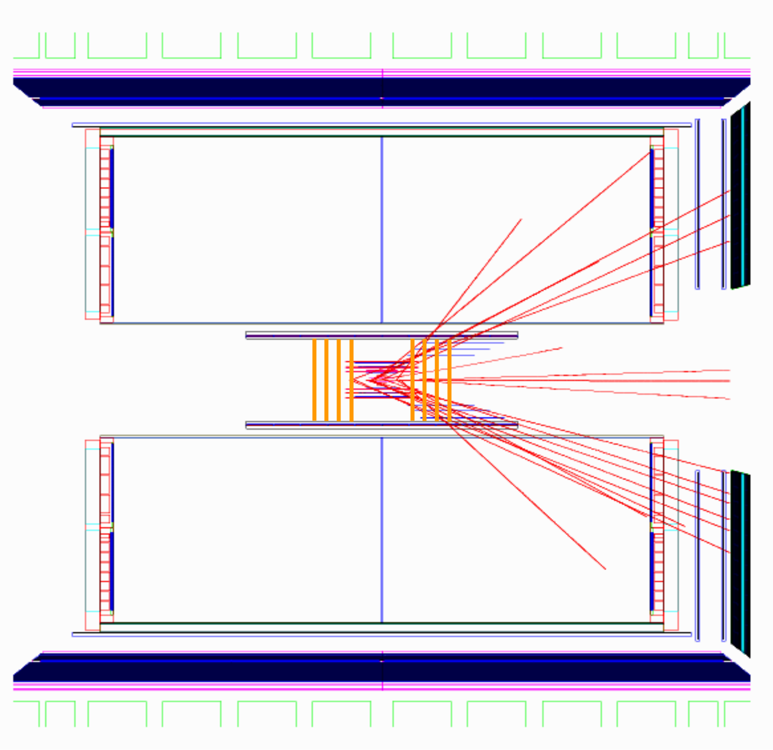
Report of STAR discussion meeting on the inner and forward tracking upgrade

Part I: Overview of physics case, possible tracking layout and technology choices



Part II: Discussion on upgrade strategy, staging of various projects and overall organization

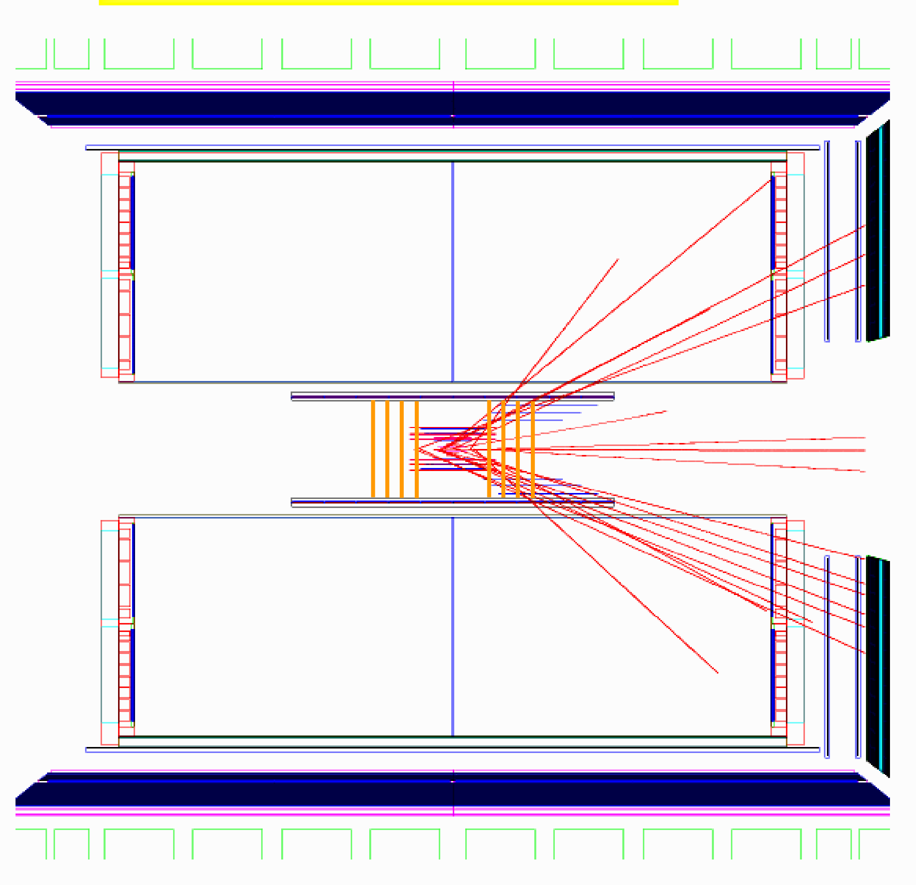
Outline of meeting - Part I

D. Majka: Overview of the STAR future upgrade plans

N. Smirnov: Possible layout of a new STAR tracking system

M. Miller: STAR tracking software

D. Lynn: Report on status and future of STAR SVT/SSD



G. v. Nieuwenhuizen: MIT Silicon laboratory

R. Milner: MIT-BATES infrastructure

J. Kiryluk: W event kinematics

S. Vigdor: Overview of pp physics topics

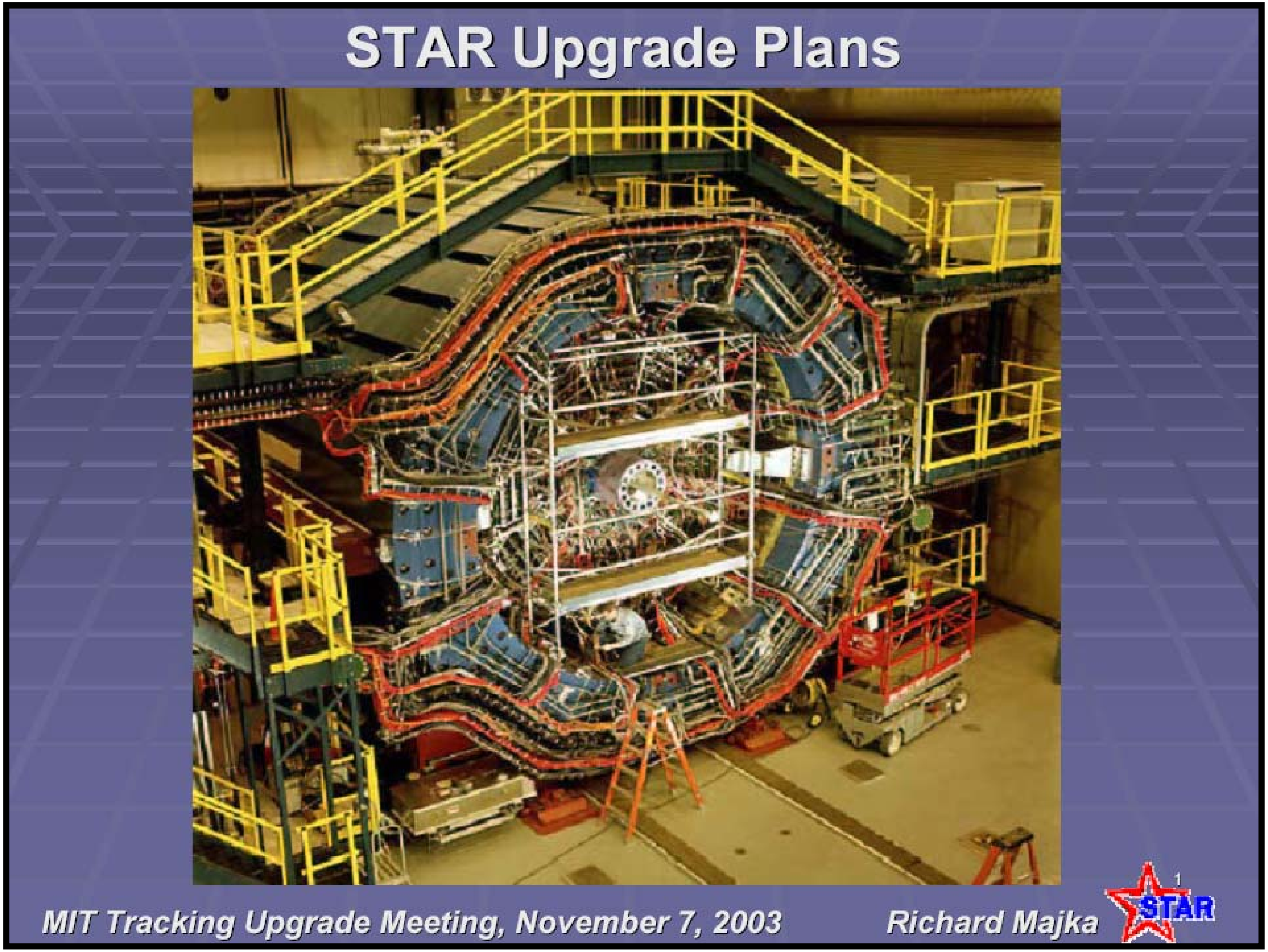
K. Schweda: Overview of Au-Au physics topics

H. Wieman: Report on Pixel activities

N. Smirnov: Report on GEM activities

B. Surrow: Overview of silicon strip detectors (ZEUS/CMS)

D. Majka: Overview of STAR future upgrade plans

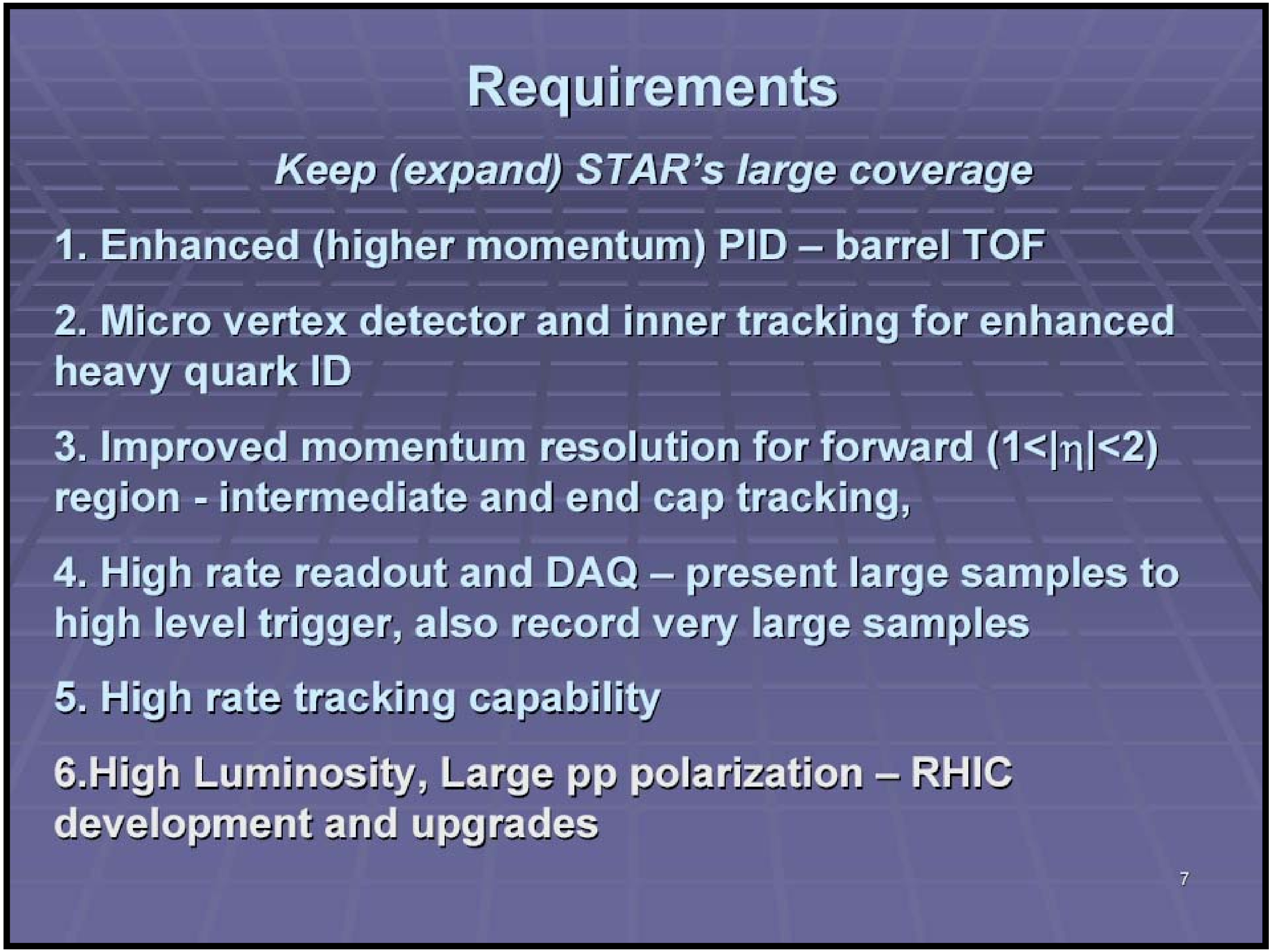


STAR Upgrade Plans

MIT Tracking Upgrade Meeting, November 7, 2003

Richard Majka

D. Majka: Overview of STAR future upgrade plans

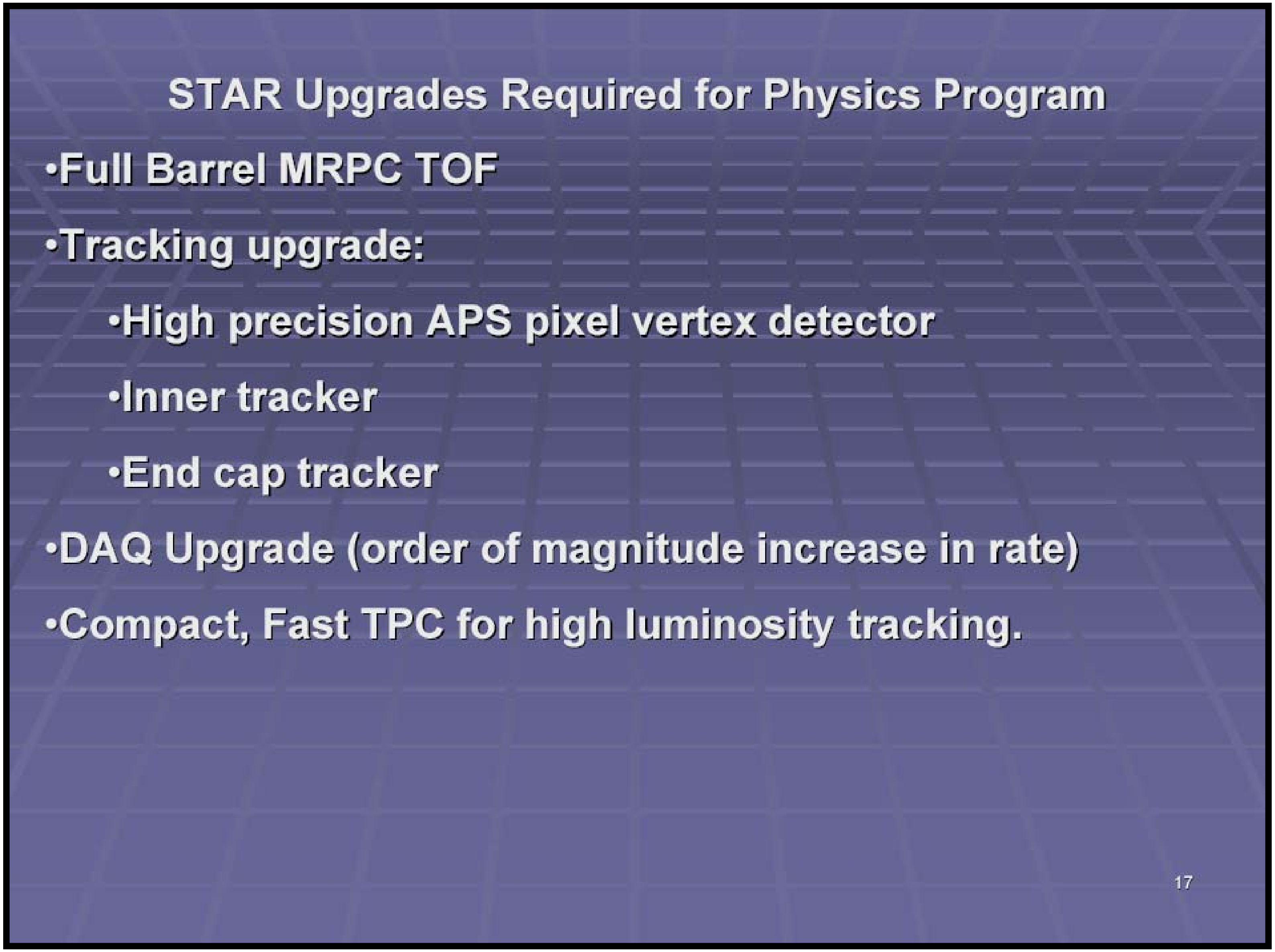


Requirements

Keep (expand) STAR's large coverage

1. Enhanced (higher momentum) PID – barrel TOF
2. Micro vertex detector and inner tracking for enhanced heavy quark ID
3. Improved momentum resolution for forward ($1<|\eta|<2$) region - intermediate and end cap tracking,
4. High rate readout and DAQ – present large samples to high level trigger, also record very large samples
5. High rate tracking capability
6. High Luminosity, Large pp polarization – RHIC development and upgrades

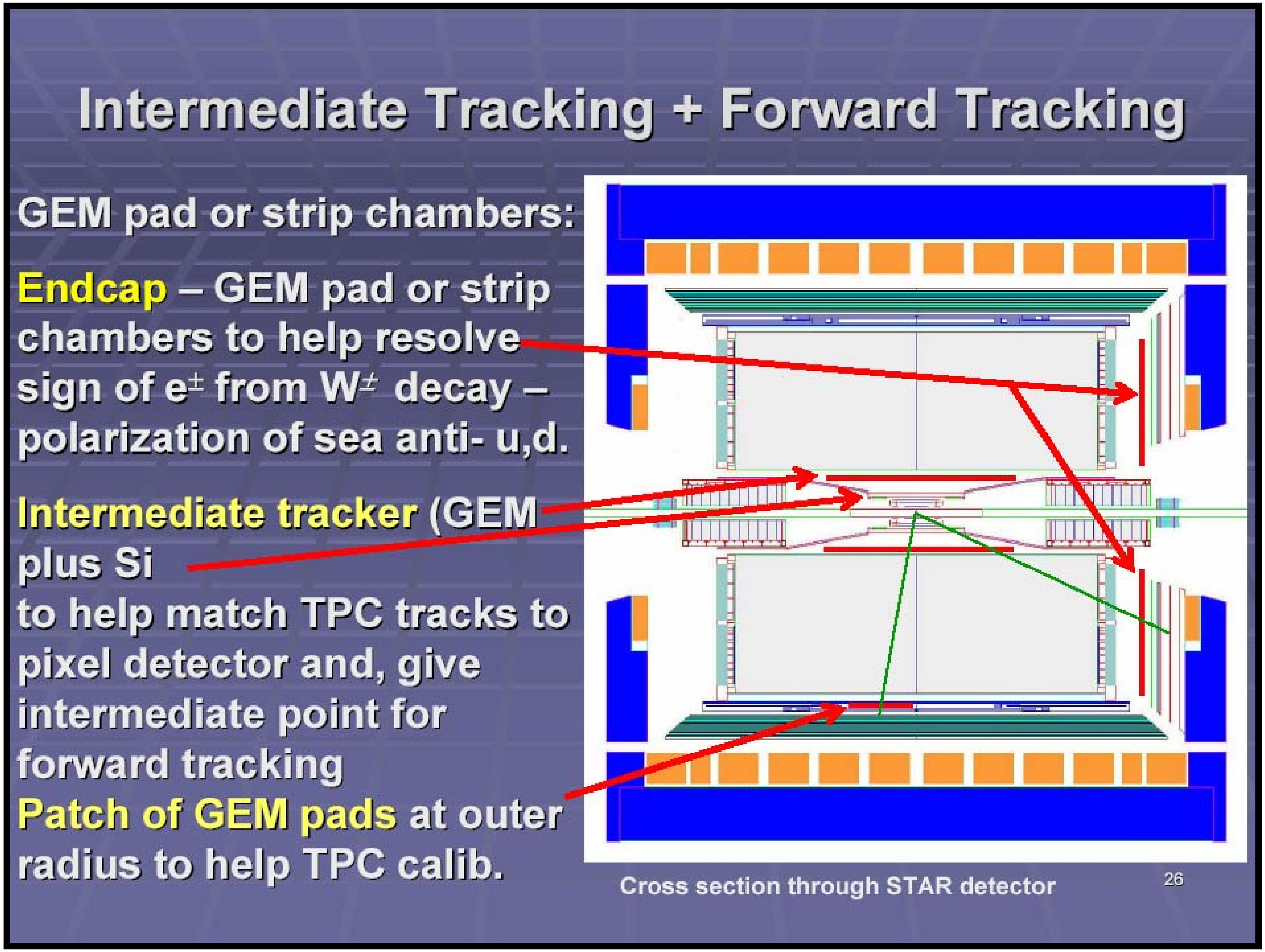
D. Majka: Overview of STAR future upgrade plans



STAR Upgrades Required for Physics Program

- Full Barrel MRPC TOF
- Tracking upgrade:
  - High precision APS pixel vertex detector
  - Inner tracker
  - End cap tracker
- DAQ Upgrade (order of magnitude increase in rate)
- Compact, Fast TPC for high luminosity tracking.

D. Majka: Overview of STAR future upgrade plans



Intermediate Tracking + Forward Tracking

GEM pad or strip chambers:

Endcap – GEM pad or strip chambers to help resolve sign of $e^{\pm}$ from $W^{\pm}$ decay – polarization of sea anti- u,d.

Intermediate tracker (GEM plus Si to help match TPC tracks to pixel detector and, give intermediate point for forward tracking

Patch of GEM pads at outer radius to help TPC calib.

Cross section through STAR detector

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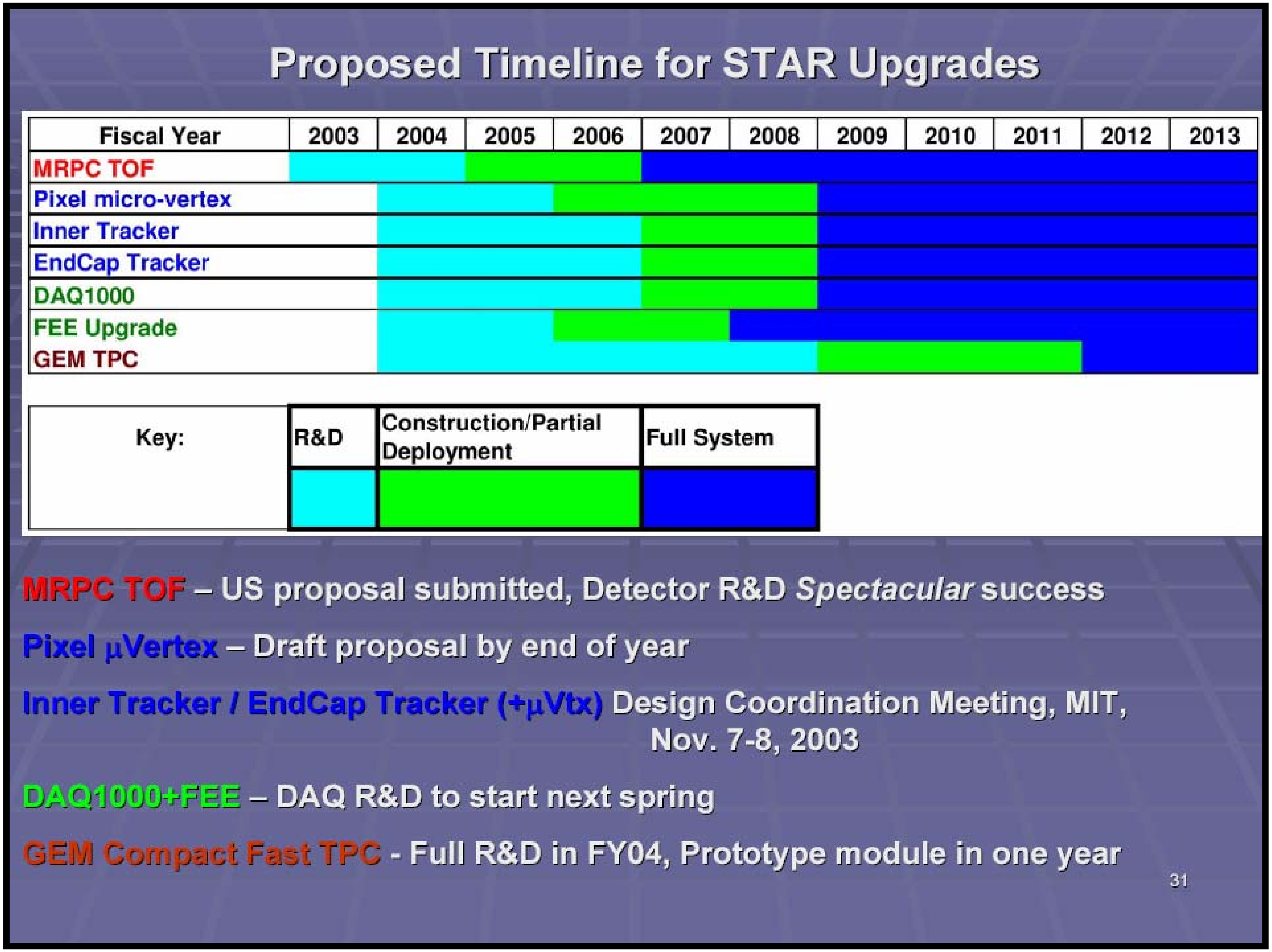
D. Majka: Overview of STAR future upgrade plans



Proposed Timeline for STAR Upgrades

Fiscal Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
MRPC TOF	▨	▨	🟩	🟩	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Pixel micro-vertex		▨	▨	🟩	🟩	🟩	🟦	🟦	🟦	🟦	🟦
Inner Tracker		▨	▨	▨	🟩	🟩	🟦	🟦	🟦	🟦	🟦
EndCap Tracker		▨	▨	▨	🟩	🟩	🟦	🟦	🟦	🟦	🟦
DAQ1000		▨	▨	▨	🟩	🟩	🟦	🟦	🟦	🟦	🟦
FEE Upgrade		▨	▨	🟩	🟩	🟦	🟦	🟦	🟦	🟦	🟦
GEM TPC		▨	▨	▨	▨	▨	🟩	🟩	🟩	🟦	🟦

Key:	R&D	Construction/Partial Deployment	Full System
	▨	🟩	🟦

MRPC TOF – US proposal submitted, Detector R&D *Spectacular* success

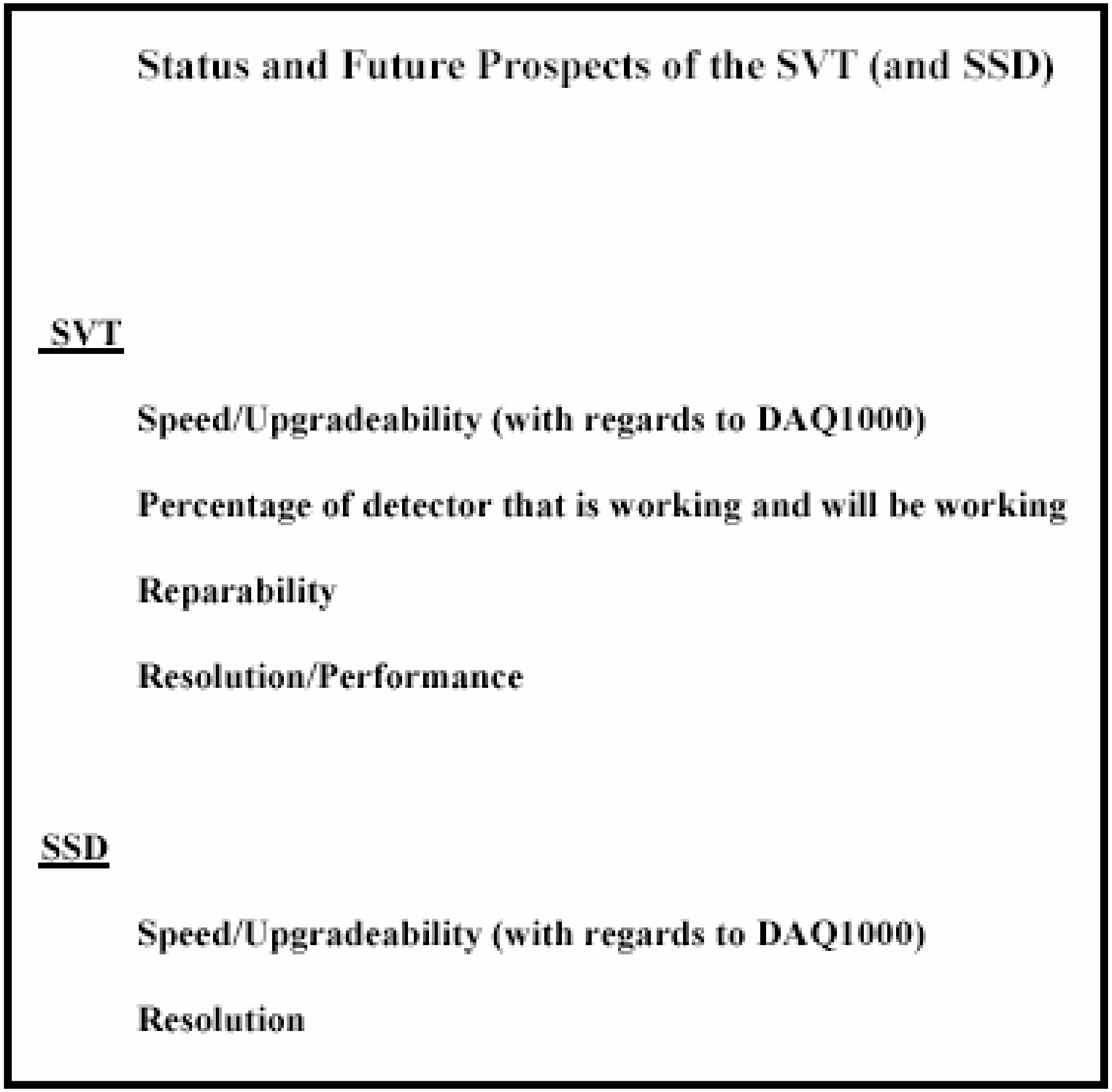
Pixel μVertex – Draft proposal by end of year

Inner Tracker / EndCap Tracker (+μVtx) Design Coordination Meeting, MIT, Nov. 7-8, 2003

DAQ1000+FEE – DAQ R&D to start next spring

GEM Compact Fast TPC - Full R&D in FY04, Prototype module in one year

D. Lynn: Report on status and future of STAR SVT/SSD



Status and Future Prospects of the SVT (and SSD)

SVT

Speed/Upgradeability (with regards to DAQ1000)

Percentage of detector that is working and will be working

Reparability

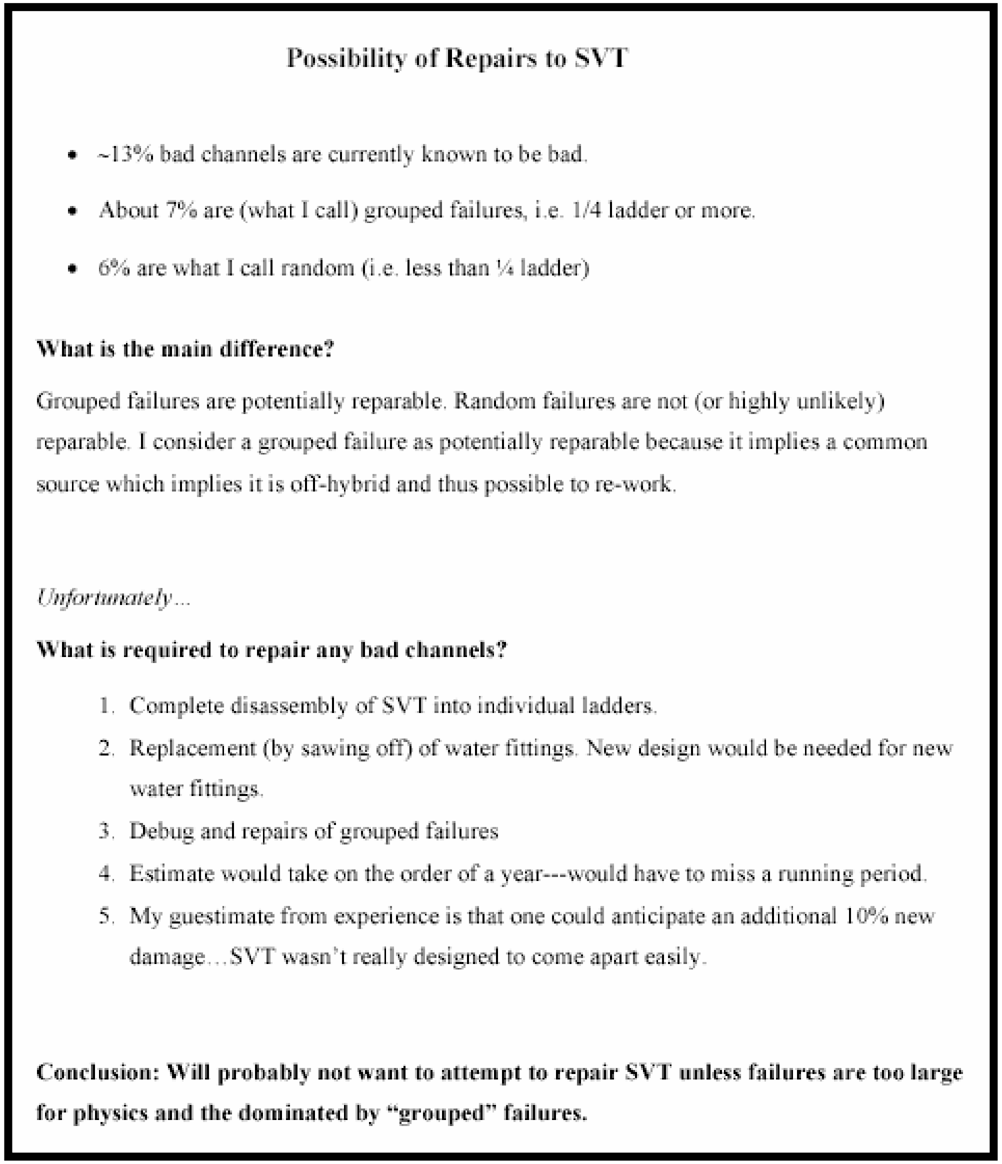
Resolution/Performance

SSD

Speed/Upgradeability (with regards to DAQ1000)

Resolution

D. Lynn: Report on status and future of STAR SVT/SSD



Possibility of Repairs to SVT

- ~13% bad channels are currently known to be bad.
- About 7% are (what I call) grouped failures, i.e. 1/4 ladder or more.
- 6% are what I call random (i.e. less than ¼ ladder)

What is the main difference?

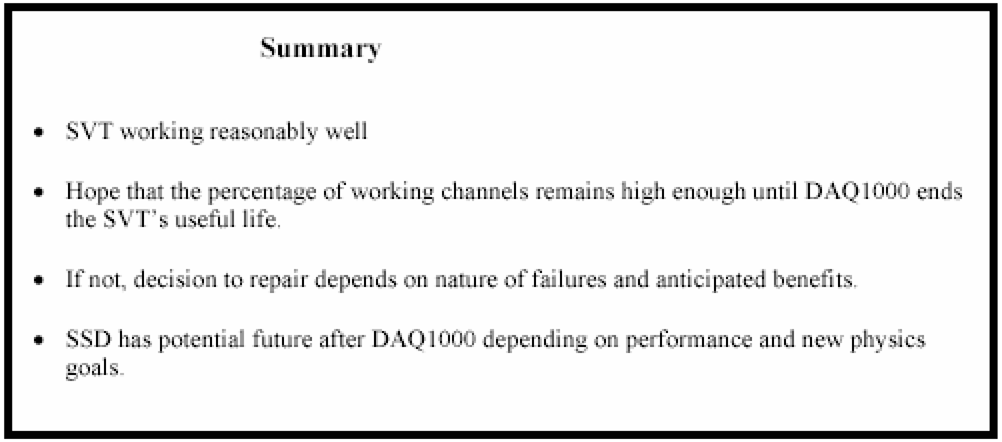
Grouped failures are potentially reparable. Random failures are not (or highly unlikely) reparable. I consider a grouped failure as potentially reparable because it implies a common source which implies it is off-hybrid and thus possible to re-work.

Unfortunately…

What is required to repair any bad channels?

1. Complete disassembly of SVT into individual ladders.
2. Replacement (by sawing off) of water fittings. New design would be needed for new water fittings.
3. Debug and repairs of grouped failures
4. Estimate would take on the order of a year---would have to miss a running period.
5. My guestimate from experience is that one could anticipate an additional 10% new damage…SVT wasn't really designed to come apart easily.

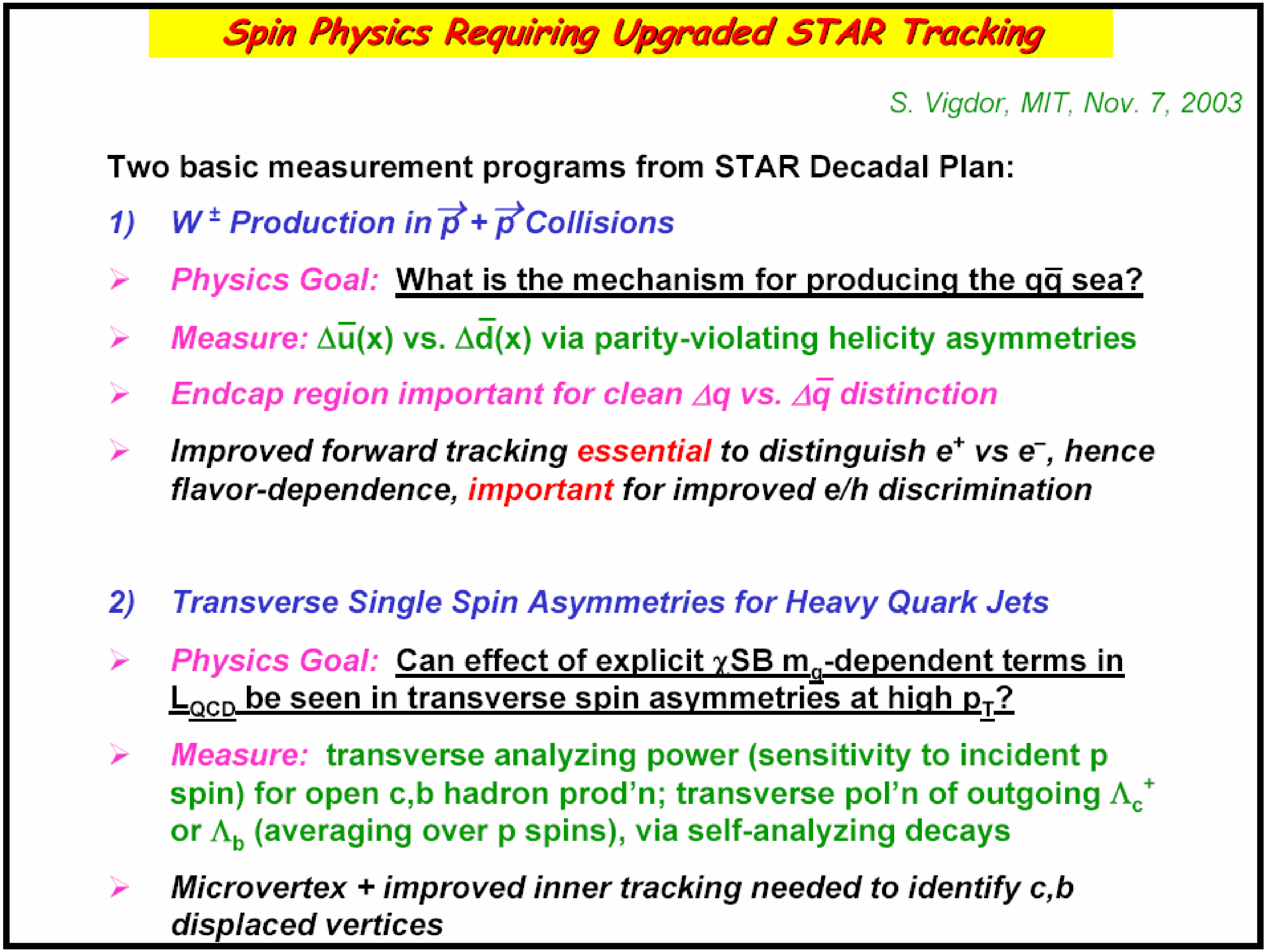
Conclusion: Will probably not want to attempt to repair SVT unless failures are too large for physics and the dominated by "grouped" failures.



Summary

- SVT working reasonably well
- Hope that the percentage of working channels remains high enough until DAQ1000 ends the SVT's useful life.
- If not, decision to repair depends on nature of failures and anticipated benefits.
- SSD has potential future after DAQ1000 depending on performance and new physics goals.

S. Vigdor: Overview of pp physics topics



Spin Physics Requiring Upgraded STAR Tracking

S. Vigdor, MIT, Nov. 7, 2003

Two basic measurement programs from STAR Decadal Plan:

1) $W^{\pm}$ Production in $\vec{p}+\vec{p}$ Collisions

- *Physics Goal:* What is the mechanism for producing the $q\bar{q}$ sea?
- *Measure:* $\Delta\bar{u}(x)$ vs. $\Delta\bar{d}(x)$ via parity-violating helicity asymmetries
- *Endcap region important for clean Δq vs. $\Delta\bar{q}$ distinction*
- *Improved forward tracking essential to distinguish e^+ vs e^-, hence flavor-dependence, important for improved e/h discrimination*

2) Transverse Single Spin Asymmetries for Heavy Quark Jets

- *Physics Goal:* Can effect of explicit χSB m_q-dependent terms in L_{QCD} be seen in transverse spin asymmetries at high p_T?
- *Measure:* transverse analyzing power (sensitivity to incident p spin) for open c,b hadron prod'n; transverse pol'n of outgoing Λ_c^+ or Λ_b (averaging over p spins), via self-analyzing decays
- *Microvertex + improved inner tracking needed to identify c,b displaced vertices*

S. Vigdor: Overview of pp physics topics

What is the Physical Origin of the $q\bar{q}$ Sea in a Nucleon?

Perturbative: $g \to q\,\bar{q} \Rightarrow$ expect:

$u\bar{u}$ and $d\bar{d}$ in $\approx$ proportions;
$\approx$ contributions to proton spin from $\bar{u}$, $\bar{d}$, $\bar{s}$, s, u_{sea}, d_{sea}

Non-perturbative:

$$u \to d\underbrace{\pi^+}_{\sim |u\bar{d}\rangle_{0^-}}$$

$$u \to s\underbrace{K^+}_{\sim |u\bar{s}\rangle_{0^-}}$$

-
-
-

Emission and reabsorption of Goldstone bosons $\Rightarrow$ naively expect:

More $\bar{d}$ than $\bar{u}$ in p; ✓

$\Delta\bar{d}/\bar{d} \approx \Delta\bar{s}/\bar{s} \approx 0$, but $\Delta s/s < 0$; ✓

$\langle L_z(\bar{q})\rangle \neq 0$. ?

But, $1/N_c$ expansion $\Rightarrow \Delta\bar{u} - \Delta\bar{d} \sim N_c(\bar{d} - \bar{u}) \Rightarrow$ LARGE!

Conclude: would be nice to measure $\bar{q}$ polarization, flavor-dependence **directly!** Best Method:

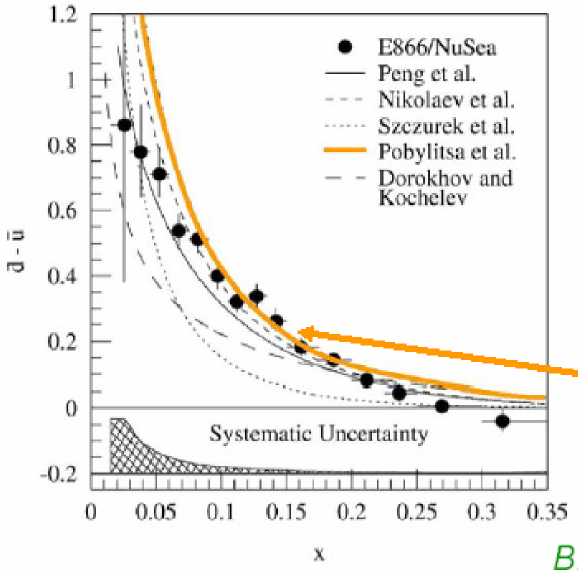
$$u + \bar{d} \to W^+ + X \to l^+ + (\nu) + X$$

$$d + \bar{u} \to W^- + X \to l^- + (\bar{\nu}) + X$$

Weak interaction $\Rightarrow$
parity-violating $\Rightarrow$
$A_L \neq 0$, given by Standard Model

S. Vigdor: Overview of pp physics topics

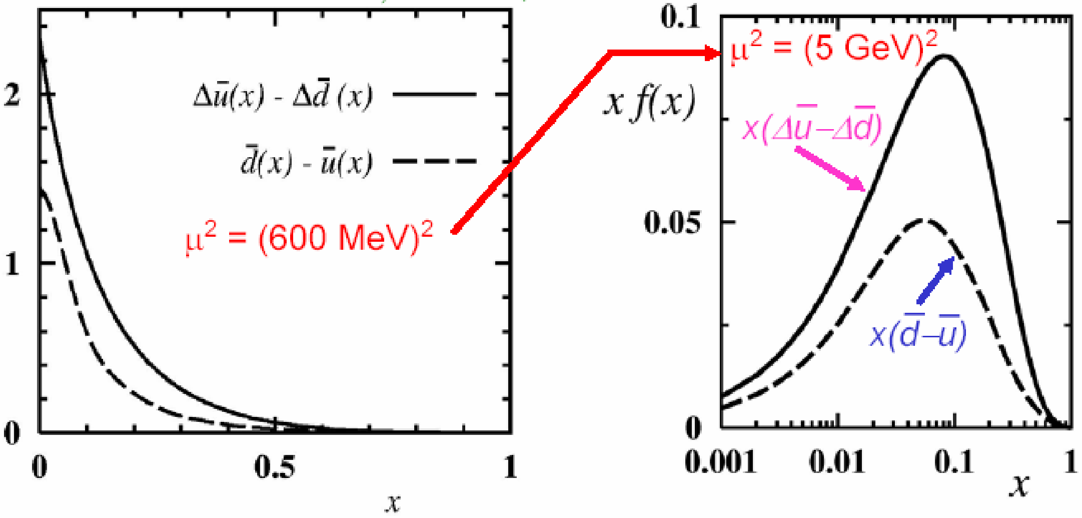
Flavor Asymmetry in the Nucleon Sea



- FNAL E866 compared Drell-Yan for p+d to p+p, to reveal sizable unpolarized flavor asymmetry $\bar{d}(x)-\bar{u}(x)$.
- Results are qualitatively consistent with pion cloud models, instanton models, chiral quark soliton models, etc.
- Chiral quark soliton model is appropriate in large-N_c limit of QCD: Dirac quarks bound in collective pion field to model χSB.

- Is there a large flavor-dependence of $\bar{q}$ polarizations in the proton?
- Most quark-based models predict $\int_0^1[\Delta\bar{u}(x)-\Delta\bar{d}(x)]dx \geq \int_0^1[\bar{d}(x)-\bar{u}(x)]dx$ most meson-based models disagree

B. Dressler et al., Chiral Quark Soliton Model Predictions

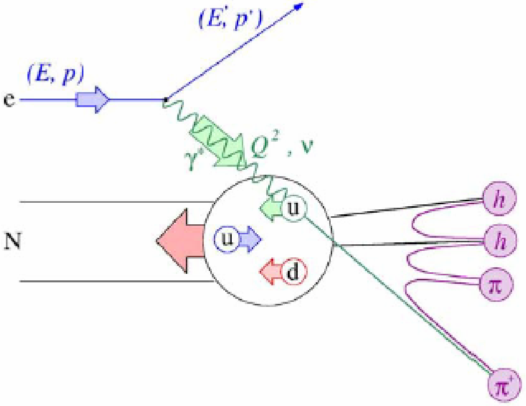


S. Vigdor: Overview of pp physics topics

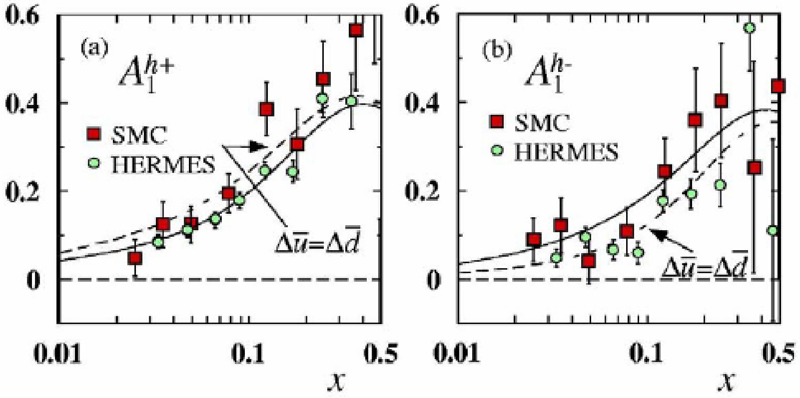
Two Proposed Methods for Probing Polarized Flavor Asymmetry Have Quite Different Sensitivities

Semi-Inclusive DIS: $\vec{e} + \vec{N} \rightarrow e' + h + X$

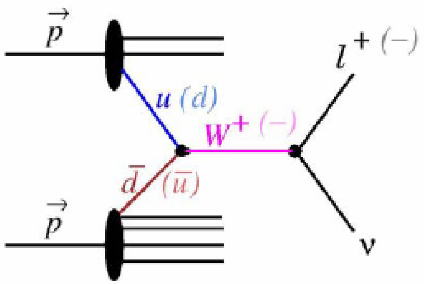
SIDIS sensitivity reduced by fragmentation functions and e_q^2 weighting

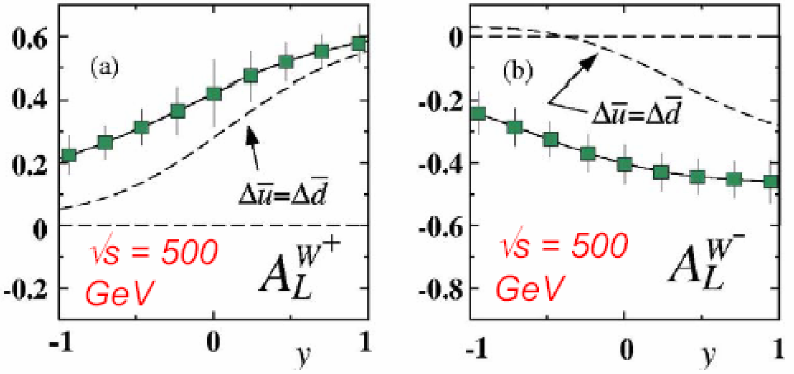


B. Dressler et al. Predictions



$W^{\pm}$ Production at RHIC





S. Vigdor: Overview of pp physics topics

New HERMES SIDIS Results…

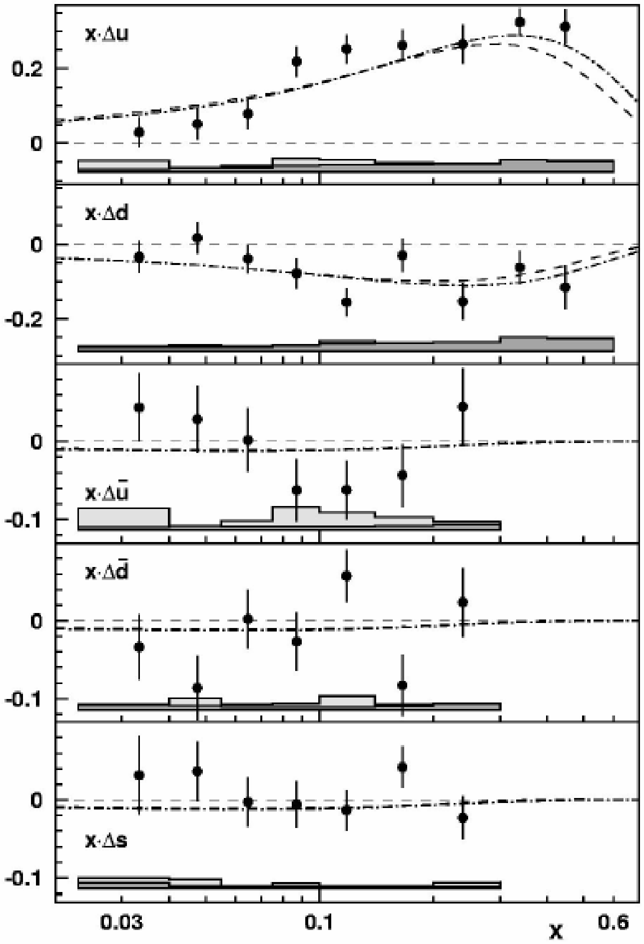
…do not appear to support either large positive $\Delta\bar{u}-\Delta\bar{d}$ or negative Δs

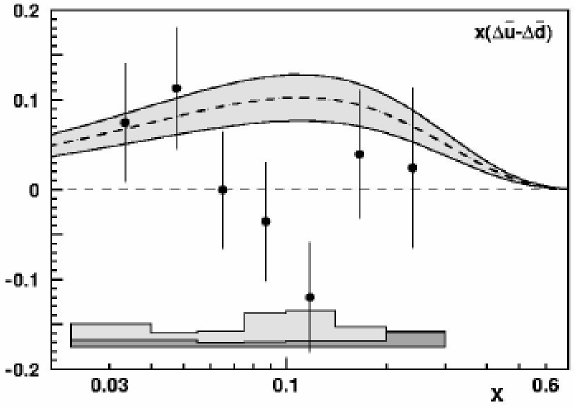
But, error bars are large and questions have been raised regarding analysis details.

See:

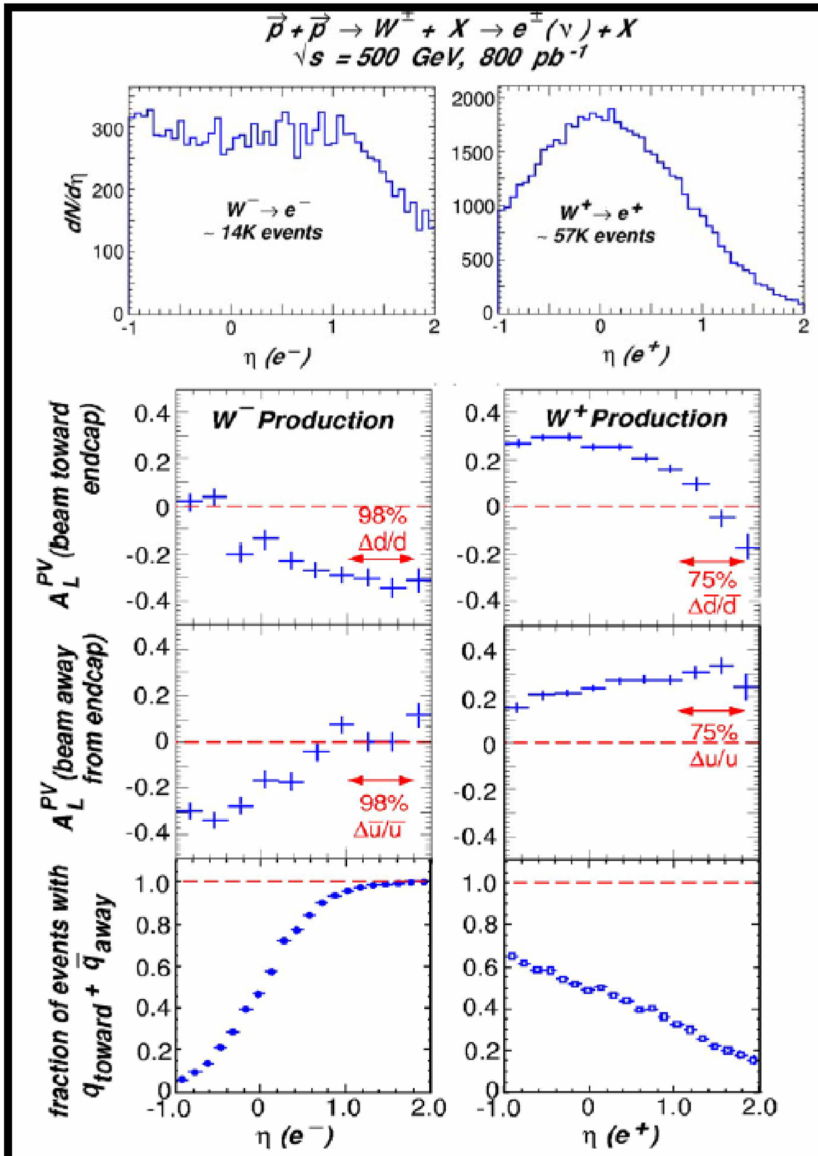
A. Airapetian et al., hep-ex/0307064

A.N. Sissakian et al., hep-ph/0307189





S. Vigdor: Overview of pp physics topics

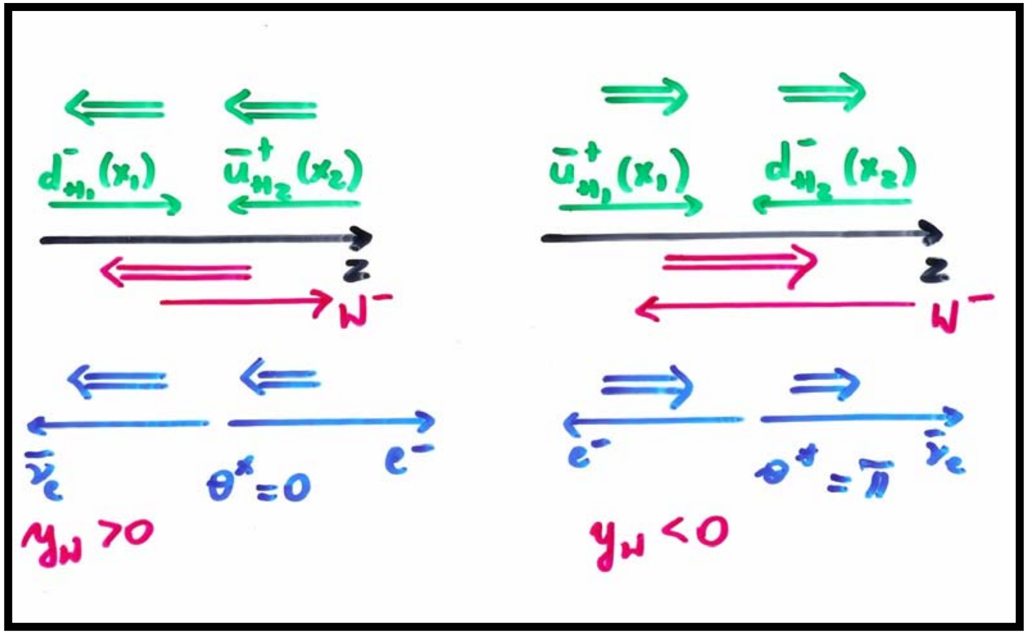


STAR Simulations of W Prod'n

L.C. Bland

- LO only (NLO doesn't alter qualitative conclusions): $u\bar{d} \to W^+$; $d\bar{u} \to W^-$
- Detect via $e^{\pm} \Rightarrow$ kinematic differences in acceptance:
  - W momentum in dir'n of higher-x parton (usually q)
  - PV decay of L-handed $W^{\pm} \oplus$ CP $\Rightarrow$ in W rest frame: e^+ (e^-) emitted pref'ly along (opposite) W^+ (W^-) spin
  - $\Rightarrow e^-$ focused in q dir'n; e^+ more spread out
  - for W^- prod'n, e^- in endcap pref'ly probes $d_{toward}\bar{u}_{away}$ collisions
- 2 charges ⊗ 2 single-spin PV asyms. constrain Δu, Δd, $\Delta\bar{u}$, $\Delta\bar{d}(x)$
- Separation of antiquark and quark polarizations is kinematically cleanest in endcap region (opposite for W^+,W^-)

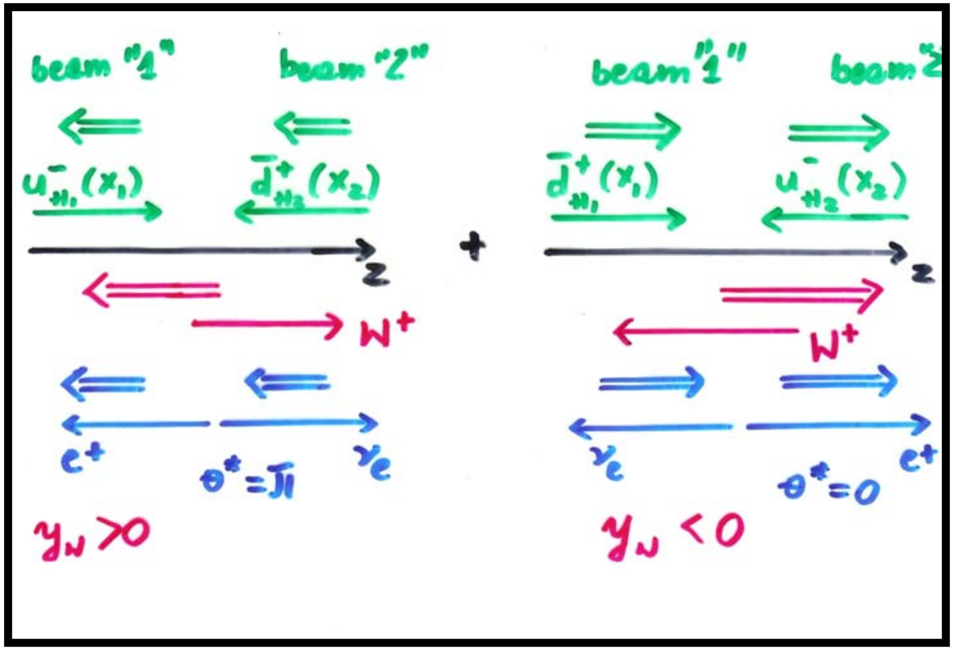
J. Kiryluk: W event kinematics



$$\frac{d\sigma_{H_1,H_2}}{dy_W\,d\cos\theta^*} \sim \left[d^-_{H_1}(x_1)\,\bar{u}^+_{H_2}(x_2)(1+\cos\theta^*)^2 + \bar{u}^+_{H_1}(x_1)\,d^-_{H_2}(x_2)(1-\cos\theta^*)^2 \right]$$

$$\frac{\mathrm{d}\sigma_{\mathrm{H_1H_2}}}{\mathrm{dywd}\cos\theta^\star} \sim \left[u^-_{H_1}(x_1)\bar{d}^+_{H_2}(x_2)(1-\cos\theta^\star)^2 + \bar{d}^+_{H_1}(x_1)u^-_{H_2}(x_2)(1+\cos\theta^\star)^2\right]$$

where $H_1H_2 \equiv (++),\ (+-),\ (-+),\ (--)$



S. Vigdor: Overview of pp physics topics

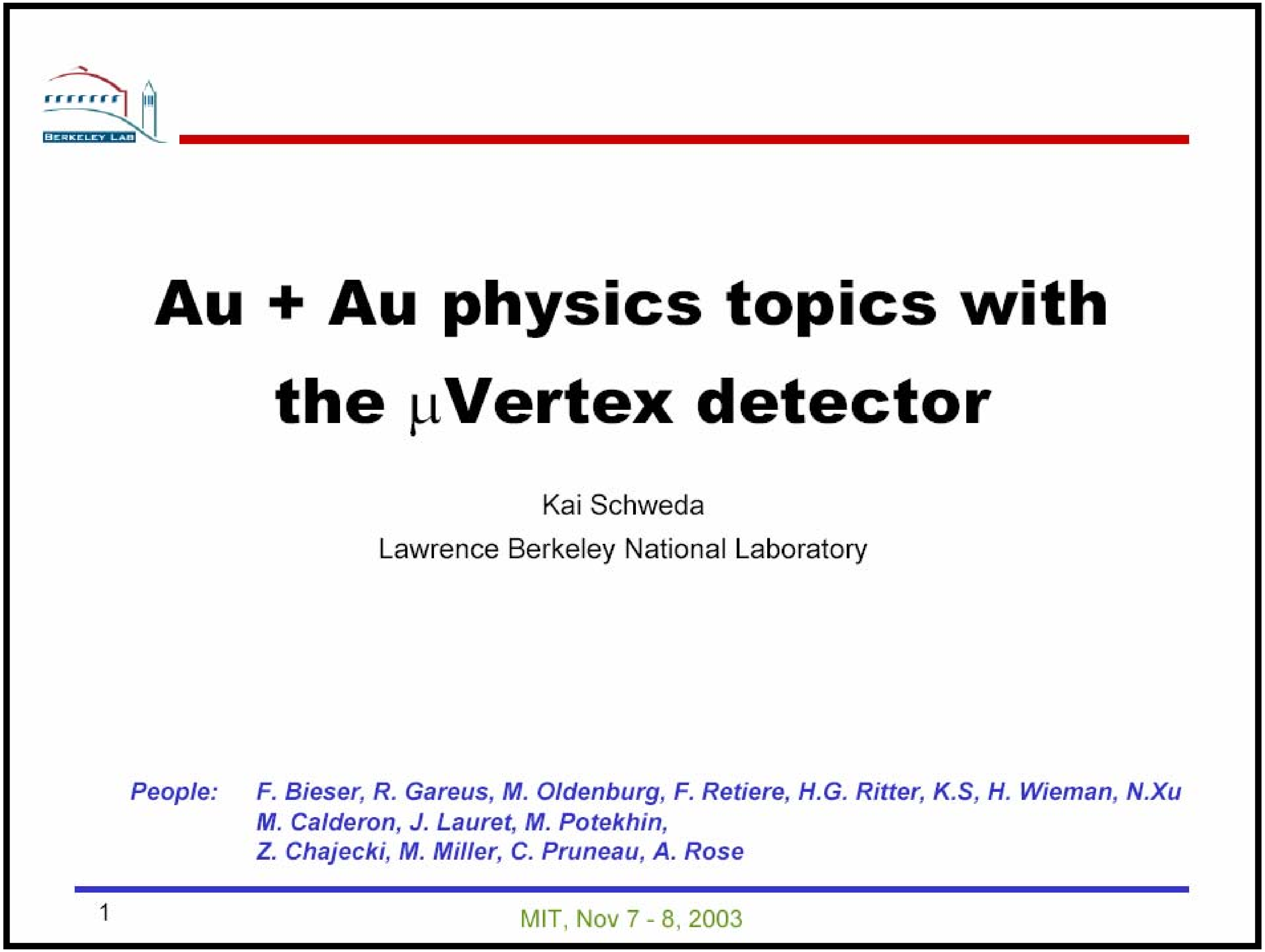
Experimental Issues for W Detection in STAR

- **Triggering:** easy – very large p_T in single EMC tower (B or E)
- **e/h Discrimination:** ~ 1 order of magnitude apiece from:
  - *Isolation of detected particle from other jet fragments*
  - *Absence of accompanying jet at opposite azimuth (dijet rejection cut serves as "poor man's" missing energy cut)*
  - *EMC response: $E_{preshower}$, E_{SMD}, $E_{postshower}$ (for EEMC) vs. E_{shower} ; E_T (EMC) vs. p_T (TPC + fwd. Tracking)*

should ⇒ W signal/hadron bkgd > 1 for p_T^e > 20 GeV/c (most of W decay phase space), but improved p_T determination very useful!

- **e^+ vs. e^- Charge Sign Discrimination:** OK for BEMC, but needs improved forward tracking for EEMC! (see N. Smirnov simulations)

K. Schweda: AuAu physics topics



BERKELEY LAB

Au + Au physics topics with the μVertex detector

Kai Schweda
Lawrence Berkeley National Laboratory

People: *F. Bieser, R. Gareus, M. Oldenburg, F. Retiere, H.G. Ritter, K.S, H. Wieman, N.Xu*
M. Calderon, J. Lauret, M. Potekhin,
Z. Chajecki, M. Miller, C. Pruneau, A. Rose

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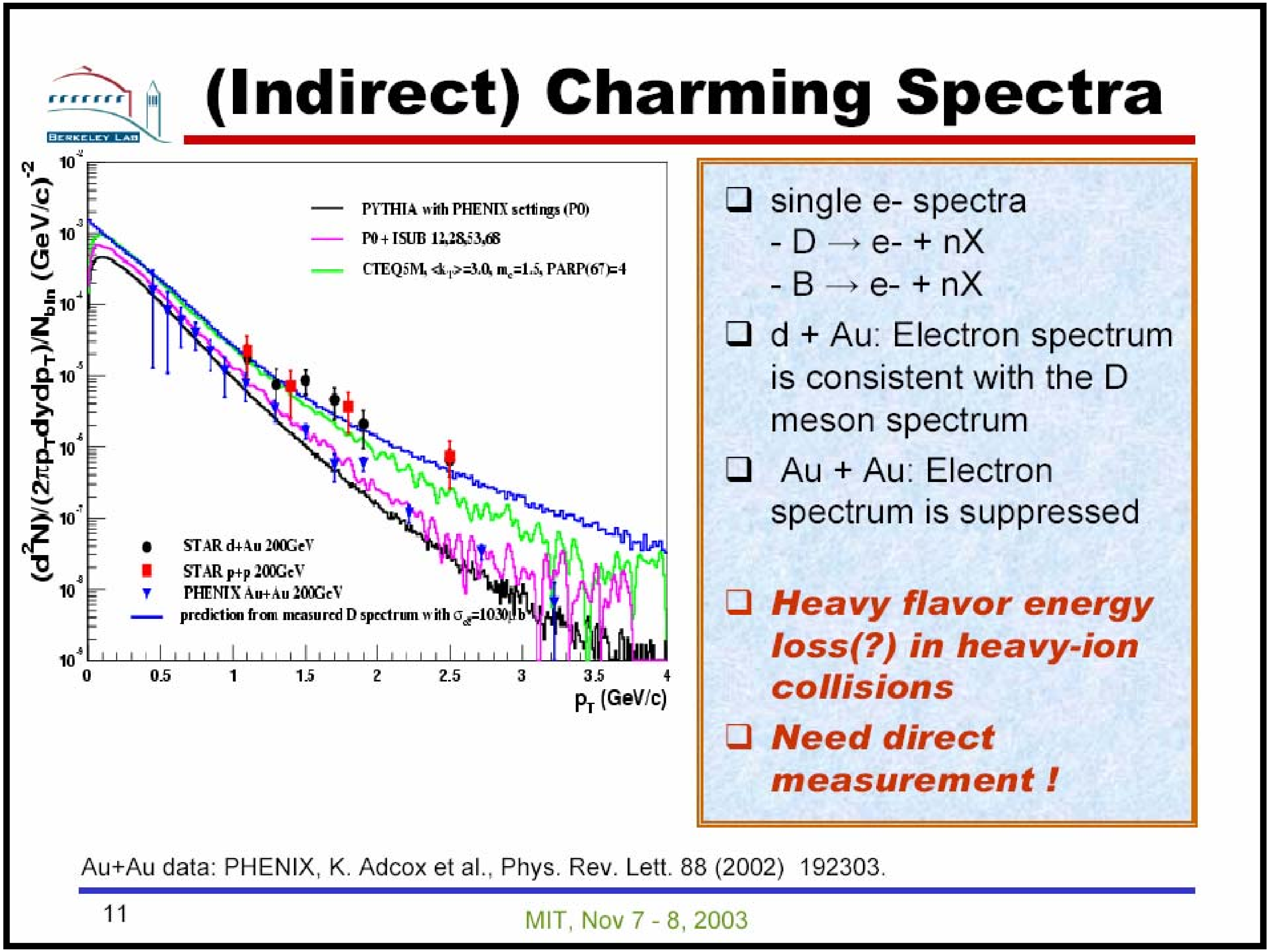
MIT, Nov 7 - 8, 2003

K. Schweda: AuAu physics topics



(Indirect) Charming Spectra

- ❑ single e- spectra
  - D → e- + nX
  - B → e- + nX
- ❑ d + Au: Electron spectrum is consistent with the D meson spectrum
- ❑ Au + Au: Electron spectrum is suppressed
- ❑ ***Heavy flavor energy loss(?) in heavy-ion collisions***
- ❑ ***Need direct measurement !***

Au+Au data: PHENIX, K. Adcox et al., Phys. Rev. Lett. 88 (2002) 192303.

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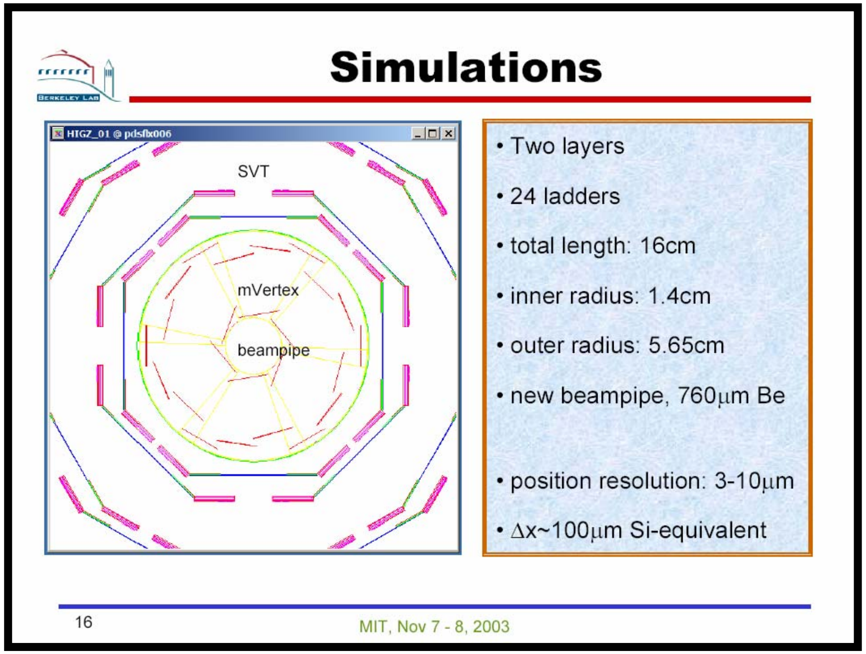
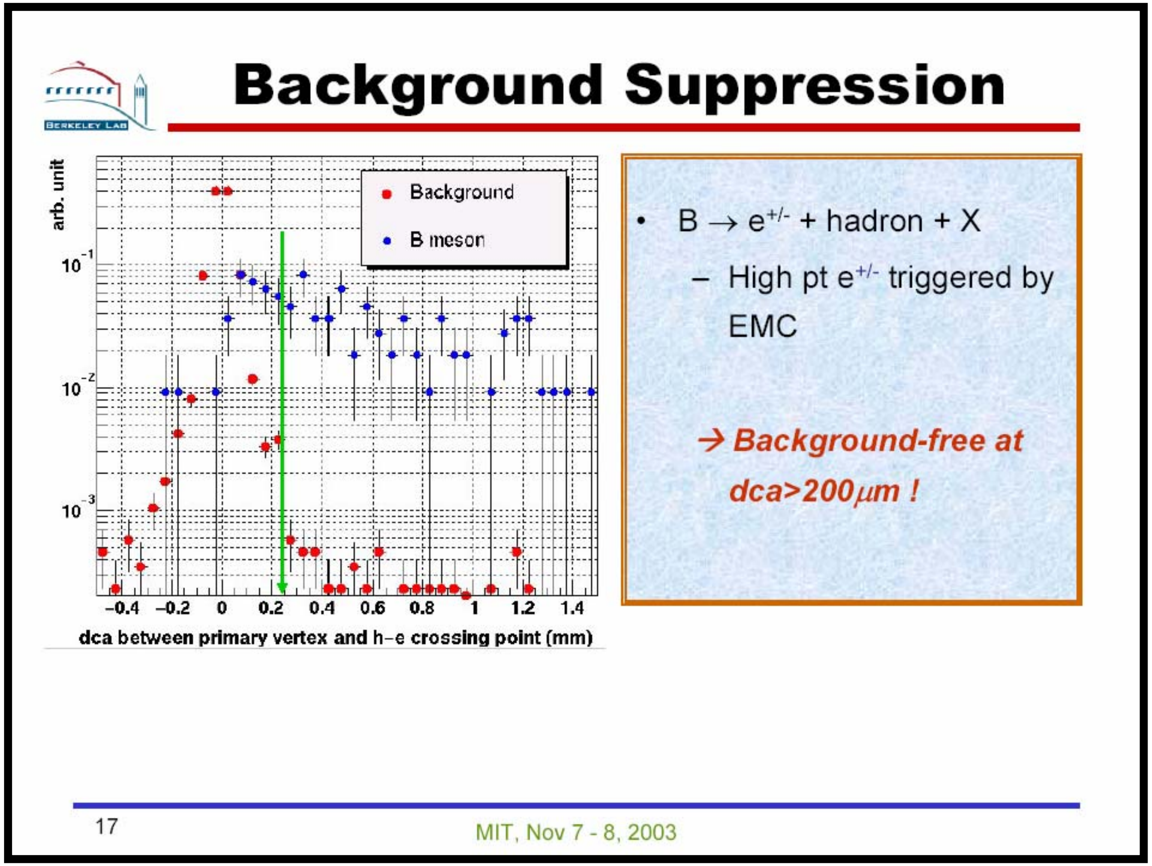
K. Schweda: AuAu physics topics



Simulations

- Two layers
- 24 ladders
- total length: 16cm
- inner radius: 1.4cm
- outer radius: 5.65cm
- new beampipe, 760μm Be
- position resolution: 3-10μm
- Δx~100μm Si-equivalent



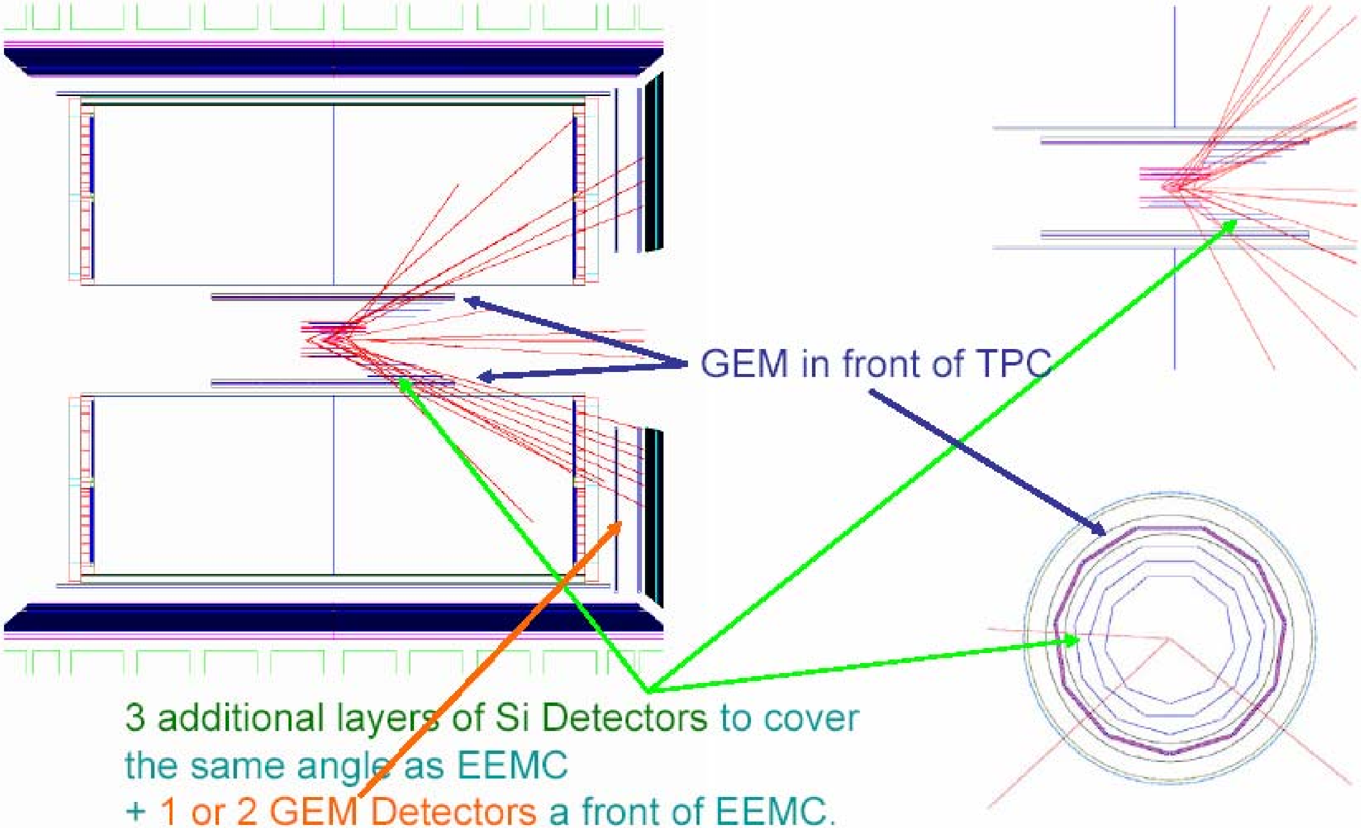
Background Suppression

- B → $e^{+/-}$ + hadron + X
  - High pt $e^{+/-}$ triggered by EMC

→ Background-free at dca>200μm !

N. Smirnov: Possible layout of new STAR tracking system

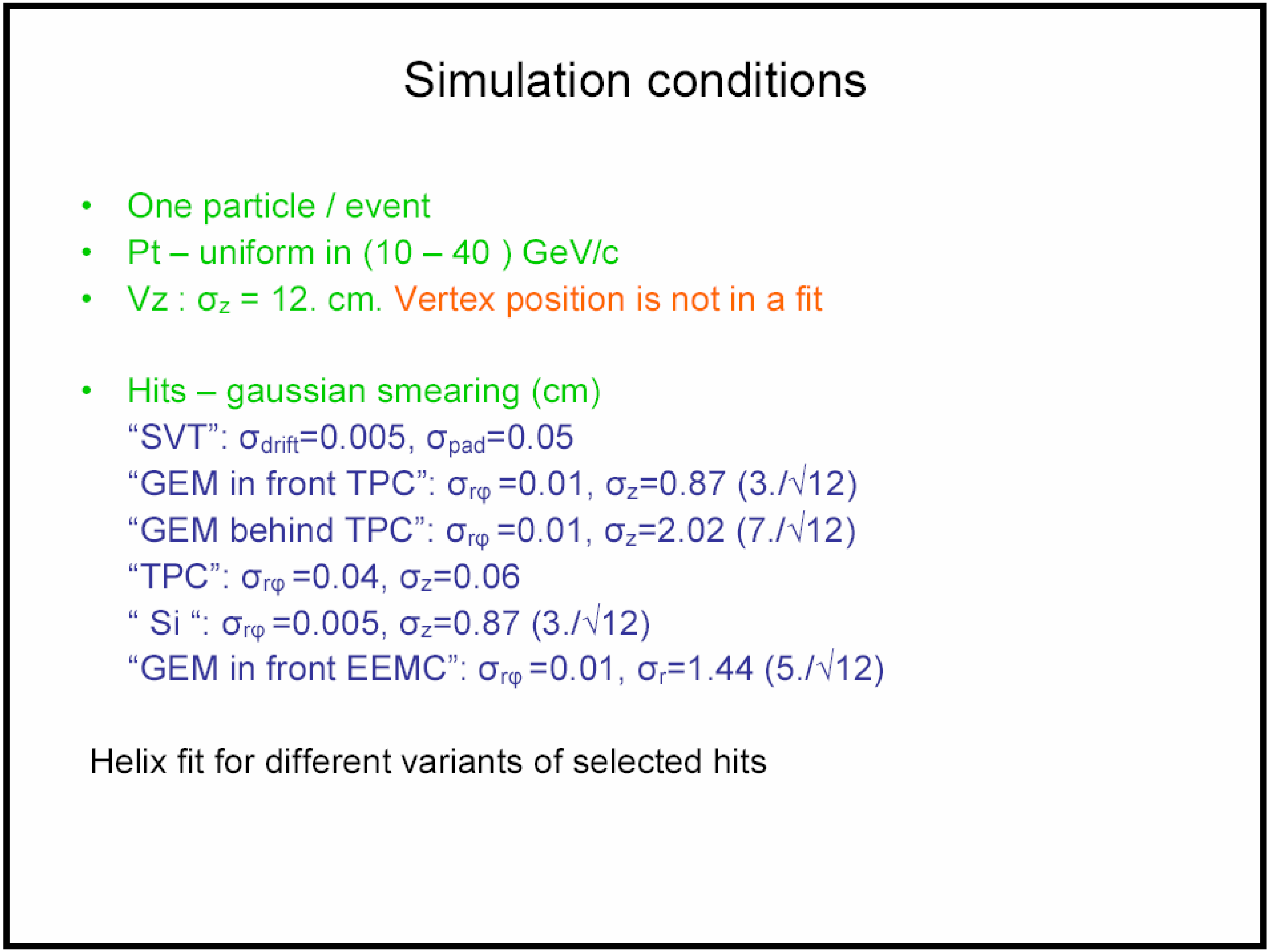
Additional tracking in 1<|η|<2 direction (in front of EEMC)
(together with B.Surrow and S.Vigdor)



GEM in front of TPC

3 additional layers of Si Detectors to cover the same angle as EEMC
+ 1 or 2 GEM Detectors a front of EEMC.

N. Smirnov: Possible layout of new STAR tracking system



Simulation conditions

- One particle / event
- Pt – uniform in (10 – 40) GeV/c
- Vz : σ_z = 12. cm. Vertex position is not in a fit

- Hits – gaussian smearing (cm)
  "SVT": σ_{drift}=0.005, σ_{pad}=0.05
  "GEM in front TPC": $\sigma_{r\varphi}$ =0.01, σ_z=0.87 $(3./\sqrt{12})$
  "GEM behind TPC": $\sigma_{r\varphi}$ =0.01, σ_z=2.02 $(7./\sqrt{12})$
  "TPC": $\sigma_{r\varphi}$ =0.04, σ_z=0.06
  " Si ": $\sigma_{r\varphi}$ =0.005, σ_z=0.87 $(3./\sqrt{12})$
  "GEM in front EEMC": $\sigma_{r\varphi}$ =0.01, σ_r=1.44 $(5./\sqrt{12})$

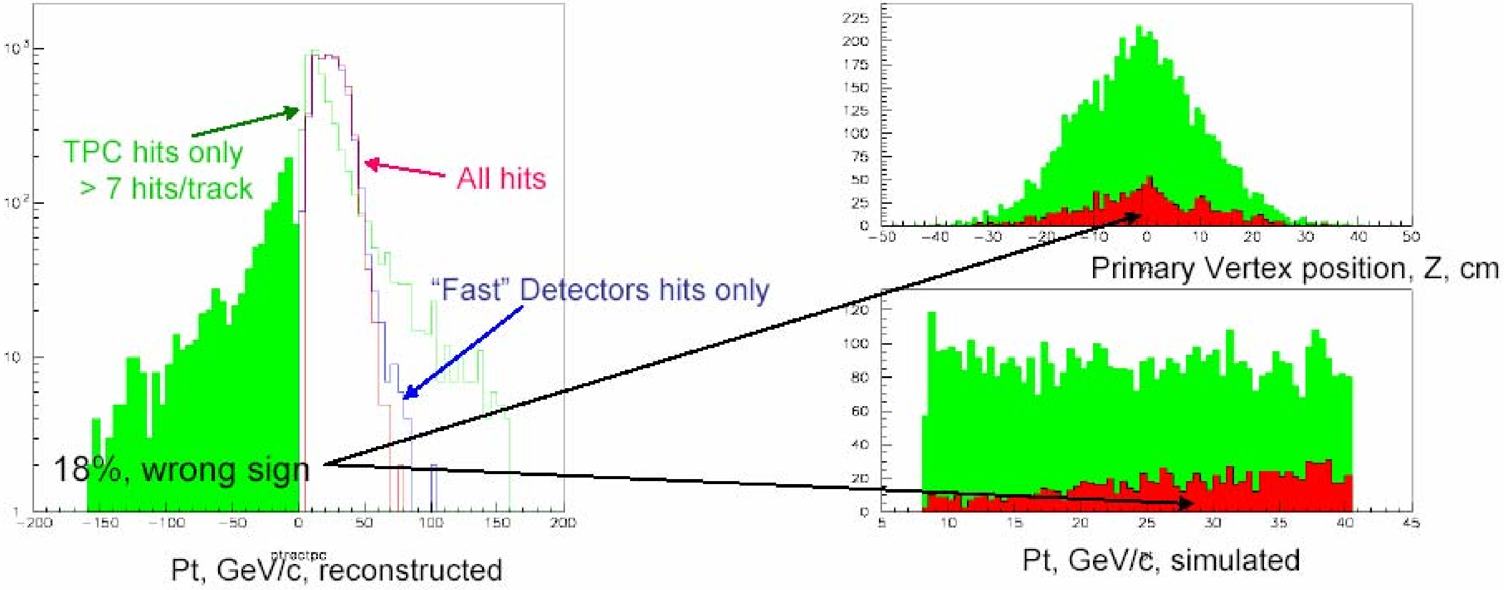
Helix fit for different variants of selected hits

N. Smirnov: Possible layout of new STAR tracking system

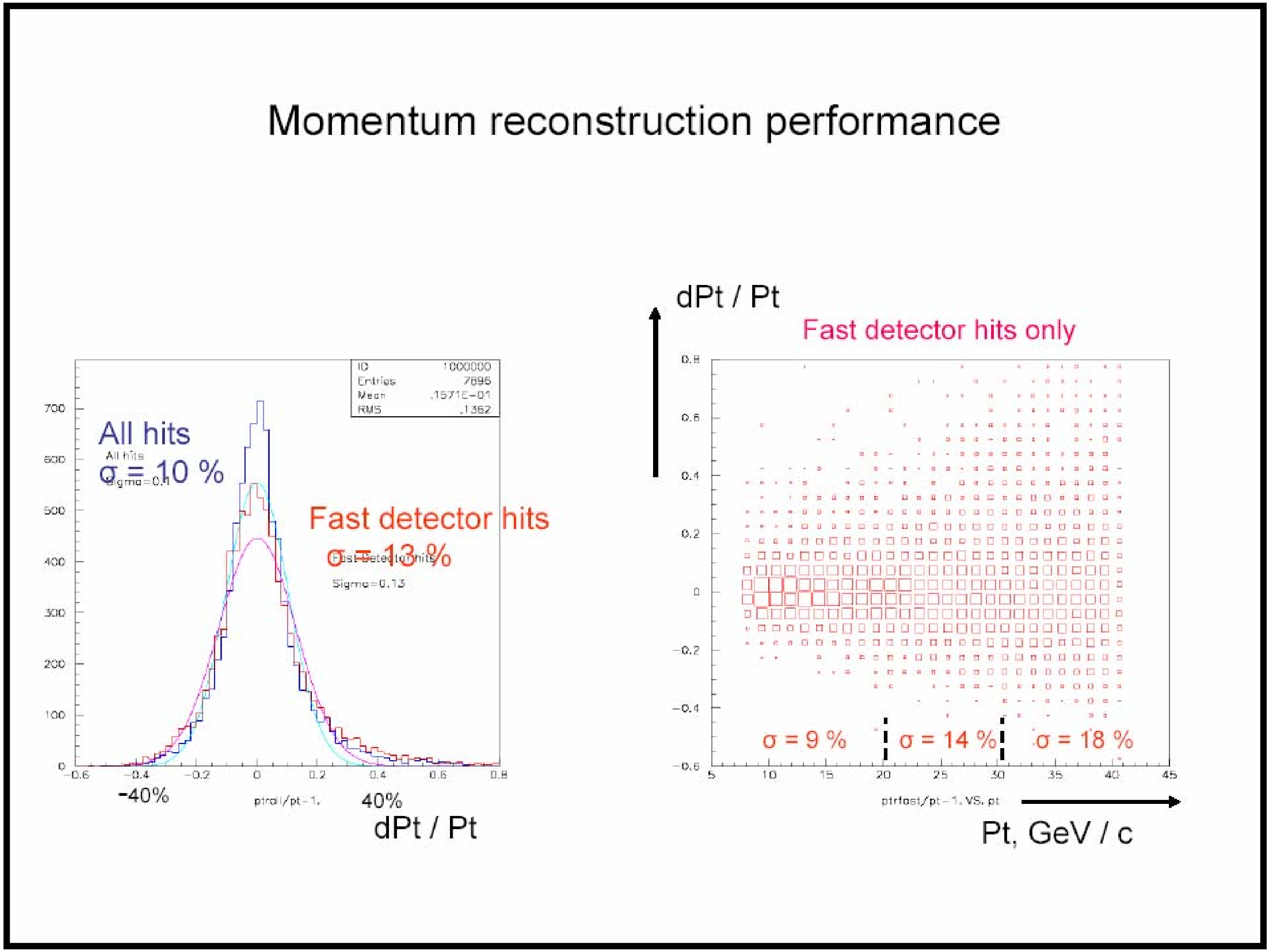
Fast simulator. One particle (π^-) / event. EEMC acceptance.

Can we measure the “sign of a charge” for high Pt particles?

Sag for Pt=30.0 GeV/c is ~2.5 mm

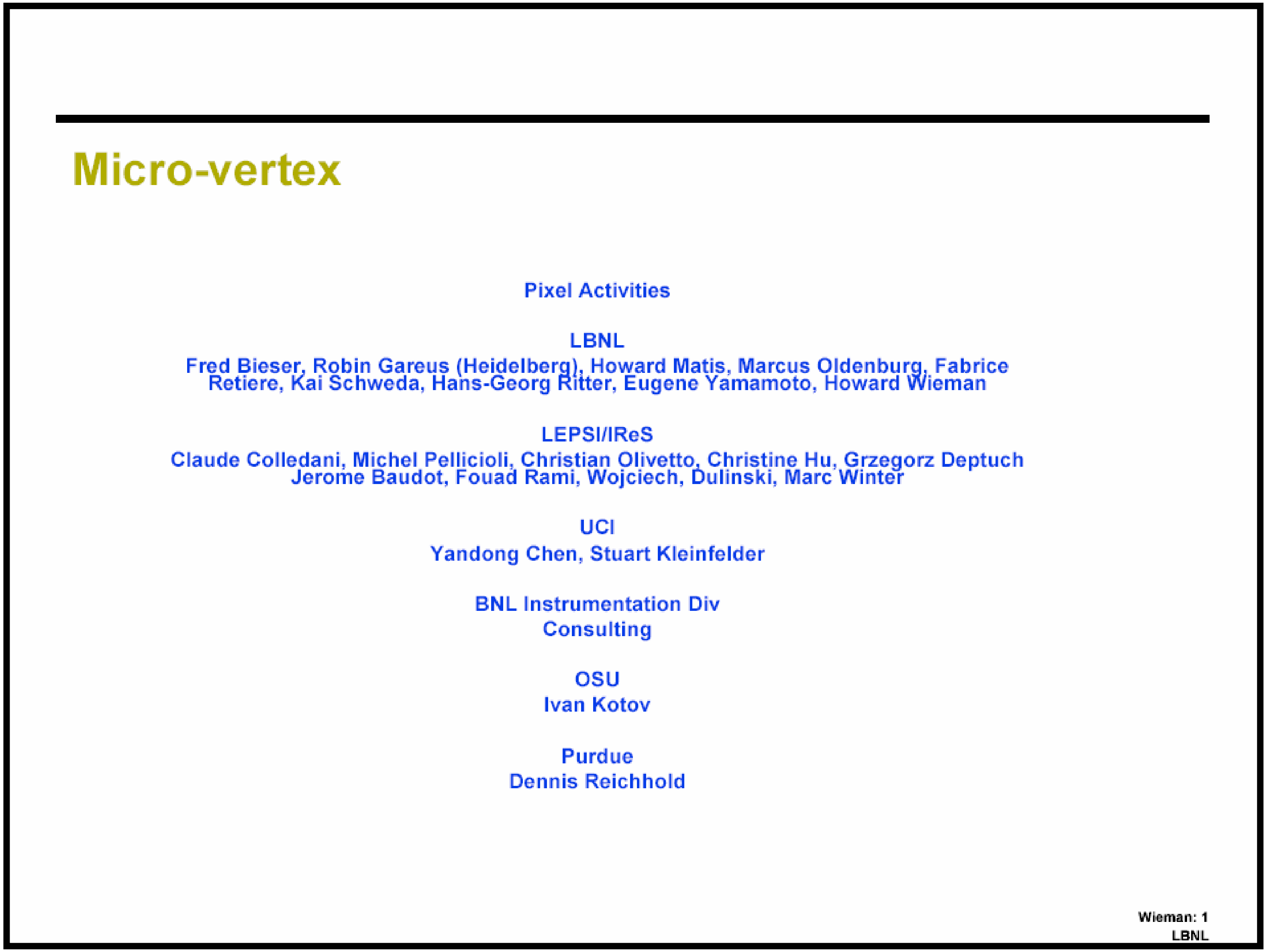


N. Smirnov: Possible layout of new STAR tracking system



Momentum reconstruction performance

H. Wieman: Report on Pixel activities



Micro-vertex

Pixel Activities

LBNL
Fred Bieser, Robin Gareus (Heidelberg), Howard Matis, Marcus Oldenburg, Fabrice Retiere, Kai Schweda, Hans-Georg Ritter, Eugene Yamamoto, Howard Wieman

LEPSI/IReS
Claude Colledani, Michel Pellicioli, Christian Olivetto, Christine Hu, Grzegorz Deptuch Jerome Baudot, Fouad Rami, Wojciech, Dulinski, Marc Winter

UCI
Yandong Chen, Stuart Kleinfelder

BNL Instrumentation Div
Consulting

OSU
Ivan Kotov

Purdue
Dennis Reichhold

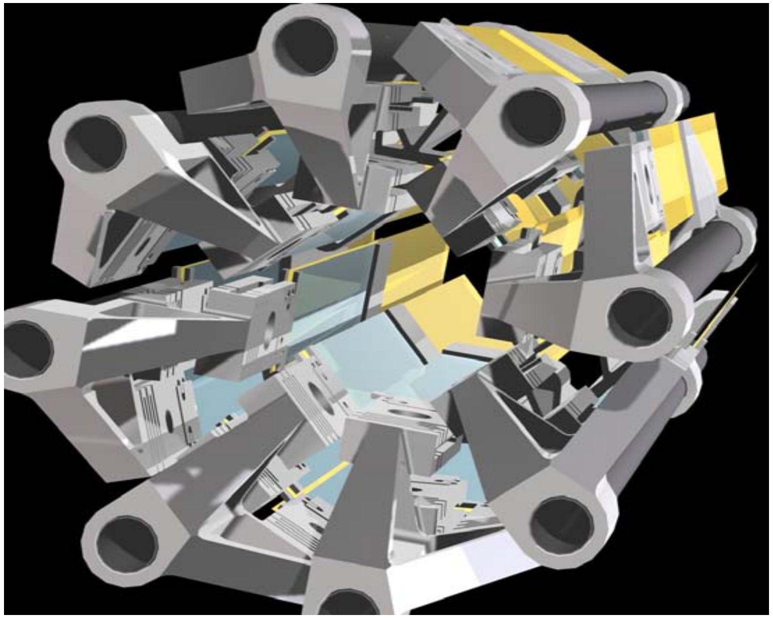
H. Wieman: Report on Pixel activities

Features

- 2 layers
- Inner radius ~1.8 cm
- Active length 20 cm
- Readout speed 20 ms (generation 1)
- Number of pixels 130 M

Mechanical

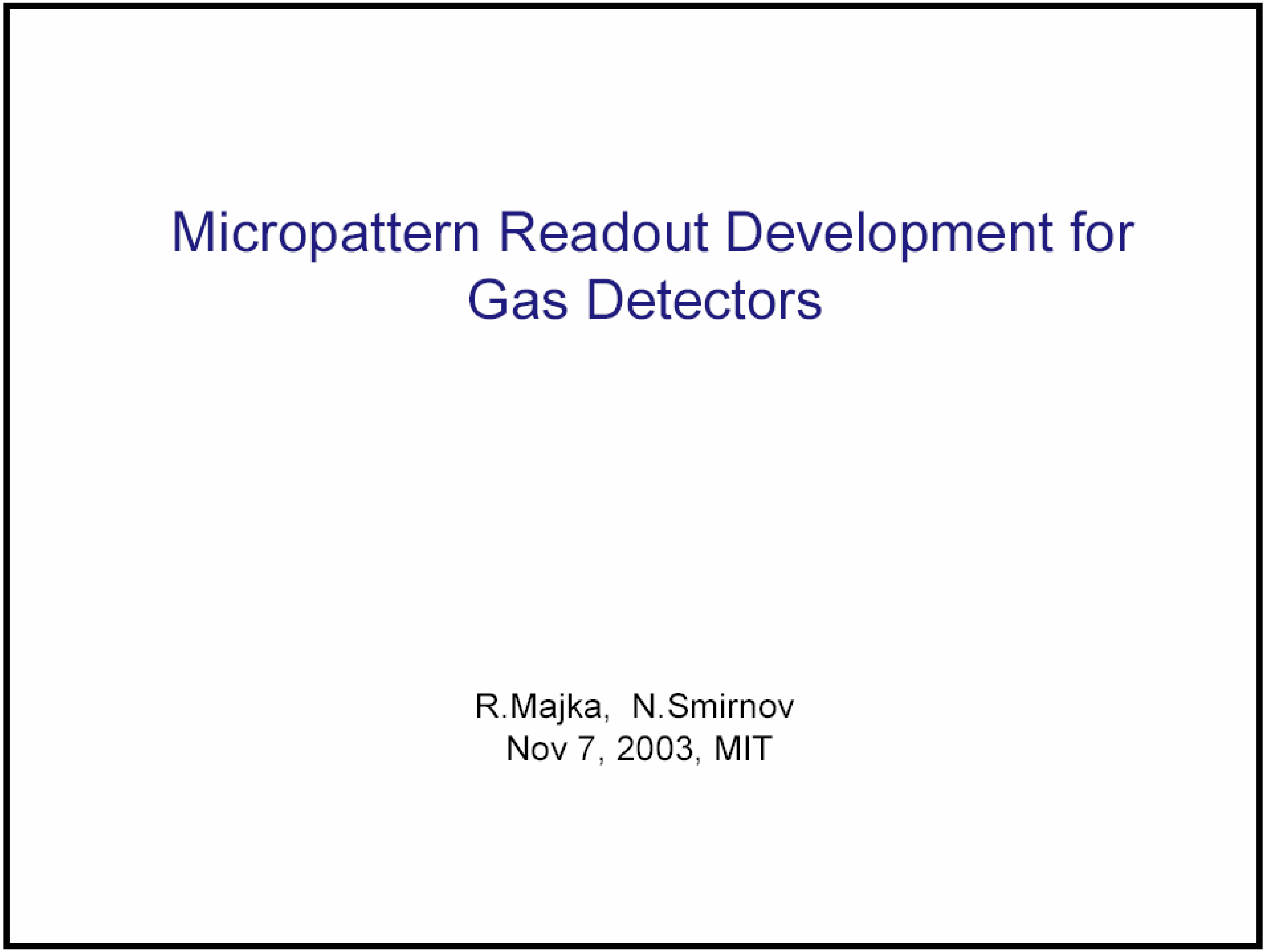
- Rapid insertion and removal for replacement and changing detector configuration
- Minimum thickness: 50 Micron Si Detector – 50 Micron Si Readout chip
- Air cooling
- Composite beam pipe?



Conclusion

- Micro-vertex detector is being designed to go inside SVT
- It is being designed for rapid insertion and removal
- Should be flexible with a variety of detector designs

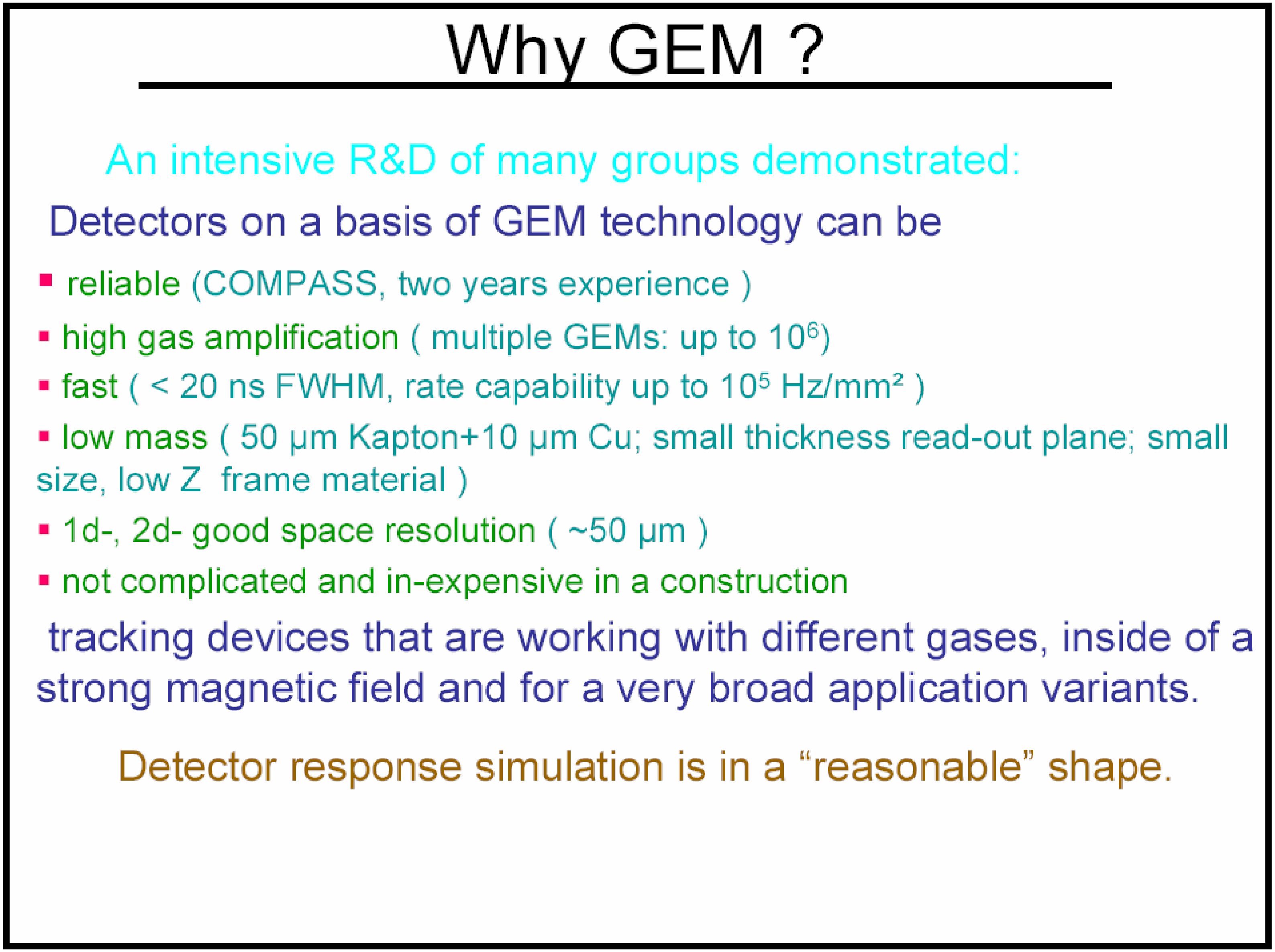
N. Smirnov: Report on GEM activities



Micropattern Readout Development for Gas Detectors

R.Majka, N.Smirnov
Nov 7, 2003, MIT

N. Smirnov: Report on GEM activities



Why GEM ?

An intensive R&D of many groups demonstrated:

Detectors on a basis of GEM technology can be

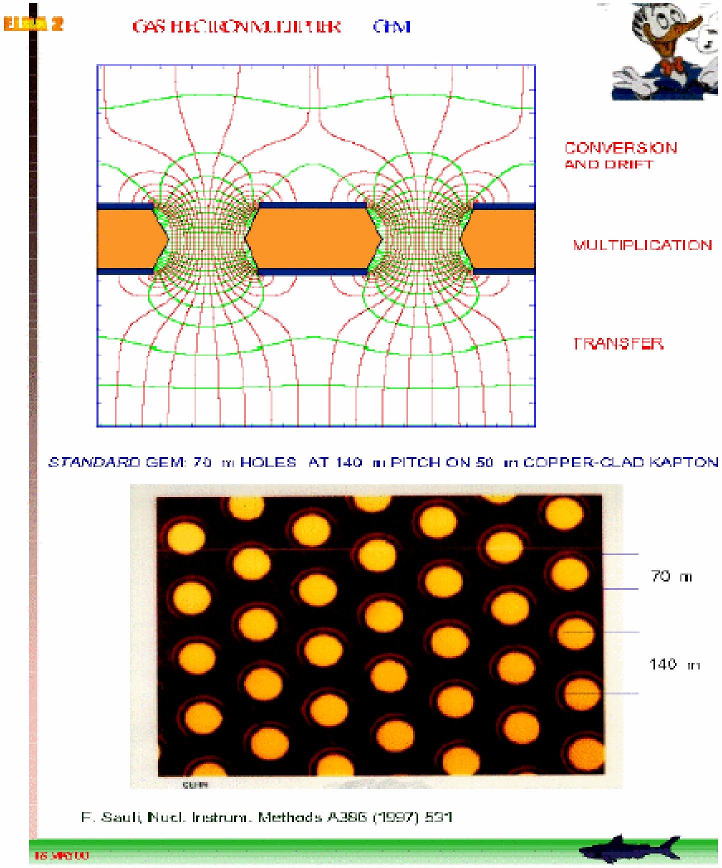
- reliable (COMPASS, two years experience)
- high gas amplification (multiple GEMs: up to 10^6)
- fast (< 20 ns FWHM, rate capability up to 10^5 Hz/mm^2)
- low mass (50 μm Kapton+10 μm Cu; small thickness read-out plane; small size, low Z frame material)
- 1d-, 2d- good space resolution (~50 μm)
- not complicated and in-expensive in a construction

tracking devices that are working with different gases, inside of a strong magnetic field and for a very broad application variants.

Detector response simulation is in a “reasonable” shape.

GEM Detector

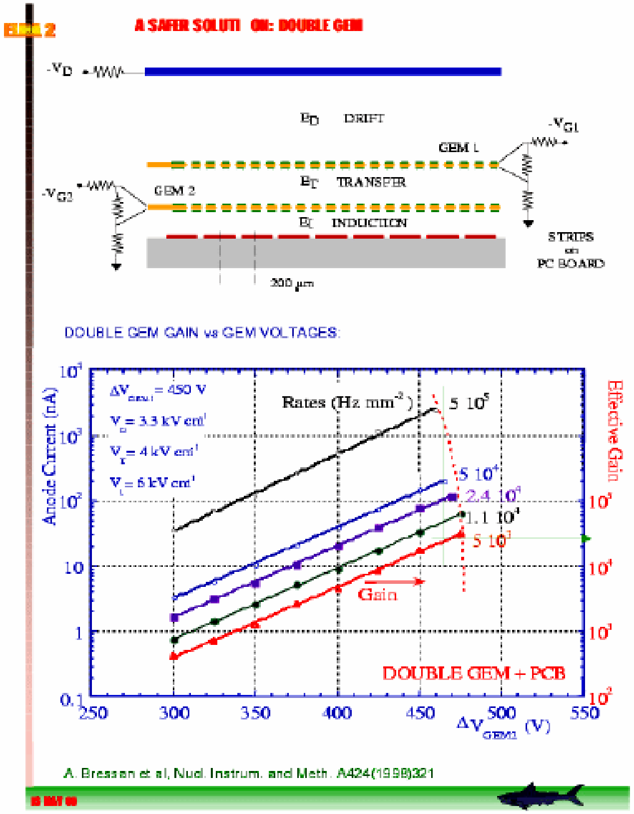
Low mass; fast; not “high” precision in construction and in-expensive; any shape and pad size; double, triple or more foils setup; checked and tested.



GAS ELECTRON MULTIPLIER GEM

STANDARD GEM: 70 m HOLES AT 140 m PITCH ON 50 m COPPER-CLAD KAPTON

F. Sauli, Nucl. Instrum. Methods A386 (1997) 531



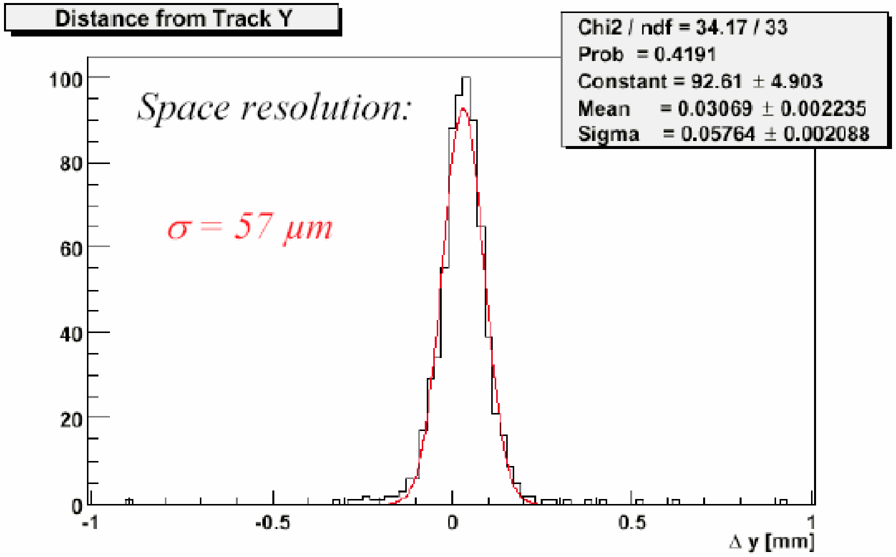
A SAFER SOLUTI ON: DOUBLE GEM

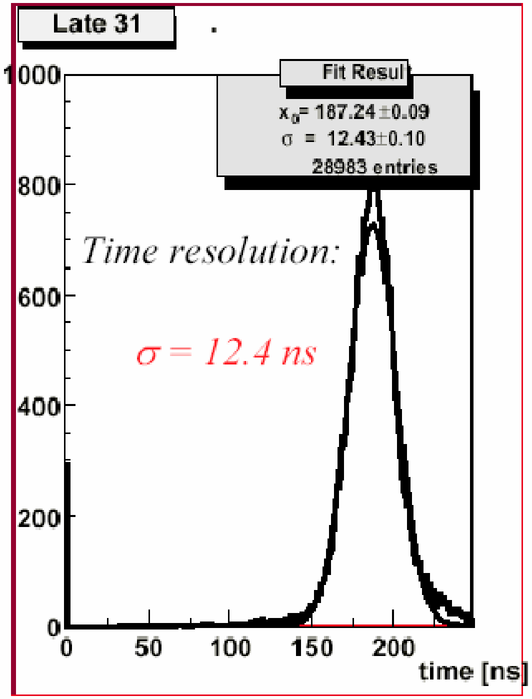
DOUBLE GEM GAIN vs GEM VOLTAGES:

A. Bressan et al, Nucl. Instrum. and Meth. A424(1998)321

N. Smirnov: Report on GEM activities

Space and time resolution (an example, not the record)





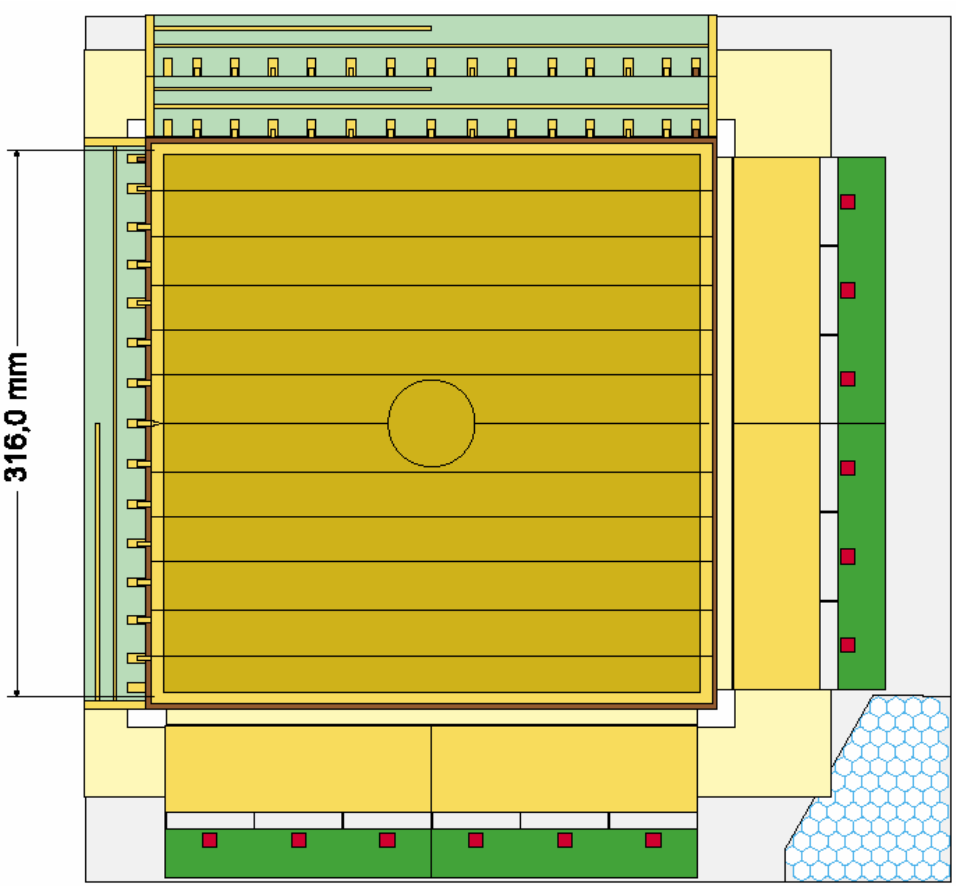
Read-out plane: pads, strips, 2D-strips with stereo angle, direct Si, …- choose pitch, technology and shape.

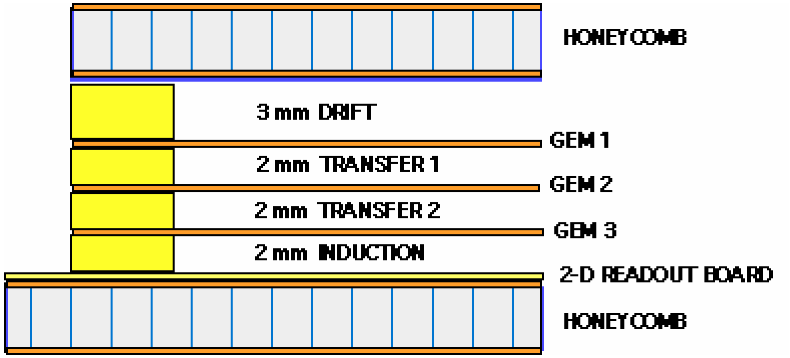
N. Smirnov: Report on GEM activities

Triple GEM detector for COMPASS

- Active area: 30.7 x 30.7 cm^2
- 2-dimensional readout with
- 2 x 768 strips @ 400 μm pitch
- 12+1 sectors GEM foils (to reduce discharge energy)
- Central Beam Killer 5 cm Ø (remotely controlled)
- Total thickness: 15 mm
- Low mass honeycomb support plates

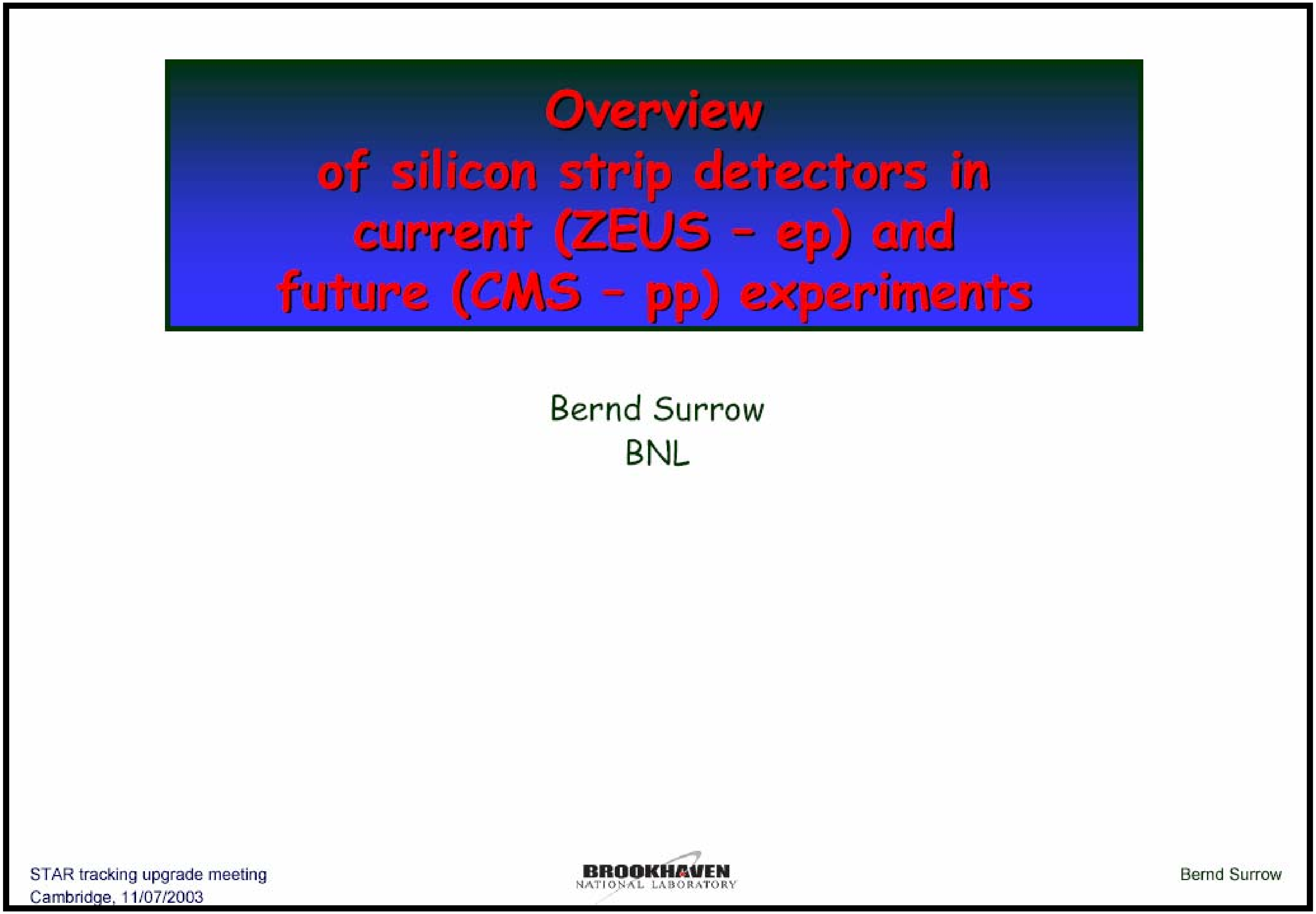
⇨ Good experience after two years of operation!





B. Ketzer et al, IEEE Trans. Nucl. Sci. NS-48(2001)1065
C. Altumbas et al, Nucl. Instrum. Methods A490(2002)177

B. Surrow: Overview of silicon strip detectors (ZEUS/CMS)



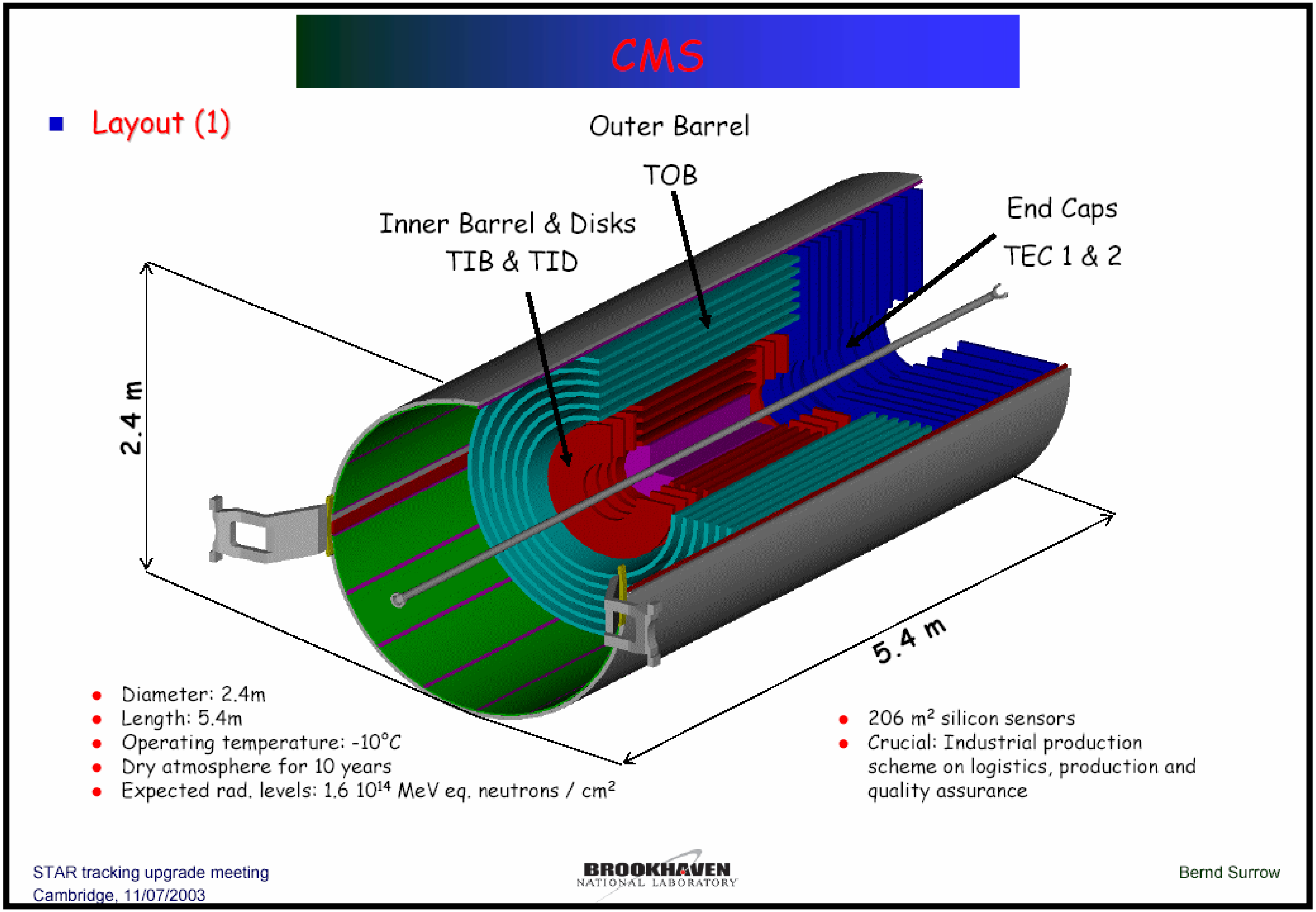
Overview of silicon strip detectors in current (ZEUS - ep) and future (CMS - pp) experiments

Bernd Surrow
BNL

STAR tracking upgrade meeting
Cambridge, 11/07/2003

Bernd Surrow

B. Surrow: Overview of silicon strip detectors (ZEUS/CMS)



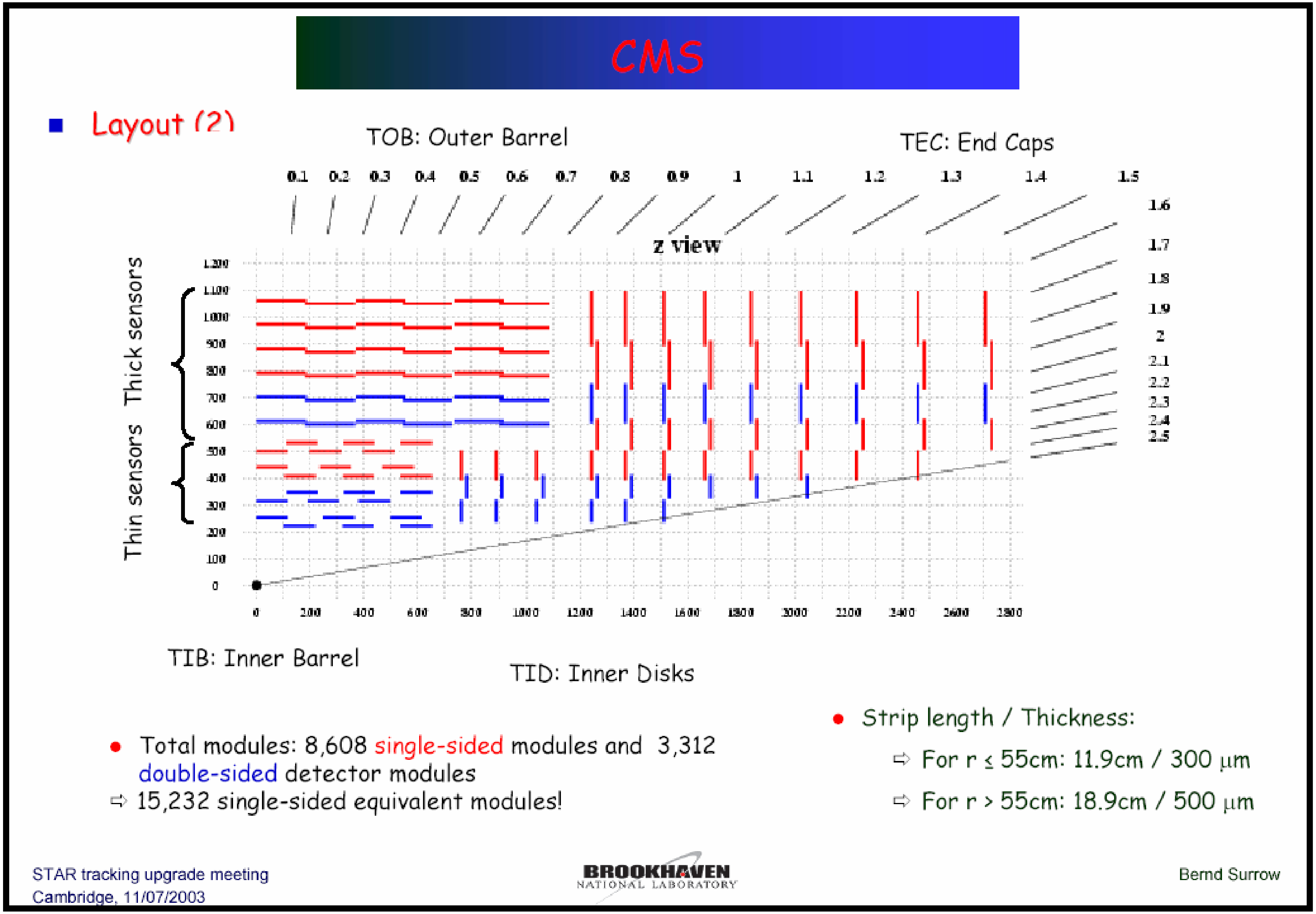
CMS

- Layout (1)

- Diameter: 2.4m
- Length: 5.4m
- Operating temperature: -10°C
- Dry atmosphere for 10 years
- Expected rad. levels: 1.6 10^{14} MeV eq. neutrons / cm^2

- 206 m^2 silicon sensors
- Crucial: Industrial production scheme on logistics, production and quality assurance

B. Surrow: Overview of silicon strip detectors (ZEUS/CMS)



CMS

- Layout (2)

- Total modules: 8,608 single-sided modules and 3,312 double-sided detector modules

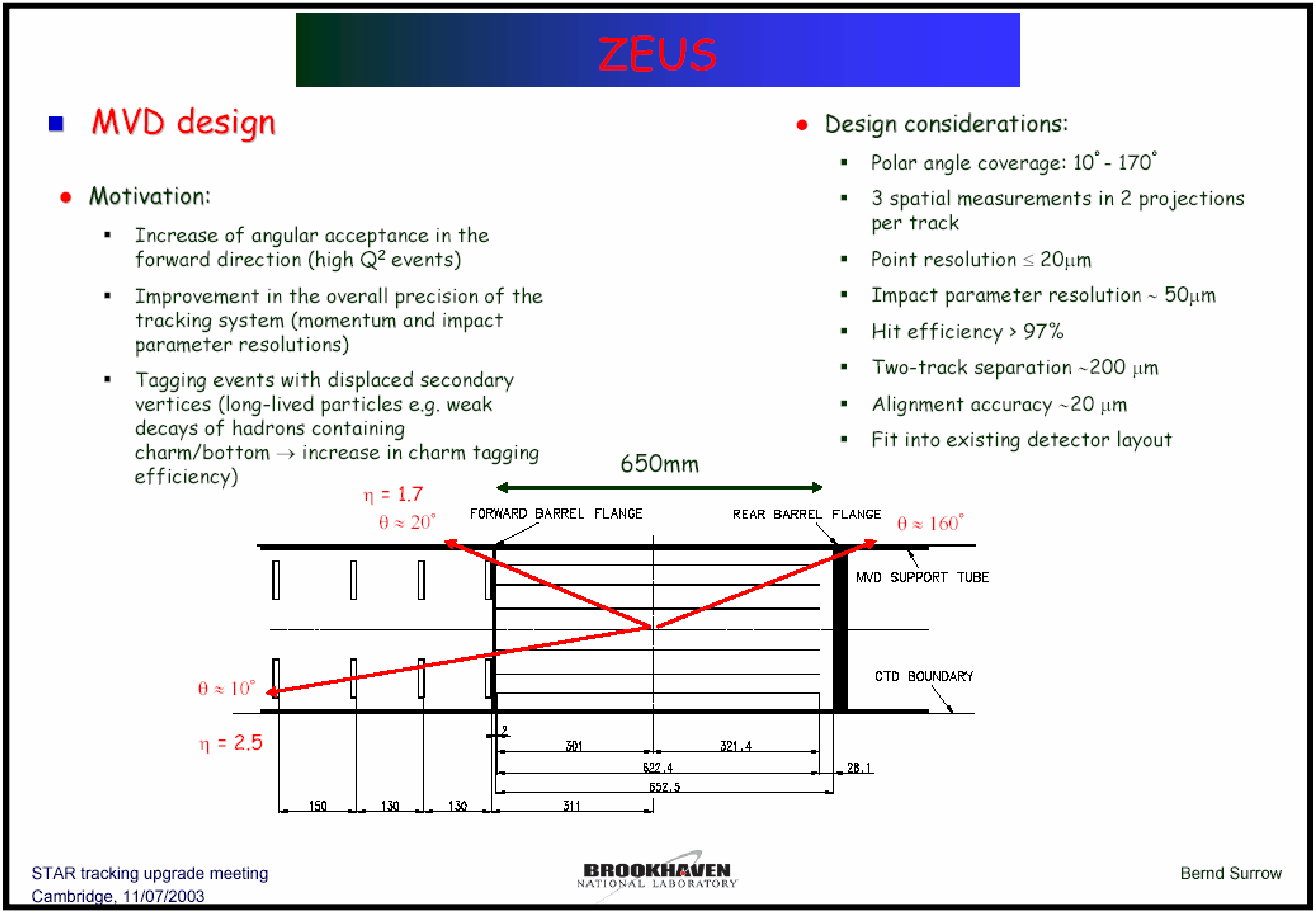
⇨ 15,232 single-sided equivalent modules!

- Strip length / Thickness:
  - ⇨ For r ≤ 55cm: 11.9cm / 300 μm
  - ⇨ For r > 55cm: 18.9cm / 500 μm

STAR tracking upgrade meeting
Cambridge, 11/07/2003

Bernd Surrow

B. Surrow: Overview of silicon strip detectors (ZEUS/CMS)



ZEUS

MVD design

- Motivation:
  - Increase of angular acceptance in the forward direction (high Q^2 events)
  - Improvement in the overall precision of the tracking system (momentum and impact parameter resolutions)
  - Tagging events with displaced secondary vertices (long-lived particles e.g. weak decays of hadrons containing charm/bottom → increase in charm tagging efficiency)

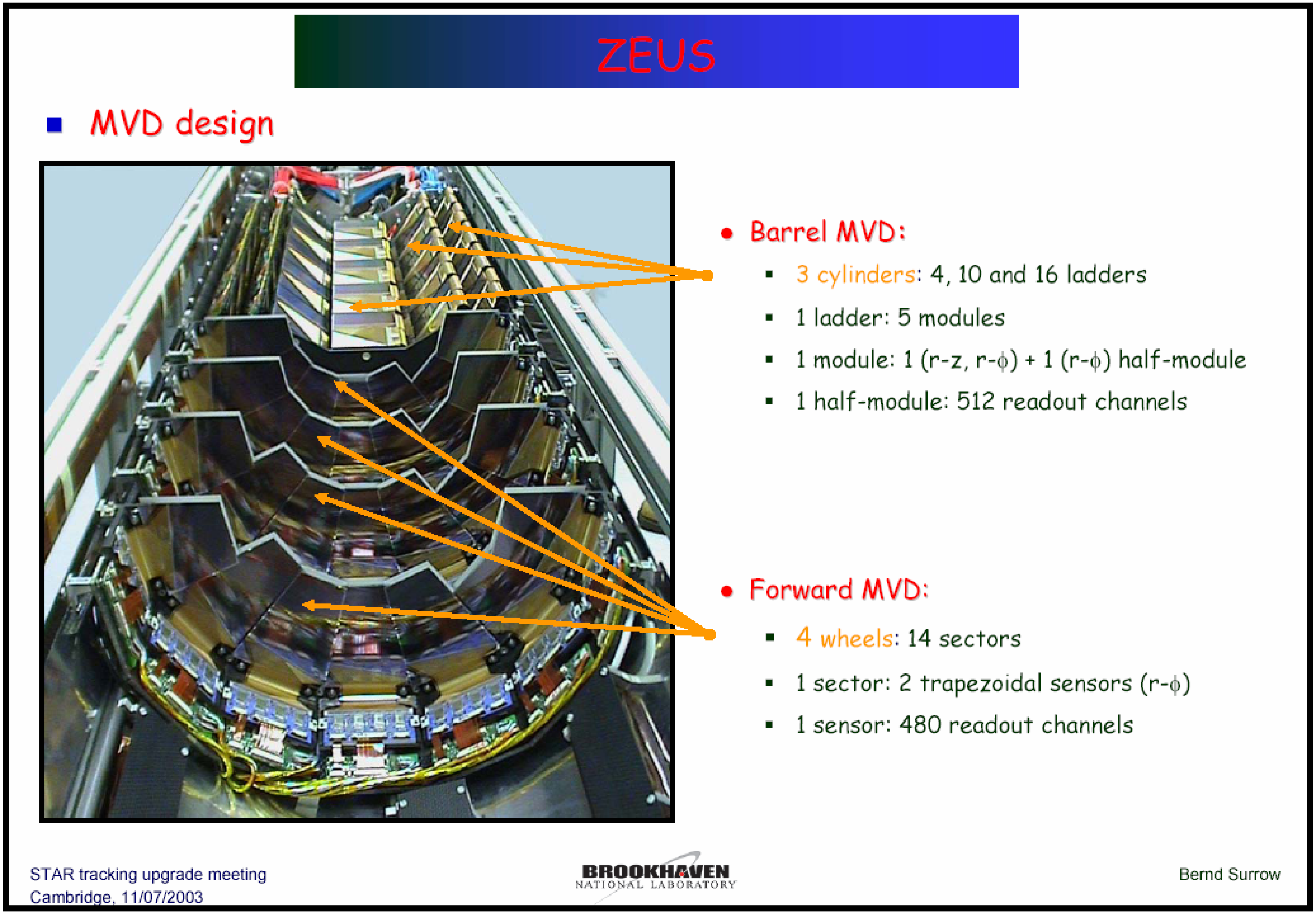
- Design considerations:
  - Polar angle coverage: 10° - 170°
  - 3 spatial measurements in 2 projections per track
  - Point resolution ≤ 20μm
  - Impact parameter resolution ~ 50μm
  - Hit efficiency > 97%
  - Two-track separation ~200 μm
  - Alignment accuracy ~20 μm
  - Fit into existing detector layout

STAR tracking upgrade meeting
Cambridge, 11/07/2003

BROOKHAVEN NATIONAL LABORATORY

Bernd Surrow

B. Surrow: Overview of silicon strip detectors (ZEUS/CMS)

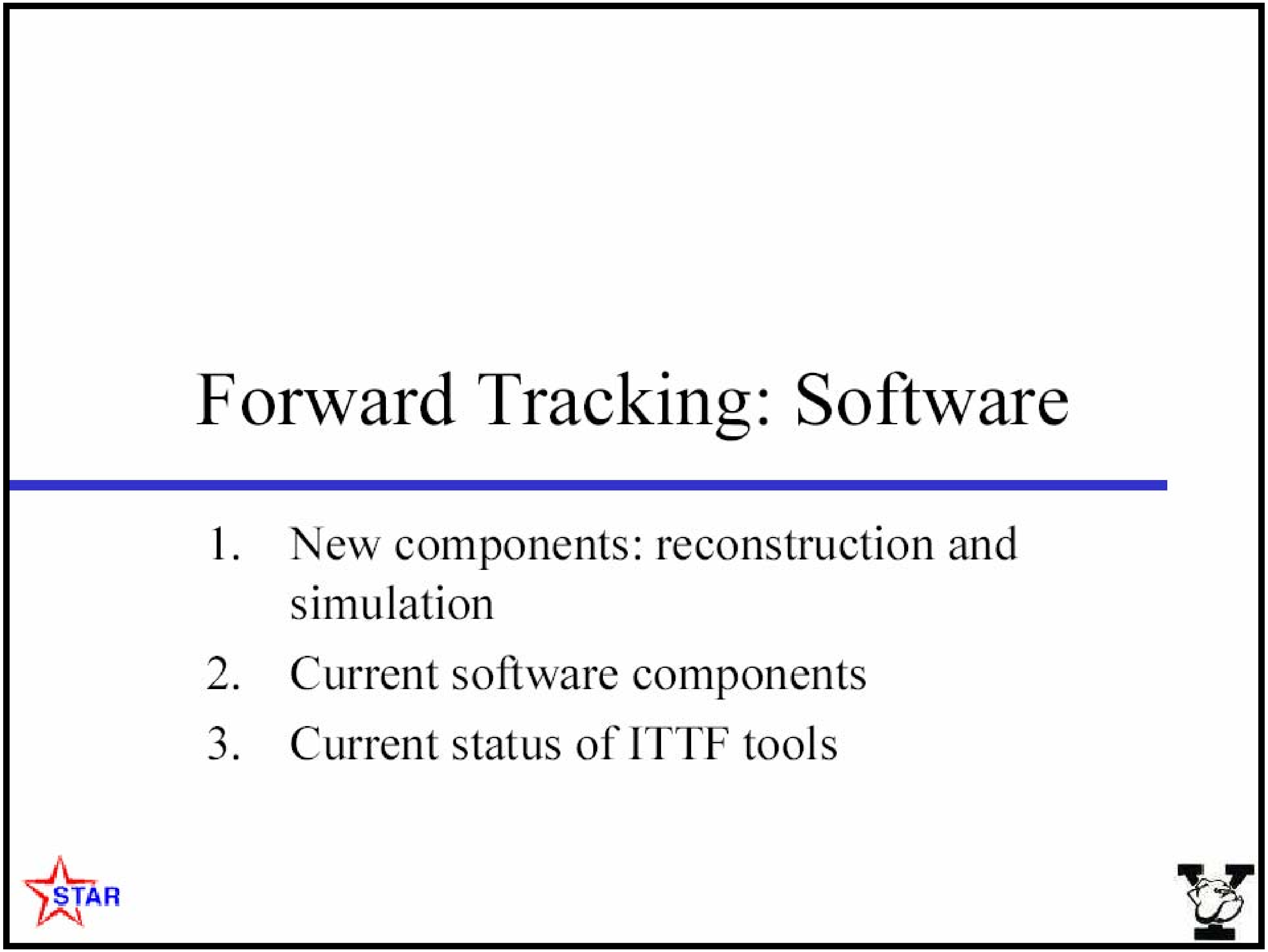


ZEUS

- MVD design

- Barrel MVD:
  - 3 cylinders: 4, 10 and 16 ladders
  - 1 ladder: 5 modules
  - 1 module: 1 (r-z, r-ϕ) + 1 (r-ϕ) half-module
  - 1 half-module: 512 readout channels
- Forward MVD:
  - 4 wheels: 14 sectors
  - 1 sector: 2 trapezoidal sensors (r-ϕ)
  - 1 sensor: 480 readout channels

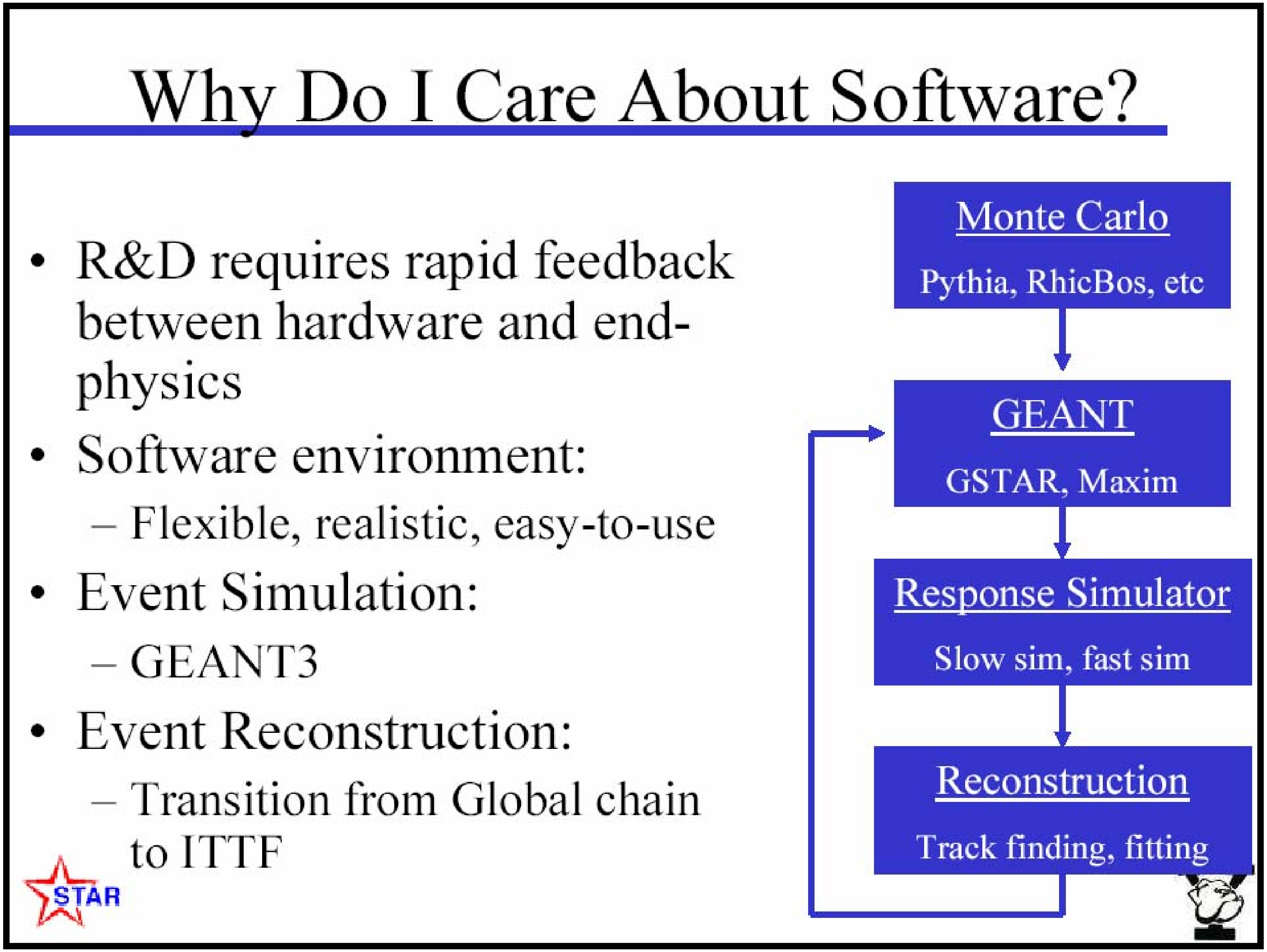
M. Miller: STAR tracking software



Forward Tracking: Software

1. New components: reconstruction and simulation
2. Current software components
3. Current status of ITTF tools

M. Miller: STAR tracking software



Why Do I Care About Software?

- R&D requires rapid feedback between hardware and end-physics
- Software environment:
  - Flexible, realistic, easy-to-use
- Event Simulation:
  - GEANT3
- Event Reconstruction:
  - Transition from Global chain to ITTF

Monte Carlo

Pythia, RhicBos, etc

GEANT

GSTAR, Maxim

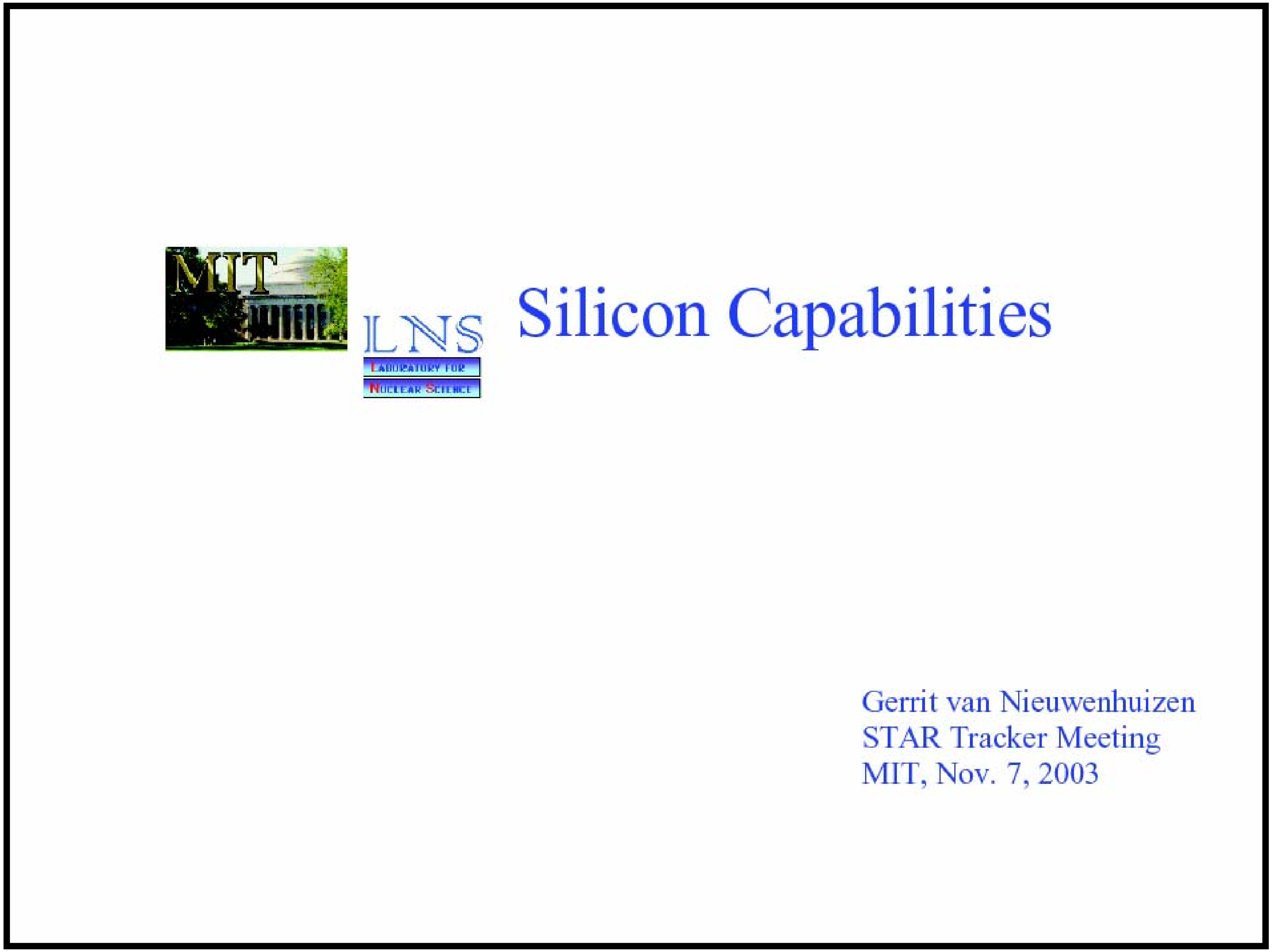
Response Simulator

Slow sim, fast sim

Reconstruction

Track finding, fitting

G. v. Nieuwenhuizen: MIT silicon laboratory



LNS

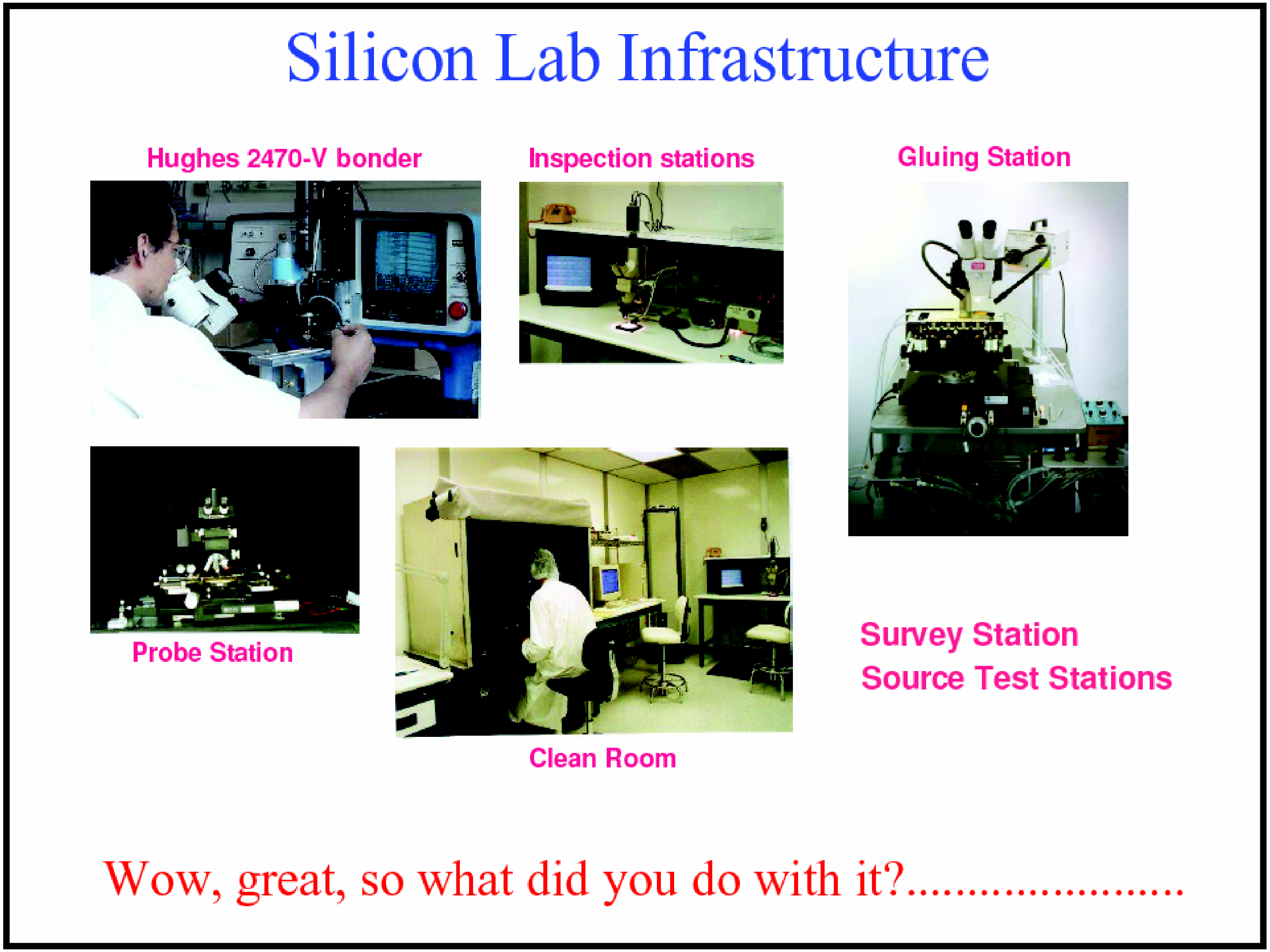
LABORATORY FOR

NUCLEAR SCIENCE

Silicon Capabilities

Gerrit van Nieuwenhuizen
STAR Tracker Meeting
MIT, Nov. 7, 2003

G. v. Nieuwenhuizen: MIT silicon laboratory



Silicon Lab Infrastructure

Hughes 2470-V bonder

Inspection stations

Gluing Station

Probe Station

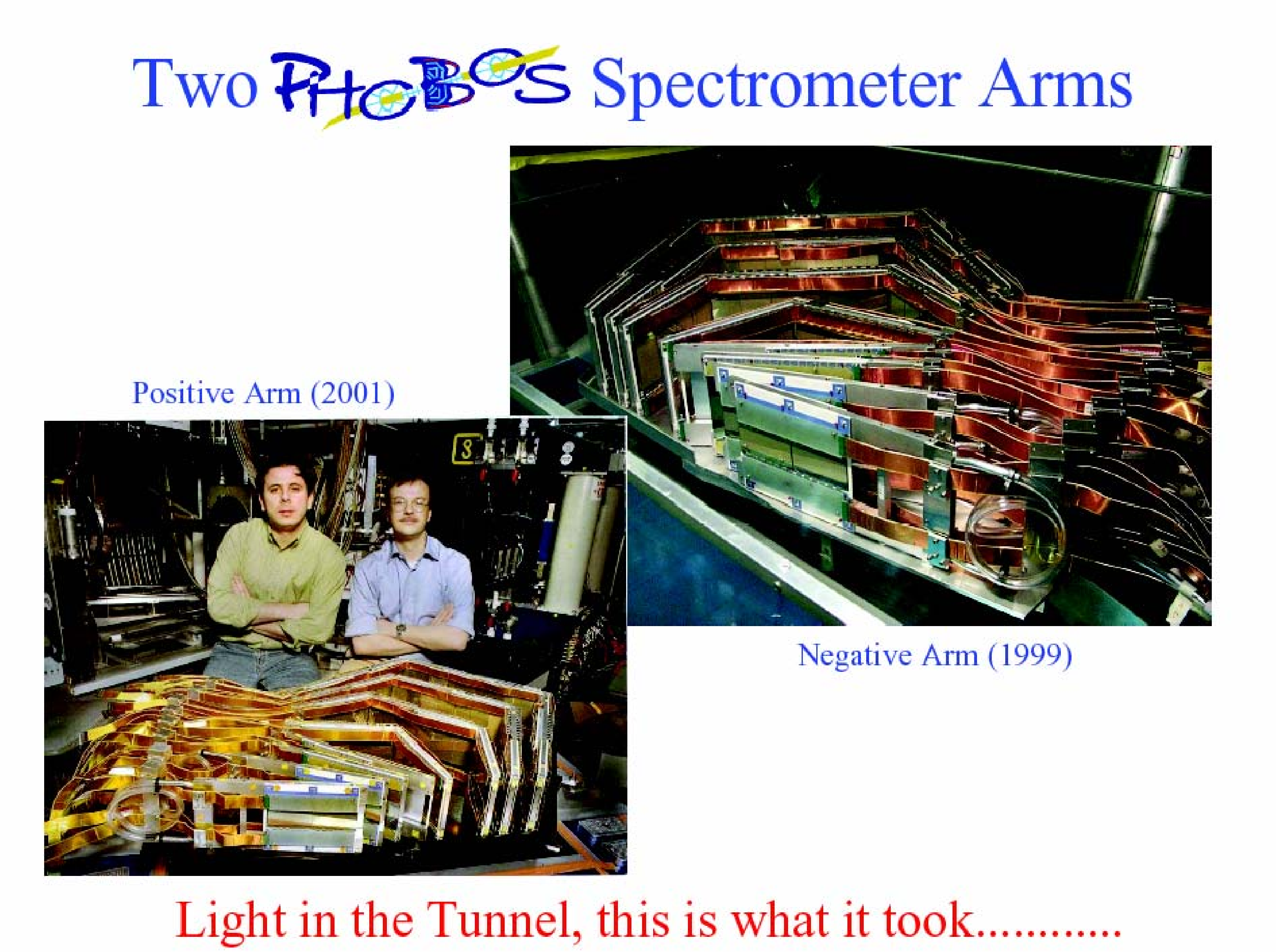
Clean Room

Survey Station

Source Test Stations

Wow, great, so what did you do with it?......................

G. v. Nieuwenhuizen: MIT silicon laboratory



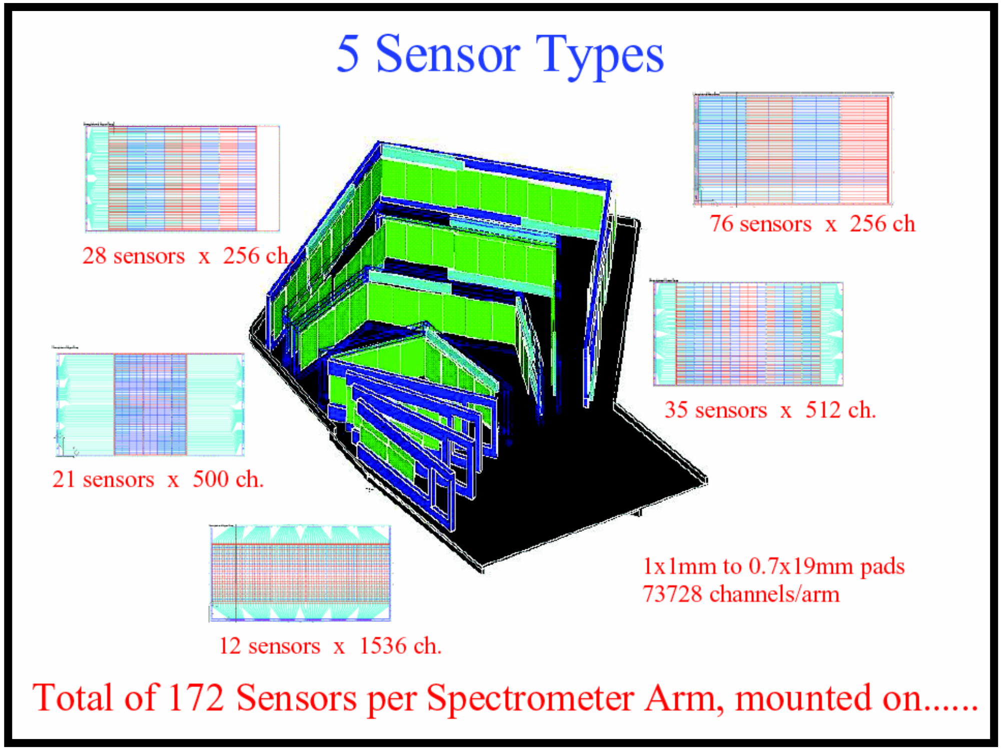
Two PHOBOS Spectrometer Arms

Positive Arm (2001)

Negative Arm (1999)

Light in the Tunnel, this is what it took...........

G. v. Nieuwenhuizen: MIT silicon laboratory



5 Sensor Types

28 sensors x 256 ch

76 sensors x 256 ch

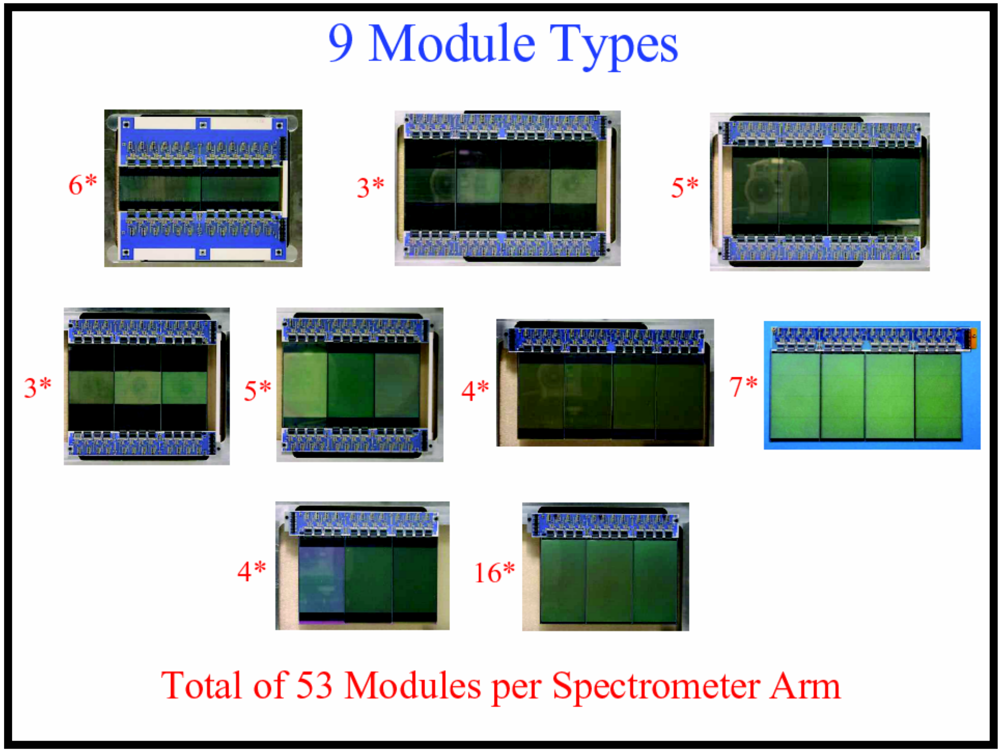
21 sensors x 500 ch.

35 sensors x 512 ch.

12 sensors x 1536 ch.

1x1mm to 0.7x19mm pads
73728 channels/arm

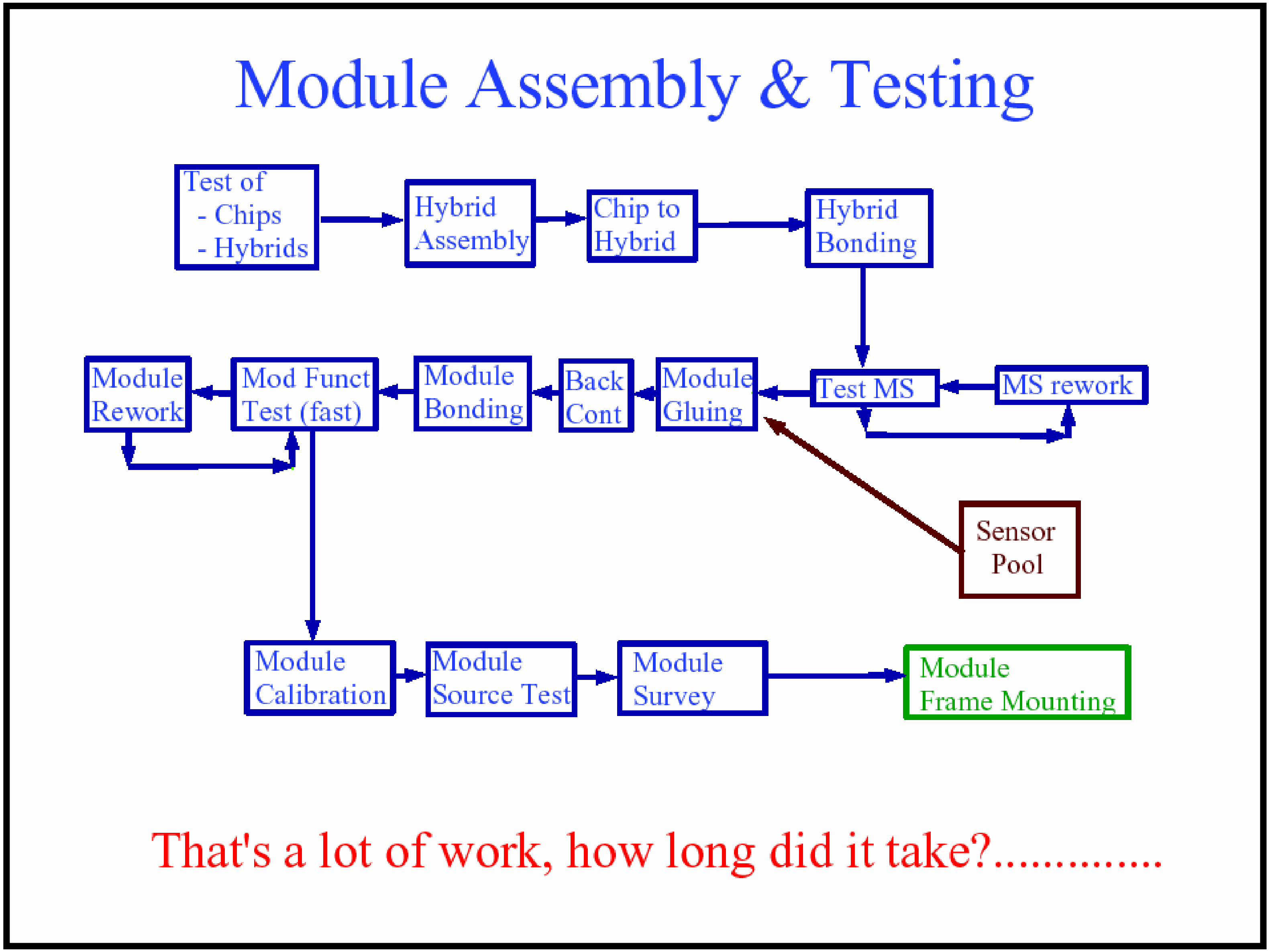
Total of 172 Sensors per Spectrometer Arm, mounted on......



9 Module Types

Total of 53 Modules per Spectrometer Arm

G. v. Nieuwenhuizen: MIT silicon laboratory



Module Assembly & Testing

Test of
- Chips
- Hybrids

Hybrid Assembly

Chip to Hybrid

Hybrid Bonding

Test MS

MS rework

Module Gluing

Back Cont

Module Bonding

Mod Funct Test (fast)

Module Rework

Sensor Pool

Module Calibration

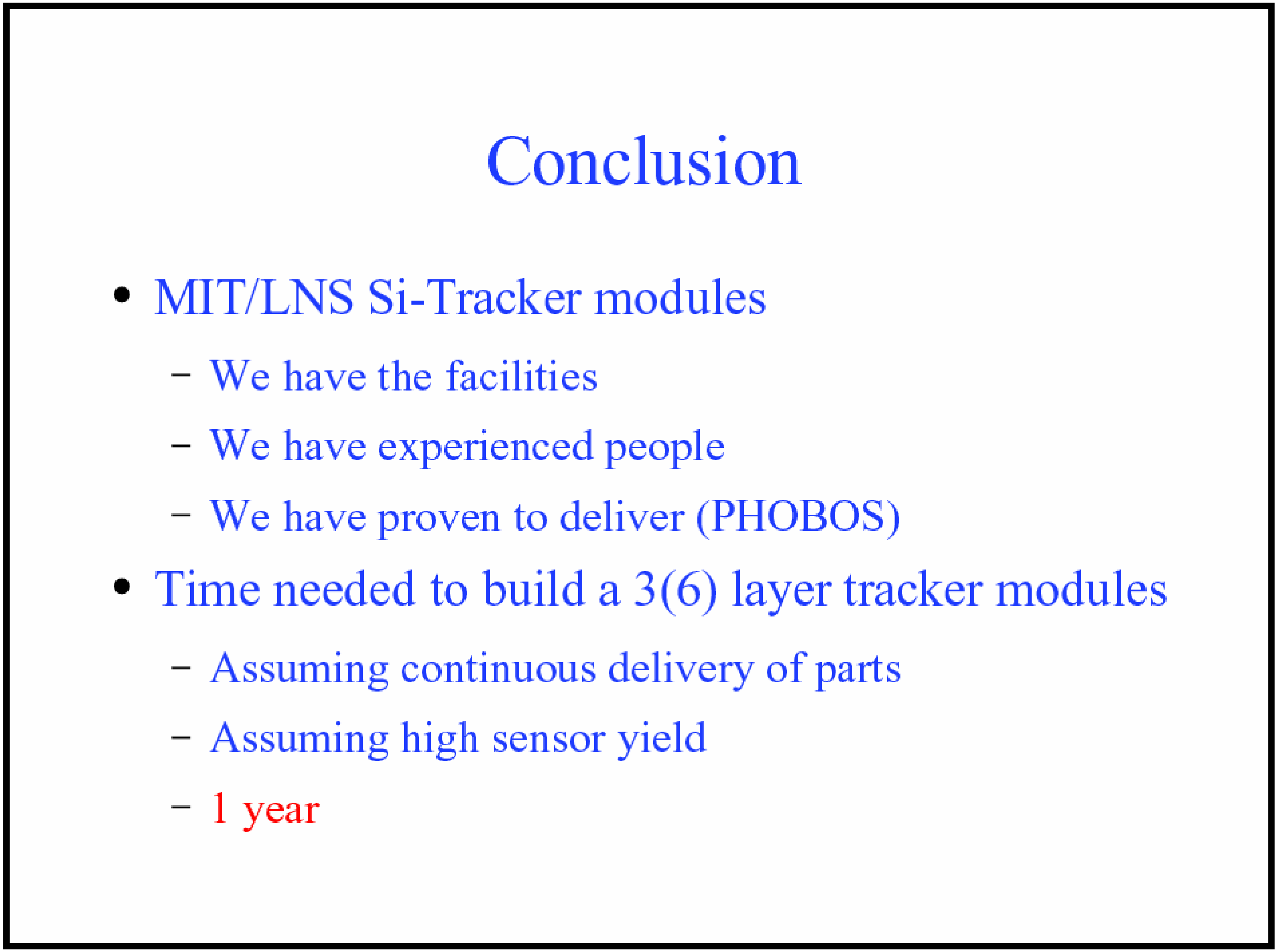
Module Source Test

Module Survey

Module Frame Mounting

That's a lot of work, how long did it take?.............

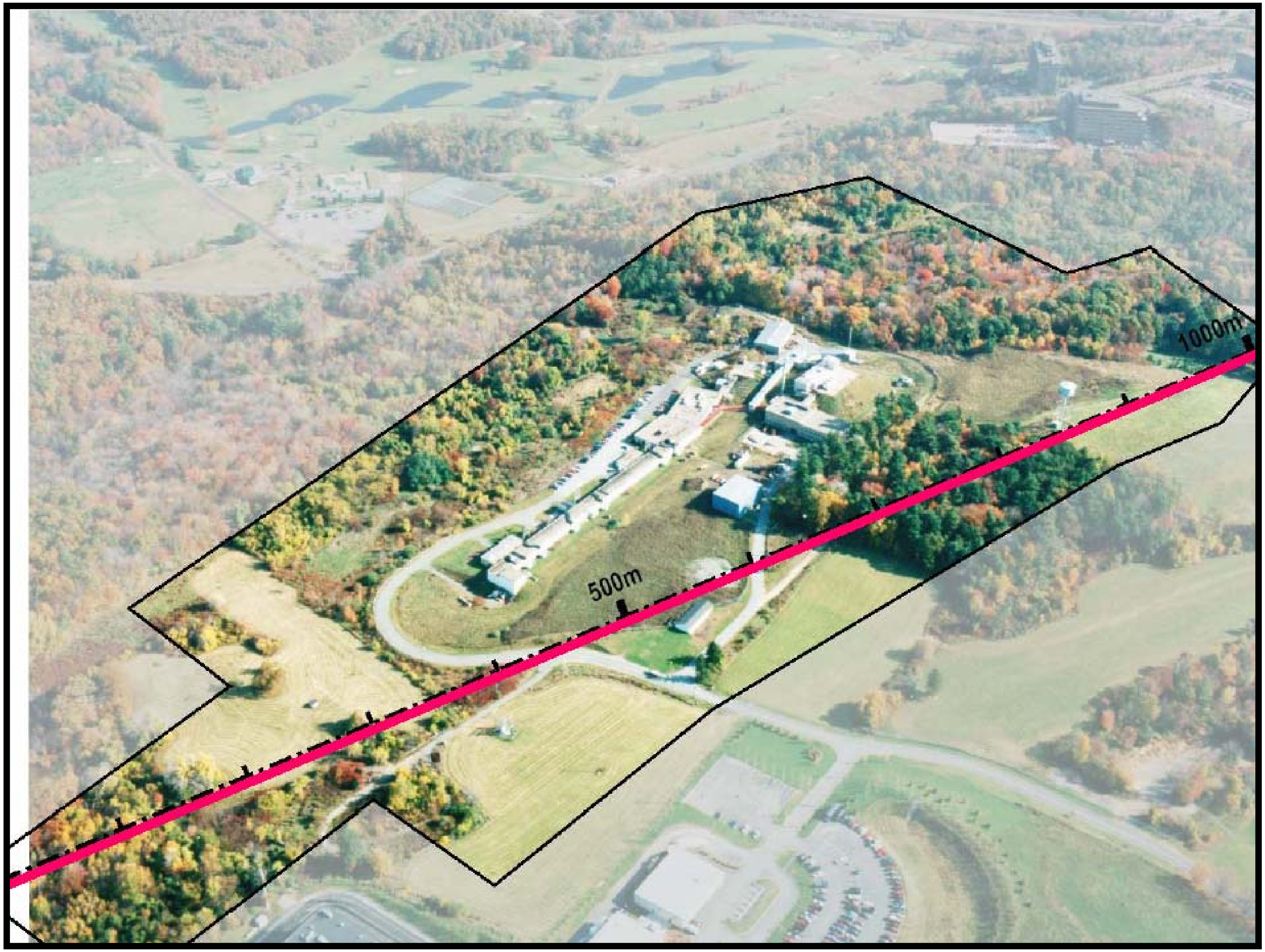
G. v. Nieuwenhuizen: MIT silicon laboratory



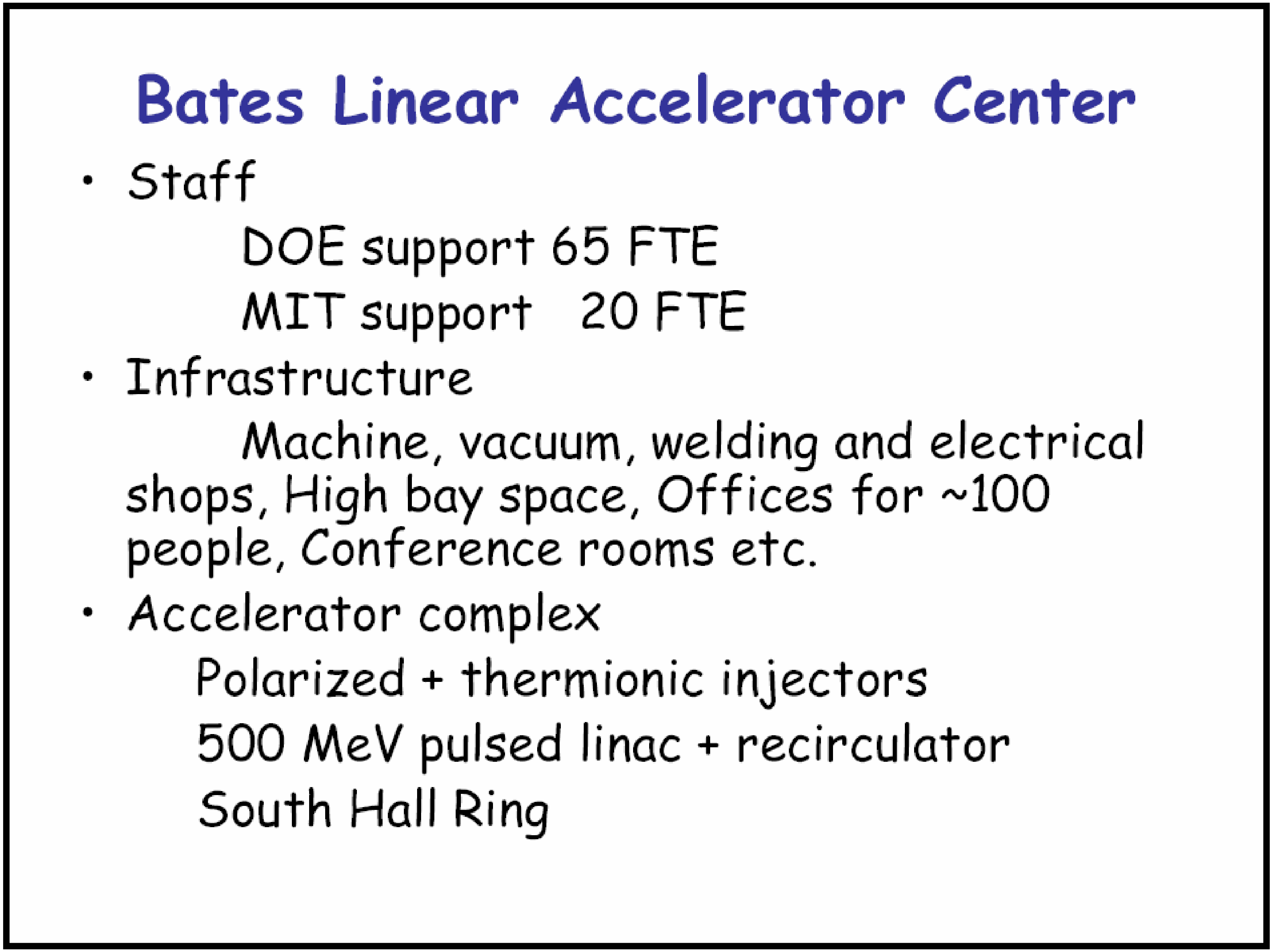
Conclusion

- MIT/LNS Si-Tracker modules
  - We have the facilities
  - We have experienced people
  - We have proven to deliver (PHOBOS)
- Time needed to build a 3(6) layer tracker modules
  - Assuming continuous delivery of parts
  - Assuming high sensor yield
  - 1 year

R. Milner: MIT-BATES infrastructure



R. Milner: MIT-BATES infrastructure



Bates Linear Accelerator Center

- Staff

  DOE support 65 FTE

  MIT support 20 FTE

- Infrastructure

  Machine, vacuum, welding and electrical shops, High bay space, Offices for ~100 people, Conference rooms etc.

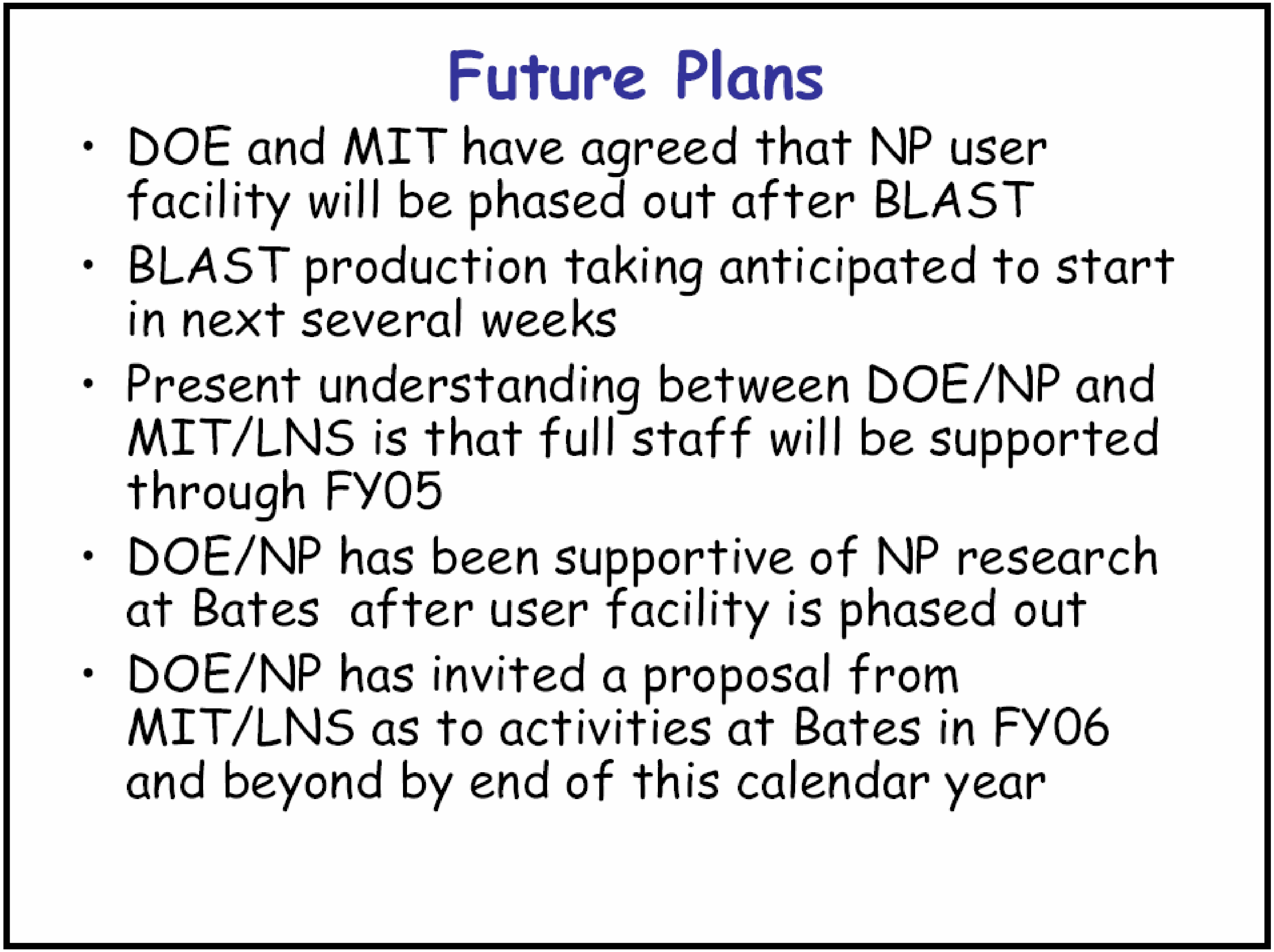
- Accelerator complex

  Polarized + thermionic injectors

  500 MeV pulsed linac + recirculator

  South Hall Ring

R. Milner: MIT-BATES infrastructure



Future Plans

- DOE and MIT have agreed that NP user facility will be phased out after BLAST
- BLAST production taking anticipated to start in next several weeks
- Present understanding between DOE/NP and MIT/LNS is that full staff will be supported through FY05
- DOE/NP has been supportive of NP research at Bates after user facility is phased out
- DOE/NP has invited a proposal from MIT/LNS as to activities at Bates in FY06 and beyond by end of this calendar year

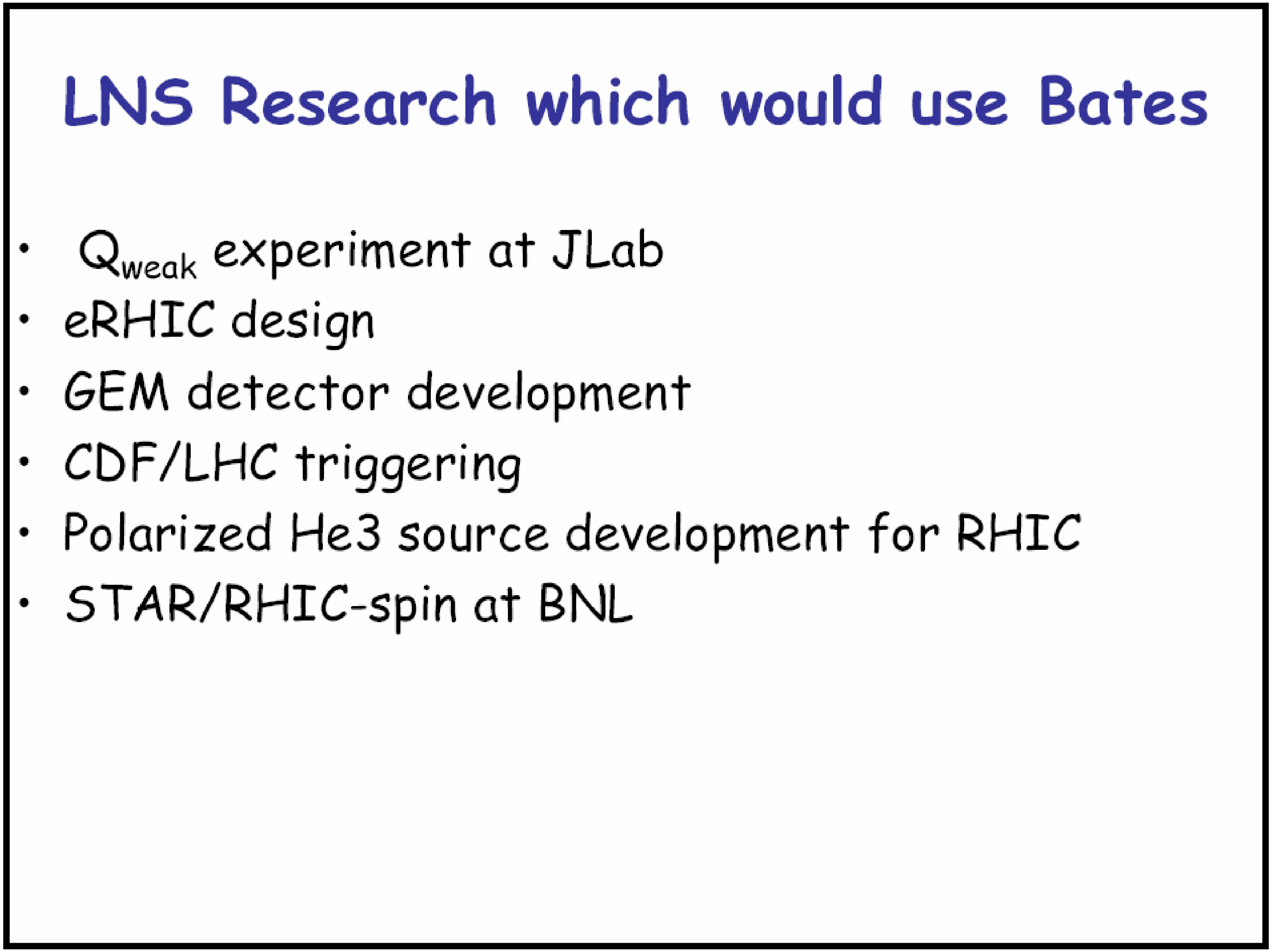
R. Milner: MIT-BATES infrastructure

LNS Research Laboratory @ Bates

- Size and nature of staffing will be asymptotically determined by research of LNS faculty
- Propose FY06 level of ~35 FTE

Research physicists	6
Accelerator Physicists	6
Mechanical Engineering	10
Electrical Engineering	10
Administration	2
Computing	1

R. Milner: MIT-BATES infrastructure



LNS Research which would use Bates

- Q_{weak} experiment at JLab
- eRHIC design
- GEM detector development
- CDF/LHC triggering
- Polarized He3 source development for RHIC
- STAR/RHIC-spin at BNL

Summary of discussion session - Part II

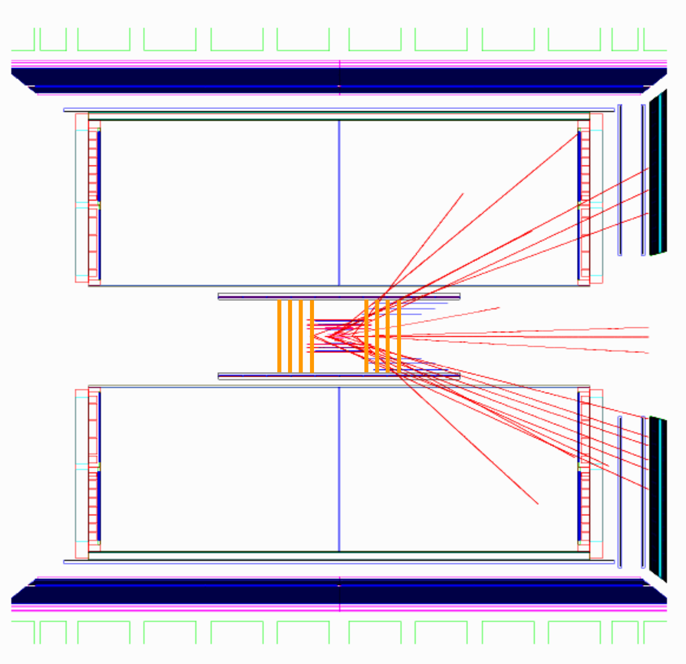
- Where do we go from here?
  - Discussion on inner/forward tracker upgrade strategy
  - Optimal sequence and staging of tracking proposals and upgrade plans

- What needs to be done?
  - Formulation of task list:
    1. Simulation (GEANT, physics simulation)
    2. Overall detector layout
    3. Detailed specific detector design

- Who is interested to look into what (Institutional responsibilities)?
  - Simulation work
  - R&D activities
  - Detector design and prototype

- Formation of a working group within STAR and coordination?

- Discussion on funding?



- When do we meet again?

Summary of discussion session – Part II

- **Summary:**
  - RHIC SPIN long-term goal (Requires continuous development of pp luminosity!):
    ⇨ Explore spin structure of QCD sea and flavor dependence through W production
    ⇨ Required for this are precise and fast tracking detectors as a result based on first GEANT simulation work:
    - EEMC forward tracker ($1 < \eta < 2$)
    - Inner/forward tracking (Extension of η coverage beyond $\eta = 1$ (Current SVT!) is necessary!)
    - Potential technology: Combination of Silicon / GEM detectors
  - SVT performance (SVT is not a fast detector) and maintenance is a concern! Repair is problematic!
  - Heavy quark physics is of great interest!
  - Forward physics has attracted a lot of interest! Forward tracking in the acceptance region beyond $\eta = 2$ will be important, e.g. through forward silicon wheels and GEM's
  - Pixel mechanical design ideas of being replaceable is difficult with the current FTPC! Starting with a new inner tracker design with forward acceptance (Pixel + inner detector system with forward acceptance) could be advantageous!

Summary of discussion session – Part II

- Outlook:

  - MIT LNS silicon laboratory and MIT-BATES exist together with experienced personnel to strongly participate in the STAR tracking upgrade
  - GEM micro-pattern facility needed (Yale and MIT-BATES)
  - Estimated time-scale to build a new silicon tracker will take 1-2 years once the sensor material is in hand based on direct experience from PHOBOS
  - Need of a forum (New working group!) where to discuss and organize those tracking upgrade projects
  - Possible outlook towards a new inner/forward tracker for STAR:
    1. Conceptual design of a new inner/forward tracker which fulfills the pp and AuAu needs by beginning of FY05
    2. Prototype and evaluation of possible silicon sensors (MIT LNS silicon laboratory)
    3. First engineering layout (Draft proposal) by January 2005
    4. Proposal by summer 2005 (After FY05 RHIC pp run)
    5. First installation of pixel and minimal inner/forward tracking system (W physics case) starting 2007/2008
    6. Completion of installation by 2008/2009