RSVP
rare symmetry violating processes

BROOKHAVEN NATIONAL LABORATORY

# Status & Plans for the Rare Symmetry Violating Processes Experiments

RSVP JOG Meeting
National Science Foundation
October 13, 2004
Jon Kotcher

# Hardcopy Materials Provided

- Project 2004-5 Timeline
- MECO Magnet Review:
  - Charge
  - Agenda
  - Brief biographies of standing Magnet Oversight Committee
- June, July, August RSVP monthly reports

# MECO Scientific Collaboration

**Boston University**
J. Miller, B. L. Roberts

**Brookhaven National Laboratory**
K. Brown, J. M. Brennan, G. Greene, L. Jia, W. Marciano, W. Morse, P. Pile, Y. Semertzidis, P. Yamin

**University of California, Irvine**
C. Chen, M. Hebert, W. Molzon, J. Popp, V. Tumakov

**University of Houston**
Y. Cui, E. V. Hungerford, N. Klantarians, K. A. Lan

**University of Massachusetts, Amherst**
K. Kumar

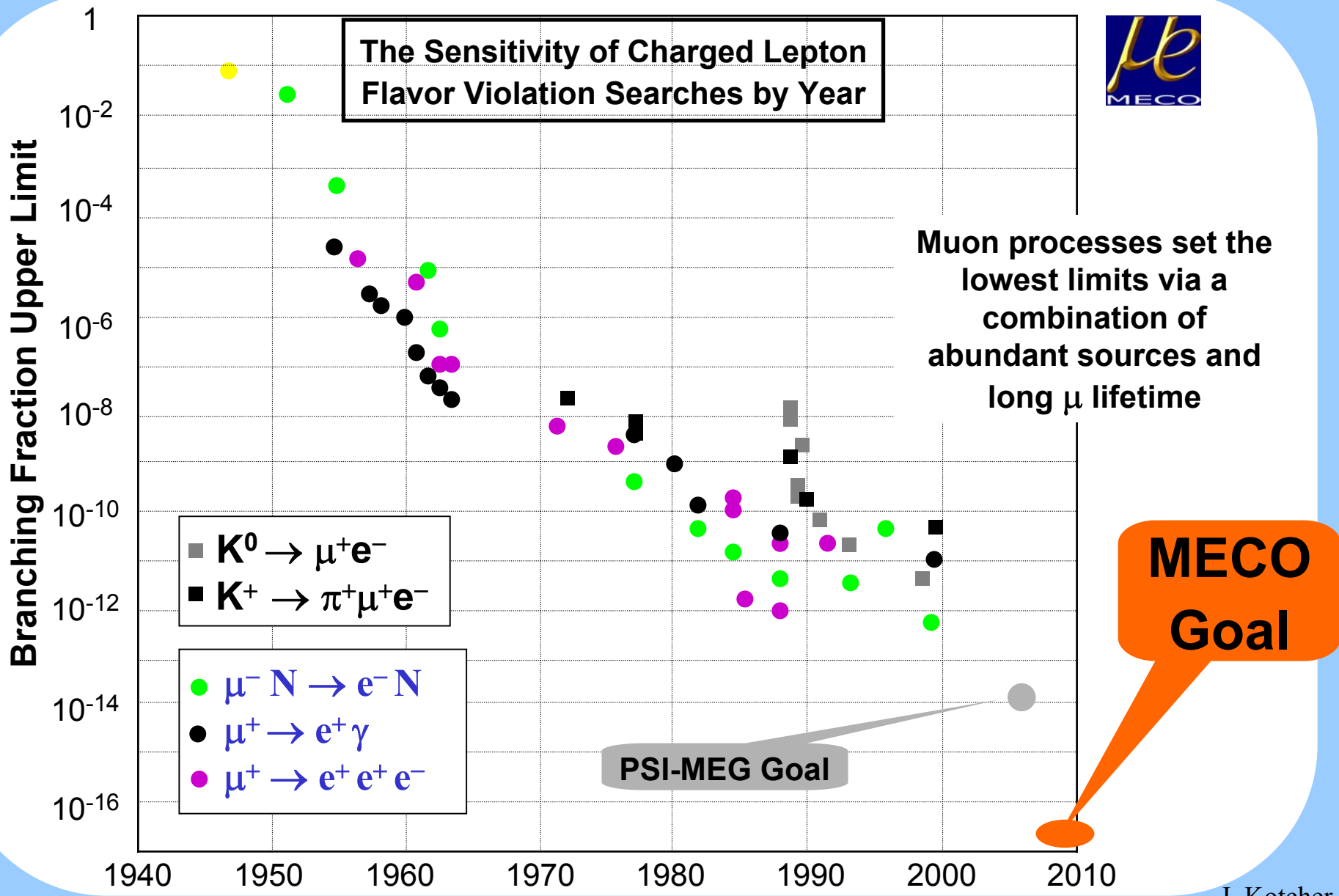
**Institute for Nuclear Research, Moscow**
V. M. Lobashev, V. Matushka,

**New York University**
R. M. Djilkibaev, A. Mincer, P. Nemethy, J. Sculli, A.N. Toropin

**Osaka University**
M. Aoki, Y. Kuno, A. Sato

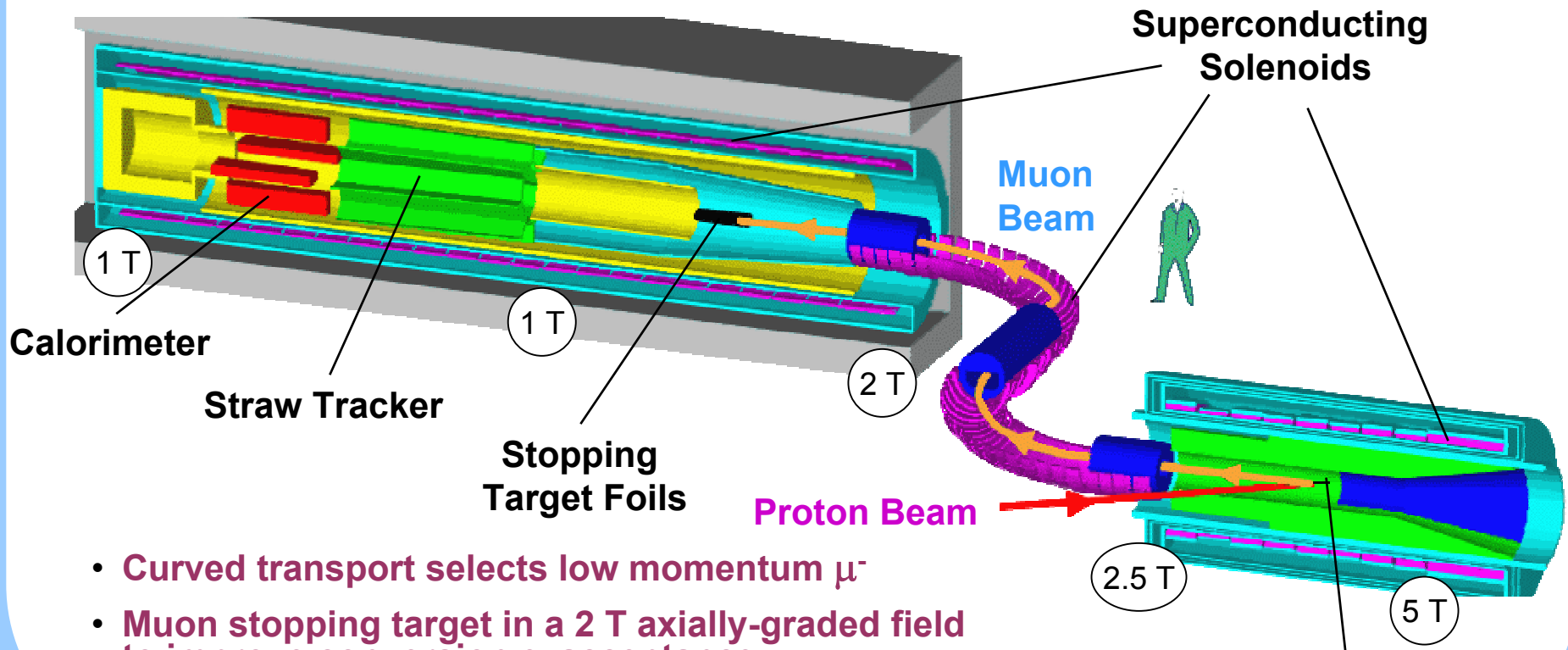
**Syracuse University**
R. Holmes, P. Souder

**College of William and Mary**
M. Eckhause, J. Kane, R. Welsh


The Sensitivity of Charged Lepton Flavor Violation Searches by Year
Branching Fraction Upper Limit
1
10-2
10-4
10-6
10-8
10-10
10-12
10-14
10-16
1940
1950
1960
1970
1980
1990
2000
2010
K0 → μ+e−
K+ → π+μ+e−
μ− N → e− N
μ+ → e+ γ
μ+ → e+ e+ e−
PSI-MEG Goal
MECO Goal
Muon processes set the lowest limits via a combination of abundant sources and long μ lifetime
MECO

# Features of MECO

- 1000–fold increase in μ beam intensity over existing facilities
  - High Z target for improved pion production
  - Axially-graded 5 T solenoidal field to maximize pion capture




- Curved transport selects low momentum $\mu^-$
- Muon stopping target in a 2 T axially-graded field to improve conversion $e^-$ acceptance
- High rate capability $e^-$ detectors in a constant 1 T field

# KOPIO Scientific Collaboration

*Arizona State University* J.R. Comfort

*Brookhaven National Laboratory* I-H. Chiang, A. Etkin, J.W. Glenn, A. Hanson, D. Jaffe, D. Lazarus, K. Li, L. Littenberg, G. Redlinger, C. Scarlett, M. Sivertz, R. Strand

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*INR, Moscow* A. Ivashkin, *D.Ishuk*, M. Khabibullin, A. Khotjanzev, Y. Kudenko, A. Levchenko, O. Mineev, N. Yershov and *A.Vasiljev*.

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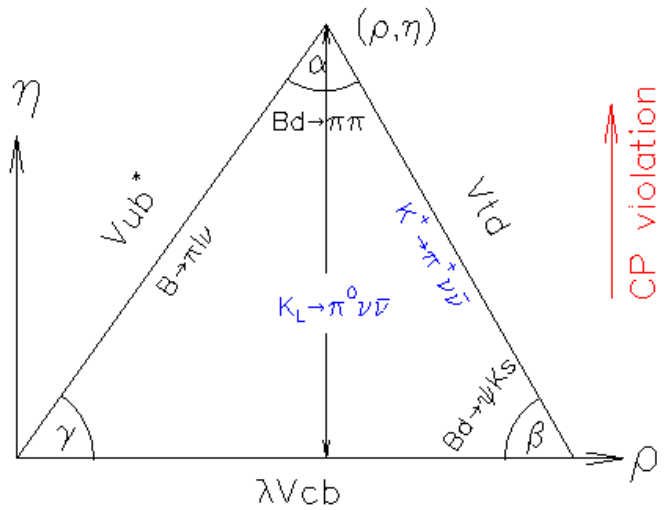
*Grad students in red*

# Standard Model CP Violation



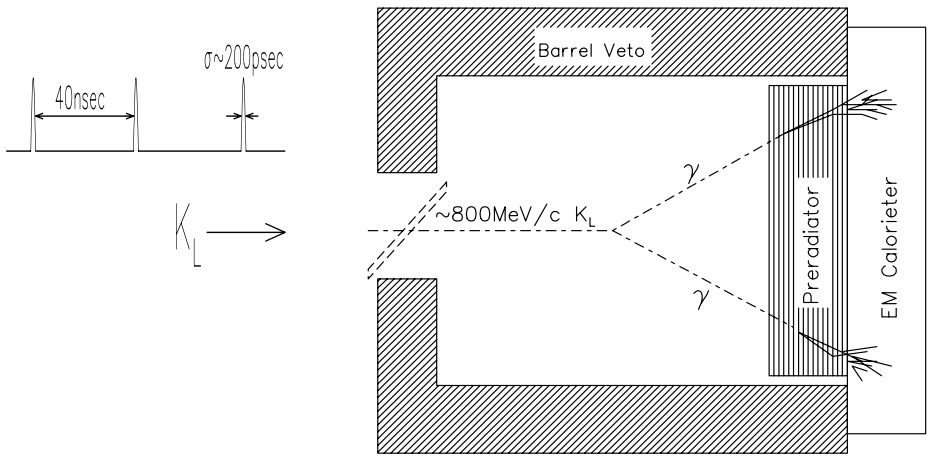

**Four very clean processes will challenge the Standard Model:**

| | | | |
|---|---|---|---|
| $K^0_L \to \pi^0 \nu\bar{\nu}$ | $\mathrm{Im}(V^*_{ts}V_{td})$ | KOPIO | $\left\{ \begin{array}{l} \text{"Jarlskog invariant"} \quad \lvert J_{CP}\rvert \\ 2A_{\square} = \left\lvert \mathrm{Im}\, V^*_{ts}V_{td} \right\rvert \lambda\left(1-\frac{\lambda^2}{2}\right) \end{array} \right\}$ |
| $K^+ \to \pi^+ \nu\bar{\nu}$ | $\lvert V^*_{ts}V_{td}\rvert$ | E949, ~~CKM~~ | |
| $B_d \to \psi K_S$ | $\sin(2\beta)$ | BABAR, BELLE, CDF, D0 | |
| $\frac{x_s}{x_d}$ | $\left\lvert \frac{V_{ts}}{V_{td}} \right\rvert$ | CDF, D0, LHCB, BTEV | |

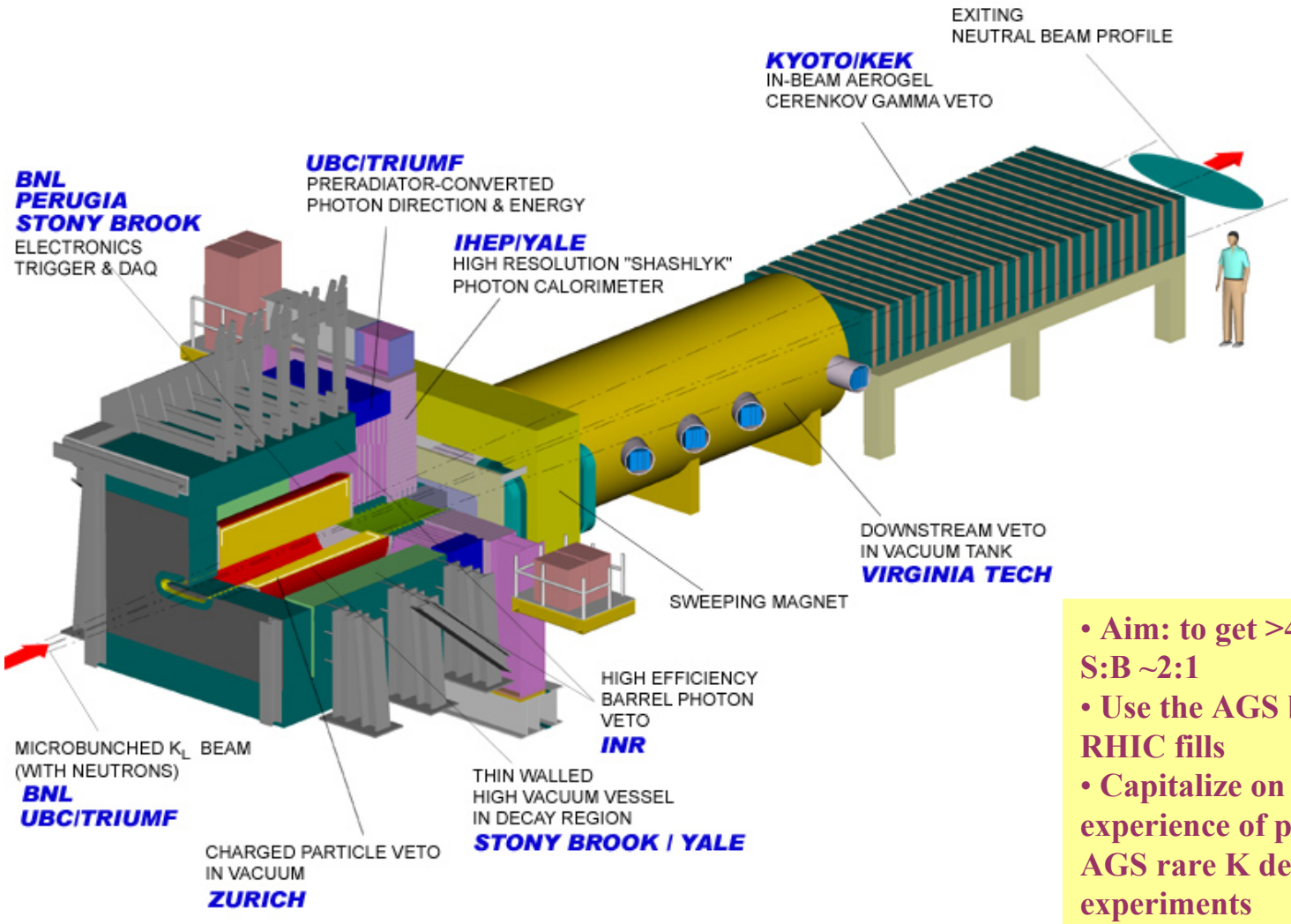
# KOPIO: Measurement of $K_L^0 \to \pi^0 \nu \bar{\nu}$

## CONCEPTS

- Measure as much as possible:
  Energy, position and $ANGLE$ of each photon.
- Work in the C.M. system :
  Use TOF to get the $K_L^0$ momentum.
- Maximize Photon Veto Efficiency
- Maximize Intensity of Microbunched Beam

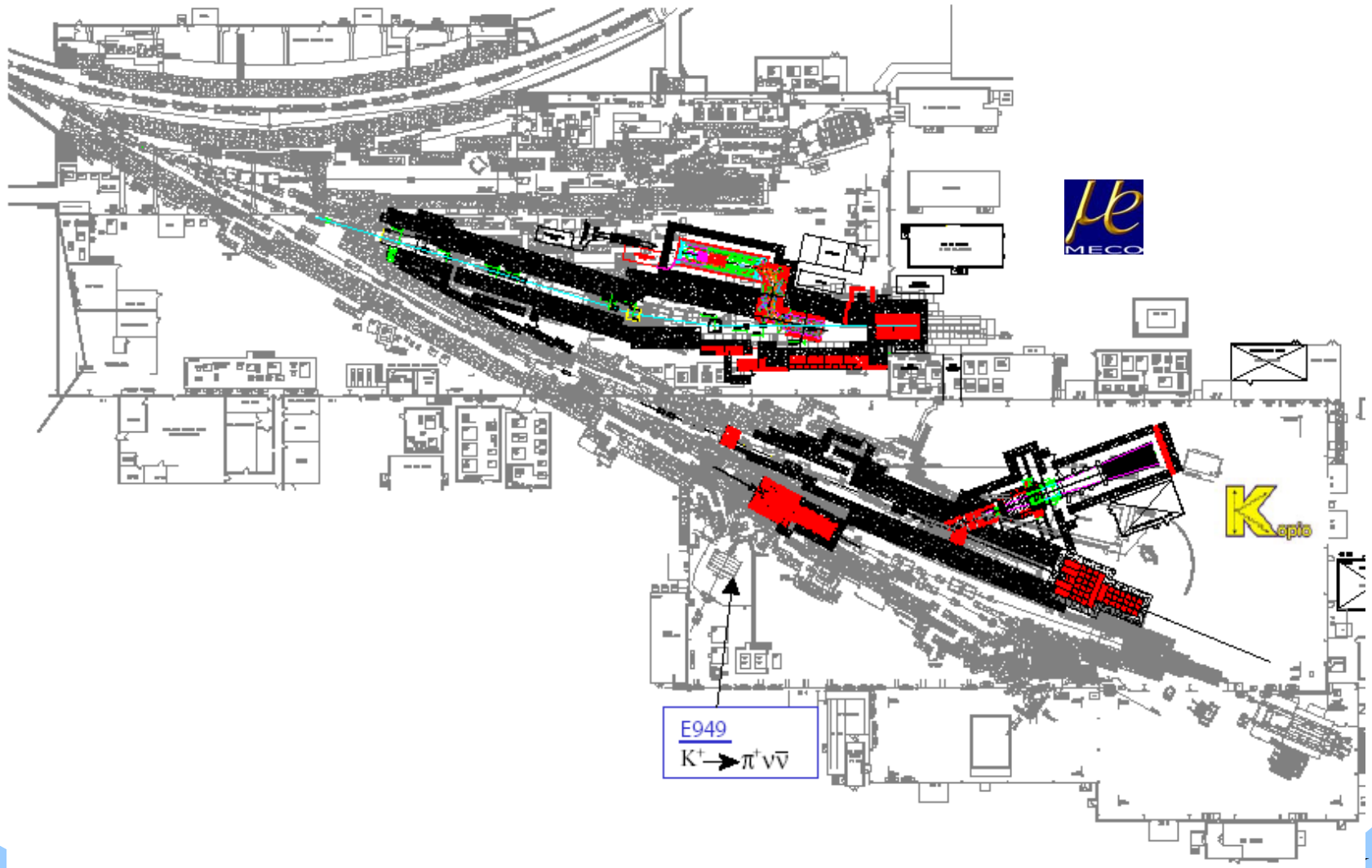


# KOPIO Experiment



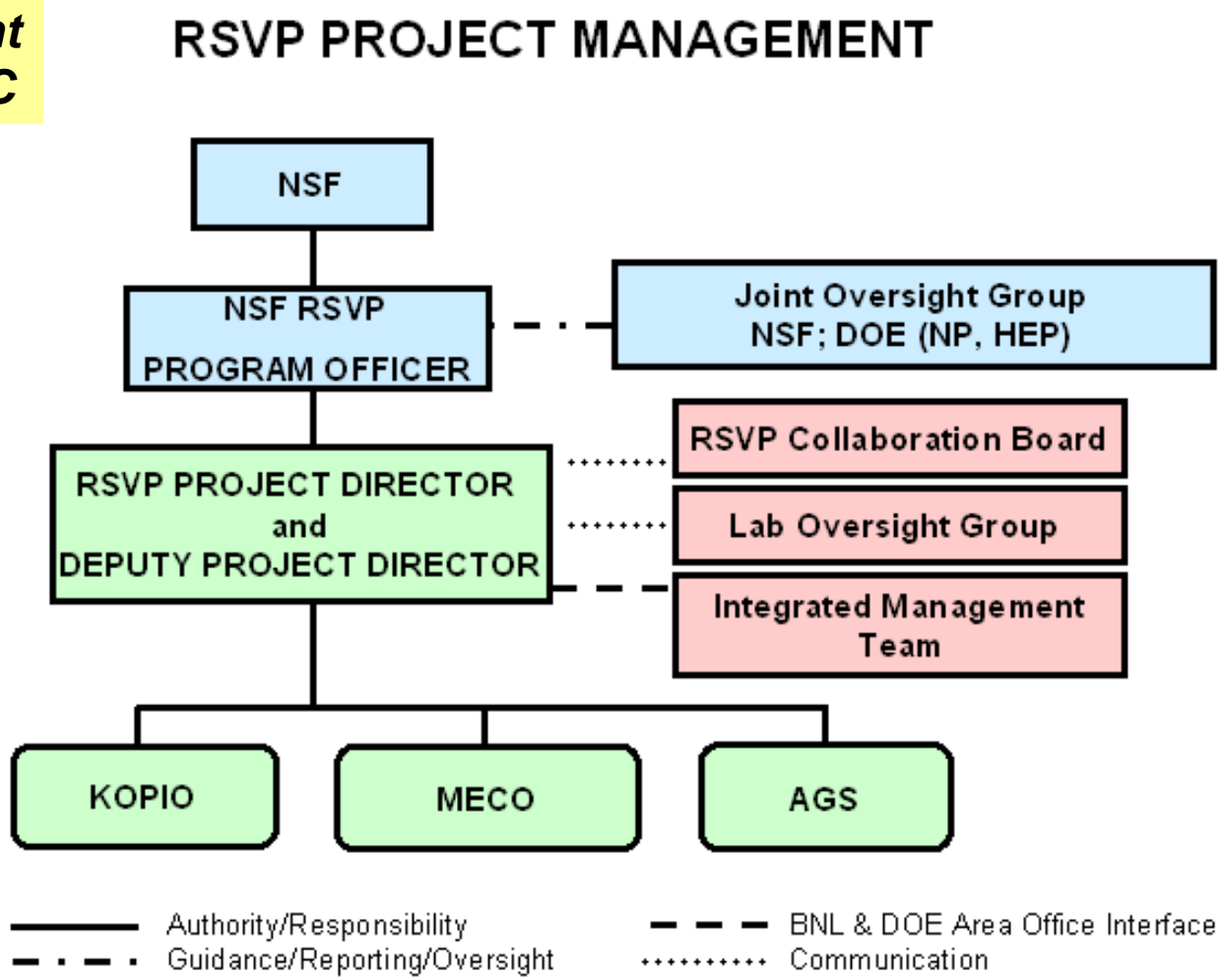

- **Aim: to get >40 evts with S:B ~2:1**
- **Use the AGS between RHIC fills**
- **Capitalize on the experience of previous AGS rare K decay experiments**

# AGS Experimental Areas for RSVP



# Draft Organization Chart

***Similar management structure to US LHC***



# Overview of Project Office

- **Current staffing:**
  - **Project Director, Deputy PD**
  - **Consultants**
    - **Tom Taylor, Chair, MECO Magnet Oversight Group**
    - **Alex Firestone, general project advice, administrative support**
  - **Two part-time BNL schedulers, admin support**
  - **Assistance from CU Physics Department Office staff**
- **Unified Project Office for RSVP is new - instituted "after the fact"**
  - **With respect to FY04 allocations, as well as in managerial sense**
- **Applying integrated approach to development of the projects**

# Project Office: Routing of Funds

- Project funds will be routed via cooperative agreement from NSF to Columbia
- Single contract written from Columbia to BNL
  - Sub-contracts written to RSVP collaborative institutions from BNL
- Project Offices (PO) being assembled at both Columbia and Brookhaven to administer these funds, assist with other project functions
  - Scheduling, project tracking, reporting, reviews, etc.
- FY04 funds routed through NYU
  - $6M - $1.2M (base grants) = $4.8M final award, transfer to NYU in July
    - March '04 Yeck Review: $2.2M for KOPIO, $2.3M for MECO, $250k for AGS technical work
    - Prior to reorganization of RSVP management – no allocation for PO activities
  - Project Office captured $200k per experiment + $250k earmarked for AGS
  - Funds being applied toward supporting three new offices (CU, BNL, AGS)
  - $500k to BNL, $150k to CU

# Supplemental Request

- Have found ways to get Project Office activities started, but funds insufficient to properly build projects, offices, maintain necessary pace
- Supplemental request submitted:
  - Supports PO at necessary levels for remainder of FY05
    - Administrative Assistants (CU, BNL half-time)
    - Dedicated Budget Officer, Scheduler (BNL)
    - Support for consultants
    - PD, DPD salaries
    - Miscellaneous (travel, reviews, etc.)
  - $1.4M requested

# Project Tools

- **RSVP will use same project tools as US ATLAS**
  - **MS Project for schedule & cost, ACCESS for additional cost tracking, WBS dictionaries/definitions, etc.**
    - **Have opted to upgrade from MS Project 2000 to 2003**
  - **Earned value calculated directly in MS Project**
  - **Technical & financial monthly status reports highly automated**
  - **Building web-based interface (including to ACCESS) to facilitate remote project tracking**
- **Allows for efficient, timely project ramp up**
  - **Much BNL infrastructure, expertise exists in use of these tools**
  - **Proven successful application in US ATLAS, agencies have signed off on their use, output**
  - **New tools would require major reinvestment in time, money, personnel, gains questionable. Resources more wisely spent elsewhere in project.**

# Toward a Full Project Plan

- Schedules will be fully resource loaded
- Appropriate rates for various labor categories applied
- Overheads, escalation included
- Physicists will be included in project plan
  - Initially used to outline labor need only (i.e., not costed initially)
- Temporally linked (predecessors, successors)
- Appropriate backup material in various stages of preparation:
  - WBS dictionary
  - Cost books
  - Risk analysis, mitigation strategies
  - Contingency analysis
  - PEP, PMP, Conceptual/Technical Design Reports
  - MoU's, SoW's
  - Hazards/safety compliance
  - Other documentation, as required:
    - Acquisition strategy, configuration management, value management/engineering, project management control systems (PMCS)

# Toward a Full Project Plan

- Project Managers have been instructed to construct schedules without regard to anticipated funding or resource availability: "tell us what you need"
- Impact of funding, resource constraints or conflicts will be applied, as appropriate, after this is in place

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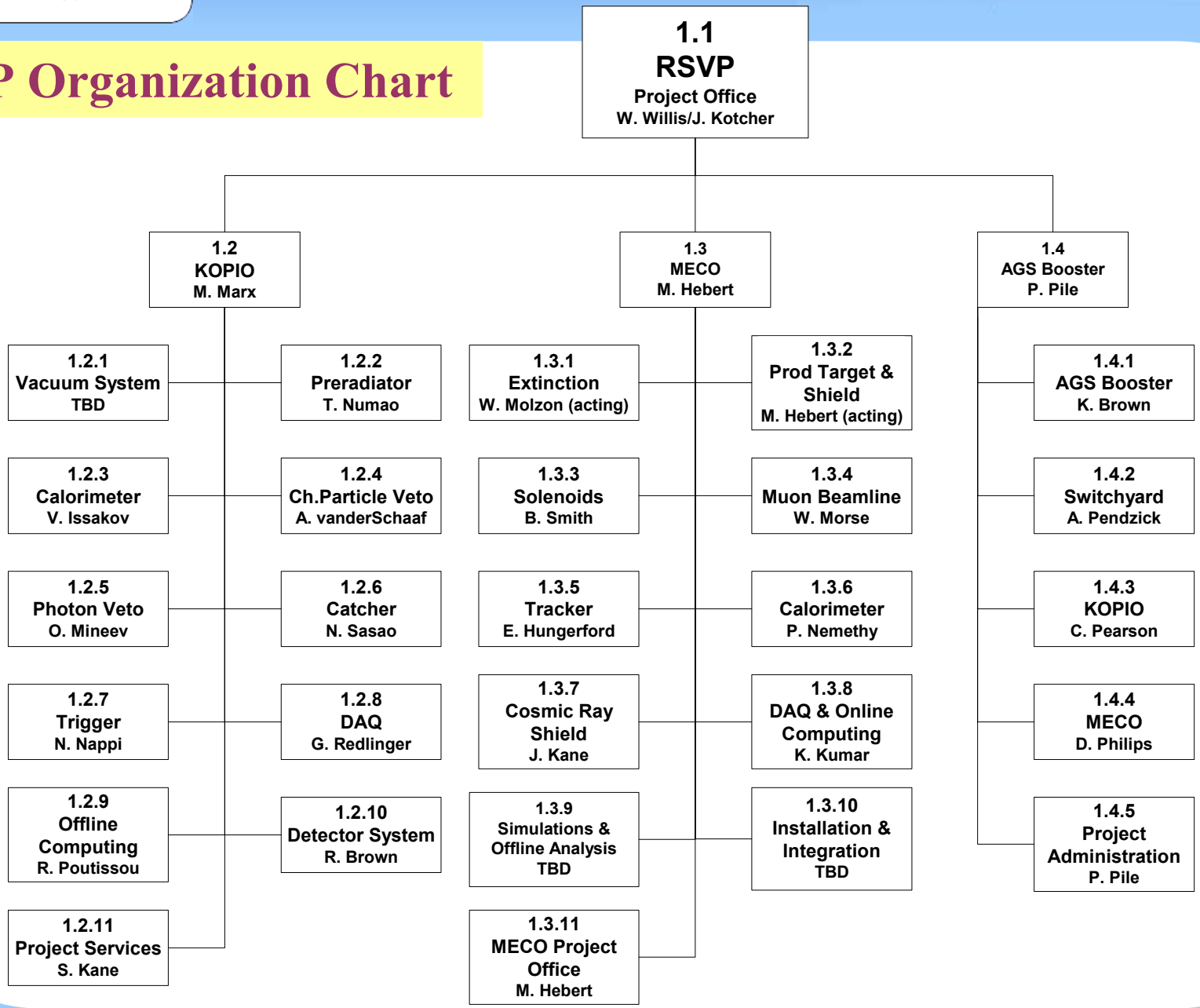
# RSVP Organization Chart



# Monthly Reports

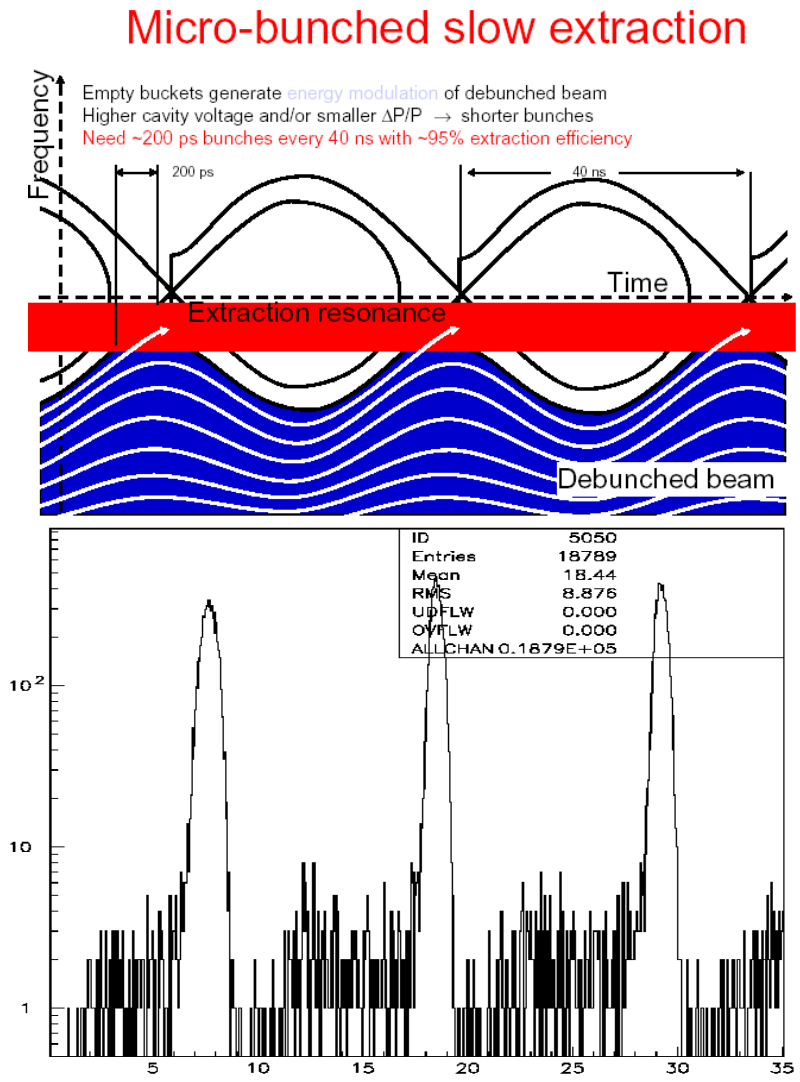
- RSVP Project Office began submitting monthly reports in June
- Compiling list of FY04 milestones against which progress can be reported
  - Will be included in monthly reports when finalized
  - More formal milestone designations will be made as resource loaded schedule matures
- Milestones will reflect high level technical goals, project office activities, development of project plan

# Status of Experiments

- **Project personnel have been focusing on key elements of project timeline finalized last month (discussed later in talk)**
  - **Review preparations**
    - **Aggressive series of that target key RSVP issues, designed to accelerate project readiness**
  - **Development of resource loaded schedule**
    - **Preparation of full project plan begun in earnest**
  - **Continuing R&D on AGS beam, detectors, electronics/trigger, magnet**
    - **Monthly reports growing in detail, complexity**

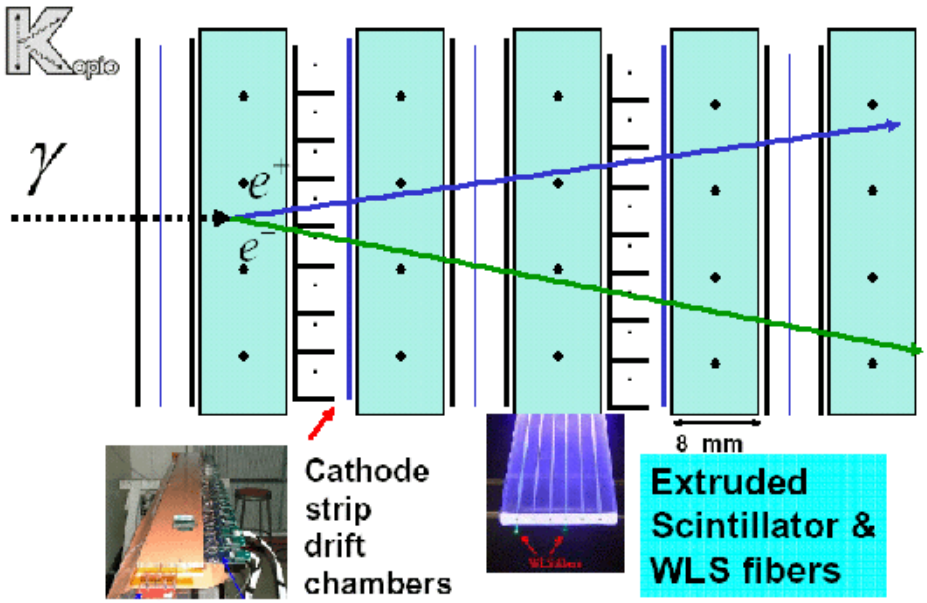
# Microbunched Beam

- Based on CERN technique
  - Used for smoothing beam
  - Cappi & Steinbach 1981
- Achieved 244ps μbunch rms with 93MHz cavity
- Recent tests with main AGS cavities showed extinction of ~ $10^{-5}$
- 25 MHz cavity in design
  - based on RHIC 28 MHz



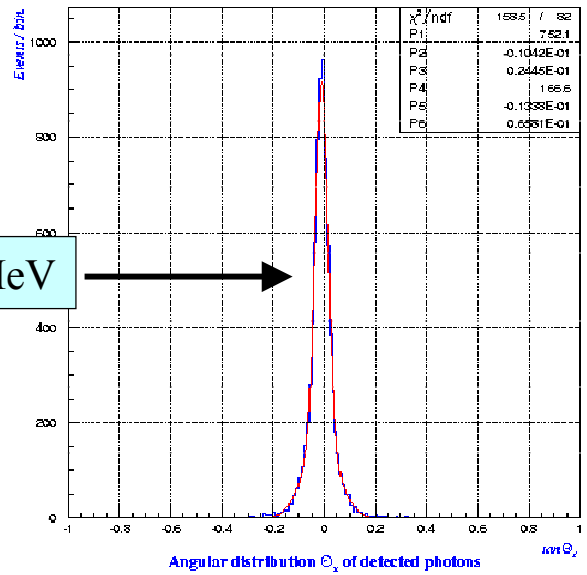
# Preradiator

- $2X_0$ alternating DC & scintillator planes
- 4m × 4m (four quadrants)
- 200,000 channels



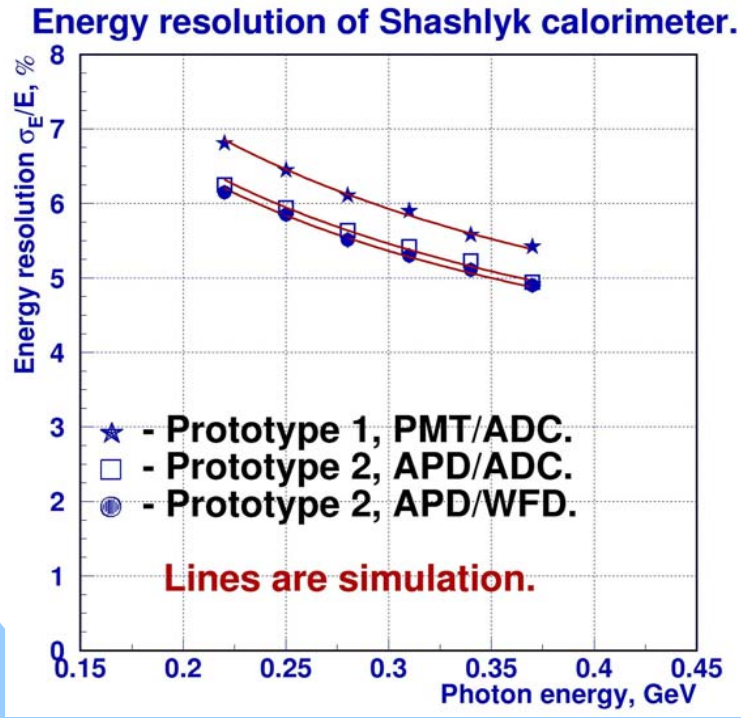

γ angular resolution measured at NSLS

σ ~ 25 mr @ 250MeV

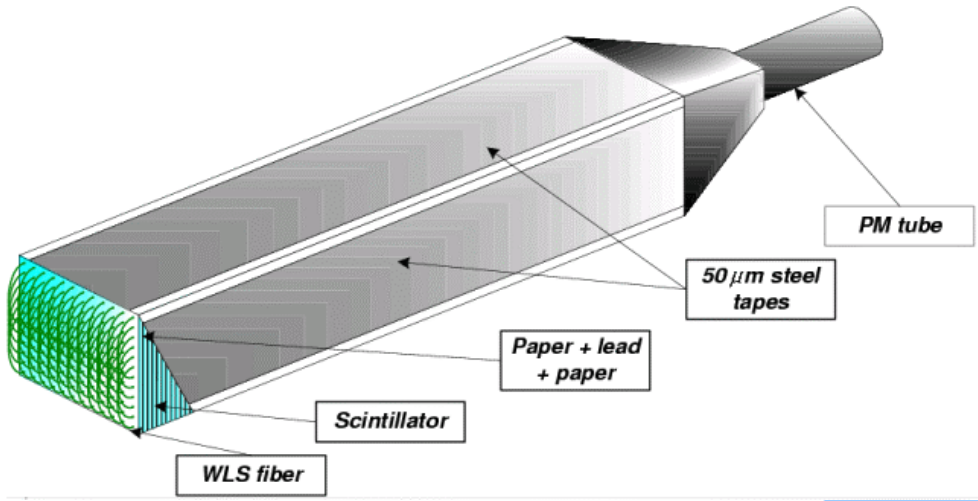


# Shashlyk Calorimeter

- 2500 11cm$^2$ modules, 16 $X_0$ deep
- PMT or APD readout
- Prototype tests have achieved
  - Energy resolution ~ 3%/ √E
  - Time resolution ~ 90ps/√E

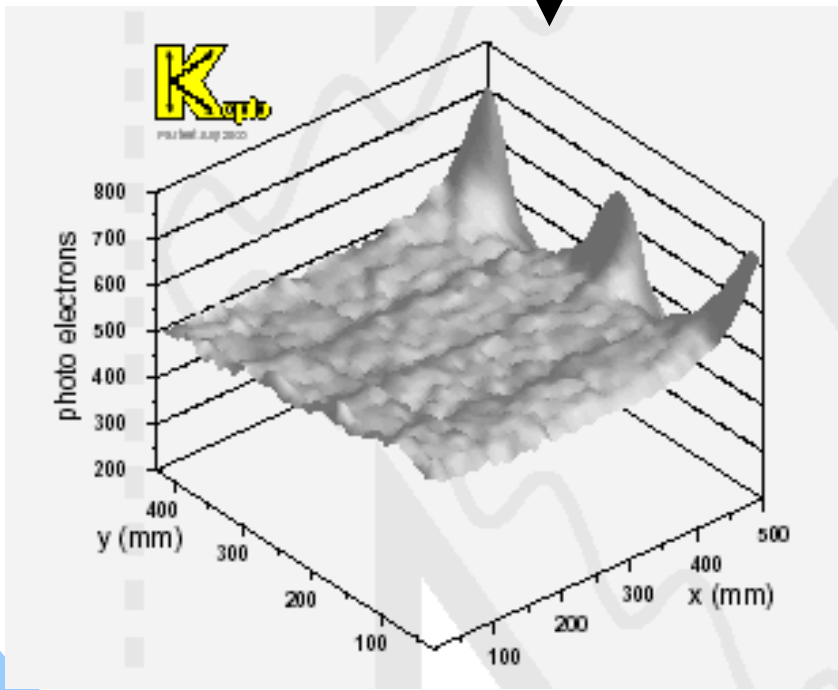


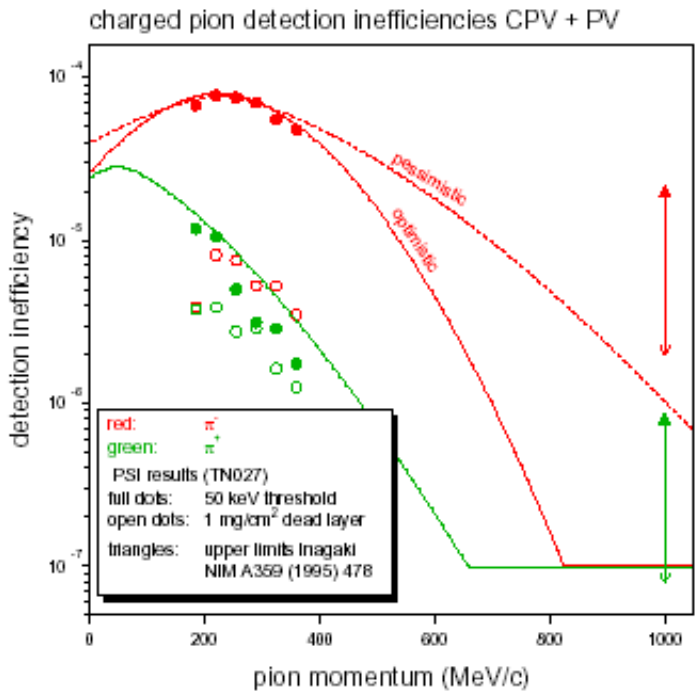

Shashlyk calorimeter



# Charged Particle Veto

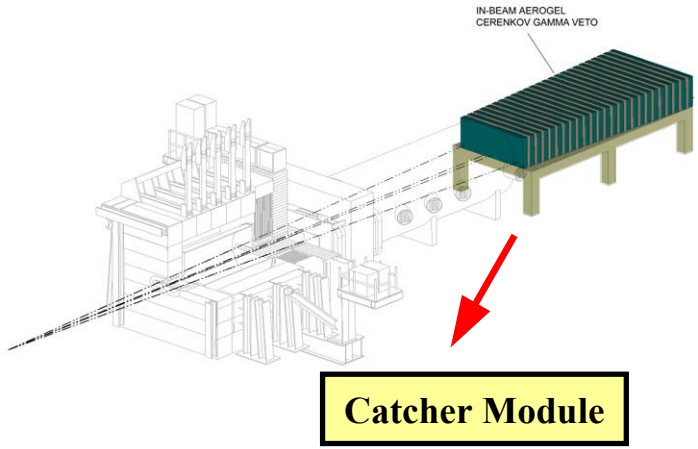
- Thin scintillator directly read out by pmts in vacuum
- Tests of achievable inefficiency at PSI
  - Note γ vetoes back up CPV
- Prototype tests at PSI



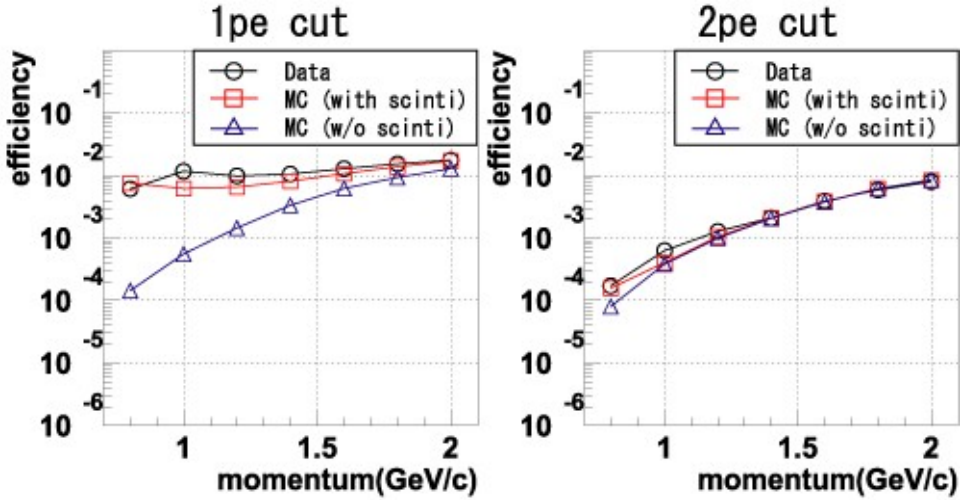



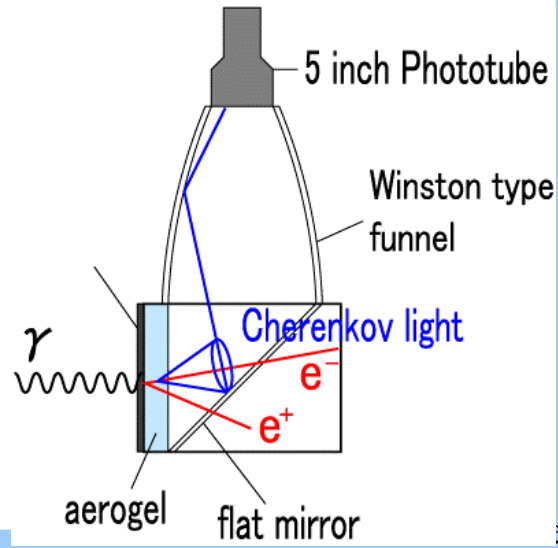
# Beam Catcher Veto

- Photon veto which covers beam core region
- in fierce neutron rate
- Needs to be…
  - efficient for γ rays
  - insensitive to neutrons
- Aerogel Cherenkov + distributed geometry
- Prototypes tested in γ & p beams:




Catcher Module

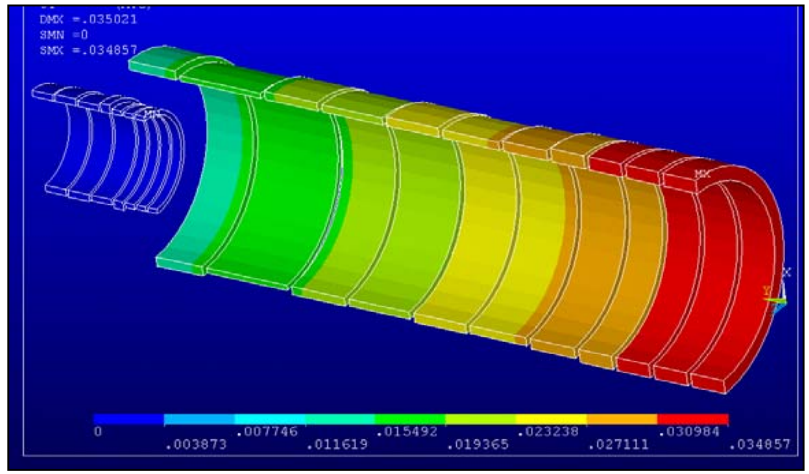


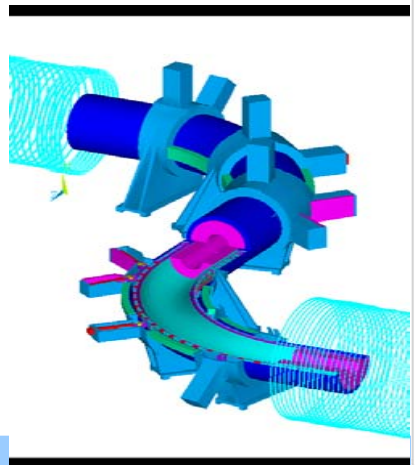



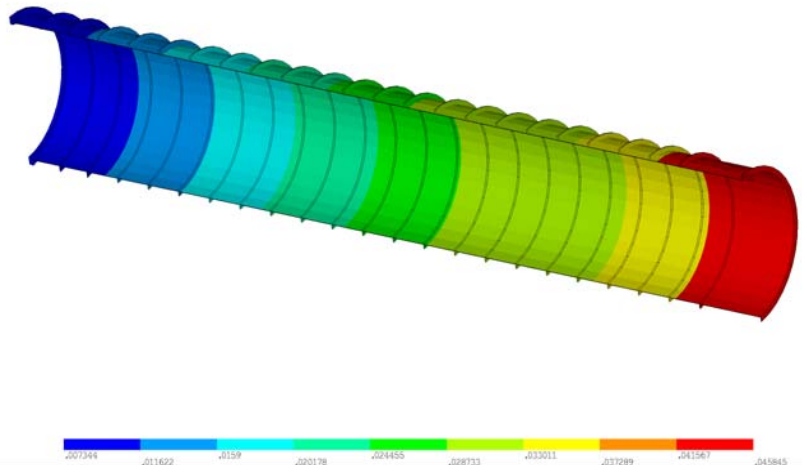
# Recent Technical Magnet Progress

- The structural models of PS, TS and DS magnets have been updated from the CDR
- Studies done to understand required manufacturing tolerances (MIT/UCI)
- Redesign of 80 K thermal shields to allow He gas cooling
- Planned cable tests
  - Short sample conductor tests
  - Test of soldering cable in conduit
  - Extracted strand tests of cable
- Work to define installation interfaces (Dave Phillips)

PS strain

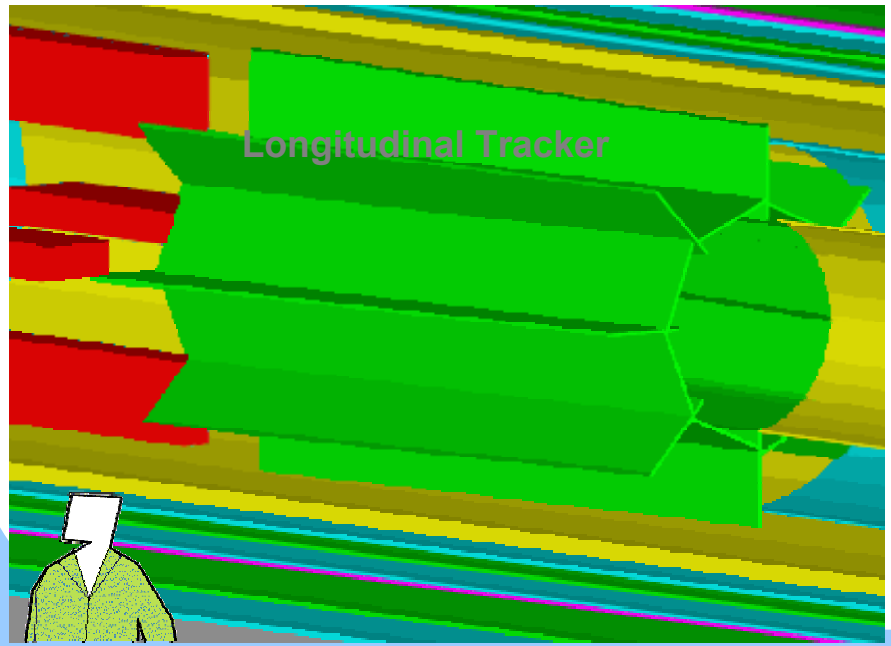


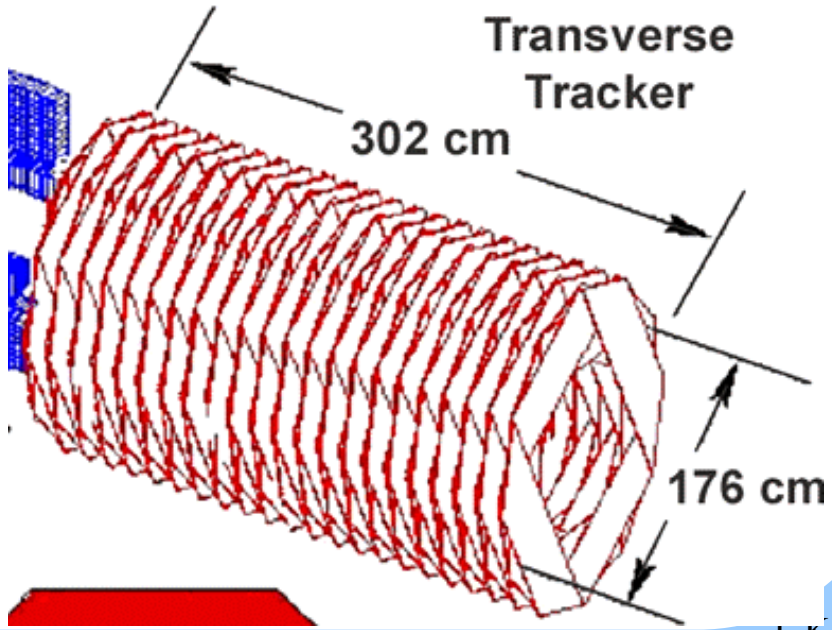





# MECO Tracking Detector

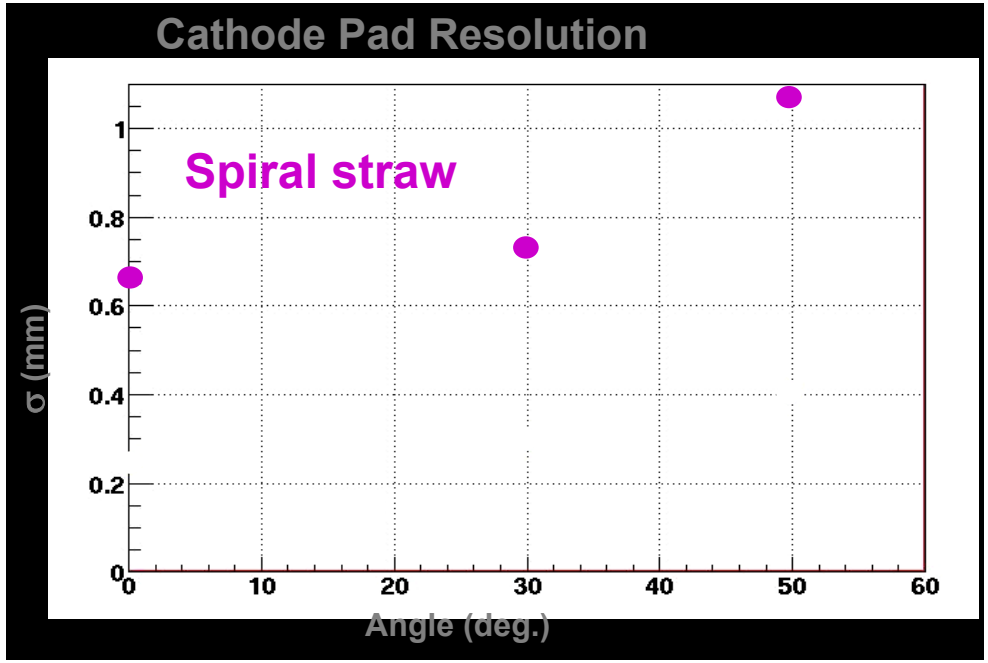
- Two tracker geometry options are being considered
  - Longitudinal geometry with ~3000 3m long straws oriented nearly coaxial with the DS and 19000 capacitively coupled cathode strips for axial coordinate measurement
  - Transverse geometry with ~13000 1.4 m straws, oriented transverse to the axis of the DS, readout at one or both ends
  - Both geometries appear to meet physics requirements



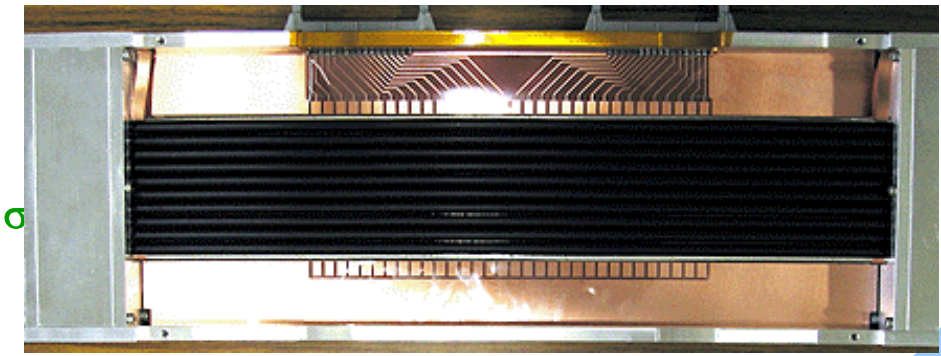



# Seamless Straw Development (Osaka)

- Seamless straws
  - Thickness : 25 μm
  - Diameter : 5 mm
  - Material : Polyamide + Carbon
  - Resistance : 6 MΩ/sq
- Advantages
  - No Adhesive
  - Thinner
  - More uniform thickness and resistance
  - Less out-gassing and leakage in vacuum
- System built and tested in Japan
- Cathode pad resolution
  - Seamless Straw (4MΩ/sq) Resolution σ = 0.4 mm at 60°
  - Spiral Straw (0.5MΩ/sq) Resolution σ =1.1 mm at 60°
  - Design goal (σ = 1.5 mm) is achieved
- Seamless straw anode performance
  - Drift Distance Resolution = 70 μm at 60°
  - Efficiency > 95% except near walls
  - Design goal (σ = 0.2 mm) is achieved

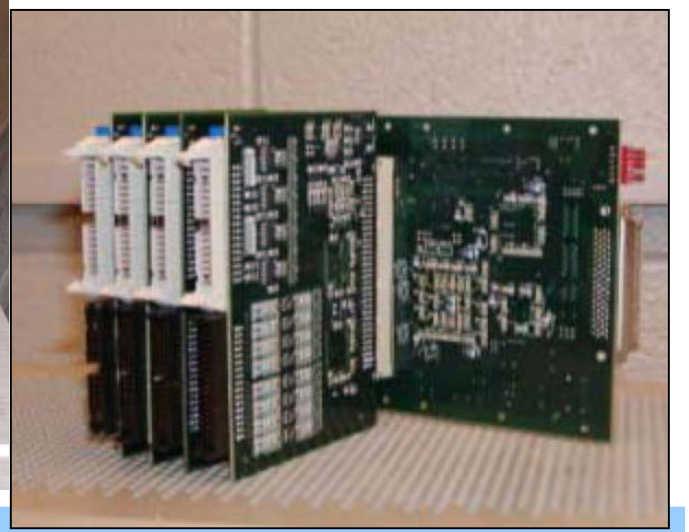


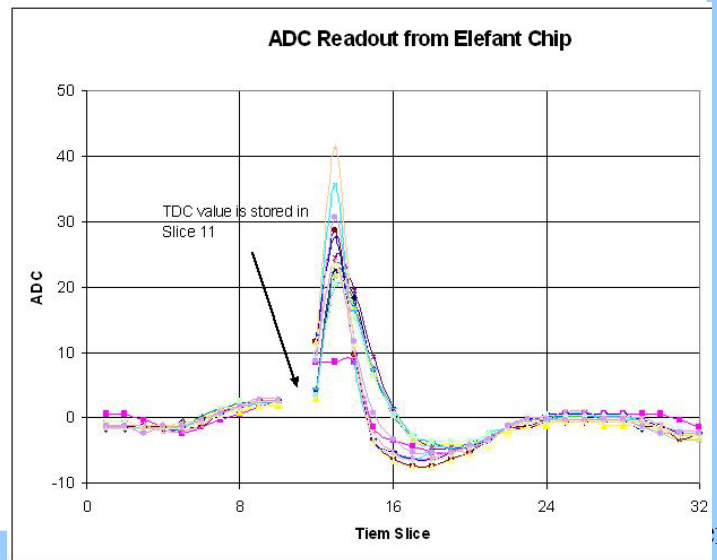

σ



# Tracker R&D (Houston)

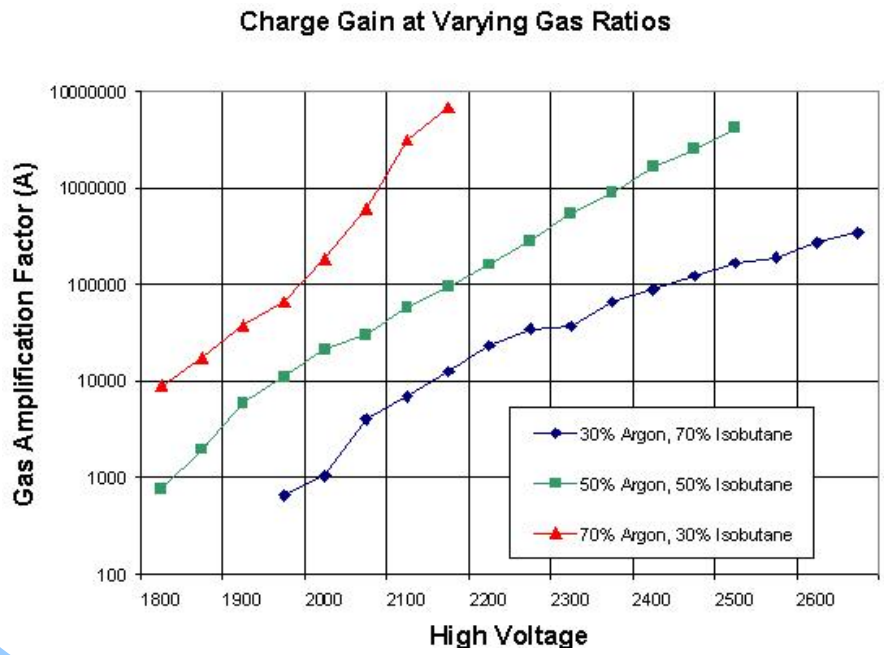
- **Studies provide input to select geometry and readout architecture**
  - **Full-length longitudinal vane prototype remains a work in progress at Houston as mechanical stability and straw bonding issues are resolved**
  - **Electronics design and prototype work at Houston has progressed to testing prototype preamplifier, digitizer, and controller boards as a system using the current version of BaBar's Elefant chip with very promising results.**
  - **Simulations of both the longitudinal and transverse geometries continue, indications are that either geometry might work from a physics standpoint**

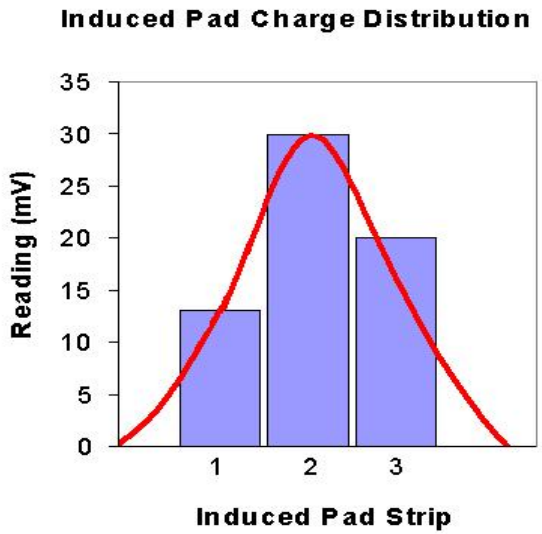




# Data From Prototype Chambers

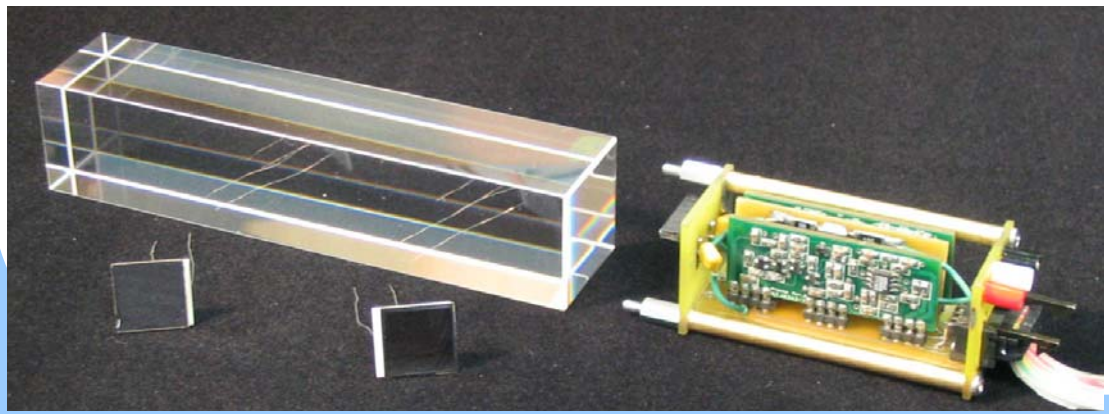
- Studies of charge distribution on pads, gas properties, and several amplifier options
- Selected ASD-4 as the leading amplifier candidate and determined the optimal straw resistivity to be 0.5 – 1 MW/sq

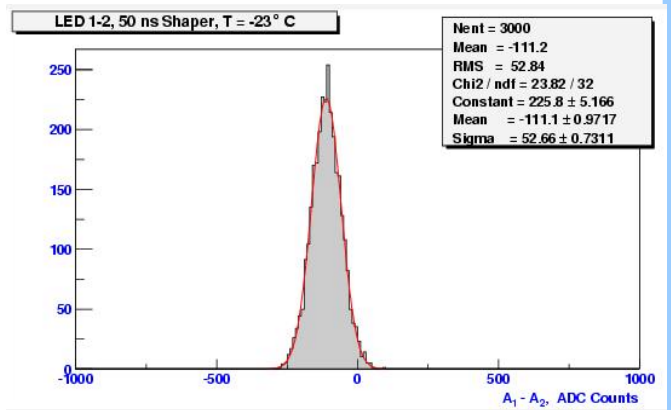


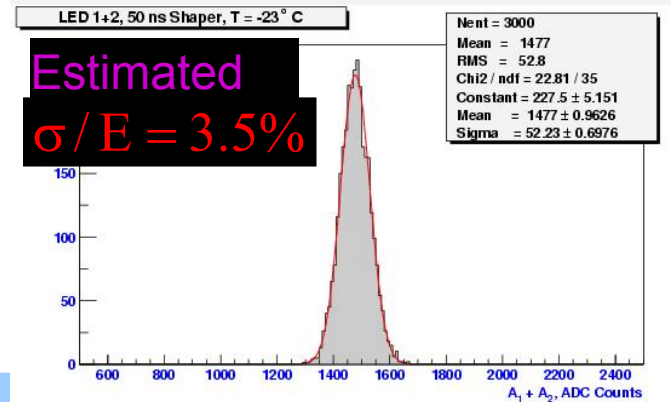



# Calorimetric Electron Detector (NYU)

- Bench tests of $PbWO_4$ crystals cooled to –23 °C and large area avalanche photodiodes continue at NYU using electronics designed and built in house
- Indications are that this material will meet MECO resolution requirements, demonstrating 20-30 photo $e^-$/MeV (as compared with CMS' 5 pe/MeV)
- We need to verify the system performance via beam tests of an 8×8 crystal array





# Cosmic Ray Shield

- Extensive testing at William & Mary has established a combination of scintillator, wavelength shifter, and multi-anode PMT that will meet MECO's 99.9% cosmic ray veto efficiency requirement
- Extrusion of ~100 4m slats this summer at Itasca – similar to MINOS design
- Test slats will be assembled into a prototype module this Fall
- Further concerns with rates (e.g. from neutrons) to be addressed

# Collaboration with Instrumentation

- Groundwork has been laid for collaboration between RSVP & Instrumentation Division
  - Unparalleled resource, expertise of great value for development of front-ends, trigger electronics
- KOPIO, MECO will each appoint an electronics expert, who will act as the interface between experiments and the Division
- Project Office will provide general oversight, guidance, direct path to RSVP for Division Head
- Projects to be pursued will be chosen on basis of interest, expertise, resource availability
- Work will be supported via RSVP project funds

# A Few Meetings of Note

- **Summer kickoff meeting with BNL Budget Officers, Procurement, Legal, Intellectual Property, AGS budget personnel**
  - **Discuss new management, general project needs, institutional roles and requirements, etc.**
- **Weekly meeting scheduled with KOPIO, MECO, AGS Project Managers**
  - **Guide, oversee development of resource-loaded schedules**
  - **Technical issues, personnel, any other concerns also aired**
  - **Meetings with full group & individual sessions**
- **Regularly scheduled monthly meeting with BNL Director (Chaudhari), Deputy (Bond), Associate Director HENP (Kirk), RSVP Deputy Project Director (Kotcher)**
  - **Discussion of all issues related to mounting RSVP at Brookhaven**
  - **Initial session in October very positive**

# May 2005 Goal

- Timeline has been generated that is designed to enable us to prepare fullest "product" possible for presentation to the NSF NSB in May 2005
- Contains project-wide milestones established by Project Office that target/review key subjects, issues
- Goal is to develop as fleshed out & accurate a picture as possible on this time scale of what it will take to mount the RSVP scientific program, and to maximize project readiness
  - Requirements for the realization of the scientific goals
  - Technical designs
  - Cost and contingency (labor, M&S)
  - Resource profiles
    - Technical personnel, physicists of all flavors, equipment spending needs, etc.
  - Schedule (+ contingency), choreography
  - Project documentation

# RSVP 2004-2005 Timeline (1)

| Milestone | Date | Status, Comments |
|---|---|---|
| Discussion of Baseline Expectations, Timeline with Experiments | September 13 | Done |
| MECO Magnet Review | Sun-Tue, Oct 10-12 | MOG established, held at Columbia University |
| AGS Review | Thu-Fri, Nov 4-5 | Set, committee almost assembled |
| Internal discussion of resource-loaded schedules (RLS) for all projects | Thu, Dec 9 | Includes PO, NSF PM, + experiments. Anticipate one full day. Date TBF. |
| Initial review of RLS for all projects | Thu-Fri, Jan 13-14 | Reviewed by LOC. Dates TBF. |
| Simulations & Backgrounds Review | Tue-Thu, Jan 11-13 | Set, Chair chosen, reviewers being assembled, held at NYU |

# RSVP 2004-2005 Timeline (2)

| Milestone | Date | Status, Comments |
|---|---|---|
| Reviews of other sub-projects | Weeks of Jan 17 – Feb 21 | Series of 1.5-day reviews, covering detectors, other sub-systems |
| Draft versions of PMP, PEP, Conceptual Design Report completed | Mon, Feb 14 | |
| Operations Review | Week of Mar 7 | |
| Project startup pre-review | Week of Mar 15 | Comprehensive preparatory review of full project, proposal |
| Project startup review | Week of Apr 18 | Final project startup review, iteration of above |
| Finalize documentation for May submission to NSF | Week of Apr 25 | |
| Product submitted to NSF/NSB | Mon, May 2 | |

# Initial Review

- First review: MECO Magnet
  - October 10-12 (Sun-Tue)
  - Columbia University Physics Building, Manhattan campus
- Single most technically demanding, expensive item in RSVP
- Moving toward fully coordinated, team-oriented approach – University/ Laboratory collaboration
  - Technical expertise, both directly involved and advisory
  - Procurement
  - Cryogenics
  - Installation, integration, commissioning
  - Operations
- Standing Magnet Oversight Committee (MOG) established to serve in ongoing advisory capacity to Project Director:
    - Elwyn Baynham (Rutherford Appleton Laboratory)
    - Gene Fisk (Fermilab)
    - Herman ten Kate (CERN)
    - Tom Taylor, Chair (CERN)
    - Akira Yamamoto (KEK)

# MECO Magnet Review

## MECO Magnet Review Charge

**[1] What are the functional requirements of the MECO magnet system?**

**(a) present magnet design and status**

**-- conductor/layout/tolerances/margins**

**(b) sensitivity of experiment to changes in magnet parameters**

**(c) technical risks and sensitivity to design choices/ justification of choices**

**(d) schedule**

**(e) costs**

**[2] What is the optimum scenario for achieving the required MECO magnet system in the appropriate time frame? Specifically, evaluate all plausible mechanisms for magnet procurement and include all technical, cost, schedule, and integration and management issues.**

# Status of the Two Other Major Reviews

- **AGS Project**
  - Brookhaven, Thu-Fri, November 4-5
  - Focus on scope, cost, schedule, technical requirements of AGS upgrades for RSVP. Operations, impact to RHIC running also covered.
  - Review Committee:
    - Ray Larsen, Chair (SLAC)
    - Alberto Marchionni (FNAL), high intensity operations in Main Injector
    - Elias Metral (CERN), PS operations, space charge limitations, projects
    - Ralph Pasquinelli (FNAL), RF, bunch structure
    - Finalizing two additional reviewers
  - Draft charge, agenda being reviewed by principals – will be distributed this week
- **Simulations & Backgrounds**
  - New York University, Tue-Thu, Jan 11-13
  - Full review of understanding of backgrounds for both experiments
  - Simulations from which that understanding is derived, and their limitations.
  - Jack Ritchie (University of Texas, Austin), Chair. Desired reviewers agreed upon, being asked to serve.