Perugia INFN Istituto Nazionale di Fisica Nucleare

SuperB

EMC for superB

Summary of the

superB Detector Workshop I

February 14th-17th SLAC

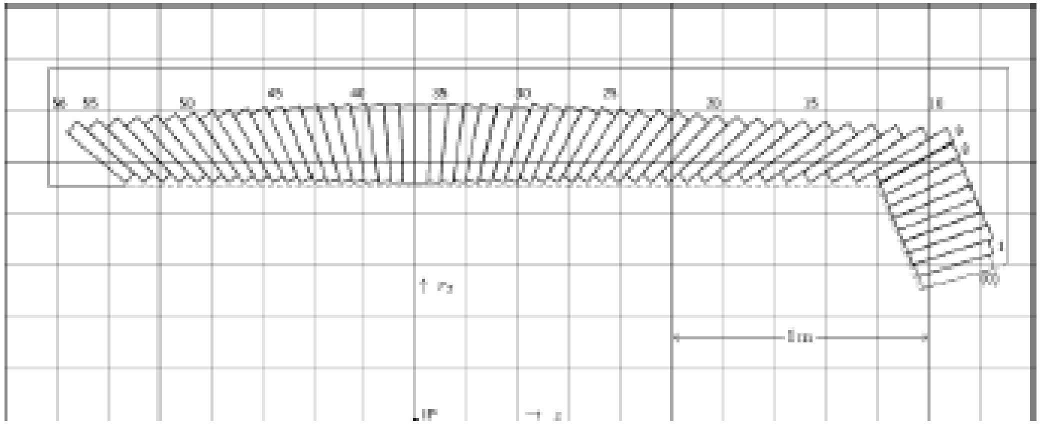
Claudia Cecchi
University of Perugia and INFN

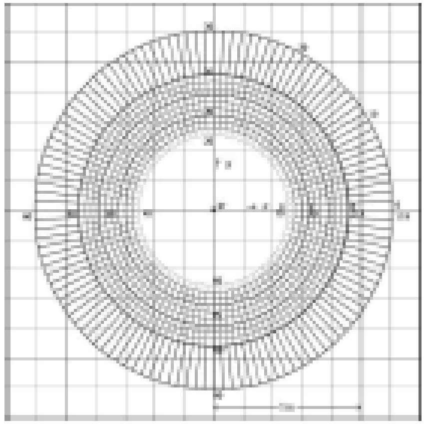
STATUS OF EMC

Measure energy and direction of e, γ

Detect neutral hadrons

Separate e, γ





BaBar Barrel

5760 CsI(Tl)

Crystals

-Barrel can be reused, retain geometry and PD read-out

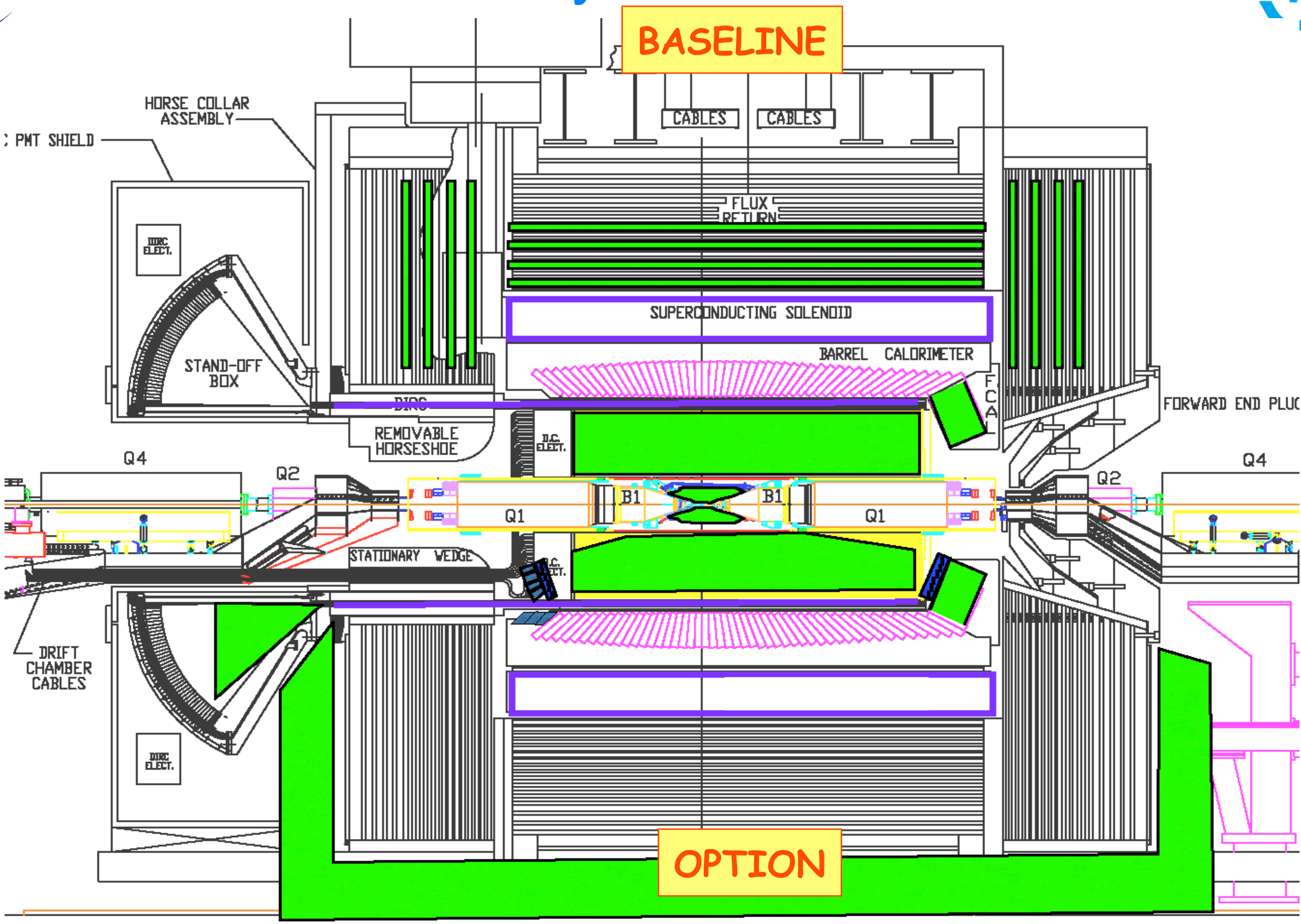
-Forward endcap to be replaced due to radiation damage, CsI too slow at superB rate $\Rightarrow$ LSO

- Backward Endcap hermeticity important for inclusive decays and decays with neutral energy

- Veto detector possibility Lead/Scintillator fibers

NEW approach scintillator tiles

CDR Detector Layout – Based on Babar



EMC Forward as well as backward should be
- FAST
- small Molière Radius and RL
- radiation hard

Mass-produced Crystals (new, for PDG)

Crystal	NaI(Tl)	CsI(Tl)	CsI	BaF_2	BGO	PWO(Y)	LSO(Ce)	GSO(Ce)
Density (g/cm^3)	3.67	4.51	4.51	4.89	7.13	8.3	7.40	6.71
Melting Point (°C)	651	621	621	1280	1050	1123	2050	1950
Radiation Length (cm)	2.59	1.86	1.86	2.03	1.12	0.89	1.14	1.38
Molière Radius (cm)	4.13	3.57	3.57	3.10	2.23	2.00	2.07	2.23
Interaction Length (cm)	42.9	39.3	39.3	30.7	22.8	20.7	20.9	22.2
Refractive Index [a]	1.85	1.79	1.95	1.50	2.15	2.20	1.82	1.85
Hygroscopicity	Yes	Slight	Slight	No	No	No	No	No
Luminescence [b] (nm) (at peak)	410	550	420 310	300 220	480	425 420	402	440
Decay Time [b] (ns)	230	1250	30 6	630 0.9	300	30 10	40	60
Light Yield [b,c] (%)	100	165	3.6 1.1	36 3.4	21	0.29 .083	83	30
d(LY)/dT [b] (%/ °C)	-0.2	0.3	-1.3	-1.3	-0.9	-2.7	-0.2	-0.1
Experiment	Crystal Ball	CLEO BaBar BELLE BES III	KTeV	TAPS (L*) (GEM)	L3 BELLE PANDA?	CMS ALICE PrimEx PANDA?	-	-

Both pure CsI and LSO could be used for EMC forward

-LSO more light, compact, radiation hard

more expensive

Crystal	CsI(Tl)	CsI	LSO
τ decay(ns)	680, 3340	16	47
χ_0(cm)	1.86	1.86	1.14
$R_{moliere}$ (cm)	3.8	3.8	2.3
$\lambda_{nuclear}$ (cm)	37	37	
LY (γ/MeV)	56000, 64:36%	2500	27000
λpeak (nm)	550	315	420
Rad Hard (Mrad)	.01	.01-.1	100
ρ (g/cm3)	4.51	4.51	7.40
n_0	1.79	1.95	1.82

Baseline LSO

CsI option still possible

CTI: LSO

CPI: LYSO

Saint-Gobain LYSO

Additional Capability: SIPAT @ Sichuan, China

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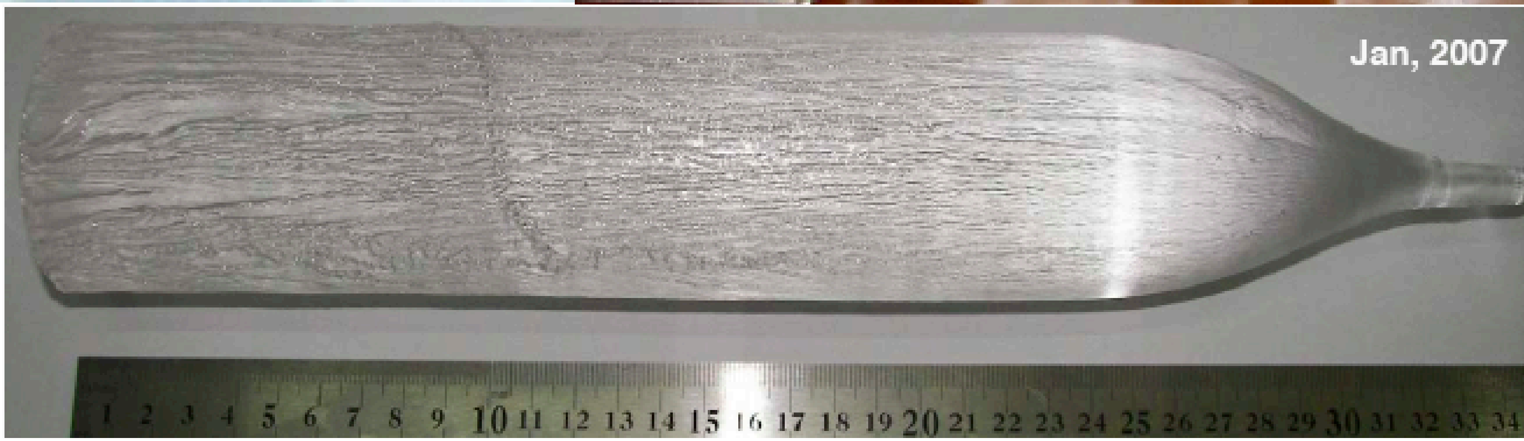
SIPAT Czochralski Furnaces

Progress of LSO/LYSO Growth

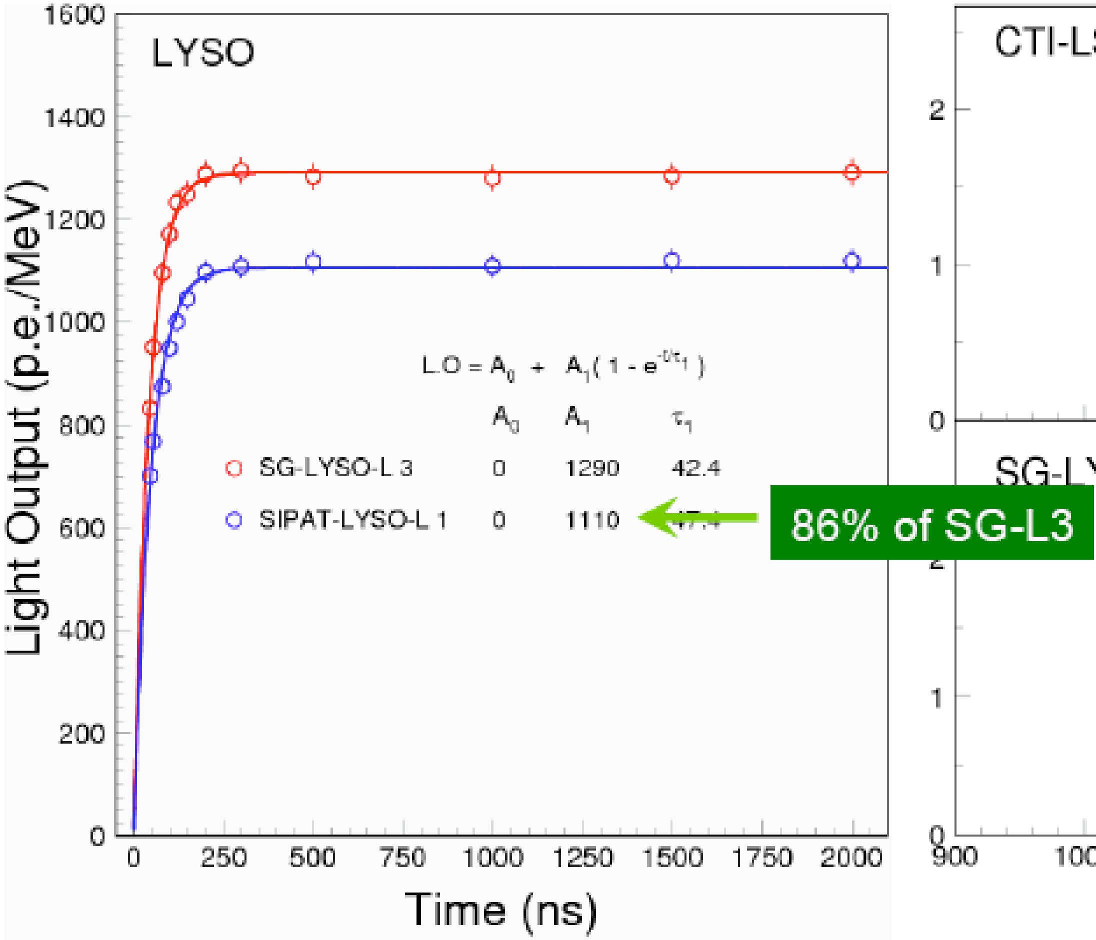
Started 2001, invested >$1M
Significant Progress in last year

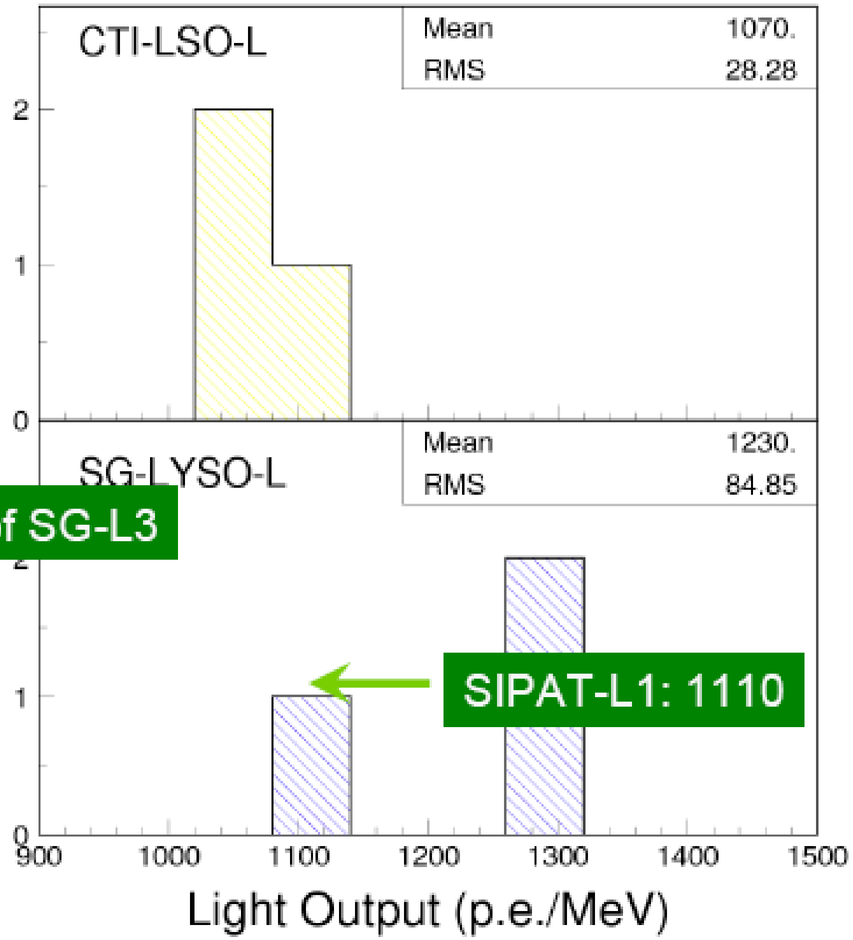


SIPAT Ø 60 x 250 mm LYSO Boles

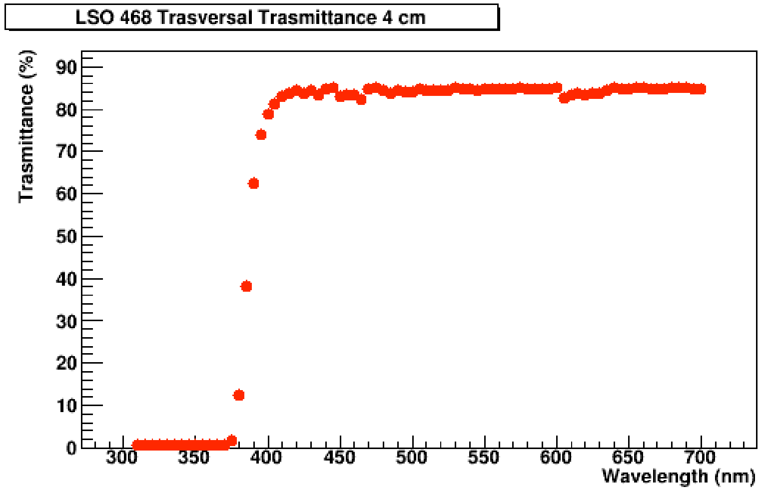
Light Output and Decay Kinetics

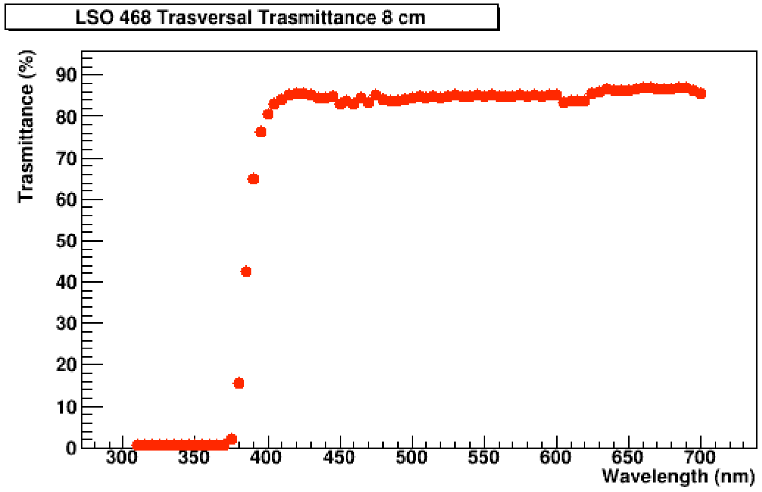
Compatible with the first batch large size samples from CTI and Saint-Gobain, and is 86% of the 'best' samples

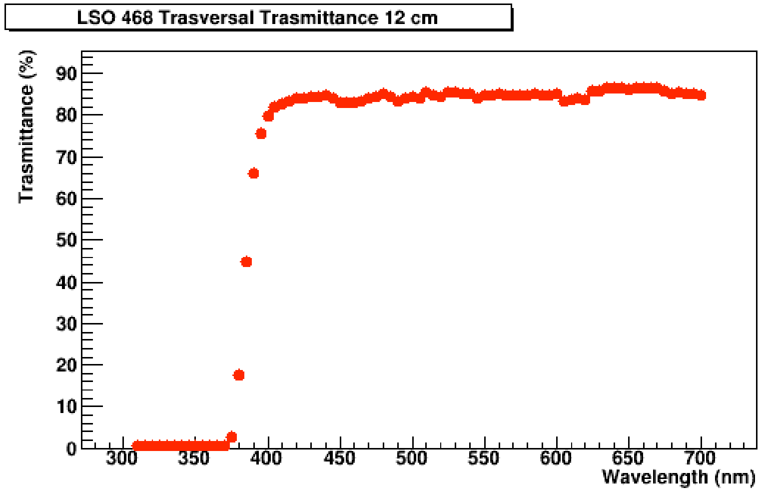


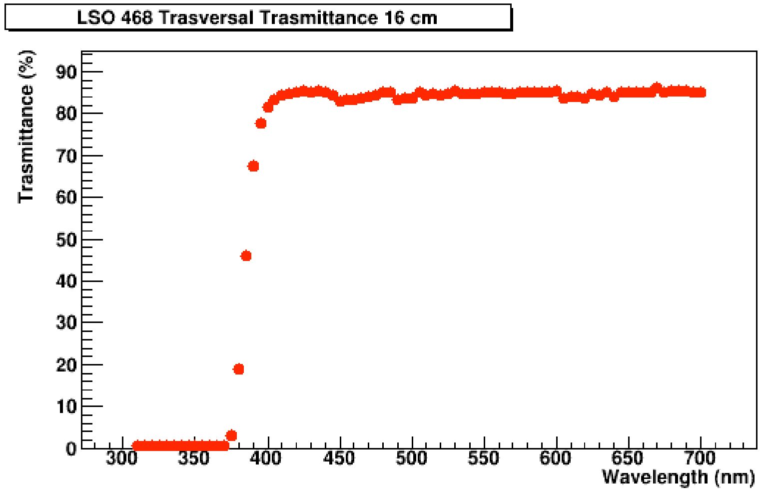


Crystals measurements in Perugia



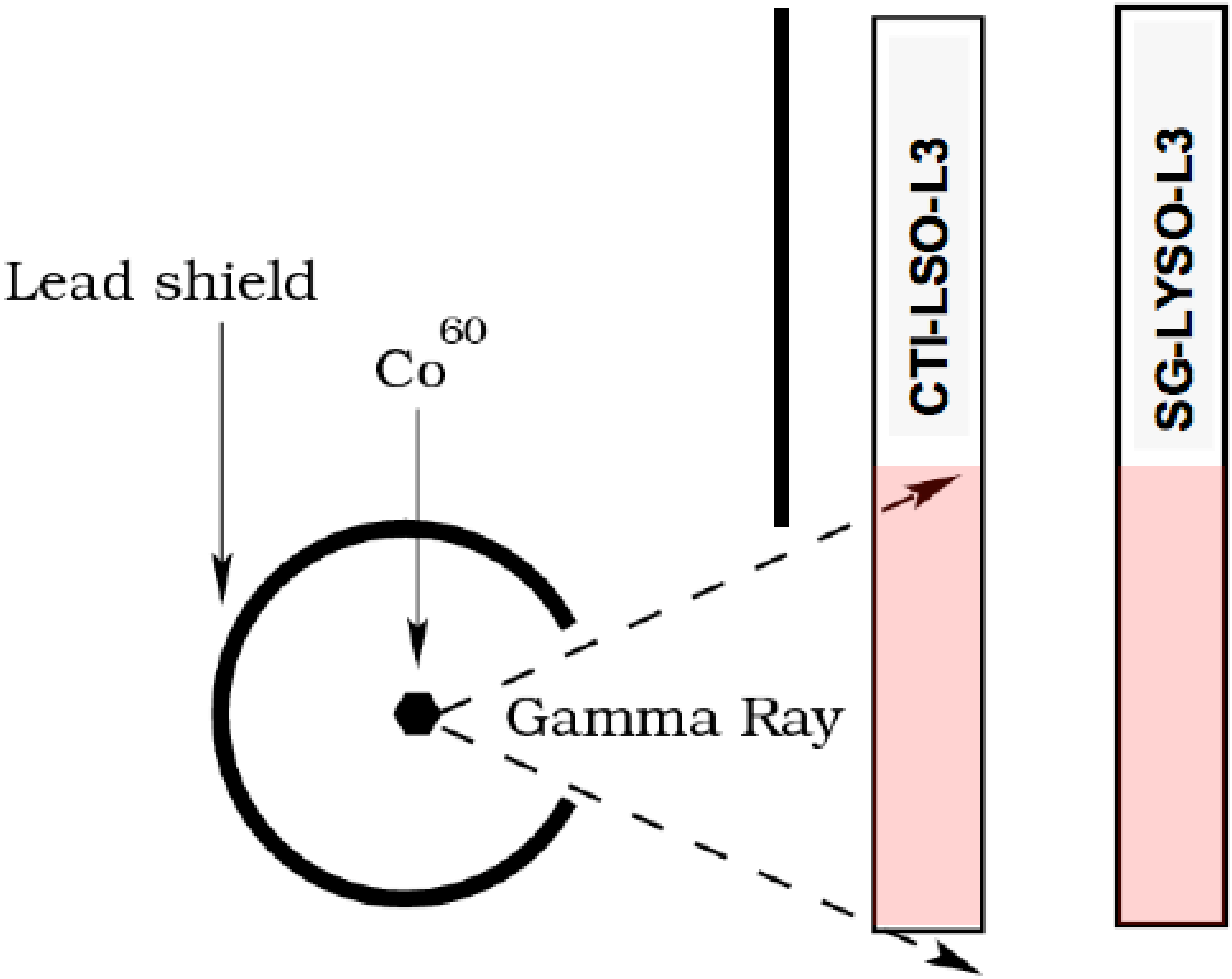






In agreement with R. Zhu measurements

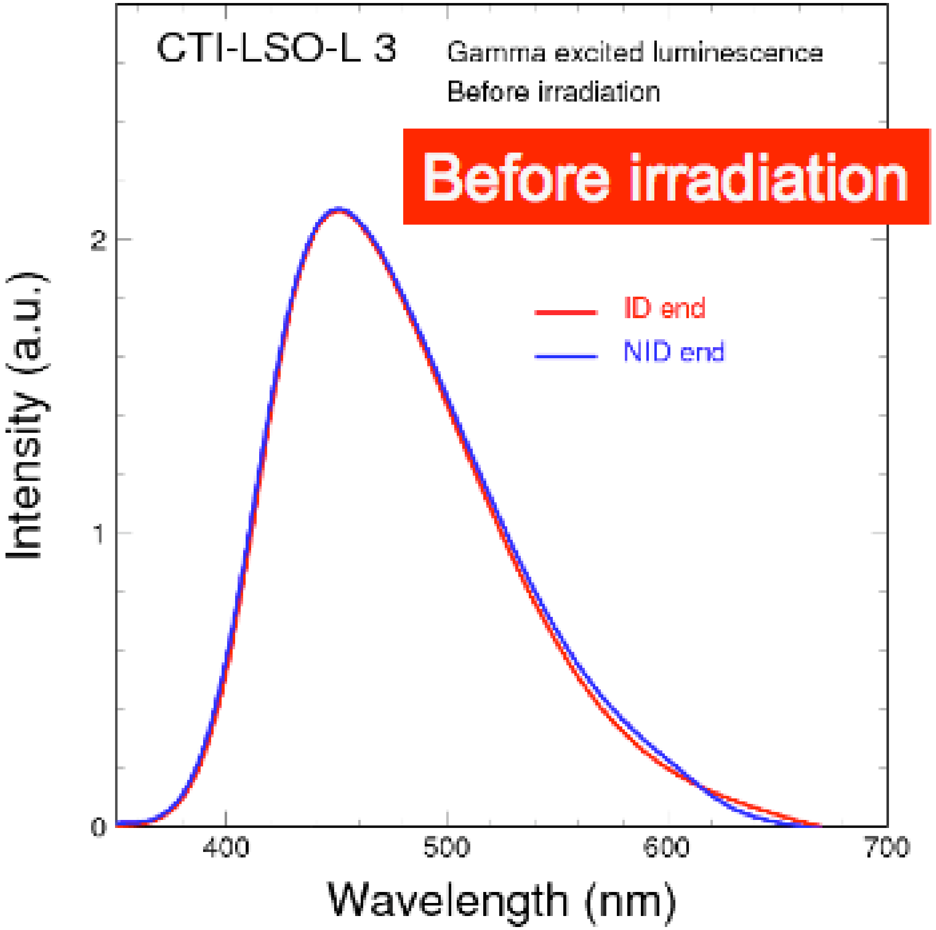
γ-Ray Irradiation on Sample's ID End

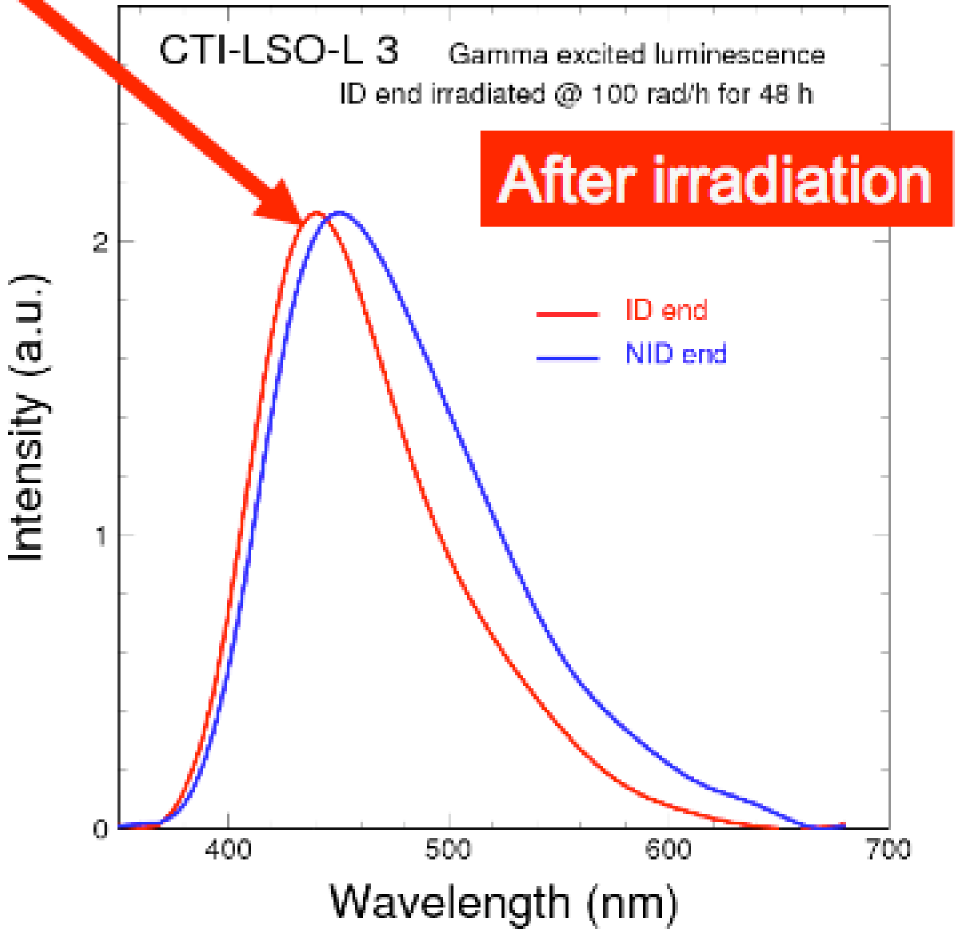


ID End received
~5,000 rad

LSO: γ -Ray Excited Emission Spectra

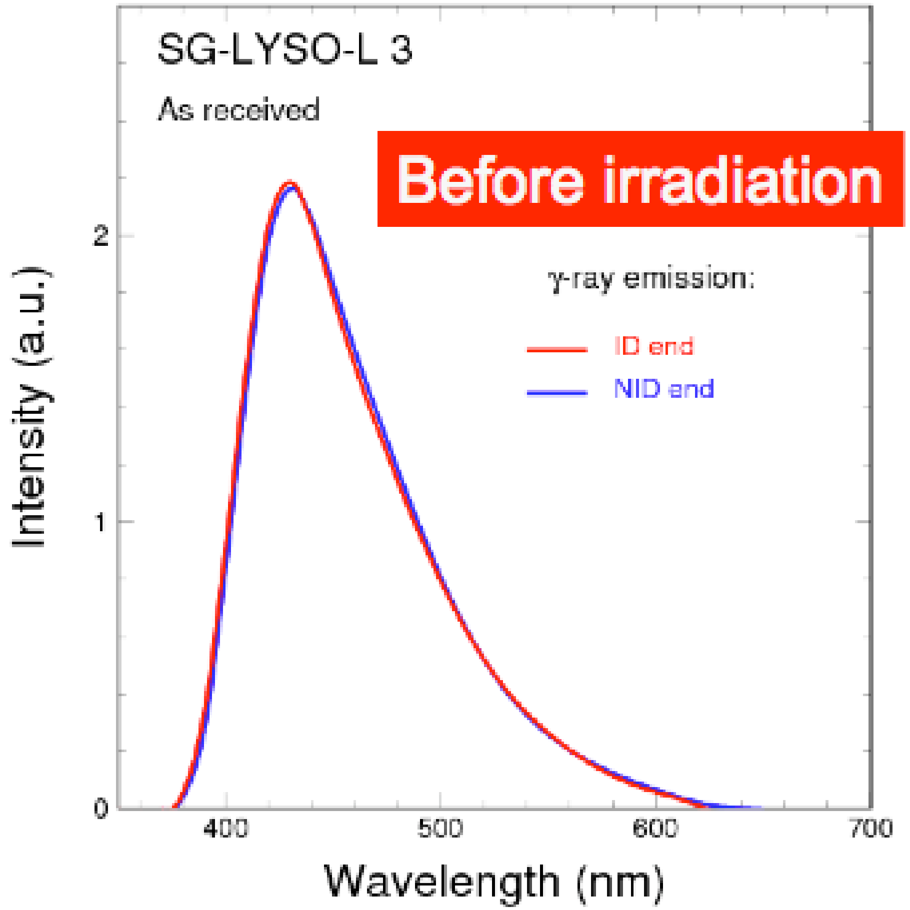
The emission peak of sample's irradiated ID end has a ~15 nm "blue" shift

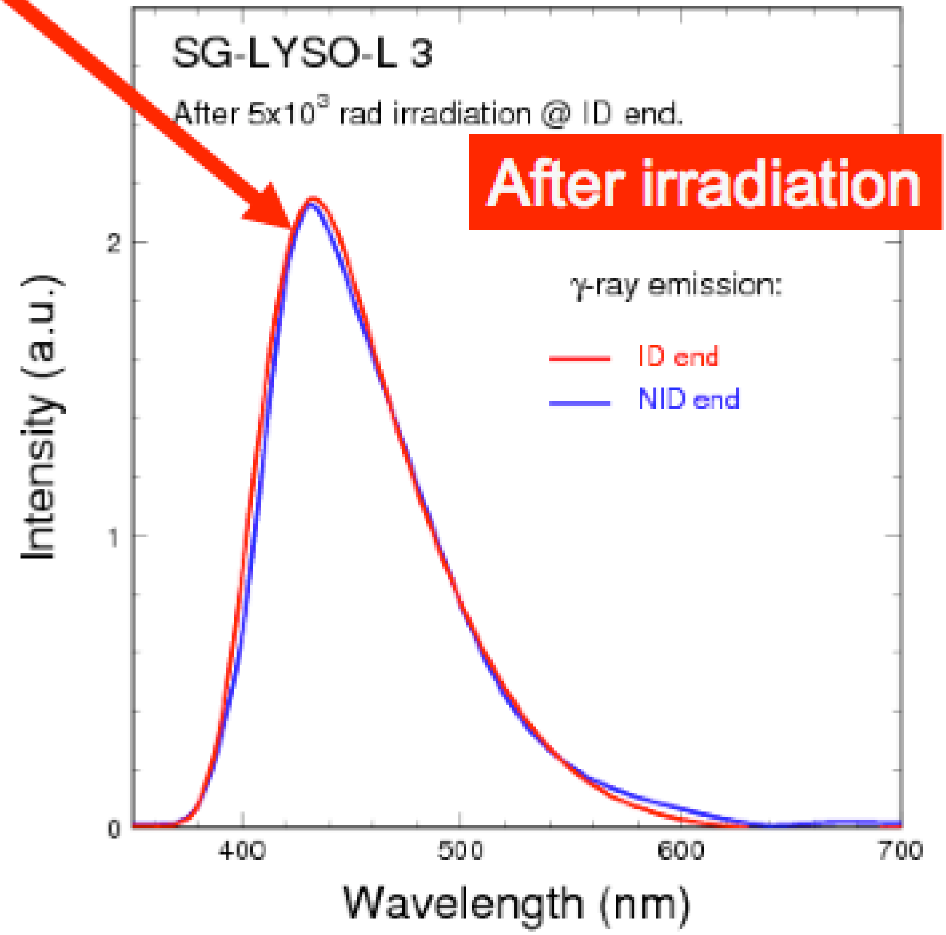




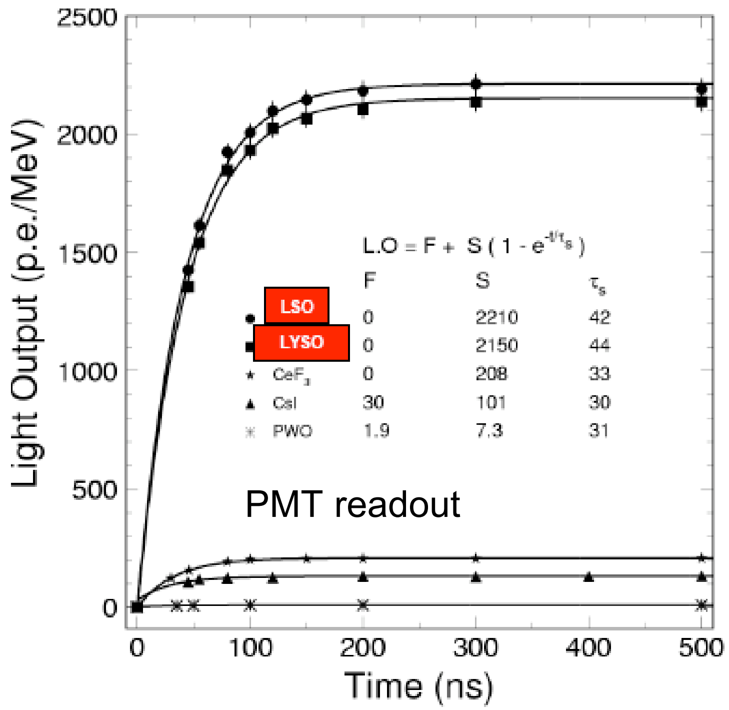
LYSO: γ -Ray Excited Emission Spectra

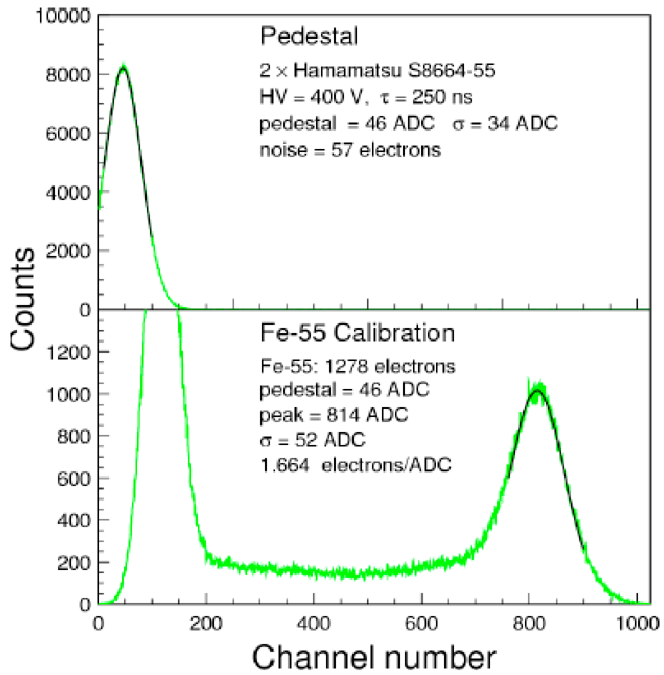
The emission peak of sample's ID (irradiated) end has NO "blue" shift





Fast Scintillators





-Very high light output, match with APD or PD

-Small temperature coefficient dependence

-Radiation less of an issue than other crystals

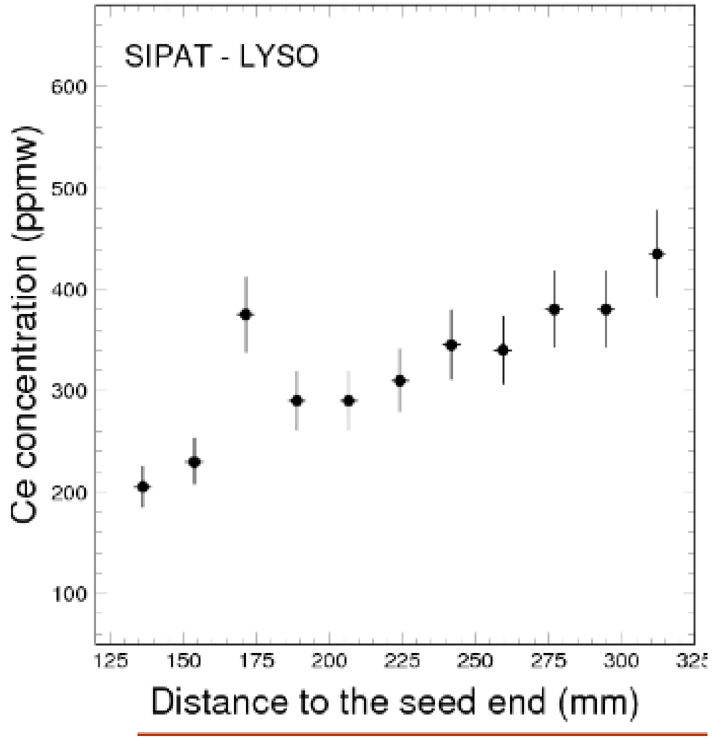
-Energy resolution should be better than BGO (L3), PWO (CMS)

CsI (BaBar/Belle): high light output, low noise

$$\frac{2.0\%}{\sqrt{E}} \oplus \frac{0.001}{E} \oplus 0.5\%$$

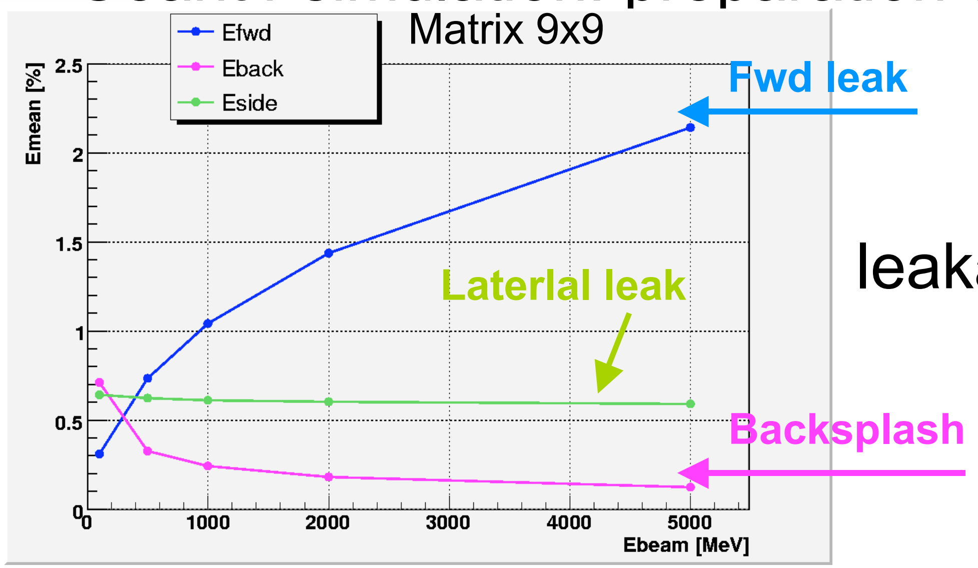
Two main points still under discussion:

1) Uniformity of Ce doping to be better understood

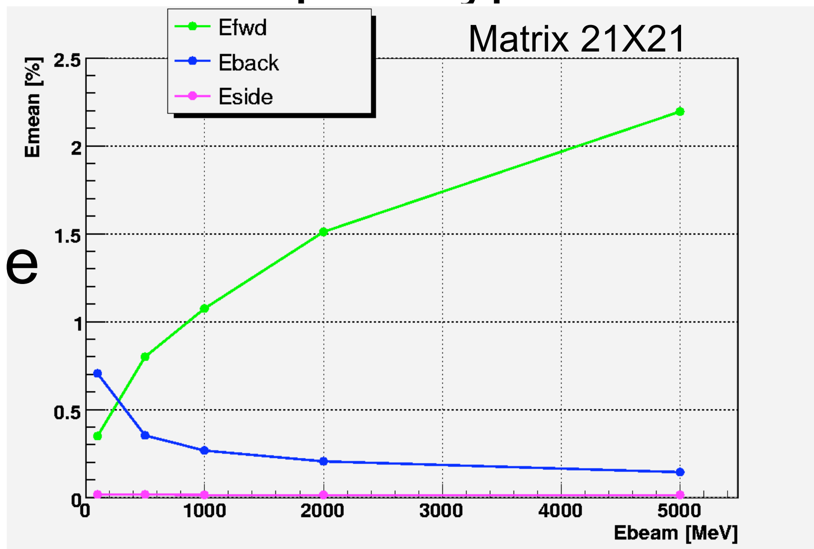


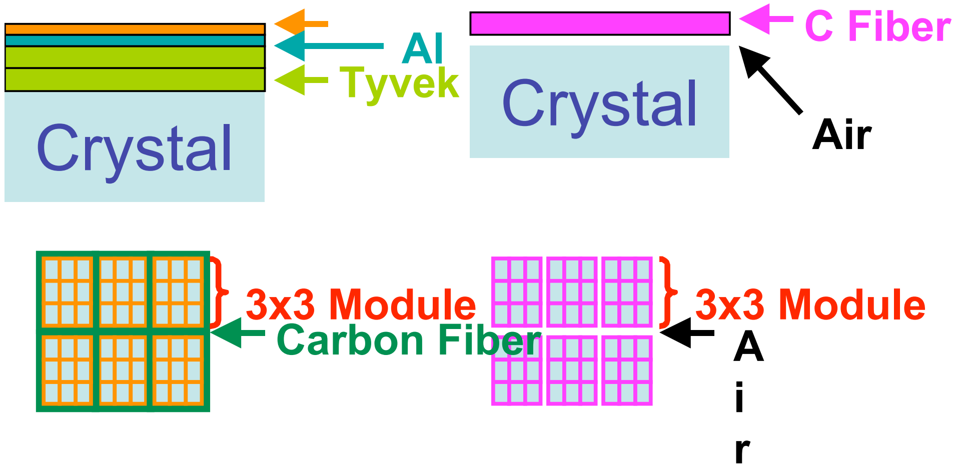
2) Is this possible to cut two crystal form one boule?

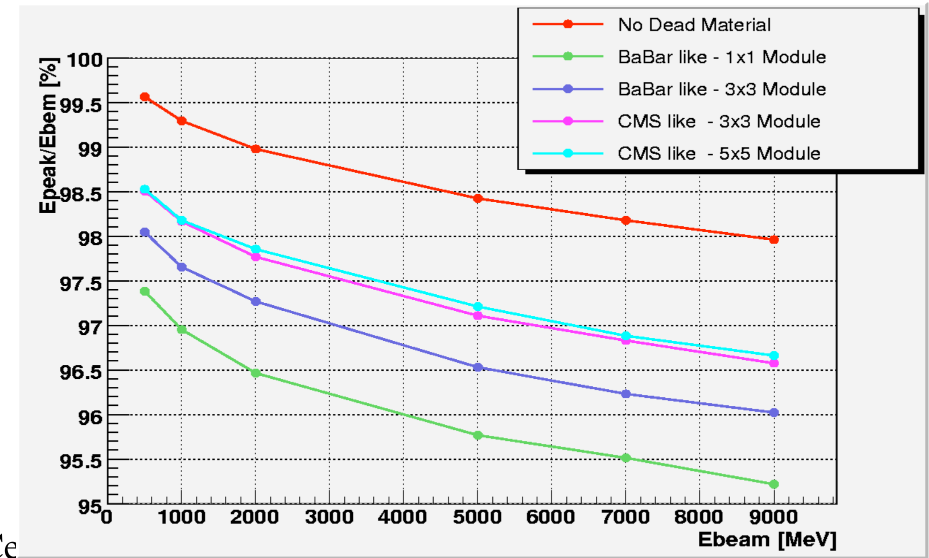
Geant4 simulation: preparation of beam test prototype 2009



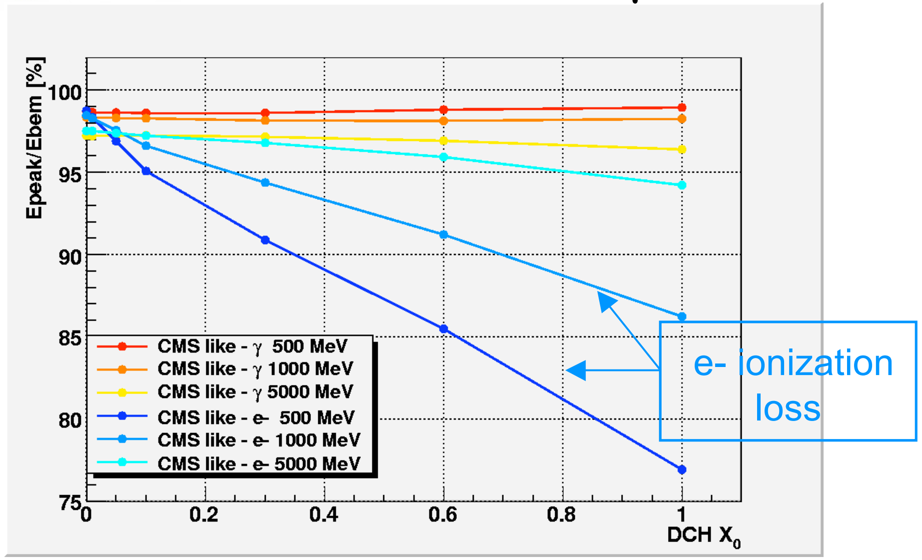
leakage

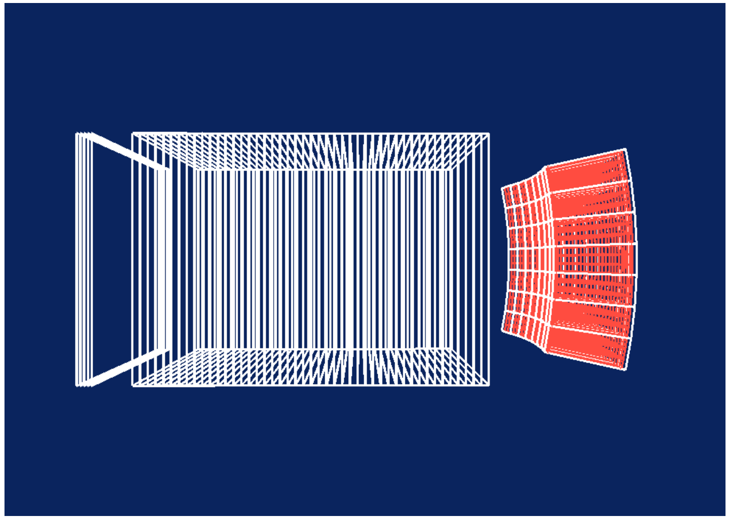


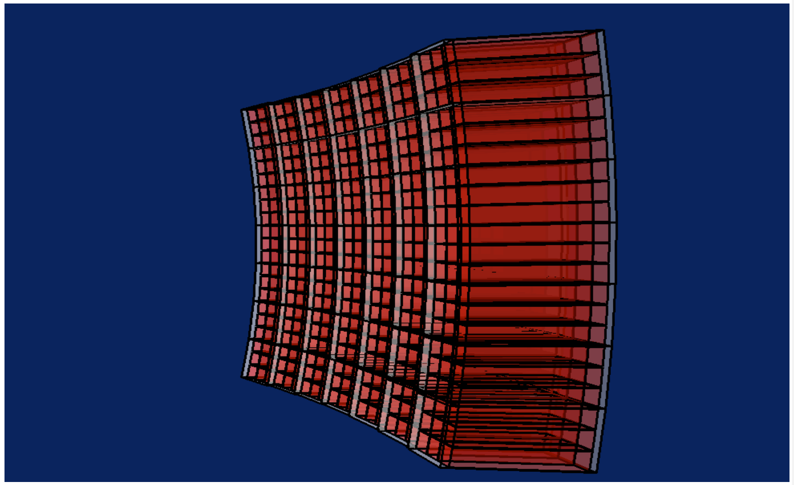


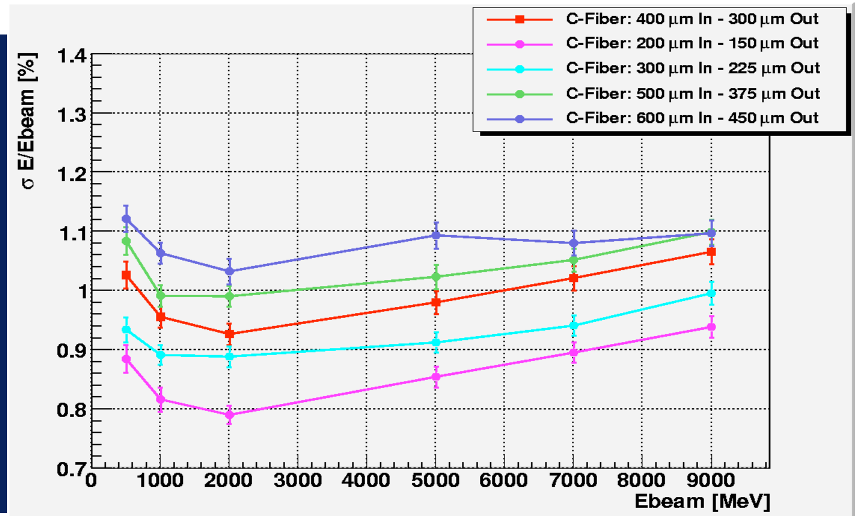


e- and γ beam on SVT + DCH

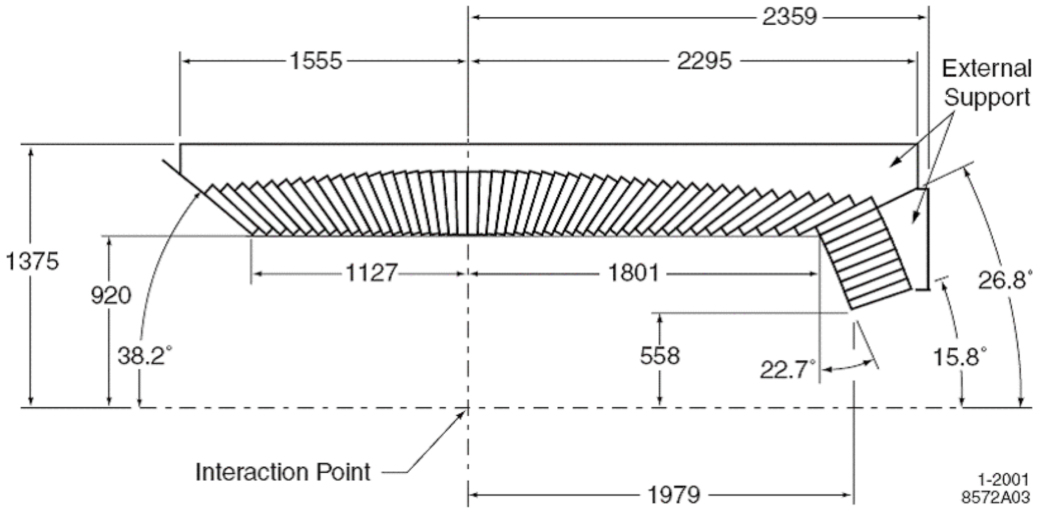


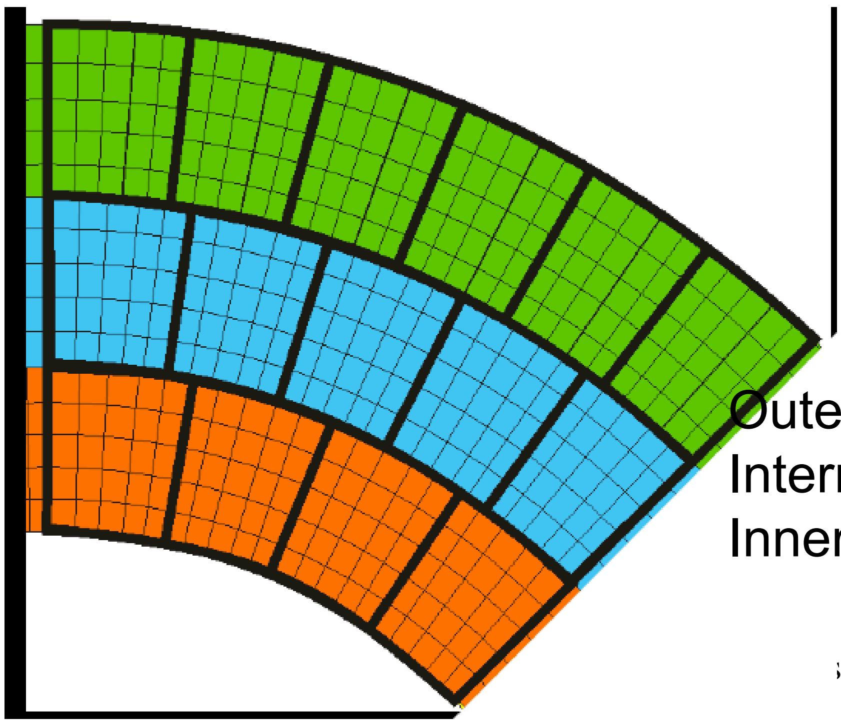






Next step Introduce a real geometry in the simulation





Outer ring 240
Interm ring 200
Inner ring 160

5x5 Modules

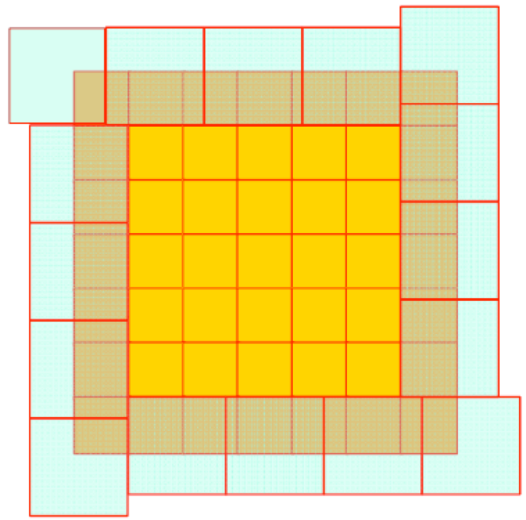
Ring	Rmax	Rmin	N	Side
1	958.6	935.7	240	24.80
2	935.7	913.4	240	24.21
3	913.4	891.6	240	23.63
4	891.6	870.3	240	23.06
5	870.3	849.5	240	22.51
6	849.5	826.9	215	24.50
7	826.9	804.9	215	23.85
8	804.9	783.5	215	23.21
9	783.5	762.7	215	22.59
10	762.7	742.4	215	21.99
11	742.4	720.1	190	24.18
12	720.1	698.4	190	23.46
13	698.4	677.4	190	22.75
14	677.4	657.1	190	22.07
15	657.1	637.3	190	21.40
16	637.3	614.7	160	24.59
17	614.7	592.8	160	23.71
18	592.8	571.7	160	22.87
19	571.7	551.3	160	22.05
20	551.3	531.7	160	21.27

TEST BEAM program:

- Put under particle beam 5x5 (7x7) matrix of LSO crystals eventually surrounded by CsI crystals
- Study different material configuration
- Different readout systems APD, PMT, PD
-Linearity, energy resolution…

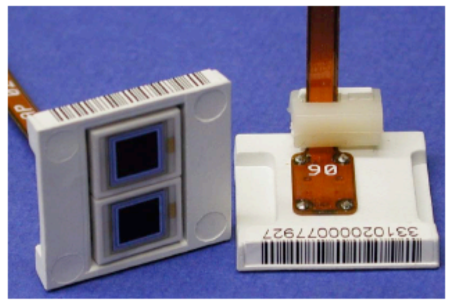
Beam line available:
CERN, DESY, LNF
with different energy ranges
Electrons, positrons,
tagged photons
High energy 0.5 - 7 GeV
Low energy 50 - 750 MeV

5x5 Projective LYSO array with CsI(Tl) surround



16 spare *BABAR* CsI(Tl) crystals may be available

A 7x7 array is best, but it can be approximated by a 5x5 array surrounded by CsI(Tl) to catch the outer few percent of shower



CMS APD readout module
2 @ 5mmx5mm APD
(10x10mm APDs are now available)

Perugia

From J.A. Bevan

Example Quotes

- 1) Non projective geometry: 9 crystals of 2.5x2.5x20cm:
  - All sides polished, LYSO
  - Cost for 9 crystals = 31 K€
  - Timescale for delivery = 8 weeks
  - Timescale / cost for 49 crystals (est) = 16 weeks (4 months) / 167 K€
- 2) Projective geometry outlined previously:
  - Cost for 9 crystals = 55.5K€
  - Timescale for delivery = 4 months
  - Timescale / cost for 49 crystals (est) = ? 8 months / ? 111K€

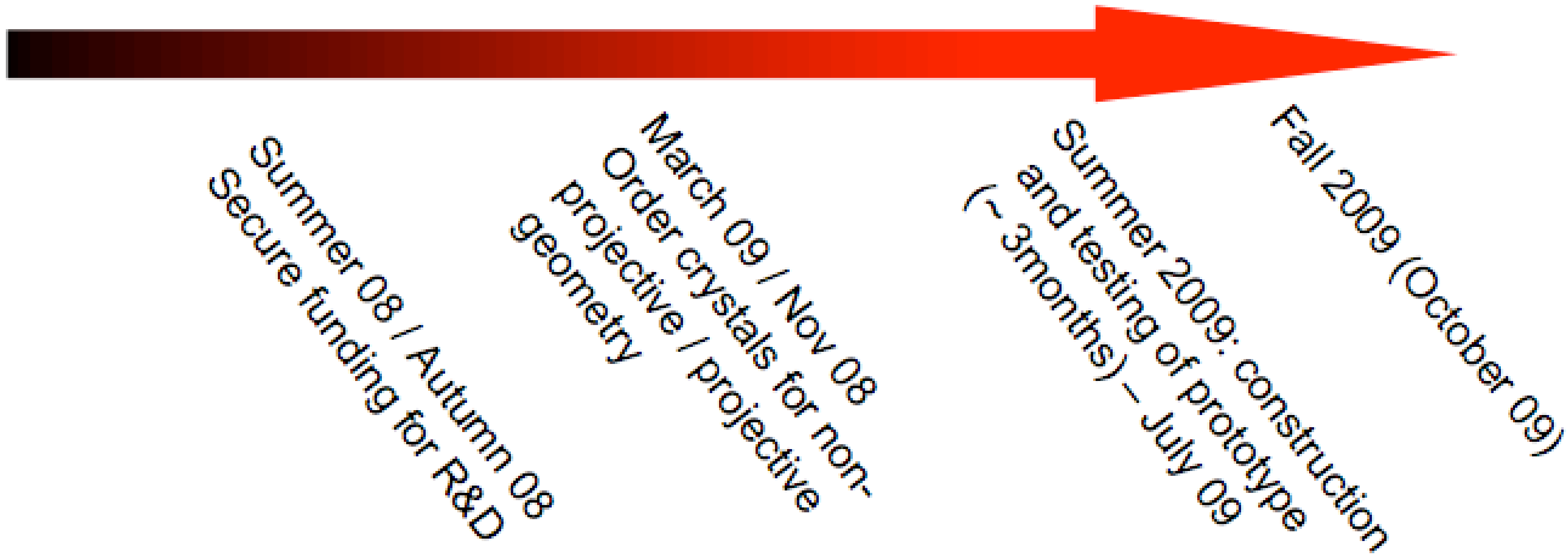
Quotes were aquired from Saint Gobain and SIPAT, and exclude tax and shipping. SIPAT were O(10% more expensive)

NOTE: The goal is to build a 5x5 or 7x7 array of crystals, this layout was investigated in a failed attempt to exploit a funding opportunity.

From J.A. Bevan

Timescales (very rough)

- Aim to have a test-beam ~ fall 2009
  - Working backward, we would need to acquire funding for R&D soon.



  - Also means we should start to design the calorimeter prototype in the next 6-9 months.
  - Timescale is more relaxed if we don't want tapered crystals.

From D. Hitlin

Beam test budget estimate (M&S)

Item	Unit cost ($)	Cost (K$)
LYSO Crystal @ $50/cc (for the test only) x 24	6250	150
CMS type dual APD module 2 x Hamamatsu S6664-55 (x(24+16))	250	10
Preamplifier/Shaper (x24+16)	200	8
DAQ system		10
Source carriage		2
Beam test mounting structure		20
Total M&S (w 25% contingency)		250

NEW under study…

Study of the mechanical structure is under discussion with engineer in Perugia and engineer who developed the mechanical structure for the CMS PWO calorimeter.

Mechanical tests on crystals have started in Ancona:
- RX to study crystallographic structure
- elastic module by ultrasound waves
- internal stress to study macroscopic defects
- diffraction and reflectivity techniques to study surface defects

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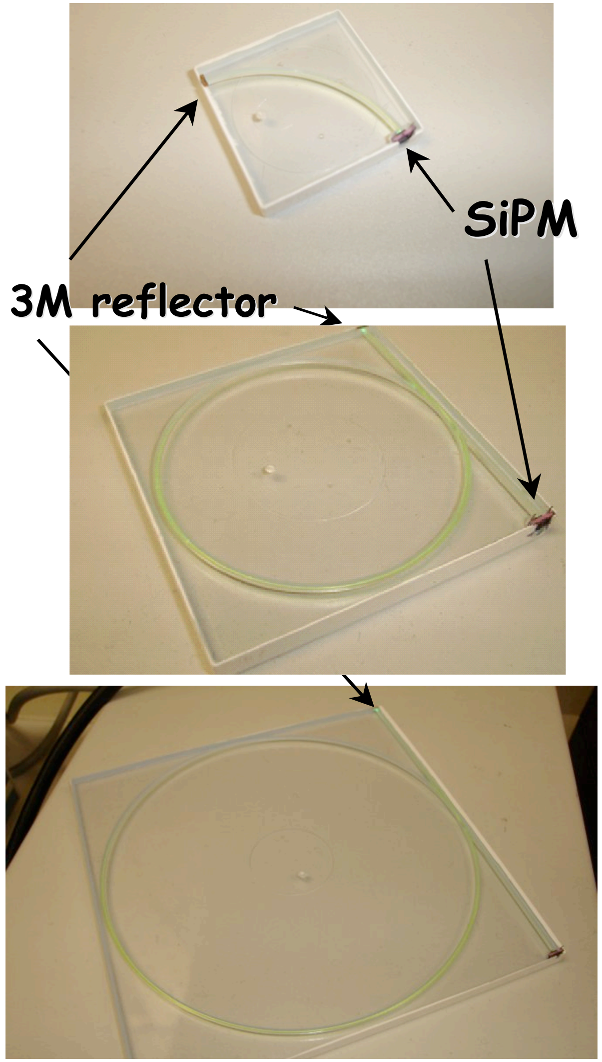
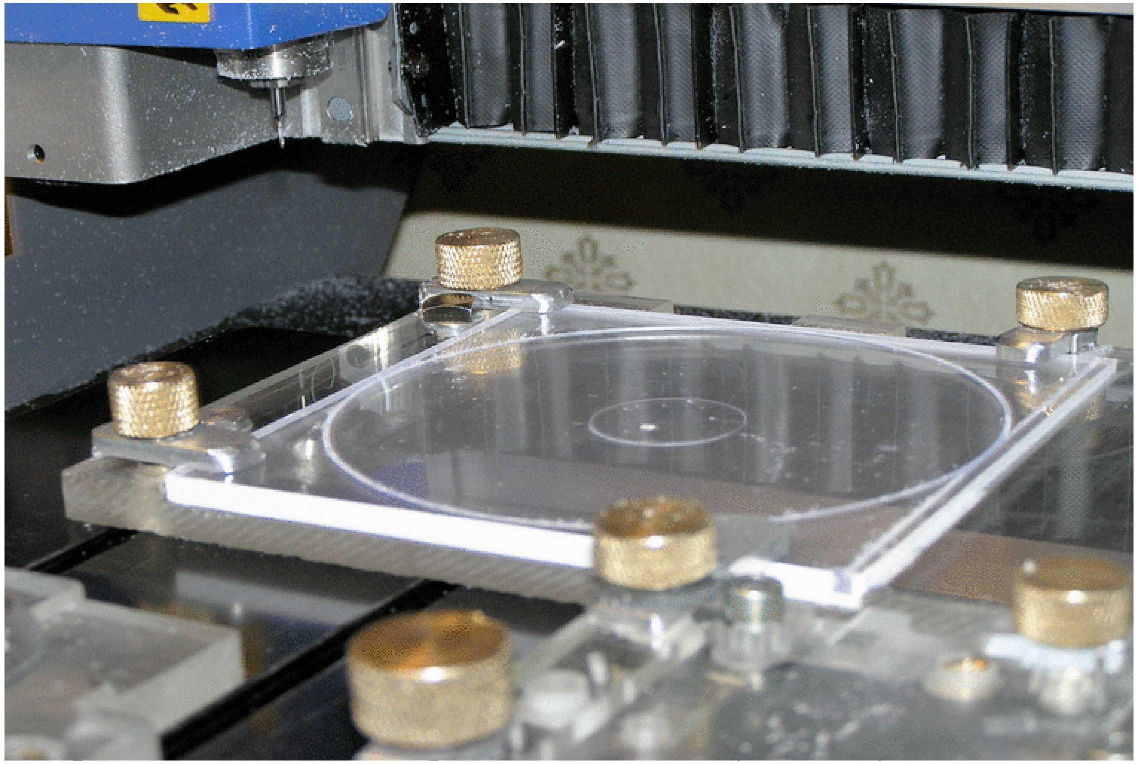
From G. Eigen

Possibility for a backward calorimeter

- All tiles have been molded and edge treated (matting)
- Mill groove into tiles at ITEP and insert WLS fiber
- Insert SiPM on one side and cover other side of WLS fiber with 3M reflector

(M. Danilov)

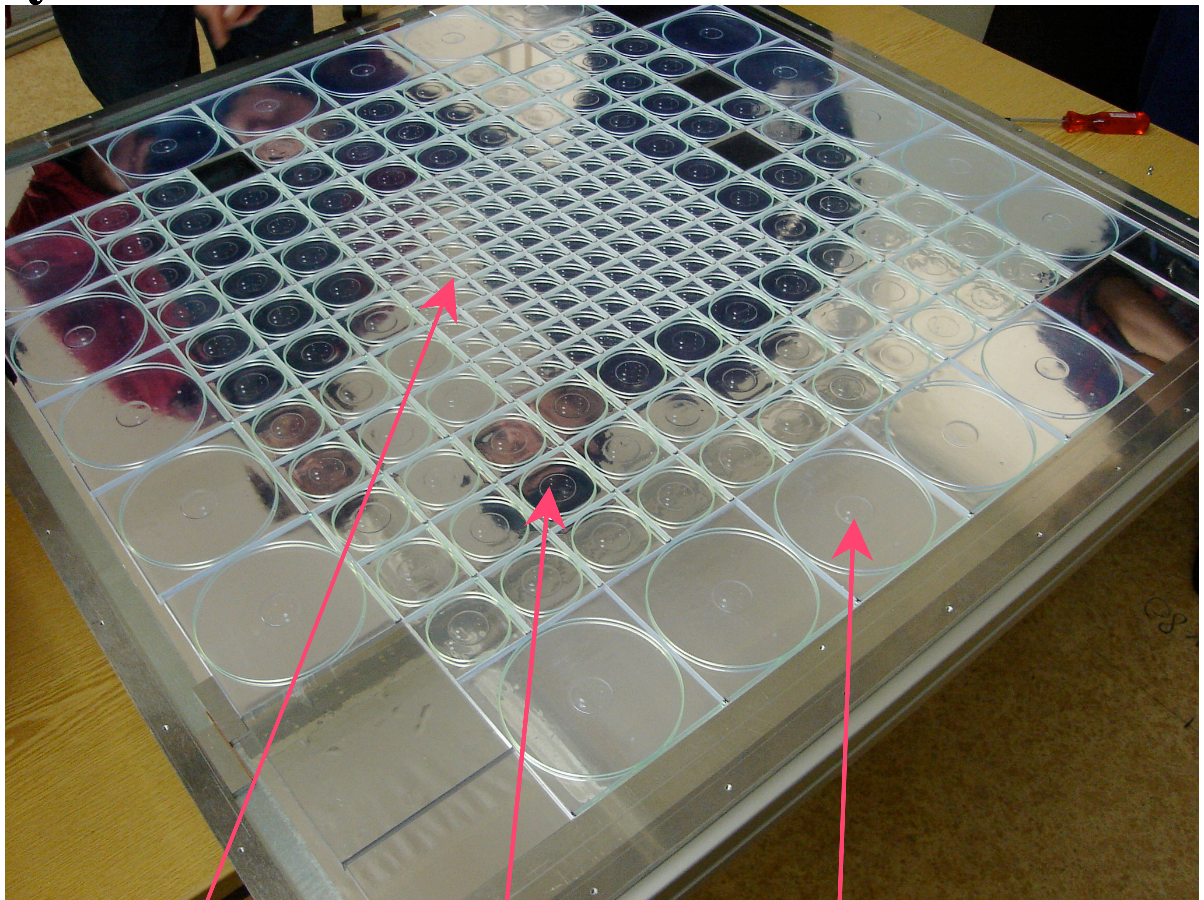




From G. Eigen

Module Layout

- 216 tiles with WLS fiber + SiPM readout mounted in one layer



3×3 cm^2 6×6 cm^2 12×12 cm^2

- Tiles are positioned and fixed in a frame
- The high granularity in the core is suited for a test of the semidigital readout option

Conclusions and perspectives

CRYSTALS:

- Lab test have been performed on LSO/LYSO crystals transmittance, emission, LY, …. (R. Zhu + test in PG with new crystals)
- More than one producer is available

  Undertsand price at mass production

SIMULATION:

- G4simulation is under development
- study of budget material is going on
- put real geometry + support structure (mechanical test)
- geometry for the whole detector

TEST BEAM:

- project for BT in fall 2009
- activities in terms of simulation, planning, site (CERN, DESY, BTF), procurement, money (250k$)…

Conclusions and perspectives cont'd

MECHANICAL TEST:

- Started in Italy mechanical qualification of the crystals
- Study for the mechanical structure, finite element calculation

BACKWARD CALORIMETER:

- New possibility with scintillator tiles as CALICE HCAL calorimeter

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