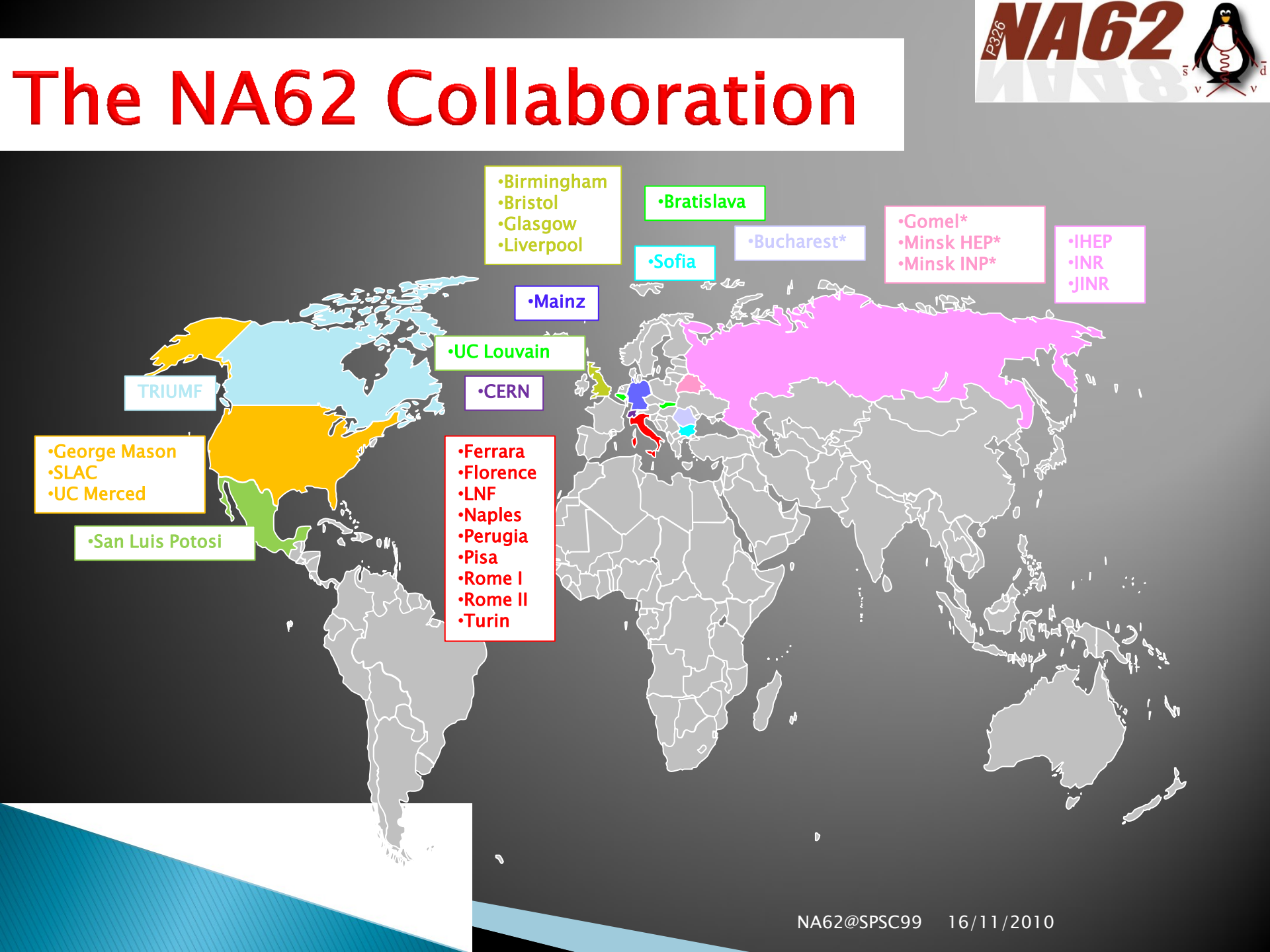
NA62 Status Report: 2010 Activities and Plans for 2011

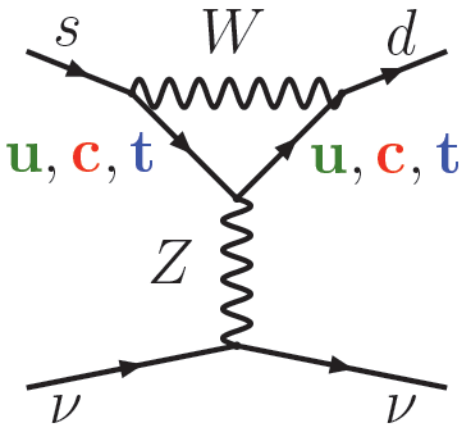
Augusto Ceccucci for the NA62 Collaboration

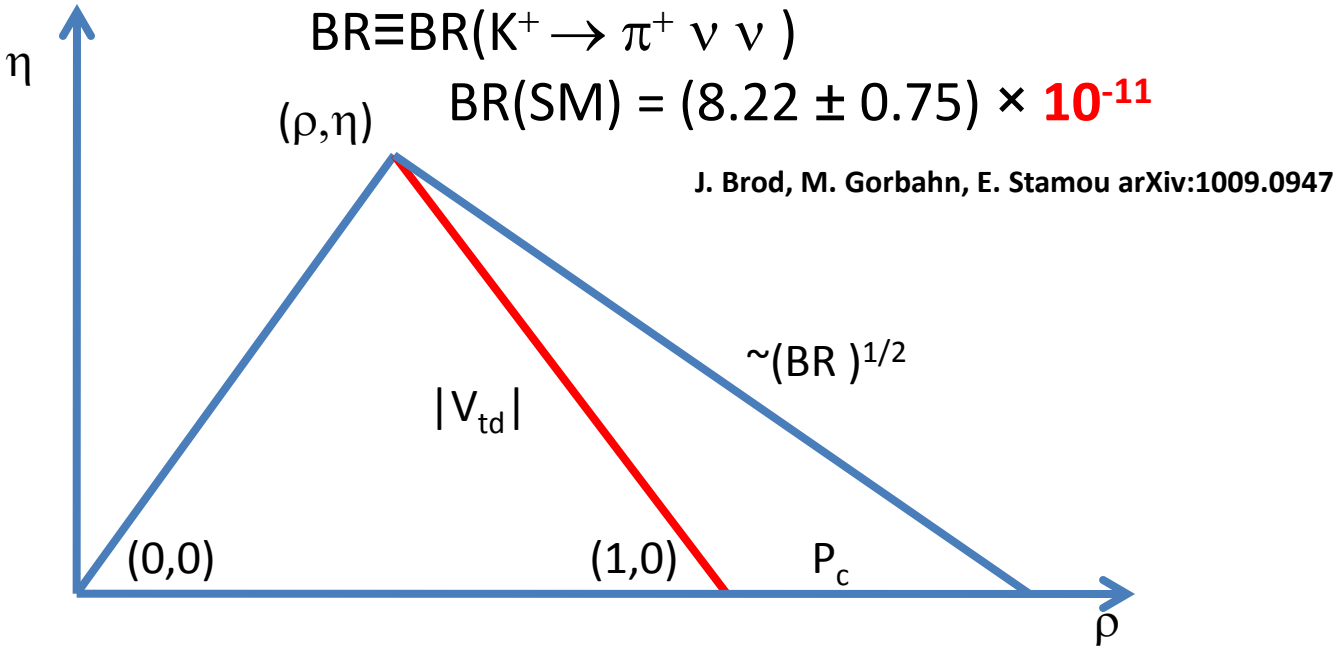
November 16, 2010

The NA62 Collaboration



$K^+ \to \pi^+ \nu \bar{\nu}$ in SM





BR≡BR($K^+ \to \pi^+ \nu \nu$)

BR(SM) = (8.22 ± 0.75) × 10^{-11}

J. Brod, M. Gorbahn, E. Stamou arXiv:1009.0947

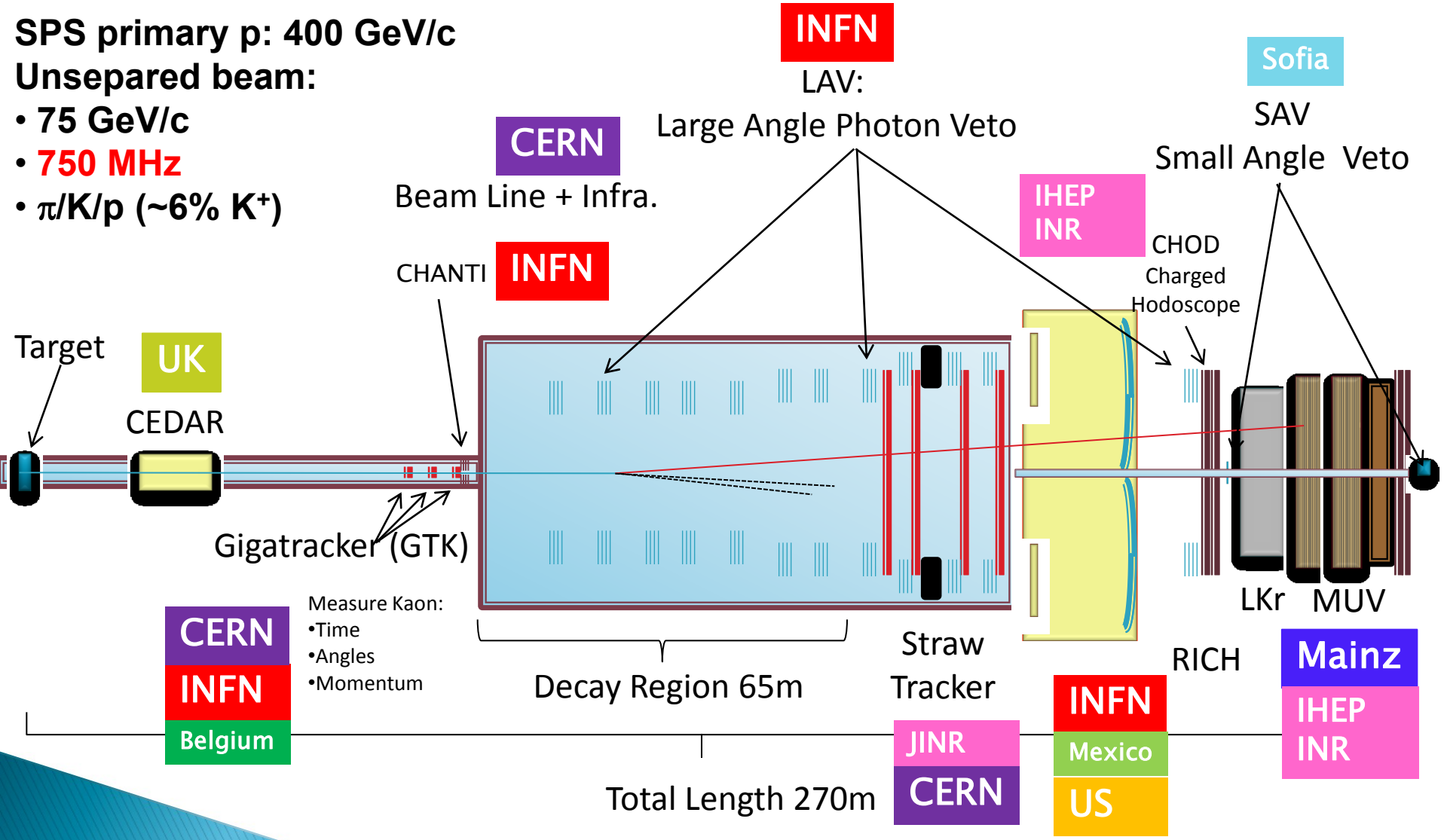
$$\delta |V_{td}| / |V_{td}| \approx 0.4\, \delta P_c/P_c \oplus 0.7\, \delta BR/BR \oplus \delta |V_{cb}| / |V_{cb}|$$

~2 % (mostly δm_c) **62 % BNL** **3 %**

7% aim of NA62 (2y)

NA62 Beam & Detectors

SPS primary p: 400 GeV/c
Unsepared beam:
- **75 GeV/c**
- **750 MHz**
- **π/K/p (~6% K^+)**



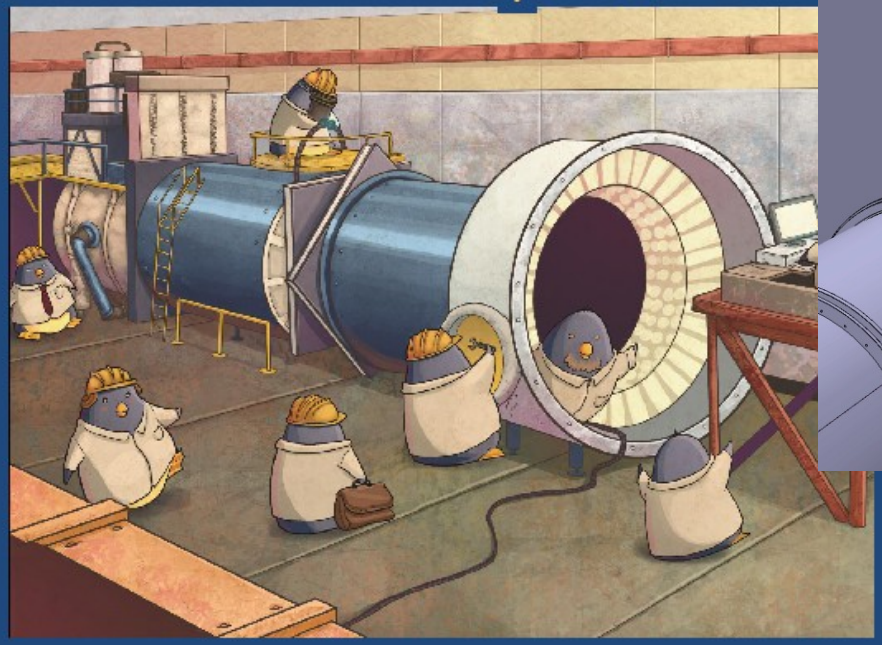
Technical Co-ordination

(cf. Ferdinand Hahn)

LABORATOIRE EUROPEEN POUR LA PHYSIQUE DES PARTICULES

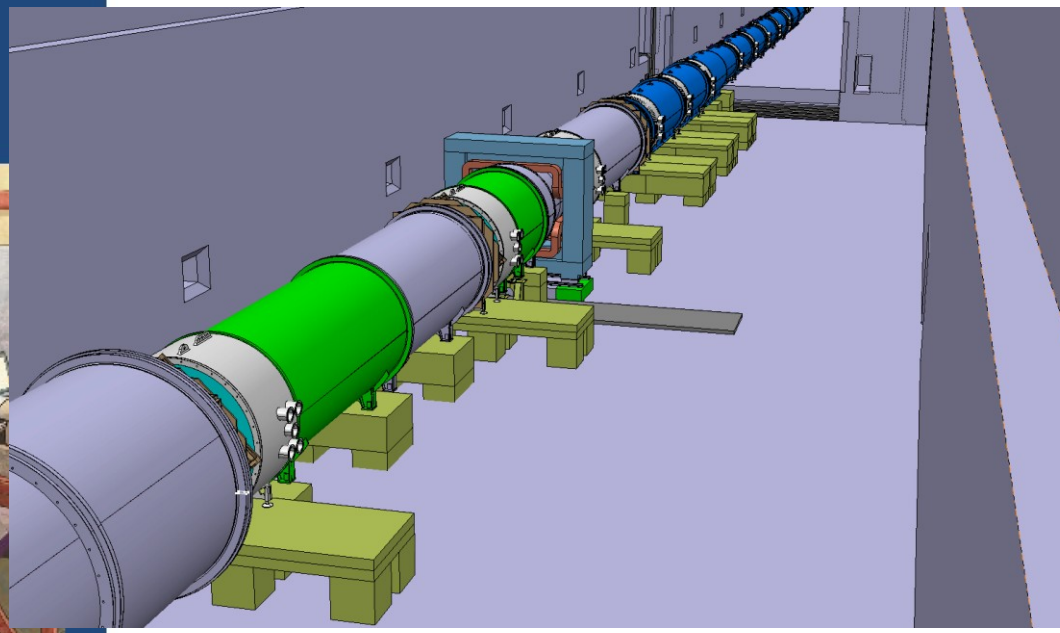
CERN EUROPEAN LABORATORY FOR PARTICLE PHYSICS

NA62



Technical Design

TD Main Editor: Ferdinand Hahn



Version 0
circulated in Sept.
Final version in print in December

Preliminary List of Milestones

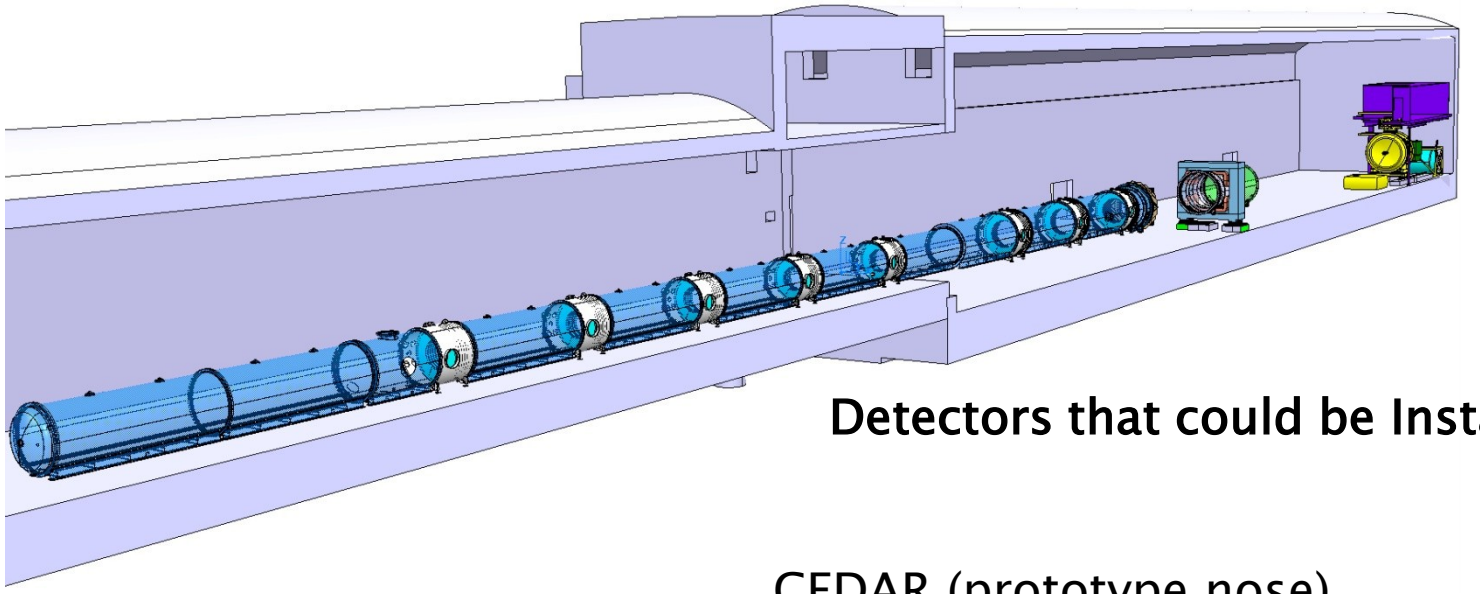
#	Sub-System	Milestone	Previous Date	New Date
1	STRAW	Freeze Chamber + Straw Design	01/09/2010	done
2	GTK	GTK Read-out Cip Choice	30/09/2010	done
3	LAV	LAV 1,2,3,4 + 5 Ready	16/12/2010	16/02/2011
4	RICH	Design for Mirror Supports and Wall Completed	New	30/06/2011
5	STRAW	Module 1 Ready	06/07/2011	06/07/2011
6	GTK	Freeze Sensor + Chip Design	30/09/2011	30/09/2011
7	LAV	LAV 6 -8 Ready	31/07/2011	30/10/2011
8	STRAW	Readout Design Completed+Tested	New	16/12/11
9	STRAW	Four Modules Ready	15/06/2012	15/06/2012
10	RICH	Vessel installation ready	New	30/04/2012
10	RICH	Vessel Ready for Closing	22/12/2011	Drop
11	Installation	Preliminary Vacuum Tube Closing	31/05/2012	30/09/2012
12	LAV	LAV 8,9,10 + 11 Ready	04/05/2012	31/10/2012
13	RICH	Mirror and PM Installation complete	31/10/2012	02/12/2012
14	ECN3	Final Vacuum Tube closing	09/09/2012	15/03/2013

…other Milestones could be added.

Synchronization Run

- Preamble: *Our goal remains physics data talking in 2013 and 14.*
- Synchronization Run in fall 2011
  - Validation Test for the new common electronics boards, e.g. TEL62, TDCB.
  - Test of timing; synchronization of detectors and beam
  - Test for readout and online systems
  - *Limitation:* uses Muons (no hadron beam) and only a subset of detectors
- Two main difficulty:
  - Advance final solutions for detectors and infrastructure, and avoid temporary patch-ups for 2011.
  - Manpower needs to be reinforced, especially to finalize the common electronics (TEL62, TDCB,…)

Synchronization Run Equipment



Detectors that could be Installed with partial readout:

CEDAR (prototype nose)
6 LAV's with partial readout
½ STRAW Chamber
CHOD (Readout ?)
IRC, SAC (prototype)
LKR (SLM readout + Prototype CREAM)
MUV3 + absorber wall
TDAQ system, using many final components (LTU, TTC, TEL62,…) .

Number of readout channels limited by quantity of TEL62 cards (≤ 8).

Beam line and Installation

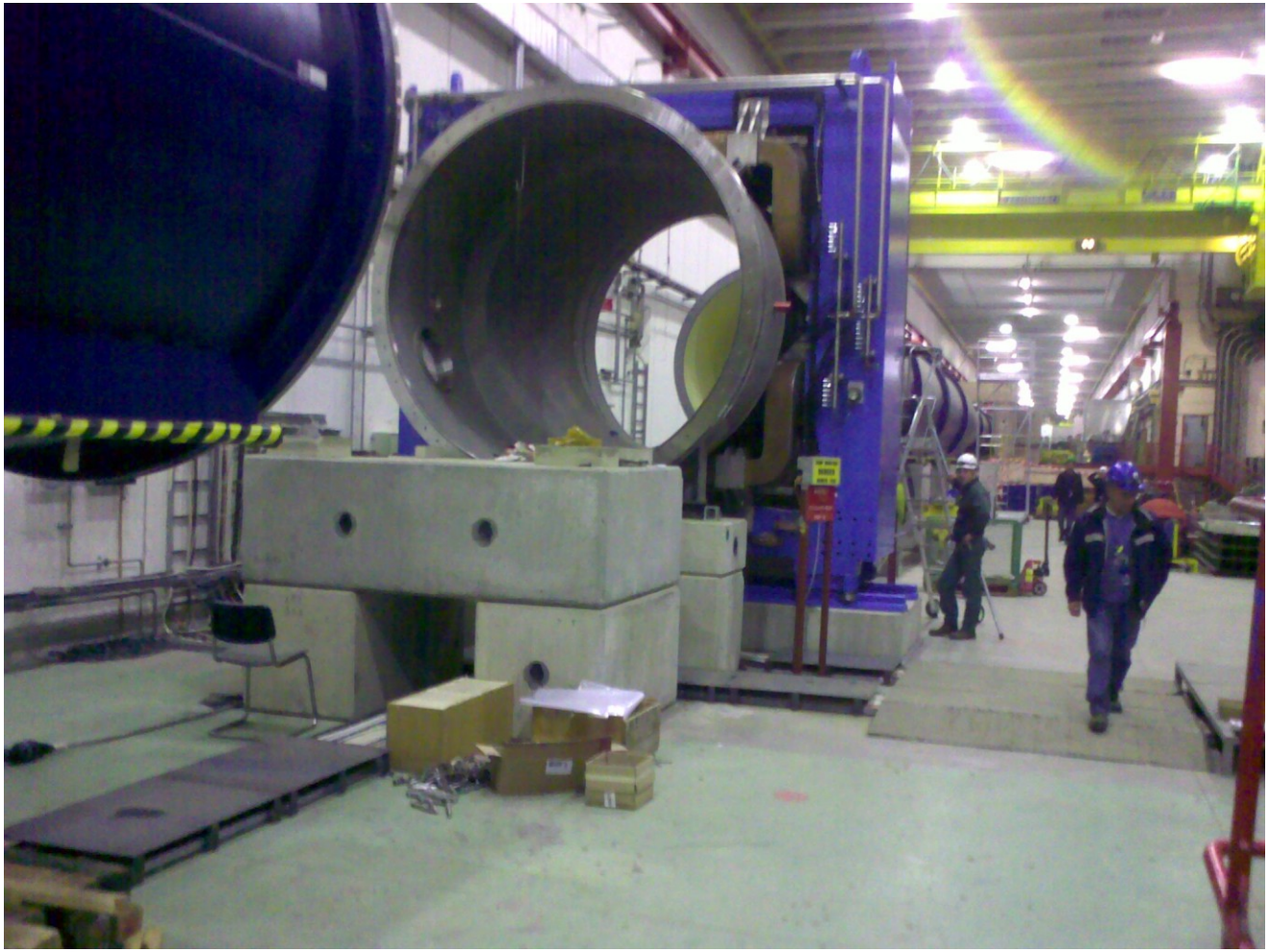
(cf. Lau Gatignon)

Old beam line mostly dismounted

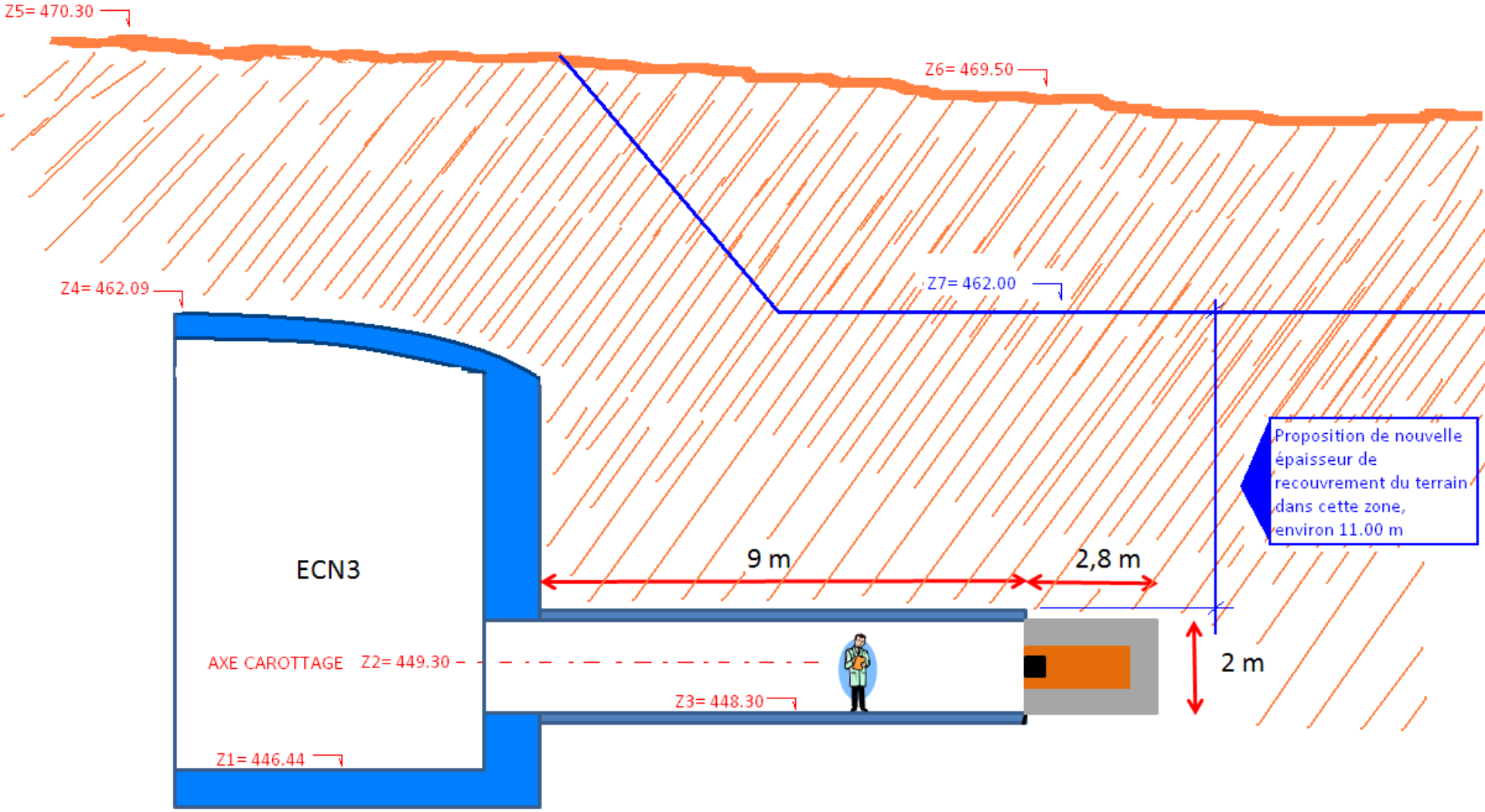
Including many radioactive parts

NA48 Dismounted

MNP33 in its new position



NA62 dump layout



Synchronization run

Possible, but with certain conditions:

- Beam dump construction must be completed (otherwise veto from radio-protection).
- T10 target cooling refurbishment must be completed.
- There must be some operational ventilation (even if not yet upgraded), but up to 2 hours wait before access (to be confirmed by measurements). Only up to 10% of nominal flux on T10.
- We have opted for muon beams only.
- The muon flux will be very much lower if from ions

CEDAR

(cf. Cristina Lazzeroni)

CEDAR

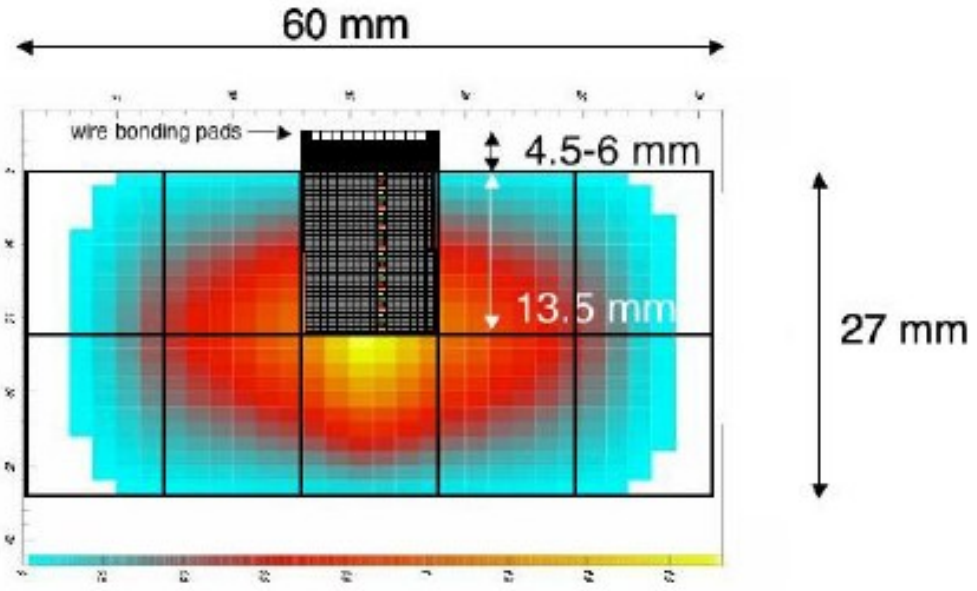
- Cherenkov Differential counters with Achromatic Ring focus (for positive kaon identification)
- The NA62 application requires new optics and read-out with respect to a standard CEDAR
- Filled with Hydrogen instead of Nitrogen in W-type CEDAR
- Activities in 2010:
  - Simulation of Radiation Environment
  - Preliminary Design of electronics
  - Simulation of light distribution
  - Preliminary mechanical design
- Plans for 2011:
  - Construction and test of the prototype mechanics
  - Verify radiation tolerance of front-end electronics
  - Read-out chain integration

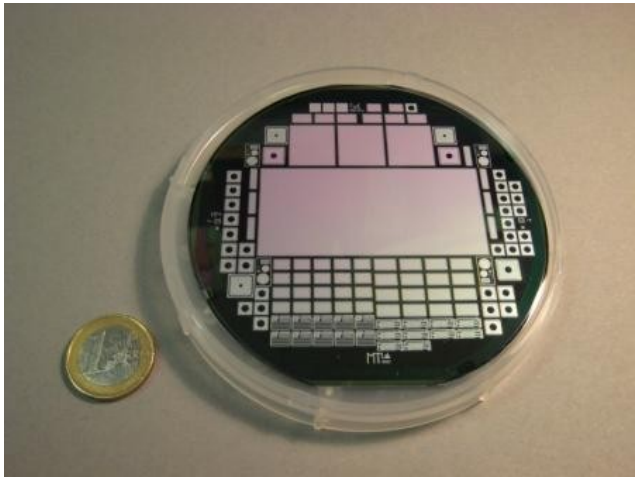
Gigatracker (GTK)

(cf. Flavio Marchetto)

GTK

- Placed in vacuum intercepting the incoming hadron beam (three stations)
- Time-stamp (200 ps /station) +tracking of <u>each</u> beam particle (of which only ~6% are K)
- Dimensions of the stations match the beam shape
- Sensor technology: p-in-n Silicon
- 300 x 300 μm^2 Si pixel
- 18000 pixels/ station -> 54000 pixels grand total





Main progresses in 2010

Chip prototype tests

Reminder, two options: Time over Threshold (ToT) and Constant Fraction Discriminator (CFD) were implemented in IBM 130 nm CMOS technology.

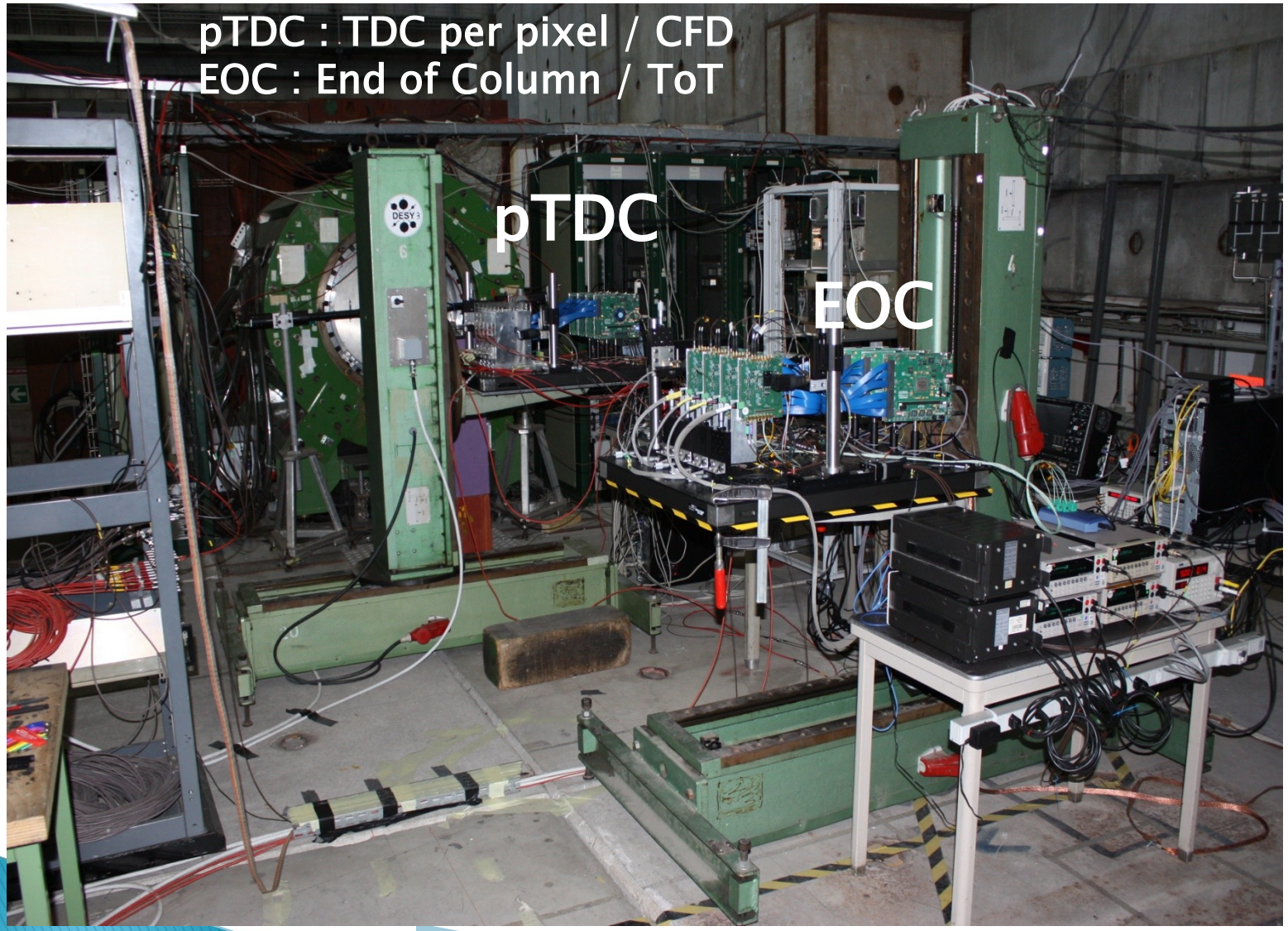
Extensive tests with:

a) Electrical tests,
b) Laser
c) Beam test

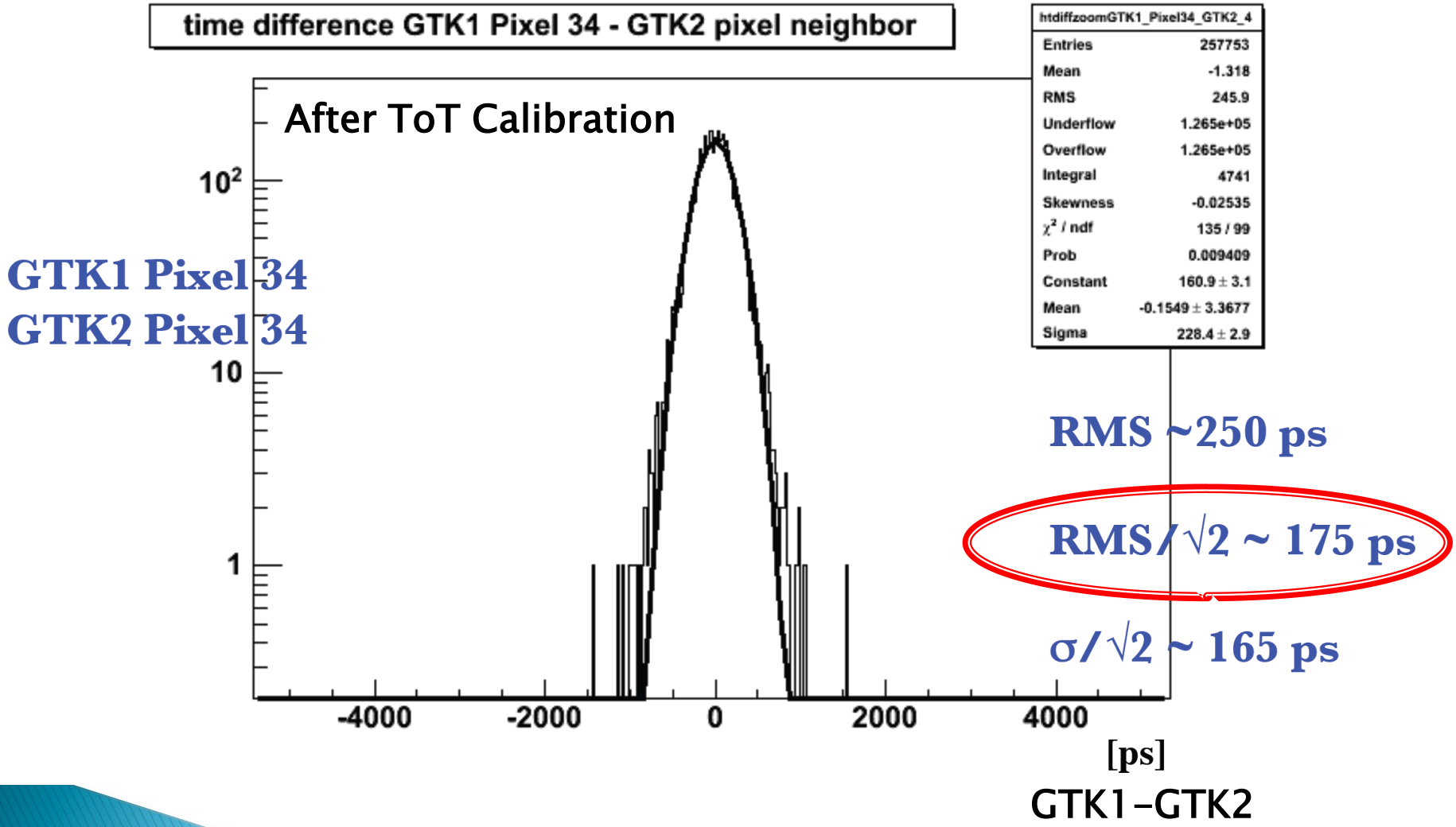
Beam test: performed at the T9-PS in September

A set of four fast scintillators provided the reference timing with 40 ps time resolution and also a meaning to extract the calibration curves for the ToT.

GTK Test beam (PS T9, Sept-Oct 2010



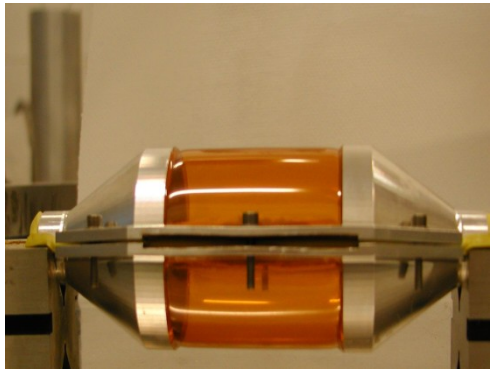
GTK (EOC-ToT) PS-T9 (Sept-Oct 2010)

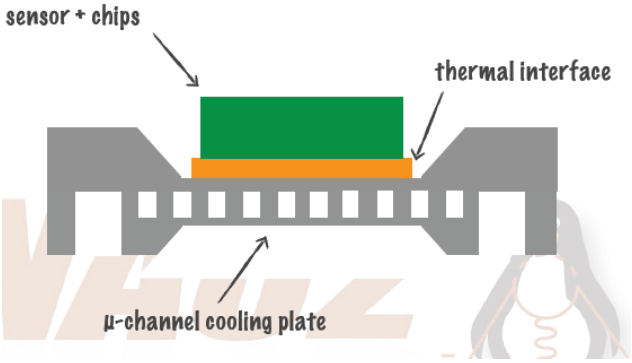


Cooling

a) **Vessel** cooling: cold nitrogen flowing through

- Several prototypes have been developed
- For the nominal power (32 W) dissipated via a thermofoil heater the obtained temperature is well below zero (average -18 ^{0}C)
- The temperature uniformity to be improved





b) micro-channel cooling:

- tested successfully a silicon-on-pyrex assembly
- a silicon-on-silicon is ready for the test
- Good temperature uniformity

GTK: Plans for 2011

• Full size ASIC chip (EOC) is expected to be ready for submission by end of September 2011

• The thinning to 100 μm of the chip is studied at VTT and IZM in synergy with Alice, which has similar specifications.

• By the end of the year 2011 and based on the performances of the prototypes the final design of the cooling will be decided.

•Studies of the design of the integration card will continue and will be finalized

•Off-detector electronics

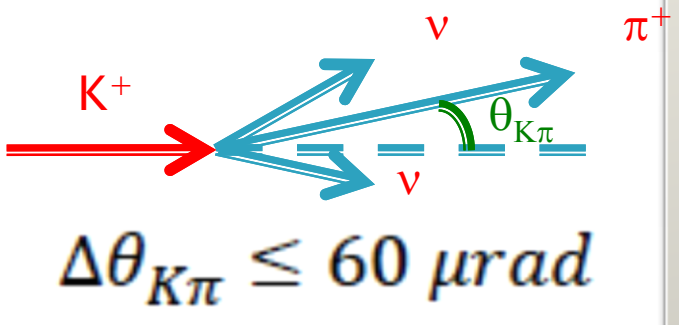
Straw Tracker

(cf. Hans Danielsson)

Straw Tracker in NA62

- There are two main performance requirements for secondary particles:

$$\frac{\Delta P}{P} \leq 1\%$$



$$\Delta\theta_{K\pi} \leq 60\ \mu rad$$

From this follow the main requirements on the straw detector:

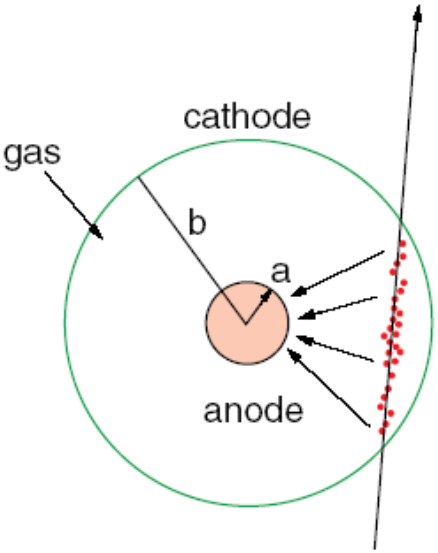
- Spatial resolution ≤ 130 μm per coordinate and ≤ 80μm per space / point
- ≤ 0.5% of a radiation length (X_0) for each chamber
- Installation inside the vacuum tank ($P < 10^{-5}$ mbar) with minimum gas load for the vacuum system *($\sim 10^{-1}$ mbar* l/s)*
- For straws near the beam, operation in a high rate environment (up to 500kHz/Straw)
- Possible multiplicity veto for triggering

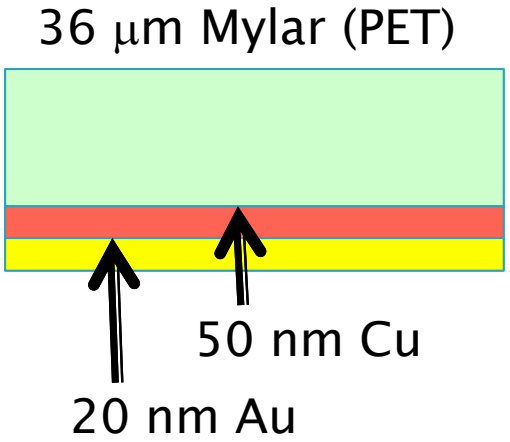
The straw

Straw construction

- Tube 2.1 meter with a diameter of 9.8 mm
- The base material is PET with thickness 36 μm

  PET = Poly Ethylene Terephthalate
- The foil is coated on the inside with 50 nm of Cu and 20 nm of Au by sputtering

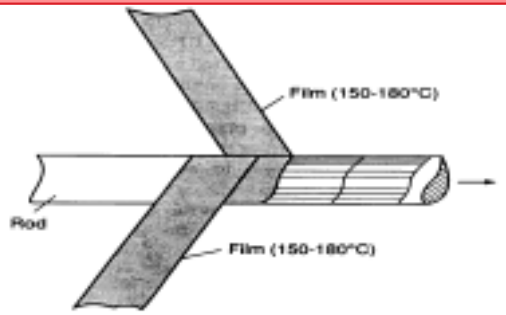




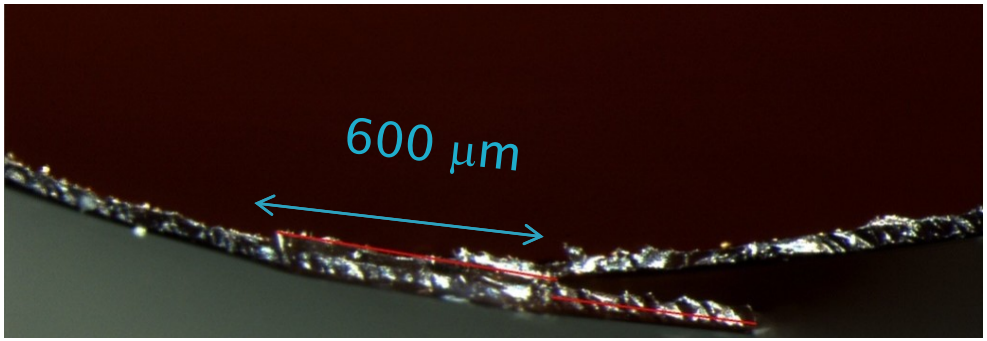
- The anode wire is 30 μm in diameter and made from gold-plated tungsten
- Gas mixture (non-flammable): a fast and a slow option were studied: Ar (70%)+ CO_2 (30%) and CO_2(90%) + CF_4(5%) + Isobutan(5%)

Ultrasonic welding of straws

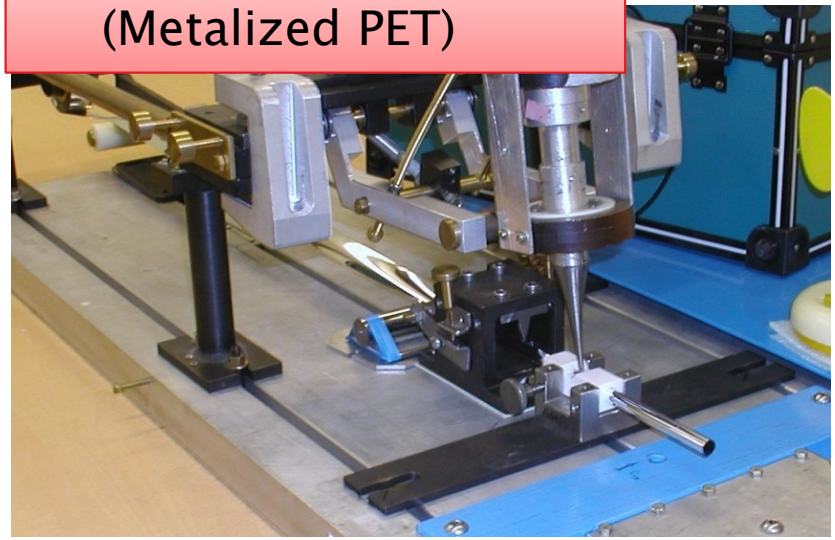
"Classical" straw winding

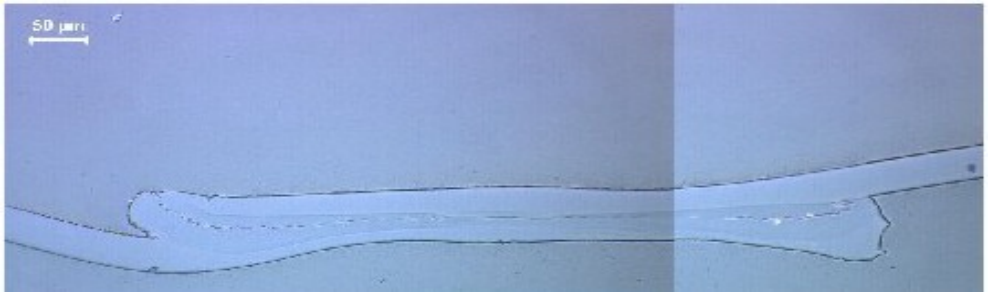


Microscope pictures of a straw cross-section for quality control of the weld



NA62 Ultrasonic welding (Metalized PET)

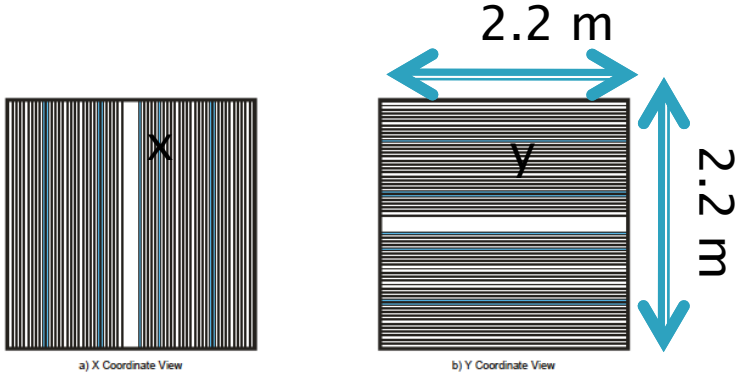


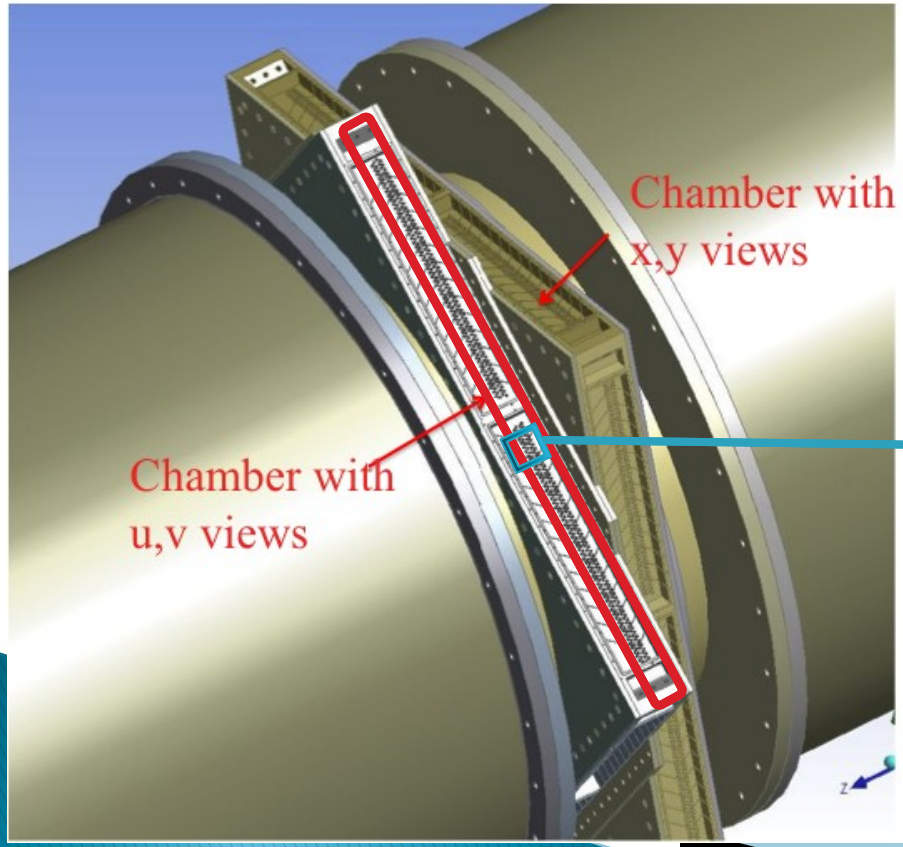


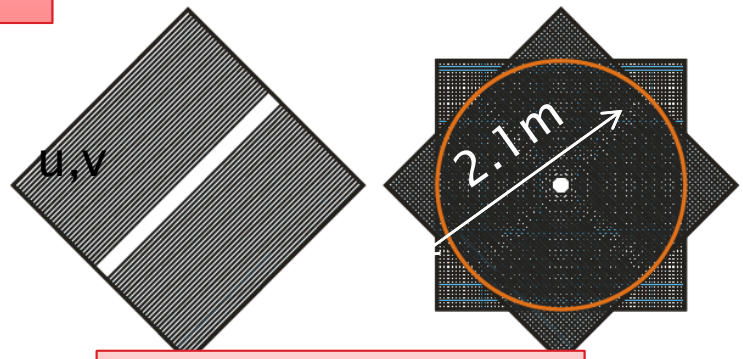
Delicate tuning of production parameters for welding (still under finalization)

The detector layout

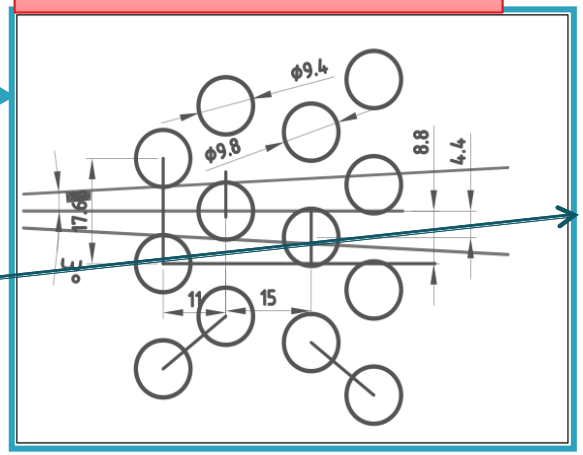
- The straw are mounted *individually* in "views"
- Each view has 4 planes with **112** straw in each
- Each view (**448** straws) gives one coordinate
- There are 4 views in each chamber and 4 chambers in total
- Total number of straws: 7168







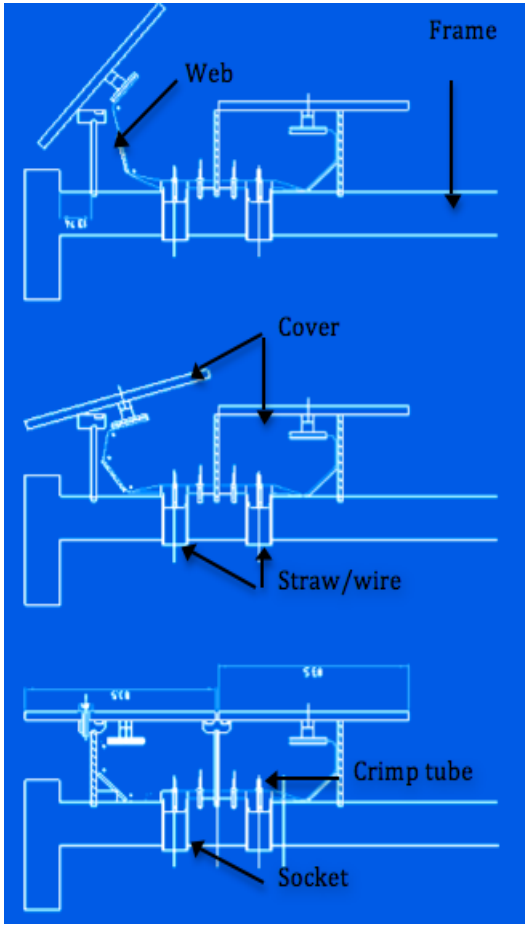
The straw layout

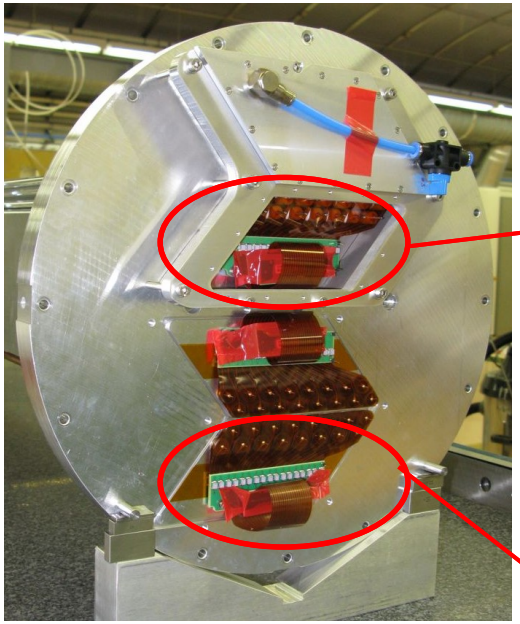


Main Achievements in 2010

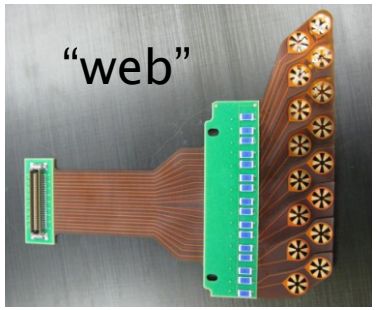
- ✓ 1. Completion of the 64-straw prototype
- ✓ 2. Finalization of the design of the full chambers (Milestone successfully achieved on September 1, 2010)
  - final straw layout (distance between neighboring straws 17.6 mm)
  - chamber structure
  - straw end-pieces
  - spacer for straw positioning
  - straw assembly tooling (insertion, alignment and gluing)
  - web (connection between straw and FE)
  - cover with HV, signal and gas connections grounding scheme
  - FEM calculation of chamber deformation and stresses
- ✓ 3. The frame for the first half chamber (Module 0) is expected to be delivered at CERN, fully assembled, at the beginning of December 2010
- ✓ 4. Straw material: Decision on the base material, Hostaphan RNK 2600 (PET), The full quantity needed for the straw production is procured. Metallization is validated and material for two modules has been coated.

Details of Straws connections and front end electronics

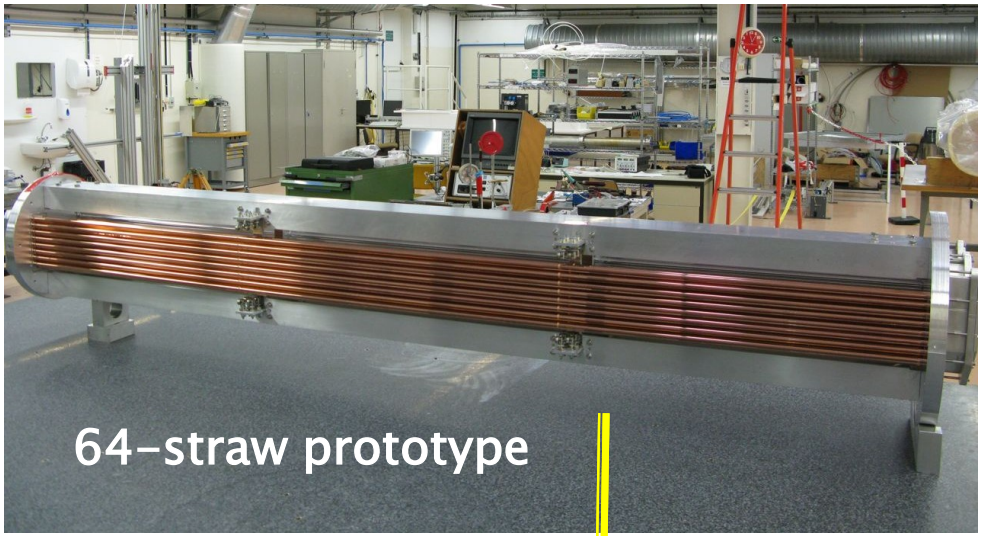


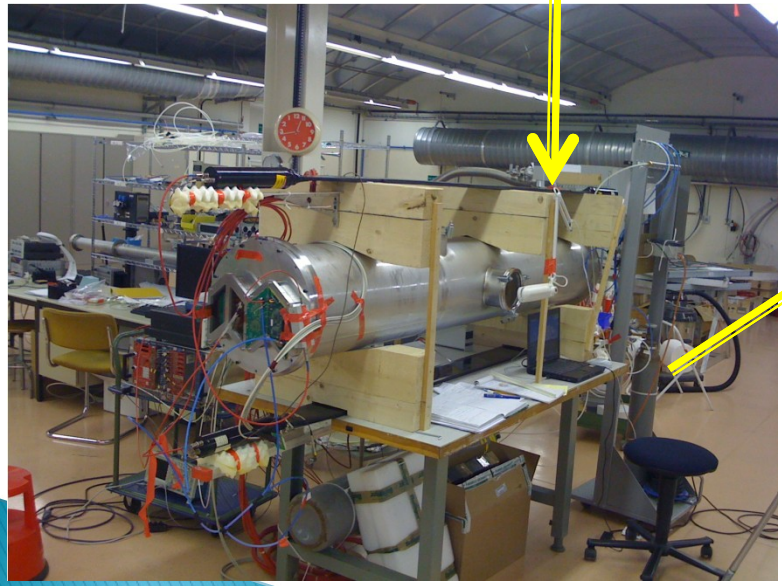


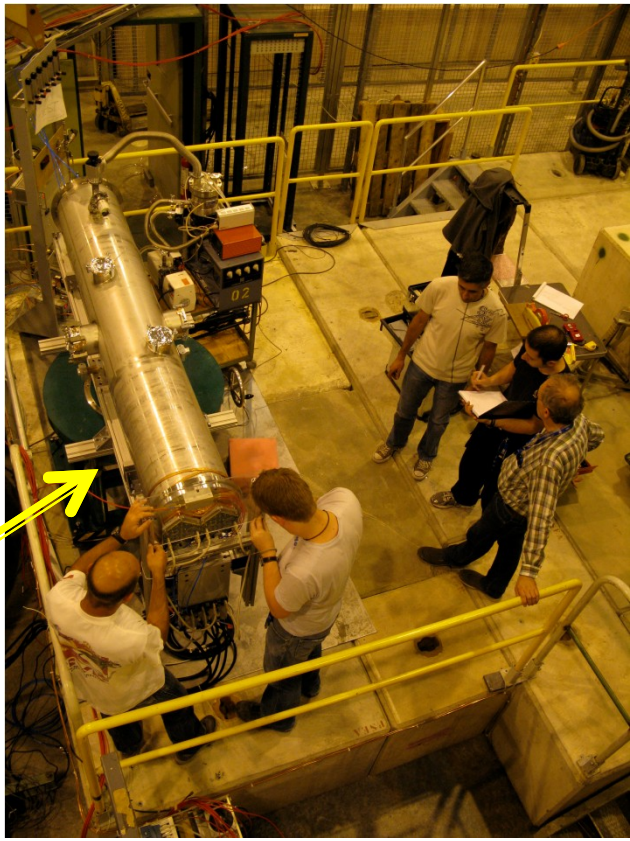
Cover



Straw Test beam (SPS-H6, June 2010)







Further testing with cosmics is underway

Straws Plans for 2011

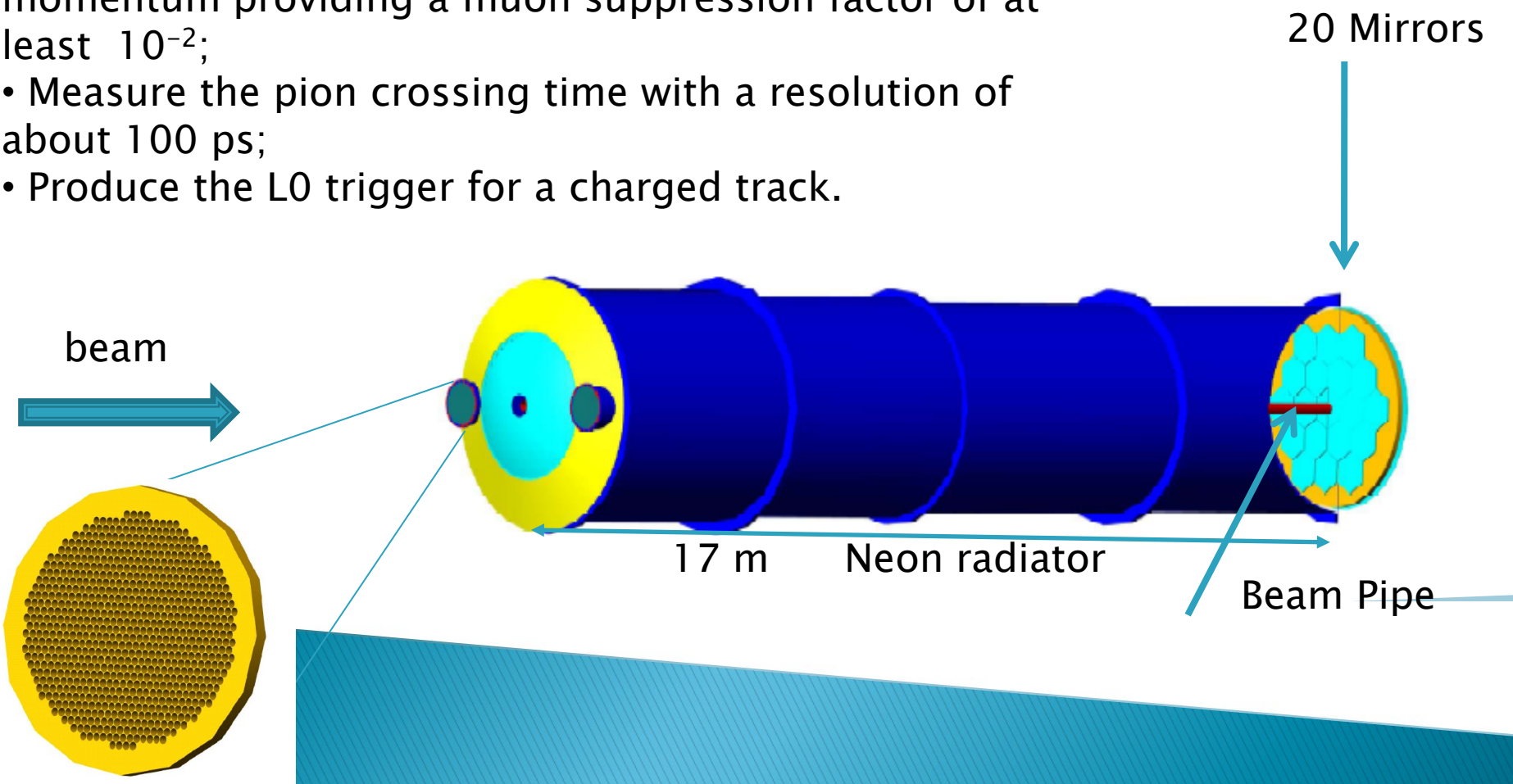
1. Frontend and readout design completed and tested by December 2011
2. Construct and test of Module 0
3. Test beam the prototype in the spring with final frontend, TDC and readout scheme
4. Integrate Module 0 in the 2011 synchronization run. The number of fully equipped channels to be read out is still to be decided.
5. Design interface parts between chamber and blue tube
6. Integrate services in the chamber design
7. Support for chamber in the experiment
8. Installation tooling (handling the chamber during installation)
9. Start building the gas system so that the final distribution can be used in the synchronization run.

RICH

(cf. Massimo Lenti)

The NA62 RICH

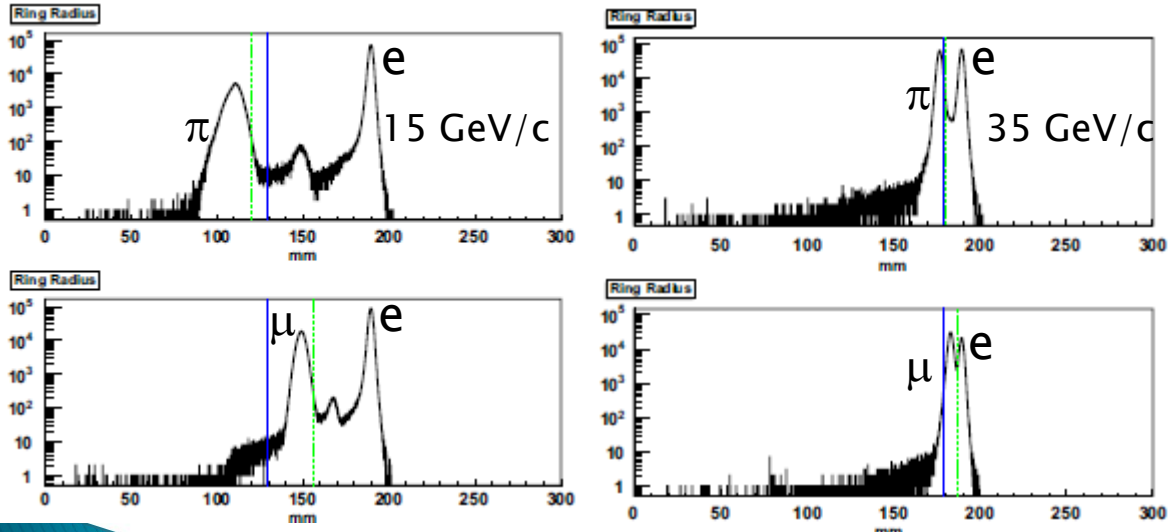
- Separate π^+ from μ^+ between 15 and 35 GeV/c momentum providing a muon suppression factor of at least 10^{-2};
- Measure the pion crossing time with a resolution of about 100 ps;
- Produce the L0 trigger for a charged track.



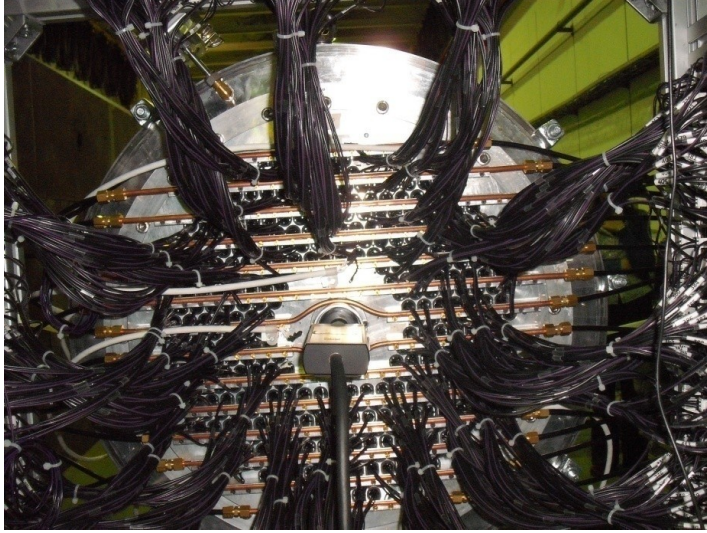
2000 Photomultipliers located in two spots (1000 PM each)

RICH prototype publications

- "Construction and test of a RICH prototype", G.Anzivino et al, NIMA, v.538, p.314-318, 2008.
- "Pion-Muon separation with a RICH prototype for the NA62 experiment", B. Angelucci et al, NIMA, v.621, p-205-211. 2010



Cherenkov Ring Radius (mm)



PM, sockets and Power Supply

- >1800 PM already delivered, last batch in order
- PM sockets (HV dividers) will be ordered to Hamamatsu during 2011
- CAEN HV power supplies already purchased, spares in order

SY1527 mainframe (16 slots)

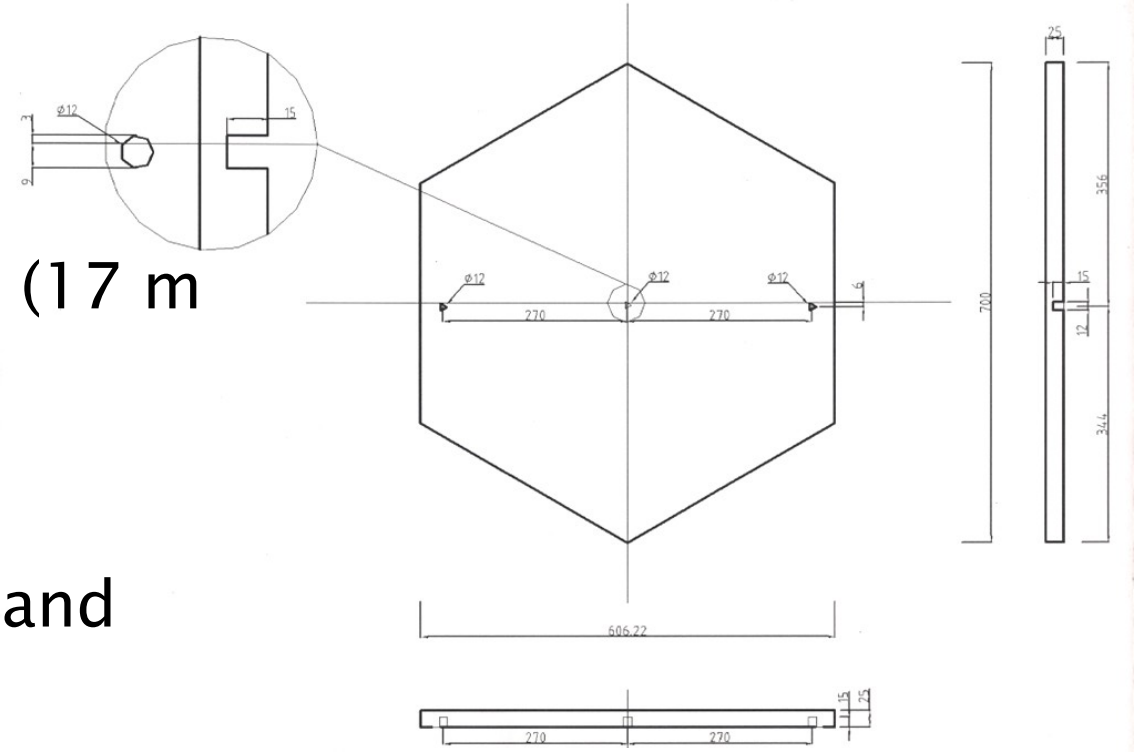
A1535 (24 ch, 2 slots)

A1733 (12 ch, 1 slot)

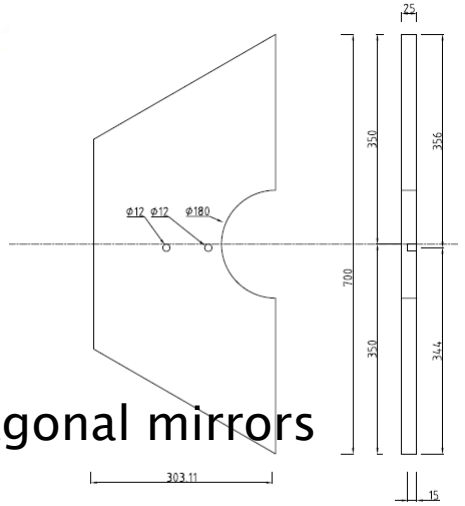
Mirrors

- 20 spherical mirrors (17 m focal lenght) of high optical quality
- Mirrors under final machining (shaping and optical refinement)
- Shipping at CERN foreseen by the end of 2010
- Aluminization and coating to be done at CERN
- Quality tests

18 hexagonal mirrors



2 semi-hexagonal mirrors



Vessel, Mirror support, gas system

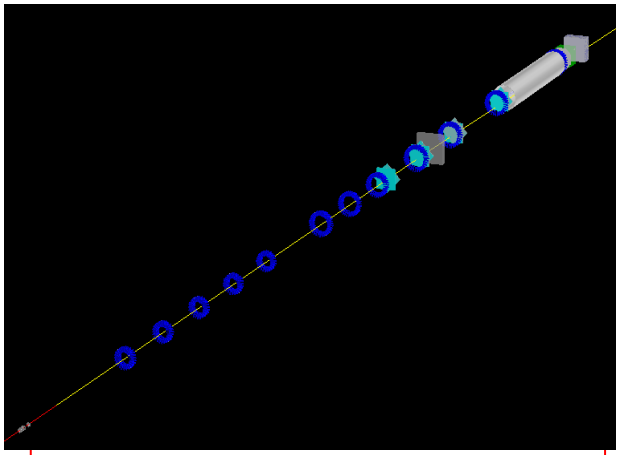
- Vessel
  - Design to be finalized in 2011 and vessel to be built by the end of the year
- Mirror support
  - Prototypes built and under tests
  - Keep material budget as small as possible to limit impact on the LKR performance
  - Design to be finalized by mid 2011, then submit the order
- Gas System
  - CO_2 used to purge the vessel, then it will be filtered out as
  - Neon is gradually injected
  - Gas system installation foreseen in 2012
  - Design well advanced

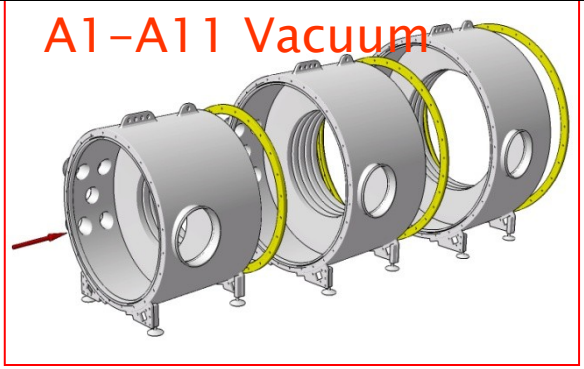
Photon Vetoes

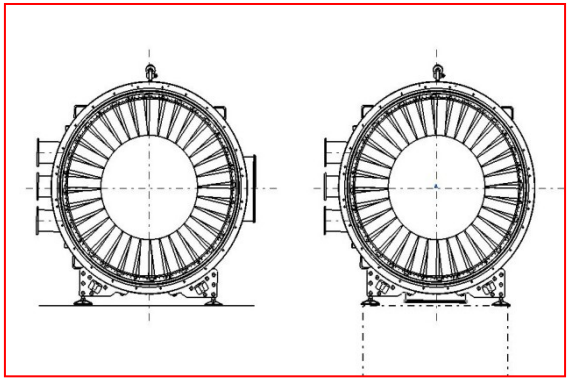
(cf. Antonella Antonelli)

Large angle veto (LAV) "Post-card"

- 12 LAV stations mounted along 120 meter decay region 6 meters apart
- 4 different types:
  - 160, 240 blocks; 5 layers in vacuum
  - 240 blocks; 4 layers in vacuum
  - 256 blocks; 4 layers in air
- Angular coverage 8-50 mrad
- Inefficiency $< 10^{-4}$ from few hundred MeV to 35 GeV
- Sensitive elements: 2500 OPAL barrel calorimeter lead glass blocks
- Efficiency measurements with electron beams in 2007:
  $1-\varepsilon<10^{-4}$ for 200 MeV<E<500 MeV







Construction status

•A2 Shipped to CERN on August 9, transport and handling monitored with ShockLog data recorders, no acceleration events during transport

•A2 installed in T9 area for test beam, then shipped to building 185

•A3 vessel **delivered** and rotated into assembly position **06 Aug**
•All needed blocks processed and “bananas” assembled
•As of 16 Nov, 3 out of five layers **installed and tested**
•Simultaneously processing blocks/bananas for A4
•**Goal is to be ready for shipping A3 by end of Nov**
•**A4 bananas ananas 15/40**

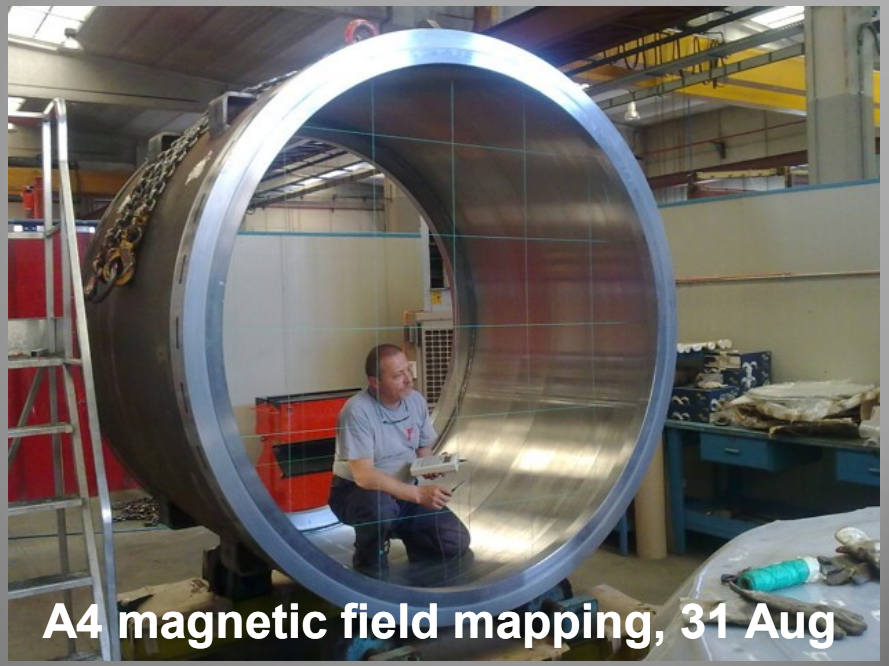
04 Aug

31 Aug

A3 rotated into position, 06 Aug

A4 & A5 vessel status

A4 vacuum & leak test, 27 Aug

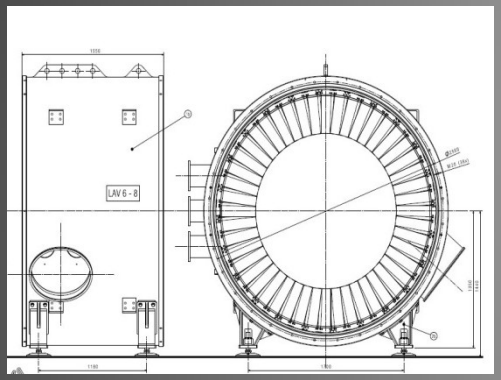

A4 magnetic field mapping, 31 Aug

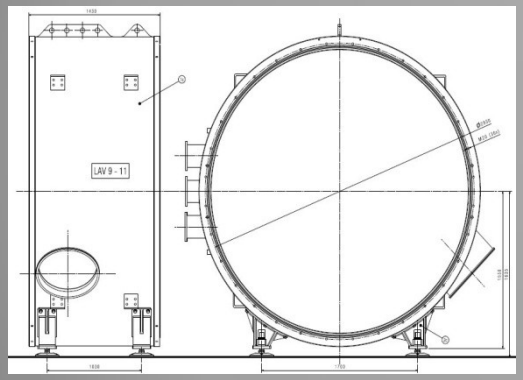
A4 Ready and tested,
Delivery expected **end of November**

A5 Steel cut, edges bevelled, magnetic field mapped
y mid December

Design and planning A6-A8, A11

A6-A8
5 layers
Ø259 cm





A11
4 layers
Ø299 cm

Reminder:

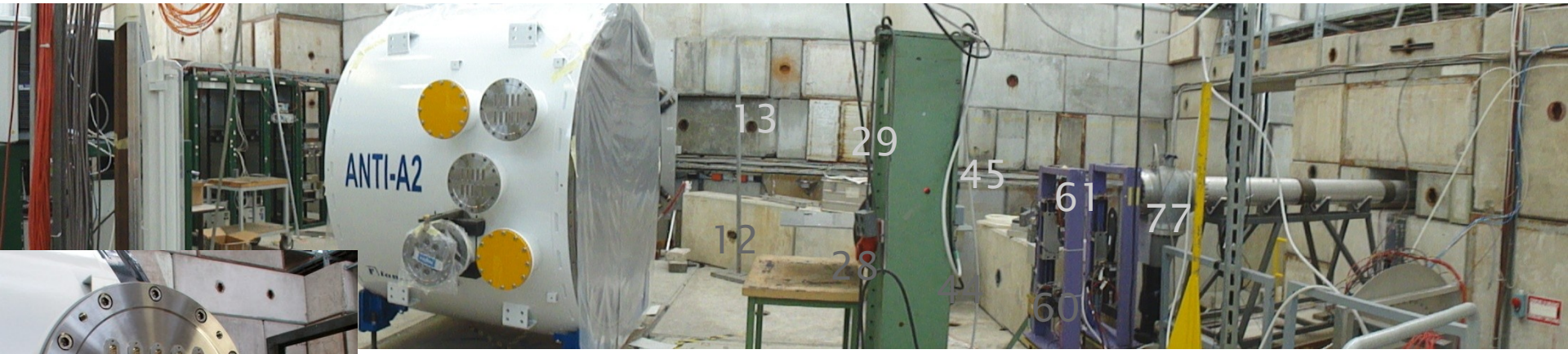
- A9, A10 have same dimensions as A11, but are made of stainless steel
- A12 has open geometry—design is totally different

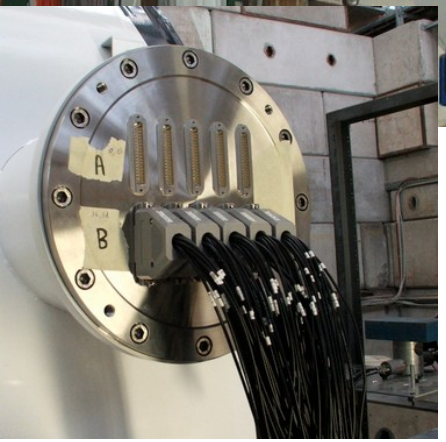
Costs considerably increase with size

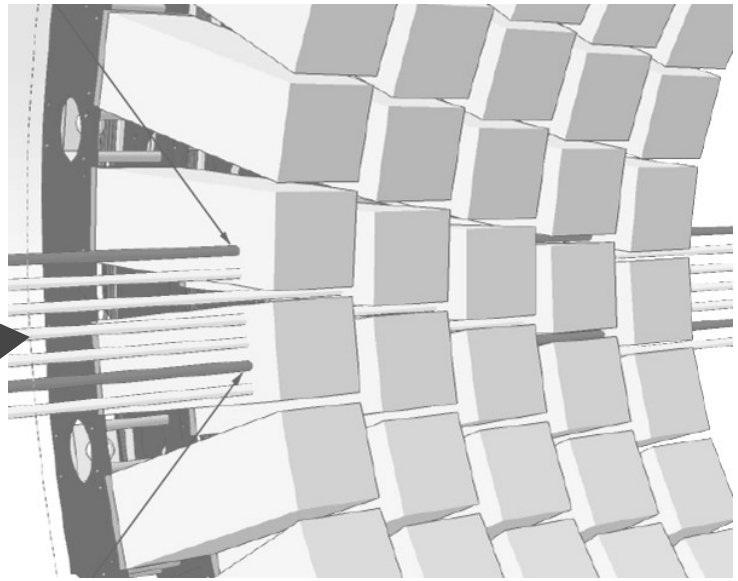
- Flanges need to be made from single slab of steel—custom casting
- Increased transportation costs (wide load)
- Labor cost is relatively unchanged (same procedures, tools, etc.)

Bidding procedure closed 15 Sep—adjudicated by Fantini factory, material proc...

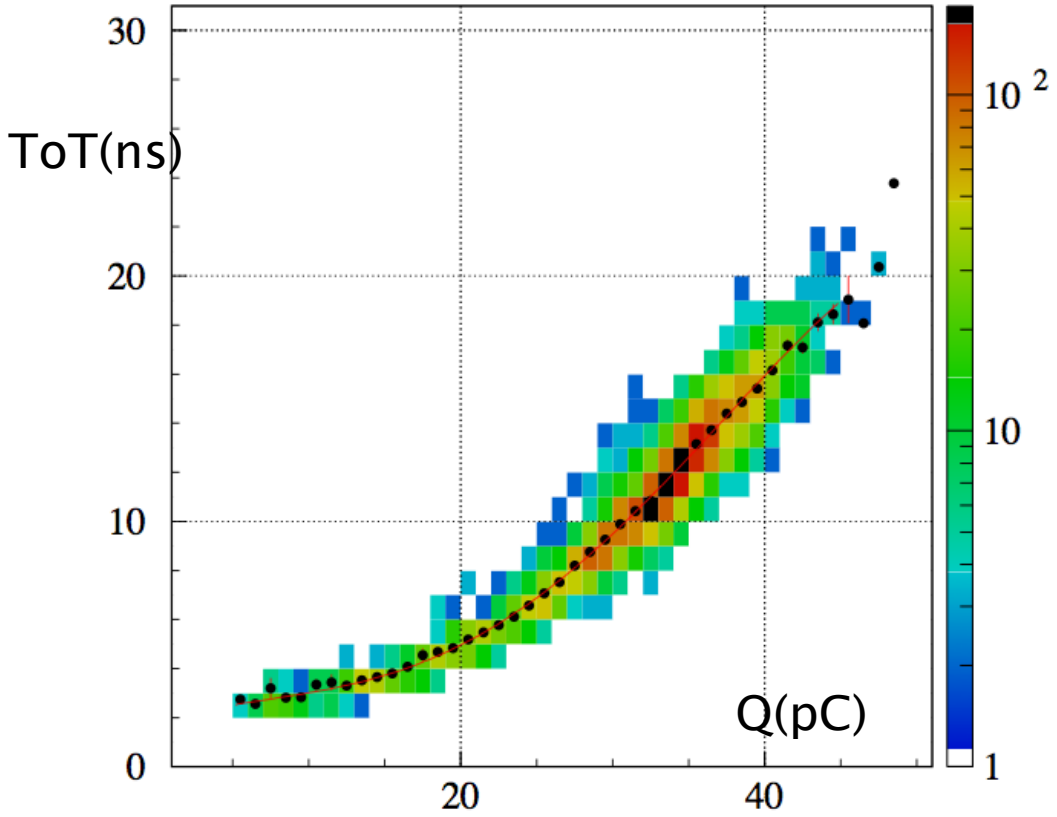
Test beam setup (PS-T9)







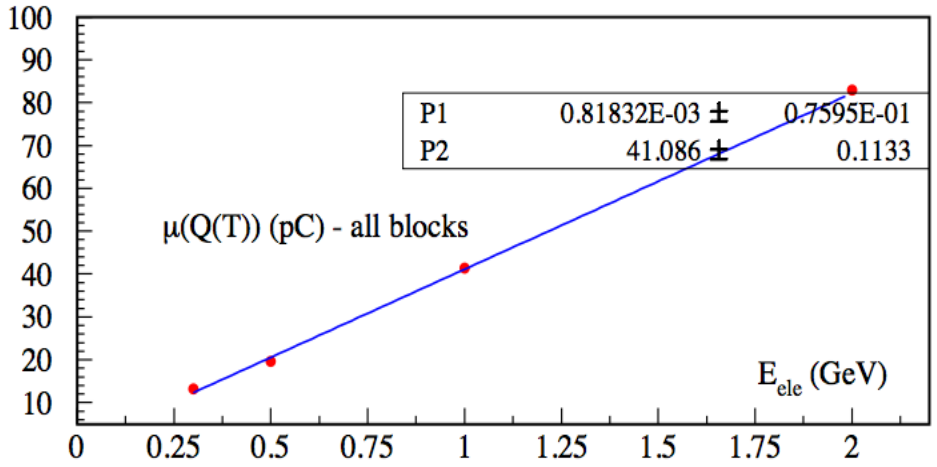
Total charge with ToT vs. QDC

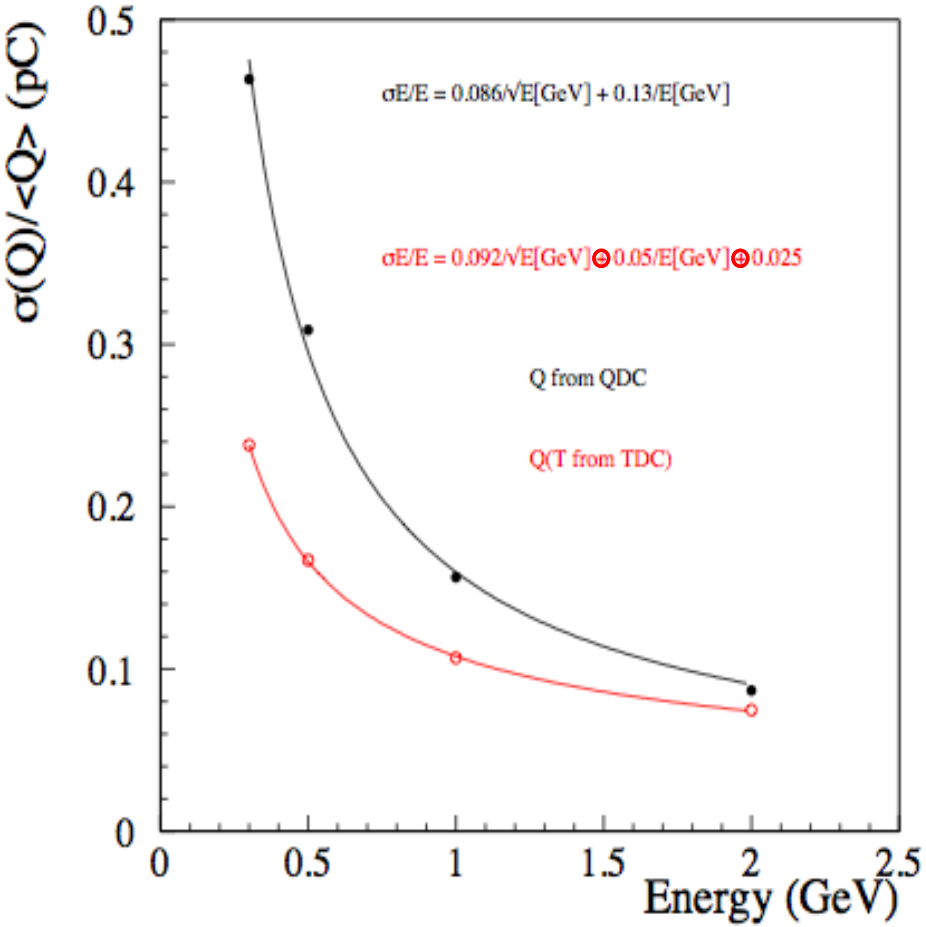


Very basic parametrization with 4th order polynomial of charge vs. ToT curve considering all the hit blocks together

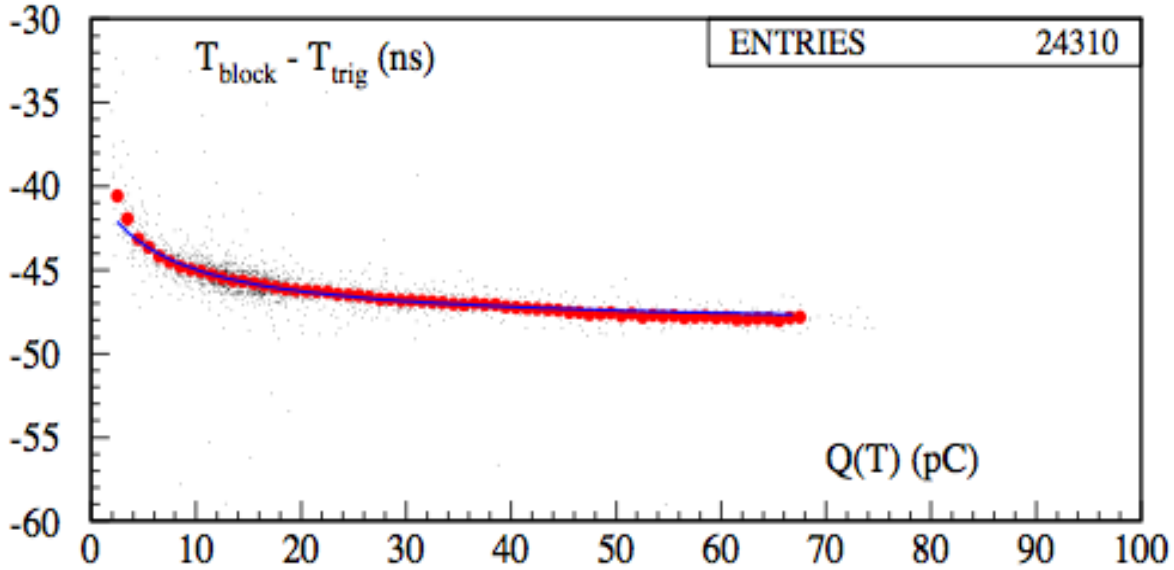
A2 Energy resolution and linearity

2 beam **Cerenkov** counters (TDC & QDC):Operated at **two different pressures** to select electrons in a given momentum range:

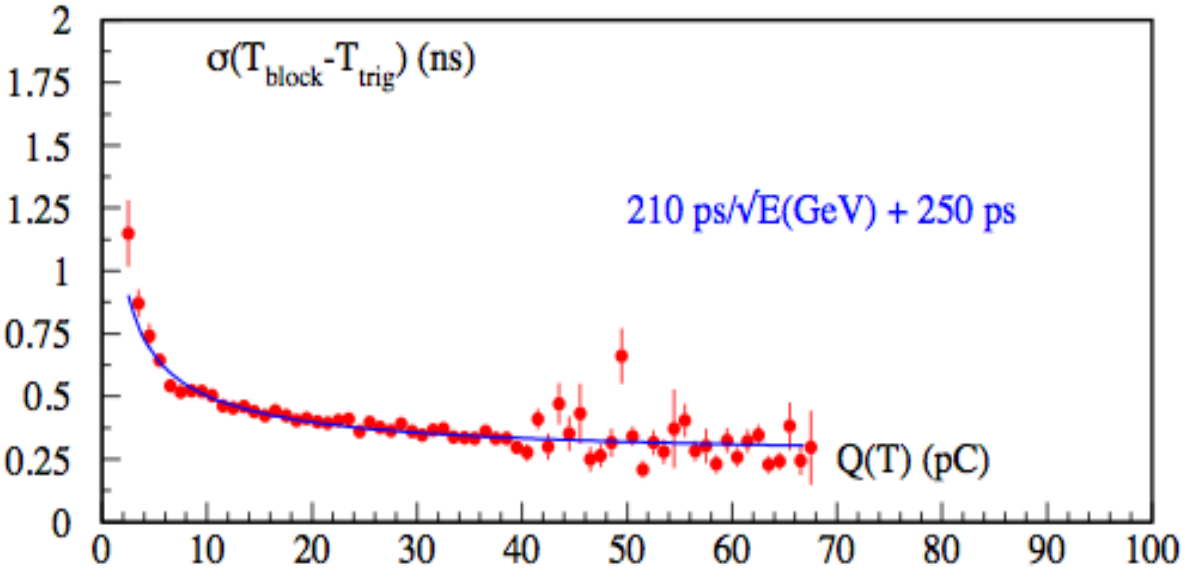




A2 Time resolution



Electrons, first hit block. Time slewing fit and corrected



Time resolution after time slewing correction

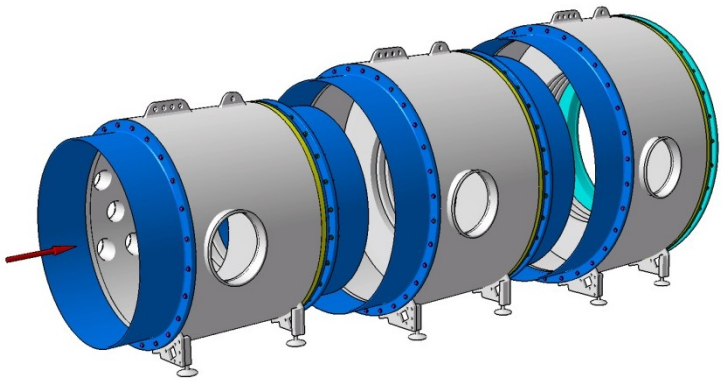
LAV: 2011 Work Plan

•Construct and test 3 intermediate diameter vessel (A6-A8) and one of the largest one (A11). By the time of the synchronization run seven vessels will be installed.

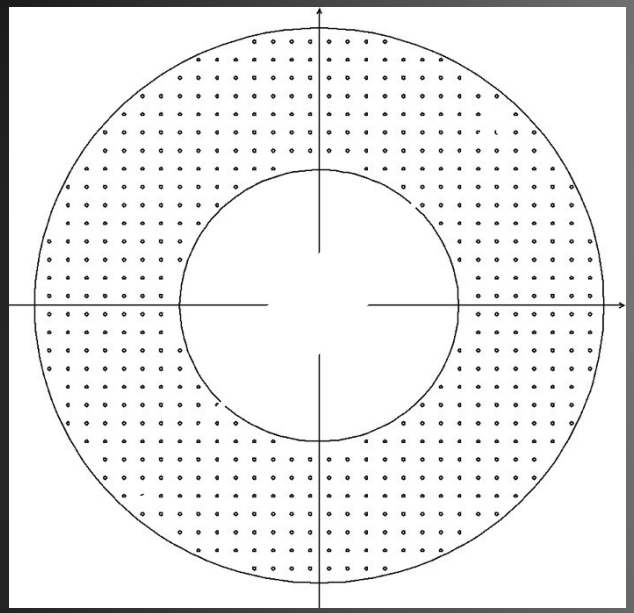
•Half of the frontend electronics will be produced tested and installed.

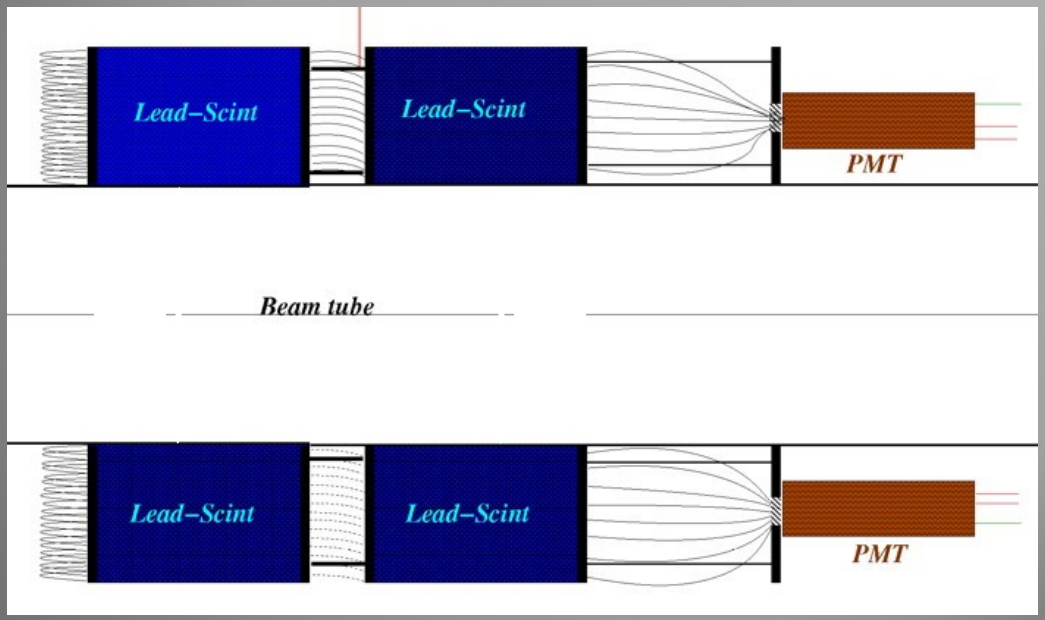
•The mechanics an the relative tools for A9,A10,A12 will be defined and the bid procedure will be started.

•Test the complete chain, final crates final frontend board and final TEL62 to be ready for the synchronization run.



Proposed shashlik design for IRC





Front and back segments read out by through WLS fibers, same PMTs

4 (or more) sectors in azimuth to decrease rate/channel

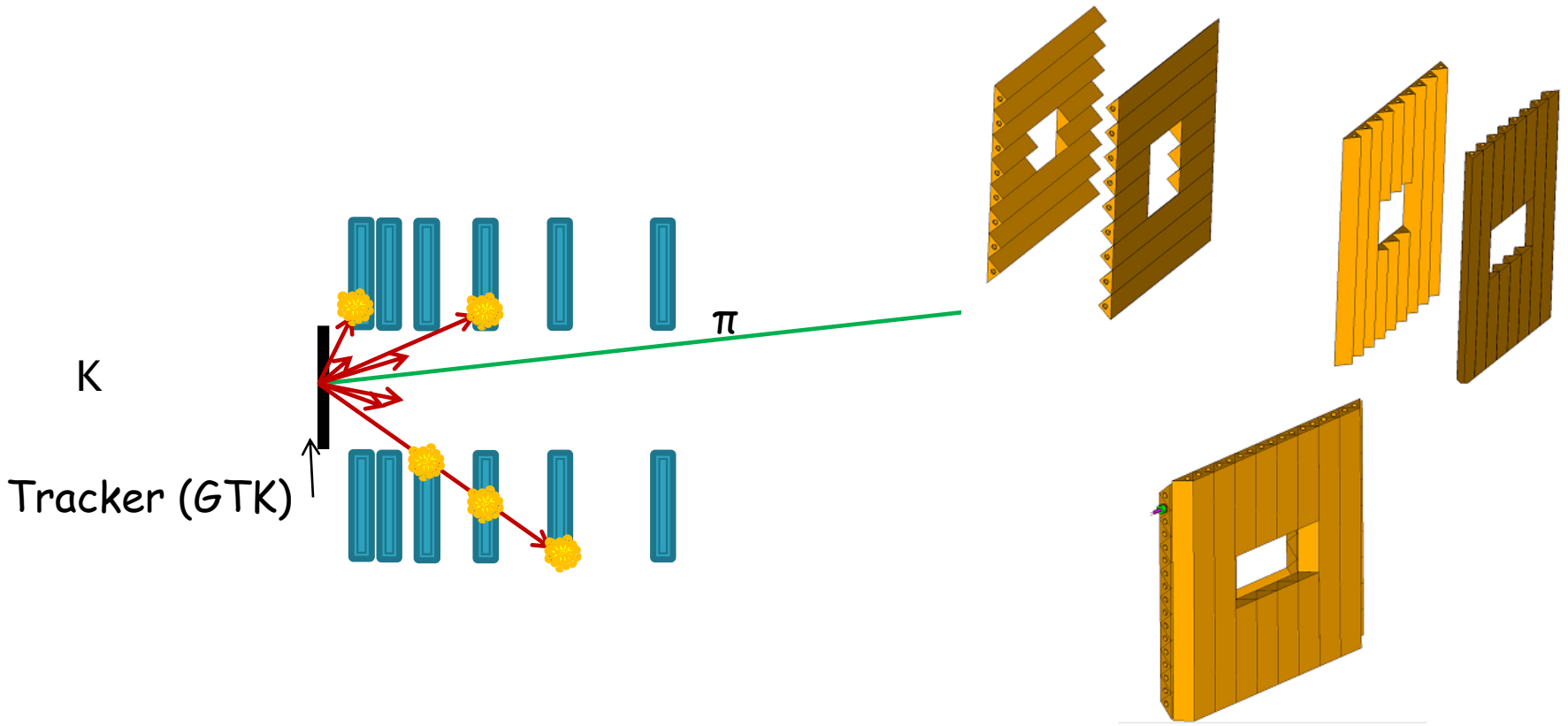
Arc-shaped scintillator tiles with aluminized edges – no cracks in lead

Relative rotation of 40 mrad between front and back segments

Detailed simulation is ongoing to fix dimensions

Stud for the high rate (~5 MHz)

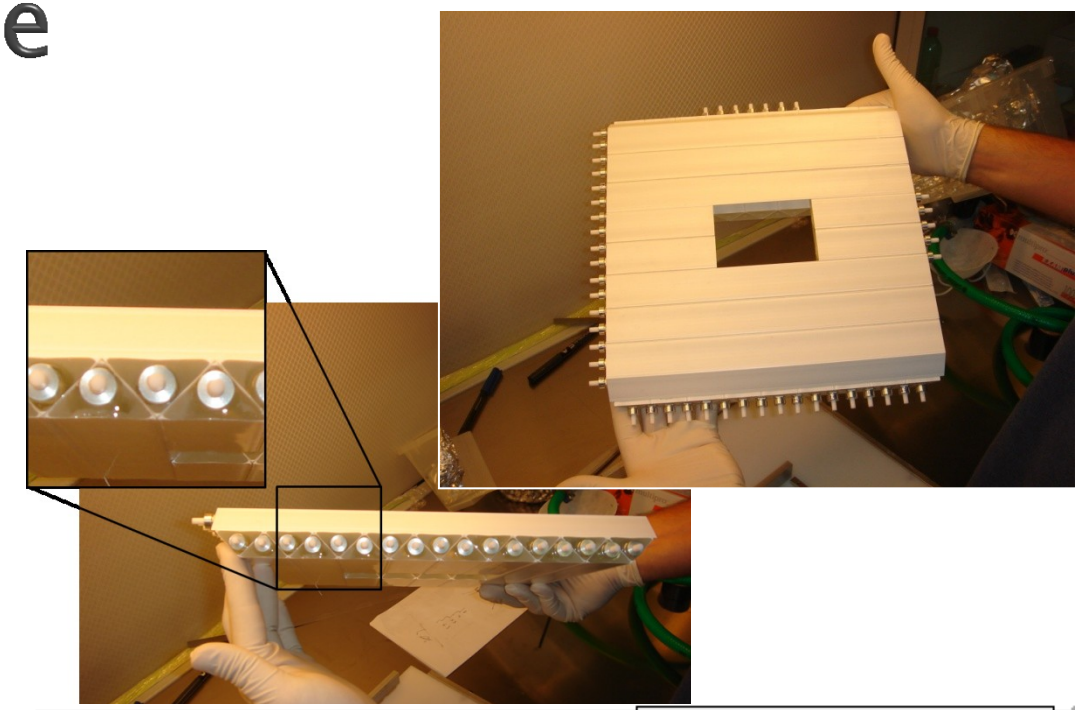
CHANTI: purpose and methods

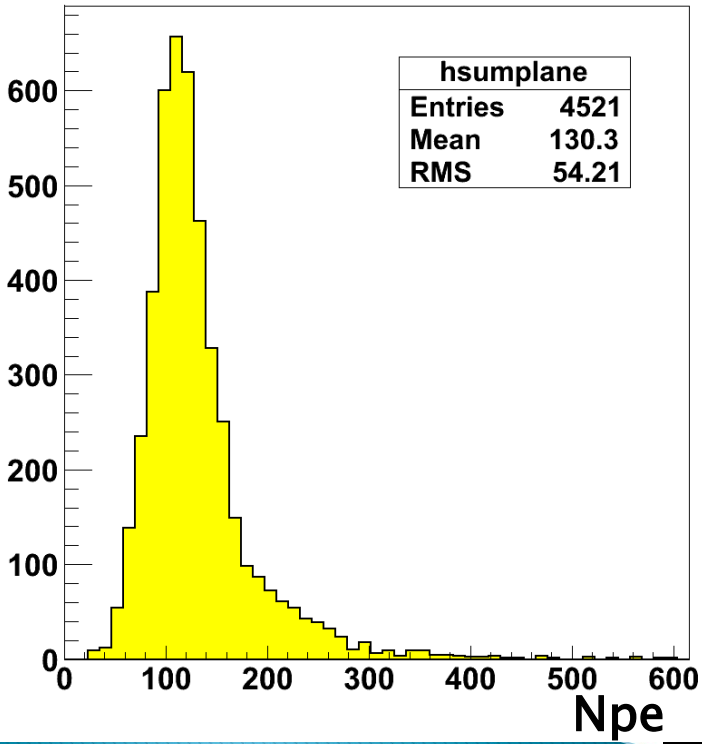


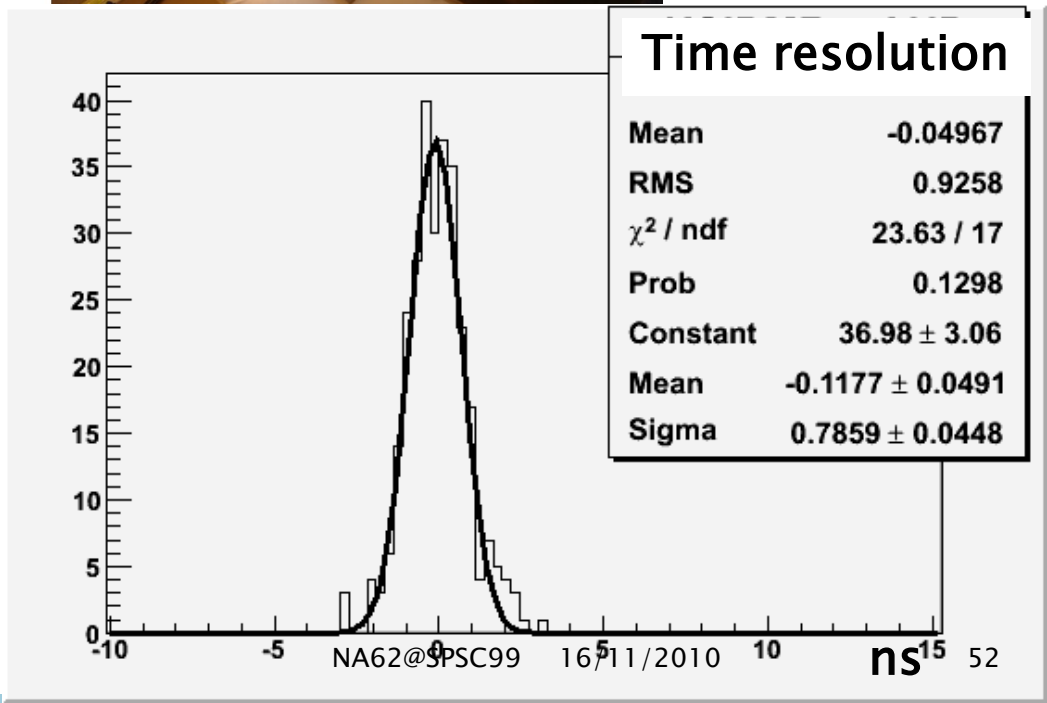
- Six "guard rings" to veto K inelastic interactions on GTK-3 (affecting ~10^{-3} of kaons)
- Staggered triangular scintillator bars coupled with fast WLS fibers with SiPM readout to form 6 xy planes
- G4 simulation: full detector rate O(2 MHz), vetoing efficiency ~99% dominated by acceptance

CHANTI: prototype

- Built in Naples end of July 2010
- All bars tested for response before assembly using a β source
- Currently under tests for MIP response and time resolution preliminary results show O(100) pe/plane and O(1 ns) resolution.



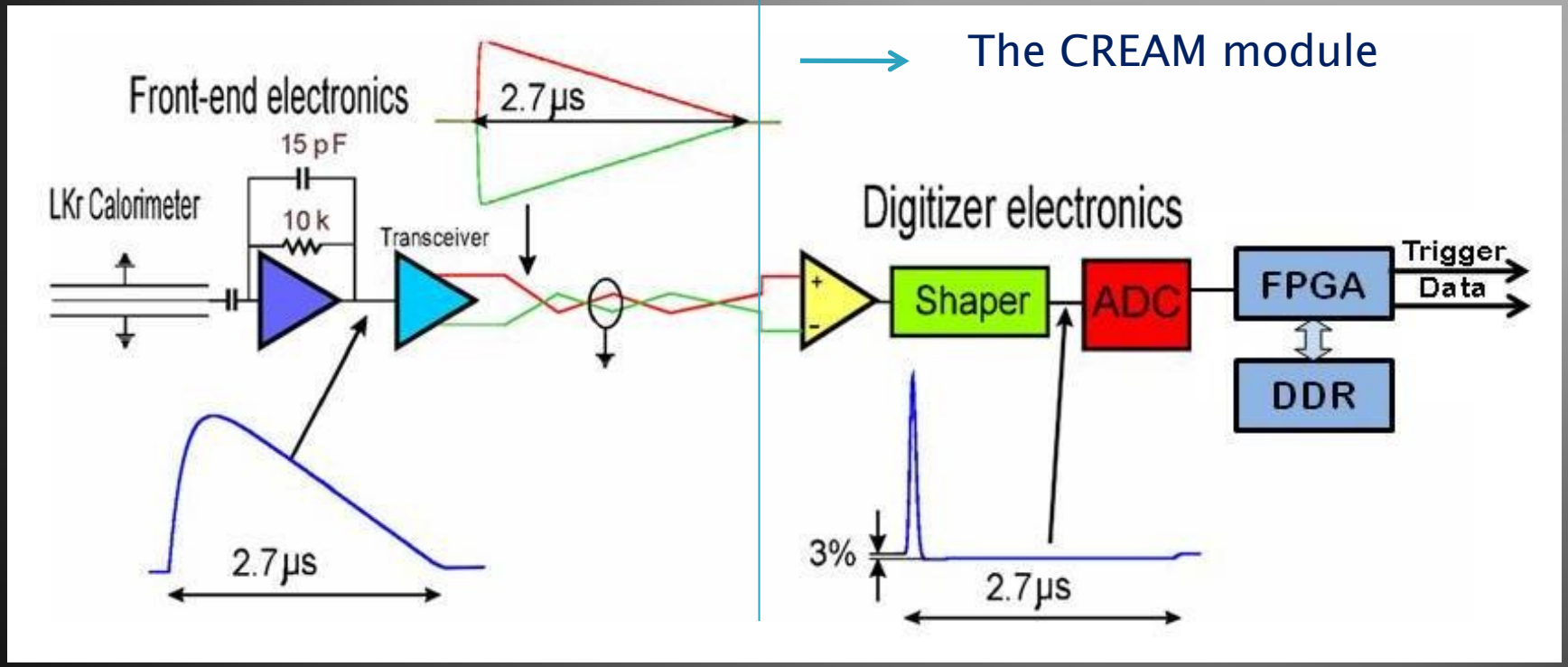




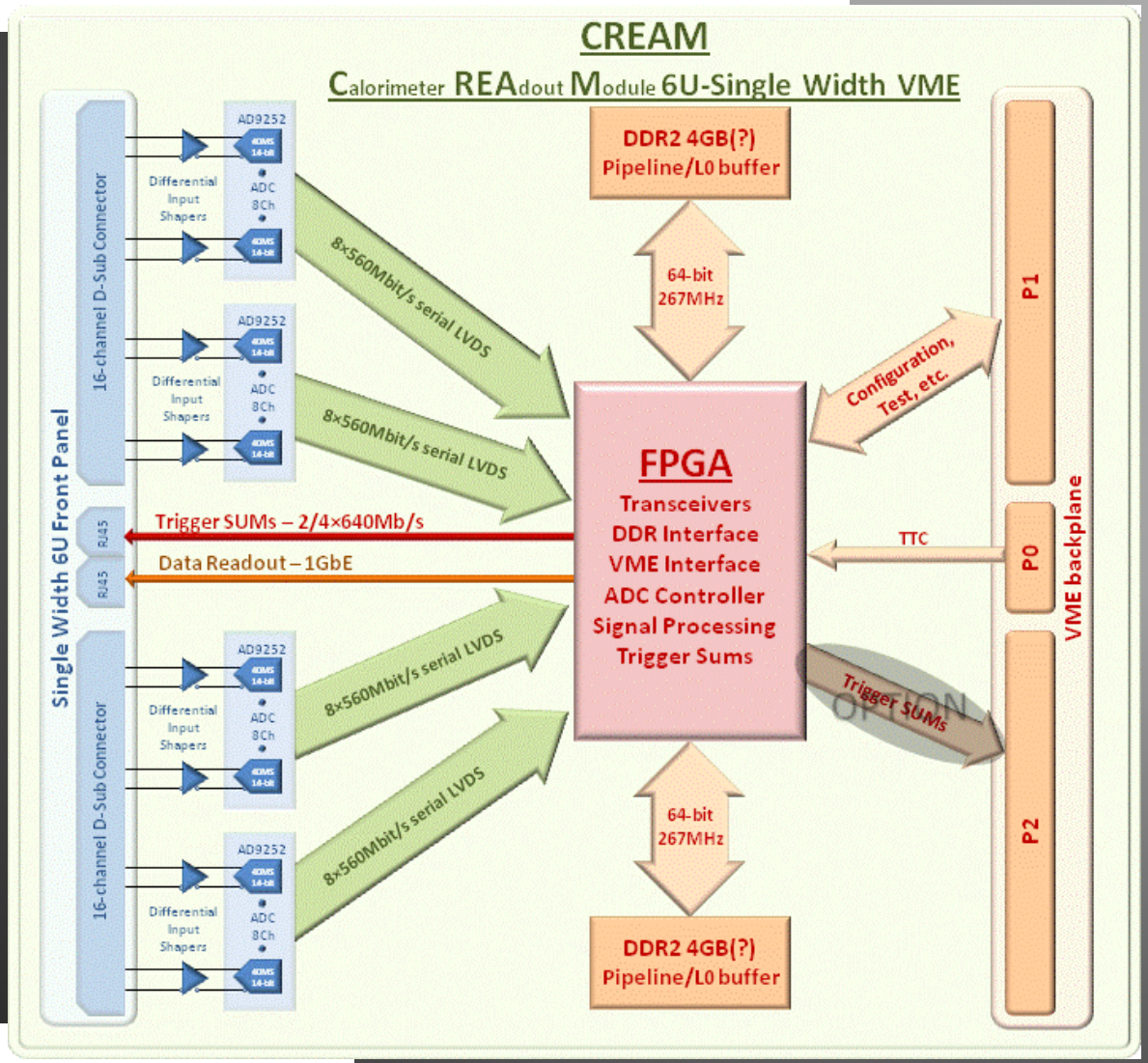
LKR Calorimeter

(cf. Riccardo Fantechi)

LKR Electronics



The CREAM module



Market Survey Completed

LKR Cryogenics work package

Work Package on the operation and maintenance of the cryogenic system of the NA62 liquid krypton calorimeter

https://edms.cern.ch/document/1097475/1.2

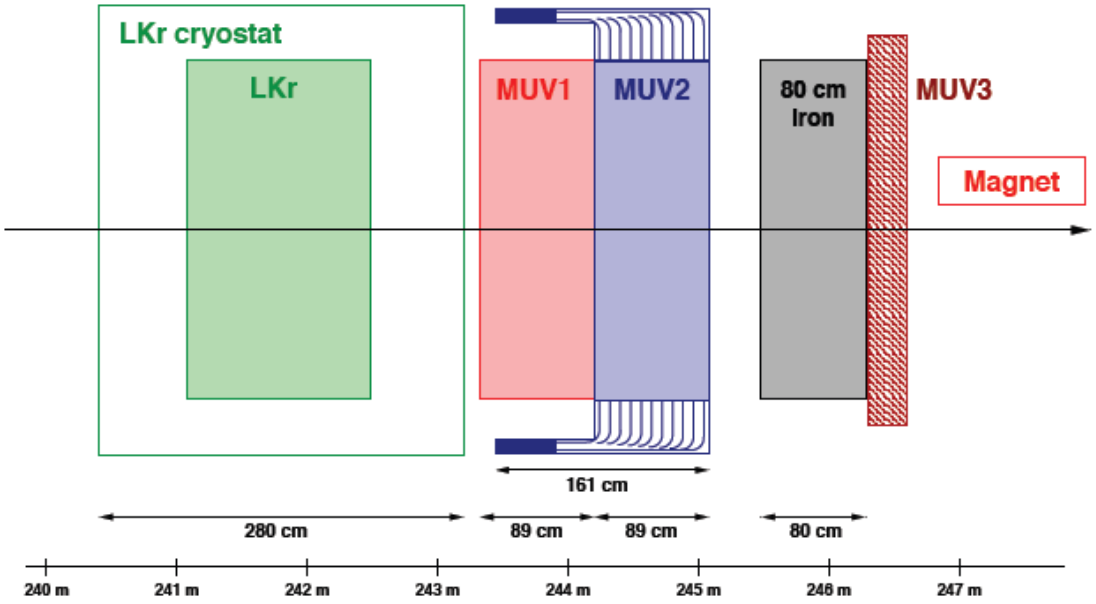
The CERN TE/CRG group shall operate and maintain the cryogenic installation of the NA62 experiment to guarantee the correct temperature and pressure of the liquid krypton in the cryostat

Muon Veto (MUV)

(cf. Rainer Wanke)

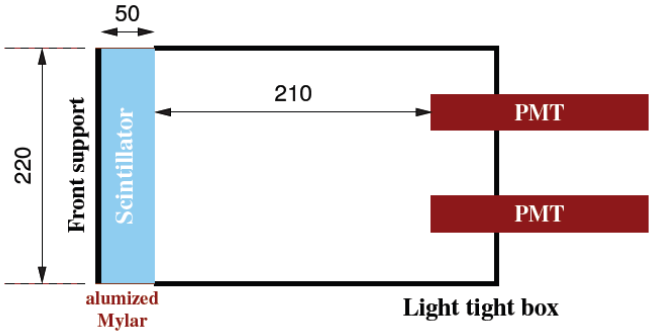
Layout of the MUV

- MUV1: New Module
- MUV2: NA48 HAC front module (turned 180 deg)
- MUV3: New Fast MUV after 80 cm iron for fast trigger veto

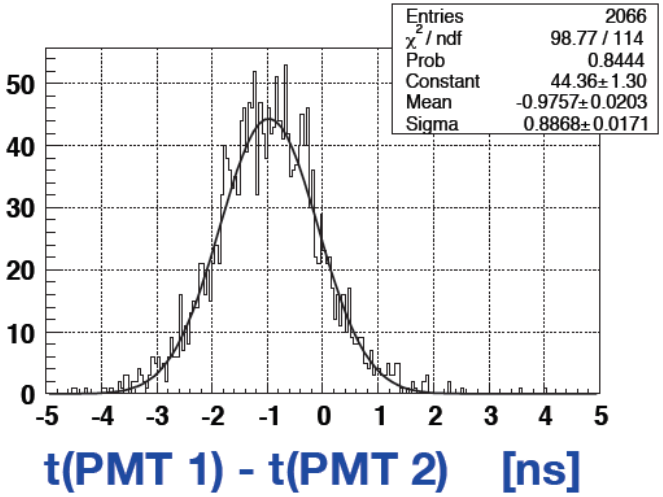


MUV Activities in 2010

- MUV1
  - 1056 scintillating strips (produced in IHEP Protvino by melting polystyrene + additives
  - R&D performed in 2010, light-yield good (10-12 p.e. with WLS fiber read-out)
  - Setup of mass production will start end 2010 and take 3-4 months
- MUV3
  - Time resolution required < 1 ns
  - New Design: 22 x 22 cm^2 tiles (284
  - PMTs from NA48 AKL)
  - Successfully tested in August 2010



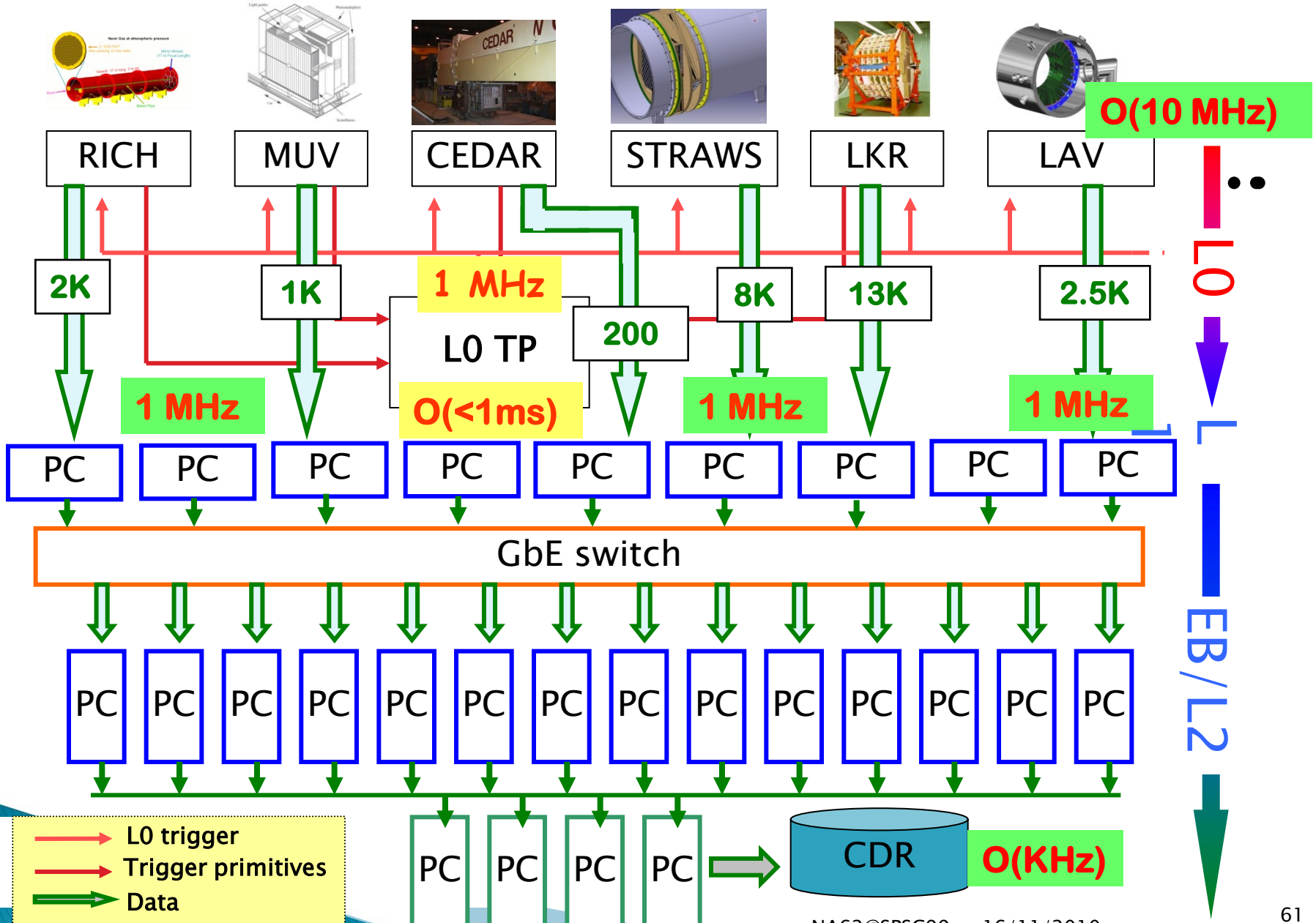
CERN PS-T9



TDAQ, Computing, DCS

(cf. Marco Sozzi, Paolo Valente, Valeri Falaleev)

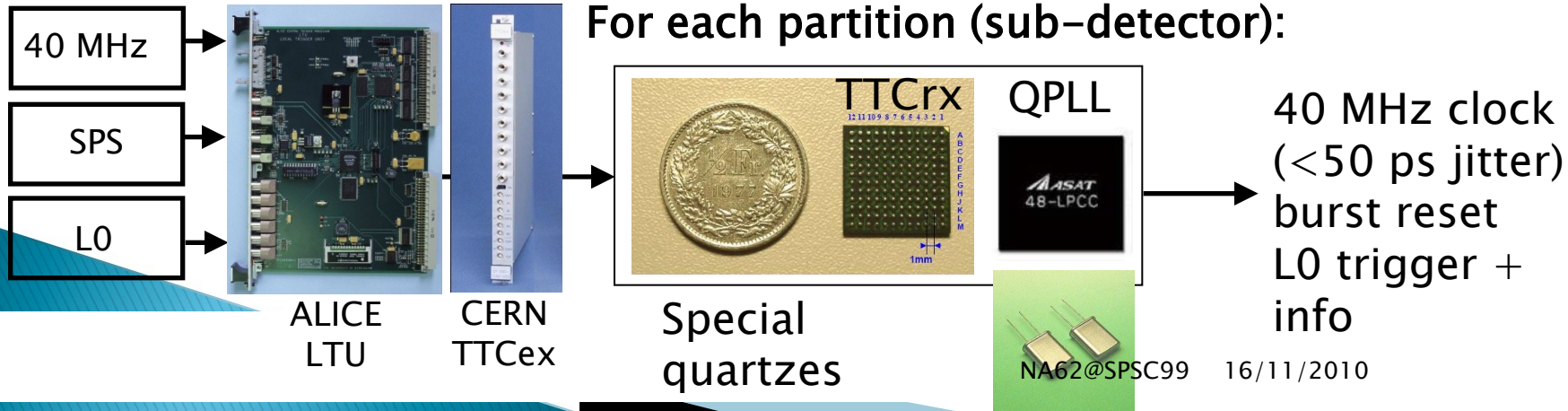
NA62 TDAQ - OVERVIEW



Clock (Birmingham, Bratislava, Pisa)

Use LHC TTC system to distribute: (1) **clock**, (2) **L0 trigger**, (3) **burst timing**.

- Laboratory tests ALICE modules + TELL1: done
- Modified design of ALICE Local Trigger Unit: testing prototypes, software in preparation
- New version of standard CERN TTC encoder: production ongoing
- Detailed definition of protocols ready; NA48 clock for LKr calorimeter: no longer required
- Definition of sub-detector clock network layout ongoing, soon ready for installation
- Oldish component procurement ongoing (future?)

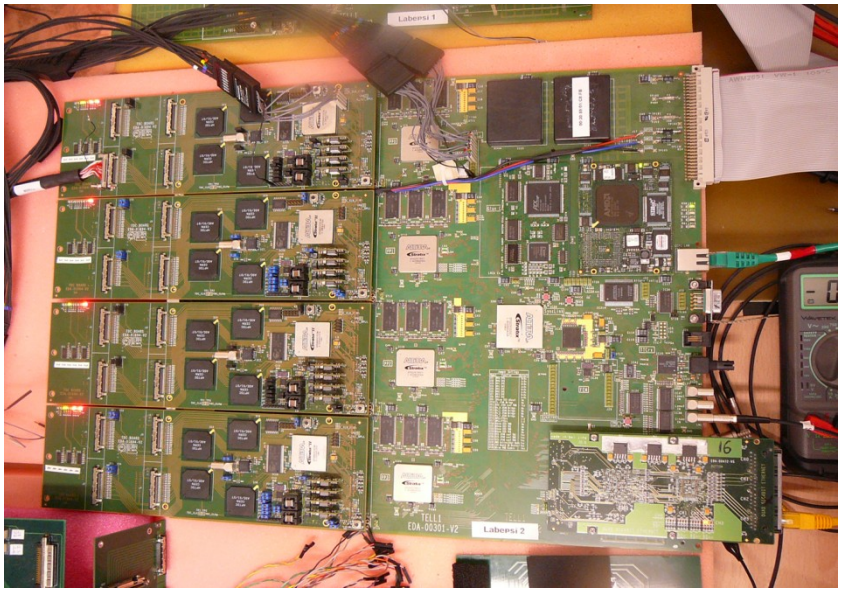


TDC-based “common” system (Pisa)

- Additional project: re-design of general-purpose readout board from LHCb (TELL1→ TEL62): driven by components obsolescence, 4x more powerful. PCB layout starting, expect prototypes early 2011. Component securing well advanced.
Testing, pre-production 2011 (Pisa+ Roma Tor Vergata)

- High-density 100ps TDC daughter-card: delay to due to cable definition, now OK.
First prototypes of final version ready.
Testing, pre-production 2011 (Pisa)

- Major firmware design work ahead.

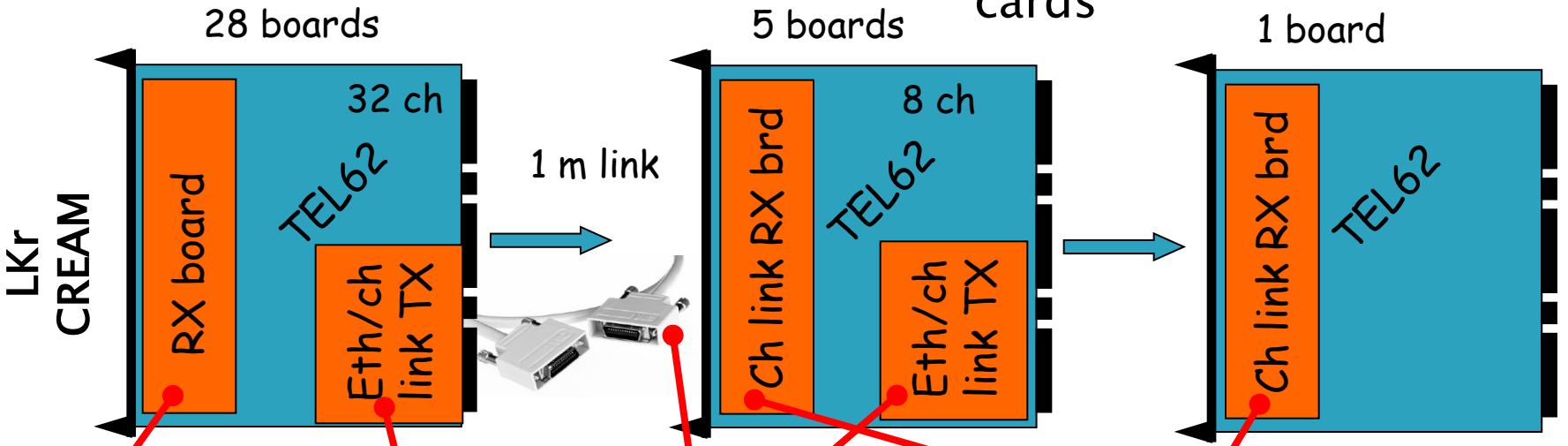


- Prototype system used for straws and (briefly) LAV test beams in 2010

- Suitable crates defined

LKr L0 trigger (Roma TV)

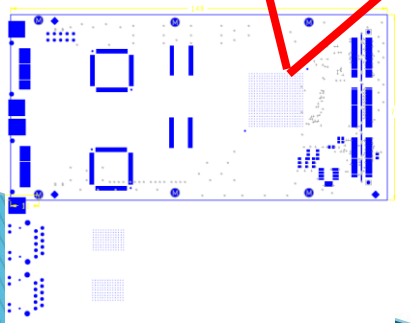
13k calorimeter channels
→ 864 trigger channels
(16-cell DIGITAL sums)
3 new TEL62 daughter-cards



Front: pulse reconstruction (time, position, energy)

No longer FADC

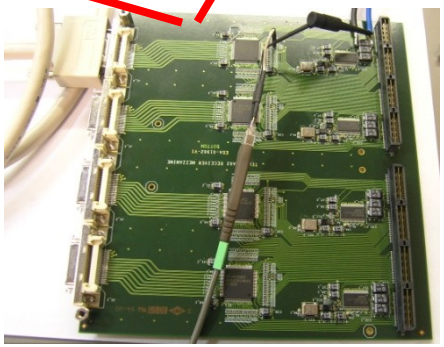
To be designed



Back: summing, reordering

Finalized, to be manufactured

L0TP interface



Tested

Tested with development board.
Manufacturing in progress

Central L0 processor (L0TP)

•Functionality quite well defined.
Design lagging (postponed due to new TEL62 project)

New involvement by additional Ferrara collaborators: started testing of real-time response of a PC-based solution; ongoing.

•Most important missing item.
Temporary replacement might be devised for a technical run.

•**Interim TEL62-based solution** being designed at CERN to allow integration of existing NA48 LKr readout in new NA62 framework: this might act temporarily as a proto-L0TP.

Other flash news

GTK **(Ferrara)**: Specifications & block diagram completed 1 custom FPGA board per GTK ASIC. Data link tests ongoing, GbE controller implemented, testing performance.

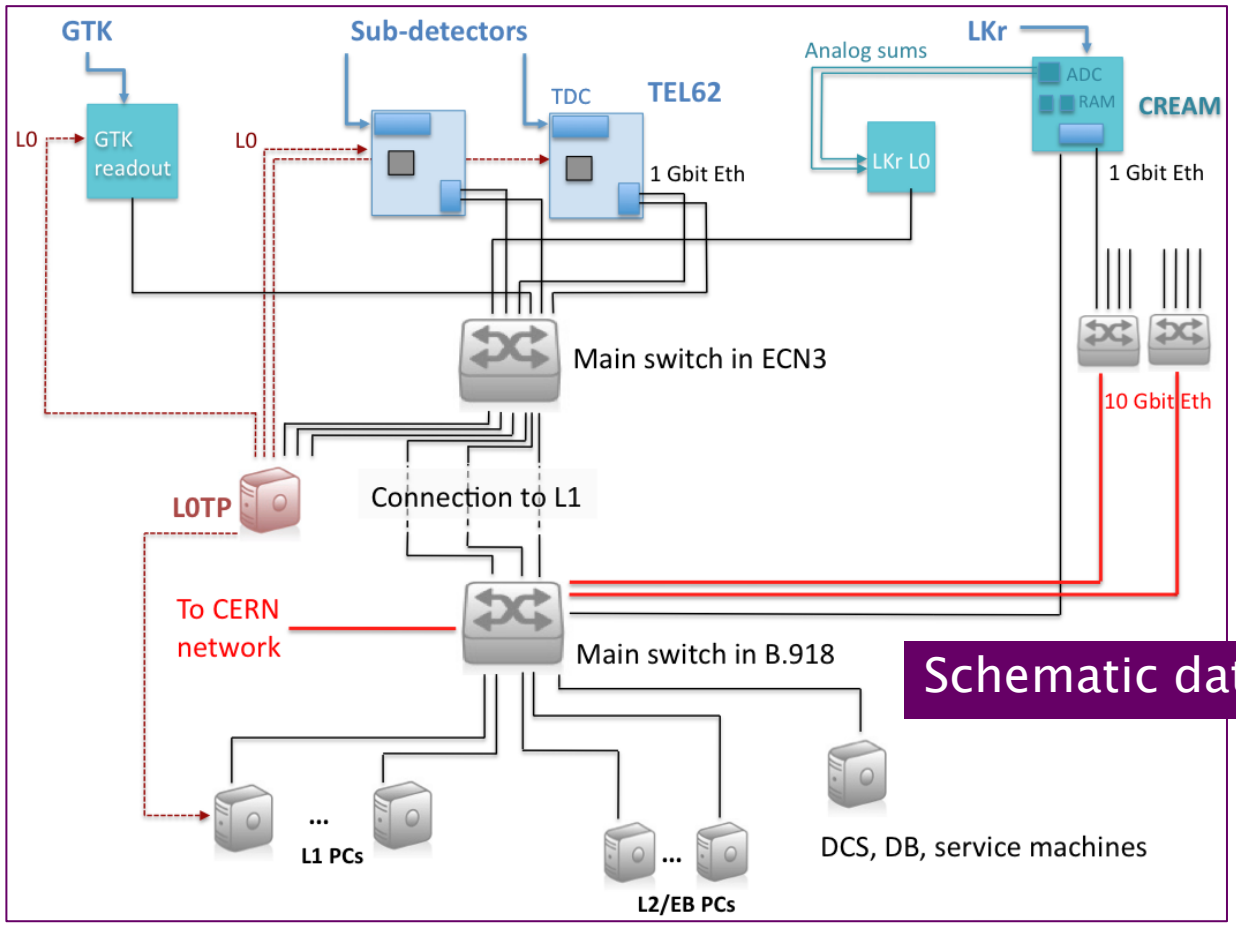
LAV **(Roma/Frascati)**: Final preamp-discri for TOT developed, used in 2010 test beam, final engineering ongoing

RICH **(Firenze)**: Re-engineering of fast pre-amplifier board to start soon (also for CEDAR)

STRAWS **(CERN)**: Pursuing the alternate project of dedicated readout boards and FPGA-based TDCs. Decision early 2011 between this and fallback (common) solution

IRC/SAC **(Sofia)**: Ideas on designing a 12-bit 1 GHz FADC daughter-card for TEL62

Online Computing



RAW event size

Detector	Event size (B)	L1 trigger rate	Through-put at L2 input (MB/s)
CEDAR	216	100 kHz	21
Gigatracker	2250		215
CHANTI	192[1]		18
Anti-Halo			
Large-angle Veto	160[2]		15
Straw tracker	768[3]		73
RICH	160[4]		15
CHOD			
MUV	768[5]		73
IRC & SAC	576[6]		55
Total	≈5k		≈500
LKr Calorimeter	222 k[7]		

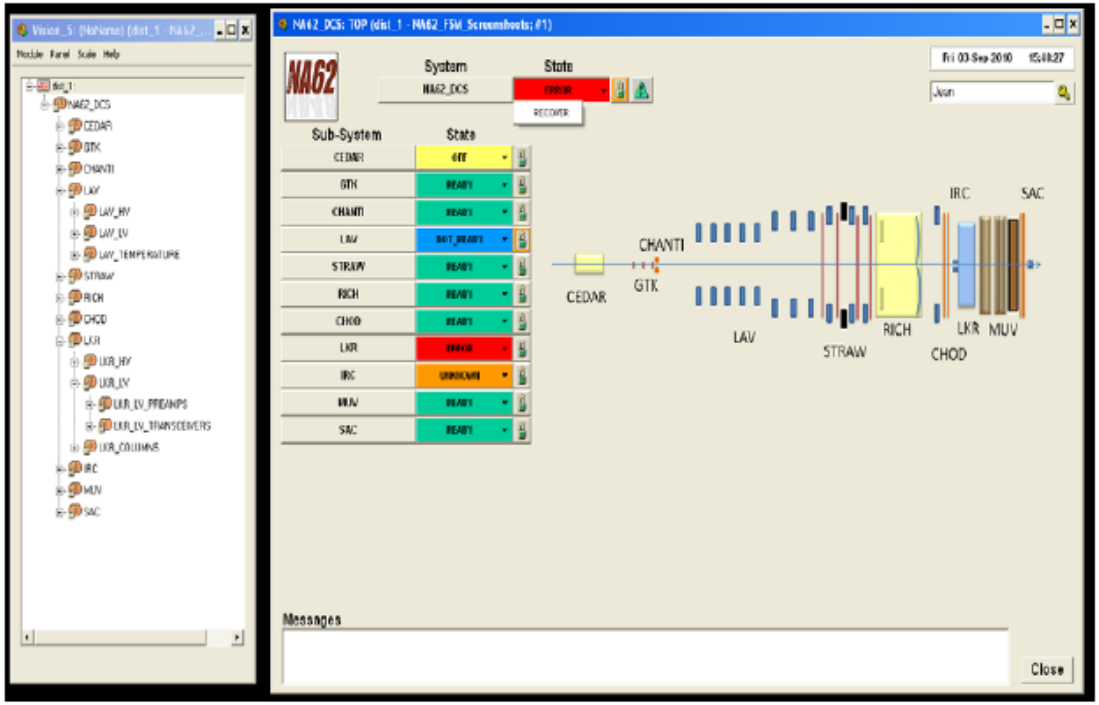
We have defined:

- RAW **event size**
- Required **bandwidth** at the different levels of the Trigger
- Data **concentration** and event-building
- **Online farm** architecture & size

DCS status report

Main DCS activities during last year:

- Prototyping
  - **A prototype system for a long term vacuum test of LAV1**
  - **The system was re-used for the beam test of the LAV2 in the summer of 2010**



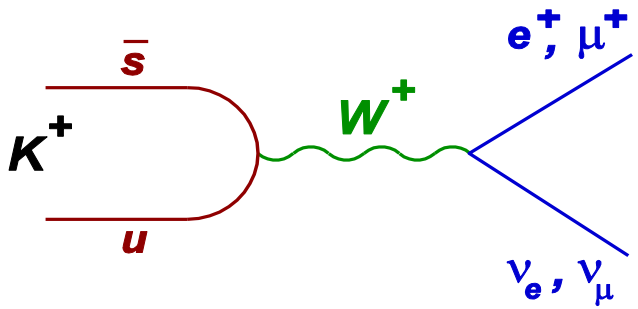
- Preparation of "User Requirement Document"
  - **A survey of sub-detector user requirements completed at the end of 2009**
  - **The first version of the URD is ready**
  - **Final State Machine model of detector operation was elaborated and will be included in the URD soon**

Status of $R_K=K_{e2}/K_{\mu 2}$ measurement

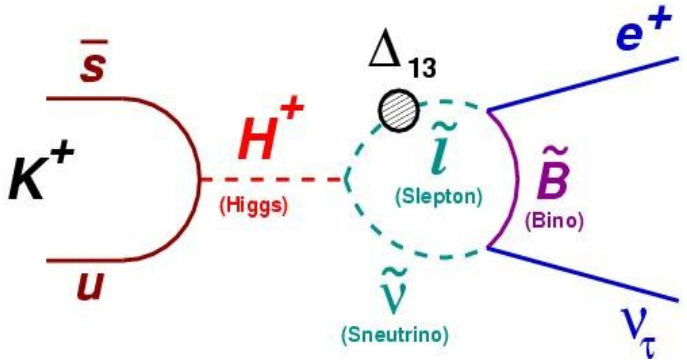
(cf. Evgueni Gudzovski)

R_K: Lepton Universality Test with $K^+ \to l^+ \nu$

SM



New Physics



$$R_K = \frac{\Gamma(K^\pm \to e^\pm \nu)}{\Gamma(K^\pm \to \mu^\pm \nu)} = \frac{m_e^2}{m_\mu^2} \cdot \left(\frac{m_K^2 - m_e^2}{m_K^2 - m_\mu^2}\right)^2 \cdot (1 + \delta R_K^{\text{rad.corr.}})$$

<0.1 % precision of the SM prediction

Partial (40%) data set

Preliminary NA62 $K_{e2}/K_{\mu 2}$ result first presented at Kaon 2009 (Tsukuba, Japan, June 2009): PoS(KAON09)025, arXiv:0908.3858

$\Delta R_K/R_K = 0.64\%$

Significant progress since then:

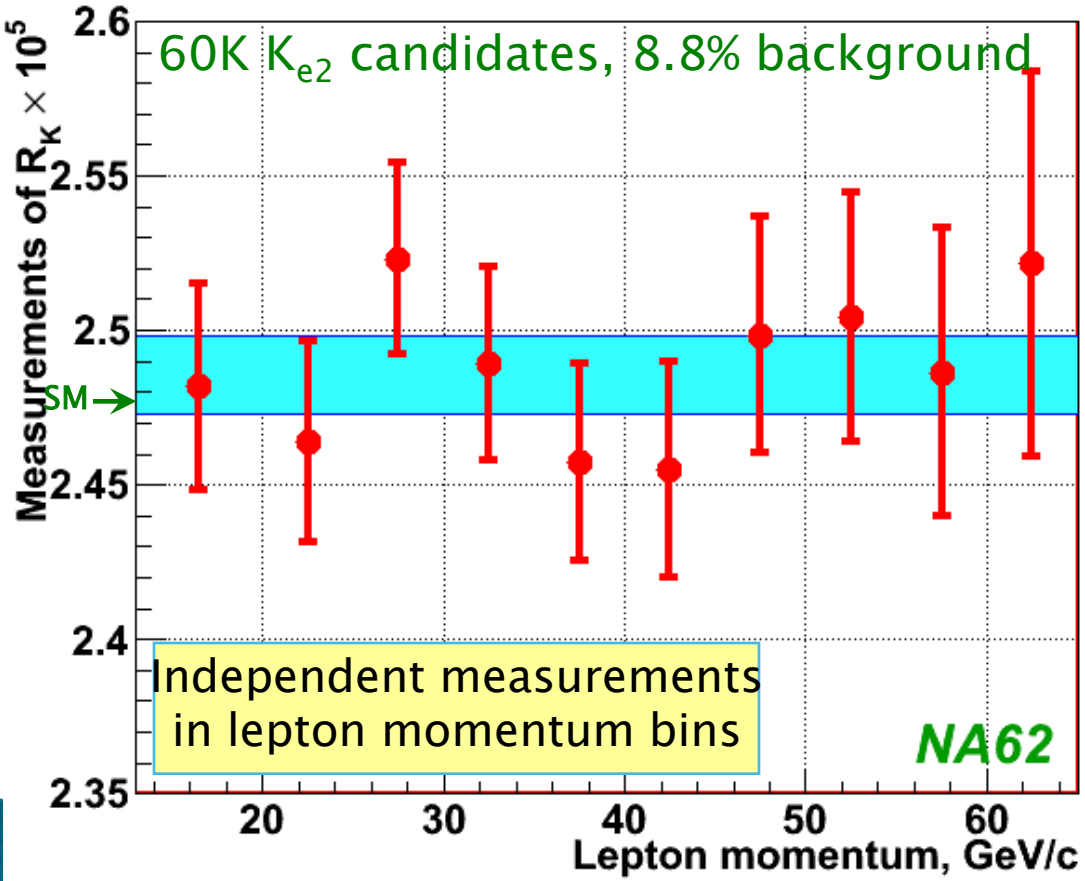
- Beam halo background subtraction procedure improved + other improvements → data sample increased by 17% to 60K K_{e2} candidates without significant change of the systematic uncertainties.
- Dedicated simulations of IB radiative corrections to the K_{l2} decay eliminated the corresponding systematic uncertainty.
- Fine corrections for the local sources of positron identification and trigger inefficiency; fine corrections to the background estimate.

$\Delta R_K/R_K = 0.52\%$

Updated result first presented at BEACH 2010 (Perugia, Italy, June 2010): arXiv:1008.1219, accepted by Nucl. Phys. B Proc. Supp.

June 2010 result (40% data set)

$R_K = (2.486 \pm 0.011_{stat} \pm 0.007_{syst}) \times 10^{-5}$
$= (2.486 \pm 0.013) \times 10^{-5}$



(systematic errors included, partially correlated)

Backgrounds

(arXiv:1008.1219)

Source	B/(S+B)
$K_{\mu 2}$	(6.10±0.22)%
$K_{\mu 2}$ ($\mu \to e$)	(0.27±0.04)%
$K_{e2\gamma}$ (SD^+)	(1.15±0.17)%
Beam halo	(1.14±0.06)%
$K_{e3(D)}$	(0.06±0.01)%
$K_{2\pi(D)}$	(0.06±0.01)%
Total	(8.78±0.29)%

Uncertainties

Source	$\delta R_K \times 10^5$
Statistical	0.011
$K_{\mu 2}$	0.005
BR($K_{e2\gamma}$ SD^+)	0.004
Beam halo	0.001
Acceptance corr.	0.002
DCH alignment	0.001
Positron ID	0.001
1-track trigger	0.002
Total	0.013

Analysis of the full NA62 data set

Varying data taking conditions:

- alternative K^+/K^- beams (for beam halo background measurement);
- Pb wall during early data taking (for muon mis-ID measurement).

K_{e2} sample	K_{e2} candidates	Beam halo background	$K_{e2\gamma}$ (SD) background	Total background
K^+ (Pb)	62,170	1.6%	4.3%	11.9%
K^+ (noPb)	59,964 (analysed)	1.1%	1.1%	8.7%
K^- (Pb)	12,063	8.3%	4.1%	17.8%
K^- (noPb)	10,566	4.7%	1.2%	12.0%

144,763 candidates with 11% averaged background → 0.28% statistical error

(NB: these numbers represent an improvement wrt the report CERN-SPSC-2010-032)

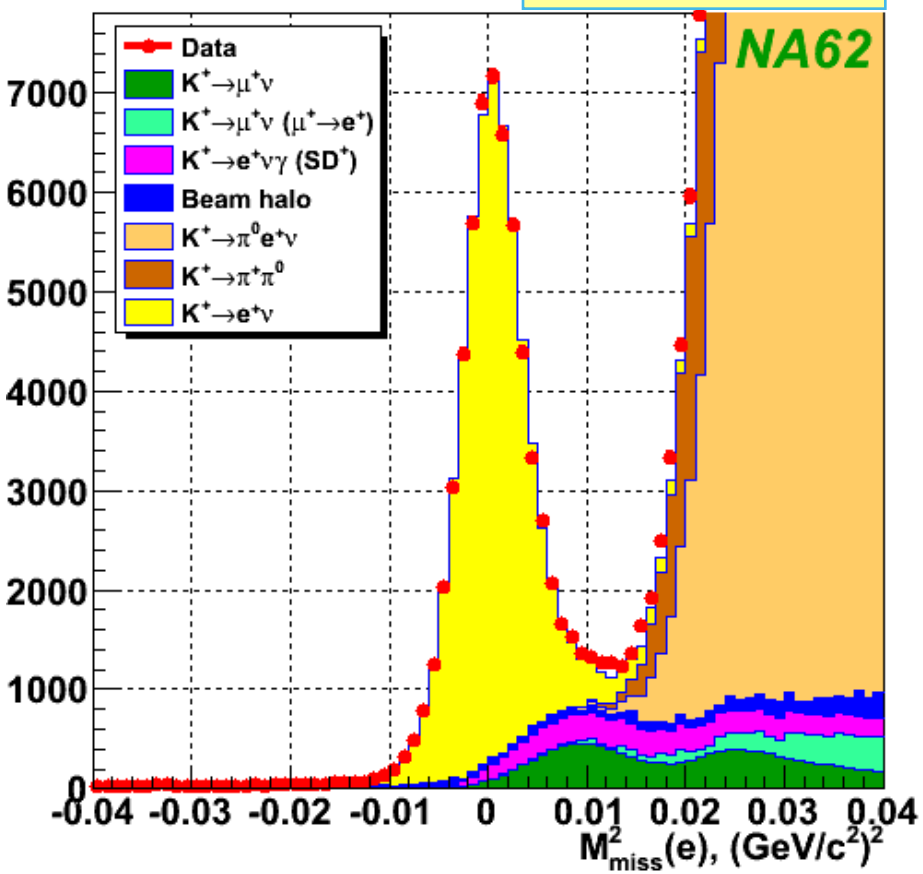
- Reprocessing of the full physics data set completed;
- Electron ID efficiency analysis completed;
- All relevant calibration databases produced;
- MC productions are progressing.

Updates:

- more elaborate beam halo background subtraction for K^- data;
- measurement of BR($K_{e2\gamma}$ SD) to address the high $K_{e2\gamma}$ background with Pb dat

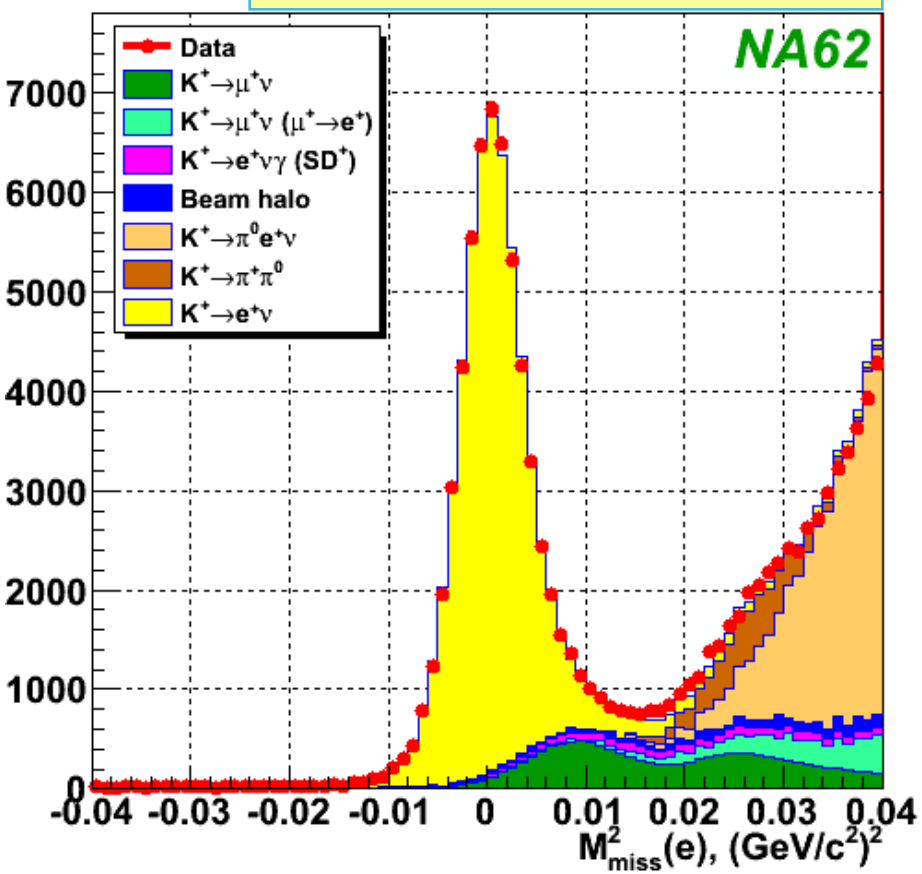
K^+_{e2} samples

Pb wall installed



K_{e2} candidates: 62,170
Background: 11.9%

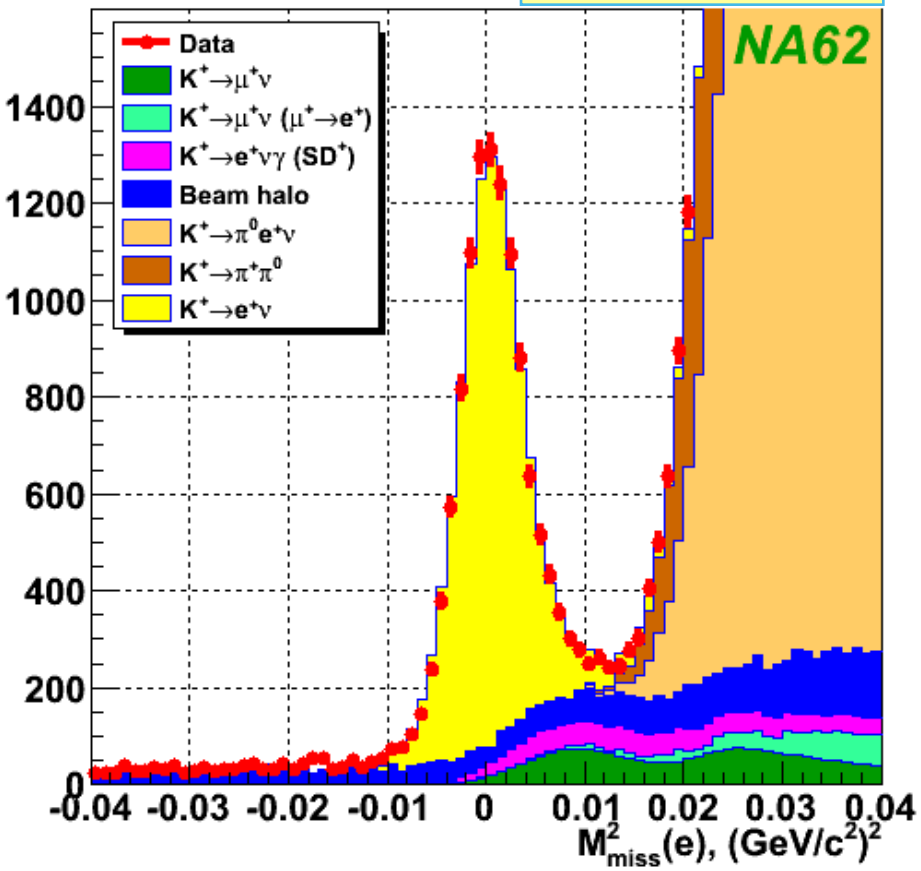
No Pb wall (sample analysed)



K_{e2} candidates: 59,964
Background: 8.7%

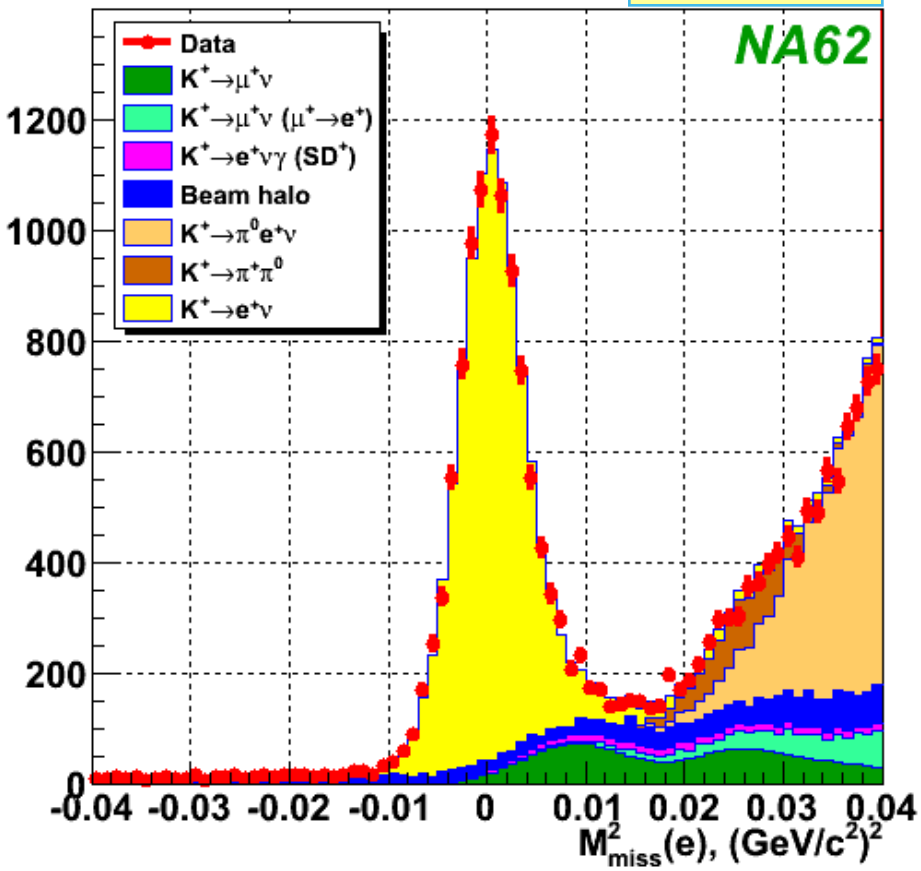
K^-_{e2} samples

Pb wall installed



K_{e2} candidates: 12,063
Background: 17.8%

No Pb wall



K_{e2} candidates: 10,566
Background: 12.0%

Summary R_K

- Analysis of the partial 40% data set was completed in 2010. The corresponding publication is being reviewed by the Collaboration, and is to be submitted as CERN preprint in Dec 2010 or Jan 2011.

- The preparatory work for the analysis of the whole 2007 data sample (calibrations, efficiency analysis, etc.) has been completed.

- Active work on $K_{e2}/K_{\mu 2}$ measurement with the **full 2007 data set**:
  (1) improvement of beam halo background subtraction methods;
  (2) measurement of the $K_{e2\gamma}$ **(SD)** background process;
  (3) averaging of the partially correlated measurements.

- The 2007 physics programme spans beyond $K_{l2(\gamma)}$ studies: precise measurements of K_{l3} and rare decays are foreseen.

Peer Reviewed Publications (since October 2009)

1. **Determination of the S-wave $\pi\pi$ scattering lengths from a study of $K^{+/-} \to \pi^{+/-} \pi^0 \pi^0$ decays.** J.R. Batley *et al.* Oct 20, 2009. NA48/2 Collaboration **Eur.Phys.J.C64:589-608,2009.**
2. **Measurement of the polarization of the Xi0 (anti-Xi0) hyperon beam by the** NA48/1 CollaborationJ.R. Batley *et al.* Nov 20, 2009. **Phys.Lett.B681:406-412,2009**
3. **Empirical parameterization of the $K^{+/-} \to \pi^{+/-} \pi^0 \pi^0$ decay Dalitz plot.** J.R. Batley *et al.*). NA48/2 Collaboration Apr 2010.**Phys.Lett.B686:101-108,2010.** e-Print: **arXiv:1004.1005** [hep-ex]
4. **Measurement of the direct emission and interference terms and search for CP violation in the decay $K^{+/-} \to \pi^{+/-} \pi^0 \gamma$.** (J.R. Batley *et al.*). NA48/2 Collaboration, CERN-PH-EP-2010-006, 2010. 19pp. Published in **Eur.Phys.J.C68:75-87,2010.** e-Print: **arXiv:1004.0494** [hep-ex]
5. **Precision measurement of the ratio $BR(K_S \to \pi^+\pi^-e^+e^-)/BR(K_L \to \pi^+\pi^-\pi^0_D)$ (accepted for publication in Physics Letters B.)**
6. **Precise tests of low energy QCD from Ke4 decay properties** Author : (J.R. Batley *et al.*). NA48/2 Collaboration, cern-ph-ep-2010-036 pdf copy accepted as CERN/PH preprint (Sep 17, 2010) Publ ref : accepted by EPJ C (Oct 11, 2010) open access online EPJ (November 6,2010)
7. **New measurement of the $K^{+/-} \to \pi^{+/-} \mu^+ \mu^-$ decay** Author (J.R. Batley *et al.*). NA48/2 Collaboration. Submitted for approval to CERN-PH Department

Summarizing: NA62 in 2011

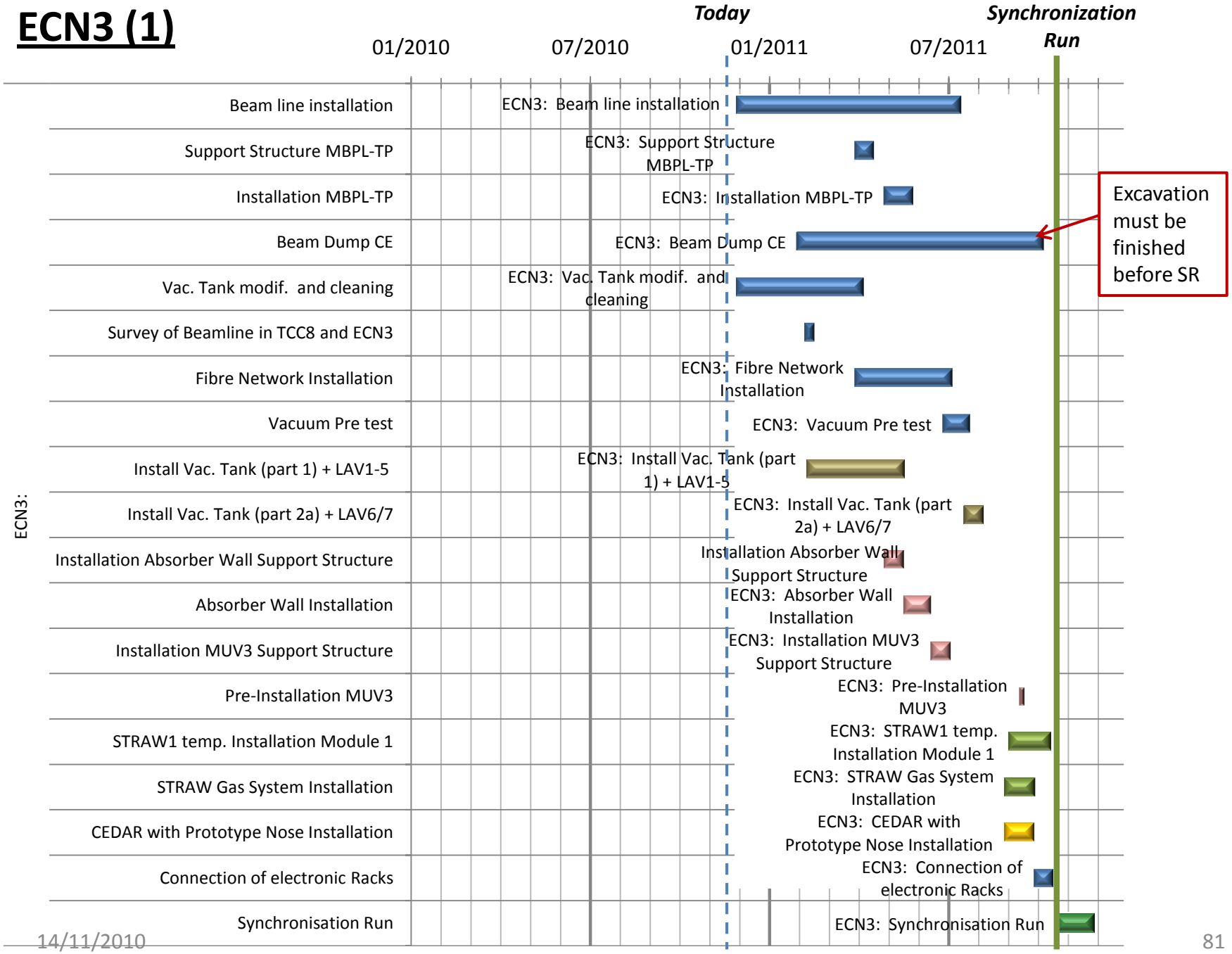
1. R_K Result (100%sample)
2. NA62MC & Reconstruction release
3. NA62 Trigger Simulation
4. GTK Submission of full size R/O chip (EOC)
5. GTK Thinning and handling of dummy wafers
6. GTK Choice of the cooling option
7. STRAW Module Zero Construction
8. STRAW Finalization of F/E -- R/O Electronics
9. LKR CREAM Prototype/Pre-series
10. RICH Vessel Construction
11. LAV / IRC Construction
12. MUV3 Installation
13. NA62 Synchronization Run

A look forward: SPS Schedule and NA62

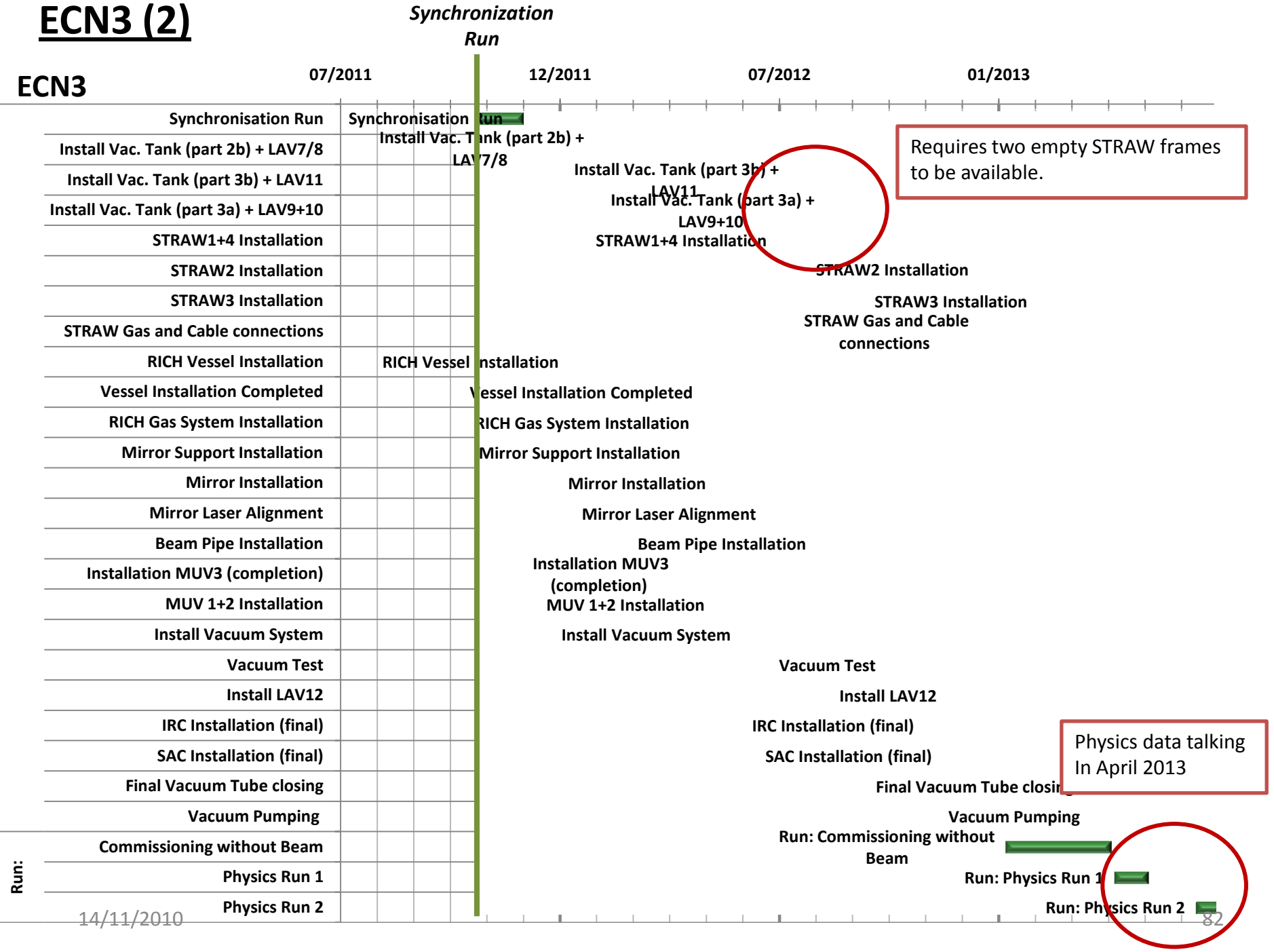
- NA62 proposes to mitigate the lack of SPS running in 2012 by planning a Synchronization run late in 2011and to start Physics Data Taking in 2013
- The synchronization run would need to take place as late as possible in 2011 (about two weeks) and would require muons in ECN3
- The Collaboration needs to collect a significant data sample before another long shutdown (in addition to the 2012 one)

Spares

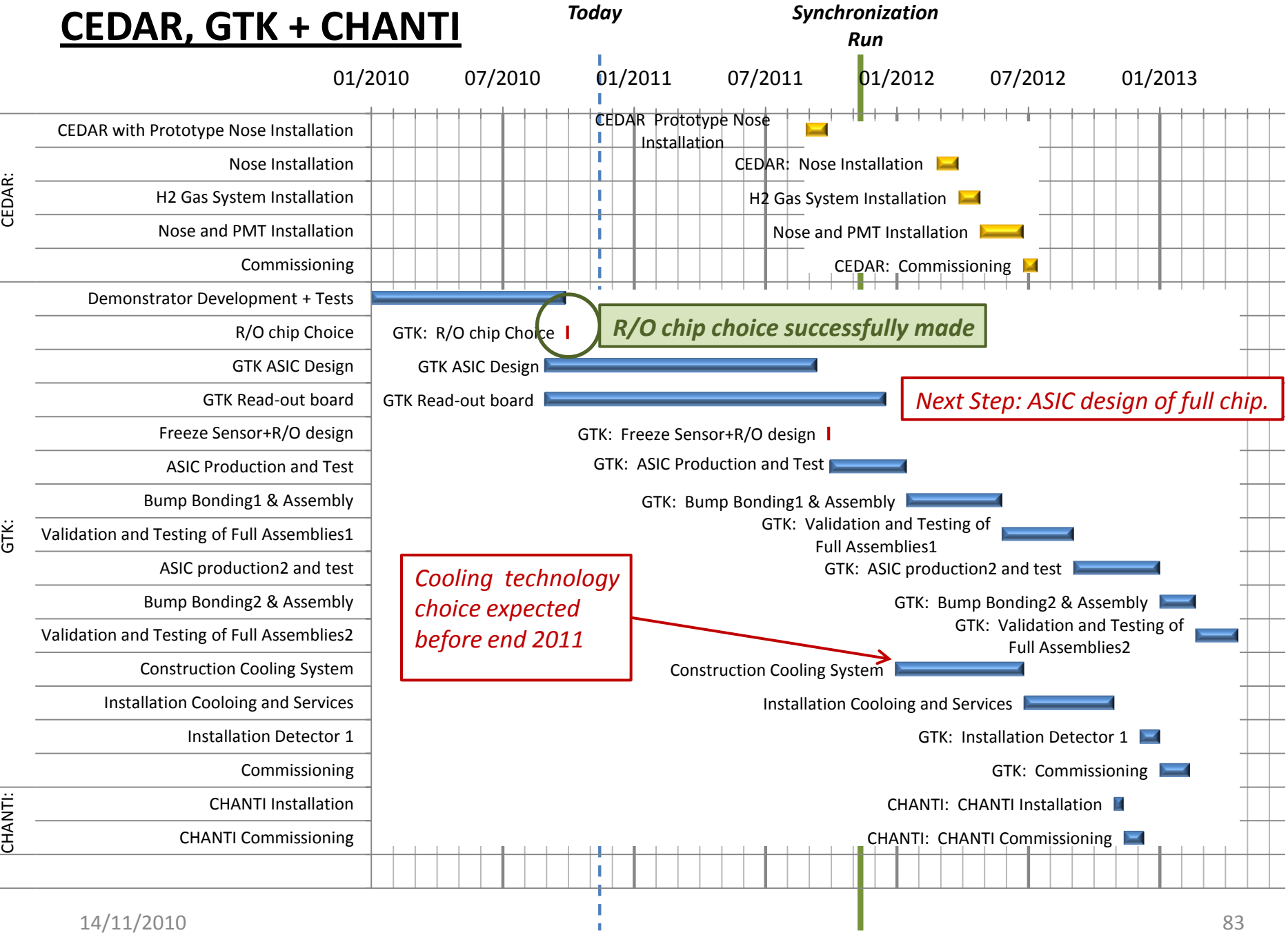
ECN3 (1)


Today
Synchronization Run
01/2010
07/2010
01/2011
07/2011
ECN3:
Beam line installation
Support Structure MBPL-TP
Installation MBPL-TP
Beam Dump CE
Vac. Tank modif. and cleaning
Survey of Beamline in TCC8 and ECN3
Fibre Network Installation
Vacuum Pre test
Install Vac. Tank (part 1) + LAV1-5
Install Vac. Tank (part 2a) + LAV6/7
Installation Absorber Wall Support Structure
Absorber Wall Installation
Installation MUV3 Support Structure
Pre-Installation MUV3
STRAW1 temp. Installation Module 1
STRAW Gas System Installation
CEDAR with Prototype Nose Installation
Connection of electronic Racks
Synchronisation Run
ECN3: Beam line installation
ECN3: Support Structure MBPL-TP
ECN3: Installation MBPL-TP
ECN3: Beam Dump CE
ECN3: Vac. Tank modif. and cleaning
ECN3: Fibre Network Installation
ECN3: Vacuum Pre test
ECN3: Install Vac. Tank (part 1) + LAV1-5
ECN3: Install Vac. Tank (part 2a) + LAV6/7
Installation Absorber Wall Support Structure
ECN3: Absorber Wall Installation
ECN3: Installation MUV3 Support Structure
ECN3: Pre-Installation MUV3
ECN3: STRAW1 temp. Installation Module 1
ECN3: STRAW Gas System Installation
ECN3: CEDAR with Prototype Nose Installation
ECN3: Connection of electronic Racks
ECN3: Synchronisation Run
Excavation must be finished before SR

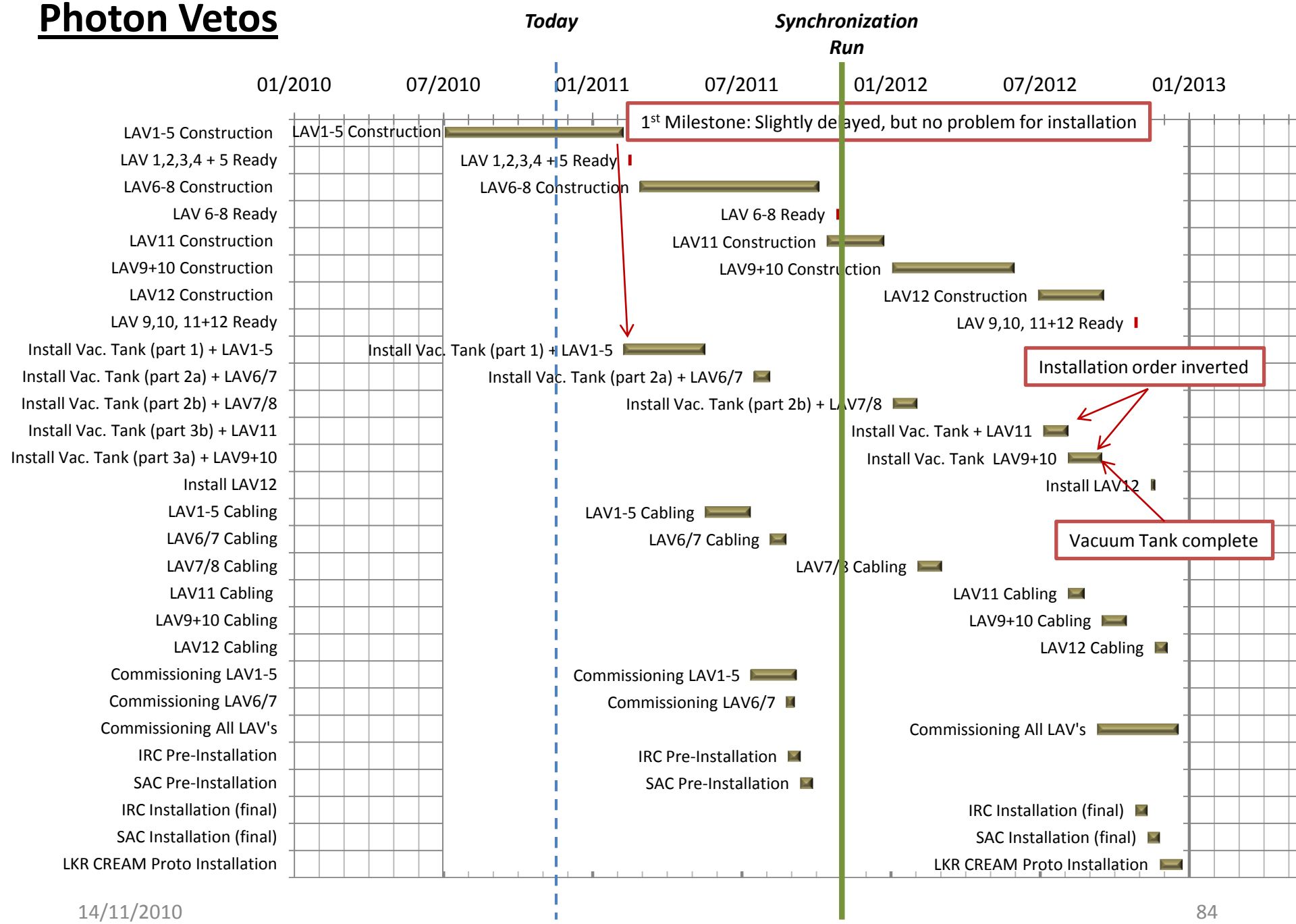
ECN3 (2)


Synchronization Run
ECN3
07/2011
12/2011
07/2012
01/2013
Synchronisation Run
Install Vac. Tank (part 2b) + LAV7/8
Install Vac. Tank (part 3b) + LAV11
Install Vac. Tank (part 3a) + LAV9+10
STRAW1+4 Installation
STRAW2 Installation
STRAW3 Installation
STRAW Gas and Cable connections
RICH Vessel Installation
Vessel Installation Completed
RICH Gas System Installation
Mirror Support Installation
Mirror Installation
Mirror Laser Alignment
Beam Pipe Installation
Installation MUV3 (completion)
MUV 1+2 Installation
Install Vacuum System
Vacuum Test
Install LAV12
IRC Installation (final)
SAC Installation (final)
Final Vacuum Tube closing
Vacuum Pumping
Run: Commissioning without Beam
Run: Physics Run 1
Run: Physics Run 2
Requires two empty STRAW frames to be available.
Physics data talking In April 2013

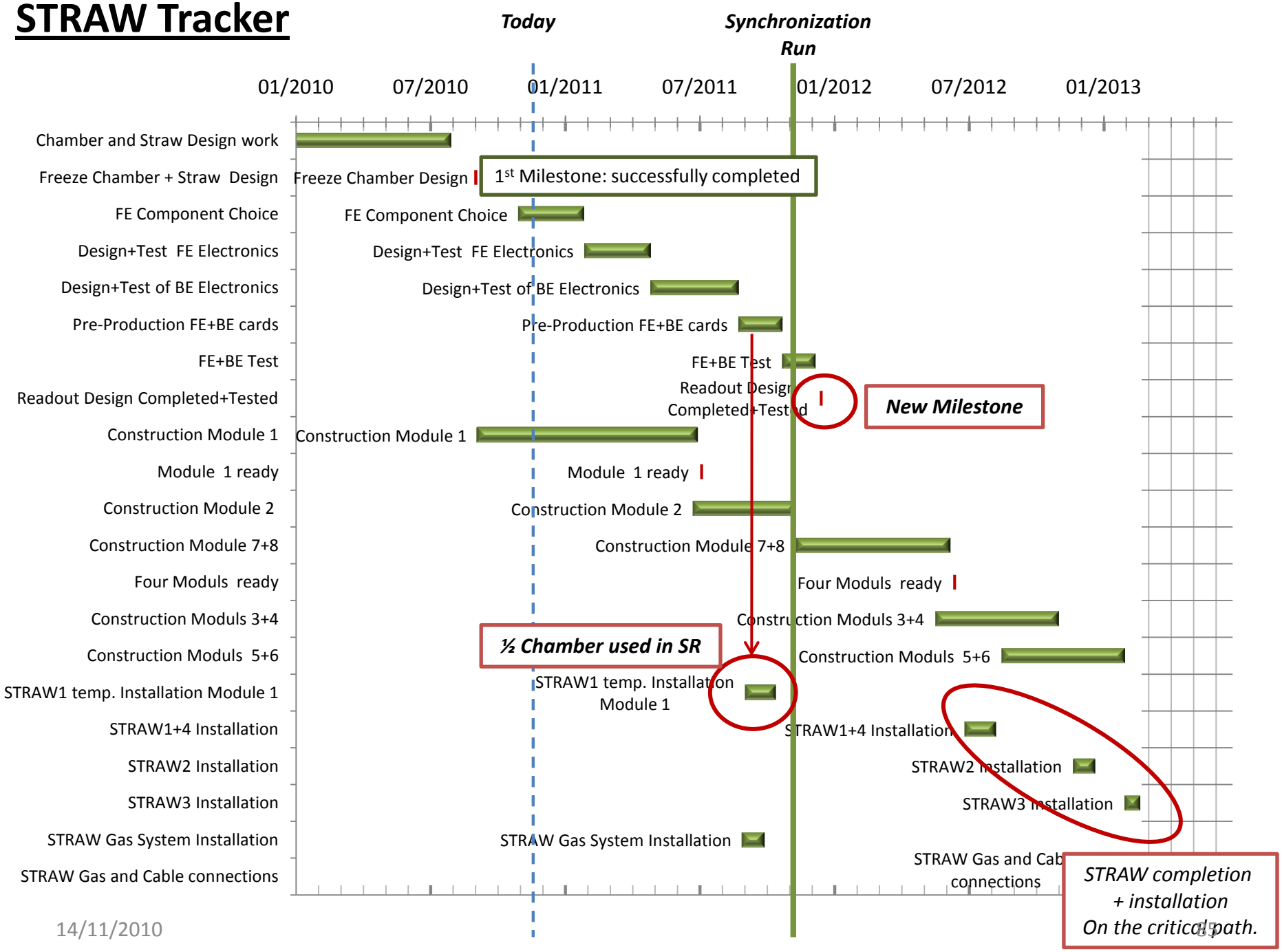
CEDAR, GTK + CHANTI



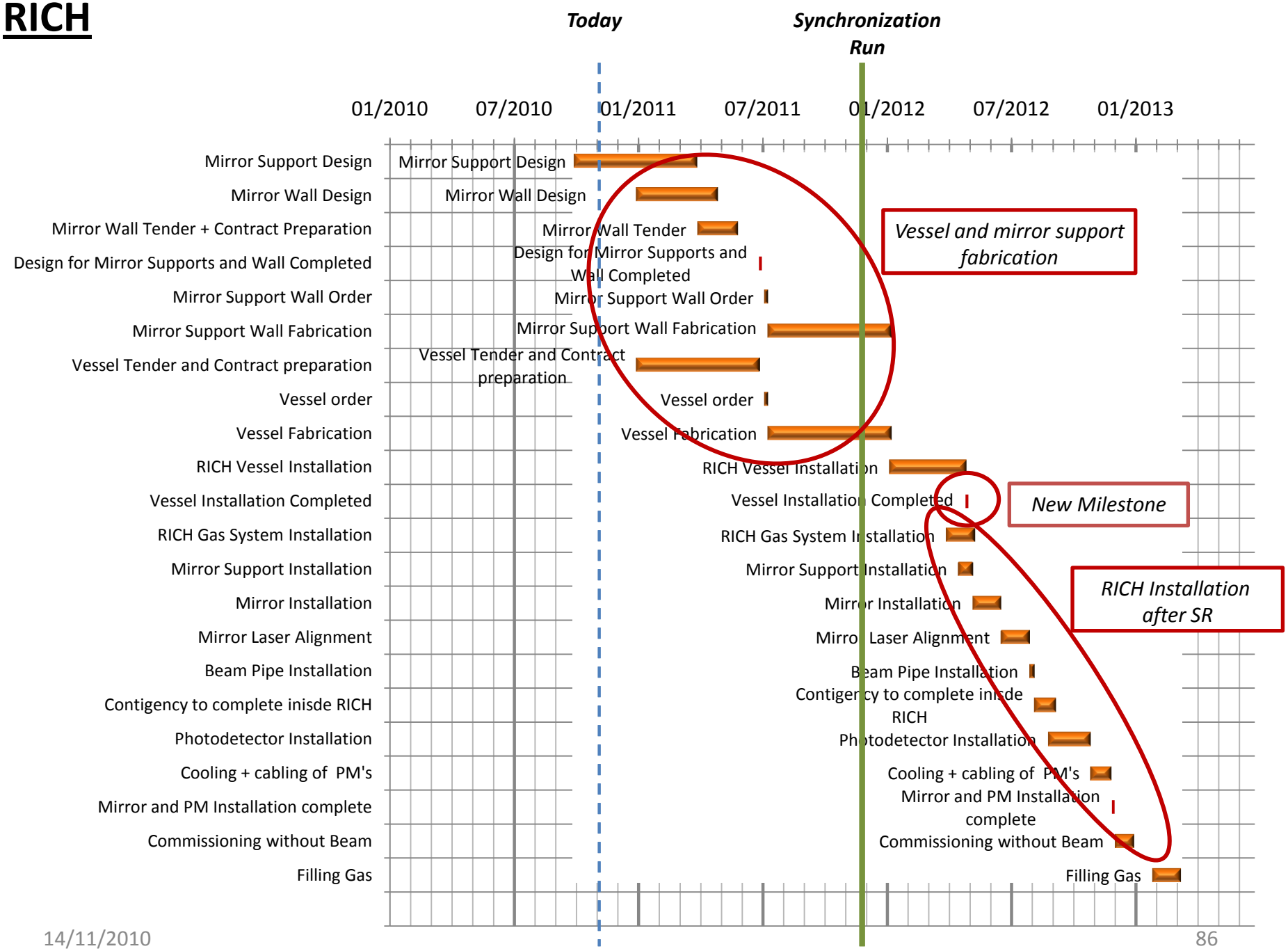
Photon Vetos



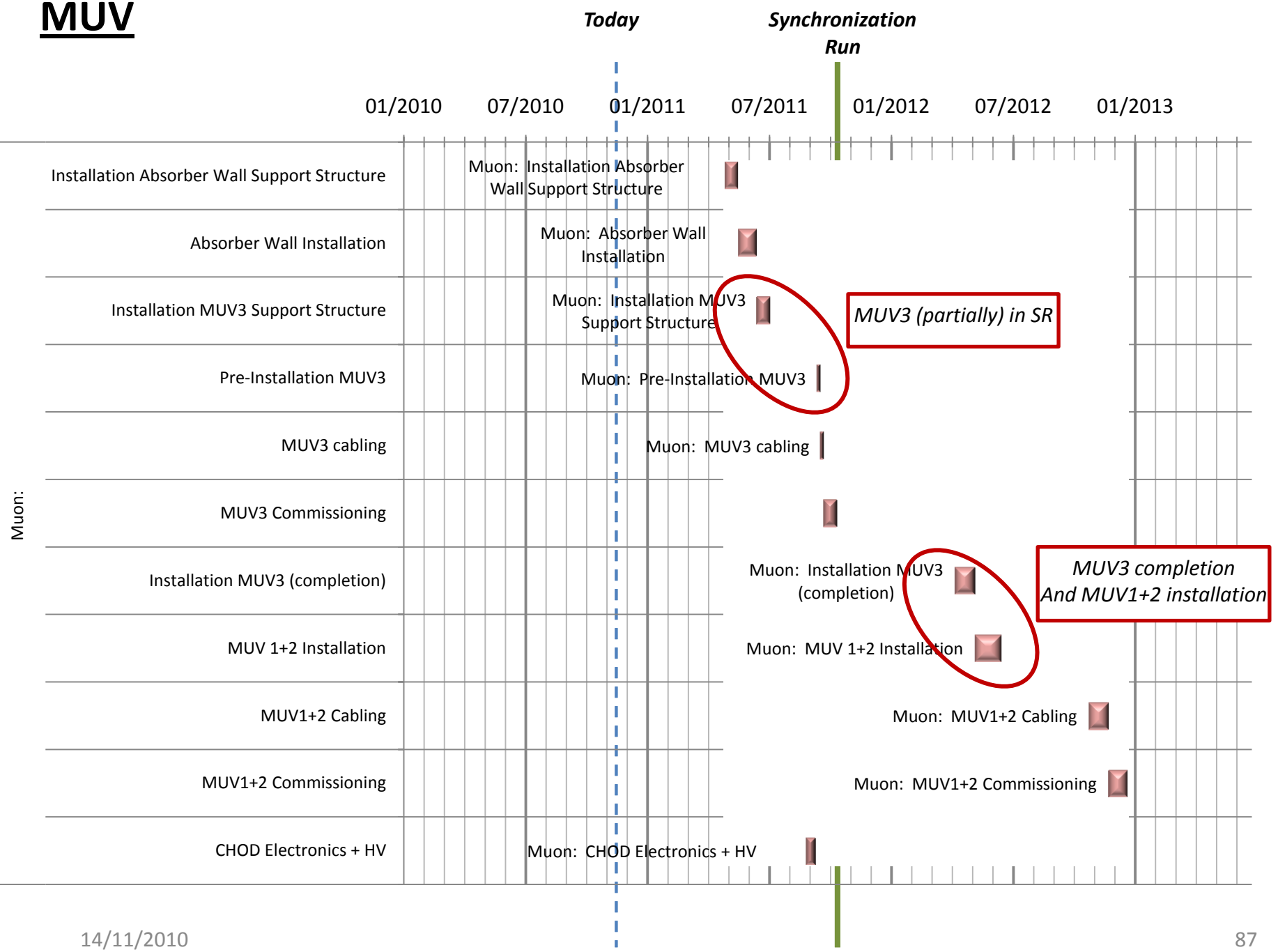
STRAW Tracker



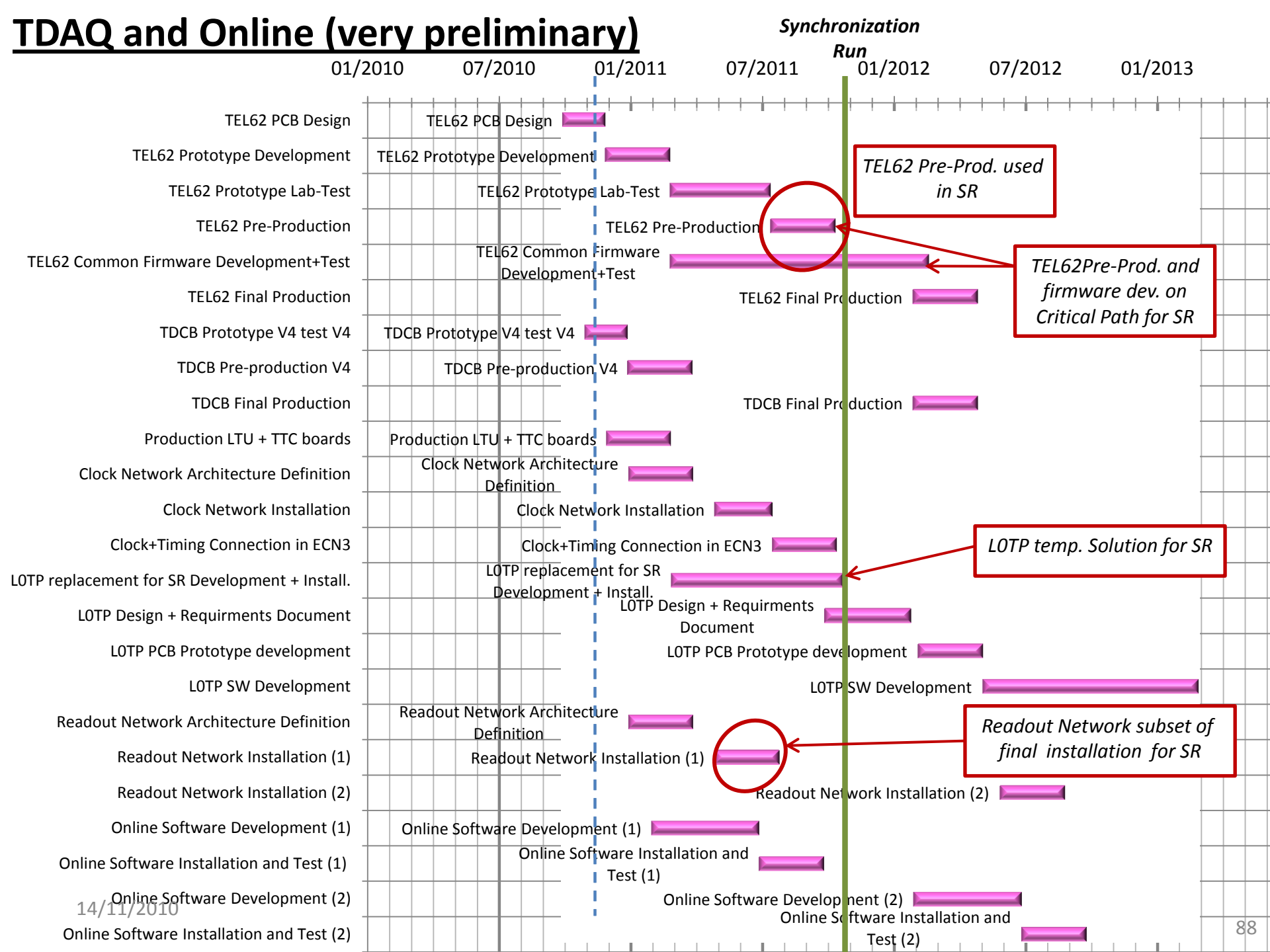
RICH


Today
Synchronization Run
01/2010
07/2010
01/2011
07/2011
01/2012
07/2012
01/2013
Mirror Support Design
Mirror Wall Design
Mirror Wall Tender + Contract Preparation
Design for Mirror Supports and Wall Completed
Mirror Support Wall Order
Mirror Support Wall Fabrication
Vessel Tender and Contract preparation
Vessel order
Vessel Fabrication
RICH Vessel Installation
Vessel Installation Completed
RICH Gas System Installation
Mirror Support Installation
Mirror Installation
Mirror Laser Alignment
Beam Pipe Installation
Contigency to complete inisde RICH
Photodetector Installation
Cooling + cabling of PM's
Mirror and PM Installation complete
Commissioning without Beam
Filling Gas
Vessel and mirror support fabrication
New Milestone
RICH Installation after SR

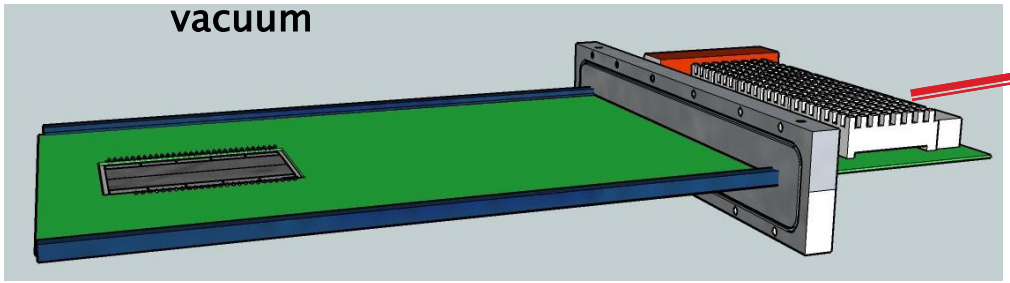
MUV


Today
Synchronization Run
01/2010
07/2010
01/2011
07/2011
01/2012
07/2012
01/2013
Muon:
Installation Absorber Wall Support Structure
Absorber Wall Installation
Installation MUV3 Support Structure
Pre-Installation MUV3
MUV3 cabling
MUV3 Commissioning
Installation MUV3 (completion)
MUV 1+2 Installation
MUV1+2 Cabling
MUV1+2 Commissioning
CHOD Electronics + HV
Muon: Installation Absorber Wall Support Structure
Muon: Absorber Wall Installation
Muon: Installation MUV3 Support Structure
Muon: Pre-Installation MUV3
Muon: MUV3 cabling
Muon: Installation MUV3 (completion)
Muon: MUV 1+2 Installation
Muon: MUV1+2 Cabling
Muon: MUV1+2 Commissioning
Muon: CHOD Electronics + HV
MUV3 (partially) in SR
MUV3 completion And MUV1+2 installation

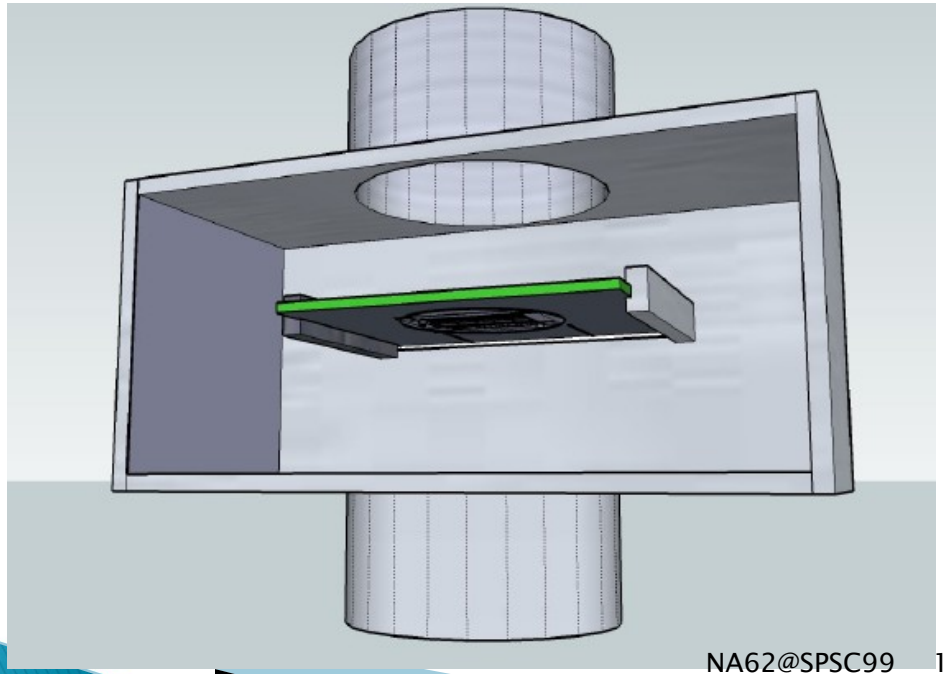
TDAQ and Online (very preliminary)



Mechanical integration

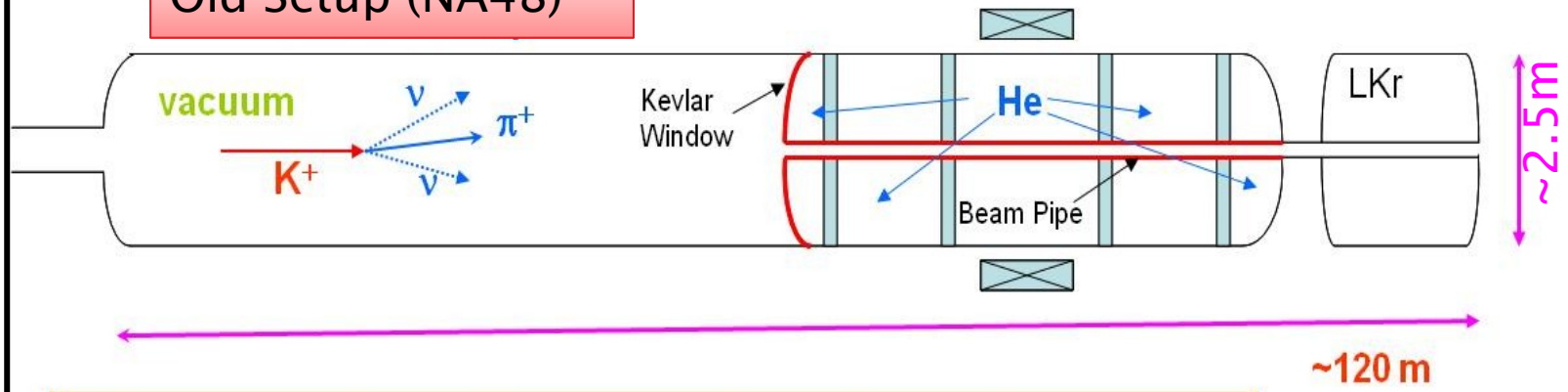


Optical fiber bundle to DAQ



A straw tracker in vacuum

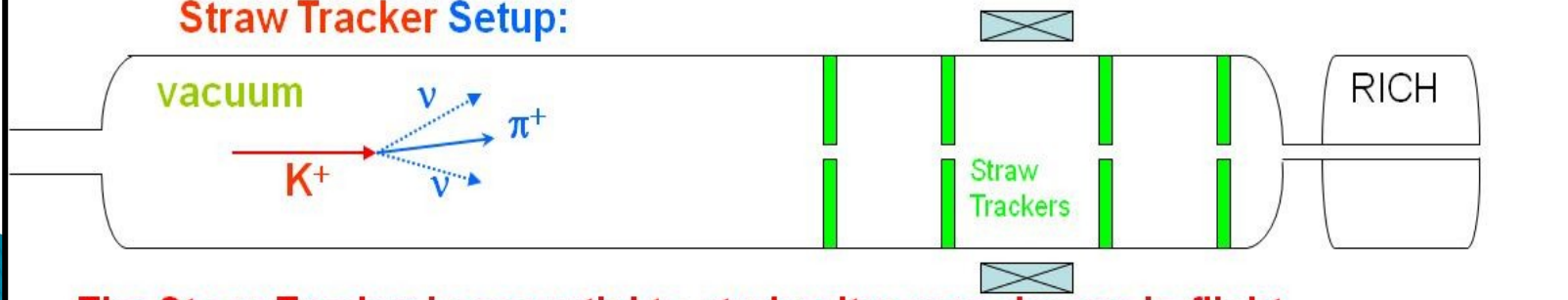
Old Setup (NA48)



The Straw Trackers operated in vacuum will enable us to:

- Remove the multiple scattering due to the Kevlar Window
- Remove the acceptance limitations due to the beam-pipe
- Remove the helium between the chambers

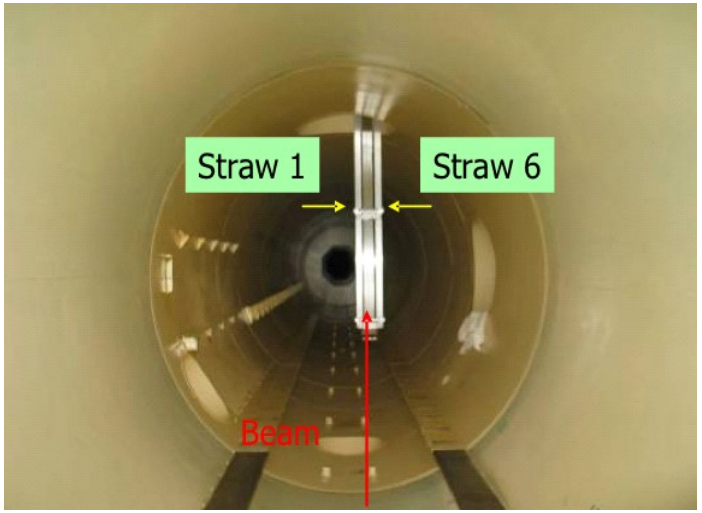
Straw Tracker Setup:



- The Straw Tracker is essential to study ultra-rare-decays in flight

Test beam in 2009

48-straw full-length prototype



Beam test 2009 straw rate and resolution

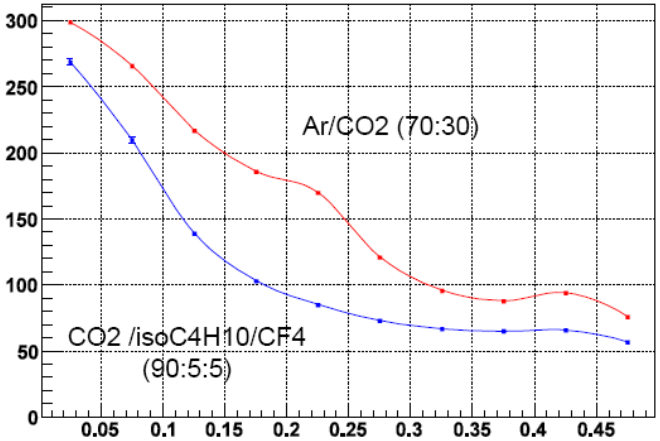
Gas mixtures:

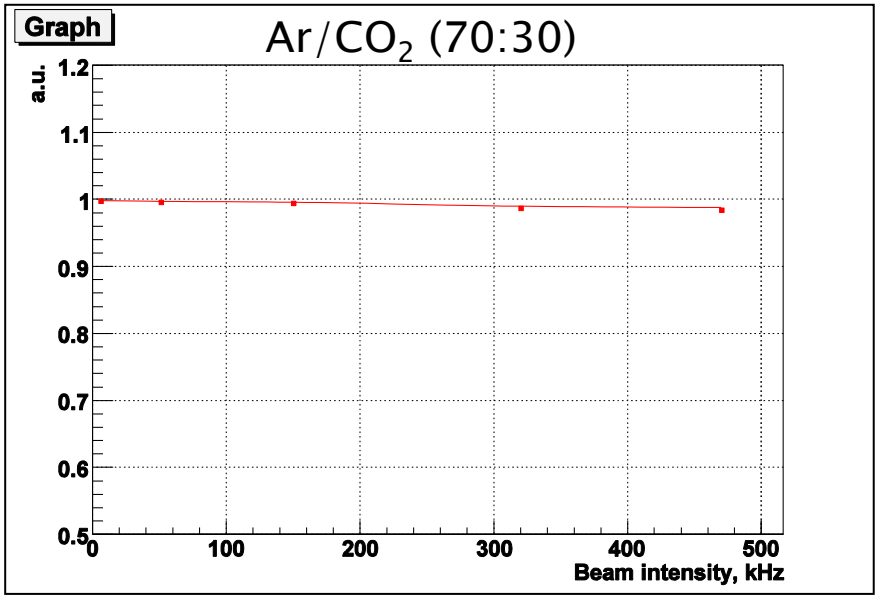
- **CO2/isoC4H10/CF4 (90:5:5) - base line**
- **Ar/CO2 (70:30)**

Gas gains:

- **G=5x10**4 (Th=6 fC)**
- **G=2x10**5 (Th=10 fC)**

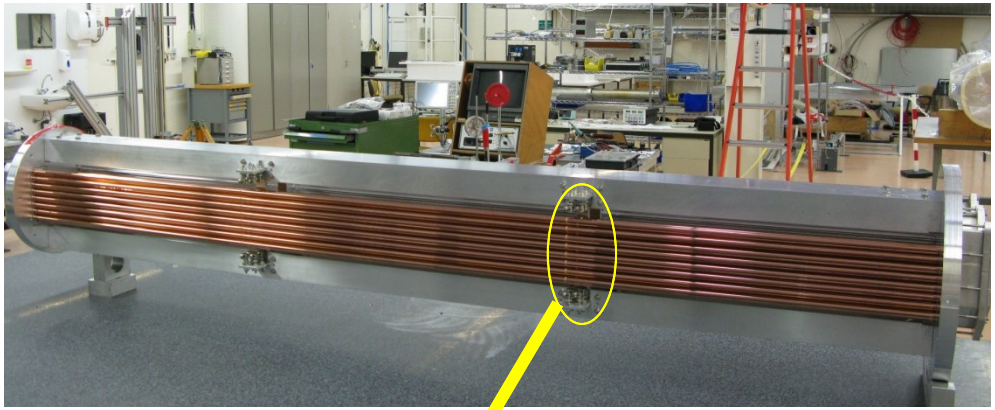
Dependence of residuals from drift distance:
red – run 21318, blue – run 21228

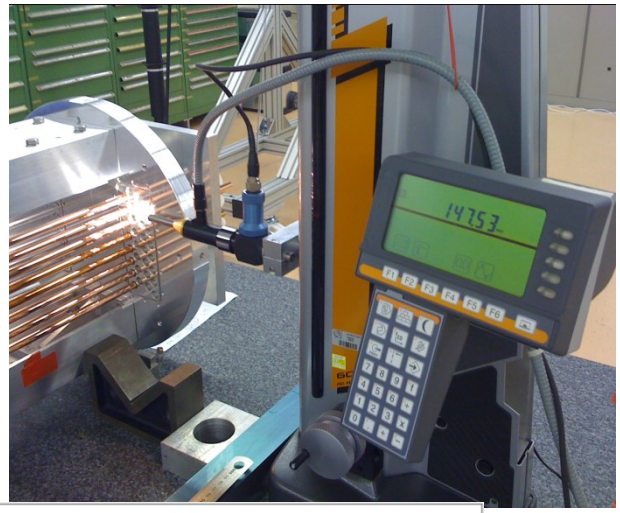


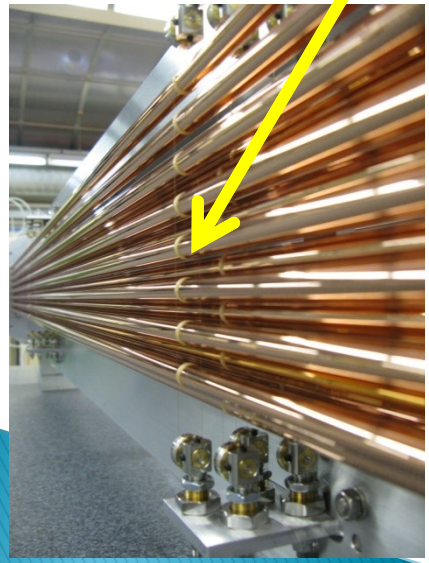


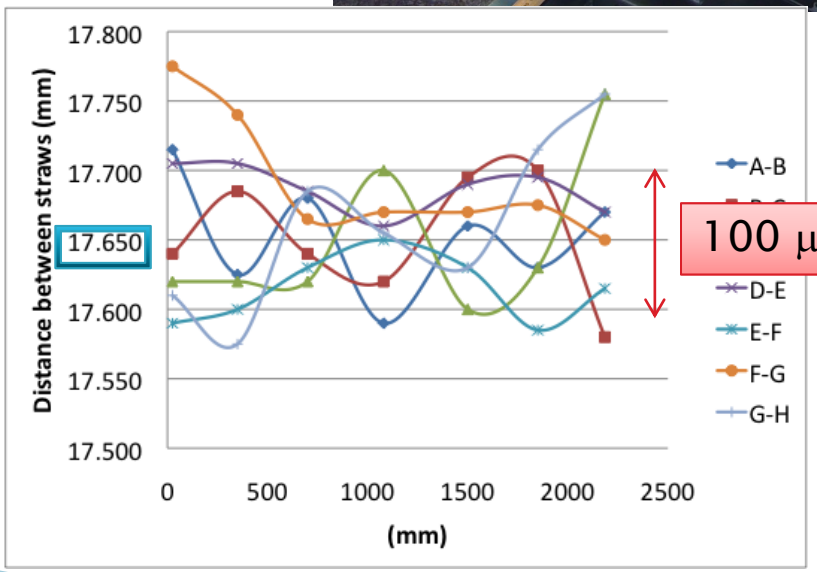
Construction of a 64-straw prototype in 2009-2010

Low material budget and hermeticity
Example: straw straightness



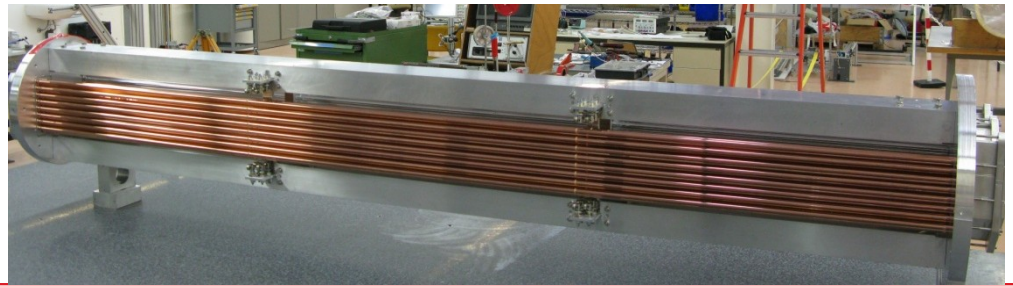






100 μm

Permeation and gas leak validation



The detector is inserted into a dedicated stainless steel tube

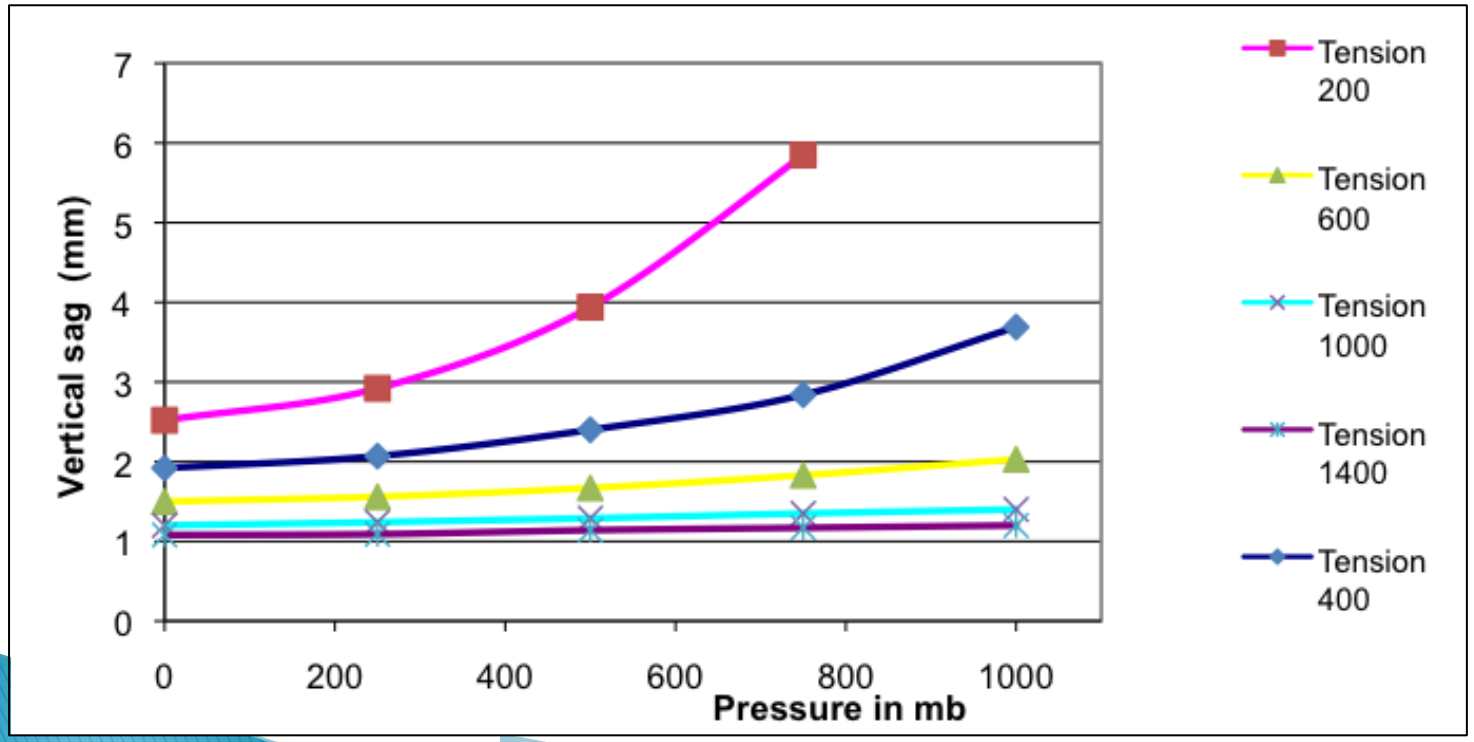
Straw detector at NPT (measurement)		LAV (estimate)	Blue tube (estimate)
Single straw	Full detector (7168 straws)		
0.82 mbar cm^3/min	9.8×10^{-2} mbar l/s	3×10^{-2} mbar l/s	2×10^{-2} mbar l/s

With these numbers the straw leaks the equivalence of one straw volume in 4.5 months at 1 bar pressure difference

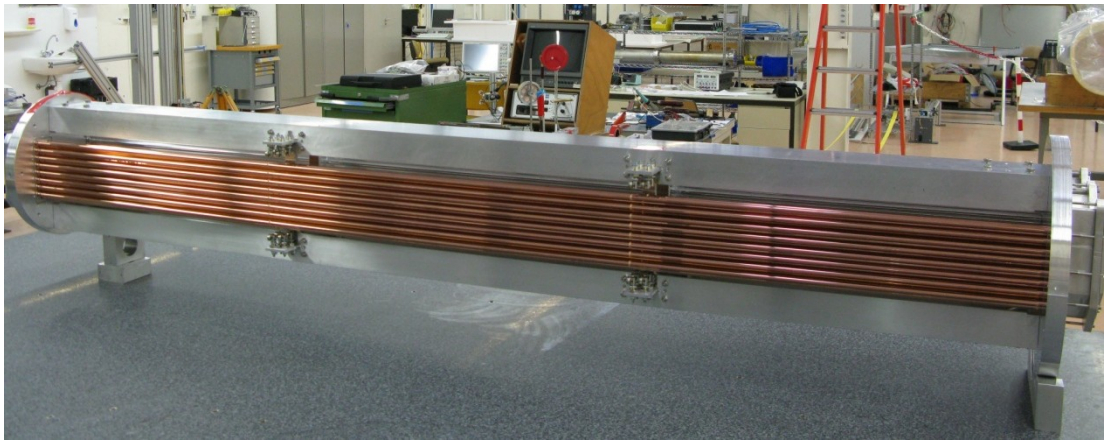
Design considerations

- A modular design for safety as the straws will be operated in direct contact with the decay vacuum (the straw operates at ~ 1 bar)
- Minimum amount of material
- The possibility to replace a straw in situ
- Pretension the straws with 1.5 kg for straightness for minimum support

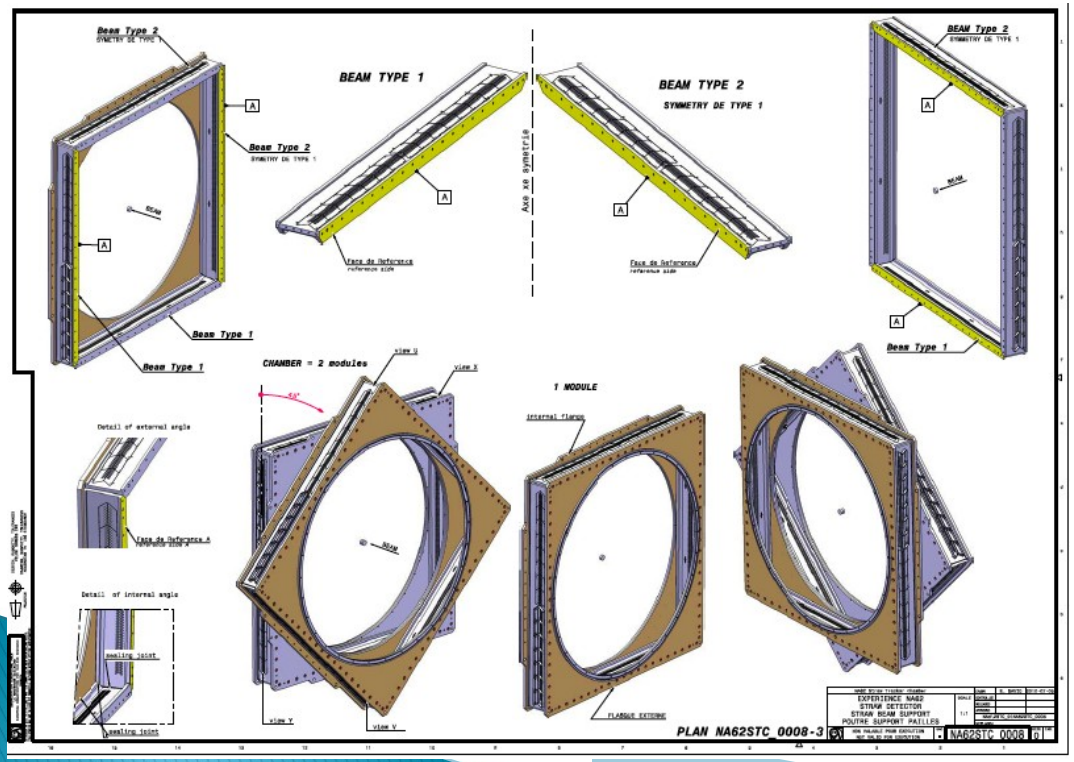
Sag of a horizontal 2m long straw



Towards the final detector

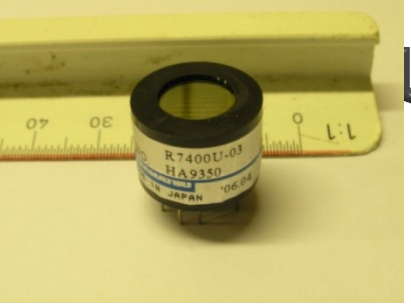


From prototype to full detector and the assembly of “module 0” in the spring 2011:

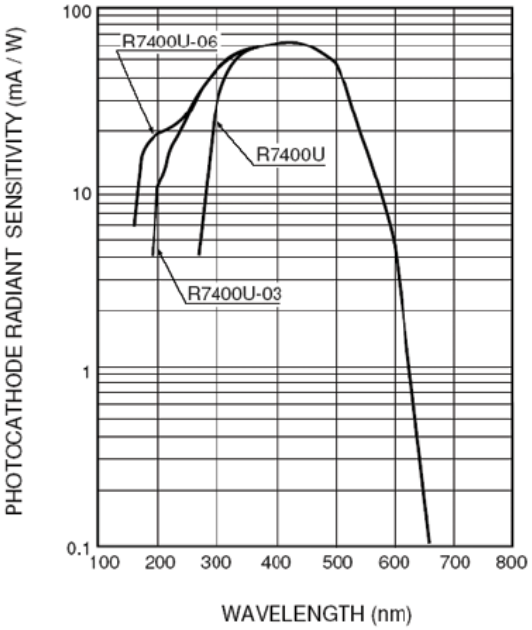


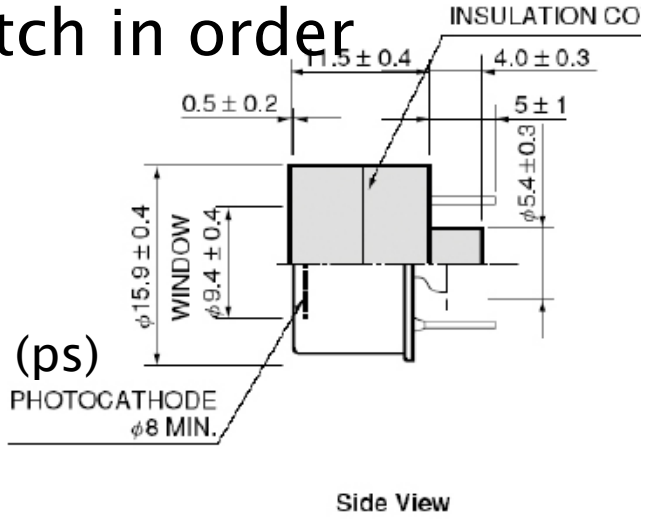
2x448 straws

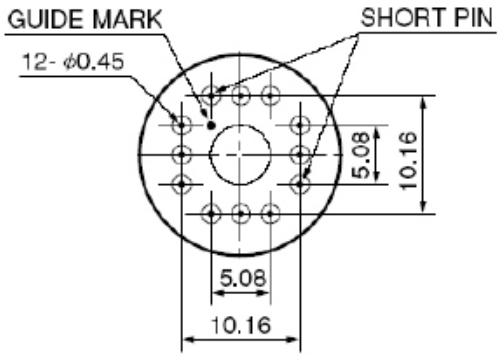
ultipliers



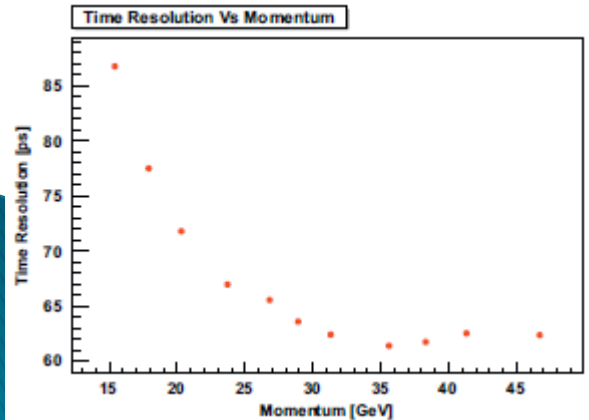
- Hamamatsu R7400 U-03
- 16mm diameter
- 230 ps Transit Time Jitter (FWHM)
- >1800 PM already available
- Last batch in order





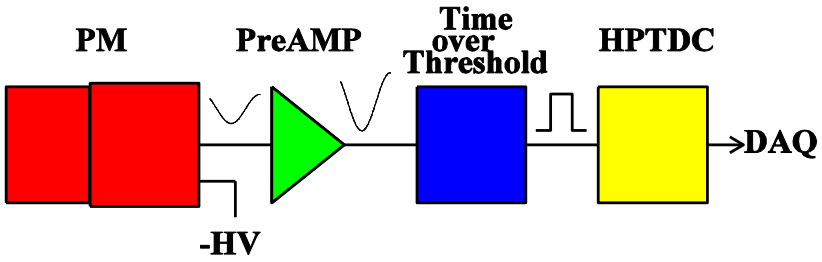


RICH proto: time resolution (ps)

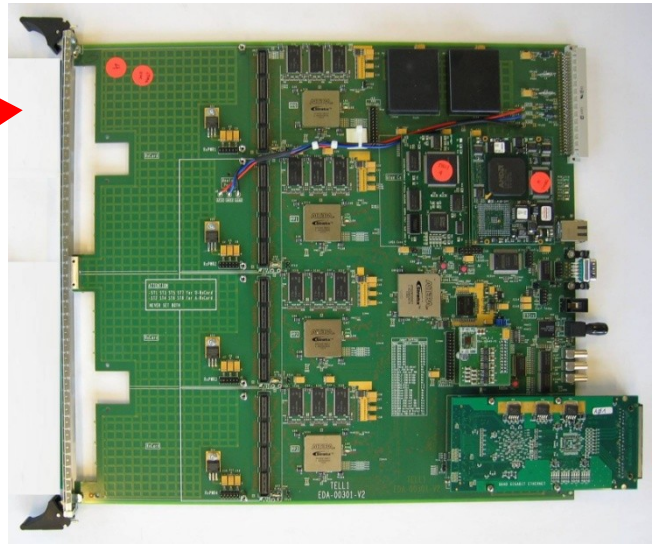


Front-End and DAQ

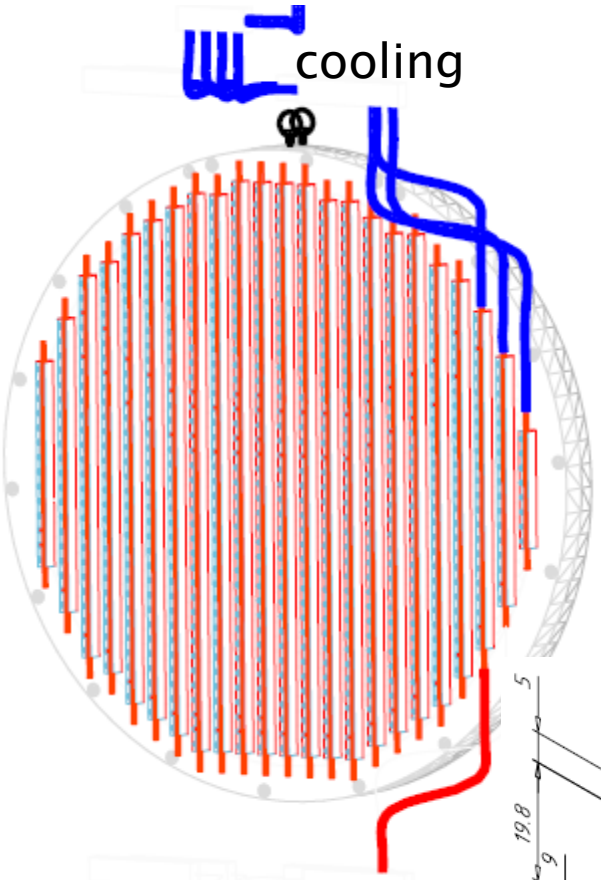
FE+DAQ contribution < 50 p

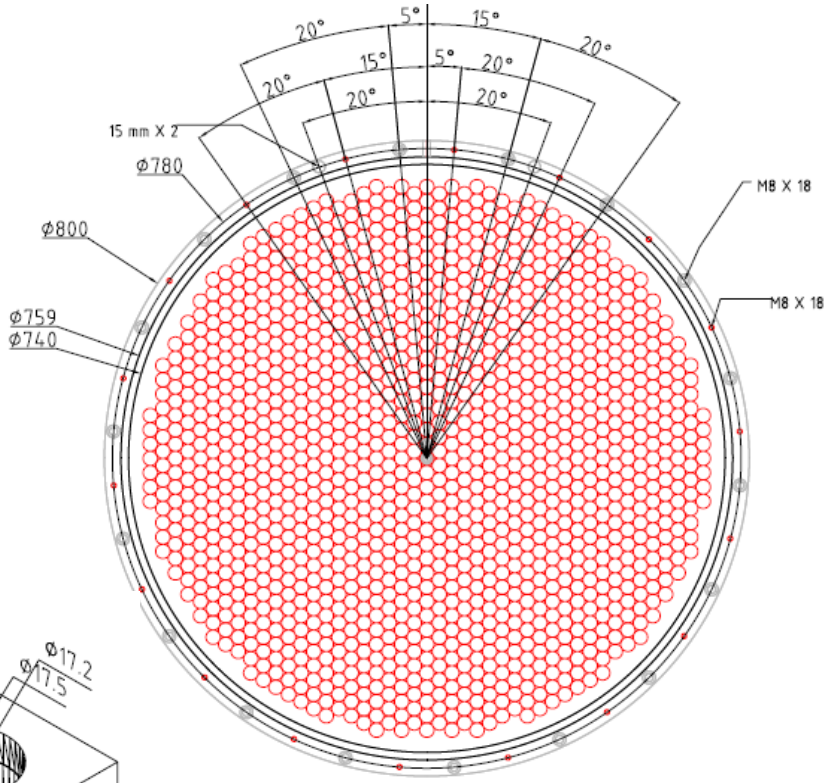


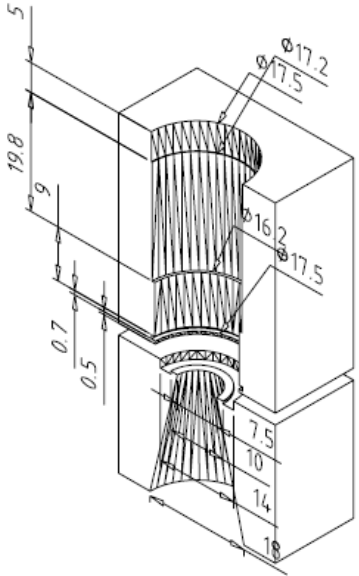
- NINO ASIC as fast discriminator: new board with 4 chips = 32 ch to be produced in 2011
- HPTDC on TEL62
- Optional use of the RICH as NA62 charged trigger



PM mechanical support

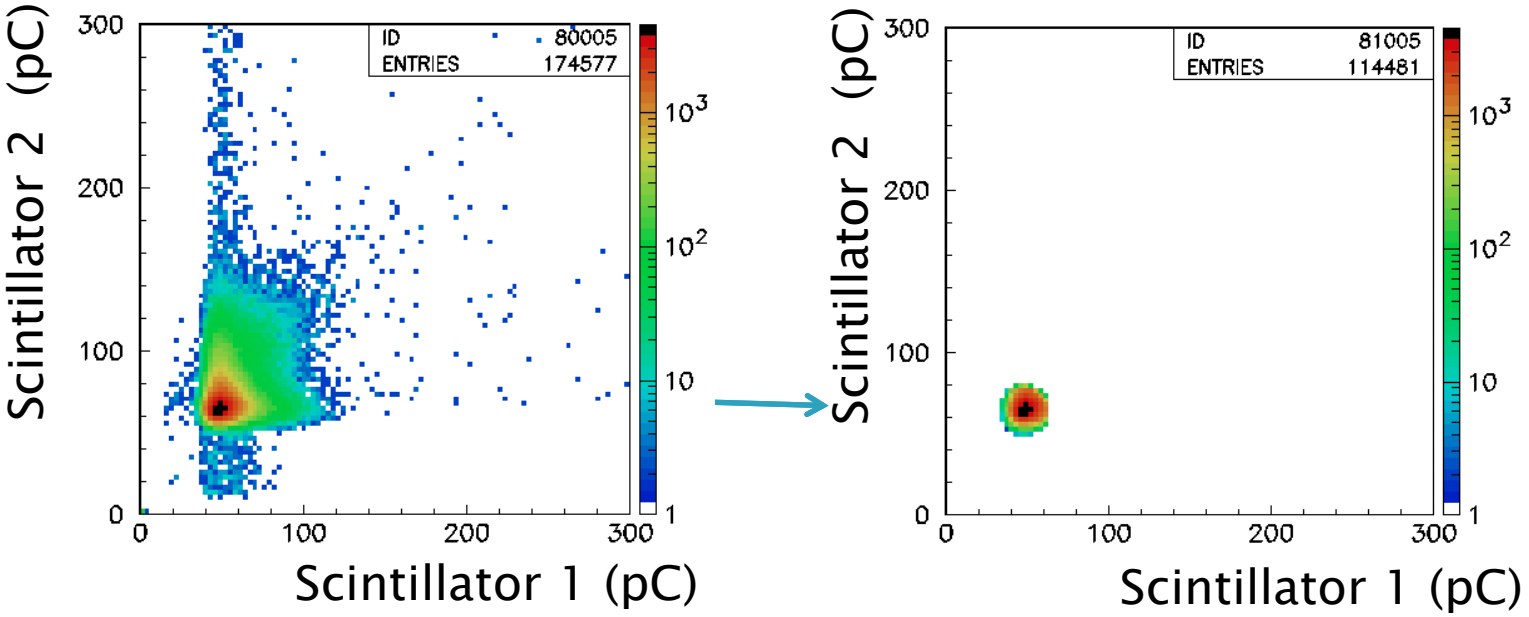






To be built during 2011

Muon selection



+ ask for hit crystal in **previous** and **following** layer
+ isolation cut (allowed only additional hit in the nearby c

A2 Test beam: objectives

1. Validate **final version** of front-end electronics **plus** modifications of voltage divider:
   a) Time-over-threshold vs. charge **calibration** curves
   b) Efficiency vs. threshold for **electrons, hadrons** and **muons**
2. Measure time and energy resolution
3. Test new FEE with TELL1 readout

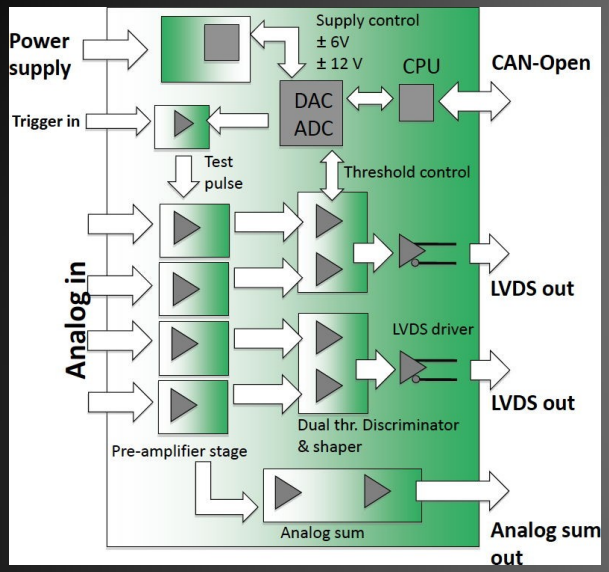
*All that on a full, **final** ANTI ring, and thus also checking:*

- *construction techniques*
- *cabling and connectors*
- *new DB37 signal flanges*
- *new ground feed-through on HV flange*

T9 beam Electrons 0,5 – 5 GeV selected using cherenkov
Muon run 8 GeV

LAV FEE status

D. Tagnani

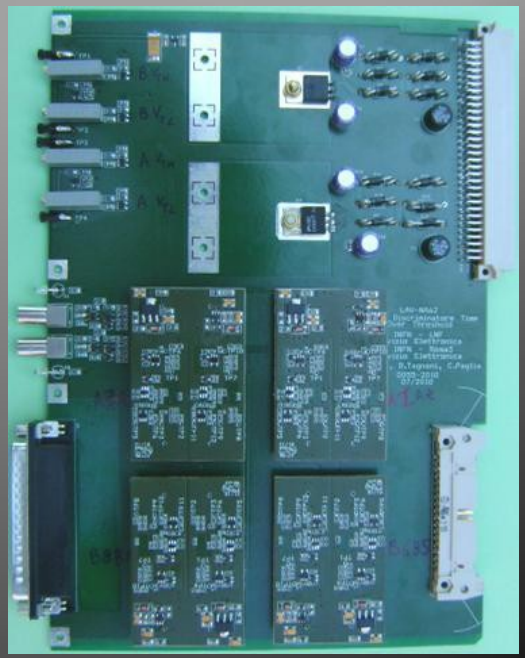


Inputs	32 signal channels
Outputs	2x32 LVDS signals (discriminated at 2 levels) 8x sum-over-4 analog signals 2x sum over-16 analog signals
Services	Individual threshold control (0-500 mV/12 bits) Programmable pulsing system CAN-Open network interface

Prototype VME6U card used at test beam

- 8 channels
- Final ToT mezzanine
  (clamping/amplifier/splitter/2 discriminators)
- Manual threshold adjustment
- No interface

Final design is frozen and we started material procurement



Readout configurations

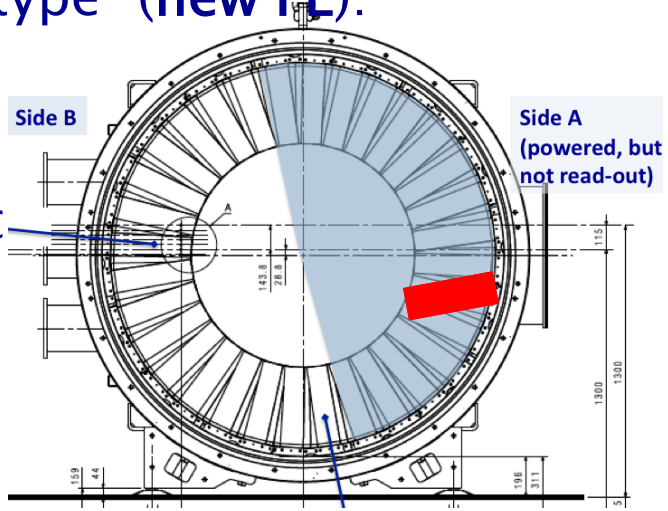
We have used two different configurations:

- *single-threshold* front-end boards (**old FE**) and one single board
- *double-threshold* eight-channels "final prototype" (**new FE**):

- **Phase 1**

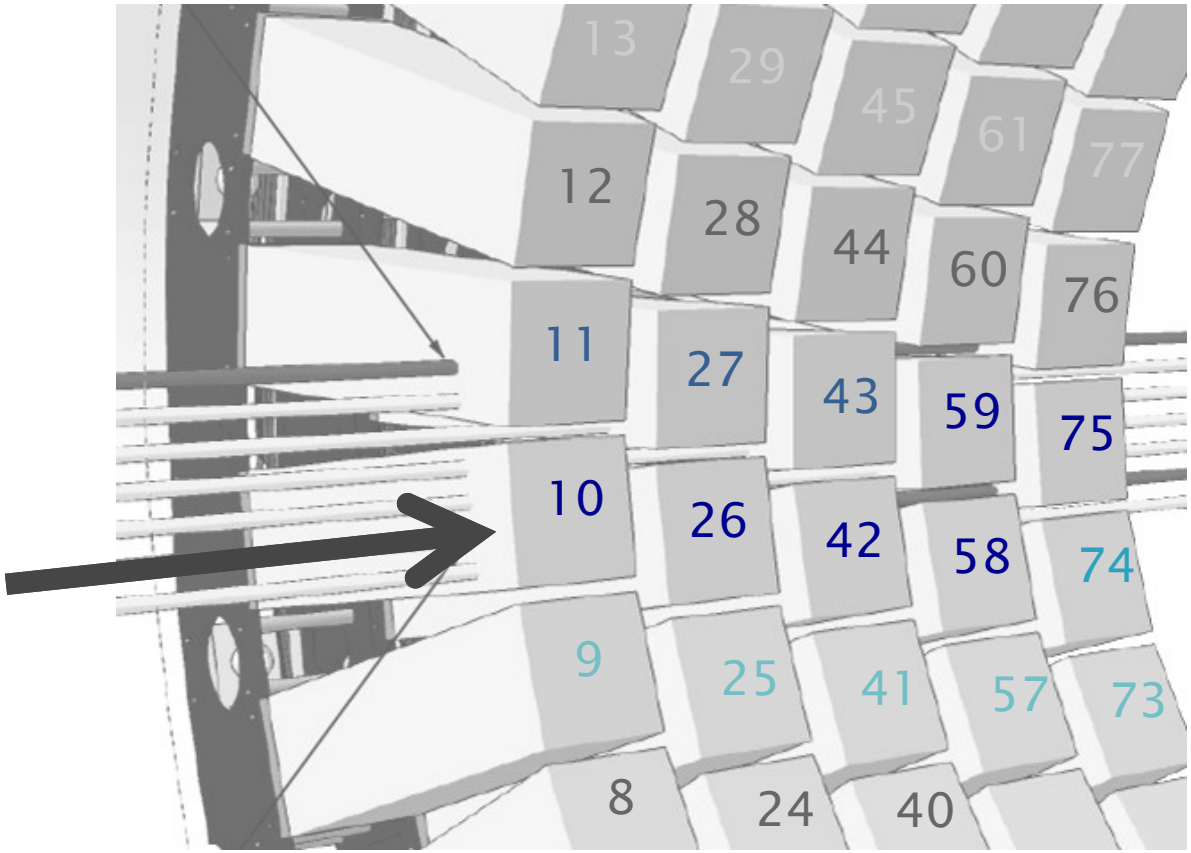
  readout by 5 **old FE** boards as in 2009 test:
  - 5×16 input ch's ➔ Threshold ➔ 5×16 out LVDS ➔ TDC
  - 5×16 input ch's ➔ 5×16 analog out ➔ delays ➔ QDC
- **Phase 2**

  new FE board instrumenting 8 central crystal on 5 layers:
  - 8 input ch's ➔ 2 Thresholds ➔ 2×8 out LVDS ➔ TDC
  - 8 input ch's ➔ 2 Analogue 4-fold sum ➔ delays ➔ QDC
- **Phase 3**:
  - old FE boards on beam
  - new FE on 8 central crystals but in the opposite half of the detector (halo) connected to the TELL1 readout



HV supplied to **all 160** ch's ,set at the equalization voltage

A2 test Beam: Most hit crystals map



Crucial issues

Manpower needs for TEL62 firmware development

Sub-detector groups involvement in testing common system

Design of L0 Trigger Processor

Complete obsolescent component securing

Some sub-detectors still not committed to a DAQ solution

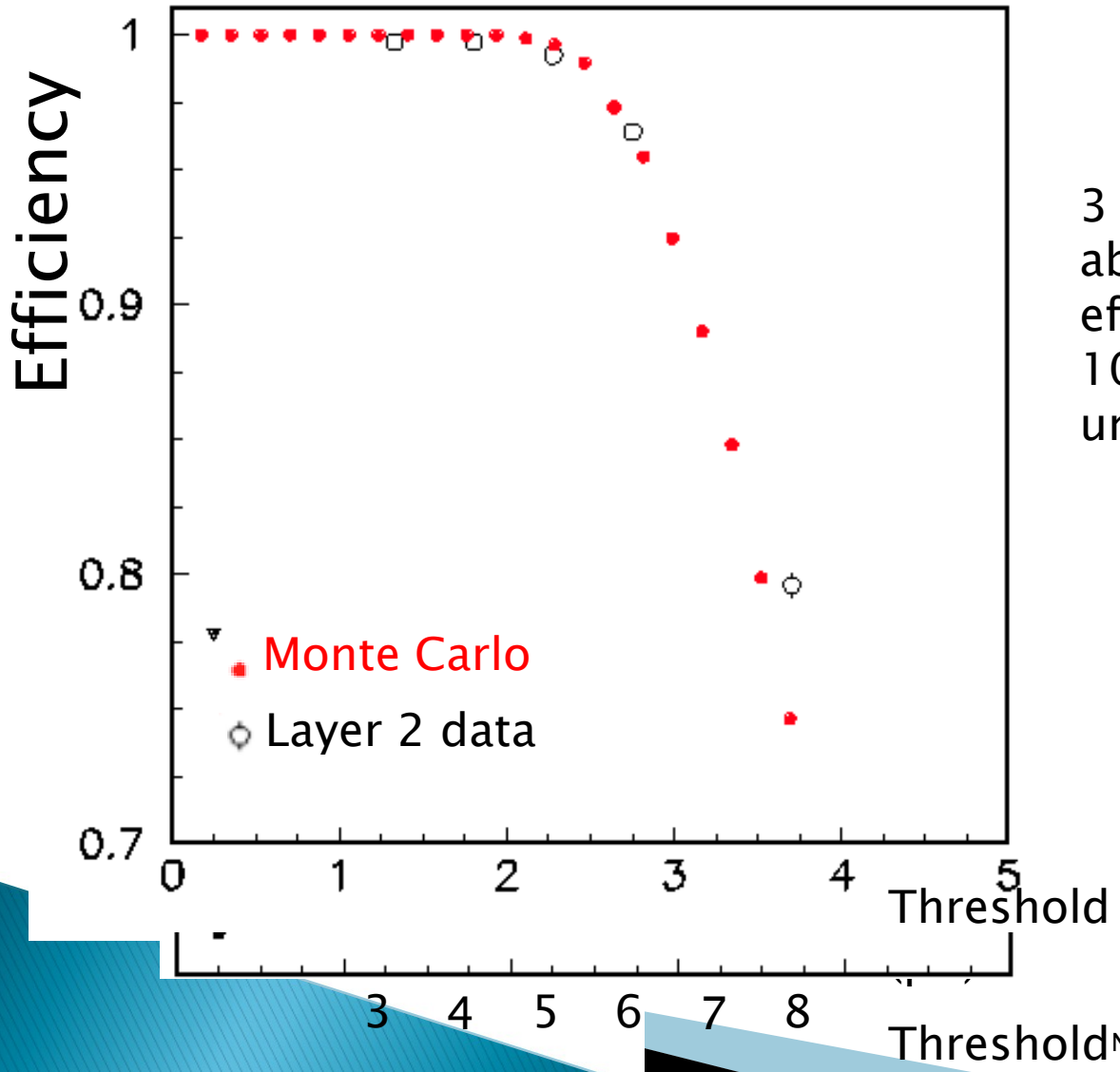
Still missing higher level (software, L1/L2) trigger simulation by sub-detector groups (significant impact on online farm dimensioning).

Technical "synchronization" run end 2011?

Requires from TDAQ:
- basic clock/trigger infrastructure, crates (OK)
- charged hodoscope with triggering electronics (GPU?)
- less than 10 new TEL62+TDCs tested, with quasi-final firmware
- Some L0TP replacement

Diversion of manpower towards TDAQ needed for such a goal

Muon efficiency vs. threshold

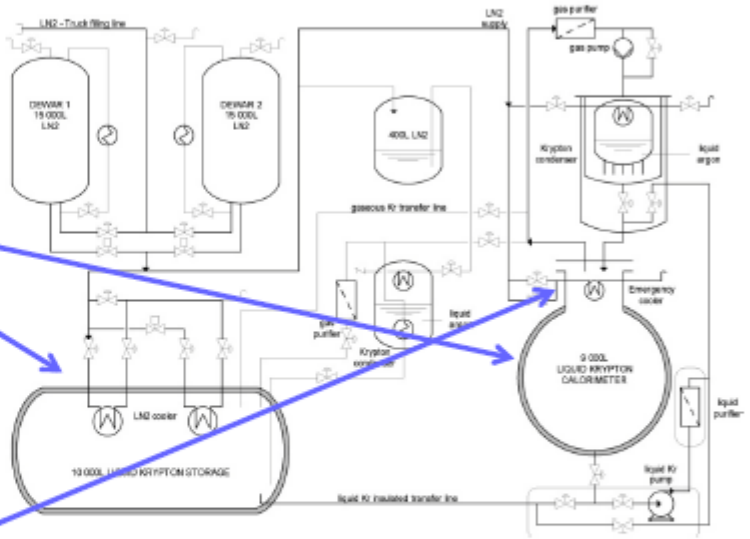


3 mV threshold is well above the noise, the efficiency for muon is 100%. Electron efficiency is under study

Cryogenics work package

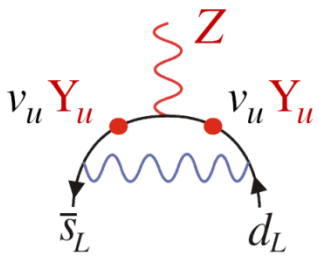
Deliverables

- The TE/CRG group shall operate and maintain the following cryogenic installation
  - **Liquid nitrogen storage system**
  - **Liquid krypton cryostat**
  - **Liquid krypton storage system**
  - **The active vacuum systems of the liquid krypton cryostat and its argon cooler**
  - **The temperature regulation of the electrical signal feed-throughs (no condensation)**
  - **The different back-up systems, guaranteeing the safe operation of the cryostat**



Kaon Rare Decays and NP

C. The Z penguin (and its associated W box)



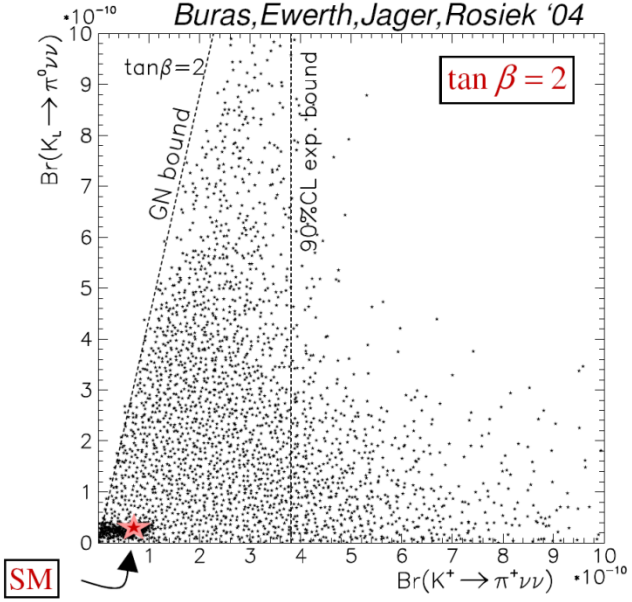
- $SU(2)_L$ breaking: $SM : v_u^2 Y_u^{*32} Y_u^{31} \sim m_t^2 V_{ts}^* V_{td}$

$MSSM : v_u^2 A_{\tilde{u}}^{*32} A_{\tilde{u}}^{31} \sim m_t^2 \times O(1)\,?$

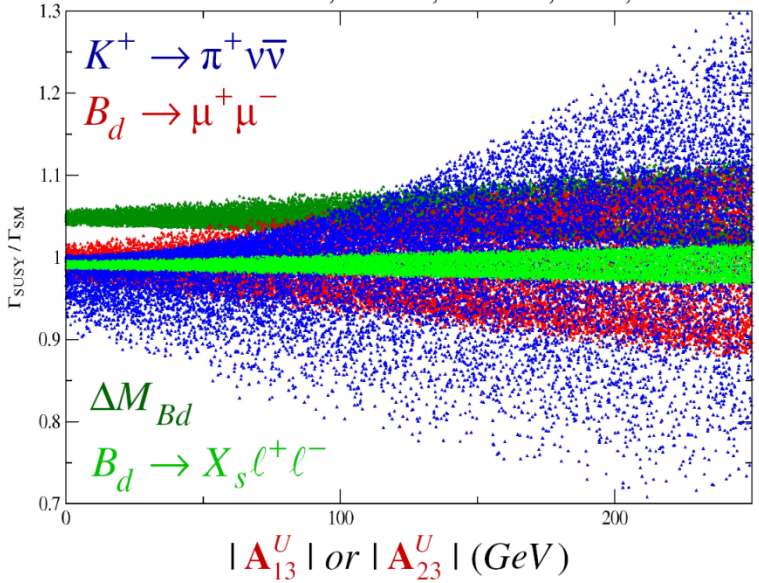
$MFV : v_u^2 A_{\tilde{u}}^{*32} A_{\tilde{u}}^{31} \sim m_t^2 V_{ts}^* V_{td} \left| A_0 a_2^* - \cot\beta\mu \right|^2 .$

- Relatively slow decoupling (w.r.t. boxes or tree).

Buras, Ewerth, Jager, Rosiek '04



Isidori, Mescia, Paradisi, Trine, C.S. '06

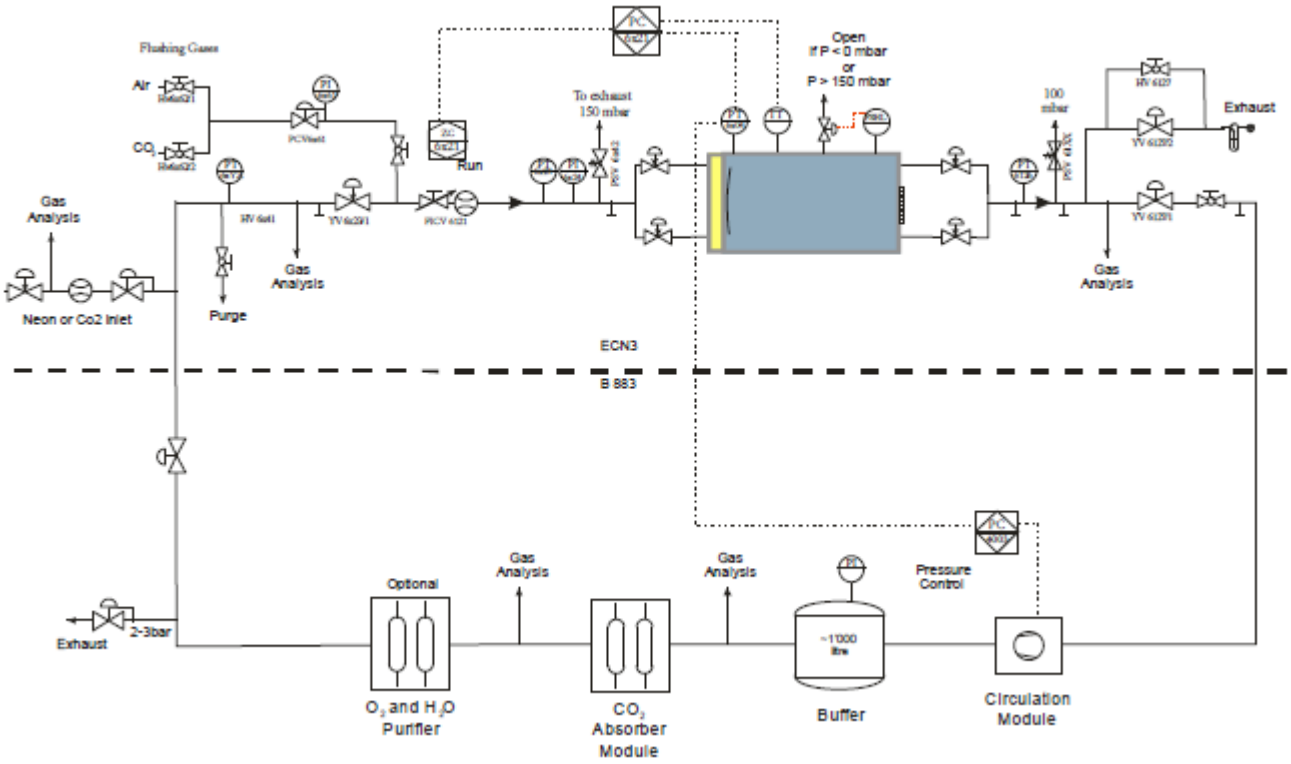


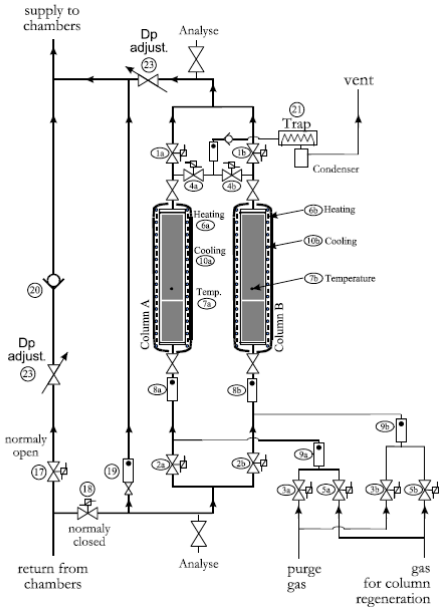
esy by Christopher Smith)

NA62 2010 Achievements

1. R_K Result (40% of the 2007-2008 data)
2. Launch of the NA62 Software Framework (C++)
3. NA60 Dismounting
4. NA48 Dismounting
5. NA62 Technical Design Document
6. STRAW Engineering Prototype & Test
7. GTK Laser Setup Construction
8. GTK Prototype Bump Bonded Assembly (IZM)
9. GTK Prototype Test Beam
10. GTK ASIC Architecture Choice
11. LKR CREAM Market Survey
12. RICH Vessel Design
13. LAV A2-A3 Construction

RICH Gas System





LKR Cryogenics work package

Not included in the WP

- The beam pipe vacuum system
- The krypton cryostat cool-down and warm-up system
- The UPS installed to protect the cryogenic system against disruption in the electrical network

- WP components:
  - **All year round operation including following-up of eventual alarms**
  - **Preventive and corrective maintenance**
- The NA62 technical coordination shall foresee
  - **a budget covering the spare material**
  - **a NA62 cryogenic system expert**