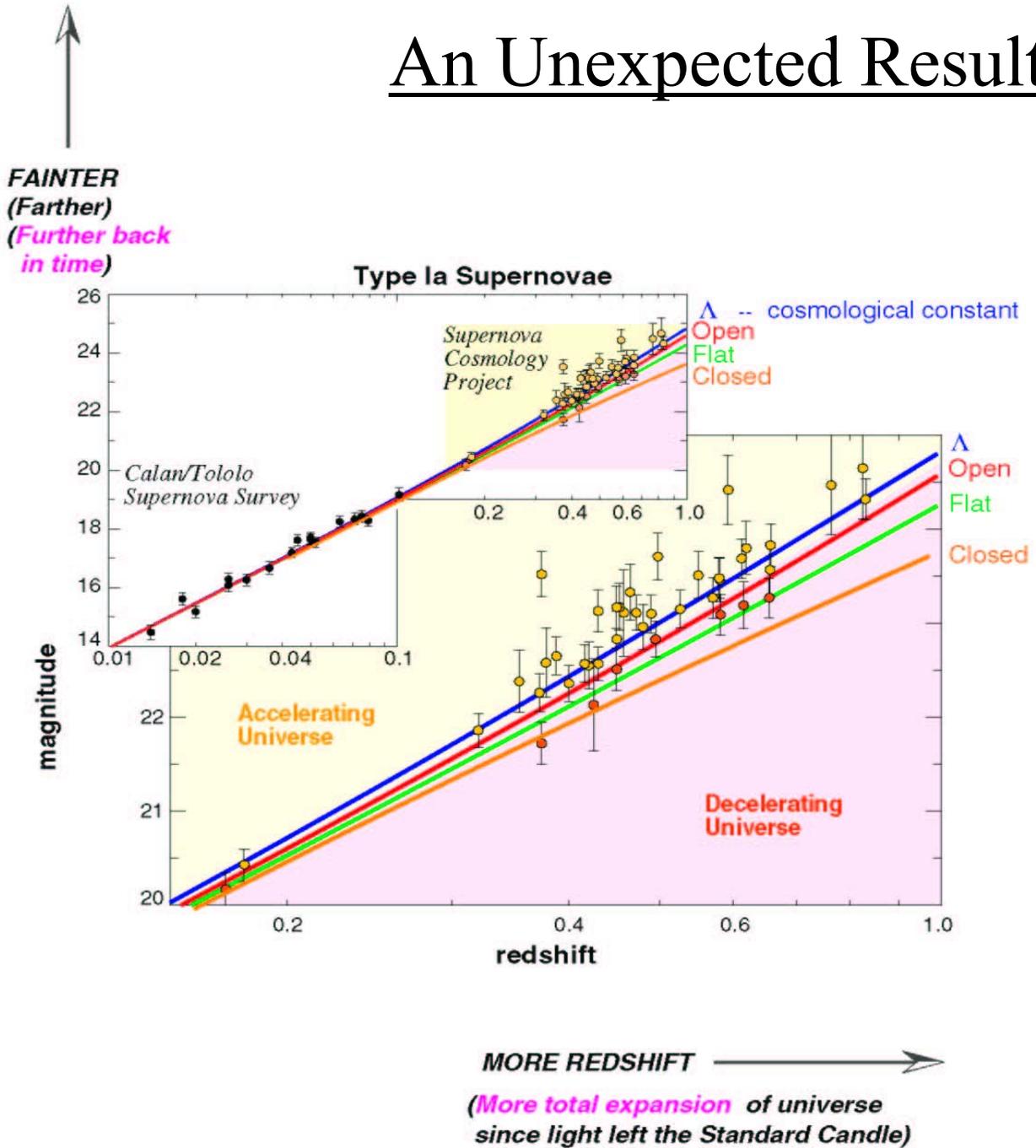

SNAP at Fermilab

**A Proposal
for
Fermilab
to
Collaborate
in
SNAP**

What is SNAP?

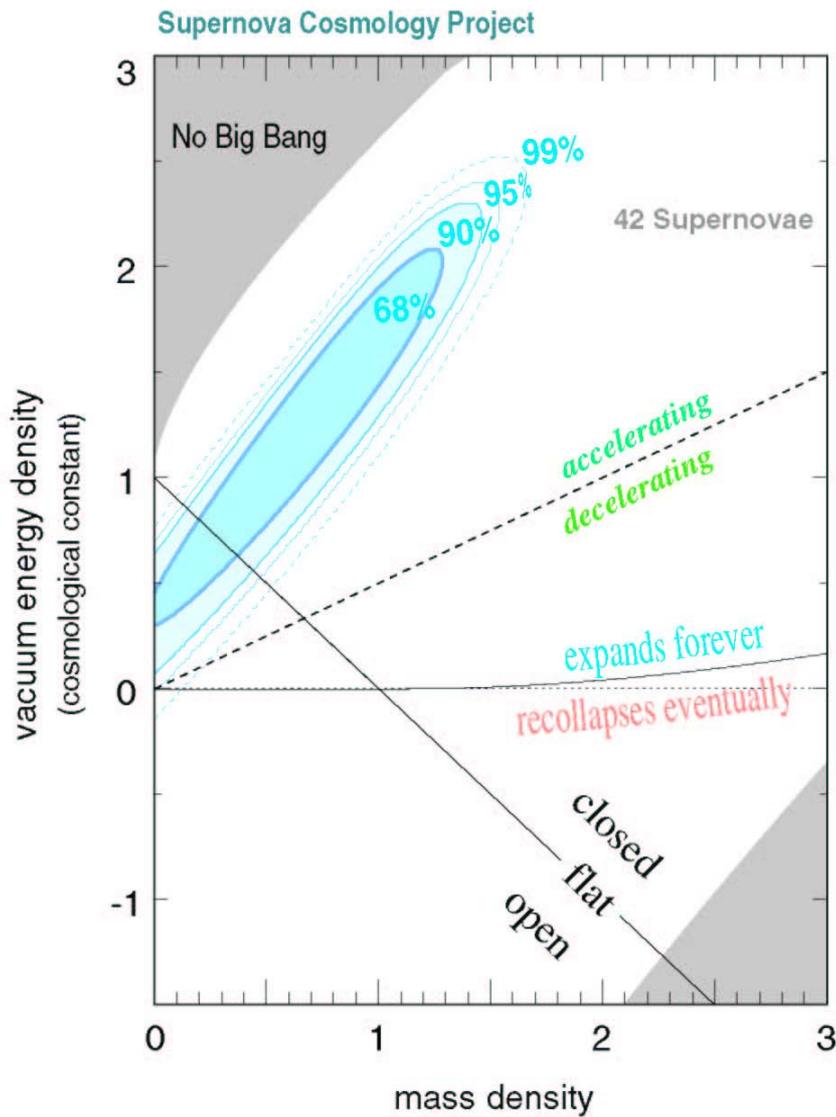
- **SNAP is a proposed space-based mission to probe the nature of dark energy and the accelerating universe.**
 - *A deep survey of Type Ia SNe, which are thought to be standard candles*
 - *Expect to see ~2000 SNe Ia in 2-3 yrs*
 - *Also has a 300 sq. deg. wide-field survey*
 - *Launch ~2010*
- <http://snap.lbl.gov>
- **SNAP is an important goal for DOE in this decade. A DOE review has recommended it for CD-0 approval.**
 - *Centered at and managed from LBNL*
- **A dark-energy mission is on the NASA roadmap, and a NASA Research Announcement (NRA) has been released for preliminary work.**
 - http://research.hq.nasa.gov/code_s/nra/current/nra-03-oss-01/appendA1_9.html

An Unexpected Result



Replot Data in $\Omega_M - \Omega_\Lambda$ Space

Best-Fit Contours



Perlmutter *et al.*
 (Ap.J. 1999)
 astro-ph/98 12133

Some Slides from Lam Hui

- **Science Motivation for SNAP**
 - **Supernovae**
 - **Science from the Wide-Field Survey**
 - **Other Possible Science**
 - **How does this connect to HEP?**
- **Other Missions to Probe Dark Energy**
 - **Ground-based/Space-based**
 - **How do they stack up?**
 - **What will we know about dark energy at the time of the SNAP launch?**
- **What will we learn from SNAP?**
 - **Error Contours, etc.**

The Supernova/Acceleration Probe (SNAP) Collaboration

G. Aldering, C. Bebek, J. Bercovitz, M. Bester, E. Commins, W. Carithers, C. Day, R. DiGennaro, G. Goldhaber, D. Groom, S. Harris, P. Harvey, H. Heetderks, S. Holland, D. Huterer, R.W. Kadel, A. Karcher, A. Kim, W. Kolbe, J. Lamoureux, R. Lafever, M. Lampton, M. Levi, E. Linder, S. Loken, R. Miquel, P. Nugent, H. Oluseyi, N. Palaio, D. Pankow, S. Perlmutter, K. Robinson, N. Roe, M. Sholl, G. Smoot, A. Spadafora, H. von der Lippe, J-P. Walder, G. Wang

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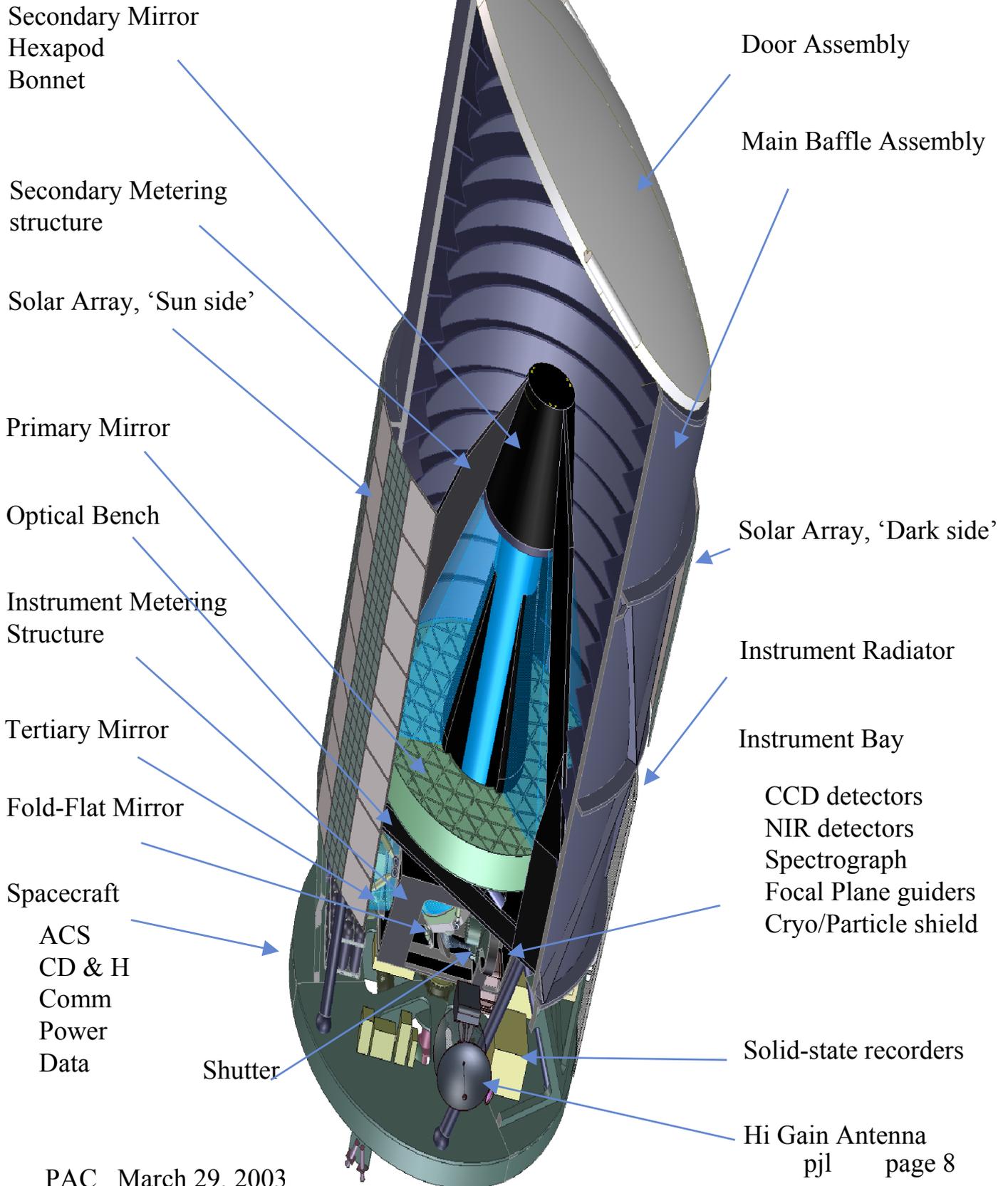
P. Astier, E. Barrelet, A. Bonissent, A. Ealet, J-F. Genat, R. Malina, R. Pain, E. Prieto, A. Refregier, G. Smadja, D. Vincent
France: IN2P3/INSU/CEA/LAM

R. Amanullah, L. Bergström, M. Eriksson, A. Goobar, E. Mörtzell
University of Stockholm

C. Baltay, W. Emmet, J. Snyder, A. Szymkowiak, D. Rabinowitz, N. Morgan
Yale University

- SNAP in a Delta IV-M Payload Bay



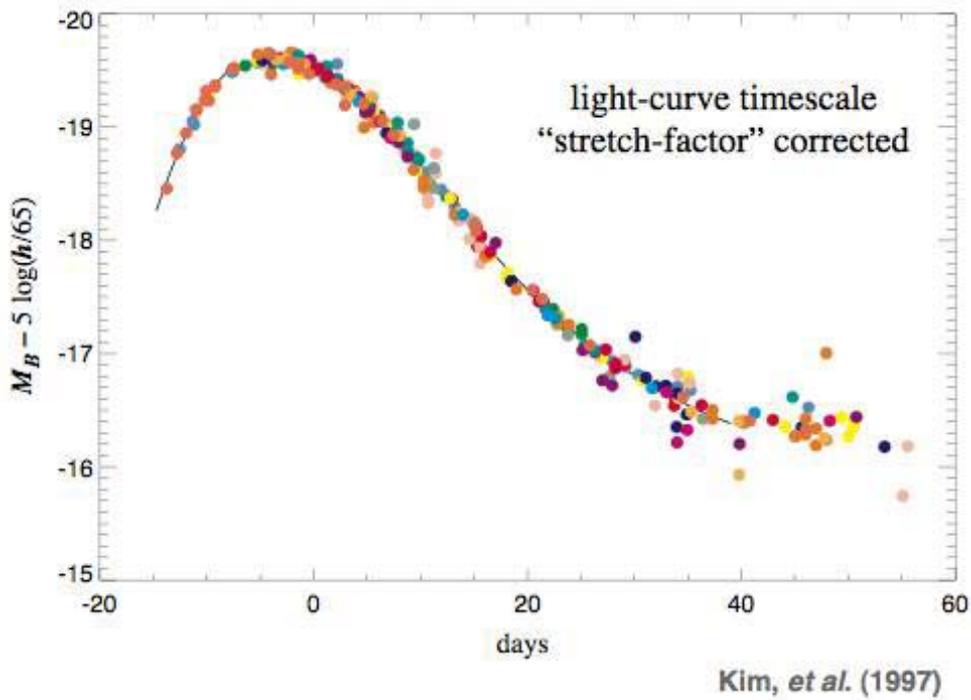
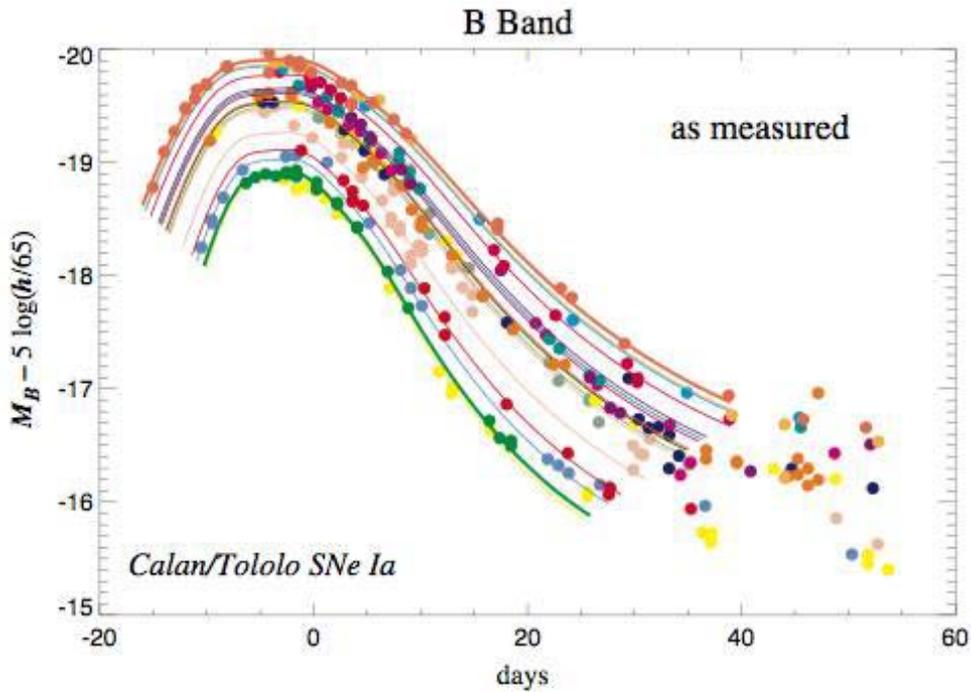


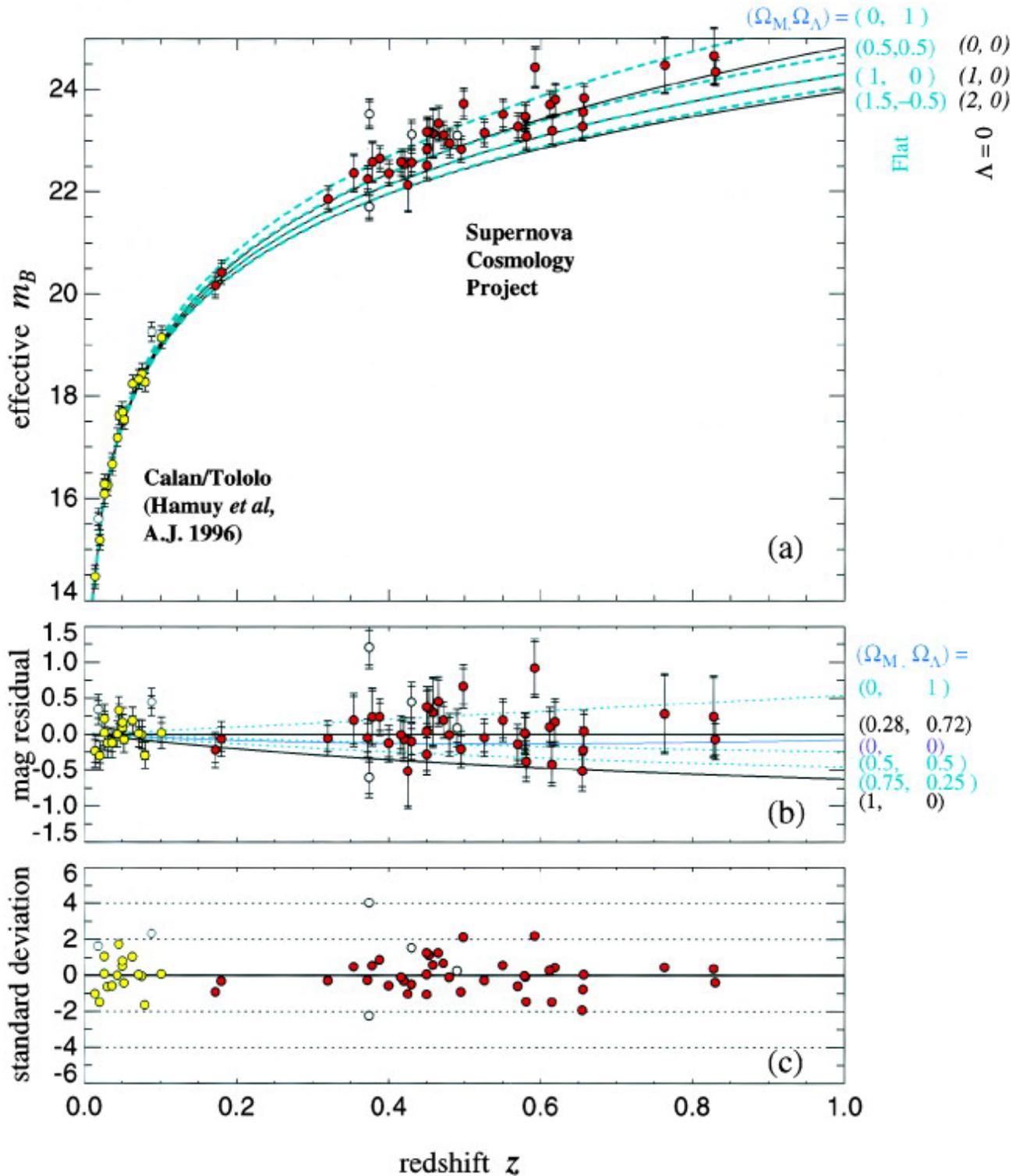
How do the surveys work?

SNe Ia are distinguished by being a standard candle and by having unique spectrographic and time-development fingerprints.

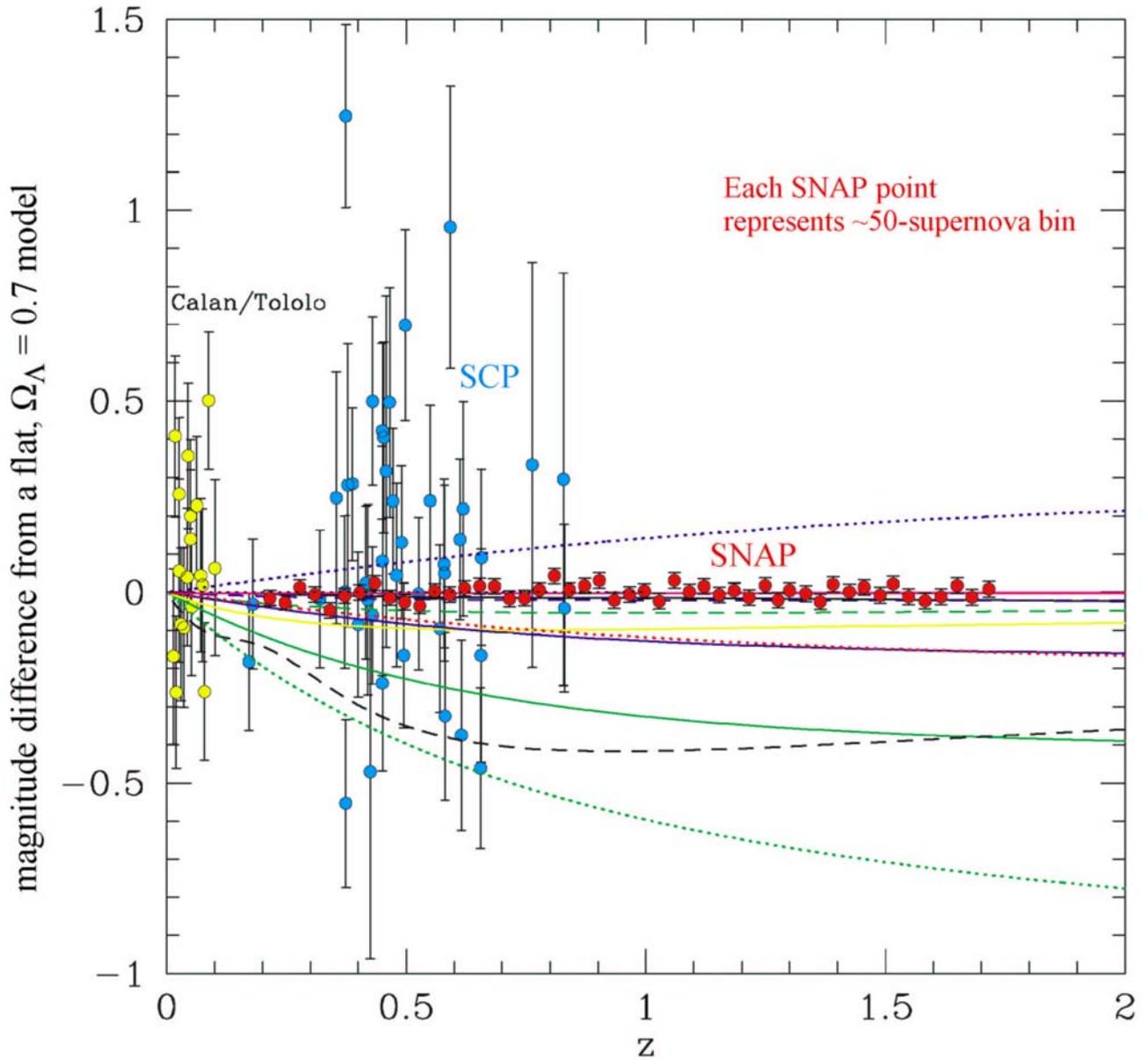
1. *Repetitively scan a two 7.5 sq. deg. pieces of the sky, one in the north, one south. Each scan takes about 3 days with the wide-field camera.*
 - a. The camera has about $5E8$ pixels and nine color filters from visible into near IR.
2. *Subtract each scan from a reference scan to look for SNe.*
3. *Use the camera with filters to “trigger” on SNe Ia. Follow progress with the camera to obtain the light curve.*
4. *Use a spectrograph to obtain the redshift of interesting SNe during peak brightness.*
 - a. This information also helps to identify type Ia SNe.
5. *The two deep surveys take ~3 yrs of a 4-year mission to get ~2000 SNe.*
 - a. The rest of the time is used for the wide-field survey and “guest observations.”
6. *All the data are stored in on-board memory and are transmitted down on every orbit at the perigee, every three days.*
7. *The wide-field survey is a single-pass look at a broad field for weak-lensing, cluster counting, etc.*
 - a. The wide-field survey is limited by data rate, so there may have to be more memory and more telemetry bandwidth, or more compression.

Type Ia Supernovae - A Standard Candle





Current ground-based data compared with binned simulated SNAP data and a sample of Dark Energy models.

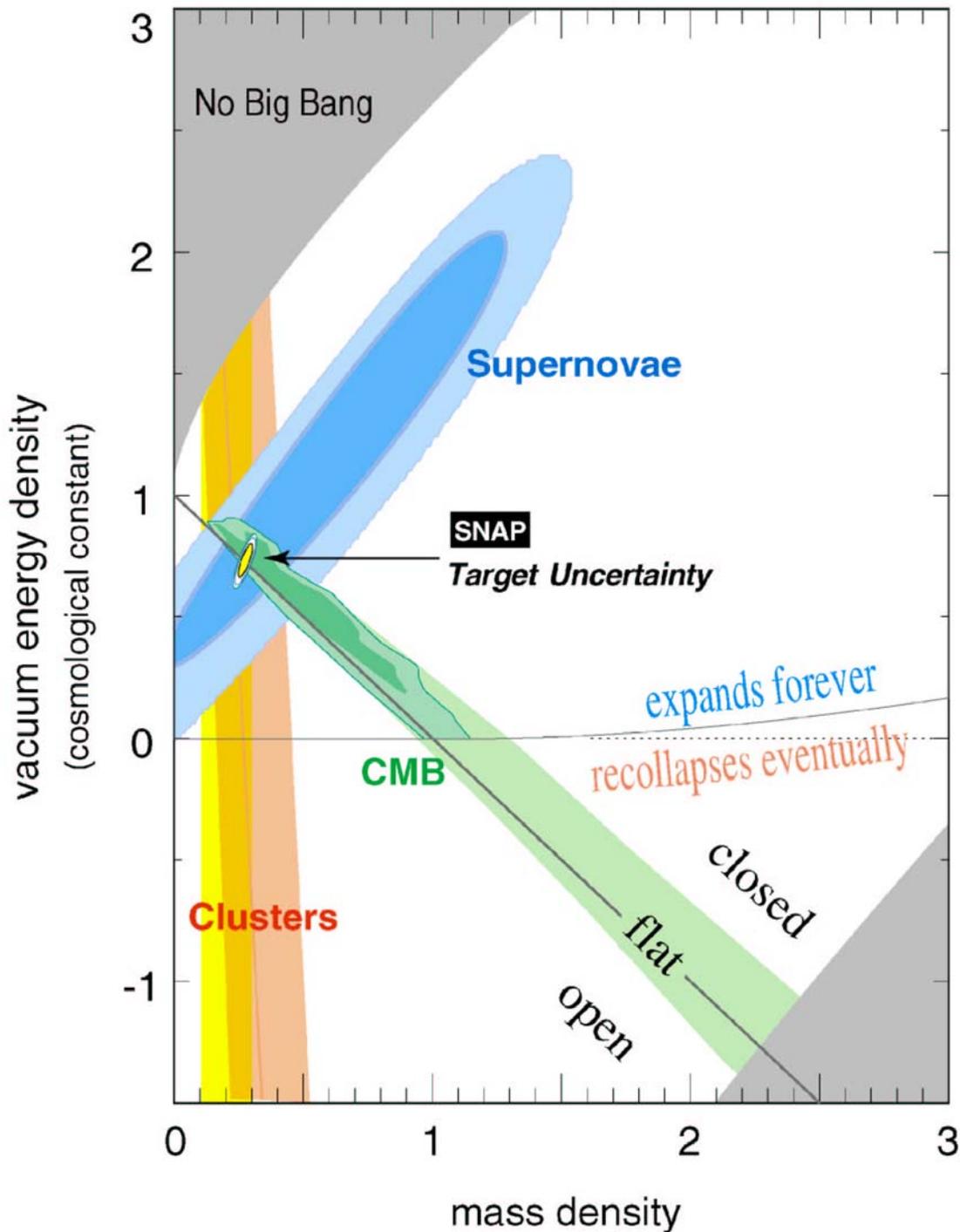


based on
Weller & Albrecht (2001)

Perlmutter, et al. (1999)

Jaffe et al. (2000)

Bahcall et al. (2000)



Present Level of Effort at Fermilab

- We have about 30 Fermilab scientists who have expressed interest.
 - Most have signed up for specific responsibilities
 - The list is a “work in progress.”
 - About half (not always the same half) attend our regular bi-weekly meetings
 - About half are members of the Experimental (SDSS) or Theoretical Astrophysics groups. The rest are high-energy physicists.
- We hope to have about 6 to 8 FTE scientists by the end of FY2003.
 - *This depends on approving nods from the SNAP collaboration, DOE and the Fermilab Director, and possibly on other issues.*

What Will Fermilab Do?

Science Interests

- Many Fermilab scientists are interested in SNe deep survey because of its apparent straight-forward connection to dark energy.
- Fermilab may propose an enlarged wide-field survey as a different look at dark energy and dark matter.
 - *We expect to lead a large-scale structure effort within SNAP.*
 - *It will provide results with different systematics*
 - *A 1000 sq. deg. survey may require some minor mission modifications*

Our Internal Criteria for Work

- Fermilab's work must be useful to SNAP
- Fermilab should have special expertise in the required scientific skills and/or technology **OR** the task should require national lab capability.
- Preference given to tasks associated with Fermilab science goals for SNAP

Fermilab Proposed Organization & Work Scope

- Overall Leaders *Steve Kent & Peter Limon*
- Science & Simulations *Albert Stebbins*
- Photometric Calibration *Steve Kent*
 - *Expertise due to SDSS work*
- Scientific Software & Archiving *Chris Stoughton*
 - *Expertise due to SDSS work*
- Electronics *John Marriner*
 - *Solid-state recorder*
 - *Data compression hardware*
 - Both of above could help wide-field survey
 - *Electronics associated with the focal plane*
 - *Microwave systems for telemetry*
- Radiation Shields *Tom Diehl*
 - *Cosmic-ray, light baffle, thermal*
 - *Involved in all three; concentrate on cosmic-ray shield and integration*
 - Uses GEANT & MARS design tools
 - Serious mechanical & thermal engineering requires solid modeling and sophisticated FEA

Electronics

Fermilab's proposal to enlarge the wide-field survey may affect some aspects of the mission, in particular, creating a larger data set. Fermilab proposes to work on electronics that will help mediate those issues.

- **The data storage system**
 - **A solid state recorder to store more data on board**
 - **Improved data compression hardware to reduce the size of stored data set for the wide-area survey**
 - **Possibly other systems & integration issues**
- **Fermilab has expertise in areas that may be useful to the mission. Not yet clear whether we will work on these items.**
 - **Electronics associated with the focal plane**
 - *Fermilab has extensive ASICs expertise.*
 - *Other electronics (control, monitoring, etc.)*
 - **Microwave systems for data telemetry on the ground and possibly on the space vehicle.**
 - *Fermilab has expertise in microwaves gained through accelerator technology.*

Cosmic Ray Shield

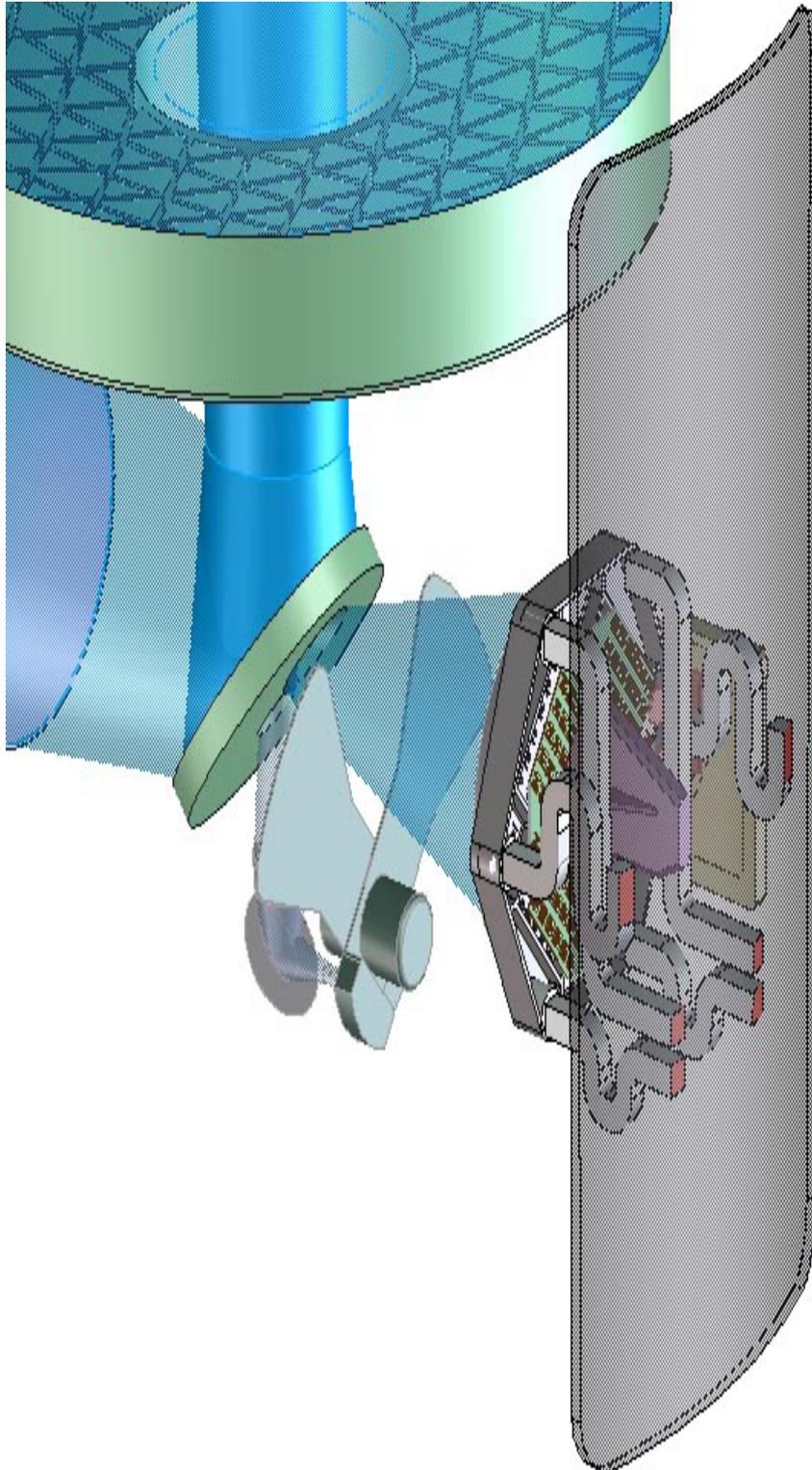
Fermilab proposes to take leadership responsibility for the cosmic-ray shield and its integration into the instrument, the other shields and the spacecraft.

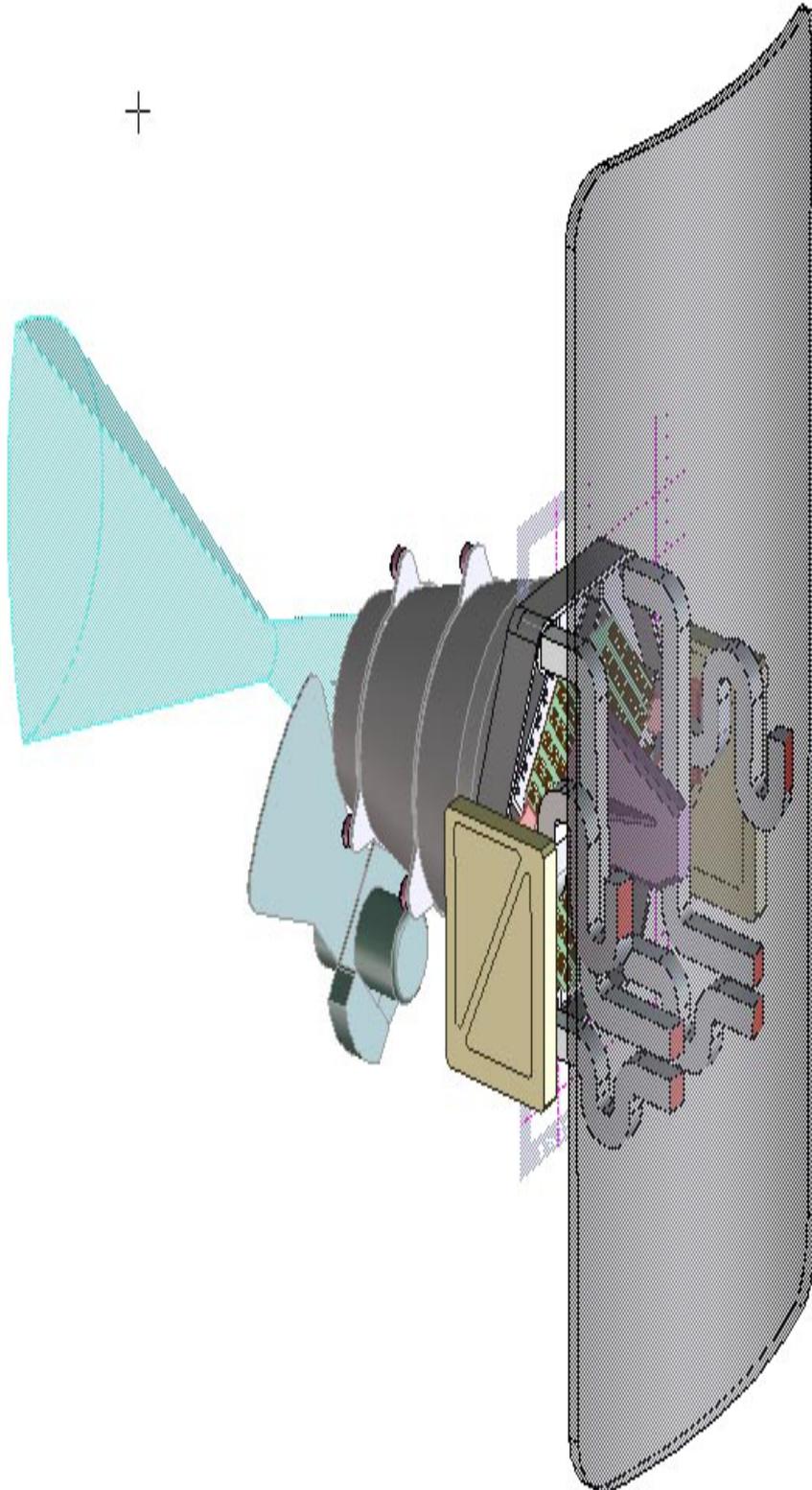
Purpose of the cosmic ray shield

- **Reduce the cosmic ray background during the ~300 s ~300 s to 500 s exposures.**
- **Reduce the radiation damage to the detector elements and the electronics from cosmic rays, solar solar wind and Van Allen belt radiation.**

Scope of Work

- **Fermilab will contribute to the design, and possibly possibly the fabrication of all the shields**
 - **Primary responsibility for the design and integration of the the cosmic ray shield. Whether fabrication is involved is not not known at this time.**
 - **Physics design involves understanding the cosmic ray flux in flux in the SNAP orbit ,simulating its effects on the detector,the electronics and signal -to-noise using GEANT GEANT and MARS, and optimizing the shield design for reduction of the flux and spacecraft weight**
 - **Engineering design takes the requirements of the physics physics design and optimizes the cosmic ray shield for mechanical stability, cost, integration into the spacecraft, the the instrument and other shields, etc.**





Status at Fermilab

- Michael Witherell has encouraged us to “investigate” involvement in SNAP.
 - *He has told the division heads to supply us with support for the investigation.*
- We have submitted a letter to the SNAP Collaboration asking for admission.
 - *Michael Witherell has seen the letter and encouraged us to send it.*
 - *We are told by the Project Director, Michael Levi, that the letter is being well received.*
 - *We have been asked for some clarifications. More requests for information will come. We hope to be approved soon.*
- We received \$40,000 from Fermilab in M&S for the rest of the fiscal year, mostly for travel.
- We have requested three engineers/engineering support for the rest of the fiscal year (i.e. approx. 1.5 FTEs), to help plan the scope of work and the needed resources.
- We are actively working on the FY2005 WPAS

The Size of the Fermilab SNAP Effort

- o **Hard to say at this time. Space missions use more engineering and more outside contracting than HEP experiments.**
- o **A wild guess - perhaps \$10 million/year, not including science salaries??**
- o **Roughly twice the Fermilab part of the LHC Accelerator Project. SNAP will involve many more scientists because there is science to do.**
- o **We may get some funds from the SNAP collaboration in 2004. We hope to be fully funded (not scientists) in 2005.**

Why Should Fermilab Join SNAP?

- **If we're in we get to participate in important science.**
 - *We bring our own science ideas to SNAP – ideas that make SNAP a better mission and are led by Fermilab scientists.*
 - *Fermilab's participation strengthens the connection between astrophysics and particle physics.*
- **Fermilab's presence makes the mission stronger and more likely to succeed.**
 - *We are a large group with the scientific, technical and organizational strengths typical of a DOE laboratory.*
 - *Fermilab's SNAP group is very strong in astronomy, something SNAP needs, with excellent experimental and theoretical astrophysics groups.*
- **Participation in SNAP will strengthen Fermilab scientifically and technically.**
 - *It helps diversify the Lab in a field that is intimately connected to particle physics.*
 - *SNAP is a challenging mission that will stretch our technical and engineering capabilities.*

Why Should Fermilab Join SNAP?

- From the Report from HEPAP to the DOE Office of Science concerning U.S. HEP Facilities.
- Three proposed facilities were considered **“Absolutely Central”**:
 - A Linear Collider
 - An LHC Luminosity Upgrade
 - **SNAP**