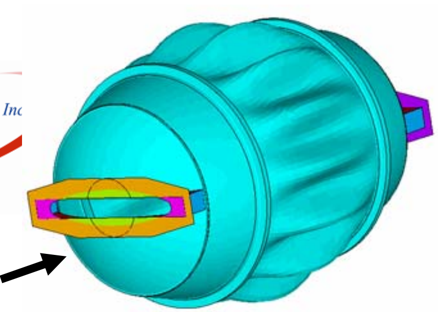
($3.2M + 25% cont.)

- U.S., Russia
  - BNL, IHEP + AES
- Engineering challenge
  - $12m^3$, 10^{-7} Torr, 7% X_0
- Investigated many options
  - Beryllium, Carbon fiber, Al Honeycomb, Aluminum
  - Carbon fiber 1/5 scale under construction in Russia
  - Spun aluminum seems best – vendor quotes and fabrication plan





Von-Mises Stress
Gray Areas Over Allowable
Need Local Design Refinement



Tank Buckling Margin = 3.2 - GOOD

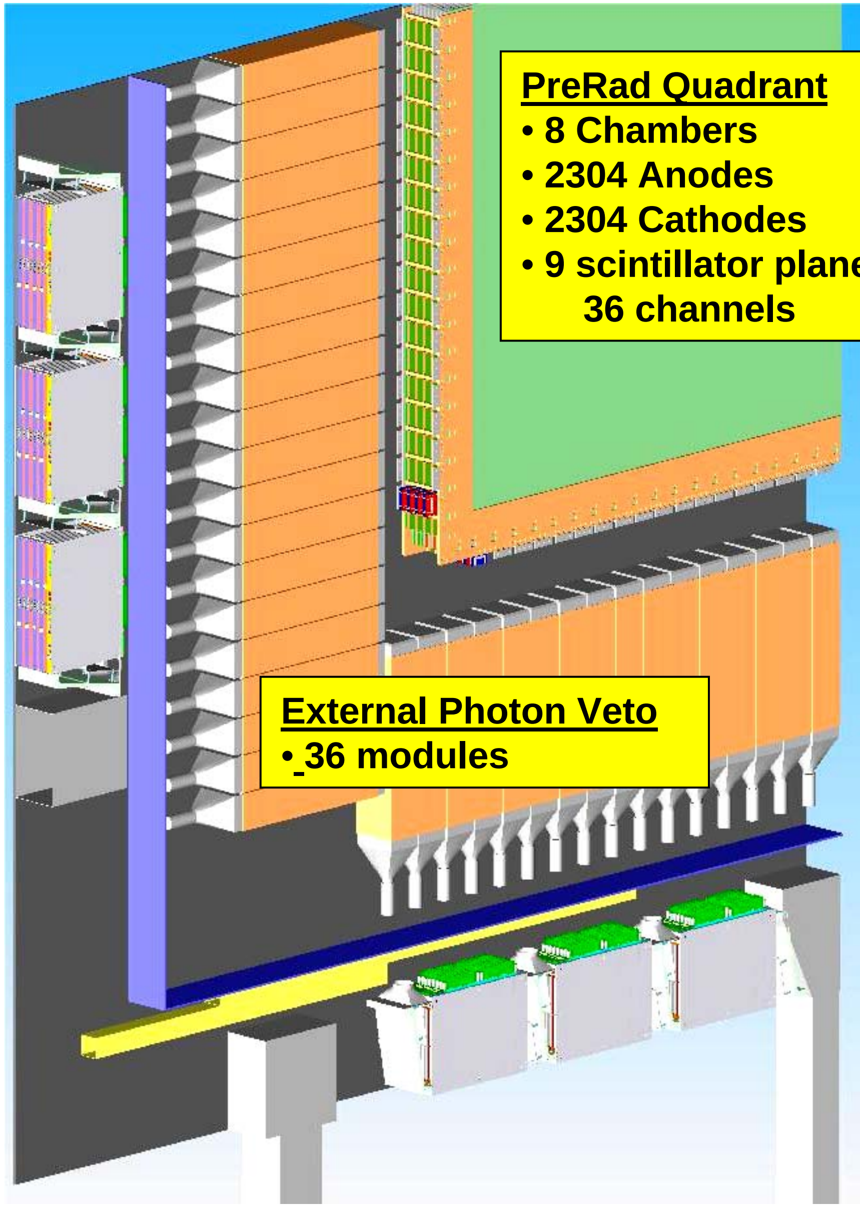
1.2.2 PreRadiator

($17M + 31% cont.)

- Canada
  - **TRIUMF, Montreal**
- Measures γ-ray direction/energy
- Provides photon veto
- Trigger source for signal events
- Largest, most complex subsystem; dominates electronics and costs

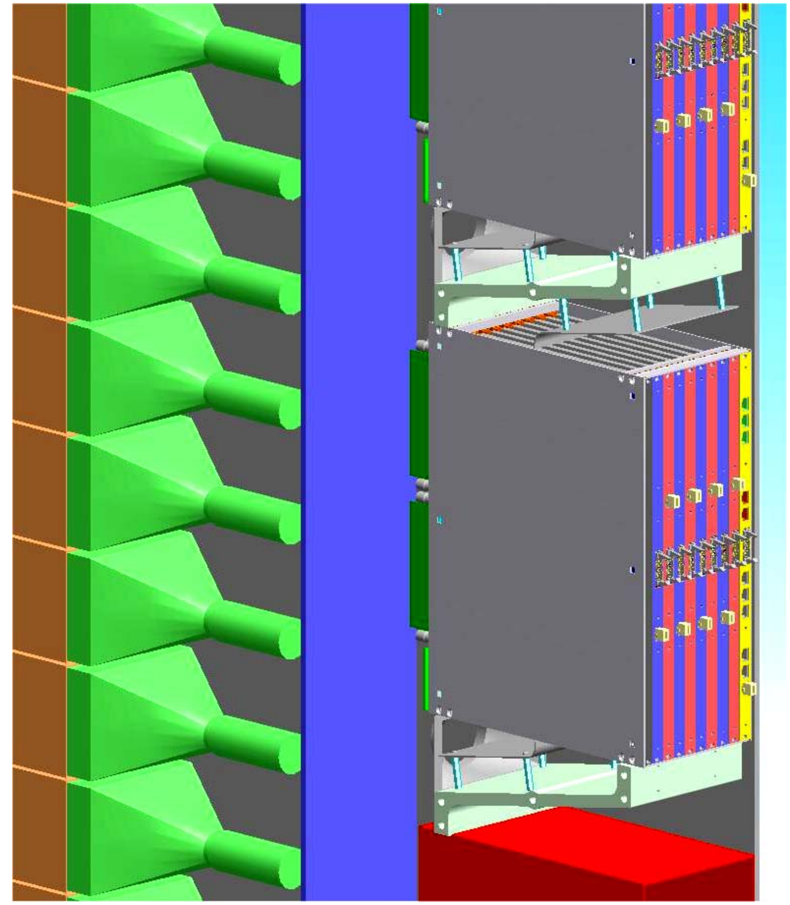
- 10 prototype chambers constructed. 200μm resolution obtained.
- Extruded scintillator successfully manufactured and tested.
- Front end electronics have been tested.
- HV board and cables prototyped.
- Simulation for mechanical support, thermal expansion and other issues

1.2.2 PreRadiator



PreRad Quadrant
- 8 Chambers
- 2304 Anodes
- 2304 Cathodes
- 9 scintillator planes
  36 channels

External Photon Veto
- 36 modules

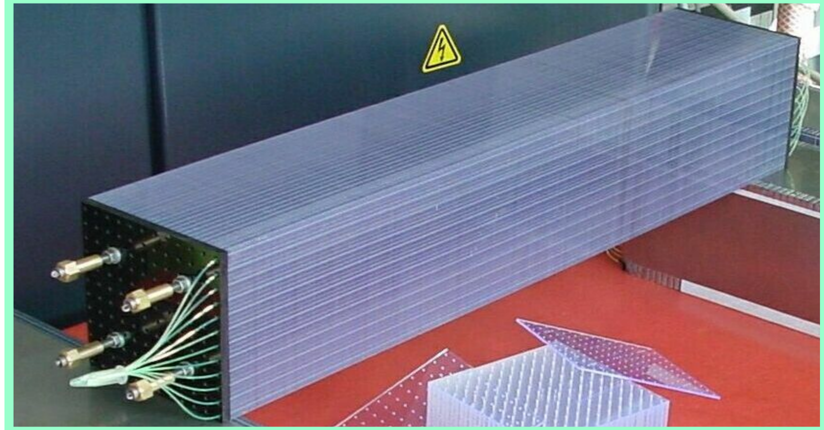


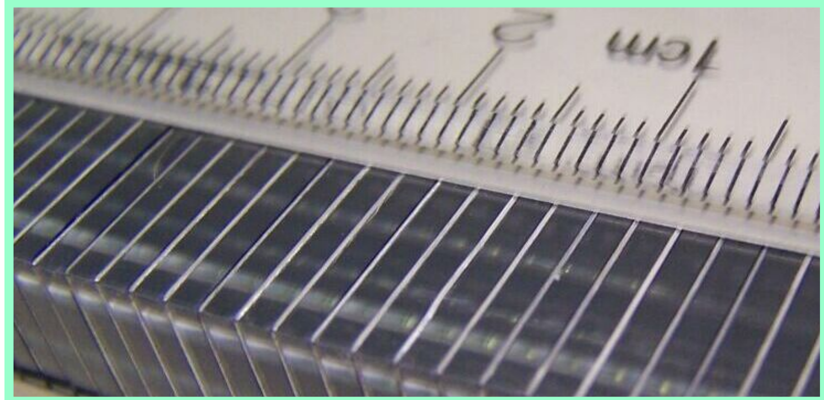
Frontend Electronic Crate:
- 4 Anode cards (96 channels each)
- 4 Cathode cards (96 channels each)
- 1 Planes Collector card

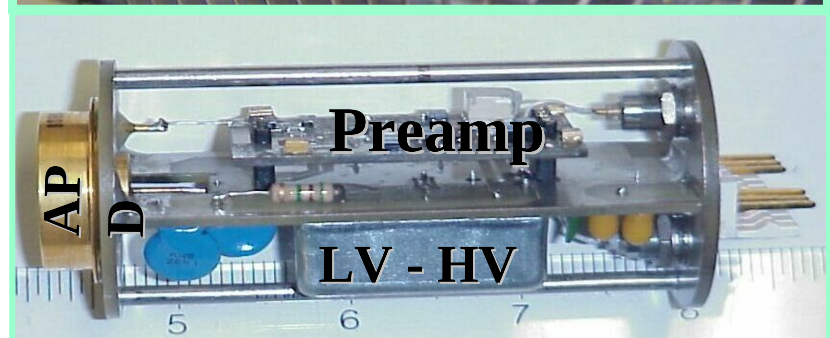
1.2.3 Calorimeter

($5.3M + 20%)

- Russia, U.S.
  - IHEP, Yale, BNL
- Precision energy(~ 3%/√E) and timing (≤ 80psec/√E)
- High efficiency photon veto
- Mature Shashlyk technology
- Ready to begin production



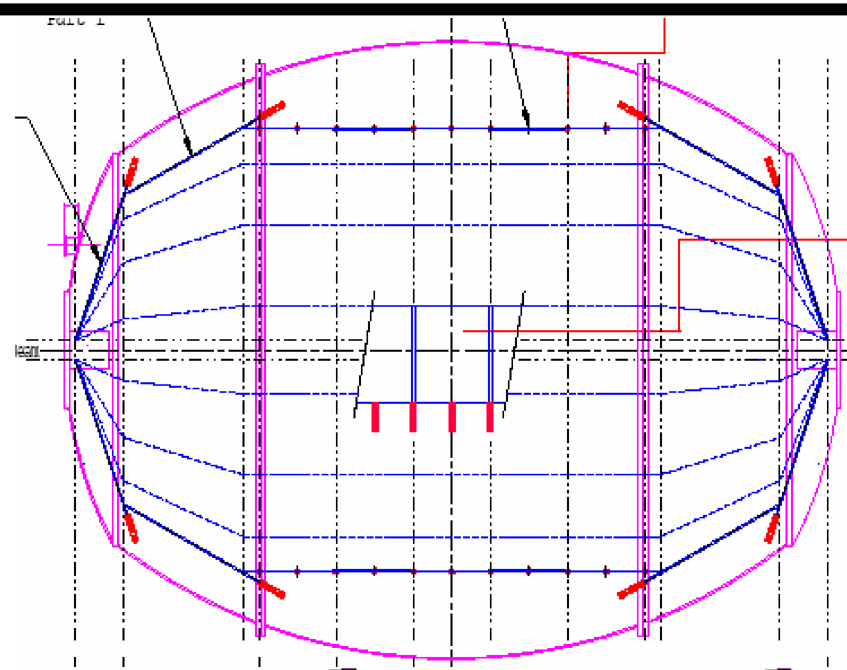


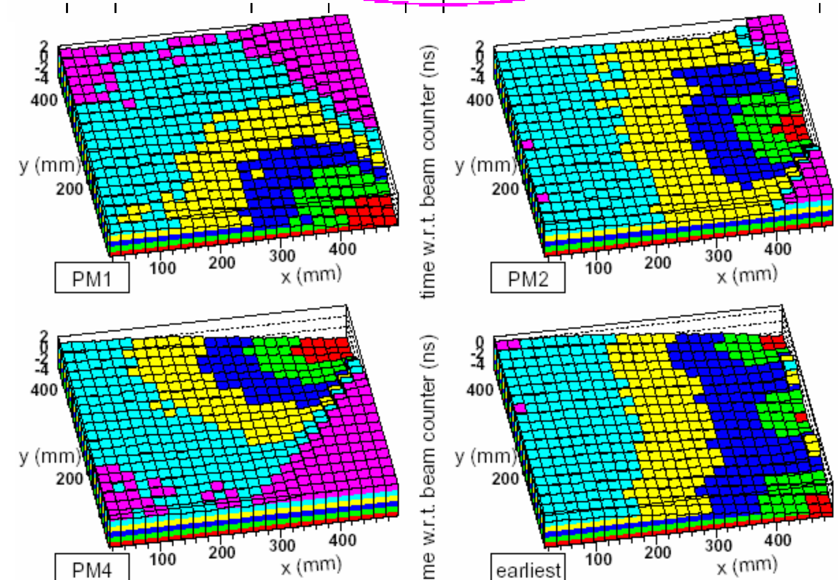


1.2.4 Charged Particle Veto

($2.6M + 28%)

- **Switzerland, Japan, U.S.**
  - **Zurich, Kyoto, BNL**
- Array of scintillators inside decay volume and downstream beam pipe
- Intrinsic efficiency better than 99.99%
  - Minimal dead layer with 50 keV threshold
  - Charge exchange not limitation
- Readout with photo detectors coupled directly to the scintillator, gives almost ten times more photo-electrons than observed with embedded wavelength shifting fibers



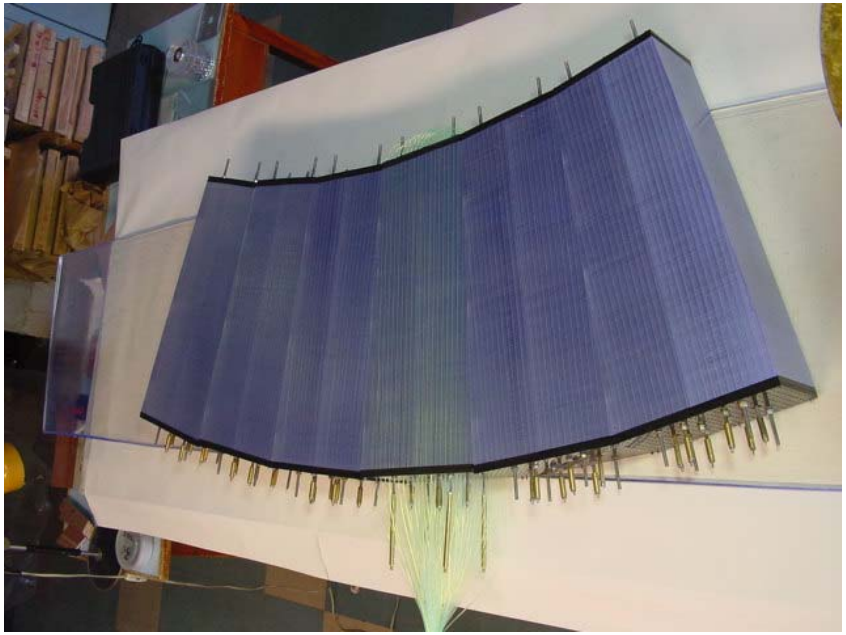


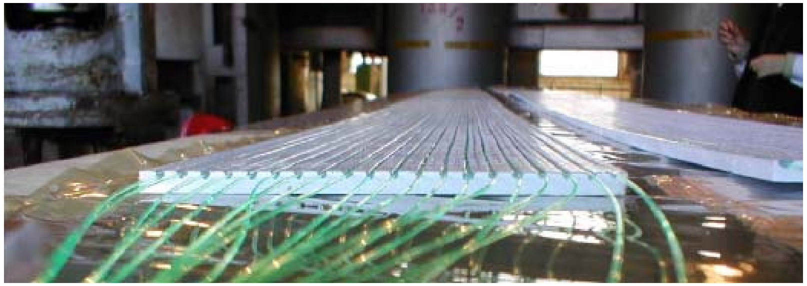
1.2.5 Photon Veto

($7.2M + 35%)
- Russia, U.S.
  - INR, BNL, VaTech
- Veto efficiency key to background suppression
- Modest extrapolation from E949 performance
  - Added depth
  - ~ $5\times10^{-3}\exp(-E/37.5\,\mathrm{MeV})$
- 5 Systems

Bar	Shashlyk
Upstream	Barrel
Magnet	PreRad (1.2.2)
Downstream	

- R&D Complete
  - Need mechanical designs



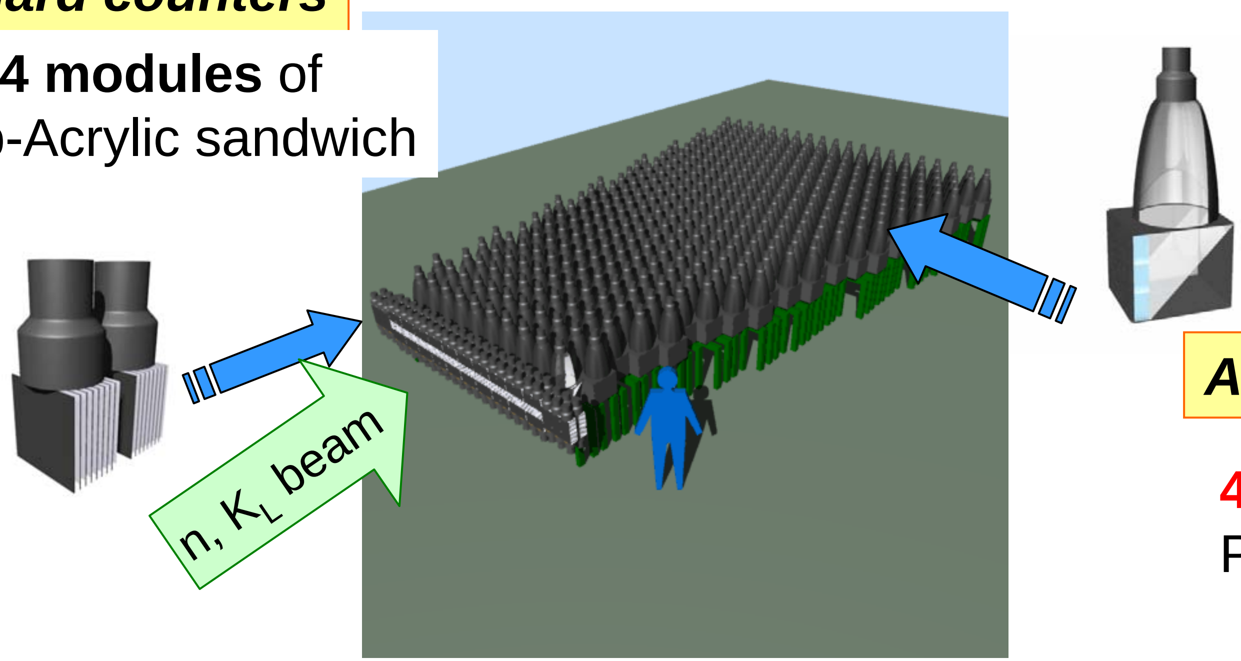


1.2.6 Catcher

- Japan ($3.2M + 21%)
  - Kyoto
- High efficiency for photons/ neutron blind
- Proof of principle done with two stages of prototypes
    - Light yield measurement by charged beam
    - Response to proton as a substitute of neutron
    - Good agreement with MC

Guard counters

144 modules of
Pb-Acrylic sandwich



Aerogel Counters

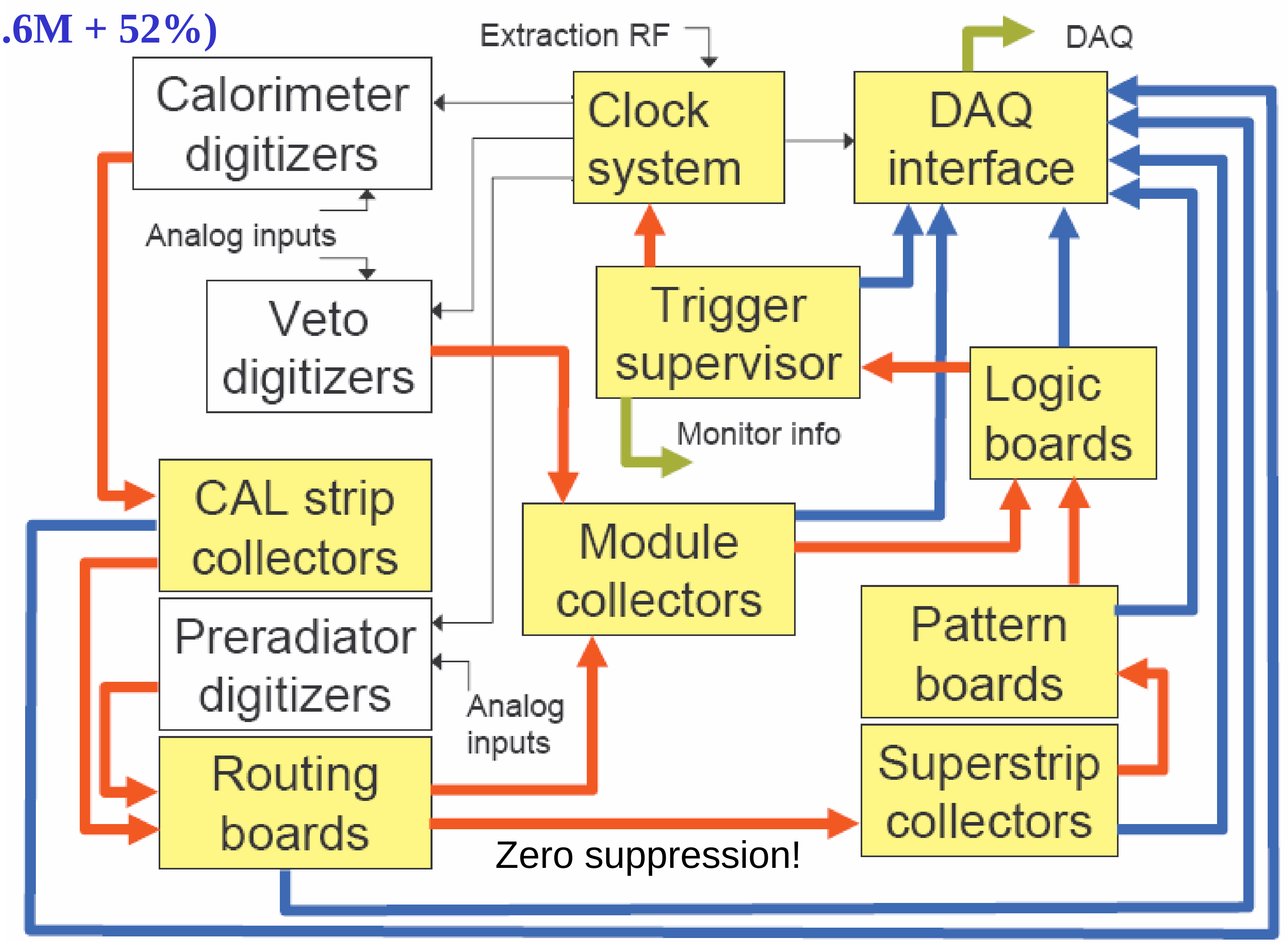
420 modules of
Pb-Aerogel counter

1.2.7/8/9 Trigger/DAQ/Off-Line

- Canada, Italy, U.S.
  - TRIUMF, Perugia (informal), BNL, Stony Brook
- Input rate (L1 accept rate): ~ 1 Mhz
- Output rate (to storage): few kHz
- Data transfer rate: 30 GByte/sec into Event Builder and L3 Farm
- Small trigger acceptance loss (use of offline algorithms)
- Flexibility to implement new triggers, adapt to new conditions

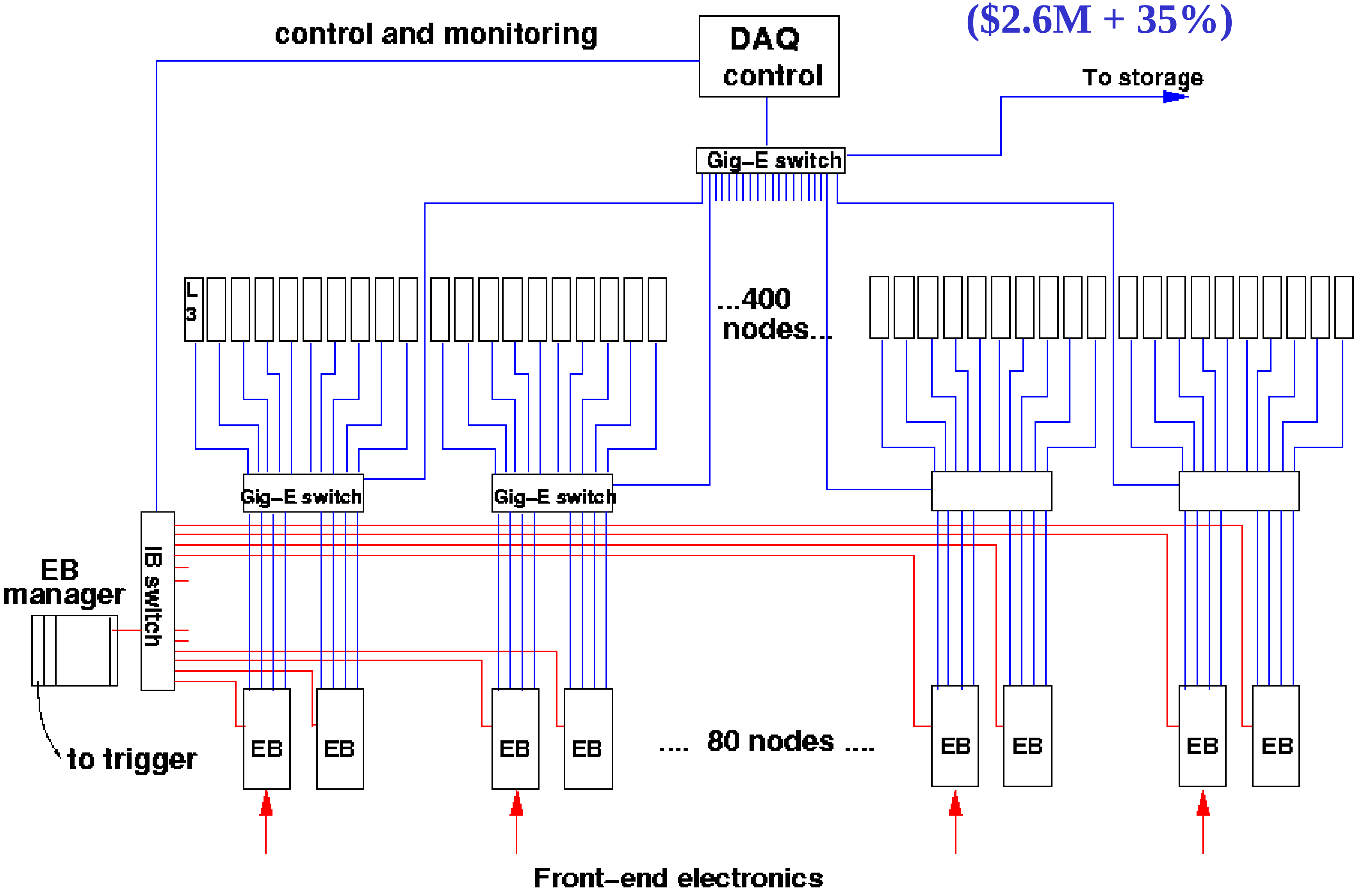
1.2.7 Trigger

($2.6M + 52%)



1.2.8 DAQ

($2.6M + 35%)



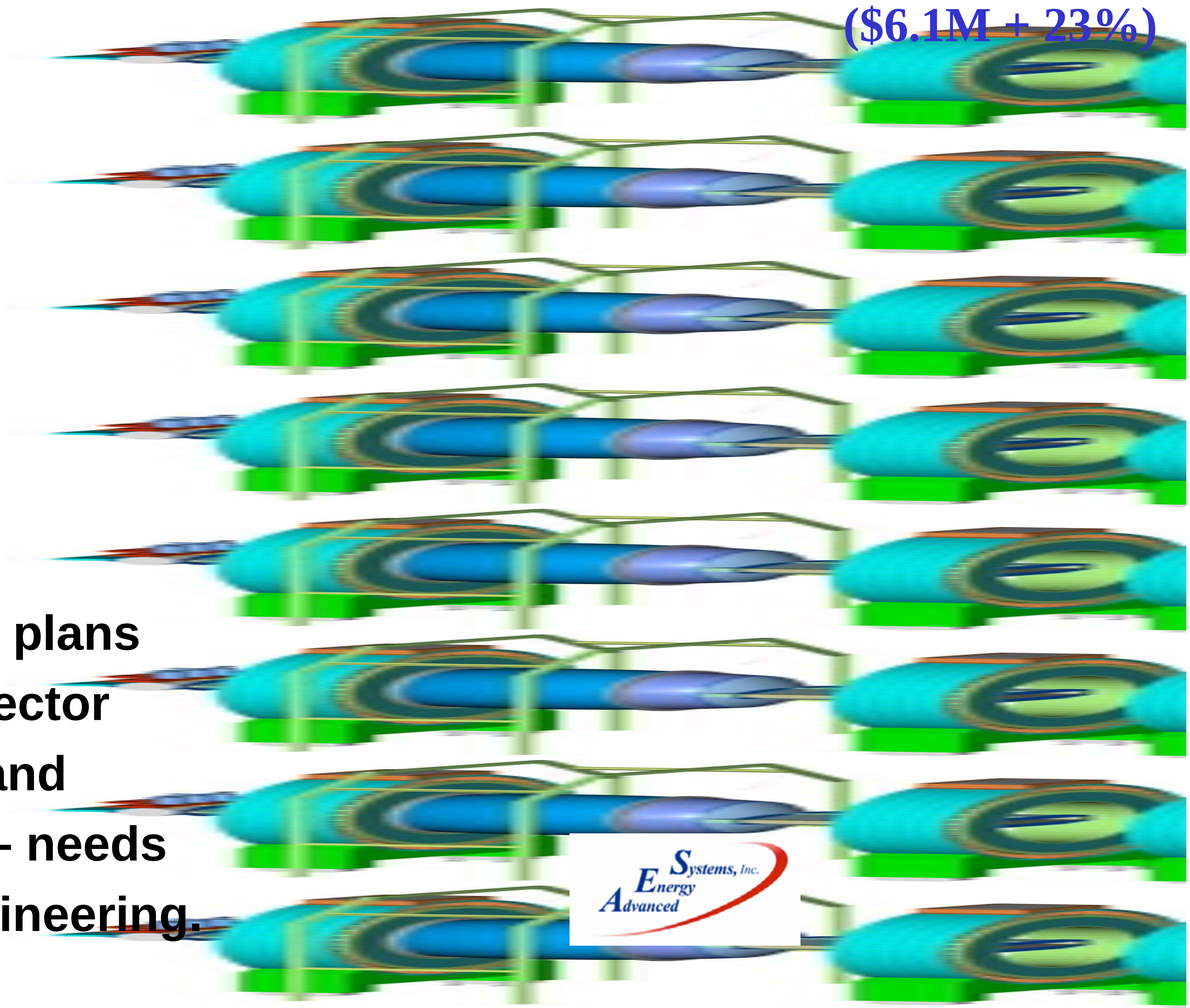
Trigger/DAQ/Off-Line

- **What has been accomplished:**
  - First pass at simulation of L1 and L3 trigger algorithms
  - First pass at breakdown of L1 trigger into individual components for implementation in hardware
  - First pass at measuring data transfer bandwidth through new networking technology
  - Established collaboration with BNL Instrumentation

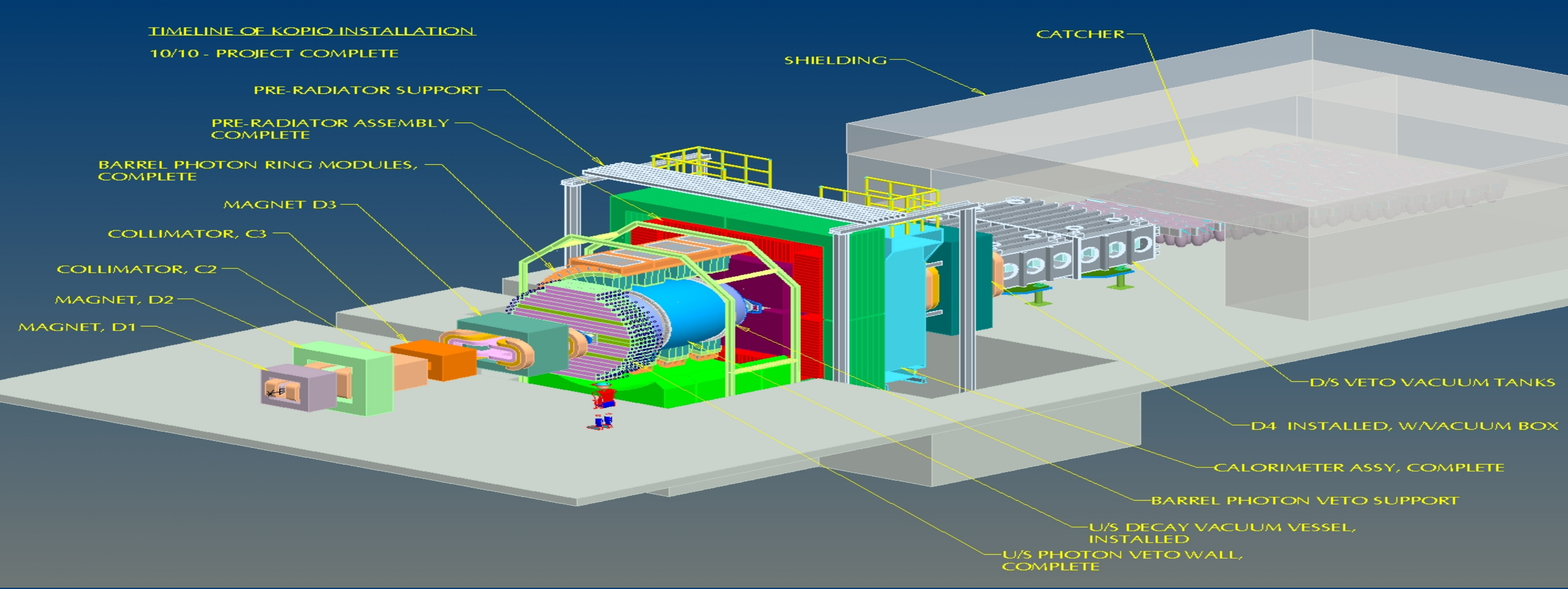
- **1.2.9 Off-Line Computing** ($0.8M + 8%)
  - Two hardware components: compute farm + workstations
  - Software (mostly physicist) effort

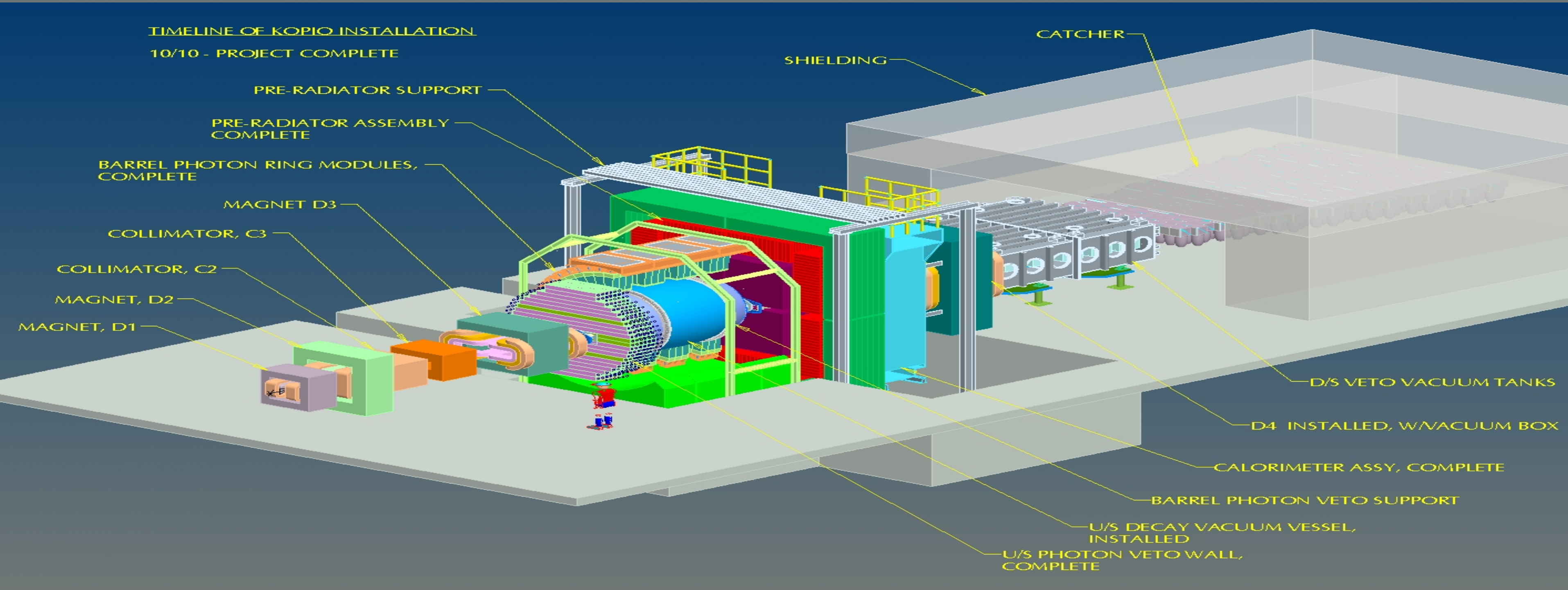
1.2.10 Systems Integration

($6.1M + 23%)



Conceptual designs and plans exist for detector integration and installation – needs detailed engineering.


TIMELINE OF KOPIO INSTALLATION
10/10 - PROJECT COMPLETE
PRE-RADIATOR SUPPORT
PRE-RADIATOR ASSEMBLY COMPLETE
BARREL PHOTON RING MODULES, COMPLETE
MAGNET D3
COLLIMATOR, C3
COLLIMATOR, C2
MAGNET, D2
MAGNET, D1
CATCHER
SHIELDING
D/S VETO VACUUM TANKS
D4 INSTALLED, W/VACUUM BOX
CALORIMETER ASSY, COMPLETE
BARREL PHOTON VETO SUPPORT
U/S DECAY VACUUM VESSEL, INSTALLED
U/S PHOTON VETO WALL, COMPLETE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MAGNET D3
COLLIMATOR, C3
COLLIMATOR, C2
MAGNET, D2
MAGNET, D1
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D4 INSTALLED, W/VACUUM BOX
CALORIMETER ASSY, COMPLETE
BARREL PHOTON VETO SUPPORT
U/S DECAY VACUUM VESSEL, INSTALLED
U/S PHOTON VETO WALL, COMPLETE

KOPIO Solid Model