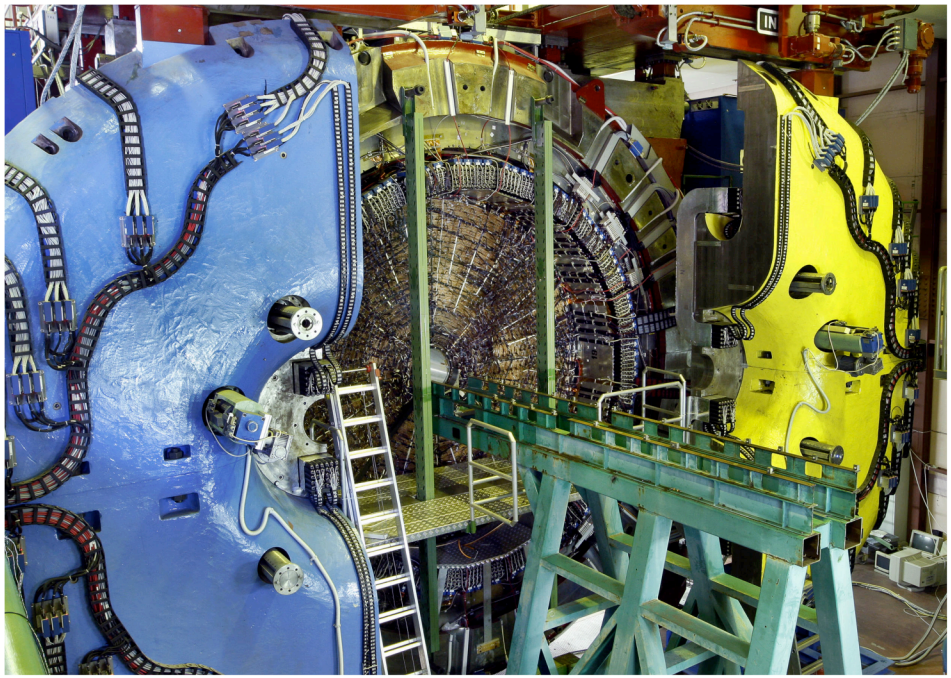
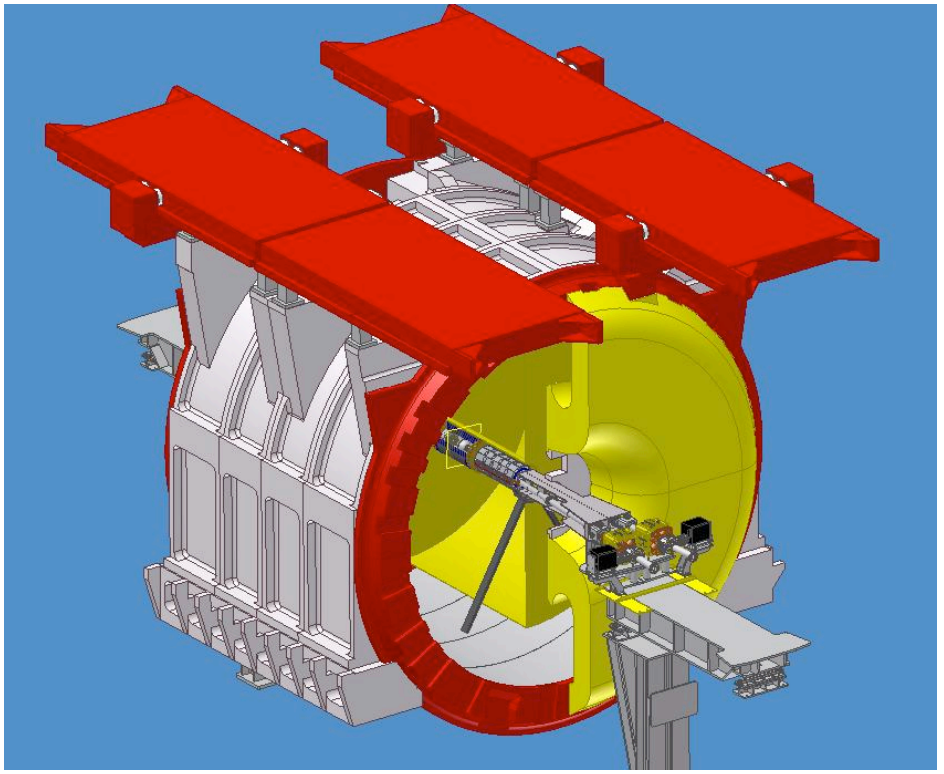
Status of KLOE-2 & γγ-tagger for step-0





S. MISCETTI
Laboratori Nazionali di Frascati

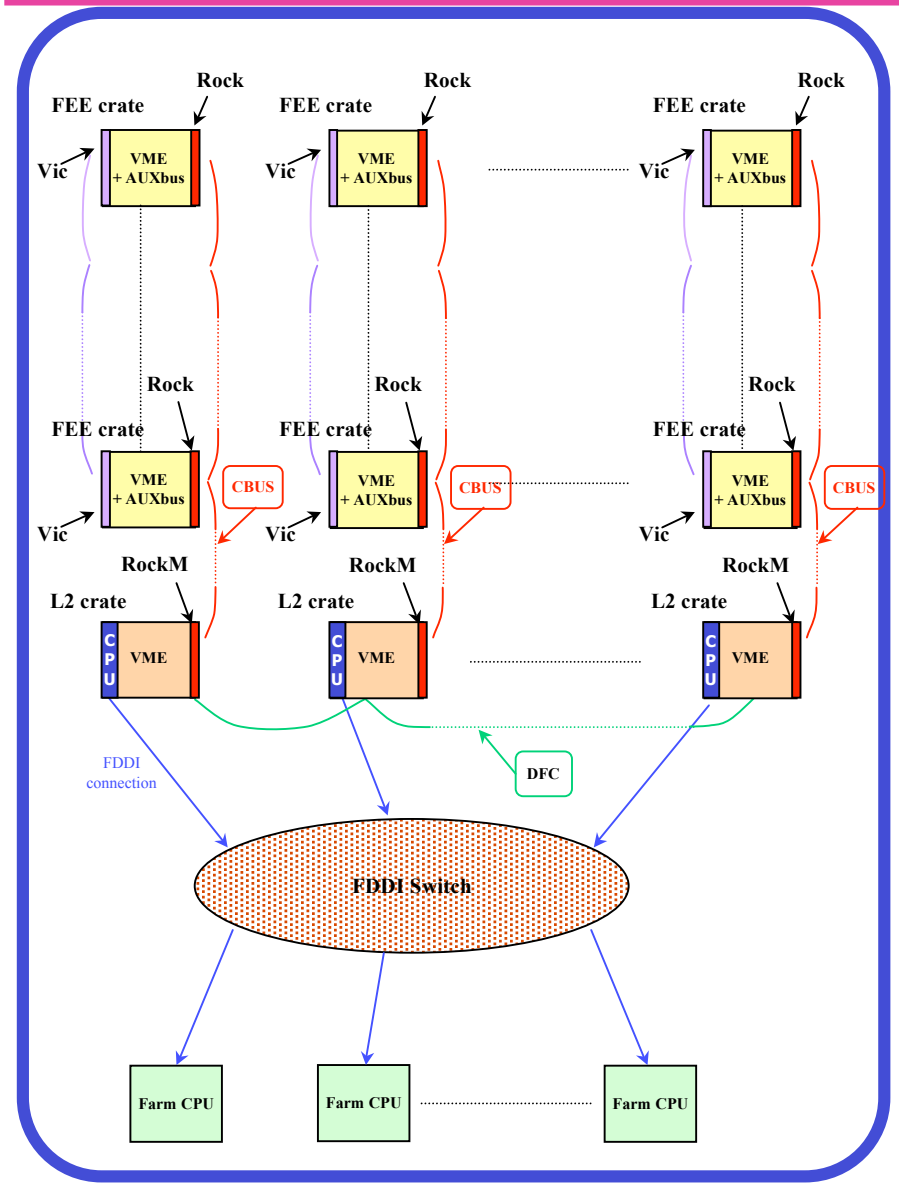
11/5/2009 - 38th LNF Scientific Committee - LNF

Talk Overview

Two major ongoing activities:

- Maintenance and upgrade of the KLOE apparatus:
  - L2 CPUs + Slow Control
  - Networking + online farm
  - Detectors (DC, calorimeter,trigger)
  - Computing power for reconstruction + storage system
  - Beam pipe and inner region
- R&D for the new detector systems
  - The $\gamma\gamma$-taggers LET+HET (Draft of TDR $\approx$ ready)
  - The inner tracker (IT)
  - The crystal calorimeters for the inner region (CCALT)
  - The quadrupole instrumentation (QCALT)

DAQ +SLOW & Rates



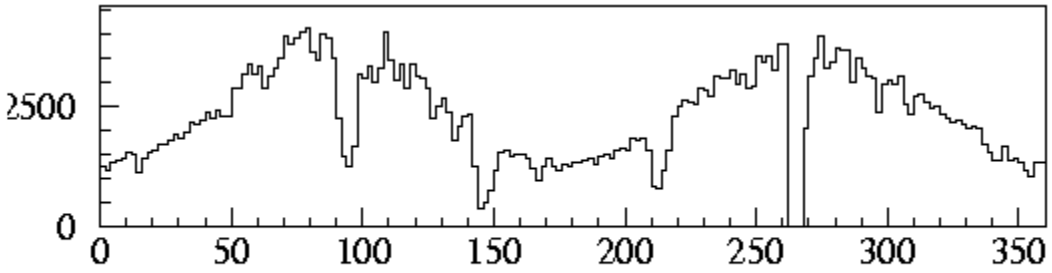
- L2 CPU (Motorola) have been delivered & inserted in DAQ chains.
- Online Farm ok
- Networking .. in progress
- Slow Control:
  Porting of software on KLOESLOW(AIX) done.

❑ Rates handling possible @ L2
- -> 50 MB/s (i.e. 25 khZ @ 2 kB/ev)
- Online FARM OK
  Next run exp: @ L = 5x10^32
  Rphi = 1.5 kHz, Rbha = 1.5 kHz
  Rcr = 0.7 kHz
  Rbkg = 0.5-3 kHz (Touschek)
  Rtot = 4-7 kHz
  2-3 times larger than old KLOE

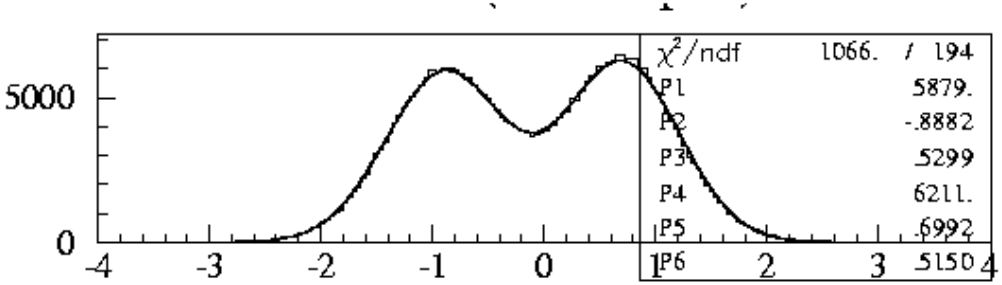
❑ Offline processing --> 50 pb-1/day

EMC status

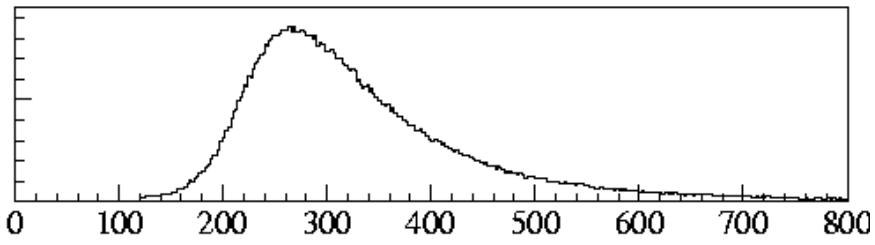
- **EMC hardware**, Calibration procedure and Monitoring
- EMC HV switched on after cleaning all crates. Failure of readout sensors 1 crate.
- Still 3 bad HV boards (24x3 channels out of 4880)
- **pedestal runs OK, noise level similar to the one in 2006**
- **pulse runs OK, Cosmic runs OK, Dead-Hot procedure working**
- **Physmon tested w CR + Resuming Calibration**



PHI Cluster (Barrel)



T1-T5 (Barrel)



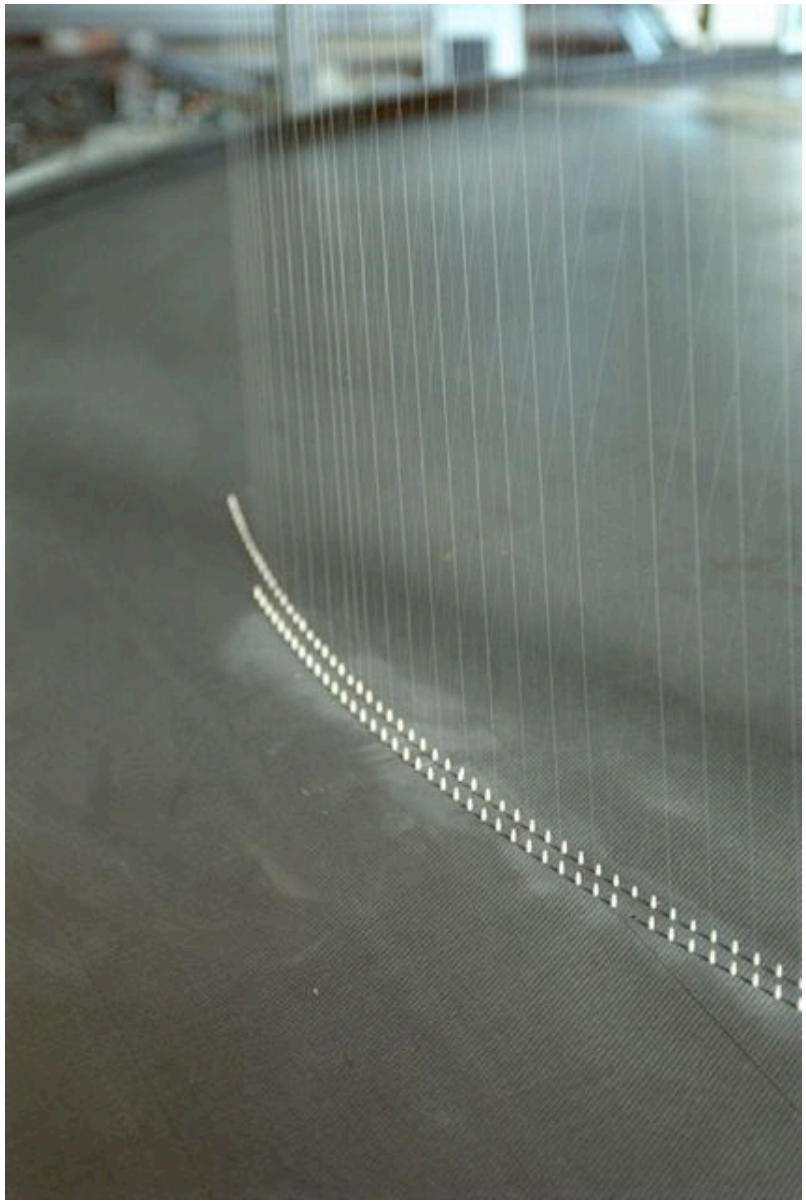
Mip Energy (Barrel)

DC status

- **DC hardware**:
  - DC switched on (HV up to 500V): all wires/channel are ok
  - FEE checks planned for the next weeks.
  - Wire mechanical tension measurement: planned before the end of june.

- **Gas system**:
  - System ok (with nitrogen)
  - Working on alarm system and security
  - Ready to flow He-IsoC_4H_{10}.

- **Calibration procedure and DB**:
  - resuming/updating old procedures



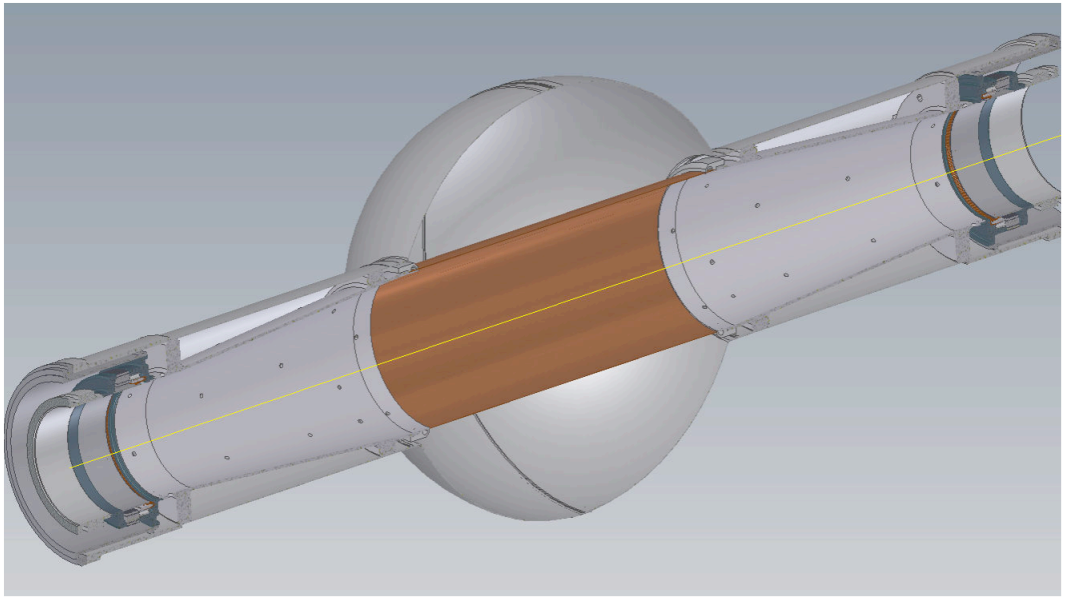
Old vs New beam pipe

Old Beam Pipe:

- Spherical beam pipe of 10 cm radius, thickness 500 μm of Albmet 162 with an internal 50 μm Be cylinder of 4.4 cm radius.
  - minimize Ks interactions + optimal sample for QM interference

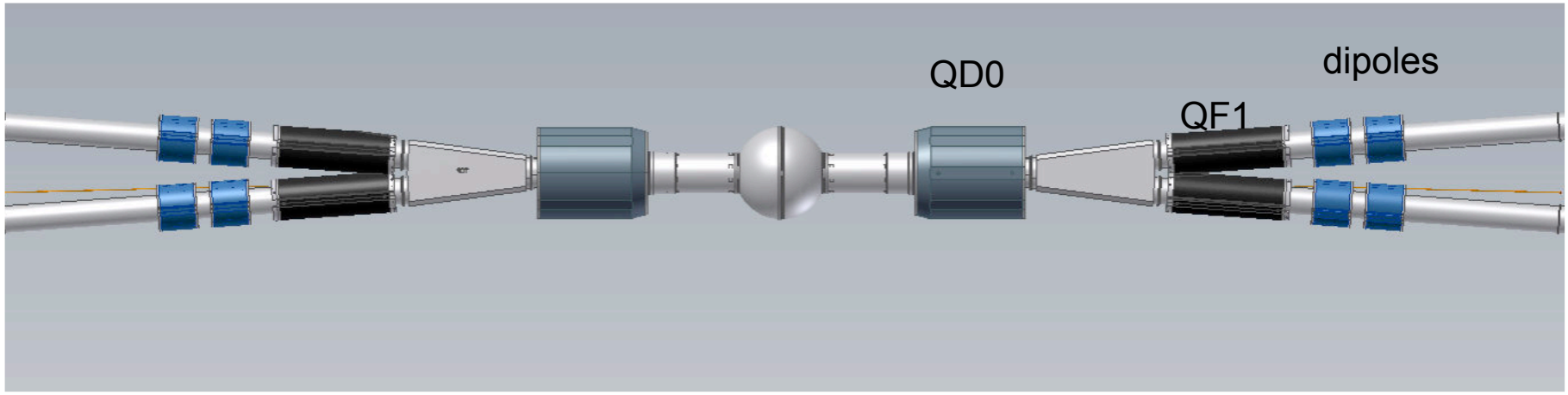
New Beam Pipe final drawing: (G.Sensolini)

- external part as it is, connected to the first quadrupole, QD0
- internal cylinder connected to the new beam pipe by a cone-shaped Al section --> Internal 30 μm Be cylinder at 3.7 cm radius.



KLOE B-fields optics

- New machine layout to compensate KLOE B-field completed.
- A new permanent dipole needed on each arm after QF1 (providing an integrated field of 344 G.m)
- Each dipole will be constituted by two pieces to allow running at 3, 4.5 , 5.2 kG
- Order in progress (+4 months delivery time).

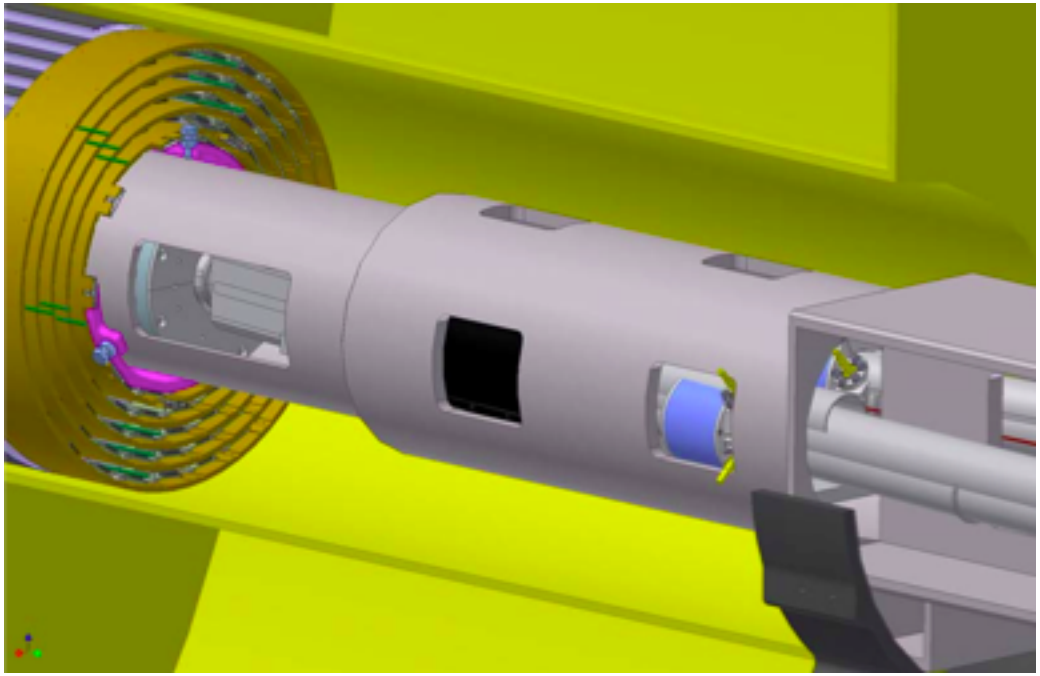


Beam pipe mechanical support

Design of mechanical support completed.

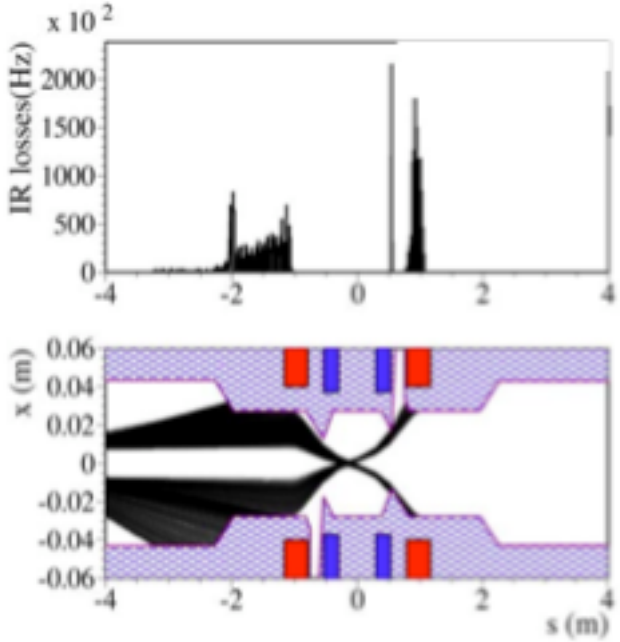
It was done with the idea of making it "as final as possible" also for step-1 --> (i.e able to grant mounting of all new components ..) IT, CCALT, QCALT & LET.

- Last details to be completed --> "BKG screens"



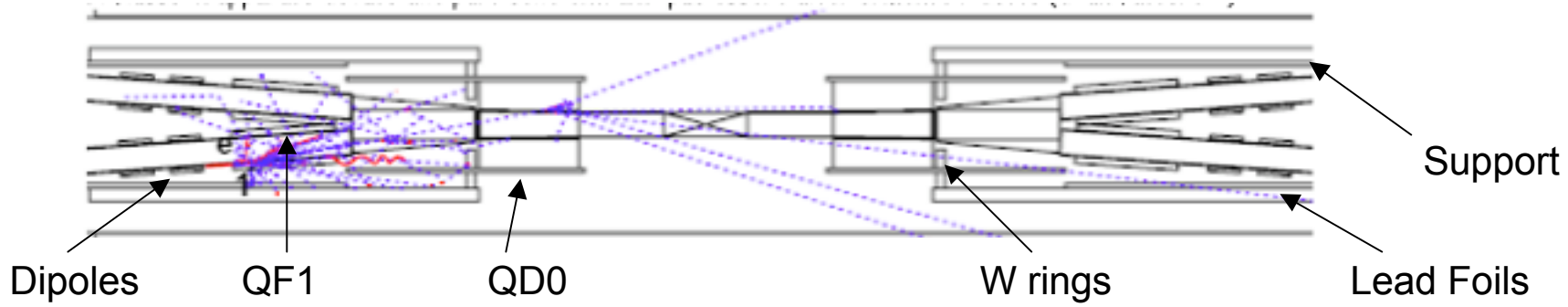
Simulation of machine background (I)

- ✓ Beam lifetime and rates of machine background dominated by Touschek effect.
- ✓ Simulation of these effect from AD (M.Boscolo) now reproduces lifetime measurements after addition of non-linearity in the Wigglers.
- ✓ Bad news are: the background rate increases of a large factor for the incoming beams in the region upstream the IP



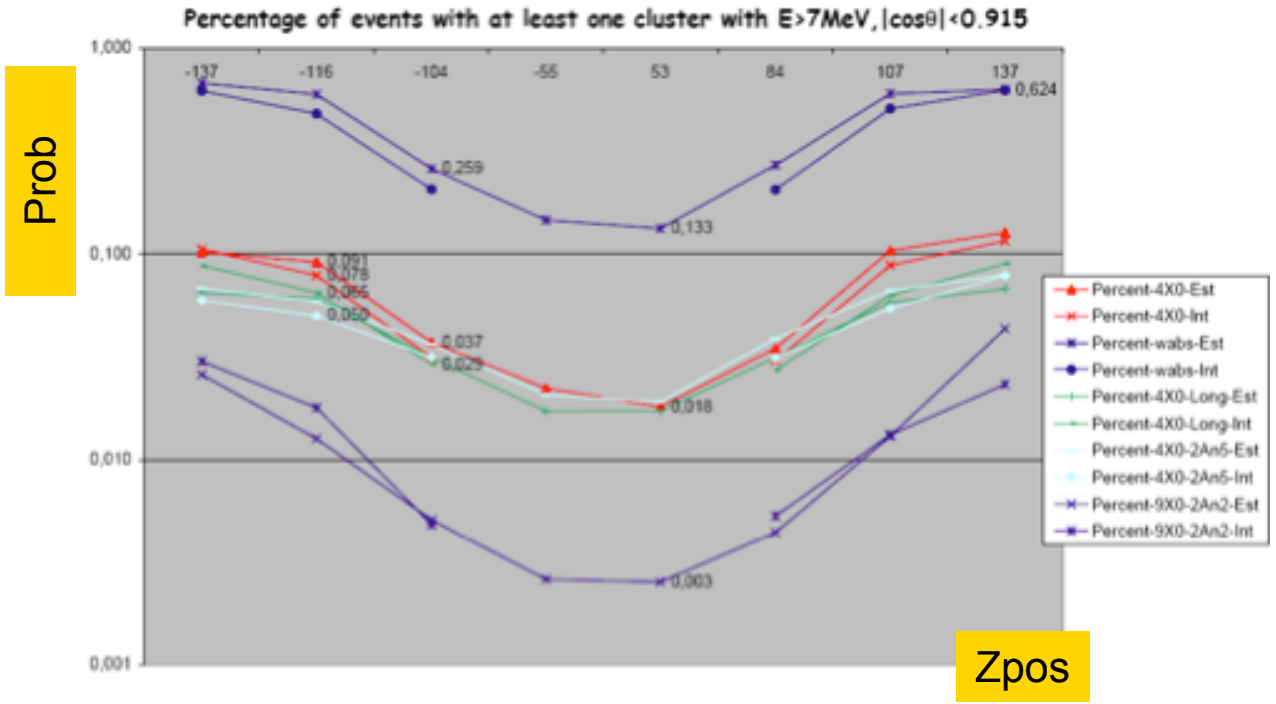
with dodecapole and decapole

Geant simulation of the KLOE IR + in INPUT the simulated Touschek events



Simulation of machine background (II)

Prob =
Probability to get a EMC cluster with E > 7 MeV

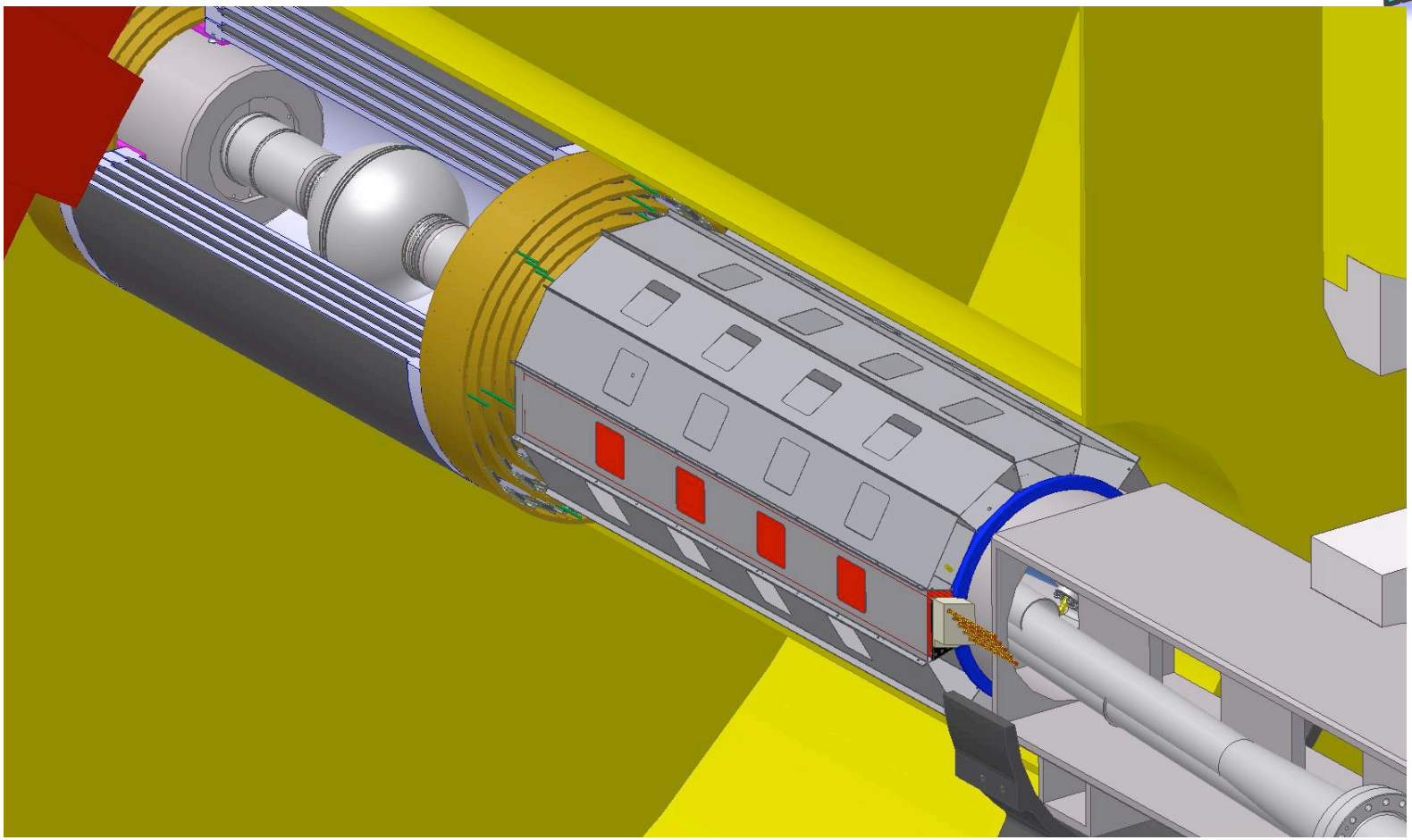


- ✓ Without any screen, the probability of having "machine clusters" in the EMC is around 60% (13%) for "Touschek" particles in the incoming (outgoing) beams

- ✓ Adding a QCAL screen done with 4 (9) Xo of lead reduces the bkg of a factor 7 (44) + a W screen (4-5 cm) before QD0 reduces the bkg due to incoming beam of a factor 2.

BKG rate: No screen (470 MHz), W+QCAL screen --> 55--15 MHz(4 -- 9Xo)
In KLOE we had a most 5 MHz --> Very useful to work on the Wrigglers.

Drawings of screens



The lead foils will be arranged inside a dodecagonal support structure

--- Wedge 0 - horiz-plane will be used at Step-0 for inserting the LET
--- The other sectors will be used in the future as location slots for the QCALT.

Summary of layout/plans & schedule

Continuous cooperation with the AD established (bi-weekly meetings)

- Extraction of the IR from KLOE - DONE
- Machine layout with B-fields - DONE
- Design of the new beam pipe ready – Apr 09
- Design of the dipoles ready – Ordering in progress
- Design of the Beam Pipe mechanical support - Apr-may 09
- Design of screens for Touschek background - Apr-may 09

Next step is the Roll_in

- First meeting done with CIF to assign operation responsibility
- A working team from KLOE under organization
- EndCap Closing in september 09 --> start the Roll-in soon after
- beam pipe insertion + magnet reconnect --> Oct 09

Still on track for running end of the year!

γγ-physics w tagging @ KLOE

$e^+e^- \rightarrow e^+e^-\ \gamma^*\gamma^* \rightarrow e^+e^-\ (\pi^o\pi^o, \pi^o, \eta)$

Tagger

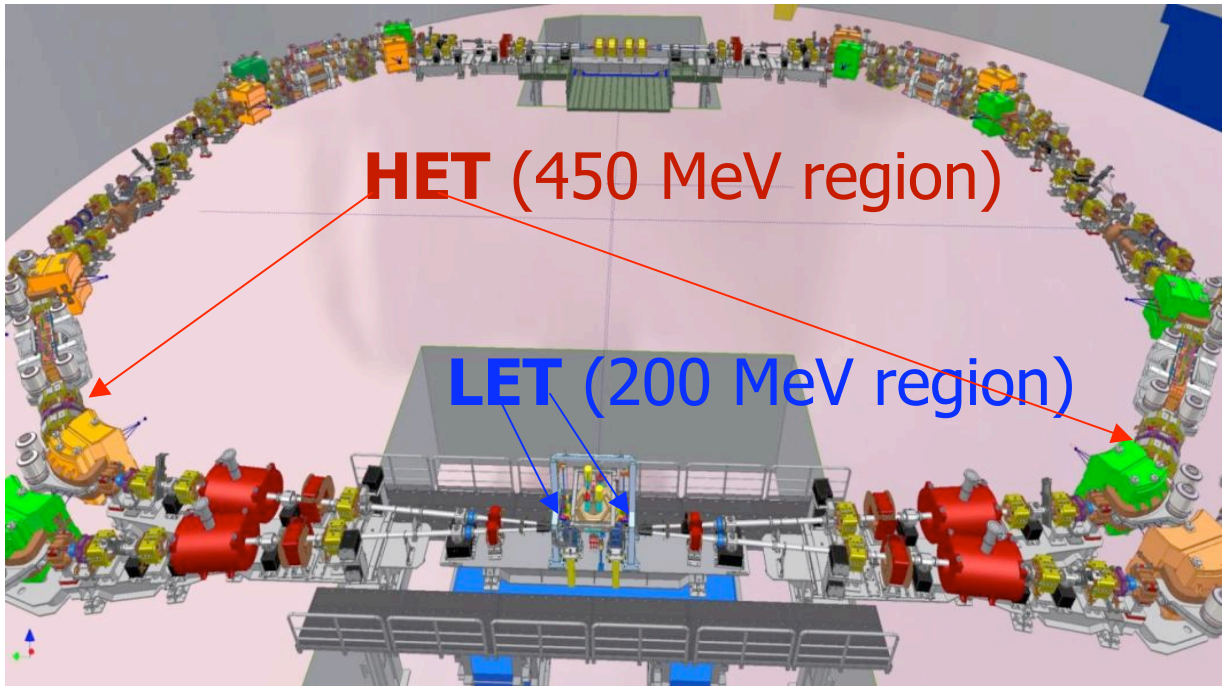
KLOE

- Use Daϕne magnets as a spectrometer to get e+e- (tagging)
- Needs knowledge of machine layout and simulation of trajectories
- Negligible contribution of ϕ decays + kinematic closure

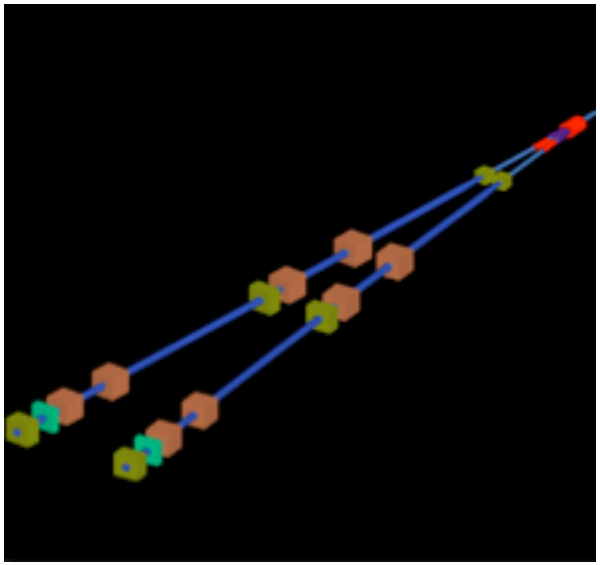
-TDR will be released as LNF note end of may

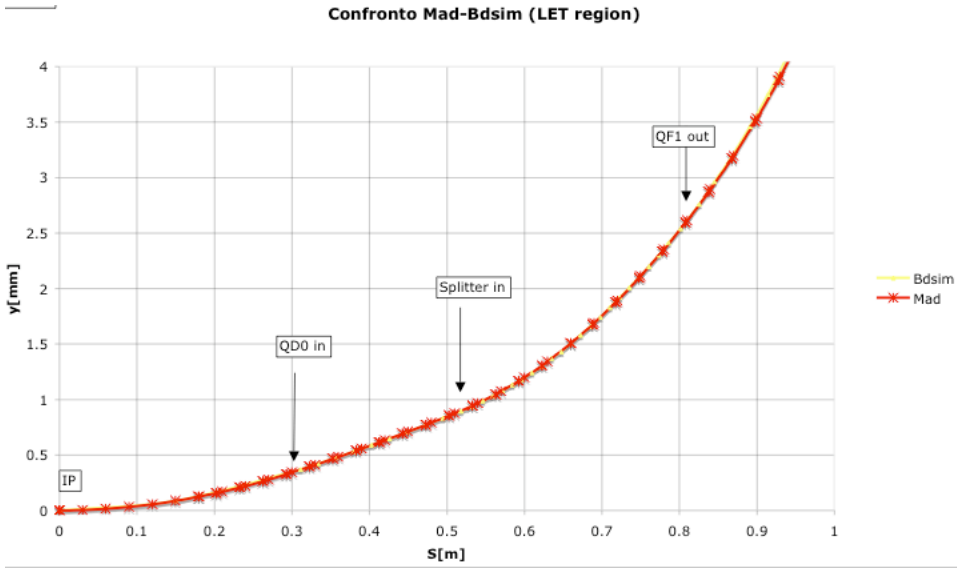
- Draft version available for referees

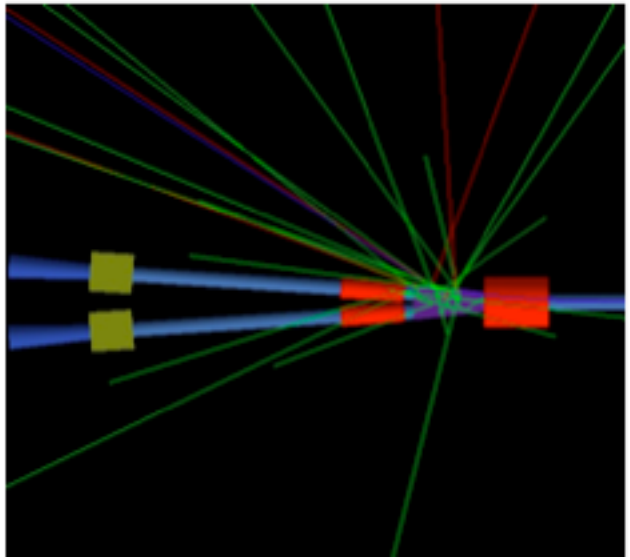
- CSN1 --> green light



Simulation of trajectories in DAFNE

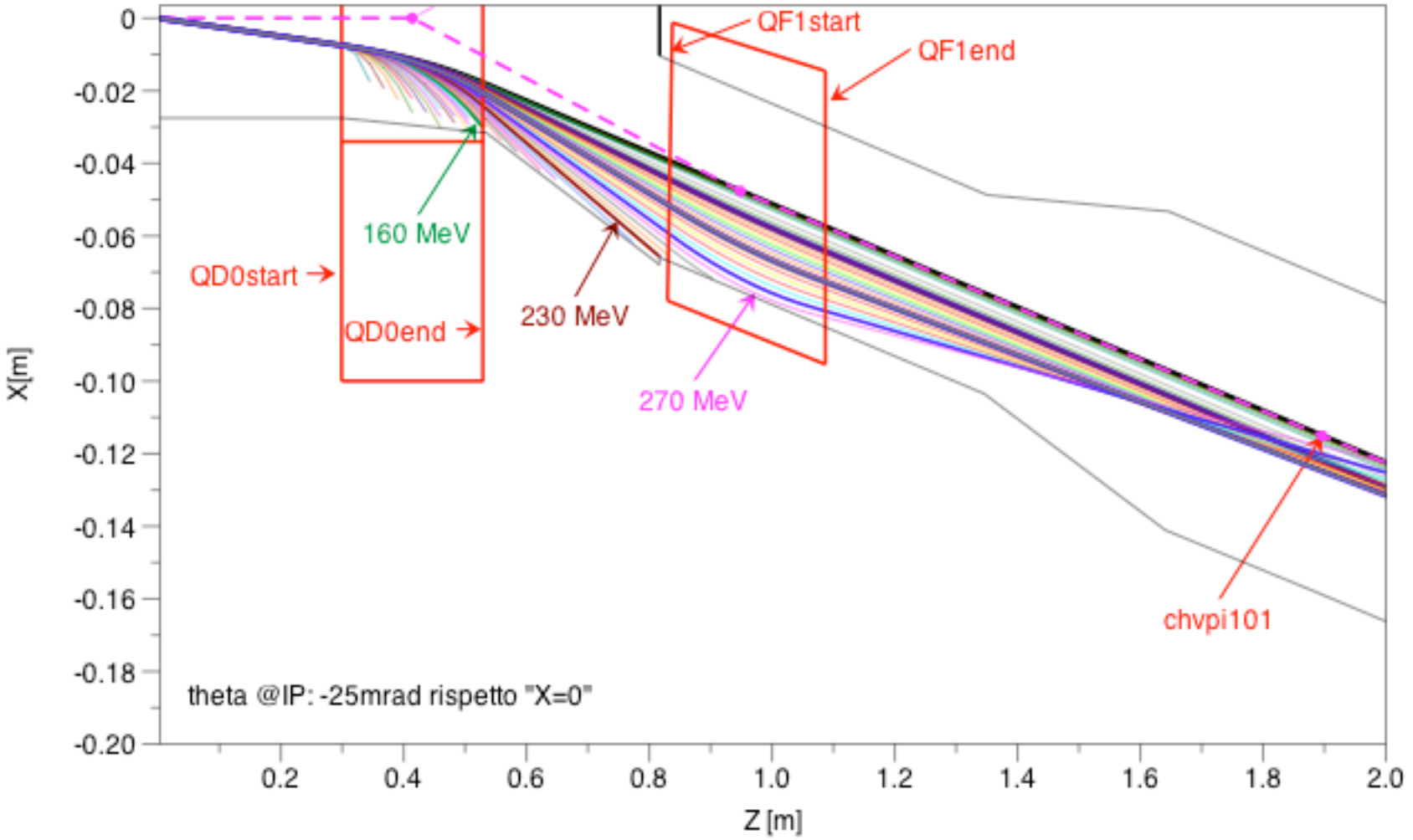






- MAD works at nominal beam energy and consider the magnetic elements as thin lens.
- BDSIM works in GEANT and is able to work also at lower momenta.
- Comparison MAD-BDSIM trajectories OK for nominal beam energy. Insertion of KLOE B-field, done up to end of QF1 region.

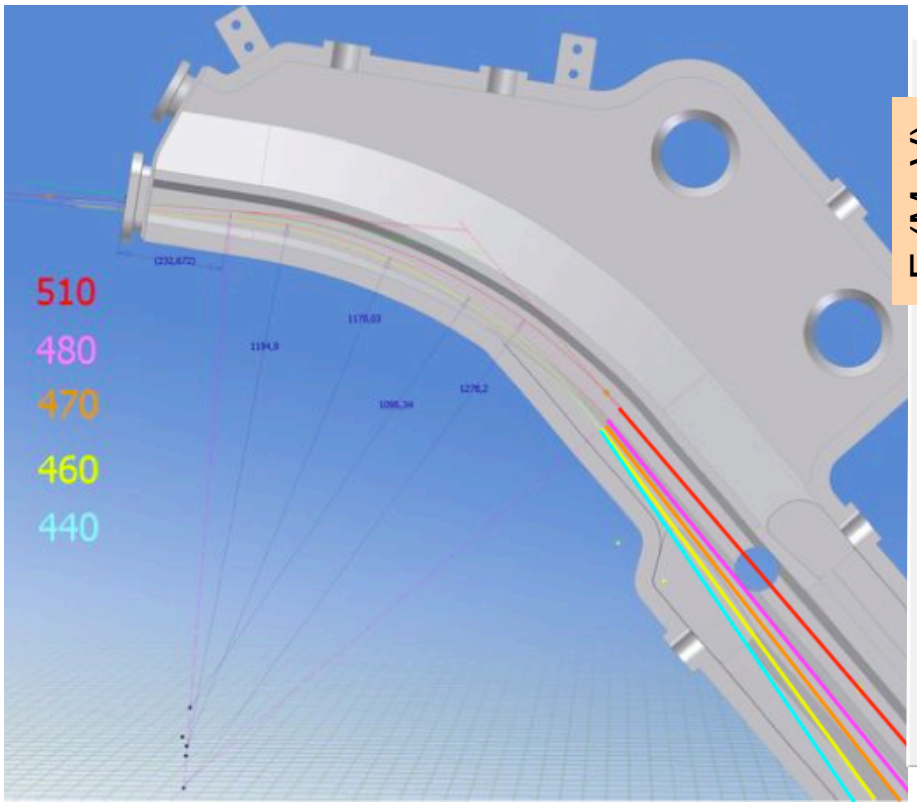
Electron tracking inside KLOE (LET)

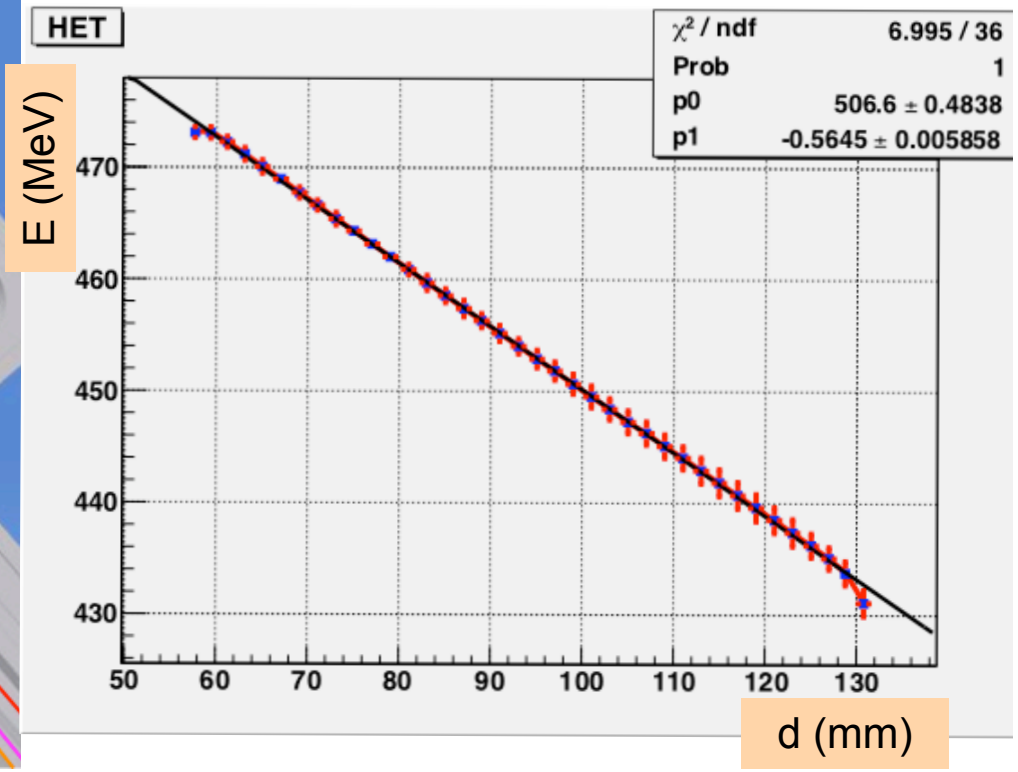


- The low energy leptons from IP reaching LET cross only QDO.
- Deflected from main orbit since they are off-axis w.r.t. QDO

We need a calorimeter

Electron tracking outside KLOE (HET)





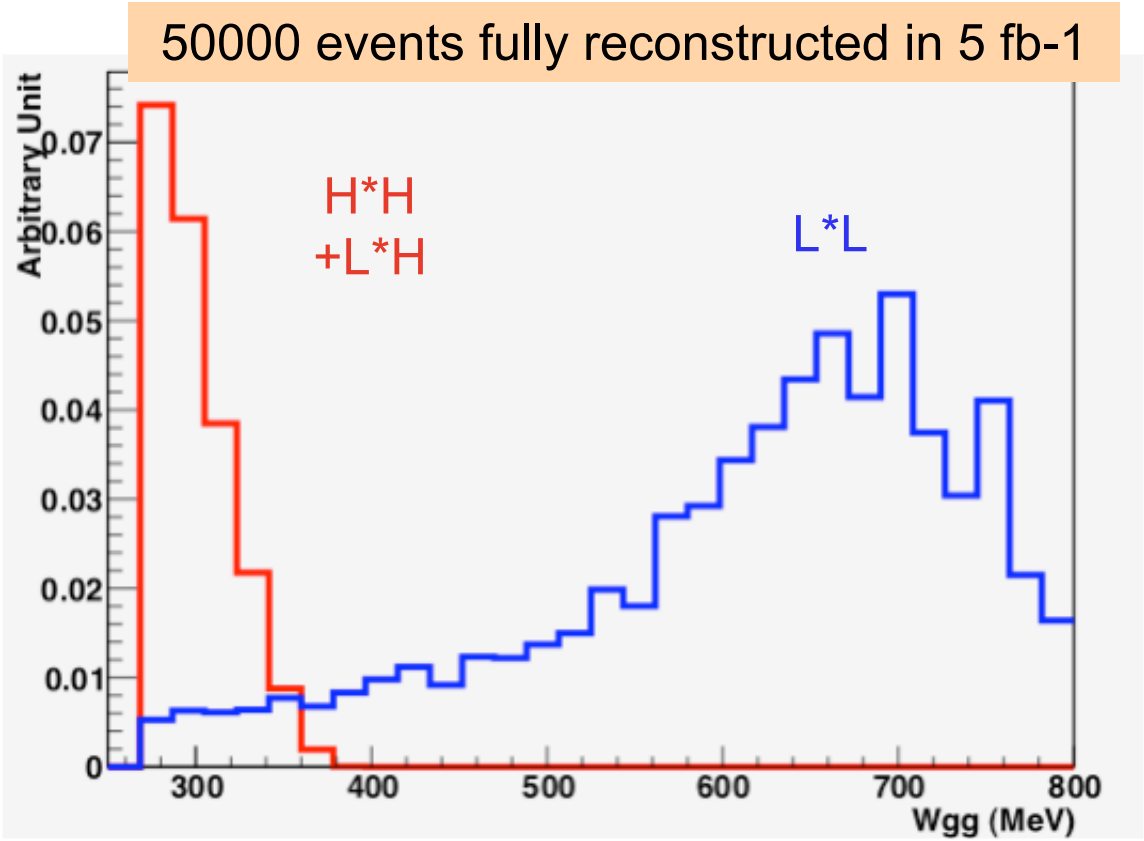
-The beam-pipe "shape" works as an angular filter for scattered leptons
-After the Dipole present at 11 m from IP, there is a large correlation between the lepton energy and the distance from the beam axis.

We need a position detector --->
(resolution of 1 mm == 0.56 MeV)

Angular coverage of the tagger

- Single arm coverage (1 HET (14%), 1LET (17%))
- Single Total acceptance = 54%
- Double arm coverage (H*H + 2*L*(H)+L*L) = 2+5+3 = 10%

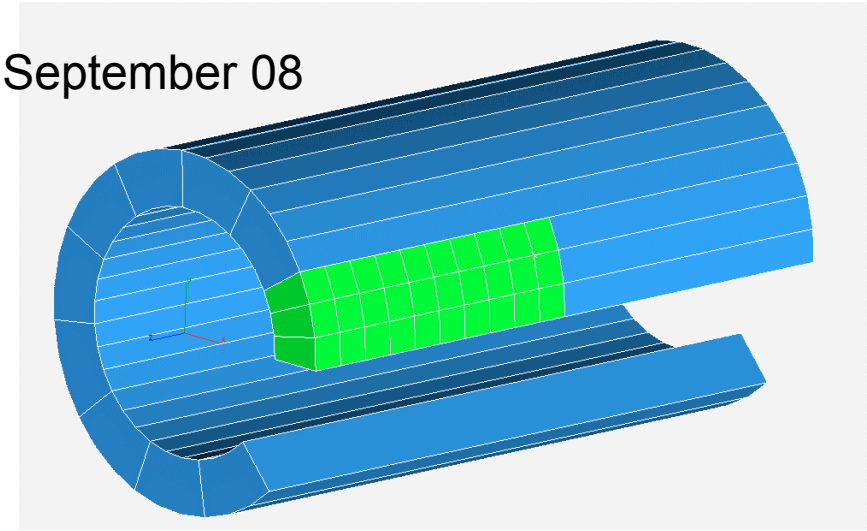
ie » 500 pb-1 of clean gg physics in Step0



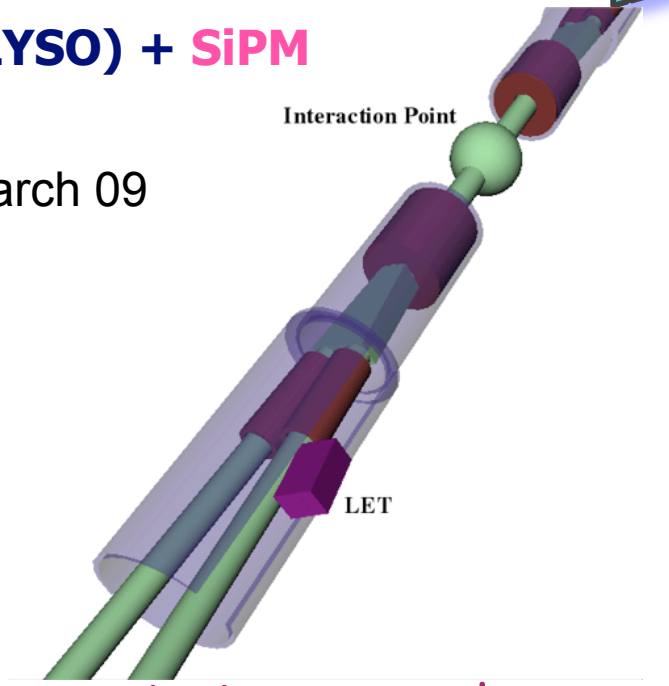
Old vs new LET proposal

Technology: Crystal (PBWO/LYSO) + SiPM

September 08



March 09



Transversal crystal array ----------> pointing crystal array

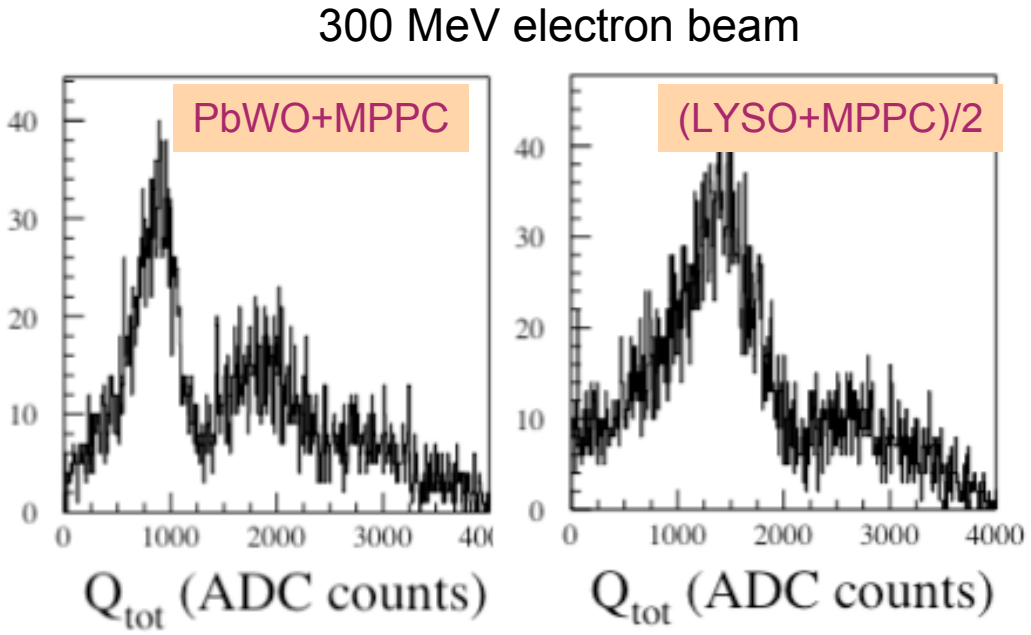
- reduced front and transversal leakage, σ/E = 10% -> 4%
- reduced number of channels --> LYSO option possible

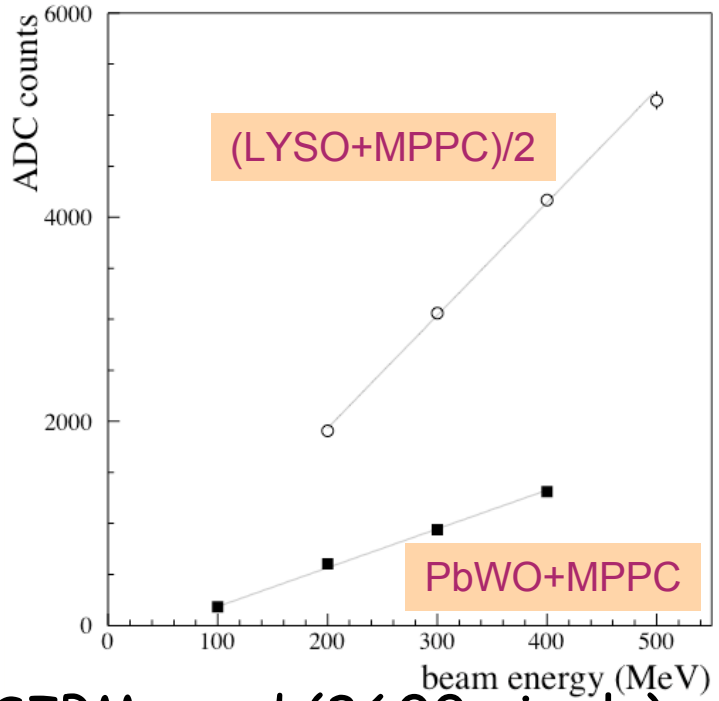
- ❑ 3x10 crystals/side
- ❑ 3x3x5 cm^3 dimension.

- ❑ 3x4 crystals/side
- ❑ 2x2x13 cm^3 dimension.

- Photosensor candidate --> MPPC 3x3 mm^2, 14400 pixels
- HV supply and amplification designed by SELF LNF group

BTF: PbWO vs LYSO "response"



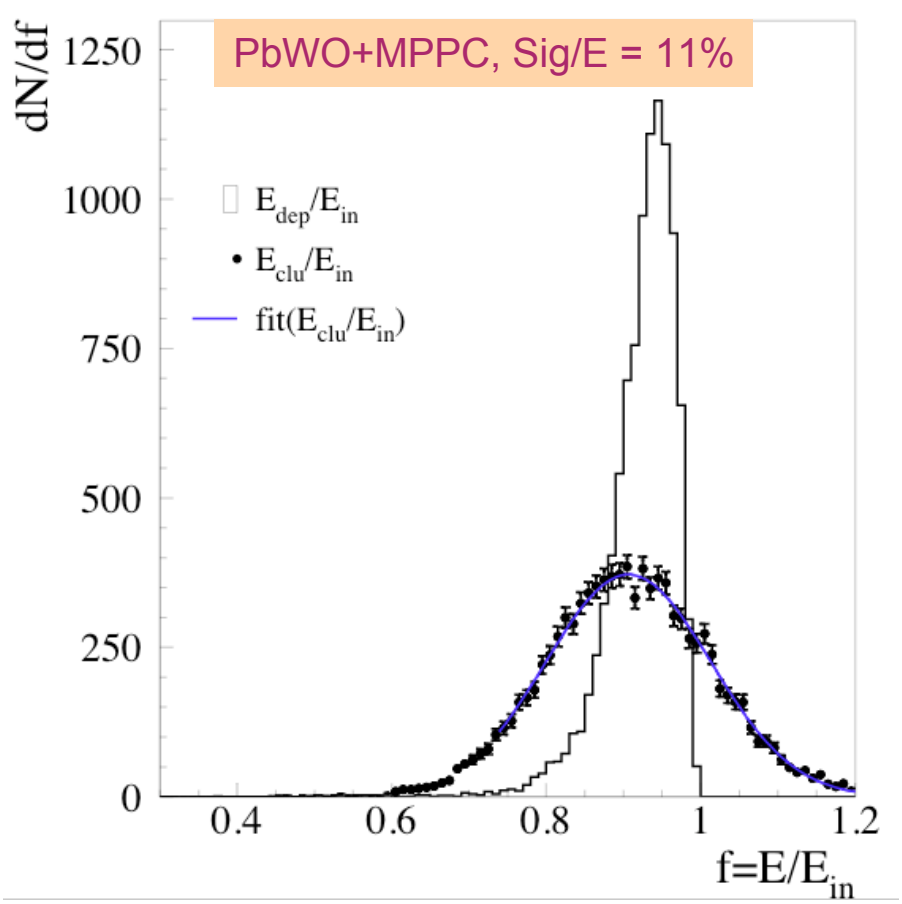


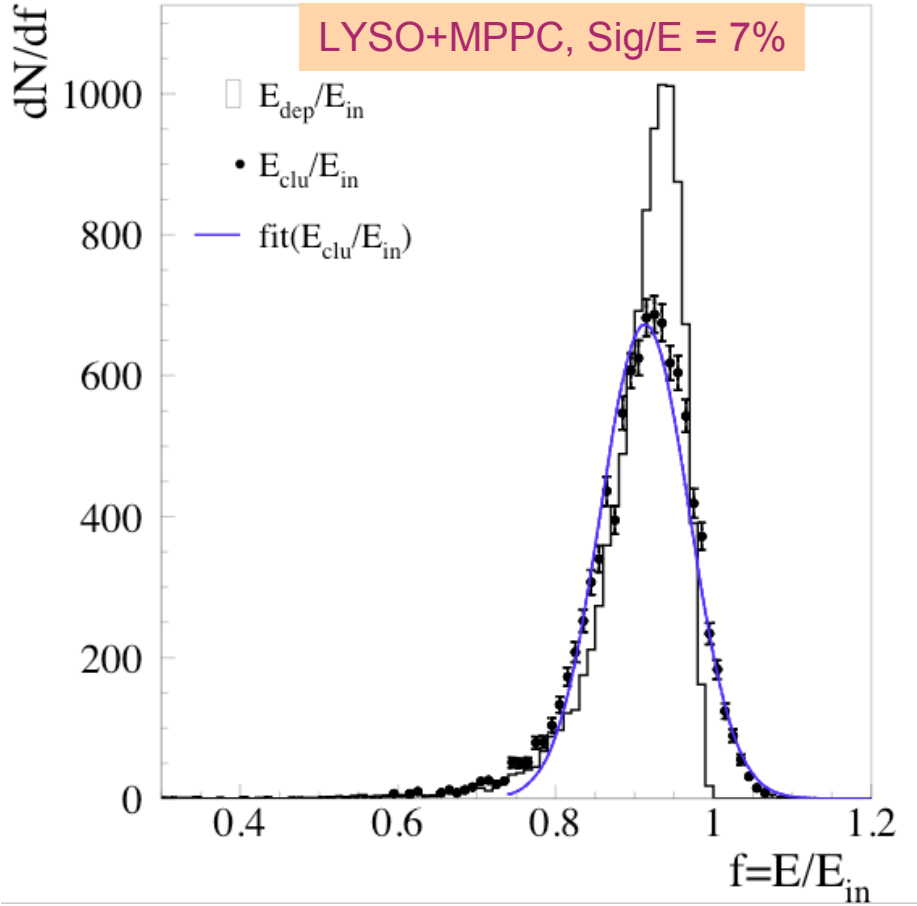
High light yield of LYSO saturates SIPM used (3600 pixels)
---> reduced w 2 layers of plastic filters

- 0.5 pe/MeV measured with PbWO
- 1.5 pe/MeV measured with LYSO
- With better tuning (1 layer+reduced ampl) + using MPPC w 14400 pixels we can reach up to 8-10 pe/MeV.
- Time resolution already in right ball park (1.1, 1.4 ns @ 300 MeV)

PbWO vs LYSO: LET simulation

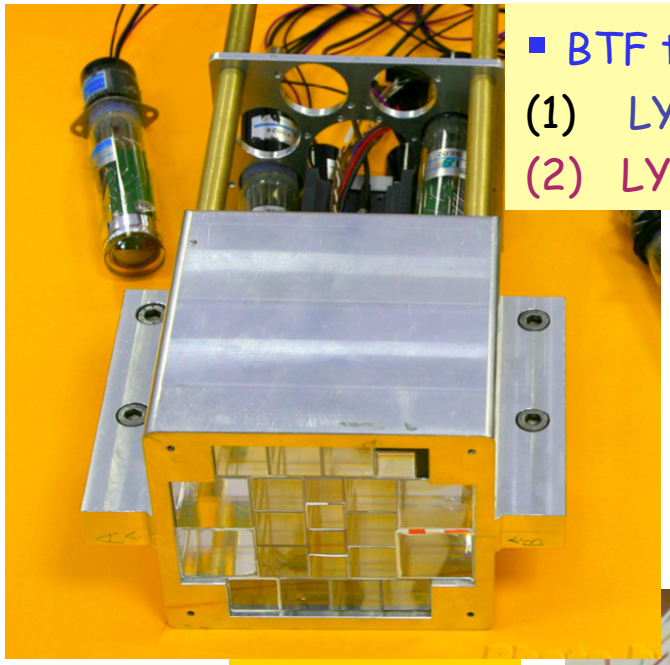
-Full simulation of LET response for electrons from 120 to 240 MeV
- L.Y used 0.5 pe/MeV (PbWO), 3 pe/MeV (LYSO)





Crystal matrix prototypes

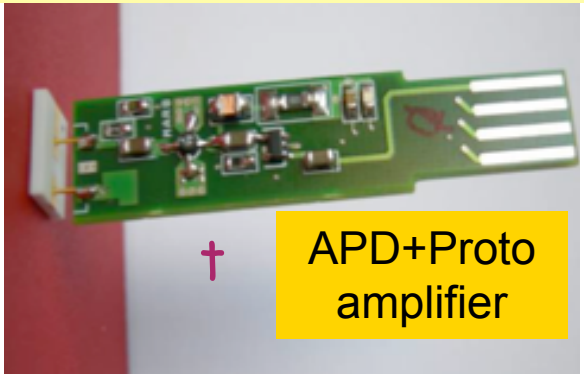
- A crystal matrix prototype constructed with an inner matrix of 10 LYSO+APD(or SIPM) and an external matrix with 8 PbWO+PM



- BTF test of the matrix underway

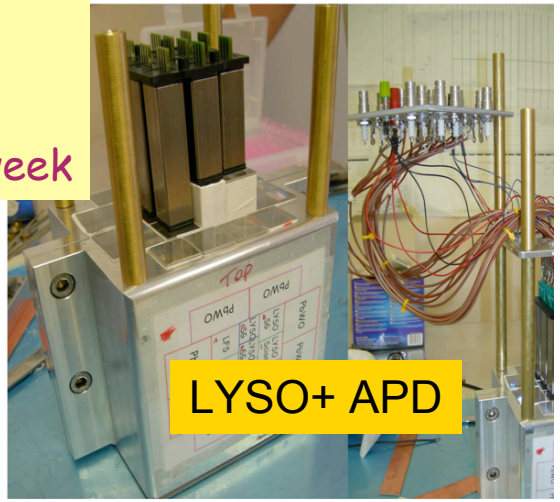
(1) LYSO+APD from 6-15 April.

(2) LYSO+SIPM ….. In progress this week

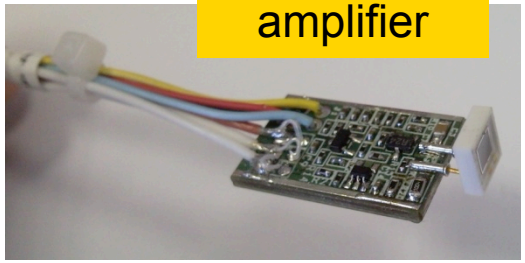


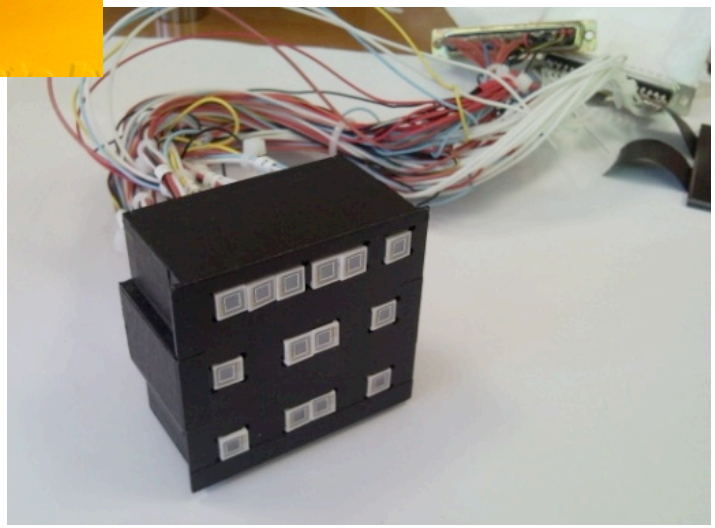
†

APD+Proto amplifier



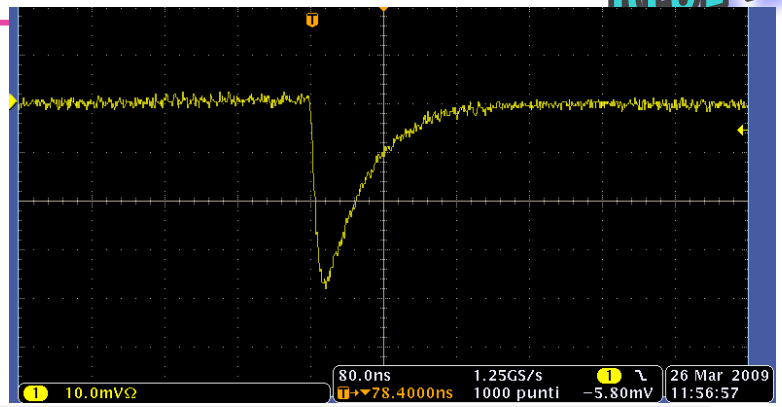
SIPM matrix+ amplifier

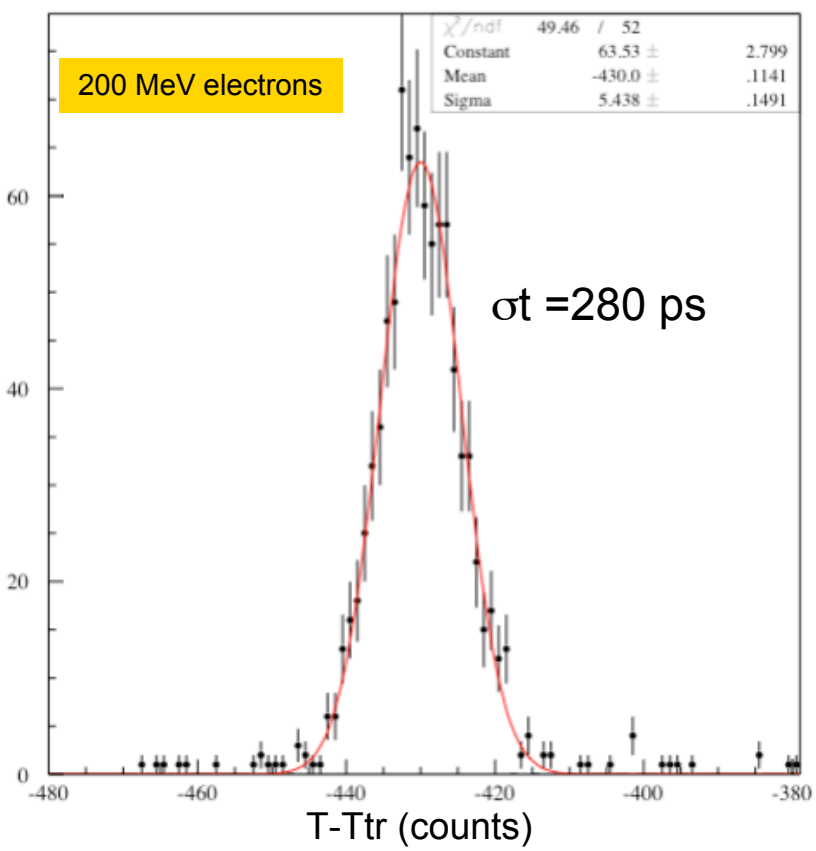


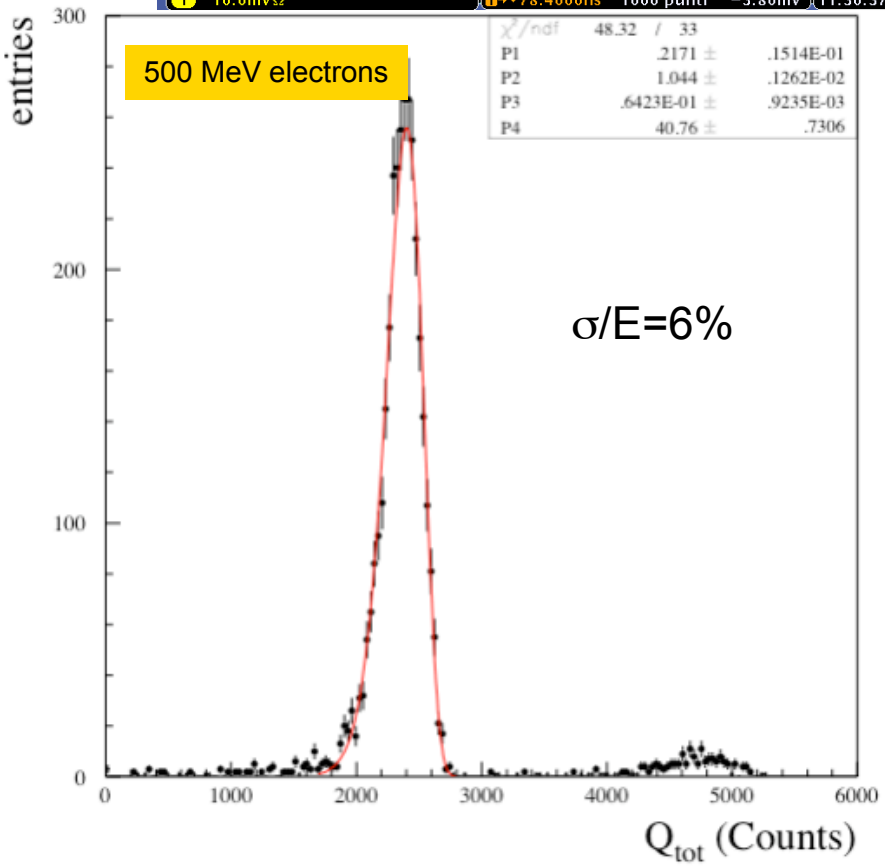


First BTF results with LYSO+APD matrix

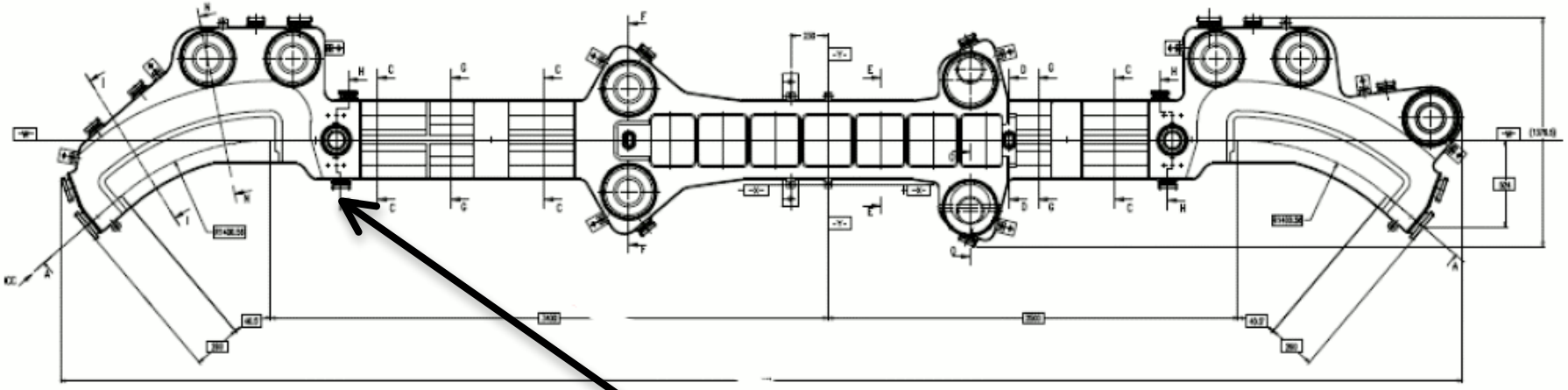
- Optical cross talk found between inner+outer matrix.
  Fixed for this week test beam with LYSO+SIPM
- Results on energy resolution obtained for the inner matrix.
  Dominated by leakage (4-5 %) and electronic noise + readout
- Results on timing resolution are excellent (< 300 ps)



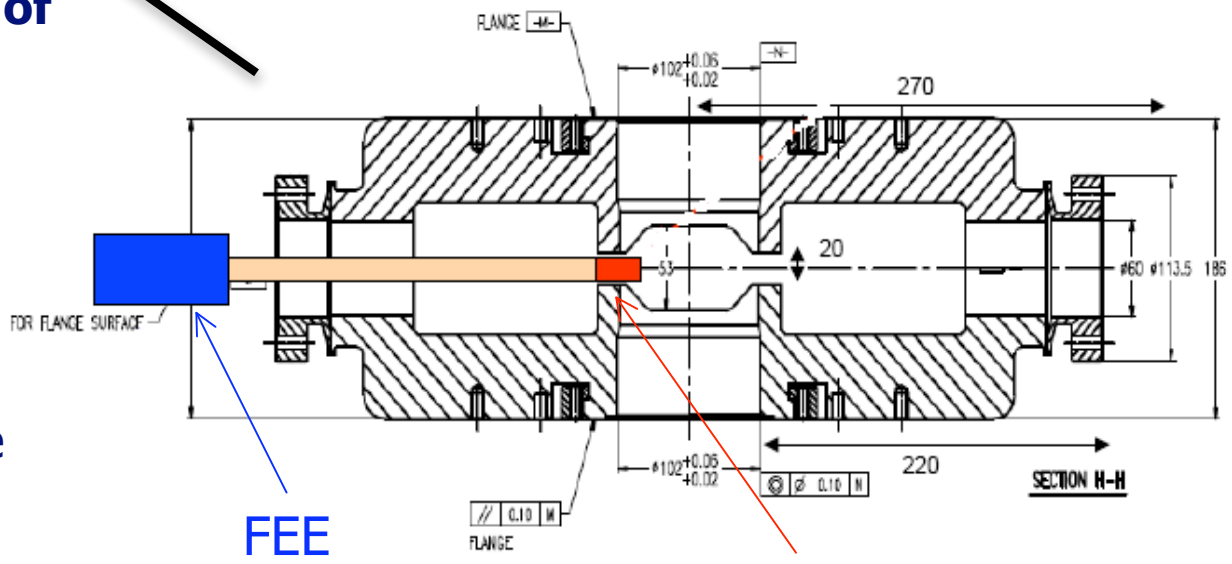




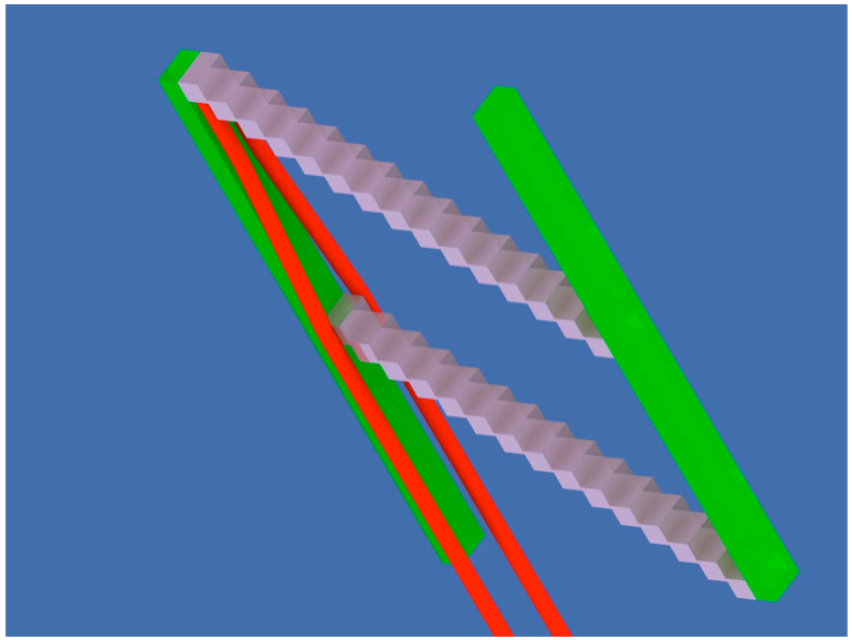
HET overall description

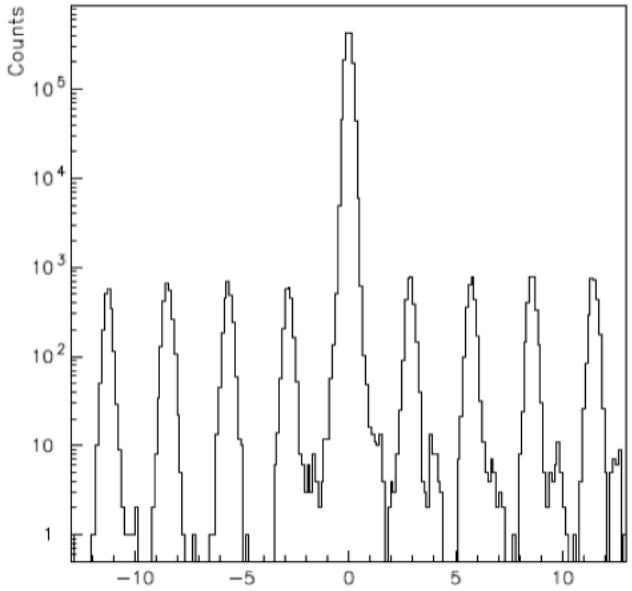


- **Tecnology: hodoscope of plastic scintillators**
- Dipole is used as a spectrometer
- Energy resolution depends on strip pitch
- Placement in an accessible H-H' flange after the dipoles



HET scintillator hodoscope



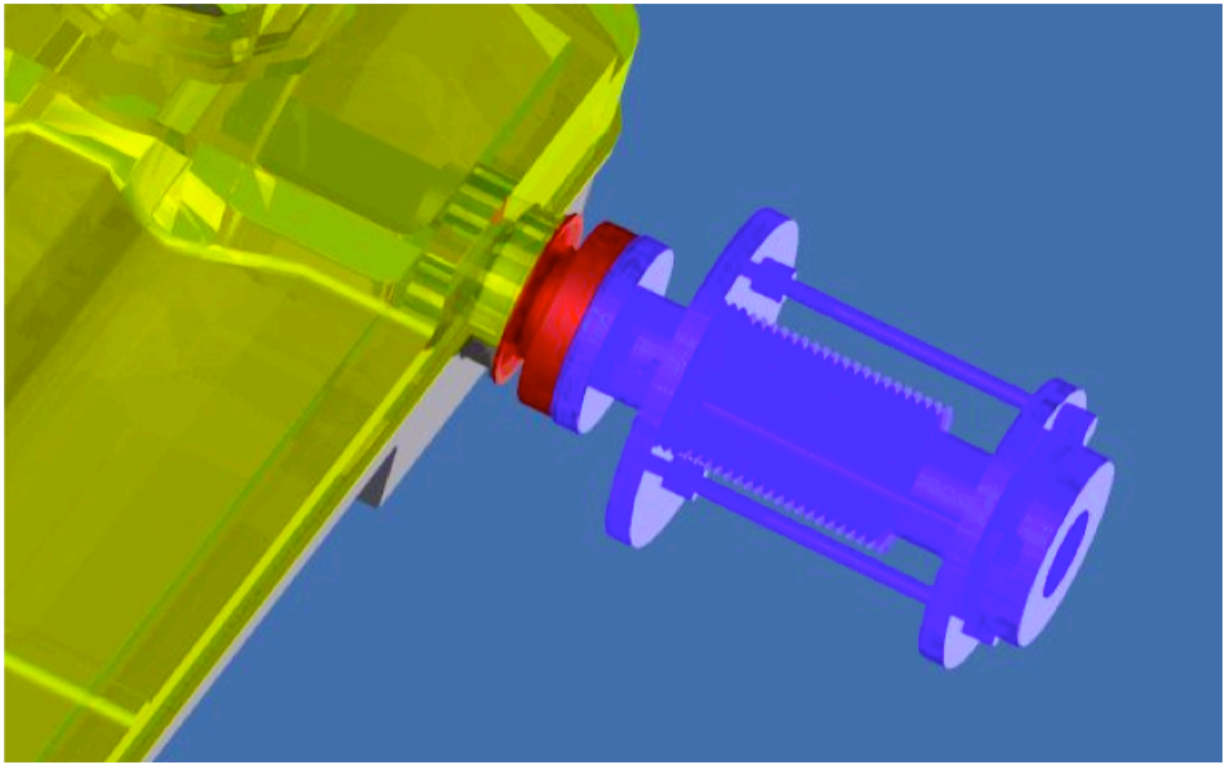


- The hodoscope is constituted by two rows of 15 scintillators of 3x3x5 mm^3 dimension -->
  pitch resolution ~ 2 mm, 1 MeV momentum resolution

- Fast BC418 scintillator used. Light transported to photosensor with clear optical fibers. SIPM(3x3 mm^2) readout.

- LY in excess of 50 pe/MIP --> 200 ps resolution (similar to GRAAL hodoscope) which should allow clear separation between consecutive bunches.

HET drawing of moveable pot



- **Drawing for the moveable station** ready and "agreed upon" with DA experts.
- Minimum safe distance from beam line is of 3 cm.
- Simple step-motors needed.

IT status and plans

Large area GEM: for final detector GEM foil 500x700mm^2 wide are needed, while standard technology produce GEM of about **400x400mm^2**.
Step1: tuning of the new "single mask technology" to allow large area GEM;
step2: building a large area "PLANAR" GEM to verify global/functionality & gain uniformity.

2-D readout (XV): P0.1 has been realized only with X-view; the problems correlated with 2-D readout (charge sharing, grounding, cross-talk…) will be studied with:
Step1: 100x100mm^2 GEM proto telescope in a dedicated test beam at CERN (H4-SPS) with B-field (0 -1.5 T);
Step2: building a full size "PLANAR" proto (500x700 mm^2)

"CF" cylinder: foreseen as mechanical support of the whole detector and in particular of the readout electrode.
Each "CF cylinder" will be realized as a sandwich of 2x200μm CF foils interleaved by ~3mm NOMEX honeycomb (0.16% X_0 per CF cylinder, 0.8% X_0 for the whole IT – X_0(CF)=250 mm). **Test before summer.**

Conclusions

- We have started a close interaction with the AD for the IR
  -- New dipoles are under way.
  -- Drawings ready for beam-pipe + beam-pipe support.
- Preparation of the detector proceeds well.
- Plans for the roll-in are being put forward --> Goal = Set 2009

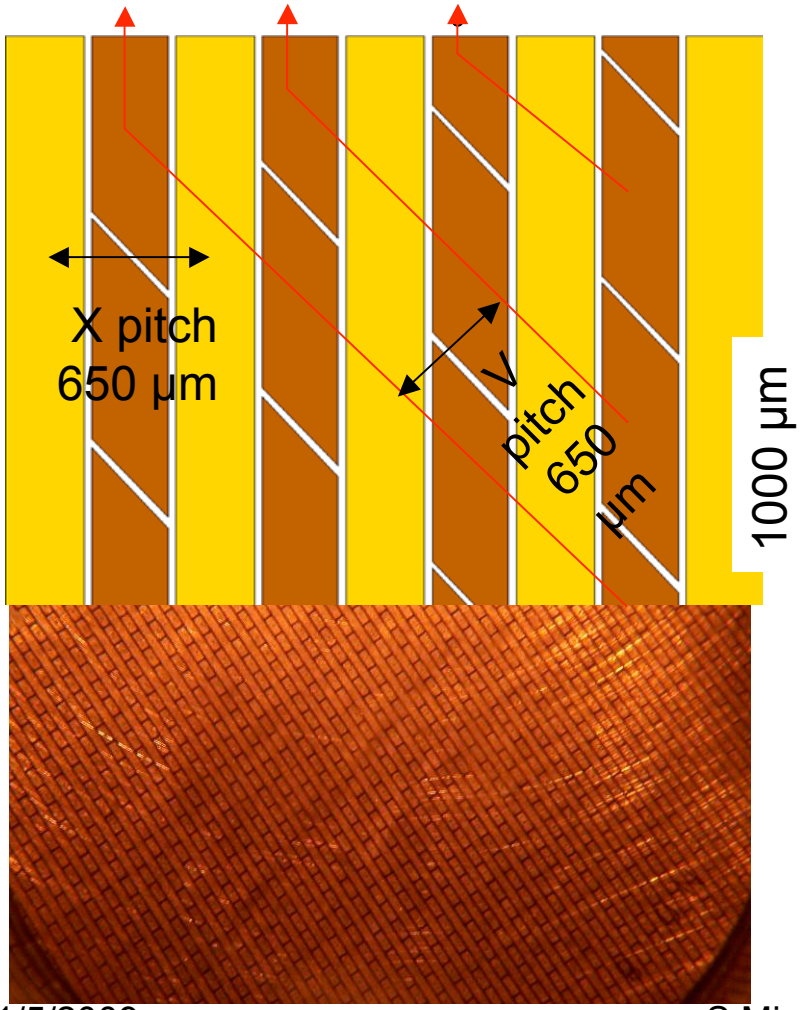
- We are planning to install the $\gamma\gamma$-tagger during 2009:
  - Simulation of trajectories completed;
  - Succesfull tests of single crystals/matrix done + new in progress.
  - Design for LET and HET exists;
  - A draft v1.0 of a TDR released.
  - Final version available on June as LNF-note.

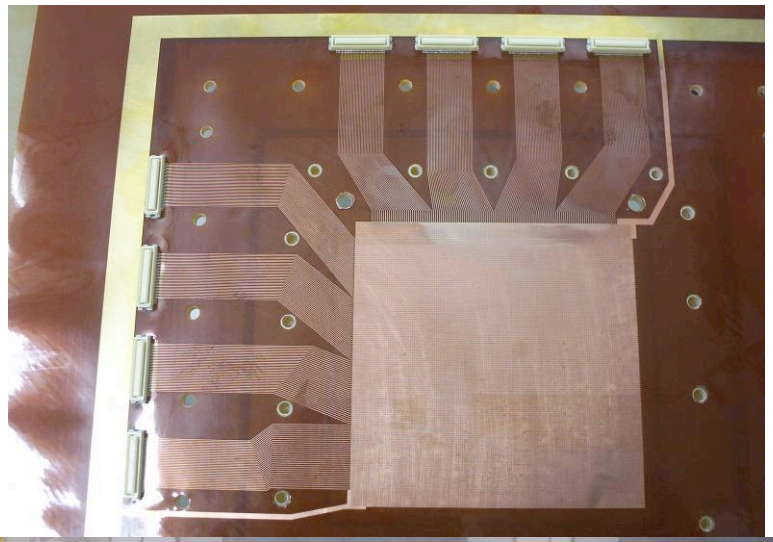
- Other upgrades are proceeding well. A TB to test XV readout on small planar Gems organized for July 09.

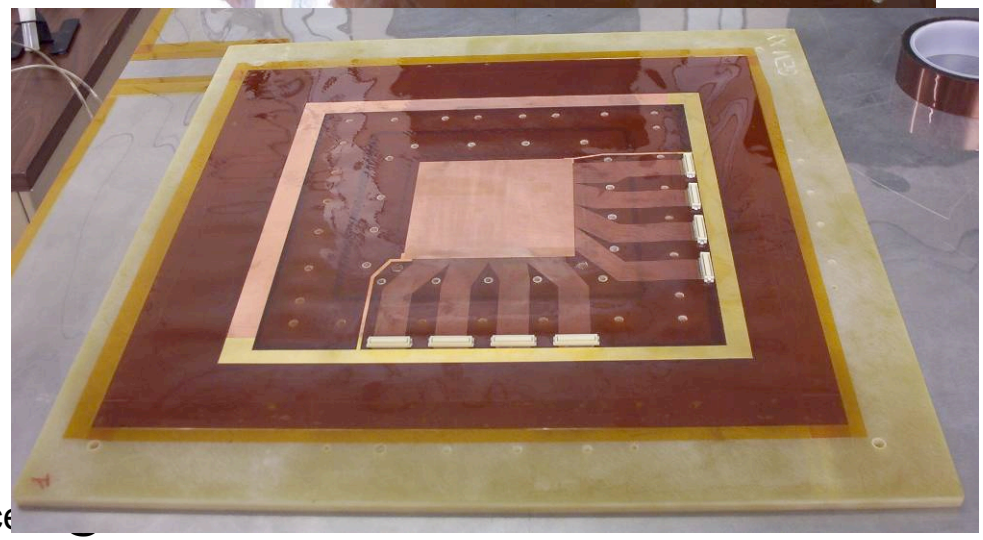
- Additional material

The XY readout

Small GEM prototypes with XY (used as “external trackers”) and XV readout strips, 650 μm pitch, with digital readout (GASTONE) under assembly for TB, first test with CR under way.







Computing & Storage

- New hardware has been bought:
  - 2 fast servers for user analysis (fibm11,12 replacement)
  - 100 cartridges + 4 TB disk space
  - Offline farm power to be improved from 30 fb^{-1}/day to 50 fb^{-1}/day
    - Purchase of 16 Power5+ CPU, 1.9 GHz, 16 GB RAM

DAS Disk system (30 TB) for data taking and data processing

- Storage capability to be increased by 0.9 PB
  - corresponding to 5 fb-1 at 175 TB/fb-1
    (Raw + rec + dst + MCdst x 2)
  - Upgrade of Library #2.
  - From 6 to 12 new mount points with higher writing density
    0.4 PB obtained writing at higher density the existing 2100 cartridges (from 300 --> 500 GB)
    0.5 PB obtained from 500 new cartridges of 1 TB
- New controller and ~50 TB of disk space for DSTs
  - Funded
- EU bid starting

Slow Control example

- Slow Control is "s"terminated.
- Next step Slow RC.
- HV, LV both for DC,DCH OK
- Readout of DAQ crates OK

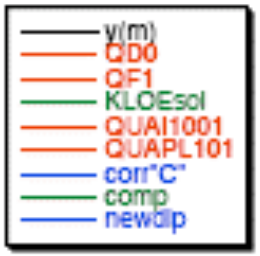
LV EMC Status at 17:01:04 (41 min 20 sec ago !) UPDATE

#	Crate	Exist	Fuse	Pulse	Hight	Power	ThrL	ThrH	Temp
1	EC_SW_1	YES	OK	NONE	100	OK	OK	OK	OK
2	EC_SW_2	YES	OK	NONE	101	OK	OK	OK	OK
3	BA_SW	YES	OK	NONE	101	OK	OK	OK	OK
4	BA_SE	YES	OK	NONE	100	OK	OK	OK	OK
5	EC_SE_2	YES	OK	NONE	101	OK	OK	OK	OK
6	EC_SE_1	YES	OK	NONE	101	OK	OK	OK	OK
7	EC_NW_1	YES	OK	NONE	101	OK	OK	OK	OK
8	EC_NW_2	YES	OK	NONE	100	OK	OK	OK	OK
9	BA_NW	YES	OK	NONE	101	OK	OK	OK	OK
10	BA_NE	YES	OK	NONE	101	OK	OK	OK	OK
11	EC_NE_2	YES	OK	NONE	101	OK	OK	OK	OK
12	EC_NE_1	YES	OK	NONE	100	OK	OK	OK	OK

New optics

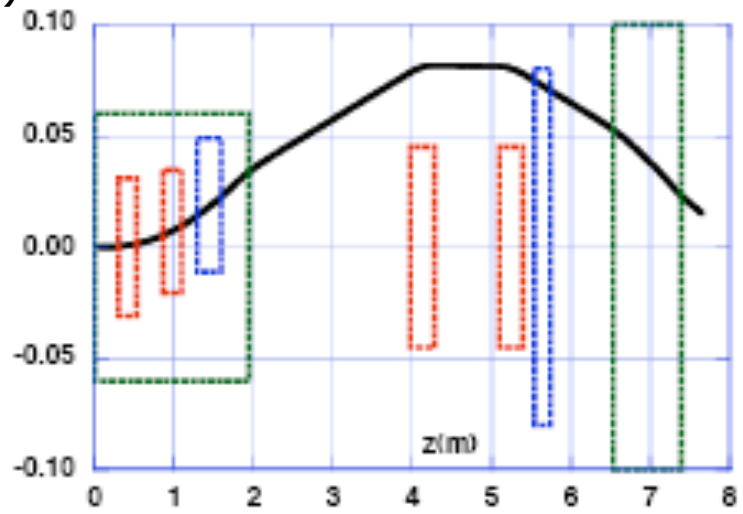
Bkloe=5.2 kG

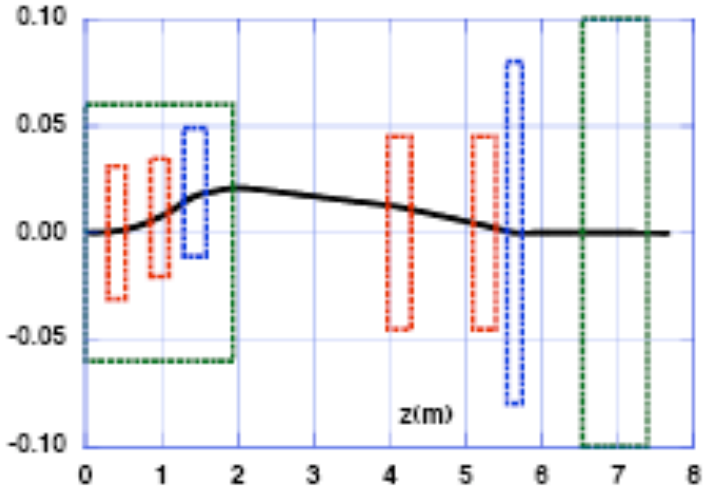
No dipole



∫Bdz=446Gm

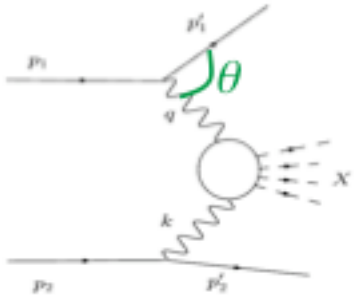
Y(m)





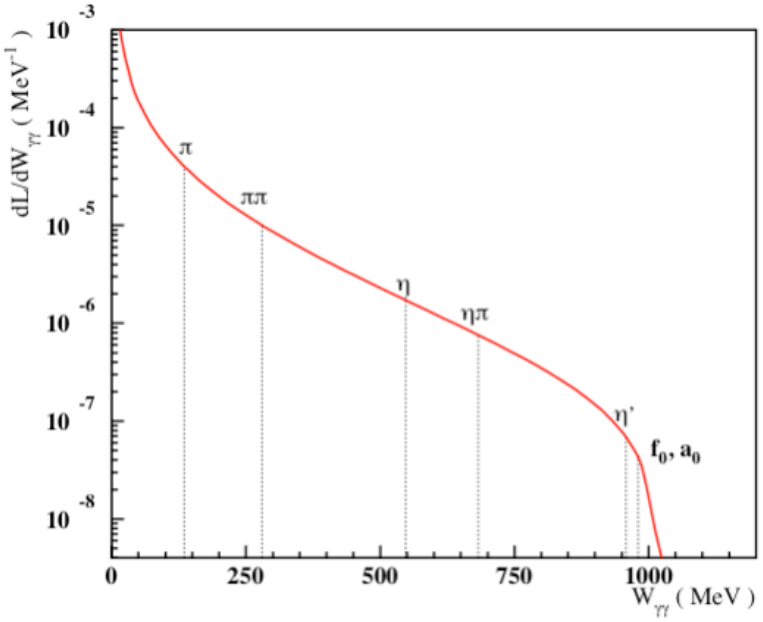
$\gamma\gamma$-physics

$e^+e^- \rightarrow e^+e^-\ \gamma^*\gamma^* \rightarrow e^+e^-\ (\pi^o\pi^o, \pi^o, \eta)$

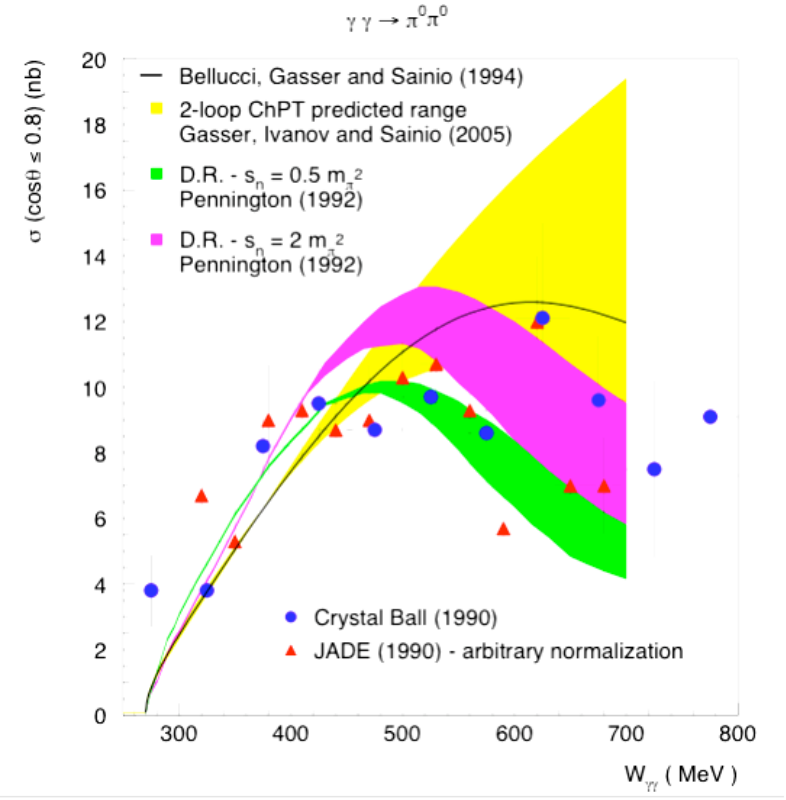


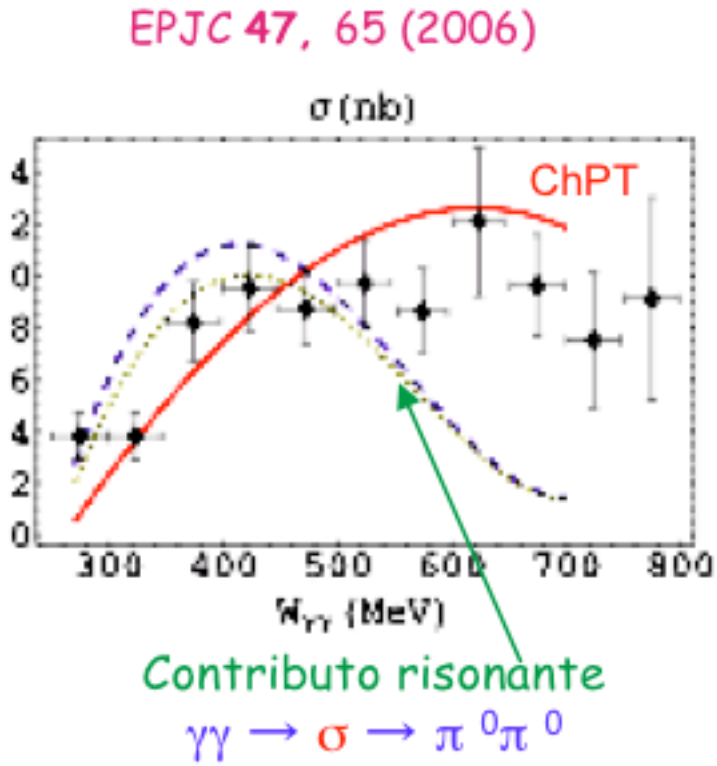
- $\sigma \propto \alpha^4 \ln^2(s)$ (vs α^2/s with 1 γ)
- Photon propagator $1/q^2$
  --> quasi real photon.
  Small angle electrons $\theta = 1/\gamma$
- Photon flux :
  Breemstrhalung spectra
  $1/E\gamma$ --> Low Mx preferred
- $J^{pc}(X) = 0^{\pm+}, 2^{\pm+}$
  (vs $J^{pc} = 1^{--}$ with 1 γ)

$$\frac{dN_X}{dW_{\gamma\gamma}} = L_{int} \frac{dL}{dW_{\gamma\gamma}} \sigma(\gamma\gamma \rightarrow X)$$



γγ-physics : the σ(600) case





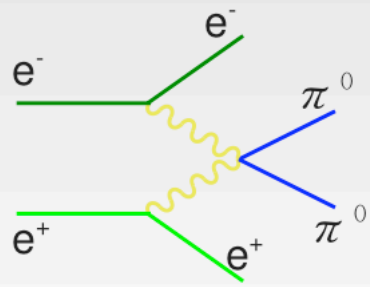
- Large production of σ(600) meson expected in $\pi^0\pi^0$ final state
- Theoretical X-sec from 13 to 100 pb-1 depending on σ(600) parameters
- Use the search for this channel to drive the detector design

γγ-event generators (1)

Coureau generator

[G. Alexander et al., Nuovo Cimento, A107, 837 (1994)]

The reaction is actually divided in 2 subreactions:



- Bremsstrahlung photon emission:
  $e^+e^- \rightarrow e^+e^- + \gamma\ \gamma$
- Pion production:
  $\gamma\ \gamma \rightarrow \pi^0\pi^0$

We made use of a 2-loop Chiral Perturbation Theory Cross Section by *[Gasser, Ivanov, Sainio, Nucl. Phys.B, B728, 31 (2005)]*

Nguyen, Piccinini, Polosa

This MC programme treats the reaction:

$$e^+e^- \rightarrow e^+e^- + \pi^0\pi^0$$

by mean of the four bodies kinematics with the inclusion of a σ particle as a Breit-Wigner resonance.

MC generator from Belle

This MC programme, called TREPS, is an event-generator for two-photon processes at e^+e^- colliders. TREPS uses an EPA in which the virtuality of photons is taken into account.

BTF: experimental test on crystals

1 week test at BTF with different kind of crystals (9-13 march)

- 2x2x13 cm^3 PbWO+ SIPM connected to:
  - 3x3 mm^2 MPPC (400x9 pixels), PDE = 50% at 420 nm, + LNF custom electronics. LY (expected)= 0.5 pe/MeV
  - 13x13 mm^2 SensL (16x3640 pixels) PDE=15% at 420 nm, Sensl electronics, LY (expected) > 2 pe/MeV

- 2x2x13 cm^3 LYSO + SIPM
  - 3x3 mm^2 MPPC (400x9 pixels), PDE = 50% at 420 nm, LNF custom electronics

  In this last case we have to reduce the light output by means of a yellow plastic filter to work in a linear region for the pixels + signal reduction with resistive attenuator (x1/2)

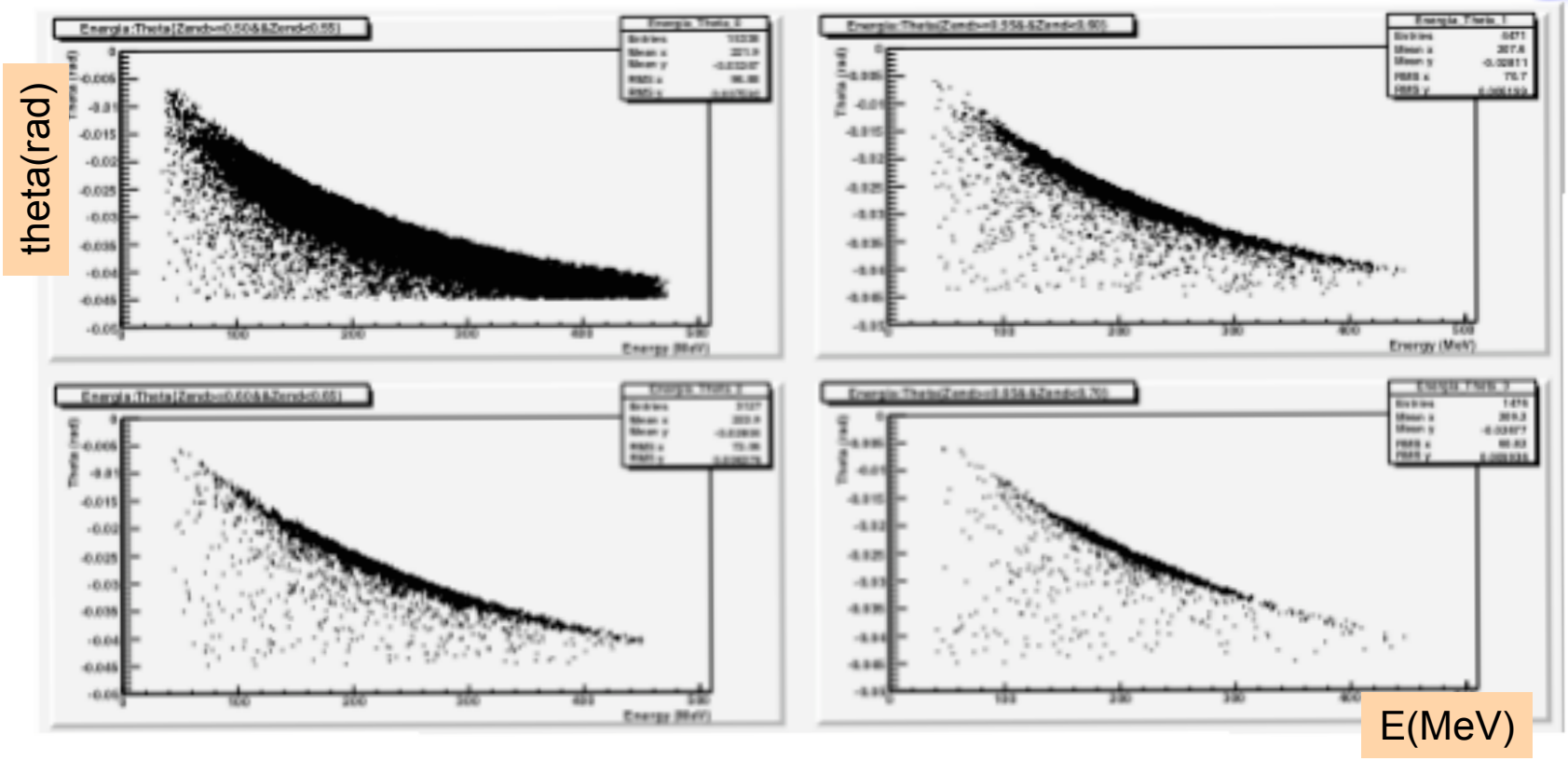
Energy scan from 100 up to 500 MeV in "single" electron mode. Single electron separation + timing start provided by a coincidence of two finger BC404 scintillators.

Requirement for a LET calorimeter

- Dense, small Xo, Rm
- Fast (timing needed to reject accidental/machine bkg)
- High resolution at low energies
  - Mgg better than central detector (aims at < 10% @ 120-240 MeV)
  - another handle for machine bkg rejection (1/E^2.2 spectra)
- Highly efficient
- Small number of channels w fotosensors working in B-Field

	L.yield	Gain	HV (V)	Preamp	Charge/pe
PbWO+apd	ok	low	400	x50	Too low
PbWO+sipm	low	ok	20-70	x20	OK
LYSO+apd	exc	low	400	x20	OK
LYSO+sipm	ok	high	20-70	X2-5	OK

Energy vs angle (LET)



- Distributions evaluated with a sample of $\gamma\gamma \rightarrow \pi^0\pi^0$ events done with Coureau generator + full BDSIM tracking.
- At the same impact position in Z corresponds a broad distribution of energy and angle for the scattered leptons

We need a calorimeter with high resolution

IT schedule

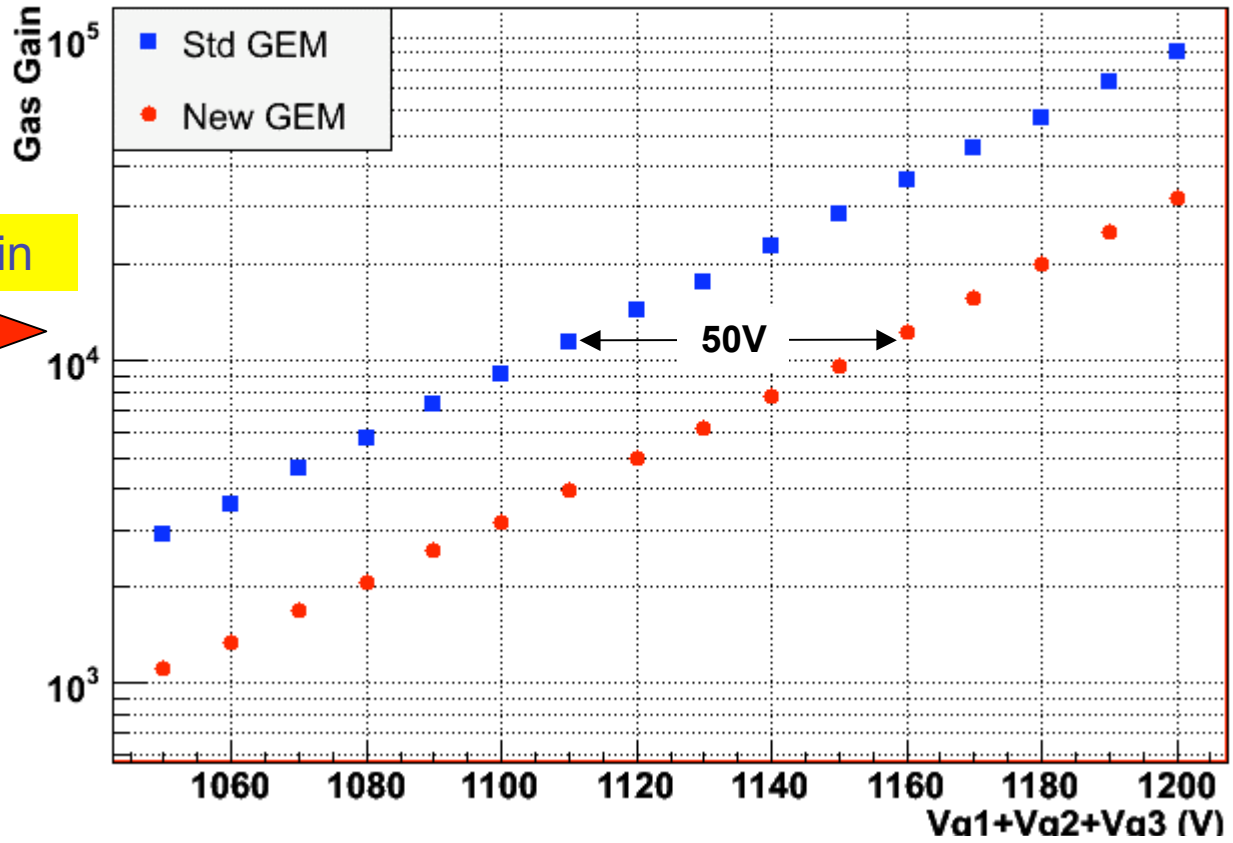
Design & construction of the full size prototype (P0.1)	12/2007
X-rays, cosmics & test beam	7/2008
XV readout proto construction with 100x100 mm^2 planar GEMs	4/2009
Test beam w/B-field of the 100x100mm^2 planar XV-protos at CERN	7/2009
Construction test of a CF cylinder with "embedded" readout anode	7/2009
Construction of the front-end mechanical support in composite material	7/2009
Construction & test of large size, 300x700mm^2 , single mask GEM	9/2009
TDR	9/2009
Design/construction/test of full size XV readout on planar configuration	12/2009
Global design of the IT detector and construction tools	3/2010

R&D on large GEM: single vs double mas

KLOE-2

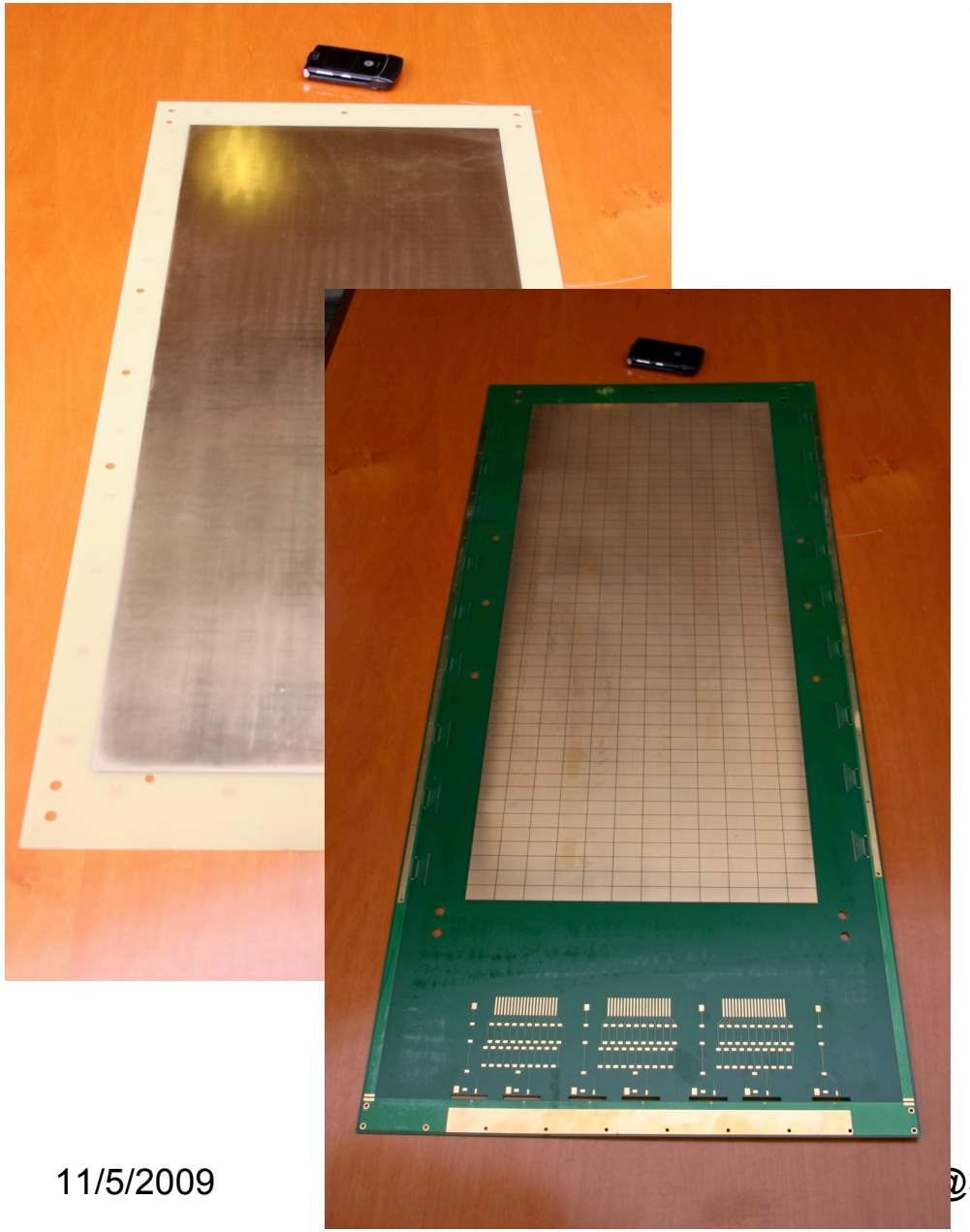
Triple – GEM detector

optimal gain



The same GAIN is achieved just increasing the global **GEM voltage** of about **50 V**

R&D on large GEM: the large prototype



We are going to build a **large area planar GEM (30x70 cm^2 active area),** with the aim to test the quality and homogenity of the large GEM produced with the new single mask technique.