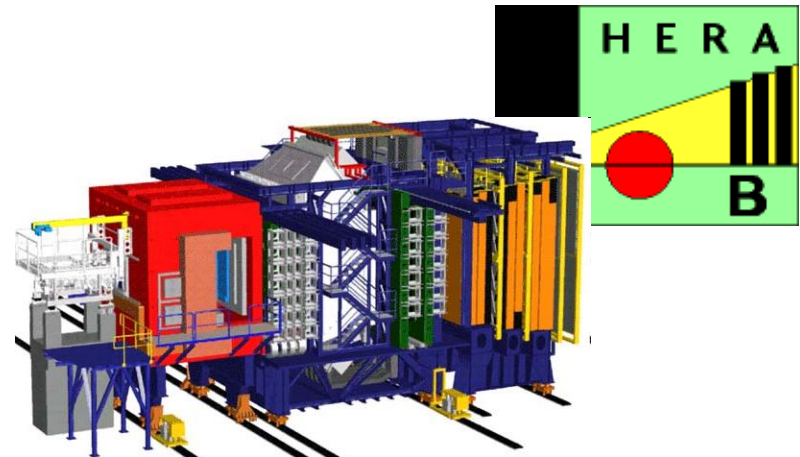
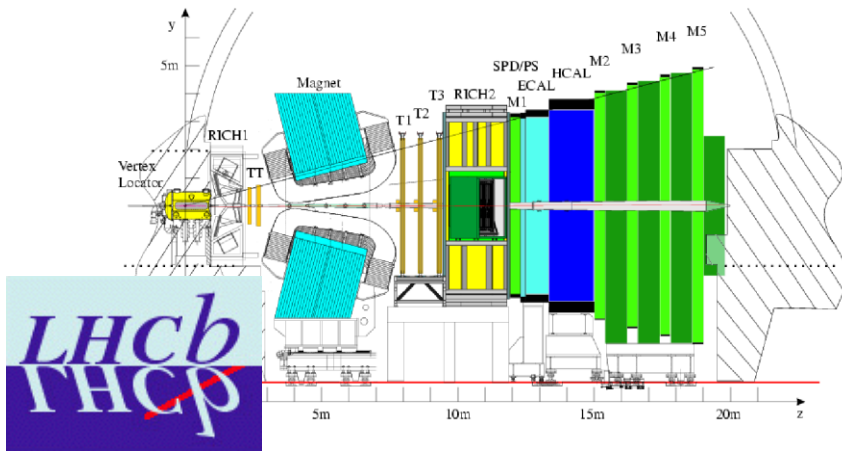
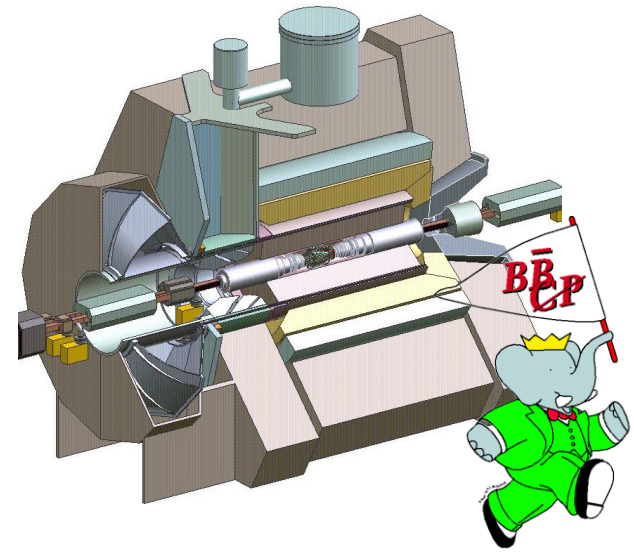


# B-physics Overview

NIKHEF Jaarvergadering  
Nijmegen  
21-22 December 2004

Niels Tuning  
on behalf of the B-physics group



# LHCb: migration of people...

## ← Graduated last Friday!

- Niels van Bakel:
- Sander Klous almost...

*"The Silicon Vertex Detector for LHCb"*

## ← New job in Lausanne!:

- Jeroen van Hunen

## ◀ Visiting engineering student from China:

- Senlong Shao

## → New AIO/OIOs:

- Aras Papadelis
- Edwin Bos

## → Visiting physicists:

- Yuri Gouz
- Seva Souvorov

## → New postdocs:

- Eduardo Rodrigues (based at CERN)
- Me

## → NWO Mozaiek grant

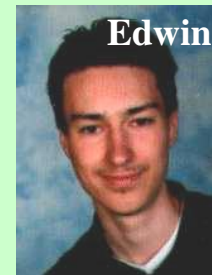
- Besma M'Charek



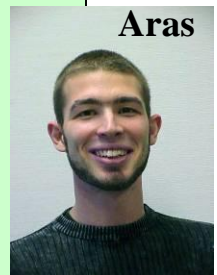
Niels



Jeroen



Edwin



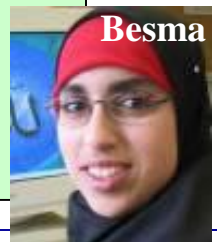
Aras



Eduardo



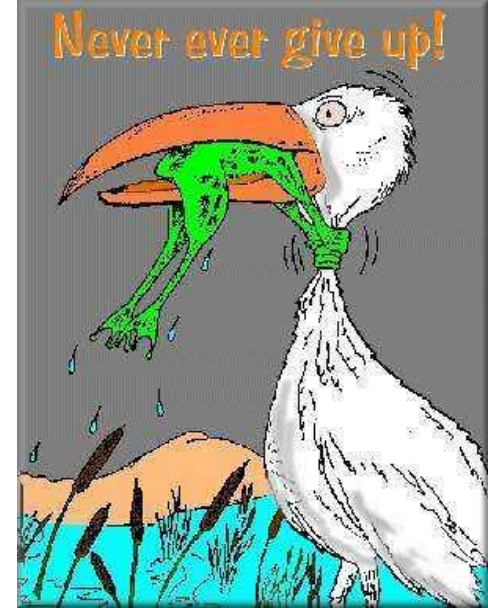
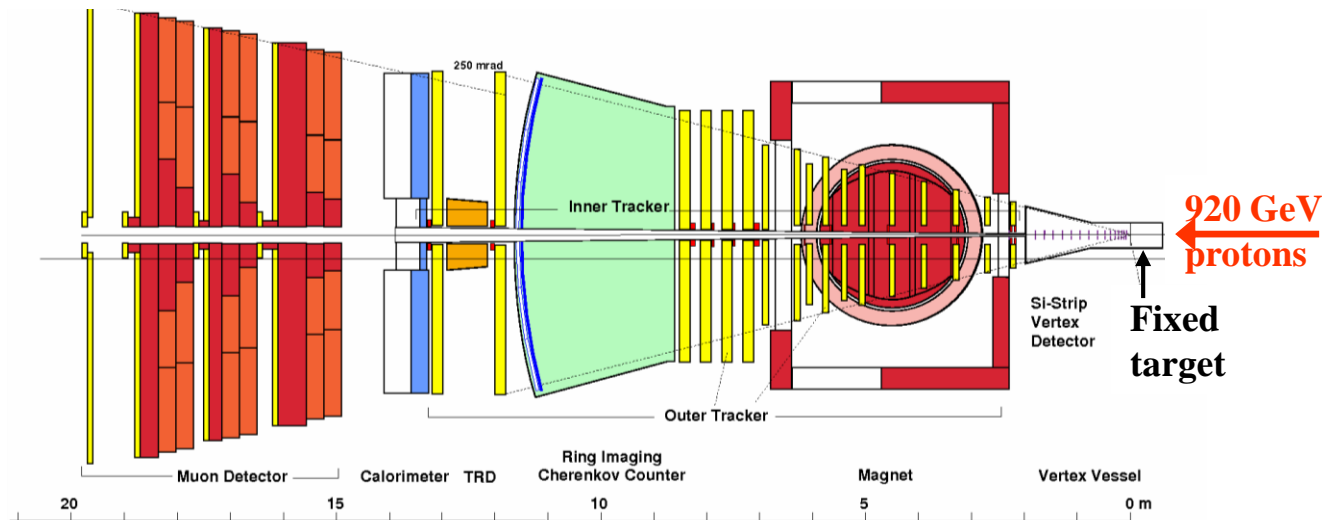
Seva



Besma

# Outline

- HERA-B
- BaBar
  - Highlights
  - News
  - Our contribution
- LHCb (→ see also Bart Hommels)
  - General
  - Vertex Locator
  - Outer Tracker
  - Tracking
  - Trigger (→ see Bart Hommels)



## Data taking upto March 2003

- Minimum bias
- Dilepton triggered data

**200  $10^6$  events on C,Ti,W**

1000 ev/s > 1TB/day

**150  $10^6$  dilepton trigger events**

300 000  $J/\psi$  (>1000 per hour)

15 000  $\chi_c$

5 000  $\psi(2S)$

# Analysing many topics:

Antonello Sbrizzi

Hernan Wahlberg

- **Pentaquark searches** ( $pK_s, \Xi\pi$ ) (PRL 93, 2004, 212003-1)
- **Inclusive  $b \bar{b}$  cross section**
- Upper limit on  $BR(D^0 \rightarrow \mu^+ \mu^-)$  (Phys.Lett.B596:173-183,2004)

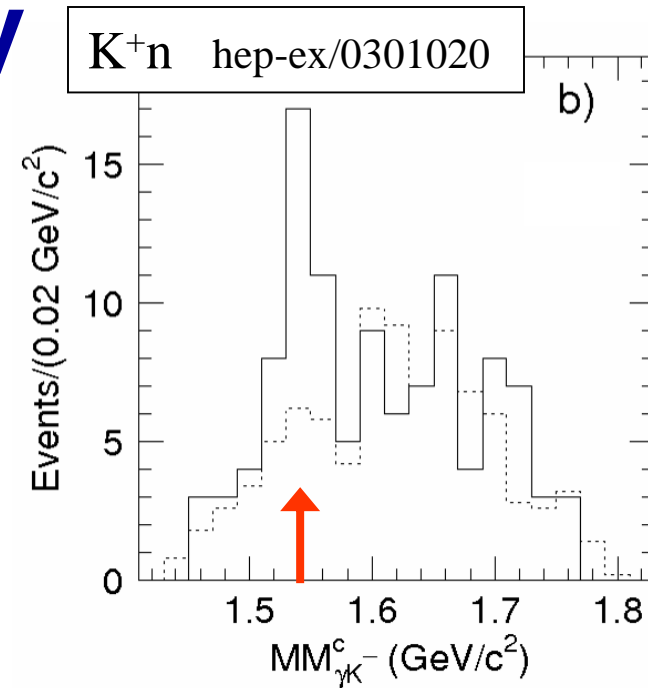
## And lots of other analyses:

- $\Upsilon$  cross section
- Production of  $\phi$  and  $K^*$  mesons
- $\psi(2S)$  production
- $D^+/D^0$  production ratio
- $J/\psi$  cross section in MB
- Hard photon production
- $\Lambda$  polarization
- $\chi_c$  production
- A dependence charmonium production
- $J/\psi$  differential distributions
- $V^0$  and hyperon production
- Jet production

## Claims:

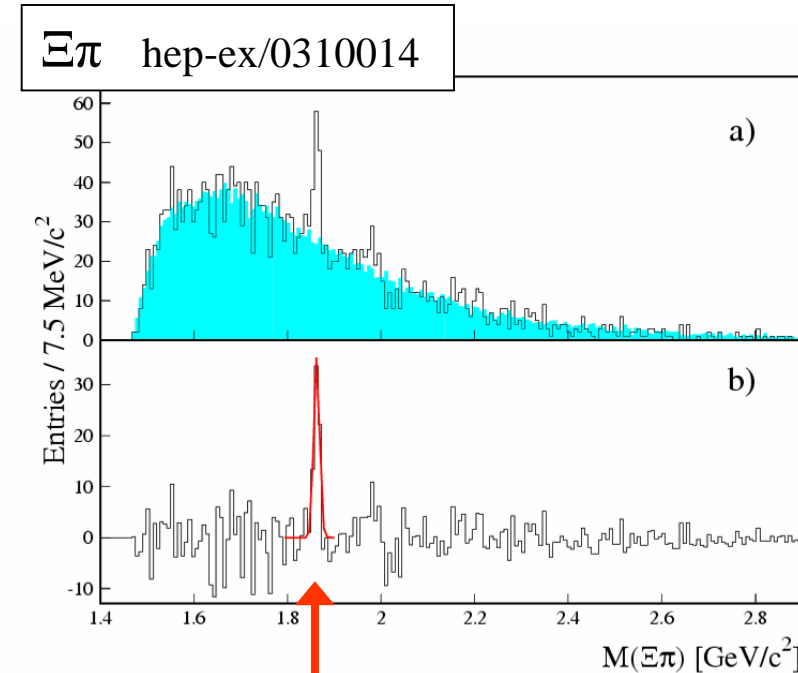
- LEPS (Osaka):

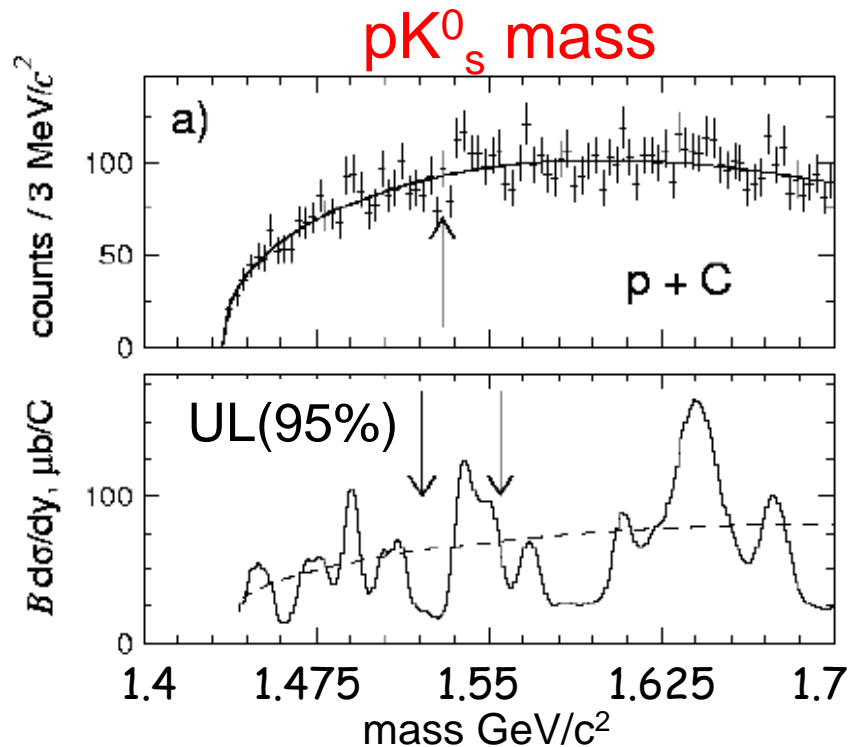
- $\gamma$   $^{12}\text{C}$  with  $E_\gamma \leq 2.4$  GeV
- $K^+n$  resonance at 1540 MeV ( $4.6 \sigma$ )
  - $\Theta^+ = \bar{s}udud$  pentaquark??
- Observed by 12 experiments...



- NA49 (CERN):

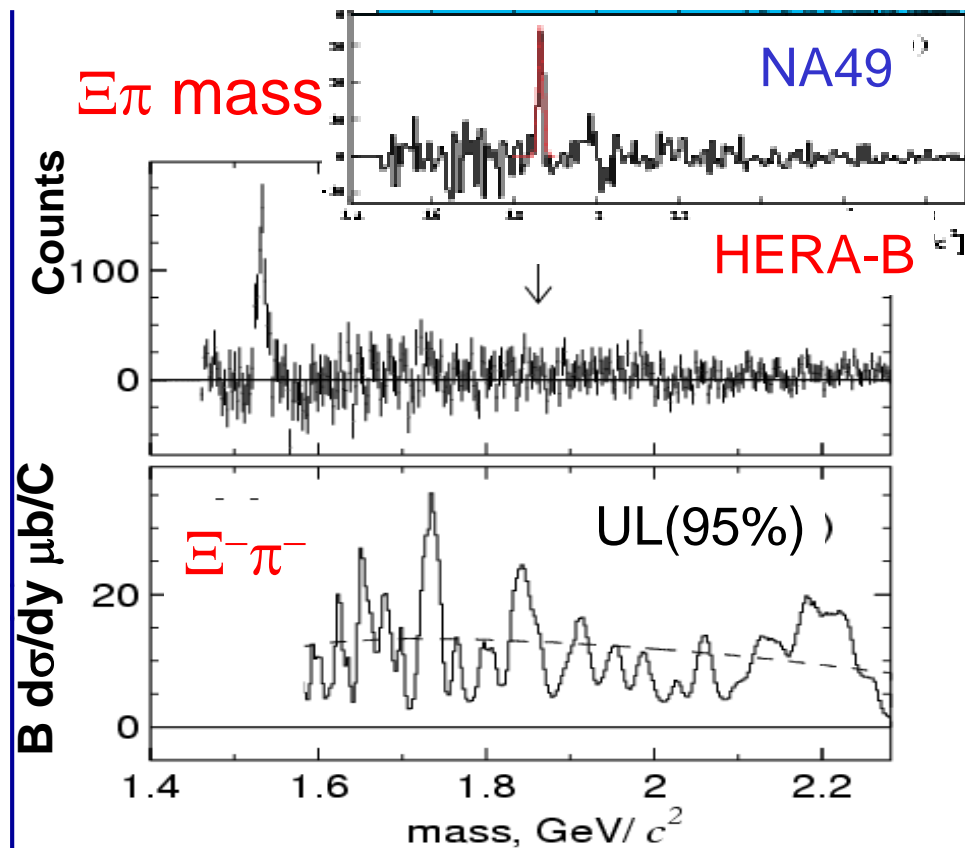
- $pp$  at  $\sqrt{s} = 17.1$  GeV
- $\Xi^-\pi^-$  resonance at 1862 MeV ( $4.0 \sigma$ )
  - $\Xi_{3/2}^- = \bar{u}dsds$  pentaquark??
- $\Xi^-\pi^+$  resonance at 1864 MeV
  - $\Xi_{3/2}^0 = \bar{d}usds$  pentaquark??





UL(95%)  $B \cdot d\sigma/dy|_{y=0} =$   
**4-16  $\mu b/N$  @ 1521-1555 MeV/c<sup>2</sup>**

$\Theta^+/\Lambda(1520) < 3 - 12 \%$   
**(HERMES:  $\Theta^+/\Lambda(1520) \approx 300\%$ )**



UL(95%)  $B \cdot d\sigma/dy|_{y=0} =$   
**2.5  $\mu b/N$  @ 1862 MeV/c<sup>2</sup>**

$\Xi^- / \Xi^- < 3/B \%$   
 $\Xi^- / \Xi(1530)^0 < 4/B \%$

**Bottom line: HERA-B does not see evidence for pentaquarks...**

# $\bar{b}b$ production

$$b(\bar{b}) \rightarrow B^0 \rightarrow J/\psi X$$

$$J/\psi \rightarrow \mu^+\mu^-, e^+e^-$$

Measurement relative to direct  $J/\psi$  production  
to minimize trigger/reconstruction uncertainties

$$\sigma_{b\bar{b}} = \sigma_{J/\psi} \cdot \frac{n_B}{n_{J/\psi}} \cdot \frac{1}{\epsilon_R \cdot \epsilon_B^{\Delta z} \cdot Br(b\bar{b} \rightarrow J/\psi + X)}$$

$\epsilon_R$  = relative efficiency  $\approx 1$

B selection eff. from MC  
30-45%

B Selection:

Lepton impact to the wire

Distance of  $J/\psi$  to wire



# $\bar{b}b$ production

preliminary

$$\frac{\sigma(b\bar{b})}{\sigma(J/\psi)} = 0.027 \pm 0.004 \pm 0.005$$

- Main contribution to unc:  
 $\text{Br}(b\bar{b} \rightarrow J/\psi X) = 2.32 \pm 0.20\%$

- E771/E789 : scaled to 41.6 GeV  
 $\sigma(J/\psi) = 357 \pm 2 \pm 36 \text{ nb/nucleon}$

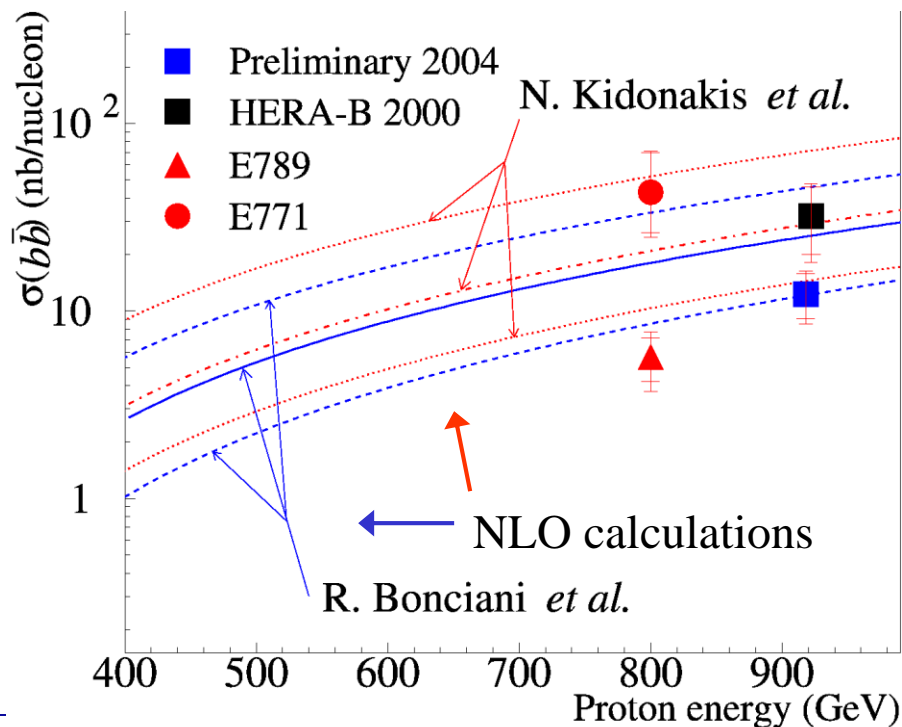
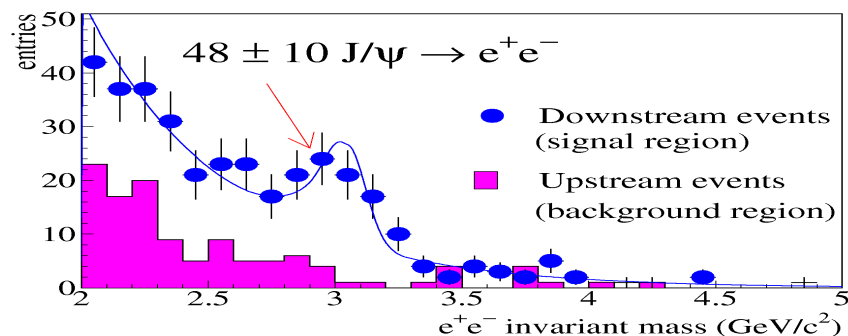
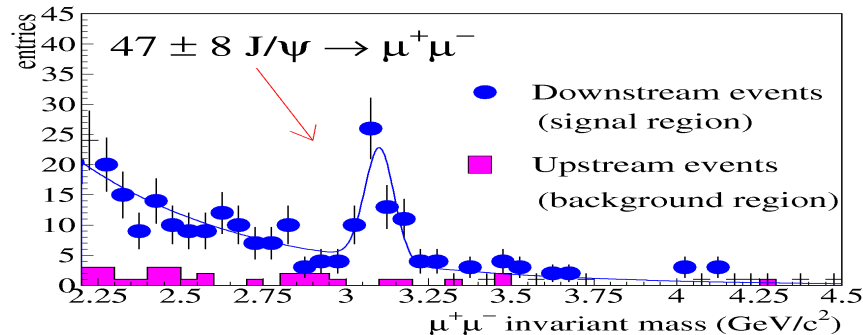
preliminary

$$\sigma(b\bar{b}) = 9.8 \pm 1.4 \pm 2.0 \text{ nb/nucleon}$$

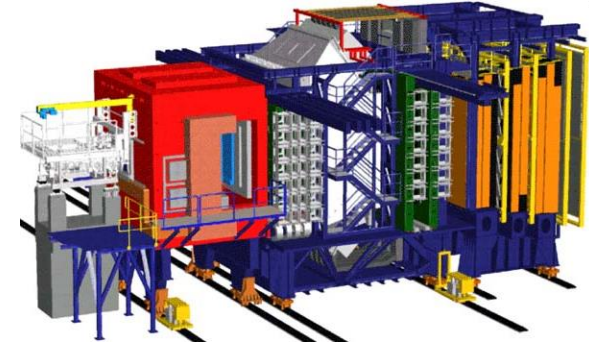
HERA-B 2000:

$$\sigma(b\bar{b}) = 32 \pm 13 \pm 6 \text{ nb/nucleon}$$

- HERA-B measurements agree
- Measurements constrain the theory



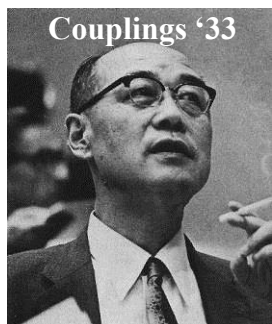
# HERA-B Summary



- Preliminary results on most topics presented at conferences (**>40**)
- 2 papers published ( **$BR(D^0 \rightarrow \mu^+ \mu^-)$ , pentaquark**)
- Publication on advanced analyses in preparation  
( **$b\bar{b}$ ,  $Y$ ,  $D^+ / D^0$ ,  $\phi / K^*$ ,  $J/\psi$ ,  $\psi(2S)$ , ...)**)
- Analysis will continue until end 2005

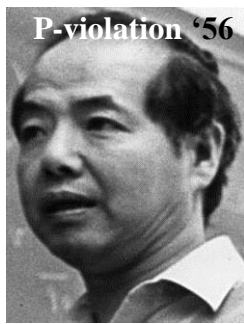
- HERA-B
- BaBar
  - Highlights
  - News
  - Our contribution
- LHCb (→ see also Bart Hommels)
  - General
  - Vertex Locator
  - Outer Tracker
  - Tracking
  - Trigger (→ see Bart Hommels)

# CP violation - Overview



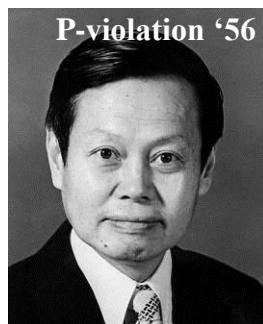
Couplings '33

Yukawa



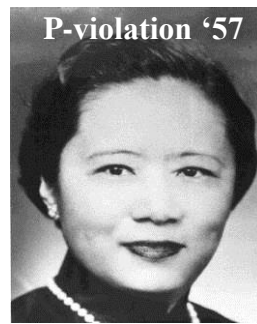
P-violation '56

Lee



P-violation '56

Yang



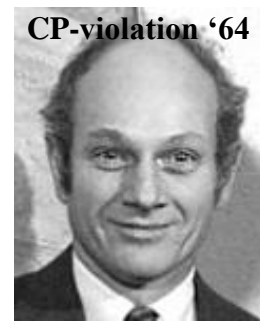
P-violation '57

Wu



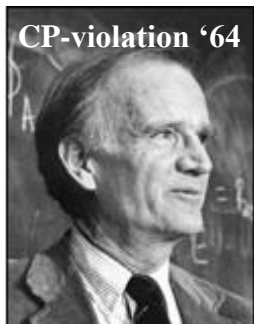
Angle  $\theta_c$  '63

Cabibbo



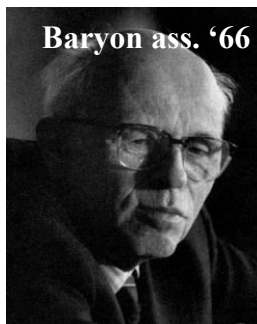
CP-violation '64

Cronin



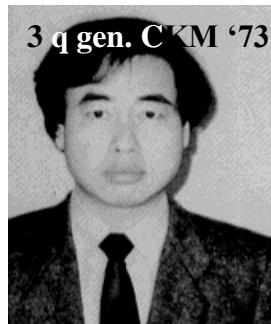
CP-violation '64

Fitch



Baryon ass. '66

Sacharov



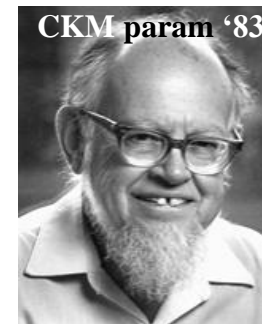
3 q gen. CKM '73

Kobayashi



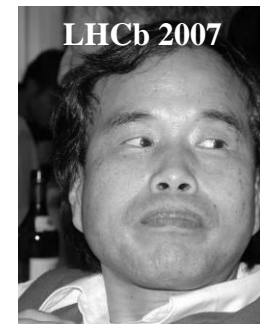
3 q gen. CKM '73

Maskawa



CKM param '83

Wolfenstein

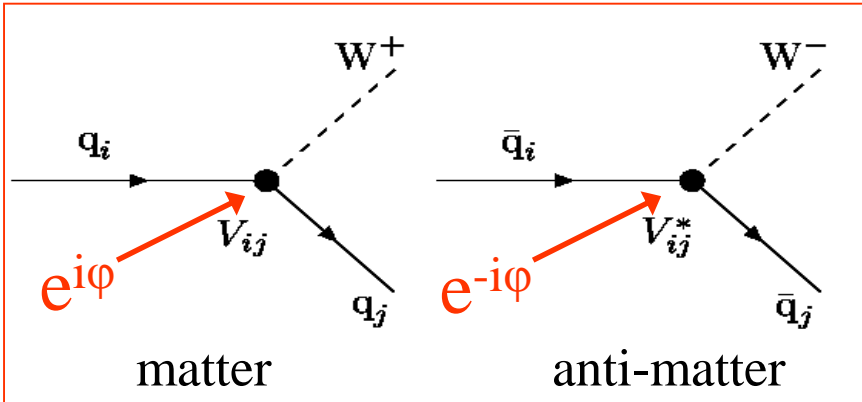


LHCb 2007

Nakada

**Homework: Is Wolfenstein Japanese?**  
SMS y/n 06-26628355

# What do we measure?



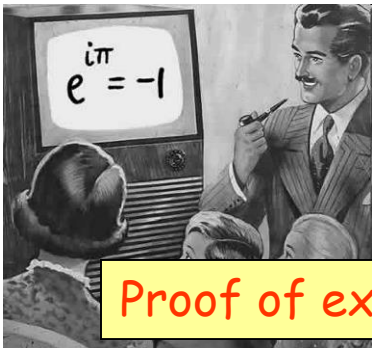
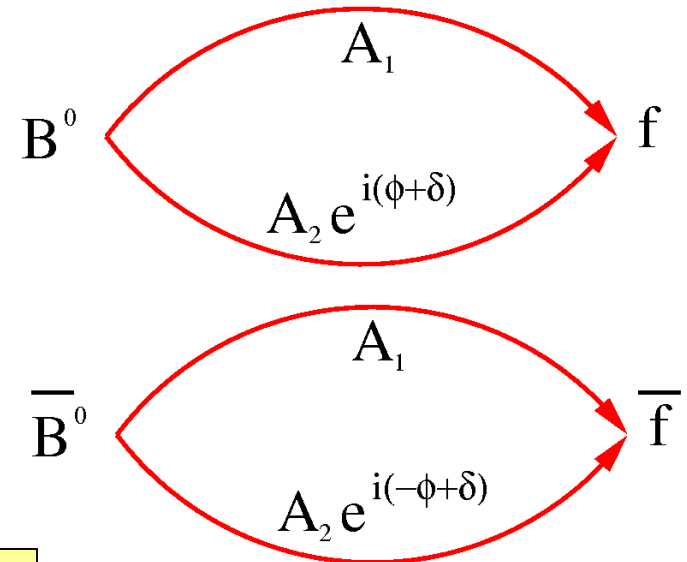
We measure **quark couplings**

There is a **complex phase** in couplings!

Visible when there are **2 amplitudes**:

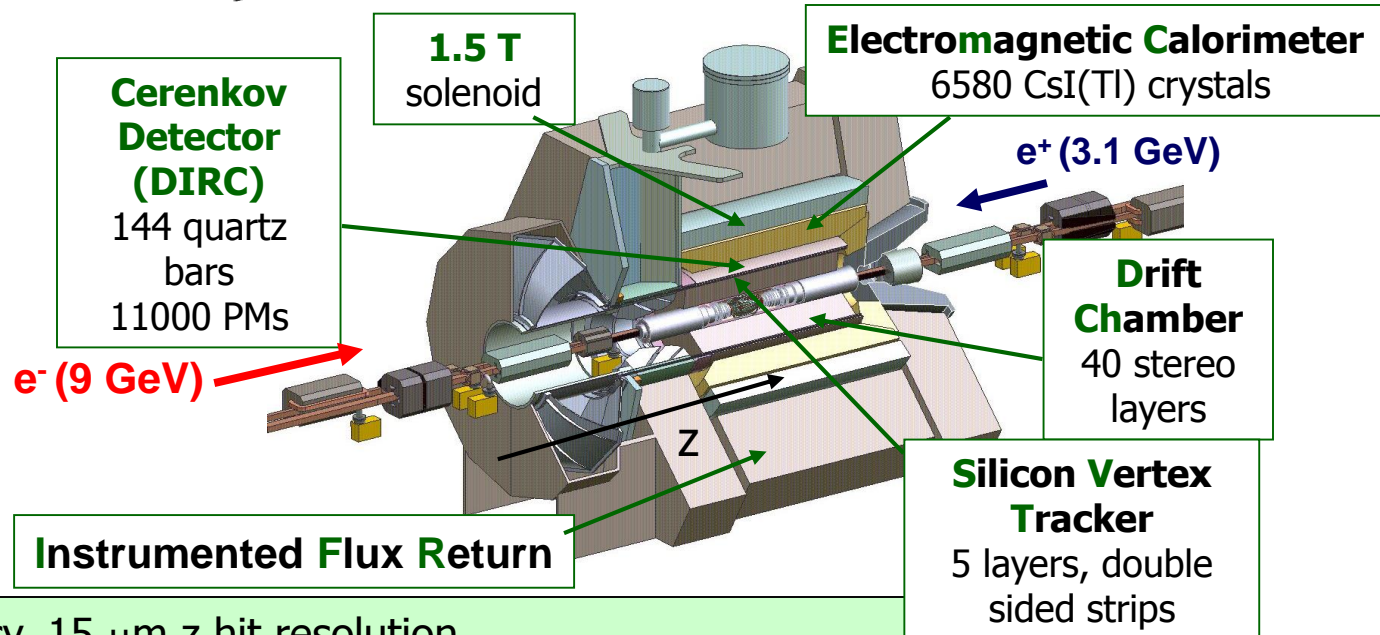
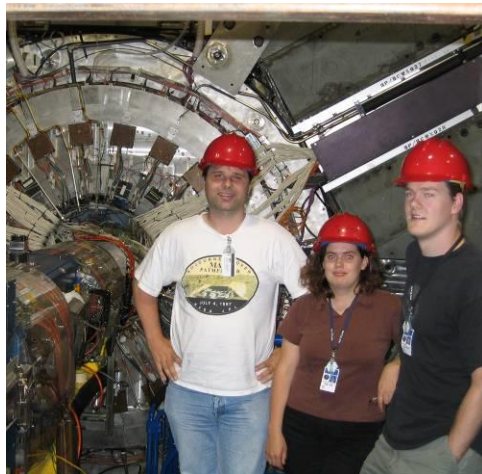
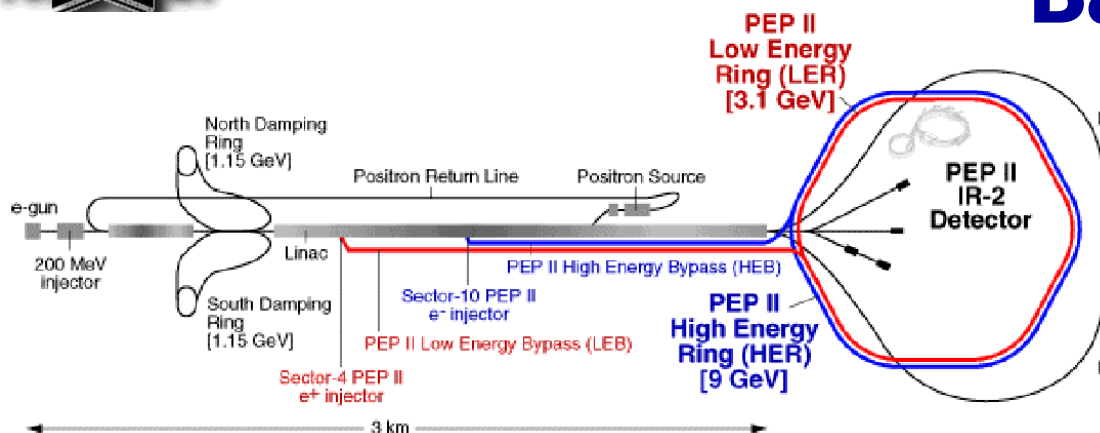
$$\Gamma(B \rightarrow f) = |A_1 + A_2 e^{i(\phi+\delta)}|^2$$

$$\Gamma(\bar{B} \rightarrow \bar{f}) = |A_1 + A_2 e^{i(-\phi+\delta)}|^2$$



**Proof of existence of complex numbers...**

# BaBar at PEP-II



**SVT:** 97% efficiency, 15  $\mu\text{m}$  z hit resolution

**SVT+DCH:**  $\sigma(p_T)/p_T = 0.13 \% \times p_T + 0.45 \%$

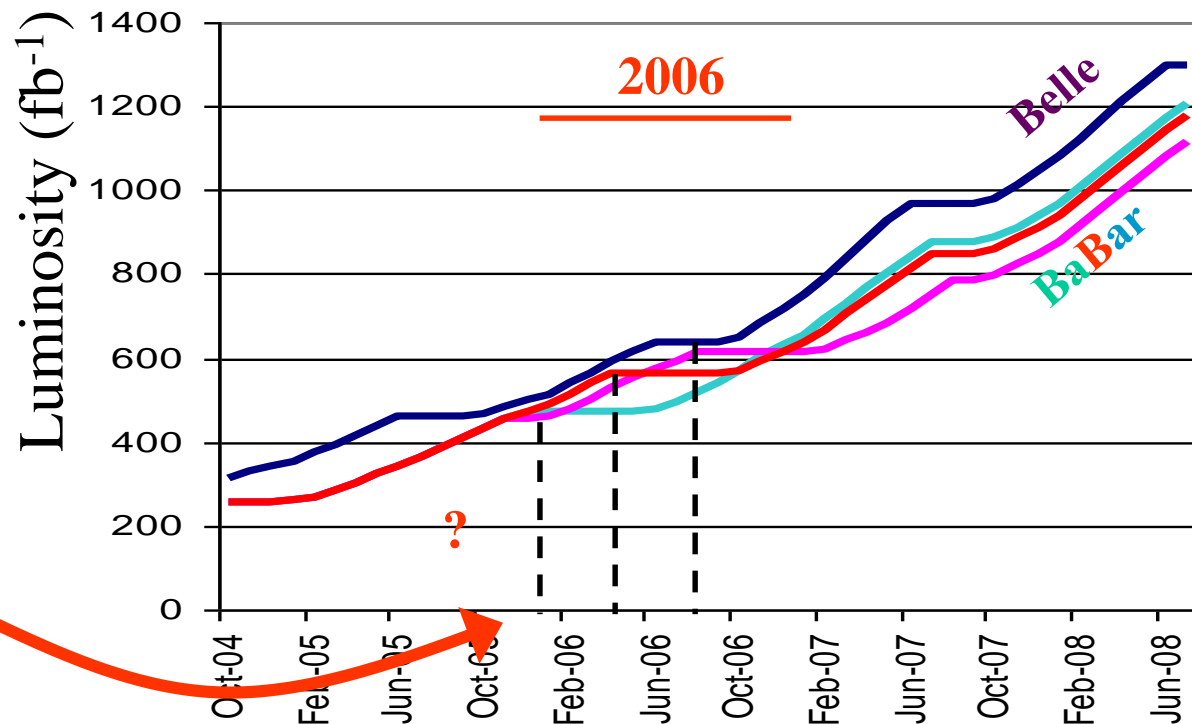
**DIRC:** K- $\pi$  separation 4.2  $\sigma$  @ 3.0 GeV/c  $\rightarrow$  2.5  $\sigma$  @ 4.0 GeV/c

**EMC:**  $\sigma_E/E = 2.3 \% \cdot E^{-1/4} \oplus 1.9 \%$



Mail from Dec. 16<sup>th</sup>:  
 "This plan continues to aim at a January  
 startup of PEP-II operation"

- Serious accident in september
  - In the Linac klystron gallery
  - Start of DOE investigation – ongoing
  - Startup of accelerator may happen in January
- Muon upgrade
  - Need 5 months
  - When finish muon upgrade??
    - Impact on  $B \rightarrow K\mu^+\mu^-$  (Rare decay,  $BR \sim 10^{-7}$ ) ?
    - Don't lag behind Belle...



# BaBar: What is NIKHEF doing?

## Common Tasks:

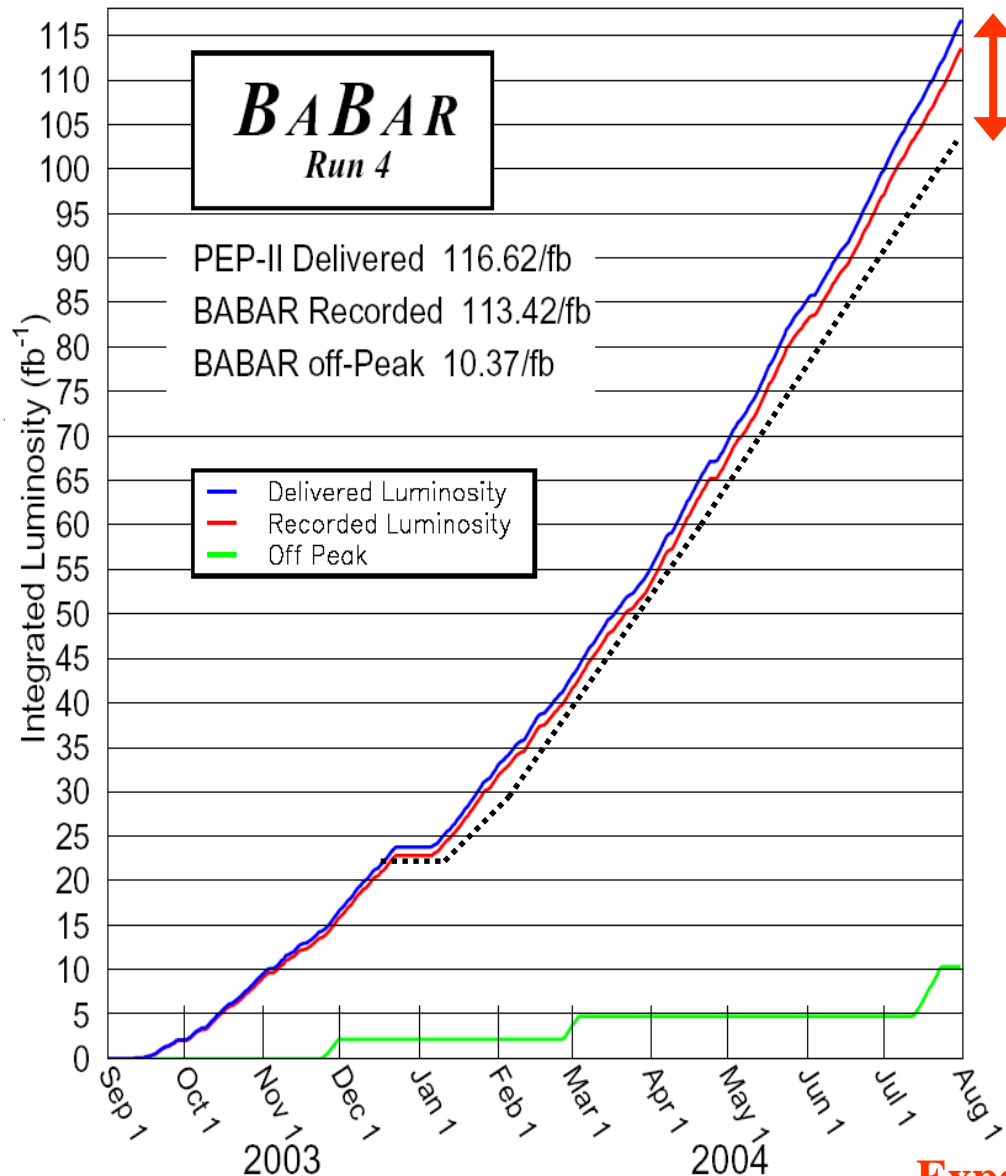
- Tracking software
- Global Alignment of vertex detector
- Beam spot determination
- Online calibration vertex detector
- Event store migration
- MC production & GRID

## • Physics Analysis

- $2\beta + \gamma$  measurement(s):
  - $B^0 \rightarrow D^{(*)}\pi$
  - $B^0 \rightarrow D^*\rho$
  - $B^0 \rightarrow D^{(*)}a_0$
  - $B^0 \rightarrow D^{(*)}a_2$
- QCD factorization test



# This years update: luminosity until ICHEP04



- PEP-II delivered **117 fb<sup>-1</sup>** for Run 4
  - sep 2003 - aug 2004
  - 100 fb<sup>-1</sup> was promised / expected from John Seeman's scenario
- A total lumi of **220 fb<sup>-1</sup>** recorded 'on the  $\Upsilon(4S)$  peak'
  - → ~240M BB pairs

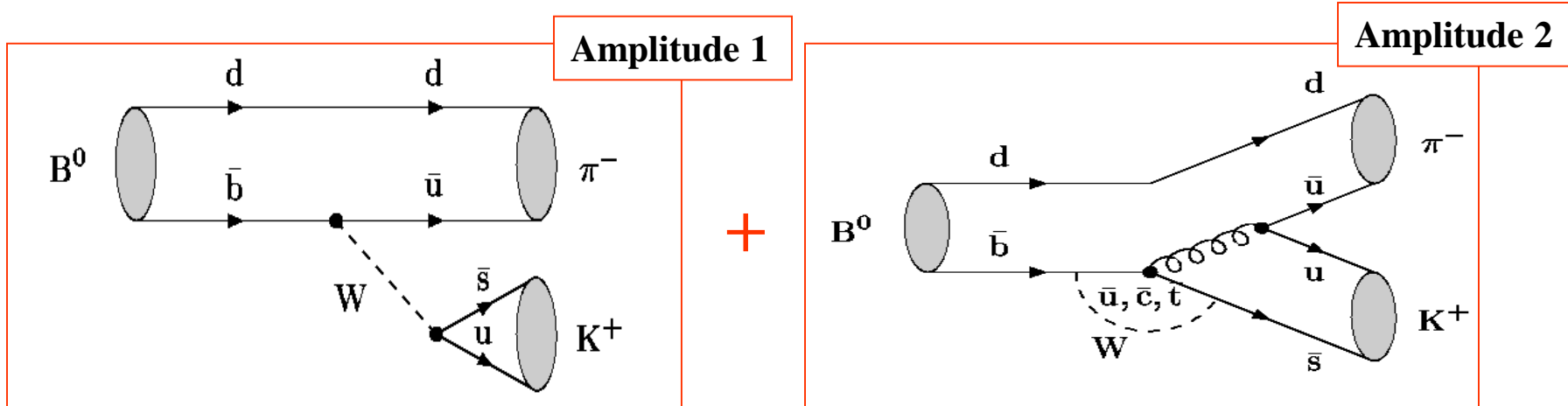
PEP-II Records	
Peak luminosity	<b><math>0.92 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}</math></b>
Best day	<b>710.5 pb<sup>-1</sup></b>
BABAR logged	<b>246.4 fb<sup>-1</sup></b>

**Expect to double again until 2006!! → 0.5 ab<sup>-1</sup>**

# I. Direct CP violation

CP violation if  $\Gamma(B^0 \rightarrow f) \neq \Gamma(\bar{B}^0 \rightarrow \bar{f})$

But: need 2 amplitudes  $\rightarrow$  interference



$$\Gamma(B^0 \rightarrow K^+ \pi^-) \propto |V_{ub}^* V_{us} e^{i\delta} + V_{tb}^* V_{ts}|^2 \approx |\lambda^4 e^{+i\gamma+i\delta} + \lambda^2|^2$$

$$\Gamma(\bar{B}^0 \rightarrow K^- \pi^+) \propto |V_{ub} V_{us}^* e^{i\delta} + V_{tb} V_{ts}^*|^2 \approx |\lambda^4 e^{-i\gamma+i\delta} + \lambda^2|^2$$

Only different if both  $\delta$  and  $\gamma$  are  $\neq 0$  !

$\rightarrow \Gamma(B^0 \rightarrow f) \neq \Gamma(\bar{B}^0 \rightarrow \bar{f})$



# First observation of **Direct CPV** in B decays

$$B^0 \rightarrow K^+ \pi^-$$

**BABAR**

hep-ex/0407057  
Phys.Rev.Lett.93:131801,2004

$$A_{CP} = -0.133 \pm 0.030 \pm 0.009$$

**4.2 $\sigma$**

**Belle**

Confirmation at ICHEP04

$$A_{CP} = -0.101 \pm 0.025 \pm 0.005$$

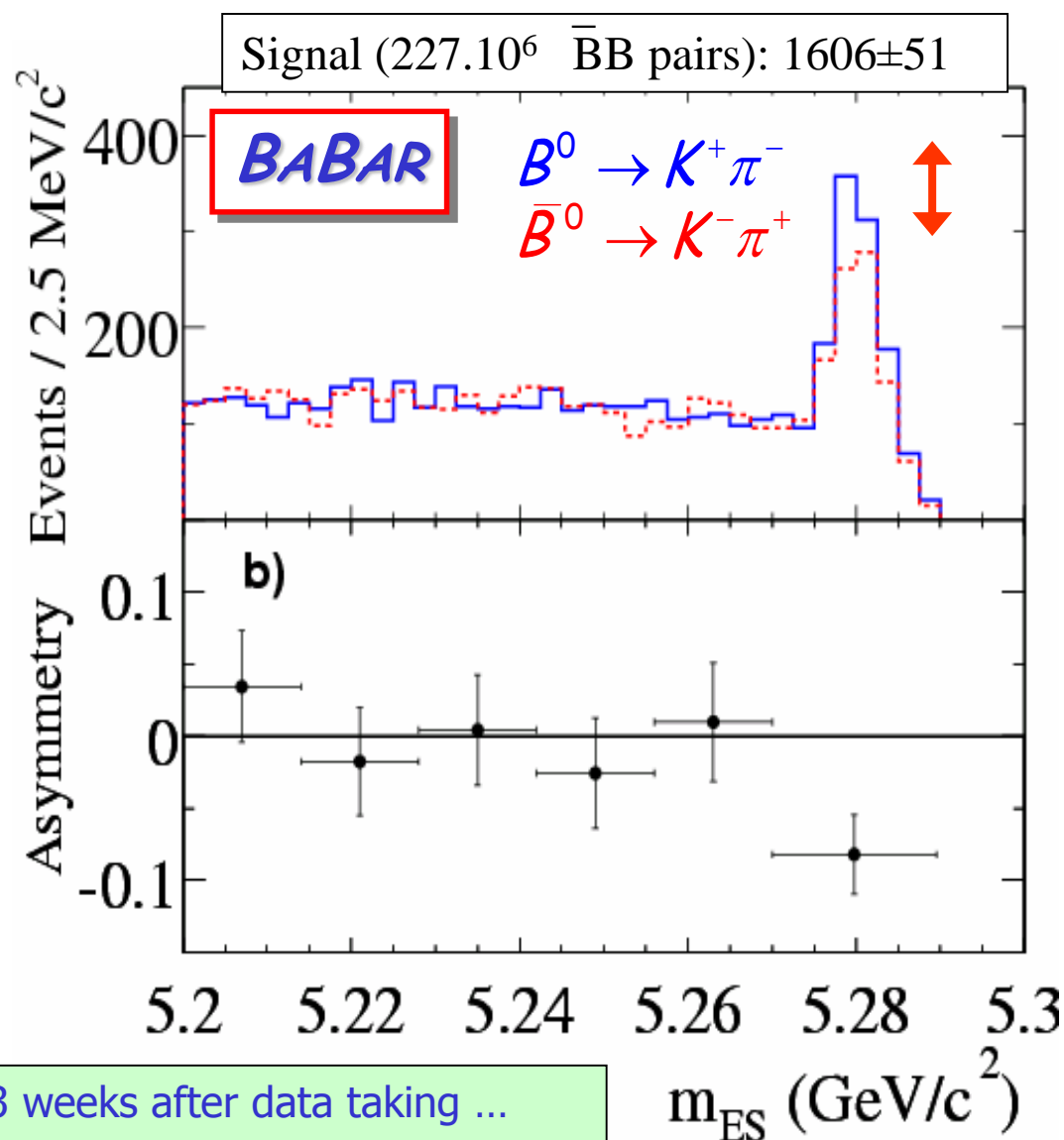
**3.9 $\sigma$**

(Signal (274M  $B\bar{B}$  pairs):  $2140 \pm 53$ )

**Average**

$$A_{CP} = -0.114 \pm 0.020$$

Submitted to PRL on July 30th 2004 ~3 weeks after data taking ...



# $B^0 \rightarrow K\pi$ and $B^\pm \rightarrow K^\pm \pi^0$

Redo the experiment with  $B^\pm$  instead of  $B^0$ ...

$$B^0 \rightarrow K^+ \pi^-$$

Average

$$A_{CP} = -0.114 \pm 0.020$$

$$B^+ \rightarrow K^+ \pi^0$$

$$A_{CP} = +0.06 \pm 0.06 \pm 0.01 \quad BABAR$$

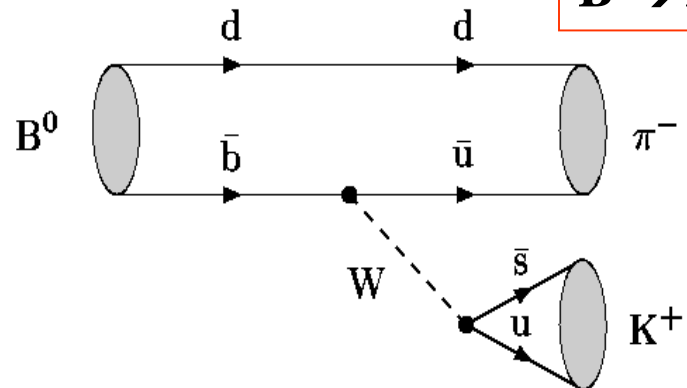
$$A_{CP} = +0.04 \pm 0.05 \pm 0.02 \quad Belle$$

Average

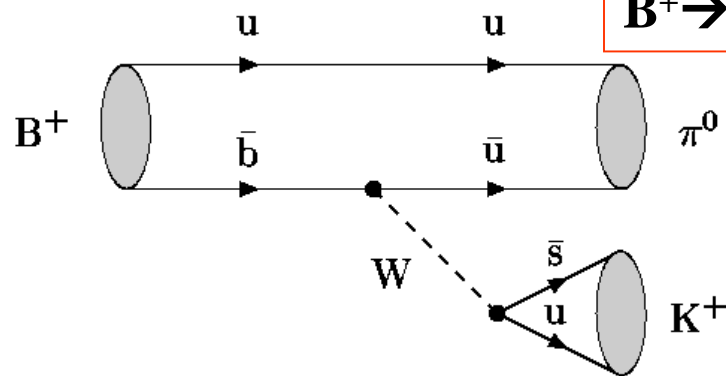
$$A_{CP} = +0.049 \pm 0.040$$

$3.6\sigma$  ?

$B^0 \rightarrow K\pi$



$B^+ \rightarrow K\pi$



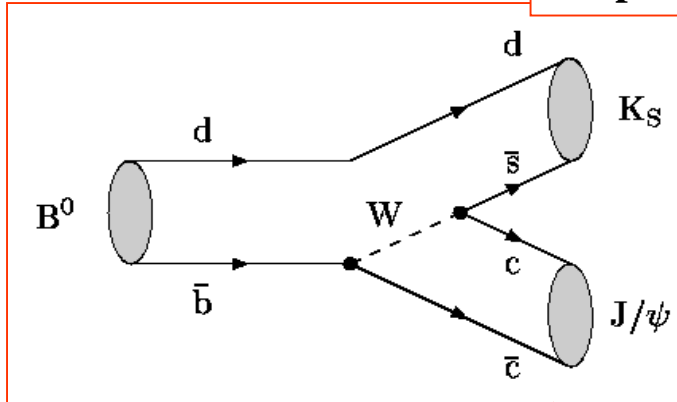
- $d$  or  $u$  spectator quark: what's the difference ??

## II. Time dependent CP violation

If final state is **CP eigenstate** then 2 amplitudes from mixing:  $B^0 \rightarrow f$  and  $B^0 \rightarrow \bar{B}^0 \rightarrow f$

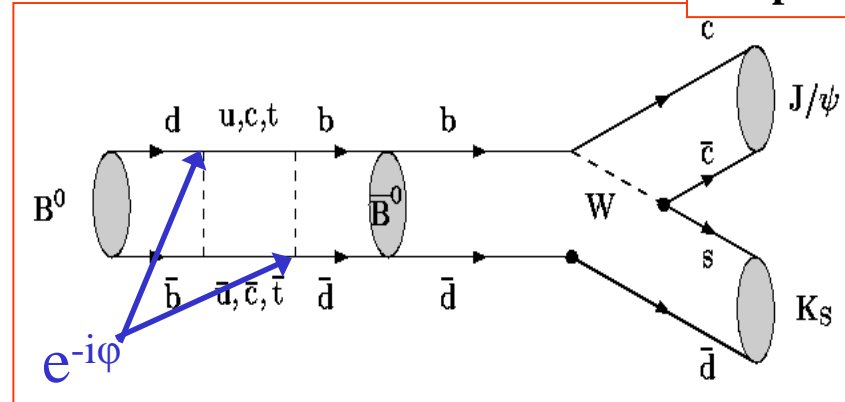
$B^0 - \bar{B}^0$  oscillation is periodic in time  $\rightarrow$  CP violation time dependent

Amplitude 1



+

Amplitude 2



$$\Gamma(B^0 \rightarrow J/\psi K_s) = \left| A e^{-imt - \Gamma t} \left( \cos \frac{\Delta m t}{2} + e^{-i\phi} \sin \frac{\Delta m t}{2} \right) \right|^2$$

$$A_{CP}(t) = \frac{\Gamma(B^0 \rightarrow J/\psi K_s) - \Gamma(\bar{B}^0 \rightarrow J/\psi K_s)}{\Gamma(B^0 \rightarrow J/\psi K_s) + \Gamma(\bar{B}^0 \rightarrow J/\psi K_s)} = -\sin 2\beta \sin \Delta m t$$

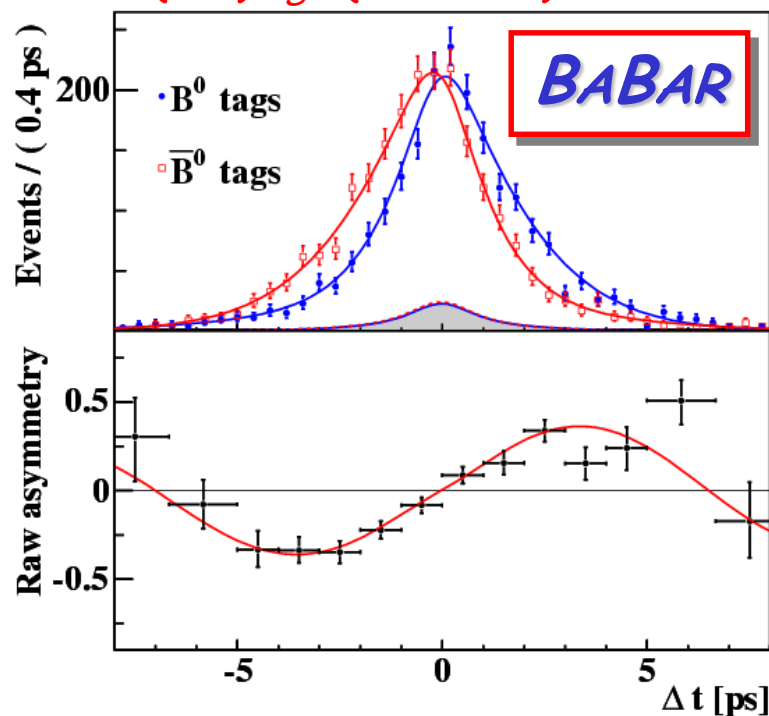
( $i = e^{i\pi/2} \rightarrow \delta = 90^\circ$ )  
( $\phi = 2\beta$ )



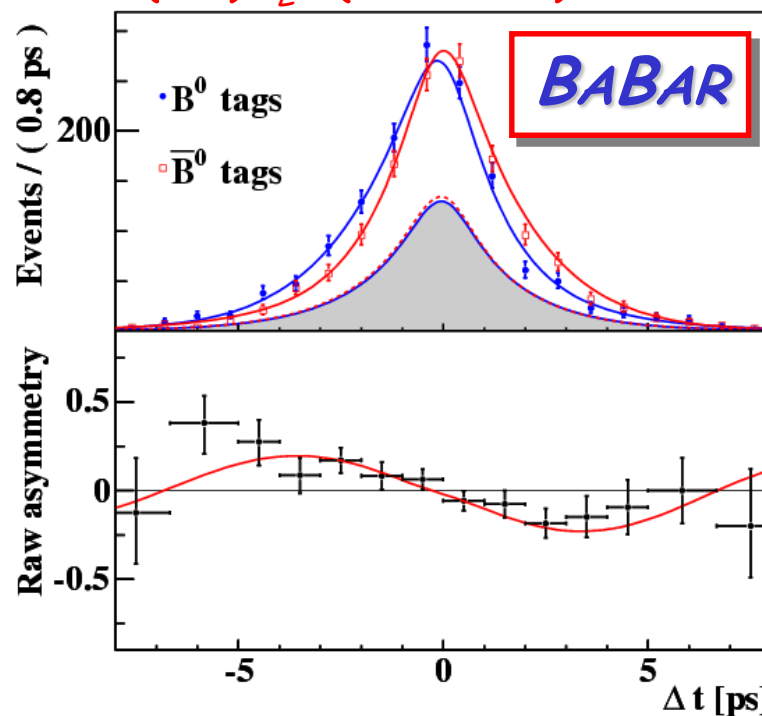
# New Precision Measurement of $\sin(2\beta)$

Maarten Bruinsma;  
BABAR PUB-04/038

$(c\bar{c})K_S^0$  (CP odd) modes



$(c\bar{c})K_L^0$  (CP even) modes



Update for ICHEP04

$$\sin 2\beta = +0.722 \pm 0.040 \pm 0.023$$

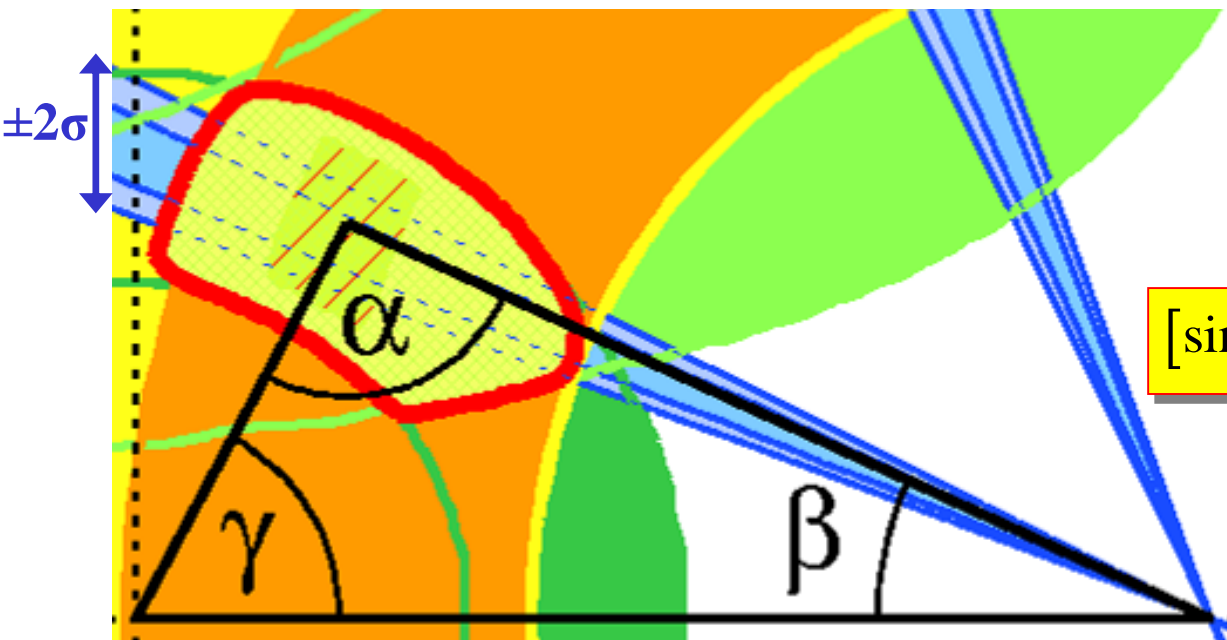
$(c\bar{c})K_S^0 +$   
 $(c\bar{c})K_L^0$


2002 result: (0.4 x statistics)

$$\sin 2\beta = +0.741 \pm 0.067 \pm 0.034$$



# sin2β vs 'non-CP' CKM constraints

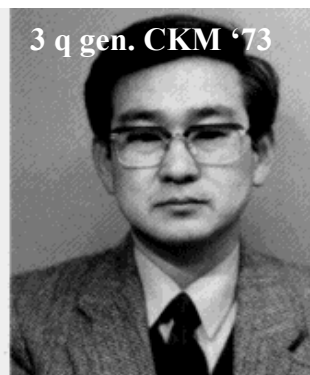


sin2β in excellent agreement with the rest!  
(rest = )

$$[\sin 2\beta]_{WA} = +0.726 \pm 0.037_{(stat+sys)}$$



3 q gen. CKM '73



3 q gen. CKM '73

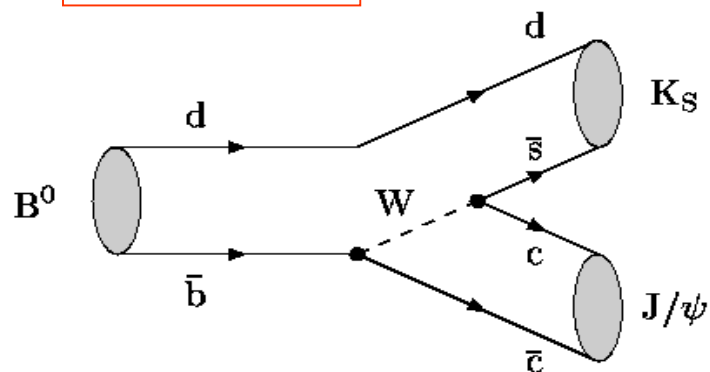
Kobayashi Maskawa



# III. "b-s penguin"

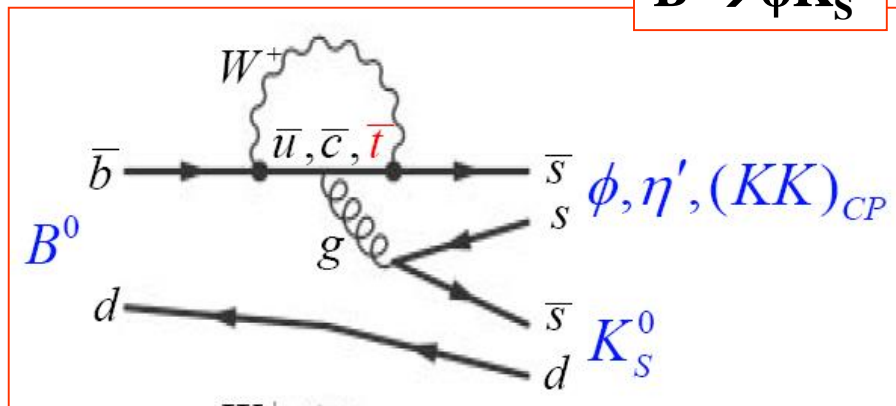
Asymmetry  
in SM

$B^0 \rightarrow J/\psi K_S$



$\approx$

$B^0 \rightarrow \phi K_S$



... unless there is new physics...

- **New particles (also heavy) can show up in loops:**
  - Can affect the **branching ratio**
  - And can introduce additional phase and affect the **asymmetry**





# What happened to the CP asymmetry in $B \rightarrow \Phi K_s$ ??

- Pure penguin diagram

- SM: expect to measure  $\sin 2\beta = 0.73 \pm 0.04$
- Relative contribution of eg. SUSY potentially large

$$(B^0 \rightarrow J/\psi K_s)$$

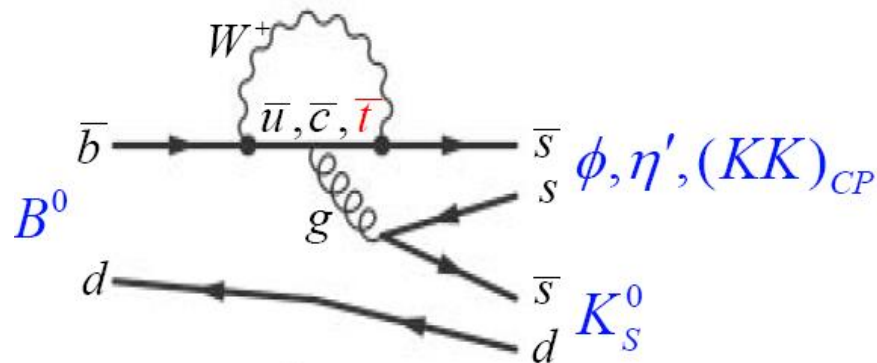
- LP'03:

- Belle:  $S = -0.96 \pm 0.51$
- BaBar:  $S = +0.45 \pm 0.43$

3.5 sigma away from SM...

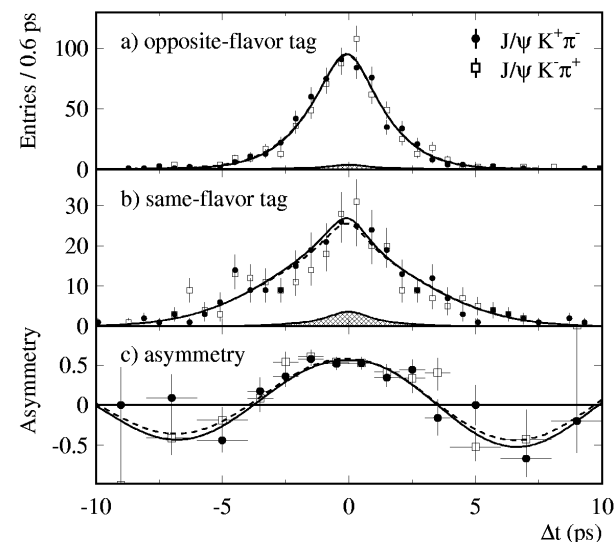
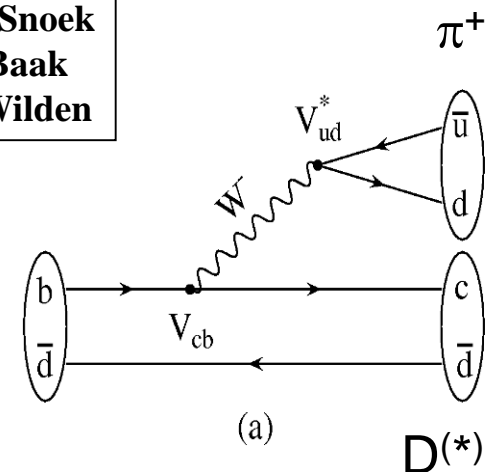
- ICHEP'04:

- Belle:  $S = +0.06 \pm 0.33$
- BaBar:  $S = +0.50 \pm 0.25$



# Outlook of our analyses

Hella Snoek  
Max Baak  
Leif Wilden



- Analysis of time-dependent CP with  $B \rightarrow D^{(*)}\pi$  published
  - First published constraint on  $\sin(2\beta+\gamma)$ 
    - See Max' talks last year
    - Phys. Rev. Lett 92 2004:251801
- Analysis of 'wrong sign' amplitude in  $B \rightarrow J/\psi K^*$  published
  - No 'wrong sign' amplitude observed
  - $J/\psi K_S$  and  $J/\psi K_L$  *do* measure the same  $\sin(2\beta)$ 
    - As expected...
    - Phys. Rev. Lett. 93 2004:081808
- Extend  $B \rightarrow D^{(*)}\pi$  analysis with  $D^{(*)}\rho^+$ ,  $\rho^+ \rightarrow \pi^0\pi^+$ ,  $\pi^0 \rightarrow \gamma\gamma$ 
  - angular analysis of  $D^*\rho$  to measure polarization
    - Important test of 'factorization' in B decays
  - extract  $\sin(2\beta+\gamma)$
- Search for  $B \rightarrow D^{(*)}a_0^+$ ,  $a_0^+ \rightarrow \eta\pi^+$ ,  $\eta \rightarrow \gamma\gamma$ 
  - Rare decay
    - $a_0$  has tiny decay constant!
  - If observed:  $\rightarrow$  good sensitivity to  $\sin(2\beta+\gamma)$ !
  - If not observed: constraints on non-factorizable contributions to B decays

# What can LHCb add ??

- In LHCb we have  $B_s^0$
- "NIKHEF" channels:

- $B_s^0 \rightarrow D_s K$
- $B_s^0 \rightarrow J/\psi(\mu^+\mu^-) \phi$
- $B^0 \rightarrow X_s \mu^+ \mu^-$

Jeroen van Tilburg  
Besma M'charek

Sander Klous  
Jan Amoraal

Marko Zupan

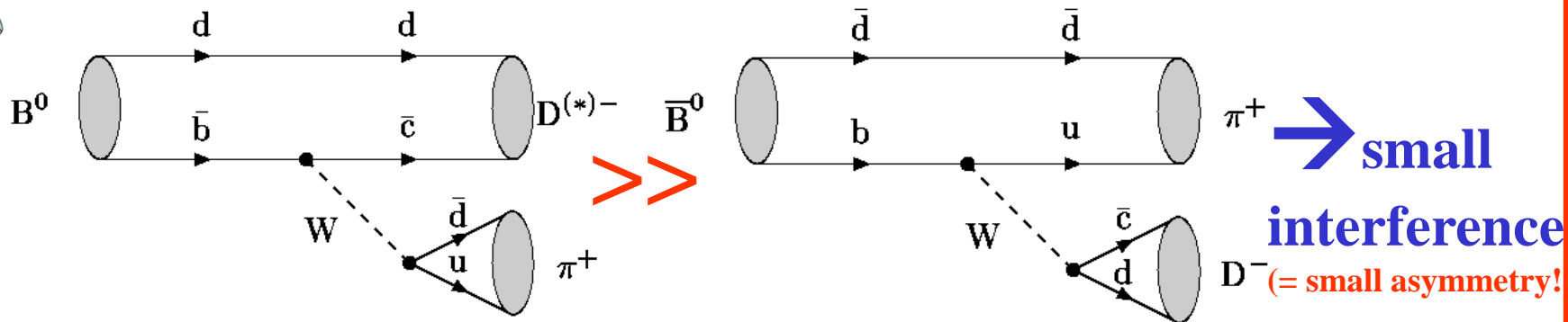


# CKM angle $\gamma$ : $B^0 \rightarrow D\pi$ and $B_s^0 \rightarrow D_s K$

Hella Snoek  
Max Baak  
Leif Wilden

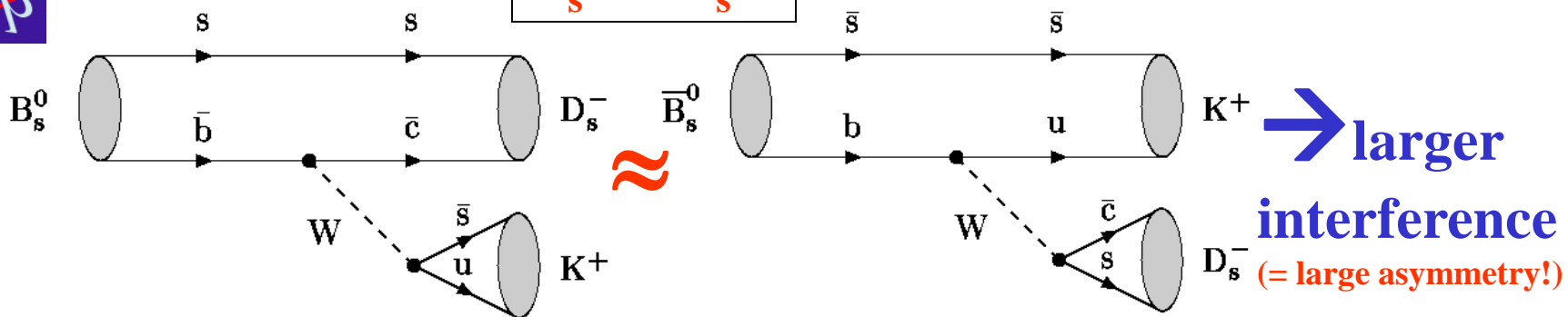


$$B_d^0 \rightarrow D^{(*)}\pi$$



$$B_s^0 \rightarrow D_s K$$

Jeroen van Tilburg  
Besma M'charek

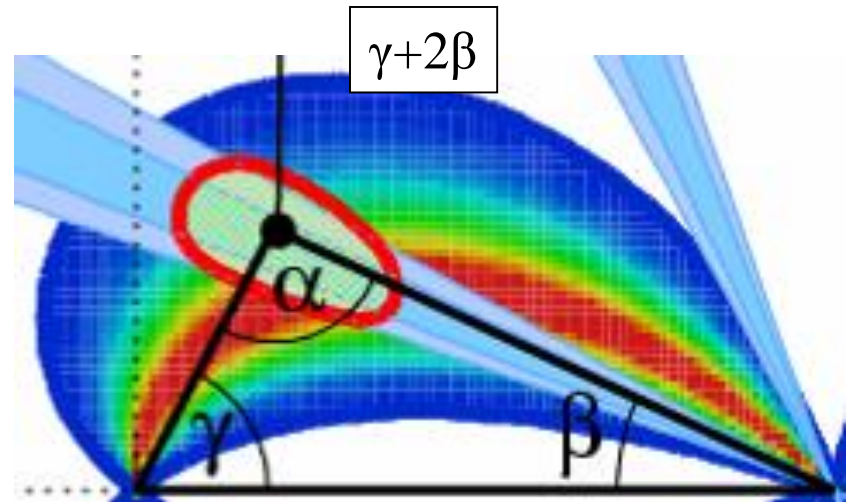


- $B_s^0 \rightarrow D_s K$  annual yield estimate: **5400 events**

# CKM angle $\gamma$

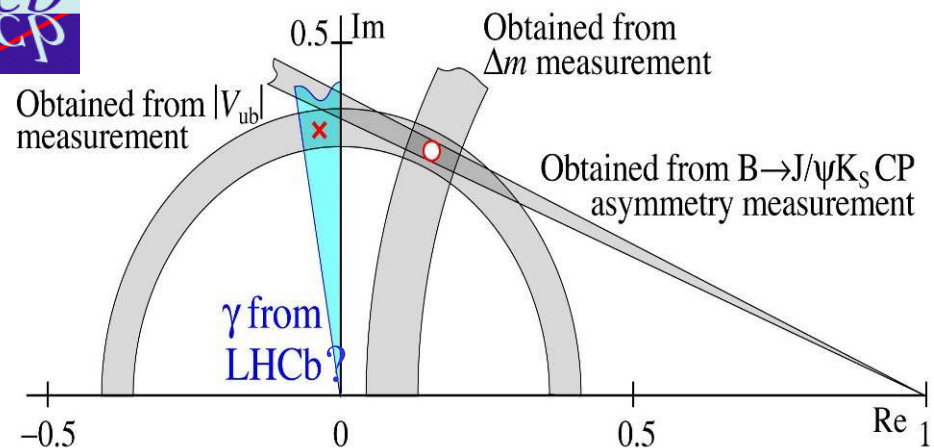
$\gamma$  not well constrained by BaBar  
with  $B \rightarrow D^{(*)}\pi$

- See Max' talks last year
- Phys. Rev. Lett 92 2004:251801

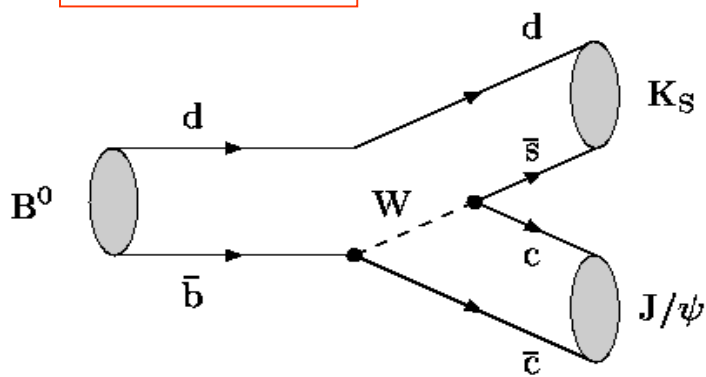


$\gamma$  sensitivity at LHCb:

- $B_s \rightarrow D_s K$   $14^\circ$ 
  - (using  $B_s \rightarrow J/\psi \phi$  for  $\chi$ )



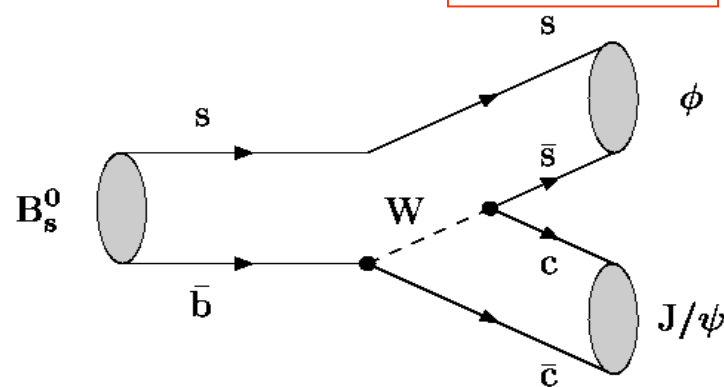
$B^0 \rightarrow J/\psi K_S$



$$\varphi_d = 2\beta$$

$$\sin 2\beta = 0.73$$

$B^0_s \rightarrow J/\psi \phi$



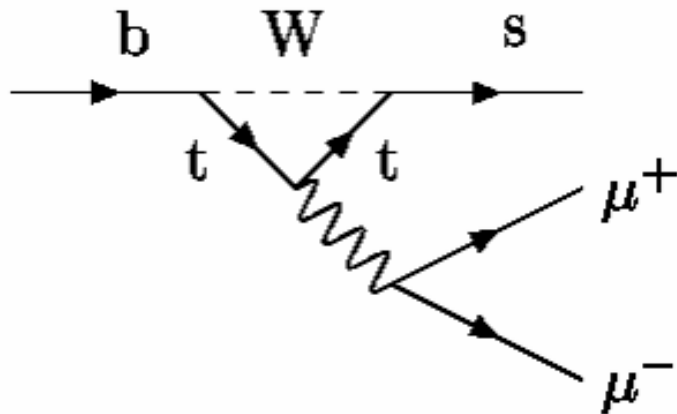
$$\varphi_s = -2\chi$$

$$\sin 2\chi = 0.04$$

- Measure angle  $\chi$ 
  - Very small in SM
  - Any asymmetry means new physics...
- Golden decay
  - Like  $B^0 \rightarrow J/\psi K_S$
  - Almost pure tree diagram
- Annual yield estimate: **100k events**

# b-s penguin: $B_s^0 \rightarrow X_s \mu \mu$

Marko Zupan



## Joint meeting LHCb/theory: Measurements of $b \rightarrow s l+l-$

[last update: Monday 06 December 2004]

Date/Time: Friday 03 December 2004 from 14:00 to 16:00

Location: CERN

Room: Council Chamber

Chairperson: [Olivier Schneider](#), [Tobias Hurth](#)

03 December 2004

Friday 03 December 2004

14:00 Welcome (05) ( [transparencies](#) )

14:05 Sensitivity studies with  $B^0 \rightarrow K^{*0} \mu^+ \mu^-$  at LHCb (25) ( [transparencies](#) )

[Helder Lopes](#)  
(UFRJ, Rio)

14:30 Theoretical prospects of  $b \rightarrow s l+l-$  transitions (30) ( [transparencies](#) )

[Tobias Hurth](#)  
(CERN)

- Electromagnetic corrections to  $b \rightarrow s l+l-$  (05) ( [transparencies](#) )

Tobias Huber

15:00 Inclusive  $b \rightarrow s \mu^+ \mu^-$  selection at LHCb (25) ( [transparencies](#) )

[Marko Zupan](#)  
(NIKHEF, Amsterdam)

15:25 Distributions in  $b \rightarrow s l+l-$  and model-independent analysis (30) ( [transparencies](#) )

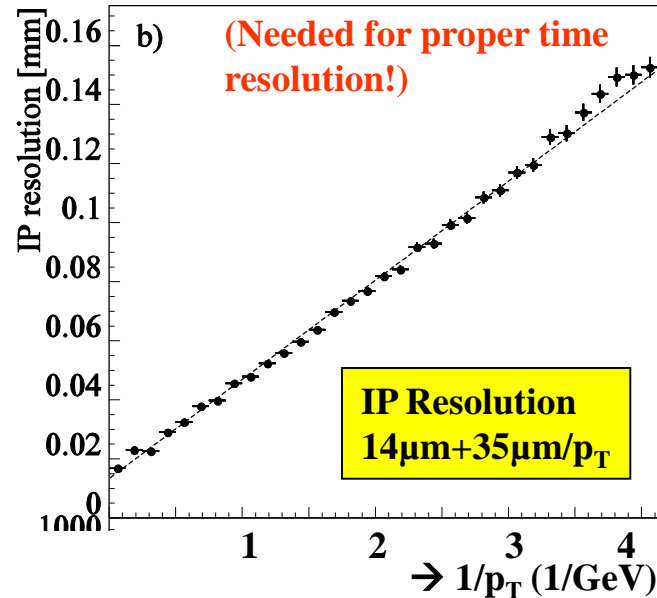
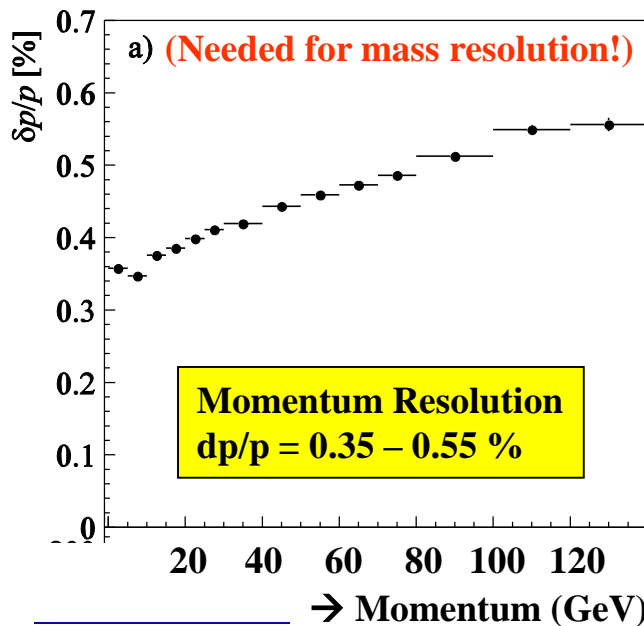
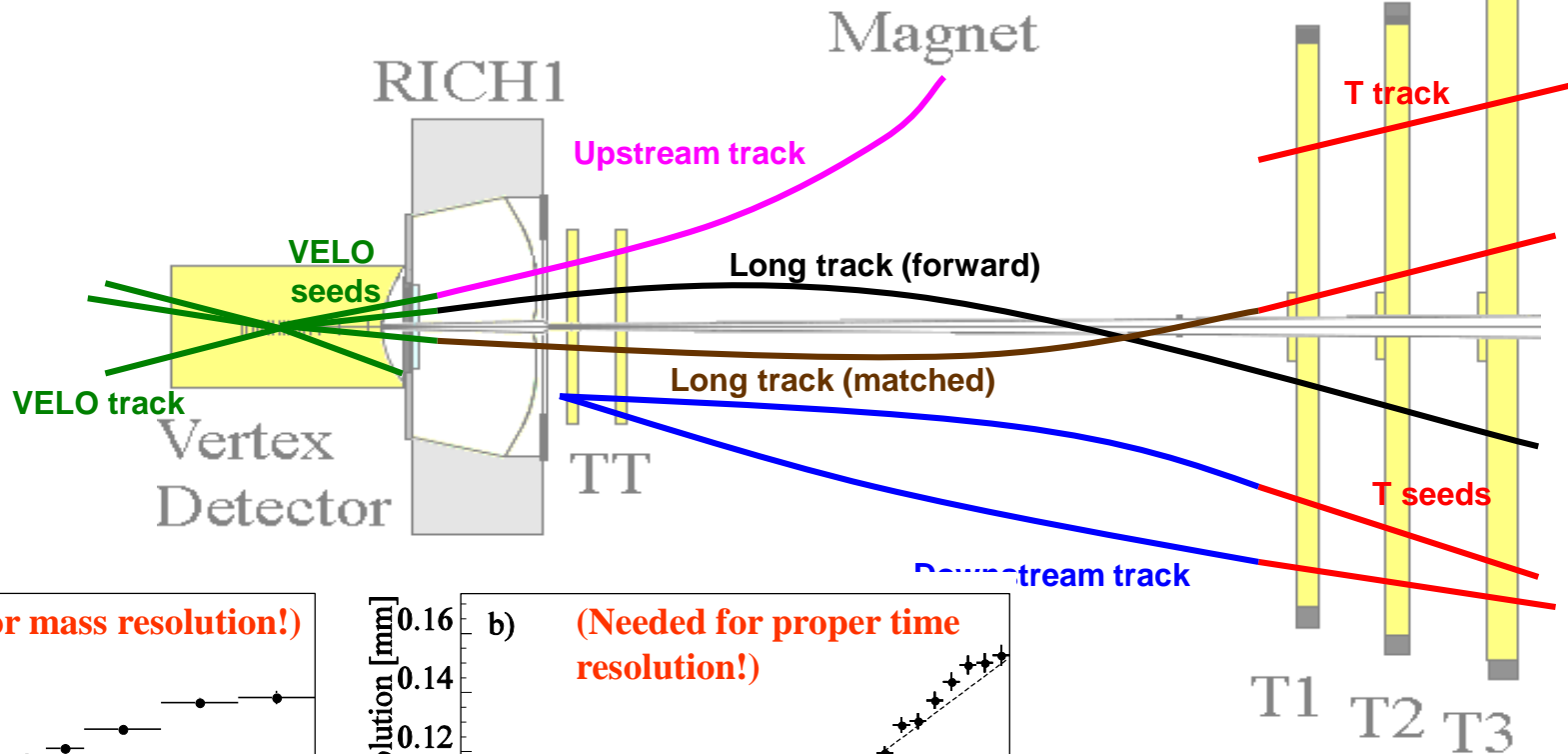
[Gudrun Hiller](#)  
(Ludwig Maximilian Univ. Munich & CERN)

15:55 Concluding remarks (05)

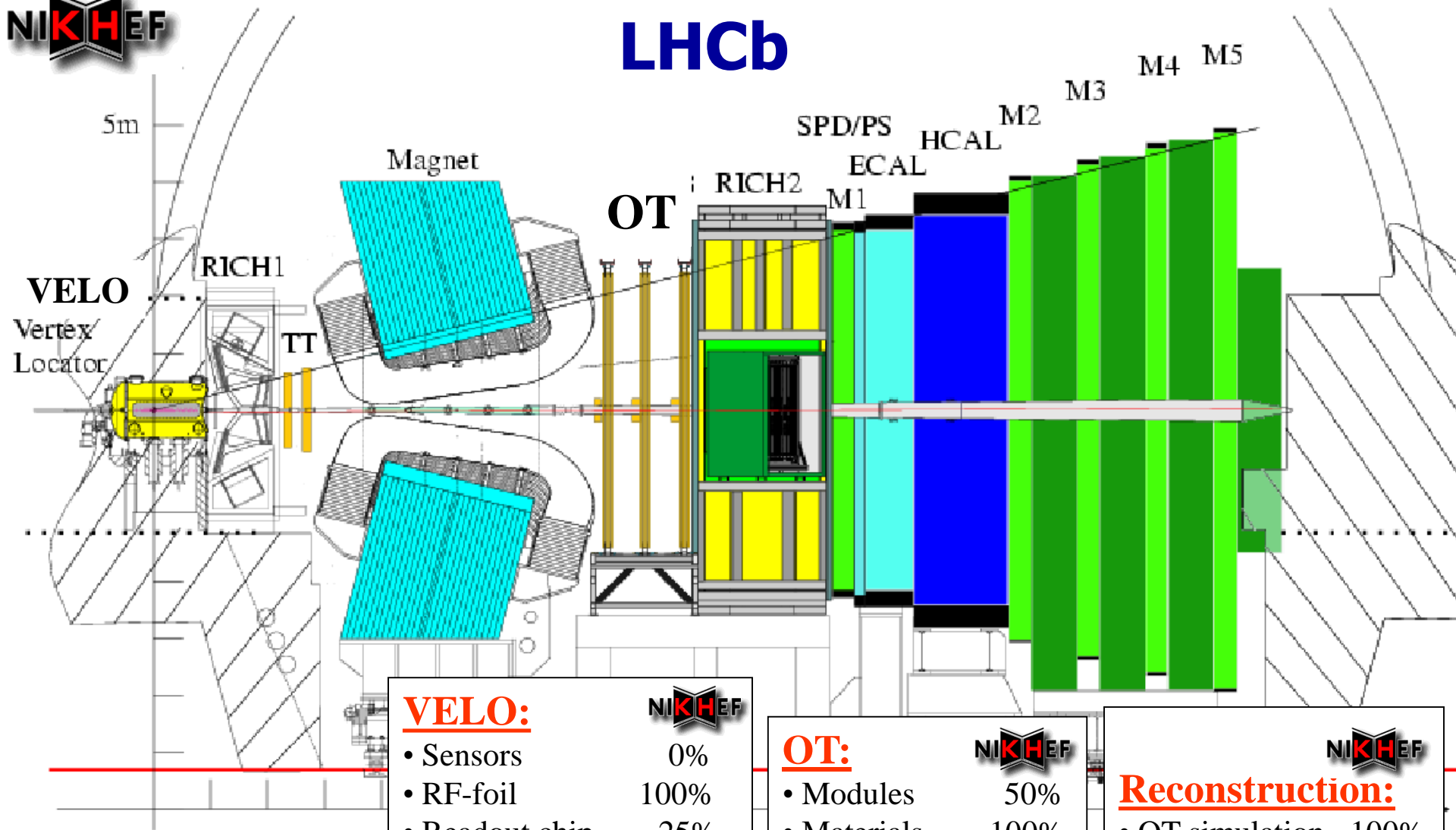
[Tatsuya Nakada](#)  
(CERN & EPFL)

- Rare decay!
  - E.g.  $BR_{SM}(B_s^0 \rightarrow K_s \mu \mu) \sim 1.2 \pm 0.4 \cdot 10^{-6}$
- New physics might appear in loops
- Annual yield estimate: **9500 events**









## Pileup VETO

- All 100%

## VELO:

- Sensors 0%
- RF-foil 100%
- Readout chip 25%
- Vacuum Vessel 100%
- Bellow 100%
- Cooling 100%

## OT:

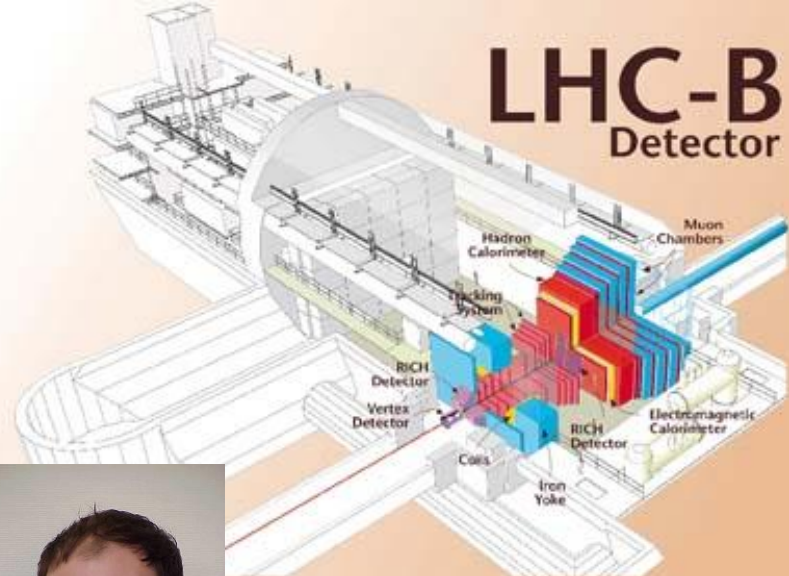
- Modules 50%
- Materials 100%
- Tooling 80%
- FE electronics 100%
- Frames 100%

## Reconstruction:

- OT simulation 100%
- Pattern recogn. 50%
- Kalman fit 100%
- Online tracking 25%

- General status of the detector:

- Design → see Bart Hommels
- Trigger → see Bart Hommels
- Status in the pit:
  - Beampipe produced
  - Magnet installed and aligned
  - Muon filter being constructed



- NIKHEF involvement:

- (Tracking and reconstruction)
- (Physics selections)
- Vertex Locator
- Outer Tracker



## Kachelpijp:

- Be
- 1<sup>st</sup> piece delivered (2m)
- other pieces: AlBe



## Magnet:

- dipole
- warm Al conductor
- 4 Tm integrated field
- 4.2 MW
- 1450 t yoke
- aligned to 1 mm



## Muon+Calorimeter:

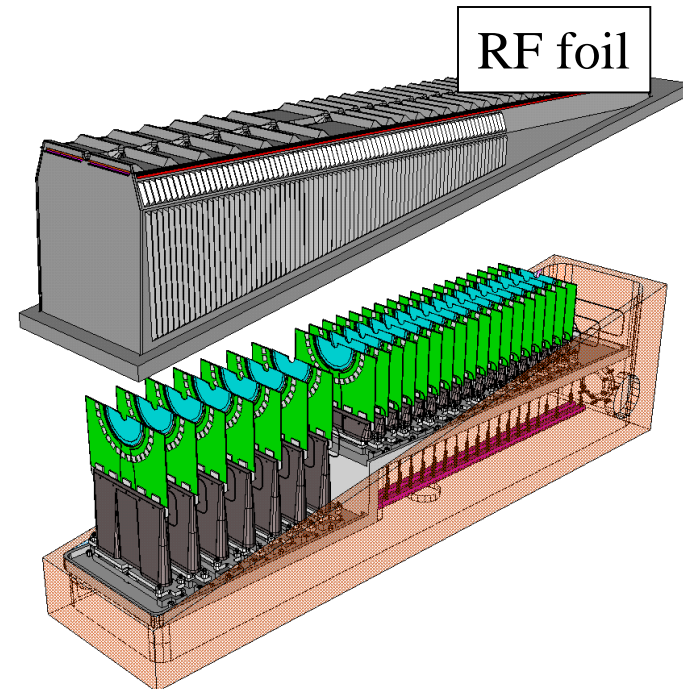
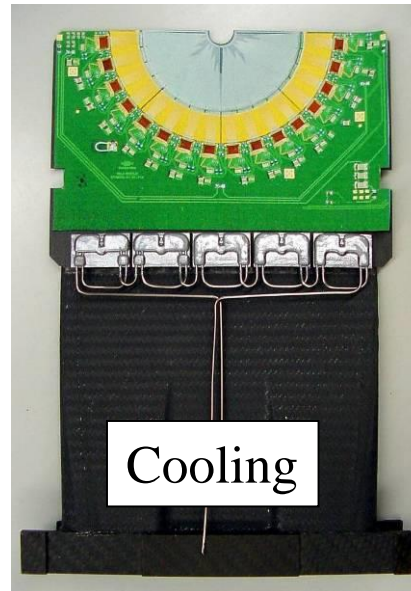
- muon filter being built
  - One of most sophisticated piece of equipment
- calorimeter behind that



- Vacuum vessel and bellow
- RF-foil design and construction
- Test beam shifts and analysis
- Readout chip (Beetle)
- CO<sub>2</sub> cooling

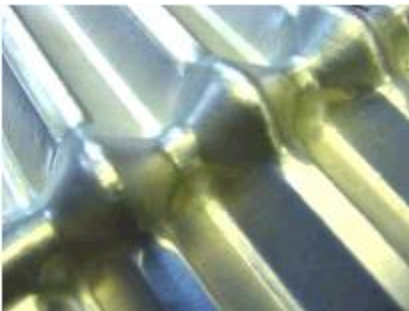


Test beam

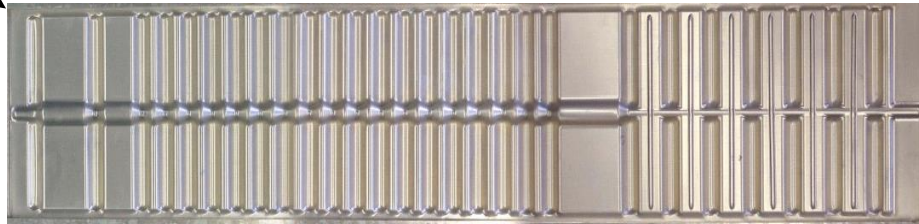


# VELO – RF foil

- Important piece!
  - Radiation length close to vertex
  - Impact on proper time resolution
- Mechanically very challenging
  - Sensor redesign at the corners...
- → 300  $\mu\text{m}$  Al
  - R&D is ongoing to try 200  $\mu\text{m}$



LHC  
beam



## RF foil:

- protect sensors from beam RF
- sensors not in primary LHC vacuum

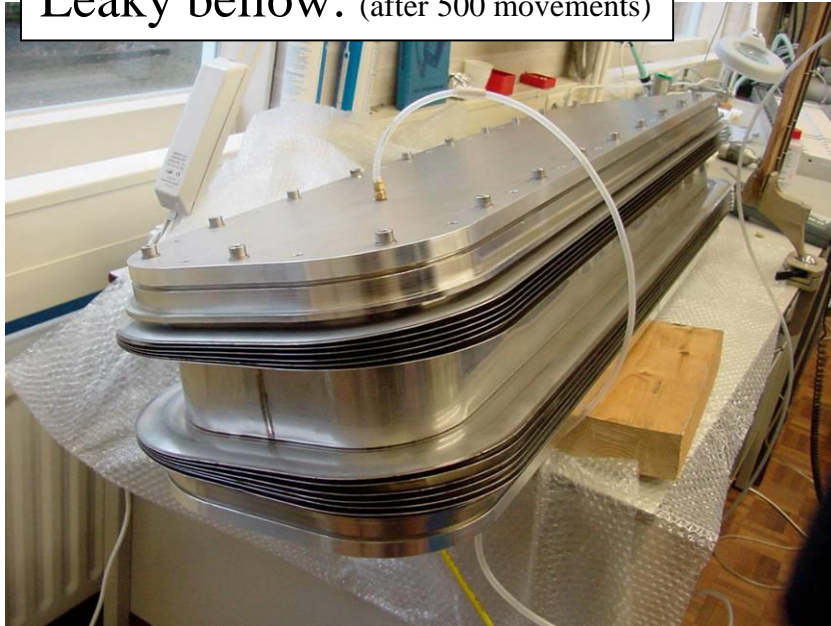




# VELO – Bellow

- VELO is moved out during LHC injection
  - (Remember: the VELO is in vacuum)

Leaky bellow: (after 500 movements)

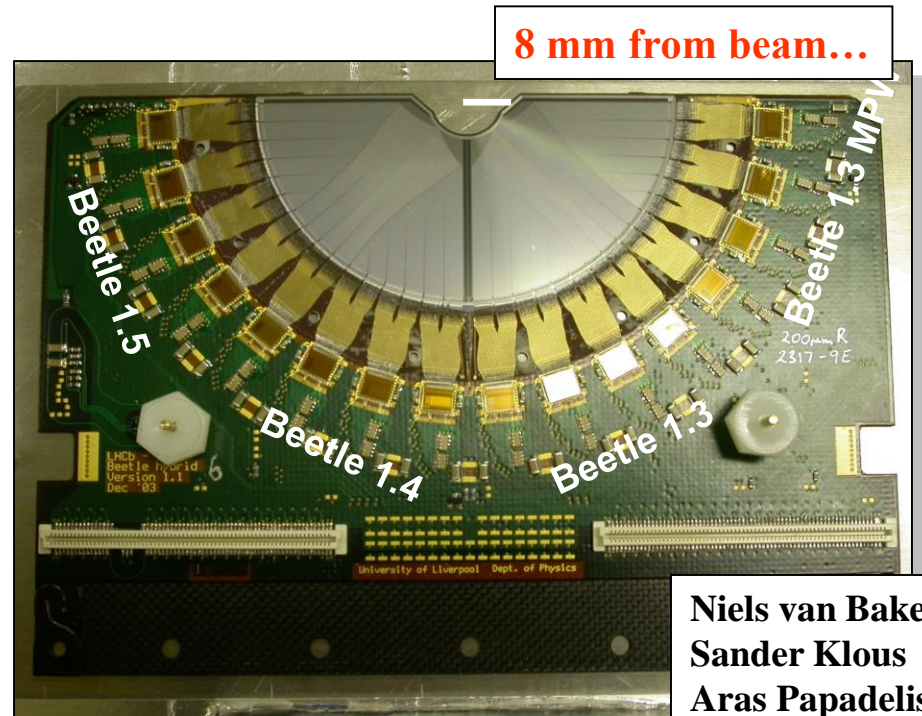
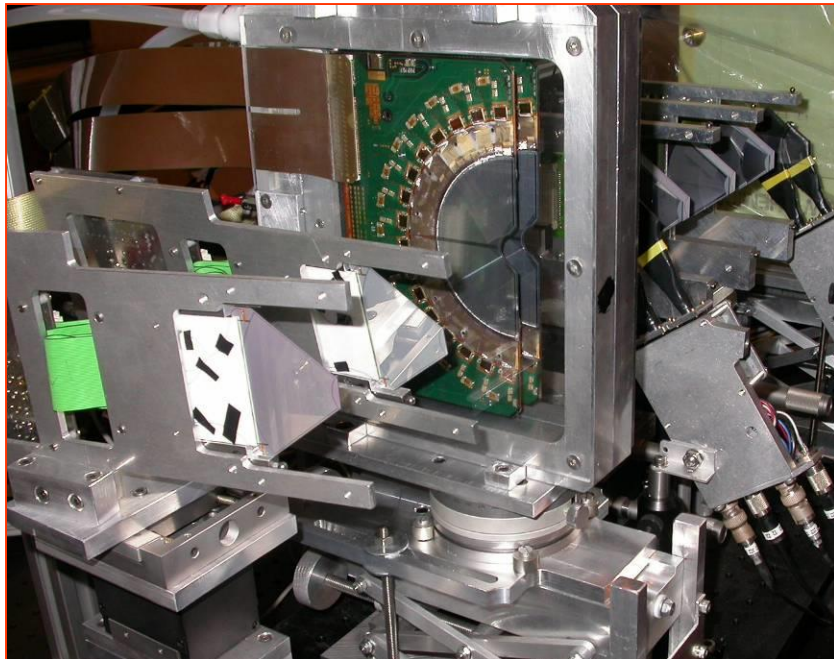


Tight bellow

# VELO test beam

## Crucial to investigate chips and sensor thickness!

- Tested 4 different Beetle flavors
- Choice between 200  $\mu\text{m}$  or 300  $\mu\text{m}$  Si to be made soon
  - **200  $\mu\text{m}$ :** low bias voltage, longer lifetime, less radiation damage, less  $X_0$
  - **300  $\mu\text{m}$ :** higher S/N !

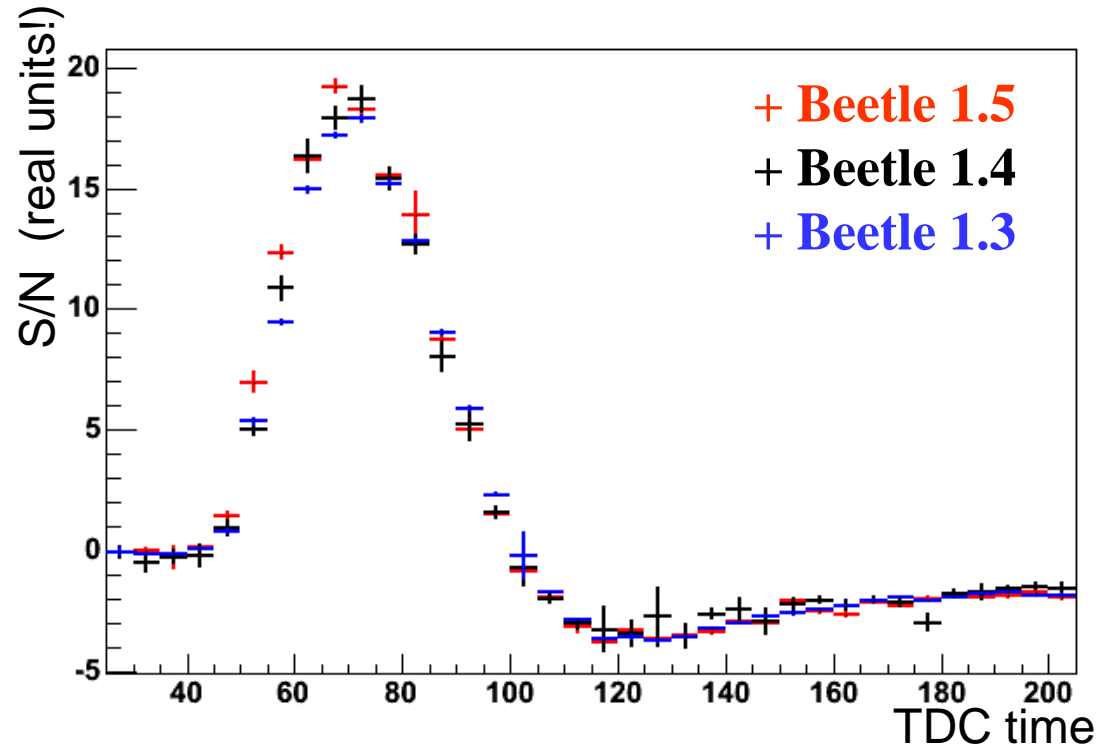


Niels van Bakel  
Sander Klous  
Aras Papadelis

# VELO 200 $\mu\text{m}$ sensor

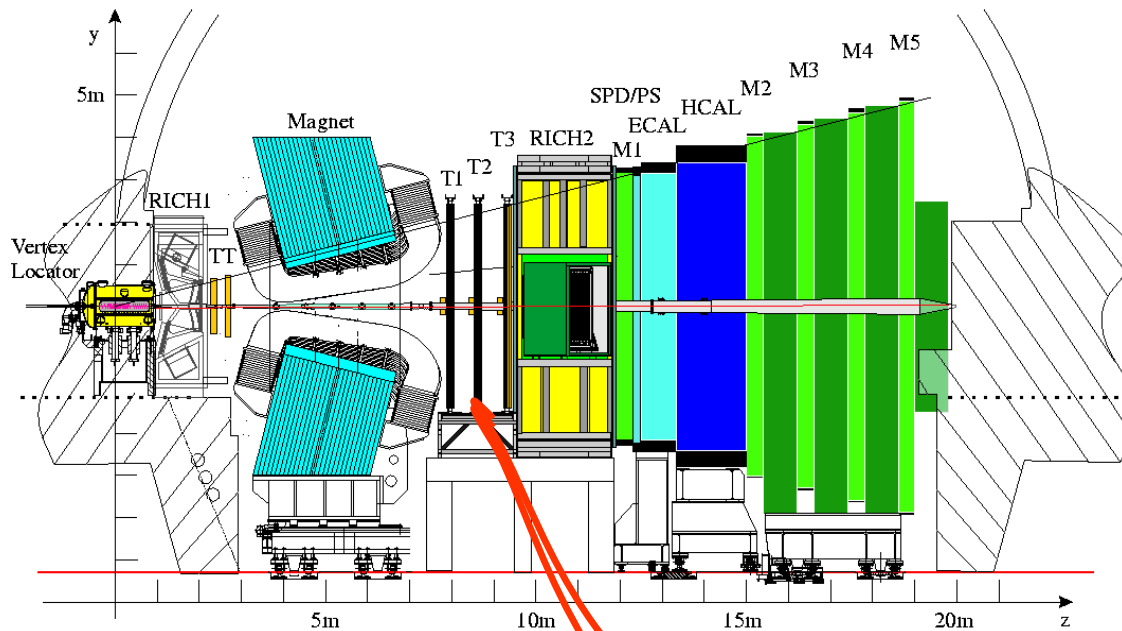
## Very preliminary result:

- 200  $\mu\text{m}$  sensor has large S/N
- Beetle chips perform well!
  - Very similar...
- Analysis ongoing
  - Resolution vs incident angle
  - Efficiencies
  - ...

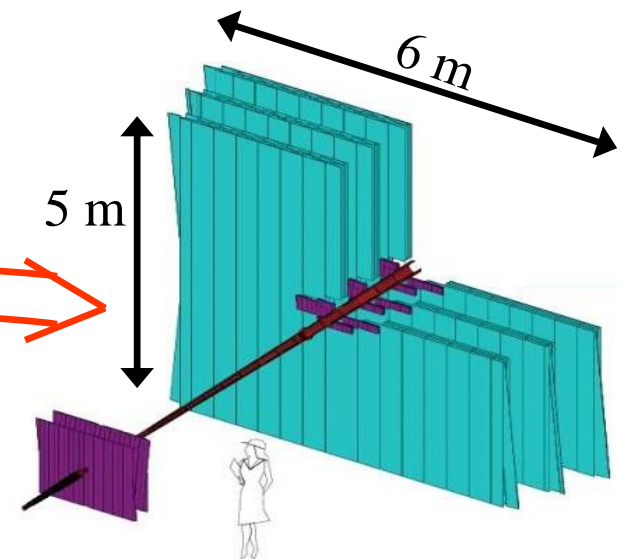




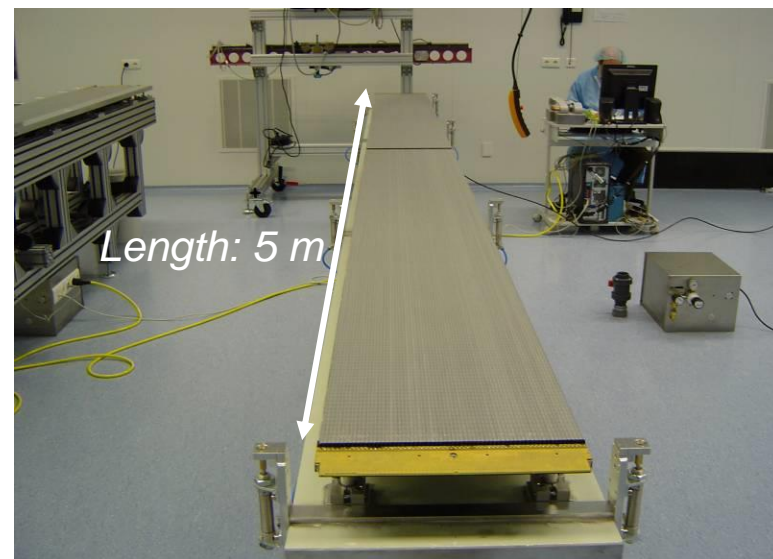
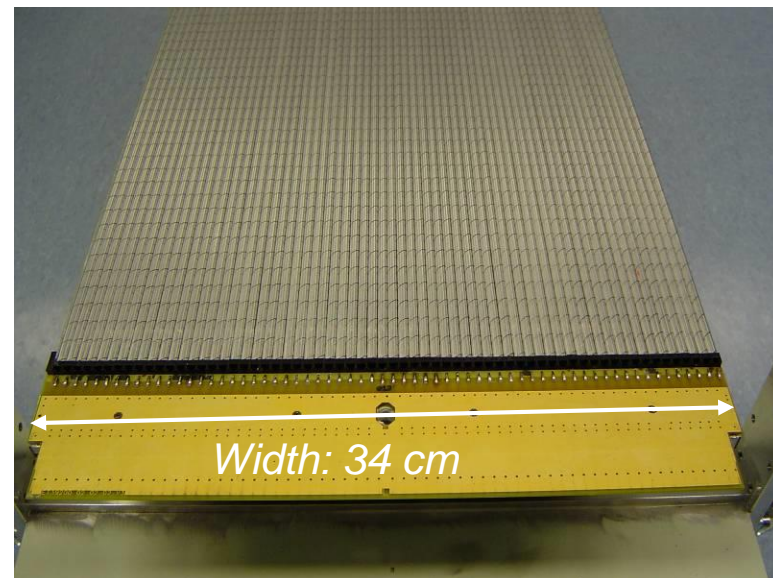
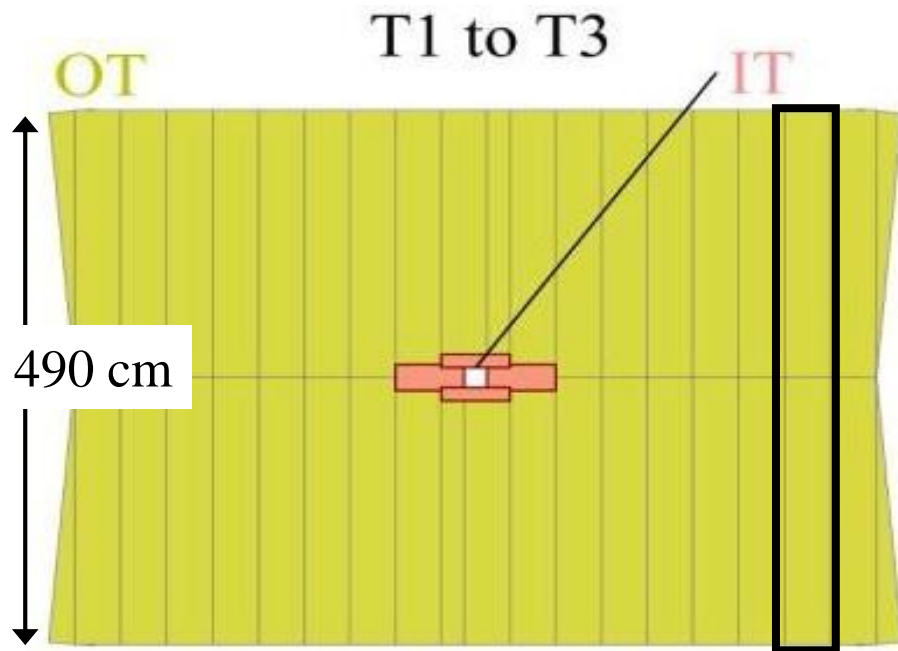
# The Outer Tracker



- 3 stations
- 1 station = 4 layers: x-u-v-x
- 1 layer = 2 straw-monolayers
- ➔ 720 m<sup>2</sup> of straw surface



# The Outer Tracker



- **Cracow:** straw-support panels
- **Warsaw:** 120 short modules
- **Heidelberg:** 60 long modules
- **NIKHEF:** 120 long modules  
(= 50% of surface)

**Total nr of straws:**

- 53.760
- → Half is made at NIKHEF



**05/2004: PRR**  
**(Production Readiness Review)**

12/2005: 100%  
prod

**02/2004: 10% prod.**

- December 2004: produced 36 / 120 = 30%
- 50% milestone challenging...

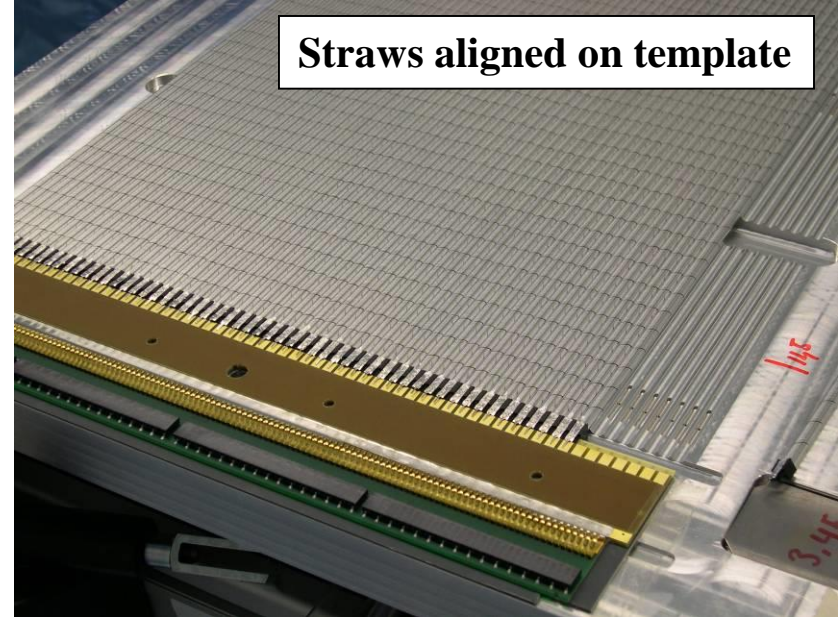


# OT Module Production

**Cutting Straws**



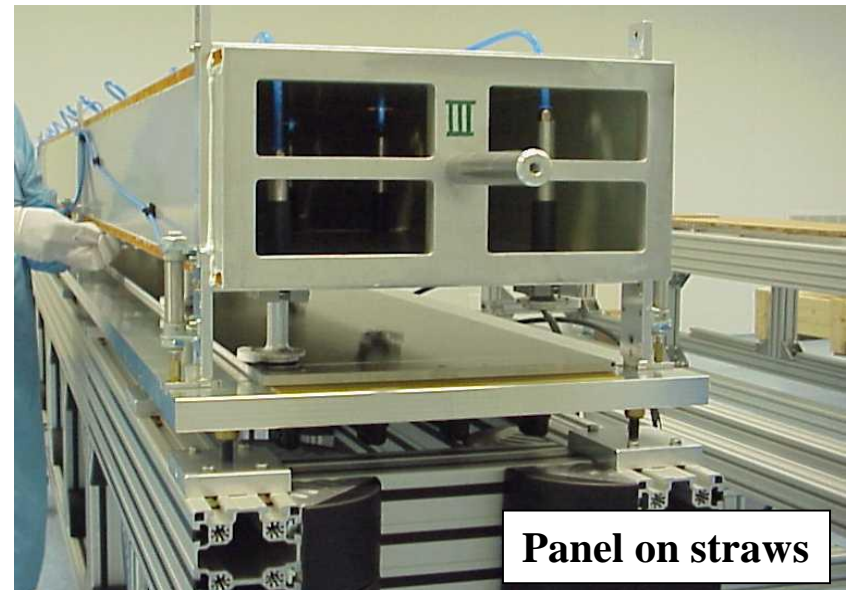
**Straws aligned on template**



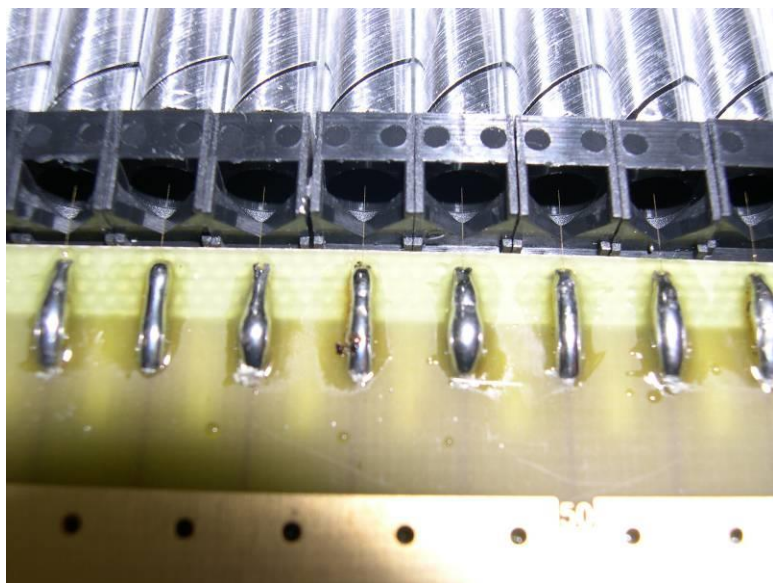
**Glue on panel**



**Panel on straws**



# The Wiring

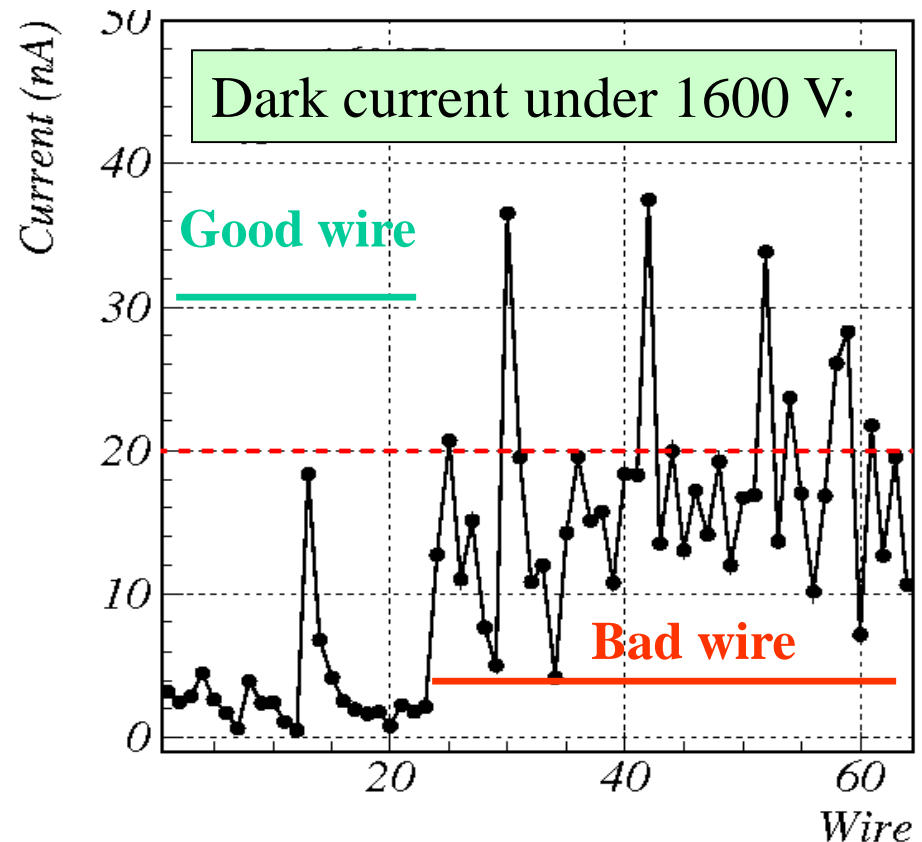




# The Wire...

30 modules finished without problems... and then:  
damaged Au plating on tungsten wire

Microscope:



→ Company sent new wire: **keep fingers crossed**  
(preliminary tests are encouraging!)

- Wire Tension: **70 g**
- Dark Current: **2 nA**
- Gas Tightness:  **$10^{-4}$  l/s**
- Response to  $^{90}\text{Sr}$ :  **$\pm 5$  %**

## • Last 25 modules:

- 3 bad wires
- $\sim 0.05\%$

OK



## Findings:

- Bad wire quality
- Leaky gluing procedure
- Bad gas flow in Heidelberg modules
- Bad soldering of connectors
- Missing wire locators
- ...

Spotted timely

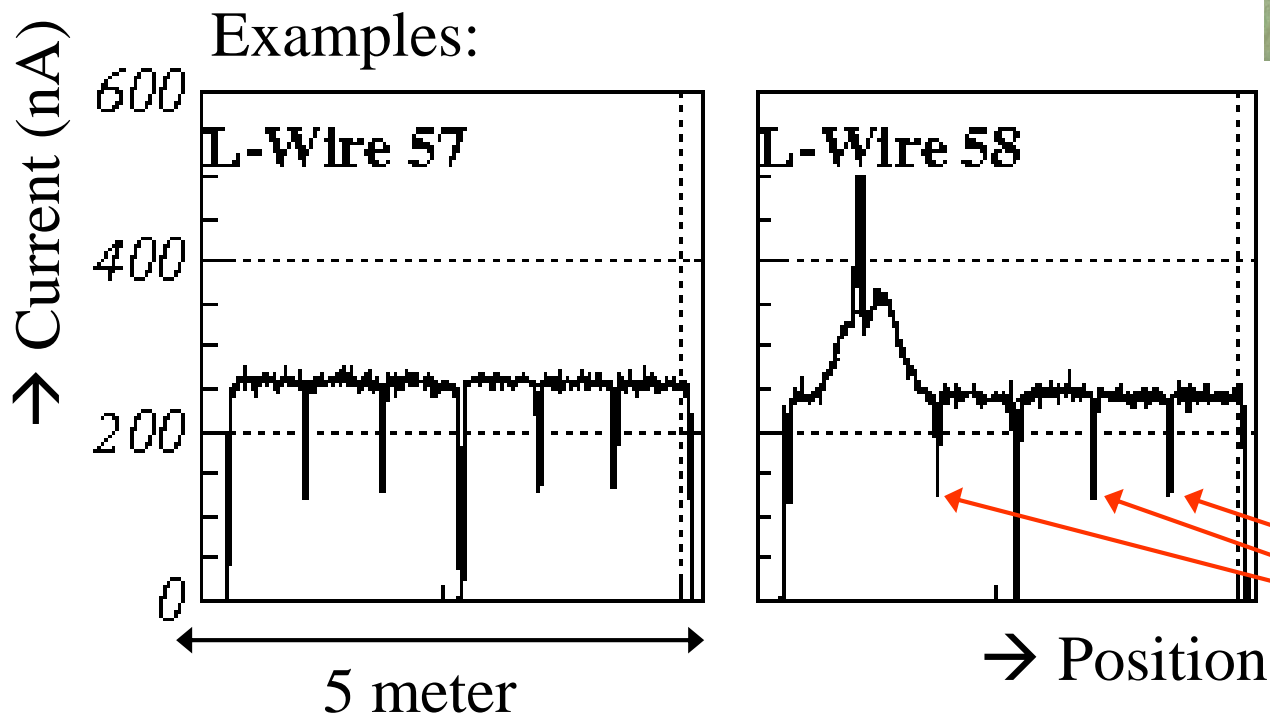
→ Adapted procedure

# Final module check: $^{90}\text{Sr}$

Measure currents originating from  $\beta$ -source

→ Very accurate diagnostics!

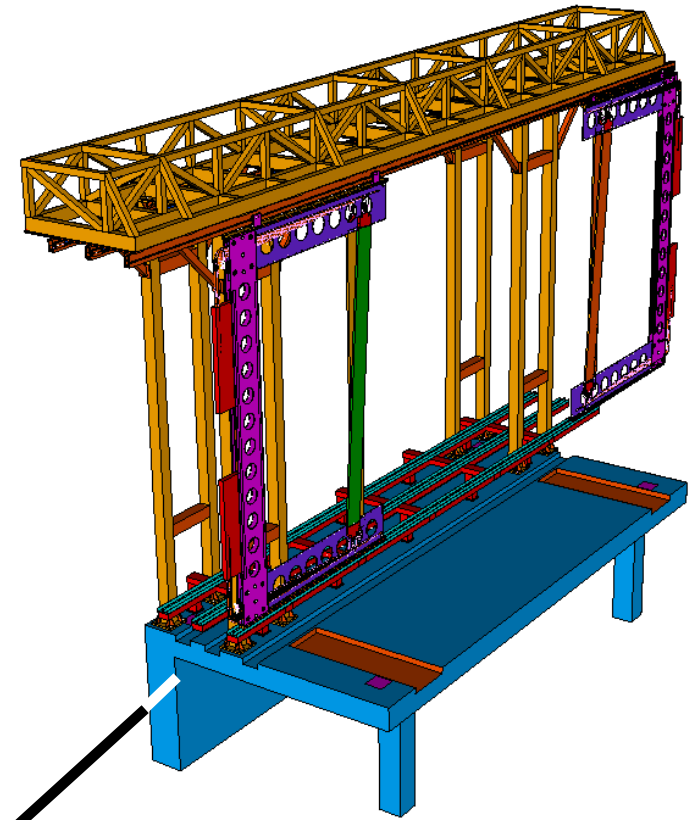
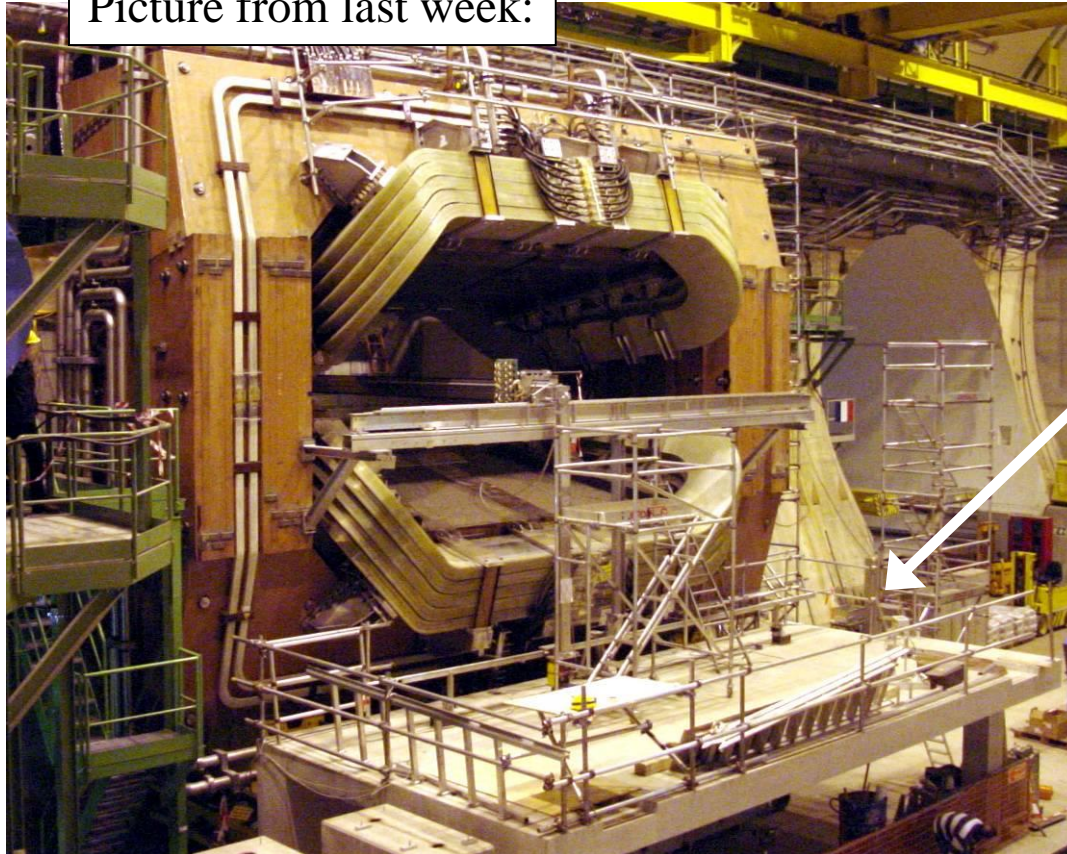
- Full scan of the entire module
  - Every  $\text{cm}^2$  of the OT is checked





# Frames

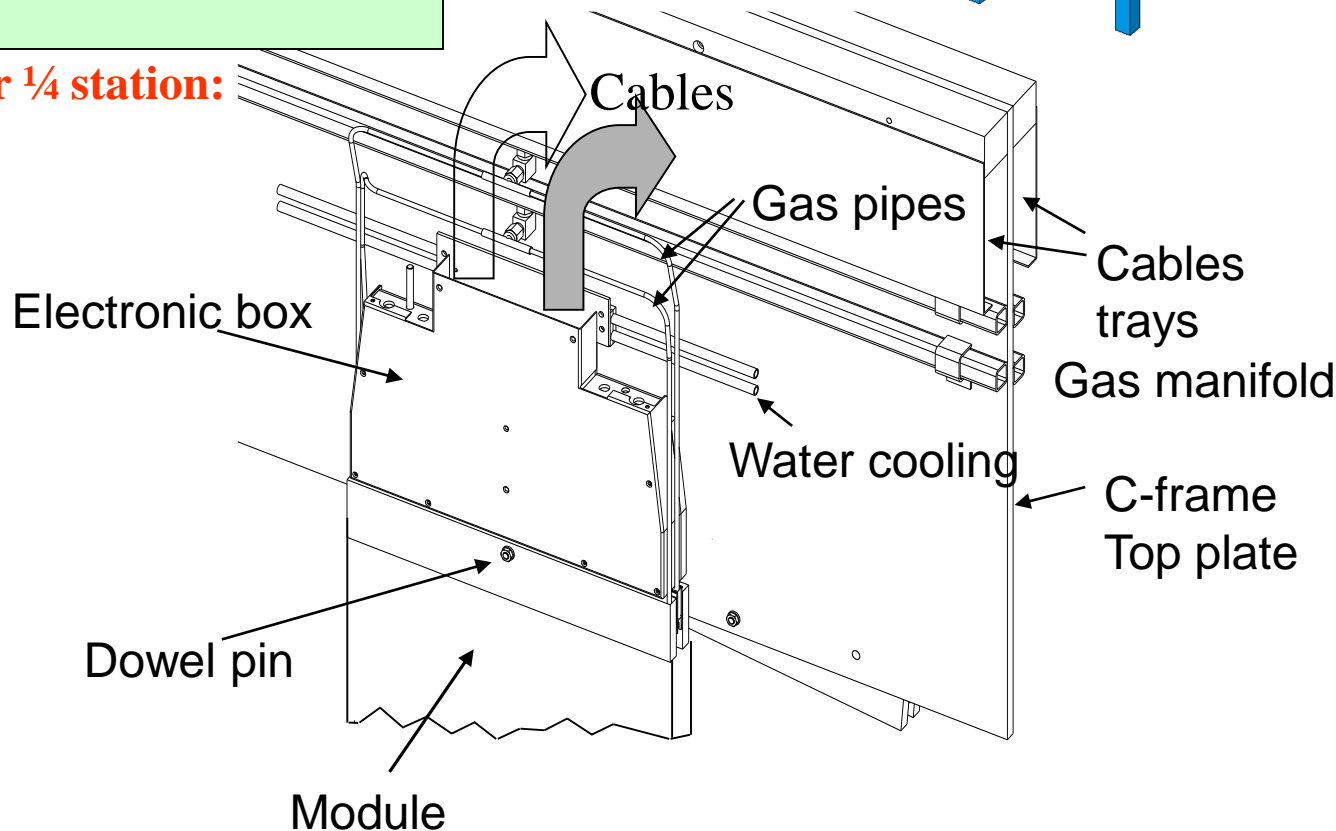
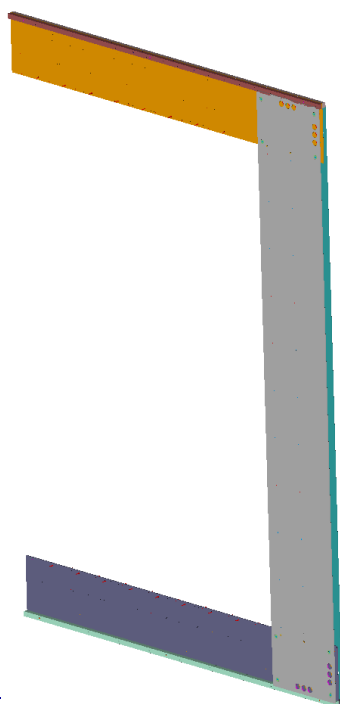
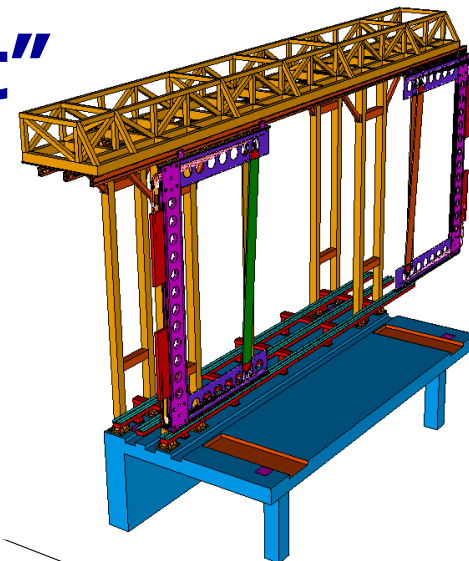
Picture from last week:



# OT – “Medium Scale Test”

- **Construct a 1/4 station**
- Test mechanics
- Fit cables, cooling, gas pipes, ...
- Test grounding scheme
- Test multi-module readout system
- ...

**C-frame = Outer tracker 1/4 station:**





# C-frame

- Plan to hang 10-20 modules (with electronics!)  
(and HV cable...)



# Bezuinigingen



Tom

shit

Smuggled with camper of Fam. Sluijk:



Ria

Courtesy of Antonio Pellegrino

Organisation Européenne pour la Recherche Nucléaire European Organization for Nuclear Research CERN - Finance Department Collaborations & Visiting Research Teams CH - 1211 GENEVA 23		TEAM ACCOUNT No : T229900 NIKHEF-LHC/B
Téléphone : +41 22 767 3320 Téléfax : +41 22 767 9870 CERN Bank Account : CH 43-300000-123456789		Recipient / Destataire: NIKHEF - PA Postbus 41883 NL-1009 CB AMSTERDAM NL-442
INVOICE / FACTURE No: F00092762 Please quote our invoice number in all correspondence or payment. Veuillez reporter notre numéro de facture dans toute correspondance ou paiement.		
Date: 05/04/2004 31/03/2004		Geneva/Genève: 30/04/2004 Amount / Montant: 3,300.00 642.80
Place: 1557768 MAG03	Description: Magasin 03-04	

Saved 200m HV cable from scrap yard!  
 → 6 CHF/ m

Item	Estimated	Bezuinigd
200m cable	786.8	786.8
Material Handling	50.0	50.0
Shipping Cost	150.0	150.0
	€ 986.8	€ 986.8

Kindly credit 247 EUR (25% of save) to OT  
 Budget 39200 or equally well (possibly better)  
 to 43.40.72.648!!!



# Summary

